

Hall B Status



CLAS Collaboration Meeting
October , 2004

Volker D. Burkert
Jefferson Lab

Run status
Publication status/analysis
Status of new projects
2005/2006 tentative run plan
12 GeV Upgrade

Nobel Prize in Physics 2004



D. Gross
UCSB

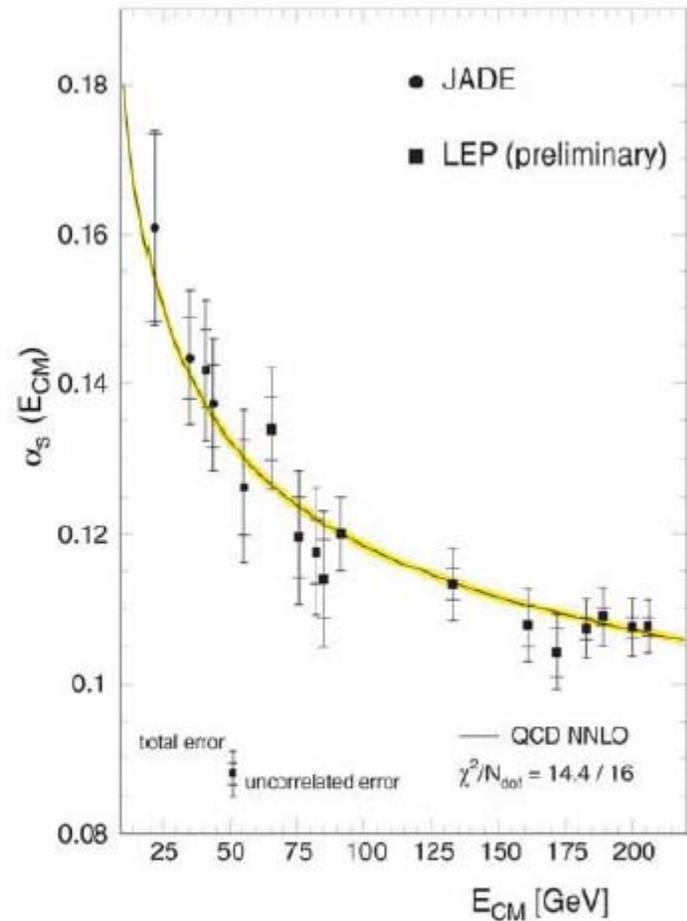
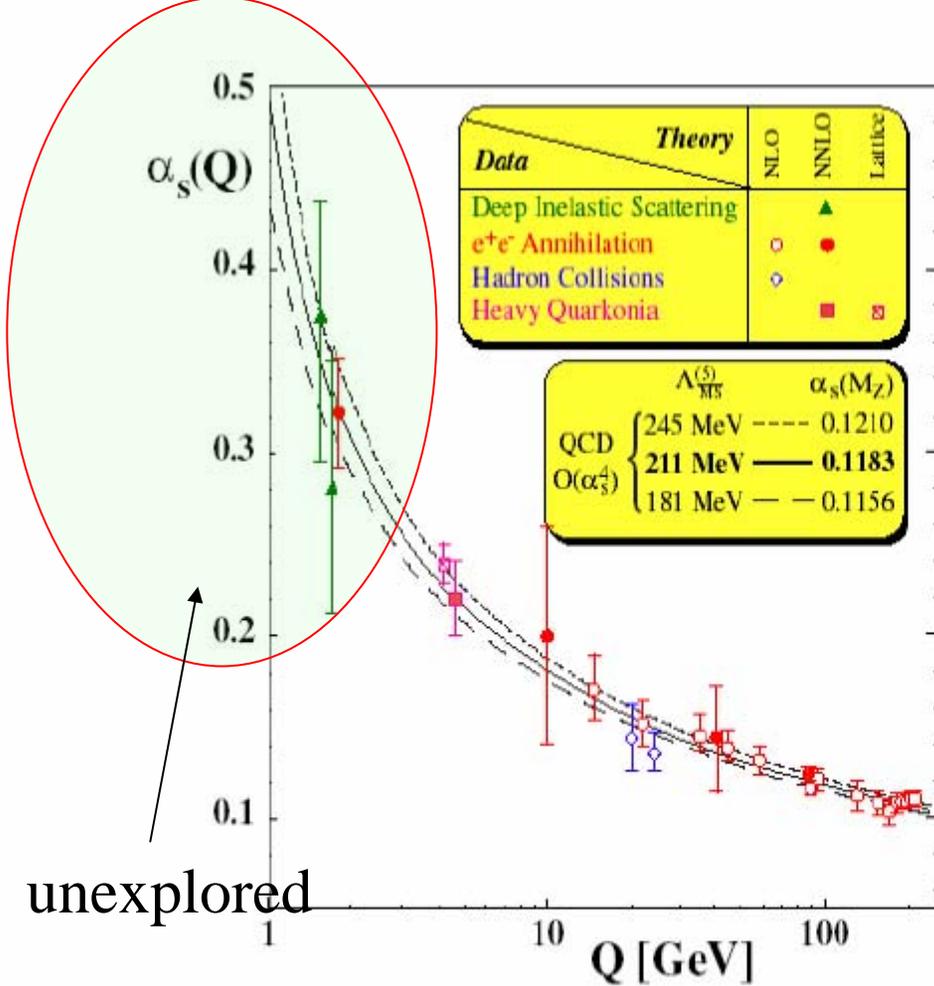


D. Politzer
CALTECH



F. Wilczek
MIT

“Asymptotic Freedom”



The left-hand panel shows a collection of different measurements by S. Bethke from High-Energy International Conference in Quantum Chromodynamics, Montpellier 2002 (hep-ex/0211012). The right-hand panel shows a collection by P. Zerwas, Eur. Phys. J. C34(2004)41. JADE was one of the experiments at PETRA at DESY. NNLO means Next-to-Next-to-Leading Order computation in QCD.

Hall B Status Overview

- 23 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, g10, **g11** (+2 non-CLAS experiments: g5, rad- ϕ)
- Running experiment – **PRIMEX**
- Publications
 - 17 technical papers published
 - 32 physics papers published/accepted in PRL, PRC, PRD (3 CLAS related papers)
 - 8 submitted (incl. 3 CLAS related papers)
 - 3 in collaboration review
- Projects in preparation for new experiments
 - **PRIMEX**
 - DAQ Upgrade to 10KHz rate (EG3)
 - **DVCS S.C. Solenoid and PbWO₄ EC (Accessing GPDs)**
 - BoNus detector (Neutron structure function)
 - **Frozen Spin Target (search for missing N*'s)**
 - Cerenkov counter for one CLAS sector (small Q² GDH)
 - Polarimeter for linearly polarized photons (g8)
- 12 GeV Upgrade on track to CD-1

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
 - Response Mauro Taiuti NIM accepted (2004)
- 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
- [FST coil design](#) [O. Dzyubak](#) [NIM A526 \(2004\) 132](#)
- CLAS Overview Bernhard Mecking NIM A503 (2003) 513

Hall B Physics Publications (PRL/PRC/PRD)

- 32 - published (3)
- 8 - submitted (3)
- 3 - in collaboration review

❖ Physics analysis papers of CLAS members based on CLAS data.

- ❖ 3 - published
- ❖ 3 - submitted

Hadron Structure & Spectroscopy

- η -Electroproduction in the S11(1535) region, PRL86 (2001) 1702
- Double Spin Asymmetry in $ep \rightarrow e\pi^+n$, PRL88 (2002) 082001
- $N \rightarrow \Delta(1232)$ Multipoles from p^0 Electroproduction, PRL88 (2002) 122001
- ❖ QED Radiative Corrections in Exclusive Pion Electroproduction PRD66 (2002) 074004
- η -Photoproduction on the Proton, PRL89, (2002) 222002-1
- Polarisation transfer in $ep \rightarrow eK^+\Lambda$, PRL90,131804 (2003),
- ❖ Single Quark Transition Analysis of N^* Excitations in $[70,1^-]$, PRC67, 035204 (2003)
- $ep \rightarrow e\pi^+\pi^-$ and baryon resonance analysis, PRL91, 022002-1(2003)
- First measurement of beam-target spin asymmetry in $ep \rightarrow epp^0$, PRC 68, 035202
- Measurement of σ_{LT} in the $\Delta(1232)$ region PRC {bf 68}, 032201 (2003)
- Evidence for an Exotic Baryon State with $S=+1$, on Deuterium PRL 91, 252001 (2003)
- Photoproduction of $K^+\Lambda/\Sigma$, PRC-RC nucl-ex/0305028 (2003)
- Electroproduction of $ep \rightarrow e\pi^+$ in the first and second resonance region, CLAS review
- Single Spin Asymmetry in $ep \rightarrow e\pi^+n$, in the $\Delta(1232)$ region, PRC-RC
- Photoproduction of cascades from proton targets, PRD subm.
- ❖ σ_L/σ_T for $p(e,e'K)\Lambda$ from polarization transfer nucl-ex/0402024.
- Evidence for $\Theta^+(1540)$ excitation on protons, PRL 92, 0322001 (2004).
- ❖ Electroproduction of Δ , P11, S11, D13, at $Q^2 = 0.4, 0.65 \text{ GeV}^2$, PRC subm.
- First Observation of Exotic Mesons in Photoproduction
- Electroproduction of η and evidence for a p -wave resonance.

Hall B Physics Publications – cont'd

Structure Functions & Hard Processes

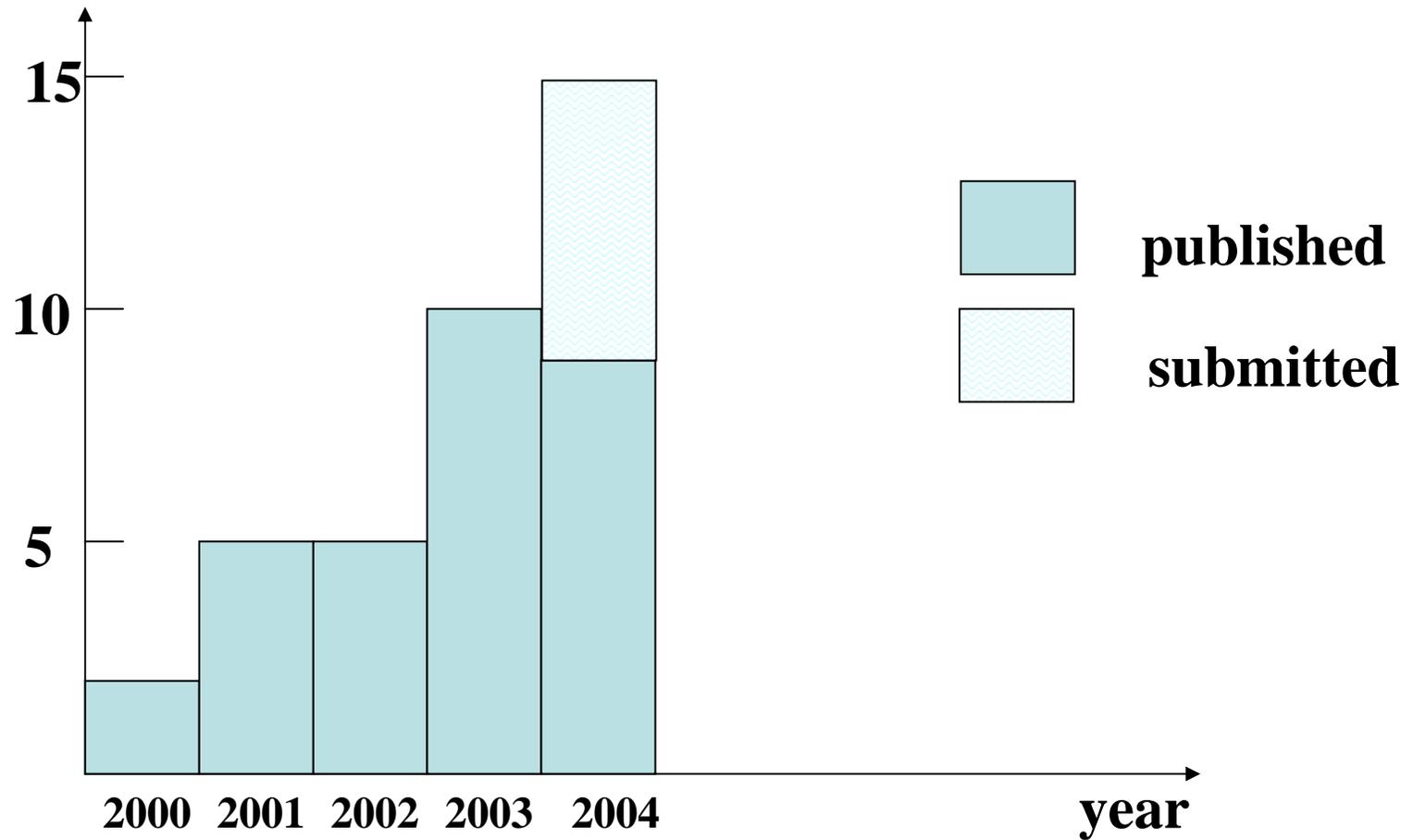
- Inclusive spin structure function in $eD \rightarrow eX$, PRC67, 055204 (2003)
- F2 and Moment analysis in $ep \rightarrow eX$, PRD 67 (2003)
- Inclusive double polarisation asymmetry, g_1 , Γ_{1p} , PRL 91, 222002.
- ϕ -Photoproduction at large t , PRL85 (2000) 4682
- ϕ -Electroproduction, PRC63 (2001) 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)
- Beam Single Spin Asymmetry in $ep \rightarrow e\pi^+X$ in the DIS kinematics, PRD 69, 112004 (2004), hep-ex/0301005
- Deeply exclusive ρ^0 production, PRL submitted
- Tensor Polarization of the ϕ meson photo-produced at high t , PRC 69, 032203(R) (2004).
- ❖ Twist analysis of $\Gamma_{1p}(Q^2)$, PRL subm.
- ❖ Bjorken Integral $\Gamma_1(p-n)$ from inclusive polarized structure functions g_{1p} , g_{1n} , PRL (2004)

