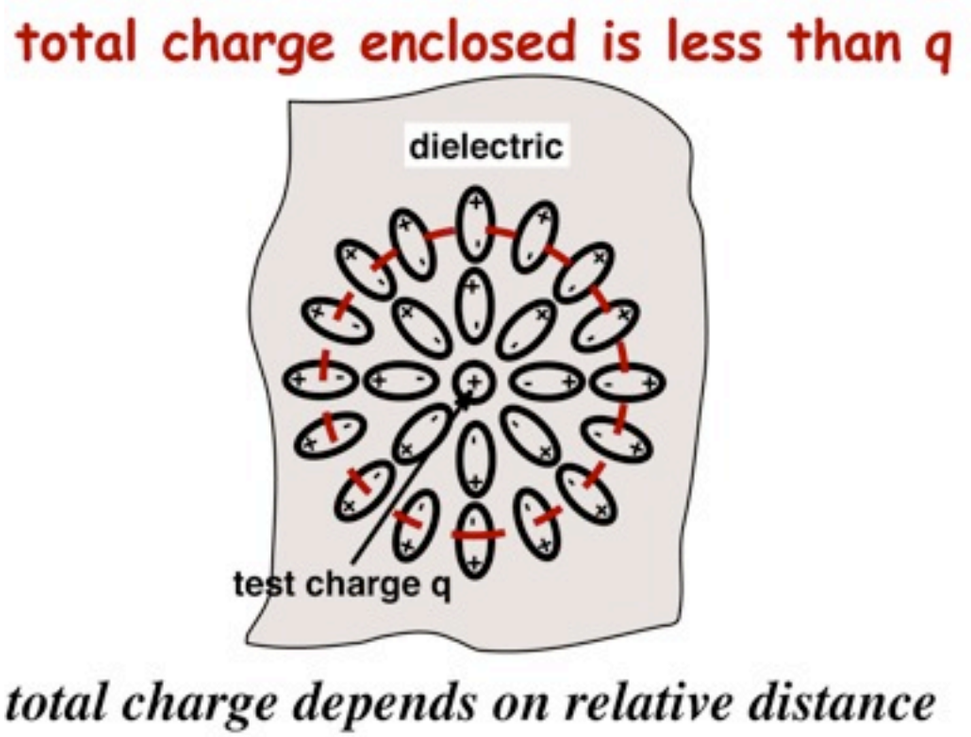
The QWeak Experiment

Mark Dalton for the Collaboration

Weak mixing angle $\sin^2\theta_W$

Coupling "runs" due to charge screening



Sensitivity to standard model deviations

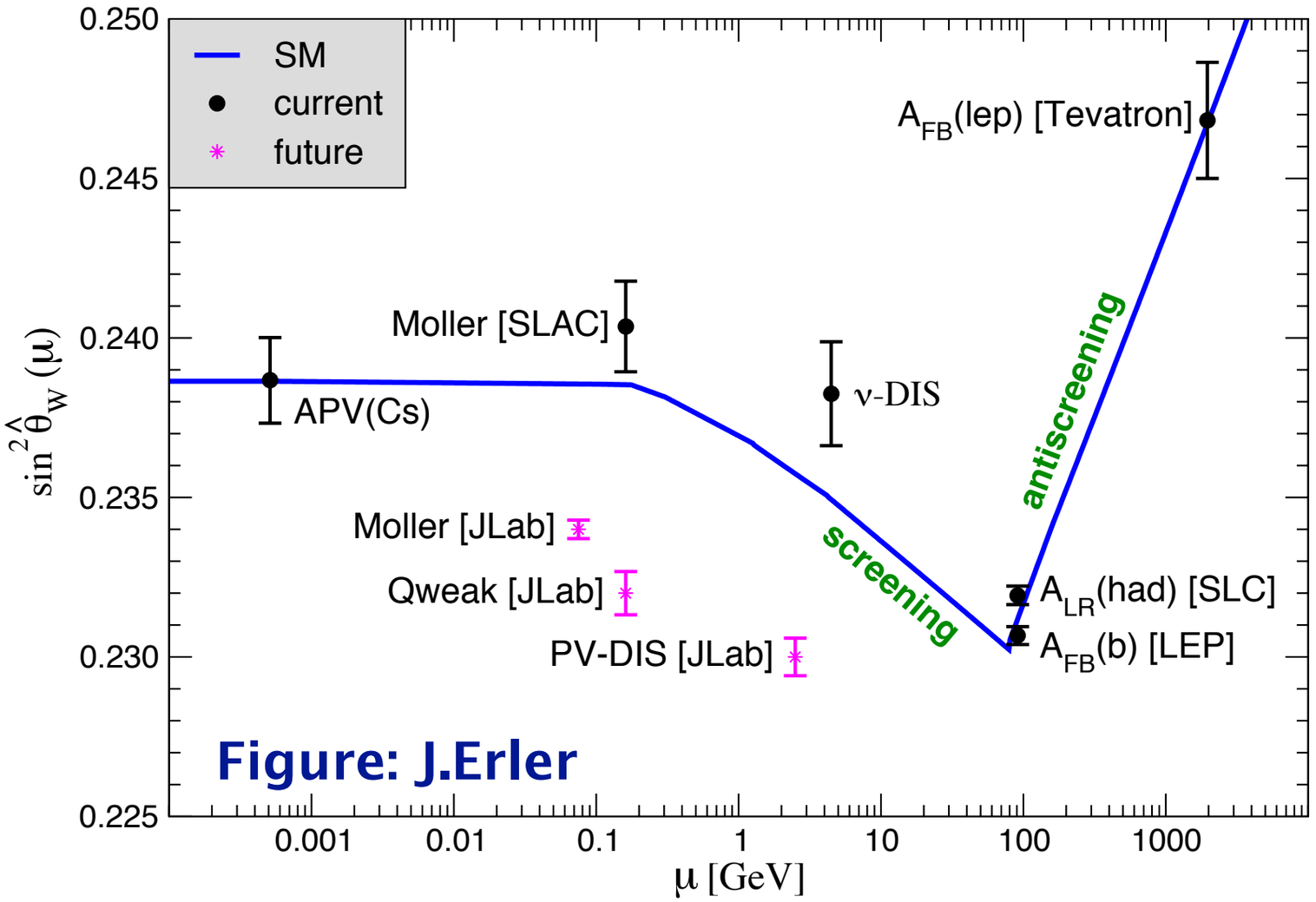


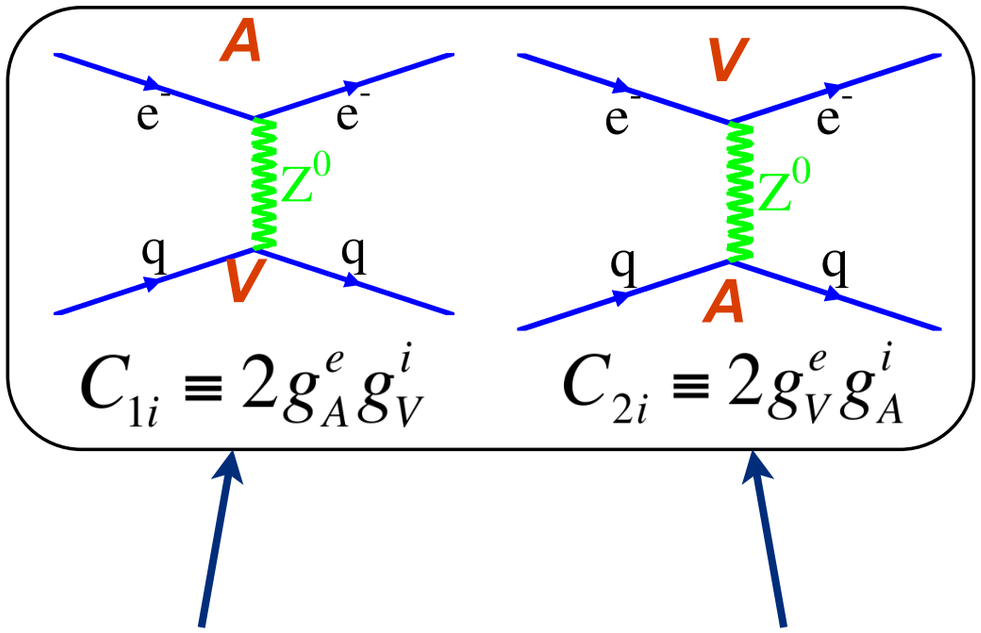
Figure: J.Erler

deviation means that some correction possibly a new interaction hasn't been accounted for when extracting the Z0 charge

Running already tested to 6 sigma

Electron-Quark Scattering

QWeak will constrain vector coupling to quarks, complimentary to Atomic Parity Violation



