# *G0 experiment*

E99-016, E01-115 and E01-116


$G^0$ Collaboration :

Caltech, Carnegie-Mellon, William&Mary, Hampton, IPN-Orsay, LPSC-Grenoble, JLab, Kentucky, LaTech, NMSU, TRIUMF, U Con, UIUC, U Manitoba, U Maryland, U Mass, UNBC, VPI, Yerevan


Experimental set-up

Status of the experiment


*J.S. Real, Athen, October 2003*

# *Nucleon weak form factors*

- $A_{PV}$ : linear combination of the Form Factors :

$$A_{PV} = A_{S=0} + \square\, G_E^s + \square\, G_M^s + \square\, G_A^e$$

$\square$, $\square$ and $\square$ depends on kinematics

- Separation of strange contributions :

At fixed $Q^2$ and 3 different kinematics: Forward, backward($LH_2$), backward($LD_2$)

**1) Proton and small $\square_e$ $\square$**

**2) Proton and large $\square_e$ $\square$**

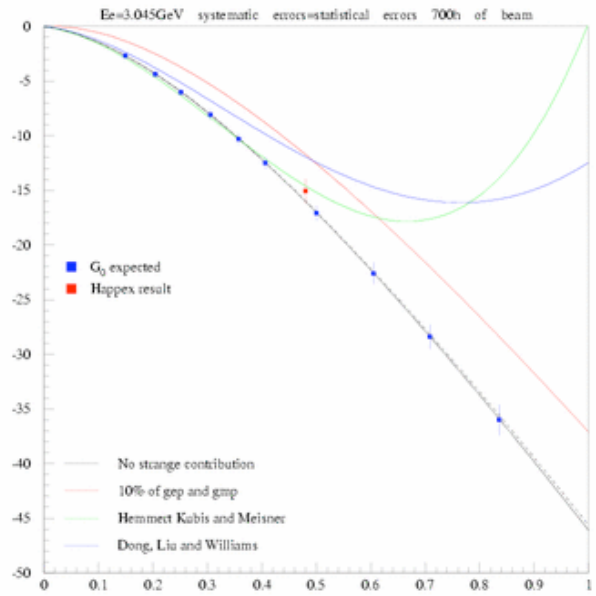
**3) Deuteron and large $\square_e$ $\square$**

| $Q^2 = 0.5$ $(GeV/c)^2$ | $A_0$(ppm) | $\square$ (ppm) | $\square$ (ppm) | $\square$ (ppm) |
|---|---|---|---|---|
| $A_F$ | -16.7 | 60.8 | 25.0 | 1.4 |
| $A_B$ ($LH_2$) | -29.0 | 18.0 | 40.3 | 8.5 |
| $A_B$ ($LD_2$) | -39.8 | 14.7 | 9.0 | 10.1 |

$\square$ **Extraction of** $G_E^s(Q^2)$ , $G_M^s(Q^2)$ **and** $G_A^e(Q^2)$

$Q^2 = 0.3, 0.5, 0.8\ (GeV/c)^2$

# *Expected Results*




Current Status :

SAMPLE (MIT-Bates) $G_M^S$, $G_A^e$ at $Q^2 = 0.1$ (GeV/c)$^2$

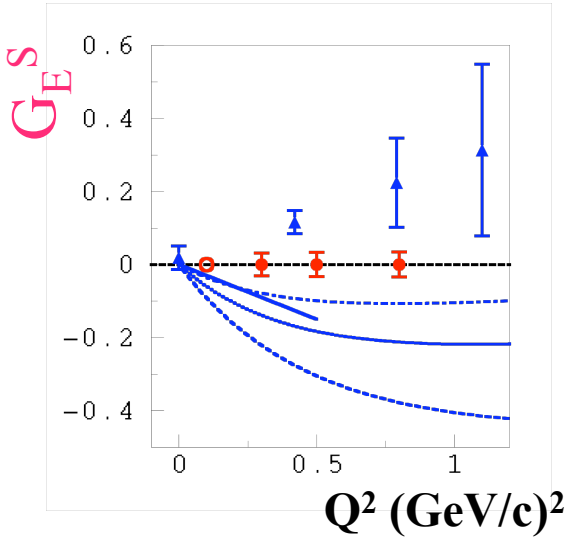
HAPPEX (JLab) $G_E^S + \square G_M^S$

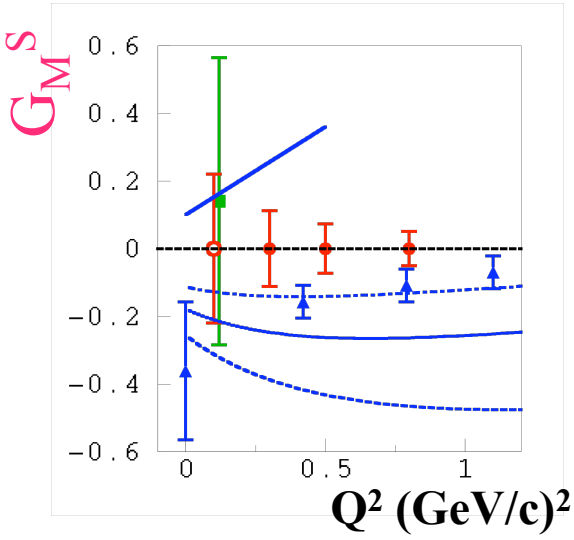
PVA4 (MAMI-Mainz) $G_E^S + \square G_M^S$ ,

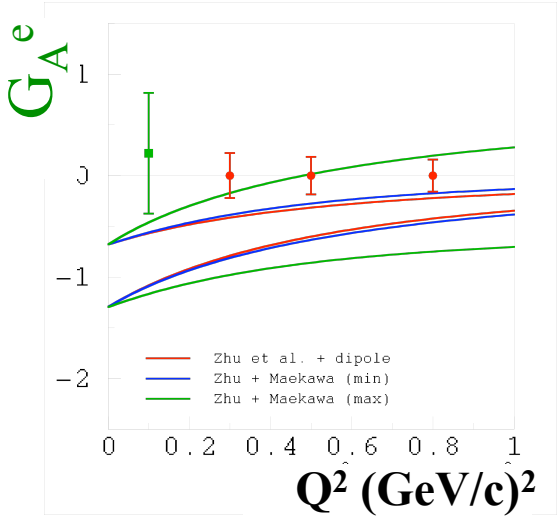
**$G^0$ :** **$A_{pv}$: 0.1□ 0.9 (GeV/c)$^2$**

