Hall B Status

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Jefferson Lab

CLAS Collaboration Meeting
July 24, 2003

Run status
Publication status
PAC24, S&T Review
Hall B Run Plan
Status of equipment projects
2003/2004 Run Schedule
CLAS – The first 5 years
Energy upgrade

Hall B Status Overview

- Completed 5+ years of physics running
- 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 (in progress) (+2 non-CLAS experiments: g5, radphi)
- Publications
  - 15 technical papers published (latest: NIM paper on CLAS)
  - 20 physics papers published/accepted in PRL, PRC, PRD
  - 5 submitted
  - 5 in collaboration review
- Major effort to repair on-board electronics for all six region 3 axial super layers (suffering from corrosion). Problem recurring in areas where electronics have been partially replaced only.
- Preparations for approved experiments
  - PrimEx (π^0 lifetime measurement)
  - Deeply Virtual Compton Scattering (Probing GPDs)
  - BoNus Experiment (Neutron Structure Functions with proton tagging)
  - Frozen Spin Target (Needed to search for missing resonances in hyperon production)
  - New Cerenkov counter for one CLAS sector (for small Q^2 GDH)
  - Polarimeter for linearly polarized photons

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)

- 20 - published/accepted
- 5 - submitted
- 5 - in collaboration review

N* program – Exclusive Processes (15)

- 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->epp0, PRC accepted
- Measurement of $\sigma_{LT'}$ in the Δ(1232) region, PRC submitted , nucl-ex/0301012
- Evidence for an Exotic Baryon State with S=+1, PRL submitted, hep-ex/0307018
- Photoproduction of K$^+\Lambda/\Sigma$, PRL 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
- Electroproduction of K$^+\Lambda/\Sigma$ from protons

N* program - Inclusive Processes (3)

- 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 submitted

Hall B Physics Publications – cont'd

Hard Processes (8)

- 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->eπ^+X in the DIS kinematics, PRL submitted, nucl-ex/0301012
- Deeply exclusive ρ^0 production, CLAS review

Nuclear Processes (4)

- Photofission of Heavy Nuclei, PRL84 (2000) 5740
- Photofission of Heavy Nuclei, PRC65, 044622 (2002)
- Nuclear Scaling in A(e,e') at x>1, PRC accepted, nucl-ex/0301008
- Two-Nucleon Momentum Distributions Measured in ^{3}He(e,e'pp)n, CLAS review

Physics Impact of CLAS Data I

Paper	Physics	#citations >20 (as of 07/22/03)
PRL 85 (2000) 4682	**ϕ-Photoproduction at high t**	29
PRL 86 (2001) 1702	**Study of $S_{11}(1535)$ in η electroproduction**	21
PRL 87 (2001) 182002	**Deeply Virtual Compton Scattering**	80
PRL 88 (2002) 182002	**Multipoles from $\gamma^*N\Delta(1232)$ transition**	21

Physics Impact of CLAS Data II

Paper	Physics	#spires citations per month>0.5
PRL 85 (2000) 4682	ϕ-Photoproduction at high t	0.8
PRL 86 (2001) 86, 1702	$S_{11}(1535)$ in η electroproduction	0.6
PRL 87 (2001) 172002	ρ^0-Photoproduction at high t	0.6
PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	3.5
PRL 88 (2002) 182002	Multipoles from $\gamma^*N\Delta(1232)$ transition	1.1
PRL 90 (2003) 22002	ω-Photoproduction at high t	0.6
hep-ex/0301005 (2003)	SSA in SIDIS $\vec{e}p \rightarrow e\pi^+X$	0.8

PAC24 - Meeting, June 2003

Hall A, B, C: requested/awarded beam time ~ 3:1

New CLAS Proposals:

Proposal	Physics	PAC days (48 days)	Rating
E-03-105	Pion photoproduction on polarized target	18	B+
E-03-113	Search for the Exotic S=+1 Baryon	30	A

JLab Science & Technology Review

June 23 – 27, 2003

Annual review of the laboratory performance

- Physics (including Hall B) received very high marks especially in the area of hadron structure

- Noted slower than hoped for results of the N* program => emphasizes need for stronger theory support in phenomenology

- Pre-proposal for N* Analysis Center to DOE received favorably

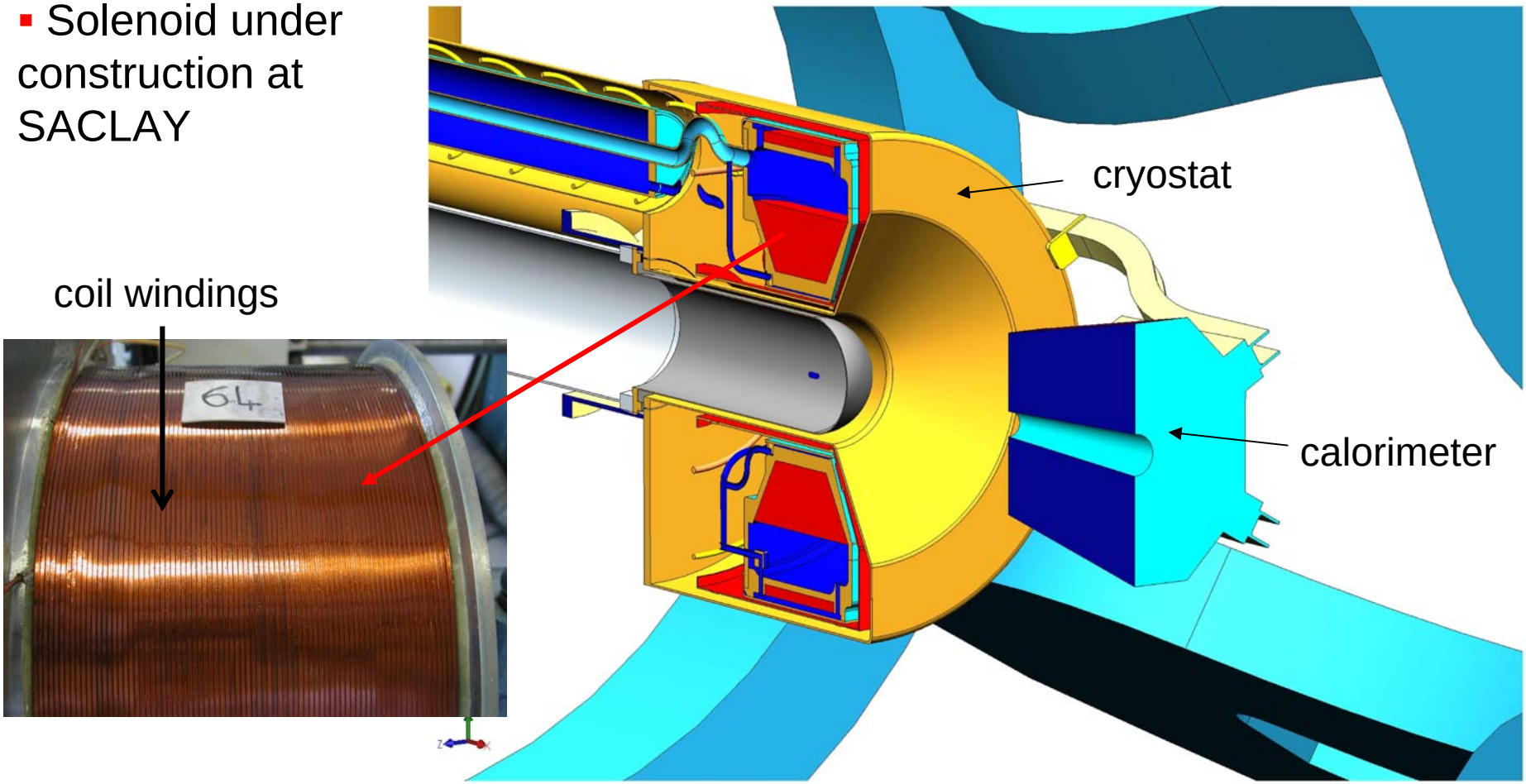
Hall B Run Plan

Run group	Run time	PAC rating	Target	Energy (GeV)	Electron polar.	Comment
e1g	10	A^-	H_2	3	High	completes original e1
eg2a	33	B^+	nuclear	4 - 6	No	
PrimEx	22	A	nuclear	6.0	No	ECALs, ..
g2c	30	A	D2	3-4	No	
e1-DVCS	60	A	H2	6.0	High	Solenoid, crystal EC
unscheduled (alphabetical order):						
Coherent ρ	50	A^-	D_2	6.0	High	uses DVCS solenoid
eg1(γ)	22	B^+	p	1.6-4.0	High	Frozen spin target
eg2	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 counter
Missing N*	38	A^-	p		No	Frozen spin target
Neutron S.F.	25	A^-	D_2 gas	4-6	No	Radial TPC
Σ unscheduled	195					

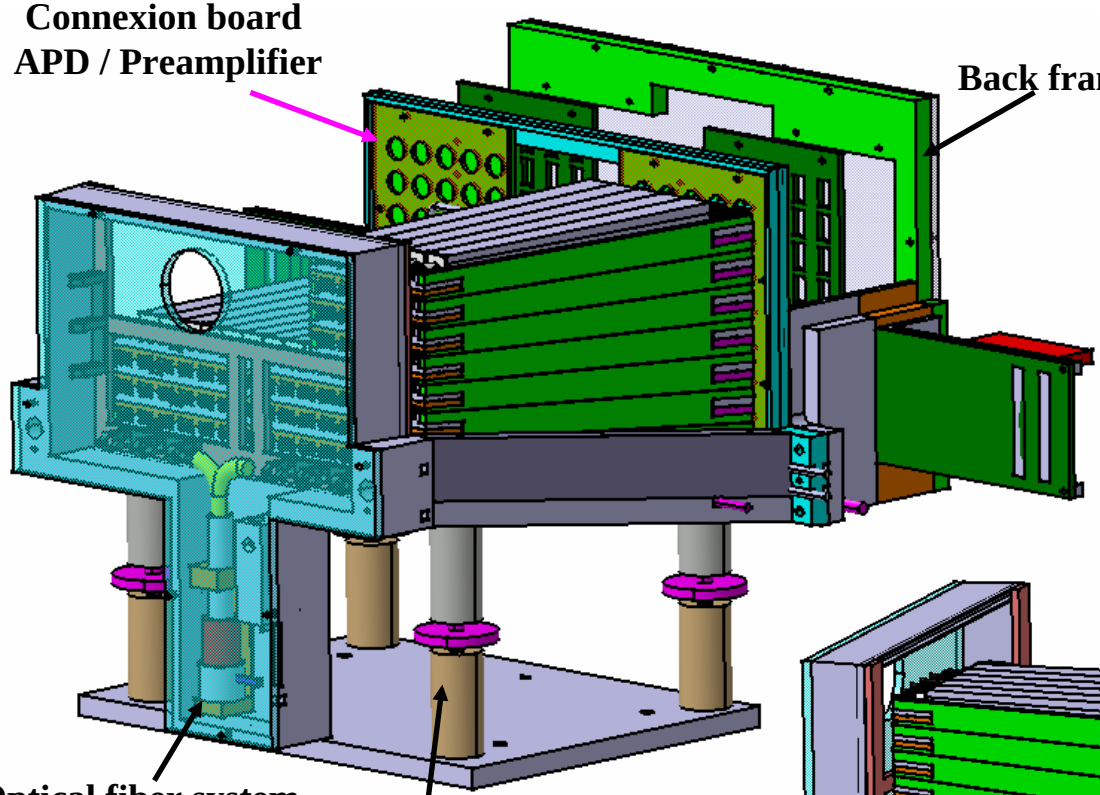
DVCS Experiment

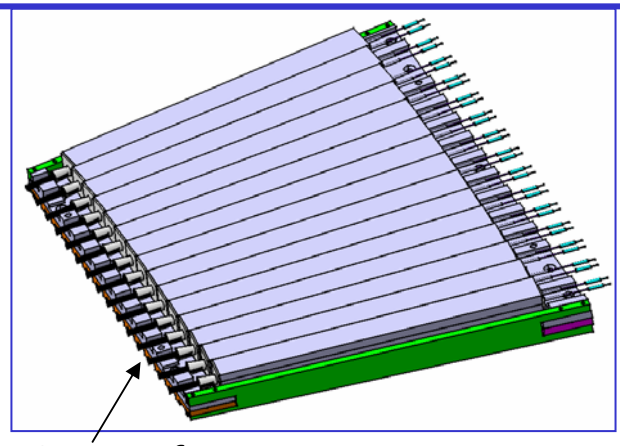
Superconducting solenoid: needed for shielding Moller electrons
$PbWO_4$ e.m. calorimeter needed for photon detection

