The G^0 Forward-Angle Measurement of Parity Violating Asymmetries in $\vec{e}p$ Elastic Scattering

Stephen Pate, New Mexico State University

for the G^0 Collaboration

Workshop on Precision ElectroWeak Interactions

College of William and Mary

16 August 2005

Virtually all slides are from Doug Beck's 17-June-2005 data release seminar at JLab.

G0 Collaboration

D.S.Armstrong[1], J.Arvieux[2], R.Asaturyan[3], T.Averett[1], S.L.Bailey[1], G.Batigne[4], D.H.Beck[5], E.J.Beise[6], J.Benesch[7], L.Bimbot[2], J.Birchall[8], A.Biselli[9], P.Bosted[7], E.Boukobza[2,7], H.Breuer[6], R.Carlini[7], R.Carr[10], N.Chant[6], Y.-C.Chao[7], S.Chattopadhyay[7], R.Clark[9], S.Covrig[10], A.Cowley[6], D.Dale[11], C.Davis[12], W.Falk[8], J.M.Finn[1], T.Forest[13], G.Franklin[9], C.Furget[4], D.Gaskell[7], J.Grames[7], K.A.Griffioen[1], K.Grimm[1,4], B.Guillon[4], H.Guler[2], L.Hannelius[10], R.Hasty[5], A. Hawthorne Allen[14], T.Horn[6], K.Johnston[13], M.Jones[7], P.Kammel[5], R.Kazimi[7], P.M.King[6,5], A.Kolarkar[11], E.Korkmaz[15], W.Korsch[11], S.Kox[4], J.Kuhn[9], J.Lachniet[9], L.Lee[8], J.Lenoble[2], E.Liatard[4], J.Liu[6], B.Loupias[2,7], A.Lung[7], G.A.MacLachlan[16], D.Marchand[2], J.W.Martin[10,17], K.W.McFarlane[18], D.W.McKee[16], R.D.McKeown[10], F.Merchez[4], H.Mkrtchyan[3], B.Moffit[1], M.Morlet[2], I.Nakagawa[11], K.Nakahara[5], M.Nakos[16], R.Neveling[5], S.Niccolai[2], S.Ong[2], S.Page[8], V.Papavassiliou[16], S.F.Pate[16], S.K.Phillips[1], M.L.Pitt[14], M.Poelker[7], T.A.Porcelli[15,8], G.Quéméner[4], B.Quinn[9], W.D.Ramsay[8], A.W.Rauf[8], J.-S.Real[4], J.Roche[7,1], P.Roos[6], G.A.Rutledge[8], J.Secrest[1], N.Simicevic[13], G.R.Smith[7], D.T.Spayde[5,19], S.Stepanyan[3], M.Stutzman[7], V.Sulkosky[1], V.Tadevosyan[3], R.Tieulent[4], J.van de Wiele[2], W.van Oers[8], E.Voutier[4], W.Vulcan[7], G.Warren[7], S.P.Wells[13], S.E.Williamson[5], S.A.Wood[7], C.Yan[7], J.Yun[14]

[1]College of William and Mary, [2]Institut de Physique Nucléaire d'Orsay, [3]Yerevan Physics Institute, [4]Laboratoire de Physique Subatomique et de Cosmologie-Grenoble, [5]University of Illinois, [6]University of Maryland, [7]Thomas Jefferson National Accelerator Facility, [8]University of Manitoba, [9]Carnegie Mellon University, [10]California Institute of Technology, [11]University of Kentucky, [12]TRIUMF, [13]Louisiana Tech University, [14]Virginia Tech, [15]University of Northern British Columbia, [16]New Mexico State University, [17]University of Winnipeg, [18]Hampton University, [19]Grinnell College

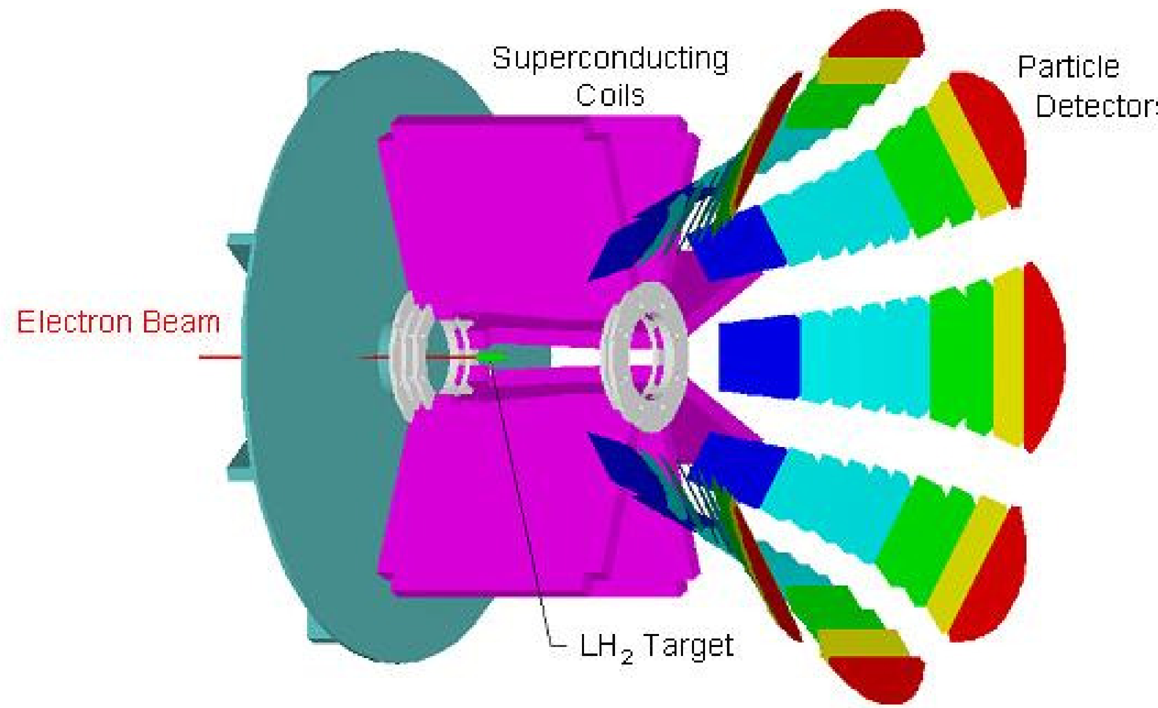
DHB, 17 June 2005

Experimental setup

G0 Experiment Overview

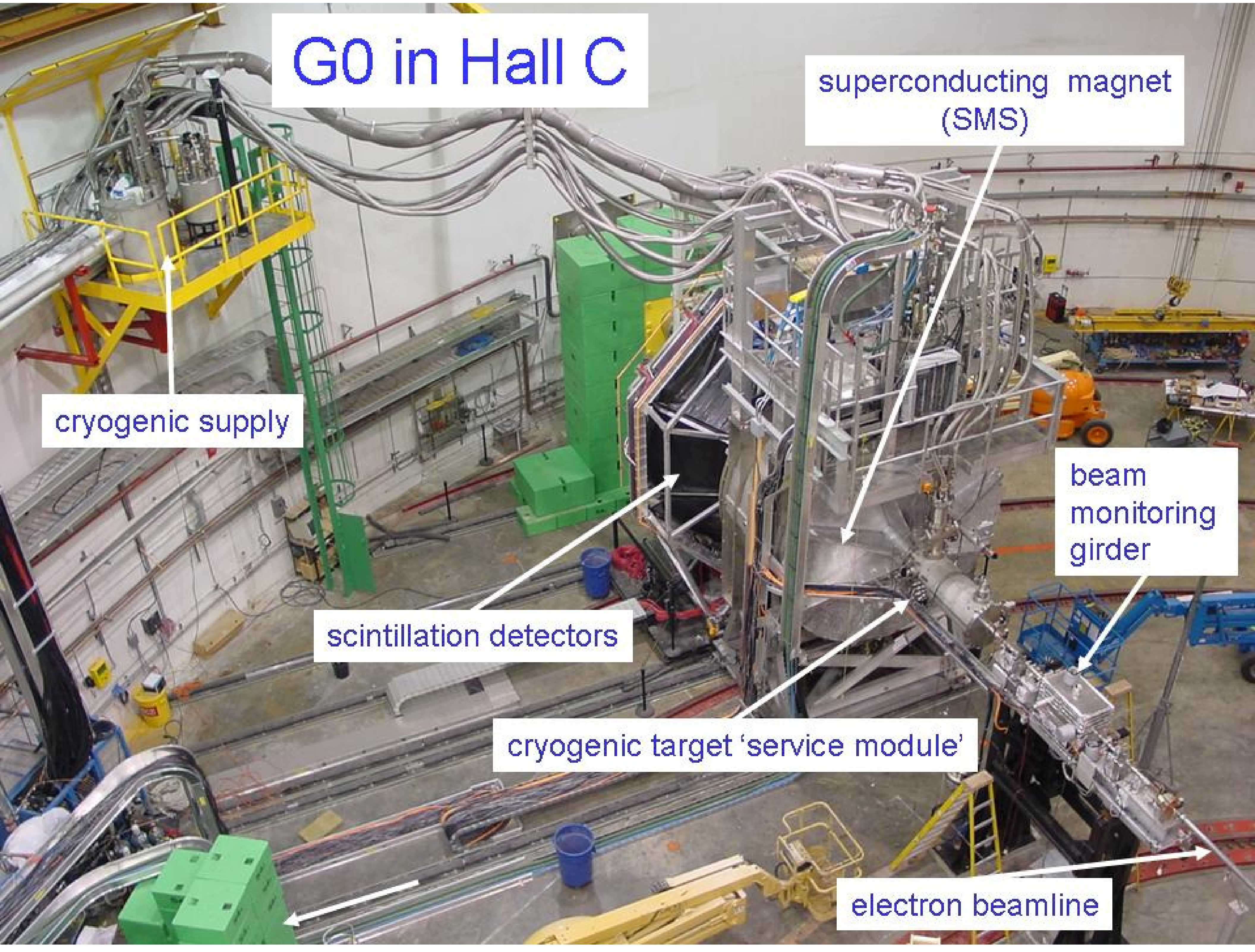
- Measure G_E^Z, G_M^Z
  - different linear combination of *u*, *d* and *s* contributions than e.m. form factors
  - $\rightarrow$ strange quark contributions to sea
- Measure forward and backward asymmetries
  - recoil protons for forward measurement
  - electrons for backward measurements
    - elastic/inelastic for ^1H, elastic for ^2H
- Forward measurements complete (101 Coulombs)

E_{beam} = 3.03 GeV, 0.33 - 0.93 GeV
I_{beam} = 40 μA, 80 μA
P_{beam} = 75%, 80%
$\theta = 52 - 76^0, 104 - 116^0$
$\Delta\Omega$ = 0.9 sr, 0.5 sr
l_{target} = 20 cm
$L = 2.1, 4.2 \times 10^{38}\ cm^{-2}\ s^{-1}$
A ~ -1 to -50 ppm, -12 to -70 ppm



DHB, 17 June 2005

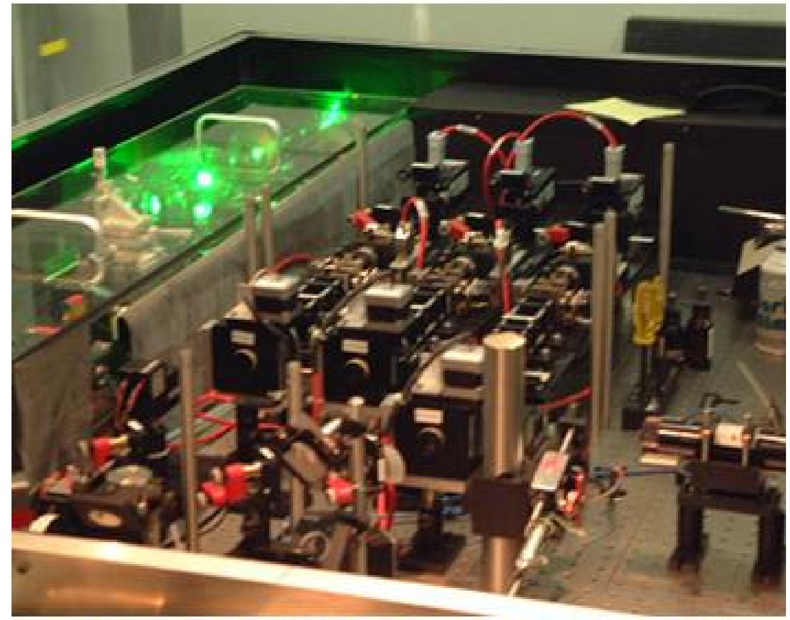
G0 in Hall C


superconducting magnet (SMS)
cryogenic supply
beam monitoring girder
scintillation detectors
cryogenic target 'service module'
electron beamline

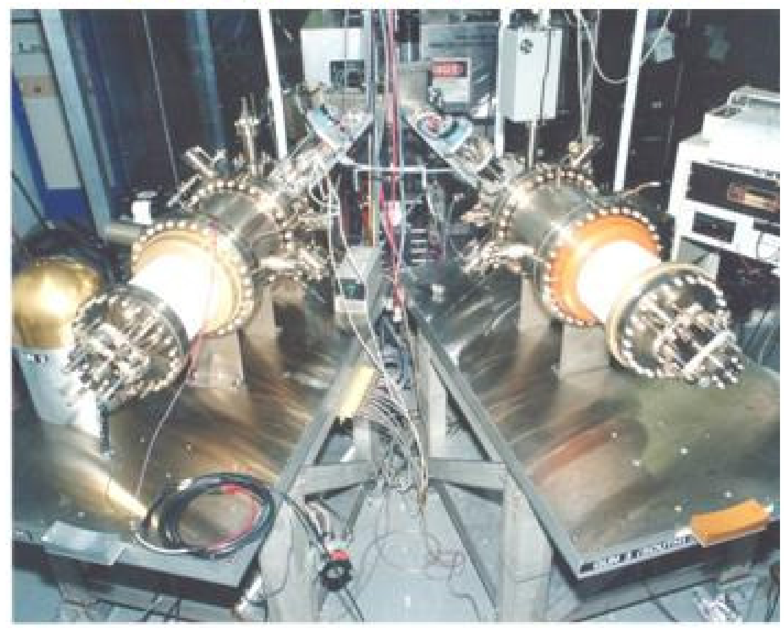
Polarized Injector/Accelerator

- Challenging specifications – all met!
  - 32 ns pulse spacing for t.o.f.
  - 40 μA beam current
    - higher bunch charge
  - run concurrently with small energy spread for Hall A

Beam Parameter	Achieved	"Specs"
Charge asymmetry	-0.14 ± 0.32 ppm	1 ppm
x position differences	3 ± 4 nm	20 nm
y position differences	4 ± 4 nm	20 nm
x angle differences	1 ± 1 nrad	2 nrad
y angle differences	1.5 ± 1 nrad	2 nrad
Energy differences	29 ± 4 eV	75 eV



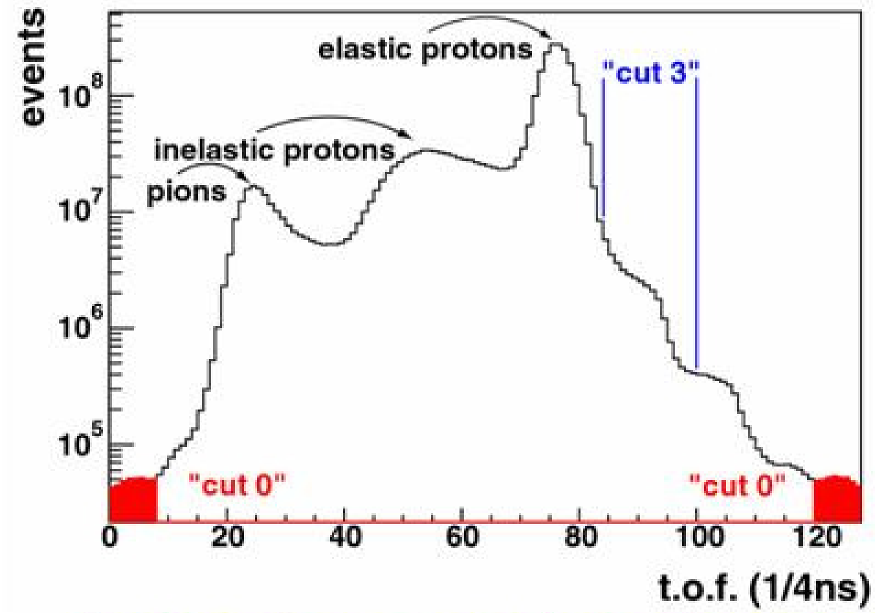
New Tiger laser system for G0



JLab polarized injector

Leakage Beam Measurement

- Use "cut0" region in actual data to measure leakage yield, asymmetry throughout run
- Cut0 certified during test runs with only leakage beam
  - uncertainty determined in 3 ways
    - compare lumi monitor (direct) measurements to cut0
    - cut3 asymmetry independent of beam current (10, 20, 40 μA)
    - variation of corrected cut3 asymmetry (should be constant over run)
  - methods consistent at 20% level
- $\delta A_{false,leak} = -0.71 \pm 0.14$ ppm

