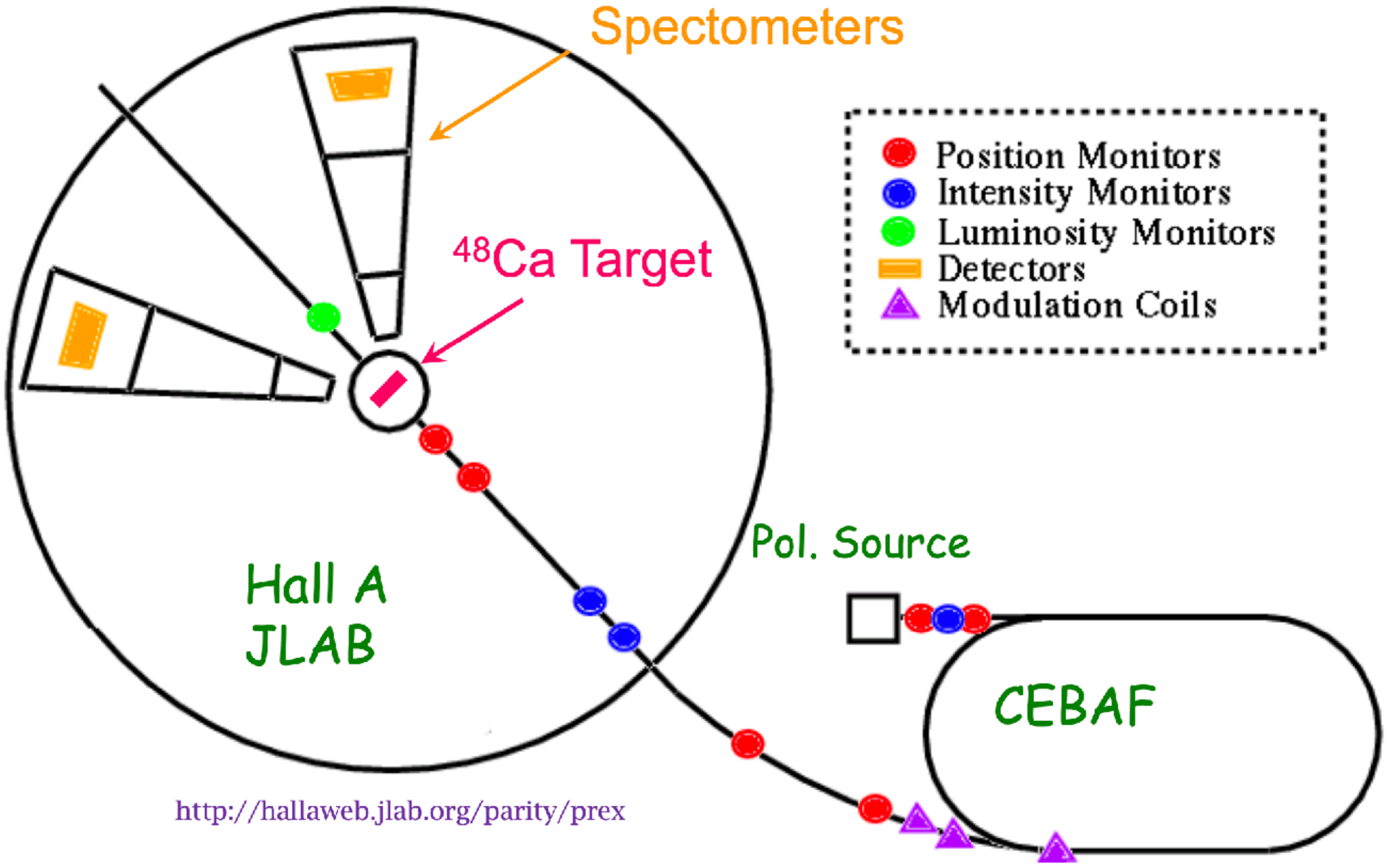
CREX parity violating electron scattering experiment results



