

# Current Status of DEAP-3600

Mark Stringer  
On Behalf of the DEAP-3600 Collaboration  
CAP Virtual Congress  
7<sup>th</sup> June 2021



Queen's  
UNIVERSITY

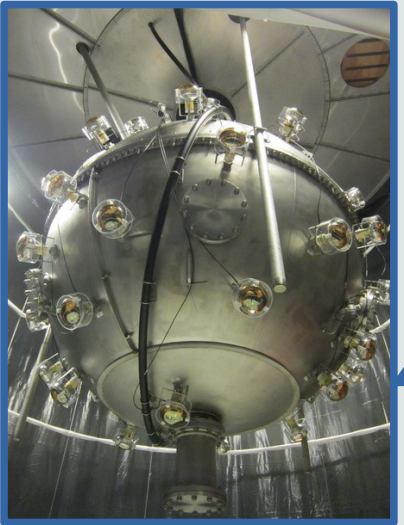
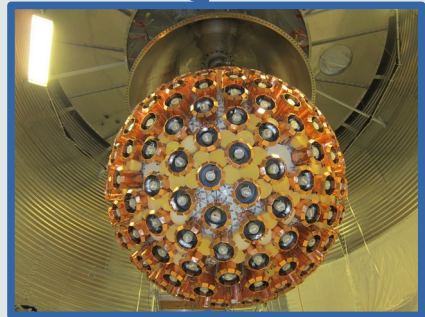
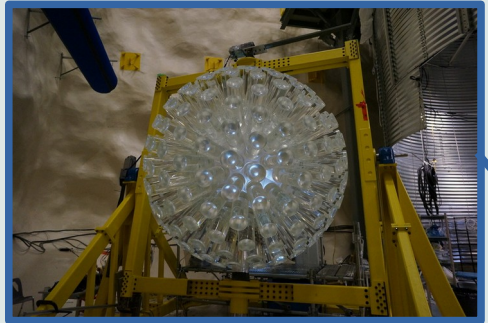




# DEAP Collaboration



# DEAP-3600



Veto PMTs external to steel shell

420 nm

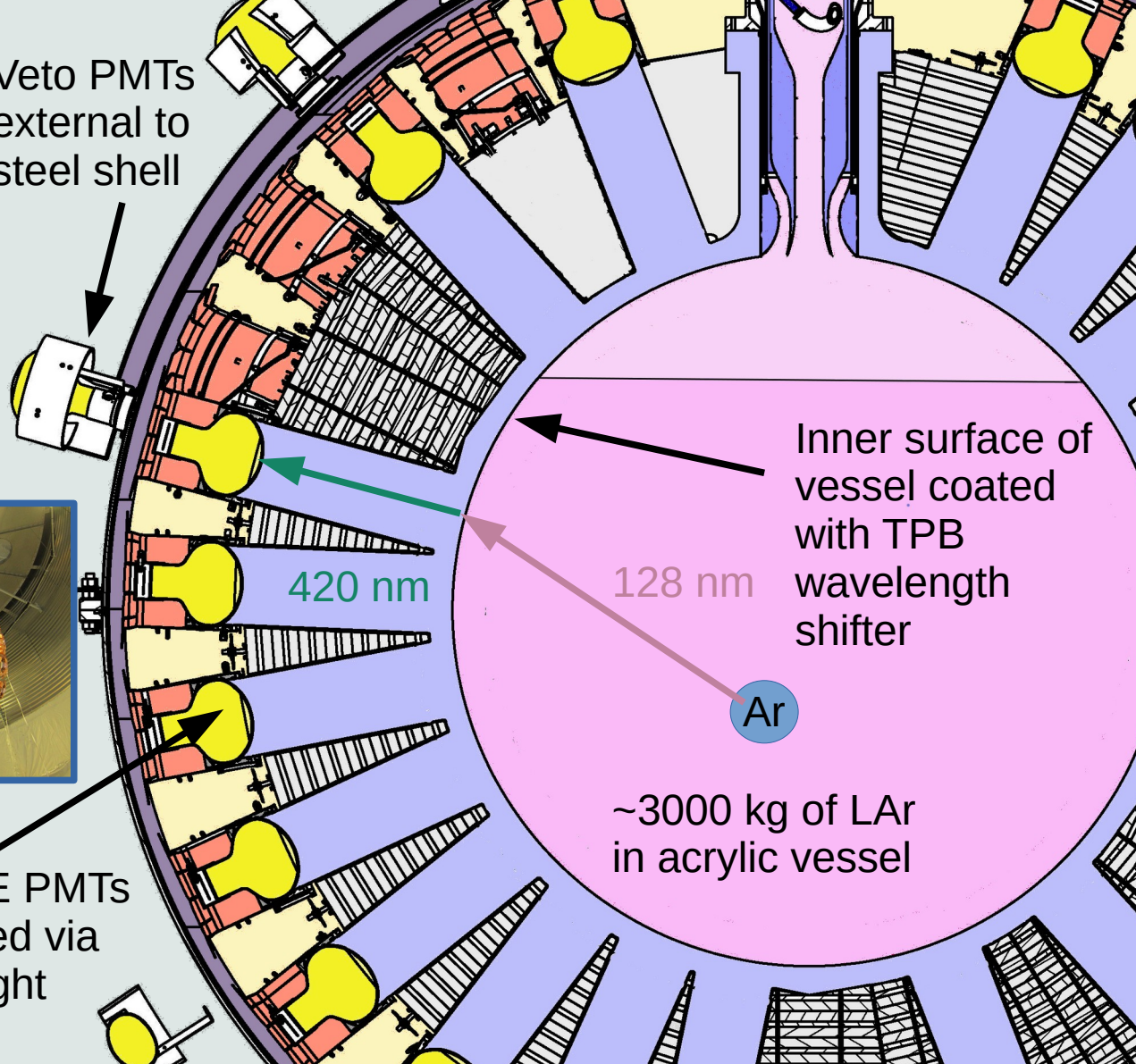
Inner surface of vessel coated with TPB wavelength shifter

