European Spallation Source: the future of Coherent ν Scattering

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In collaboration with P. Coloma, M.C. Gonzalez-Garcia, J. Collar, P. Ferrario, J.J. Gomez-Cadenas, F. Monrabal and others
Based on `arXiv:1911.00762` *[see also* `arXiv:1911.09109`*]*

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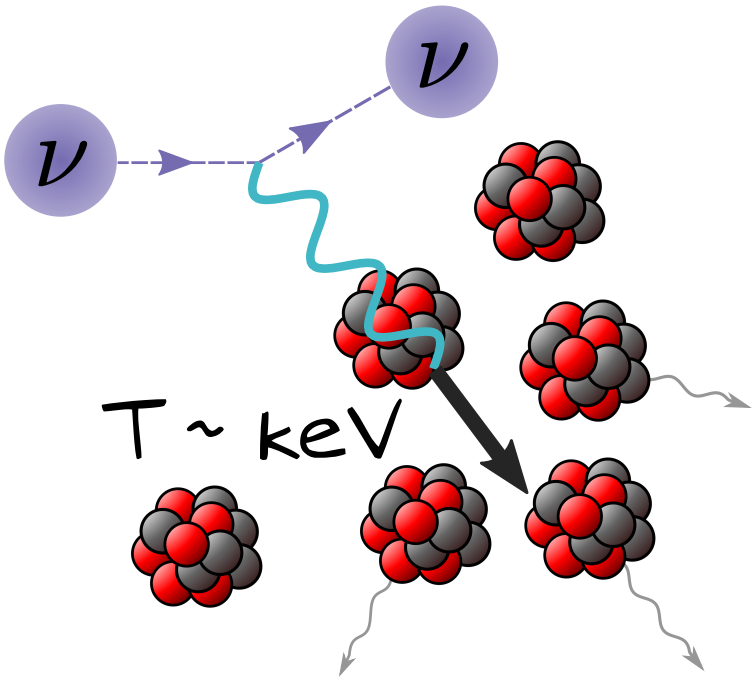
Coherent Elastic νeutrino Nucleus Scattering

- CEνNS has the largest ν cross section at low energies, as ν interacts with *the whole* nucleus.
- Very small nuclear recoils made it challenging to detect, *until recently!*



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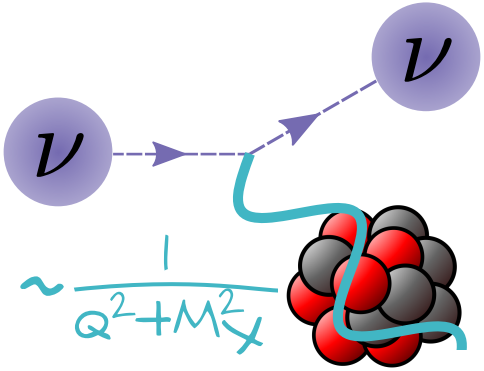
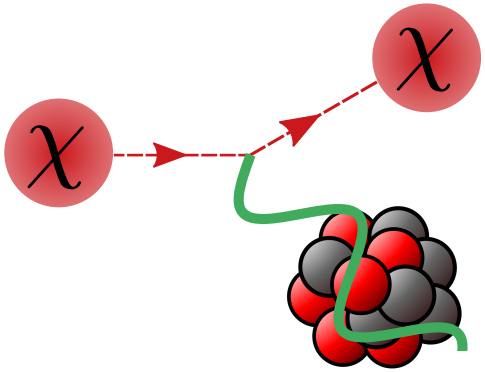
A very rich physics programme

New (light) forces



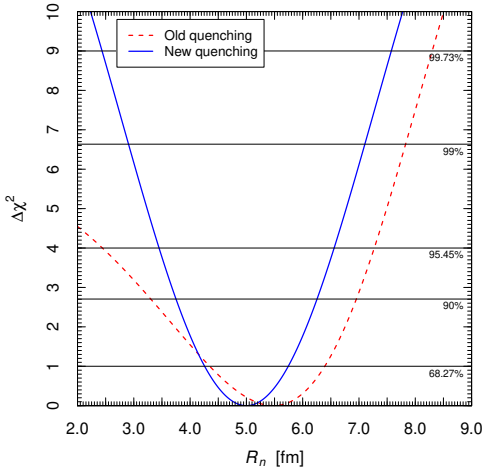
Barranco, Miranda, Rashba, hep-ph/0508299