CREX uses Parity V. to Isolate Neutrons

- In Standard Model Z^0 boson couples to the weak charge.
- Proton weak charge is small:

$$Q_W^p = 1 - 4\sin^2\Theta_W \approx 0.05$$

- Neutron weak charge is big:

$$Q_W^n = -1$$

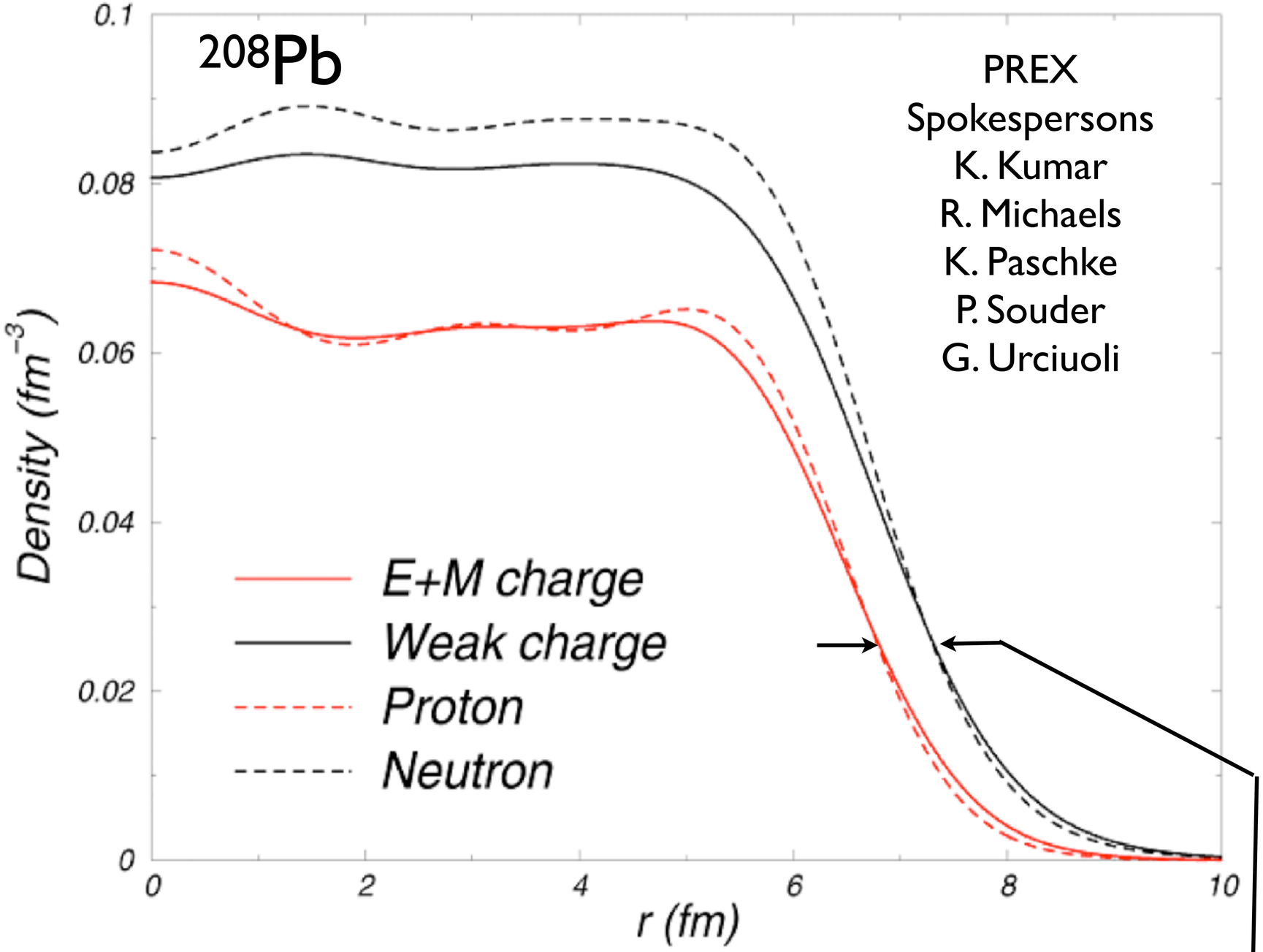
- Weak interactions, at low Q^2, probe neutrons.
- Parity violating asymmetry A_{pv} is cross section difference for positive and negative helicity electrons

