Deep Inelastic cross-section for E12-06-114

DVCS collaboration meeting

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DIS x-section

- **Reproducing DIS cross section ensure our understanding of luminosity and e detection by HRS**

$$\frac{d^2\sigma}{dx dQ^2} = \frac{N_c}{\mathcal{L}} \times \left(\frac{1}{\alpha \times \eta_{virt} \times \eta_{exp} \times \Gamma_{DIS}}\right)$$

Integrated luminosity

α term to modify phase space due to radiative effects

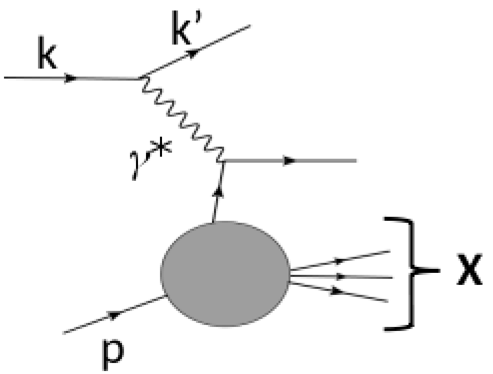
η_{virt} term correcting virtual radiative effects

η_{exp} term correcting detectors inefficiencies

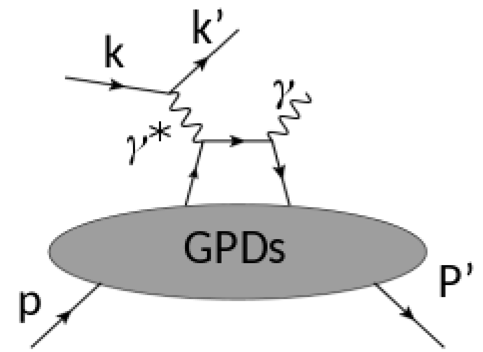
Γ_{DIS} phase space covered by LHRS

N_c no. of event passing analysis cut (PID, vertex, track...)

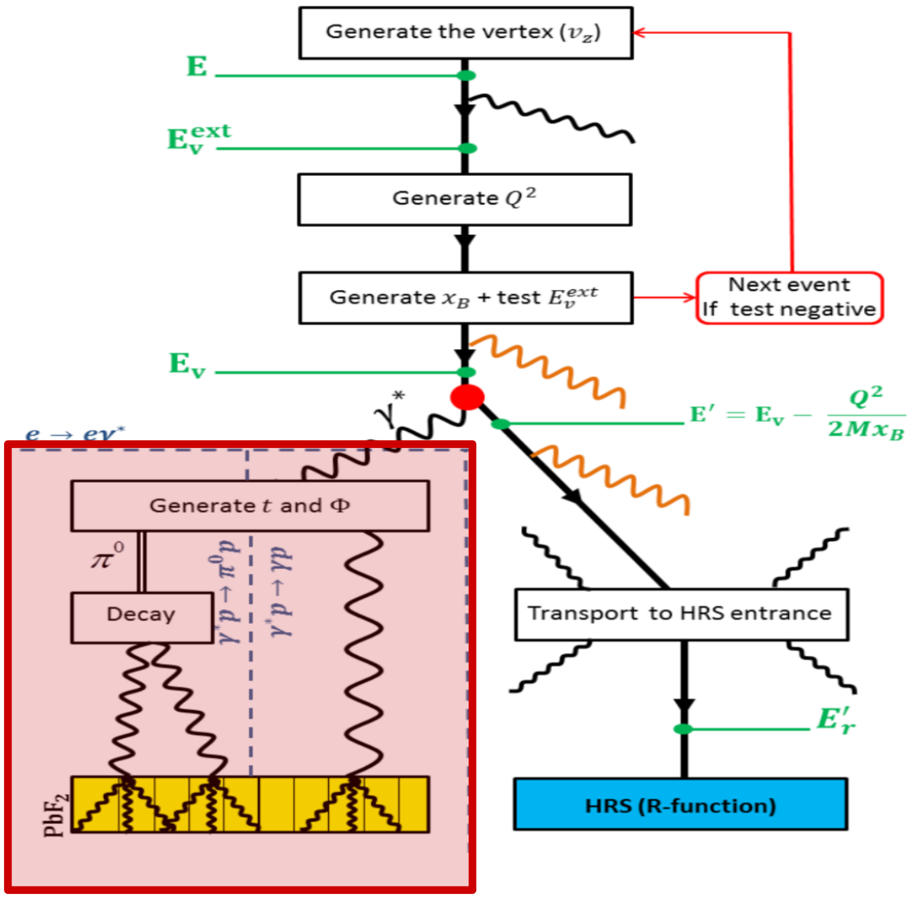
DIS



DVCS



HRS phase space (Γ_{DIS})



Main steps of Monte-Carlo simulation

Generating electrons

dvcsPrimaryGeneratorAction::Generate Primaries()

gev->GenerateVertex()

gev->ExtBrem()

gev->GenKin()

gev->IntRCBef()

dvcsEventAction::DefinePrimaries()

dvcsEventAction::EndofEventAction()

TGenGeo::HitsSpectro(TLorentzVector *e)

- The Monte-Carlo(MC) simulation for DVCS was modified to generate DIS events
- Γ_{DIS} is estimated by MC simulation
- Γ_{DIS} depends on the HRS acceptance & R-cut

$$\Gamma_{DIS} = \frac{1}{N_{gen}} \sum_{i \in C} \Gamma^{i}_{MC}$$

https://hallaweb.jlab.org/dvcslog/12+GeV/171023_200242/DIS.pdf

$$\Gamma^{i}_{MC} = \frac{\Delta Q^2_i \cdot \Delta x_{B_i}}{2\pi}$$

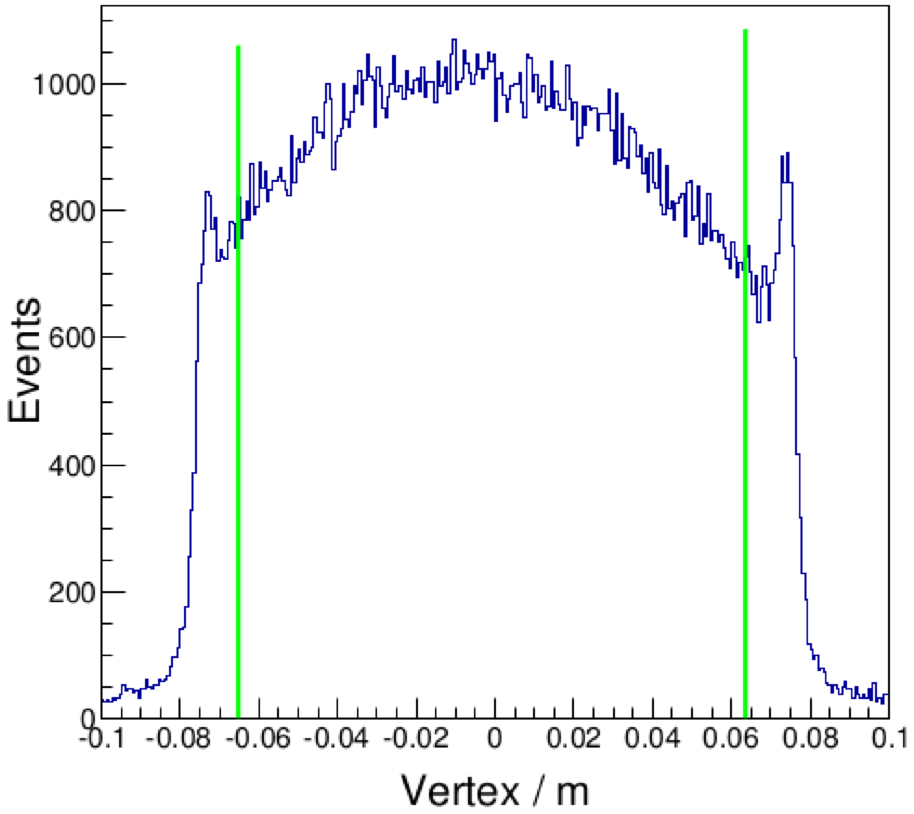
DIS phase space

Event selection
(N_c)

(H.Rashad)

- PID – CherADCSum > 150 + Normalized PRSum>600 + Normalized PR1>200
- Single track – (0M4S + 1M3S)
- Vertex – within the hydrogen
- DIS events – with triggerPatternWord
- Acceptance cut (R-cut from G.Hamad)

Kinematic	R-cut
361	0.1
362	0.06
363	0.06
481	0.05
482	0.06
483	0.05
484	0.05
601	0.06
603	0.02



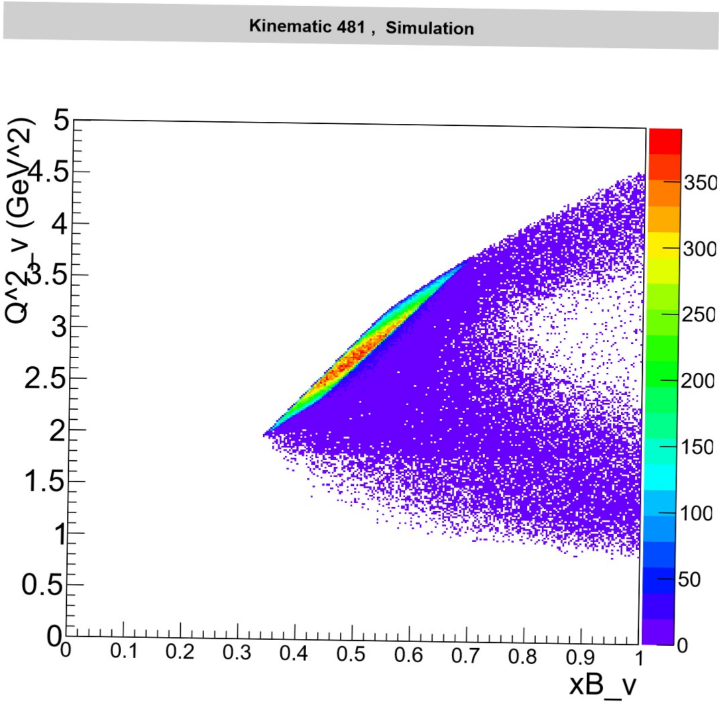
Modification of the Phase Space due to the Radiative Effects (α)

- Radiative effects may move events which are outside the small L-HRS acceptance at the vertex into the HRS acceptance.

