High Pressure Dark Matter Detectors

James T White
Texas A&M University
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DM10 – UCLA

High Pressure Gas?

- Possible Advantages
  - Nuclear Recoil Discrimination – how does it compare to liquid phase?
  - Room Temperature Operation
    - ➔ ease of purification !!!
    - ➔ no cryogenics !!!
    - ➔ no leveling !!!
  - Different targets (Xe, Ar, Ne), ~same approach

- Arguments Against
  - Pressure vessel vs cryostat
    - BUT: composites?, pressure held externally?
  - Size of vessel
    - density ~ 0.1 g/cc ➔ e.g. $30^{1/3}$ ~3 x bigger for xenon
  - Shielding/surface area
    - Active shield + large water tank – ideal for Room T, HP detector

- Bottom Line
  - It ain't over until …
  - AND: future, long term running to collect large samples – may be of use

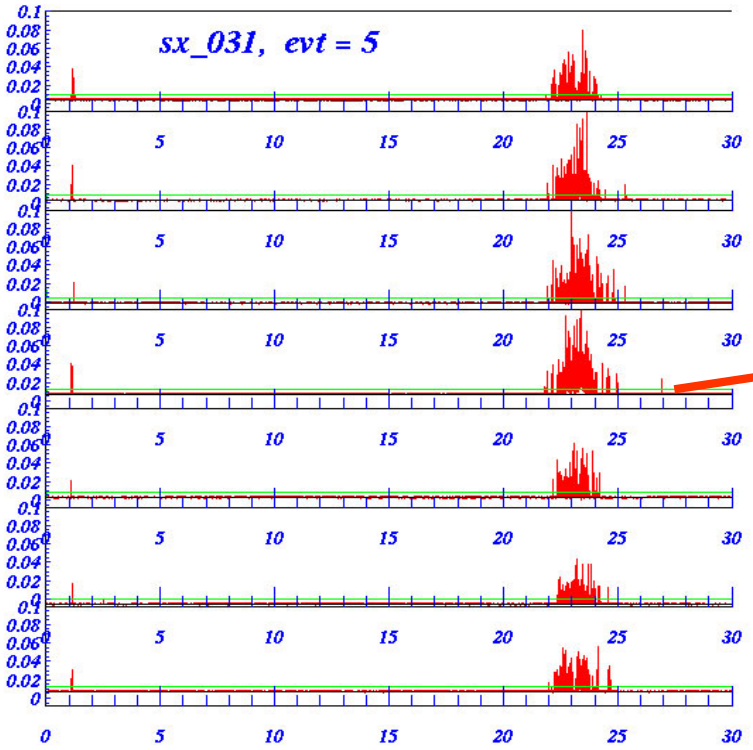
Outline

- S2 vs S1 discrimination
  - Quick review of previous results
- S1 shape discrimination
  - Recent data
- Plans

