

Low amplitude signal detection techniques in 2-phase xenon detectors

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Overview

- Motivation
- Xenon in 2-Phase Detectors
- Micropatterned Structures and Photosensors
- Experimental Setup
- Light Results and MC Simulation
- Future Work

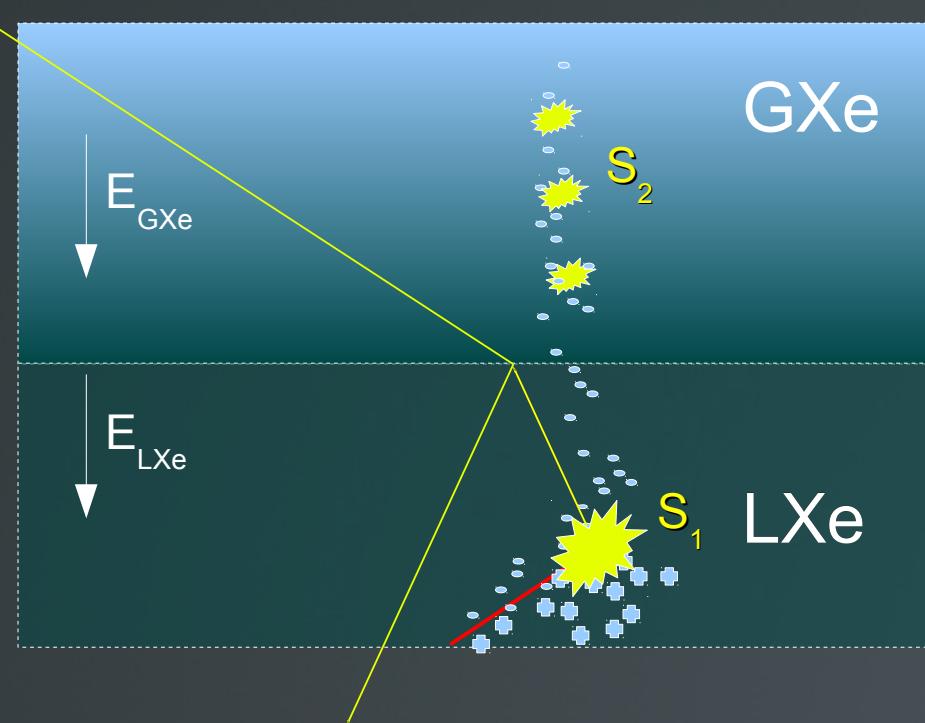


Liquid Xenon

- Large Atomic Number (131 g/mol)
- High Density (2.9 g/cm³)
- Fast Decay Time (2.2, 27 and 45 ns)
- High Light Output (W_s: 23eV for e-)
- Low Intrinsic Background
- Allows discrimination of e-/nuclear recoils (PSD, S₂/S₁)
- Scalability and self shielding



2-Phase Xenon Detectors



Gas Phase

- GXe ionization
- Secondary Scintillation (S_2)

