

A blurred photograph of a laboratory or industrial setting. Several people wearing hard hats are visible, working at a long table or bench. The scene is lit with overhead fluorescent lights, creating a sense of motion and activity. The overall color palette is dominated by cool blues and greys.

DARWIN

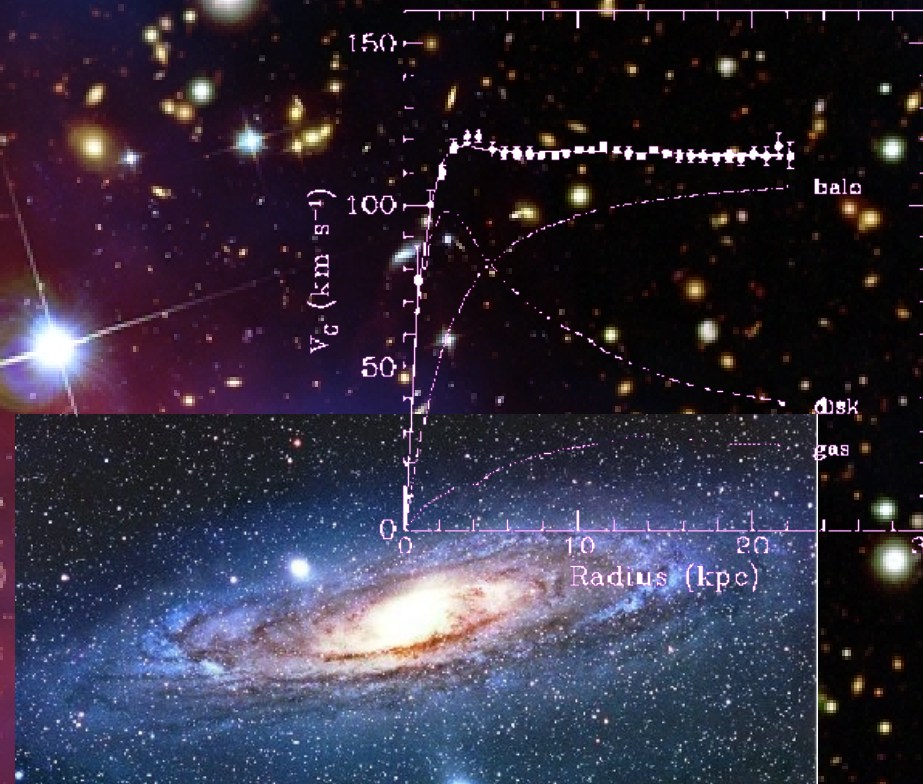
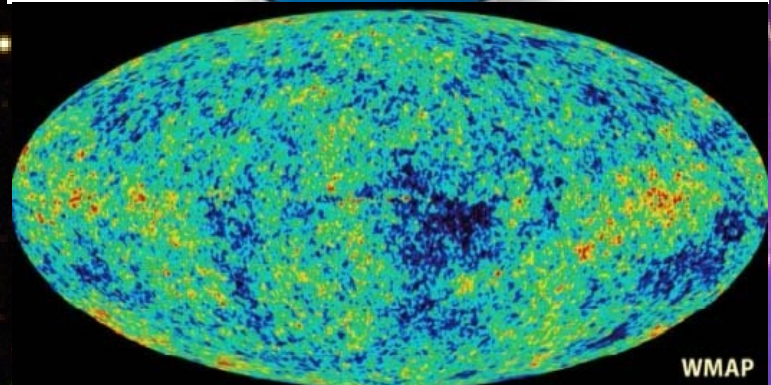
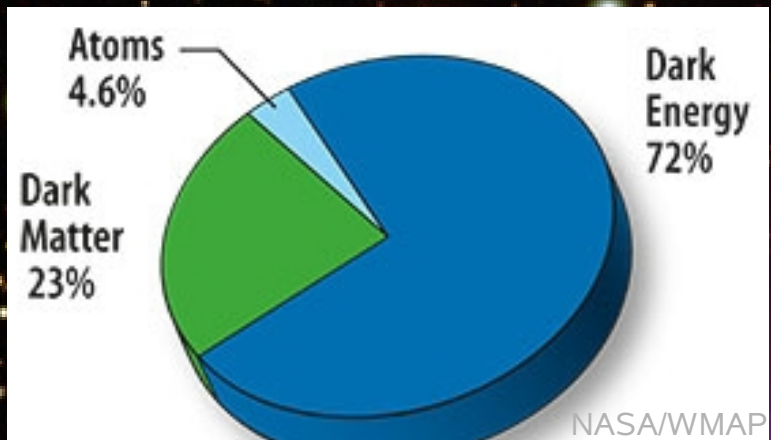
DARWIN

