Geant4 Simulation package for DVCS experiments in Hall A

Rafayel Paremuzyan (IPNO)

2012 Hall A DVCS Collaboration Meeting (Nov 12-13)
and Workshop : "DVCS and other opportunities in Hall C" (Nov 11)

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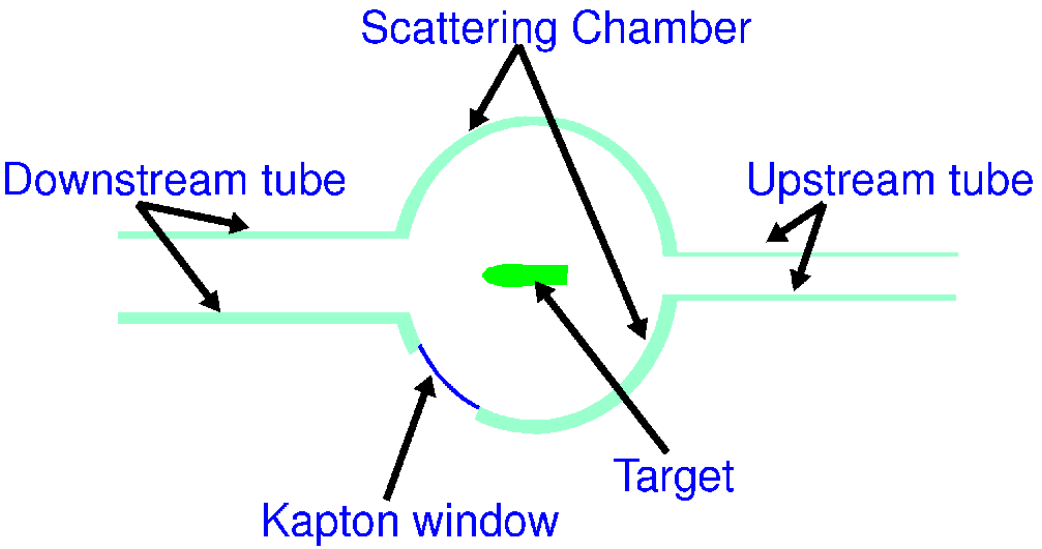
Outline

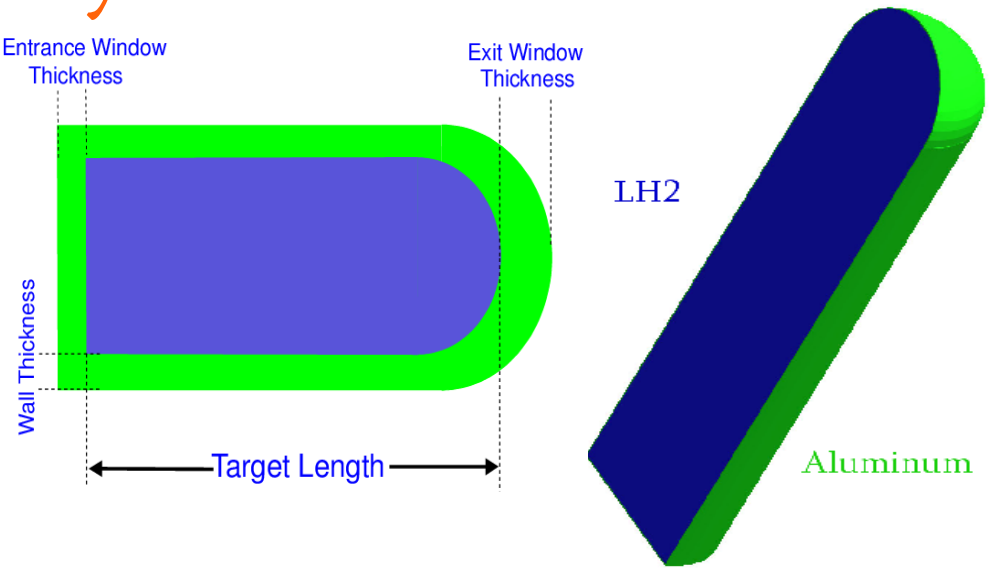
- Code structure: Geometry and materials and output variables
- Resolutions: Energy and angular.
- Counting rate estimations for DVCS experiments
- Summary

Geometry 1

DVCSDetecotrConstruction

- Geometry
- Materials
- Physical properties of materials





Target

$LH2$ density	$0.0708\ g/cm^3$
target length	15 cm
wall thickness	0.141 mm
entrance window thickness	0.128 mm
exit window thickness	0.207 mm
external radius	2.032 cm

Target

Component	Inner radius (cm)	outer radius
SC (Sphere)	61.29	62.25
Down-tube (cylinder)	7.702	8.413
Upper-tube (cylinder)	2.85	3.15

Kapton Window

thickness	0.508 mm
horizontal angular range	18 : 44 degree
vertical angular range	-5.04 : 5.04 degree

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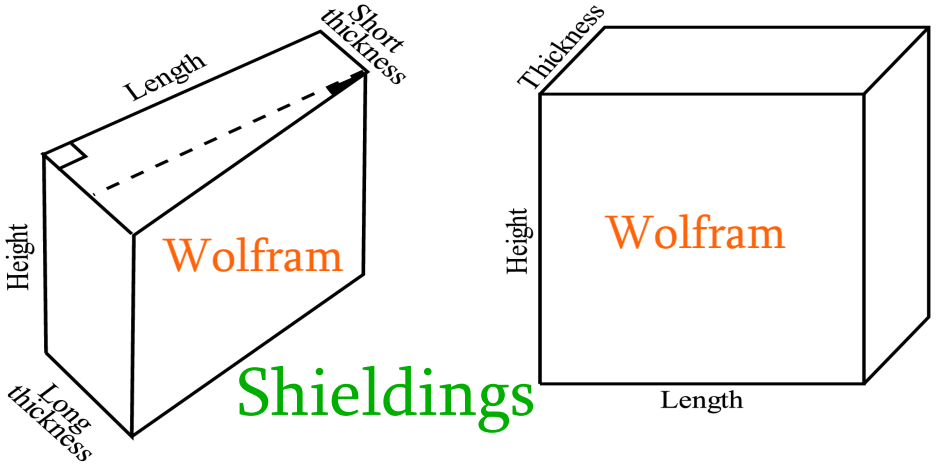
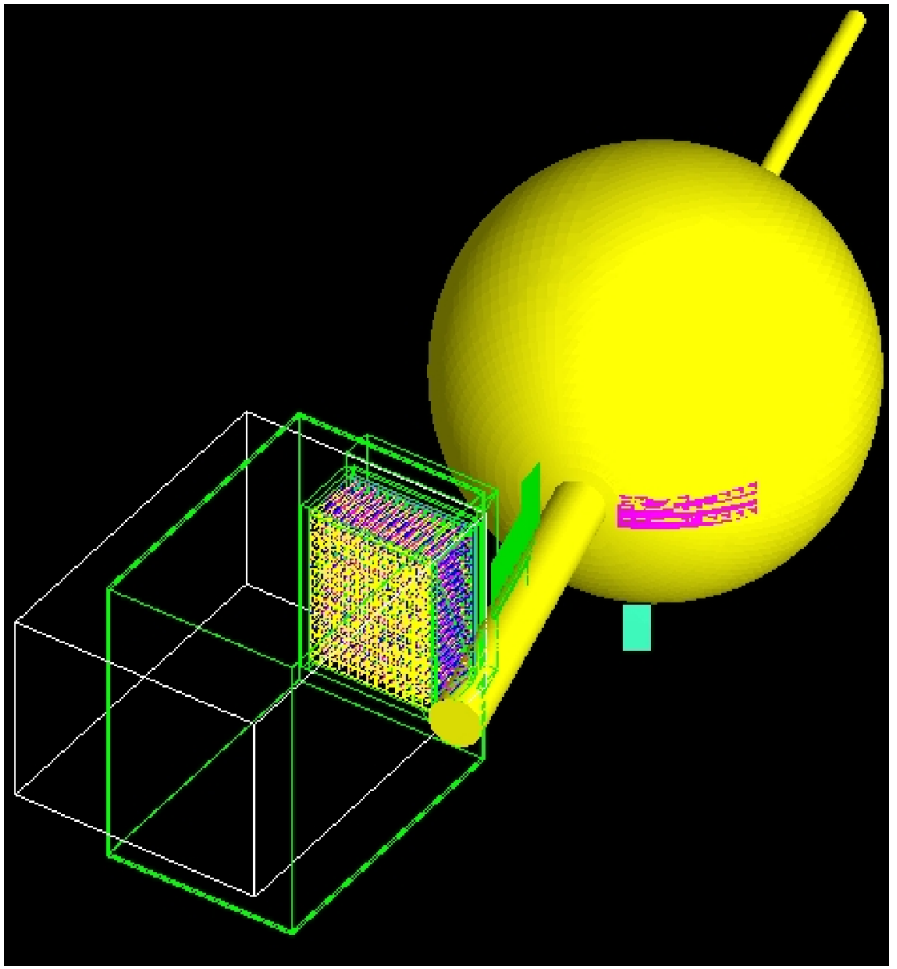
Geometry 2



