Hashir Rashad
<O|D|U>
On behalf of DVCS Collaboration

Hall A/C Collaboration Meeting, JLab, 6/22/2017

E12-06-114

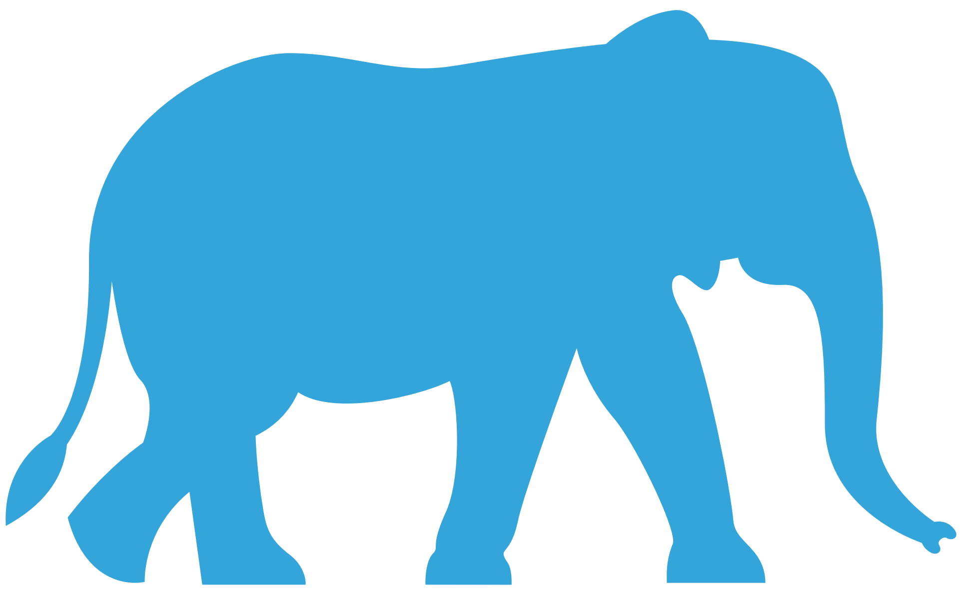
DEEPLY VIRTUAL COMPTON SCATTERING (DVCS)

OUTLINE

- INTRODUCTION AND BACKGROUND
  - OVERVIEW OF DVCS3
- RECAPS FROM JANUARY 2016 MEETING
- UPDATES FROM SPRING AND FALL 2016
- STATUS SUMMARY AND OUTLOOK

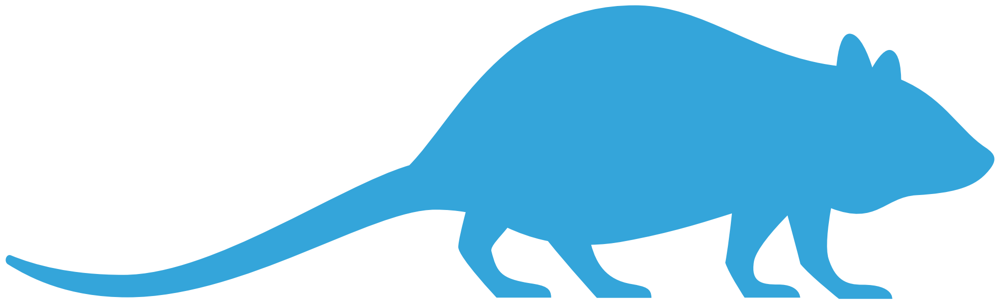
WHY DVCS?

ELASTIC SCATTERING



Elastic Form Factors : Spacial Distribution, no underlying dynamics data

DIS



Parton Distribution Functions : Momentum distributions, No Spacial Distribution

GENERALIZED PARTON DISTRIBUTIONS

Relates spacial and momentum distributions. DVCS is the cleanest process to access GPD’s

GPD: QUARK AND GLUON MATRIX ELEMENTS IN THE PROTON

$$\int \frac{d\lambda}{2\pi} e^{i\lambda x} \langle P' | \bar{\psi}(-\lambda n/2) \gamma^\mu \psi(\lambda n/2) | P \rangle = H(x,\xi,\Delta^2) \bar{U}(P') \gamma^\mu U(P) + E(x,\xi\Delta^2) \bar{U}(P') \frac{i\sigma^{\mu\nu}\Delta_\nu}{2M} U(P) + \ldots,$$

$$\int \frac{d\lambda}{2\pi} e^{i\lambda x} \langle P' | \bar{\psi}(-\lambda n/2) \gamma^\mu \gamma_5 \psi(\lambda n/2) | P \rangle = \tilde{H}(x,\xi,\Delta^2) \bar{U}(P') \gamma^\mu \gamma_5 U(P) + \tilde{E}(x,\xi,\Delta^2) \bar{U}(P') \frac{\gamma_5 \Delta^\mu}{2M} U(P) + \ldots,$$

$$\int_{-1}^{1} dx H(x,\xi,\Delta^2) = F_1(\Delta^2),$$

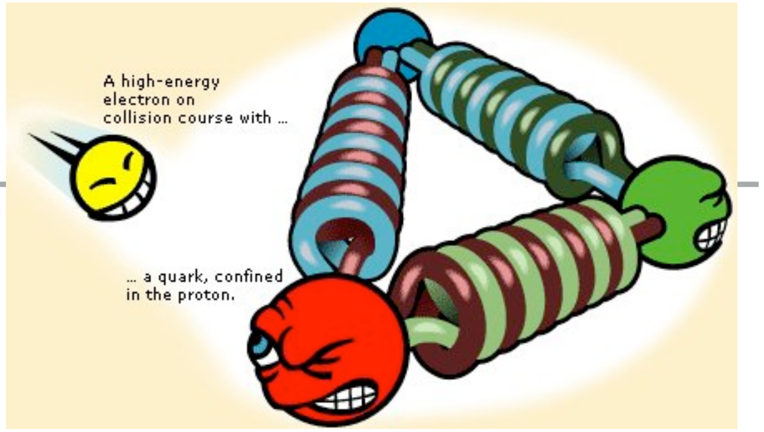
$$\int_{-1}^{1} dx E(x,\xi,\Delta^2) = F_2(\Delta^2),$$

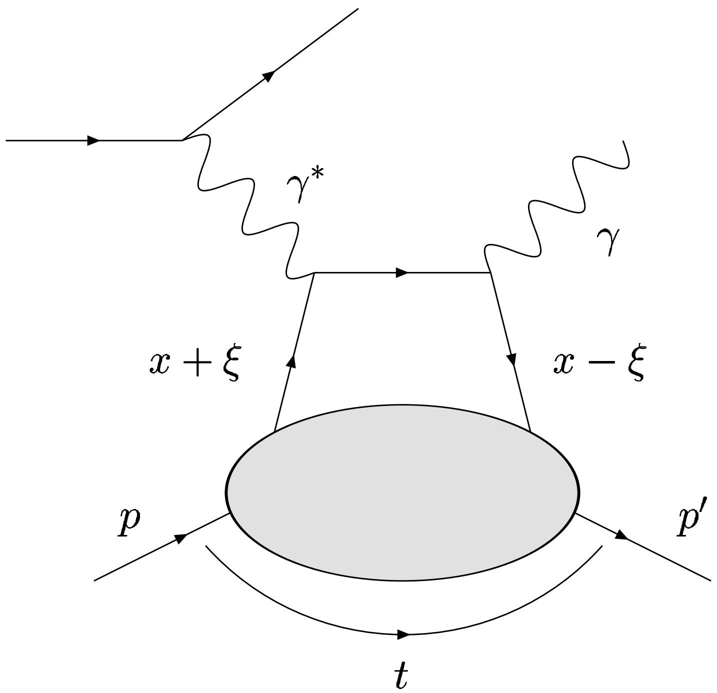
$$\int_{-1}^{1} dx \tilde{H}(x,\xi,\Delta^2) = G_A(\Delta^2),$$

$$\int_{-1}^{1} dx \tilde{E}(x,\xi,\Delta^2) = G_P(\Delta^2).$$

- $x \pm \xi$: Longitudinal momentum of quark in proton
- $\Delta^\perp$: Net Transverse momentum transfer to proton, Fourier conjugate to transverse spatial position of quark in proton.
- These Objects relate the Spatial and Momentum Distributions and can be probed through Deeply Virtual Compton Scattering (DVCS).

DEEPLY VIRTUAL COMPTON SCATTERING





$$\xi \sim \frac{\chi_b}{2 - \chi_b}$$

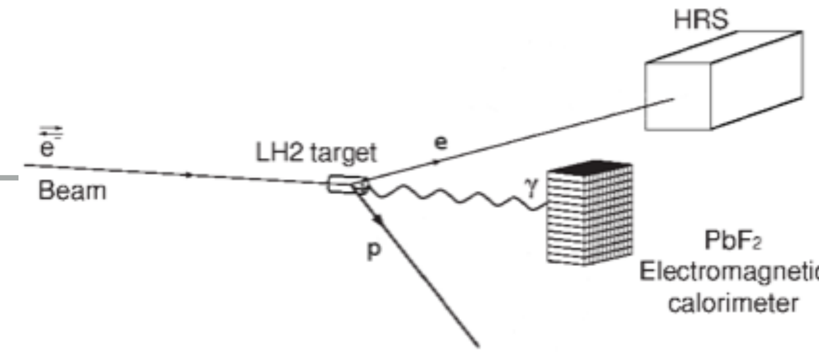
$$\chi_b = -\frac{Q^2}{2P.Q} = \frac{Q^2}{2M\nu}$$

$$Q^2 = -q^2 = (k-k')^2 = 2kk'(1-\cos(\theta e))$$

$$\nu = (k-k')$$

$$t = (P' - P)^2$$

- Underling process is, a virtual photon, scattering off of a quark which produces a real photon.
- Q^2, resolution of probe
- χ_b, selects momentum of struck quark



