Dark Matter

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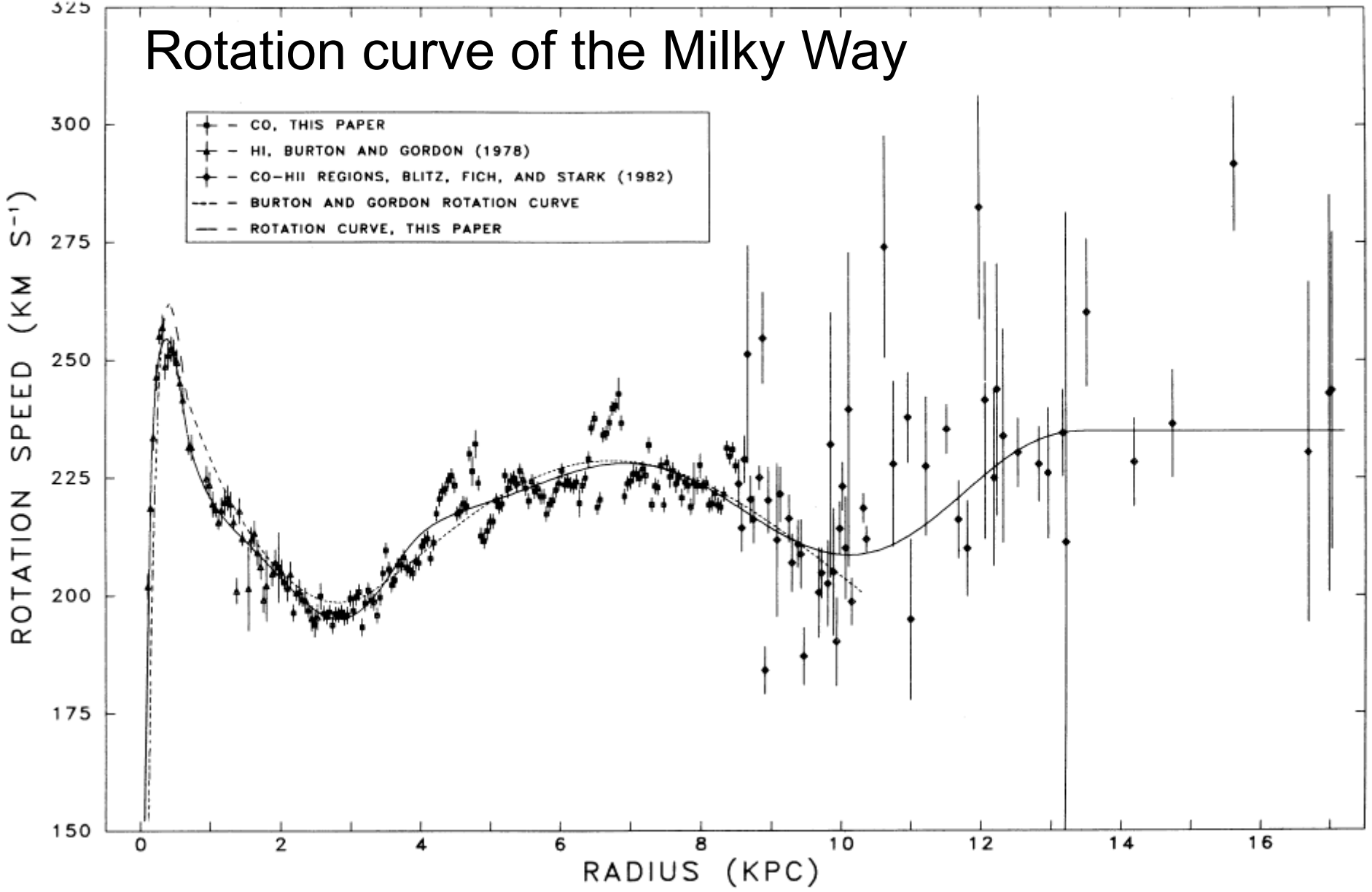
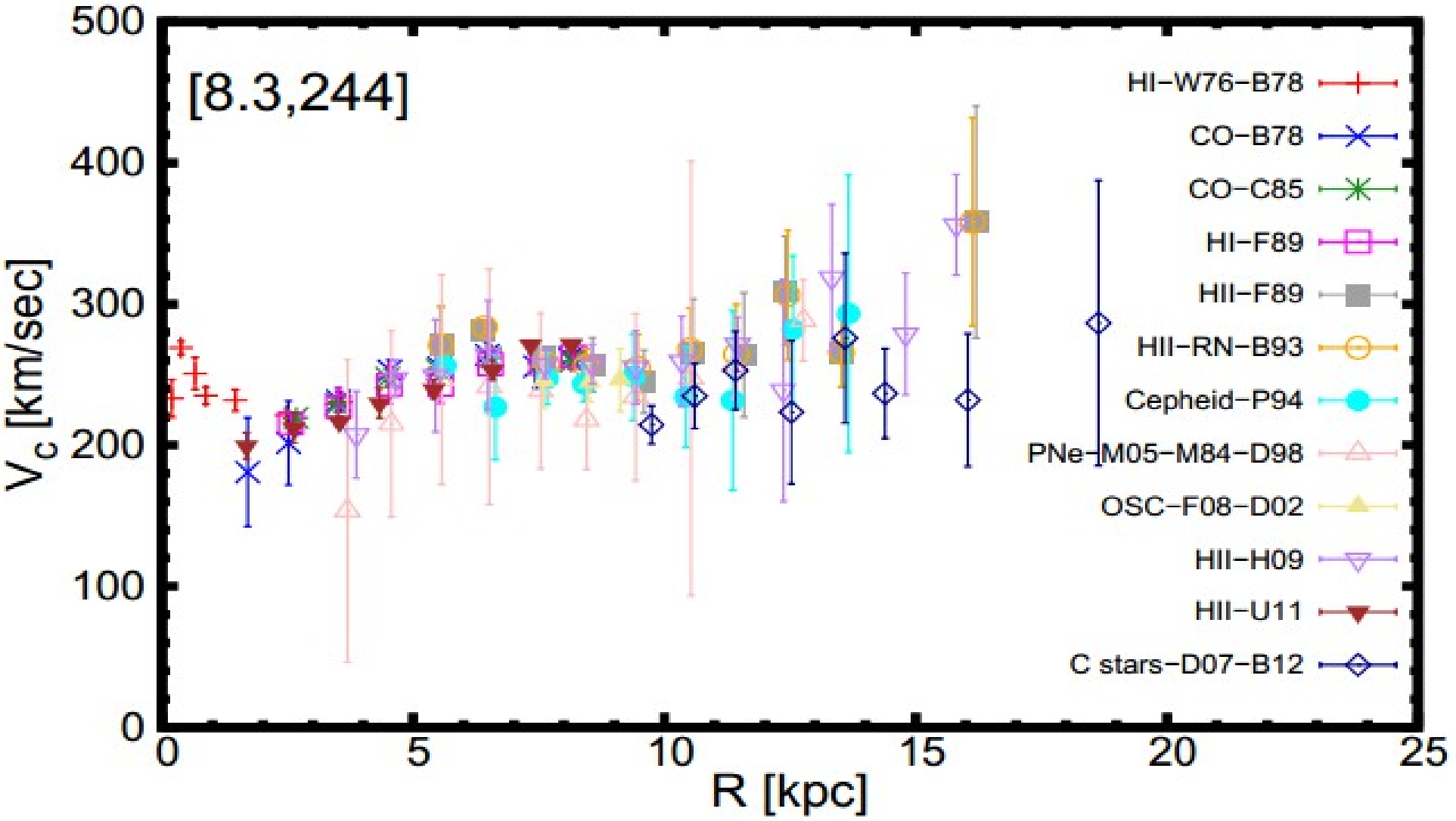
Physical Research Laboratory

Symposium on Astro-Particle and Nuclear Physics
In Honour of 70th Birthday of Prof. Q.N. Usmani

Rotation curve of the Milky Way



Clemens (1985), Ap. J. 295, 422



Pijushpani Bhattacharjee, Soumini Chaudhury , Susmita Kundu , 2013

The total amount of matter in the solar neighborhood inferred by the motion of stars in the direction perpendicular to the Galactic plane

$$\Sigma_{|z|<1.1\mathrm{kpc}} = (71 \pm 6) M_\odot \ \mathrm{pc}^{-2}$$

local surface density corresponding to the visible components

$$\Sigma_* = (48 \pm 8) M_\odot \ \mathrm{pc}^{-2}$$

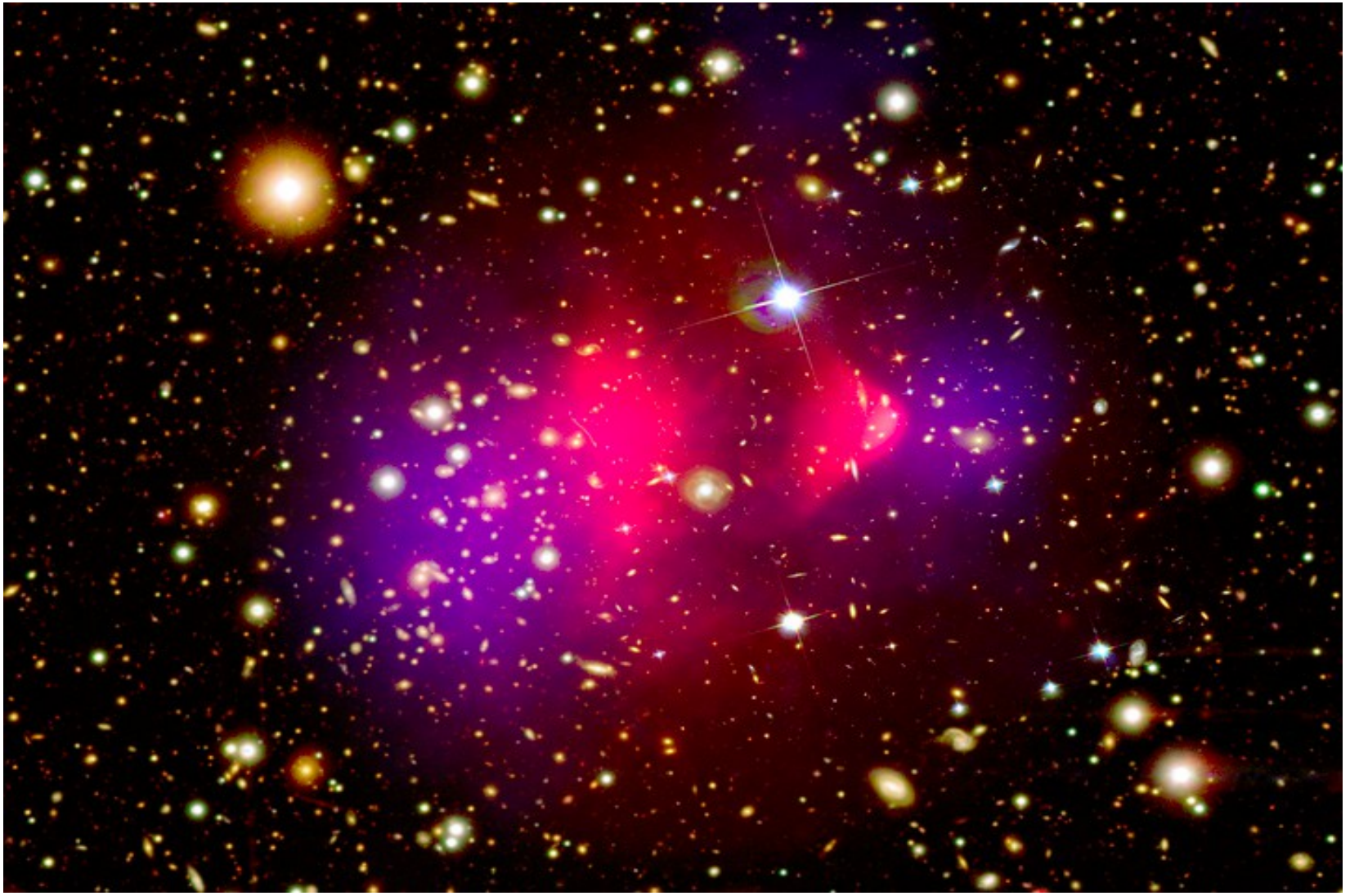
K. Kuijken and G. Gilmore, Astrophys. J. **367** (1991) L9