Shieldings

	Nose shielding	beamline shielding
Length	3.94 in	10.236 in
Height	4.24 in	7.087 in
Short/Long thickness	0.732/0.84 in	0.591 in
distance from target along "Z" axis	68.3 cm	78.3 cm



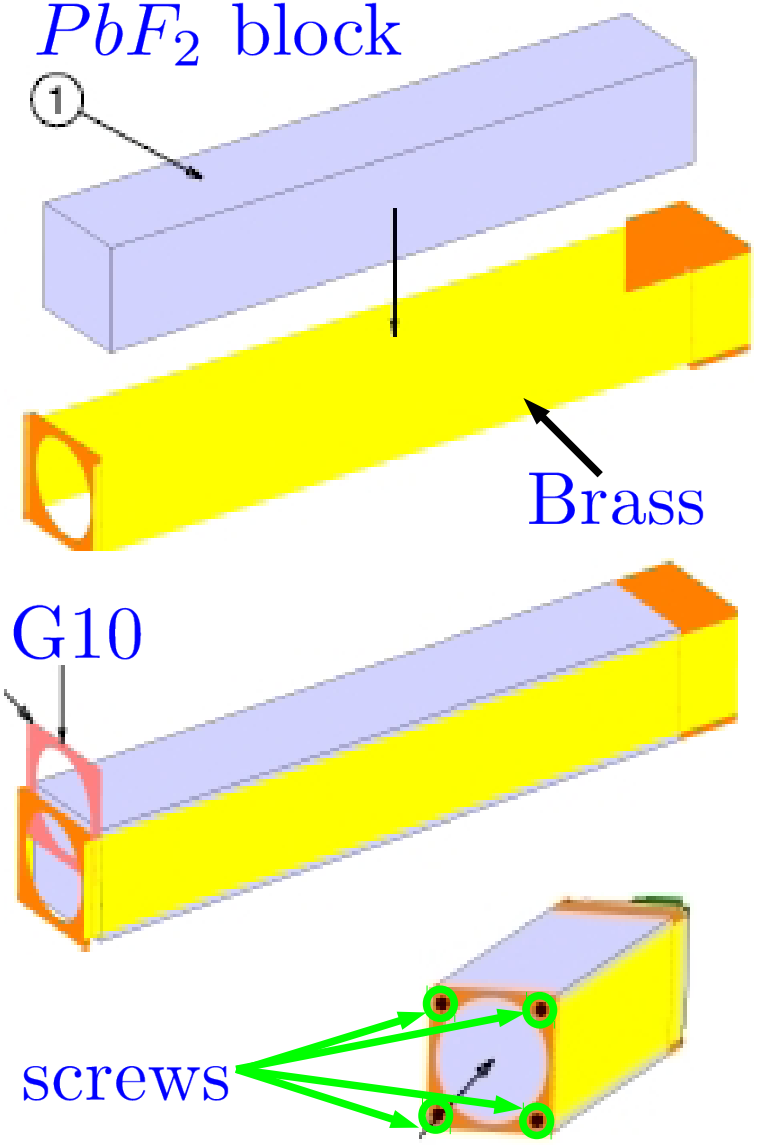
PbF2 block 3x3 cm and 20 rad. length

Totally there are 16x13 blocks

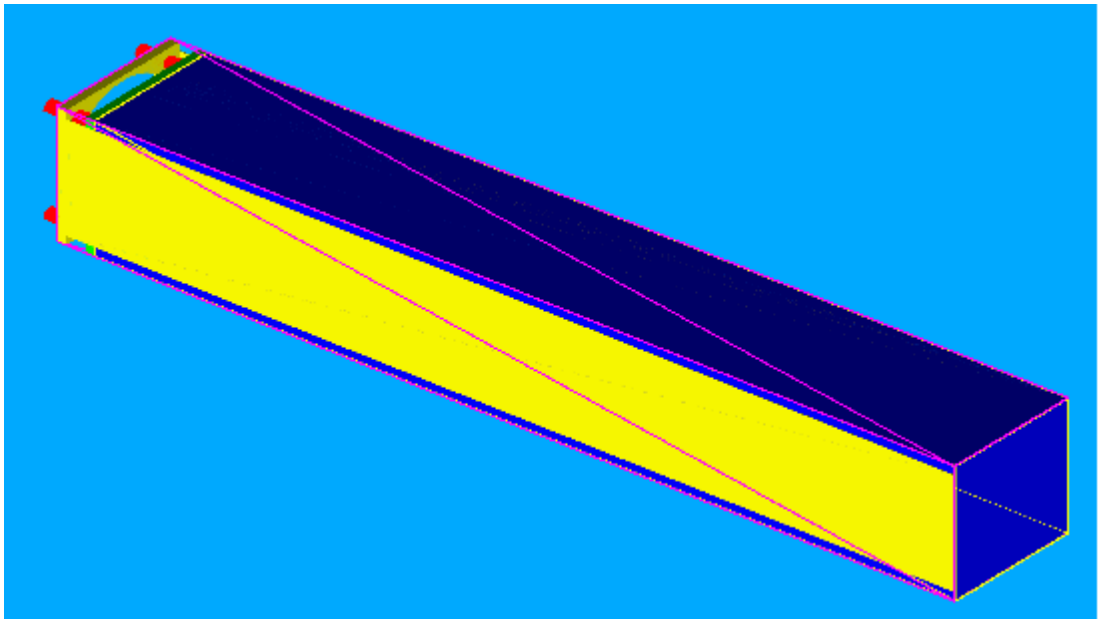
Implemented by Maxime Defurne

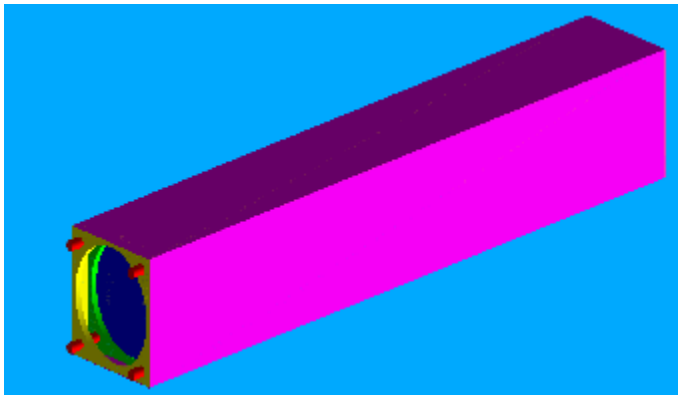
Geometry 3

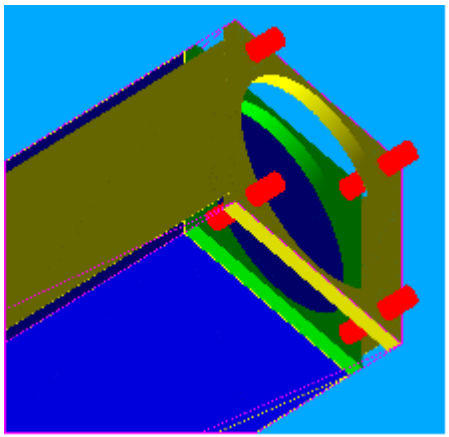
Technical drawings



Geant4 drawings







Each block is placed according to survay coordinates.

Implemented by Maxime Defurne

Code structure

PhysicsList:
Define physics processes

Detector Construction:
Describe all material geometry and physical properties

PrimaryGeneratorAction:
Describe generated particles

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Calculate kinematic variables, Q2, xB etc...

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N-tuple

Variables at production vertex

Code structure

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Event Action

BeginOfEventAction

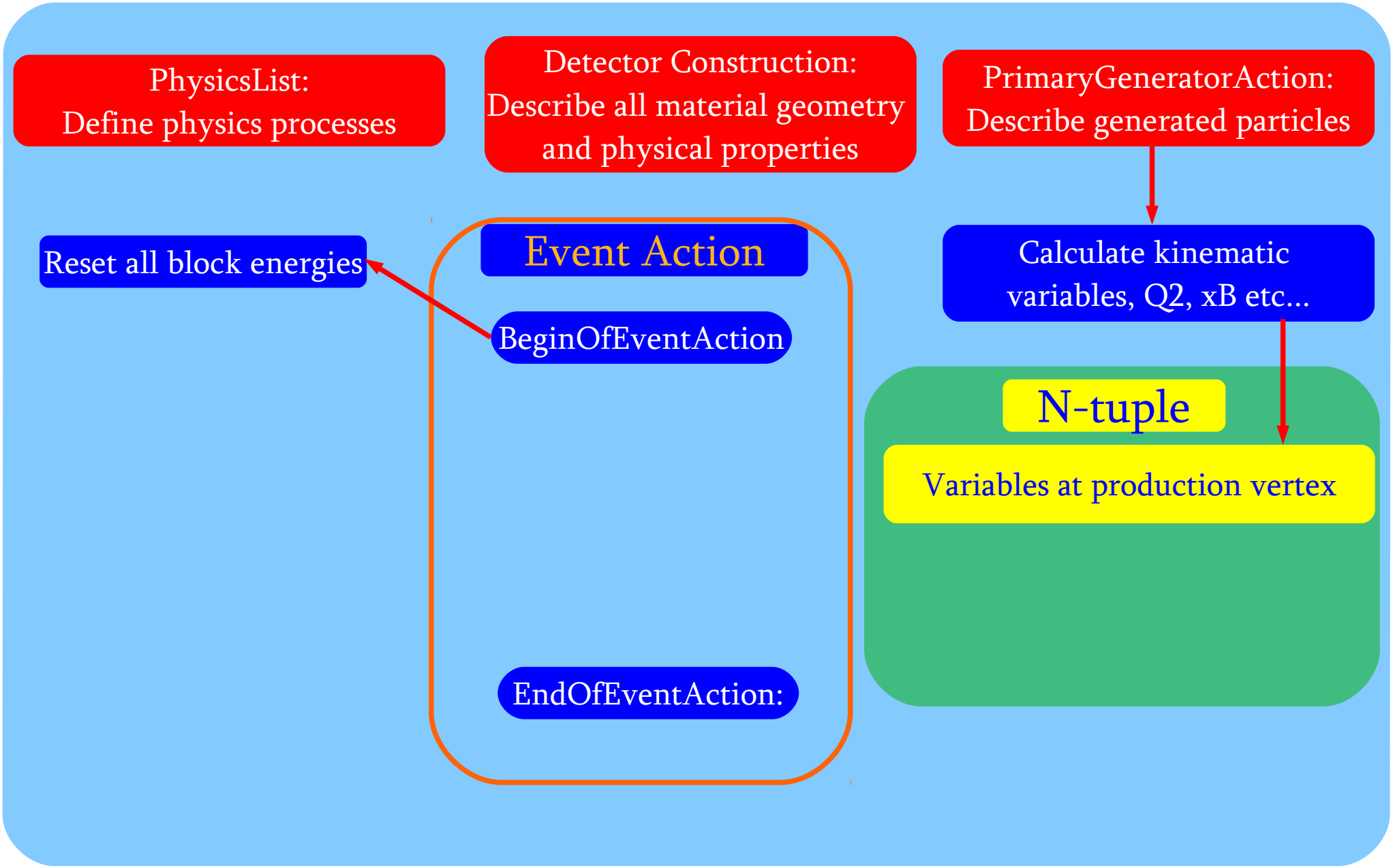
EndOfEventAction:

Calculate kinematic variables, Q2, xB etc...

N-tuple

Variables at production vertex

Code structure



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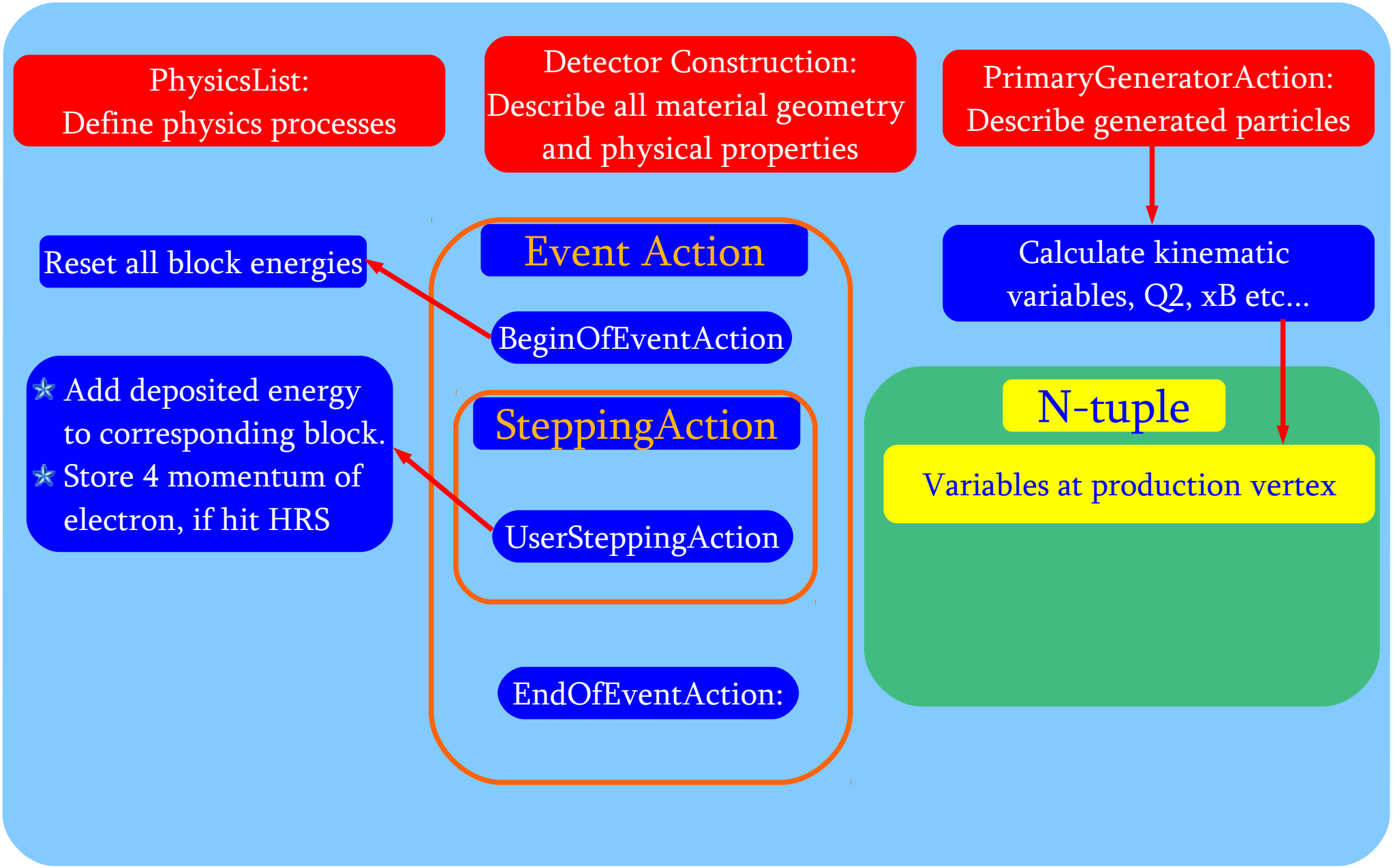