- We must correct the DIS cross section for for this radiation effects

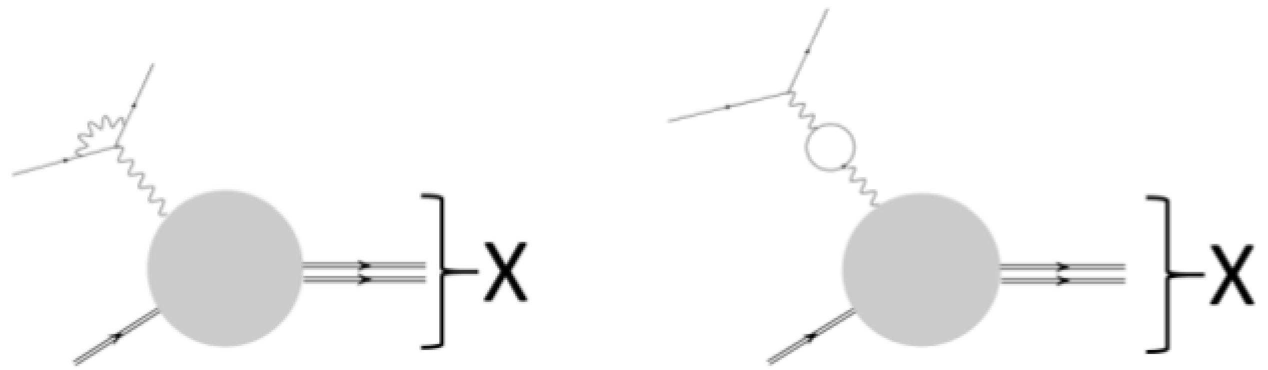
- To obtain the cross section at the nominal kinematic values, we compute a coefficient α

$$\alpha = \frac{1}{N_{acc} \times \left(\frac{d\sigma}{dx_B dQ^2}\right)_{HRS}} \sum_{i=1}^{N_{acc}} \left(\frac{d\sigma}{dx_B dQ^2}\right)_i$$



Kinematic	α
361	1.053
362	0.991
363	1.037
481	1.026
482	1.049
483	0.947
484	0.945
601	0.987
603	1.092

Virtual radiative corrections
(η_{virt})



$$\eta_{virt} = \frac{e^{\delta_R^0 + \delta_{ver}}}{(1-\delta_{vac})^2}$$

$$\delta_{vac} = \frac{\alpha}{3\pi}\left[\ln\left(\frac{Q^2}{m_e^2}\right) - \frac{5}{3}\right],$$

$$\delta_{ver} = \frac{\alpha}{\pi}\left[\frac{3}{2}\ln\left(\frac{Q^2}{m_e^2}\right) - 2 + \frac{\pi^2}{6} - \frac{1}{2}\ln^2\left(\frac{Q^2}{m_e^2}\right)\right]$$

$$\delta_R^{(0)} = \frac{\alpha}{\pi}\left[\mathrm{Sp}\left(cos\frac{\theta_e}{2}\right) - \frac{\pi^2}{3} - \frac{1}{2}\ln^2\left(\frac{Q^2}{m_e^2}\right)\right]$$

Kinematics	$\eta_{virtual}$
361	1.070
362	1.071
363	1.072
481	1.069
482	1.072
483	1.073
484	1.074
601	1.073
603	1.075

Detector efficiencies (η_{exp})

- Cherenkov efficiency (**η_{Cher}**) **–** special runs triggered by S0&&S2M ~1
- S2M efficiency (**η_{s2m}**) **–** special runs triggered by S0&&S2M ~1
- Tracking efficiency(**η_{track}**) **–** (from H. Rasad) – Major correction (~7 % correction)

- 3 cases: 0M4S, 1M3S, and 2M2S events yields single track reconstruction. **Keep 0M4S and 1M3S exclude 2M2S**
- ~5-10% events are reconstructed with more than one track and are excluded

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

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

Multi-cluster and Multi-track correction factors are mutually exclusive

$$\eta_{Final} = \eta_{MultiCluster} + \eta_{MultiTrack}$$

$$\eta_{exp} = \eta_{track} \times \eta_{Cher} \times \eta_{s2m}$$

Detector efficiencies (η_{exp})

H. Rasad

Kinematic	η_{Final}
361	0.940
362	0.936
363	0.930
481	0.957
482	0.937
483	0.943
484	0.940
601	0.937
603	0.936

Tracking correction ~7% correction

Integrated luminosity

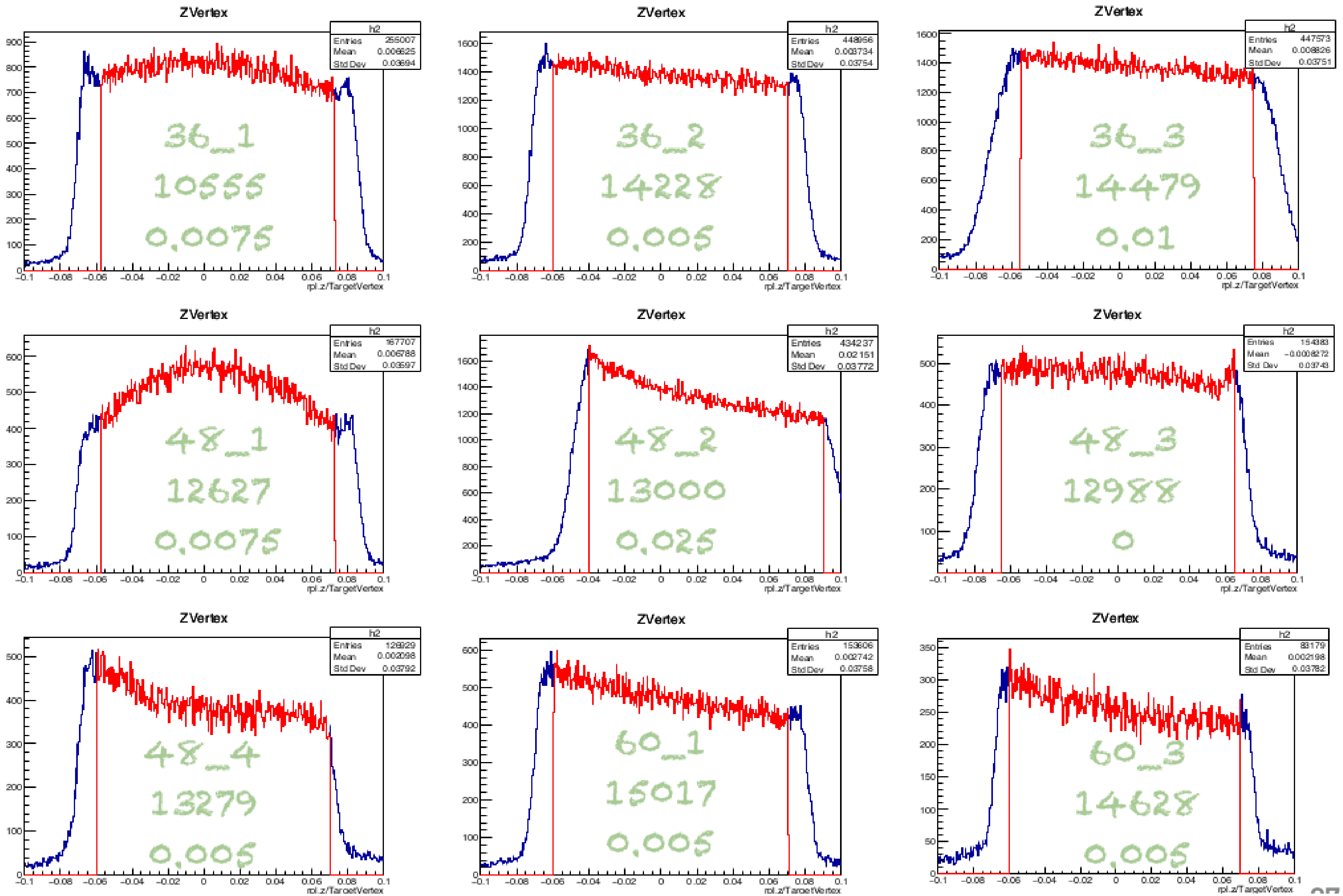
$$\mathcal{L} = \frac{Q}{e}\frac{N_A \rho l}{A_H}$$

