First Measurement of CEvNS on a Liquid Argon Target from the COHERENT Collaboration

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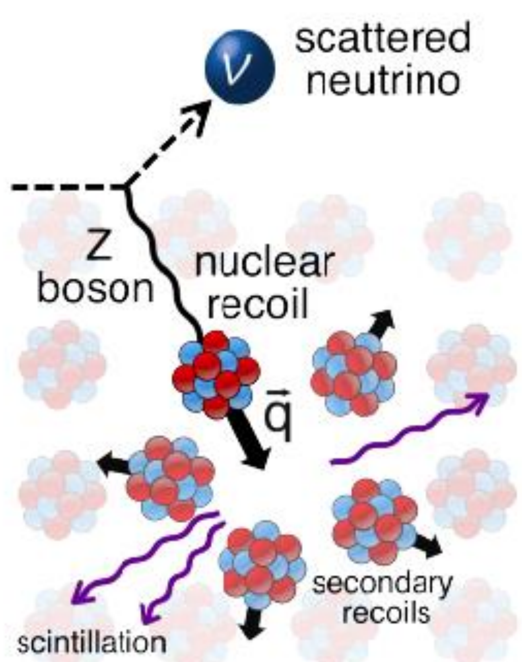
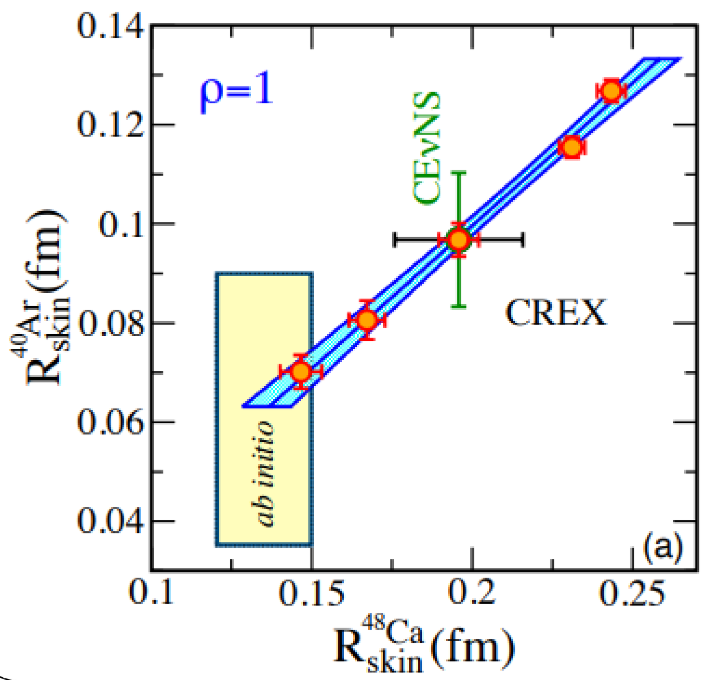
Physics with CEvNS

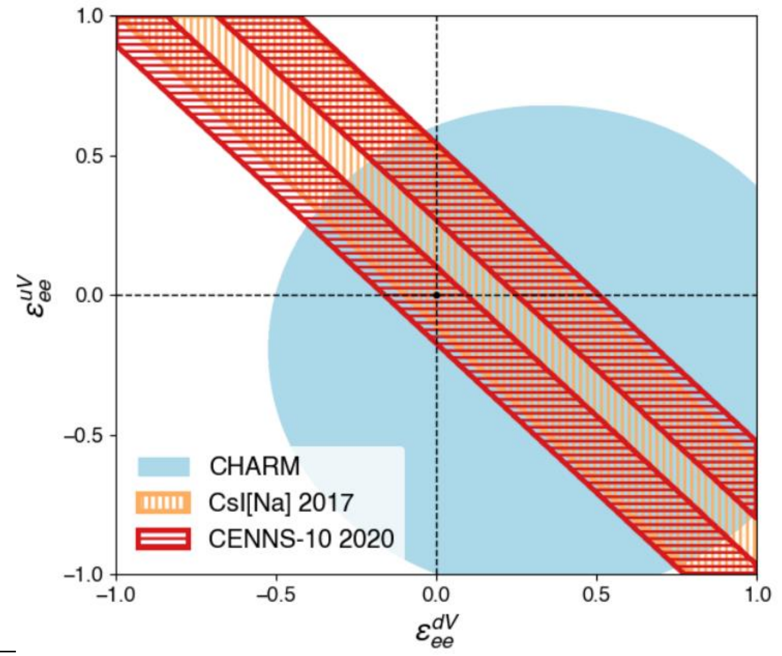
- CEvNS very cleanly predicted by Standard Model
- Deviations could indicate new physics
- NSI coupling constants
  - Observation of CEvNS places constraints on nonstandard neutrino-quark interactions
- Weak mixing angle
- Weak nuclear radius
- Development of CEvNS-sensitive technologies useful for other physics searches
  - WIMP dark matter searches
  - Sterile neutrino searches



