PREX/CREX

Hall A collaboration Meeting

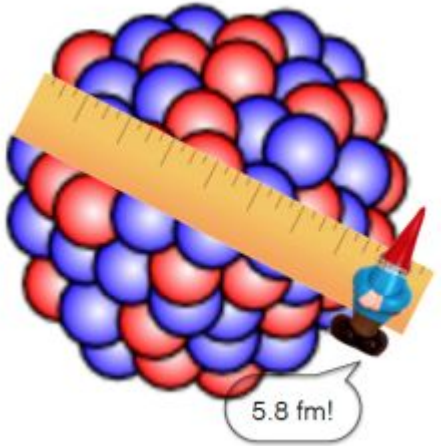
Chandan Ghosh
(on behalf of PREX/CREX collaboration)

Stony Brook University

30 Jan 2020

Jefferson Lab

Size of atomic nuclei



Charge	Proton	Neutron
Electric	1	0
Weak	0.08	1

Photon sees protons, z^0 sees neutrons

- Proton distribution:
  - Due to electric charge - proton distribution is measured using electron scattering.
- Neutron distribution:
  - Studied with hadron scatterings - model dependent.
  - Parity-violating electron scattering gives a clean measurement of neutron distribution.
- For neutron rich nuclei - may exist neutron skin (R_n-R_p).

PVES as clean probe for neuton distributions

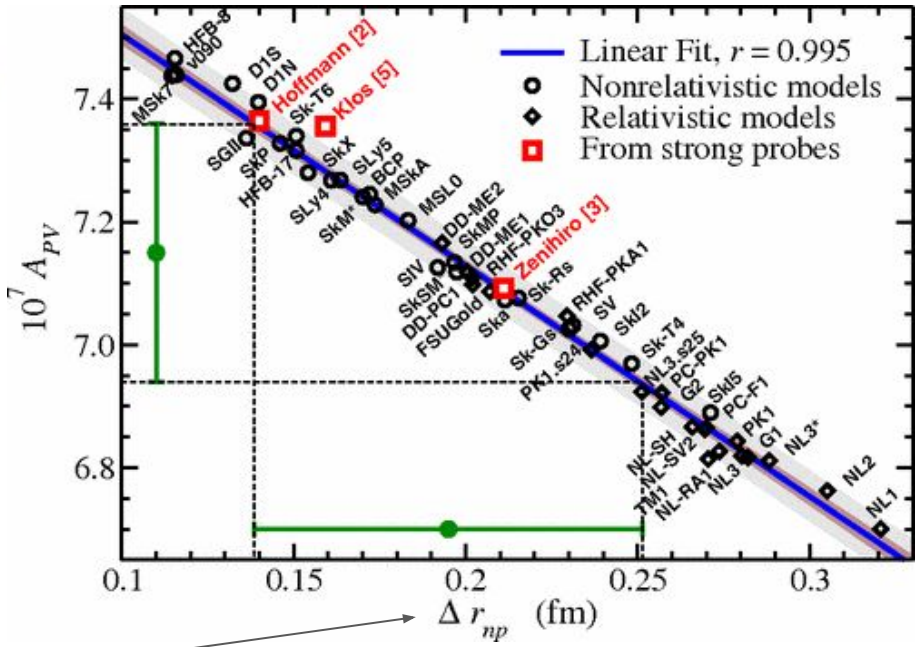
For spin 0 nuclei: $A_{PV} \approx -\frac{G_F Q^2 Q_W}{4\pi\alpha\sqrt{2}Z}\frac{F_W(Q^2)}{F_{ch}(Q^2)}$

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

$$\sigma \approx \left| e^- \gamma + e^- Z^0 \right|^2$$

A_{PV} ⇨ $F_W(Q^2)$ ⇨ R_n ⇨ R_{np}

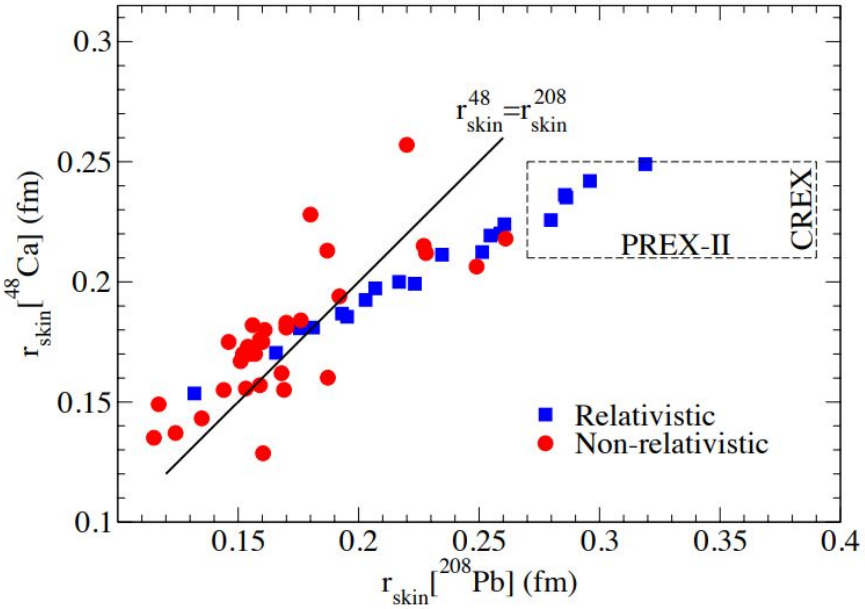
PRL 106, 252501 (2011)



Asymmetry could be used for testing models

Choice of two targets - ^{208}Pb and ^{48}Ca

- ^{208}Pb is doubly magic neutron rich nucleus - well studied both experimentally and theoretically.
- ^{48}Ca is also doubly magic nuclei - ab initio calculations [G. Hagen et al., Nature Physics 12, 186 (2016)] are possible.
- First excited state for these nuclei are high in energy (2.6 MeV for ^{208}Pb and 3.8 MeV for ^{48}Ca).
- Theoretical correlation of R_{np} can be compared with measured values.

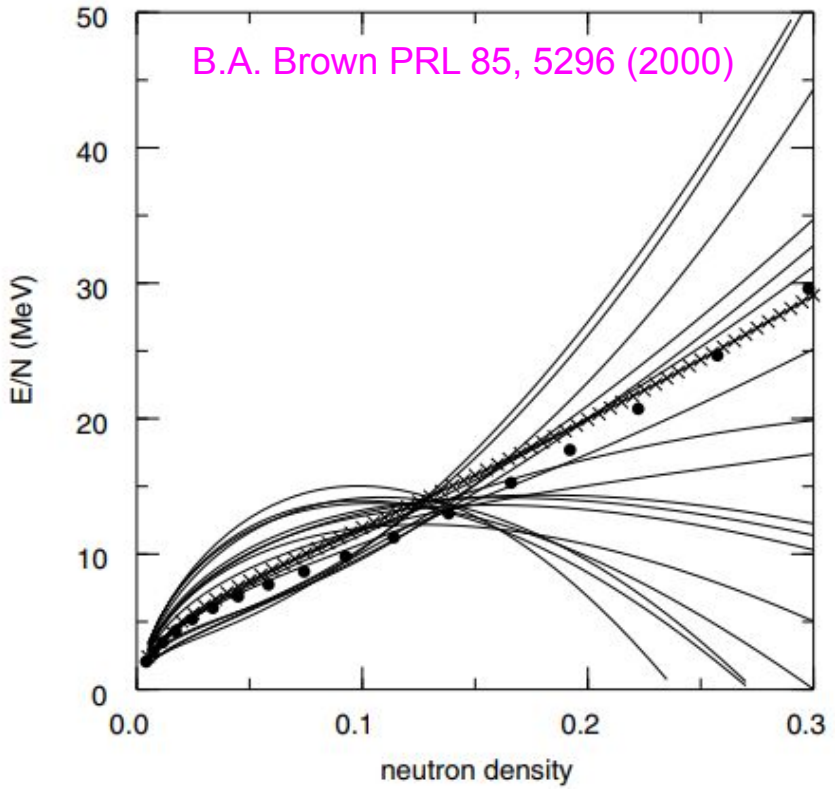


Nuclear symmetry energy and PREX

Symmetry energy (S): Variation of binding energy as n/p changes.

