PREX CREX Archival Paper for PRC

98% finished

114 authors 49 institutes

56 pages

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About 25 people wrote the paper.

Editorial Board

- David Armstrong William & Mary
- Cameron Clarke Jefferson Lab
- Chandan Ghosh Jefferson Lab
- Ciprian Gal Jefferson Lab
- Krishna Kumar Univ. Massachusetts
- Robert Michaels Jefferson Lab
- Sanghwa Park Jefferson Lab
- Kent Paschke Univ. Virginia
- Paul Souder Syracuse University

What is .... ?

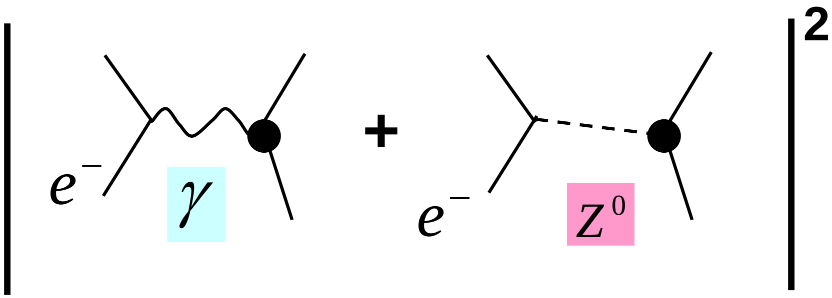
^{48}Ca CREX and ^{208}Pb PREX

http://hallaweb.jlab.org/parity/prex

PRL 129, 042501 (2022)

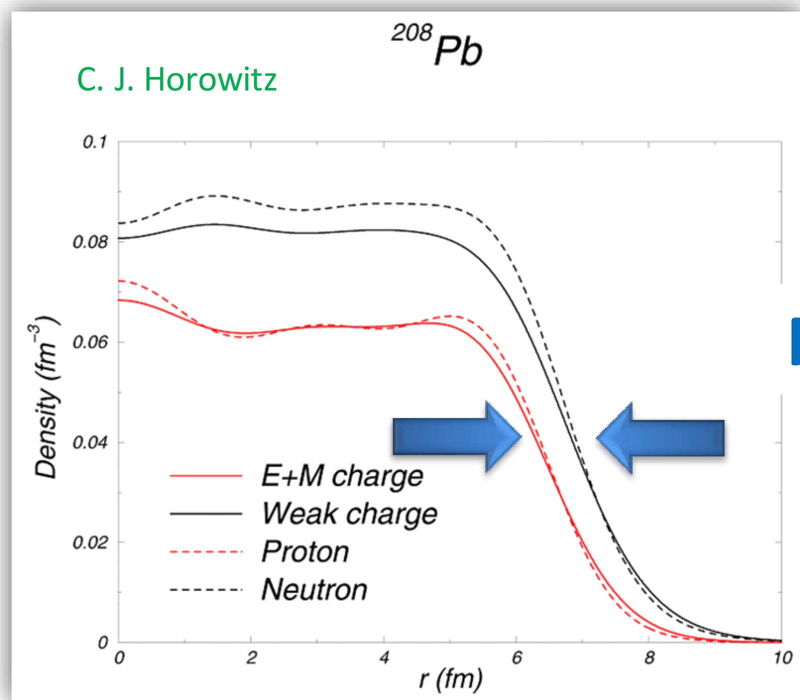
PRL 126, 172502 (2021)

$\sigma \approx$



$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \sim 10^{-4} \times Q^2 \sim 10^{-6}$$

