Hall B Status

Volker D. Burkert
Jefferson Lab

CLAS Collaboration Meeting
February 26 - 28, 2004

Run status
Publication status/analysis
Status of new projects
EG2 run
PAC25
Preparation of upcoming experiments
2004/2005 tentative run schedule

Hall B Status Overview

- Added 3 Staff Scientists: Harut Avakian, Alexandre Deur, Mary Bishai (June 1)

- 20 major CLAS production runs completed
  - e1a/b, g1a/b, g6a, e1c, e2a, g6b, g2a, g1c, g3, e1d, e5, eg1b, g8a, g6c, e1-6, e6, e2b, g7, e1e, e1f/g, eg2 (in progress) (+2 non-CLAS experiments: g5, radphi)

- Publications
  - 15 technical papers published
  - 26 physics papers published/accepted in PRL, PRC, PRD
  - 2 submitted
  - 6 in collaboration review

- Equipment in preparation for approved experiments
  - New Start Counter (photon runs, especially g11)
  - PrimEx (π^0 lifetime measurement)
  - Deeply Virtual Compton Scattering (Accessing GPDs)
  - BoNus Experiment (Neutron structure function)
  - Frozen Spin Target (search for missing N*'s)
  - New Cerenkov counter for one CLAS sector (for small Q^2 GDH)
  - Polarimeter for linearly polarized photons (g8)

- Initiative to calibrate the photon tagging energy system

- Prototyping effort for 12 GeV Upgrade – W-SciFi EC, SVT, ToF

Technical Publications

Torus Magnet		IEEE Mag.25 (1989) 1902
Drift Chambers		
construction	Mac Mestayer	NIM A323 (1992) 191
update	Mac Mestayer	NIM A367 (1995) 316
Region I	Dan Carman	NIM A419 (1998) 315
Region II	L.M. Qin	NIM A411 (1998) 265
Summary	Dan Carman	NIM A449 (2000) 81
Cerenkov Counter	Paul Stoler	NIM A465 (2001) 414
TOF Counters	Elton Smith	NIM 432 (1999) 265
Start Counters	Simon Taylor	NIM A462 (2001) 484
Forward Cal.	Cole Smith	NIM A460 (2001) 239
Large Angle Cal.	Mauro Taiuti	NIM A447 (2000) 431
Tagging System		
window	Jim O'Brien	NIM 421 (1999)
tagger	Jim O'Brien	NIM 440/2 (2000) 263
Polarized target	Chris Keith	NIM A501 (2003) 327
CLAS Overview	Bernhard Mecking	NIM A503 (2003) 513

Hall B Physics Publications (PRL/PRC/PRD)

- 26 – published
- o 2 - submitted
- ➢ 5 - in collaboration review

Hadron Structure & Spectroscopy

- η-Electroproduction in the S11(1535) region, PRL86 (2001) 1702
- Double Spin Asymmetry in ep->eπ^+n, PRL88 (2002) 082001
- N->Δ(1232) Multipoles from π^0 Electroproduction, PRL88 (2002) 122001
- QED Padiative Corrections in Exclusive Pion Electroproduction PRD66 (2002) 074004
- η-Photoproduction on the Proton, PRL89, (2002) 222002-1
- Polarisation transfer in ep->eK$^+\Lambda$, PRL90,131804 (2003),
- Single Quark Transition Analysis of N* Excitations in [70,1-], PRC67, 035204 (2003)
- ep -> ep$\pi^+\pi^-$ and baryon resonance analysis, PRL91, 022002-1(2003)
- First measurement of beam-target spin asymmetry in ep->epπ^0, PRC 68, 035202
- Measurement of $\sigma_{LT'}$ in the Δ(1232) region PRC {\bf 68}, 032201 (2003)
- Evidence for an Exotic Baryon State with S=+1, on Deuterium PRL 91, 252001 (2003)
- o Photoproduction of K$^+\Lambda/\Sigma$, PRD submitted, nucl-ex/0305028 (2003)
- ➢ Electroproduction of ep -> enπ^+ in the first and second resonance region, CLAS review
- ➢ Single Spin Asymmetry in ep -> eπ^+n , in the Δ(12232) region, CLAS review
- Evidence for Θ^+(1540) excitation on protons, PRL 92, 0322001 (2004).

Hall B Physics Publications – cont'd

Structure Functions & Hard Processes

- Inclusive spin structure function in eD -> eX, PRC67, 055204 (2003)
- F2 and Moment analysis in ep-> eX, PRD 67 (2003)
- Inclusive double polarisation asymmetry, g_1, Γ_{1p}, PRL 91, 222002.
- ϕ-Photoproduction at large t, PRL85 (2000) 4682
- ϕ-Electroproduction, PRC63 (2001) 065205-1
- $K^+\Lambda(1520)$ Electroproduction, PRC63 (2001) 044601
- ρ^0-Photoproduction, PRL87 (2001) 172002
- Beam Asymmetry in DVCS PRL87 (2001) 182002
- Photoproduction of ω mesons at high t, PRL90, 022002-1 (2003)
- o Beam Single Spin Asymmetry in ep->eπ^+X in the DIS kinematics, PRL submitted, nucl-ex/0301012
- ➢ Deeply exclusive ρ^0 production, CLAS review
- Tensor Polarization of the ϕ meson photo-produced at high t, PRC RC accepted.

Nuclear Processes

- Photofission of Heavy Nuclei, PRL84 (2000) 5740
- Photofission of Heavy Nuclei, PRC65, 044622 (2002)
- Nuclear Scaling in A(e,e') at x>1, PRC 68, 014313 (2003)
- Two-Nucleon Momentum Distributions in ^{3}He(e,e'pp)n, PRL 92, 52303 (2004).
- ➢ Deuteron Photo-disintegration
- ➢ Proton source size in eA -> eppX

Hall B Publication Overview (refereed Journals only)

	Hadron Spectroscopy & Structure	Hard scattering & Structure F.	Nuclear processes	Sum
2000	-	1	1	2
2001	1	4	-	5
2002	4	-	1	5
2003	6	4	2	12
2004	1 +1 + 2	1 + 1 + 1	2	2+2
Sum	12 +1 + 2	10 + 1 + 1	4 + 2	26+ 2+5

Published/accepted submitted in CLAS review

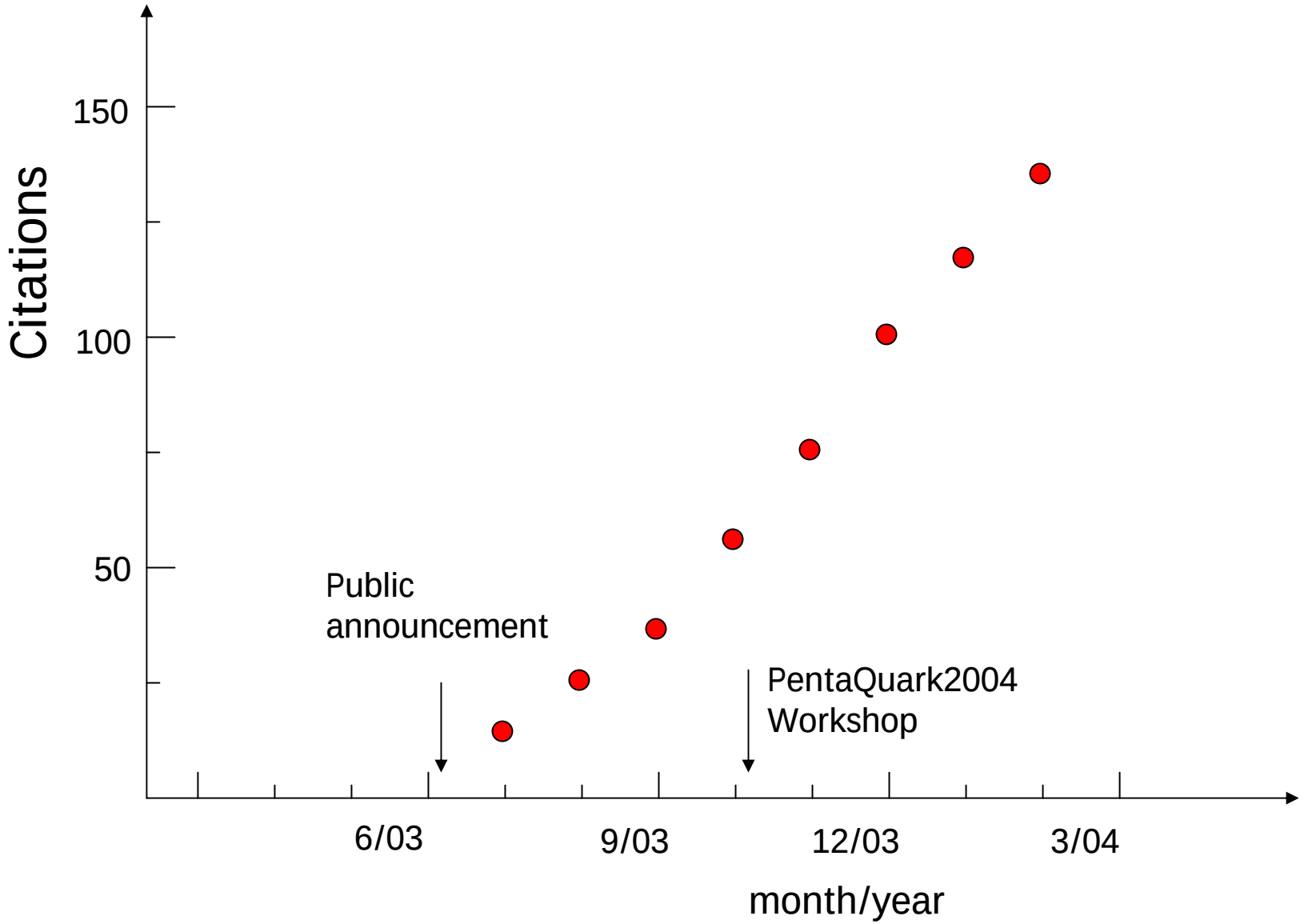
Physics Impact of CLAS Data I

Paper	Physics	#citations (>20) 02/08/04	
PRL 85 (2000) 4682	ϕ-Photoproduction at high t	33	
PRL 86 (2001) 1702	Study of $S_{11}(1535)$ in η electroproduction	24	
PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	91	CAA
PRL 88 (2002) 182002	Multipoles in the $\gamma^*N\Delta(1232)$ transition	29	
PRL 91 (2003) 252001	Evidence for an Exotic Baryon State with S=+1 on deuterium	134	CAA
PRL 92 (2004) 32001	Evidence for an exotic Baryon with S=+1 on Protons	30	

Physics Impact of CLAS Data II

Paper	Physics	#spires citations per month>0.7	
PRL 85 (2000) 4682	ϕ-Photoproduction at high t	0.7	
PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	3.0	CAA
PRL 88 (2002) 182002	Multipoles from $\gamma^*N\Delta(1232)$ transition	1.2	
hep-ex/0301005	SSA in SIDIS $\vec{e}p \to e\pi^+X$	1.2	CAA
PRL 91 (2003) 252001	Evidence for exotic baryon on deuterium	18	CAA
PRL 92 (2004) 032001	Evidence for exotic baryon on protons	10	CAA

Cumulative Citations for Θ^+ Paper on D_2.



Important Events since last CLAS Meeting

- PRIMEX readiness review November 20, 2003
  - 12 member panel, chair: Dave Mack
  - Report: PRIMEX "on track for commissioning and physics running in early summer 2004"

- December 2 – 10: Luminosity test for DVCS calorimeter (100 $PbWO_4$ crystal in close proximity to electron beam).

- December 10 -13: PRIMEX luminosity test run

- December 15 – now, eg2 run at 4 GeV and 5 GeV

- PAC25 Meeting.

DVCS Experiment

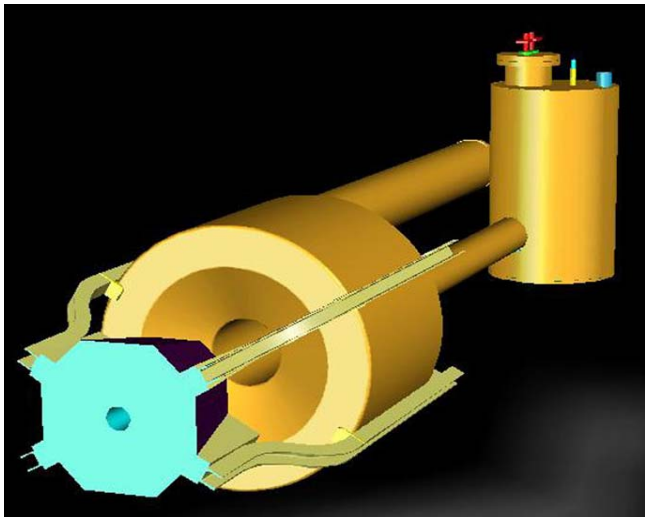
- Approved for 60 PAC days of running @ 6 GeV
  Access to GPDs through DVCS.
  Institutions: ITEP, JLab, Orsay, RPI, Saclay, UVa

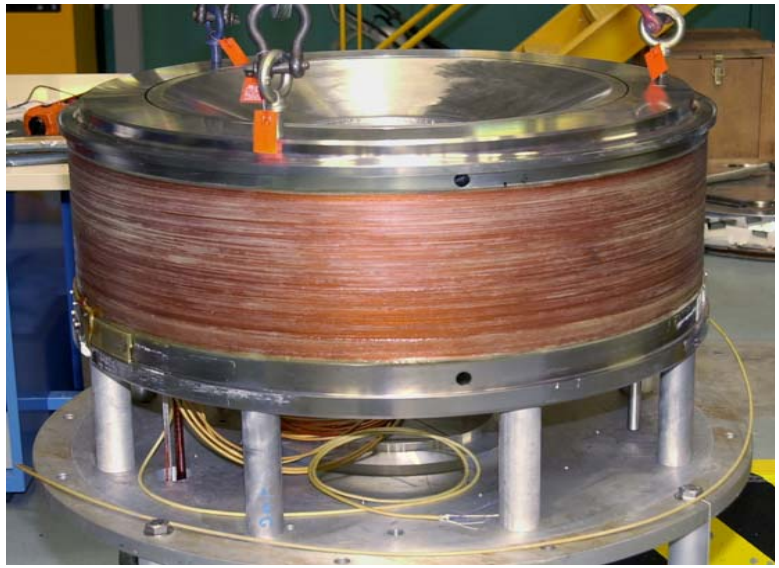
Major new components:

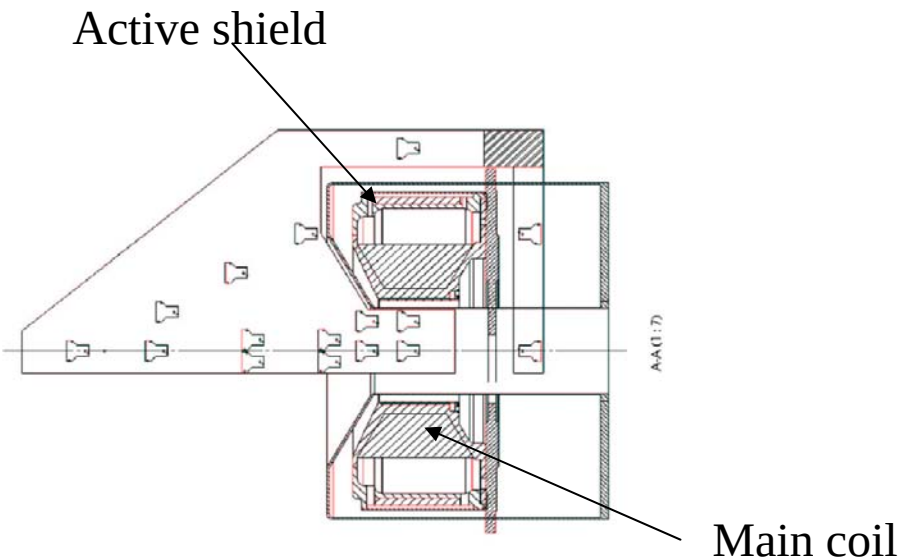
- High granularity calorimeter array
  - 424 $PbWO_4$ tapered crystal (15x15x160 mm3)
  - APD readout (high magnetic field operation)
  - Low noise pre-amplifiers
  - Laser light monitoring system

