The Hunt For Dark Matter With Liquid Xenon

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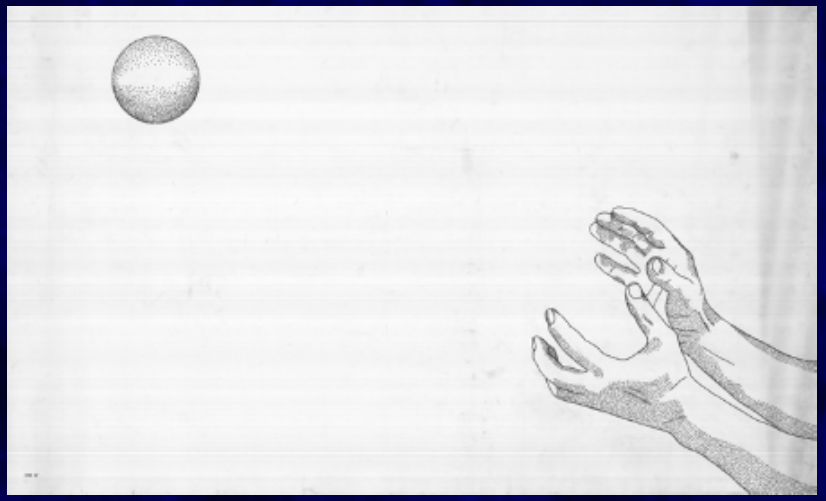
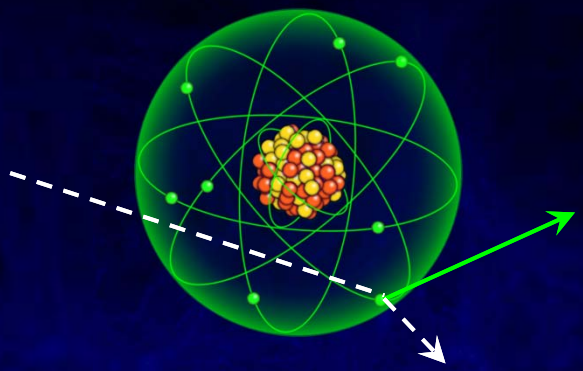
Yes, Dark Matter Exists

- We already know of one form (neutrinos), now we search for WIMPS
  - Low energy
- Search using liquid scintillators
  - XENON10, XENON100, XENON1T

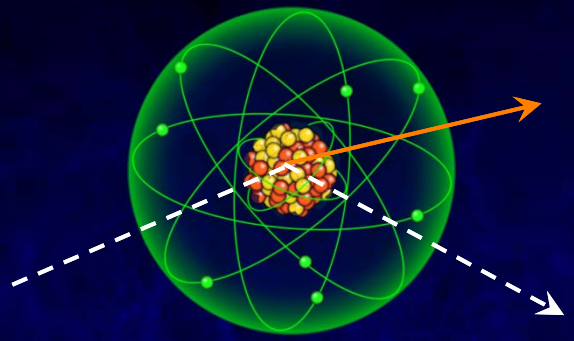


The Power of Discrimination

e^-/γ: electronic recoil



n/WIMPs: nuclear recoil



electronic recoils

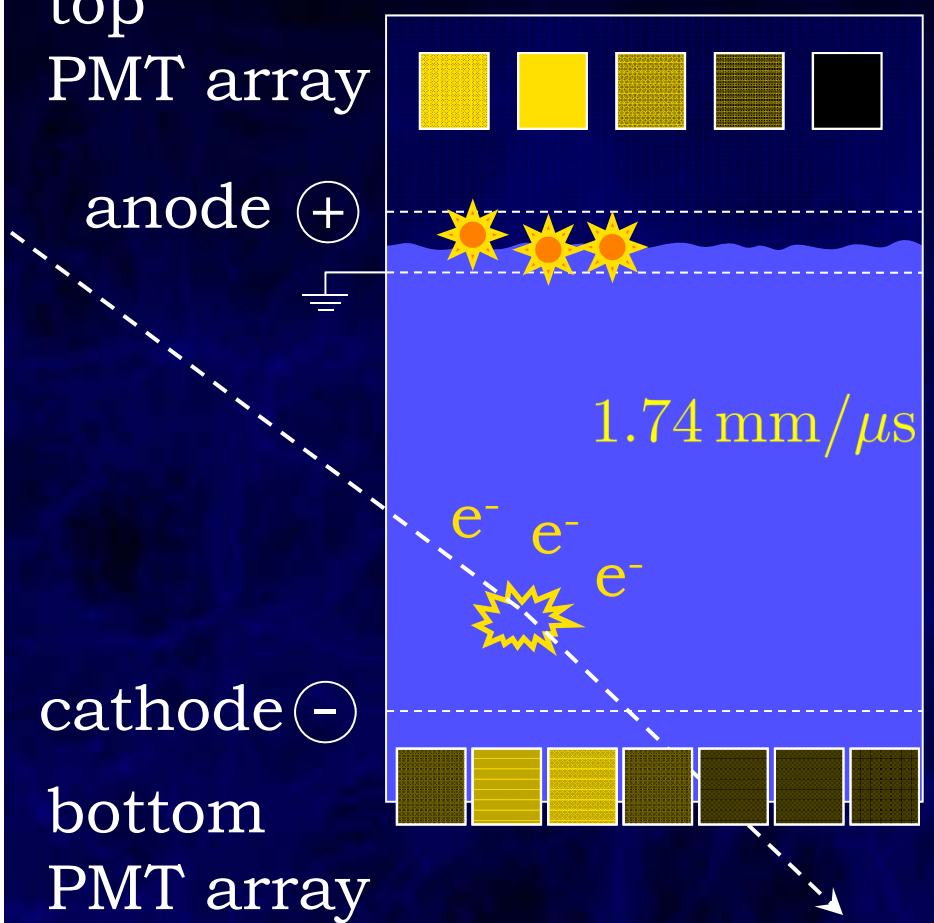
- are most common background
- scintillate and ionize more (for given energy)

