جامعة نيويورك أبوظبي

NYU | ABU DHABI

DARWIN

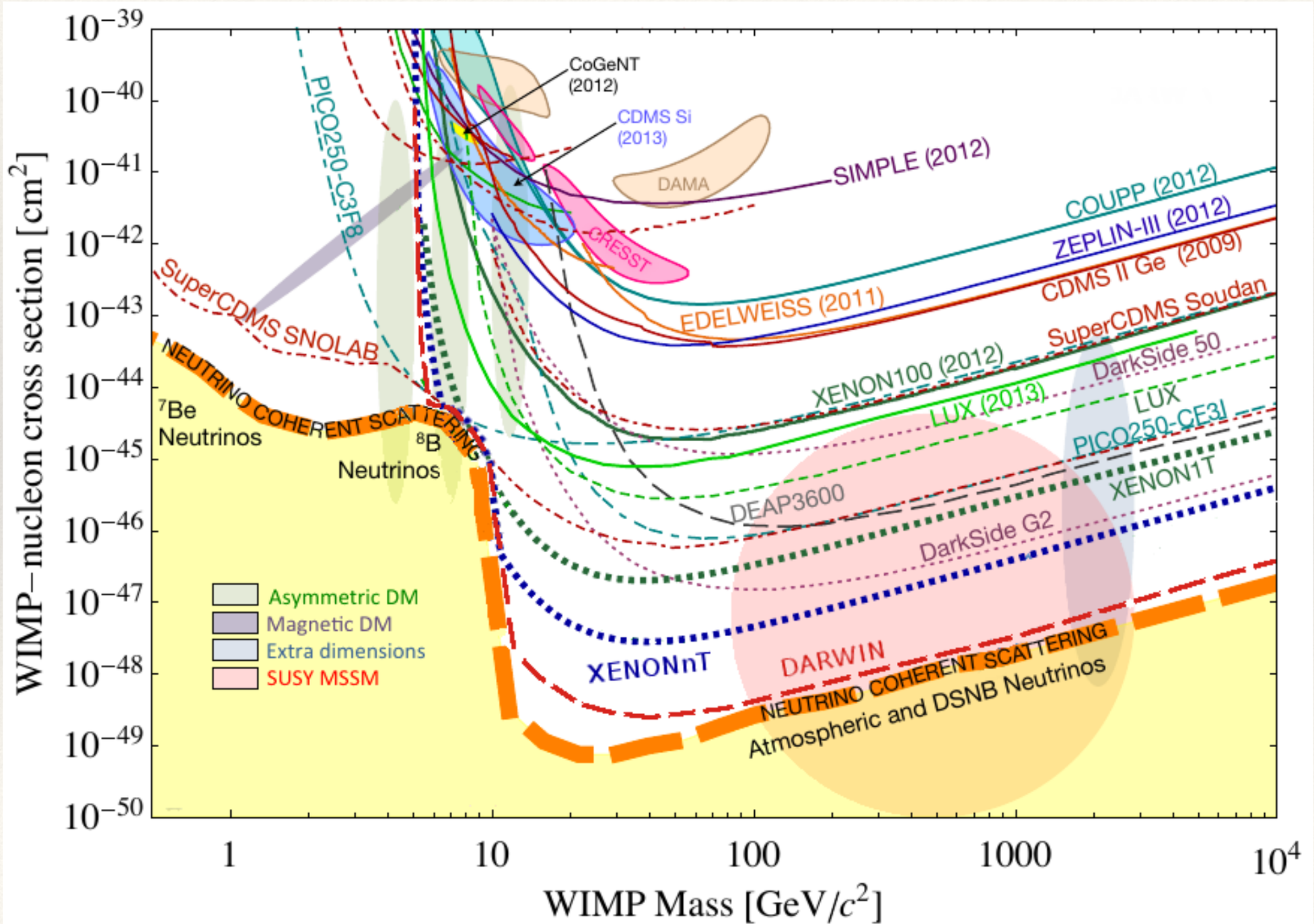
DARWIN: towards the ultimate dark matter detector