Local dark matter density

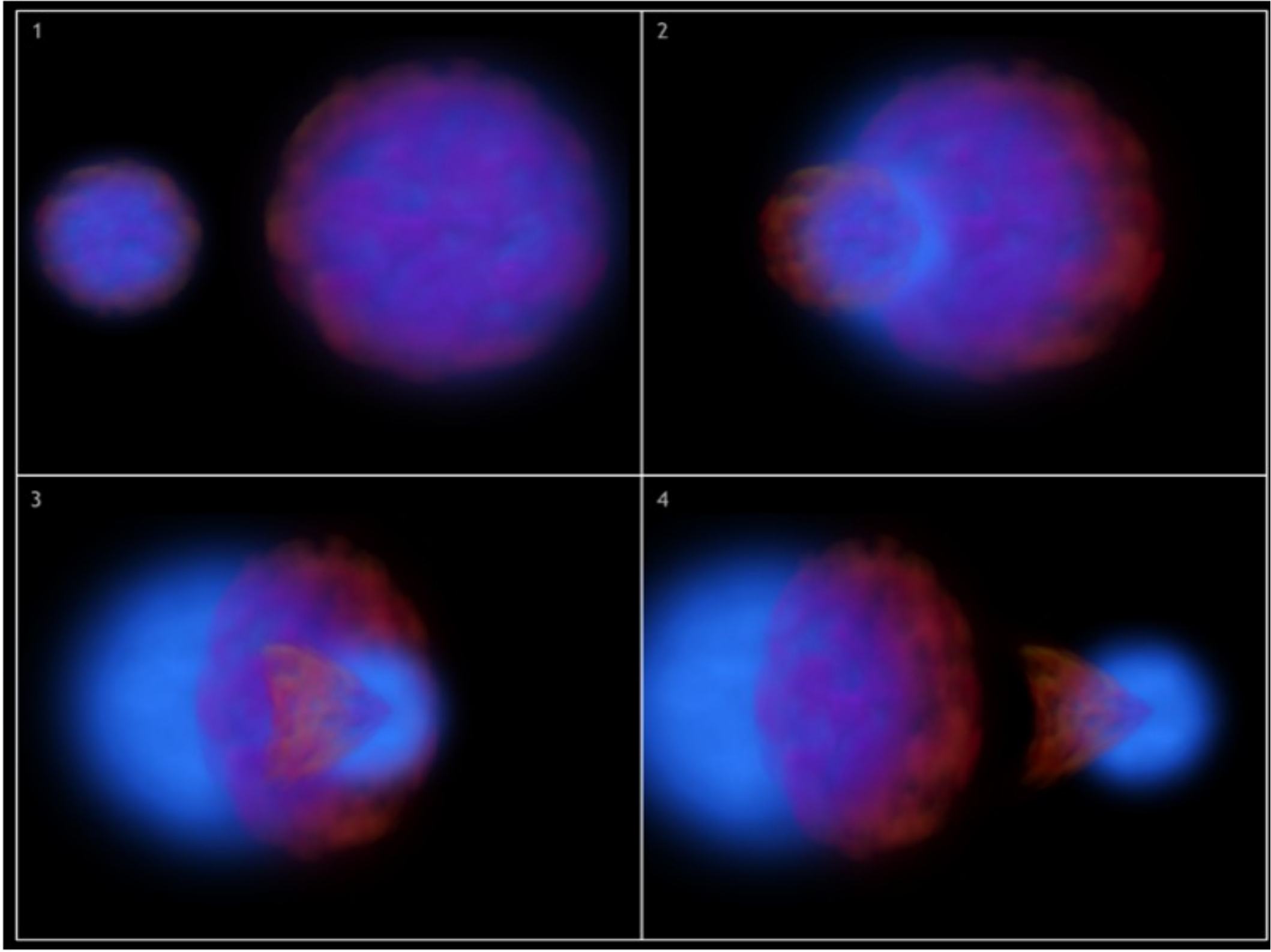
$$\rho_{DM}(R_0) = 0.389 \pm 0.025\,\mathrm{GeV\ cm^{-3}}$$

Catena and Ullio 2009

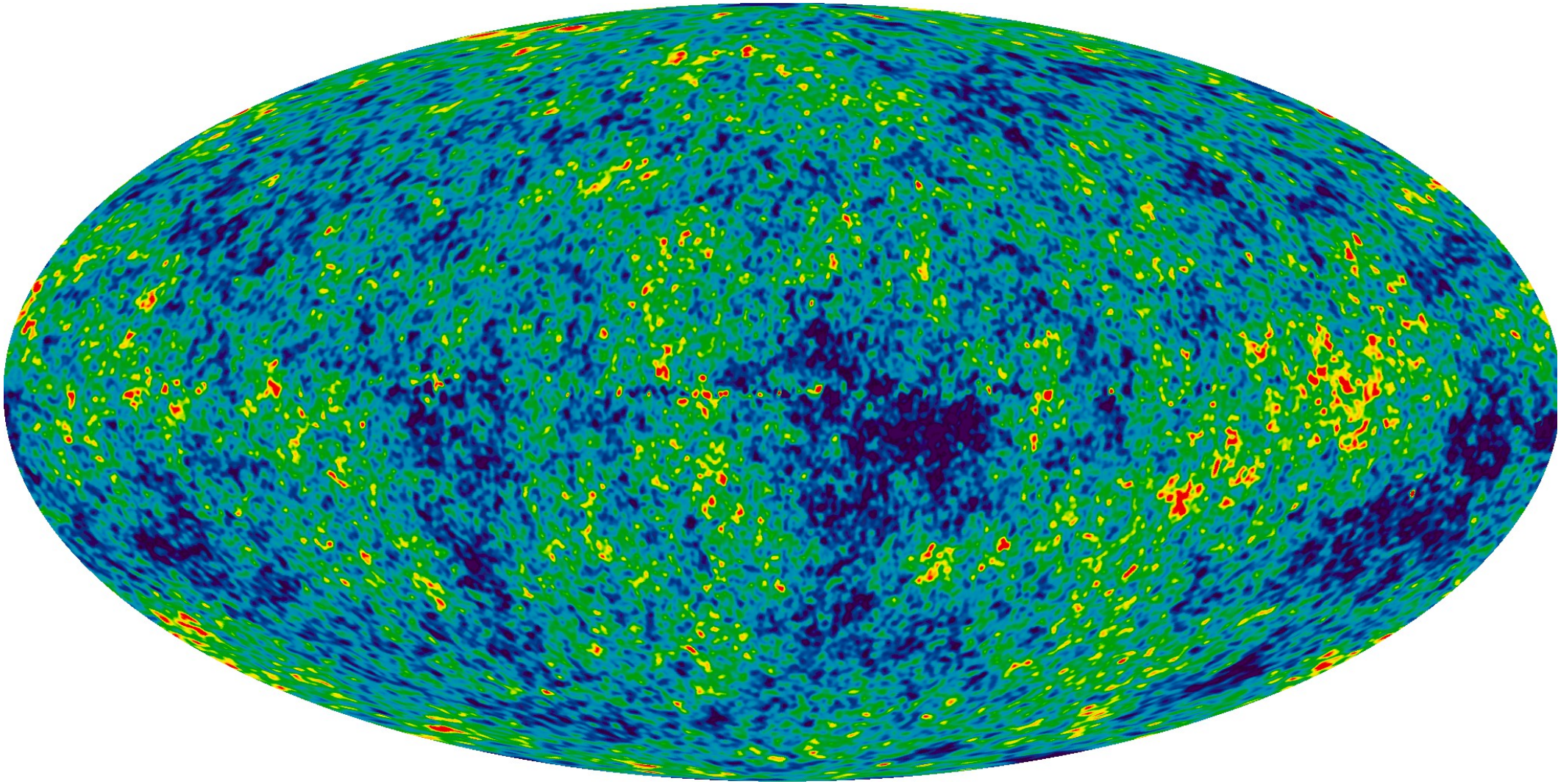
Dark matter are particles not modified gravity



Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

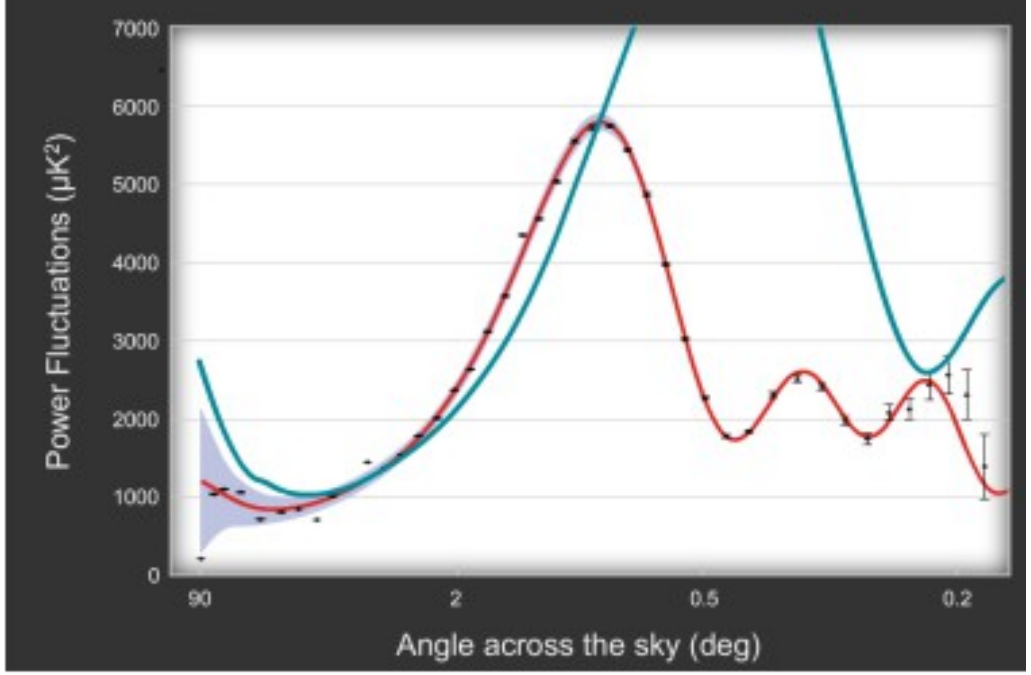

1
2
3
4

Evidence of Dark Matter from CMB

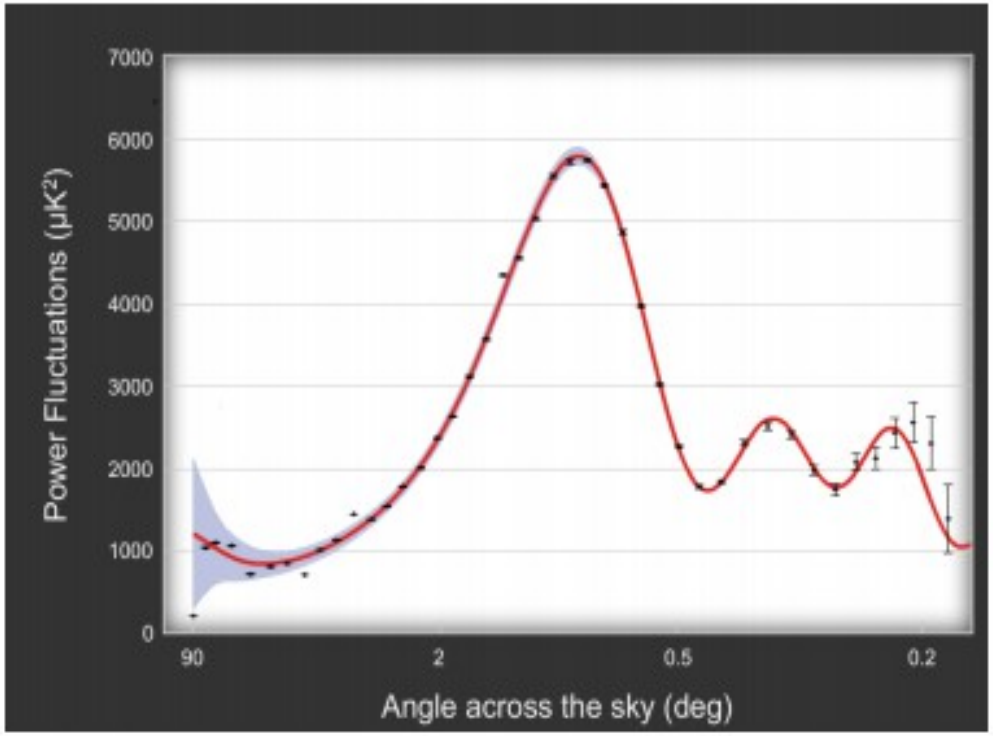


WMAP 7 year map

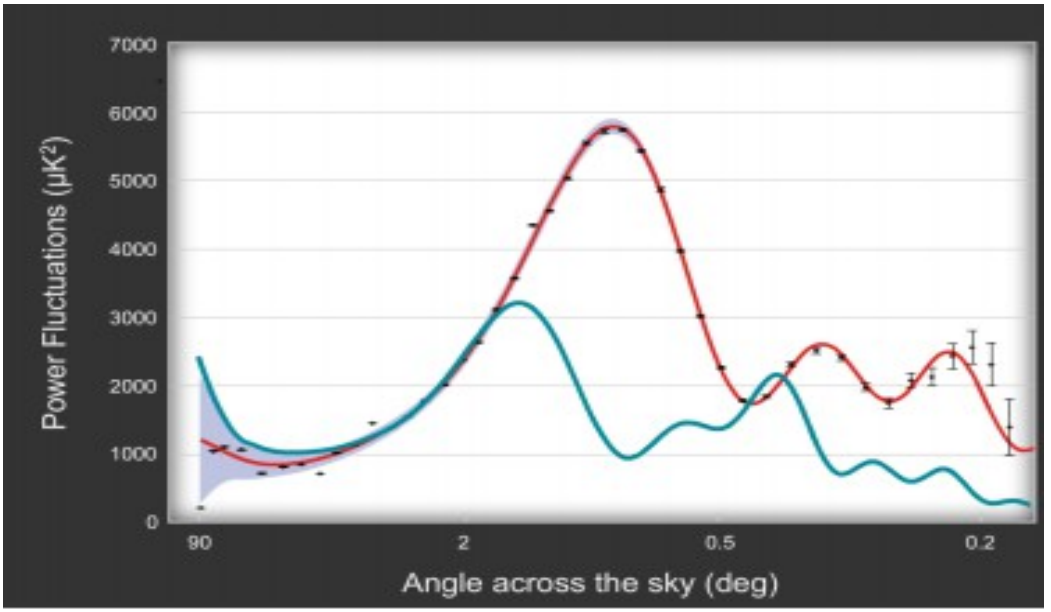
http://map.gsfc.nasa.gov/resources/camb_tool/cmb_plot.swf



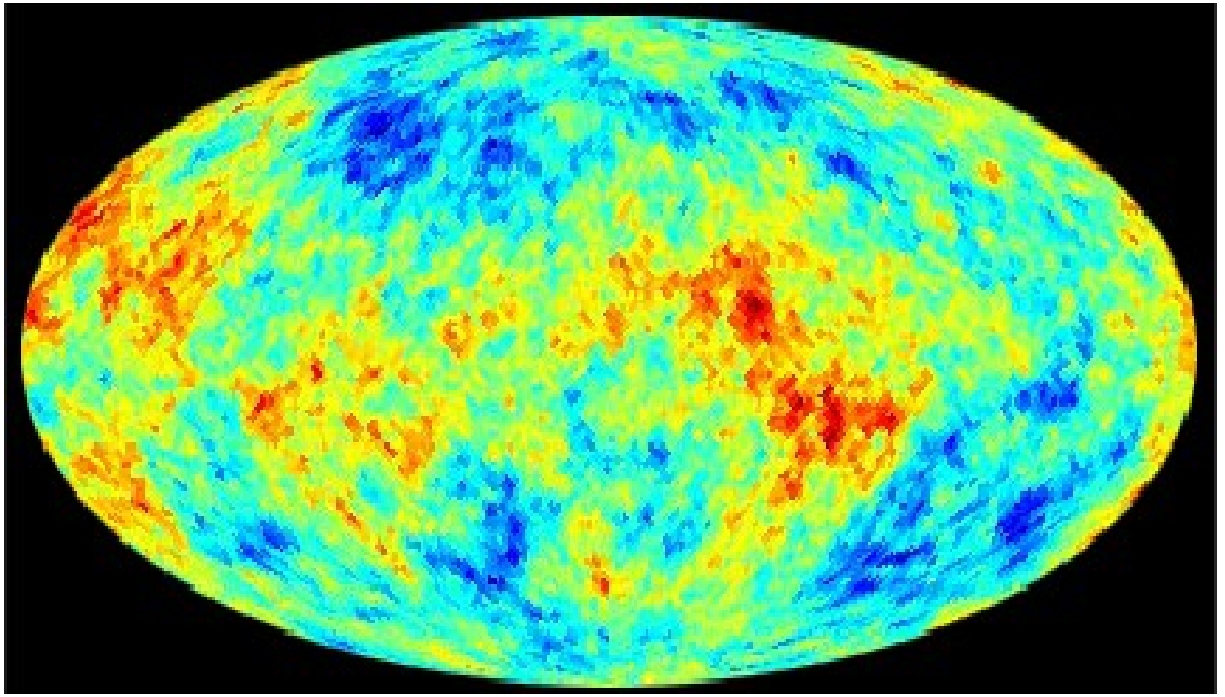
too little DM ($0.04\rho_c$)

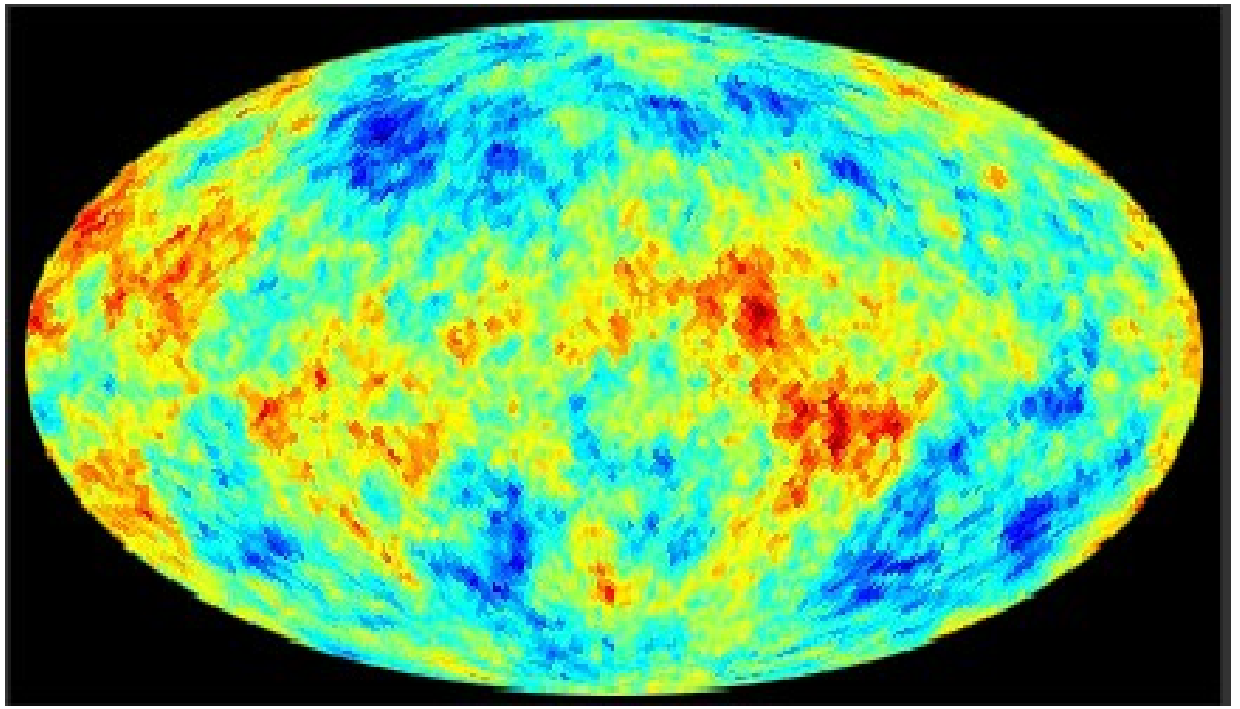


right amount of DM ($0.22\rho_c$)

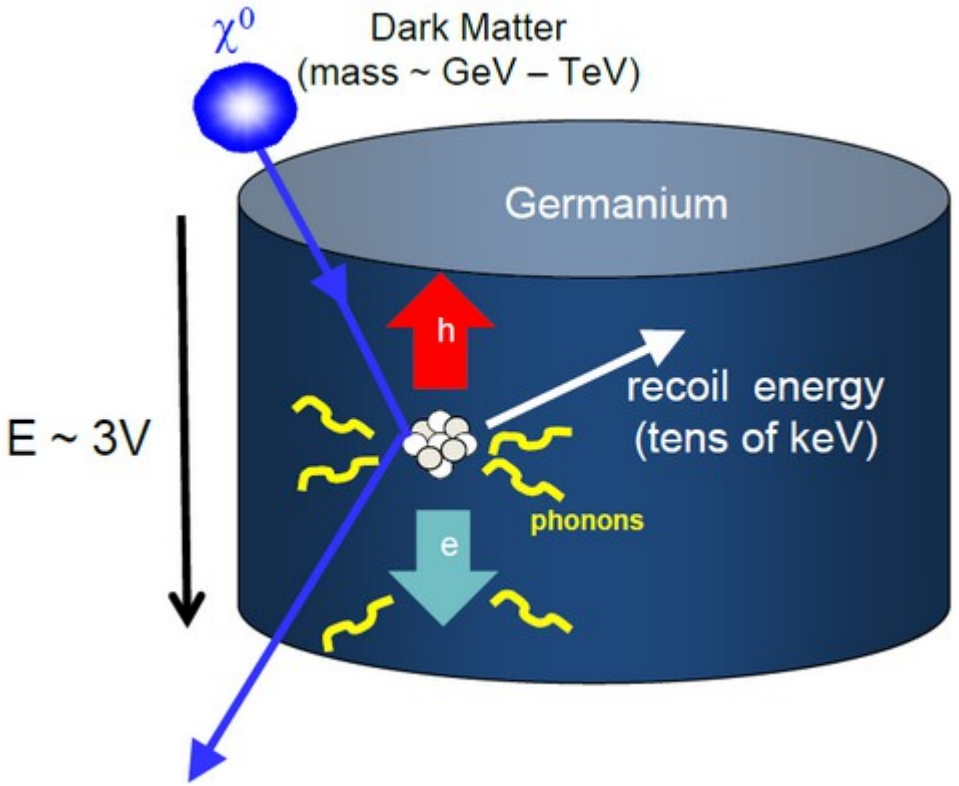


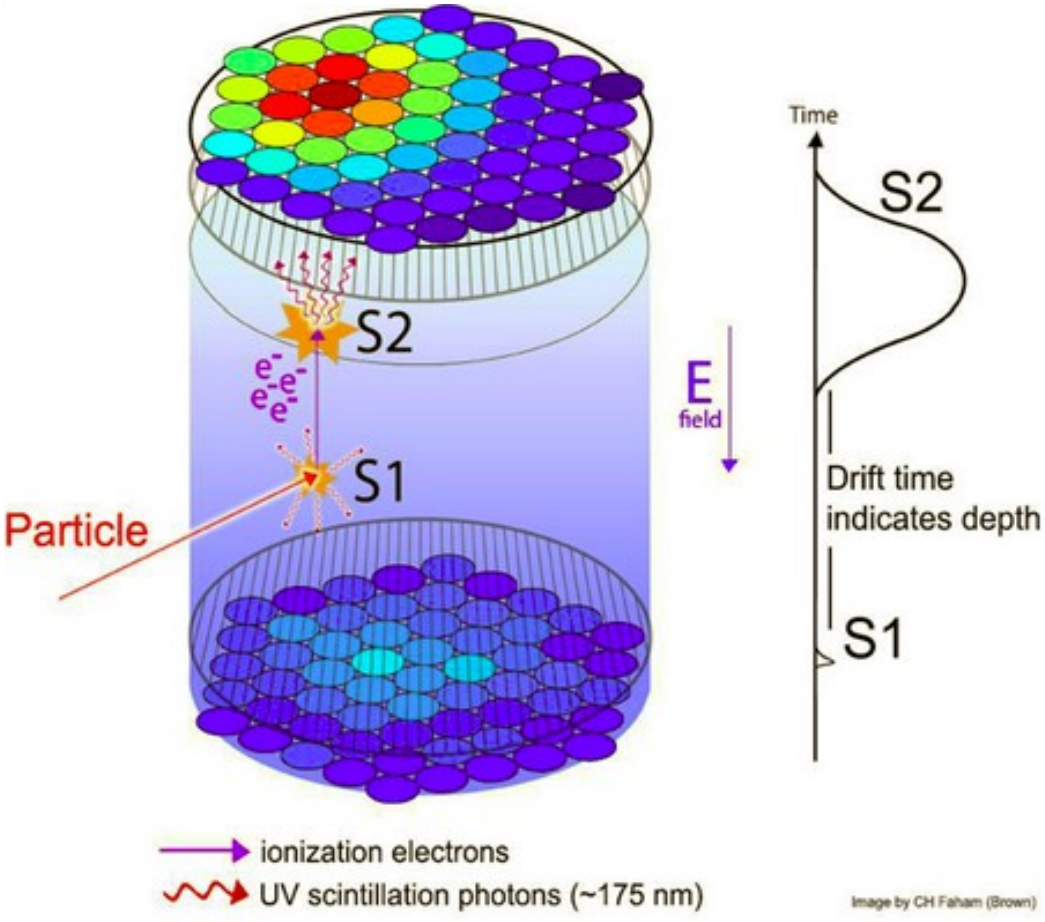
too much DM ($0.74\rho_c$)