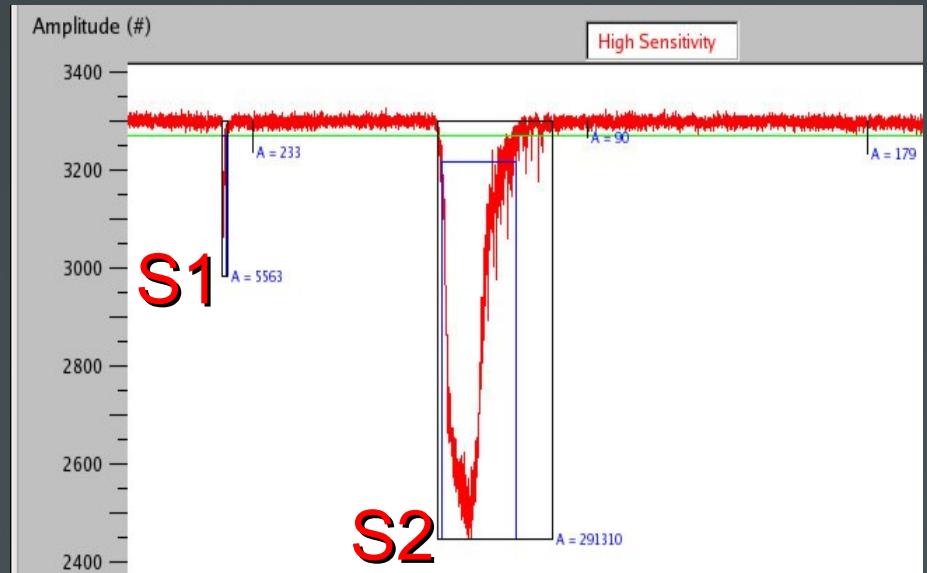
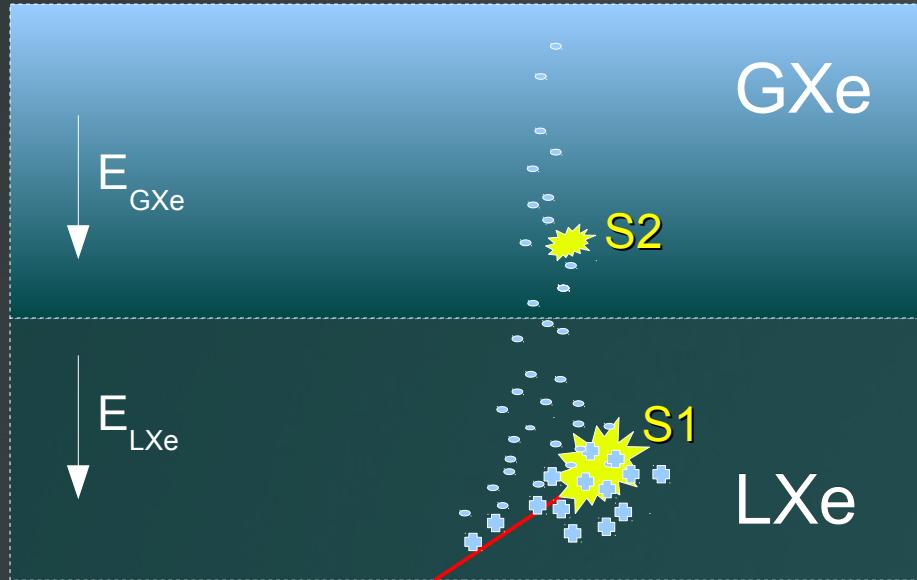
Liquid/Gas Interface

