DARWIN

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FOR FUNDAMENTAL PHYSICS

Dark Matter Search with DARWIN

Moritz v. Sivers
on behalf of the DARWIN Consortium
LHEP, AEC
Universität Bern

20.06.-24.06.2016, Patras Workshop, Jeju Island

Dark Matter Experiments

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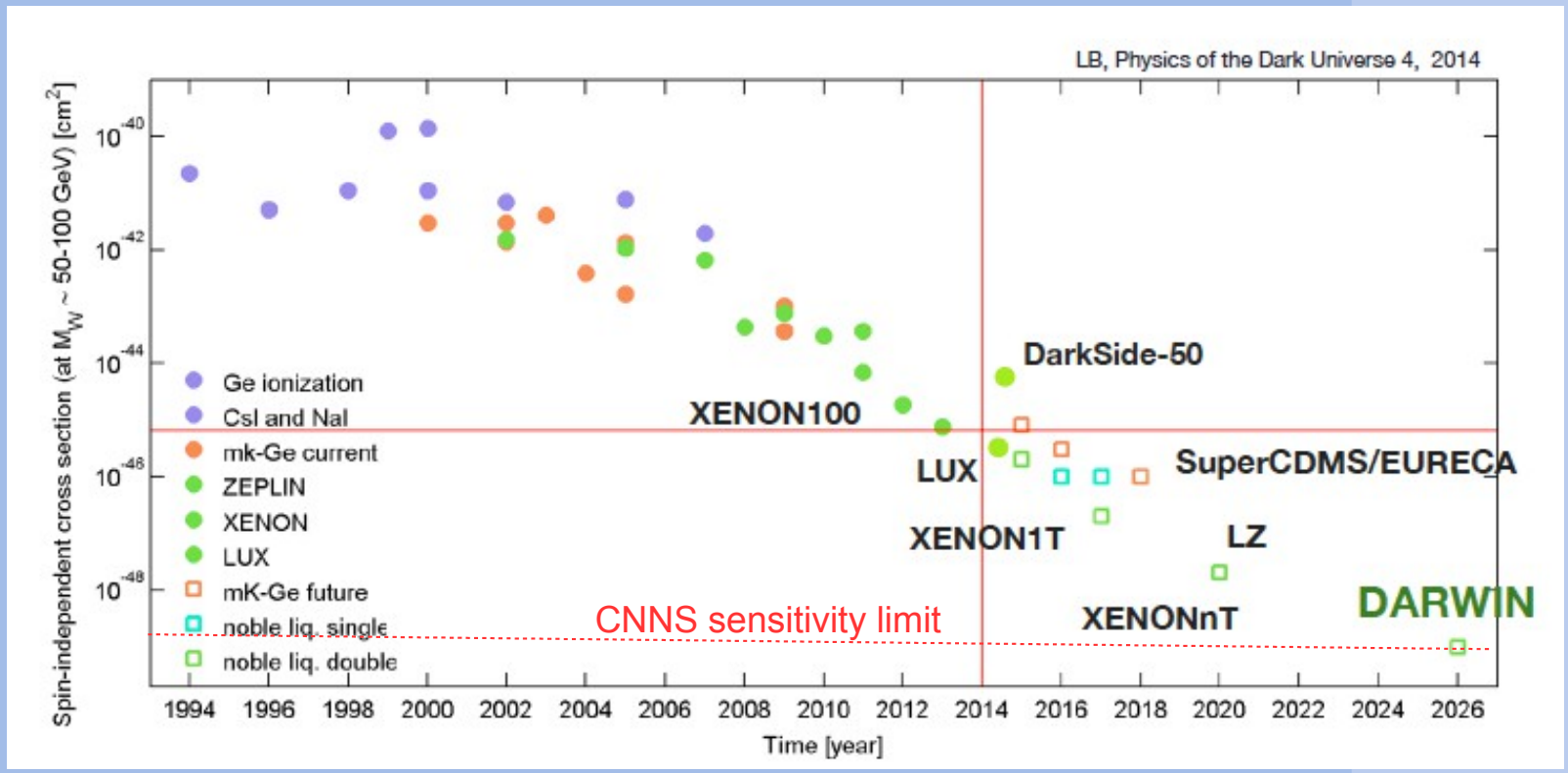
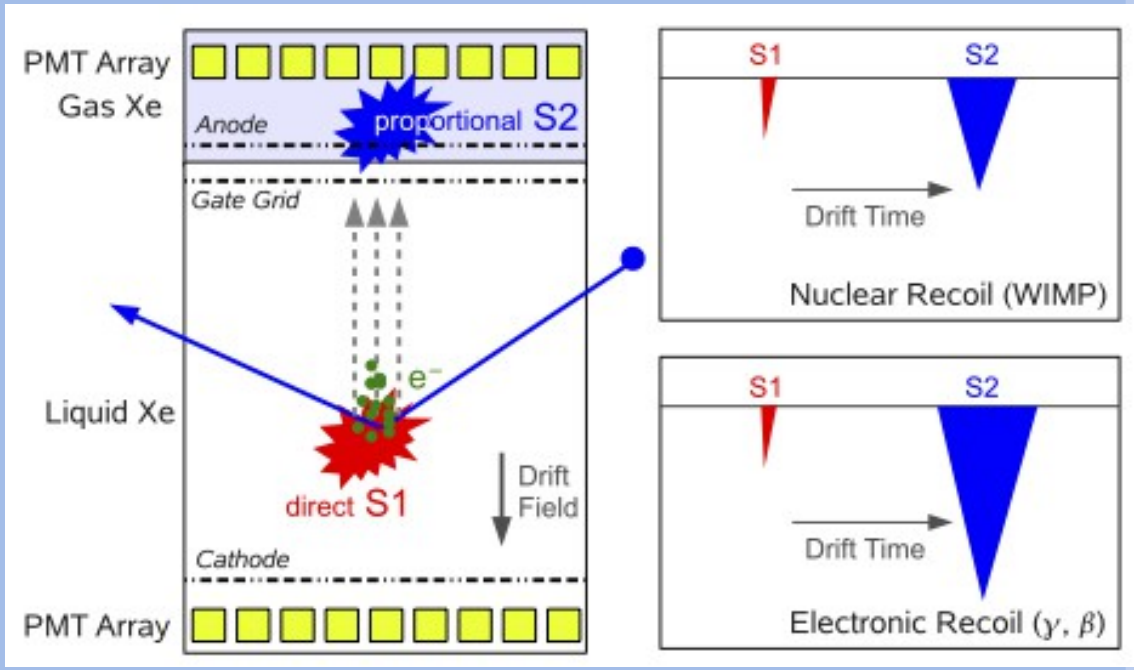