128 nm

Ar

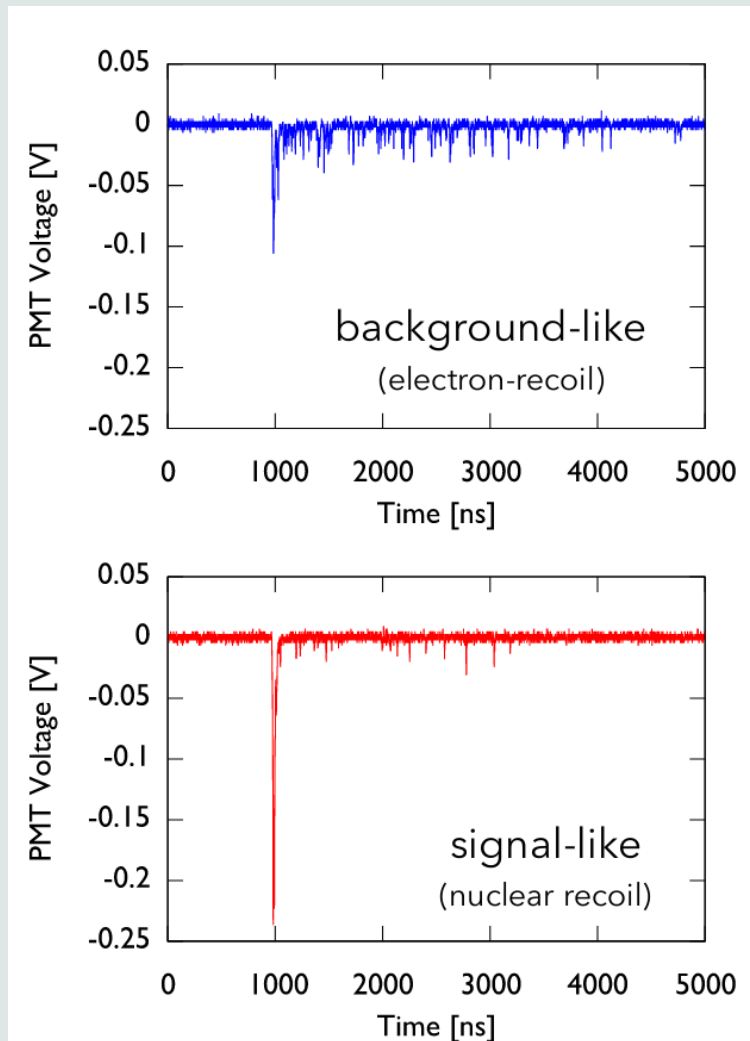
~3000 kg of LAr in acrylic vessel

255 HQE PMTs connected via acrylic light guides



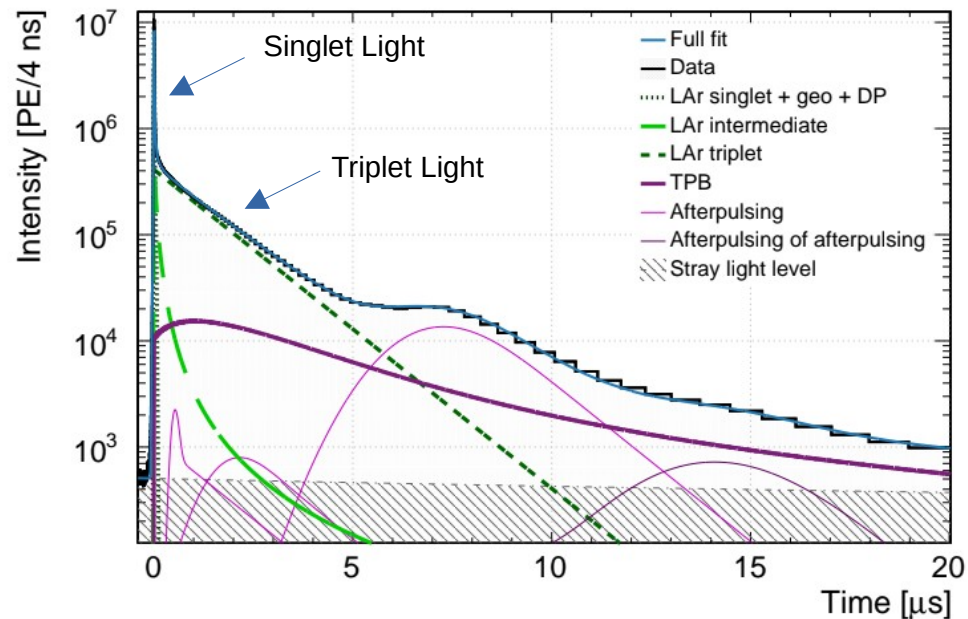
# Use of Liquid Argon

- Argon is chosen as:
  - It has a good scintillation light yield (40,000 photons/MeV)
  - Transparent to its scintillation light (128 nm)
- Scintillation time profile allows removal of backgrounds
  - Nuclear Recoils (NR)  
i.e. (WIMP,  $\alpha$ , n)  $\rightarrow$  Singlet State (6 ns)
  - Electron Recoils (ER)  