Electroweak Asymmetry in Elastic Electron-Nucleus Scattering

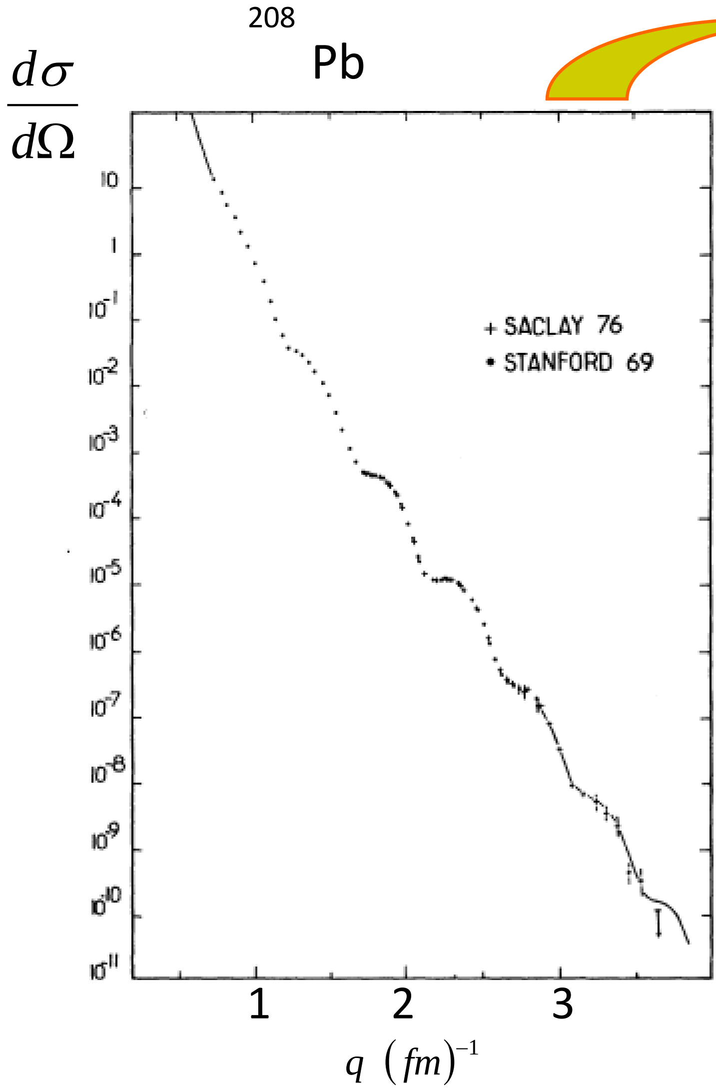


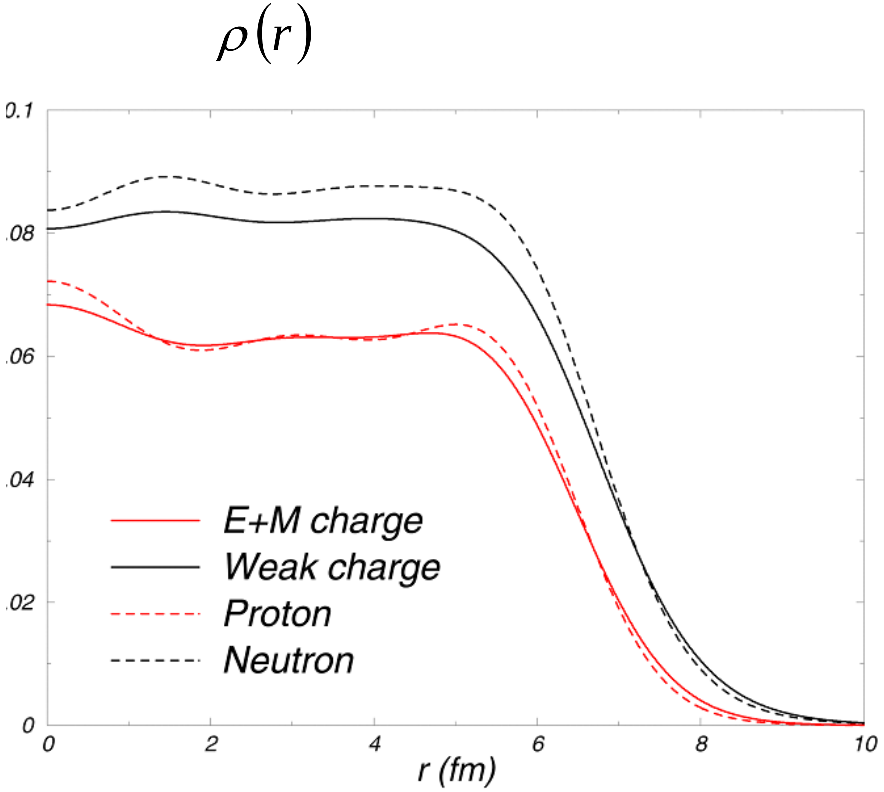
Neutron Skin

$$R_n - R_p = \sqrt{\langle r_n^2 \rangle} - \sqrt{\langle r_p^2 \rangle}$$

Reminder: Electromagnetic Scattering determines $\rho(r)$

(charge distribution)





