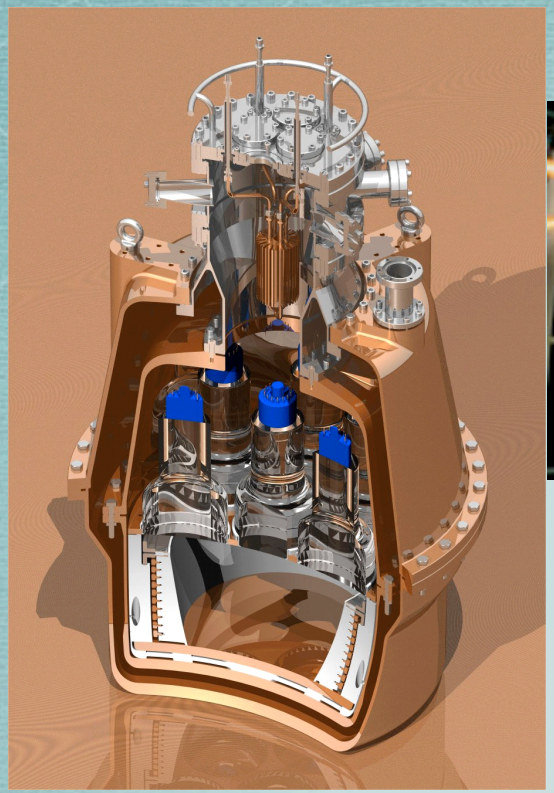
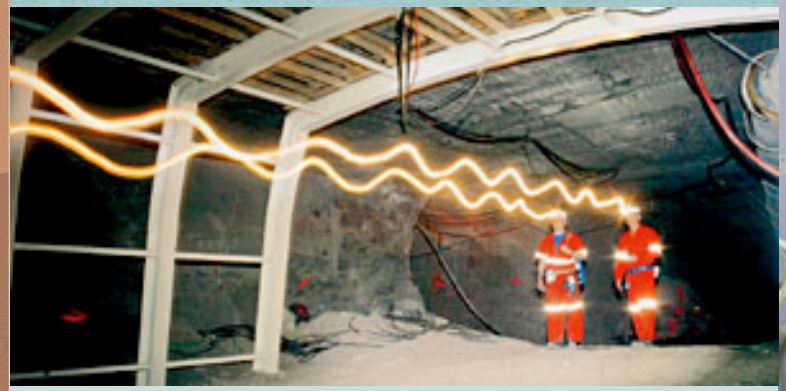




ZEPLIN:
The Hunt for Dark Matter

Blair Edwards

Imperial College London & Rutherford Appleton Laboratory

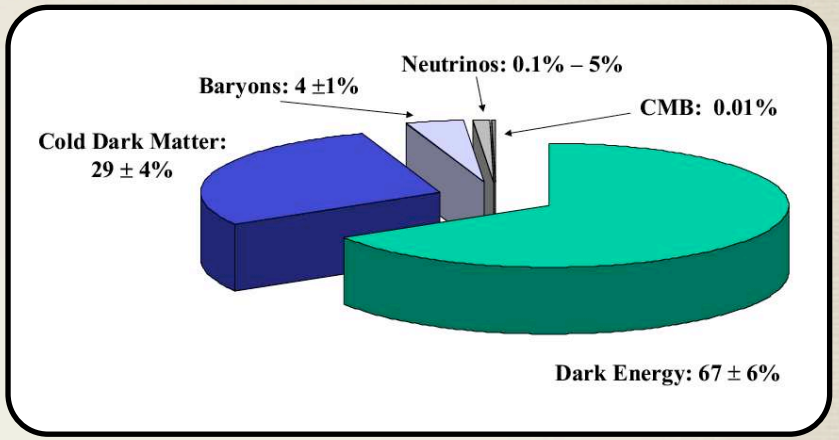
Dark Matter

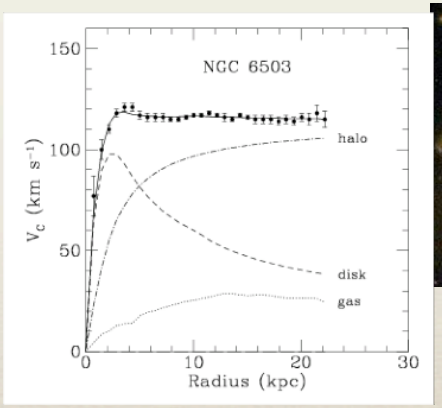
* Why??

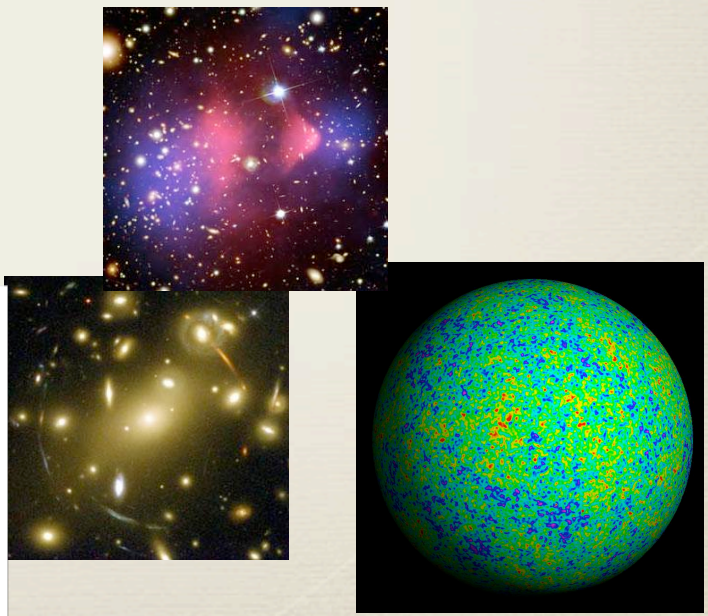
  Most of our Universe is "missing". What is the other 95% made of?

* All current evidence is from the gravitational effects DM has on baryonic matter we can observe.

* WIMPs are best motivated candidate for CDM.