- Superconducting solenoid for Möller electron shielding

DVCS Experiment – Solenoid (Saclay)



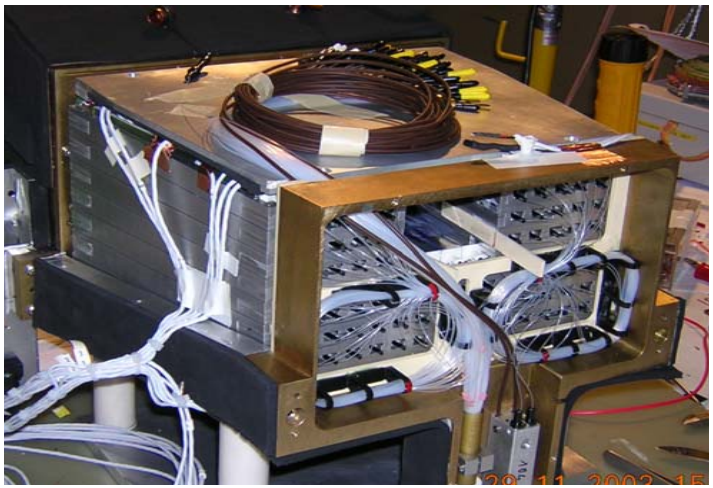


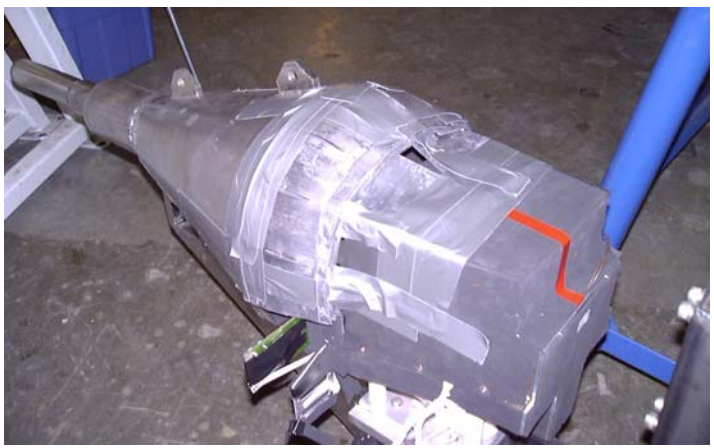


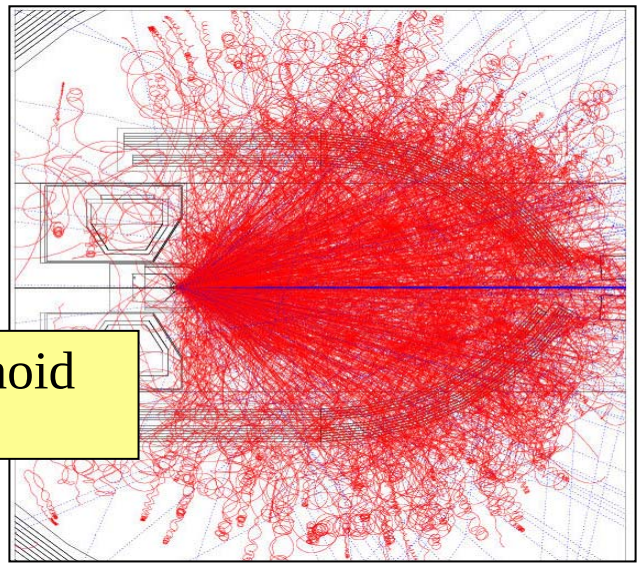
- 2/2004 - Map field for warm coil
- 8/25/2004 - Delivery to JLab
- Fall/2004 - Safety review
- 10/1/2004 – Ready for installation

DVCS $PbWO_4$ Prototype Test Run

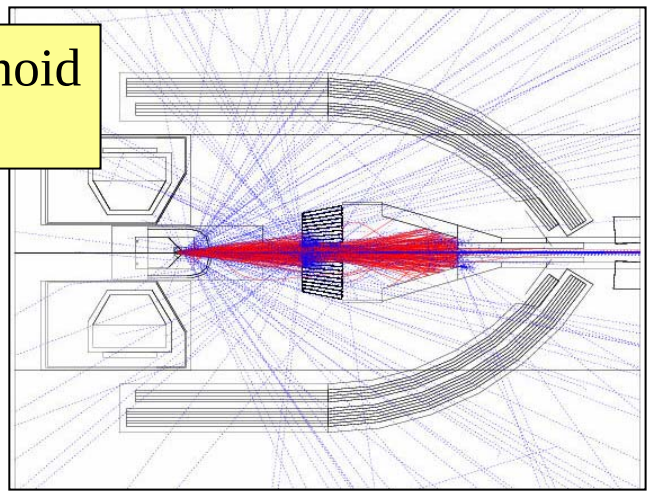
- 100 crystal with APDs/pre-amps/ADC/TDC
- Calorimeter performance
- Luminosity limitations
- Use Helmholtz coils as shield (for solenoid)



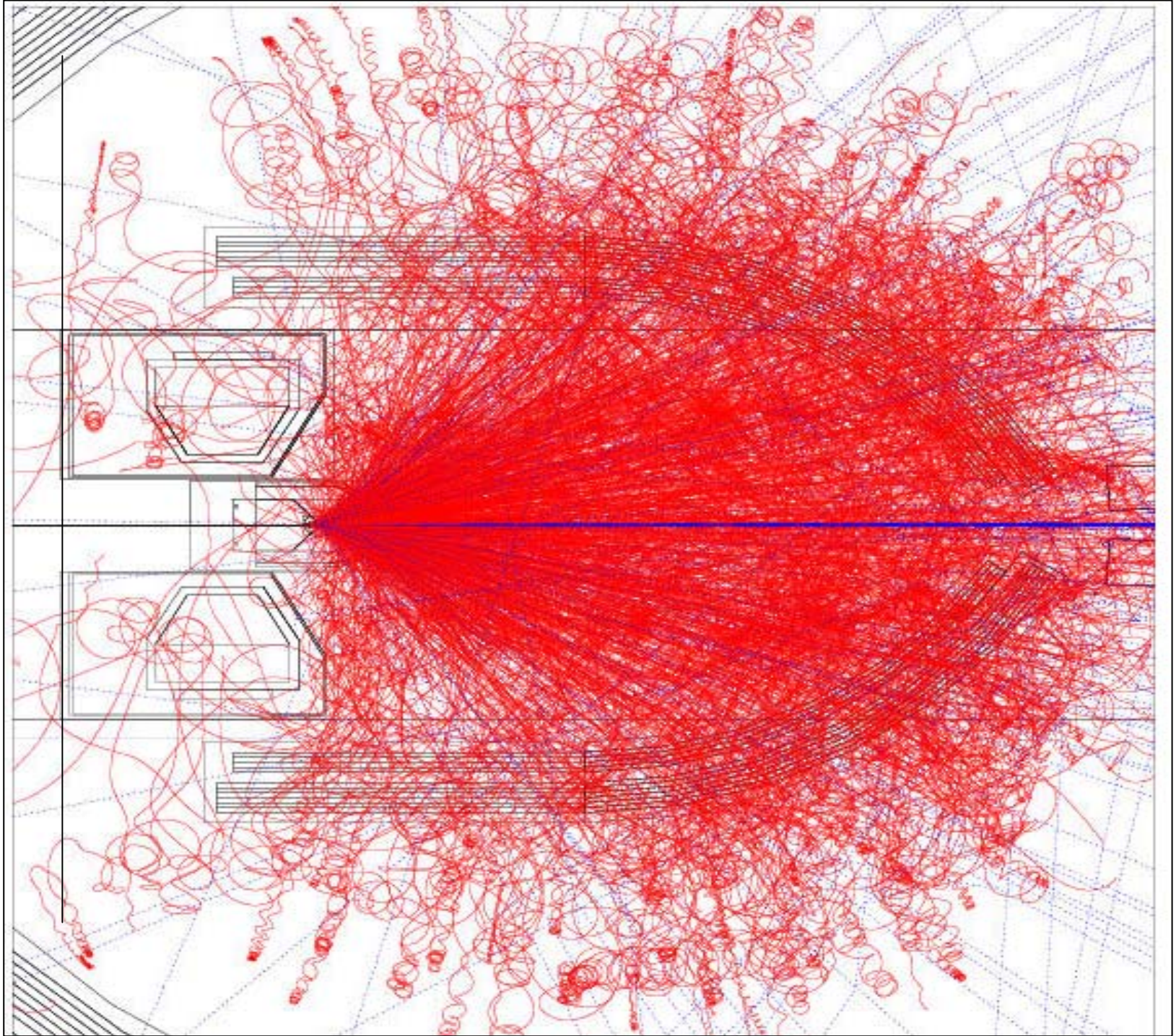


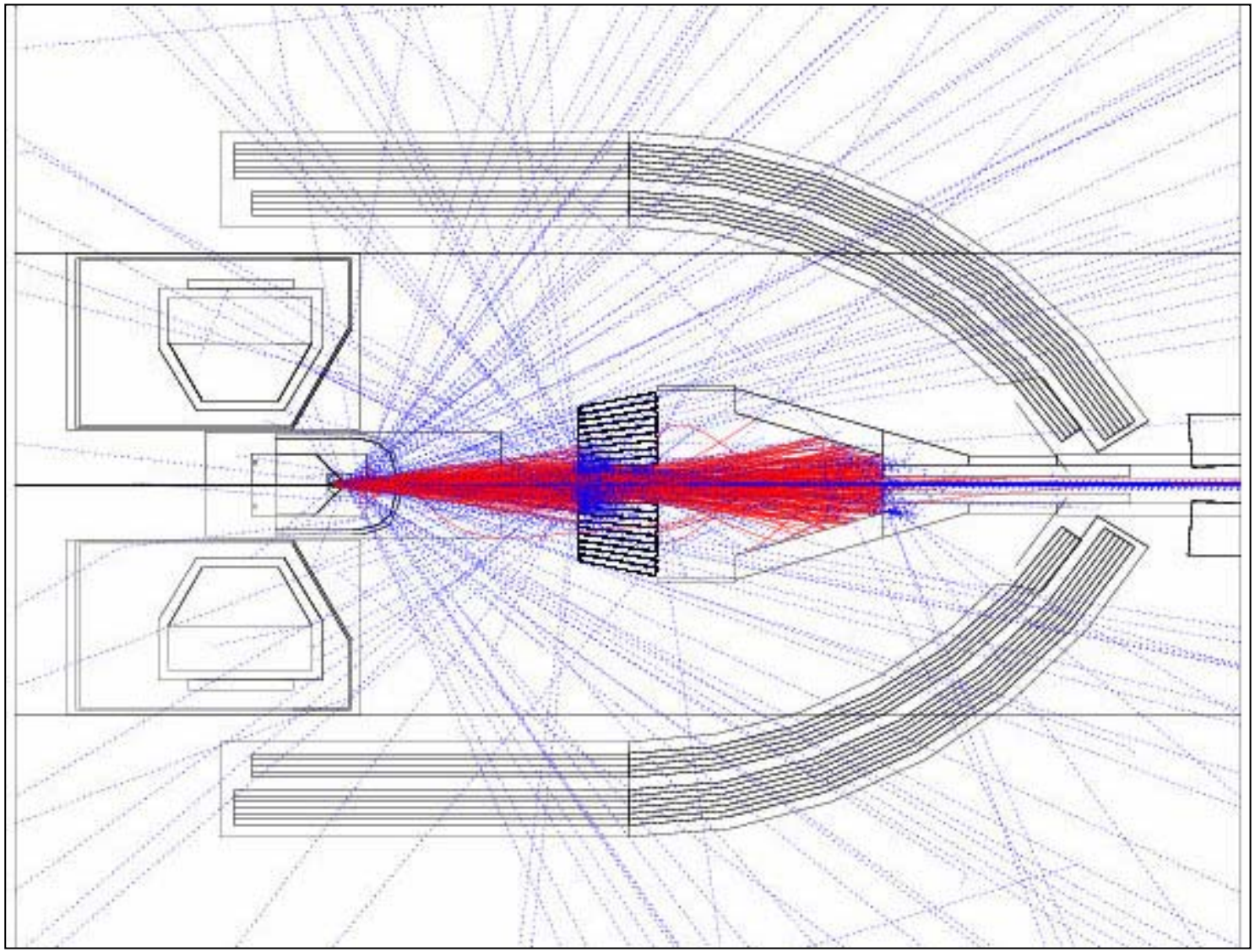


Solenoid OFF.

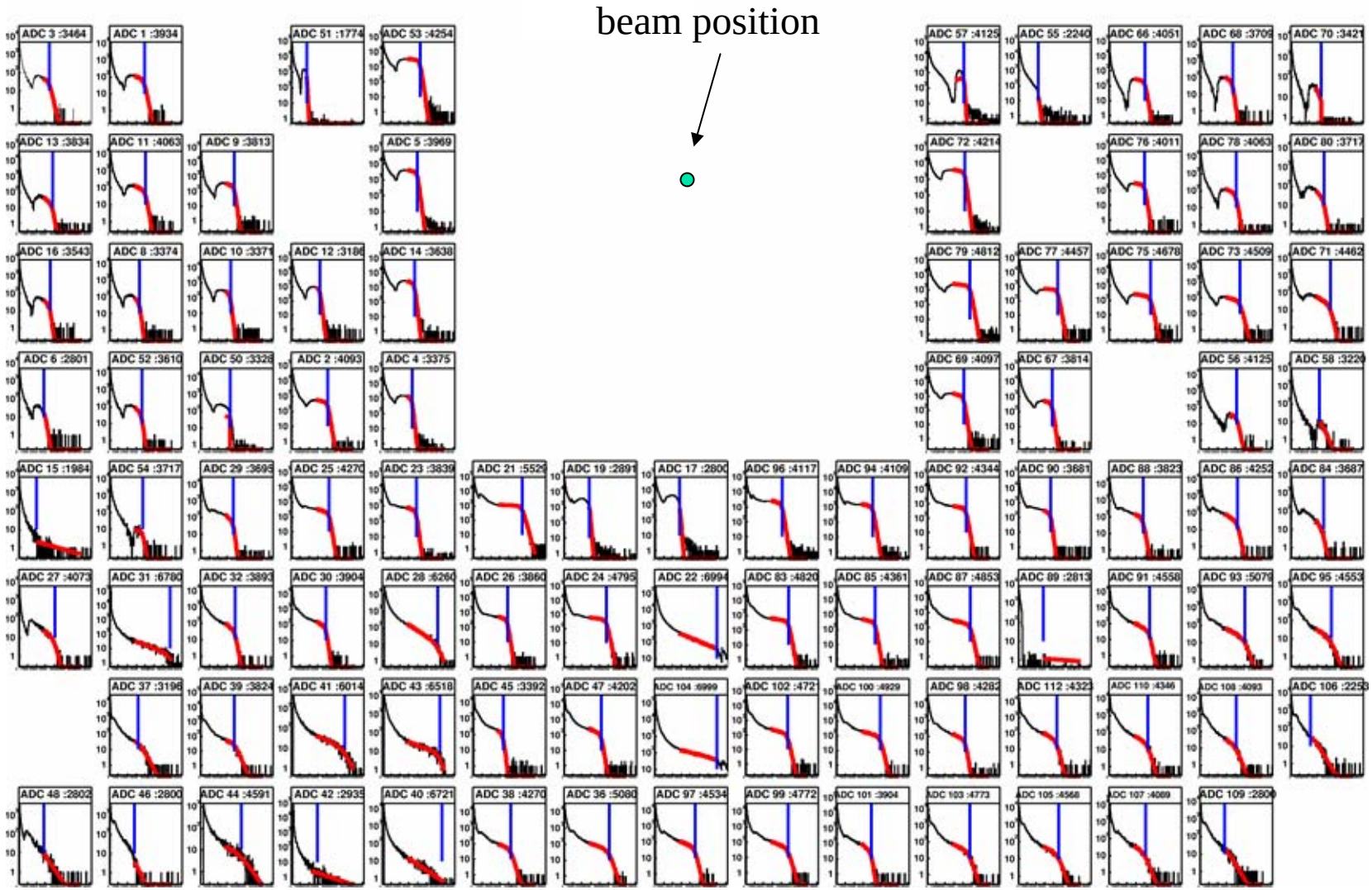


Solenoid ON.





