WIMPs and Other Particles Searches for

OMITTED FROM SUMMARY TABLE

WIMPS AND OTHER PARTICLE SEARCHES

Revised August 2013 by K. Hikasa (Tohoku University).

We collect here those searches which do not appear in any of the above search categories. These are listed in the following order:

1. Galactic WIMP (weakly-interacting massive particle) searches
2. Concentration of stable particles in matter
3. General new physics searches
4. Limits on jet-jet resonance in hadron collisions
5. Limits on neutral particle production at accelerators
6. Limits on charged particles in e^+e^- collisions
7. Limits on charged particles in hadron reactions
8. Limits on charged particles in cosmic rays
9. Searches for quantum black hole production

Note that searches appear in separate sections elsewhere for Higgs bosons (and technipions), other heavy bosons (including W_R, W', Z', leptoquarks, axigluons), axions (including pseudo-Goldstone bosons, Majorons, familons), heavy leptons, heavy neutrinos, free quarks, monopoles, supersymmetric particles, and compositeness. We include specific WIMP searches in the appropriate sections when they yield limits on hypothetical particles such as supersymmetric particles, axions, massive neutrinos, monopoles, *etc.*

We omit papers on CHAMP's, millicharged particles, and other exotic particles. We no longer list for limits on tachyons and centauros. See our 1994 edition for these limits.

GALACTIC WIMP SEARCHES

These limits are for weakly-interacting stable particles that may constitute the invisible mass in the galaxy. Unless otherwise noted, a local mass density of 0.3 GeV/cm^3 is assumed; see each paper for velocity distribution assumptions. In the papers the limit is given as a function of the X^0 mass. Here we list limits only for typical mass values of 20 GeV, 100 GeV, and 1 TeV. Specific limits on supersymmetric dark matter particles may be found in the Supersymmetry section.

Limits for Spin-Independent Cross Section of Dark Matter Particle (X^0) on Nucleon

Isoscalar coupling is assumed to extract the limits from those on X^0–nuclei cross section.

For m_{X^0} = 20 GeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<7.3 \times 10^{-7}$	90	AGNES 16	DS50	Ar
$<1 \times 10^{-5}$	90	[1] AGNESE 16	CDMS	Ge
$<2 \times 10^{-4}$	90	[2] AGUILAR-AR... 16	DMIC	Si CCDs
$<4 \times 10^{-5}$	90	[3] ANGLOHER 16	CRES	$CaWO_4$
$<2 \times 10^{-6}$	90	[4] APRILE 16	X100	Xe
$<9.4 \times 10^{-8}$	90	[5] ARMENGAUD 16	EDE3	Ge
$<1.0 \times 10^{-7}$	90	[6] HEHN 16	EDE3	Ge
$<4 \times 10^{-6}$	90	[7] ZHAO 16	CDEX	Ge
$<1 \times 10^{-5}$	90	AGNES 15	DSID	Ar
$<1.5 \times 10^{-6}$	90	[8] AGNESE 15A	CDM2	Ge
$<1.5 \times 10^{-7}$	90	[9] AGNESE 15B	CDM2	Ge
$<2 \times 10^{-6}$	90	[10] AMOLE 15	PICO	C_3F_8
$<1.2 \times 10^{-5}$	90	CHOI 15	SKAM	H, solar ν ($b\overline{b}$)
$<1.19 \times 10^{-6}$	90	CHOI 15	SKAM	H, solar ν ($\tau^+\tau^-$)
$<2 \times 10^{-8}$	90	[11] XIAO 15	PANX	Xe
$<2.0 \times 10^{-7}$	90	[12] AGNESE 14	SCDM	Ge
$<3.7 \times 10^{-5}$	90	[13] AGNESE 14A	SCDM	Ge
$<1 \times 10^{-9}$	90	[14] AKERIB 14	LUX	Xe
$<2 \times 10^{-6}$	90	[15] ANGLOHER 14	CRES	$CaWO_4$
$<5 \times 10^{-6}$	90	FELIZARDO 14	SMPL	C_2ClF_5
$<8 \times 10^{-6}$	90	[16] LEE 14A	KIMS	CsI
$<2 \times 10^{-4}$	90	[17] LIU 14A	CDEX	Ge
$<1 \times 10^{-5}$	90	[18] YUE 14	CDEX	Ge
$<1.08 \times 10^{-4}$	90	[19] AARTSEN 13	ICCB	H, solar ν ($\tau^+\tau^-$)
$<1.5 \times 10^{-5}$	90	[20] ABE 13B	XMAS	Xe
$<3.1 \times 10^{-6}$	90	[21] AGNESE 13	CDM2	Si
$<3.4 \times 10^{-6}$	90	[22] AGNESE 13A	CDM2	Si
$<2.2 \times 10^{-6}$	90	[23] AGNESE 13A	CDM2	Si
$<5 \times 10^{-5}$	90	[24] LI 13B	TEXO	Ge

		[25] ZHAO	13	CDEX	Ge
$<1.2 \times 10^{-7}$	90	AKIMOV	12	ZEP3	Xe
		[26] ANGLOHER	12	CRES	$CaWO_4$
$<8 \times 10^{-6}$	90	[27] ANGLOHER	12	CRES	$CaWO_4$
$<7 \times 10^{-9}$	90	[28] APRILE	12	X100	Xe
		[29] ARCHAMBAU...	12	PICA	F (C_4F_{10})
$<7 \times 10^{-7}$	90	[30] ARMENGAUD	12	EDE2	Ge
		[31] BARRETO	12	DMIC	CCD
$<2 \times 10^{-6}$	90	BEHNKE	12	COUP	CF_3I
$<7 \times 10^{-6}$		[32] FELIZARDO	12	SMPL	C_2ClF_5
$<1.5 \times 10^{-6}$	90	KIM	12	KIMS	CsI
$<5 \times 10^{-5}$	90	[33] AALSETH	11	CGNT	Ge
		[34] AALSETH	11A	CGNT	Ge
$<5 \times 10^{-7}$	90	[35] AHMED	11	CDM2	Ge, inelastic
$<2.7 \times 10^{-7}$	90	[36] AHMED	11A	RVUE	Ge
		[37] AHMED	11B	CDM2	Ge, low threshold
$<3 \times 10^{-6}$	90	[38] ANGLE	11	XE10	Xe
$<7 \times 10^{-8}$	90	[39] APRILE	11	X100	Xe
		[40] APRILE	11A	X100	Xe, inelastic
$<2 \times 10^{-8}$	90	[28] APRILE	11B	X100	Xe
		[41] HORN	11	ZEP3	Xe
$<2 \times 10^{-7}$	90	AHMED	10	CDM2	Ge
$<1 \times 10^{-5}$	90	[42] AKERIB	10	CDM2	Si, Ge, low threshold
$<1 \times 10^{-7}$	90	APRILE	10	X100	Xe
$<2 \times 10^{-6}$	90	ARMENGAUD	10	EDE2	Ge
$<4 \times 10^{-5}$	90	FELIZARDO	10	SMPL	C_2ClF_3
$<1.5 \times 10^{-7}$	90	[43] AHMED	09	CDM2	Ge
$<2 \times 10^{-4}$	90	[44] LIN	09	TEXO	Ge
		[45] AALSETH	08	CGNT	Ge

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[1] AGNESE 16 CDMSlite excludes low mass WIMPs 1.6–5.5 GeV and SI scattering cross section depending on m(WIMP); see Fig. 4.

[2] AGUILAR-AREVALO 16 search low mass 1–10 GeV WIMP scatter on Si CCDs; set limits Fig. 11.

[3] ANGLOHER 16 requires SI WIMP-nucleon cross section $< 9 \times 10^{-3}$ pb for m(WIMP) = 1 GeV on $CaWO_4$ target.

[4] APRILE 16 search low mass WIMP SI scatter on Xe; exclude $\sigma > 1.4 \times 10^{-5}$ pb for m(WIMP) = 6 GeV.

[5] ARMENGAUD 16 require SI WIMP-p cross section $< 4.3 \times 10^{-4}$ pb for m(WIMP) = 5 GeV on Ge target.

[6] HEHN 16 search for low mass WIMPs via SI scatter on Ge target; σ(SI) $< 5.8 \times 10^{-4}$ pb for m(WIMP) = 5 GeV, Fig. 6.

[7] ZHAO 16 require SI scatter $< 4 \times 10^{-6}$ pb for m(WIMP) = 20 GeV using Ge target; limits also on SD scatter, see Fig. 19.

[8] AGNESE 15A reanalyse AHMED 11B low threshold data. See their Fig. 12 (left) for improved limits extending down to 5 GeV.

[9] AGNESE 15B reanalyse AHMED 10 data.

[10] See their Fig. 7 for limits extending down to 4 GeV.

[11] See their Fig. 13 for limits extending down to 5 GeV.

[12] This limit value is provided by the authors. See their Fig. 4 for limits extending down to $m_{X^0} = 3.5$ GeV.

[13] This limit value is provided by the authors. AGNESE 14A result is from CDMSlite mode operation with enhanced sensitivity to low mass m_{X^0}. See their Fig. 3 for limits extending down to m_{X^0} = 3.5 GeV (see also Fig. 4 in AGNESE 14).

[14] See their Fig. 5 for limits extending down to m_{X^0} = 5.5 GeV.

[15] See their Fig. 5 for limits extending down to m_{X^0} = 1 GeV.

[16] See their Fig. 5 for limits extending down to m_{X^0} = 5 GeV.

[17] LIU 14A result is based on prototype CDEX-0 detector. See their Fig. 13 for limits extending down to m_{X^0} = 2 GeV.

[18] See their Fig. 4 for limits extending down to m_{X^0} = 4.5 GeV.

[19] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[20] See their Fig. 8 for limits extending down to m_{X^0} = 7 GeV.

[21] This limit value is provided by the authors. AGNESE 13 use data taken between Oct. 2006 and July 2007. See their Fig. 4 for limits extending down to m_{X^0} = 7 GeV.

[22] This limit value is provided by the authors. AGNESE 13A use data taken between July 2007 and Sep. 2008. Three candidate events are seen. Assuming these events are real, the best fit parameters are m_{X^0} = 8.6 GeV and $\sigma = 1.9 \times 10^{-5}$ pb.

[23] This limit value is provided by the authors. Limit from combined data of AGNESE 13 and AGNESE 13A. See their Fig. 4 for limits extending down to m_{X^0} = 5.5 GeV.

[24] See their Fig. 4 for limits extending down to m_{X^0} = 4 GeV.

[25] See their Fig. 5 for limits for m_{X^0} = 4–12 GeV.

[26] ANGLOHER 12 observe excess events above the expected background which are consistent with X^0 with mass $\sim$ 25 GeV (or 12 GeV) and spin-independent X^0-nucleon cross section of 2×10^{-6} pb (or 4×10^{-5} pb).

[27] Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

[28] See also APRILE 14A.

[29] See their Fig. 7 for cross section limits for m_{X^0} between 4 and 12 GeV.

[30] See their Fig. 4 for limits extending down to m_{X^0} = 7 GeV.

[31] See their Fig. 13 for cross section limits for m_{X^0} between 1.2 and 10 GeV.

[32] See also DAHL 12 for a criticism.

[33] See their Fig. 4 for limits extending to m_{X^0} = 3.5 GeV.

[34] AALSETH 11A find indications of annual modulation of the data, the energy spectrum being compatible with X^0 mass around 8 GeV. See also AALSETH 13.

[35] AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits. The inelastic cross section reduces to the elastic cross section at the limit of zero mass splitting (Fig. 8, left).

[36] AHMED 11A combine CDMS II and EDELWEISS data.

[37] AHMED 11B give limits on spin-independent X^0-nucleon cross section for m_{X^0} = 4–12 GeV in the range 10^{-3}–10^{-5} pb. See their Fig. 3.

[38] See their Fig. 3 for limits down to m_{X^0} = 4 GeV.

[39] APRILE 11 reanalyze APRILE 10 data.

[40] APRILE 11A search for X^0 inelastic scattering. See their Fig. 2 and 3 for limits. See also APRILE 14A.

[41] HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

[42] See their Fig. 10 and 12 for limits extending to X^0 mass of 1 GeV.

[43] Superseded by AHMED 10.

[44] See their Fig. 6(a) for cross section limits for m_{X^0} extending down to 2 GeV.

[45] See their Fig. 2 for cross section limits for m_{X^0} between 4 and 10 GeV.

For $m_{X^0} = 100$ GeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (pb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<1 \times 10^{-10}$	90	[1] AKERIB	17	LUX	Xe
$<2.0 \times 10^{-8}$	90	AGNES	16	DS50	Ar
$<1 \times 10^{-9}$	90	[2] AKERIB	16	LUX	Xe
$<1 \times 10^{-9}$	90	[3] APRILE	16B	X100	Xe
$<2 \times 10^{-8}$	90	[4] TAN	16	PNDX	Xe
$<4 \times 10^{-10}$	90	[5] TAN	16B	PNDX	Xe
$<6 \times 10^{-8}$	90	AGNES	15	DSID	Ar
$<4 \times 10^{-8}$	90	[6] AGNESE	15B	CDM2	Ge
$<7.13 \times 10^{-6}$	90	CHOI	15	SKAM	H, solar ν ($b\overline{b}$)
$<6.26 \times 10^{-7}$	90	CHOI	15	SKAM	H, solar ν ($W^+ W^-$)
$<2.76 \times 10^{-7}$	90	CHOI	15	SKAM	H, solar ν ($\tau^+ \tau^-$)
$<1.5 \times 10^{-8}$	90	XIAO	15	PANX	Xe
$<1 \times 10^{-9}$	90	AKERIB	14	LUX	Xe
$<4.0 \times 10^{-6}$	90	[7] AVRORIN	14	BAIK	H, solar ν ($W^+ W^-$)
$<1.0 \times 10^{-4}$	90	[7] AVRORIN	14	BAIK	H, solar ν ($b\overline{b}$)
$<1.6 \times 10^{-6}$	90	[7] AVRORIN	14	BAIK	H, solar ν ($\tau^+ \tau^-$)
$<5 \times 10^{-6}$	90	FELIZARDO	14	SMPL	C_2ClF_5
$<6.01 \times 10^{-7}$	90	[8] AARTSEN	13	ICCB	H, solar ν ($W^+ W^-$)
$<3.30 \times 10^{-5}$	90	[8] AARTSEN	13	ICCB	H, solar ν ($b\overline{b}$)
$<1.9 \times 10^{-6}$	90	[9] ADRIAN-MAR..	13	ANTR	H, solar ν ($W^+ W^-$)
$<1.2 \times 10^{-4}$	90	[9] ADRIAN-MAR..	13	ANTR	H, solar ν ($b\overline{b}$)
$<7.6 \times 10^{-7}$	90	[9] ADRIAN-MAR..	13	ANTR	H, solar ν ($\tau^+ \tau^-$)
$<2 \times 10^{-6}$	90	[10] AGNESE	13	CDM2	Si
$<1.6 \times 10^{-6}$	90	[11] BOLIEV	13	BAKS	H, solar ν ($W^+ W^-$)
$<1.9 \times 10^{-5}$	90	[11] BOLIEV	13	BAKS	H, solar ν ($b\overline{b}$)
$<7.1 \times 10^{-7}$	90	[11] BOLIEV	13	BAKS	H, solar ν ($\tau^+ \tau^-$)
$<1.67 \times 10^{-6}$	90	[12] ABBASI	12	ICCB	H, solar ν ($W^+ W^-$)
$<1.07 \times 10^{-4}$	90	[12] ABBASI	12	ICCB	H, solar ν ($b\overline{b}$)
$<4 \times 10^{-8}$	90	AKIMOV	12	ZEP3	Xe
$<1.4 \times 10^{-6}$	90	[13] ANGLOHER	12	CRES	$CaWO_4$
$<3 \times 10^{-9}$	90	[14] APRILE	12	X100	Xe
$<3 \times 10^{-7}$	90	BEHNKE	12	COUP	CF_3I
$<7 \times 10^{-6}$		FELIZARDO	12	SMPL	C_2ClF_5
$<2.5 \times 10^{-7}$	90	[15] KIM	12	KIMS	CsI
$<2 \times 10^{-4}$	90	AALSETH	11	CGNT	Ge
		[16] AHMED	11	CDM2	Ge, inelastic
$<3.3 \times 10^{-8}$	90	[17] AHMED	11A	RVUE	Ge
		[18] AJELLO	11	FLAT	
$<3 \times 10^{-8}$	90	[19] APRILE	11	X100	Xe
		[20] APRILE	11A	X100	Xe, inelastic
$<1 \times 10^{-8}$	90	[14] APRILE	11B	X100	Xe
$<5 \times 10^{-8}$	90	[21] ARMENGAUD	11	EDE2	Ge
		[22] HORN	11	ZEP3	Xe
$<4 \times 10^{-8}$	90	AHMED	10	CDM2	Ge

$<9 \times 10^{-6}$	90	AKERIB	10	CDM2	Si, Ge, low threshold
		[23] AKIMOV	10	ZEP3	Xe, inelastic
$<5 \times 10^{-8}$	90	APRILE	10	X100	Xe
$<1 \times 10^{-7}$	90	ARMENGAUD	10	EDE2	Ge
$<3 \times 10^{-5}$	90	FELIZARDO	10	SMPL	C_2ClF_3
$<5 \times 10^{-8}$	90	[24] AHMED	09	CDM2	Ge
		[25] ANGLE	09	XE10	Xe, inelastic
$<3 \times 10^{-4}$	90	LIN	09	TEXO	Ge
		[26] GIULIANI	05	RVUE	

[1] AKERIB 17 exclude SI cross section $> 10^{-10}$ pb for m(WIMP) = 100 GeV; complete LUX data set.

[2] AKERIB 16 re-analysis of 2013 data exclude SI cross section $> 1\times10^{-9}$ pb for m(WIMP) = 100 GeV on Xe target.

[3] APRILE 16B combined 447 live days using Xe target exclude σ(SI) $> 1.1 \times 10^{-9}$ pb for m(WIMP) = 50 GeV.

[4] TAN 16 search for WIMP scatter off Xe target; see SI exclusion plot Fig. 6.

[5] TAN 16B search for WIMP-p scatter off Xe target; see Fig. 5 for SI exclusion.

[6] AGNESE 15B reanalyse AHMED 10 data.

[7] AVRORIN 14 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun in data taken between 1998 and 2003. See their Table 1 for limits assuming annihilation into neutrino pairs.

[8] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[9] ADRIAN-MARTINEZ 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between Jan. 2007 and Dec. 2008.

[10] AGNESE 13 use data taken between Oct. 2006 and July 2007.

[11] BOLIEV 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken from 1978 to 2009. See also SUVOROVA 13 for an older analysis of the same data.

[12] ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[13] Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

[14] See also APRILE 14A.

[15] See their Fig. 6 for a limit on inelastically scattering X^0 for $m_{X^0} = 70$ GeV.

[16] AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits.

[17] AHMED 11A combine CDMS and EDELWEISS data.

[18] AJELLO 11 search for $e^{\pm}$ flux from X^0 annihilations in the Sun. Models in which X^0 annihilates into an intermediate long-lived weakly interacting particles or X^0 scatters inelastically are constrained. See their Fig. 6–8 for limits.

[19] APRILE 11 reanalyze APRILE 10 data.

[20] APRILE 11A search for X^0 inelastic scattering. See their Fig. 2 and 3 for limits. See also APRILE 14A.

[21] Supersedes ARMENGAUD 10. A limit on inelastic cross section is also given.

[22] HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

[23] AKIMOV 10 give cross section limits for inelastically scattering dark matter. See their Fig. 4.

[24] Superseded by AHMED 10.

[25] ANGLE 09 search for X^0 inelastic scattering. See their Fig. 4 for limits.

[26] GIULIANI 05 analyzes the spin-independent X^0-nucleon cross section limits with both isoscalar and isovector couplings. See their Fig. 3 and 4 for limits on the couplings.