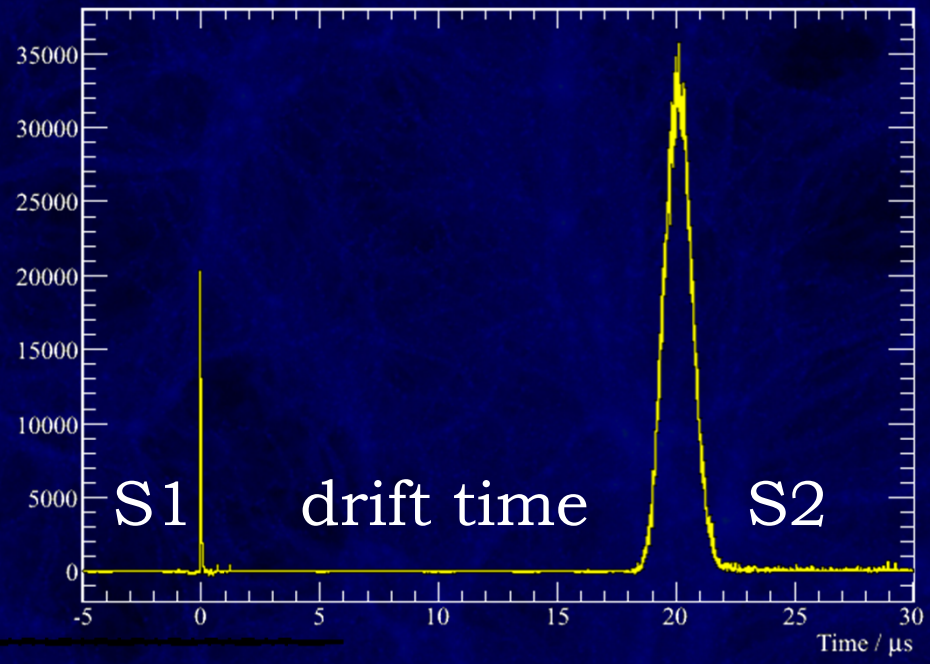
→ discriminate between the two

e.g. measure both energy and some additional parameter (ionization yield, scintillation yield, ratio ionization/ scintillation)

Dual-Phase Xenon TPC

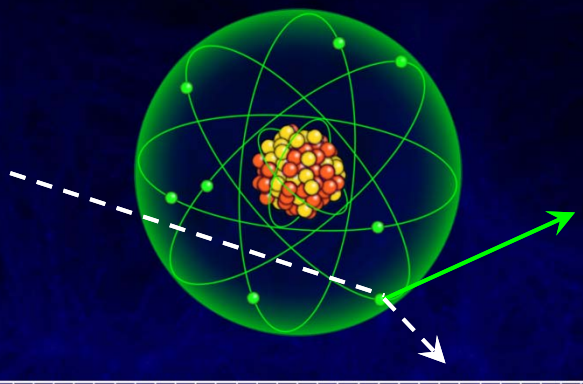
3D position information
S2 hit pattern: $\Delta r < 3\,\mathrm{mm}$
drift time: $\Delta z < 300\,\mu\mathrm{m}$