DVCS $PbWO_4$ Prototype Test Run

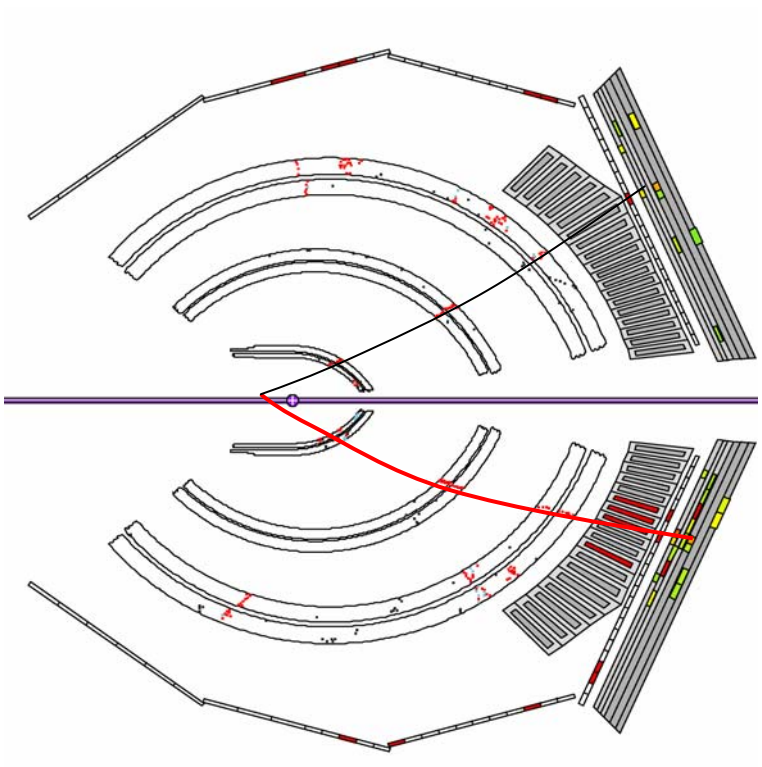


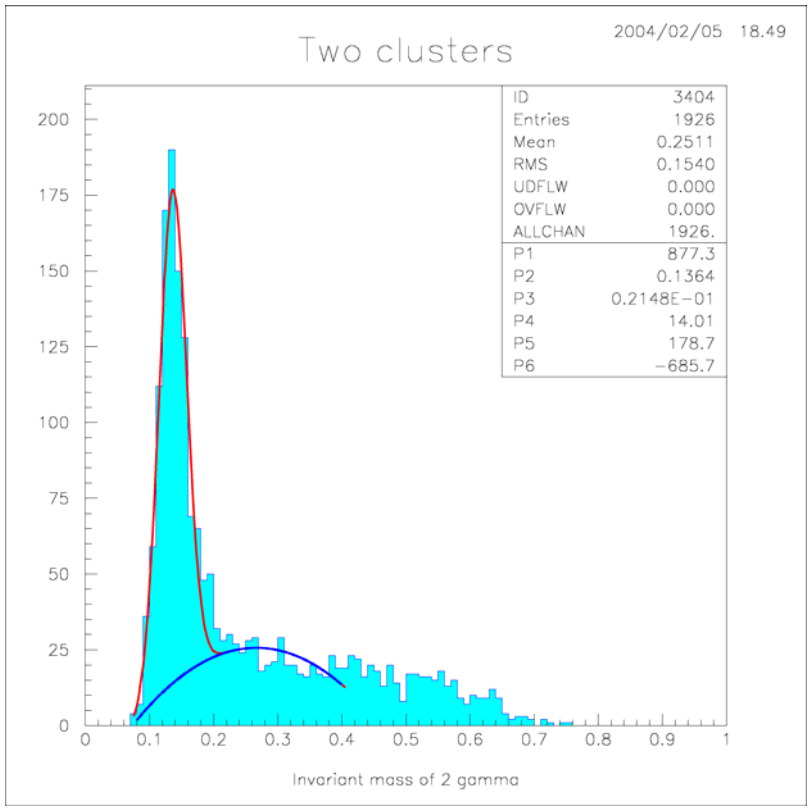
DVCS $PbWO_4$ Prototype Test Run

Run 40651 I = 18 nA

$\sigma_{\gamma\gamma}$ = 21 MeV,
(expect ~ 10 MeV)

$L = 1.8 * 10^{34}\ cm^{-2}s^{-1} * A/Z$





DVCS $PbWO_4$ Prototype Test Run

Main results:

- Luminosity in experiment not limited by calorimeter but by the drift chamber over current protection.

- Experiment can run at a luminosity of $(3\text{-}4)*10^{34}\ cm^{-2}s^{-1}$ on ^{12}C Target, corresponding to $(1.5\text{-}2)*10^{34}\ cm^{-2}s^{-1}$ hydrogen equivalent.

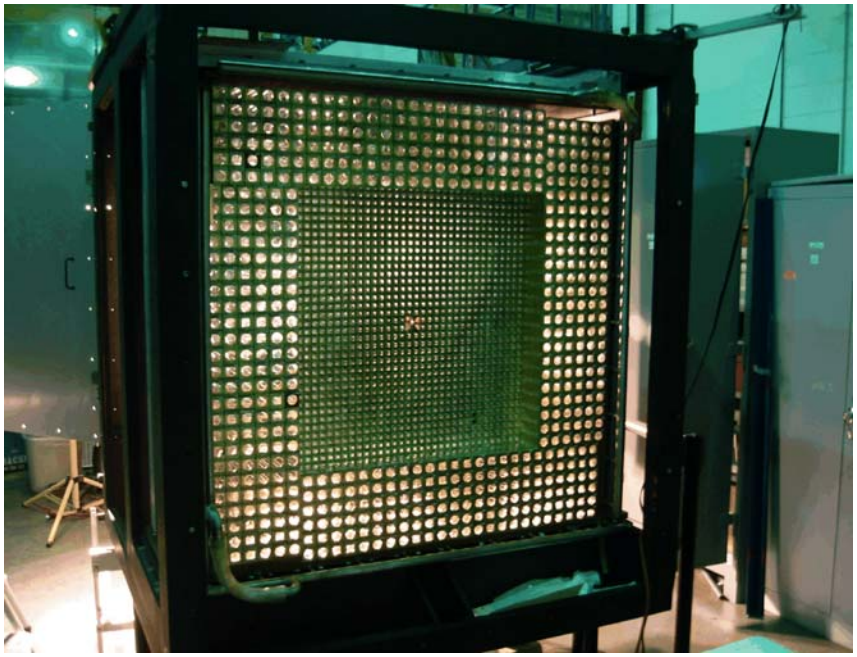
- Learned a lot about:
  - sensitivity of low noise electronics
  - cross talk and oscillations
  - laser light monitoring system
  - effect of temperature variations
  - ……

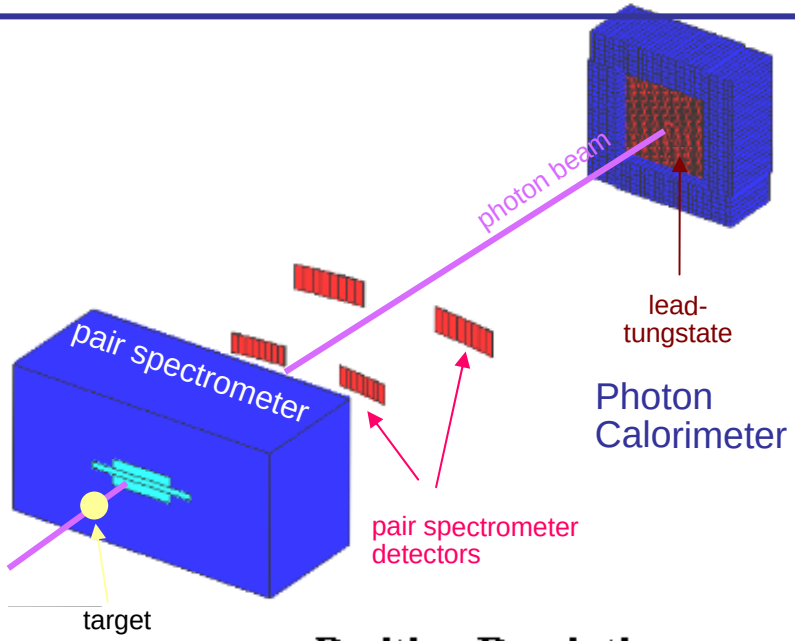
PrimEx Experiment

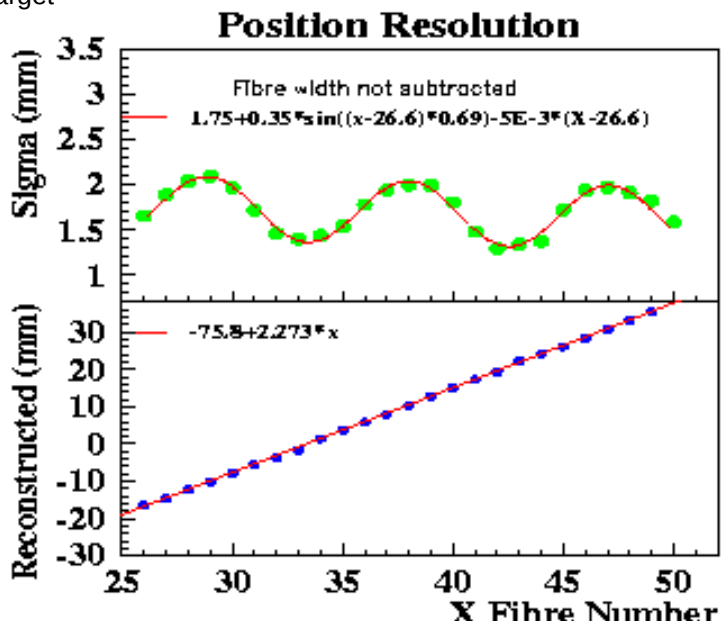
Purpose: Precise measurement of the π^0 lifetime using the Primakoff process. Absolute cross section measurement.

Hybrid Calorimeter (HyCal)

Needed to reconstruct $\pi^0 \rightarrow \gamma\gamma$ events

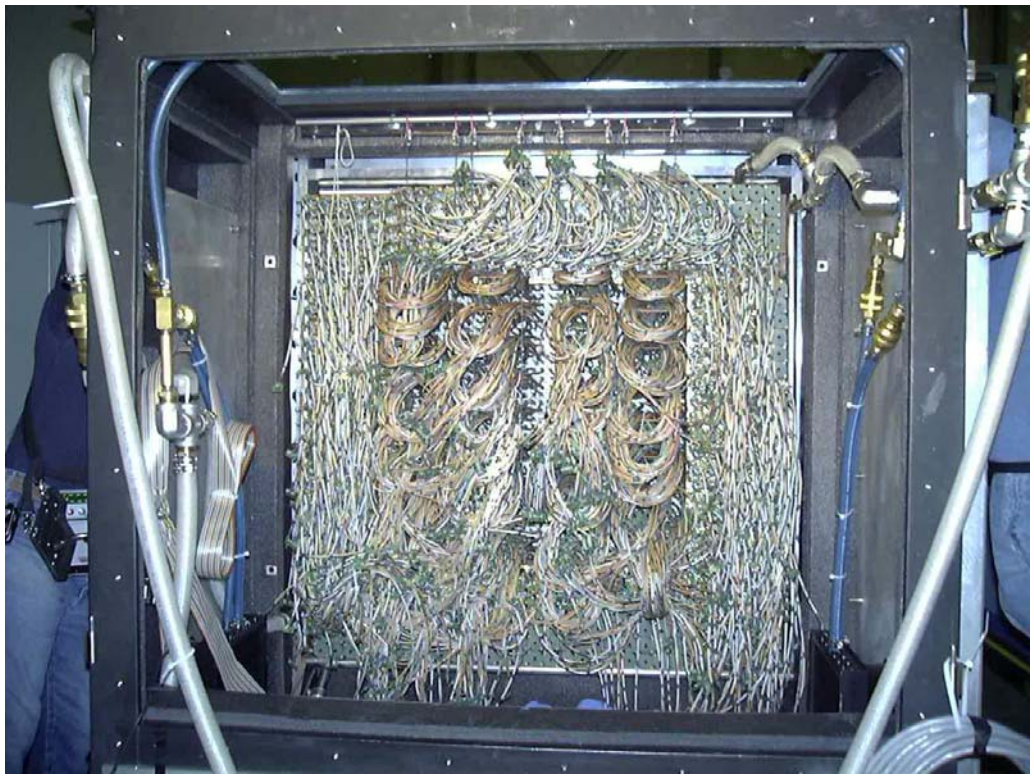




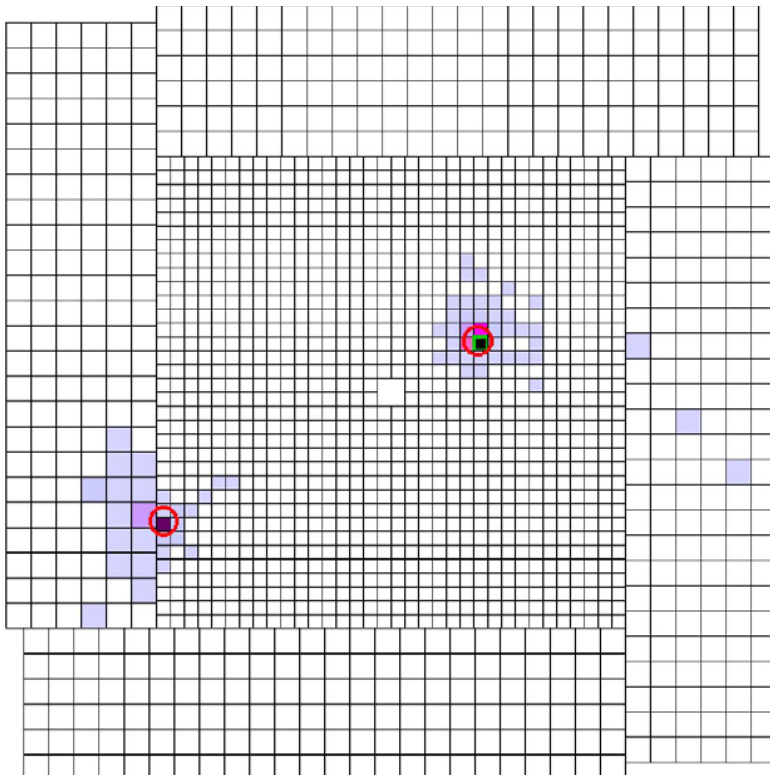


PrimEx Experiment, cont'd

View from the back



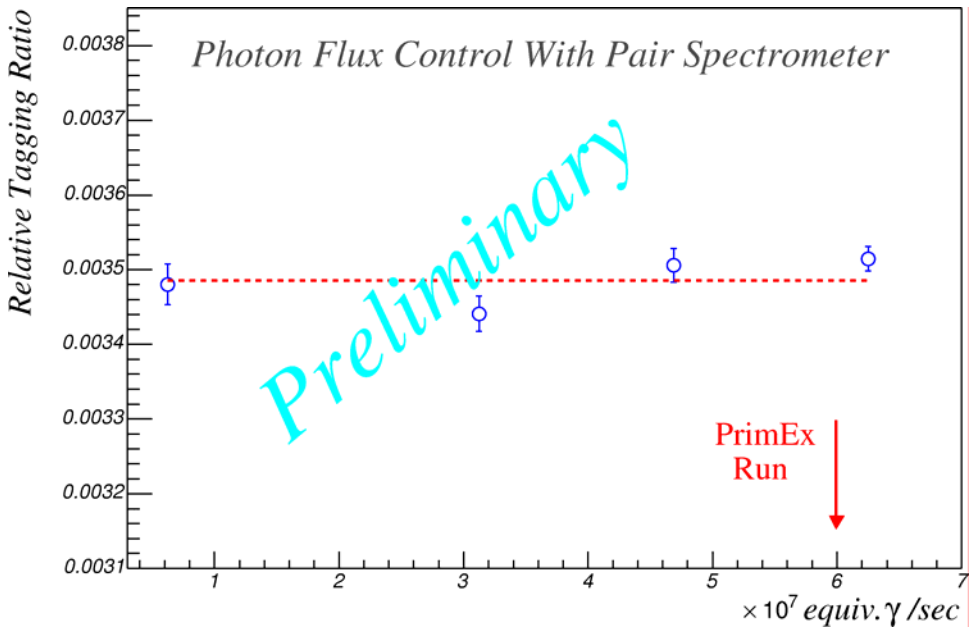
A simulated π^0 event in HyCal



Primakoff Experiment (PrimEx)

- Pair spectrometer for relative photon flux monitoring at the 1% level.