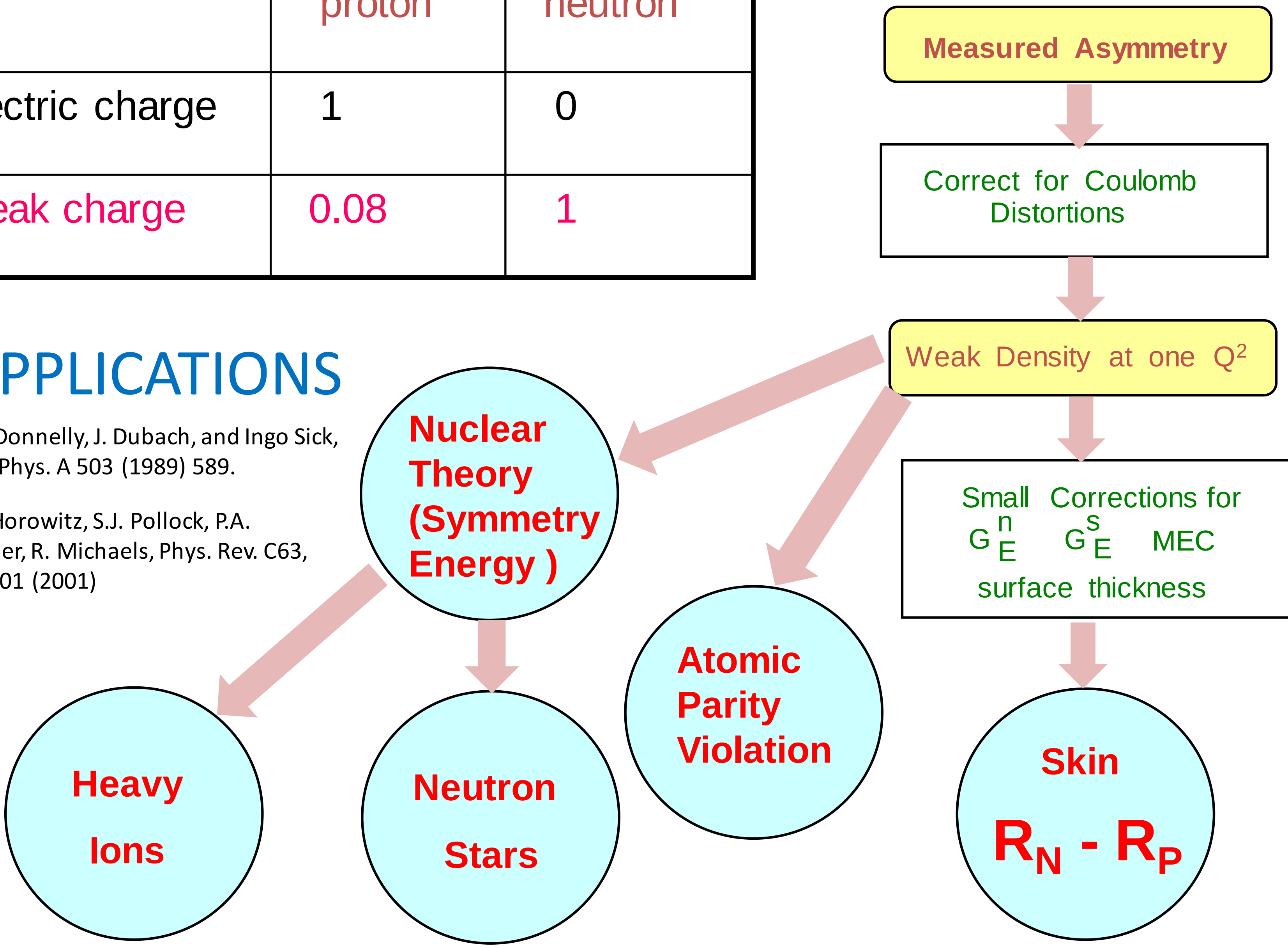
Weak Interaction: Sees the Neutrons

	proton	neutron
Electric charge	1	0
Weak charge	0.08	1

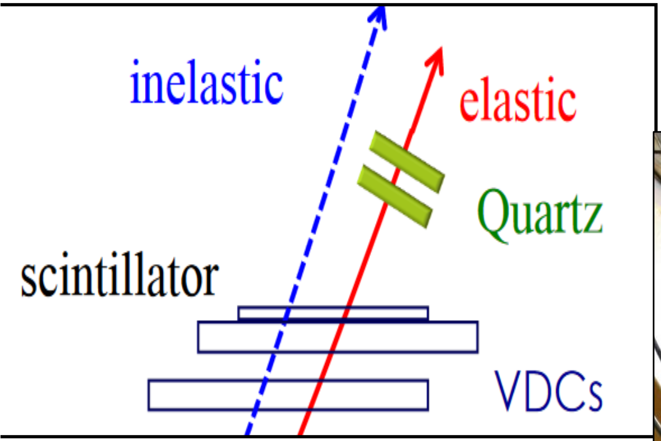
APPLICATIONS

T.W. Donnelly, J. Dubach, and Ingo Sick, Nuc. Phys. A 503 (1989) 589.