F. Arneodo

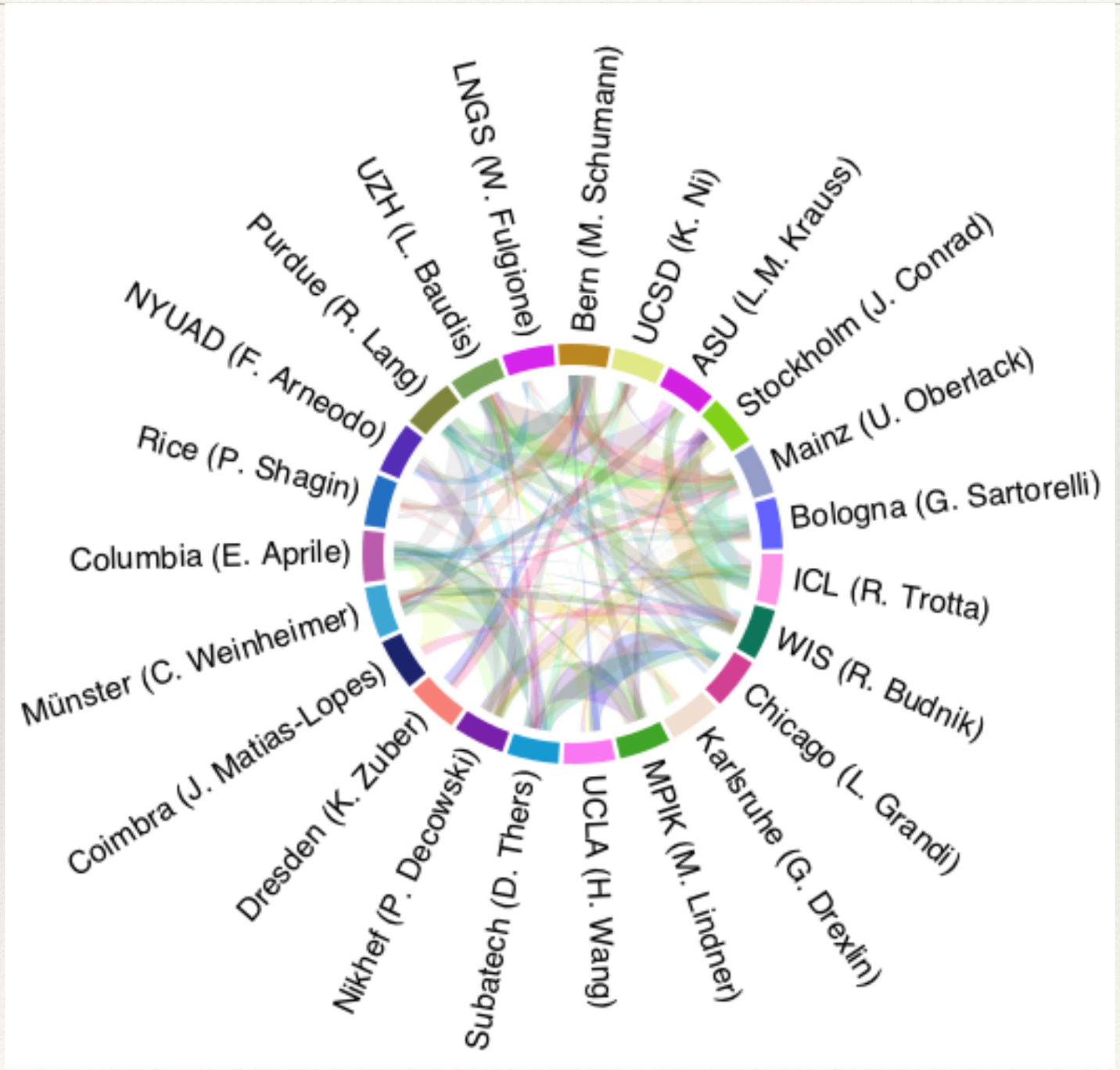
New York University Abu Dhabi

a lively arena

SNOWMASS Cosmic Frontiers 2013

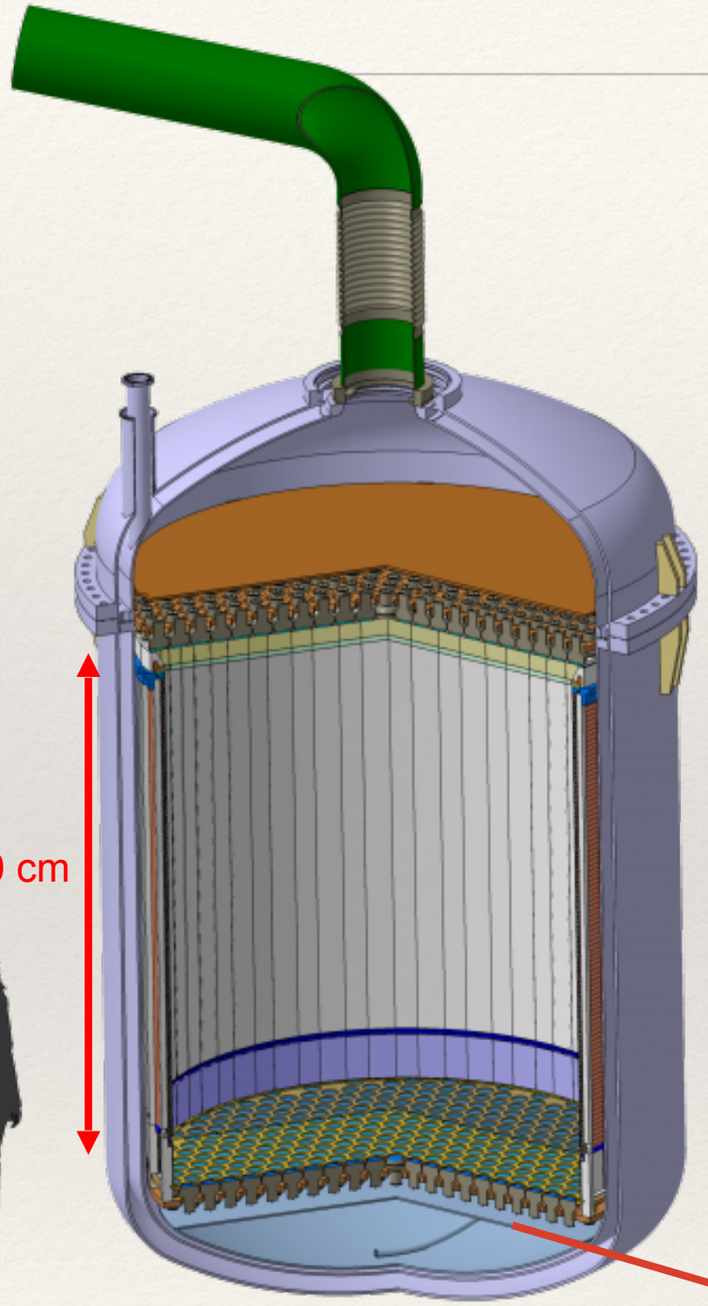


the DARWIN consortium

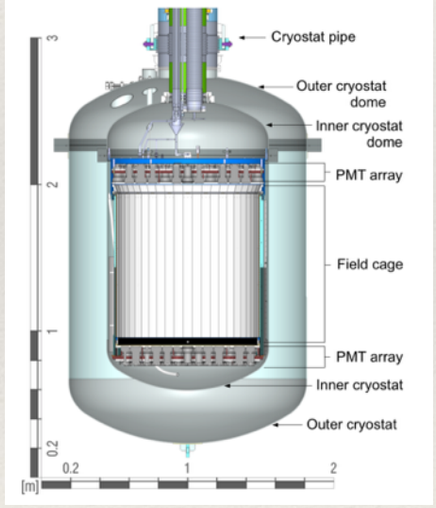


http://darwin.physik.uzh.ch/collaboration.html

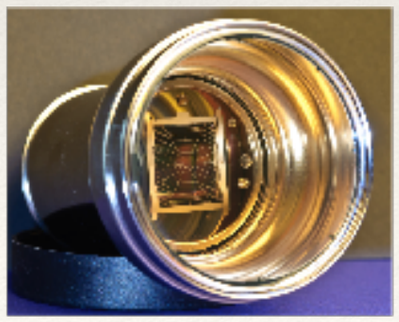
DARWIN



XENON1T

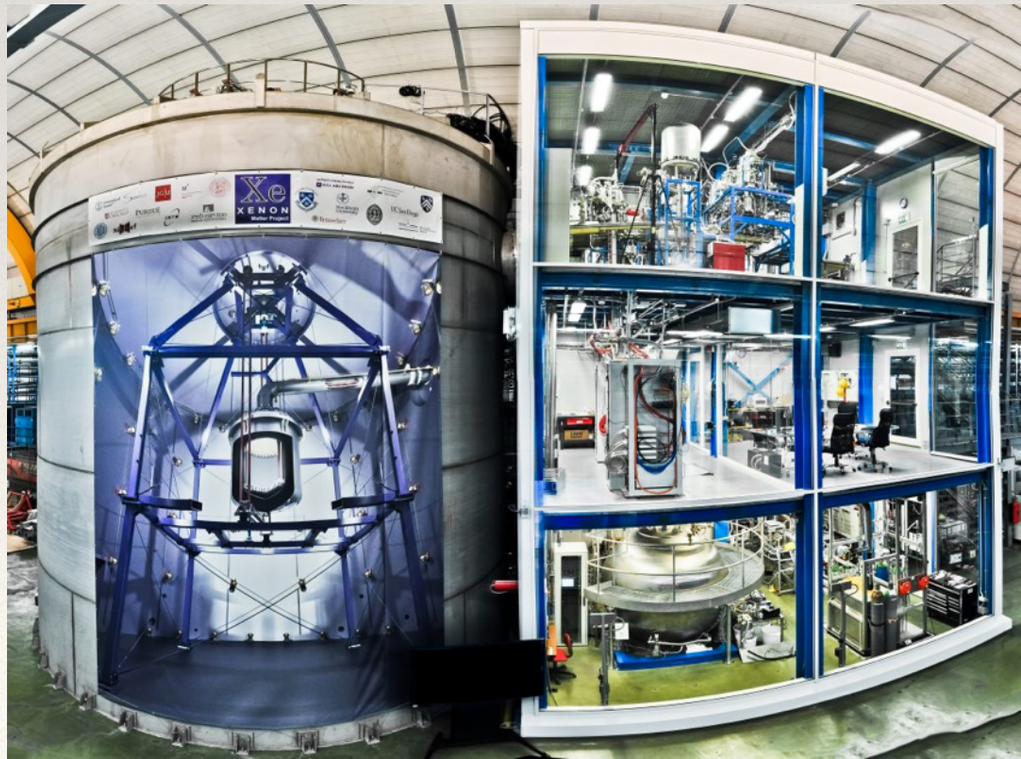


?

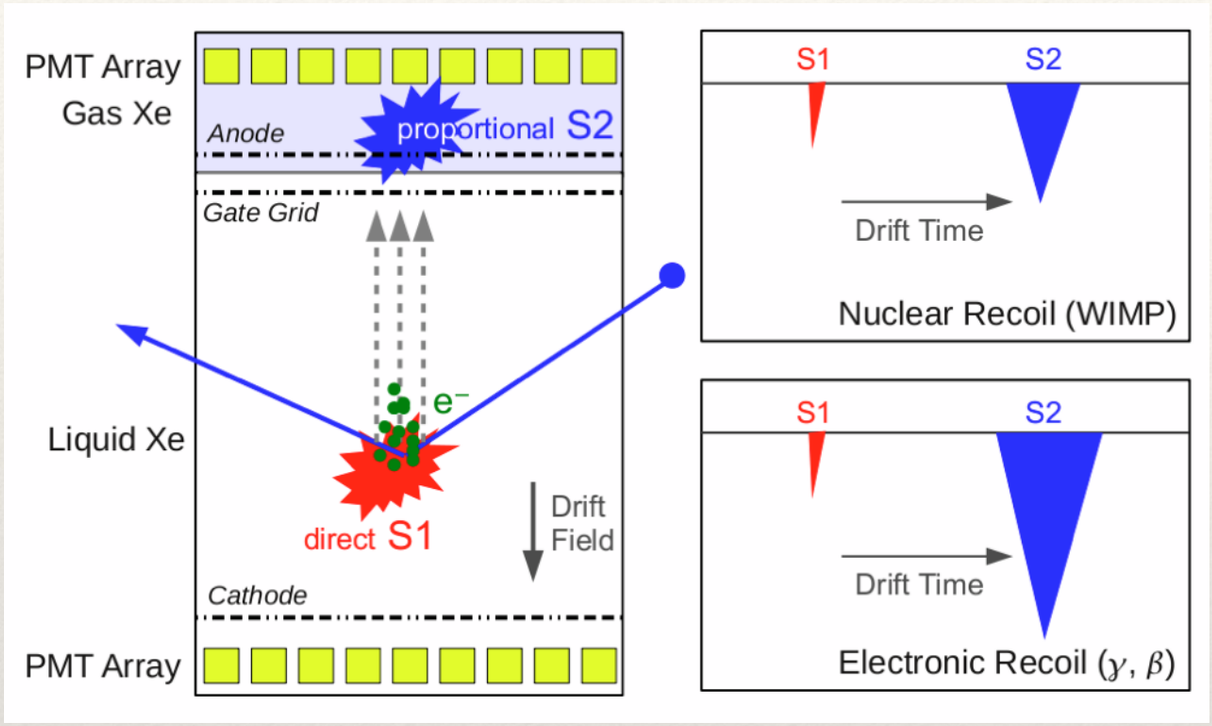


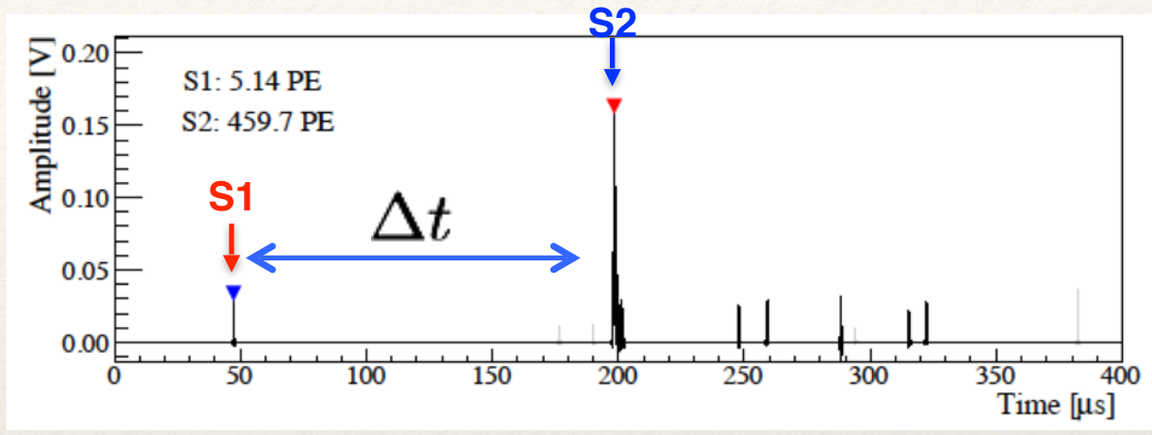
3-inch PMT, R11410-21

- 30 t fiducial mass (baseline)
- 40 t LXe TPC
- 50 t total LXe mass
- 130 kV HV for 500 V/cm
- ~ 14 m water tank
- 7 x current Xe storage facility
- ~1000 photosensors (which ones?)