Hall B Physics Publications – cont'd

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 ${}^3\text{He}(e,e'pp)n$, PRL 92, 52303 (2004).
- Deuteron Photo-disintegration, PRC (2004)
- Deuteron Photo-disintegration PRL, submitted.
- Proton source size in $eA \rightarrow eppX$, PRL accepted
- Survey of beam asymmetries in semi-inclusive scattering on ${}^4\text{He}$ or ${}^{12}\text{C}$.
- Complete measurement of 3-body photodisintegration of He-3 for photon energies between 0.55 and 3 GeV, PRC submitted

Hall B Physics Publications (PRL, PRC, PRD)



Hall B Publication Overview

PRL, PRC, PRD

	Spectroscopy & Structure	Hard scattering & Structure F.	Nuclear processes	Sum
2000	-	1	1	2
2001	1	4	-	5
2002	4	-	1	5
2003	4	4	2	10
2004	4 + 2 + 3	3 + 2 + 1	2 + 3	8 + 8 + 4
Sum	13 + 2 + 3	12 + 3 + 1	6 + 3	30 + 8 + 4

Published/accepted
 submitted
 in review

Physics Impact of CLAS Data I

Paper

Physics

**#citations (>30)
10/13/04**

• PRL 85 (2000) 4682	ϕ -Photoproduction at high t	35	
• PRL 86 (2001) 1702	Study of $S_{11}(1535)$ in η electroproduction	31	
• PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	98	CAA
• PRL 88 (2002) 182002	Multipoles in the $\gamma^*N\Delta(1232)$ transition	40	
• PRL 91 (2003) 252001	Evidence for an $S=+1$ Exotic Baryon State on deuterium	287	CAA
• PRL 92 (2004) 32001	Evidence for an exotic Baryon with $S=+1$ on Protons	147	<u>CAA</u>

Physics Impact of CLAS Data II

Paper

Physics

**#spires citations
per month (>0.7)**

- | | | | |
|------------------------|--|------|-----|
| • PRD 67 (2003) 092001 | Kinematically complete measurement of F2 | 0.8 | CAA |
| • PRL 87 (2001) 182002 | Deeply Virtual Compton Scattering | 2.6 | CAA |
| • PRL 88 (2002) 182002 | Multipoles from $\gamma^*N\Delta(1232)$ transition | 1.1 | |
| • PRD69 (2004) 112004 | SSA in SIDIS $\vec{e}p \rightarrow e\pi^+X$ | 1.3 | CAA |
| • PRL 91 (2003) 252001 | Evidence for exotic baryon on deuterium | 19.0 | CAA |
| • PRL 92 (2004) 032001 | Evidence for exotic baryon on protons | 13.1 | CAA |
| • PRL 91 (2003) 222002 | Measurement of polarized structure function g1 | 0.8 | |

Summary of Events since last CLAS Meeting

- PAC26 – two proposals for Hall B, two LOI's

PR-04-116	W. Brooks	5 days (35)	A-
PR-04-102 jeopardy	D. Sober	9 days (19)	B+

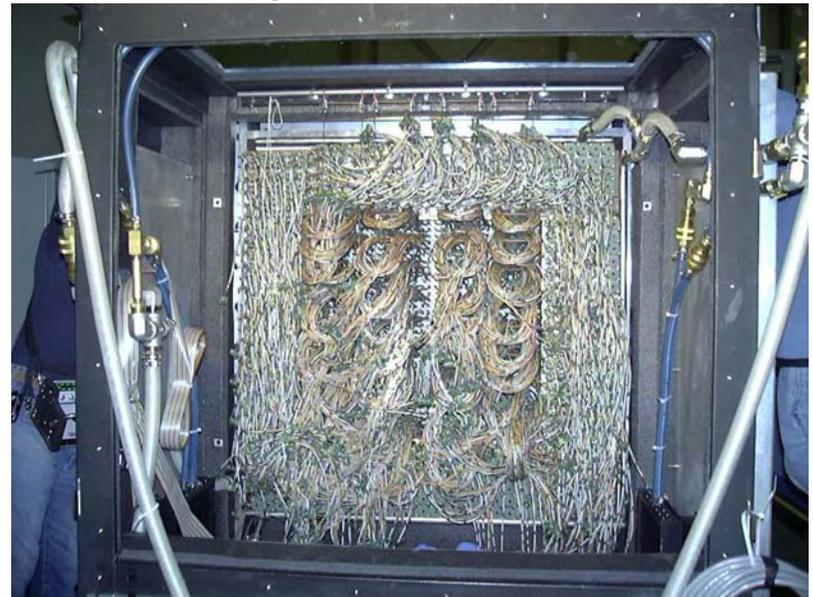
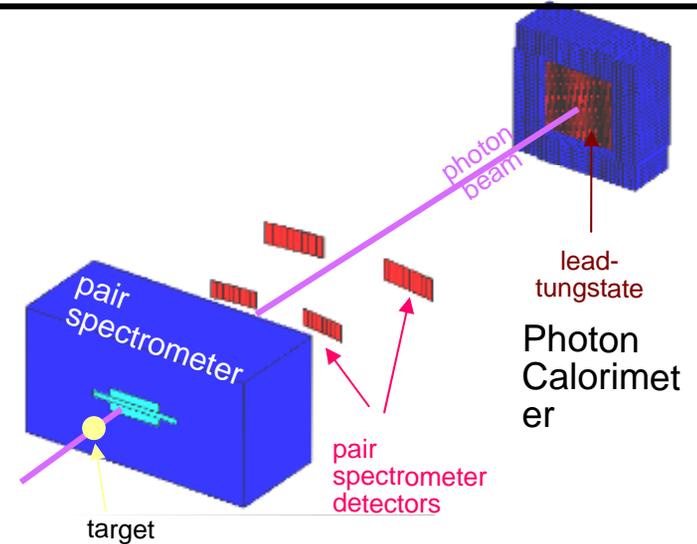
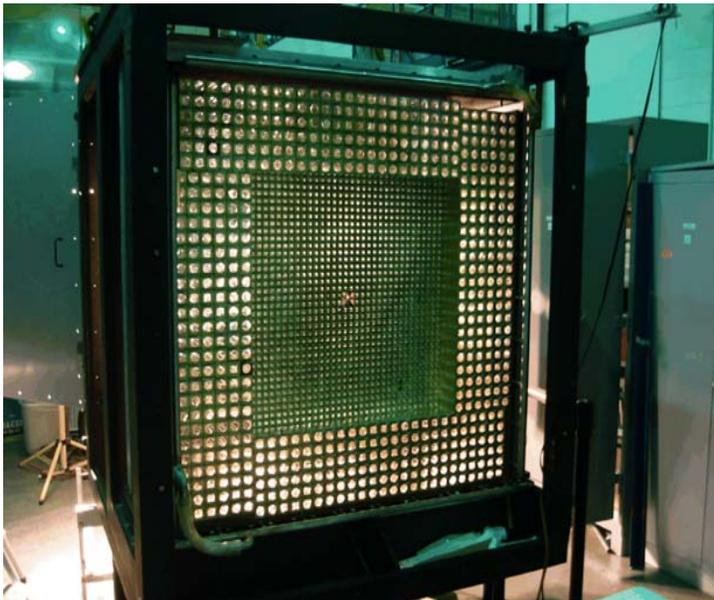
- Completed G11 run (Θ^+ search and excited states on hydrogen)
=> Talks on G10, G11 analysis status
- Repairs of drift chambers in five sectors R2/R3
 - The electronics corrosion problem seems to have stopped
 - Current repairs due to broken wires, HV disconnects, other electronics problems.
- PrimEx
 - Installation of HyCal and experimental infrastructure
 - Started PrimEx Engineering Run and Physics Run
- Preparations for CD-1 (Allison Lung's presentation)
 - Update of physics case for Hall B => afternoon session organized by Latifa
 - Experimental equipment => talk by Will

