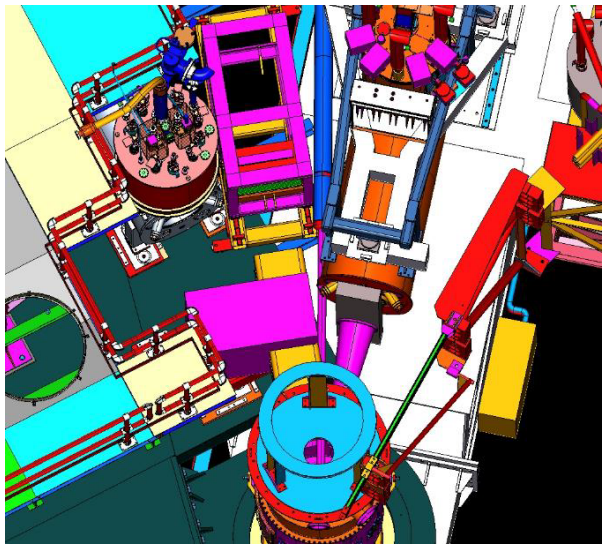
Hall C 2015 Winter Meeting
15 Jan 2015
Jefferson Lab

The Neutral Particle Spectrometer Physics Program



Charles Hyde,
for the NPS Collaboration

Deep Inelastic and Deep Virtual Scattering

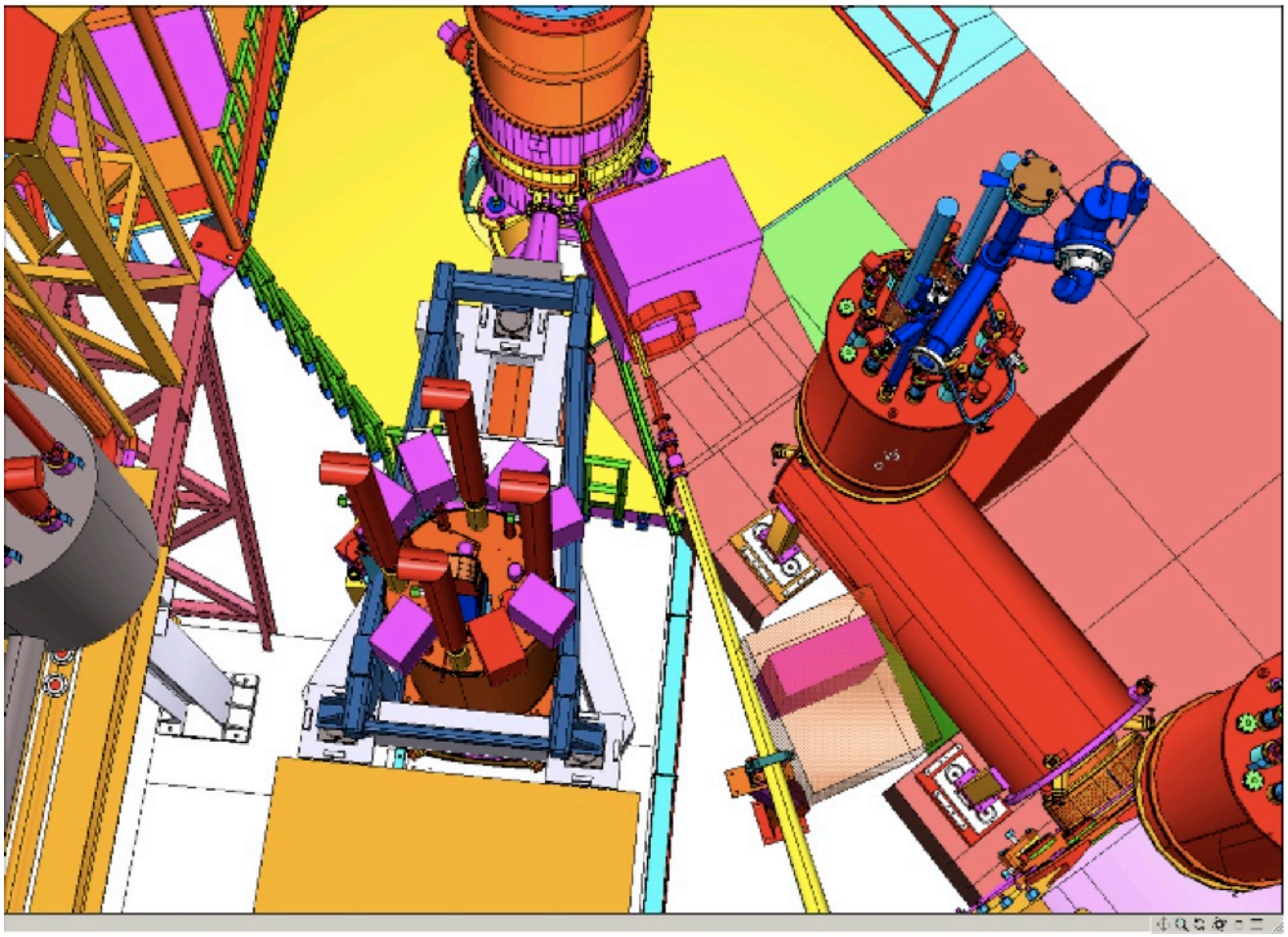
- Deep Virtual Exclusive Reactions:
  - H(e,e'γ)p
  - H(e,e'π^0)p
  - Exploit the full kinematic range of 11 GeV electrons
  - Precision cross sections for higher-twist studies (≤4% syst.)
  - Multiple beam energies at fixed Q^2, x_{Bj}
    - Isolate $|DVCS|^2$ from $Re[DVCS^{+}BH]$
    - Rosenbluth separations of H(e,e'π^0)p
- SIDIS:
  - H(e,e'π^0)X
  - Flavor and p_T dependence of H(e,e' $\pi^{+,-,0}$)X

Wide-Angle Photo-Production

- H(γ,γ' p)
  - Beyond the Handbag approximation:
    Soft Collinear Effective Theory (SCET)…
  - $d\sigma \sim f(s)R(t)$
- $\vec{\gamma}+\vec{p} \rightarrow \gamma' + p$
  - Factorization and the Tensor Form Factor $R_A(-t)$
  - *Talk by J.Zhang*
- H(γ,π^0 p)
  - Reaction mechanism and scaling in photoproduction:
    D(γ,p)n, p(γ,π^+)n show scaling for $p_\perp$>1 GeV
  - *H(γ,π^0 p) is simplest reaction beyond RCS for testing Handbag, SCET…*