- e- emission
- Reflexion/Refraction

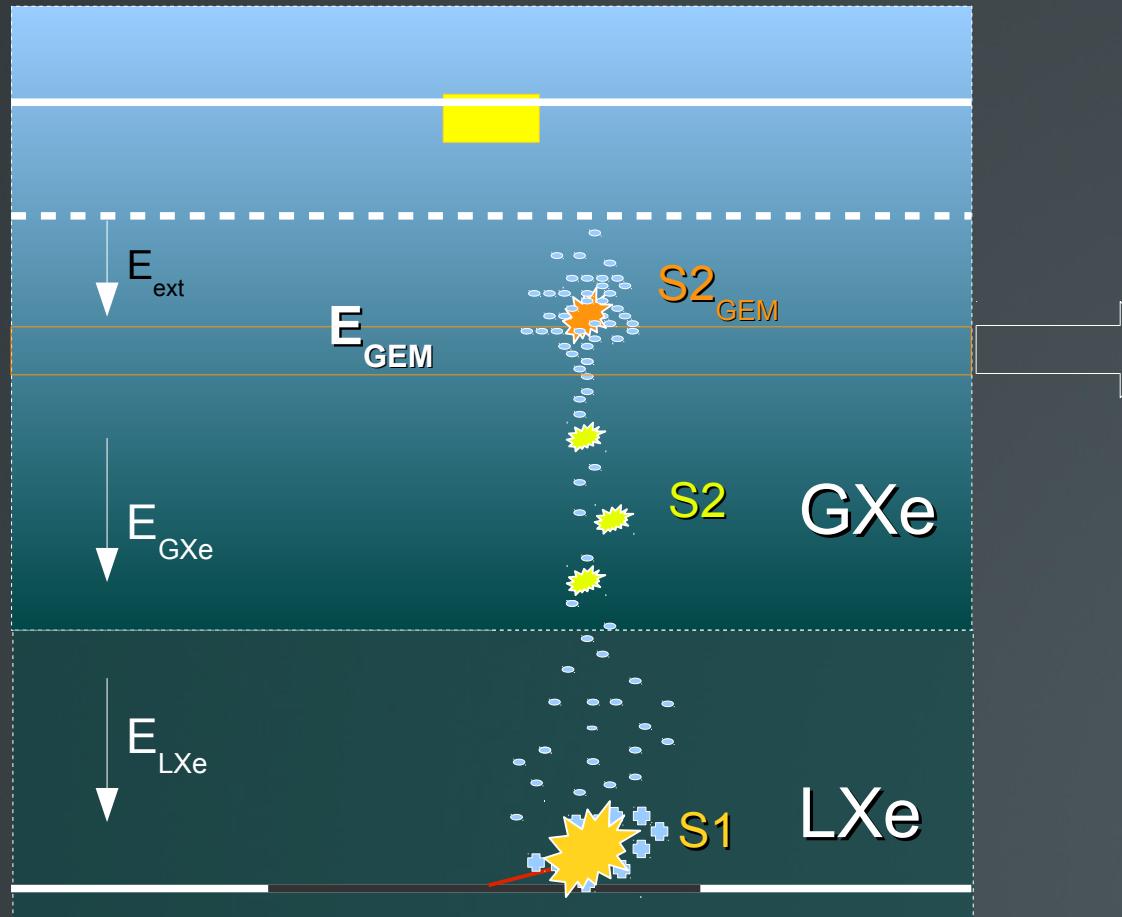
Liquid Phase

- LXe ionization
- e-/ion recombination
- Primary Scintillation (S_1)

2-Phase Xenon Detectors



2-Phase Detectors



Alternative
readout
techniques



Micropatterned
Structure



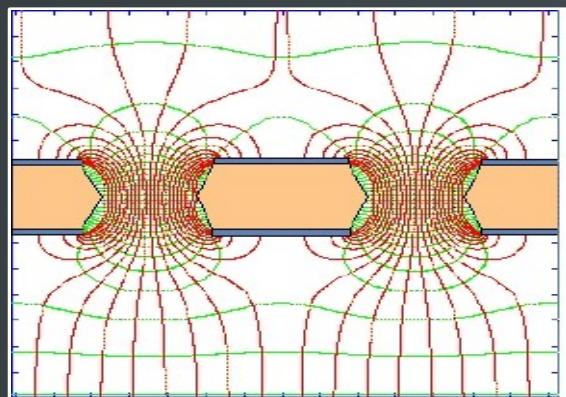
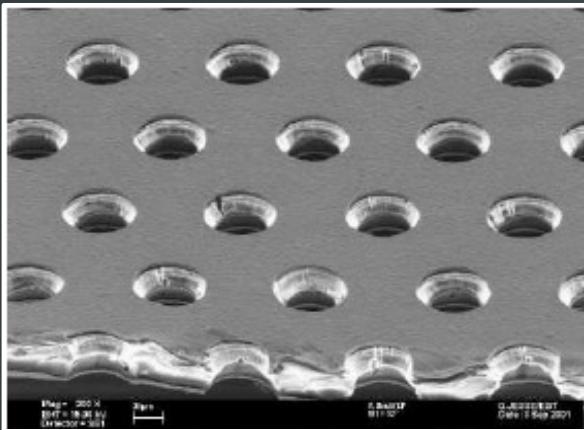
Signal
Amplification
inside!