For $m_{X^0} = 1$ TeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<8.6 \times 10^{-8}$	90	AGNES 16	DS50	Ar
$<2 \times 10^{-7}$	90	AGNES 15	DSID	Ar
$<2 \times 10^{-7}$	90	[1] AGNESE 15B	CDM2	Ge
$<1 \times 10^{-8}$	90	AKERIB 14	LUX	Xe
$<2.2 \times 10^{-6}$	90	[2] AVRORIN 14	BAIK	H, solar ν ($W^+ W^-$)
$<5.5 \times 10^{-5}$	90	[2] AVRORIN 14	BAIK	H, solar ν ($b\overline{b}$)
$<6.8 \times 10^{-7}$	90	[2] AVRORIN 14	BAIK	H, solar ν ($\tau^+ \tau^-$)
$<3.46 \times 10^{-7}$	90	[3] AARTSEN 13	ICCB	H, solar ν ($W^+ W^-$)
$<7.75 \times 10^{-6}$	90	[3] AARTSEN 13	ICCB	H, solar ν ($b\overline{b}$)
$<6.9 \times 10^{-7}$	90	[4] ADRIAN-MAR..13	ANTR	H, solar ν ($W^+ W^-$)
$<1.5 \times 10^{-5}$	90	[4] ADRIAN-MAR..13	ANTR	H, solar ν ($b\overline{b}$)
$<1.8 \times 10^{-7}$	90	[4] ADRIAN-MAR..13	ANTR	H, solar ν ($\tau^+ \tau^-$)
$<4.3 \times 10^{-6}$	90	[5] BOLIEV 13	BAKS	H, solar ν ($W^+ W^-$)
$<3.4 \times 10^{-5}$	90	[5] BOLIEV 13	BAKS	H, solar ν ($b\overline{b}$)
$<1.2 \times 10^{-6}$	90	[5] BOLIEV 13	BAKS	H, solar ν ($\tau^+ \tau^-$)
$<2.12 \times 10^{-7}$	90	[6] ABBASI 12	ICCB	H, solar ν ($W^+ W^-$)
$<6.56 \times 10^{-6}$	90	[6] ABBASI 12	ICCB	H, solar ν ($b\overline{b}$)
$<4 \times 10^{-7}$	90	AKIMOV 12	ZEP3	Xe
$<1.1 \times 10^{-5}$	90	[7] ANGLOHER 12	CRES	$CaWO_4$
$<2 \times 10^{-8}$	90	[8] APRILE 12	X100	Xe
$<2 \times 10^{-6}$	90	BEHNKE 12	COUP	CF_3I
$<4 \times 10^{-6}$		FELIZARDO 12	SMPL	C_2ClF_5
$<1.5 \times 10^{-6}$	90	KIM 12	KIMS	CsI
		[9] AHMED 11	CDM2	Ge, inelastic
$<1.5 \times 10^{-7}$	90	[10] AHMED 11A	RVUE	Ge
$<2 \times 10^{-7}$	90	[11] APRILE 11	X100	Xe
$<8 \times 10^{-8}$	90	[8] APRILE 11B	X100	Xe
$<2 \times 10^{-7}$	90	[12] ARMENGAUD 11	EDE2	Ge
		[13] HORN 11	ZEP3	Xe
$<2 \times 10^{-7}$	90	AHMED 10	CDM2	Ge
$<4 \times 10^{-7}$	90	APRILE 10	X100	Xe
$<6 \times 10^{-7}$	90	ARMENGAUD 10	EDE2	Ge
$<3.5 \times 10^{-7}$	90	[14] AHMED 09	CDM2	Ge

[1] AGNESE 15B reanalyse AHMED 10 data.

[2] AVRORIN 14 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun in data taken between 1998 and 2003. See their Table 1 for limits assuming annihilation into neutrino pairs.

[3] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[4] ADRIAN-MARTINEZ 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between Jan. 2007 and Dec. 2008.

[5] BOLIEV 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken from 1978 to 2009. See also SUVOROVA 13 for an older analysis of the same data.

[6] ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[7] Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

[8] See also APRILE 14A.

[9] AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits.

[10] AHMED 11A combine CDMS and EDELWEISS data.

[11] APRILE 11 reanalyze APRILE 10 data.

[12] Supersedes ARMENGAUD 10. A limit on inelastic cross section is also given.

[13] HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

[14] Superseded by AHMED 10.

Limits for Spin-Dependent Cross Section of Dark Matter Particle (X^0) on Proton

For $m_{X^0} = 20$ GeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$< 5 \times 10^{-4}$	90	[1] AMOLE 16A	PICO	C_3F_8
$< 2 \times 10^{-6}$	90	[2] KHACHATRY...16AJ	CMS	8 TeV $pp \to Z + \not{E}_T$; $Z \to \ell\overline{\ell}$
$< 1.2 \times 10^{-3}$	90	AMOLE 15	PICO	C_3F_8
$< 1.43 \times 10^{-3}$	90	CHOI 15	SKAM	H, solar ν ($b\overline{b}$)
$< 1.42 \times 10^{-4}$	90	CHOI 15	SKAM	H, solar ν ($\tau^+\tau^-$)
$< 5 \times 10^{-3}$	90	FELIZARDO 14	SMPL	C_2ClF_5
$< 1.29 \times 10^{-2}$	90	[3] AARTSEN 13	ICCB	H, solar ν ($\tau^+\tau^-$)
$< 3.17 \times 10^{-2}$	90	[4] APRILE 13	X100	Xe
$< 3 \times 10^{-2}$	90	ARCHAMBAU..12	PICA	F (C_4F_{10})
$< 6 \times 10^{-2}$	90	BEHNKE 12	COUP	CF_3I
< 20	90	DAW 12	DRFT	F (CF_4)
$< 7 \times 10^{-3}$		FELIZARDO 12	SMPL	C_2ClF_5
< 0.15	90	KIM 12	KIMS	CsI
$< 1 \times 10^5$	90	[5] AHLEN 11	DMTP	F (CF_4)
< 0.1	90	[5] BEHNKE 11	COUP	CF_3I
$< 1.5 \times 10^{-2}$	90	[6] TANAKA 11	SKAM	H, solar ν ($b\overline{b}$)
< 0.2	90	ARCHAMBAU..09	PICA	F
< 4	90	LEBEDENKO 09A	ZEP3	Xe
< 0.6	90	ANGLE 08A	XE10	Xe
< 100	90	ALNER 07	ZEP2	Xe
< 1	90	LEE 07A	KIMS	CsI
< 20	90	[7] AKERIB 06	CDMS	^{73}Ge, ^{29}Si
< 2	90	SHIMIZU 06A	CNTR	F (CaF_2)
< 0.5	90	ALNER 05	NAIA	NaI
< 1.5	90	BARNABE-HE..05	PICA	F (C_4F_{10})
< 1.5	90	GIRARD 05	SMPL	F (C_2ClF_5)
< 35	90	MIUCHI 03	BOLO	LiF
< 30	90	TAKEDA 03	BOLO	NaF

[1] AMOLE 16A require SD WIMP-p scattering $< 5 \times 10^{-4}$ pb for m(WIMP) = 20 GeV; bubbles from C_3F_8 target.

[2] KHACHATRYAN 16AJ require SD WIMP-p $< 2 \times 10^{-6}$ pb for m(WIMP) = 20 GeV from $pp \rightarrow Z + \not\!\!E_T$; $Z \rightarrow \ell\overline{\ell}$ signal.

[3] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[4] The value has been provided by the authors. APRILE 13 note that the proton limits on Xe are highly sensitive to the theoretical model used. See also APRILE 14A.

[5] Use a direction-sensitive detector.

[6] TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[7] See also AKERIB 05.

For m_{X^0} = 100 GeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.553–0.019	95	[1] AABOUD 16D	ATLS	$pp \rightarrow j + \not\!\!E_T$
$< 1 \times 10^{-5}$	90	[2] AABOUD 16F	ATLS	$pp \rightarrow \gamma + \not\!\!E_T$
$< 1 \times 10^{-4}$	90	[3] AARTSEN 16C	ICCB	solar ν ($W^+ W^-$)
$< 2 \times 10^{-4}$	90	[4] ADRIAN-MAR..16	ANTR	solar ν ($W W$, $b\overline{b}$, $\tau\overline{\tau}$)
$< 3 \times 10^{-3}$	90	[5] AKERIB 16A	LUX	Xe
$< 5 \times 10^{-4}$	90	[6] AMOLE 16	PICO	CF_3I
$< 1.5 \times 10^{-3}$	90	AMOLE 15	PICO	C_3F_8
$< 3.19 \times 10^{-3}$	90	CHOI 15	SKAM	H, solar ν ($b\overline{b}$)
$< 2.80 \times 10^{-4}$	90	CHOI 15	SKAM	H, solar ν ($W^+ W^-$)
$< 1.24 \times 10^{-4}$	90	CHOI 15	SKAM	H, solar ν ($\tau^+\tau^-$)
$< 8 \times 10^{2}$	90	[7] NAKAMURA 15	NAGE	CF_4
$< 1.7 \times 10^{-3}$	90	[8] AVRORIN 14	BAIK	H, solar ν ($W^+ W^-$)
$< 4.5 \times 10^{-2}$	90	[8] AVRORIN 14	BAIK	H, solar ν ($b\overline{b}$)
$< 7.1 \times 10^{-4}$	90	[8] AVRORIN 14	BAIK	H, solar ν ($\tau^+\tau^-$)
$< 6 \times 10^{-3}$	90	FELIZARDO 14	SMPL	C_2ClF_5
$< 2.68 \times 10^{-4}$	90	[9] AARTSEN 13	ICCB	H, solar ν ($W^+ W^-$)
$< 1.47 \times 10^{-2}$	90	[9] AARTSEN 13	ICCB	H, solar ν ($b\overline{b}$)
$< 8.5 \times 10^{-4}$	90	[10] ADRIAN-MAR..13	ANTR	H, solar ν ($W^+ W^-$)
$< 5.5 \times 10^{-2}$	90	[10] ADRIAN-MAR..13	ANTR	H, solar ν ($b\overline{b}$)
$< 3.4 \times 10^{-4}$	90	[10] ADRIAN-MAR..13	ANTR	H, solar ν ($\tau^+\tau^-$)
$< 1.00 \times 10^{-2}$	90	[11] APRILE 13	X100	Xe
$< 7.1 \times 10^{-4}$	90	[12] BOLIEV 13	BAKS	H, solar ν ($W^+ W^-$)
$< 8.4 \times 10^{-3}$	90	[12] BOLIEV 13	BAKS	H, solar ν ($b\overline{b}$)
$< 3.1 \times 10^{-4}$	90	[12] BOLIEV 13	BAKS	H, solar ν ($\tau^+\tau^-$)
$< 7.07 \times 10^{-4}$	90	[13] ABBASI 12	ICCB	H, solar ν ($W^+ W^-$)
$< 4.53 \times 10^{-2}$	90	[13] ABBASI 12	ICCB	H, solar ν ($b\overline{b}$)
$< 7 \times 10^{-2}$	90	ARCHAMBAU..12	PICA	F (C_4F_{10})
$< 1 \times 10^{-2}$	90	BEHNKE 12	COUP	CF_3I
< 1.8	90	DAW 12	DRFT	F (CF_4)
$< 9 \times 10^{-3}$		FELIZARDO 12	SMPL	C_2ClF_5
$< 2 \times 10^{-2}$	90	KIM 12	KIMS	CsI

$< 2 \times 10^{3}$	90	[7] AHLEN	11	DMTP	F (CF_4)
$< 7 \times 10^{-2}$	90	BEHNKE	11	COUP	CF_3I
$< 2.7 \times 10^{-4}$	90	[14] TANAKA	11	SKAM	H, solar ν ($W^+ W^-$)
$< 4.5 \times 10^{-3}$	90	[14] TANAKA	11	SKAM	H, solar ν ($b\overline{b}$)
		[15] FELIZARDO	10	SMPL	C_2ClF_3
$< 6 \times 10^{3}$	90	[7] MIUCHI	10	NAGE	CF_4
< 0.4	90	ARCHAMBAU..	09	PICA	F
< 0.8	90	LEBEDENKO	09A	ZEP3	Xe
< 1.0	90	ANGLE	08A	XE10	Xe
< 15	90	ALNER	07	ZEP2	Xe
< 0.2	90	LEE	07A	KIMS	CsI
$< 1 \times 10^{4}$	90	[7] MIUCHI	07	NAGE	F (CF_4)
< 5	90	[16] AKERIB	06	CDMS	^{73}Ge, ^{29}Si
< 2	90	SHIMIZU	06A	CNTR	F (CaF_2)
< 0.3	90	ALNER	05	NAIA	NaI
< 2	90	BARNABE-HE..	05	PICA	F (C_4F_{10})
<100	90	BENOIT	05	EDEL	^{73}Ge
< 1.5	90	GIRARD	05	SMPL	F (C_2ClF_5)
< 0.7		[17] GIULIANI	05A	RVUE	
		[18] GIULIANI	04	RVUE	
		[19] GIULIANI	04A	RVUE	
< 35	90	MIUCHI	03	BOLO	LiF
< 40	90	TAKEDA	03	BOLO	NaF

[1] AABOUD 16D use ATLAS 13 TeV 3.2 fb^{-1} of data to search for monojet plus missing E_T; agree with SM rates; present limits on large extra dimensions, compressed SUSY spectra and wimp pair production.

[2] AABOUD 16F search for monophoton plus missing E_T events at ATLAS with 13 Tev and 3.2 fb^{-1}; signal agrees with SM background; place limits on SD WIMP-proton scattering vs. mediator mass and large extra dimension models.

[3] AARTSEN 16C search for high energy νs from WIMP annihilation in solar core; limits set on SD WIMP-p scattering (Fig. 8).

[4] ADRIAN-MARTINEZ 16 search for WIMP annihilation into νs from solar core; exclude SD cross section $<$ few 10^{-4} depending on m(WIMP).

[5] AKERIB 16A using 2013 data exclude SD WIMP-proton scattering $> 3 \times 10^{-3}$ pb for m(WIMP) = 100 GeV.

[6] AMOLE 16 use bubble technique on CF_3I target to exclude SD WIMP-p scattering $> 5 \times 10^{-4}$ pb for m(WIMP) = 100 GeV.

[7] Use a direction-sensitive detector.

[8] AVRORIN 14 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun in data taken between 1998 and 2003. See their Table 1 for limits assuming annihilation into neutrino pairs.

[9] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[10] ADRIAN-MARTINEZ 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between Jan. 2007 and Dec. 2008.

[11] The value has been provided by the authors. APRILE 13 note that the proton limits on Xe are highly sensitive to the theoretical model used. See also APRILE 14A.

[12] BOLIEV 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken from 1978 to 2009. See also SUVOROVA 13 for an older analysis of the same data.

[13] ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[14] TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.
[15] See their Fig. 3 for limits on spin-dependent proton couplings for X^0 mass of 50 GeV.
[16] See also AKERIB 05.
[17] GIULIANI 05A analyze available data and give combined limits.
[18] GIULIANI 04 reanalyze COLLAR 00 data and give limits for spin-dependent X^0-proton coupling.
[19] GIULIANI 04A give limits for spin-dependent X^0-proton couplings from existing data.

For $m_{X^0} = 1$ TeV

For limits from X^0 annihilation in the Sun, the assumed annihilation final state is shown in parenthesis in the comment.

VALUE (pb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] ADRIAN-MAR..	16B	ANTR	solar μ from WIMP annihilation
$< 1 \times 10^{-2}$	90	AMOLE	15	PICO	C_3F_8
$< 1.5 \times 10^{3}$	90	NAKAMURA	15	NAGE	CF_4
$< 2.7 \times 10^{-3}$	90	[2] AVRORIN	14	BAIK	H, solar ν ($W^+ W^-$)
$< 6.9 \times 10^{-2}$	90	[2] AVRORIN	14	BAIK	H, solar ν ($b\overline{b}$)
$< 8.4 \times 10^{-4}$	90	[2] AVRORIN	14	BAIK	H, solar ν ($\tau^+\tau^-$)
$< 4.48 \times 10^{-4}$	90	[3] AARTSEN	13	ICCB	H, solar ν ($W^+ W^-$)
$< 1.00 \times 10^{-2}$	90	[3] AARTSEN	13	ICCB	H, solar ν ($b\overline{b}$)
$< 8.9 \times 10^{-4}$	90	[4] ADRIAN-MAR..	13	ANTR	H, solar ν ($W^+ W^-$)
$< 2.0 \times 10^{-2}$	90	[4] ADRIAN-MAR..	13	ANTR	H, solar ν ($b\overline{b}$)
$< 2.3 \times 10^{-4}$	90	[4] ADRIAN-MAR..	13	ANTR	H, solar ν ($\tau^+\tau^-$)
$< 7.57 \times 10^{-2}$	90	[5] APRILE	13	X100	Xe
$< 5.4 \times 10^{-3}$	90	[6] BOLIEV	13	BAKS	H, solar ν ($W^+ W^-$)
$< 4.2 \times 10^{-2}$	90	[6] BOLIEV	13	BAKS	H, solar ν ($b\overline{b}$)
$< 1.5 \times 10^{-3}$	90	[6] BOLIEV	13	BAKS	H, solar ν ($\tau^+\tau^-$)
$< 2.50 \times 10^{-4}$	90	[7] ABBASI	12	ICCB	H, solar ν ($W^+ W^-$)
$< 7.86 \times 10^{-3}$	90	[7] ABBASI	12	ICCB	H, solar ν ($b\overline{b}$)
$< 8 \times 10^{-2}$	90	BEHNKE	12	COUP	CF_3I
< 8	90	DAW	12	DRFT	F (CF_4)
$< 6 \times 10^{-2}$		FELIZARDO	12	SMPL	C_2ClF_5
$< 8 \times 10^{-2}$	90	KIM	12	KIMS	CsI
$< 8 \times 10^{3}$	90	[8] AHLEN	11	DMTP	F (CF_4)
< 0.4	90	BEHNKE	11	COUP	CF_3I
$< 2 \times 10^{-3}$	90	[9] TANAKA	11	SKAM	H, solar ν ($b\overline{b}$)
$< 2 \times 10^{-2}$	90	[9] TANAKA	11	SKAM	H, solar ν ($W^+ W^-$)
$< 1 \times 10^{-3}$	90	[10] ABBASI	10	ICCB	KK dark matter
$< 2 \times 10^{4}$	90	[8] MIUCHI	10	NAGE	CF_4
$< 8.7 \times 10^{-4}$	90	ABBASI	09B	ICCB	H, solar ν ($W^+ W^-$)
$< 2.2 \times 10^{-2}$	90	ABBASI	09B	ICCB	H, solar ν ($b\overline{b}$)
< 3	90	ARCHAMBAU..	09	PICA	F
< 6	90	LEBEDENKO	09A	ZEP3	Xe
< 9	90	ANGLE	08A	XE10	Xe
<100	90	ALNER	07	ZEP2	Xe
< 0.8	90	LEE	07A	KIMS	CsI

$< 4 \times 10^4$	90	[8] MIUCHI 07	NAGE	F (CF_4)
< 30	90	[11] AKERIB 06	CDMS	^{73}Ge, ^{29}Si
< 1.5	90	ALNER 05	NAIA	NaI
< 15	90	BARNABE-HE..05	PICA	F (C_4F_{10})
<600	90	BENOIT 05	EDEL	^{73}Ge
< 10	90	GIRARD 05	SMPL	F (C_2ClF_5)
<260	90	MIUCHI 03	BOLO	LiF
<150	90	TAKEDA 03	BOLO	NaF

[1] ADRIAN-MARTINEZ 16B search for secluded DM via WIMP annihilation in solar core into light mediator which later decays to μ or νs; limits presented in Figures 3 and 4.

[2] AVRORIN 14 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun in data taken between 1998 and 2003. See their Table 1 for limits assuming annihilation into neutrino pairs.

[3] AARTSEN 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between June 2010 and May 2011.

