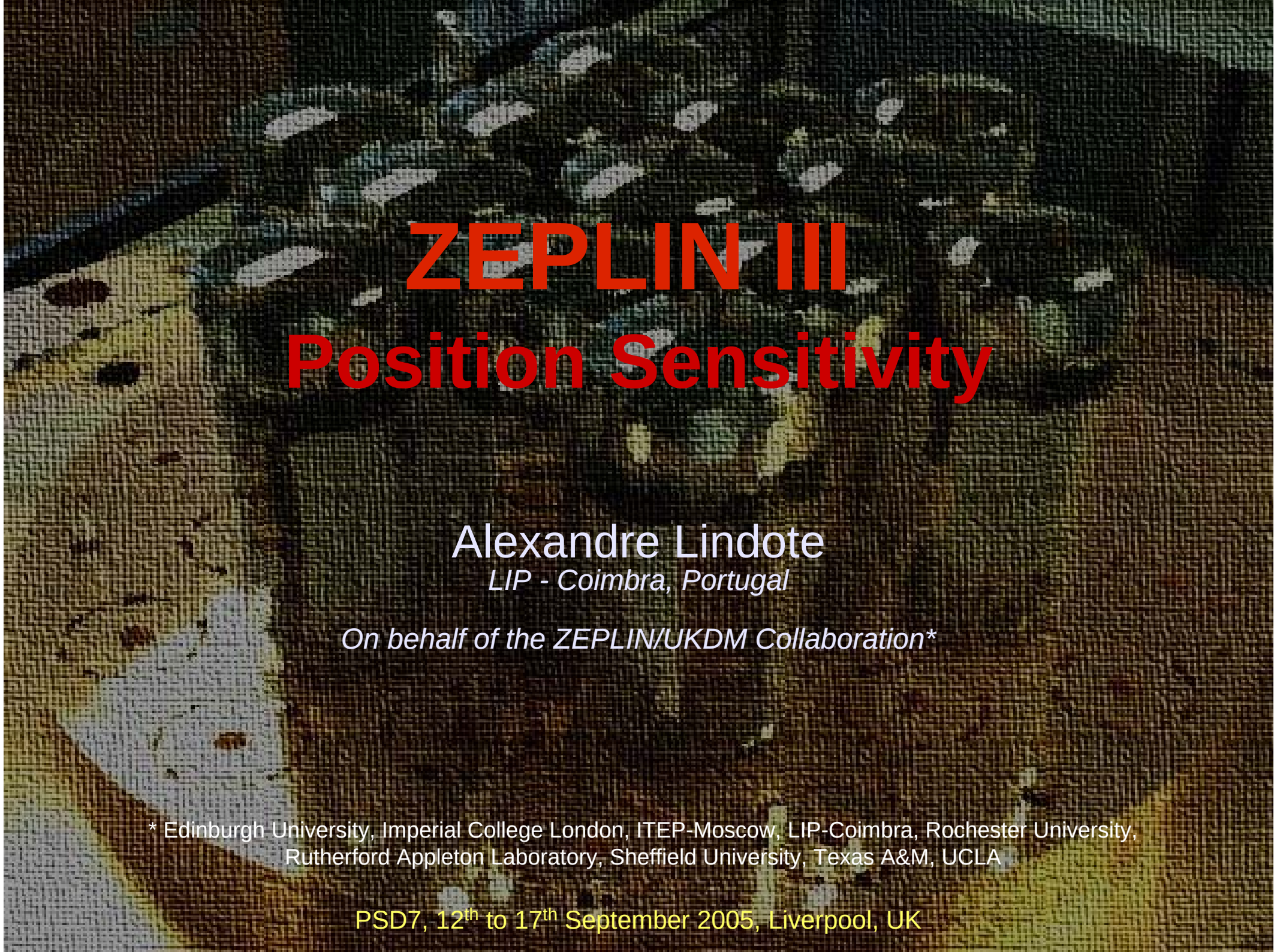

ZEPLIN III
Position Sensitivity

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*On behalf of the ZEPLIN/UKDM Collaboration**

* Edinburgh University, Imperial College London, ITEP-Moscow, LIP-Coimbra, Rochester University, Rutherford Appleton Laboratory, Sheffield University, Texas A&M, UCLA