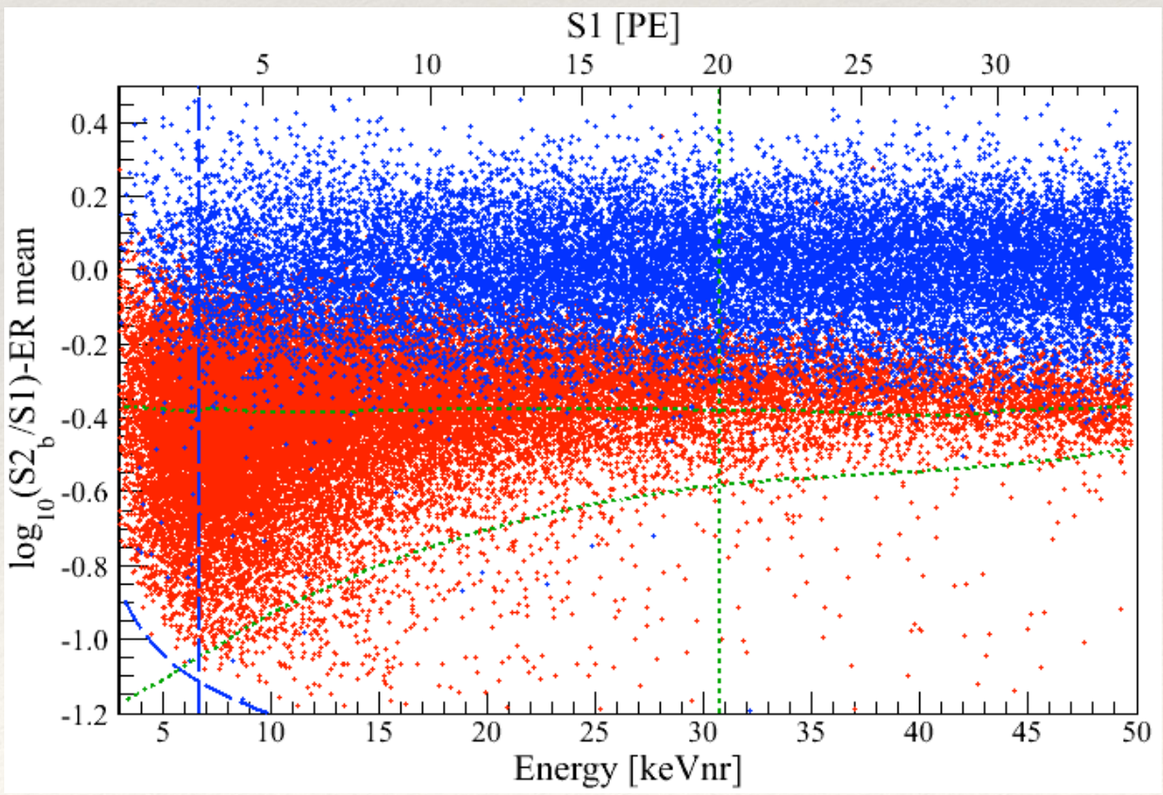


the wonders of double phase TPCs





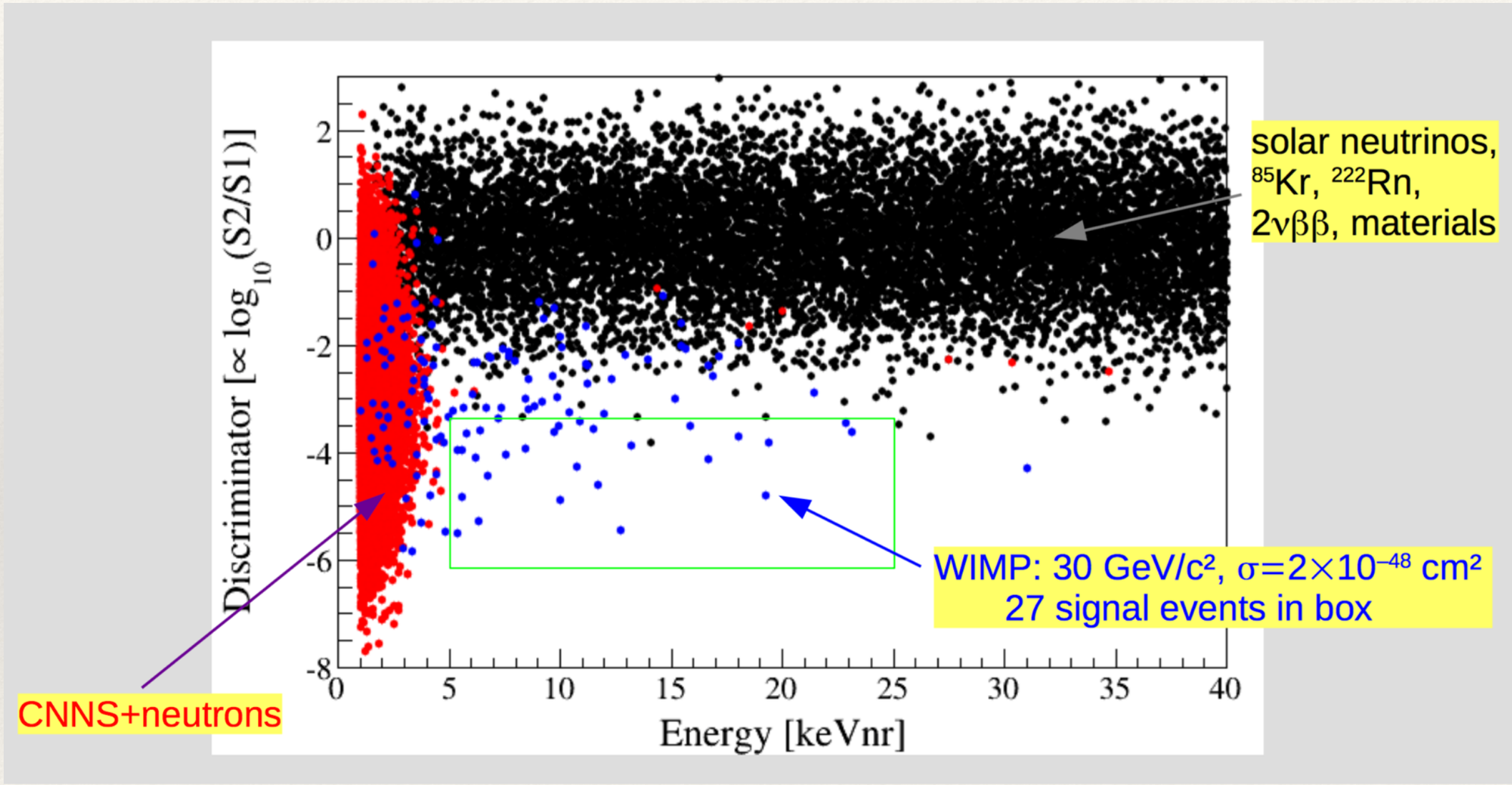
XENON100, ER rejection power 99.75%



physics with DARWIN

- WIMP search (SI, SD)
- solar neutrinos
- axions and axion-like particles
- neutrinoless double beta decay
- SN neutrinos
- neutrino coherent scattering

what we would see?