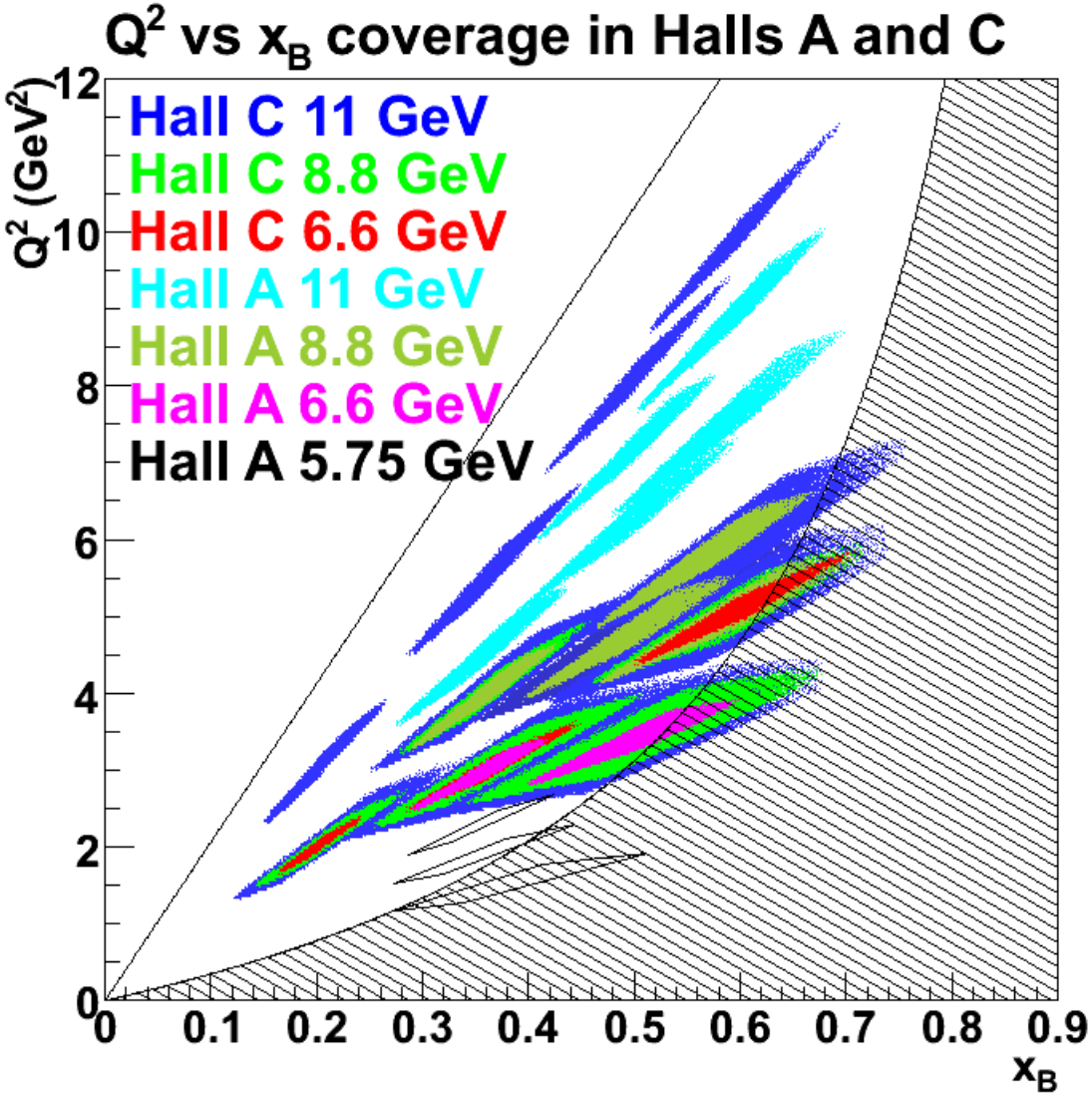
Beam Line for SIDIS, Deep Virtual

- Electrons in HMS
- γ, π^0 :
  - small angle Calorimeter.
  - Variable distance for $\gamma\gamma$ separation
- Sweep magnet reduces small angle rad dose to calo by factor 10



DVCS

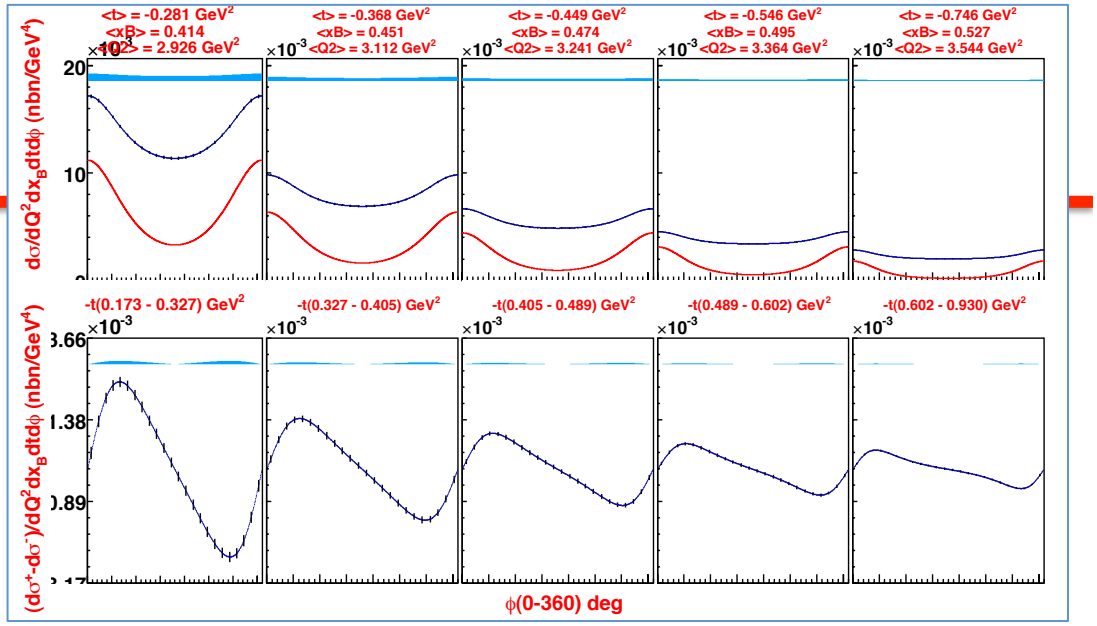
- Wide kinematic coverage
- Multiple Beam Energies