Dark Matter



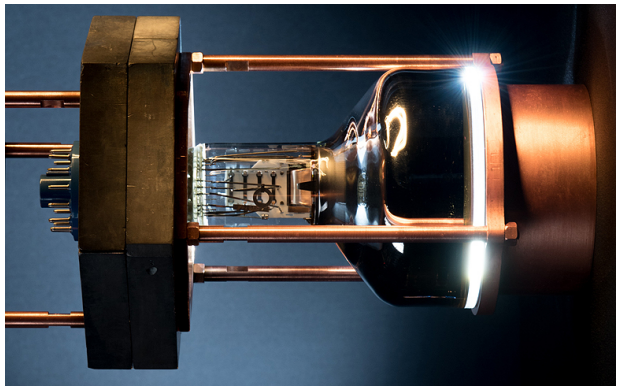
deNiverville, Pospelov, Ritz, arXiv:1505.07805

Nuclear properties



Cadeddu, Giunti, Li, Zhang, arXiv:1710.02730

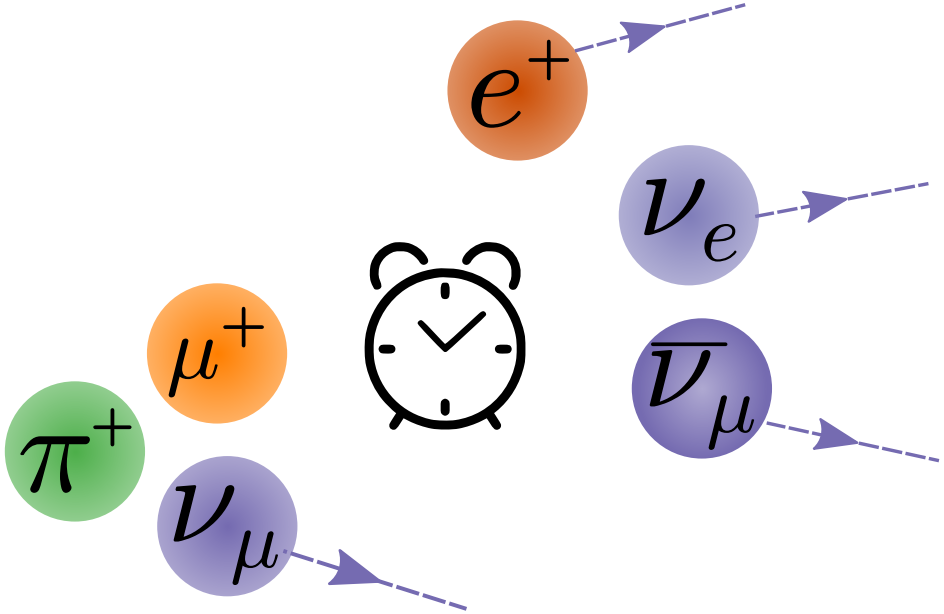
Detector miniaturization

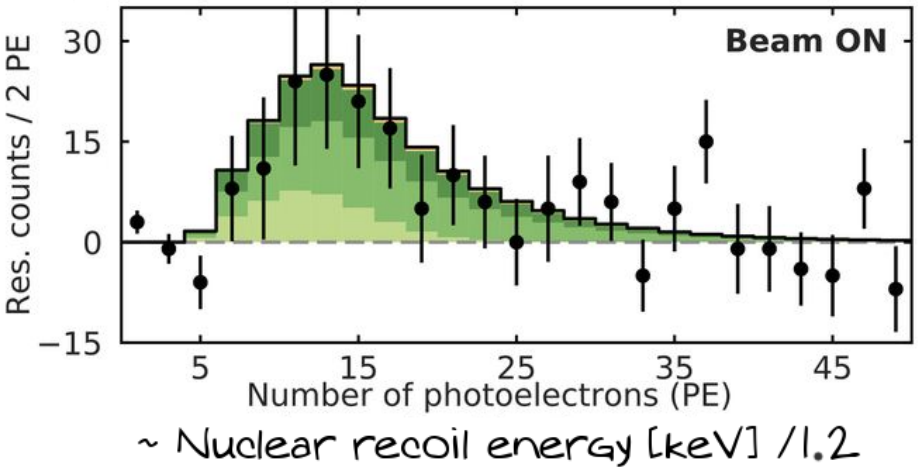


COHERENT Collaboration, arXiv:1708.01294

...