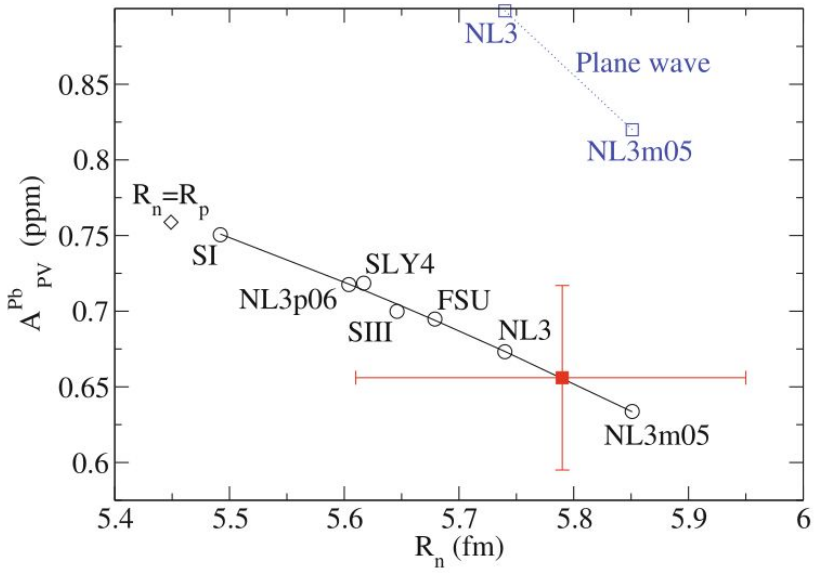
Slope of symmetry energy: $L \propto \frac{\delta S(\rho)}{\delta \rho}\Big|_{\rho_0}$

R_{np} is highly sensitive to pressure of pure nuclear matter: greater the *L*, larger the neutron skin thickness as the neutrons are pushed against 'surface tension'.

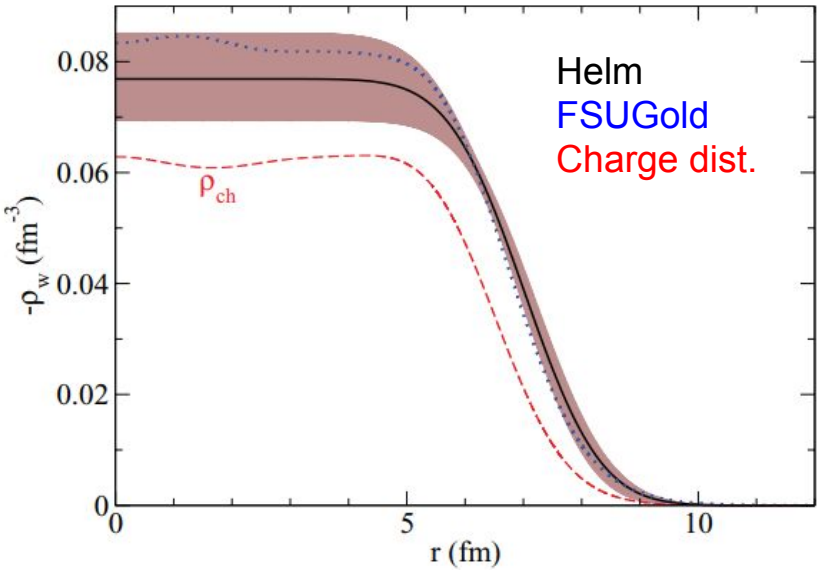


PREXI results

PREX-I result: $A_{PV} = 0.656 \pm 0.060 \pm 0.014\text{ppm} \quad \Delta R_{np} = 0.33^{+0.16}_{-0.18}\text{fm}$

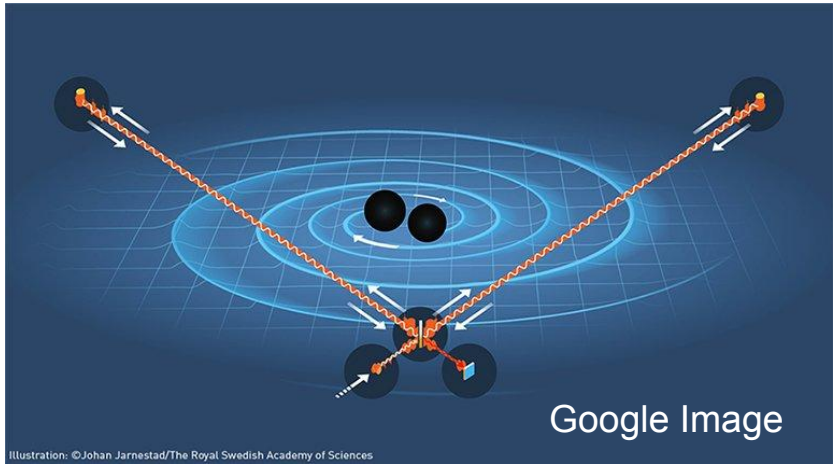


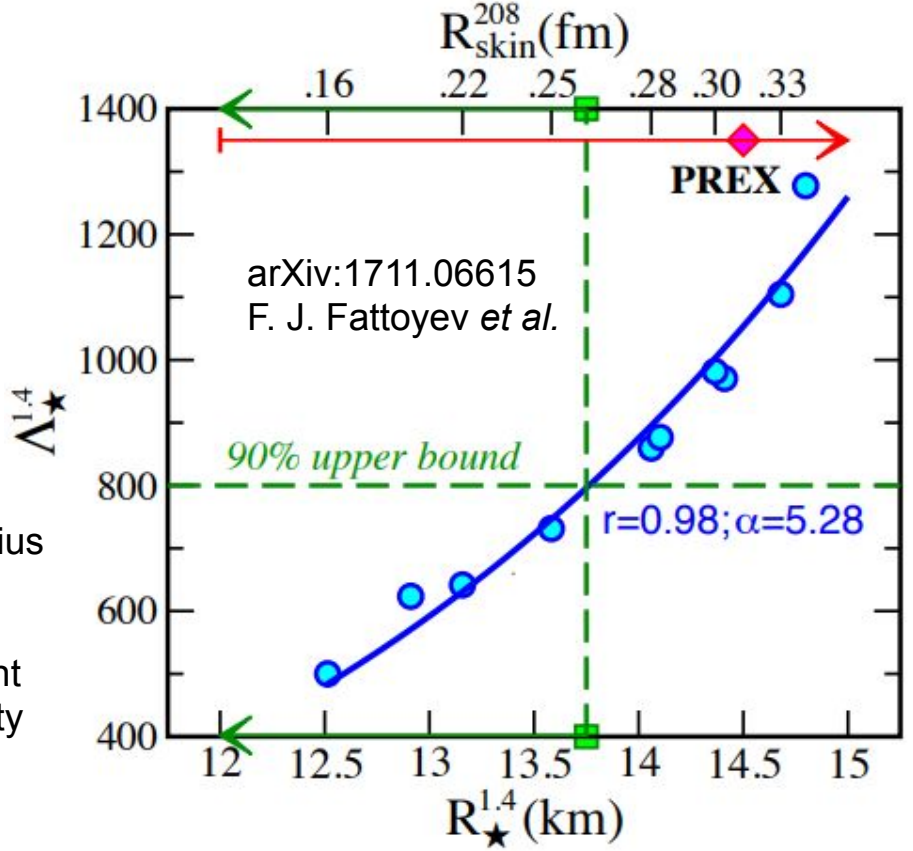
Phys Rev Lett. 108, 112502 (2012);
(251 citations)