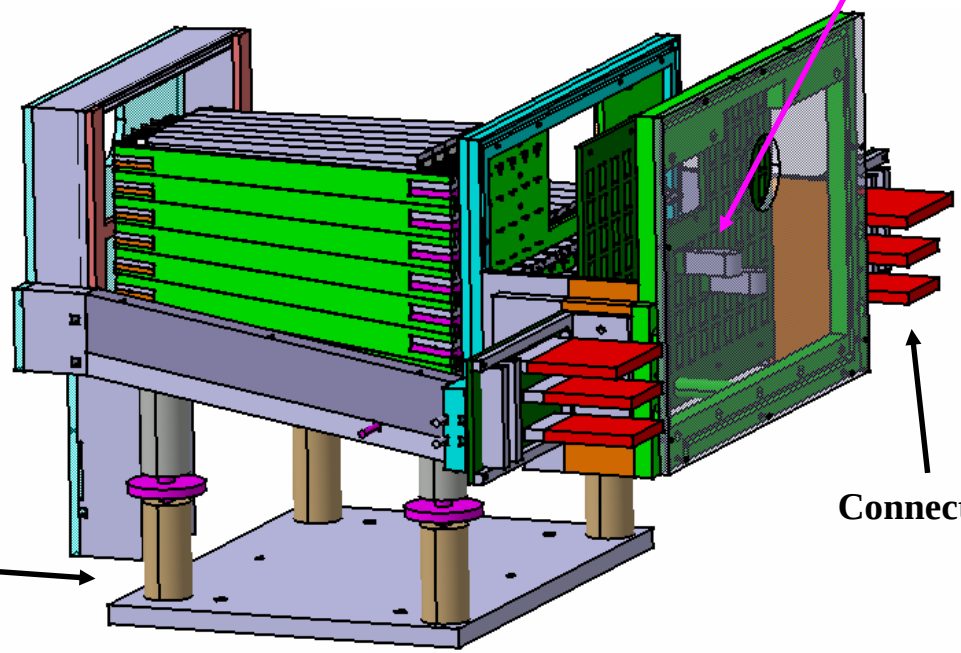
- Solenoid under construction at SACLAY



DVCS - 100 crystal prototype for test run





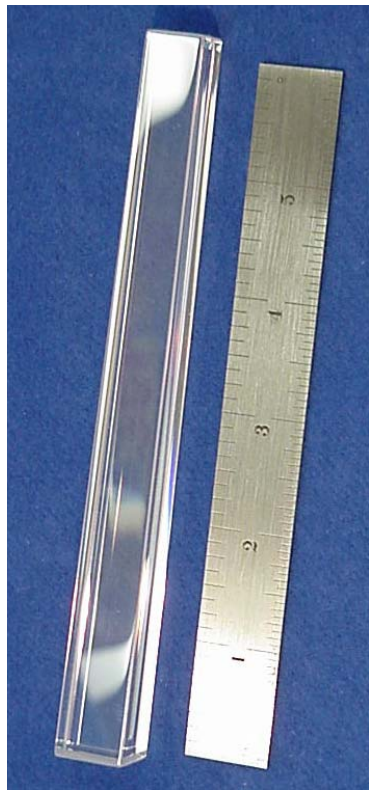


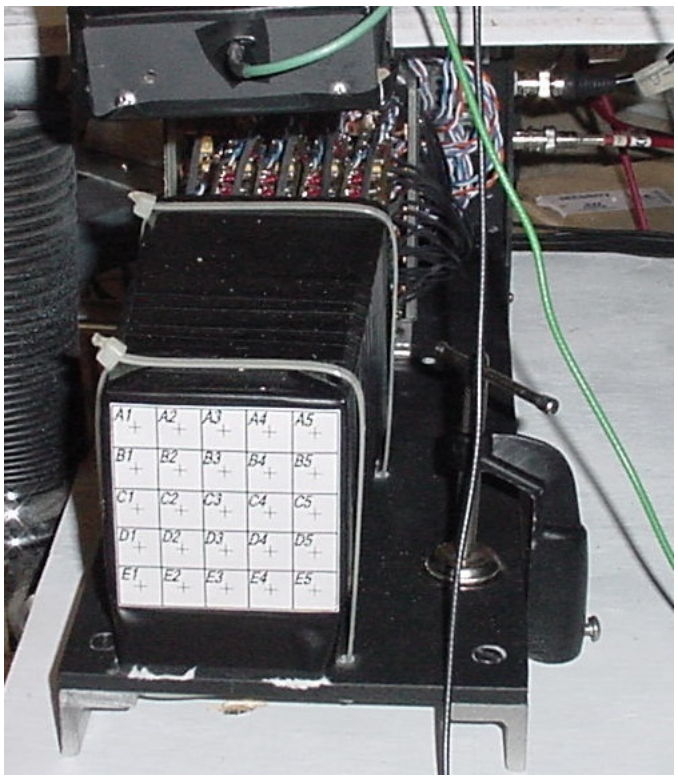
General view of the calorimeter

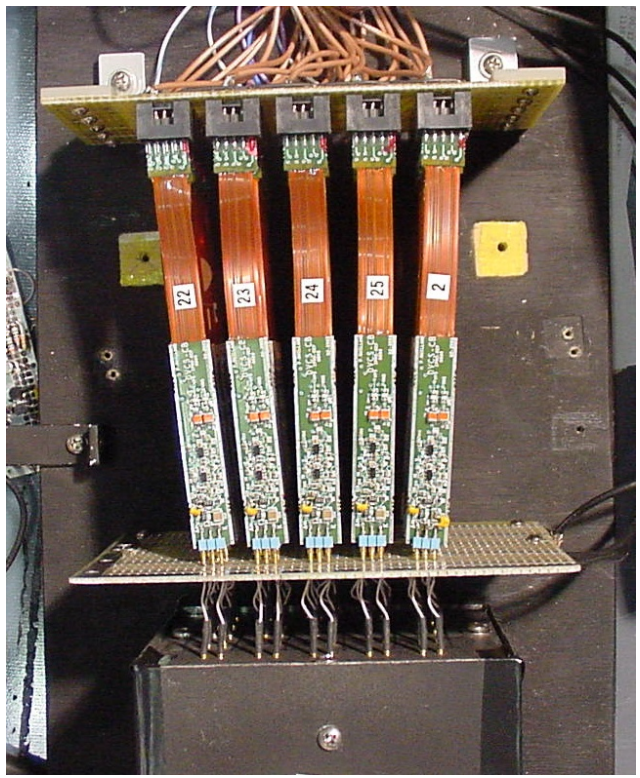
Ph. Rosier, Orsay

DVCS Experiment

- $PbWO_4$ crystal calorimeter
  - 440 tapered crystals, APDs, on site (ITEP, JLab)
  - Mechanical structure in final design stage (Orsay)
  - Preamps - designs being evaluated (ITEP, Orsay)
  - 5 x 5 crystal prototype built and being tested





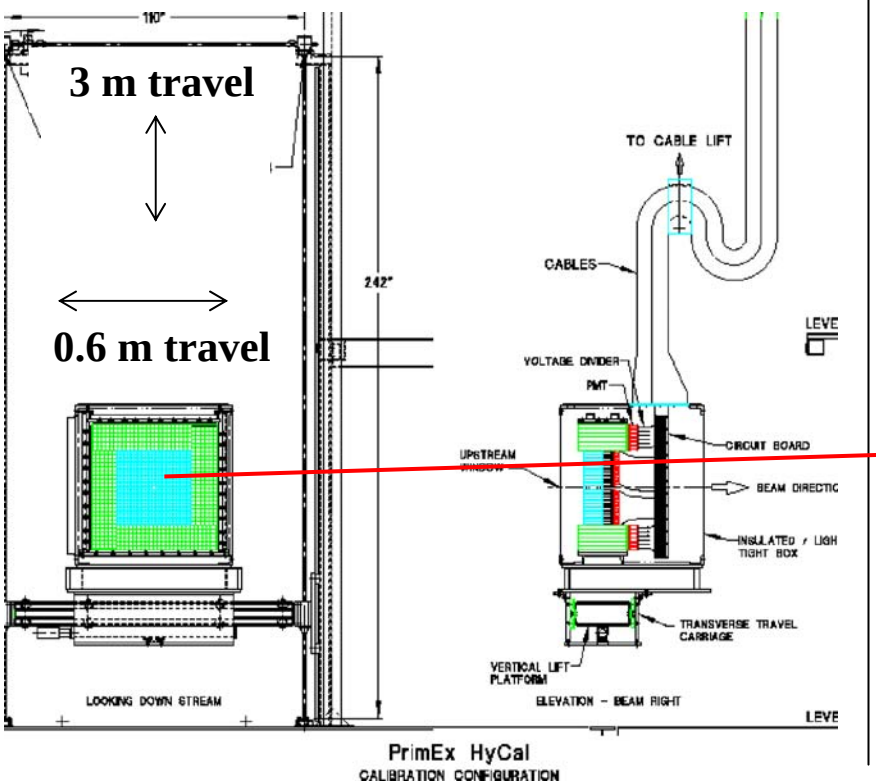


PrimEx Experiment

Purpose: Precise measurement of The π^0 lifetime using the Primakoff process.

Hybrid Calorimeter (HyCal)

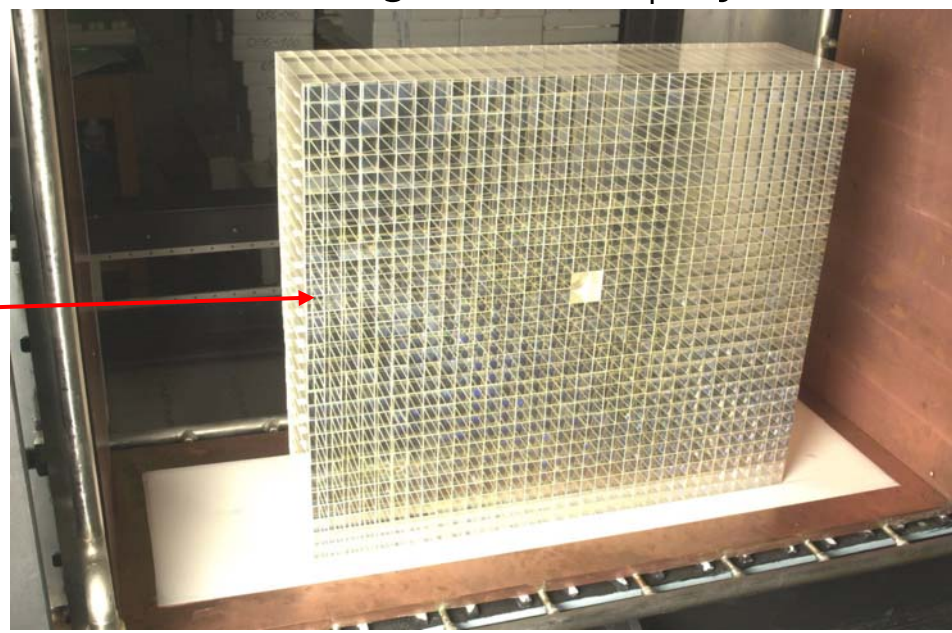
Needed to reconstruct $\pi^0 \rightarrow \gamma\gamma$ events



Status:

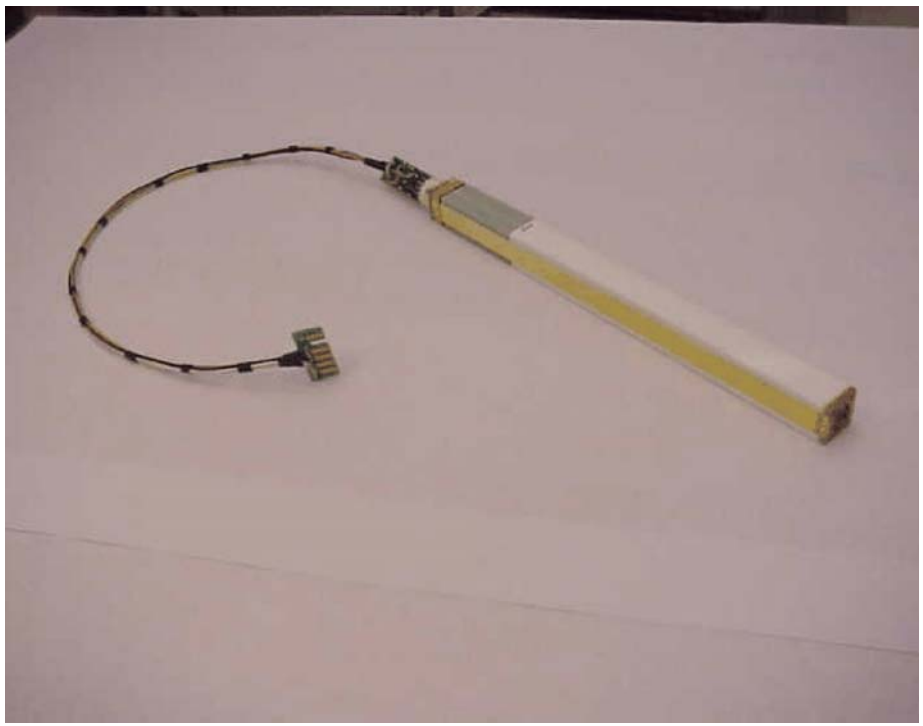
- Engineering design completed
- All $PbW0_4$ crystals and Pb-glass blocks at JLab, being assembled
- Plan for cosmic ray testing in August
- Readiness review in 11/03
- Installation in Hall B in 01/2004

