Status of the G0 Experiment

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for
G0 Collaboration

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G0 Experiment Highlights:

- Map the vector strange form factors of the Nucleon over Q^2 range 0.1-1 (GeV/c^2)
- First single experiment to separate strange electric, strange magnetic and axial form factors
- Parity violation experiment, measures PV asymmetries of the order 10^{-6} or ppm
- Level of precision 5% of the measured asymmetries

First checkout of the G0 apparatus – engineering run Oct 2002 – Jan 2003

Parity Violating Electron Scattering (1)

$$s^{EW} \propto \left| \; e \xrightarrow{\;\gamma\;} N \; + \; e \xrightarrow{\;Z^0\;} N \; \right|^2$$

$$G_{E,M}^{g,N} \qquad G_{E,M}^{Z,N},\ G_{A}^{Z,N} \longrightarrow G_{E,M}^{s},\ G_{A}^{e}$$

Longitudinally polarized electrons on unpolarized target:

$$A = \frac{s_R - s_L}{s_R + s_L} \sim \frac{\left| e \xrightarrow{\;\gamma\;} N \right| \cdot \left| e \xrightarrow{\;Z^0\;} N \right|}{\left| e \xrightarrow{\;\gamma\;} N \right|^2}$$

$$A = \left(\frac{-G_F Q^2}{4\pi\alpha\sqrt{2}} \right) \cdot \frac{A_E + A_M + A_A}{D}$$

$$A_E = \varepsilon G_E^g G_E^Z$$

$$A_M = \tau G_M^g G_M^Z$$

$$D = \varepsilon \left(G_E^g\right)^2 + \tau \left(G_M^g\right)^2$$

$$A_A = -(1 - \sin^2\theta_W) \varepsilon' G_M^g G_A^Z$$

(1) D.H. Beck & R. D. McKeown, Ann. Rev. Nucl. Part. Sci. **51**:189 (2001)

G0 Physics Program

Map the vector strange form factors over Q^2 range 0.1 to 1 $(GeV/c)^2$ (~ 5 years)

A_F : one measurement for all Q^2 $\rightarrow$ detect recoil protons at $54° < \theta_p < 76°$

A_B : three measurements for three Q^2 values: $\rightarrow$ detect electrons at 108°

A_d : Quasielastic scattering from deuterium $\rightarrow$ detect electrons at 108°

For a specific Q^2

$$\begin{pmatrix} A_F \\ A_B \\ A_d \end{pmatrix} = \begin{pmatrix} x_F & c_F & y_F \\ x_B & c_B & y_B \\ x_d & c_d & y_d \end{pmatrix} \begin{pmatrix} G_E^s \\ G_M^s \\ G_A^e \end{pmatrix} + \begin{pmatrix} h_F \\ h_B \\ h_d \end{pmatrix}$$

