Latest Results from DEAP-3600

Joseph McLaughlin
On Behalf of the DEAP Collaboration

ICHEP 2022
Bologna, Italy

ROYAL HOLLOWAY UNIVERSITY OF LONDON

joseph.mclaughlin.2018@live.rhul.ac.uk

Contents

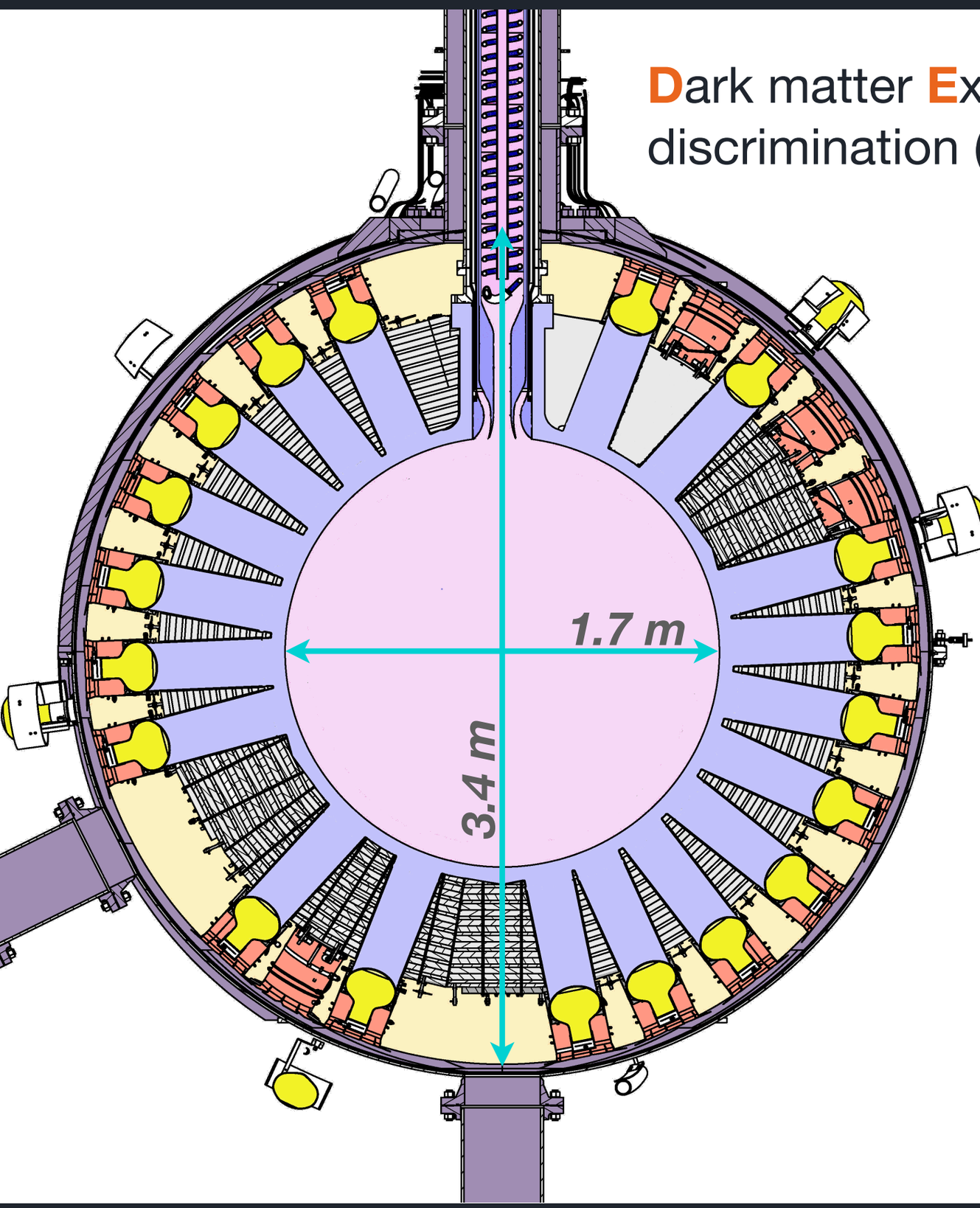
- Overview of the DEAP-3600 Experiment
- Precision Measurements
- WIMP Searches
- Beyond WIMPs
- Outlook

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON

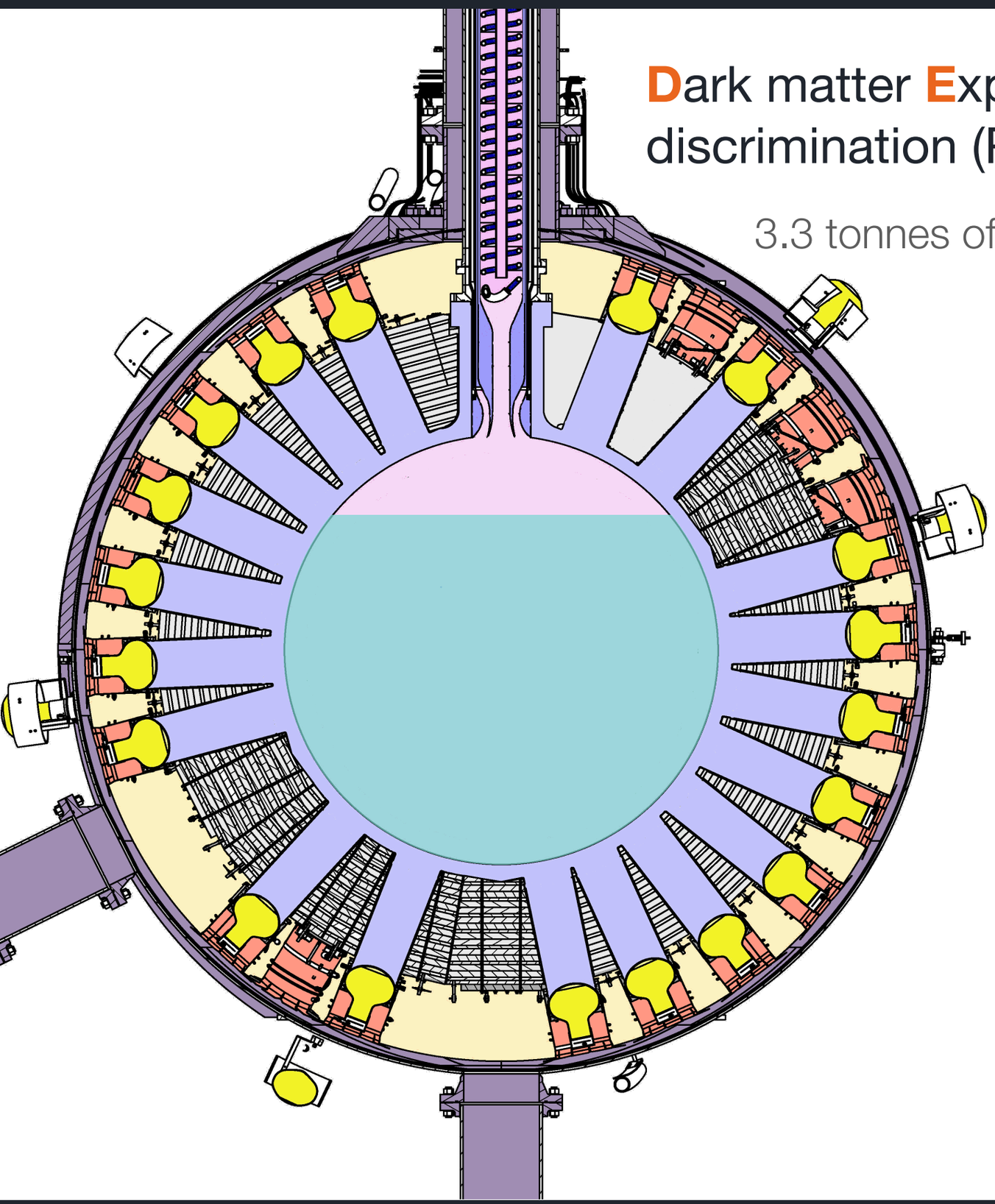
Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)



joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON



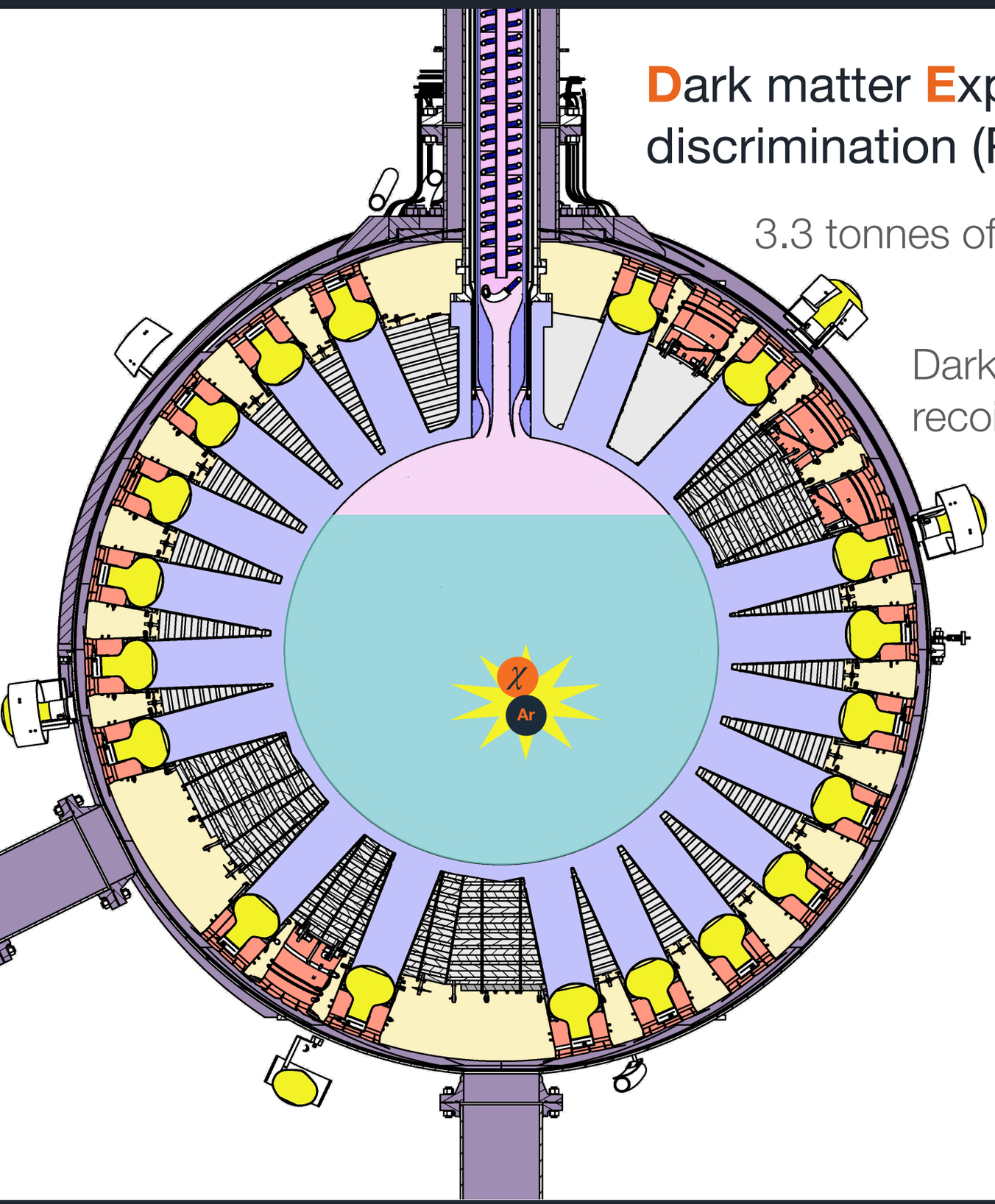
Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)

3.3 tonnes of Liquid Argon (LAr) as target

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON



Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)

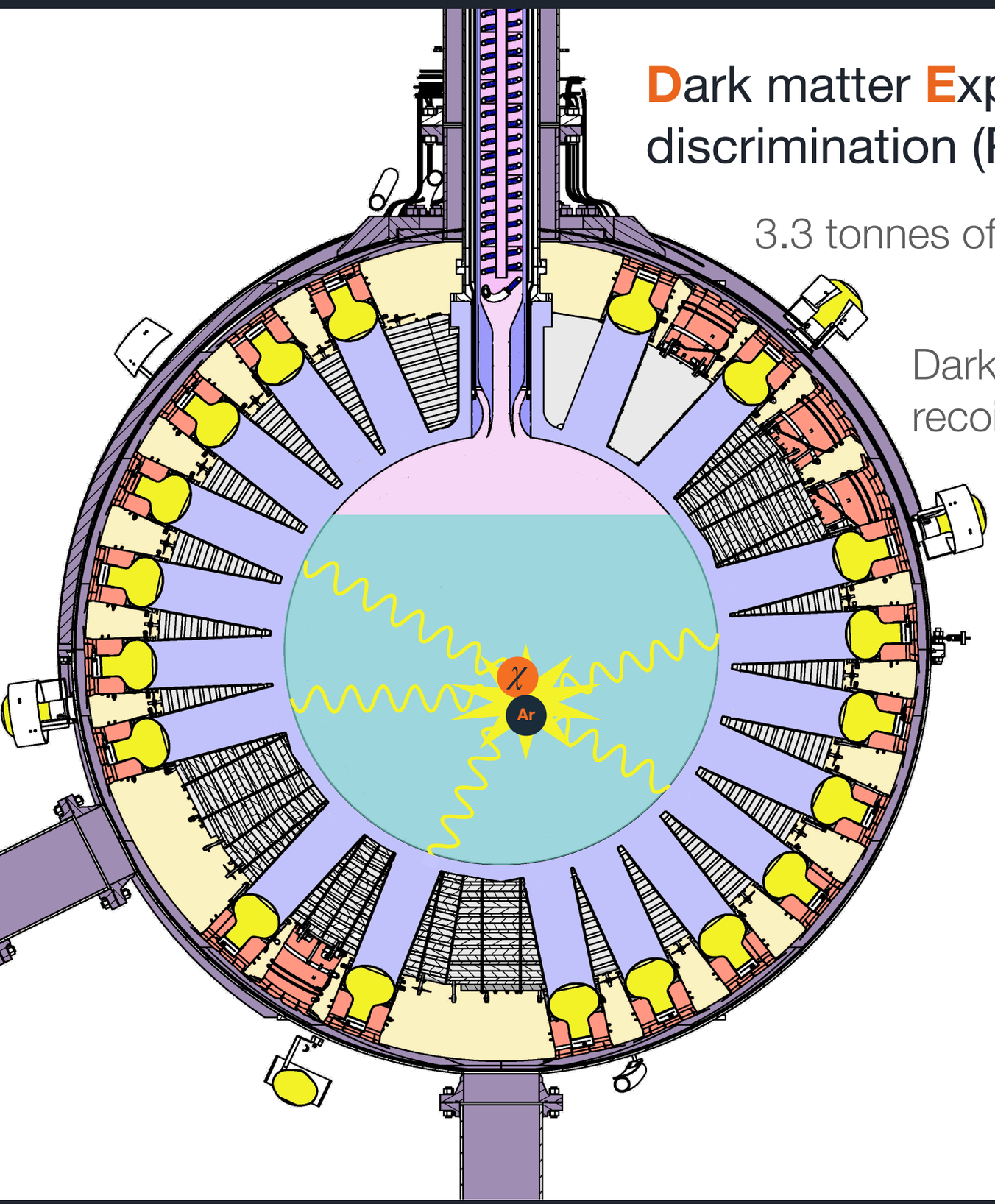
3.3 tonnes of Liquid Argon (LAr) as target

Dark matter elastically scatters off argon nucleus, recoiling argon excites/ionizes nearby argon atoms

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON



Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)

3.3 tonnes of Liquid Argon (LAr) as target

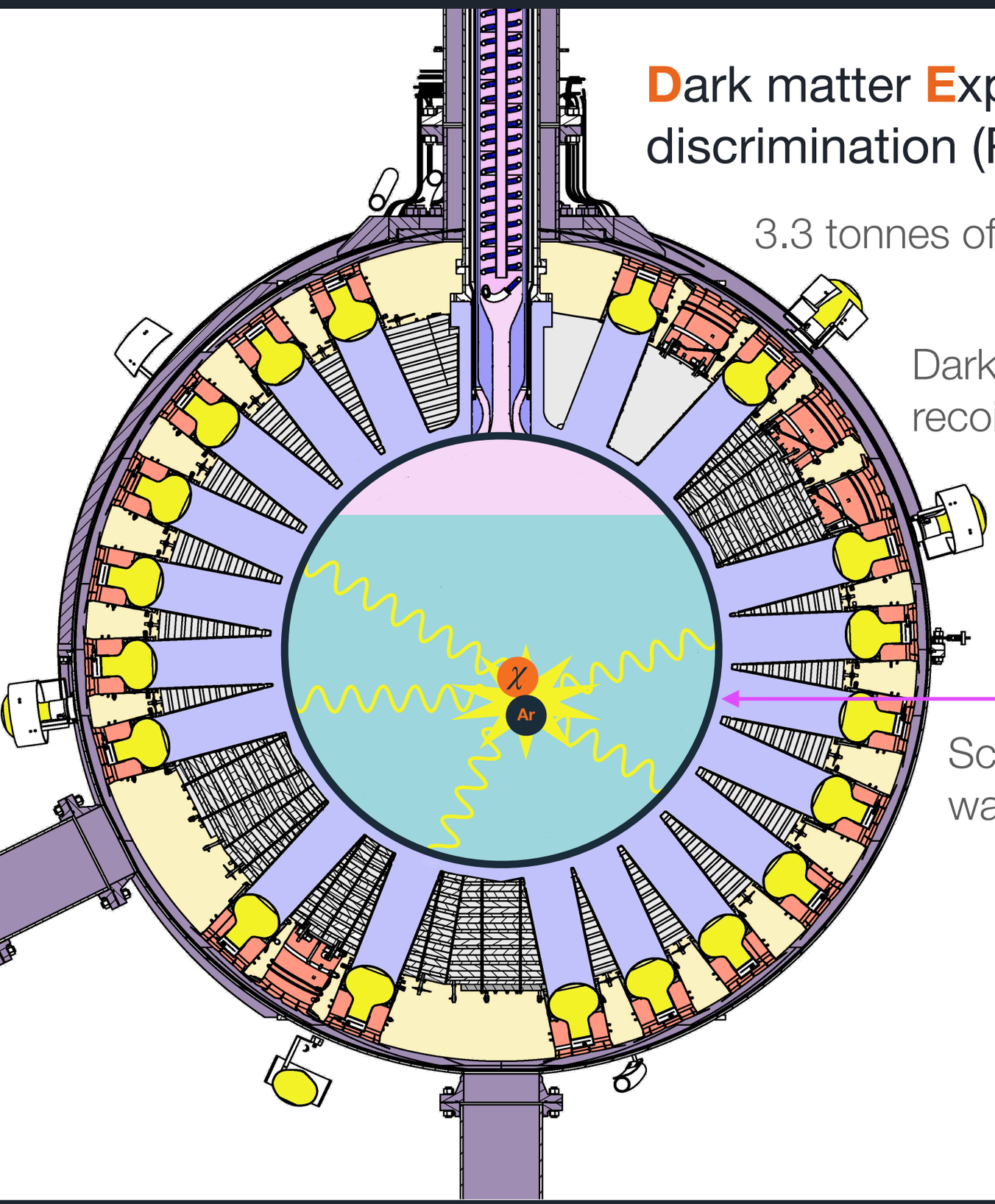
Dark matter elastically scatters off argon nucleus, recoiling argon excites/ionizes nearby argon atoms

Excited/ionized argon form excited dimer states, relax to ground state via scintillation of 128 nm photons

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON



Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)

3.3 tonnes of Liquid Argon (LAr) as target

Dark matter elastically scatters off argon nucleus, recoiling argon excites/ionizes nearby argon atoms

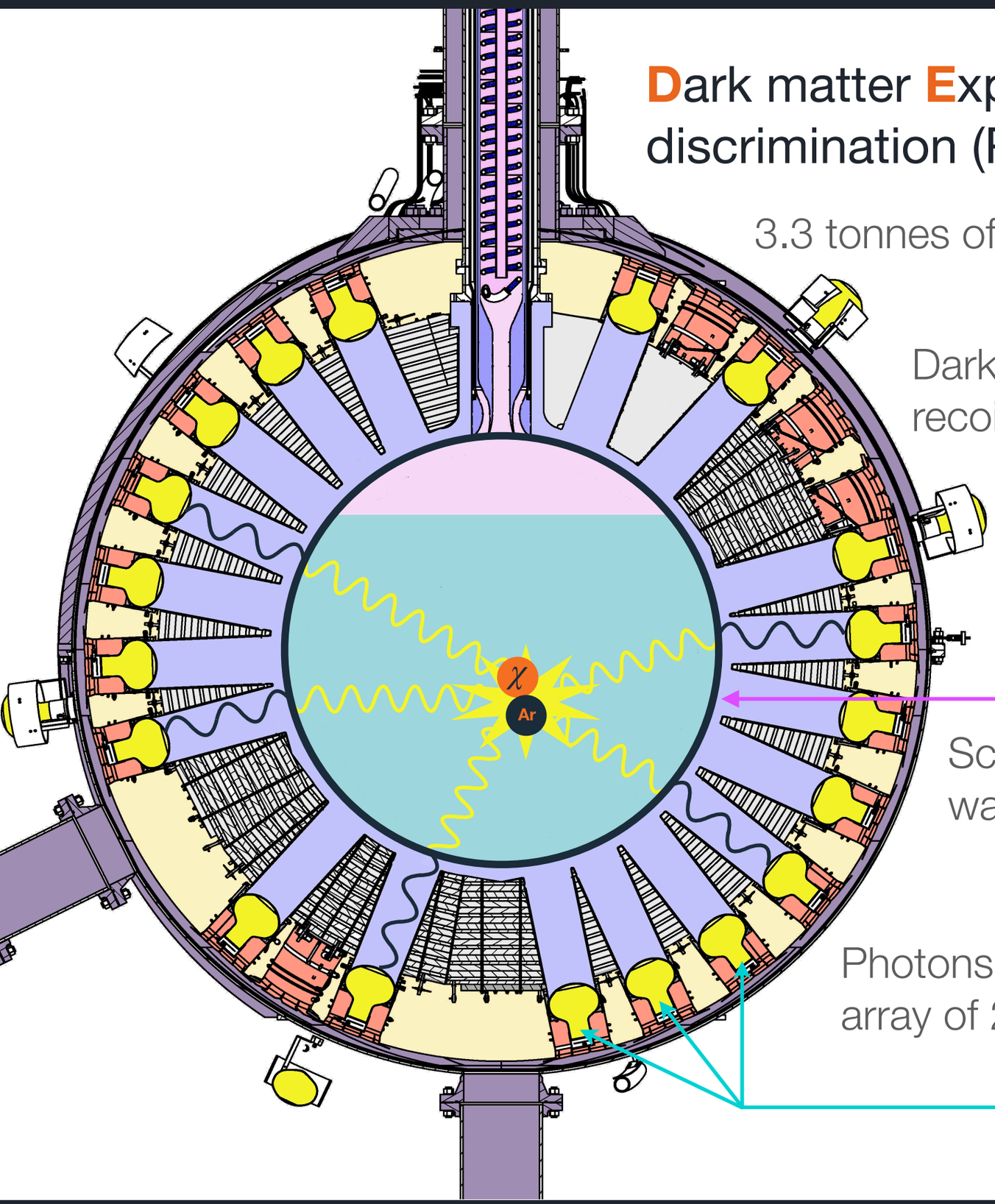
Excited/ionized argon form excited dimer states, relax to ground state via scintillation of 128 nm photons

Scintillation photons pass through TPB wavelength shifter, become 420 nm photons

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
The Detector

ROYAL HOLLOWAY UNIVERSITY OF LONDON



Dark matter **E**xperiment using **A**rgon **P**ulse shape discrimination (PSD)

3.3 tonnes of Liquid Argon (LAr) as target

Dark matter elastically scatters off argon nucleus, recoiling argon excites/ionizes nearby argon atoms

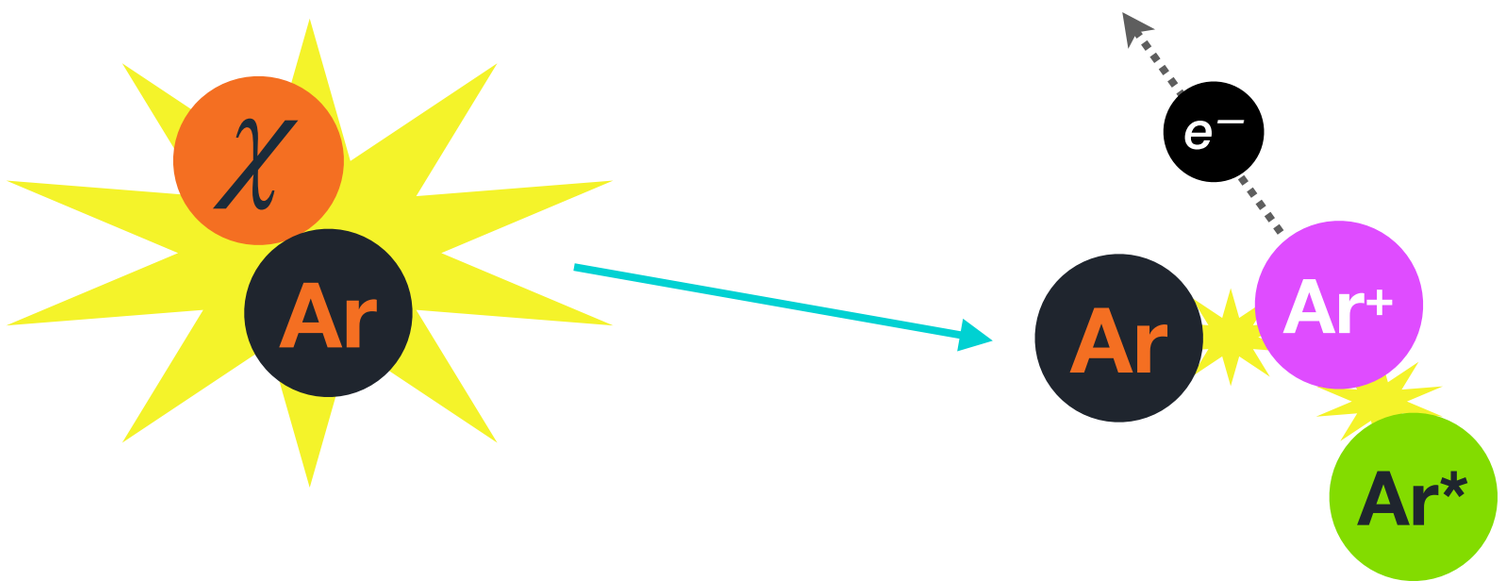
Excited/ionized argon form excited dimer states, relax to ground state via scintillation of 128 nm photons

