

Carbon with Solenoidal Spectrometer, and more...

Comments on talks by O. Moreno
and T. W. Donnelley (PAVI 14)
and K. Gertz + Kumar and Chuck

P. A. Souder

IEB and PVES with Nuclear targets

- More energy than MESA.
- High intensity.
- Good for NP at the $Q=200$ Mev (1 fm^{-1}) level.
- Carbon can take the intensity (Pb and Ca are more difficult).

What physics does this allow us to do?

Theory

$$A_{PV} = \frac{G_F Q^2}{\pi \alpha \sqrt{2}} \left(\sin^2 \theta_W + \frac{G_E^s}{2(G_E^{\gamma p} + G_E^{\gamma n})} \right)$$

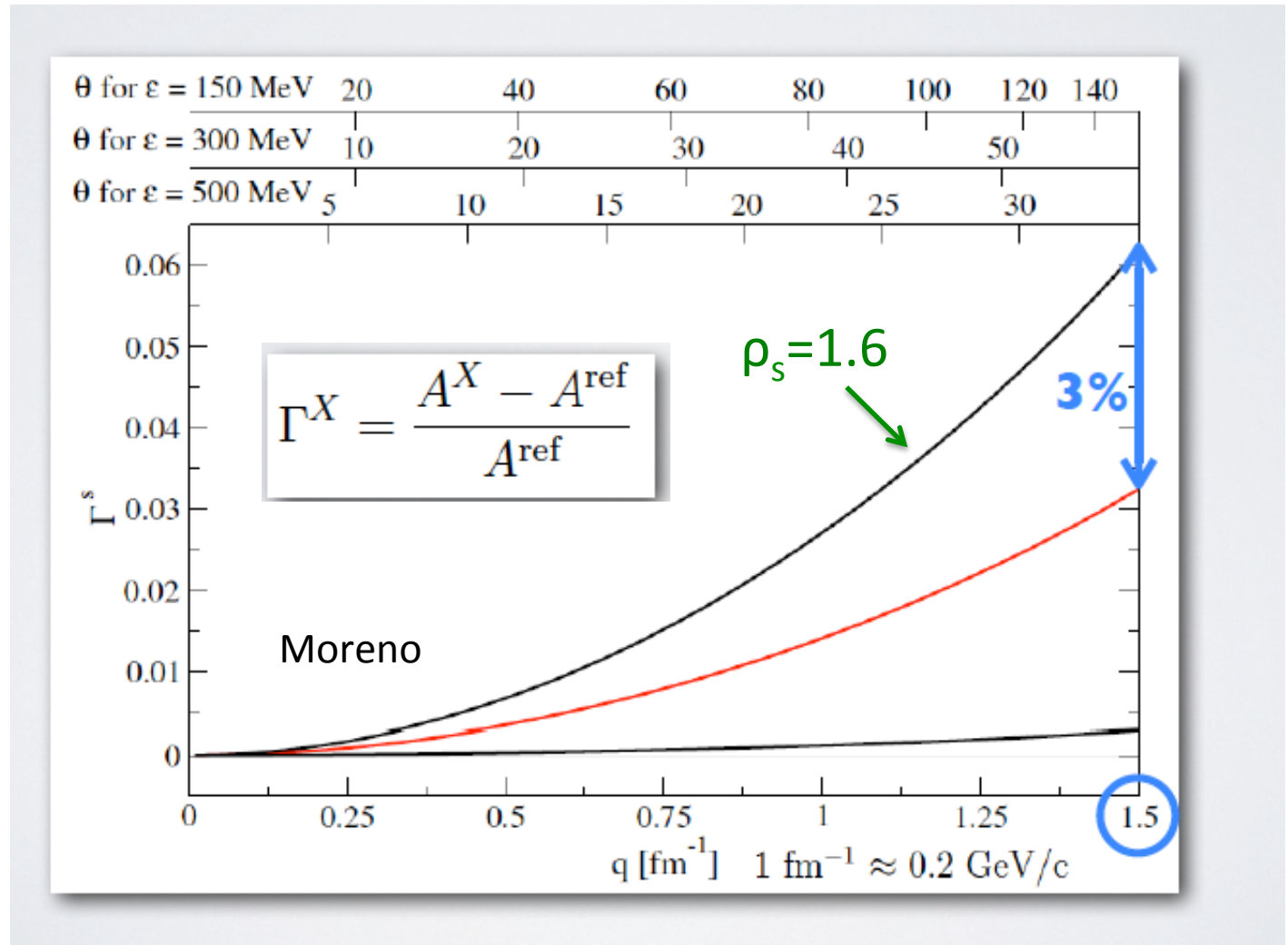
$A \sim 10^{-6}$ for relevant experiments