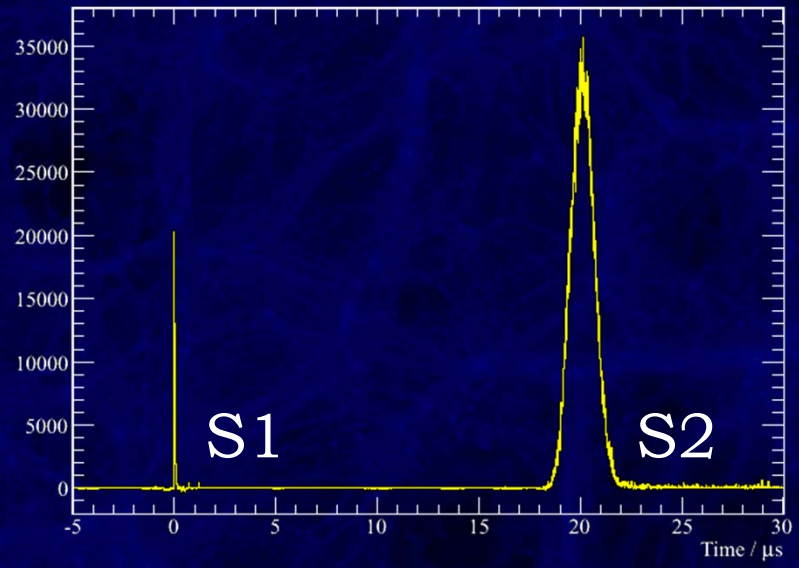




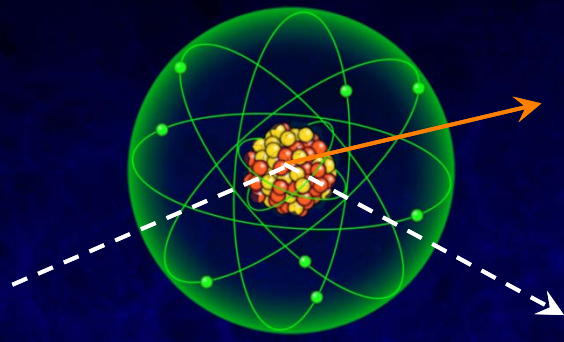
Recoil Discrimination > 99%

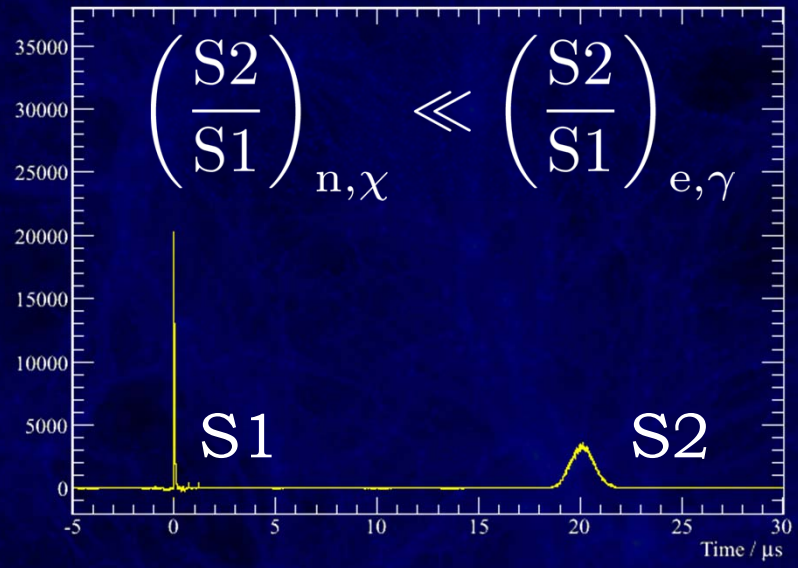
e^-/γ: electronic recoil





n/WIMPs: nuclear recoil



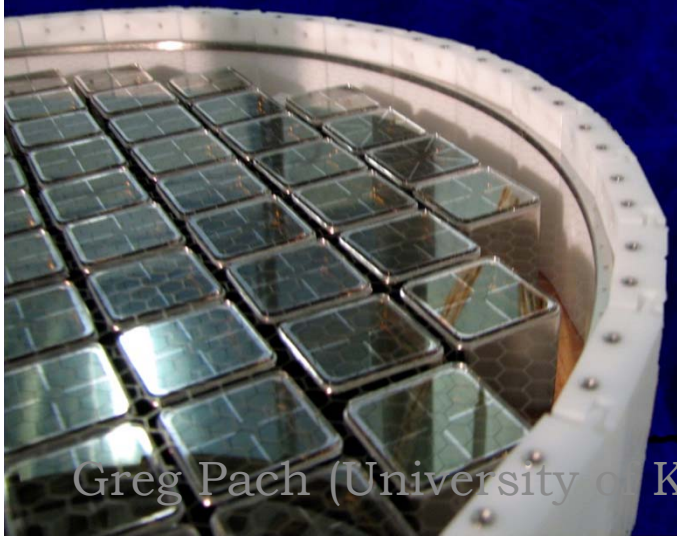


(illustration)