[4] ADRIAN-MARTINEZ 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken between Jan. 2007 and Dec. 2008.

[5] The value has been provided by the authors. APRILE 13 note that the proton limits on Xe are highly sensitive to the theoretical model used. See also APRILE 14A.

[6] BOLIEV 13 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the sun in data taken from 1978 to 2009. See also SUVOROVA 13 for an older analysis of the same data.

[7] ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[8] Use a direction-sensitive detector.

[9] TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0-proton cross section.

[10] ABBASI 10 search for ν_μ from annihilations of Kaluza-Klein photon dark matter in the Sun.

[11] See also AKERIB 05.

Limits for Spin-Dependent Cross Section of Dark Matter Particle (X^0) on Neutron

For $m_{X^0} = 20$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
< 0.09	90	FELIZARDO 14	SMPL	C_2ClF_5
< 8	90	[1] UCHIDA 14	XMAS	^{129}Xe, inelastic
$< 1.13 \times 10^{-3}$	90	[2] APRILE 13	X100	Xe
< 0.02	90	AKIMOV 12	ZEP3	Xe
		[3] AHMED 11B	CDM2	Ge, low threshold
< 0.06	90	AHMED 09	CDM2	Ge
< 0.04	90	LEBEDENKO 09A	ZEP3	Xe
< 50		[4] LIN 09	TEXO	Ge
$< 6 \times 10^{-3}$	90	ANGLE 08A	XE10	Xe
< 0.5	90	ALNER 07	ZEP2	Xe
< 25	90	LEE 07A	KIMS	CsI
< 0.3	90	[5] AKERIB 06	CDMS	^{73}Ge, ^{29}Si

<30	90	SHIMIZU	06A	CNTR	F (CaF_2)
<60	90	ALNER	05	NAIA	NaI
<20	90	BARNABE-HE...	05	PICA	F (C_4F_{10})
<10	90	BENOIT	05	EDEL	^{73}Ge
<4	90	KLAPDOR-K...	05	HDMS	^{73}Ge (enriched)
<600	90	TAKEDA	03	BOLO	NaF

[1] Derived limit from search for inelastic scattering $X^0 + {}^{129}\text{Xe} \rightarrow X^0 + {}^{129}\text{Xe}^*$(39.58 keV).

[2] The value has been provided by the authors. See also APRILE 14A.

[3] AHMED 11B give limits on spin-dependent X^0-neutron cross section for m_{X^0} = 4–12 GeV in the range 10^{-3}–10 pb. See their Fig. 3.

[4] See their Fig. 6(b) for cross section limits for m_{X^0} extending down to 2 GeV.

[5] See also AKERIB 05.

For m_{X^0} = 100 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (pb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.1	90	FELIZARDO	14	SMPL	C_2ClF_5
<0.05	90	[1] UCHIDA	14	XMAS	^{129}Xe, inelastic
$<4.68 \times 10^{-4}$	90	[2] APRILE	13	X100	Xe
<0.01	90	AKIMOV	12	ZEP3	Xe
		[3] FELIZARDO	10	SMPL	C_2ClF_3
<0.02	90	AHMED	09	CDM2	Ge
<0.01	90	LEBEDENKO	09A	ZEP3	Xe
<100	90	LIN	09	TEXO	Ge
<0.01	90	ANGLE	08A	XE10	Xe
<0.05	90	[4] BEDNYAKOV	08	RVUE	Ge
<0.08	90	ALNER	07	ZEP2	Xe
<6	90	LEE	07A	KIMS	CsI
<0.07	90	[5] AKERIB	06	CDMS	^{73}Ge, ^{29}Si
<30	90	SHIMIZU	06A	CNTR	F (CaF_2)
<10	90	ALNER	05	NAIA	NaI
<30	90	BARNABE-HE...	05	PICA	F (C_4F_{10})
<0.7	90	BENOIT	05	EDEL	^{73}Ge
<0.2		[6] GIULIANI	05A	RVUE	
<1.5	90	KLAPDOR-K...	05	HDMS	^{73}Ge (enriched)
		[7] GIULIANI	04	RVUE	
		[8] GIULIANI	04A	RVUE	
		[9] MIUCHI	03	BOLO	LiF
<800	90	TAKEDA	03	BOLO	NaF

[1] Derived limit from search for inelastic scattering $X^0 + {}^{129}\text{Xe}^* \rightarrow X^0 + {}^{129}\text{Xe}^*$(39.58 keV).

[2] The value has been provided by the authors. See also APRILE 14A.

[3] See their Fig. 3 for limits on spin-dependent neutron couplings for X^0 mass of 50 GeV.

[4] BEDNYAKOV 08 reanalyze KLAPDOR-KLEINGROTHAUS 05 and BAUDIS 01 data.

[5] See also AKERIB 05.

[6] GIULIANI 05A analyze available data and give combined limits.

[7] GIULIANI 04 reanalyze COLLAR 00 data and give limits for spin-dependent X^0-neutron coupling.

[8] GIULIANI 04A give limits for spin-dependent X^0-neutron couplings from existing data.

[9] MIUCHI 03 give model-independent limit for spin-dependent X^0-proton and neutron cross sections. See their Fig. 5.

For m_{X^0} = 1 TeV

VALUE (pb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<$ 0.07	90	FELIZARDO	14	SMPL	C_2ClF_5
$<$ 0.2	90	[1] UCHIDA	14	XMAS	^{129}Xe, inelastic
$<$ 3.64 $\times 10^{-3}$	90	[2] APRILE	13	X100	Xe
$<$ 0.08	90	AKIMOV	12	ZEP3	Xe
$<$ 0.2	90	AHMED	09	CDM2	Ge
$<$ 0.1	90	LEBEDENKO	09A	ZEP3	Xe
$<$ 0.1	90	ANGLE	08A	XE10	Xe
$<$ 0.25	90	[3] BEDNYAKOV	08	RVUE	Ge
$<$ 0.6	90	ALNER	07	ZEP2	Xe
$<$ 30	90	LEE	07A	KIMS	CsI
$<$ 0.5	90	[4] AKERIB	06	CDMS	^{73}Ge, ^{29}Si
$<$ 40	90	ALNER	05	NAIA	NaI
$<$200	90	BARNABE-HE...	05	PICA	F (C_4F_{10})
$<$ 4	90	BENOIT	05	EDEL	^{73}Ge
$<$ 10	90	KLAPDOR-K...	05	HDMS	^{73}Ge (enriched)
$<$ 4 $\times 10^{3}$	90	TAKEDA	03	BOLO	NaF

[1] Derived limit from search for inelastic scattering $X^0 + {}^{129}\text{Xe}^* \rightarrow X^0 + {}^{129}\text{Xe}^*$(39.58 keV).

[2] The value has been provided by the authors. See also APRILE 14A.

[3] BEDNYAKOV 08 reanalyze KLAPDOR-KLEINGROTHAUS 05 and BAUDIS 01 data.

[4] See also AKERIB 05.

Cross-Section Limits for Dark Matter Particles (X^0) on Nuclei

For m_{X^0} = 20 GeV

VALUE (nb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<$ 0.03	90	[1] UCHIDA	14	XMAS	^{129}Xe, inelastic
$<$ 0.08	90	[2] ANGLOHER	02	CRES	Al
		[3] BENOIT	00	EDEL	Ge
$<$ 0.04	95	[4] KLIMENKO	98	CNTR	^{73}Ge, inel.
$<$ 0.8		ALESSAND...	96	CNTR	O
$<$ 6		ALESSAND...	96	CNTR	Te
$<$ 0.02	90	[5] BELLI	96	CNTR	^{129}Xe, inel.
		[6] BELLI	96C	CNTR	^{129}Xe
$<$ 4 $\times 10^{-3}$	90	[7] BERNABEI	96	CNTR	Na
$<$ 0.3	90	[7] BERNABEI	96	CNTR	I
$<$ 0.2	95	[8] SARSA	96	CNTR	Na
$<$ 0.015	90	[9] SMITH	96	CNTR	Na
$<$ 0.05	95	[10] GARCIA	95	CNTR	Natural Ge
$<$ 0.1	95	QUENBY	95	CNTR	Na
$<$90	90	[11] SNOWDEN-...	95	MICA	^{16}O
$<$ 4 $\times 10^{3}$	90	[11] SNOWDEN-...	95	MICA	^{39}K
$<$ 0.7	90	BACCI	92	CNTR	Na
$<$ 0.12	90	[12] REUSSER	91	CNTR	Natural Ge
$<$ 0.06	95	CALDWELL	88	CNTR	Natural Ge

[1] UCHIDA 14 limit is for inelastic scattering $X^0 + {}^{129}\text{Xe}^* \rightarrow X^0 + {}^{129}\text{Xe}^*$ (39.58 keV).

[2] ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

[3] BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

[4] KLIMENKO 98 limit is for inelastic scattering $X^0\ {}^{73}\text{Ge} \rightarrow X^0\ {}^{73}\text{Ge}^*$ (13.26 keV).

[5] BELLI 96 limit for inelastic scattering $X^0\ {}^{129}\text{Xe} \rightarrow X^0\ {}^{129}\text{Xe}^*$(39.58 keV).

[6] BELLI 96C use background subtraction and obtain $\sigma < 150$ pb (< 1.5 fb) (90% CL) for spin-dependent (independent) X^0-proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

[7] BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

[8] SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

[9] SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

[10] GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

[11] SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si. See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.

[12] REUSSER 91 limit here is changed from published (0.04) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

For m_{X^0} = 100 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (nb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$< 3 \times 10^{-3}$	90	[1] UCHIDA 14	XMAS	^{129}Xe, inelastic
< 0.3	90	[2] ANGLOHER 02	CRES	Al
		[3] BELLI 02	RVUE	
		[4] BERNABEI 02C	DAMA	
		[5] GREEN 02	RVUE	
		[6] ULLIO 01	RVUE	
		[7] BENOIT 00	EDEL	Ge
$< 4 \times 10^{-3}$	90	[8] BERNABEI 00D		^{129}Xe, inel.
		[9] AMBROSIO 99	MCRO	
		[10] BRHLIK 99	RVUE	
$< 8 \times 10^{-3}$	95	[11] KLIMENKO 98	CNTR	^{73}Ge, inel.
< 0.08	95	[12] KLIMENKO 98	CNTR	^{73}Ge, inel.
< 4		ALESSAND... 96	CNTR	O
<25		ALESSAND... 96	CNTR	Te
$< 6 \times 10^{-3}$	90	[13] BELLI 96	CNTR	^{129}Xe, inel.
		[14] BELLI 96C	CNTR	^{129}Xe
$< 1 \times 10^{-3}$	90	[15] BERNABEI 96	CNTR	Na
< 0.3	90	[15] BERNABEI 96	CNTR	I
< 0.7	95	[16] SARSA 96	CNTR	Na
< 0.03	90	[17] SMITH 96	CNTR	Na
< 0.8	90	[17] SMITH 96	CNTR	I
< 0.35	95	[18] GARCIA 95	CNTR	Natural Ge

< 0.6	95	QUENBY	95	CNTR	Na
< 3	95	QUENBY	95	CNTR	I
$< 1.5 \times 10^2$	90	[19] SNOWDEN-...	95	MICA	^{16}O
$< 4 \times 10^2$	90	[19] SNOWDEN-...	95	MICA	^{39}K
< 0.08	90	[20] BECK	94	CNTR	^{76}Ge
< 2.5	90	BACCI	92	CNTR	Na
< 3	90	BACCI	92	CNTR	I
< 0.9	90	[21] REUSSER	91	CNTR	Natural Ge
< 0.7	95	CALDWELL	88	CNTR	Natural Ge

[1] UCHIDA 14 limit is for inelastic scattering $X^0 + {}^{129}\mathrm{Xe}^* \rightarrow X^0 + {}^{129}\mathrm{Xe}^*$(39.58 keV).

[2] ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

[3] BELLI 02 discuss dependence of the extracted WIMP cross section on the assumptions of the galactic halo structure.

[4] BERNABEI 02C analyze the DAMA data in the scenario in which X^0 scatters into a slightly heavier state as discussed by SMITH 01.

[5] GREEN 02 discusses dependence of extracted WIMP cross section limits on the assumptions of the galactic halo structure.

[6] ULLIO 01 disfavor the possibility that the BERNABEI 99 signal is due to spin-dependent WIMP coupling.

[7] BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

[8] BERNABEI 00D limit is for inelastic scattering $X^0\,{}^{129}\mathrm{Xe} \rightarrow X^0\,{}^{129}\mathrm{Xe}$ (39.58 keV).

[9] AMBROSIO 99 search for upgoing muon events induced by neutrinos originating from WIMP annihilations in the Sun and Earth.

[10] BRHLIK 99 discuss the effect of astrophysical uncertainties on the WIMP interpretation of the BERNABEI 99 signal.

[11] KLIMENKO 98 limit is for inelastic scattering $X^0\,{}^{73}\mathrm{Ge} \rightarrow X^0\,{}^{73}\mathrm{Ge}^*$ (13.26 keV).

[12] KLIMENKO 98 limit is for inelastic scattering $X^0\,{}^{73}\mathrm{Ge} \rightarrow X^0\,{}^{73}\mathrm{Ge}^*$ (66.73 keV).

[13] BELLI 96 limit for inelastic scattering $X^0\,{}^{129}\mathrm{Xe} \rightarrow X^0\,{}^{129}\mathrm{Xe}^*$(39.58 keV).

[14] BELLI 96C use background subtraction and obtain $\sigma < 0.35$ pb (< 0.15 fb) (90% CL) for spin-dependent (independent) X^0-proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

[15] BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

[16] SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

[17] SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

[18] GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

[19] SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si. See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.

[20] BECK 94 uses enriched ^{76}Ge (86% purity).

[21] REUSSER 91 limit here is changed from published (0.3) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

For $m_{X^0} = 1$ TeV

VALUE (nb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<$ 0.03	90	[1] UCHIDA	14	XMAS	^{129}Xe, inelastic
$<$ 3	90	[2] ANGLOHER	02	CRES	Al
		[3] BENOIT	00	EDEL	Ge
		[4] BERNABEI	99D	CNTR	SIMP
		[5] DERBIN	99	CNTR	SIMP
$<$ 0.06	95	[6] KLIMENKO	98	CNTR	^{73}Ge, inel.
$<$ 0.4	95	[7] KLIMENKO	98	CNTR	^{73}Ge, inel.
$<$ 40		ALESSAND...	96	CNTR	O
$<$700		ALESSAND...	96	CNTR	Te
$<$ 0.05	90	[8] BELLI	96	CNTR	^{129}Xe, inel.
$<$ 1.5	90	[9] BELLI	96	CNTR	^{129}Xe, inel.
		[10] BELLI	96C	CNTR	^{129}Xe
$<$ 0.01	90	[11] BERNABEI	96	CNTR	Na
$<$ 9	90	[11] BERNABEI	96	CNTR	I
$<$ 7	95	[12] SARSA	96	CNTR	Na
$<$ 0.3	90	[13] SMITH	96	CNTR	Na
$<$ 6	90	[13] SMITH	96	CNTR	I
$<$ 6	95	[14] GARCIA	95	CNTR	Natural Ge
$<$ 8	95	QUENBY	95	CNTR	Na
$<$ 50	95	QUENBY	95	CNTR	I
$<$700	90	[15] SNOWDEN-...	95	MICA	^{16}O
$<$ 1 $\times 10^3$	90	[15] SNOWDEN-...	95	MICA	^{39}K
$<$ 0.8	90	[16] BECK	94	CNTR	^{76}Ge
$<$ 30	90	BACCI	92	CNTR	Na
$<$ 30	90	BACCI	92	CNTR	I
$<$ 15	90	[17] REUSSER	91	CNTR	Natural Ge
$<$ 6	95	CALDWELL	88	CNTR	Natural Ge

[1] UCHIDA 14 limit is for inelastic scattering $X^0 + {}^{129}\text{Xe}^* \rightarrow X^0 + {}^{129}\text{Xe}^*$ (39.58 keV).

[2] ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

[3] BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

[4] BERNABEI 99D search for SIMPs (Strongly Interacting Massive Particles) in the mass range 10^3–10^{16} GeV. See their Fig. 3 for cross-section limits.

[5] DERBIN 99 search for SIMPs (Strongly Interacting Massive Particles) in the mass range 10^2–10^{14} GeV. See their Fig. 3 for cross-section limits.

[6] KLIMENKO 98 limit is for inelastic scattering $X^0\,{}^{73}\text{Ge} \rightarrow X^0\,{}^{73}\text{Ge}^*$ (13.26 keV).

[7] KLIMENKO 98 limit is for inelastic scattering $X^0\,{}^{73}\text{Ge} \rightarrow X^0\,{}^{73}\text{Ge}^*$ (66.73 keV).

[8] BELLI 96 limit for inelastic scattering $X^0\,{}^{129}\text{Xe} \rightarrow X^0\,{}^{129}\text{Xe}^*$(39.58 keV).

[9] BELLI 96 limit for inelastic scattering $X^0\,{}^{129}\text{Xe} \rightarrow X^0\,{}^{129}\text{Xe}^*$(236.14 keV).

[10] BELLI 96C use background subtraction and obtain $\sigma < 0.7$ pb (< 0.7 fb) (90% CL) for spin-dependent (independent) X^0-proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

[11] BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

[12] SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

[13] SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

[14] GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

[15] SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si. See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.

[16] BECK 94 uses enriched ^{76}Ge (86% purity).

[17] REUSSER 91 limit here is changed from published (5) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

Miscellaneous Results from Underground Dark Matter Searches

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$<4 \times 10^{-3}$	90	[1] ANGLOHER 16A	CRES	$CaWO_4$
		[2] APRILE 15	X100	Event rate modulation
		[3] APRILE 15A	X100	Electron scattering

[1] ANGLOHER 16A require q^2 dependent scattering $< 8 \times 10^{-3}$ pb for asymmetric DM m(WIMP) = 3 GeV on $CaWO_4$ target. It uses a local dark matter density of 0.38 GeV/cm^3.

[2] APRILE 15 search for periodic variation of electronic recoil event rate in the data between Feb. 2011 and Mar. 2012. No significant modulation is found for periods up to 500 days.

[3] APRILE 15A search for X^0 scattering off electrons. See their Fig. 4 for limits on cross section through axial-vector coupling for m_{X^0} between 0.6 GeV and 1 TeV. For m_{X^0} = 2 GeV, $\sigma < 60$ pb (90%CL) is obtained.

X^0 Annihilation Cross Section

Limits are on σv for X^0 pair annihilation at threshold.

