PREX / CREX Status

Jan 25, 2018

Bob Michaels, on behalf of the PREX collaboration.

Wiki
https://prex.jlab.org/wiki/index.php/Main_Page

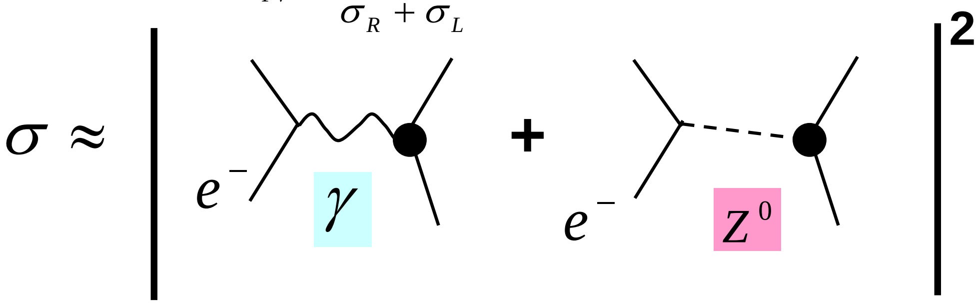
docDB
http://prex.jlab.org/cgi-bin/DocDB/public/DocumentDatabase
(private and public)

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

PREX and CREX

^{208}Pb ^{48}Ca

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



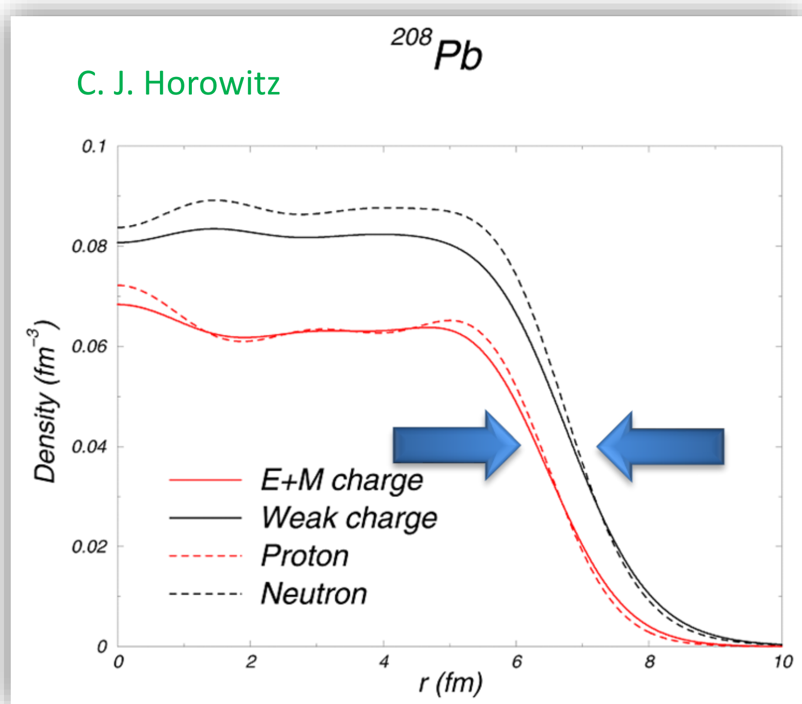
Electroweak Asymmetry in Elastic Electron-Nucleus Scattering :