i.e. ( $\beta$ ,  $\mu$ ,  $\gamma$ )  $\rightarrow$  Triplet State (1.4  $\mu$ s)
- **Signal events have much more light earlier in the pulse**

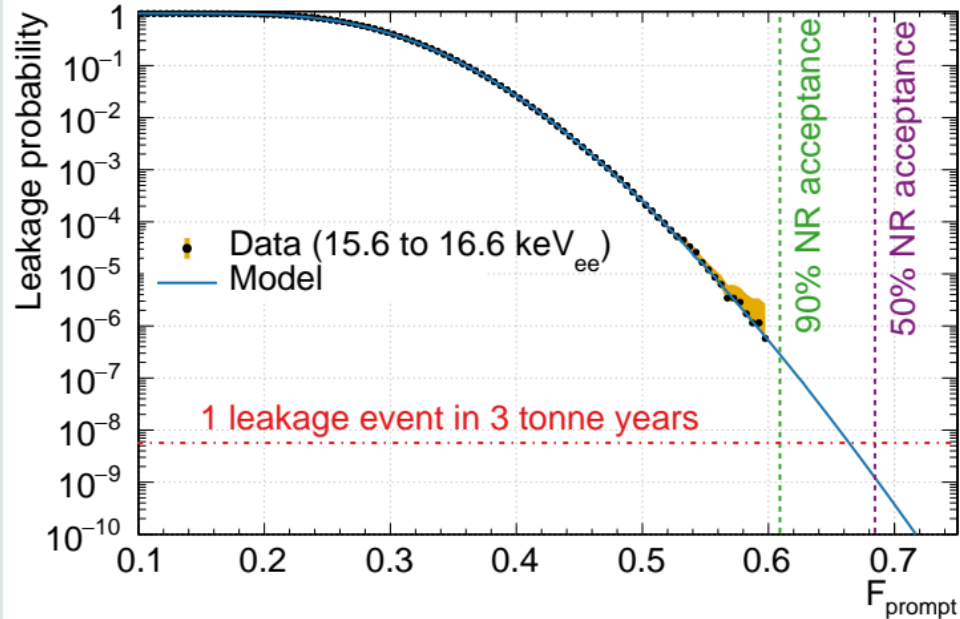


# Pulse shape discrimination

<https://arxiv.org/abs/2001.09855>



<https://arxiv.org/abs/1902.04048>



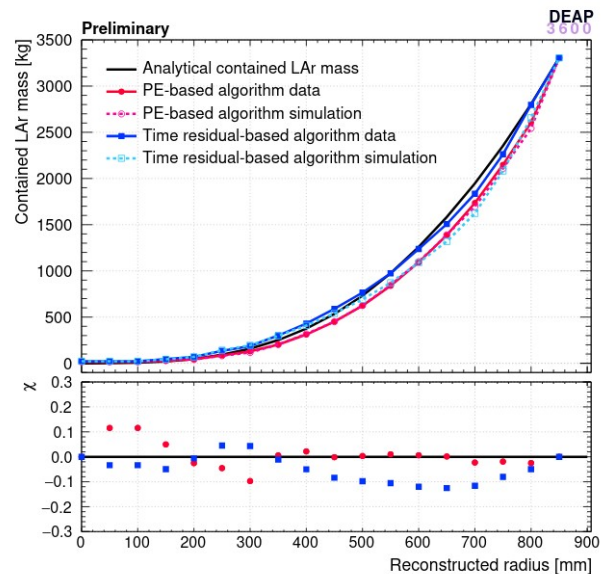
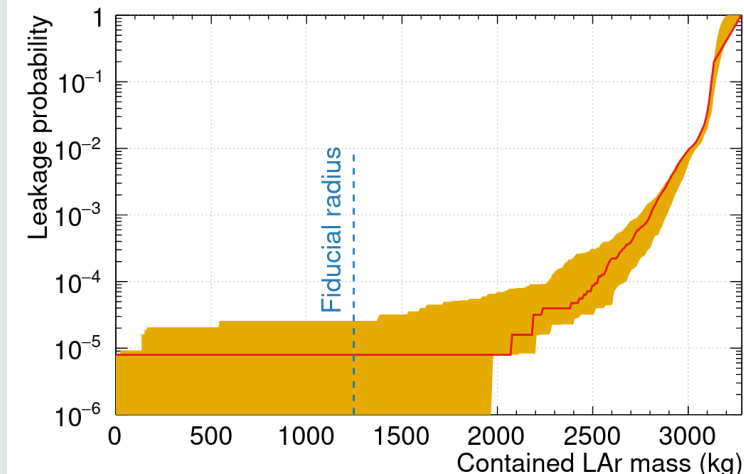
NR (Signal) = More Singlet Light  
ER (Background) = More Triplet Light

$$F_{\text{prompt}} = \frac{\sum_{-28 \text{ ns}}^{60 \text{ ns}} \text{PE}(t)}{\sum_{-28 \text{ ns}}^{10 \text{ } \mu\text{s}} \text{PE}(t)}$$