Extraction of $G_E^s(Q^2)$, $G_M^s(Q^2)$ and $G_A^e(Q^2)$

At **$Q^2 = 0.3$, $0.5$** and **$0.8$ (GeV/c)$^2$**



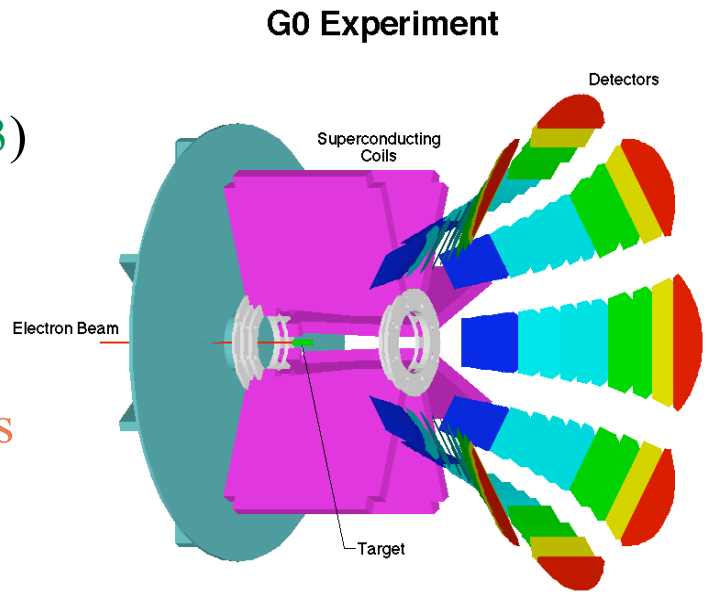




● $G^0$ proposed ○HAPPEX2 proposed ■ SAMPLE 2000

# *The $G^0$ Experiment in Jefferson Lab Hall C*

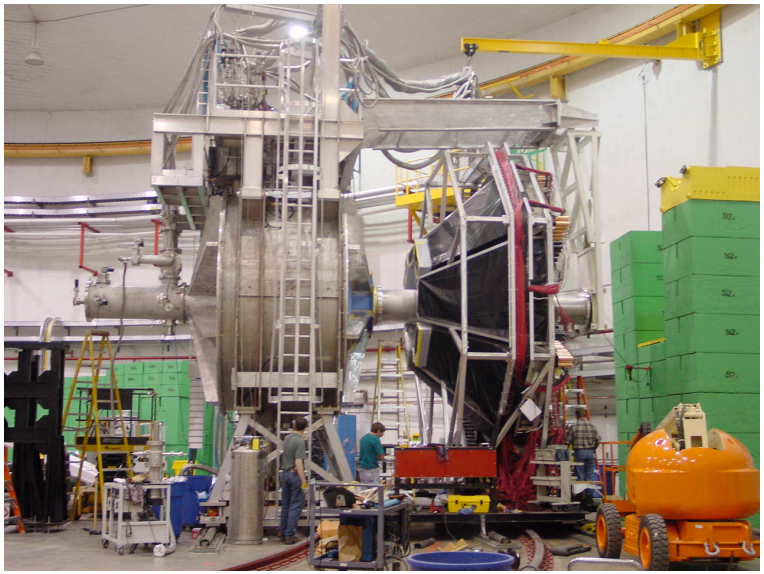
- Design and construction (1993 – 2001)
- Commissioning run (fall 2002/winter 2003-fall 2003)
- Forward angle production run (winter 2004)
- Back angle runs (2004 – 2007)



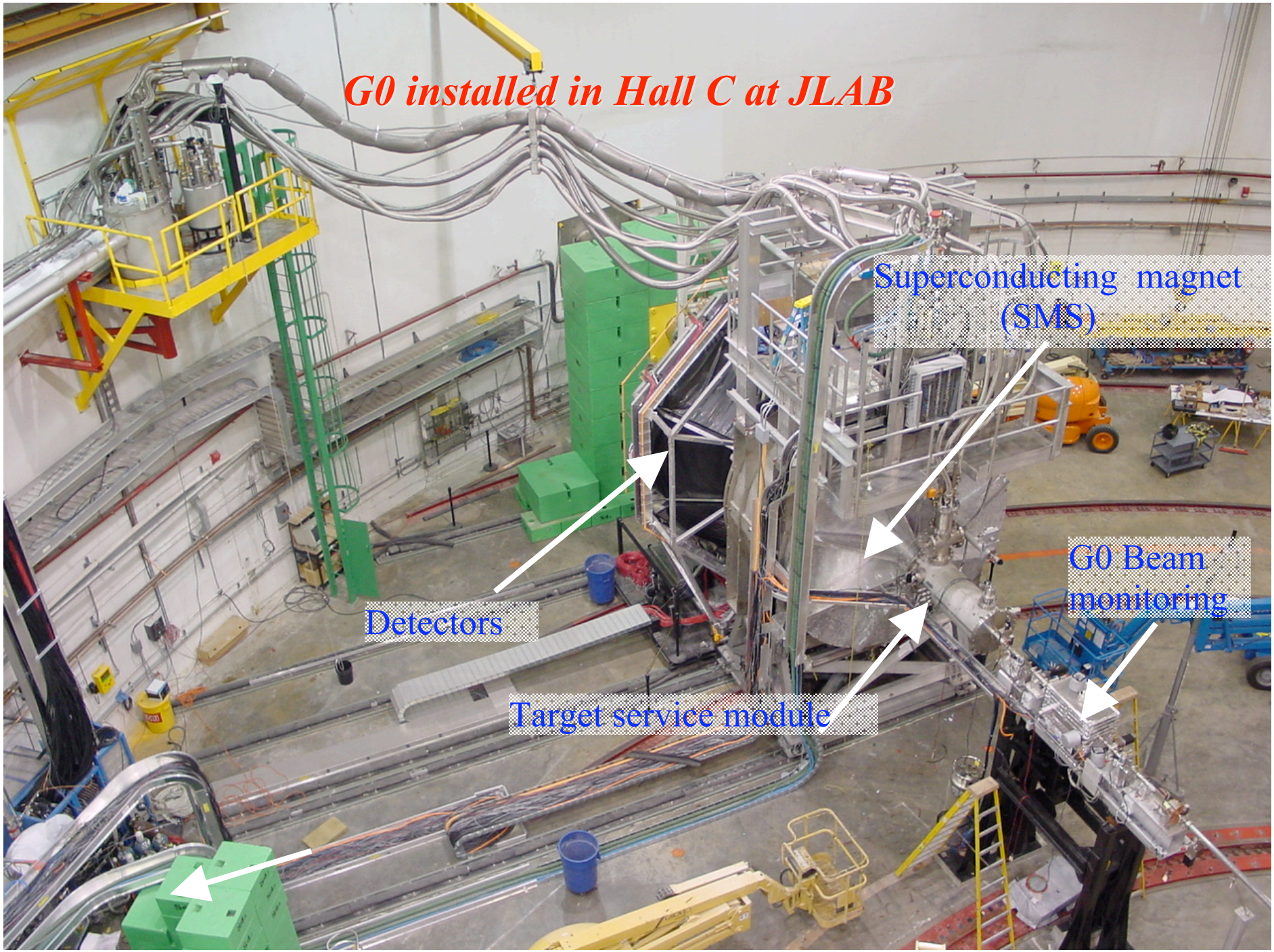

Goals: Apv ~ -3 to -40 ppm, ΔApv/Apv ~ 5 %
high statistics ($10^{13}$-$10^{14}$ events), small systematics

Main components:

- Jefferson Lab polarized source and accelerator
  - Reliable high polarization,
  - High current polarized electron source
  - Small helicity-correlated beam properties
- High power $H_2$ /$D_2$ target
- Superconducting magnet, toroidal field
- Large acceptance scintillation detector array
- Custom high count rate electronics
  - Low dead time



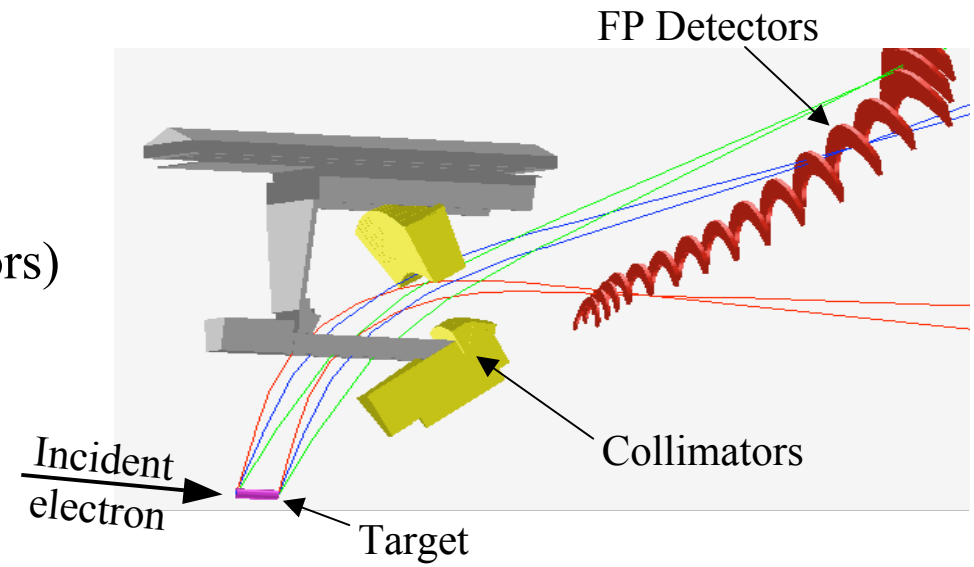
Capability to isolate elastic scattering from other processes:
Reduce and accuratly measure dilution factor and false asymetries