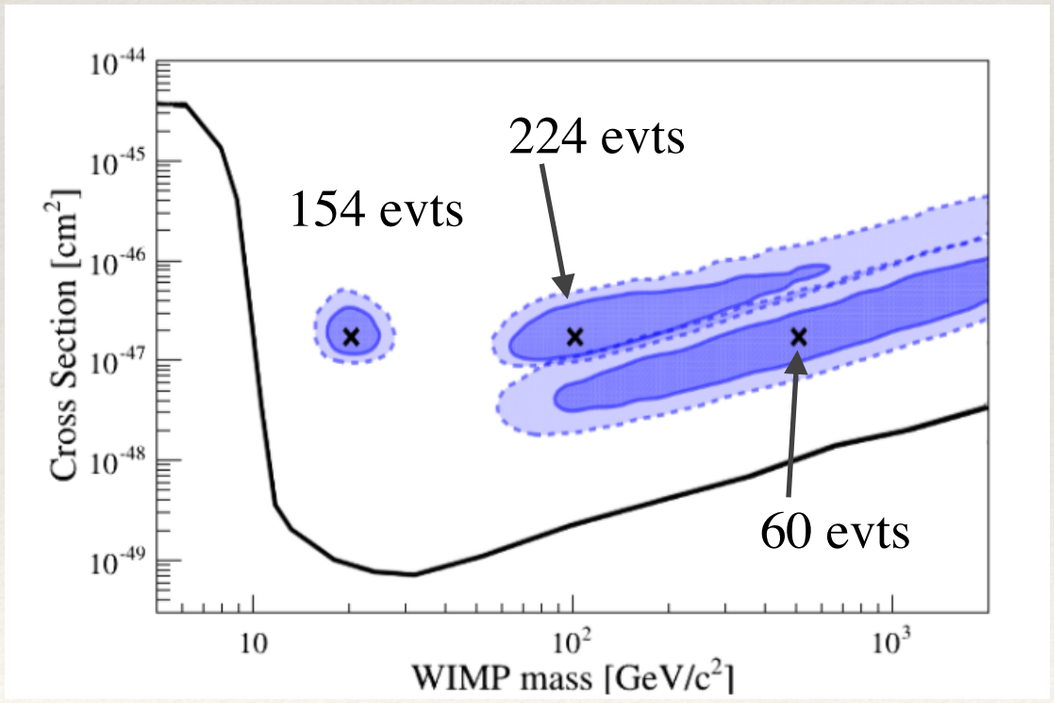


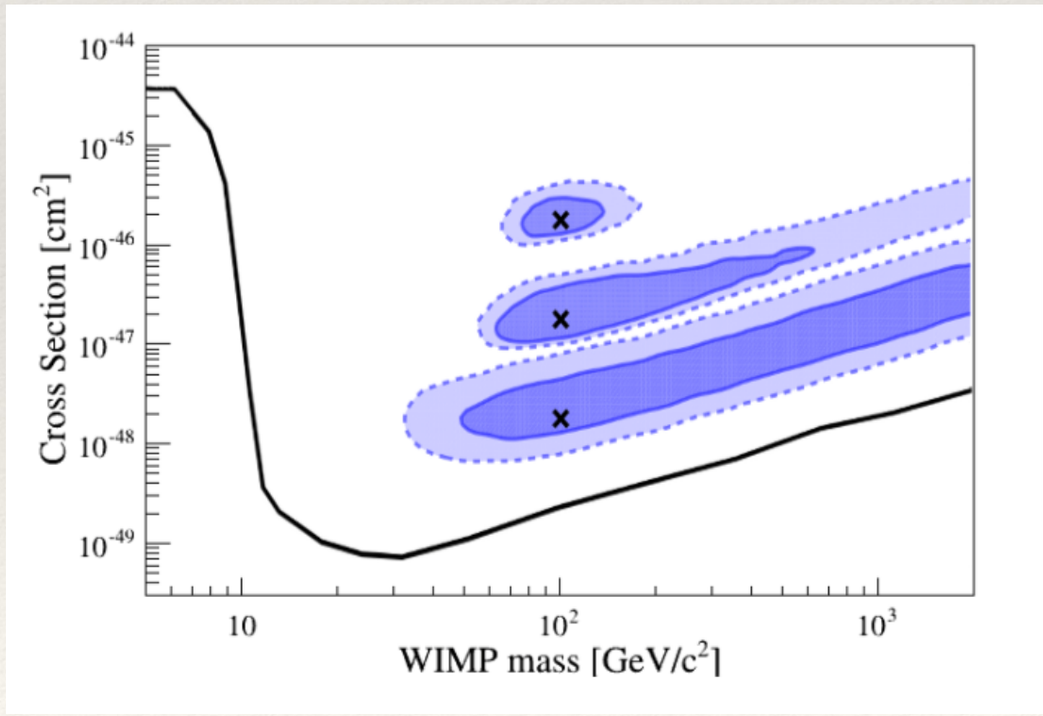
Marc Schumann's talk, Patras 2017

WIMP search

- sensitivity of 2.5 x 10^{-49} cm^2 at 40 GeV for 200 t x y exposure
- spin dependent sensitivity (50% abundance of ^{129}Xe and ^{131}Xe)
- inelastic scattering

200 t x y

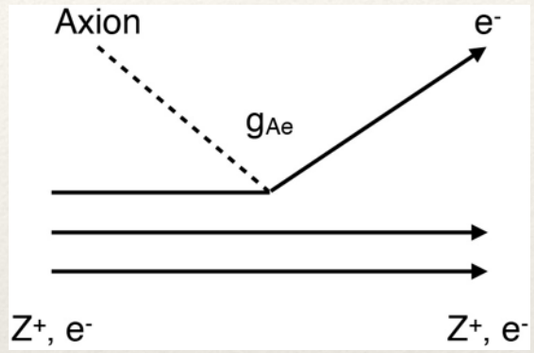


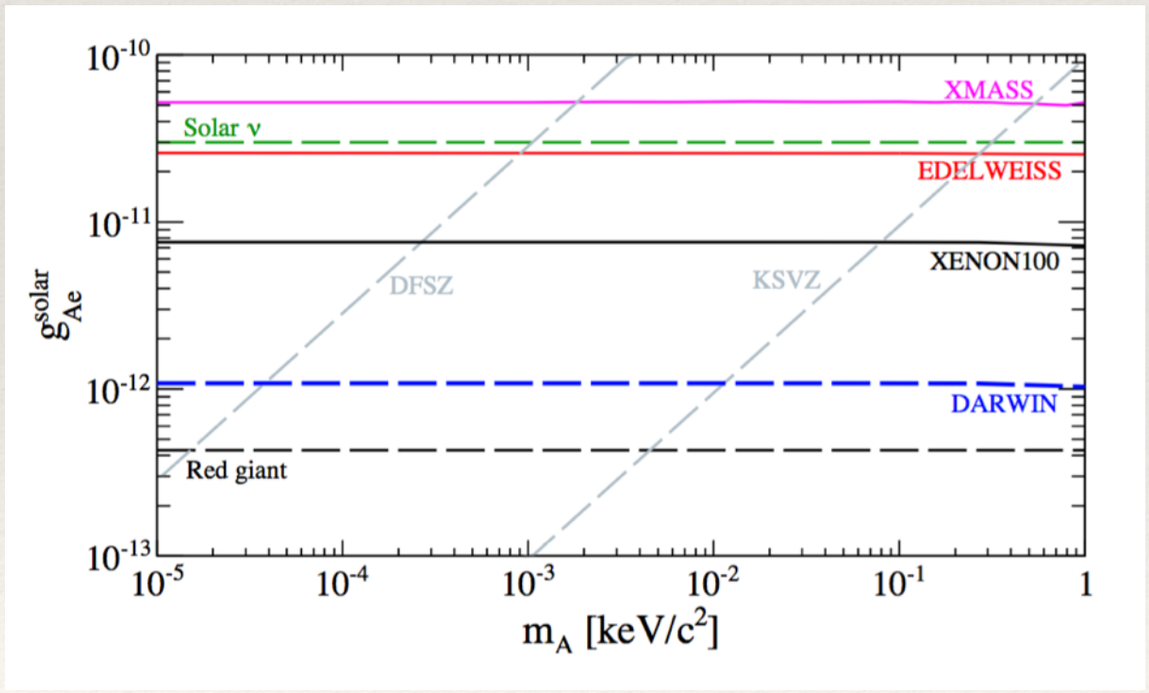


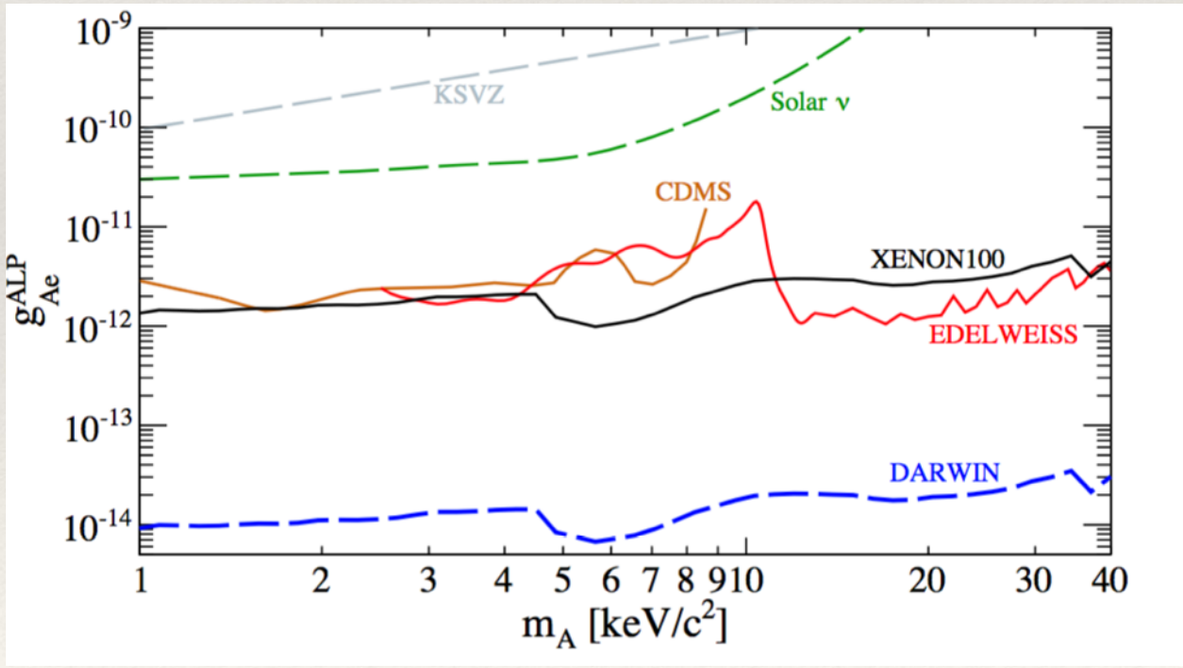
JCAP Nov. 2016

axions and ALPs

- detectable through axio-electric effect
  - mono energetic peak
- improvement over XENON100 (more significant for galactic axions)