$$\frac{d\sigma}{dT}_{coh} = \frac{G_f^2 M}{2\pi} G_V^2 \left[1 + \left(1 - \frac{T}{E_\nu}\right)^2 - \frac{MT}{E_\nu^2}\right]$$

$$G_V = ((g_V^p + \underline{2\epsilon_{ee}^{uV}} + \underline{\epsilon_{ee}^{dV}})\, Z + (g_V^n + \underline{\epsilon_{ee}^{uV}} + \underline{2\epsilon_{ee}^{dV}})\, N)\, F_{\text{nucl}}^V(Q^2)$$

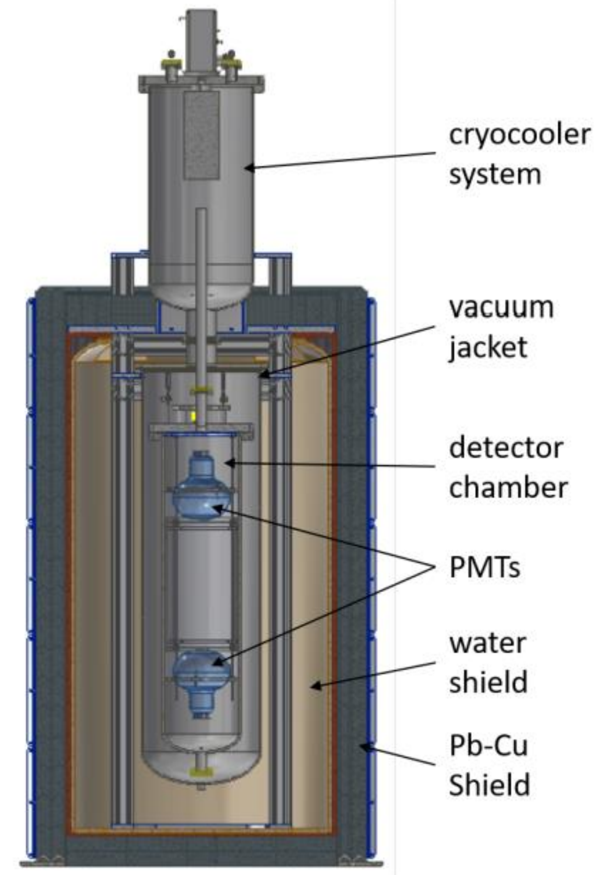




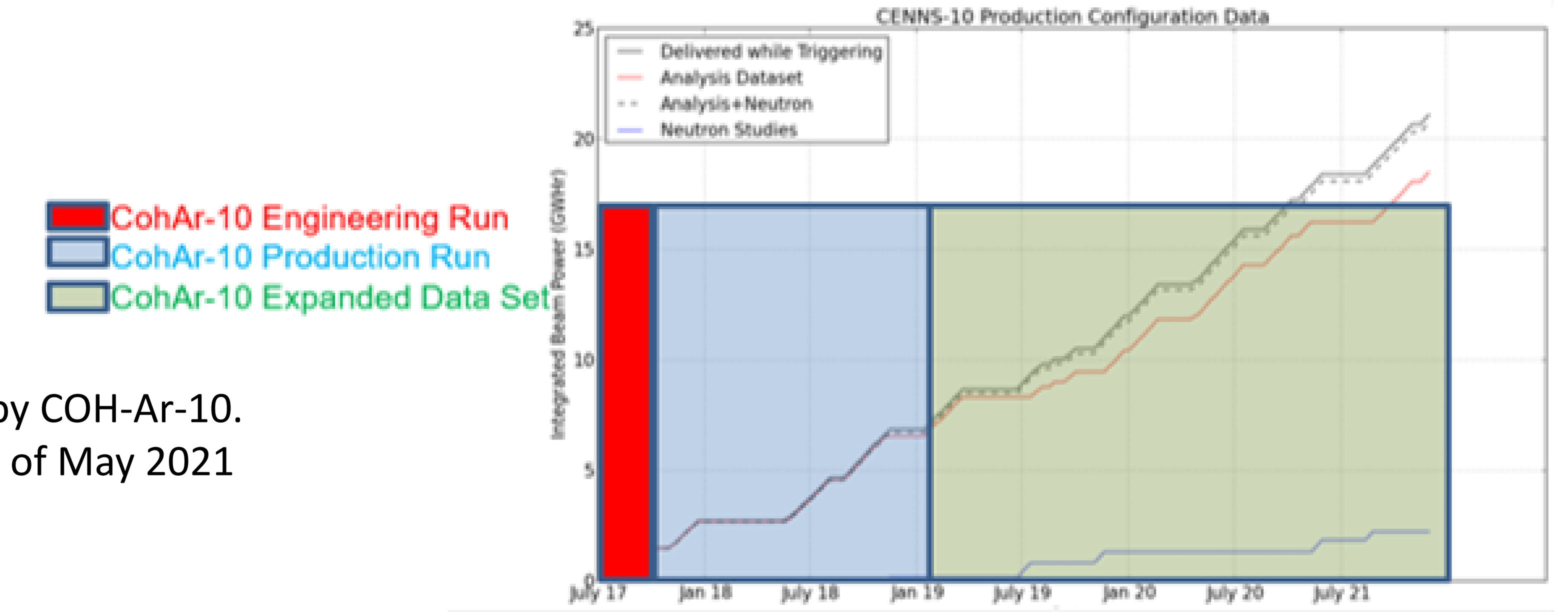
Left: Constraints on weak nuclear radius[4]
Right: Constraints on NSI parameters from CsI and Ar results[2]
Top: Cross-section with NSI parameters underlined

