Status report and recent results from the UK Dark Matter Collaboration

Talk Outline

UKDMC programme, ongoing aiming for <0.1 events/kg/day
(Fully funded 91-94, 60% funded 94-98)

UKDMC underground facility

Detectors - calibration

background rejection - discrimination

Recent results from NaI xtals

Future propects

<u>Conclusions</u>

UKDMC- Detectors

Look for small (~50 keV) nuclear recoil

Room temperature NaI(1000ppmTl):

- Operational since mid 93, continuing R&D. 400g-several kg xtals
- Run in water tank and castles
- Variation in time constant:Neutrons~150ns
  Gammas~190ns

Cooled NaI(minimal Tl):

- Operational since mid 94, continuing R&D.
- Run in Pb/Cu castle
- UV and visible emission wavelengths each with own characteristic time constant of tens of ns and few μs.

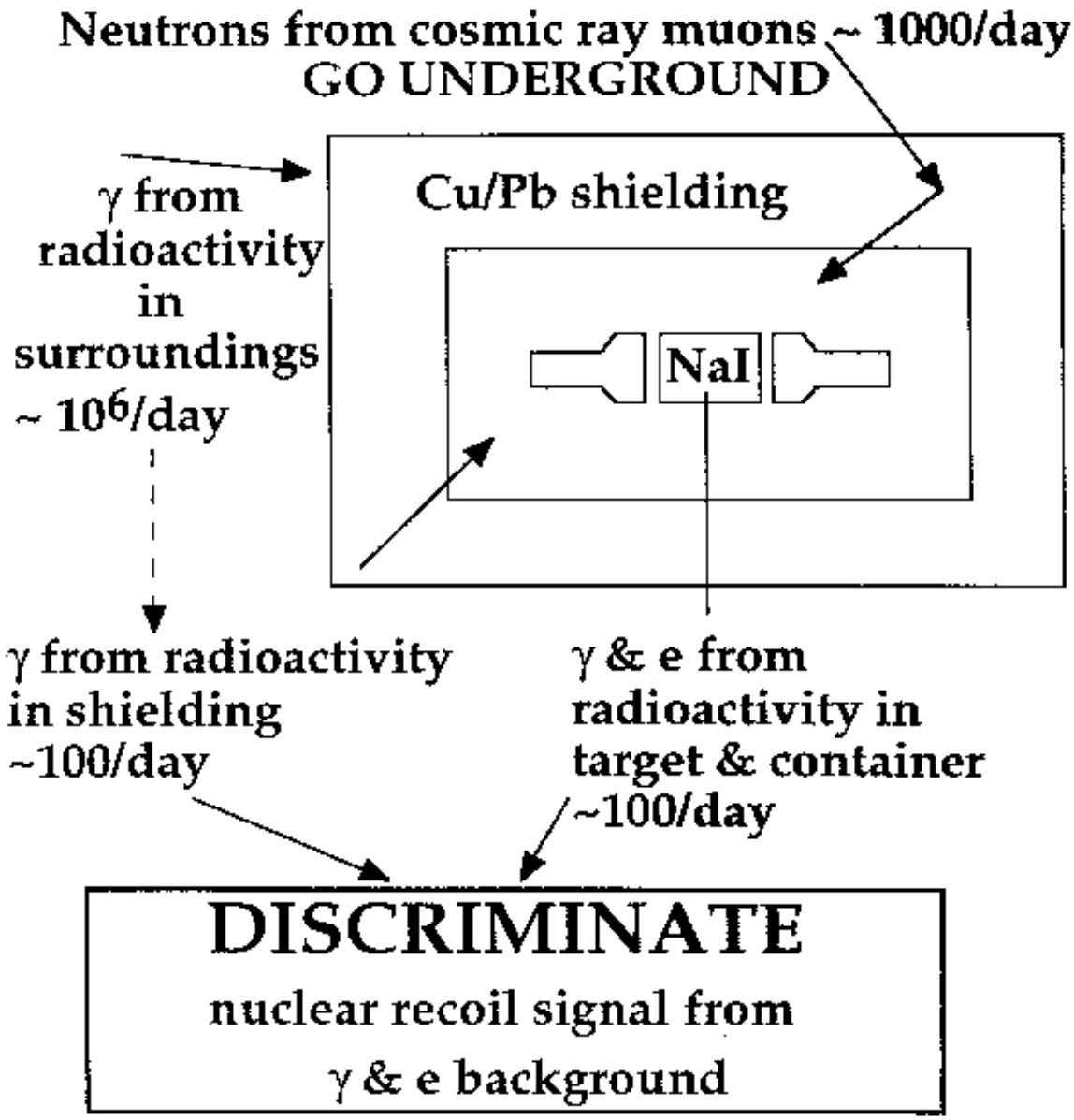
Variation in UV component or overall time constant.