Scintillation photons pass through TPB wavelength shifter, become 420 nm photons

Photons collected by light guides, detected by array of 255 photomultiplier tubes (PMTs)

joseph.mclaughlin.2018@live.rhul.ac.uk

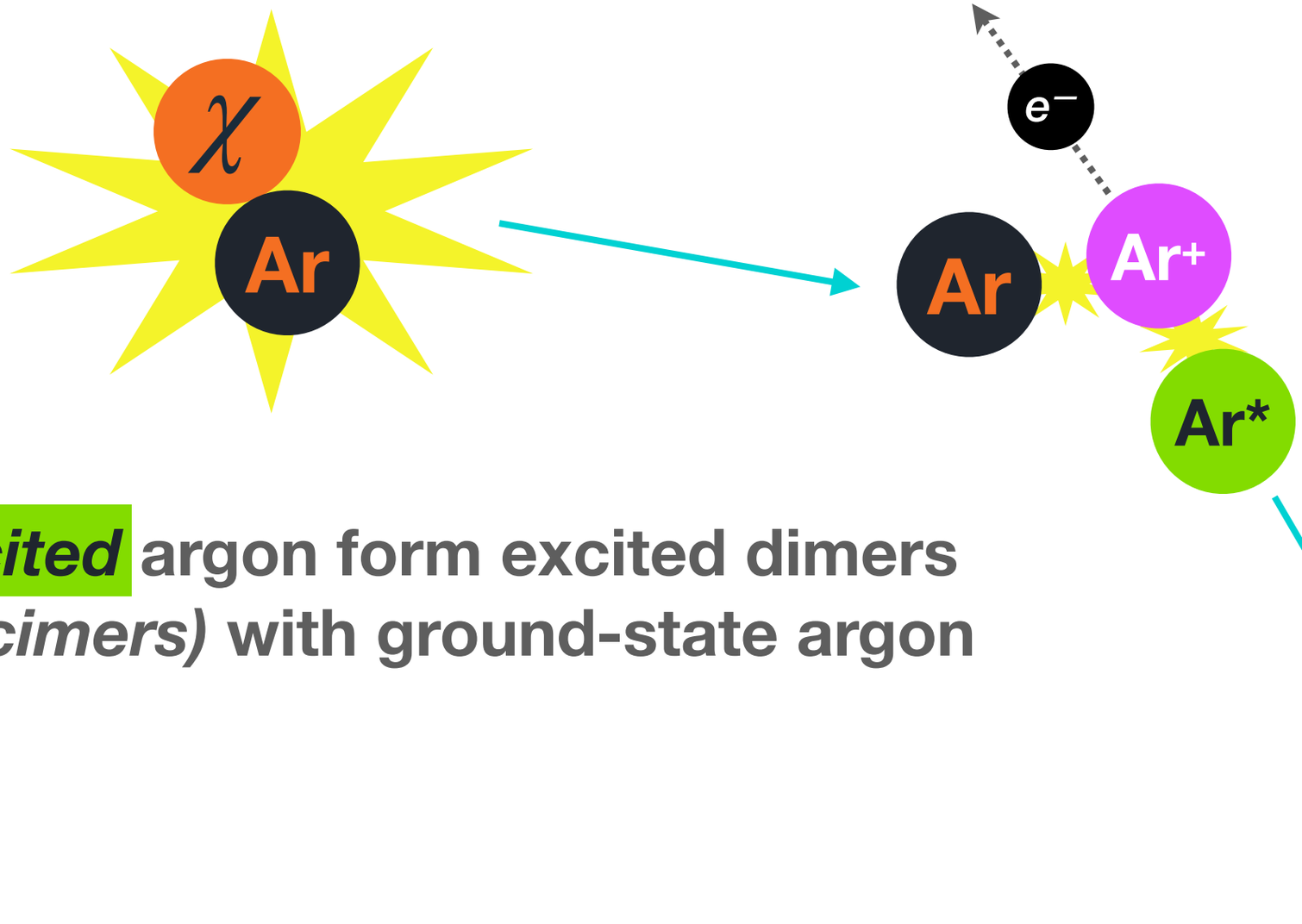
Overview of DEAP-3600:
Liquid Argon Scintillation



Other atoms in the track of the recoiling argon becomes *excited* or *ionized*

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Liquid Argon Scintillation

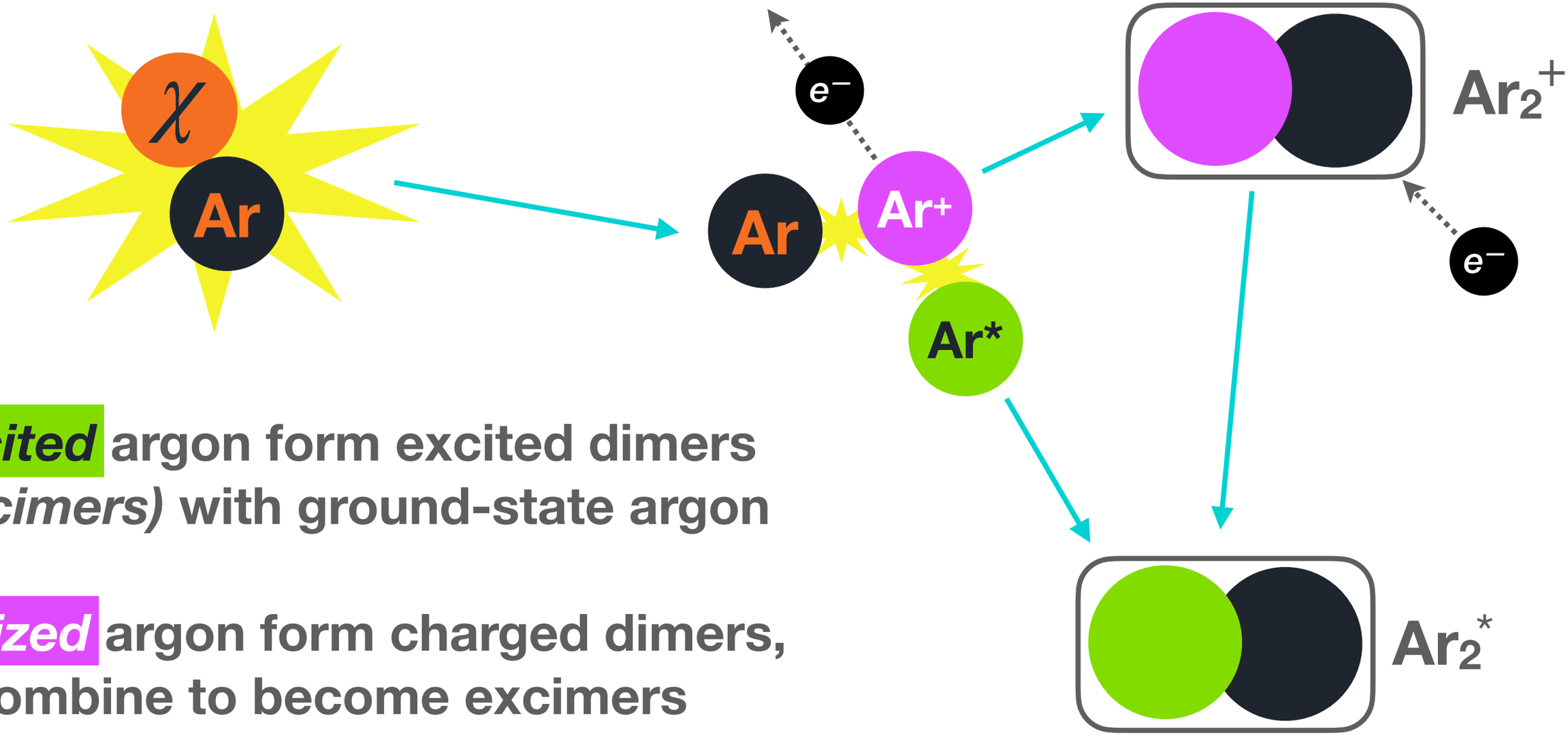


Excited **argon form excited dimers *(excimers)* with ground-state argon**

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Liquid Argon Scintillation

ROYAL HOLLOWAY UNIVERSITY OF LONDON



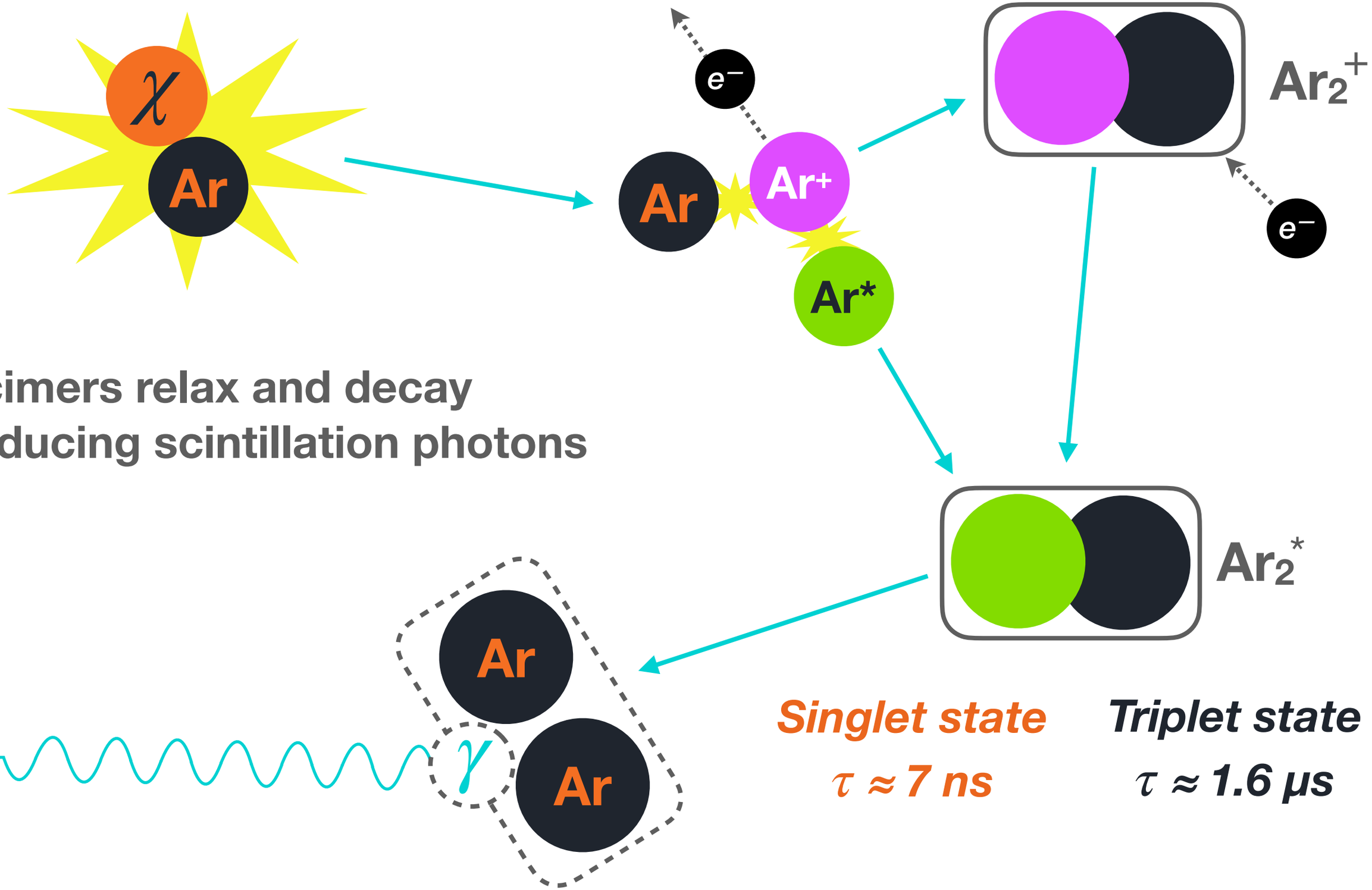
Excited **argon form excited dimers *(excimers)* with ground-state argon**

Ionized **argon form charged dimers, recombine to become excimers**

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Liquid Argon Scintillation

ROYAL HOLLOWAY UNIVERSITY OF LONDON



Excimers relax and decay producing scintillation photons

Singlet state $\tau \approx 7$ ***ns***

Triplet state $\tau \approx 1.6$ ***μs***

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Pulse Shape Discrimination

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Nuclear Recoils

Scattering directly with argon nuclei; excimers mostly populate the ***singlet state***, relax quickly. Induced by:

- Neutrons
- Alphas
- WIMPs

Electronic Recoils

Scattering with argon atomic electrons, ionizing argon; excimers tend to populate ***triplet state***, relax slowly. Induced by:

- Betas (especially ^{39}Ar at ~3 kHz)
- Gammas

joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Pulse Shape Discrimination

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Nuclear Recoils

Scattering directly with argon nuclei; excimers mostly populate the ***singlet state***, relax quickly. Induced by:

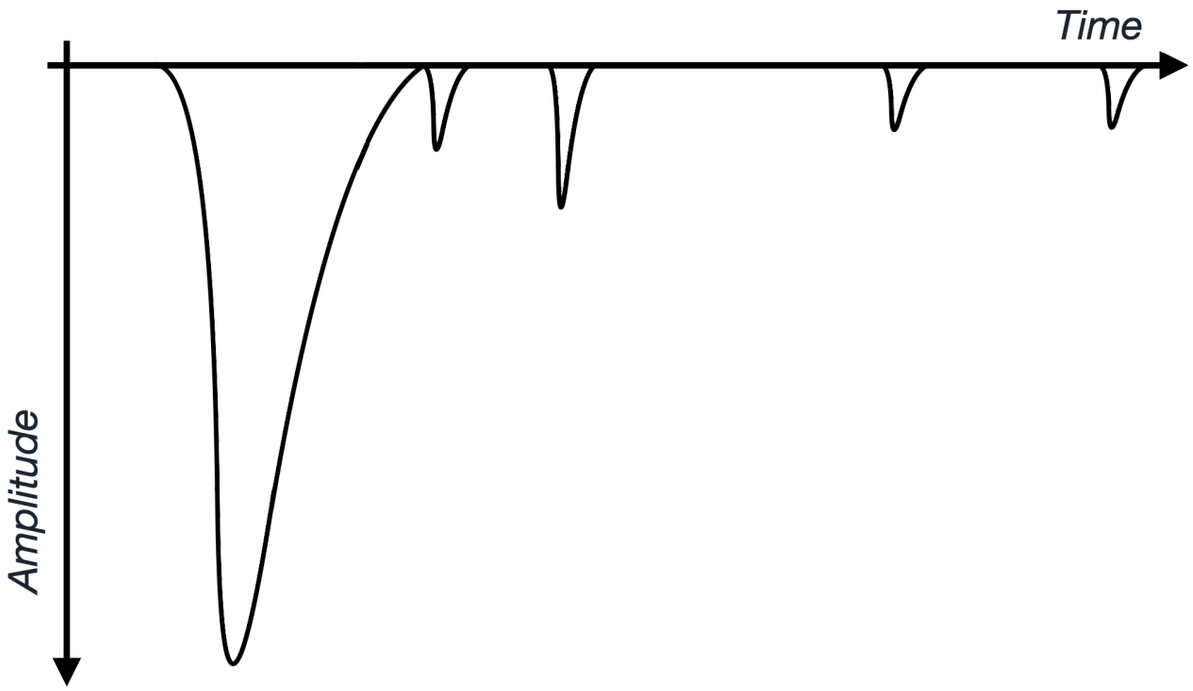
- Neutrons
- Alphas
- WIMPs

Electronic Recoils

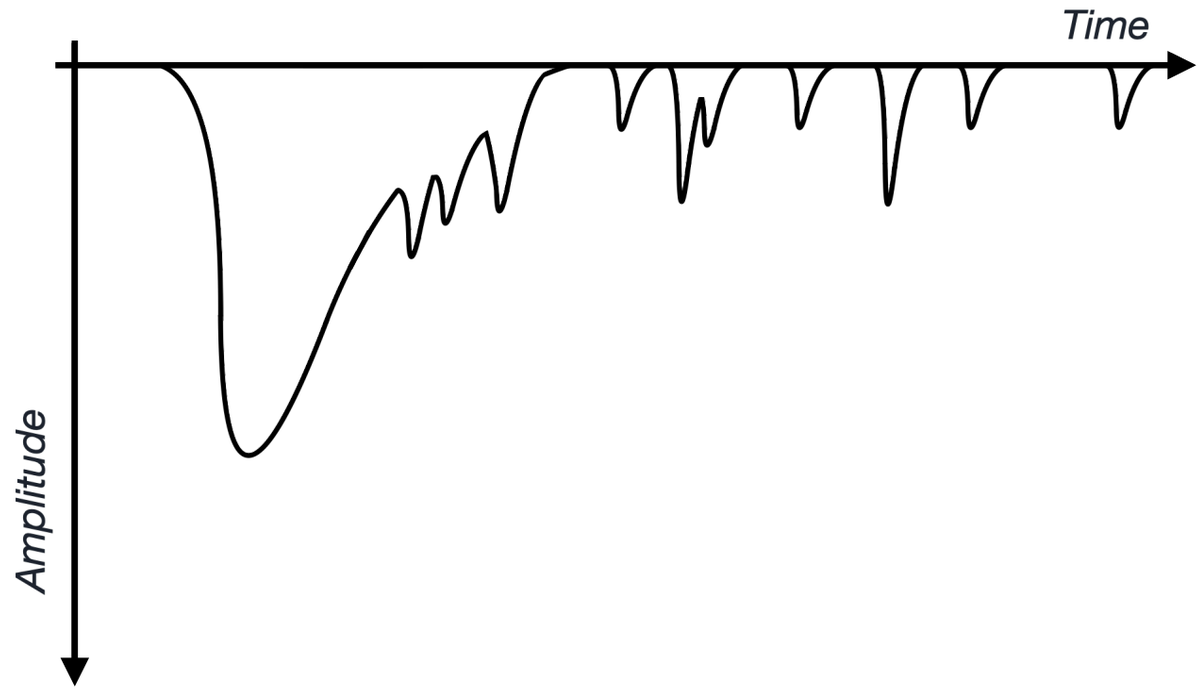
Scattering with argon atomic electrons, ionizing argon; excimers tend to populate ***triplet state***, relax slowly. Induced by:

- Betas (especially ^{39}Ar at ~3 kHz)
- Gammas

NR Pulse Shape



ER Pulse Shape



joseph.mclaughlin.2018@live.rhul.ac.uk

Overview of DEAP-3600:
Pulse Shape Discrimination

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Nuclear Recoils

Scattering directly with argon nuclei; excimers mostly populate the ***singlet state***, relax quickly. Induced by:

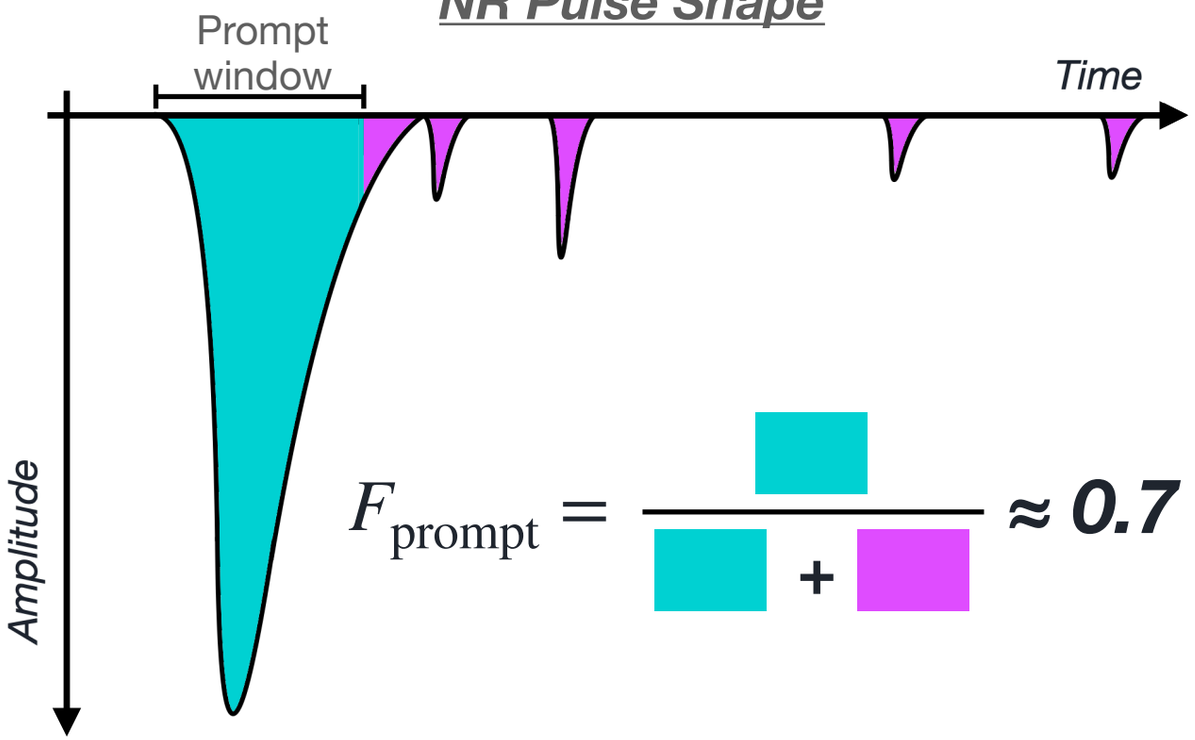
- Neutrons
- Alphas
- WIMPs

Electronic Recoils

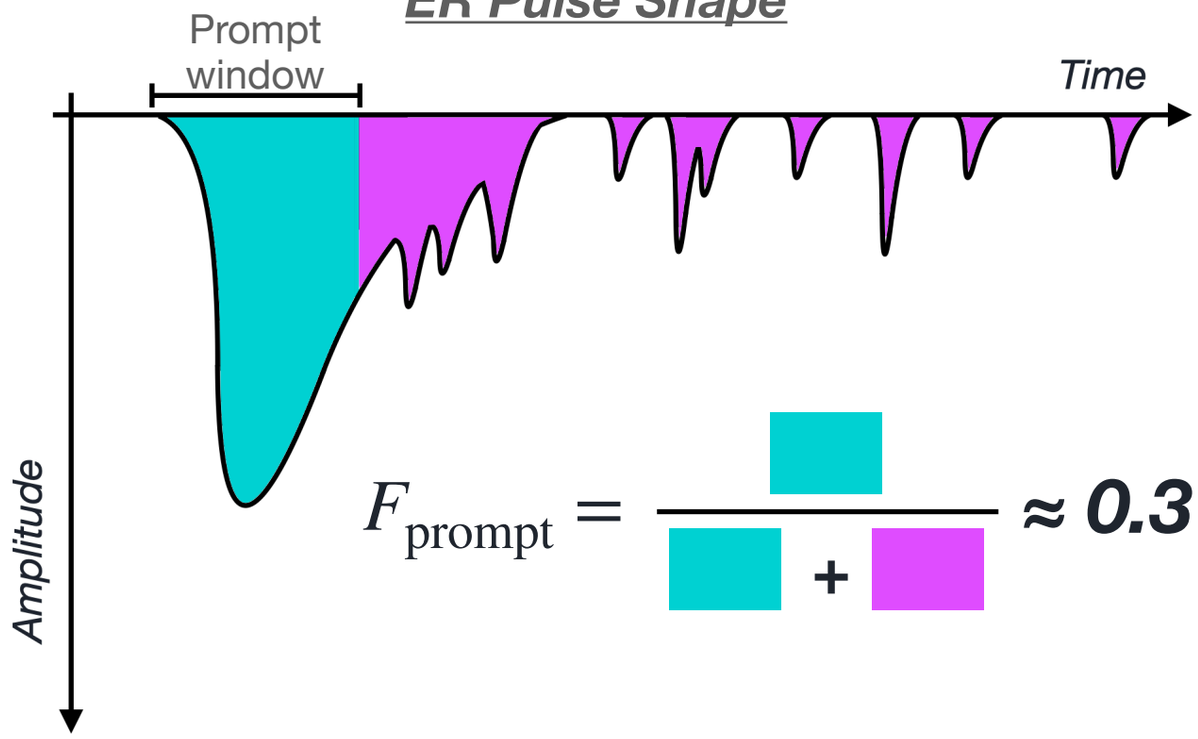
Scattering with argon atomic electrons, ionizing argon; excimers tend to populate ***triplet state***, relax slowly. Induced by:

- Betas (especially ^{39}Ar at ~3 kHz)
- Gammas

NR Pulse Shape



ER Pulse Shape

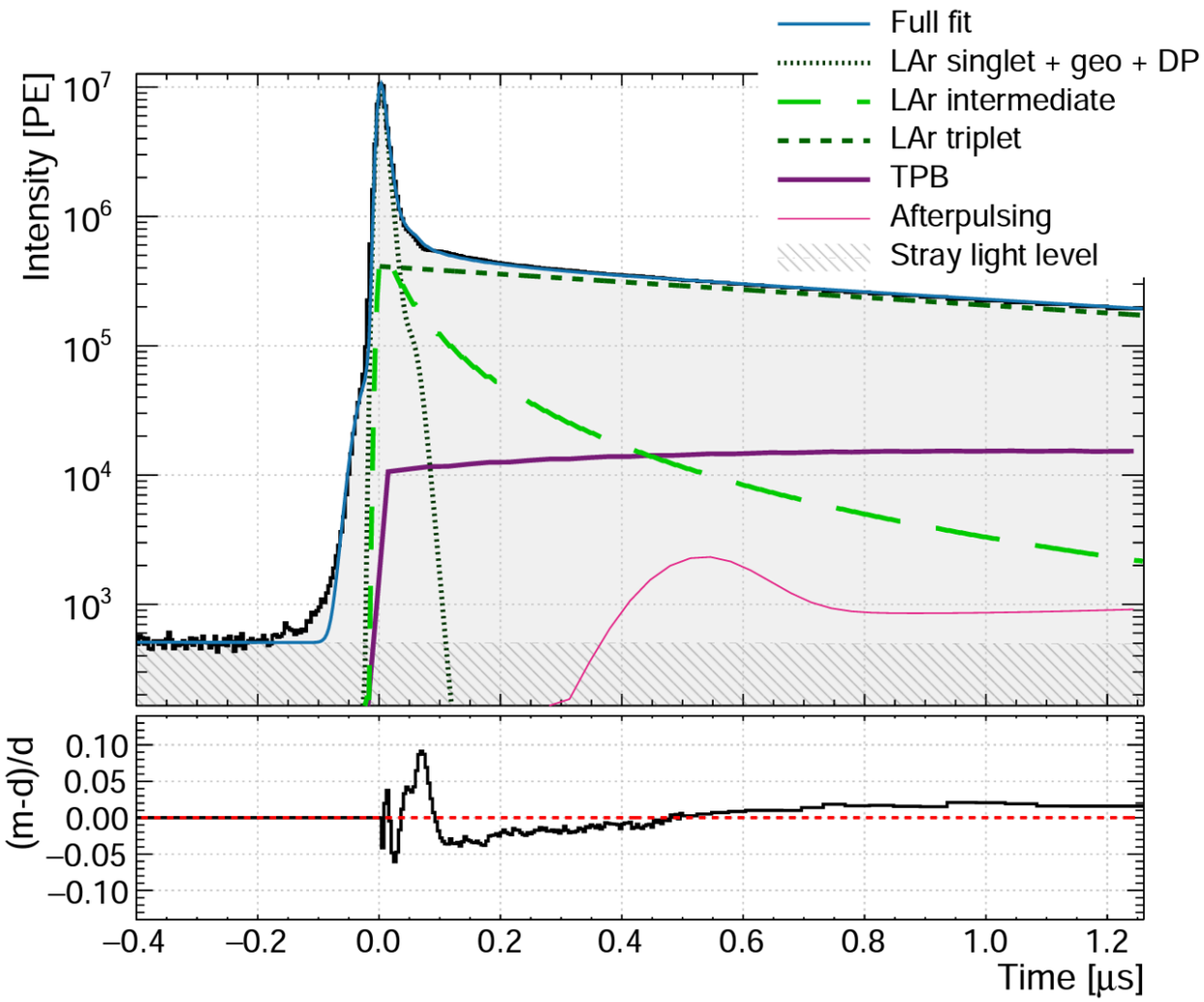


joseph.mclaughlin.2018@live.rhul.ac.uk

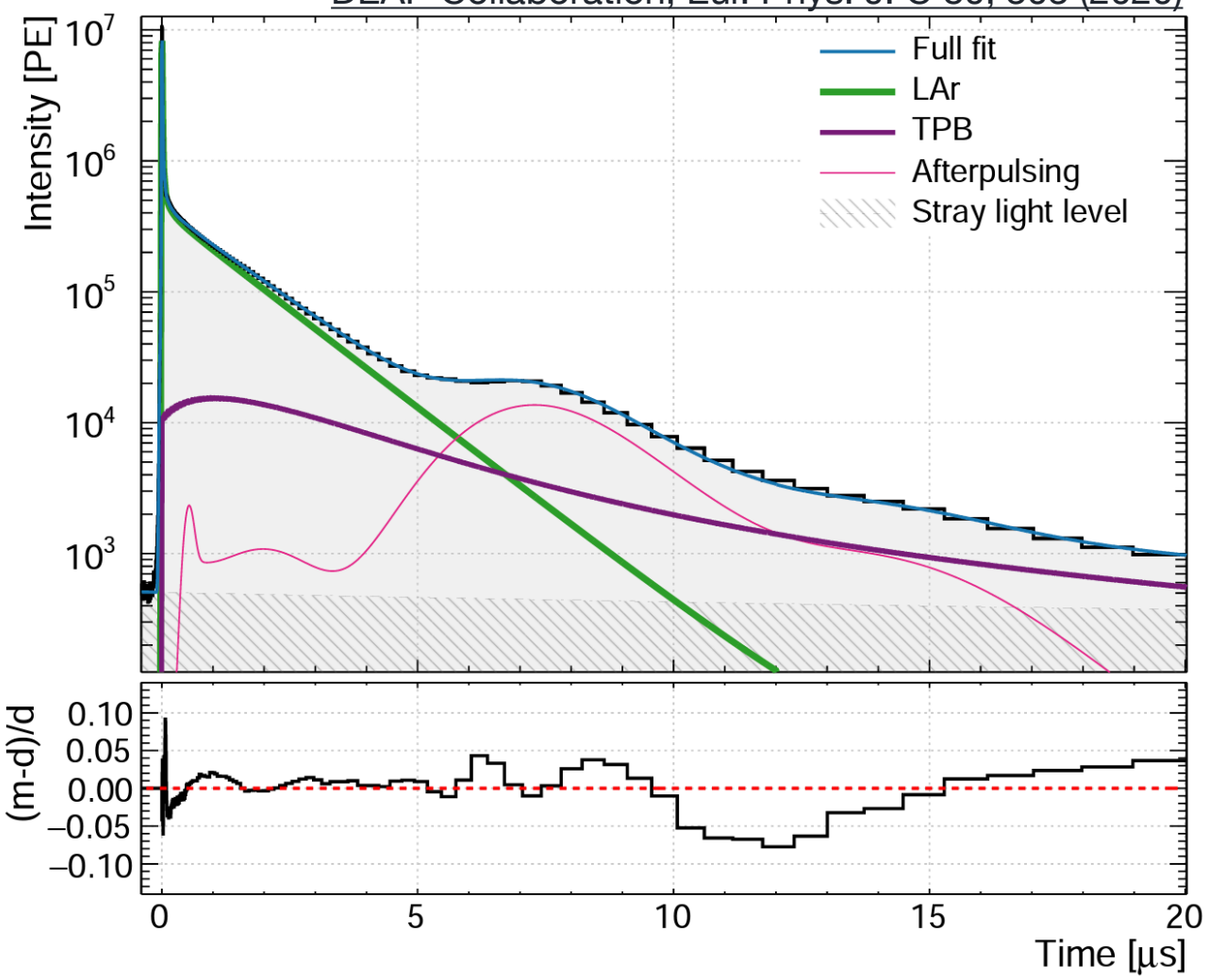
Precision Measurements:
Liquid Argon Pulse Shape

ROYAL HOLLOWAY UNIVERSITY OF LONDON

DEAP Collaboration, Eur. Phys. J. C 80, 303 (2020)



DEAP Collaboration, Eur. Phys. J. C 80, 303 (2020)



- Characterized the LAr pulse shape, accounting for detector geometry, and contributions from TPB, PMT afterpulsing, double/late pulsing, and stray light

- Pulse shape includes known singlet & triplet components, also ***intermediate*** component

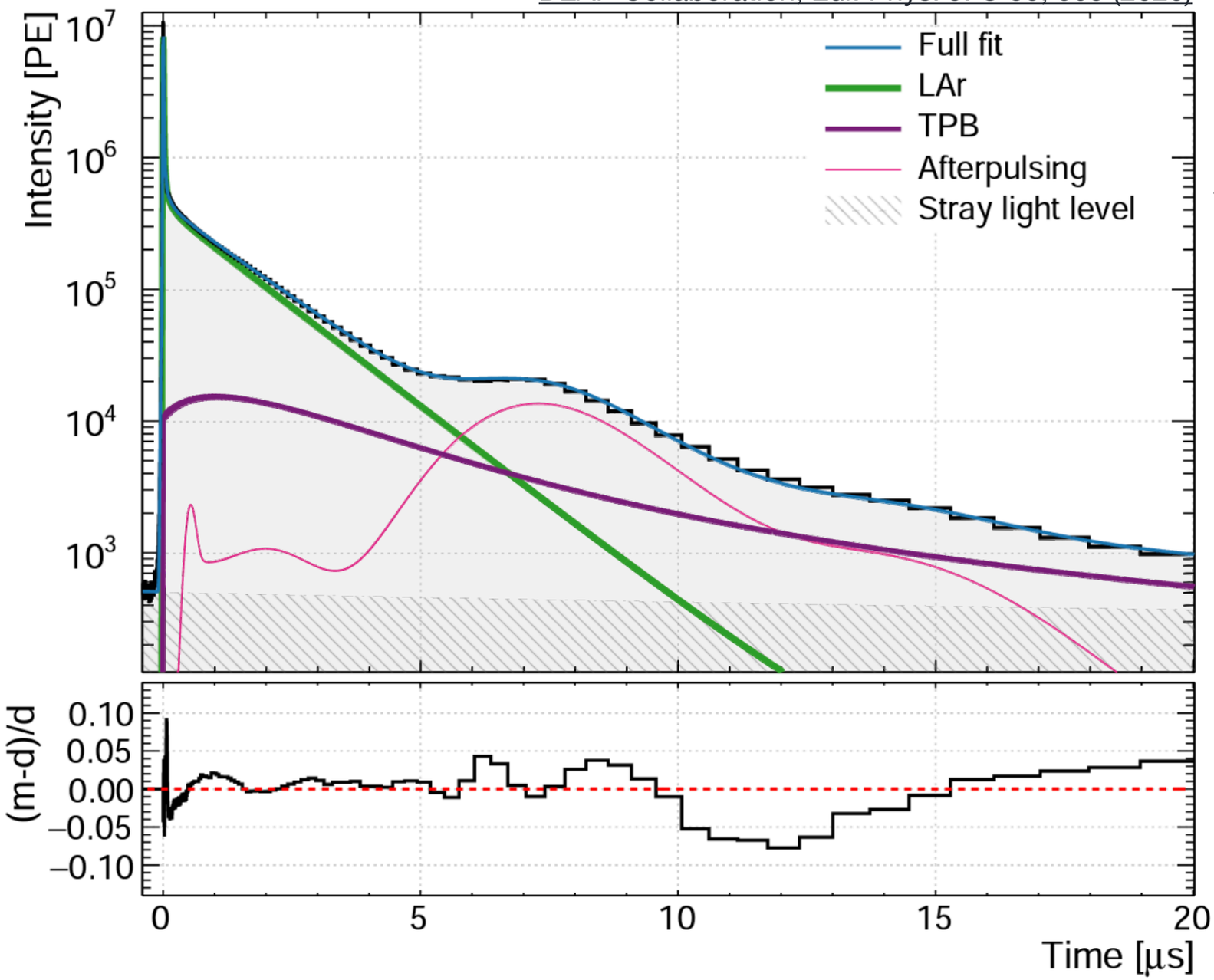
joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Detailed pulse shape modelling allows for ability to separate scintillation from PMT artifacts; i.e. PMT afterpulsing

DEAP Collaboration, Eur. Phys. J. C 80, 303 (2020)



Prompt Window Length

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

Full Event Window Length

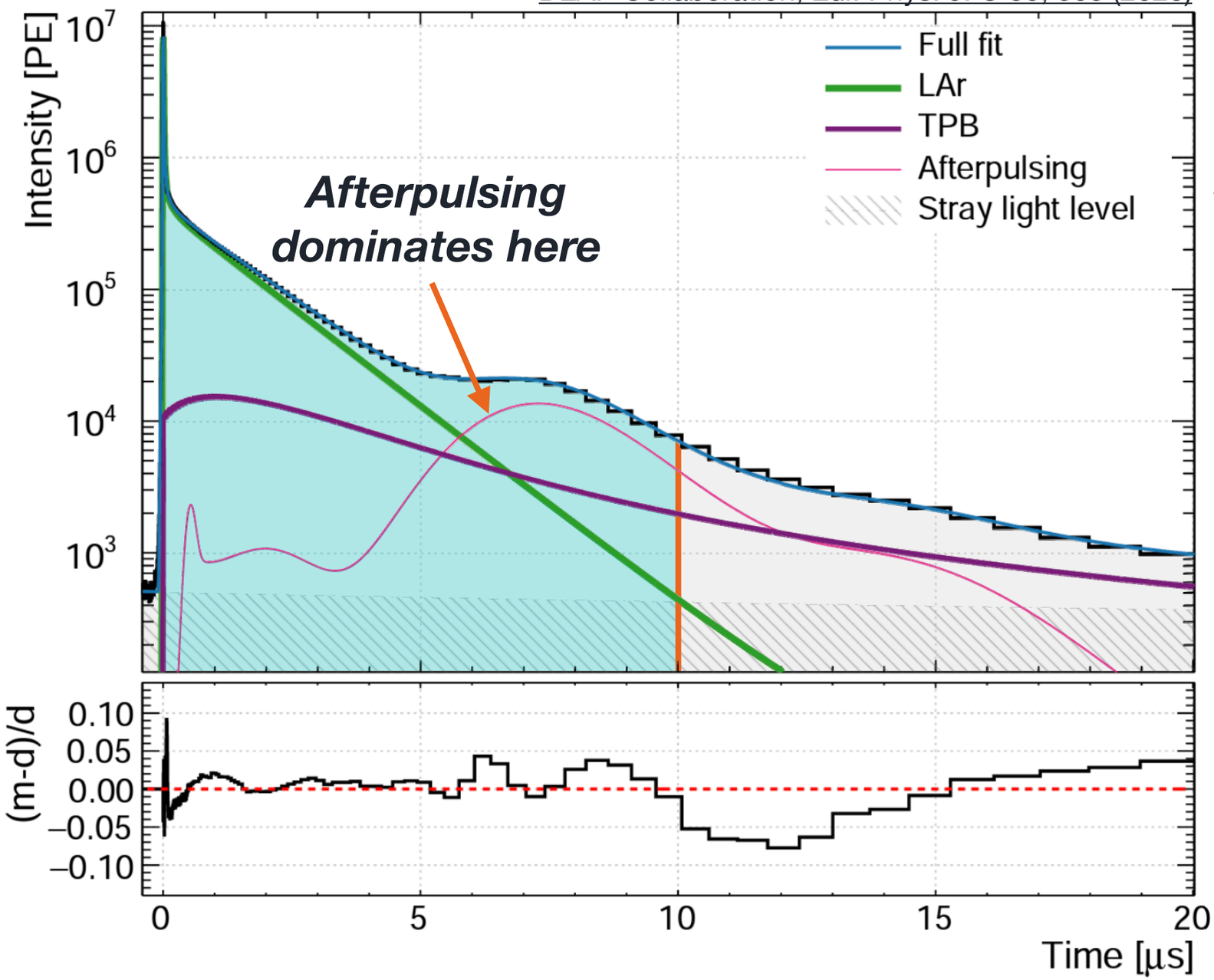
joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Detailed pulse shape modelling allows for ability to separate scintillation from PMT artifacts; i.e. PMT afterpulsing

DEAP Collaboration, Eur. Phys. J. C 80, 303 (2020)



Prompt Window Length

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

Full Event Window Length

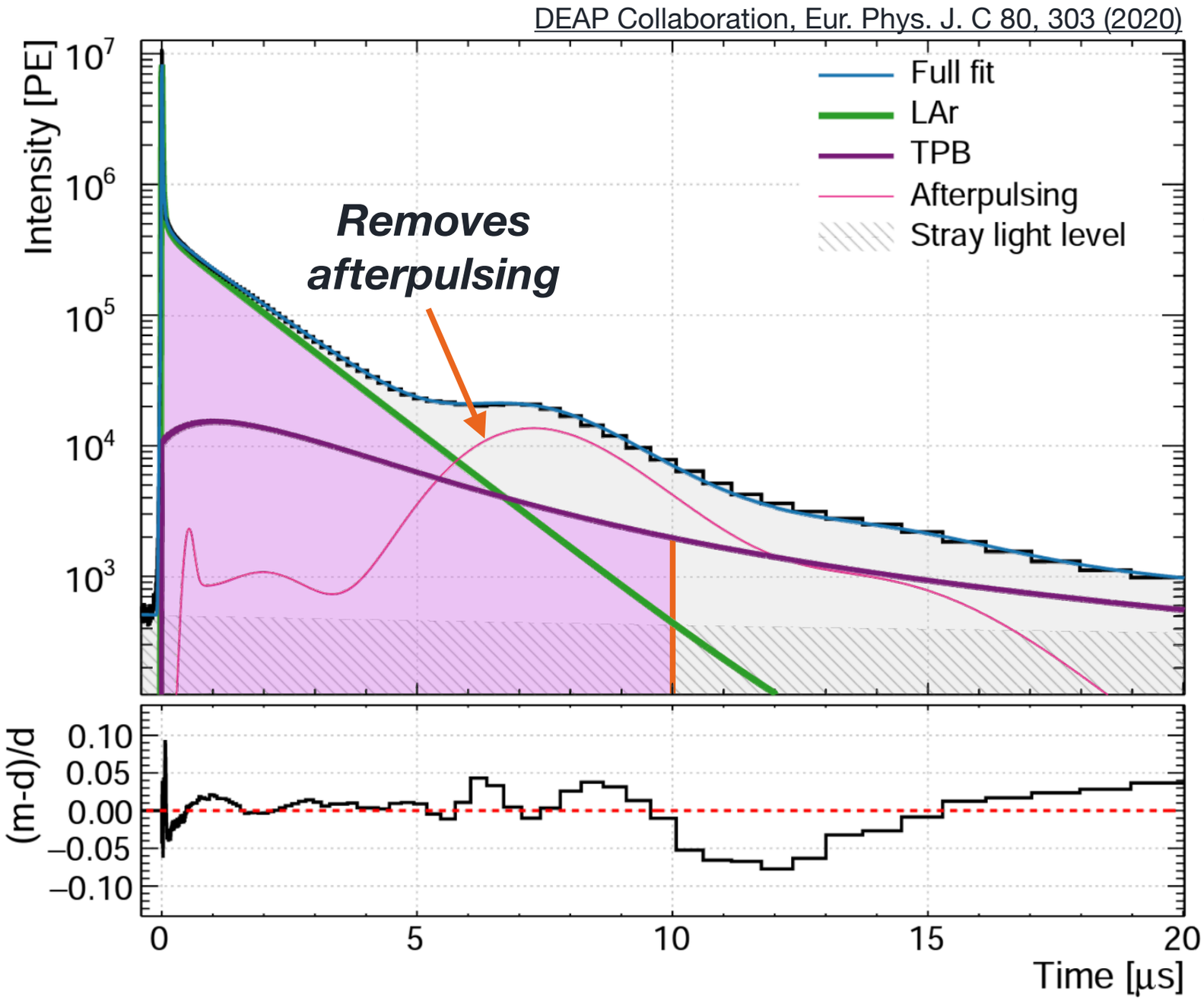
$$\text{PE} \equiv \frac{\textit{Total Integrated Charge}}{\textit{Single Photoelectron Charge}}$$

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Detailed pulse shape modelling allows for ability to separate scintillation from PMT artifacts; i.e. PMT afterpulsing



Prompt Window Length

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

Full Event Window Length

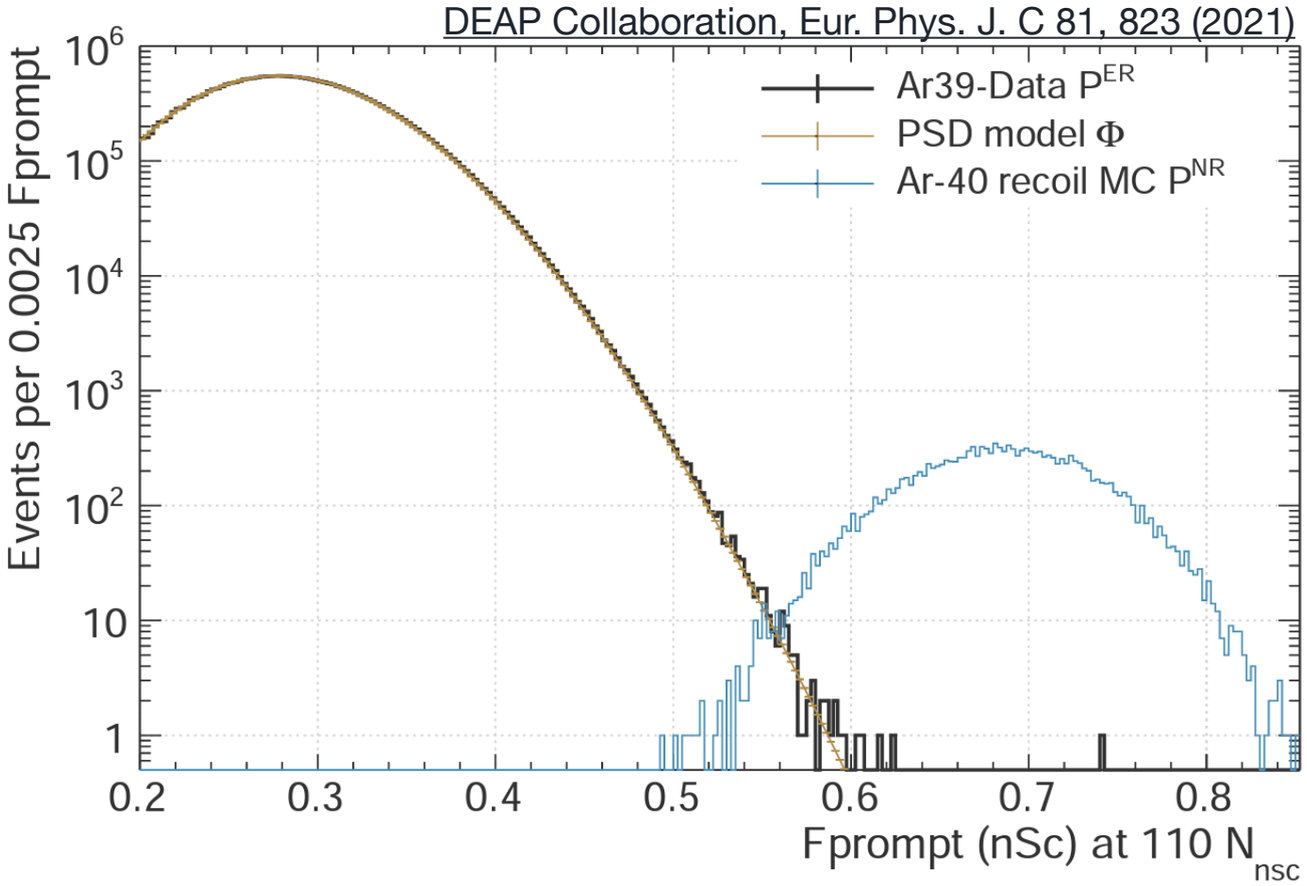
$$\text{PE} \equiv \frac{\textit{Total Integrated Charge}}{\textit{Single Photoelectron Charge}}$$