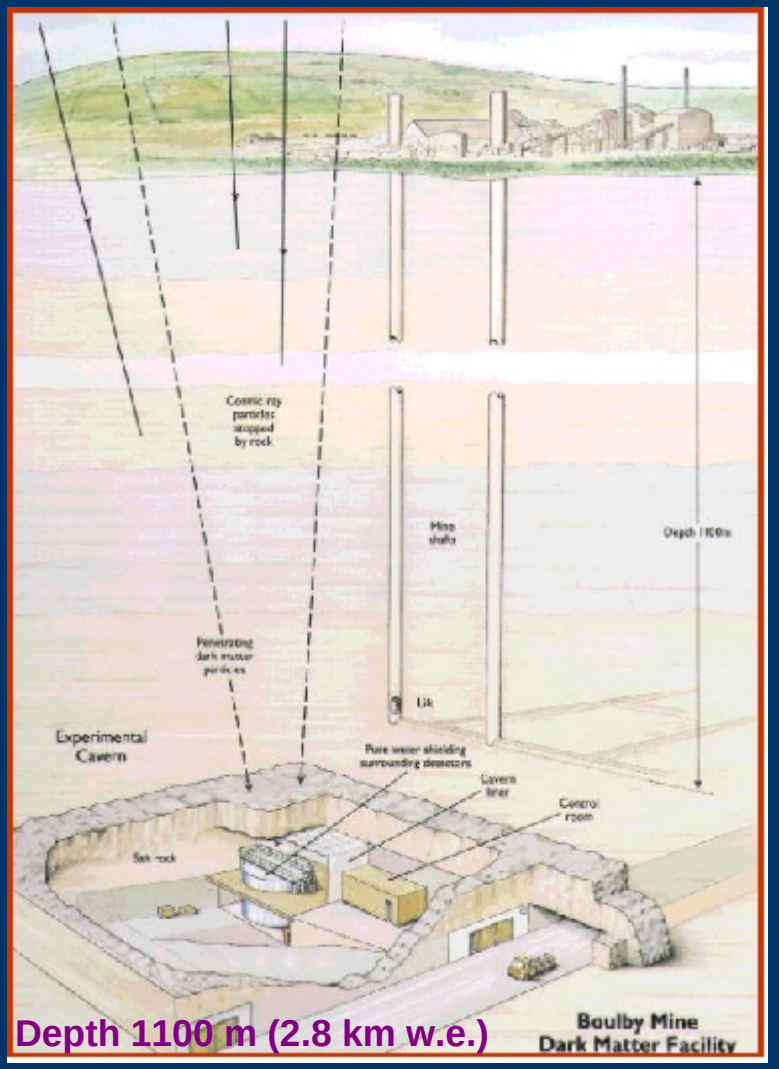
PSD7, 12th to 17th September 2005, Liverpool, UK

Outline

- Zeplin III detector
- Signal structure
- Objectives of the reconstruction routine
- Method used
- Results
- Conclusions

Zeplin III

- Xenon detector for WIMP search
- Nuclear recoils from elastic scattering (WIMP – nucleus)
- Operate underground, at Boulby

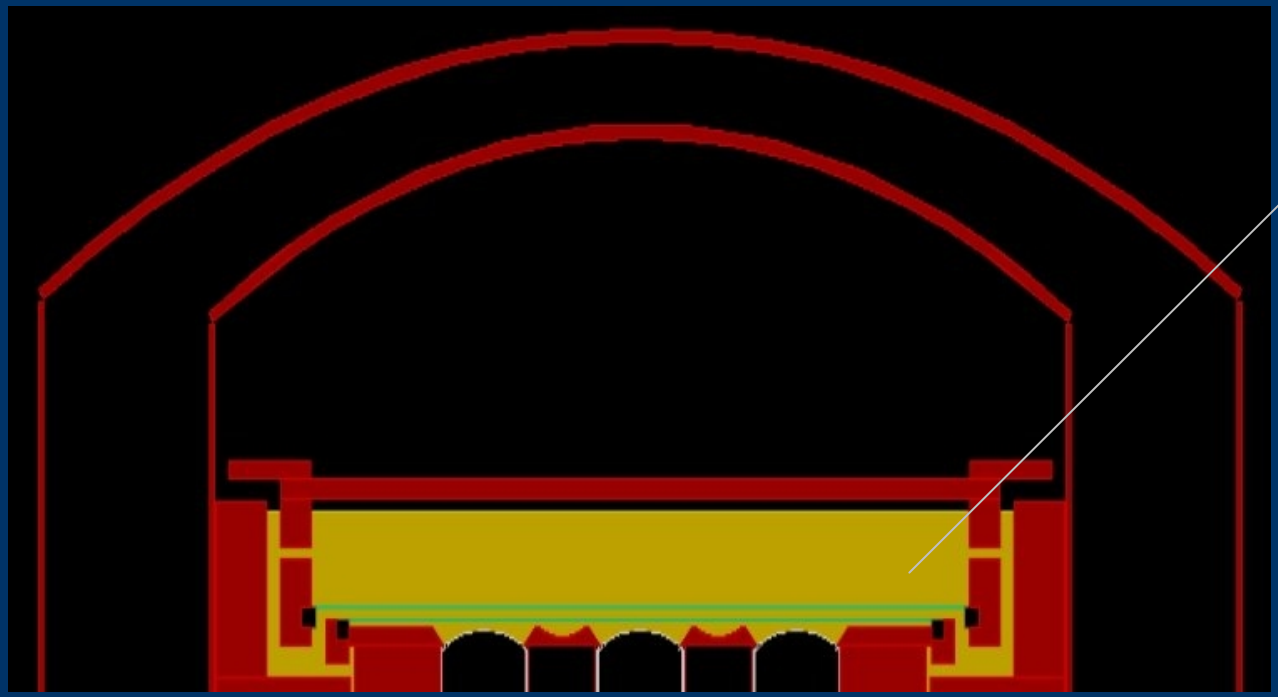


Zeplin III

- Built with xenon-friendly materials (copper, stainless, quartz)
- Copper construction for low radioactivity
- Array with 31 PMTs immersed in the liquid for better light collection (Quantum Efficiency ~30%)