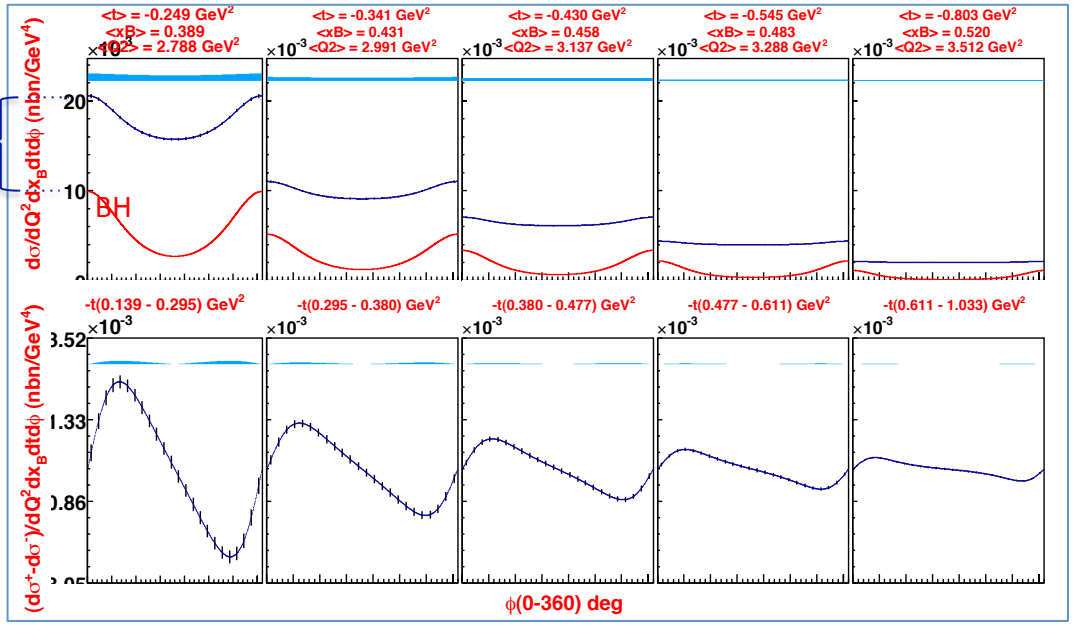


$x_{Bj} = 0.50$
$Q^2 = 3.0\ GeV^2$

DVCS @ Two Beam Energies

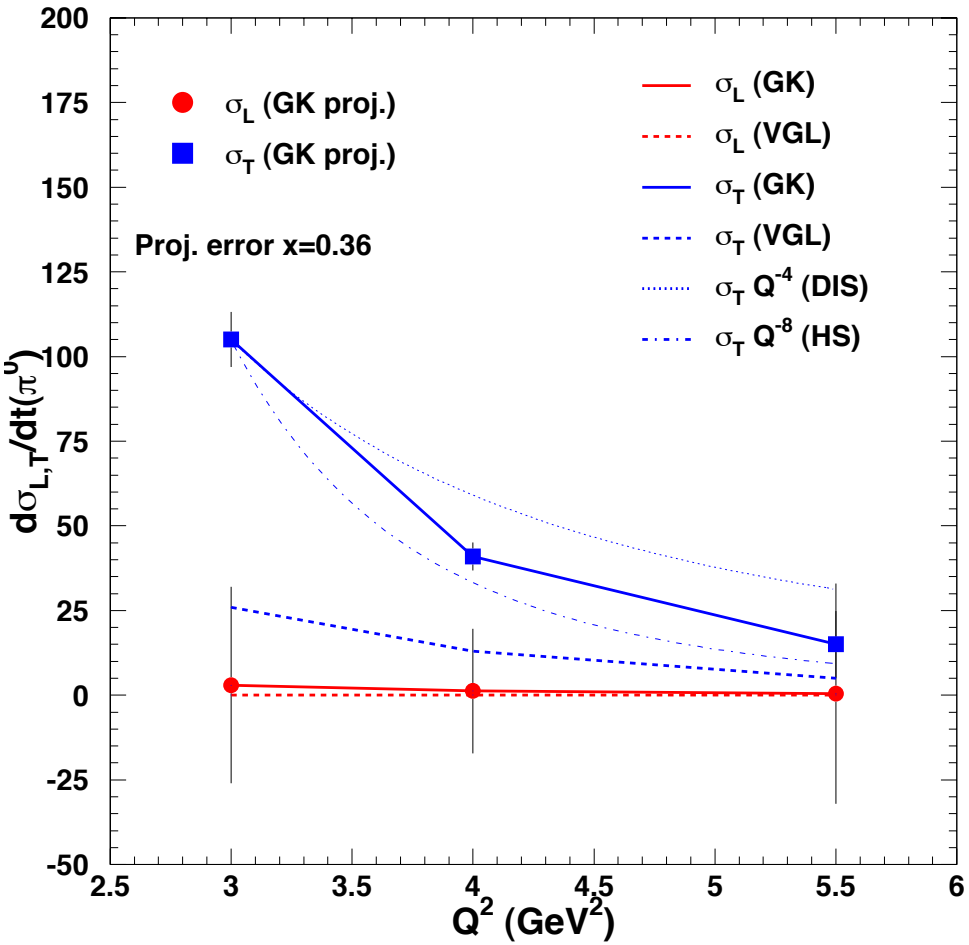
- 8.8 GeV
- 11.0 GeV
- 5 bins in *t*





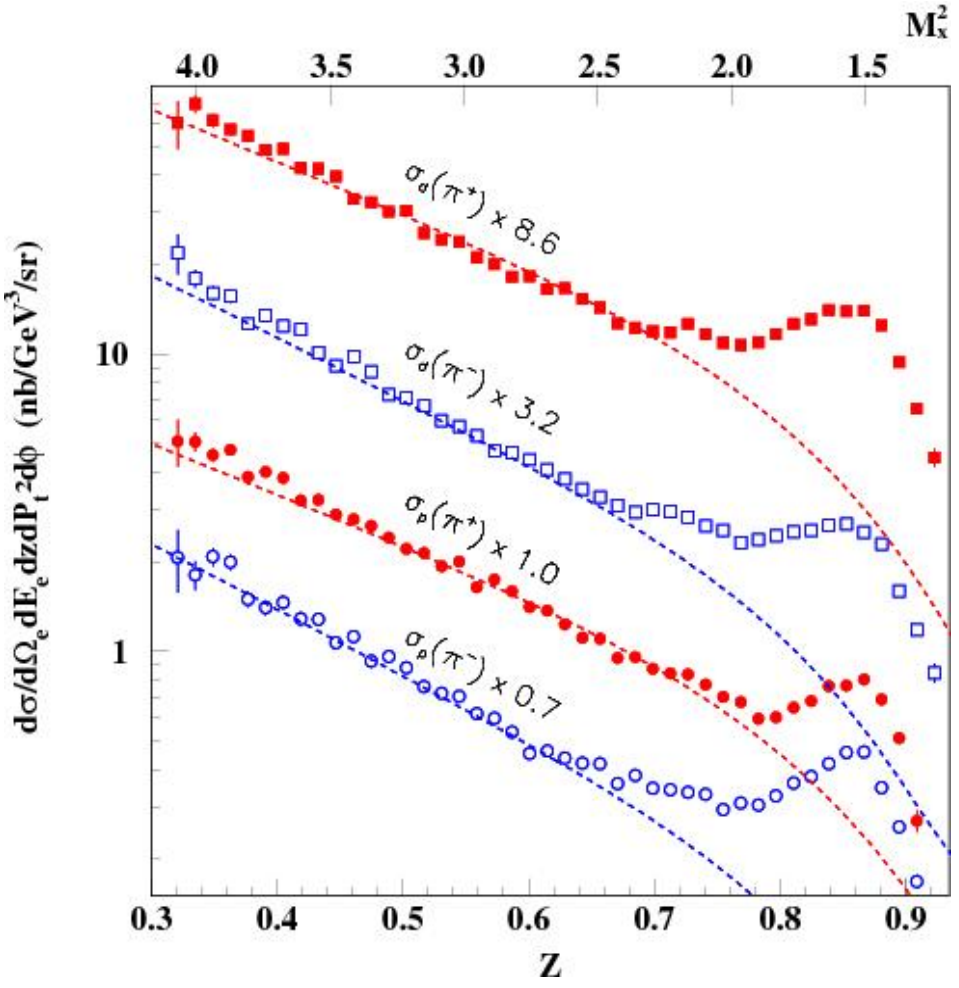
Deep Virtual π^0 Production

- Naïve factorization:
  - $d\sigma_L \sim Q^{-6}$
  - $d\sigma_T \sim Q^{-8}$
- Large helicity flip Distribution amplitude: $q\bar{q} \to \pi^0$
  - Couples to Transversity GPD
  - $d\sigma_T \sim$ dominant