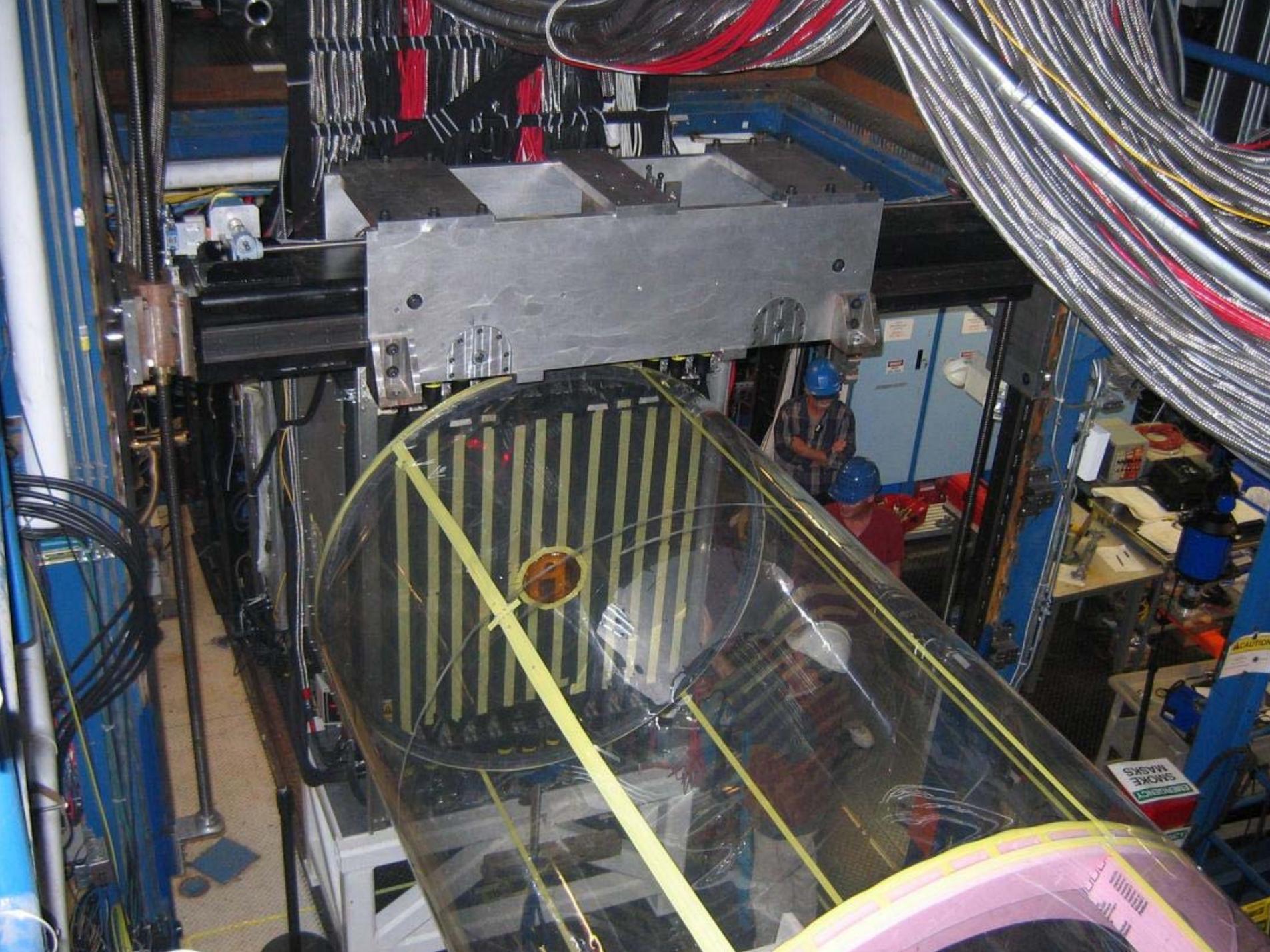
PrimEx Experiment

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 – Run

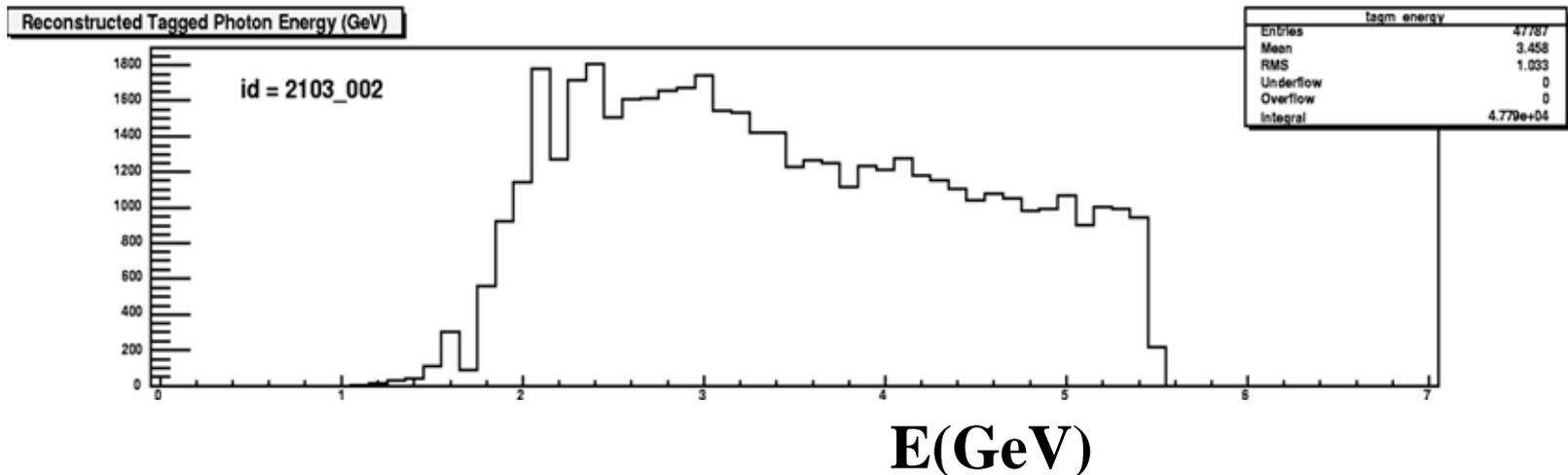
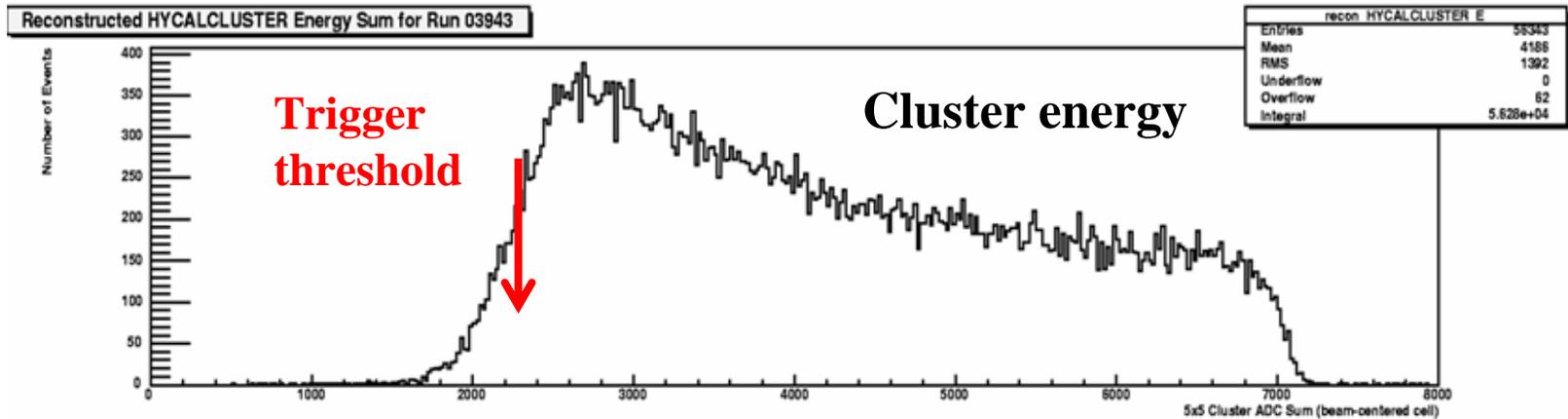
Commissioning completed

- All ~ 2000 channel operational
- Gain matching of all PbWO₄ crystals and all Pb-glass counters in direct photon beam.
- Trigger uniformity studies
- Tagging efficiency measured
- Problems with Pair spectrometer power supply (was fixed yesterday)

Production run started

PrimEx – Energy Trigger

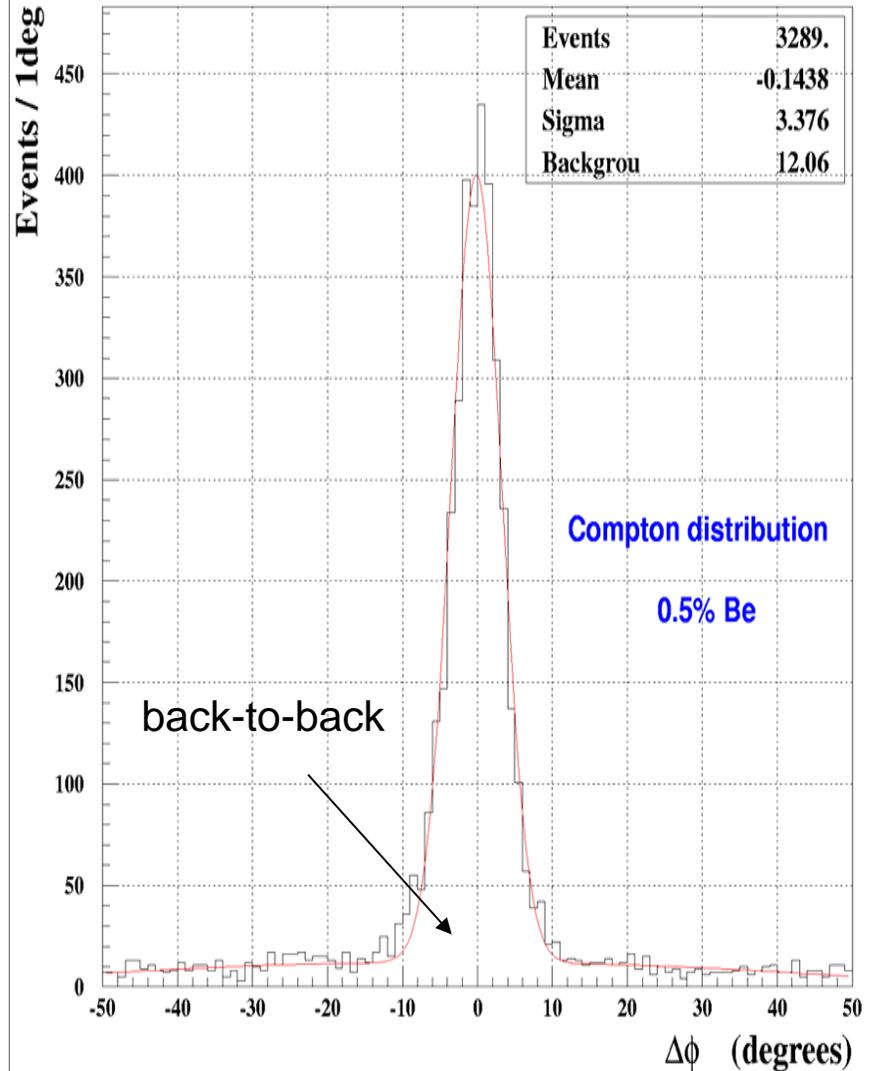
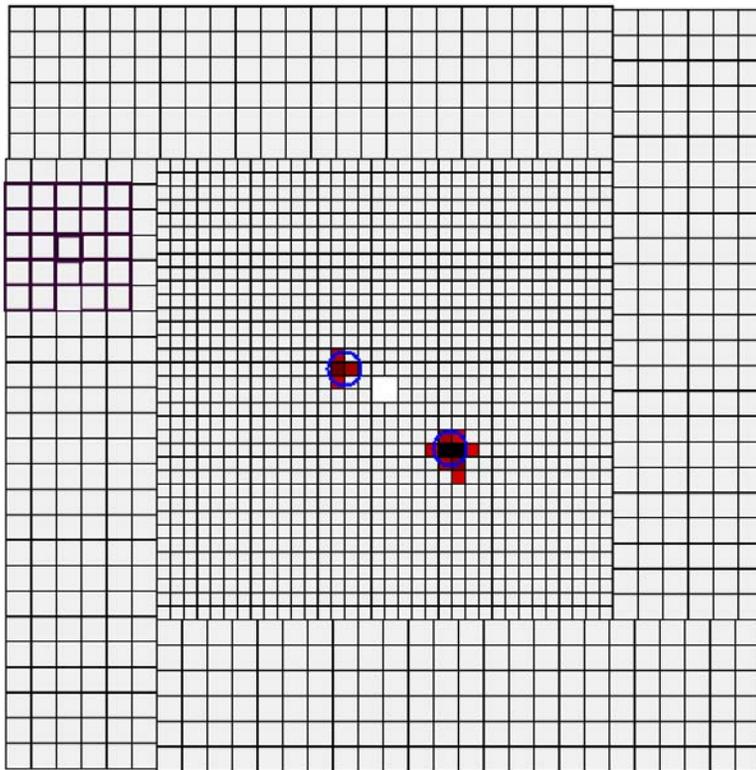
Trigger:
Total energy in HyCal