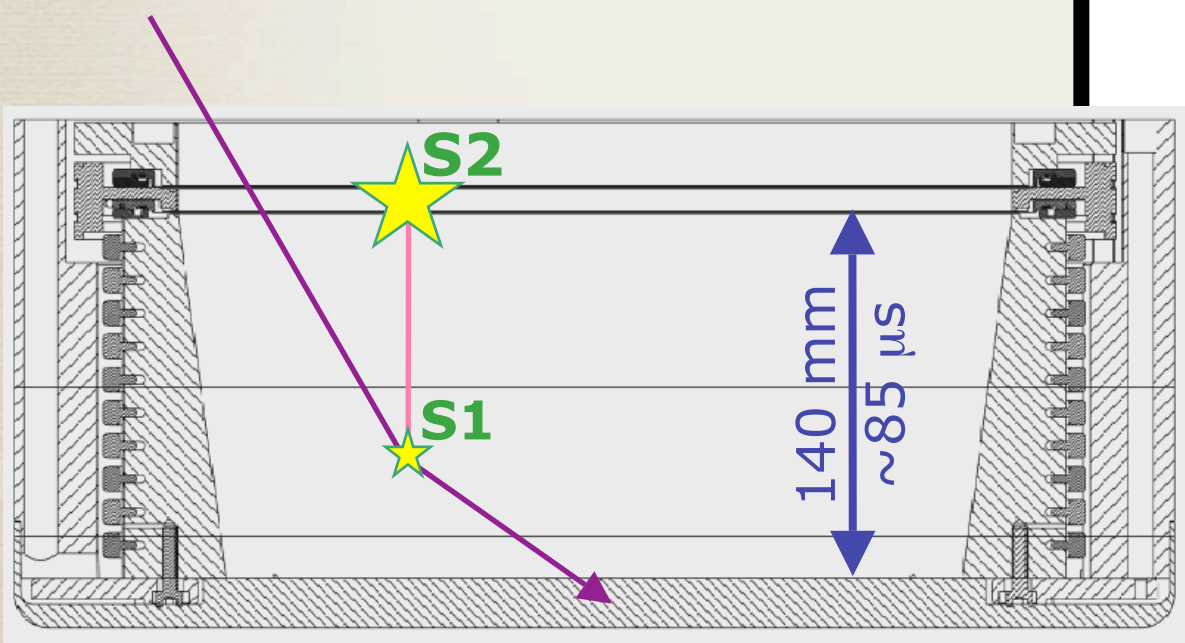
Detection with Two-phase Xenon

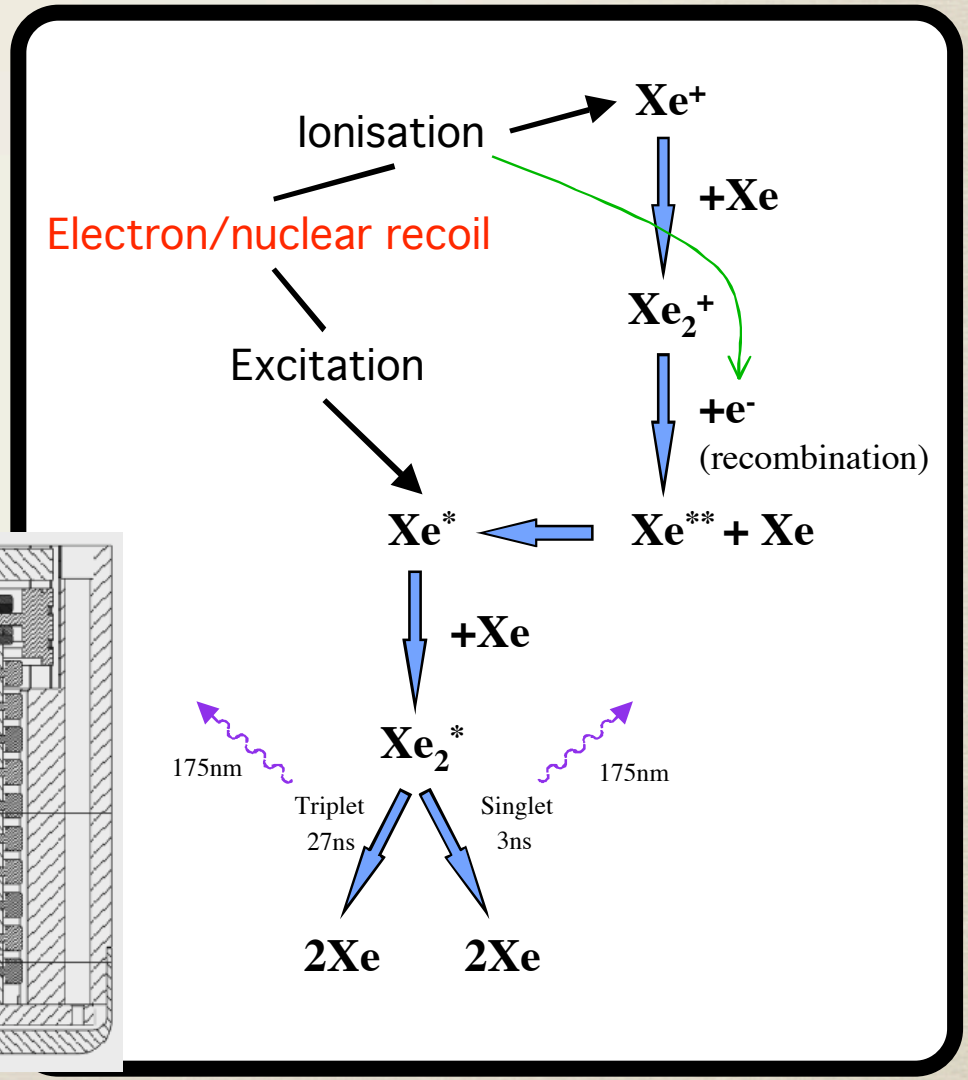
Interaction with Xenon atom

-> Prompt Scintillation, S1 signal

Ionisation electrons drifted to extraction region by electric field

-> Electroluminescence, S2 signal





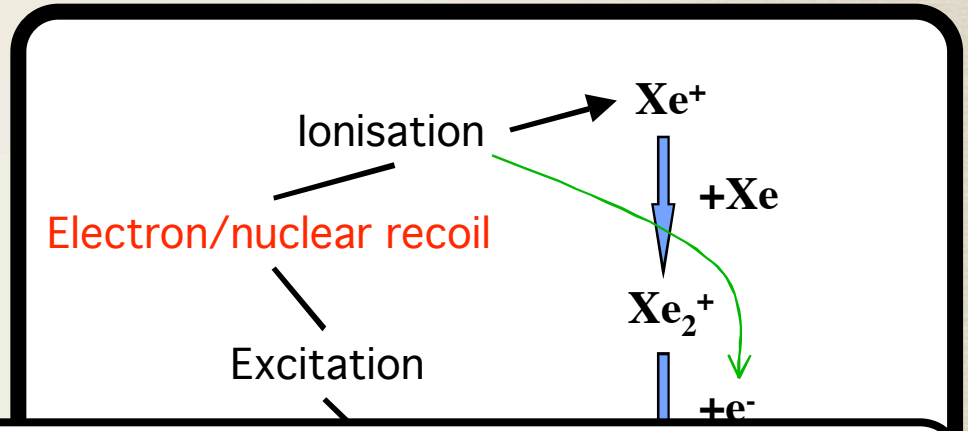
Detection with Two-phase Xenon

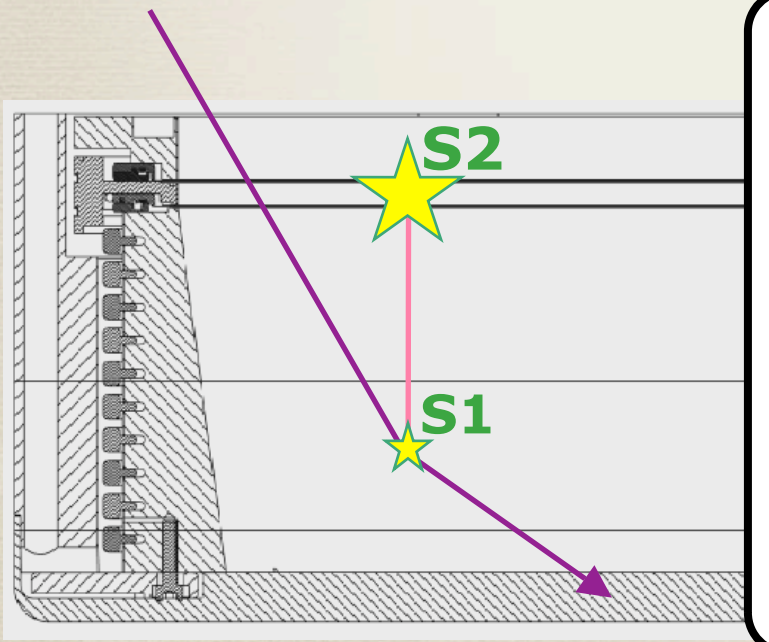
Interaction with Xenon atom

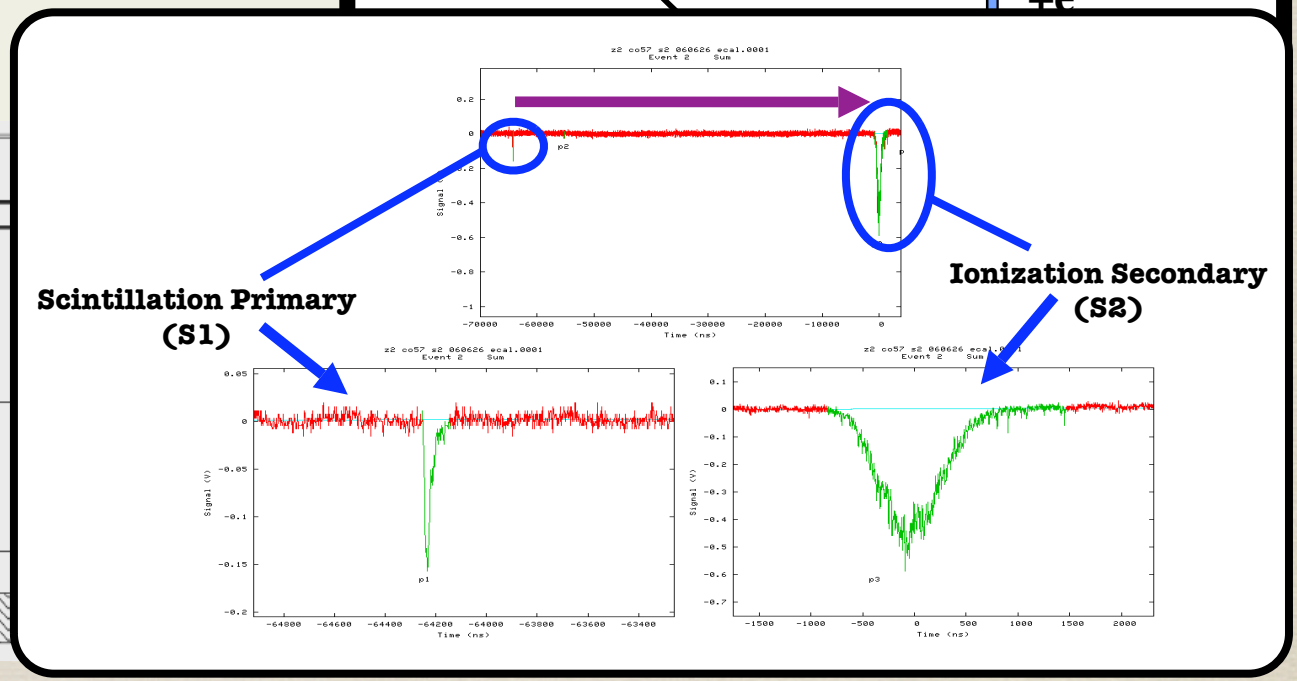
-> Prompt Scintillation, S1 signal