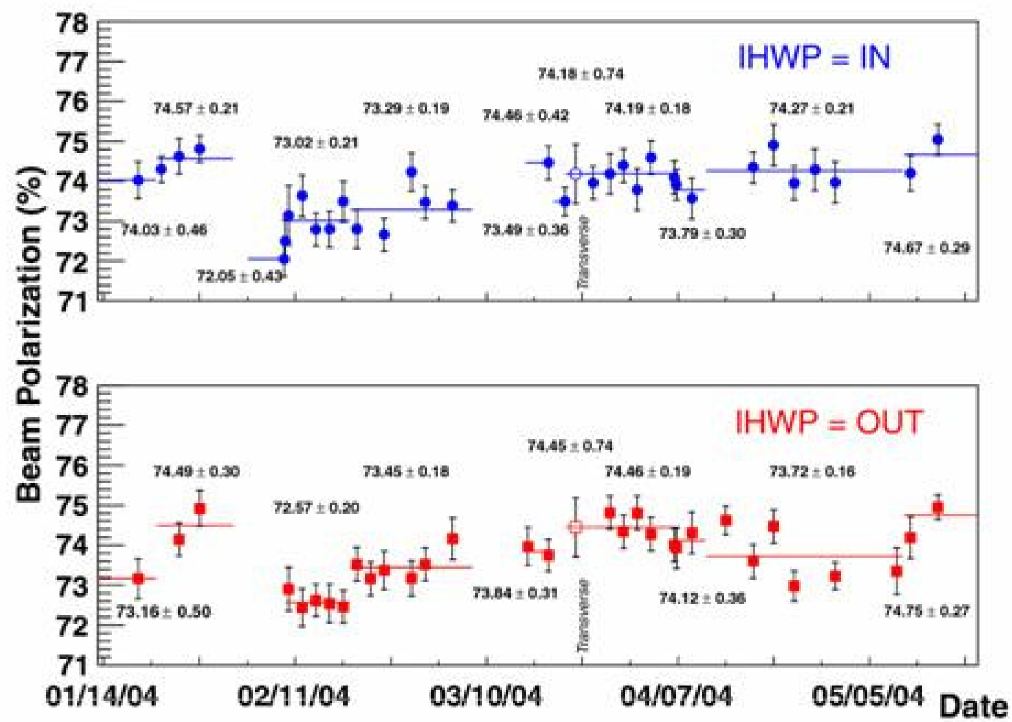


Leakage beam measurement regions

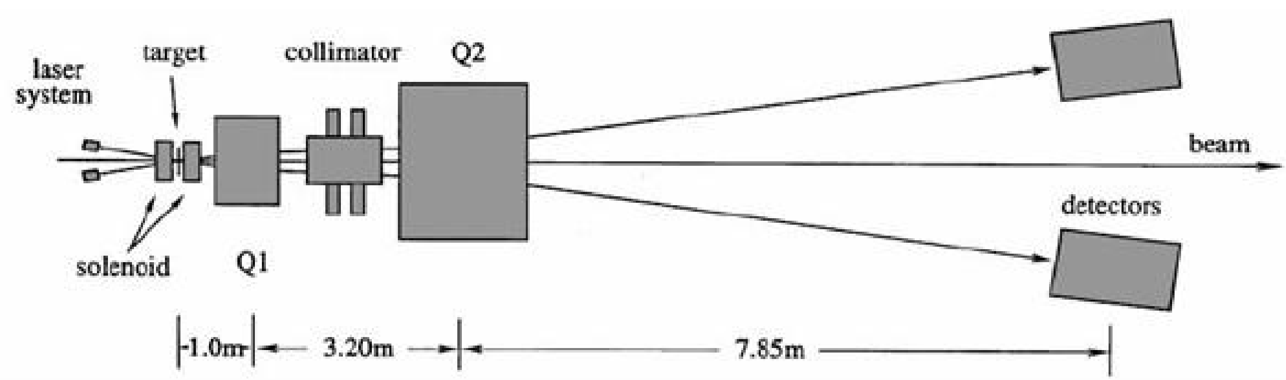
I (μA)	$A_{3,meas}$ (ppm)	$A_{3,corr}$ (ppm)
40	0.14±0.43	−2.5±0.43
20	−29.6±2.1	−7.2±2.1
10	−51.3±3.9	−9.5±3.9

Beam Polarization

- Beam polarization measured with interleaved Møller measurements
  - std Hall C polarimeter
    (M. Hauger, et al. NIM **A462** (2001) 382.)
  - apply for groups of runs as shown
  - average: P = 73.7%

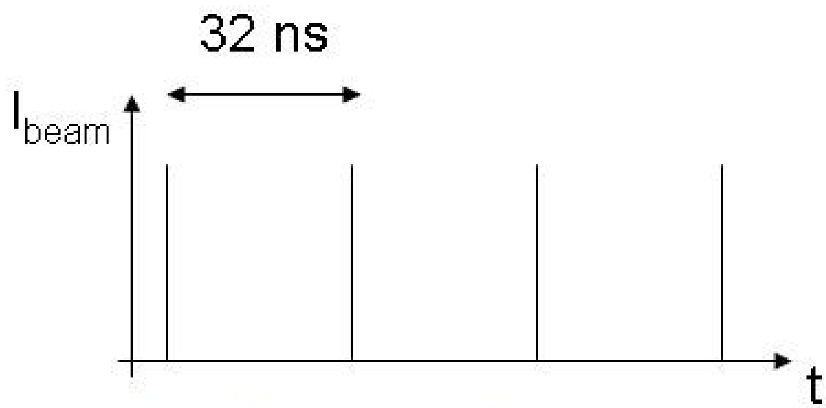


Source	Rel. uncertainty (%)
Target	0.42
Leakage	0.2
Current extrap'n	1
Beam	0.52
Levchuk	0.3
Detection	0.35
Total	**1.32**

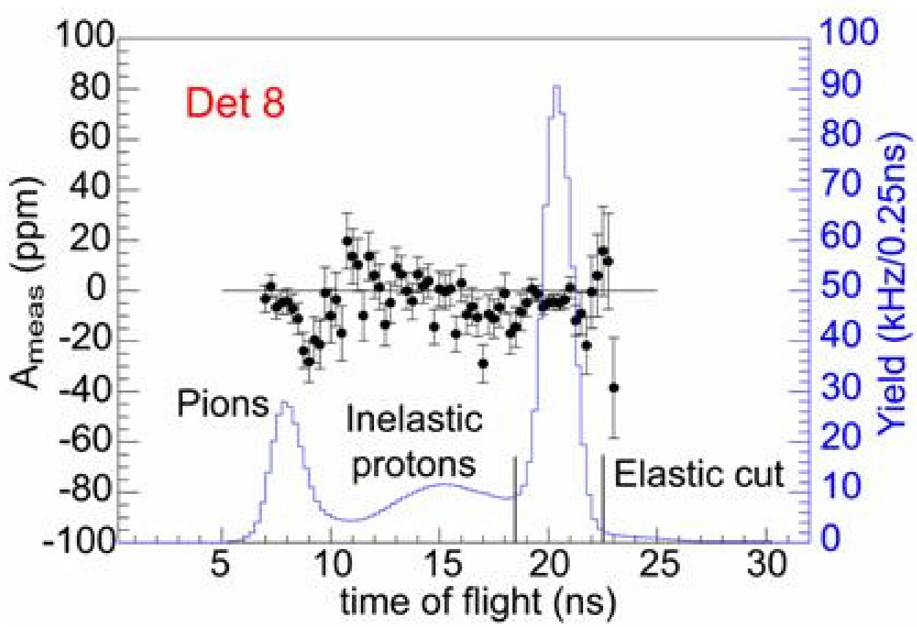


DHB, 17 June 2005

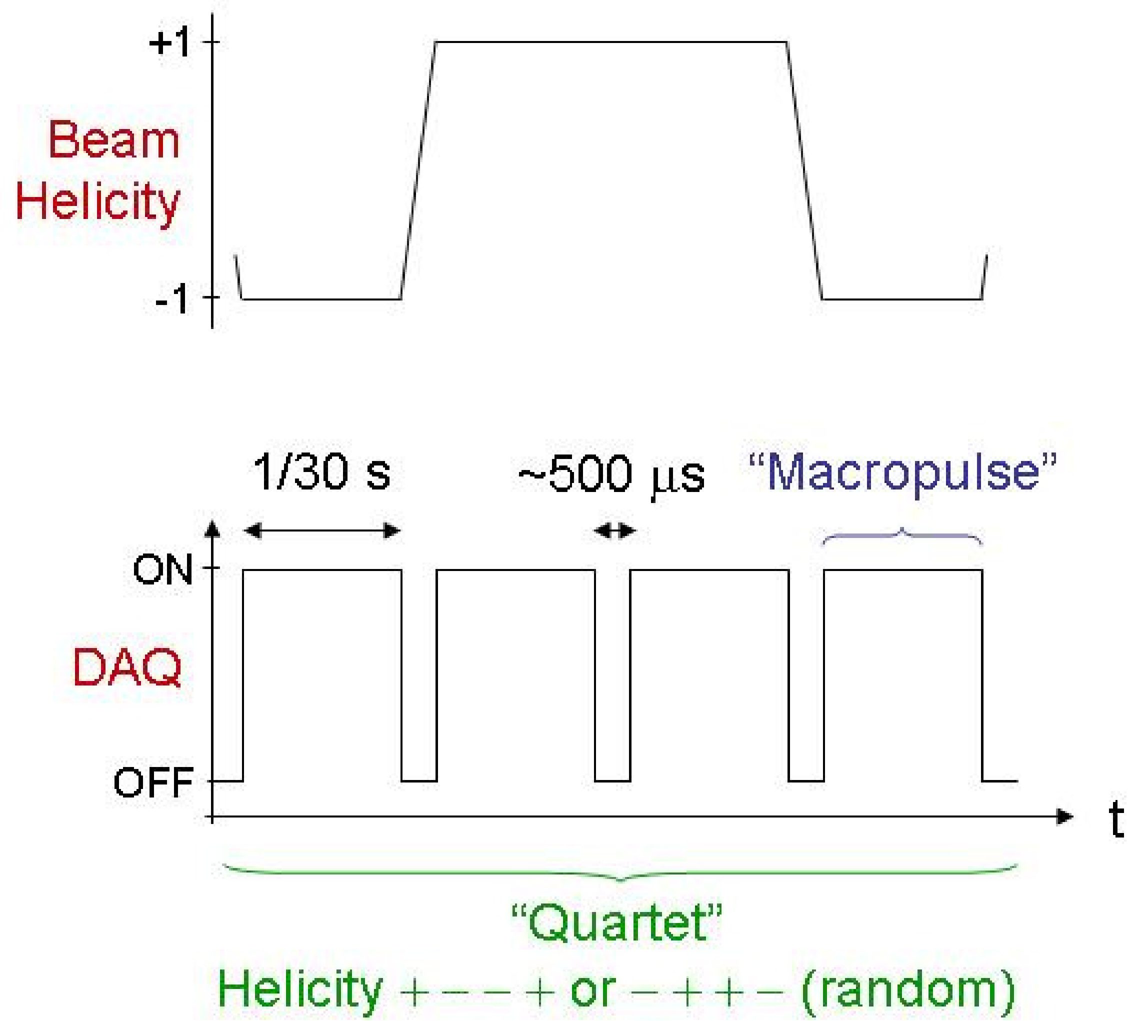
Timing in the Experiment



Accelerator pulse structure



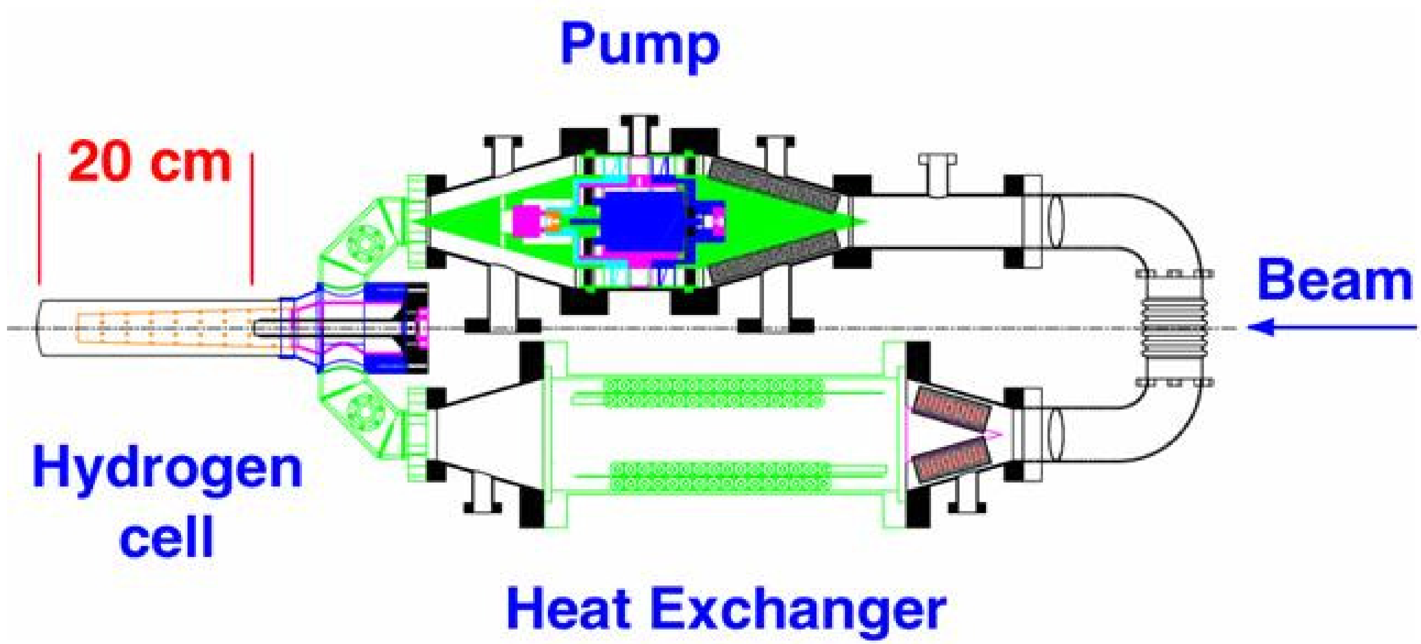
Typical t.o.f. spectrum



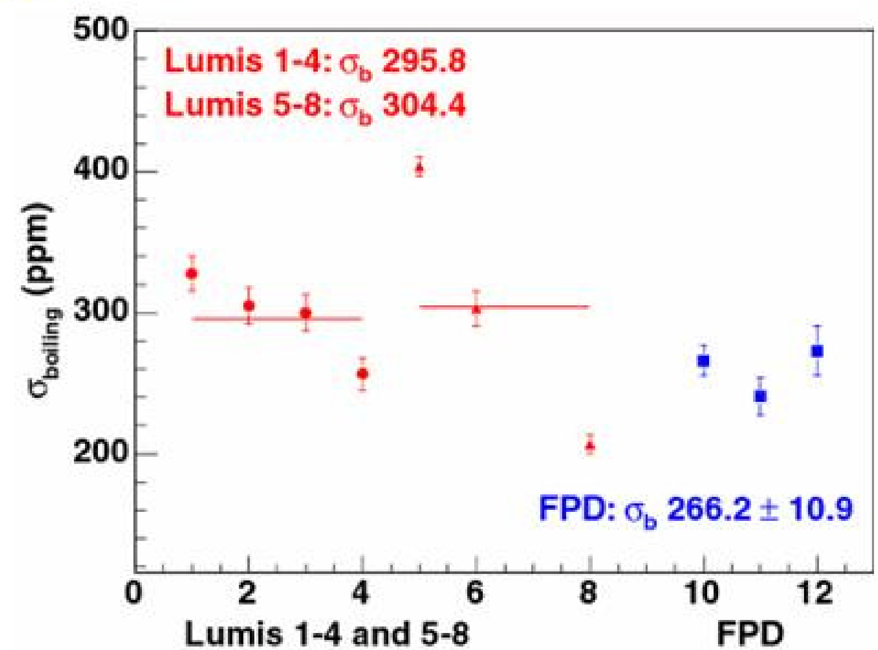
Measurement timing

DHB, 17 June 2005

Target

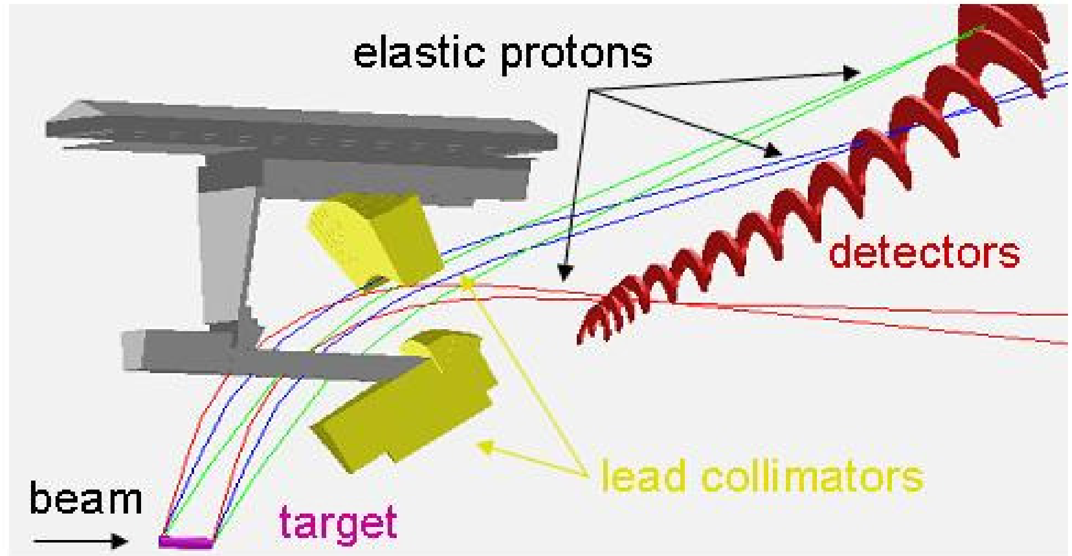


- 20 cm LH_2, aluminum target cell
- longitudinal flow, v ~ 8 m/s,
  P > 1000 W!
- negligible density change < 1.5%
- measured small boiling contribution
  - 260 ppm/1200 ppm statistical width



