Direct WIMP Detection with Noble Liquids

Katsushi Arisaka

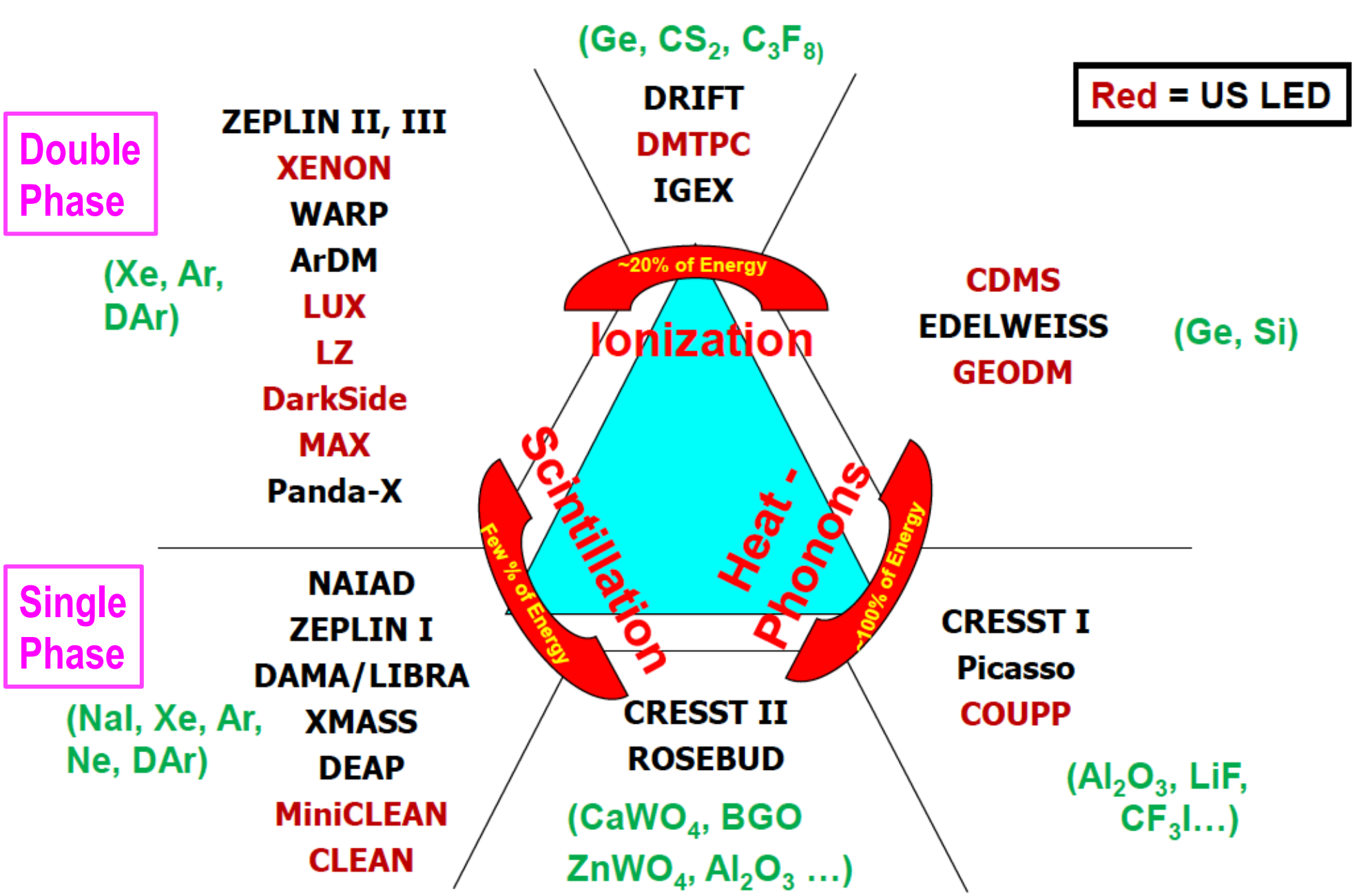
University of California, Los Angeles
Department of Physics and Astronomy

arisaka@physics.ucla.edu

Talk Outline

- **Introduction**
  - Properties of Xenon & Argon
- **G1**
  - XENON100 - *new results*
  - DarkSide 50
- **G2**
  - XENON 1 Ton
- **G3**
  - LZD and MAX
  - Xenon 10 Ton + Argon 50 Ton

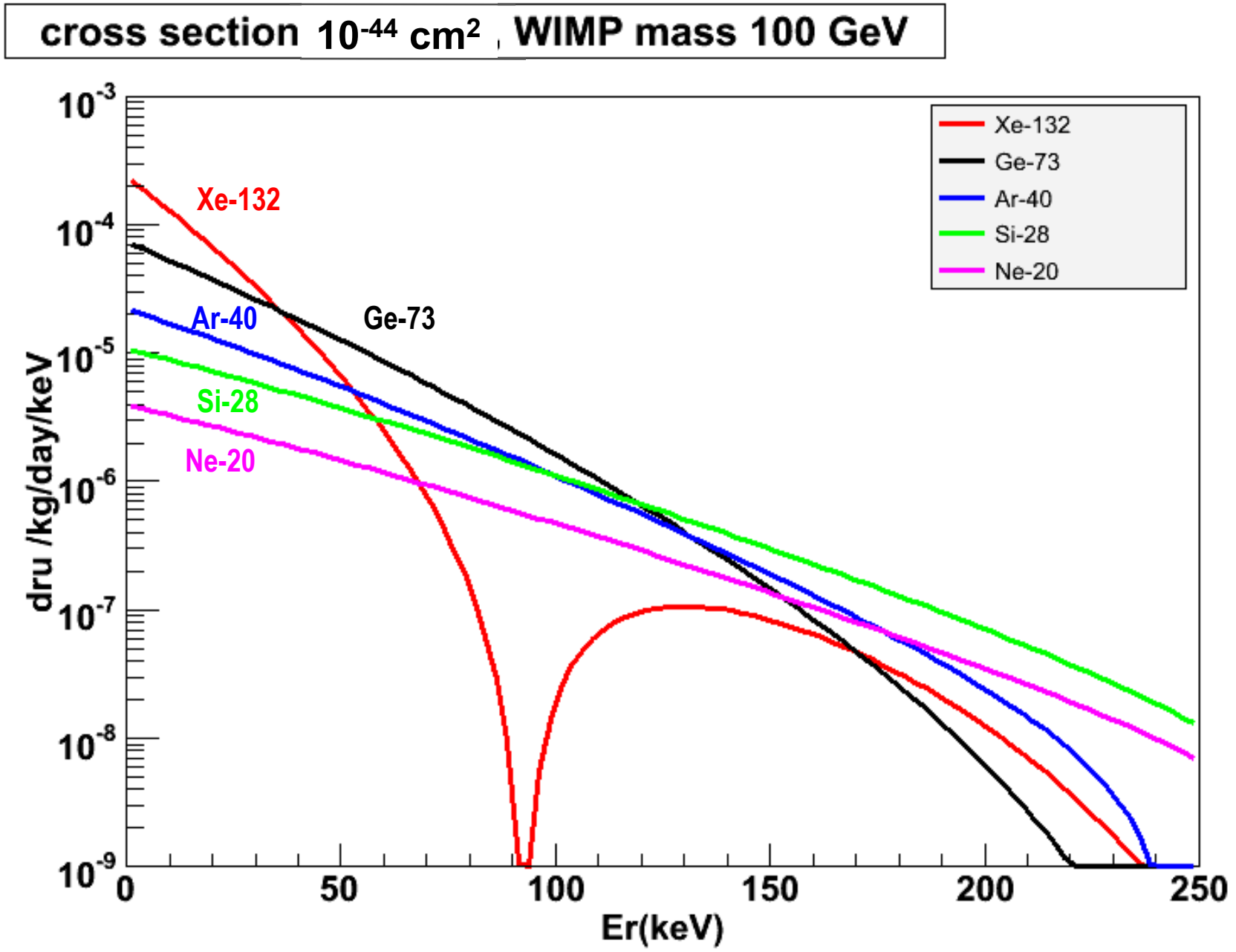
Detection Technique



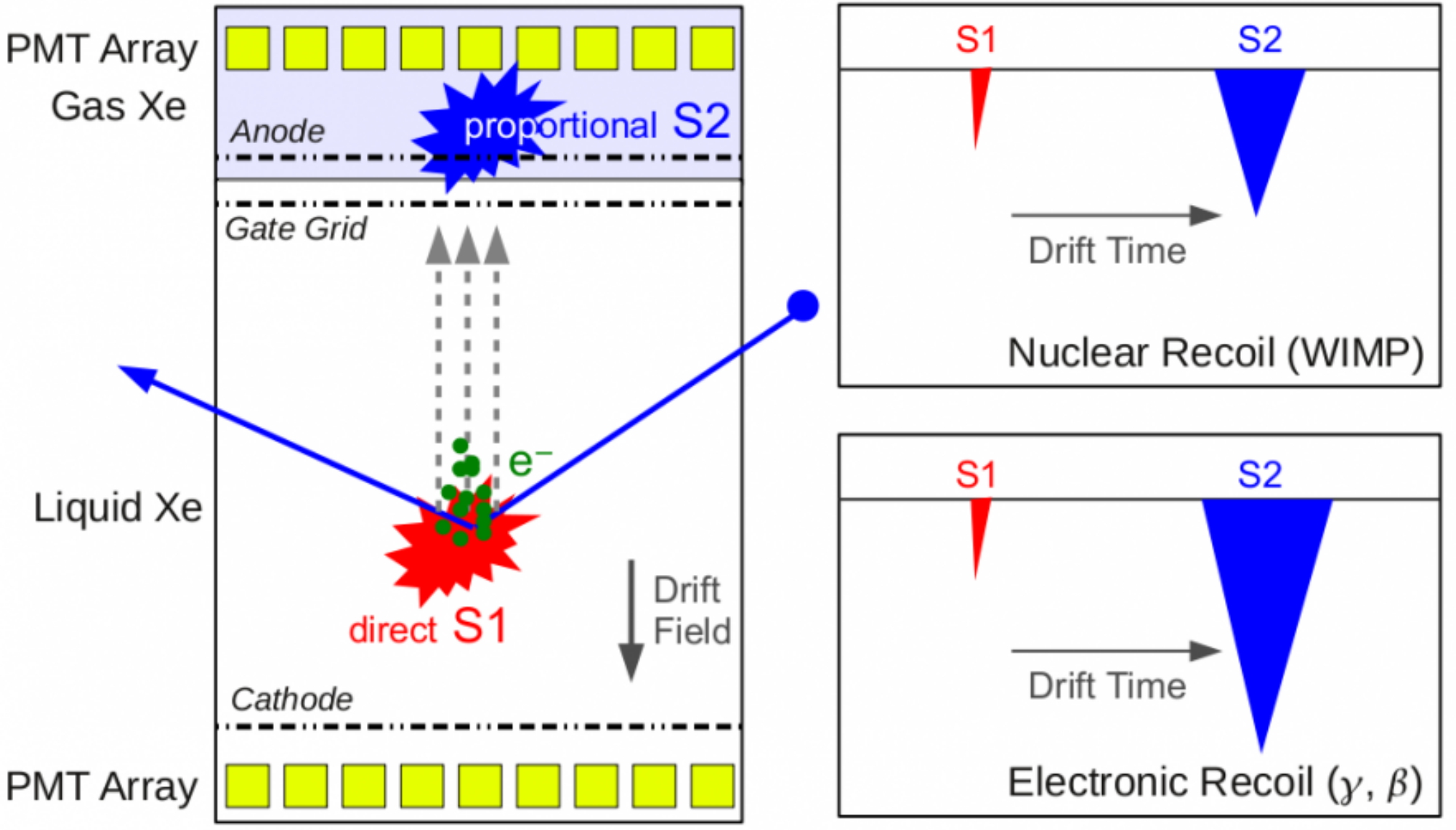
Properties of Noble Liqud

	Unit	Neon	Argon	Xenon
Z		10	18	54
A		20	40	~132
Liquid Density	g/cc	1.21	1.4	3.06
Energy Loss (dE/dX)	MeV/cm	1.4	2.1	3.8
Radiation Length	cm	24	14	2.8
Collision Length	cm	80	80	34
Boiling Temperature	°K	27.1	87.3	165
Scintillation Wavelength	nm	85	125	178
Scintillation	photon/keV	30	40	46
Ionization	e-/keV	46	42	64
Decay time (Fast Component)	nsec	19	7	4
Decay time (Slow Component)	nsec	1500	1600	26
Isotope		No	^{39}Ar (1 Bq/kg)	^{136}Xe
Price	$ /ton	$90k	~$2k	~$1M
Single Phase Experiments		CLEAN	DEAP, CLEAN	XMASS
Double Phase Experiments			WARP, ArDM, DarkSide, MAX	ZEPLIN, XENON, MAX LUX, LZD

