G0 experiment
- Back Angle Measurement –

E99-016, E01-115 and E01-116

G^0 Collaboration :

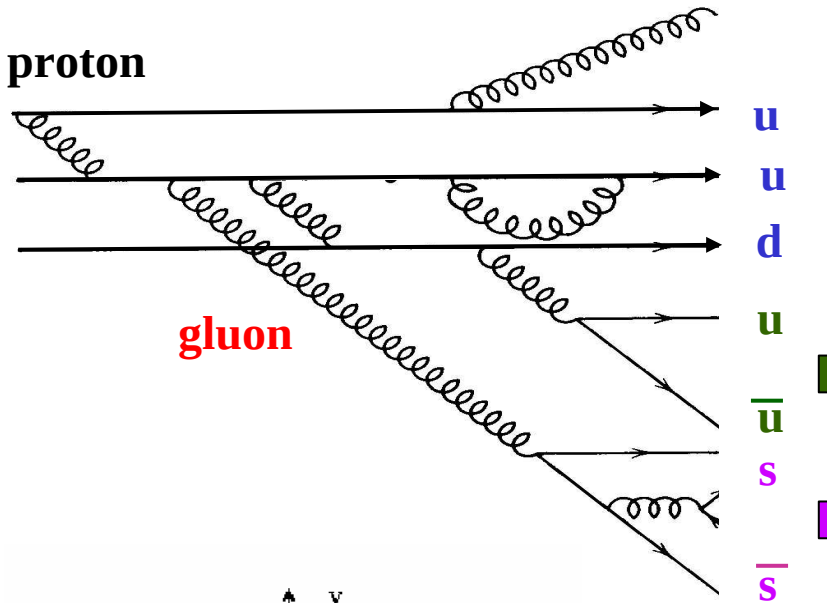
Caltech, Carnegie-Mellon, William&Mary, Hampton, IPN-Orsay, LPSC-Grenoble, JLab, Kentucky, LaTech, NMSU, TRIUMF, U Con, UIUC, U Manitoba, U Maryland, U Mass, UNBC, VPI, Yerevan

Introduction

Experimental details

Status of the experiment

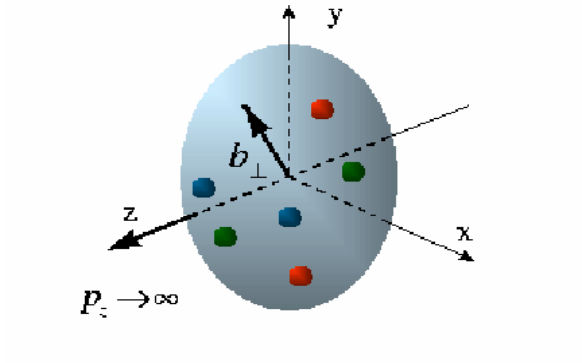
What role do strange quarks play in nucleon properties?



valence quarks

"non-strange" sea ($u, u\bar{}, d, d\bar{}$) quarks

"strange" sea ($s, s\bar{}$) quarks



Elastic scattering:
transverse quark distribution in coordinate space

Electric and magnetic form factors well - measured

G_E G_M for p, n

BUT quark flavor decomposition of these form factors is not yet known

$G_{E,M}^{u}$ $G_{E,M}^{d}$ $G_{E,M}^{s}$

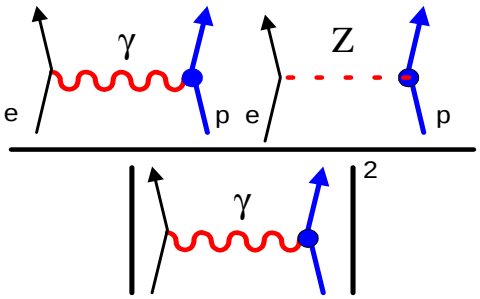
Main goal of G^0 : To determine the contributions of the strange quark sea (s s) to the electromagnetic properties of the nucleon ("strange form factors").

Form Factors from Parity-Violating Asymmetry

Asymmetry **Proton Weak Form Factors**

$$A(Q^2) = -\frac{(G_F Q^2)}{\pi\alpha\sqrt{2}} \frac{\{\ \varepsilon G^{\gamma}_E G^{Z}_E + \tau G^{\gamma}_M G^{Z}_M + \eta G^{\gamma}_M G^{Z}_A\ \}}{\varepsilon (G^{\gamma}_E)^2 + \tau (G^{\gamma}_M)^2}\ [\ 1/P_Z\ ]$$

(where ε , τ , η are kinematical parameters)



Determine G^{Z}_E and G^{Z}_M

Do **2** measurements of $A(Q^2)$ *[Rosenbluth separation]*

For a given Q^2, ε ranges from **1** (small angles) à **0** (large angles)

i) At small **(forward)** angles, measure a combination of G^{Z}_E and G^{Z}_M
ii) At large **(backward)** angles, measure G^{Z}_M
à Combine both measurements to ***extract*** G^{Z}_E

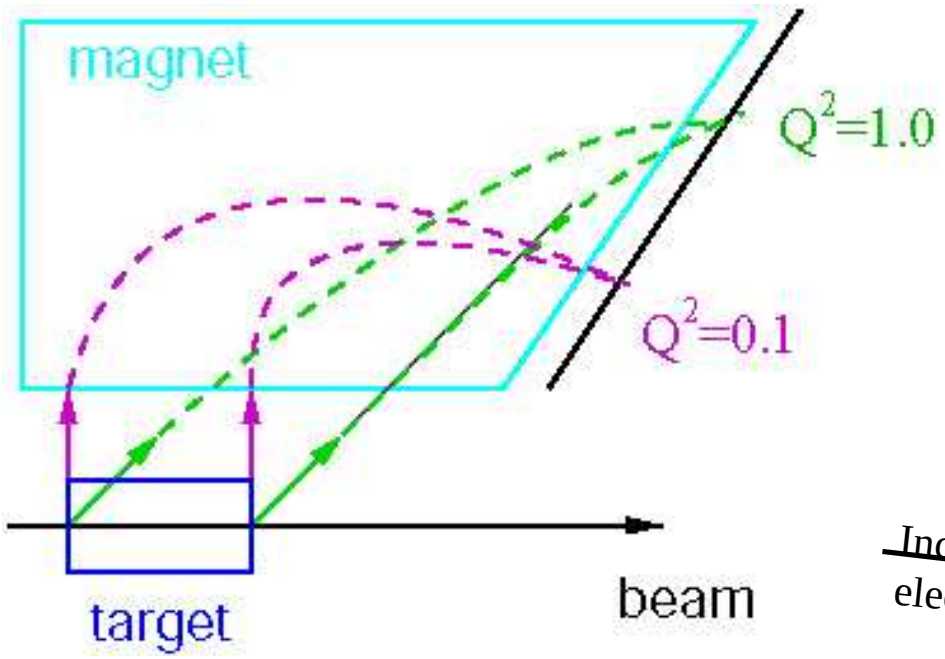
G0 MEASUREMENTS : 3 Phases

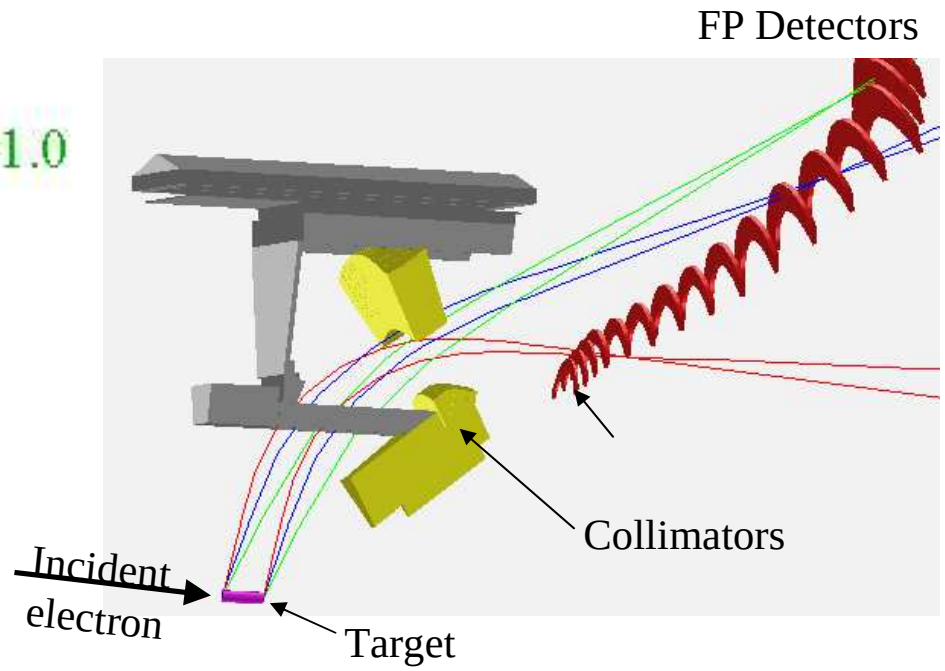
A) Forward Angle Mode ü
B) Backward Angle Mode
C) Deuterium Target Mode *(Rad. Corr. to G^{Z}_A)*