CENNS-10

- Single-phase liquid argon detector deployed by COHERENT collaboration to the SNS, fall 2016
  - Engineering run[5]: 1.8GWhr, ~80keVnr threshold. Early 2017
  - Production run[6]: 6.12GWhr, ~20keVnr threshold. June 2017-January 2019
- 24kg fiducial volume
  - 99.6% abundance ^{40}Ar
- Tetraphenyl butadiene (TPB) coating to shift wavelength of scintillation light from 128nm to 400nm
- Shielding
  - 20cm of water shielding
  - 1.25cm of Cu shielding
  - 10cm of Pb shielding



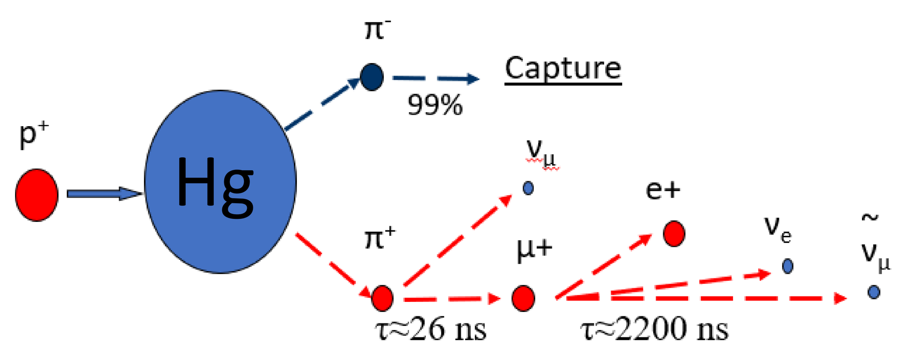
COH-Ar-10 detector with shielding at location



