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# Profile Likelihood Ratio WIMP search in DEAP-3600

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ASTROCENT

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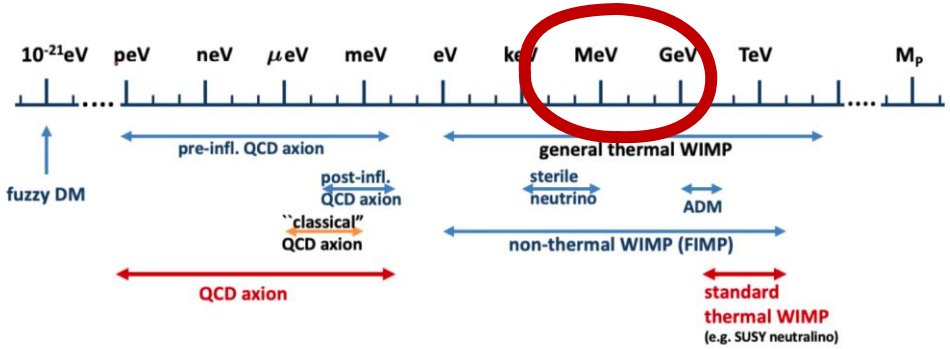
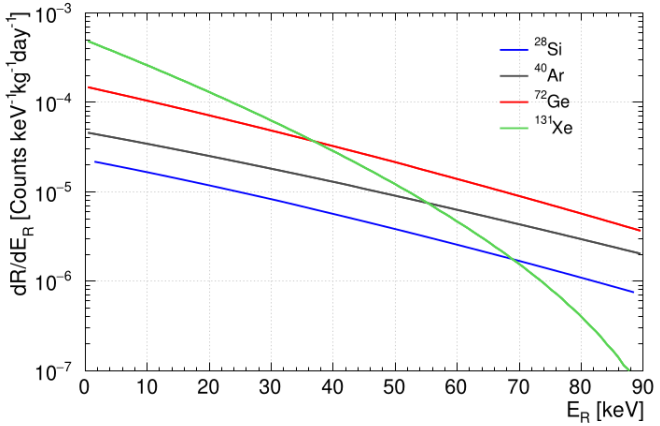
# PLR WIMP DM search - overview

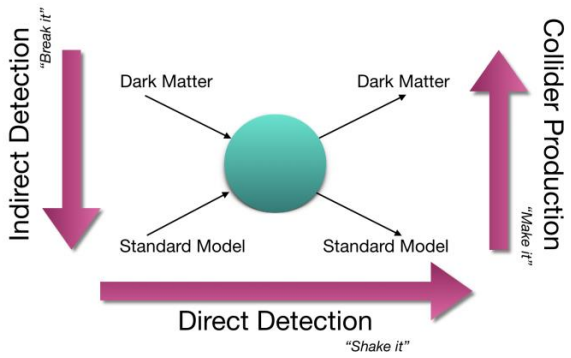
We search for WIMPs of mass in 10-$10^3$ GeV range.




For 100 GeV DM and cross section of $10^{-44}$ cm$^2$ we can calculate differential nuclear recoil rate (i.e. the expected energy distribution of WIMPs as a function of their recoil energy ) for various target materials. For DEAP-3600 $^{40}$Ar is used.

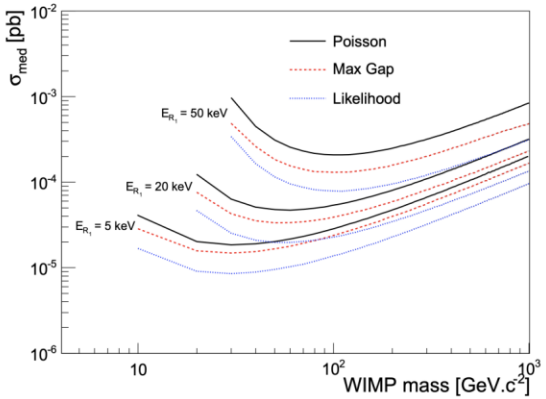



This is Direct Detection search – we assume SM particle to be recoiled by incoming DM candidate.