NR events have a higher  $F_{\text{prompt}}$  value

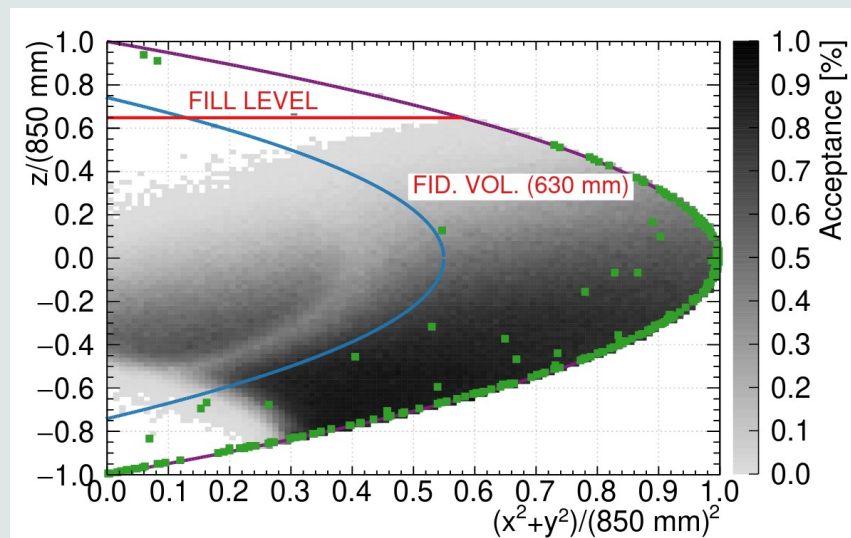
# Surface Backgrounds

- Other backgrounds exist after energy and prompt cuts
  - i.e. alphas on the surface of the AV
- Surface backgrounds constrained by fiducial cut

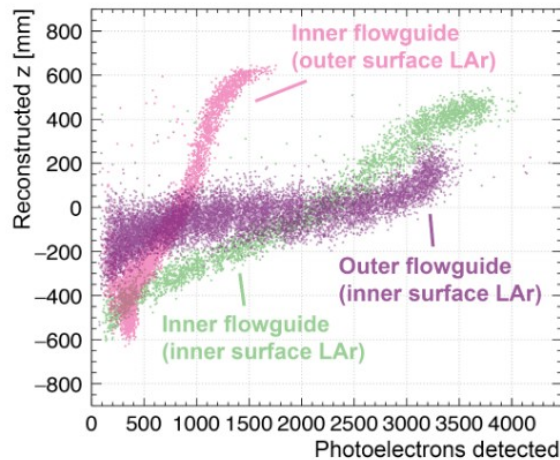
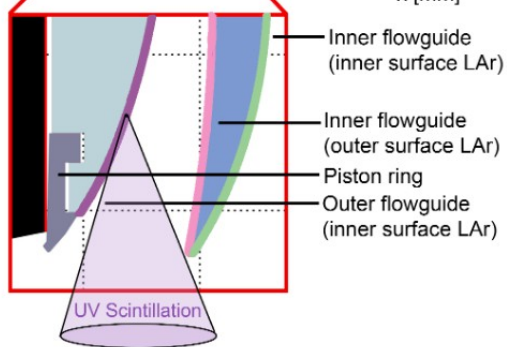
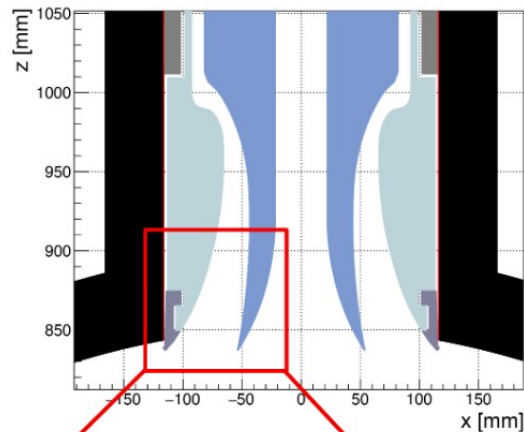