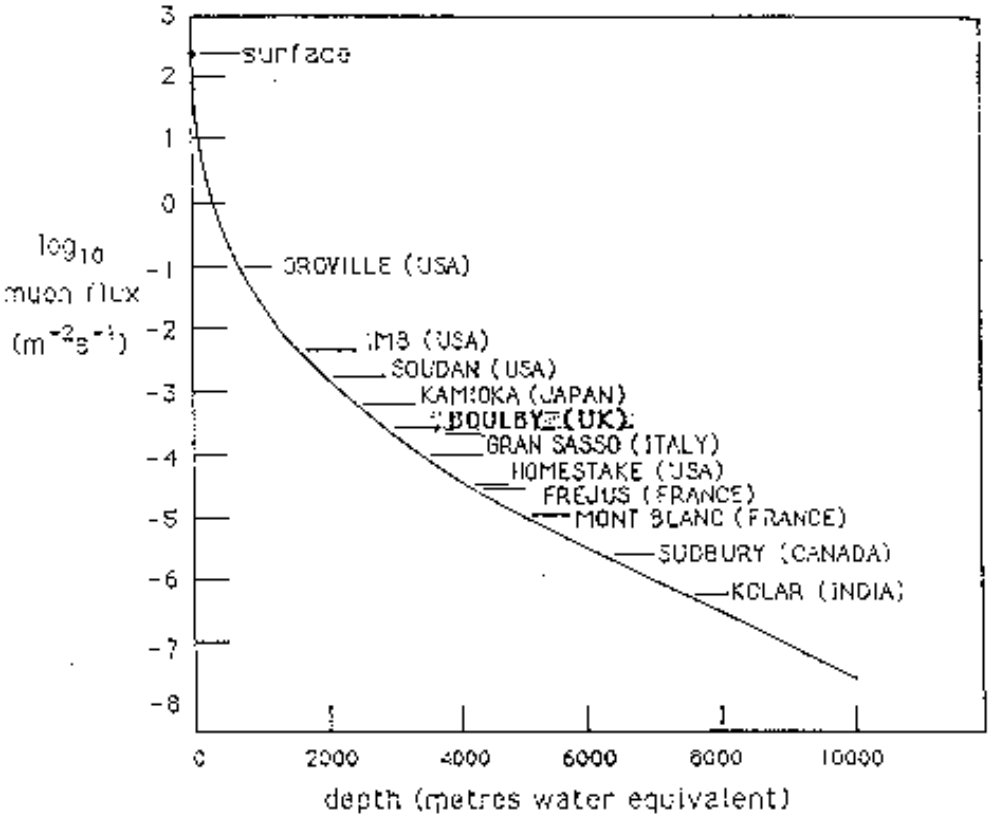
Liquid Xenon:

- R&D, Scintillation seen down to 100 keV.
- Possibility of reaching lowest event rates.

WIMP searches - Backgrounds

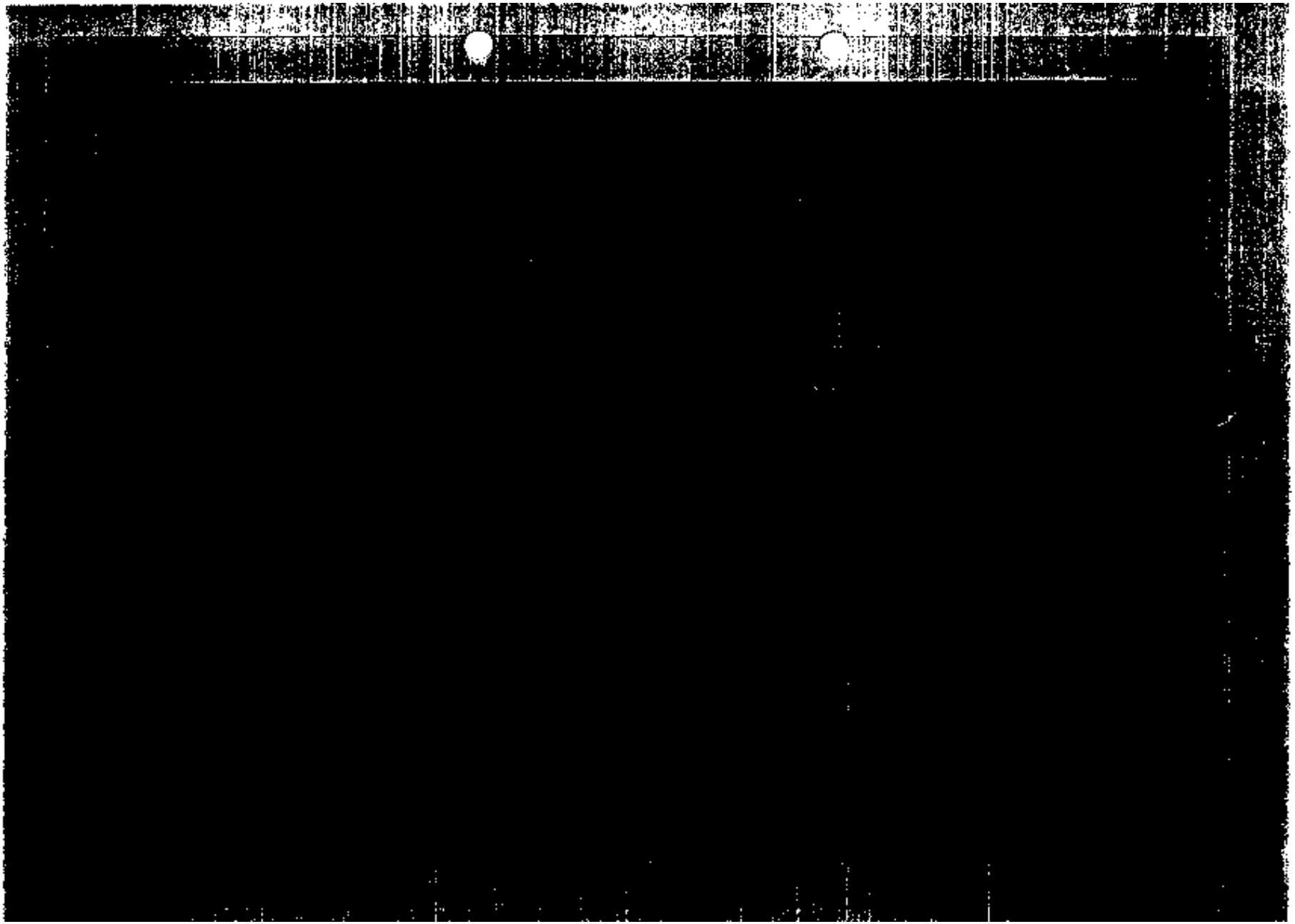
Sources of background in 0-100 keV range.