Spectrometer Optics

- zero magnification along beam axis
- elastic protons dispersed in Q^2 along focal surface



- acceptance $0.12 < Q^2 < 1.0$ GeV^2 for 3 GeV incident beam

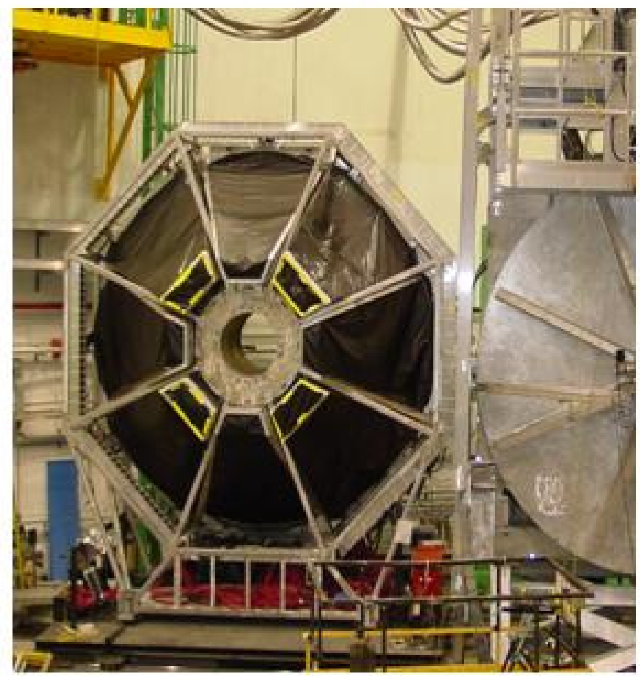
- detector 15 acceptance: 0.44 – 0.88 GeV^2
  - 3 Q^2 bins at 0.51, 0.63 and 0.78 GeV^2
- detector 14: Q^2 = 0.41, 1.0 GeV^2
- det. 16: no elastic acceptance
  - important for measuring backgrounds

Detectors

- 16 detectors per octant
- Arc shape (const. Q^2), protons at normal incidence

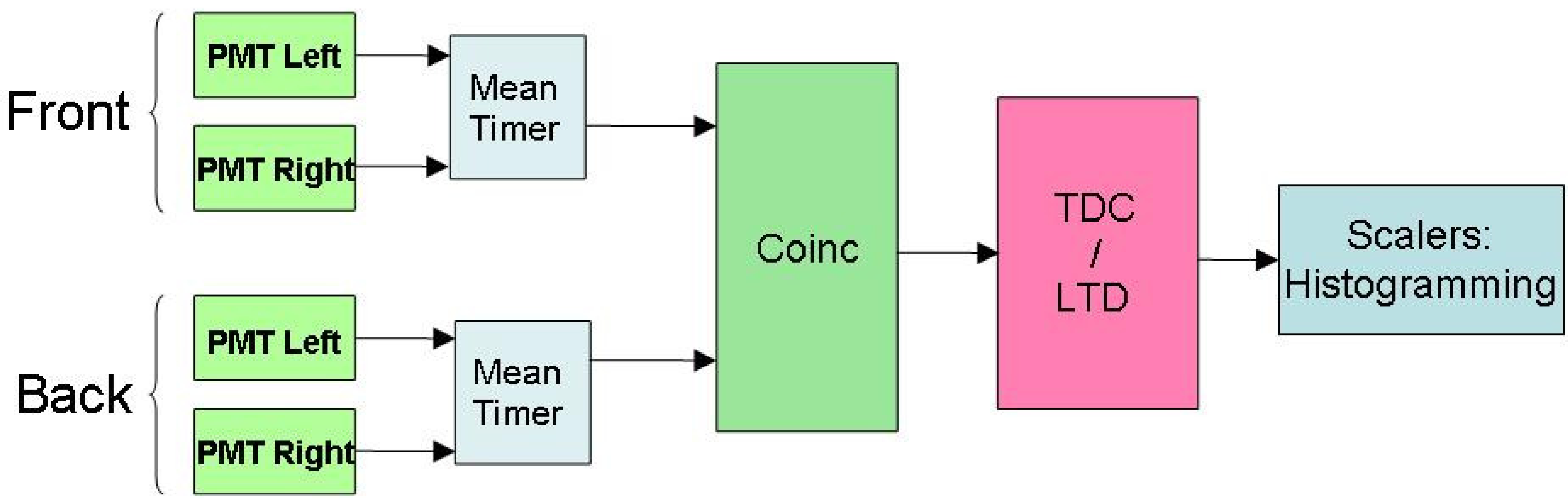
- Each detector: scintillator pair
  - BC408: 0.5, 1.0 cm thick
  - 1/8 in. shielding in-between
- PMT at each end of each scintillator
  - XP2262B (NA), XP2282B (Fr)
- Signal: mean-time-front .AND. mean-time-back

- Assembled with ~ 2 mm accuracy
- Octants in light-tight enclosures



Electronics

- Measure time-of-flight target to detectors
- Counting rates $\leq$ 4 MHz per scintillator pair
- Fast time encoding
  – NA: dual 500 MHz shift registers –> scalers (1 ns resolution)
    - "latching time digitizer" (LTD)
  – Fr: flash TDC –> DSP –> scalers (1/4 ns resolution)



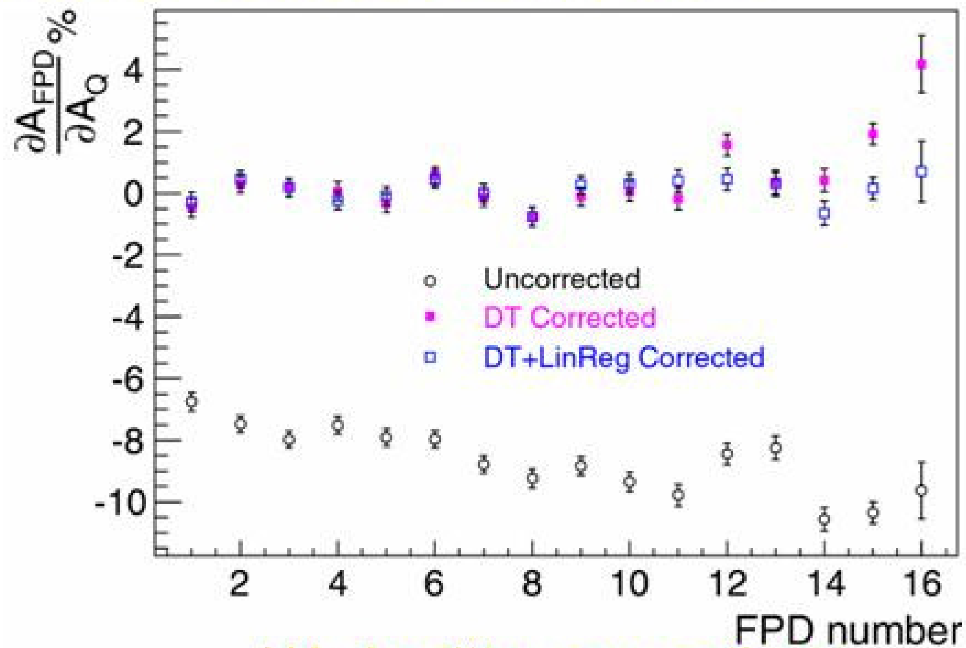
Electronics Deadtime Corrections

- Residual effect on asymmetry
  - scale factor

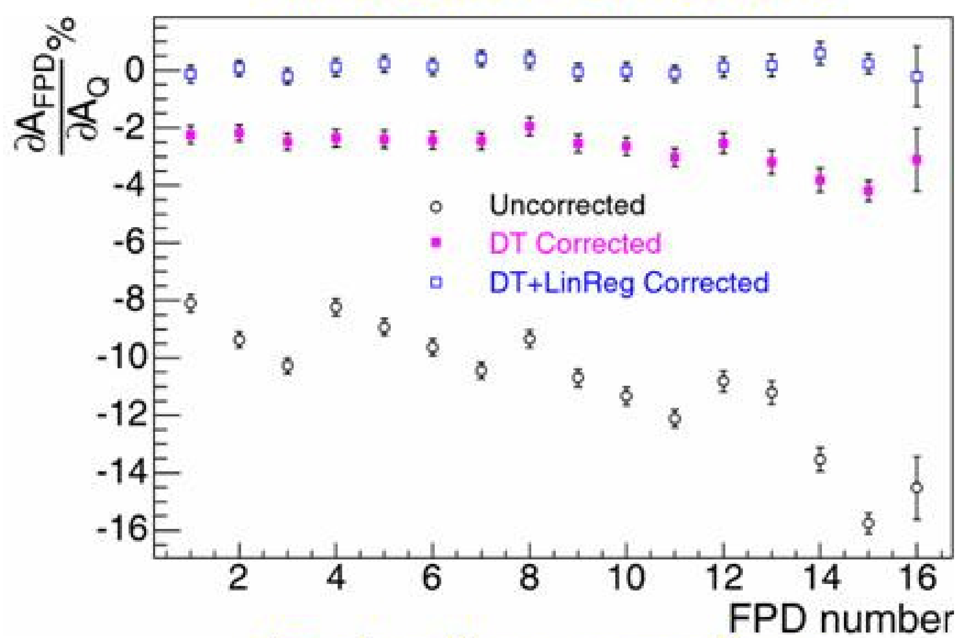
$$A_{meas} = \frac{R_+(1-\tau R_+) - R_-(1-\tau R_-)}{R_+(1-\tau R_+) + R_-(1-\tau R_-)}$$

$$\cong A\left(1-\tau\frac{R_+ + R_-}{2}\right)$$

- A is sum of physics *and* charge asymmetries
  - helicity-correlated beam current changes corrected in linear regression analysis
  - correction for residual effect ~ 0.05±0.05 ppm (pt-pt systematic unc.)



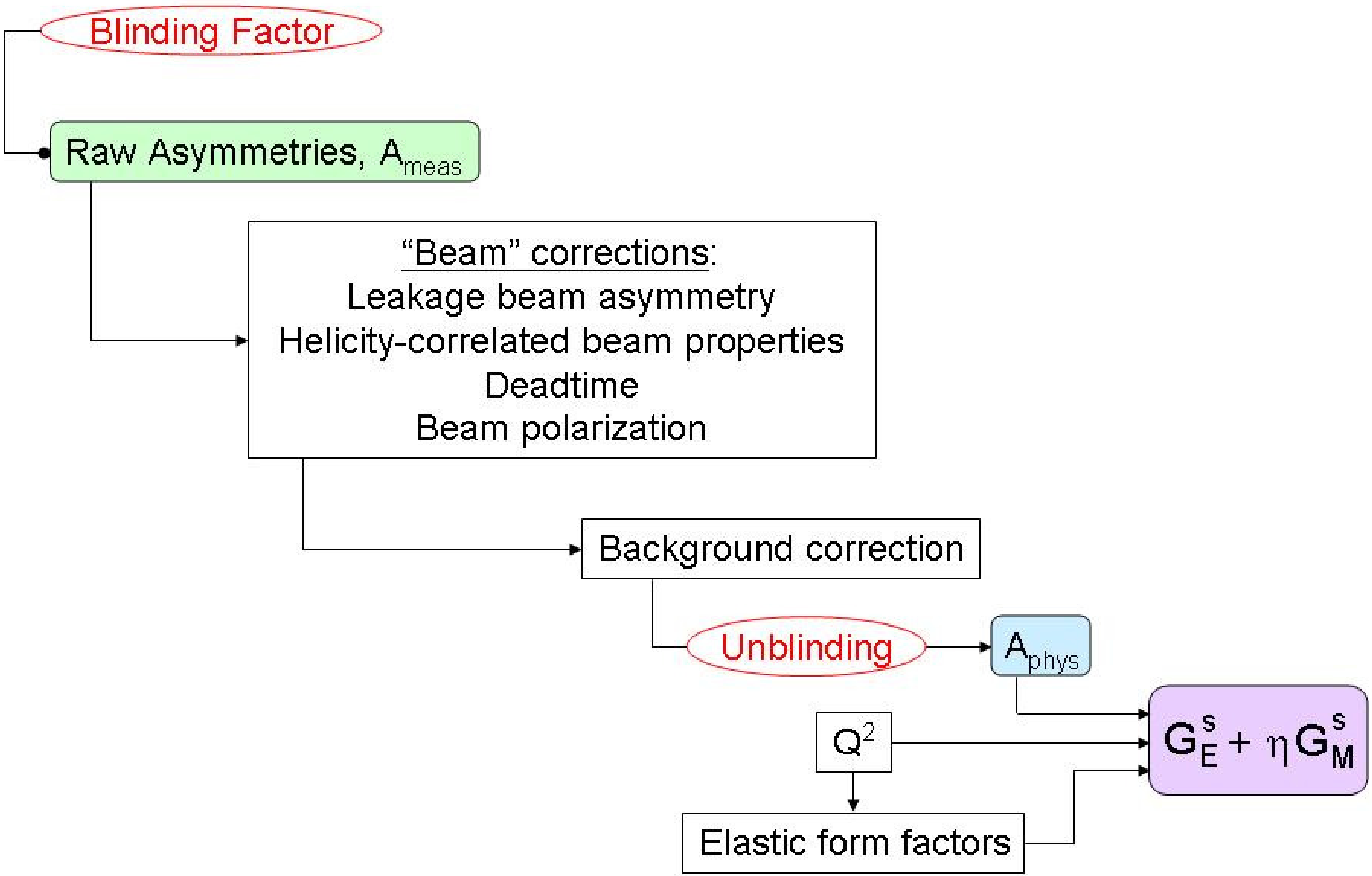
NA deadtime corrections



Fr deadtime corrections

Analysis

Analysis Overview



Forward Data Summary

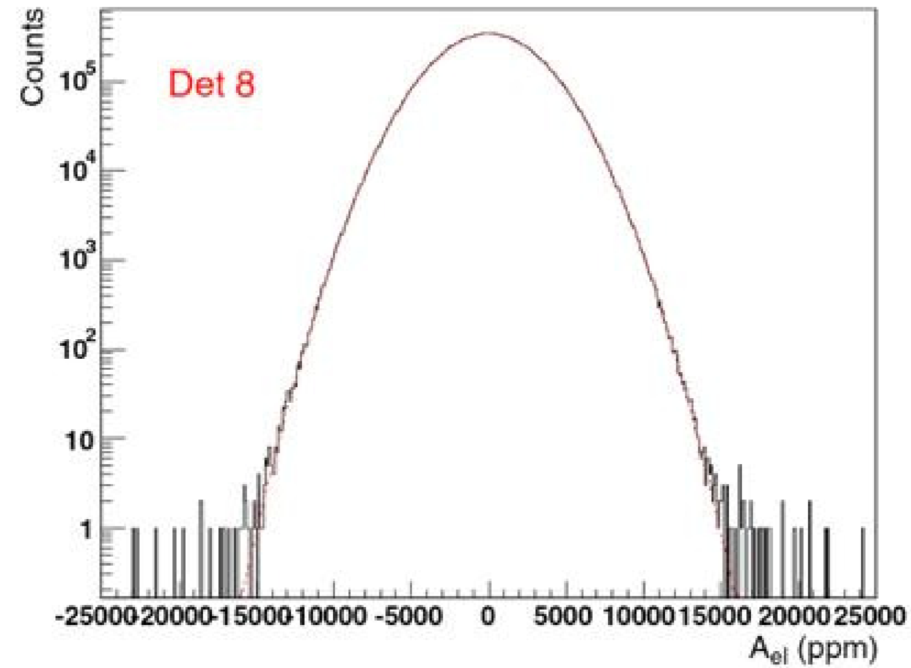
- 101 Coulombs of parity-quality beam
  - cuts on helicity-correlated beam parameter are 4 x std. dev. for given run:

Quantity	Std. dev.
charge asymmetry	600 ppm
x, *y* position differences	8, 10 μm
x, *y* angle difference	0.6, 1.1 μrad
energy difference	7.5 keV