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE ($cm^3 s^{-1}$)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
		[1] AARTSEN 16D	ICCB	ν, galactic center
$<6 \times 10^{-26}$	95	[2] ABDALLAH 16	HESS	Central Galactic Halo
$<1 \times 10^{-27}$	95	[3] ABDALLAH 16A	HESS	WIMP+WIMP → $\gamma\gamma$; galactic center
$<3 \times 10^{-26}$	95	[4] AHNEN 16	MGFL	Satellite galaxy, m(WIMP)=100 GeV
$<1.9 \times 10^{-21}$	90	[5] AVRORIN 16	BAIK	νs from galactic center
$<3 \times 10^{-26}$	95	[6] CAPUTO 16	FLAT	small Magellanic cloud
$<1 \times 10^{-25}$	95	[7] FORNASA 16	FLAT	Fermi-LAT γ-ray anisotropy
$<5 \times 10^{-27}$		[8] LEITE 16		WIMP, radio
$<2 \times 10^{-26}$	95	[9] LI 16	FLAT	dwarf galaxies
$<1 \times 10^{-25}$	95	[10] LI 16A	FLAT	Fermi-LAT; M31
$<1 \times 10^{-26}$		[11] LIANG 16	FLAT	Fermi-LAT, gamma line
$<1 \times 10^{-25}$	95	[12] LU 16	FLAT	Fermi-LAT and AMS-02
$<1 \times 10^{-23}$	95	[13] SHIRASAKI 16	FLAT	extra galactic
		[14] AARTSEN 15C	ICCB	ν, Galactic halo
		[15] AARTSEN 15E	ICCB	ν, Galactic center
		[16] ABRAMOWSKI 15	HESS	Galactic center
		[17] ACKERMANN 15	FLAT	monochromatic γ
		[18] ACKERMANN 15A	FLAT	isotropic γ background

		[19] ACKERMANN	15B	FLAT	Satellite galaxy
		[20] ADRIAN-MAR..	15	ANTR	ν, Galactic center
$<2.90 \times 10^{-26}$	95	[21,22] ACKERMANN	14	FLAT	Satellite galaxy, $m = 10$ GeV
$<1.84 \times 10^{-25}$	95	[21,23] ACKERMANN	14	FLAT	Satellite galaxy, $m = 100$ GeV
$<1.75 \times 10^{-24}$	95	[21,23] ACKERMANN	14	FLAT	Satellite galaxy, $m = 1$ TeV
$<4.52 \times 10^{-24}$	95	[24] ALEKSIC	14	MGIC	Segue 1, $m = 1.35$ TeV
		[25] AARTSEN	13C	ICCB	Galaxies
		[26] ABRAMOWSKI	13	HESS	Central Galactic Halo
		[27] ACKERMANN	13A	FLAT	Galaxy
		[28] ABRAMOWSKI	12	HESS	Fornax Cluster
		[29] ACKERMANN	12	FLAT	Galaxy
		[30] ACKERMANN	12	FLAT	Galaxy
		[31] ALIU	12	VRTS	Segue 1
$<1 \times 10^{-22}$	90	[32] ABBASI	11C	ICCB	Galactic halo, m=1 TeV
$<3 \times 10^{-25}$	95	[33] ABRAMOWSKI	11	HESS	Near Galactic center, m=1 TeV
$<1 \times 10^{-26}$	95	[34] ACKERMANN	11	FLAT	Satellite galaxy, m=10 GeV
$<1 \times 10^{-25}$	95	[34] ACKERMANN	11	FLAT	Satellite galaxy, m=100 GeV
$<1 \times 10^{-24}$	95	[34] ACKERMANN	11	FLAT	Satellite galaxy, m=1 TeV

[1] AARTSEN 16D search for GeV νs from WIMP annihilation in galaxy; limits set on $\langle\sigma{\cdot}v\rangle$ in Fig. 6, 7.

[2] ABDALLAH 16 require $\langle\sigma{\cdot}v\rangle < 6 \times 10^{-26}$ cm^3/s for m(WIMP) = 1.5 TeV from 254 hours observation ($W W$ channel) and $< 2 \times 10^{-26}$ cm^3/s for m(WIMP) = 1.0 TeV in $\tau^+\tau^-$ channel.

[3] ABDALLAH 16A search for line spectra from WIMP + WIMP → $\gamma\gamma$ in 18 hr HESS data; rule out previous 130 GeV WIMP hint from Fermi-LAT data.

[4] AHNEN 16 require $\langle\sigma{\cdot}v\rangle < 3 \times 10^{-26}$ cm^3/s for m(WIMP) = 100 GeV ($W W$ channel).

[5] AVRORIN 16 require $\langle$s.v$\rangle$ $< 1.91 \times 10^{-21}$ cm^3/s from WIMP annihilation to νs via $W W$ channel for m(WIMP) = 1 TeV.

[6] CAPUTO 16 place limits on WIMPs from annihilation to gamma rays in Small Magellanic Cloud using Fermi-LaT data: $\langle\sigma{\cdot}v\rangle < 3 \times 10^{-26}$cm^3/s for m(WIMP) = 10 GeV.

[7] FORNASA 16 use anisotropies in the γ-ray diffuse emission detected by Fermi-LAT to bound $\langle\sigma{\cdot}v\rangle < 10^{-25}$cm^3/s for m(WIMP) = 100 GeV in $b\overline{b}$ channel: see Fig. 28. The limit is driven by dark-matter subhalos in the Milky Way and it refers to their Most Constraining Scenario.

[8] LEITE 16 constrain WIMP annihilation via search for radio emissions from Smith cloud; $\langle\sigma{\cdot}v\rangle < 5 \times 10^{-27}$cm^3/s in $e e$ channel for m(WIMP) = 5 GeV.

[9] LI 16 re-analyze Fermi-LAT data on 8 dwarf spheroidals; set limit $\langle\sigma{\cdot}v\rangle < 2 \times 10^{-26}$ cm^3/s for m(WIMP) = 100 GeV in $b\overline{b}$ mode with substructures included.

[10] LI 16A constrain $\langle\sigma{\cdot}v\rangle < 10^{-25}$cm^3/s in $b\overline{b}$ channel for m(WIMP) = 100 GeV using Fermi-LAT data from M31; see Fig. 6.

[11] LIANG 16 search dwarf spheroidal galaxies, Large Magellanic Cloud, and Small Magellanic Cloud for γ-line in Fermi-LAT data.

[12] LU 16 re-analyze Fermi-LAT and AMS-02 data; require $\langle\sigma{\cdot}v\rangle < 10^{-25}$cm^3/s for m_m(WIMP) = 1 TeV in $b\overline{b}$ channel .

[13] SHIRASAKI 16 re-anayze Fermi-LAT extra-galactic data; require $\langle\sigma{\cdot}v\rangle < 10^{-23}$cm^3/s for m(WIMP) = 1 TeV in $b\overline{b}$ channel; see Fig. 8.

[14] AARTSEN 15C search for neutrinos from X^0 annihilation in the Galactic halo. See their Figs. 16 and 17, and Table 5 for limits on $\sigma \cdot$ v for X^0 mass between 100 GeV and 100 TeV.

[15] AARTSEN 15E search for neutrinos from X^0 annihilation in the Galactic center. See their Figs. 7 and 9, and Table 3 for limits on $\sigma \cdot$ v for X^0 mass between 30 GeV and 10 TeV.

[16] ABRAMOWSKI 15 search for γ from X^0 annihilation in the Galactic center. See their Fig. 4 for limits on $\sigma \cdot$ v for X^0 mass between 250 GeV and 10 TeV.

[17] ACKERMANN 15 search for monochromatic γ from X^0 annihlation in the Galactic halo. See their Fig. 8 and Tables 2–4 for limits on $\sigma \cdot$ v for X^0 mass between 0.2 GeV and 500 GeV.

[18] ACKERMANN 15A search for γ from X^0 annihilation (both Galactic and extragalactic) in the isotropic γ background. See their Fig. 7 for limits on $\sigma \cdot$ v for X^0 mass between 10 GeV and 30 TeV.

[19] ACKERMANN 15B search for γ from X^0 annihilation in 15 dwarf spheroidal satellite galaxies of the Milky Way. See their Figs. 1 and 2 for limits on $\sigma \cdot$ v for X^0 mass between 2 GeV and 10 TeV.

[20] ADRIAN-MARTINEZ 15 search for neutrinos from X^0 annihilation in the Galactic center. See their Figs. 10 and 11 and Tables 1 and 2 for limits on $\sigma \cdot$ v for X^0 mass between 25 GeV and 10 TeV.

[21] ACKERMANN 14 search for γ from X^0 annihilation in 25 dwarf spheroidal satellite galaxies of the Milky Way. See their Tables II–VII for limits assuming annihilation into $e^+ e^-$, $\mu^+ \mu^-$, $\tau^+ \tau^-$, $u \overline{u}$, $b \overline{b}$, and $W^+ W^-$, for X^0 mass ranging from 2 GeV to 10 TeV.

[22] Limit assuming X^0 pair annihilation into $b \overline{b}$.

[23] Limit assuming X^0 pair annihilation into $W^+ W^-$.

[24] ALEKSIC 14 search for γ from X^0 annihilation in the dwarf spheroidal galaxy Segue 1. The listed limit assumes annihilation into $W^+ W^-$. See their Figs. 6, 7, and 16 for limits on $\sigma \cdot$ v for annihilation channels $\mu^+ \mu^-$, $\tau^+ \tau^-$, $b \overline{b}$, $t \overline{t}$, $\gamma \gamma$, γZ, $W^+ W^-$, $Z Z$ for X^0 mass between 10^2 and 10^4 GeV.

[25] AARTSEN 13C search for neutrinos from X^0 annihilation in nearby galaxies and galaxy clusters. See their Figs. 5–7 for limits on $\sigma \cdot$ v for $X^0 X^0 \rightarrow \nu \overline{\nu}$, $\mu^+ \mu^-$, $\tau^+ \tau^-$, and $W^+ W^-$ for X^0 mass between 300 GeV and 100 TeV.

[26] ABRAMOWSKI 13 search for monochromatic γ from X^0 annihilation in the Milky Way halo in the central region. Limit on $\sigma \cdot$ v between 10^{-28} and 10^{-25} cm^3 s^{-1} (95% CL) is obtained for X^0 mass between 500 GeV and 20 TeV for $X^0 X^0 \rightarrow \gamma \gamma$. X^0 density distribution in the Galaxy by Einasto is assumed. See their Fig. 4.

[27] ACKERMANN 13A search for monochromatic γ from X^0 annihilation in the Milky Way. Limit on $\sigma \cdot$ v for the process $X^0 X^0 \rightarrow \gamma \gamma$ in the range 10^{-29}–10^{-27} cm^3 s^{-1} (95% CL) is obtained for X^0 mass between 5 and 300 GeV. The limit depends slightly on the assumed density profile of X^0 in the Galaxy. See their Tables VII−X and Fig.10. Supersedes ACKERMANN 12.

[28] ABRAMOWSKI 12 search for γ's from X^0 annihilation in the Fornax galaxy cluster. See their Fig. 7 for limits on $\sigma \cdot$ v for X^0 mass between 0.1 and 100 TeV for the annihilation channels $\tau^+ \tau^-$, $b \overline{b}$, and $W^+ W^-$.

[29] ACKERMANN 12 search for monochromatic γ from X^0 annihilation in the Milky Way. Limit on $\sigma \cdot$ v in the range 10^{-28}–10^{-26} cm^{3}s^{-1} (95% CL) is obtained for X^0 mass between 7 and 200 GeV if X^0 annihilates into $\gamma \gamma$. The limit depends slightly on the assumed density profile of X^0 in the Galaxy. See their Table III and Fig. 15.

[30] ACKERMANN 12 search for γ from X^0 annihilation in the Milky Way in the diffuse γ background. Limit on $\sigma \cdot$ v of 10^{-24} cm^{3}s^{-1} or larger is obtained for X^0 mass between 5 GeV and 10 TeV for various annihilation channels including $W^+ W^-$, $b \overline{b}$, $g g$, $e^+ e^-$, $\mu^+ \mu^-$, $\tau^+ \tau^-$. The limit depends slightly on the assumed density profile of X^0 in the Galaxy. See their Figs. 17–20.

[31] ALIU 12 search for γ's from X^0 annihilation in the dwarf spheroidal galaxy Segue 1. Limit on $\sigma \cdot$ v in the range 10^{-24}–10^{-20} cm^{3}s^{-1} (95% CL) is obtained for X^0 mass

between 10 GeV and 2 TeV for annihilation channels e^+e^-, $\mu^+\mu^-$, $\tau^+\tau^-$, $b\overline{b}$, and W^+W^-. See their Fig. 3.

[32] ABBASI 11C search for ν_μ from X^0 annihilation in the outer halo of the Milky Way. The limit assumes annihilation into $\nu\nu$. See their Fig. 9 for limits with other annihilation channels.

[33] ABRAMOWSKI 11 search for γ from X^0 annihilation near the Galactic center. The limit assumes Einasto DM density profile.

[34] ACKERMANN 11 search for γ from X^0 annihilation in ten dwarf spheroidal satellite galaxies of the Milky Way. The limit for $m = 10$ GeV assumes annihilation into $b\overline{b}$, the others W^+W^-. See their Fig. 2 for limits with other final states. See also GERINGER-SAMETH 11 for a different analysis of the same data.

Dark Matter Particle (X^0) Production in Hadron Collisions

Searches for X^0 production in asociation with observable particles (γ, jets, ...) in high energy hadron collisions. If a specific form of effective interaction Lagrangian is assumed, the limits may be translated into limits on X^0-nucleon scattering cross section.

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
	[1] AABOUD 17A	ATLS	pp ($H \rightarrow b\overline{b}$ + WIMP pair)
	[2] KHACHATRY... 17A	CMS	forward jets + $\not\!\!E_T$
	[3] AABOUD 16AD	ATLS	(W or $Z \rightarrow$ jets) + $\not\!\!E_T$
	[4] AAD 16AF	ATLS	$VV \rightarrow$ forward jets + $\not\!\!E_T$
	[5] AAD 16AG	ATLS	ℓ + jets
	[6] AAD 16M	ATLS	$pp \rightarrow H + \not\!\!E_T$, $H \rightarrow b\overline{b}$
	[7] KHACHATRY... 16BZ	CMS	jet(s) + $\not\!\!E_T$
	[8] KHACHATRY... 16CA	CMS	jets + $\not\!\!E_T$
	[9] KHACHATRY... 16N	CMS	$pp \rightarrow \gamma + \not\!\!E_T$
	[10] AAD 15AS	ATLS	b ($\overline{b}$) + $\not\!\!E_T$, $t\overline{t}$ + $\not\!\!E_T$
	[11] AAD 15BH	ATLS	jet + $\not\!\!E_T$
	[12] AAD 15CF	ATLS	H^0 + $\not\!\!E_T$
	[13] AAD 15CS	ATLS	γ + $\not\!\!E_T$
	[14] KHACHATRY... 15AG	CMS	$t\overline{t}$ + $\not\!\!E_T$
	[15] KHACHATRY... 15AL	CMS	jet + $\not\!\!E_T$
	[16] KHACHATRY... 15T	CMS	ℓ + $\not\!\!E_T$
	[17] AAD 14AI	ATLS	W + $\not\!\!E_T$
	[18] AAD 14BK	ATLS	W, Z + $\not\!\!E_T$
	[19] AAD 14K	ATLS	Z + $\not\!\!E_T$
	[20] AAD 14O	ATLS	Z + $\not\!\!E_T$
	[21] AAD 13AD	ATLS	jet + $\not\!\!E_T$
	[22] AAD 13C	ATLS	γ + $\not\!\!E_T$
	[23] AALTONEN 12K	CDF	t + $\not\!\!E_T$
	[24] AALTONEN 12M	CDF	jet + $\not\!\!E_T$
	[25] CHATRCHYAN 12AP	CMS	jet + $\not\!\!E_T$
	[26] CHATRCHYAN 12T	CMS	γ + $\not\!\!E_T$

[1] AABOUD 17A search for $H \rightarrow b\overline{b} + \not\!\!E_T$. See Fig. 4b for limits set on VB mediator vs WIMP mass.

[2] KHACHATRYAN 17A search for WIMPs in forward jets + $\not\!\!E_T$ channel with 18.5 fb^{-1} at 8 TeV; limits set in effective theory model, Fig. 3.

[3] AABOUD 16AD place limits on $VVXX$ effective theory via search for hadronic W or Z plus WIMP pair production. See Fig. 5.

[4] AAD 16AF search for $VV \rightarrow$ ($H \rightarrow$ WIMP pair) + forward jets with 20.3 fb^{-1} at 8 TeV; set limits in Higgs portal model, Fig. 8 .

[5] AAD 16AG search for lepton jets with 20.3 fb^{-1} of data at 8 TeV; Fig. 13 excludes dark photons around 0.1–1 GeV for kinetic mixing 10^{-6}–10^{-2}.

[6] AAD 16M search with 20.3 fb^{-1} of data at 8 TeV pp collisions; limits placed on EFT model (Fig. 7) and simplified Z' model (Fig. 6).

[7] KHACHATRYAN 16BZ search for jet(s) + $\not{E}_T$ in 19.7 fb^{-1} at 8 TeV; limits set for variety of simplified models.

[8] KHACHATRYAN 16CA search for WIMPs via jet(s) + $\not{E}_T$ using razor variable; require mediator scale > 1 TeV for various effective theories.

[9] KHACHATRYAN 16N search for γ + WIMPs in 19.6 fb^{-1} at 8 TeV; limits set on SI and SD WIMP-p scattering in Fig. 3.

[10] AAD 15AS search for events with one or more bottom quark and missing E_T, and also events with a top quark pair and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See their Figs. 5 and 6 for translated limits on X^0-nucleon cross section for m = 1–700 GeV.

[11] AAD 15BH search for events with a jet and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See their Fig. 12 for translated limits on X^0-nucleon cross section for m = 1–1200 GeV.

[12] AAD 15CF search for events with a H^0 ($\rightarrow \gamma\gamma$) and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See paper for limits on the strength of some contact interactions containing X^0 and the Higgs fields.

[13] AAD 15CS search for events with a photon and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See their Fig. 13 (see also erratum) for translated limits on X^0-nucleon cross section for m = 1–1000 GeV.

[14] KHACHATRYAN 15AG search for events with a top quark pair and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 19.7 fb^{-1}. See their Fig. 8 for translated limits on X^0-nucleon cross section for m = 1–200 GeV.

[15] KHACHATRYAN 15AL search for events with a jet and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 19.7 fb^{-1}. See their Fig. 5 and Tables 4–6 for translated limits on X^0-nucleon cross section for m = 1–1000 GeV.

[16] KHACHATRYAN 15T search for events with a lepton and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 19.7 fb^{-1}. See their Fig. 17 for translated limits on X^0-proton cross section for m = 1–1000 GeV.

[17] AAD 14AI search for events with a W and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See their Fig. 4 for translated limits on X^0–nucleon cross section for m = 1–1500 GeV.

[18] AAD 14BK search for hadronically decaying W, Z in association with $\not{E}_T$ in 20.3 fb^{-1} at 8 TeV pp collisions. Fig. 5 presents exclusion results for SI and SD scattering cross section. In addition, cross section limits on the anomalous production of W or Z bosons with large missing transverse momentum are also set in two fiducial regions.

[19] AAD 14K search for events with a Z and missing E_T in pp collisions at E_{cm} = 8 TeV with L = 20.3 fb^{-1}. See their Fig. 5 and 6 for translated limits on X^0–nucleon cross section for m = 1–10^3 GeV.

[20] AAD 14O search for ZH^0 production with H^0 decaying to invisible final states. See their Fig. 4 for translated limits on X^0–nucleon cross section for m = 1–60 GeV in Higgs-portal X^0 scenario.

[21] AAD 13AD search for events with a jet and missing E_T in pp collisions at E_{cm} = 7 TeV with L = 4.7 fb^{-1}. See their Figs. 5 and 6 for translated limits on X^0-nucleon cross section for m = 1–1300 GeV.

[22] AAD 13C search for events with a photon and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.6 fb^{-1}. See their Fig. 3 for translated limits on X^0-nucleon cross section for m = 1–1000 GeV.

[23] AALTONEN 12K search for events with a top quark and missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 7.7 fb^{-1}. Upper limits on $\sigma(tX^0)$ in the range 0.4–2 pb (95% CL) is given for m_{X^0} = 0–150 GeV.

[24] AALTONEN 12M search for events with a jet and missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 6.7 fb^{-1}. Upper limits on the cross section in the range 2–10 pb (90% CL) is given for m_{X^0} = 1–300 GeV. See their Fig. 2 for translated limits on X^0-nucleon cross section.

[25] CHATRCHYAN 12AP search for events with a jet and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 5.0 fb^{-1}. See their Fig. 4 for translated limits on X^0-nucleon cross section for m_{X^0} = 0.1–1000 GeV.

[26] CHATRCHYAN 12T search for events with a photon and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 5.0 fb^{-1}. Upper limits on the cross section in the range 13–15 fb (90% CL) is given for m_{X^0} = 1–1000 GeV. See their Fig. 2 for translated limits on X^0-nucleon cross section.