Ionisation electrons drifted to extraction region by electric field

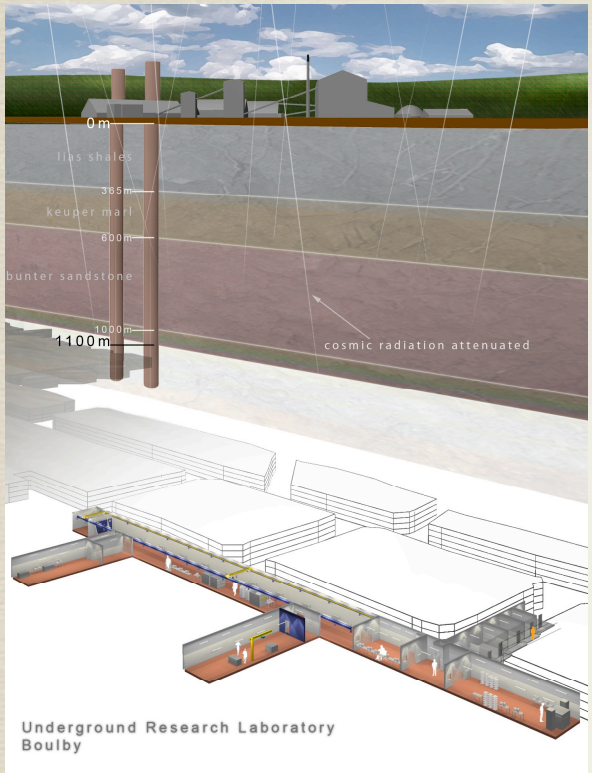
-> Electroluminescence, S2 signal







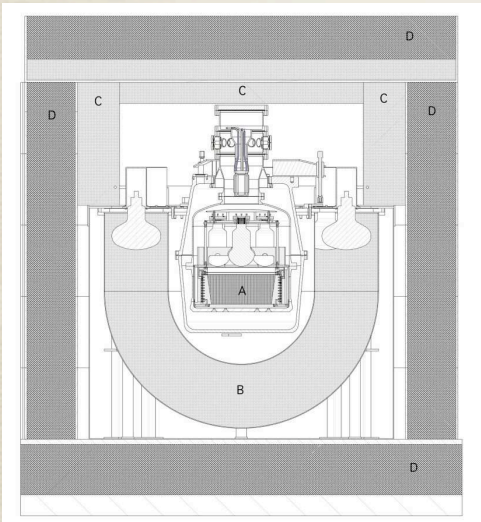
ZEPLIN-II: Operations



Searching for very rare and small signals requires a very low background. To achieve this the detector is located within a shielding castle, in the Palmer UG lab at Boulby mine.

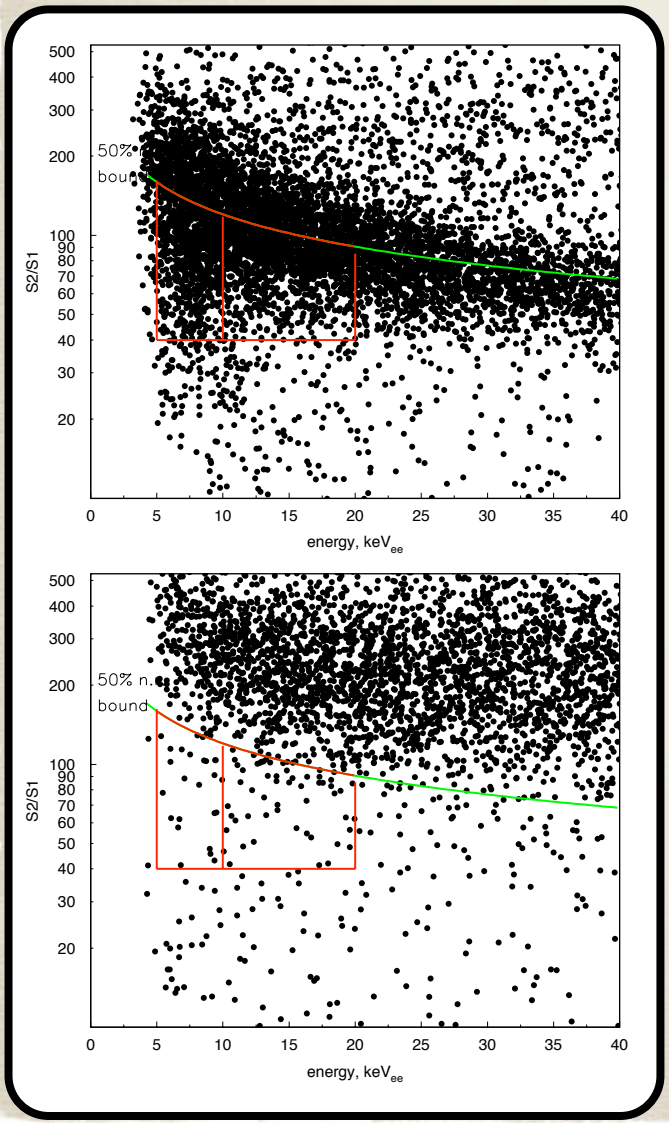
After a commisioning period, a 31-day high-quality data set was acquired.