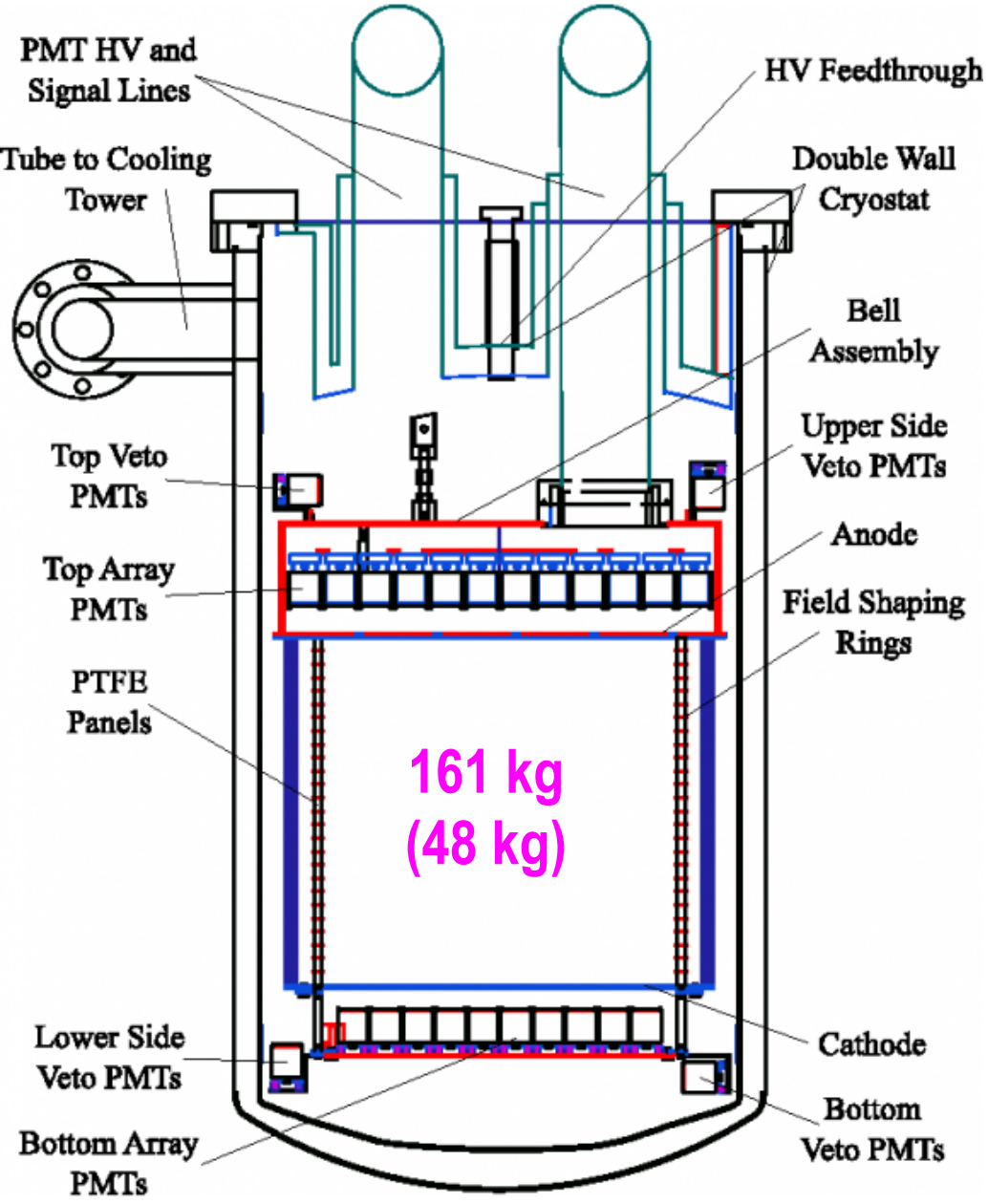
Target Mass Dependence of WIMP Cross Section



Double-Phase Noble Liquids



XENON100 Detector



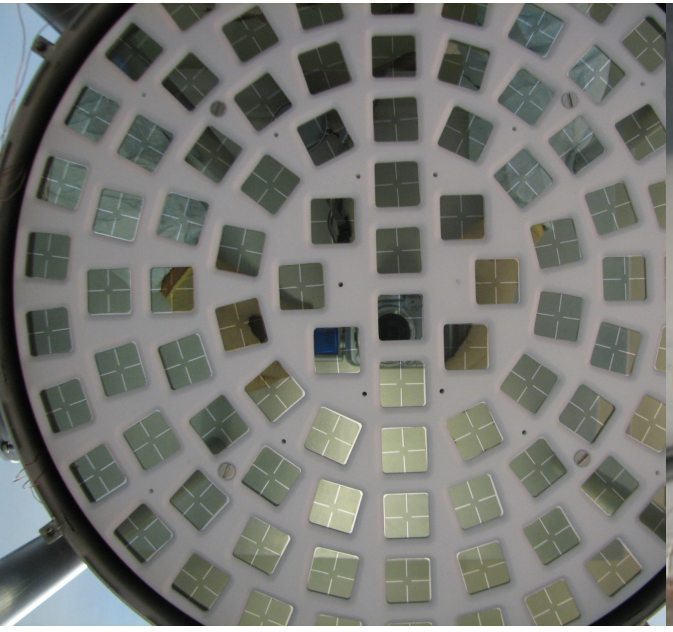
PMT Arrays

242 Hamamatsu R8520 PMTs

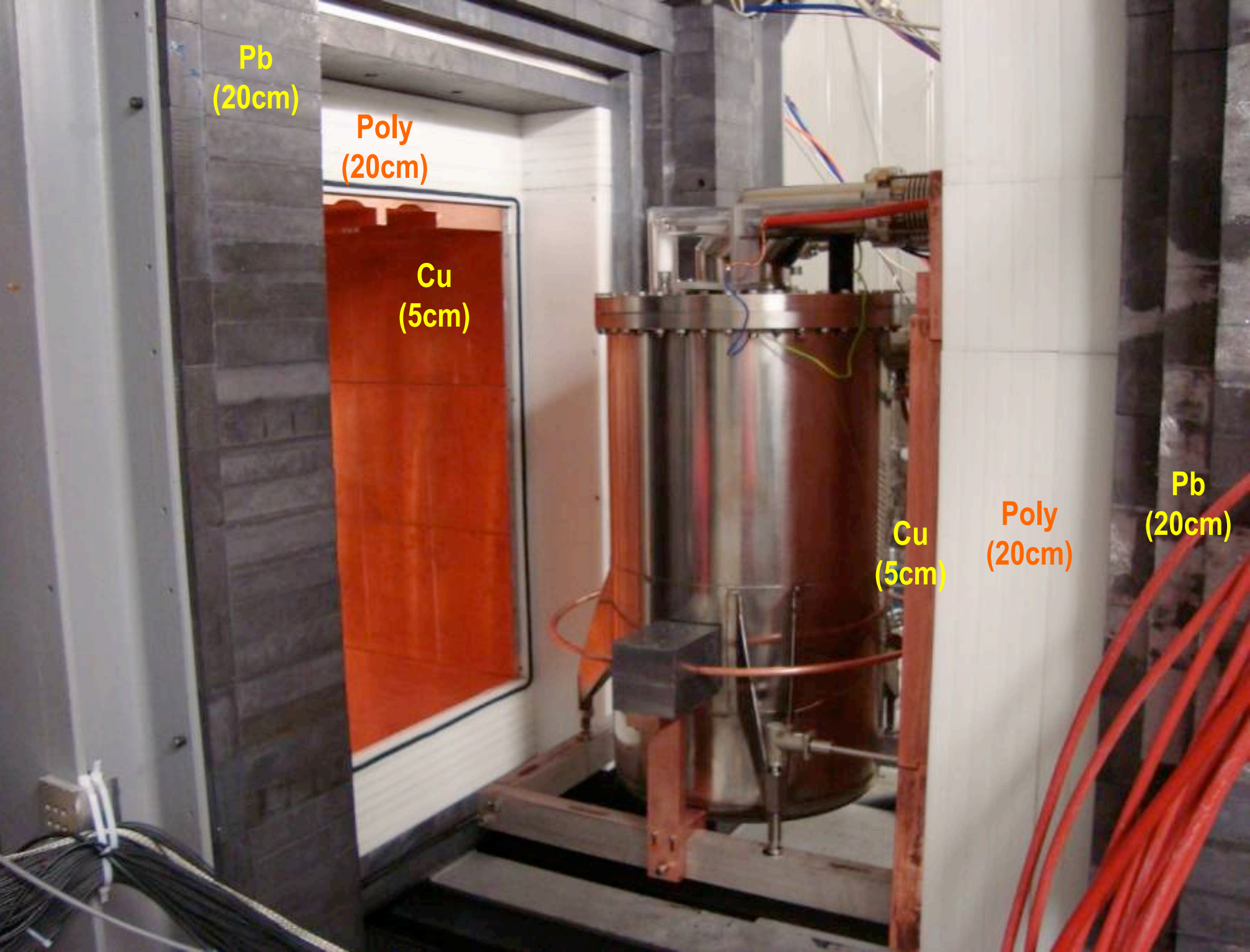
1"x1", optimized for response @ Xe scintillation light (178 nm)

Low radioactivity (~ <1 mBq/PMT)

Top Array	Bottom Array	Active Veto
98 PMTs	80 PMTs	64 PMTs
~23% QE	~33% QE	~23% QE

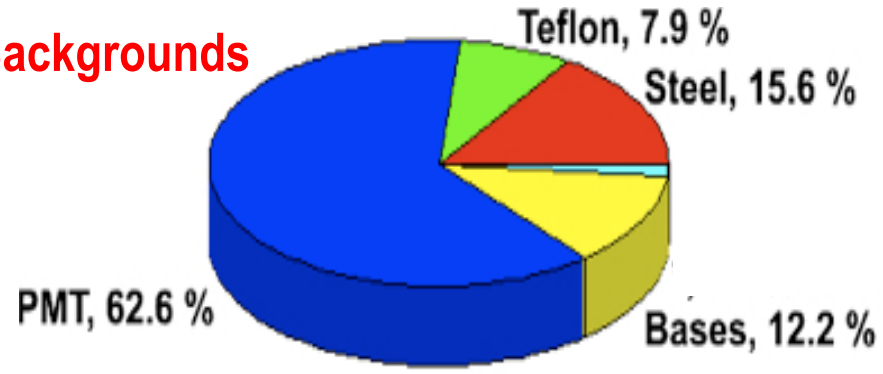


XENON100 Detector

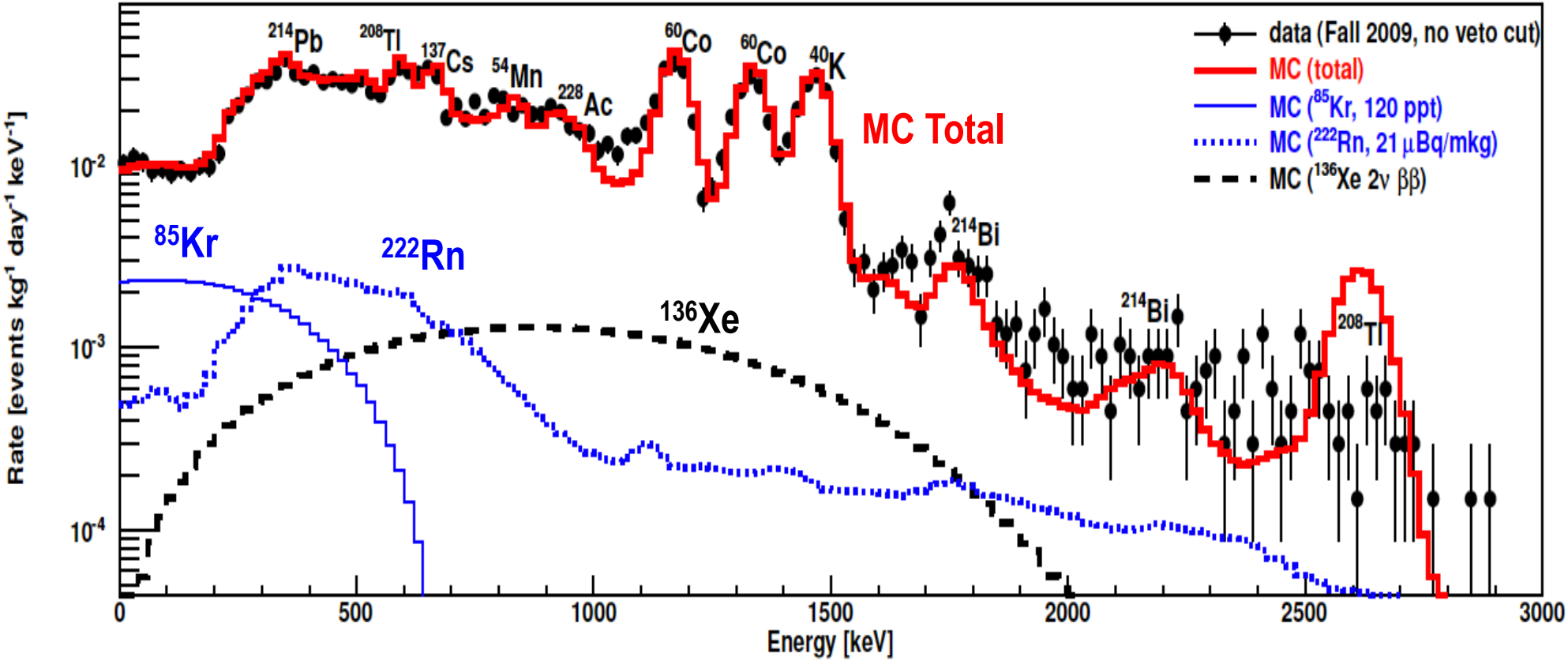

Pb
(20cm)
Poly
(20cm)
Cu
(5cm)
Cu
(5cm)
Poly
(20cm)
Pb
(20cm)