Phys. Rev. C 85, 032501(R) (2012)

LIGO: Neutron star merger (2017)





- Theoretical limit on ^{208}Pb and neutron star radius -same physics for two wildly different systems
- PREXII constrains the EOS of neutron rich matter. If data are inconsistent it could be a hint of possible phase transition at very high density of neutron star.

PREX/CREX beam time and systematic goal

PREX - 25+10 days, 0.06fm
CREX - 35+10 days, 0.02fm

PREXI

E = 1.06 GeV, 70 uA
A_{pv} = 0.6 ppm;

Charge Normalization	0.2%
Beam Asymmetries	1.1%
Detector nonlinearity	1.2%
Transverse Asym	0.2%
Polarization	1.3%
Inelastic Contribution	<0.1%
Effective Q^2	0.5%
Total	2.1%

PREXII

E = 0.95 GeV, 70 uA
A_{pv} = 0.6 ppm; Rate ~ 2.2 GHz

Charge Normalization	0.1%
Beam Asymmetries	1.1%
Detector nonlinearity	0.5%
Transverse Asym	0.2%
Polarization	1.1%
Inelastic Contribution	<0.1%
Effective Q^2	0.4%
Total	2%

CREX

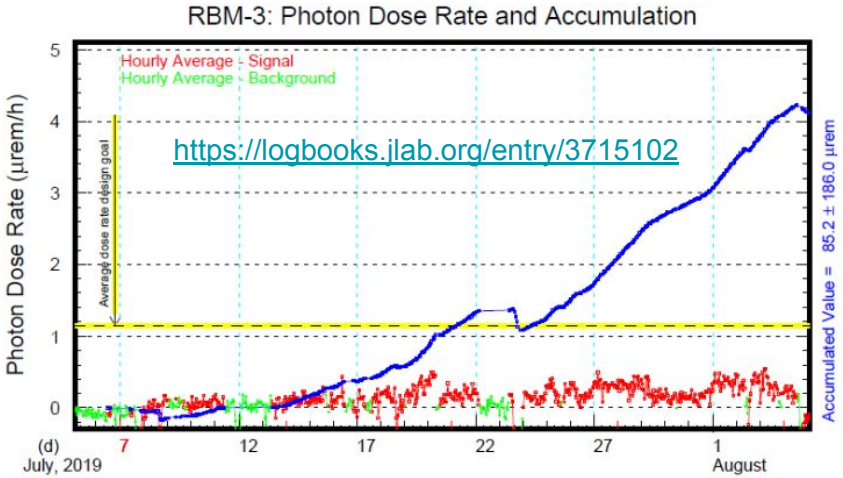
E = 2.18 GeV, 150 uA
A_{pv} = 2 ppm; Rate ~ 27 MHz

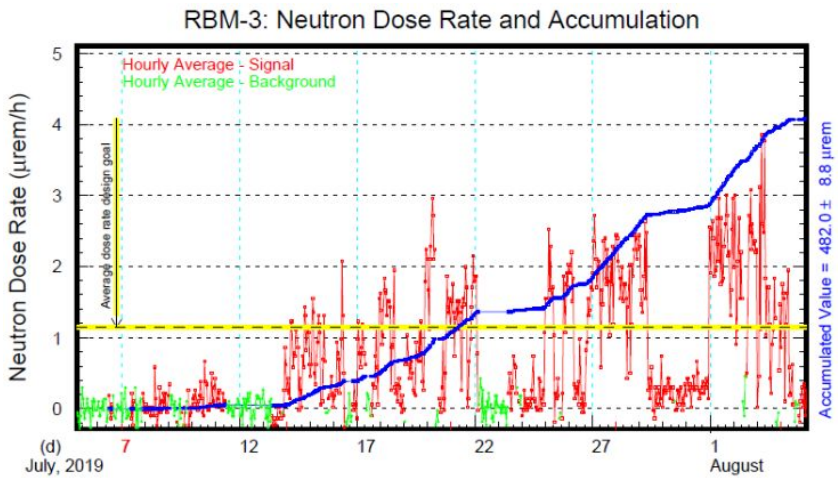
Charge Normalization	0.1%
Beam Asymmetries	0.3%
Detector nonlinearity	0.3%
Transverse Asym	0.1%
Polarization	0.8%
Inelastic Contribution	0.2%
Effective Q^2	0.8%
Total	1.2%

PREXI - Goal achieved - Systematic was under control, limited by statistics

PREX running and radiation

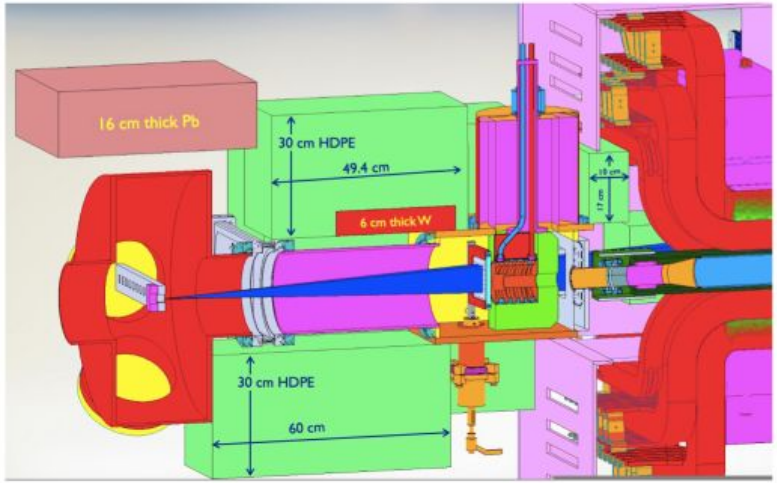
- Started -17 June 2019; Ends - 18 Aug 2019 (scheduled)
- Lost some time due to leakage in the water cell target and sitewide power outage.
- Extension - 3 weeks (Ends -9 Sept) - Thanks to Lab management.
- We were very good in terms of radiation inside hall and boundary detector.



