Hall Research Programs and Technical Developments

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Jefferson Lab

Science & Technology Review
June 2004

Program Overview
Status of Experiments in the Halls
Hall Experimental Equipment Development
Summary

PHYSICS STATUS 6/04

Accelerator delivered excellent beams for the physics program:

- Recovery from Isabel was outstanding
- Simultaneous G0 parity quality beam and high resolution ($\Delta E/E \sim 2 \times 10^{-5}$) for Hall A was a tour de force

Delivered Physics 19.4 weeks through May 31, 2004 (compared to plan of 17.8 for the period)

Halls had good availability (average of 86% through May)

101 full experiments and parts of 10 more have been completed:

Hall	Physics Began	Experiments Completed (full/partial)	Experiments Completed (equivalent)
C	10/95	22 / 2	23.0
A	5/97	29 / 1	29.7
B	11/97	50 / 7	54.0
	Today	101 / 10	106.7
Totals	2003 S&T	81 / 23	97.3

PHYSICS STATUS 6/04 (cont.)

The program includes 149 approved experiments involving over half of our 2100 member user community:
1132 scientists from 187 institutions in 30 countries

Working to reduce the substantial backlog of experiments:

~ 4.9 years in Hall A
~ 4.0 years in Hall B
~ 4.0 years in Hall C

} goal: ~ 3.5 years/hall

Publications and PhDs from JLab research continue to grow:

- 102 PRL and PL (57 expt. / 45 theory) (+8 submitted)
- 259 publications in other refereed journals (+9 submitted)
- 348 Invited talks and 343 contributed talks
- 172 PhDs to date, 172 more in progress

Operations Experience in FY04 to date (FY04 Goal is 27 weeks)

Metric	FY04 Goal	FY04 (Through May)
Beam Availability (%)	71.2%	72.9%
Hall A	78%	61%
Hall B	80%	95%
Hall C	78%	94%
Overall (3-hall ops average)	78%	86%
Hall Multiplicity	2.0	2.5
Physics Delivered (weeks)	17.8*	19.4

* Pro-rated based on anticipated 27 weeks of running after time lost due to Hurricane Isabel taken into account.

Publications (Users and JLab staff)

Type of Publication	Calendar Year						
	'98	'99	'00	'01	'02	'03	'04
Phys Rev Lett and Phys Lett	9	13	15	24	20	16	5 + (8)
Other Refereed Journals	5	29	39	51	52	38	8 + (9)
Invited Talks in Conf. Proc.	16	16	23	79	98	163	17 + (7)
Instrumentation Papers	2	4	4	8	3	6	2 + (0)
Contributed Papers	52	96	191	68	141	109	8 + (4)

* As of June, 2004,

- Brackets indicate papers submitted, not yet published

Advanced Degrees

- **A total of 172 PhD's have been awarded to date**

Year	Number of PhDs
1997 + previous years	17
1998	18
1999	22
2000	31
2001	25
2002	27
2003	24
2004*	8
In Progress: PhD MSc	 172 26

* As of March, 2004

Status of Experiments in the Halls

Overview of Experimental Program (pre PAC26)

Topic	Number of Experiments			
	Hall A	Hall B	Hall C	Total
Nucleon and Meson Form Factors and Sum Rules	11	4	10	25
Few Body Physics	18	6	5	29
Properties of Nuclei	7	11	10	28
N* and Meson Properties	7	31	8	46
Strange Quarks	4	15	2	21
TOTAL	**47**	**67**	**35**	**149**

- Eight conditionally approved experiments
- Ten new experiments were approved by PAC25 (Five Pentaquark experiments)

Overview of Hall A Experiments

	Number Approved	Number Completed	Days Approved	Days Run	Days To Run
Nucleon and Meson Form Factors/Sum Rules	11	7	206	147	59
Few Body Nuclear Properties	18	11	280	165	115
Properties of Nuclei	7	4	114	52	62
N* and Meson Properties	7	4	138	91	47
Strange Quarks	4	2	123	63	60
Total	47	29	861	518	343

- 12 physics publications (PRL and PRC) since last review
- 3 new proposals approved and 2 jeopardy proposals re-approved by PAC24/25
- 25 Experiments require polarized beam
- 1 Previously approved experiment removed by jeopardy process
- Backlog ~ 5 years (one jeopardy proposal for PAC26)

Experiments completed in Hall A since last review

Exp	Title	Spokespersons
E97-110	The GDH Sum Rule and the Spin Structure of ^{3}He and the Neutron using nearly Real Photons	F. Garibaldi, J.-P. Chen, A. Deur
E94-107	High-Resolution Hypernuclear 1p-shell Spectroscopy	S. Frullani, F. Garibaldi, J. LeRose, P. Markowitz
E04-012	High-Resolution Study of the 1540 Exotic State	B. Wojtsekhowski

Upcoming Program in Hall A

Date	Exp	Program	
2004			
June	E00-114	Parity Violation from ^{4}He at low Q^2	D. Armstrong, R. Michaels
July	E99-115	Constraining the Nucleon Strangeness Radius in Parity-Violating Electron Scattering	K. Kumar, D. Lhuillier
Aug/Sept		Removal of septum magnets Install DVCS calorimeter	
Sep/Oct	E00-110	Deep Virtual Compton Scattering	F. Sabatie, C. Hyde-Wright, P. Bertin, R. Ransome
Oct/Nov	E03-106	Deep Virtual Compton Scattering	F. Sabatie, C. Hyde-Wright, P. Bertin, E. Voutier
Dec		Installation of Big Bite	
2005			
Jan/Mar	E01-015	Studying the Internal Small-Distance Structure of Nuclei	S. Wood, E. Piasetzky, W. Bertozzi
Apr/May		Install septa and waterfall target	
June	E94-107	High-Resolution Hypernuclear 1p-shell Spectroscopy	S. Frullani, F. Garibaldi, J. LeRose, P. Markowitz

Overview of experiments in Hall B

Run Group	Title	# Exps	PAC time	% Complete
e1	e p -> e' X, N* excitation	15	141	100
eg2	Quark propagation and hadronization in nuclei	2	44	66
g10	Search for the θ^+ pentaquark on deuterium	1	30	100
g11	Spectroscopy of Exotic Baryons	1	25	Just started

- 12 physics publications (PRL,PRD and PRC) since last review, 3 more submitted
- 6 more under CLAS Collaboration review
- Backlog about 4 years

Upcoming Program in Hall B

Date	Exp	Physics Goals
2004		
Aug - Sept		Install Primex
Oct - Nov	PRIMEX	π^0 lifetime
Dec	eg3	Search for cascade pentaquarks
2005		
Jan	eg3 continued	
Feb	DVCS Install	
Mar - Apr	DVCS	Accessing Generalized Parton Distributions
May - June	g8	Search for missing resonances in γp -> Vector mesons
July - Aug	DVCS Install	

Overview of Hall C Experiments

	Number Approved	Number Completed	Days Approved	Days Run	Days To Run
Nucleon and Meson Form Factors/Sum Rules	11	5.5	299	168	131
Few Body Nuclear Properties	5	3.5	99	85	14
Properties of Nuclei	9	5	153	89	64
N* and Meson Properties	8	7	92	85	7
Strange Quarks	4	2	151	91	60
Total	37	23	794	518	276