Radioactive Background
Reduction

Micropatterned Structures

- Gas Electron Multiplier (3M GEM)

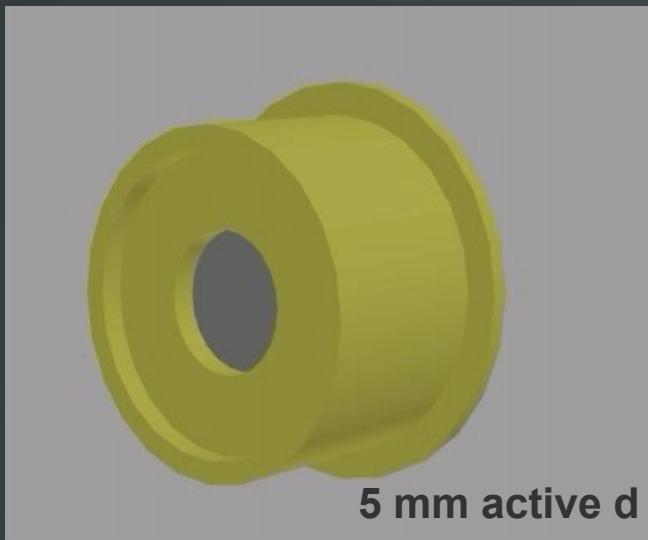


- Standard 70/50 μm – 140 μm
- Sensitive area 7 cm^2
- Maximum gain
 - ~80 @ 25 °C
 - ~150 @ -100 °C



Photosensors

- Large Area Avalanche Photodiode (Advanced Photonix LAAPD)

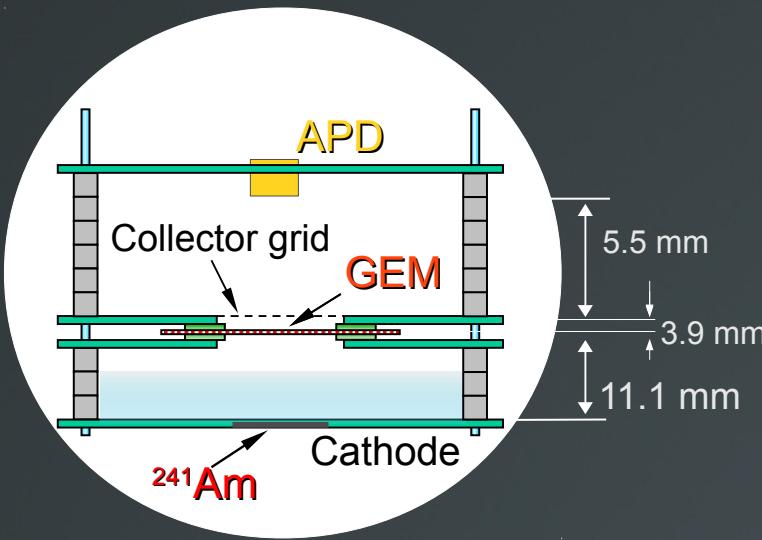


- Sensitive area $\sim 0.2 \text{ cm}^2$
- QE ~ 1 @ 175 nm
- Dark current
 - 50 nA typical @ 25 °C
 - $<1\text{nA}$ @ -100 °C
- Maximal gain
 - 250 @ 25 °C
 - >1000 @ -100 °C