PrimEx – Compton Events

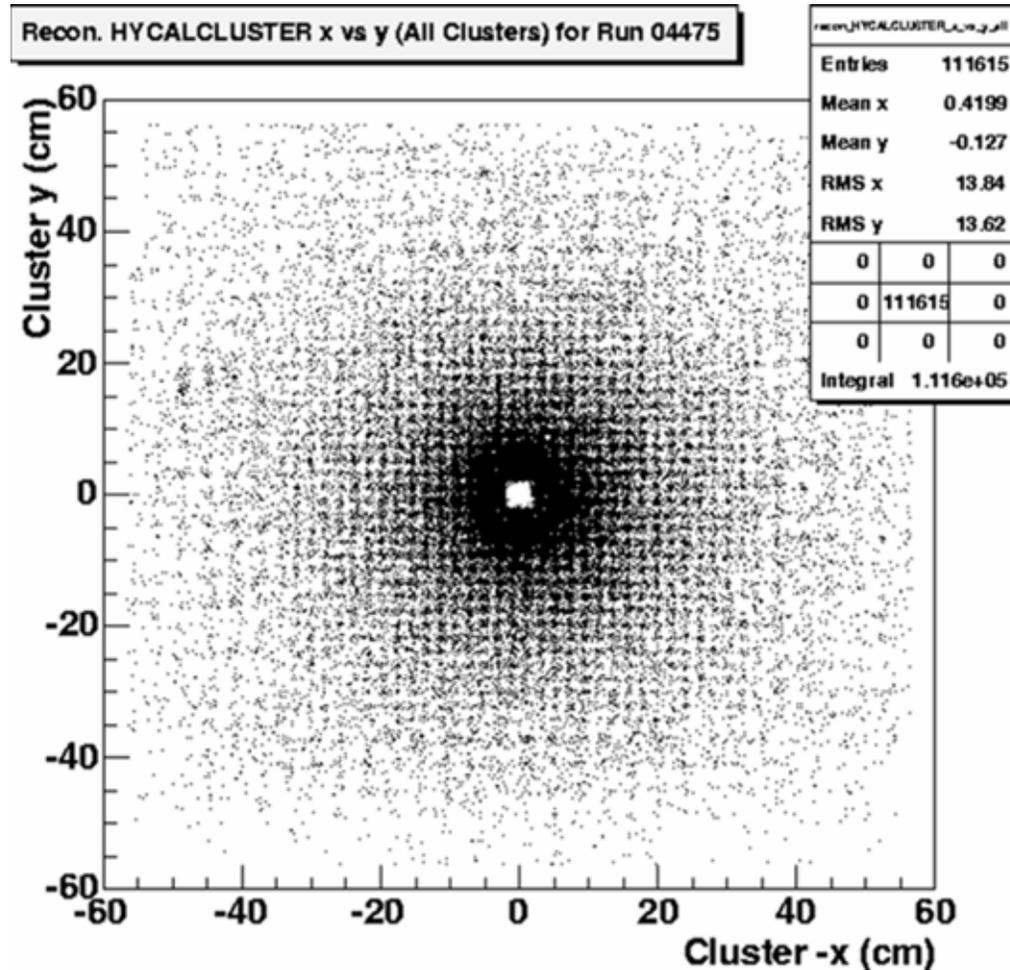
Compton event candidate

$\gamma e \rightarrow \gamma e$ event



PrimEx – Energy Trigger

Hit distribution on HyCal front face



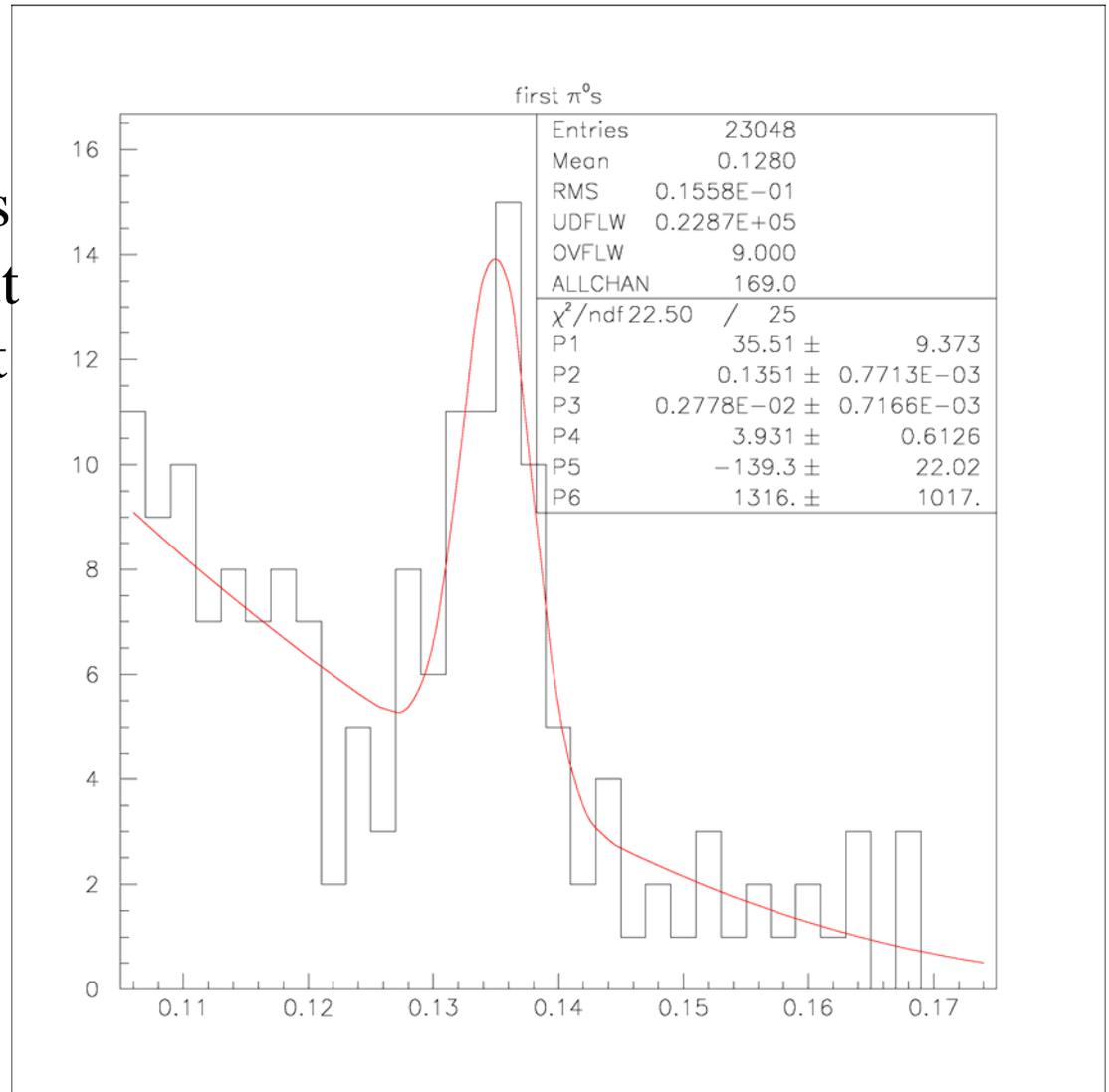
PrimEx – Production Events

First π^0 events

“I have seen billions of π^0 on my plot, but these thirty are most exciting”

e-mail message by
Ilia Larin, 10/14,
00:53hrs.

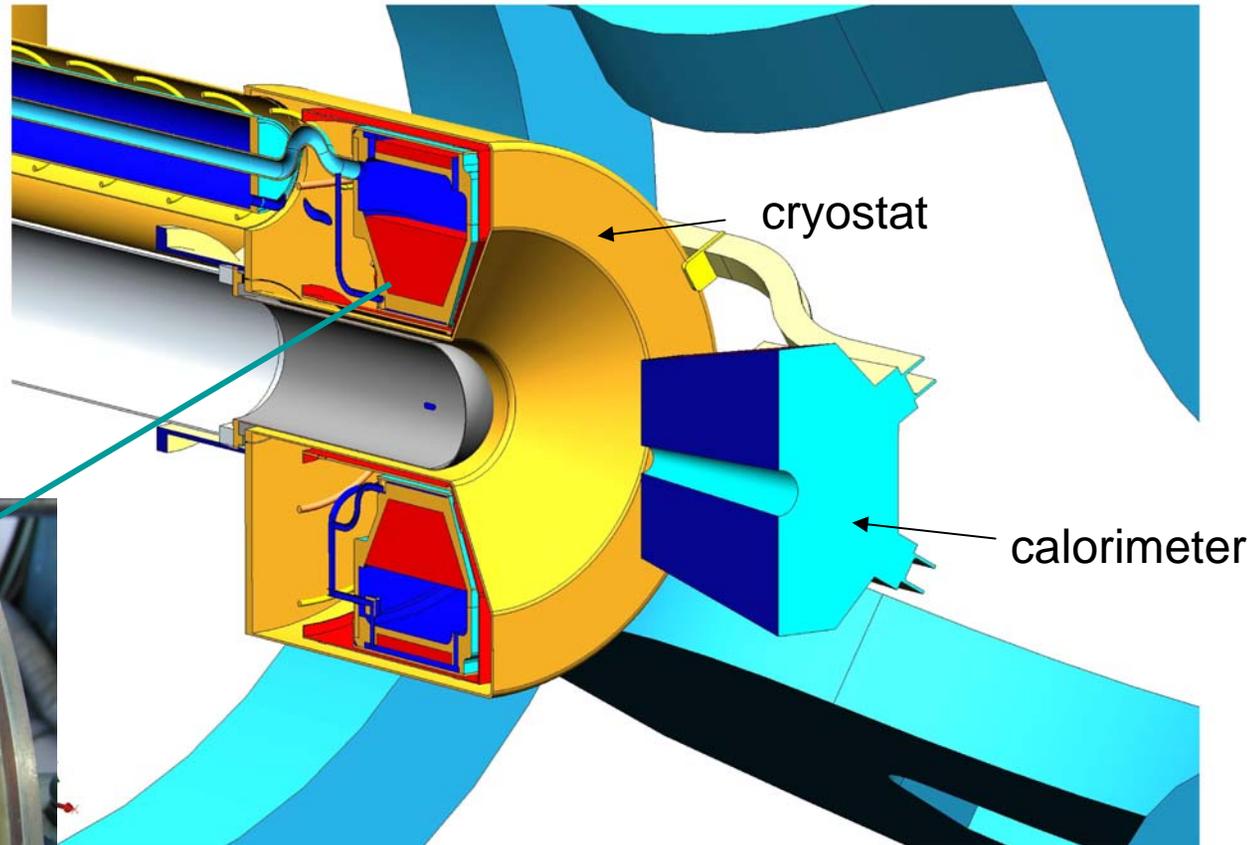
Congratulations!



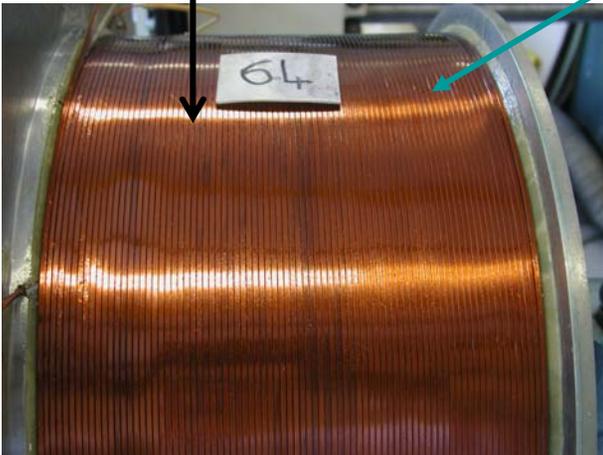
CLAS - DVCS Experiment

Superconducting solenoid: needed for shielding Moller electrons
PbWO₄ e.m. calorimeter needed for photon detection

- Solenoid under construction
- Cold test Nov '04 at Saclay.