- 9 physics publications (PRL and PRC) since last review
- 10 Approved experiments require polarized beam
- 2.5 Approved experiments removed by jeopardy process
- Backlog ~ 4 years

Experiments completed in Hall C since last review

Exp	Title	Spokespersons
E01-002	Baryon Resonance Electroproduction at High Momentum Transfer	P. Bosted, V. Frolov, M. Jones, V. Koubarovski, P. Stoler
E00-116	F_2^N Moments at High Q^2	C. Keppel
E01-004	The Charged Pion Form Factor Extension	H.P. Blok, G. Huber, D. Mack
E00-108 (half)	Duality in Meson Electroproduction	H. Mkrtchyan, G. Niculescu, R. Ent
E00-006	G0 Experiment: Forward Angle Measurements, Second Engineering Run	D. Beck
E00-006	G0 Experiment: Forward Angle Measurements, Physics Run	D. Beck

- In September, 2003 re-installation of G0 experiment started
- Finished forward angle data taking for the G0 experiment on May 17, 2004 and started changing over to HMS + SOS running

Upcoming Program in Hall C

DATE	EXP	PROGRAM	SPOKESPERSON
June, 2004	E01-109	G_E^p/G_M^p to Q^2 = 9 GeV^2 BigCal-HMS test	E. Brash, M. Jones, C. Perdrisat, V. Punjabi
June	E02-019	x > 1 at high Q^2 Part I at 5 GeV	J. Arrington, D. Day, B. Filippone, A. Lung
July	E01-107	Pion Transparency in Nuclei Part I at 5 + 4 GeV	D. Dutta, K. Garrow, R. Ent
August-September		HMS Controls, G0 Turnaround	
September-November	E02-019	x > 1 at high Q^2 Part II at 5.75 GeV	J. Arrington, D. Day, B. Filippone, A. Lung
November-December	E03-103	EMC Effect in Light Nuclei	J. Arrington, D. Gaskell
December	E01-107	Pion Transparency in Nuclei Part II at 5.75 GeV	D. Dutta, K. Garrow, R. Ent
January-April, 2005		HKS Experiment Installation	
April-July	E01-011	Spectroscopy Study of Medium to Medium-Heavy Mass Λ Hypernuclei	O. Hashimoto, S. Nakamura, J. Reinhold, L. Tang

Hall Instrumentation

Hall A Instrumentation

Septum magnets (scattering angle 6°)

- Coil cooling and electrical connections fixed, the substantial rework of the cryostat resulting in over a three months delay in the physics program
- Both septa now operating

Short-range correlations through triple coincidences

- Detector systems assembled
- Scattering chamber leak checked

Deep Virtual Compton Scattering

- Proton and photon detector arrays assembled

G_E^n up to 3.5 GeV^2

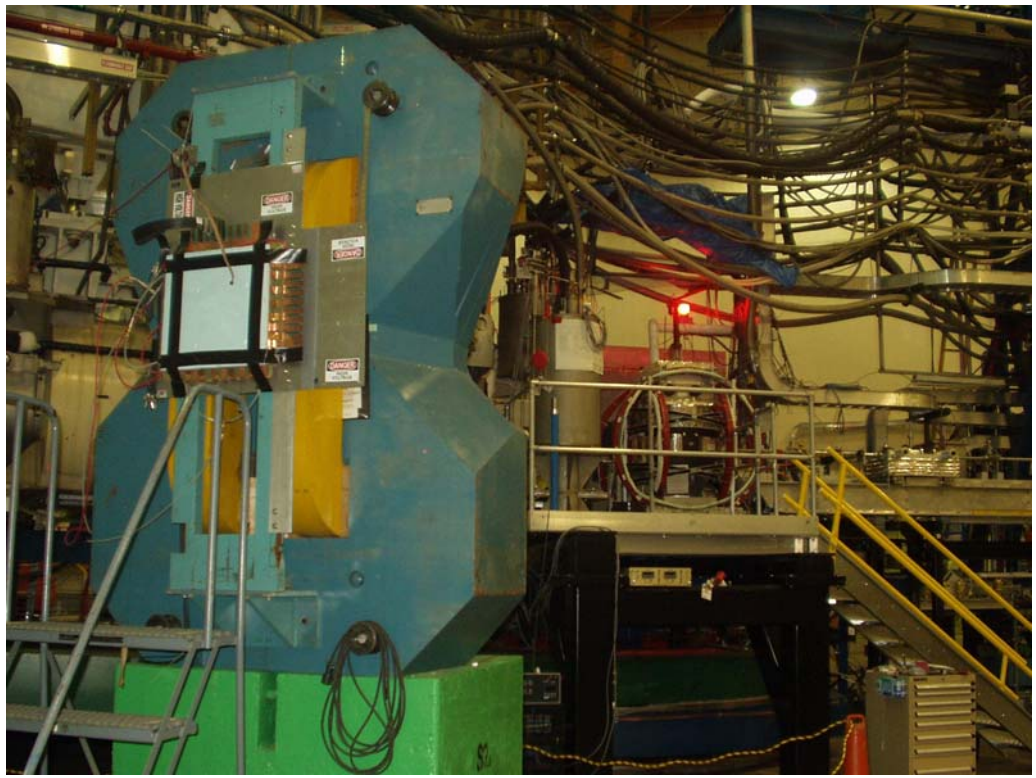
- VDC's under construction
- Assembly of neutron scintillator array started

BigBite in Hall A

• Will be first used for the Short Range Correlation experiment $^{12}C(e,e'p+n)$.

• BigBite will detect correlated protons and a scintillator array detects the correlated neutrons.