A blinded analysis procedure was carried out, meaning only 10% of the background data was available for detector characterisation.

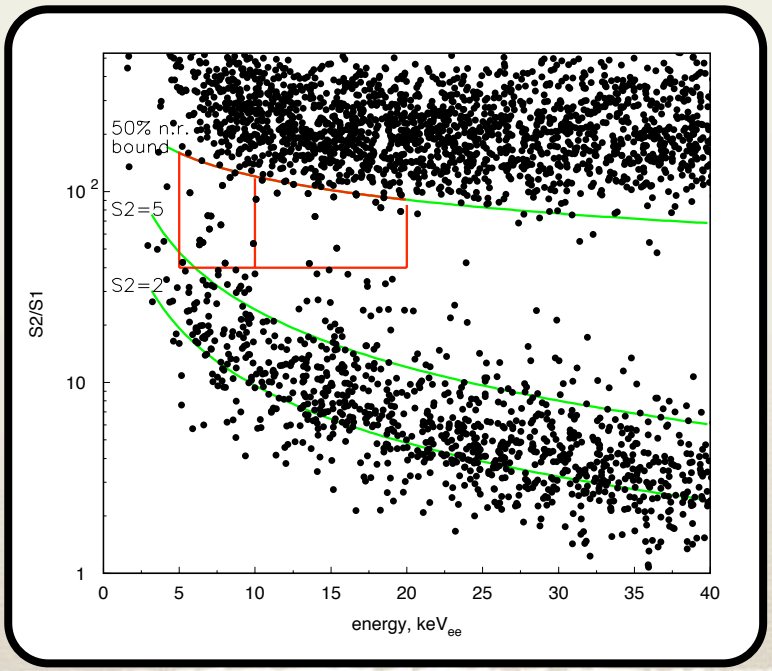


ZEPLIN-II: Results

Signal (AmBe) and Background (^{60}Co) Calibrations



- Detector calibrated for expected signal and search-box set. Difference in S2/S1 ratio provides discrimination power.
- Blind science dataset analysed → Unexpected background population observed from Rn progeny events located at the walls of the detector.



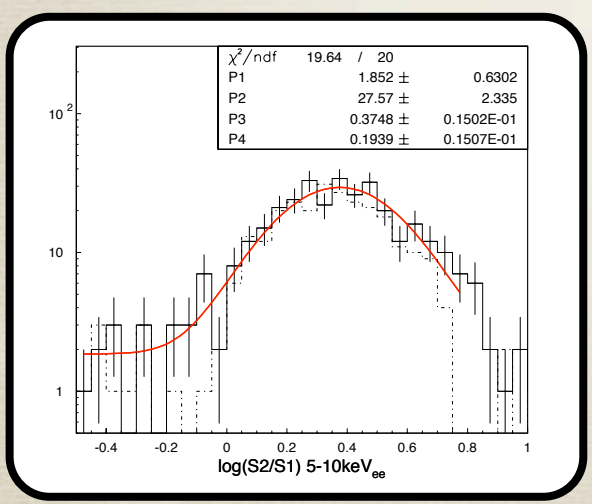
Science dataset

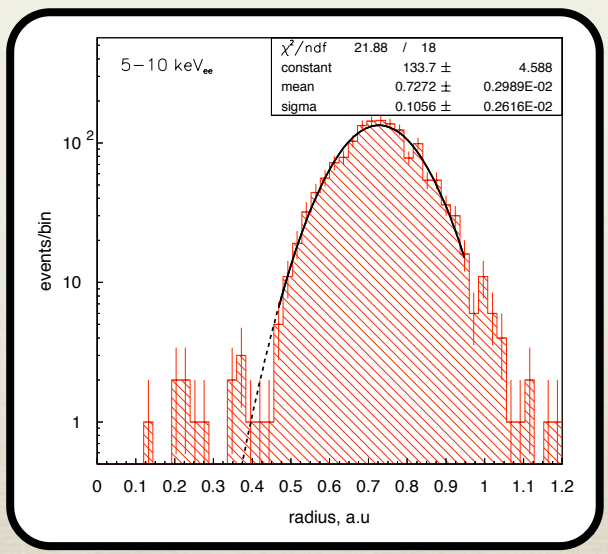
ZEPLIN-II: Science Result

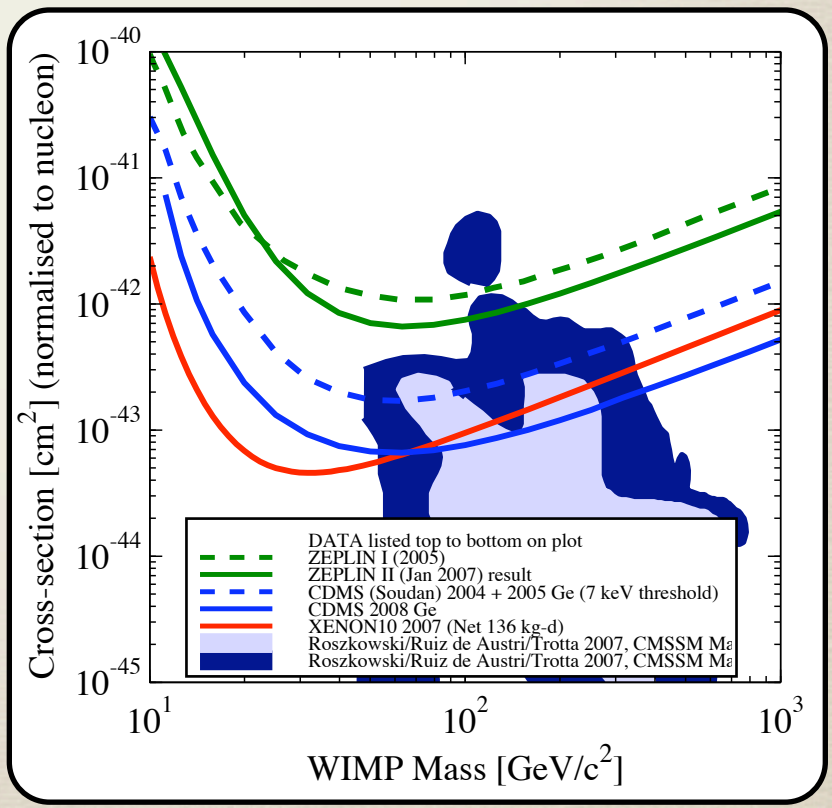
- Number of events expected in the box calculated from calibrations and background data.
- We observed 29 events with a total expectation of 28.6 ± 4.3 events.
- Giving a limit on cross-section with a minimum of 6.6 x 10^{-7} pb at M_D= 65 GeV.

"First Limits on WIMP nuclear recoil signals in ZEPLIN-II..."