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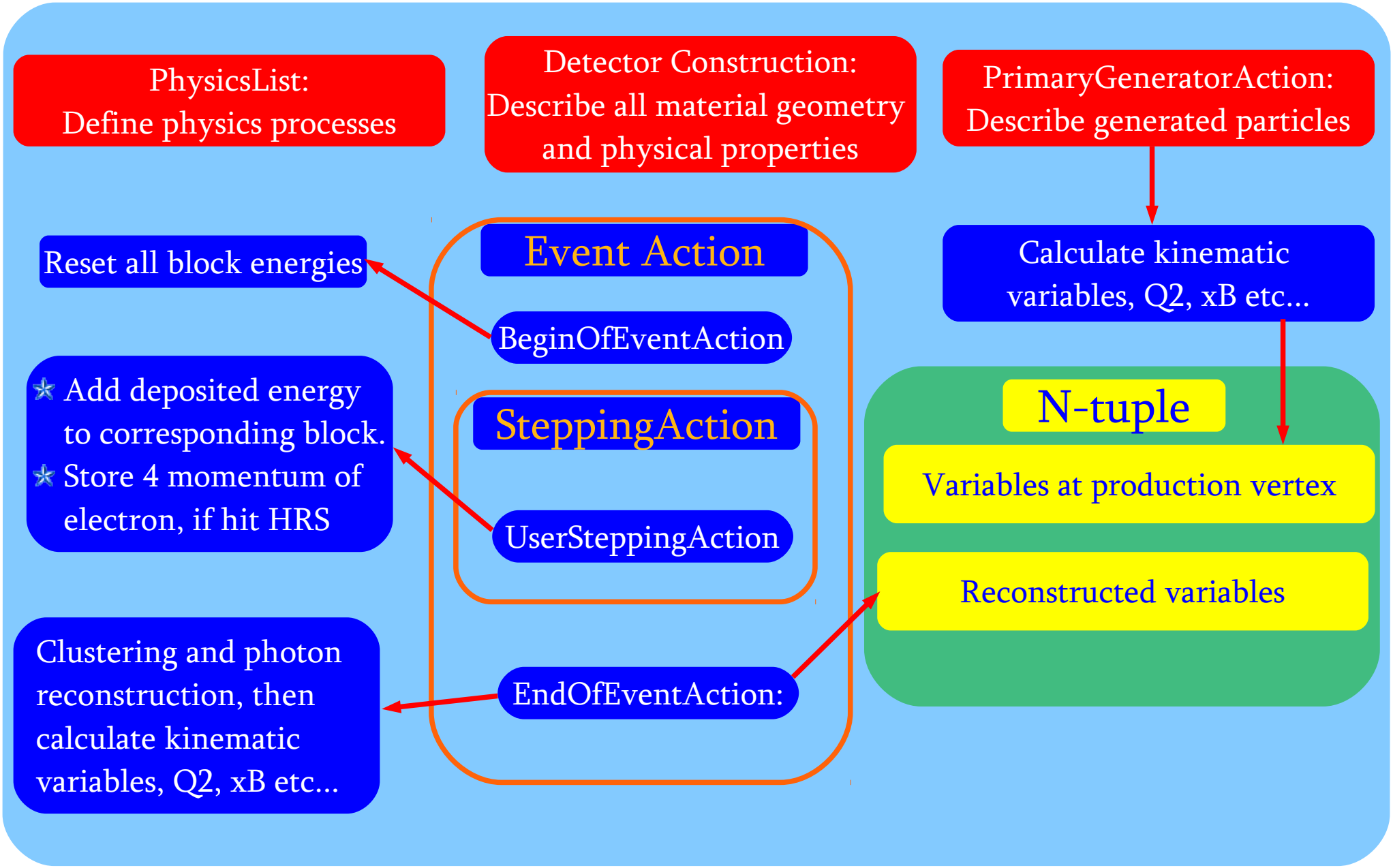
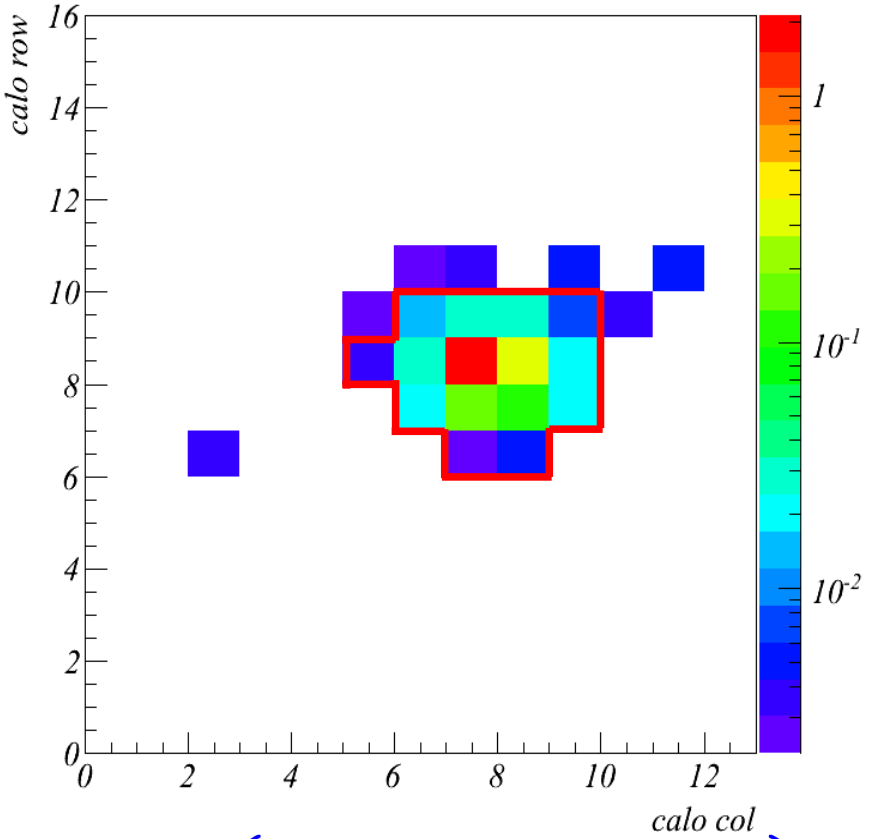