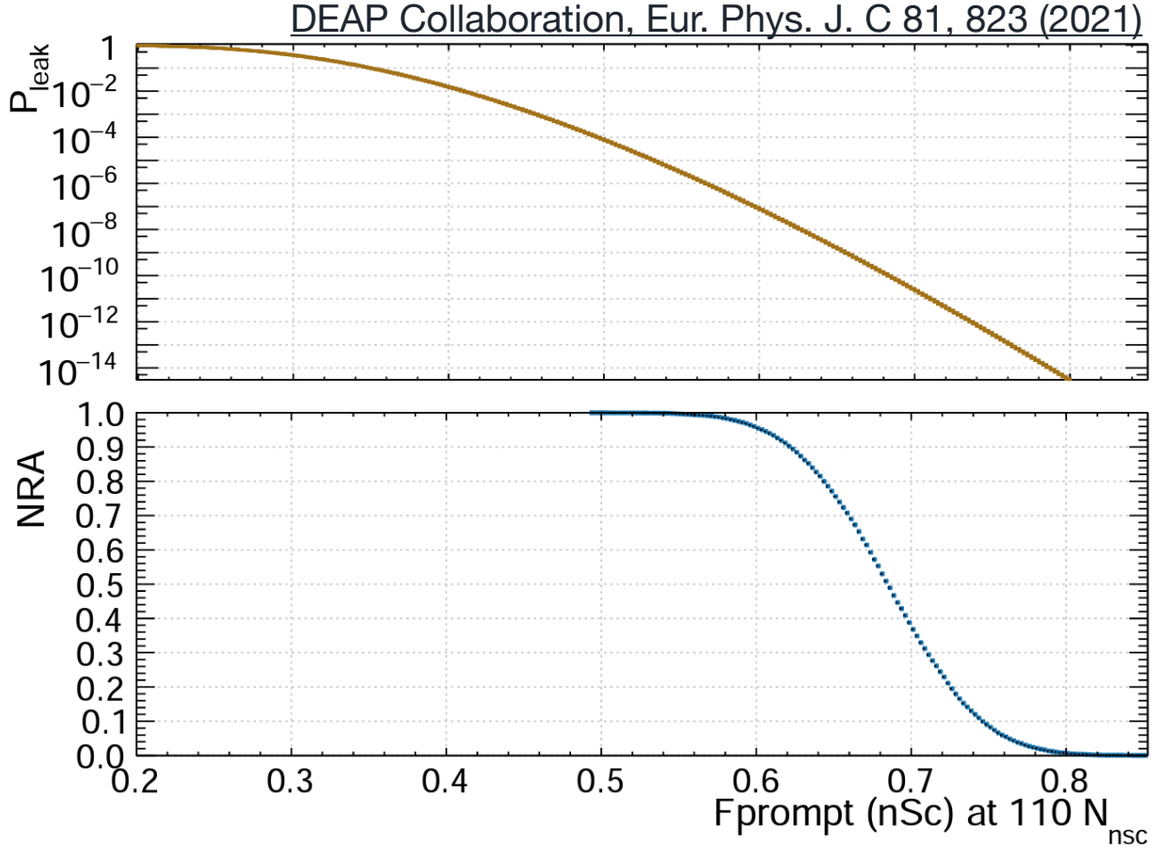
$$\text{PE} \equiv \textit{Bayesian Photoelectron Counting}$$

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON



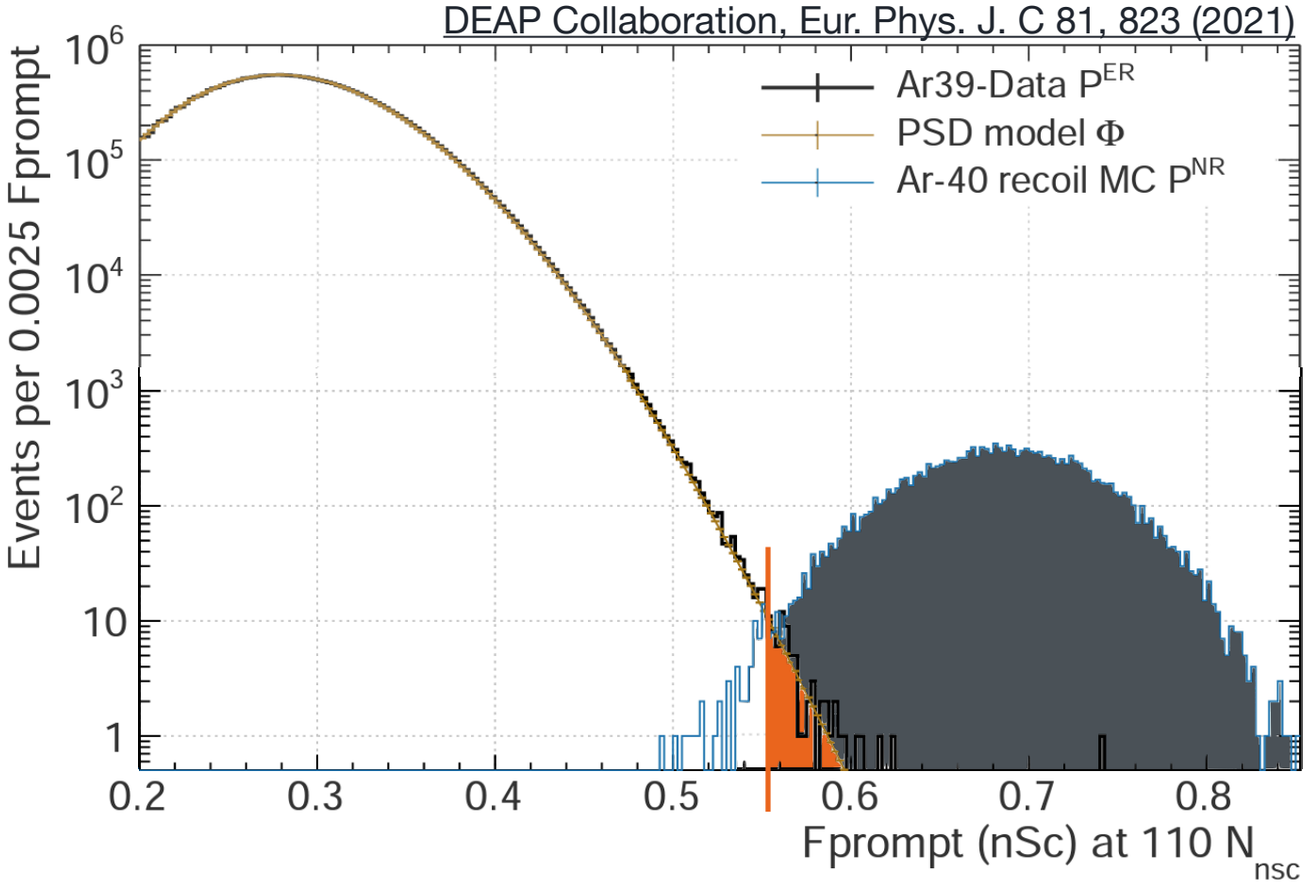


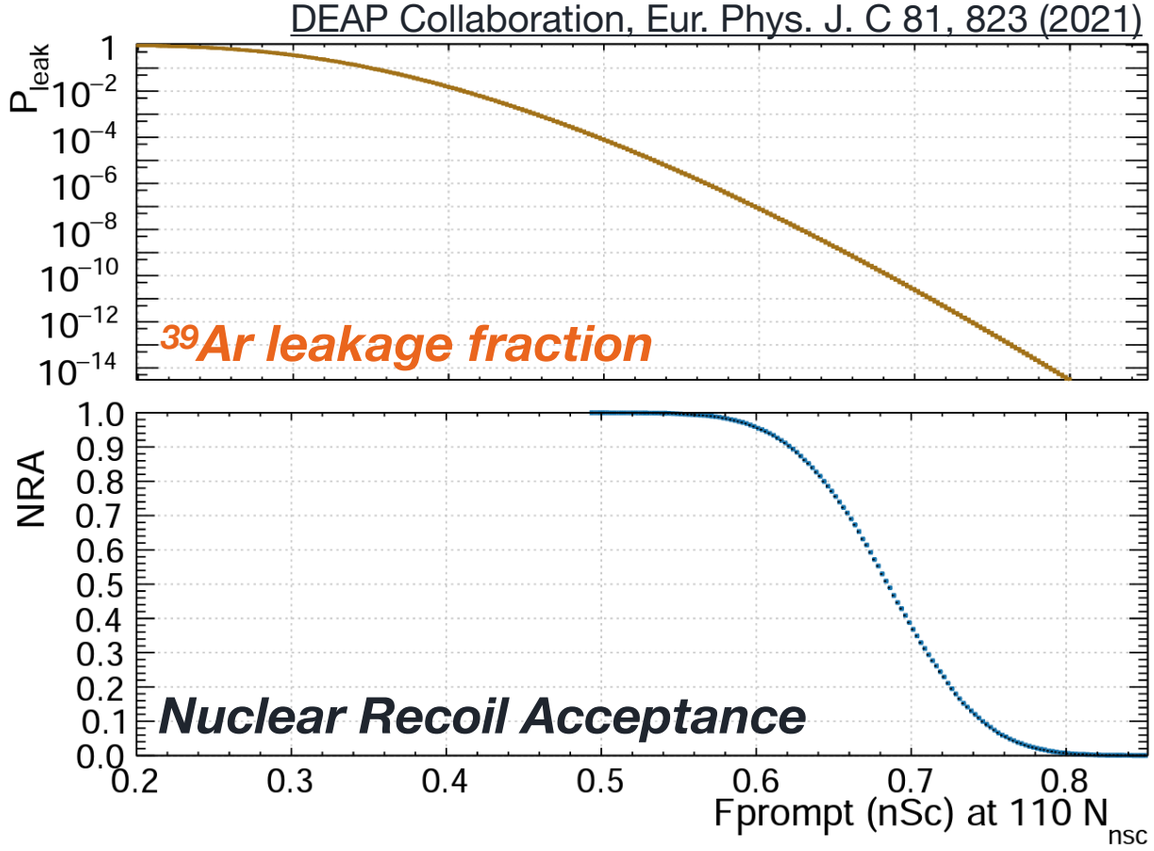
- PSD model tested with both energy estimators: total integrated charge & with afterpulsing removal

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON



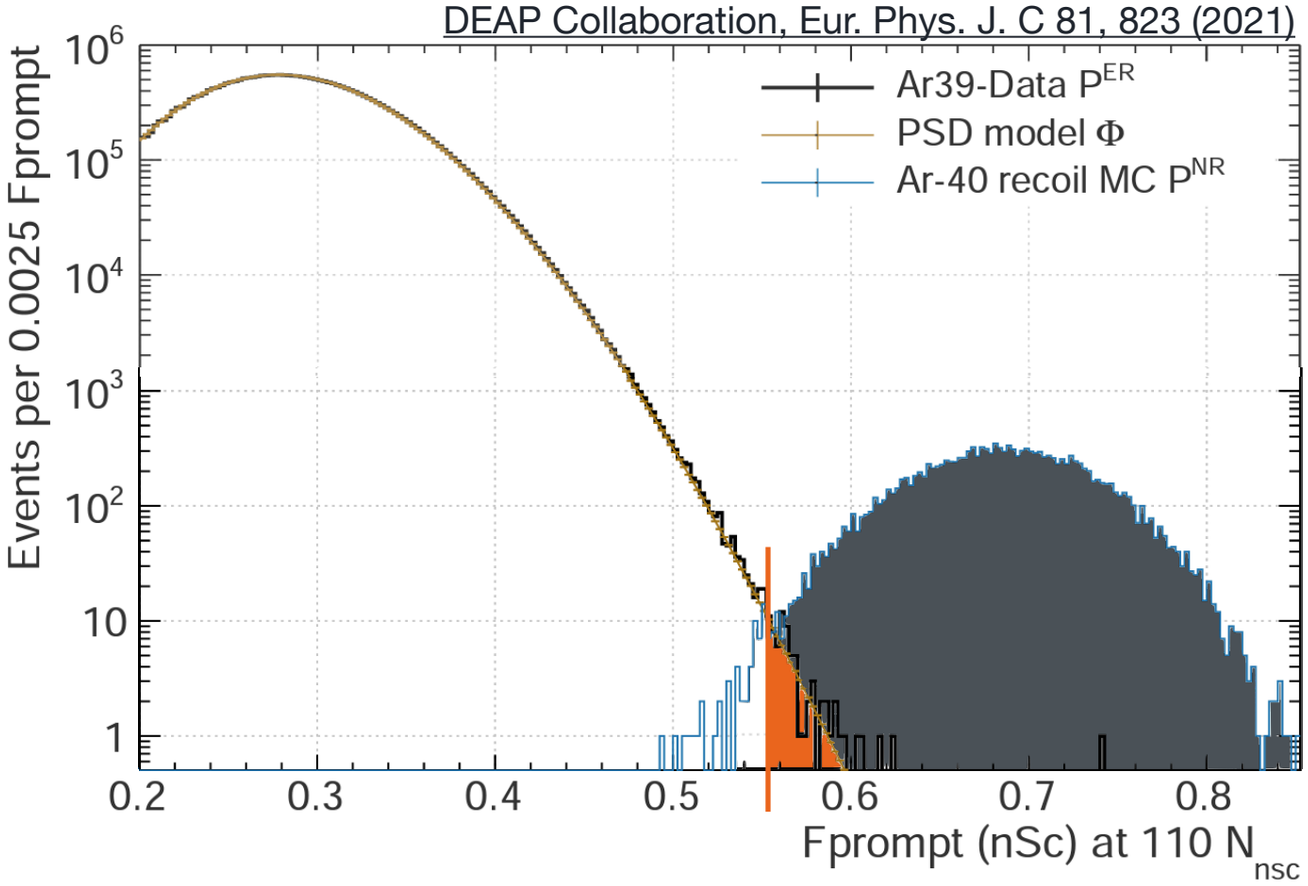


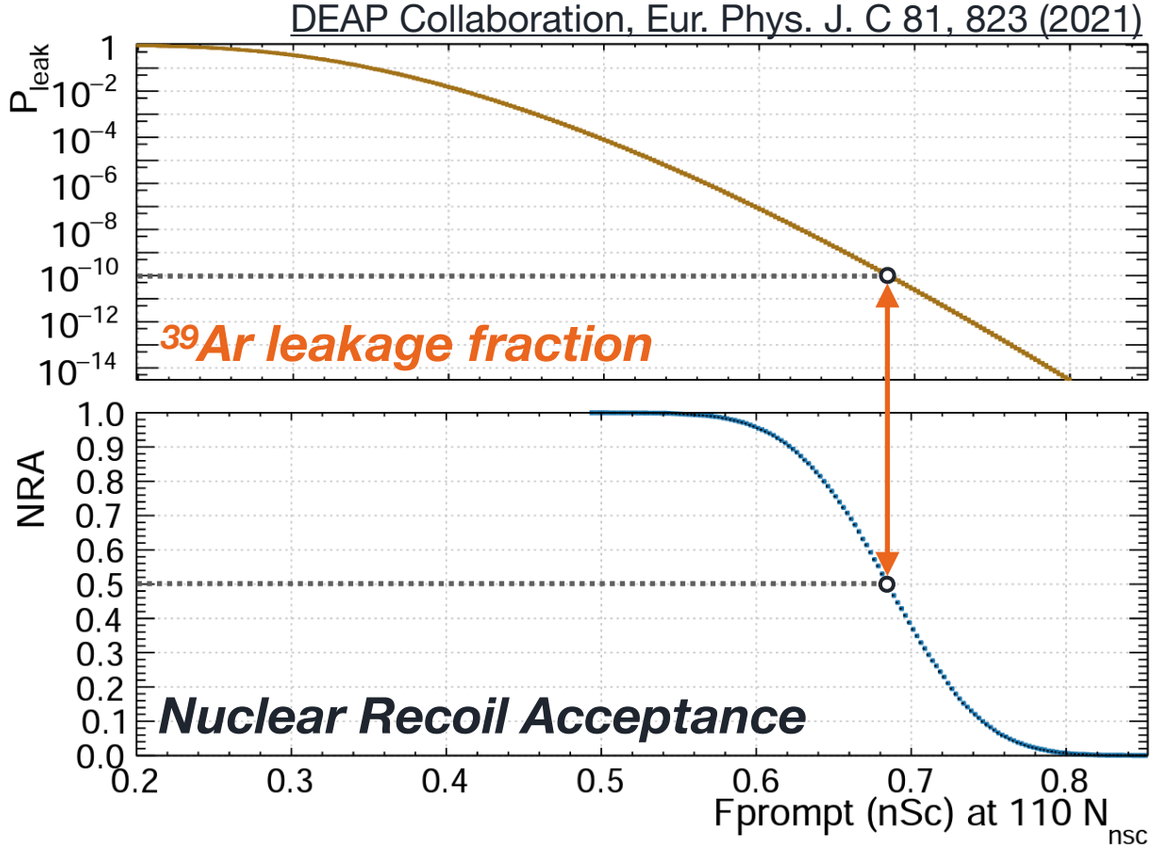
- PSD model tested with both energy estimators: total integrated charge & with afterpulsing removal
- ^{39}Ar leakage is reduced by an order magnitude with afterpulsing removal compared to total charge integration

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
PSD in 4.5 Tonne-Year Exposure

ROYAL HOLLOWAY UNIVERSITY OF LONDON





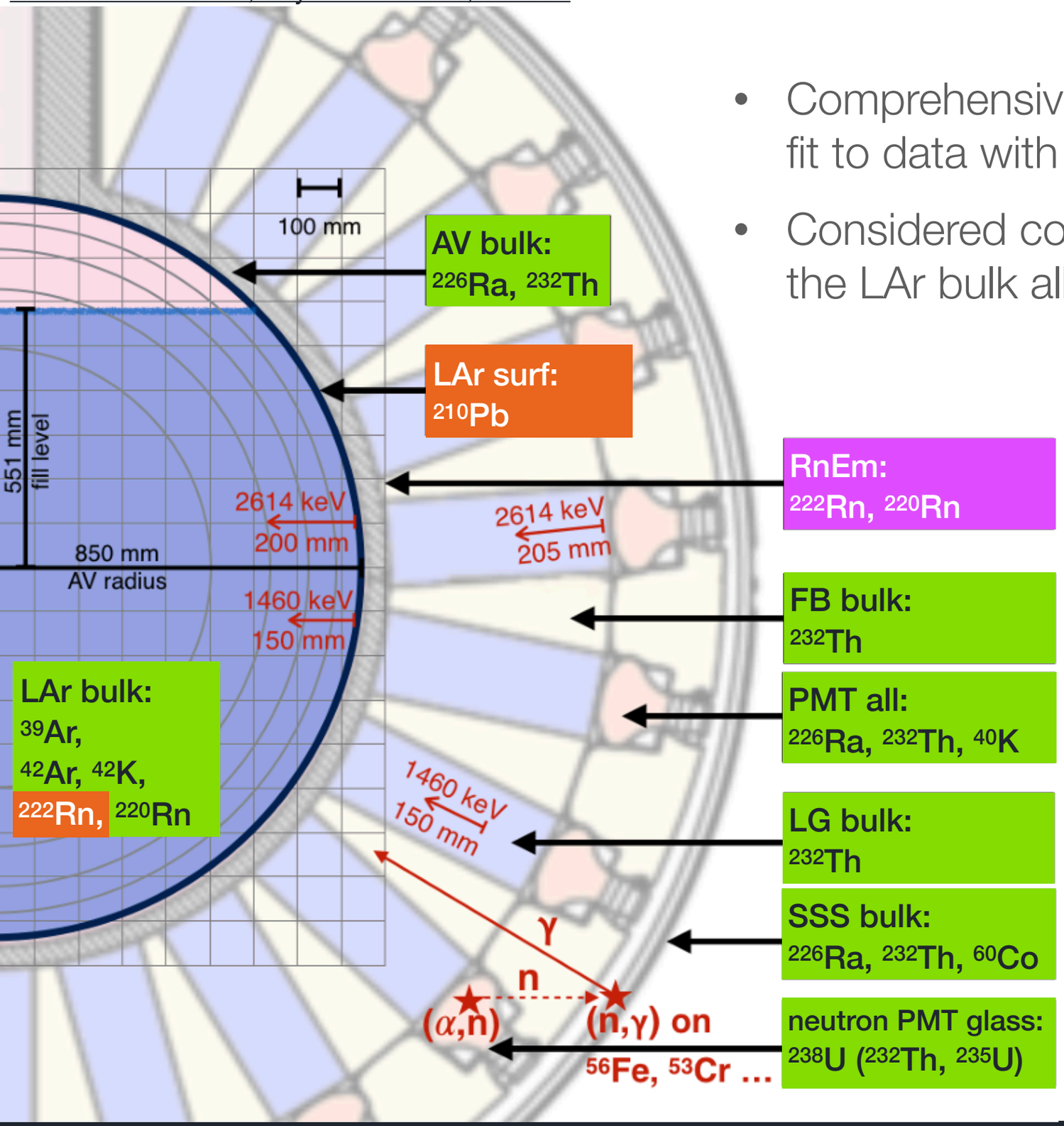
- PSD model tested with both energy estimators: total integrated charge & with afterpulsing removal
- ^{39}Ar leakage is reduced by an order magnitude with afterpulsing removal compared to total charge integration
- Result: ***world leading PSD!***
  10^{-10} leakage fraction of ^{39}Ar for 50% NR acceptance at 110 PE (117.5 keV_{ee})

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements:
Electromagnetic Backgrounds

ROYAL HOLLOWAY UNIVERSITY OF LONDON

DEAP Collaboration, Phys. Rev. D 100, 072009



- Comprehensive electromagnetic backgrounds model fit to data with BAT (Bayesian Analysis Toolkit)
- Considered components include sources located in the LAr bulk all the way out to the stainless steel shell

EM Backgrounds Model

14 sources as free parameters

2 sources as fixed parameters

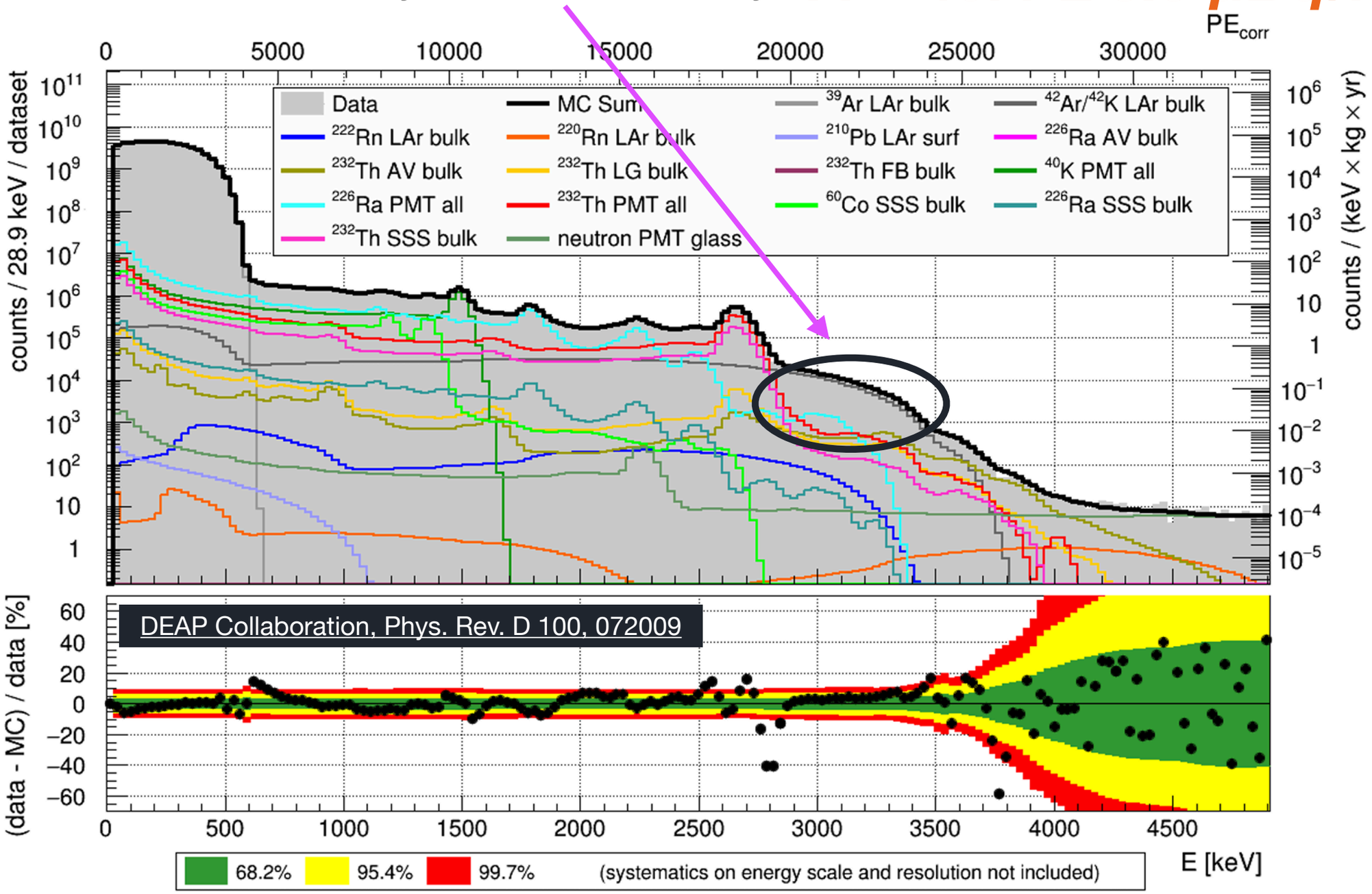
2 sources included as systematics

joseph.mclaughlin.2018@live.rhul.ac.uk

Precision Measurements: **Electromagnetic Backgrounds**

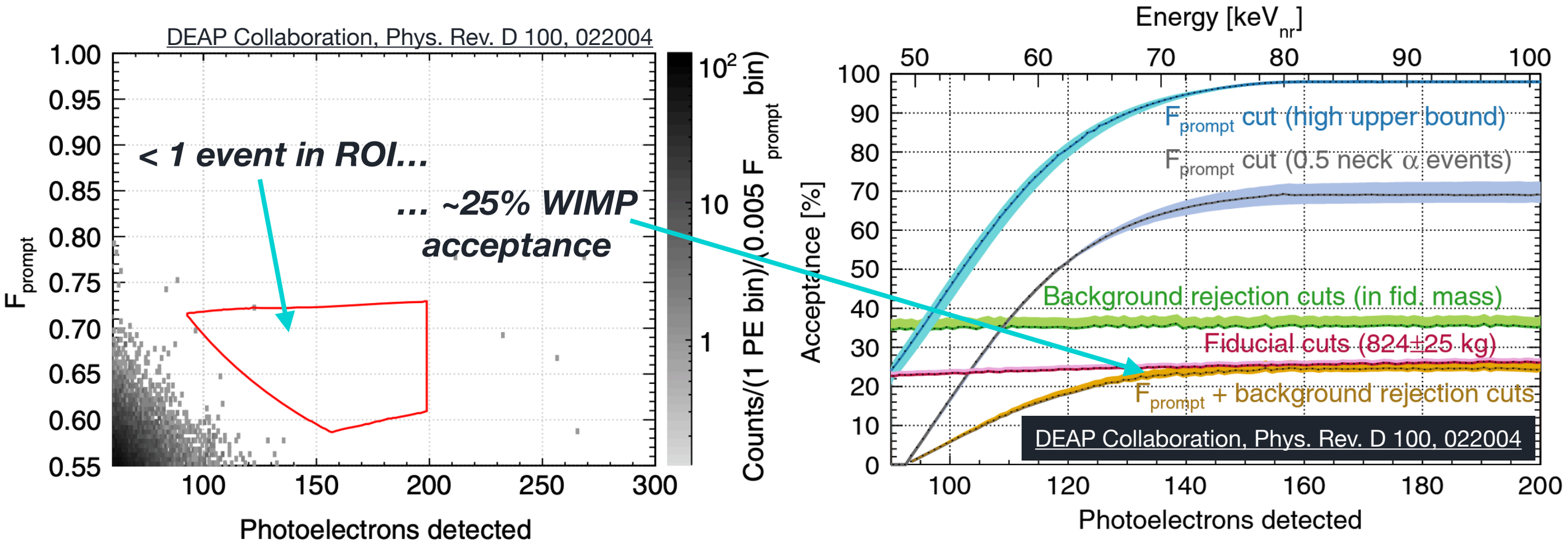
ROYAL HOLLOWAY UNIVERSITY OF LONDON

- ^{42}Ar betas are source of background for DarkSide-20k, GERDA, LEGEND—previously measurements of its specific activity are in tension, have large uncertainties
- DEAP measures ^{42}Ar activity via ^{42}K beta decay: ***A = 40.4 ± 5.9 μBq/kg***



joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
DEAP Standard Analysis

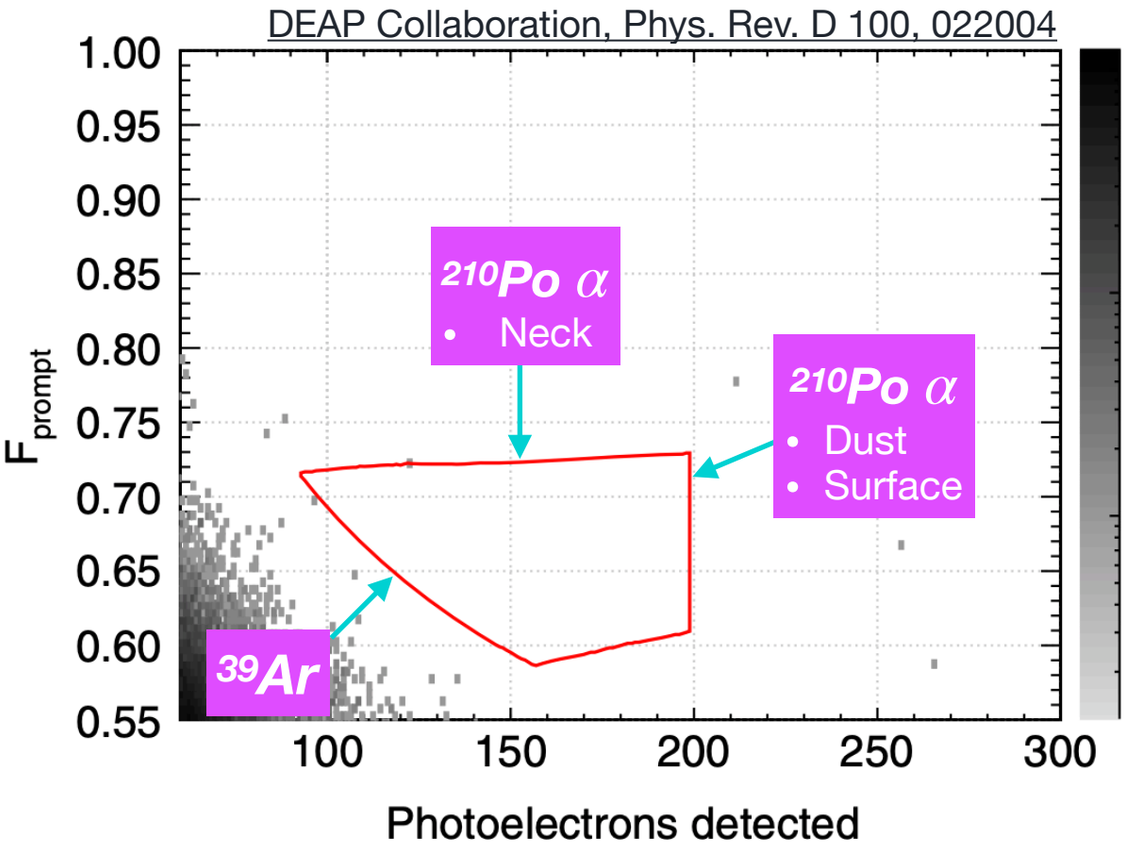


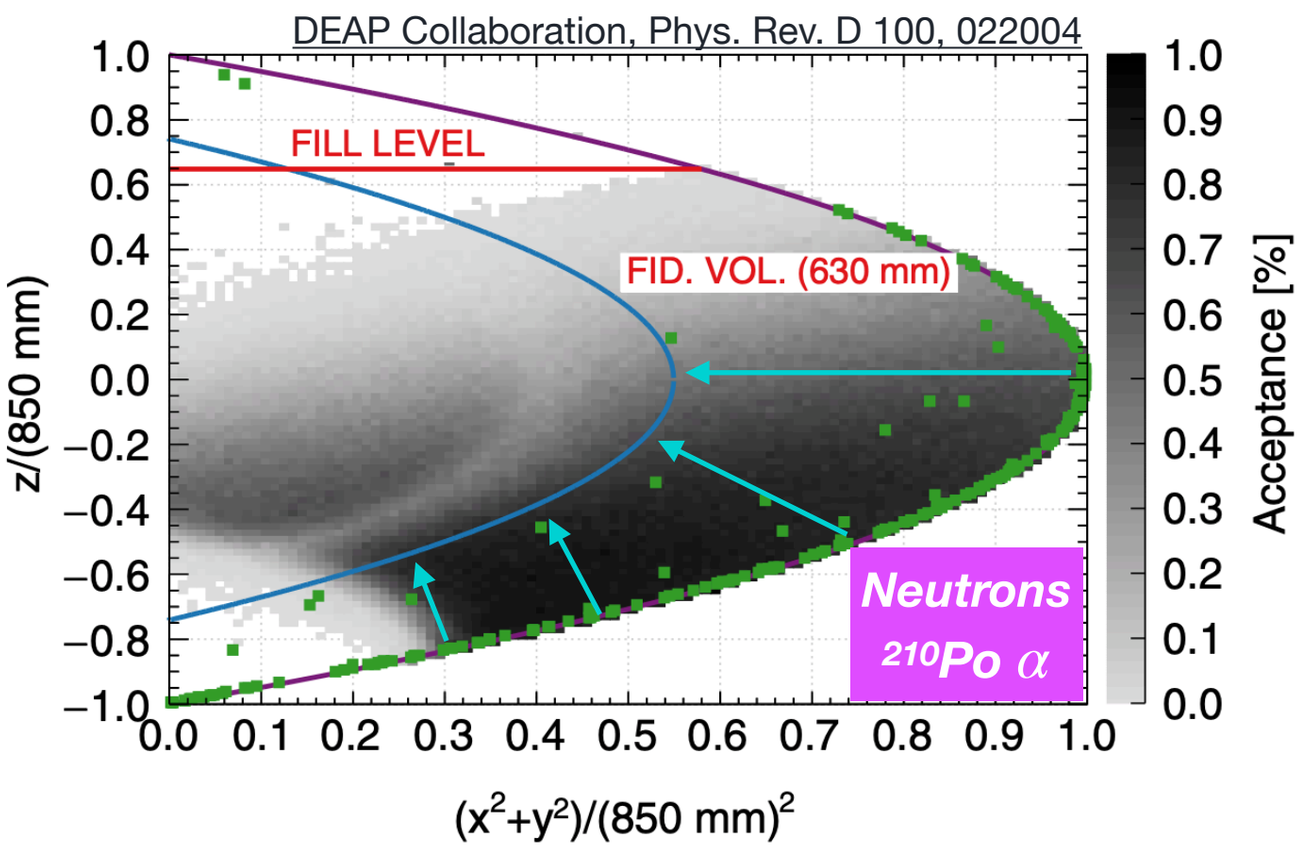
- DEAP's 231 live-day exposure with region of interest (ROI), fiducial volume (FV), and event selection cuts had zero background events

joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Profile Likelihood Ratio

ROYAL HOLLOWAY UNIVERSITY OF LONDON





- DEAP's 231 live-day exposure with region of interest (ROI), fiducial volume (FV), and event selection cuts had zero background events
- Improved background model and machine learning algorithms will allow us to expand ROI and FV, as well as ease event selection cuts

joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Profile Likelihood Ratio

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Define a Likelihood Function

$$\mathscr{L}(\mathbf{x}\,|\,\sigma,\theta) = \mathscr{L}_{\mathrm{PDFs}}(\mathbf{x}\,|\,\sigma,\theta)\cdot\mathscr{L}_{\mathrm{Con}}(\theta)\cdot\mathscr{L}_{\mathrm{SB}}(\theta)$$

Set of observed data points

WIMP-nucleon elastic scattering cross-section

Set of nuisance parameters (systematics)

joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Profile Likelihood Ratio

ROYAL HOLLOWAY UNIVERSITY OF LONDON

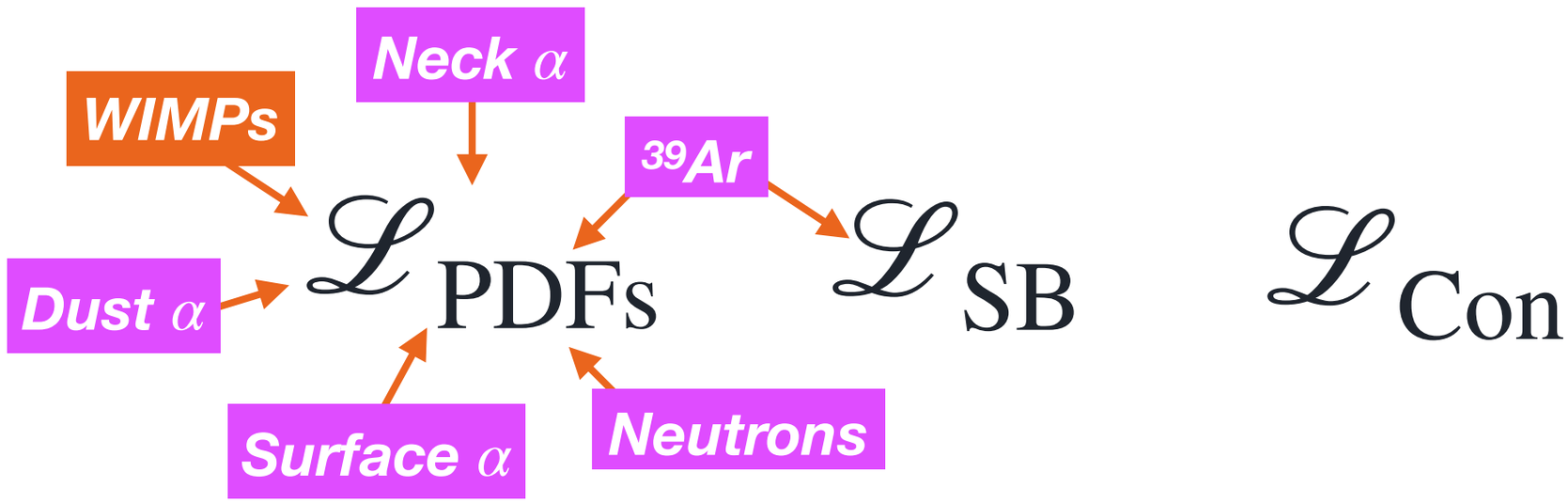
Define a Likelihood Function

$$\mathscr{L}(\mathbf{x}\,|\,\sigma,\theta) = \mathscr{L}_{\mathrm{PDFs}}(\mathbf{x}\,|\,\sigma,\theta)\cdot\mathscr{L}_{\mathrm{Con}}(\theta)\cdot\mathscr{L}_{\mathrm{SB}}(\theta)$$

Set of observed data points

WIMP-nucleon elastic scattering cross-section

Set of nuisance parameters (systematics)



joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Profile Likelihood Ratio

ROYAL HOLLOWAY UNIVERSITY OF LONDON

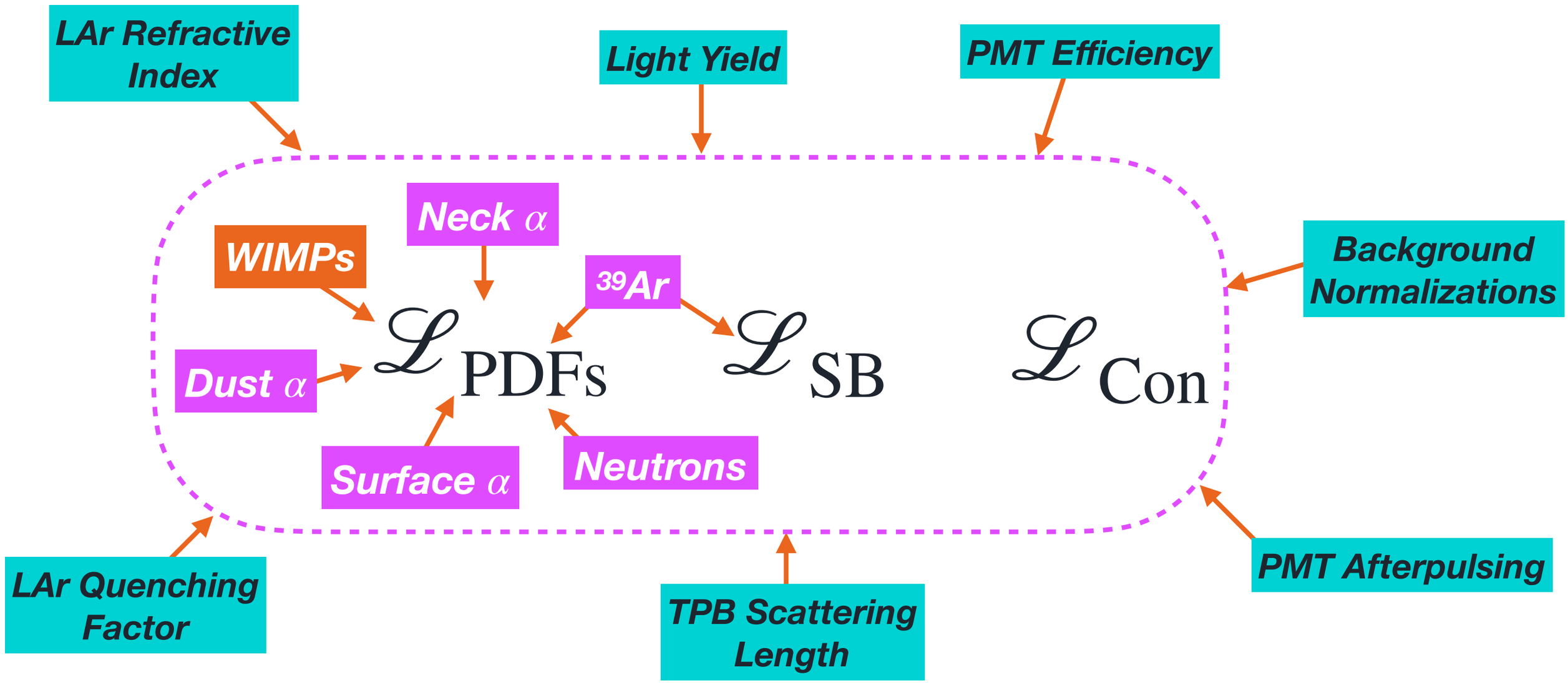
Define a Likelihood Function

$$\mathscr{L}(\mathbf{x}\,|\,\sigma,\theta) = \mathscr{L}_{\mathrm{PDFs}}(\mathbf{x}\,|\,\sigma,\theta)\cdot\mathscr{L}_{\mathrm{Con}}(\theta)\cdot\mathscr{L}_{\mathrm{SB}}(\theta)$$

Set of observed data points

WIMP-nucleon elastic scattering cross-section

Set of nuisance parameters (systematics)



joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Profile Likelihood Ratio

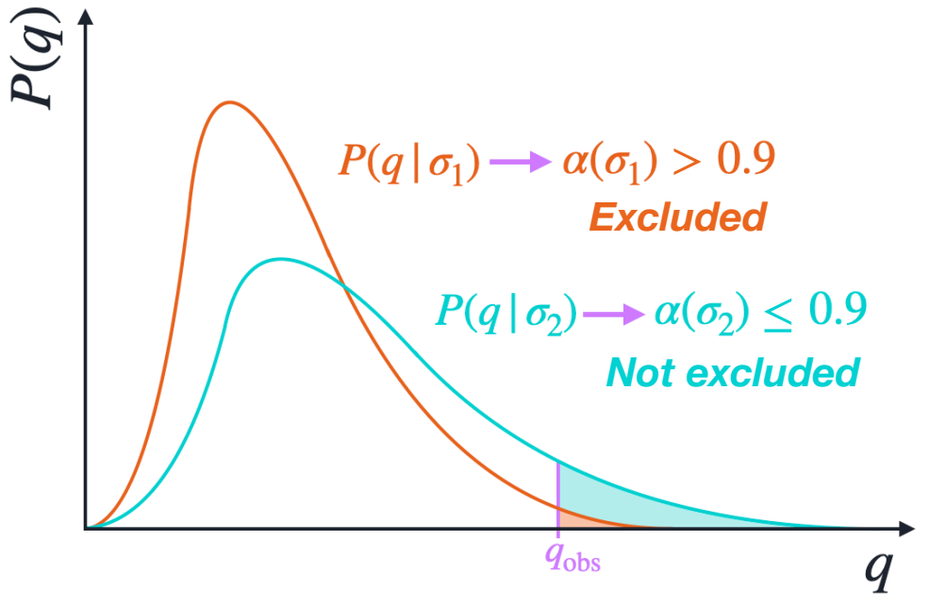
ROYAL HOLLOWAY UNIVERSITY OF LONDON

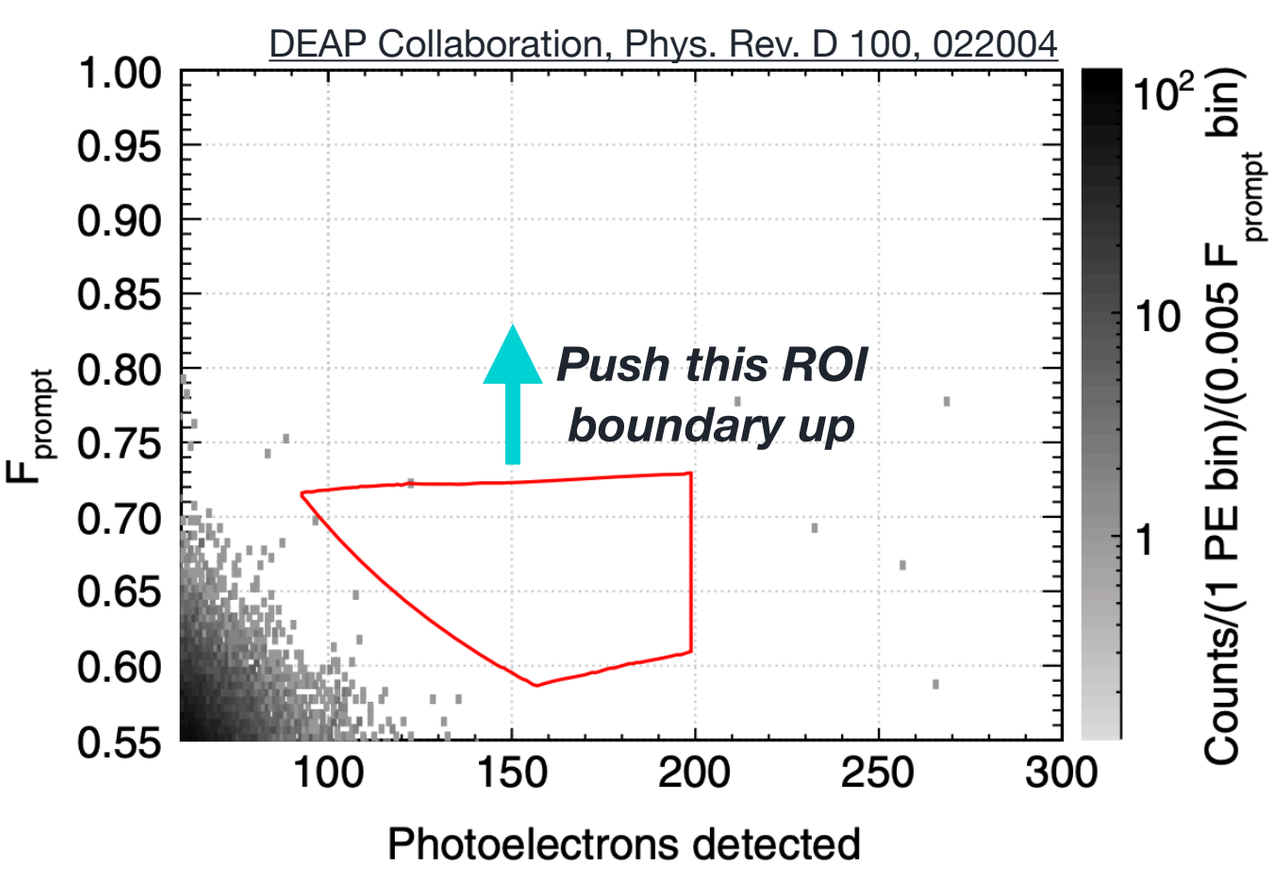
$$\lambda = \frac{\mathscr{L}(\mathbf{x}\,|\,\sigma, \hat{\hat{\theta}})}{\mathscr{L}(\mathbf{x}\,|\,\hat{\sigma}, \hat{\theta})}$$

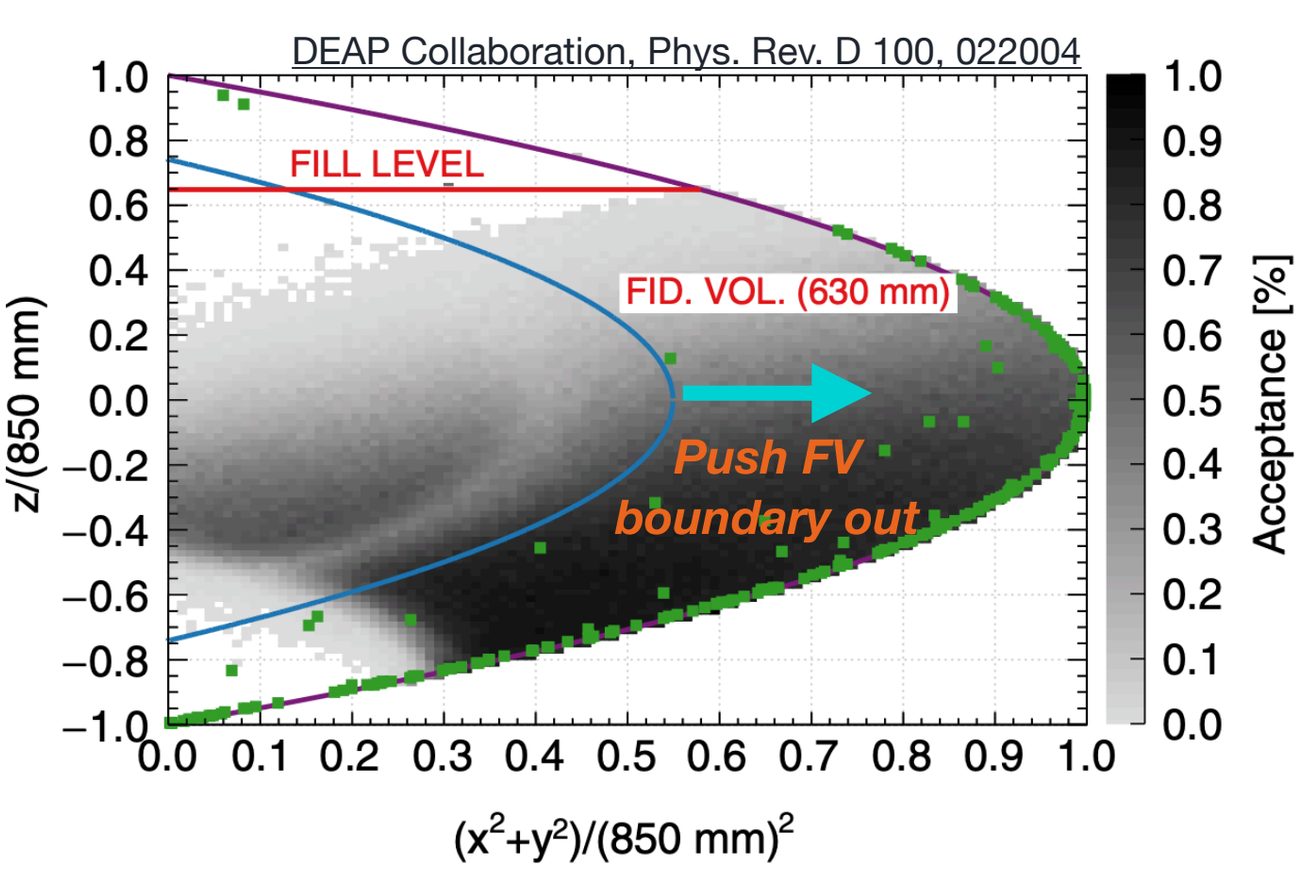
Best fit for a given value of σ

Best possible fit

$$q = \begin{cases} -2\ln\lambda & \sigma \geq \hat{\sigma} \\ 0 & \sigma < \hat{\sigma} \end{cases}$$