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Aspera Technology Forum 2010, October 21-22, 2010

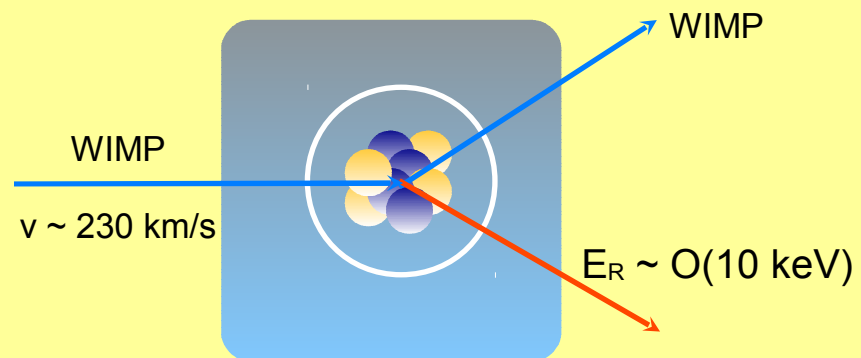
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Dark Matter: Evidence & Detection

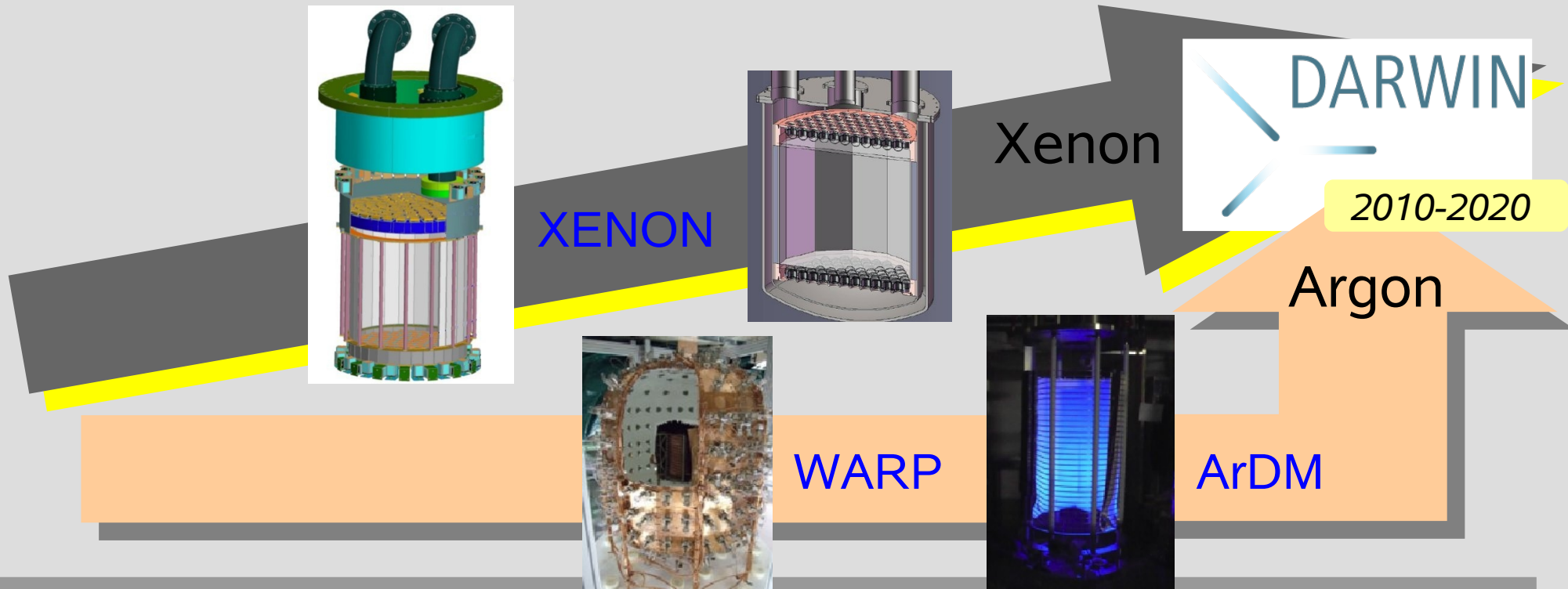


Direct Detection:

Elastic Scattering of WIMPs off target nuclei
→ nuclear recoil



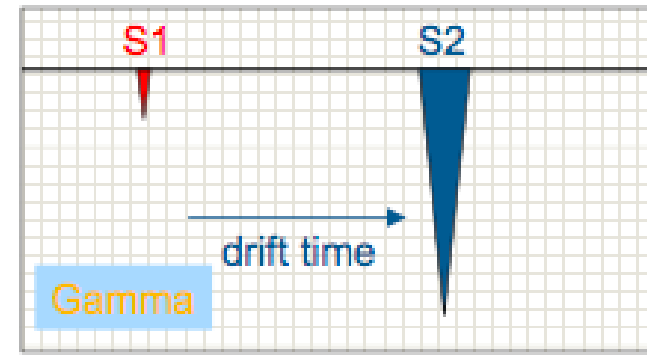
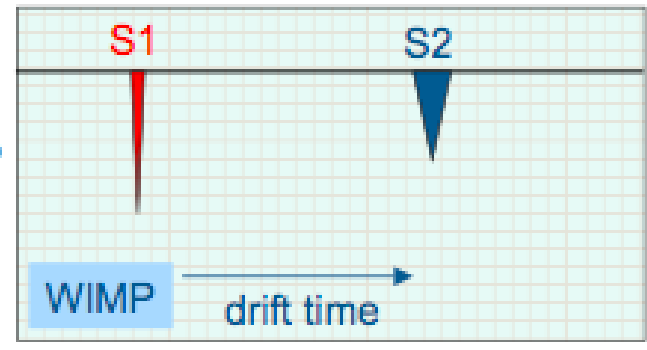
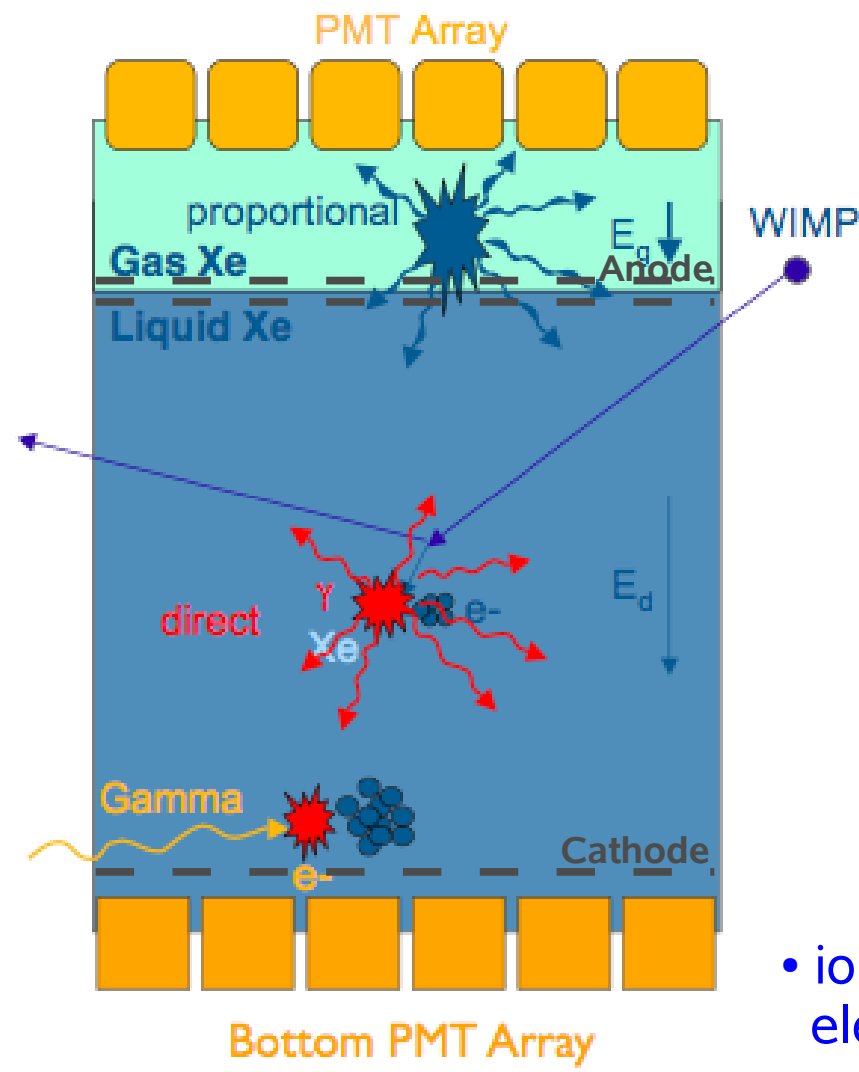
DARWIN - Overview