G0 will perform all three measurements at three different Q2 values - 0.3, 0.5, 0.8 GeV

G^0 Forward Angle Mode

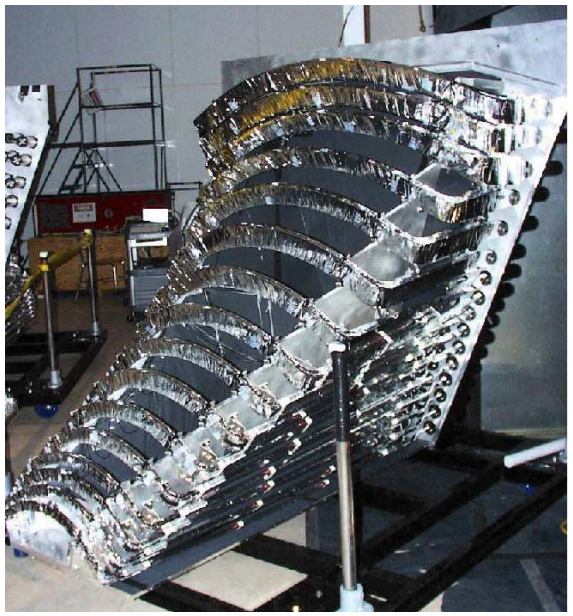
- **Electron beam energy = 3 GeV on 20 cm LH_2 target**
- **Detect recoil protons ($\theta \sim 62 - 78^o$ corresponding to $15 - 5^o$ electrons)**
- **Magnet sorts protons by Q^2 in focal plane detectors**
- **Full desired range of Q^2 (0.16 - 1.0 GeV^2) obtained in one setting**
- **Beam bunches 32 nsec apart (31.25 MHz = 499 MHz/16)**
- **Flight time separates p (about 20 ns) and p^+ (about 8 ns)**



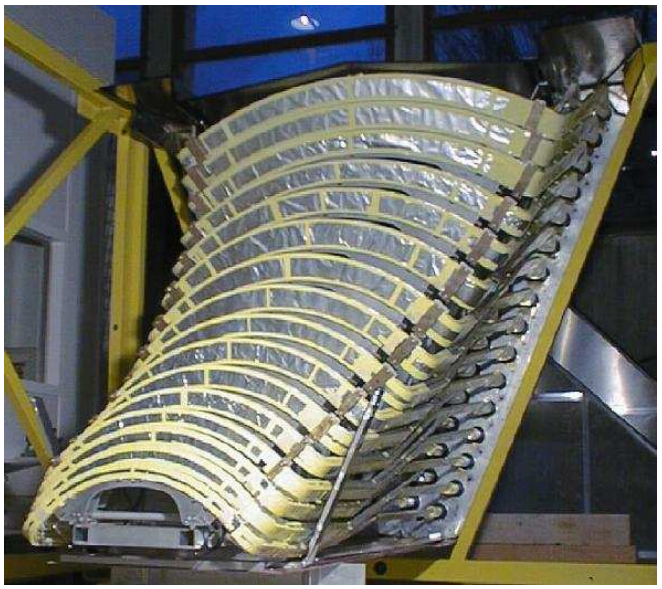


G^0 Focal Plane Detectors (FPD)

- 16 pairs of arc-shaped scintillators (iso-Q^2)
- Back and front coincidences to eliminate neutrals
- 4 PMTs (one at each end of scintillators)
- Long light guides (PMT in low B field)