$$\mathrm{H}(e, e'\gamma)X$$

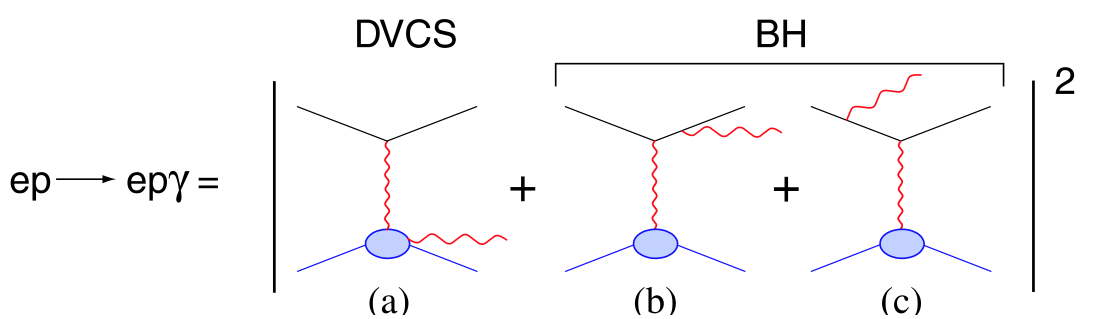
Exclusive DVCS

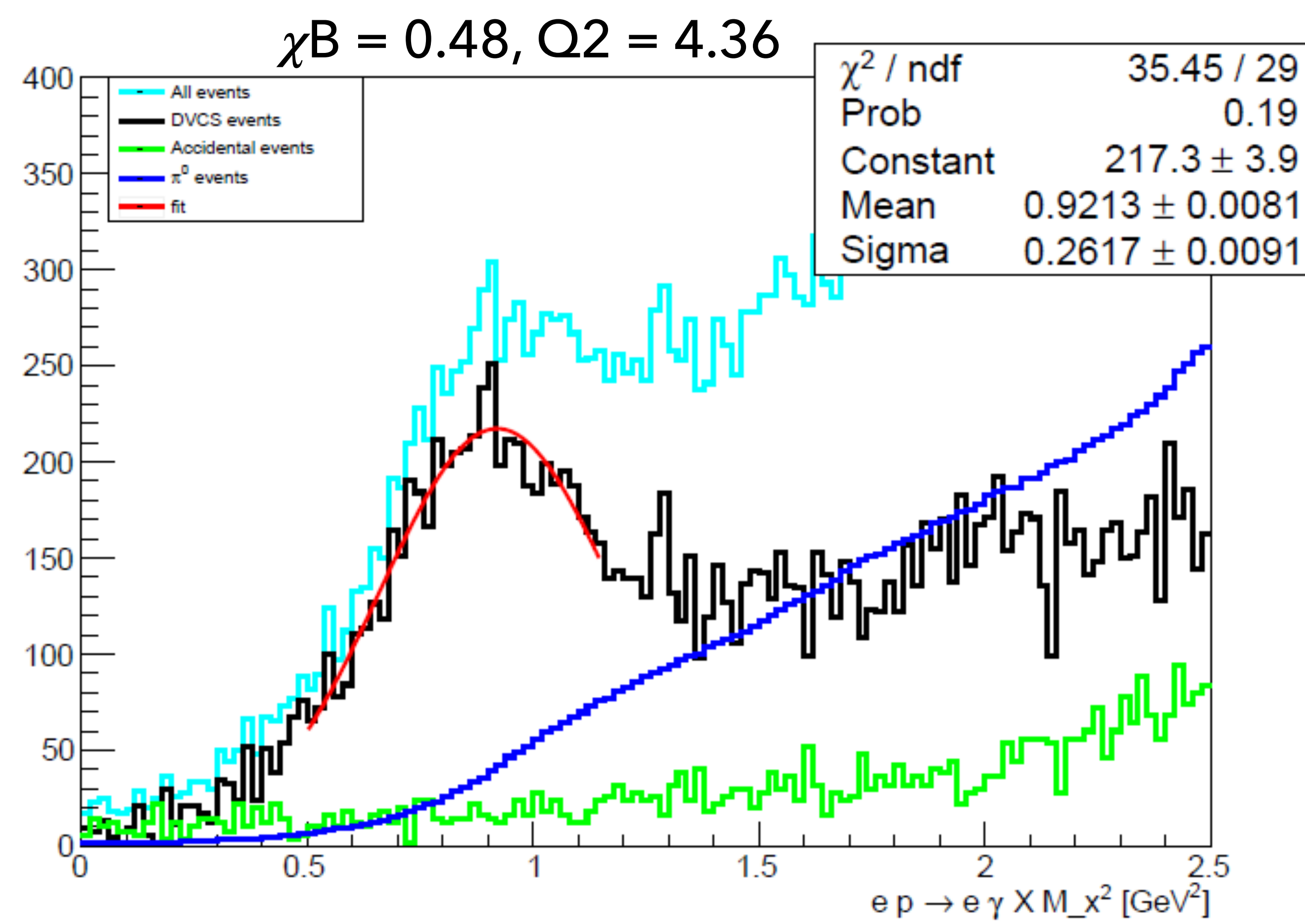
$$ep \longrightarrow ep\gamma$$

$$M_X^2 \leq (M + m_\pi)^2$$

Associated DVCS

$$e + p \longrightarrow e + \gamma + N\pi$$

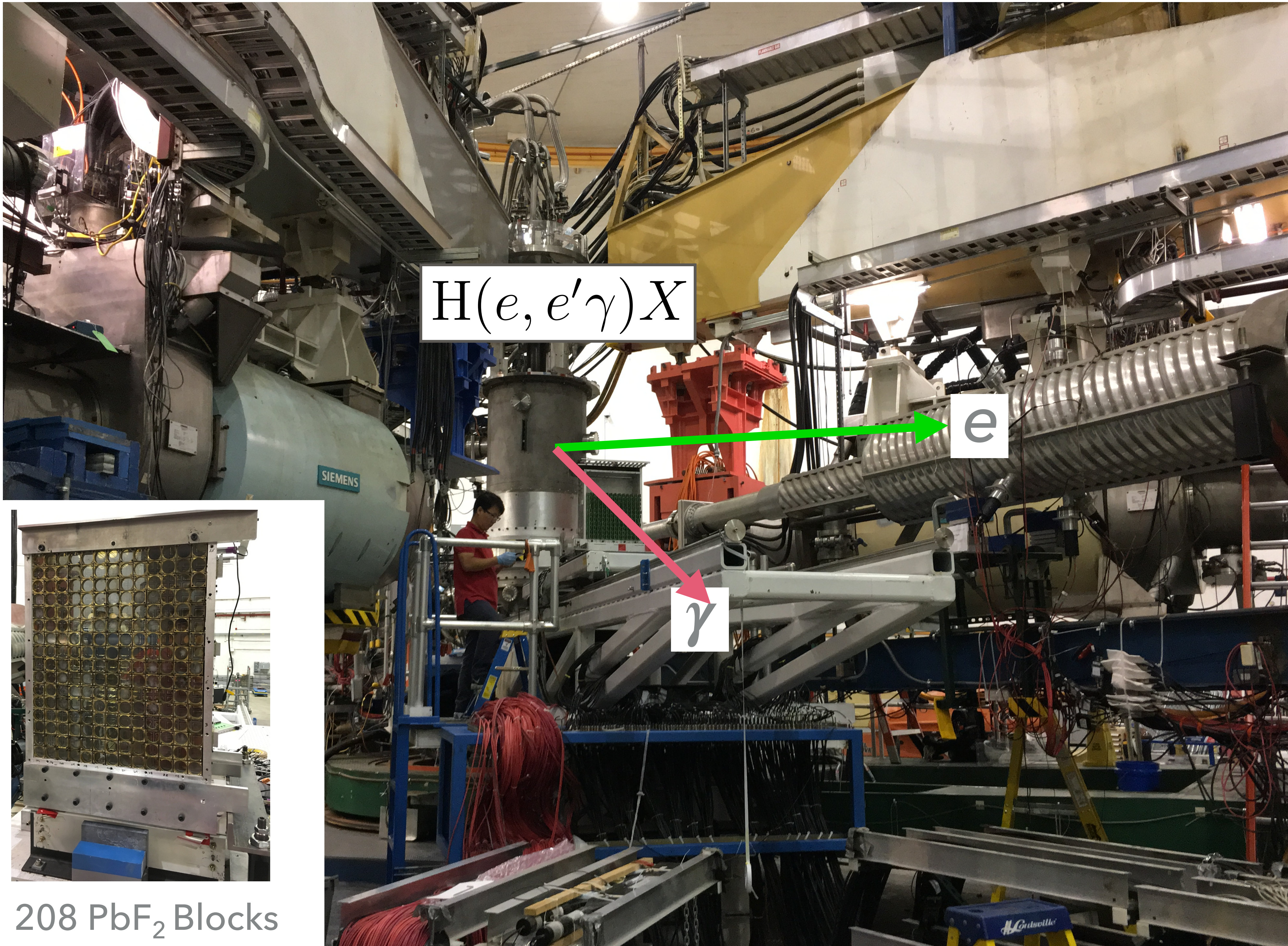




$$\frac{d\sigma}{dx_{\mathrm{B}}dyd|\Delta^2|d\phi d\varphi} = \frac{\alpha^3 x_{\mathrm{B}} y}{16\,\pi^2\,Q^2\sqrt{1+\epsilon^2}} \left|\frac{\mathcal{T}}{e^3}\right|^2$$

$$\mathcal{T}^2 = |\mathcal{T}_{\mathrm{BH}}|^2 + |\mathcal{T}_{\mathrm{DVCS}}|^2 + \mathcal{I}$$

HIGH RESOLUTION SPECTROMETER

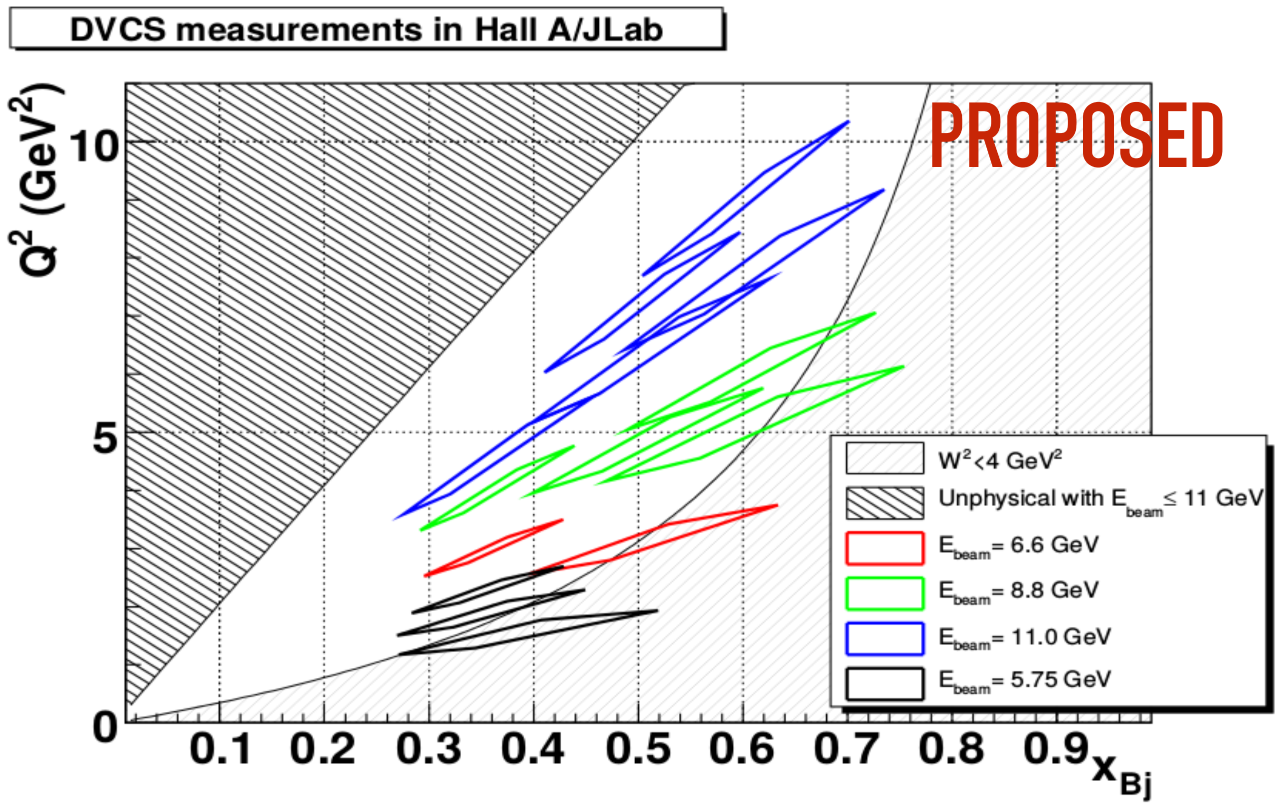


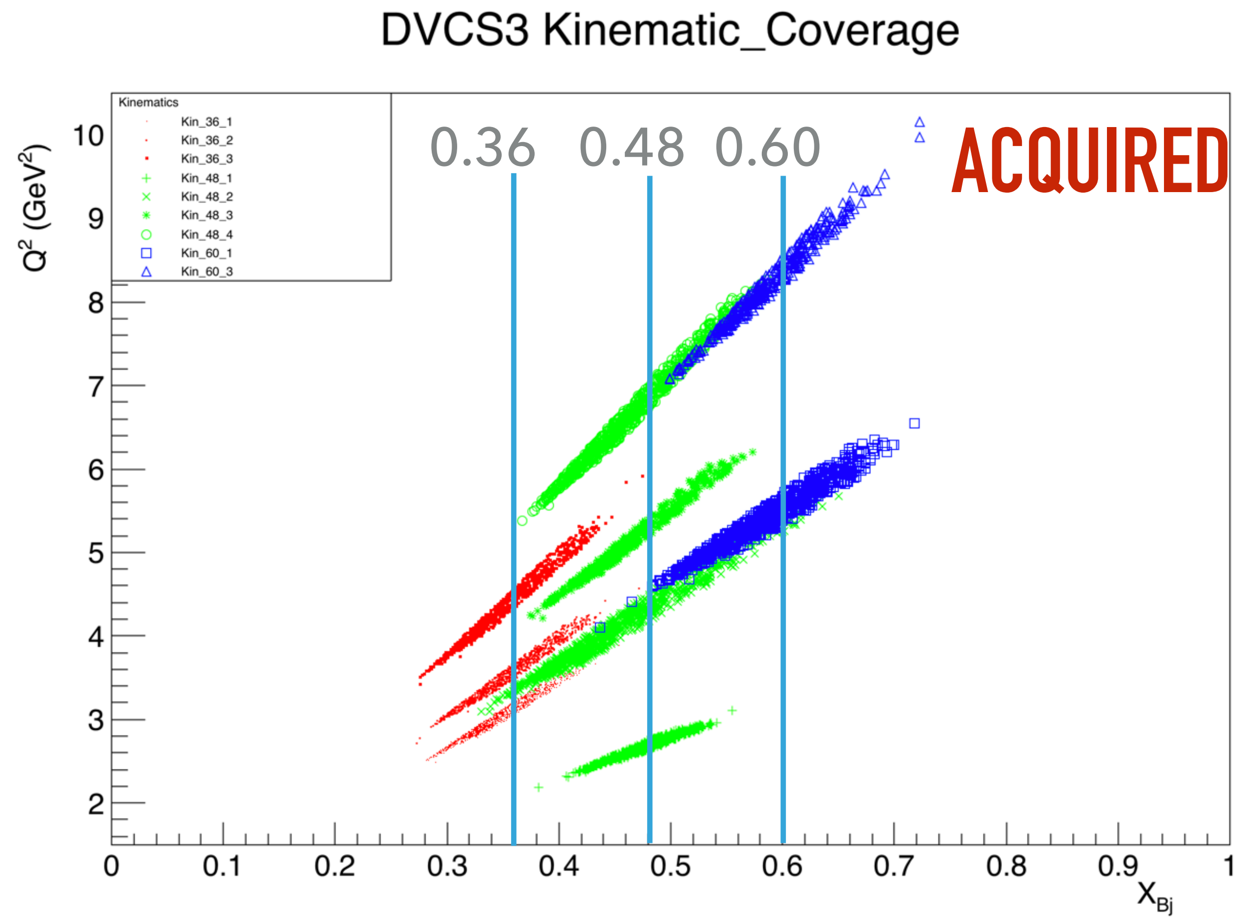
- 208 PbF_2 Blocks

DVCS AT HALL A

- 3 Generation of Experiments so far
- 2004 (Gen 1)
  - χ_b=0.36, Q^2 = 1.5, 1.9, 2.3 GeV^2
  - First measurement of DVCS Cross Section (5 Thesis and 4 peer reviewed papers)
- 2010 (Gen 2)
  - χ_b=0.36, Q^2 = 1.5, 1.75, 2.0 GeV^2
  - Electron Beam 5.5 and 4.5 GeV
  - 3 Thesis, 2 publication in PRL, 1 under review

DVCS3 – PUSHING TO HIGH Q^2 AT EACH χ





- 2014 Fall, 2015 Spring, 2016 Spring and Fall
- ~50% of allocated 100 PAC days
- Electron beams from 7 to 11 GeV
  - First data ever in this range
    - χ_B = 0.36, Q^2 = 3.2 – 4.5 GeV^2 (Fall 2014 and Fall 2016)
    - χ_B = 0.48, Q^2 =2.7 – 6.9 GeV^2 (Spring 2016)
    - χ_B = 0.60, Q^2 =5.5 – 8.4 GeV^2 (Fall 2016)

OVERVIEW OF DVCS3 RUNNING

E12-06-114:
Deeply Virtual Compton Scattering in Hall A

Hall A collaboration meeting
18 January 2017
Fall 2016 DVCS run: summary & outlook

Frédéric Georges
(Institut de Physique Nucléaire d'Orsay, France)

- Fall 2014
  - New EDTM system in LHRS
  - Beam dump certification
  - DVCS electronic commissioning
  - Moller polarimeter commissioning
  - DVCS calorimeter calibration
  - DVCS production : 1 kinematic point (3 PAC days)

- Spring 2015
  - New raster system
  - BPM & BCM calibration
  - Beam energy measurement
  - Compton polarimeter commissioning
  - Target Boiling studies
  - LHRS optics calibration (detuned Q1)
  - No production data taken

- Spring 2016
  - Beam polarization measurement (Moller &Compton)
  - Beam energy measurement
  - BPM & BCM calibration (up to 30 μA)
  - DVCS calorimeter calibration at 4.4GeV (x2)
  - LHRS optics calibration (Q1 : max current too low, detuned against {Q2, D, Q3} → need 4 calibrations)
  - DVCS production : 4 new kinematic points

- Fall 2016
  - Beam polarization measurement (Moller, x4)
  - Beam energy measurement (x6)
  - BPM (x1) & BCM (x3) calibration
  - Trigger efficiency measurement (x12)
  - DVCS calorimeter calibration at 6.4 GeV (x2)
  - DVCS production : 4 new kinematic points

Many thanks to the collaboration, the accelerator, the techs, RCs, and shift workers for making this run possible!