Resolution is 30-45 mm at 630 mm for lower energy events

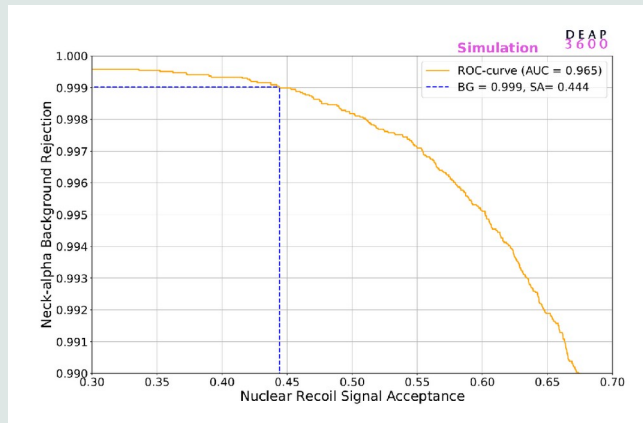
Event Reconstruction in DEAP-3600 at SNOLAB  
- Sumanta Pal



# Neck and Dust Backgrounds

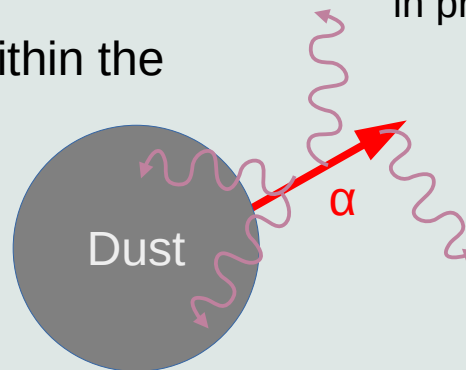


Shadowed alpha decays on the surface can misreconstruct within the fiducial volume



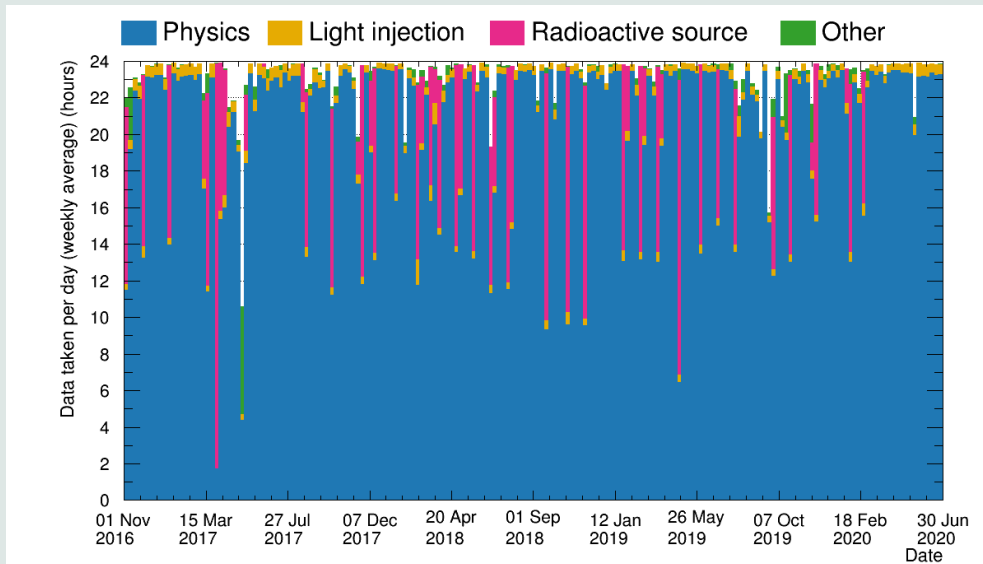
Machine Learning techniques applied to discriminate neck/dust events and signal events – work in progress

Alpha decays on the surface of the acrylic can deposit energy in thin argon layer on the surface – event will have high fprompt.

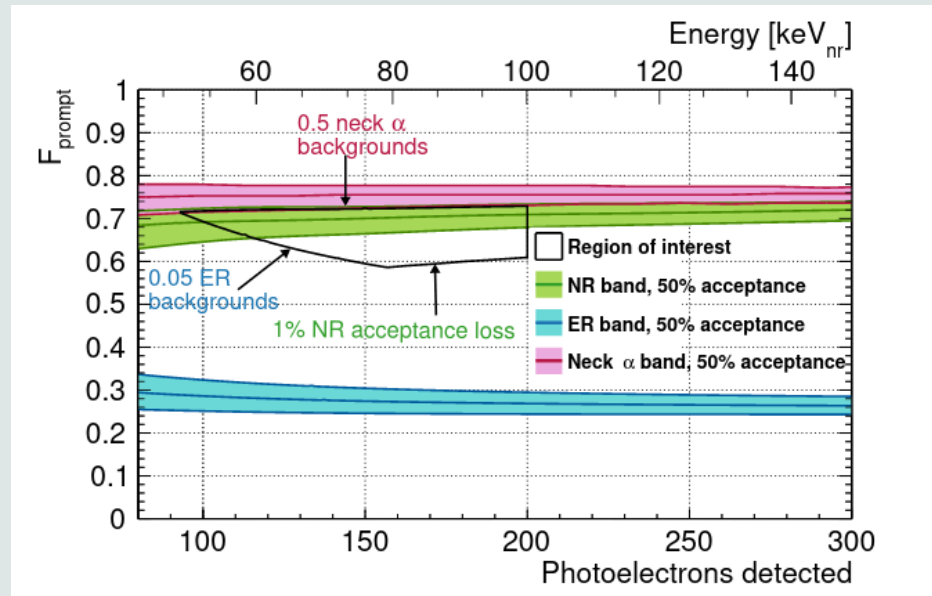


Alpha particles from decays in dust can be moderated and scintillation light shadowed