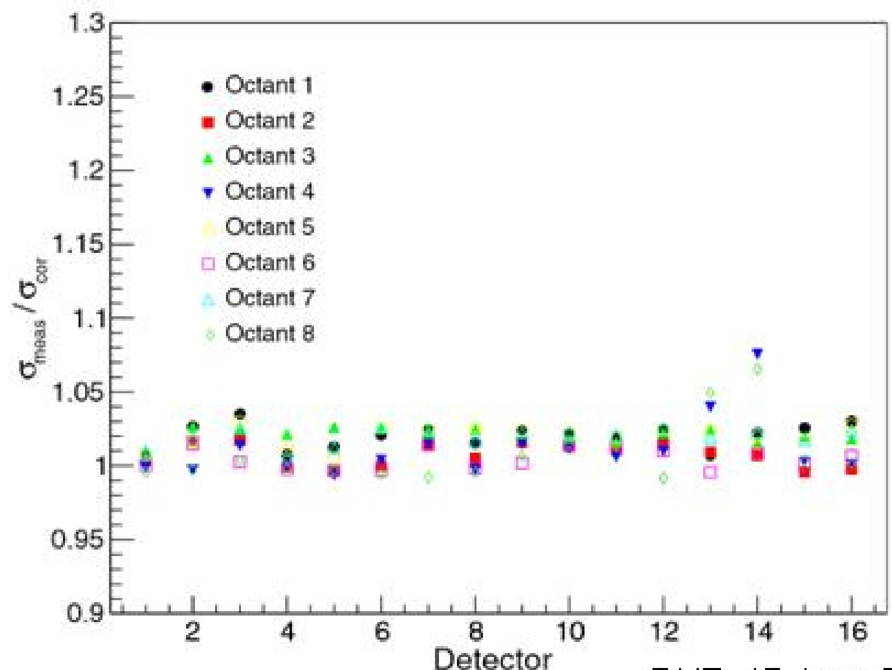
- Includes running with both Hall A and Hall B (leakage beam asymmetry measured satisfactorily)
- Corresponds to: 701 h at 40 μA
  19×10^6 quartets
  76×10^6 MPS

Statistical Properties of the Data

- Asymmetry distributions very clean over range of 10^5



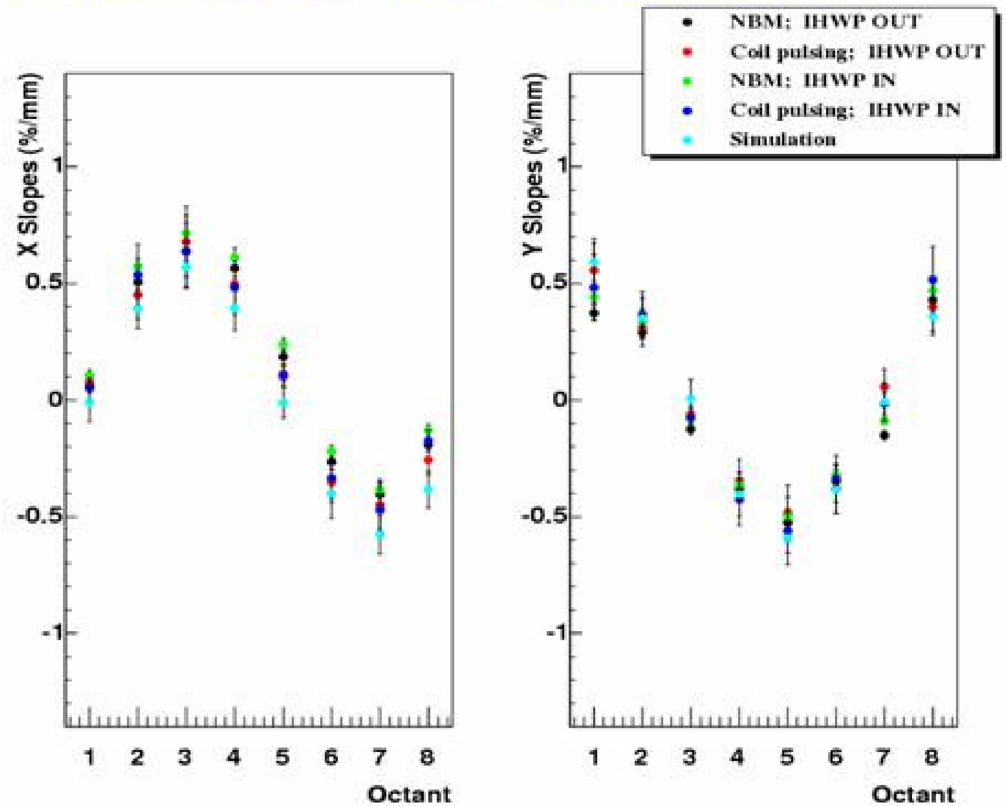
- Measured and expected widths agree at few % level

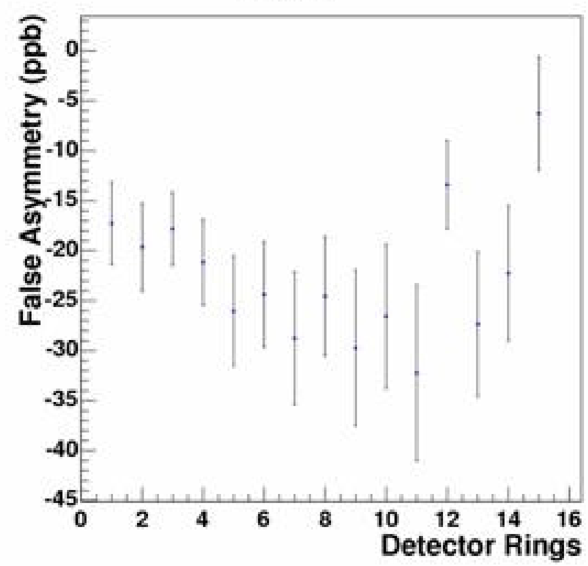


DHB, 17 June 2005

Helicity-Correlated Beam Parameters

- Response of spectrometer to beam changes well understood
- Average helicity-correlated beam parameters very small
- False asymmetries due to helicity-correlated beam parameters very small
  - overall about –0.02 ppm
  - largest is 0.01 ppm from residual charge asymmetry
  - uncertainties small as well: 0.01 ppm





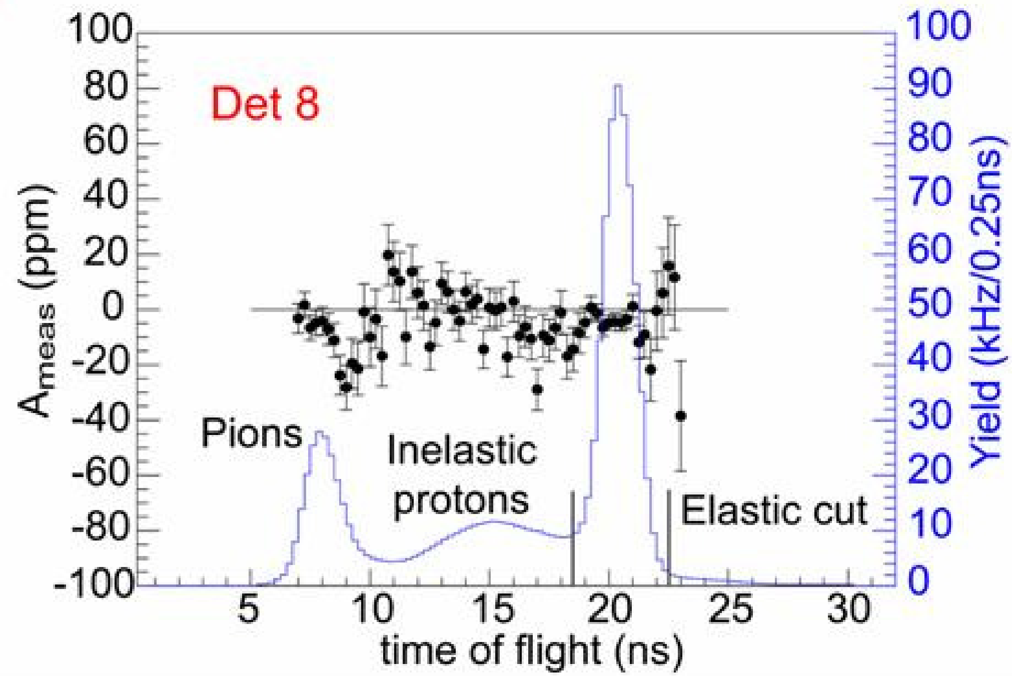
Background Overview

- Measure yield and asymmetry of entire spectrum
- Correct asymmetry according to

$$A_{meas} = (1-f)A_{el} + f A_{back}$$

where A_{el} is the raw elastic asymmetry,

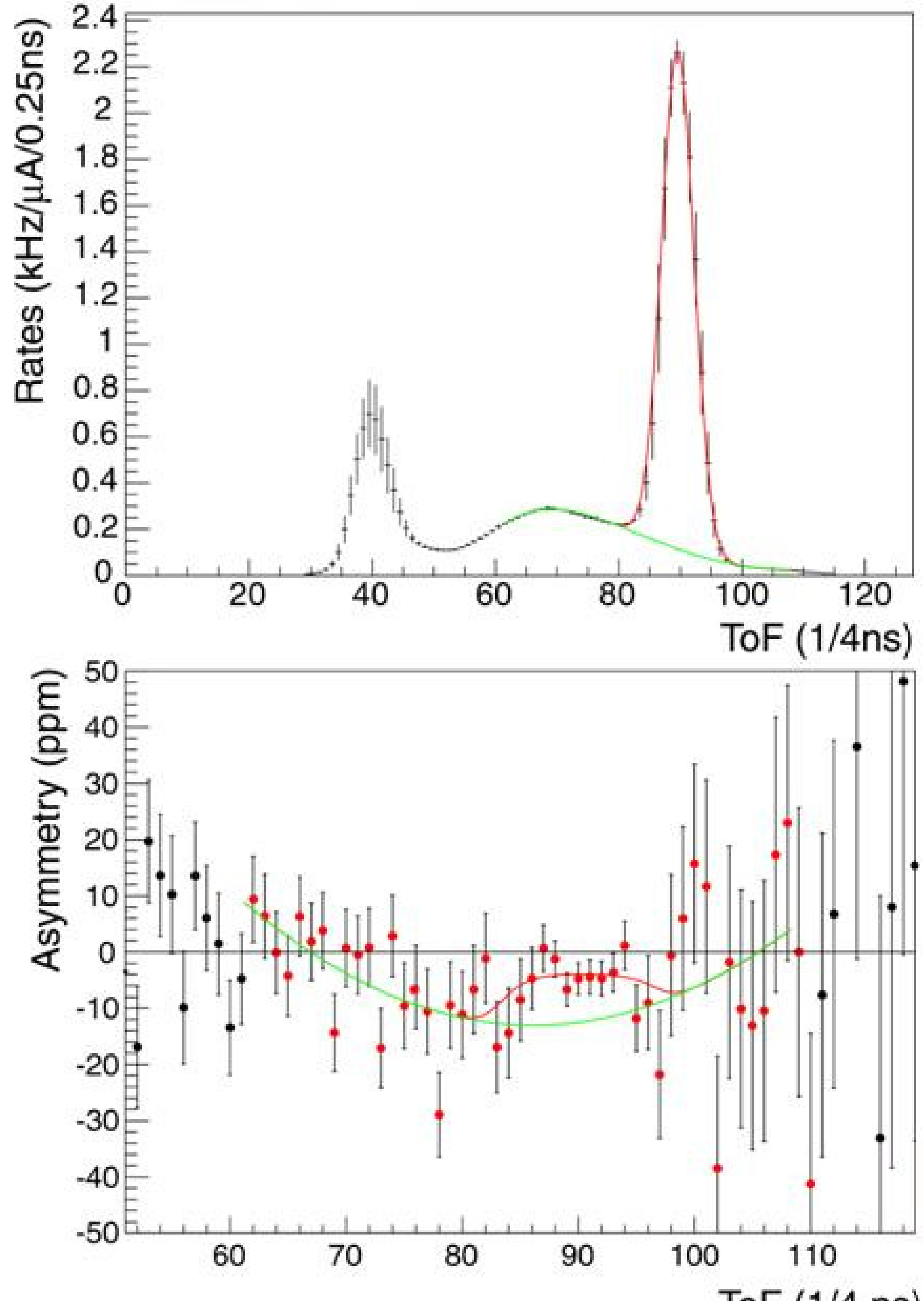
$$f = \frac{Y_{back}}{Y_{meas}}$$



- Actual analysis: $f = f(t)$
  - det. 1-14
    - fit Y_{back} (polynomial of degree 4), Gaussian for elastic peak
    - then fit A_{back} (polynomial of degree 2), constant A_{el}
  - det. 15
    - interpolate over detectors for Y_{back}, A_{back}
    - fit 3 constants for A_{el}

Det 1-14 Background

- Results of 2-step fitting procedure: det 8
  - fit Y_{back} (poly'l of degree 4), Gaussian for elastic peak
  - then fit A_{back} (poly'l of degree 2), constant A_{el}
  - example fits
    - yield: $\chi^2 = 31.1/40$
    - asym: $\chi^2 = 37.5/44$
  - f determined from Y_{back}, Y_{meas} in subsequent analysis
    - don't use detailed shape of elastic peak



DHB, 17 June 2005

- Det 14 similar except it has 2 elastic peaks
  - $Q^2 = 0.41,\ 1.0\ GeV^2$

Det. 1-14 Background Uncertainty

- Statistical uncertainty includes that from A_{el} and from A_{back}

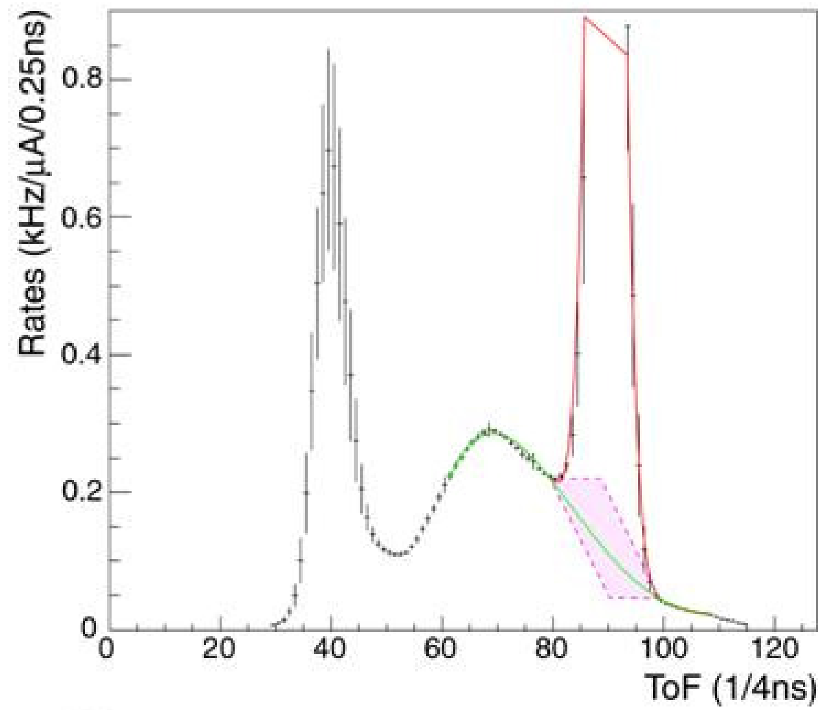
$$A_{meas} = (1 - f)A_{el} + f A_{back}$$

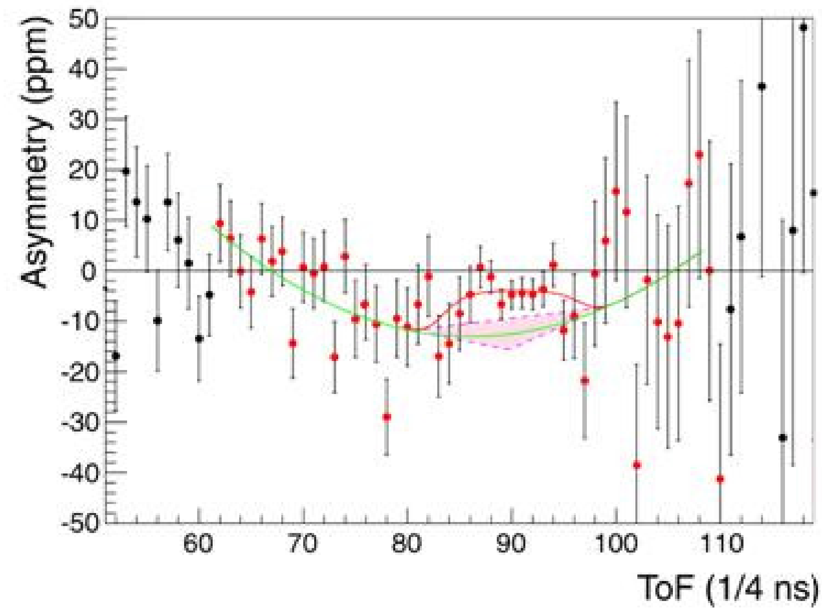
- Systematic uncertainty: general philosophy
  - vary background yield and asymmetry over plausible ranges
  - consider distributions of results for A_{el}
    - unweighted
    - weighted by χ^2
    - systematic uncertainty is average of std. dev. of these two distributions

Det. 1-14 Background Uncertainty

- Background yield varied within "lozenge"
  - use a variety of shapes

- Similar approach for asymmetry
  - vary throughout range





Correlations in Det 1-14 Backgrounds

- Separate point-to-point (pt-pt) uncertainties in background correction from global uncertainties
  - e.g. changing from linear to quadratic model for background asymmetry changes all det.1 -14 asymmetries downward on average
- Again using the distributions of results for A_{el}
  - calculate ~ correlation coefficient
  - correlated uncertainty is change in centroid of distribution for given background model compared to width of overall distribution (L total systematic uncertainty)
- For det. 1-14