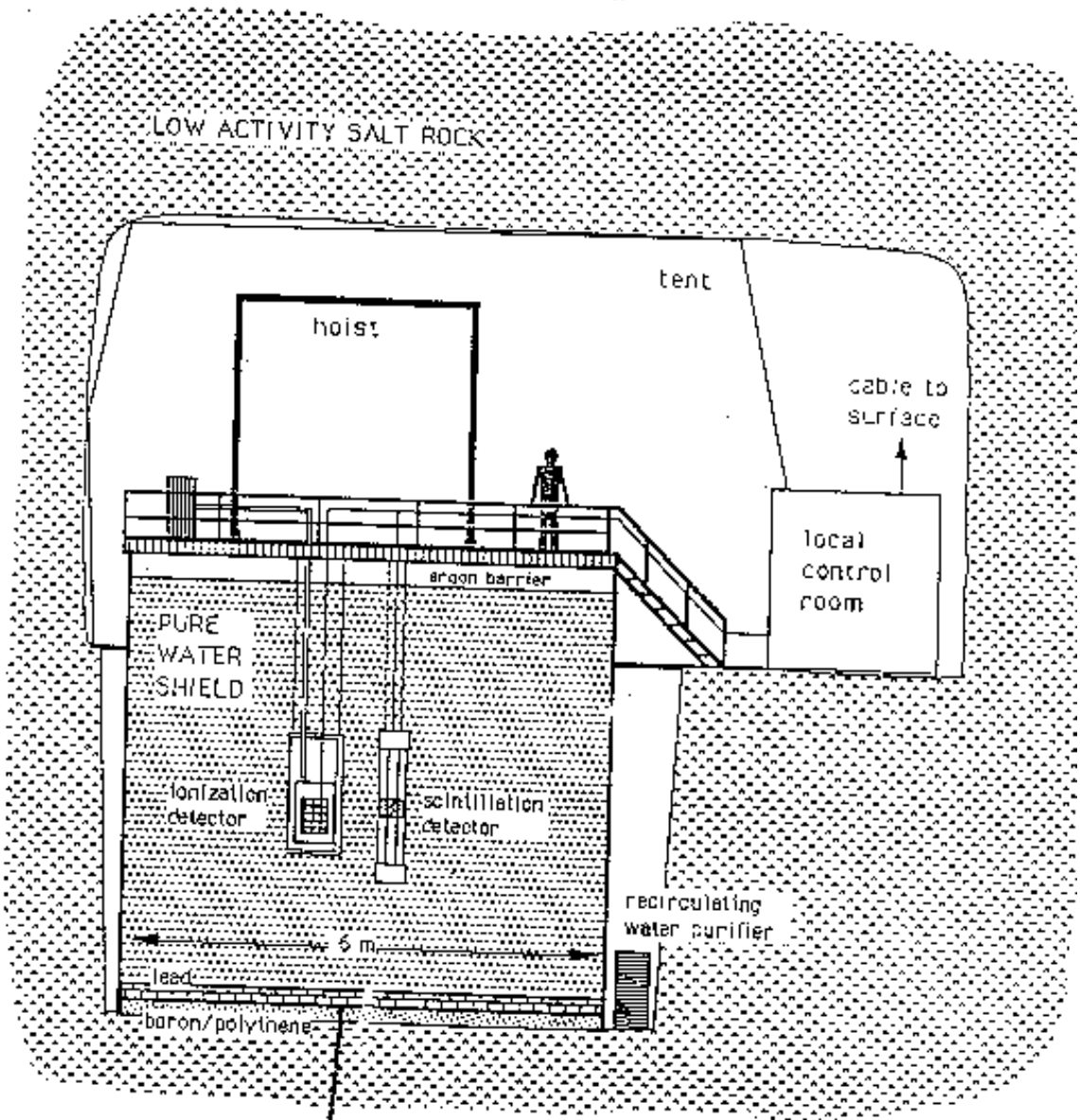
Approximate muon flux and depth for some underground physics sites.