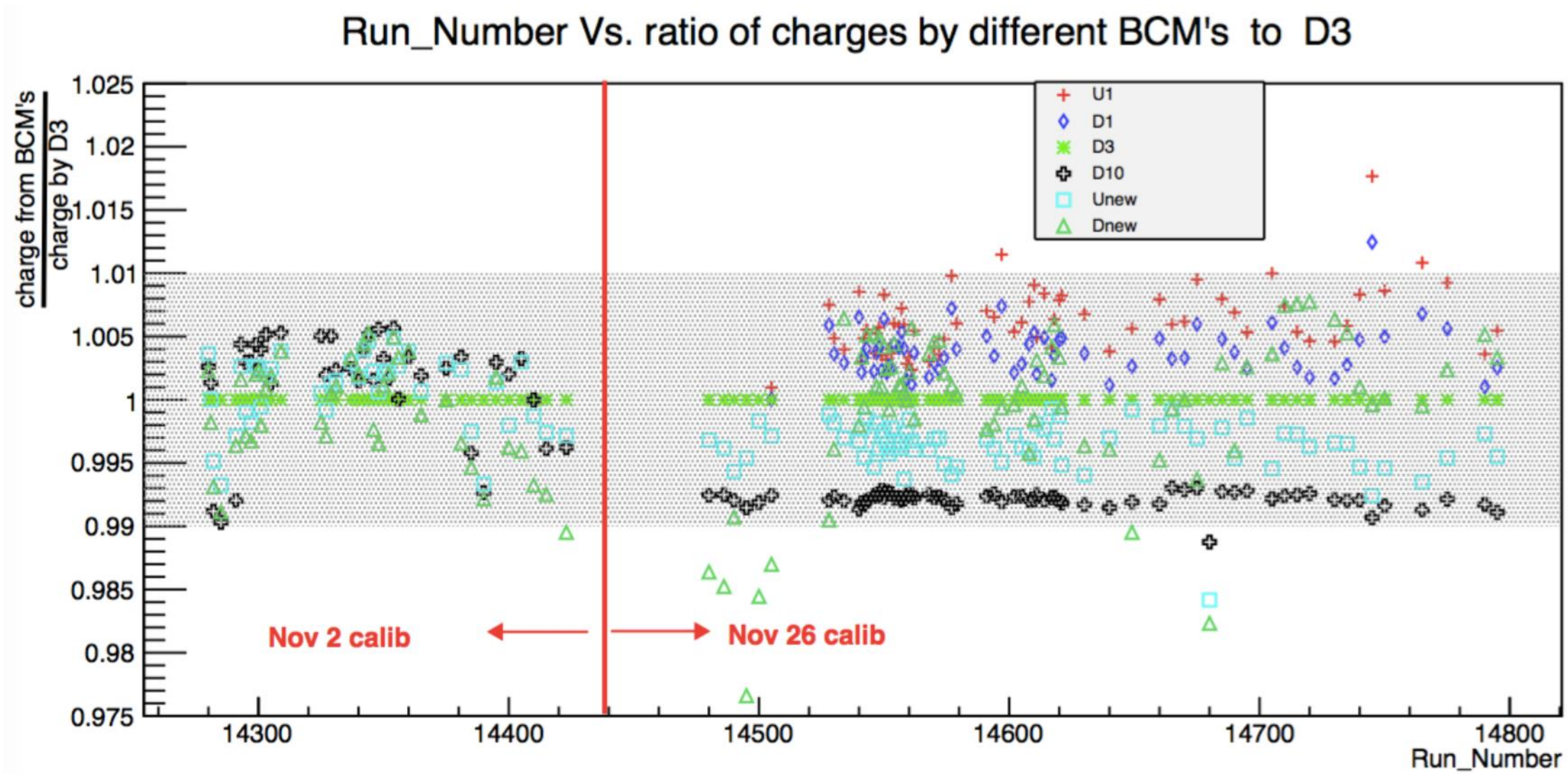
Special Thanks for all the people who made it possible to run through Thanksgiving!

SOME CHECK LISTS AND RECAPS FROM LAST UPDATE

- ☑ Quality Analysis
- ☑ Beam Studies
  - ☑ Beam Energy Measurement
  - ☑ Polarization Measurement
  - ☑ Raster Calibration
  - ☑ BCM/BPM Calibration
- ☑ Calorimeter
  - ☑ Elastic and π_0 Calibration
  - ☑ Coincidence Time Correction
  - ☑ Wave form Analysis
- ☑ High resolution spectrometer
  - ☑ Optics Calibration
  - ☑ Acceptance Studies
  - ☑ Trigger Efficiency
  - ☑ Tracking Efficiency
  - ☑ Particle Identification

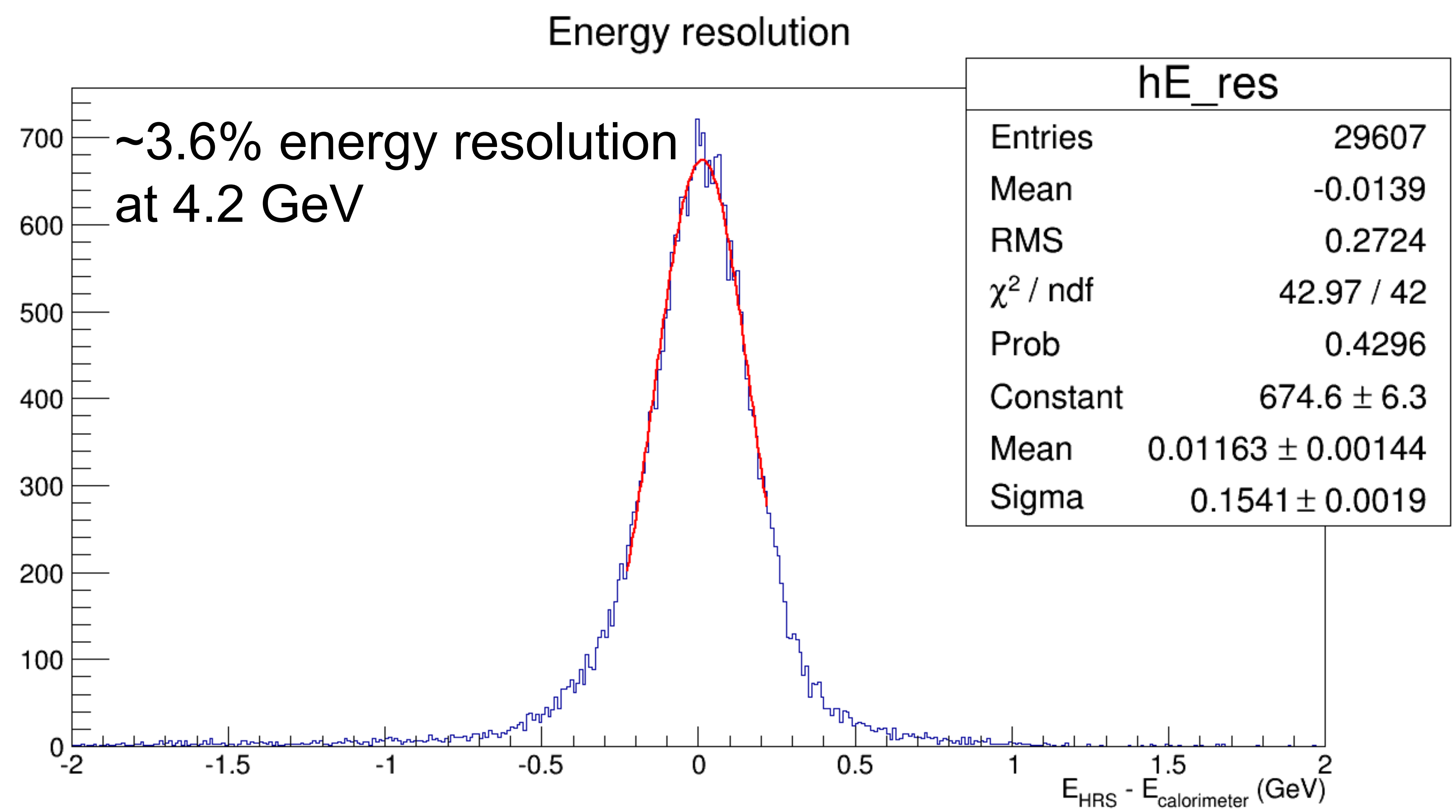
- Spring 2016 Q1 Maximum current was limited to 2.8 GeV setting. 3 out 4 kinematic points with detuned Q1 Settings.
- Q1 was replaced for Fall 2016.
- Fall 2014 has the old Q1 at Full field.

BCM CALIBRATION FALL 2016 : BISHNU KARKI



- 3 BCM Calibration against Unser in Fall 2016
  - October 15 (up to 80 μA at 1 pass), November 2 (up to 30 μA at 4 pass) and November 26 (up to40 μA at 5 pass).
- D3 and D10 agrees within 1%, Unew & Dnew are noisier
- Rely on D3 and D10 or the average of them.