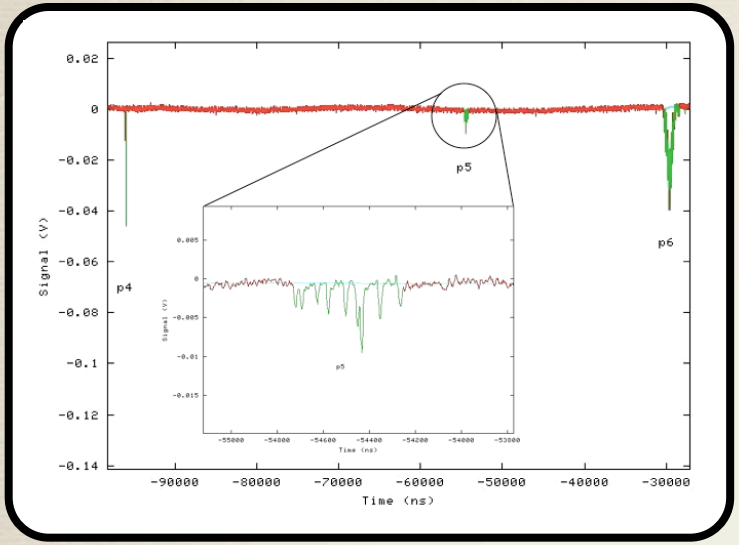
G.J. Alner et al., Astroparticle Physics 28 (2007) 287-302





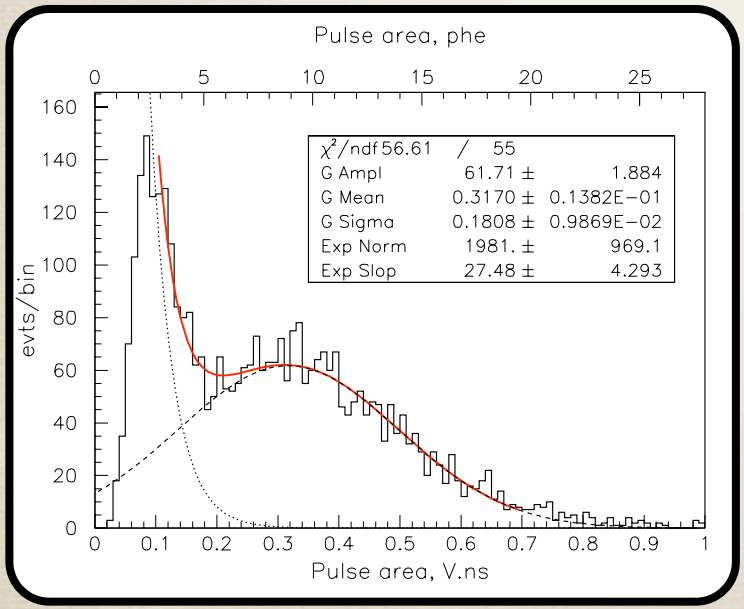


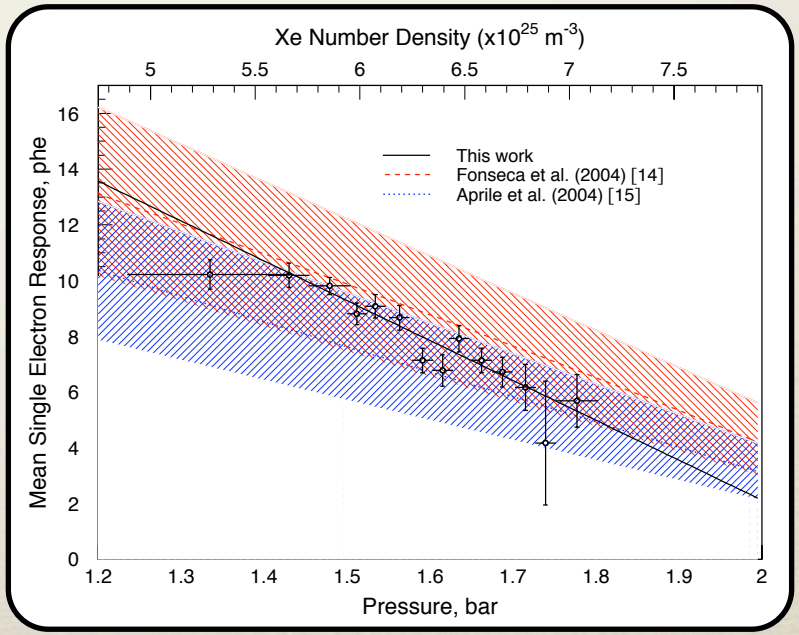
Single Electron Emission



First quantitative measurements of single ionisation electron emission in noble liquid detectors.

Agreement of signal size with predictions from electroluminescence yield measurements provides strong evidence.





Single Electron Production

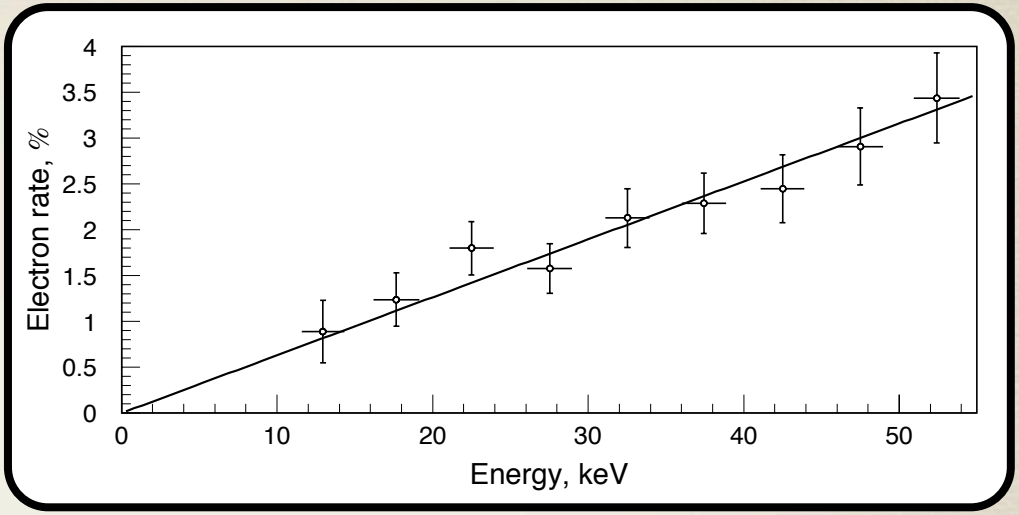
Radial and depth distributions suggest source/production throughout the bulk of the liquid.

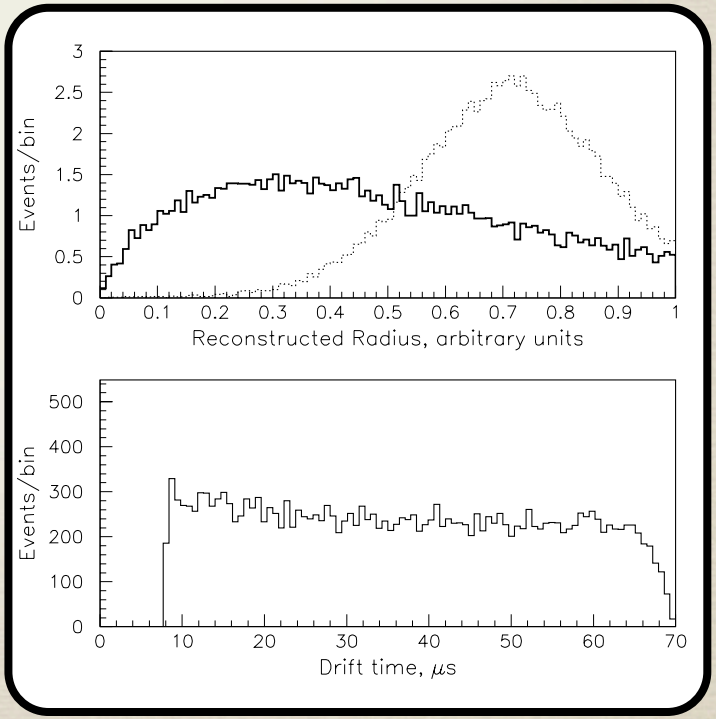
Clear link between number of scintillation photons and rate of single electron production.