Q Charge measured by D3
$\mathbf{N_A}$ = Avogardo's No. = 6.022 x 10^{23} mol^{-1}
ρ = density of H at **17 K and 25 psi** = 0.07229 g/cm^3
l = length of target = ~ 13 cm
e = electronic charge = 1.602x 10^{-19} C
$\mathbf{A_H}$ = atomic mass of H = 1.0079 g/mol

Period	Kinematic	Z end) (cm)	Z end (cm)	Length (cm)	Offset (cm)
Fall '14	361	-7.0	6.0	13.0	-0.5
Spring '16	481	-6.5	6.5	13.0	0.0
Spring '16	482	-6.3	6.8	13.1	0.25
Spring '16	483	-6.3	6.8	13.1	0.0
Spring '16	484	-6.0	7.0	13.0	0.5
Fall '16	362	-6.3	6.8	13.1	0.5
Fall '16	363	-5.5	7.5	13.0	1.0
Fall '16	601	-6.0	7.0	13.0	0.5
Fall '16	603	-6.0	7.0	13.0	0.5

Z vertex

H. Rashad



DIS x-section status

- E12-06-114 DIS cross section compared to world data from
  M. E. Christy et al. Phys. Rev. **C81**, 055213 (2010)

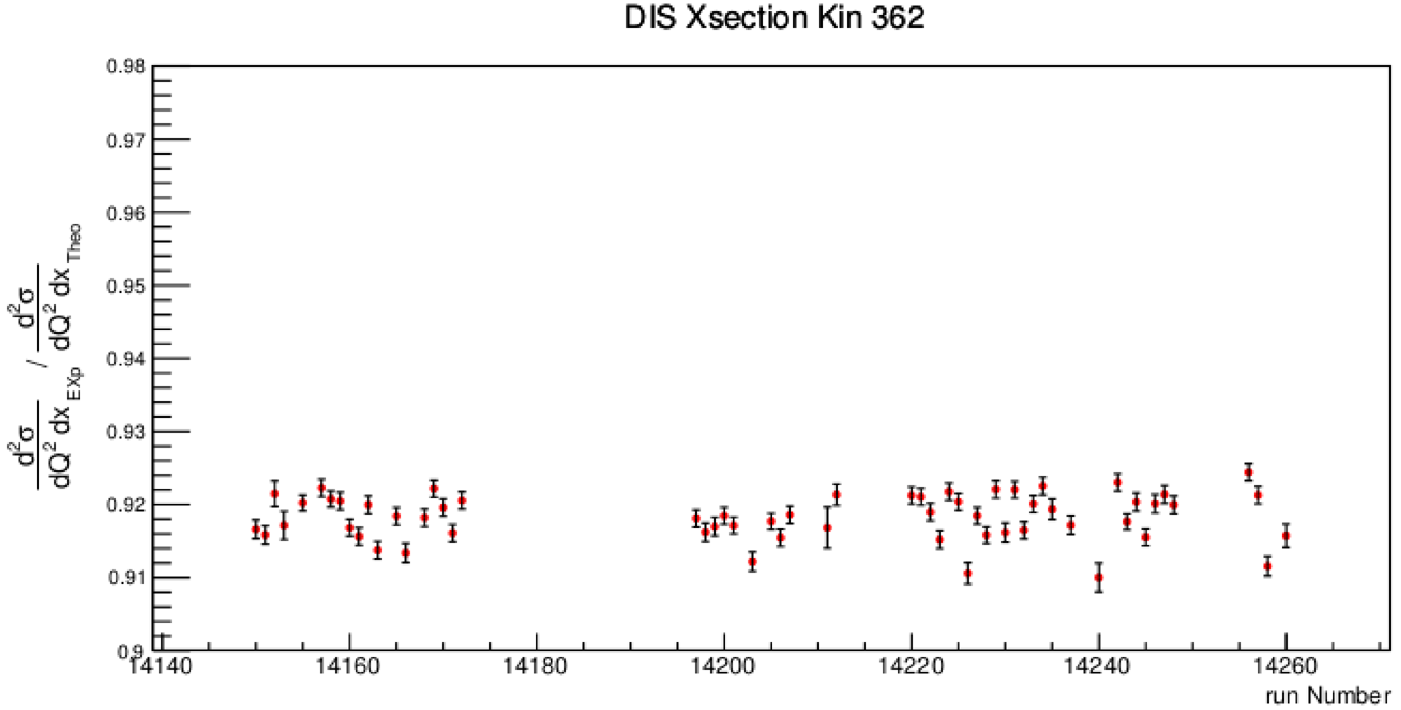
- Upto 5% uncertainty in reference cross-section

Period	**Kinematic**	**Relative difference(%)**
Fall 2014	361	-2
Fall 2016	362	-8
Fall 2016	363*	-15
Spring 2016	481**	-2
Spring 2016	482	-7
Spring 2016	483	-5
Spring 2016	484	-6
Fall 2016	601**	-5
Fall 2016	603	+3

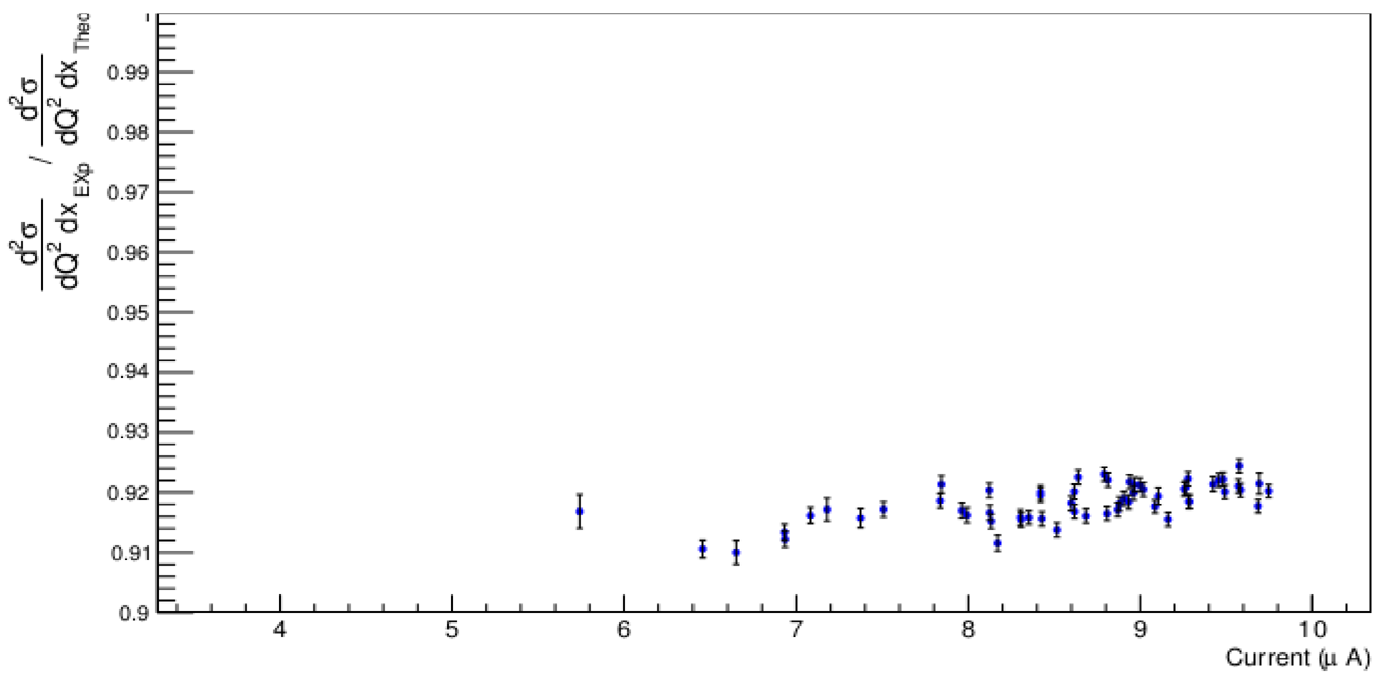
* Q1 saturation effect
** atypical run to run stability

Work in progress..