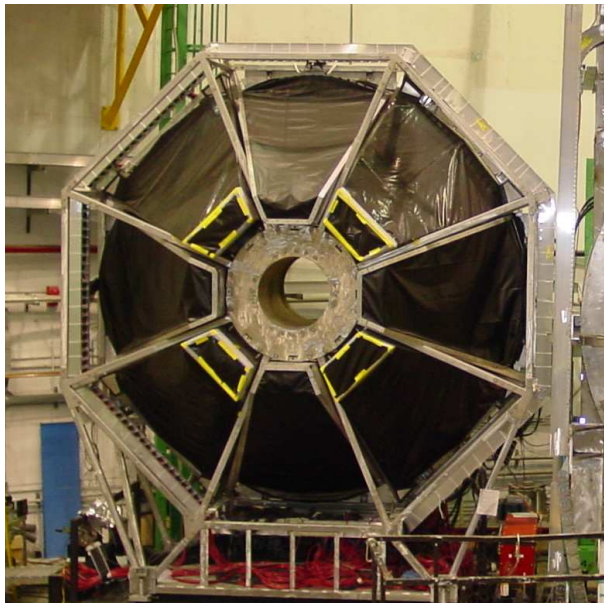


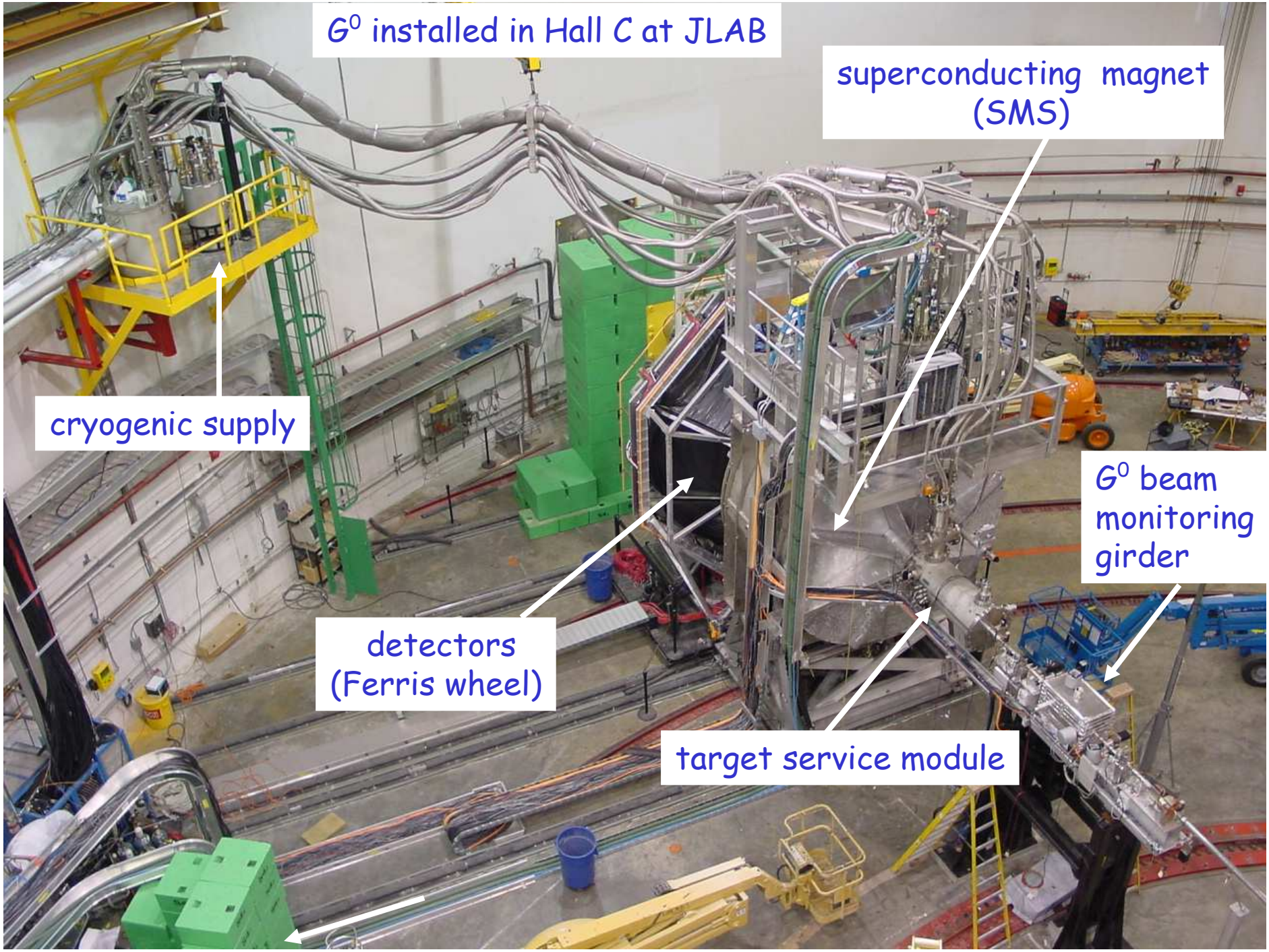
French octant



North American octant

Detector
"ferris wheel"

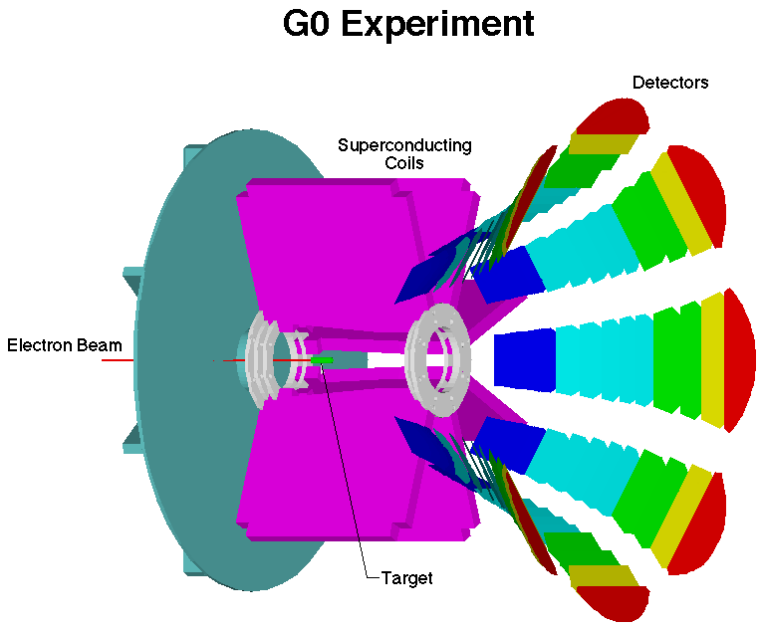



G⁰ installed in Hall C at JLAB
superconducting magnet (SMS)
cryogenic supply
G⁰ beam monitoring girder
detectors (Ferris wheel)
target service module

The G^0 Experiment in Jefferson Lab Hall C

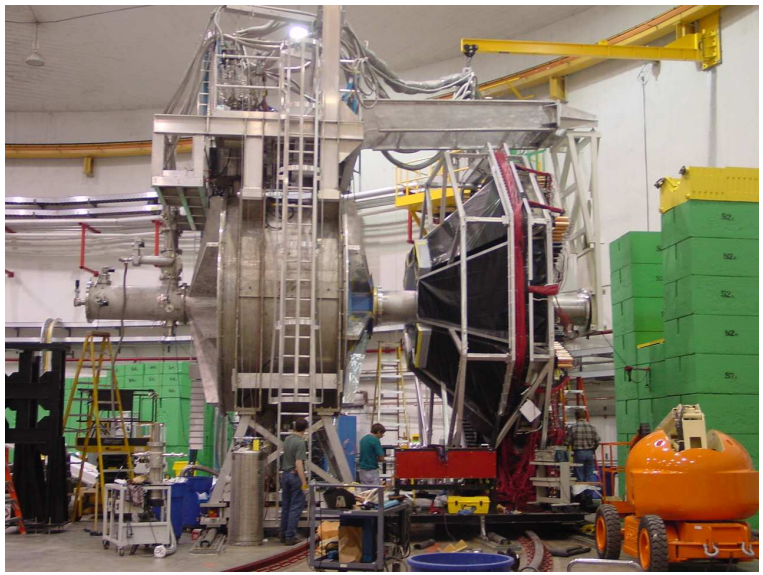
Main components:

- Superconducting toroidal magnet
- Jefferson Lab polarized source
- High power H_2 /D_2 target
- Large acceptance scintillation detector array
- Custom high count rate electronics

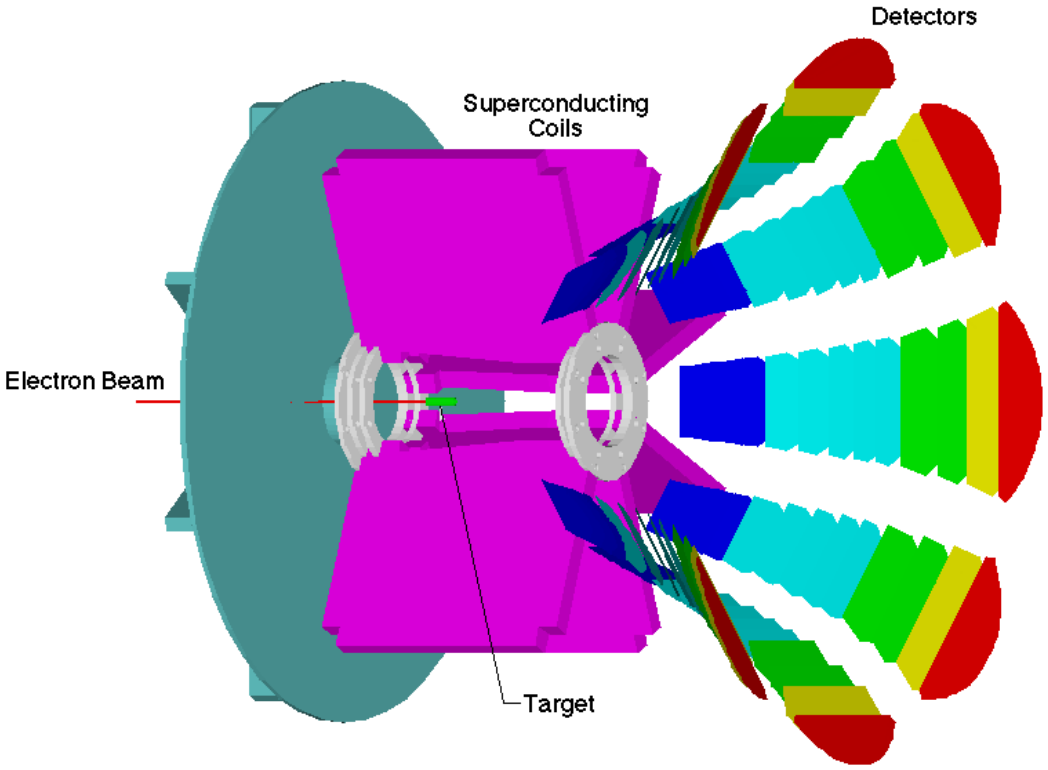


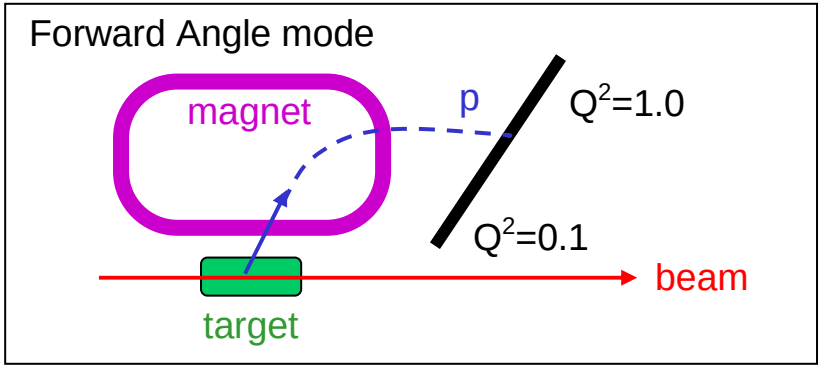
History:

- Design and construction (1993 - 2001)
- Commissioning run (fall 2002/winter 2003)
- Finish commissioning run (winter 2003)
- Forward angle production run (spring 2004)
- Back angle production runs (2005 - 2007)

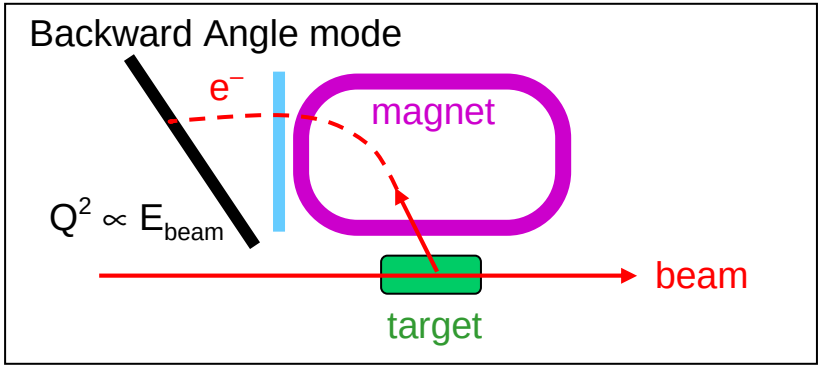


G0 Schematic Layout





All measurements at 1 beam energy



Measurements at 3 separate beam energies

G^0 Backward Angle Measurement

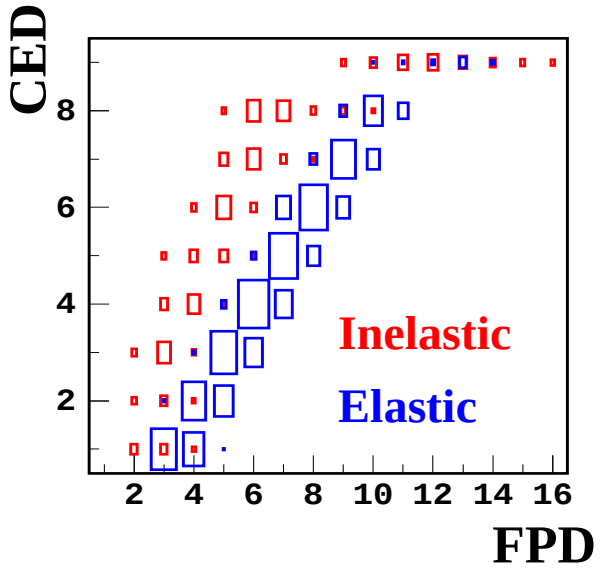
- Detect scattered electrons at $\theta_e \sim 110^o$
- At back angles Q^2 only has small variation in G^0 acceptance

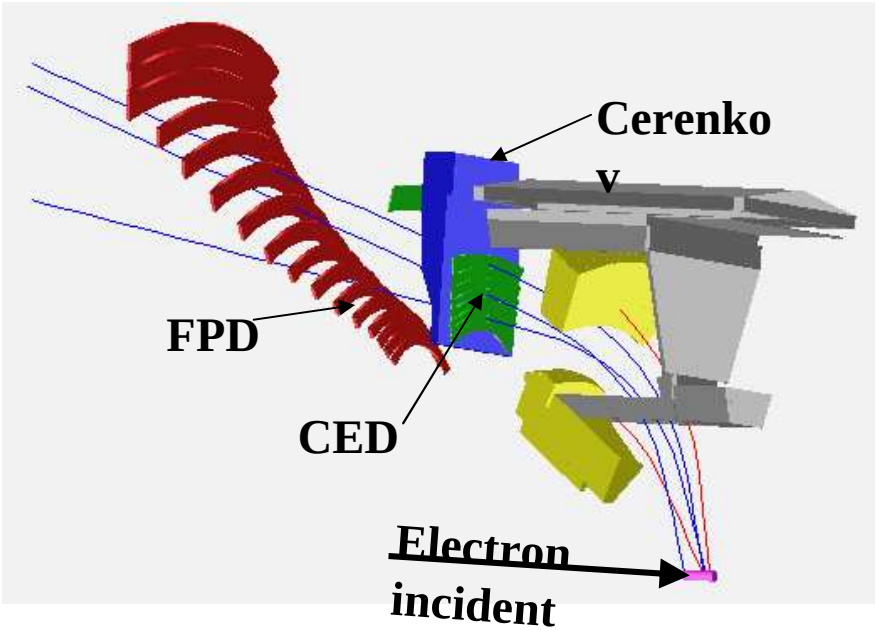
  → Need separate runs at E = 424, 576, 799 MeV
  for Q^2 = 0.3, 0.5, 0.8 $(GeV/c)^2$
  for both LH_2 and LD_2 targets
  (total of 6 runs x 700 hours)

Requires additional detectors:

- Cryostat Exit Detectors (CED) to separate elastic and inelastic electrons
- Cerenkov detector for pion rejection (primarily for LD_2 target)