muon flux down by 10^6



BOULBY MINE DARK MATTER "OBSERVATORY"

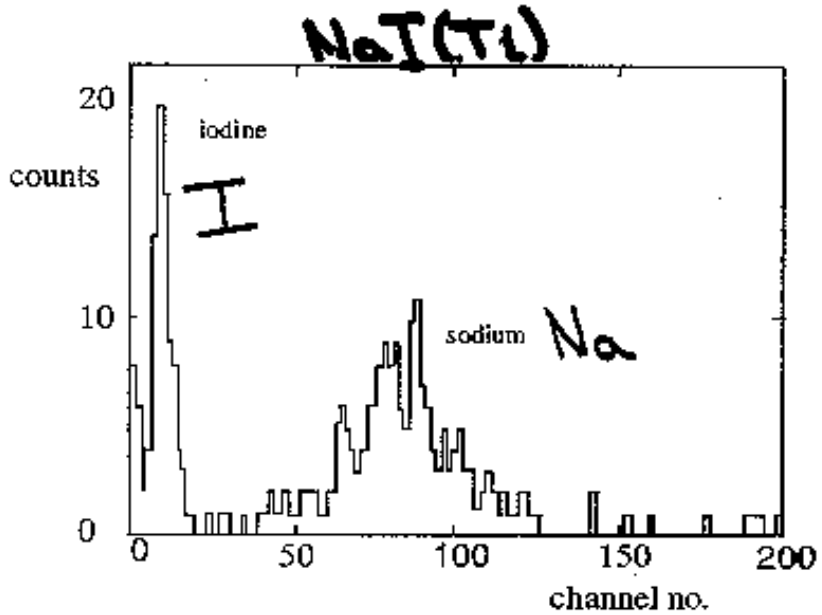
EXPERIMENTAL CAVERN (DEPTH 1100 M)



additional upward Shielding

UKDMC Detectors:

Response Results



Coincidence spectrum for sodium iodide

Previously unpublished

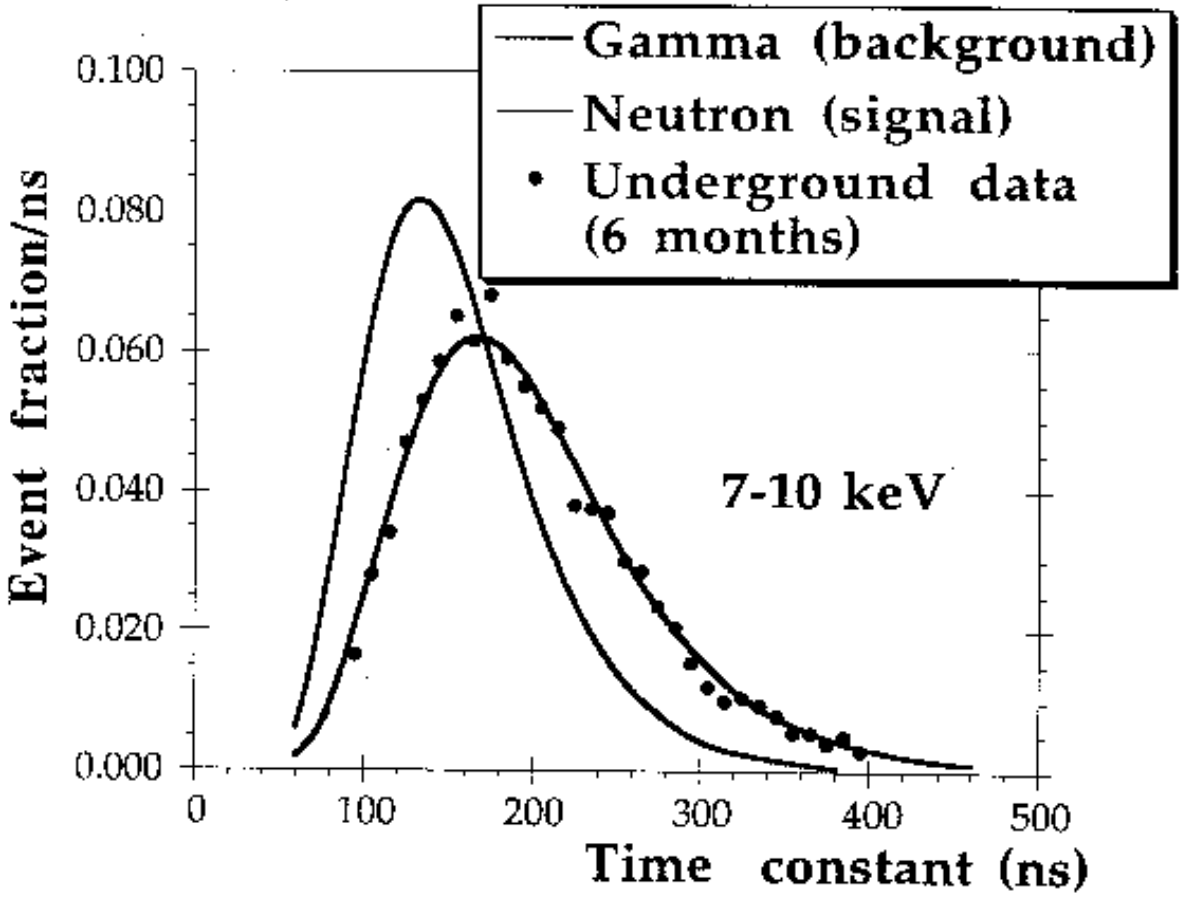
Target Scintillator	Element	Response (%)
NaI(Tl)	Na	30±3
NaI(Tl)	I	10±2
NaI(undoped	As for NaI(Tl)	
CaF2(Eu 0.5%)	Ca	8±2
CaF2(Eu 0.03%)	Ca	7±2
CaF2(Eu 0.5%)	F	12±2
CaF2(Eu 0.03%)	F	10±2
C6F6	C	~0.7
C6F6	F	<0.7

Table of measured nuclear recoil responses

(See PLB 321 Spooner et al, PLB 322 Davies et al.)

UKDMC- Discrimination

Room temperature NaI(Tl)



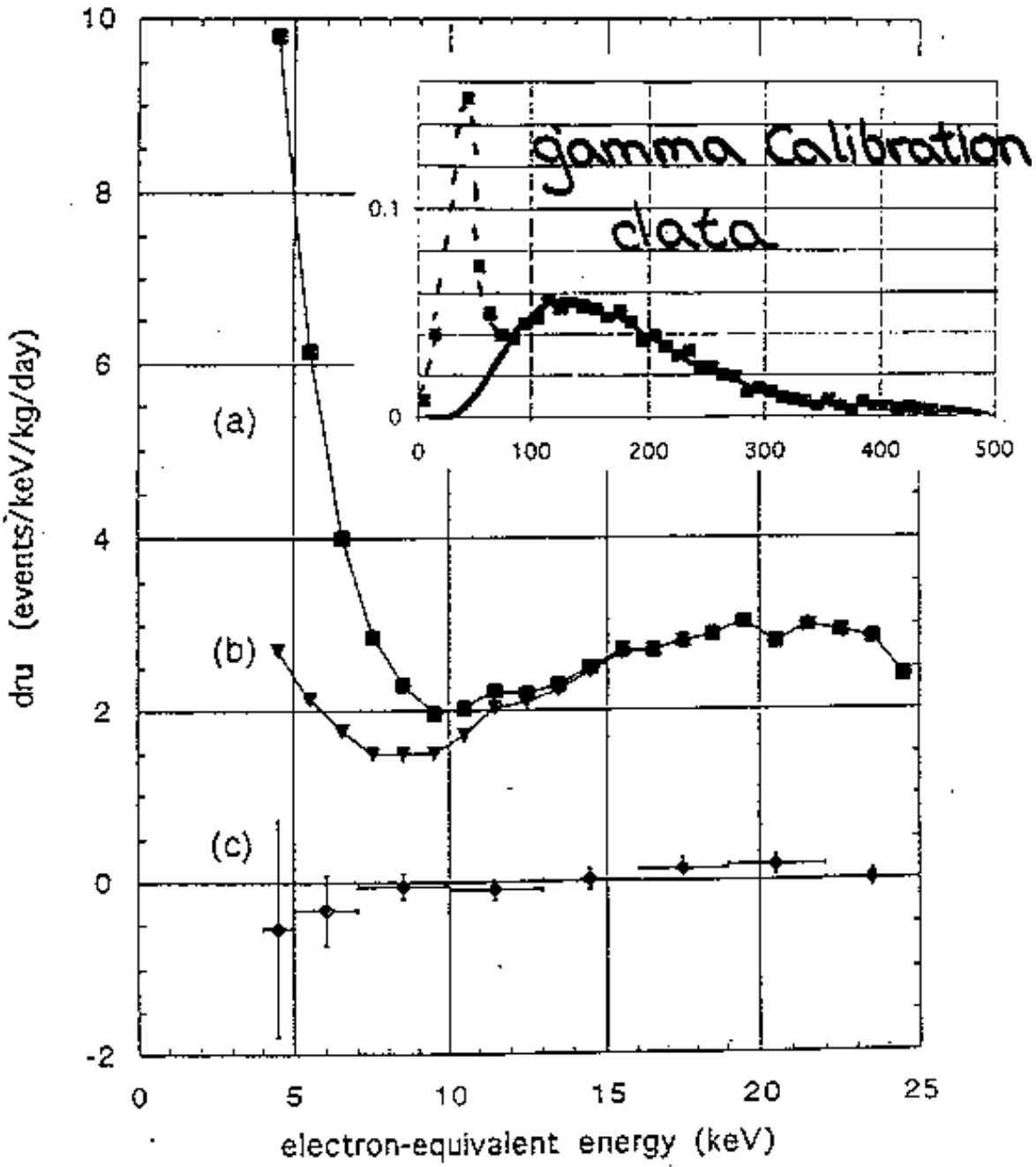
Express data as a linear combination of n and γ