Small scattering angles

Large scattering angles

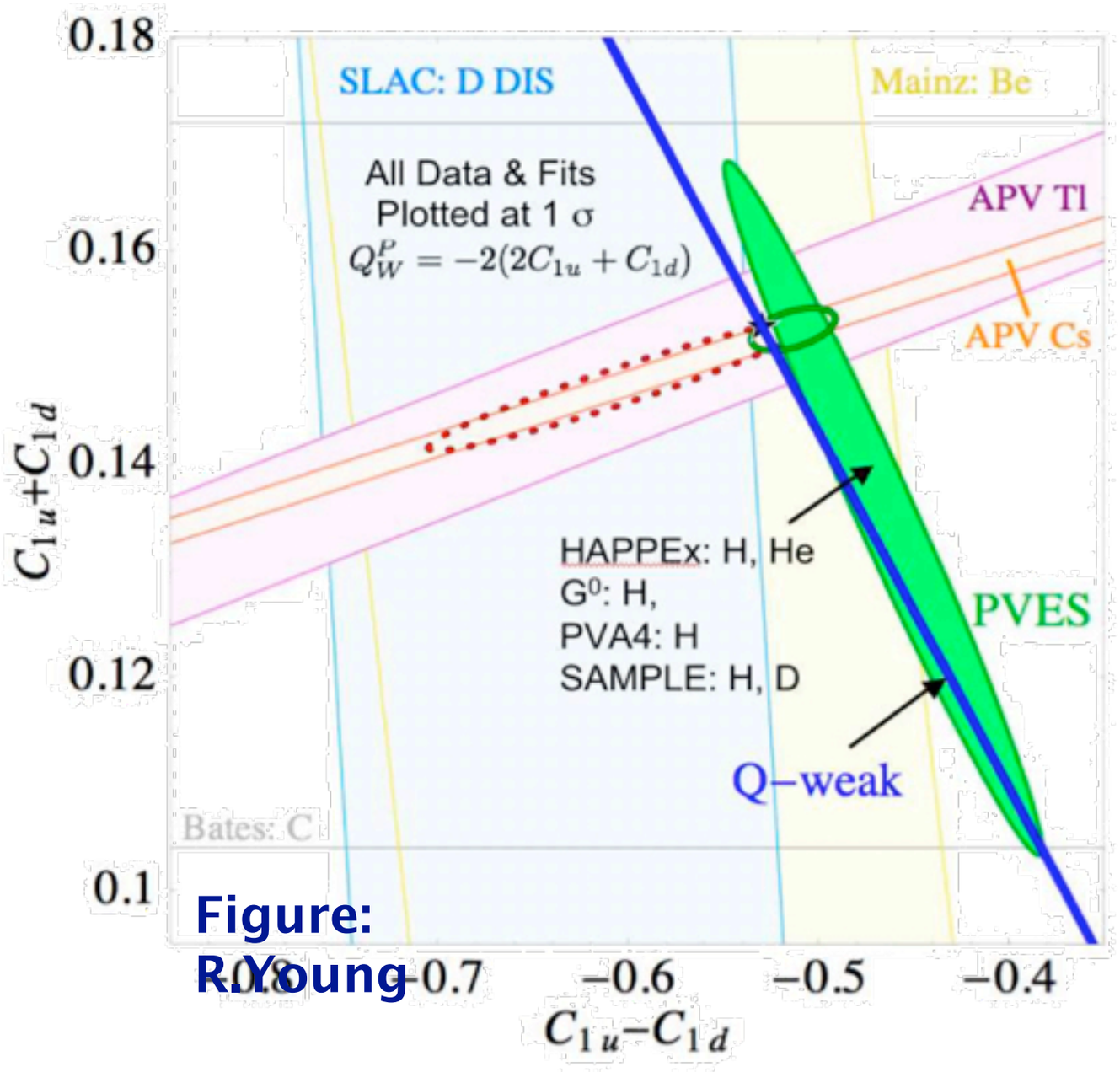


Figure: R.Young

QWeak Experiment

$$A_{PV} \approx -230 \pm 5 \pm 4 \text{ ppb}$$

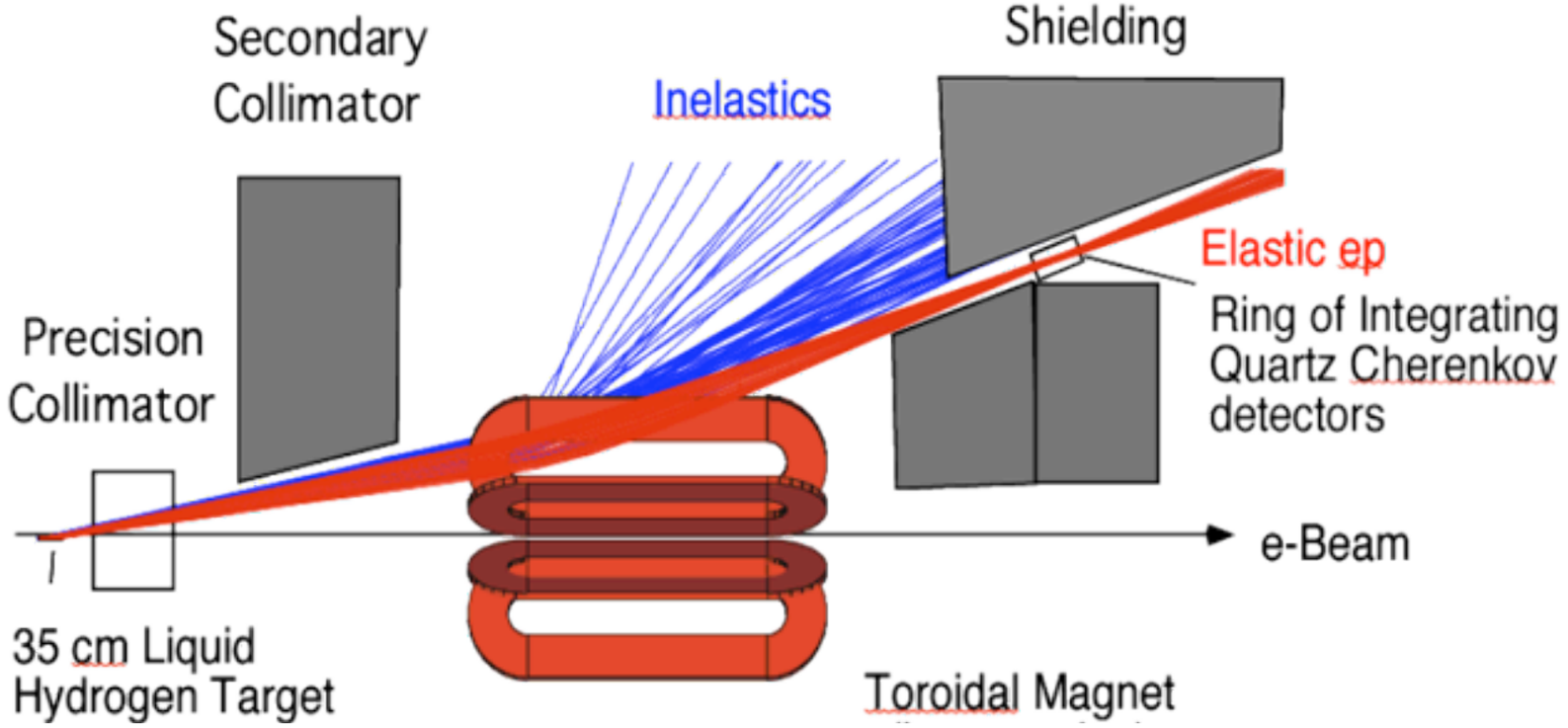
Small angle, low $Q^2 \sim 0.03$ GeV^2
to suppress target structure

Small relative and absolute uncertainty.
Gives great precision on SM parameter.

$$F \sim \frac{Q^2}{4M_p^2}(1+\mu_p)\mu_n + O(Q^2)\text{strange quarks}$$

$$\delta Q_W^p = \pm 4\%$$
$$\implies \delta(\sin^2\theta_W) = \pm 0.3\%$$

Proton structure *F*, constrained by strange quark program, contributes
~30% to asymmetry,
~2% to $\delta(Q_W^p)/Q_W^p$

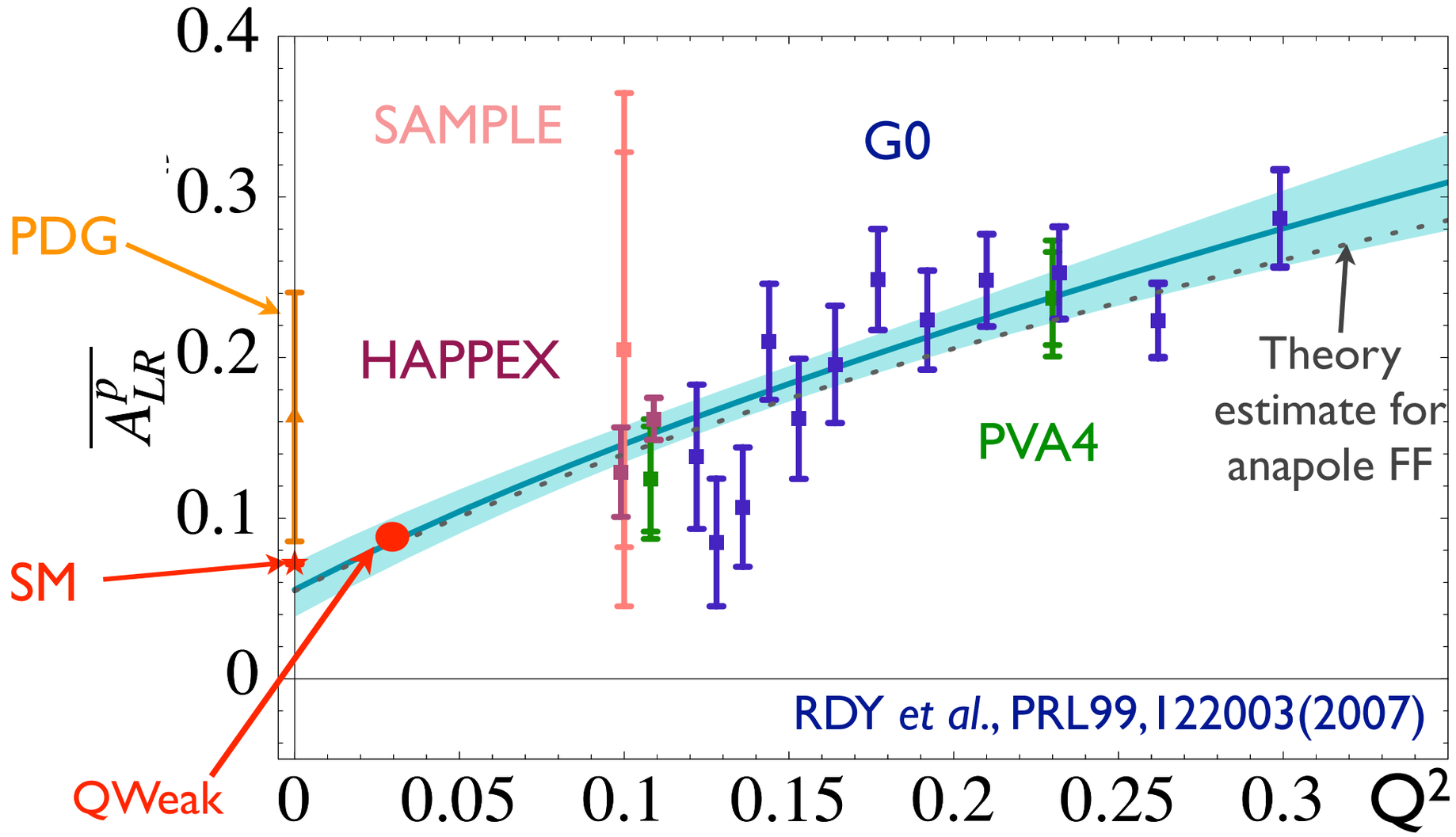


Proton Weak Charge

Proton weak charge precisely known from EW gauge theory and precision EW at the Z-pole