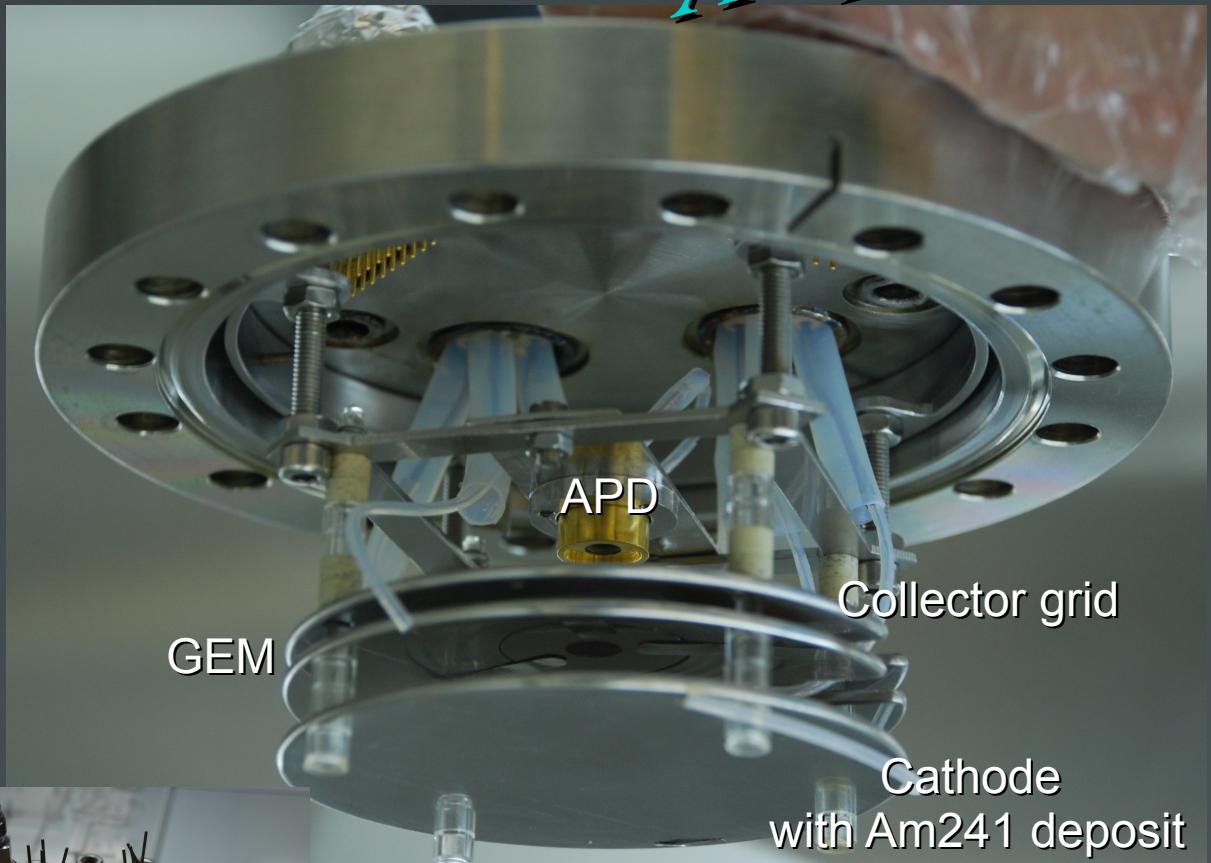
Detection Chamber

Xe purity!