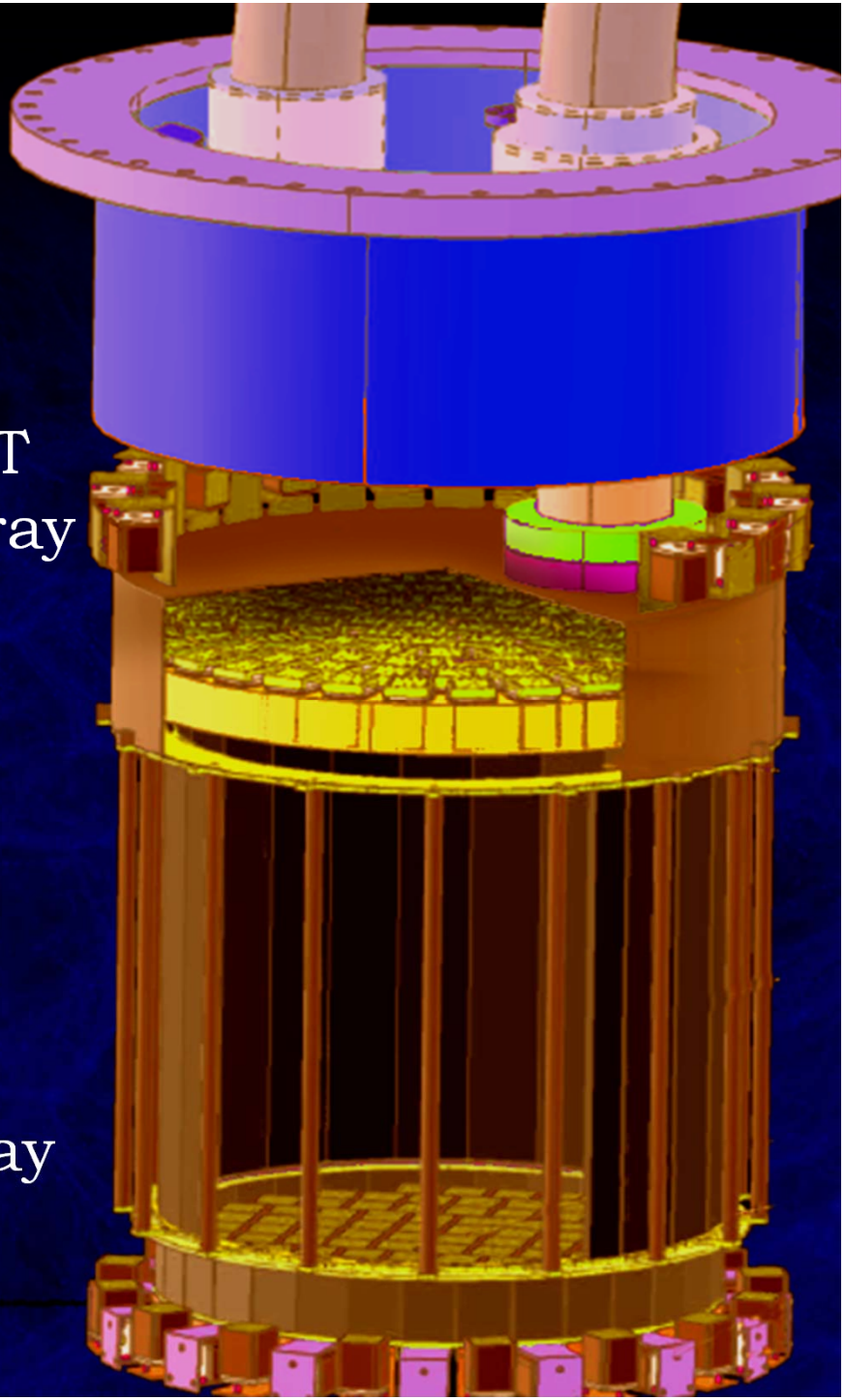
→ lots of information for each event

XENON100

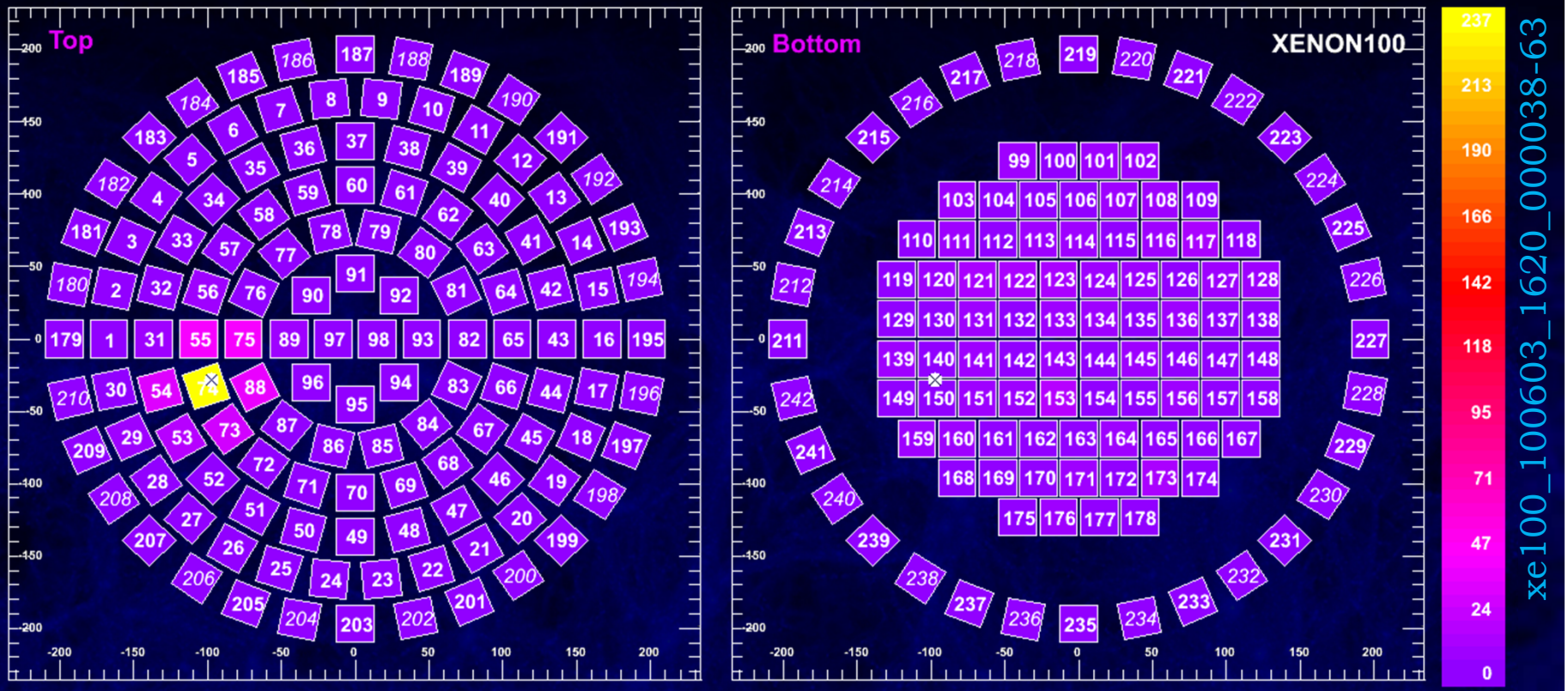
98 PMT
top array



80 PMT
bottom array



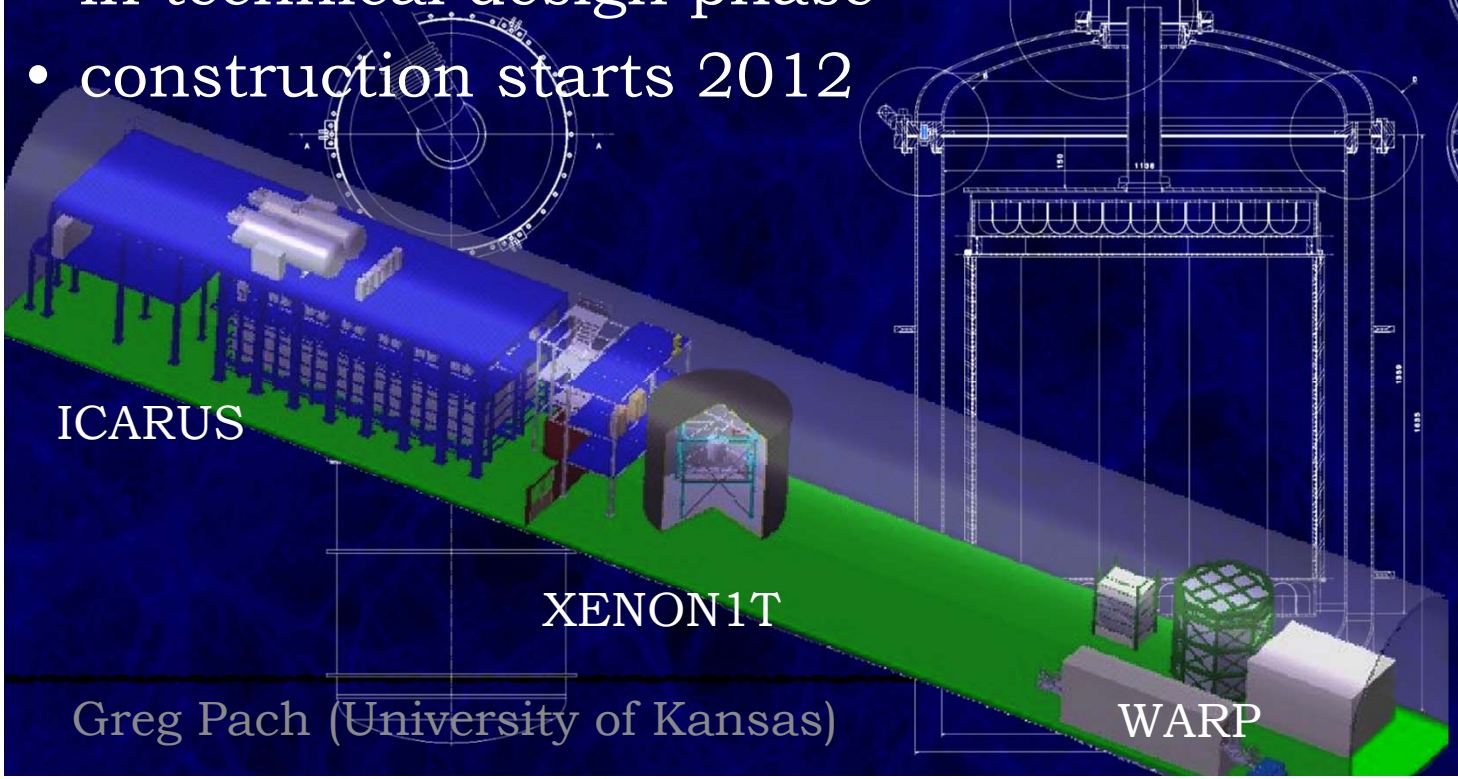
Candidate Event: S2 PMT Pattern



excellent positioning ($\delta r < 3\,\mathrm{mm}$) even near threshold