Kin 362



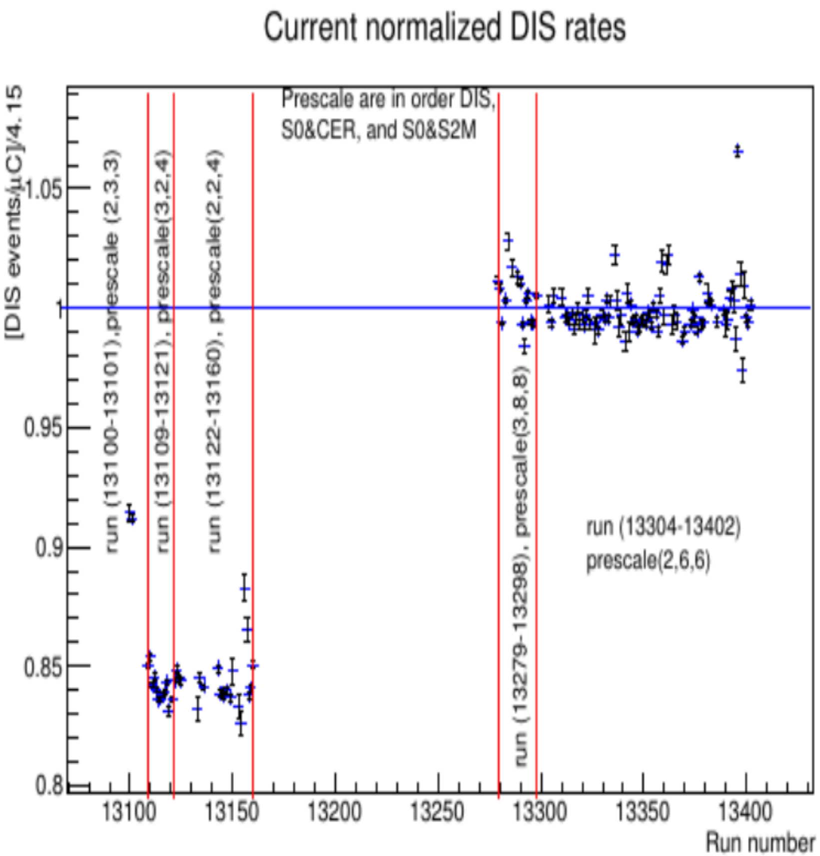
DIS Xsection Kin 362
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
14140
14160
14180
14200
14220
14240
14260
run Number



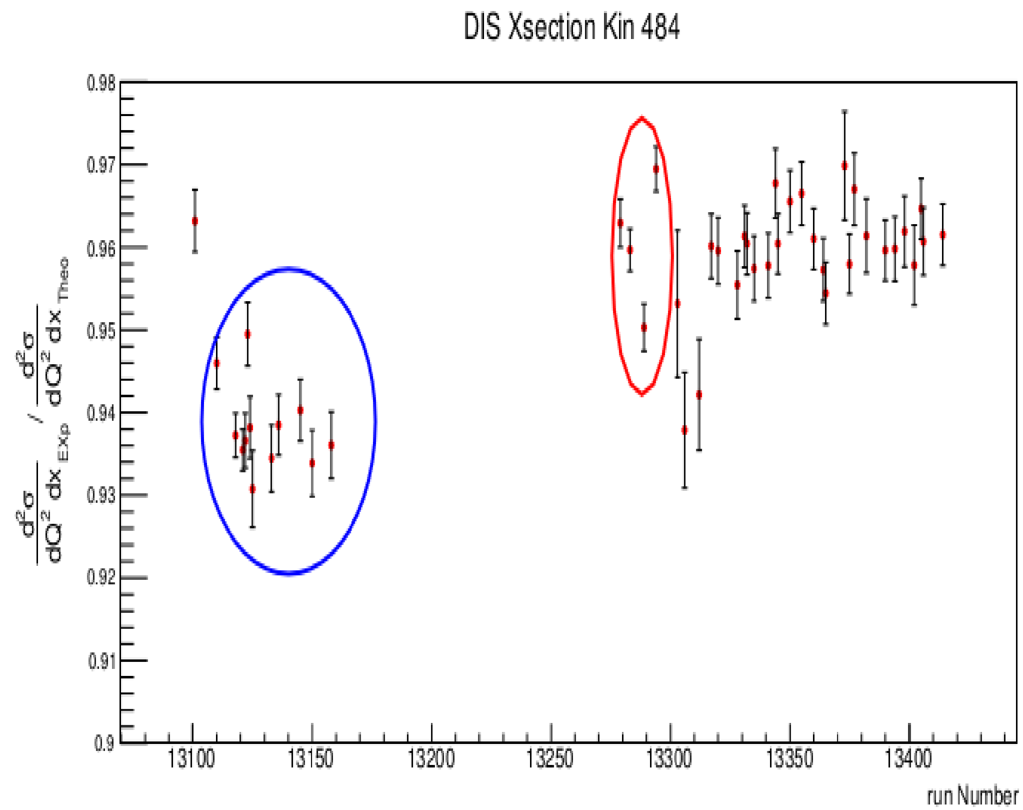
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
4
5
6
7
8
9
10
Current (μ A)

Kin 482

Before missing correction



After missing correction



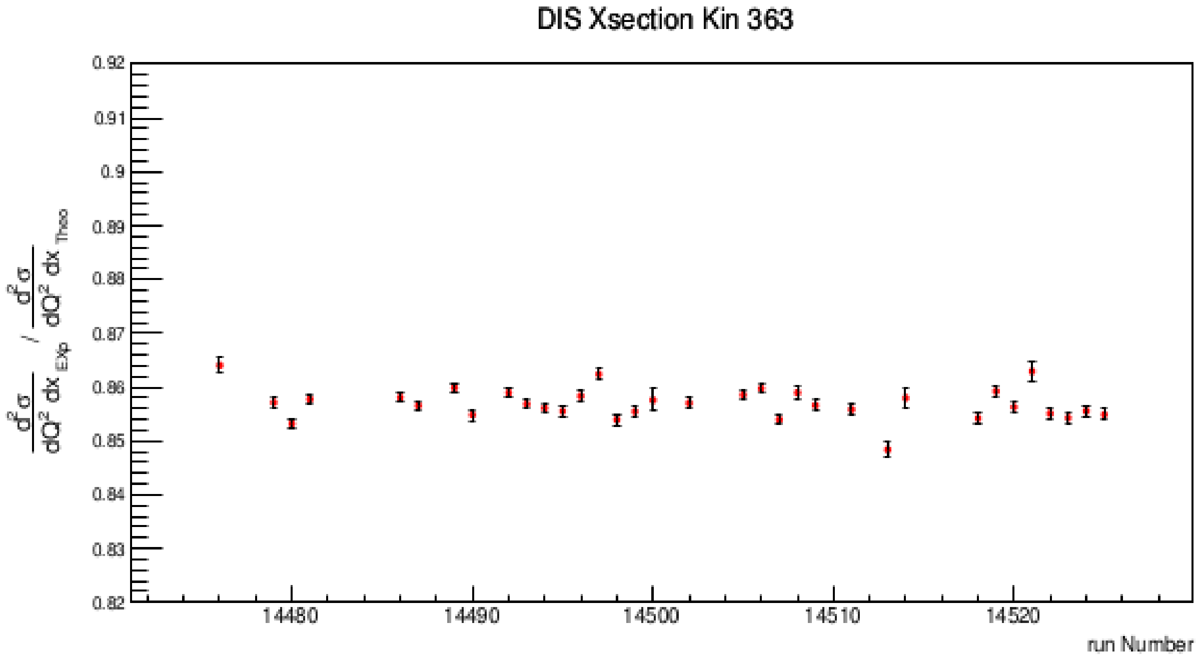
- **Missing DIS** = Exclusive S0&CER **+** S0, CER, S2M (in singles) **+** S2M&CER Coinc
- **Corrected DIS** = DIS rates **+** Missing DIS

$$\frac{d^2\sigma}{dQ^2dx}$$

Stable within 2% even for the multiple coincidence trigger with S0&CER

- S0, CER, S2M (in singles) = "(triggerPatternWord &0x3f > 50"
- S2M&CER Coincidence = "DL.t3"