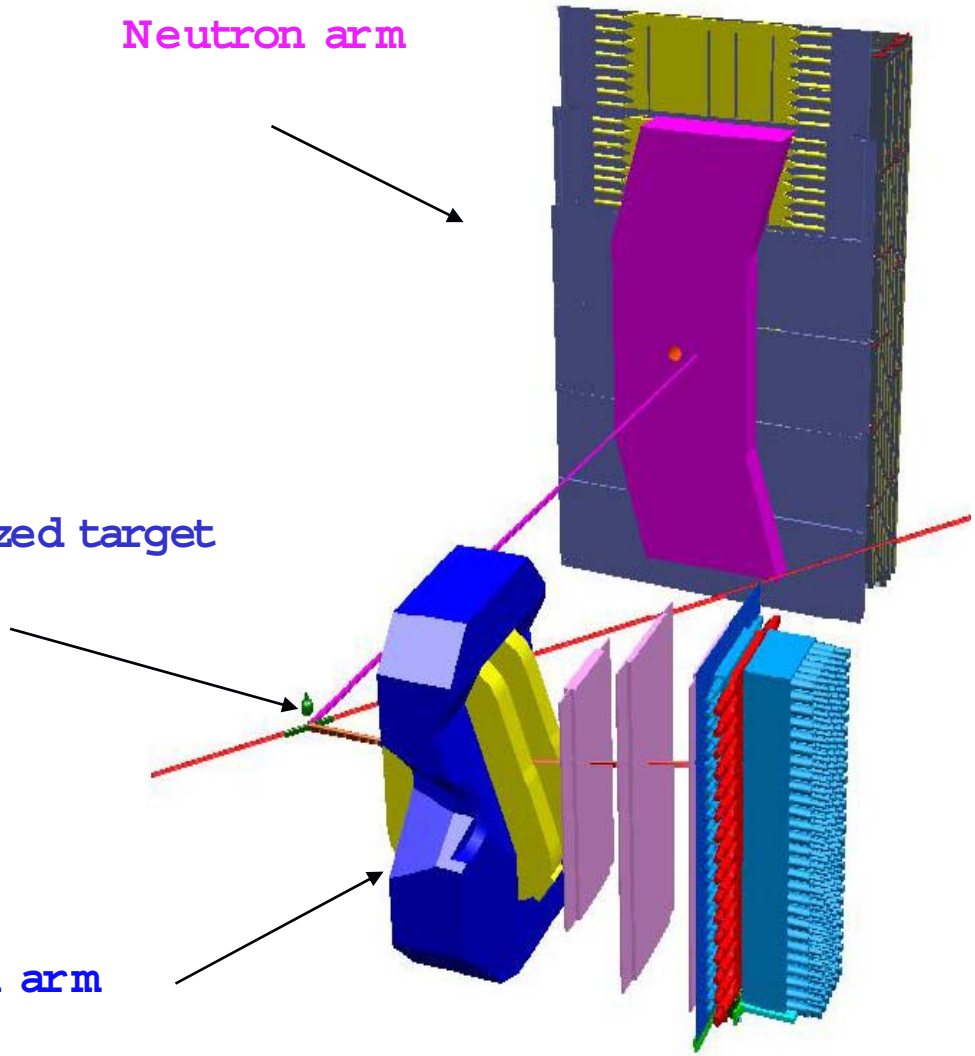
• Along with the platform and detectors, a new scattering chamber has been built with extra large exit windows in order to match the large out-of-plane acceptance of BigBite.



Measurement of G_E^n at high Q^2

- Figure of Merit about 25 better than earlier experiment which allows extension to higher Q**2

- Complete set-up will be ready to run by late summer 2005



Hall B Instrumentation

Experiment	Physics Motivation	Technical Solution	To run in
G11 + future tagged γ exp.	High-rate search for penta-quark states	new highly segmented start counter	2004
PrimEx	test Chiral PT prediction for $\pi^o \rightarrow \gamma\ \gamma$	leadglass calorimeter with high resolution lead tungstate insert	2004
DVCS	constrain GPD's via $ep \rightarrow e'p\gamma$	5T solenoidal Moeller shield crystal detector inside CLAS	2005
BONUS	*n* structure functions via tagging spectator proton in $eD \rightarrow e'p\ X$	GEM drift chamber for low momentum (p_p > 70 MeV/c) protons	2005
Missing resonance search	explore spectrum of excited 3-quark-states via $\gamma\ p \rightarrow K^+\Lambda$, …	frozen spin target for tagged photon experiments	2006
GDH	Determine GDH integral at very small Q^2	Cerenkov counter specialized for electron detection at small angles	2006

New Start Counter for Tagged Photon Experiments

Required for penta-quark searches

- Existing start counter insufficient for new generation of high-rate tagged photon experiments since it can't trigger on event multiplicity
- New capabilities required for G11 penta-quark search (approved by PAC in January 2004)

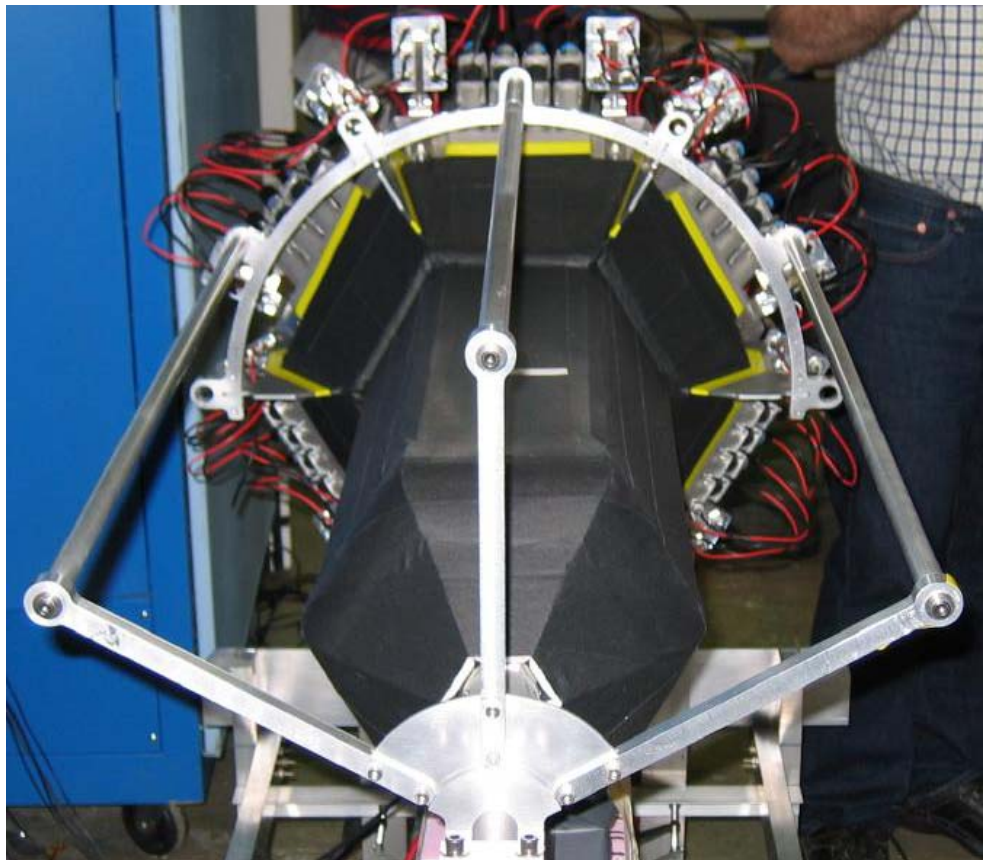
Solution

construct new start counter with

- 24 scintillator strips each covering $\Delta\phi$ interval
- individual PMT readout

Status

- installed on 5/19/2004 for G11 experiment



Calorimeter for PrimEx (Primakoff Experiment)