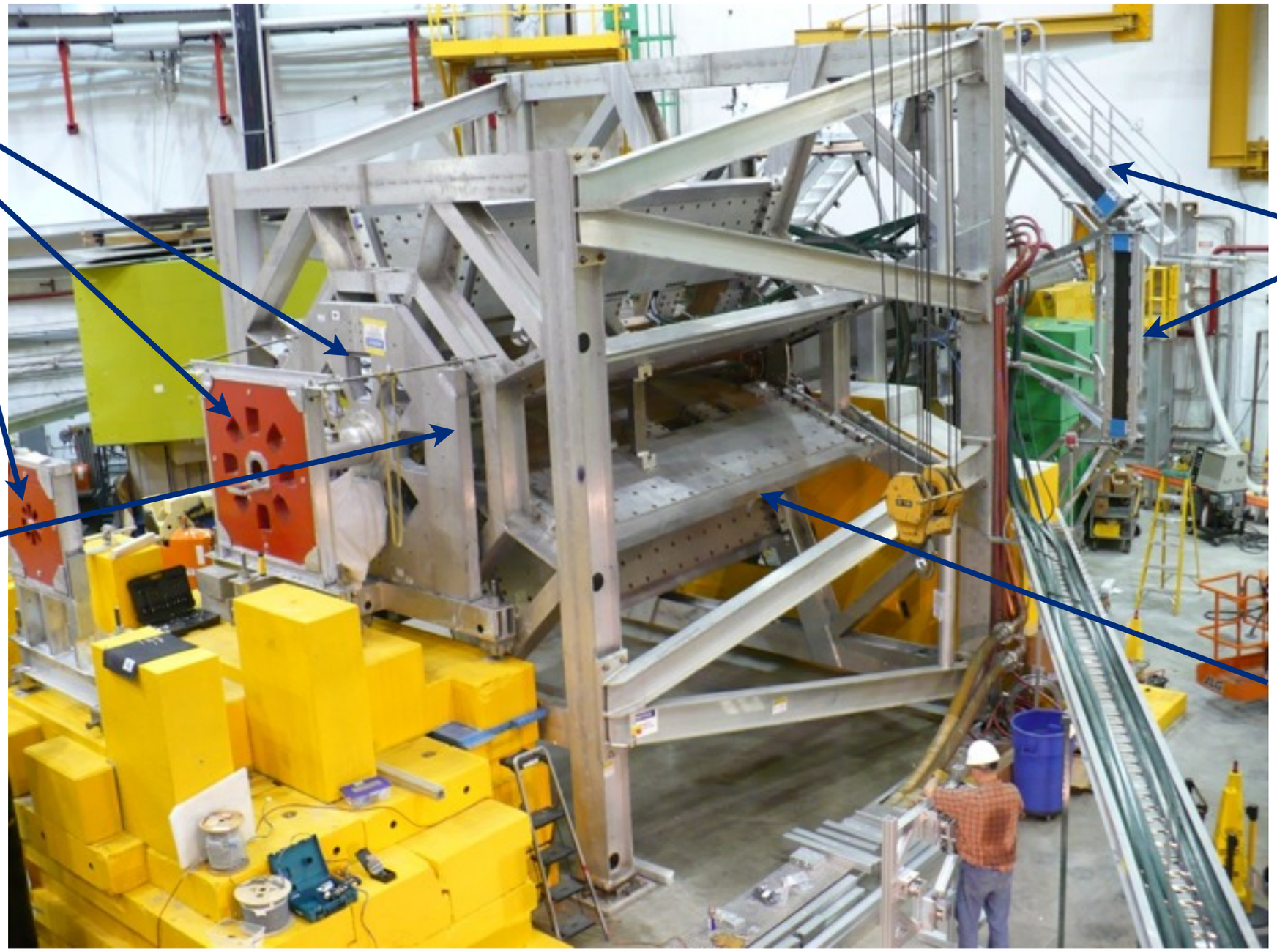
If measurement at low energy comes up different, indicates proton charged for some other (parity-violating) interaction

$$A_{PV} = -\frac{Q^2 G_F}{4\sqrt{2}\pi\alpha}[Q_W^p + F(\theta, Q^2)]$$

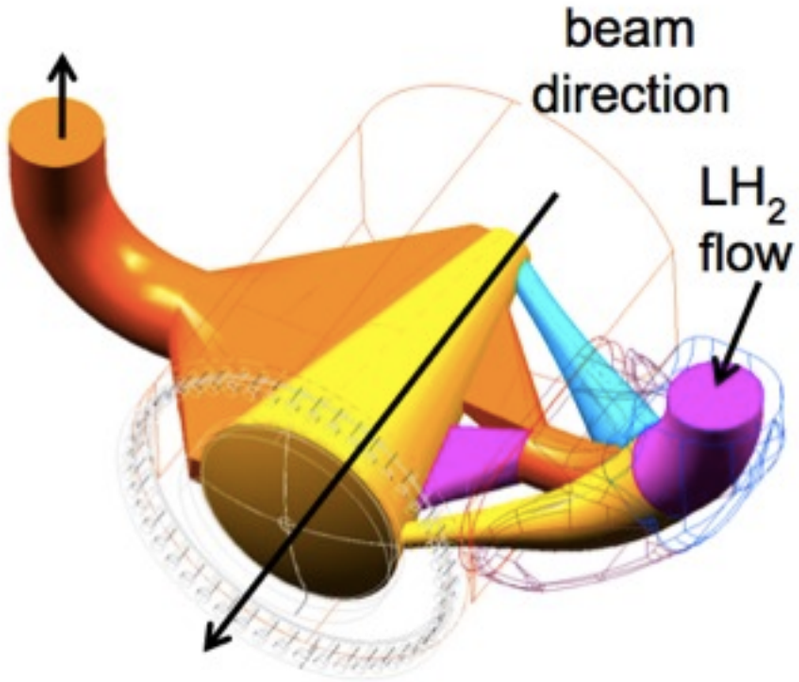


Spectrometer

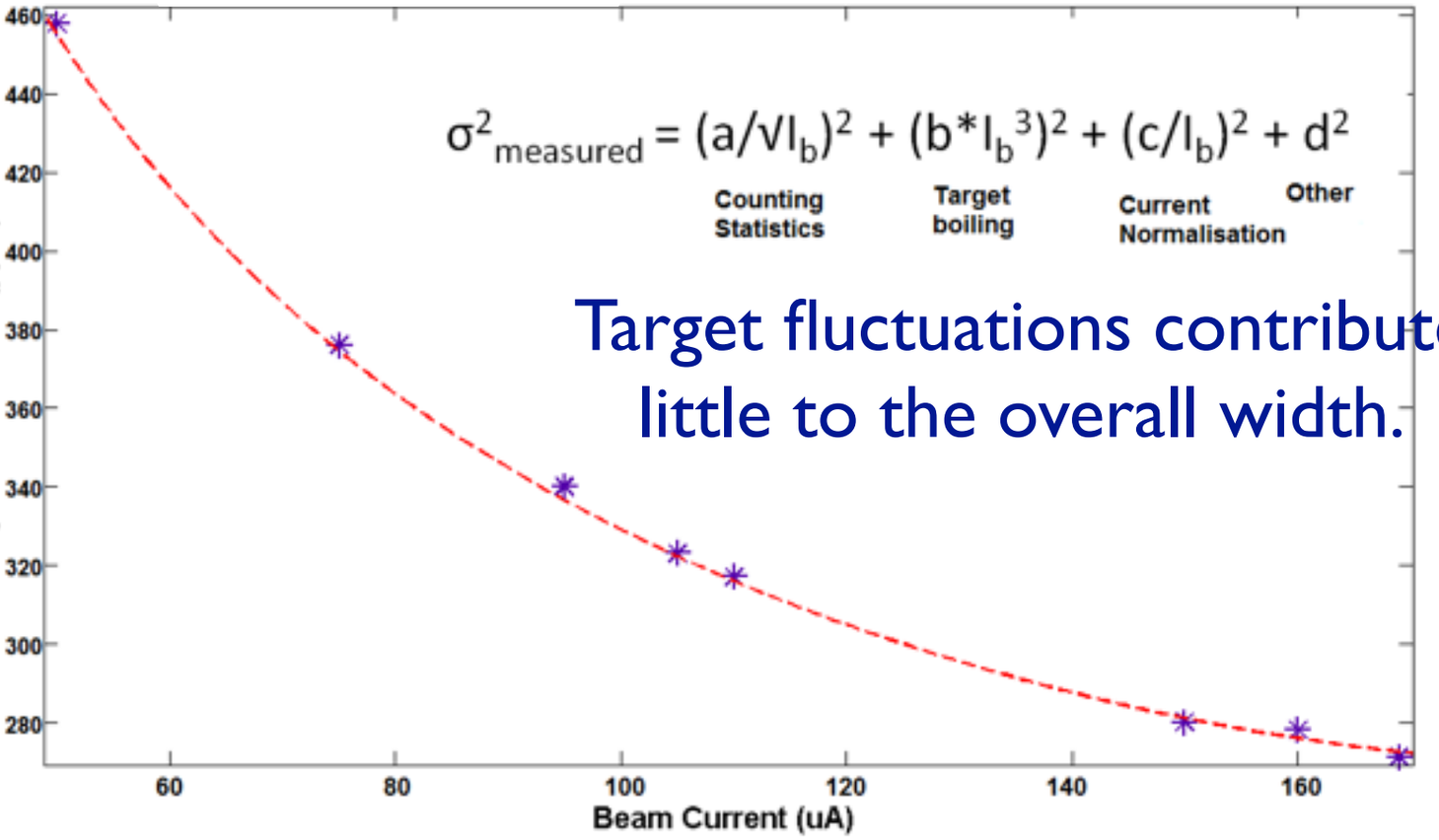
We have had a number of power supply issues to date.



Target



2.5 kW LH_2
Cryotarget

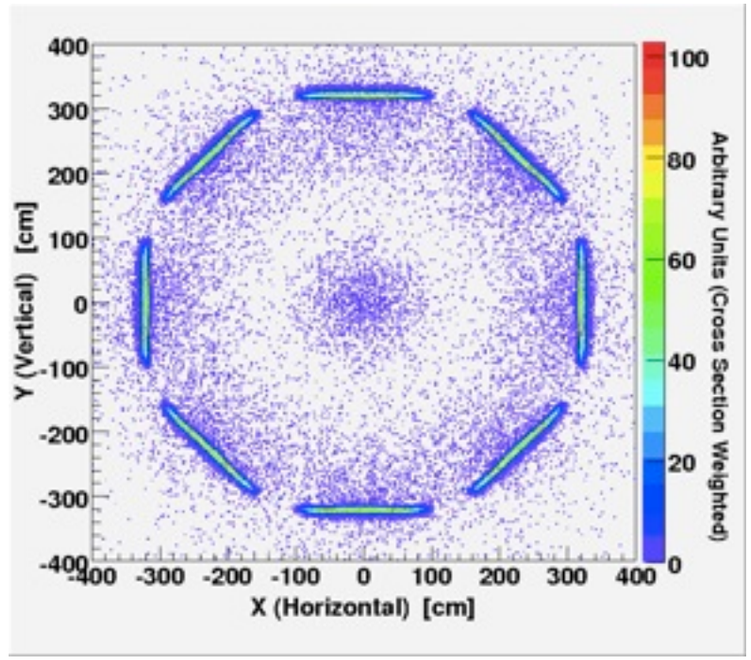


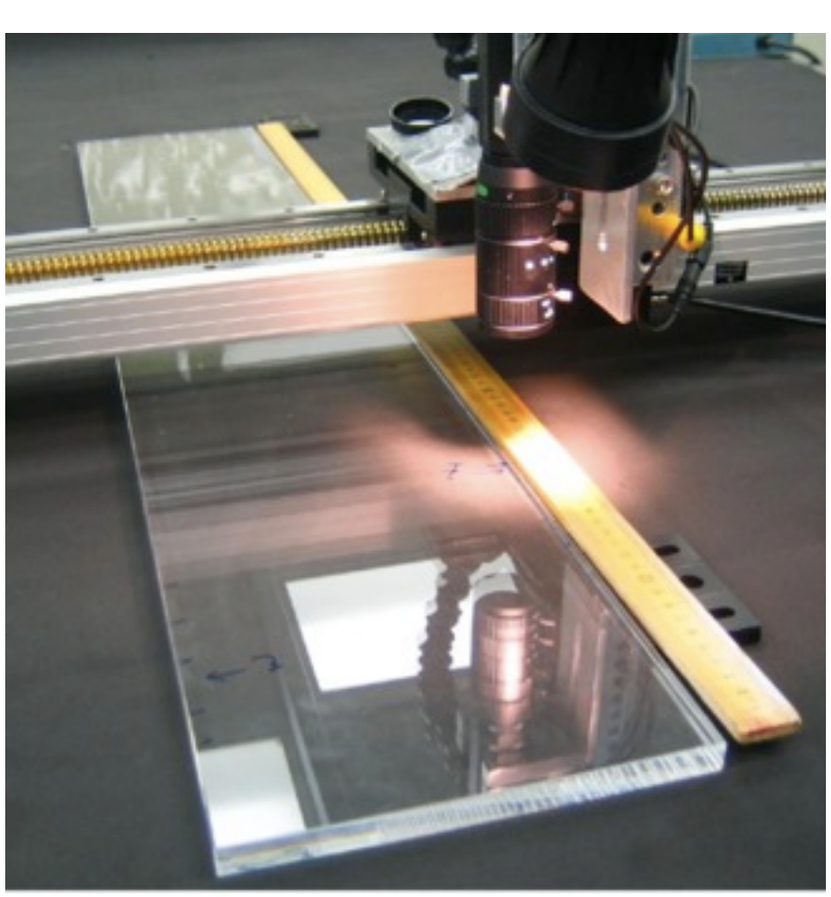
Target fluctuations contribute little to the overall width.