# Searching For WIMPs



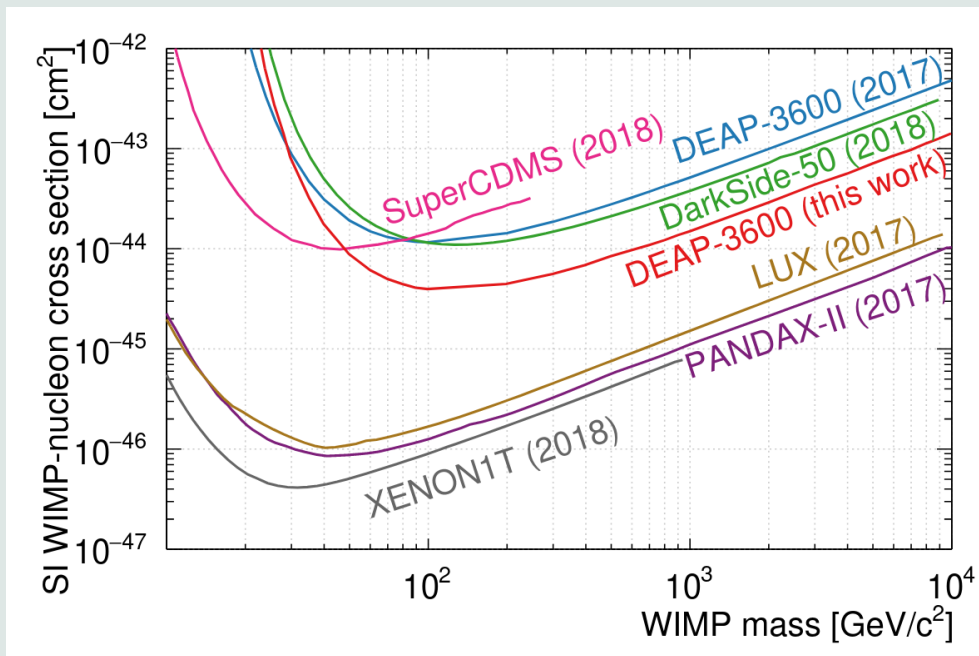
- Detector has been running in current configuration since November 2016
- Detector was drained 28<sup>th</sup> March 2020
- 80% of the data is blind since 1<sup>st</sup> January 2018



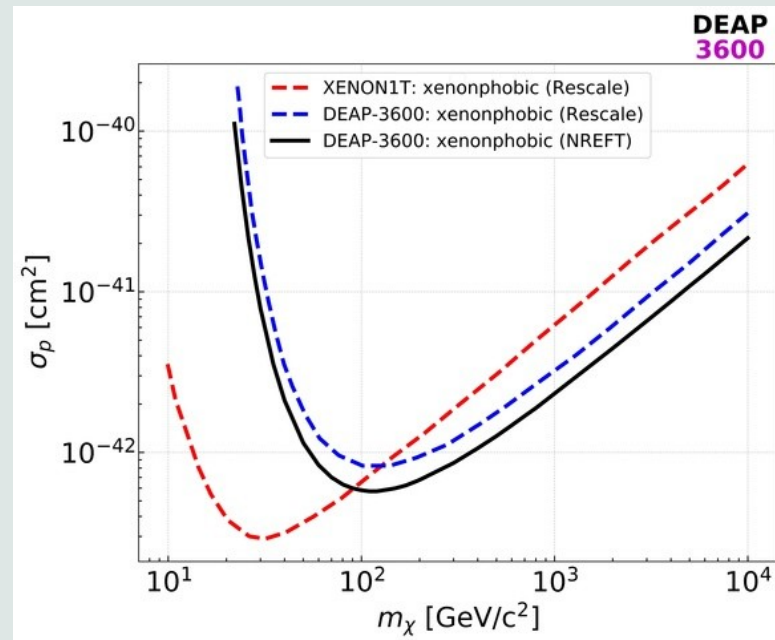
- WIMP search region defined by ROI
- ROI is defined such that expected number of events in ROI is  $< 1$



# Sensitivity



Current sensitivity of DEAP-3600 to WIMPs (90% CL) Assuming standard DM halo model (Phys. Rev. D 82, 023530) – No MVA techniques applied



Can explore isopin-violating couplings –  
World leading sensitivity for certain configurations