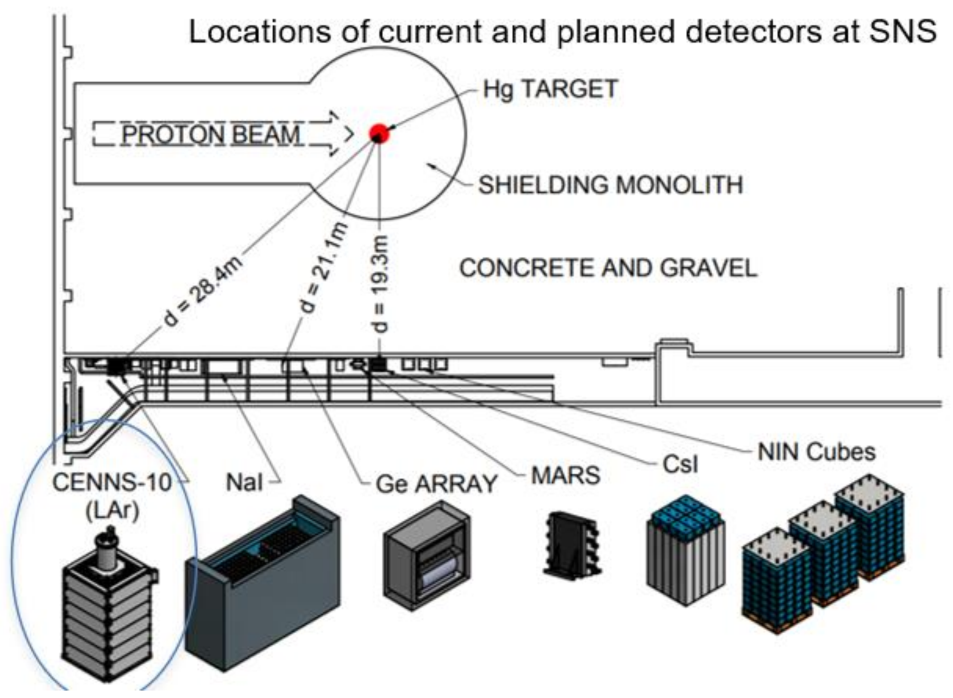
Total data collected by COH-Ar-10.
18GWhr collected as of May 2021