$$G_E^s \sim \rho_s \tau$$

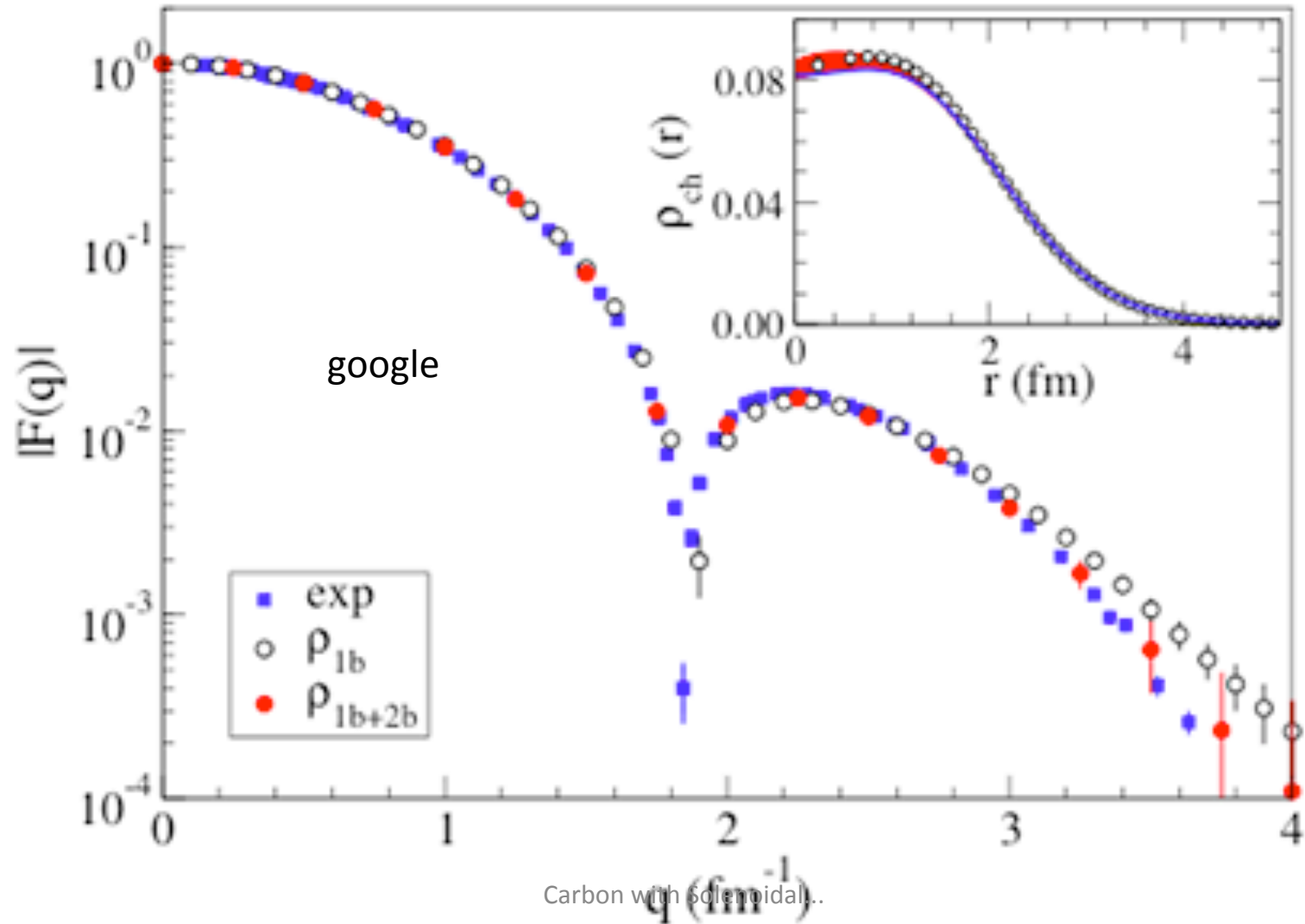
$$M = \frac{d\sigma}{d\Omega} \Delta\Omega A_{PV}^2 \sim Q^2 |F|^2 b \cos^2(\theta/2) \Delta\phi$$