Energy Spectrum of Real Data vs. MC

Surface Backgrounds



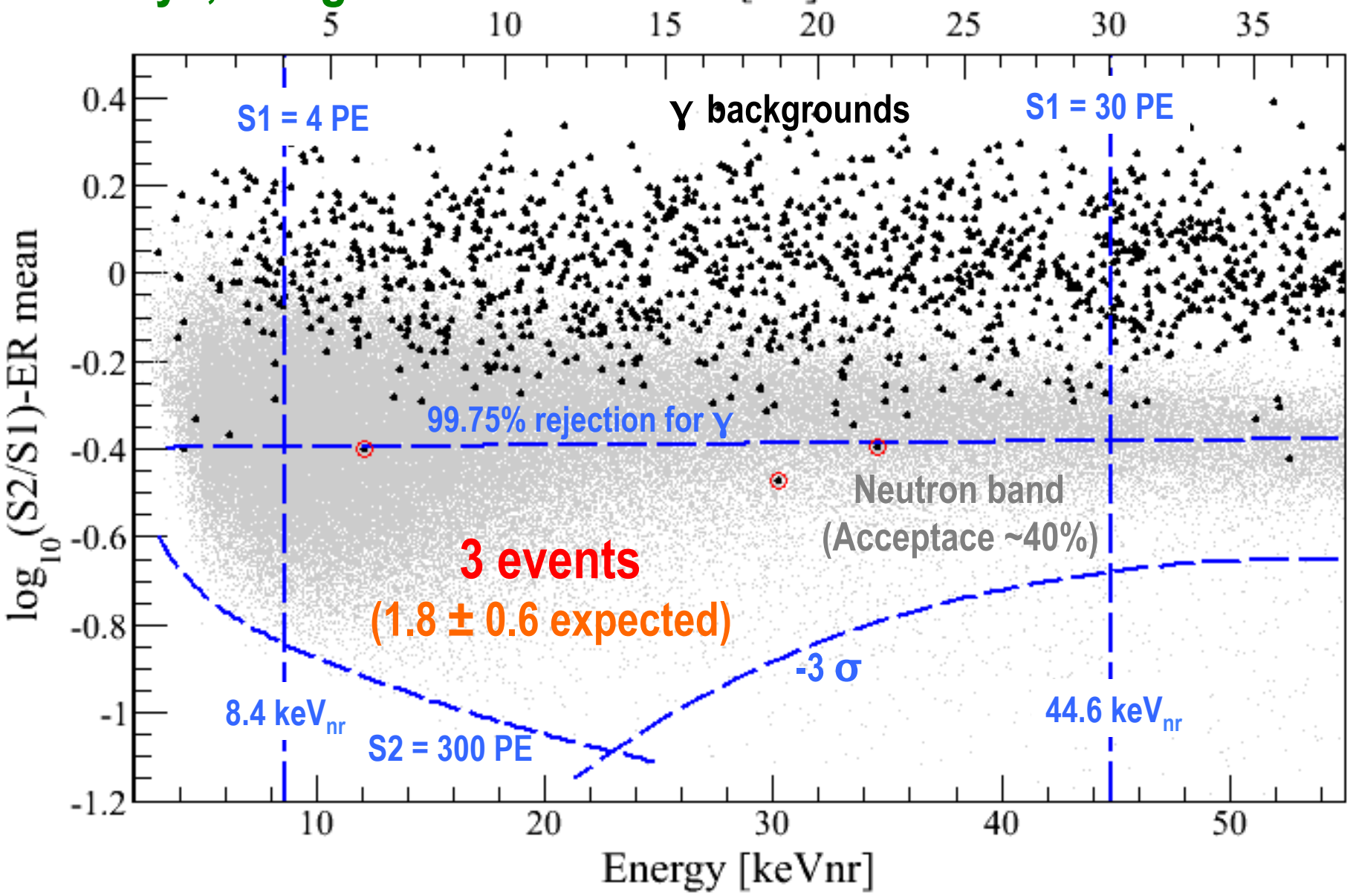
arXiv:1101.3866



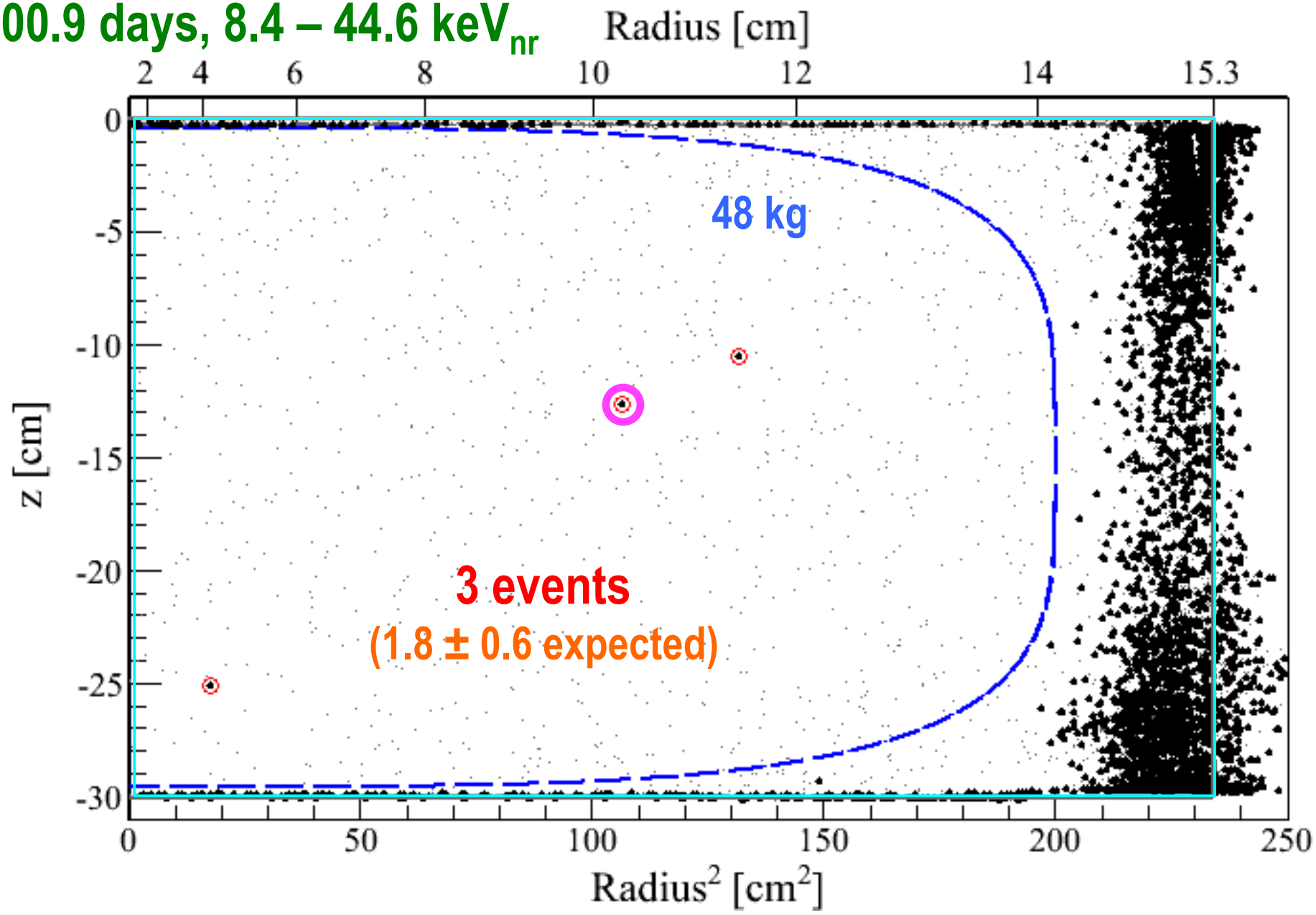
Log(S2/S1) vs. Energy

100.9 days, 48 kg

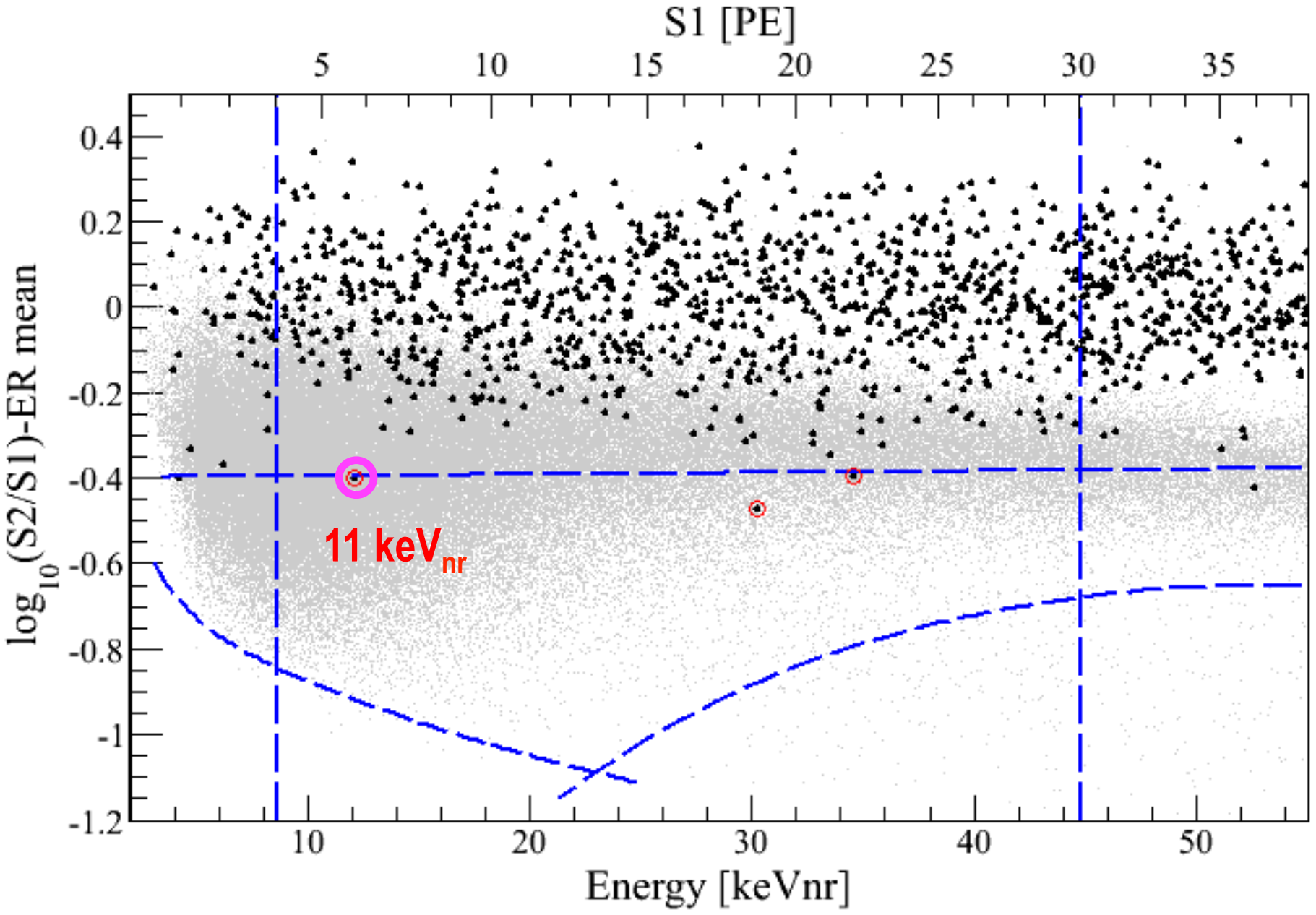
arXiv:1104.2549



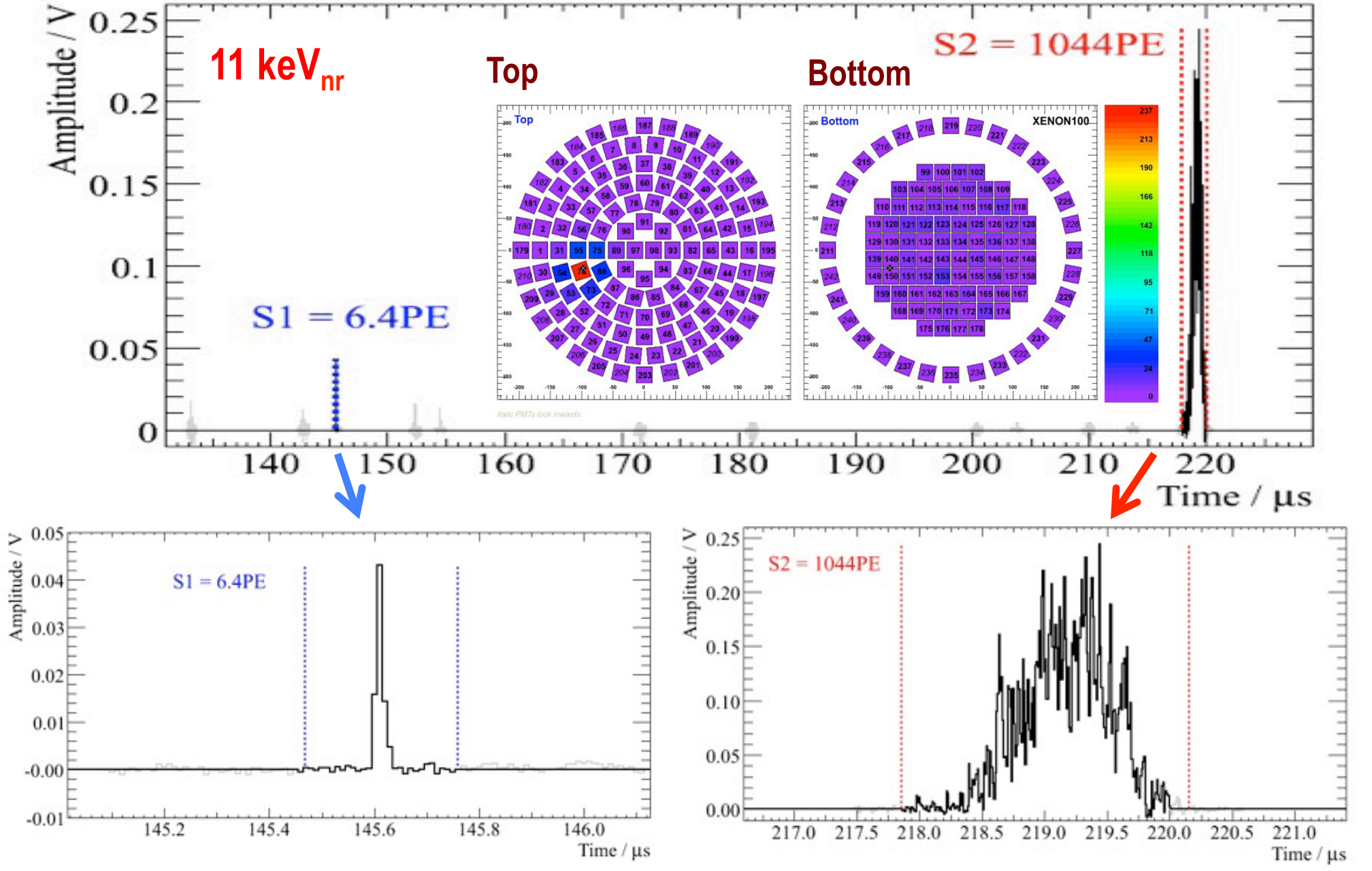
Event distribution in z vs. R^2



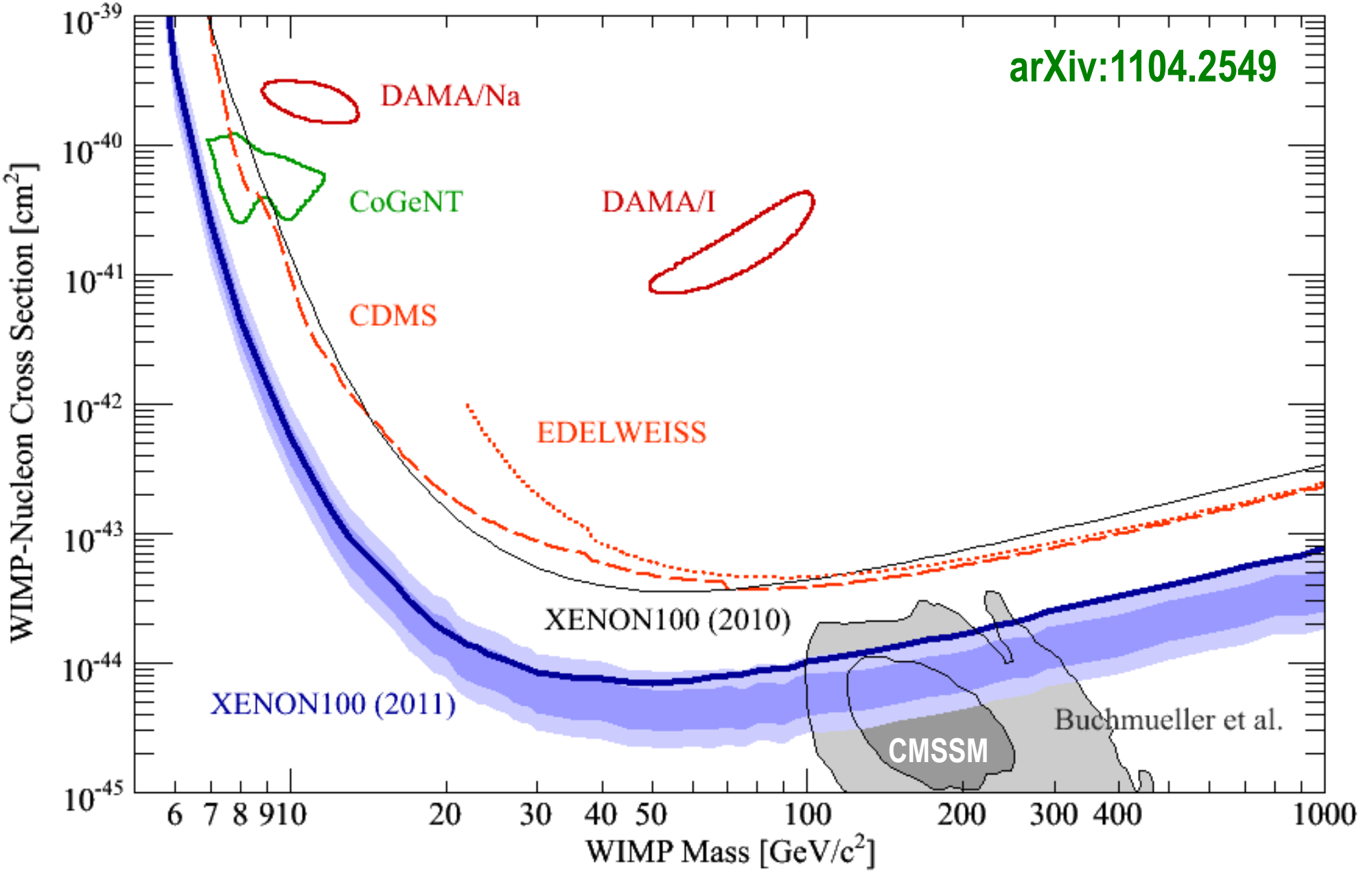