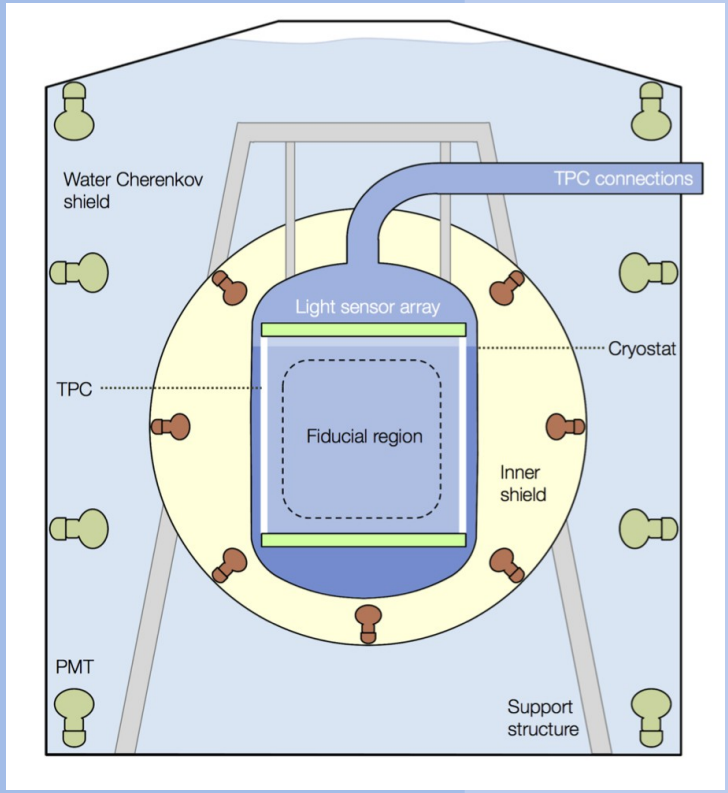
Liquid Xenon TPCs

- 3D position reconstruction → fiducialization
- ER/NR discrimination
- Removal of double scatters



DARWIN Setup

- Water Cherenkov shield (14m diameter)
- Liquid scintillator shield under study
- LXe TPC (2.6m diameter/height)
- Possible location LNGS



DARWIN TPC

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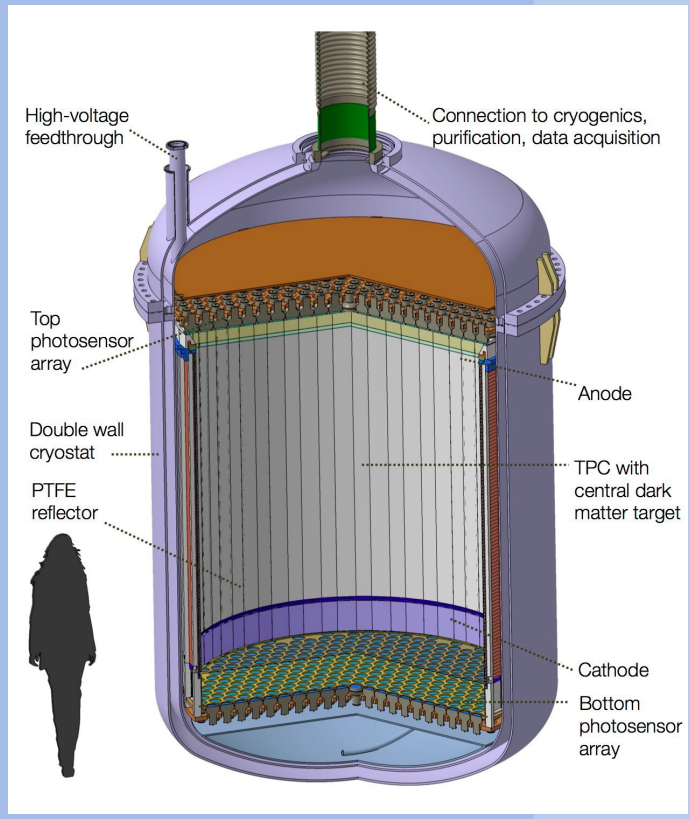
- SS/Ti/Cu cryostat (2.6m height/diameter)
- 40 tons LXe target
- ~1800x 3“ PMTs (1000x 4“)
- PTFE reflectors
- OFHC Cu field shaping rings



DARWIN Sensitivity: WIMPs

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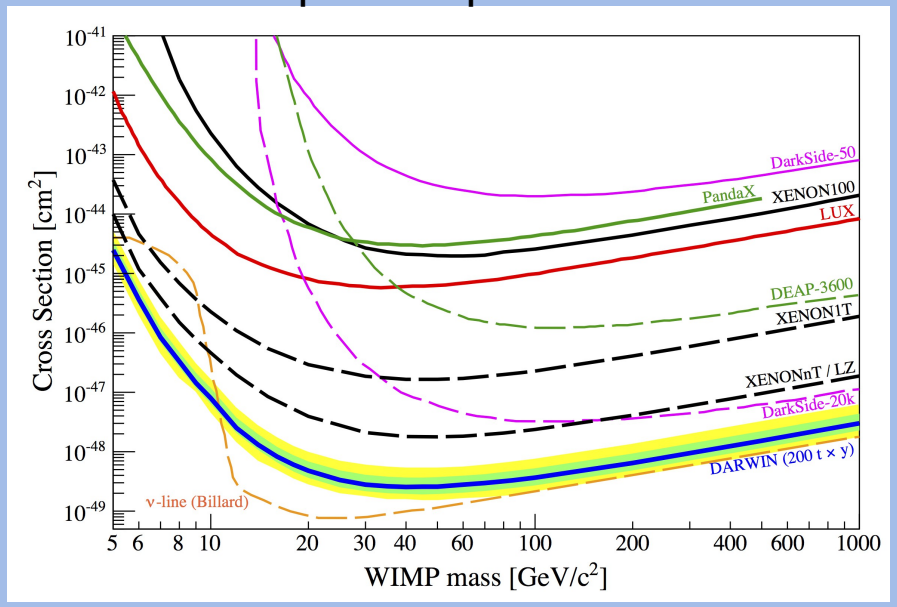
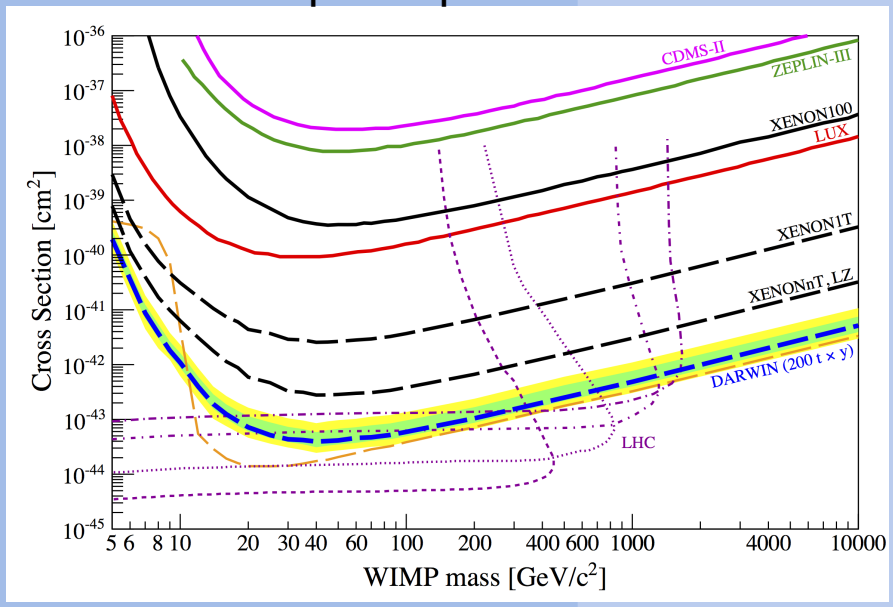
- 99.98% ER rejection, 30% NR acceptance