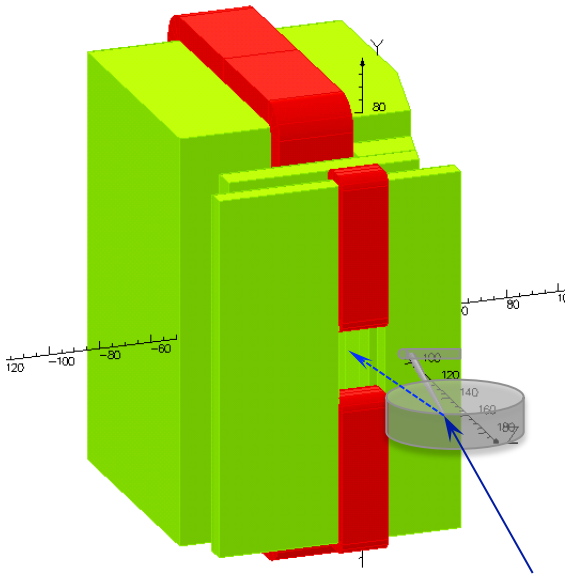
SIDIS

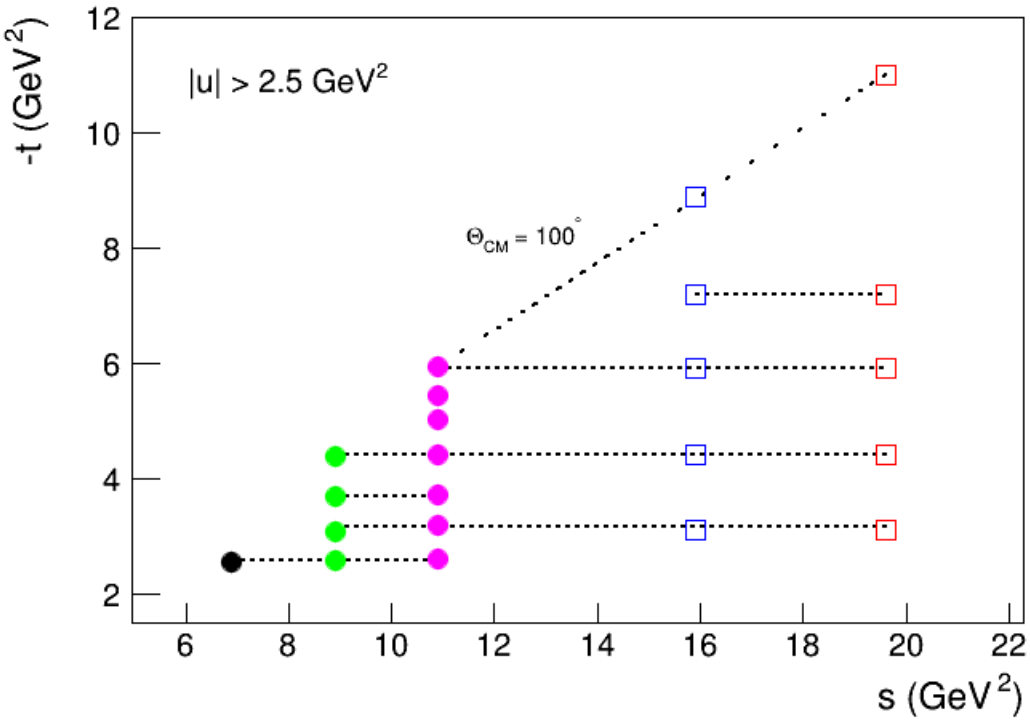
- Scaling in x_{Bj} and $z=p_h/\nu$?
  - Q^2 study at 12 GeV
- Flavor deconvolution from π^+, π^-, π^0 ?
- Example of JLab 6 GeV charged pion data:
  - PRL **98** (2007) 022001
- What is p_T dependence?



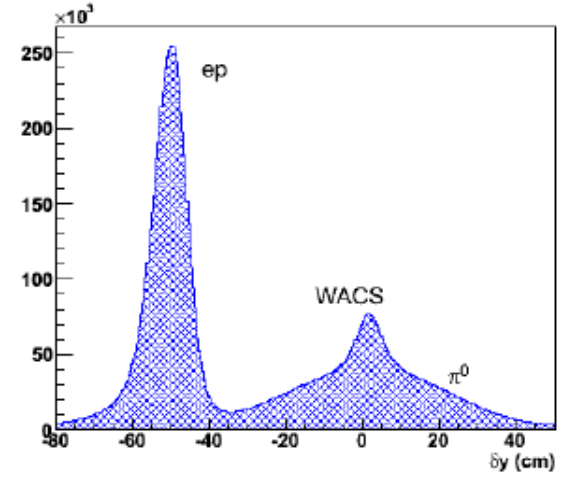
Wide Angle Compton and π^0

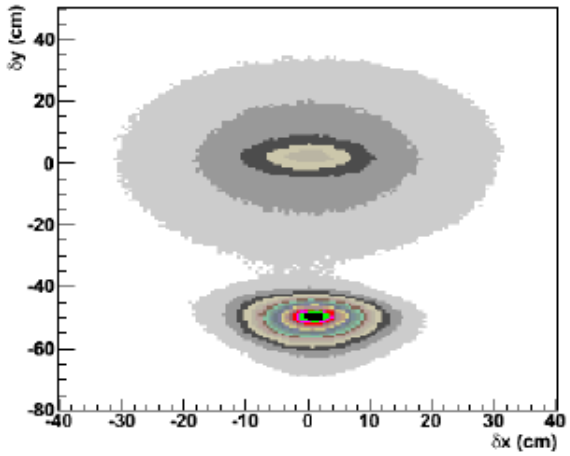
- Bremsstrahlung beam
- Vertical bend sweep magnet for tail of pre-radiated elastic H(e,e')p