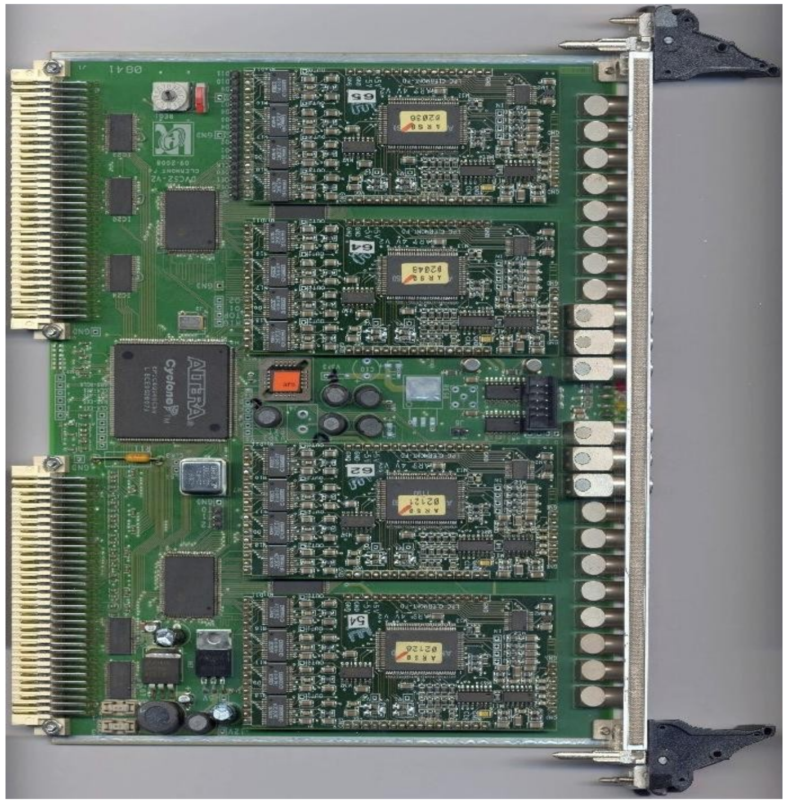
ELASTIC CALIBRATION : MONGI DLAMINI

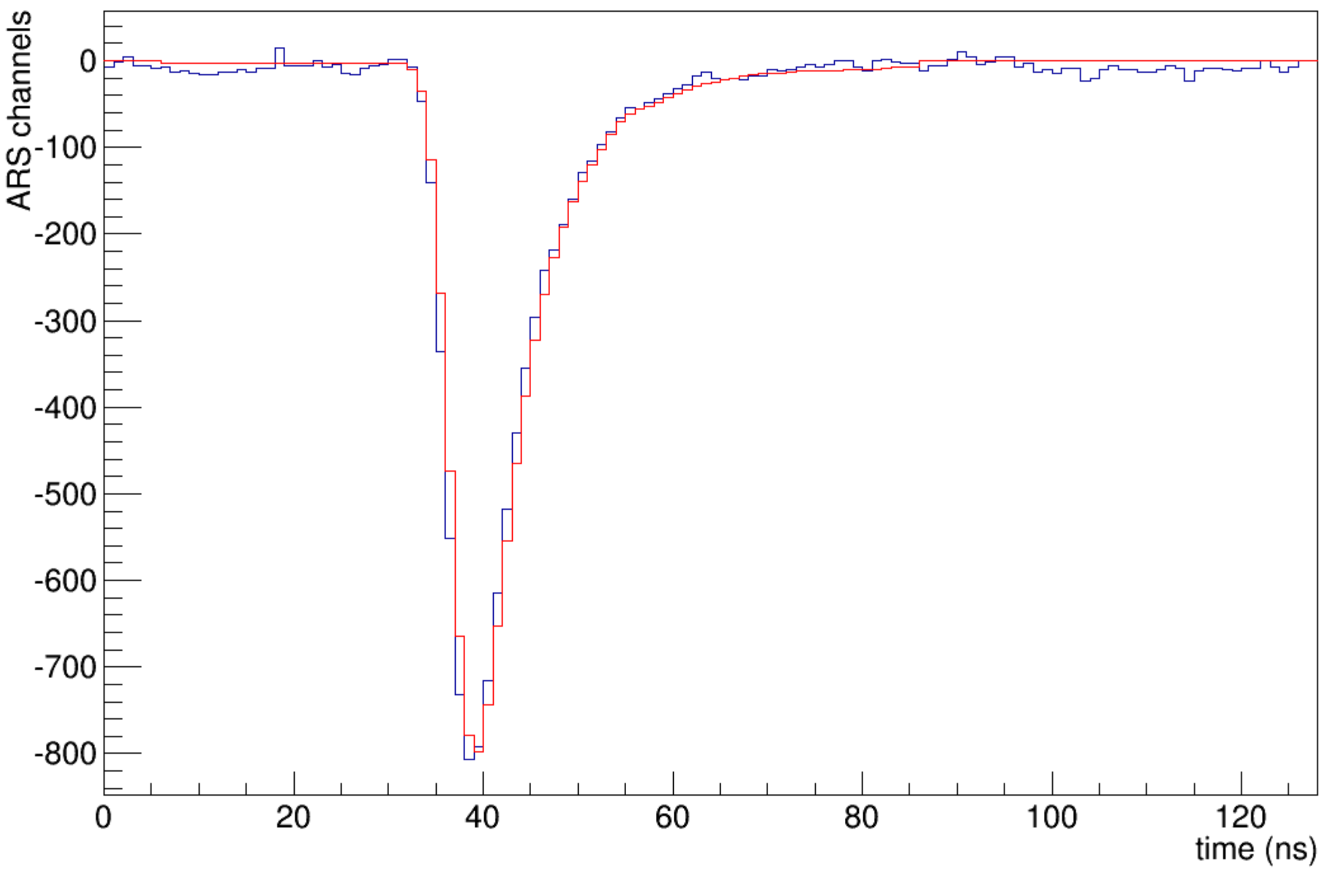


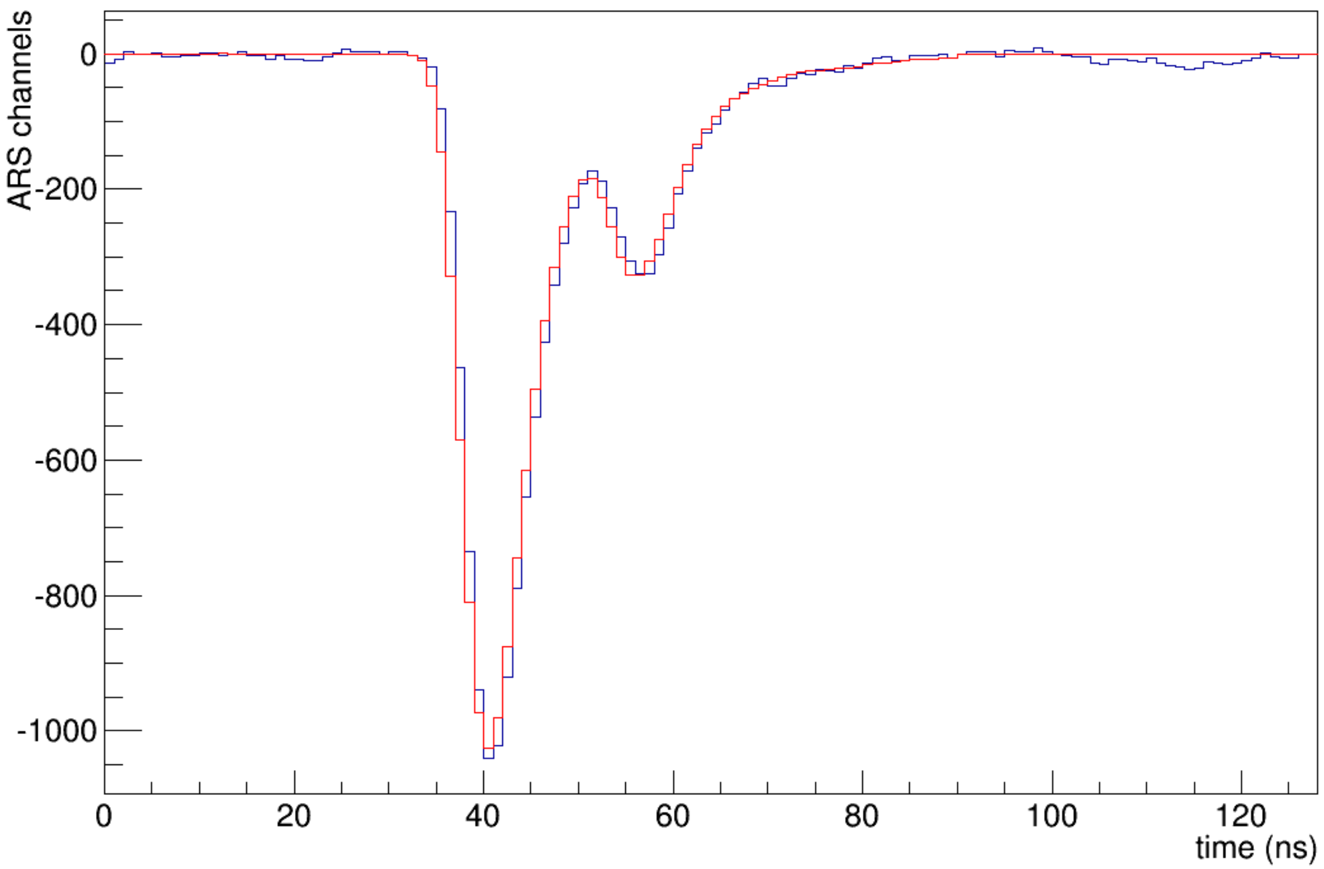
- Adjusting calorimeter block gains using Elastic Data
- Compute and reconstruct the expected electron energy in calorimeter using the Protons detected in LHRS.
- 1 in Fall 2014, 2 in Spring 2016 and 2 in Fall 2016.

WAVE FORM ANALYSIS : FREDERIC GEORGES

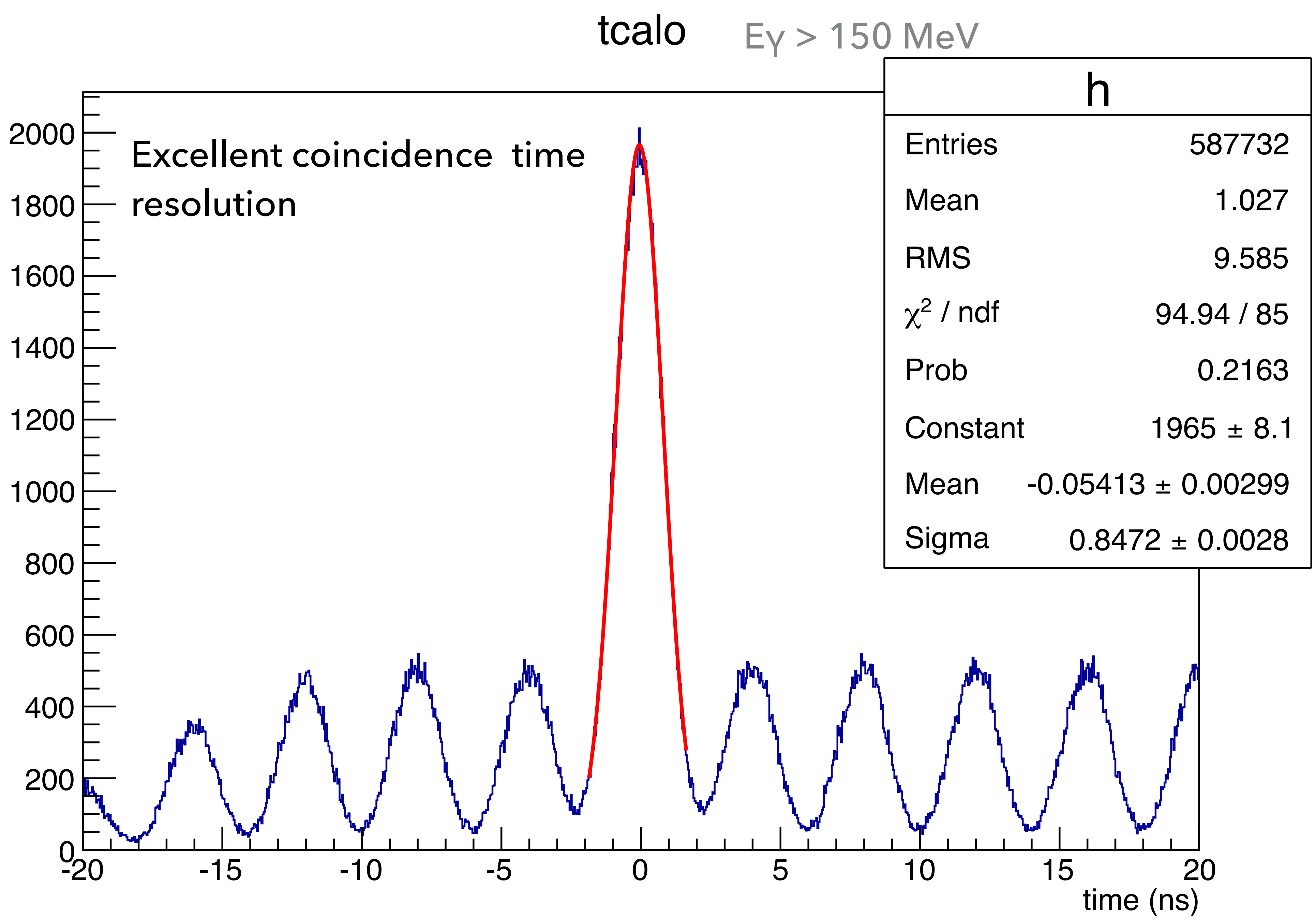
- ARS (Analog Ring Sampler) for calorimeter signals
- Allows us to deal with high pile-up due to the high luminosity and close proximity of calorimeter to the beam line.







COINCIDENCE TIME CORRECTION : MONGI DLAMINI

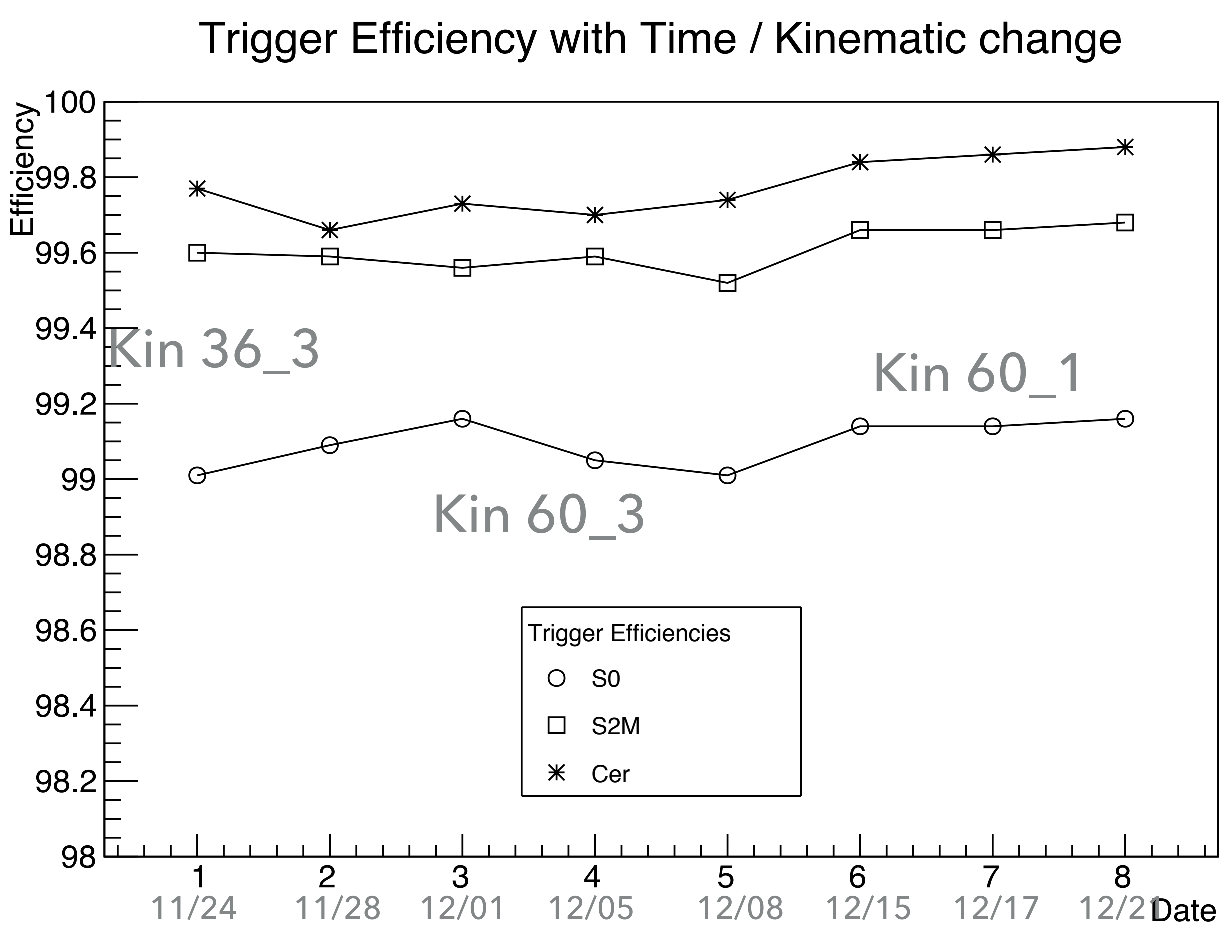


In DVCS production, Photon is detected at the calorimeter and Electron at LHRS. Determining good coincidence is important to eliminate accidentals.

- Arrival time as a function of each calorimeter block(208 blocks)
- Time as a function of each S2m scintillator paddle(16 of them)
- Distance(time) of light propagation from the hit point in a paddle to the timing phototube.
- Electron path length as determined by the relative momentum and vertical angle theta.
- ARS stop

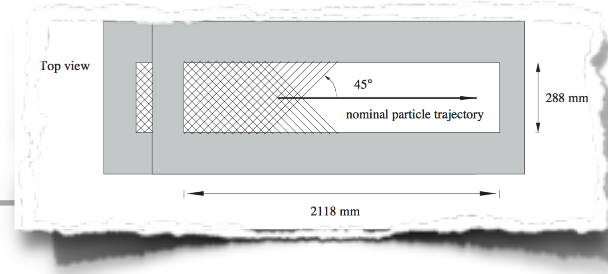
TRIGGER EFFICIENCY STUDIES : HASHIR RASHAD

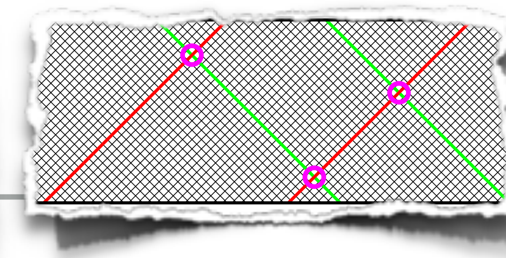
	11/24/16 (36_3, 15uA)	11/28/16 (60_3, 20uA)	12/01/16 (60_3, 20uA)	12/05/16 (60_3, 20uA)	12/08/16 (60_3, 20uA)	12/15/16 (60_1, 10uA)	12/17/16 (60_1, 10uA)	12/21/16 (60_1, 10uA)
S0	99.0	99.1	99.2	99.1	99.0	99.1	99.1	99.2
S2M	99.6	99.6	99.6	99.6	99.5	99.7	99.7	99.7
Cer	99.8	99.7	99.7	99.7	99.7	99.8	99.9	99.9



- DVCS Production data is triggered by the coincidence between S2M && Cherenkov with DVCS Calorimeter
- Complete for Fall 2016
  - S0, S2M and Cherenkov all have > 99% efficiency
- Machinery ready for Spring 2016 and Fall 2014*