-> $\text{Data} = f_n \times n + f_g \times \gamma$

f_n and f_g are the fractions of n's and γ's.

Find most likely f_n and 90% c.l.

90% c.l. < 0.10 i.e.>90% background rejection.

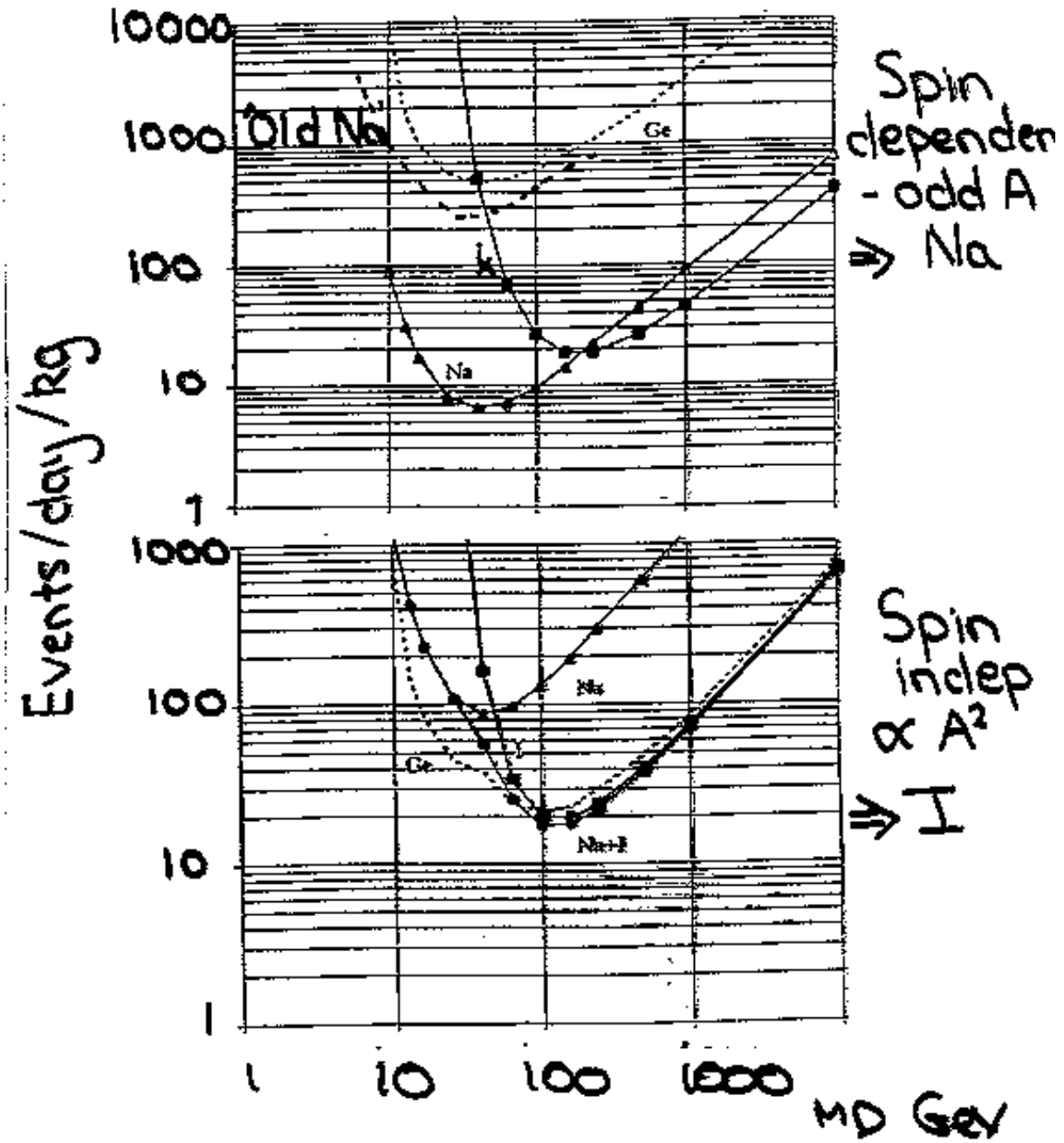


Background differential spectra:

- (a) observed total rate
- (b) after subtraction of distribution of fast noise pulses
- (c) 2σ limits on nuclear recoil events for energy spans shown by horizontal bars.

UKDMC - Results

Normalised rate as independent of target.



×50 better than Ge spin dependent limits.

Towards lower event rates