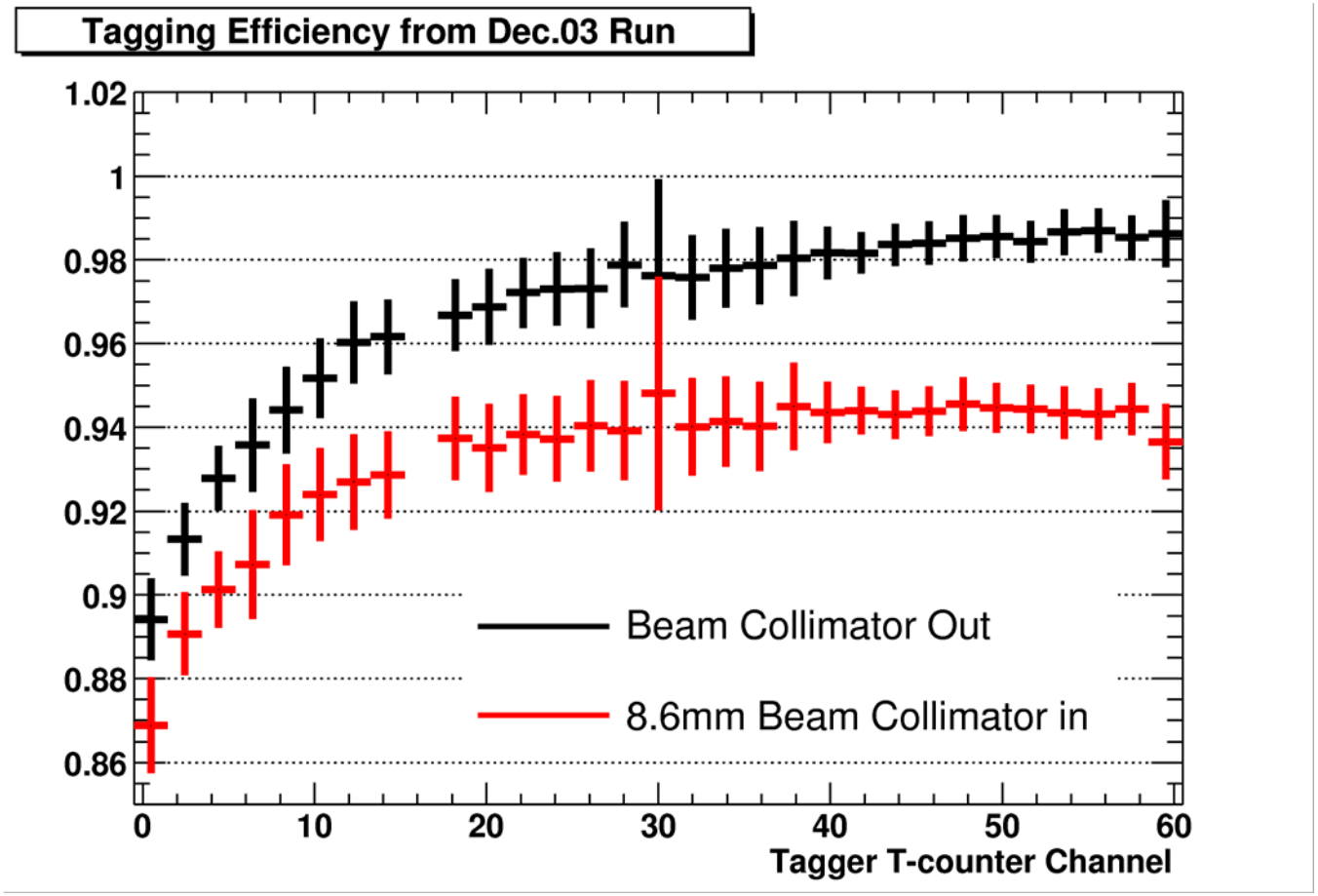
2 days test run Dec. 2003



- Infrastructure installed in Hall B to move the complete HyCal vertically and horizontally through the beam for calibration.

PrimEx Experiment, cont'd

Test run Dec. 2003

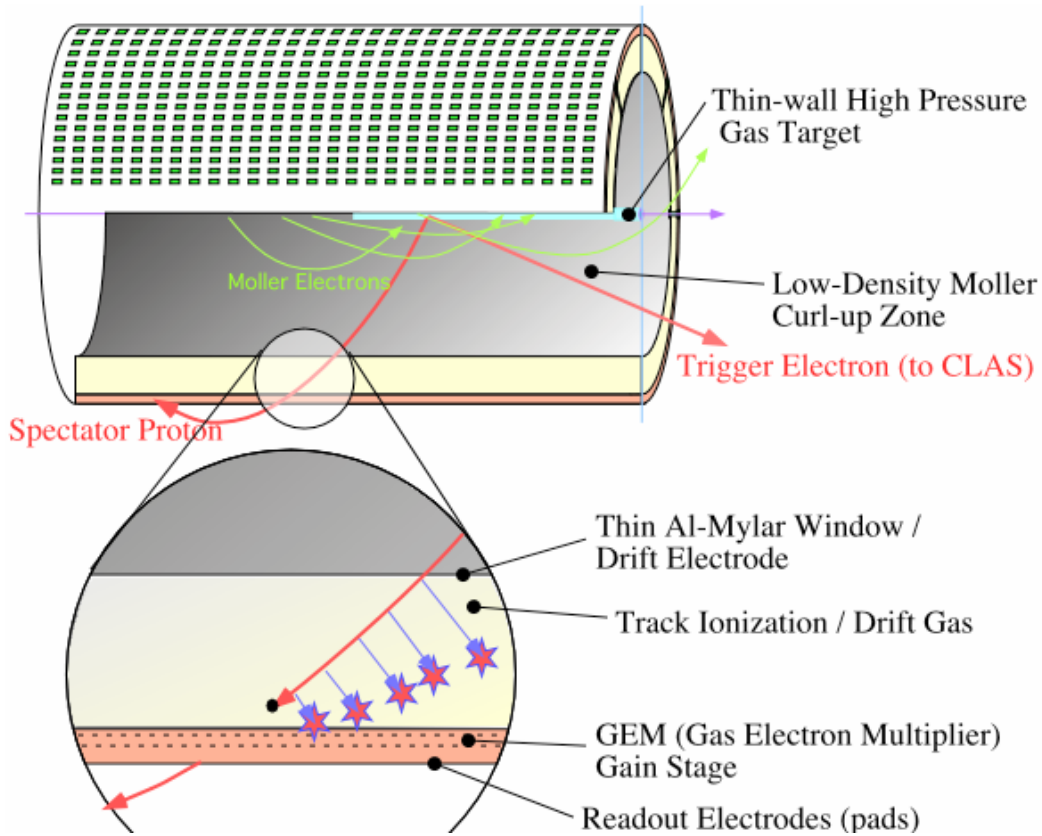


The BoNuS Detector

(needed for experiment E03-012; Neutron structure functions measurement.)

Goal: detect spectator protons with momenta as low as 70 MeV/c

Radial Time Projection Chamber (RTPC)

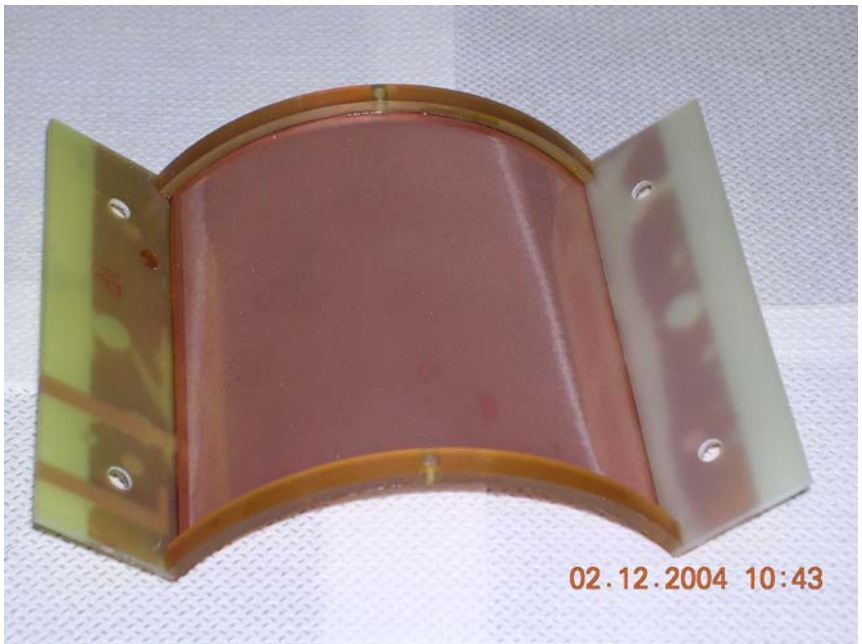


Status of the BoNuS Experiment

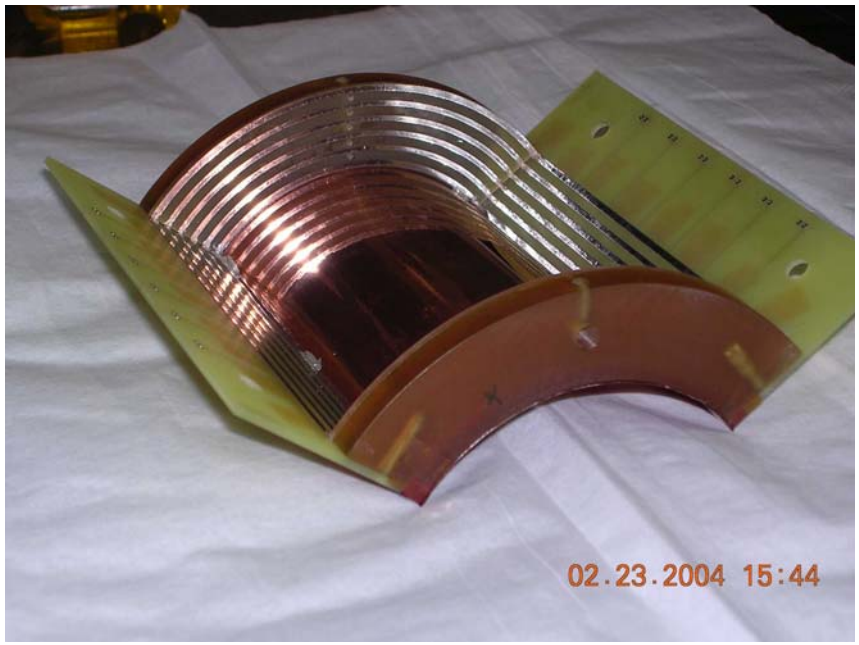
- Construction of curved prototype Radial Time Projection Chamber under way
  - GEM foil planes built with improved gain (>100)
- Test of prototype RTPC in February and March at Jlab and with slow protons at TUNL
- Readout electronics ordered from CERN (ALICE)
- Final design of RTPC during March incorporating experiences obtained from construction of prototype RTPC

Status of the BoNuS Experiment

- One of three GEM foil planes for curved prototype RTPC after gluing at ODU
- Standard 10 x 10 cm^2 GEM foil from 3M Corp.



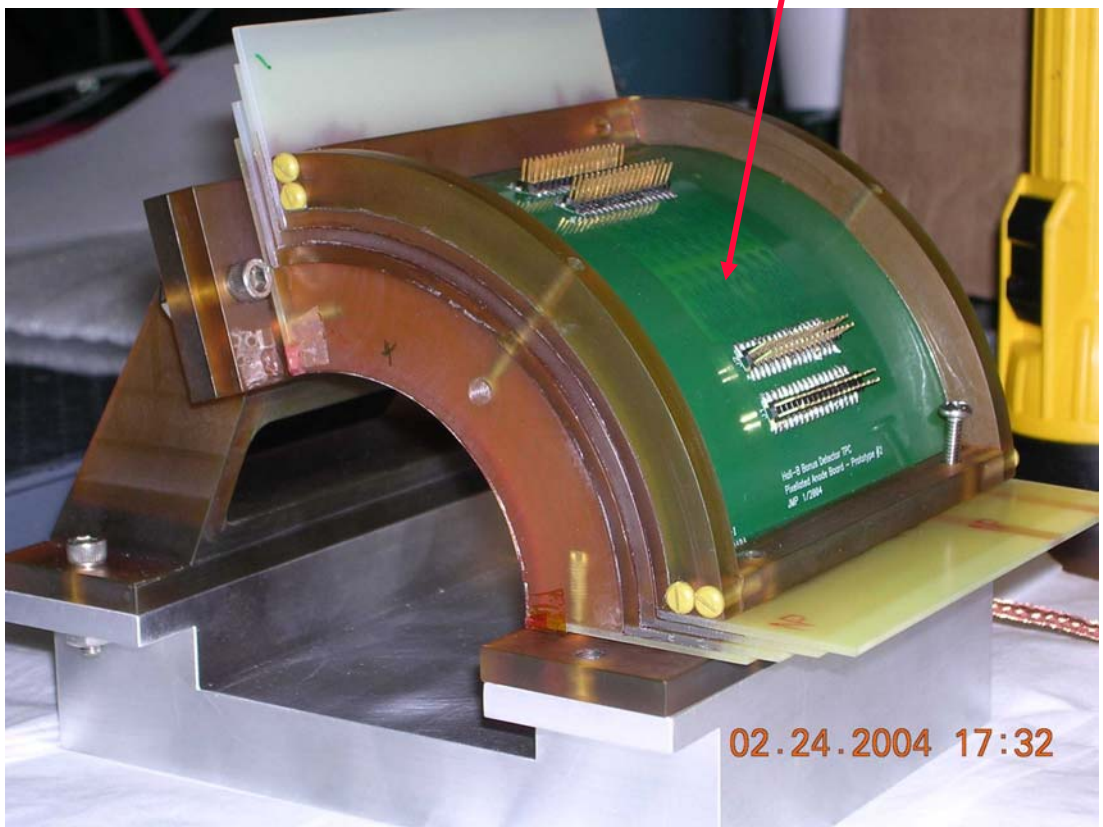
Drift region with cathode plane
(field shaping potential lines visible)