Log(S2/S1) vs. Energy



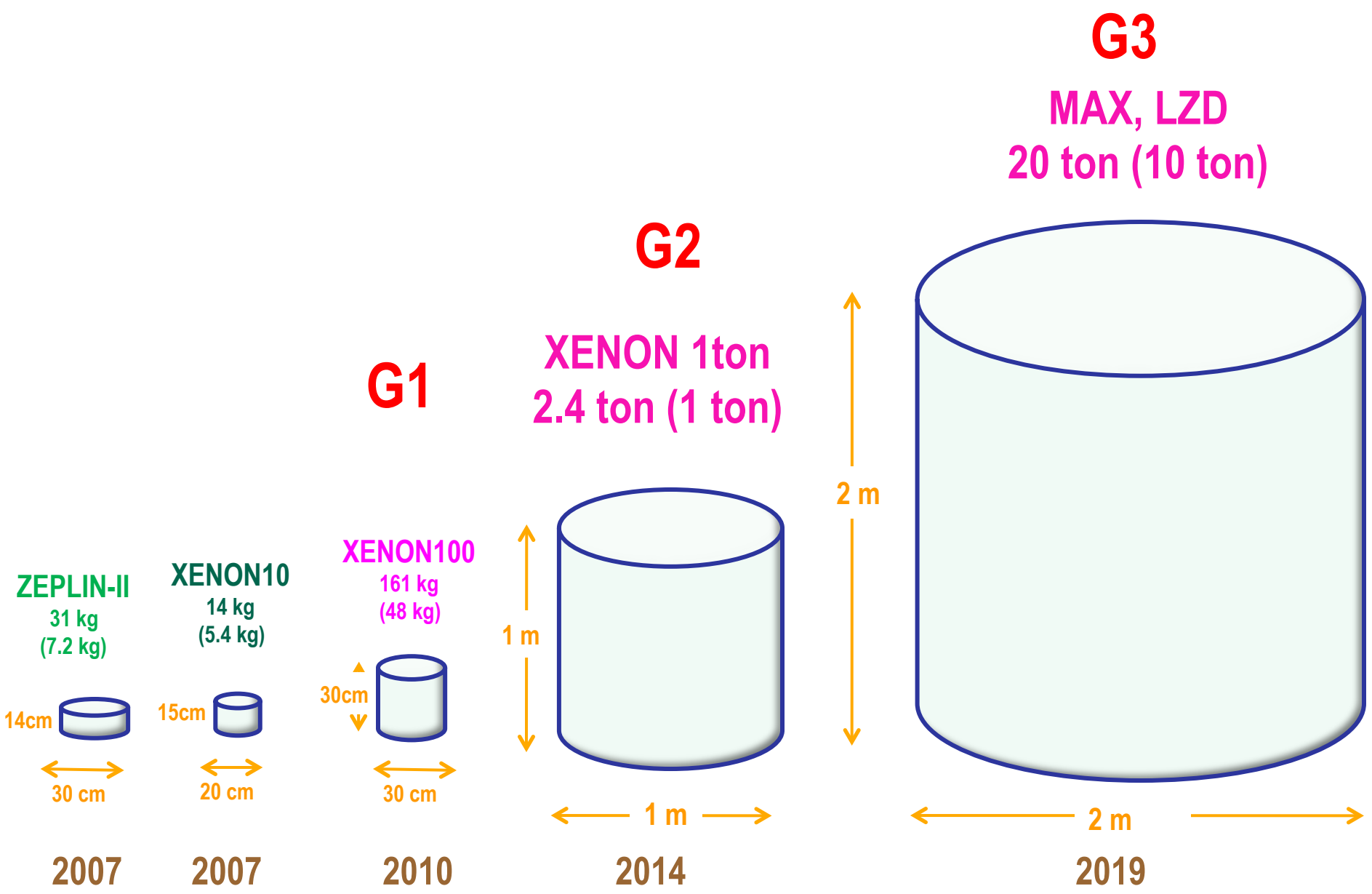
Single Scatter Nuclear Recoil Event Candidate



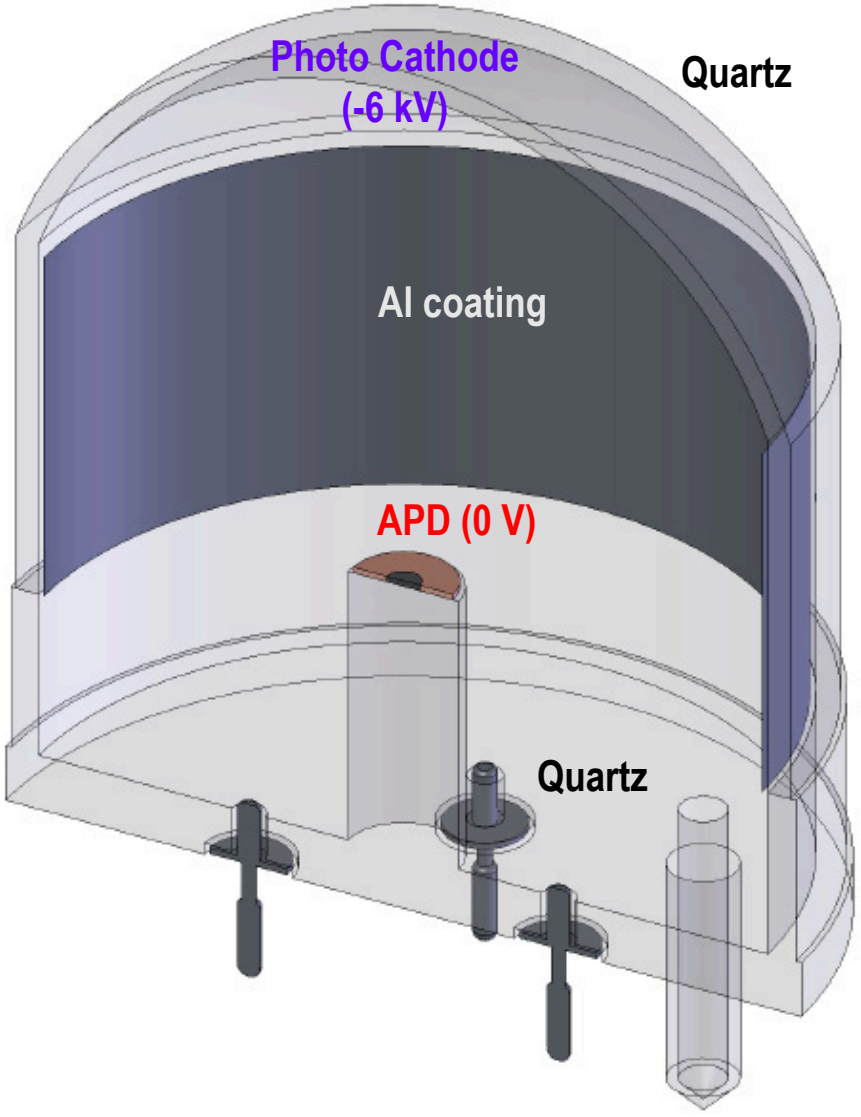
90% CL Limits of SI Cross Section

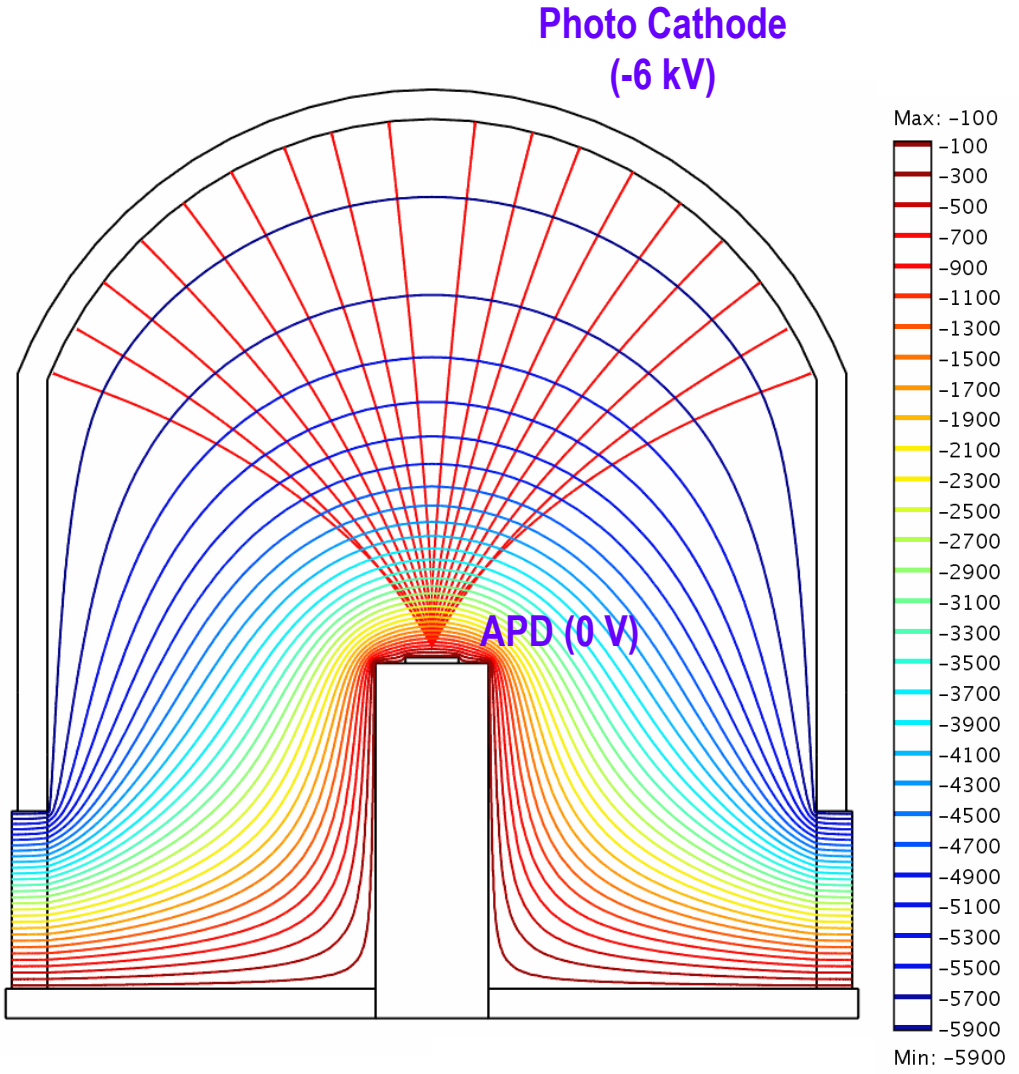


Comparison of Xenon Detector Size



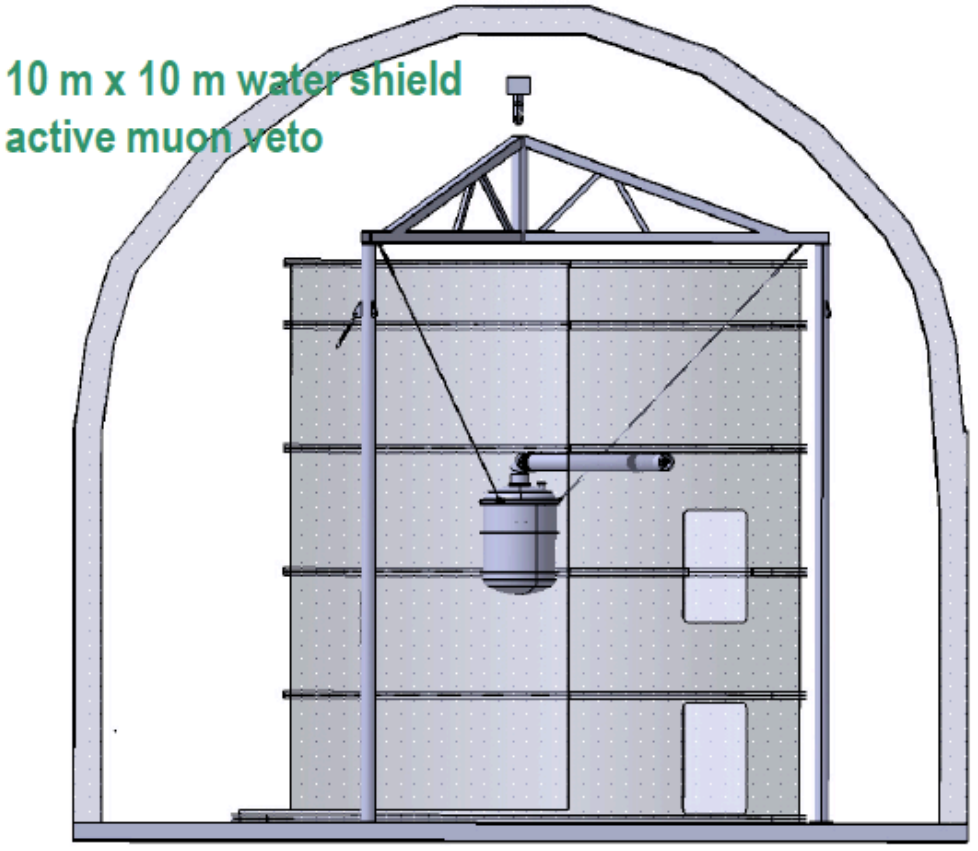
QUPID (QUartz Photon Intensifying Detector)