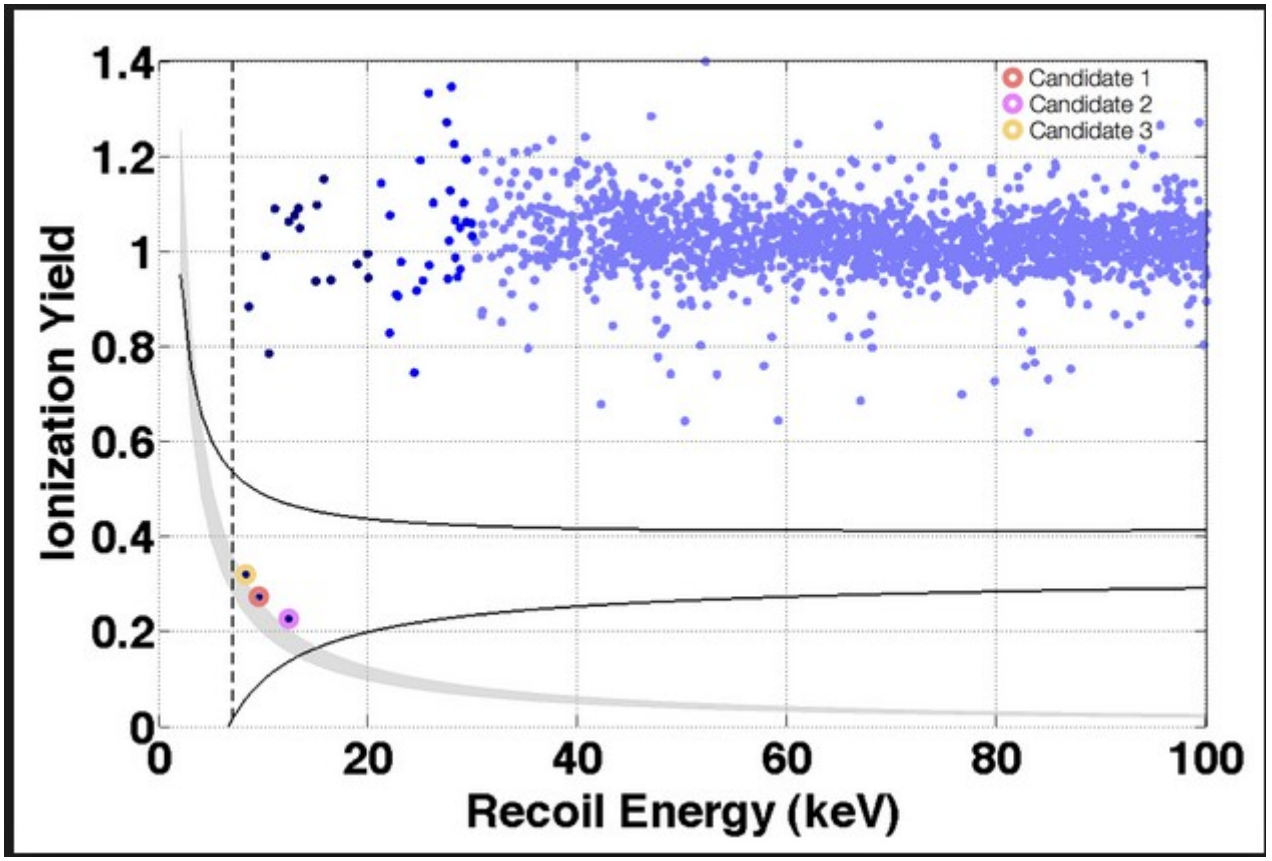




Direct Detection of Dark Matter






Candidate 1
Candidate 2
Candidate 3
Ionization Yield
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
Recoil Energy (keV)

First results from the LUX dark matter experiment

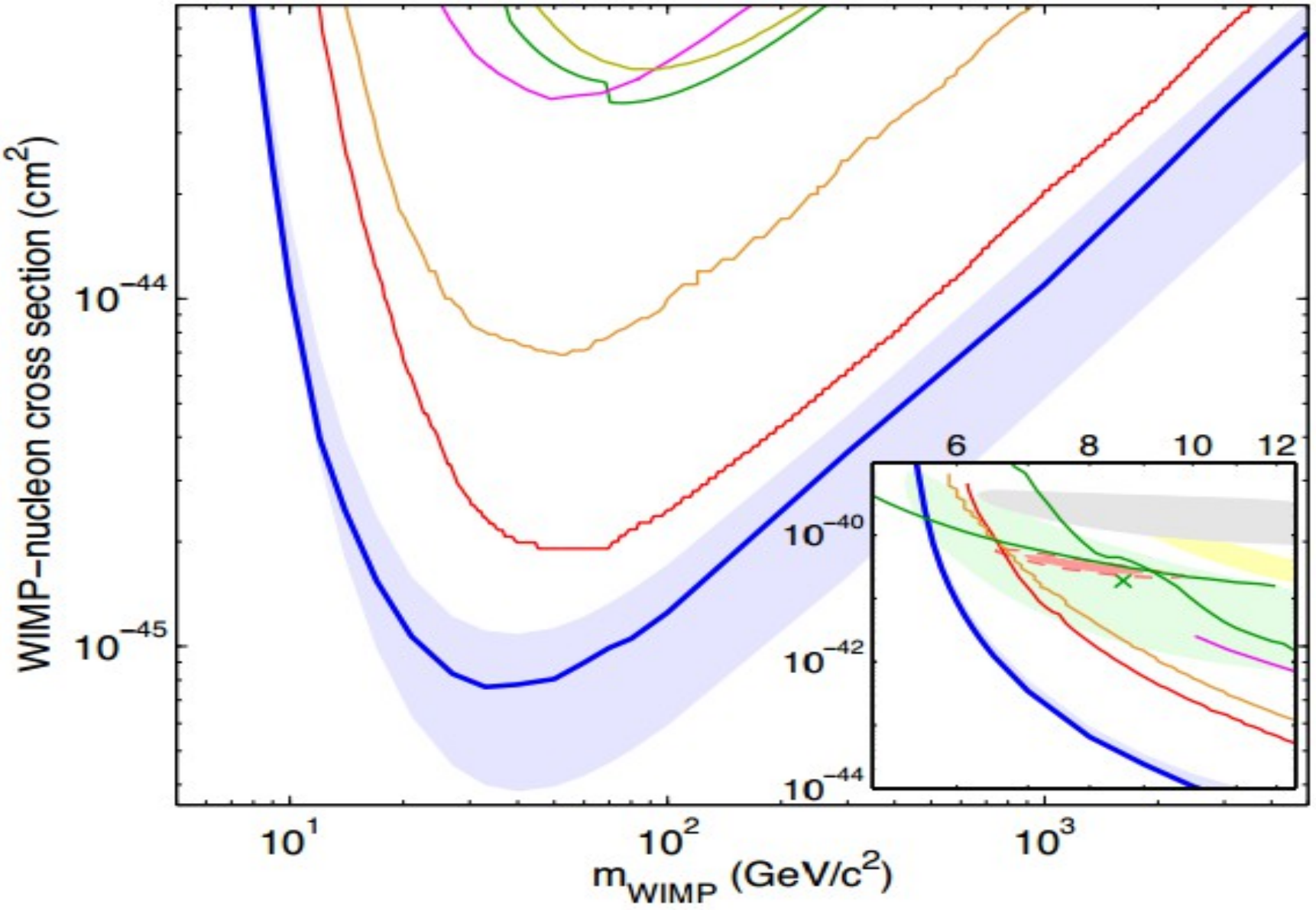
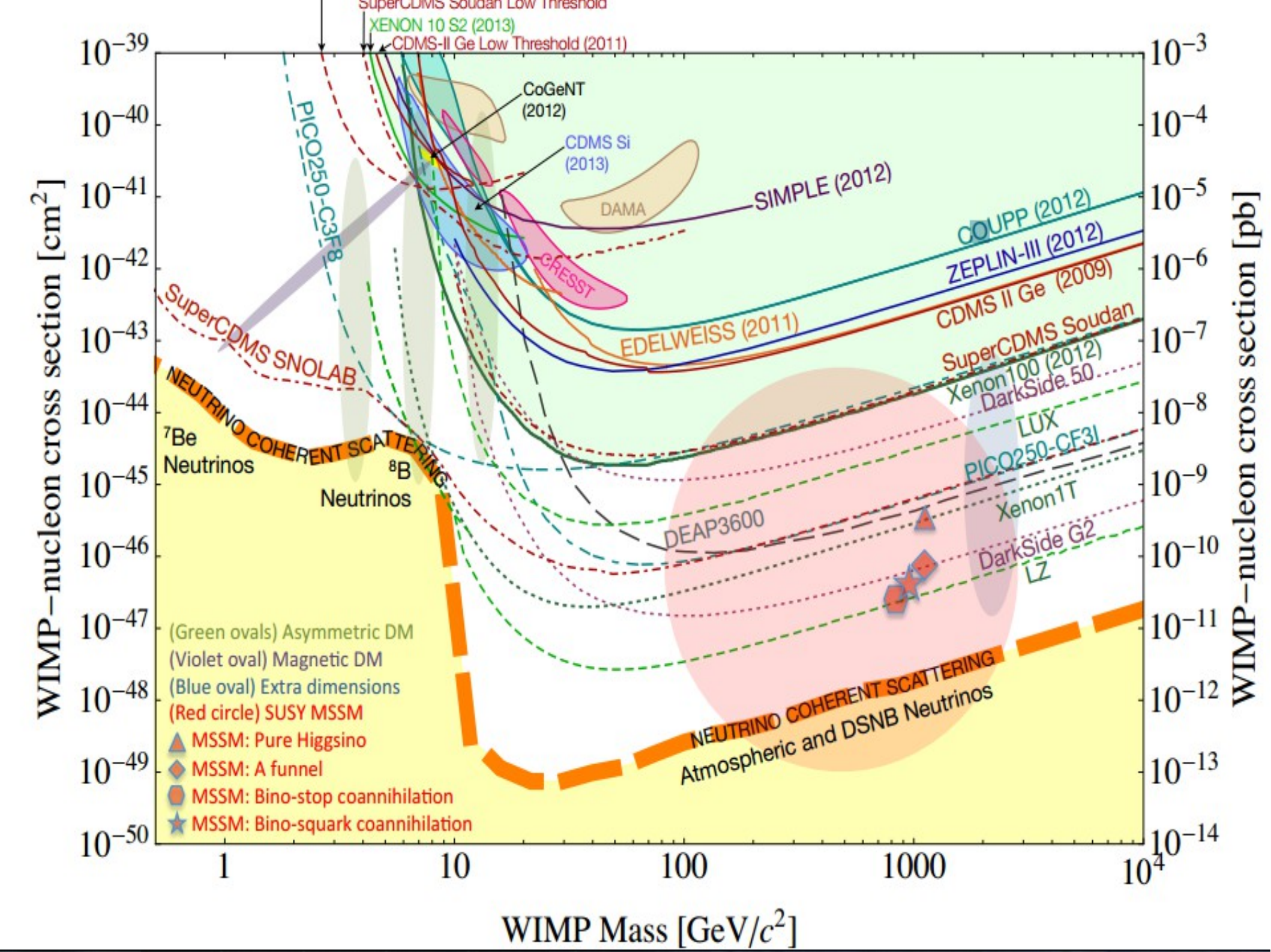
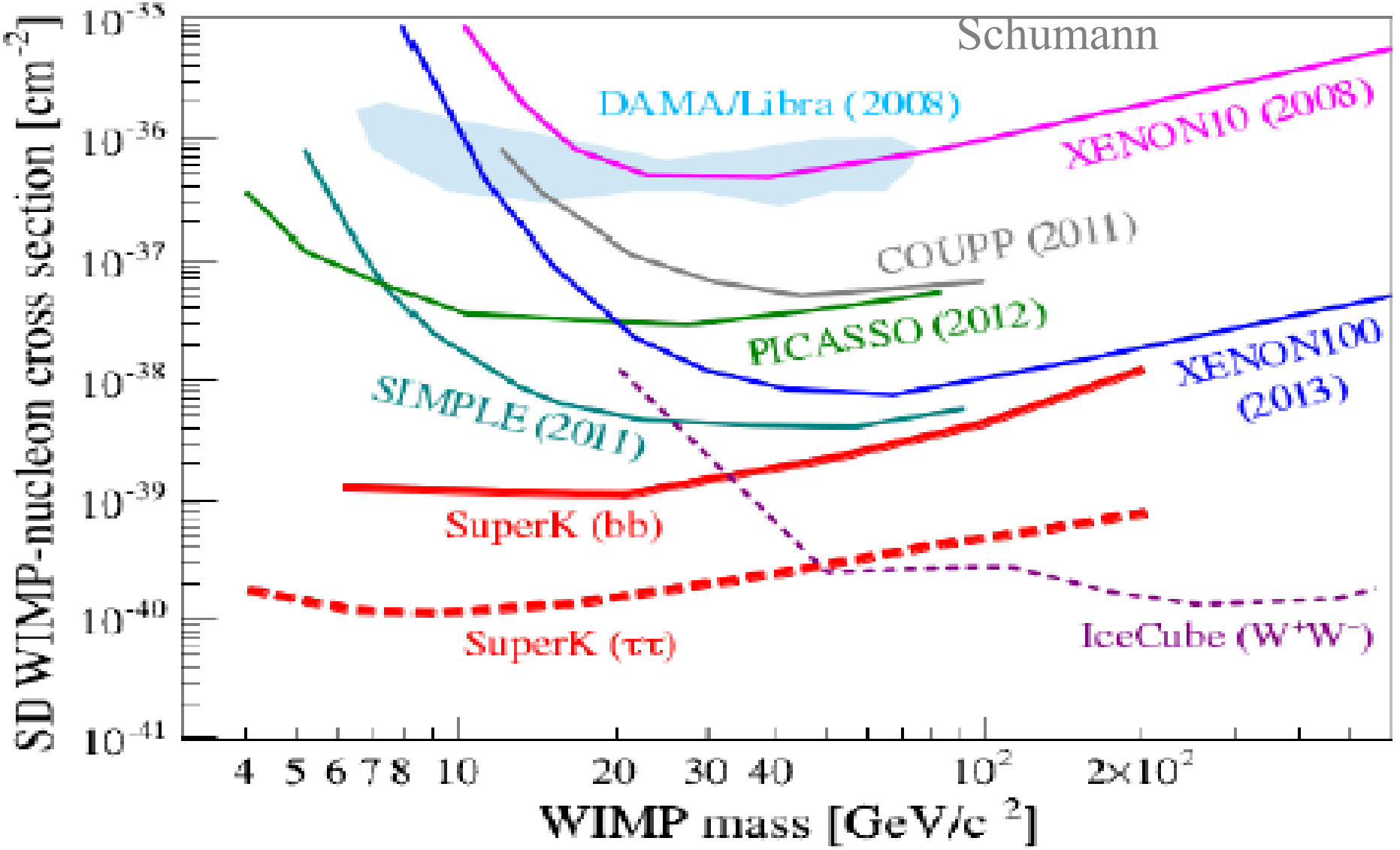