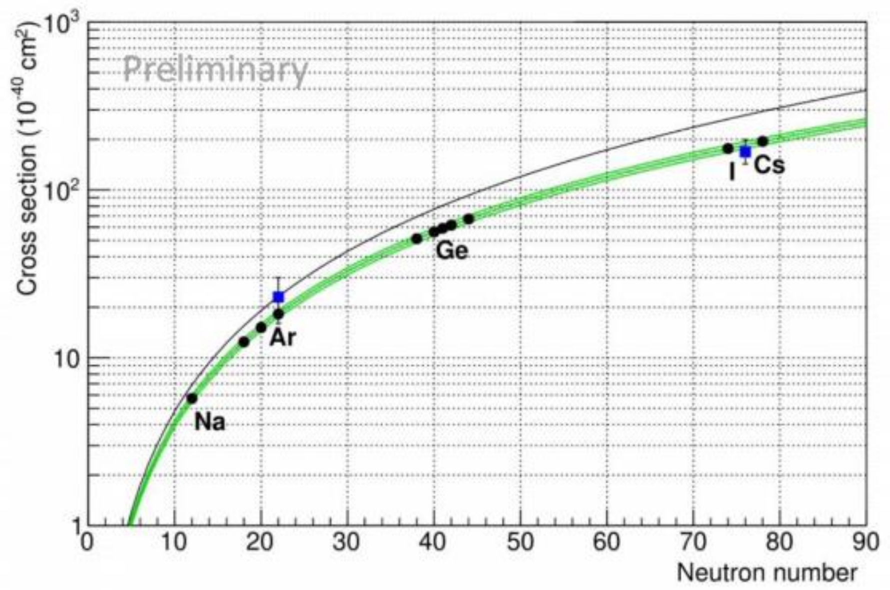
COHERENT at the SNS

- Spallation Neutron Source at Oak Ridge National Laboratory
  - Highest flux of pulsed neutrinos in the world: $4.3 \times 10^7\ \nu/\ cm^2$/s at 20m
  - Timing used for background rejection
- Multiple detectors with target nuclei in basement of SNS, "neutrino alley"
  - Test N^2 dependence of cross-section
  - First observation of CEvNS in 2017, using CsI[Na] crystal scintillator[2]
  - First observation of CEvNS on Ar in 2020
    - PhysRevLett. 126.012002