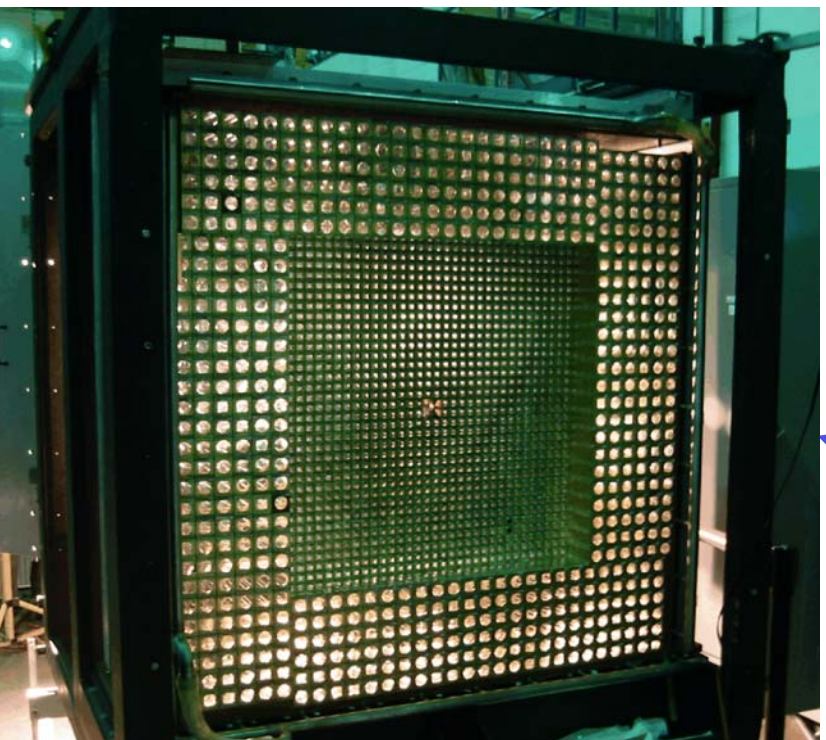
Technical requirement for $\gamma A \rightarrow \pi^o A$

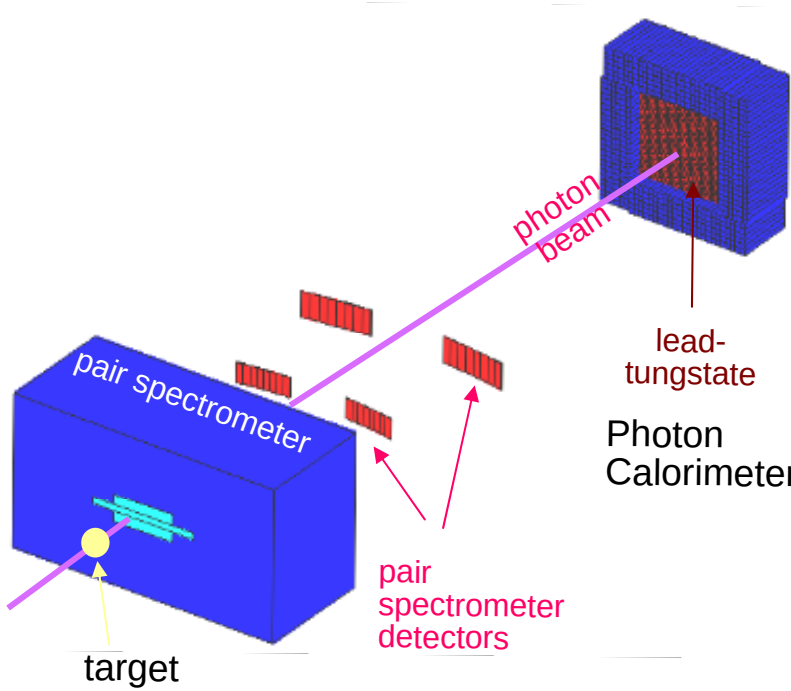
- decay photon detection at very small angles
- need good photon angular and energy resolution

Solution

Hybrid calorimeter for γ detection (NSF MRI)

- lead-glass blocks at large angles
- lead-tungstate crystals at small angles





Status:

- pair spectrometer installed and commissioned
- calorimeter construction completed at JLab
- Hall B infrastructure ready
- installation scheduled for July 2004

Setup for Deeply Virtual Compton Scattering in CLAS

Technical requirement for $\vec{e}p \rightarrow e'p\,\gamma$

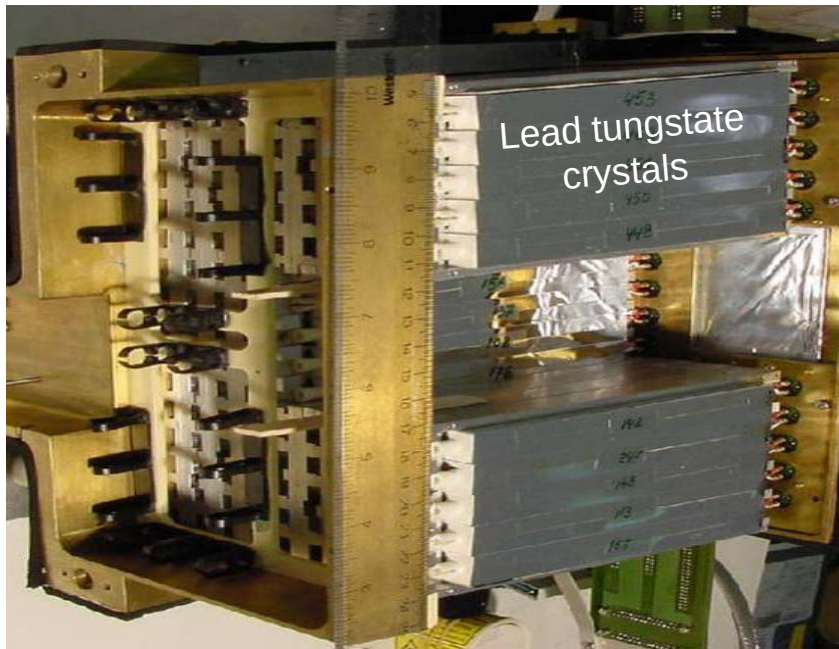
- Detect all final state particles to cleanly identify process
- Double luminosity to $2 \times 10^{34}\ cm^{-2}\ s^{-1}$

Technical solution

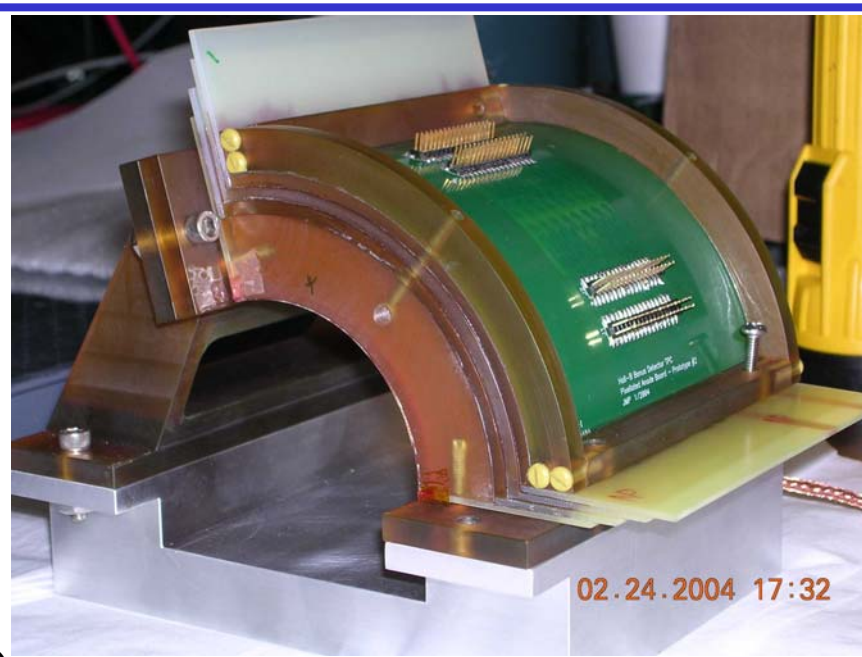
- Forward calorimeter with 436 lead tungstate crystals readout via avalanche photodiodes (APD)
- Super-conducting 5Tesla solenoid Moller shield