FIG. 5. The LUX 90% confidence limit on the spin-independent elastic WIMP-nucleon cross section (blue),

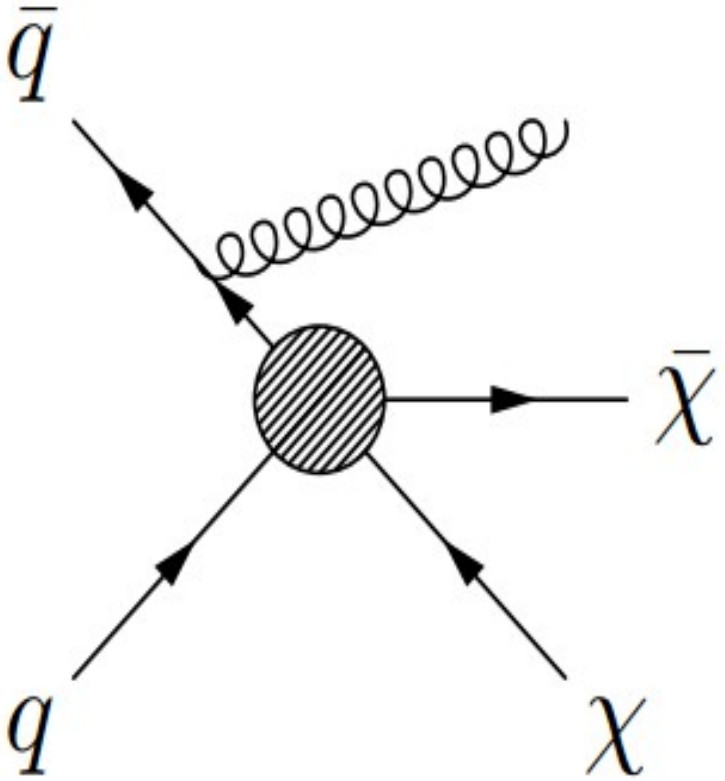

SuperCDMS Soudan Low Threshold
XENON 10 S2 (2013)
CDMS-II Ge Low Threshold (2011)
CoGeNT (2012)
CDMS Si (2013)
DAMA
SIMPLE (2012)
CRESST
COUPP (2012)
ZEPLIN-III (2012)
CDMS II Ge (2009)
EDELWEISS (2011)
SuperCDMS Soudan
Xenon100 (2012)
DarkSide 50
LUX
PICO250-CF3I
Xenon1T
DarkSide G2
LZ
DEAP3600
PICO250-C3F8
SuperCDMS SNOLAB
NEUTRINO COHERENT SCATTERING
^{7}Be Neutrinos
^{8}B Neutrinos
NEUTRINO COHERENT SCATTERING
Atmospheric and DSNB Neutrinos
(Green ovals) Asymmetric DM
(Violet oval) Magnetic DM
(Blue oval) Extra dimensions
(Red circle) SUSY MSSM
MSSM: Pure Higgsino
MSSM: A funnel
MSSM: Bino-stop coannihilation
MSSM: Bino-squark coannihilation
WIMP–nucleon cross section [cm^2]
WIMP–nucleon cross section [pb]
WIMP Mass [GeV/c^2]
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
10^{-49}
10^{-50}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
1
10
100
1000
10^4