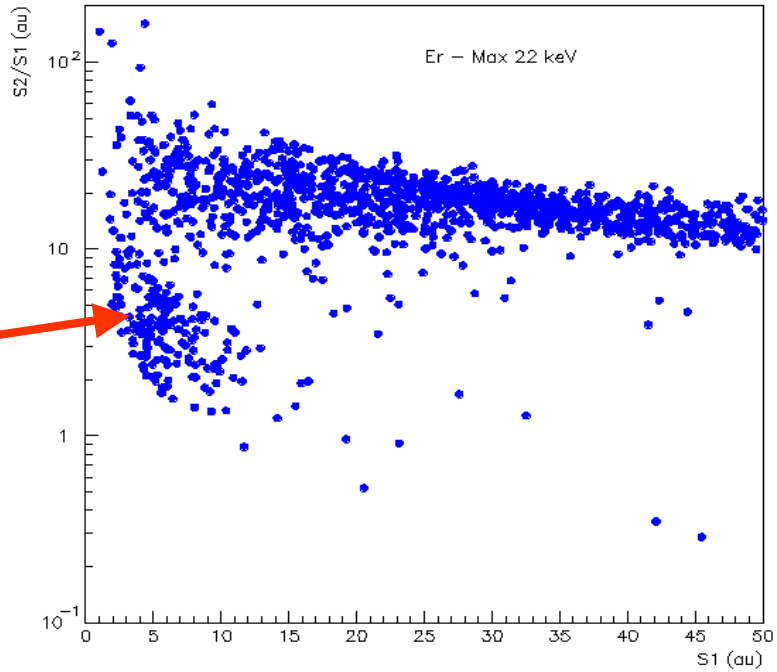
S1 vs S2 Discrimination

Xenon – 20 Bar

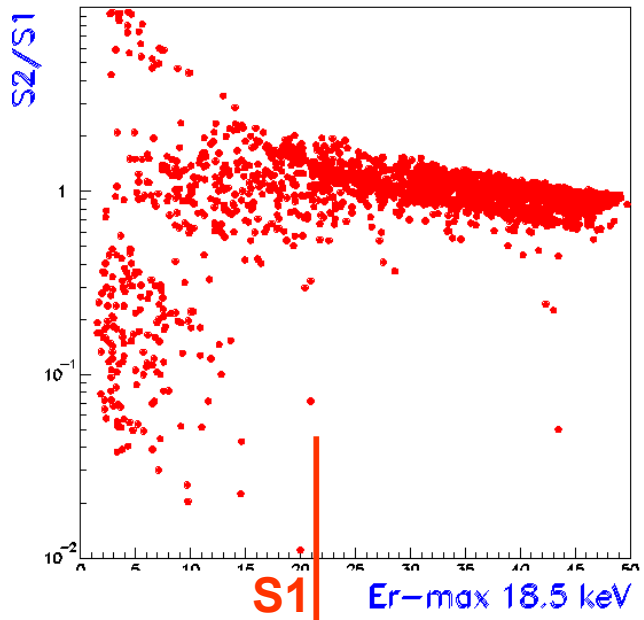
Neutron Interaction



S2/S1 vs S1



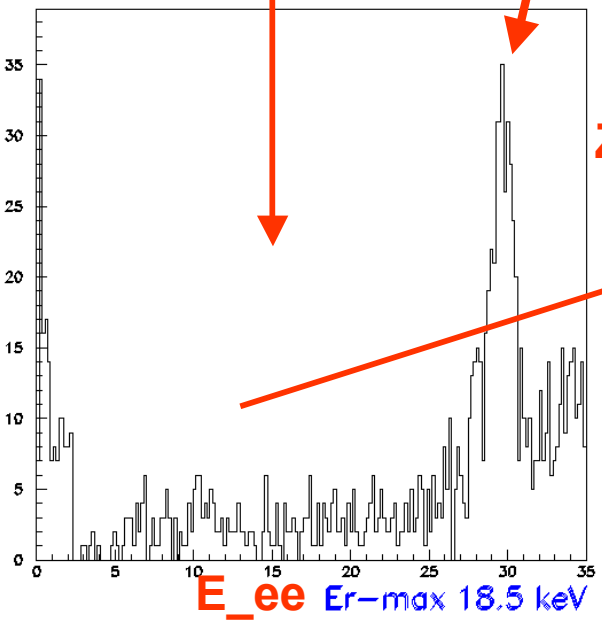
NR @ 10 Bar in 7-PMT cell



S1