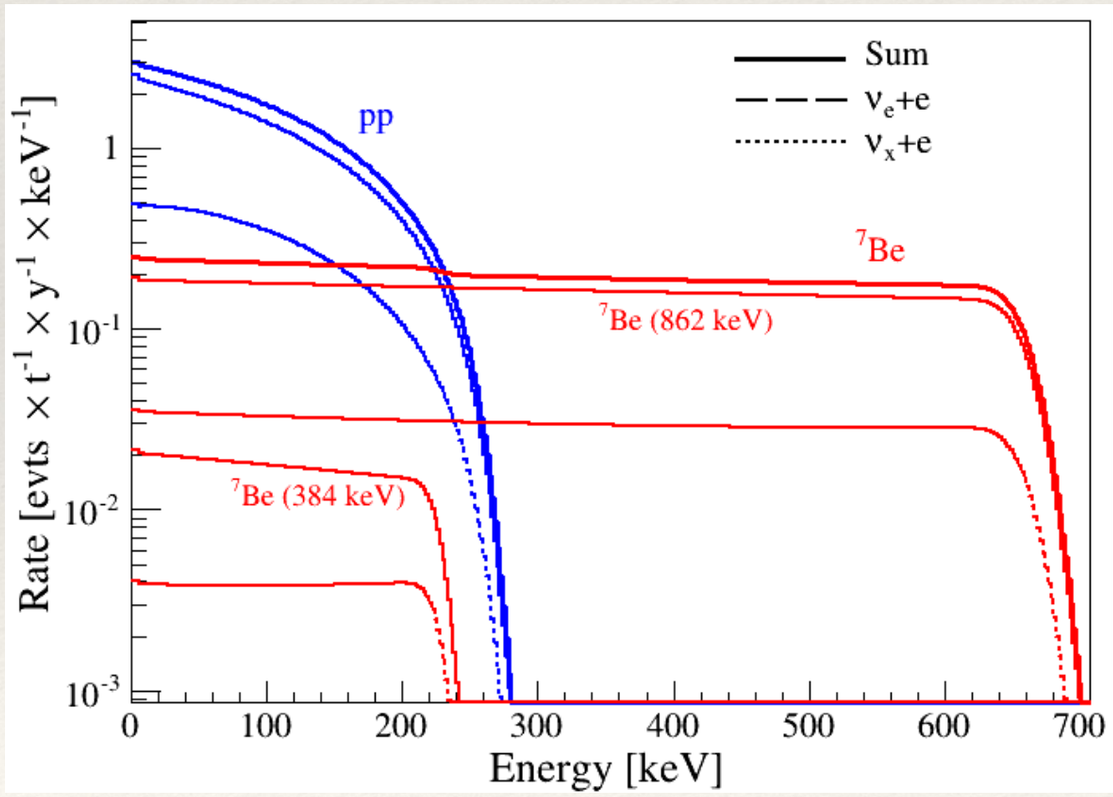


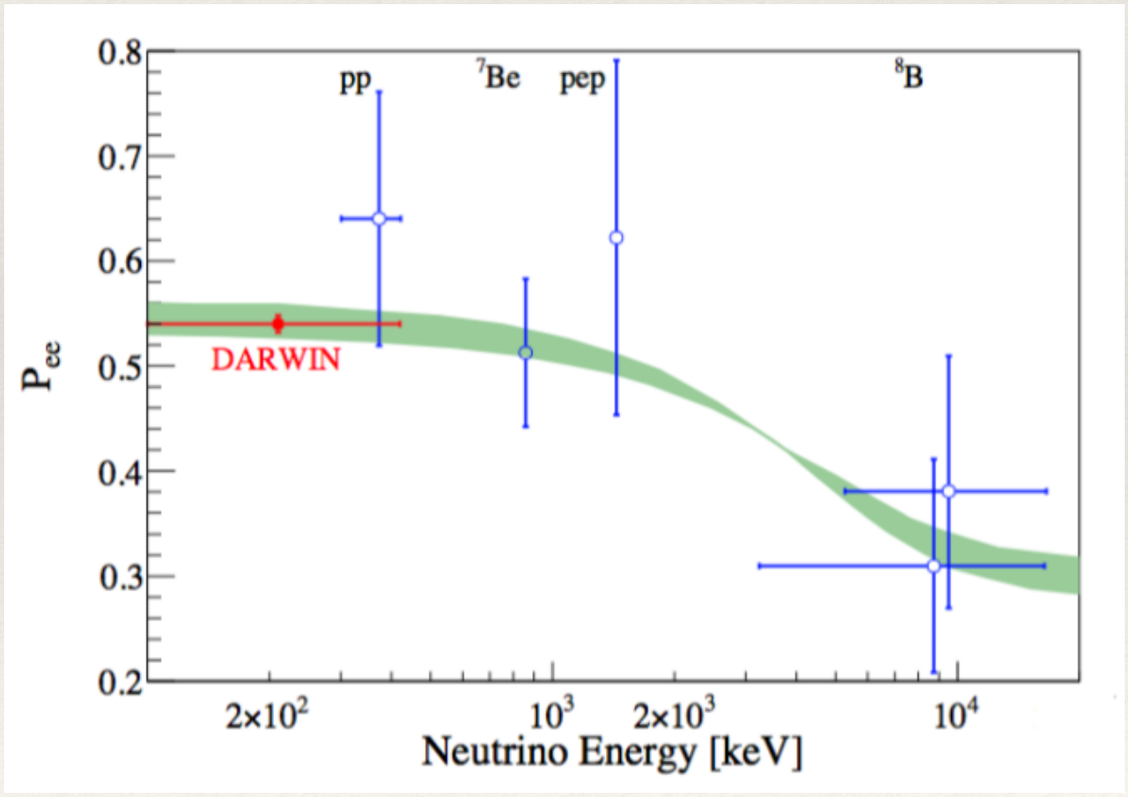




solar neutrinos

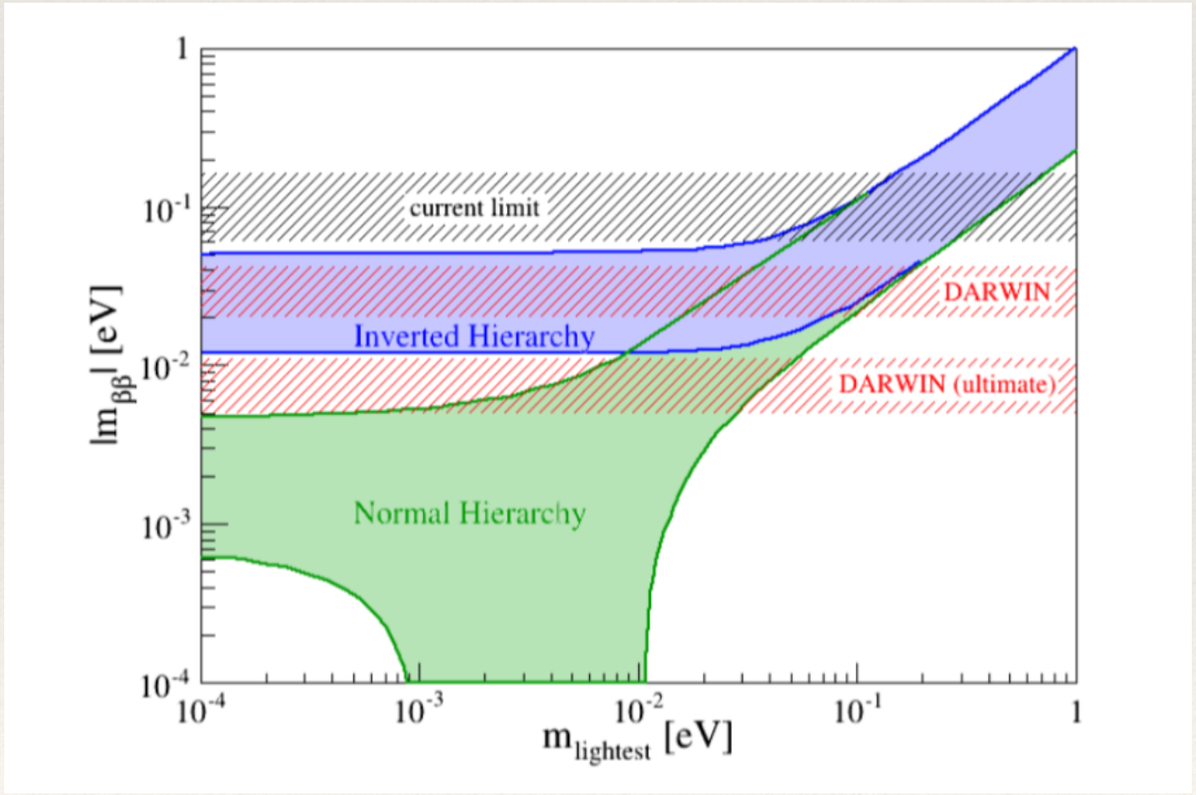
- ν_{pp} = 7.2/day - $\nu_{^7Be}$ = 0.9/day (2-30 keV_{ee}, 30 t fiducial)
- <1% comparison of neutrino and em luminosity