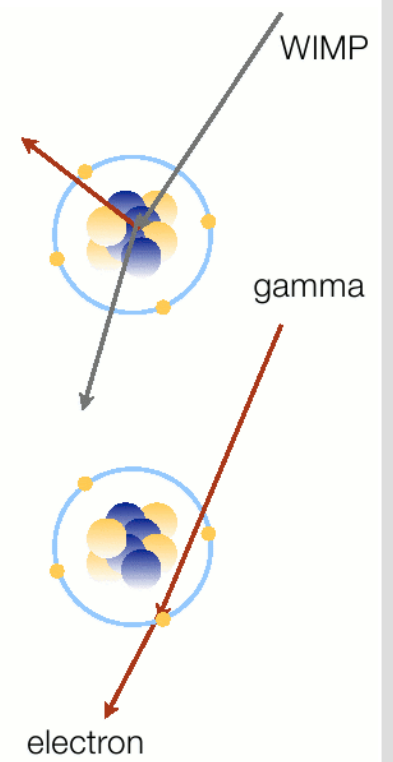
DARWIN – Dark Matter WIMP Search with Noble Liquids

- *R&D and Design Study* for a next generation noble liquid facility in Europe. Approved by ASPERA in late 2009
- Coordinate existing European activities in LXe and LAr towards a multi-ton Dark Matter facility
- Physics goal: probe WIMP cross sections well below 10^{-47} cm²