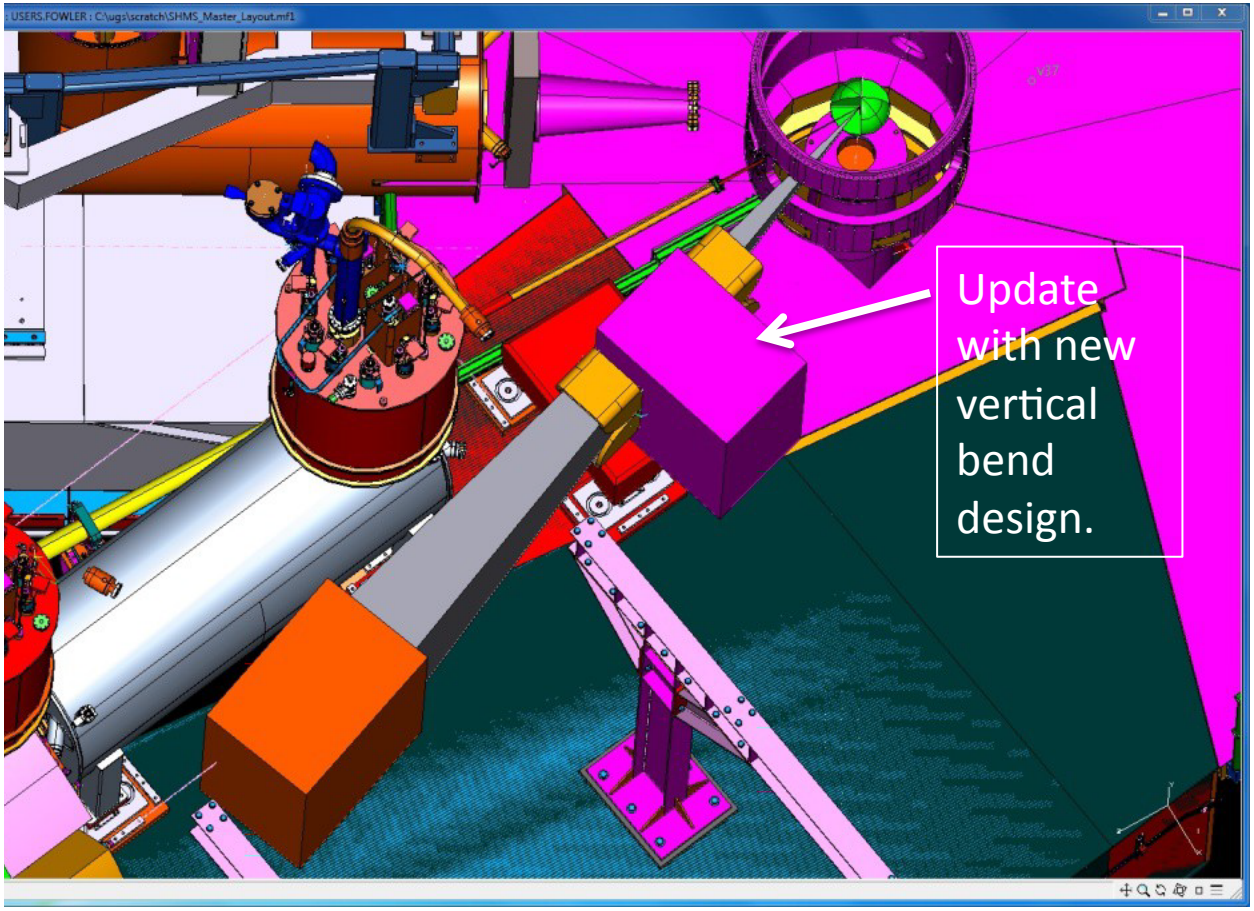




H(γ,γ p), H(γ,π^0p), H(e,e'p)γ



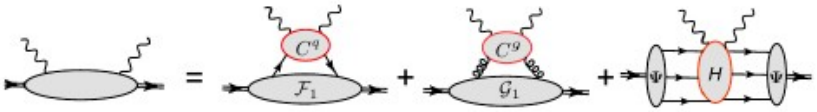




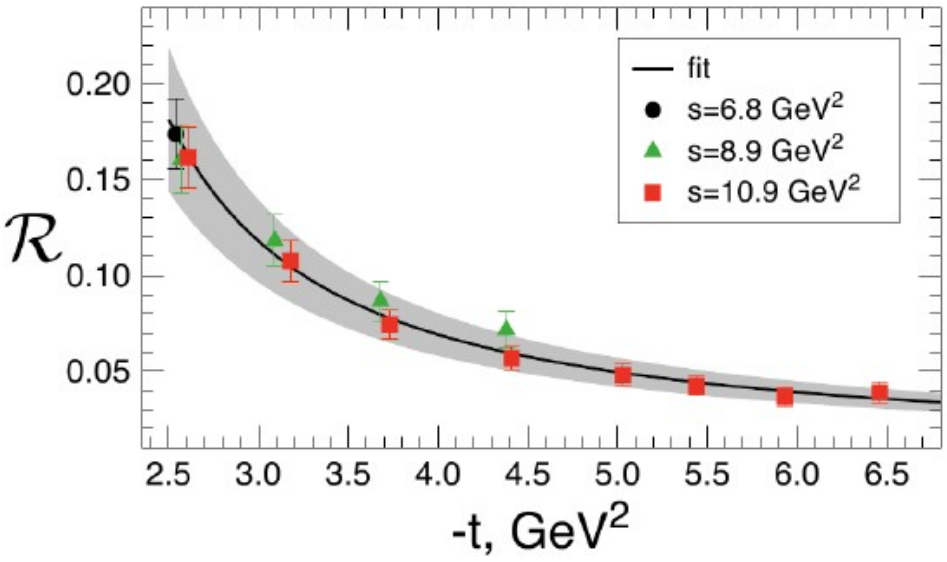
Soft Collinear Effective Theory

- The recent development of the SCET approach by Kivel and Vanderhaeghen has shown the importance of WACS in understanding two-photon exchange effects in elastic ep scattering.
- In this framework, a new universal form factor is introduced, the t-dependence of which is extracted from WACS cross section data.
- This form factor describes the soft-overlap contribution in a variety of hard exclusive reactions, such as time-like Compton scattering.