G0 installed in Hall C at JLAB
Superconducting magnet (SMS)
G0 Beam monitoring
Detectors
Target service module

# *G0 Forward Angle Measurement*

- Beam Energy : 3 GeV, 20 cm LH2 target
- Detect recoil protons □□62□78° □ □$_e$ = 5-15°
- Magnet sort protons by $Q^2$ (16 iso-$Q^2$ Detectors)
- All desired $Q^2$ in one measurement

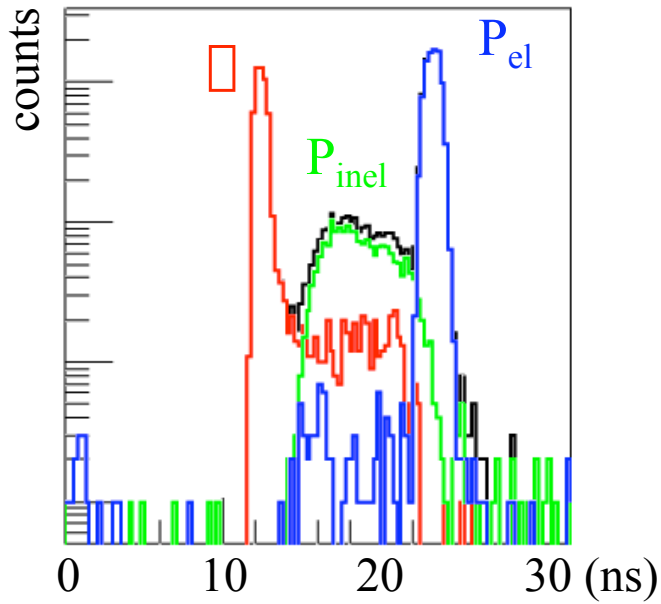
  (0.16 □ 1 $(GeV/c)^2$)




Background removal :

- neutrals : collimators +
  coincidence front-back scintillators
- charged particles (π, inelastics) :
  Time of Flight spectrum

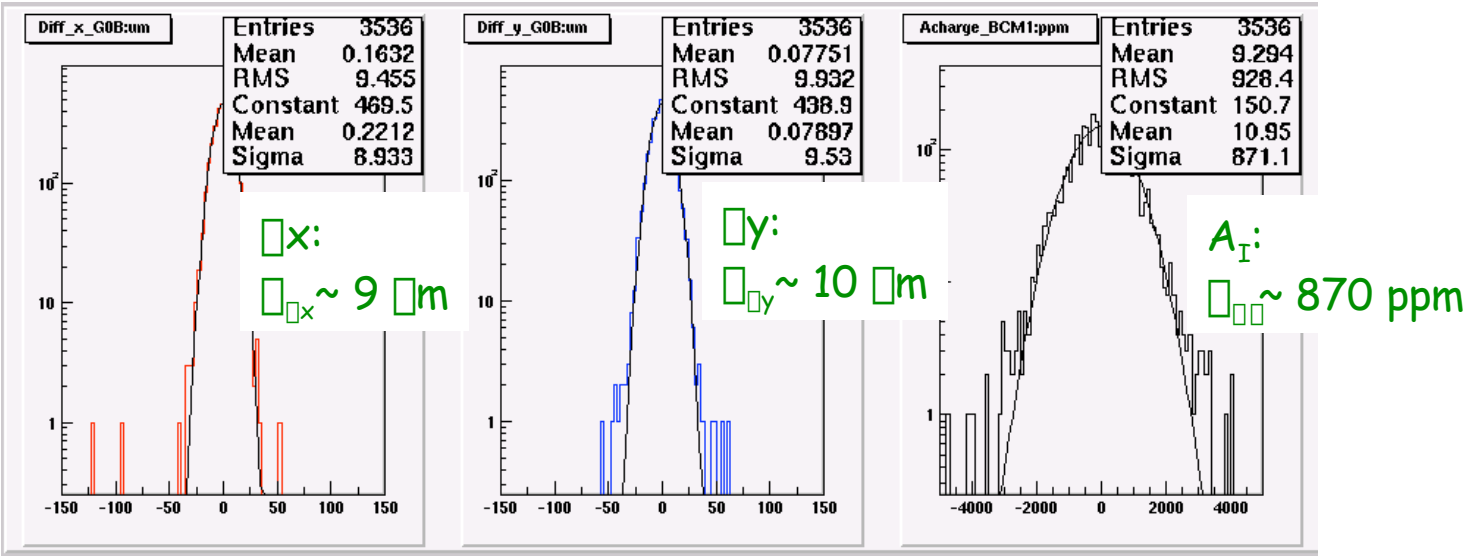
Beam bunch 32 ns apart




Forward mode installed in summer 2002
Commissioned in Oct 2002 - Jan 2003

# $G^0$ Beam

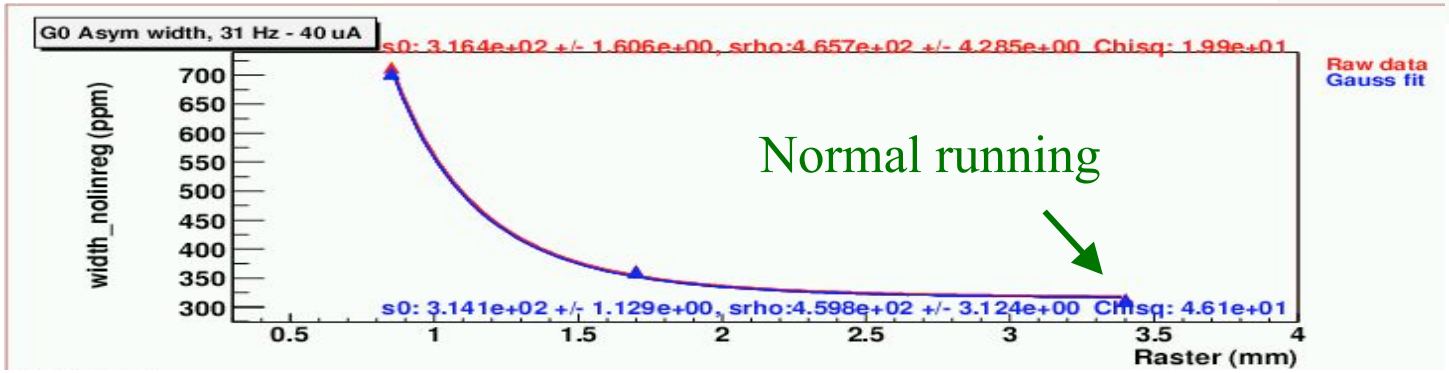
- High polarisation : 75 %
- Helicity reversal (data readout) : 30 Hz
- Polarization flip sequence (pseudo-random): -++- and +--+
- High current : 40 μA
- Unusual time structure: 31 MHz (32 nsec between pulses)
  (1/16 of usual CEBAF time structure of 499 MHz, 2 nsec between pulses)
- Higher charge per bunch (X6 100μA/2ns vs 40μA/32ns)
  → Required new Ti:Sapphire laser in polarized electron gun
  → space charge effects complicated beam transport in injector (challenging beam optics problem)

