SANE
Spin Asymmetries on the Nucleon Experiment

TJNAF E-03-109

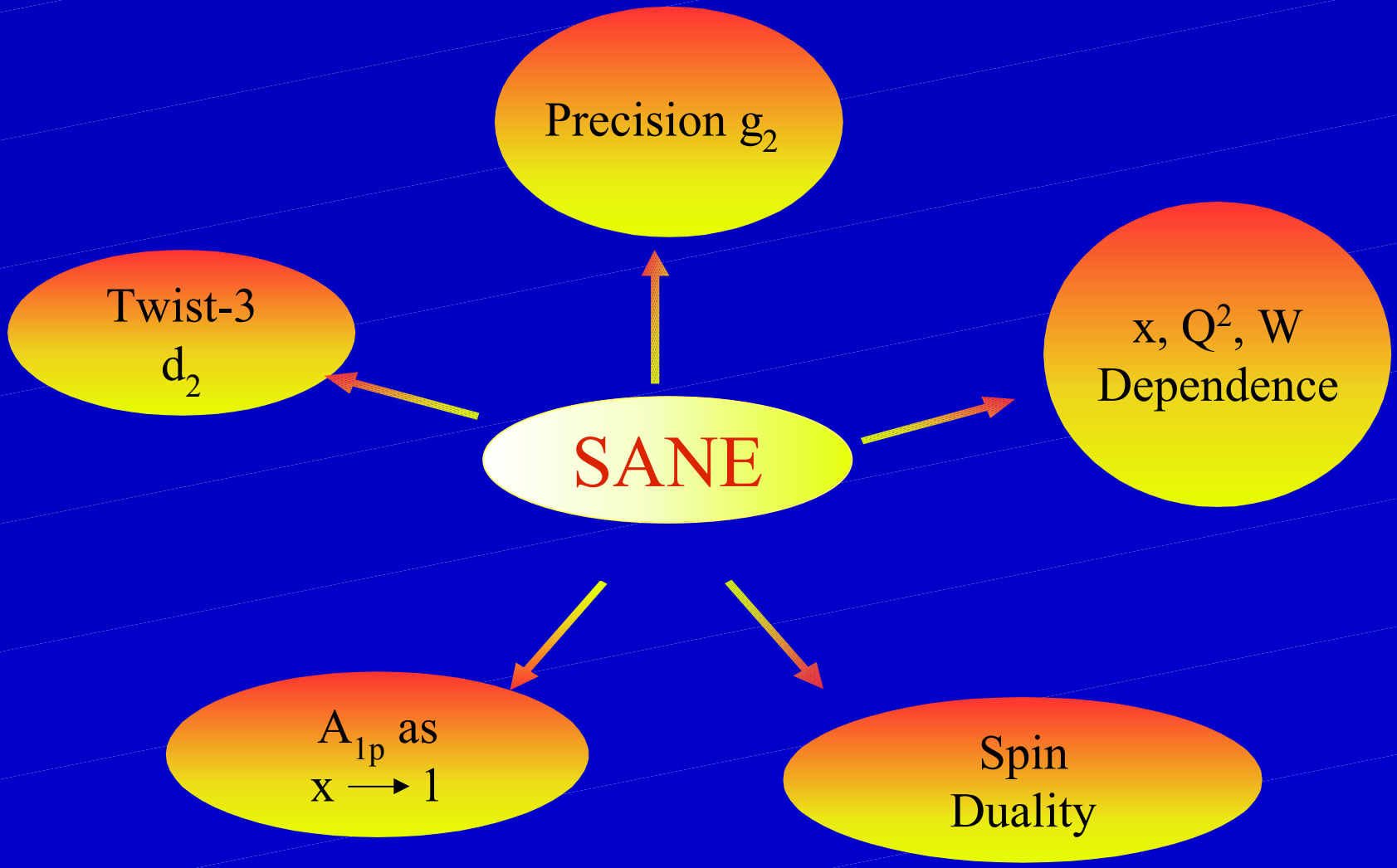
U. Basel, Hampton U., Louisiana Technical U., IHEP Protvino, Rensselaer Polytechnic I., Temple U., TJNAF, U. of Virginia, College of William & Mary, Yerevan Physics I.

Spokespersons: Seonho Choi (Temple), Zein-Eddine Meziani (Temple), Oscar A. Rondon (U. of Virginia)
(G. Warren (PNNL) - proposal spokesperson)

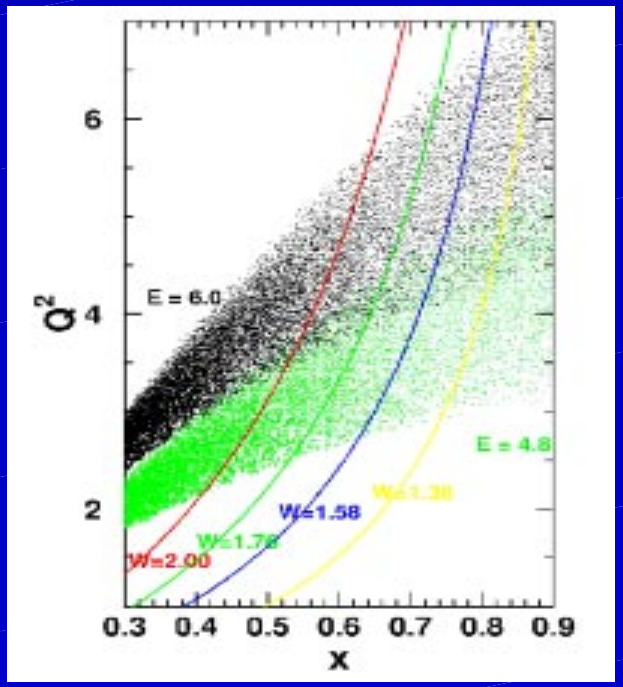
Physics:

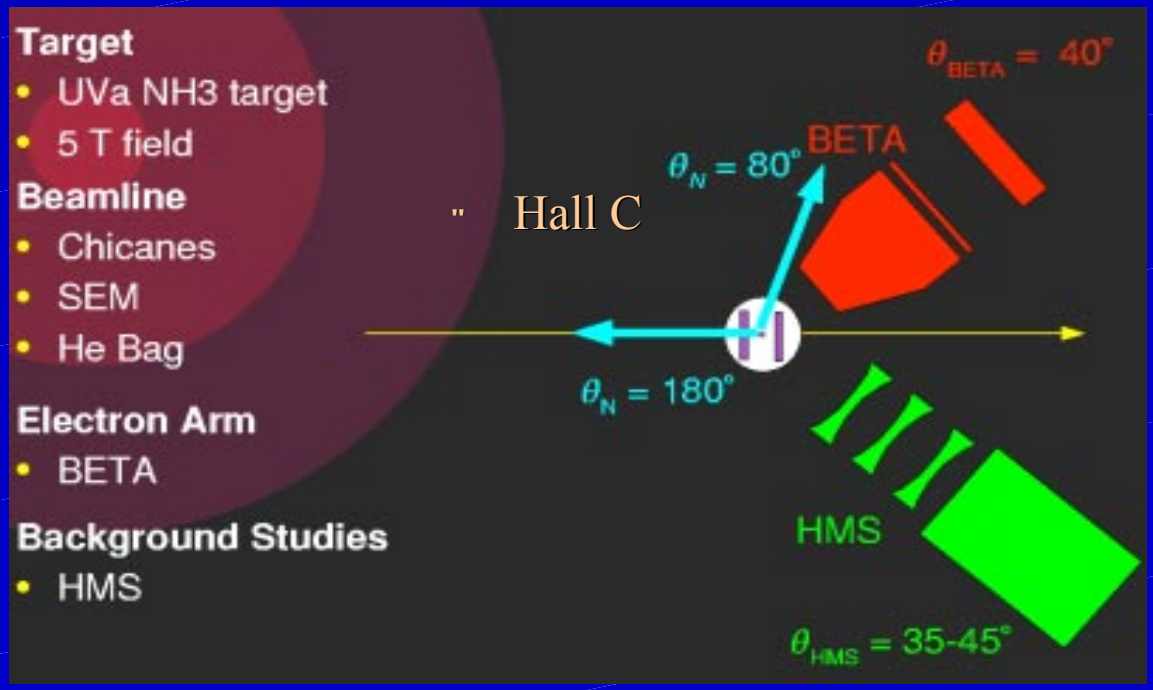
- Measure proton spin structure function $g_2(x, Q^2)$ and spin asymmetry $A_1(x, Q^2)$ at momentum transfer $2.5 \leq Q \leq 6.5$ GeV and Bjorken x $0.3 \leq x \leq 0.8$
- Study x and Q^2 dependence, twist-3 effects, moments of g_2 and g_1, comparison with Lattice QCD predictions, test polarized local duality for $W > 1.4$ GeV,
- Single-arm experiment with large solid angle electron telescope **BETA**

Physics from SANE



SANE Kinematics and Layout

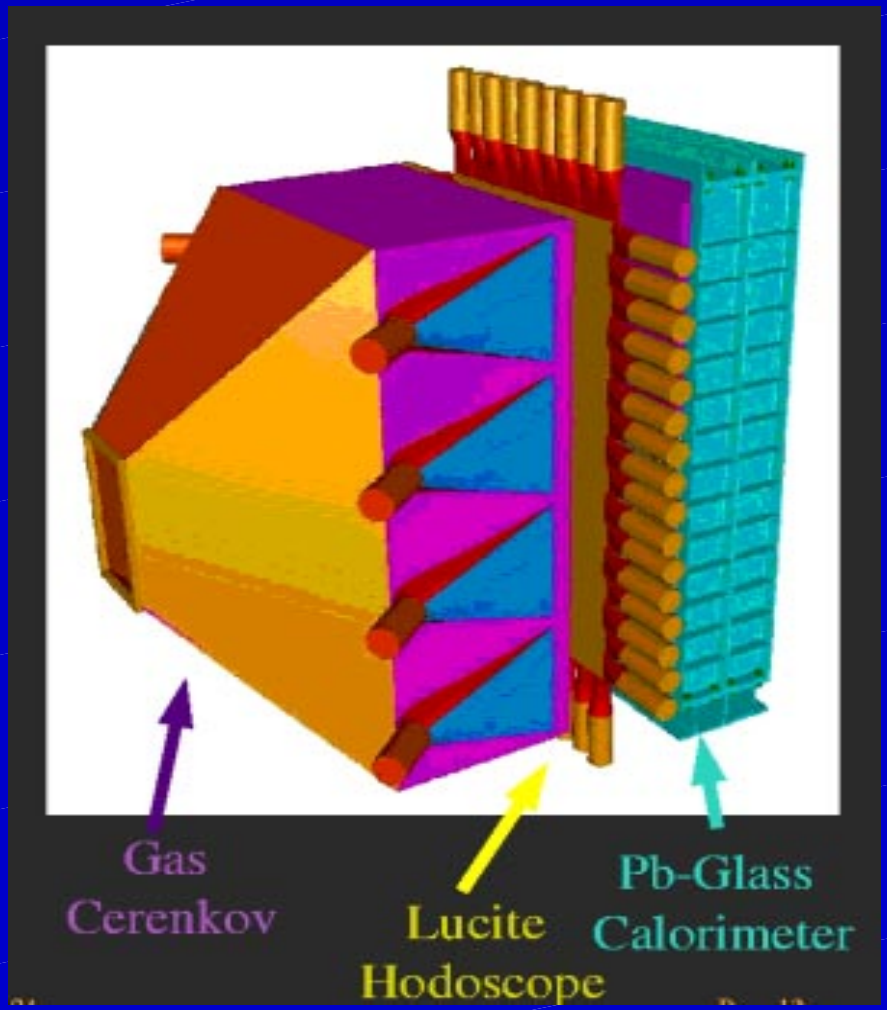




- Two beam energies:
  - 6 GeV (black)
  - **4.8 GeV (green)**
- CEBAF polarized beam
  - 85 nA
  - 75% beam polarization