Detectors

Azimuthal symmetry maximizes rate and decreases sensitivity to HC beam motion, transverse asymmetry.

Yield 100 pe's/track with 2cm Pb pre-radiators





Spectrosil 2000: Rad-hard, non-scintillating, low-luminescence with 5 Angstroms RMS polish

Uncertainty Budget

	$\Delta A_z/A_z$	$\Delta Q_w/Q_w$
Statistical	2.1%	3.2%
Systematic:		
Hadronic structure uncertainties	N/A	1.9%
Beam polarimetry	1.0%	1.6%
Absolute Q^2 determination	0.5%	1.1%
Backgrounds	0.5%	0.8%
HC beam properties	0.5%	0.8%
Total:	2.5%	4.1%

Status

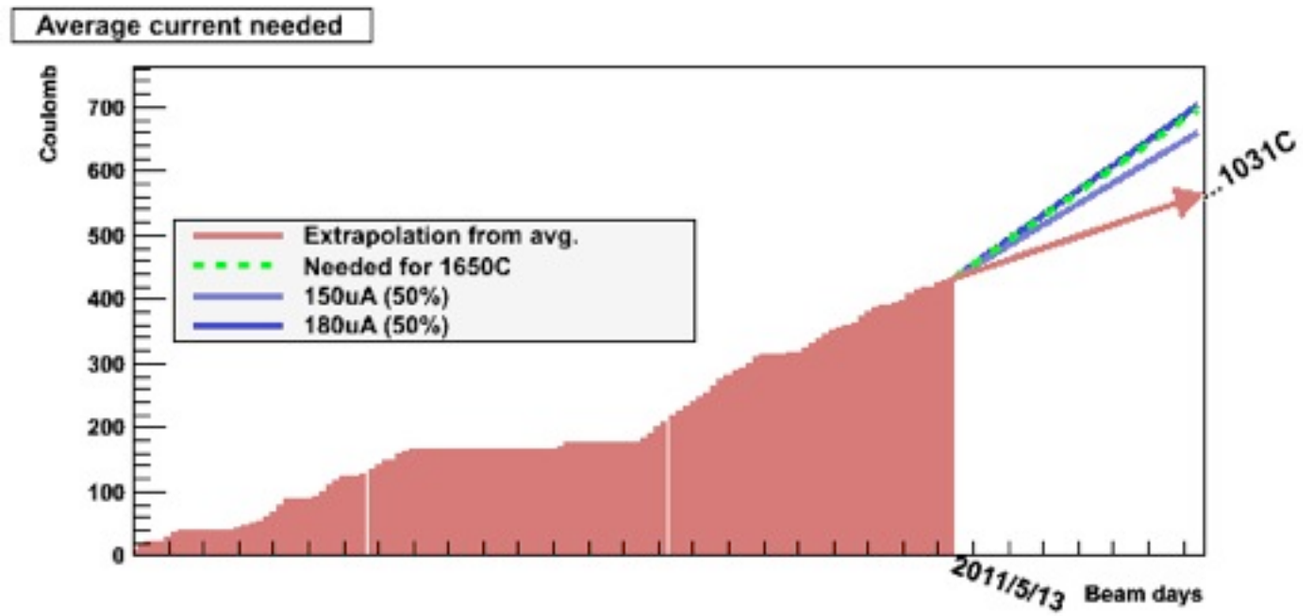
~120 collaborators,
~26 institutions,
~22 PhD students and counting!
~8 senior faculty taking sabbaticals

Data quality generally good.
Accumulated ~36 % of proposal statistics.
116 calendar days remaining.
Will need to obtain at least 57% on LH2 at 180 uA to achieve experiment goal.

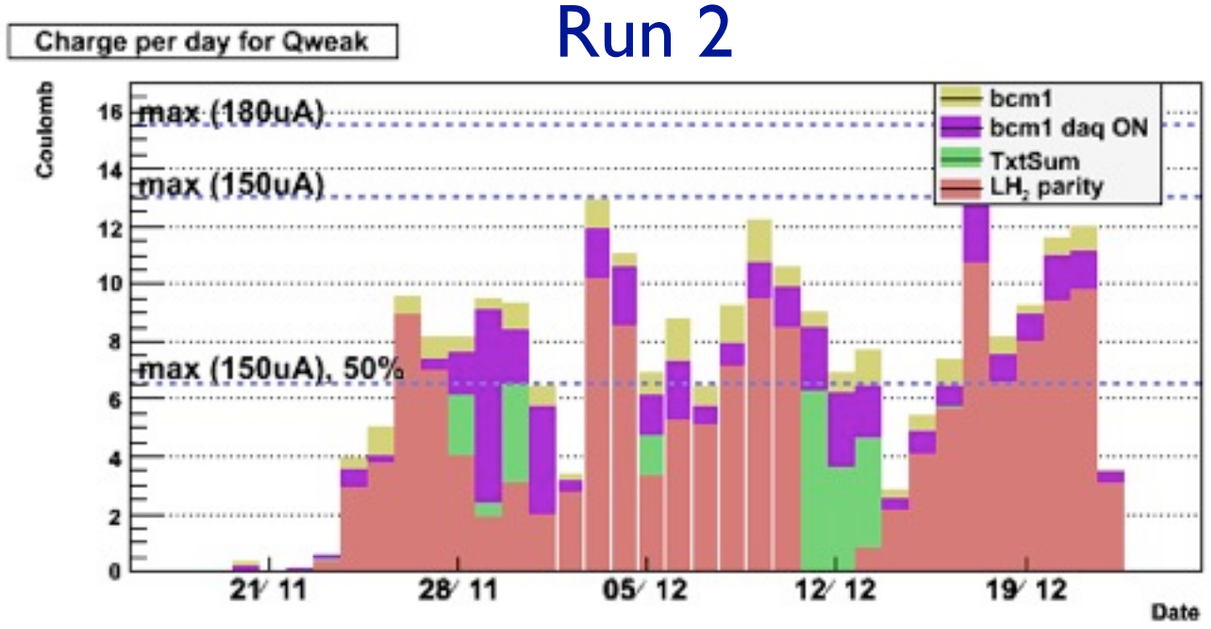
The major sources of "inefficiency" for Run 2: background measurements (tracking, N-Δ, Aluminum), data quality cuts, accelerator down, magnet and power supply issues.

Latest Statistics

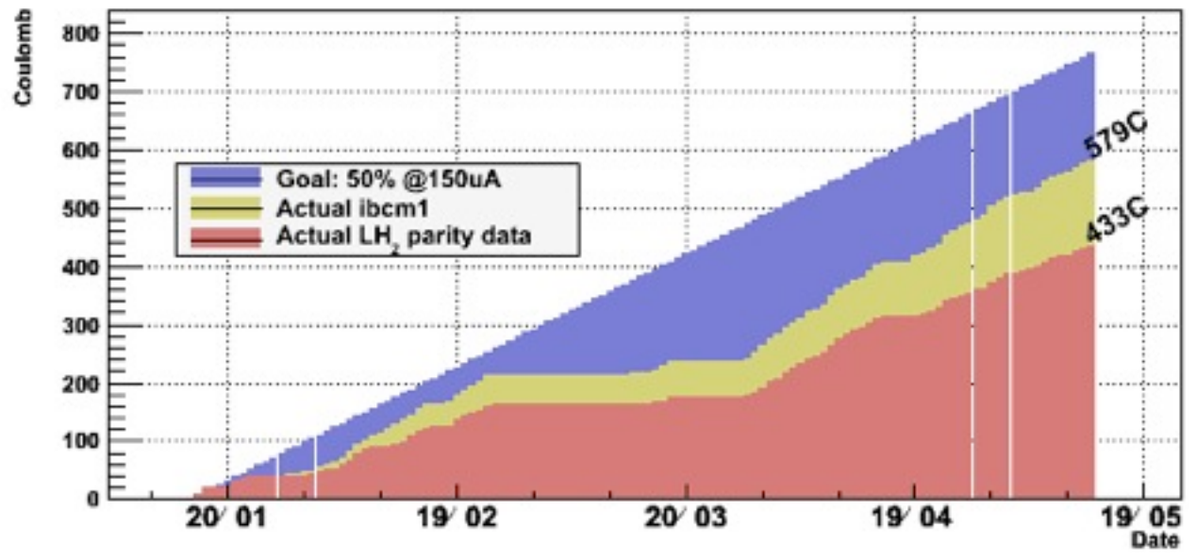
Averaging at less that 50% efficiency since start of experiment.
Will need to obtain at least 57% at 180 uA to achieve experiment goal.