CED/FPD coincidences at $Q^2 = 0.3\ GeV^2$

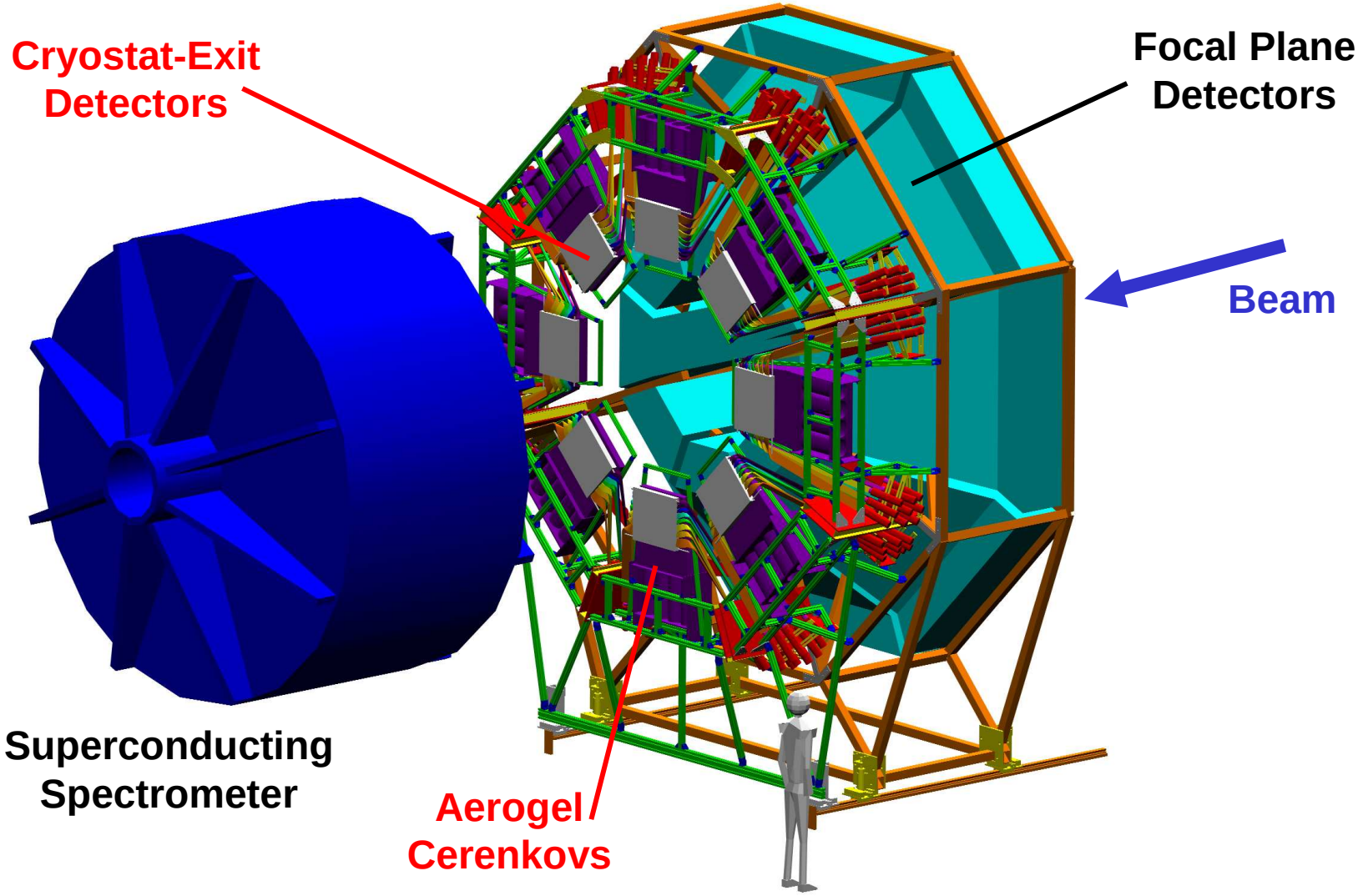




G0 BackAngle Configuration

Magnet & Detector Package *turned around ;* Detect back-scattered electrons

Additional Detectors ; 2nd *(Mini)* Ferris-Wheel Support Structure



G0 Back Angle Running

Back Angle rates (elastic, quasielastic) @ 80μA

Target	E(GeV)	Q^2(GeV^2)	Rate (MHz)	Asymmetry (ppm)
LH2	0.424	0.3	2.03	-18
LD2	0.424	0.3	2.80	-25
LH2	0.585	0.5	0.72	-32
LD2	0.585	0.5	1.10	-43
LH2	0.799	0.8	0.19	-54
LD2	0.799	0.8	0.27	-72

Ø $\theta \sim 110°$

à 700 hours running time for each target & each Q^2

à 499 MHz beam, 80μA

à 75% polarization assumed (80% likely?)

à $(\Delta A/A) \sim \pm 5\%$ à $\pm 3.5\%$

à Contrib.^{s} from false asym, $\Delta A_j^{false} \sim 10^{-8}$

Over 30 days running, h.c. asymmetries:

ΔE	$< 2.5 \times 10^{-8}$
$\Delta Q/Q$	< 1 ppm
$\Delta x, \Delta y$	< 20 nm
$\Delta\theta, \Delta\phi$	< 2 nrad

$\Delta G^s_E \sim 0.03 - 0.05$

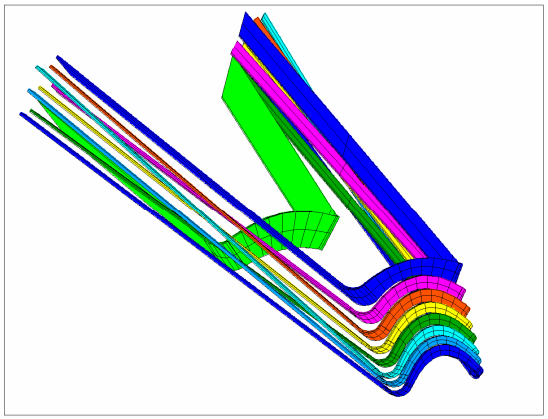
$\Delta G^s_M \sim 0.09 - 0.04$

$\Delta G^e_A \sim 0.19 - 0.14$

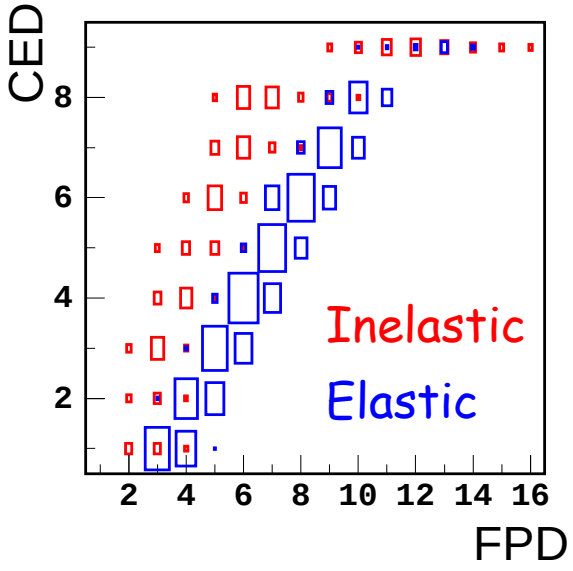
Cryostat-Exit Detectors *(new)*

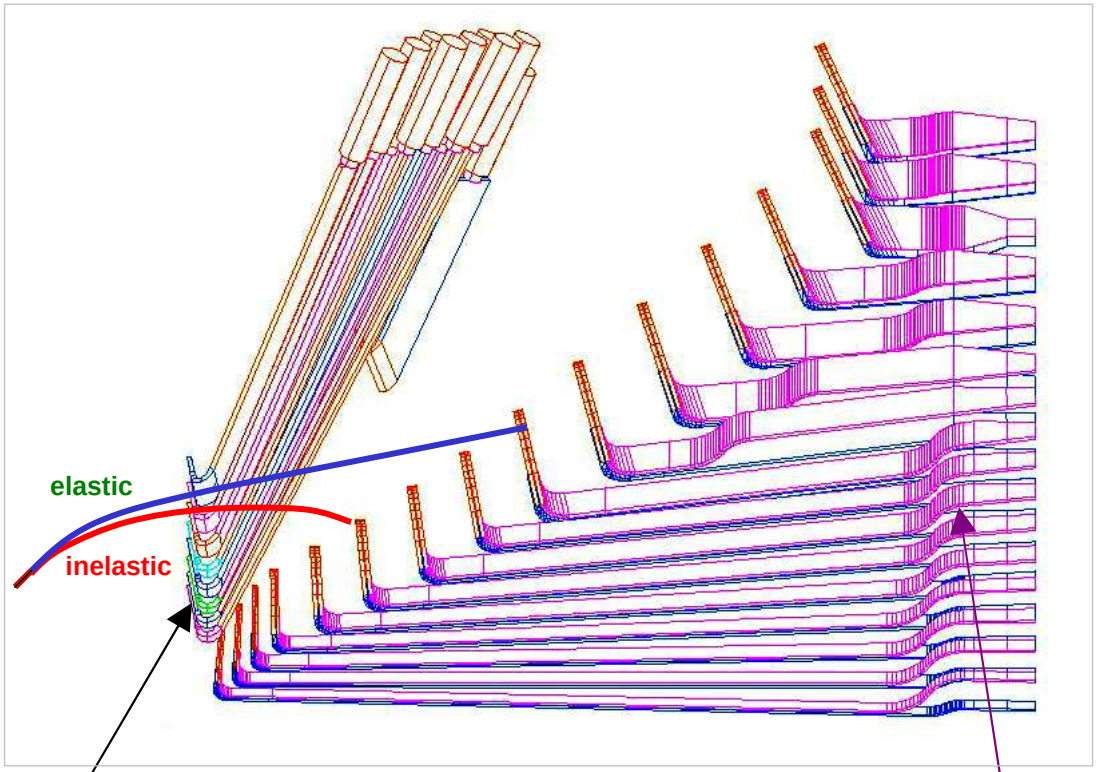
Measure back-scattered electrons

- Require additional det.^{s}: Cryostat-Exit Detectors (CED) (9 detectors per octant)
- CED-FPD coincidence to separate elastics/inelastics e^{-}
- Inelastics also interesting (N-Δ axial transition FF)