Cluster reconstruction

Photon reconstruction was implemented Using clustering algorithm developed by Carlos

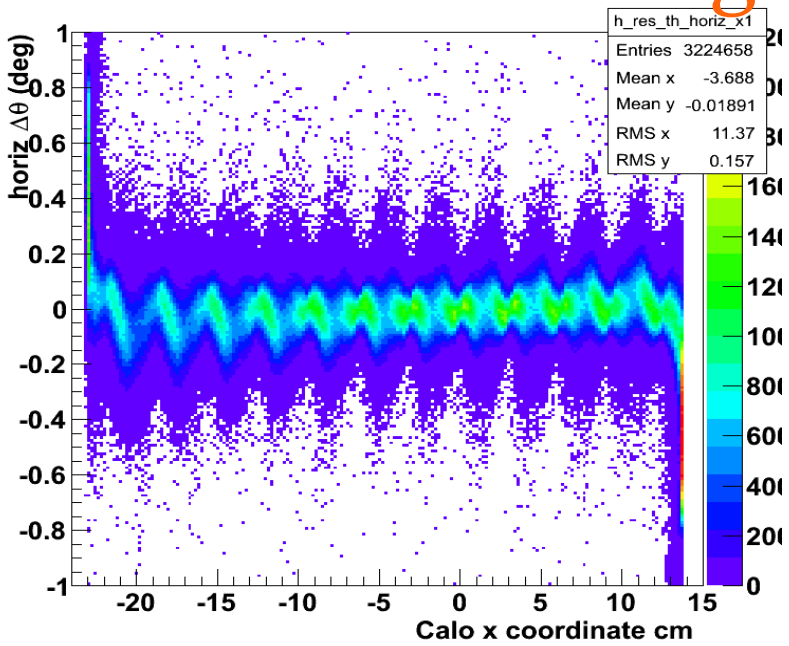
- Scan all sets of 2x2 blocks and remove those whose total energy is below a threshold (100 MeV)
- Find local maxima, and blocks belong to a cluster, if they have a decreasing energy from the cluster center (maximum), up to an energy e^{-W_0} of the total energy

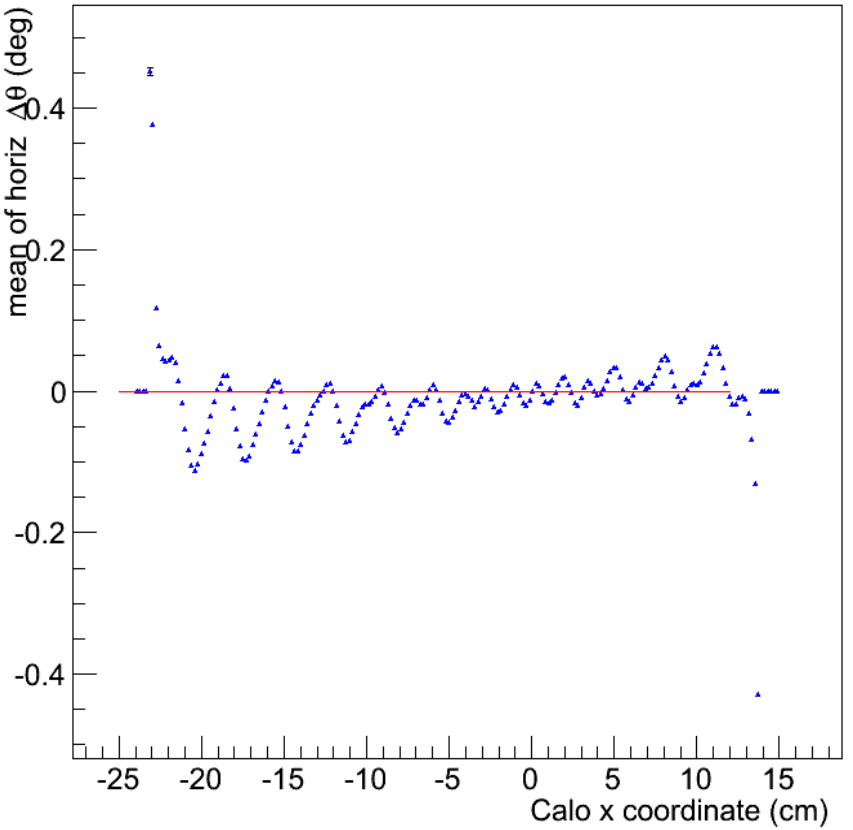
Energy distribution in blocks for One particular event

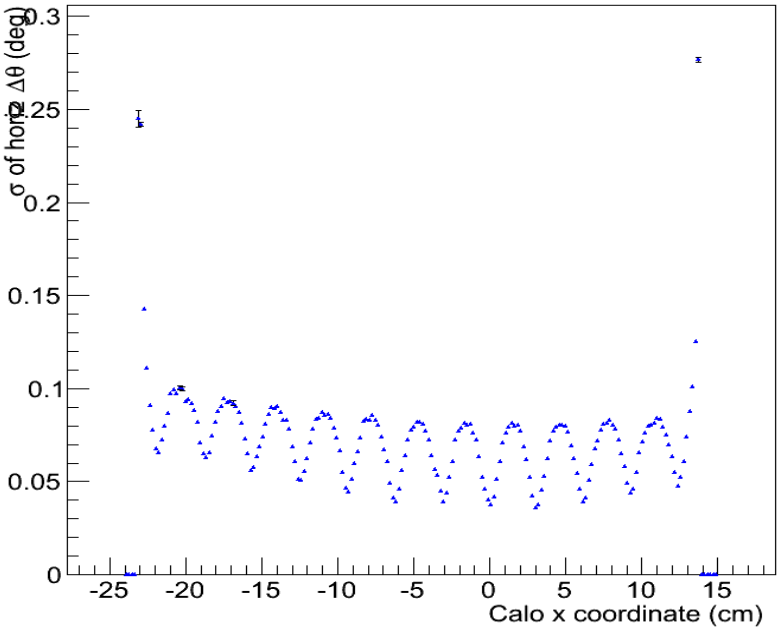


$$E = \sum_i E_i \qquad x = \sum_i \frac{w_i x_i}{w_i} \qquad w_i = max\left\{0, W_0 + ln(\frac{E_i}{E})\right\}$$