Spin independent



Spin dependent



WIMP Spectroscopy

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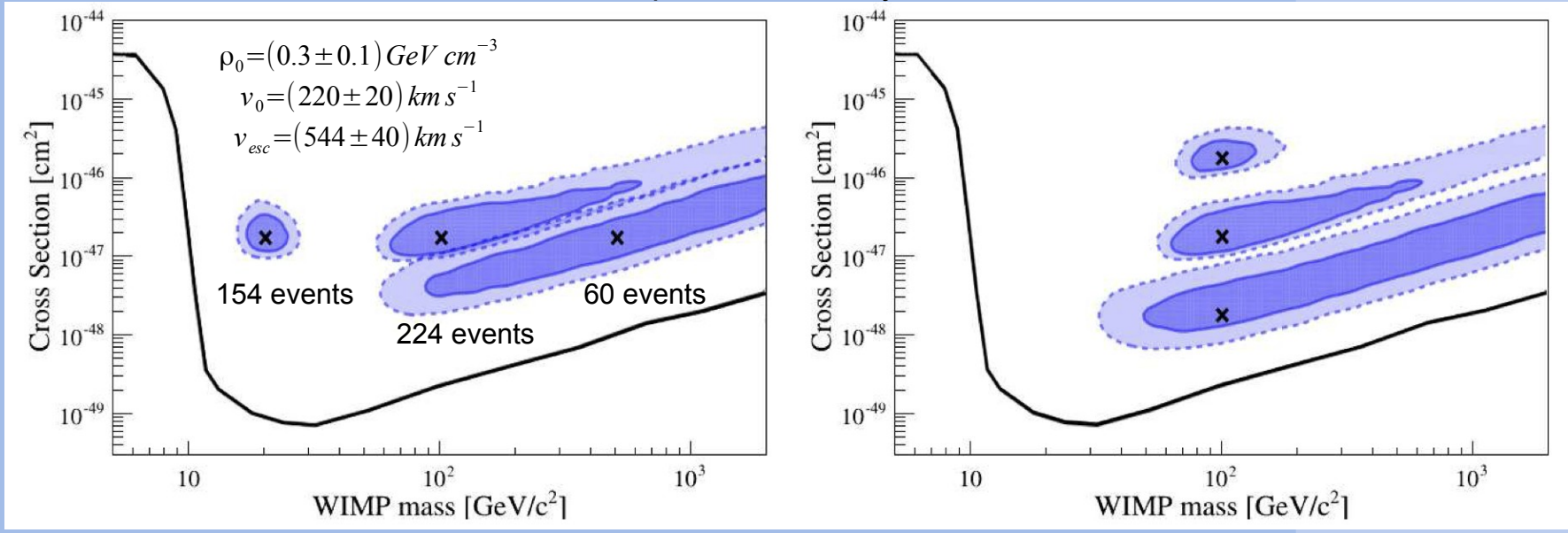
- Substantial uncertainty on WIMP properties for large masses and small cross sections

exposure 200 ton yr



arXiv:1306.3244

DARWIN Backgrounds: Neutrons

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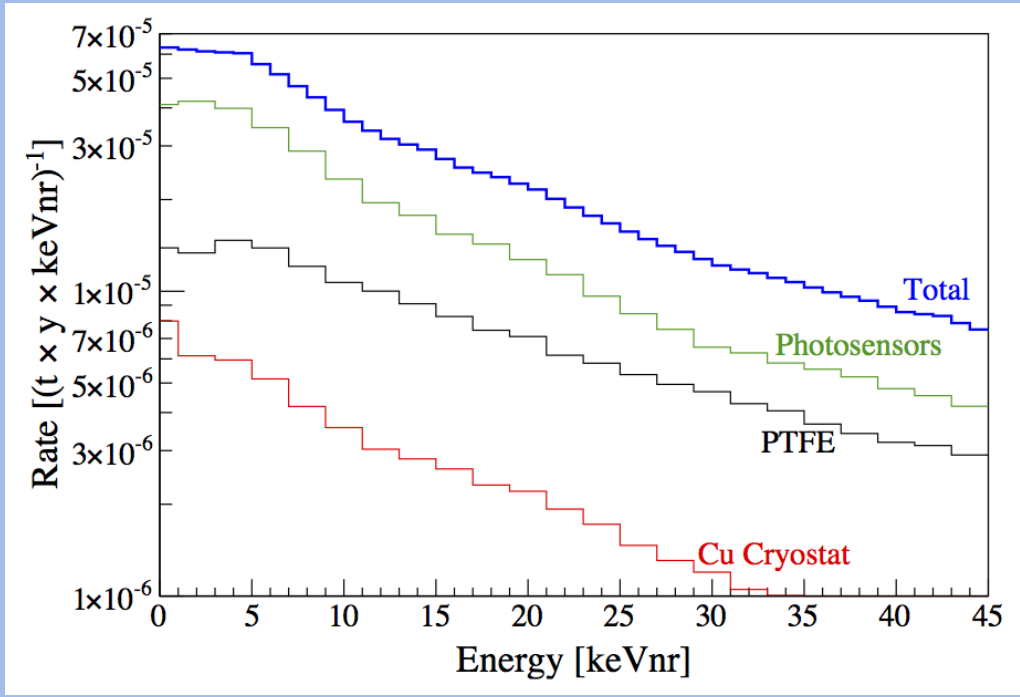
- Radiogenic neutrons
  - 3.8×10^{-5} events/t/yr/keV$_{nr}$
  - Radiopurity of materials has to be improved by factor 2-5



arXiv: 1506.08309

DARWIN Backgrounds: Electron Recoils

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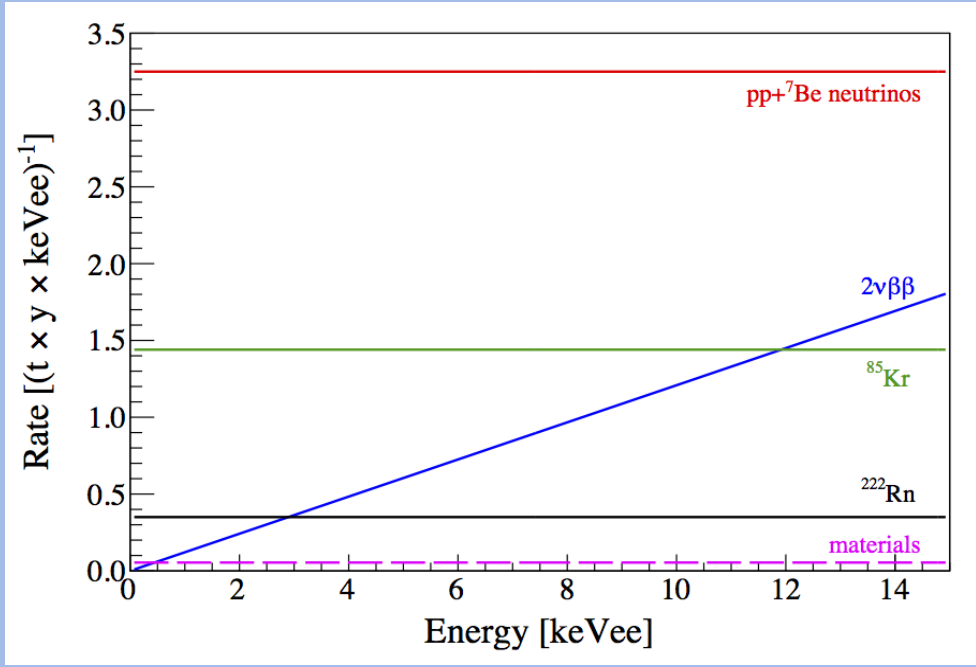
- Electron recoil background