Test stacking of $PbWO_4$ crystals

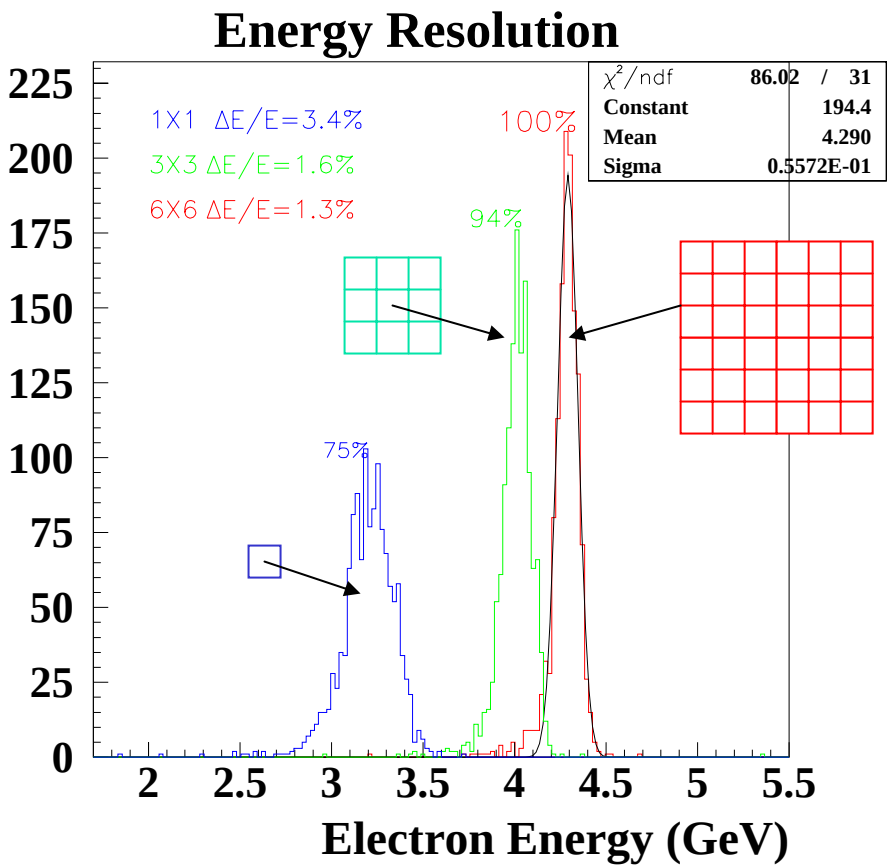


PrimEx Experiment

$PbWO_4$ crystal channel



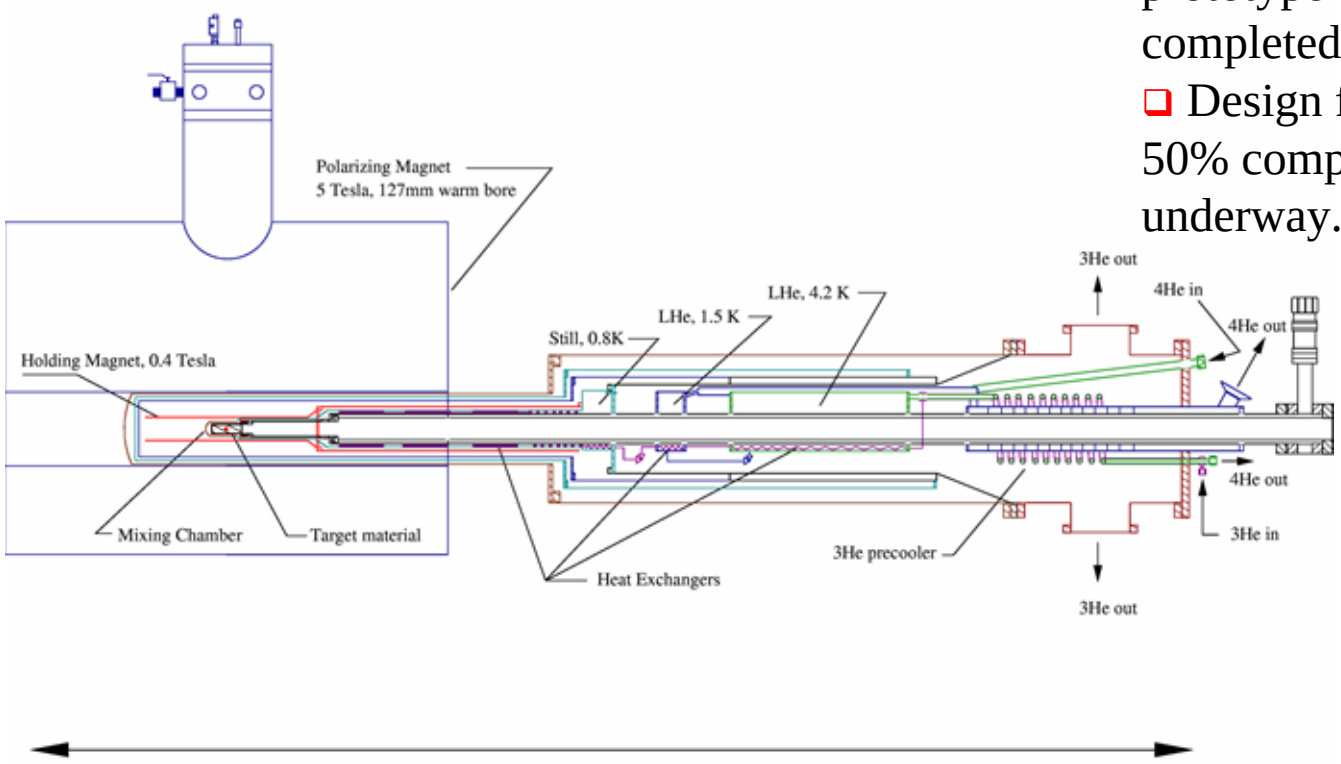
Electron beam test results



Frozen Spin Target

- Needed for Search for missing N* in pion and kaon photoproduction, Experiment E-02-112, F. Klein et al., E-03-105, S. Strauch et al.

Work by Target group (Chris Keith, et al.)



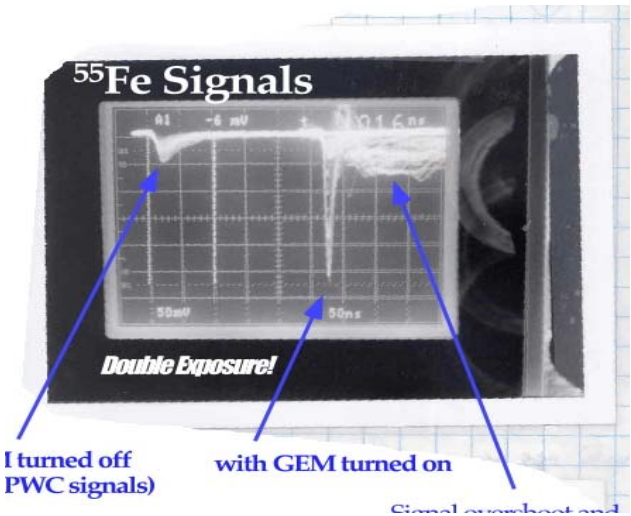
- Polarizing magnet ordered, estimated delivery: Feb. 2004
- Longitudinal holding magnet; prototype constructed – being tested
- Transverse holding magnet: prototype for “racetrack” design completed
- Design for dilution refrigerator 50% completed, construction underway.

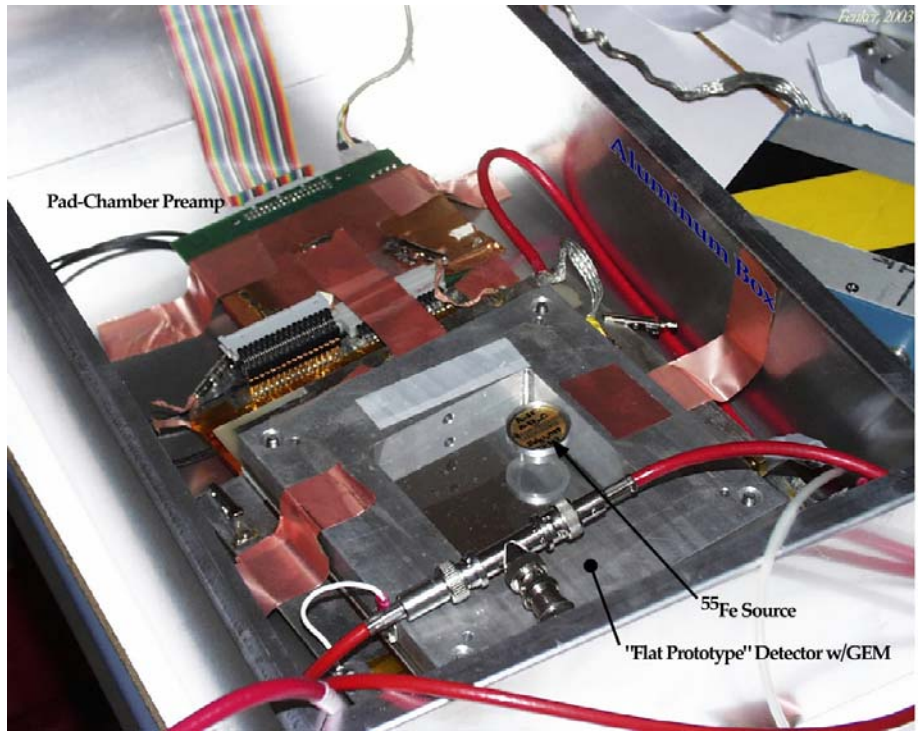
BoNuS Detector

- Radial Time Projection Chamber (RTPC)

(needed for experiment E03-012; S. Kuhn, et al.)
Goal: detect spectator protons with momenta as low as 70 MeV/c

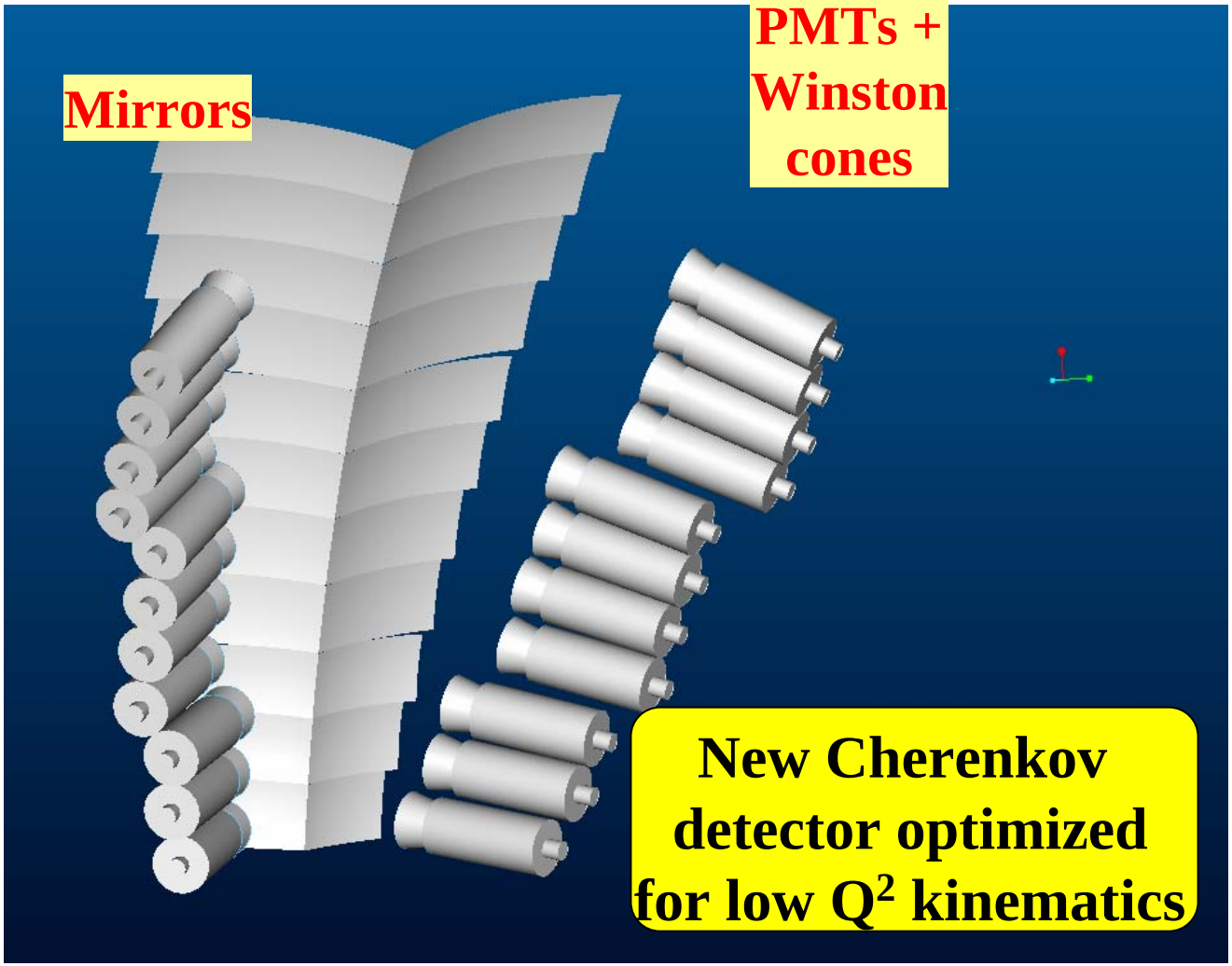
- Cylindrical prototype with GEM readout being developed by Howard Fenker
- Flat GEM prototype has been built and is being tested





Gas Cherenkov Counter, INFN Genova

- Needed for E-03-106 (GDH Integral at very low Q^2), M. Ripani, et al.



multilayer μ-metal + iron shield

Photon Beam Polarimeter

Needed for g8 run group, and follow-up measurements with linearly polarized photon beams.