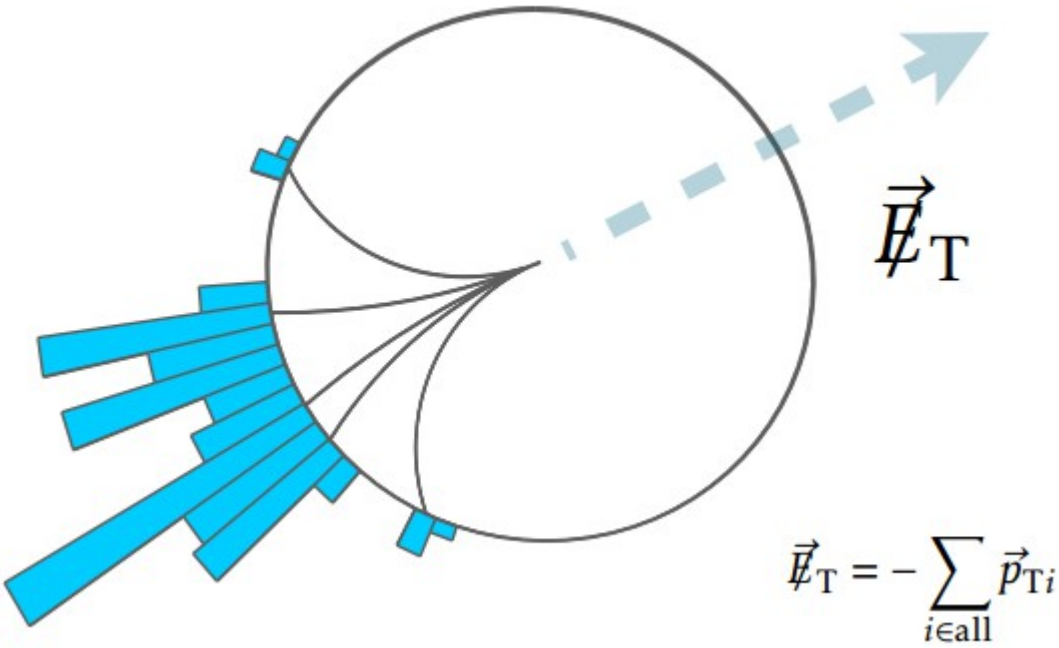
Spin dependent cross section

ArXiv:1310.5217
Schumann

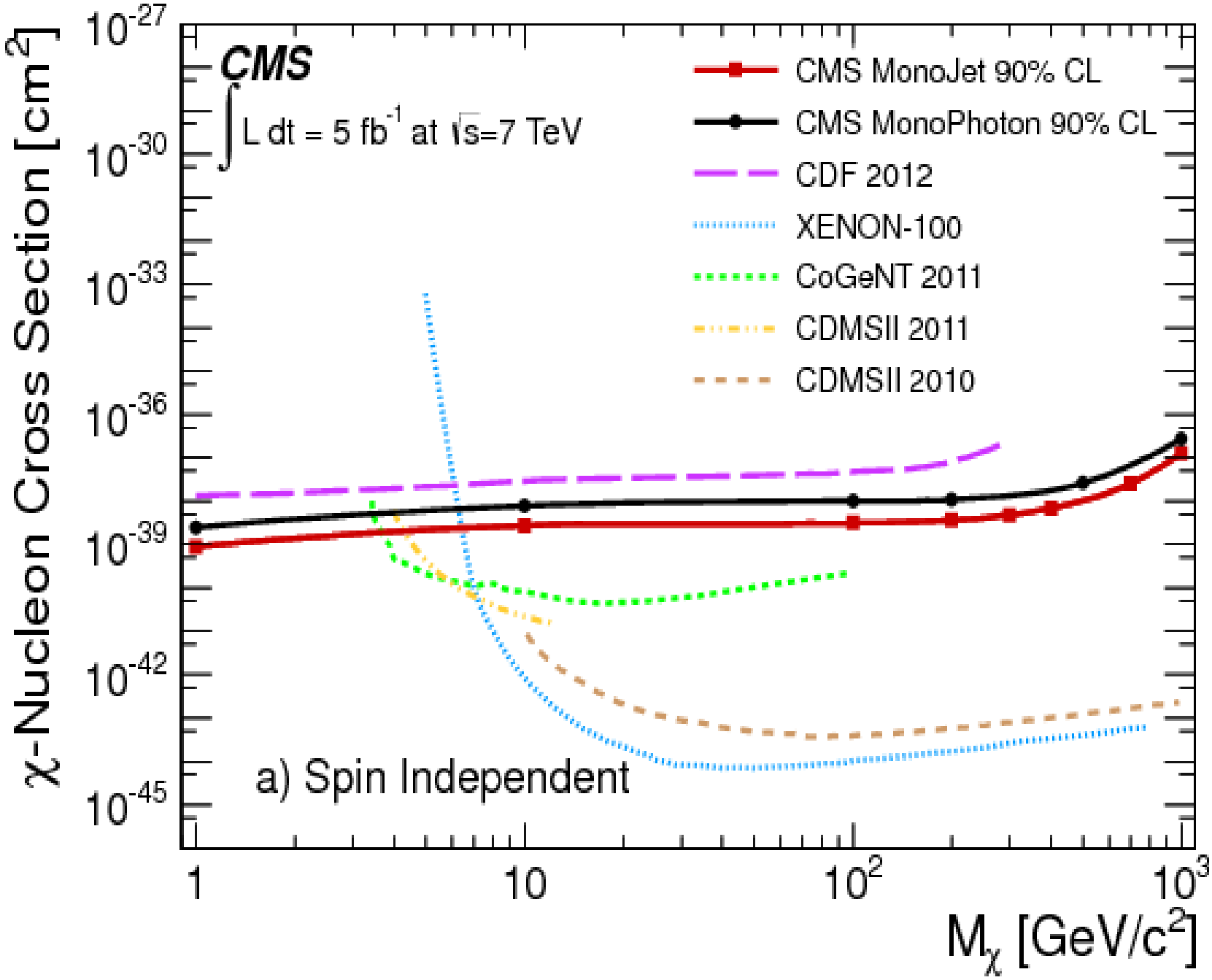


Dark matter bounds from LHC

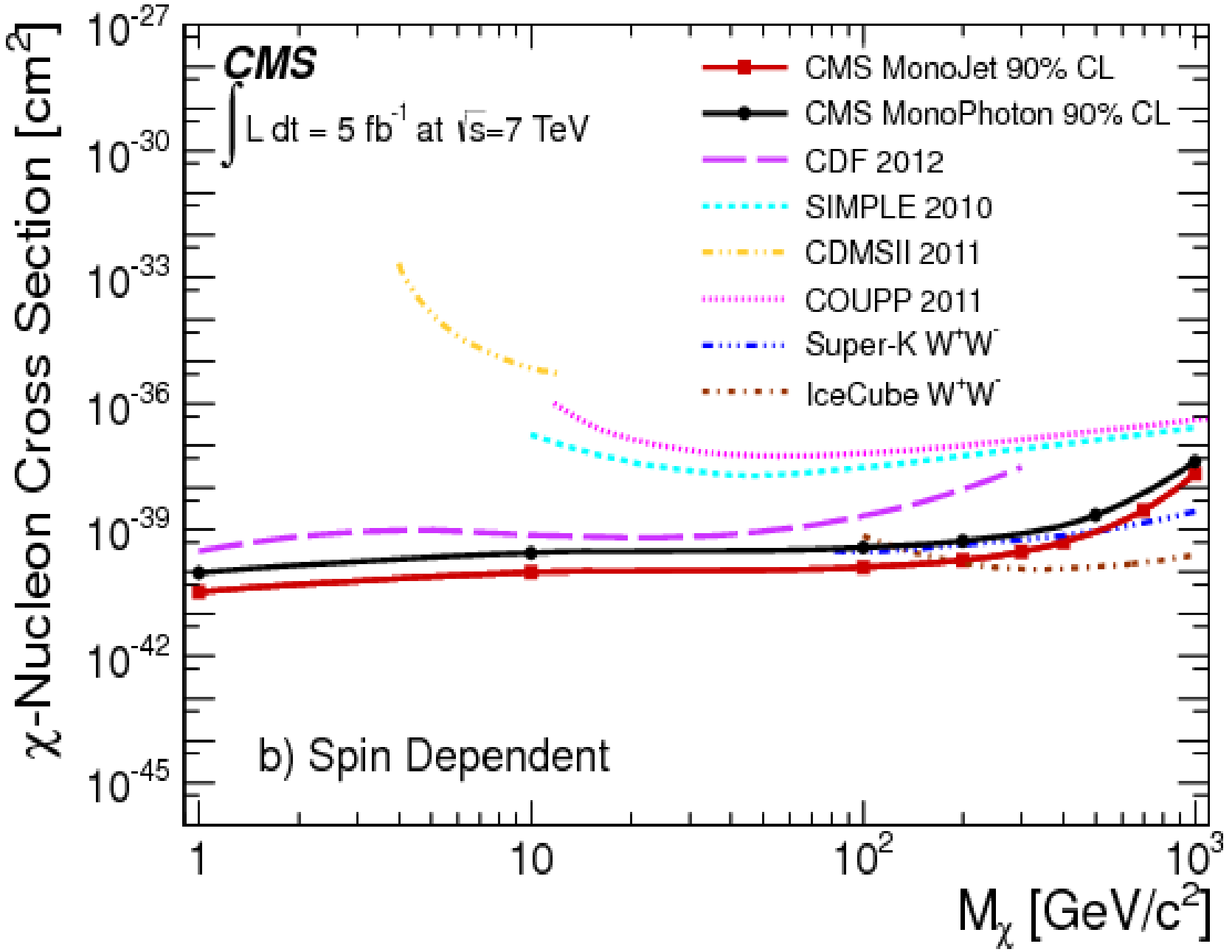




$$\vec{\not{E}}_{\mathrm{T}} = -\sum_{i \in \mathrm{all}} \vec{p}_{\mathrm{T}i}$$



Search for dark matter at the LHC using missing transverse energy - CMS Collaboration
arXiv:1206.0753



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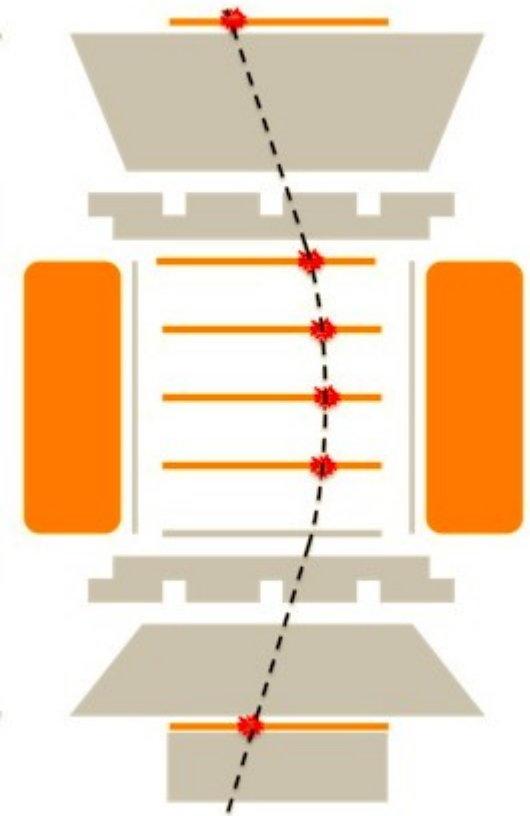
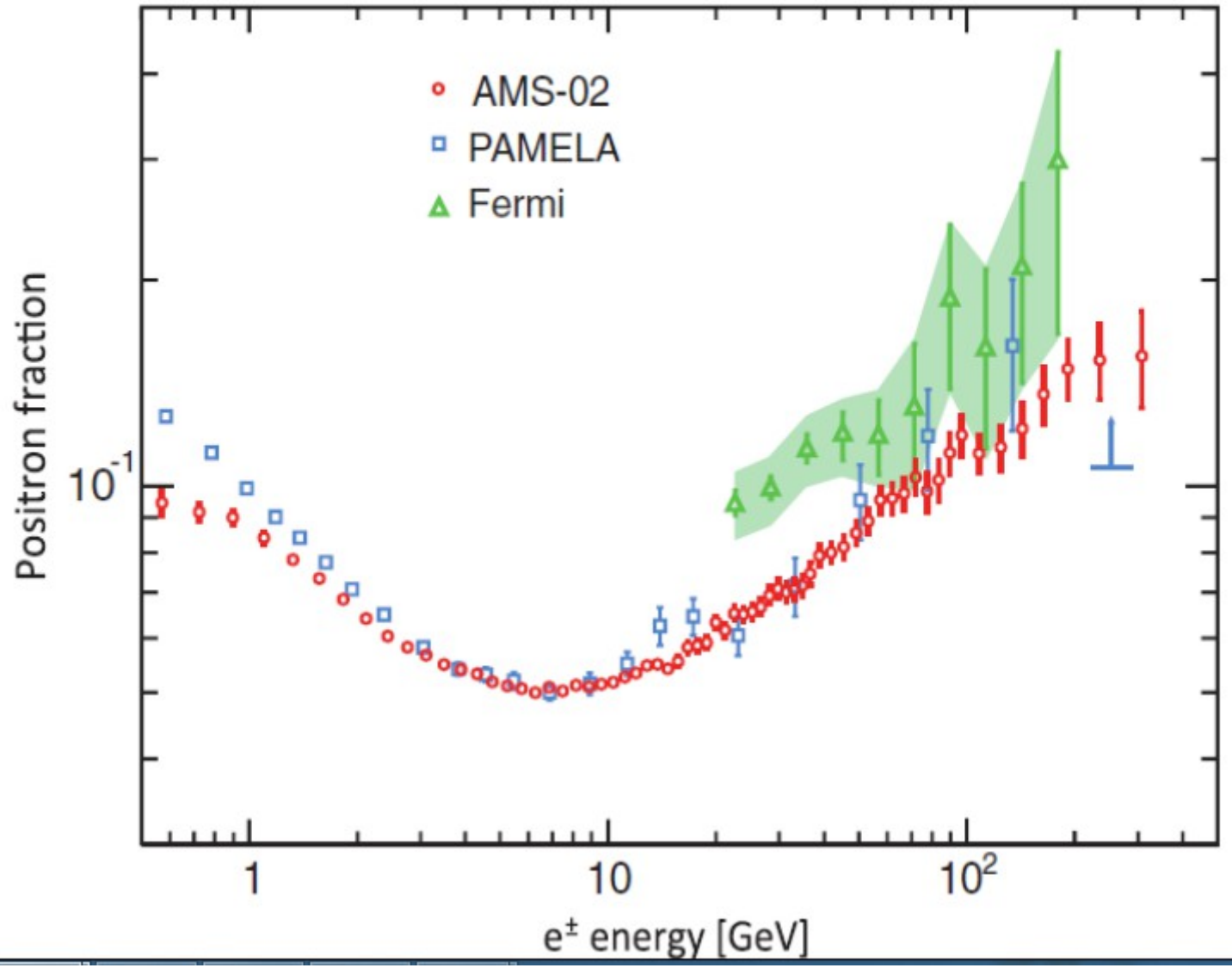
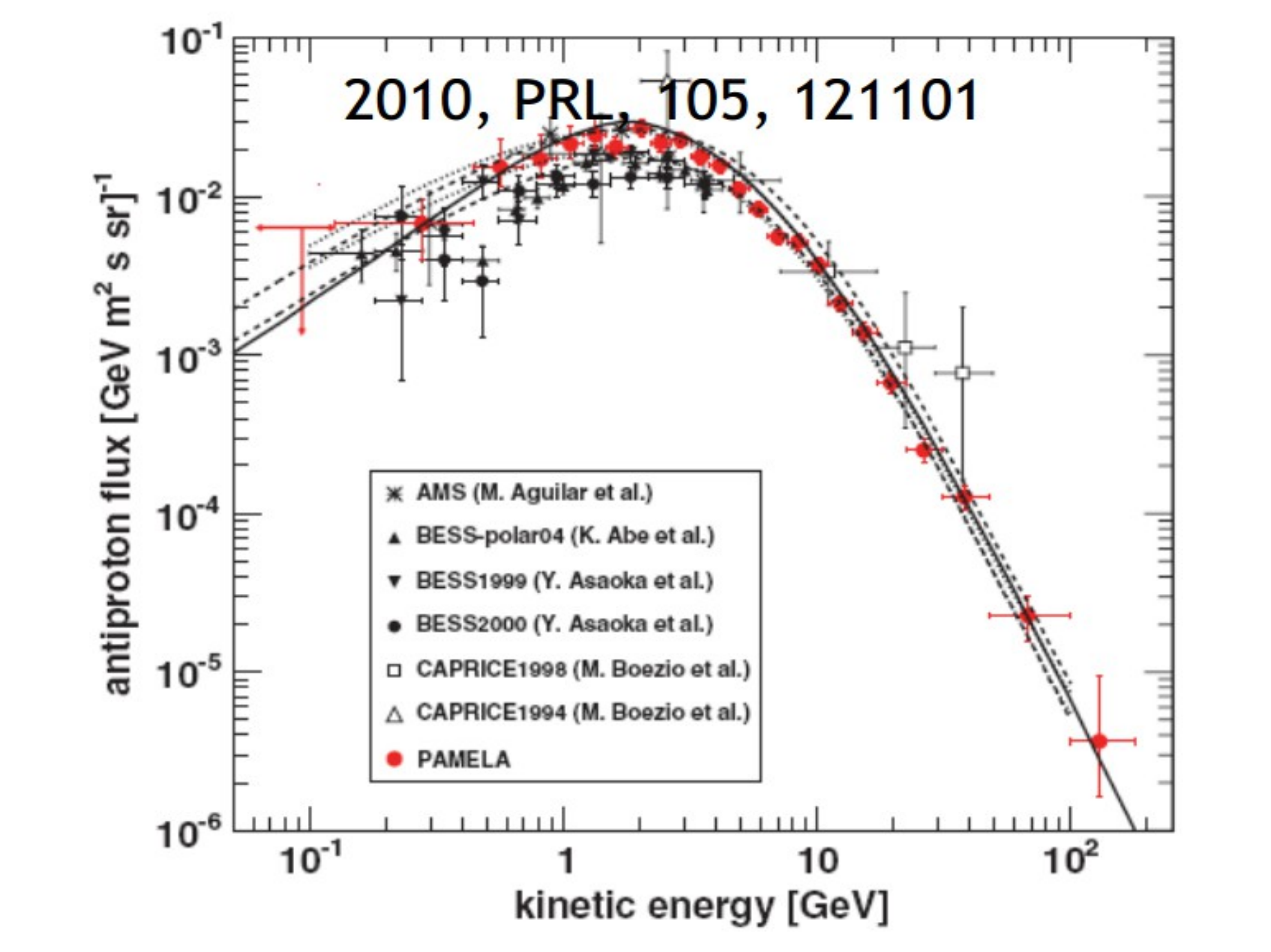
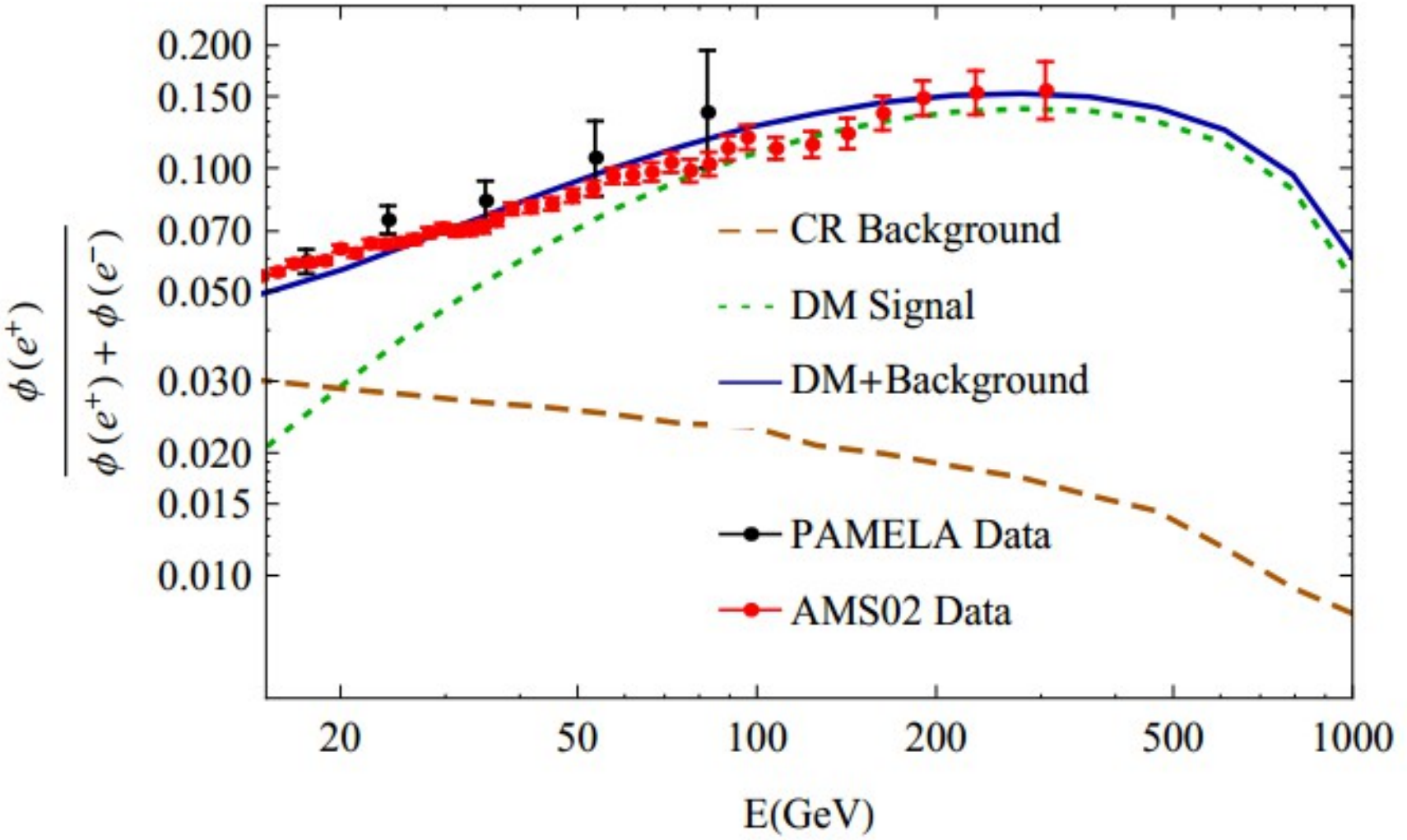