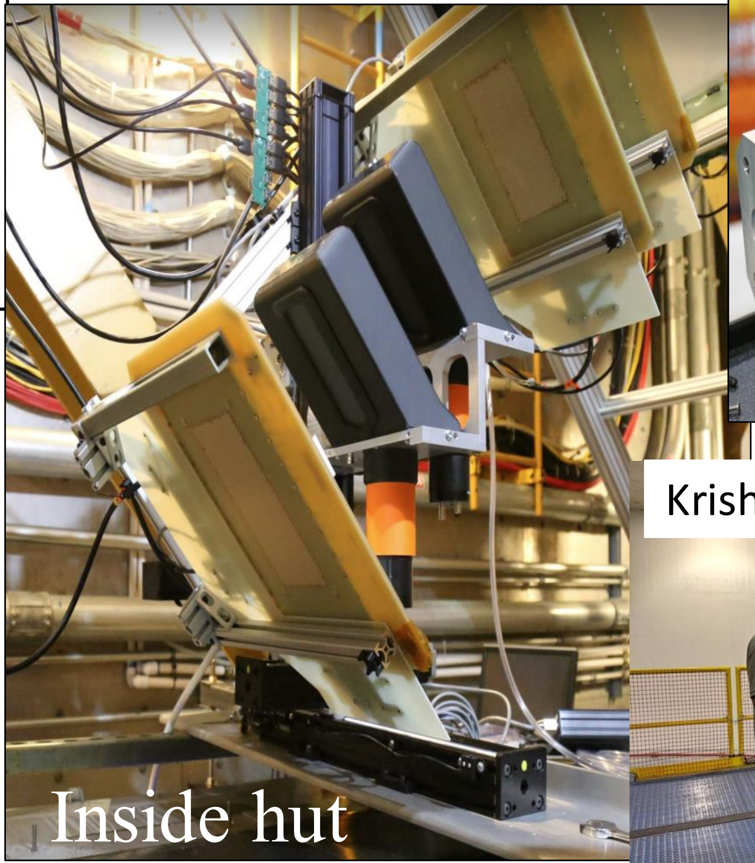
C.J. Horowitz, S.J. Pollock, P.A. Souder, R. Michaels, Phys. Rev. C63, 025501 (2001)