Status:

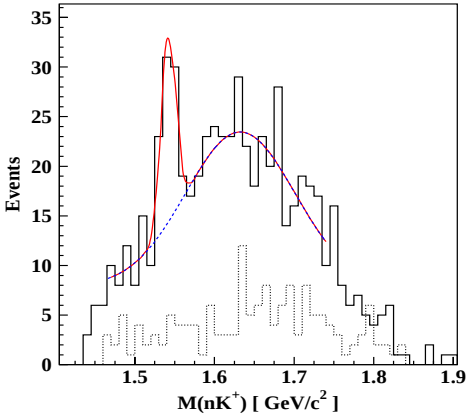
- mechanical layout on the beam line completed
- detector box constructed
- target box which holds the microstrip and motion mechanism on order
- VME/PC part of readout, software is operational

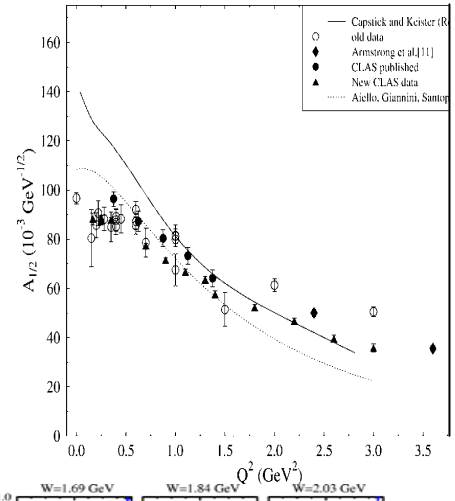
Hall B 2003/2004 Schedule - Draft

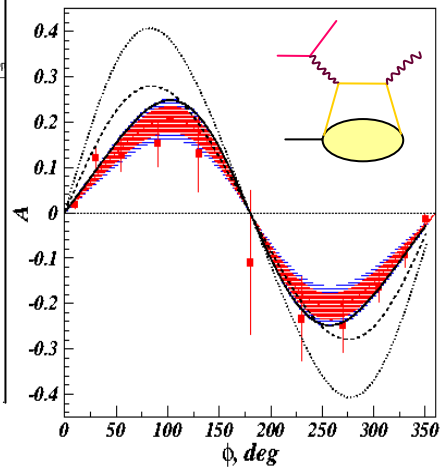
Schedule heavily constraint by two parity experiments in A/C, both need ~ 3 GeV

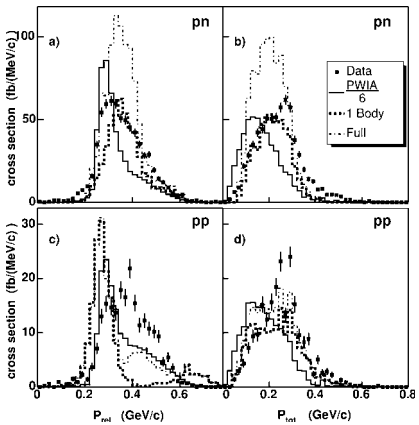
07/09 - 07/29/03	e1g	p(e,e'X)	3.3 GeV
08/01 - 08/29/03	eg2	A(e,e'X), A(γ,X)	4.7-5.5 GeV
09/02 - 10/16/03	Accelerator and Hall maintenance, DC electronics repair Region 3, PRIMEX installation, Polarized target magnet installation for DVCS test		
10/17 - 10/26/03	DVCS Tests		5.0 GeV
10/26 – 10/30/03	Remove polarized target magnet		
10/31 - 12/24/03	eg2	continued	4-5 GeV
01/04 - 02/12/04	PRIMEX Installation & commissioning		
02/18 – 04/25/04	g2c		4.0 GeV
04/27 – 05/24/04	PRIMEX		5.5 GeV
05/25 – 06/30/04	DVCS Installation & DC maintenance		
Tentative			
07/	PRIMEX		5.5 GeV
08/ -	DVCS		6.0 GeV

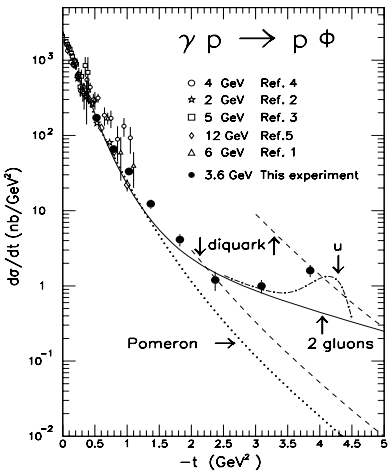
CLAS
the first
5
years

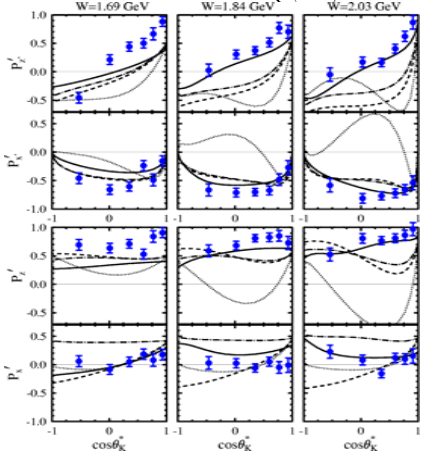


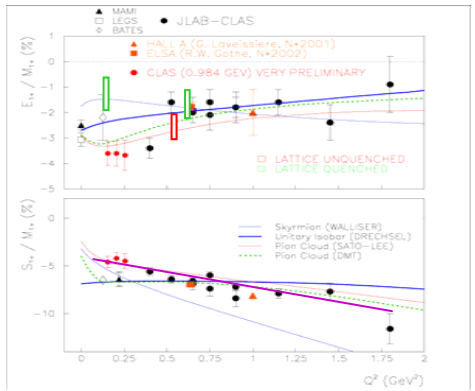


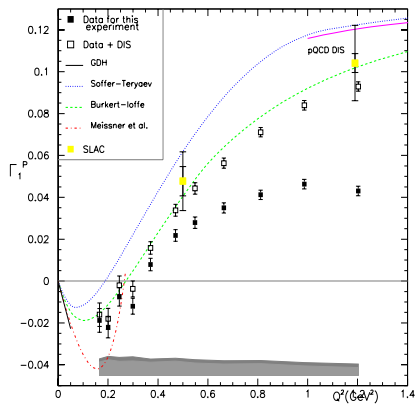


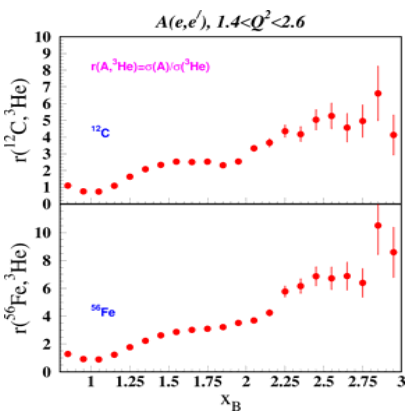


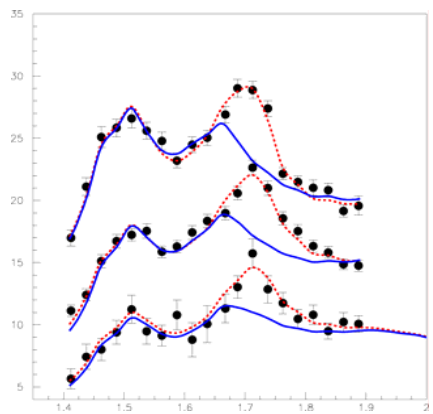


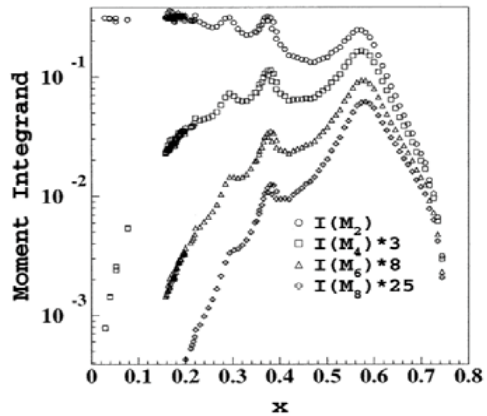






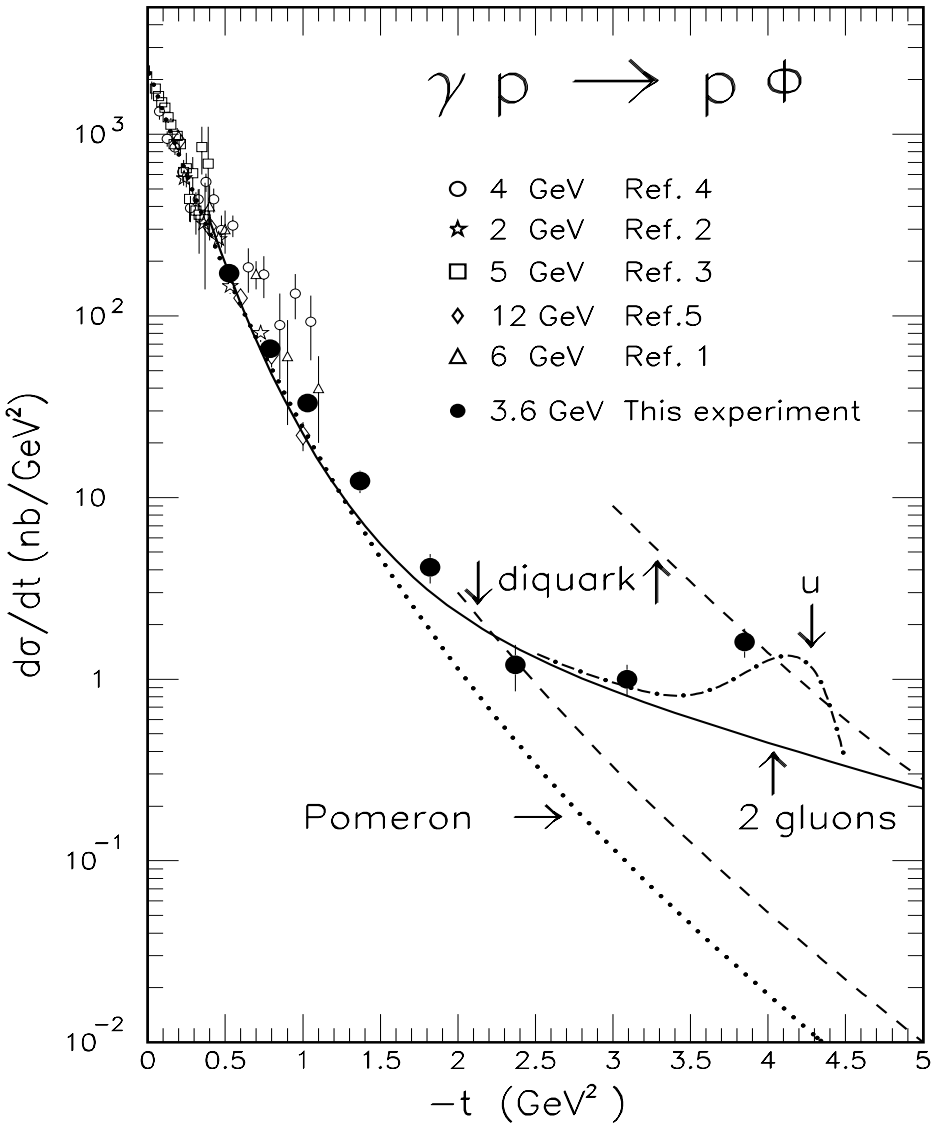






CLAS – The first 5 years 2-gluon exchange

- Establish relevance of the 2-gluon exchange contribution for ϕ productionat high transverse momentum
- u-channel contributions near kinematic limit