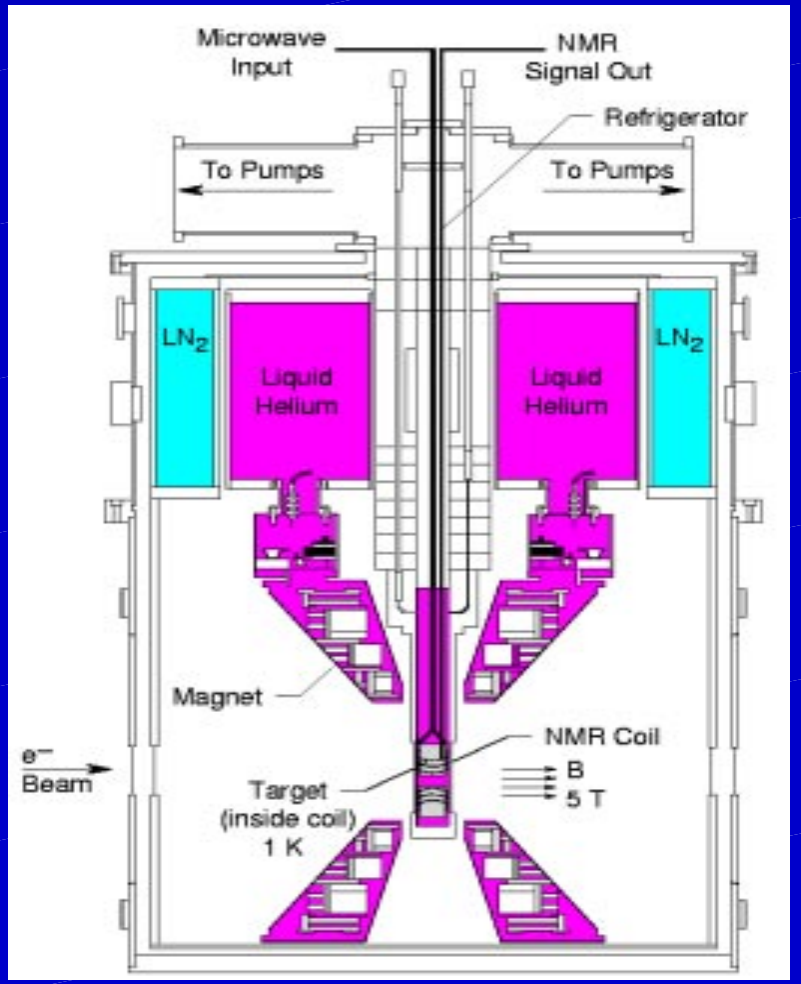
Big Electron Telescope Array - BETA

- Three subsystems:
  - Lead glass calorimeter BigCal: main detector
  - Gas Cherenkov (N_2): additional pion rejection
  - Lucite hodoscope: tracking
- Target field sweeps low *E* background
- Characteristics
  - Effective solid angle (with cuts) = 0.194 sr
  - Energy resolution 5%/$\sqrt{E}$(GeV)
  - angular resolution = 2°
  - 1000:1 pion rejection

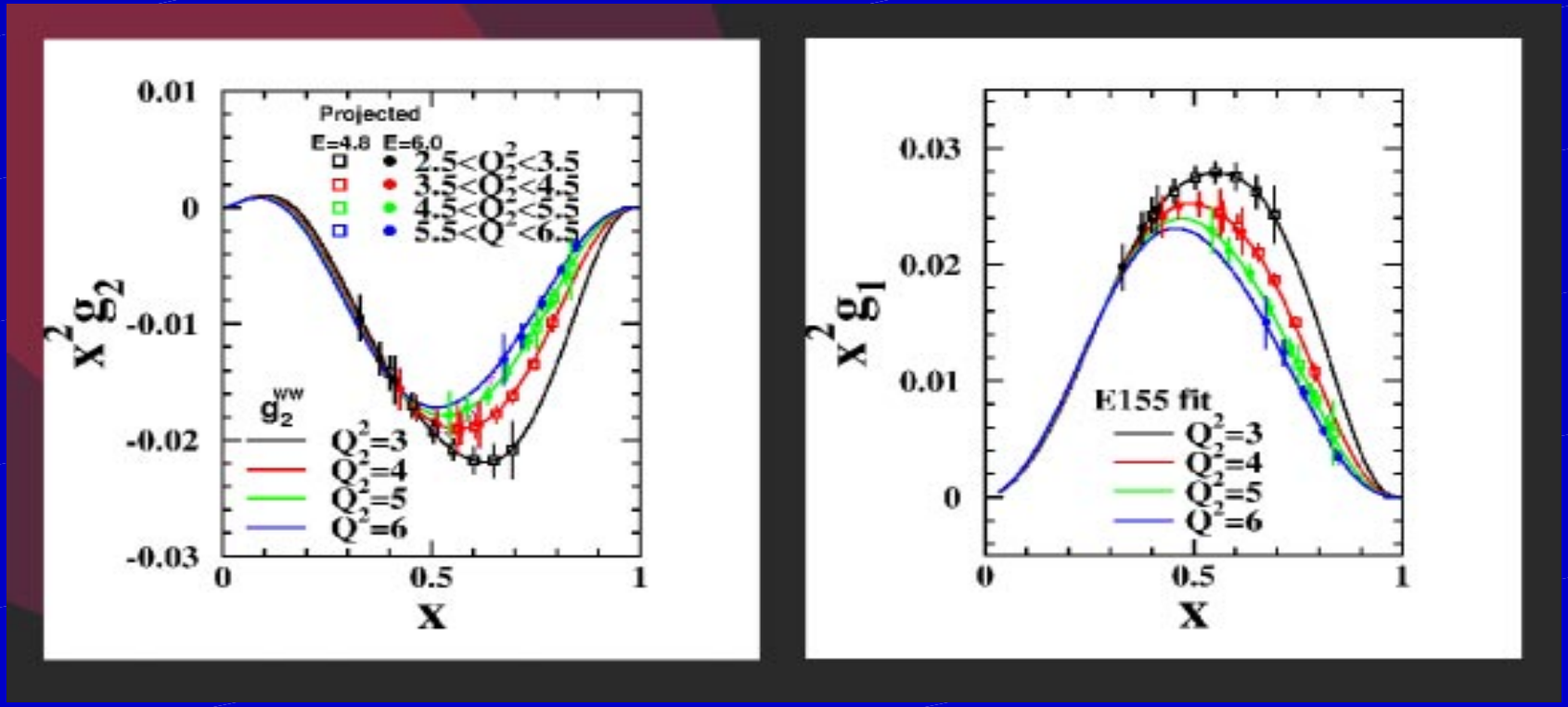


UVa Polarized Target

- Dynamic Nuclear Polarization
- 5 T Field
  - can steer beam
  - affect optics of scattered electrons
- 1 K evaporative refrigerator
- Composite target: N+H+He
  - asymmetry is diluted by unpolarized materials
- Measure target polarization
  - calibration: thermal equilibrium
  - continuous monitoring by NMR