Angular resolution







Mainly $\sigma < 0.08\ deg \Rightarrow \delta_x < 0.2\ cm$

This is consistent with previous Geant3 Simulations for old calorimeter

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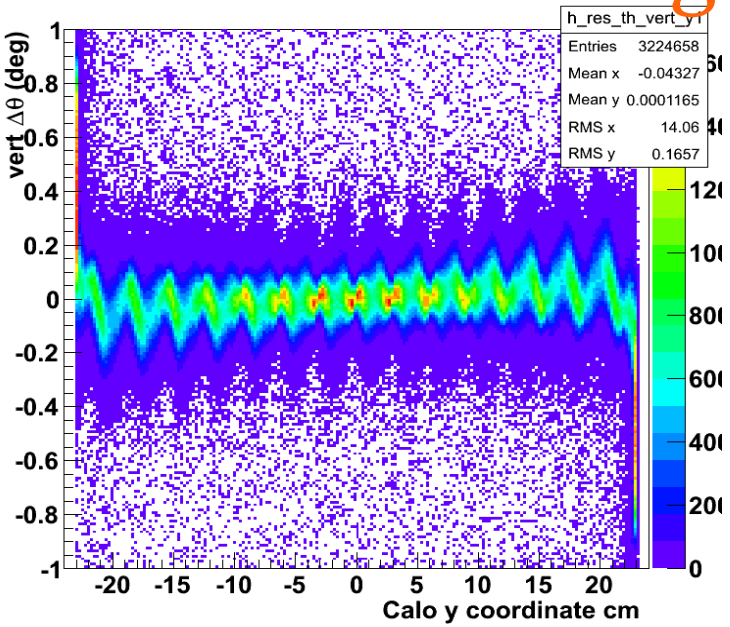
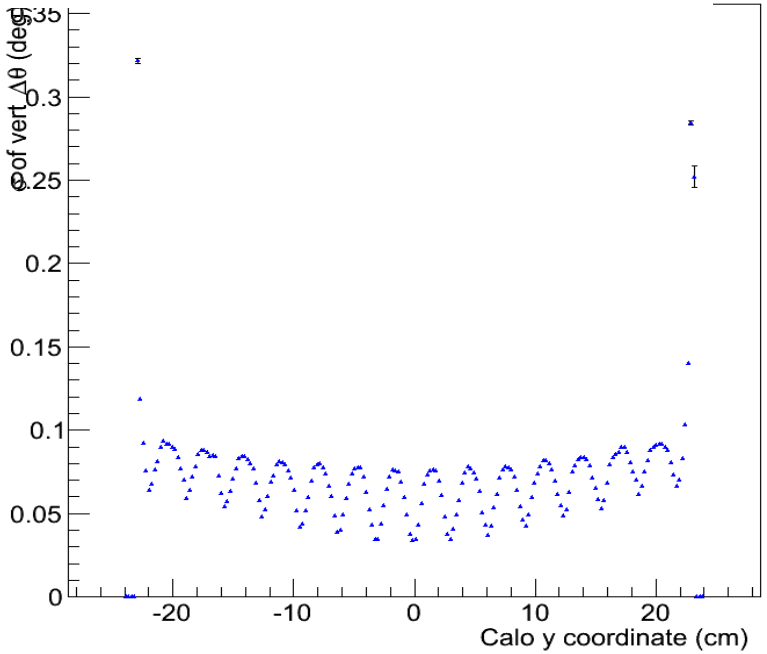
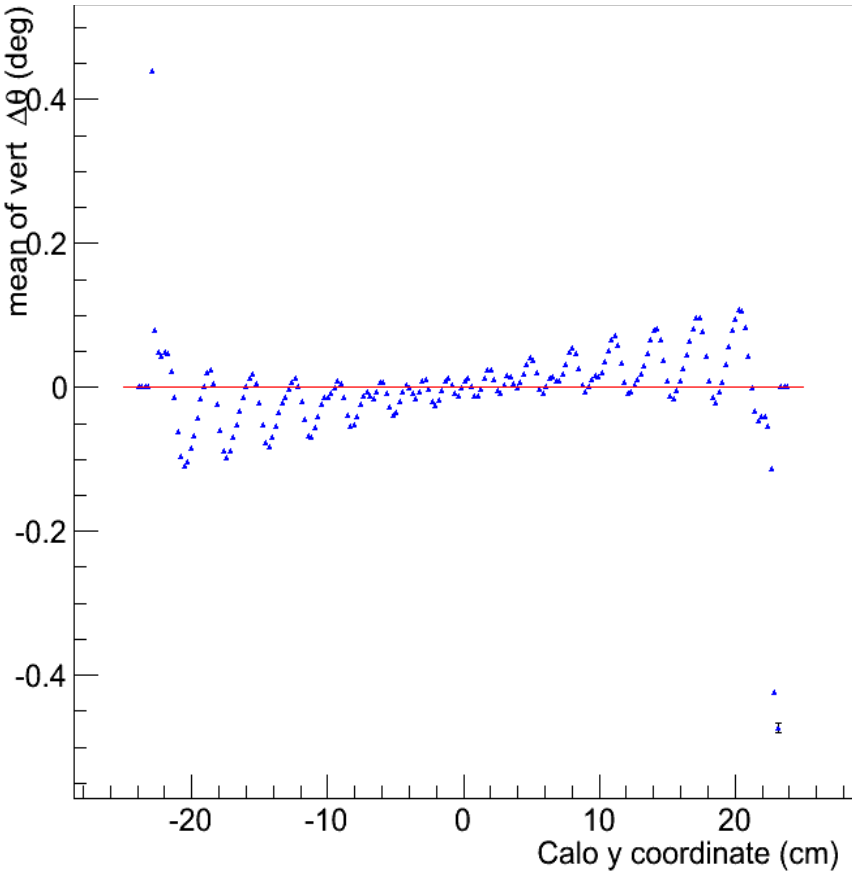
Angular resolution