- A_{pv} from interference of photon and Z^0 exchange.
- Determines weak form factor

$$F_W(Q^2) = \int d^3r \frac{\sin(Qr)}{Qr} \rho_W(r)$$

- Model independently map out distribution of weak charge in a nucleus.
- **Electroweak reaction free from most strong interaction uncertainties.**

$$A_{PV} = \frac{\sigma_L - \sigma_R}{\sigma_L - \sigma_R} \approx \frac{G_F Q^2 |Q_W|}{4\pi\alpha\sqrt{2}Z} \frac{F_W(Q^2)}{F_{ch}(Q^2)}$$



- PREX measures how much neutrons stick out past protons (neutron skin).

CREX

Extracting A_{PV}

Blinded Corrected Asymmetry A_{corr}:
2080.3 ± 83.8ppb

$$A_{phys} = R_{radcorr}\, R_{accept}\, R_{Q^2} \frac{A_{corr} - P_L \sum_i f_i A_i}{P_L(1 - \sum_i f_i)}$$

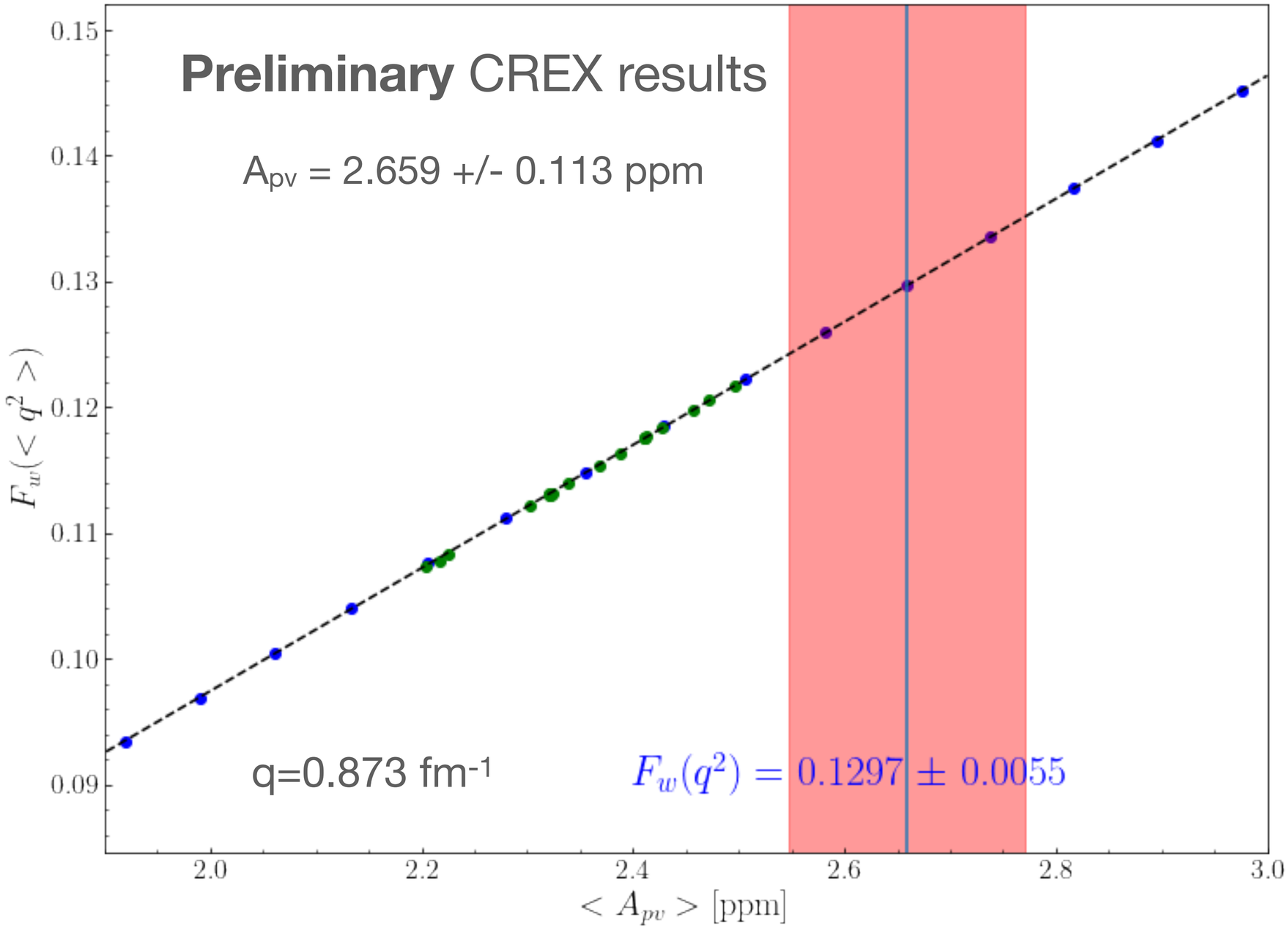
$$A_{corr} = A_{det} - A_{beam} - A_{trans} - A_{nonlin} - A_{blind}$$