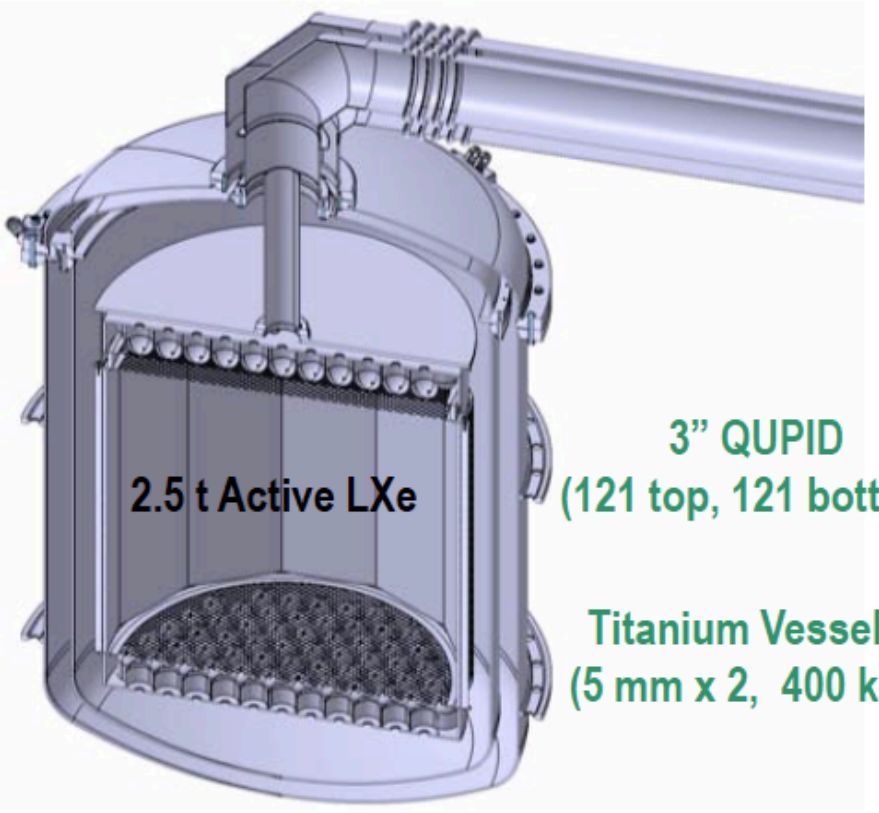


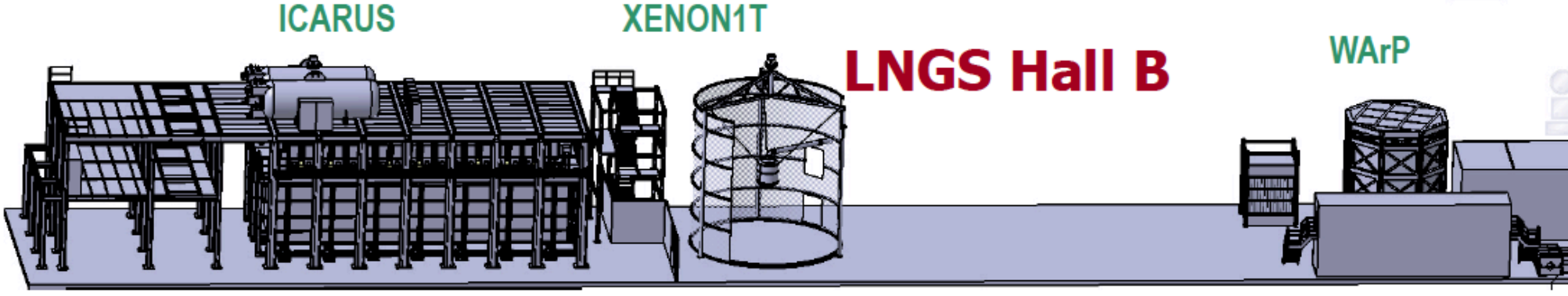


Artin Teymourian's talk

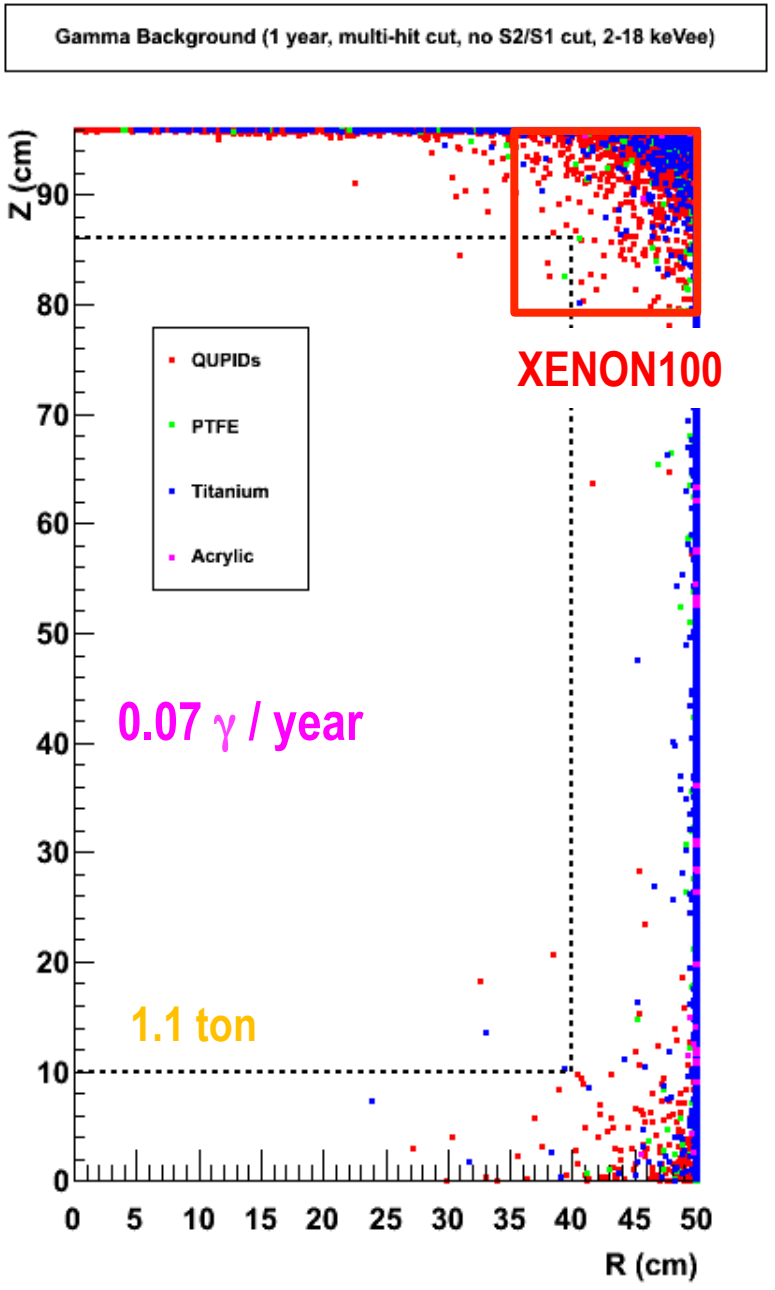
XENON1T

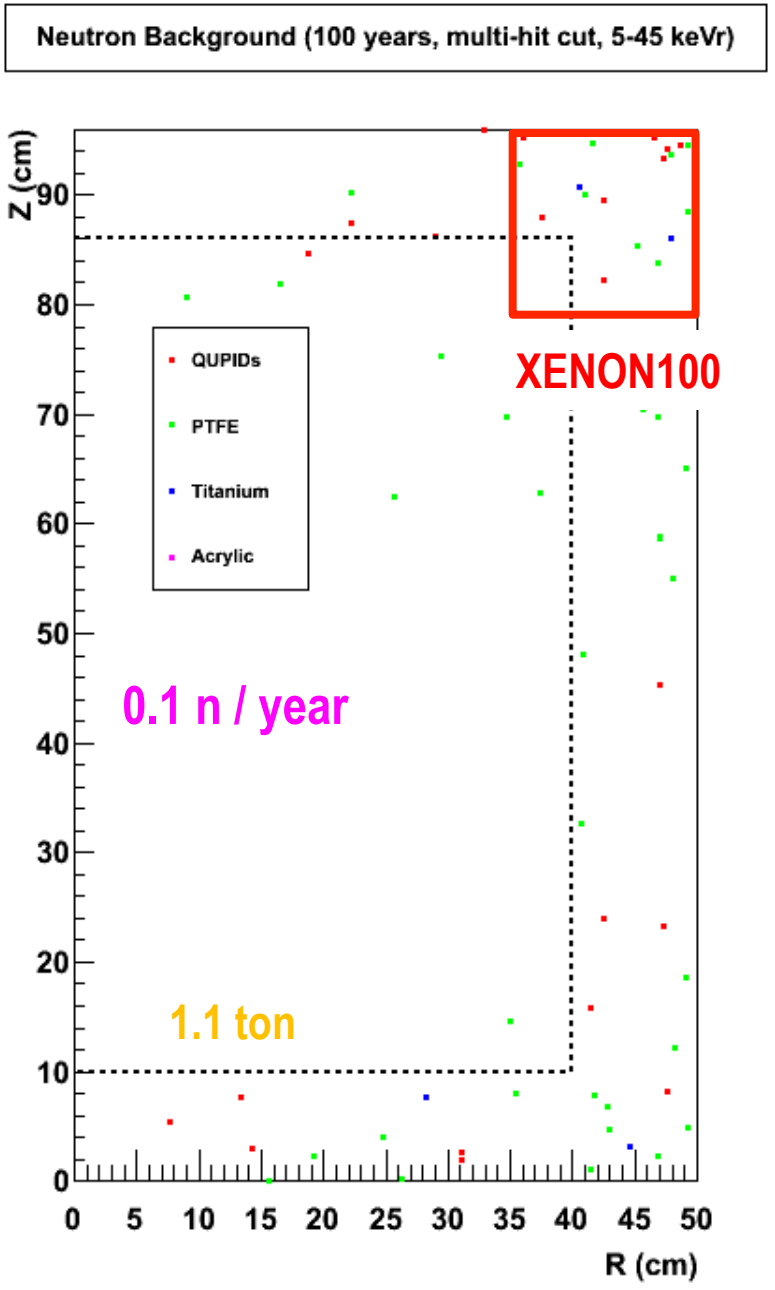

10 m x 10 m water shield
active muon veto


2.5 t Active LXe
3" QUPID
(121 top, 121 bottom)
Titanium Vessels
(5 mm x 2, 400 kg)