TRACKING EFFICIENCY

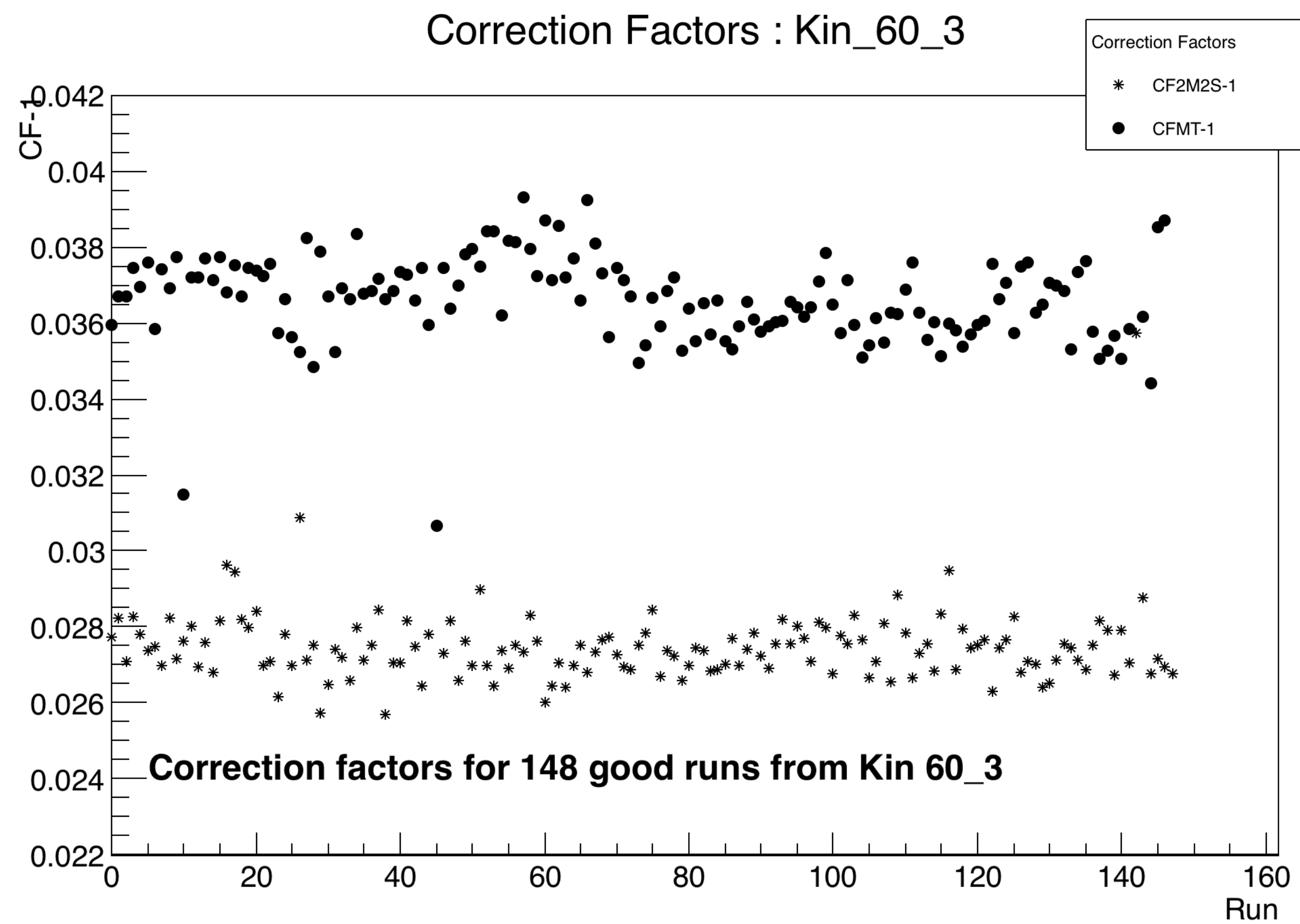




- Analyzer 1.5 has known issues with reconstructing tracks for events with more than one cluster in any given VDC wire plane.
- We keep events with at most 1 wire plane with multiple clusters. (0M4S + 1M3S)
- We exclude events with more than 1 reconstructed track (~5-10%)
- We also exclude events with 2 clusters in both wire plane of 1 VDC chamber and only 1 cluster each in both wire planes of the other chamber (2M2S)
- We correct for the excluded events with high energy signal in pion rejector

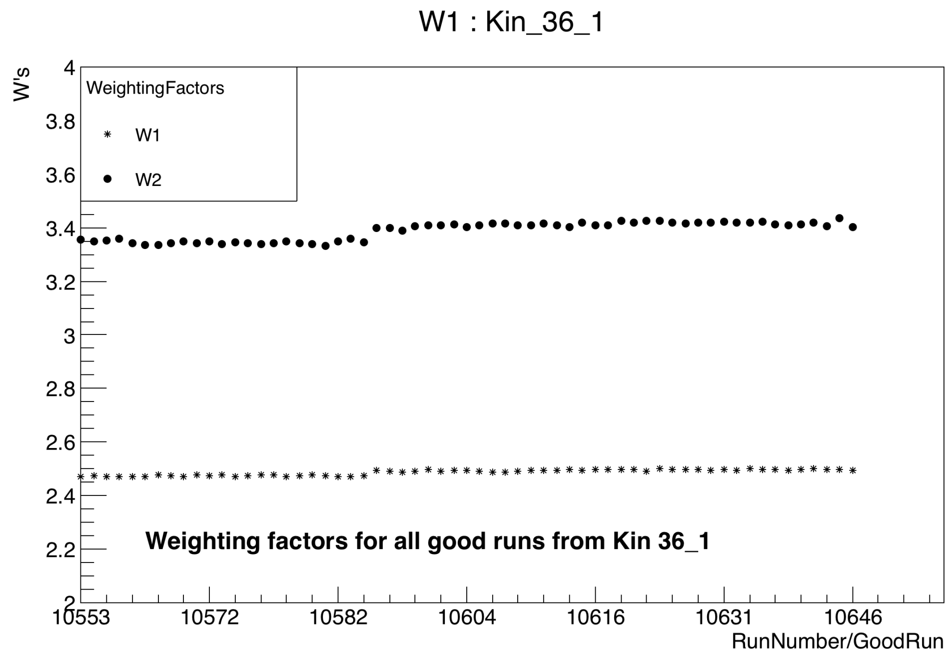
$$\eta_{MultiCluster} = 1 + \frac{N_{2M2S\ Electrons}}{N_{(0M4S+1M3S)\ Electrons}}$$

$$\eta_{MultiTrack} = 1 + \frac{N_{MultiTrack\ Electrons}}{N_{(0M4S+1M3S)\ Electrons}}$$



Multi Cluster and Multi Track correction factors are mutually exclusive and the sum of both will be the final correction factor

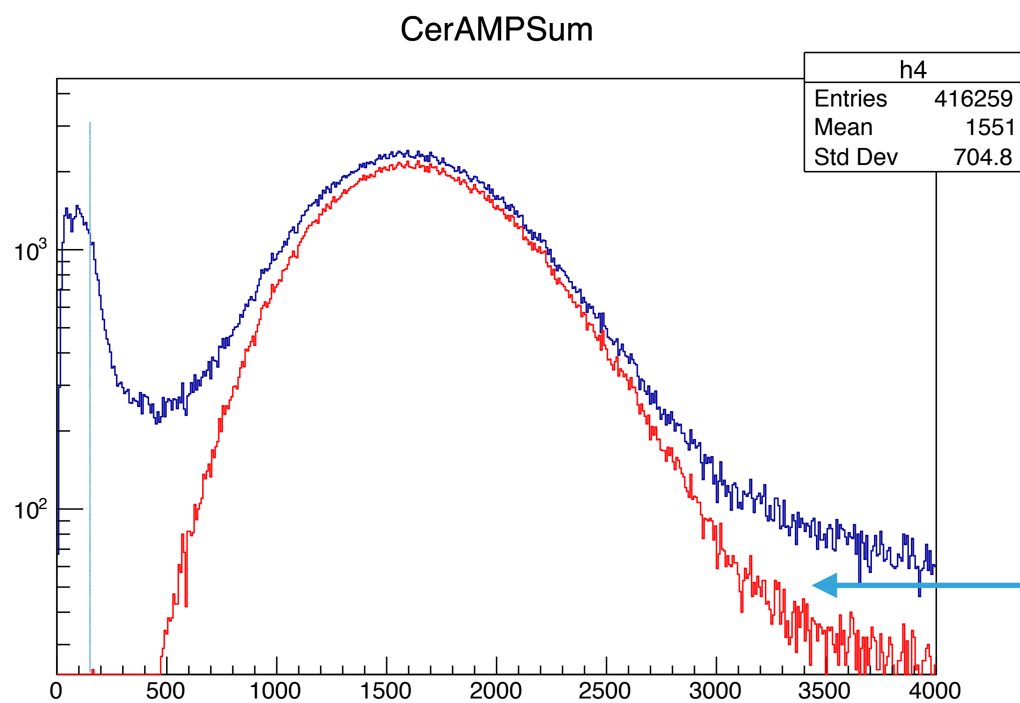
ELECTRON IDENTIFICATION

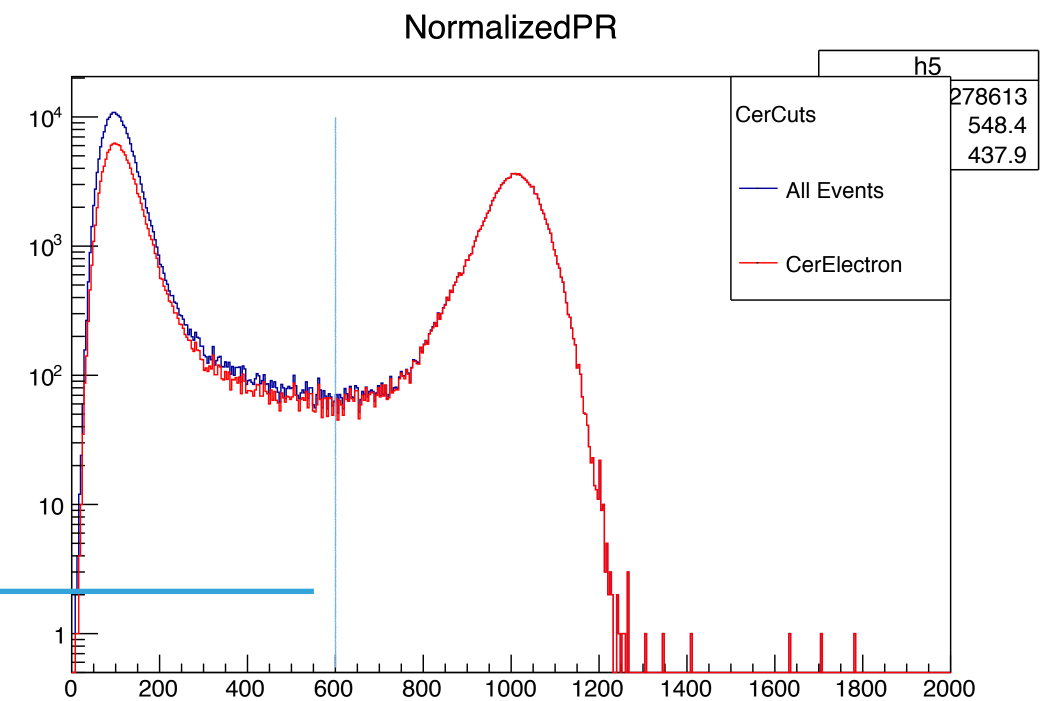


$$PRElectron = \frac{PRL1}{W1} + \frac{PRL2}{W2} > 600 \ \&\& \ \frac{PRL1}{W1} > 200$$

$$CerElectron = CerAmpSum > 150$$

- W1 and W2 are two renormalization factors

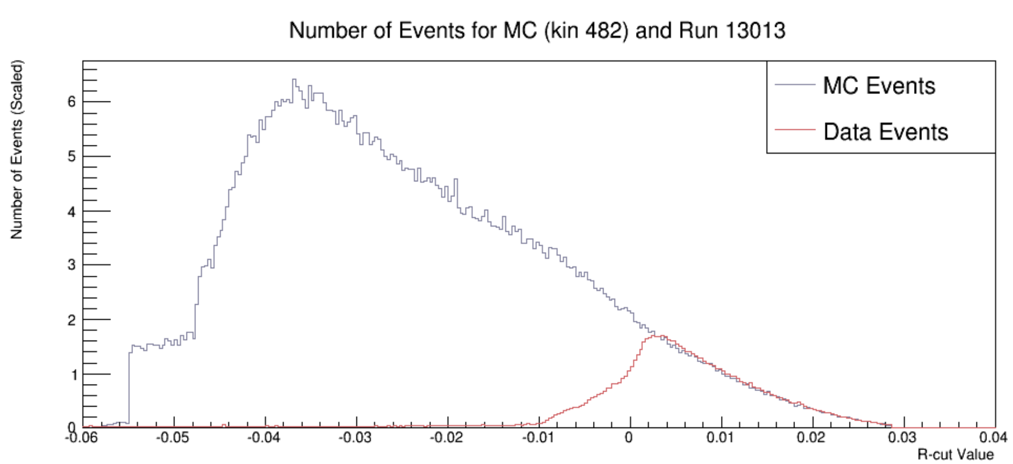


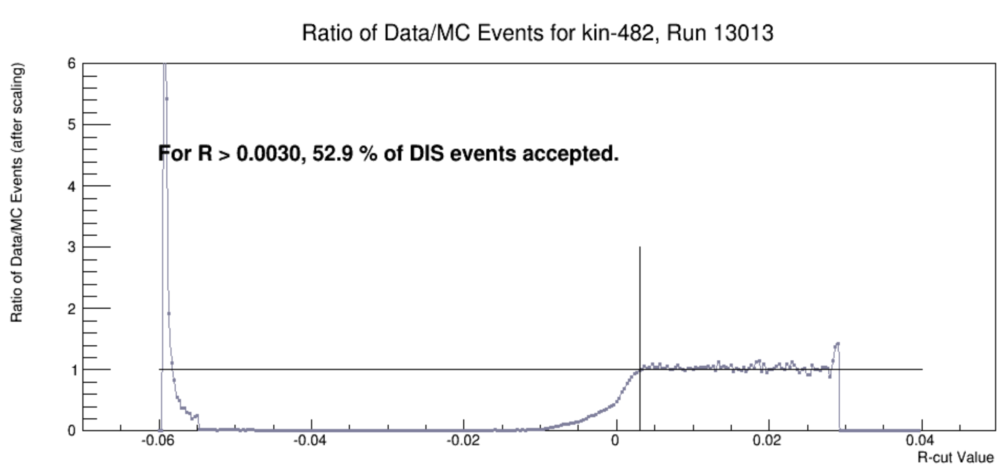


- Cherenkov spectrum with PRElectron cut (left - Red) hints that PRElectron cut eliminates the electron shower from downstream, Resulting in the separation of Good but corrupted events from bad events, in the case of Multiple clusters in VDC wire planes. Run #10555