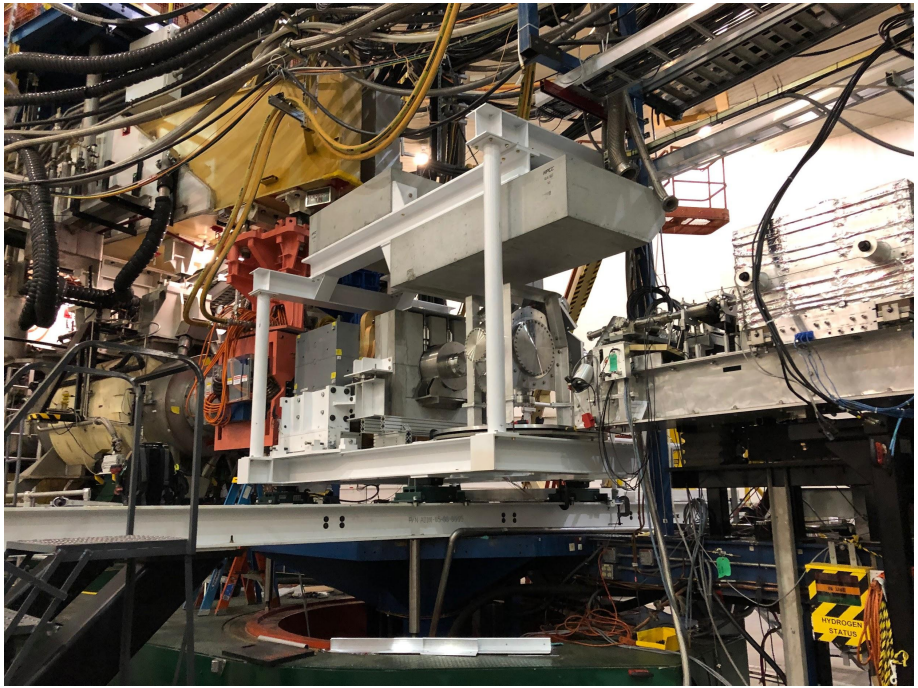


Upto 5th August 2019, we reached 6% of year's radiation budget!!