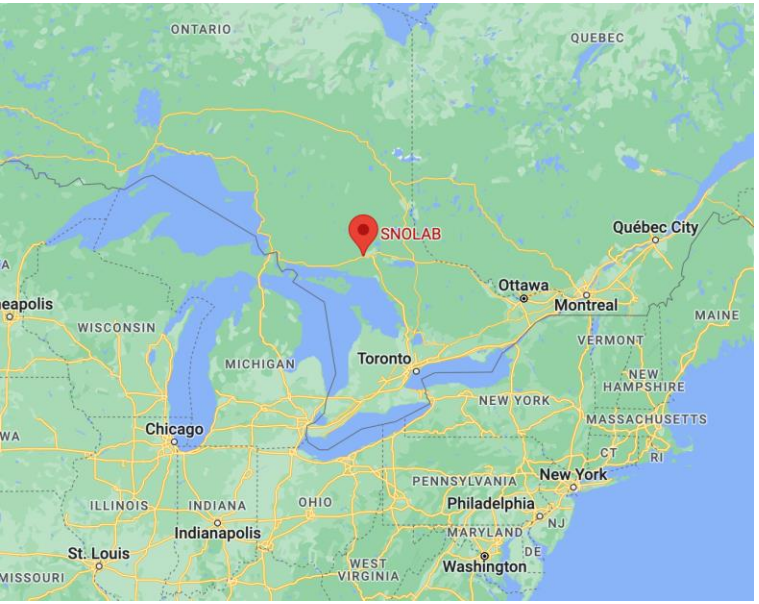

To boost sensitivity Profile Likelihood Ratio (PLR) approach is used. In PLR signal p-value can by calculated from PDF of the test statistics defined by ratio of likelihoods of the alternate hypothesis (there is DM) to the likelihood of the null hypothesis (there is no DM).

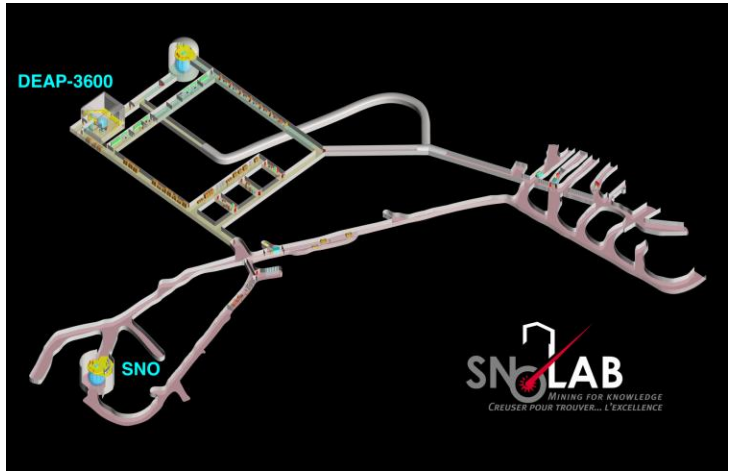
$$\lambda = \frac{\mathcal{L}(H_1|x)}{\mathcal{L}(H_0|x)}.$$