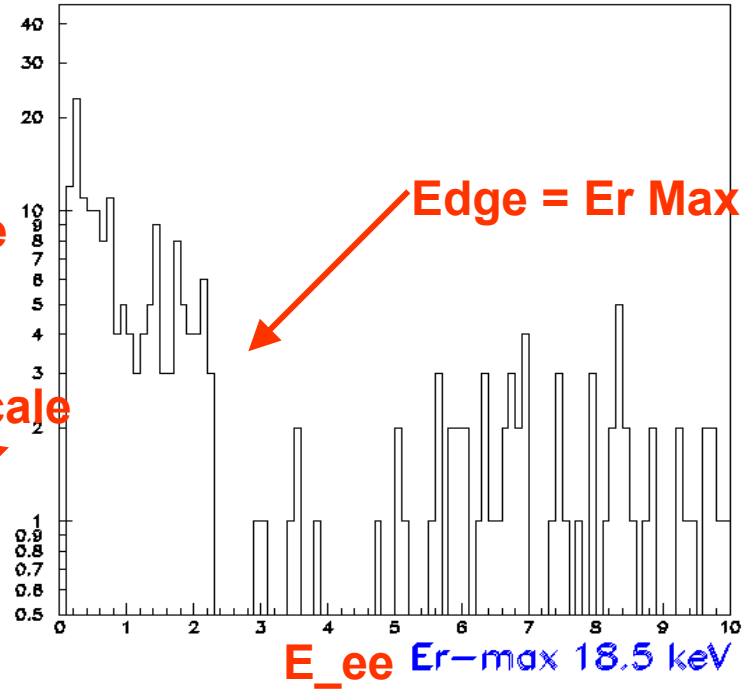
S2 Projection

30 keV reference



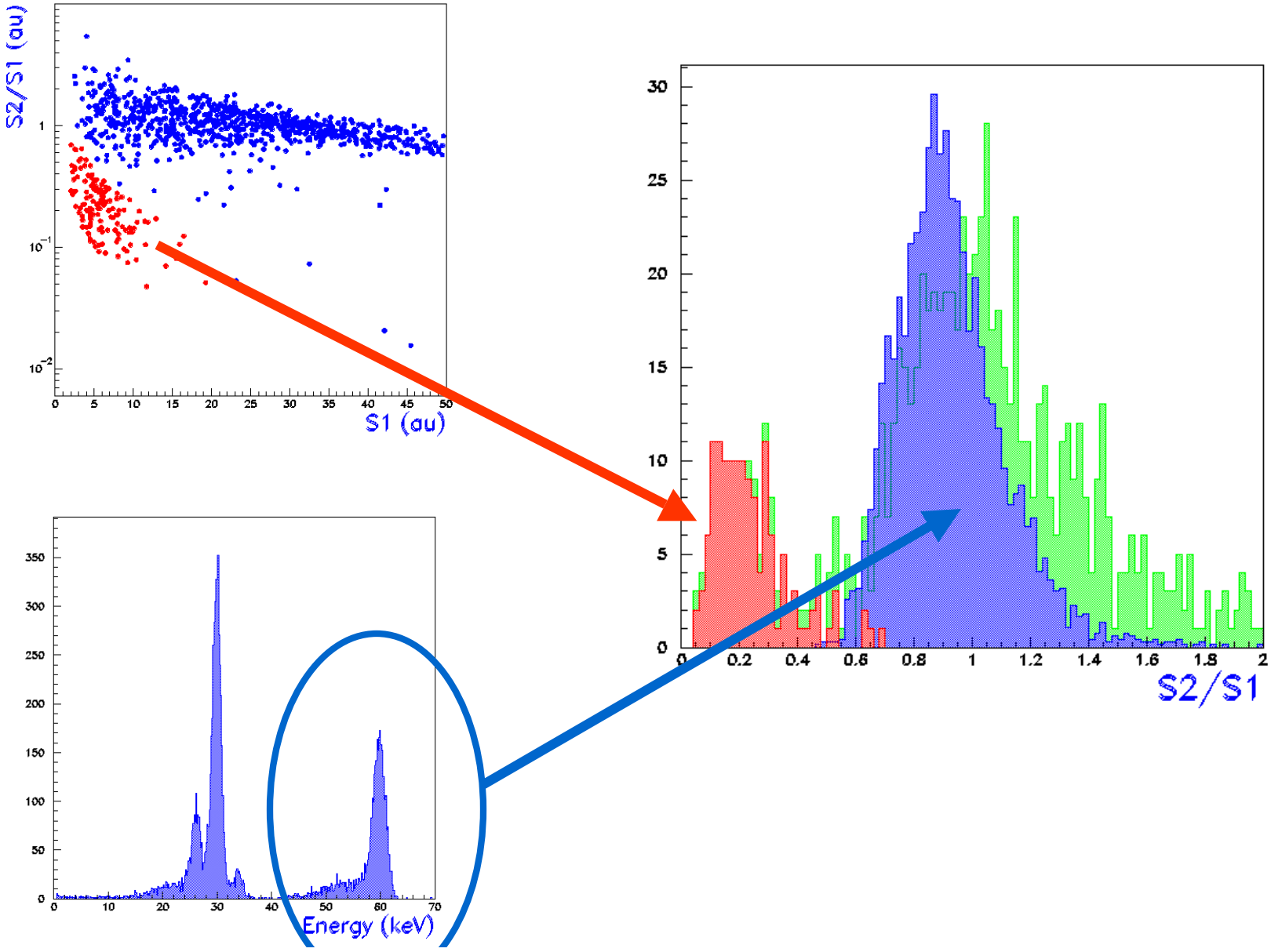
Zoom & Log scale

Edge = Er Max

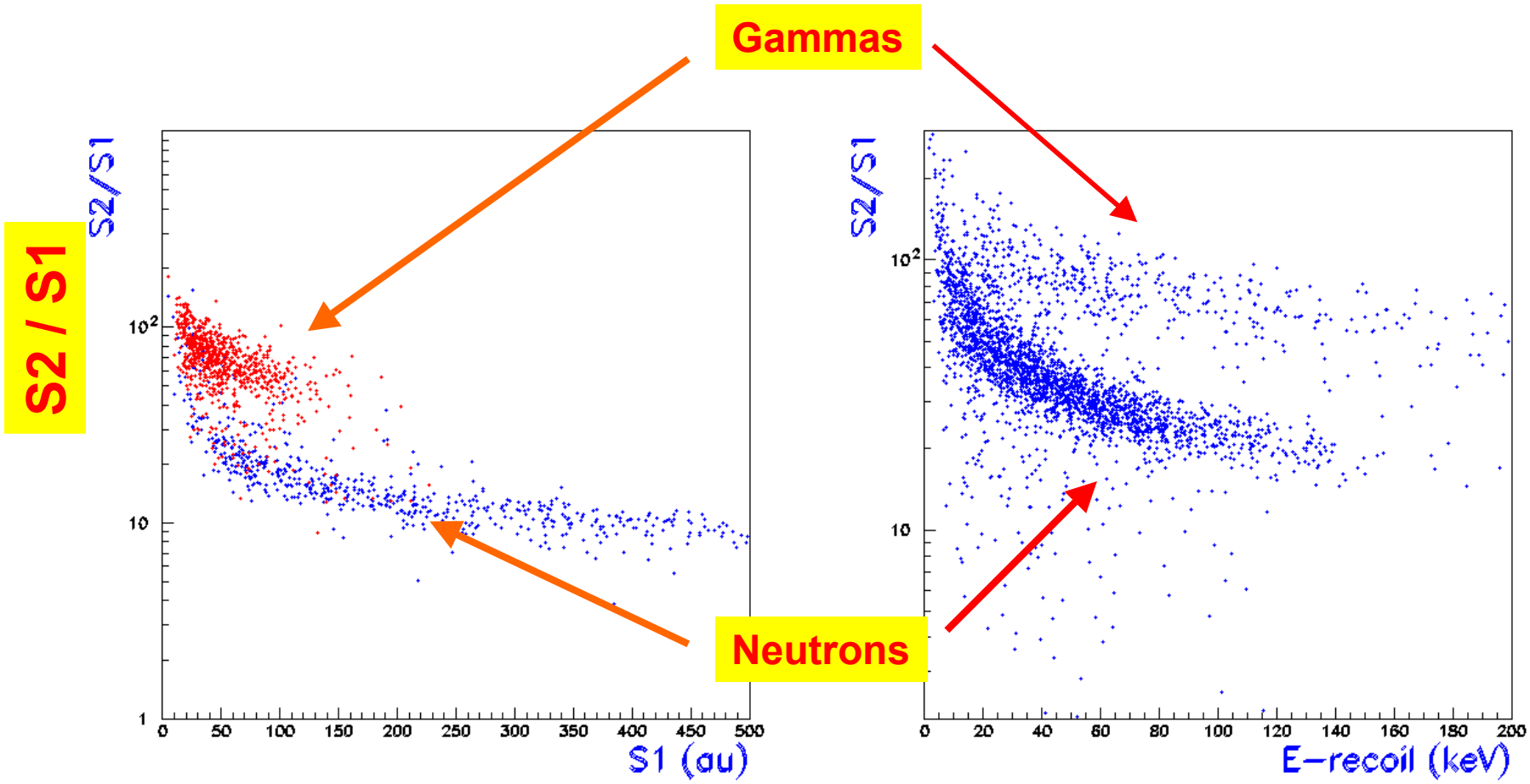


Note: ~ 5.4 ions/keVNR for W~22 eV/ion

Xenon



Neon (+.05%Xenon)