DARWIN: Dual Phase TPC



$$(S2/S1)_{wimp} \ll (S2/S1)_{gamma}$$

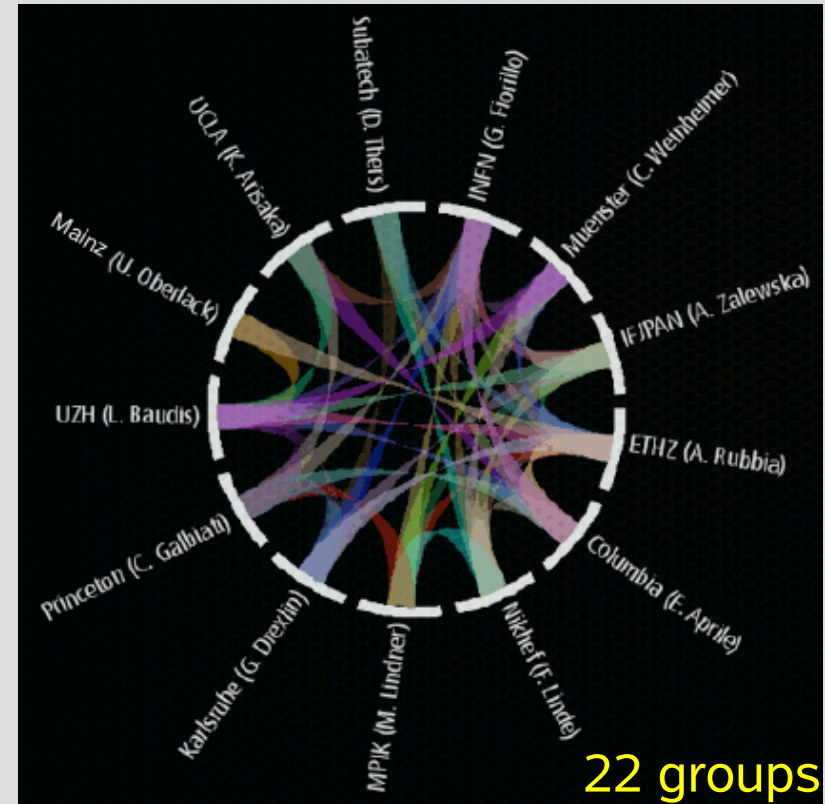
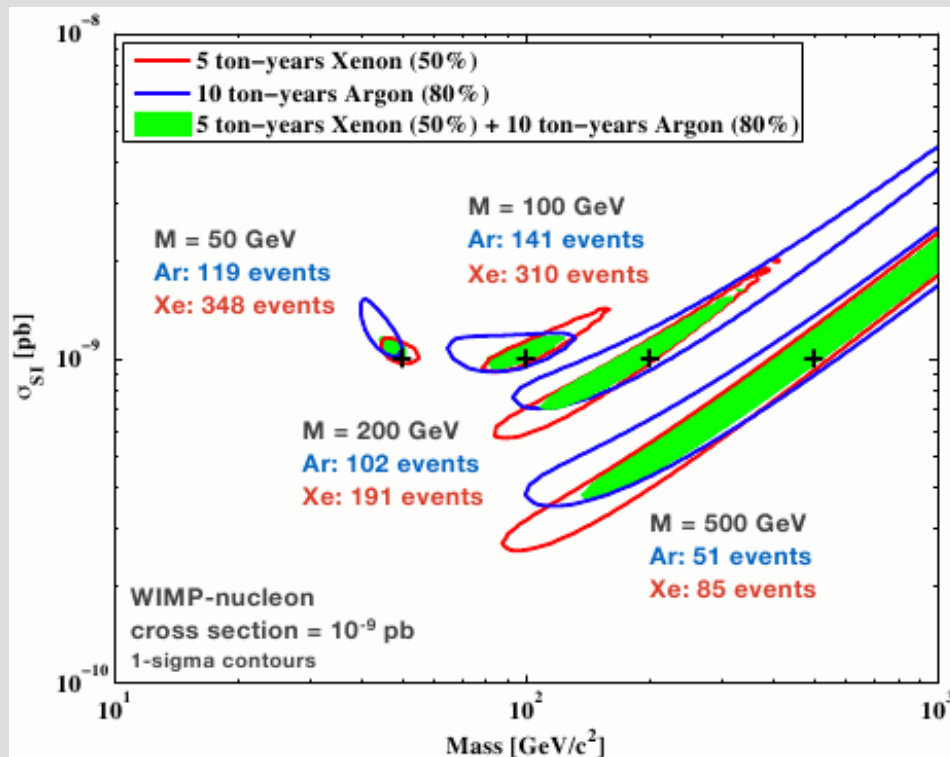


- ionization/scintillation ratio ($S2/S1$) allows electron recoil rejection to >99.5%
- 3D position reconstruction in TPC
- Pulse Shape Discrimination in LAr

Goals and Structure



R&D and Design Study for
 Light/Charge Readout, Electronics/DAQ,
 Detector/Underground/Shield Infrastructure,
 Material Screening/Backgrounds, Science Impact
 Multiton LXe and/or LAr WIMP detector
 find best choice/design, exploit complementarity?