Source	Goal	Achieved
^{85}Kr	0.1 ppt ^{nat}Kr	0.03 ppt (XENON1T)
^{222}Rn	0.1 μBq/kg	3.65 ± 0.37 μBq/kg (EXO)



arXiv: 1506.08309

DARWIN Backgrounds: CNNS

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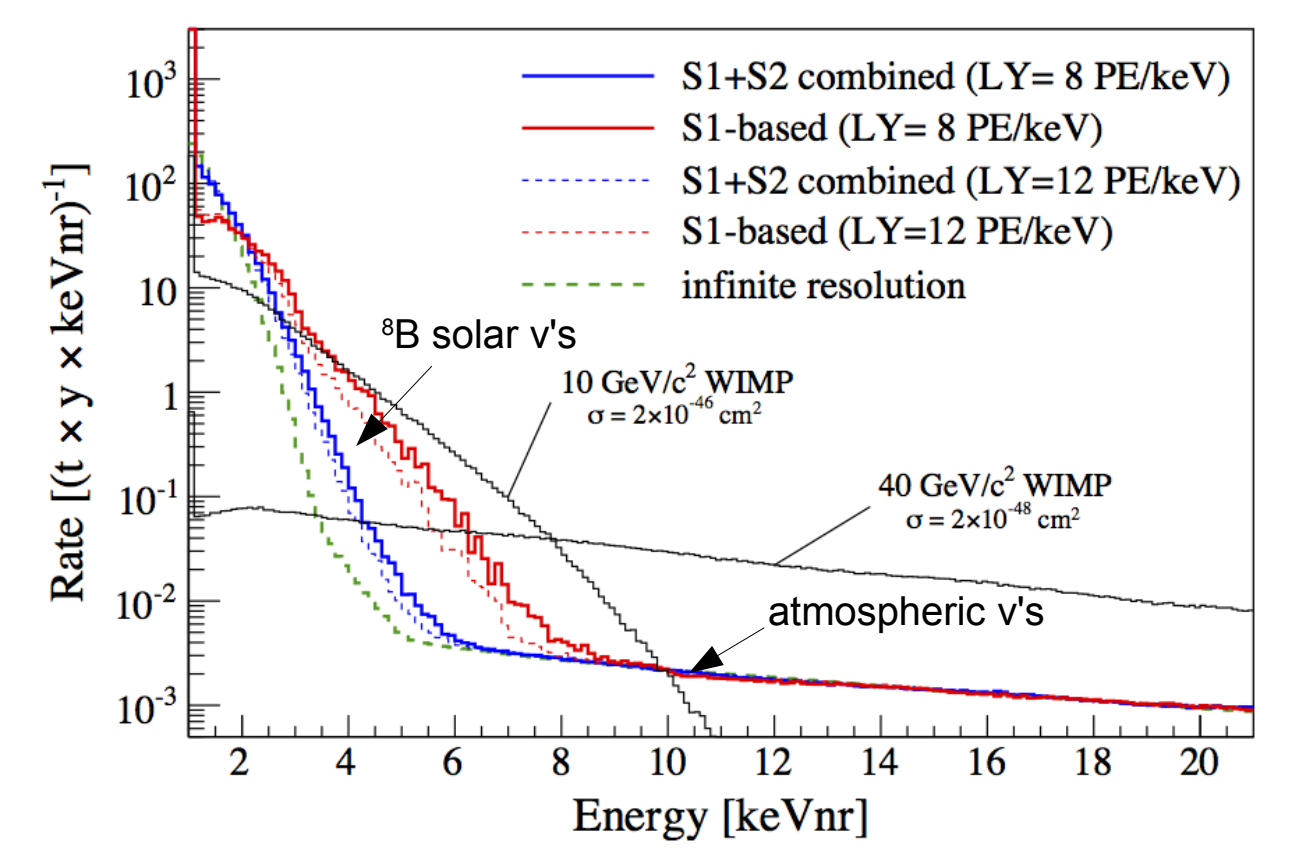
- Coherent Neutrino Nucleus Scattering



arXiv: 1506.08309

DARWIN Sensitivity: Axions

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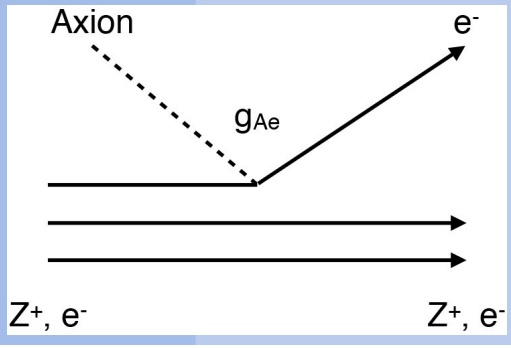
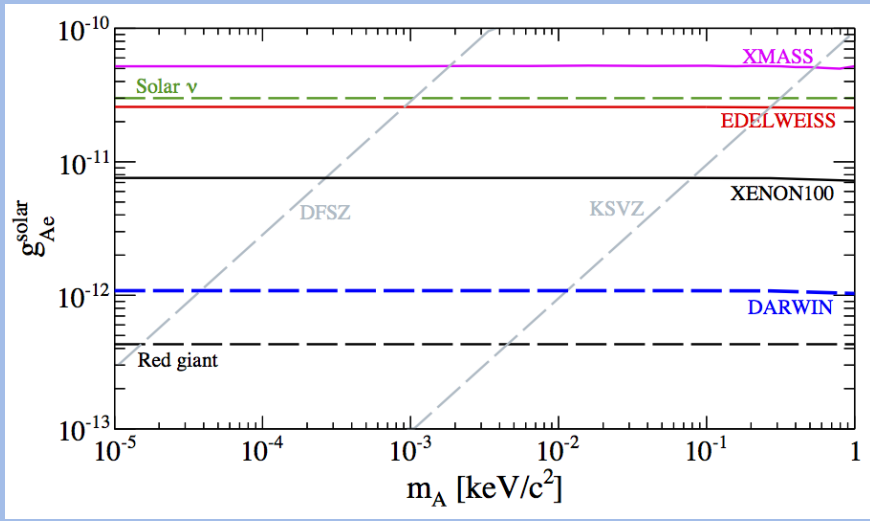
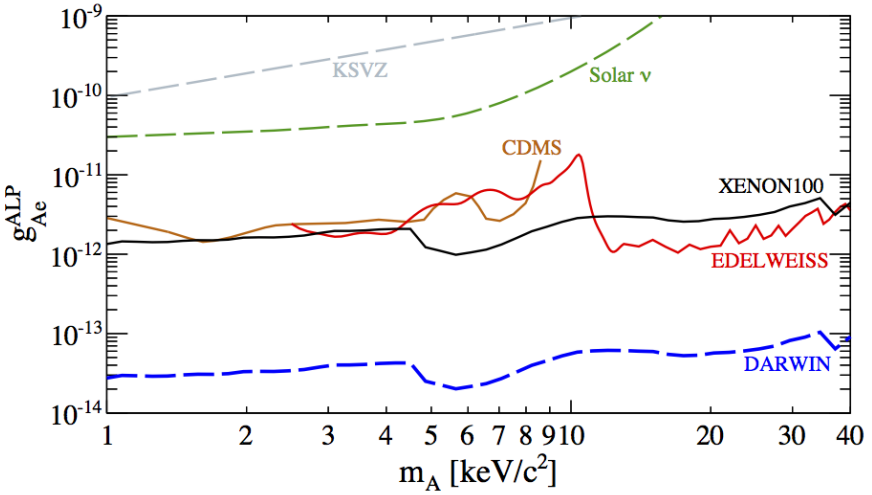
- Sensitivity to solar axions and galactic ALPs via axio-electric effect