Next Step: XENON1T

- Fiducial mass 1t liquid xenon, about 2.4t total
- Gran Sasso underground lab
- 975m^3 water tank
- in technical design phase
- construction starts 2012



ICARUS

XENON1T

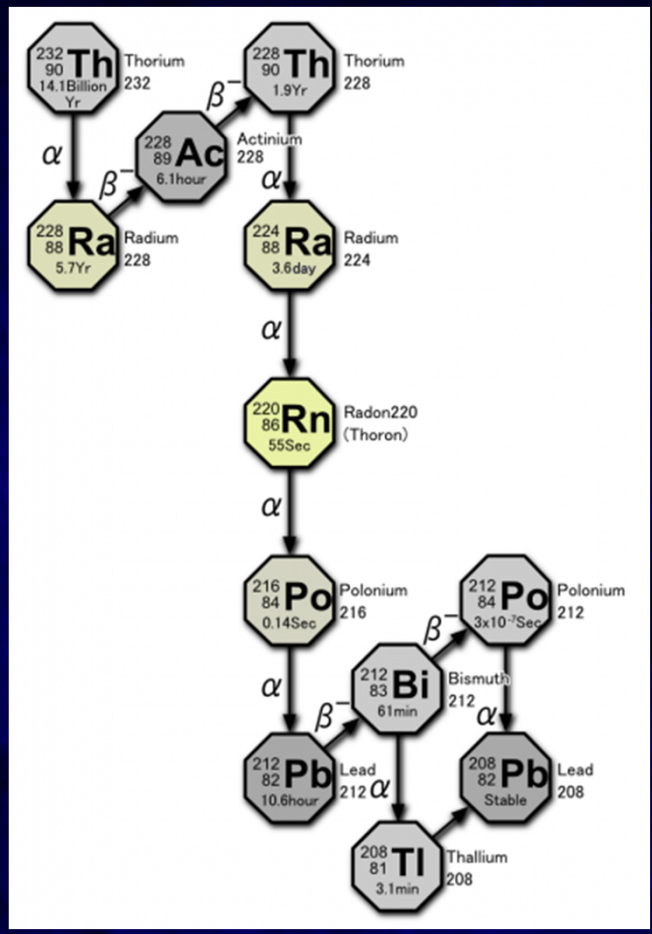
WARP

Why Xenon?

