

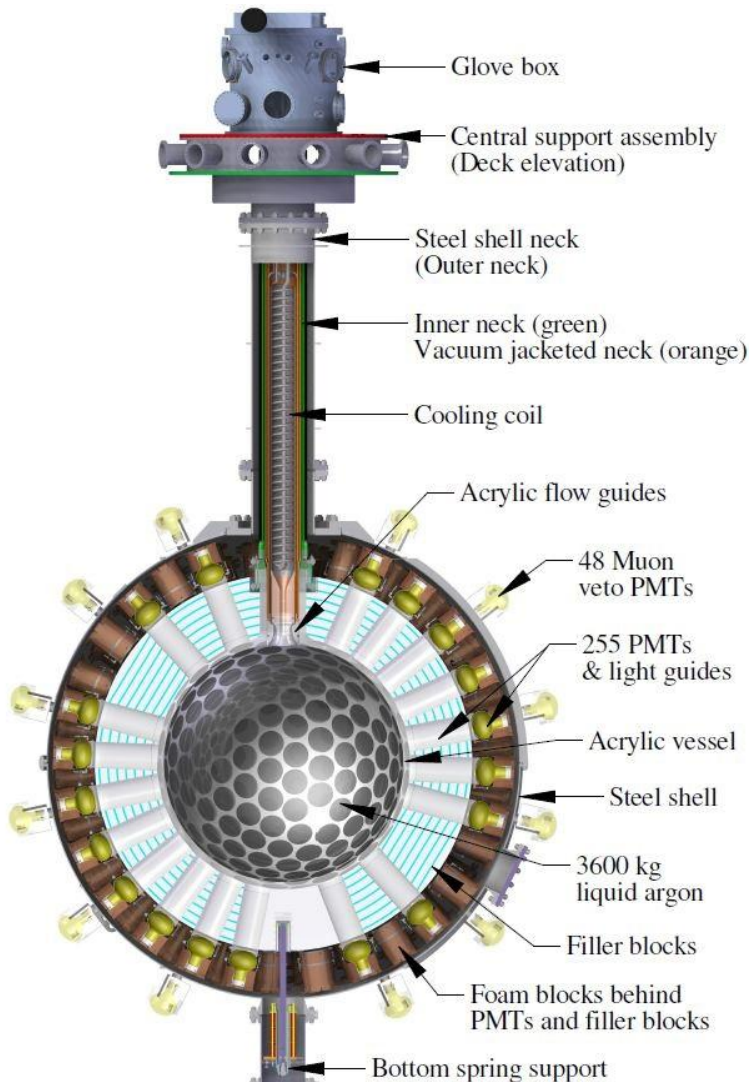


Optimizing Wavelength-Shifter Thickness for Alpha Suppression in DEAP-3600

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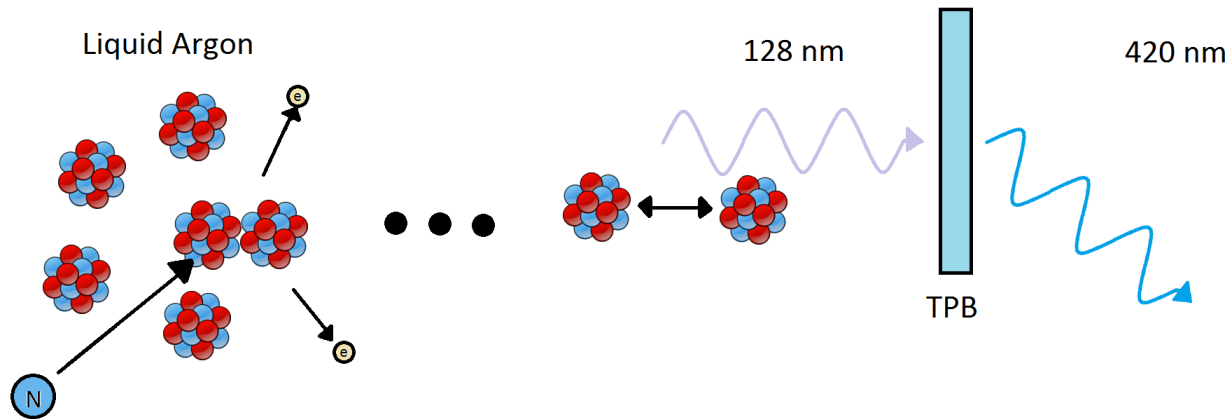
DEAP-3600 Overview