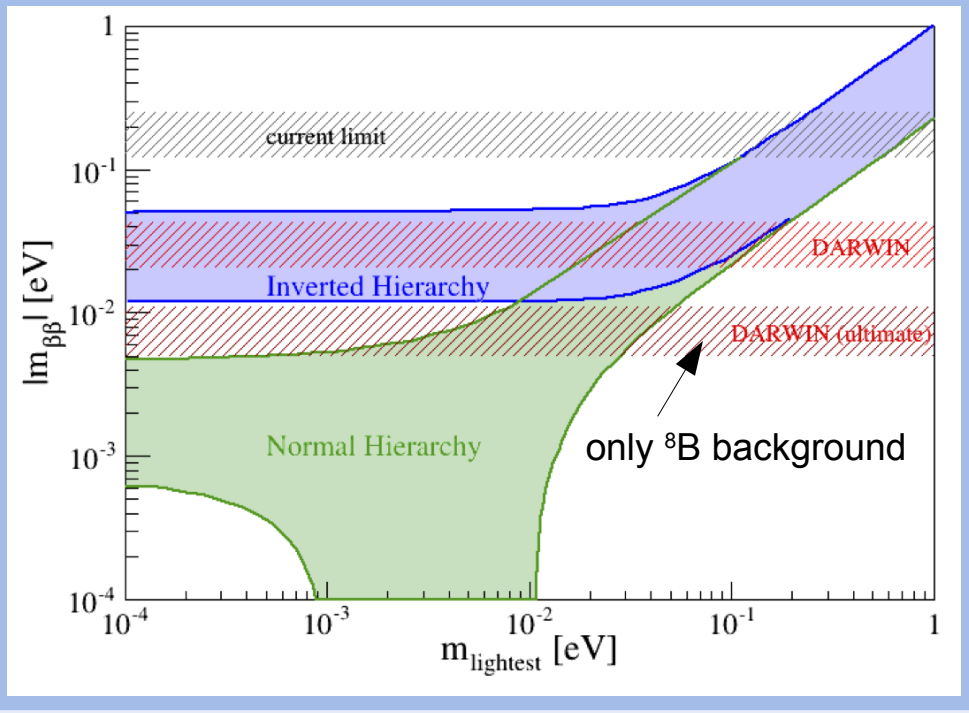




arXiv: 1209.3810

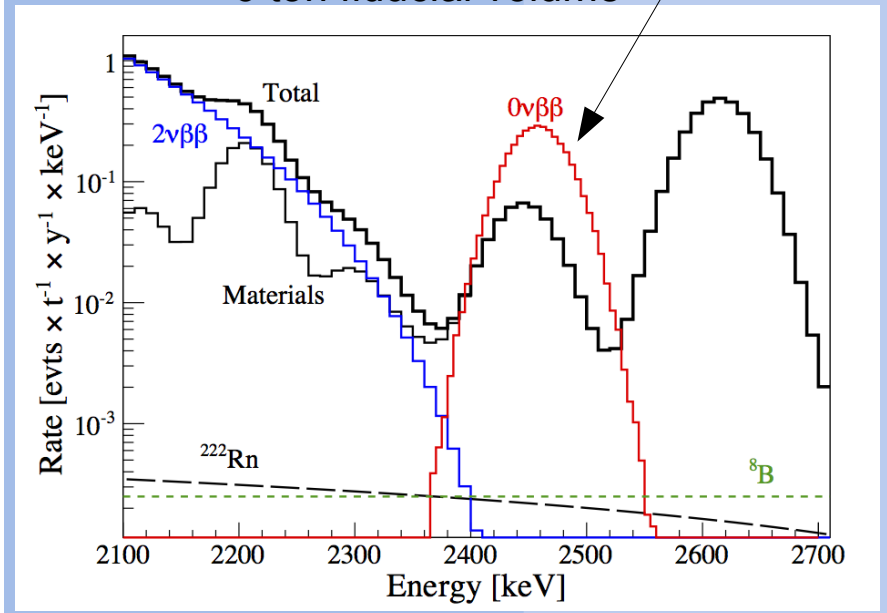
DARWIN Sensitivity: ^{136}Xe 0νββ

- Natural abundance 8.9%
- $T_{1/2} > 5.6 \times 10^{26}$ y for 30 ton yr ($> 8.5 \times 10^{27}$ y for 140 ton yr)