Status

- solenoid construction nearing completion (Saclay)
- calorimeter prototype built (ITEP, Orsay, JLab)
- prototype tested in CLAS under realistic conditions



Bound Nucleon Structure (BONUS)



Technical requirement

Detect spectator protons in coincidence with scattered e’

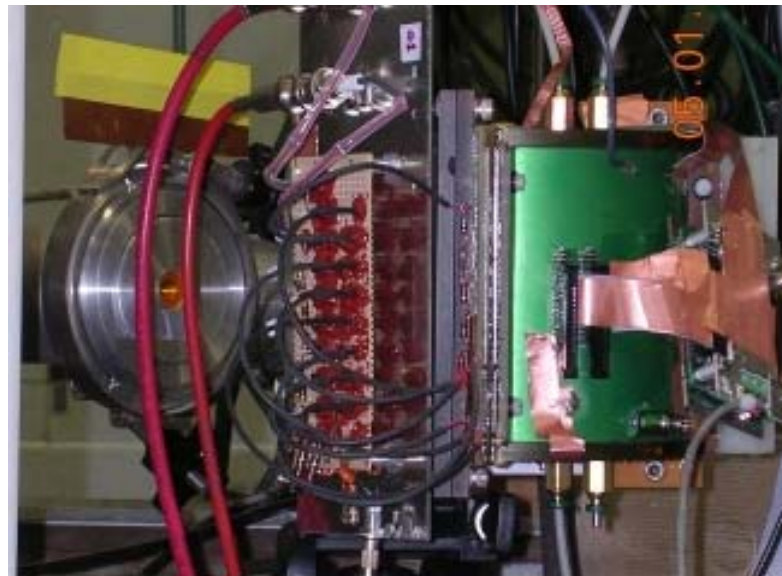
- Low momentum and low range protons
- High rate, isotropic angular distribution (no correlation)

Solution

- High pressure gas target in 5T field
- Surrounded by radial time projection chamber (RTPC)
- Curved Gas Electron Multiplier (GEM) amplification gap

Status

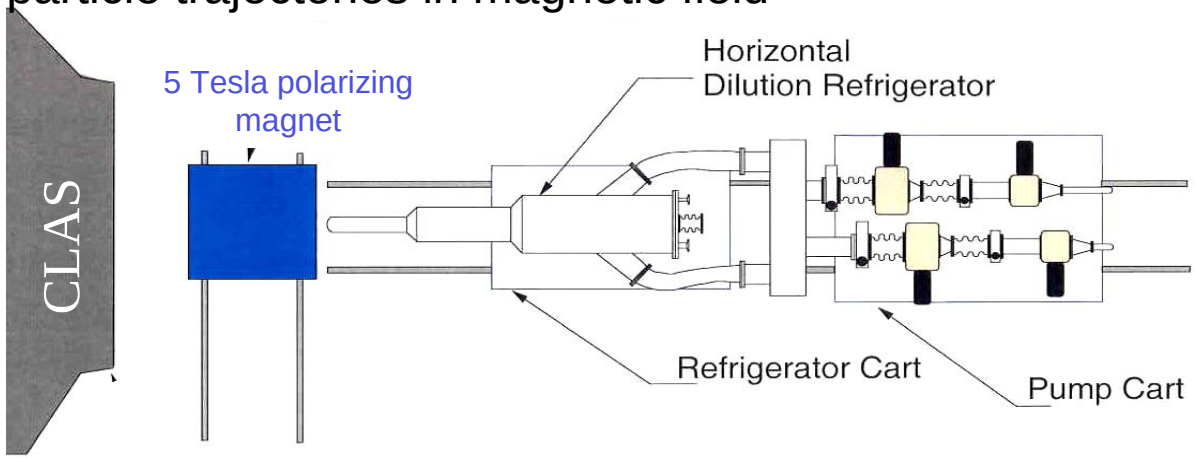
- design in advanced stage (JLab/ODU)
- flat and curved prototypes constructed
- prototype tested at TUNL low-energy p beam



Frozen Spin Target for CLAS

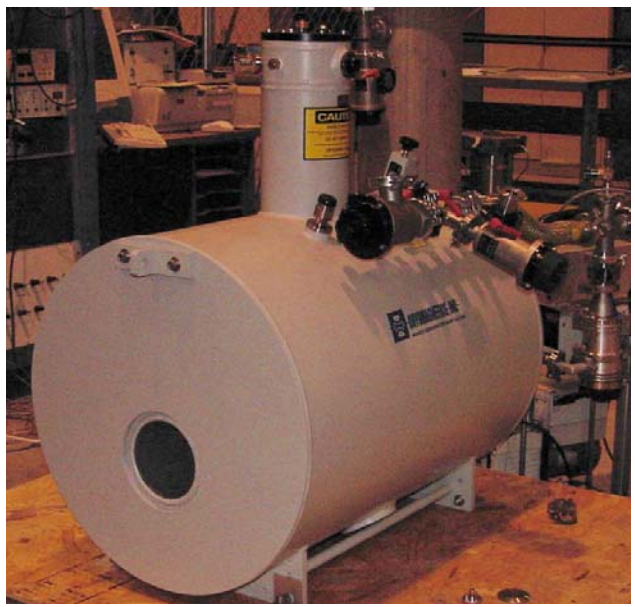
Technical requirement:

construct polarized target for tagged photon beam with minimum obstruction of CLAS solid angle and low distortion of particle trajectories in magnetic field



Solution: frozen spin target

- polarize target at 1K and 5T using microwave transitions
- lower temperature to 50mK
- switch off microwaves
- lower magnetic field to 0.5T



Status:

- design completed
- construction started
- polarizing magnet commissioned

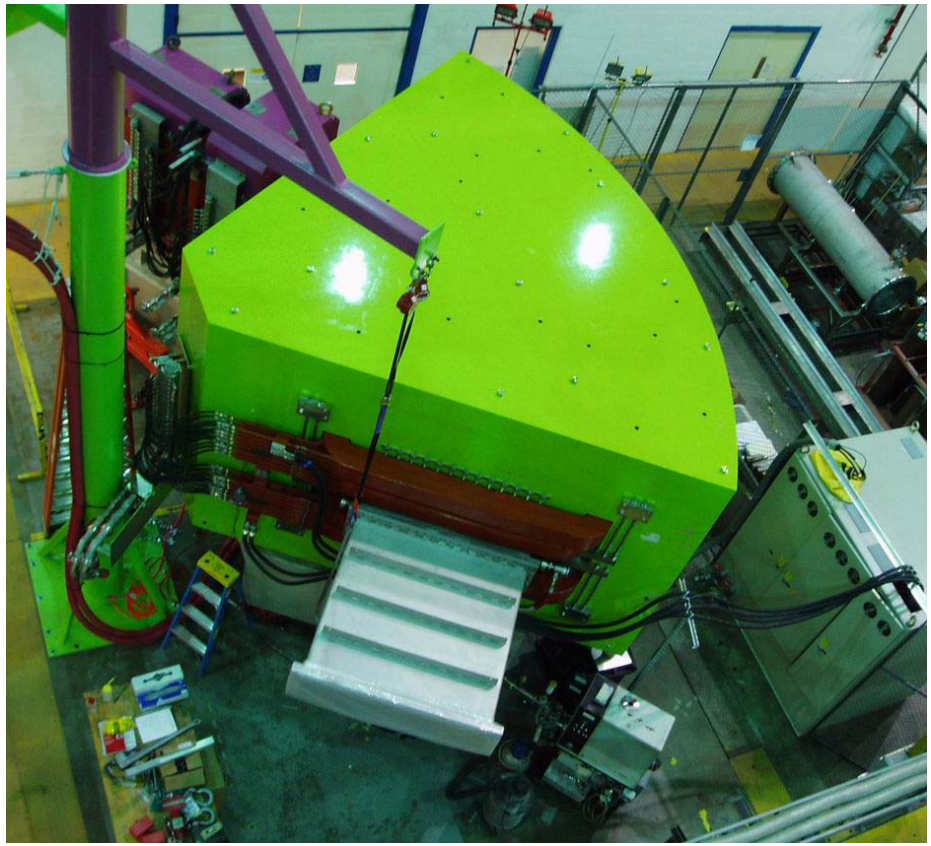
Hall C Instrumentation

HKS Magnets arrived from Mitsubishi at end of November

- On time and within their budget($3.0M)
- Tohoku has also received a new grant to build a complementary electron spectrometer ($2.5M)

Detector work is ongoing, most prototype detectors were tested in KEK or Sendai beam, now cosmics testing in EEL

HKS Chambers	Hampton
HKS Hodoscope	Tohoku U
HKS Water Cerenkov	Tohoku U
HKS Aerogel Detectors	Florida Int.
Enge Honeycomb	Tohoku U
Enge Hodoscope	Tohoku U

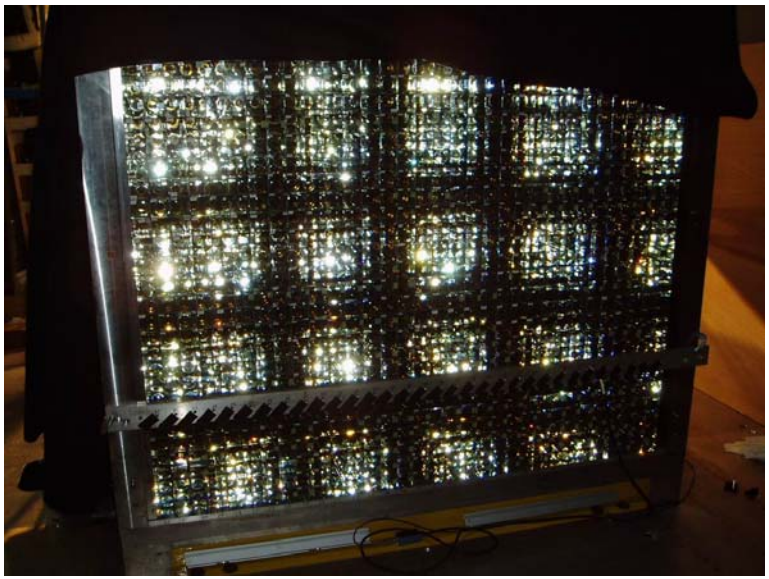


(above) aerial photo of HKS in Test Lab

Remaining work: finalize construction of sieve and vacuum systems (JLab)
construction of beam dump line and new DZ magnet (Accel. Division)
work on data acquisition and analysis software (Collaboration)
finalize electronics work (including new F1 TDC's – Fast Electronics)

GEp-III Status

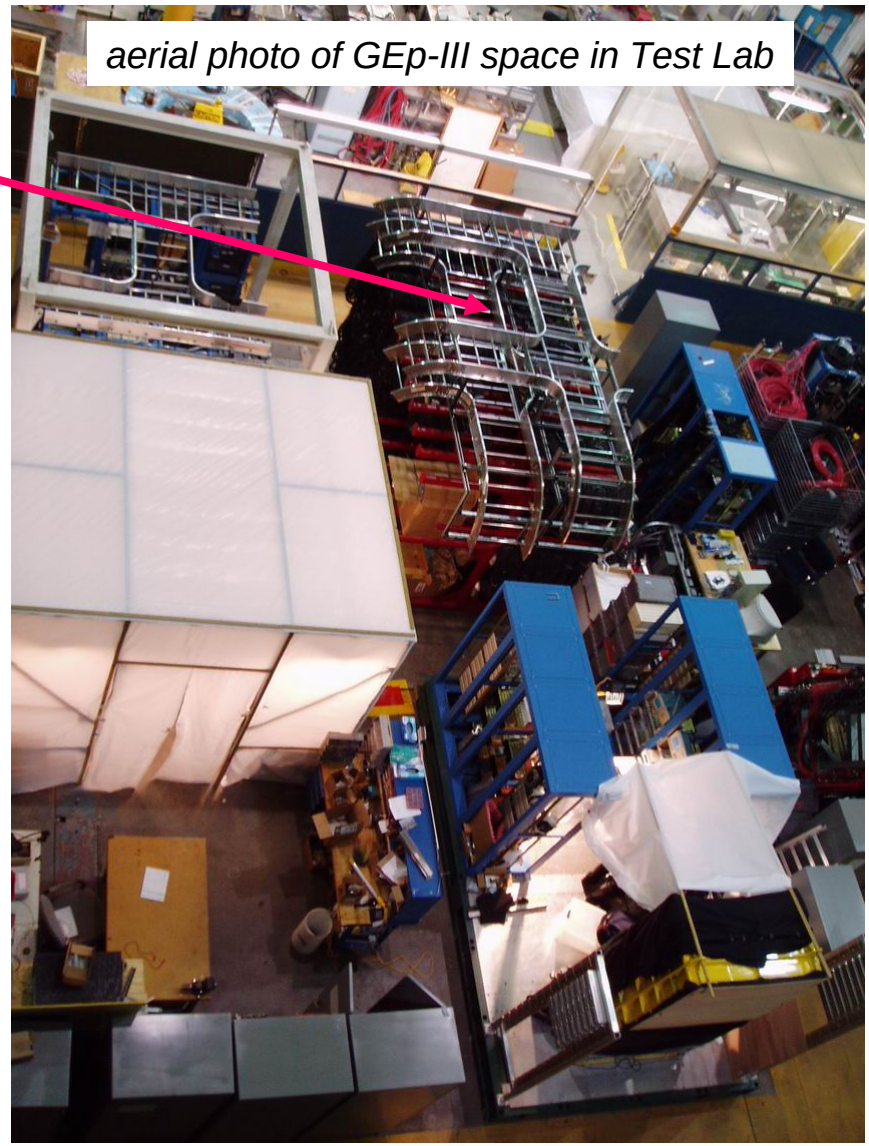
All 1744 bars have been installed in the large calorimeter. The cabling has been installed in a separate frame.