- Single phase
- Spherical vessel
- Highly radio-pure acrylic
- Liquid argon as scintillation material

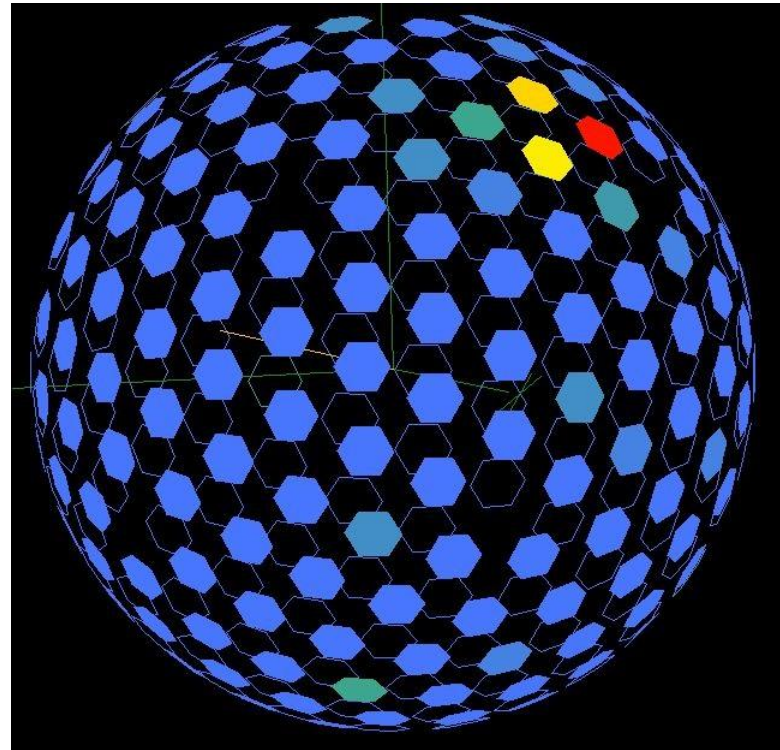
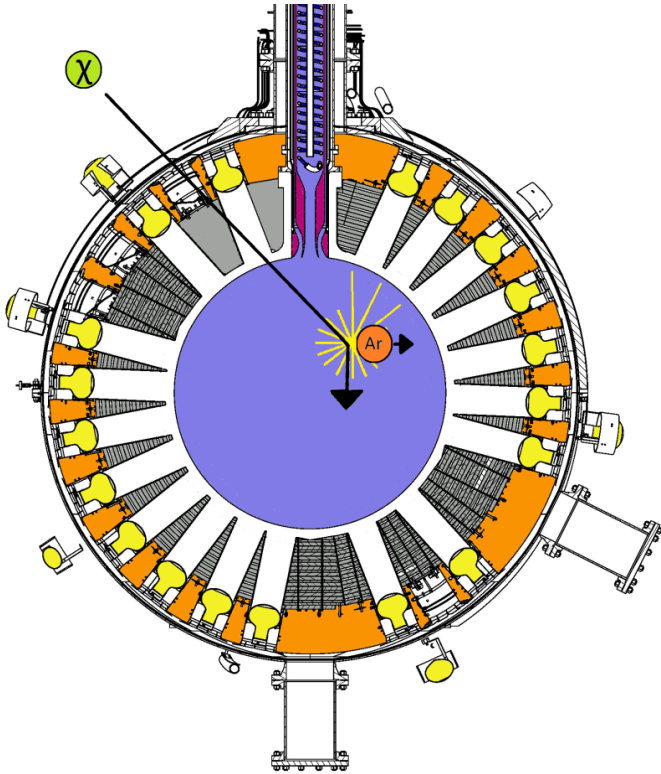
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Light Generation & Wavelength Shifter