CED-FPD correlation at $Q^2 \sim 0.3$ (GeV/c)^2





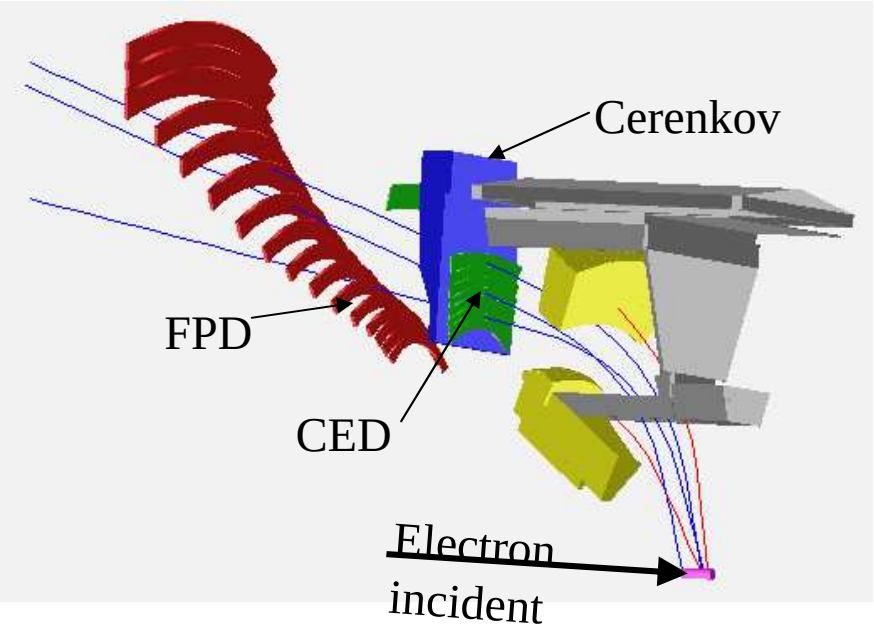
Cerenkov Detectors *(new)*

Back-scattered electron:

- CED-FPD coinc. separates elastic & inelastic e^- 's

Deuterium measurement:

- pion production off D_2
- $(\pi+\mu)/e$ ratio ~ 8:1 (at 0.8 GeV^2)
  [somewhat better at other Q^2]
- Pion rejection important
- Cerenkov for π^-/e^- discrimination
  [rejection factor ~125 ; δ-ray]



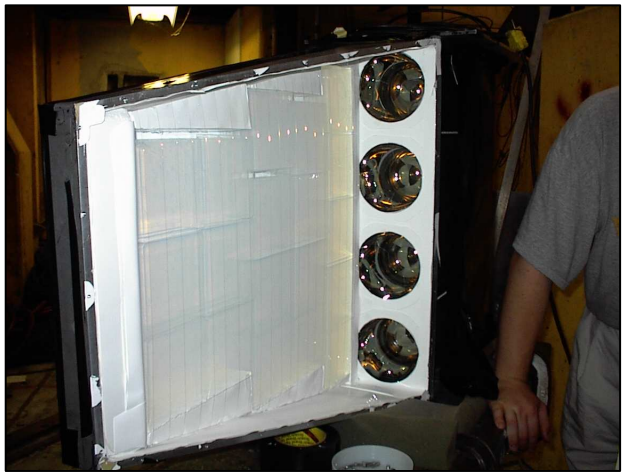
Cerenkov Detector:

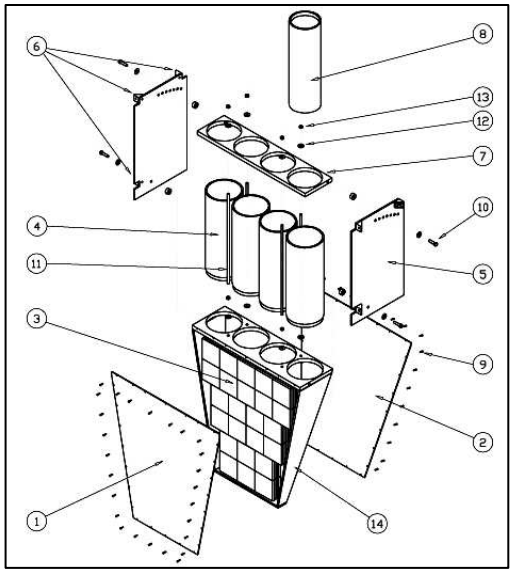
- single detector in each octant à 4 North American, 4 French detectors
- 5 cm of aerogel, n ~ 1.03, p_{thres} ~ 570 MeV
- diffuse reflection, viewed by 4 x 5 inch PMTs
- simulations: expect ~7 photoelectrons
- included in electron trigger

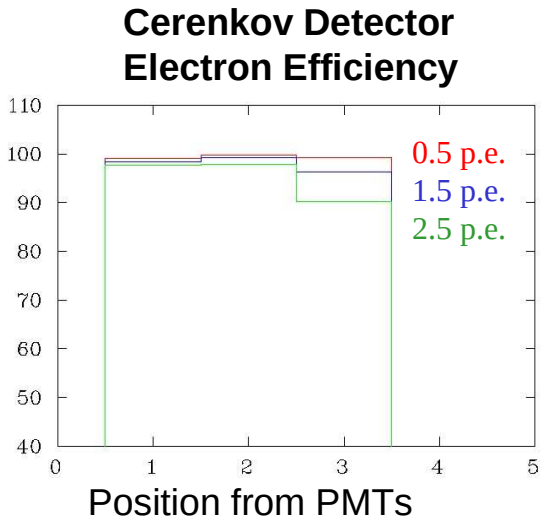
Aerogel Cerenkovs

Aerogel Cerenkov Detector: 11 x 11 x 1 cm^3 tiles (5 deep), Millipore-lined Light Diffusion Box