Still statistics-limited





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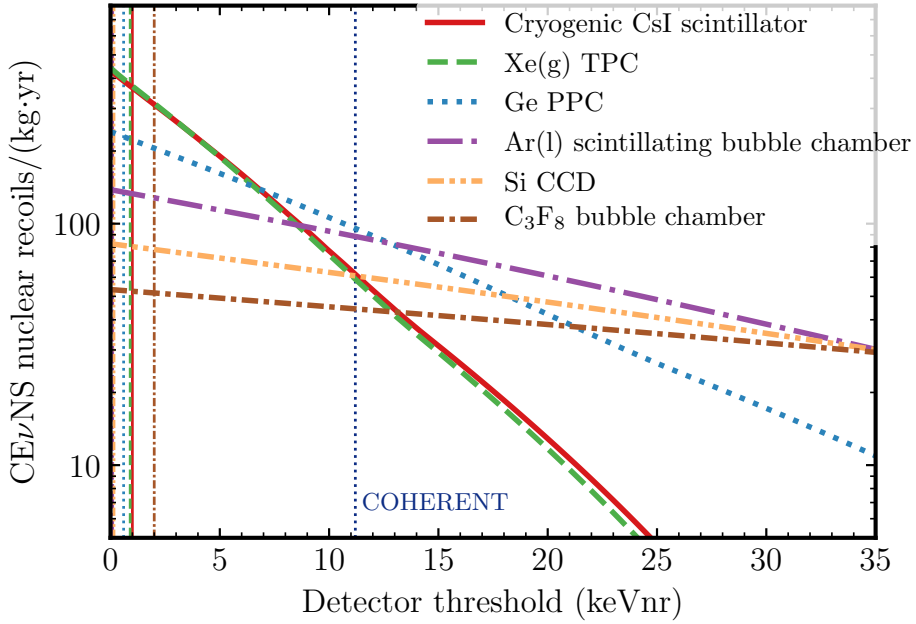
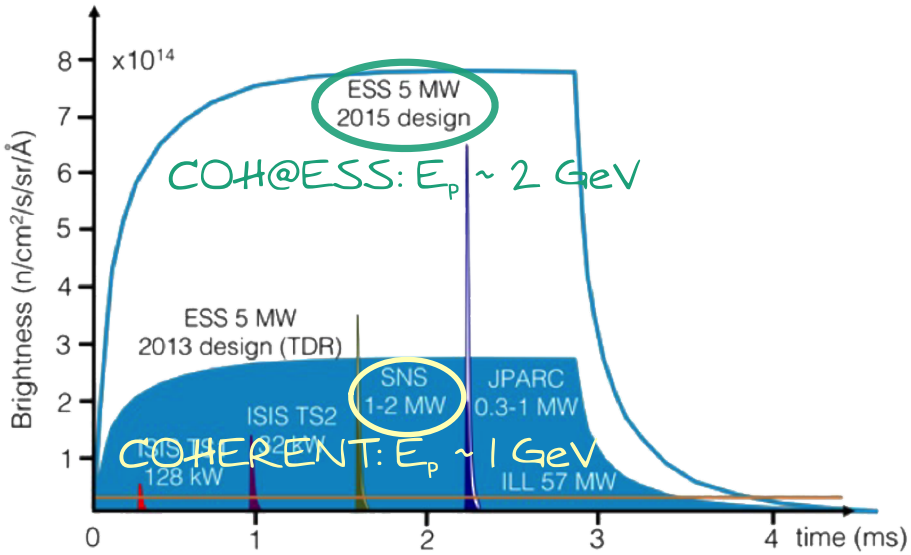
Overcoming the statistics frontier

Low threshold, state-of-the-art detectors



Large neutrino flux: **ESS**



Online $\sim$ 2023

$\sim$ 1 order of magnitude more νs!