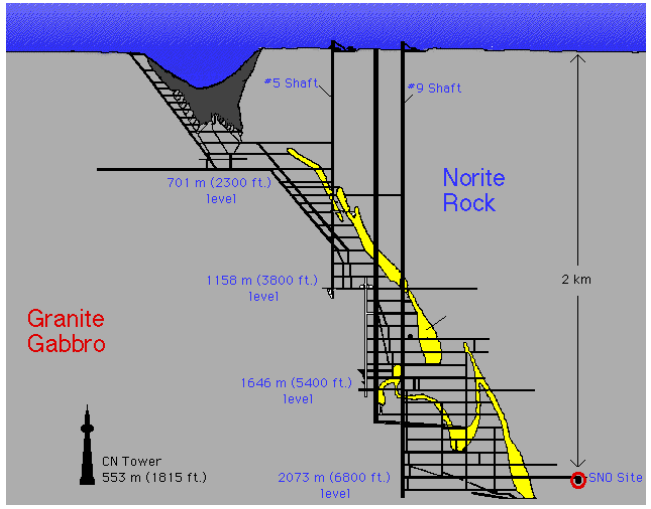


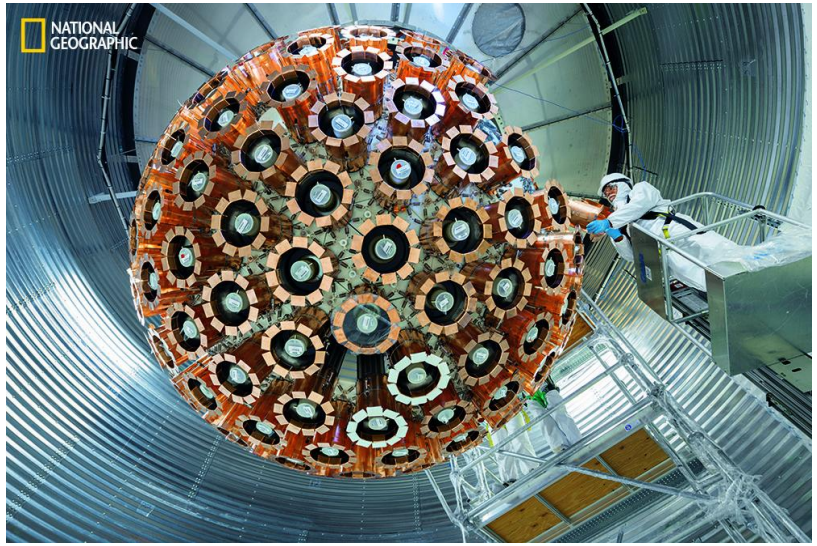

**Publication planned in couple of months – will set up new best upper limit on the WIMP-nucleon spin-independent cross section as a function of WIMP mass for LAr detectors.**