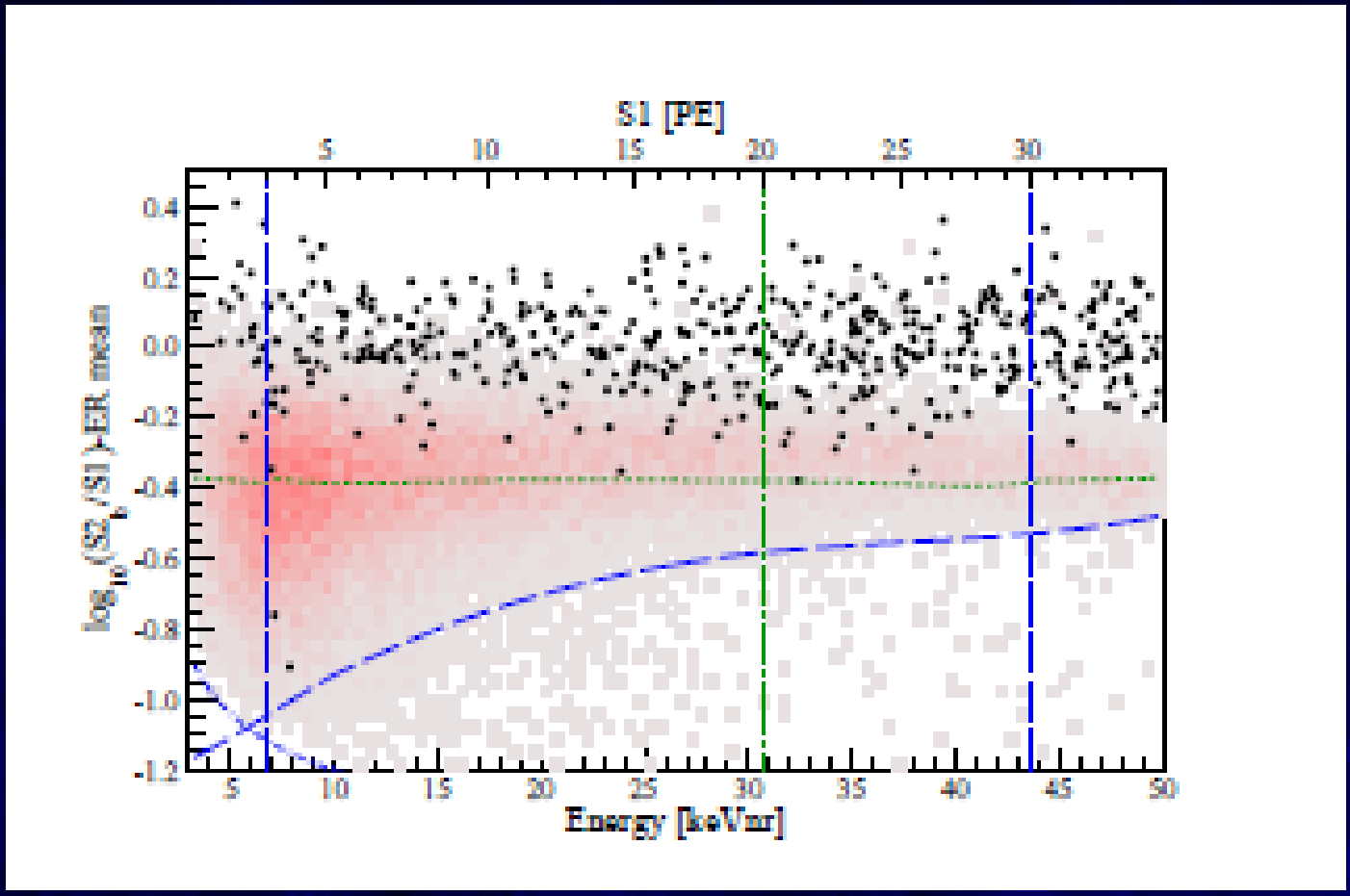
- High electron mobility (noble gas)
- Dense liquid
  - Greater chance of collision
- Transparent to its own light
  - Emits ~175nm/7eV photon
  - First ionization energy ~12eV
- Coherent Scattering by A^2
  - Xenon A~134

Calibration

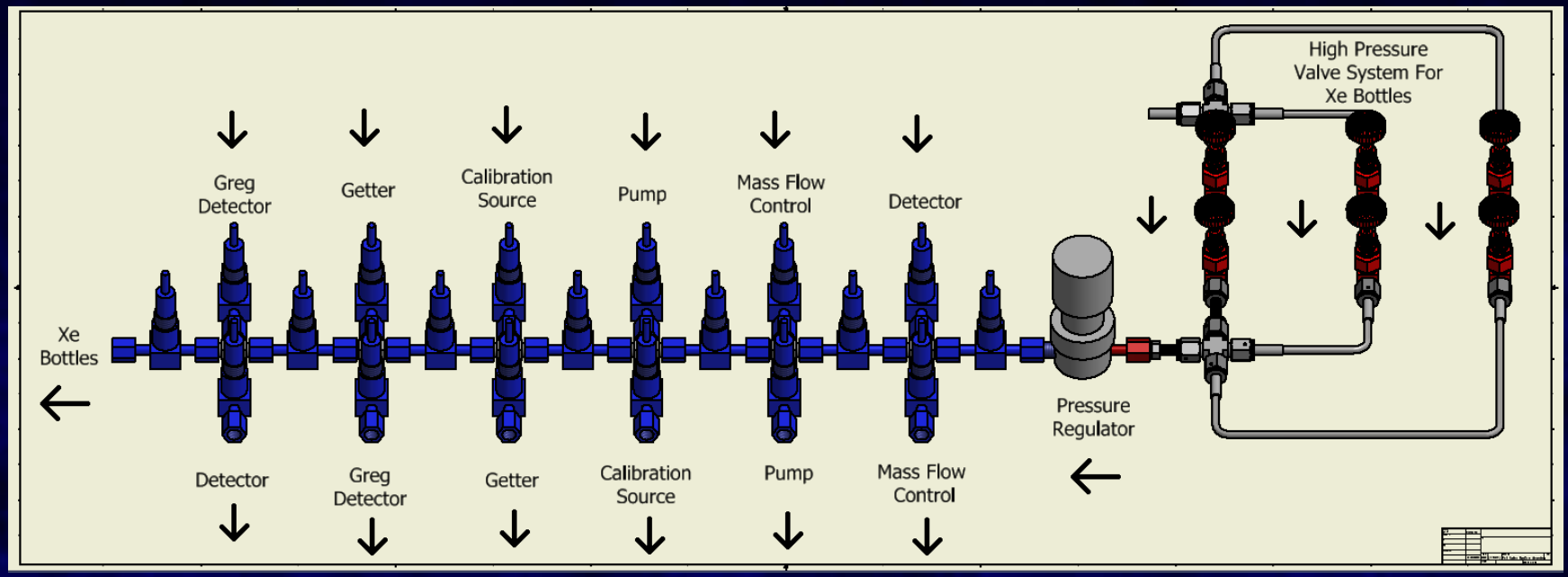
- Electronic Recoil Calibration
  - Introduce radioactivity in the gas system
  - Radon 220
  - Continuous energy spectrum
    - Usable: 2-20 KeV
- Nuclear Recoil Calibration
  - Neutron generator