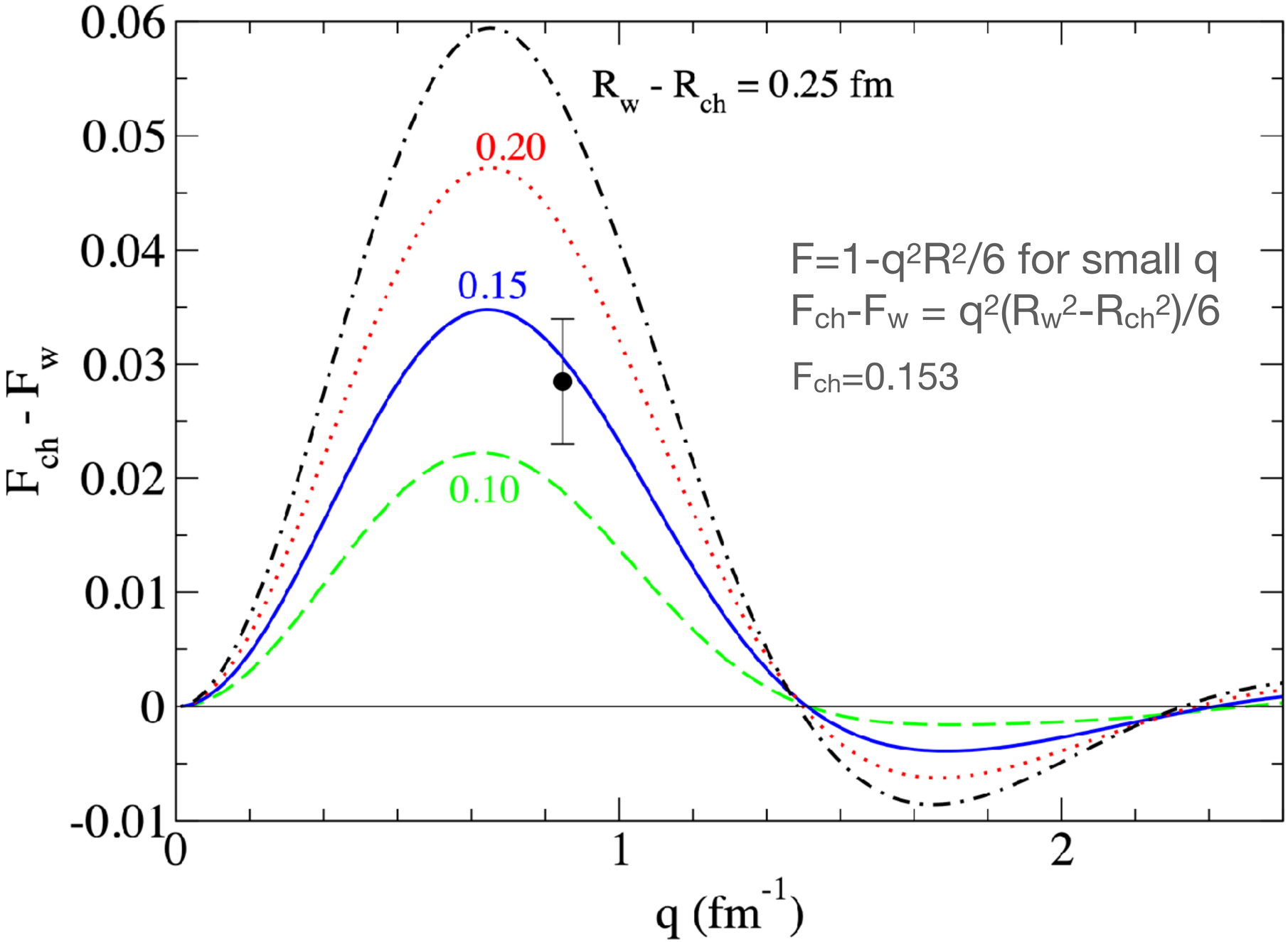
Blinded A_{PV}:
2334.8 ± 106.1(stat) ± 37.3(sys)ppb
[± 112.4ppb(tot)]