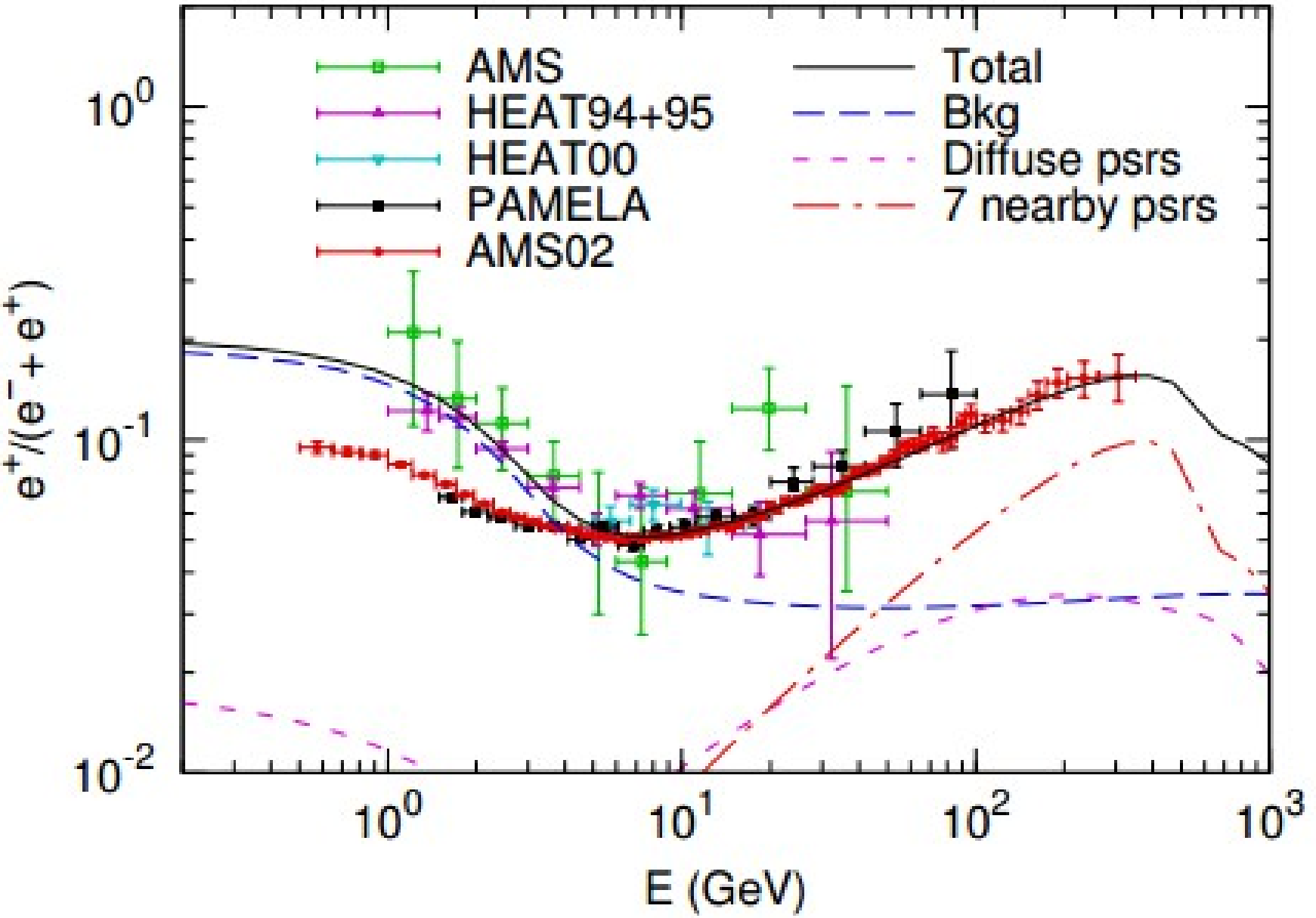
AMS02: Phys. Rev. Lett., 2013, 110, 141102