Test setup in Hall C during the N-Δ experiment shows acceptable background rates.

The Dubna/Protvino prototype chamber + electronics for the FPP is on site and being tested. Expect first (last) two chambers in 6 (12) months.

Anticipated “Ready” Date: Fall 2005

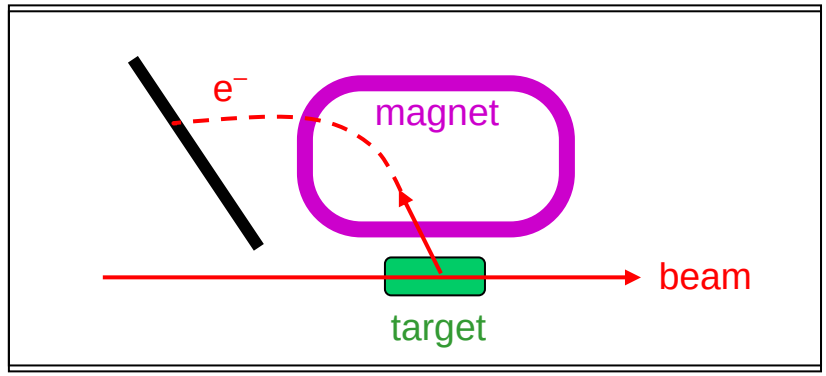


aerial photo of GEp-III space in Test Lab

G0 Backward Angle Status

Cryostat-Exit Detectors:

Scintillators - fabrication completed, delivered to JLab
Lightguides - first octant completed, delivered to JLab
Test-fit w/ scintillators & support structure
- delivery to JLab ~ spring/summer 04



Aerogel Cerenkov Detectors:

French & NA - fabrication of detectors underway
- delivery to JLab ~ spring/summer 04

Electronics:

NA CED•FPD boards
- prototype boards tested → production
- delivery to JLab ~ fall 04

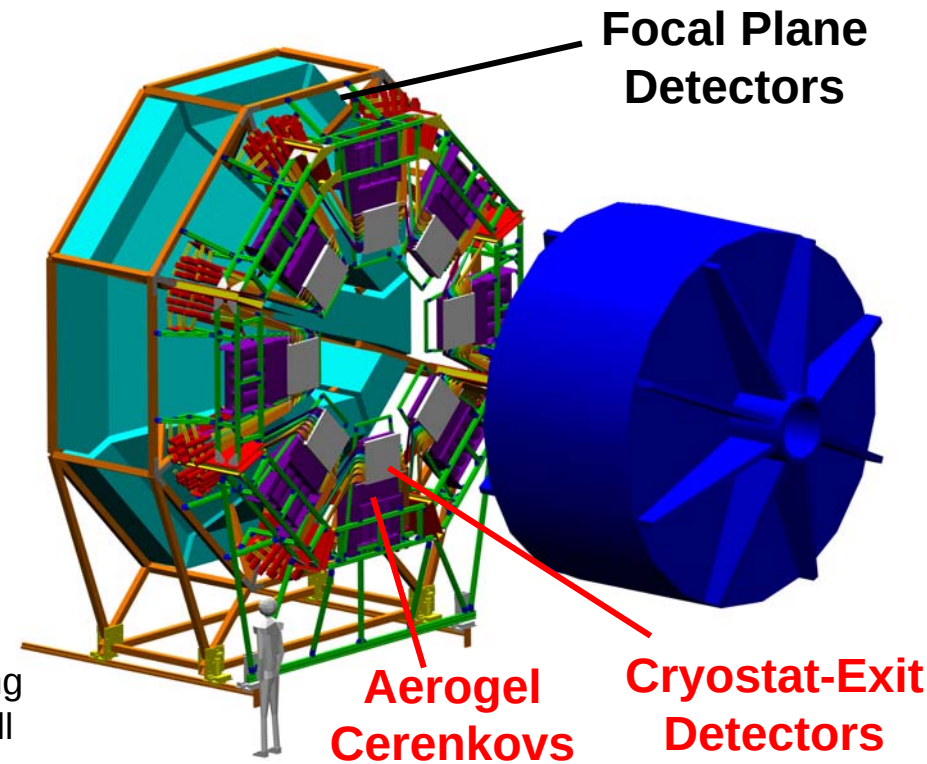
French CED•FPD boards
- prototype boards tested → production
- delivery to JLab ~ summer 04

Magnet/Cryotarget:

- Rotate Ferris Wheel in July
- Rotate Superconducting Magnet in Fall
- Relocation of target and cryogenic service lines ongoing

Complete Program:

- Potentially 3 more 70-day blocks of running
- Only one energy compatible with other hall running



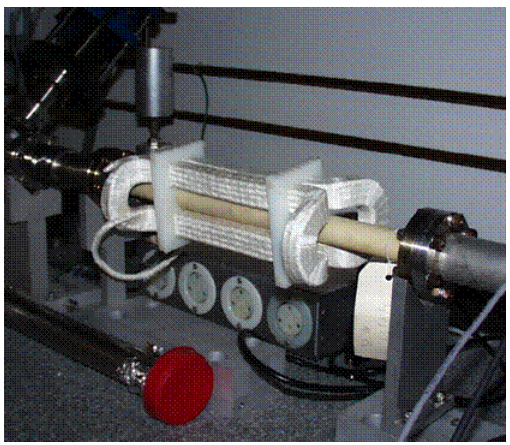
Basel/UVa/Hall C Moller Polarimeter

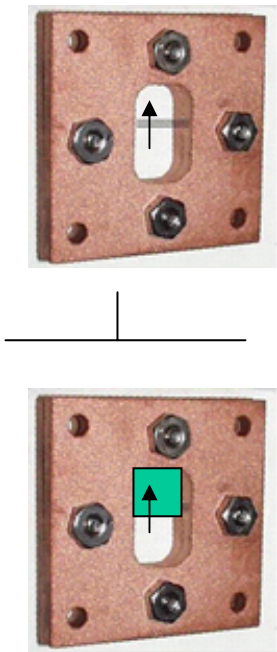
Sub-1% polarimeter

(M. Hauger et al., NIM A462 (2001) 382:
If injector conditions and foil temperature under control 0.5% precision, but a major disadvantage is that the existing device is limited to ~1 μA

