Background in the DEAP-1 prototype Dark Matter detector

Tina Pollmann
CAP Congress 2012
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Dark matter is invoked to explain a plethora of astronomical and cosmological observations.

Example: Luminous matter distribution vs gravitating matter distribution in the bullet cluster.

optical/x-ray

optical/lensing

http://chandra.harvard.edu/photo/2006/1e0657/

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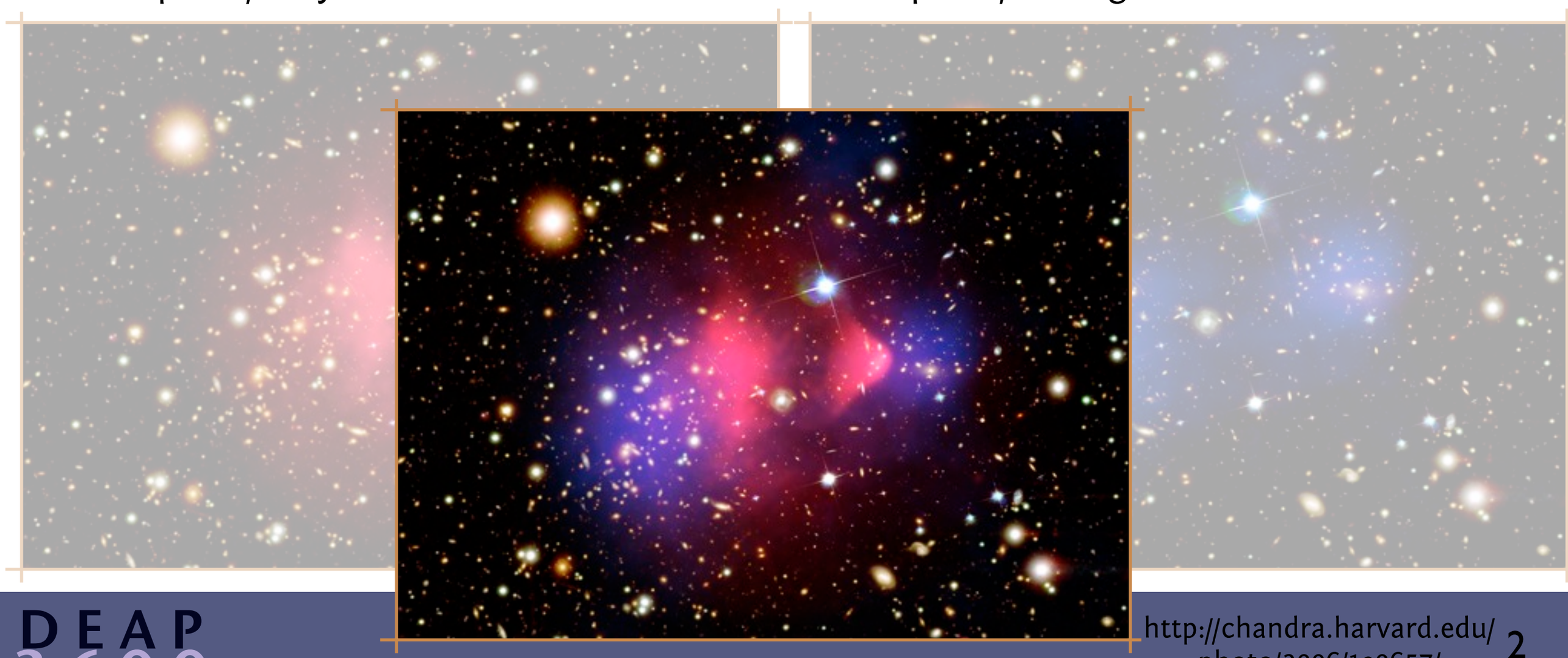
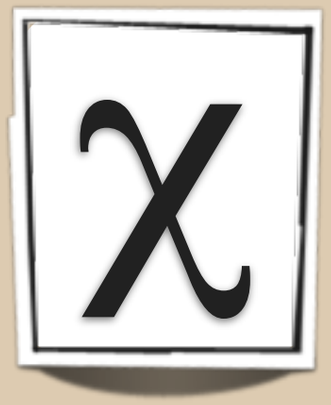


http://chandra.harvard.edu/photo/2006/1e0657/

WANTED

preferably cold



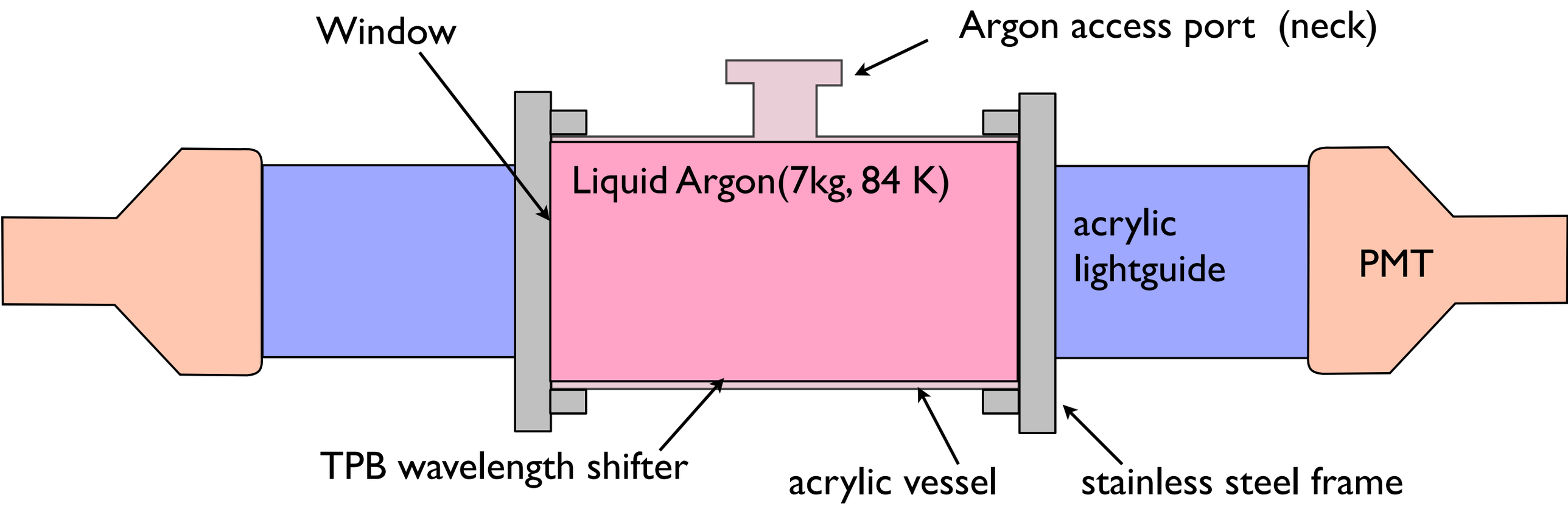
WIMP

For gravitationally dominating the universe.

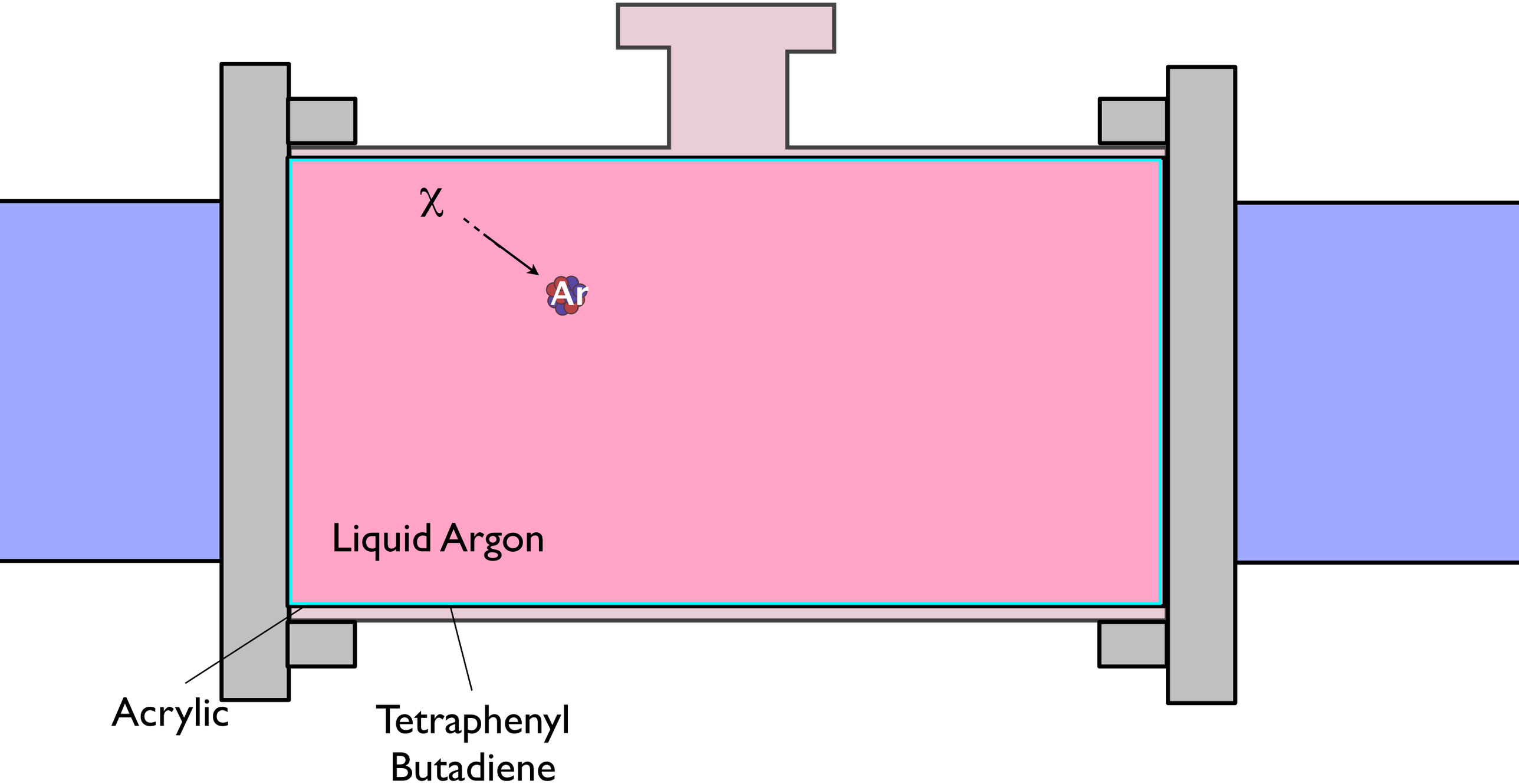
Reward: Nobel Prize (probably)

- Stable (or very long lived)
- Abundant
- Weak interaction
- Heavy (>100 GeV).

The DEAP-1 prototype LAr based Dark Matter detector.



WIMP detection in DEAP-1:



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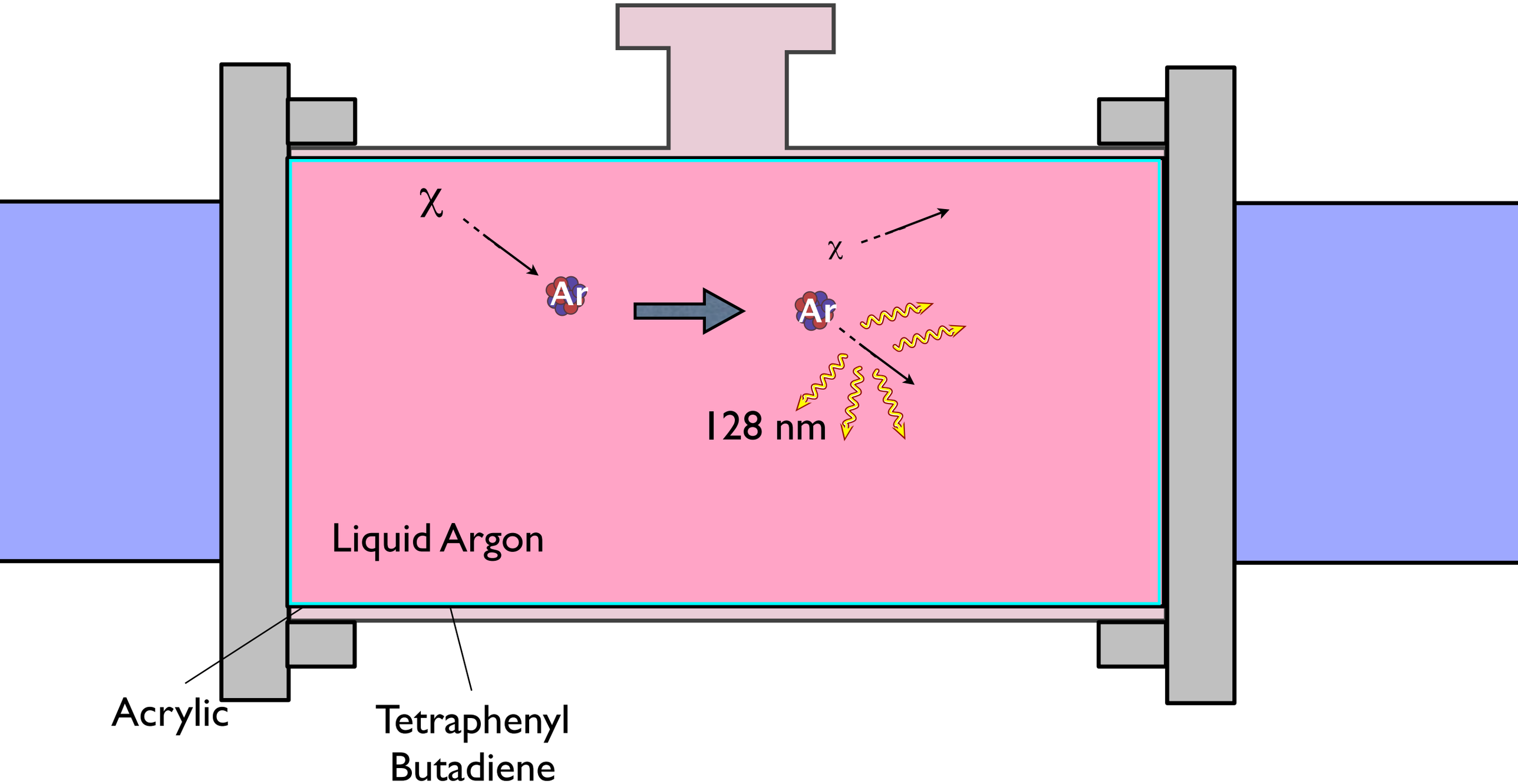