Z^0 sees the neutrons

$$A = 0.656 \ ppm \pm 0.060\,(stat) \pm 0.014\,(syst)$$

(PREX-I) PRL 108 (2012) 112502

243 citations, Jan 2018



Neutron Skin

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

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PREX

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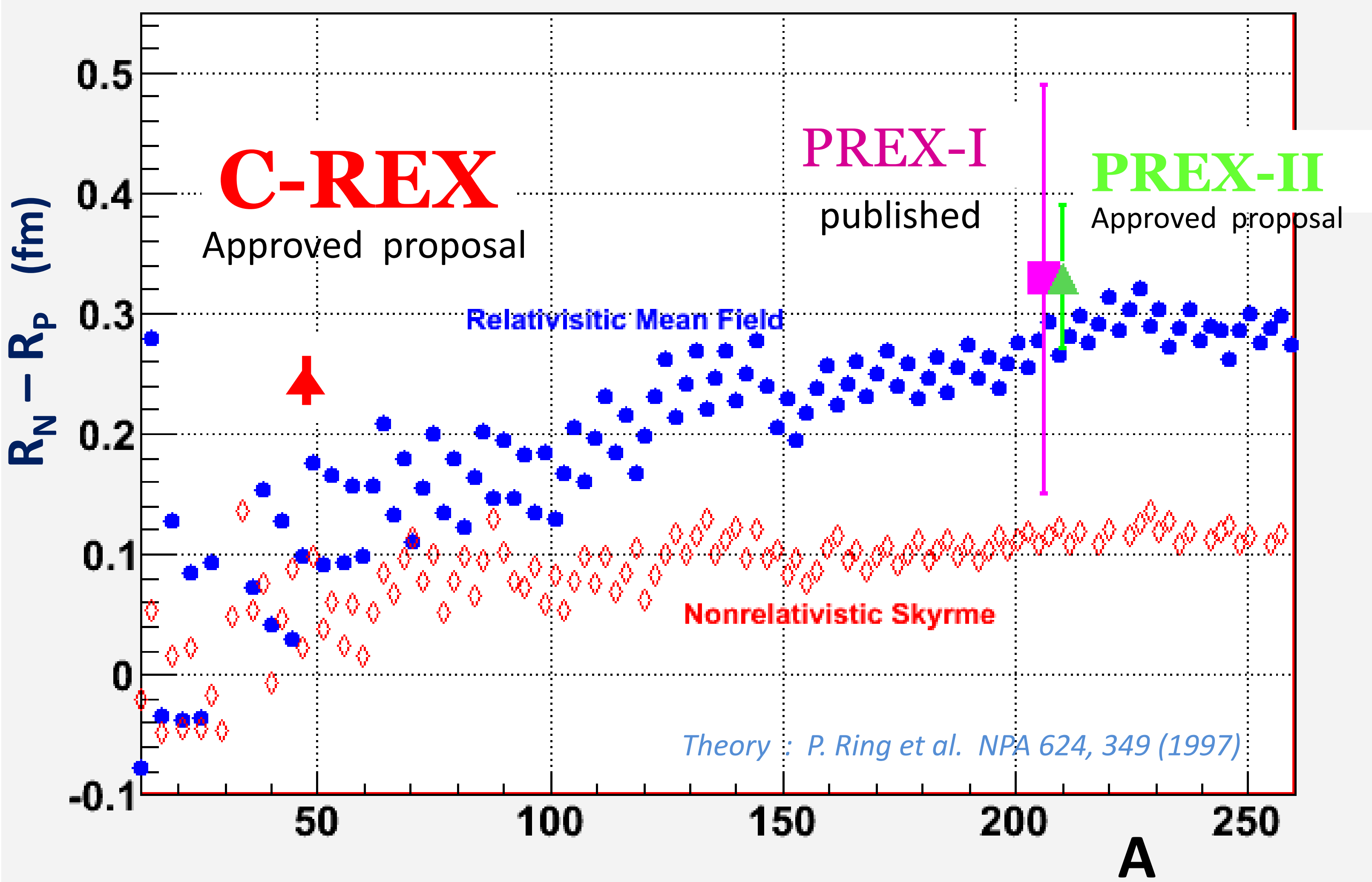
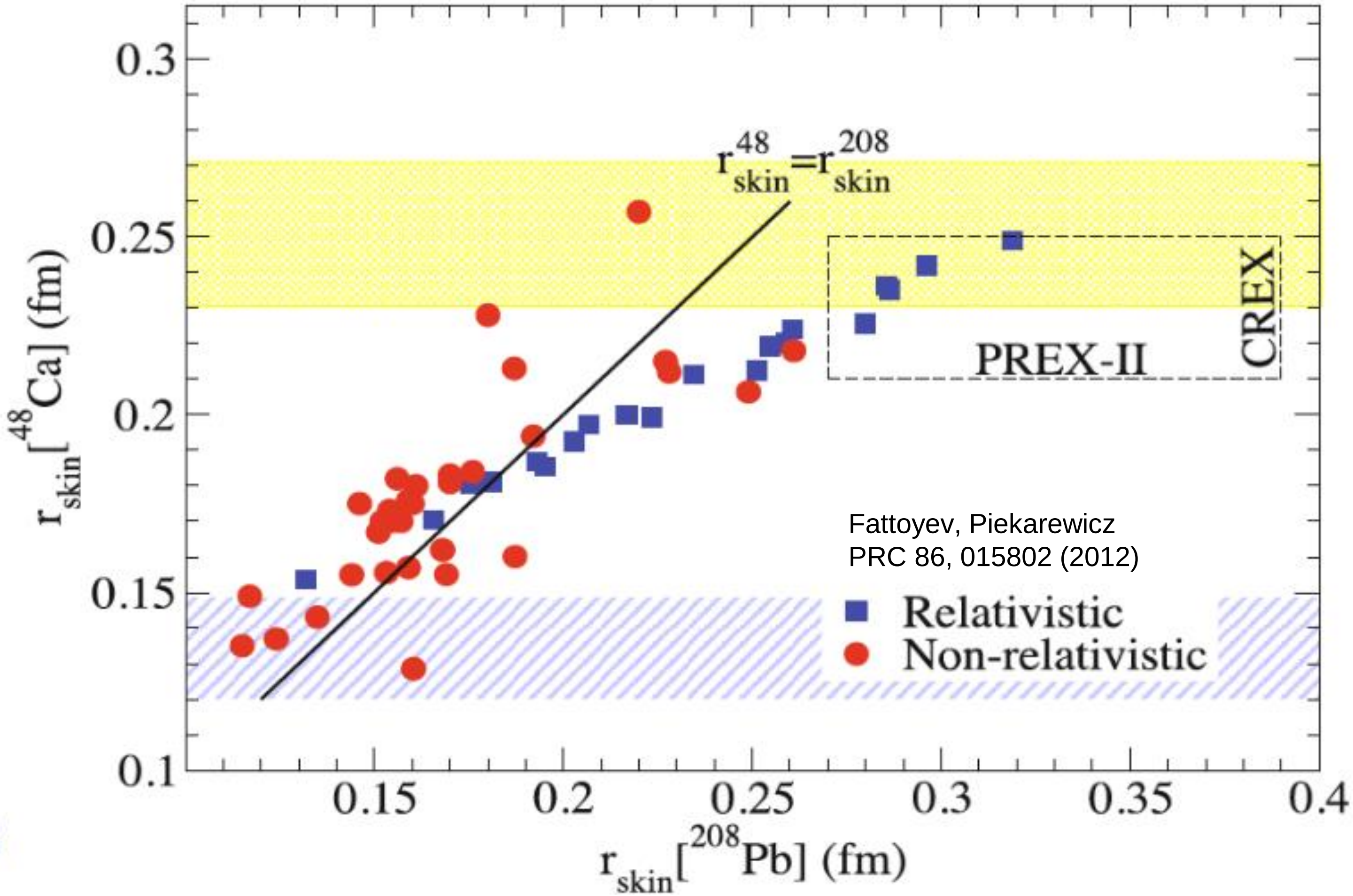
Neutron Skin vs Mass Number A



"Ab Initio" (exact microscopic) calculations of R_{skin} for ^{48}Ca have recently been published. G. Hagen et al., Nature Physics 12, 186 (2016).

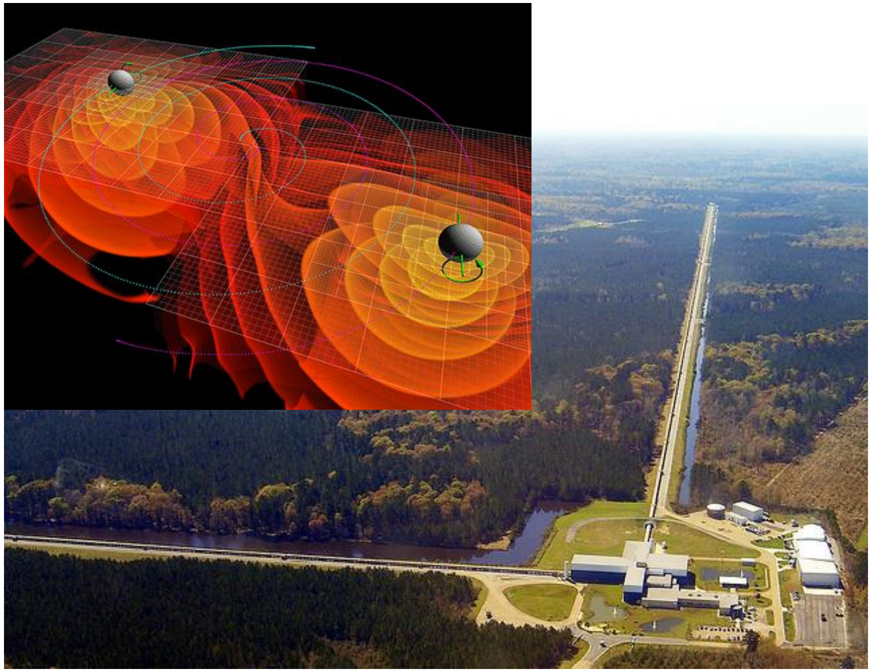
Can be compared to Density Functional Theory (the red and blue points) and Dispersive Optical Model (DOM).



DOM
W. Dickhoff, et al.
PRL 119, 222503 (2017)

ab initio
G. Hagen, et al.
Nature 12, 186 (2015)

LIGO has recently (2017) detected a Neutron Star Merger



Tidal Deformability (Λ) vs **Neutron Star Radius** (R). Upper limit of Λ from **LIGO** data. Points: RMF models.