JHEP 04, 029 (2013) & arxiv:13125456

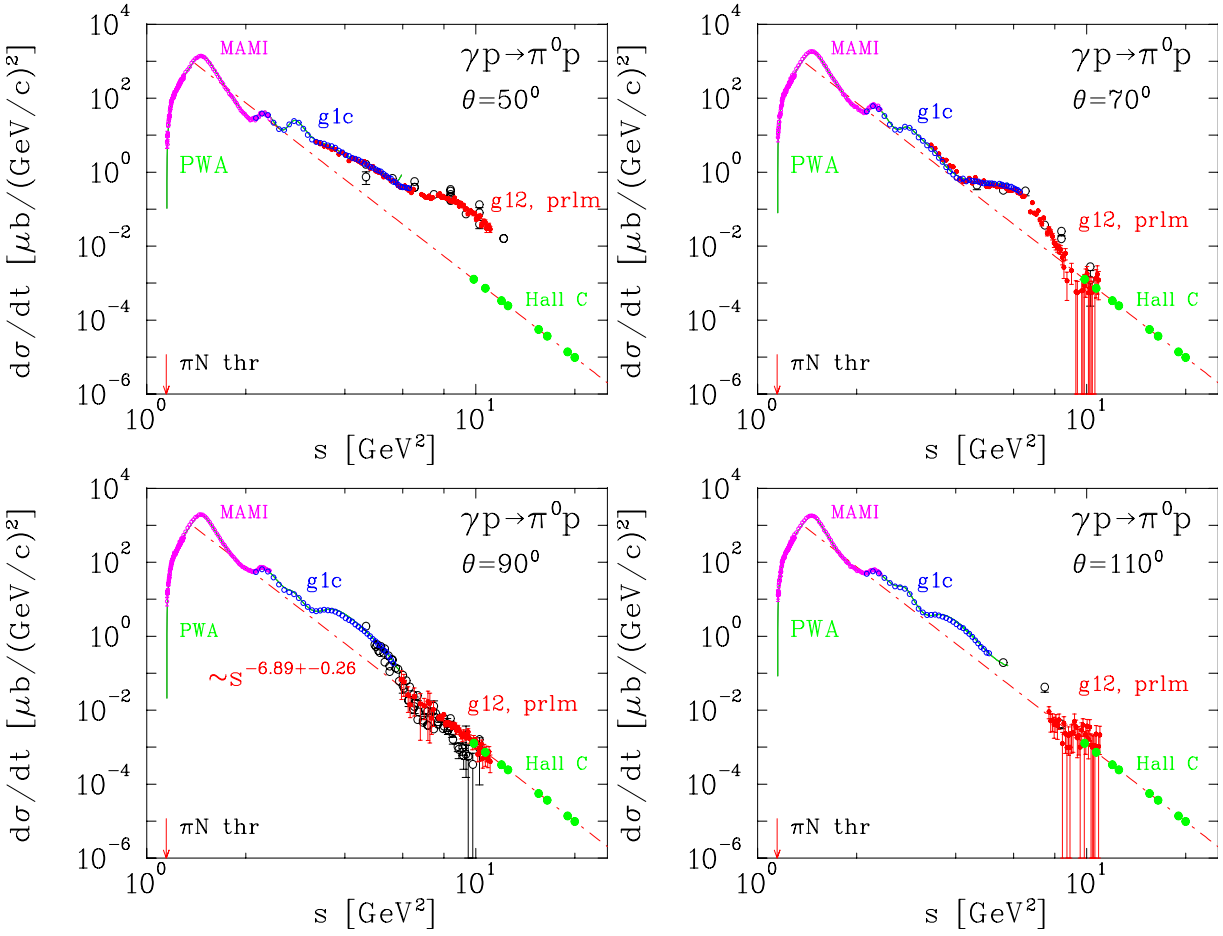


$$\frac{d\sigma}{dt} \simeq \frac{2\pi\alpha^2}{(s-m^2)^2}\left(\frac{1}{1-t/s}+1-t/s\right)|\mathcal{R}|^2 = \frac{d\sigma^{KN}}{dt}|\mathcal{R}|^2,$$



Wide Angle π^0 Photo-Production

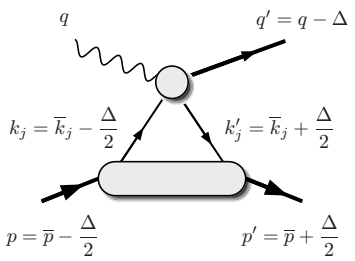
World Data with This Proposal

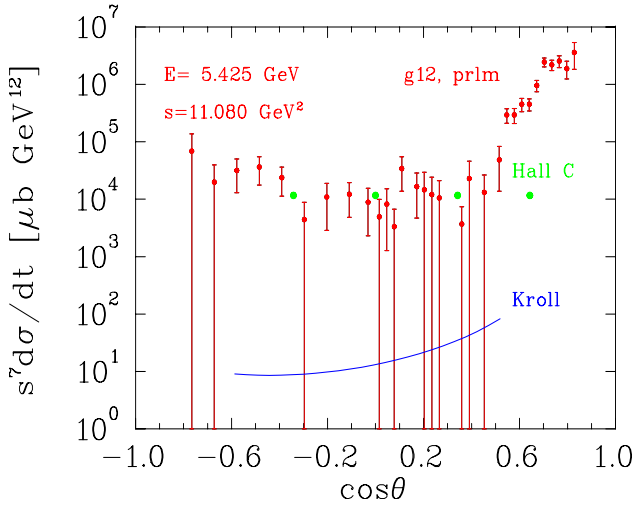


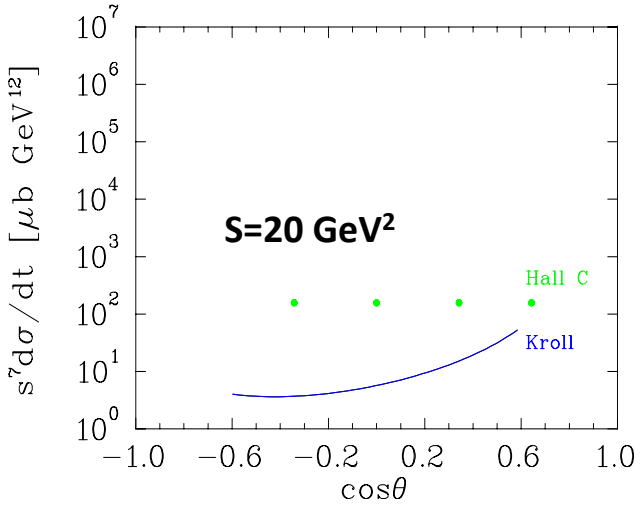
Handbag Model

Handbag Diagram for pi0 production
Model calculations by P.Kroll et al.

H.W. Huang, P. Kroll, Eur. Phys. J. C **17**, 423 (2000)
H.W. Huang, R. Jacob, P. Kroll, Eur. Phys. J. C **33**,91 (2004)
M. Diehl, P. Kroll, arXiv: 1302.4604 [hep-ph]







Model Predictions are off by orders of magnitude!

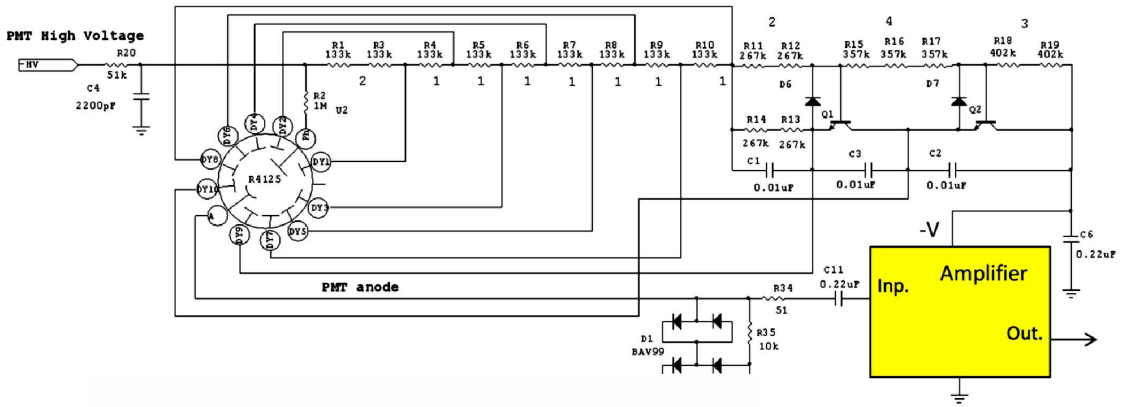
- Need Helicity Flip DA?