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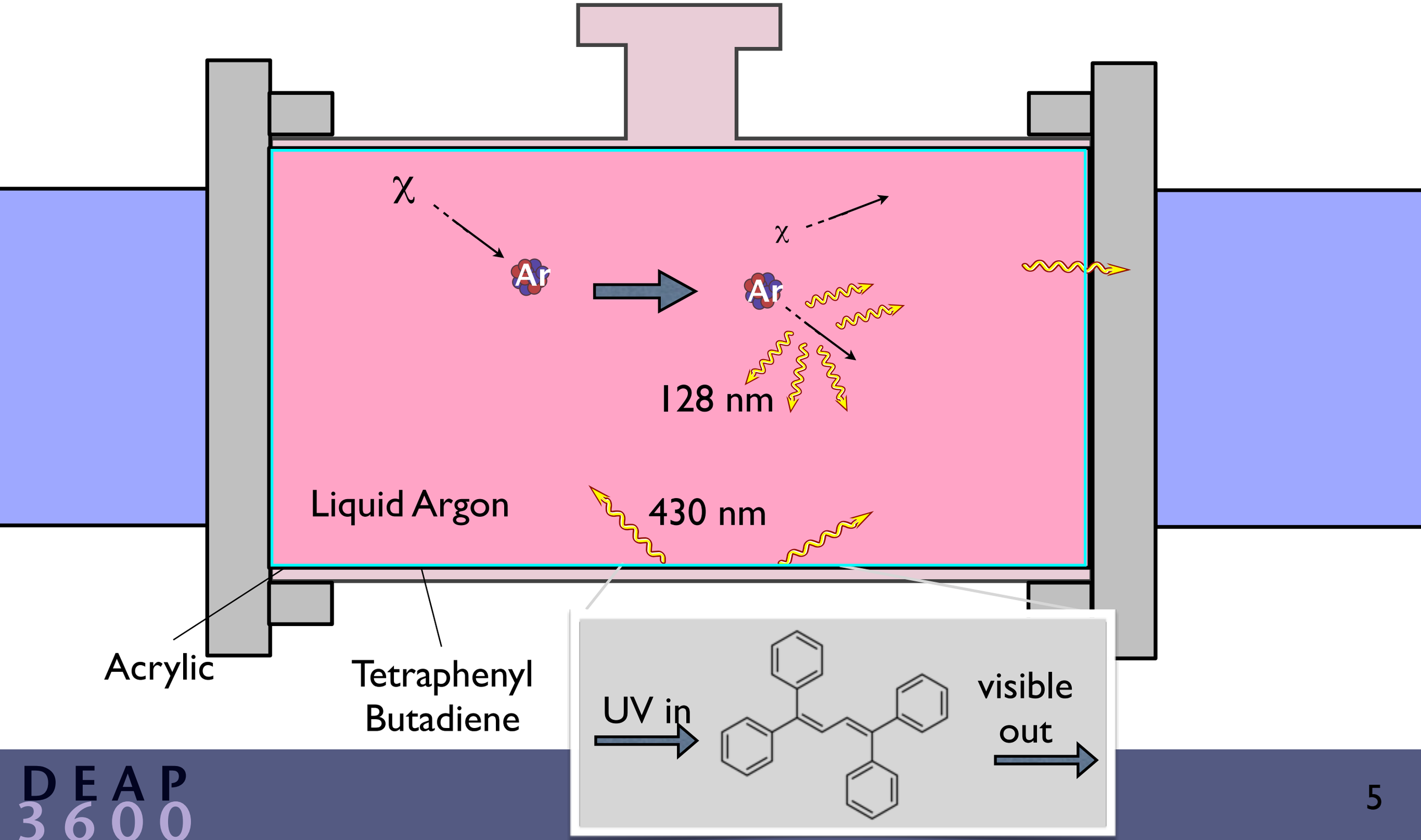
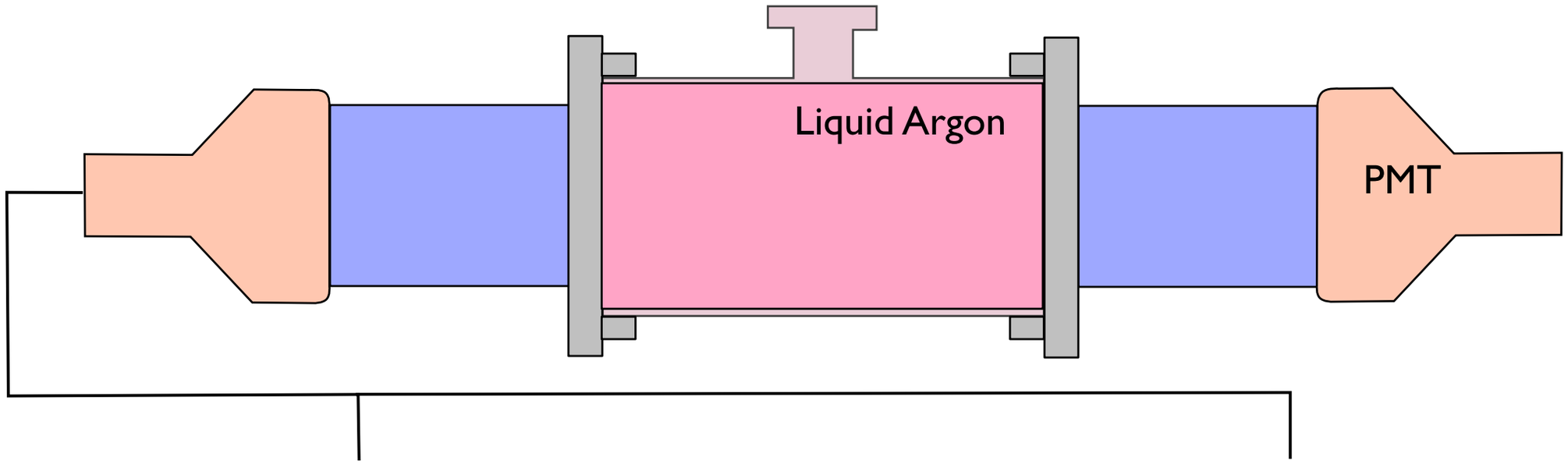
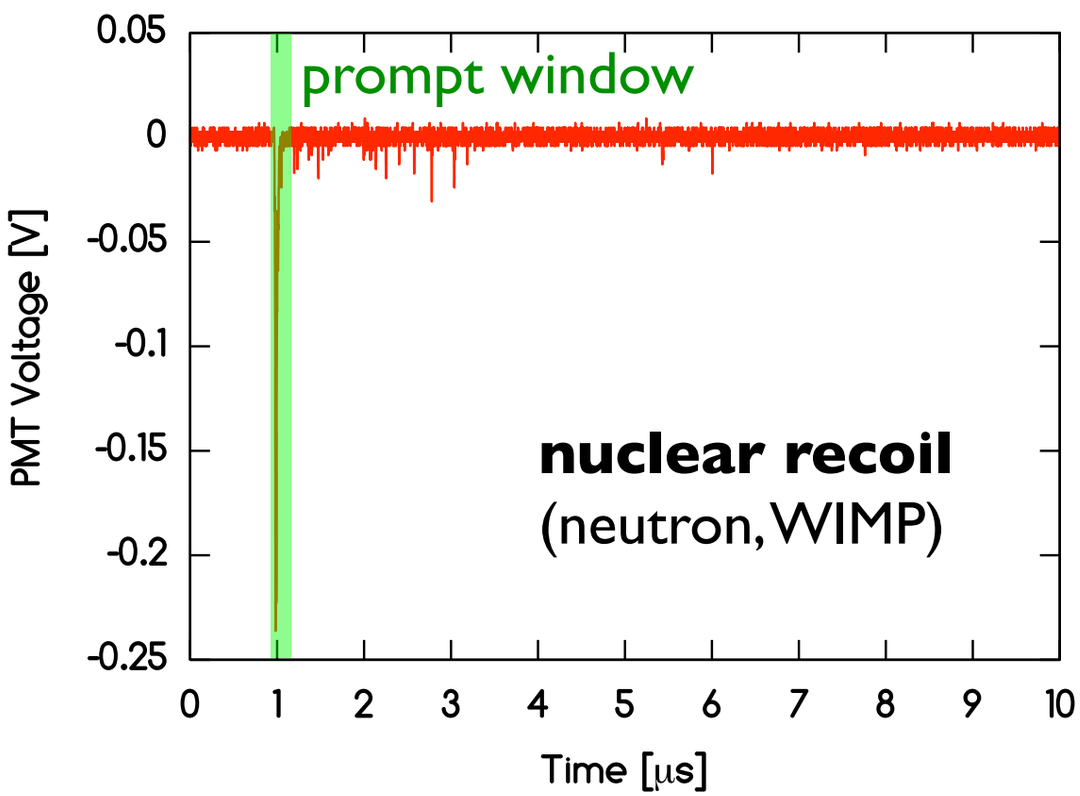
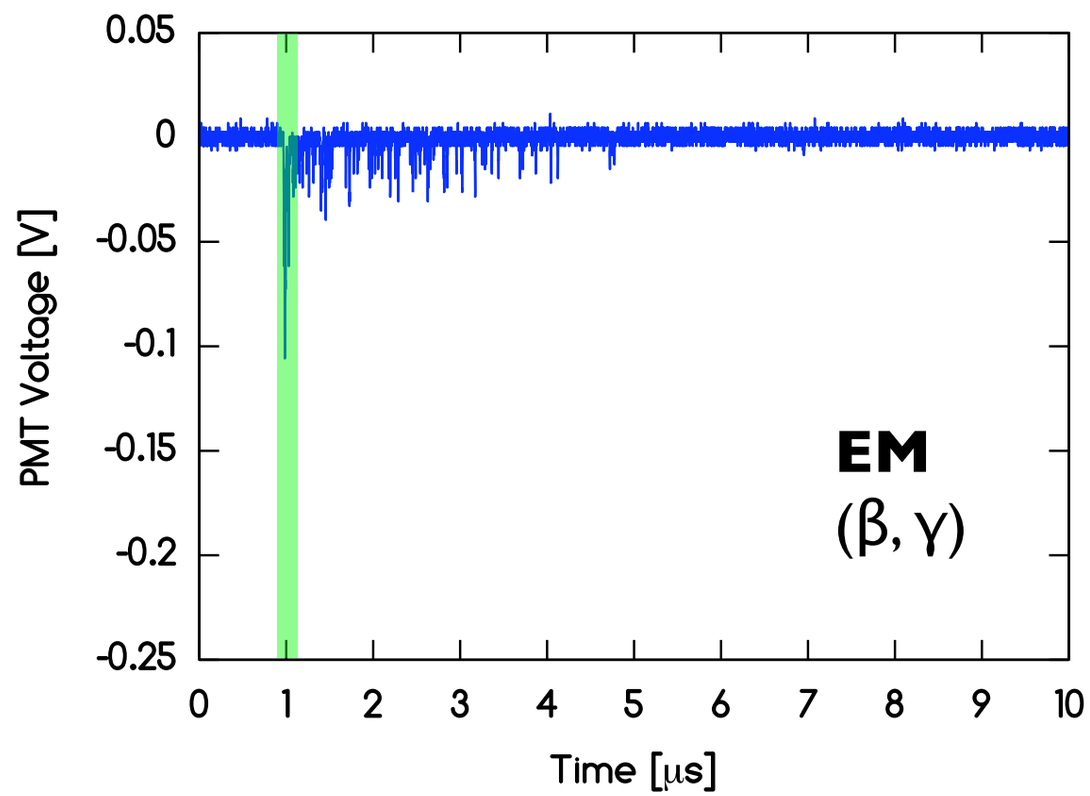


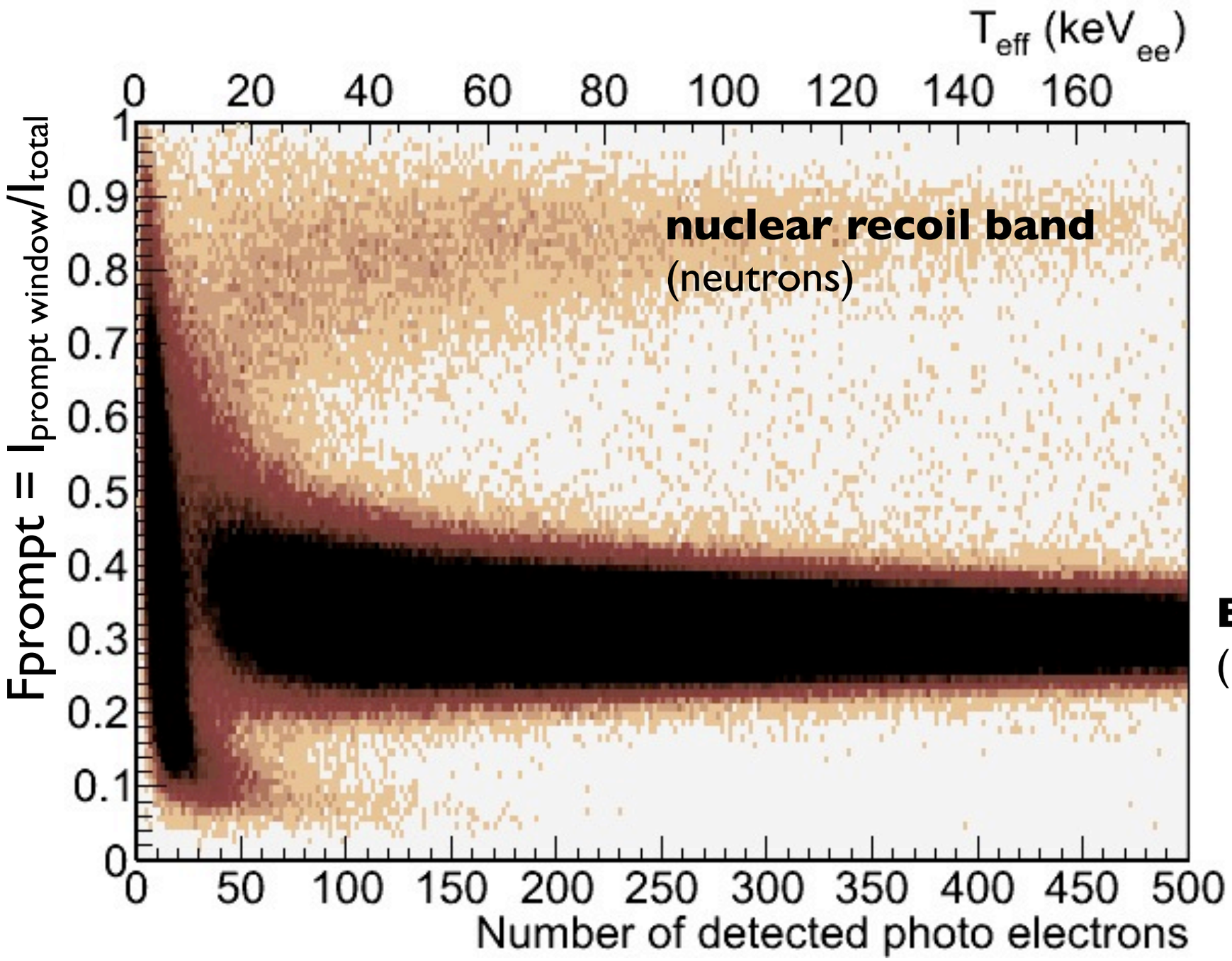
PSD: Nuclear recoil traces differ from EM traces …





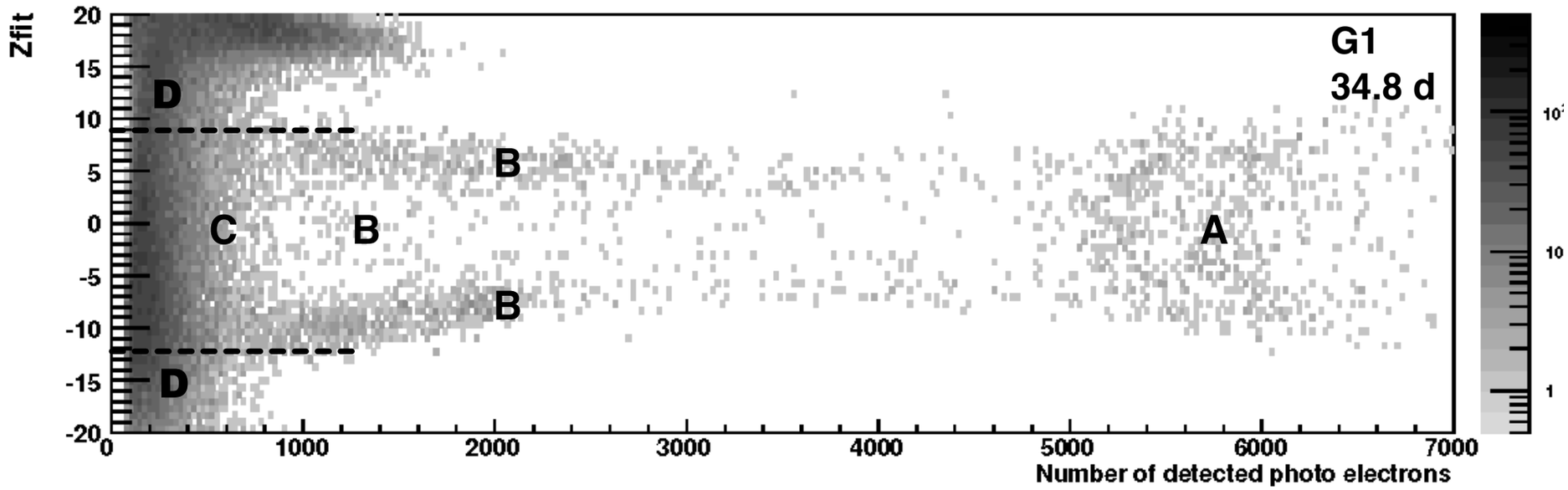


… they have a higher Fprompt value.