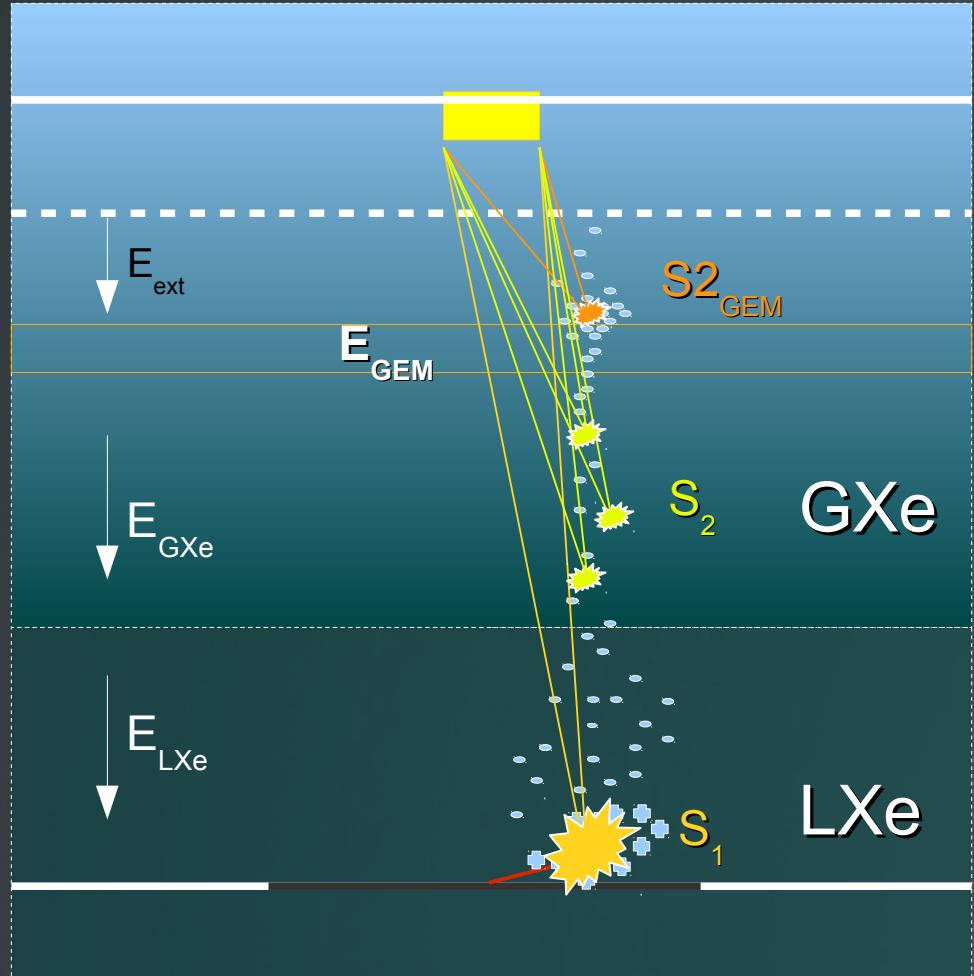


Clean materials inside...

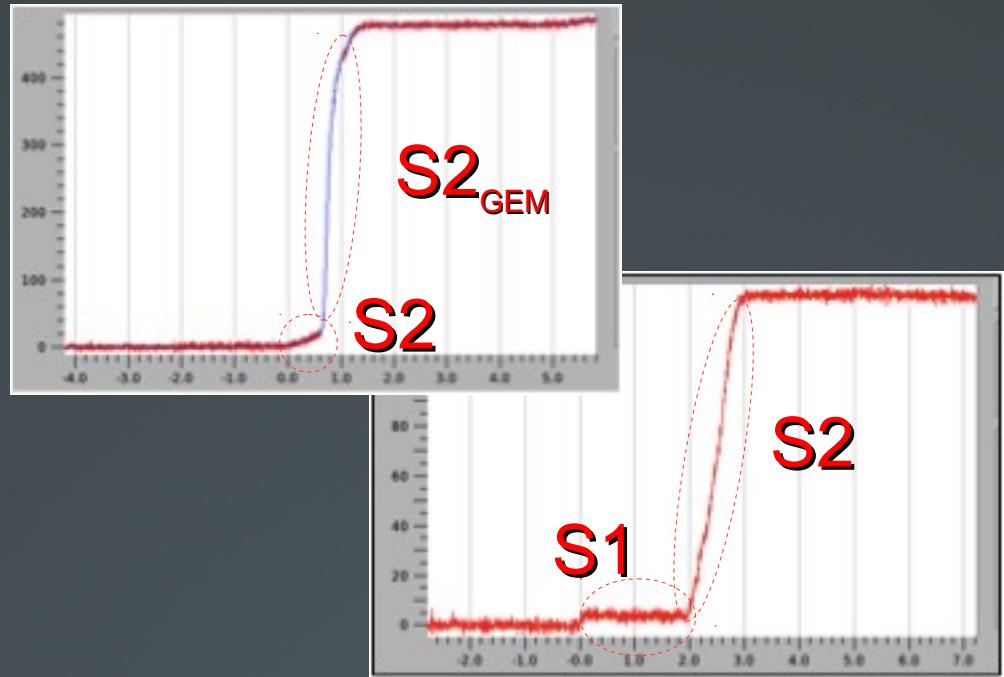
- Stainless Steel
- PTFE
- Glass
- Ceramic
- Copper/Kapton