Hardware Upgrades

- New (or borrowed) Calorimeter
  - 1100 $PbWO_4$: 2x2x18 cm^3
    - No reliable supplier at present: PANDA (also Orsay, CUA, etc EIC R&D project) working with SICCAS (China) and Cythur (Czech Republic)
  - New stabilized bases
  - Radiation Damage/Curing Studies
    - Expected dose ~300KRad=3KGy
  - Gain Monitoring System: LED or Laser.
- Horizontal field sweep magnet
  - New universal design (with modular yoke pieces)
  - 0.3 T-m for DVCS (small angles)
  - 0.6 T-m for WACS (wide angles)

New Active PMT Base

- V. Popov, H. Mkrtchyan, IEEE Proceedings 2012



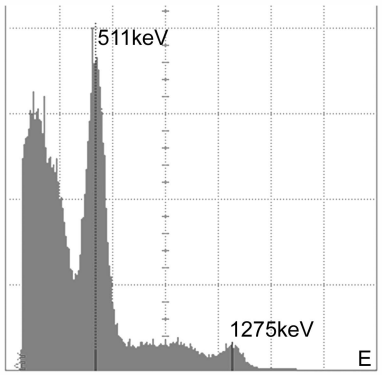


Fig. 4. Pulse Height Distribution histogram, energy spectrum of ^{22}Na gamma source, obtained with new active base and PMT with Pr:LuAG scintillator.

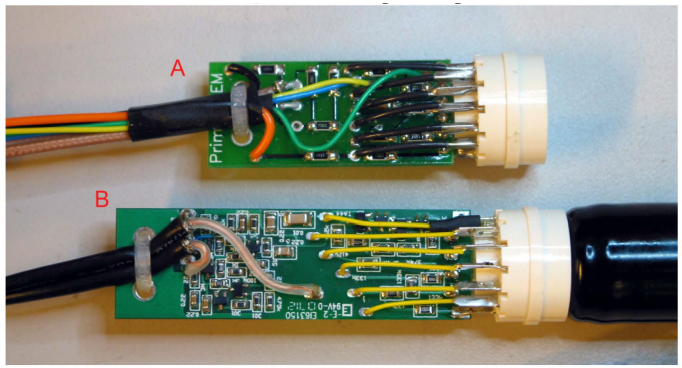


Fig. 2. Photography of PrimEx-resistive PMT base (A), and new active base (B).

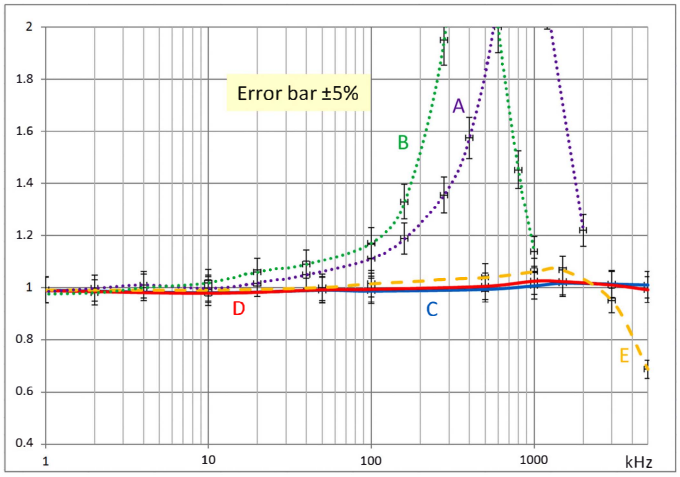
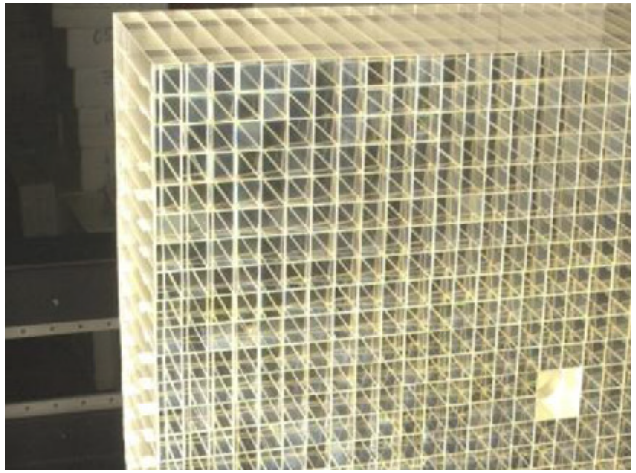


Fig. 6. PMT+base assembly normalized output amplitude as function of rate with LED light source adjusted to simulate light pulse of $PbWO_4$ scintillator. A and B-passive divider; initial amplitude 600mV for A and 300mV for B; C, D and E-active base: initial amplitude 600mV for C, 300mV for D and 1000mV for E.

$PbWO_4$

- PrimEx Calo possibly available
  - Also in demand for Hall D
  - Is Hall C NPS rad dose acceptable? ~300 KRad
- Curing
  - Blue light*, in situ,* invasive
  - Heating, invasive
  - IR illumination: possible in real time

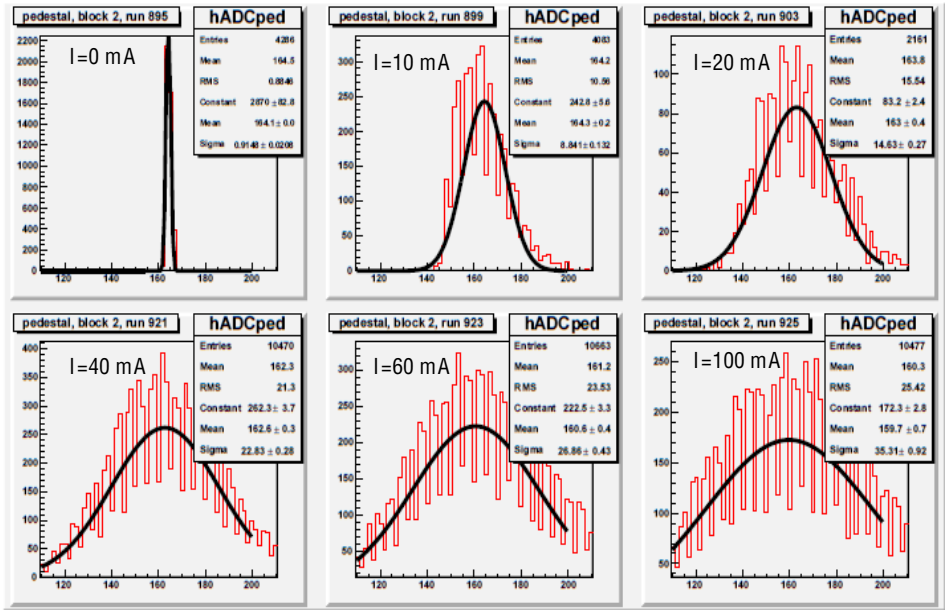


NPS prototype: PMT sensitivity to IR light

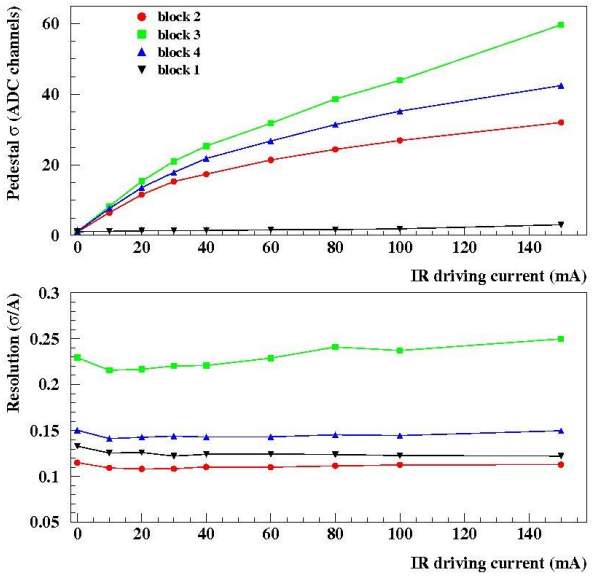
A.Mkrtchyan, CUA

https://wiki.jlab.org/cuawiki/index.php/General_Meeting_Agenda_11/19/14

- To quantify the effect of IR light, the prototype PMTs pedestal, and signal (generated by cosmic particle and GMS) amplitude sensitivity to the IR light intensity were studied