M is a figure of merit $\sim 1/\text{run time}$

Size of Strange Quark Contribution



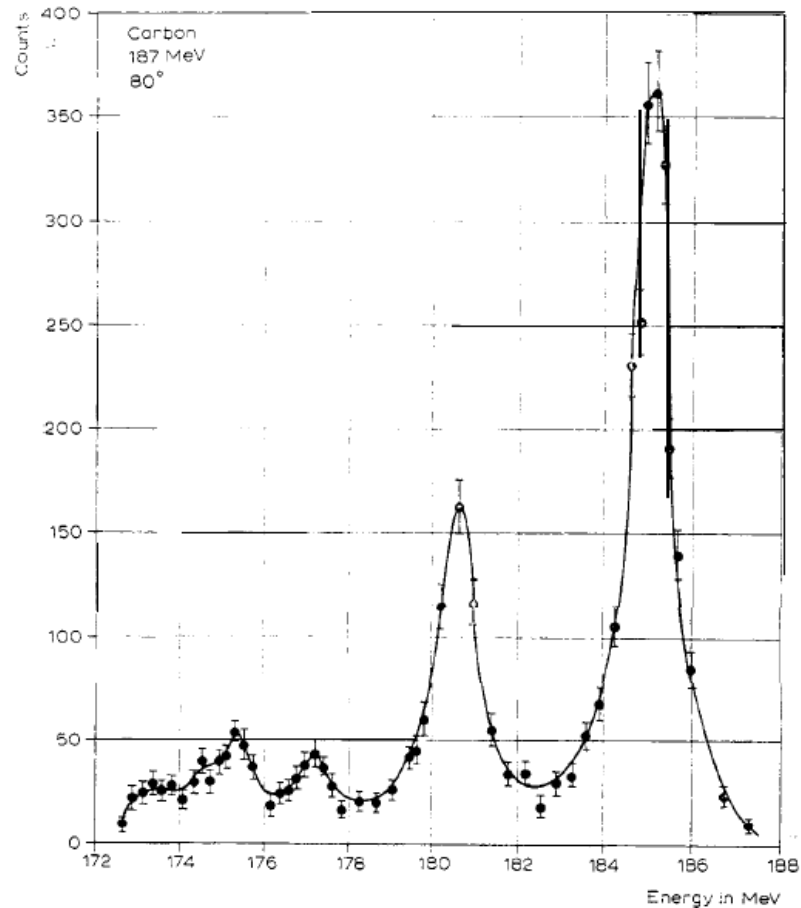
Carbon Form Factor



Inelastic Levels: Experiment

566

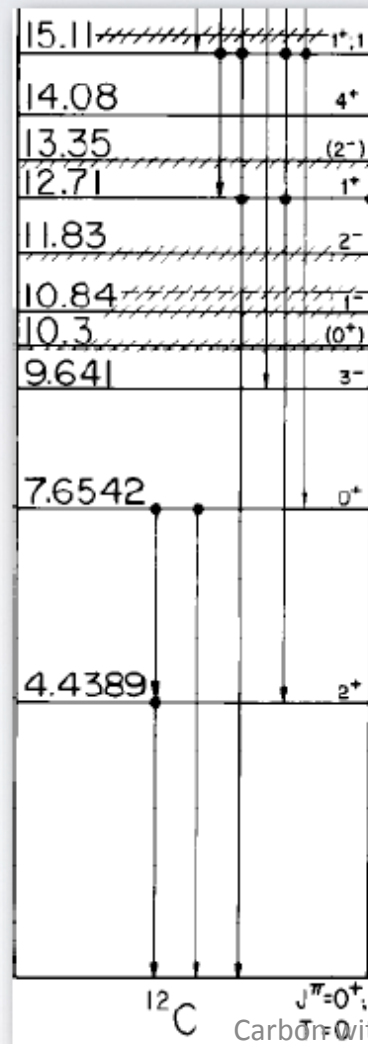
1961 R. HOFSTADTER



$Q = 240 \text{ MeV}$
 $= 1.2 \text{ fm}^{-1}$

Fig. 4. This figure⁸ shows the elastic-scattering peak from carbon at an abscissa near 185 MeV, and the inelastic-scattering peaks from the excited states of ^{12}C . The peak near 180.7 MeV is associated with the 4.43-MeV level.

Inelastic Levels: Theory



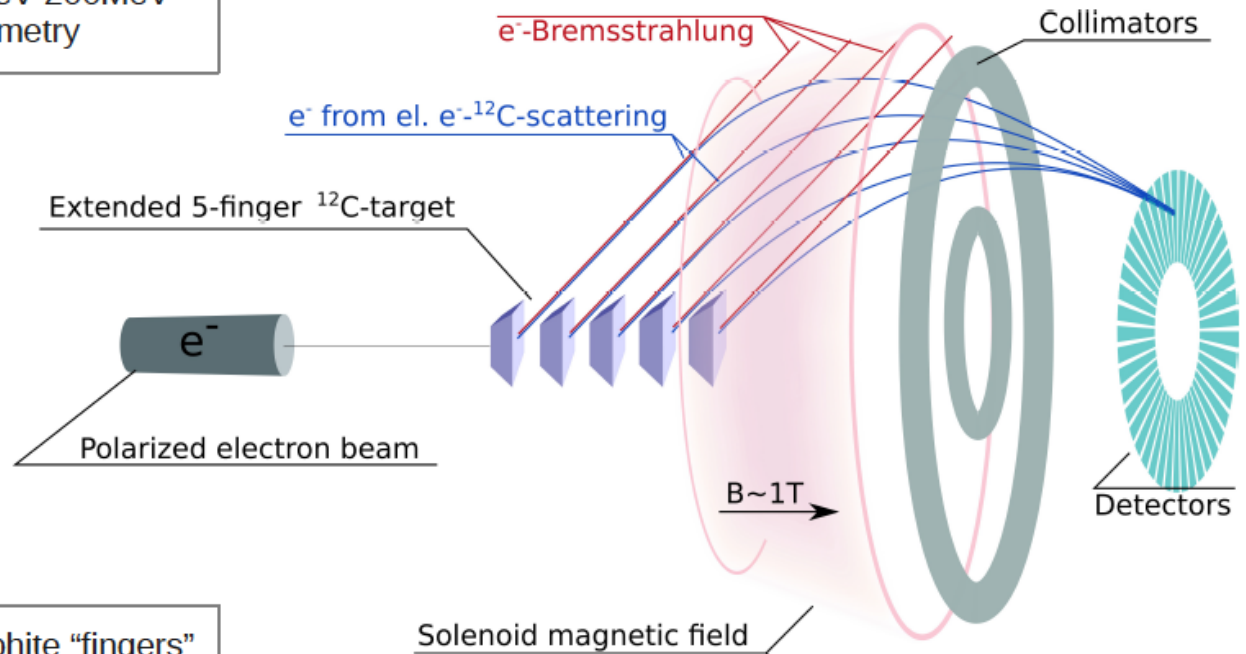
$T = 1$ levels:
Different asymmetry
(isovector contribution)

$T = 0$ levels:
Same asymmetry
as for ground state
(in absence of strangeness
and at tree-level)

Strange FF for
for excited states?