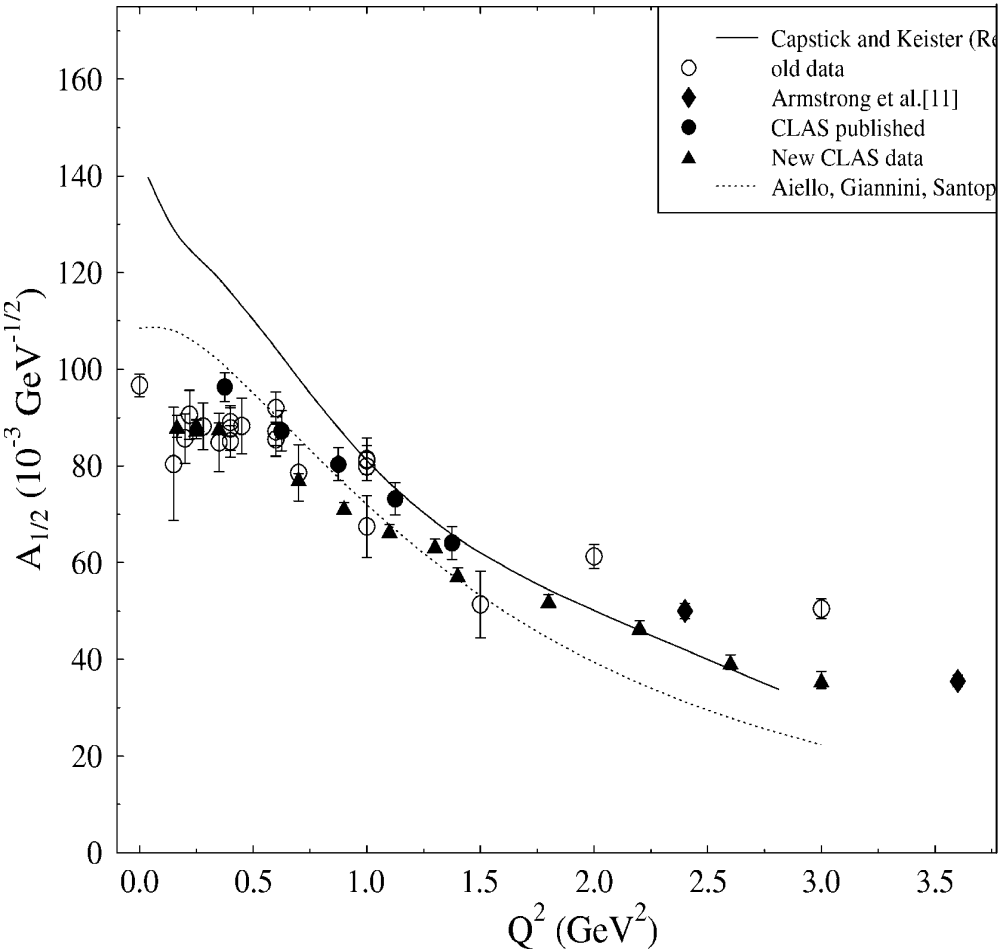


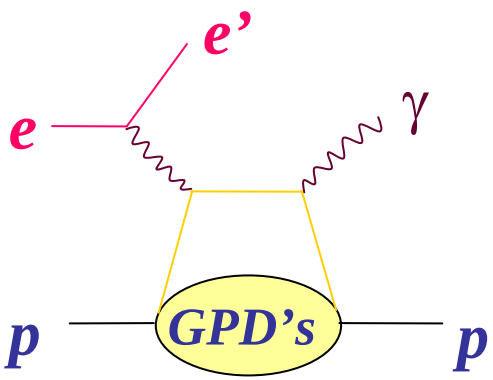
The first 5 years

S_{11} Formfactor

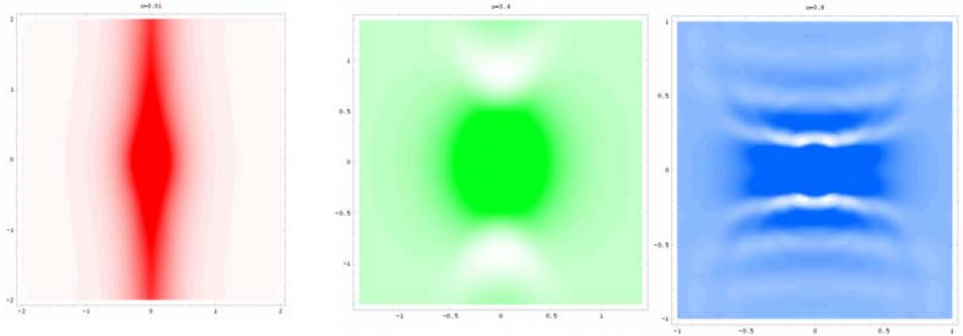
- The pS11(1535) transition form factor shows a very slow fall off with Q^2.

- Indicative of a resonance transition involving a small quark core.

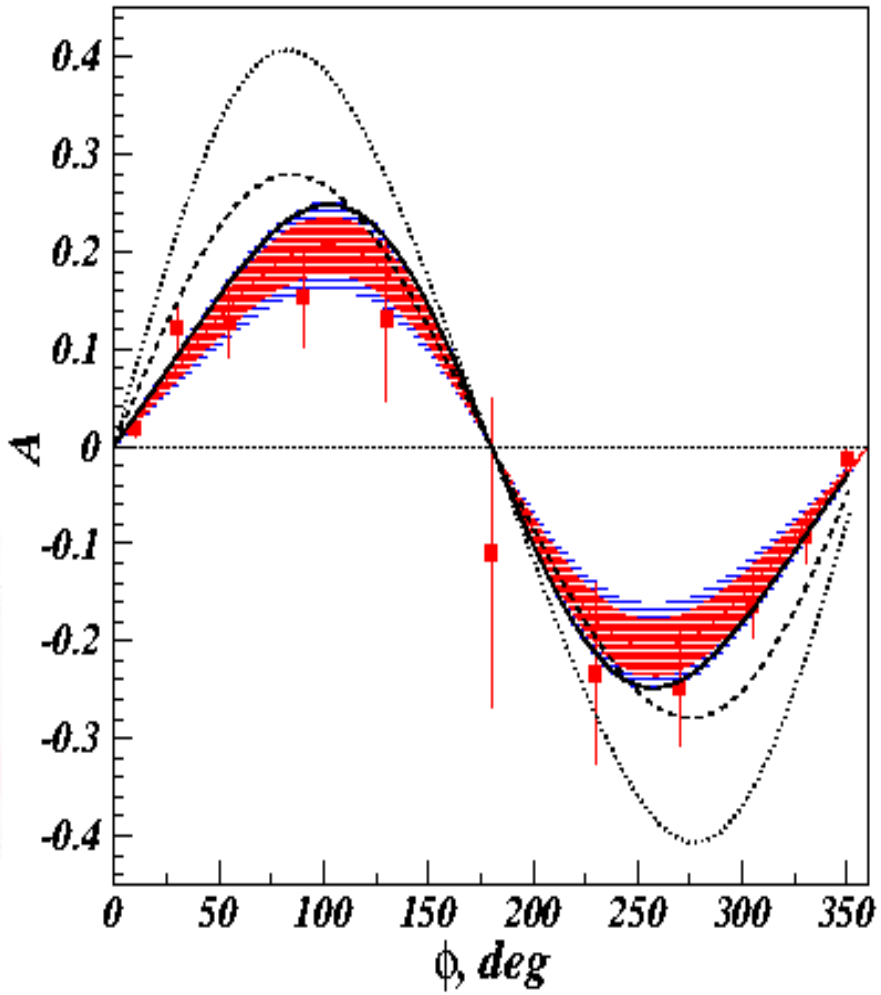




x=0.01 x=0.4 x=0.9

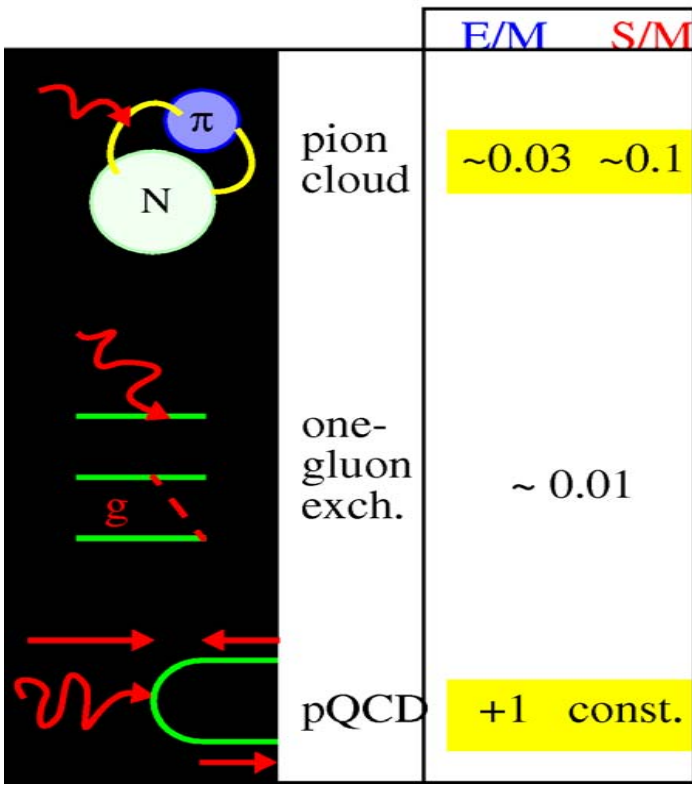


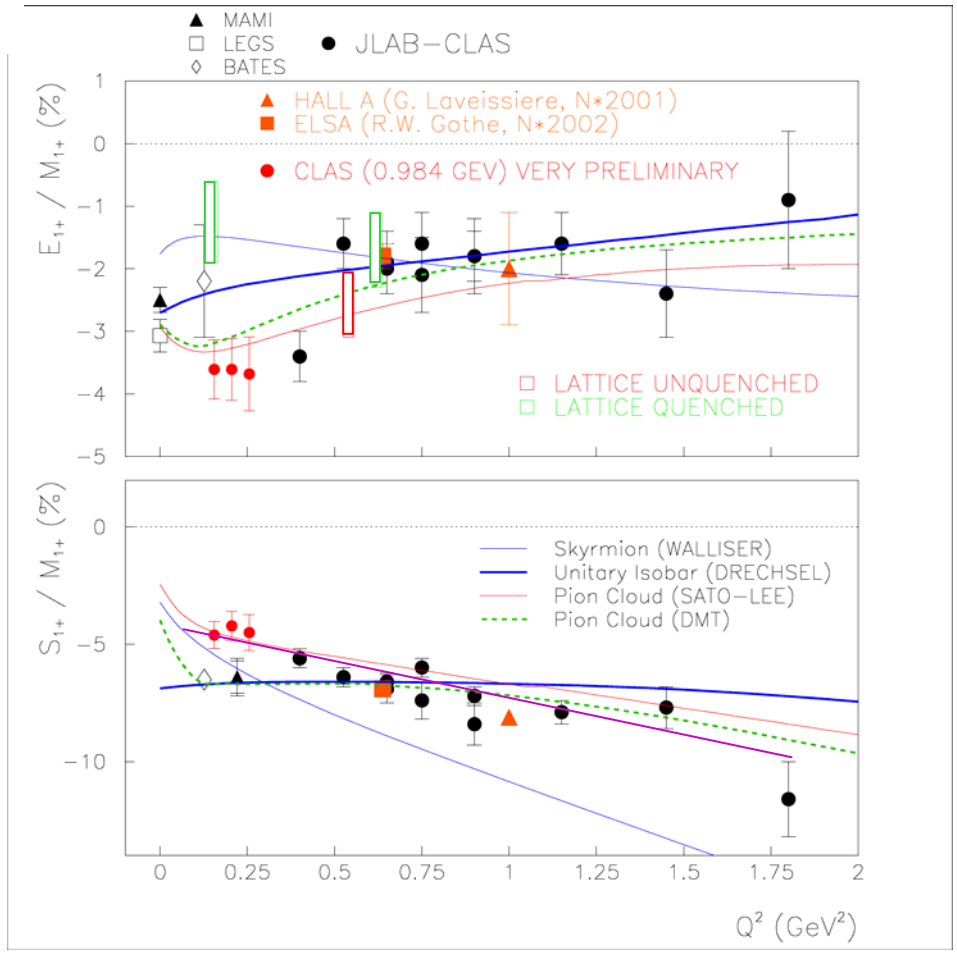
Charge density distributions for u-quarks
at different quark momentum fractions x