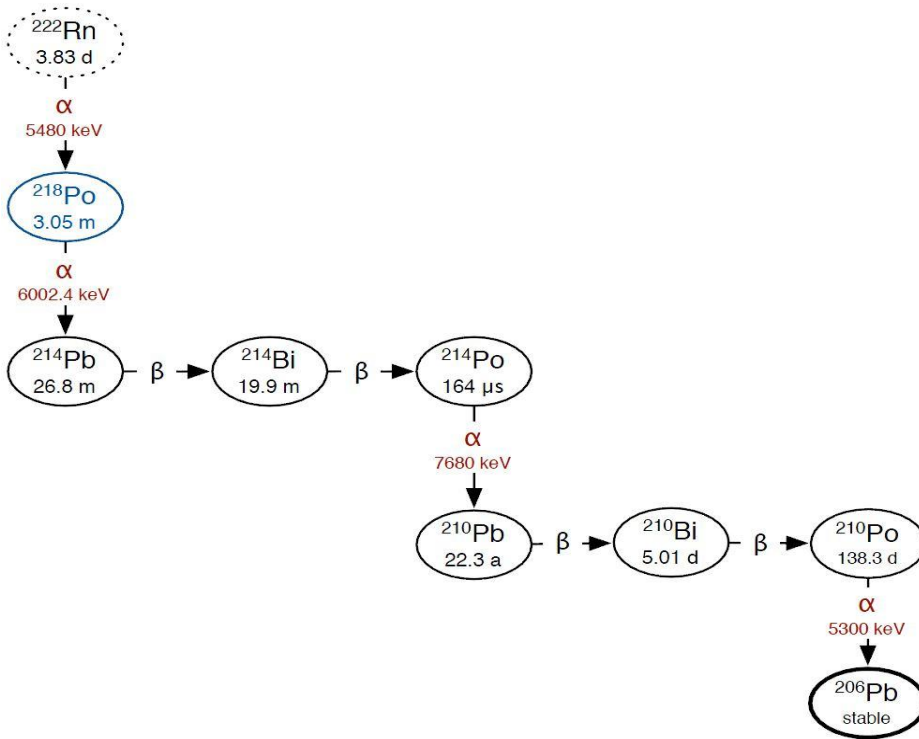
- Incident radiation causes liquid argon to emit scintillation light
 1. Argon atoms ionize
 2. Unstable argon dimers form
 3. Dimers decay, emitting 128nm photons
 4. Wavelength-shifting layer of **tetraphenyl butadiene (TPB)** absorbs 128nm photons and re-emits 420nm photons
 5. Optical photons travel to surrounding photomultiplier tubes
- TPB, through a different mechanism, emits scintillation light as well when excited by alpha particles

Energy & Position Reconstruction



- Total number of gathered photoelectrons \rightarrow total energy estimate
- Distribution of gathered photoelectrons \rightarrow position estimate
- Energy region of interest: 15-30 keVee (120-240 photoelectrons)
- Fiducial volume: inner sphere of radius 55cm