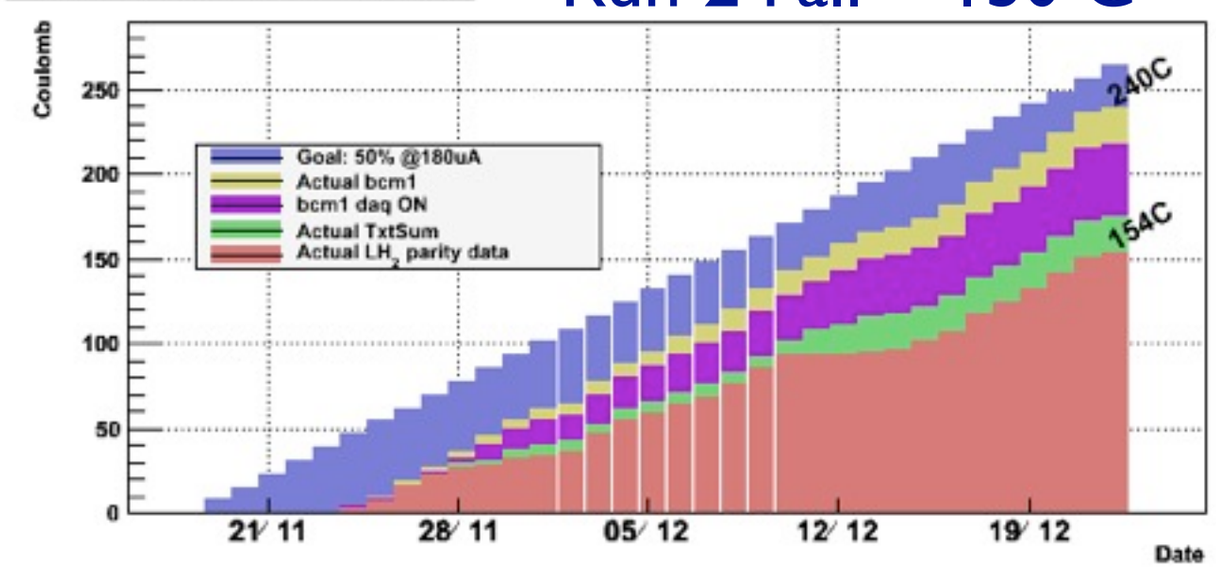
Run 2



Run 1 ~450 C



Run 2 Fall ~ 150 C

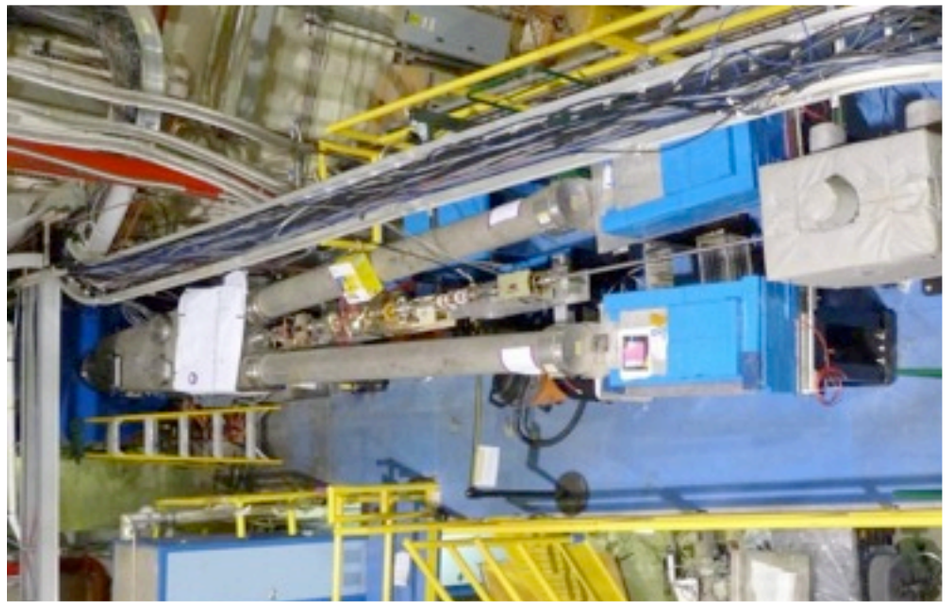


Polarimetry

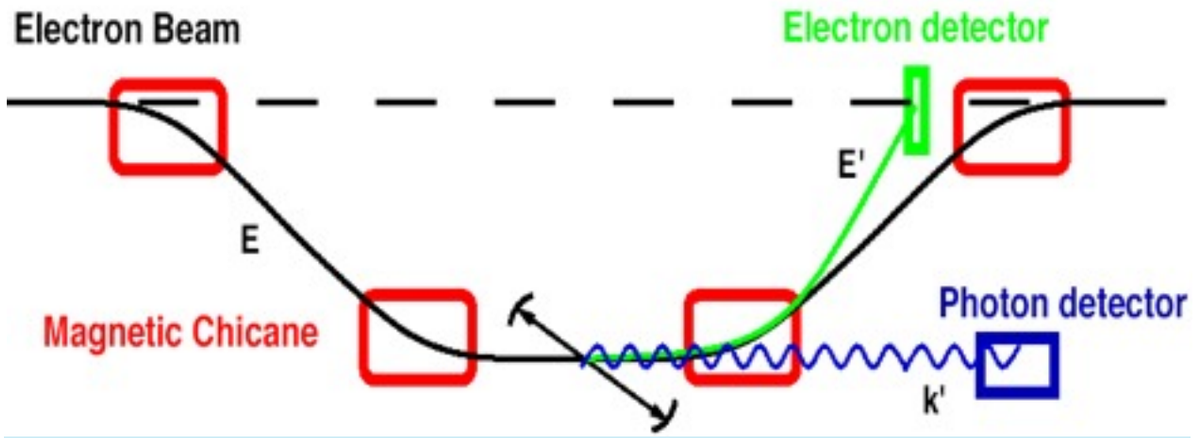
Will be discussed in detail in following talk by Vladas Tvaskis

Aim is to measure the beam polarization to 1% using three polarimeters

Moller

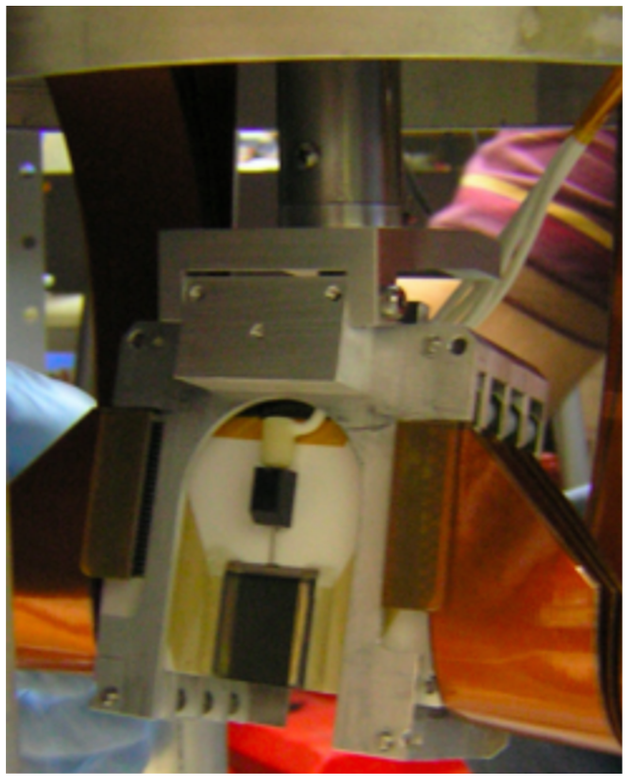


Compton Photon



Resonant cavity "photon target", up to 1 kW intensity

Compton Electron



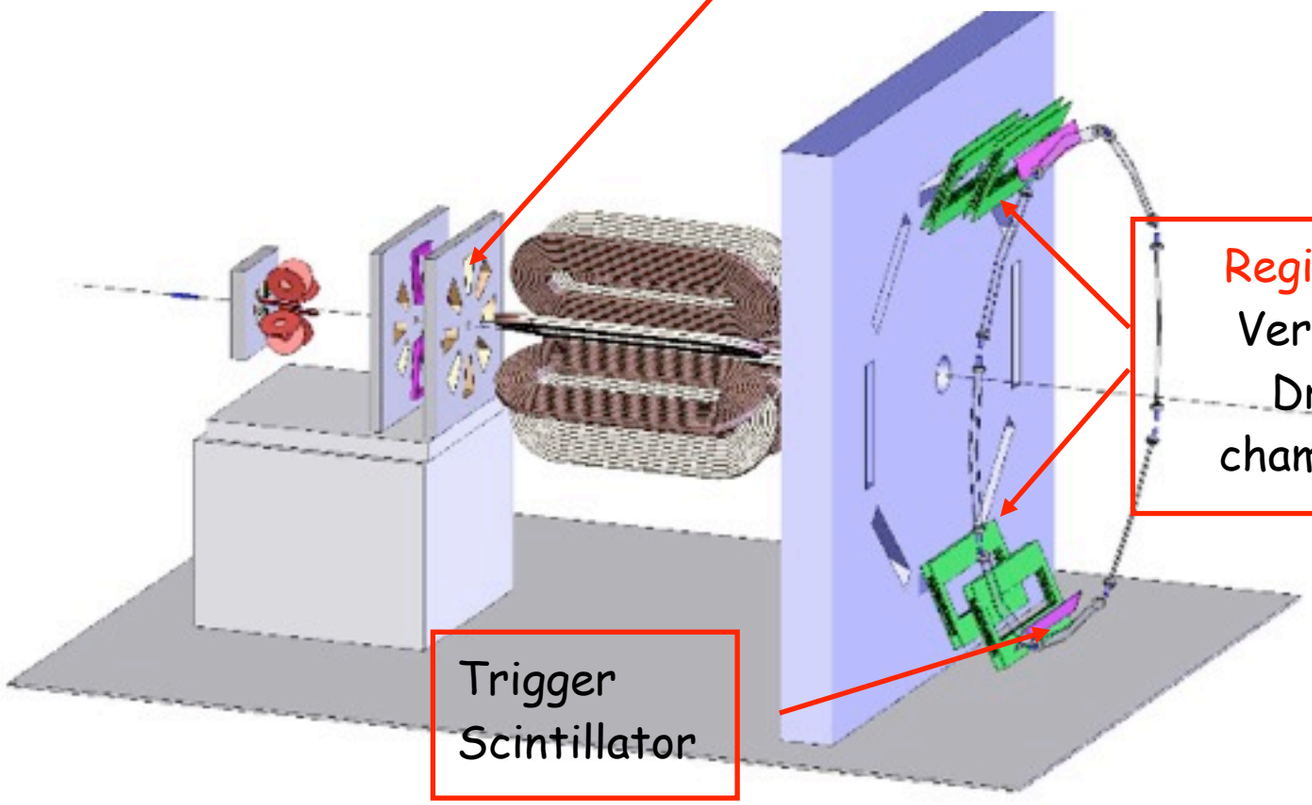
Tracking Mode Running

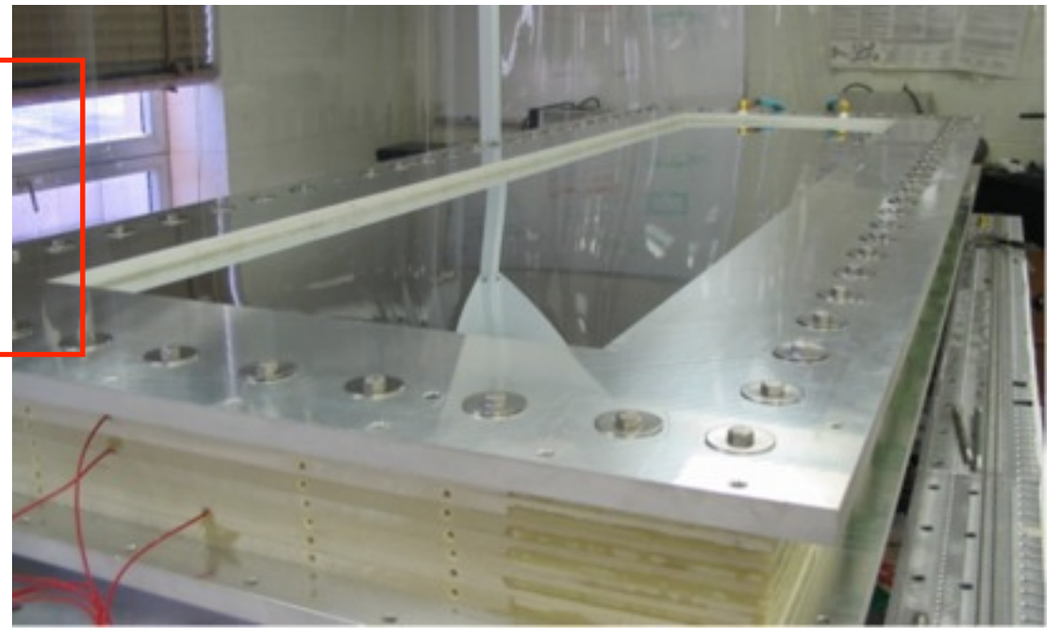
Will be discussed in detail in following talk by Siyuan Yang