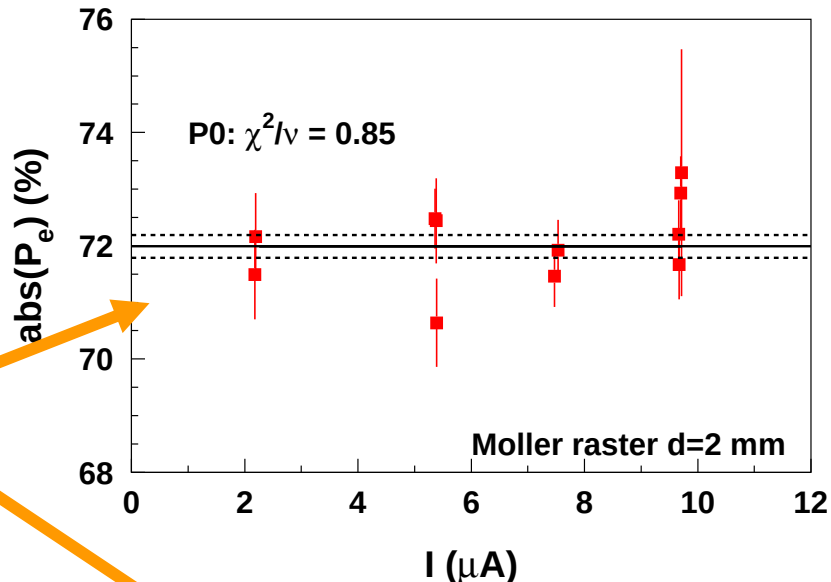
June 2003 Polarimetry Workshop: Idea is to go to higher currents (100 μA) and quasi-continuous measurements by combination of 1 μ foil and kicker (Basel/Hall C)

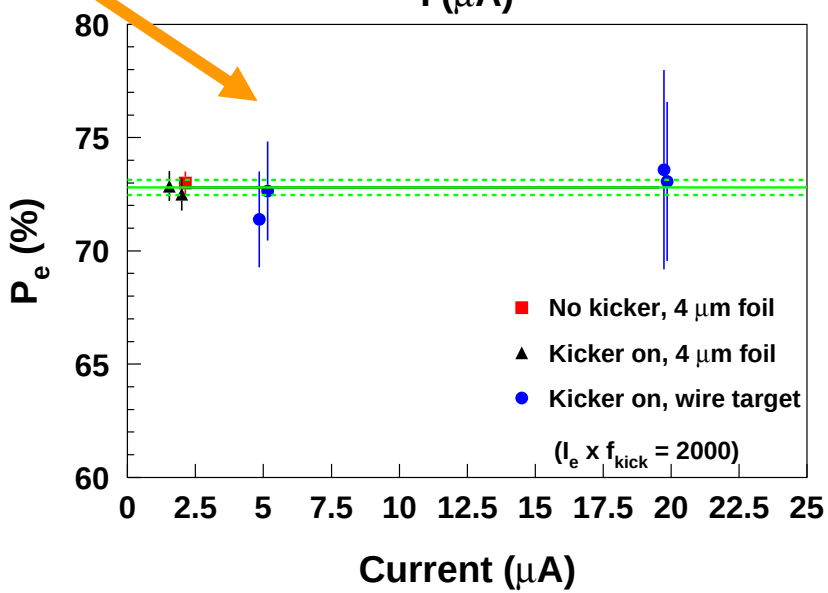
1) Test at 10 μA G0 beam w. 1 μ foil
2) Test with kicker magnet and wire target





Next test: modify kicker time structure, use "half" a 1 μ foil





Q_{weak} Status

- JLab PAC "A" rated experiment. Very positive reviews from NSF and NSERC. Part of a world-wide program of research to test aspects of the Standard Model.

- Strong scientific support for the measurement from both nuclear theory (M. Ramsey-Musolf, W. Haxton, W. Donnelly, J. Friar,……) and the high energy theory community-(W. Marciano & P. Langacker, J. Erler).

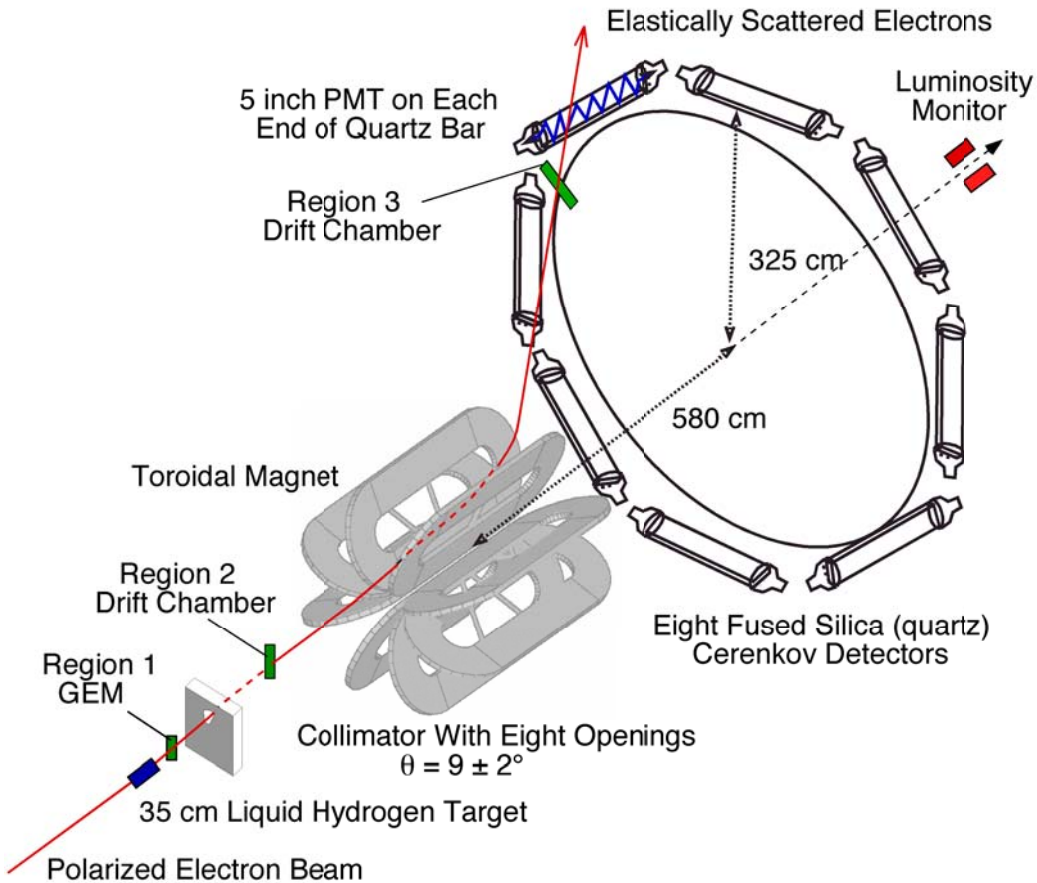
- Capital funding (NSF/NSERC/University matching = $1.4M, DOE/JLAB "infrastructure" - AC, DC, cooling water, installation manpower, recycled G^0 beamline systems, < $1.9M)

- The collaboration is continuing to expand and attract interest. Major contributions come from MIT/Bates and University of Manitoba

- On track for a ~3.5 year construction effort with possible installation in late calendar 07.

Illustration of the Qweak Experiment

Parity-violating elastic electron scattering off a proton target → weak charge of proton Q^p_{weak}



Summary

Remarkable recovery from Hurricane Isabel

Simultaneous beam delivery to two very demanding experiments accomplished

Publications and scientific impact of Jlab research continues to grow

- Archival publications increasing
- Excellent publication records in all three Halls
- Growing theory interest in Jlab results

Physics interest remains very strong

- Submissions to the PAC are increasing and of very high quality
- Experiments approved have gone from 1/2 to 1/3

Delivered Physics is solid, 19 weeks to date (planned 18)

Halls running with high availability

101 full experiments and parts of 10 more have been completed