Kin 363

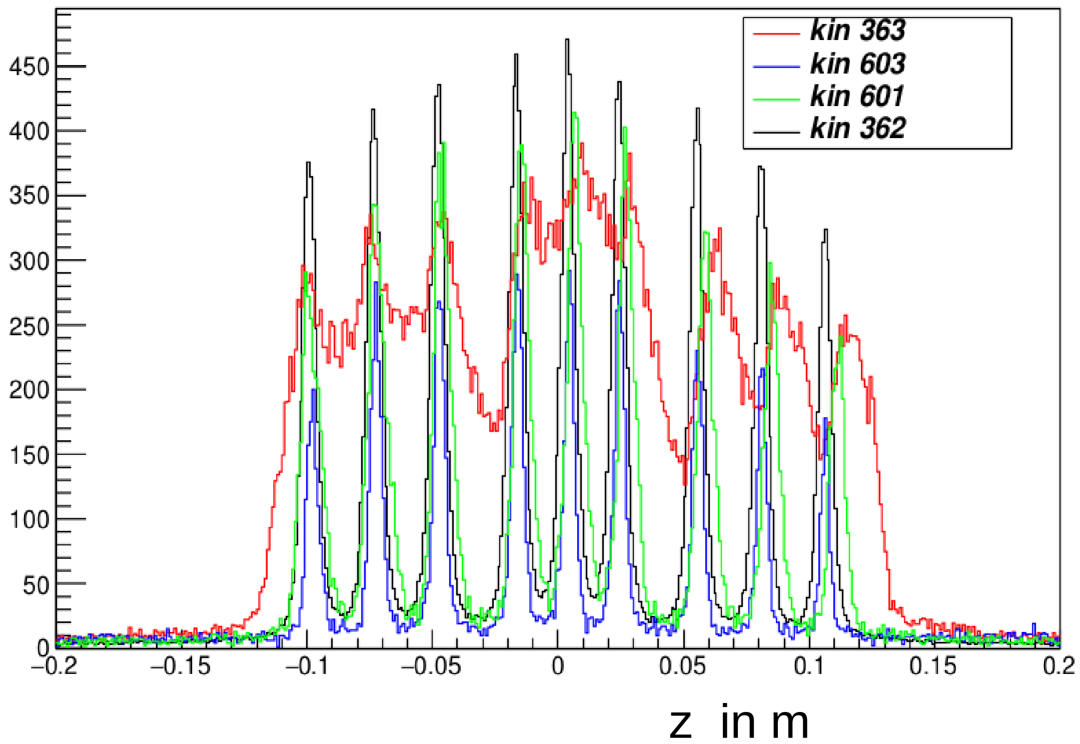


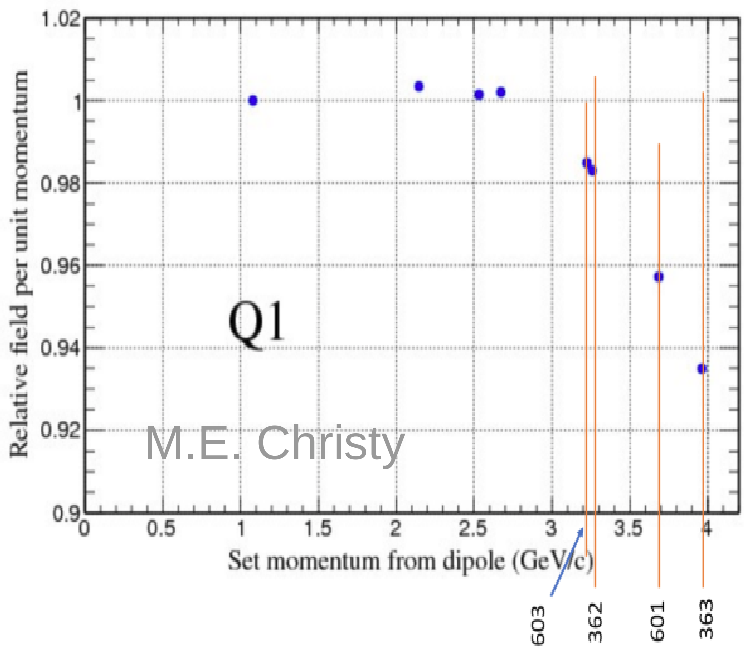
$$\frac{d^2\sigma}{dQ^2dx}$$

~ 15% systematically below than the reference cross section

But very stable with in 1%

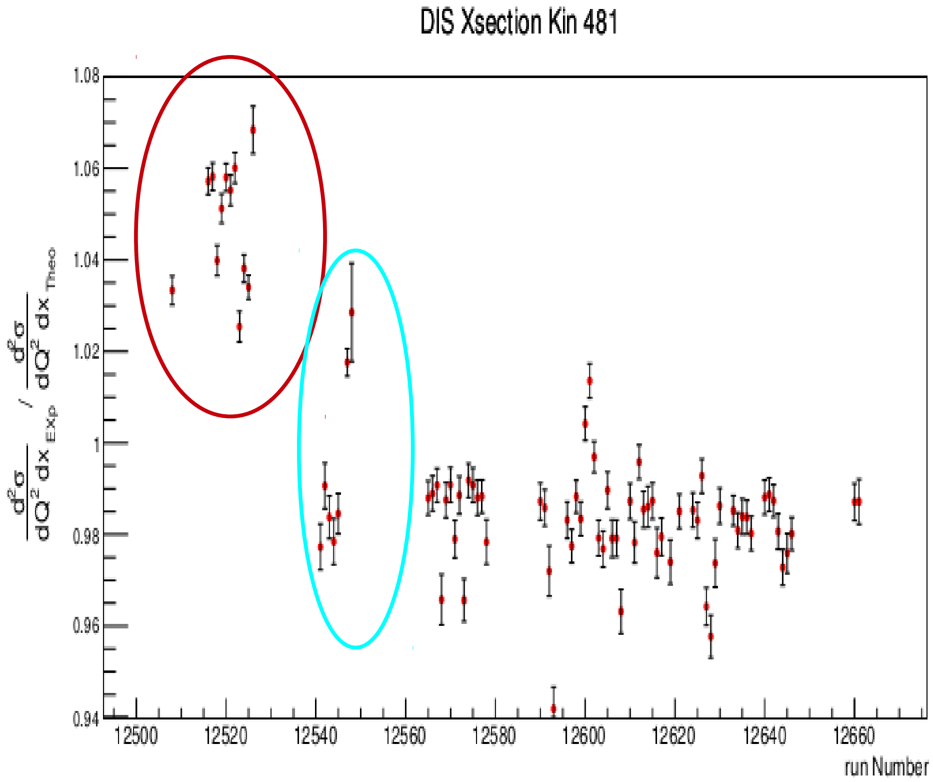
Z vertex reconstruction for Fall 2016 kinematics





Outcomes of previous discussions will be implemented in near future

Kin 481



Test run results from Fall 2016 (kin 362)

Run	S0&CER	$\left(\frac{d^2\sigma}{dQ^2dx}\right)_{Exp}$
14174	0	19.11 ± 0.08
14183	2	18.88 ± 0.09

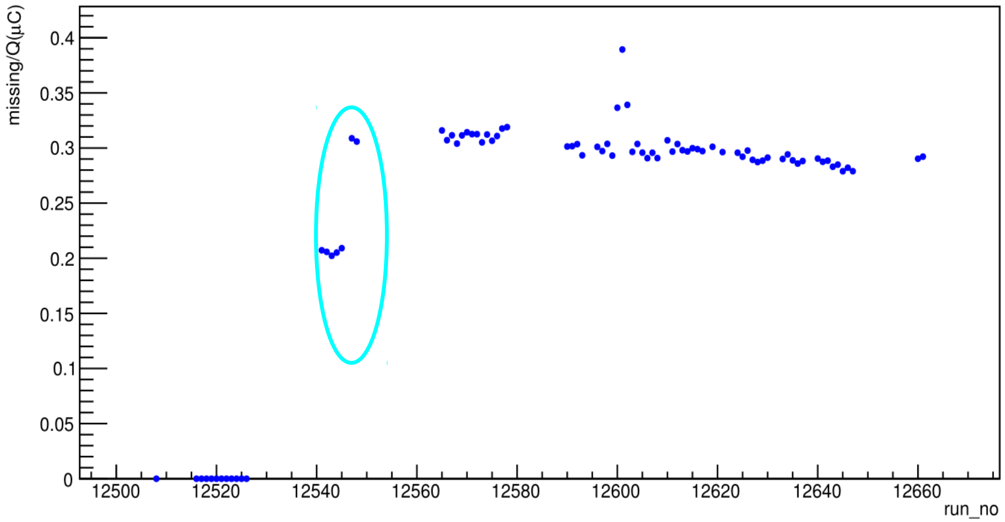
Corrected DIS works well upto ~1%

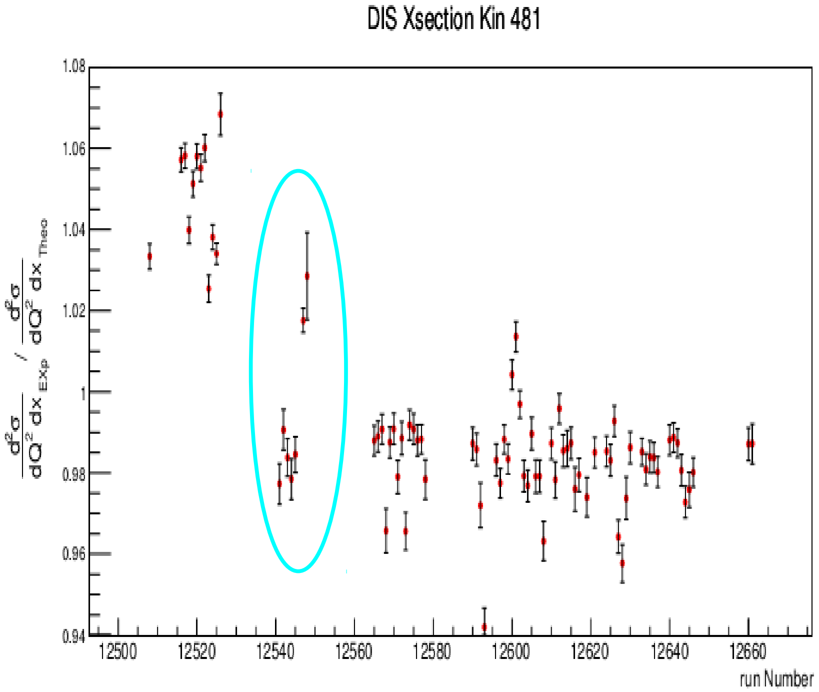
For 481 first and second chunk have different prescale both on S0&&Cer and S2M&&Cer