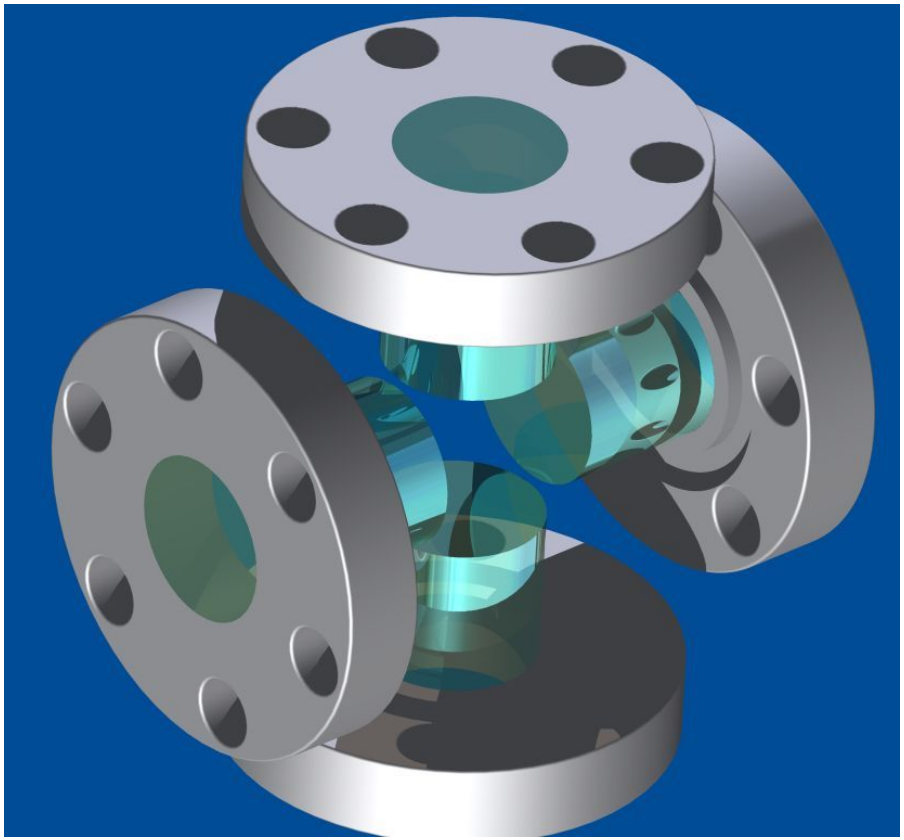


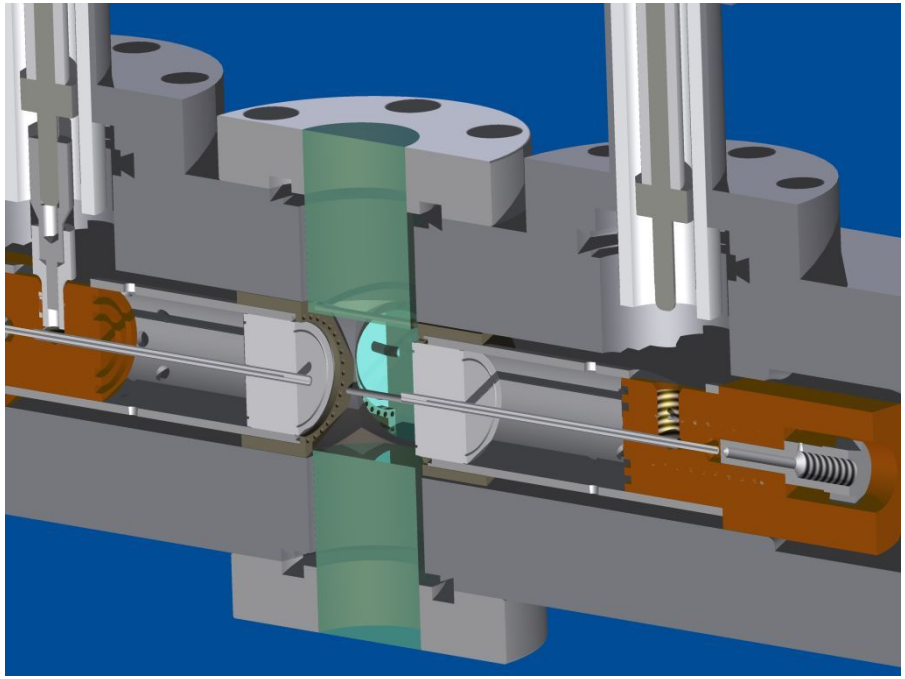
AmBe Source
High energy Neutrons

Neutron Beam
Er Max ~ 120 KeV

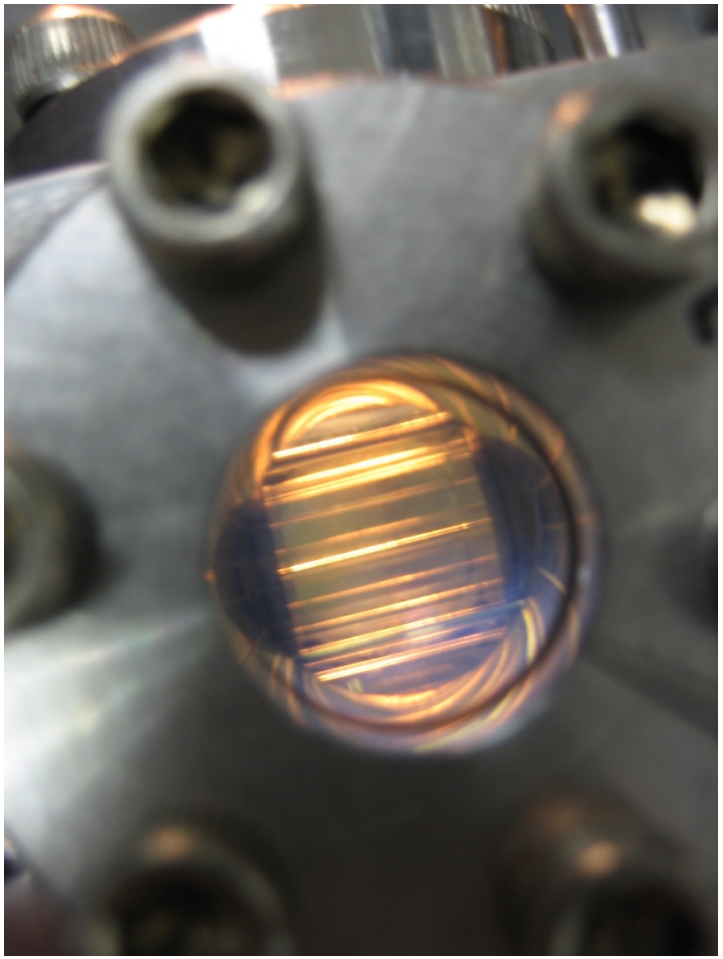
S1 Shape Discrimination

View Region