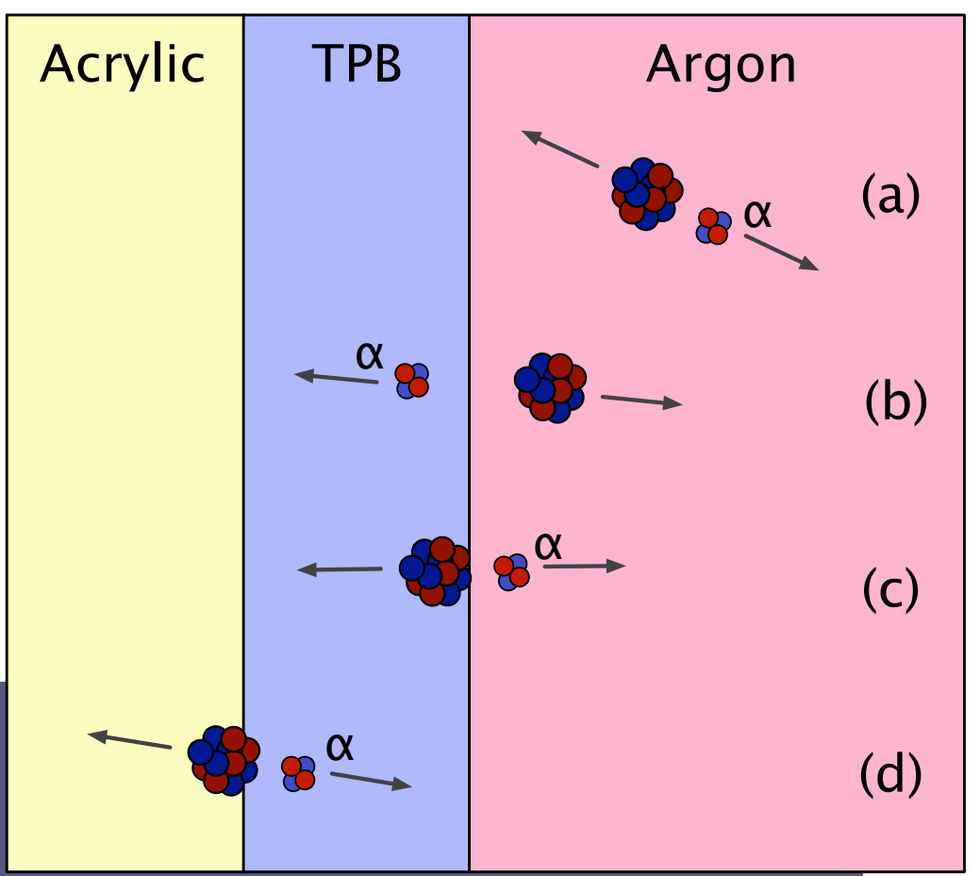


Data from an AmBe (neutron emitter) run

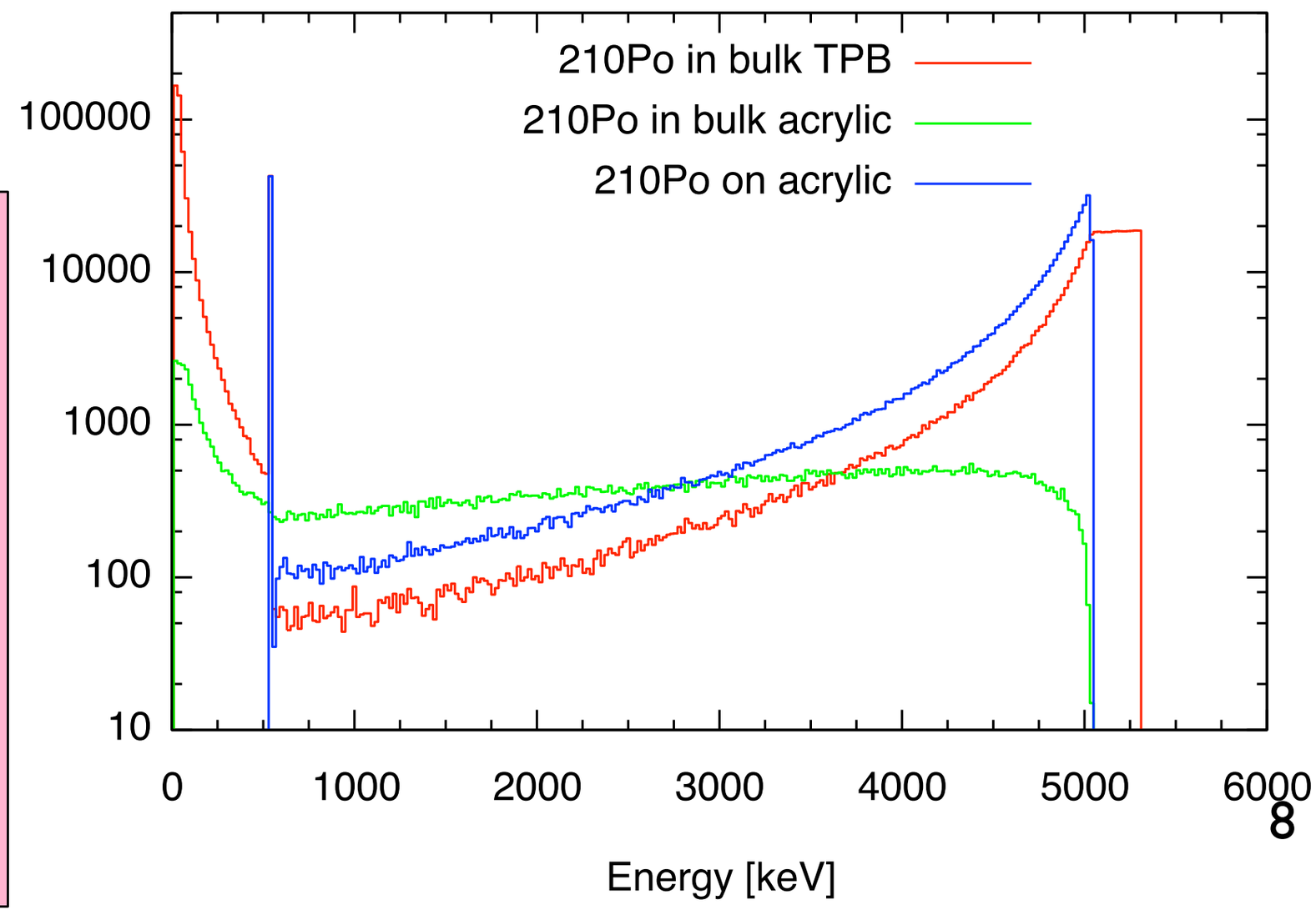
Background seen in nuclear recoil band at energies from 0 to 8 MeV.



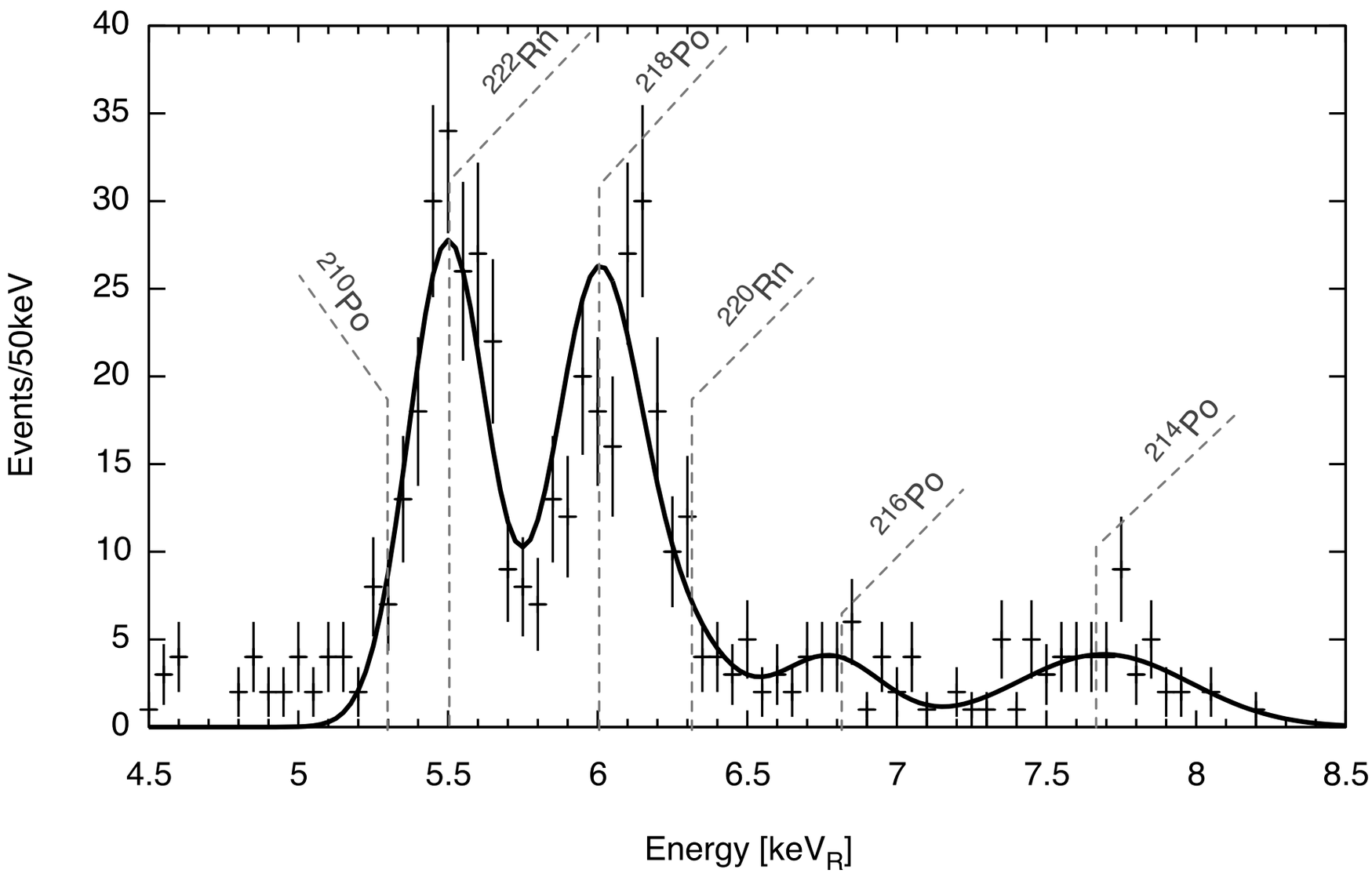
Surface background model.



Simulated spectra

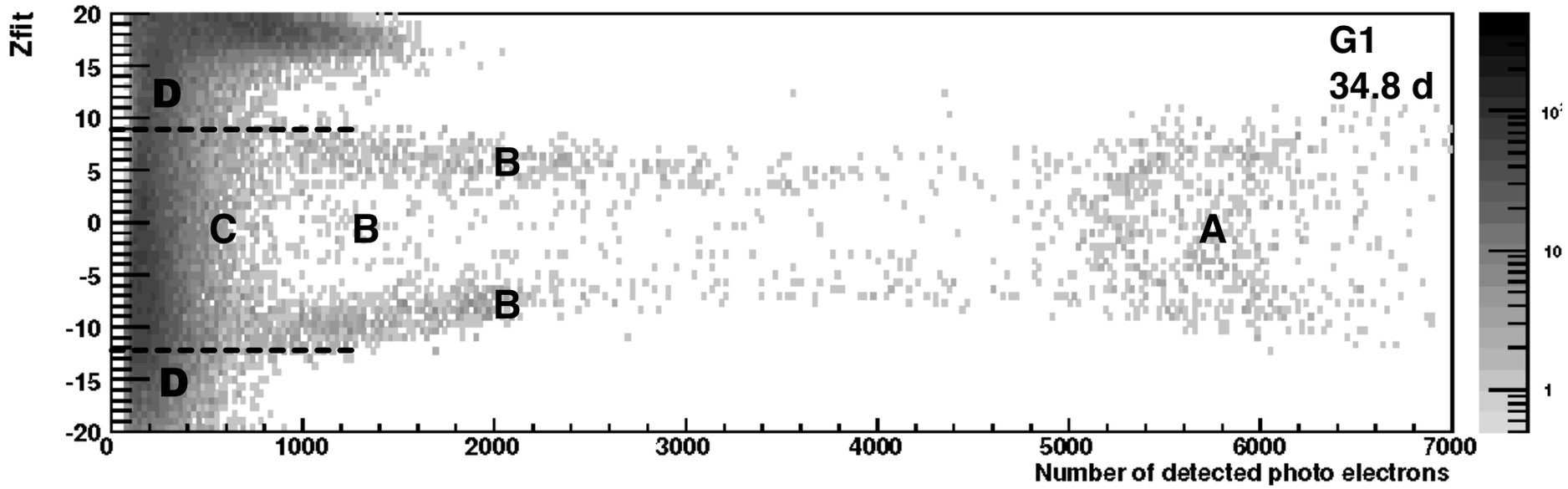


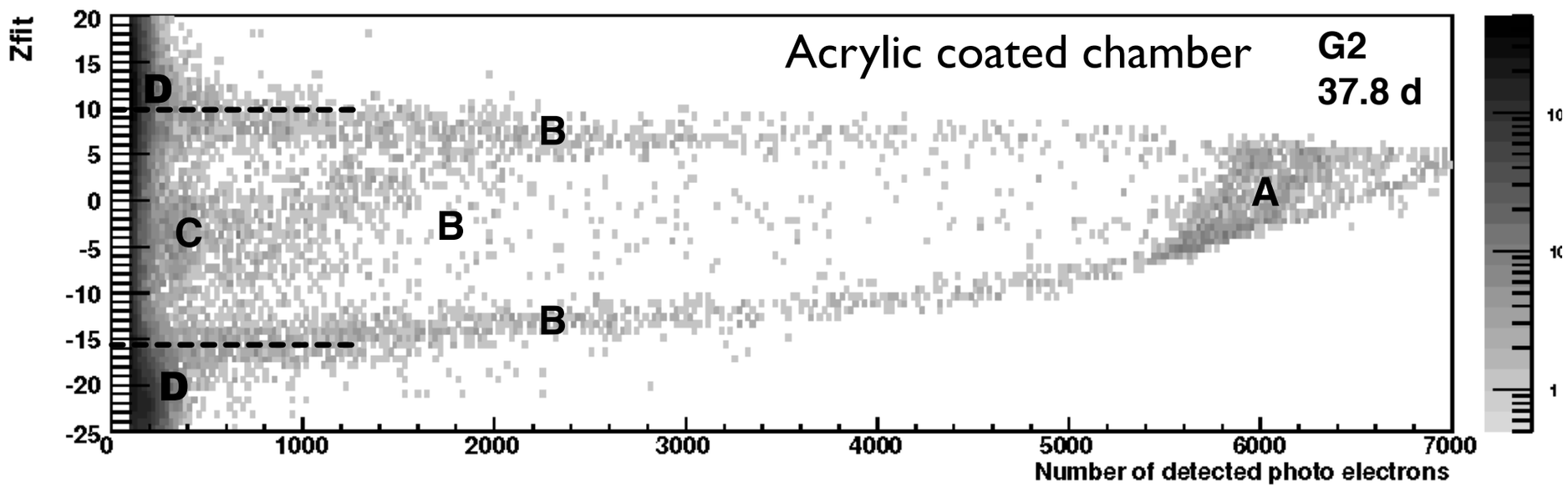
Radon spectrum leaves a maximum of $4 \cdot 10^{-5}$ Hz unexplained.
This is inconsistent with surface background model.



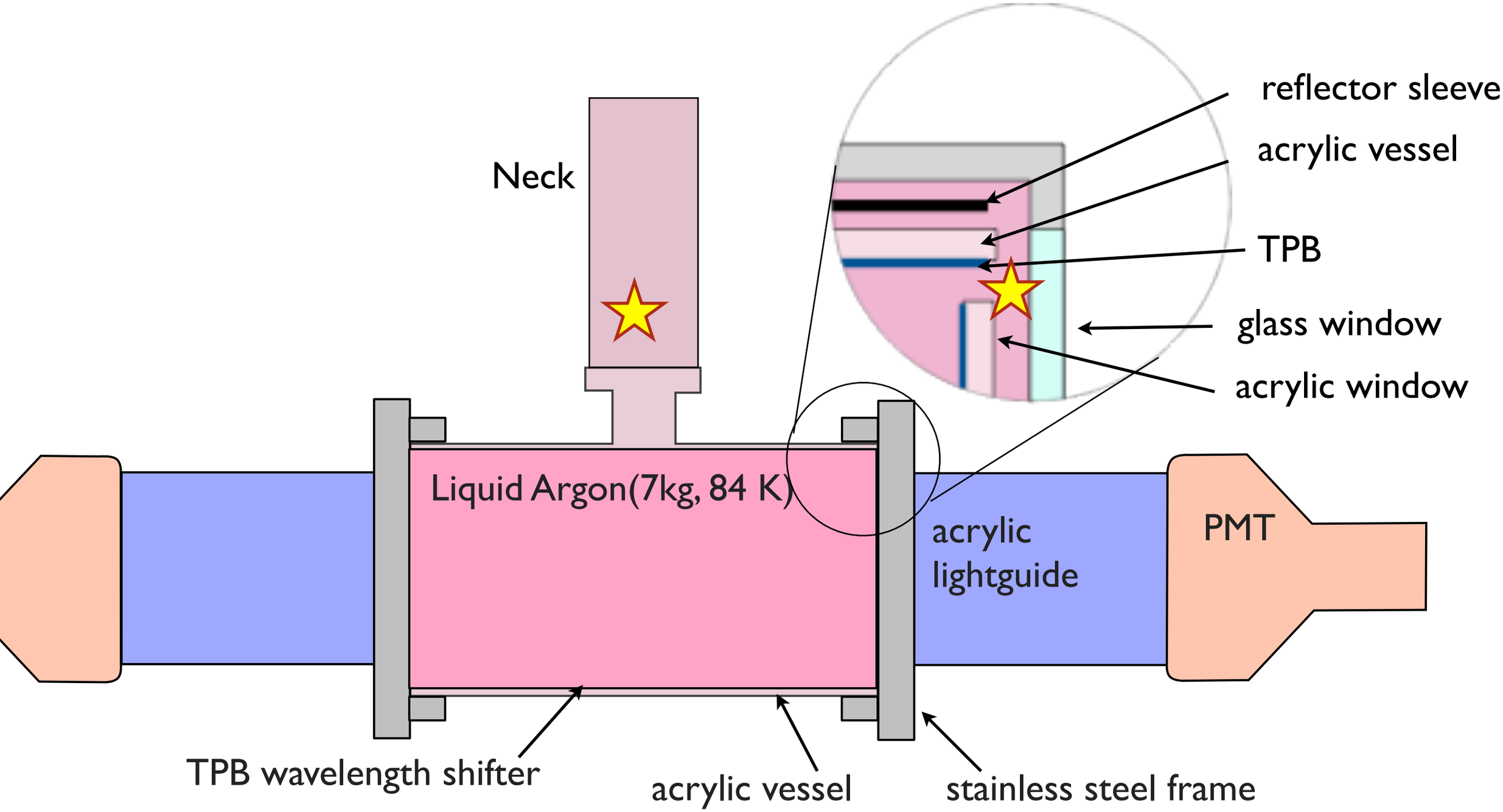
N_{total}	516 ±23
N_{tagged}	529 ±40
N_{fitted}	496 ±35

Background seen in nuclear recoil band at energies from 0 to 8 MeV.