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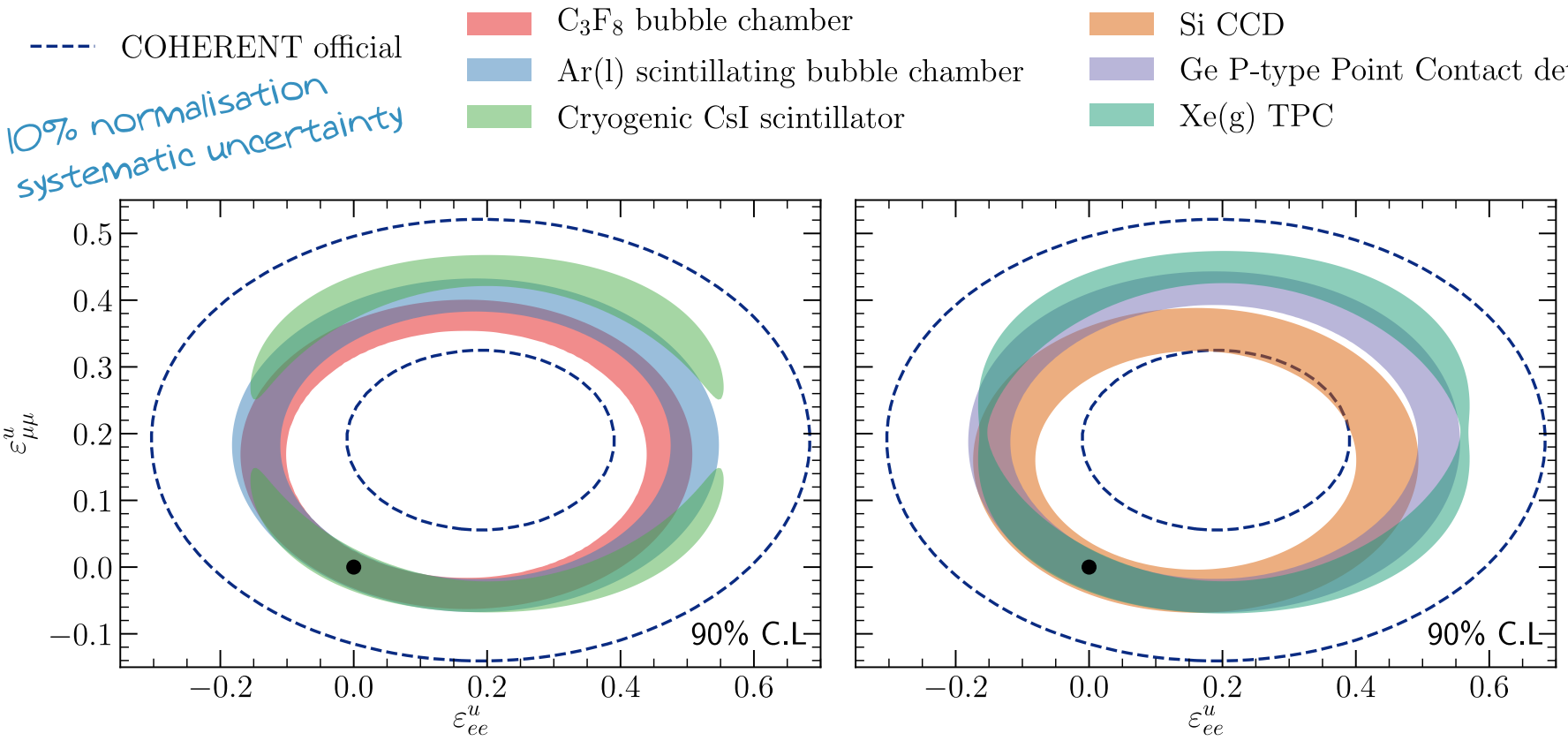
Sensitivity to Non-Standard Interactions after 3 years

$$\mathcal{L}_{\text{NSI, NC}} = 2\sqrt{2}G_F \sum_{\alpha\beta} \varepsilon^u_{\alpha\beta} \left(\bar{\nu}_\alpha \gamma_\mu P_L \nu_\beta\right)\left(\bar{u}\gamma^\mu u\right) + \text{h.c.}$$

$\varepsilon \sim 10^9 \text{MeV}^2 \frac{g^2}{M_X^2}$



Conclusions

- CEνNS is a leading channel in the ν **intensity frontier**.
- In addition to detector miniaturization, it is sensitive to a plethora of light new physics scenarios.
- Currently, COHERENT is statistics-limited.
- The statistics frontier can be overcome with a combination of a large neutrino flux + low threshold detectors.
- **ESS** can achieve both in $\sim$ 2023. Initial inquiries to the ESS team indicate available, properly shielded space.
- For more information (e.g., flavour discrimination) + caveats in current COHERENT analysis, **come to my poster!**
- Stay tuned!

Thanks!