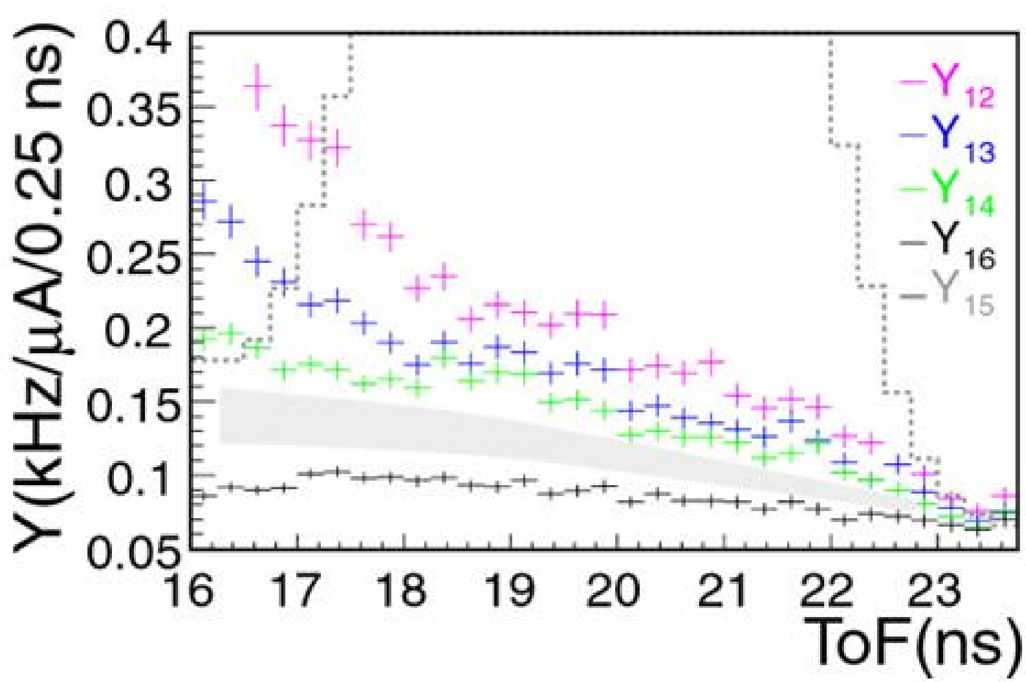
$$\Delta^2 A_{el,sys} = \Delta^2 A_{el,pt-pt} + \Delta^2 A_{el,glob}$$

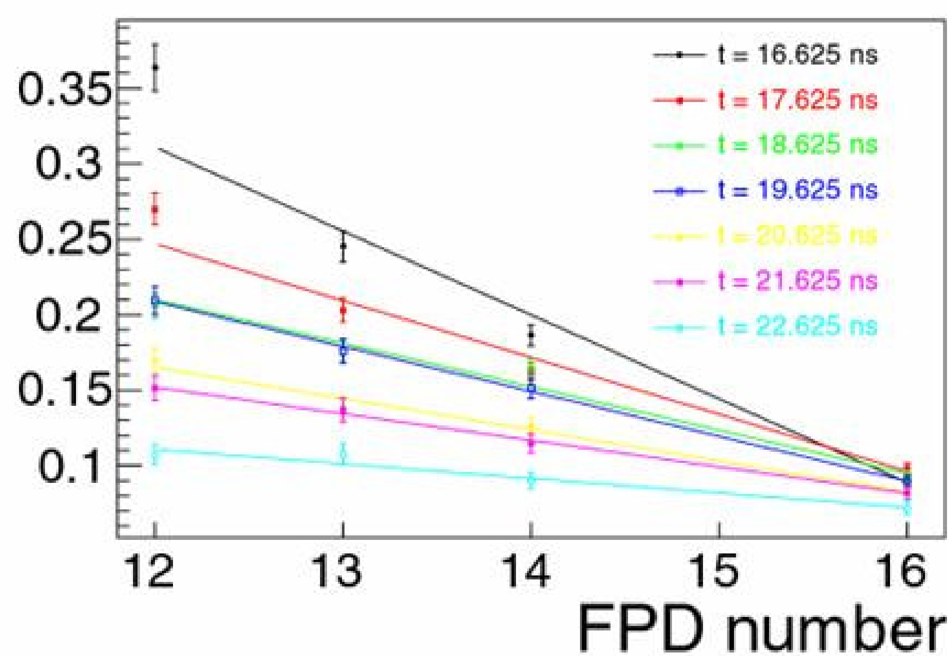
$$\Delta^2 A_{el,pt-pt} = \frac{1}{4}\Delta^2 A_{el,sys}$$

$$\Delta^2 A_{el,glob} = \frac{3}{4}\Delta^2 A_{el,sys}$$

Det. 15 Background Yields

- Elastic protons shifted to lower t.o.f.
- Elastic peak broadened because of increased Q^2 acceptance
- Interpolate over detector range 12-14, 16
  - take out changing acceptance first



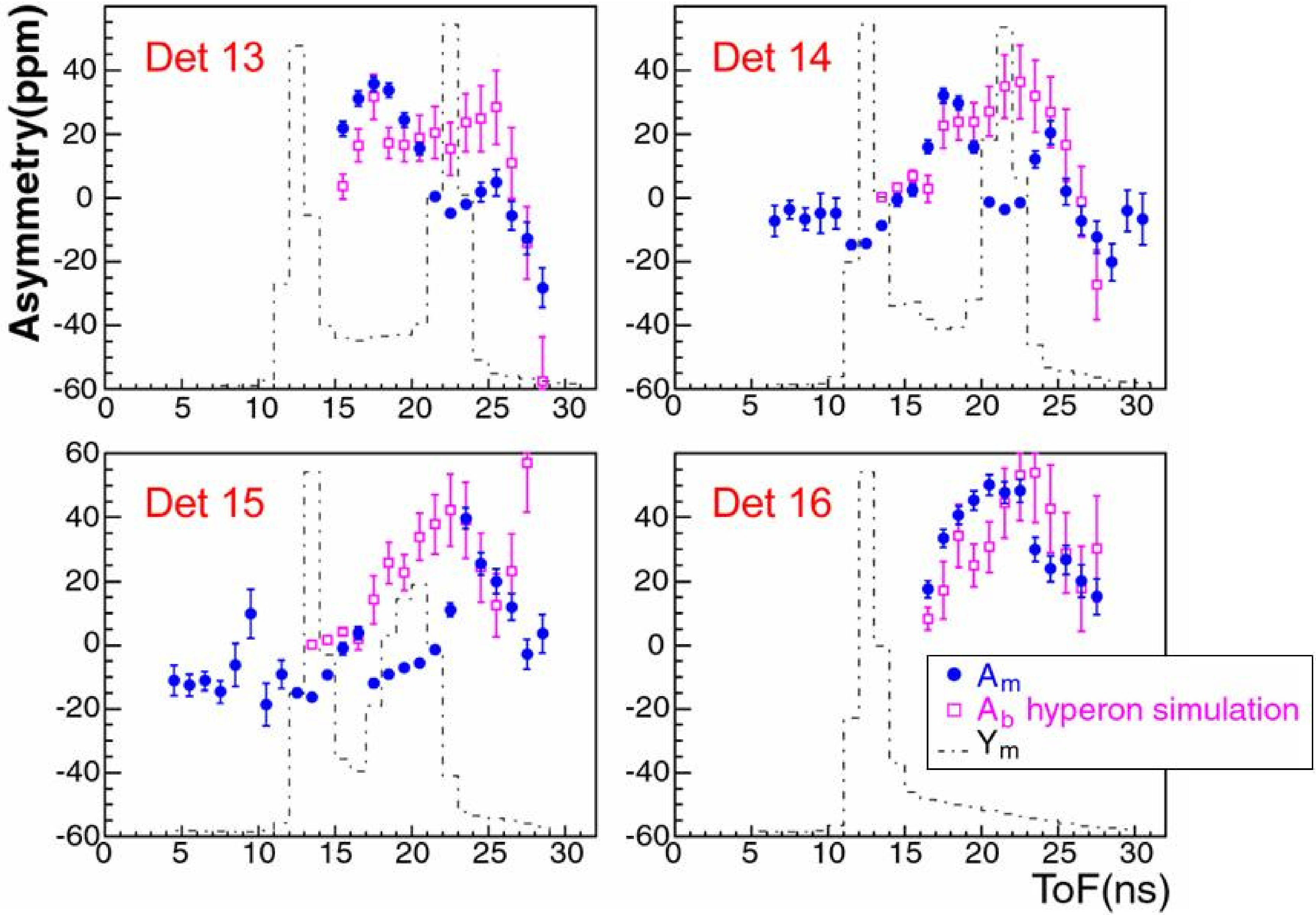


Positive Background Asymmetries

- Det. 12-16 see smoothly varying peak in background asymmetries
  - maximum magnitude ~ +45 ppm

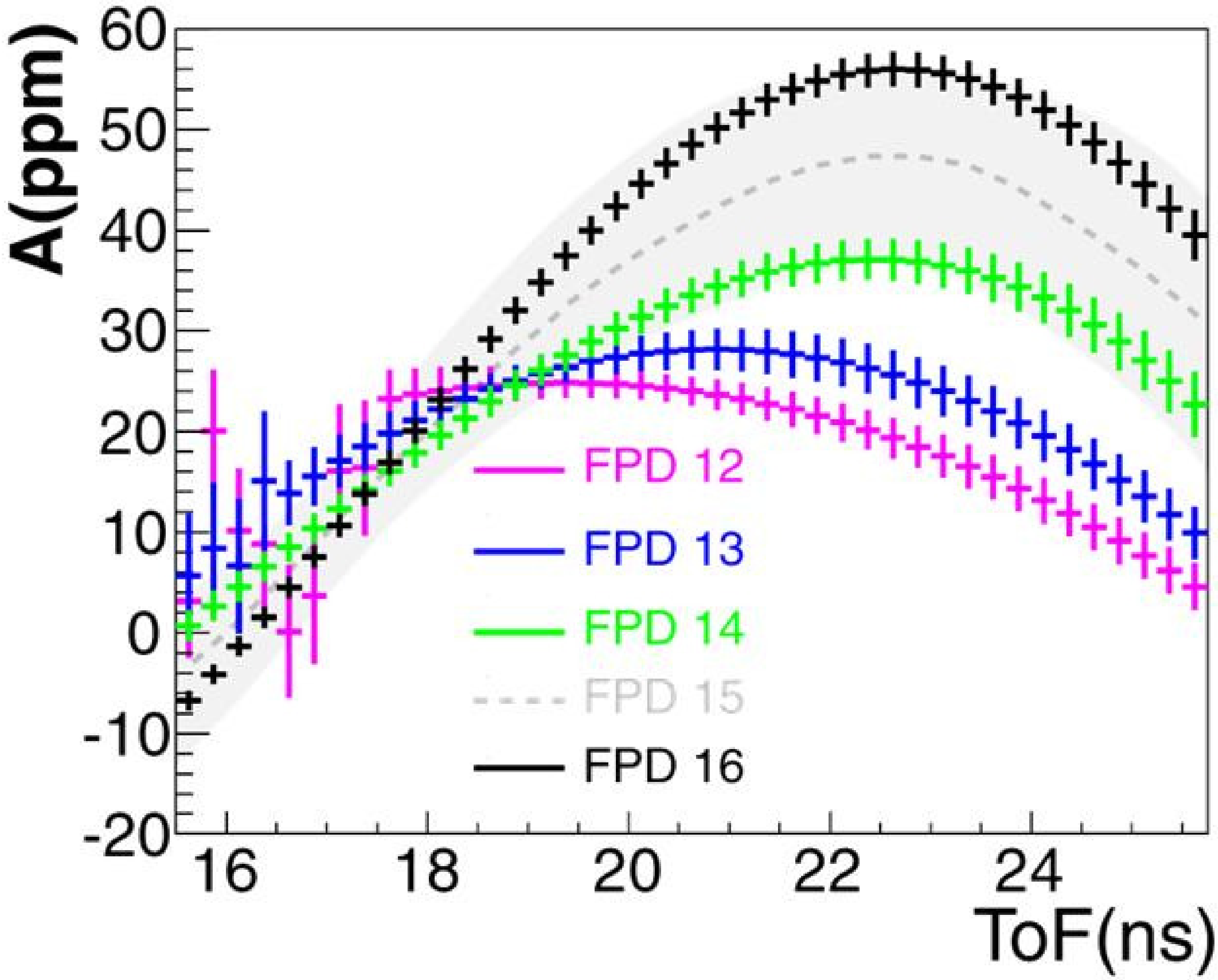
- Source is protons from hyperon weak decay scattering inside spectrometer
  - GEANT simulation with generator for hyperon production based on CLAS data
  - simulate both Λ and $\Sigma^{+,0}$ decays
    - polarization transfer for Λ 100%
    - assume 70% for Σ^+
    - Σ^0 asymmetry scaled by further factor of $-1/3$ (CG coefficient)
  - simulation explains source; use measured data for actual analysis

Positive Background Asymmetries: GEANT



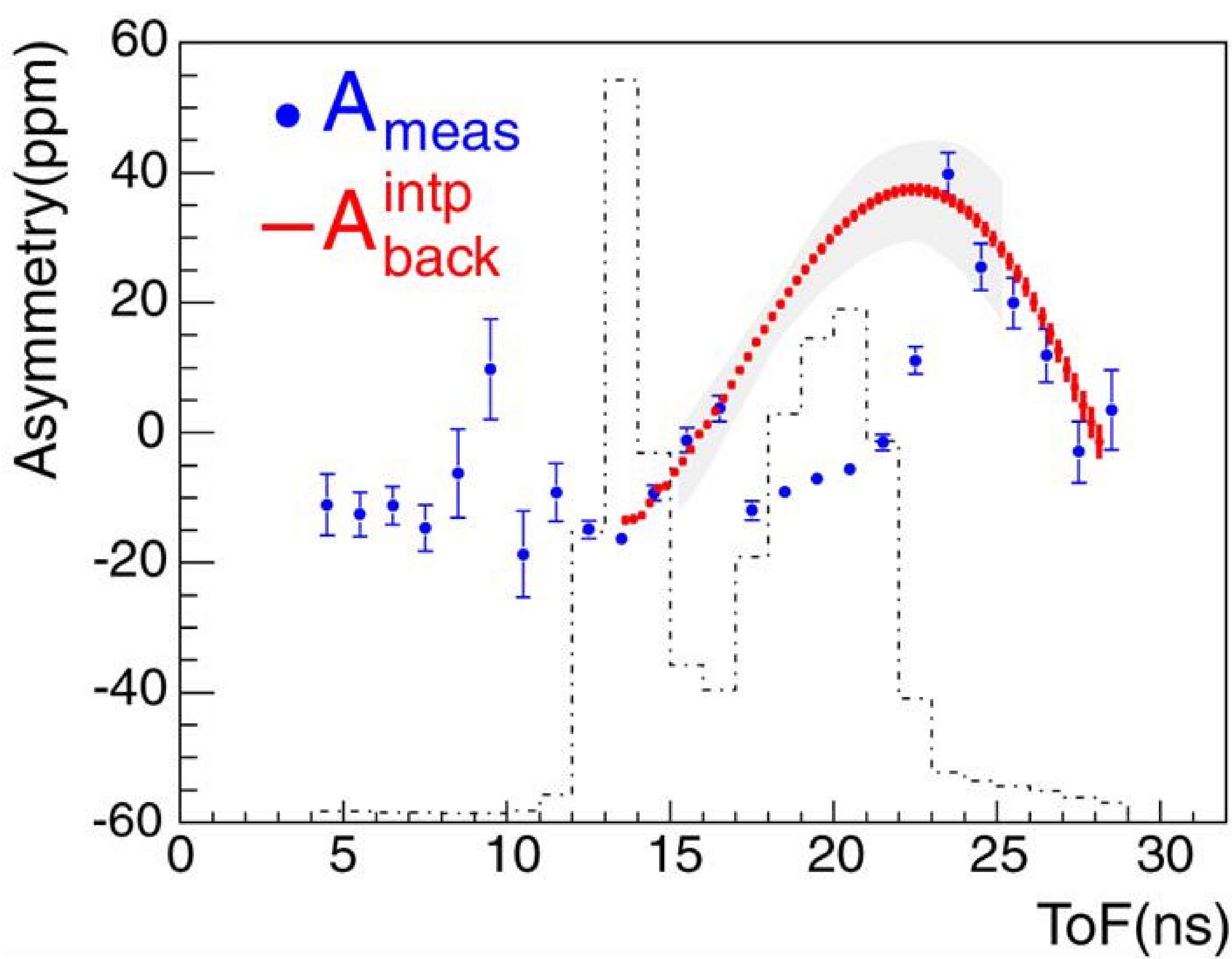
Det. 15 Background Asymmetry

- Use smoothed interpolation of A_{back} from det. 12-14, 16
- Uncertainties are ± 1 detector AND ± 0.5 ns time shift



Det. 15 Asymmetry

- Compare interpolated background asymmetry and data



Correlations in Det. 15 Backgrounds

- Separate point-to-point (pt-pt) uncertainties in background correction from global uncertainties
  - in det. 15, correlations larger because bins are contiguous
- Consider distributions of results for A_{el}
  - for variety of randomly generated models determine correlation coefficient
- For det. 15