→ Likely source: Photoionisation

What is being photoionised?

Most probable candidates are impurities in the liquid. Although, none can be confirmed or ruled out.





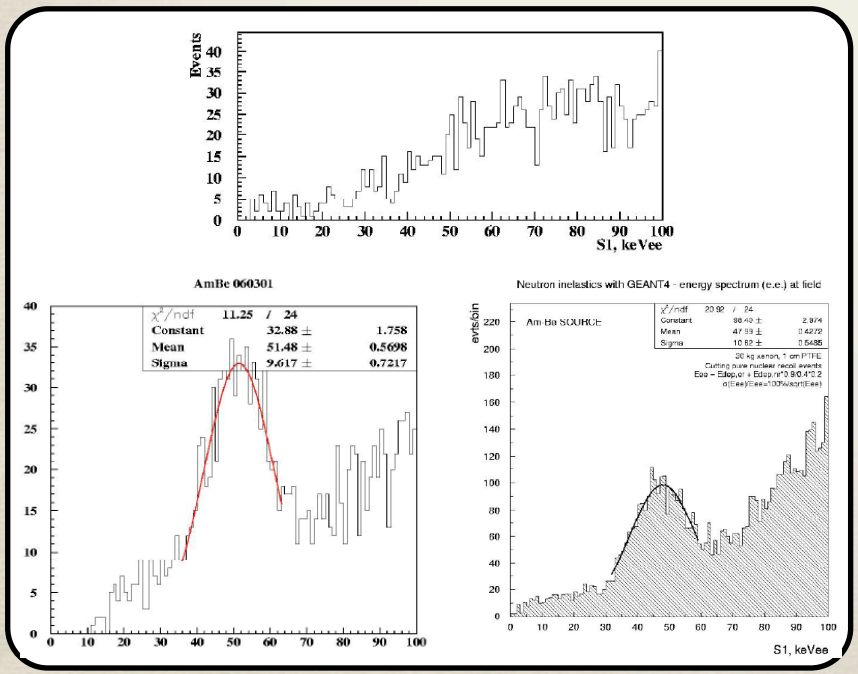
"Measurement of single electron emission in two-phase xenon"

B. Edwards et al., arXiv:0708.0768v1
(submitted to Astroparticle Phys.)

ZEPLIN-II: Related Work

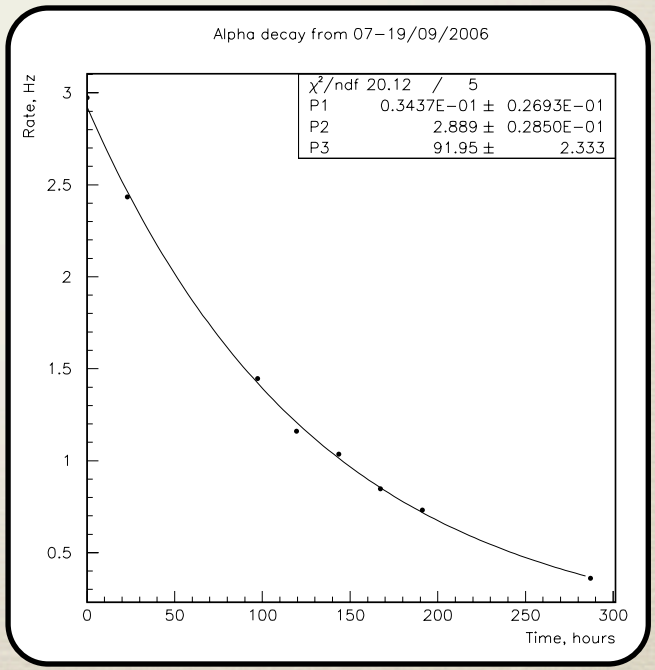
S1-S2 Anti-correlation

- Applied combination of S1 and S2 signals to improve energy resolution. $E^* = S1 + k.S2$
- Used to resolve 40 keV inelastic feature from AmBe.

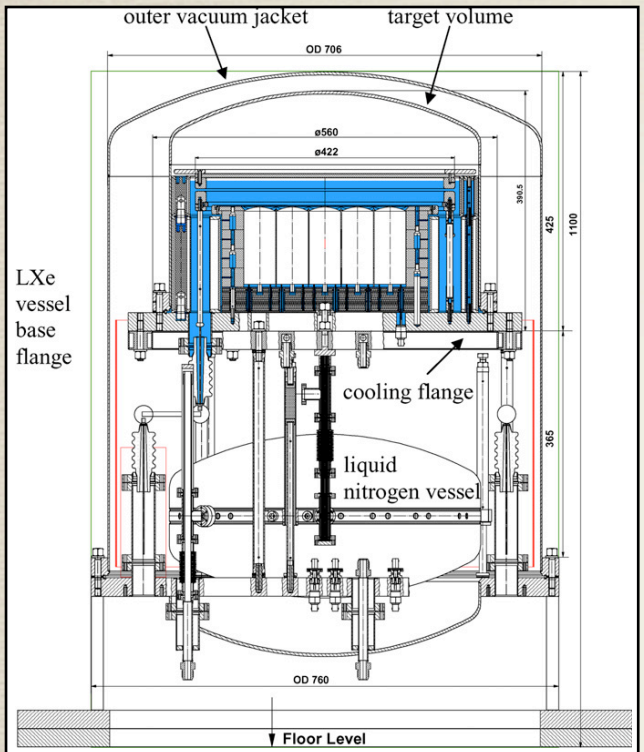


Alpha emanation from Getters

- Alpha rates monitored and decay time constants calculated.
- Confirmed Rn emanating from SAES getters.
- Results confirmed by experimental test.



ZEPLIN-III: Design



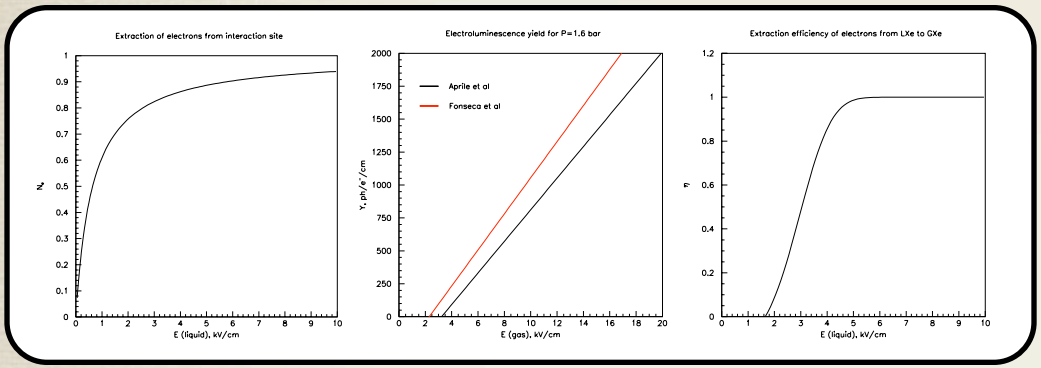
Same operating principle as ZEPLIN-II, but with **high-field operation** and **surface-free geometry**.