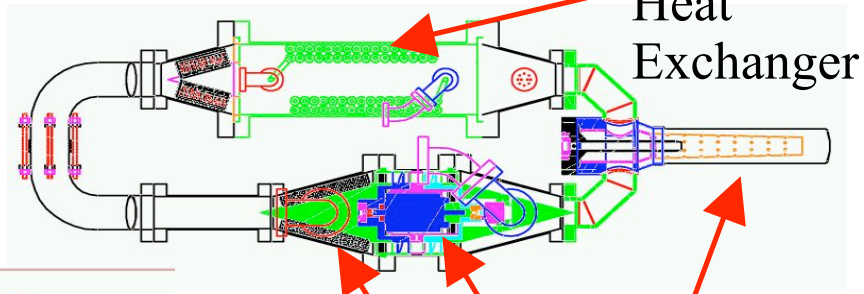



- Beam with most desired properties delivered for Jan. 2003
  Beam fluctuations at (30 Hz/4) ~ $\Delta X, \Delta Y < 20$ μm $\Delta I/I < 2000$ ppm

# $G^0$ target

- 20 cm $LH_2$ cell, 250 W heat load from beam at 40 μA
- High flow rate to minimize target density fluctuations



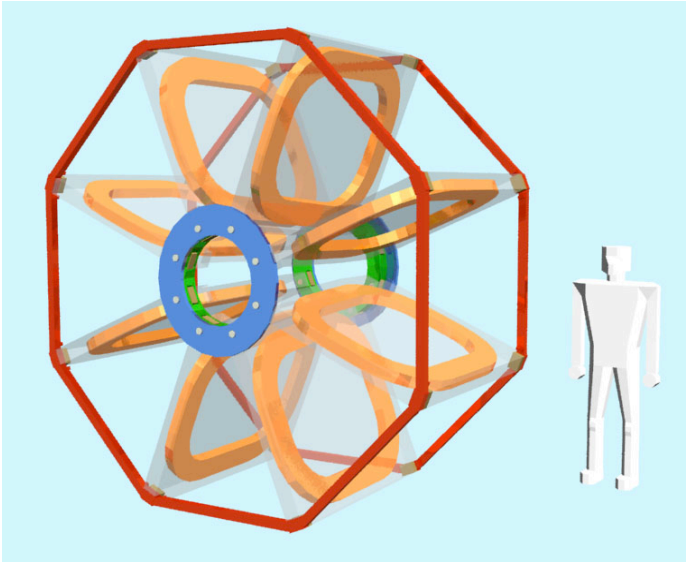

Commissionning: Observed target density fluctuations at 40 μA negligible

# $G^0$ Magnet

- Superconducting toroidal magnet, 8 coils
- Initial manufacturing defects – repaired in early 2002

Commissionning:

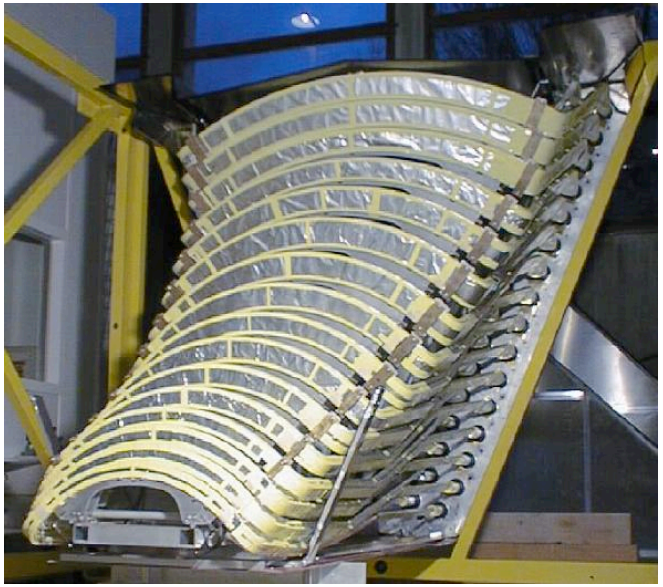
- Ran at 4500 A initially (Aug. -Dec. 2002)
- Ran at full design current (5000 A) on Dec. 18, 2002 and during Jan. 2003 running



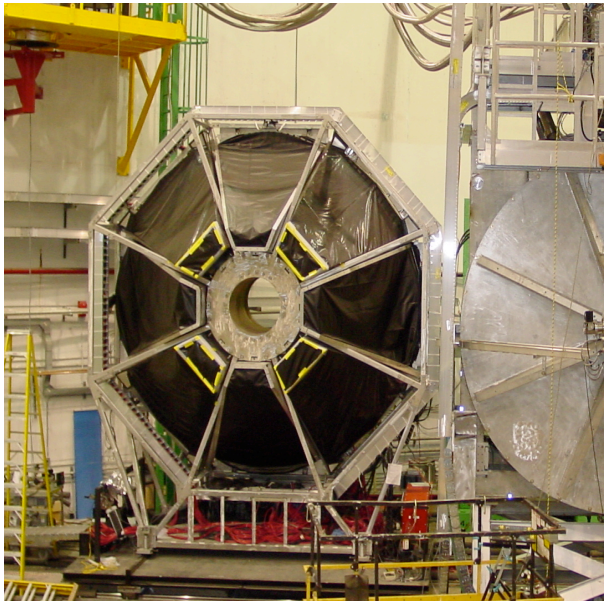
# *G0 Focal Plane Detectors (FPD)*

- 16 pairs of arc-shaped scintillators (iso-Q2)
  - Back and front coincidences to eliminate neutrals
  - 4 PMTs (one at each end of scintillators)
- Long light guides (PMT in low B field)

North American octant



French octant

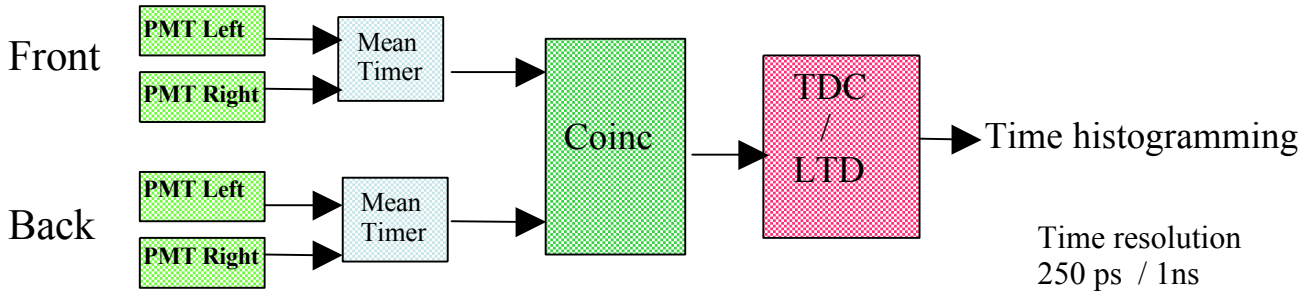


Detector
"ferris wheel"

Commissionning: HV and threshold settings (uniform gain)
Reduced anode current by improvement of shielding around the beam pipe