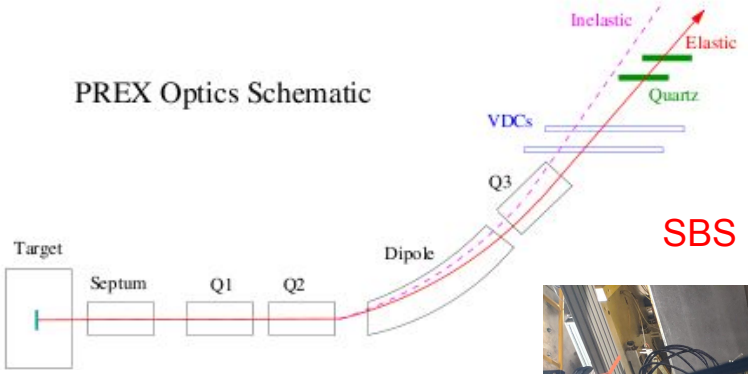
Radiation Shielding

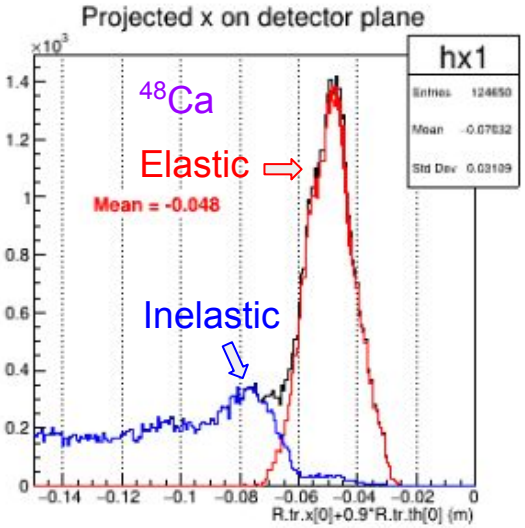


CAD drawing near target region

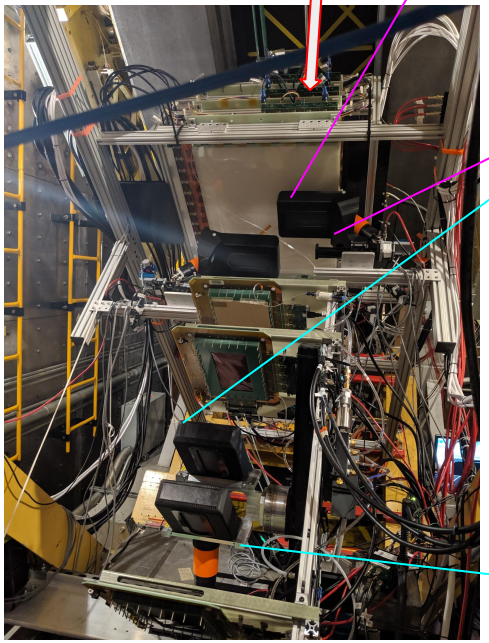


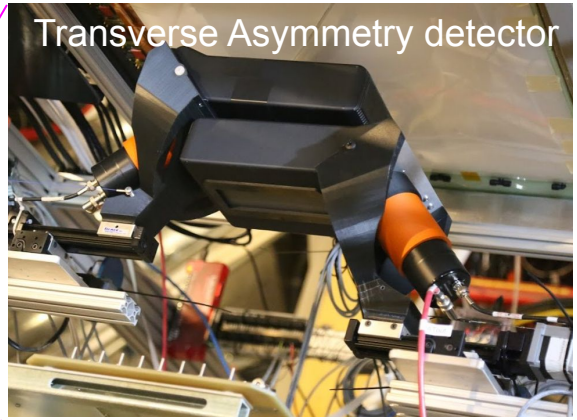
Detectors

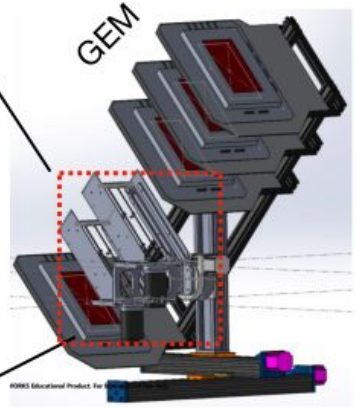




SBS GEM dets







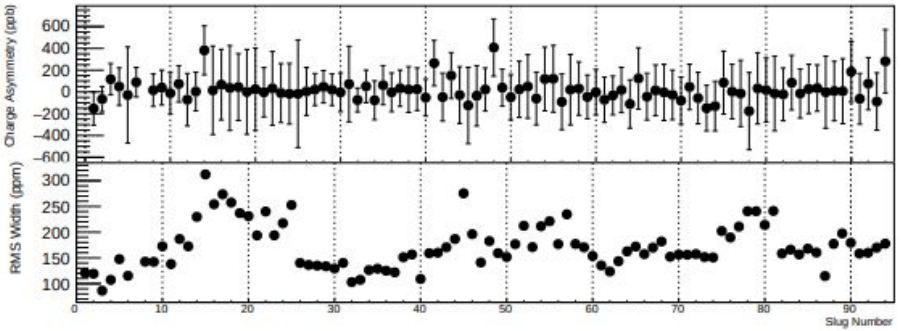
D. McNulty

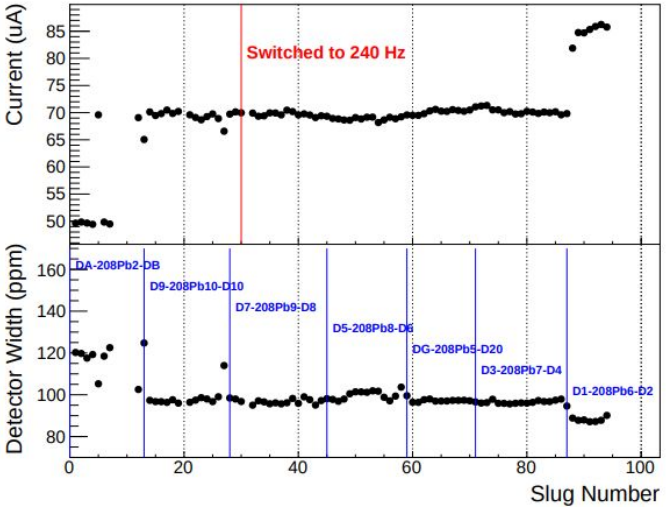
PREXII beam quality

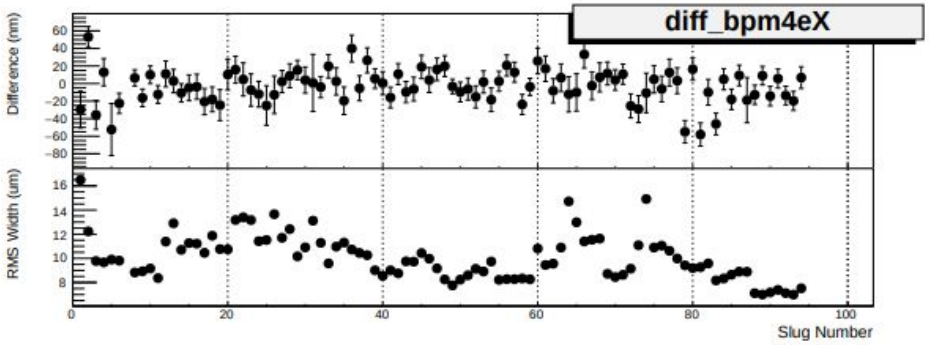
$$Asym = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$$

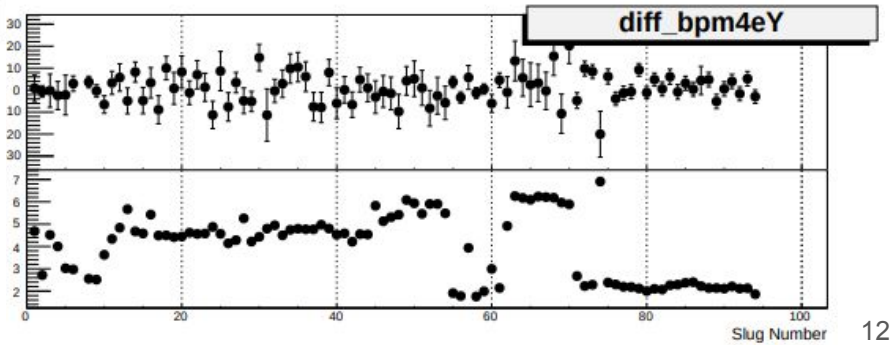
Slug - change of half-wave plate or wien flip