Zeplin III

- 2-phase (liquid/gas) xenon detector
- High electric field (8 kV/cm in liquid, 16 kV/cm in gas)
- Readout of both scintillation light and ionisation

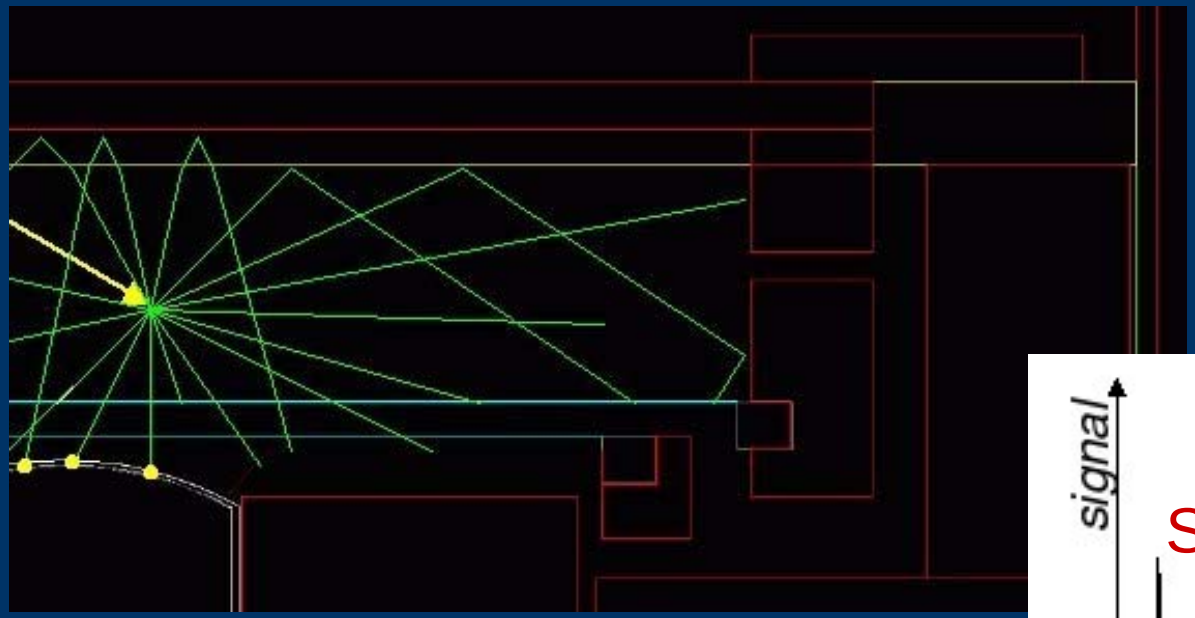


Liquid Xenon Target

- 38 cm in diameter
- 3.5 cm height
- 12 kg active region

Signal Structure

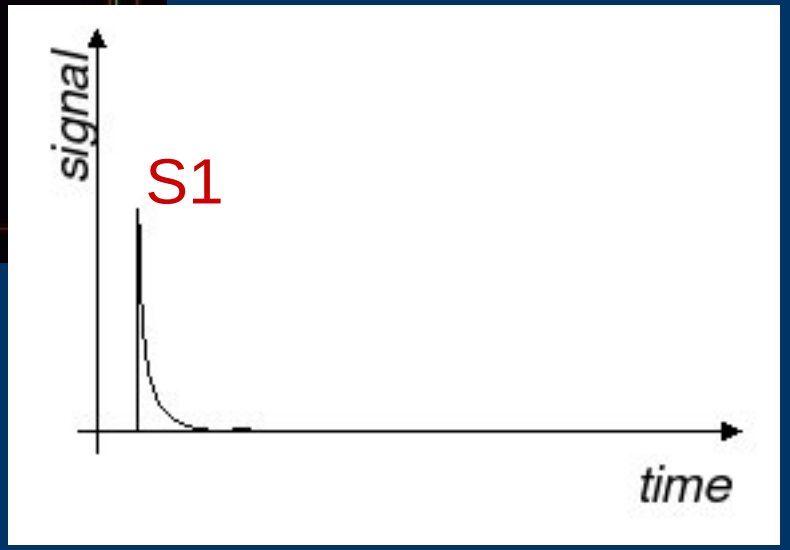
- Primary signal (prompt scintillation)