Solenoidal Spectrometer

- MESA:
- 150 μ A
 - 150MeV-200MeV
 - Polarimetry

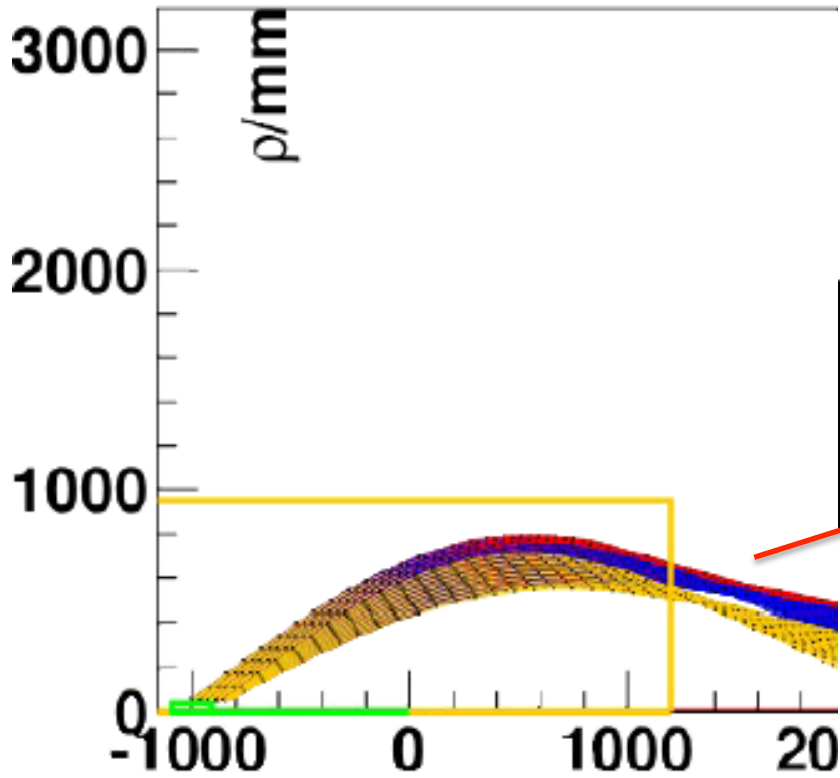


- Target:
- 5 graphite "fingers"
 - 5 g/cm² total
 - 36mm spacing

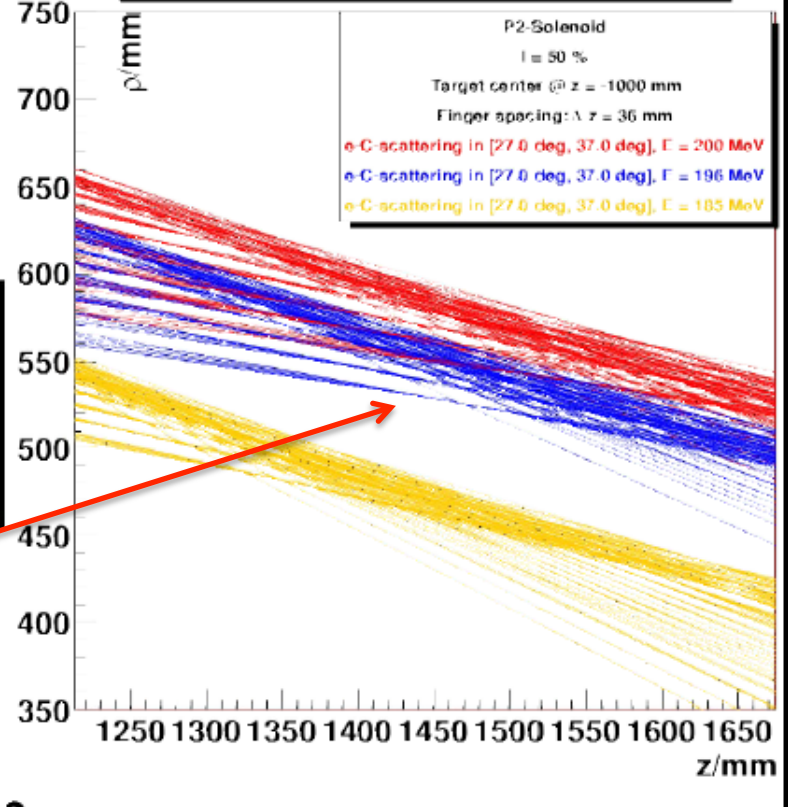


Gertz

Existence of Focus



Projection of electron trajectories



P2-Solenoid
 $I = 50\%$
 Target center @ $z = -1000$ mm
 Finger spacing: $\Delta z = 36$ mm
 e-C scattering in [27.0 deg, 37.0 deg], $E = 200$ MeV
 e-C scattering in [27.0 deg, 37.0 deg], $E = 196$ MeV
 e-C scattering in [27.0 deg, 37.0 deg], $E = 185$ MeV