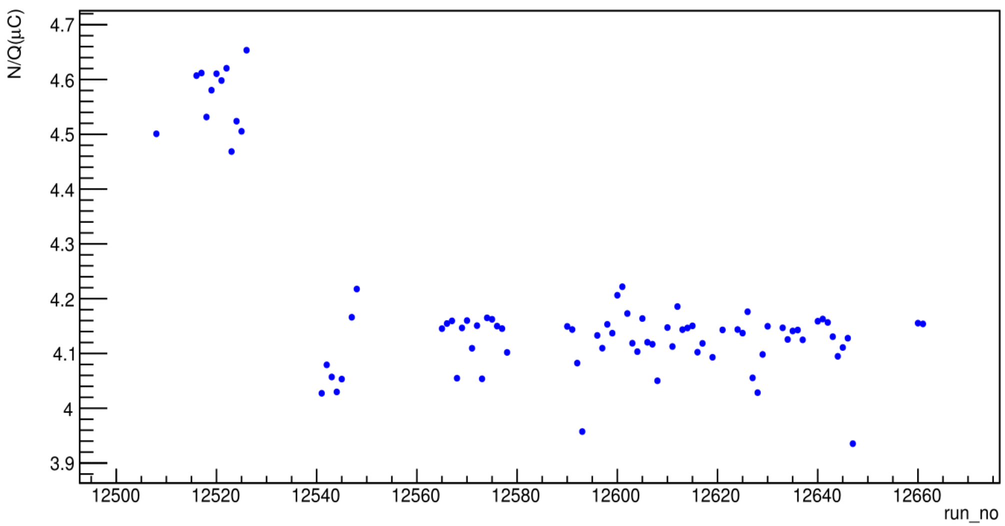
Prescale on S0&CER do not explain the observed ~8% discrepancy

Kin 481

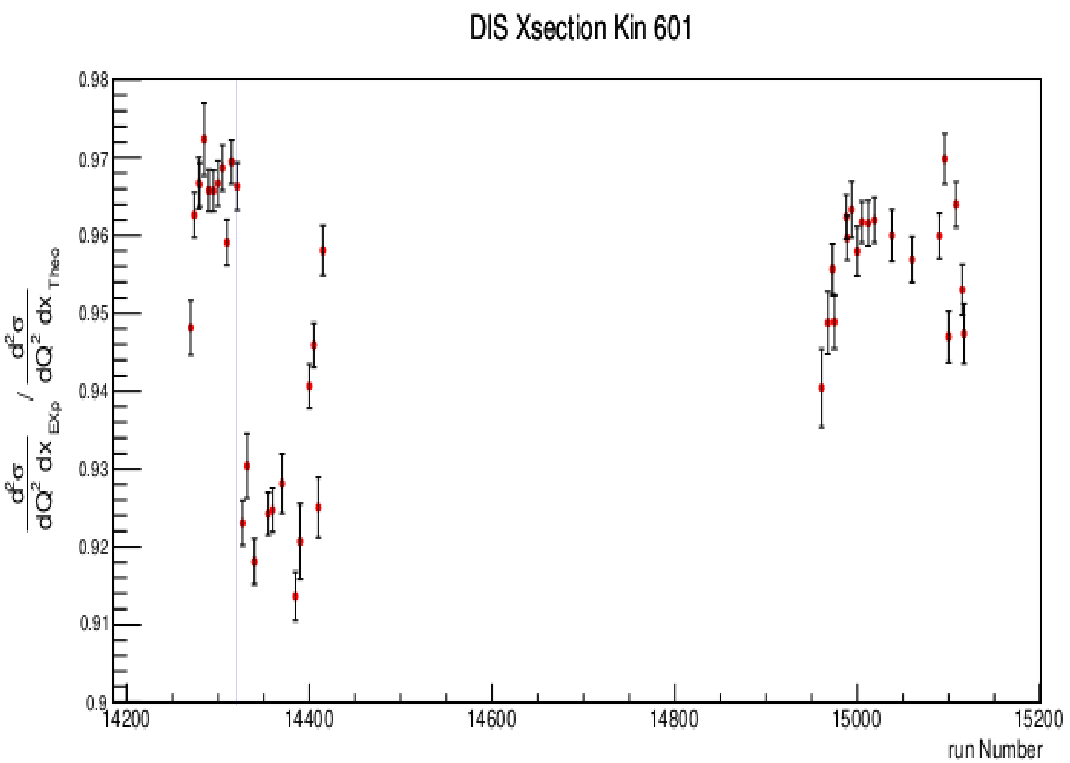
DIS and Missing events







Kin 601



- Discriminator for S2 was replaced beyond 14325 (https://logbooks.jlab.org/entry/3436133)
- Does not explain this discrepancy
- No any other major changes in kin 601

Beam energy variation

M. E. Christy et al. Phys. Rev. **C81**, 055213 (2010)

Kinematic	Reference	+ 0.5%	- 0.5%
361	28.04	0.4	0.7
362	20.79	0.5	0.5
363	13.19	0.7	0.8
481	19.60	0.5	0.5
482	7.62	0.0	0.0
483	4.58	0.7	0.4
484	2.55	0.8	0.8
601	2.05	0.5	0.2
603	0.70	0.5	0.4

+0.5% : Beam E increased by 0.5%

-0.5% : Beam E decreased by 0.5%

$\frac{d^2\sigma}{dQ^2dx}$ (E, θ, k') in order of 10^{-6} Gev^{-4}

The cross-section changes by less than 1% when beam energy is change by 0.5%

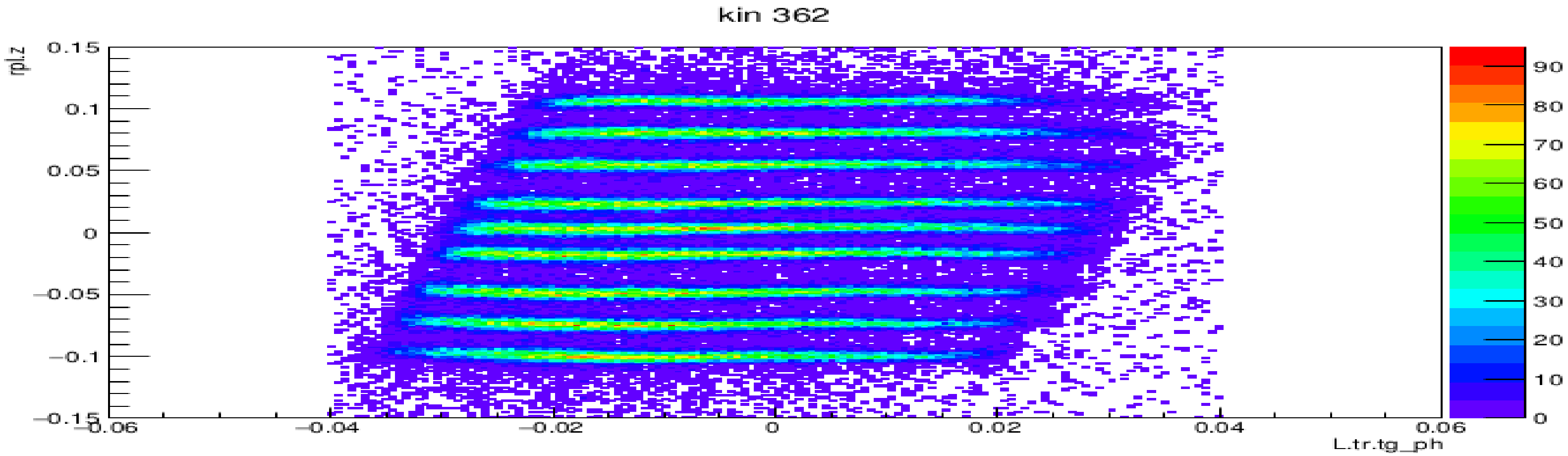
Change in beam energy does not explain the observed discrepancy in kin 481 and 601