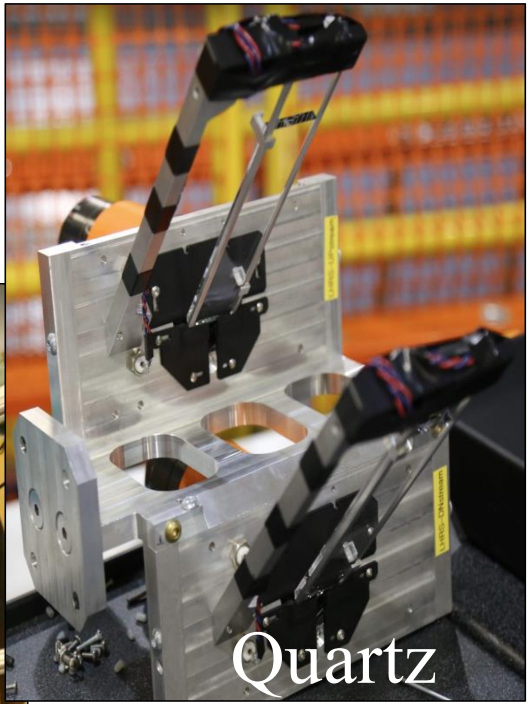


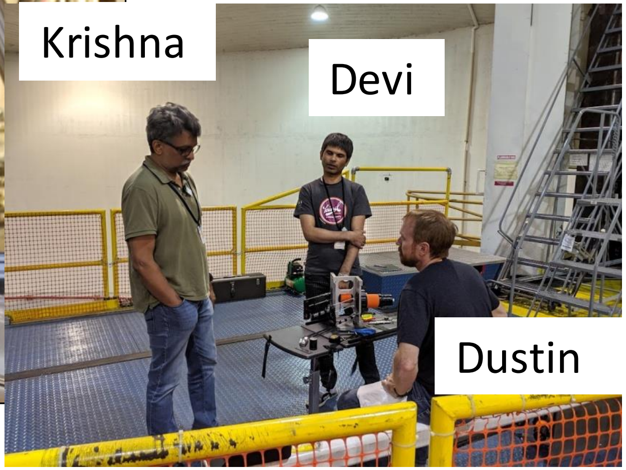
Detectors at the HRS Focus



"HRS" = high resolution spectrometers



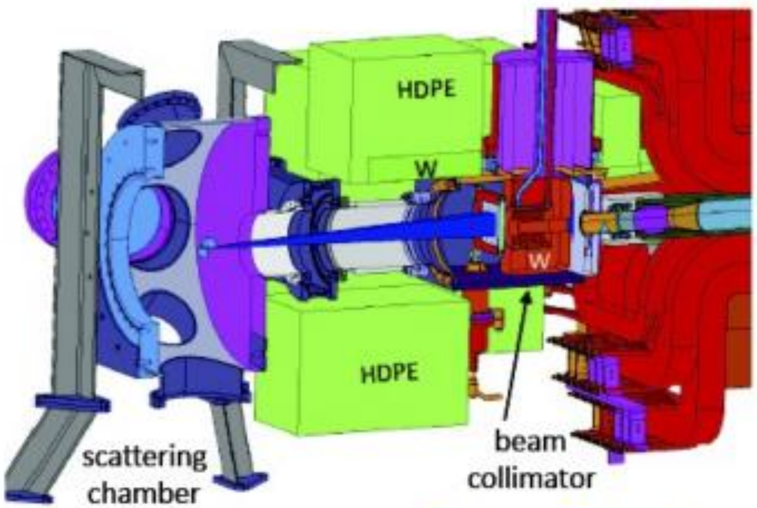


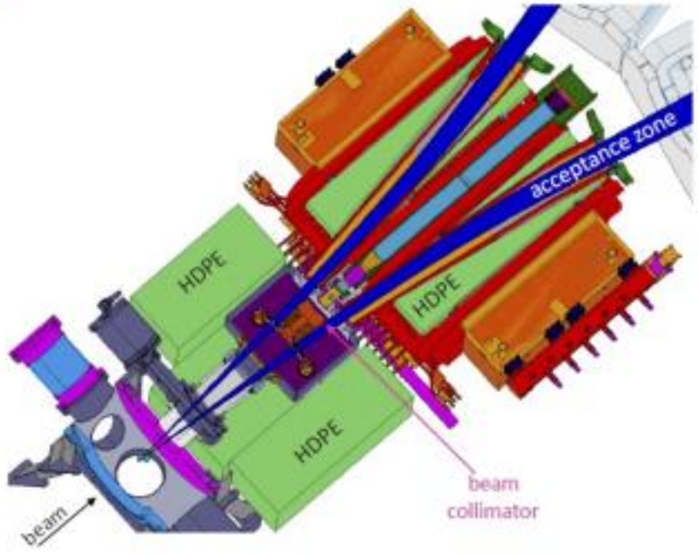


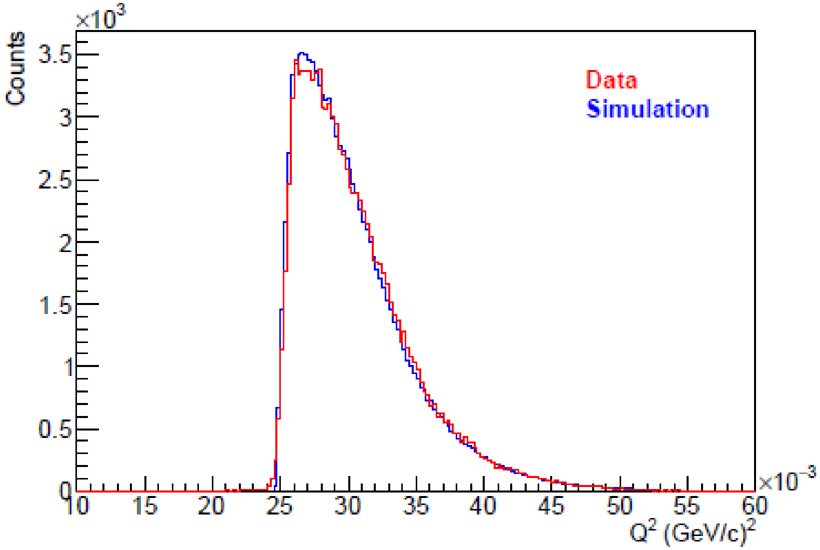
Quartz detectors are placed in the detector hut. They were used for both PREX and CREX.