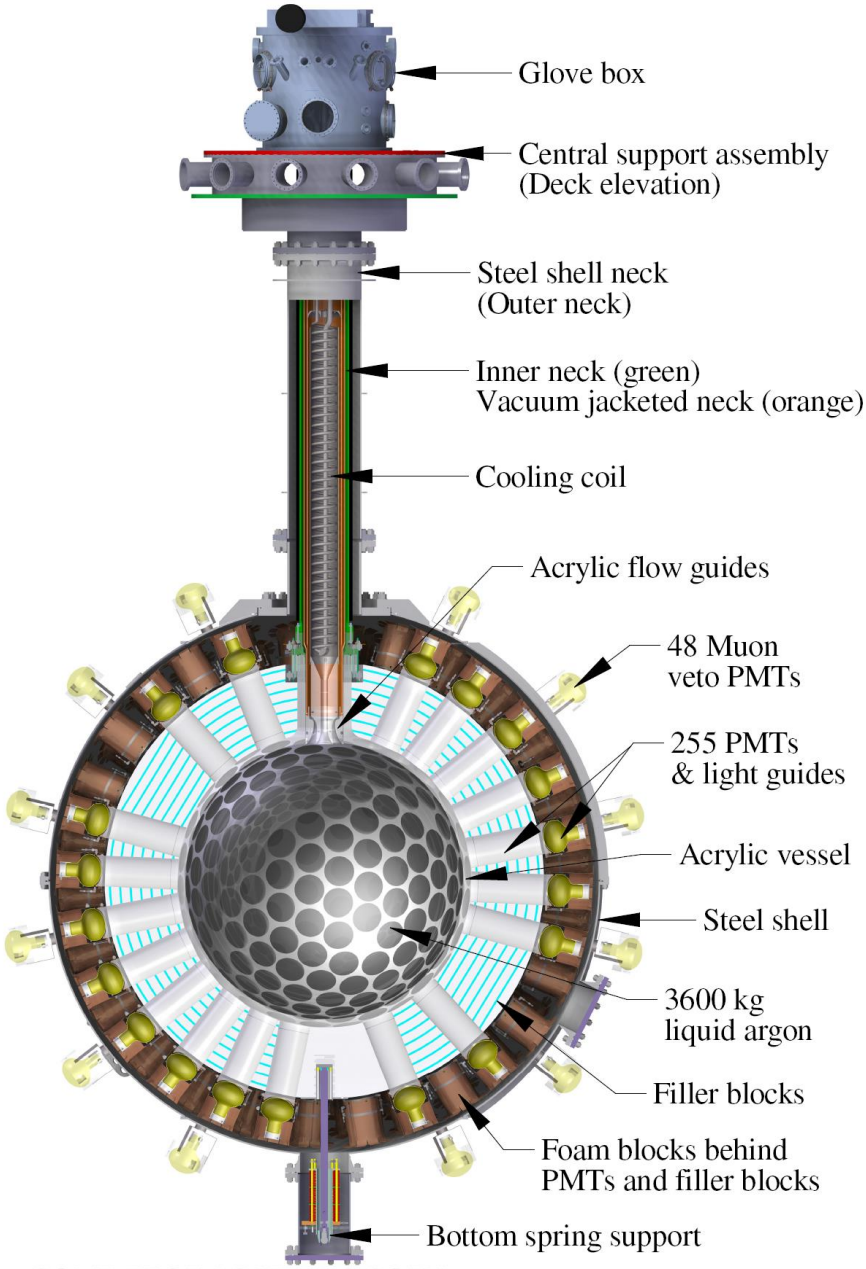
# DEAP-3600



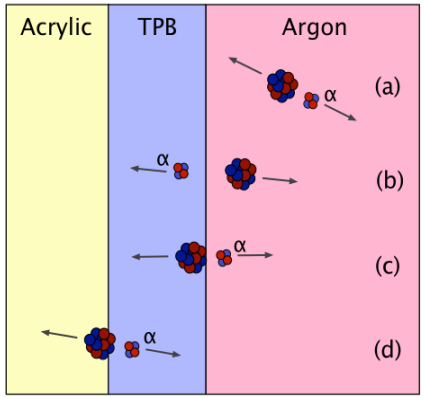



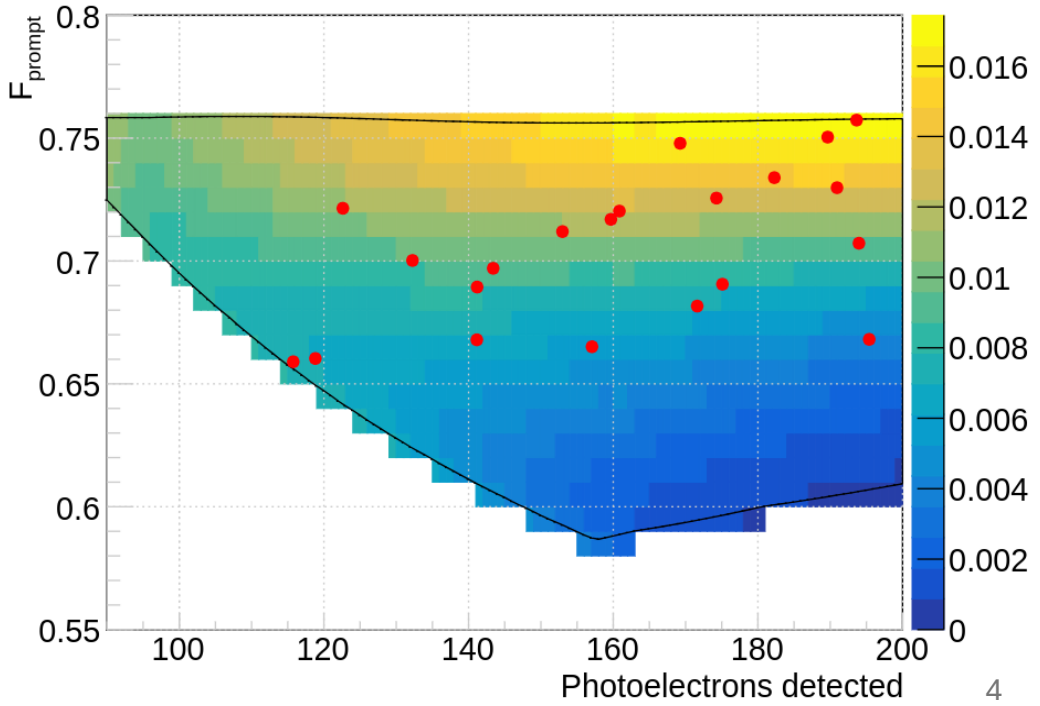
# Backgrounds and signal variables / Region of Interest (ROI)

- **$^{39}$Ar β-decays – long-lived isotope present in target volume, highest trigger rate at DEAP-3600, used for detector energy response calibration;**
- Surface α-decays – radioactive isotopes (mainly $^{222}$Rn, $^{238}$U, $^{232}$Th, $^{210}$Pb) from acrylic vessel and TPB coating;




- Neck α-decays – like above but coming from surfaces of the flow guides in the neck. Put separately as fiducialisation not efficient here.
- Dust α-decays – metallic/residual acrylic/rock dust circulating within the LAr target
- Radiogenic background – neutrons coming from the rock around the laboratory

The WIMP ROI is defined in the two-dimensional PE-Fprompt (i.e. Energy vs Pulse Share Discriminator / PSD) plane. Since the PLR analysis is not a zero-background approach, the ROI bounds can be relaxed compared to a cut-and-count analysis, to enhance sensitivity. Range of 93 - 200 PE is used.