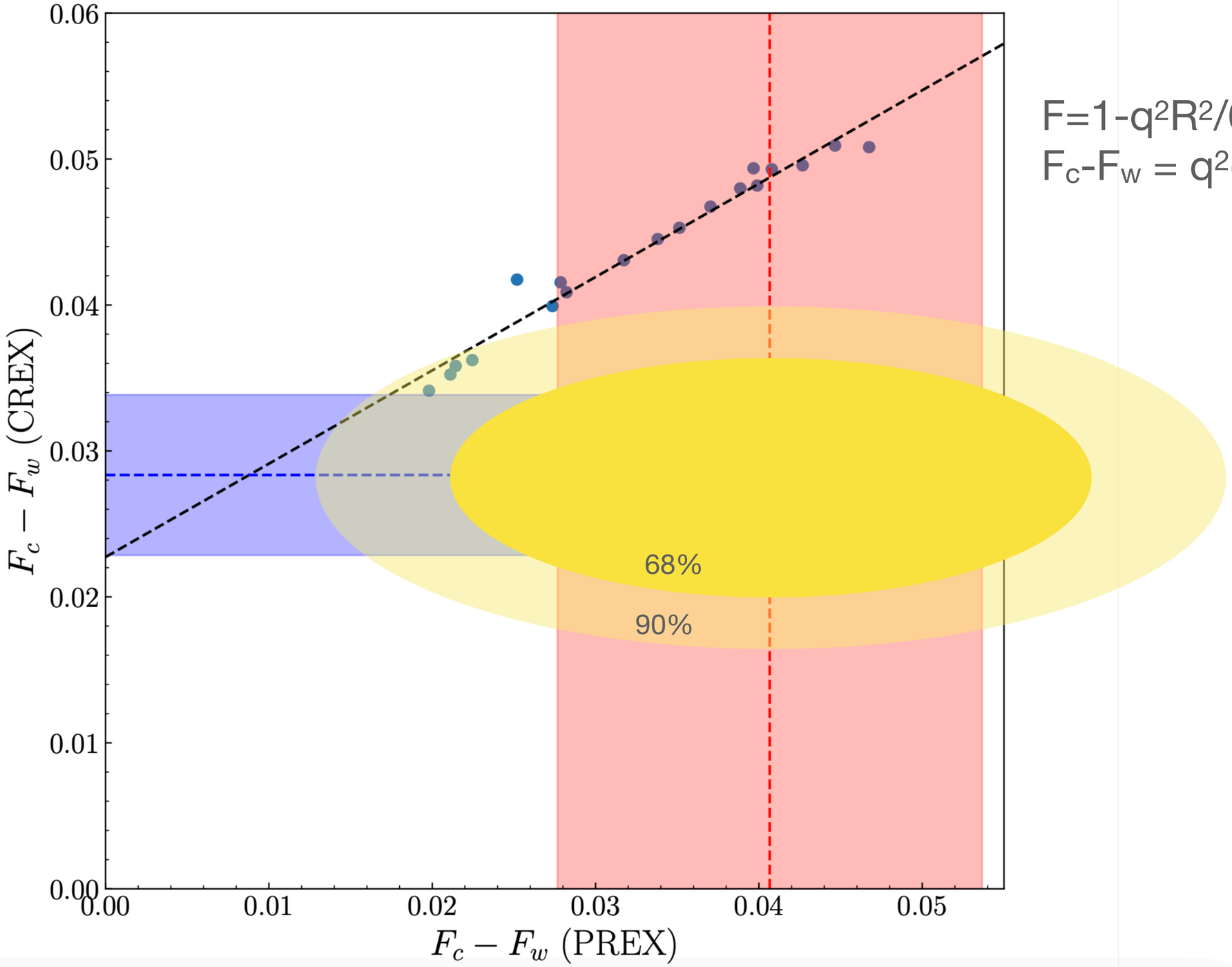
Unblinded A_{PV}:
2658.6 ± 113.2ppb (4.3%)