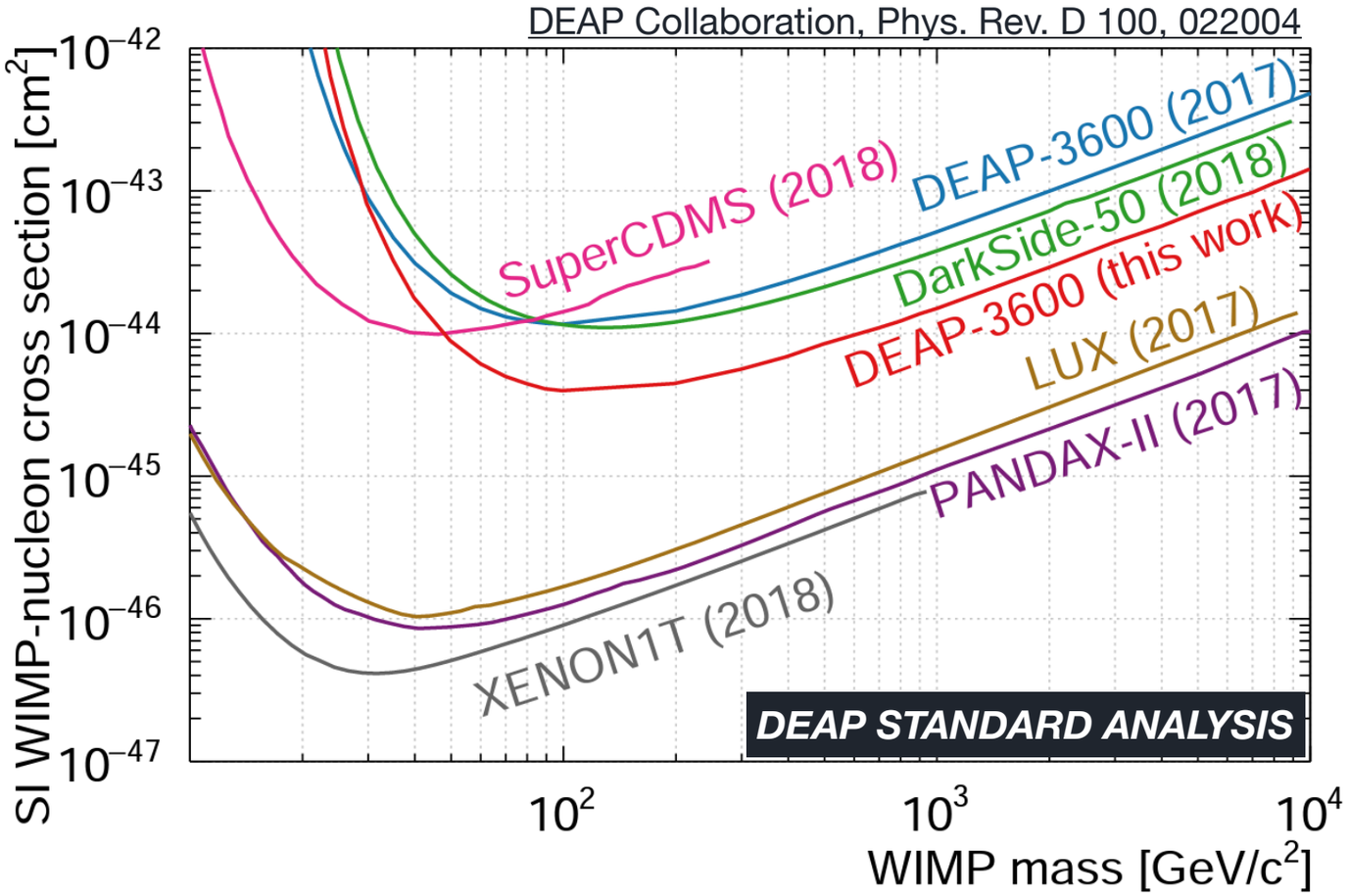






joseph.mclaughlin.2018@live.rhul.ac.uk

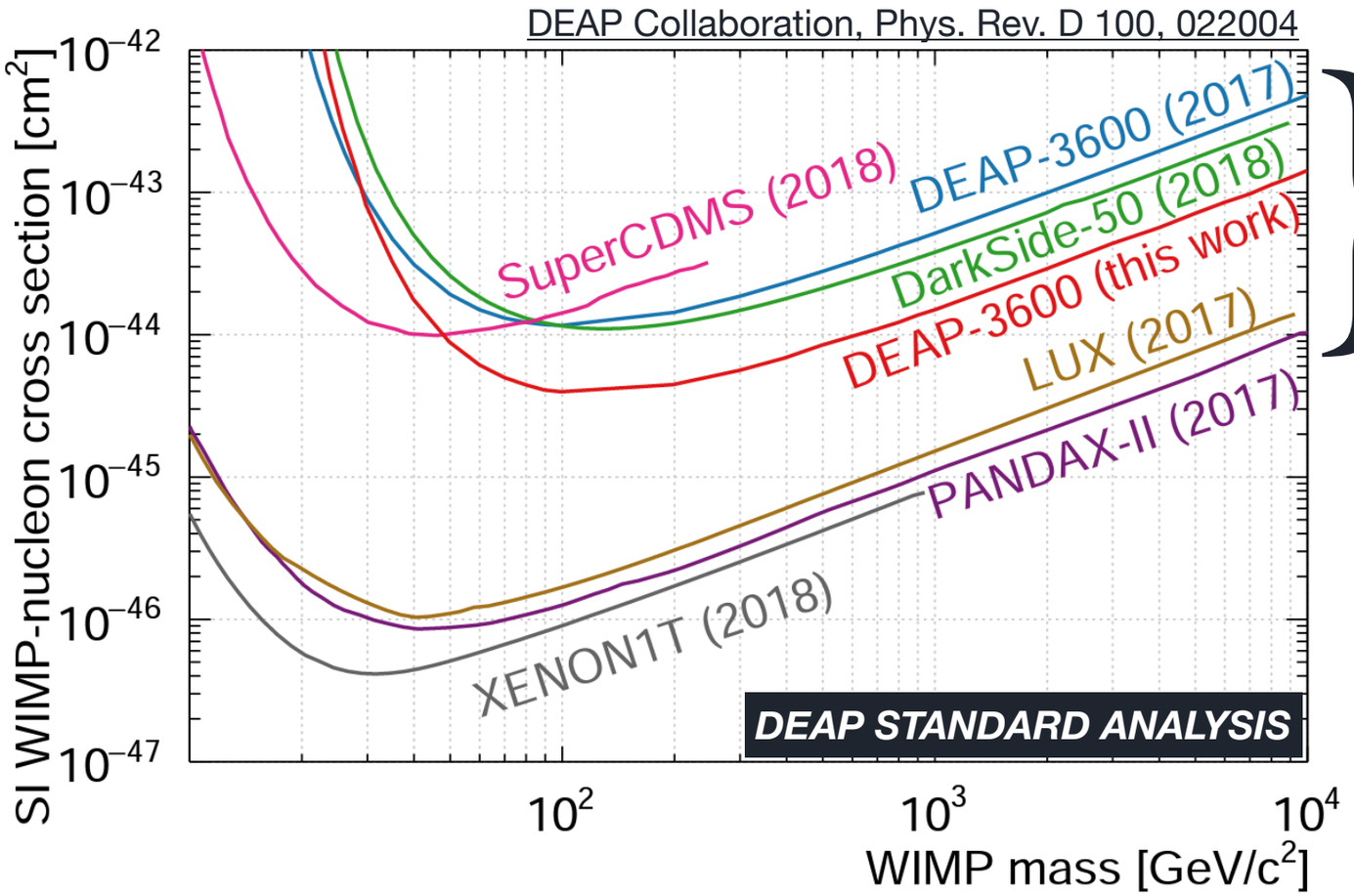
WIMP Searches:
Profile Likelihood Ratio



DEAP sensitivity from 231-day exposure can be improved with PLR and Machine Learning

joseph.mclaughlin.2018@live.rhul.ac.uk

WIMP Searches:
Nonrelativistic Effective Field Theory



All assuming a scalar WIMP-nucleon coupling; i.e. coherent scattering with entire nucleus

A more general non-relativistic effective field theory includes velocity and spin dependent mechanisms

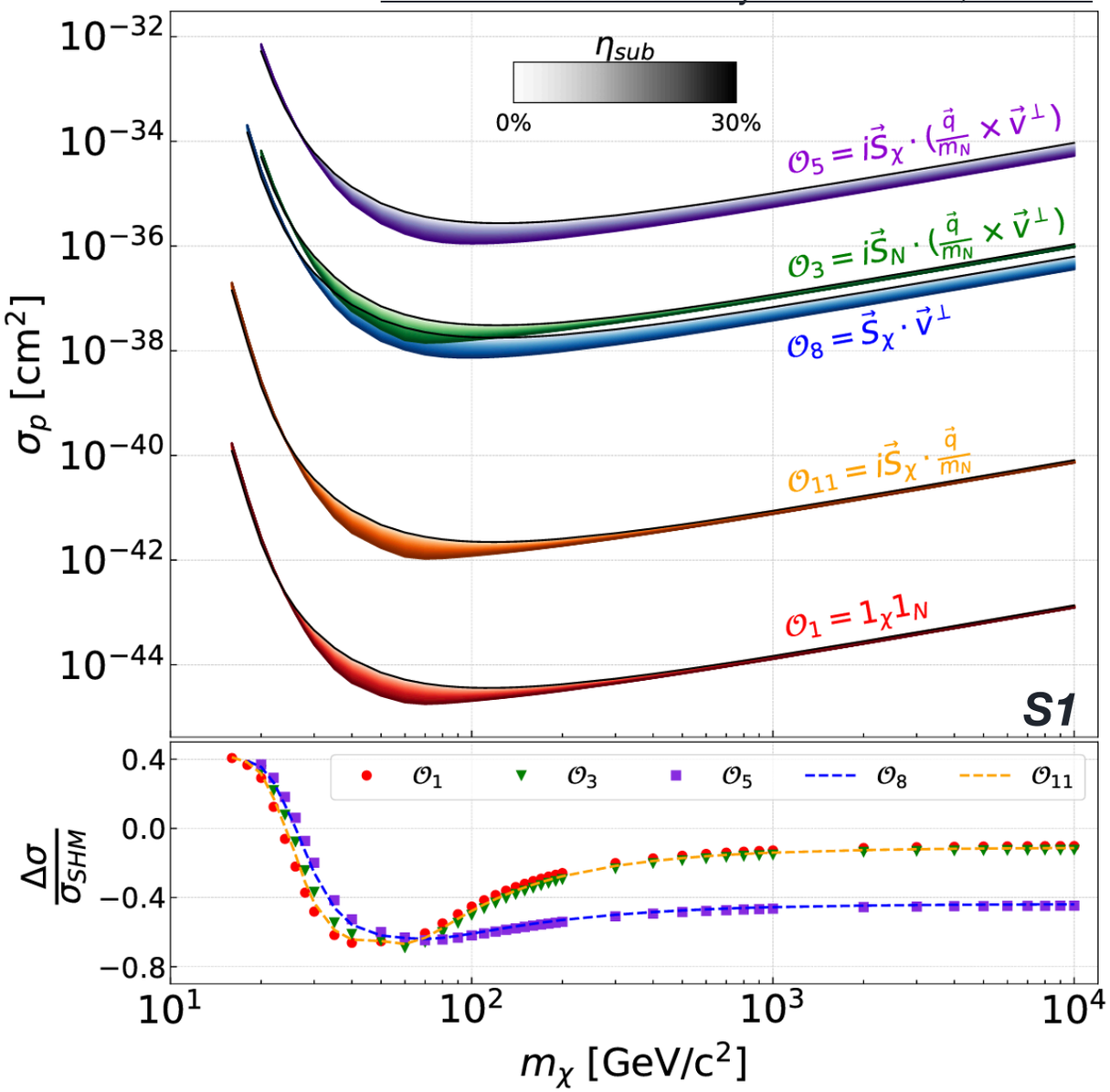
$\mathcal{O}_1$	$1_\chi 1_N$	$\mathcal{O}_{11}$	$iS_\chi \cdot \frac{\vec{q}}{m_N}$
$\mathcal{O}_3$	$iS_N \cdot \left(\frac{\vec{q}}{m_N} \times \vec{v}_\perp\right)$	$\mathcal{O}_{12}$	$\vec{v}_\perp \cdot \left(S_\chi \times S_N\right)$
$\mathcal{O}_5$	$iS_\chi \cdot \left(\frac{\vec{q}}{m_N} \times \vec{v}_\perp\right)$	$\mathcal{O}_{15}$	$-\left(s_\chi \cdot \frac{\vec{q}}{m_N}\right)\left[\left(S_N \times \vec{v}_\perp\right) \cdot \frac{\vec{q}}{m_N}\right]$
$\mathcal{O}_8$	$S_\chi \cdot \vec{v}_\perp$		

joseph.mclaughlin.2018@live.rhul.ac.uk

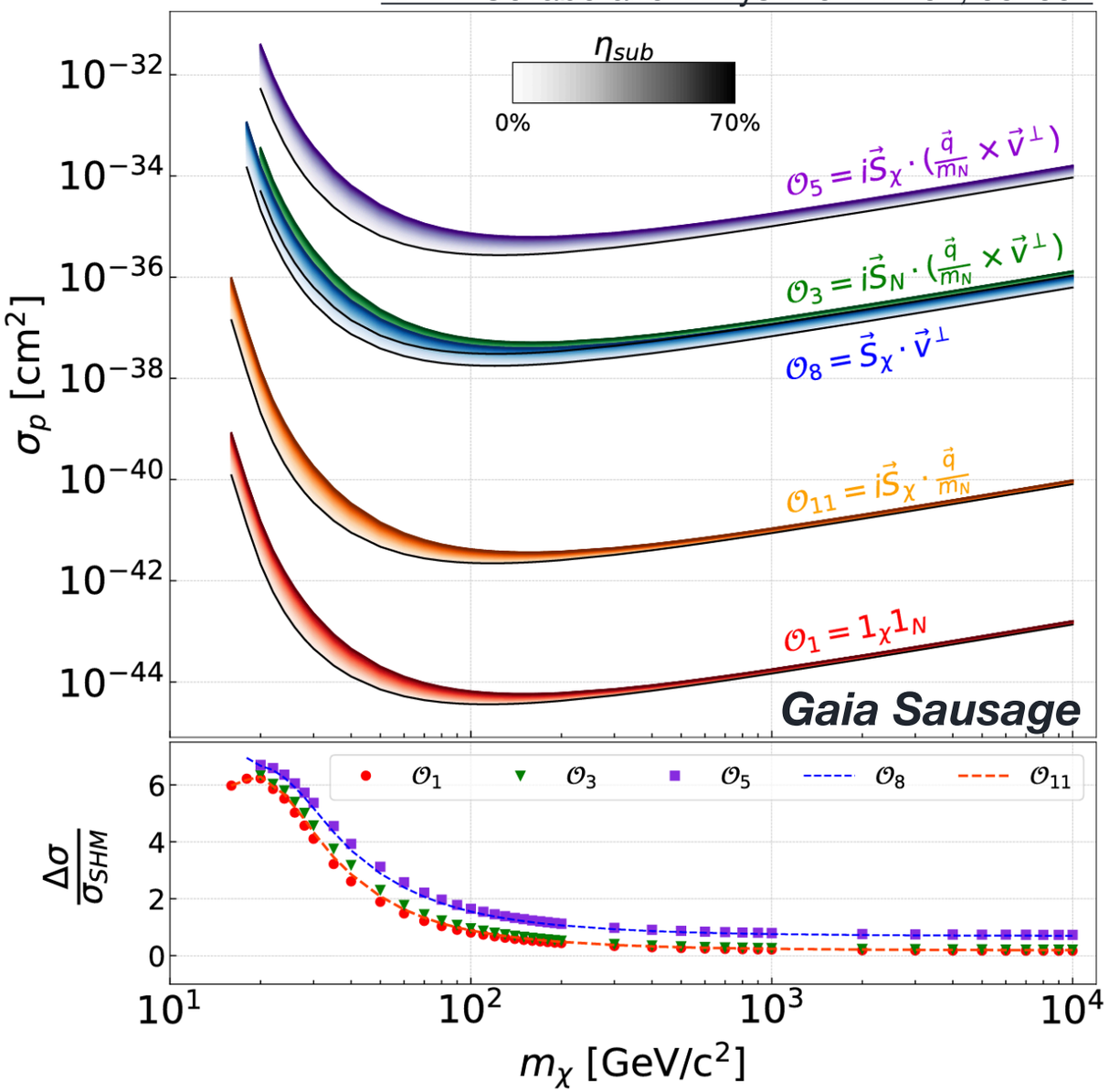
WIMP Searches:
Nonrelativistic Effective Field Theory

ROYAL HOLLOWAY UNIVERSITY OF LONDON

DEAP Collaboration Phys. Rev. D 102, 082001



DEAP Collaboration Phys. Rev. D 102, 082001



- Interactions in generalized NR-EFT explored with various extensions of standard halo model; substructures like S1 retrograde stellar stream and *Gaia* Sausage considered

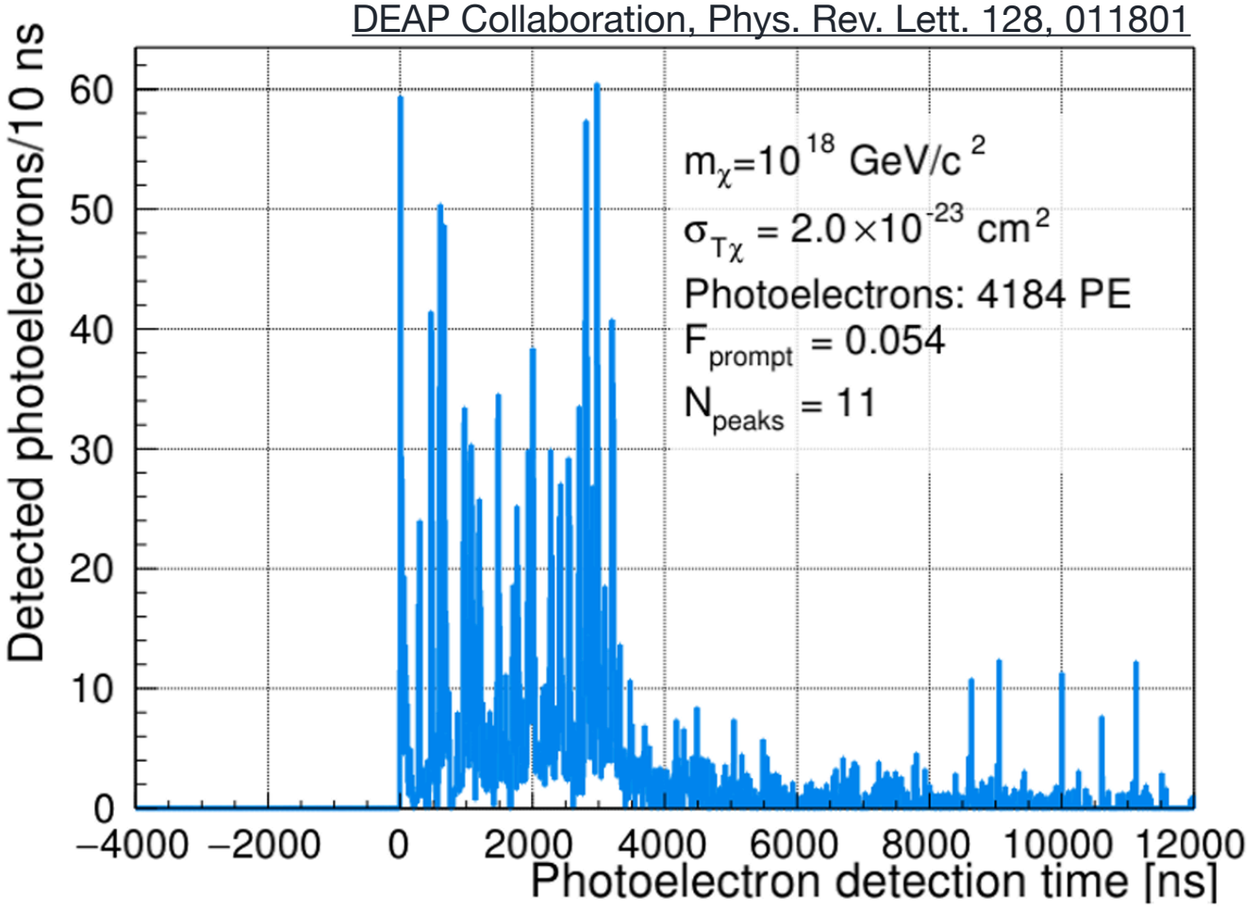
joseph.mclaughlin.2018@live.rhul.ac.uk

Beyond WIMPs:
Planck Scale Dark Matter

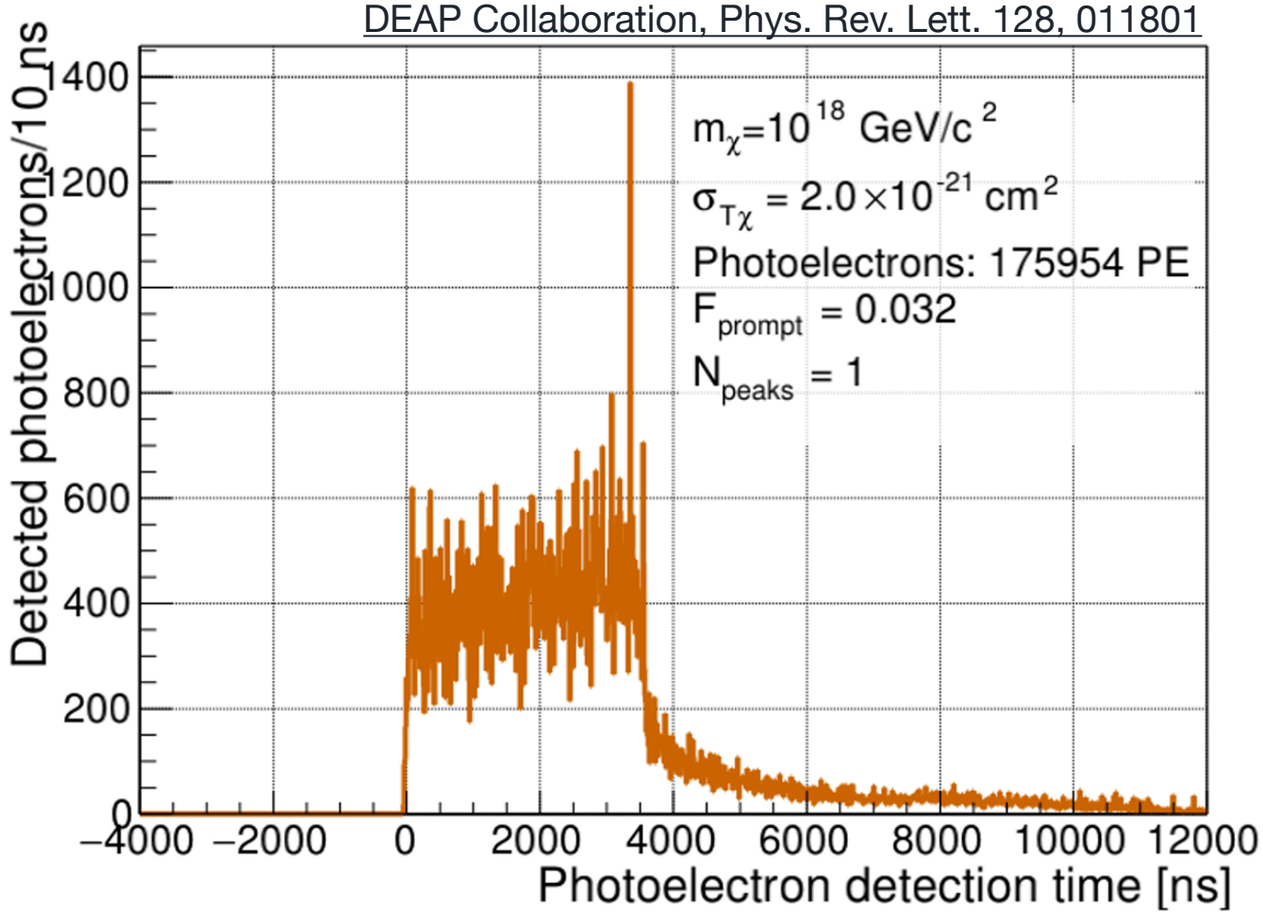
ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Dark matter with Planck scale mass is theoretically well motivated; could have much higher cross-sections than WIMPs and not yet be excluded
- Higher cross-sections → multiply scattering DM, which is usually cut in WIMP searches