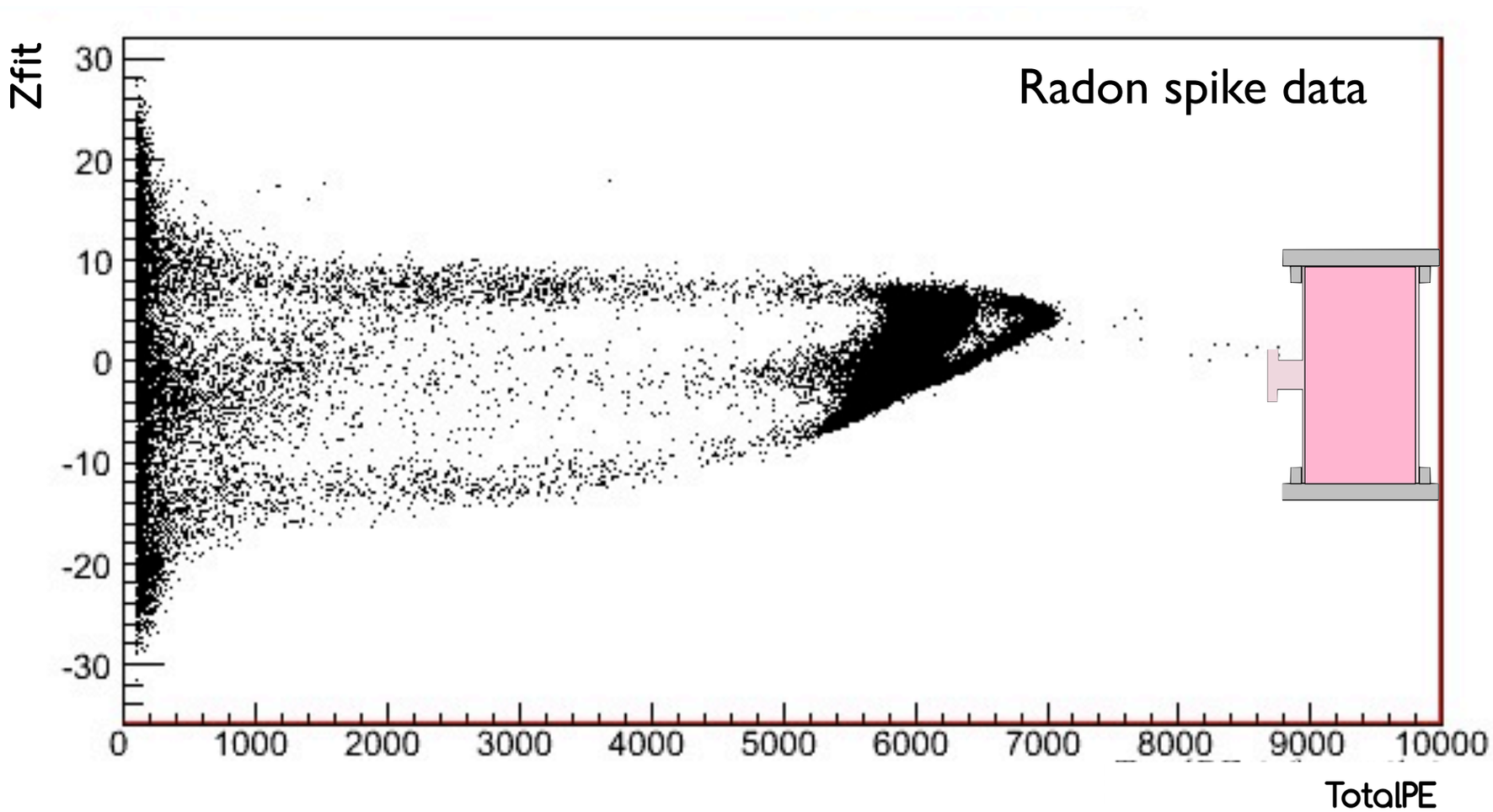




Geometric background model: There are areas in the detector from which not all scintillation light reaches the PMTs ...



... this leads to geometric background events.



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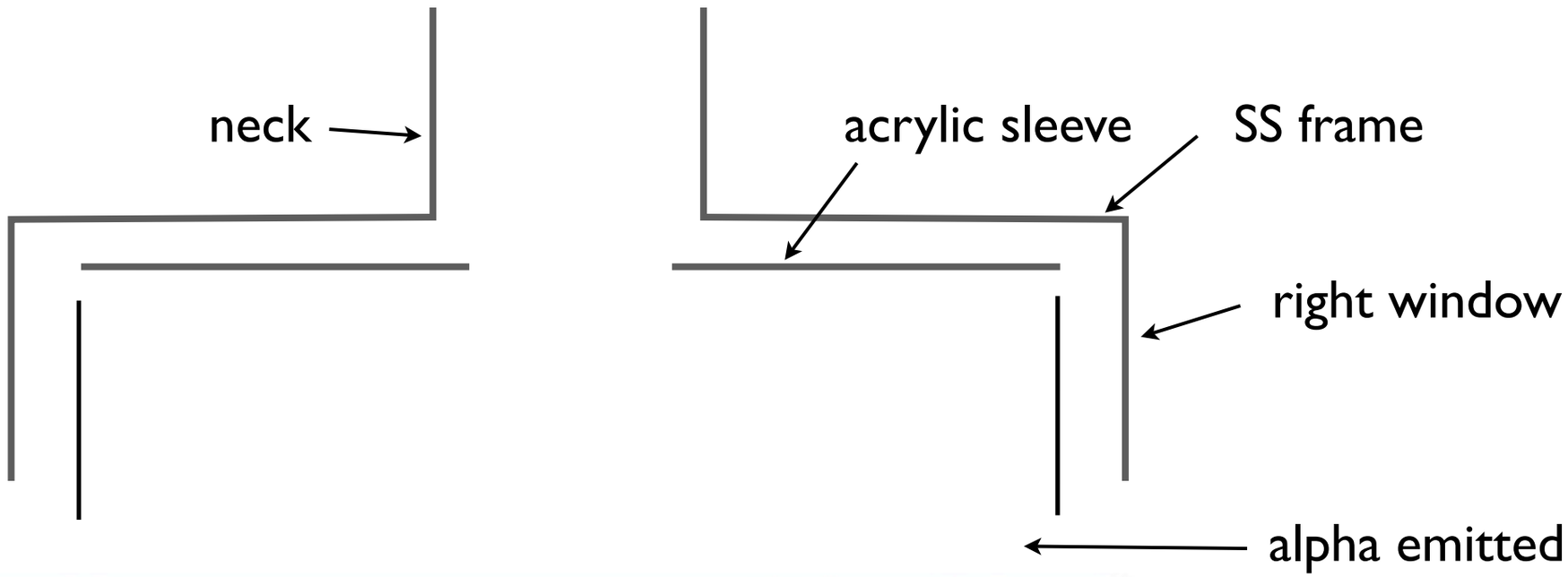
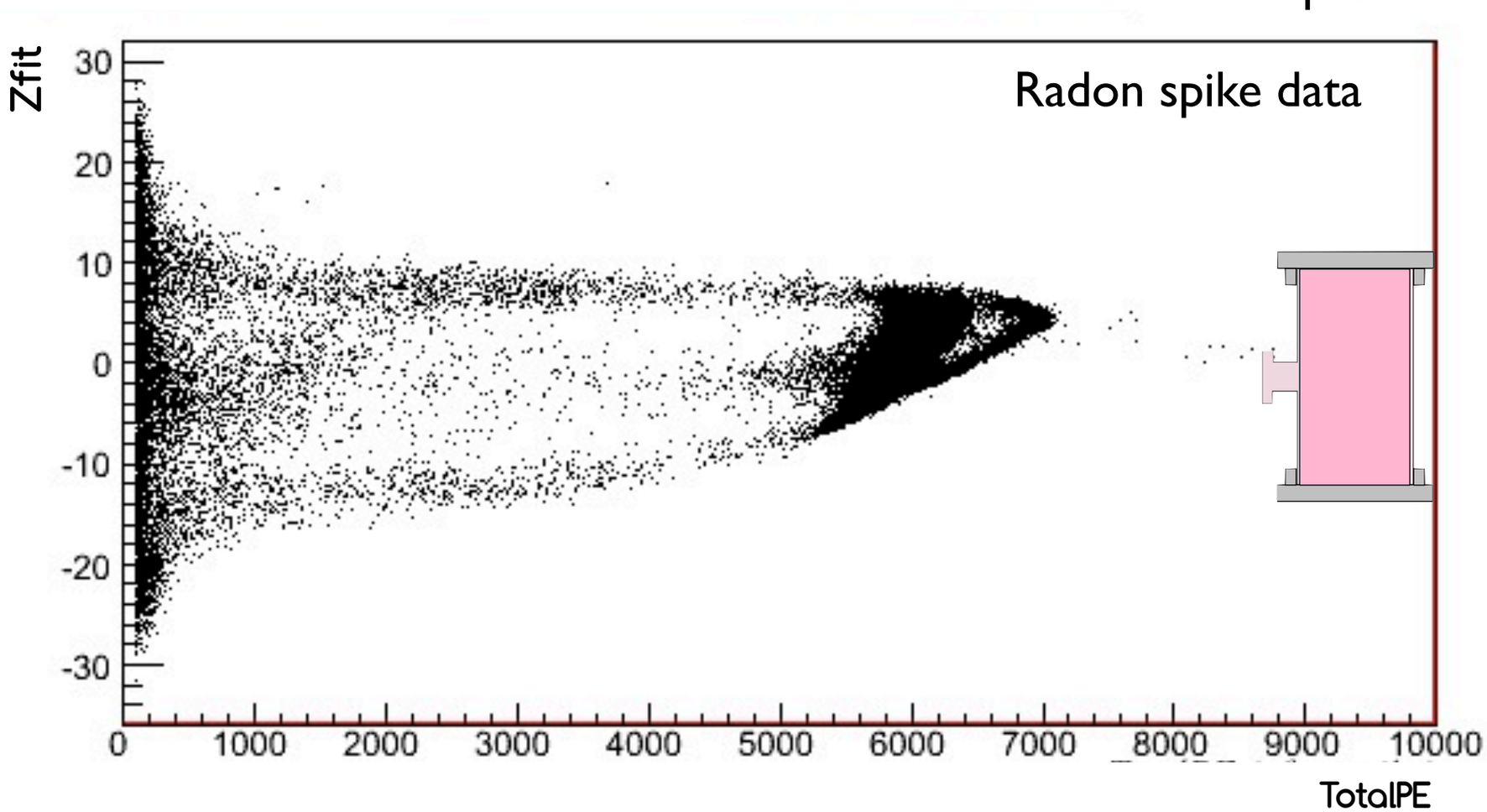
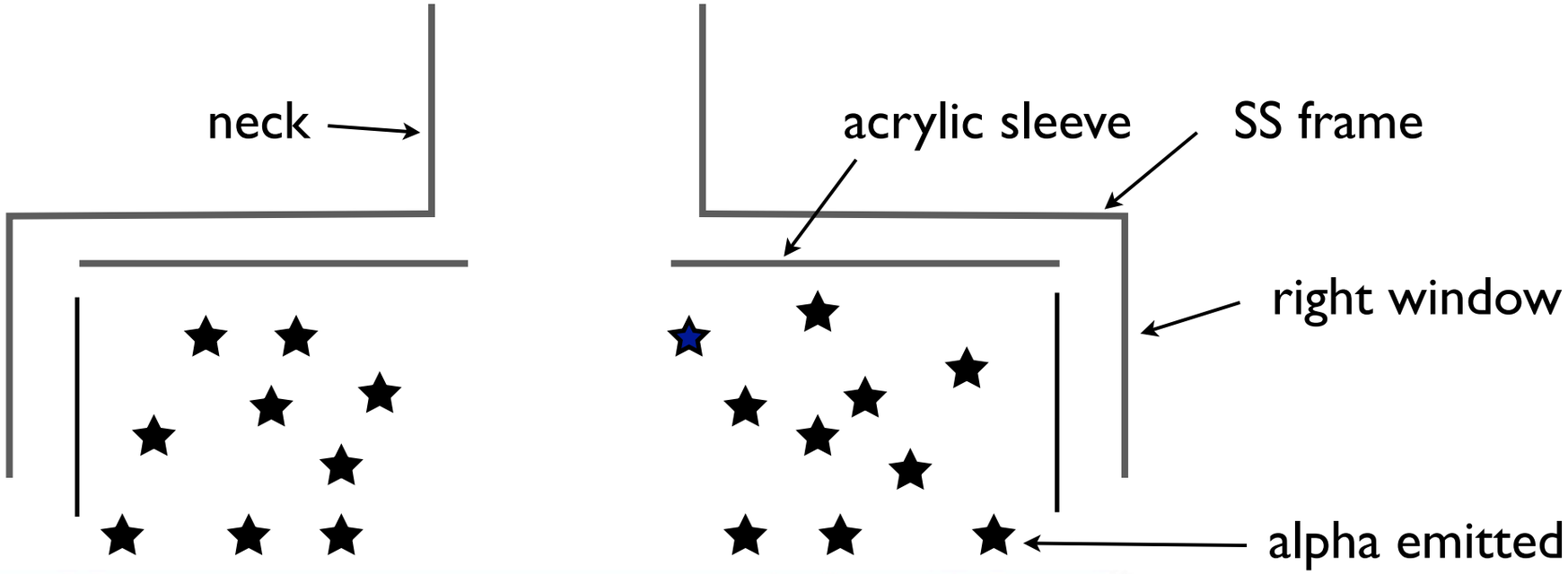
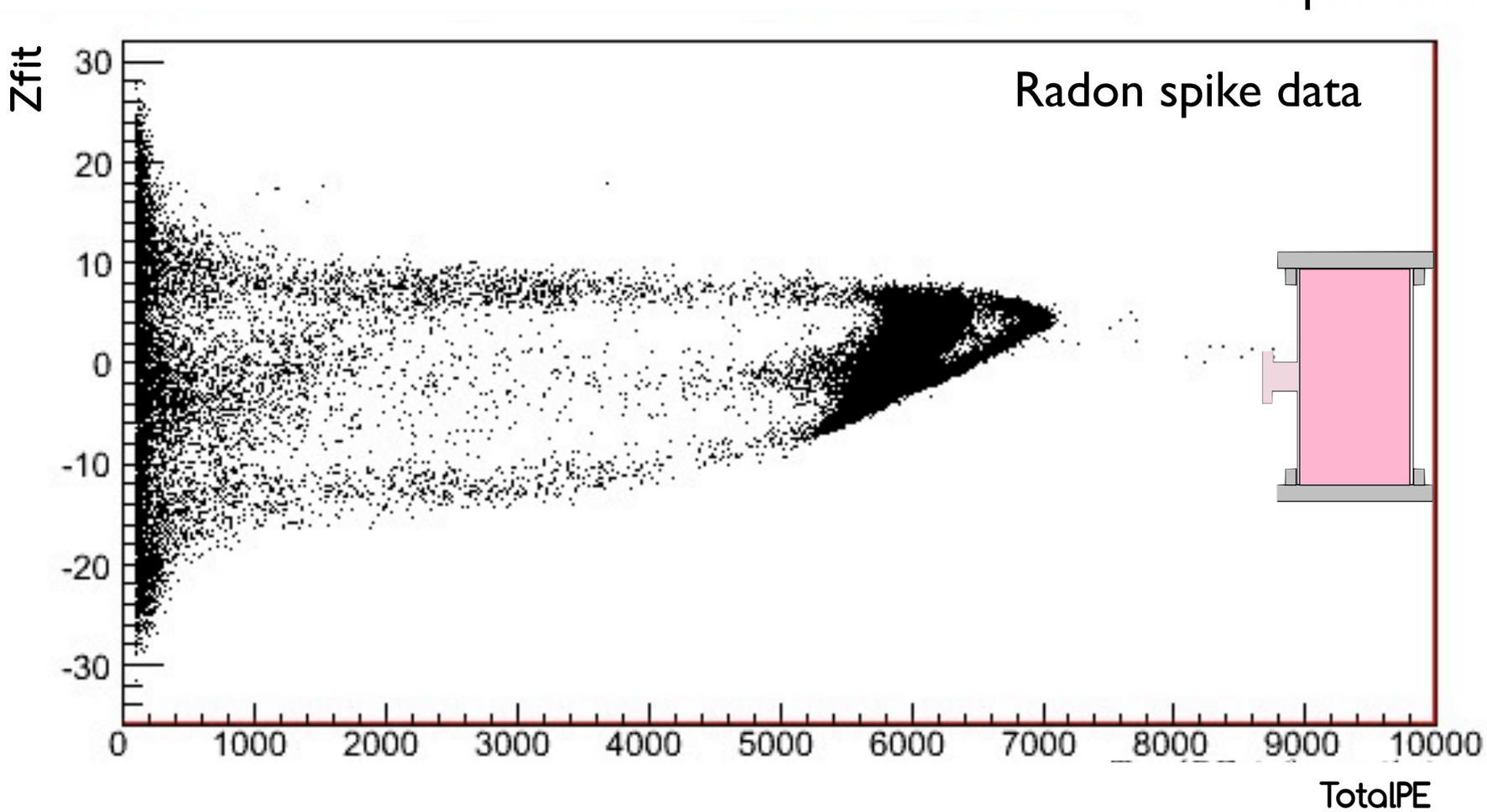




DEAP 3600

... this leads to geometric background events.