Charge asymmetry

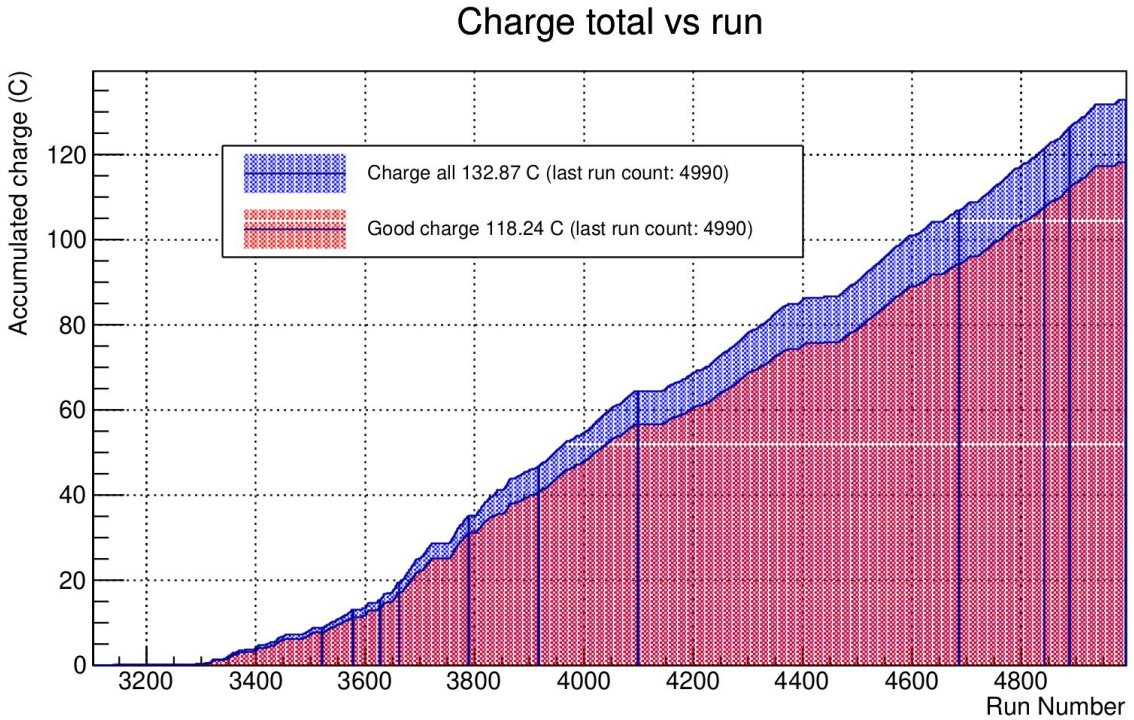








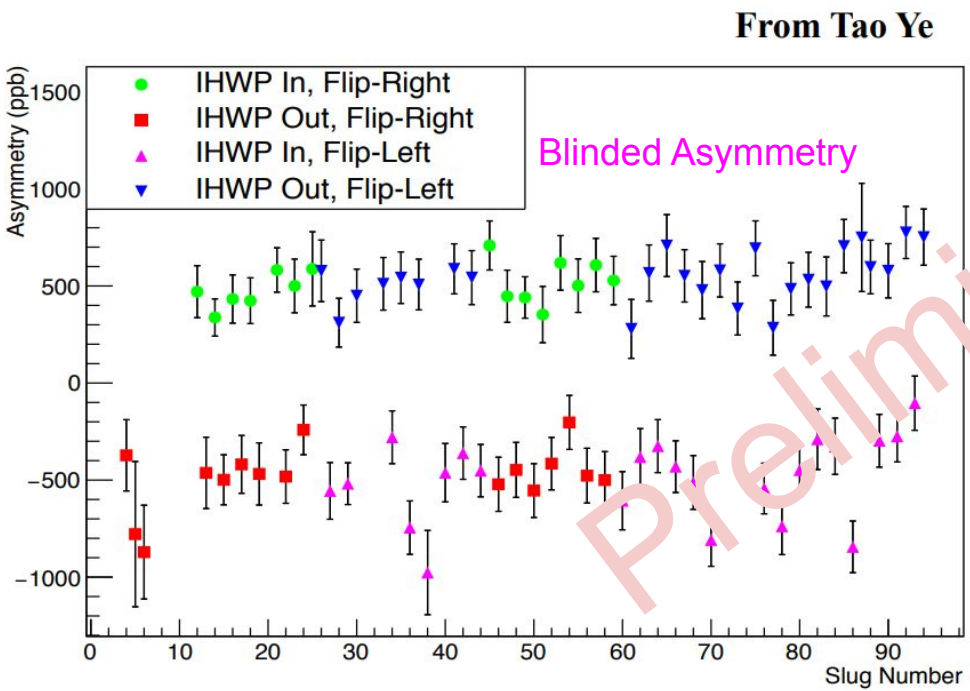
PREXII charge

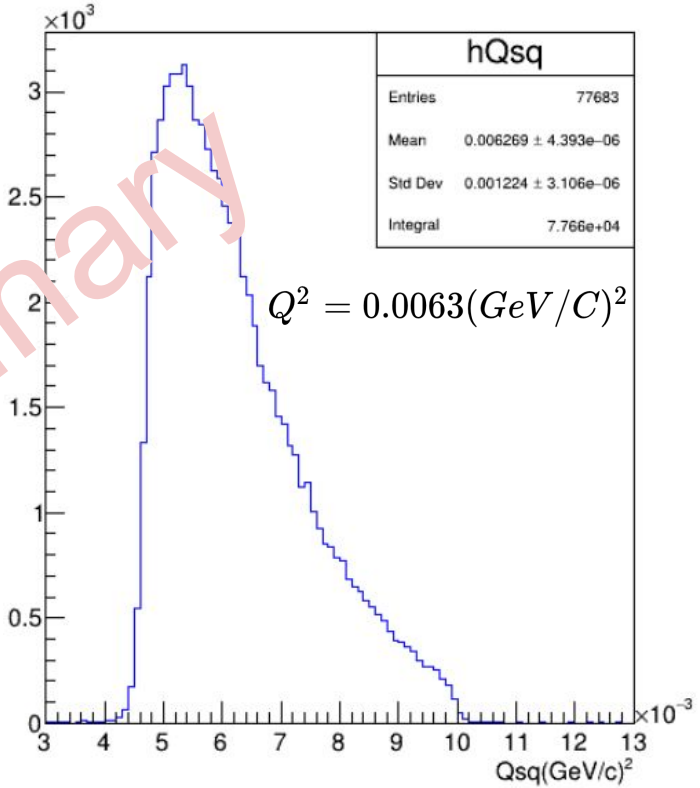


End of run target condition

- Goal of accumulated charge : 150 C
- Good charge accumulated: 118.24 C (~79%)