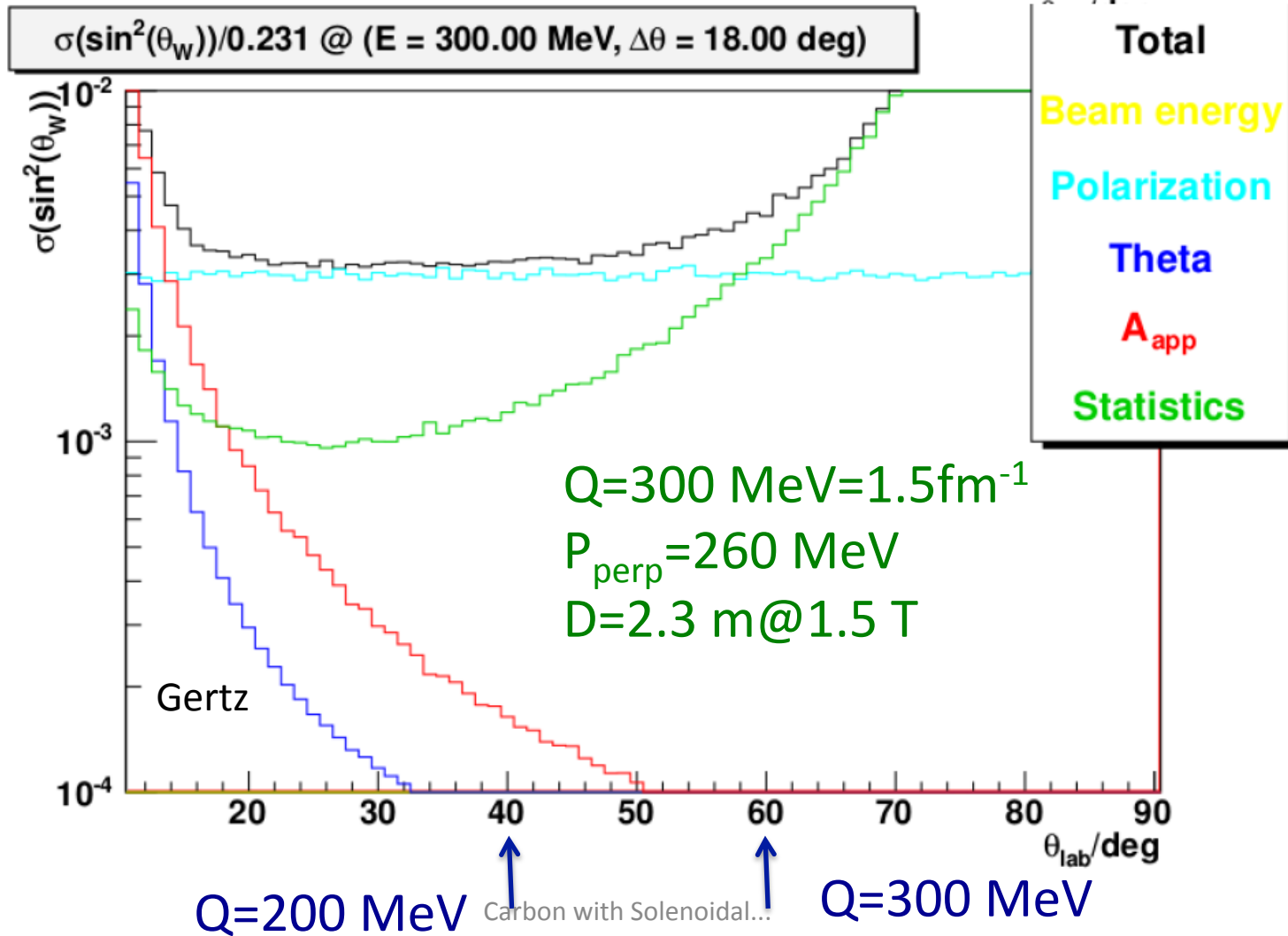
Elastic 4.2 MeV level

15 MeV Isovector level

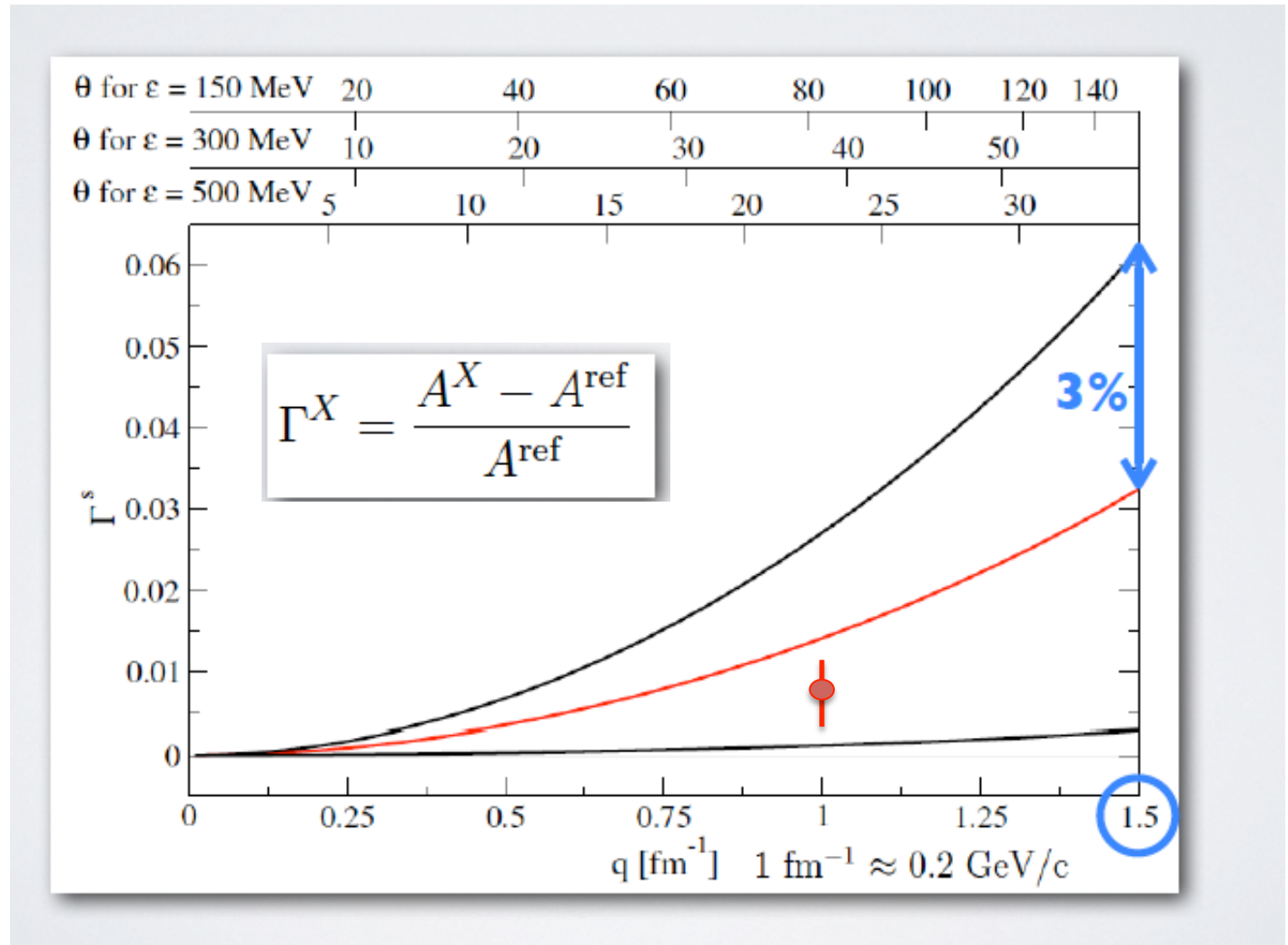
Gertz

Carbon with Solenoidal...