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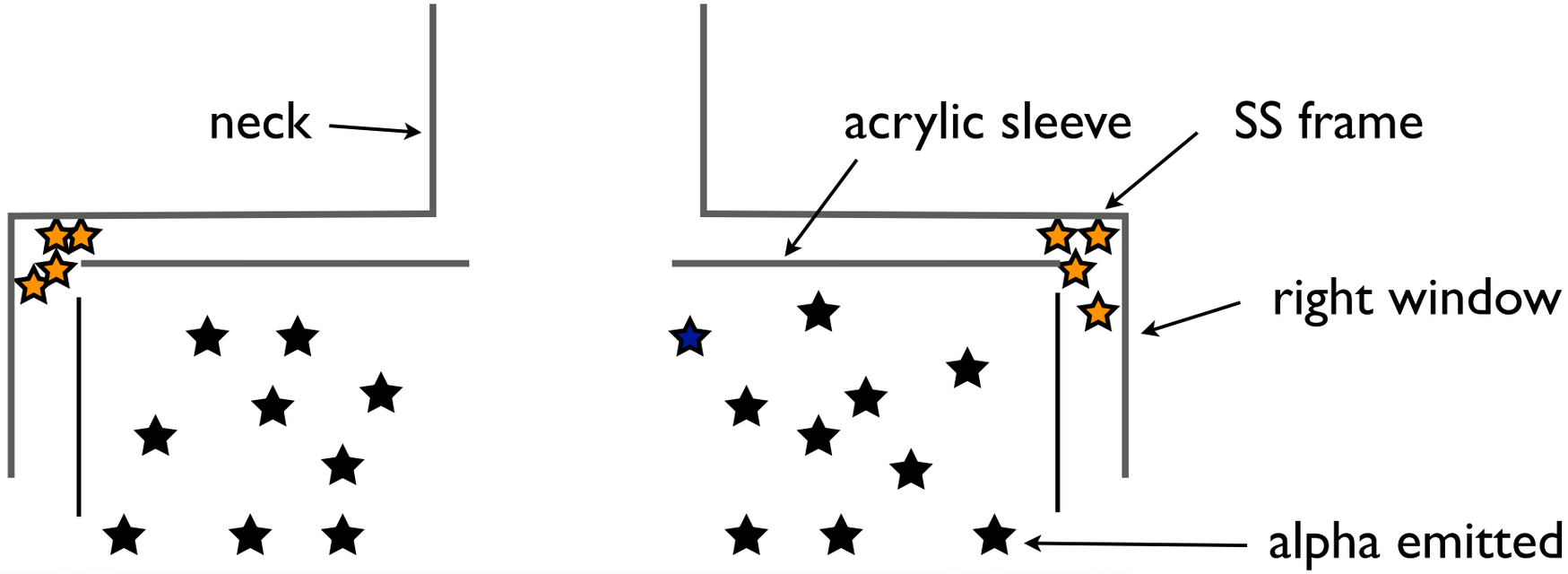

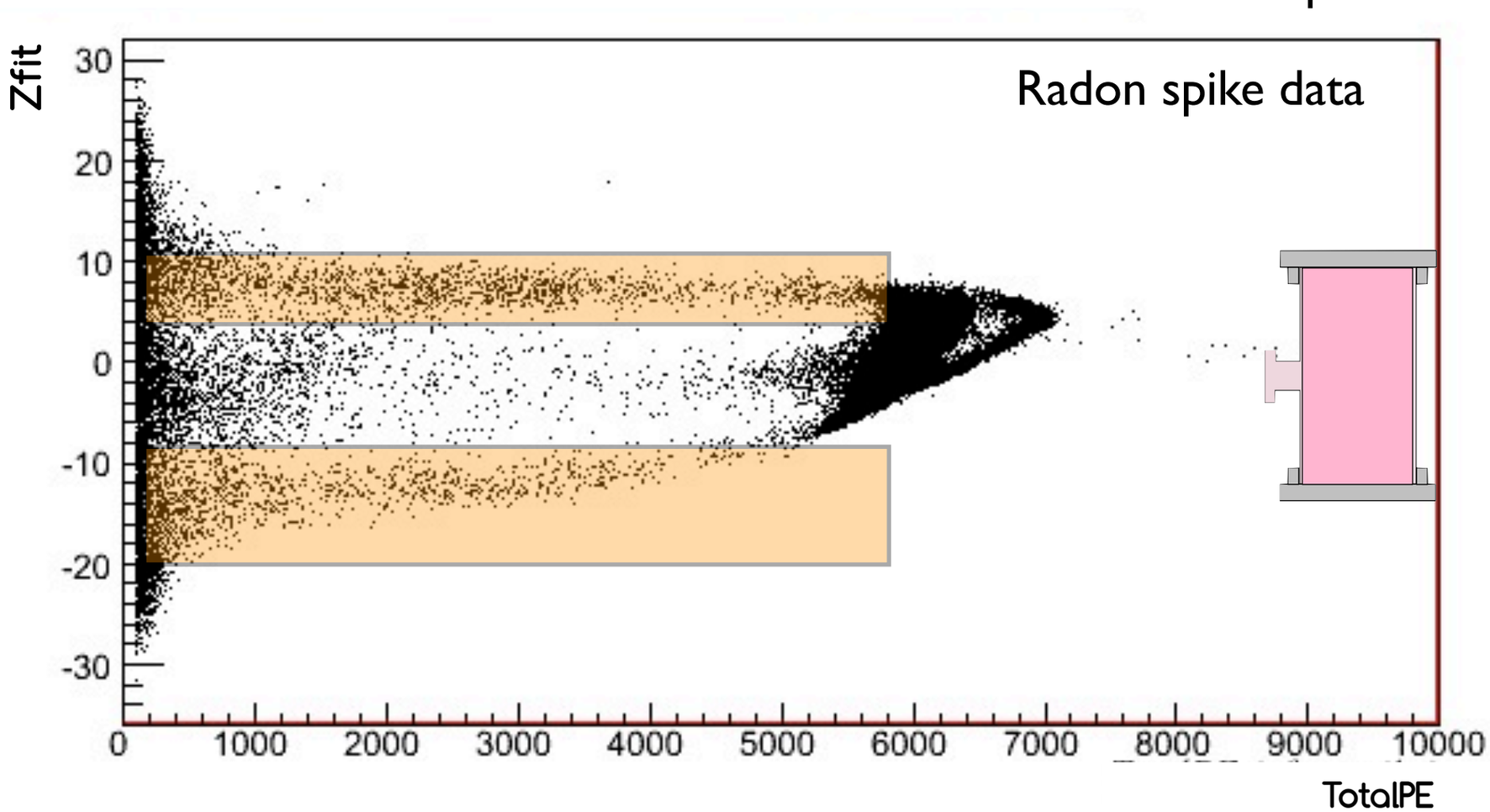

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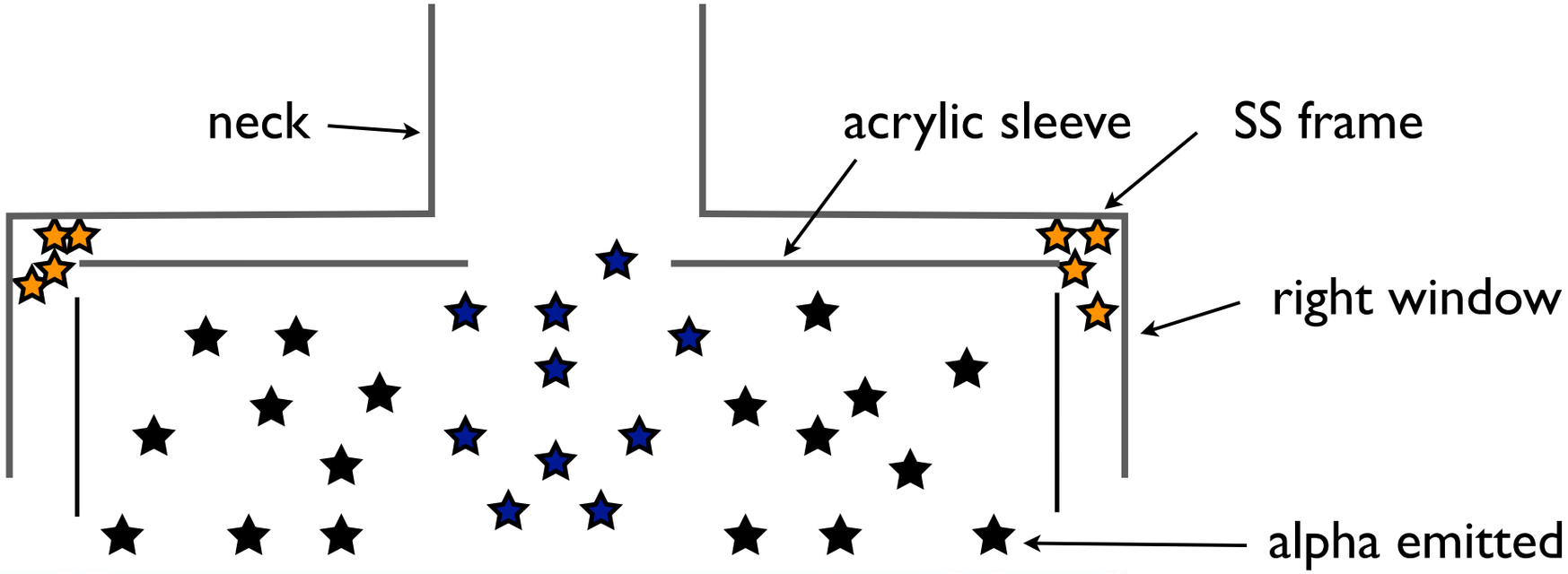