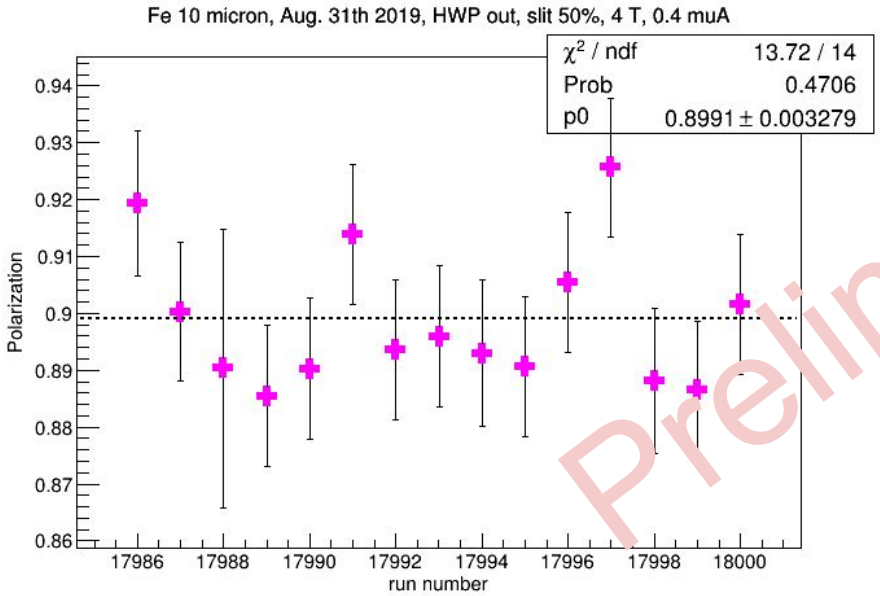
PREXII Data Set



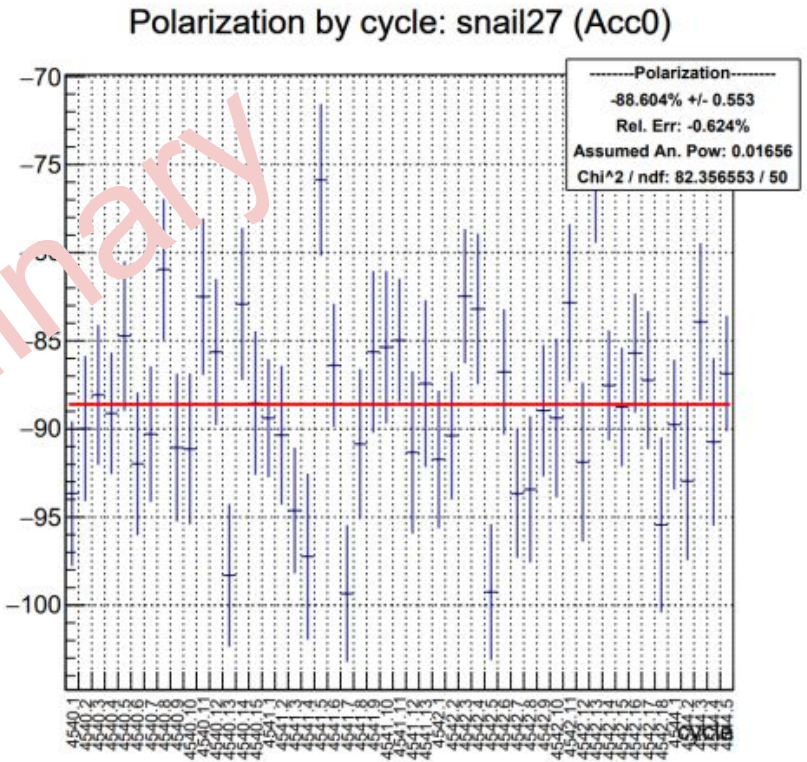


Collaboration is working actively on analysis

PREXII Polarization measurements



MOLLER

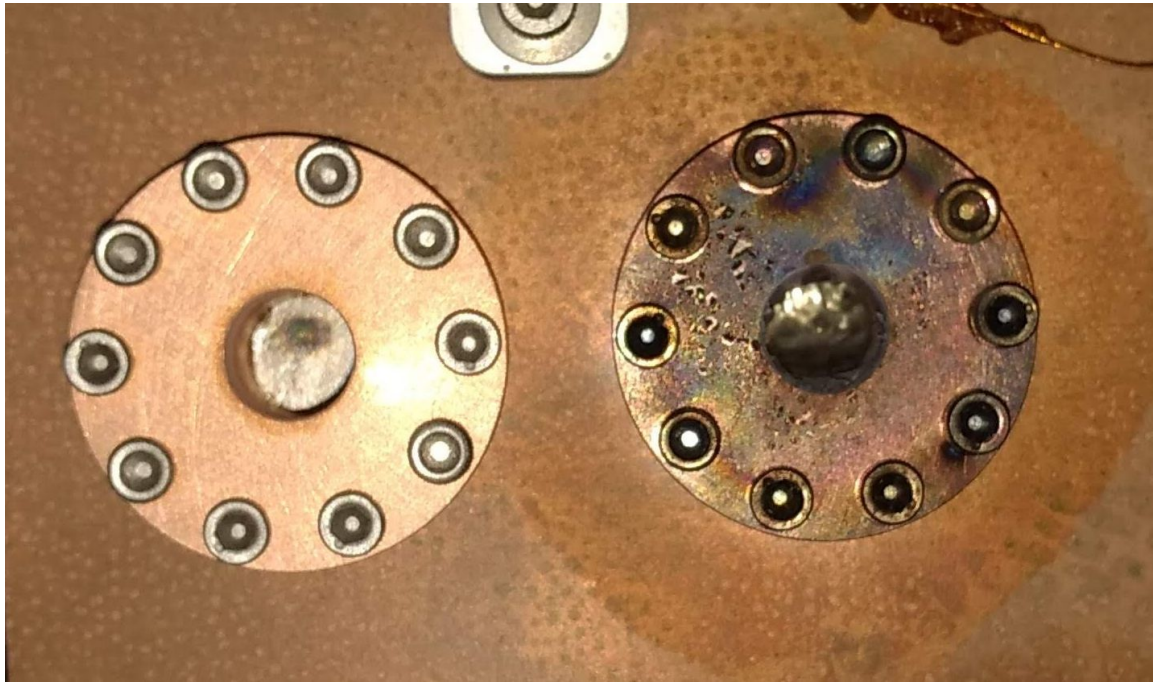


Compton

CREX running

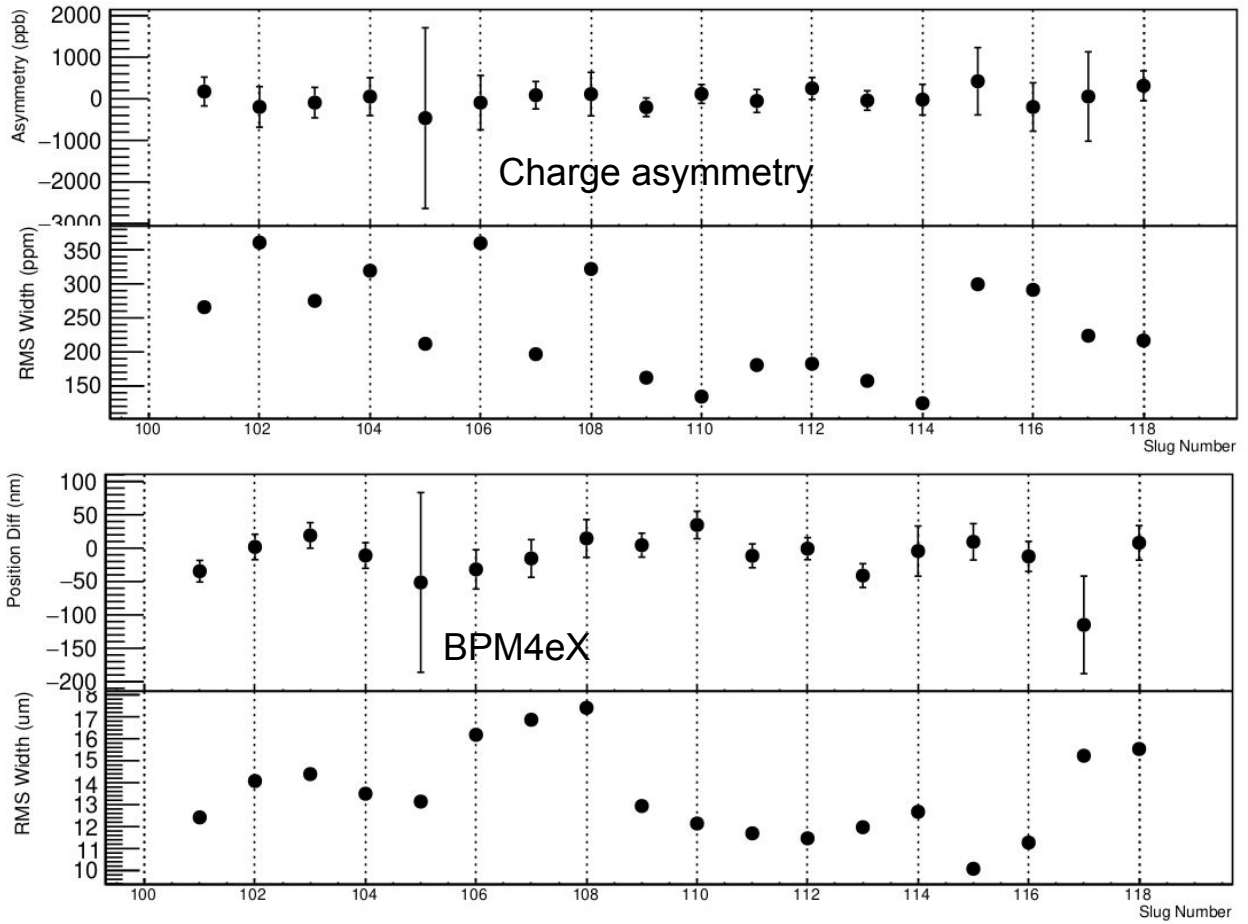
- Started: 5 Dec 2019 - 17 Dec 2019; 6 Jan 2020 - still going (47% of scheduled time)

- We had a target accident on Jan 18.
- Thanks to target and radiation group to replace the target quickly and bring us back to production