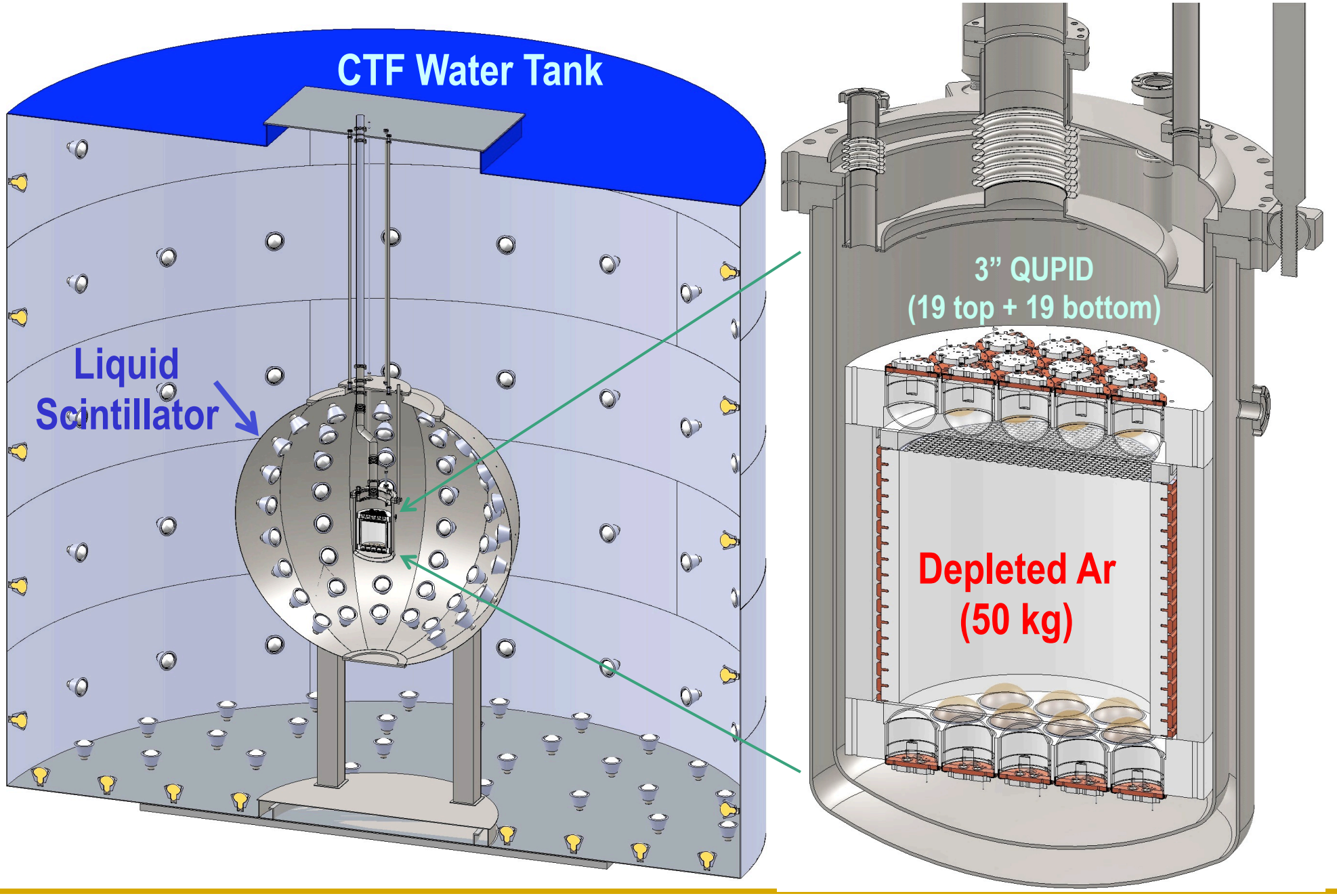

ICARUS
XENON1T
LNGS Hall B
WArP

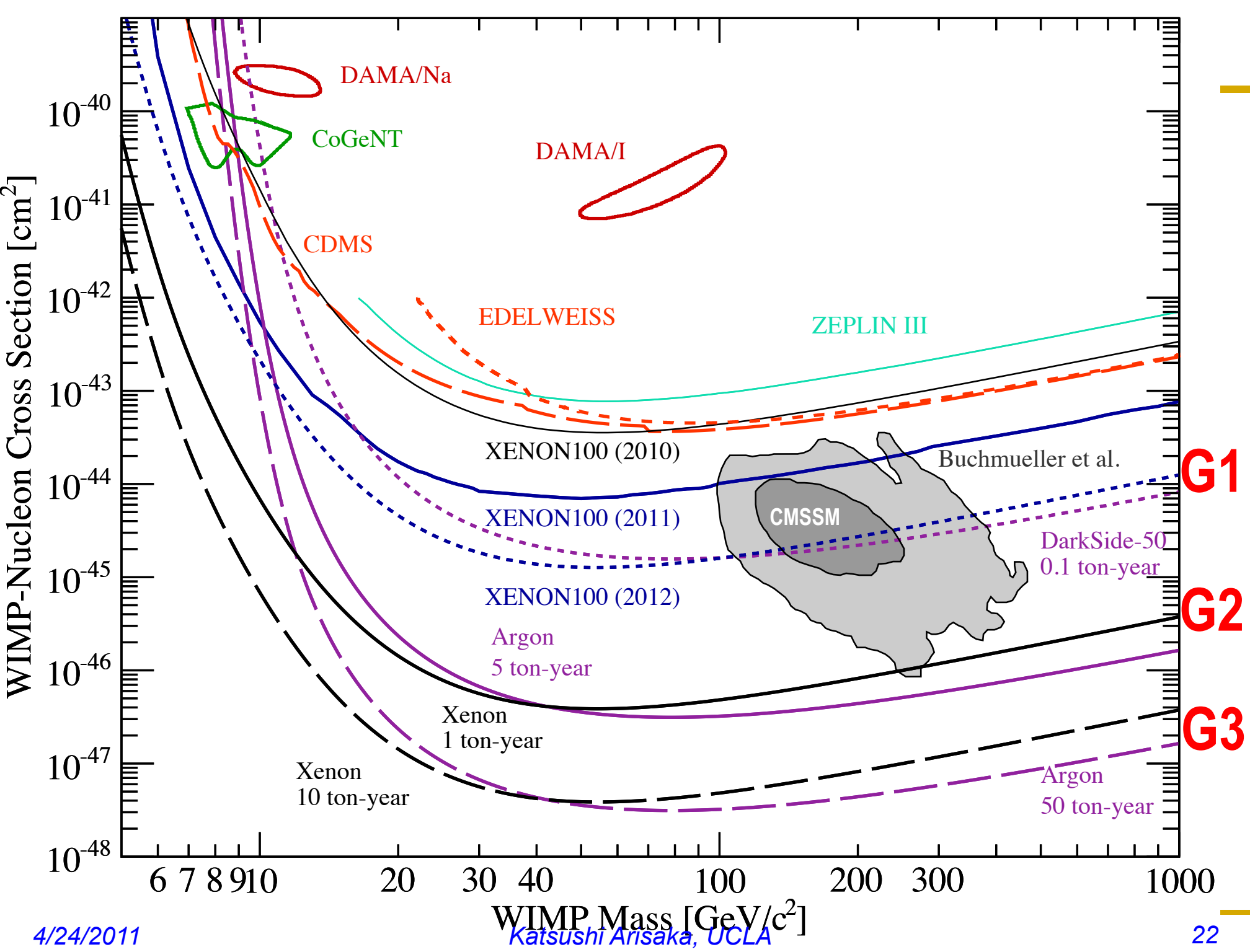
Expected Backgrounds in XENON 1Ton (100 Year, Multi-hit Cut)



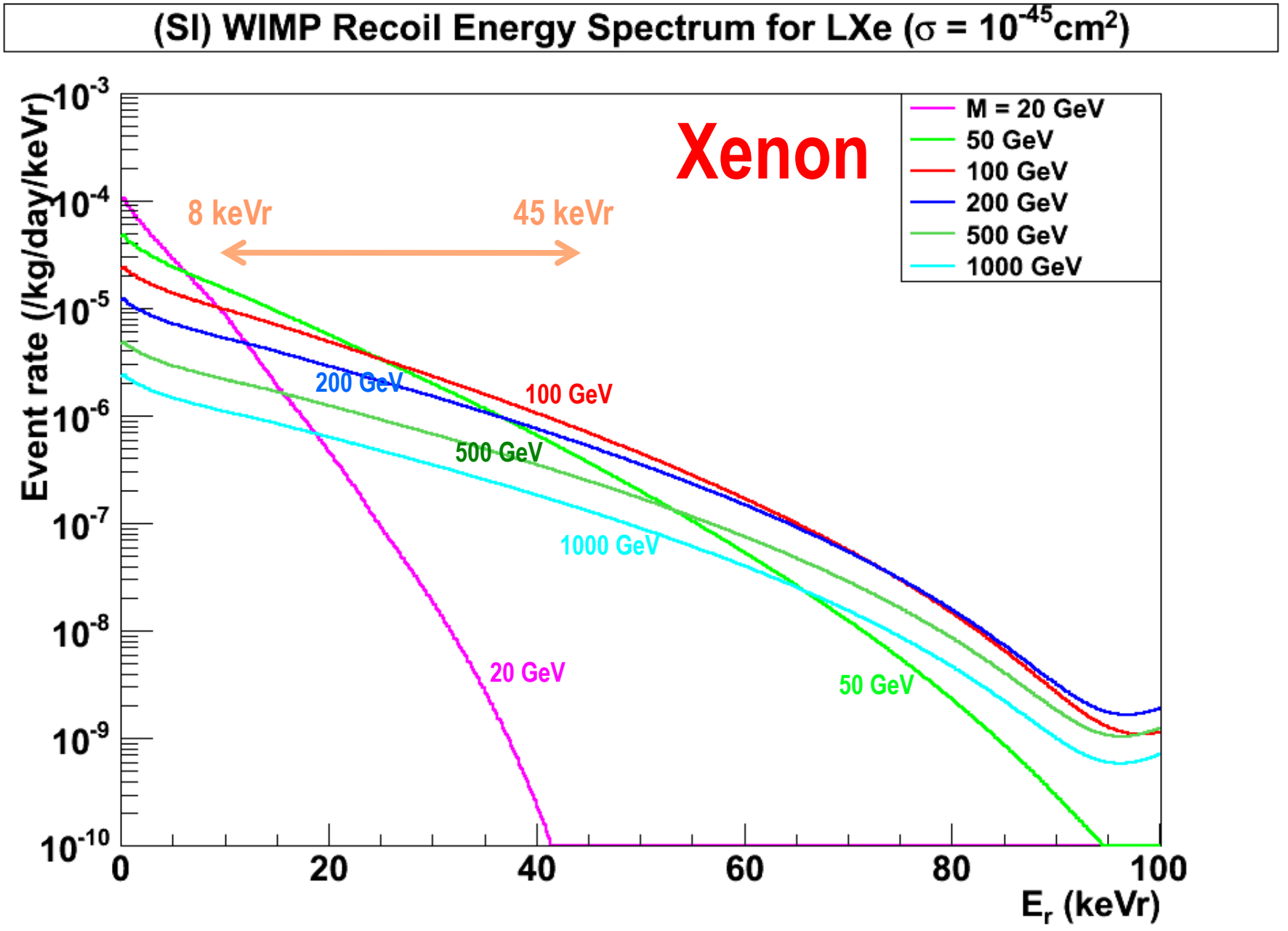


DarkSide 50 kg → 5 Ton

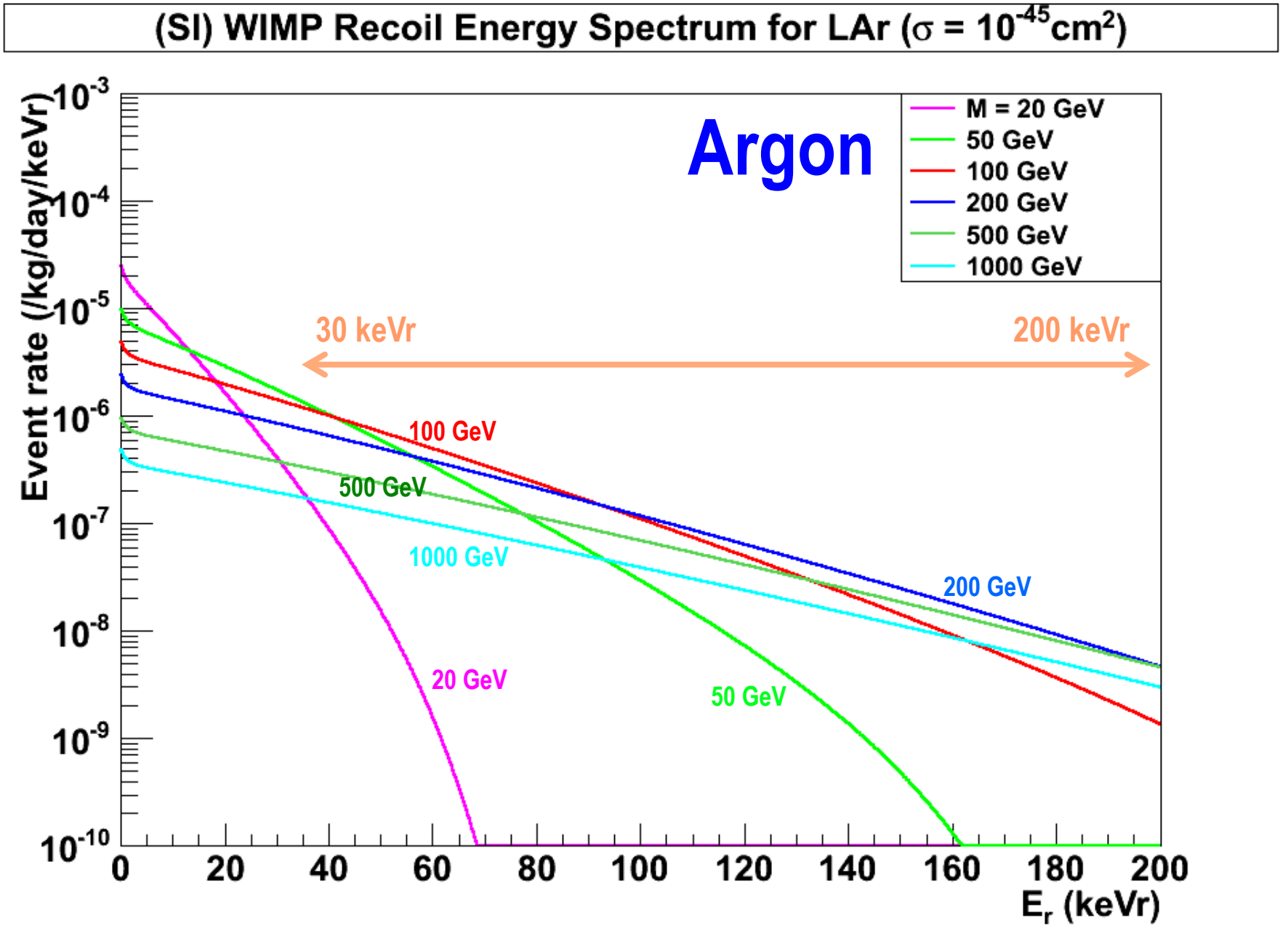



DAMA/Na
CoGeNT
DAMA/I
CDMS
EDELWEISS
ZEPLIN III
XENON100 (2010)
XENON100 (2011)
XENON100 (2012)
Buchmueller et al.
CMSSM
DarkSide-50
0.1 ton-year
Argon
5 ton-year
Xenon
1 ton-year
Xenon
10 ton-year
Argon
50 ton-year
G1
G2
G3
WIMP-Nucleon Cross Section [cm^2]
WIMP Mass [GeV/c^2]
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
6 7 8 9 10 20 30 40 100 200 300 1000