CONCENTRATION OF STABLE PARTICLES IN MATTER

Concentration of Heavy (Charge +1) Stable Particles in Matter

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4 \times 10^{-17}$	95	[1] YAMAGATA	93	SPEC	Deep sea water, M=5–1600m_p
$<6 \times 10^{-15}$	95	[2] VERKERK	92	SPEC	Water, M= 10^5 to 3×10^7 GeV
$<7 \times 10^{-15}$	95	[2] VERKERK	92	SPEC	Water, M= 10^4, 6×10^7 GeV
$<9 \times 10^{-15}$	95	[2] VERKERK	92	SPEC	Water, M= 10^8 GeV
$<3 \times 10^{-23}$	90	[3] HEMMICK	90	SPEC	Water, M = 1000m_p
$<2 \times 10^{-21}$	90	[3] HEMMICK	90	SPEC	Water, M = 5000m_p
$<3 \times 10^{-20}$	90	[3] HEMMICK	90	SPEC	Water, M = 10000m_p
$<1. \times 10^{-29}$		SMITH	82B	SPEC	Water, M=30–400m_p
$<2. \times 10^{-28}$		SMITH	82B	SPEC	Water, M=12–1000m_p
$<1. \times 10^{-14}$		SMITH	82B	SPEC	Water, M >1000 m_p
$<(0.2–1.) \times 10^{-21}$		SMITH	79	SPEC	Water, M=6–350 m_p

[1] YAMAGATA 93 used deep sea water at 4000 m since the concentration is enhanced in deep sea due to gravity.

[2] VERKERK 92 looked for heavy isotopes in sea water and put a bound on concentration of stable charged massive particle in sea water. The above bound can be translated into into a bound on charged dark matter particle (5×10^6 GeV), assuming the local density, ρ=0.3 GeV/cm^3, and the mean velocity $\langle v\rangle$=300 km/s.

[3] See HEMMICK 90 Fig. 7 for other masses 100–10000 m_p.

Concentration of Heavy Stable Particles Bound to Nuclei

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
$<1.2 \times 10^{-11}$	95	[1] JAVORSEK 01	SPEC	Au, M= 3 GeV
$<6.9 \times 10^{-10}$	95	[1] JAVORSEK 01	SPEC	Au, M= 144 GeV
$<1 \times 10^{-11}$	95	[2] JAVORSEK 01B	SPEC	Au, M= 188 GeV
$<1 \times 10^{-8}$	95	[2] JAVORSEK 01B	SPEC	Au, M= 1669 GeV
$<6 \times 10^{-9}$	95	[2] JAVORSEK 01B	SPEC	Fe, M= 188 GeV
$<1 \times 10^{-8}$	95	[2] JAVORSEK 01B	SPEC	Fe, M= 647 GeV
$<4 \times 10^{-20}$	90	[3] HEMMICK 90	SPEC	C, $M = 100 m_p$
$<8 \times 10^{-20}$	90	[3] HEMMICK 90	SPEC	C, $M = 1000 m_p$
$<2 \times 10^{-16}$	90	[3] HEMMICK 90	SPEC	C, $M = 10000 m_p$
$<6 \times 10^{-13}$	90	[3] HEMMICK 90	SPEC	Li, $M = 1000 m_p$
$<1 \times 10^{-11}$	90	[3] HEMMICK 90	SPEC	Be, $M = 1000 m_p$
$<6 \times 10^{-14}$	90	[3] HEMMICK 90	SPEC	B, $M = 1000 m_p$
$<4 \times 10^{-17}$	90	[3] HEMMICK 90	SPEC	O, $M = 1000 m_p$
$<4 \times 10^{-15}$	90	[3] HEMMICK 90	SPEC	F, $M = 1000 m_p$
$< 1.5 \times 10^{-13}$/nucleon	68	[4] NORMAN 89	SPEC	$^{206}\mathrm{Pb}X^-$
$< 1.2 \times 10^{-12}$/nucleon	68	[4] NORMAN 87	SPEC	$^{56,58}\mathrm{Fe}X^-$

[1] JAVORSEK 01 search for (neutral) SIMPs (strongly interacting massive particles) bound to Au nuclei. Here M is the effective SIMP mass.

[2] JAVORSEK 01B search for (neutral) SIMPs (strongly interacting massive particles) bound to Au and Fe nuclei from various origins with exposures on the earth's surface, in a satellite, heavy ion collisions, etc. Here M is the mass of the anomalous nucleus. See also JAVORSEK 02.

[3] See HEMMICK 90 Fig. 7 for other masses 100–10000 m_p.

[4] Bound valid up to $m_{X^-} \sim$ 100 TeV.

GENERAL NEW PHYSICS SEARCHES

This subsection lists some of the search experiments which look for general signatures characteristic of new physics, independent of the framework of a specific model.

The observed events are compatible with Standard Model expectation, unless noted otherwise.

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
	[1] AAD 15AT	ATLS	$t + \not\!\!E_T$
	[2] KHACHATRY... 15F	CMS	$t + \not\!\!E_T$
	[3] AALTONEN 14J	CDF	W + 2 jets
	[4] AAD 13A	ATLS	$WW \rightarrow \ell\nu\ell'\nu$
	[5] AAD 13C	ATLS	$\gamma + \not\!\!E_T$
	[6] AALTONEN 13I	CDF	Delayed $\gamma + \not\!\!E_T$
	[7] CHATRCHYAN 13	CMS	$\ell^+\ell^-$ + jets + $\not\!\!E_T$
	[8] AAD 12C	ATLS	$t\bar{t} + \not\!\!E_T$
	[9] AALTONEN 12M	CDF	jet + $\not\!\!E_T$
	[10] CHATRCHYAN 12AP	CMS	jet + $\not\!\!E_T$

[11] CHATRCHYAN	12Q	CMS	Z + jets + $\not\!\!E_T$
[12] CHATRCHYAN	12T	CMS	$\gamma + \not\!\!E_T$
[13] AAD	11S	ATLS	jet + $\not\!\!E_T$
[14] AALTONEN	11AF	CDF	$\ell^\pm \ell^\pm$
[15] CHATRCHYAN	11C	CMS	$\ell^+ \ell^-$ + jets + $\not\!\!E_T$
[16] CHATRCHYAN	11U	CMS	jet + $\not\!\!E_T$
[17] AALTONEN	10AF	CDF	$\gamma\gamma$ + ℓ, $\not\!\!E_T$
[18] AALTONEN	09AF	CDF	$\ell \gamma b \not\!\!E_T$
[19] AALTONEN	09G	CDF	$\ell\ell\ell \not\!\!E_T$

[1] AAD 15AT search for events with a top quark and mssing E_T in pp collisions at $E_{\rm cm}$ = 8 TeV with L = 20.3 fb^{-1}.

[2] KHACHATRYAN 15F search for events with a top quark and mssing E_T in pp collisions at $E_{\rm cm}$ = 8 TeV with L = 19.7 fb^{-1}.

[3] AALTONEN 14J examine events with a W and two jets in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 8.9 fb^{-1}. Invariant mass distributions of the two jets are consistent with the Standard Model expectation.

[4] AAD 13A search for resonant WW production in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.7 fb^{-1}.

[5] AAD 13C search for events with a photon and missing $\not\!\!E_T$ in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.6 fb^{-1}.

[6] AALTONEN 13I search for events with a photon and missing E_T, where the photon is detected after the expected timing, in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 6.3 fb^{-1}. The data are consistent with the Standard Model expectation.

[7] CHATRCHYAN 13 search for events with an opposite-sign lepton pair, jets, and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.98 fb^{-1}.

[8] AAD 12C search for events with a $t\overline{t}$ pair and missing $\not\!\!E_T$ in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 1.04 fb^{-1}.

[9] AALTONEN 12M search for events with a jet and missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 6.7 fb^{-1}.

[10] CHATRCHYAN 12AP search for events with a jet and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 5.0 fb^{-1}.

[11] CHATRCHYAN 12Q search for events with a Z, jets, and missing $\not\!\!E_T$ in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.98 fb^{-1}.

[12] CHATRCHYAN 12T search for events with a photon and missing $\not\!\!E_T$ in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 5.0 fb^{-1}.

[13] AAD 11S search for events with one jet and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 33 pb^{-1}.

[14] AALTONEN 11AF search for high-p_T like-sign dileptons in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 6.1 fb^{-1}.

[15] CHATRCHYAN 11C search for events with an opposite-sign lepton pair, jets, and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 34 pb^{-1}.

[16] CHATRCHYAN 11U search for events with one jet and missing E_T in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 36 pb^{-1}.

[17] AALTONEN 10AF search for $\gamma\gamma$ events with e, μ, τ, or missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 1.1–2.0 fb^{-1}.

[18] AALTONEN 09AF search for $\ell\gamma b$ events with missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 1.9 fb^{-1}. The observed events are compatible with Standard Model expectation including $t\overline{t}\gamma$ production.

[19] AALTONEN 09G search for $\mu\mu\mu$ and $\mu\mu e$ events with missing E_T in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 976 pb^{-1}.

LIMITS ON JET-JET RESONANCES

Heavy Particle Production Cross Section

Limits are for a particle decaying to two hadronic jets.

• • • We do not use the following data for averages, fits, limits, etc. • • •

Units(pb)	CL%	Mass(GeV)	DOCUMENT ID	TECN	COMMENT
			[1] AABOUD 16	ATLS	$pp \to b +$ jet
			[2] AAD 16N	ATLS	$pp \to$ 3 high E_T jets
			[3] AAD 16S	ATLS	$pp \to jj$ resonance
			[4] KHACHATRY... 16K	CMS	$pp \to jj$ resonance
			[5] KHACHATRY... 16L	CMS	$pp \to jj$ resonance
			[6] AAD 13D	ATLS	7 TeV $pp \to$ 2 jets
			[7] AALTONEN 13R	CDF	1.96 TeV $p\overline{p} \to$ 4 jets
			[8] CHATRCHYAN 13A	CMS	7 TeV $pp \to$ 2 jets
			[9] CHATRCHYAN 13A	CMS	7 TeV $pp \to b\overline{b}X$
			[10] AAD 12S	ATLS	7 TeV $pp \to$ 2 jets
			[11] CHATRCHYAN 12BL	CMS	7 TeV $pp \to t\overline{t}X$
			[12] AAD 11AG	ATLS	7 TeV $pp \to$ 2 jets
			[13] AALTONEN 11M	CDF	1.96 TeV $p\overline{p} \to W+$ 2 jets
			[14] ABAZOV 11I	D0	1.96 TeV $p\overline{p} \to W+$ 2 jets
			[15] AAD 10	ATLS	7 TeV $pp \to$ 2 jets
			[16] KHACHATRY... 10	CMS	7 TeV $pp \to$ 2 jets
			[17] ABE 99F	CDF	1.8 TeV $p\overline{p} \to b\overline{b}+$ anything
			[18] ABE 97G	CDF	1.8 TeV $p\overline{p} \to$ 2 jets
<2603	95	200	[19] ABE 93G	CDF	1.8 TeV $p\overline{p} \to$ 2 jets
<44	95	400	[19] ABE 93G	CDF	1.8 TeV $p\overline{p} \to$ 2 jets
<7	95	600	[19] ABE 93G	CDF	1.8 TeV $p\overline{p} \to$ 2 jets

[1] AABOUD 16 search for resonant dijets including one or two b-jets with 3.2 fb^{-1} at 13 TeV; exclude excited b^* quark from 1.1–2.1 TeV; exclude leptophilic Z' with SM couplings from 1.1–1.5 TeV.

[2] AAD 16N search for $\geq$ 3 jets with 3.6 fb^{-1} at 13 TeV; limits placed on micro black holes (Fig. 10) and string balls (Fig. 11).

[3] AAD 16S search for high mass jet-jet resonance with 3.6 fb^{-1} at 13 TeV; exclude portions of excited quarks, W', Z' and contact interaction parameter space.

[4] KHACHATRYAN 16K search for dijet resonance in 2.4 fb^{-1} data at 13 TeV; see Fig. 3 for limits on axigluons, diquarks etc.

[5] KHACHATRYAN 16L use data scouting technique to search for jj resonance on 18.8 fb^{-1} of data at 8 TeV. Limits on the coupling of a leptophobic Z' to quarks are set, improving on the results by other experiments in the mass range between 500–800 GeV.

[6] AAD 13D search for dijet resonances in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 4.8$ fb^{-1}. The observed events are compatible with Standard Model expectation. See their Fig. 6 and Table 2 for limits on resonance cross section in the range $m = 1.0$–4.0 TeV.

[7] AALTONEN 13R search for production of a pair of jet-jet resonances in $p\overline{p}$ collisions at $E_{\rm cm} = 1.96$ TeV with $L = 6.6$ fb^{-1}. See their Fig. 5 and Tables I, II for cross section limits.

[8] CHATRCHYAN 13A search for qq, qg, and gg resonances in pp collisions at $E_{\rm cm} =$ 7 TeV with $L = 4.8$ fb^{-1}. See their Fig. 3 and Table 1 for limits on resonance cross section in the range $m = 1.0$–4.3 TeV.

[9] CHATRCHYAN 13A search for $b\overline{b}$ resonances in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 4.8$ fb^{-1}. See their Fig. 8 and Table 4 for limits on resonance cross section in the range $m = 1.0$–4.0 TeV.

[10] AAD 12S search for dijet resonances in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 1.0 fb^{-1}. See their Fig. 3 and Table 2 for limits on resonance cross section in the range m = 0.9–4.0 TeV.

[11] CHATRCHYAN 12BL search for $t\overline{t}$ resonances in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 4.4 fb^{-1}. See their Fig. 4 for limits on resonance cross section in the range m = 0.5–3.0 TeV.

[12] AAD 11AG search for dijet resonances in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 36 pb^{-1}. Limits on number of events for m = 0.6–4 TeV are given in their Table 3.

[13] AALTONEN 11M find a peak in two jet invariant mass distribution around 140 GeV in W + 2 jet events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 4.3 fb^{-1}.

[14] ABAZOV 11I search for two-jet resonances in W + 2 jet events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV with L = 4.3 fb^{-1} and give limits $\sigma <$ (2.6–1.3) pb (95% CL) for m = 110–170 GeV. The result is incompatible with AALTONEN 11M.

[15] AAD 10 search for narrow dijet resonances in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 315 nb^{-1}. Limits on the cross section in the range 10–10^3 pb is given for m = 0.3–1.7 TeV.

[16] KHACHATRYAN 10 search for narrow dijet resonances in pp collisions at $E_{\rm cm}$ = 7 TeV with L = 2.9 pb^{-1}. Limits on the cross section in the range 1–300 pb is given for m = 0.5–2.6 TeV separately in the final states qq, qg, and gg.

[17] ABE 99F search for narrow $b\overline{b}$ resonances in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. Limits on $\sigma(p\overline{p} \rightarrow X+$ anything$)\times$B$(X \rightarrow b\overline{b})$ in the range 3–10^3 pb (95%CL) are given for m_X=200–750 GeV. See their Table I.

[18] ABE 97G search for narrow dijet resonances in $p\overline{p}$ collisions with 106 pb^{-1} of data at $E_{\rm cm}$ = 1.8 TeV. Limits on $\sigma(p\overline{p} \rightarrow X+$ anything$)\cdot$B$(X \rightarrow jj)$ in the range 10^4–10^{-1} pb (95%CL) are given for dijet mass m=200–1150 GeV with both jets having $|\eta| <$ 2.0 and the dijet system having $|\cos\theta^*| <$ 0.67. See their Table I for the list of limits. Supersedes ABE 93G.

[19] ABE 93G give cross section times branching ratio into light (d, u, s, c, b) quarks for Γ = 0.02 M. Their Table II gives limits for M = 200–900 GeV and Γ = (0.02–0.2) M.

LIMITS ON NEUTRAL PARTICLE PRODUCTION

Production Cross Section of Radiatively-Decaying Neutral Particle

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.0008	95	[1] AAD 16AI	ATLS	$pp \rightarrow \gamma$ + jet
		[2] KHACHATRY...16M	CMS	$pp \rightarrow \gamma\gamma$ resonance
<(0.043–0.17)	95	[3] ABBIENDI 00D	OPAL	$e^+e^- \rightarrow X^0Y^0$, $X^0 \rightarrow Y^0\gamma$
<(0.05–0.8)	95	[4] ABBIENDI 00D	OPAL	$e^+e^- \rightarrow X^0X^0$, $X^0 \rightarrow Y^0\gamma$
<(2.5–0.5)	95	[5] ACKERSTAFF 97B	OPAL	$e^+e^- \rightarrow X^0Y^0$, $X^0 \rightarrow Y^0\gamma$
<(1.6–0.9)	95	[6] ACKERSTAFF 97B	OPAL	$e^+e^- \rightarrow X^0X^0$, $X^0 \rightarrow Y^0\gamma$

[1] AAD 16AI search for excited quarks (EQ) and quantum black holes (QBH) in 3.2 fb^{-1} at 13 TeV of data; exclude EQ below 4.4 TeV and QBH below 3.8 (6.2) TeV for RS1 (ADD) models. The visible cross section limit was obtained for 5 TeV resonance with σ_G/M_G = 2%.

[2] KHACHATRYAN 16M search for $\gamma\gamma$ resonance using 19.7 fb^{-1} at 8 TeV and 3.3 fb^{-1} at 13 Tev; slight excess at 750 GeV noted; limit set on RS graviton.

[3] ABBIENDI 00D associated production limit is for m_{X^0}= 90–188 GeV, m_{Y^0}=0 at $E_{\rm cm}$=189 GeV. See also their Fig. 9.

[4] ABBIENDI 00D pair production limit is for m_{X^0} = 45–94 GeV, m_{Y^0}=0 at $E_{\rm cm}$=189 GeV. See also their Fig. 12.

[5] ACKERSTAFF 97B associated production limit is for m_{X^0} = 80–160 GeV, m_{Y^0}=0 from 10.0 $\rm pb^{-1}$ at $E_{\rm cm}$ = 161 GeV. See their Fig. 3(a).

[6] ACKERSTAFF 97B pair production limit is for m_{X^0} = 40–80 GeV, m_{Y^0}=0 from 10.0 $\rm pb^{-1}$ at $E_{\rm cm}$ = 161 GeV. See their Fig. 3(b).

Heavy Particle Production Cross Section

VALUE ($\rm cm^2/N$)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	16O	ATLS	ℓ + (ℓs or jets)
		[2] AAD	16R	ATLS	WW, WZ, ZZ resonance
		[3] LEES	15E	BABR	e^+e^- collisions
		[4] ADAMS	97B	KTEV	m= 1.2–5 GeV
$< 10^{-36}$–10^{-33}	90	[5] GALLAS	95	TOF	m= 0.5–20 GeV
$<(4$–$0.3) \times 10^{-31}$	95	[6] AKESSON	91	CNTR	m = 0–5 GeV
$<2 \times 10^{-36}$	90	[7] BADIER	86	BDMP	τ = (0.05–1.) $\times 10^{-8}$s
$<2.5 \times 10^{-35}$		[8] GUSTAFSON	76	CNTR	$\tau > 10^{-7}$ s

[1] AAD 16O search for high E_T ℓ + (ℓs or jets) with 3.2 $\rm fb^{-1}$ at 13 TeV; exclude micro black holes mass < 8 TeV (Fig. 3) for models with two extra dimensions.

[2] AAD 16R search for WW, WZ, ZZ resonance in 20.3 $\rm fb^{-1}$ at 8 TeV data; limits placed on massive RS graviton (Fig. 4).

[3] LEES 15E search for long-lived neutral particles produced in e^+e^- collisions in the Upsilon region, which decays into e^+e^-, $\mu^+\mu^-$, $e^\pm\mu^\mp$, $\pi^+\pi^-$, K^+K^-, or $\pi^\pm K^\mp$. See their Fig. 2 for cross section limits.

[4] ADAMS 97B search for a hadron-like neutral particle produced in pN interactions, which decays into a ρ^0 and a weakly interacting massive particle. Upper limits are given for the ratio to K_L production for the mass range 1.2–5 GeV and lifetime 10^{-9}–10^{-4} s. See also our Light Gluino Section.