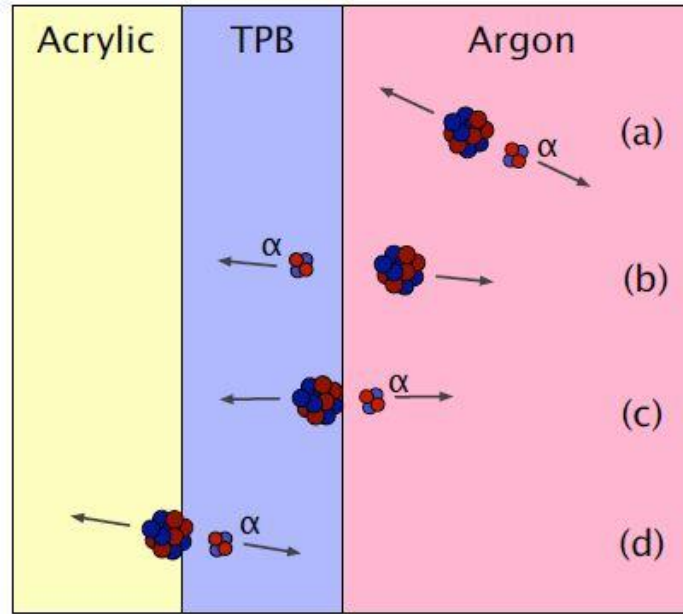
Inner Surface Contaminants



	Isotopes
Inside AV	^{238}U ^{232}Th ^{210}Pb
Inside TPB	^{238}U ^{232}Th ^{210}Pb
On TPB Surface	$^{210}\text{Pb/Po}$

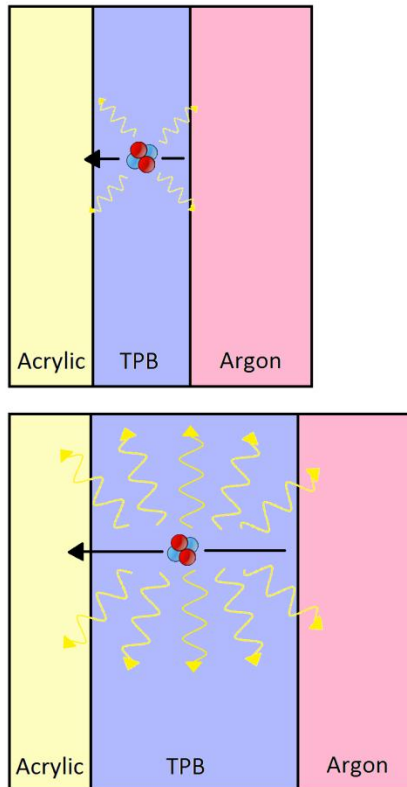
- Radon, abundant in lab air especially underground, absorbs fairly readily into acrylic
- Rn222 decays into Pb210, a long-lived isotope which will cause a constant source of alpha radiation (through Po210)
- These background events may enter the WIMP energy region of interest, depending on the decay location and the propagation direction of the emitted alpha