SNS uses stopped pion source

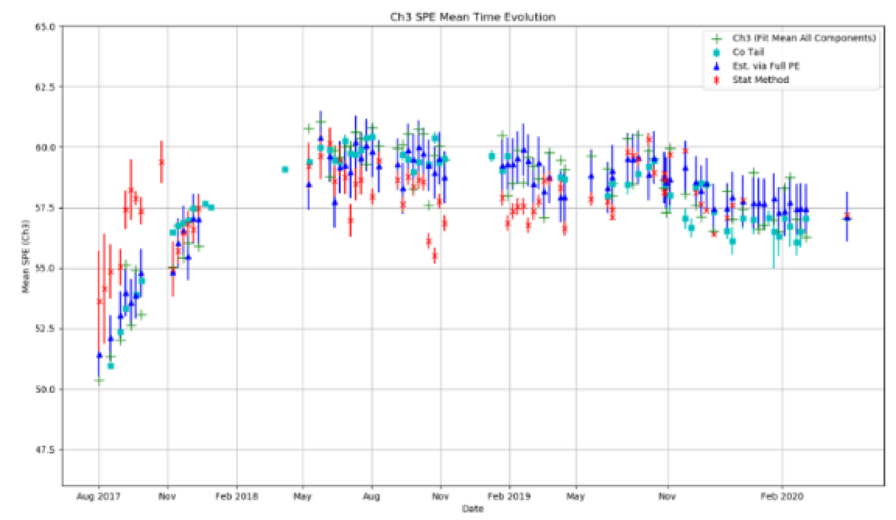


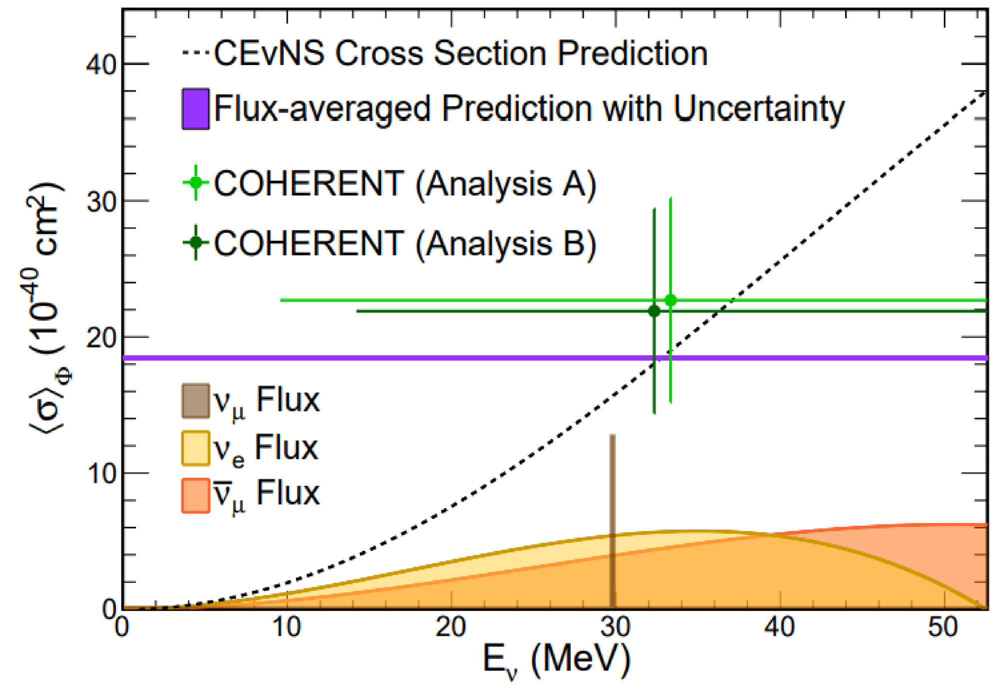


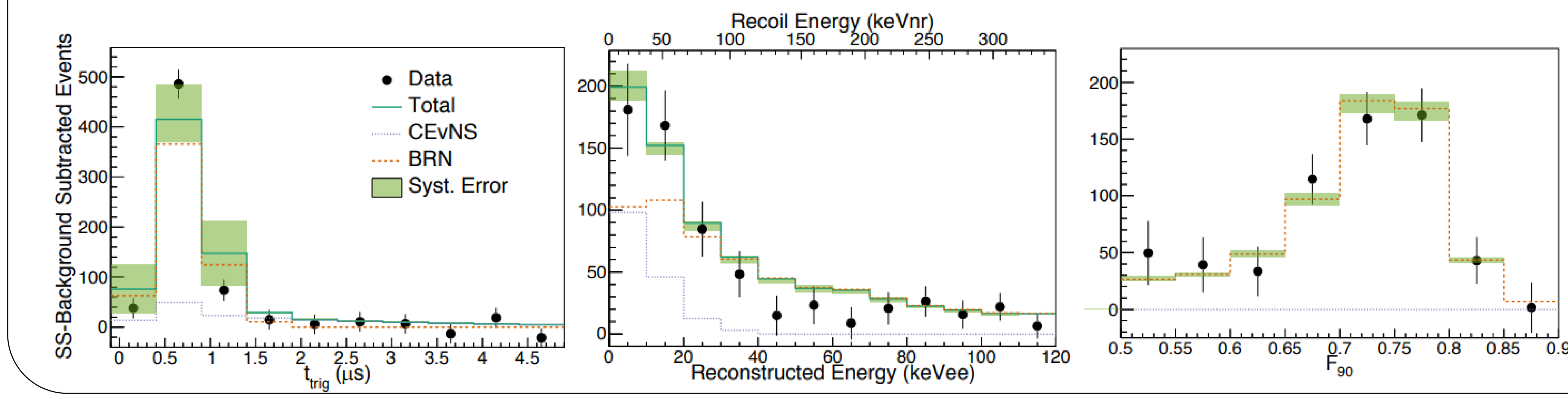
Left: CEvNS cross-section vs. N
Above: Current and planned detectors at the SNS

Current Work

- Analysis result from 3D binned likelihood analysis in trigger time, energy, and F90(see talk by R. Tayloe)
  - Dual parallel blind analysis, US and Moscow
  - Excess of events within 1σ of SM prediction after background subtraction
- Plan to increase data set to yield 5σ result
  - Improved calibrations over
  - Lower energy threshold
- Further running for development of ton-scale LAr detector, COH-Ar-750(see poster by M. Hughes)







Top Left: Calibration of CohAr-10, weekly SPE measurements
Top Right: Measured CEvNS flux-averaged cross-section. Null CEvNS hypothesis rejected by both analyses at >3σ
Left: Projection of best-fit maximum likelihood probability density function

Acknowledgements

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References

1. D.Z. Freedman, Phys. Rev. D9 (1974)
2. D. Akimov et al. (COHERENT). Science 357, 1123–1126 (2017)
3. D. Akimov et al. (COHERENT). arXiv:1803.09183
4. Jorge Piekarewicz, Magnificent CEvNS 2019 invited talk
5. D. Akimov et al. (COHERENT). Phys. Rev. D100(1019) 11, 115020
6. D. Akimov et al. (COHERENT). Phys. Rev. Lett. 126, 012002