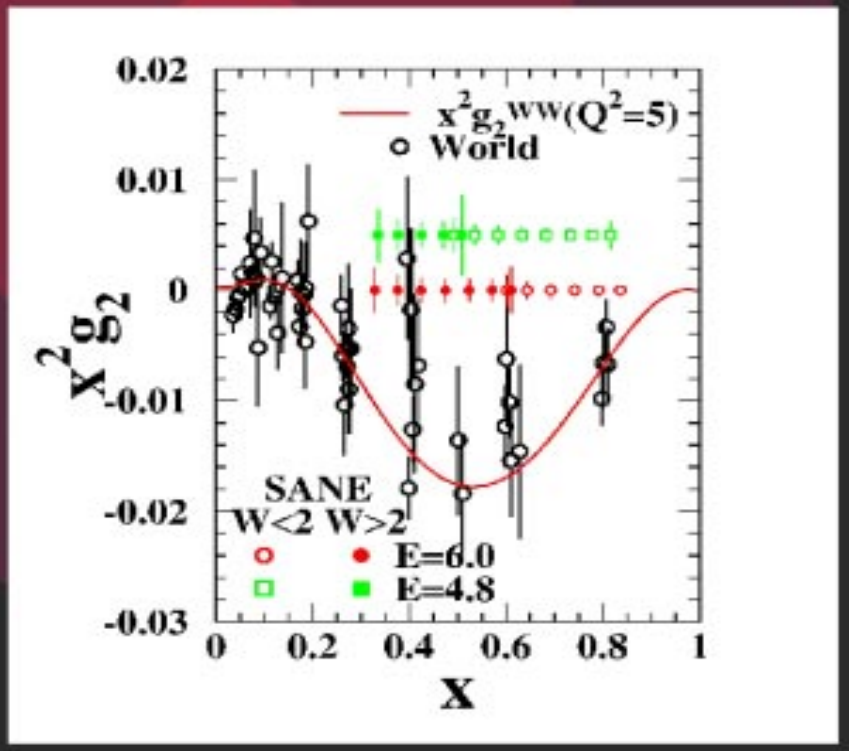


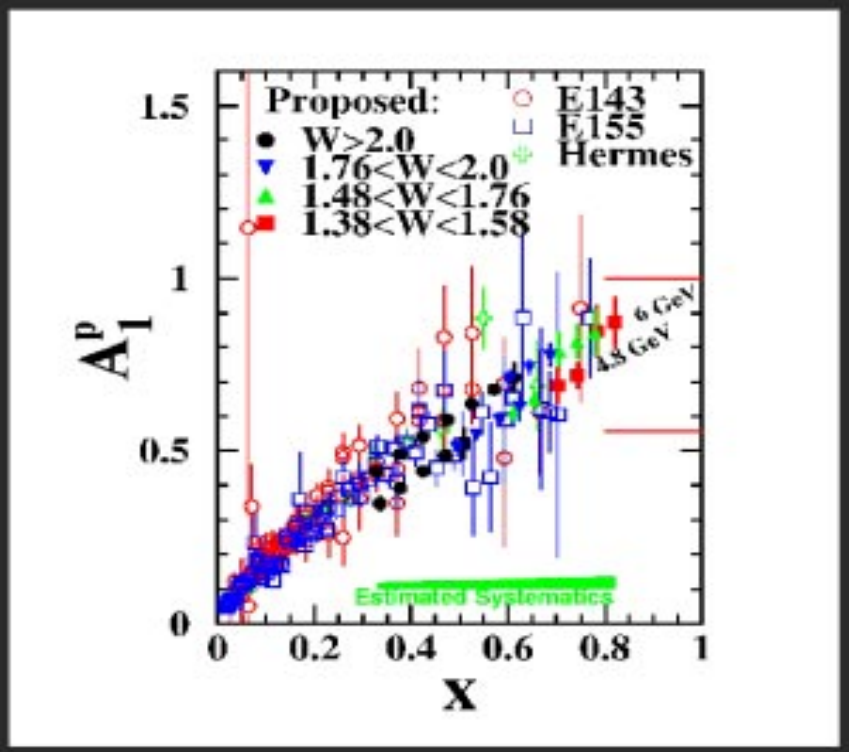
SANE Expected Results



- x dependence at constant Q^2 and Q^2 dependence at fixed x
- Multiple data points at different Q^2 values for each value of x

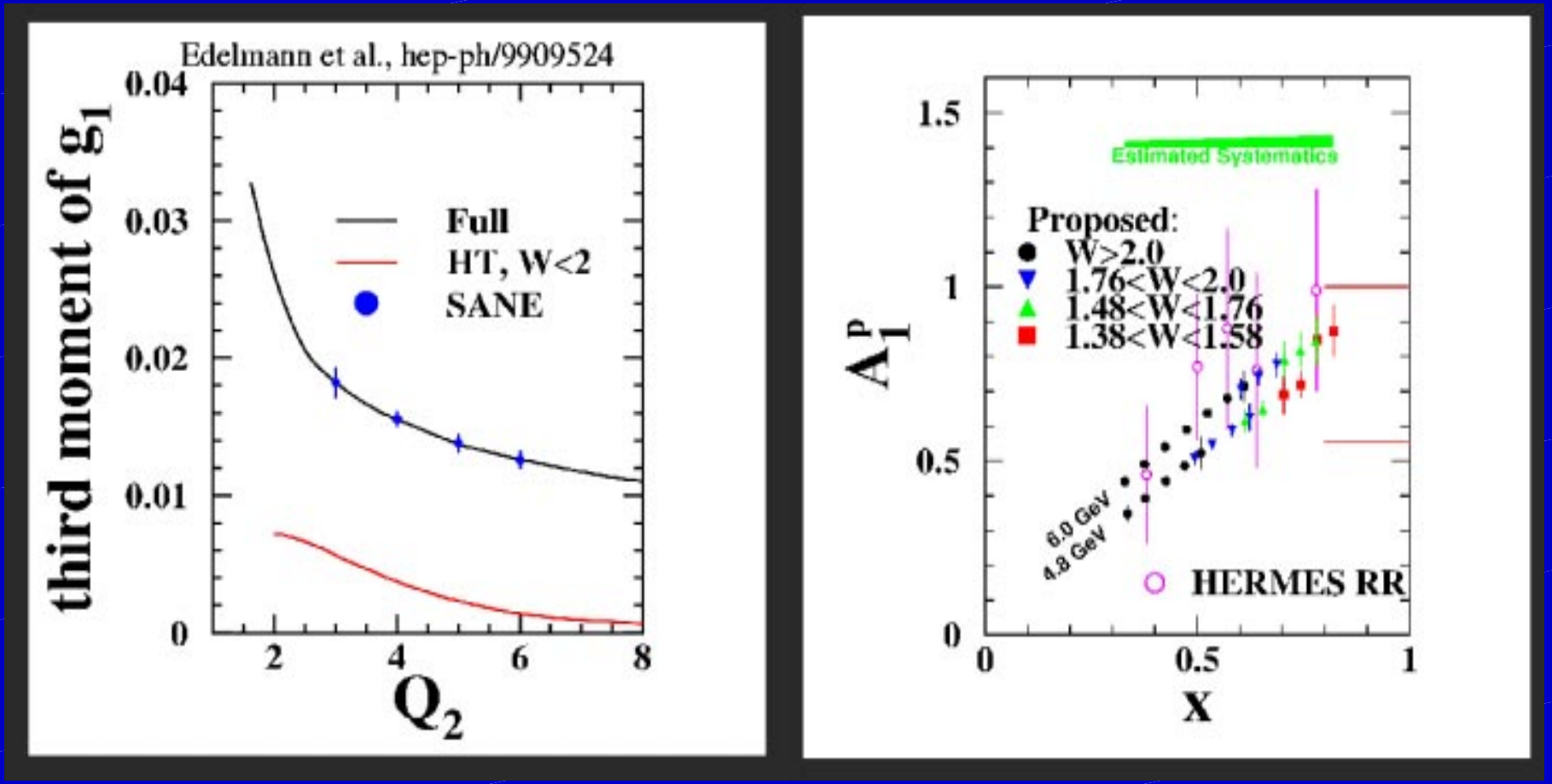
SANE Expected Results (II)