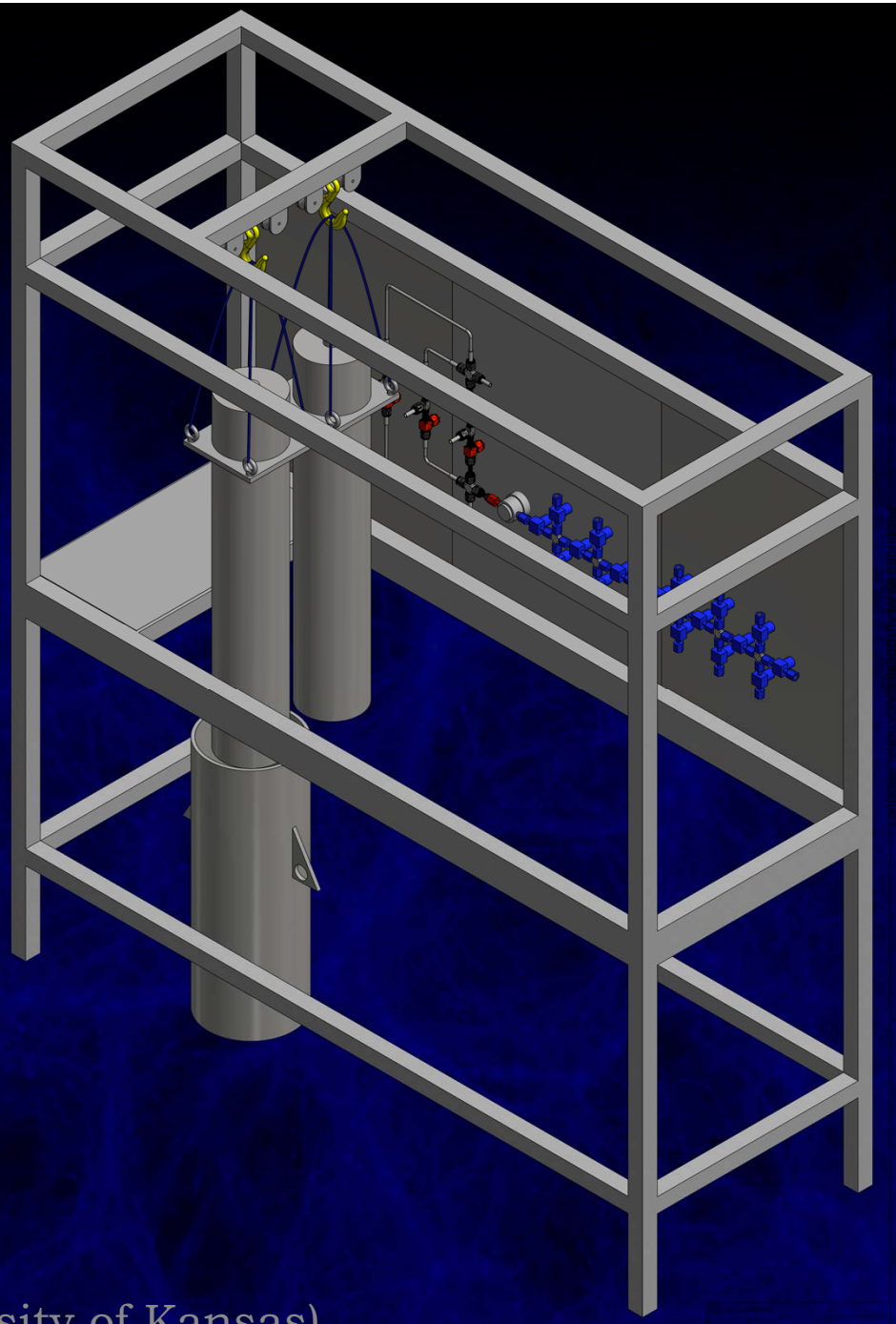
Recoil Calibration



Gas System



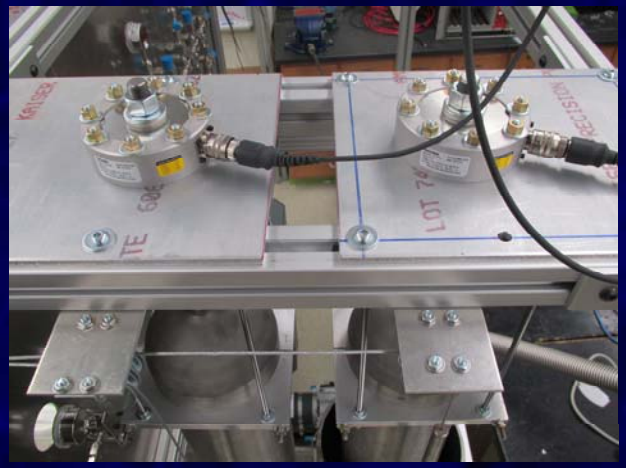
Detector ← Greg Detector ← Calibration Source ← Getter ← Calibration Source ← Pump ← MFC ← Detector



Recirculation
Detector1
Detector2

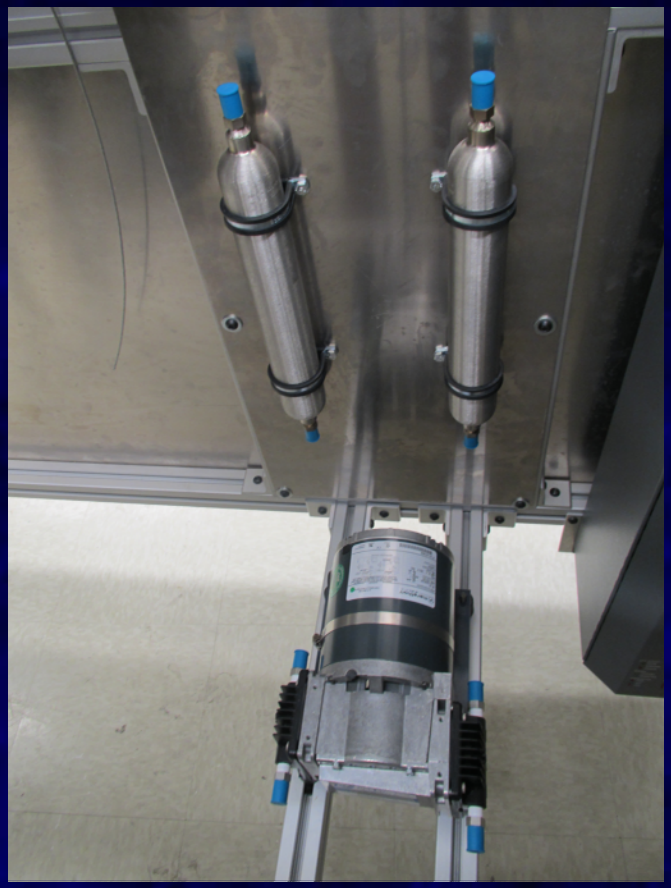
High Pressure Bottles