Cross section: some formulae

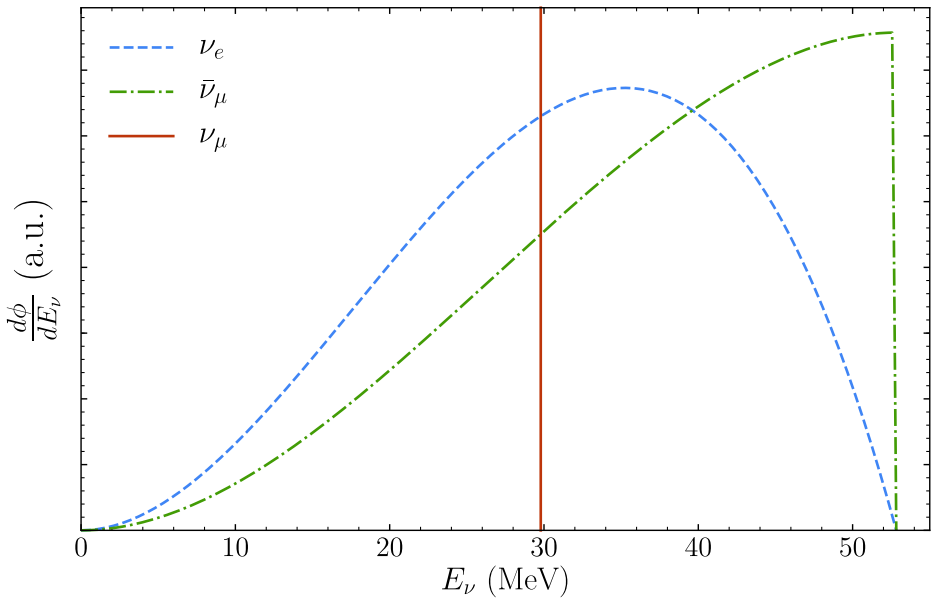
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\,T_{\mathrm{nuc}}} = \left[\frac{G_F^2}{2\pi}\frac{\mathcal{Q}_W^2(Z,N)}{4}\right] M_{\mathrm{nuc}} F^2(Q^2)\left(2 - \frac{Q^2}{2E_\nu^2}\right)$$

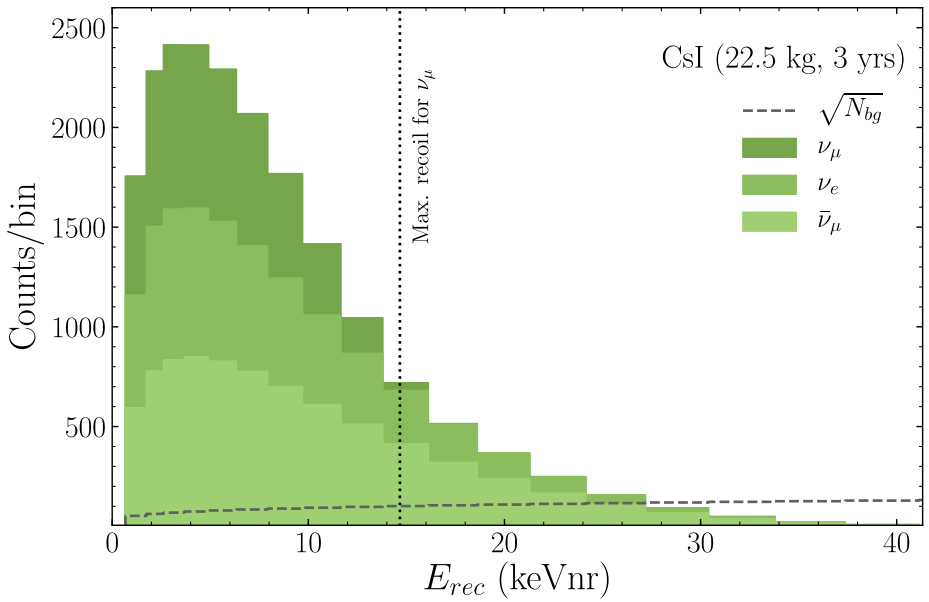
$$Q^2 = 2M_{\mathrm{nuc}}\,T_{\mathrm{nuc}}$$