$T_{1/2} = 1.6 \times 10^{25}$ y

6 ton fiducial volume



arXiv: 1309.7024

DARWIN Sensitivity: Solar Neutrinos

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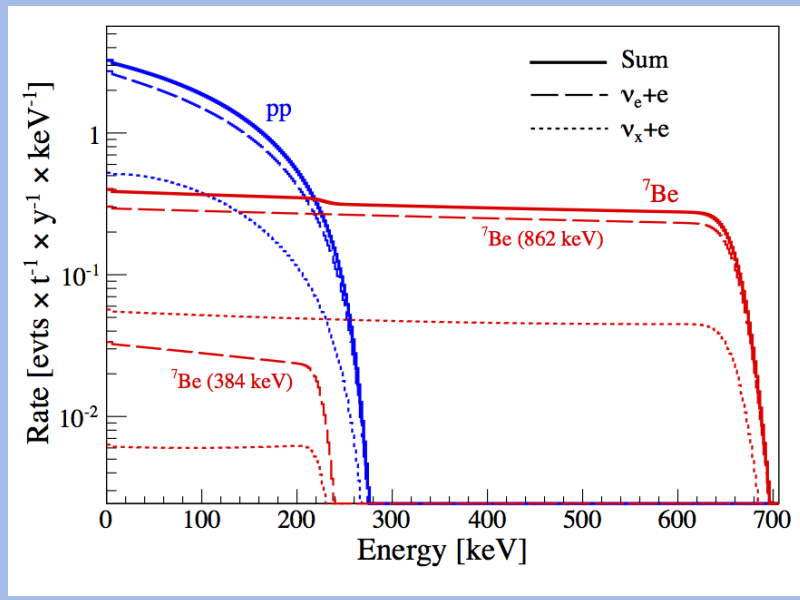
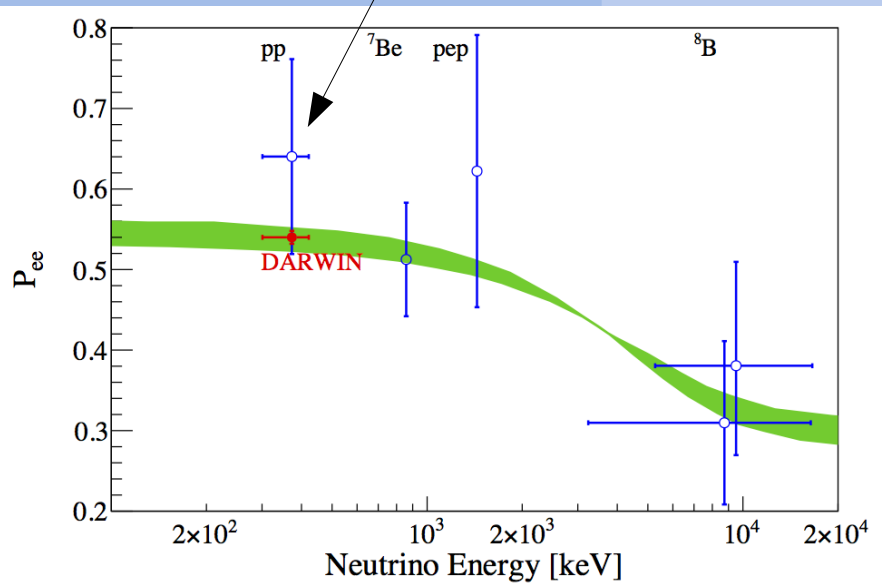
- Realtime measurement of pp-neutrino flux
- < 1% precision after 5 years

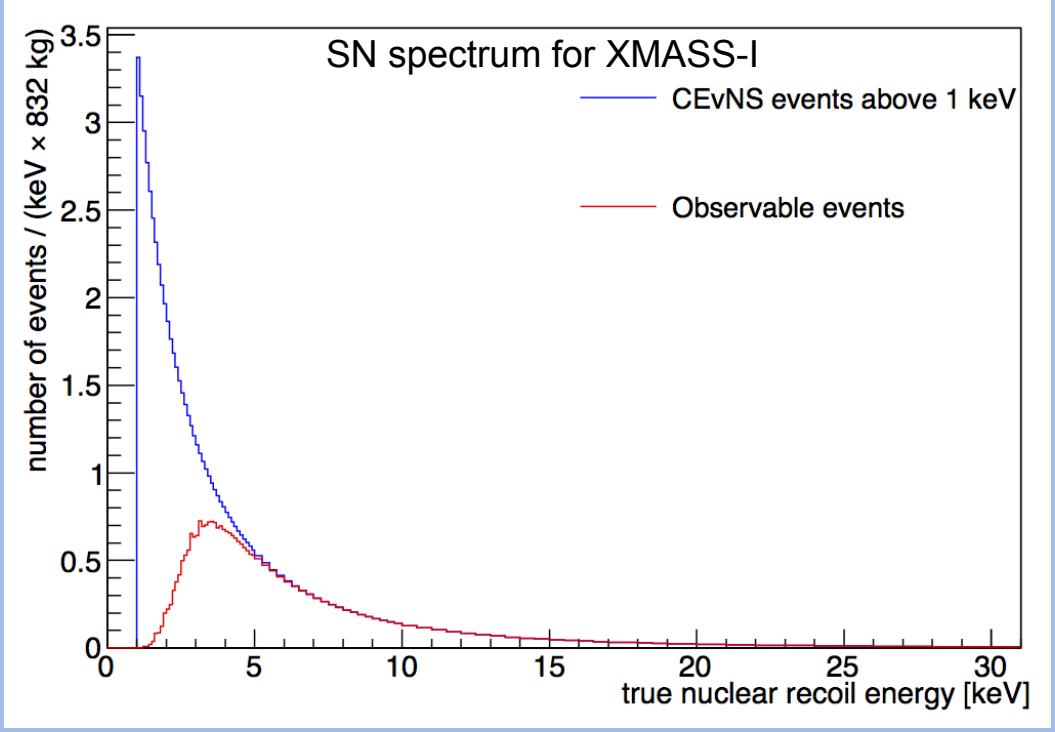
BOREXINO (Nature 512, 2014)





DARWIN Sensitivity: Supernova Neutrinos

- ~100 events from galactic SN
- Detection of all flavors via CNNS
- Negligible background due to short burst (~sec.)



arXiv: 1604.01218

DARWIN Technical Challenge: HV

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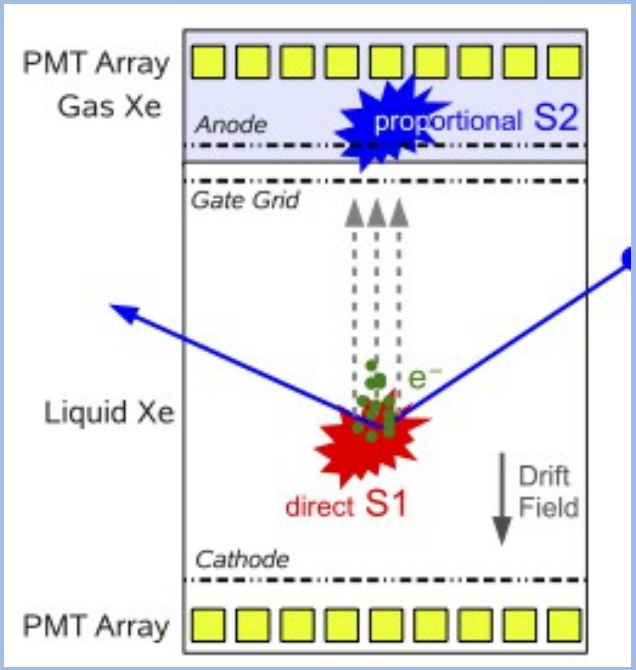
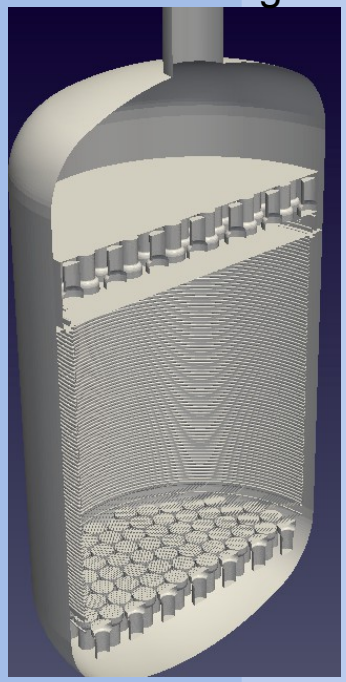
- Drift field 0.5-1kV/cm requires cathode voltage of 130-260kV
- Cathode: 100 µm thin wires for good optical transparency
- Anode: constant gap, parallel to liquid surface over 2.6m
- 3D field simulations based on BEM