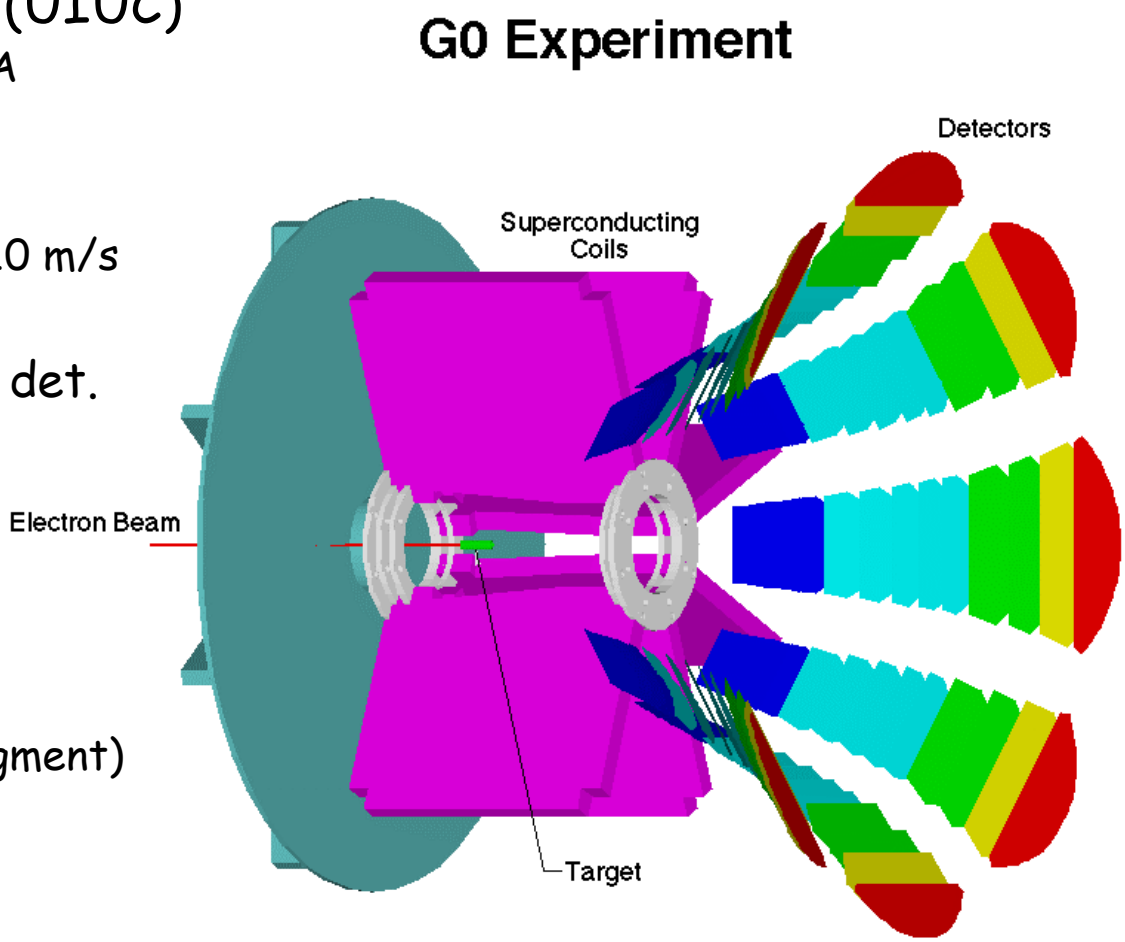
at $Q^2 = 0.44$ $(GeV/c)^2$

	η (ppm)	ξ (ppm)	χ (ppm)	ψ (ppm)
A_F	-13.79	51.77	18.61	1.01
A_B	-25.01	16.10	31.41	6.96
A_d	-34.00	13.13	7.07	8.41

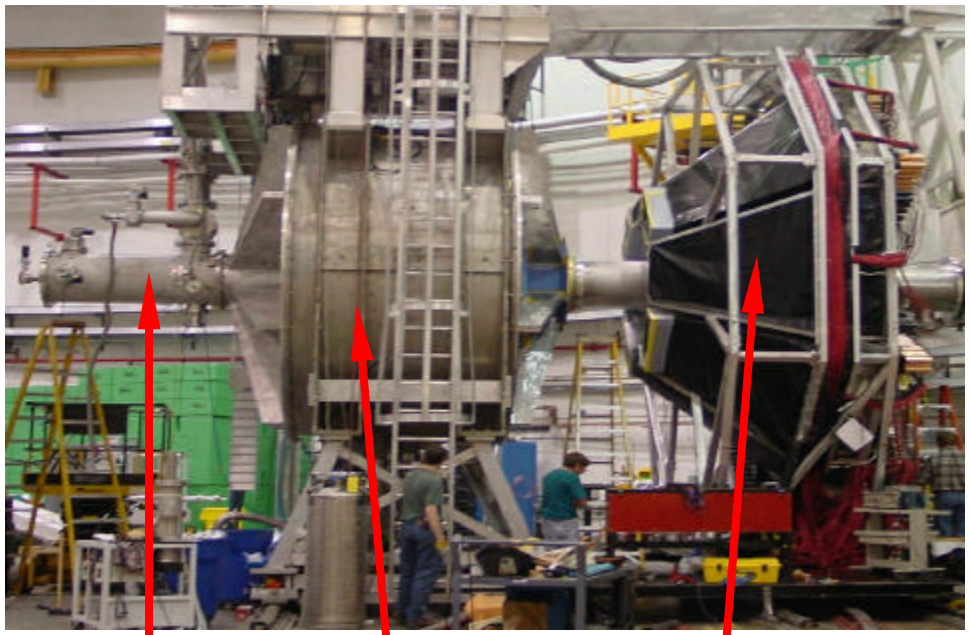
The G0 experiment at JLAB

Subsystems:

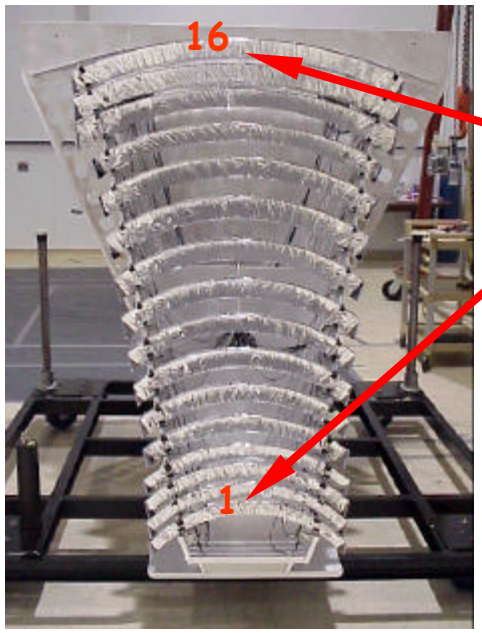
- superconducting toroidal magnet (UIUC)
  - designed for operation at 5000 A
- high power LH_2 target (Caltech)
  - designed for high speed flow 7-10 m/s
- segmented large area focal plane det.
  - 8 octants = 4 French + 4 US
  - 16 segments/Octant -> Q^2 bins
  - use scintillators
- custom/commercial electronics
  - high rate counting (~ 1 MHz/segment)
  - particle ID -> TOF
- G0 Beam
  - G0 Laser 31 MHz, 40 μA / 3 GeV e^-
  - Luminosity ~ 10^{38} $cm^{-2}s^{-1}$
  - high polarization beam ~ 75 %



G0 Apparatus



Target Magnet Detector



Detector segments

One octant's scintillator array

Cryogenic loop V = 6 L

LH_2 Al Target Cell L = 20 cm

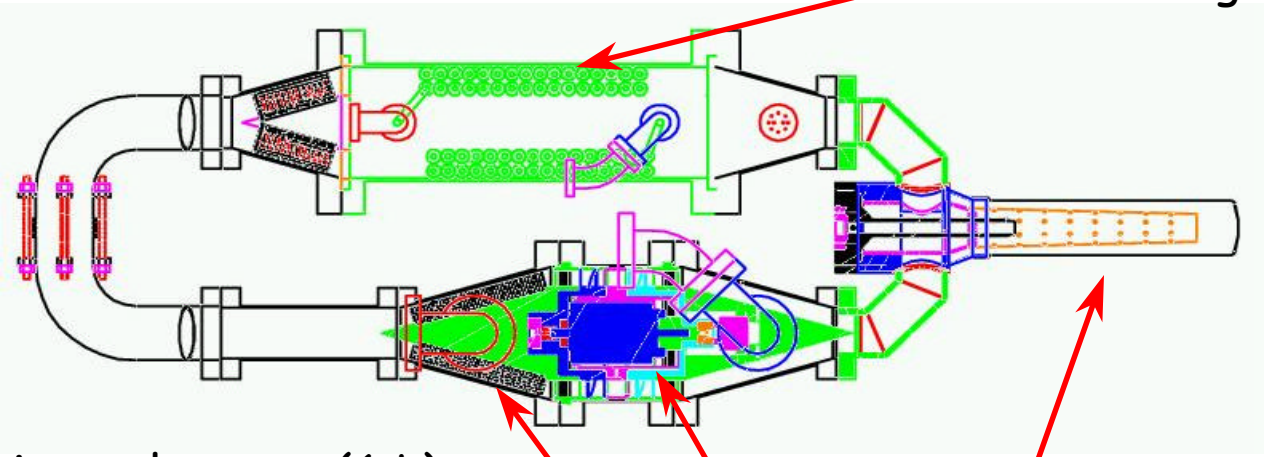
The G0 target system

Nominal running point

1.7 atm / 19 K LH_2

High power target

500 W



Cryogenic single loop horizontal target (6 L):

- 20 cm Al target cell
- cryogenic vane-axial pump -> 5.94 L/s at 30 Hz
- high power heater -> max 1000 W
- counter-flow heat exchanger