neutrinoless double β decay

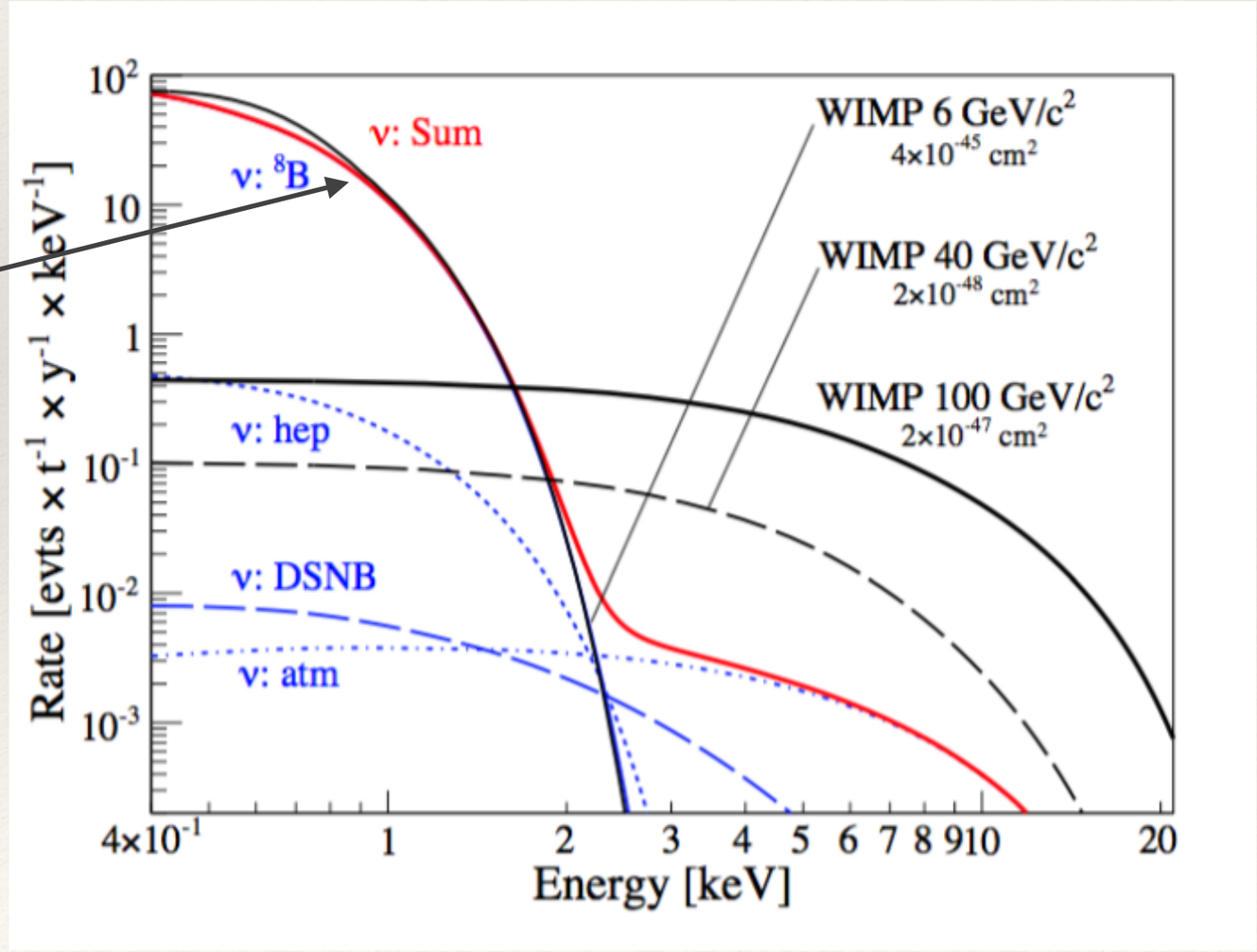
- ^{136}Xe, 8.9%, Q_{value}=2.458 MeV (1% resolution achievable)
- challenge of the different energy scale



coherent neutrino-nucleus scattering

- ^{8}B solar neutrinos and atmospheric
- with a 1.4 keV_{nr} threshold, ~ 90 events per ton per year (mostly ^{8}B)
- predicted but never observed

differential nuclear recoil spectrum from coherent scattering of neutrinos (will use this again for backgrounds)



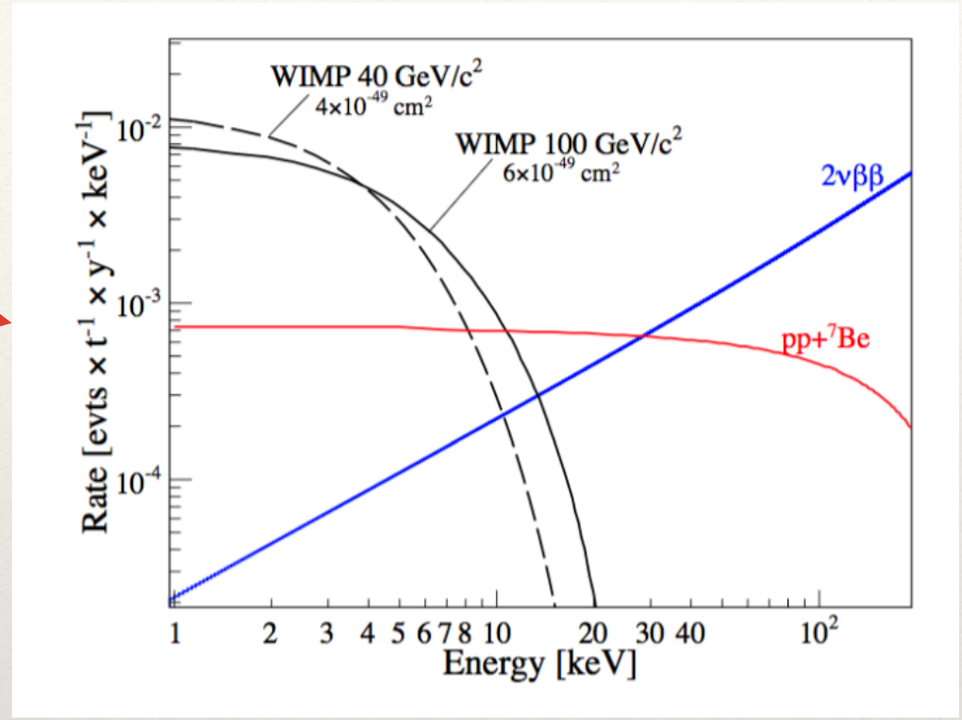
backgrounds: cosmogenic&intrinsic

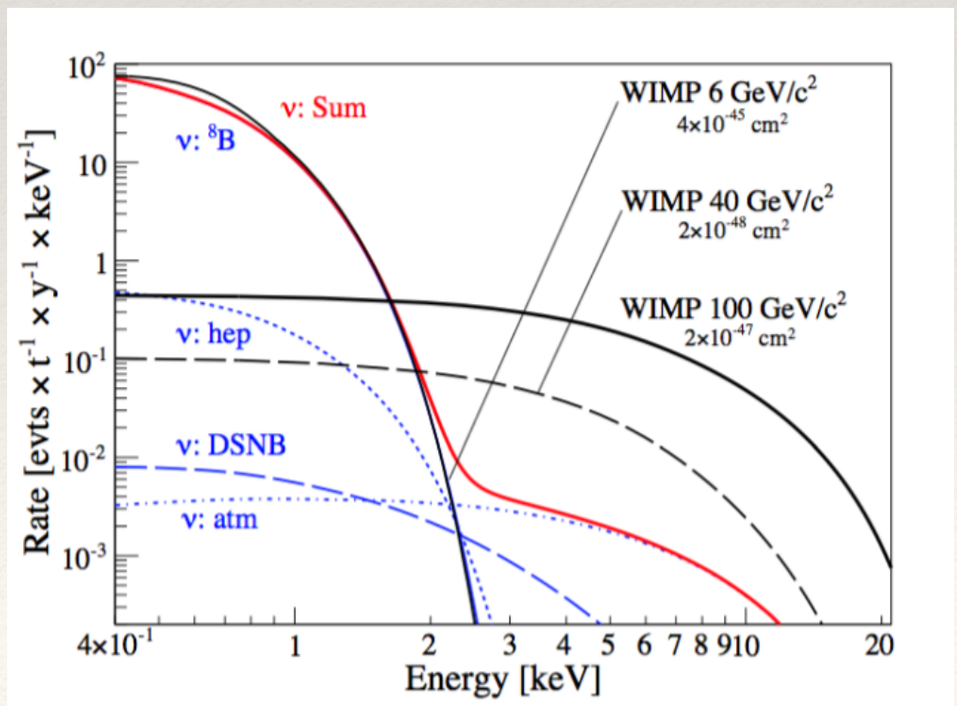
- neutrons, of course!
  - a14 m diameter active water tank will make cosmogenic neutrons negligible
  - materials (especially PTFE)must be carefully chosen
  - expected single-scatter nuclear recoil rate of about 3.8×10^{-5} events t^{-1} y^{-1} keV^{-1} in the fiducial 30t.