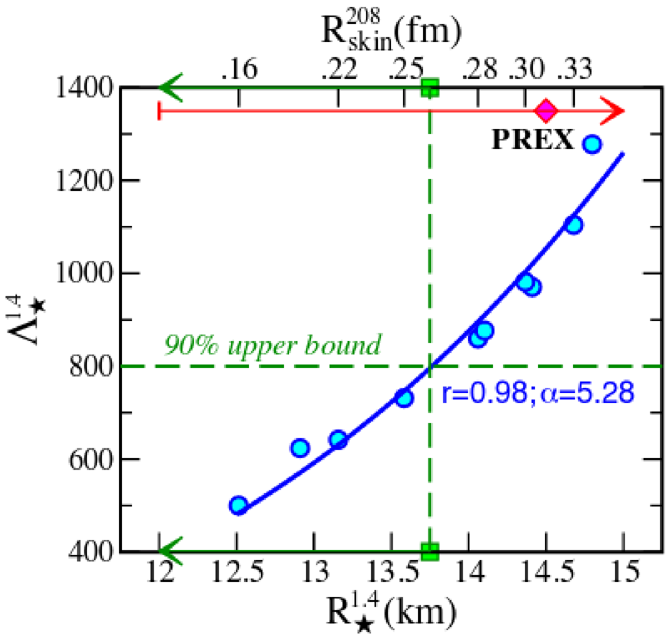


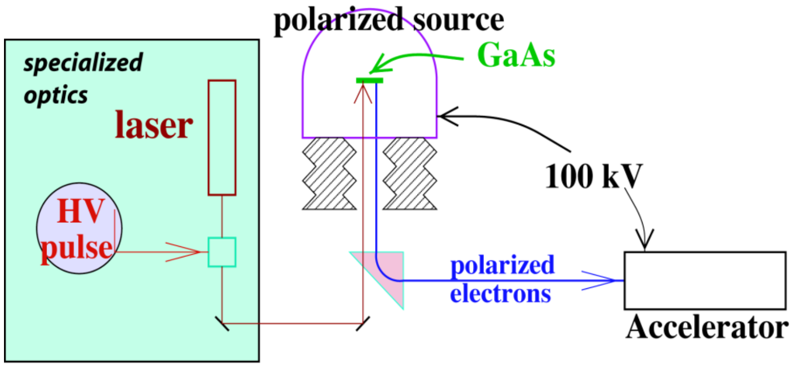
FIG. 3: (Color online). As in Fig. 1, predictions are shown for $\Lambda_{\star}^{1.4}$ as a function of the radius of a 1.4 $M_{\odot}$ neutron star and the neutron-skin thickness of ^{208}Pb, but now for the ten RMF models discussed in the text.

Fattoyev, Piekarewicz, Horowitz
arXiv 1711.06615

PREX constrains the equation of state of neutron-rich matter. If data are inconsistent it could signal a phase transition at the extremely high density of neutron stars.

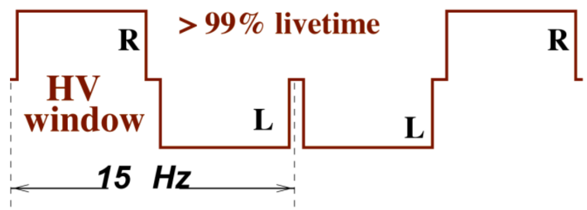
Parity Experiment Method

(integrating mode)



rapid, random, helicity flipping

Rapid, Random Helicity Flips

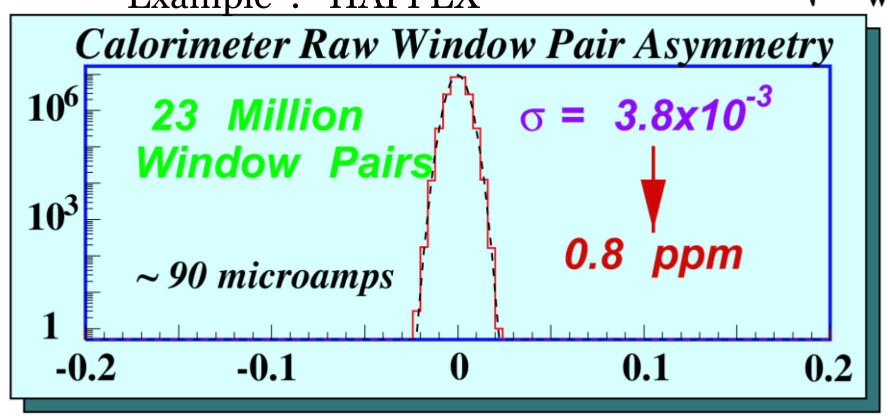


Measure flux F for each window

$$A_{\text{window pair}} = \frac{F_R - F_L}{F_R + F_L}$$

Signal Average N Windows Pairs: $A \pm \frac{\sigma(A)}{\sqrt{N_{\text{windows}}}}$

Example : HAPPEX

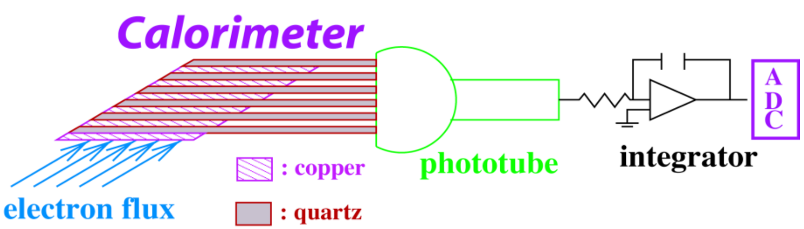


No non-gaussian tails to +/- 5σ

Flux Integration Technique:

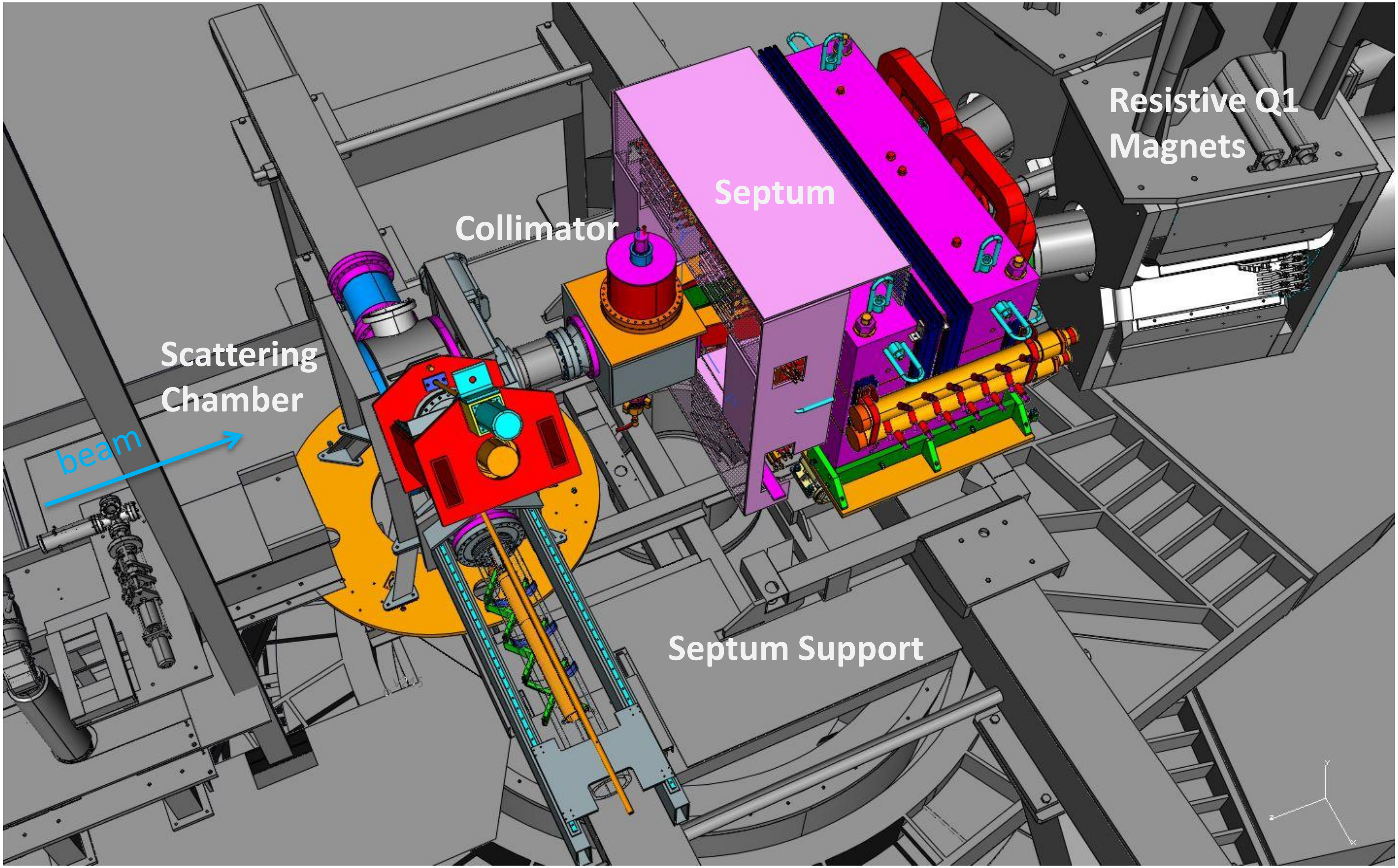
C-REX : 140 MHz

PREX: 500 MHz



Hall Configuration

Credit: Robin Wines

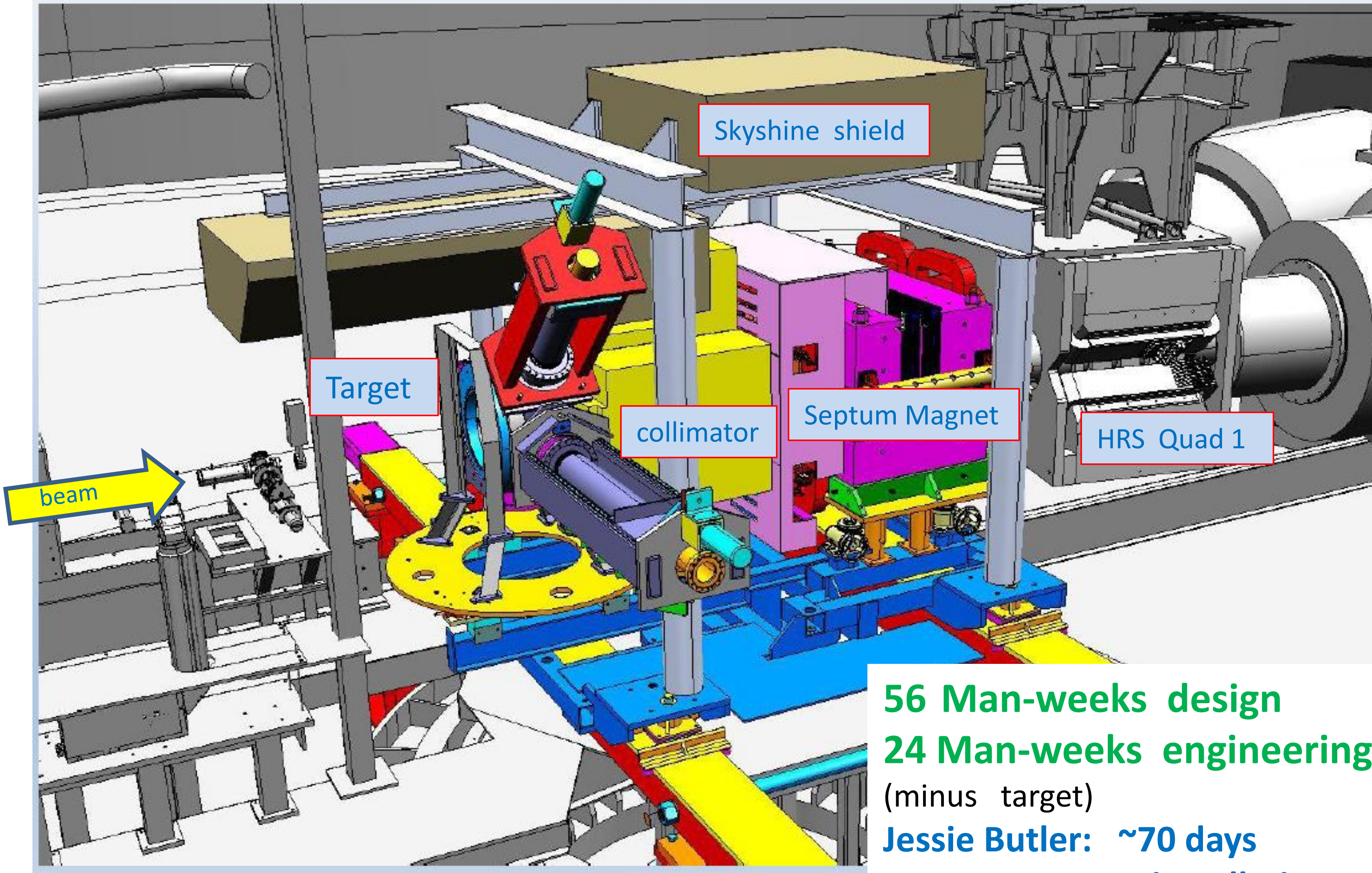


ERR Design Drawings

New apparatus in target region

ERR Design Drawings

Credit: Robin Wines



56 Man-weeks design

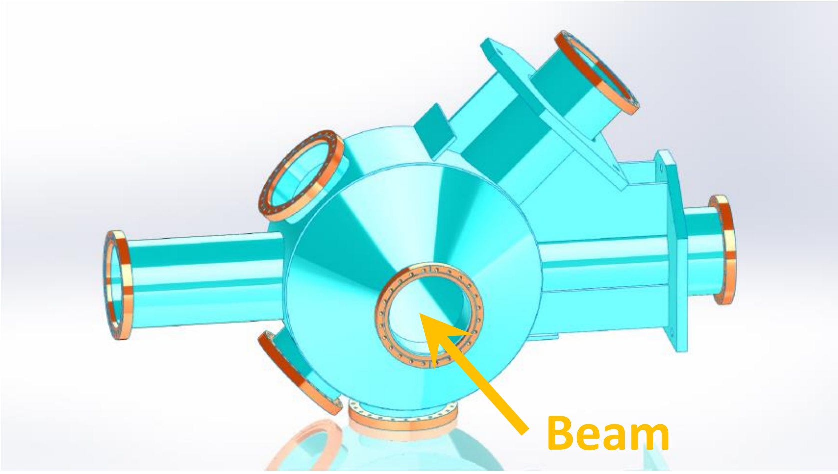
24 Man-weeks engineering

(minus target)