Light Yield

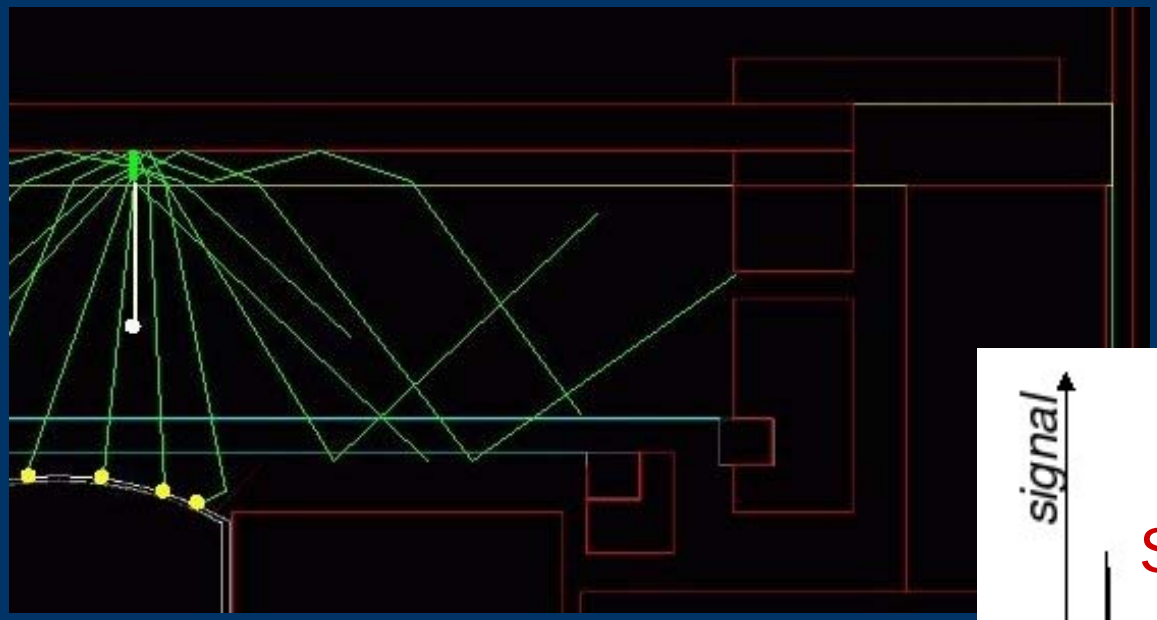
~ 3.5 phe/keV ee @ 0 field

(5-7 phe for 10 keV recoil, determines the threshold)



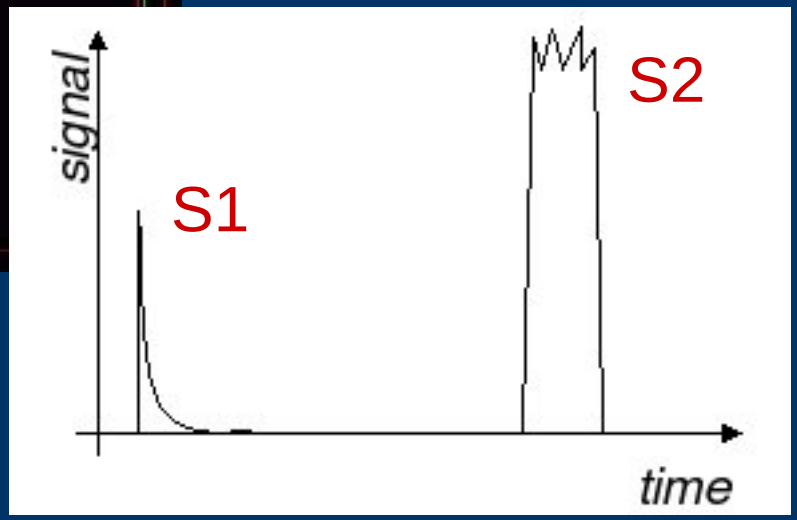
Signal Structure (2)

- Secondary signal (electroluminescence)



Light Yield

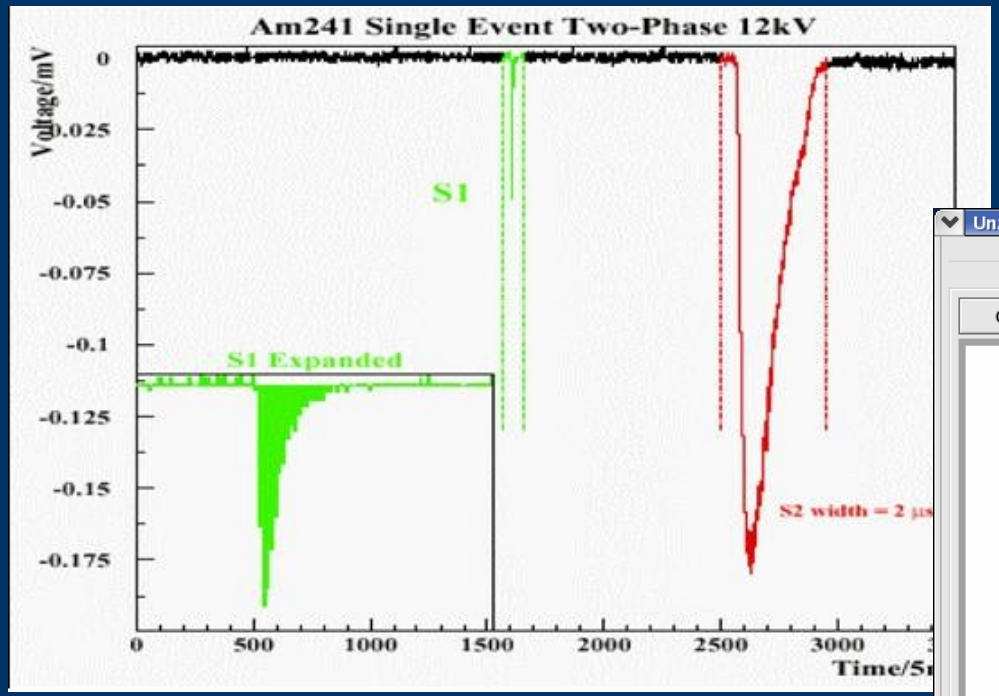
~ 25 phe for each extracted electron



Signal Structure (3)