Status of the BoNuS Experiment

- Test fitting the prototype RTPC at Jlab

Pad readout plane with connectors

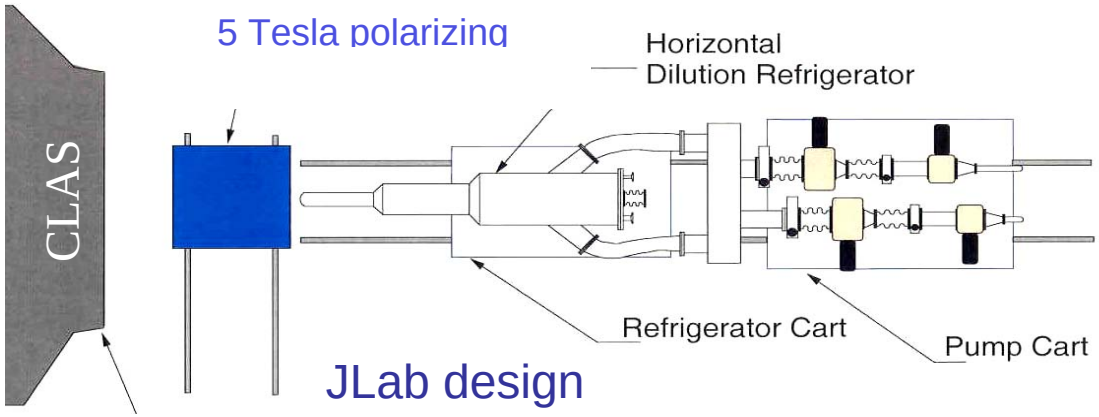


- Overall mechanical design with C. Hutton
- Artwork for readout plane with J. Profitt
- Cathode plane development with J. Segal and M. Wissmann

Frozen Spin Target for CLAS

Technical problem:

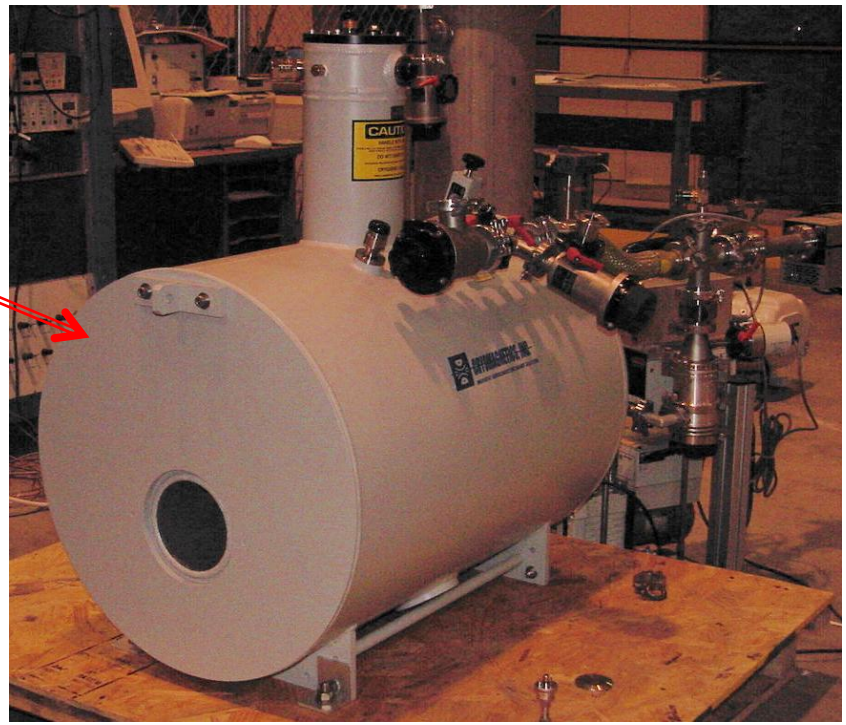
- build polarized target for tagged photon beam
- minimum obstruction of CLAS solid angle
- low distortion of particle trajectories in magnetic field



Solution:

- frozen spin target
- temperature 50mK
- magnetic field 5kG

Polarizing Magnet (in EEL)

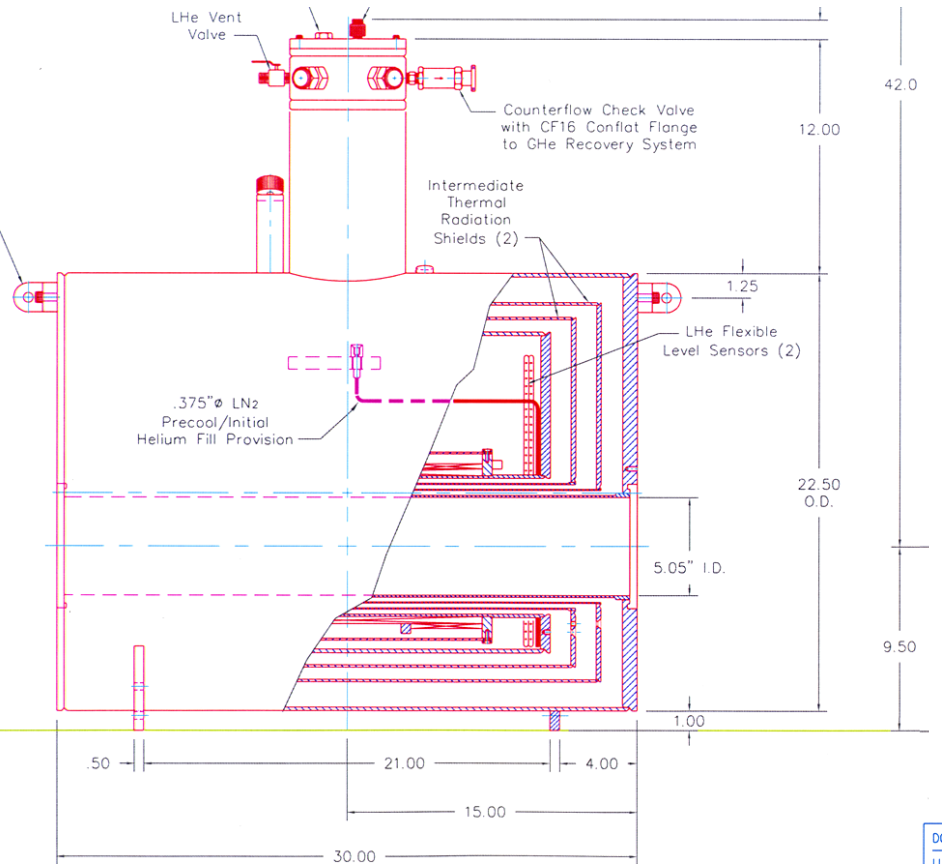


Status:

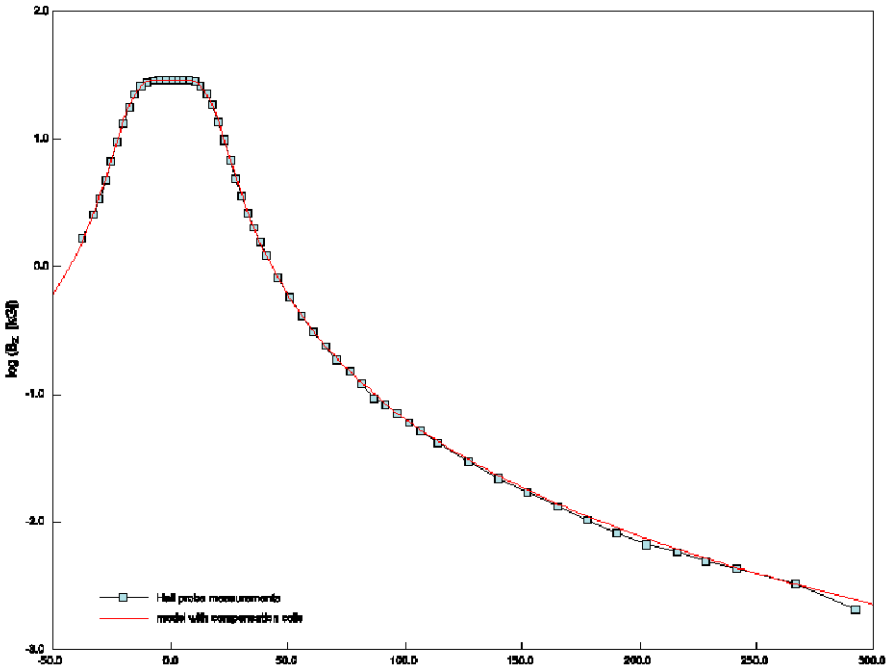
- design completed at JLab
- polarizing magnet delivered, energized to full field, field distribution measured
- Holding coil prototype built

Hall B: Frozen Spin Target for *CLAS*

Magnet layout



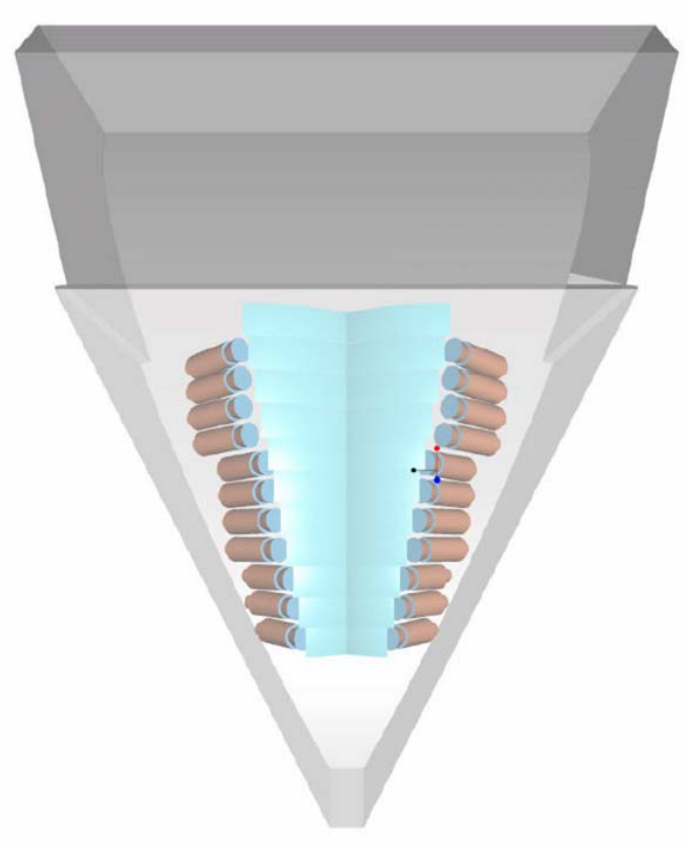
Longitudinal magnetic field distribution –
measured vs computed



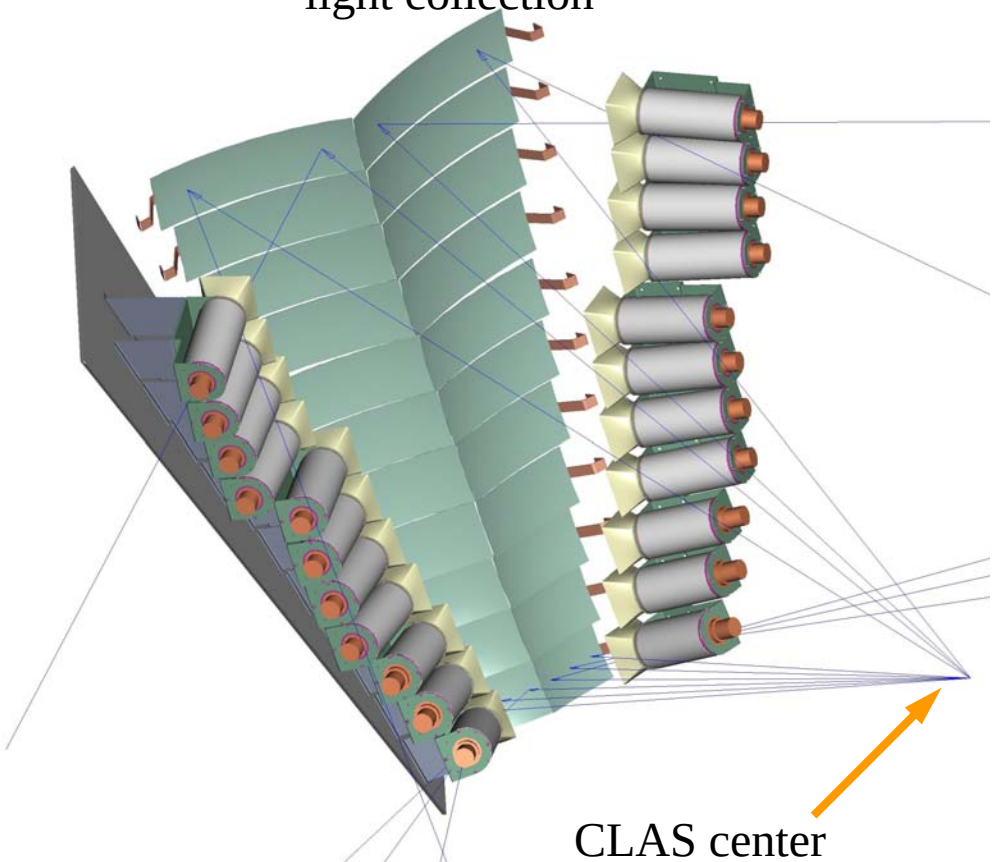
Small Angle Cerenkov Counter for CLAS

Needed for a measurement of the GDH integral at small Q2
M. Ripani, A. Deur, M. Battaglieri, R. DeVita, co-spokespersons

Detect scattered electrons at very small angles.