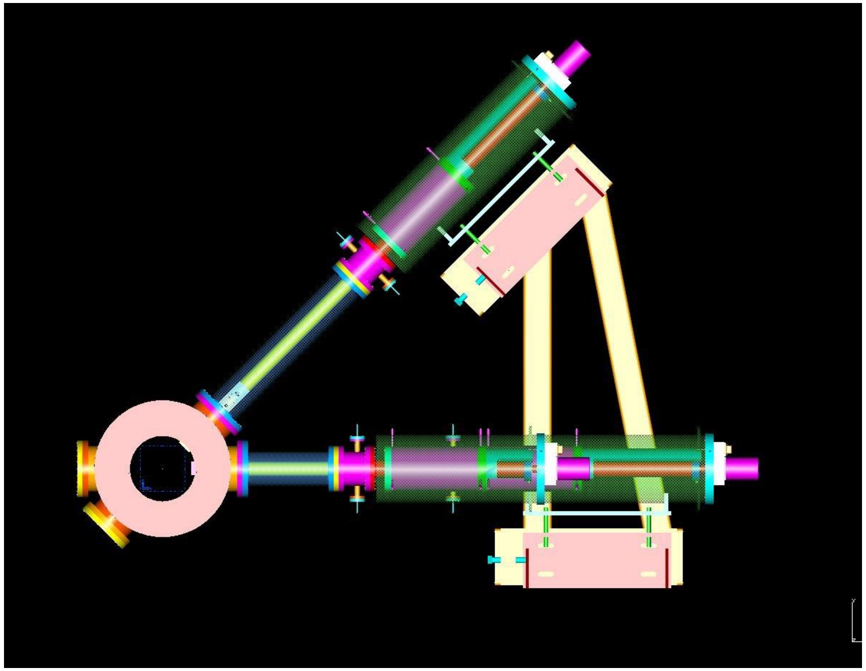
Jessie Butler: ~70 days installation

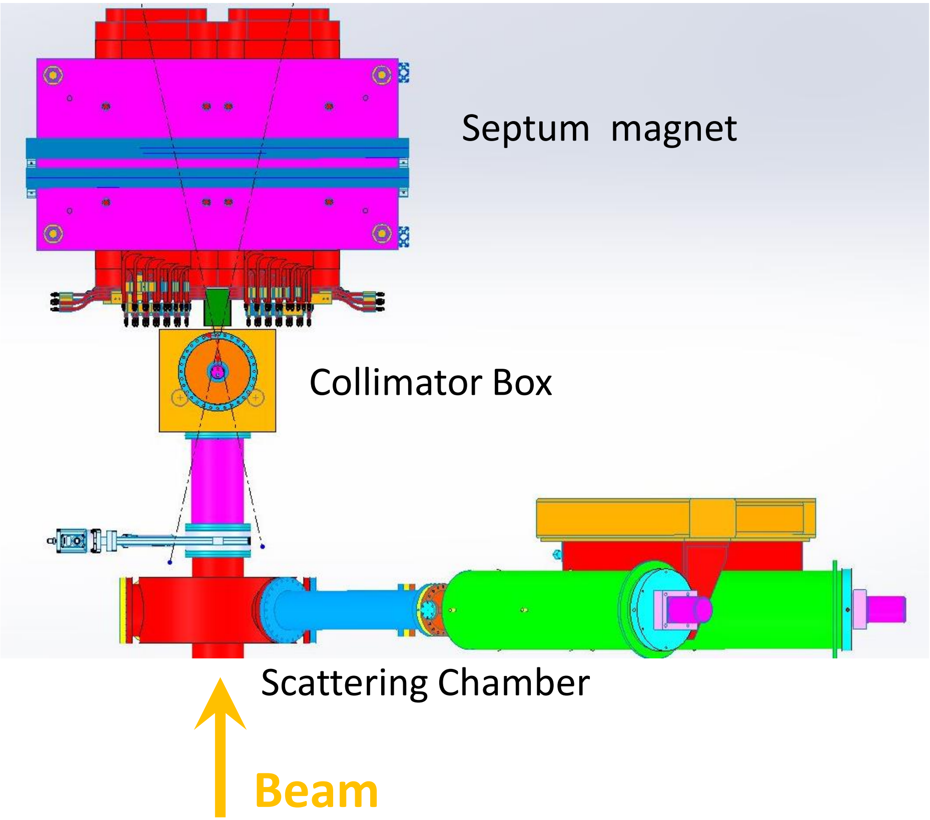
New PREX / CREX Scattering Chamber

Silviu Covrig & target group

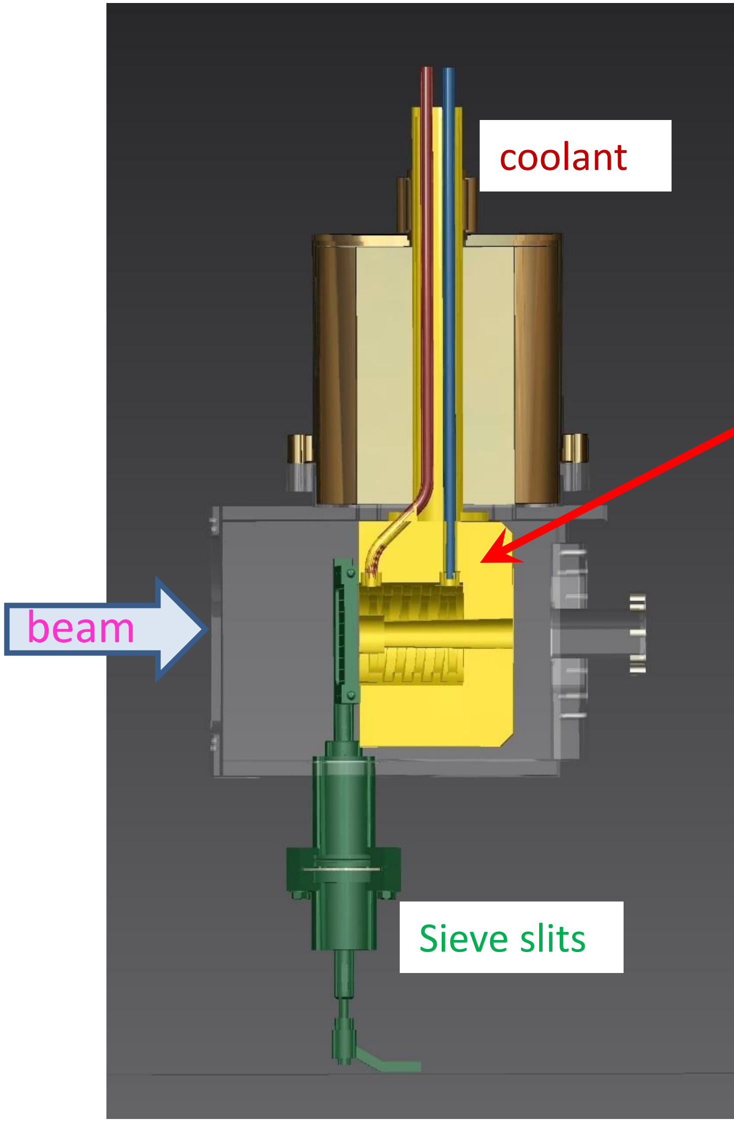


- One cryo-cooled production target ladder and one calibration-target ladder.
- Improved (hard) vacuum seals
- Run PREX and CREX with one installation
- Small chamber allows efficient shielding