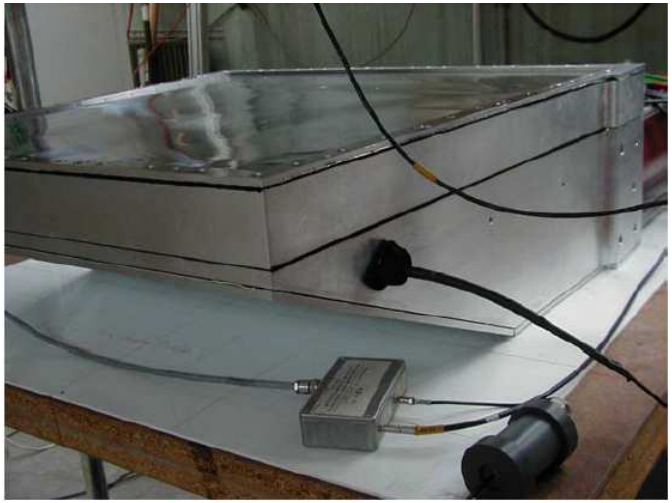
North American Cerenkov

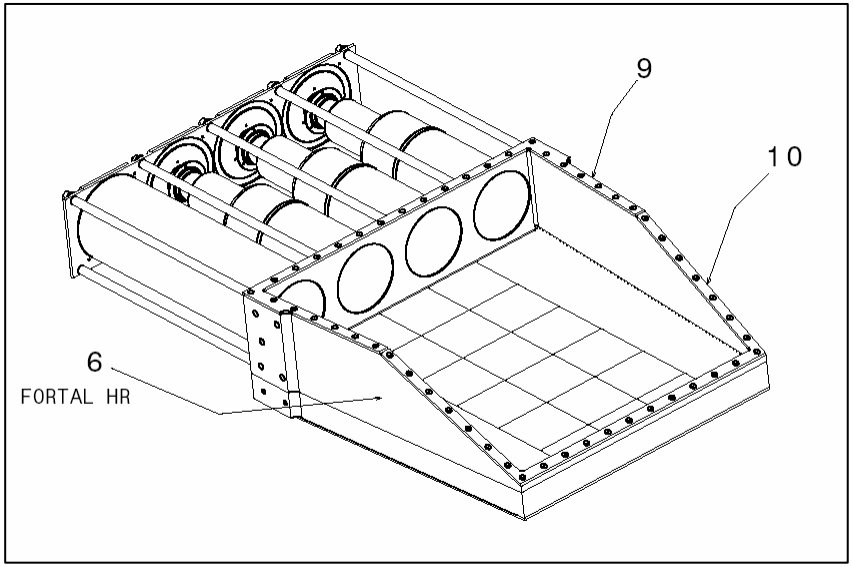




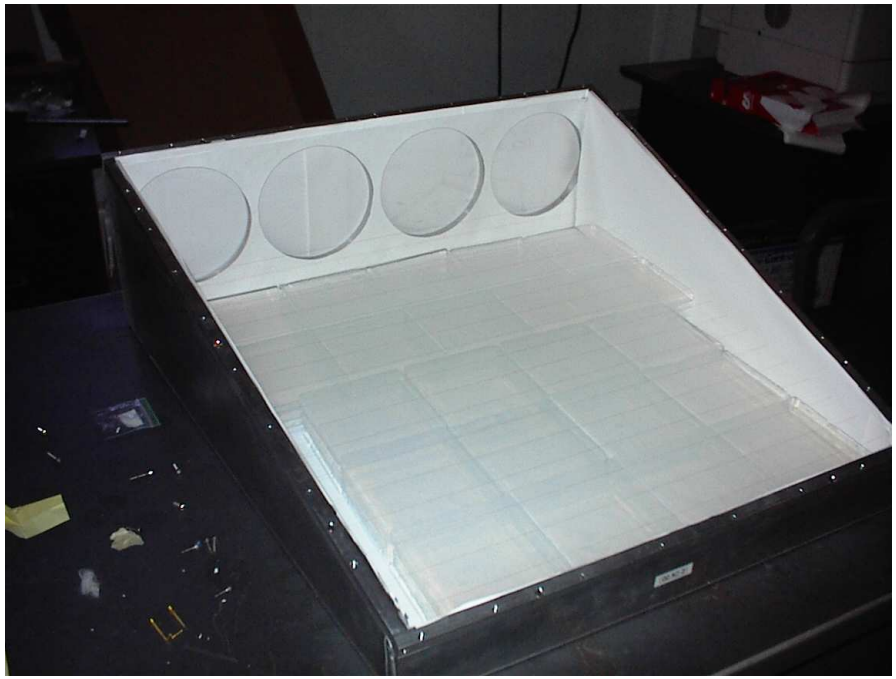


French Cerenkov





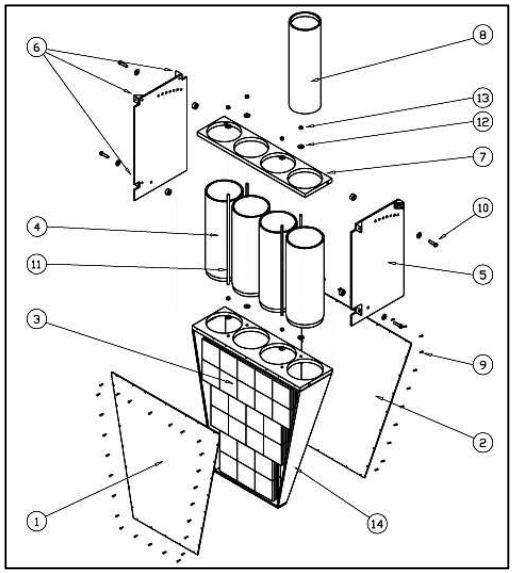
Detector Loaded with Aerogel and Retainer System



- Box with retainer inserted

- Passes the stand-up test
  (and upside down test)

N.A. Aerogel Cerenkov Tests



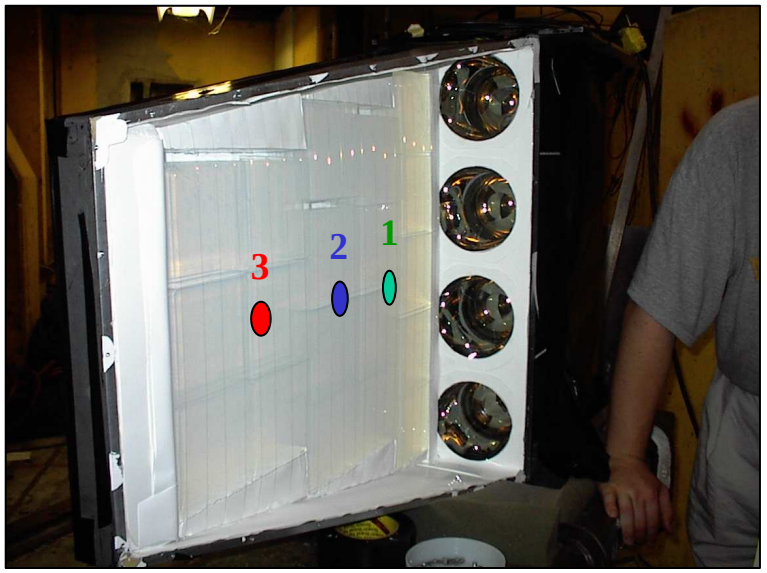
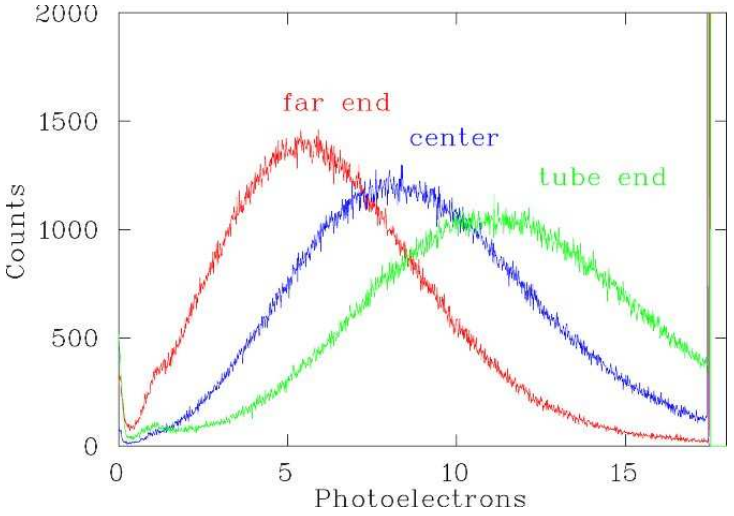
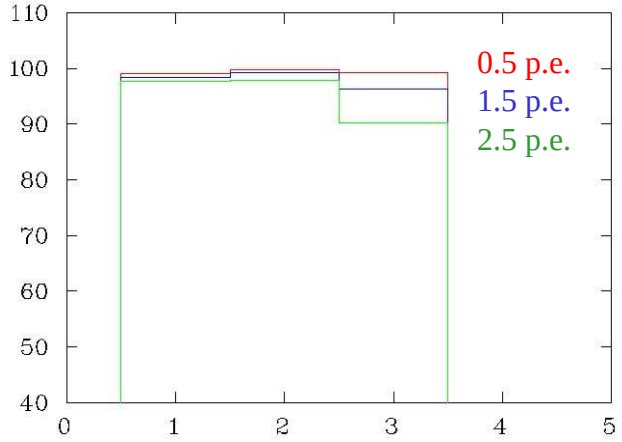