Goal: 0.5% on Q^2

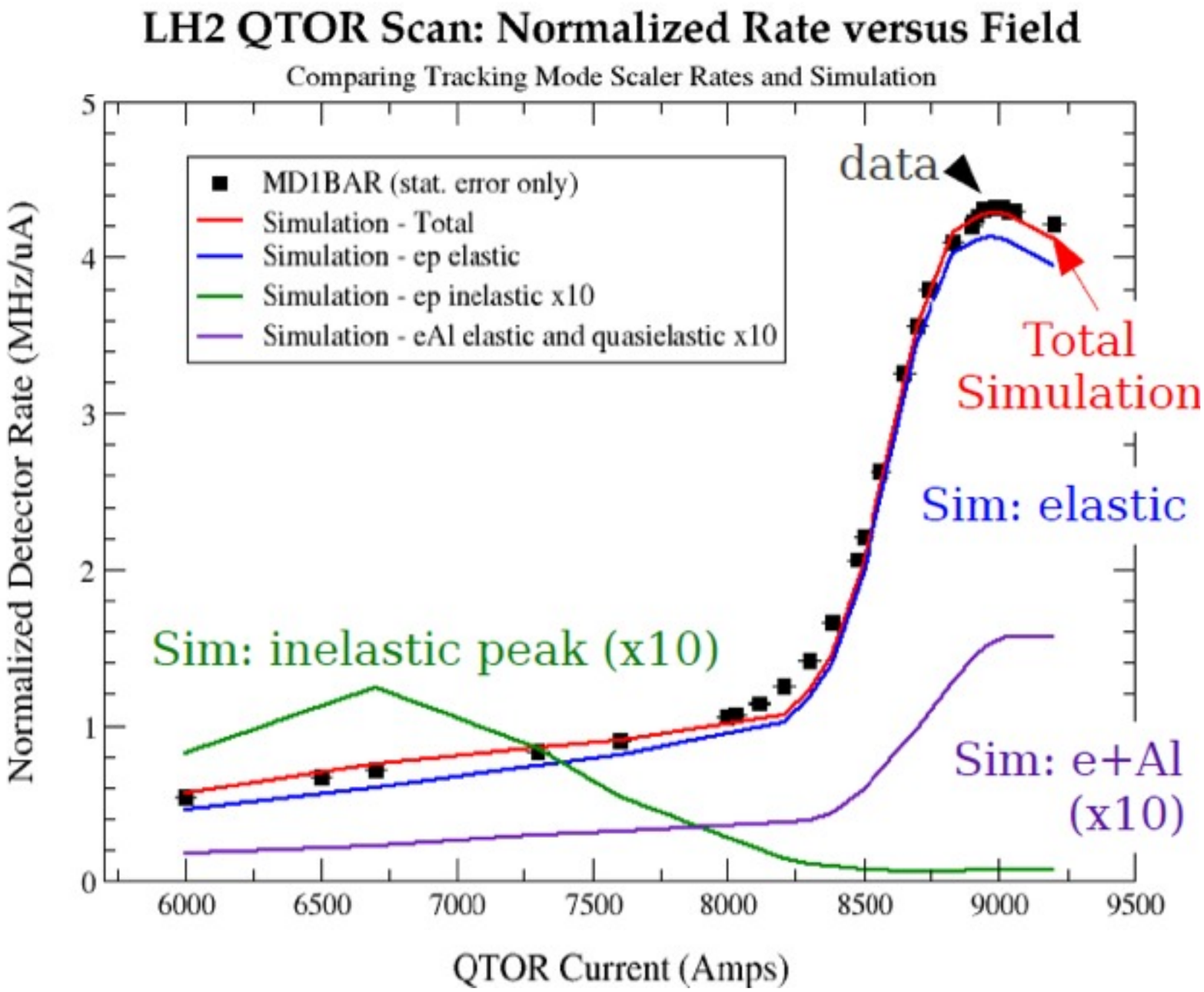
Additionally: determine Al rate/ target wall thickness; measure neutral particle backgrounds; benchmark simulation

Region 2:
Horizontal drift chamber location





Backgrounds



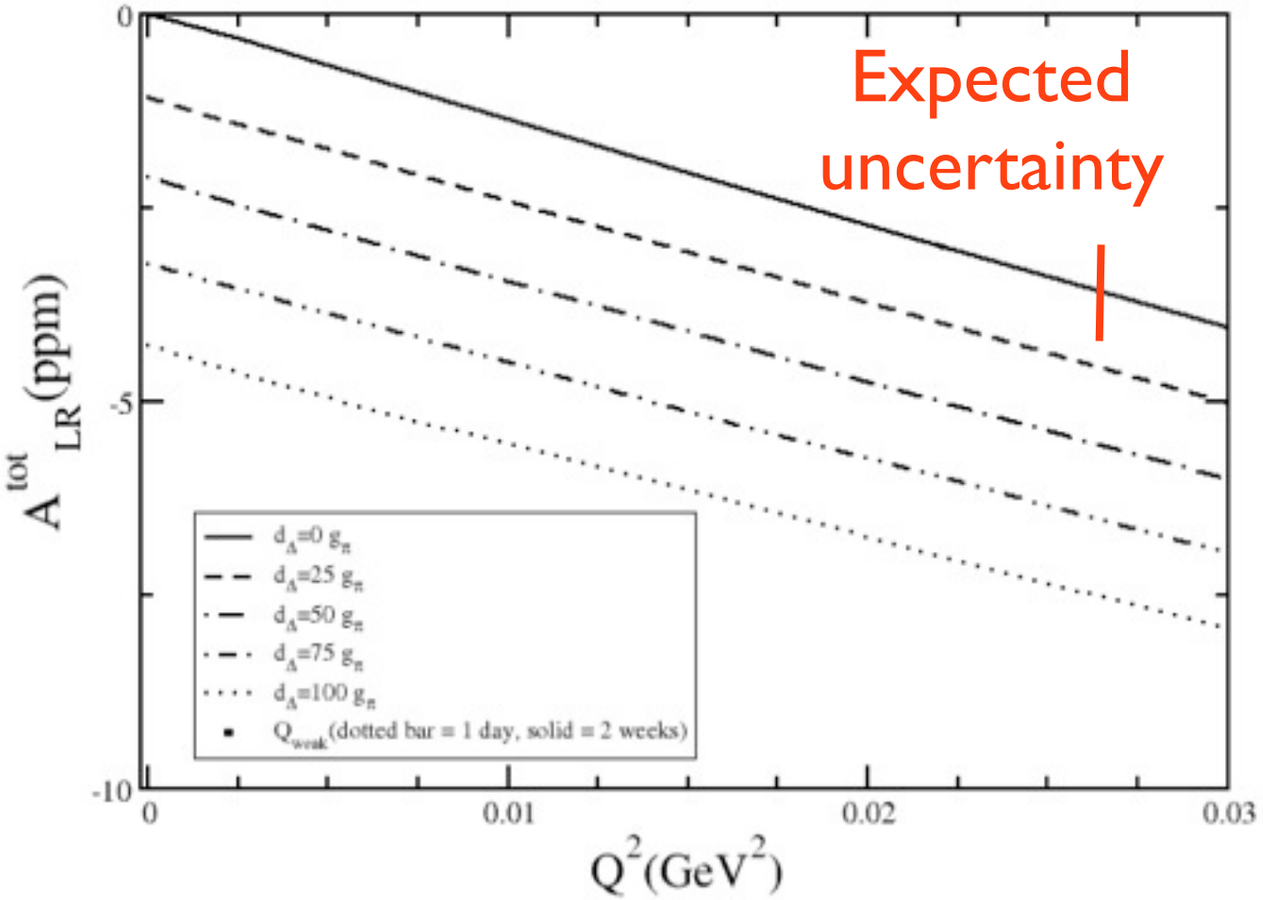
We need to measure background contributions for subtraction.

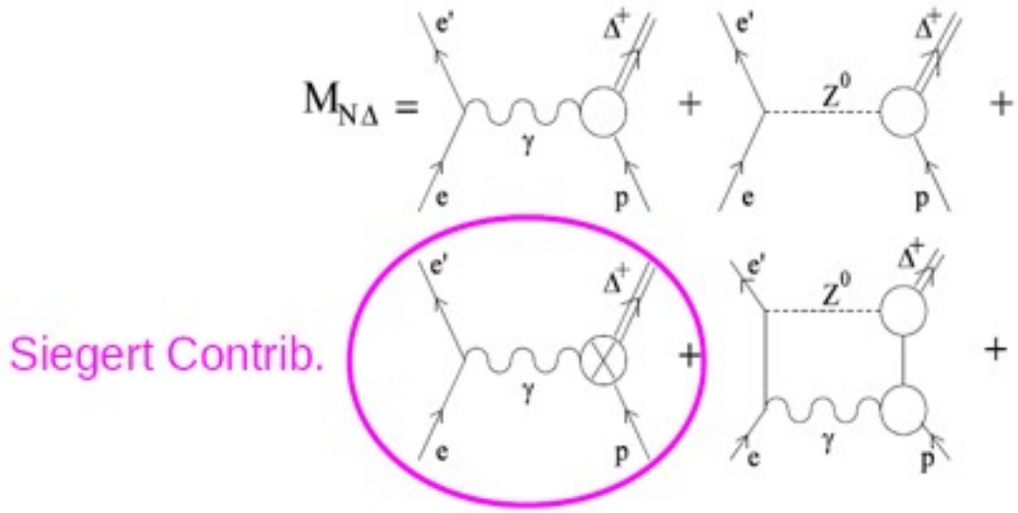
Interesting physics results in their own right.