31 PMTs in the liquid phase provide **better precision position reconstruction** and **better light yield**.

Low-background components and construction throughout. Ultra low background PMT upgrade in preparation.

Detector **fully shielded**, with calibration source delivery system and detector levelling mechanism.

ZEPLIN-III: Commissioning

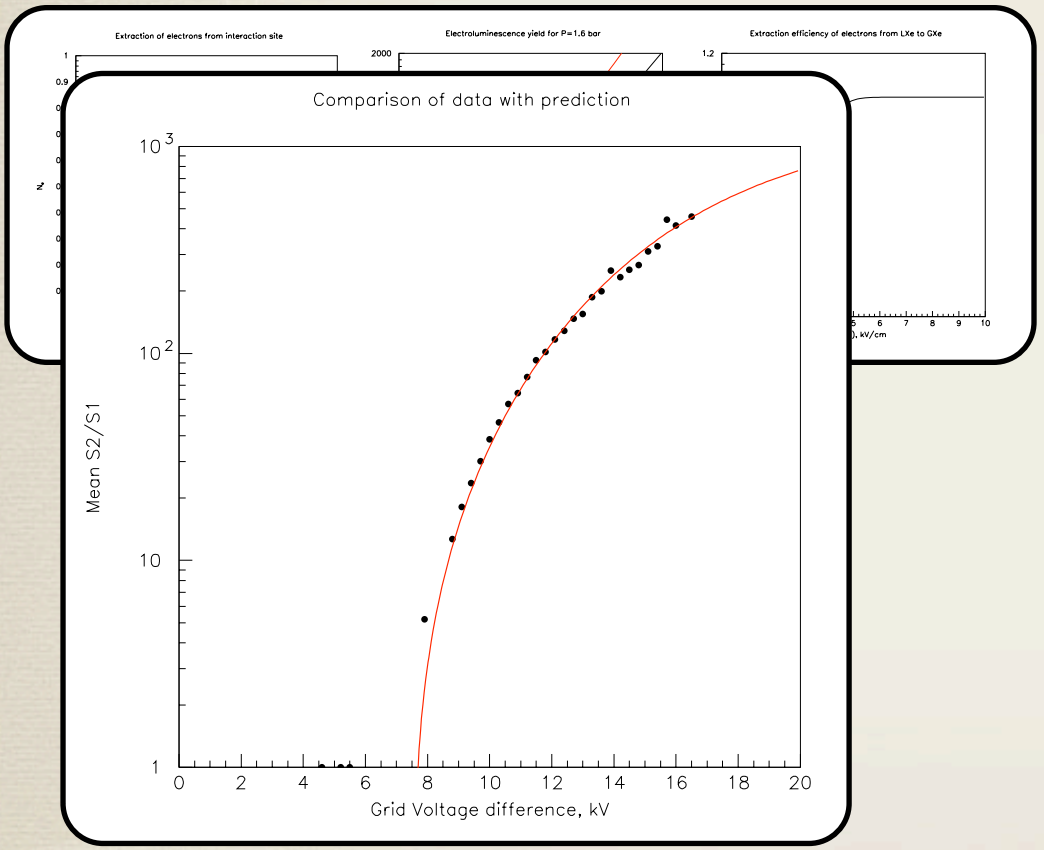


Size of secondary signal as a function of electric field can be predicted from parameterisations of different processes.

Preliminary dataset to test this shows excellent agreement with prediction.

Preliminary AmBe and ^{137}Cs calibrations appear to show **improved separation** of populations at higher field.

ZEPLIN-III: Commissioning

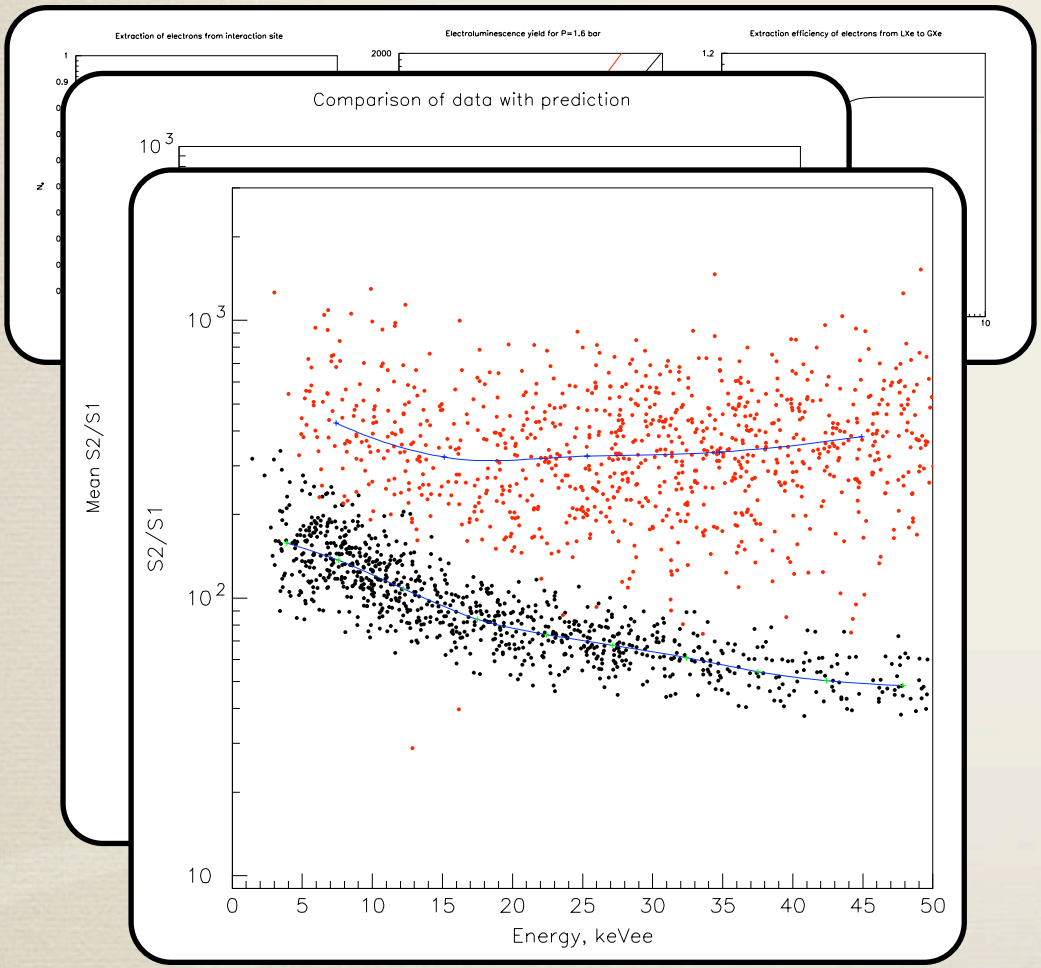


Size of secondary signal as a function of electric field can be predicted from parameterisations of different processes.

Preliminary dataset to test this shows excellent agreement with prediction.

Preliminary AmBe and ^{137}Cs calibrations appear to show **improved separation** of populations at higher field.

ZEPLIN-III: Commissioning



Size of secondary signal as a function of electric field can be predicted from parameterisations of different processes.

Preliminary dataset to test this shows excellent agreement with prediction.