$$T_{\mathrm{max}} = \frac{2E_\nu^2}{M_{\mathrm{nuc}}}$$

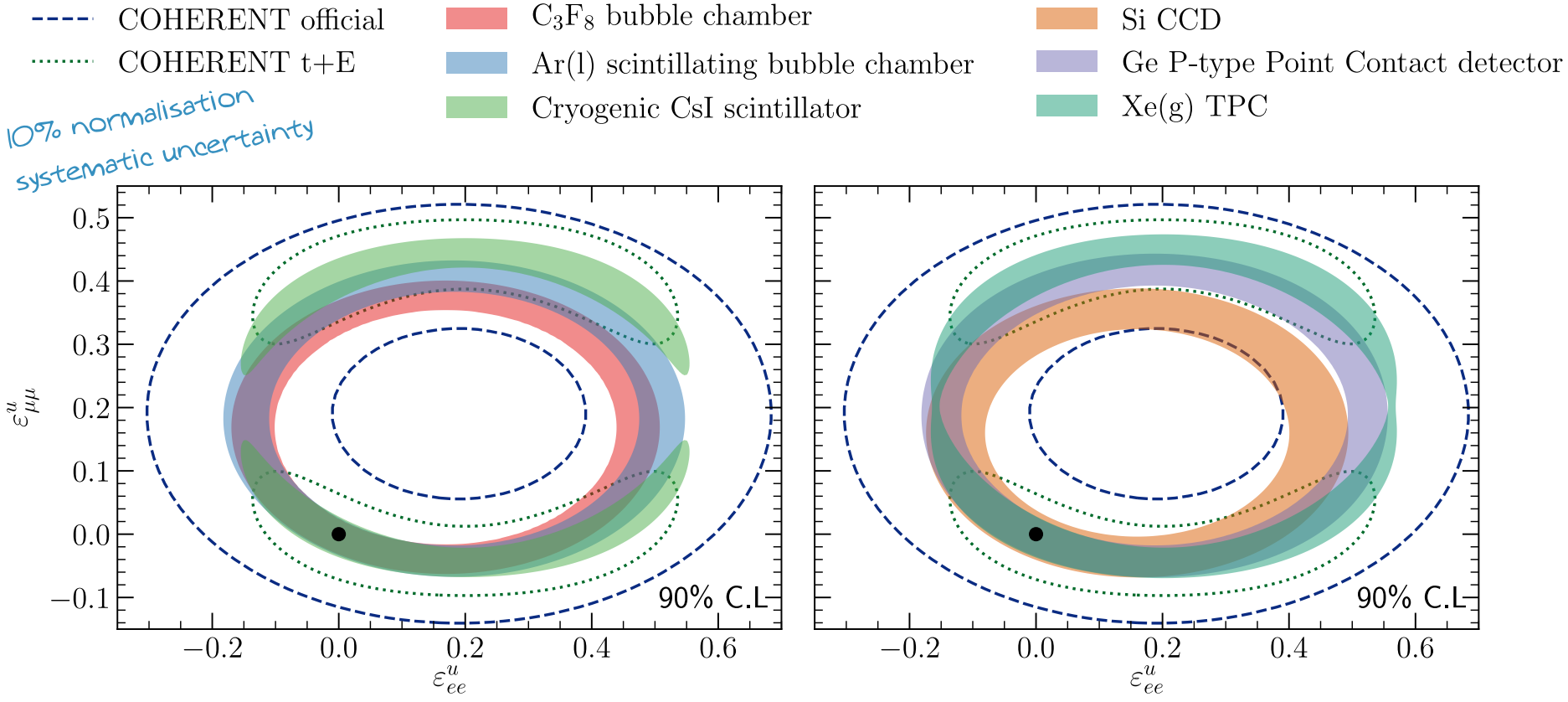
COH@ESS: flavour discrimination

- ESS long pulse spoils flavour discrimination through timing
- Very large statistics might permit *kinematic* discrimination