# $^{39}$Ar model

Fprompt (PE) model for 39Ar background:

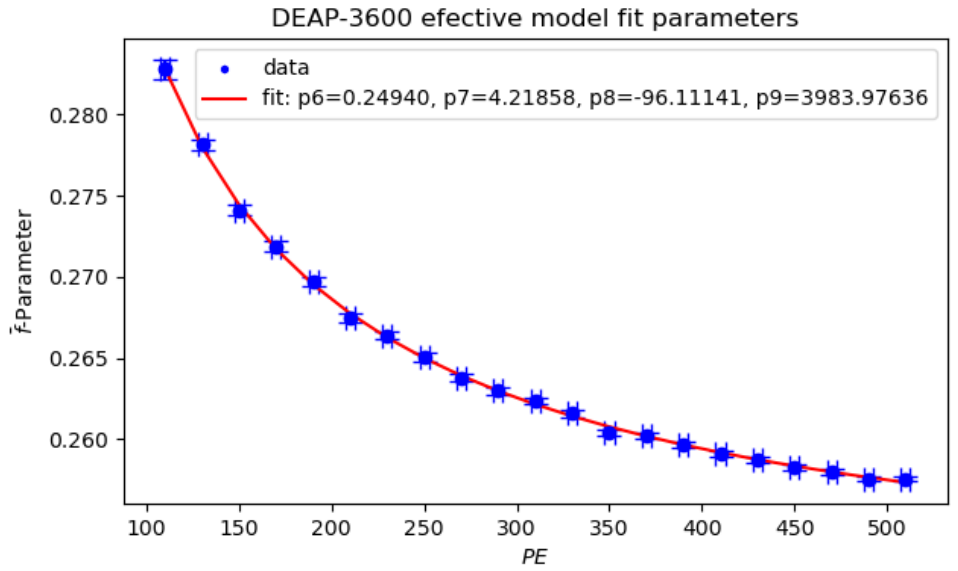
$$F^{ER} = \Gamma(f; \bar{f}, b) * \mathrm{Gaus}(f; \sigma).$$

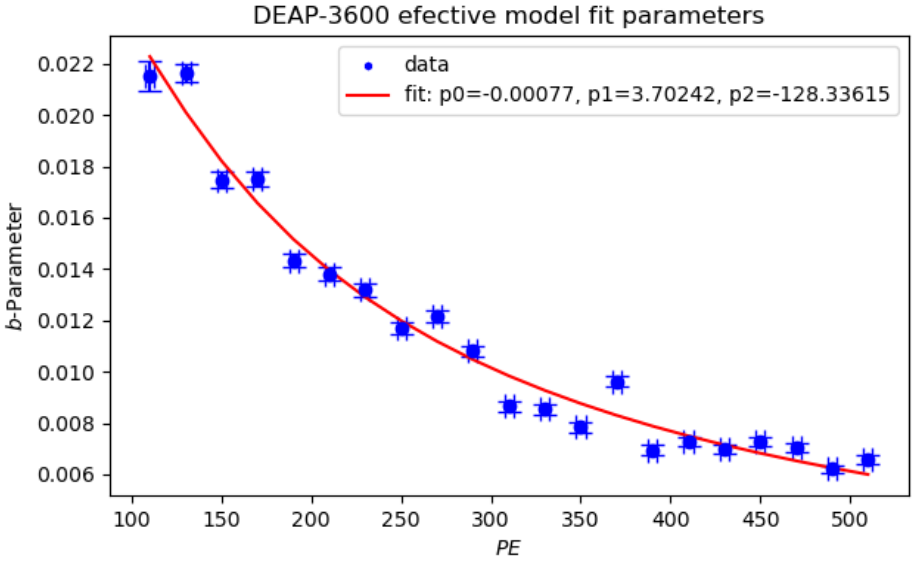
$$\bar{f} \to \bar{f}(PE) = m_0 + \frac{m_1}{PE} + \frac{m_2}{PE^2} + \frac{m_3}{PE^3},$$