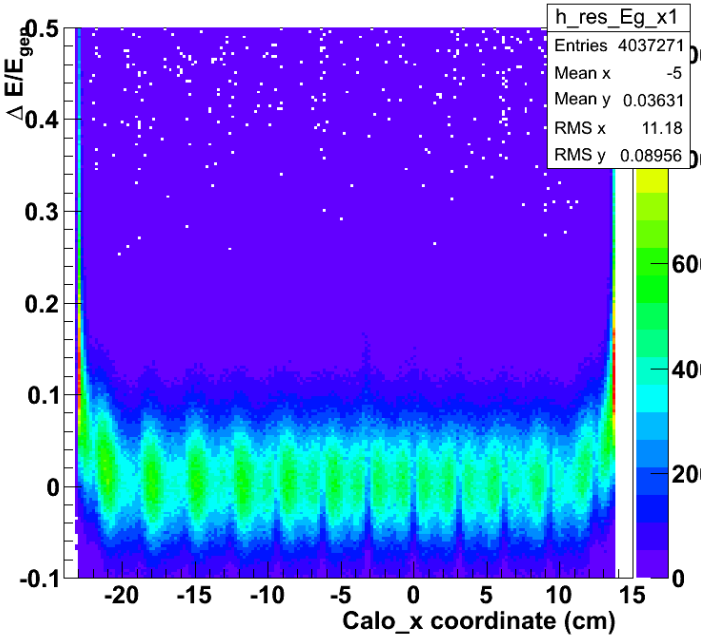


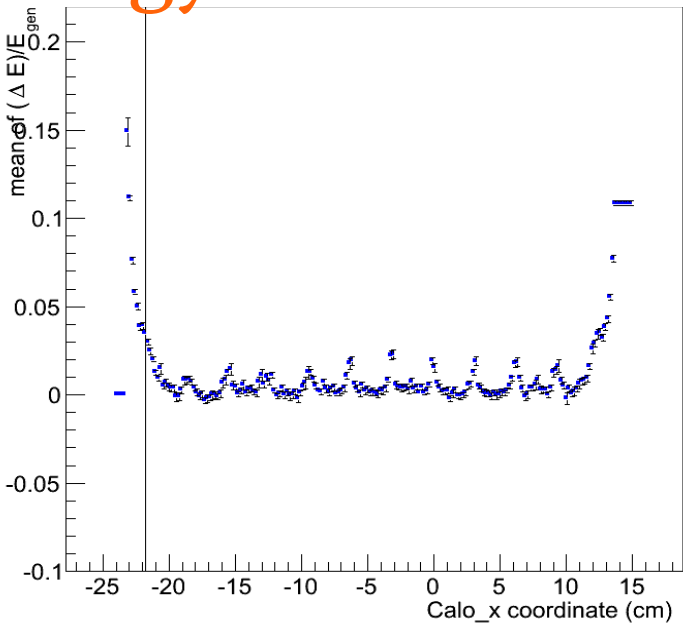


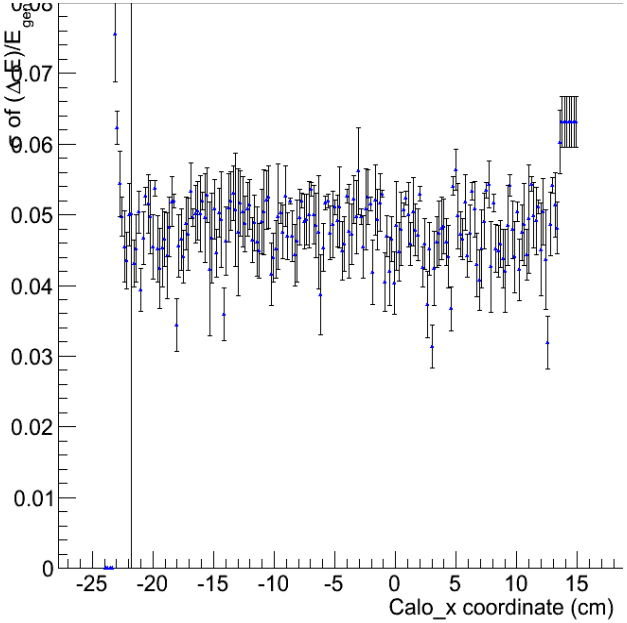
Vertical angle also has the same resolution

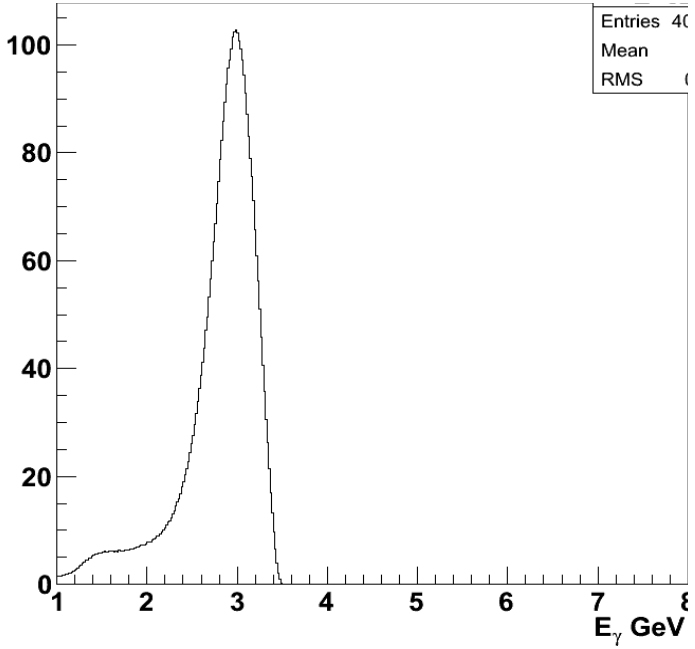
In terms of angular resolutions this Simulation Is consistent with previous Geant3 simulations

Energy resolution









Energy in the block was smeard by $\sigma = 1/\sqrt{175}$

$$\frac{\sigma(\Delta E)}{E} \approx \frac{8.\%}{\sqrt{E(GeV)}}$$

This is also consistent with Geant3 simulation

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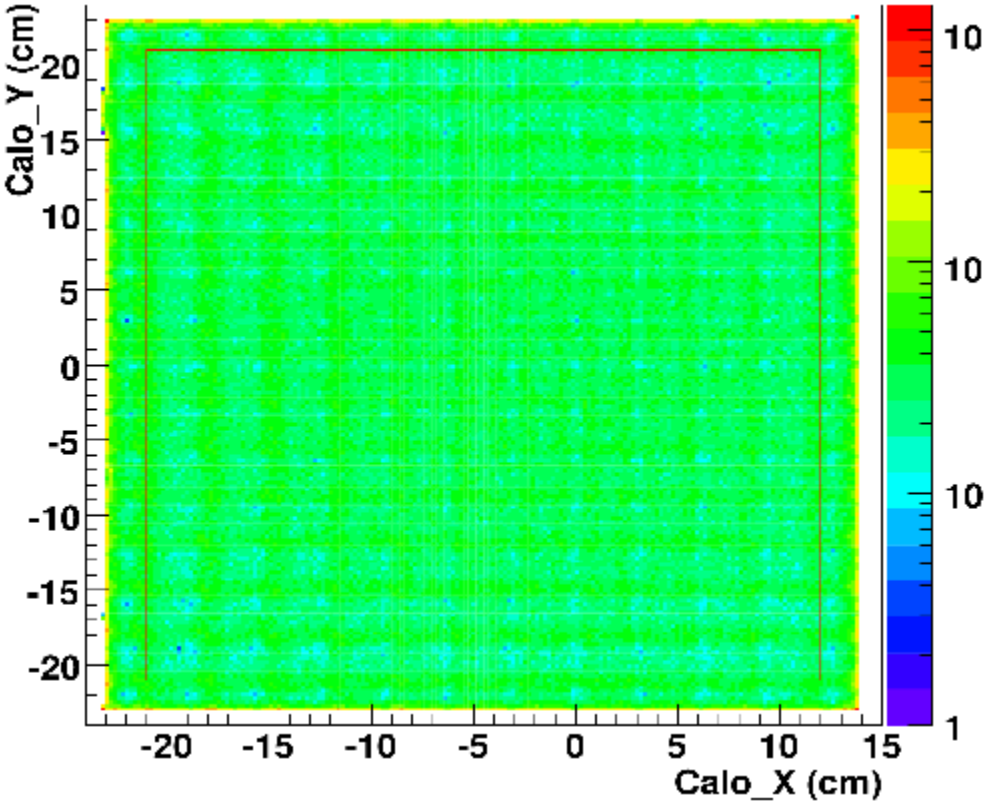
Fiducial and MM2 cuts