[5] GALLAS 95 limit is for a weakly interacting neutral particle produced in 800 GeV/c pN interactions decaying with a lifetime of 10^{-4}–10^{-8} s. See their Figs. 8 and 9. Similar limits are obtained for a stable particle with interaction cross section 10^{-29}–10^{-33} $\rm cm^2$. See Fig. 10.

[6] AKESSON 91 limit is from weakly interacting neutral long-lived particles produced in pN reaction at 450 GeV/c performed at CERN SPS. Bourquin-Gaillard formula is used as the production model. The above limit is for $\tau > 10^{-7}$ s. For $\tau > 10^{-9}$ s, $\sigma < 10^{-30}$ $\rm cm^{-2}$/nucleon is obtained.

[7] BADIER 86 looked for long-lived particles at 300 GeV π^- beam dump. The limit applies for nonstrongly interacting neutral or charged particles with mass >2 GeV. The limit applies for particle modes, $\mu^+\pi^-$, $\mu^+\mu^-$, $\pi^+\pi^-$X, $\pi^+\pi^-\pi^\pm$ etc. See their figure 5 for the contours of limits in the mass-τ plane for each mode.

[8] GUSTAFSON 76 is a 300 GeV FNAL experiment looking for heavy (m >2 GeV) long-lived neutral hadrons in the M4 neutral beam. The above typical value is for m = 3 GeV and assumes an interaction cross section of 1 mb. Values as a function of mass and interaction cross section are given in figure 2.

Production of New Penetrating Non-ν Like States in Beam Dump

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] LOSECCO	81	CALO	28 GeV protons

[1] No excess neutral-current events leads to σ(production) × σ(interaction)×acceptance $< 2.26 \times 10^{-71}$ cm^4/nucleon^2 (CL = 90%) for light neutrals. Acceptance depends on models (0.1 to 4. × 10^{-4}).

LIMITS ON CHARGED PARTICLES IN e^+e^-

Heavy Particle Production Cross Section in e^+e^-

Ratio to $\sigma(e^+e^- \rightarrow \mu^+\mu^-)$ unless noted. See also entries in Free Quark Search and Magnetic Monopole Searches.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] ACKERSTAFF	98P	OPAL	Q=1,2/3, m=45–89.5 GeV
		[2] ABREU	97D	DLPH	Q=1,2/3, m=45–84 GeV
		[3] BARATE	97K	ALEP	Q=1, m=45–85 GeV
$<2 \times 10^{-5}$	95	[4] AKERS	95R	OPAL	Q=1, m= 5–45 GeV
$<1 \times 10^{-5}$	95	[4] AKERS	95R	OPAL	Q=2, m= 5–45 GeV
$<2 \times 10^{-3}$	90	[5] BUSKULIC	93C	ALEP	Q=1, m=32–72 GeV
$<(10^{-2}$–1)	95	[6] ADACHI	90C	TOPZ	Q=1, m=1–16, 18–27 GeV
$<7 \times 10^{-2}$	90	[7] ADACHI	90E	TOPZ	Q = 1, m = 5–25 GeV
$<1.6 \times 10^{-2}$	95	[8] KINOSHITA	82	PLAS	Q=3–180, m <14.5 GeV
$<5.0 \times 10^{-2}$	90	[9] BARTEL	80	JADE	Q=(3,4,5)/3 2–12 GeV

[1] ACKERSTAFF 98P search for pair production of long-lived charged particles at E_{cm} between 130 and 183 GeV and give limits σ <(0.05–0.2) pb (95%CL) for spin-0 and spin-1/2 particles with m=45–89.5 GeV, charge 1 and 2/3. The limit is translated to the cross section at E_{cm}=183 GeV with the s dependence described in the paper. See their Figs. 2–4.

[2] ABREU 97D search for pair production of long-lived particles and give limits σ <(0.4–2.3) pb (95%CL) for various center-of-mass energies E_{cm}=130–136, 161, and 172 GeV, assuming an almost flat production distribution in cosθ.

[3] BARATE 97K search for pair production of long-lived charged particles at E_{cm} = 130, 136, 161, and 172 GeV and give limits σ <(0.2–0.4) pb (95%CL) for spin-0 and spin-1/2 particles with m=45–85 GeV. The limit is translated to the cross section at E_{cm}=172 GeV with the E_{cm} dependence described in the paper. See their Figs. 2 and 3 for limits on J = 1/2 and J = 0 cases.

[4] AKERS 95R is a CERN-LEP experiment with $W_{\text{cm}} \sim m_Z$. The limit is for the production of a stable particle in multihadron events normalized to $\sigma(e^+e^- \rightarrow$ hadrons). Constant phase space distribution is assumed. See their Fig. 3 for bounds for $Q = \pm 2/3$, $\pm 4/3$.

[5] BUSKULIC 93C is a CERN-LEP experiment with $W_{\text{cm}} = m_Z$. The limit is for a pair or single production of heavy particles with unusual ionization loss in TPC. See their Fig. 5 and Table 1.

[6] ADACHI 90C is a KEK-TRISTAN experiment with W_{cm} = 52–60 GeV. The limit is for pair production of a scalar or spin-1/2 particle. See Figs. 3 and 4.

[7] ADACHI 90E is KEK-TRISTAN experiment with W_{cm} = 52–61.4 GeV. The above limit is for inclusive production cross section normalized to $\sigma(e^+e^- \rightarrow \mu^+\mu^-)\cdot\beta(3-\beta^2)/2$, where $\beta = (1 - 4m^2/W^2_{\text{cm}})^{1/2}$. See the paper for the assumption about the production mechanism.

[8] KINOSHITA 82 is SLAC PEP experiment at $W_{cm} = 29$ GeV using lexan and ^{39}Cr plastic sheets sensitive to highly ionizing particles.

[9] BARTEL 80 is DESY-PETRA experiment with W_{cm} = 27–35 GeV. Above limit is for inclusive pair production and ranges between $1. \times 10^{-1}$ and $1. \times 10^{-2}$ depending on mass and production momentum distributions. (See their figures 9, 10, 11).

Branching Fraction of Z^0 to a Pair of Stable Charged Heavy Fermions

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<5 \times 10^{-6}$	95	[1] AKERS	95R	OPAL	m= 40.4–45.6 GeV
$<1 \times 10^{-3}$	95	AKRAWY	90O	OPAL	m = 29–40 GeV

[1] AKERS 95R give the 95% CL limit $\sigma(X\overline{X})/\sigma(\mu\mu) < 1.8\times10^{-4}$ for the pair production of singly- or doubly-charged stable particles. The limit applies for the mass range 40.4–45.6 GeV for $X^{\pm}$ and < 45.6 GeV for $X^{\pm\pm}$. See the paper for bounds for $Q = \pm2/3, \pm4/3$.

LIMITS ON CHARGED PARTICLES IN HADRONIC REACTIONS

MASS LIMITS for Long-Lived Charged Heavy Fermions

Limits are for spin 1/2 particles with no color and $SU(2)_L$ charge. The electric charge Q of the particle (in the unit of e) is therefore equal to its weak hypercharge. Pair production by Drell-Yan like γ and Z exchange is assumed to derive the limits.

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>660	95	[1] AAD	15BJ	ATLS	$\lvert Q\rvert = 2$
>200	95	[2] CHATRCHYAN	13AB	CMS	$\lvert Q\rvert = 1/3$
>480	95	[2] CHATRCHYAN	13AB	CMS	$\lvert Q\rvert = 2/3$
>574	95	[2] CHATRCHYAN	13AB	CMS	$\lvert Q\rvert = 1$
>685	95	[2] CHATRCHYAN	13AB	CMS	$\lvert Q\rvert = 2$
>140	95	[3] CHATRCHYAN	13AR	CMS	$\lvert Q\rvert = 1/3$
>310	95	[3] CHATRCHYAN	13AR	CMS	$\lvert Q\rvert = 2/3$

[1] AAD 15BJ use 20.3 fb^{-1} of pp collisions at E_{cm} = 8 TeV. See paper for limits for $\lvert Q\rvert$ = 3, 4, 5, 6.

[2] CHATRCHYAN 13AB use 5.0 fb^{-1} of pp collisions at E_{cm} = 7 TeV and 18.8 fb^{-1} at E_{cm} = 8 TeV. See paper for limits for $\lvert Q\rvert$ = 3, 4,. . ., 8.

[3] CHATRCHYAN 13AR use 5.0 fb^{-1} of pp collisions at E_{cm} = 7 TeV.

Heavy Particle Production Cross Section

VALUE (nb)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAIJ	15BD	LHCB	m=124–309 GeV
		[2] AAD	13AH	ATLS	$\lvert q\rvert$=(2–6)e, m=50–600 GeV
$<1.2 \times 10^{-3}$	95	[3] AAD	11I	ATLS	$\lvert q\rvert$=10e, m=0.2–1 TeV
$<1.0 \times 10^{-5}$	95	[4,5] AALTONEN	09Z	CDF	m>100 GeV, noncolored
$<4.8 \times 10^{-5}$	95	[4,6] AALTONEN	09Z	CDF	m>100 GeV, colored
$< 0.31–0.04 \times 10^{-3}$	95	[7] ABAZOV	09M	D0	pair production
<0.19	95	[8] AKTAS	04C	H1	m=3–10 GeV
<0.05	95	[9] ABE	92J	CDF	m=50–200 GeV
<30–130		[10] CARROLL	78	SPEC	m=2–2.5 GeV
<100		[11] LEIPUNER	73	CNTR	m=3–11 GeV

[1] AAIJ 15BD search for production of long-lived particles in pp collisions at $E_{\mathrm{cm}} = 7$ and 8 TeV. See their Table 6 for cross section limits.

[2] AAD 13AH search for production of long-lived particles with $|\mathrm{q}|$=(2–6)e in pp collisions at $E_{\mathrm{cm}} = 7$ TeV with 4.4 fb^{-1}. See their Fig. 8 for cross section limits.

[3] AAD 11I search for production of highly ionizing massive particles in pp collisions at $E_{\mathrm{cm}} = 7$ TeV with L = 3.1 pb^{-1}. See their Table 5 for similar limits for $|\mathrm{q}| = 6e$ and $17e$, Table 6 for limits on pair production cross section.

[4] AALTONEN 09Z search for long-lived charged particles in $p\overline{p}$ collisions at $E_{\mathrm{cm}} = 1.96$ TeV with $L = 1.0$ fb^{-1}. The limits are on production cross section for a particle of mass above 100 GeV in the region $|\eta| \lesssim 0.7$, $p_T > 40$ GeV, and $0.4 < \beta < 1.0$.

[5] Limit for weakly interacting charge-1 particle.

[6] Limit for up-quark like particle.

[7] ABAZOV 09M search for pair production of long-lived charged particles in $p\overline{p}$ collisions at $E_{\mathrm{cm}} = 1.96$ TeV with $L = 1.1$ fb^{-1}. Limit on the cross section of (0.31–0.04) pb (95% CL) is given for the mass range of 60–300 GeV, assuming the kinematics of stau pair production.

[8] AKTAS 04C look for charged particle photoproduction at HERA with mean c.m. energy of 200 GeV.

[9] ABE 92J look for pair production of unit-charged particles which leave detector before decaying. Limit shown here is for m=50 GeV. See their Fig. 5 for different charges and stronger limits for higher mass.

[10] CARROLL 78 look for neutral, $S = -2$ dihyperon resonance in $pp \rightarrow 2K^+X$. Cross section varies within above limits over mass range and $p_{\mathrm{lab}} = 5.1$–5.9 GeV/c.

[11] LEIPUNER 73 is an NAL 300 GeV p experiment. Would have detected particles with lifetime greater than 200 ns.

Heavy Particle Production Differential Cross Section

VALUE (cm^{2}sr^{-1}GeV^{-1})	*CL%*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<2.6 \times 10^{-36}$	90	[1] BALDIN	76	CNTR	$-$	Q= 1, m=2.1–9.4 GeV
$<2.2 \times 10^{-33}$	90	[2] ALBROW	75	SPEC	$\pm$	Q= $\pm$1, m=4–15 GeV
$<1.1 \times 10^{-33}$	90	[2] ALBROW	75	SPEC	$\pm$	Q= $\pm$2, m=6–27 GeV
$<8. \times 10^{-35}$	90	[3] JOVANOV...	75	CNTR	$\pm$	m=15–26 GeV
$<1.5 \times 10^{-34}$	90	[3] JOVANOV...	75	CNTR	$\pm$	Q= $\pm$2, m=3–10 GeV
$<6. \times 10^{-35}$	90	[3] JOVANOV...	75	CNTR	$\pm$	Q= $\pm$2, m=10–26 GeV
$<1. \times 10^{-31}$	90	[4] APPEL	74	CNTR	$\pm$	m=3.2–7.2 GeV
$<5.8 \times 10^{-34}$	90	[5] ALPER	73	SPEC	$\pm$	m=1.5–24 GeV
$<1.2 \times 10^{-35}$	90	[6] ANTIPOV	71B	CNTR	$-$	Q=$-$, m=2.2–2.8
$<2.4 \times 10^{-35}$	90	[7] ANTIPOV	71C	CNTR	$-$	Q=$-$, m=1.2–1.7, 2.1–4
$<2.4 \times 10^{-35}$	90	BINON	69	CNTR	$-$	Q=$-$, m=1–1.8 GeV
$<1.5 \times 10^{-36}$		[8] DORFAN	65	CNTR		Be target m=3–7 GeV
$<3.0 \times 10^{-36}$		[8] DORFAN	65	CNTR		Fe target m=3–7 GeV

[1] BALDIN 76 is a 70 GeV Serpukhov experiment. Value is per Al nucleus at $\theta = 0$. For other charges in range -0.5 to -3.0, CL = 90% limit is $(2.6 \times 10^{-36})/|(\mathrm{charge})|$ for mass range (2.1–9.4 GeV) $\times$ $|(\mathrm{charge})|$. Assumes stable particle interacting with matter as do antiprotons.

[2] ALBROW 75 is a CERN ISR experiment with $E_{\mathrm{cm}} = 53$ GeV. $\theta = 40$ mr. See figure 5 for mass ranges up to 35 GeV.

[3] JOVANOVICH 75 is a CERN ISR 26+26 and 15+15 GeV pp experiment. Figure 4 covers ranges $Q = 1/3$ to 2 and $m = 3$ to 26 GeV. Value is per GeV momentum.

[4] APPEL 74 is NAL 300 GeV pW experiment. Studies forward production of heavy (up to 24 GeV) charged particles with momenta 24–200 GeV (−charge) and 40–150 GeV (+charge). Above typical value is for 75 GeV and is per GeV momentum per nucleon.

[5] ALPER 73 is CERN ISR 26+26 GeV pp experiment. $p >$0.9 GeV, 0.2 $< \beta <$0.65.

[6] ANTIPOV 71B is from same 70 GeV p experiment as ANTIPOV 71C and BINON 69.

[7] ANTIPOV 71C limit inferred from flux ratio. 70 GeV p experiment.

[8] DORFAN 65 is a 30 GeV/c p experiment at BNL. Units are per GeV momentum per nucleus.

Long-Lived Heavy Particle Invariant Cross Section

VALUE ($\mathrm{cm}^2/\mathrm{GeV}^2/N$)	*CL%*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$< 5–700 \times 10^{-35}$	90	[1] BERNSTEIN	88	CNTR		
$< 5–700 \times 10^{-37}$	90	[1] BERNSTEIN	88	CNTR		
$<2.5 \times 10^{-36}$	90	[2] THRON	85	CNTR	−	Q= 1, m=4–12 GeV
$<1. \times 10^{-35}$	90	[2] THRON	85	CNTR	+	Q= 1, m=4–12 GeV
$<6. \times 10^{-33}$	90	[3] ARMITAGE	79	SPEC		m=1.87 GeV
$<1.5 \times 10^{-33}$	90	[3] ARMITAGE	79	SPEC		m=1.5–3.0 GeV
		[4] BOZZOLI	79	CNTR	±	Q = (2/3, 1, 4/3, 2)
$<1.1 \times 10^{-37}$	90	[5] CUTTS	78	CNTR		m=4–10 GeV
$<3.0 \times 10^{-37}$	90	[6] VIDAL	78	CNTR		m=4.5–6 GeV

[1] BERNSTEIN 88 limits apply at $x = 0.2$ and $p_T = 0$. Mass and lifetime dependence of limits are shown in the regions: $m = 1.5$–7.5 GeV and $\tau = 10^{-8}$–2×10^{-6} s. First number is for hadrons; second is for weakly interacting particles.

[2] THRON 85 is FNAL 400 GeV proton experiment. Mass determined from measured velocity and momentum. Limits are for $\tau > 3 \times 10^{-9}$ s.

[3] ARMITAGE 79 is CERN-ISR experiment at $E_{\mathrm{cm}} = 53$ GeV. Value is for $x = 0.1$ and $p_T = 0.15$. Observed particles at $m = 1.87$ GeV are found all consistent with being antideuterons.

[4] BOZZOLI 79 is CERN-SPS 200 GeV pN experiment. Looks for particle with τ larger than 10^{-8} s. See their figure 11–18 for production cross-section upper limits vs mass.

[5] CUTTS 78 is pBe experiment at FNAL sensitive to particles of $\tau > 5 \times 10^{-8}$ s. Value is for $-0.3 < x < 0$ and $p_T = 0.175$.

[6] VIDAL 78 is FNAL 400 GeV proton experiment. Value is for $x = 0$ and $p_T = 0$. Puts lifetime limit of $< 5 \times 10^{-8}$ s on particle in this mass range.

Long-Lived Heavy Particle Production (σ(Heavy Particle) / $\sigma(\pi)$)

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<10^{-8}$		[1] NAKAMURA	89	SPEC	±	Q= (−5/3,±2)
	0	[2] BUSSIERE	80	CNTR	±	Q= (2/3,1,4/3,2)

[1] NAKAMURA 89 is KEK experiment with 12 GeV protons on Pt target. The limit applies for mass $\lesssim$ 1.6 GeV and lifetime $\gtrsim 10^{-7}$ s.

[2] BUSSIERE 80 is CERN-SPS experiment with 200–240 GeV protons on Be and Al target. See their figures 6 and 7 for cross-section ratio vs mass.

Production and Capture of Long-Lived Massive Particles

VALUE (10^{-36} cm^2)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<20 to 800	[1] ALEKSEEV	76	ELEC	τ=5 ms to 1 day
<200 to 2000	[1] ALEKSEEV	76B	ELEC	τ=100 ms to 1 day
<1.4 to 9	[2] FRANKEL	75	CNTR	τ=50 ms to 10 hours
<0.1 to 9	[3] FRANKEL	74	CNTR	τ=1 to 1000 hours

[1] ALEKSEEV 76 and ALEKSEEV 76B are 61–70 GeV p Serpukhov experiment. Cross section is per Pb nucleus.

[2] FRANKEL 75 is extension of FRANKEL 74.

[3] FRANKEL 74 looks for particles produced in thick Al targets by 300–400 GeV/c protons.

Long-Lived Particle Search at Hadron Collisions

Limits are for cross section times branching ratio.

VALUE (pb/nucleon)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAIJ	16AR	LHCB	$H \rightarrow XX$ long-lived particles
		[2] KHACHATRY...	16BW	CMS	direct production: HSCPs
<2	90	[3] BADIER	86	BDMP	$\tau = (0.05\text{–}1.) \times 10^{-8}$s

[1] AAIJ 16AR search for long lived particles from $H \rightarrow XX$ with displaced X decay vertex using 0.62 fb^{-1} at 7 TeV; limits set in Fig. 7.

[2] KHACHATRYAN 16BW search for heavy stable charged particles via ToF with 2.5 fb^{-1} at 13 TeV; require stable m(gluinoball) > 1610 GeV.

[3] BADIER 86 looked for long-lived particles at 300 GeV π^- beam dump. The limit applies for nonstrongly interacting neutral or charged particles with mass >2 GeV. The limit applies for particle modes, $\mu^+\pi^-$, $\mu^+\mu^-$, $\pi^+\pi^-$X, $\pi^+\pi^-\pi^\pm$ etc. See their figure 5 for the contours of limits in the mass-τ plane for each mode.