Sodium Iodide:

Gain $\propto \sqrt{N}$, N = total number of counts.

So...

Continued running, higher mass targets.

and/or

More light -> improve threshold /discrimin.

and/or (APD's)

Higher purity -> lower background.

=> <1 event/kg/day with ~30kg detector.

Greater discrimination:

Liquid xenon: 0.01-0.1 events/day/kg possible after a few years running.

Predictions proven-ICARUS Collaboration.

Range:

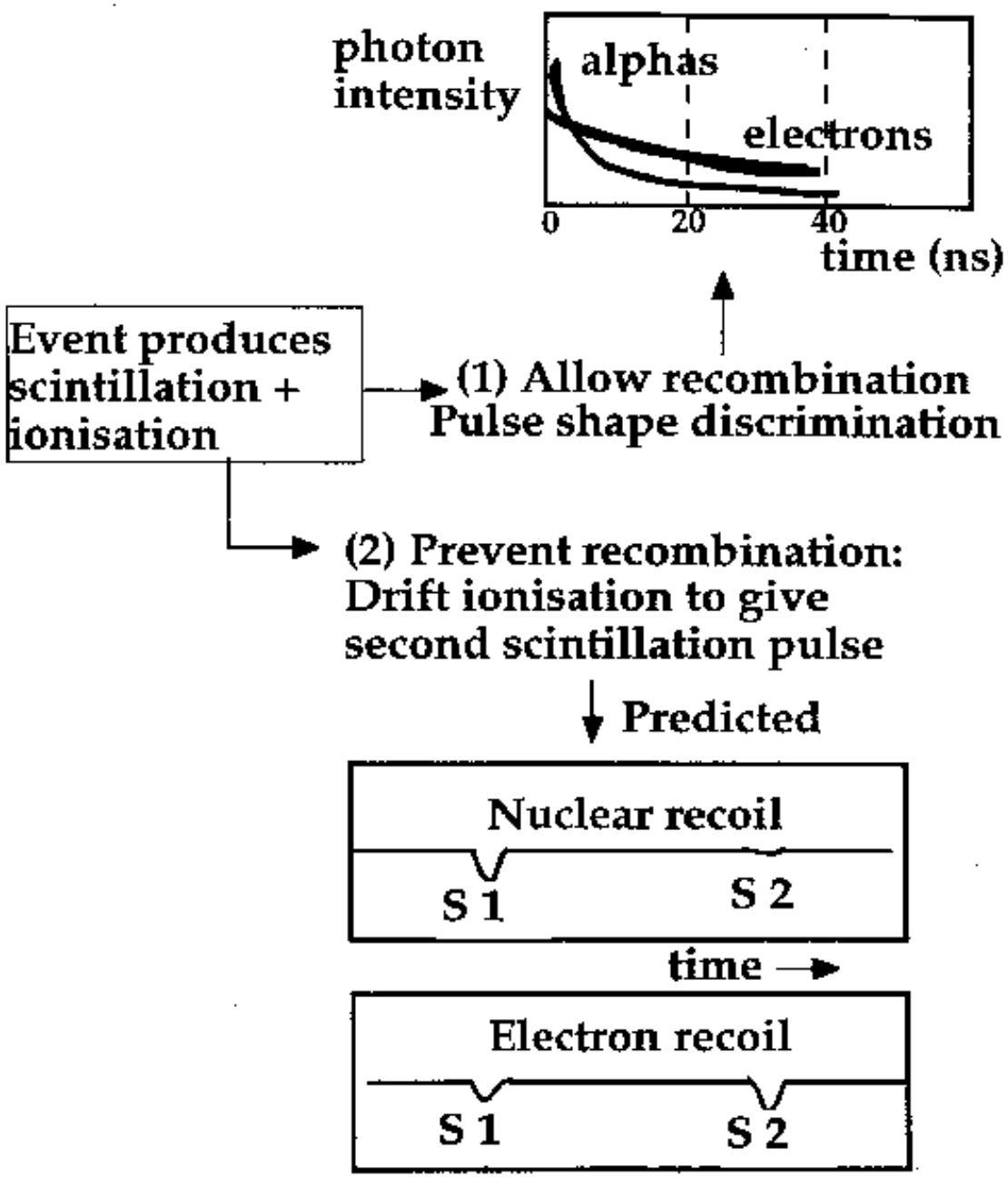
Electron recoil 'longer' than nuclear recoil

=> (Granules in liquid Scintillator)

(1) Improved background discrimination.