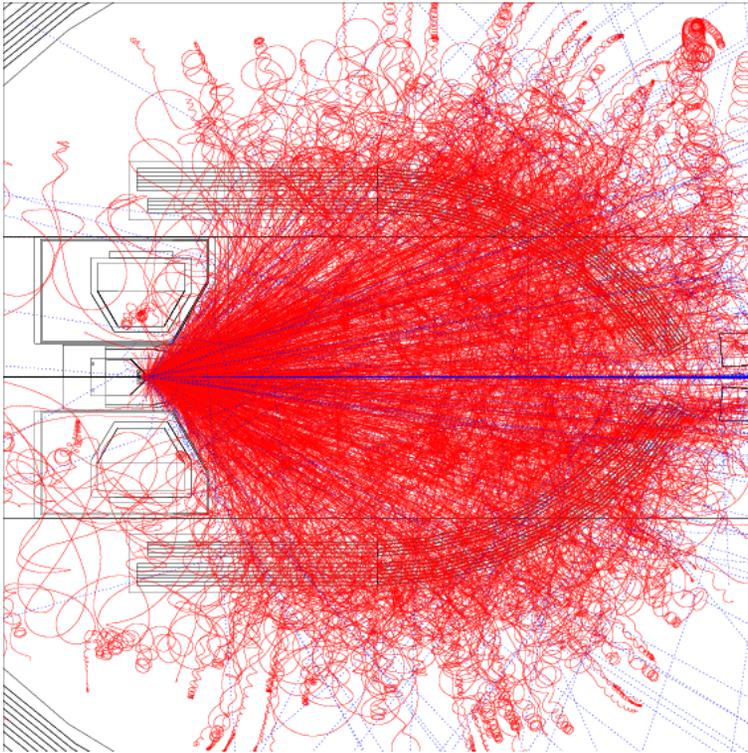
coil windings



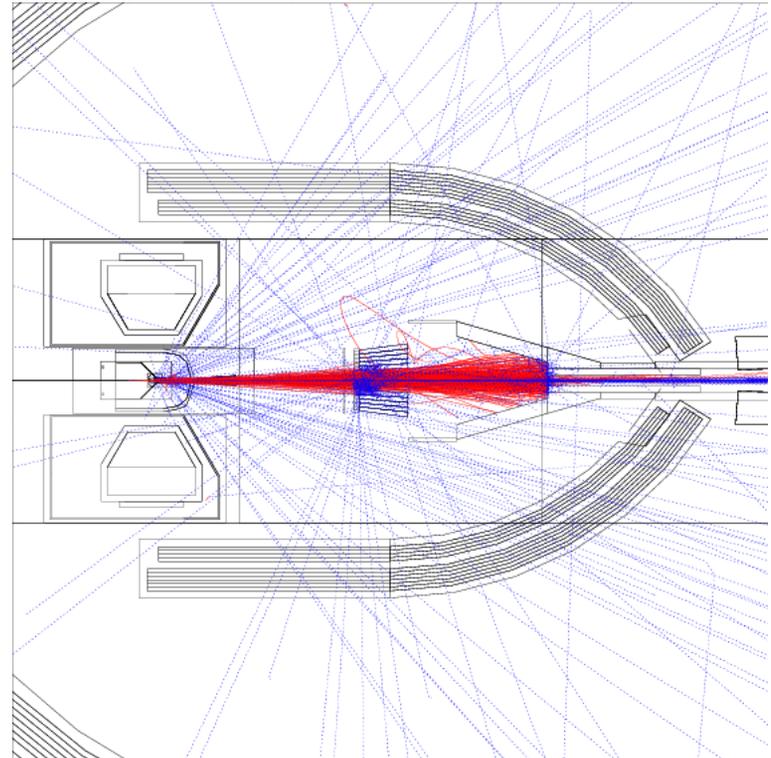
CLAS - DVCS Experiment

Effect of Solenoid Field on Moeller Electrons

Solenoid field OFF

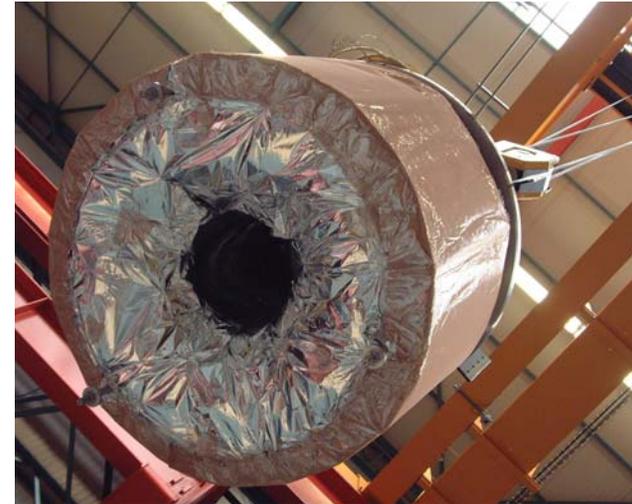


Solenoid field ON



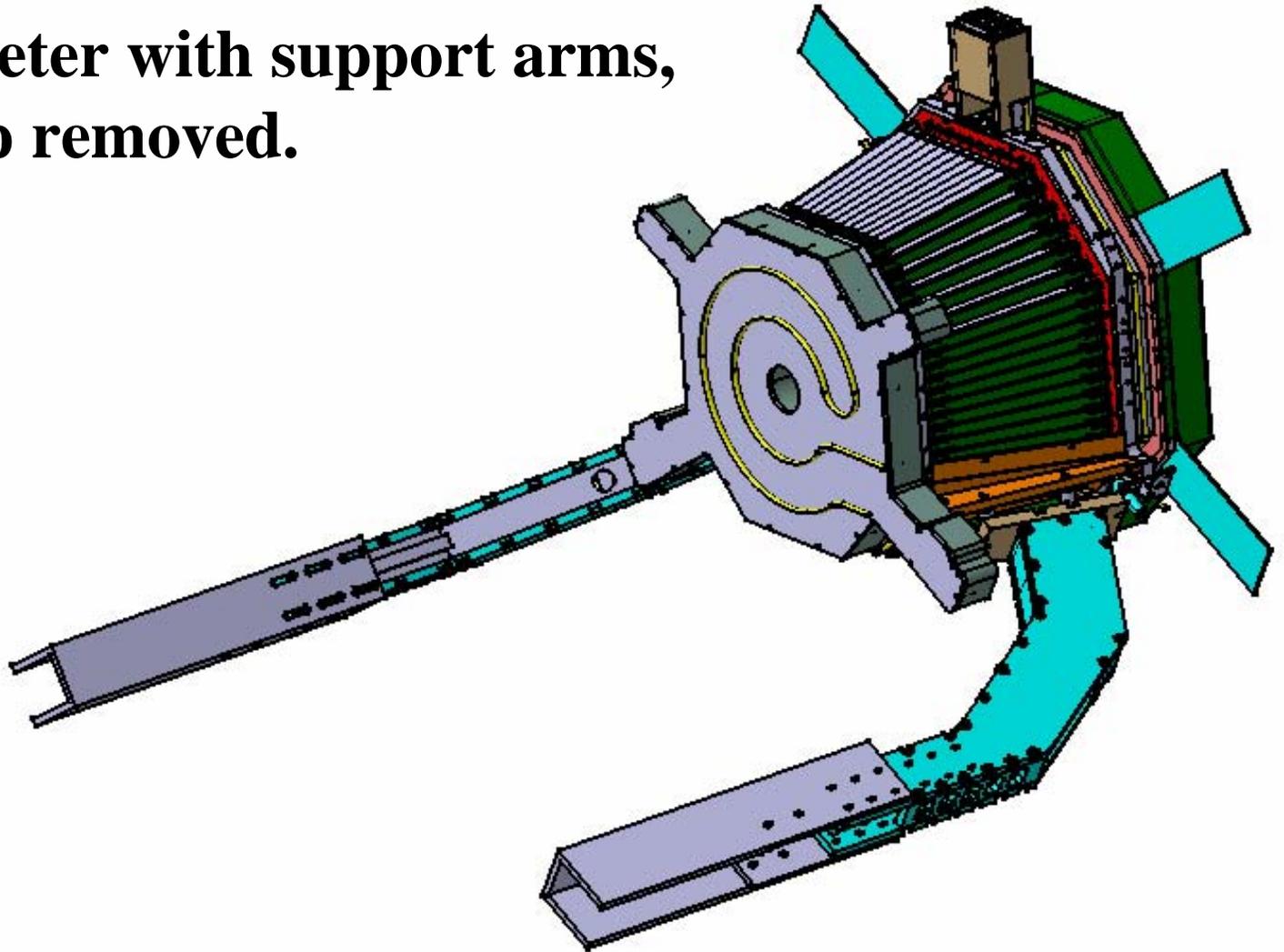
CLAS - DVCS Experiment

**Solenoid Coil in
preparation
for cold test at
Saclay**



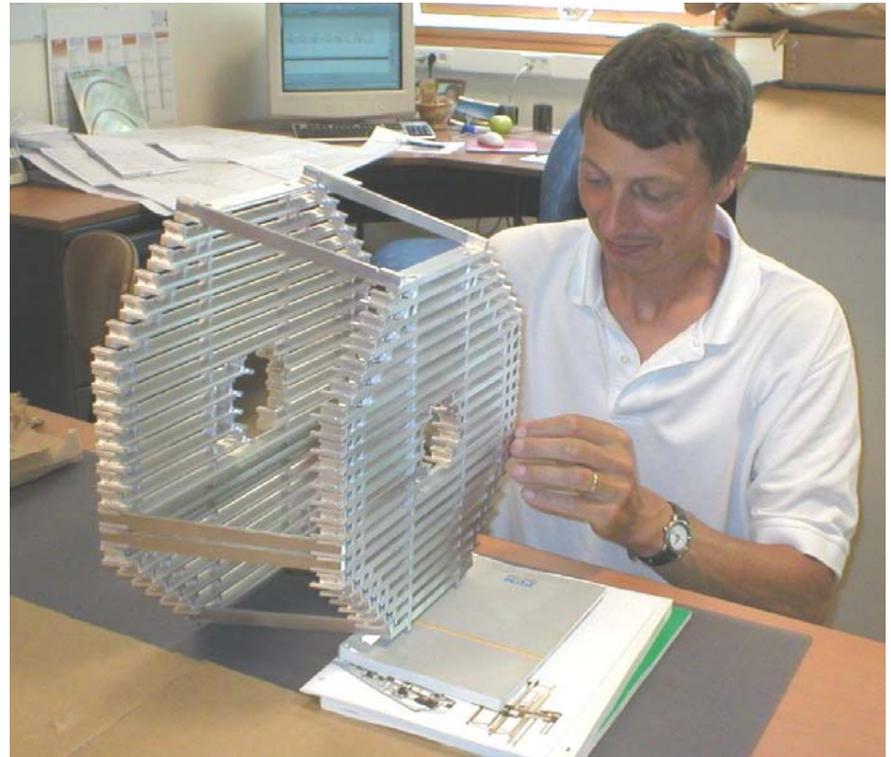
CLAS - DVCS Experiment

Orsay – CAD view of assembled calorimeter with support arms, with top removed.

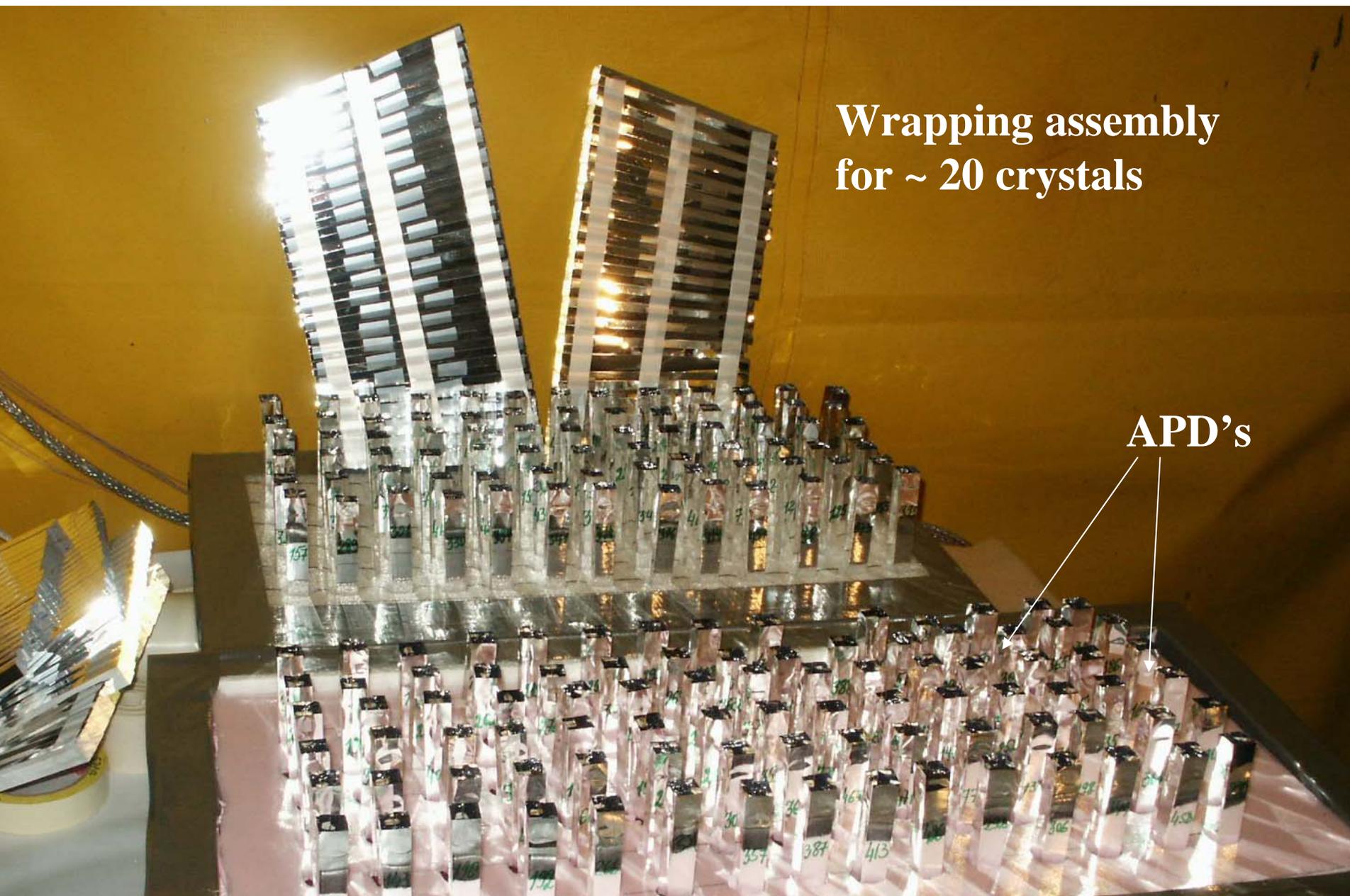


CLAS - DVCS Experiment

**DVCS - Calorimeter frames
and mounting of Motherboard
At Orsay**

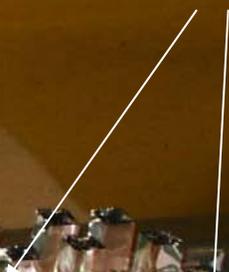


PbWO_4 crystals in preparation for assembly at JLab.