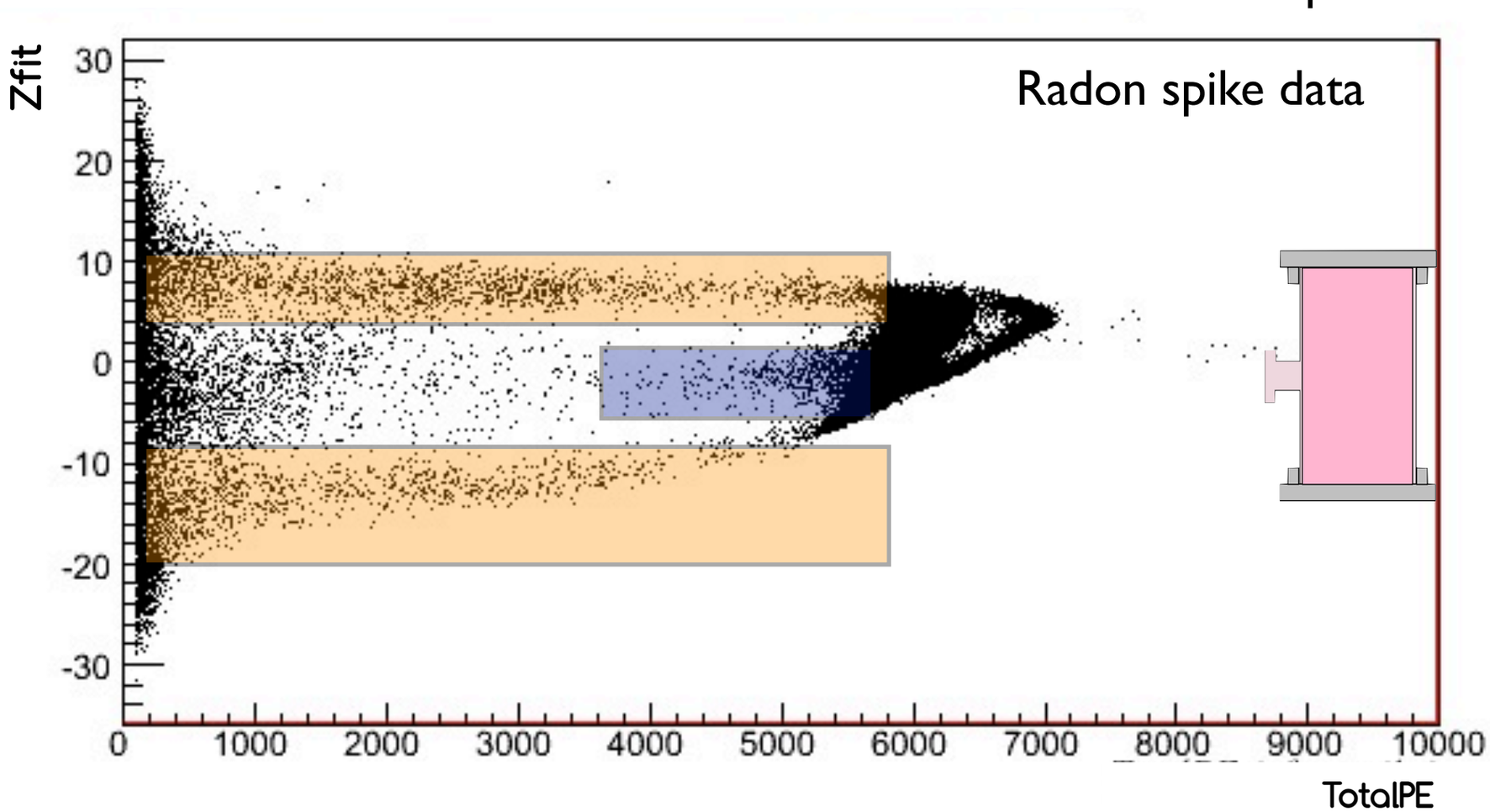

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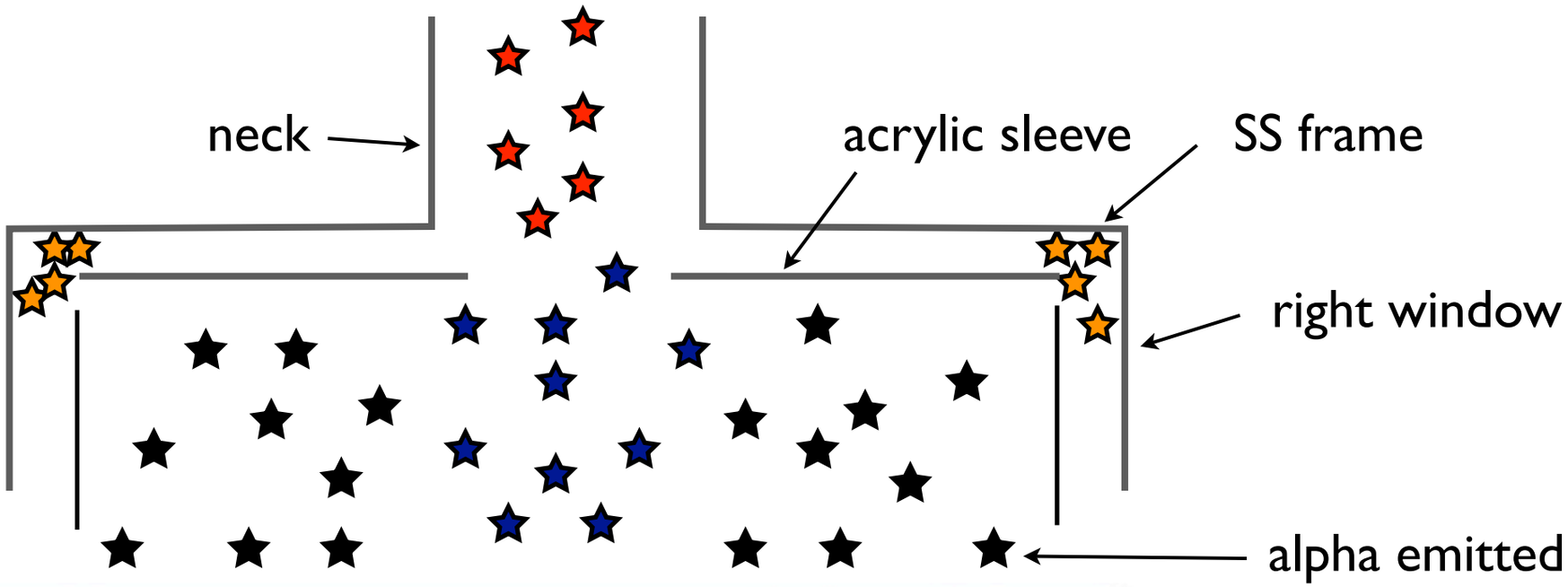
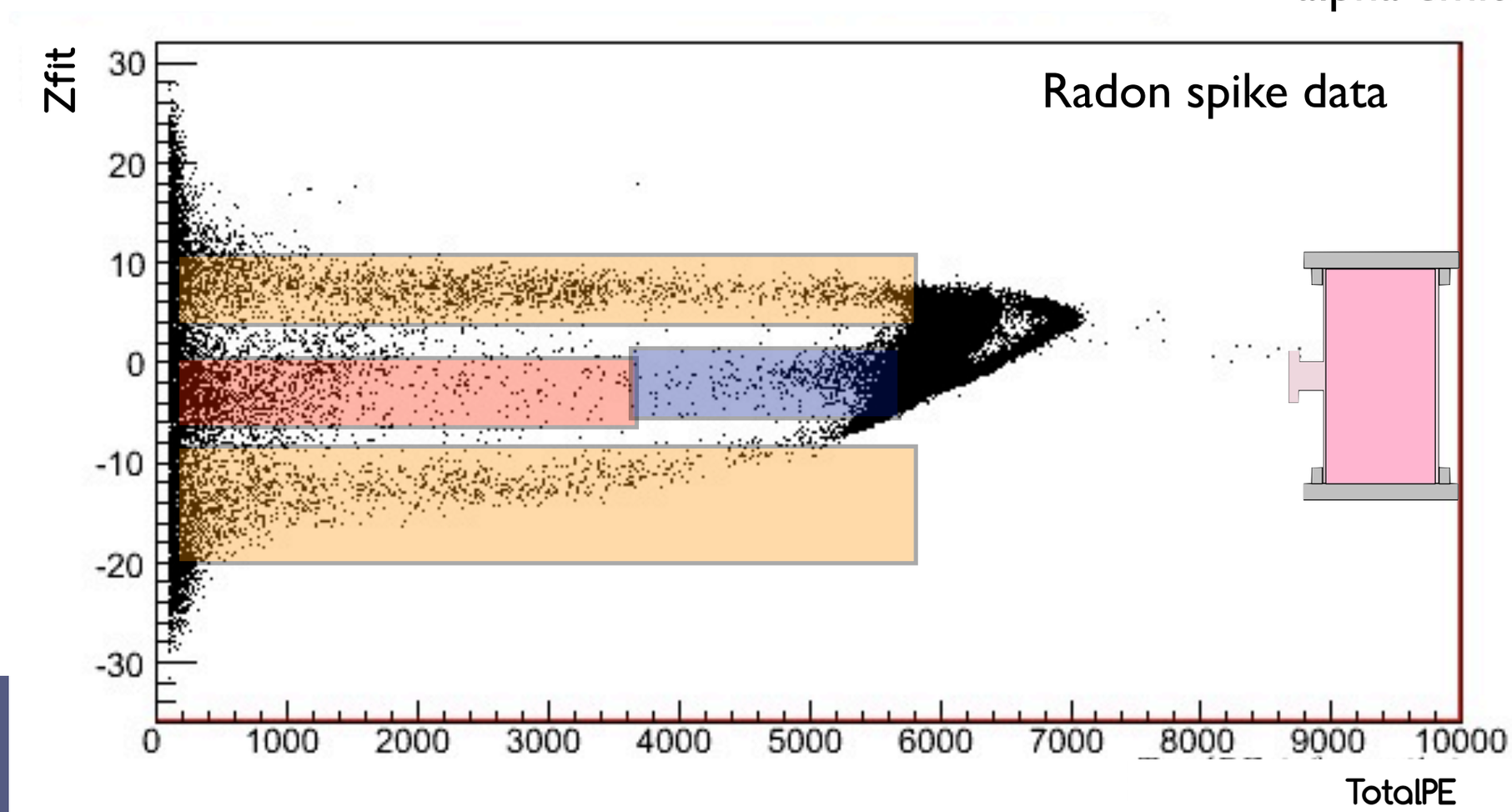
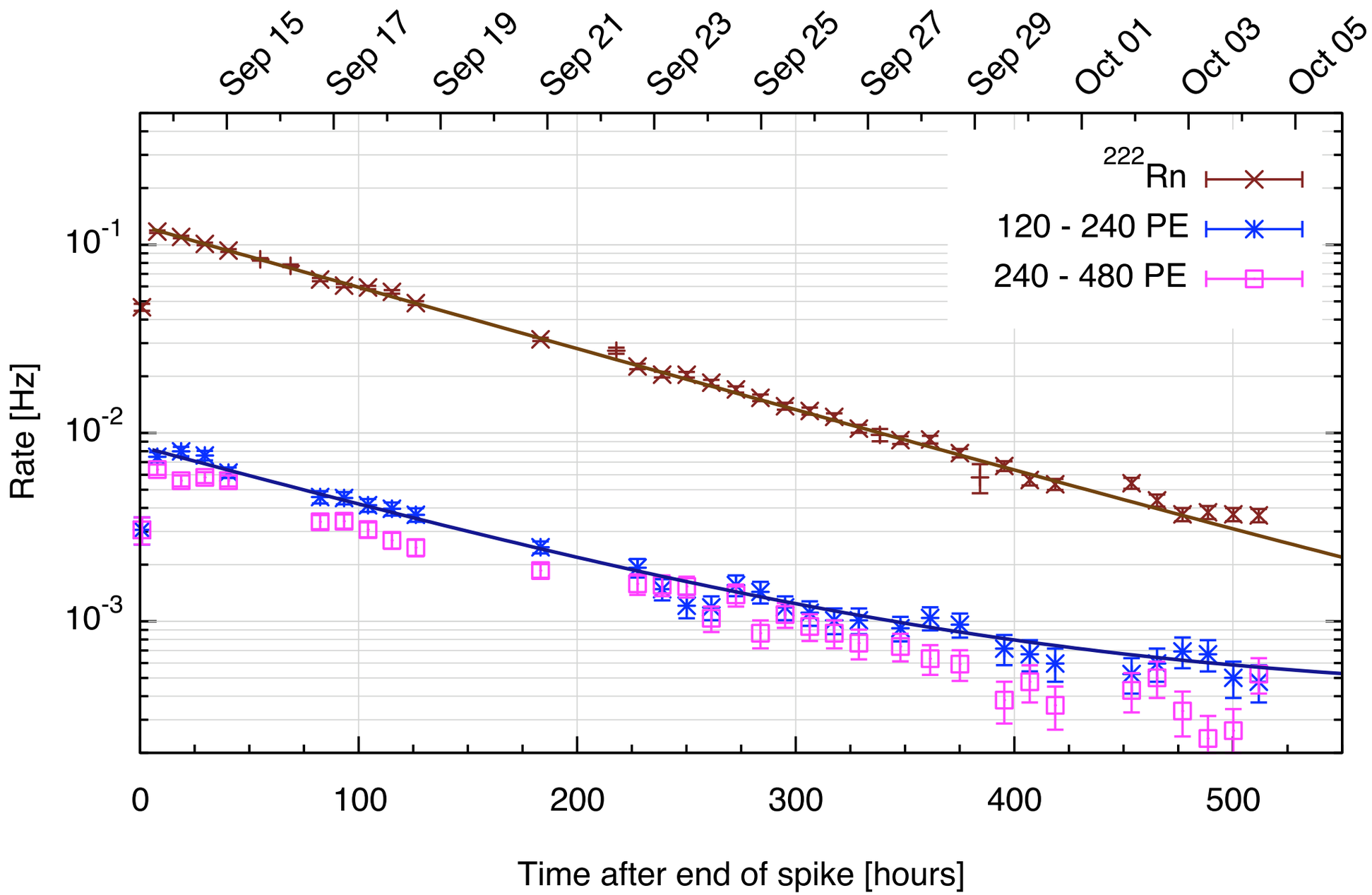
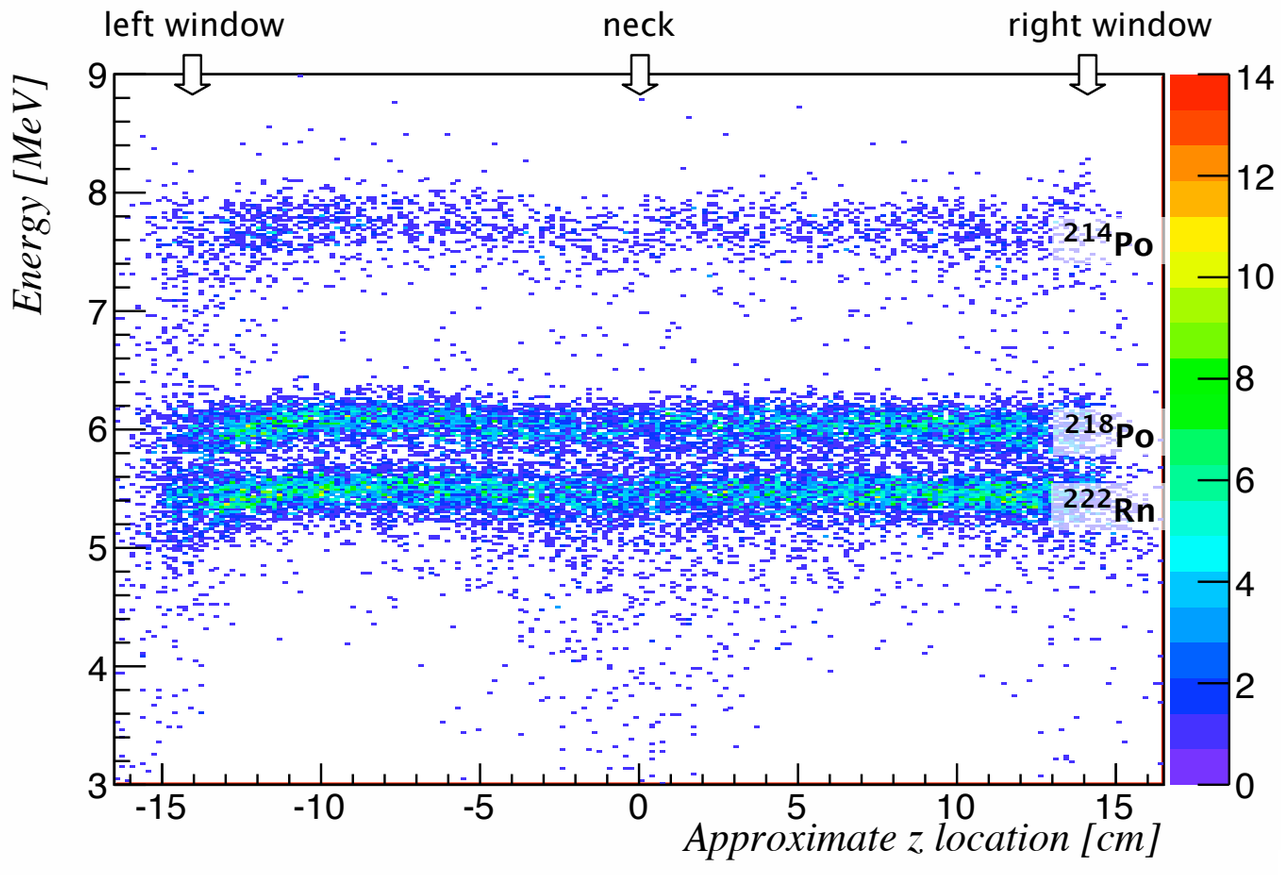


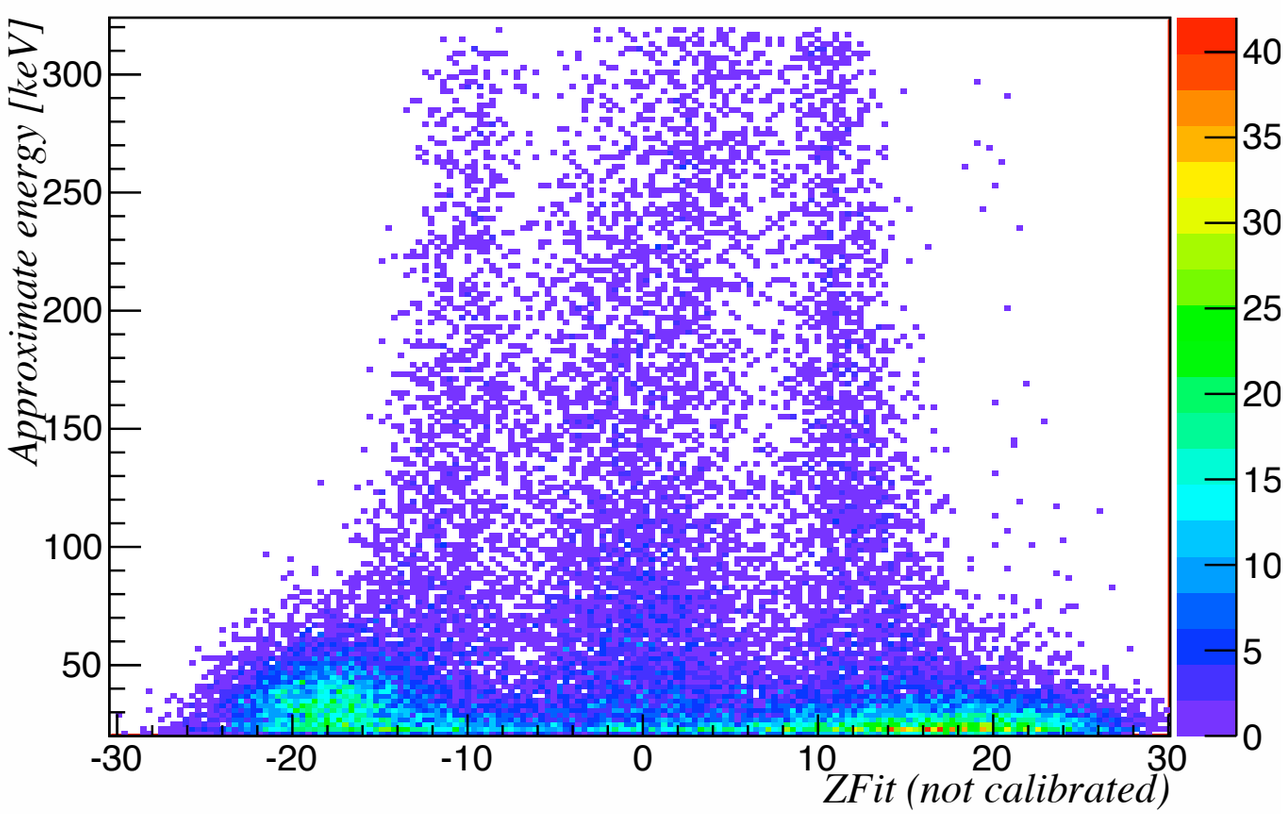


DEAP 3600

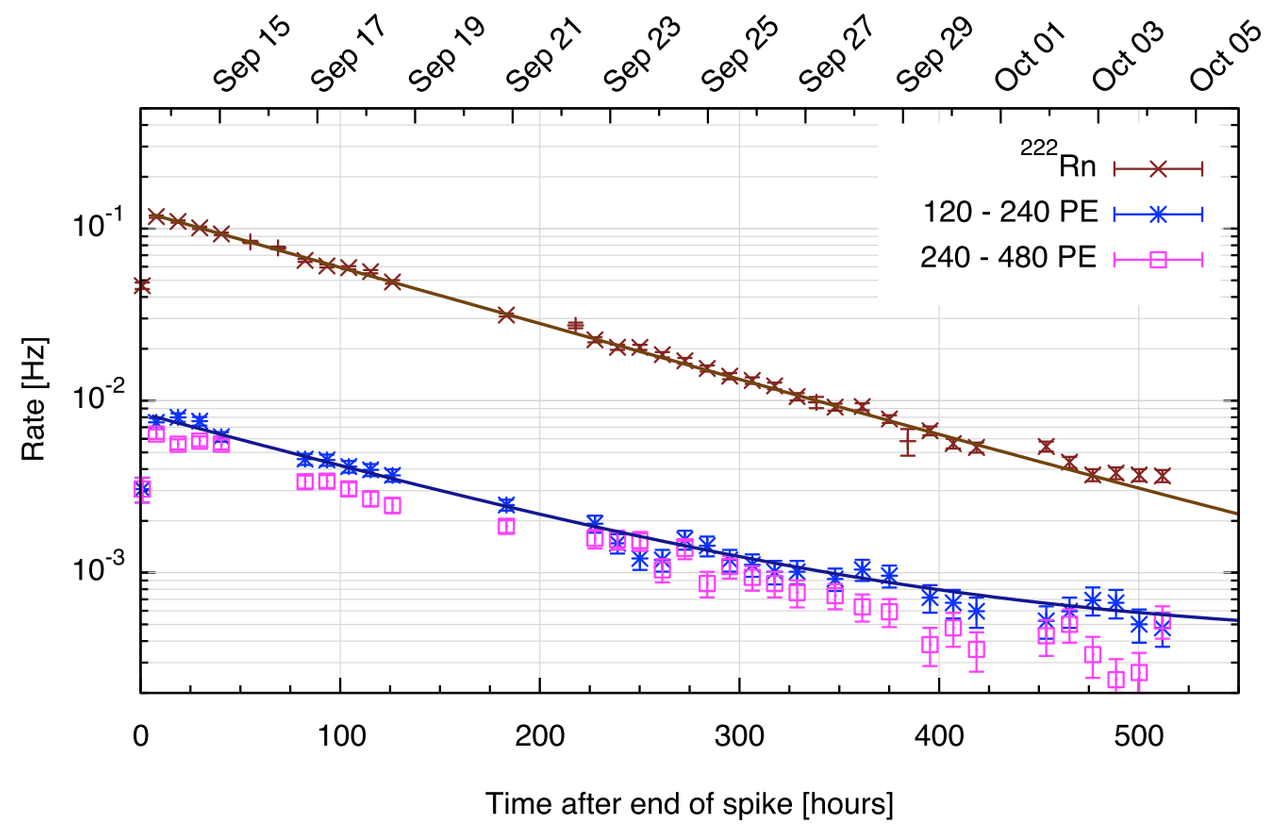
Rate in low energy windows follows radon decay.