Events in WIMP Energy ROI

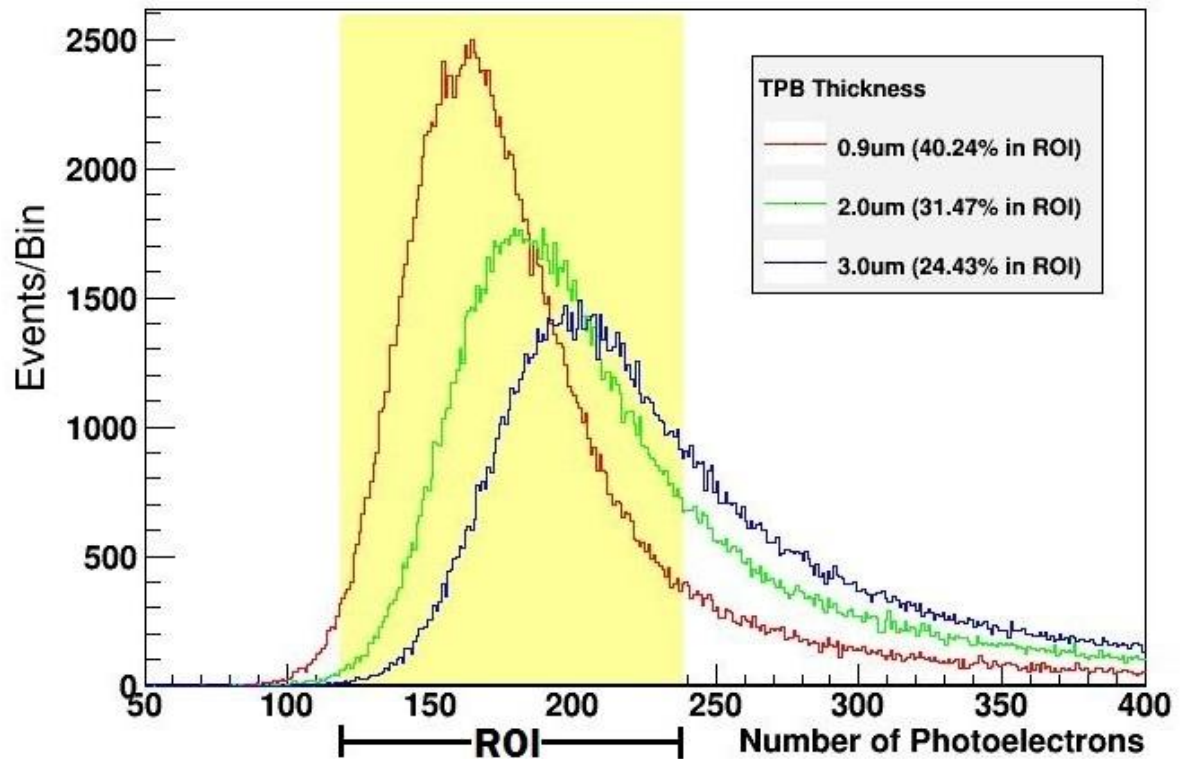


- a) Full alpha energy \rightarrow well above WIMP energy ROI
- b) Ejects nucleus into LAr \rightarrow energy contribution in ROI possible for wide band of alpha emission angles
- c) Full alpha energy \rightarrow well above WIMP energy ROI
- d) Alpha deposits energy in TPB and LAr \rightarrow energy contribution in ROI possible for narrow band of depth & emission angle combinations

Effects of TPB Thickness

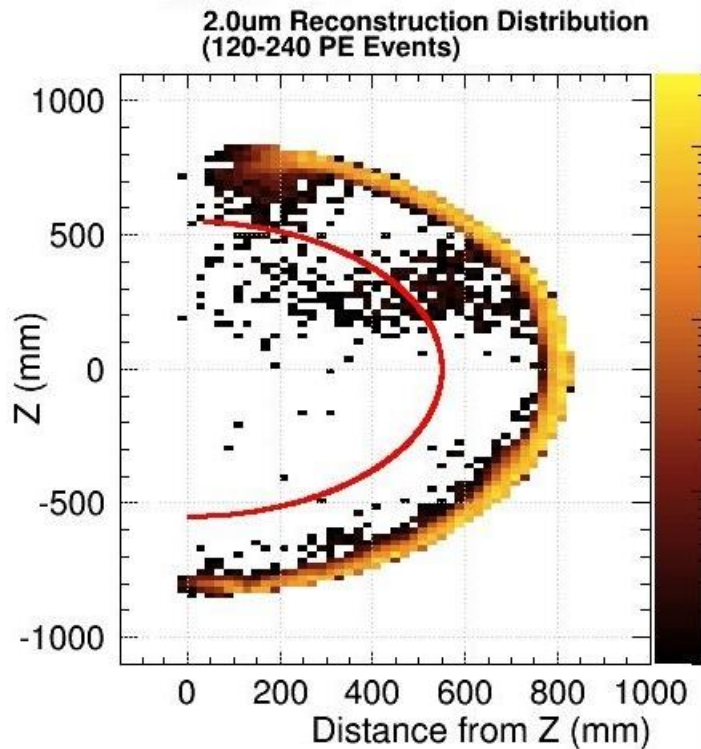


Simulated TPB-LAr Boundary Po210 Decays



- Thicker TPB causes alphas to generate more light, sometimes moving event outside WIMP energy ROI
- Thicker TPB causes photons to scatter more often on their way to the PMTs, potentially reducing our position reconstruction resolution