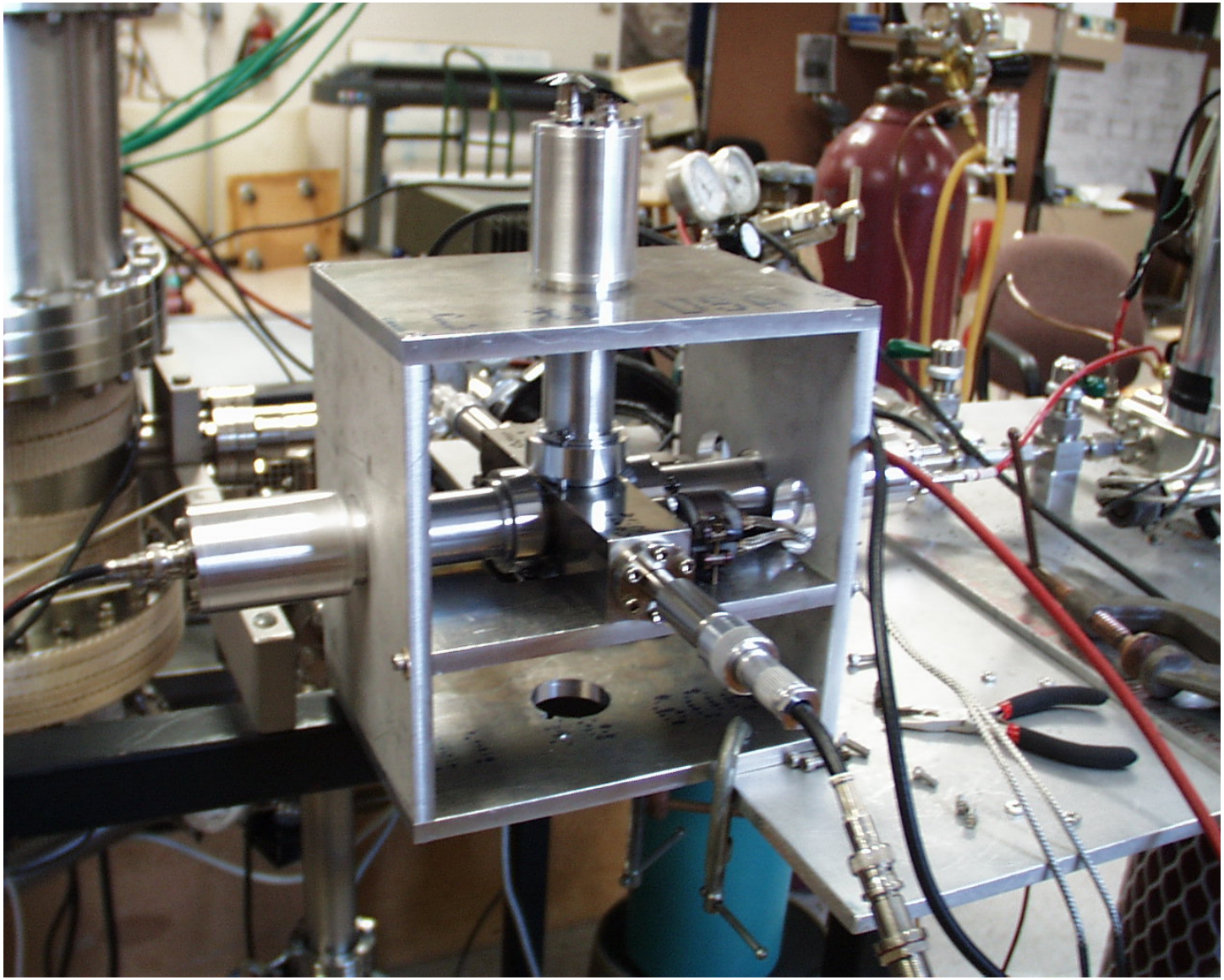




Windows

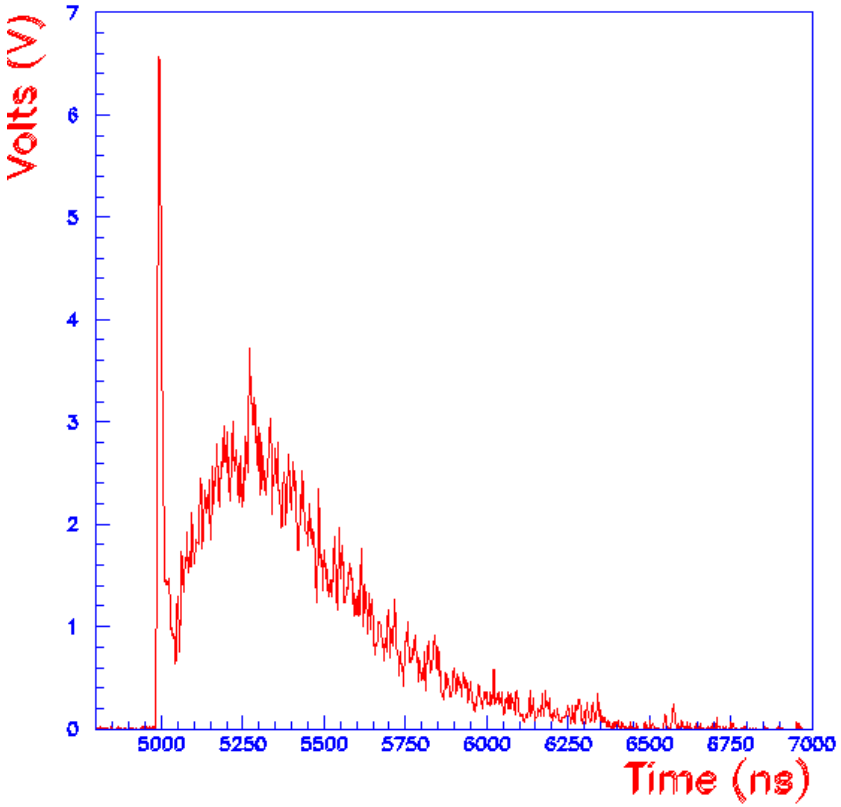


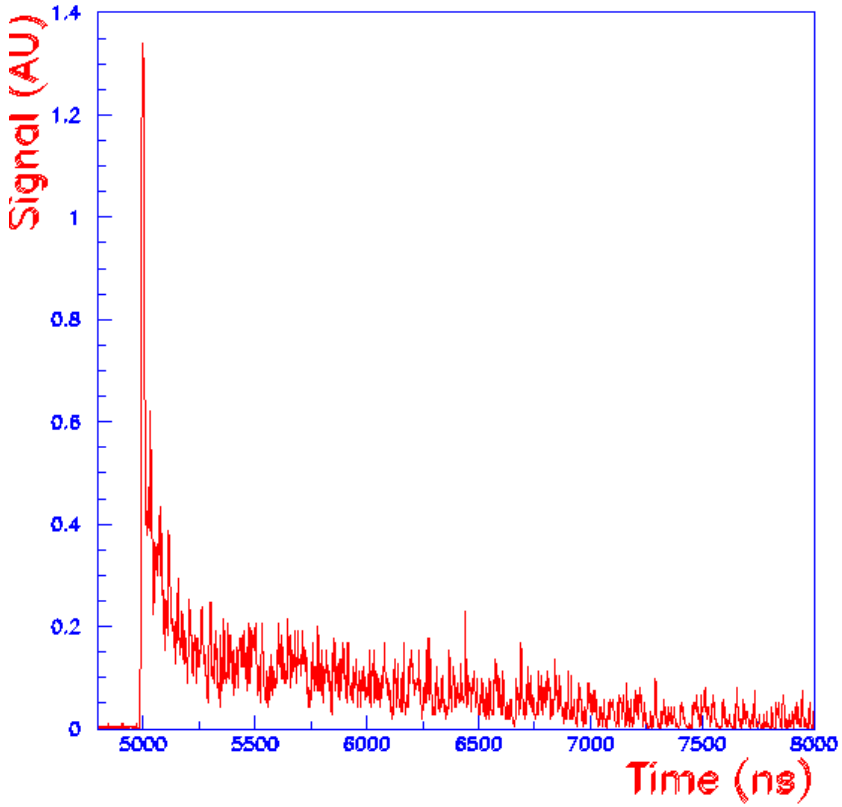
100 Bar Test Cell



Argon S1

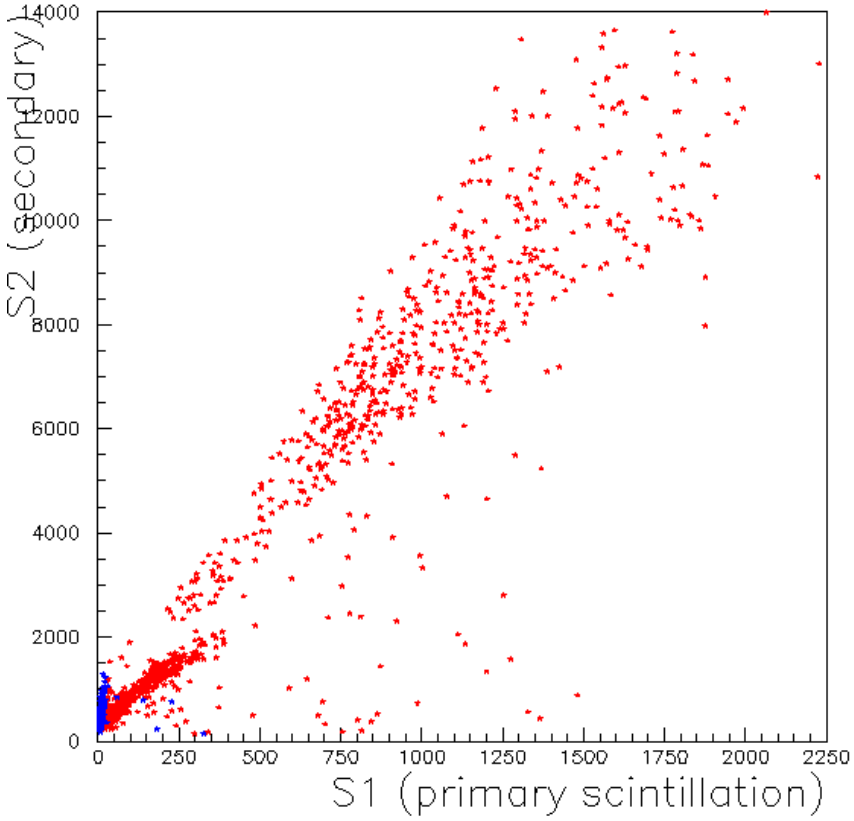
Zero-field alpha signal?