	A_{PV} uncertainty contribution [ppb]	A_{PV} uncertainty contribution [%]
Polarization	11.7	0.50%
Horizontal Polarization	12.7	0.54%
Vertical Polarization	0.9	0.04%
Acceptance normalization	21.0	0.90%
Beam correction	6.9	0.30%
Non-linear detector response	6.7	0.29%
Ca40 background	8.8	0.38%
Charge correction	1.1	0.05%
Inelastic contamination 2+	19.1	0.82%
Inelastic contamination 3-(1)	10.2	0.44%
Inelastic contamination 2-(3)	3.6	0.15%
Rescattering	0.4	0.02%
Total	**37.3**	**1.6%**

- When taken all into account the experimental systematic uncertainty comes to 1.6%, less than half the 4.5% statistical uncertainty
- Total uncertainty of is 112.4ppb (4.8%)

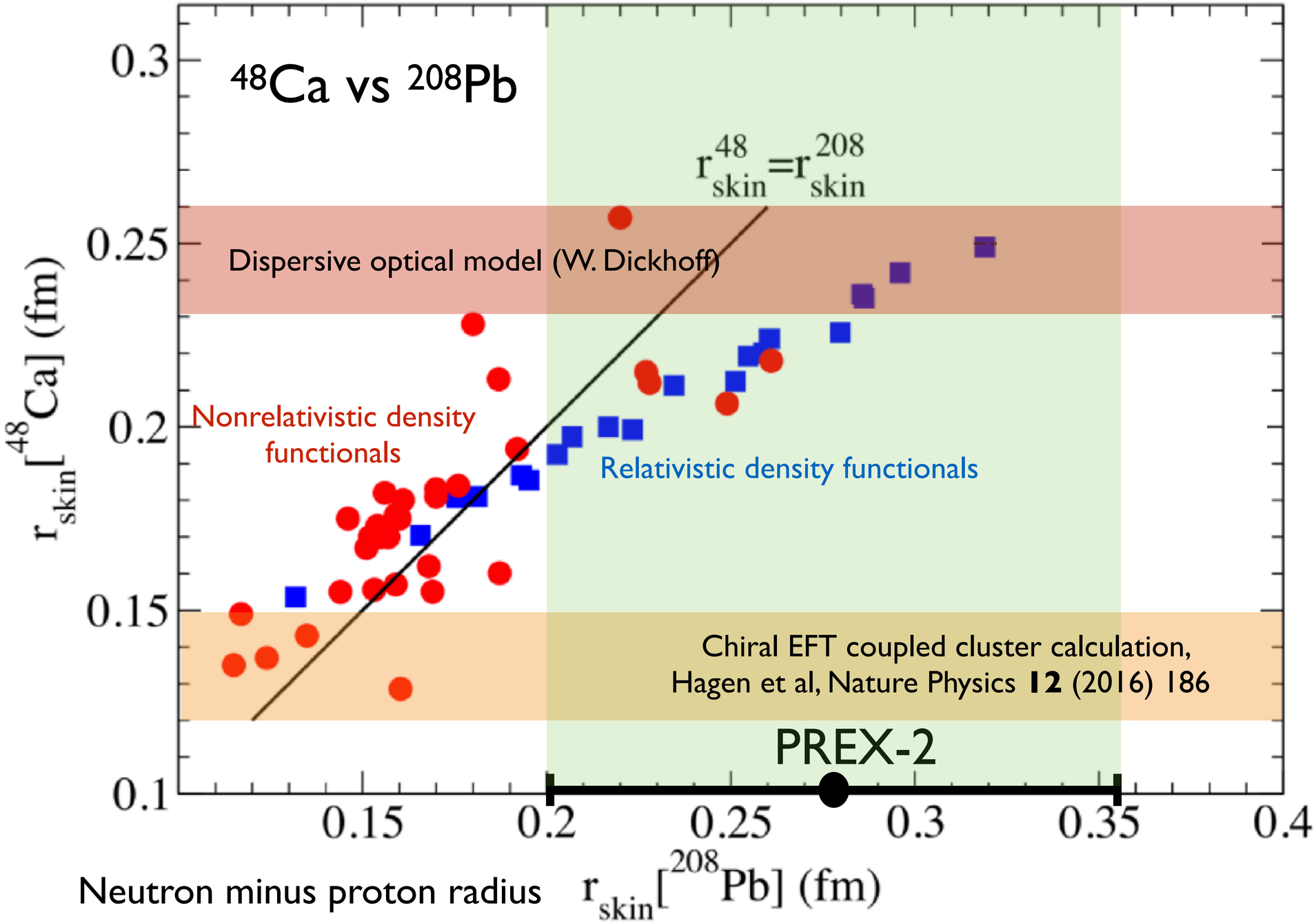

Preliminary CREX results
A_{pv} = 2.659 +/- 0.113 ppm
q=0.873 fm^{-1}
$F_w(q^2) = 0.1297 \pm 0.0055$
$F_w(< q^2 >)$
$< A_{pv} >$ [ppm]
0.09
0.10
0.11
0.12
0.13
0.14
0.15
2.0
2.2
2.4
2.6
2.8
3.0


$R_w - R_{ch} = 0.25$ fm
0.20
0.15
0.10
$F=1-q^2R^2/6$ for small q
$F_{ch}-F_w = q^2(R_w^2-R_{ch}^2)/6$
$F_{ch}=0.153$
$F_{ch} - F_w$
q (fm^{-1})
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
0
1
2