Wrapping assembly
for ~ 20 crystals

APD's



CLAS - DVCS Experiment

Solenoid:

- Magnet coil currently being prepared for cold test planned for early November at Saclay
- If no major problems occur the magnet should arrive at JLab early December.

Electronics and support frames:

- Test of all electronics channels to begin this week
- Frames to be shipped to JLab early November

Laser monitoring system:

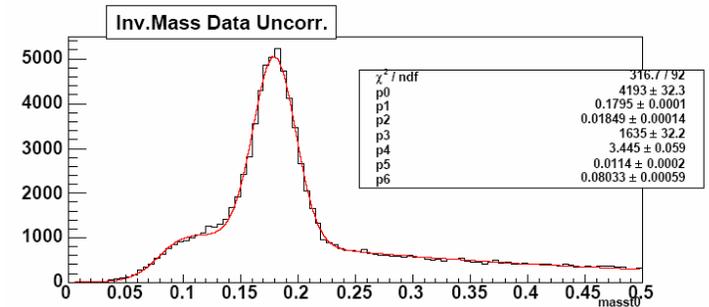
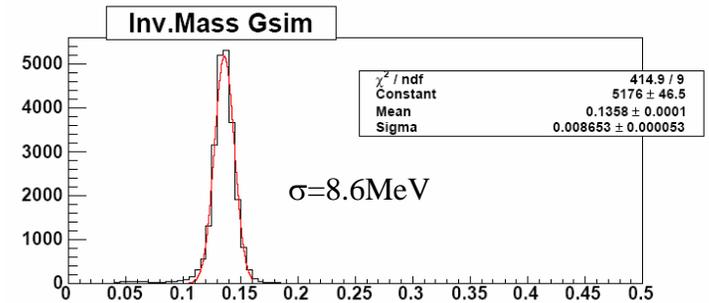
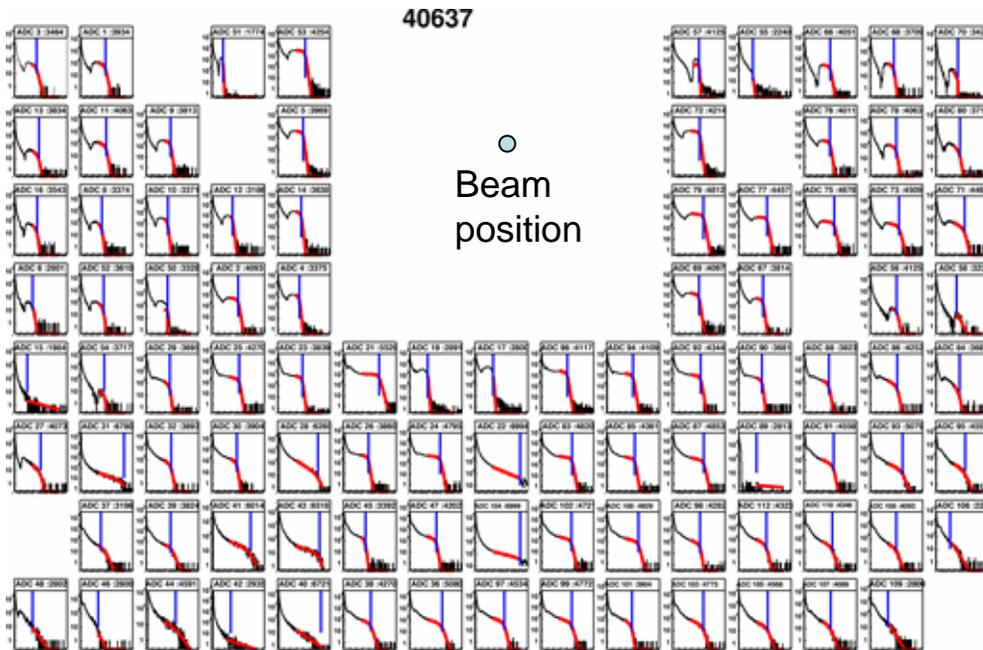
- Completed

Lead-tungstate crystals:

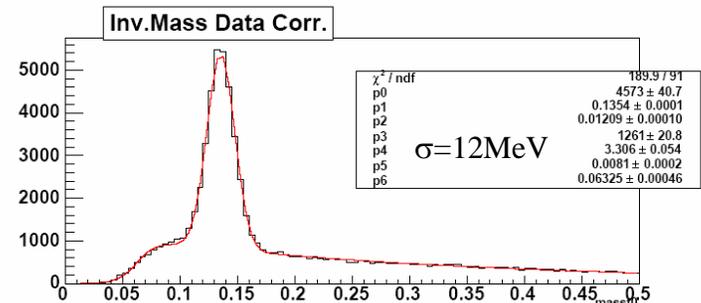
- Wrapping channel assembly, APD gluing, well underway
- Calorimeter assembly can start as soon as frames arrive

$\pi^0 \rightarrow \gamma\gamma$ Reconstruction in DVCS EC - Beam Test

(100 PbWO₄ crystals
prototype)



Iterative π^0 mass calibration



CLAS - BoNuS Experiment

Measurement of “Free” Neutron Structure Function F_{2n}

Prototype RTPC thoroughly tested

Design of final RTPC and support almost finished (with P. Hemler)

TPC Readout

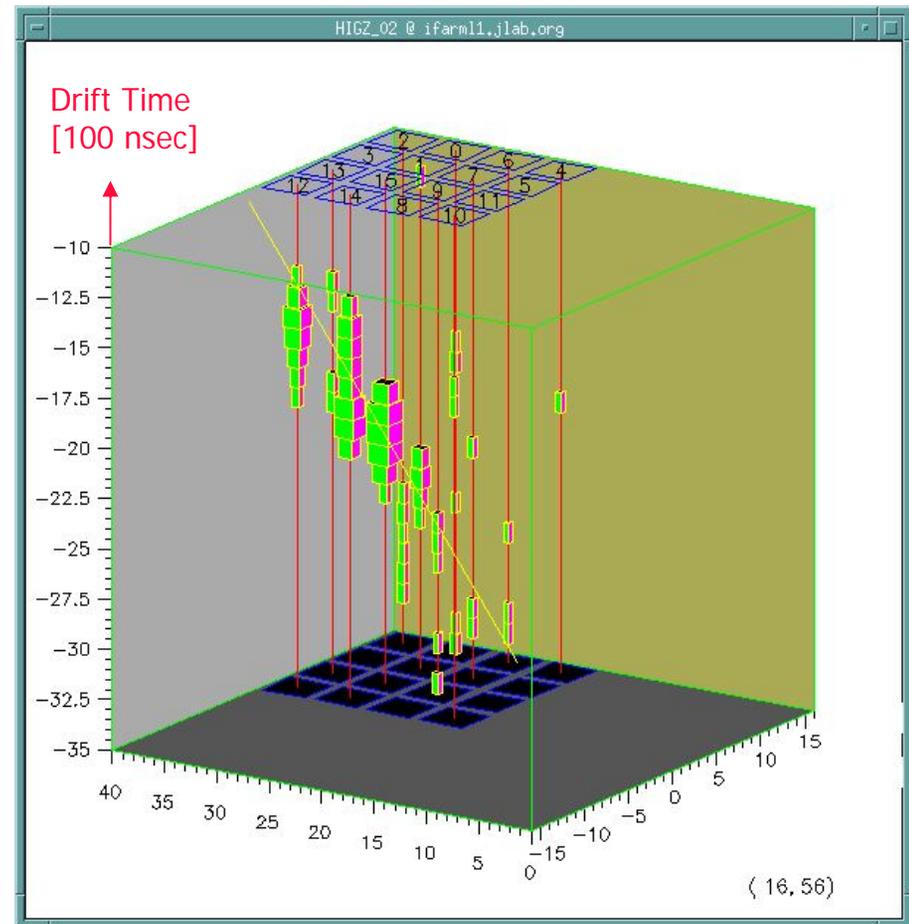
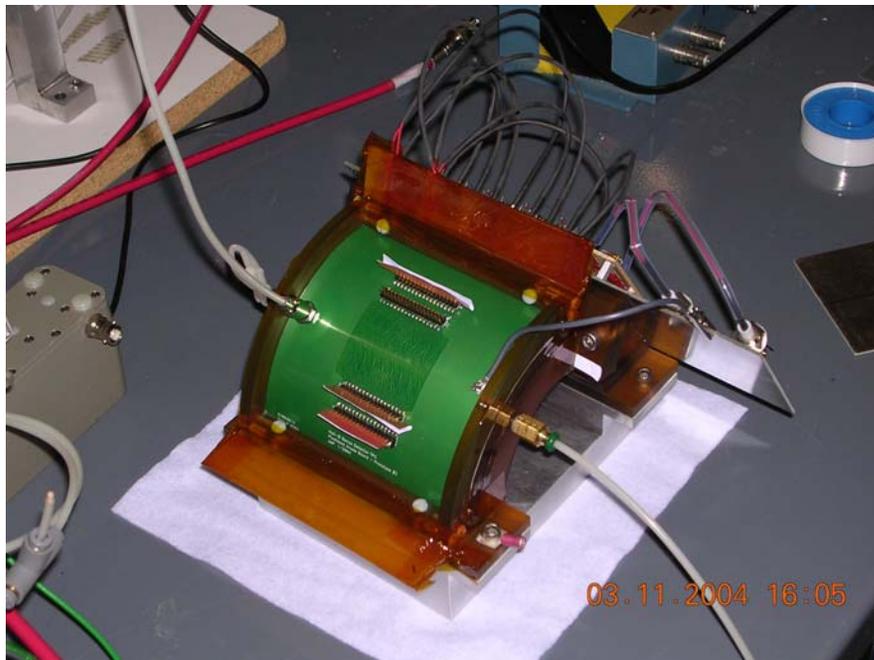
- Received and tested first front-end electronics card from CERN (ALICE TPC FEC)
- Working decision to integrate TPC readout into CLAS VME controller software
- Design of signal transmission electronics from TPC to FEC input using long cables and transmitter/inverter and receiver cards tested successfully (together with JLab fast electronics group)

Software for track reconstruction being created and tested (including integration of wire chamber data for cosmic ray data)

Track Finding Code Development

Cosmic ray passing through the prototype
RTPC with 4x4 readout pad geometry

Size of the green squares correspond to
amount of charge collected on pad for
a given 100 nsec time interval