Some Light Results



$S2_{\text{GEM}} \sim 400 S1$



$$E_{\text{LXe}} \sim 4 \text{ KV/cm}$$

$$V_{\text{GEM}} \sim 400 \text{ V}$$

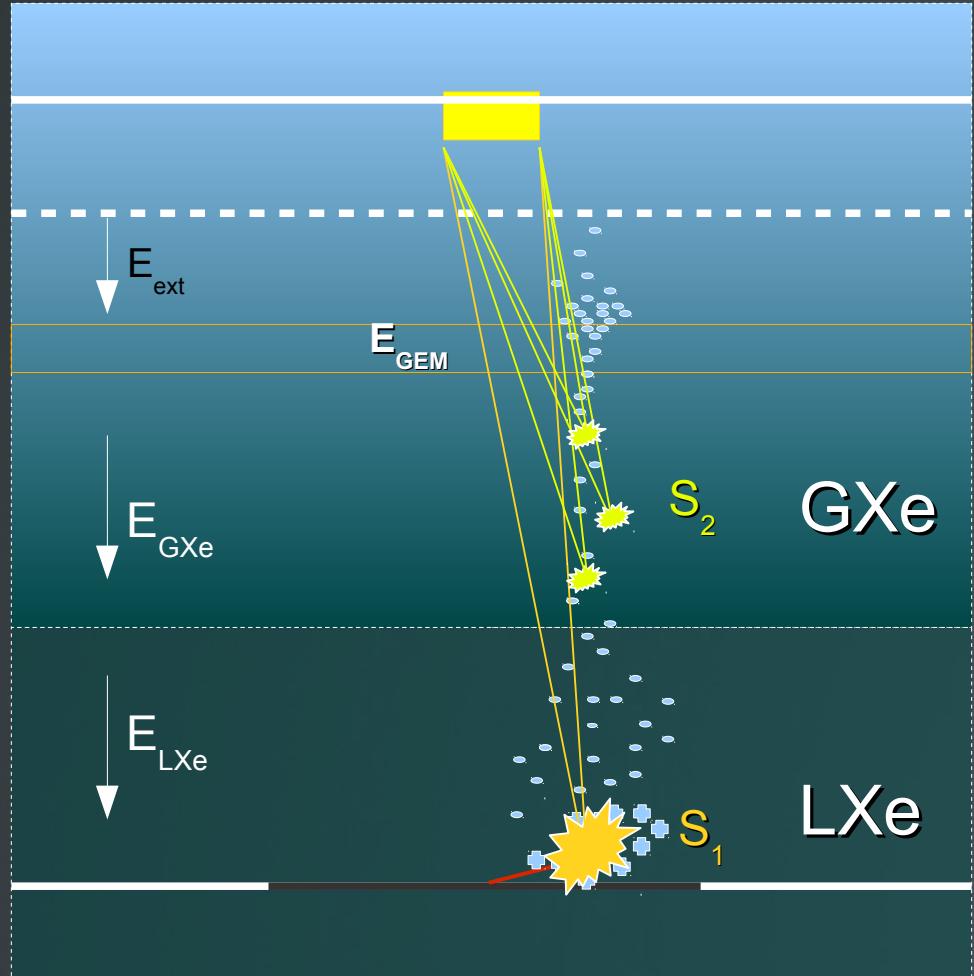
$\text{LXe level} \sim 8 \text{ mm}$

$P \sim 1.4 \text{ bar}$

$T \sim -100 \text{ C}$

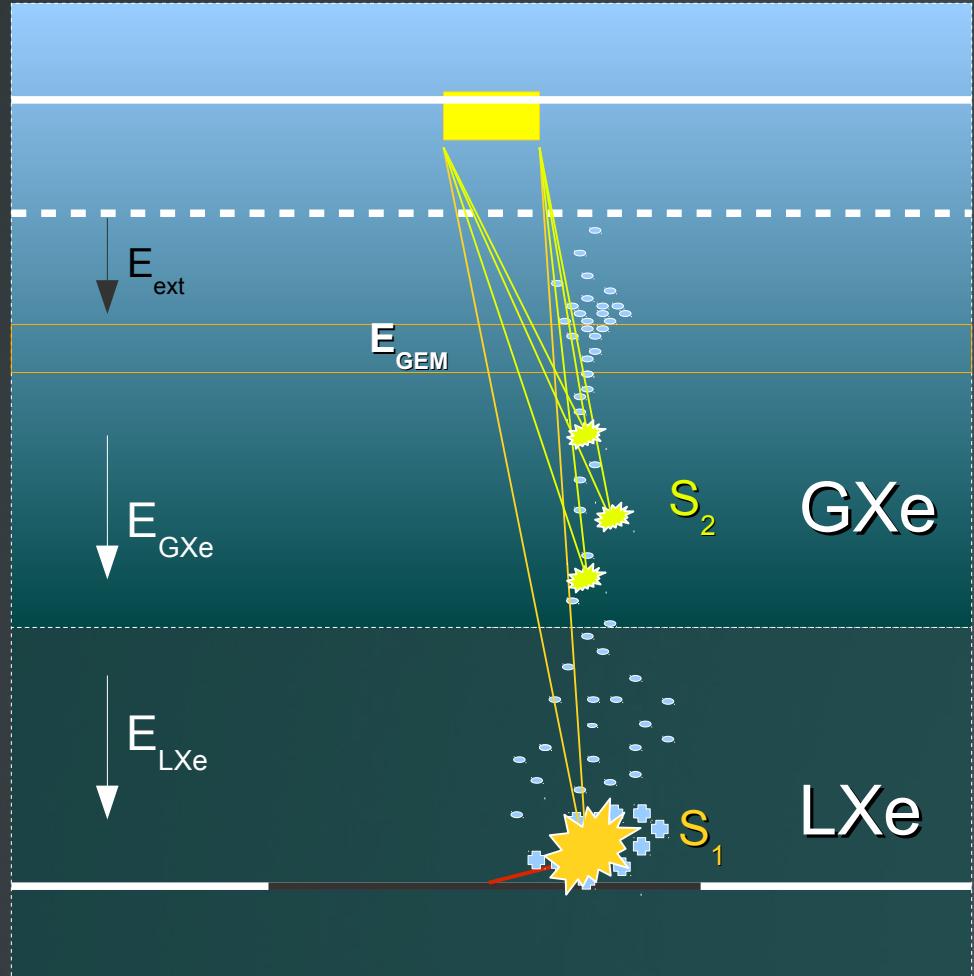


Monte Carlo Simulation Light Analysis



- Point-like photon emission along z axis (1e5ph/10um)
 - Optical Transparency (GEM + Grid)
-
- Point-like photon emission at cathode level (1e4pt x 1e5ph isotrop. and uniform.)
 - Reflexion at LXe/GXe interface
 - Optical Transparency (GEM + Grid)