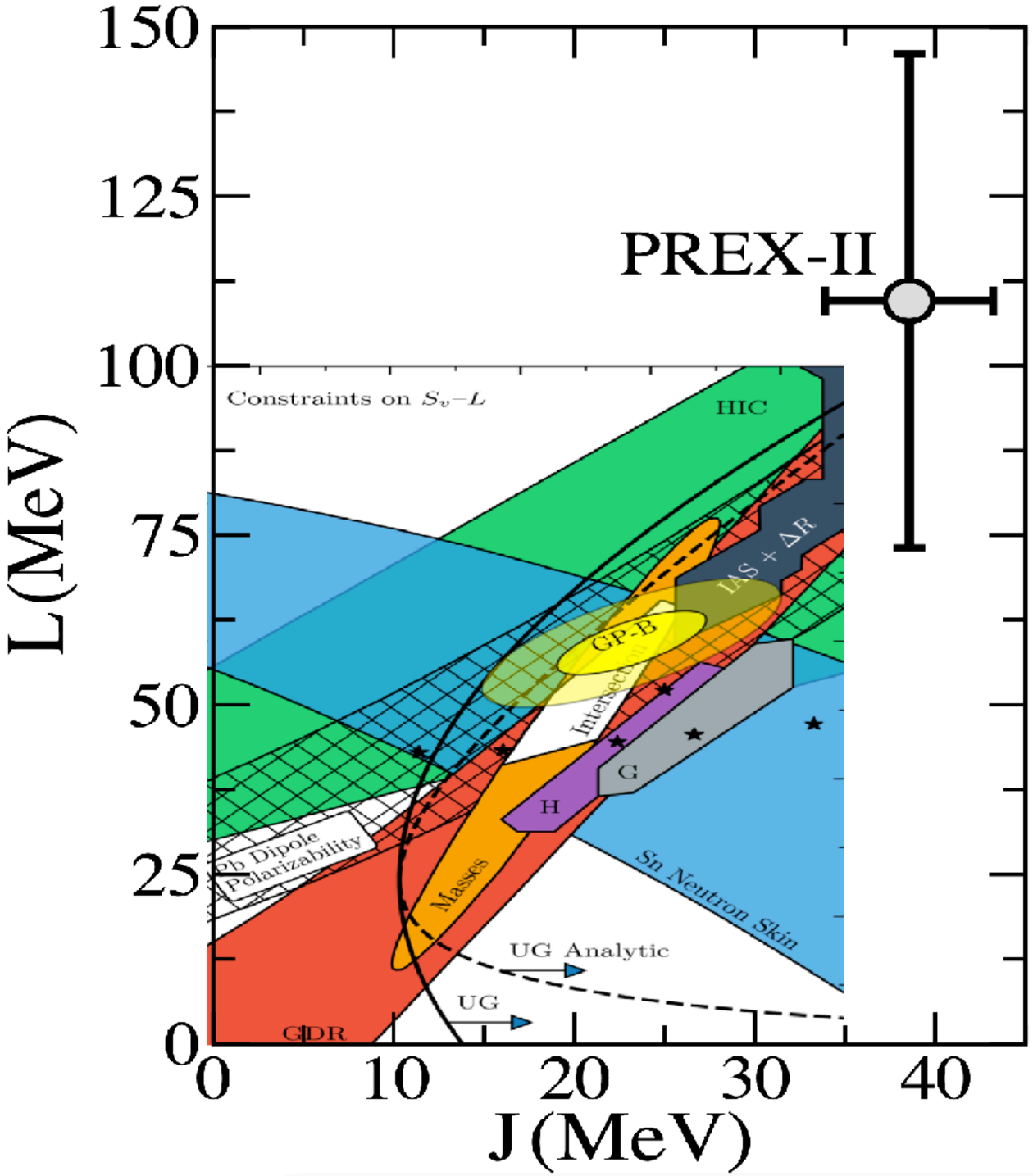


$F=1-q^2R^2/6$ for small q

$F_c-F_w = q^2(R_w^2-R_c^2)/6$



Neutron minus proton radius


PREX-II
Constraints on S_v–L
HIC
IAS + ΔR
GP-B
Intersection
G
H
Masses
Sn Neutron Skin
UG Analytic
UG
GDR
Pb Dipole Polarizability
L(MeV)
J(MeV)
0
25
50
75
100
125
150
0
10
20
30
40

Parity violation at Mainz

- At MESA (new high current low energy machine) measure:
  - Weak charge of proton (improve on Qweak)
  - Weak charge of ^{12}C ("Atomic PNC without the atomic structure")
  - MREX: Neutron skin thickness of ^{208}Pb (improve on PREX II by more than factor of two).

CREX Collaboration

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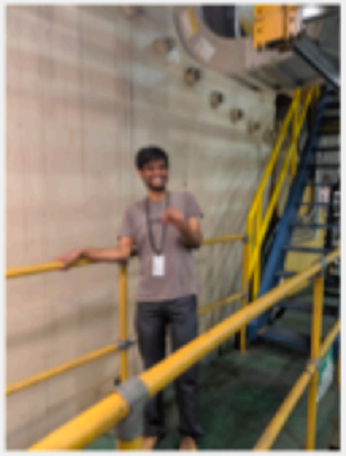


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