Collimator Box -- located after target, intercepts small-angle scatters so they don't hit beamline elements.

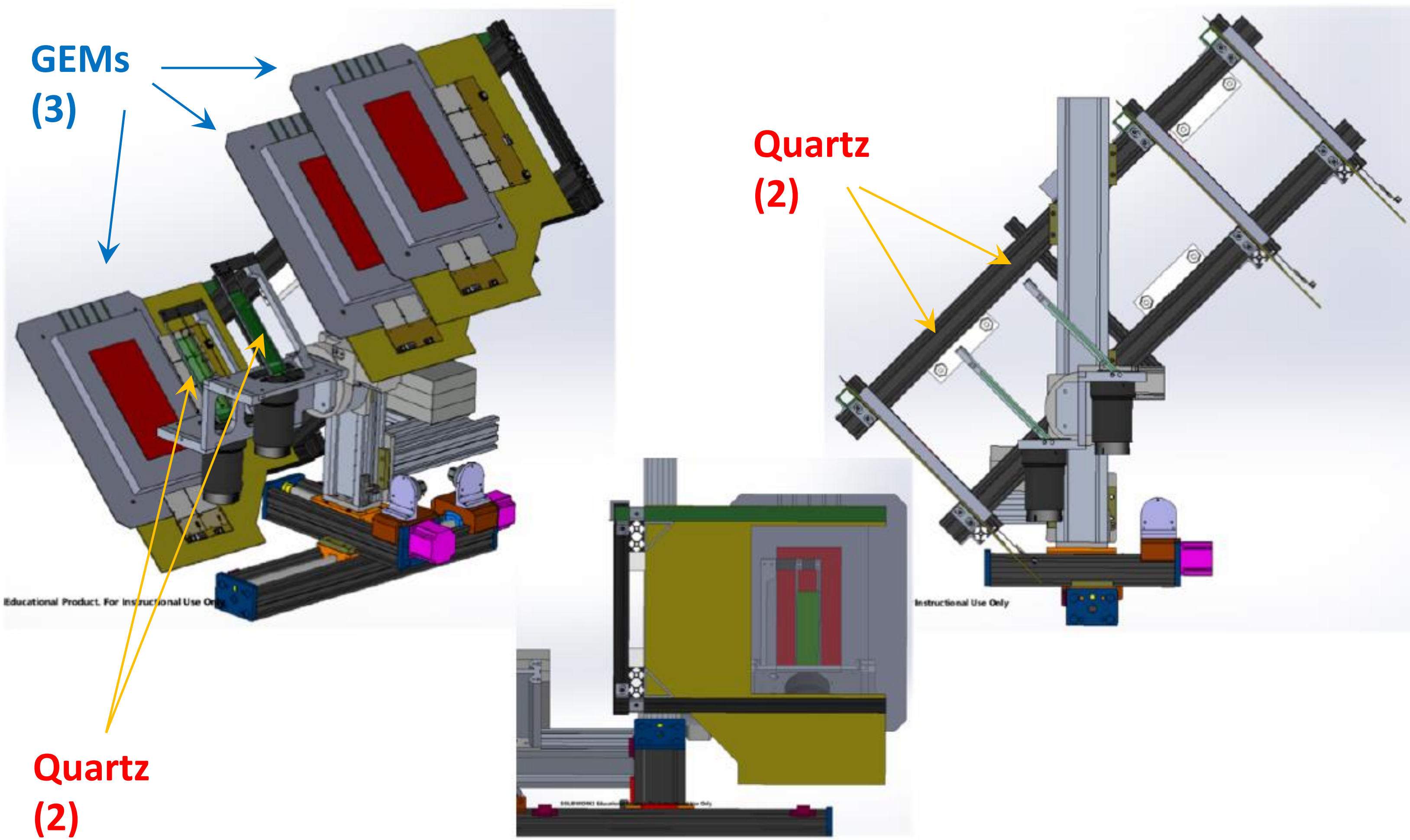


Septum Magnet

PREX/CREX Detectors

Dustin McNulty (Idaho State)
Krishna Kumar (Stony Brook)

RHRS Tandem Quartz Mount with GEMs

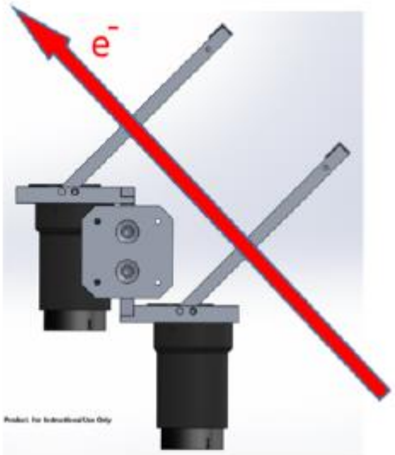


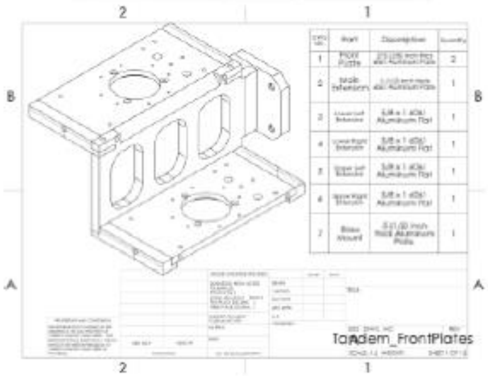
Electron's view (from below)