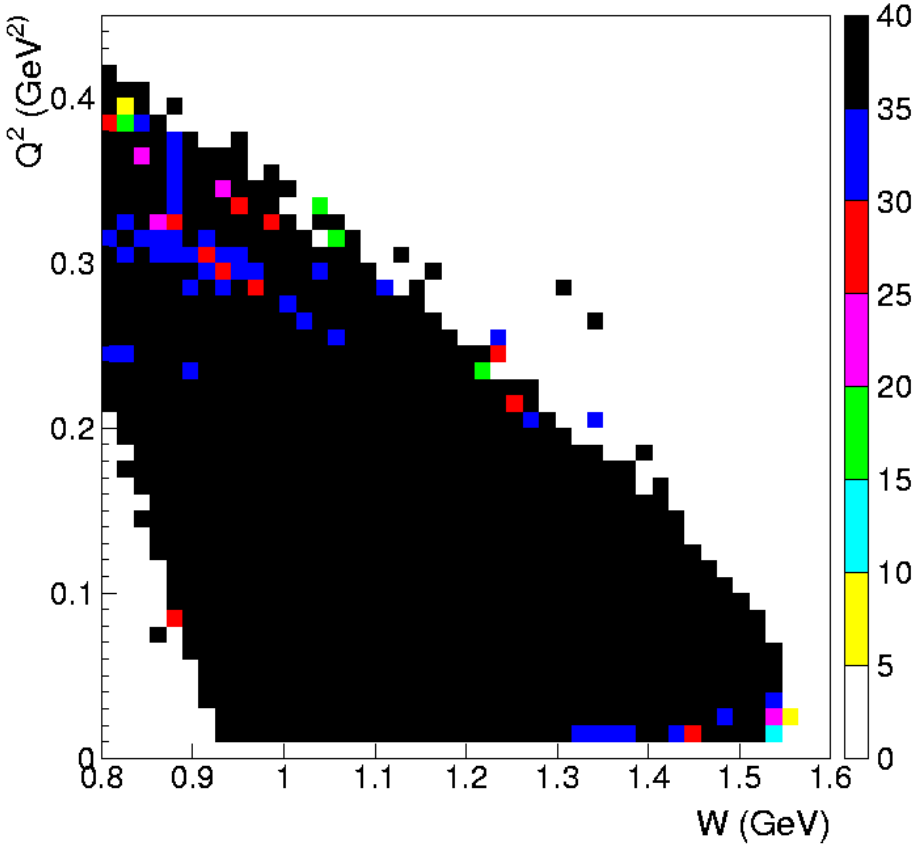
CAD implementation & test of light collection



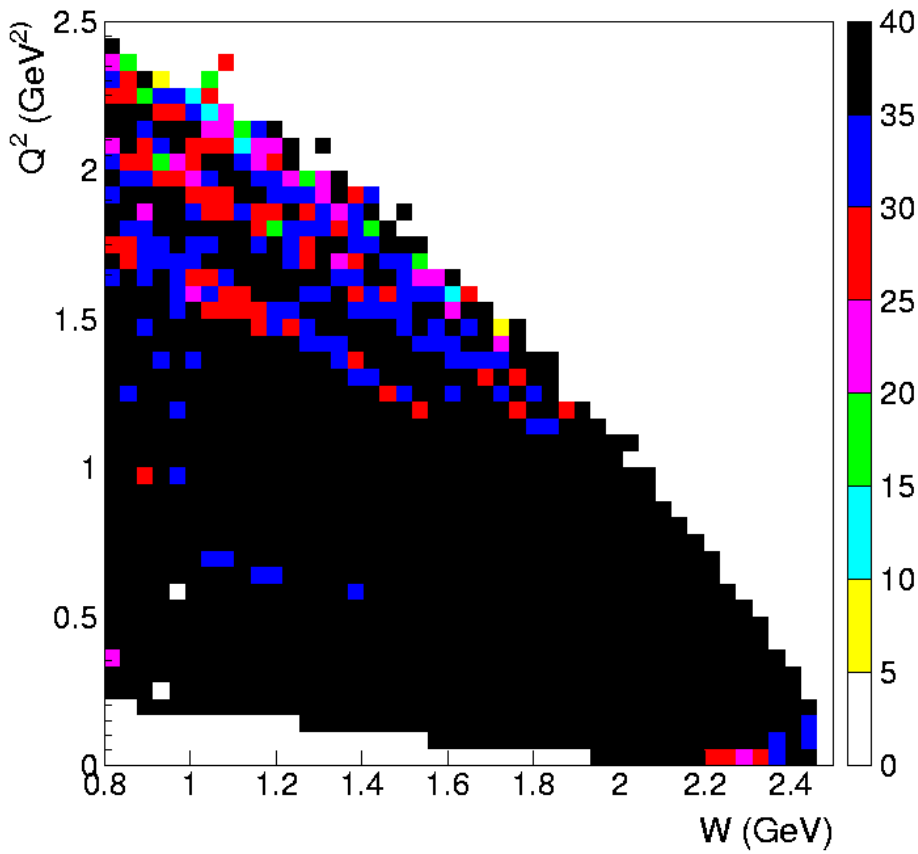
Cerenkov Response

 # photoelectrons as a function of the electron variables W and Q^2

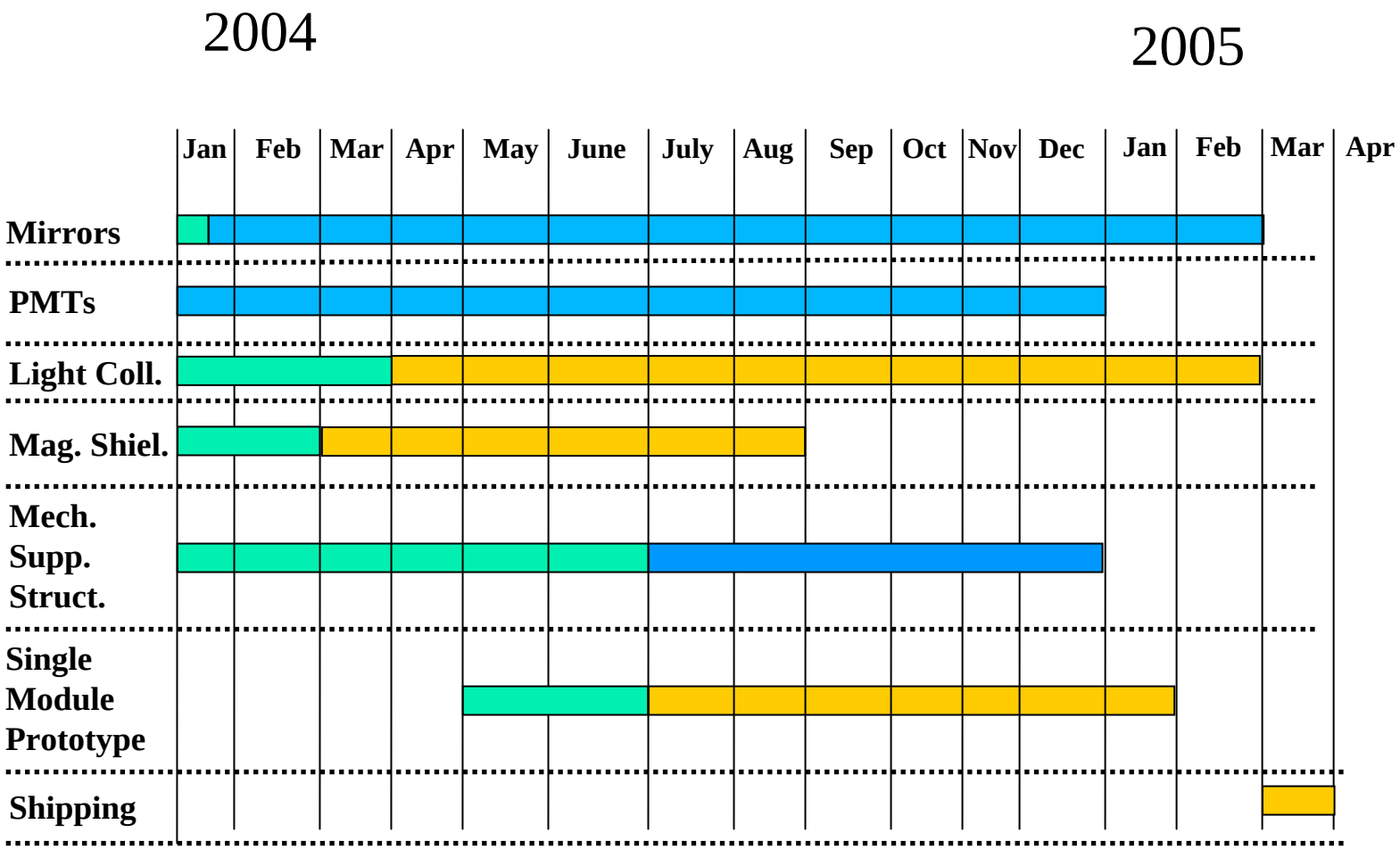
E_{beam} = 1100 MeV I_{torus}=-1500 A



E_{beam} = 3200 MeV I_{torus}=-2250 A

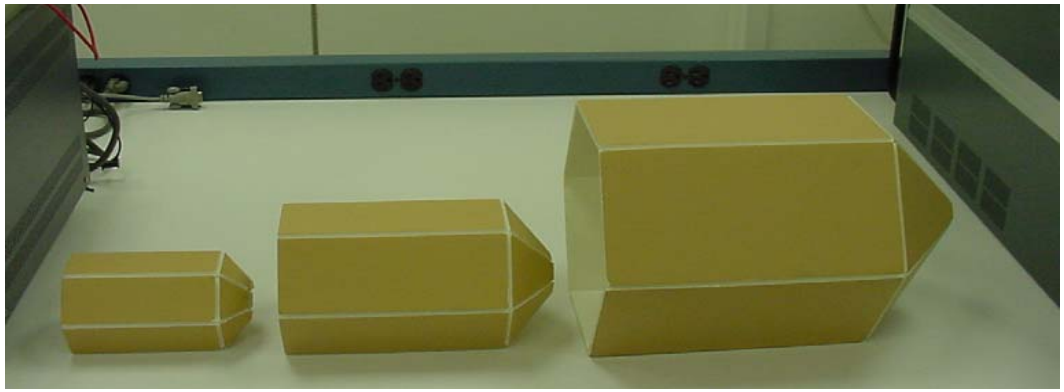


Construction Time Table (tentative)



Silicon Vertex Tracker – Prototyping effort

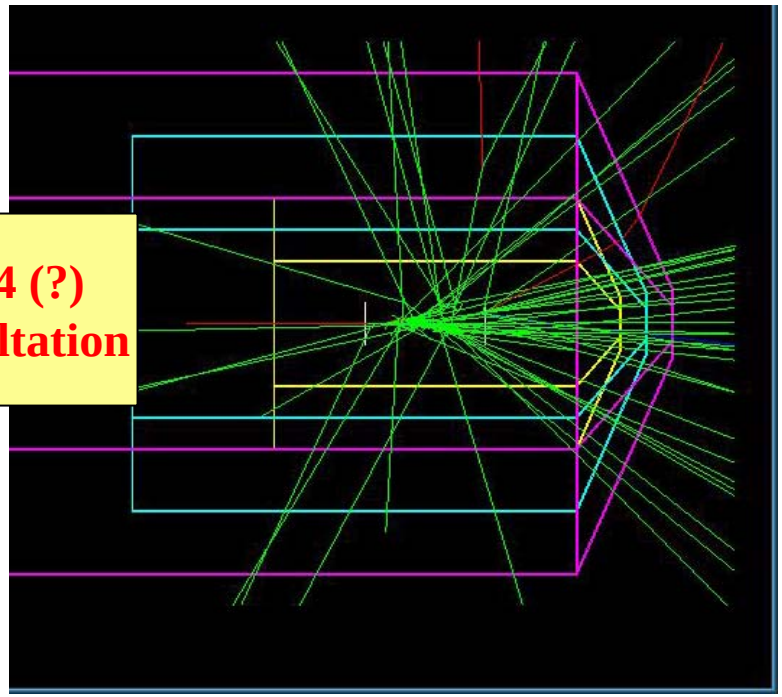
Model of a 3 (6) layer, hexagonally shaped SVT.



- For use in future experiments with more stringent vertex reconstruction requirements.

- Central tracker for CLAS++ at 12 GeV.

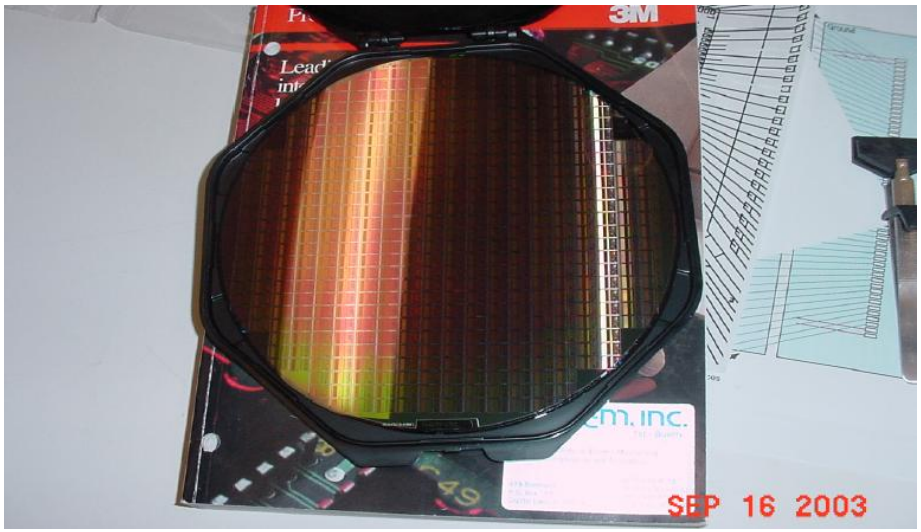
- To operate in a 5T magnetic field.



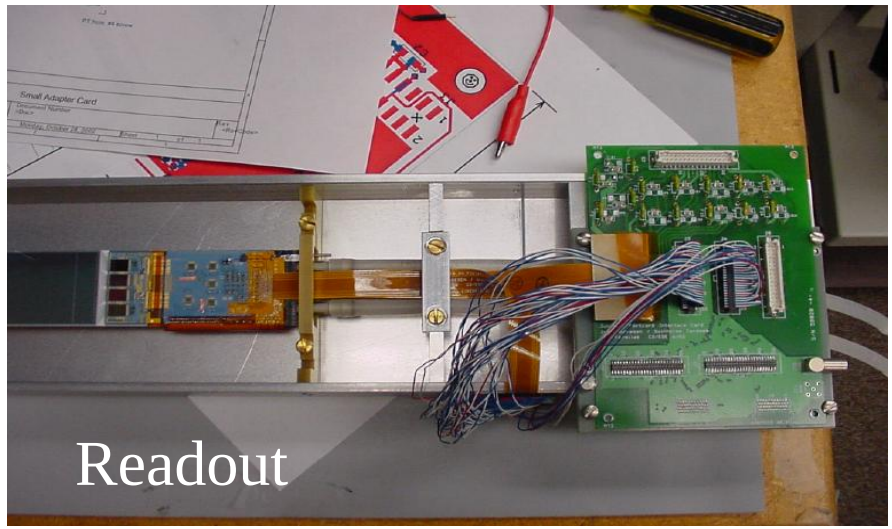
GEANT 4 (?) event simultation

Goal: Build and test prototype of one segment.

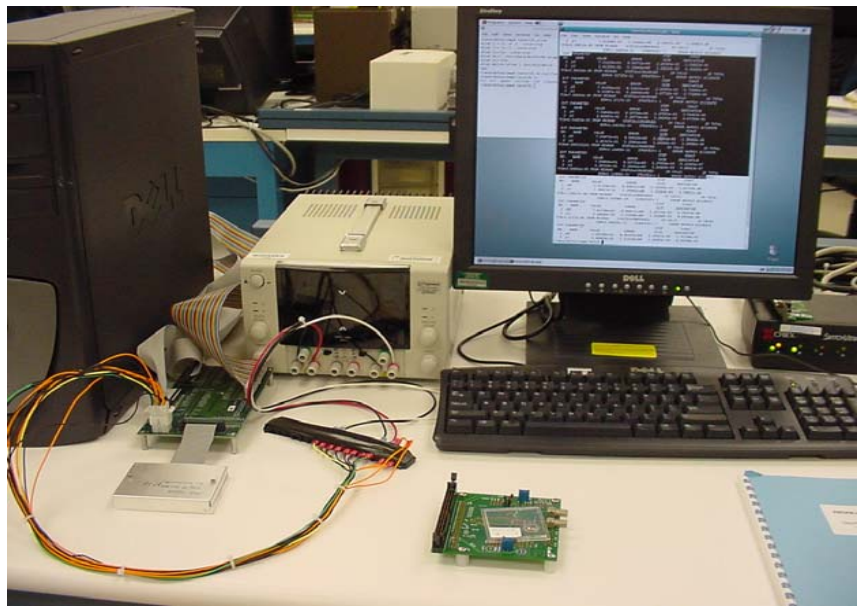
Silicon Vertex Tracker – Prototyping effort