- intrinsic backgrounds
  - ^{85}Kr (needed a 0.1 ppt Kr contamination or less)
  - ^{222}Rn biggest challenge, have to achieve ~0.1 μBq/kg
  - total Xe-intrinsic background ~17 events t^{-1} y^{-1} (2-10 keVee interval) -> may be further reduced

neutrino background

- solar ν scattering on electrons (pp, ^{7}Be): about ~0.26 ν events $t^{-1}d^{-1}$ (2-30 keV) - > 2850 events/year
- need 99.98% rejection power
- coherent scattering:
  - irreducible background, indistinguishable from WIMP scattering
    - expect >90 events $t^{-1}y^{-1}$ for a 1 keV_{ee} threshold





backgrounds

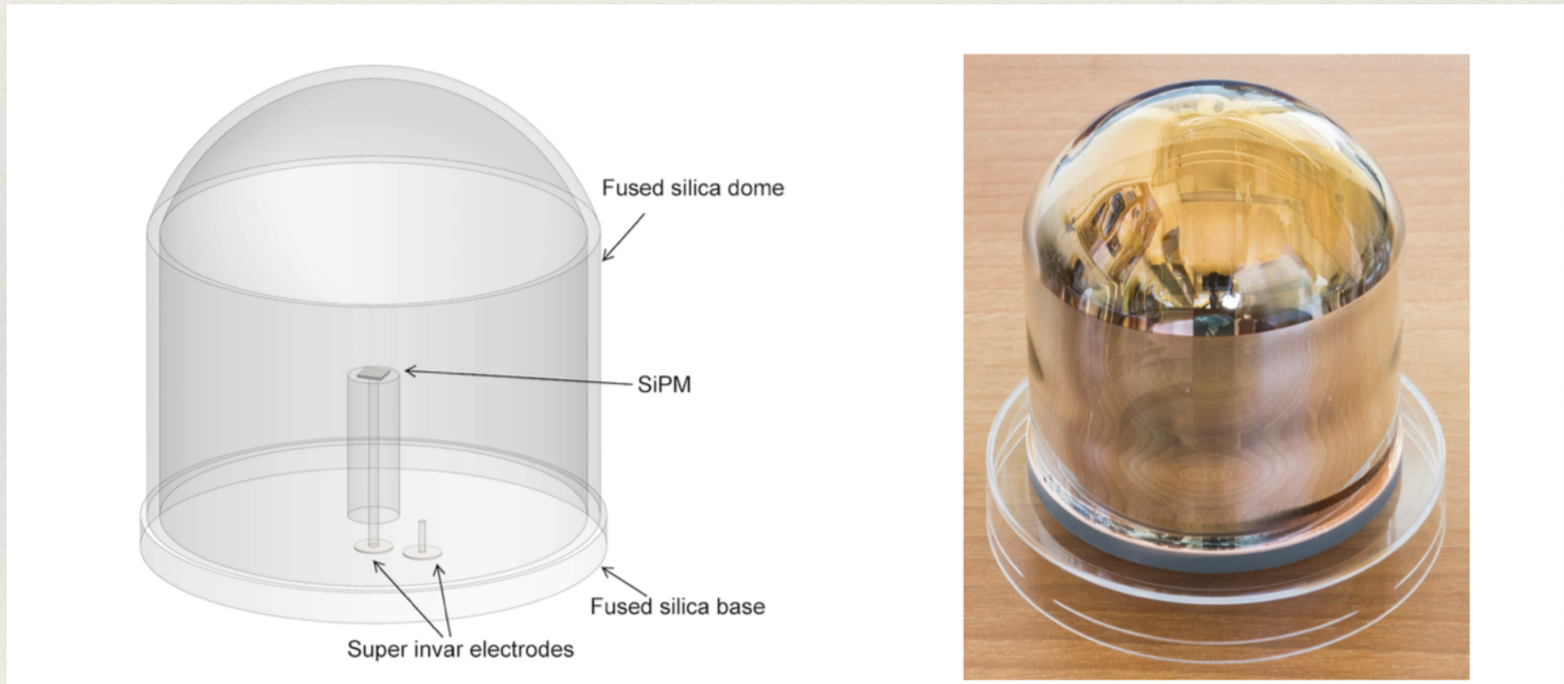
Source	Rate [events/(t·y·keVxx)]	Spectrum	Comment
γ-rays materials	0.054	flat	assumptions as discussed in text
neutrons*	3.8×10^{-5}	exp. decrease	average of [5.0-20.5] keVnr interval
intrinsic ^{85}Kr	1.44	flat	assume 0.1 ppt of ^{nat}Kr
intrinsic ^{222}Rn	0.35	flat	assume 0.1 μBq/kg of ^{222}Rn
$2\nu\beta\beta$ of ^{136}Xe	0.73	linear rise	average of [2-10] keVee interval
pp- and ^{7}Be ν	3.25	flat	details see [19]
CNNS*	0.0022	real	average of [4.0-20.5] keVnr interval

from JCAP 10, 016 (2015)

novel photodetectors

SIGHT:
Silicon Geiger Hybrid Tube

ArXiv 1611.04713



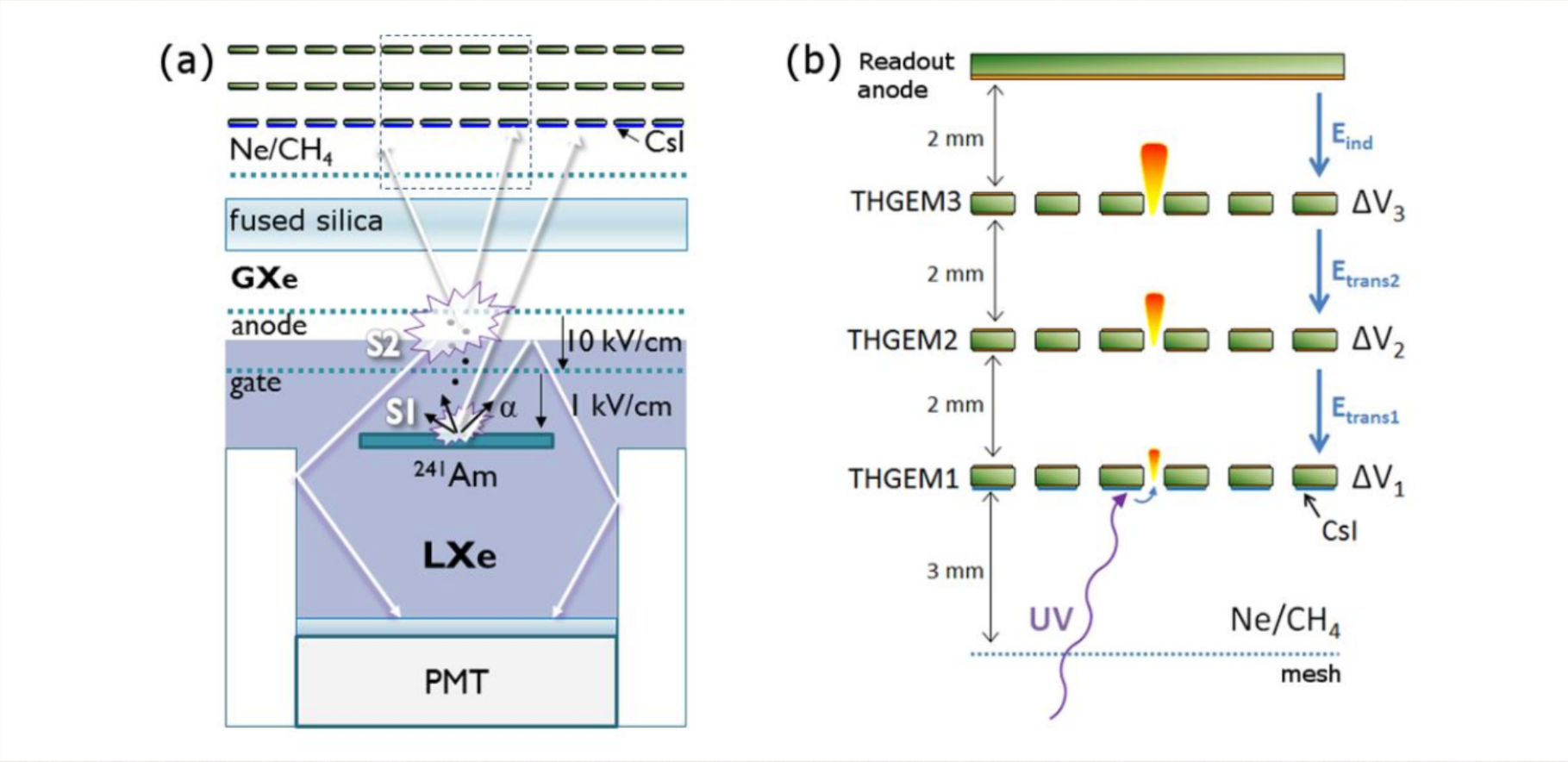
(a) 3D view

(b) SiGHT model

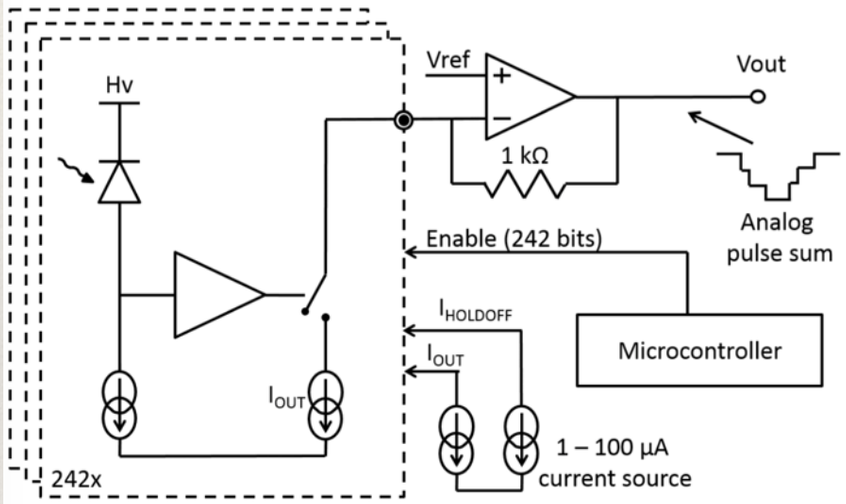
Figure 1. *Left*: 3D view of SiGHT, SiGHT only consists of one fused silica dome, one fused silica base, one SiPM and two super invar electrodes; *Right*: Picture of a SiGHT model fabricated and assembled at the UCLA SiGHT lab.