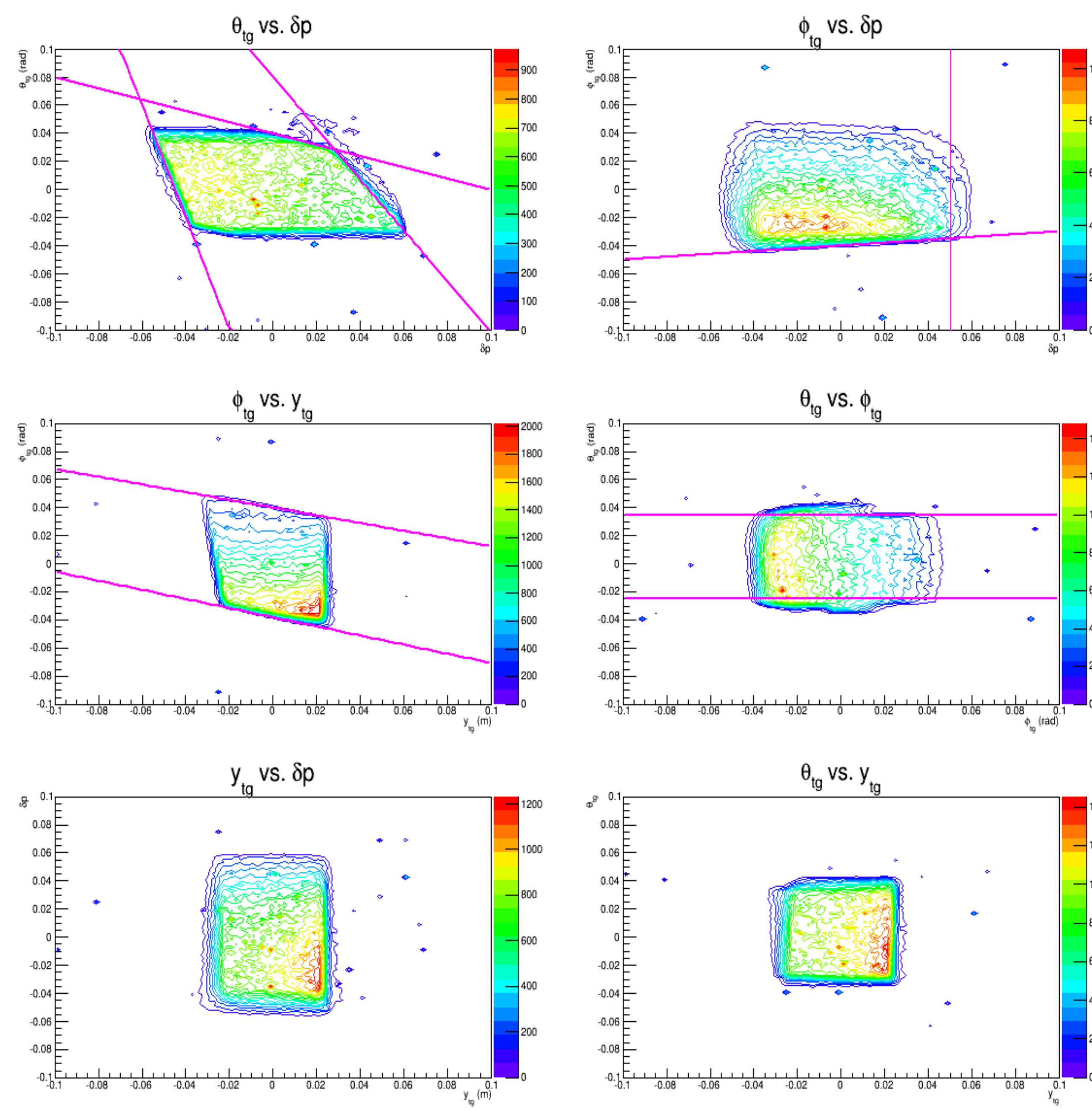
ACCEPTANCE - R-FUNCTIONS : ALEXA JOHNSON AND GULAKSHAN HAMAD

- Up to13 R-Functions in 4 different planes together with R-Cut values determines the acceptance region.
- 5 new sets of R-Functions. Machinery ready for all kinematics*





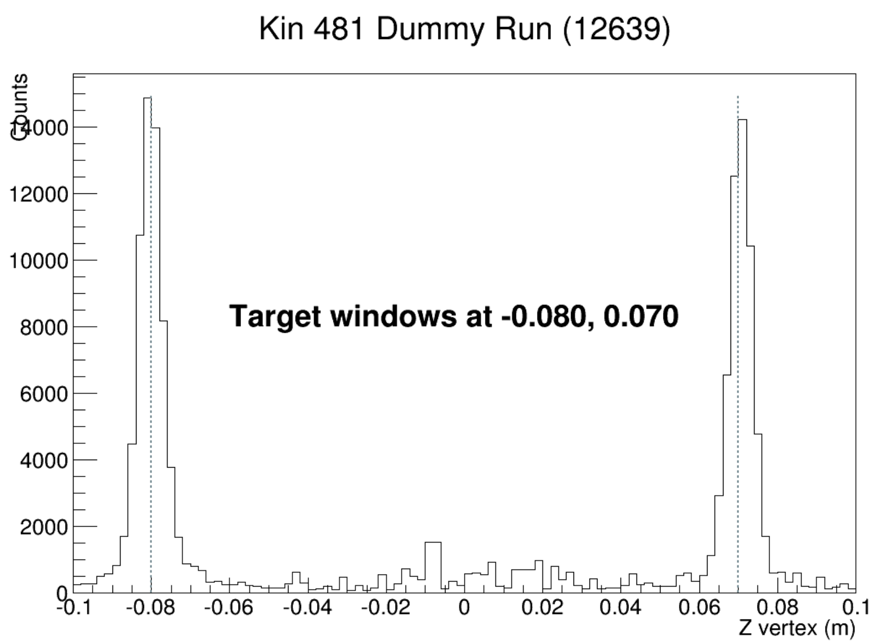
Setting	R-Cut
48_1	0.005
48_2	0.003
48_3	0.003
48_4	0.004
36_2	0.0035
36_3	0.0035
60_1	0.0035
60_3	0.0035

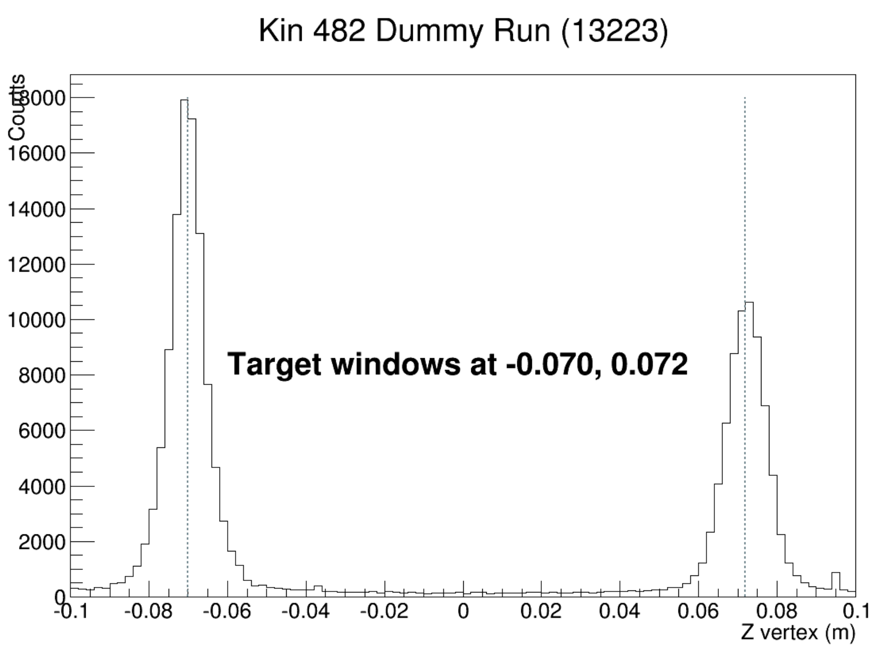


ACCEPTANCE – TARGET VERTEX (ALEXA JOHNSON)

abs(Zvertex -Targetoffset) ≤ 0.65

- 15 cm Liquid hydrogen target



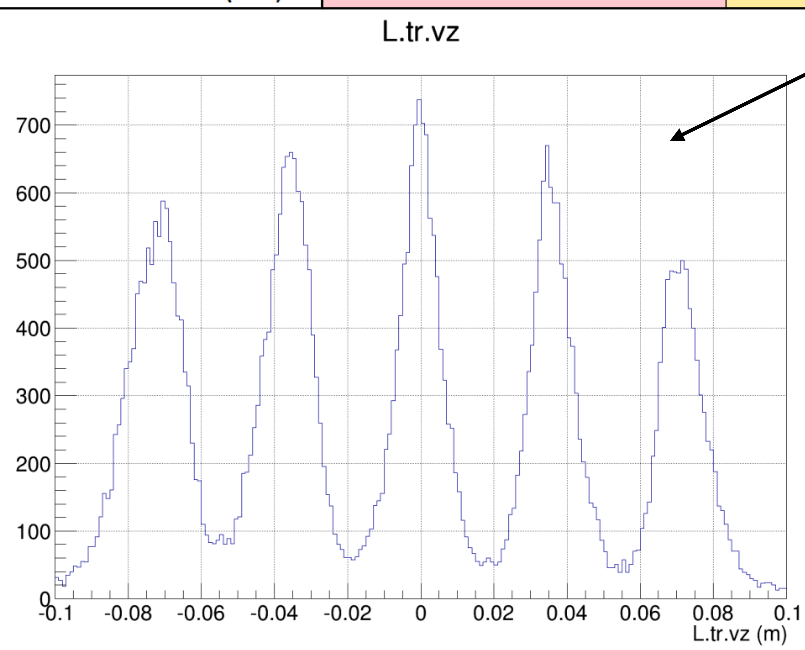


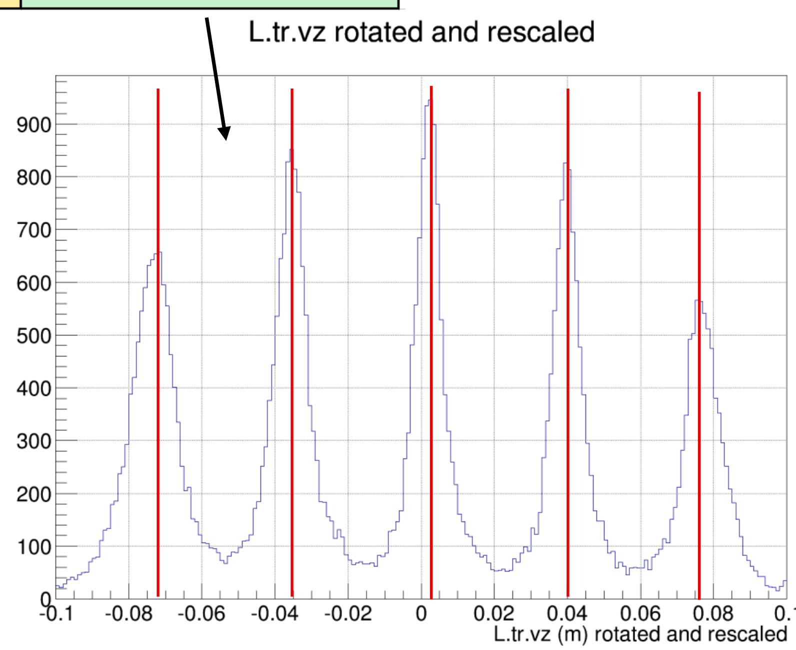
- Dummy runs reveal a reconstructed target of less than 15 cm long for Kin 48_2
- In Spring 2016, old Q1 current limited to "2.8 GeV" setting. Kin 48_1 ran at full field and Kin 48_2 detuned to 62%.

OPTICS RE-CALIBRATION SPRING 2016: FREDERIC GEORGES

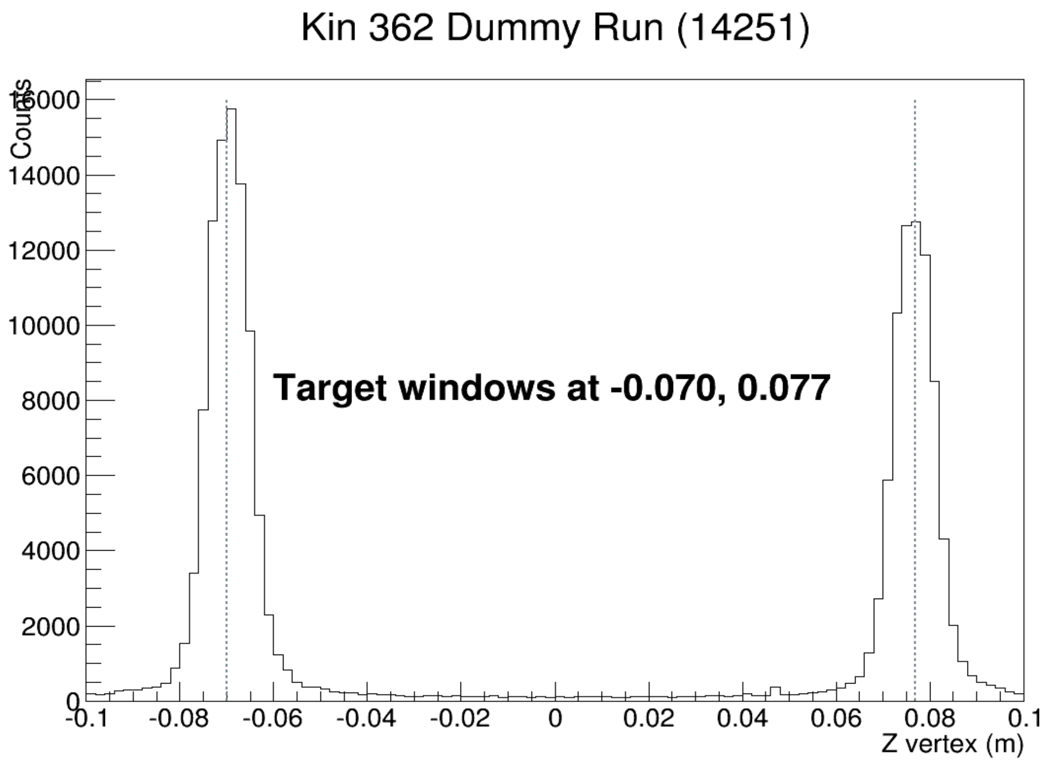
- Previous Spring 2016 Optics calibration was done with a calibration run taken with LHRS at 16°. This lead to a poor illumination of some parts of the focal plane area leading to poor reconstruction of target vertex closer to the edges
- A Recalibration of optics matrix with calibration run to the second order (instead of 5th order) yields a better target vertex reconstruction.