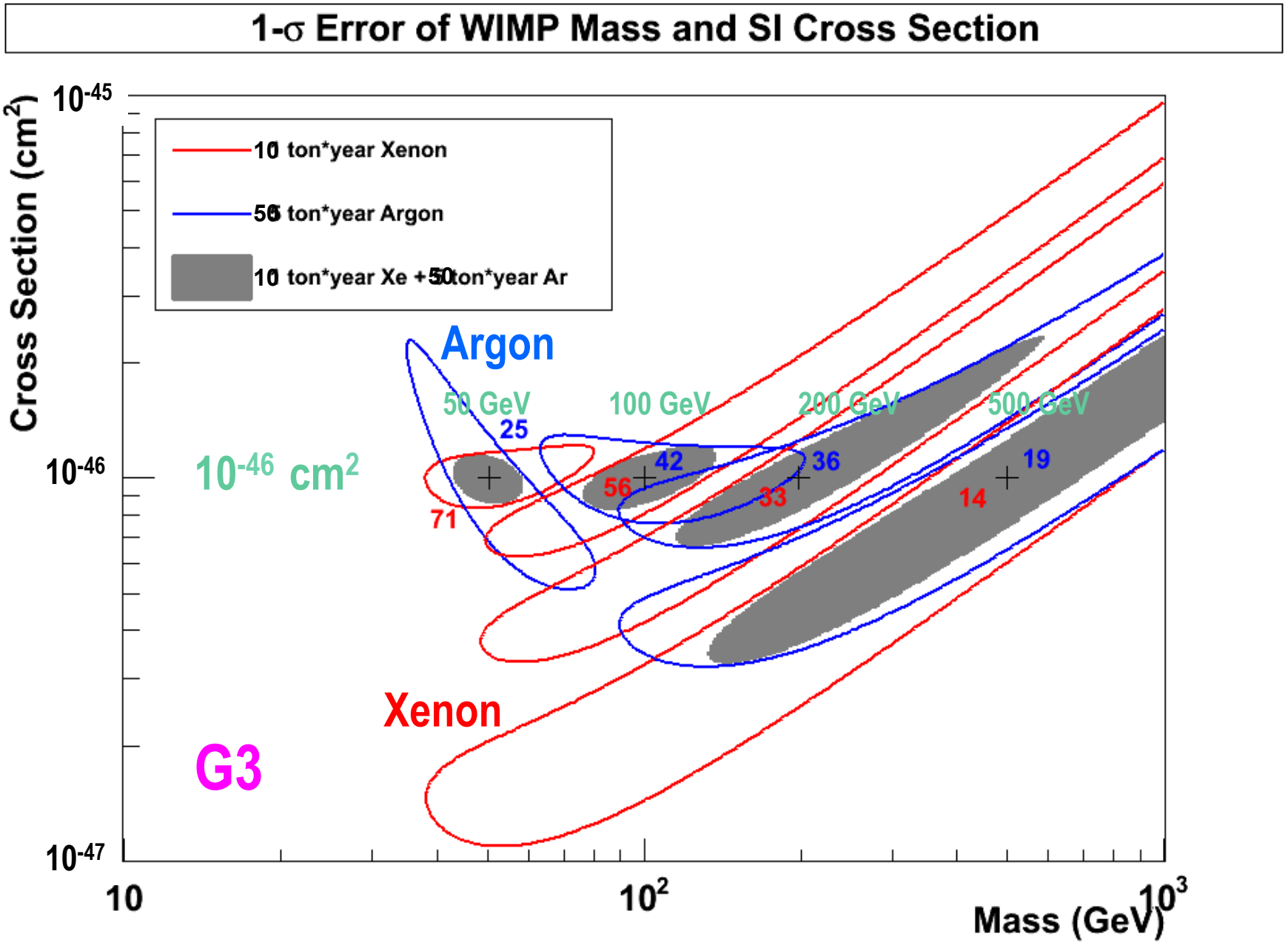
(SI) WIMP Energy Spectrum for LXe
(Cross Section = $10^{-45}cm^2$)



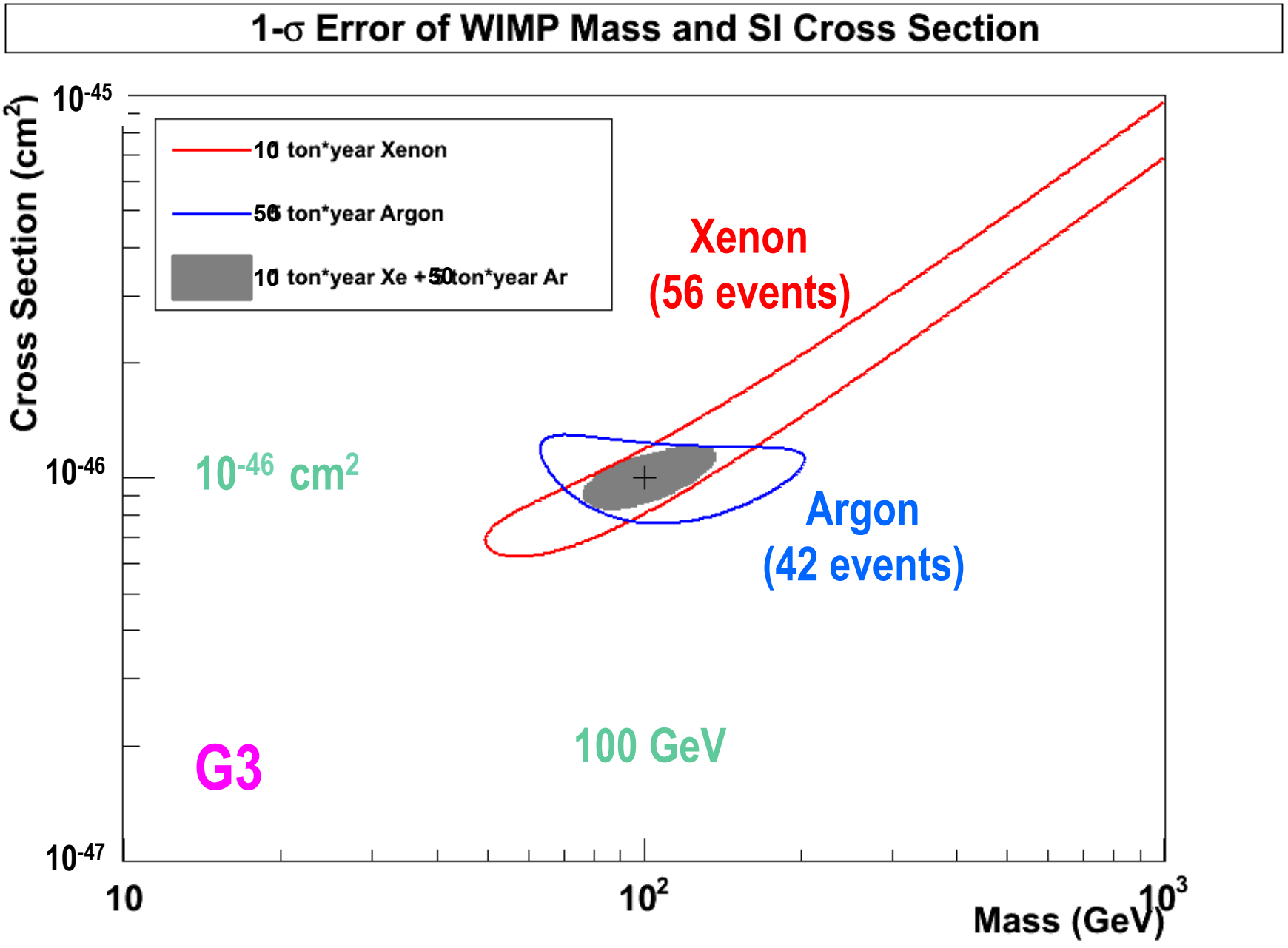
(SI) WIMP Energy Spectrum for LAr
(Cross Section = $10^{-45}cm^2$)



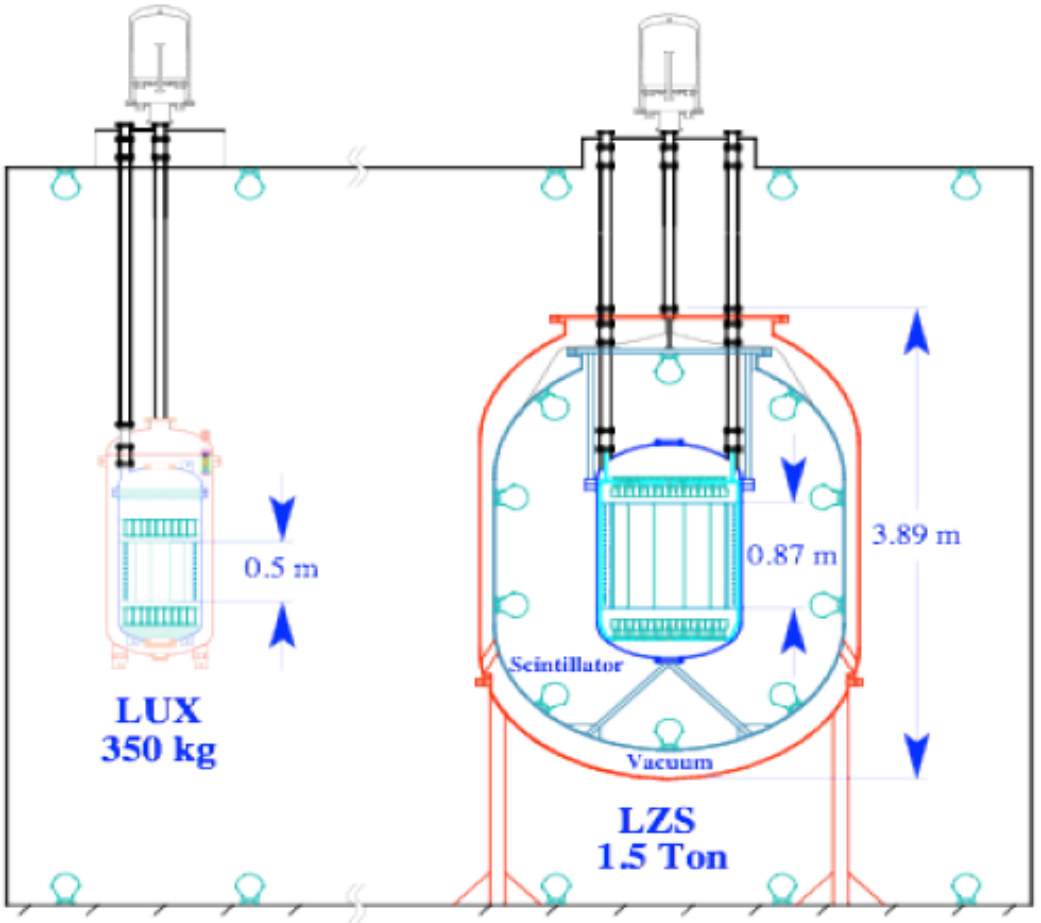
1-σ Error of WIMP Mass vs SI Cross Section (10 ton*year Xe and 50 ton*year Ar)

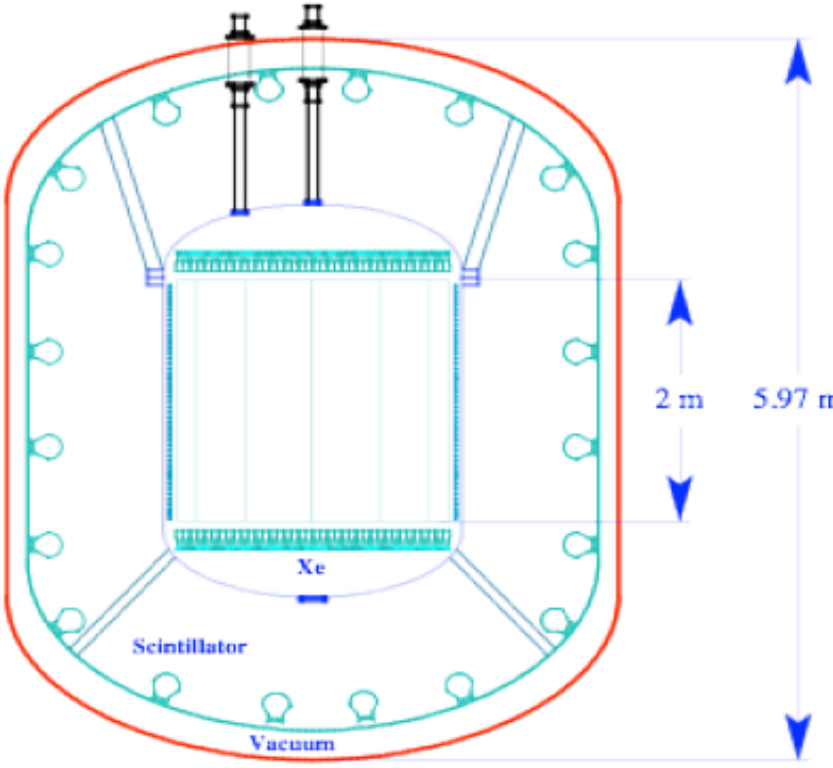


1-σ Error of WIMP Mass vs SI Cross Section (10 ton*year Xe and 50 ton*year Ar)



LUX and LZD

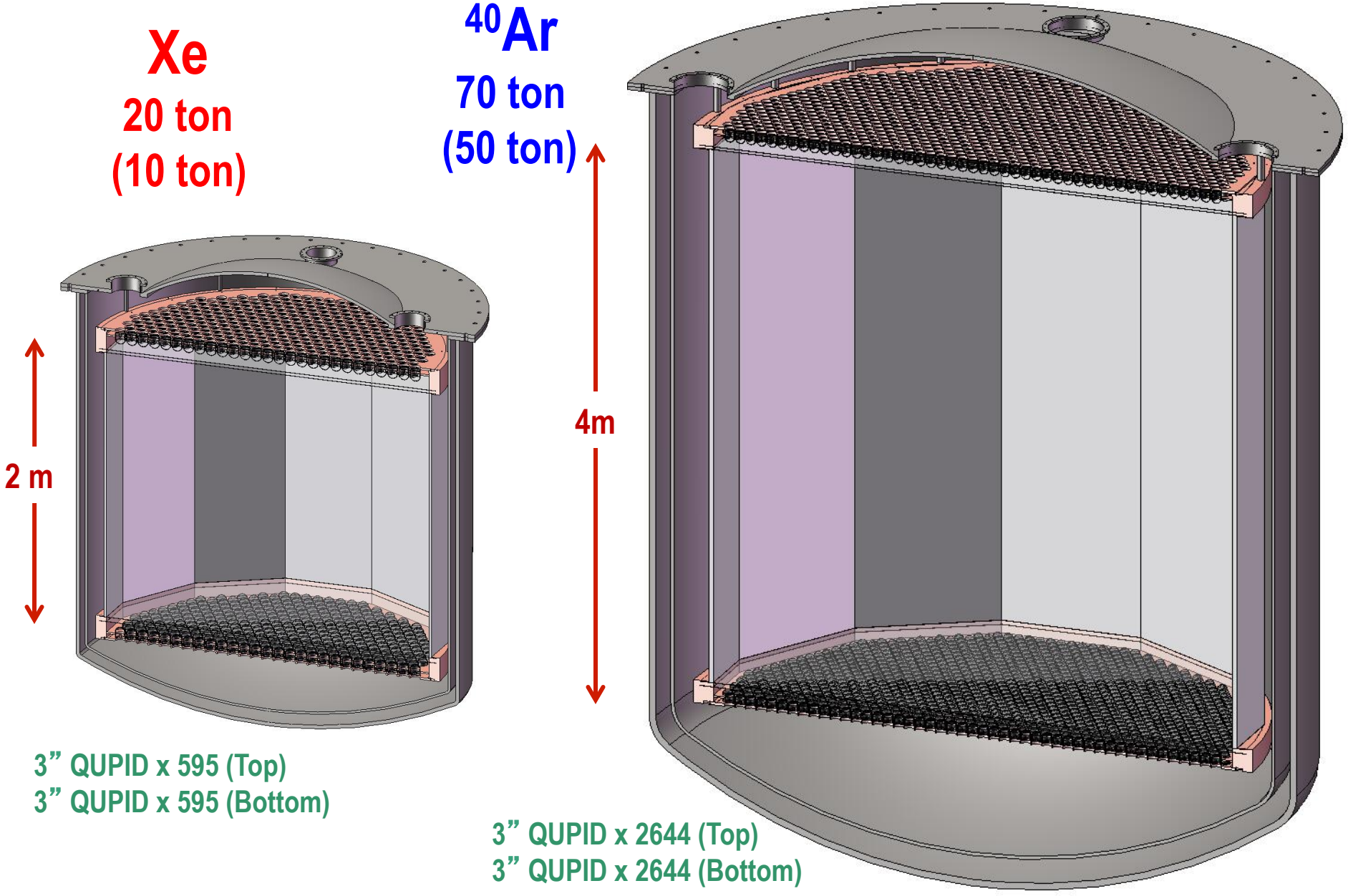

0.5 m
LUX
350 kg
0.87 m
3.89 m
Scintillator
Vacuum
LZS
1.5 Ton
Davis Cavern Water Tank