- DIS data up to $x = 0.6$; Resonances measured down to $W = 1.38$ GeV
- g_2 measured in region of most sensitivity for d_2

SANE Expected Results (III)



- Twist-3 matrix element $d_2 = \int_0^1 x^2 (2g_1 + 3g_2)\, dx$ calculable in lattice QCD
- expected error on d_2 (Q^2 = 2.5 to 6.5 GeV^2) = 0.0009 (1/2 the current world error)
- Test of polarized local duality with ΔW resolution ≤ 130 MeV, constant Q^2

Beam Time Request

	Energy	θ_N	Time (h)	
Production	6.0	180	100	
	6.0	80	200	
	4.8	180	70	
	4.8	80	130	
	2.4	-	10	
Systematics	Packing Fraction		20	
	Mollers		21	
	Total beam time		551	(23 d)
Overhead	Anneals		62	
	Energy Change		48	
	Target Rotation		48	
	Stick Changes		48	
	Total Overhead		206	(9 d)
	Requested Time		654	(27 d)

PAC 24 Report

Individual Proposal Report

Proposal:	PR 03-109
Scientific Rating:	A-
Title:	Spin Asymmetries on the Nucleon Experiment (SANE)

Monte Carlo simulations have also been performed to simulate the impact of the beam line background. Given the present expectations for the detector performance and for the background rate, the measurement should be feasible.

Issues: Due to the novel technique and to the uncertainties of the background in the measurement configuration, the PAC recommends that prior to the detector installation, experimental tests should be performed in order to verify the expected performances in terms of energy resolution and calibration, pion rejection and track reconstruction. In addition, the Collaboration should develop all the needed software and hardware tools to determine in the very early stage of the commissioning of the detector/polarized target set-up whether the background conditions and rates are in agreement with expectations.

Recommendation: Conditionally Approve for 27 days in Hall C

Collaboration (11/03)

J.-P. Chen, R. Ent, D. Gaskell, J. Gomez, D. Higinbotham, M. Jones, D. Mack, J. Roche, G. Smith, B. Wojtsekhowski, S. Wood
Jefferson Lab

D. Crabb, D. Day, E. Frlez, N. Liyanage, P. McKee, D.Pocanic, O. Rondon, F. Wesselmann, H. Zhu,
University of Virginia

E. Christy, C. Keppel
Hamption University

T. Averett
College of William and Mary

A. Vasiliev
Institute for High Energy Physics, Protvino

V. Kubarovsky
Rensselaer Polytechnic Institute

Seonho Choi, Z.-E. Meziani
Temple University

J. Jourdan, M. Kotulla, D. Rohe
University of Basel, Switzerland

A. Agalaryan, R. Asaturyan, H. Mkrtchyan, S. Stepanyan, V. Tadevosyan
Yerevan Physics Institute, Armenia

Spin Structure Physics
⇒ JLab, Temple, UVa,W&M

Detectors
⇒ Yerevan, JLab (LA Tech)

Calorimeter
⇒Protvino, UVA, Temple

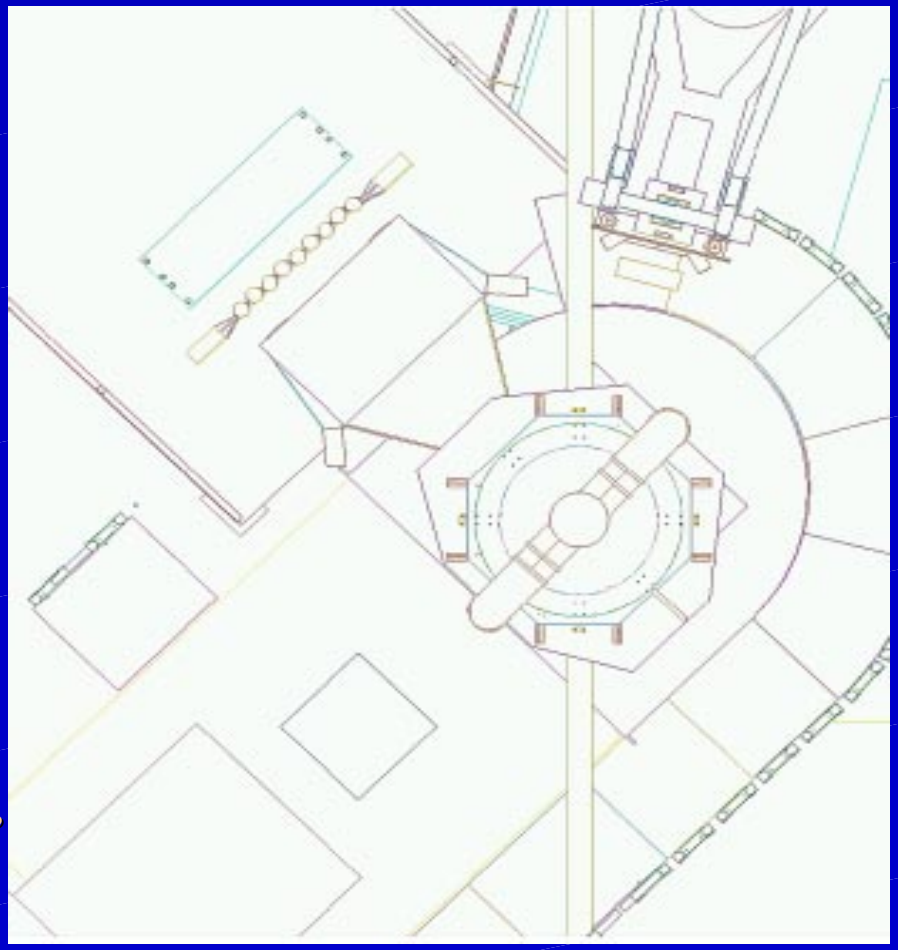
Target
⇒JLab, UVA

First SANE collaboration meeting

- Morning, Friday November 21st., 2003 - CEBAF Center L104
  - 9:00 Welcome - O. Rondon
  - Hall C's view on SANE and JLab schedule - R. Ent
  - 9:10 SANE overview and physics - O. Rondon, UVA
  - 9:40 BigCal - M. Jones, JLab
  - 10:00 Energy calibration and gain monitoring - D. Mack, JLab
  - 10:20 RadPhi Calorimeter Gain Monitoring System - E. Frlez, UVA
  - 10:45 Cherenkov - Z-E. Meziani, Temple
  - 11:05 Hall backgrounds and simulations - Z.E.M for S. Choi, Temple
  - 11:20 Discussion and collaboration business - next mtg.'s date.