N-Δ Asymmetry

Sufficient data already taken for this background.
correction is ~1%
~ 0.1% of total rate is from inelastics
inelastic asymmetry ~10x bigger than elastic asymmetry

Interesting as a physics result since N-Δ PV asymmetry unknown to factor 2





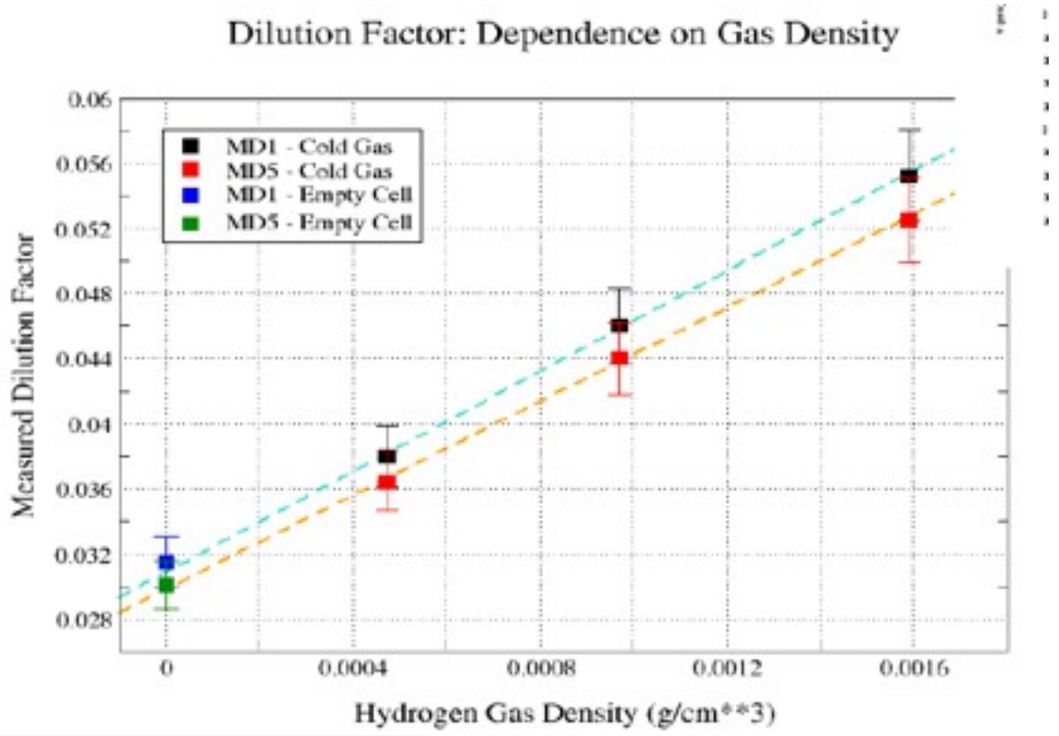
$$\Delta^{\pi}_{(3)} \propto (1+R^{\Delta}_{A})\, G^{A}_{N\Delta}$$

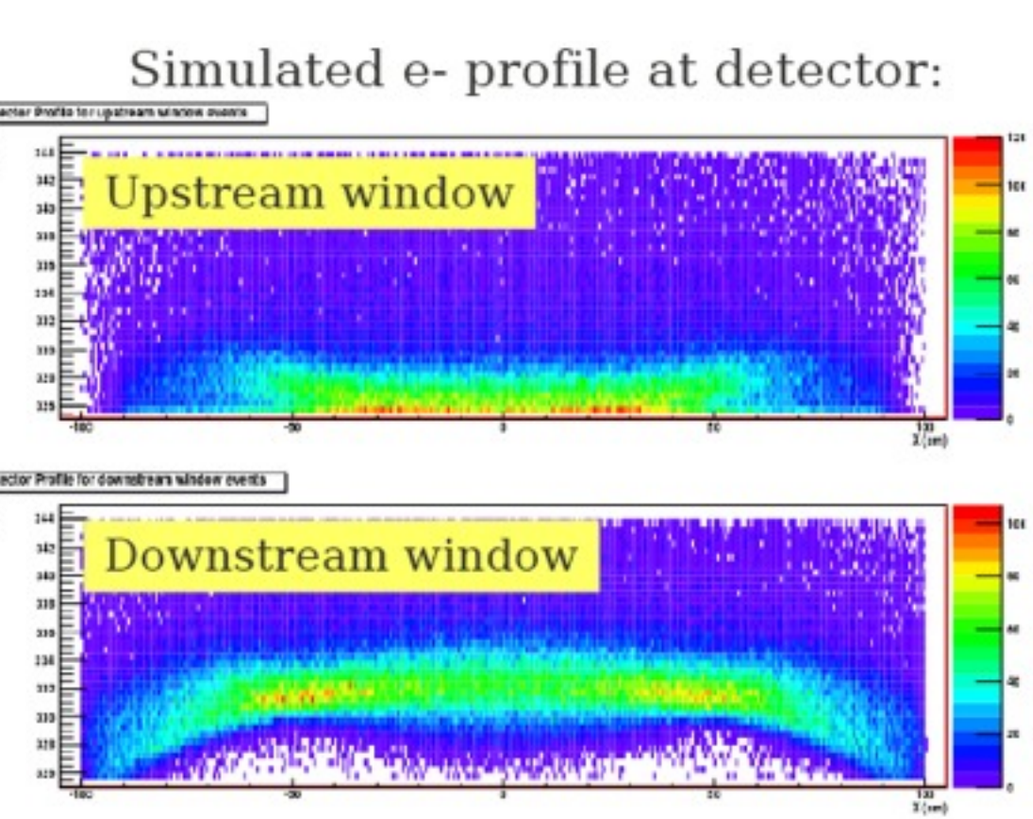
$$R_A^\Delta = R_A^{ewk} + R_A^{Siegert} + R_A^{Anapole} + R_A^{Box} + \cdots$$

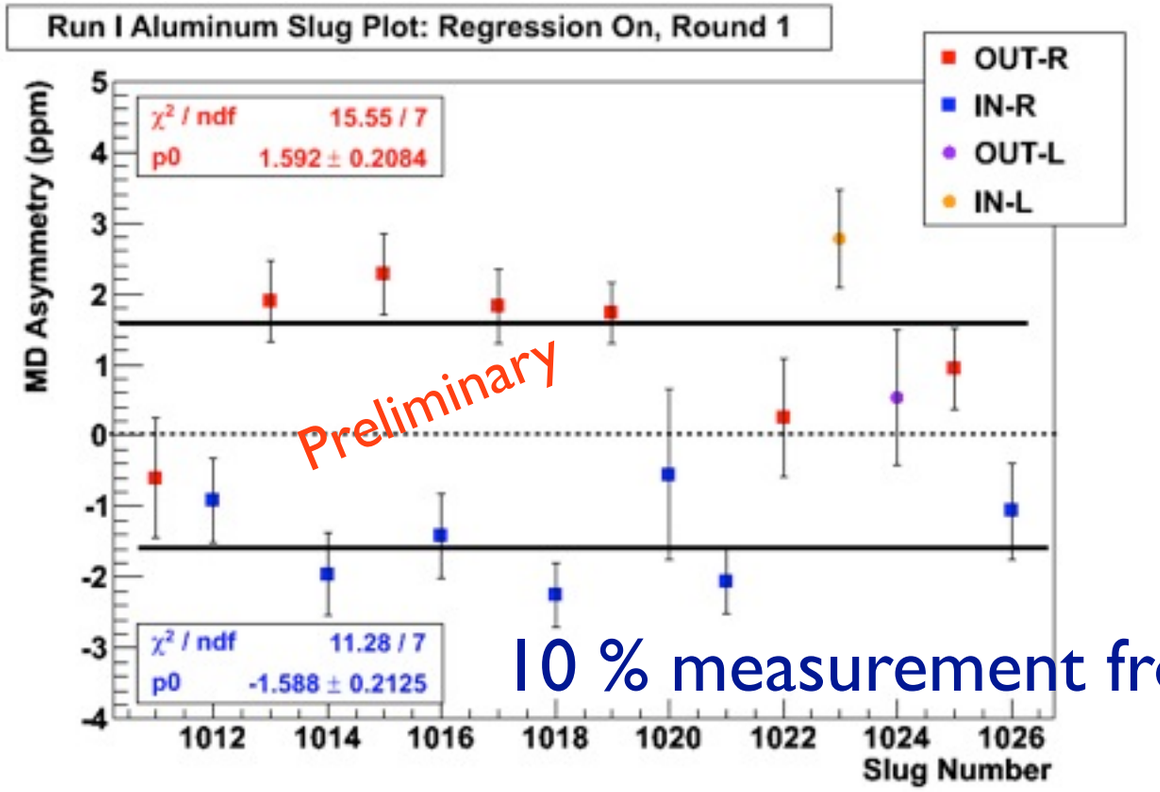
S.-L. Zhu et al., Phys. Rev. D65:033001, 2002

Aluminum Target Walls

correction is ~30%
~3.4% of total rate is from Al
Al asymmetry ~7x bigger and opposite sign
Need to measure Al asymmetry to 2%
=> take Al data ~10% of the time