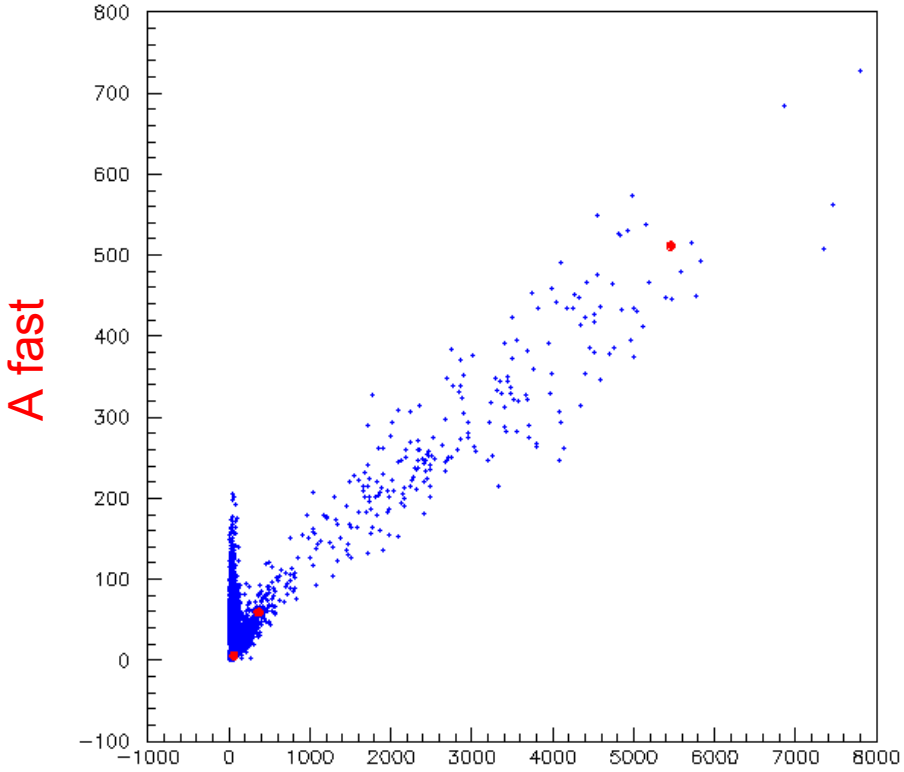


Neon

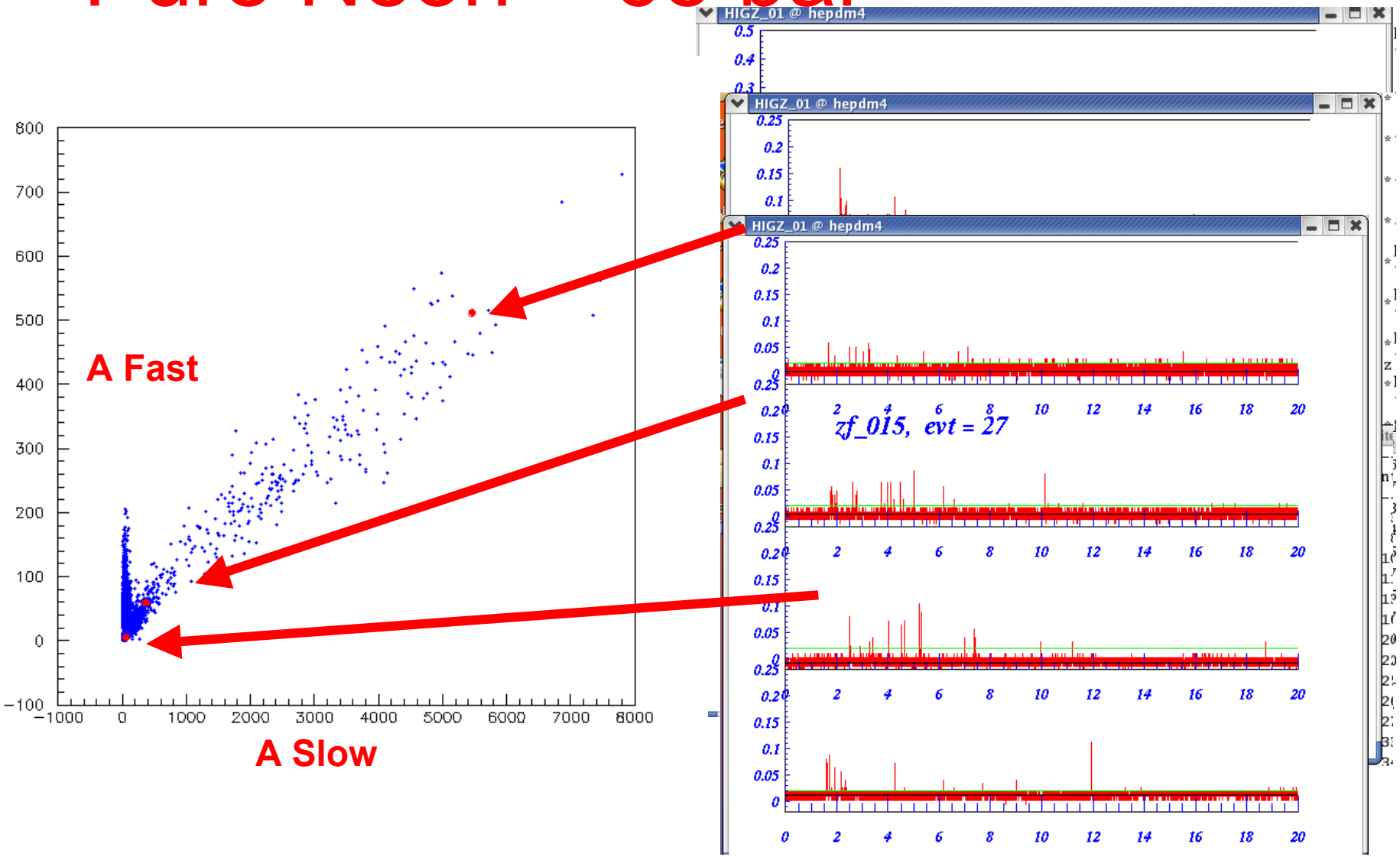
AmBe Neutrons
NeXe(0.5%) – S1 vs S2



Pure Neon
Zero Field – S1 Shape

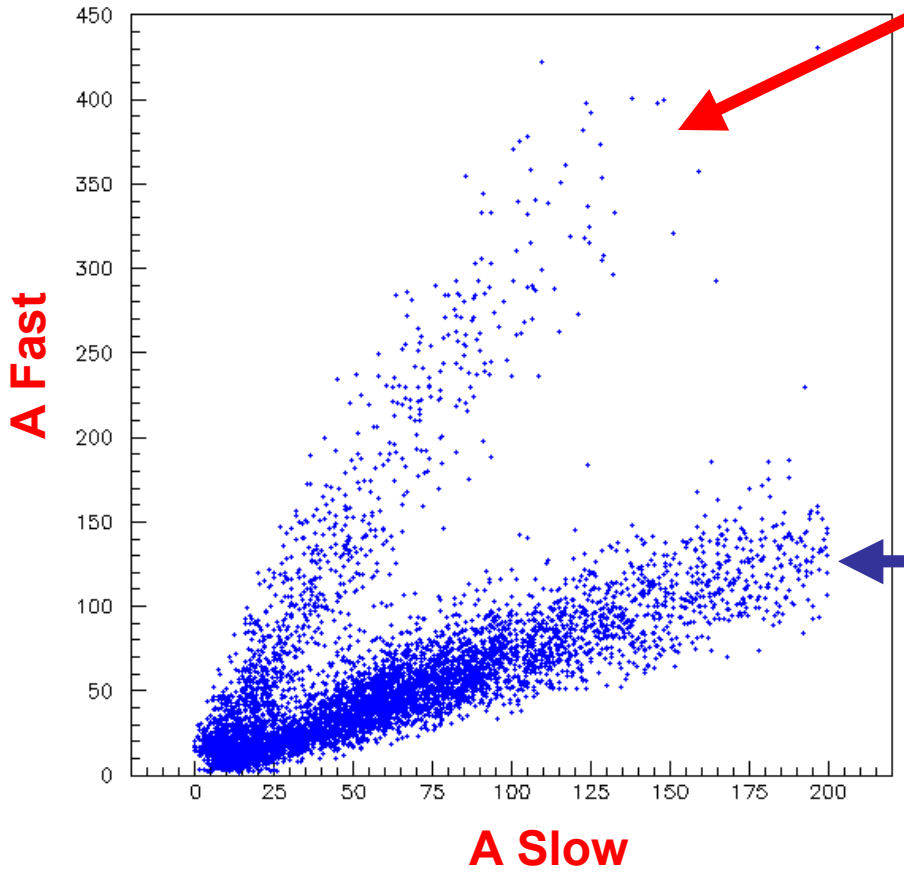


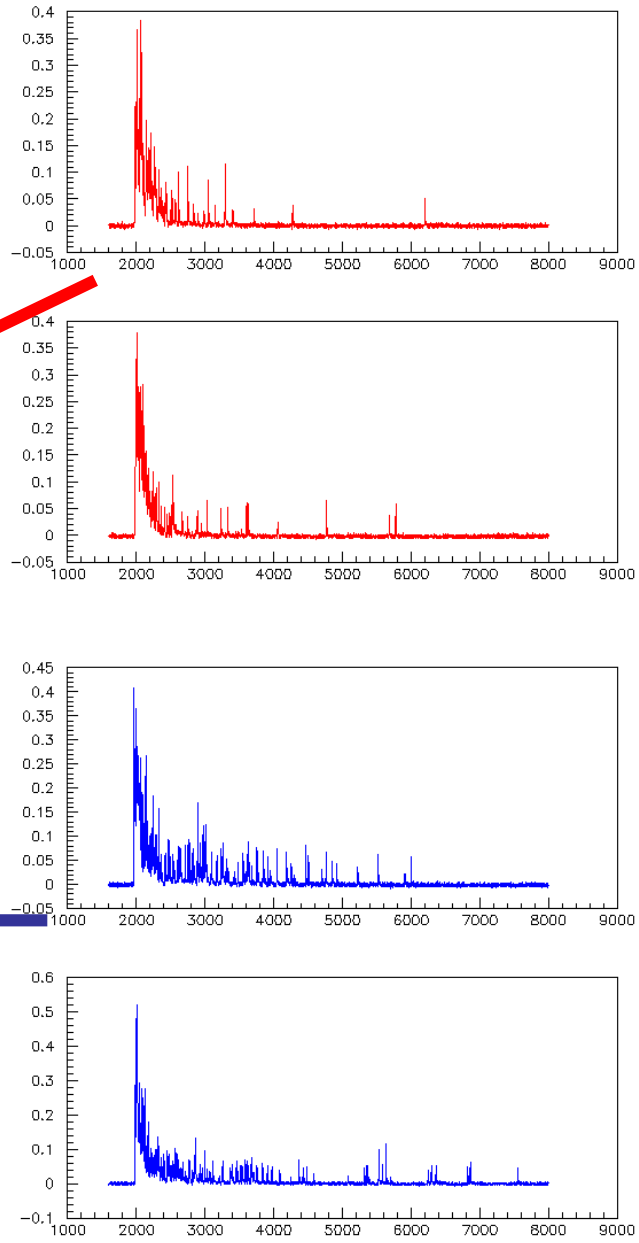
Pure Neon – 68 bar



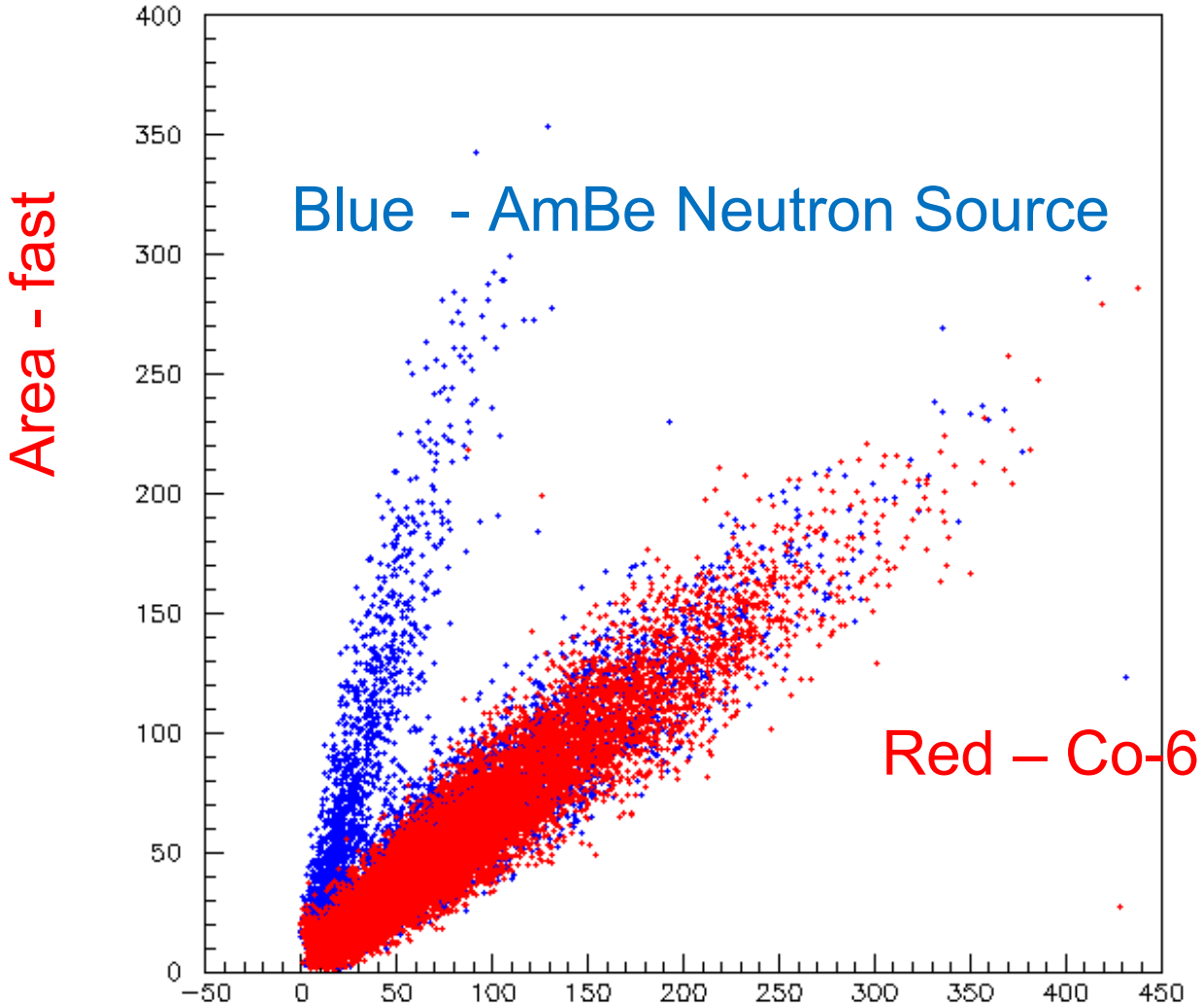
NeXe(0.5%)

A Fast = area in first 400 ns

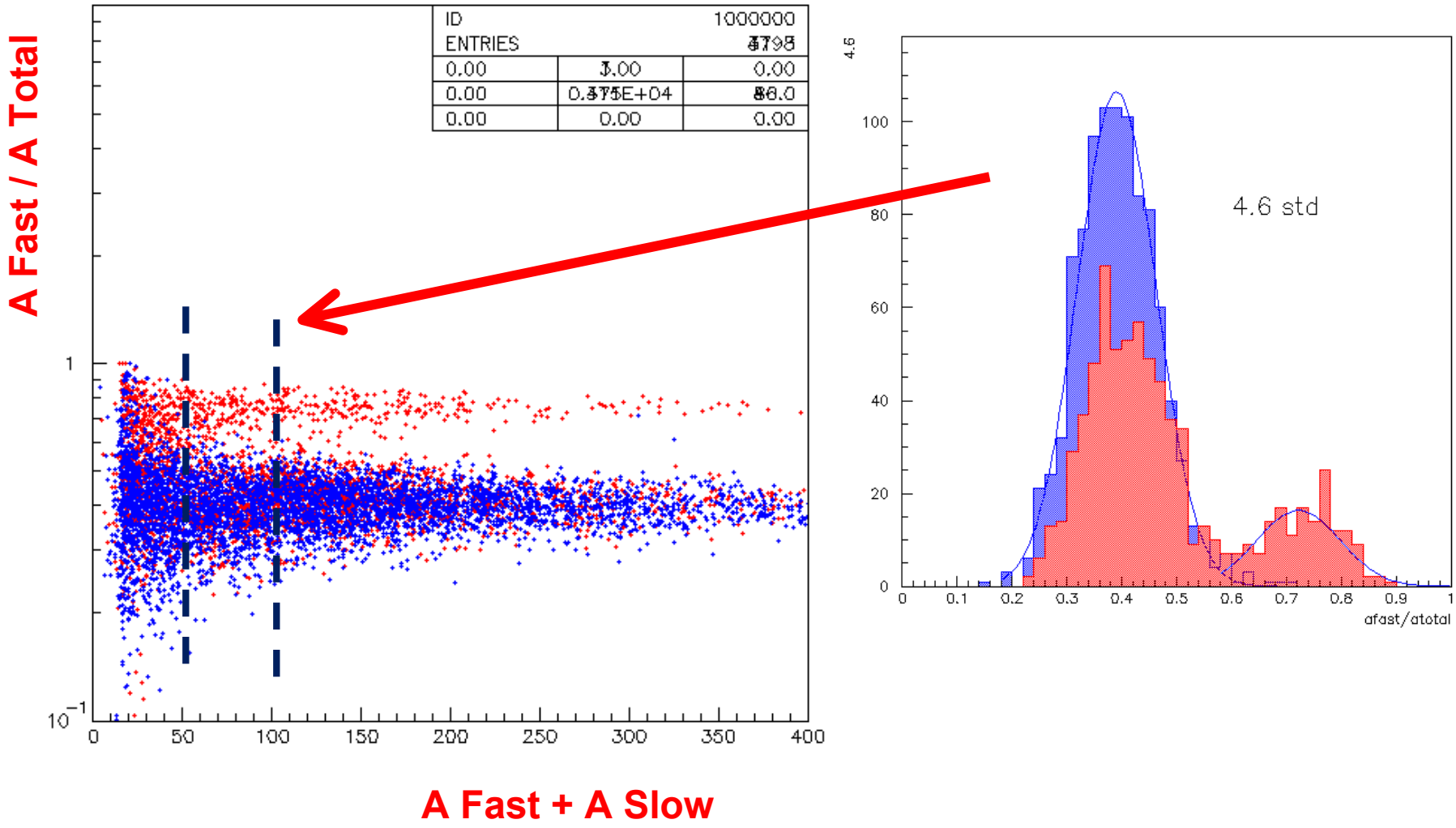




NeXe(0.5%)


Blue - AmBe Neutron Source
Red – Co-60 gammas
Area - fast
Area - slow
400
350
300
250
200
150
100
50
0
−50
0
50
100
150
200
250
300
350
400
450

NeXe(0.5%)
Pulse Shape Discrimination



Conclusions/Plans

- HP noble gases and mixtures have excellent discrimination in both S1 vs S2 and S1 pulse shape discrimination (not so sure about xenon S1 disc. at WIMP scale recoil energies)
- But, with the advanced state of development and higher density of liquid nobles, is there a need for future HP detectors?
- Plans:
  - continue investigation of light yield and properties at low recoil energies using neutron beam
  - look at NR discrimination in xenon up to 0.5 g/cc (~ 1.8 X lq)
- With combination: water shield, active shield, thin-walled vessels and appropriate light detection instrumentation, it may turn out that HP detectors have a future for long term WIMP property measurement experiments.

Hard to Choose…

Cryogenic?

Room Temperature?