SANE in Hall C

BigCal



- Lucite Cherenkov:
  - 16 *x* by 8 *y* hodoscope
  - 1.25 cm thick *x*, 2.5 cm thick *y*
- PMT at each end
- reflective wrap: 10 p.e.'s

BigCal Status (M. Jones)

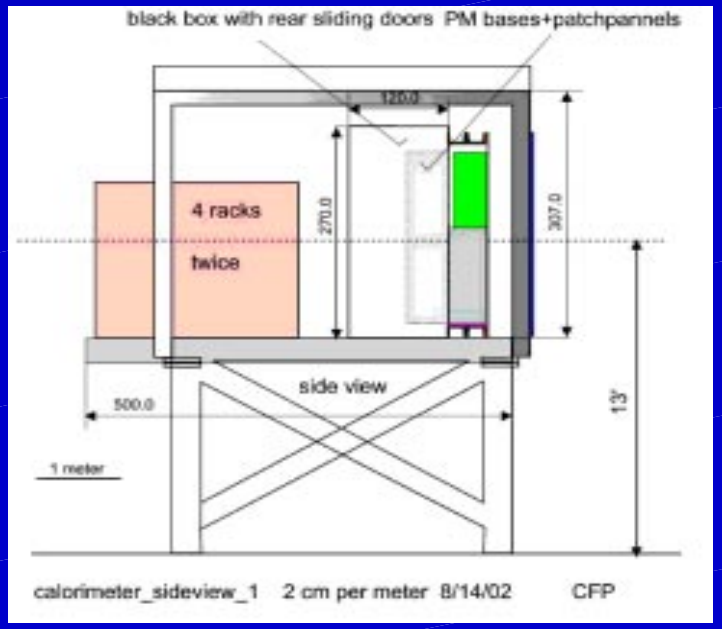
Present Status of BigCal

- The 1744 blocks have been stacked and the cross bars (to attach phototubes) mounted.
- Cable rack in the Testlab with 1100 cables.
- Yuri Melnik and Konstantin Shestermanov (IHEP, Protvino) are onsite and attaching phototubes (128 done so far).
- All major items have been ordered (HV crates and modules, NIM crates and racks, discriminators, summing modules, patch panels), except the HV cable and patch panels.

BigCal needs for SANE

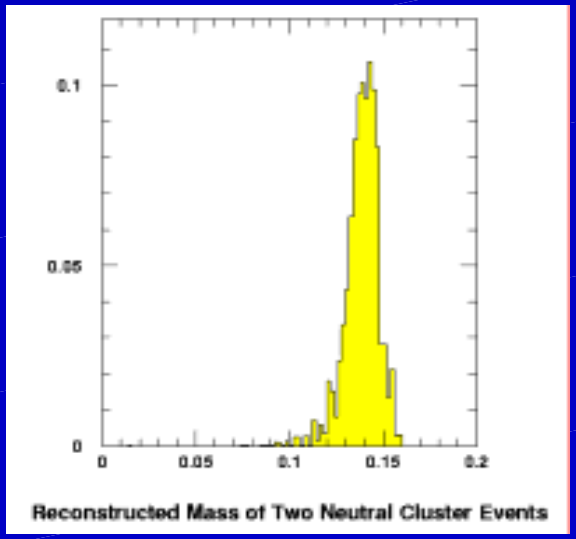
- Gain calibration and monitoring system.
- System for "curing" the glass after Gep3.
- One Fastbus crate and 15 1881M ADC modules are on loan from Fermilab for just for Gep3 experiment.
- General maintenance

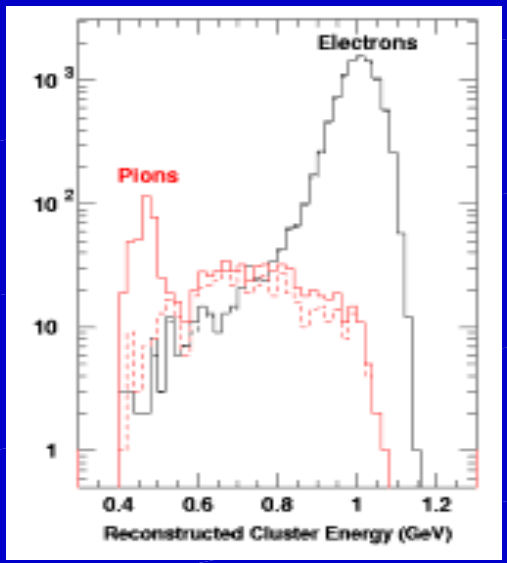
Side View



Absolute Energy Calibration (D. Mack)

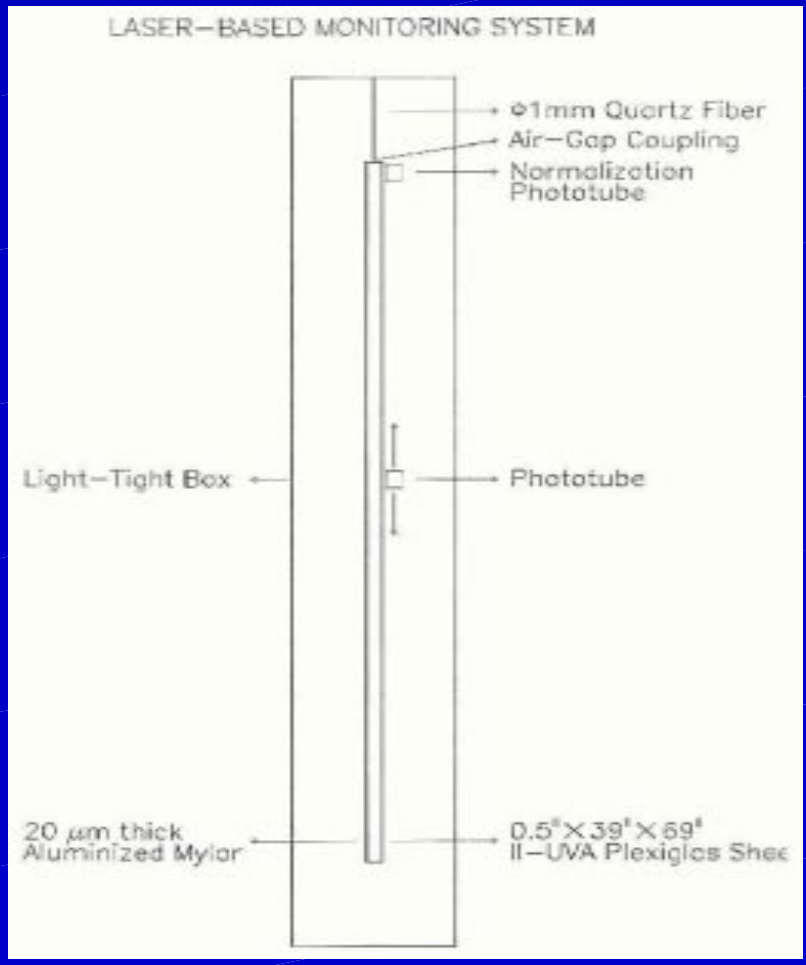
- Elastic ep:
  - Accurate but covers only a fraction of BigCal's area
- $\pi^0 \rightarrow \gamma\gamma$:
  - copious statistics
  - convergence, depth effect issues
- Punch-through **à** :
  - needs scintillator behind glass
  - monitoring and gain matching
- Cosmics: rough gain matching only
- Radiation damage not likely a problem