Nucleon pion cloud

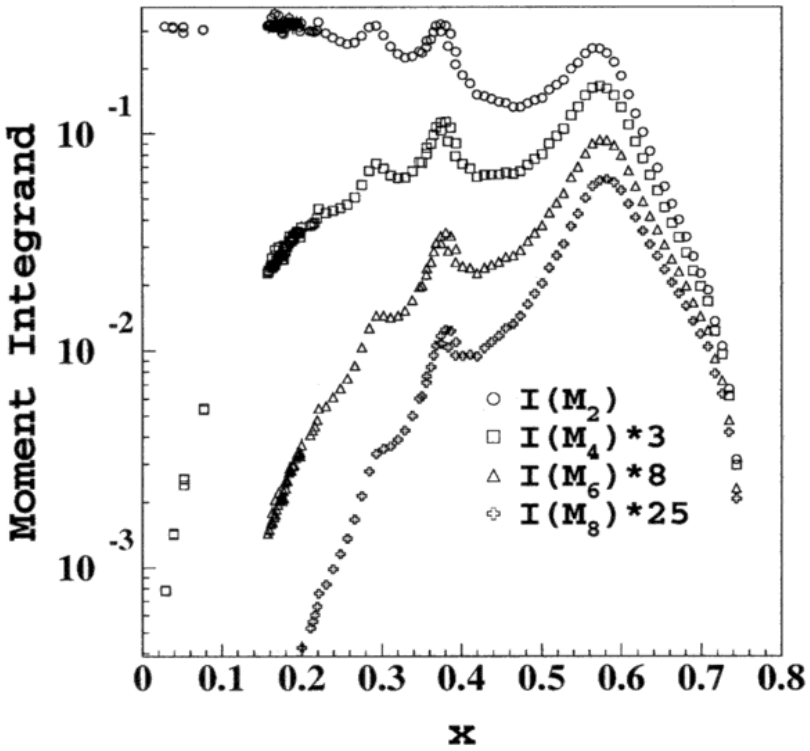
NΔ(1232) Transition

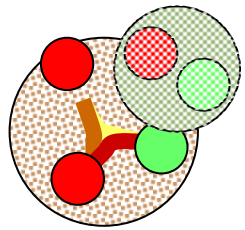


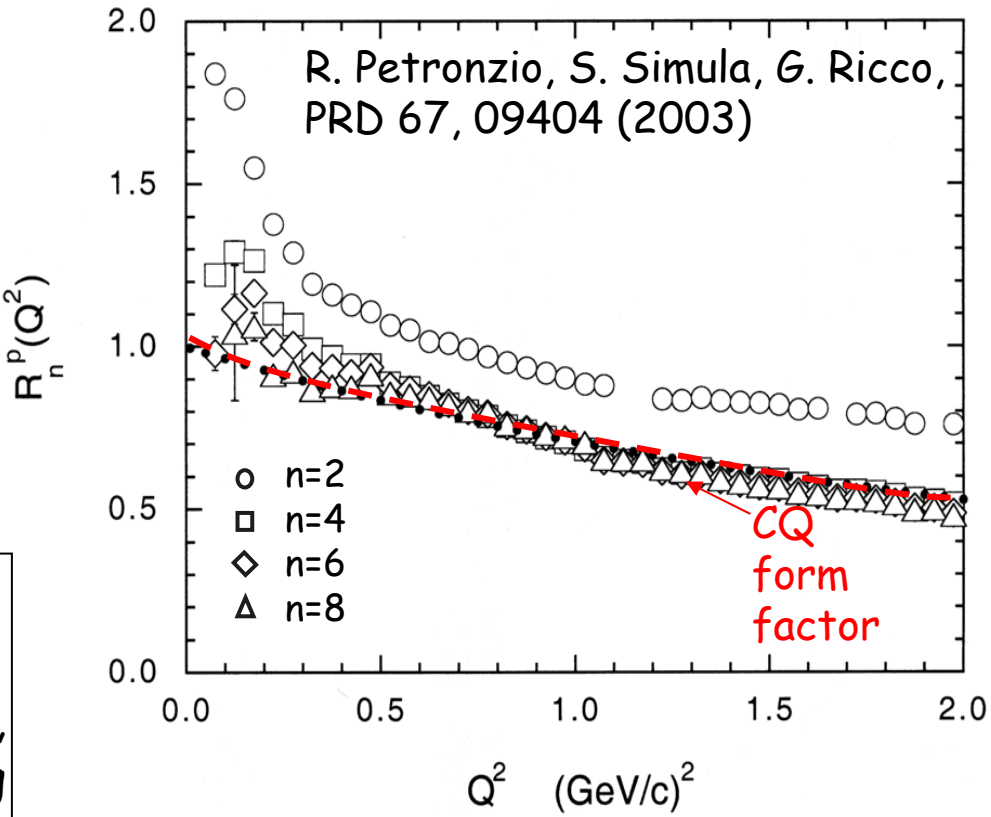


- **Nucleon pion cloud responsible for large part of Δ deformation.**

The first 5 years Constituent quark size



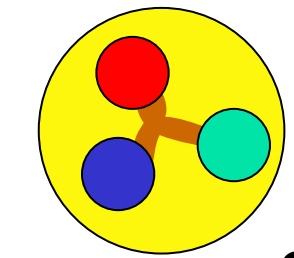




The scaling behavior in the Q^2-dependence observed for different orders n in the Nachtmann moments, is interpreted as "elastic" scattering off CQs with radius ~ 0.2-0.3 fm.

The first 5 years N*'s in 2π production

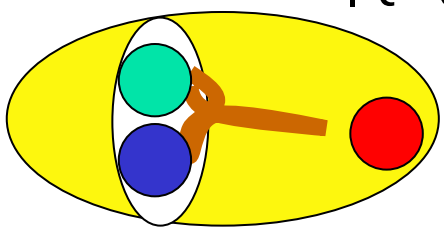
Discover a missing N* state or drastically change our understanding of a known state?