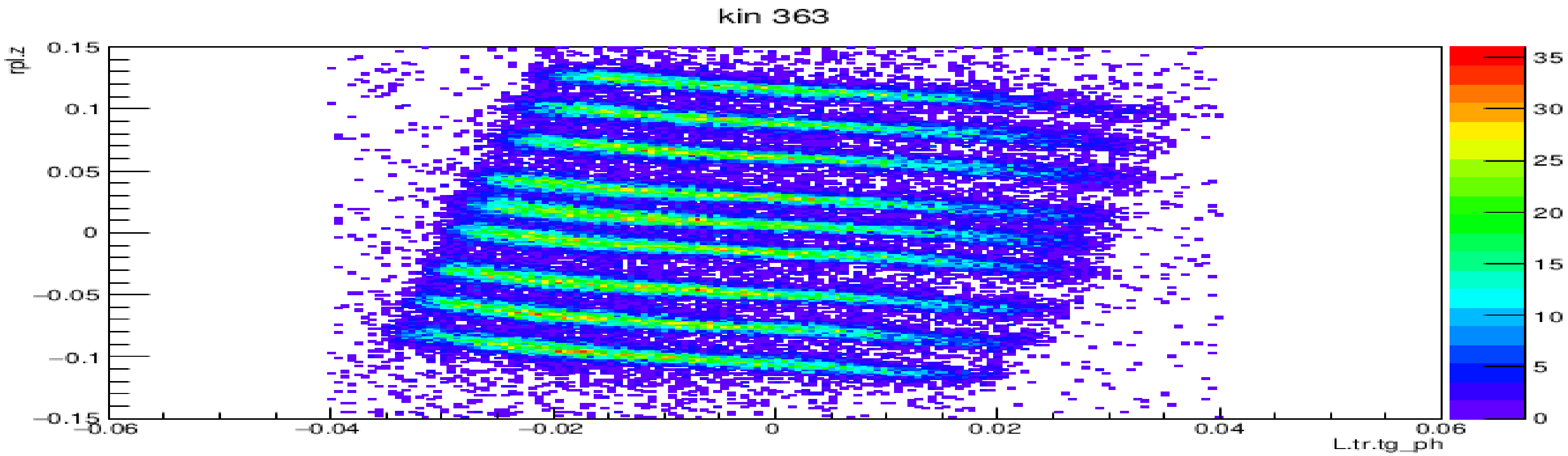
Conclusion and Outlook

- DIS cross run by run stable for most kinematic (<2%)
- Suggestion from previous discussion can be implemented and reanalyzed for 363 or Fall 2016 data
- Check detector efficiencies for problematic runs kin 601 and 481
- Target offset re-analysis

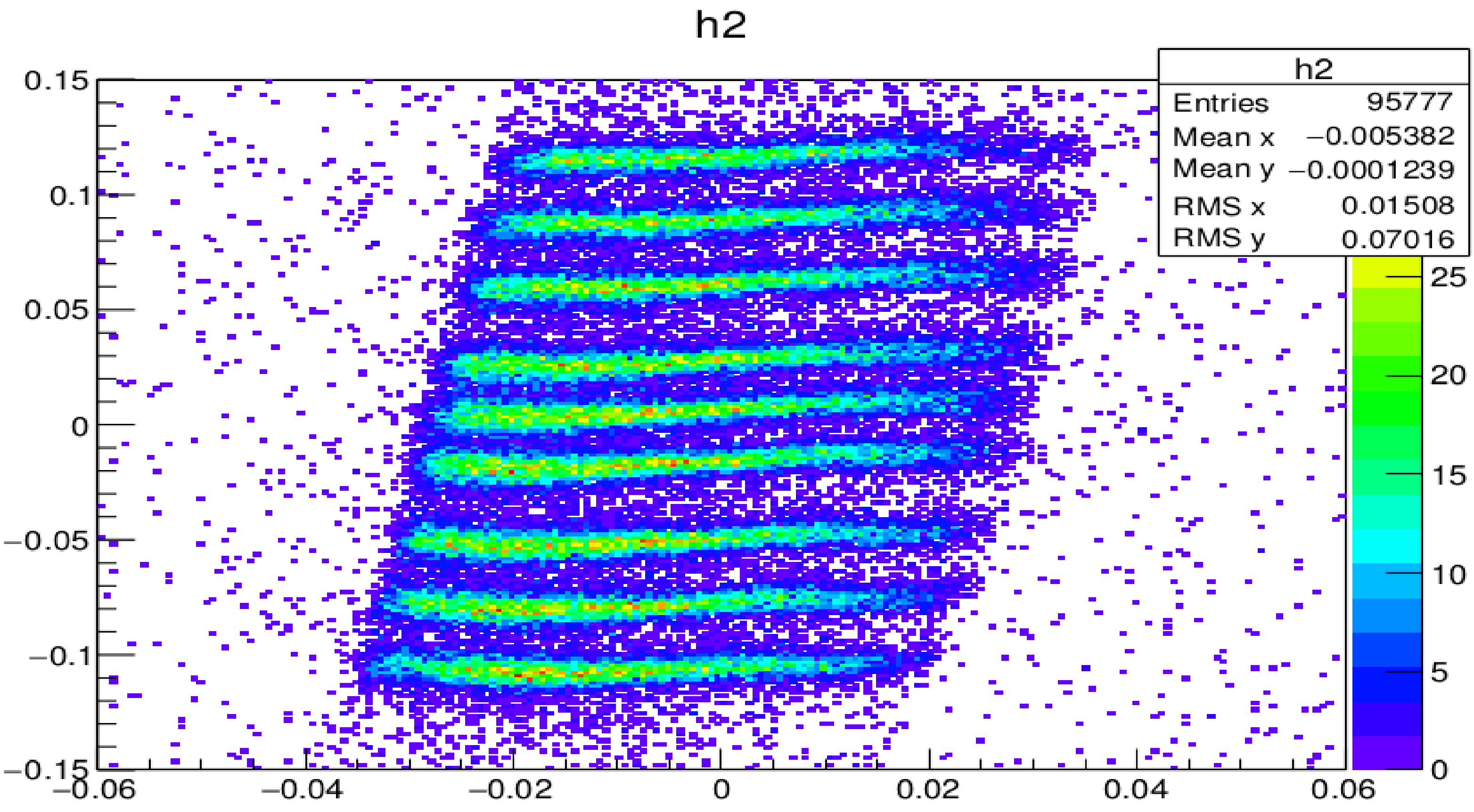
THANK YOU !

Zvertex and phi



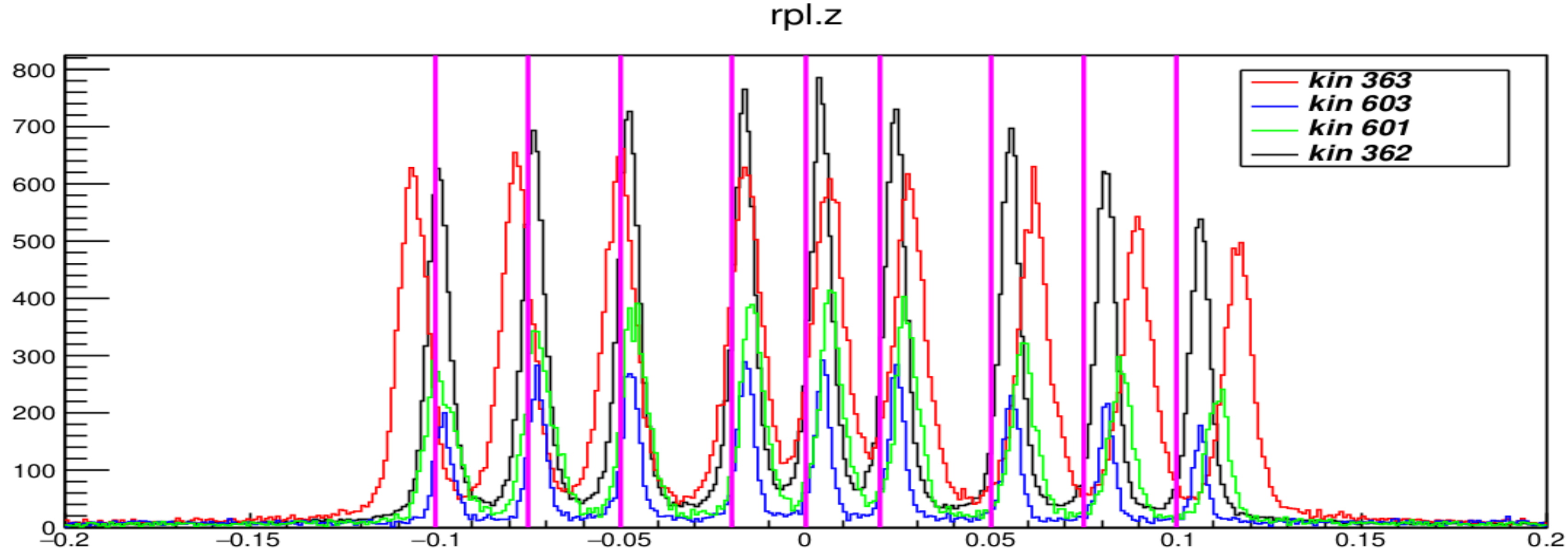


Rotation for kin 363

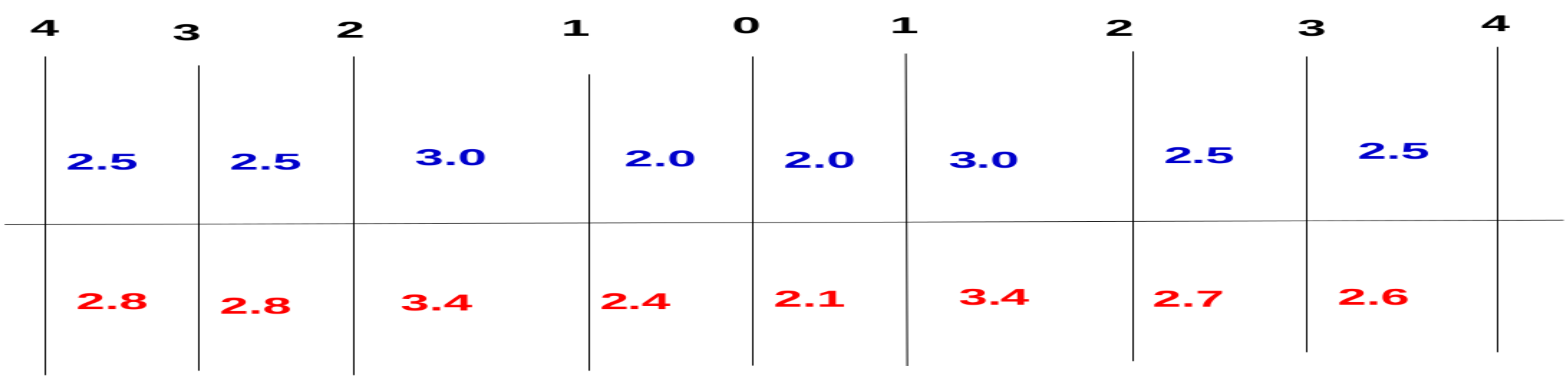


Zrotated = z+(slope* phi)