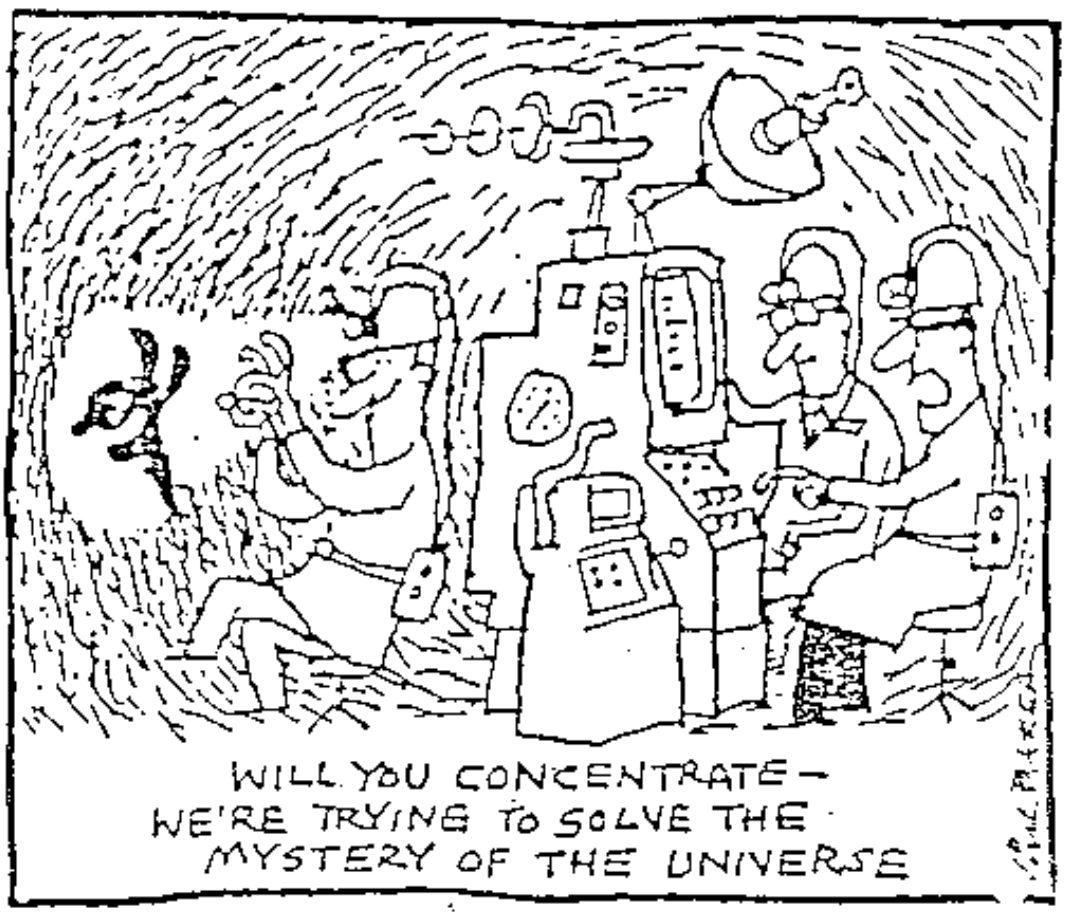
(2) Directionality - confirm galactic origin.

Discrimination in liquid xenon



Observed by ICARUS Collaboration

Proto-collaboration with various groups set-up


WILL YOU CONCENTRATE—
WE'RE TRYING TO SOLVE THE
MYSTERY OF THE UNIVERSE

UKDMC Detectors:

Scintilation Response

- Efficiency of scintillation at low energies? (quenching..)

- Need to know to select a good target and to be able to set an exclusion plot on WIMP rate (and confirm discrimation seen in lab with n source)

- Use a mono-energetic (E_n) neutron beam

$$E_{recoil} = \frac{2.A.E_n.(1 - \cos\theta^*)}{(A+1)}$$

- Measure observed energy, E_{obs}
- Ratio of E_{obs}/E_{recoil} gives efficiency
- Vary angle and E_n

- Have tested NaI(Tl and undoped), CaF_2, C_6F_6 and NE224