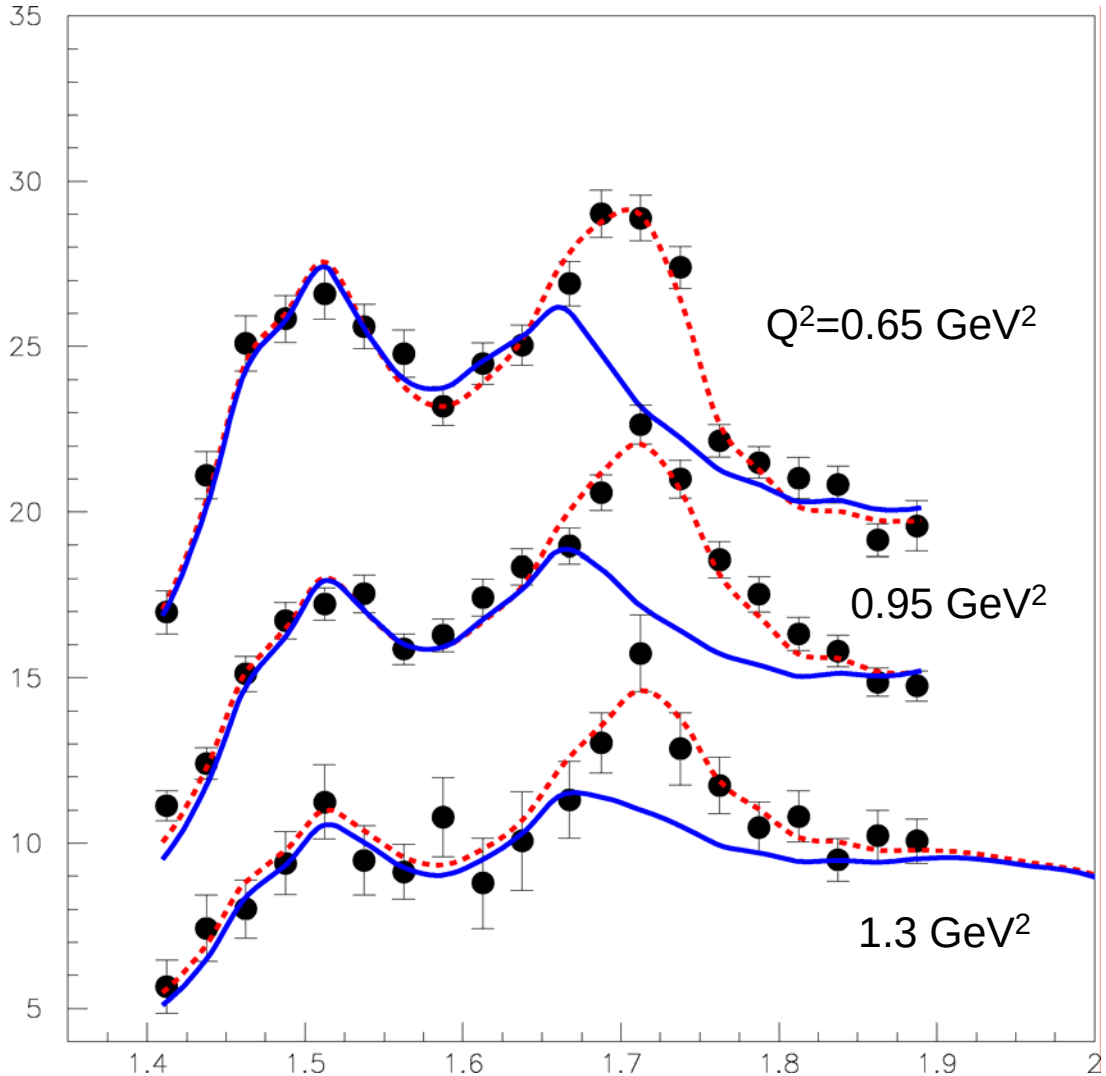


$|Q^3\rangle$

or

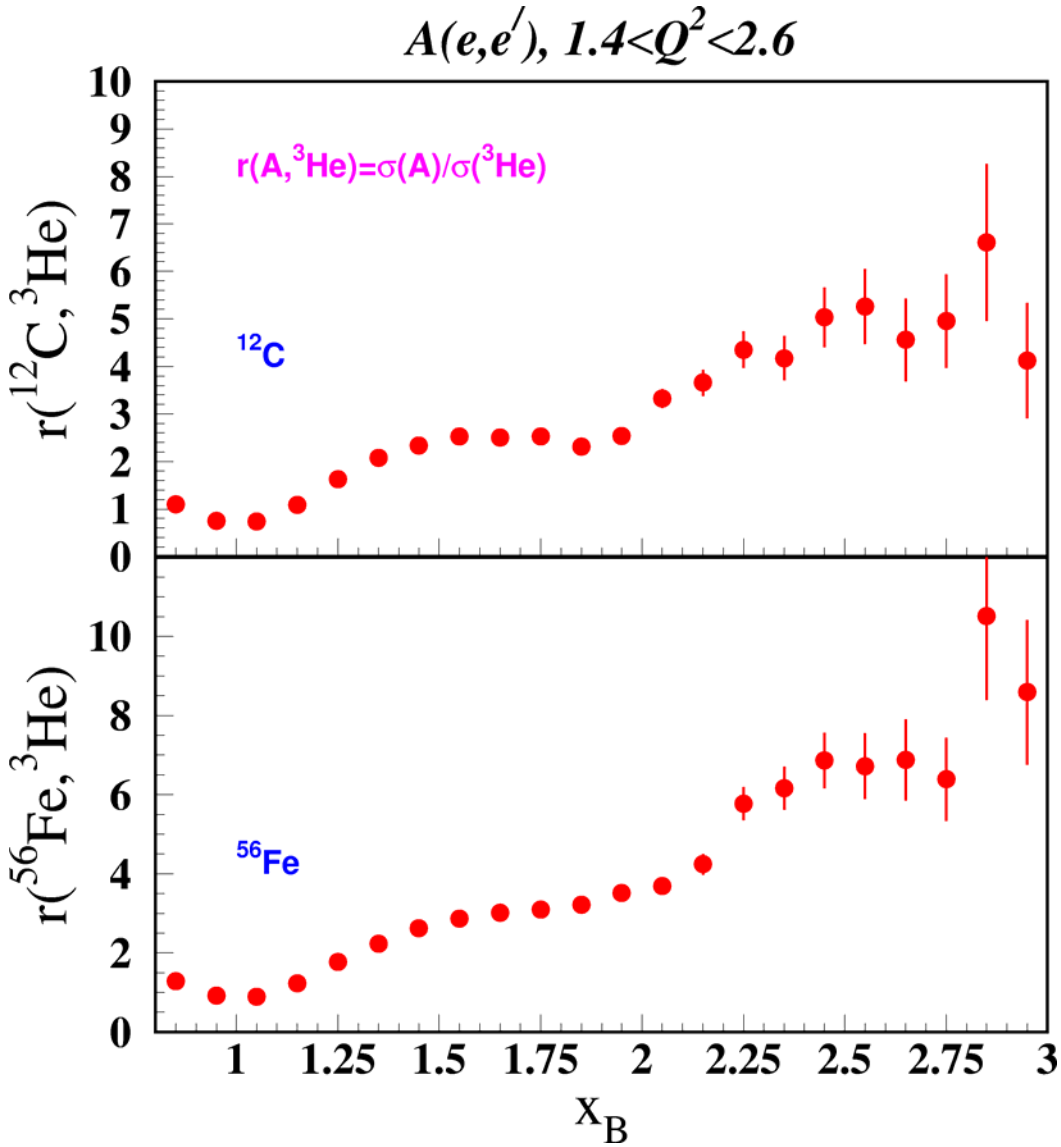
$|Q^2Q\rangle$





Nuclear Scaling

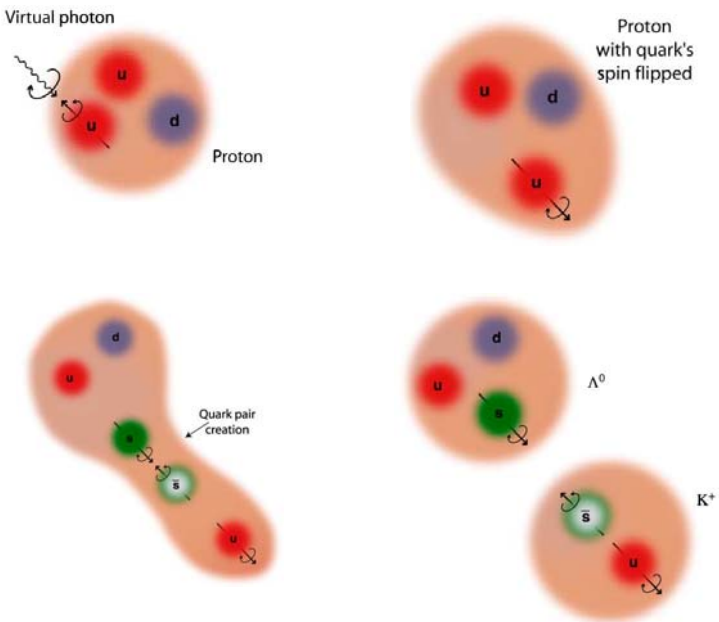
Ratio of inclusive cross sections for C-12 and He-3 at high x_B show nuclear Scaling for the involvement of one, two, or three nucleons in the interaction.



The first 5 years

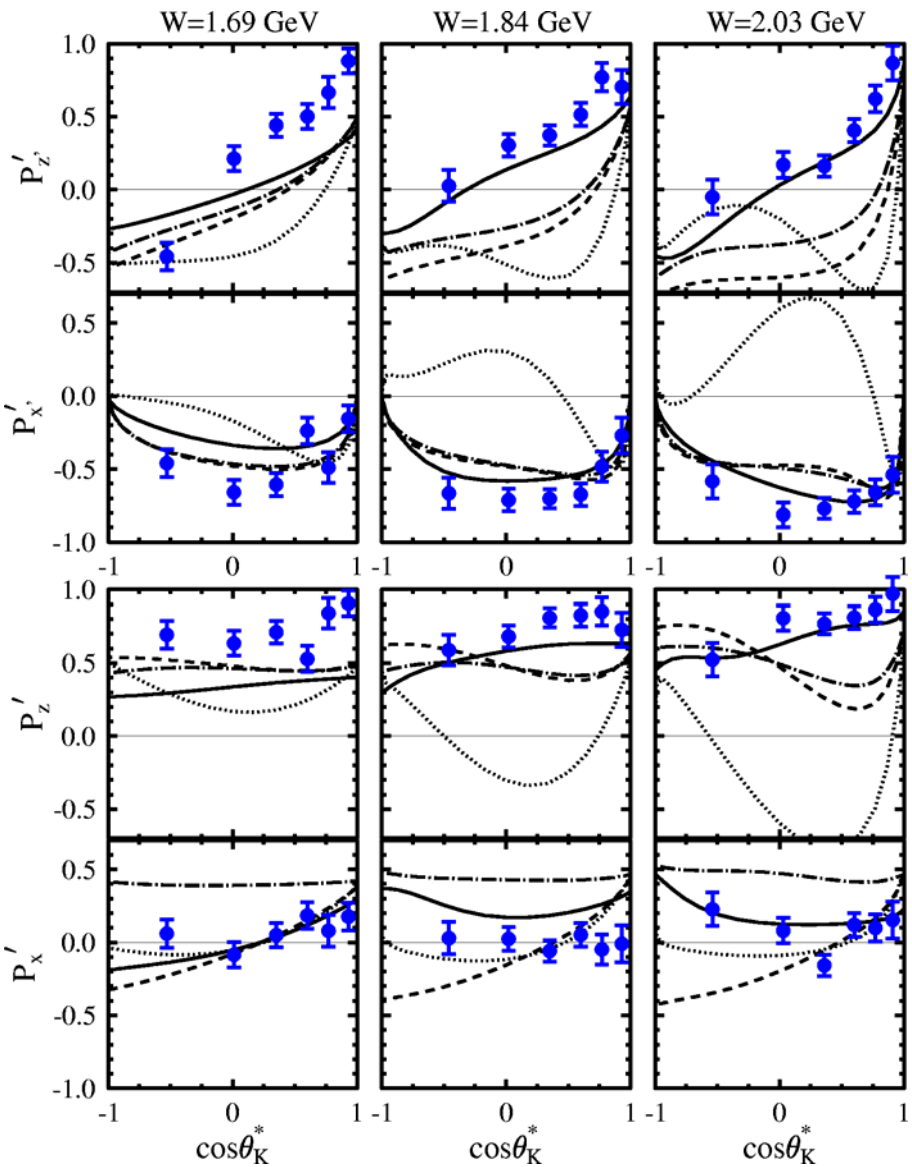
Hyperon polarization

Good News about "Nothing"