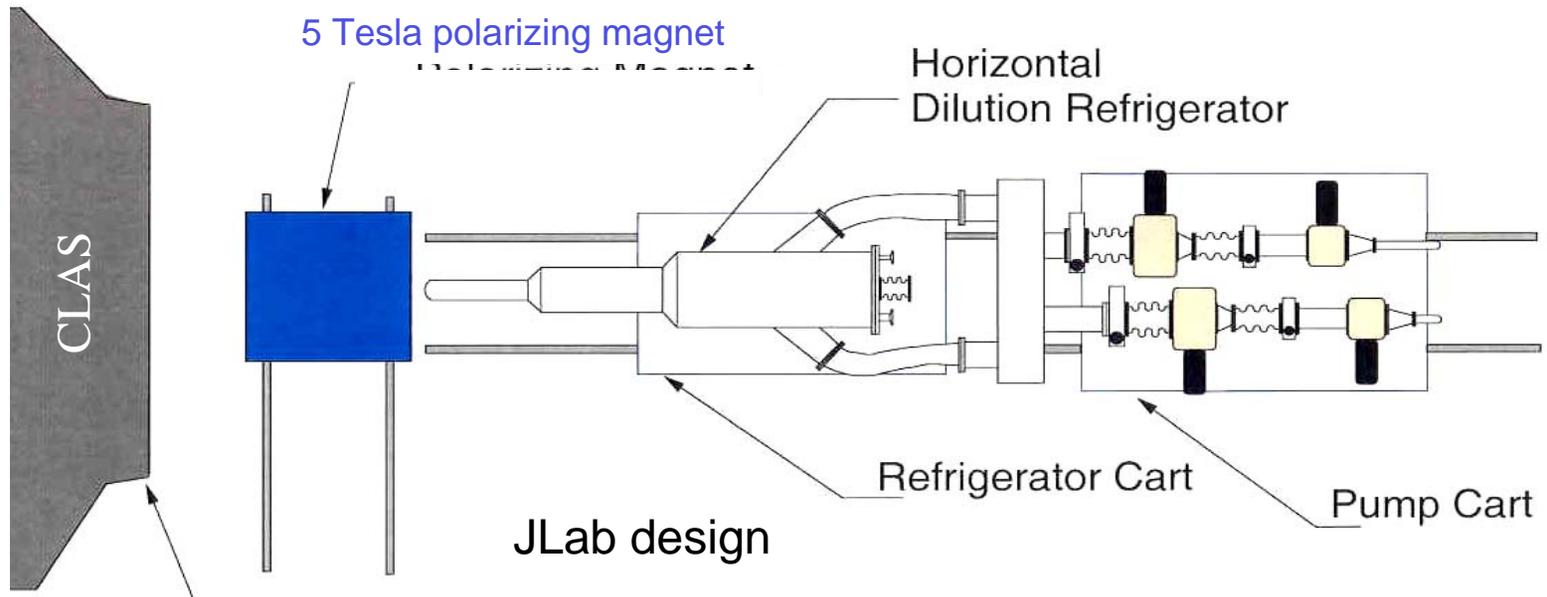
Near- and Long-Term BoNuS Plans

- Finish second prototype RTPC at ODU
(radial drift length increases from 2 cm to 3 cm for more track length)
- Design and build readout pad board with complete pad coverage for prototype RTPC
- Set up complete DAQ system based on CLAS CODA with VxWorks at ODU
- Continue design of final RTPC and gas target (integration into CLAS)
- Plan another test run with slow protons at TUNL for late 2004 or early 2005
 - Upgrade to more than 16 readout channels (ALICE FEC and USB-RCU)
 - Use prototype with 3 cm drift region
 - ↳ More track information and longer tracks as input for analysis software presently under development
- Test run of pRTPC inside Møller solenoid in conjunction with DVCS experiment in spring 2005
- Ready for data taking in fall 2005

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

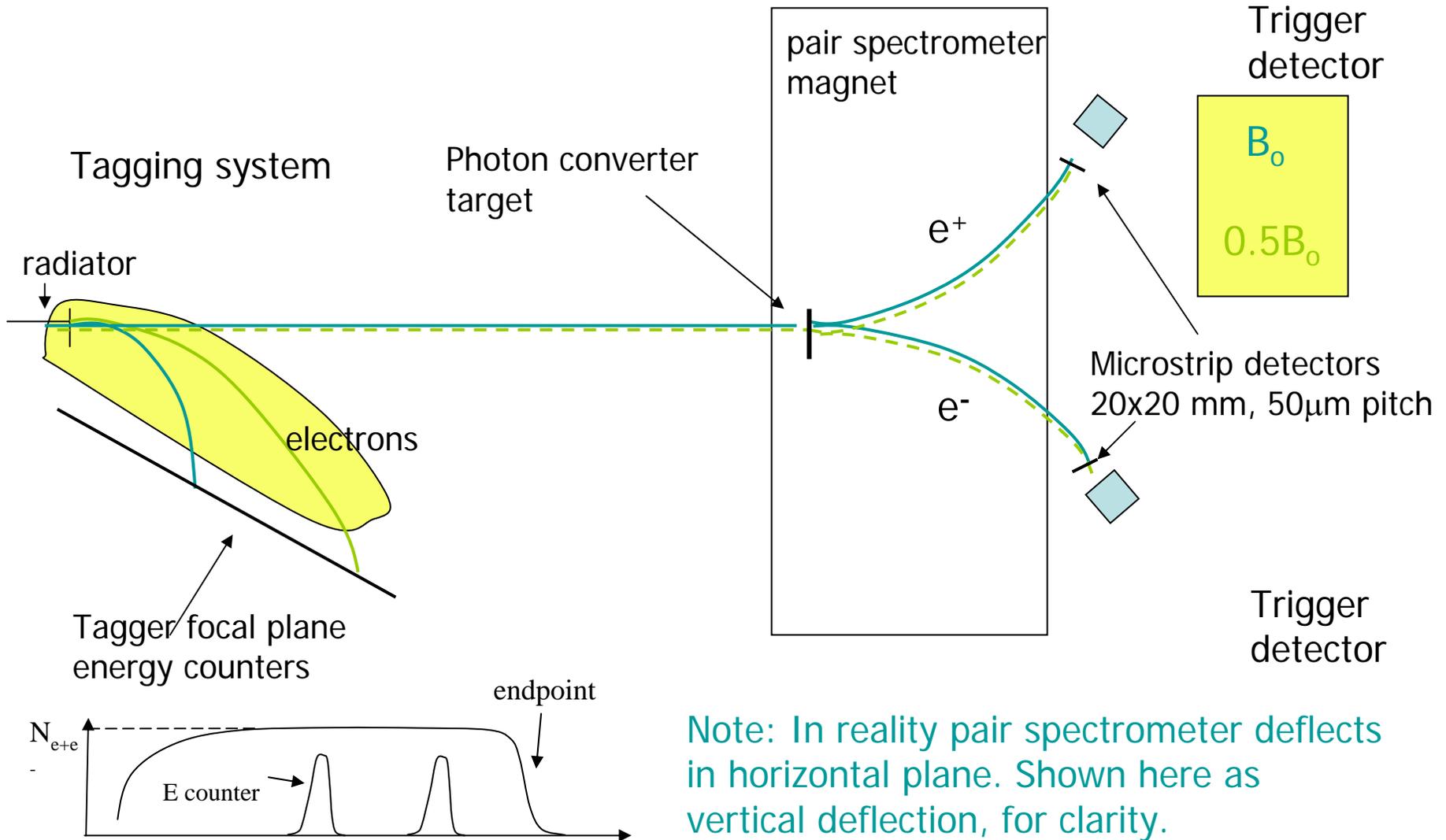


CLAS Frozen Spin Target Progress

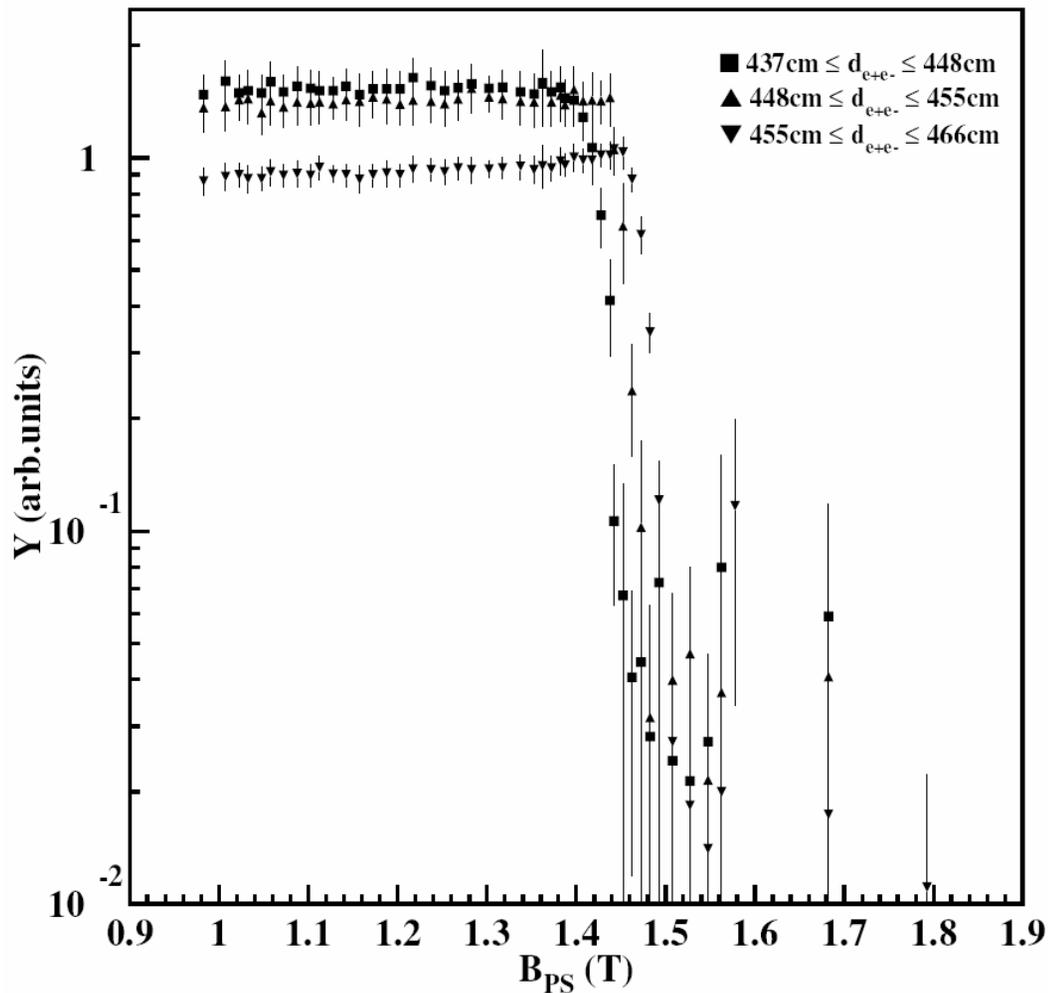
- outer vacuum can fabricated and leak tested
- 4.2K and 1.5K pre-cooling stages under construction
- mixing chamber design finalized, under construction
- all components (electronics, pumps, etc.) in-house
- sintered silver heat exchangers under construction (2 of 5 complete).
- refrigerator pump set assembled
- ^3He gas handling system complete
- ^4He gas handling system under construction
- short (10cm) solenoid designed, fabricated, test in progress
- preliminary design work on insertion cart and target positioning system
- polarizing magnet positioning system completed
- work on the transverse coil continues



Tagger energy calibration



Photon Endpoint Energy Calibration



3 out of 11 runs near Endpoint energy.

- With increasing distance between the e^+ and the e^- measured in the microstrip detectors, the magnetic field, corresponding to the beam energy increases.

Hall B Run Plan

Run group	Run time	PAC rating	Target	Energy (GeV)	Electron polar.	Comment
PrimEx	22	A	nuclear	>5	-	HyCal
2 γ test	1 **)	A-	?	5.75	-	Needs justification
eg3-cascade	20	A	D2	>5.75	-	DAQ upgrade
E1-DVCS(a)	40-50 *)	A	H2	>5.75	High	SC Solenoid, PbWO4 E
BoNuS test	5 **)	A-	D2	4.5	-	SC Solenoid
G8b	29	A-	H2	4.5	-	Goniometer, polarimeter
EG4-GDH	20	A	NH3	1.2-4.0	High	New Cerenkov
E8-BoNuS	25	A-	D2 gas	4 & 6	No	Radial TPC
EG5-Frozen	47	A-	Butanol	various	High	Frozen spin target
G12	35	A	H2	>5.75	No	New Start Counter ?
E1-DVCS(b)	10-20	A	H2	>5.75	High	Solenoid, PbWO4 - IC
E7 (coherent ρ)	50	A-	D2	>5.75	High	uses DVCS solenoid
2 γ experiment	5	A-	H2	>5.75	No	Major change in set up
EG2b	11	B+	nuclear	> 5	No	
Σ (unscheduled)	334 (252)					

*) Expect higher efficiency due to single Hall operation (60-75%)

**) at the discretion of management - needs justification for approval

Hall B 2004-2006 Schedule - Tentative

Date	Experiment	days	Energy (GeV)	Rating	Polarization?
10/01 - 11/24/04	PRIMEX		5.75	A	-
12/02 - 01/30/05	eg3-cascade	20	5.75	A	-
02/01 - 03/10/05	DVCS installation				
03/11 - 05/08/05	E1-DVCS(a)	40-50	5.75	A	High
06/02 -	G8	29	4.5	A-	-
	Unscheduled 2005/2006				
	EG4-GDH	20	1.2-5.0	A	High
	E8-BoNuS	25	4 & 5.75	A-	-
	EG5-Frozen	47	various	A-	High
	G12	35	5.75	A	-
	TPE	5	>5.75	A-	-

12 GeV Upgrade

=> Presentation by Allison Lung (Project Director)

Major Goal: CD-1 in FY2005

Sequence of events:

⇒ **Conceptual Design Report for the CEBAF Upgrade to 12 GeV outlining the science and equipment (~40 pages document).**

⇒ First draft January 2005

⇒ Internal review

⇒ Final draft in spring 2005

⇒ DOE science review: February – June 2005

⇒ Lehman Review of Upgrade Project: July 2005

⇒ CD-1 approval September 2005 (Goal)

What does this mean for Hall B?