2 m
5.97 m
Xe
Scintillator
Vacuum
LZD
20 Ton

MAX+LZD = G3 Detector

Xe
20 ton
(10 ton)

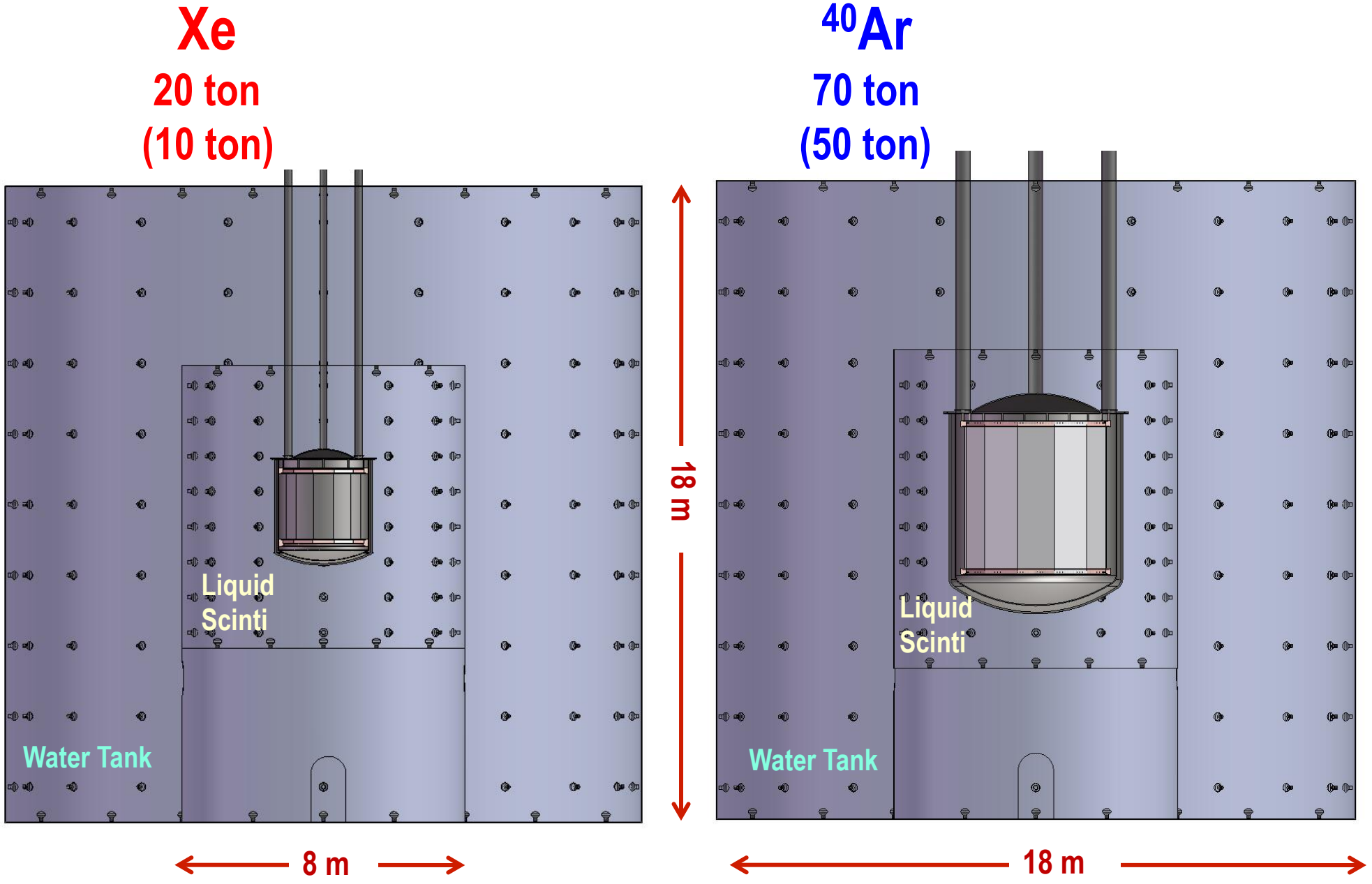
^{40}Ar
70 ton
(50 ton)



3” QUPID x 595 (Top)
3” QUPID x 595 (Bottom)

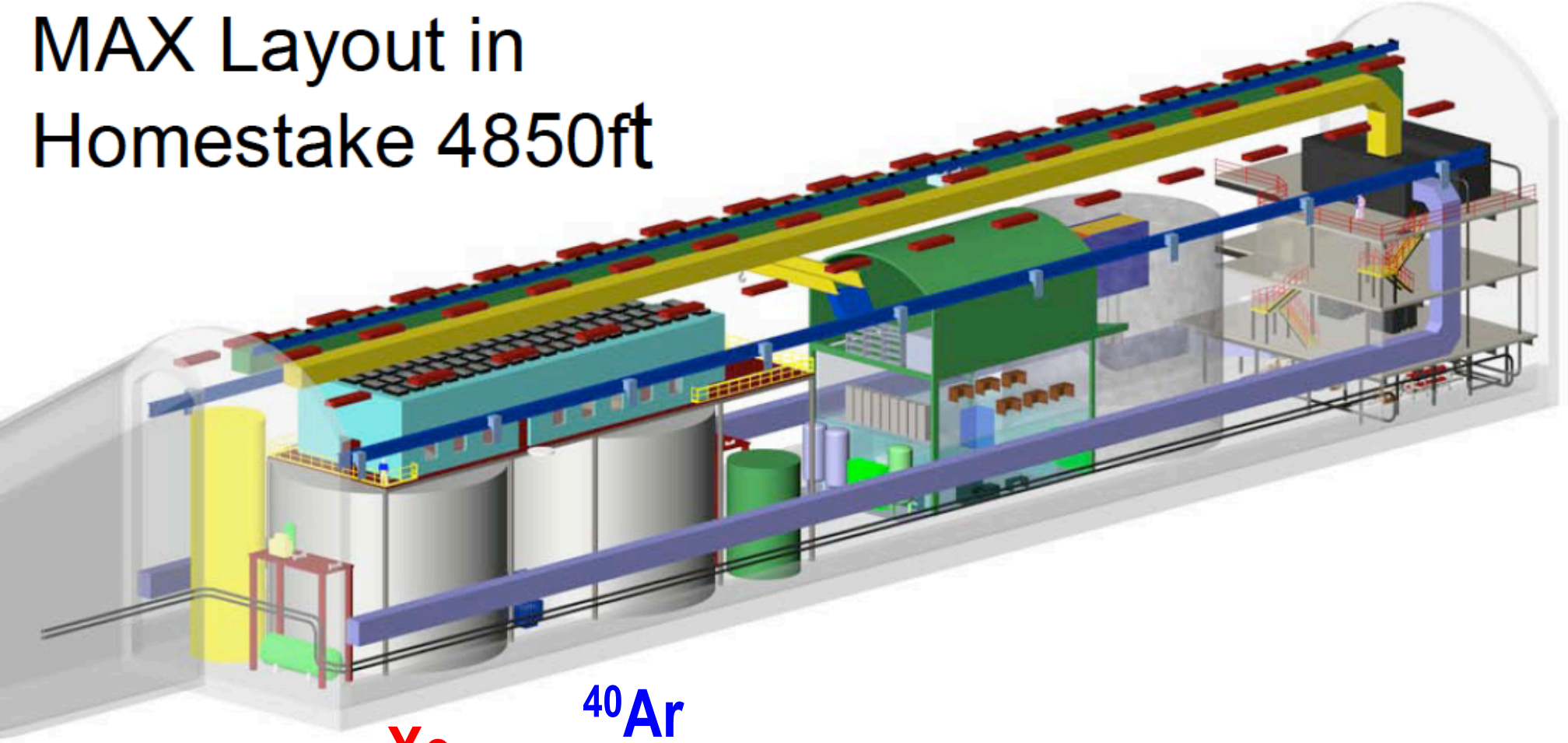
3” QUPID x 2644 (Top)
3” QUPID x 2644 (Bottom)

MAX+LZD = G3 Shielding Structure



G3 (MAX) at DUSEL

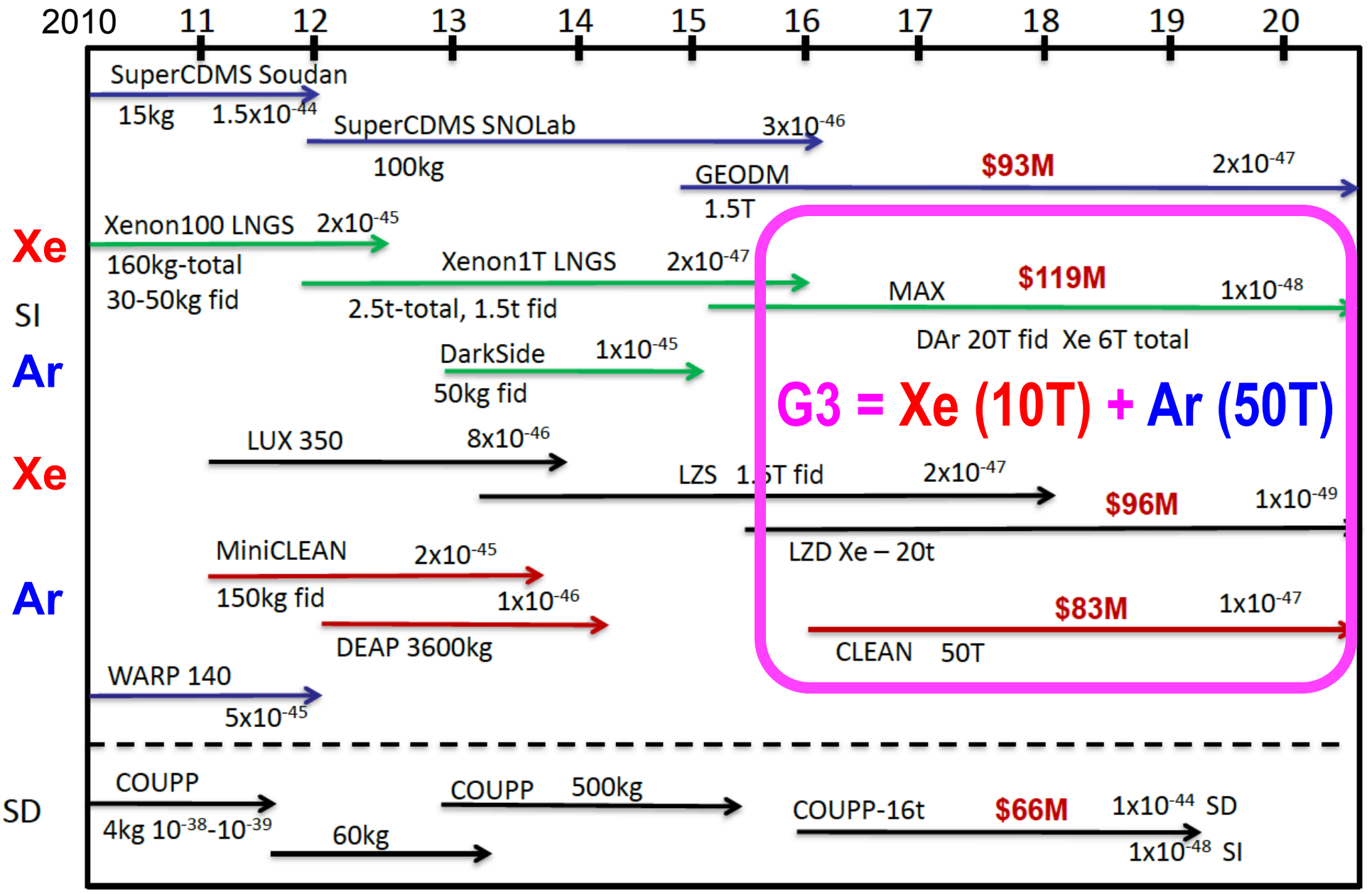
MAX Layout in
Homestake 4850ft



Xe
20 ton
(10 ton)

^{40}Ar
70 ton
(50 ton)

Projected Sensitivity



Conclusions

- **XENON100 new results announced.**
  - 3 event observed (1.8 ± 0.6 events expected)
  - < 7 x 10^{-45} cm^2 (at 50 GeV)
  - < 2 x 10^{-45} cm^2 by the end of 2011 expected.

- **Future multi-ton Xe/Ar detectors designed and proposed.**
  - XENON 1T and DarkSide 50 / 5T at Gran Sasso.
  - G3 = MAX + LZD (Xe 10T + Ar 50T) at DUSEL.