# *G0 Forward Angle Electronics*

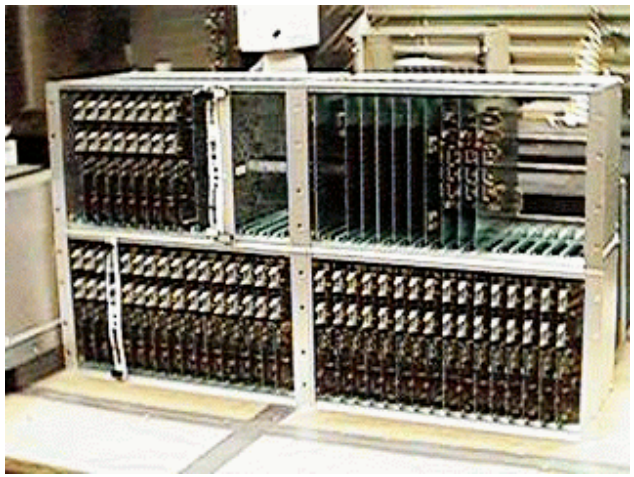
## Time of Flight measurement




French DMCH16 Module 1/8

- Custom electronics designed to provide high-rate histogramming
- French: mean timer  flash TDCs (0.25 ns)
- NA: mean timer  latching time digitizer  scalers (1 ns)
- Time histograms read out by DAQ system at 30 Hz

NA LTD crate (1/2)

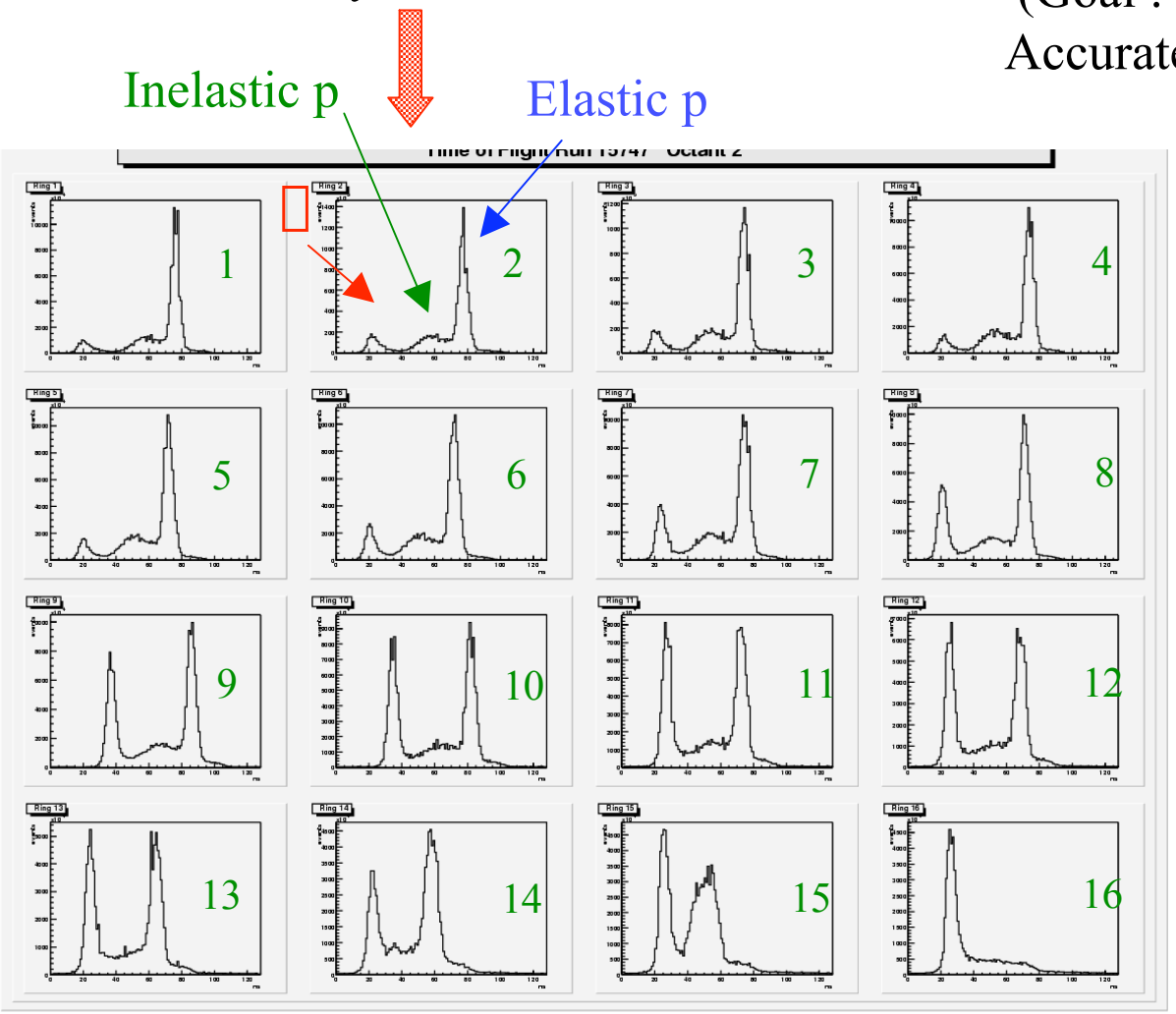


- Commissionning:
  - Time measurement stability
  - Deadtime studies and correction

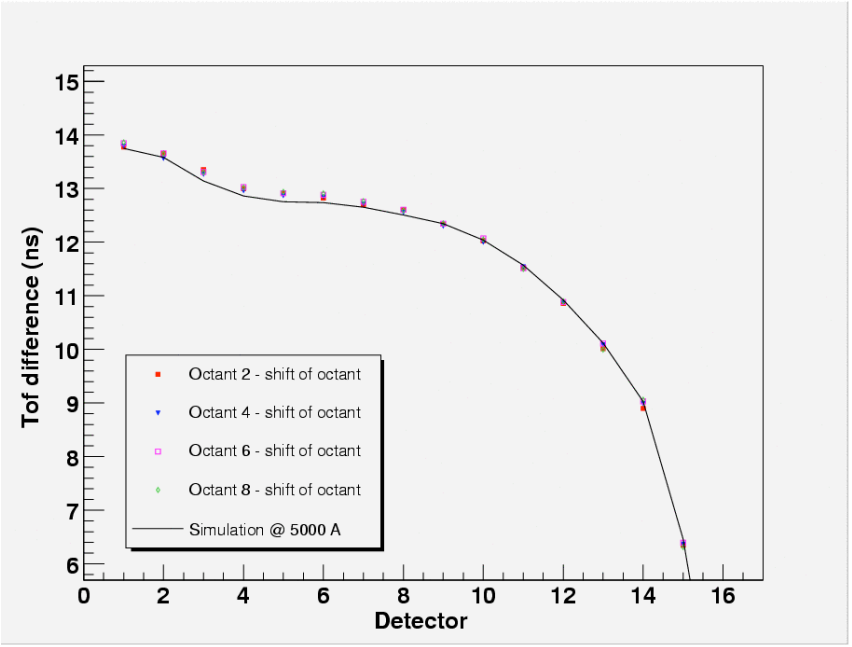
# *Time of Flight Spectra from G0 Commissioning Run*

Time of flight spectra for all 16 detectors
- recorded every 33 msec

Comparison Data-Simulation :
$Q^2$ determination  ToF difference between $P_{el}$ and 
(Goal : $Q^2/Q^2 = 1\%$  $t_{p} = 100ps$ )
Accurate checks of detectors/electronics set-up




ToF(p) - ToF() (ns)



# *Corrections to the raw asymmetry*

- Correct for false asymmetries from helicity-correlated beam properties (700 hours run):