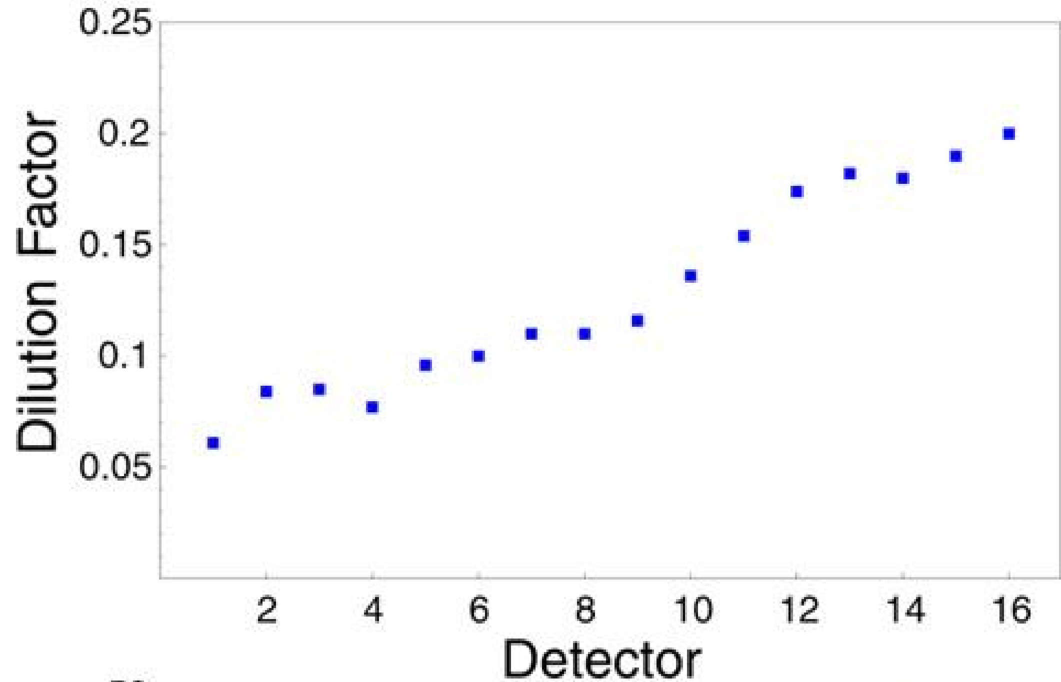
$$\Delta^2 A_{el,sys} = \Delta^2 A_{el,pt-pt} + \Delta^2 A_{el,glob}$$

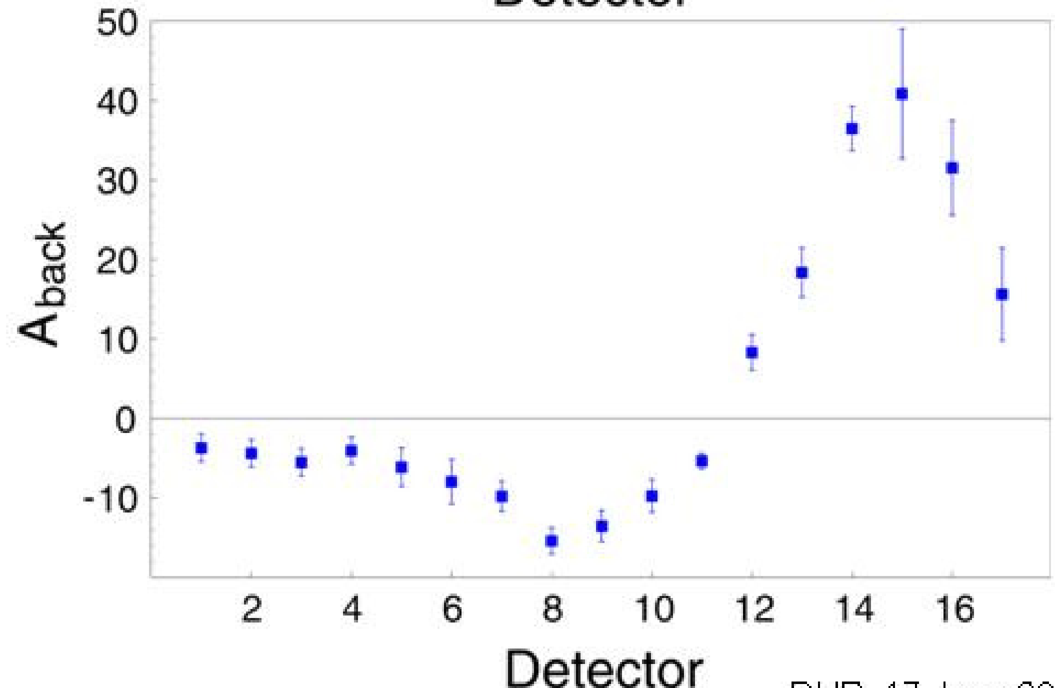
$$\Delta^2 A_{el,pt-pt} = \frac{1}{2}\Delta^2 A_{el,sys}$$

$$\Delta^2 A_{el,glob} = \frac{1}{2}\Delta^2 A_{el,sys}$$

Dilution factor and Background Asymmetry

- Smooth, systematic progression
  - dilution factor
  - background asymmetry
  - both averaged over t.o.f. for demonstration





G0 results

Experimental Results

- A_{phys} corrected for all beam, electronics, background factors

Det	Q^2 (GeV^2)	A_{phys} (ppm)	ΔA_{stat} (ppm)	$\Delta A_{sys,pt}$ (ppm)	$\Delta A_{sys,glob}$ (ppm)	f (ppm)	ΔA_{meas}
1	0.122	−1.513	0.436	0.224	0.176	0.061	−1.380
2	0.128	−0.972	0.409	0.198	0.173	0.084	−1.070
3	0.136	−1.298	0.424	0.174	0.170	0.085	−1.340
4	0.144	−2.707	0.433	0.183	0.176	0.077	−2.670
5	0.153	−2.223	0.431	0.284	0.214	0.096	−2.460
6	0.164	−2.880	0.434	0.324	0.234	0.100	−3.130
7	0.177	−3.949	0.426	0.251	0.205	0.110	−4.470
8	0.192	−3.850	0.485	0.218	0.192	0.110	−5.010
9	0.210	−4.683	0.475	0.258	0.212	0.116	−5.730
10	0.232	−5.267	0.505	0.301	0.232	0.136	−6.080
11	0.262	−5.260	0.520	0.108	0.166	0.154	−5.550
12	0.299	−7.715	0.602	0.531	0.349	0.174	−5.400
13	0.344	−8.400	0.676	0.850	0.521	0.182	−3.650
14 a	0.410	−10.25	0.674	0.895	0.551	0.180	−1.700
15 a	0.511	−16.81	0.889	1.478	1.498	0.190	−5.800
15 b	0.631	−19.96	1.112	1.277	1.306	0.200	−9.740
15 c	0.788	−30.83	1.857	2.556	2.589	0.400	−12.660
14 b	0.997	−37.93	7.237	9.000	0.519	0.780	4.210

Asymmetry with EW Radiative Corrections

- Full form of asymmetry used to extract $G_E^s + \eta G_M^s$

$$A = -\frac{G_F Q^2}{4\pi\alpha\sqrt{2}} \frac{1}{\varepsilon {G_E^p}^2 + \tau {G_M^p}^2} \Big\{ \left(1 - 4\sin^2\theta_W\right)\left(\varepsilon {G_E^p}^2 + \tau {G_M^p}^2\right)\left(1 + R_V^p\right) -$$

$$\left(\varepsilon G_E^p G_E^n + \tau G_M^p G_M^n\right)\left(1 + R_V^n\right) - \left(\varepsilon G_E^p G_E^s + \tau G_M^p G_M^s\right)\left(1 + R_V^{(0)}\right) -$$

$$\varepsilon'\left(1 - 4\sin^2\theta_W\right) G_M^p G_A^e \Big\}$$

where

$$G_A^e = -G_A^p\left(1 + R_A^{T=1}\right) + \left[\frac{1}{2}(3F - D)R_A^{T=0} + \Delta s\left(1 + R_A^{(0)}\right)\right] G_A^{dip}$$

and

$$G_A^p = g_A G_A^{dip} = (F + D) G_A^{dip} = \frac{g_A}{\left(1 + Q^2/\Lambda_A^2\right)^2}$$

Standard Parameters

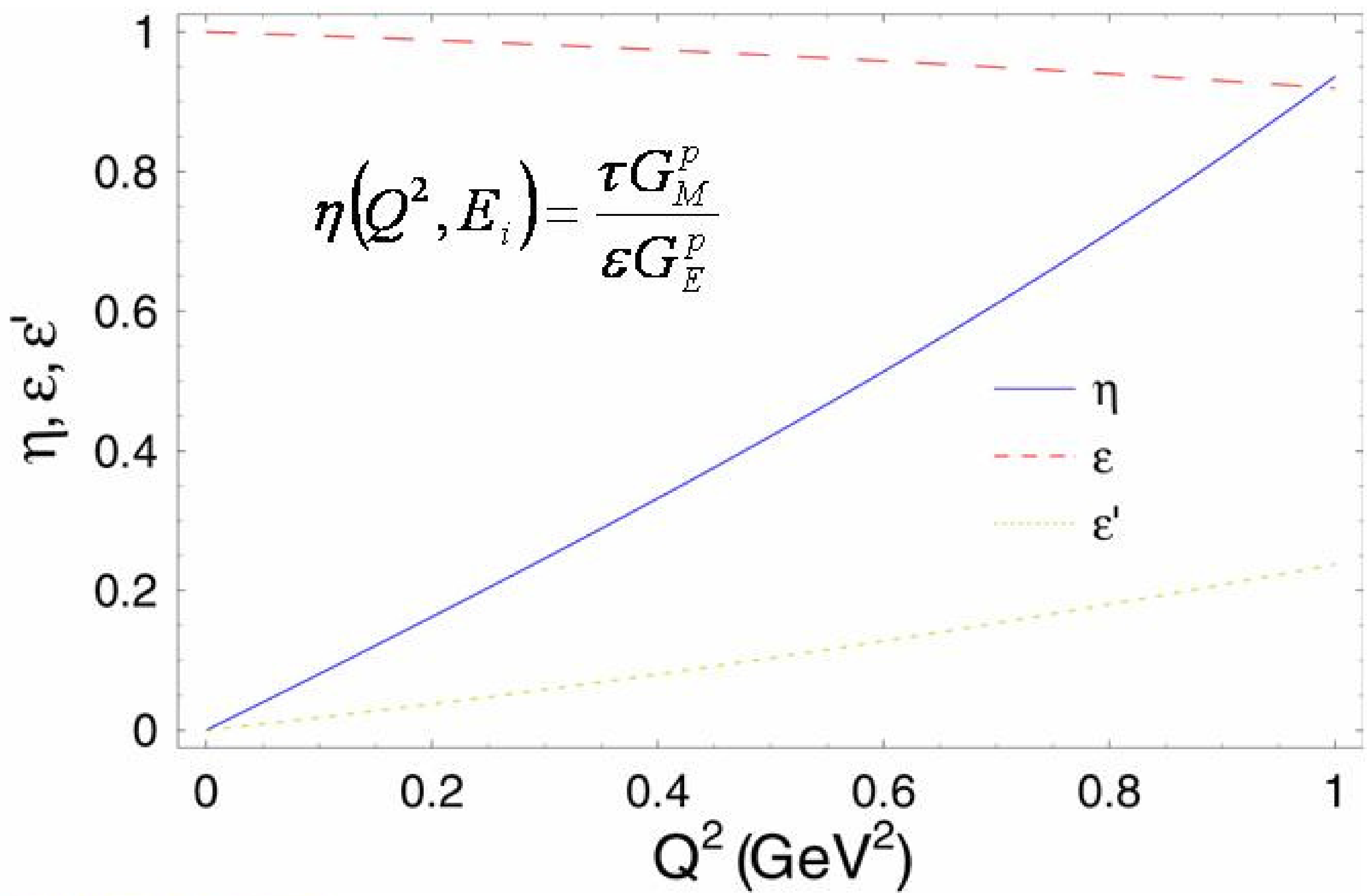
- em form factors: Kelly PRC **70** (2004) 068202
- use Zhu, et al. $R_A^{T=1}$, $R_A^{T=0}$ including anapole
- incident energy 3.028 GeV

α	1/137.03599976	R_V^p	−0.0447091
$\sin^2\theta_W$	0.2312	R_V^n	−0.011789
G_F	0.0000116639 GeV^2	$R_V^{(0)}$	−0.011789
m_p	0.938272 GeV	$R_A^{T=1}$	−0.259163
μ_p	2.79285	$R_A^{T=0}$	−0.23826
μ_n	−1.91304	$R_A^{(0)}$	−0.551753
Λ^2	0.711 GeV^2		
Λ_A^2	1.00 GeV^2		
g_A/g_V	1.2695		
3F−D	0.585		

Strange Quark Contribution

- Strange quark contribution to asymmetry

$$G_E^s + \eta G_M^s = \frac{4\pi\alpha\sqrt{2}}{G_F Q^2} \frac{\varepsilon G_E^{p\,2} + \tau G_M^{p\,2}}{\varepsilon G_E^p \left(1 + R_V^{(0)}\right)} \left(A_{phys} - A_{NVS}\right)$$



$$\eta\left(Q^2, E_i\right) = \frac{\tau G_M^p}{\varepsilon G_E^p}$$

A_{NVS} Sensitivities

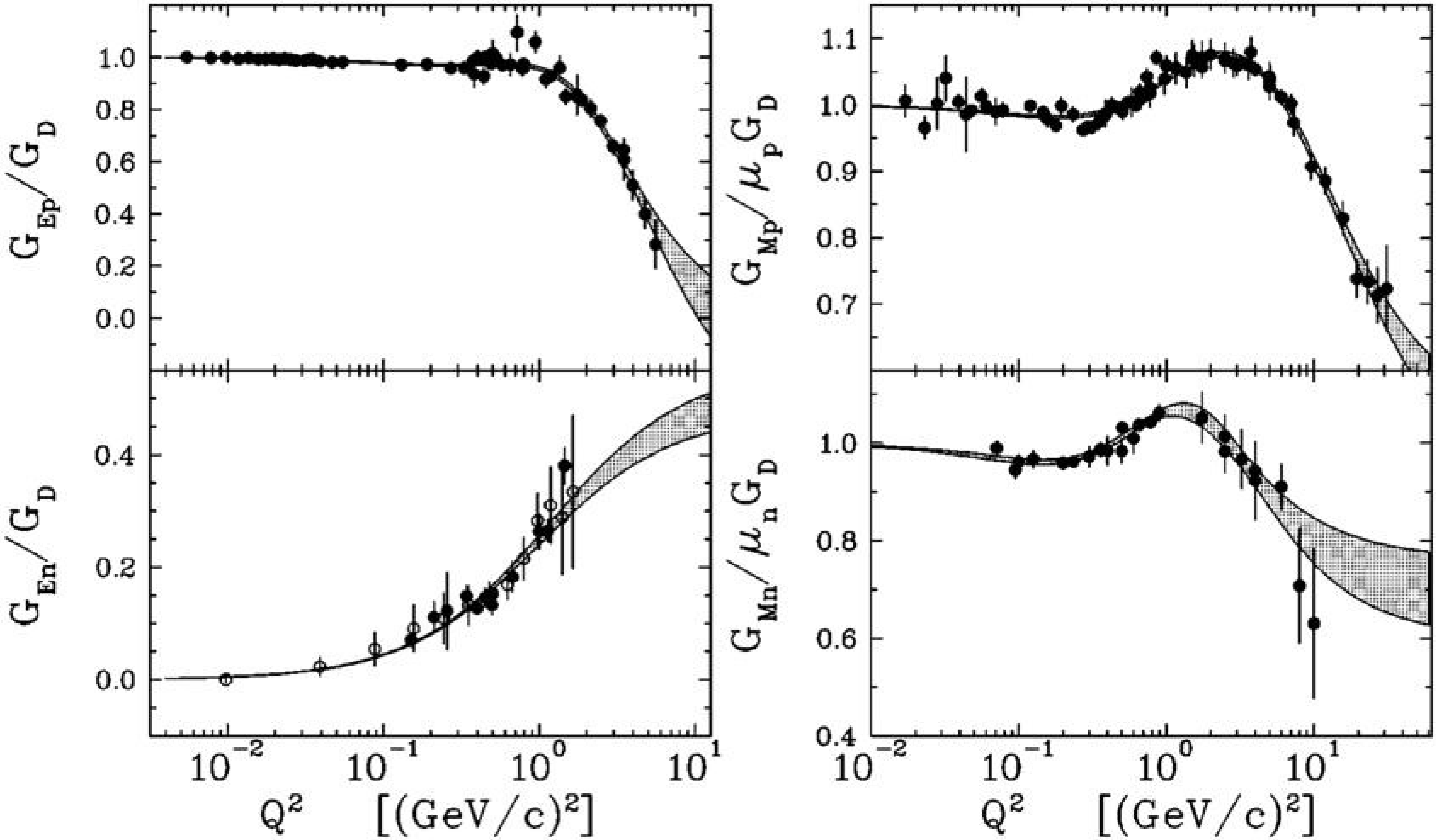
- Base calculation uses Kelly electromagnetic form factors and uncertainties
  - PRC **70** (2004) 068202
  - Friedrich & Walcher, Eur. Phys. J. A **17** (2003) 607.
  - Arrington, Phys. Rev. C **69** (2004) 022201.
    - "Rosenbluth" fit for G_E^p , G_M^p
    - Kelly for G_E^n, G_M^n