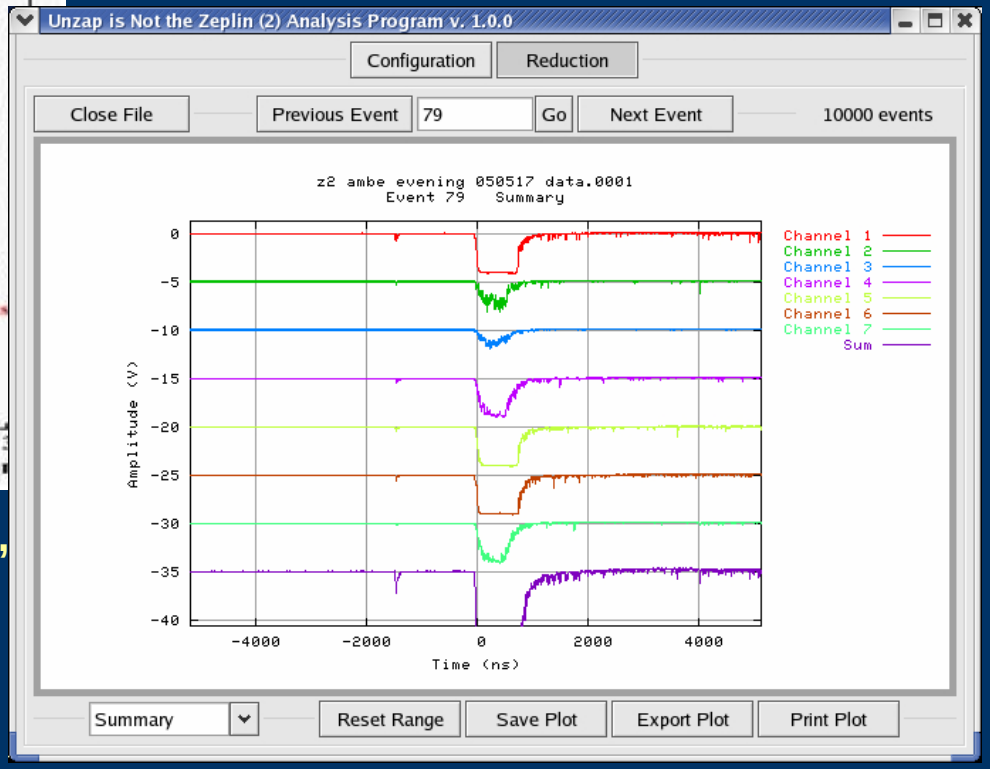
- Real 2-phase signals

(from the ICL Prototype)



A. S. Howard *et al., World Scientific (*2001),

(from Zeplin II surface tests)



Objective

To develop a position reconstruction algorithm that provides a good enough spacial resolution to:

- Determine the boundaries of the fiducial volume
- Improve the energy resolution (and therefore the discrimination power)
- Investigate the spatial distribution of rare events
- Help with understanding the gamma/neutron calibration

Must be fast enough to run on-line
(5 events/s expected underground)

Method

- Reconstruction for the z coordinate:

- From drift time $\Rightarrow$ ~ 0.1 mm FWHM

- x-y plane reconstruction

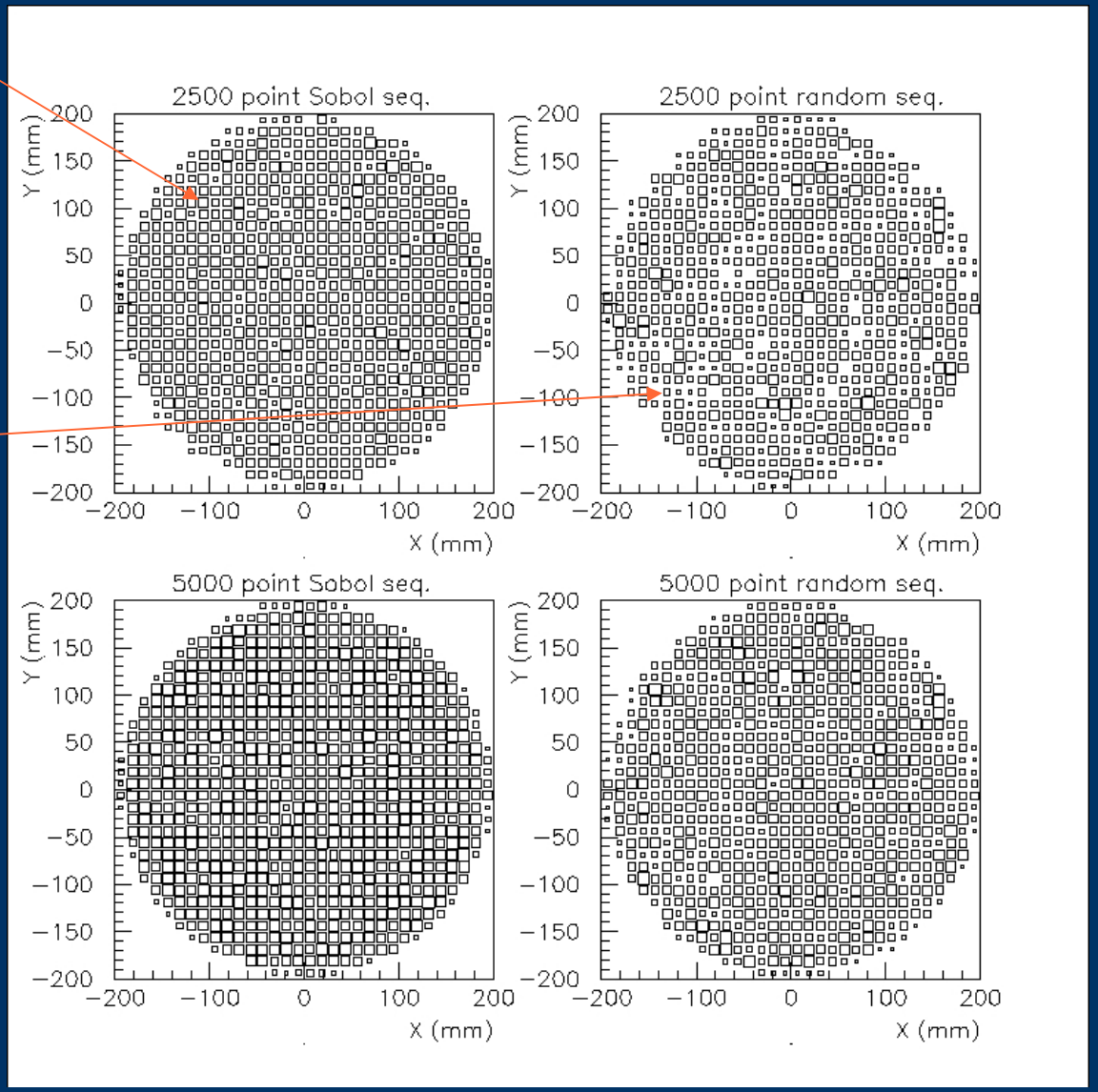
- Uses only the secondary signal (>>primary)
- 2D template from the ZepIII simulation*
  (~ 20000 points 2.5mm apart, 1.5×10^6 photons/point)
- Samples for 1, 4 and 10 extracted electrons, also from the simulation
- Best estimate $\Leftarrow$ minimum χ^2
- Template grid searched with a 2D Sobol sequence followed by a local search

* - by H. Araujo, ICL, RAL

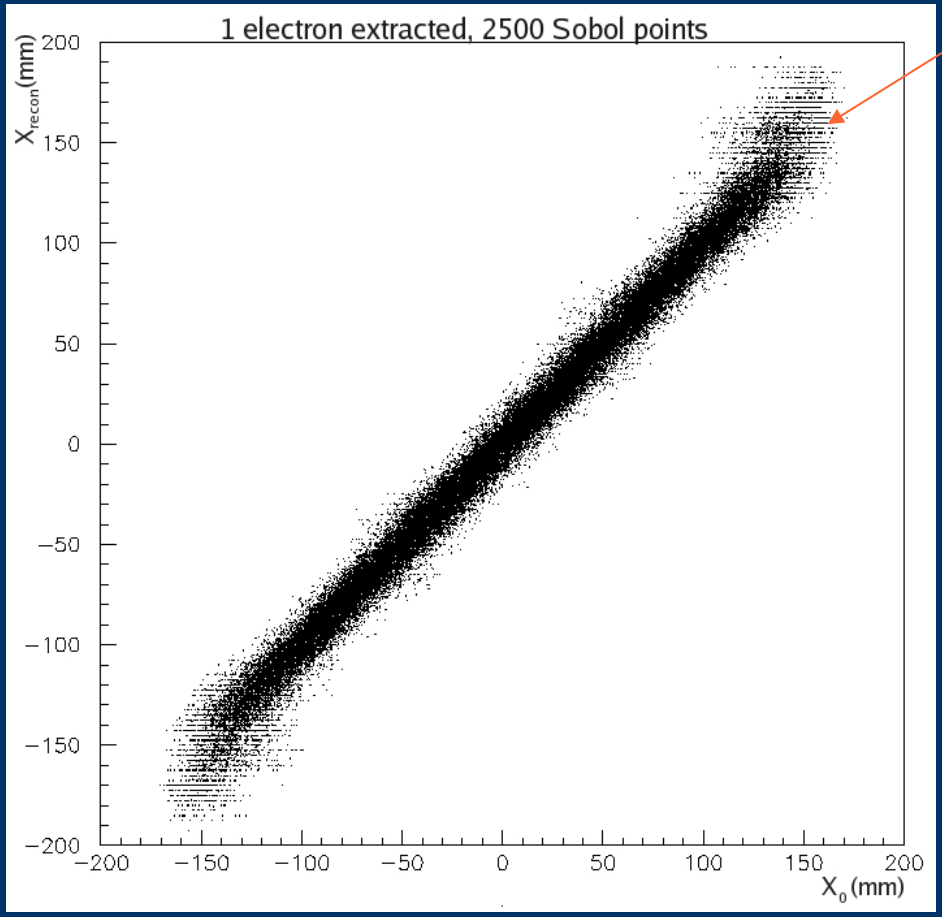
Sobol Sequence

- Sobol sequence provides a much better space uniformity than a pure random sequence