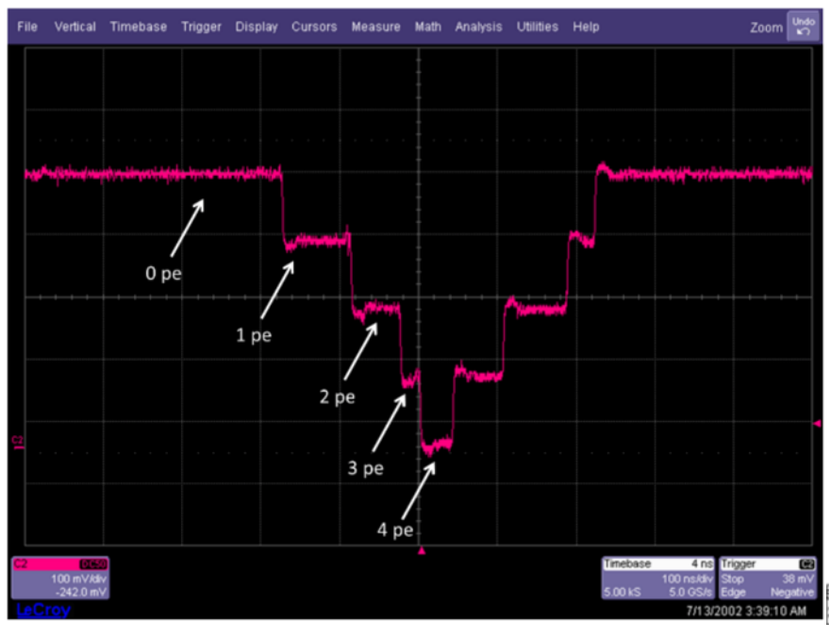
novel photodetectors: THGEMs

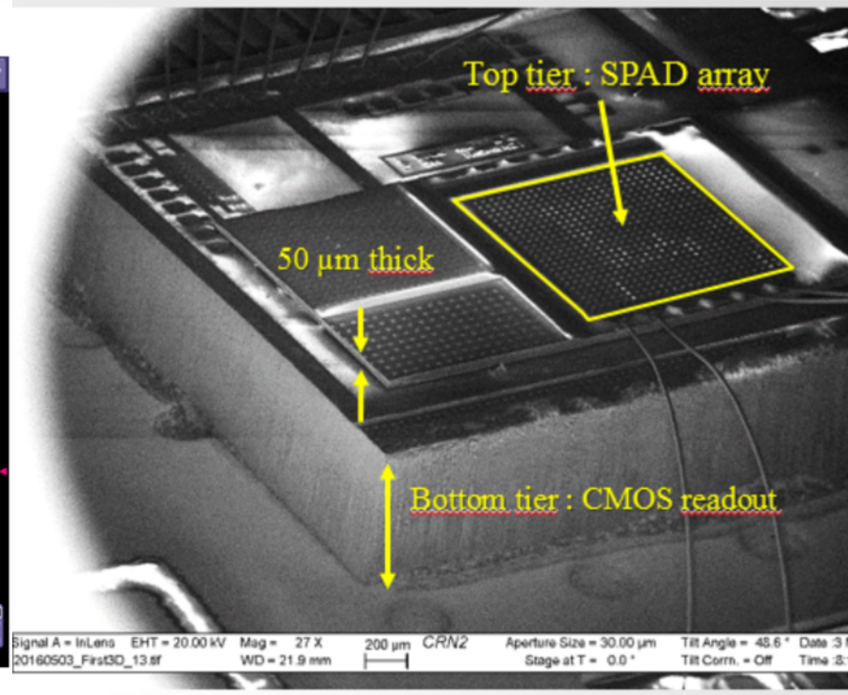
2015 JINST 10 P10020



novel photodetectors: Digital SiPMs





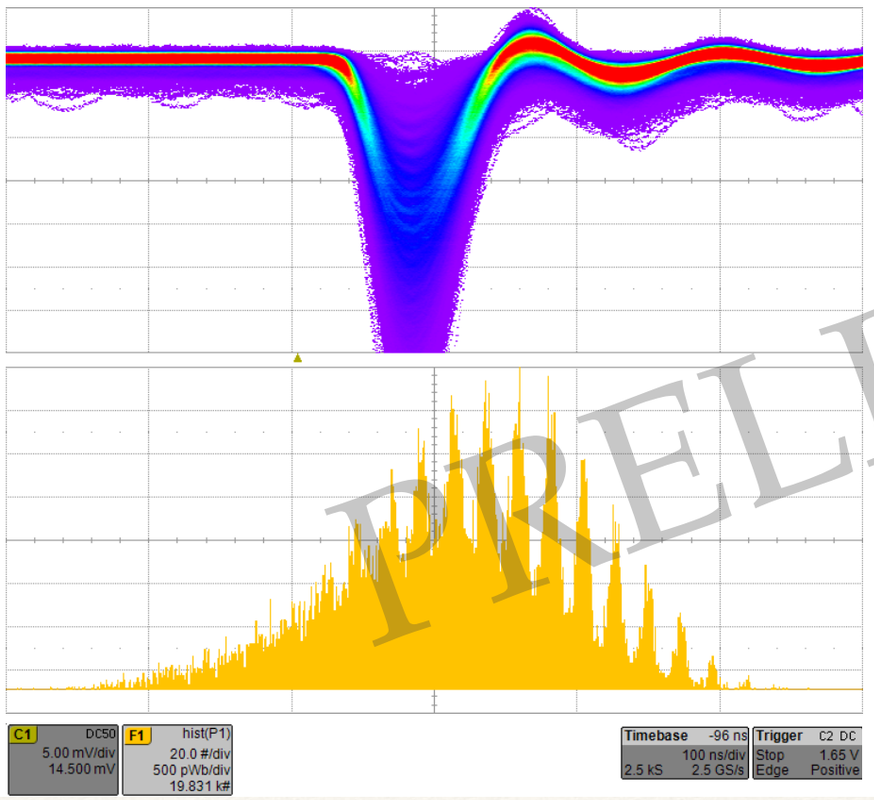


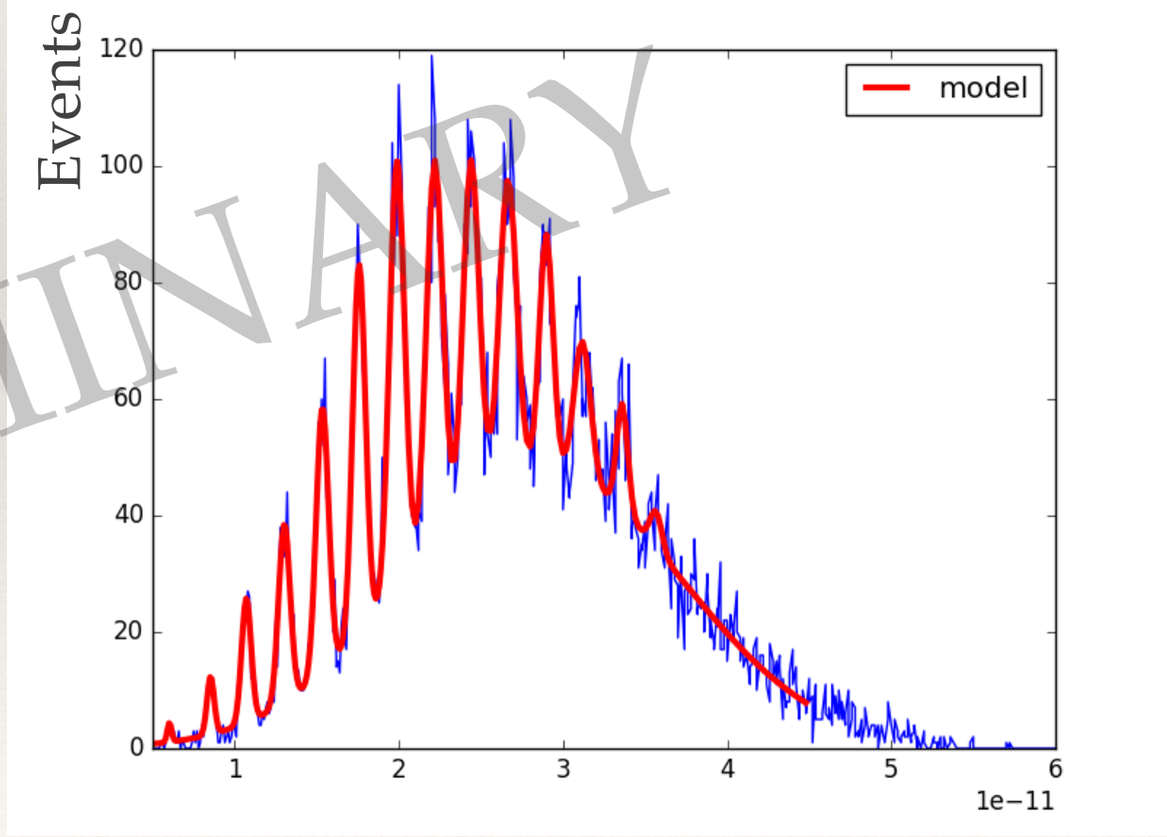
F. Retiere @TIPP17

http://indico.ihep.ac.cn/event/6387/session/19/contribution/211/material/slides/0.pdf

ongoing R&D

- ongoing efforts across the consortium on several technologies
- an example from NYUAD, working with an array of 16 Hamamatsu VUV4 MPPC, publication coming soon.





PRELIMINARY

conclusions

- DARWIN will be the ultimate LXe detector for WIMP search
- several interesting physics channels available
- need for a large collaboration to share efforts and costs
- technological challenges
- time scale ~ 2025 onwards