- Key factors, uncertainties

$\Delta G_A^p / G_A^p$	2.2%
$R_A^{T=0}$	-0.24±0.20
$R_A^{T=1}$	-0.26±0.35
$R_A^{(0)}$	-0.55±0.55
3F - D	0.585±0.025

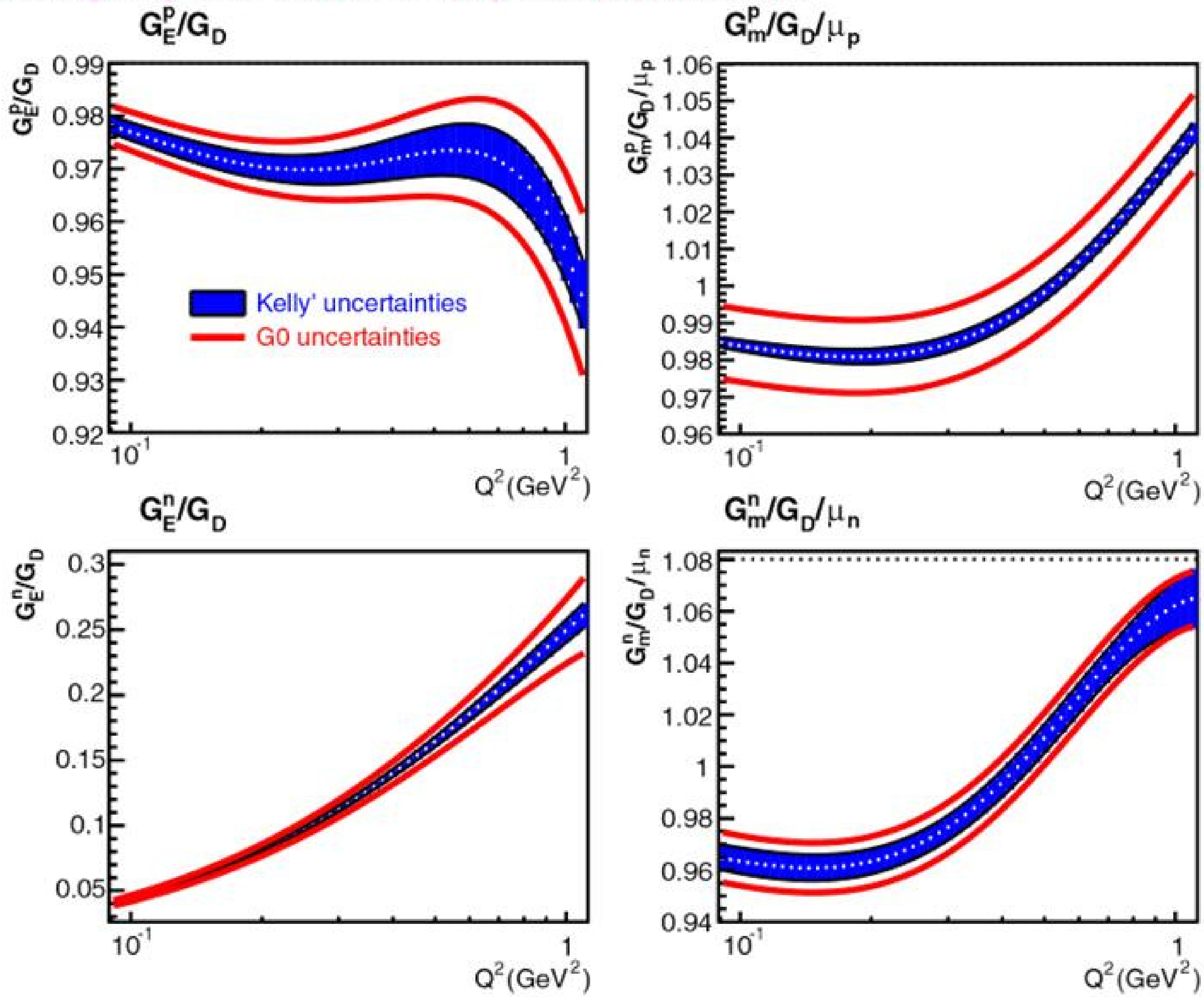
Electromagnetic Form Factors

- Use Kelly parameterization for baseline results
  - omits Rosenbluth data for G_E^p, $Q^2 > 1$ GeV^2
  - omits some neutron data using associate particle calibration



Electromagnetic Form Factor Uncertainties

- Use slightly modified Kelly uncertainties



G0 Sensitivities for G_E^s

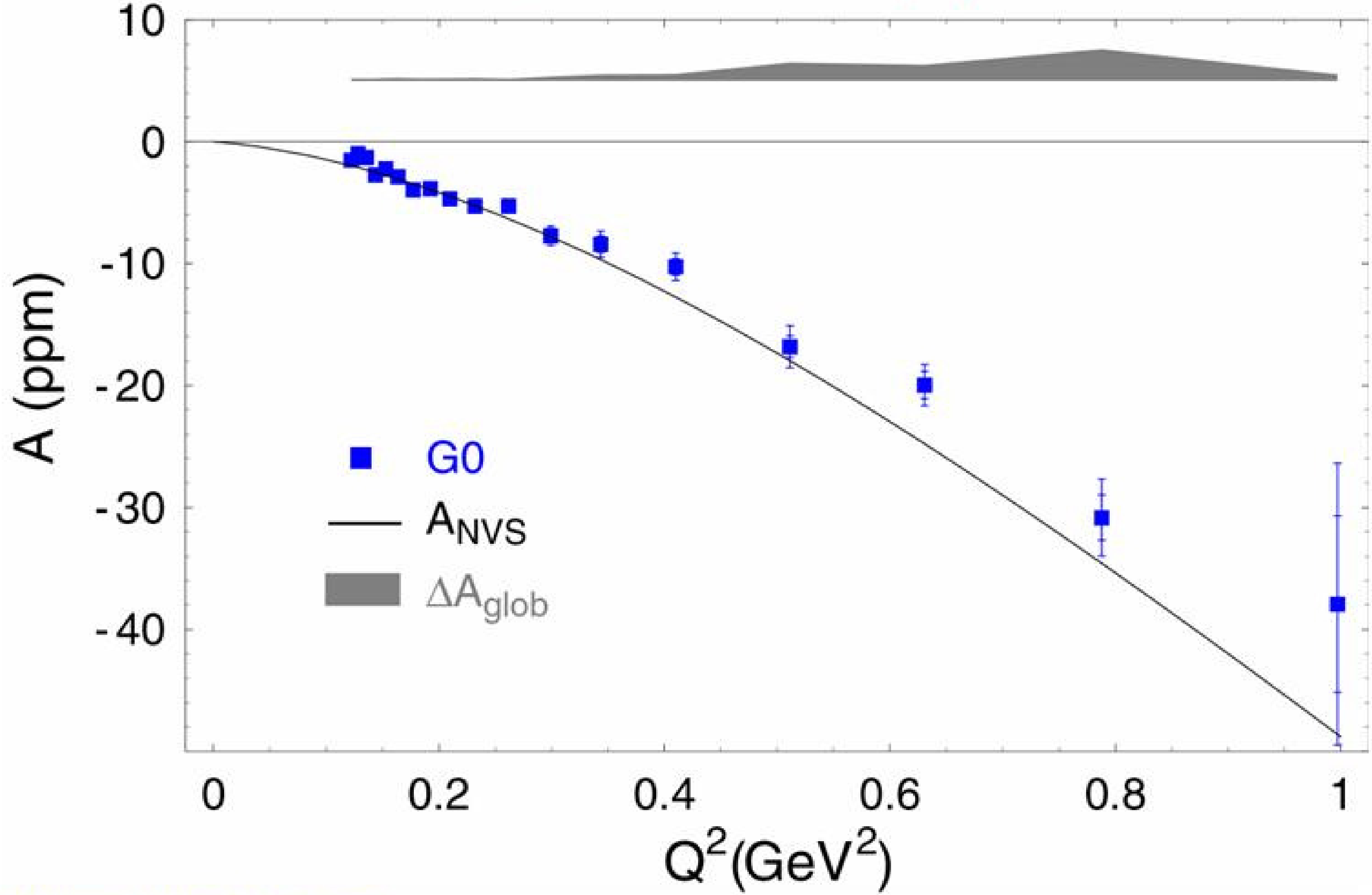
$$\frac{\partial G_E^s}{\partial p}:$$

	Det 1	Det 8	Det 14a
A_{meas} (1/ppm)	8.344×10^{-2}	5.068×10^{-2}	2.113×10^{-2}
E_i (1/GeV)	-1.911×10^{-3}	-3.021×10^{-3}	-6.755×10^{-3}
Q^2 (1/GeV^2)	1.680	1.575	8.718×10^{-1}
$G_E^{\gamma p}$	-2.396×10^{-1}	-3.909×10^{-1}	-6.987×10^{-1}
$G_M^{\gamma p}$	5.488×10^{-2}	6.063×10^{-2}	1.010×10^{-1}
$G_E^{\gamma n}$	-1.000	-1.000	-1.000
$G_M^{\gamma n}$	-9.839×10^{-2}	-1.559×10^{-1}	-3.407×10^{-1}
G_A^{Zp}	3.992×10^{-3}	6.471×10^{-3}	1.516×10^{-2}
G_A^s	-1.721×10^{-3}	-2.472×10^{-3}	-4.140×10^{-3}
R_V^p	6.896×10^{-2}	6.589×10^{-2}	5.861×10^{-2}
R_V^n	9.440×10^{-2}	1.307×10^{-1}	2.060×10^{-1}
$R_V^{(0)}$	-3.739×10^{-2}	-2.846×10^{-3}	-5.320×10^{-2}
R_A^0	-1.123×10^{-3}	-1.613×10^{-3}	-2.702×10^{-3}
R_A^1	4.875×10^{-3}	7.002×10^{-3}	1.173×10^{-2}
$R_A^{(0)}$	3.226×10^{-4}	4.633×10^{-4}	7.759×10^{-4}
3F−D	4.575×10^{-4}	6.571×10^{-4}	1.100×10^{-3}

DHB, 17 June 2005

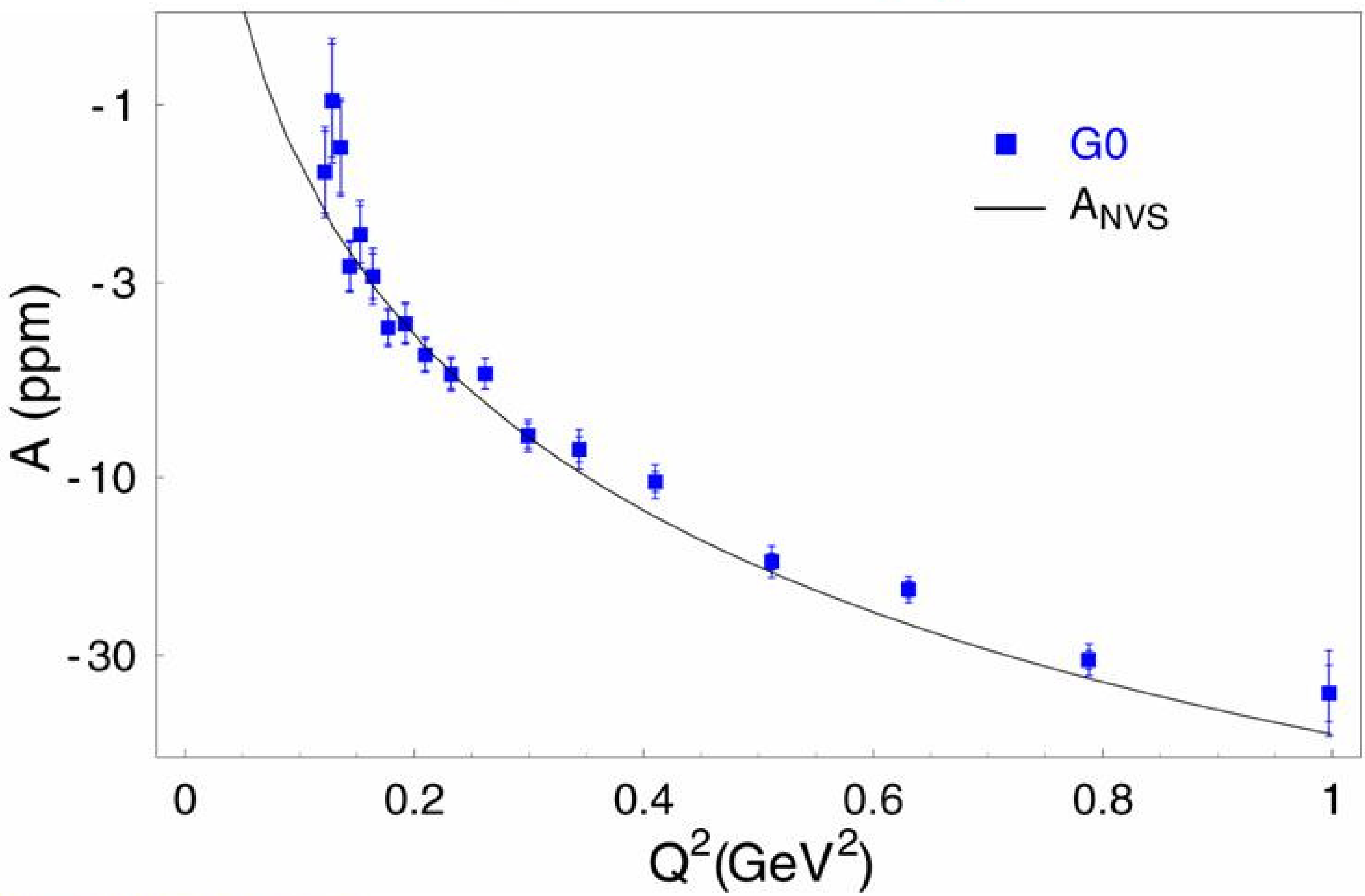
Experimental Asymmetries

- em form factors: Kelly PRC **70** (2004) 068202
- "no vector strange" asymmetry, A_{NVS}, is $A(G_E^s, G_M^s = 0)$
- inside error bars: stat, outside: stat & pt-pt