Newly published details about the shielding and the Geant 4 model for HRS optics

Kent Paschke (leader)
Rakitha Beminiwattha, Cameron Clarke, Ciprian Gal, Tyler Kutz, Juliette Mammei, Seamus Riordan, Allison Zec, Weibin Zhang.







Newly published details about the ^{48}Ca and ^{208}Pb targets

Thanks to the target group (Dave Meekins et. al.) and Silviu Covrig Dusa. (early career award)

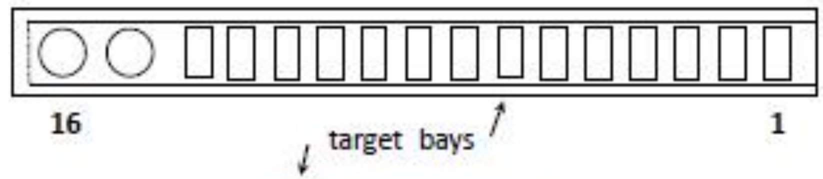


TABLE I. Listing of the production targets (see Fig. 14). Shown are the material, the thickness of the material, the type of backing, if any, and the total thickness of the two foils in the backing. "Natural Pb" means naturally-occurring 99.9% chemically pure lead. The thicknesses are nominal.

Position	Material	Thickness mg/cm^2	Backing	Tot. Back. mg/cm^2
1	Natural Pb	556	Graphite	176
2	Natural Pb	556	Diamond	180
3	^{208}Pb	630	Graphite	176
4	Graphite	445	None	N/A
5 – 13	^{208}Pb	630	Diamond	180
14	Carbon Hole	N/A	N/A	N/A
15 (1st)	^{48}Ca	1016	None	N/A
15 (2nd)	^{48}Ca	992	None	N/A
16	^{40}Ca	1004	None	N/A

Newly published detailed theory of the beam corrections

$$A_{raw} = A_{det} - A_Q + \alpha\, \Delta_E + \Sigma \beta_i\, \Delta x_i$$

Regression

$$\chi^2 = \sum \left(A_{raw} - \sum_i \beta_i \Delta M_i \right)^2, \quad \frac{\partial \chi^2}{\partial \beta_i} = 0$$

Dithering

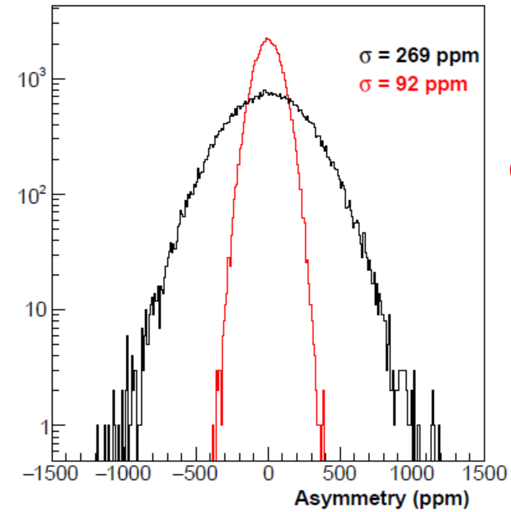
$$\frac{\partial \hat{D}}{\partial C_\mu} = \sum_{i=1}^{N_{BPM}} \beta_i \frac{\partial M_i}{\partial C_\mu}, \quad \beta_i = \frac{\partial \hat{D}}{\partial M_i},$$

for $\mu = 1, 2, ..., N_{coil}$, **and can be solved if** $N_{coil} \geq N_{BPM}$.

Lagrange -- a combination of the above two

$$\mathcal{L} = \chi^2 + \sum_\mu \lambda_\mu \left(\frac{\partial D}{\partial C_\mu} - \sum_i \beta_i \frac{\partial M_i}{\partial C_\mu} \right),$$

χ^2 **minimization** with **beam modulation sensitivities constraints:** $\frac{\partial \mathcal{L}}{\partial \beta_i} = 0, \quad \frac{\partial \mathcal{L}}{\partial \lambda_\mu} = 0$



Raw
Beam-corrected

Paul Souder, Tao Ye, Kent Paschke, Cameron Clarke, Ye Tian, Victoria Owen

Extracting the Weak Form Factor

Comparing PREX (^{208}Pb) and CREX (^{48}Ca) to Theory