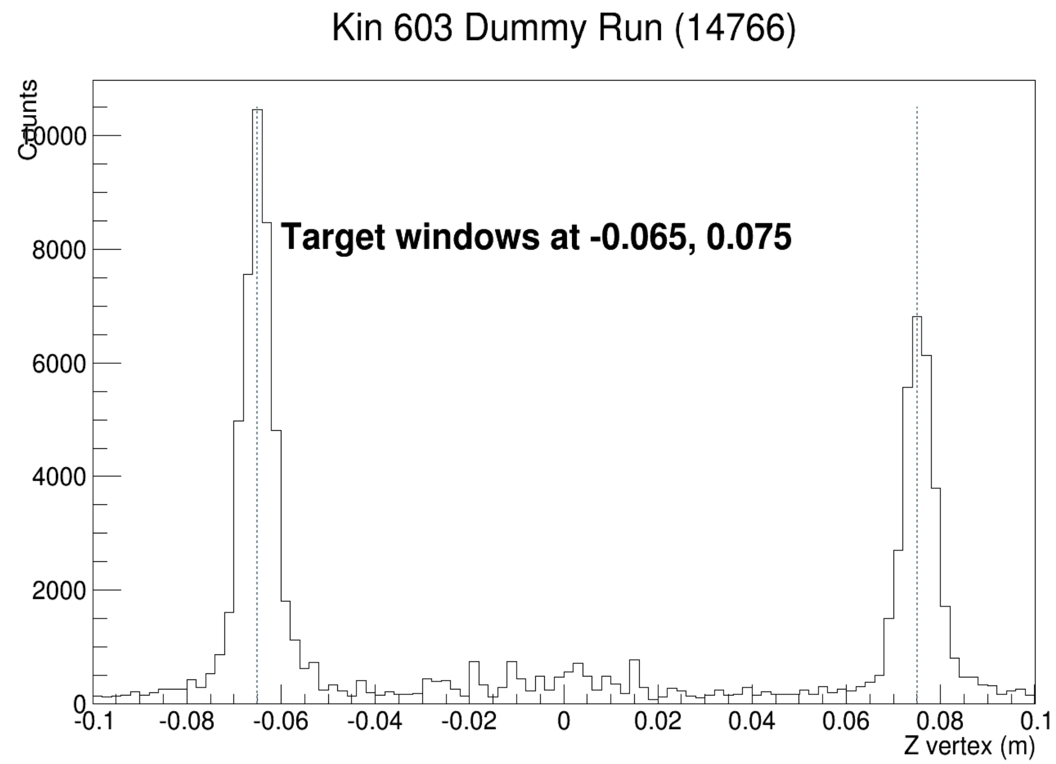
kin48_2 (Q1 at 62%, kscatt = 3.996 GeV)				
Calibration methode	everything at order 5 (reference)	vertex&phi at order 2 and set higher terms to 0	vertex-phi rotated and vertex rescaled	
run number	13006	13006	13006	
run type	pointing	pointing	pointing	
target length (cm)	14.19	14.38	15.00	Expected value : 15 cm
1st foil sigma (mm)	3.44	8.31	5.85	
5th foil sigma (mm)	4.76	6.41	4.91	
distance foils 1-2 (cm)	3.18	3.65	3.74	
distance foils 2-3 (cm)	3.64	3.58	3.76	Expected values : 3,75 cm
distance foils 3-4 (cm)	3.70	3.60	3.78	
distance foils 4-5 (cm)	3.65	3.60	3.72	





TARGET VERTEX RECONSTRUCTION - FALL 2016: NEW Q1 (WARM)





- For Fall 2016, Optics calibration run was taken with LHRS at 42°.
- Reconstructed target is 0.5 cm short for Kin 36_2 and 1 cm short for Kin 60_2
- Both kinematics have similar momentum (~3.1 GeV), 36_2 is at ~21° and 60_2 at ~28° (Hinting at a saturation issue: Inadvertently detuned)
- Use GMP optics matrix and recheck vertex reconstruction.

SUMMARY AND OUTLOOK

- All calibrations are ready despite a small set back of target vertex reconstruction issues
  - Re-do HRS Calibration with new optics matrix
- Preliminary results on π° at χ_B = 0.36 early next year

THANK YOU!

DVCS Collaboration

ODU

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Kijun Park

IPN-Orsay

Carlos Munoz Camacho

Frederic Georges

CMU

Alexa Johnson

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Julie Roche

Paul King

Mongi Dlamini

Bishnu Karki

Gulakshan Hamad

LIST OF THESIS AND PEER REVIEWED PUBLICATIONS (PARTIAL LIST)

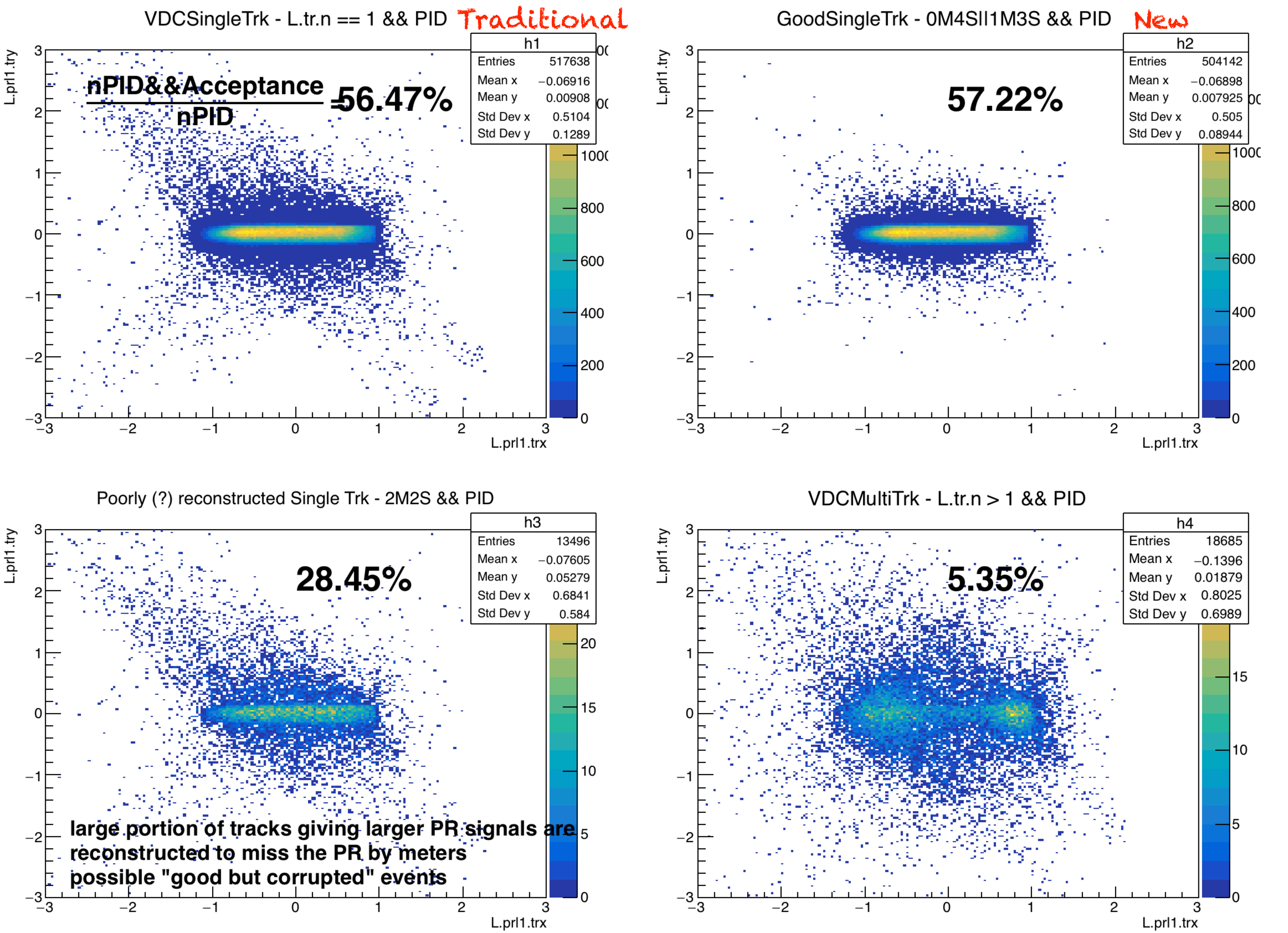
Articles in peer-reviewed journals

- M. Defurne *et al*. [Jefferson Lab Hall A Collaboration], The E00-110 experiment at Jefferson Lab Hall A: Deeply virtual Compton scattering off the proton at 6 GeV
- E. Fuchey *et al*. [Jefferson Lab Hall A Collaboration], Exclusive Neutral Pion Electroproduction in the Deeply Virtual Regime
- M. Mazouz *et al*. [Jefferson Lab Hall A Collaboration], "Deeply virtual compton scattering off the neutron"
- C. Munoz Camacho *et al*. [Jefferson Lab Hall A Collaboration], "Scaling tests of the cross section for deeply virtual Compton scattering"

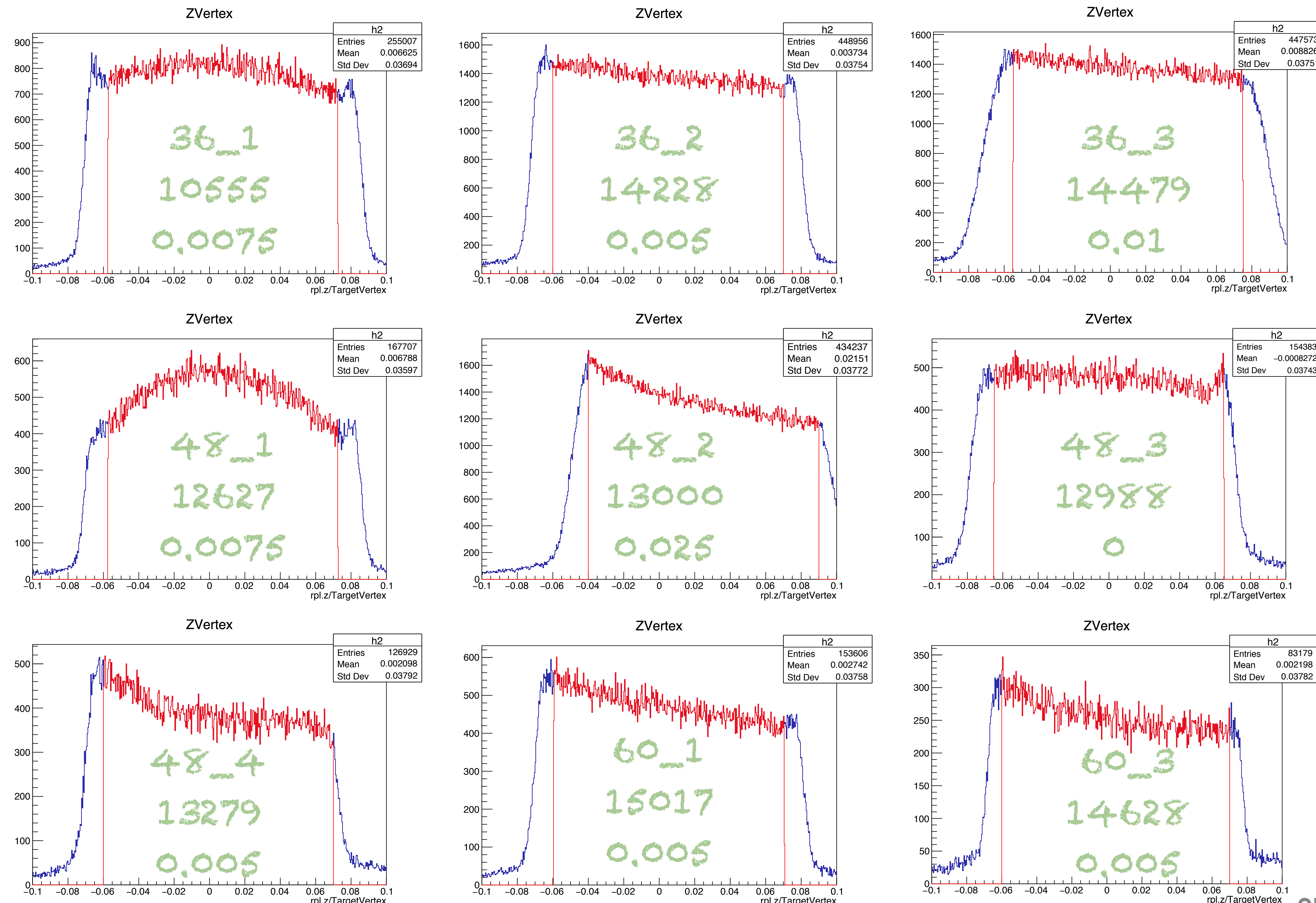
Thesis

- September 2015: D. Desnault: Mesure de la section efficace d'électroproduction de photons sur le neutron à Jefferson Lab en vue de la séparation du terme de diffusion Compton profondément virtuelle
- June 2015: M. Defurne: Photon and π^0 electroproduction at Jefferson Laboratory - Hall A
- July 2014: A. Martí Jimenez-Argüello: Measurement of the photon electroproduction cross section at JLab with the goal of performing a Rosenbluth separation of the DVCS contribution
- April 2011: E. Fuchey: Electroproduction de pions neutres dans le Hall A au Jefferson Laboratory
- December 06: M. Mazouz: Exploration of the DVCS on the neutron in Hall A at Jefferson Laboratory
- December 05: C. Munoz Camacho: DVCS in Hall A at Jefferson Laboratory
- April 05: A. Camsonne: Experimental setup for Deeply Virtual Compton Scattering (DVCS) experiment in Hall at Jefferson Laboratory