  $\Delta A_{charge} < 1$ ppm

  $\Delta A_{false}(\Delta y) \sim 0.01$ ppm for desired $\Delta y = 20$ nm

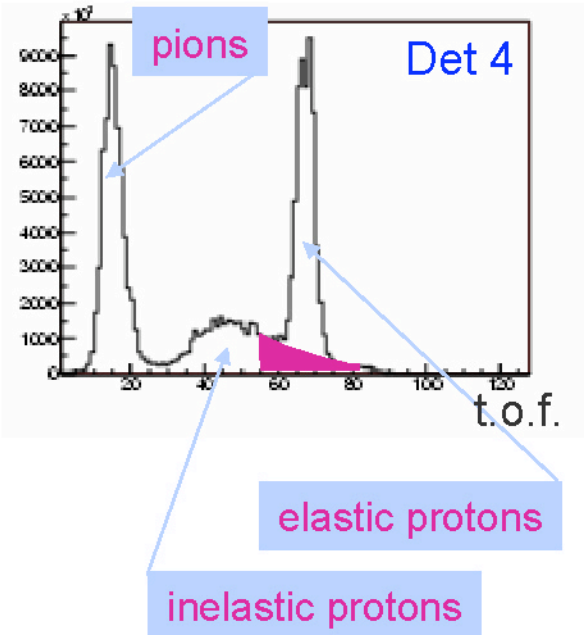
  $\Delta A_{false}$(dead time) ~ 0.01 ppm (typical effect ~ 10%, after correction ~ 1%)

- Correct for background and its asymmetry:

$$A_{sig} = \frac{A_{corr} - A_{back} f_{back}}{f_{sig}}$$

Both yield and asymmetry of background needed

- Yield ~ 10 to 25 % depending on detector
- $|A_{background}| \sim |A_{elastic}|$ preliminary




Important contribution from aluminium target windows:

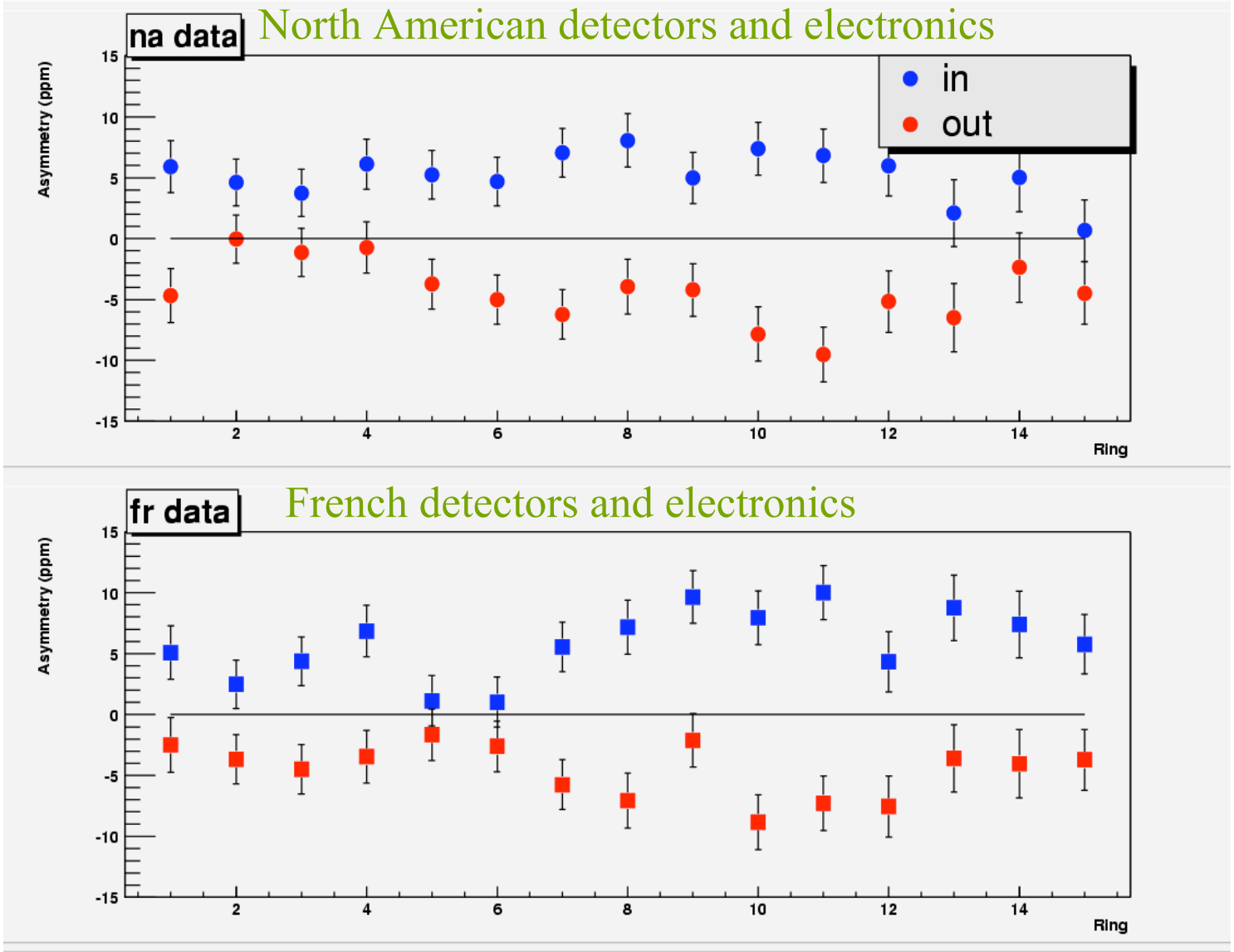
Next Run:

- Reduce downstream window thickness (X1/4)
- Add insertable thicker dummy window
  - asymmetry measurement