Experimental Errors



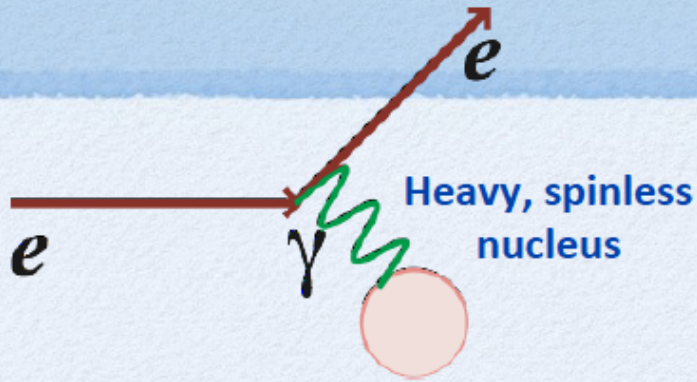
Size of Strange Quark Contribution



R_n : Radius of Neutron Distribution

Relativistic Electron Scattering

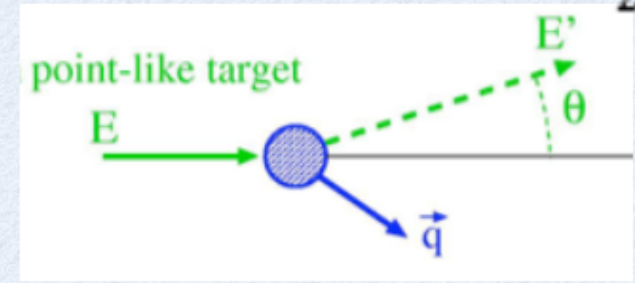
and nuclear size



4-momentum transfer $q^2 = -4EE' \sin^2 \frac{\theta}{2}$

Q2: -(4-momentum)² of the virtual photon

$$Q \approx \frac{hc}{\lambda}$$



Differential Cross Section

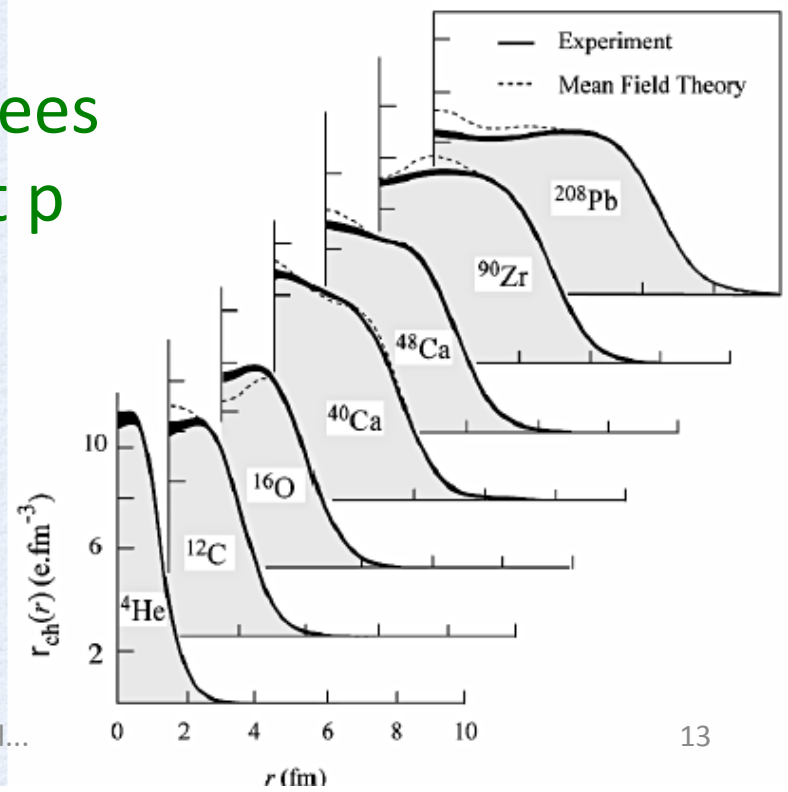
$$\left(\frac{d\sigma}{d\Omega}\right)_{Mott} = \frac{4Z^2\alpha^2 E^2}{q^4}$$