Gas handling system

- gas panel, ballast tank and service lines

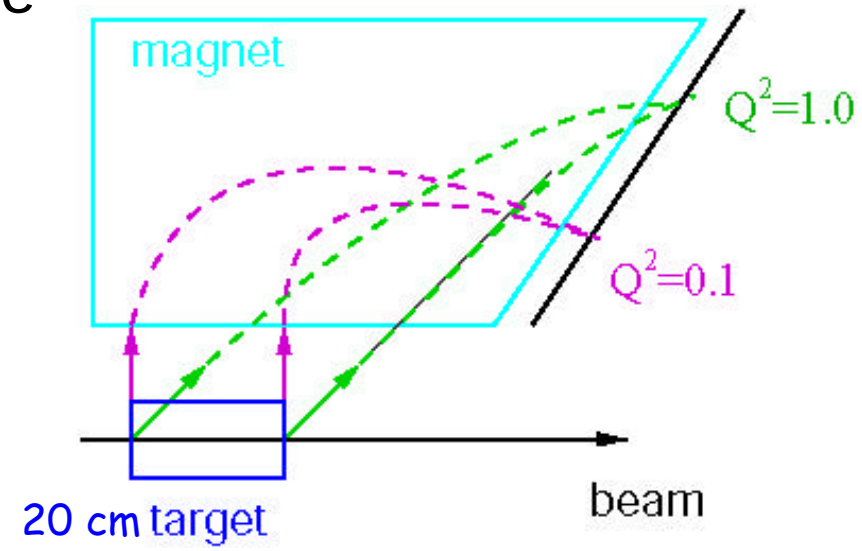
Target controls

- electronics readout
- monitoring through MEDM and StripTool GUI's

G0 Forward Detection Scheme

Detect recoil elastic Protons:

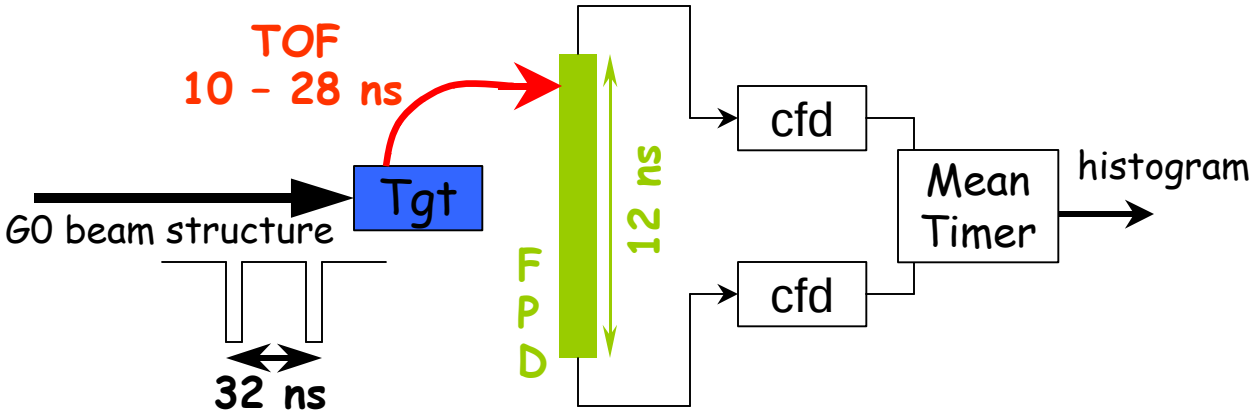
- Magnet sorts protons by Q^2 in FPD
- Beam bunches 32 nsec apart
- Flight time separates p and π^+



Beam spin flipped every 30 ms -> Macro pulse (MPS)