DEAP Collaboration, Phys. Rev. Lett. 128, 011801



DEAP Collaboration, Phys. Rev. Lett. 128, 011801

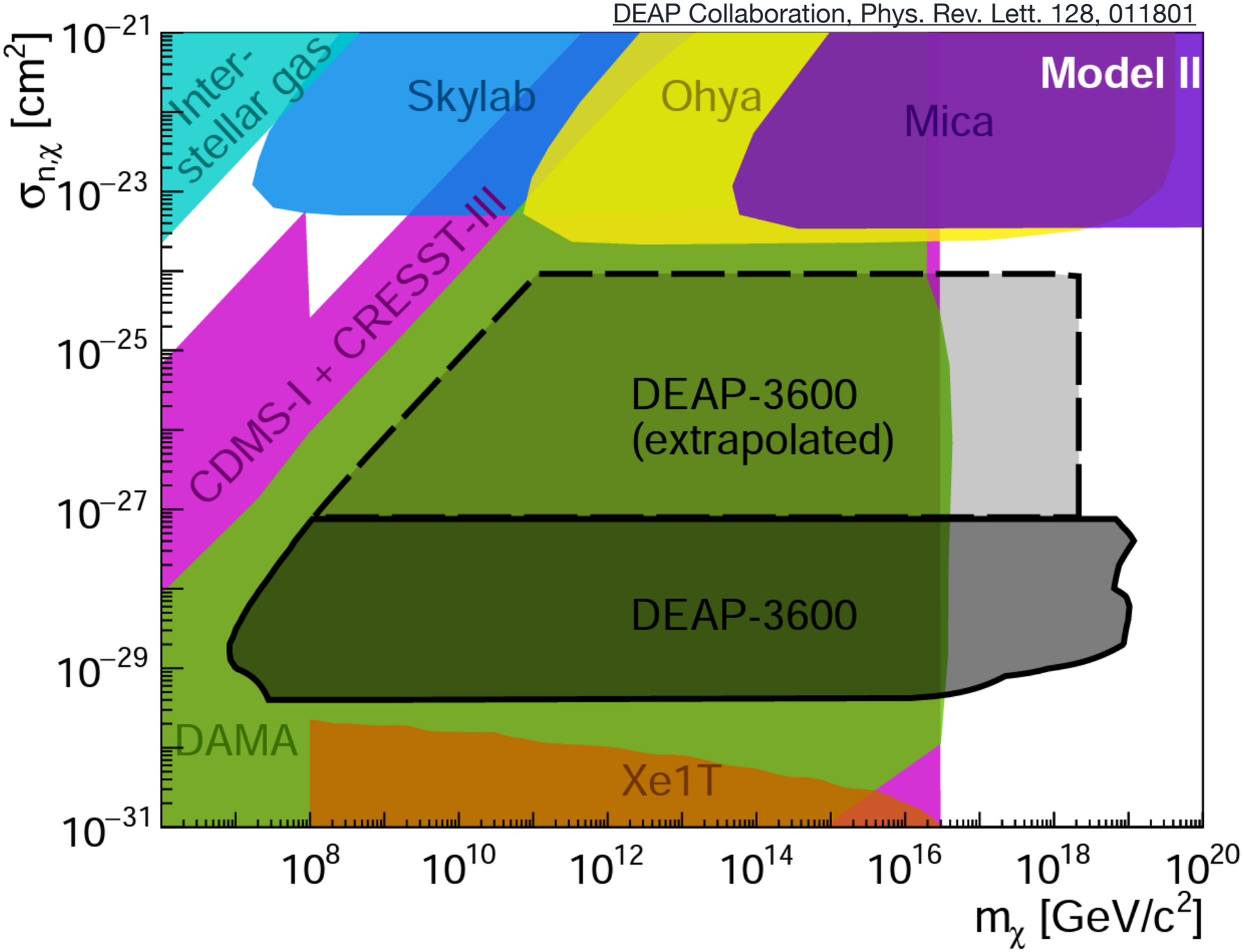


joseph.mclaughlin.2018@live.rhul.ac.uk

Beyond WIMPs:
Planck Scale Dark Matter

ROYAL HOLLOWAY UNIVERSITY OF LONDON

DEAP Collaboration, Phys. Rev. Lett. 128, 011801



First ever direct detection constraint on Planck scale dark matter!

joseph.mclaughlin.2018@live.rhul.ac.uk

In the Pipeline

ROYAL HOLLOWAY UNIVERSITY OF LONDON

^{39}Ar Specific Activity and Half-Life

- Dedicated papers for ^{39}Ar specific activity and half-life measurements in DEAP are currently under collaboration review
- Extra slides available for those interested!

5.5 MeV Solar Axion Search

- Search for axions produced in sun's core via the reaction: $p + {}^{2}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + a$
- Requires precise knowledge of EM backgrounds in MeV range

^{8}B Neutrino Absorption

- DEAP has an active search for inverse beta decay of ^{40}Ar induced by ^{8}B solar neutrinos via $\nu_e + {}^{40}\mathrm{Ar} \rightarrow {}^{40}\mathrm{K}^{*} + e^{-}$
- Currently working on background model for this signal, understanding detector response at high energies (4–18 MeV)

Muon Flux at SNOLAB

- Dedicated group on DEAP working on muon veto instrumentation paper as well as a muon flux measurement at SNOLAB
- Currently validating MC model, developing event selection criteria to eliminate instrumental events, studying systematics

joseph.mclaughlin.2018@live.rhul.ac.uk

Conclusion

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Precise LAr pulse shape measurements contribute to excellent background rejection
  - World leading PSD!
- Competitive dark matter searches spanning 17 orders of magnitude in mass
  - 100 GeV WIMP search extended with NR-EFT
  - Previously unprobed Planck Scale DM parameter space excluded at 10^{19} GeV
- Ongoing analyses aimed at improving sensitivity to WIMPs and other new physics
  - PLR and Machine Learning analyses are well along their way!

joseph.mclaughlin.2018@live.rhul.ac.uk

DEAP Collaboration

ROYAL HOLLOWAY UNIVERSITY OF LONDON

UNIVERSITY OF ALBERTA

ASTROCENT
NICOLAUS COPERNICUS ASTRONOMICAL CENTER OF THE POLISH ACADEMY OF SCIENCES

Canadian Nuclear Laboratories
Laboratoires Nucléaires Canadiens

INFN
Istituto Nazionale di Fisica Nucleare

Carleton UNIVERSITY

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

JOHANNES GUTENBERG UNIVERSITÄT MAINZ · JG|U

IF Instituto de Física

NATIONAL RESEARCH CENTER "KURCHATOV INSTITUTE"

LaurentianUniversity UniversitéLaurentienne

PRINCETON UNIVERSITY

Queen's UNIVERSITY

US University of Sussex

SNOLAB

TRIUMF

Technical University of Munich

Particle Physics Rutherford Appleton Laboratory

joseph.mclaughlin.2018@live.rhul.ac.uk

Grazie per l’attenzione!

ROYAL HOLLOWAY UNIVERSITY OF LONDON

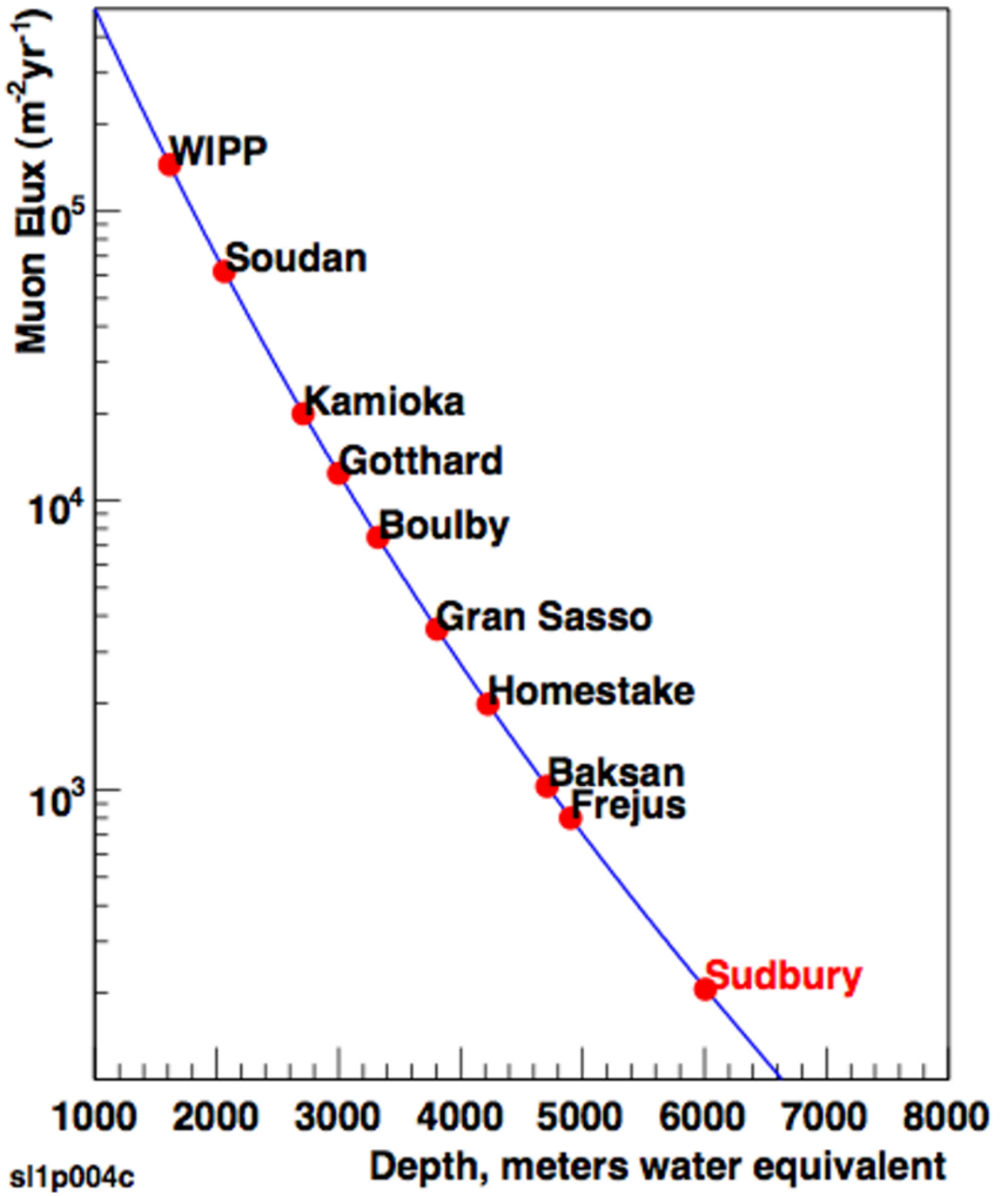
DEAP 3600

joseph.mclaughlin.2018@live.rhul.ac.uk

Extra Slides:
SNOLAB

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Muon Flux = 0.27/m²/day



joseph.mclaughlin.2018@live.rhul.ac.uk

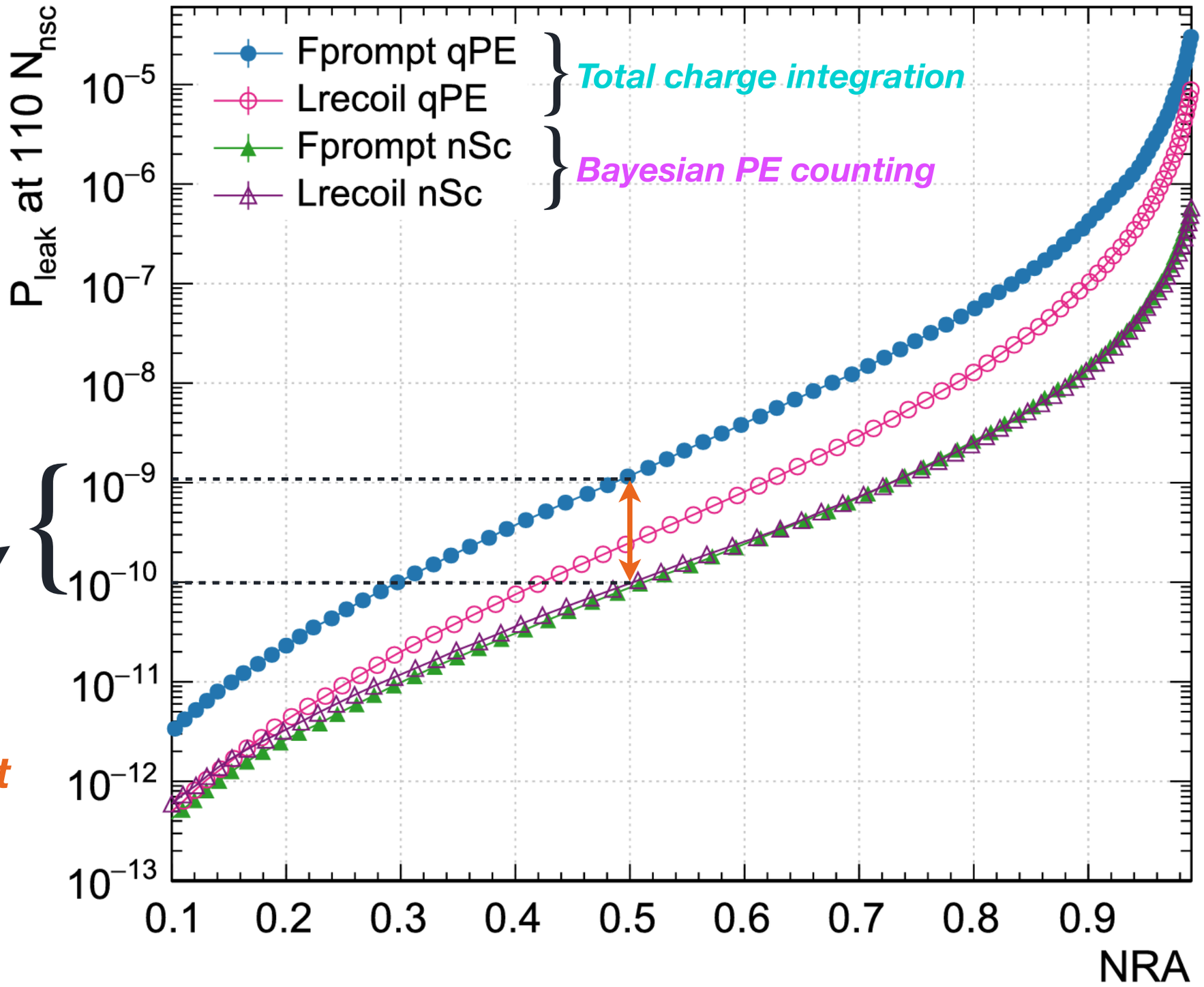
Extra Slides:
^{39}Ar Specific Activity and Half-Life

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- DEAP has two energy estimators and two PSD models, total of four unique algorithms
- Our best algorithms use the Bayesian PE counting estimator

10x reduction of ^{39}Ar leakage from simplest algorithm

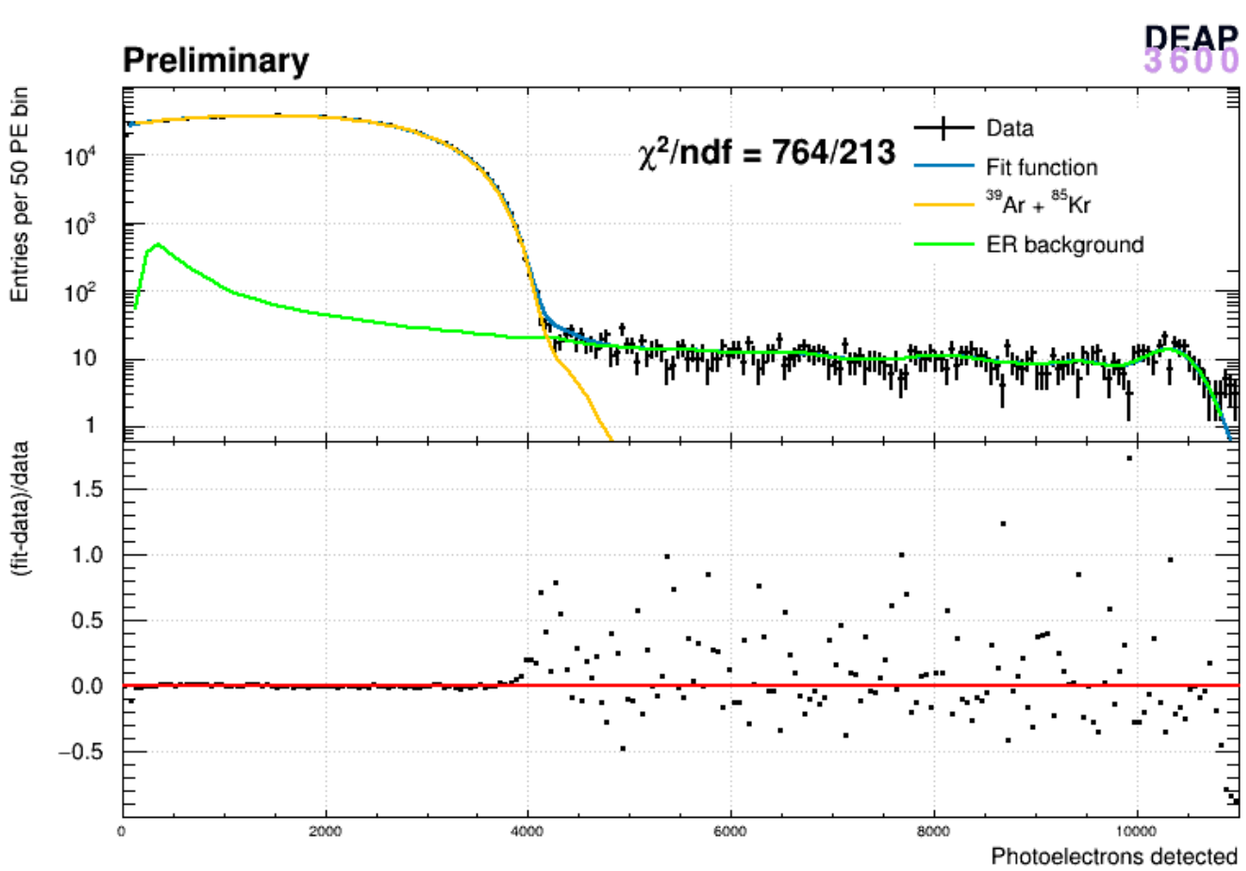
P. Adhikari, et al. Eur. Phys. J. C 81, 823 (2021)

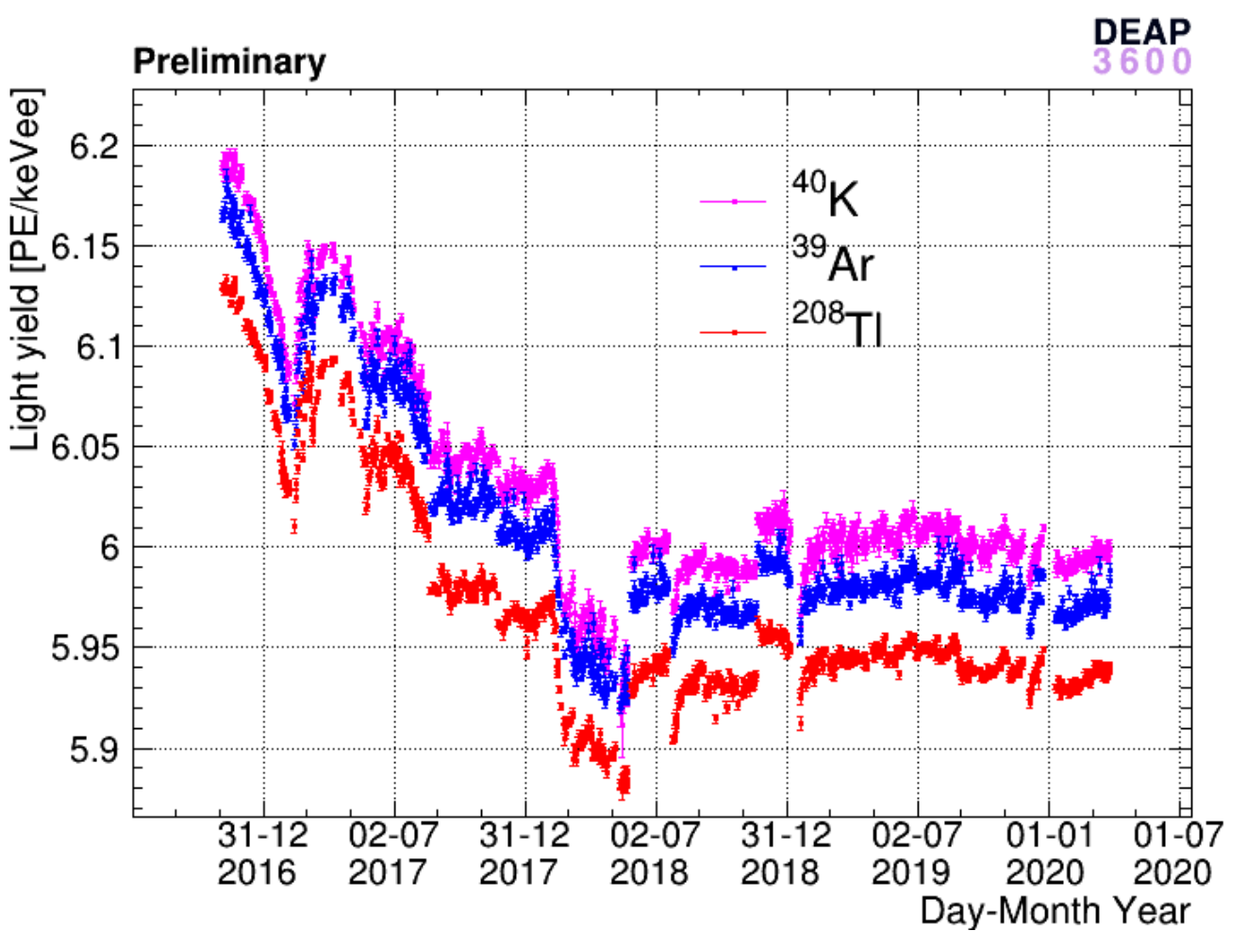


joseph.mclaughlin.2018@live.rhul.ac.uk

Extra Slides:
^{39}Ar Specific Activity and Half-Life

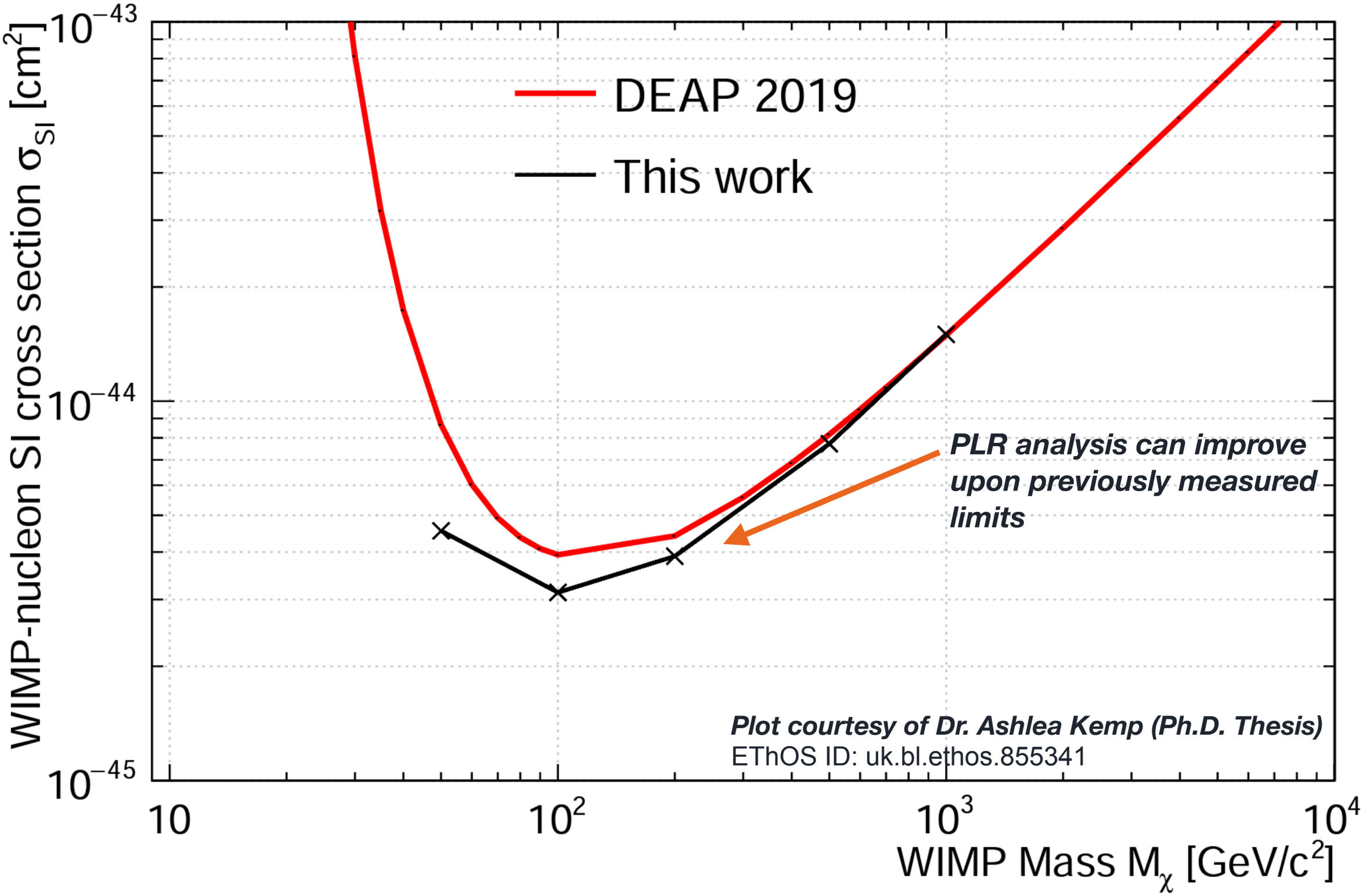
- Dedicated papers for ^{39}Ar specific activity and half-life in DEAP are currently under collaboration review
- low energy beta spectrum model accounts for ^{39}Ar and ^{85}Kr betas, low energy ER band backgrounds, pileup with various other sources
- Drifting of light yield also included in systematic analysis; stable to within ~0.3 PE/keV$_{ee}$