PVES sees
n, not p

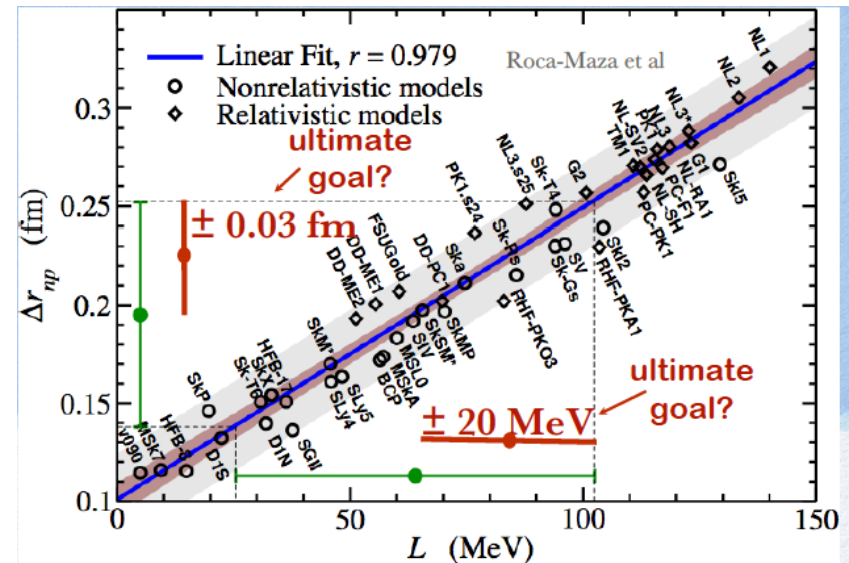
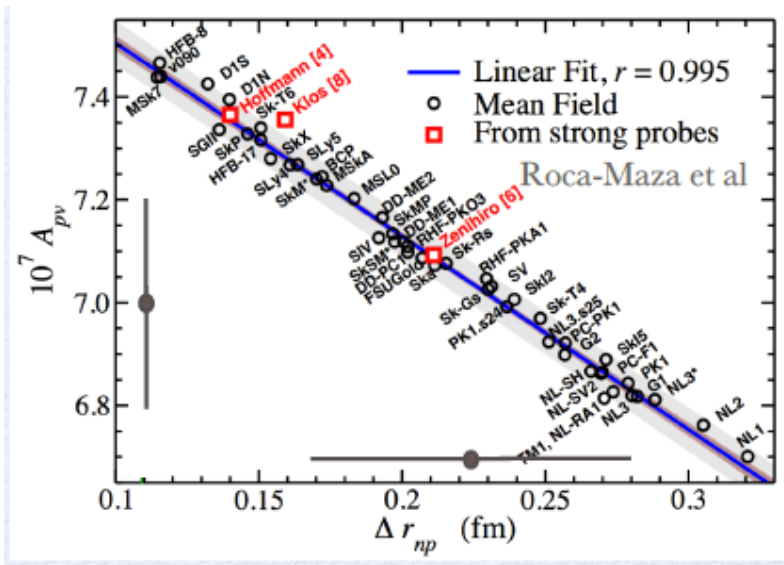
$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{Mott} |F(q)|^2$$

As Q increases, nuclear size modifies formula

Neglecting recoil, form factor $F(q)$ is the Fourier transform of charge distribution

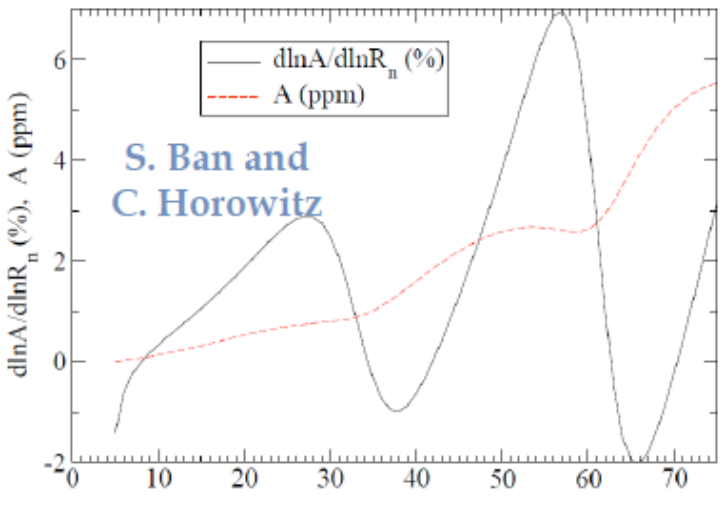


A_{pV} and R_n and L



L is the density dependence of the symmetry Energy, a critical parameter for neutron stars, etc.