Monte-Carlo Preliminary Results



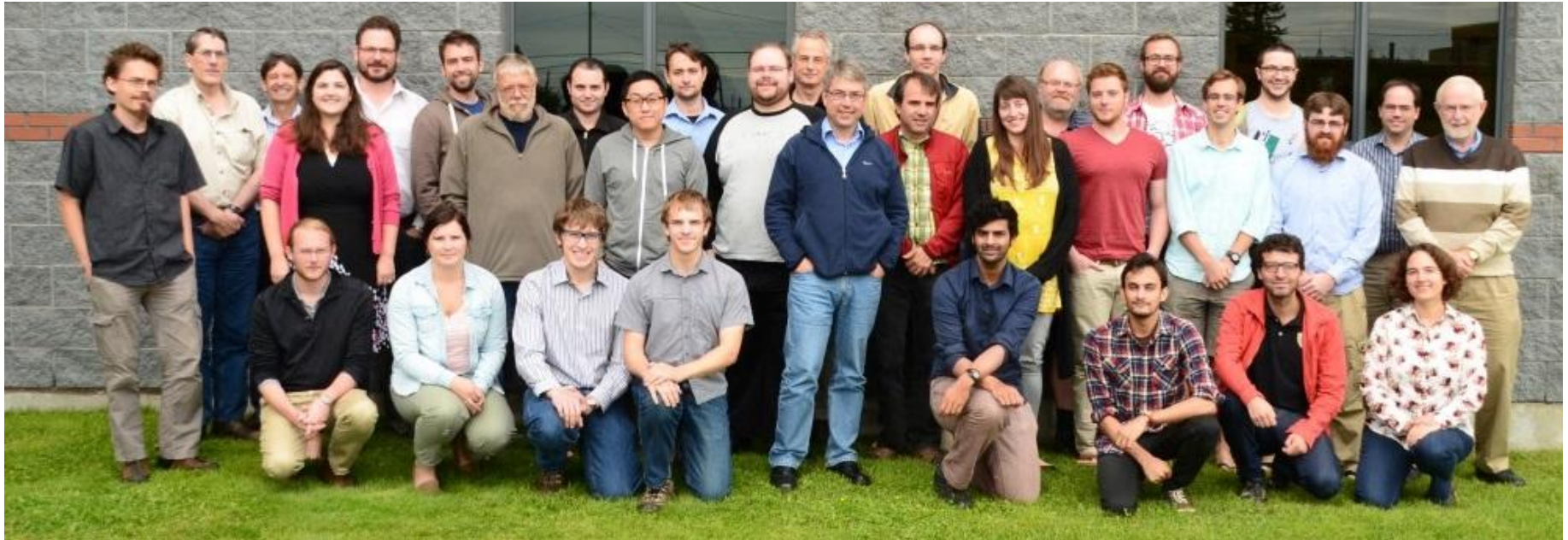
TPB Thickness	WIMP Leakage Probability
0.9 μ m	$5.62 \cdot 10^{-4}$
2.0 μ m	$2.94 \cdot 10^{-4}$
3.0 μ m	$1.16 \cdot 10^{-4}$

- 500,000 simulated Po210 decays on TPB-LAr boundary
- Clear dependence of total number of WIMP-like events on TPB thickness