pointing runs (after rotation 363 only)



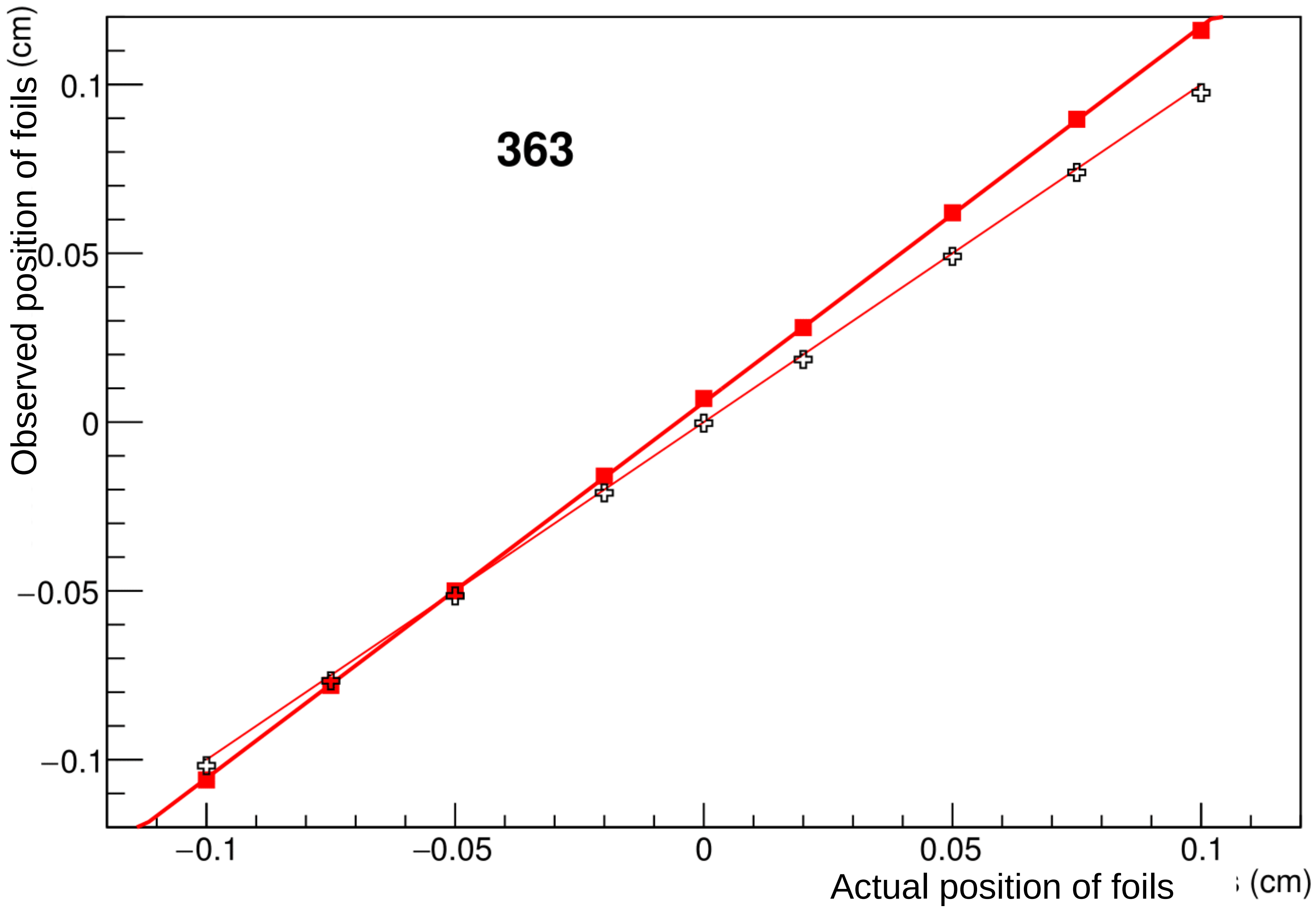
Position of foils



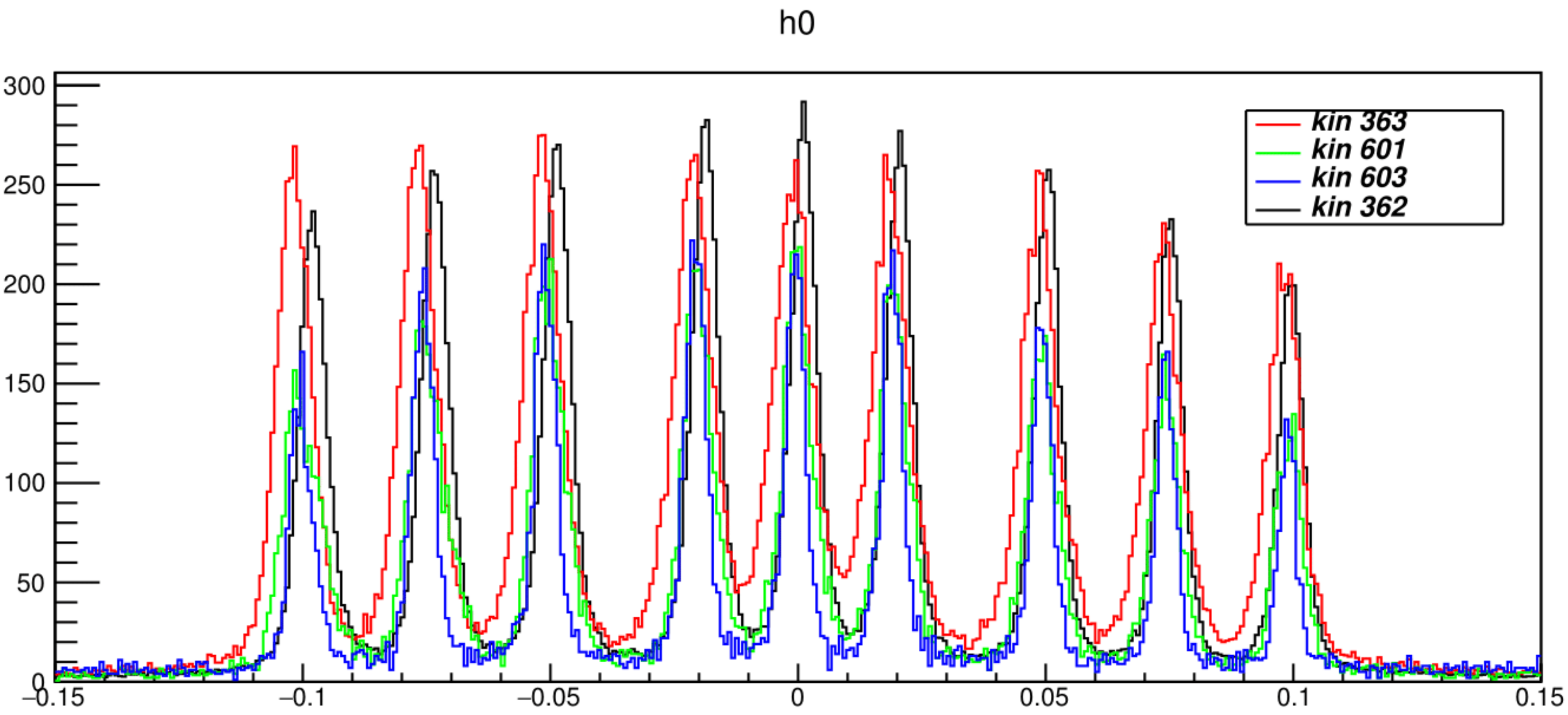
Kin 363
Actual
Observed

http://hallaweb.jlab.org/12GeV/experiment/E12-07-108/Documents/Target/Fall2016/HallATargetConfiguration10-11-16.pdf

Rotation of vertex



After rotation and rescaling



Looks nice