# *Behavior of raw asymmetry under helicity reversal*

# *(slow half wave plate reversal, Jan. 2003)*

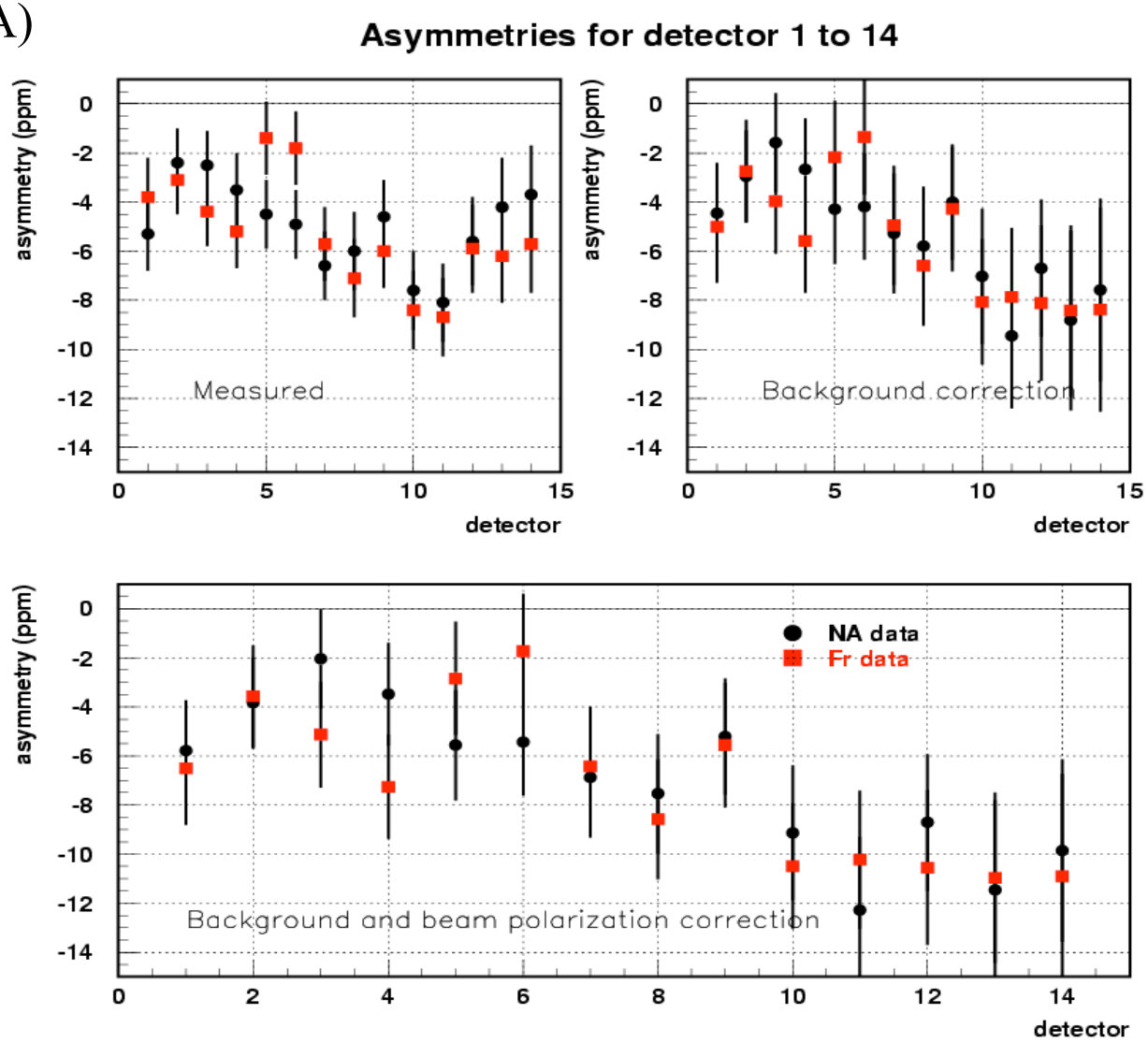
Based on 51 hours of data at 40 μA



# *Asymmetry results from Jan. 2003 running*

- Based on 51 hours of data (40 μA) (note: full production run will be 700 hours)

- Includes :
  - false asymmetry corrections
  - deadtime corrections
  - background corrections
  - beam polarization correction



# *G0 Backward Angle Measurement*

$\theta_e = 110°$ detection of the electron
Small variation of $Q^2$

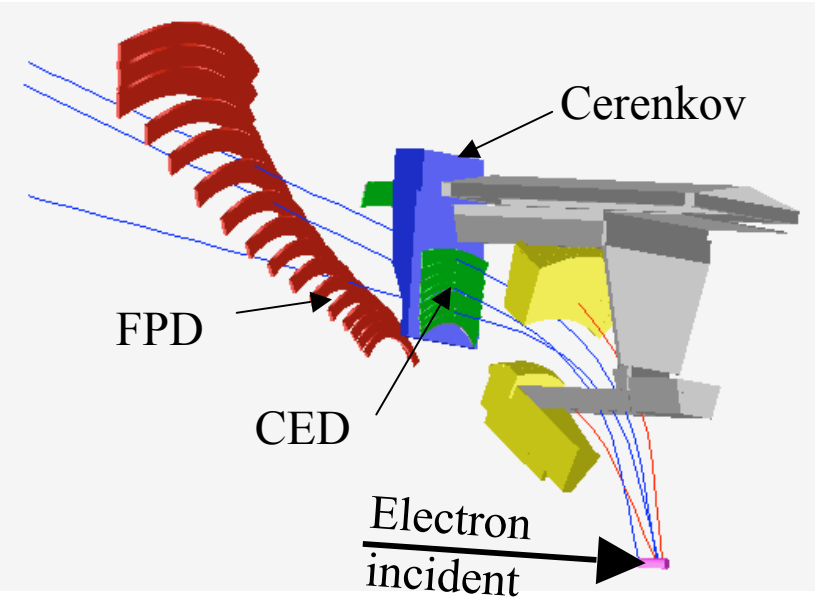
3 Beam Energies :
424, 576 and 799 MeV

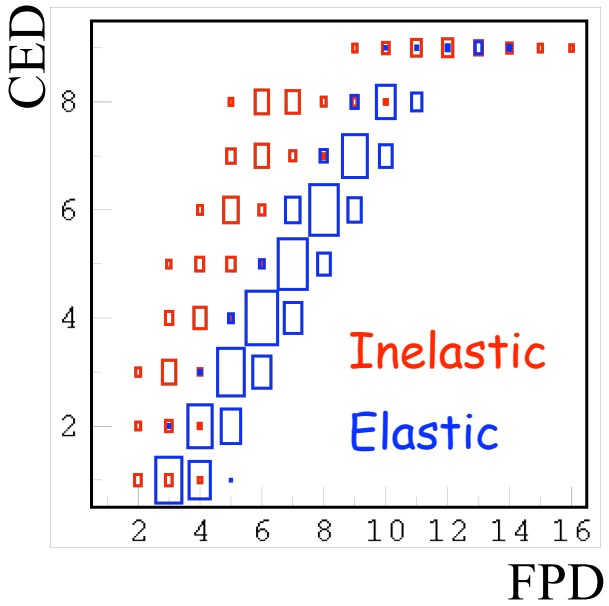
$Q^2$ : 0.3, 0.5 and 0.8 $(GeV/c)^2$

$LH_2$ and $LD_2$ measurements for each $Q^2$
total of 6 runs x 700 hours

Background removal :

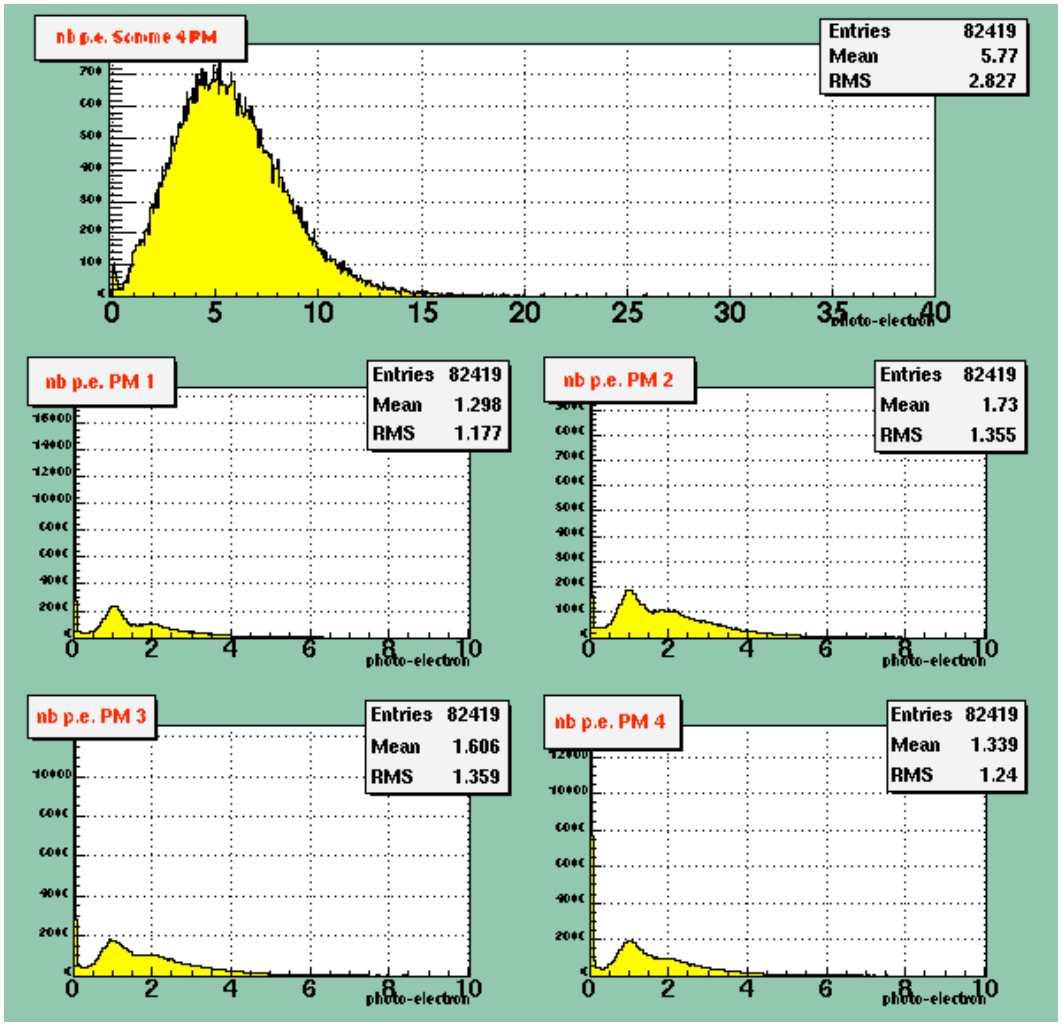
- neutral from target : collimators
- inelastic electrons :
  coincidence FPD-CED scintillators
- : Cerenkov detector (reduction 1/100)
  (used for $LD_2$ measurement)