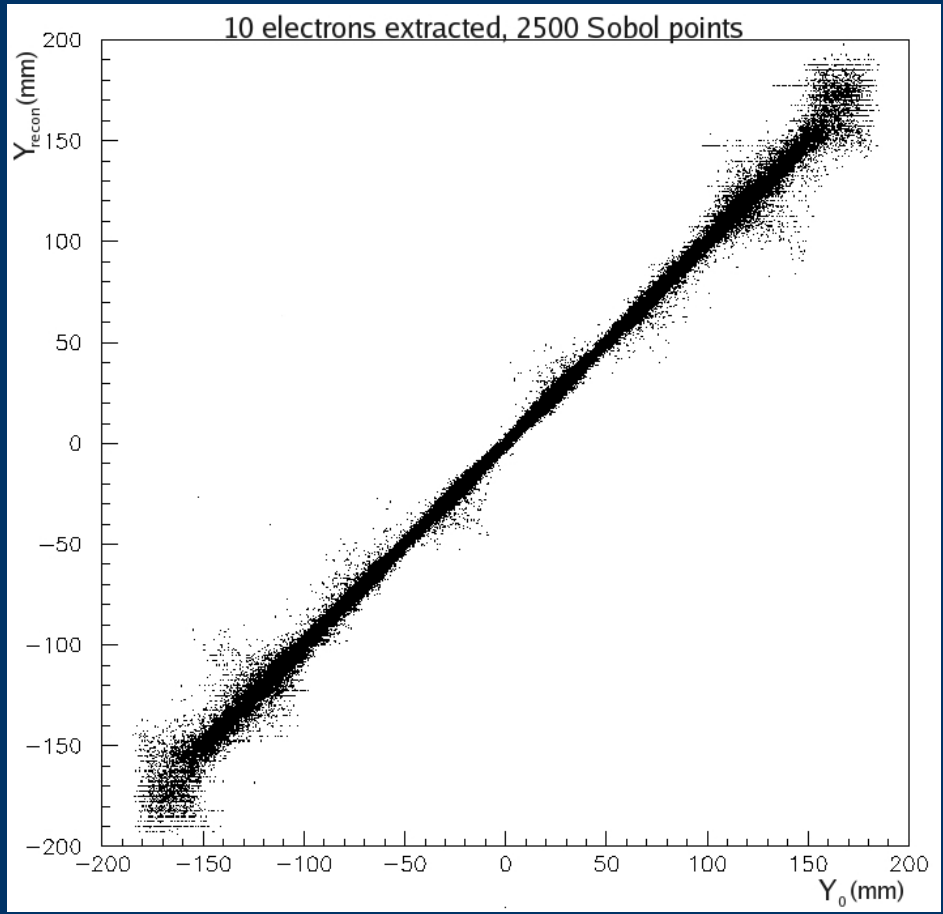
- Enhances speed up to ~200 Hz for a 2500 points sequence