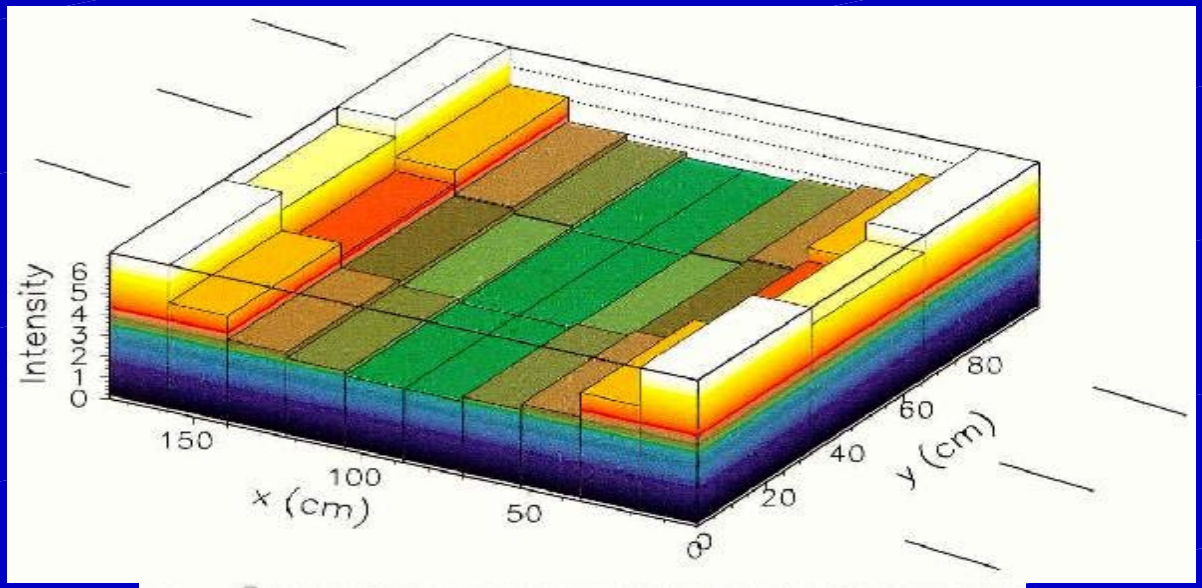


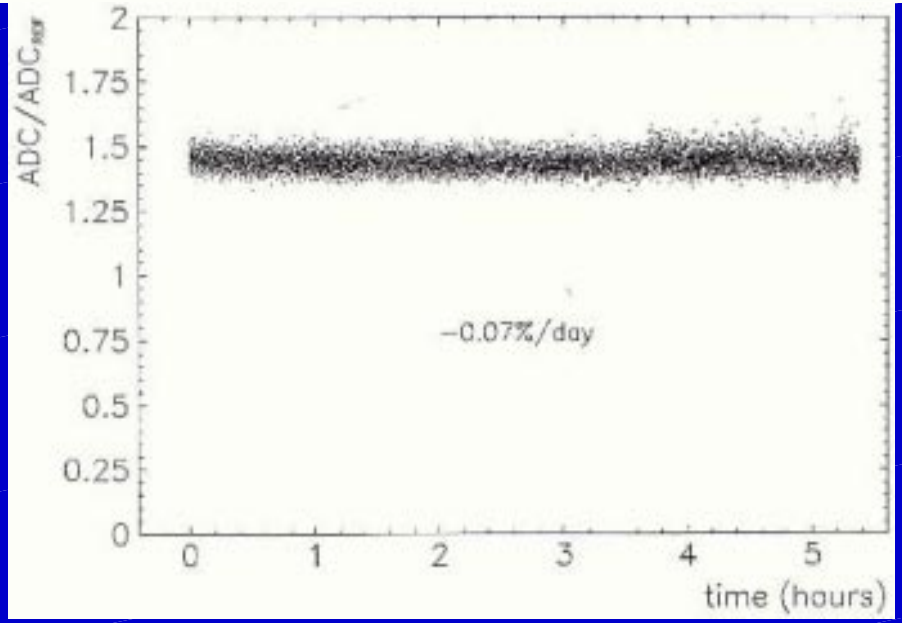
Laser Based Gain Monitoring (E. Frlez)

- Method tested/used with RADPHI calorimeter
- Plexiglass plate lighted by several lasers via quartz fibers
- Reference phototube to monitor laser output variation
- Another phtotube scans the surface of the plate
- Quite good light uniformity in the central region
- Stable in time (-0.07%/day)
- No signs of damage (radiation/mechanical) in time were observed



Light Uniformity and Stability



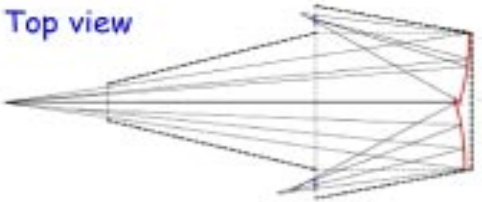


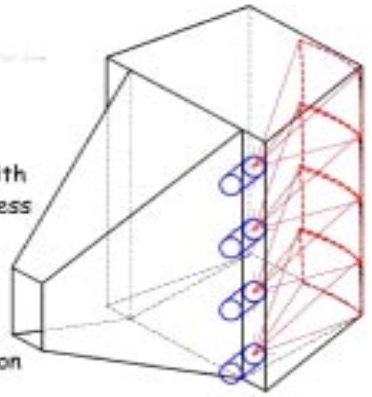
Gas Cherenkov (Z-E. Meziani)

- Goal:
  - High electron detection efficiency
  - Pion rejection of at least 1000:1
- Reference design presented in the proposal
  - Operation at about atmospheric pressure (over pressure 1cm for water equivalent)
  - Radiator: dry nitrogen at 20°C, n=1.000279
  - Pion momentum threshold: 5.9 GeV.
  - Electron momentum threshold: 21.6 MeV
  - Windows:
    - tedlar for light seal
    - polymer window for gas-tight seal
  - Mirrors cover an area 71 cm (H)x 150cm (V) (8 mirrors)
  - Point-to-Point focusing of the mirrors for electrons > 0.7 GeV from target cell to phototube
  - Detailed ray trace simulation to be done

New configuration for the Box

Top view





·Box made out of flat sheets of aluminum with frame reinforcement or non magnetic stainless steel.

·Mirrors with R~1.3m and less likely to be at 45°. Flanges for mounting phototubes easy to setup with the proposed configuration

·Need to start design with a full simulation.