BEM simulation geometry



DARWIN R&D: LHM

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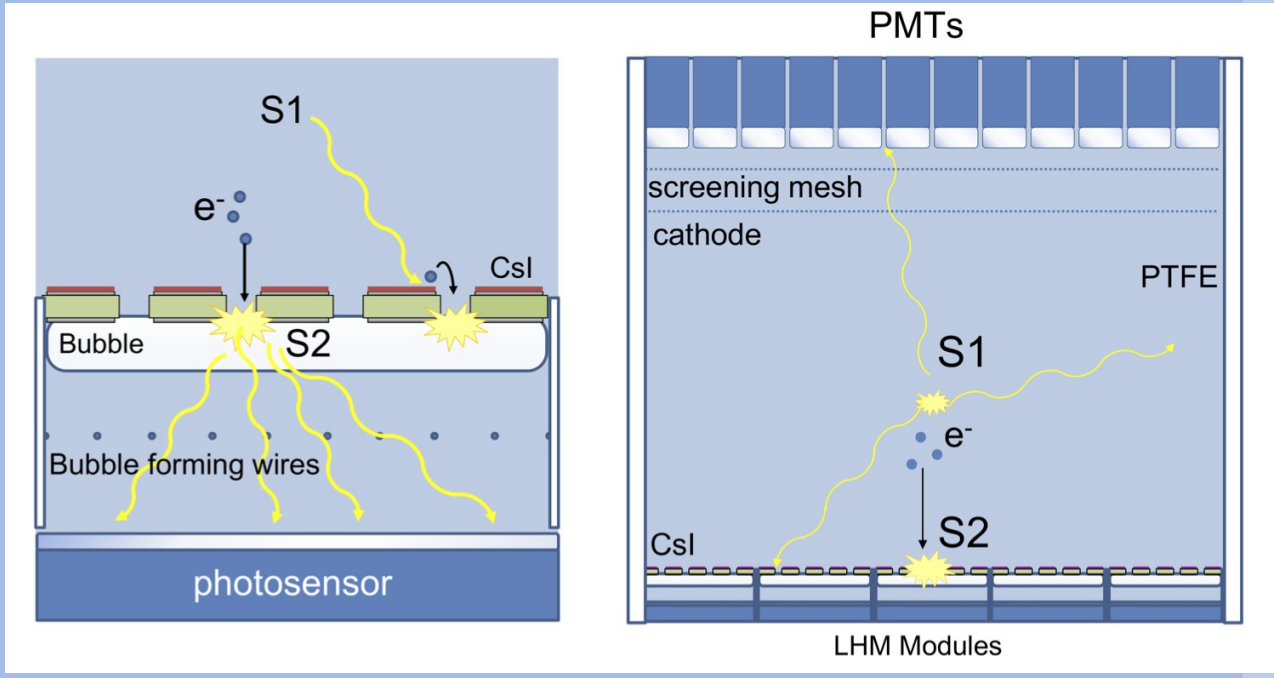
- Baseline design PMTs, alternatives: SiPM, SiGHT, GPM
- Single Phase TPC with Liquid Hole Multipliers (LHM)
  - No liquid-gas interface
  - No anode grids



arXiv: 1603.07669

DARWIN Consortium

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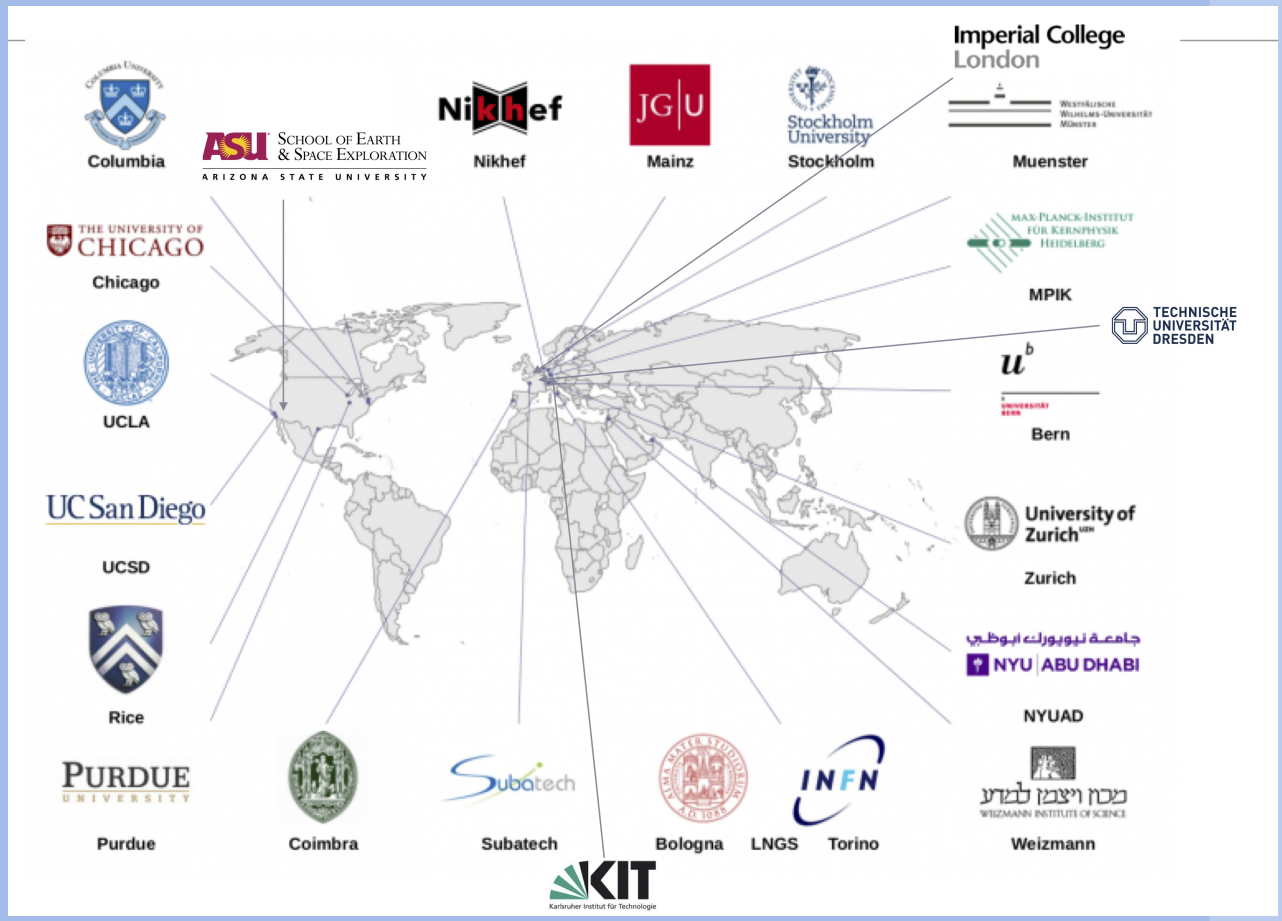
- 25 groups from 11 countries