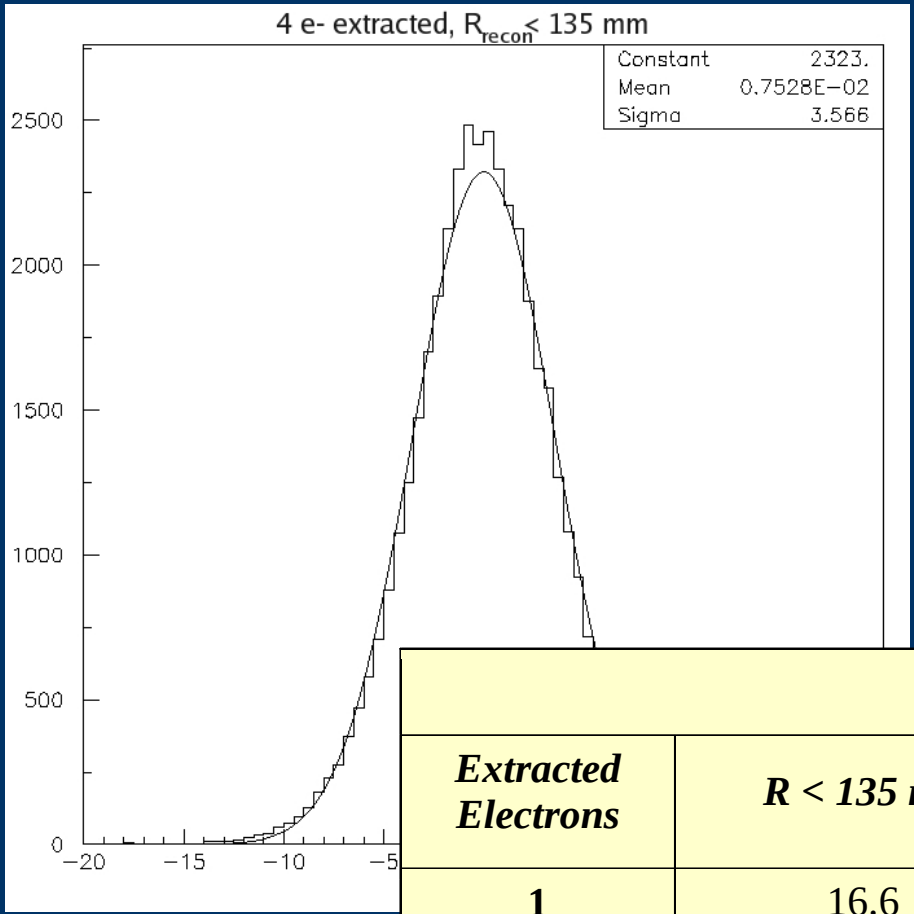
Results - Accuracy



Even with only 1 e- extracted from the liquid (~keV NR), we are able to reconstruct up to the edge of the PMT array (~160 mm)



Results – Accuracy



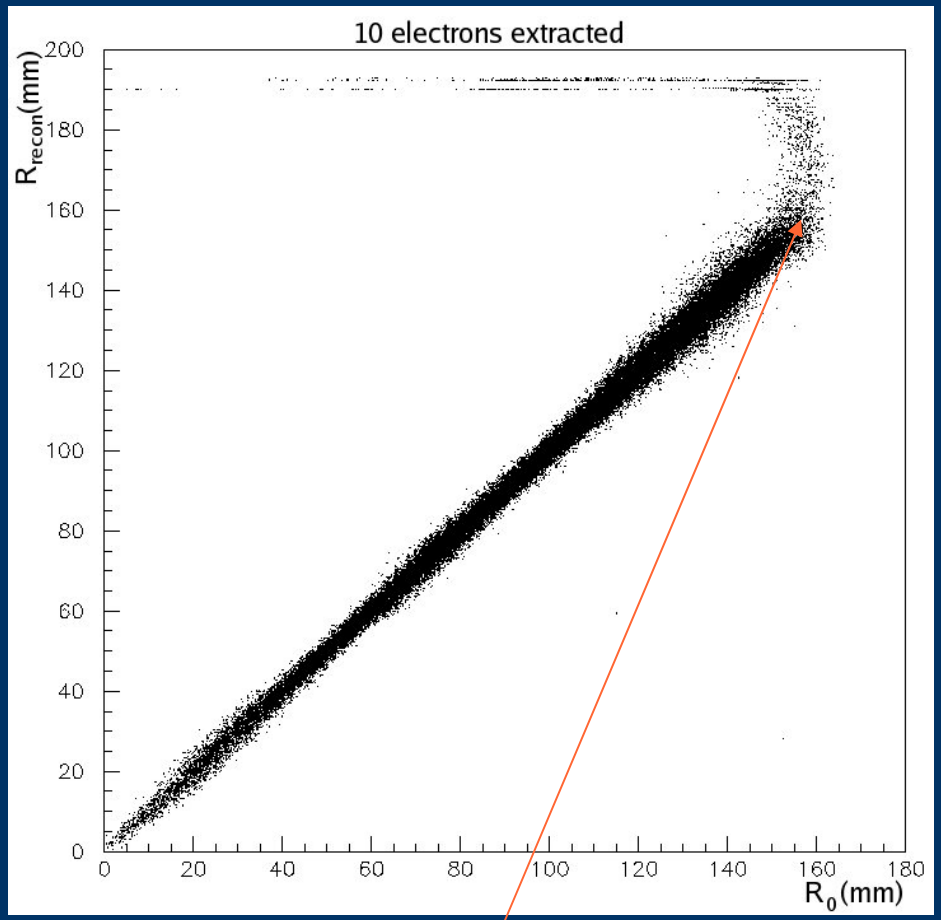
Remember that energy threshold is determined by S1 (~10keV recoil)

⇒ probably more than 10 electrons extracted

FWHM$_{(Yr-Y0)}$ (mm)			
Extracted Electrons	***R < 135 mm***	***R < 155 mm***	***135 < R < 155 mm***
1	16.6	17.2	19.9
4	8.4	9.2	12.5
10	4.9	5.5	8

Results – Fiducial Volume

False Positives: events occurring above the reconstruction limit that are placed inside a given fiducial volume by the algorithm



Reconstruction fails at ~160 mm
(also limit of PMT array and field uniformity)

	Xenon Volume (kg)				S2 above (phe)
	6	7	7.5	8	
False Positives (%)	0.0	0.1	0.4	1.6	25
	0.0	0.1	0.2	1.1	50
	0.0	0.0	0.0	0.4	100

A fiducial volume up to 8 kg is achievable!

Conclusions

- Resolution of ~1 cm even for very small energy deposits
  (1 electron extracted)

- At threshold (probably > 10 electrons extracted) a FWHM of a few mm is achievable

- Reconstruction up to the limits of the PMT array
  (~155 mm, 8 kg fiducial volume)

- Computing speed up to 200 Hz
  (with a 2500 points Sobol sequence)