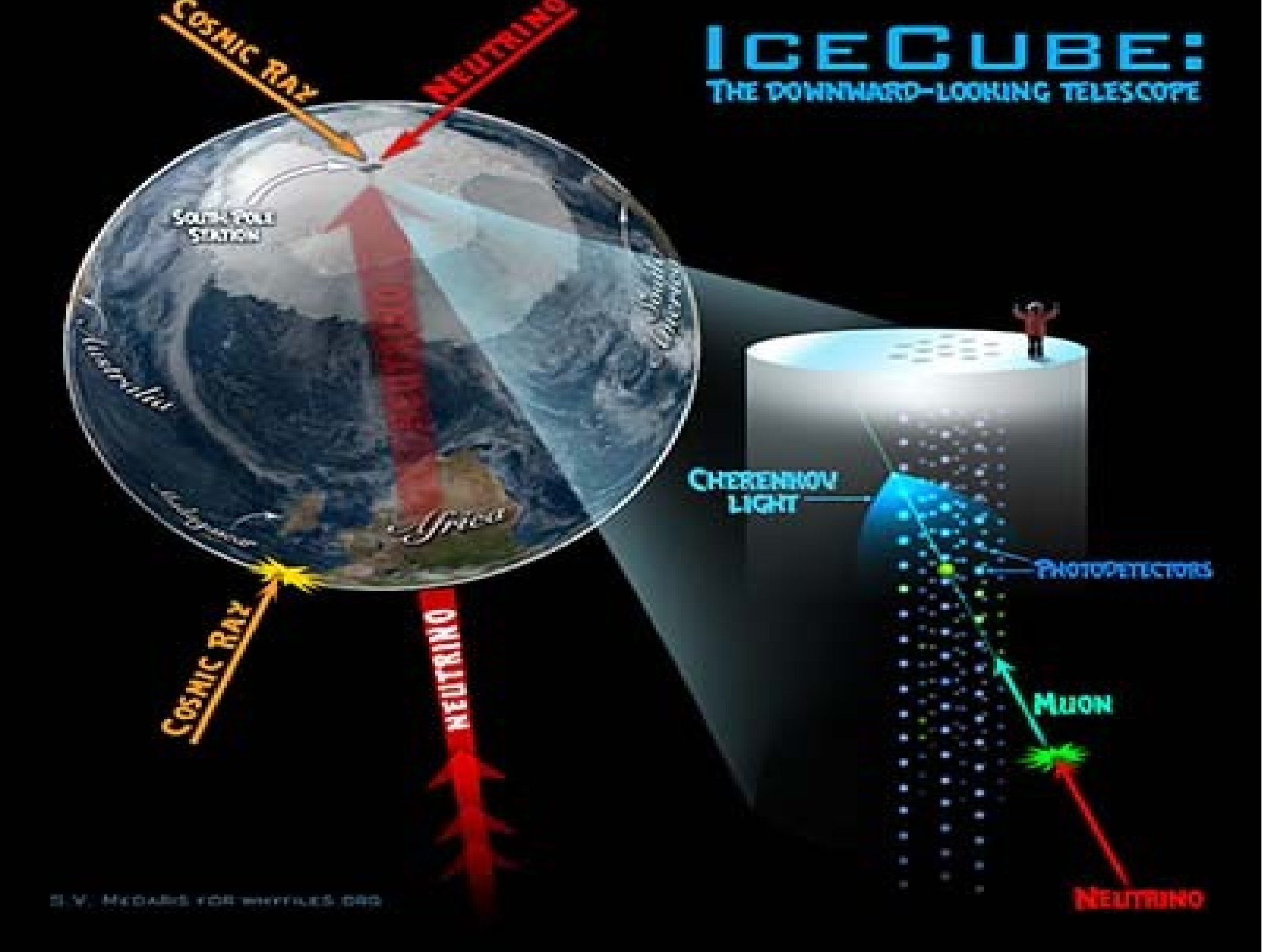

2010, PRL, 105, 121101
antiproton flux [GeV m^2 s sr]$^{-1}$
kinetic energy [GeV]
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
1
10
10^2
AMS (M. Aguilar et al.)
BESS-polar04 (K. Abe et al.)
BESS1999 (Y. Asaoka et al.)
BESS2000 (Y. Asaoka et al.)
CAPRICE1998 (M. Boezio et al.)
CAPRICE1994 (M. Boezio et al.)
PAMELA

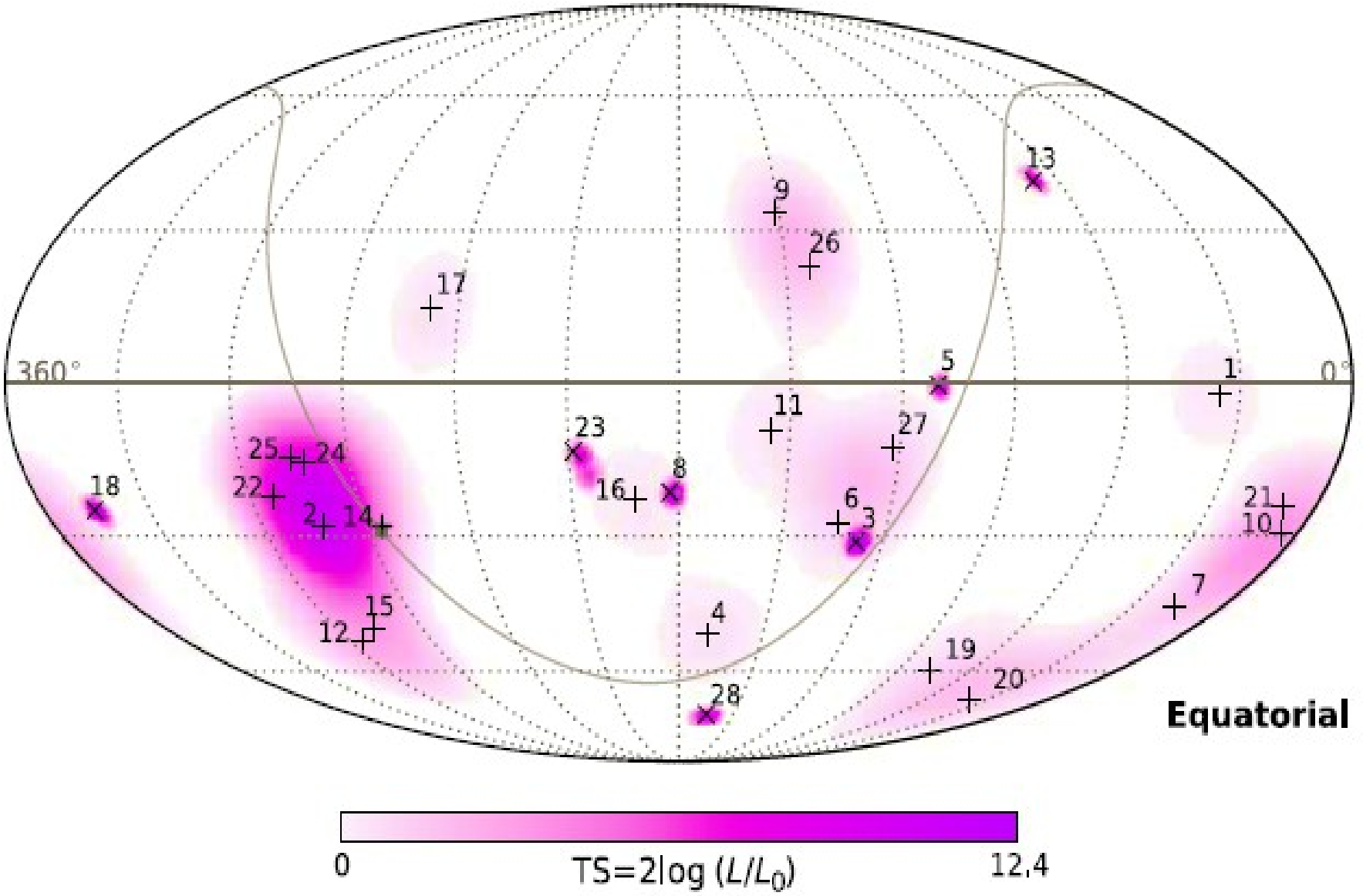


Leptophilic dark matter in gauged Lμ − Lτ extension of MSSM, Moumita Das, SM , Phys Rev D 2014



P.-F. Yin et al., Phys. Rev. D 88 (2013) 023001.

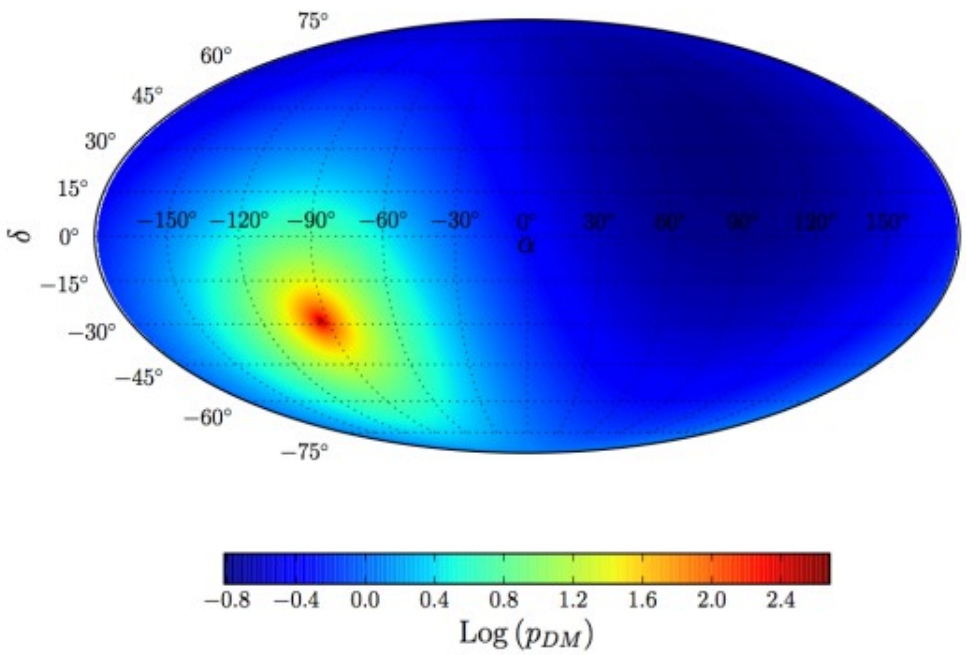

ICECUBE:
THE DOWNWARD-LOOKING TELESCOPE
COSMIC RAY
NEUTRINO
SOUTH POLE STATION
CHERENKOV LIGHT
PHOTODETECTORS
MUON
NEUTRINO
COSMIC RAY
NEUTRINO


360°
0°
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
Equatorial
0
TS=2log (L/L0)
12,4

IceCube Events

SCIENCE VOL 342 22 NOVEMBER 2013

ID	Deposited energy (TeV)
1	$47.6^{+6.5}_{-5.4}$
2	117^{+15}_{-15}
3	$78.7^{+10.8}_{-8.7}$
4	165^{+20}_{-15}
5	$71.4^{+9.0}_{-9.0}$
6	$28.4^{+2.7}_{-2.5}$
7	$34.3^{+3.5}_{-4.3}$
8	$32.6^{+10.3}_{-11.1}$
9	$63.2^{+7.1}_{-8.0}$
10	$97.2^{+10.4}_{-12.4}$
11	$88.4^{+12.5}_{-10.7}$
12	104^{+13}_{-13}
13	253^{+26}_{-22}
14	1041^{+132}_{-144}
15	$57.5^{+8.3}_{-7.8}$
16	$30.6^{+3.6}_{-3.5}$
17	200^{+27}_{-27}
18	$31.5^{+4.6}_{-3.3}$
19	$71.5^{+7.0}_{-7.2}$
20	1141^{+143}_{-133}
21	$30.2^{+3.5}_{-3.3}$
22	220^{+21}_{-24}
23	$82.2^{+8.6}_{-8.4}$
24	$30.5^{+3.2}_{-2.6}$
25	$33.5^{+4.9}_{-5.0}$
26	210^{+29}_{-26}
27	$60.2^{+5.6}_{-5.6}$
28	$46.1^{+5.7}_{-4.4}$



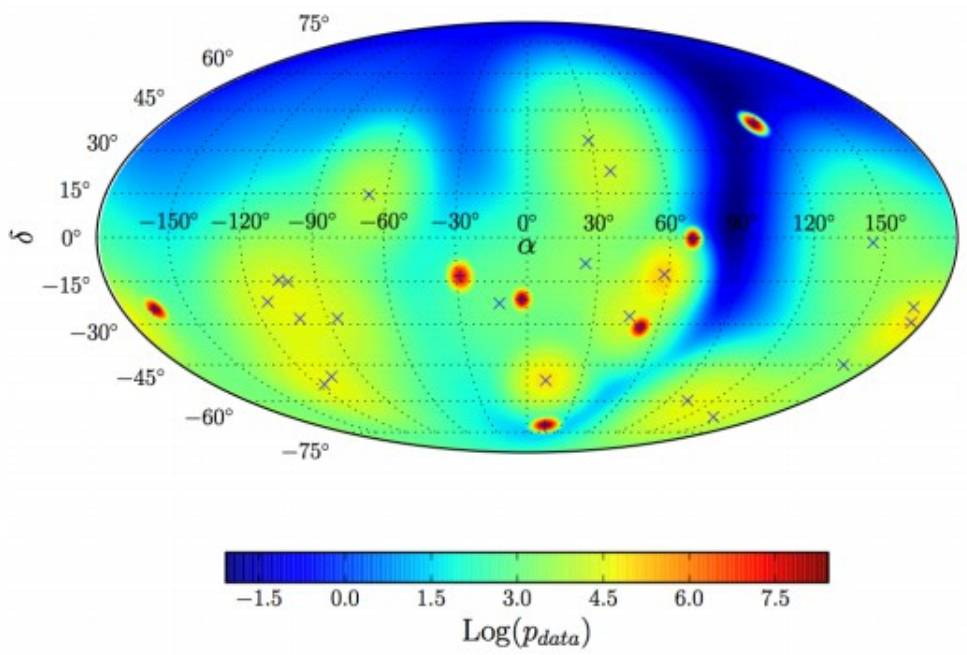


FIG. 1: Left panel: the sky map of the neutrinos from decaying DM with an Einasto profile in Eq. (1). Right panel: the sky map of the IceCube 28 events after taking into account the angular resolution. The seven red spots correspond to the seven "track" events.

Yang Bai,Ran Lu Jordi Salvado

arXiv:1311.5864v1

THANK YOU