Monte Carlo Simulation Light Analysis



LXe level ~ 8 mm

S2:

Nph APD ~ 0.25% Nph emitted

S1:

Nph APD ~ 0.04% Nph emitted

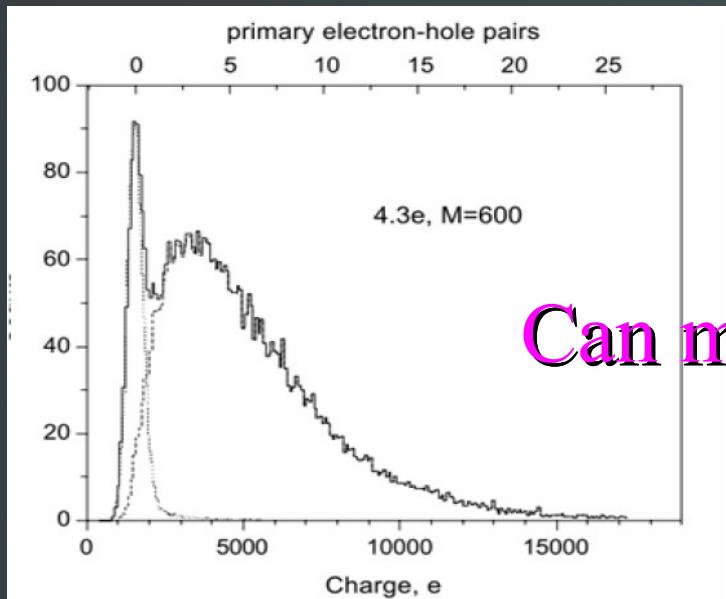


Results + Simulation Analysis

S1: 130 ph @ APD;

S2_{GEM}: 56,000 ph @ APD;

This correspond to ~500 ph/e- extracted from LXe
8.5 ph @ APD per e- extracted from LXe



ELXe \sim 4 KV/cm
VGEM \sim 400 V
LXe level \sim 8 mm
P \sim 1.4 bar
T \sim -100 C



Future Work

- Study the performance of new devices:
 - Photosensors (SiPMs instead APDs)
 - Microstructures (MHSP and Micromegas)
- Try to see single e-

Thank you!