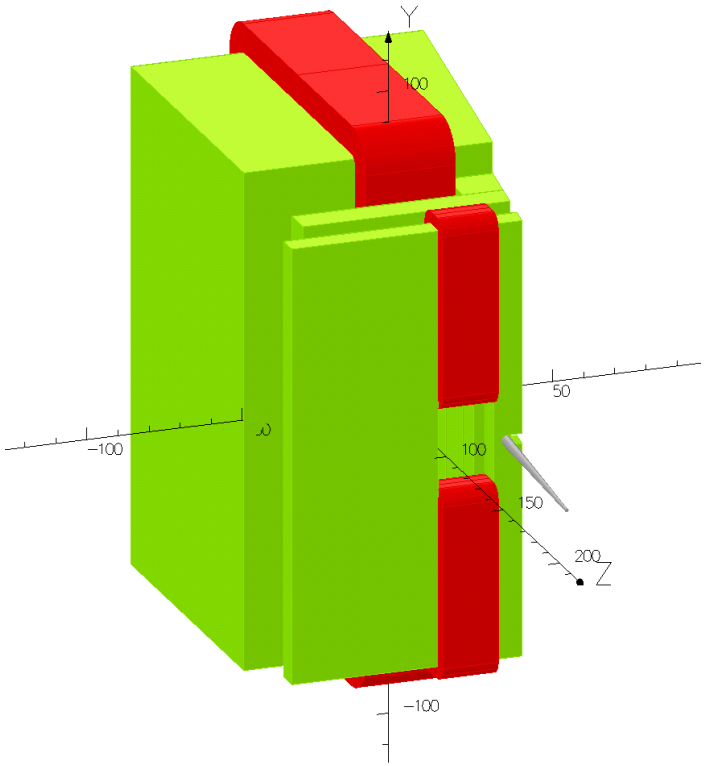
Crystals with 4 IR LEDs

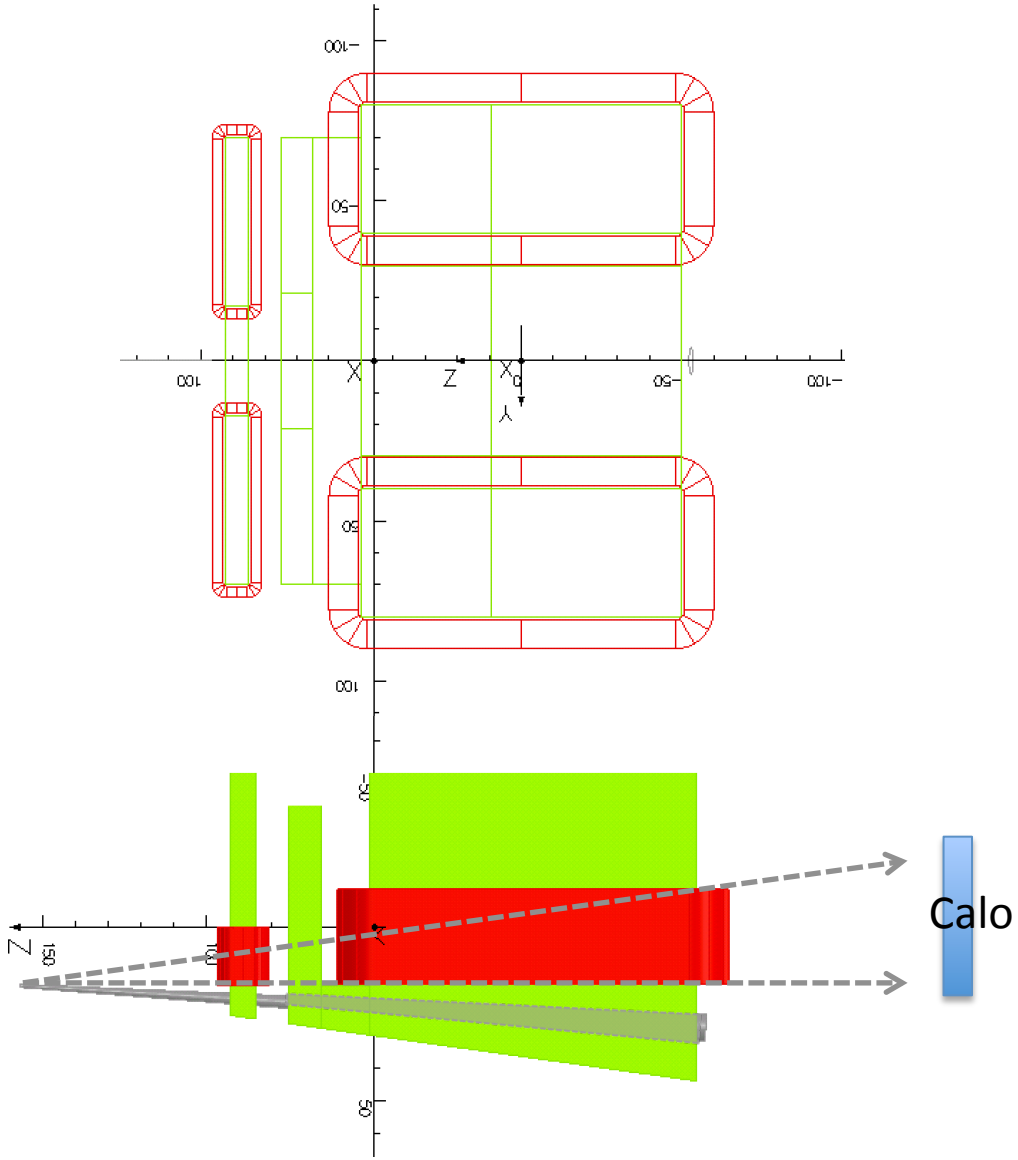


- The observed increase in signal pedestal widths suggest that the PMTs (R4125) are sensitive to IR light
- No changes in the PMTs amplitude or resolution due to IR light were observed
- There is a sharp increase in PMTs noise when the IR system runs at a driving current ~150 mA (or about 50 mA for each IR diode). The level of noise-signals at PMT high voltage of 1400 V are ~8-10 mV. The noise disappears when the IR system current is turned off

Further tests will help to fully understand how the observations of PMT sensitivity to IR light may impact its long-term stability and live-time

Horizontal field dipole, model SAM-DVCS





Iron weight is of 15 tons
Coils weight is of 1.5 tons

Conclusions, Outlook

- NSF-MRI proposal to be submitted Jan 20.
  - Sweep Magnet
  - Active Bases
  - Gain Monitoring System
  - Curing system
- Exciting physics program
  - Powerful, flexible detector system.
- Meetings every ~3rd Thursday am
  - Join us!