<https://arxiv.org/abs/2005.14667>

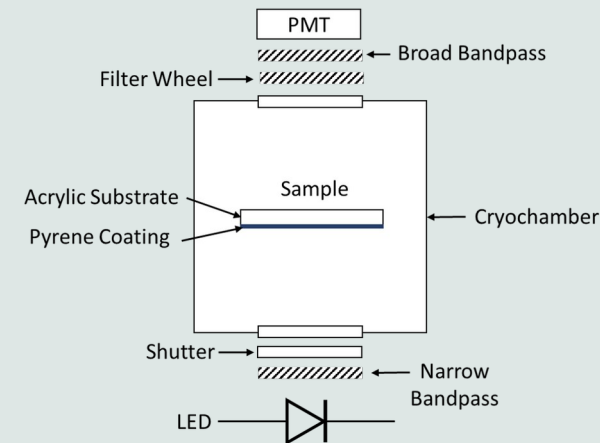
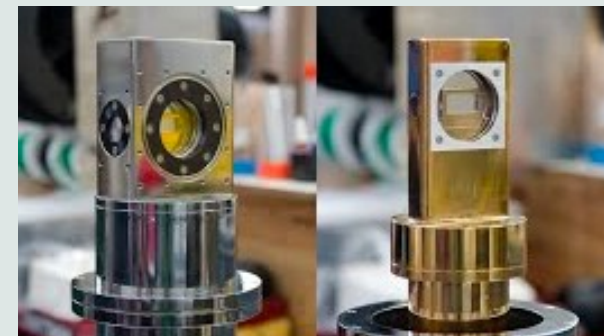
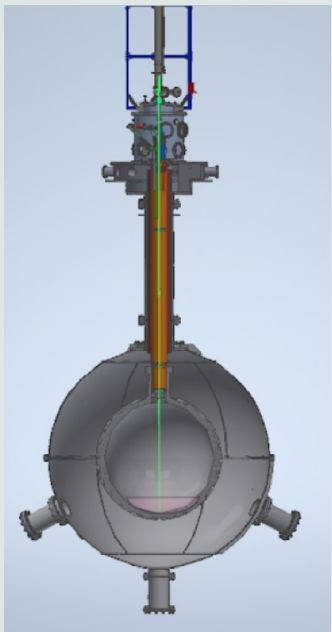
<https://arxiv.org/abs/1902.10256>

# Detector Upgrades

- Repair to the neck seal allows acrylic vessel to be completely filled

-Addition of pyrene to the surface of the flow guides reduces the number of backgrounds due to neck events

-Installation of alternate cooling system allows the filtering of dust particles



Ex-situ measurements characterising pyrene coatings performed



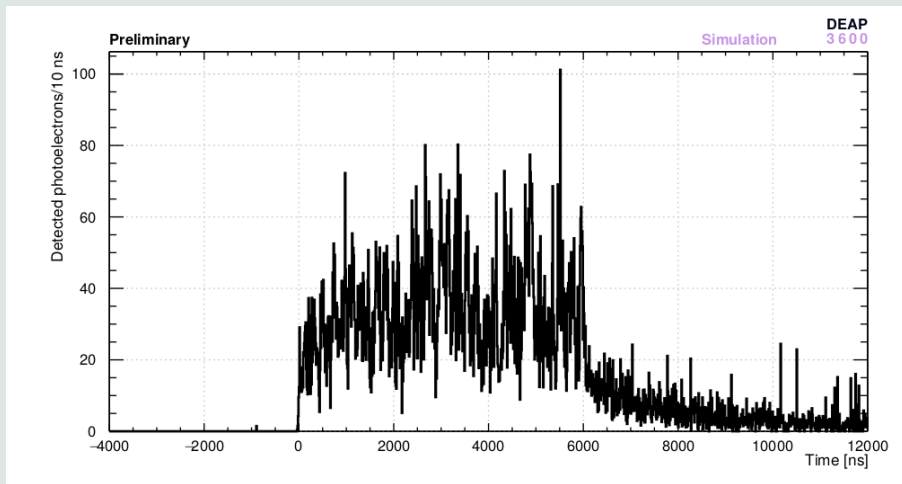
Background characterization and detector model after hardware upgrades of the DEAP-3600 detector – Courtney Mielnichuk

Alpha background rejection in DEAP-3600 using slow wavelength shifters – Shivam Garg

Characterization of wavelength shifters for background rejection in liquid argon dark matter experiments - Hicham Benmansour

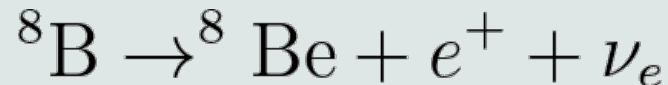
# Other Physics Measurements

## Search for Multiple Interacting Massive Particles

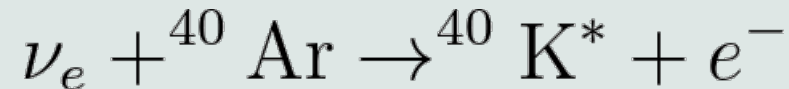


Simulated signal from a MIMP passing through the detector. Size of DEAP gives good sensitivity

## Solar neutrino absorption



Look for highest energy  ${}^8\text{B}$  solar  $\nu_e$  via:

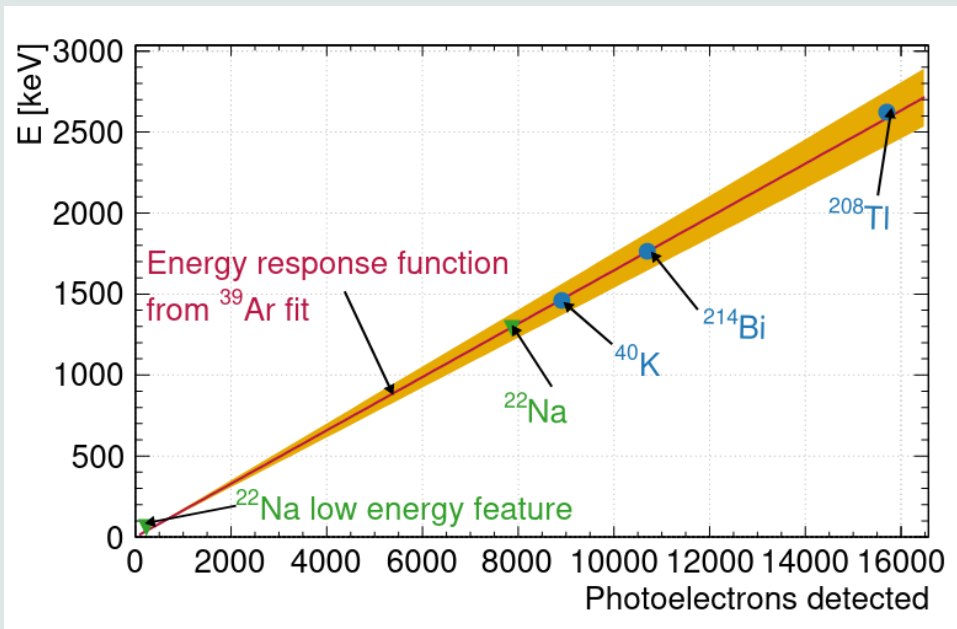


$$E_{\nu_e} > 3.9 \text{ MeV}$$

Excited state of  ${}^{40}\text{K}$  decays via  $\gamma$  emission with mean lifetime of 480 ns

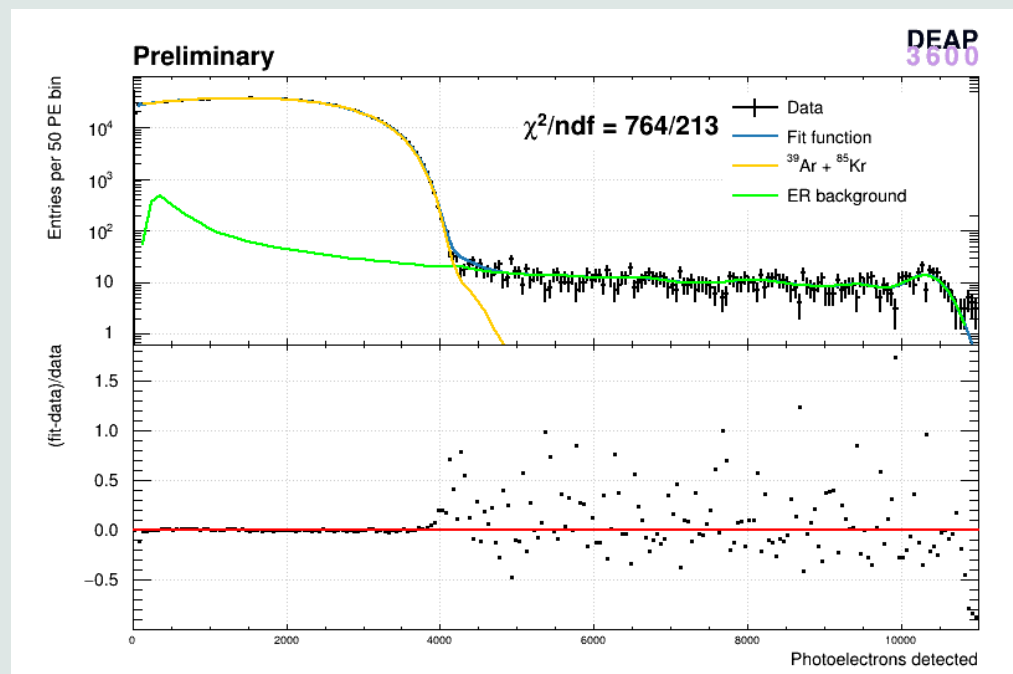
Expect up to  $17 \pm 5$  events in three years of live data.

# $^{39}\text{Ar}$ Measurements



High rate of  $^{39}\text{Ar}$  allows calibration of energy response of detector and monitoring of detector stability.

The stability of the DEAP-3600 dark matter detector and projected sensitivities for time-varying signals – Gurpreet Kaur



Including  $^{85}\text{Kr}$  in  $^{39}\text{Ar}$  spectrum fit of can lead to improved energy response of the detector

POS-J101 -- Constraining contributions from Kr-85 in DEAP-3600 - Sean Daugherty

# Conclusions

- Original configuration of DEAP-3600 ran until March 2020
  - WIMP search data is currently blinded – analysis underway
  - MVA techniques being applied to reduce some backgrounds
- The detector is currently being upgraded which will reduce some of the dominant backgrounds significantly
- The detector can also be used to perform other physics analyses
  - MIMPs
  - Solar Neutrinos
  - $^{39}\text{Ar}$  measurements