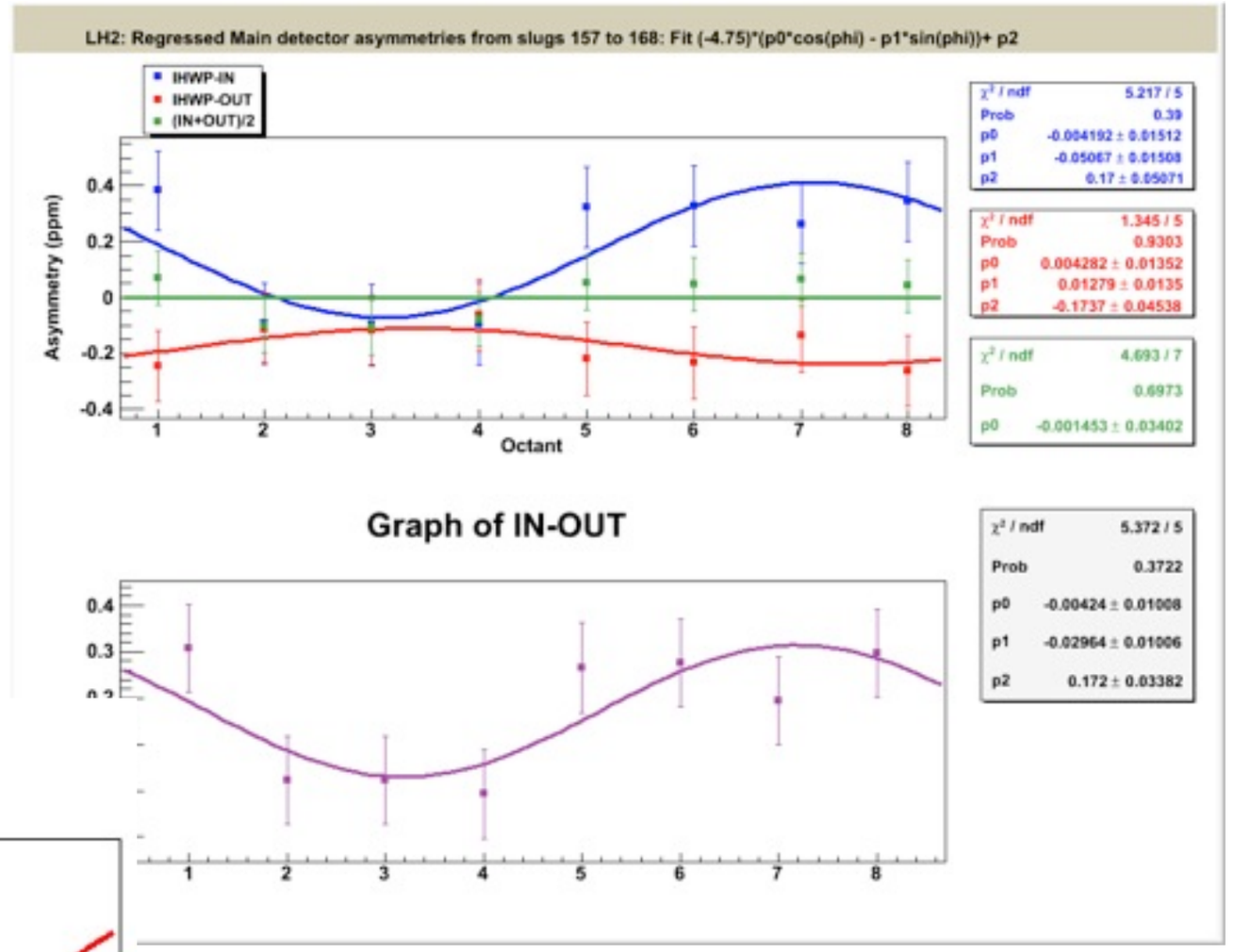


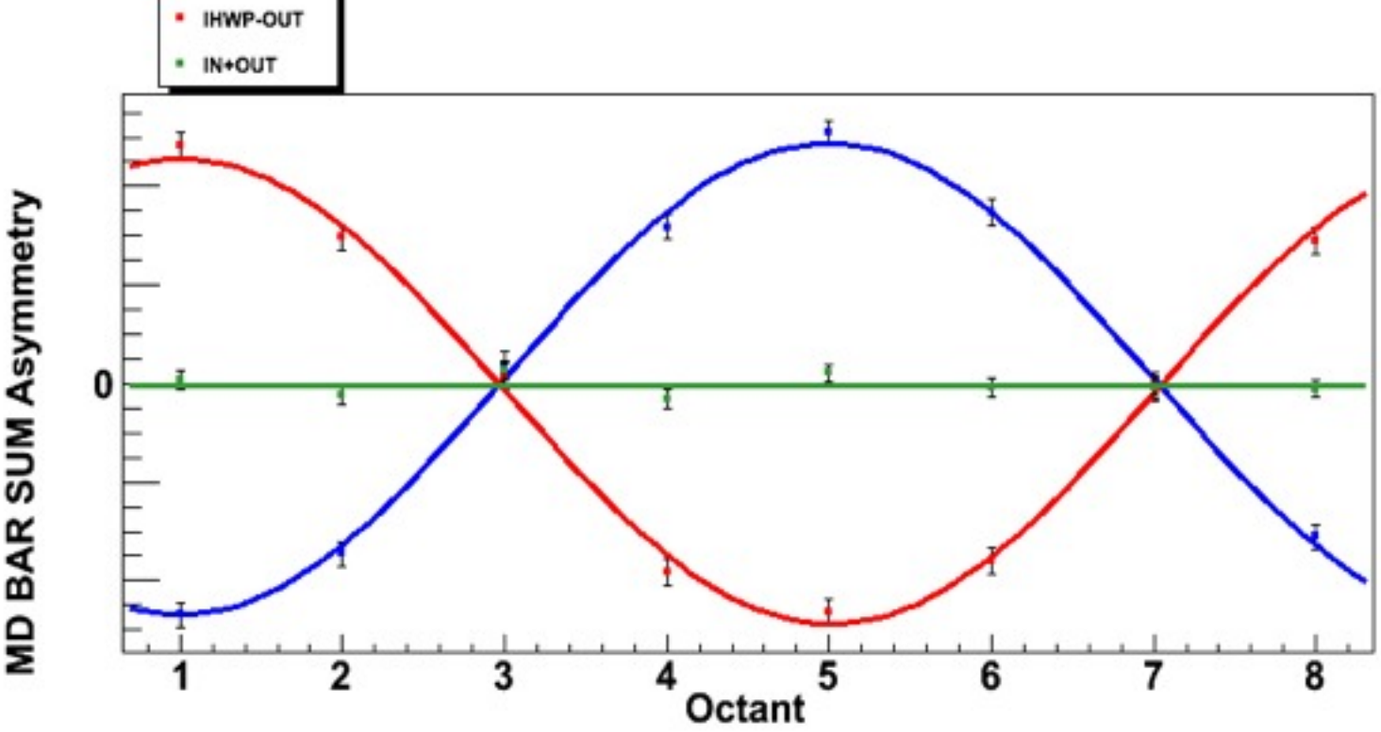


10 % measurement from run I

Transverse Asymmetry

multi-ppm level asymmetry - should cancel to 1st order due to detector symmetry.
Measuring pure transverse gives:
size of background
azimuthal symmetry of detectors





Can make continuous measurement of residual transverse polarization which allows timely correction.

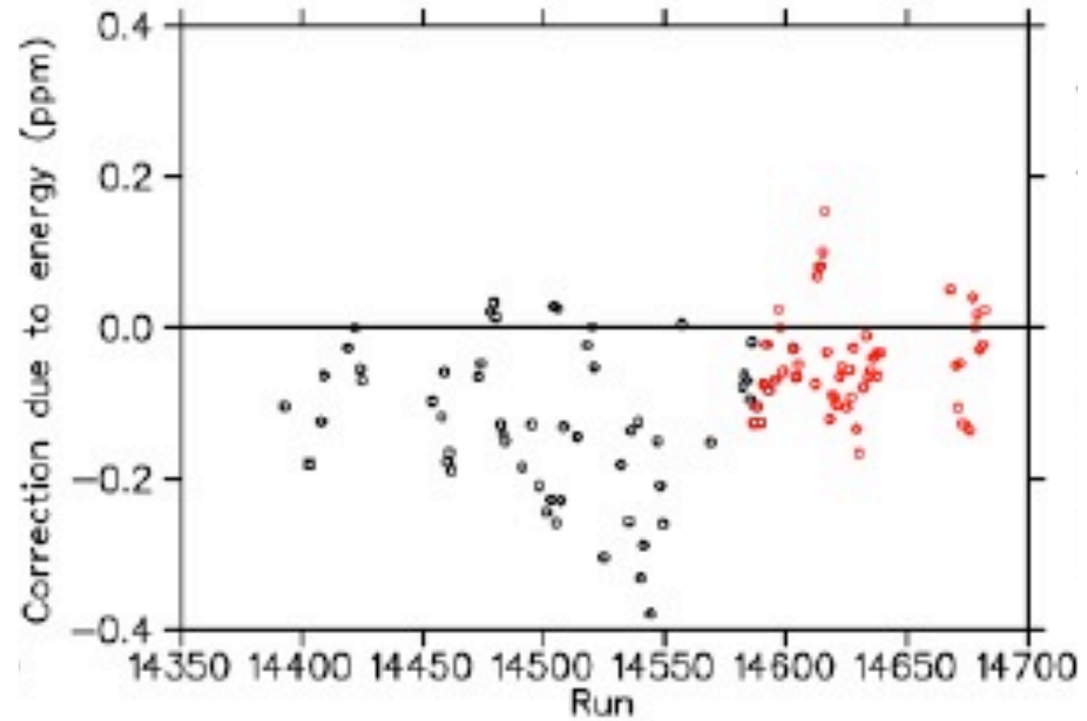
Helicity Correlated Beam Properties

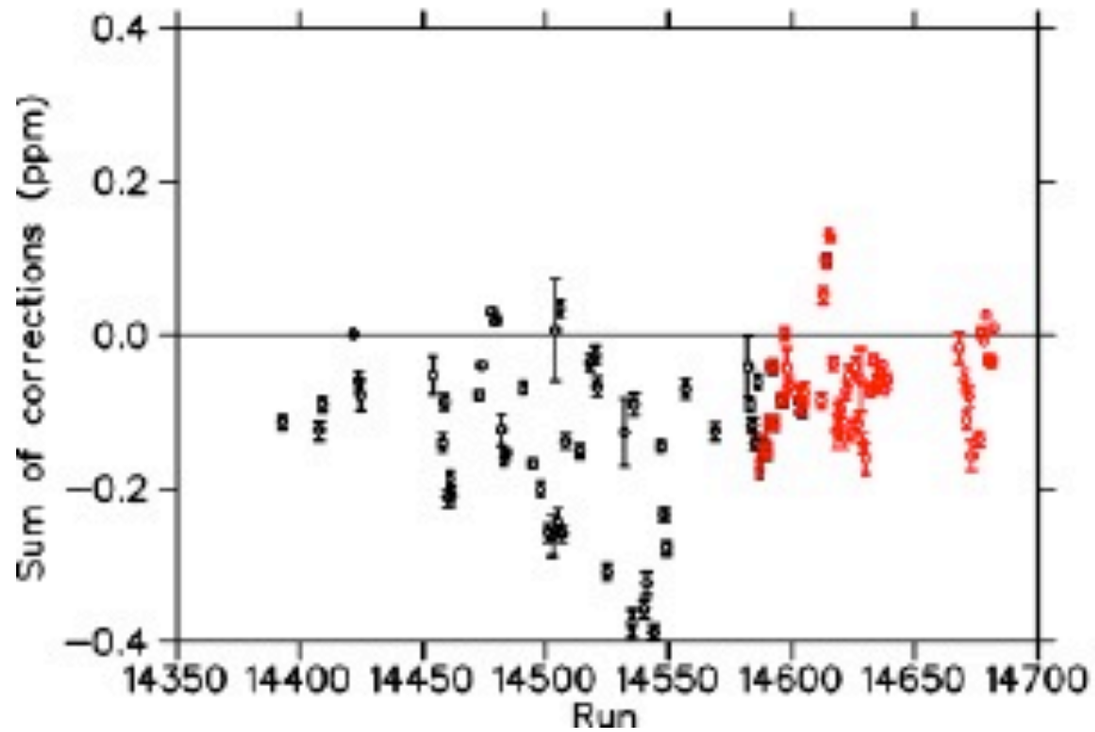
We are needing to make ~100 ppb corrections to the measured asymmetry for beam properties.

Dominated by HC-energy difference since we do not have a cancellation.

This requires us to know these corrections to high precision.

We have recently been experimenting with new apparatus in the injector which may be able to cancel HC position differences.





Summary

Qweak is making the first direct measurement of the weak charge of the proton.

Qweak is currently taking data and has > 1/3 of the statistics but we are behind.

Efficiency is the primary concern.

D. Androic, D. Armstrong, A. Asaturyan, T. Averett, R. Beminiwattha, J. Benesch, J. Birchall, P. Bosted, C. Capuano, R. D. Carlini[1] (PI), G. Cates, S. Covrig, M Dalton, C. A. Davis, W. Deconinck, K. Dow, J. Dunne, D. Dutta, R. Ent, J. Erler, W. Falk, H. Fenker, J.M. Finn, T. A. Forest, W. Franklin, M. Furic, D. Gaskell, M. Gericke, J. Grames, K. Grimm, D. Higinbotham, M. Holtrop, J.R. Hoskins, K. Johnston, E. Ihloff, M. Jones, R. Jones, K. Joo, J. Kelsey, C. Keppel, M. Khol, P. King, E. Korkmaz, S. Kowalski[1], J. Leacock, J.P. Leckey, J. H. Lee, L. Lee, A. Lung, D. Mack, J. Mammei, J. Martin, D. Meekins, A. Micherdzinska, A. Mkrtchyan, H. Mkrtchyan, N. Morgan, K. E. Myers, A. Narayan, Nuruzzaman, A. K. Opper, S. A. Page[1], J. Pan, K. Paschke, S. Phillips, M. Pitt, B. (Matt) Poelker, Y. Prok, W. D. Ramsay, M. Ramsey-Musolf, J. Roche, N. Simicevic, G. Smith[2], T. Smith, P. Souder, D. Spayde, R. Suleiman, B. Sawatzky, E. Tsentalovich, W.T.H. van Oers, B. Waidyawansa, W. Vulcan, P. Wang, S. Wells, S. A. Wood, S. Yang, R. Young, H. Zhu, C. Zorn

[1]Spokespersons, [2]Project Manager