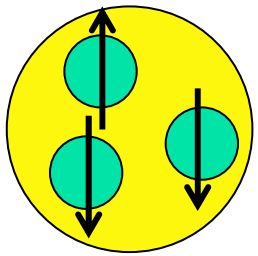


The transferred Λ polarization is maximal along the photon direction

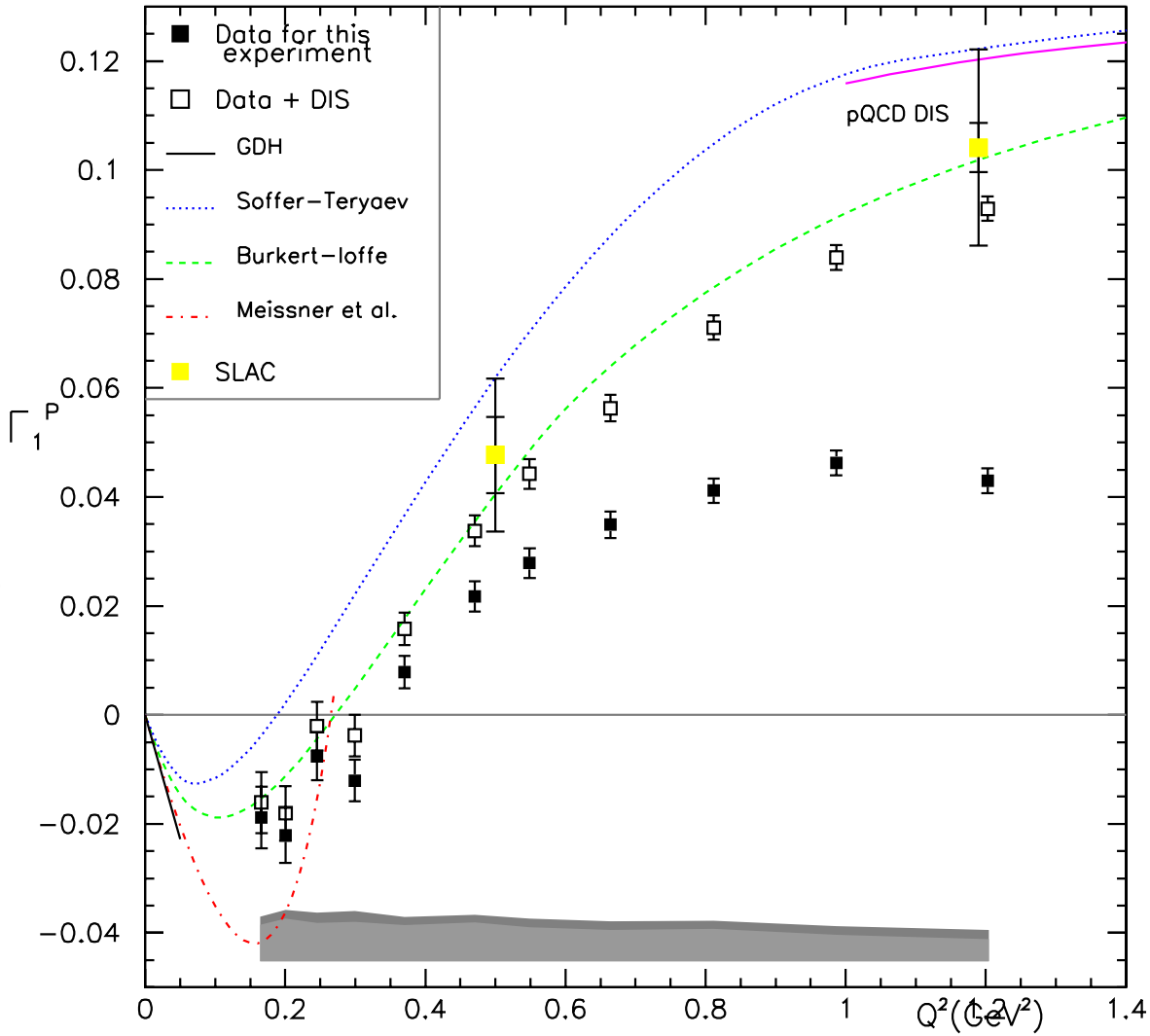
CERN Courier On Target



Nucleon spin structure

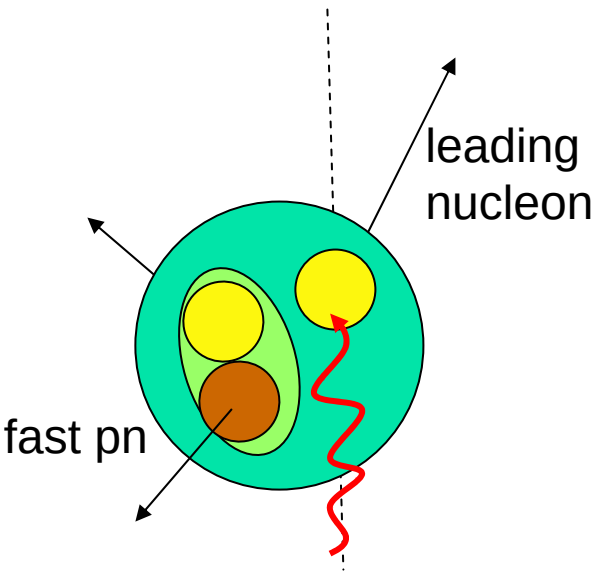


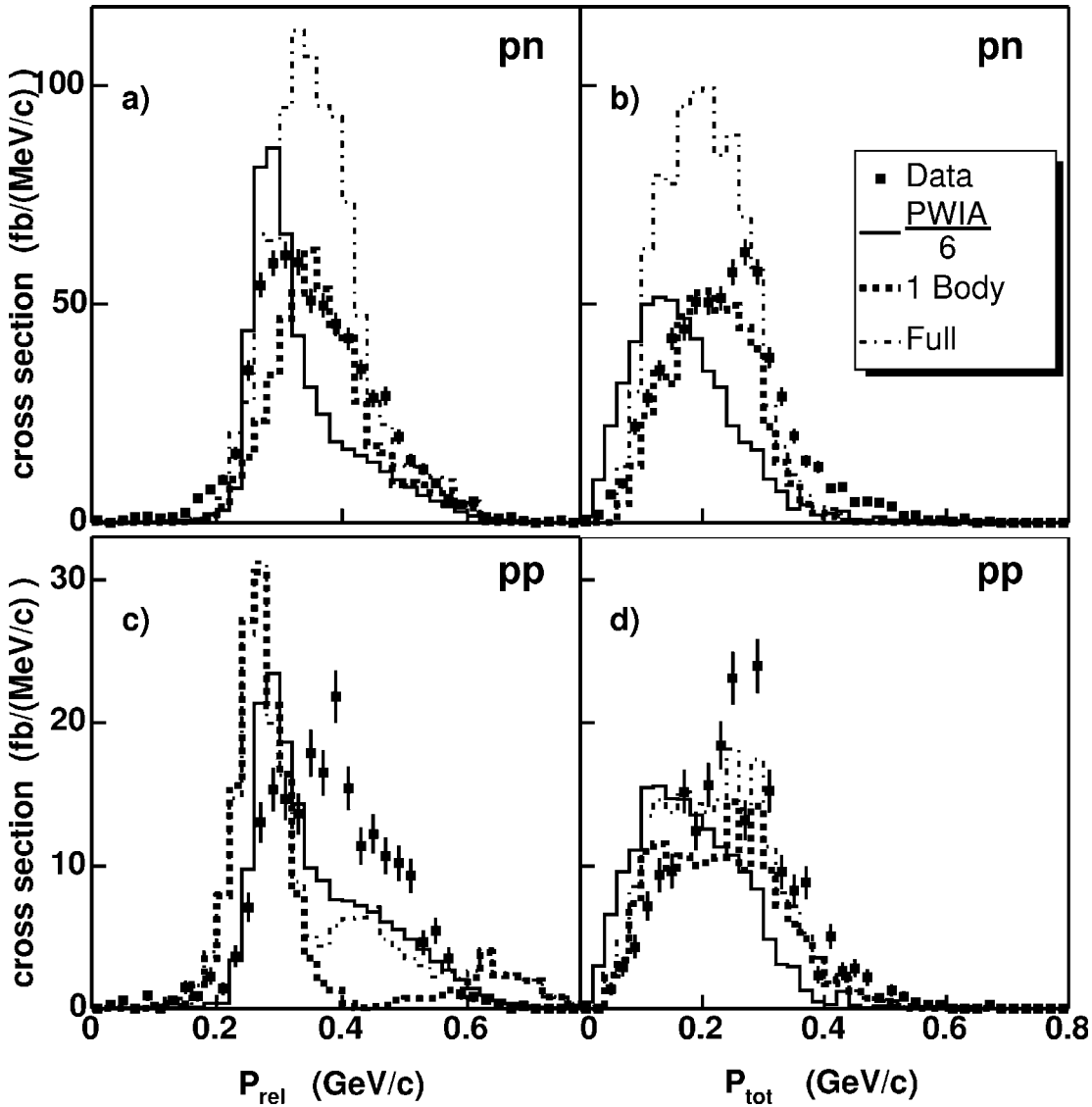
$\Gamma_{1p}(Q^2)$ showing the importance of resonance contributions to the spin structure frunctions at medium and low Q^2.



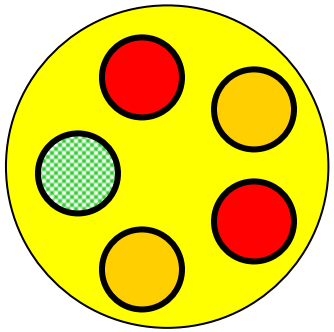
N-N Correlations

2-nucleon knockout shows evidence for correlations in the np pair, which is not involved in the initial interaction. Correlations are evident at high relative momentum of the pair.



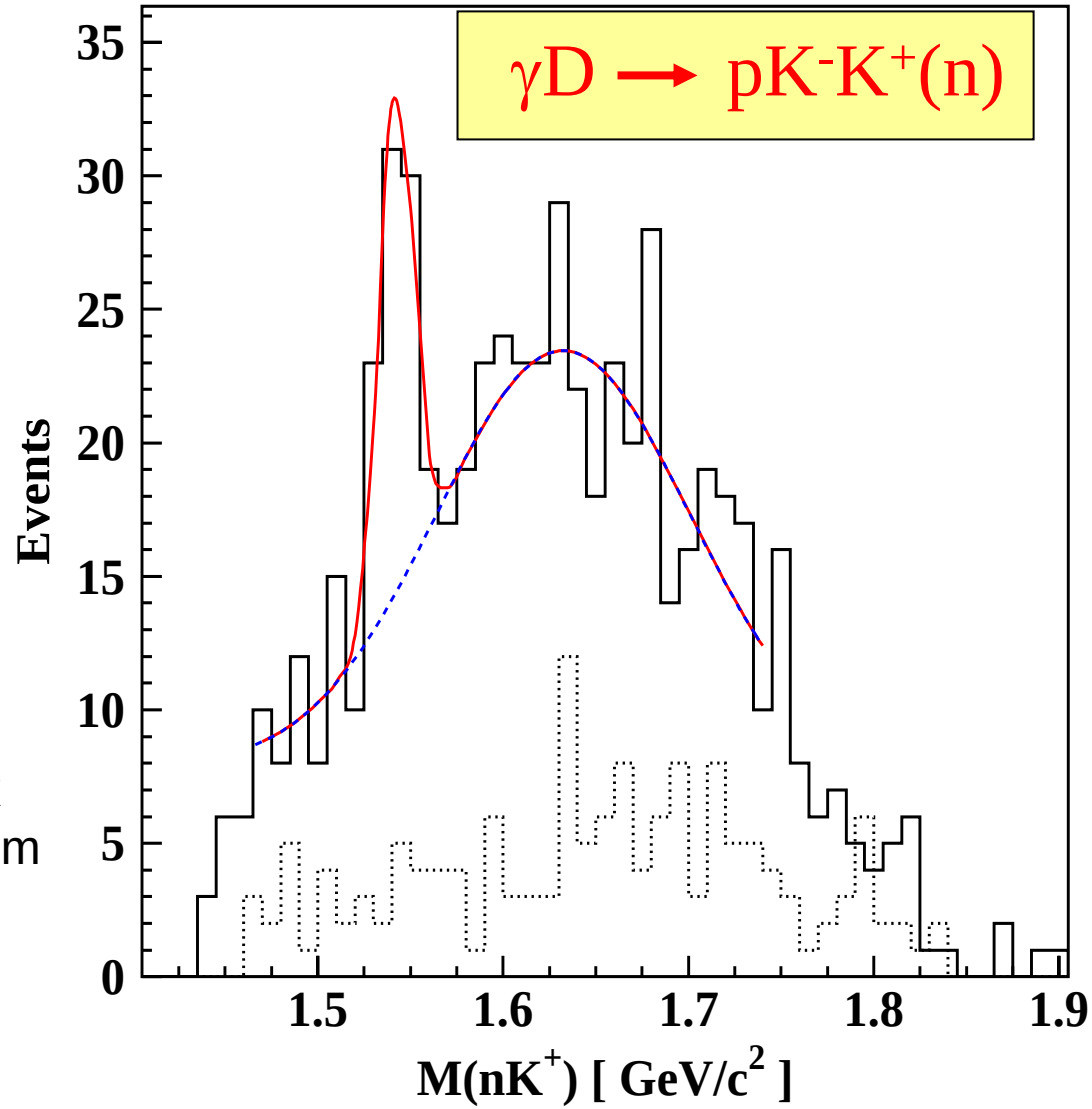


Pentaquark



$M_\Theta = 1542$ MeV
$\Gamma_\Theta < 20$ MeV

Co-discovery of a 5-quark Baryon with exotic quantum number, S=+1.



CLAS in the News

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Jefferson Lab
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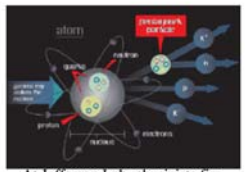
JLab in the News

Jefferson Lab experiment yields evidence of exotic 5-quark particle



At Jefferson Lab, physicists fire gamma rays into the nucleus of heavy hydrogen atoms, releasing pentaquarks and other subatomic particles.

At the Conference on the Intersections of Particle and Nuclear Physics (CIPANP) held from May 19 to 24 in New York City, researcher Stepan Stepanyan from the Department of Energy's Thomas Jefferson National Accelerator Facility (Jefferson Lab), located in Newport News, Va., revealed the most convincing evidence yet of a subatomic particle consisting of five quarks. He was representing his CLAS (CEBAF Large Acceptance Spectrometer) collaboration, a multi-national group of researchers, as he presented Jefferson Lab research supporting the existence of the "pentaquark."

For almost 40 years, all subatomic particles have fit neatly into two categories: three-quark baryons, like protons and neutrons; or mesons, made up of one quark and one anti-quark. The new particle spotted at Jefferson Lab is a sort of baryon-meson hybrid with five quarks - or, more precisely, four quarks and one anti-quark. The pentaquark is a member of the baryon family, but it's said to be "exotic" because the anti-quark has a different "flavor" to the other quarks.

There are six known flavors of quarks, three of which are studied at Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF). They are called up, down and strange quarks, with symbols u, d and s, respectively. The other three known flavors are charm (c), top (t) and bottom (b) quarks. Each of these six quarks also has a corresponding anti-quark.

With six quarks and six anti-quarks to choose from, one could think of many possible combinations of quarks. But not all of them can exist, according to the rules of Quantum Chromodynamics (QCD), the theory that describes the strong interactions between quarks. For instance, QCD forbids four-quark configurations, while the pentaquark that left its signature on the Jefferson Lab data is an allowed state. Physicists know from conservation laws that the only possible configuration for this new particle, dubbed Theta-plus, is two up quarks, two down quarks and an anti-strange quark (uudd s-bar).

Preprint of CLAS Results available at LANL
http://arXiv.org/hep-ex/0307018

Related Press Coverage

- Physicists Find Evidence for an Exotic Baryon
  (*Ohio University Physics Department*)
- Five-Quark Particle Found
  (July 7, 2003, *California Academy of Sciences*)

- Quark to Pentaquark
  (July 7, 2003, *Britannica*)
- Physicists discover new form of matter
  (July 7, 2003, *Wissenschaft*)
- Pentaquarks: New Matter Discovered
  (July 7, 2003, *Science ORF.at*)
- Pentaquark: A Five Quark State Has Been Discovered
  (July 7, 2003, *About, Inc.*)
- Lab finds evidence of tinier part of matter
  (July 7, 2003, *Daily Ppress*)
- Wild Bunch: First five-quark particle turns up
  (July 7, 2003, *Science News*)
- Five Alive!
  (July 3, 2003, *Economist.com*)
- Pentaquark discovery confounds sceptics
  (July 2, 2003, *NewScientist.com*)
- Scientists Report Discovery of a New Kind of Subatomic Particle
  (July 2, 2003, *The Chronicle*)
- New subatomic species found: Collision debris yields five-quark particle
  (July 2, 2003, *Nature*)
- Behold the pentaquark
  (July 2, 2003, *BBC News*)
- Physicists discover particle with five quarks
  (July 2003, *PhysicsWeb*)
- Subatomic breakthrough announced by physicists
  (July 2003, *Dallas Morning Newss*)
- A Subatomic Discovery Emerges From Experiments in Japan
  (July 1, 2003, *New York Times*)
- New Matter May Have Been Found
  (July 1, 2003, *Los Angeles Times*)
- Japanese physicists' 'pentaquark' hints at answers to makeup of matter
  (July 2003, *USA Today*)
- 'Pentaquark' hints at answers to matter
  (July 1, 2003, *The Washington Times*)
- Elusive pentaquark captured
  (June 30, 2003, *MSNBC News*)
- A Five-Quark State Has Been Discovered
  (June 30, 2003, *Physics News Update*)

CEBAF 12 GeV Upgrade

Congress: E&W Appropriations Requests for Nuclear Physics

HOUSE: $399.4M, increase of 17.5M
SENATE: $389.4M, increase of 7.5M

HOUSE: Wants additional $7.5M to increase operating time and enhance user support for facilities at BNL and at JLab, and asks DOE to make a prompt CD0 decision.

SENATE: The Committee supports the CEBAF at the Thomas Jeferson National Accelerator Facility and encourages the Jefferson Lab to increase operational time…. .. and begin work toward the 12GeV upgrade. ..,the Committee urges the Department to grant approval and include adequate funds in its fiscal year 2005 request to continue this process."

Conclusions

Hall B and CLAS are doing well:

- Science results with potentially high impact
- Physics scope is broadening, largely based on data "mining"
  - CAA's give us an advantage, as e.g. in DVCS, SSA in SIDIS, Pentaquark

  With so much data already on tape, this source should be exploited more systematically!
- Interesting instrumentation developments provide basis for future experiments (DVCS, BoNuS, Frozen Spin Target, ..)

But:

- We have many exciting projects, but a shortage of PhD students. Need good ideas how to make CLAS more attractive to students.
- Need to tackle the extraction of physics from more complicated processes, as e.g. presented in the N* program, in a systematic fashion. This has become a high priority for us and for the laboratory!

- Hardware problem still not fully resolved: Drift chamber electronics board corrosion