Conclusions

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- DARWIN: multi-purpose rare event search
  - **WIMPs**: $\sigma_{SI} < 2.5 \times 10^{-49} cm^2$ @ $40 GeV/c^2$
  - **solar axions**: $g_{Ae} < 10^{-12}$ for $10^{-5} < m_A < 1$ keV/c^2
  - **ALPs**: $g_{Ae} < 10^{-14}$ for $1 < m_A < 40$ keV/c^2
  - **pp-neutrino flux**: <1% precision after 5 years
  - **0v2β ^{136}Xe**: $T_{1/2} > 8.5 \times 10^{27}$ y after 140 ton yr
  - **CNNS**: ~20 events/ton/yr from ^{8}B
  - **Supernova neutrinos**: ~10-20 events/ton for 10kpc

DARWIN Timescale

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2016	2017	2018	2019	2020	2021
R&D and design study			Engineering studies		
		CDR/TDR	demonstrators		

2022	2023	2024
construction	comissioning	science run

DM Complementary

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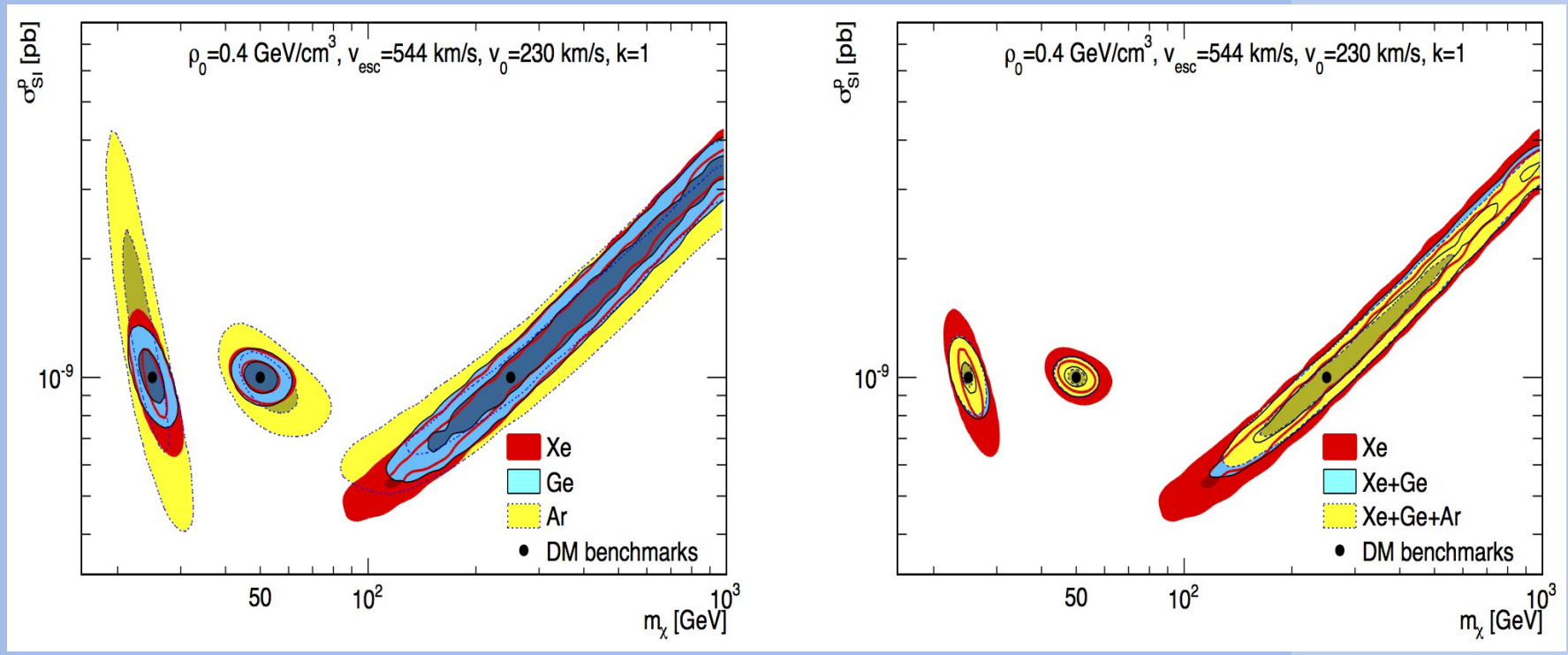

DARWIN Light Yield

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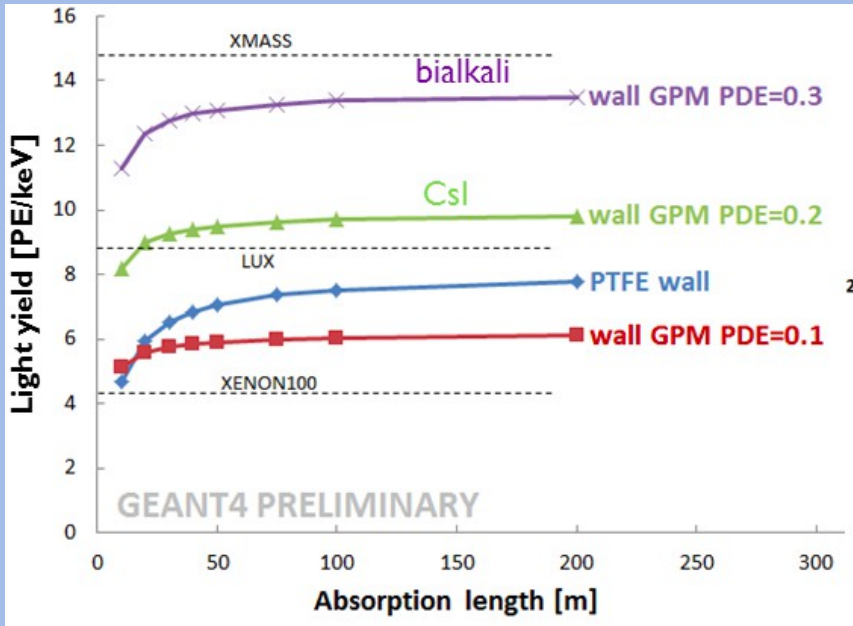

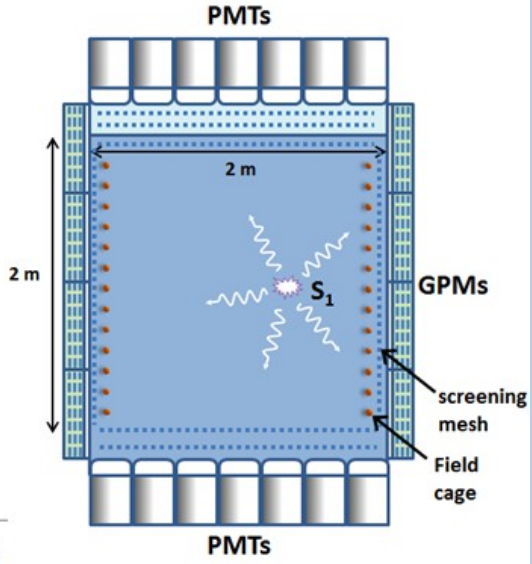

Light yield for 122 keV, E = 0

PDE = photon detection efficiency

(for photons hitting the GPM window)

- PTFE reflectivity = 95%
- Rayleigh scattering length = 30 cm
- XENON1T PMTs and meshes
- 90% transparent field cage