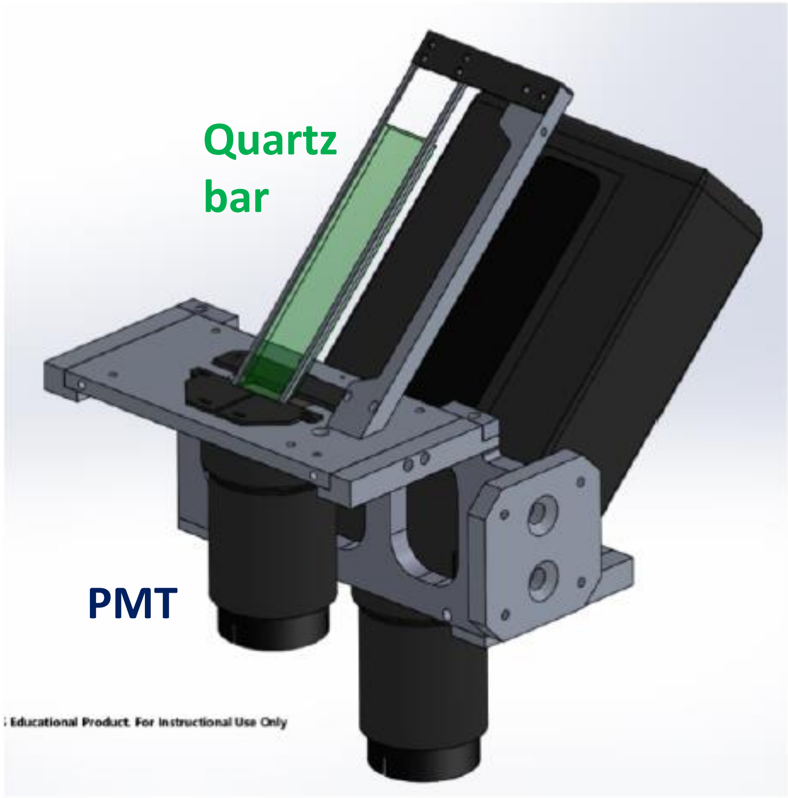
Integrating Detectors

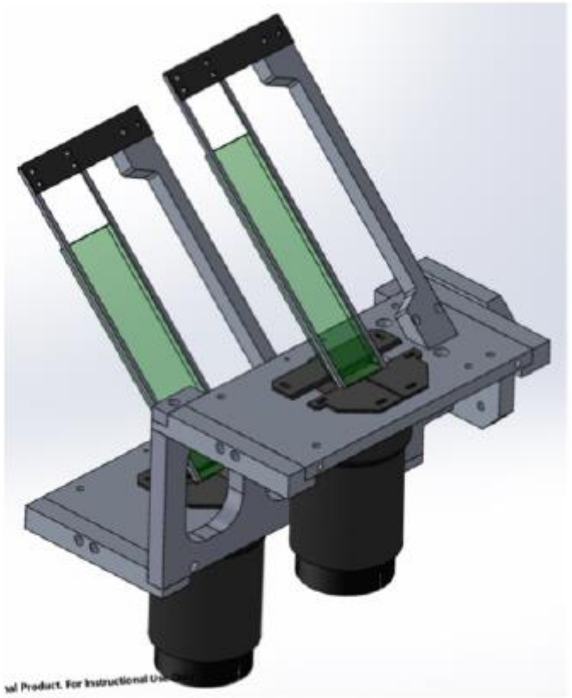
Dustin McNulty (Idaho State)
Krishna Kumar (Stony Brook)

Placed above the VDCs in HRS detector stack







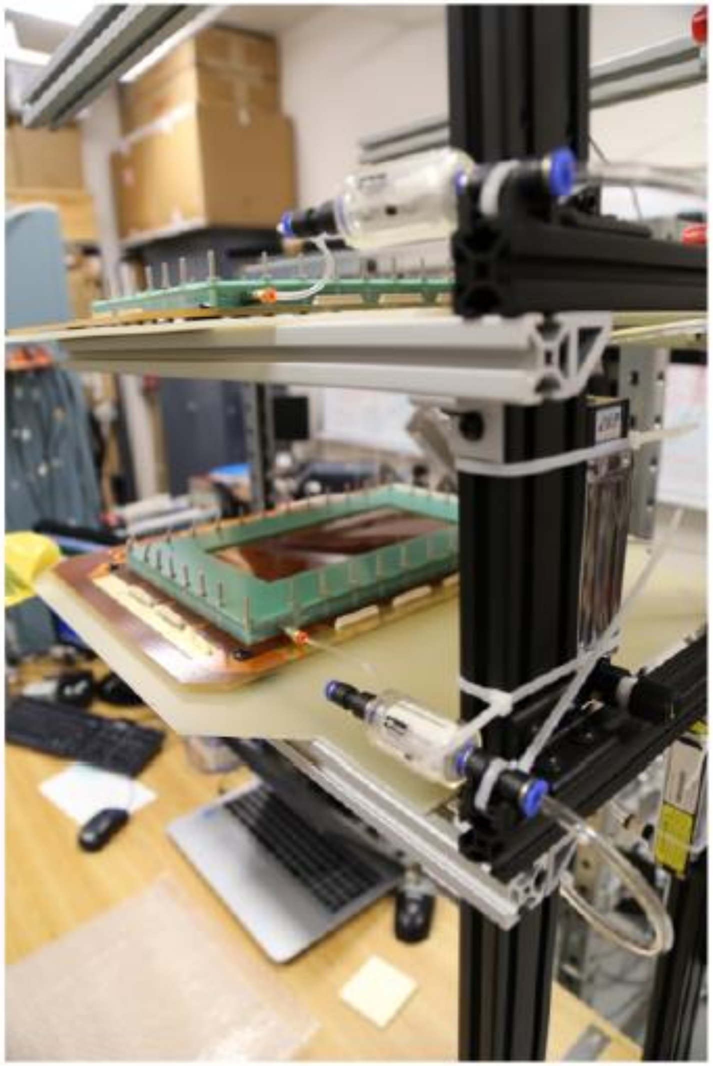


- Two (redundant) quartz bars, which intercept elastically scattered electrons.
- We integrate this signal for our main signal.
- Design similar to PREX-I. Beam tests at Mainz confirm simulation.