- Hung from high-sensitivity load cells
- Liquid Nitrogen dewar used to create a pressure gradient



Mass Flow Control and Pump

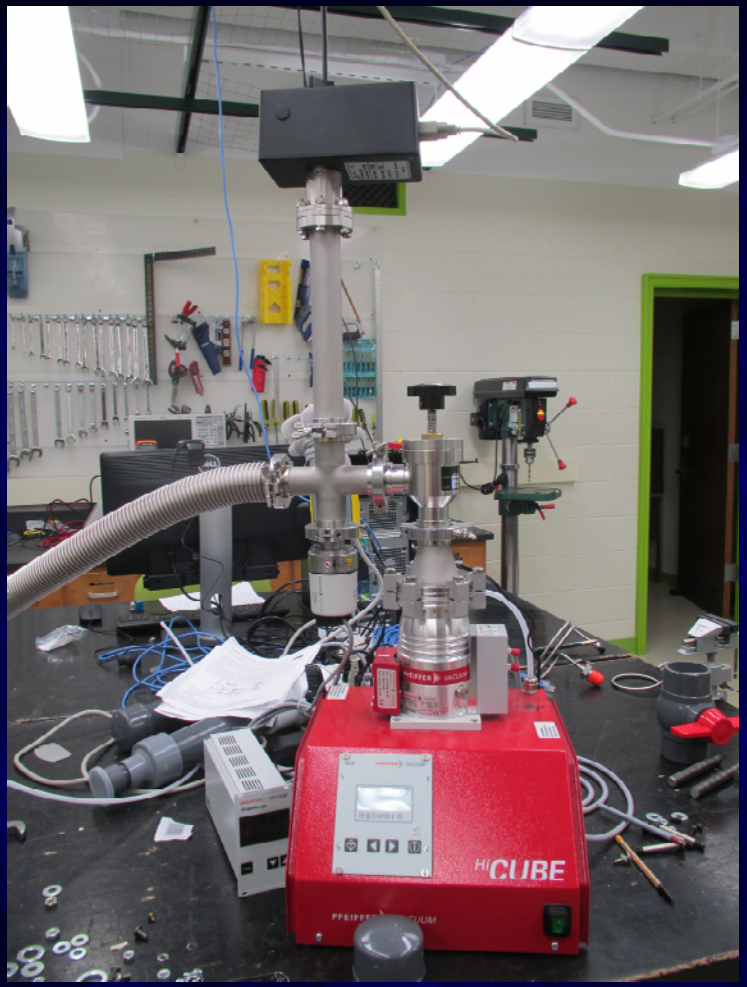
- Keep system at a steady flow



Getter

- Purifies the Xenon Gas
- Uses hot Zirconium plates to purify

Leak Checking



Recirculation
Detector 1
Detector 2