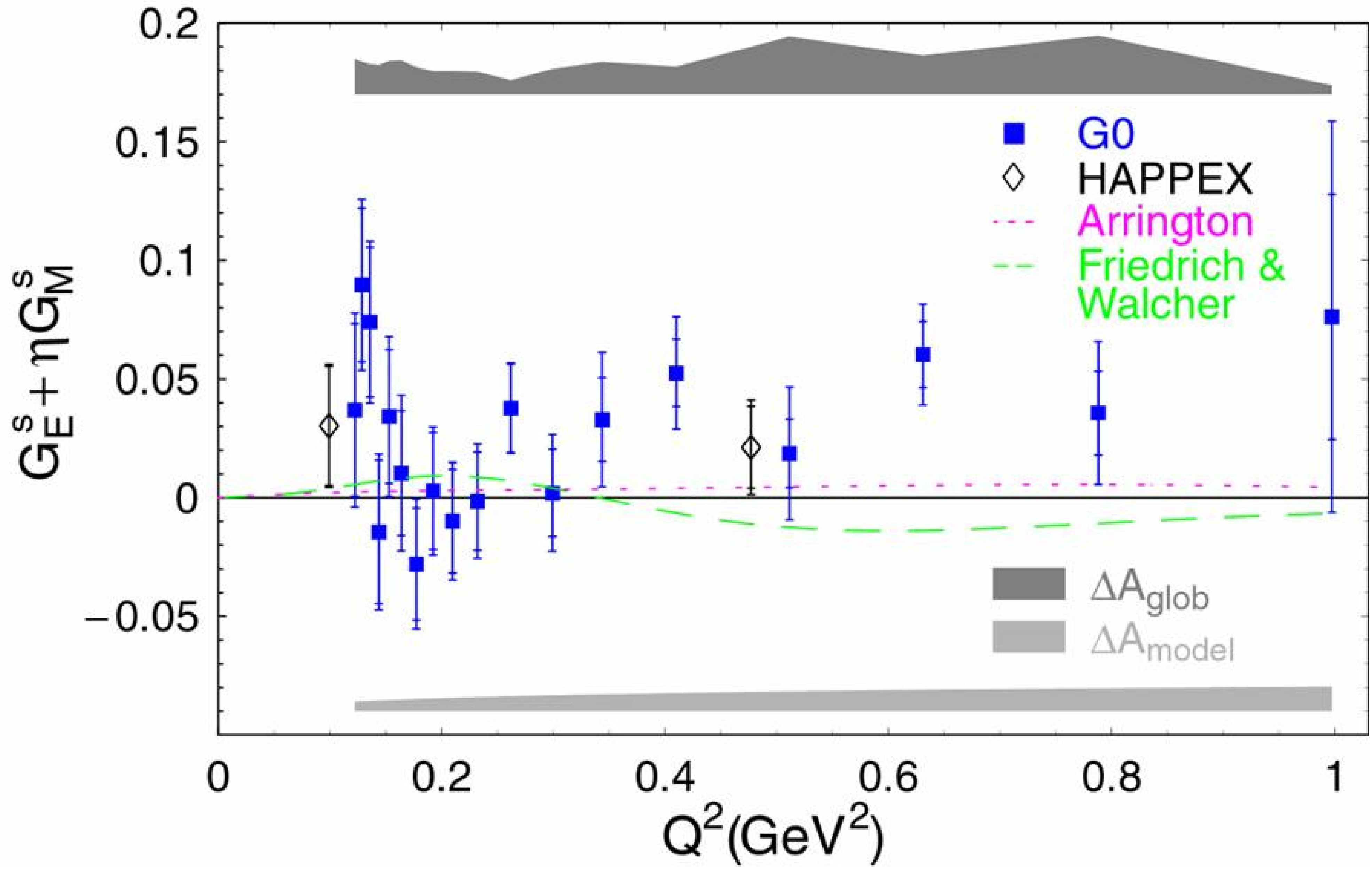


Experimental Asymmetries

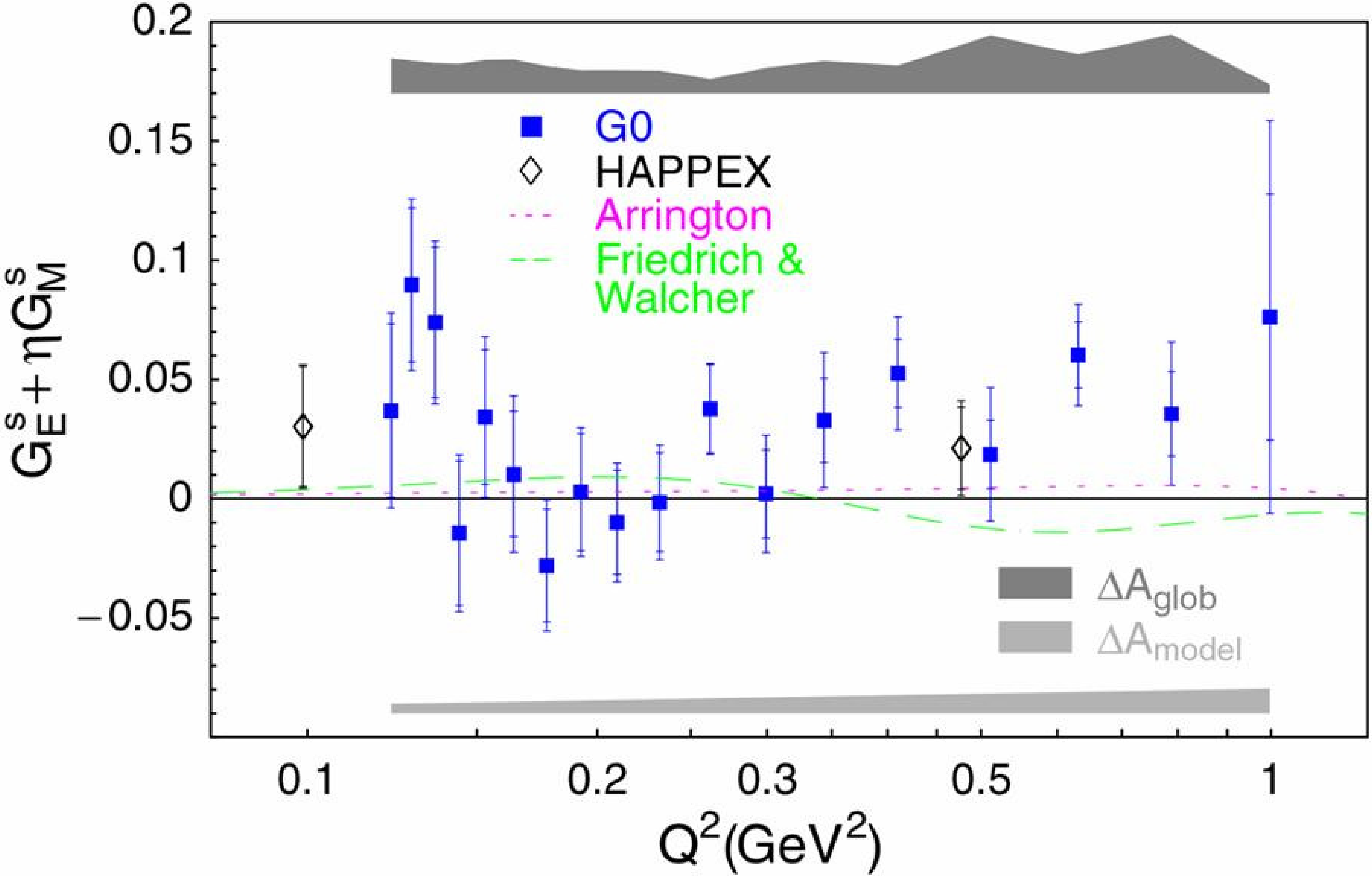
- em form factors: Kelly PRC **70** (2004) 068202
- "no vector strange" asymmetry, A_{NVS}, is $A(G_E^s, G_M^s = 0)$
- inside error bars: stat, outside: stat & pt-pt



Strange Quark Contribution to Proton



Strange Quark Contribution to Proton



http://www.npl.uiuc.edu/exp/G0/Forward

DHB, 17 June 2005

Speculation

Simple Fits to World Hydrogen Data

- Fit

$$G_E^s(Q^2)+\eta(Q^2,E_i)G_M^s(Q^2)=\frac{4\pi\alpha\sqrt{2}}{G_F Q^2}\frac{\varepsilon G_E^{p\,2}+\tau G_M^{p\,2}}{\varepsilon G_E^p\left(1+R_V^{(0)}\right)}\left(A_{phys}-A_{NVS}(Q^2,E_i)\right)$$

with simple forms for G_E^s , G_M^s

$$G_E^s(Q^2)=\frac{c_2 Q^4}{1+d_1Q^2+d_2Q^4+d_3Q^6}$$ à la Kelly

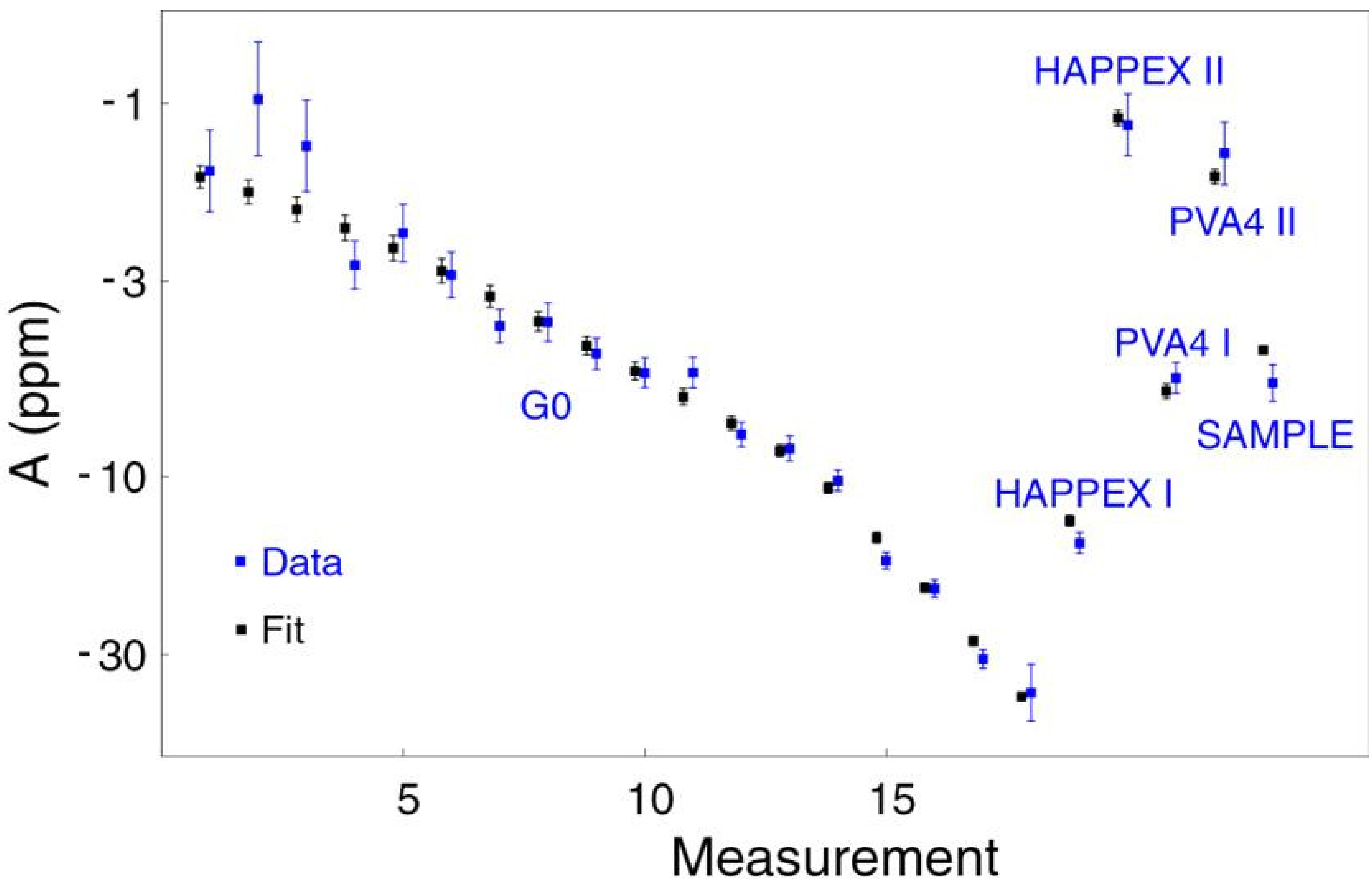
$$G_M^s(Q^2)=\frac{G_M^s(Q^2=0)}{\left(1+Q^2/\Lambda_M^{s\,2}\right)^2}$$

with

$$G_M^s(Q^2=0)=0.81$$ from Q^2 = 0.1 GeV^2 plot, dipole ff

"Fit" to World Hydrogen Data

- $\chi^2 = 31/20$



"Fit" to World Hydrogen Data

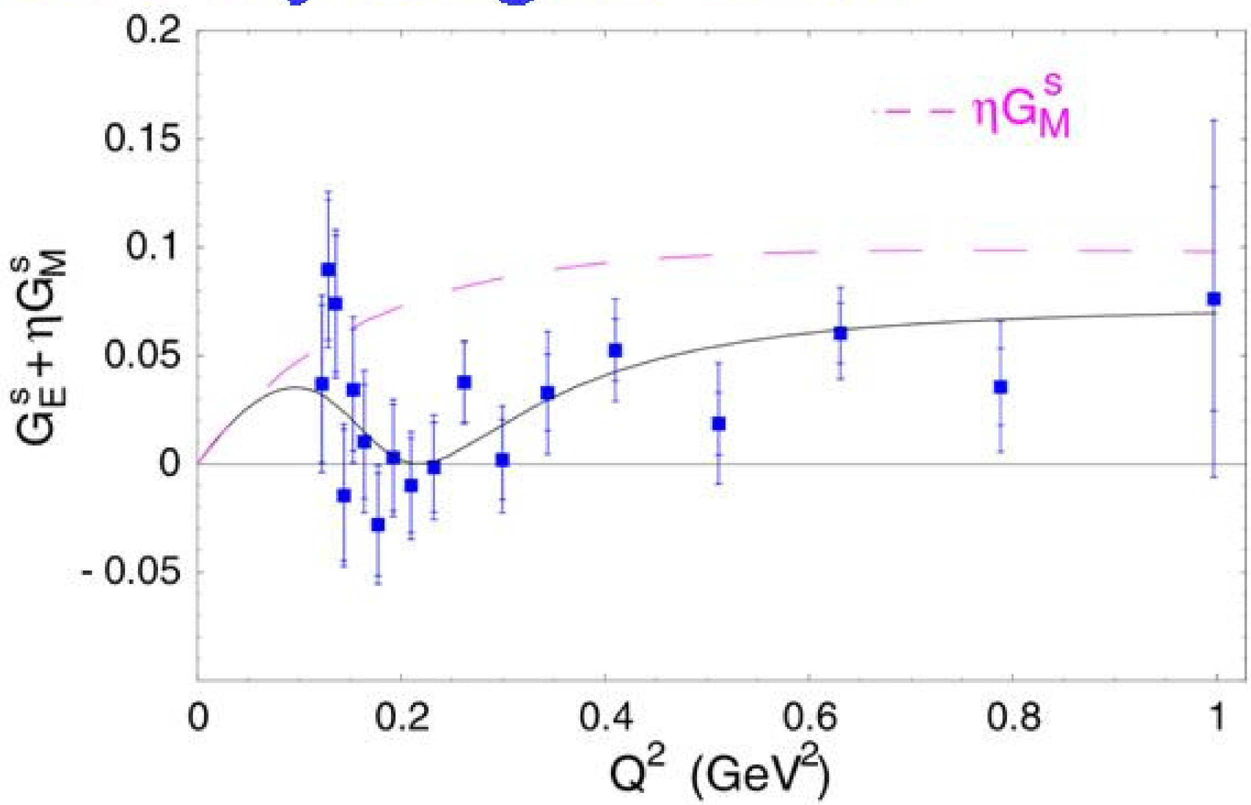
$c_2 = -0.51 \pm 0.25$

$d_1 = -8.5 \pm 0.9$

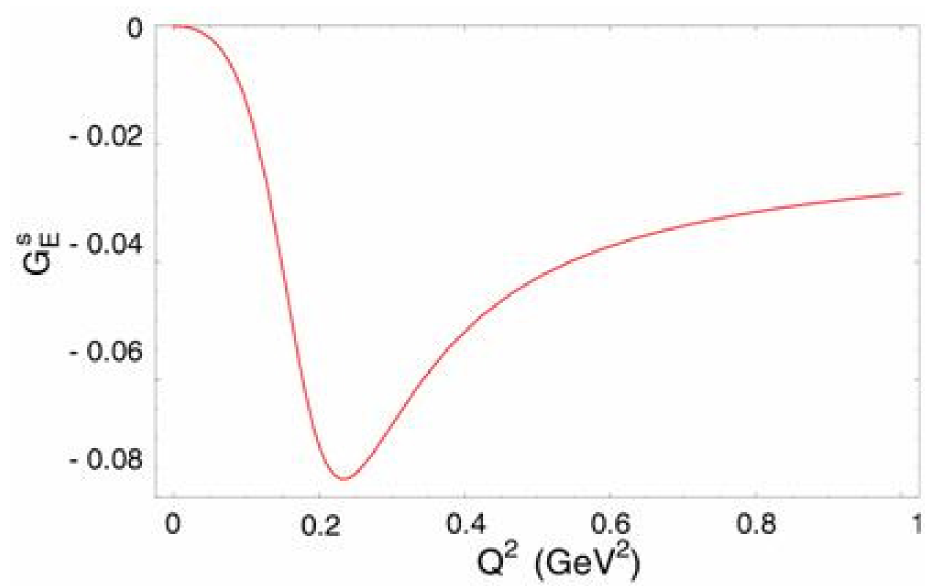
$d_2 = 24 \pm 6$

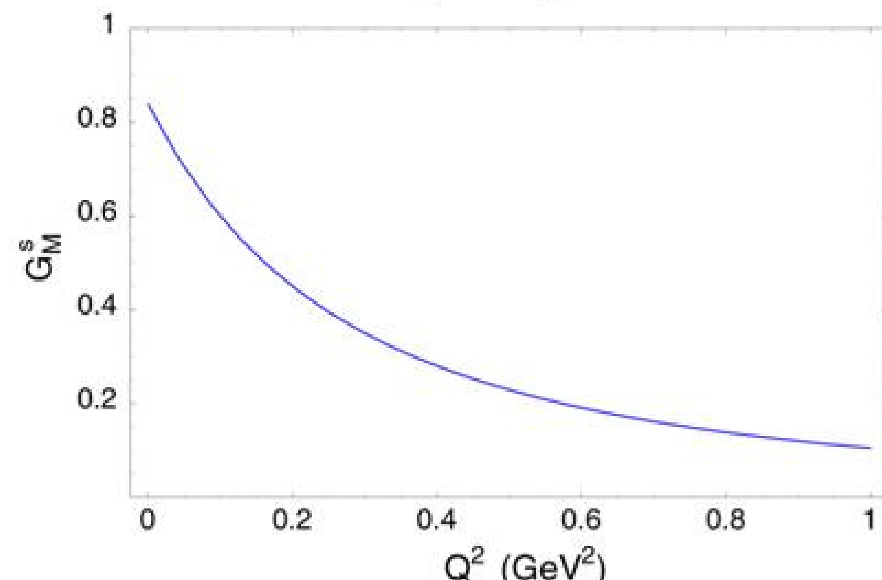
$d_3 = 1$

$\Lambda_M^{s\,2} = \Lambda^2 / 1.3$



Remember the factor of -1/3





DHB, 17 June 2005

G0 Summary

- First measurement of parity-violating asymmetries over broad Q^2 range
- Excellent performance of accelerator, experimental equipment
- Conservative estimates of uncertainties
  - careful assessment of backgrounds

- Results consistent with previous measurements
- Emerging picture
  - $G_M^s > 0$ at low Q^2
  - $G_E^s < 0$ at medium Q^2 a possibility
  - $G_E^s + \eta G_M^s$ positive at higher Q^2