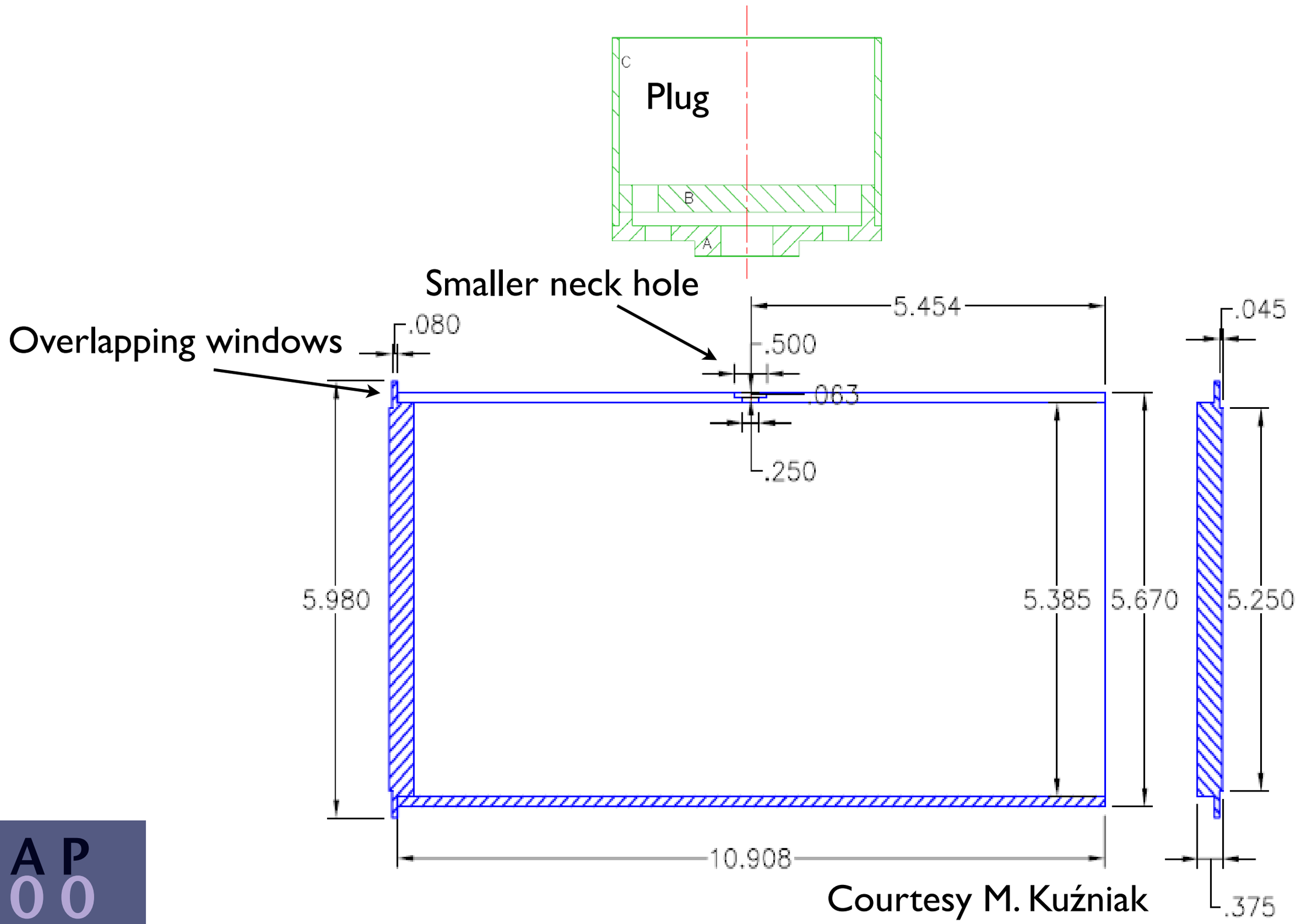




A closer look at the high and low energy regions after the radon spike.

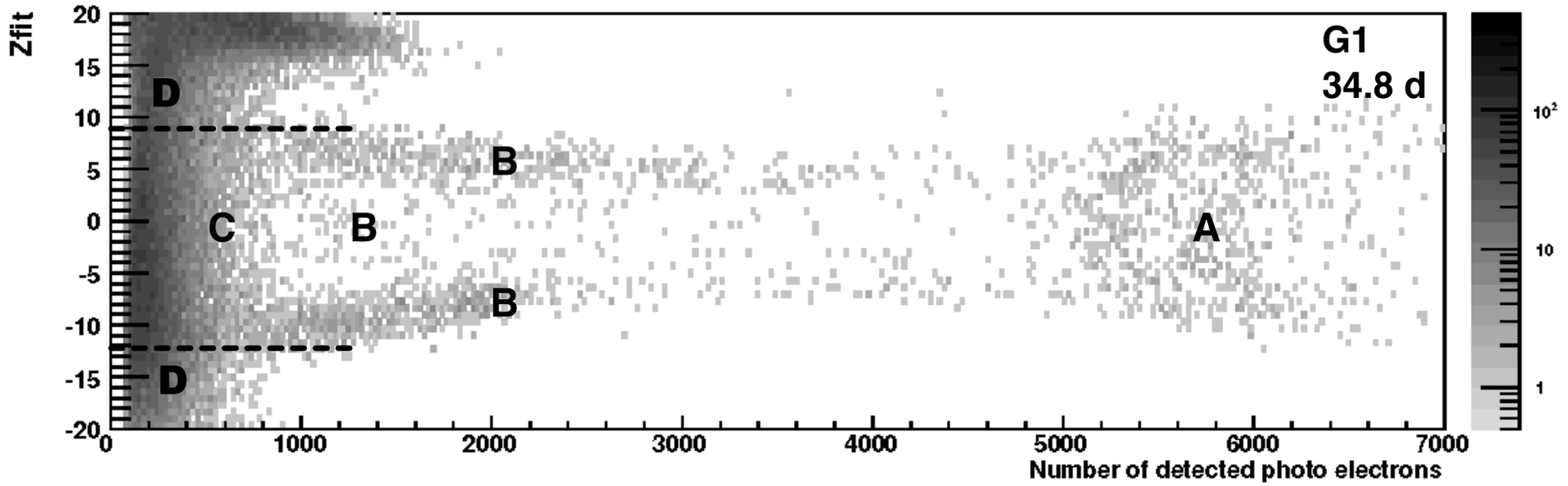


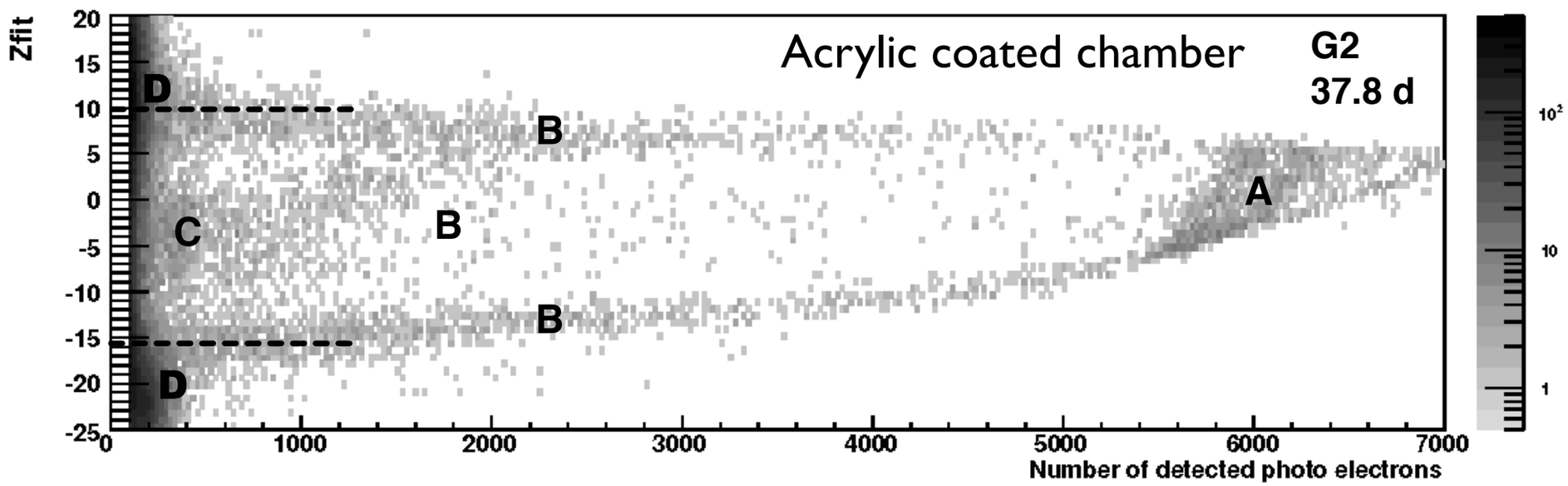
Detector modification to eliminate gaps:

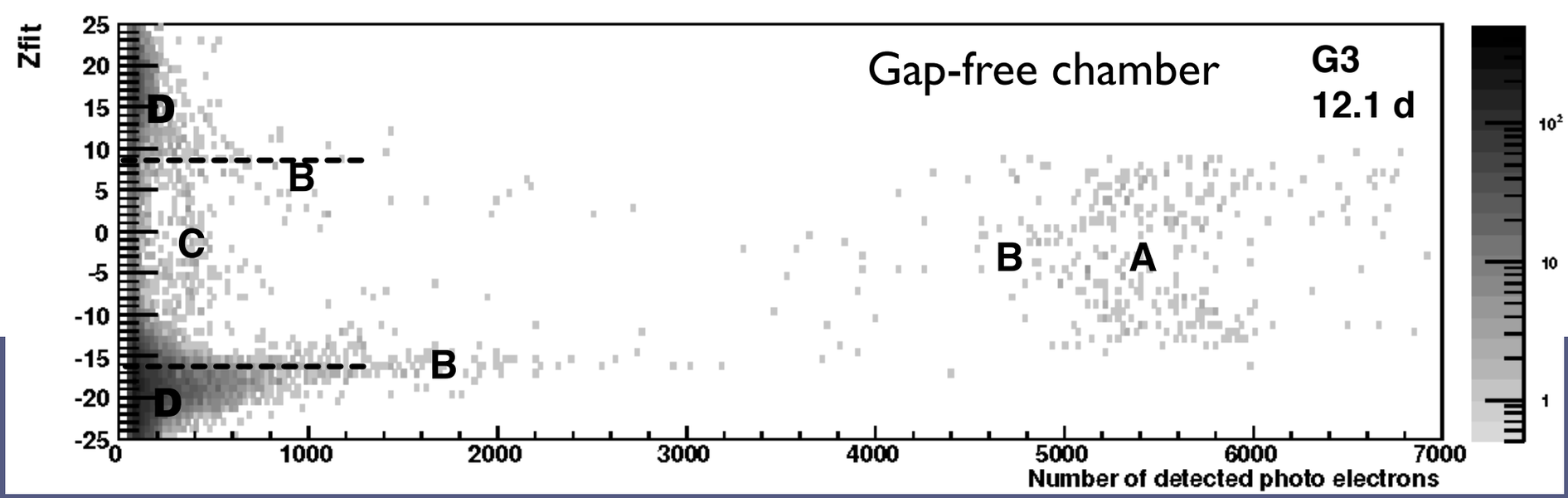


Courtesy M. Kuźniak

Background seen in nuclear recoil band at energies from 0 to 8 MeV.

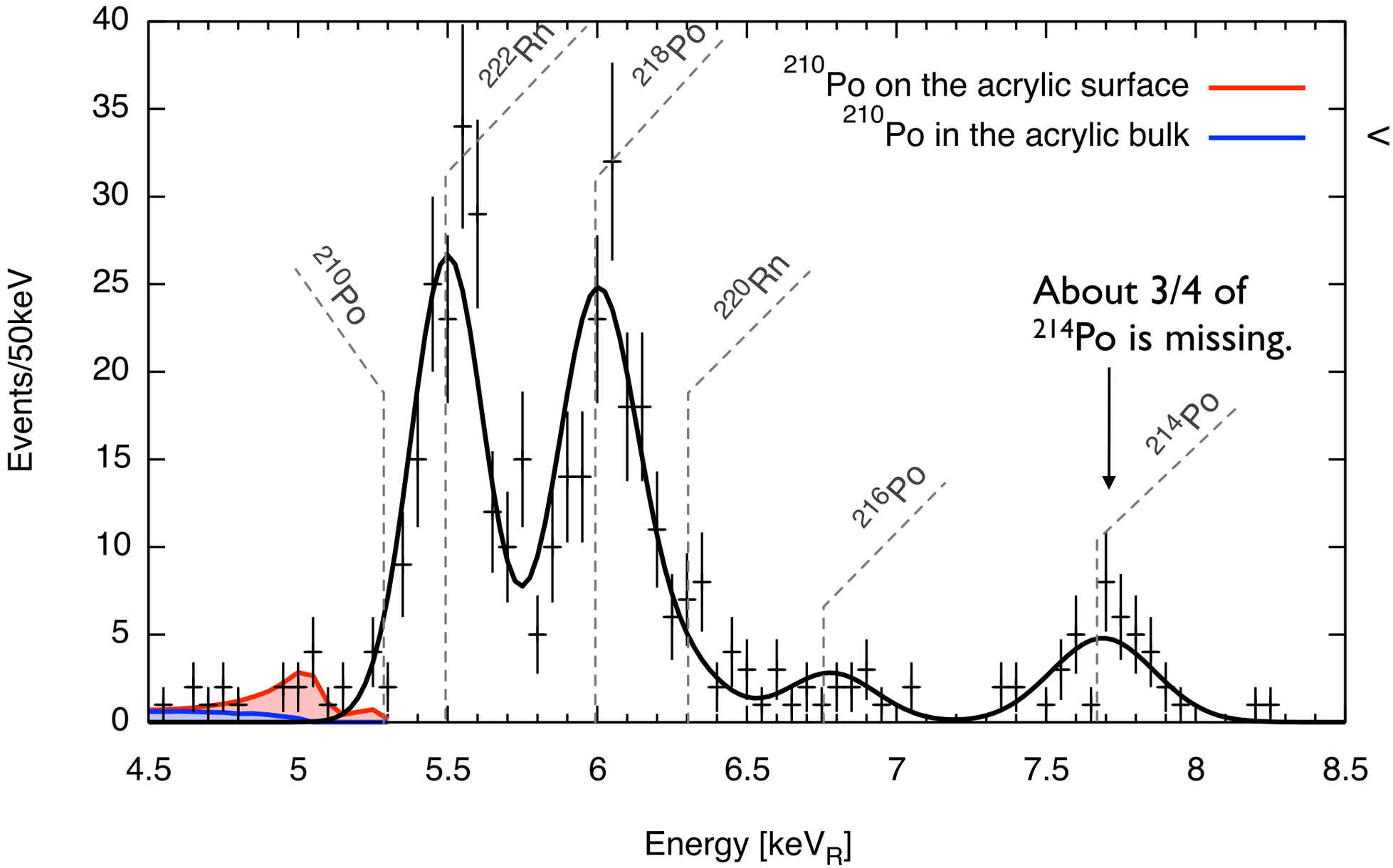






DEAP 3600

Surface background model now fits data.