Silicon wafer from Fermilab



Test station
in EEL

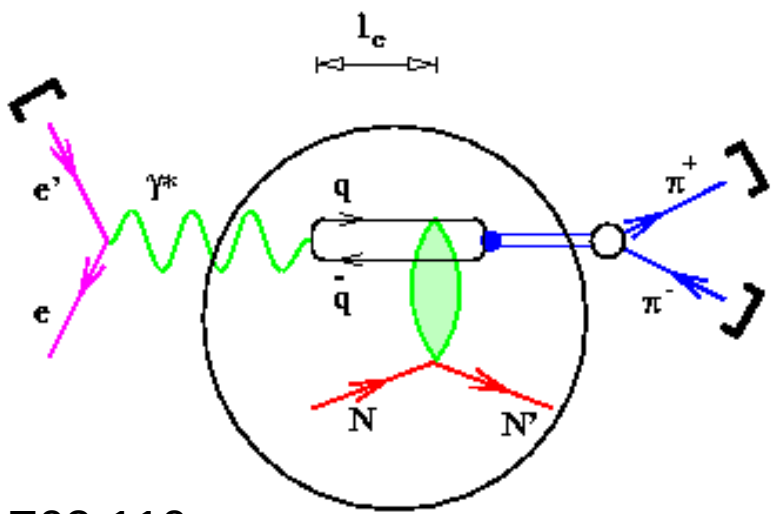


CLAS EG2 - Physics Focus

Search for Color Transparency

Measure rho absorption vs. Q^2 at fixed coherence length

Compare absorption in deuterium, carbon, aluminum, and iron

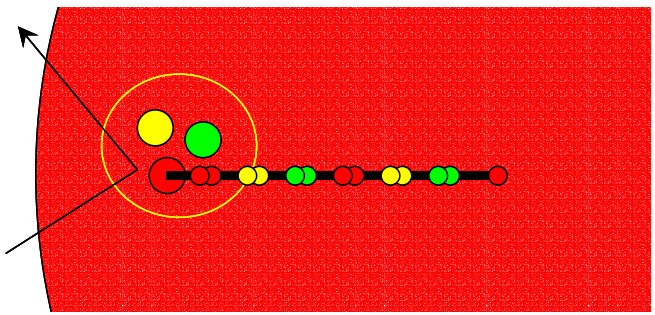


E02-110

Quark Propagation through Nuclei

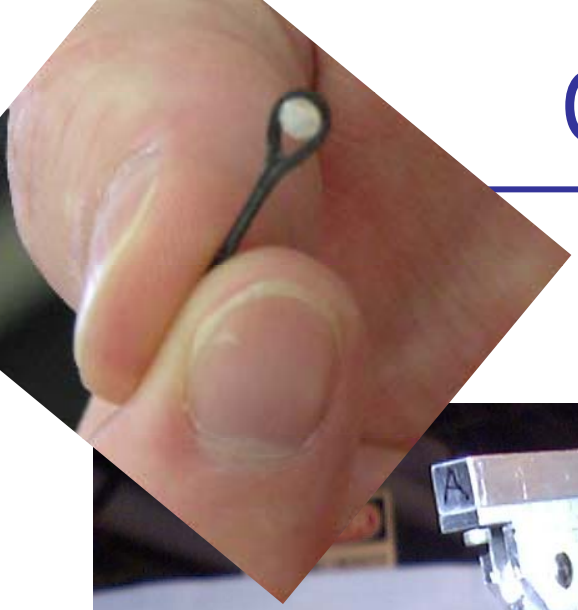
Measure attenuation and transverse momentum broadening of hadrons (π, K) in DIS kinematics

Compare absorption in deuterium, carbon, iron, tin, and lead



E02-104

CLAS EG2 - Targets



- *Two* targets in the beam simultaneously
- 2 cm LD2, upstream
- Solid target downstream
- Six solid targets:

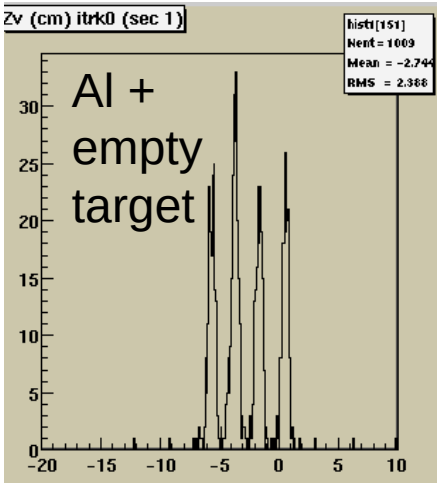
  -Carbon

  -Aluminum (2 thicknesses)

  -Iron

  -Tin

  -Lead

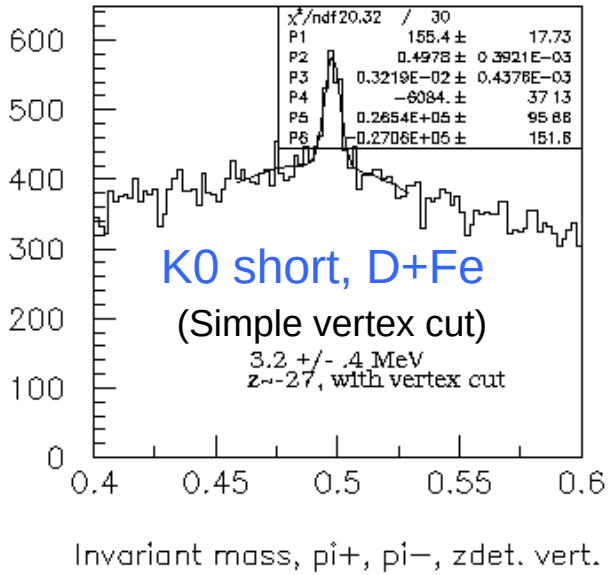


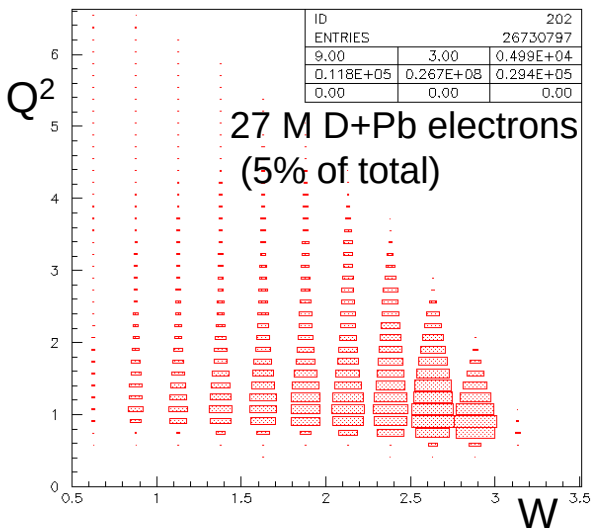
CLAS EG2

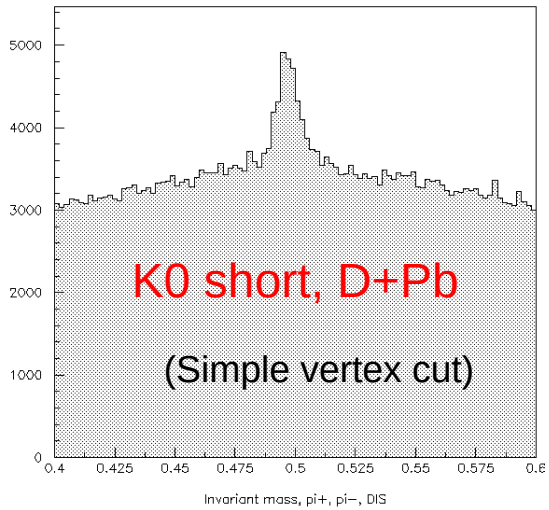
Running Conditions

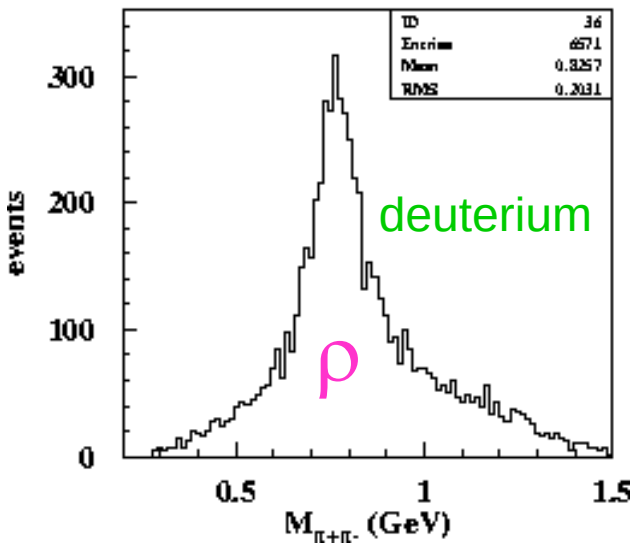
- Beam energies: 4 GeV (7 days) and 5 GeV (50 days)
- Luminosity: 1.9-2.0 E34 (D_2+Fe), 1.3 E34 (D_2+Pb)
- Data taking:
  - DC occupancy < 3%,
  - deadtime 7% (D_2+Pb) and 14% (D_2+Fe)
- Number of triggers:
  - 0.6 billion (D_2+Fe, 4 GeV)
  - 2 billion (D_2+Fe, 5 GeV)
  - 1.5 billion (D_2+Pb, 5 GeV)
  - Anticipate ~1 billion (D_2+C, 5 GeV)
- Primary challenges:
  - Beam current stability
  - Beam profile
  - DAQ stability (December 2003 – January 2004)
  - DC gas (summer 2003) and temperature (December 2003)
- New beamline diagnostics: BOM

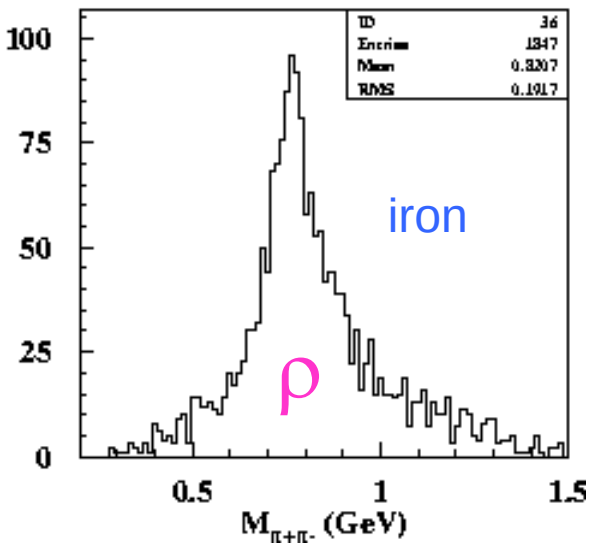
CLAS EG2 - Online Physics Results

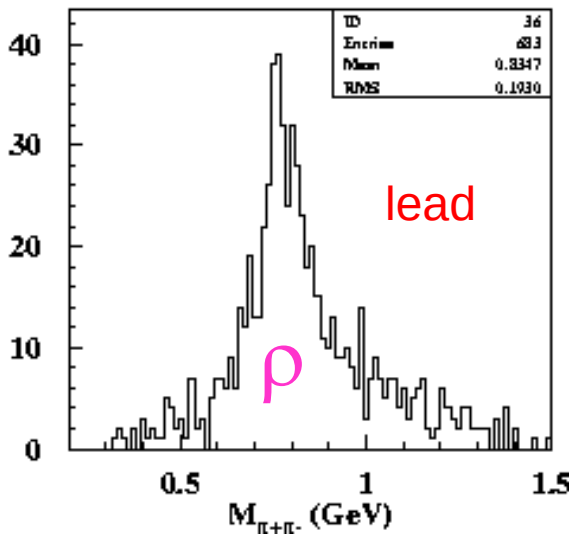












PAC 25 Results

Requested beam time : 97 days
Approved beam time : 87 days
Guidelines: 30 days

Proposal	Contact	Physics	PAC action	Rating
P-04-005:	P. Eugenio	Exotic mesons	42 days	A
P-04-010	E. Smith	Pentaquark Ξ	20	A
P-04-017	D. Weygand	Θ^+/Ξ_5 studies	with 04-005	A-
P-04-020	M. Battaglieri	Θ^+ spectroscopy	25	A

Great !! But ……

Promised the PAC that we can determine Θ^+ and other masses with $\delta M \sim 2$ MeV !

Kinematics corrections for e1-6

K. Park et al. CLAS Note 03-012 (2003)

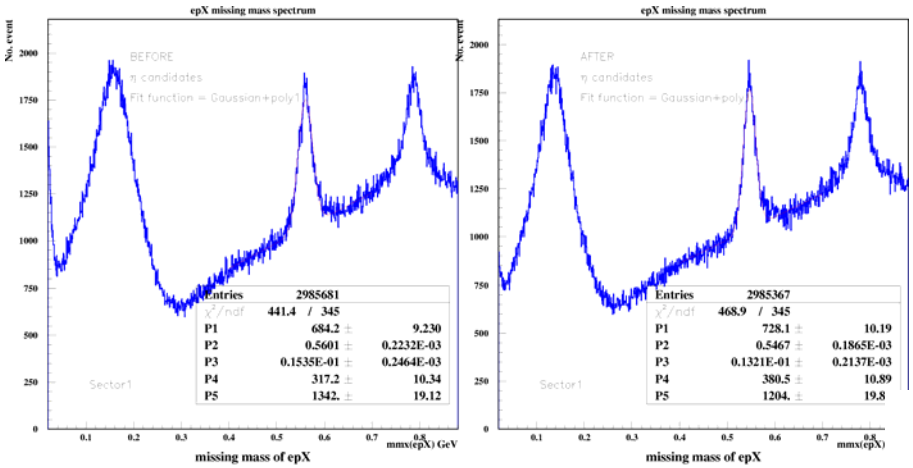


Figure 27: Missing mass spectrum of $e'pX$ (η) in sector 1

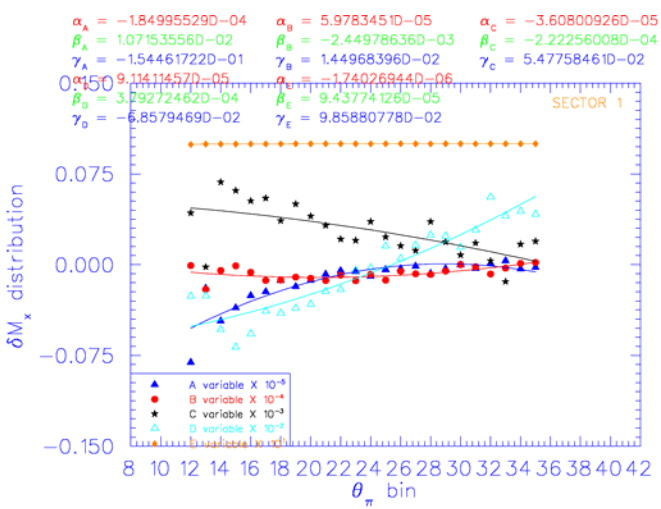


Figure 25: δM_X vs. θ_π. Each data point ($-\star--\bullet--\diamond--\triangleleft-$) corresponds to the order of paramters in sector 1. To get the parameters, the fit function $h_{A,B,C,D,E} = \alpha^h{}_{A,B,C,D,E} * \theta^2 + \beta^h{}_{A,B,C,D,E} * \theta + \gamma^h{}_{A,B,C,D,E}$ is used. The indices (A,B,C,D,E) correspond to the fit parameters in Figure 23 and Figure 24

ep → epX, E=5.754 GeV.

Masses determined to < 2 MeV

MMX	PDG value mean	Before mean	Correction sigma
π^0	0.13498	0.1586	0.4667E-01
η	0.54730	0.5601	0.1535E-01
ω	0.78257	0.7871	0.1838E-01
n	0.93956	0.9495	0.2446E-01

Table 2: The mean and width of missing mass of $e'pX$ and $e'\pi^+X$ before and after applying the kinematic corrections

Energy Calibration of CLAS and Tagger

- Calibration problems apparent in recent Θ^+ publications
(1542 MeV vs 1555 MeV, and recent analysis (INFN Genova) showing Peaks in missing mass at 1525-1531 (Θ^+ ?) and 1575-1585 MeV (Θ^{+*} ?)