Long-Lived Heavy Particle Cross Section

VALUE (pb/sr)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<34	95	[1] RAM	94	SPEC	$1015 < m_{X^{++}} < 1085$ MeV
<75	95	[1] RAM	94	SPEC	$920 < m_{X^{++}} < 1025$ MeV

[1] RAM 94 search for a long-lived doubly-charged fermion X^{++} with mass between m_N and $m_N + m_\pi$ and baryon number +1 in the reaction $pp \rightarrow X^{++} n$. No candidate is found. The limit is for the cross section at 15° scattering angle at 460 MeV incident energy and applies for $\tau(X^{++}) \gg 0.1\,\mu$s.

LIMITS ON CHARGED PARTICLES IN COSMIC RAYS

Heavy Particle Flux in Cosmic Rays

VALUE (cm^{-2}sr^{-1}s^{-1})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •							
$< 1 \times 10^{-8}$	90	0	[1] AGNESE	15	CDM2		$Q = 1/6$
$\sim 6 \times 10^{-9}$		2	[2] SAITO	90			$Q \simeq 14$, $m \simeq 370 m_p$

$< 1.4 \times 10^{-12}$	90	0	[3] MINCER	85	CALO		$m \geq 1$ TeV
			[4] SAKUYAMA	83B	PLAS		$m \sim 1$ TeV
$< 1.7 \times 10^{-11}$	99	0	[5] BHAT	82	CC		
$< 1. \times 10^{-9}$	90	0	[6] MARINI	82	CNTR	±	$Q = 1$, $m \sim 4.5 m_p$
$2. \times 10^{-9}$		3	[7] YOCK	81	SPRK	±	$Q = 1$, $m \sim 4.5 m_p$
		3	[7] YOCK	81	SPRK		Fractionally charged
3.0×10^{-9}		3	[8] YOCK	80	SPRK		$m \sim 4.5\ m_p$
$(4 \pm 1) \times 10^{-11}$		3	GOODMAN	79	ELEC		$m \geq 5$ GeV
$< 1.3 \times 10^{-9}$	90		[9] BHAT	78	CNTR	±	$m > 1$ GeV
$< 1.0 \times 10^{-9}$		0	BRIATORE	76	ELEC		
$< 7. \times 10^{-10}$	90	0	YOCK	75	ELEC	±	$Q > 7e$ or $< -7e$
$> 6. \times 10^{-9}$		5	[10] YOCK	74	CNTR		$m > 6$ GeV
$< 3.0 \times 10^{-8}$		0	DARDO	72	CNTR		
$< 1.5 \times 10^{-9}$		0	TONWAR	72	CNTR		$m > 10$ GeV
$< 3.0 \times 10^{-10}$		0	BJORNBOE	68	CNTR		$m > 5$ GeV
$< 5.0 \times 10^{-11}$	90	0	JONES	67	ELEC		m=5–15 GeV

[1] See AGNESE 15 Fig. 6 for limits extending down to Q = 1/200.

[2] SAITO 90 candidates carry about 450 MeV/nucleon. Cannot be accounted for by conventional backgrounds. Consistent with strange quark matter hypothesis.

[3] MINCER 85 is high statistics study of calorimeter signals delayed by 20–200 ns. Calibration with AGS beam shows they can be accounted for by rare fluctuations in signals from low-energy hadrons in the shower. Claim that previous delayed signals including BJORNBOE 68, DARDO 72, BHAT 82, SAKUYAMA 83B below may be due to this fake effect.

[4] SAKUYAMA 83B analyzed 6000 extended air shower events. Increase of delayed particles and change of lateral distribution above 10^{17} eV may indicate production of very heavy parent at top of atmosphere.

[5] BHAT 82 observed 12 events with delay $> 2. \times 10^{-8}$ s and with more than 40 particles. 1 eV has good hadron shower. However all events are delayed in only one of two detectors in cloud chamber, and could not be due to strongly interacting massive particle.

[6] MARINI 82 applied PEP-counter for TOF. Above limit is for velocity = 0.54 of light. Limit is inconsistent with YOCK 80 YOCK 81 events if isotropic dependence on zenith angle is assumed.

[7] YOCK 81 saw another 3 events with $Q = \pm 1$ and m about $4.5 m_p$ as well as 2 events with $m > 5.3 m_p$, $Q = \pm 0.75 \pm 0.05$ and $m > 2.8 m_p$, $Q = \pm 0.70 \pm 0.05$ and 1 event with $m = (9.3 \pm 3.) m_p$, $Q = \pm 0.89 \pm 0.06$ as possible heavy candidates.

[8] YOCK 80 events are with charge exactly or approximately equal to unity.

[9] BHAT 78 is at Kolar gold fields. Limit is for $\tau > 10^{-6}$ s.

[10] YOCK 74 events could be tritons.

Superheavy Particle (Quark Matter) Flux in Cosmic Rays

VALUE ($\mathrm{cm}^{-2}\mathrm{sr}^{-1}\mathrm{s}^{-1}$)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] ADRIANI	15	PMLA	$4 < m < 1.2 \times 10^5\ m_p$
$< 5 \times 10^{-16}$	90	[2] AMBROSIO	00B	MCRO	$m > 5 \times 10^{14}$ GeV
$< 1.8 \times 10^{-12}$	90	[3] ASTONE	93	CNTR	$m \geq 1.5 \times 10^{-13}$ gram
$< 1.1 \times 10^{-14}$	90	[4] AHLEN	92	MCRO	$10^{-10} < m < 0.1$ gram
$< 2.2 \times 10^{-14}$	90	[5] NAKAMURA	91	PLAS	$m > 10^{11}$ GeV

$<6.4 \times 10^{-16}$	90	[6] ORITO 91	PLAS	$m > 10^{12}$ GeV
$<2.0 \times 10^{-11}$	90	[7] LIU 88	BOLO	$m > 1.5 \times 10^{-13}$ gram
$<4.7 \times 10^{-12}$	90	[8] BARISH 87	CNTR	$1.4 \times 10^{8} < m < 10^{12}$ GeV
$<3.2 \times 10^{-11}$	90	[9] NAKAMURA 85	CNTR	$m > 1.5 \times 10^{-13}$gram
$<3.5 \times 10^{-11}$	90	[10] ULLMAN 81	CNTR	Planck-mass 10^{19}GeV
$<7. \times 10^{-11}$	90	[10] ULLMAN 81	CNTR	$m \leq 10^{16}$ GeV

[1] ADRIANI 15 search for relatively light quark matter with charge $Z = 1$–8. See their Figs. 2 and 3 for flux upper limits.

[2] AMBROSIO 00B searched for quark matter ("nuclearites") in the velocity range $(10^{-5}$–$1)\ c$. The listed limit is for $2 \times 10^{-3}\ c$.

[3] ASTONE 93 searched for quark matter ("nuclearites") in the velocity range $(10^{-3}$–$1)\ c$. Their Table 1 gives a compilation of searches for nuclearites.

[4] AHLEN 92 searched for quark matter ("nuclearites"). The bound applies to velocity $< 2.5 \times 10^{-3}\ c$. See their Fig. 3 for other velocity/c and heavier mass range.

[5] NAKAMURA 91 searched for quark matter in the velocity range $(4 \times 10^{-5}$–$1)\ c$.

[6] ORITO 91 searched for quark matter. The limit is for the velocity range $(10^{-4}$–$10^{-3})\ c$.

[7] LIU 88 searched for quark matter ("nuclearites") in the velocity range $(2.5 \times 10^{-3}$–$1) c$. A less stringent limit of 5.8×10^{-11} applies for $(1$–$2.5) \times 10^{-3} c$.

[8] BARISH 87 searched for quark matter ("nuclearites") in the velocity range $(2.7 \times 10^{-4}$–$5 \times 10^{-3}) c$.

[9] NAKAMURA 85 at KEK searched for quark-matter. These might be lumps of strange quark matter with roughly equal numbers of u, d, s quarks. These lumps or nuclearites were assumed to have velocity of $(10^{-4}$–$10^{-3})\ c$.

[10] ULLMAN 81 is sensitive for heavy slow singly charge particle reaching earth with vertical velocity 100–350 km/s.

Highly Ionizing Particle Flux

VALUE ($m^{-2} yr^{-1}$)	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.4	95	0	KINOSHITA 81B	PLAS	Z/β 30–100

SEARCHES FOR BLACK HOLE PRODUCTION

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	[1] AABOUD 16P	ATLS	13 TeV $p p \rightarrow e\mu, e\tau, \mu\tau$
	[2] AAD 15AN	ATLS	8 TeV $p p \rightarrow$ multijets
	[3] AAD 14A	ATLS	8 TeV $p p \rightarrow \gamma +$ jet
	[4] AAD 14AL	ATLS	8 TeV $p p \rightarrow \ell +$ jet
	[5] AAD 14C	ATLS	8 TeV $p p \rightarrow \ell + (\ell$ or jets)
	[6] AAD 13D	ATLS	7 TeV $p p \rightarrow$ 2 jets
	[7] CHATRCHYAN 13A	CMS	7 TeV $p p \rightarrow$ 2 jets
	[8] CHATRCHYAN 13AD	CMS	8 TeV $p p \rightarrow$ multijets
	[9] AAD 12AK	ATLS	7 TeV $p p \rightarrow \ell + (\ell$ or jets)
	[10] CHATRCHYAN 12W	CMS	7 TeV $p p \rightarrow$ multijets
	[11] AAD 11AG	ATLS	7 TeV $p p \rightarrow$ 2 jets

[1] AABOUD 16P set limits on quantum BH production in n = 6 ADD or n = 1 RS models.

[2] AAD 15AN search for black hole or string ball formation followed by its decay to multijet final states, in pp collisions at $E_{\rm cm} = 8$ TeV with $L = 20.3$ fb^{-1}. See their Figs. 6–8 for limits.

[3] AAD 14A search for quantum black hole formation followed by its decay to a γ and a jet, in pp collisions at $E_{\rm cm} = 8$ TeV with $L = 20$ fb^{-1}. See their Fig. 3 for limits.

[4] AAD 14AL search for quantum black hole formation followed by its decay to a lepton and a jet, in pp collisions at $E_{\rm cm} = 8$ TeV with $L = 20.3$ fb^{-1}. See their Fig. 2 for limits.

[5] AAD 14C search for microscopic (semiclassical) black hole formation followed by its decay to final states with a lepton and $\geq$ 2 (leptons or jets), in pp collisions at $E_{\rm cm} = 8$ TeV with $L = 20.3$ fb^{-1}. See their Figures 8–11, Tables 7, 8 for limits.

[6] AAD 13D search for quantum black hole formation followed by its decay to two jets, in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 4.8$ fb^{-1}. See their Fig. 8 and Table 3 for limits.

[7] CHATRCHYAN 13A search for quantum black hole formation followed by its decay to two jets, in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 5$ fb^{-1}. See their Figs. 5 and 6 for limits.

[8] CHATRCHYAN 13AD search for microscopic (semiclassical) black hole formation followed by its evapolation to multiparticle final states, in multijet (including γ, ℓ) events in pp collisions at $E_{\rm cm} = 8$ TeV with $L = 12$ fb^{-1}. See their Figs. 5–7 for limits.

[9] AAD 12AK search for microscopic (semiclassical) black hole formation followed by its decay to final states with a lepton and $\geq$ 2 (leptons or jets), in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 1.04$ fb^{-1}. See their Fig. 4 and 5 for limits.

[10] CHATRCHYAN 12W search for microscopic (semiclassical) black hole formation followed by its evapolation to multiparticle final states, in multijet (including γ, ℓ) events in pp collisions at $E_{\rm cm} = 7$ TeV with $L = 4.7$ fb^{-1}. See their Figs. 5–8 for limits.

[11] AAD 11AG search for quantum black hole formation followed by its decay to two jets, in pp collisions at $E_{\rm cm} = 7$ TeV with L = 36 pb^{-1}. See their Fig. 11 and Table 4 for limits.

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AKERIB	17	PRL 118 021303	D.S. Akerib *et al.*	(LUX Collab.)
KHACHATRY...	17A	PRL 118 021802	V. Khachatryan *et al.*	(CMS Collab.)
AABOUD	16	PL B759 229	M. Aaboud *et al.*	(ATLAS Collab.)
AABOUD	16AD	PL B763 251	M. Aaboud *et al.*	(ATLAS Collab.)
AABOUD	16D	PR D94 032005	M. Aaboud *et al.*	(ATLAS Collab.)
AABOUD	16F	JHEP 1606 059	M. Aaboud *et al.*	(ATLAS Collab.)
AABOUD	16P	EPJ C76 541	M. Aaboud *et al.*	(ATLAS Collab.)
AAD	16AF	JHEP 1601 172	G. Aad *et al.*	(ATLAS Collab.)
AAD	16AG	JHEP 1602 062	G. Aad *et al.*	(ATLAS Collab.)
AAD	16AI	JHEP 1603 041	G. Aad *et al.*	(ATLAS Collab.)
AAD	16M	PR D93 072007	G. Aad *et al.*	(ATLAS Collab.)
AAD	16N	JHEP 1603 026	G. Aad *et al.*	(ATLAS Collab.)
AAD	16O	PL B760 520	G. Aad *et al.*	(ATLAS Collab.)
AAD	16R	PL B755 285	G. Aad *et al.*	(ATLAS Collab.)
AAD	16S	PL B754 302	G. Aad *et al.*	(ATLAS Collab.)
AAIJ	16AR	EPJ C76 664	R. Aaij *et al.*	(LHCb Collab.)
AARTSEN	16C	JCAP 1604 022	M.G. Aartsen *et al.*	(IceCube Collab.)
AARTSEN	16D	EPJ C76 531	M.G. Aartsen *et al.*	(IceCube Collab.)
ABDALLAH	16	PRL 117 111301	H. Abdallah *et al.*	(H.E.S.S. Collab.)
ABDALLAH	16A	PRL 117 151302	H. Abdallah *et al.*	(H.E.S.S. Collab.)
ADRIAN-MAR...	16	PL B759 69	S. Adrian-Martinez *et al.*	(ANTARES Collab.)
ADRIAN-MAR...	16B	JCAP 1605 016	S. Adrian-Martinez *et al.*	(ANTARES Collab.)
AGNES	16	PR D93 081101	P. Agnes *et al.*	(DarkSide-50 Collab.)
AGNESE	16	PRL 116 071301	R. Agnese *et al.*	(SuperCDMS Collab.)
AGUILAR-AR...	16	PR D94 082006	A.A. Aguilar-Arevalo *et al.*	(DAMIC Collab.)
AHNEN	16	JCAP 1602 039	M.L. Ahnen *et al.*	(MAGIC and Fermi-LAT Collab.)
AKERIB	16	PRL 116 161301	D.S. Akerib *et al.*	(LUX Collab.)

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AMOLE	16	PR D93 052014	C. Amole *et al.*	(PICO Collab.)
AMOLE	16A	PR D93 061101	C. Amole *et al.*	(PICO Collab.)
ANGLOHER	16	EPJ C76 25	G. Angloher *et al.*	(CRESST-II Collab.)
ANGLOHER	16A	PRL 117 021303	G. Angloher *et al.*	(CRESST-II Collab.)
APRILE	16	PR D94 092001	E. Aprile *et al.*	(XENON100 Collab.)
APRILE	16B	PR D94 122001	E. Aprile *et al.*	(XENON100 Collab.)
ARMENGAUD	16	JCAP 1605 019	E. Armengaud *et al.*	(EDELWEISS-III Collab.)
AVRORIN	16	ASP 81 12	A.D. Avrorin *et al.*	(BAIKAL Collab.)
CAPUTO	16	PR D93 062004	R. Caputo *et al.*	
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KHACHATRY...	16CA	JHEP 1612 088	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	16K	PRL 116 071801	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	16L	PRL 117 031802	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	16M	PRL 117 051802	V. Khachatryan *et al.*	(CMS Collab.)
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LEITE	16	JCAP 1611 021	N. Leite *et al.*	
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LIANG	16	PR D94 103502	Y.-F. Liang *et al.*	
LU	16	PR D93 103517	B-Q. Lu, H-S. Zong	
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TAN	16B	PRL 117 121303	A. Tan *et al.*	(PandaX Collab.)
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AAD	15AN	JHEP 1507 032	G. Aad *et al.*	(ATLAS Collab.)
AAD	15AS	EPJ C75 92	G. Aad *et al.*	(ATLAS Collab.)
AAD	15AT	EPJ C75 79	G. Aad *et al.*	(ATLAS Collab.)
AAD	15BH	EPJ C75 299	G. Aad *et al.*	(ATLAS Collab.)
Also		EPJ C75 408 (errat.)	G. Aad *et al.*	(ATLAS Collab.)
AAD	15BJ	EPJ C75 362	G. Aad *et al.*	(ATLAS Collab.)
AAD	15CF	PRL 115 131801	G. Aad *et al.*	(ATLAS Collab.)
AAD	15CS	PR D91 012008	G. Aad *et al.*	(ATLAS Collab.)
Also		PR D92 059903 (errat.)	G. Aad *et al.*	(ATLAS Collab.)
AAIJ	15BD	EPJ C75 595	R. Aaij *et al.*	(LHCb Collab.)
AARTSEN	15C	EPJ C75 20	M.G. Aartsen *et al.*	(IceCube Collab.)
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ADRIAN-MAR...	15	JCAP 1510 068	S. Adrian-Martinez *et al.*	(ANTARES Collab.)
AGNES	15	PL B743 456	P. Agnes *et al.*	(DarkSide-50 Collab.)
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AAD	14A	PL B728 562	G. Aad *et al.*	(ATLAS Collab.)
AAD	14AI	JHEP 1409 037	G. Aad *et al.*	(ATLAS Collab.)
AAD	14AL	PRL 112 091804	G. Aad *et al.*	(ATLAS Collab.)
AAD	14BK	PRL 112 041802	G. Aad *et al.*	(ATLAS Collab.)
AAD	14C	JHEP 1408 103	G. Aad *et al.*	(ATLAS Collab.)
AAD	14K	PR D90 012004	G. Aad *et al.*	(ATLAS Collab.)
AAD	14O	PRL 112 201802	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	14J	PR D89 092001	T. Aaltonen *et al.*	(CDF Collab.)
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ANGLOHER	14	EPJ C74 3184	G. Angloher *et al.*	(CRESST-II Collab.)
APRILE	14A	ASP 54 11	E. Aprile *et al.*	(XENON100 Collab.)
AVRORIN	14	ASP 62 12	A.D. Avrorin *et al.*	(BAIKAL Collab.)
FELIZARDO	14	PR D89 072013	M. Felizardo *et al.*	(SIMPLE Collab.)
LEE	14A	PR D90 052006	H.S. Lee *et al.*	(KIMS Collab.)
LIU	14A	PR D90 032003	S.K. Liu *et al.*	(CDEX Collab.)
UCHIDA	14	PTEP 2014 063C01	H. Uchida *et al.*	(XMASS Collab.)
YUE	14	PR D90 091701	Q. Yue *et al.*	(CDEX Collab.)
AAD	13A	PL B718 860	G. Aad *et al.*	(ATLAS Collab.)
AAD	13AD	JHEP 1304 075	G. Aad *et al.*	(ATLAS Collab.)
AAD	13AH	PL B722 305	G. Aad *et al.*	(ATLAS Collab.)
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AAD	13D	JHEP 1301 029	G. Aad *et al.*	(ATLAS Collab.)
AALSETH	13	PR D88 012002	C.E. Aalseth *et al.*	(CoGeNT Collab.)
AALTONEN	13I	PR D88 031103	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13R	PRL 111 031802	T. Aaltonen *et al.*	(CDF Collab.)
AARTSEN	13	PRL 110 131302	M.G. Aartsen *et al.*	(IceCube Collab.)
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AGNESE	13A	PRL 111 251301	R. Agnese *et al.*	(CDMS Collab.)
APRILE	13	PRL 111 021301	E. Aprile *et al.*	(XENON100 Collab.)
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CHATRCHYAN	13	PL B718 815	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13A	JHEP 1301 013	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13AB	JHEP 1307 122	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13AD	JHEP 1307 178	S. Chatrchyan *et al.*	(CMS Collab.)
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LI	13B	PRL 110 261301	H.B. Li *et al.*	(TEXONO Collab.)
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ZHAO	13	PR D88 052004	W. Zhao *et al.*	(CDEX Collab.)
AAD	12AK	PL B716 122	G. Aad *et al.*	(ATLAS Collab.)
AAD	12C	PRL 108 041805	G. Aad *et al.*	(ATLAS Collab.)
AAD	12S	PL B708 37	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	12K	PRL 108 201802	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12M	PRL 108 211804	T. Aaltonen *et al.*	(CDF Collab.)
ABBASI	12	PR D85 042002	R. Abbasi *et al.*	(IceCube Collab.)
ABRAMOWSKI	12	APJ 750 123	A. Abramowski *et al.*	(H.E.S.S. Collab.)
ACKERMANN	12	PR D86 022002	M. Ackermann *et al.*	(Fermi-LAT Collab.)
AKIMOV	12	PL B709 14	D.Yu. Akimov *et al.*	(ZEPLIN-III Collab.)
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ANGLOHER	12	EPJ C72 1971	G. Angloher *et al.*	(CRESST-II Collab.)
APRILE	12	PRL 109 181301	E. Aprile *et al.*	(XENON100 Collab.)
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ARMENGAUD	12	PR D86 051701	E. Armengaud *et al.*	(EDELWEISS Collab.)
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BEHNKE	12	PR D86 052001	E. Behnke *et al.*	(COUPP Collab.)
Also		PR D90 079902 (errat.)	E. Behnke *et al.*	(COUPP Collab.)
BROWN	12	PR D85 021301	A. Brown *et al.*	(OXF)
CHATRCHYAN	12AP	JHEP 1209 094	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BL	JHEP 1212 015	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12Q	PL B716 260	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12T	PRL 108 261803	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12W	JHEP 1204 061	S. Chatrchyan *et al.*	(CMS Collab.)
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AAD	11AG	NJP 13 053044	G. Aad *et al.*	(ATLAS Collab.)
AAD	11I	PL B698 353	G. Aad *et al.*	(ATLAS Collab.)
AAD	11S	PL B705 294	G. Aad *et al.*	(ATLAS Collab.)
AALSETH	11	PRL 106 131301	C.E. Aalseth *et al.*	(CoGeNT Collab.)
AALSETH	11A	PRL 107 141301	C.E. Aalseth *et al.*	(CoGeNT Collab.)