$< (5 \pm 0.5) \cdot 10^{-19}$ g/g

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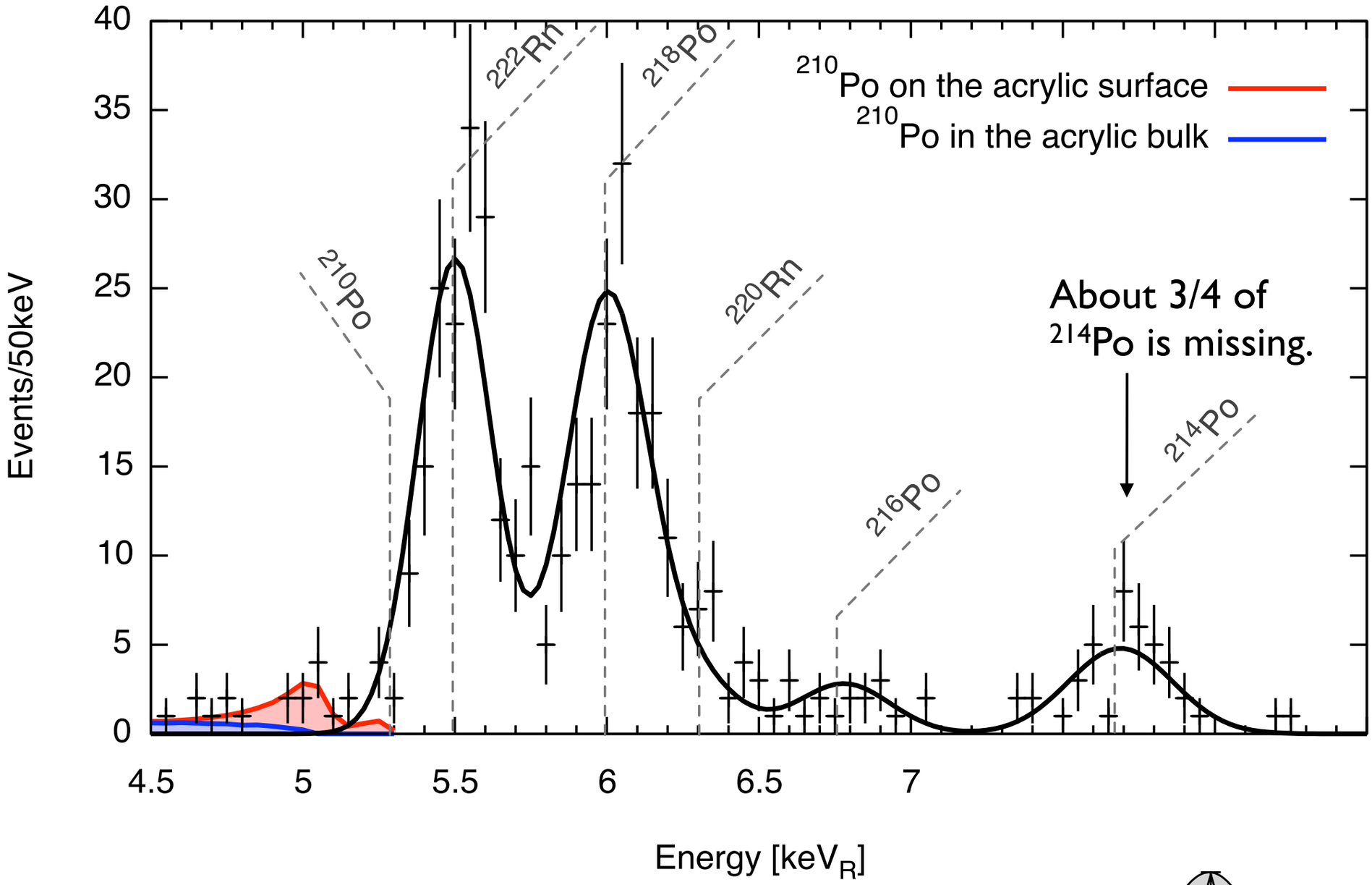

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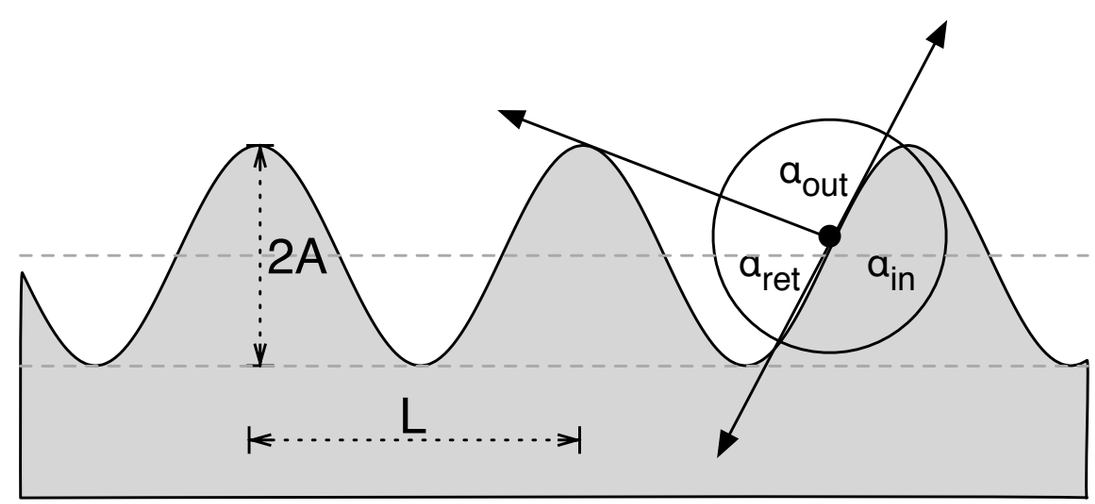
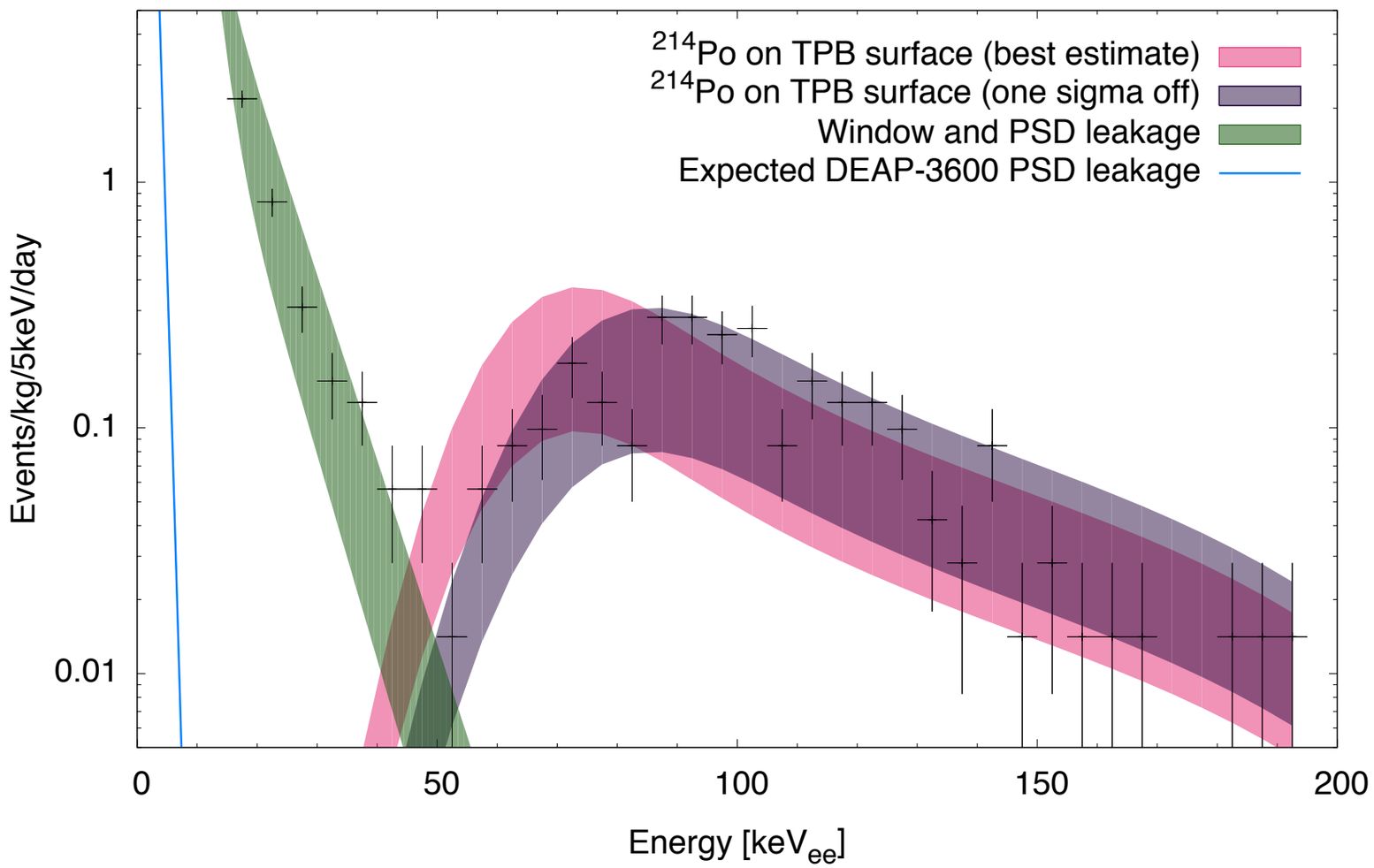
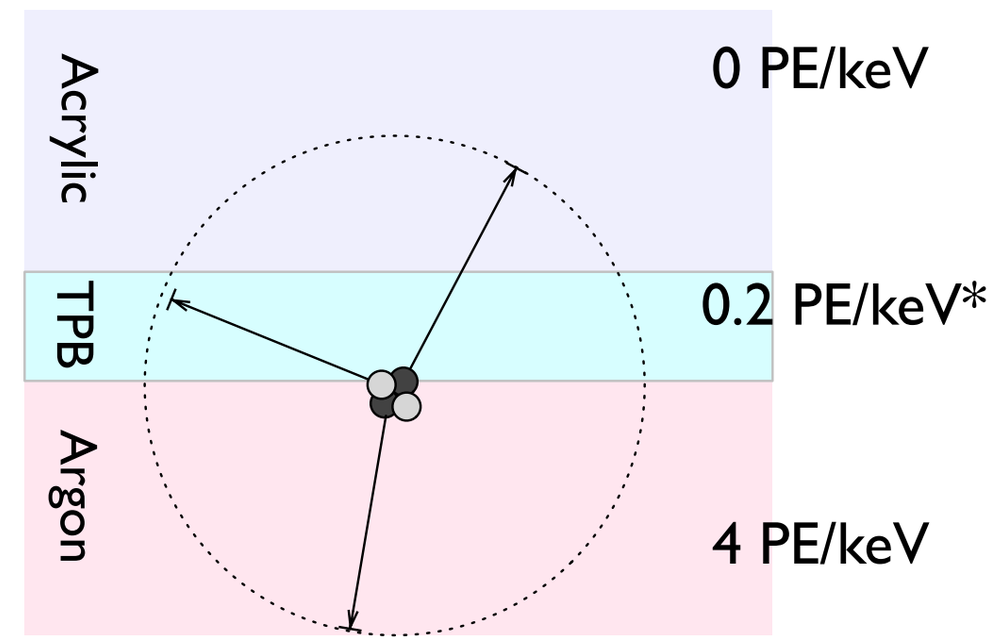


Low energy background is now dominated by ^{214}Po on TPB.

85% recoil efficiency



^{214}Po alpha from TPB surface



^{214}Po missing at high energies: 142±10

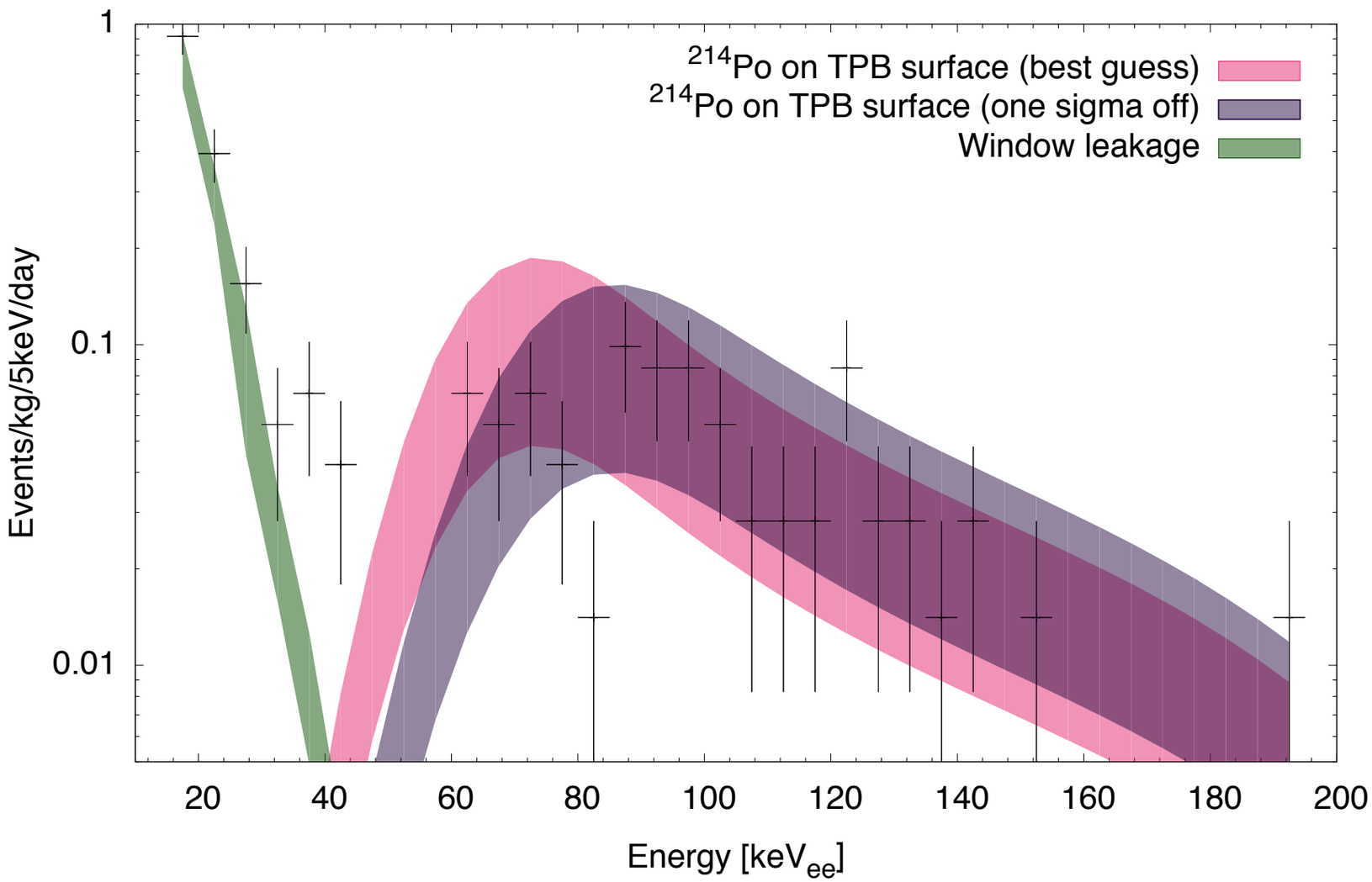
^{214}Po found at low energies: 180±30

$$E_{app} = \frac{E_{tpb}\epsilon_{tpb}}{\epsilon_{lar}} + q \cdot E_{r,lar}$$

* **Pollmann, T. & Boulay, M.** Scintillation of thin tetraphenyl butadiene films under alpha particle excitation. *Nuclear Instruments and Methods in …* (2011).

Low energy background is now dominated by ^{214}Po on TPB.

50% recoil efficiency



Limit on radon rate for DEAP-3600 from this: $R_{Rn} < 1 \cdot 10^{-4}$Hz.