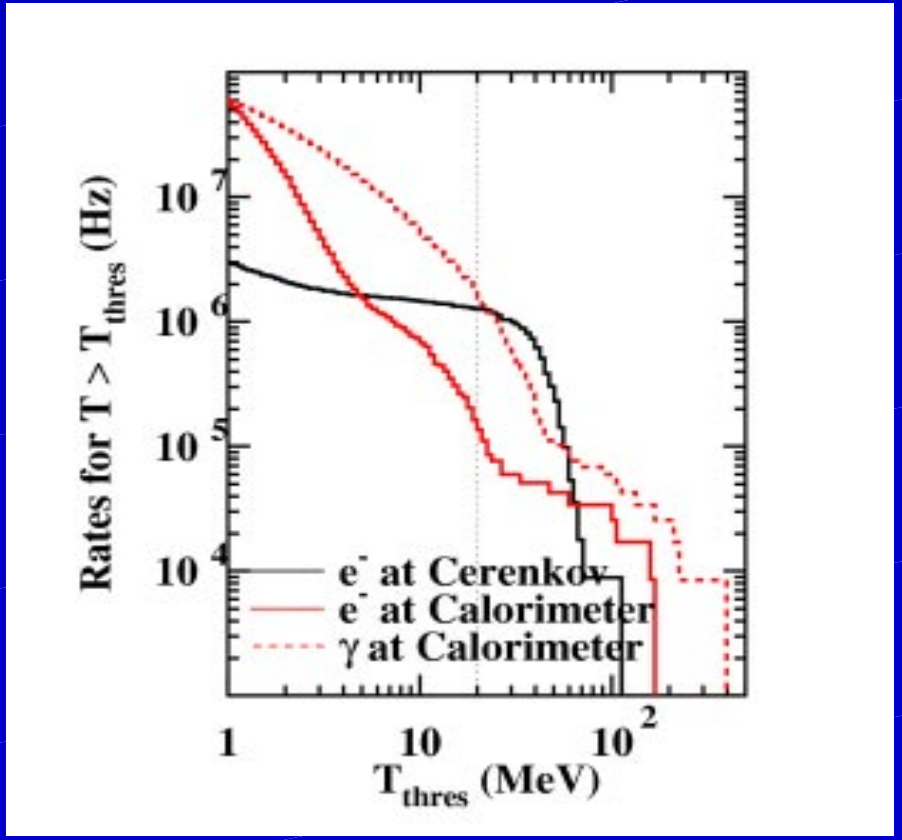
Plans

- Detailed ray trace simulation
- Mirrors radius of curvature and final dimensions to be defined
- Detailed box design
- Building of prototype with one mirror, one photomultiplier, same length of radiator
- Test of prototype at UVA and in Hall C for designing a good magnetic shield for the tubes.
- Plan to write an instrumentation proposal to DOE or NSF

Beam Line Background Studies

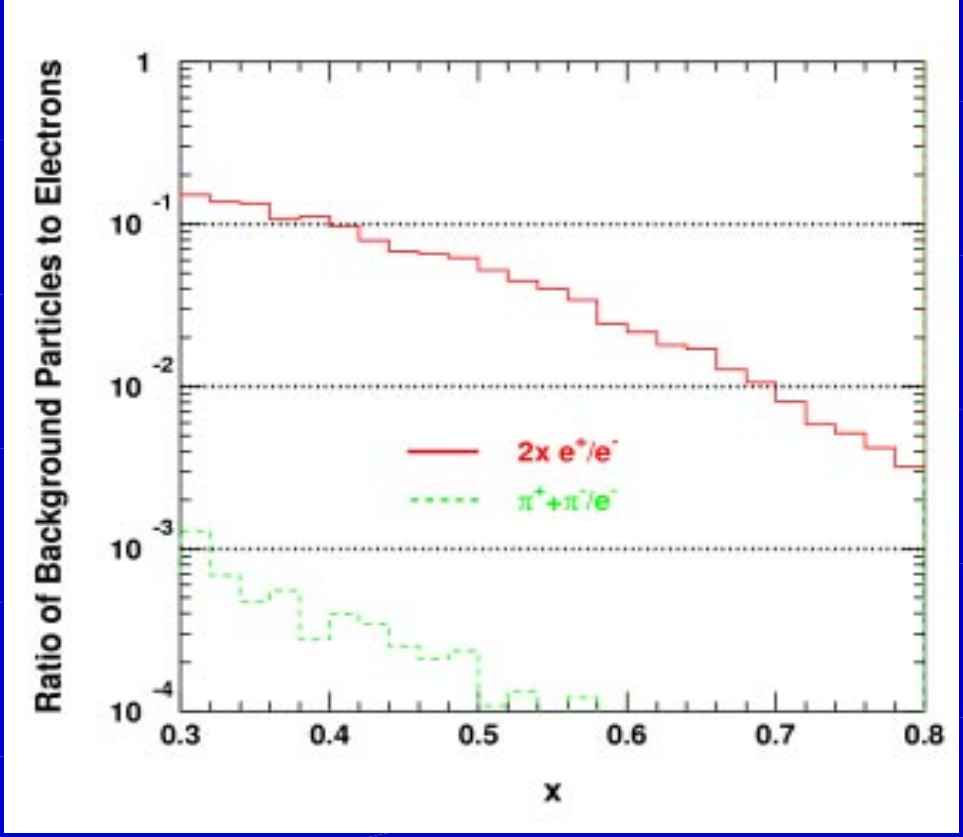
Conducted preliminary beam line background studies using simulation package of Pavel Degtiarenko.

- *Parallel field:* no problems with BETA at 40°.
- *Transverse field:* a large fraction of electrons escape pathologically into BETA:
  - expect at most 200 kHz/PMT for Gas Cerenkov.
  - Pileup, trigger rates, detector rates all remain manageable.
  - These numbers are conservative... will probably have a reduction of at least 2 in Cerenkov rates.



Background Rates

- Dominated by charge-symmetric processes, mostly $\pi^0 \rightarrow \gamma\, e^+\, e^-$.
- Measure ratio of rates in HMS.
- Measure ratio of asymmetries using events with γ, $\gamma\gamma$ and $e^+\, e^-$ in BETA and use CLAS data.
- Hadron backgrounds measured by ignoring Gas Cerenkov in trigger.
- Reduce Positron Rates by increasing energy threshold



Summary

- Comprehensive study of proton spin structure at Q^2 from 2.5 to 6.5 GeV^2 with improved precision
- Could be scheduled for the 2nd half of 2006 (just after Gep3)
- Uva frozen NH_3 target
- New large solid angle electron detector BETA
  - BigCal: getting ready for Gep3 and eventually for SANE
  - Cerenkov: simulation in progress for a prototype
- Background from the target
  - Hadrons: reduction by Cerenkov
  - Positrons: on-line monitoring with HMS
- Beam Background still manageable with conservative estimates