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AALTONEN	11M	PRL 106 171801	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	11I	PRL 107 011804	V.M. Abazov *et al.*	(D0 Collab.)
ABBASI	11C	PR D84 022004	R. Abbasi *et al.*	(IceCube Collab.)
ABRAMOWSKI	11	PRL 106 161301	A. Abramowski *et al.*	(H.E.S.S. Collab.)
ACKERMANN	11	PRL 107 241302	M. Ackermann *et al.*	(Fermi-LAT Collab.)
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AHMED	11	PR D83 112002	Z. Ahmed *et al.*	(CDMS Collab.)
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ANGLE	11	PRL 107 051301	J. Angle *et al.*	(XENON10 Collab.)
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APRILE	11	PR D84 052003	E. Aprile *et al.*	(XENON100 Collab.)
APRILE	11A	PR D84 061101	E. Aprile *et al.*	(XENON100 Collab.)
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ARMENGAUD	11	PL B702 329	E. Armengaud *et al.*	(EDELWEISS II Collab.)
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AAD	10	PRL 105 161801	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	10AF	PR D82 052005	T. Aaltonen *et al.*	(CDF Collab.)
ABBASI	10	PR D81 057101	R. Abbasi *et al.*	(IceCube Collab.)
AHMED	10	SCI 327 1619	Z. Ahmed *et al.*	(CDMS II Collab.)
AKERIB	10	PR D82 122004	D.S. Akerib *et al.*	(CDMS-II Collab.)
AKIMOV	10	PL B692 180	D.Yu. Akimov *et al.*	(ZEPLIN-III Collab.)
APRILE	10	PRL 105 131302	E. Aprile *et al.*	(XENON100 Collab.)
ARMENGAUD	10	PL B687 294	E. Armengaud *et al.*	(EDELWEISS II Collab.)
FELIZARDO	10	PRL 105 211301	M. Felizardo *et al.*	(The SIMPLE Collab.)
KHACHATRY...	10	PRL 105 211801	V. Khachatryan *et al.*	(CMS Collab.)
Also		PRL 106 029902	V. Khachatryan *et al.*	(CMS Collab.)
MIUCHI	10	PL B686 11	K. Miuchi *et al.*	(NEWAGE Collab.)
AALTONEN	09AF	PR D80 011102	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09G	PR D79 052004	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09Z	PRL 103 021802	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	09M	PRL 102 161802	V.M. Abazov *et al.*	(D0 Collab.)
ABBASI	09B	PRL 102 201302	R. Abbasi *et al.*	(IceCube Collab.)
AHMED	09	PRL 102 011301	Z. Ahmed *et al.*	(CDMS Collab.)
ANGLE	09	PR D80 115005	J. Angle *et al.*	(XENON10 Collab.)
ANGLOHER	09	ASP 31 270	G. Angloher *et al.*	(CRESST Collab.)
ARCHAMBAU...	09	PL B682 185	S. Archambault *et al.*	(PICASSO Collab.)
LEBEDENKO	09A	PRL 103 151302	V.N. Lebedenko *et al.*	(ZEPLIN-III Collab.)
LIN	09	PR D79 061101	S.T. Lin *et al.*	(TEXONO Collab.)
AALSETH	08	PRL 101 251301	C.E. Aalseth *et al.*	(CoGeNT Collab.)
Also		PRL 102 109903 (errat.)	C.E. Aalseth *et al.*	(CoGeNT Collab.)
ANGLE	08A	PRL 101 091301	J. Angle *et al.*	(XENON10 Collab.)
BEDNYAKOV	08	PAN 71 111 Translated from YAF 71 112.	V.A. Bednyakov, H.P. Klapdor-Kleingrothaus, I.V. Krivosheina	
ALNER	07	PL B653 161	G.J. Alner *et al.*	(ZEPLIN-II Collab.)
LEE	07A	PRL 99 091301	H.S. Lee *et al.*	(KIMS Collab.)
MIUCHI	07	PL B654 58	K. Miuchi *et al.*	
AKERIB	06	PR D73 011102	D.S. Akerib *et al.*	(CDMS Collab.)
SHIMIZU	06A	PL B633 195	Y. Shimizu *et al.*	
AKERIB	05	PR D72 052009	D.S. Akerib *et al.*	(CDMS Collab.)
ALNER	05	PL B616 17	G.J. Alner *et al.*	(UK Dark Matter Collab.)
BARNABE-HE...	05	PL B624 186	M. Barnabe-Heider *et al.*	(PICASSO Collab.)
BENOIT	05	PL B616 25	A. Benoit *et al.*	(EDELWEISS Collab.)
GIRARD	05	PL B621 233	T.A. Girard *et al.*	(SIMPLE Collab.)
GIULIANI	05	PRL 95 101301	F. Giuliani	
GIULIANI	05A	PR D71 123503	F. Giuliani, T.A. Girard	
KLAPDOR-K...	05	PL B609 226	H.V. Klapdor-Kleingrothaus, I.V. Krivosheina, C. Tomei	
AKTAS	04C	EPJ C36 413	A. Atkas *et al.*	(H1 Collab.)
GIULIANI	04	PL B588 151	F. Giuliani, T.A. Girard	
GIULIANI	04A	PRL 93 161301	F. Giuliani	
MIUCHI	03	ASP 19 135	K. Miuchi *et al.*	
TAKEDA	03	PL B572 145	A. Takeda *et al.*	
ANGLOHER	02	ASP 18 43	G. Angloher *et al.*	(CRESST Collab.)
BELLI	02	PR D66 043503	P. Belli *et al.*	

BERNABEI	02C	EPJ C23 61	R. Bernabei *et al.*	(DAMA Collab.)
GREEN	02	PR D66 083003	A.M. Green	
JAVORSEK	02	PR D65 072003	D. Javorsek II *et al.*	
BAUDIS	01	PR D63 022001	L. Baudis *et al.*	(Heidelberg-Moscow Collab.)
JAVORSEK	01	PR D64 012005	D. Javorsek II *et al.*	
JAVORSEK	01B	PRL 87 231804	D. Javorsek II *et al.*	
SMITH	01	PR D64 043502	D. Smith, N. Weiner	
ULLIO	01	JHEP 0107 044	P. Ullio, M. Kamionkowski, P. Vogel	
ABBIENDI	00D	EPJ C13 197	G. Abbiendi *et al.*	(OPAL Collab.)
AMBROSIO	00B	EPJ C13 453	M. Ambrosio *et al.*	(MACRO Collab.)
BENOIT	00	PL B479 8	A. Benoit *et al.*	(EDELWEISS Collab.)
BERNABEI	00D	NJP 2 15	R. Bernabei *et al.*	(DAMA Collab.)
COLLAR	00	PRL 85 3083	J.I. Collar *et al.*	(SIMPLE Collab.)
ABE	99F	PRL 82 2038	F. Abe *et al.*	(CDF Collab.)
AMBROSIO	99	PR D60 082002	M. Ambrosio *et al.*	(Macro Collab.)
BERNABEI	99	PL B450 448	R. Bernabei *et al.*	(DAMA Collab.)
BERNABEI	99D	PRL 83 4918	R. Bernabei *et al.*	(DAMA Collab.)
BRHLIK	99	PL B464 303	M. Brhlik, L. Roszkowski	
DERBIN	99	PAN 62 1886	A.V. Derbin *et al.*	
		Translated from YAF 62 2034.		
ACKERSTAFF	98P	PL B433 195	K. Ackerstaff *et al.*	(OPAL Collab.)
KLIMENKO	98	JETPL 67 875	A.A. Klimenko *et al.*	
		Translated from ZETFP 67 835.		
ABE	97G	PR D55 R5263	F. Abe *et al.*	(CDF Collab.)
ABREU	97D	PL B396 315	P. Abreu *et al.*	(DELPHI Collab.)
ACKERSTAFF	97B	PL B391 210	K. Ackerstaff *et al.*	(OPAL Collab.)
ADAMS	97B	PRL 79 4083	J. Adams *et al.*	(FNAL KTeV Collab.)
BARATE	97K	PL B405 379	R. Barate *et al.*	(ALEPH Collab.)
SARSA	97	PR D56 1856	M.L. Sarsa *et al.*	(ZARA)
ALESSAND...	96	PL B384 316	A. Alessandrello *et al.*	(MILA, MILAI, SASSO)
BELLI	96	PL B387 222	P. Belli *et al.*	(DAMA Collab.)
Also		PL B389 783 (erratum)	P. Belli *et al.*	(DAMA Collab.)
BELLI	96C	NC 19C 537	P. Belli *et al.*	(DAMA Collab.)
BERNABEI	96	PL B389 757	R. Bernabei *et al.*	(DAMA Collab.)
COLLAR	96	PRL 76 331	J.I. Collar	(SCUC)
SARSA	96	PL B386 458	M.L. Sarsa *et al.*	(ZARA)
Also		PR D56 1856	M.L. Sarsa *et al.*	(ZARA)
SMITH	96	PL B379 299	P.F. Smith *et al.*	(RAL, SHEF, LOIC+)
SNOWDEN-...	96	PRL 76 332	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)
AKERS	95R	ZPHY C67 203	R. Akers *et al.*	(OPAL Collab.)
GALLAS	95	PR D52 6	E. Gallas *et al.*	(MSU, FNAL, MIT, FLOR)
GARCIA	95	PR D51 1458	E. Garcia *et al.*	(ZARA, SCUC, PNL)
QUENBY	95	PL B351 70	J.J. Quenby *et al.*	(LOIC, RAL, SHEF+)
SNOWDEN-...	95	PRL 74 4133	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)
Also		PRL 76 331	J.I. Collar	(SCUC)
Also		PRL 76 332	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)
BECK	94	PL B336 141	M. Beck *et al.*	(MPIH, KIAE, SASSO)
RAM	94	PR D49 3120	S. Ram *et al.*	(TELA, TRIU)
ABE	93G	PRL 71 2542	F. Abe *et al.*	(CDF Collab.)
ASTONE	93	PR D47 4770	P. Astone *et al.*	(ROMA, ROMAI, CATA, FRAS)
BUSKULIC	93C	PL B303 198	D. Buskulic *et al.*	(ALEPH Collab.)
YAMAGATA	93	PR D47 1231	T. Yamagata, Y. Takamori, H. Utsunomiya	(KONAN)
ABE	92J	PR D46 R1889	F. Abe *et al.*	(CDF Collab.)
AHLEN	92	PRL 69 1860	S.P. Ahlen *et al.*	(MACRO Collab.)
BACCI	92	PL B293 460	C. Bacci *et al.*	(Beijing-Roma-Saclay Collab.)
VERKERK	92	PRL 68 1116	P. Verkerk *et al.*	(ENSP, SACL, PAST)
AKESSON	91	ZPHY C52 219	T. Akesson *et al.*	(HELIOS Collab.)
NAKAMURA	91	PL B263 529	S. Nakamura *et al.*	
ORITO	91	PRL 66 1951	S. Orito *et al.*	(ICEPP, WASCR, NIHO, ICRR)
REUSSER	91	PL B255 143	D. Reusser *et al.*	(NEUC, CIT, PSI)
ADACHI	90C	PL B244 352	I. Adachi *et al.*	(TOPAZ Collab.)
ADACHI	90E	PL B249 336	I. Adachi *et al.*	(TOPAZ Collab.)
AKRAWY	90O	PL B252 290	M.Z. Akrawy *et al.*	(OPAL Collab.)
HEMMICK	90	PR D41 2074	T.K. Hemmick *et al.*	(ROCH, MICH, OHIO+)
SAITO	90	PRL 65 2094	T. Saito *et al.*	(ICRR, KOBE)
NAKAMURA	89	PR D39 1261	T.T. Nakamura *et al.*	(KYOT, TMTC)
NORMAN	89	PR D39 2499	E.B. Norman *et al.*	(LBL)
BERNSTEIN	88	PR D37 3103	R.M. Bernstein *et al.*	(STAN, WISC)
CALDWELL	88	PRL 61 510	D.O. Caldwell *et al.*	(UCSB, UCB, LBL)
LIU	88	PRL 61 271	G. Liu, B. Barish	
BARISH	87	PR D36 2641	B.C. Barish, G. Liu, C. Lane	(CIT)

NORMAN	87	PRL 58 1403	E.B. Norman, S.B. Gazes, D.A. Bennett	(LBL)
BADIER	86	ZPHY C31 21	J. Badier *et al.*	(NA3 Collab.)
MINCER	85	PR D32 541	A. Mincer *et al.*	(UMD, GMAS, NSF)
NAKAMURA	85	PL 161B 417	K. Nakamura *et al.*	(KEK, INUS)
THRON	85	PR D31 451	J.L. Thron *et al.*	(YALE, FNAL, IOWA)
SAKUYAMA	83B	LNC 37 17	H. Sakuyama, N. Suzuki	(MEIS)
Also		LNC 36 389	H. Sakuyama, K. Watanabe	(MEIS)
Also		NC 78A 147	H. Sakuyama, K. Watanabe	(MEIS)
Also		NC 6C 371	H. Sakuyama, K. Watanabe	(MEIS)
BHAT	82	PR D25 2820	P.N. Bhat *et al.*	(TATA)
KINOSHITA	82	PRL 48 77	K. Kinoshita, P.B. Price, D. Fryberger	(UCB+)
MARINI	82	PR D26 1777	A. Marini *et al.*	(FRAS, LBL, NWES, STAN+)
SMITH	82B	NP B206 333	P.F. Smith *et al.*	(RAL)
KINOSHITA	81B	PR D24 1707	K. Kinoshita, P.B. Price	(UCB)
LOSECCO	81	PL 102B 209	J.M. LoSecco *et al.*	(MICH, PENN, BNL)
ULLMAN	81	PRL 47 289	J.D. Ullman	(LEHM, BNL)
YOCK	81	PR D23 1207	P.C.M. Yock	(AUCK)
BARTEL	80	ZPHY C6 295	W. Bartel *et al.*	(JADE Collab.)
BUSSIERE	80	NP B174 1	A. Bussiere *et al.*	(BGNA, SACL, LAPP)
YOCK	80	PR D22 61	P.C.M. Yock	(AUCK)
ARMITAGE	79	NP B150 87	J.C.M. Armitage *et al.*	(CERN, DARE, FOM+)
BOZZOLI	79	NP B159 363	W. Bozzoli *et al.*	(BGNA, LAPP, SACL+)
GOODMAN	79	PR D19 2572	J.A. Goodman *et al.*	(UMD)
SMITH	79	NP B149 525	P.F. Smith, J.R.J. Bennett	(RHEL)
BHAT	78	PRAM 10 115	P.N. Bhat, P.V. Ramana Murthy	(TATA)
CARROLL	78	PRL 41 777	A.S. Carroll *et al.*	(BNL, PRIN)
CUTTS	78	PRL 41 363	D. Cutts *et al.*	(BROW, FNAL, ILL, BARI+)
VIDAL	78	PL 77B 344	R.A. Vidal *et al.*	(COLU, FNAL, STON+)
ALEKSEEV	76	SJNP 22 531 Translated from YAF 22 1021.	G.D. Alekseev *et al.*	(JINR)
ALEKSEEV	76B	SJNP 23 633 Translated from YAF 23 1190.	G.D. Alekseev *et al.*	(JINR)
BALDIN	76	SJNP 22 264 Translated from YAF 22 512.	B.Y. Baldin *et al.*	(JINR)
BRIATORE	76	NC 31A 553	L. Briatore *et al.*	(LCGT, FRAS, FREIB)
GUSTAFSON	76	PRL 37 474	H.R. Gustafson *et al.*	(MICH)
ALBROW	75	NP B97 189	M.G. Albrow *et al.*	(CERN, DARE, FOM+)
FRANKEL	75	PR D12 2561	S. Frankel *et al.*	(PENN, FNAL)
JOVANOV...	75	PL 56B 105	J.V. Jovanovich *et al.*	(MANI, AACH, CERN+)
YOCK	75	NP B86 216	P.C.M. Yock	(AUCK, SLAC)
APPEL	74	PRL 32 428	J.A. Appel *et al.*	(COLU, FNAL)
FRANKEL	74	PR D9 1932	S. Frankel *et al.*	(PENN, FNAL)
YOCK	74	NP B76 175	P.C.M. Yock	(AUCK)
ALPER	73	PL 46B 265	B. Alper *et al.*	(CERN, LIVP, LUND, BOHR+)
LEIPUNER	73	PRL 31 1226	L.B. Leipuner *et al.*	(BNL, YALE)
DARDO	72	NC 9A 319	M. Dardo *et al.*	(TORI)
TONWAR	72	JP A5 569	S.C. Tonwar, S. Naranan, B.V. Sreekantan	(TATA)
ANTIPOV	71B	NP B31 235	Y.M. Antipov *et al.*	(SERP)
ANTIPOV	71C	PL 34B 164	Y.M. Antipov *et al.*	(SERP)
BINON	69	PL 30B 510	F.G. Binon *et al.*	(SERP)
BJORNBOE	68	NC B53 241	J. Bjornboe *et al.*	(BOHR, TATA, BERN+)
JONES	67	PR 164 1584	L.W. Jones	(MICH, WISC, LBL, UCLA, MINN+)
DORFAN	65	PRL 14 999	D.E. Dorfan *et al.*	(COLU)