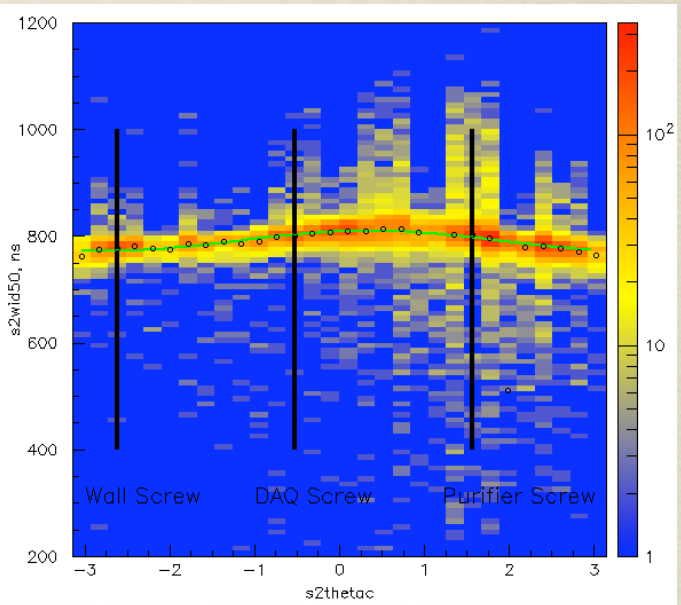
Preliminary AmBe and ^{137}Cs calibrations appear to show **improved separation** of populations at higher field.

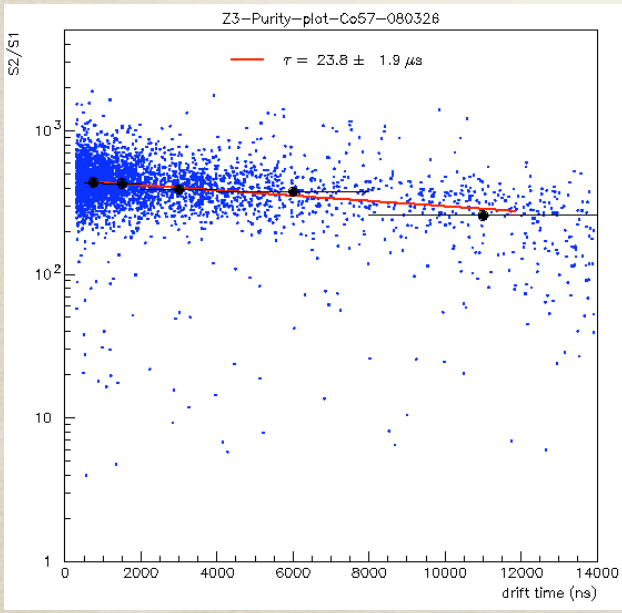
ZEPLIN-III: Operations

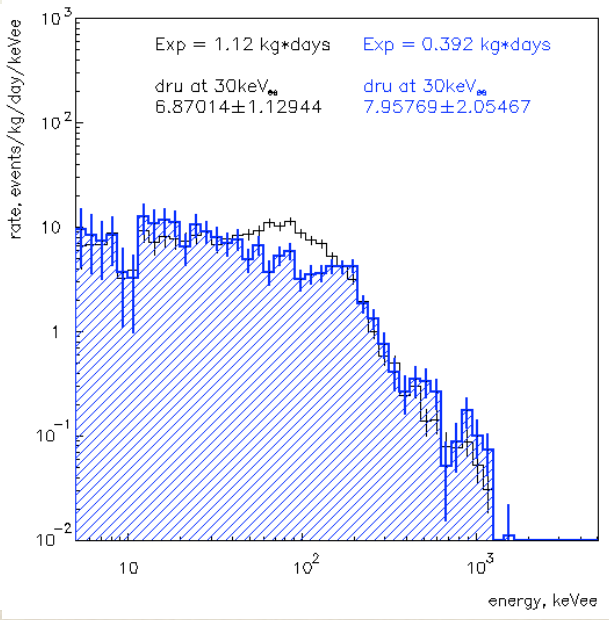
First science data run underway. ~300 kg.days of science data collected to date. ~600-700 kg.days will be collected.

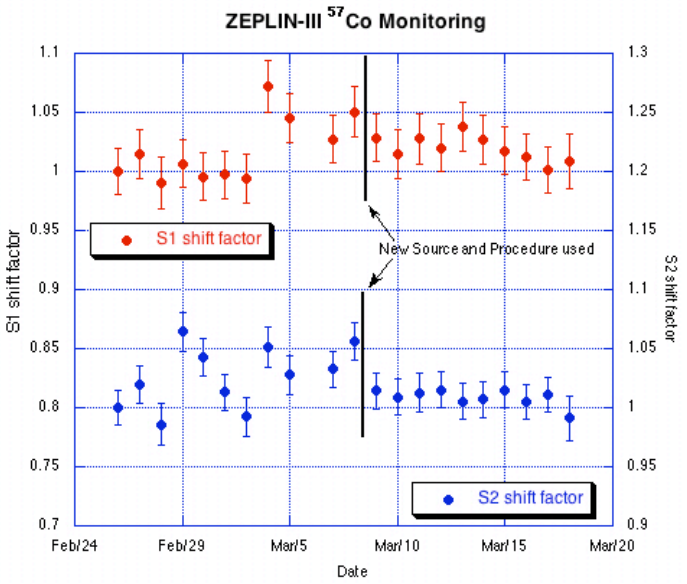
Aim: reach ~1 x 10^{-7} pb level.

Daily monitoring carried out for detector tilt, energy calibrations, background rates and xenon purity.









Summary

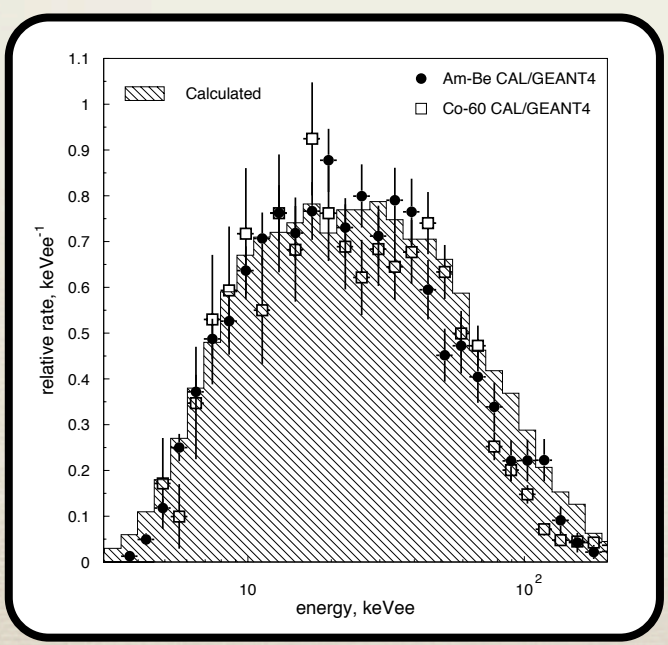
- ZEPLIN-II operated underground from 2005 to 2007. One tonne day of raw data collected, giving final exposure of 225 kg.days.
- ZEPLIN-II set a limit of 6.6 x 10^{-7} pb at M_D = 65 GeV.
- Additional work done highlighting areas of interest for future experiments: Single electron emission, alpha emanation and S1/S2 anti-correlation.
- ZEPLIN-III fully commissioned and shielded. First science run **underway**, with ~300 kg.days of data acquired so far.

Thanks to the ZEPLIN-III Collaboration

Imperial College London

ZEPLIN-II: Analysis

- Detector characterised with calibrations and an unblinded sample of background data.
- Position reconstruction using a simple centroid method, giving resolution of about 1 cm.
- Efficiencies for all cuts carefully calculated.



^{57}Co Energy and Position Calibrations