GEMs

Dustin McNulty (Idaho State)
Krishna Kumar (Stony Brook)

- Supplement the VDCs in HRS
- So we can do Q^2 measurements at ~1 uA (rates high)
- These are "small" 10 x 20 cm^2
  400 um pitch
- Capitalizes on SBS developments (INFN / Uva)



Two Chambers installed; gas flowing

Radiation status @ ERR

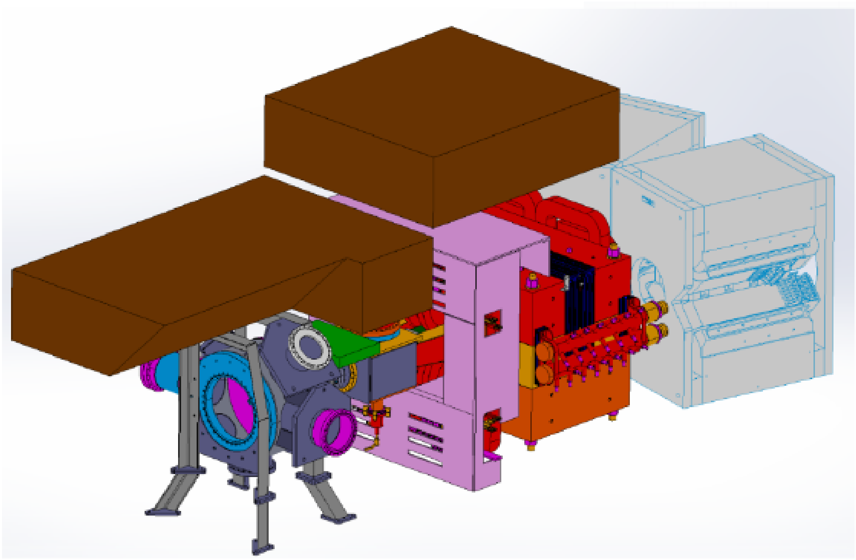
PREXII + CREX total integrated dose will be on the same level as HAPPEX-II or PVDIS:

1MeV n_{eq} / cm^2

HRS power supply	PREX-I	PREX-II	CREX	P2/P1	CREX/P1	P2/H2	P2/PVDIS
neutron	1.0E+11	7.6E+09	1.5E+10	7%	20%	70%	73%
electron	1.2E+11	1.4E+10	2.1E+10	11%	12%	94%	84%
total	**2.3E+11**	**2.1E+10**	**3.6E+10**	9%	16%	83%	80%

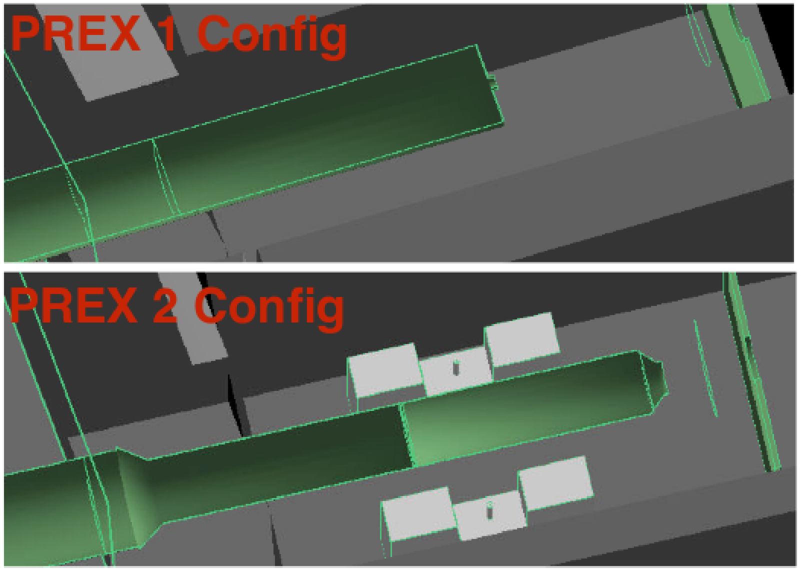
We evaluated the effect of the Q1 fringe field.

- **If both HRS are used, no shield is needed.**
- **A thin shield would also allow 1-arm running (planned tritium shield would be sufficient)**



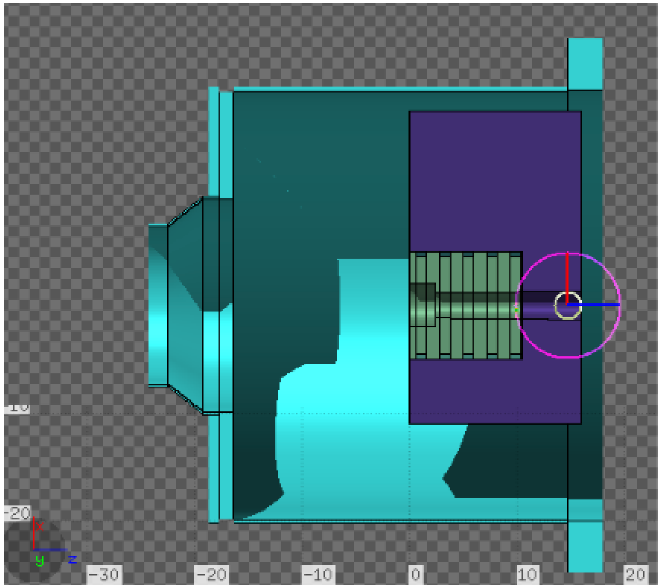
- Extrapolating from measurements during the original PREX run, we estimate the site boundary dose to be <3 mrem for PREX-II + CREX

Radiation updates



- We found that the changes to the dump beam line will produce significant radiation splash-back
- We are talking to designers and management to find a reasonable solution to bring back the radiation dose at the HRS electronics to the level we had for the 2017 ERR

- Significant progress has been made with the design of the region around the collimator
- Modeling pivot region in FLUKA. We are now able to estimate dose rates during deinstallation, to guide design and planning.



PREX / CREX Experiments

PREX-2: 3% stat, 0.06 fm

CREX: 2.4% stat, 0.02fm

PREX-I

E=1.1 GeV, 5°

A=0.6 ppm

Charge Normalization	0.2%
Beam Asymmetries	1.1%
Detector Non-linearity	1.2%
Transverse Asym	0.2%
Polarization	1.3%
Target Backing	0.4%
Inelastic Contribution	<0.1%
Effective Q^2	0.5%
Total Systematic	**2.1%**
Total Statistical	**9%**

Achieved, published

statistics limited result, systematics well under control

PREX-II

E=1.1 GeV, 5°

A=0.6 ppm

70 μA, 25+10 days

Charge Normalization	0.1%
Beam Asymmetries*	1.1%
Detector Non-linearity*	1.0%
Transverse Asym	0.2%
Polarization*	1.1%
Target Backing	0.4%
Inelastic Contribution	<0.1%
Effective Q^2	0.4%
Total Systematic	**2%**
Total Statistical	**3%**

*Experience suggests that leading systematic errors can be improved beyond proposal

CREX

E=1.9 GeV, 5°

A = 2.3 ppm

150 μA, 35 + 10 days

Charge Normalization	0.1%
Beam Asymmetries	0.3%
Detector Non-linearity	0.3%
Transverse Asym	0.1%
Polarization	0.8%
Target Contamination	0.2%
Inelastic Contribution	0.2%
Effective Q^2	0.8%
Total Systematic	**1.2%**
Total Statistical	**2.4%**

PREX, C-REX : Summary

- Fundamental Nuclear Physics with many applications. Results are highly anticipated by a broad community.
- PREX-I achieved systematic error goals
- Problems being fixed: shielding and rad-hard vacuum seals.
- PREX-II & C-REX passed the Experiment Readiness Review (ERR) in 2017
- Please join us !