ArDM, WARP, XENON Groups:
 UZH (CH), INFN (I), ETHZ (CH),
 Subatech (F), Mainz (D), MPIK (D),
 Münster (D), Nikhef (NL), KIT (D),
 IFJ-PAN (PL)
 + Columbia, Princeton, UCLA (USA)

<http://darwin.physik.uzh.ch>

DARWIN is a **Design Study**
for a next-to-next generation
Dark Matter detection experiment
based on LXe/LAr

Most technical requirements
have not been defined yet.
They are the outcome of
the DARWIN study.

Key Requirements:

- lowest radioactivity
- large number of channels
[$\sim O(1000)$ \rightarrow large data amount]
- high sensitivity (QE) in order to reach low threshold
- large area sensors
- operation in cryogenic liquid
- moderate cost

3 Workpackages (WP)

WP3: Light Readout

- **Photodetectors**

- (a) large area PMTs

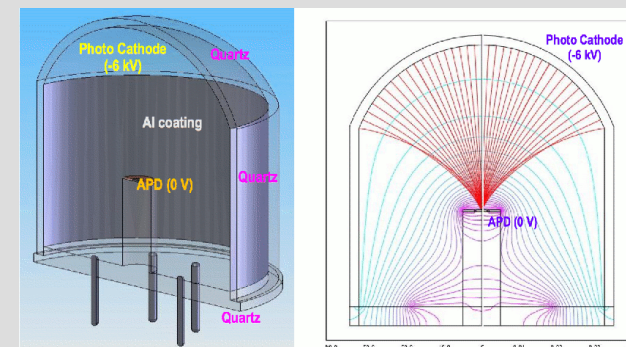
- low radioactivity
 - high QE, high collection efficiency
 - operation at cryogenic temperatures

- (b) hybrid detectors with large cathode and solid state e-multiplier (QUPID)

- extremely low radioactivity
 - for LXe and LAr

„Classic“ Approach:

The same photosensors detect S1 (light) and S2 (charge) signal.



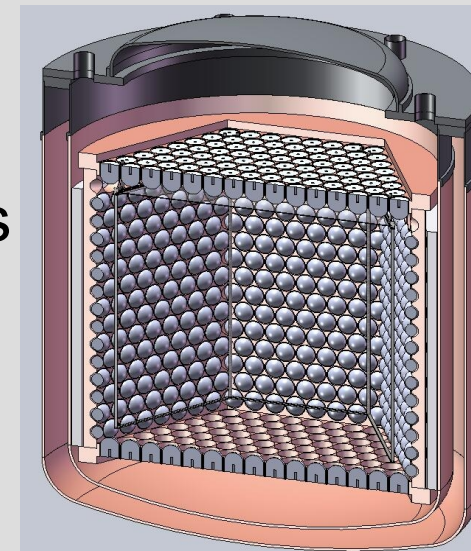
- **UV light collection**

- (a) co-doping of Ar with Xe (\rightarrow shift light emission)

- (b) LAr: wavelength shifters, coating of light sensors

- (c) surface properties of materials (reflection, diffusion)

- (d) 4 geometry: challenges? Light guides?



- **Idea:**

- good position resolution for signal / background discrimination
- charge cloud in TPC is very localized (<1 mm)
- large scale charge readout structures can keep this information

Goal: Investigate and develop new concepts for readout of ionization produced in keV energy events, independent of scintillation readout.