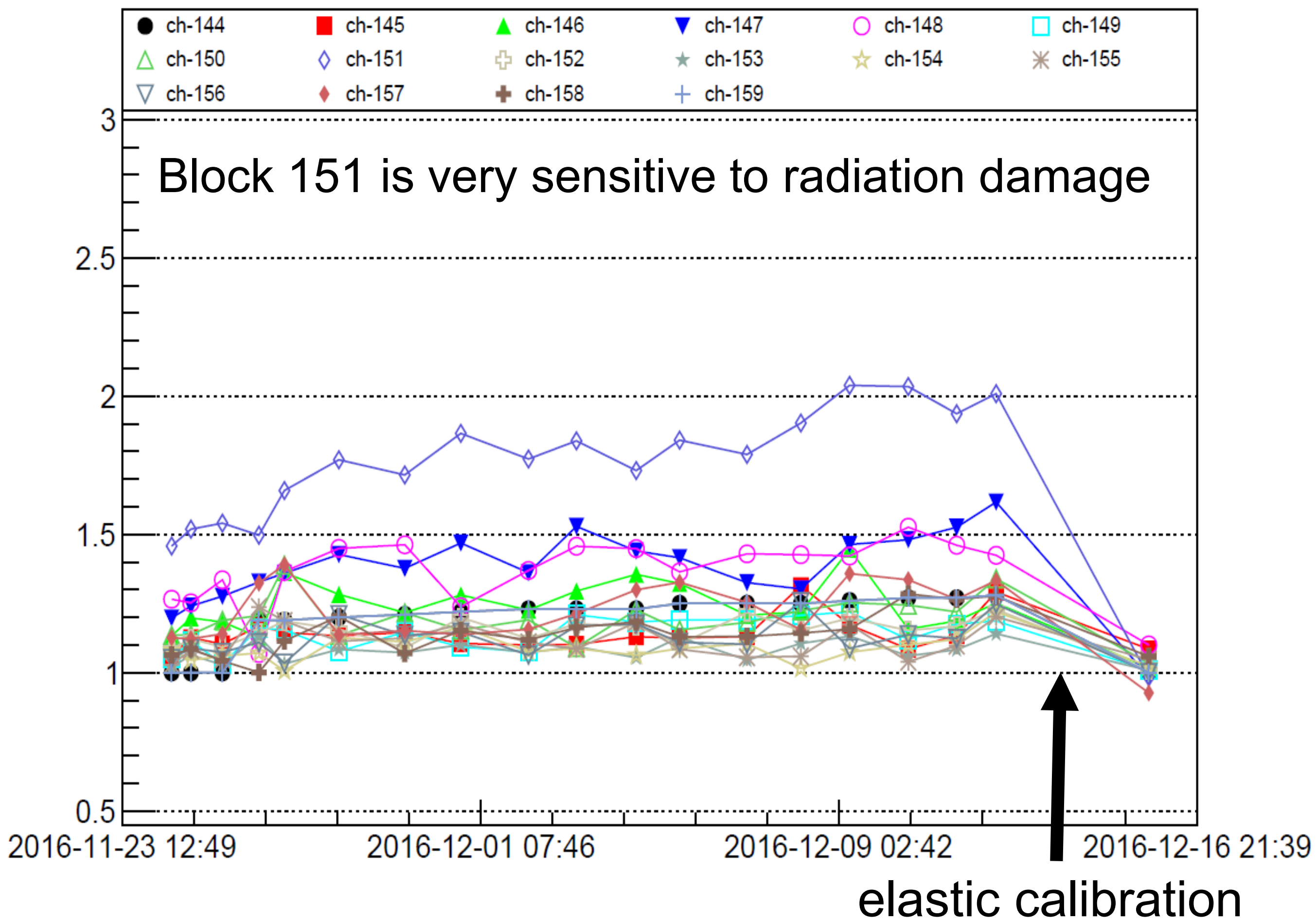
TRACKING EFFICIENCY

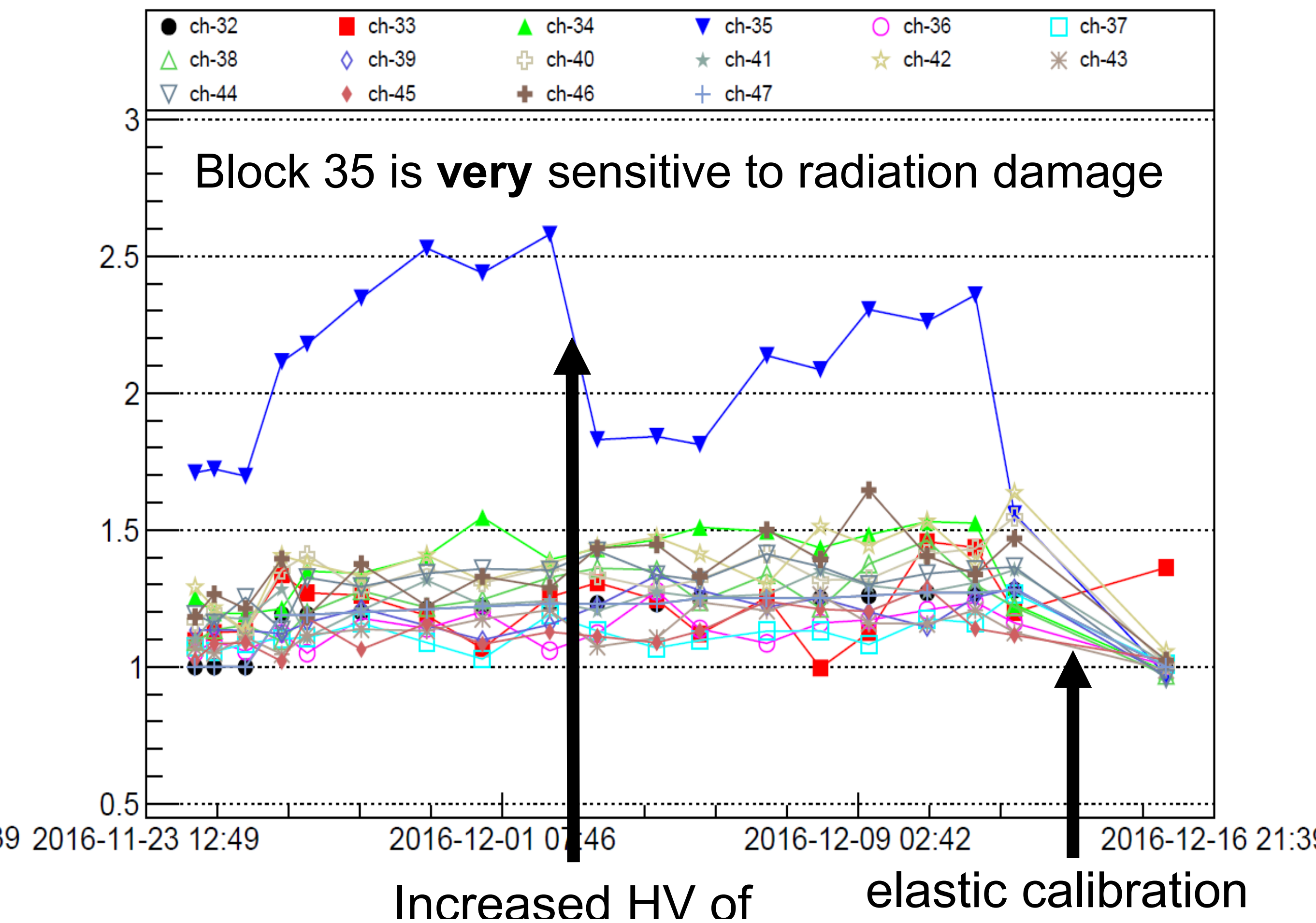


TARGET VERTEX AND VERTEX RECONSTRUCTION ISSUES



π° CALIBRATION : MONGI DLAMINI & FREDERIC GEORGES





- π° calibration enables us to compensate for radiation damage of the calorimeter blocks in between elastic calibration
- Achieved by adjusting the correction coefficients by reconstruction of π° invariant mass

DVCS KINEMATICS

DVCS Kinematics														
	HRS_Acc	6.00E-03	sr											5
	HRS_ddelta	0.08	(kMax-kMin)/k0											2
	Calo_A	0.1386	m^2	208-54'	Crystals	3x3 cm^2								4
	HMS_Acc	6.00E-03	sr											5
	HMS_ddelta	0.16	(kMax-kMin)/k0											2
	Calo_C	0.4096	m^2	34x34-4*33'	Crystals	2x2 cm^2								
	DeltaT	0.1	GeV^2						Q1 Limit	1900	Amp	2.5255	GeV/c	
	nbarn	1.00E-33	cm^2/nb					**Fall 2016**						
	Injector	1.23E-01	1.000	0.123	Injector energy scales with linac			InjectorFY17	0.117					
	Linac	2.18E+00	GeV	2.180	GeV			LinacFY17	2.1					

DVCS-Fall2016 Kinematics, Last update 22-April-2016 C.Hyde

		Hall A											
		FY2016	**FY2017**		**FY2016**				**FY2017 ? + FY202X ?**				
Name		**Kin_36_1**	**Kin_36_2**	**Kin_36_3**	**Kin_48_1**	**Kin_48_2**	**Kin_48_3**	**Kin_48_4**	**Kin_60_1**	**Kin_60_2**	**Kin_60_3**	**Kin_60_4**	
Pass		3	4	5	2	4	4	**5**	4	4	5	5	Pass
kBeam	(GeV)	6.663	8.517	10.617	4.483	8.843	8.843	11.023	8.517	8.517	10.617	10.617	kBeam
Q2	(GeV^2)	3.200	3.600	4.470	2.700	4.365	5.334	6.900	5.541	6.100	8.400	9.000	Q2
xBj		0.360	0.360	0.360	0.480	0.480	0.480	0.480	0.600	0.600	0.600	0.600	xBj
MProton	(GeV)	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	MProton
nu	(GeV)	4.738	5.330	6.619	2.998	4.847	5.923	7.663	4.923	5.419	7.463	7.996	nu
kScatt	**(GeV)**	**1.925**	**3.187**	**3.998**	**1.485**	**3.996**	**2.920**	**3.360**	**3.594**	**3.098**	**3.154**	**2.621**	**kScatt**
csThe		0.875	0.934	0.947	0.797	0.938	0.897	0.907	0.909	0.884	0.875	0.838	csThe
epsilon		0.484	0.621	0.631	0.506	0.711	0.548	0.518	0.663	0.584	0.495	0.412	epsilon
the	(deg)	28.926	20.985	18.675	37.140	20.244	26.271	24.925	24.564	27.823	29.004	33.039	the
snThq		0.184	0.202	0.184	0.262	0.262	0.203	0.175	0.274	0.243	0.191	0.167	snThq
Thq	**(deg)**	**10.592**	**11.635**	**10.618**	**15.198**	**15.184**	**11.728**	**10.069**	**15.892**	**14.050**	**11.014**	**9.633**	**Thq**
CaloSetting	**(deg)**	**10.592**	**11.635**	**10.618**	**15.198**	**15.184**	**11.728**	**10.069**	**15.892**	**14.050**	**11.014**	**9.633**	**CaloSetting**
pMin	(GeV/c)	0.422	0.422	0.422	0.624	0.624	0.624	0.624	0.890	0.890	0.890	0.890	pMin
1./(1.-eps)		1.938	2.639	2.712	2.023	3.458	2.212	2.076	2.963	2.402	1.980	1.701	1./(1.-eps)
qvec	(GeV/c)	5.065	5.658	6.948	3.419	5.278	6.358	8.100	5.457	5.956	8.006	8.540	qvec
q'	(GeV)	4.651	5.243	6.529	2.827	4.664	5.736	7.471	4.570	5.061	7.089	7.620	q'
tmin	(GeV^2)	-0.163	-0.165	-0.167	-0.321	-0.344	-0.351	-0.359	-0.661	-0.671	-0.700	-0.706	tmin
sqrt(tmin)	(GeV)	0.404	0.406	0.409	0.567	0.586	0.593	0.599	0.813	0.819	0.837	0.840	sqrt(tmin)
CaloDist	(m)	1.500	2.000	2.500	1.500	2.000	2.500	2.500	1.500	2.000	2.500	3.000	CaloDist
DOmega	(sr)	6.16E-02	3.47E-02	2.22E-02	6.16E-02	3.47E-02	2.22E-02	2.22E-02	6.16E-02	3.47E-02	2.22E-02	1.54E-02	DOmega
Th_gg_max	(rad)	1.24E-01	9.31E-02	7.45E-02	1.24E-01	9.31E-02	7.45E-02	7.45E-02	1.24E-01	9.31E-02	7.45E-02	6.20E-02	Th_gg_max
q'_min	(GeV)	4.37	5.04	6.33	2.69	4.46	5.54	7.15	4.14	4.76	6.71	7.31	q'_min
tmax	(GeV^2)	-0.69	-0.54	-0.54	-0.58	-0.72	-0.71	-0.96	-1.47	-1.24	-1.41	-1.28	tmax
tmin-tmax	(GeV^2)	0.52	0.38	0.38	0.26	0.38	0.36	0.60	0.81	0.57	0.71	0.57	tmin-tmax
Th_calo_edge	deg	4.86	7.34	7.18	9.47	10.89	8.29	6.63	10.16	9.75	7.58	6.77	Th_calo_edge
Calo_1stCol	deg	6.01	8.20	7.87					11.31	10.61	8.26	7.34	
Lumi	/cm^2/s	1.86E+37	3.31E+37	5.17E+37	1.86E+37	3.31E+37	5.17E+37	5.17E+37	1.86E+37	3.31E+37	5.17E+37	7.44E+37	Lumi
Beam Curre	**(muAmp)**	**4.9**	**8.8**	**13.7**	**4.9**	**8.8**	**13.7**	**13.7**	**4.9**	**8.8**	**13.7**	**19.8**	**muAmp**
~~d4sig(0deg)~~	~~nb/GeV^4~~	8.21E-02	3.64E-02	1.92E-02	1.24E-03	4.47E-03	2.33E-03	2.38E-03	1.16E-03	9.95E-04	5.44E-04	5.12E-04	
~~d4sig(180)~~	~~nb/GeV^4~~	1.44E-02	7.80E-03	4.69E-03	4.07E-03	1.73E-03	1.01E-03	1.06E-03	5.91E-04	4.68E-04	3.59E-04	2.95E-04	d4sig(180)
Days		**3.00**	**2**	**1**	**5**	**4**	**4**	**7**	**13**	**16**	**13**	**20**	**Days**
Charge	Coulomb	1.3	1.5	1.2	2.1	3.0	4.7	8.3	5.6	12.1	15.4	34.2	Coulomb
Jacob_e	GeV	1.95	3.67	4.62	2.13	7.00	4.18	4.64	7.46	5.84	5.39	4.18	Jacob_e
counts in DeltaT bin		4.18E+04	7.07E+04	4.72E+04	3.24E+03	4.75E+04	1.75E+04	4.01E+04	2.35E+04	2.90E+04	2.14E+04	2.72E+04	counts in Delta
Total Beam Time		**Hall A Total = 88 PAC Days**											**Total Beam Ti**