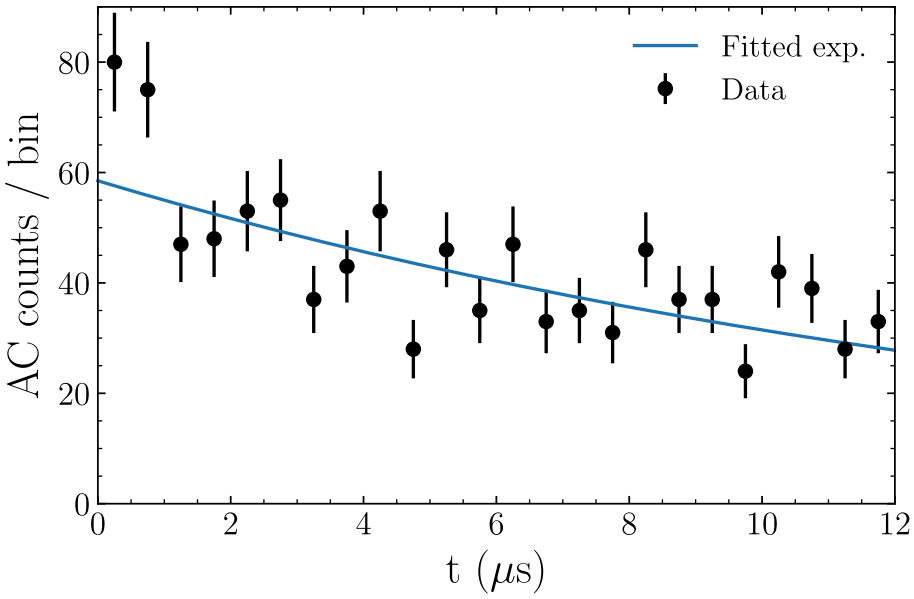


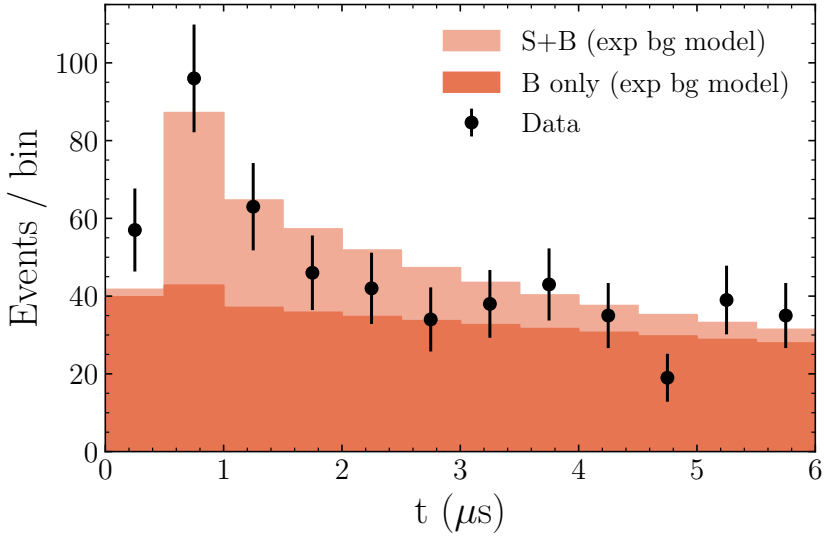
COHERENT t+E

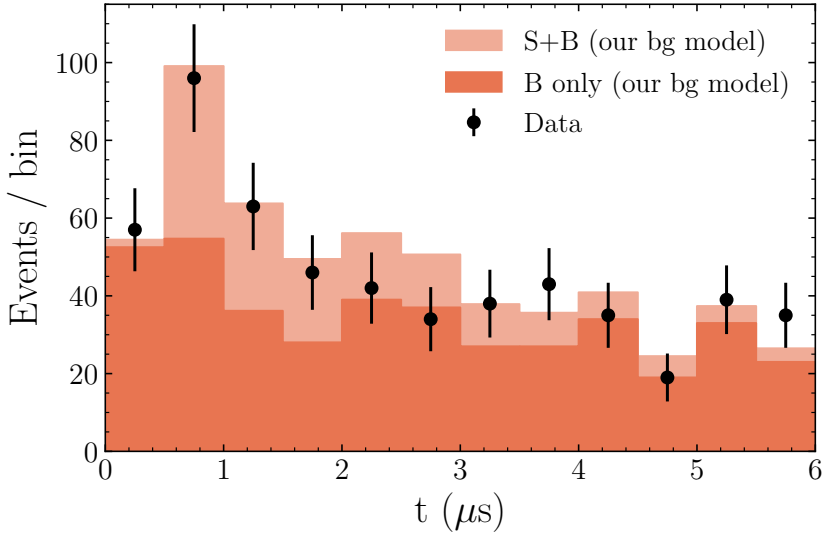

COHERENT official
COHERENT t+E
C_3F_8 bubble chamber
Ar(l) scintillating bubble chamber
Cryogenic CsI scintillator
Si CCD
Ge P-type Point Contact detector
Xe(g) TPC
10% normalisation
systematic uncertainty
$\varepsilon^u_{\mu\mu}$
ε^u_{ee}
90% C.L
90% C.L