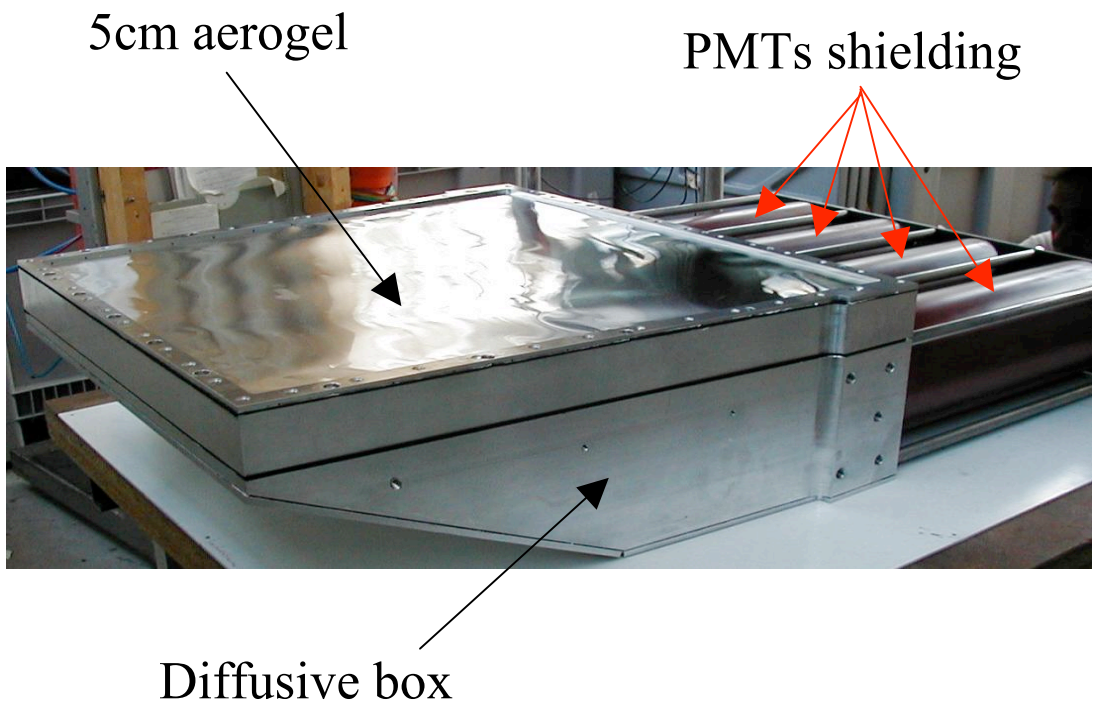


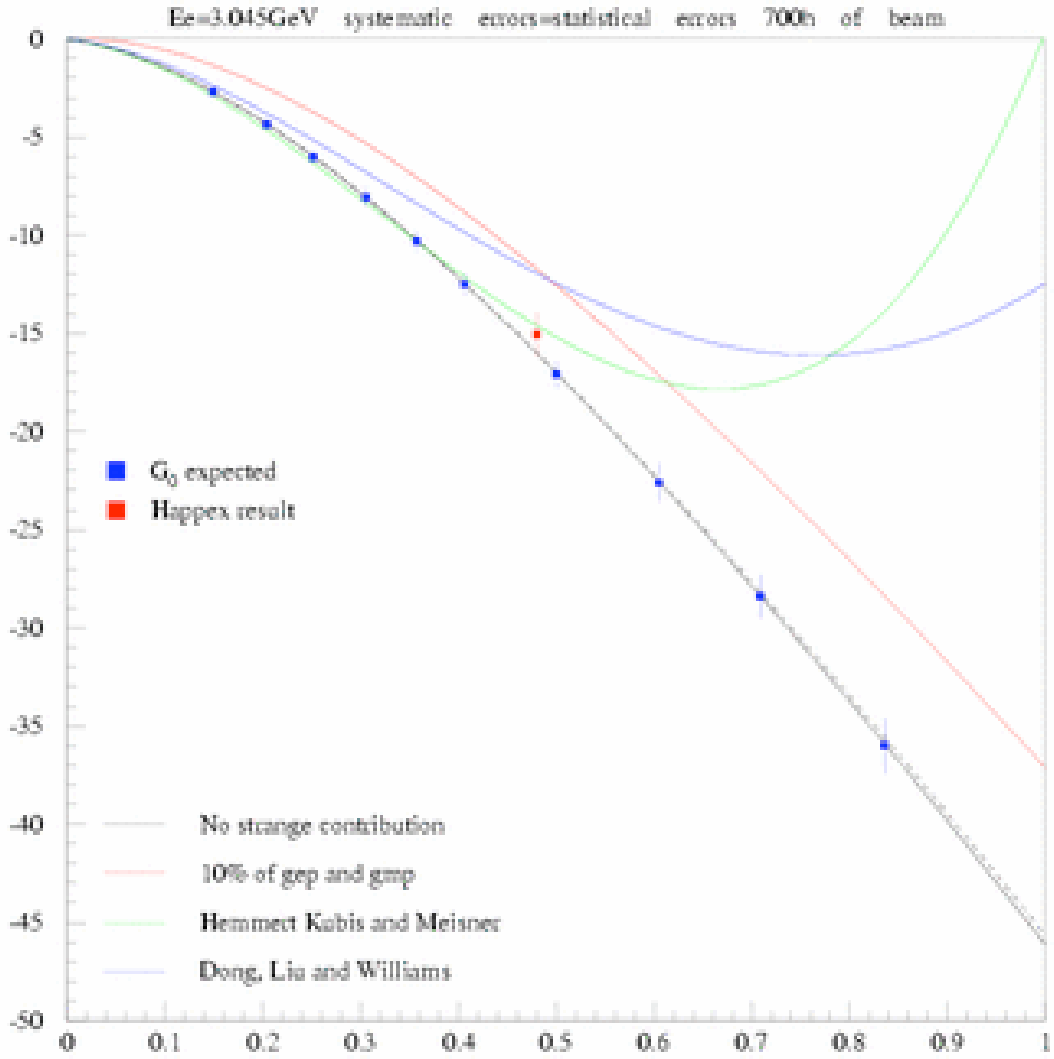



# *G0 Cerenkov*

Prototype test with cosmic rays
septembre 2003



# *Conclusion*

- $G^0$ apparatus successfully commissioned:
  - Capabilities to measure a PV asymmetry
  - Change to reduce/measure the background contribution
- 2nd $G^0$ commissioning run in Fall 2003
- Forward angle production run
  Winter 2004 (700 hours)
- Back angle running
  2005 - 2007 (3 X 1400 hours)