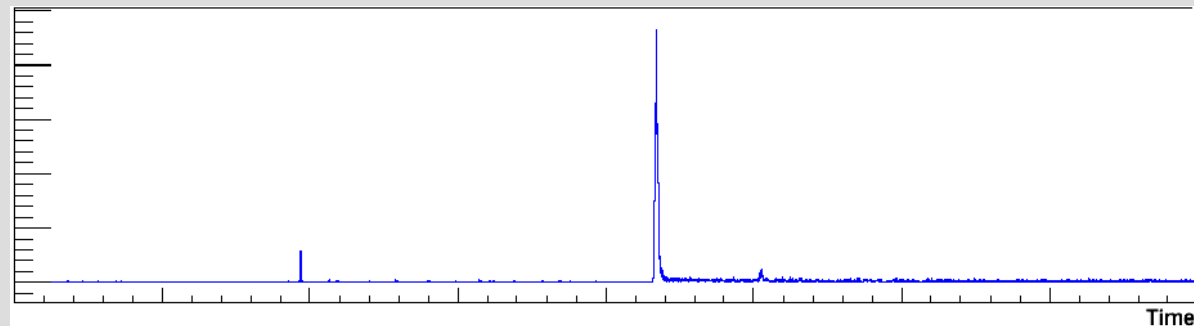
- **Approach:**

- (a) Large cryogenic LEM / THGEM / Micromegas for noble liquids
→ charge amplification in holes (GEM)
- (b) Gaseous PMTs without dead zone
→ separation with MgF₄ window allows use of quencher
- (c) CMOS pixel detector coupled to electron multipliers (GridPix)
→ low radioactivity is possible

Goal: identify electronics, DAQ, and data processing solutions for large-scale noble liquid experiments

1. Low noise electronics for light and charge readout

- amplifiers for QUPIDs / charge readout structures
- FADCs: large bandwidth and fast sampling (100 MHz – 1 GHz)
- intelligent data reduction algorithms (long drift times)
- cabling studies
(→ purity, cross talk)
- study possibility to digitize directly on sensor



2. DAQ and trigger

- intelligent trigger, multi-stage trigger
- multi-hit veto, high energy veto, first online analysis

3. Common computing resource center

- increased demand for computing power
- MC, data storage, duplication, processing, analysis

Summary

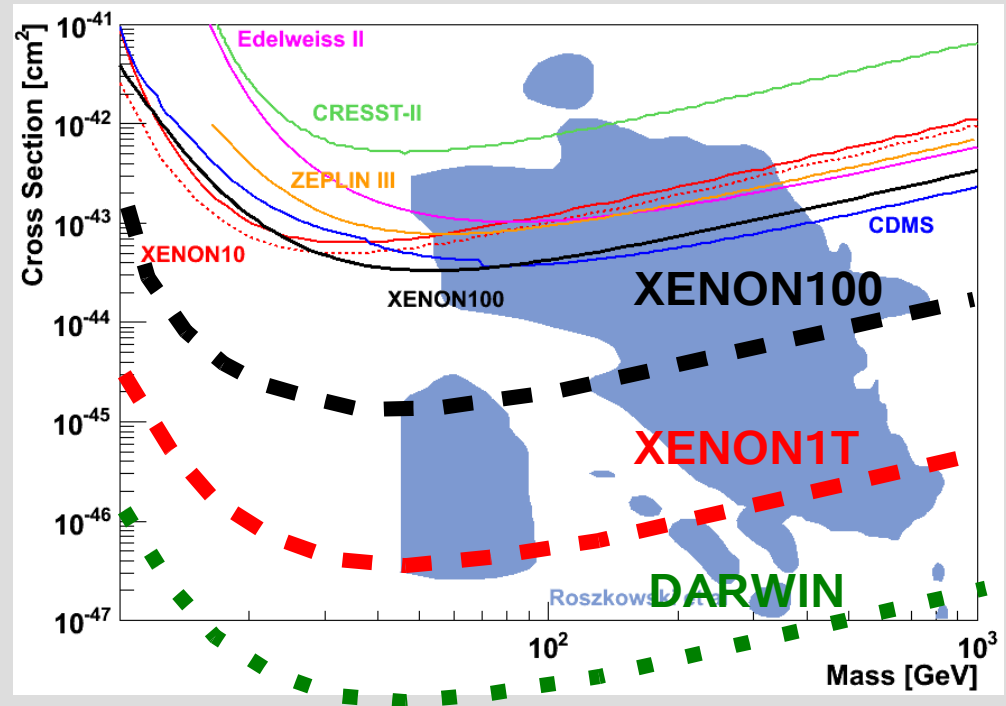
- **DARWIN:**

a multiton LXe/LAr detector to explore cross sections well below 10^{-47} cm^2

- design study approved by ASPERA, timeline 2010 — end 2012
- outcome will be a proposal for the DARWIN facility

Technical Challenges:

- lowest radioactivity
- large number of channels
- high sensitivity (QE)
- large area sensors
- operation in cryogenic liquid
- moderate cost



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