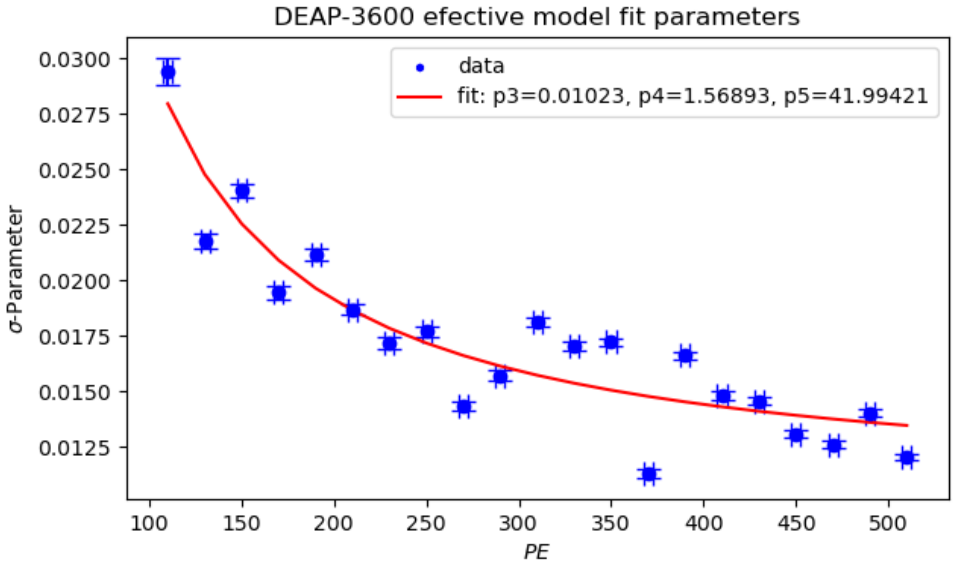
$$b \to b(PE) = b_0 + \frac{b_1}{PE} + \frac{b_2}{PE^2},$$

$$\sigma \to \sigma(PE) = s_0 + \frac{s_1}{PE} + \frac{s_2}{PE^2}.$$

Results:



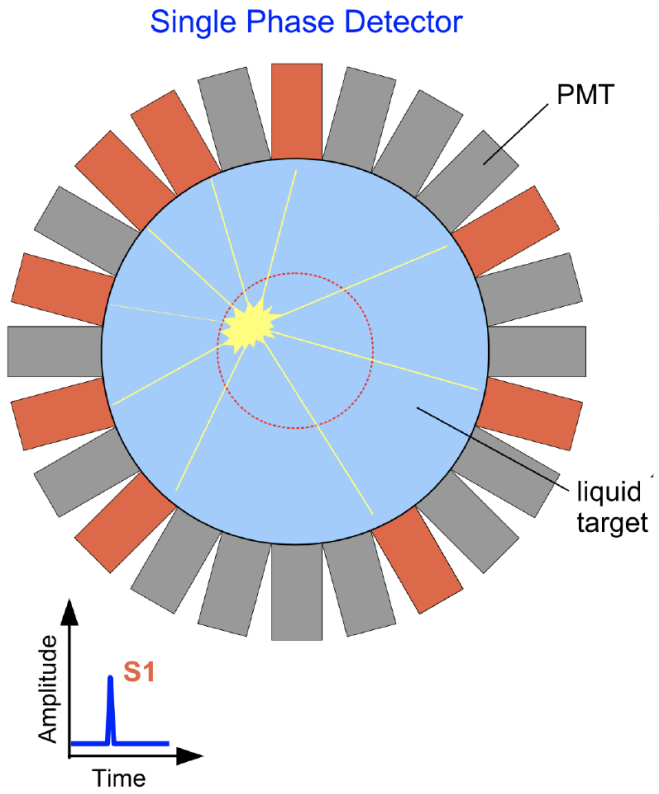
# Other activities

- NCN Miniatura Grant: *"Determination of the sensitivity of the ARGO, DarkSide-20k, and DEAP-3600 experiments to supermassive charged gravitinos"*;
- Serving as Database Manager for DEAP-3600 collaboration;
- Done several DAQ shifts during 2024;
- Involvement in setting up computing infrastructure for DarkSide-20k;
- Publications: *"Direct Measurement of the $^{39}Ar$ Half-life from 3.4 Years of Data with the DEAP-3600 Detector"* - in preparation