COHERENT binned analysis: caveats

Background time-modelling







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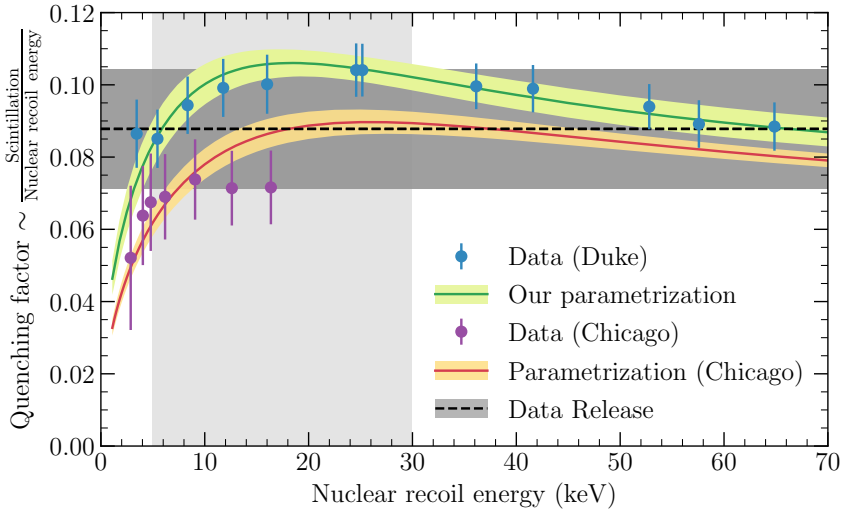
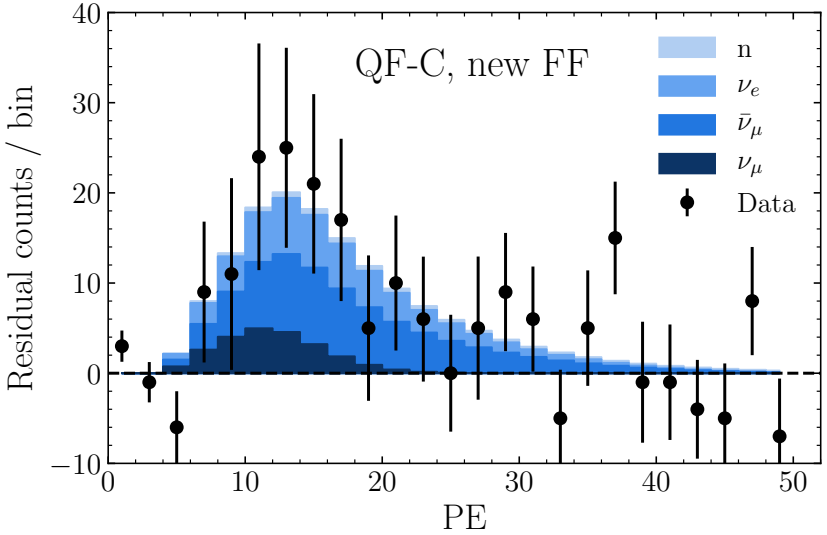
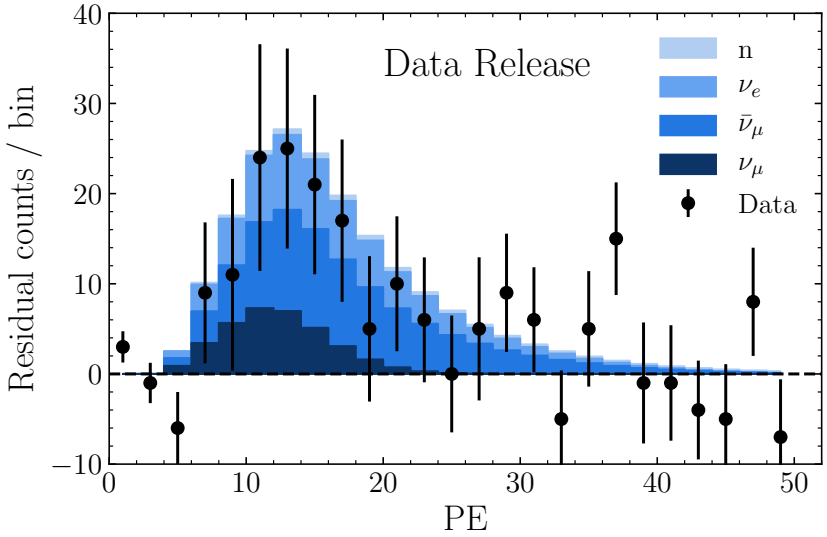
COHERENT binned analysis: caveats

Energy modelling







Backup

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