4MPS = Quartet -> Asymmetry computing unit: + − − +

$$A = \frac{Y_{1+} + Y_{2+} - Y_{1-} - Y_{2-}}{\sum Y_i}$$



G0 Fall 02 Engineering Run

G0 Apparatus Checkout

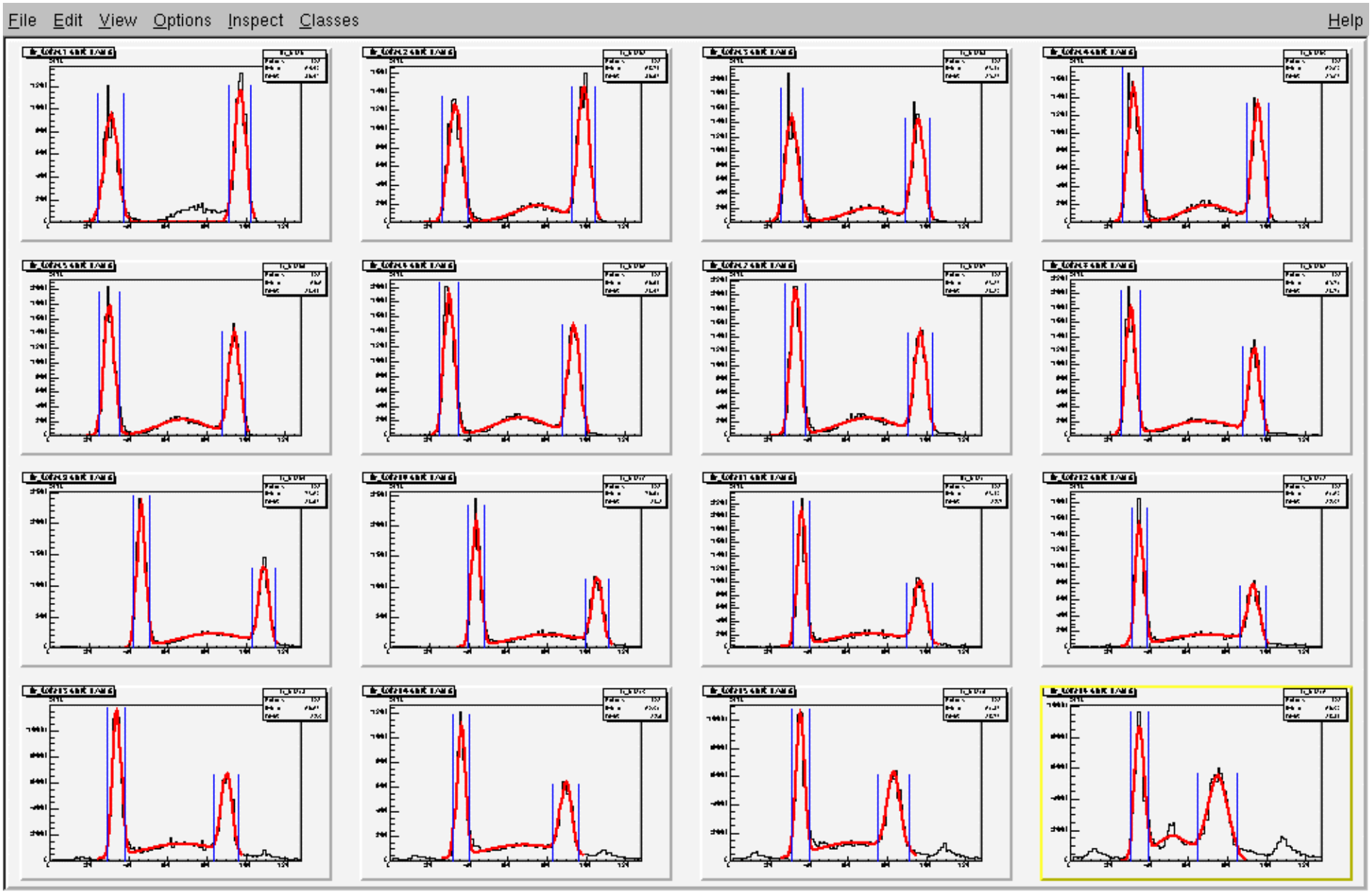
- Magnet commissioned at designed operation current, 5000 A, stable
- LH2 target
  - commissioned with nominal 40 μA G0 beam, 500 W power target
  - operation very smooth
  - can put LH_2, GH_2, He, ^{12}C and "halo" targets in beam
  - density fluctuations negligible at nominal running point (30 Hz cryopump rotation)
- G0 Detector
  - detailed studies of detector gains, symmetry and centering
  - beam manipulation to measure detector sensitivity
  - photon background rates initially high, now shielded (dropped by 2, need more)
- Electronics + DAQ,
  - generally working well
  - deadtime studies underway.

Beam checkout

- 40 μA G0 beam structure achieved but not stable
- beam polarization measured to be 75.03 +/- 1.2 %
- parity quality beam parameters: some achieved, some not

12 C of Physics asymmetry data acquired in Jan "03 at 5000 A (12% of data)

TOF Spectra



Target boiling studies

Detector asymmetry width:

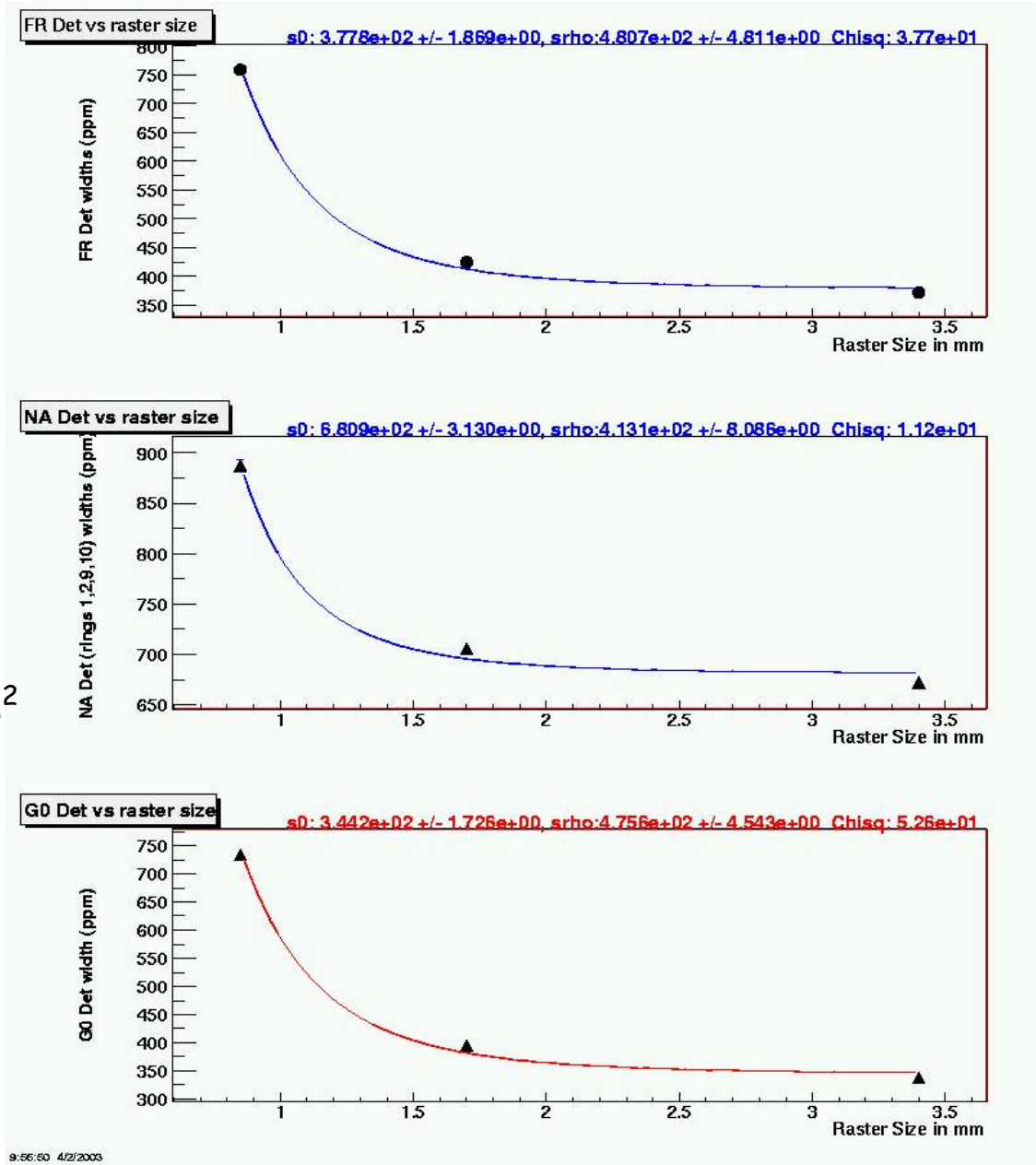
$$s_{DET}^2 = s_0^2 + s_{boil}^2 = s_0^2 + \frac{s_r^2}{A_{raster}^2}$$

For G0 nominal conditions:

- Cryogenic pump at 30 Hz
- 40 μA G0 beam rastered to 2x2 mm²

σ_0 = 344.2 +/- 1.73 ppm

σ_{boil} = 118.9 +/-2.3 ppm



G0 Experiment Schedule

To do list before next run

- target modifications (to reduce and/or measure inelastic p background)
- luminosity detector
- better understanding of deadtime
- parity quality beam needs work to meet the G0 requirements

Forward angle

- First engineering run completed Oct 2002 – Jan 2003, great success
- Second engineering run Fall 2003
- Followed directly by the Physics production run, early 2004

Backward angle

- One Q^2 approved by PAC Jul 2001, G0 wish - turnaround and Physics late 2004