Solenoidal Spectrometer for Nuclei

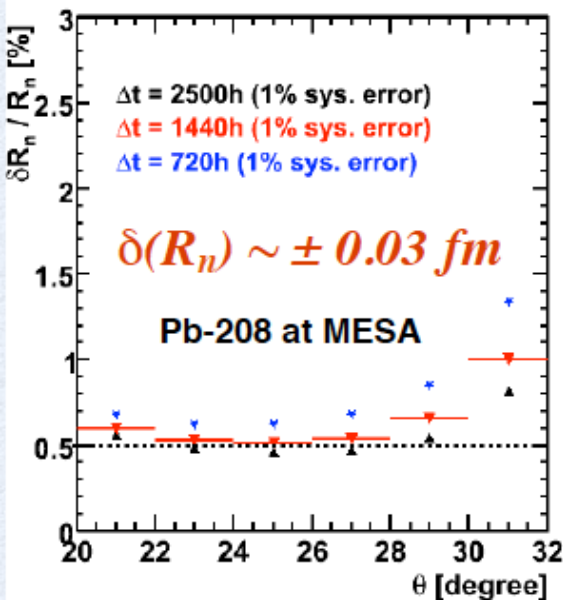


200 MeV: FOM peaks around 25 degrees

Not surprising: same Q^2 as PREX

In elastic scattering, the only parameter is Q^2

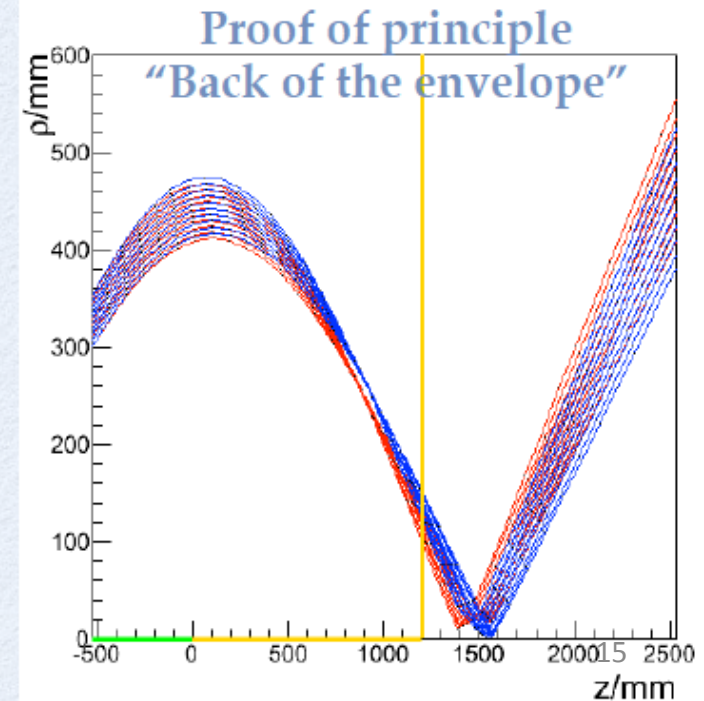
Why might one do better than PREX-II? Very simple: HRS picks up about 25% of the azimuth



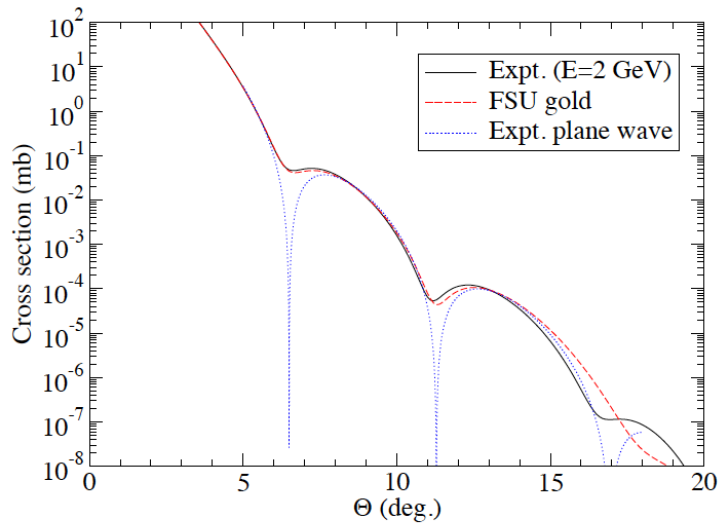
solenoidal spectrometer will separate inelastics over the full range of the azimuth

0.5% R_n in 1500 hours of running; same luminosity as PREX

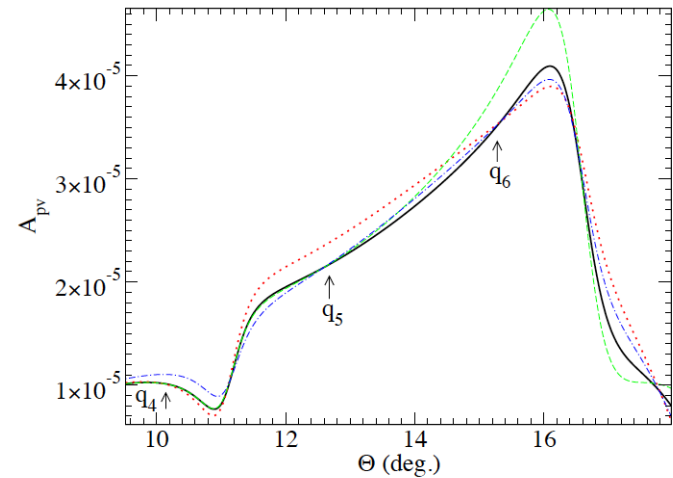
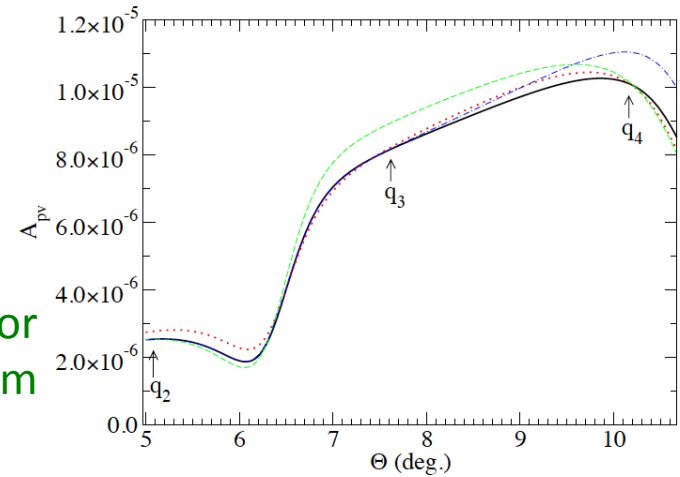
Carbon with Solenoidal...
kk



Program for ^{48}Ca (Horowitz)



Plots are for
2 GeV beam



q_i fm^{-1}	E GeV	$\frac{d\sigma}{d\Omega}$ mb	A_{pv} ppm	T days	a_i fm^{-3}	$\Delta a_i/a_i$ %
0.45					0.0752	1.1
0.90	2.06	2.44	2.54	5	0.0468	5.9
1.35	3.09	1.07×10^{-1}	8.31	7	-0.0438	7.6
1.80	4	2.9×10^{-3}	9.92	10	-0.0147	27
2.24	4	4.05×10^{-4}	22.5	15	0.0161	29
2.69	4	9.7×10^{-6}	36.5	23	0.0066	90

Conclusions

- With higher energy beam, ^{12}C experiment can be extended to larger Q values where strange form factors might be important.
- ^{208}Pb and especially ^{48}Ca are attractive targets.
- Experimental Requirements
 - CLEO II-size magnet.
 - 0.3% polarimetry.
 - Etc.

Backup

Experimental Errors