joseph.mclaughlin.2018@live.rhul.ac.uk

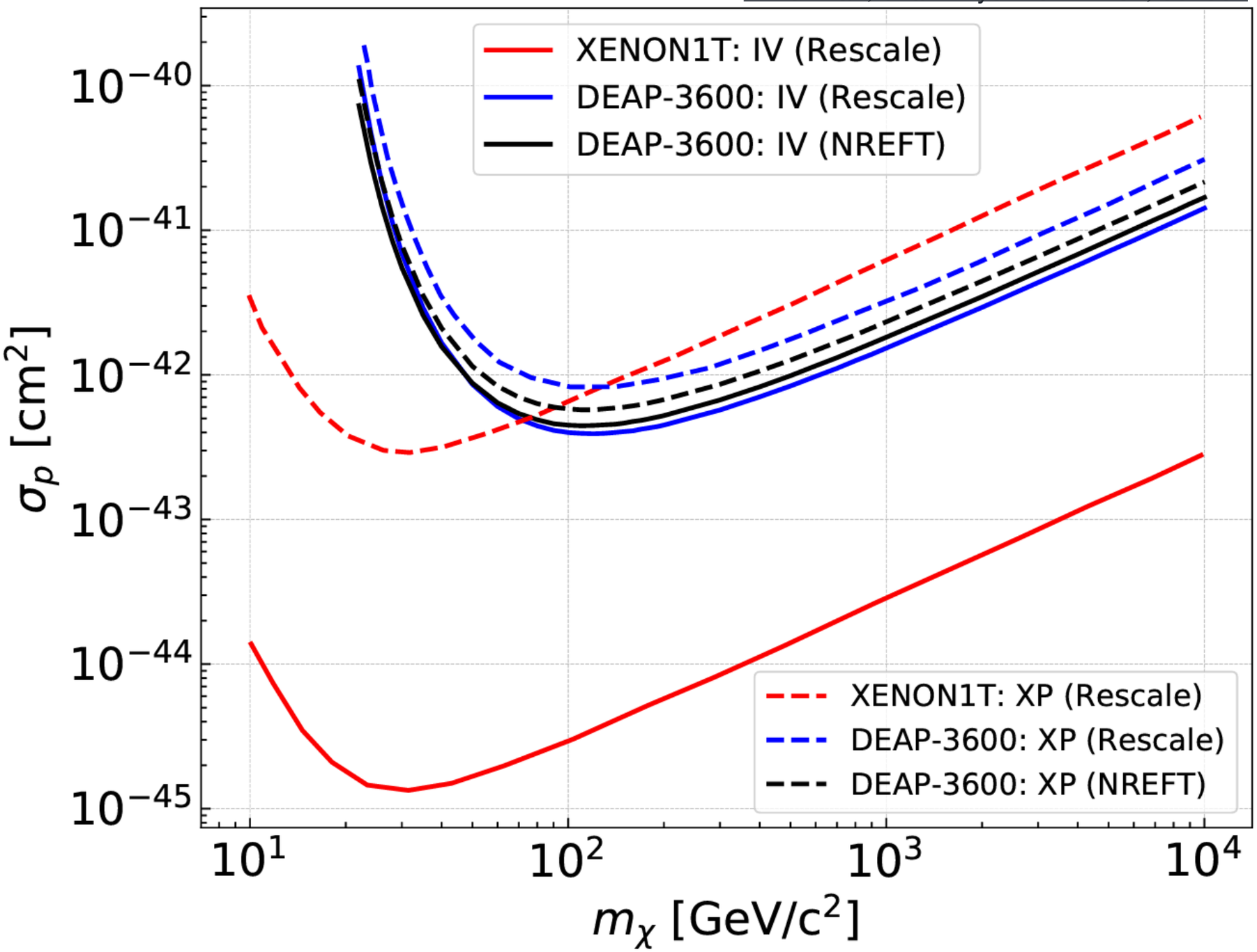
Extra Slides:
Profile Likelihood Ratio



joseph.mclaughlin.2018@live.rhul.ac.uk

Extra Slides:
Xenonphobic WIMPs

P. Adhikari, et al. Phys. Rev. D 102, 082001



- Isospin-violating interactions also considered in NR-EFT framework
- *xenonphobic* (XP) interactions cover a range of isospin-violating models
- DEAP sets world leading limit on these isospin-violating interactions

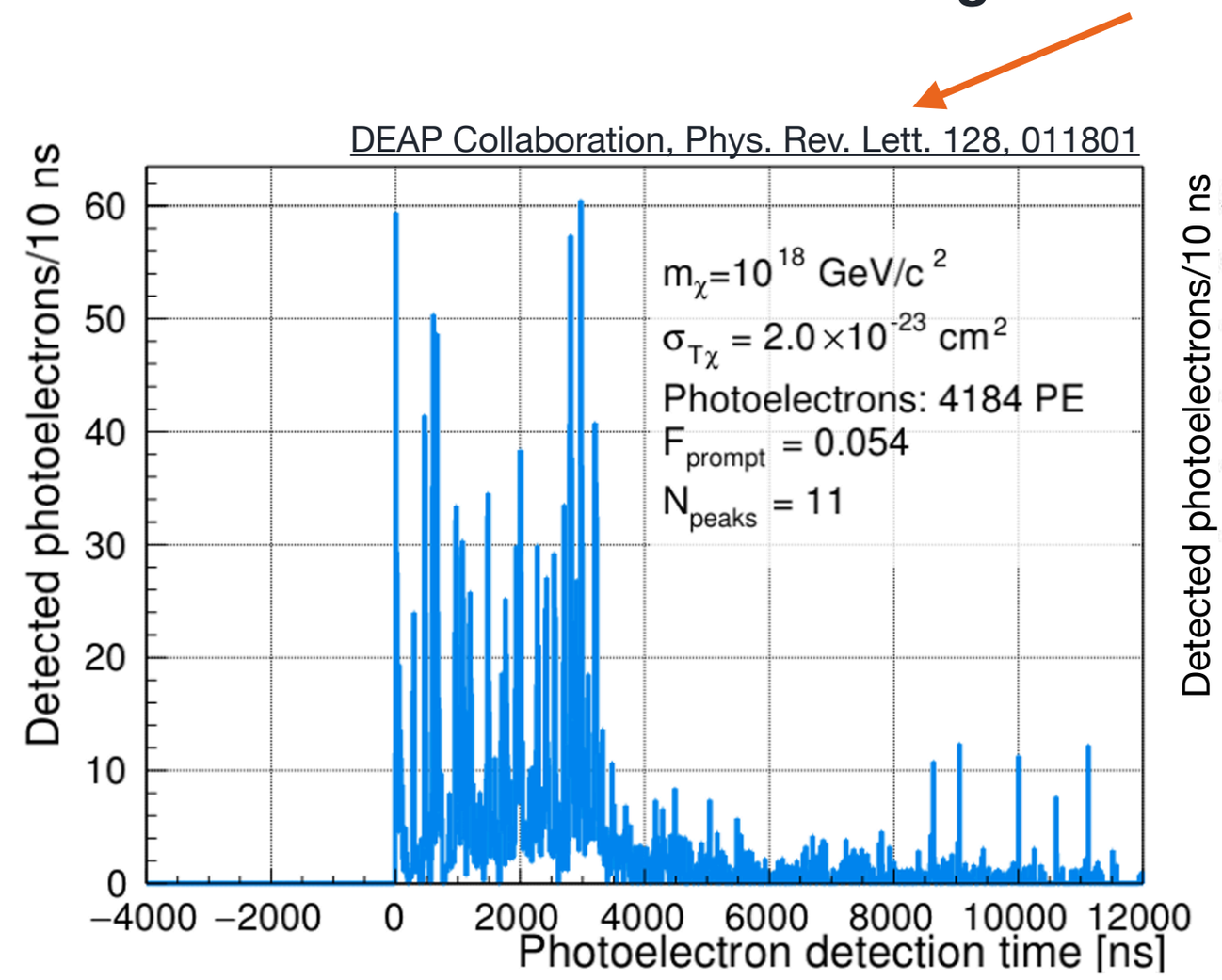
joseph.mclaughlin.2018@live.rhul.ac.uk

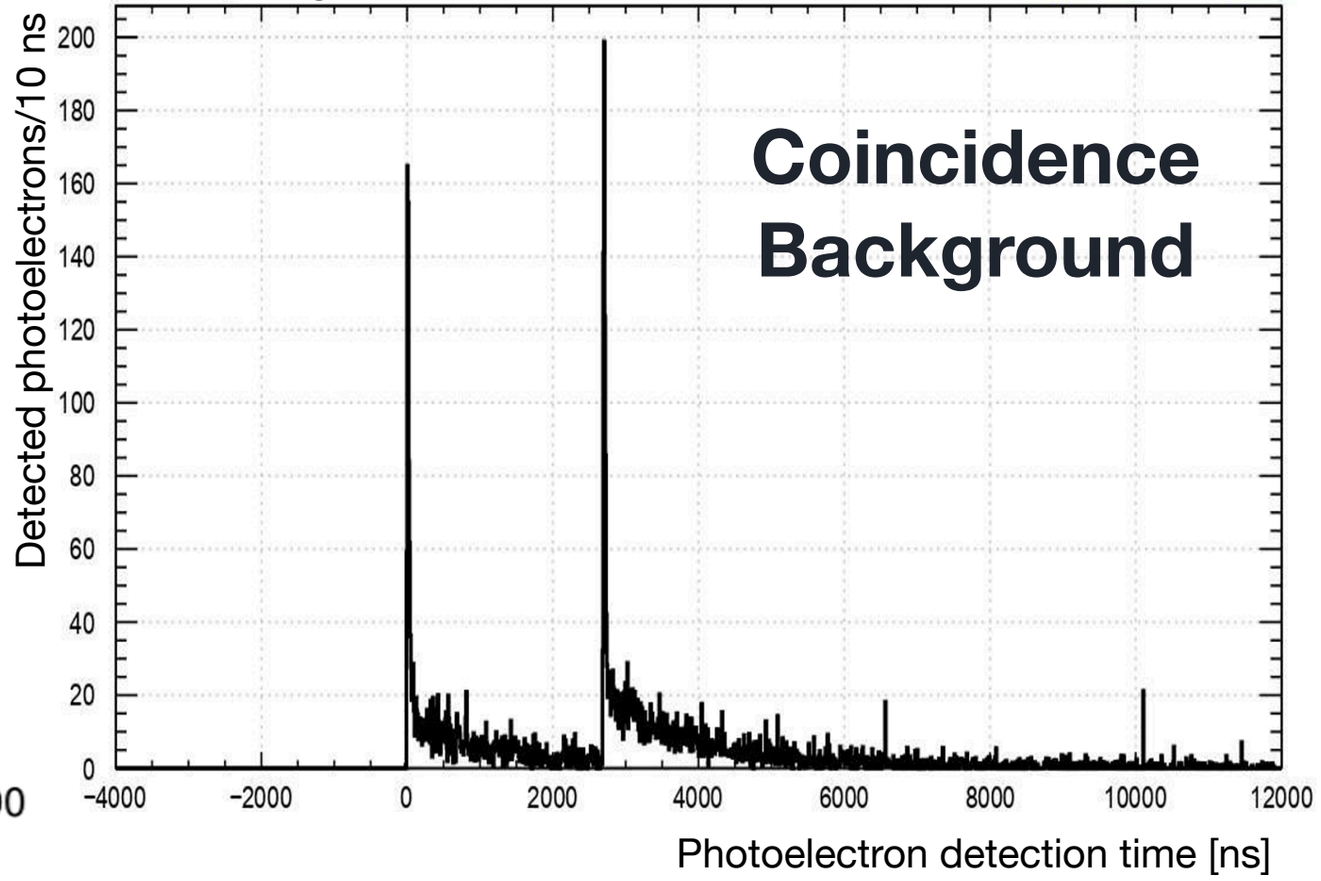
Extra Slides:
Planck Scale Dark Matter

ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Dark matter with Planck scale mass is theoretically well motivated; could have much higher cross-sections than WIMPs and not yet be excluded
- Higher cross-sections → multiply scattering DM, which is usually cut in WIMP searches

Distinguishable from pileup





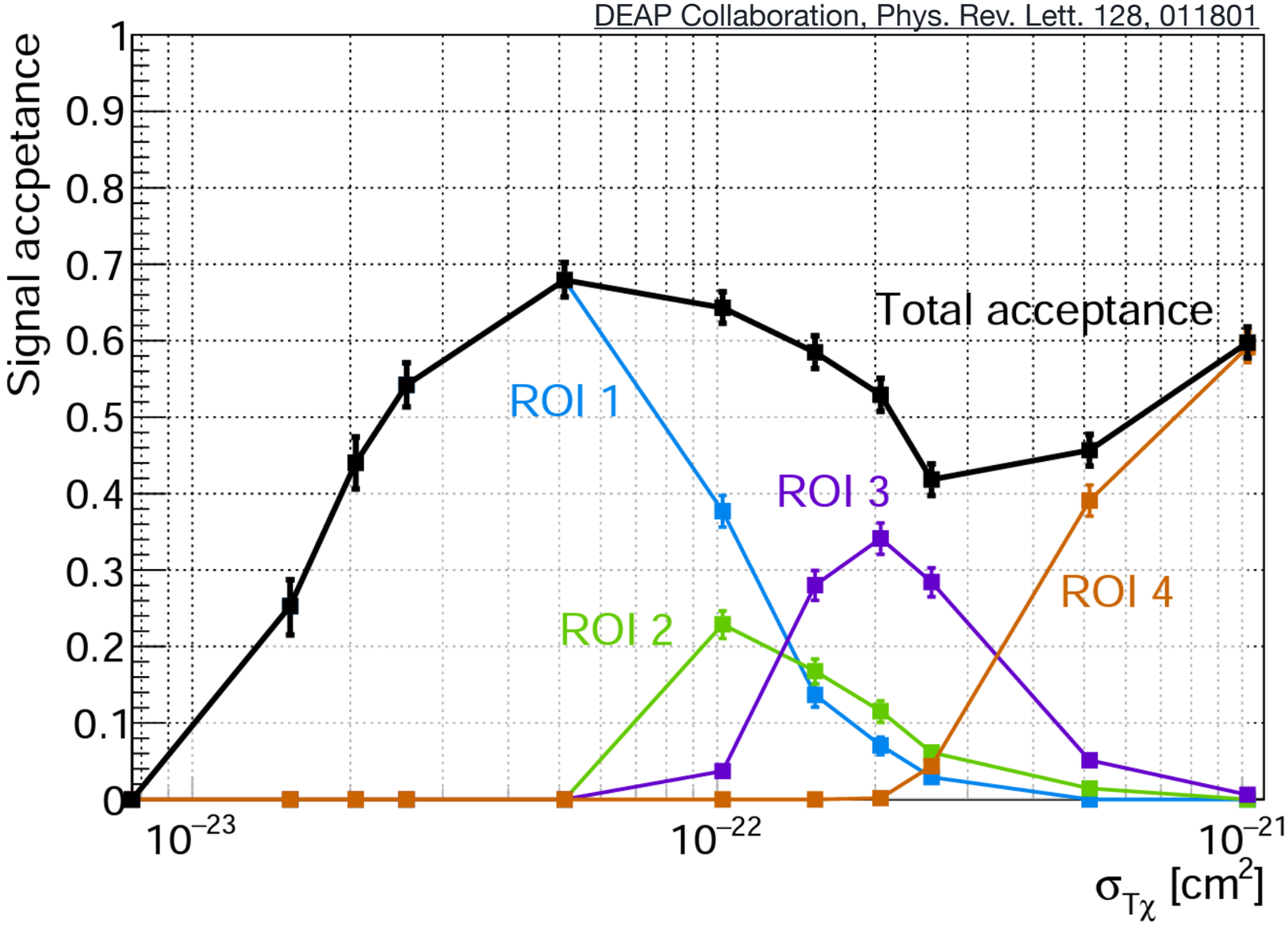
joseph.mclaughlin.2018@live.rhul.ac.uk

Extra Slides:
Planck Scale Dark Matter

ROYAL HOLLOWAY UNIVERSITY OF LONDON

ROI	PE range	Energy [MeV_{ee}]	N^{min}_{peaks}	F^{max}_{prompt}	μ_b	$N_{obs.}$
1	4000–20 000	0.5–2.9	7	0.10	$(4 \pm 3) \times 10^{-2}$	0
2	20 000–30 000	2.9–4.4	5	0.10	$(6 \pm 1) \times 10^{-4}$	0
3	30 000–70 000	4.4–10.4	4	0.10	$(6 \pm 2) \times 10^{-4}$	0
4	70 000–4×10^8	10.4–60 000	0	0.05	$(10 \pm 3) \times 10^{-3}$	0

DEAP Collaboration, Phys. Rev. Lett. 128, 011801



- Look for events with multiple peaks and/or very low F_{prompt}
- Defined 4 ROIs with high signal acceptance
- Backgrounds in these ROIs are negligible; $\ll 1$ event in 813 live days

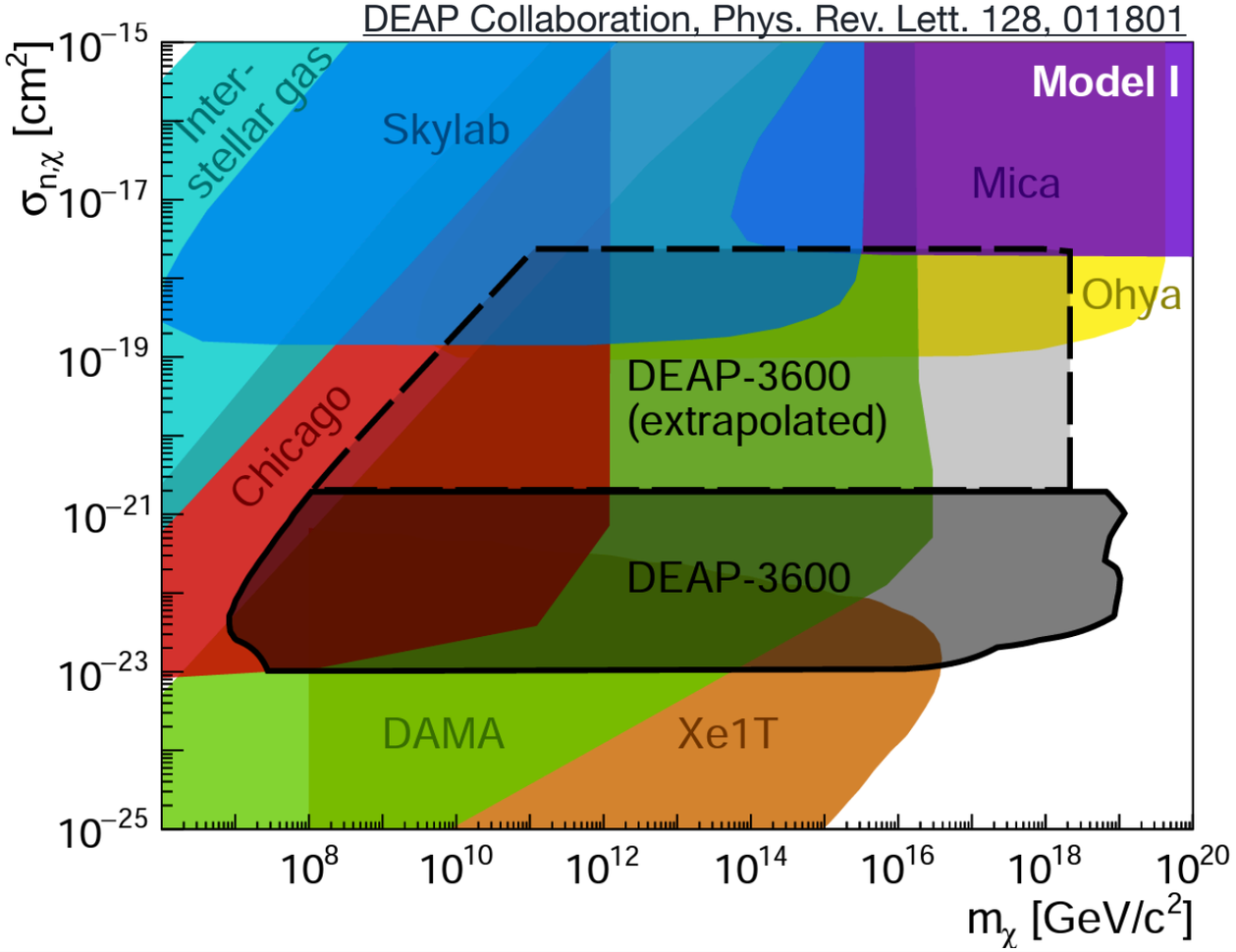
joseph.mclaughlin.2018@live.rhul.ac.uk

Extra Slides:
Planck Scale Dark Matter

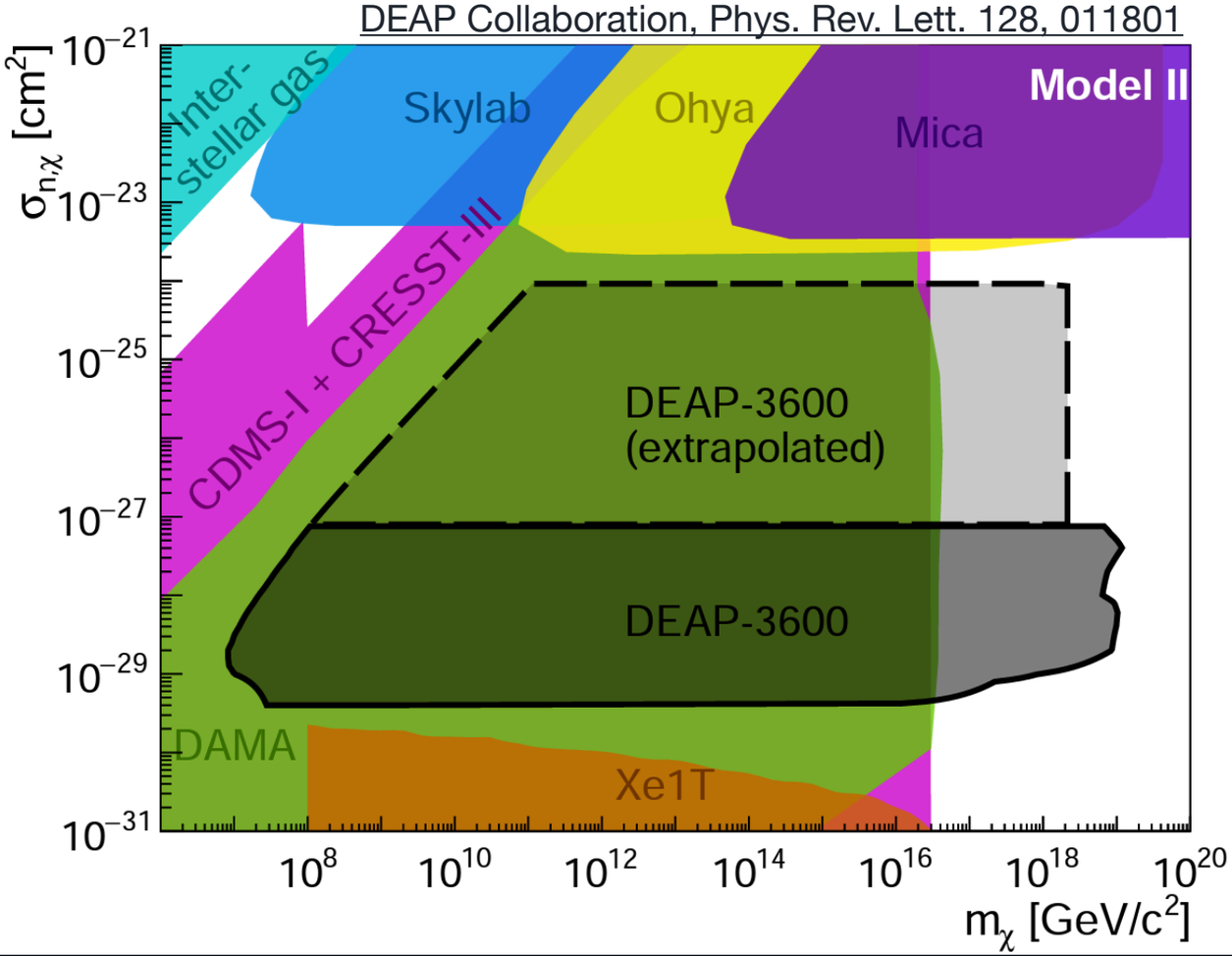
ROYAL HOLLOWAY UNIVERSITY OF LONDON

- Model I considers the case where: $\frac{d\sigma_{T\chi}}{dE_R} = \frac{d\sigma_{n\chi}}{dE_R} |F_T(q)|^2$
- Model II considers the case where: $\frac{d\sigma_{T\chi}}{dE_R} \approx \frac{d\sigma_{n\chi}}{dE_R} A^4 |F_T(q)|^2$
- DEAP sets new world leading constraints for Planck Scale DM in both scenarios

DEAP Collaboration, Phys. Rev. Lett. 128, 011801



DEAP Collaboration, Phys. Rev. Lett. 128, 011801



joseph.mclaughlin.2018@live.rhul.ac.uk