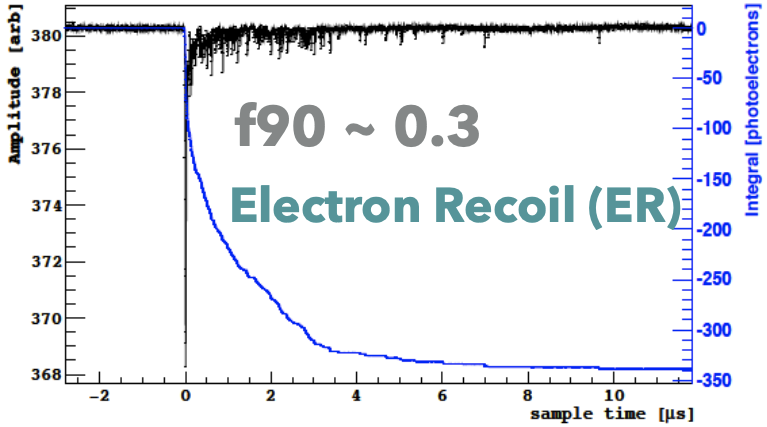
Thank you!

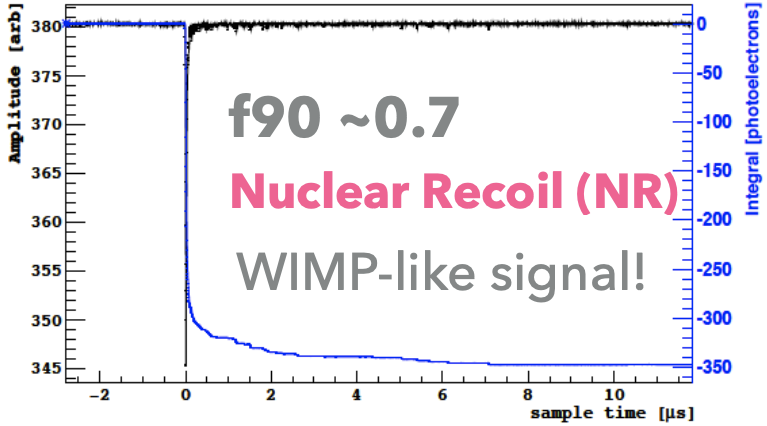
# Backup

# Pulse Shape Discrimination in LAr

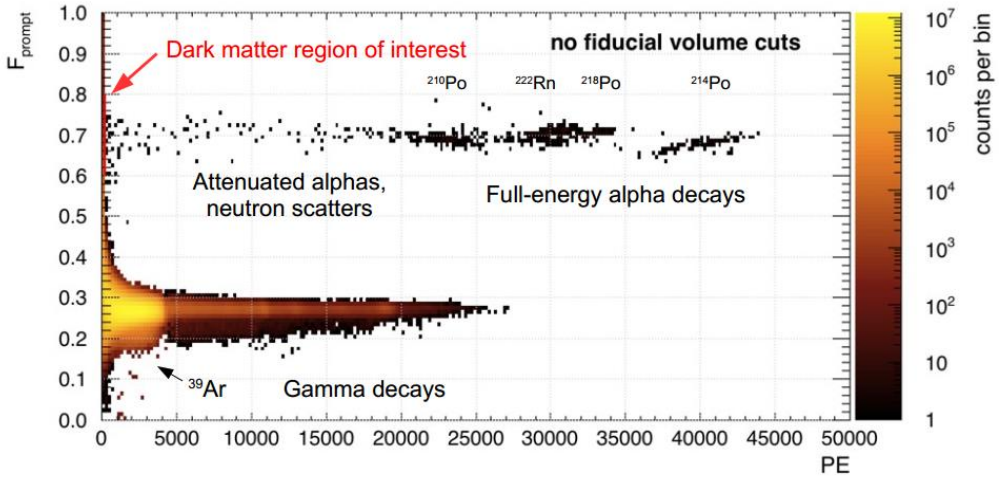



PSD: tool to distinguish light from a recoiling electron and nuclear recoil




PE/S1: total integral of the primary scintillation pulse (photoelectrons, PE)




**First DEAP-3600 dark matter search, with 4.4 live days**

Phys. Rev. Lett. 121, 071801 (2018) arXiv:1707.08042