Summary & Future Work

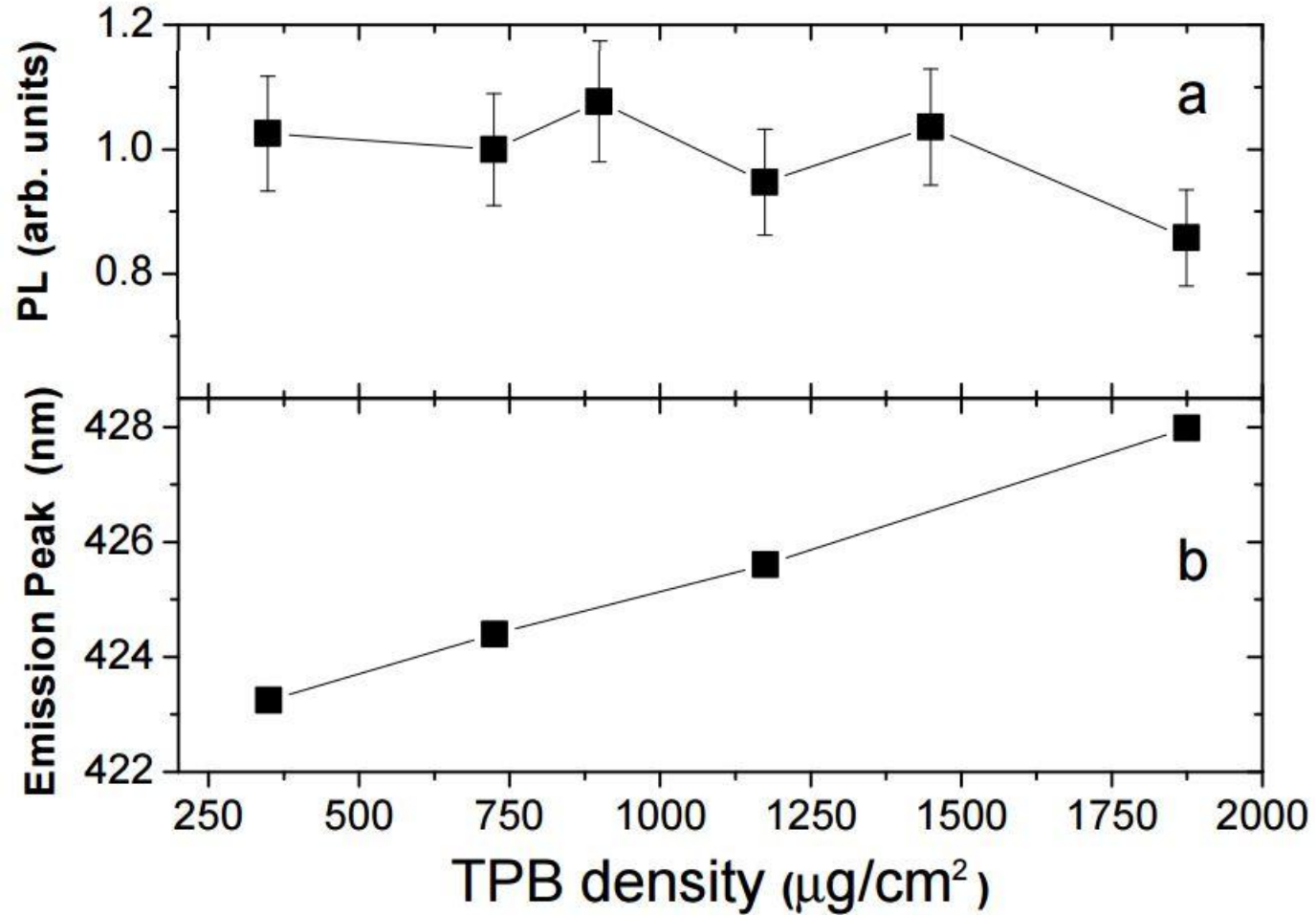
- Po210 contamination on inner surface of detector presents significant source of background events
- Thickness of wavelength-shifting layer of TPB affects total energy and estimated position of events due to
 - Alpha scintillation in TPB
 - Multiple scattering effects of post-shifted photons in TPB
- More detailed investigation of how multiple scattering affects position reconstruction is needed
- Incorporation of other less dominant sources of surface backgrounds, such as Th232 and U238
- Study of the effects on energy and position reconstruction of non-uniform TPB deposition, both microscopic and macroscopic

DEAP Collaboration



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Backup: Absorption in TPB



Francini et al., 2013 JINST 8 P09006