Photo-electron Yields

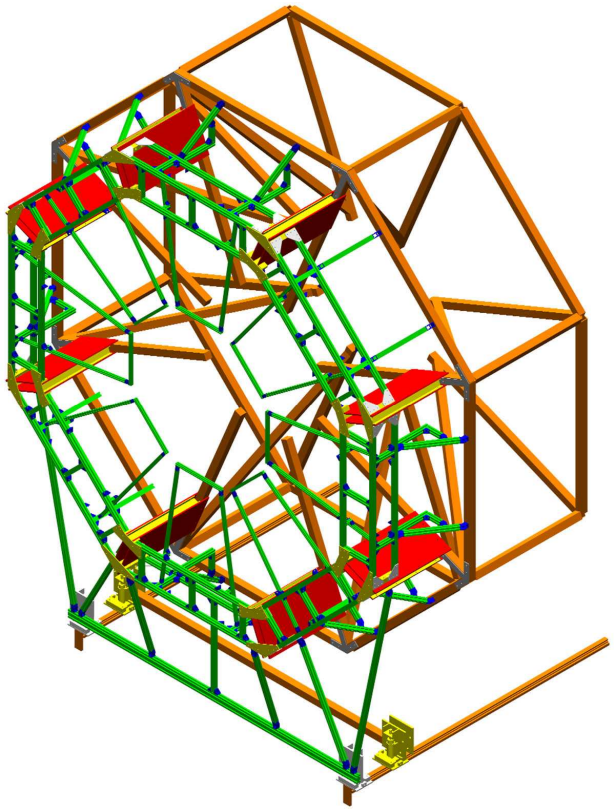


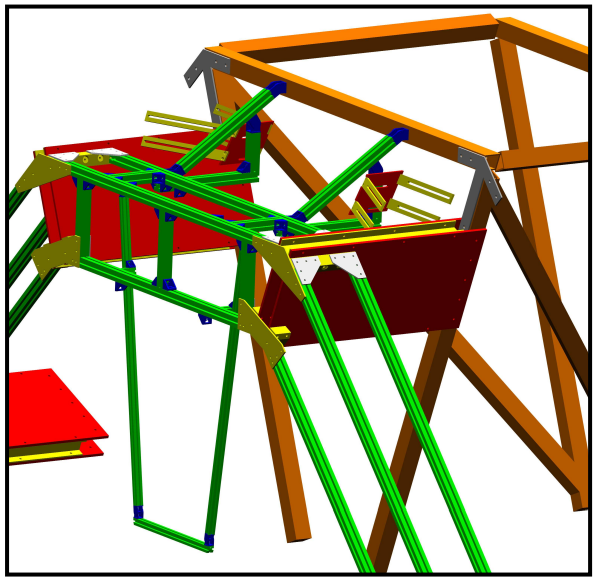
Detector Efficiency (electrons)



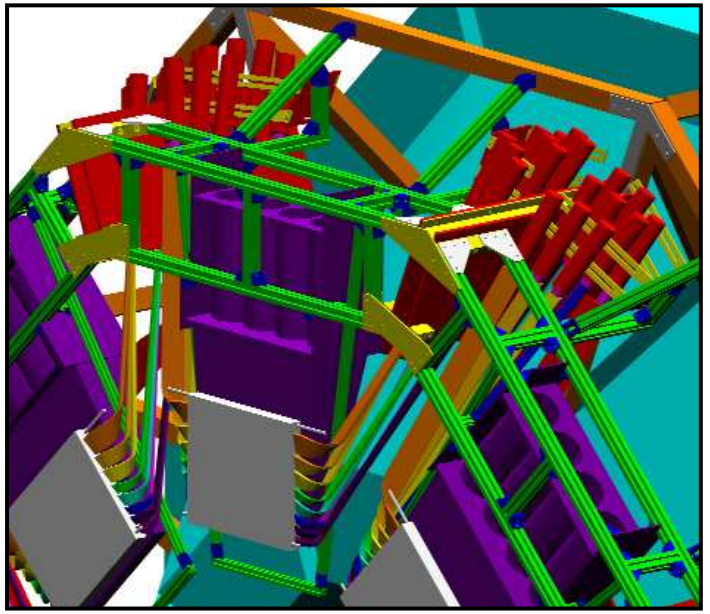
Position from PMTs

Cerenkov-CED Support Frame



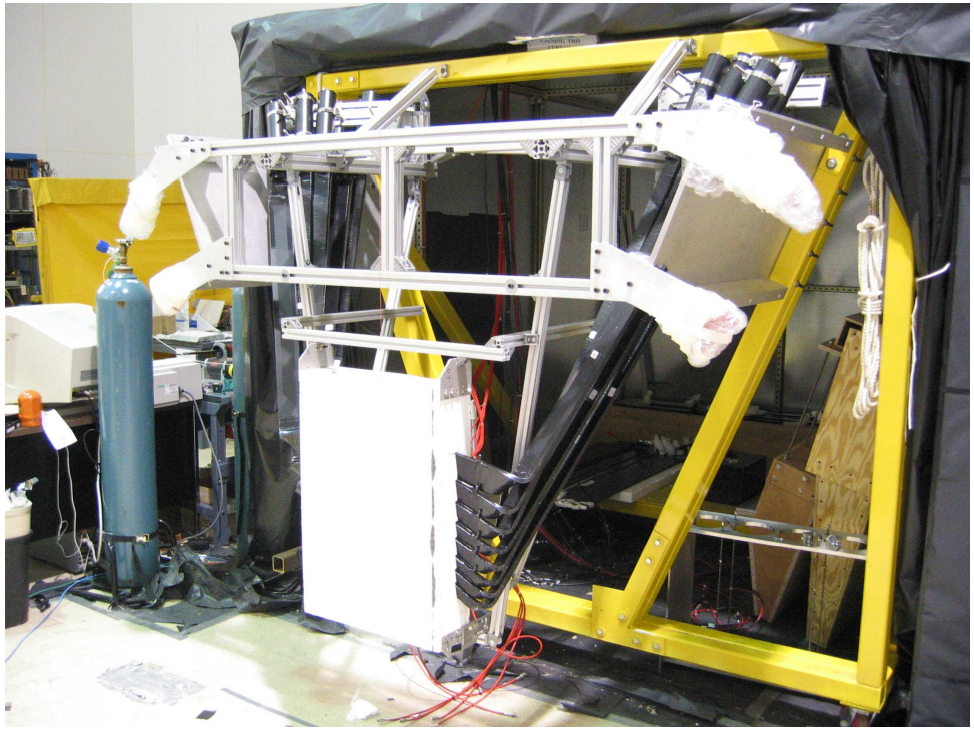


Octant-1 Support Frame



“Mini”-Ferris Wheel

- à Supports CEDs & Cerenkov Detectors
- à Supports lead (Pb) shielding
- à Coupled to existing FPD Ferris Wheel
- à Uses existing rail system



- Rohacel: Rigid, ***Machinable***, structural foam
  - Material: Polymethacrylimide (IG 71 PMI)
  - Physical Properties: 0.075(g/cm)
  - Radiation length: 545cm

Status of BackAngle Detectors & Electronics

Cryostat-Exit Detectors:

Scintillators & Lightguides
- fabrication completed, delivered to JLab
- Rohacell boxes: 2 per week.
- Assembly of octant-1 complete
- Assembly of octant – 2 underway

Aerogel Cerenkov Detectors:

French & NA
- fabrication of detectors complete
- One NA Cerenkov remains at TRIUMF for testing

Octant Frames:

- Complete.

General Assembly:

Octant completion
- Pace limited only by the gluing Light-Guides to scintillators.

Summary: G0 Backangle Configuration

- Measurement of elastic asymmetries at backangles
  - at Q^2 = 0.3, 0.5, 0.8 GeV^2
- Physics goal is to separate G^s_E, G^s_M, G^e_A
  - Measurements at forward and back angles on hydrogen target
  - Measurements at back angles on deuterium target
- Additional detectors and support structure required
  - Cryostat-Exit Detectors
  - Aerogel Cerenkov
  - Mini-Ferris wheel
  - New CED-FPD “coincidence” electronics
- Modifications to existing system required
  - G0 Magnet & Ferris Wheel “Turn-Around”
  - Target Extensions
  - Moller Polarimeter upgrades/modifications
- Beamtime (~ 70 days per Q^2 point)
  - 10 days commissioning time
  - 30 days on hydrogen target
  - 30 days on deuterium target