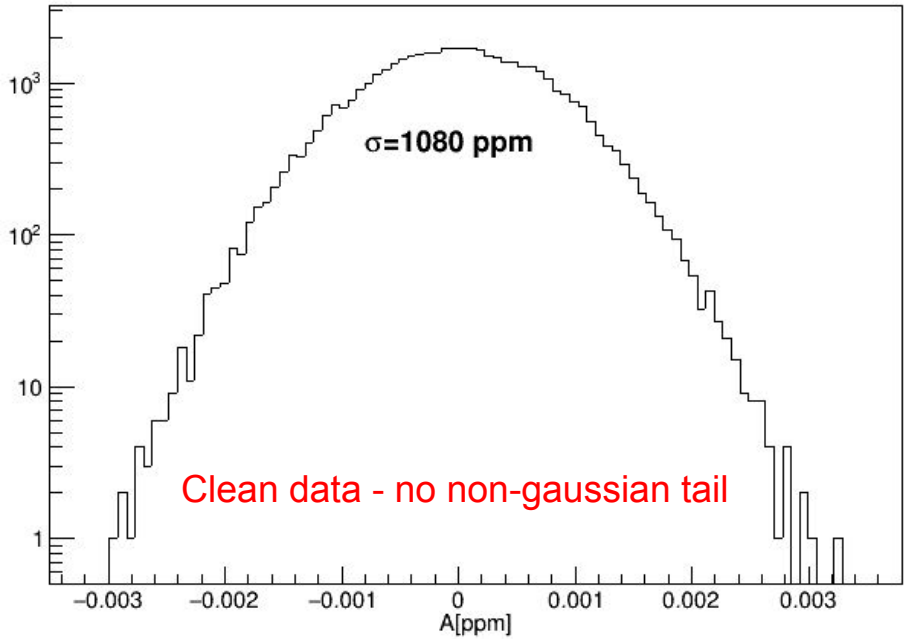


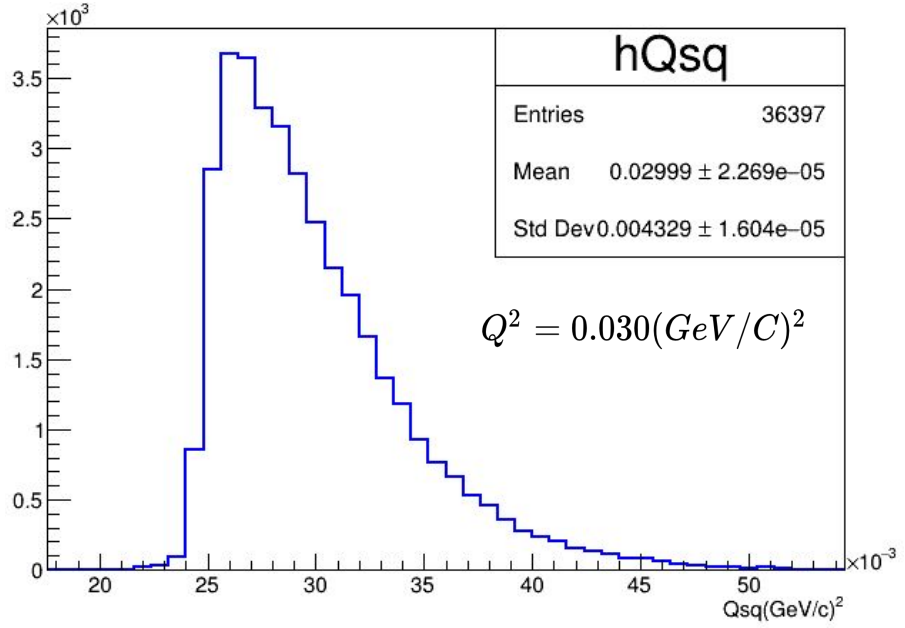
CREX beam quality

$$Asym = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma -}$$

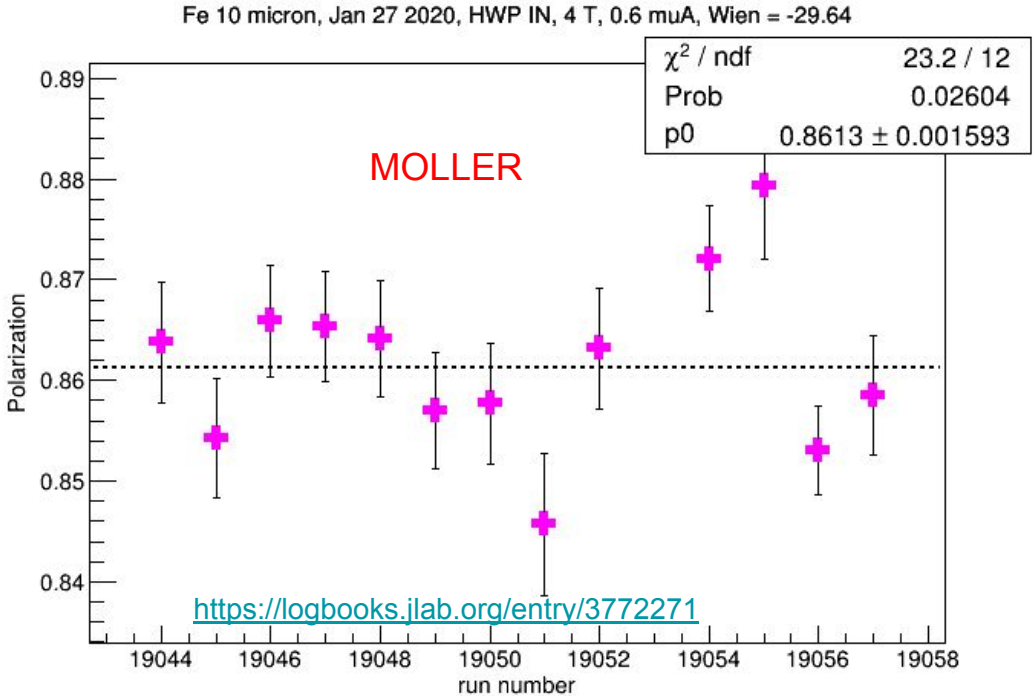


CREX results - online analysis plots





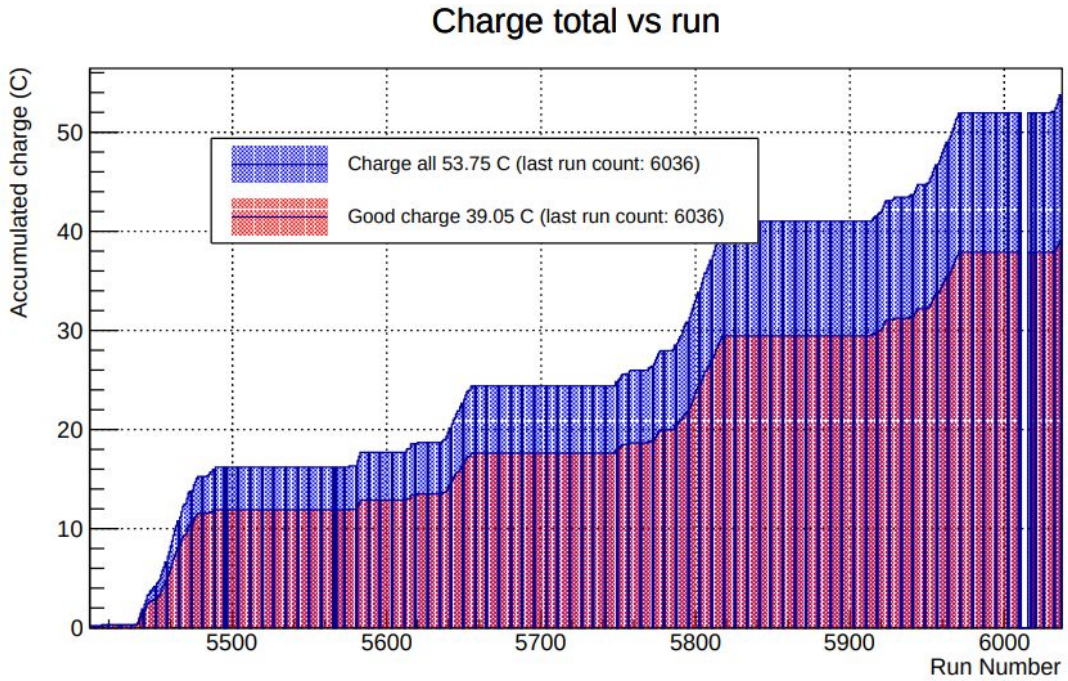
CREX Polarization measurements



So far we don’t have beam polarization measurement using Compton setup

Where are we in CREX running??

- Goal: 450 C; Good charge accumulated: 39 C (~9%)!!



We have to go a long way - please join..

Summary

-PREX/CREX - fundamental nuclear physics with many applications..Results are highly anticipated by abroad community

-PREXII went well.. We are working on analysis- aiming results in fall 2020

-CREX is running - long way to go...