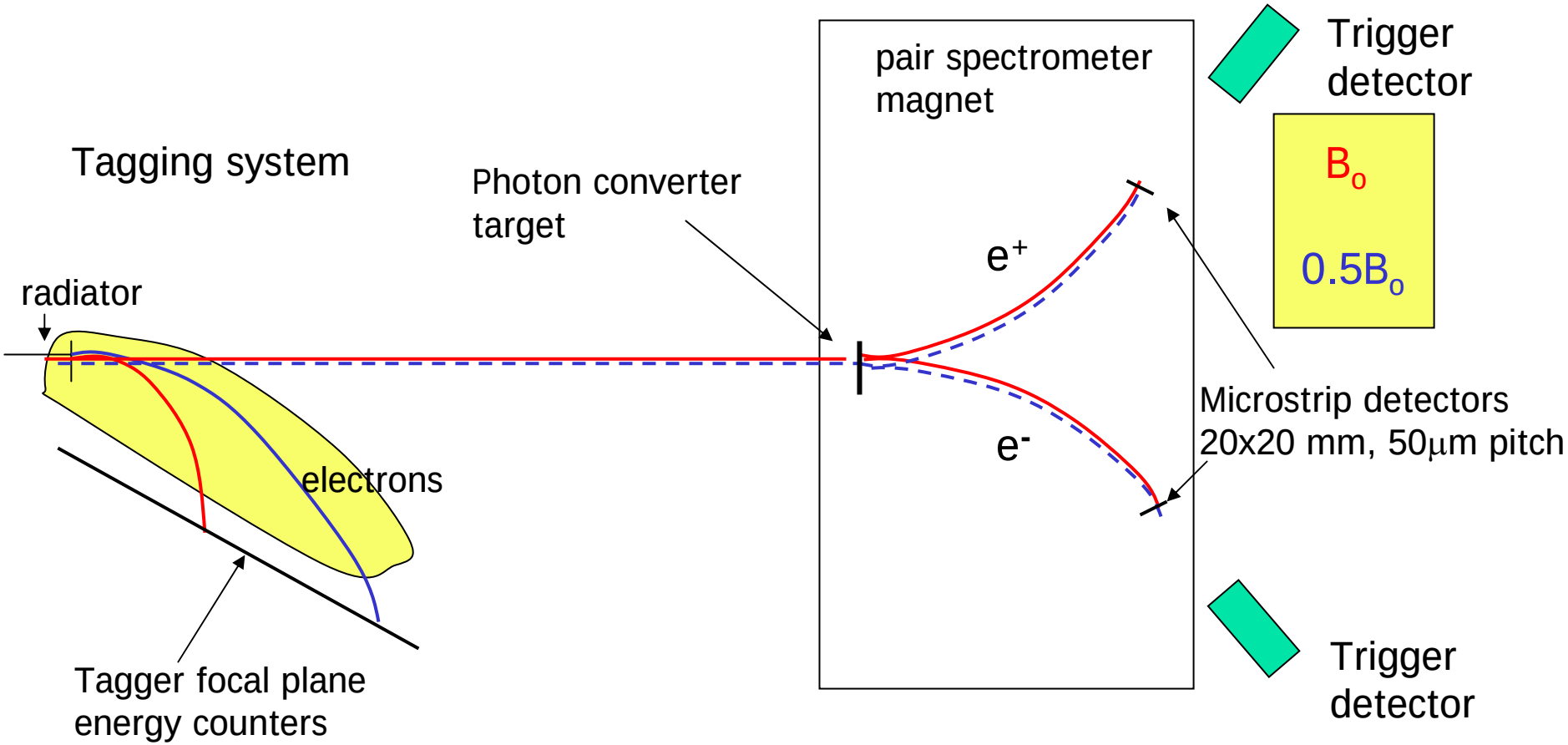
- Experiments using invariant mass method (Hermes, Zeus, COSY) have mass near 1525-1530 MeV.

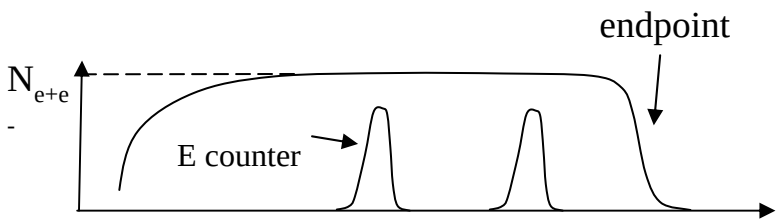
- Masses determined using missing mass techniques need knowledge of photon energy.

- Need to understand energy calibration of tagging system and CLAS momentum reconstruction in full kinematics.

- Initiatives within g10, OTWG, individuals to solve problem, Must be collaboration effort to benefit entire program.

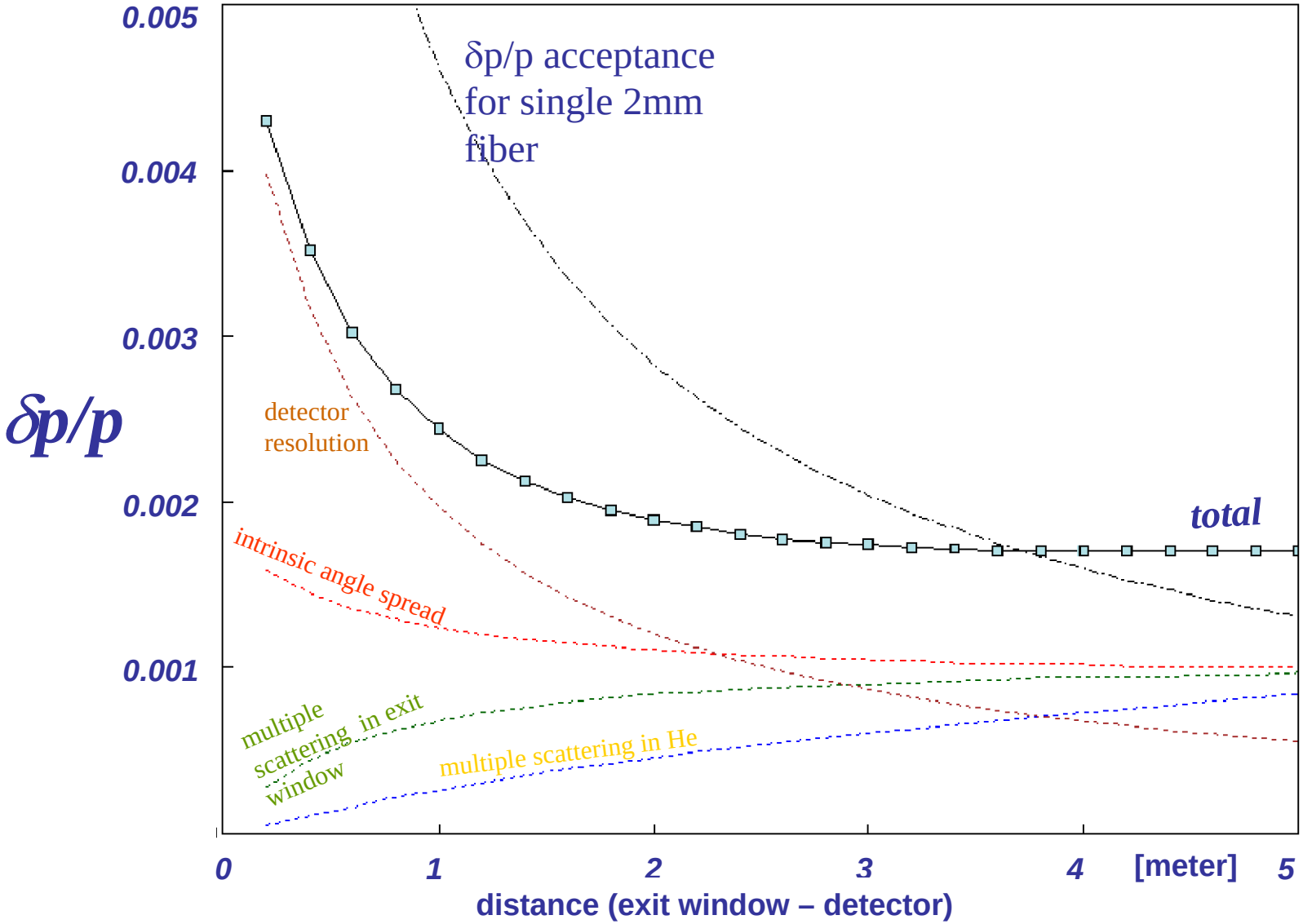
Tagger energy calibration (B. Mecking proposal)





Note: In reality pair spectrometer deflects in horizontal plane. Shown here as vertical deflection, for clarity.

Pair Spectrometer Resolution (Helium)



Start Counter for Tagged Photon Experiments

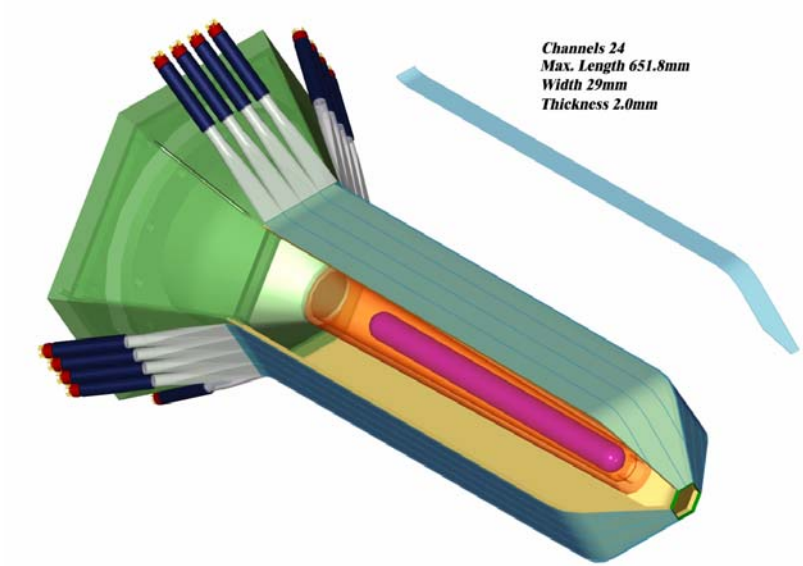
- Needed in tagged photon experiments for triggering and particle identification

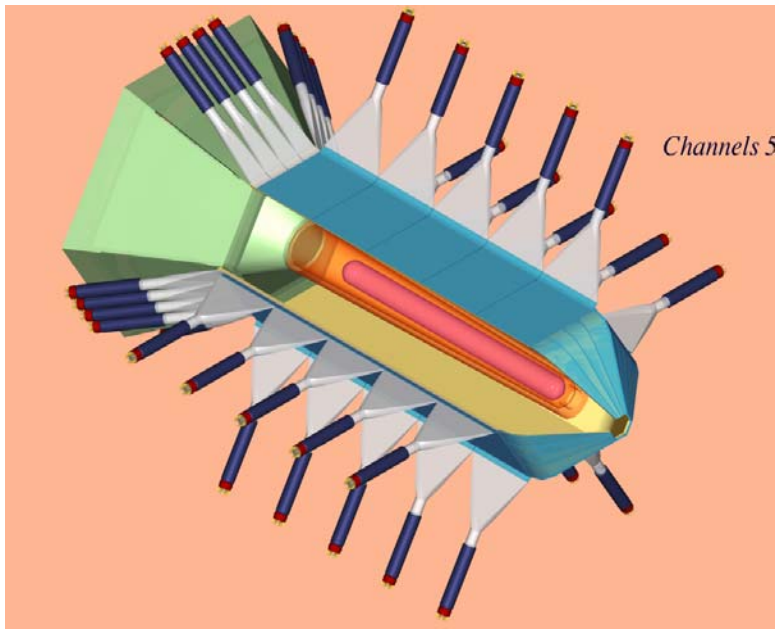
- For Penta-Quark Program and exotic meson program with tagged photons need SC with better segmentation.

- First stage with 24 azimuthal-strips under construction. Scheduled for use in g11 run.

- Second stage with higher granularity in polar angle being designed. To be used for experiment E-04-005 (hybrid mesons), and E-04-017 (penta-quark).

- Both stages are designed for compatibility with frozen spin target operation.



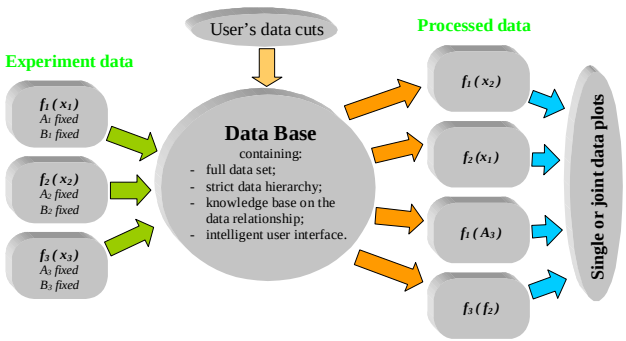


CLAS Physics Data Base

- There is a pressing need for archiving CLAS results in an organized fashion. Some CLAS experiments result in many thousands of data points and cannot be included in a publication.

- Want interactive, direct, and fast access to data with suitable display options.

- Prototype of a CLAS physics data base developed by the MSU group => Boris Ishkhanov presentation



Hall B Run Plan

Run group	Run time	PAC rating	Target	Energy (GeV)	Electron polar.	Comment
eg2a	33	B^+	nuclear	4 - 6	No	
g10	30	A	D2	4	No	
g11	25	A	H2	4	No	Start Counter
PrimEx	22	A	nuclear	>5	No	HyCal
eg3-cascade	20	A	D2	>5.7	No	DAQ upgrade
unscheduled(alphabethic order)						
coherent ρ	50	A-	D2	6.0	High	uses DVCS solenoid
e1-DVCS		60	A	H2	6.0	High Solenoid, PbWO4 EC
E04-005	42	A	H2	6.0	No	
E04-017	--	A^-	H2	6.0	No	
eg1(g)	22	A^-	p	1.6-4.0	High	Frozen spin target
eg2b	11	B^+	nuclear	> 5	No	
g8	29	A^-	H_2	4.2-4.5	No	Photon polarimeter
GDH (Low Q^2)	20	A	p	1.2-4.0	High	New Cerenkov
Missing N*	38	A^-	p		No	Frozen spin target
Neutron S.F.	25	A^-	D_2 gas	4-6	No	Radial TPC
Σ unscheduled	307					

Hall B 2004/2005 Schedule - Draft

01/08 - 03/04/04	eg2a continued	5.0 GeV
03/04 - 03/06/04	cascade tests	5.0 GeV
03/10 - 05/15/04	g10	3.75 GeV
05/19 - 07/18/04	g11	4.0 GeV
07/19 - 07/25/04	calibration	2/4/5 GeV
07/25 – 09/19/04	PRIMEX Installation	

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tentative

09/24 - 10/03/04	PRIMEX Engineering run	**5.75 GeV**
10/04 - 11/24/04	PRIMEX Physics run	5.75 GeV
11/29 - 12/23/04	eg3-pentaquark	**5.75 GeV**

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unscheduled

01/05 - 01/31/05	eg3	5.75 GeV
02/1/05- 02/28/05	DVCS installation	
03/01 -	DVCS	6.00 GeV

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The Bottom Line

- Penta-quark runs are a CLAS collaboration priority

- We need high quality data in a timely fashion
  - calibration of tagging system
  - data calibration & cooking
  - changes to software, e.g. implemetation of new start counter, < 5 s.l. fitting, kinematically contraint fitting, ..

- Must be collaboration efforts. We need students, postdocs, assigned to this effort.

Conclusions

CLAS and Hall B continue to do well:

- Two penta-quark papers brought us increased visibility and …. increased responsibility to serve the community with first class experiments and unassailable results!

- The PAC25 award of four new experiments with highest scientific ratings gives us excellent near term prospects but also the responsibility to do our absolute best in meeting the expectations in the quality and timeliness of our scientific program.

- We also must continue to preserve and further develop our capabilities for first class experiments.