Need to update the Equipment & Science in Hall B pCDR

- Re-establish Hall B Upgrade working groups
 - ✓ Five WGs for physics in Hall B, NP12 workshop on nuclear physics at 12 GeV
 - ✓ WGs for equipment in Hall B, revised cost estimate. We should broaden collaborator involvement in defining equipment.

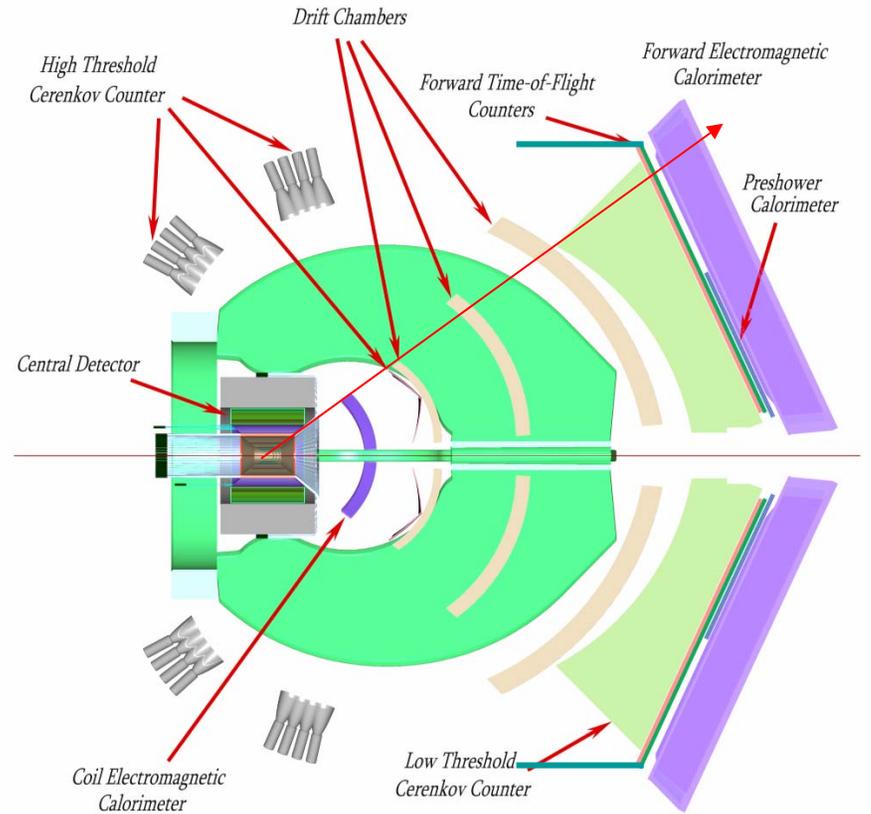
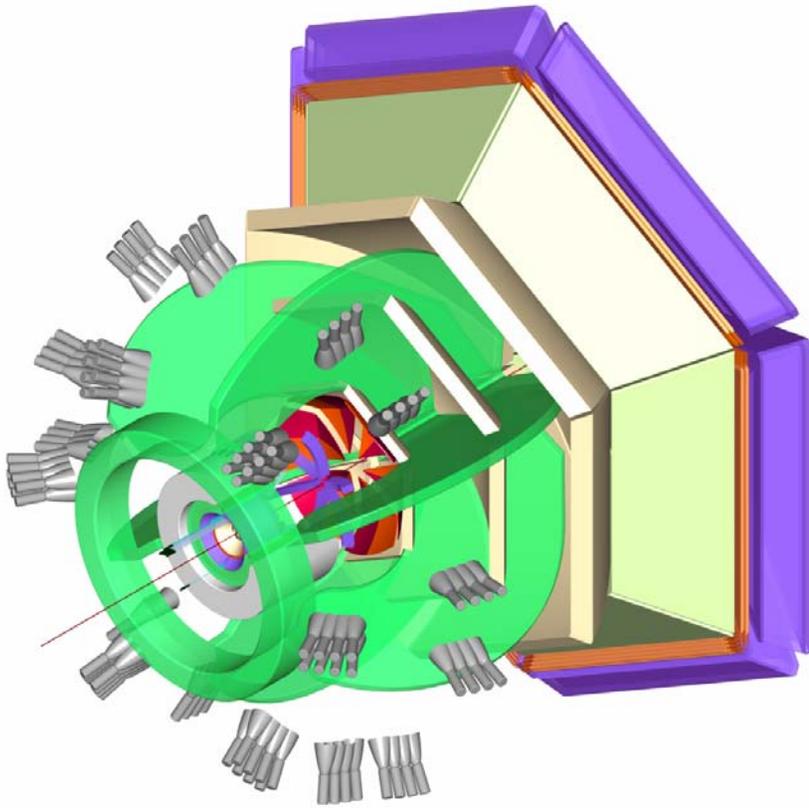
- Prepare updated Hall B pCDR

11/30/04	Updated Science motivation in Hall B pCDR
12/06/04	Submit requests for PAC27 presentations to enhance specific physics programs or add new programs not included in JLAB pCDR . Should emerge from new physics working groups.
12/18/04	Review of Science & Equipment for Hall B Upgrade.
01/14/05	PAC27 – Continue science review & equipment matching
02/xx/05	Revise Hall B pCDR Input into JLAB CDR.

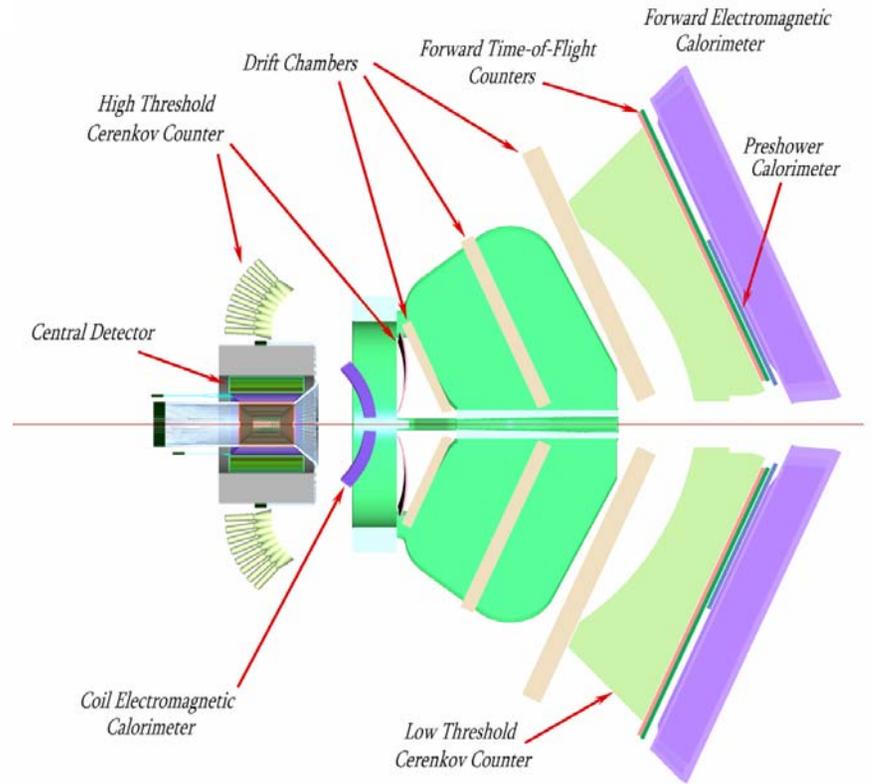
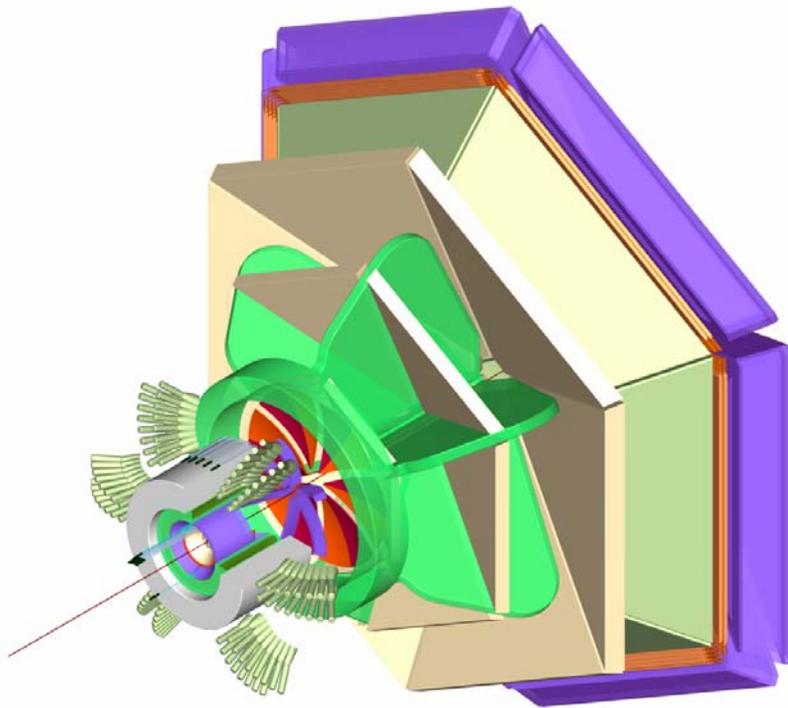
Physics Working Groups

- **What should the Physics Working Groups achieve?**
 - Put together a new version of Hall B pCDR
 - Feed material to the editorial board of JLAB *pCDR*.
 - Prepare material for presentations of new programs to PAC27
- **What to we need to have for PAC27?**
 - **Each WG should prepare the following materials**
 - a prioritized physics program that can be carried out in *one(two) year(s) (1 year = 2500 hrs at 100% efficiency)* at a ep(A) luminosity of $L= 1(2)\times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$
 - Identify the detector components needed for the program
 - Prepare appealing graphs/tables showing the expected data and physics results, especially demonstrating the full scope of results achievable with the Hall B upgrade, i.e. all kinematics dependencies $x_B/W, Q^2, t, \phi$; simultaneous measurement of several processes, e.g: $ep \rightarrow ep\gamma, en\rho^+, epp^0, ep\omega, en\pi^+, \dots$ etc.
 - Discuss the expected novel physics results and their impact on our understanding of hadronic matter.
 - **Demonstrate how the Hall B upgrade program as a whole provides exciting and *qualitatively* new insights in hadron/nuclear physics.**

CLAS++



CLAS12



Outlook

- We have an excited program underway or planned in many different areas of hadronic physics. Higher level physics analysis becomes increasingly important.
- We still have not solved the ~8% normalization problem observed in the g1c data. We need to address this with the new data sets.
- With g10 and g11 we have by far the world largest data set on meson photoproduction on hydrogen and deuterium. This needs to be analyzed also in terms of non-pentaquark physics. Excited hyperons and N^* are abundant in these data sets
- Any new proposal for PAC27 should be evaluated if it fills a gap in our program that is important to fill. We need to think carefully what enhances the CLAS program and can also run on a short time scale.
- Started work on the next phase (CD-1) of the 12 GeV upgrade to ensure a brilliant future of our exciting program.
We now need to move towards a broader involvement of collaborators in hardware and software projects, and a more formal structure in this effort. Define responsibilities of collaborating institutions, MOU's, etc. , ..