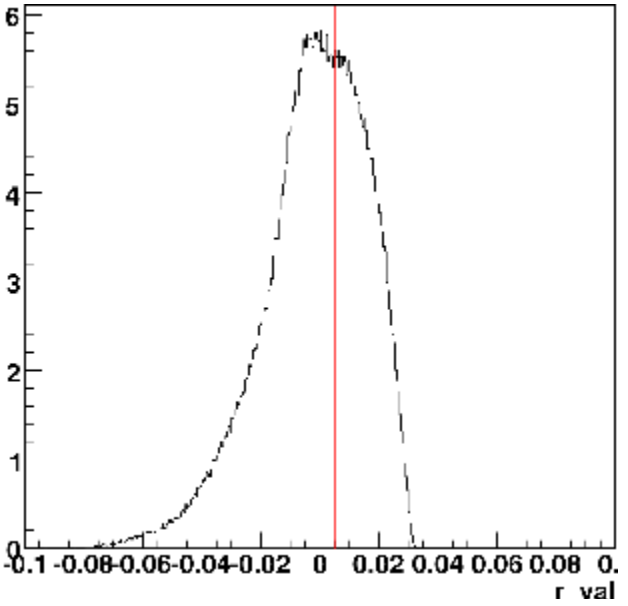
In order to get estimates for rates

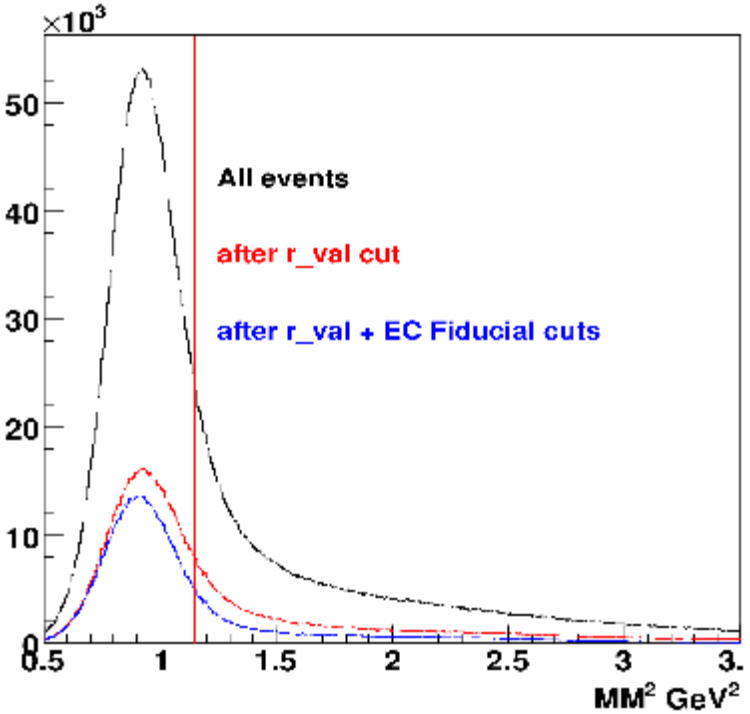
Events were generated flat over Q^2, x_B, t, $\phi_{\gamma,\gamma}$, and ϕ_e, then weighted by DVCS cross section.

arXiv:1210.6975v1,

Peter Kroll, Hervé Moutarde, Franck Sabatié

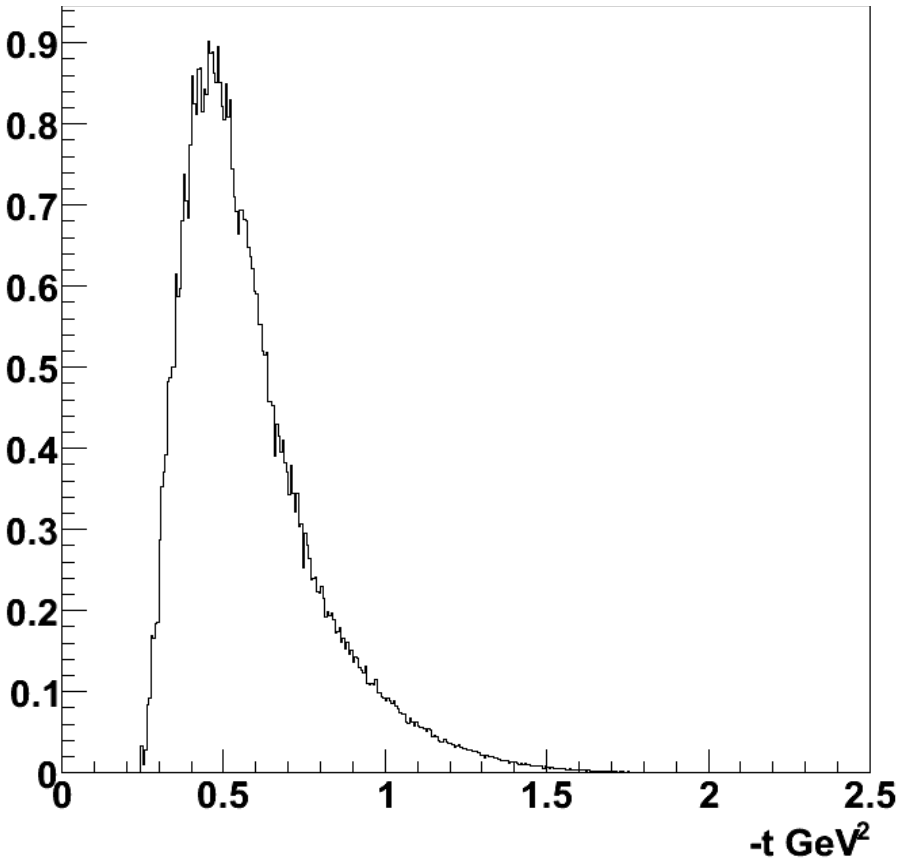


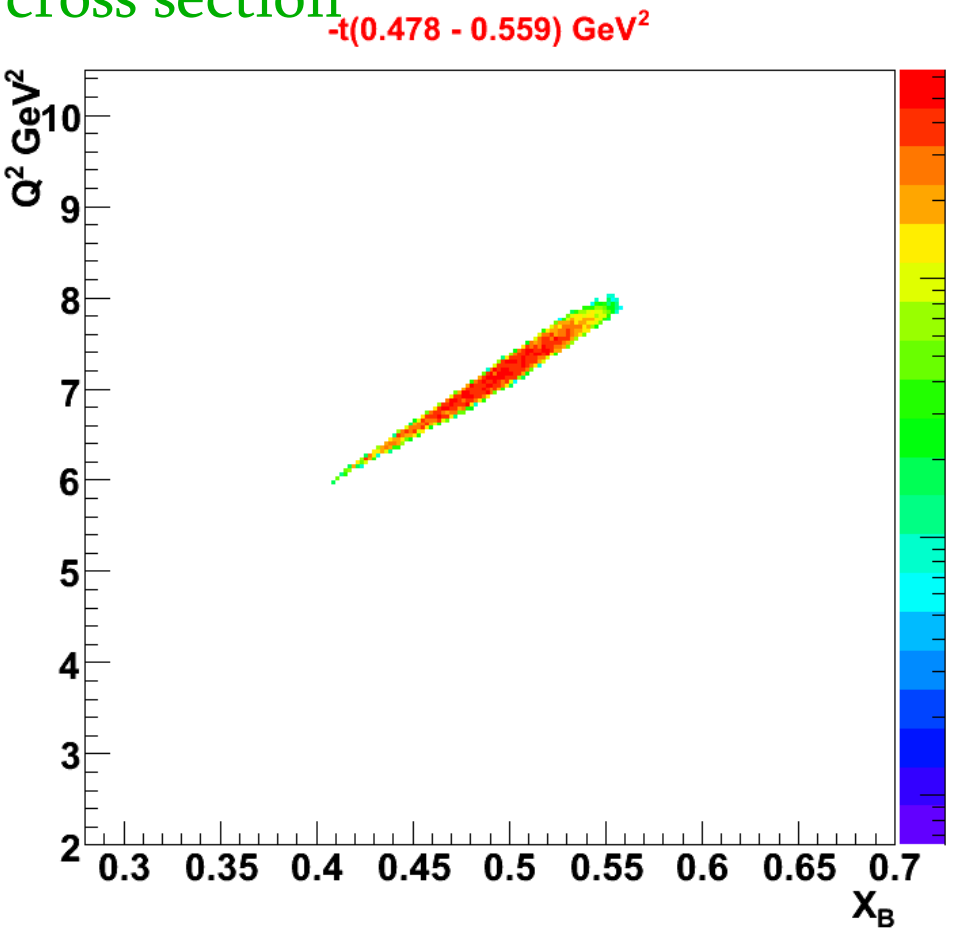




Kinematic distributions

Weighted by cross section



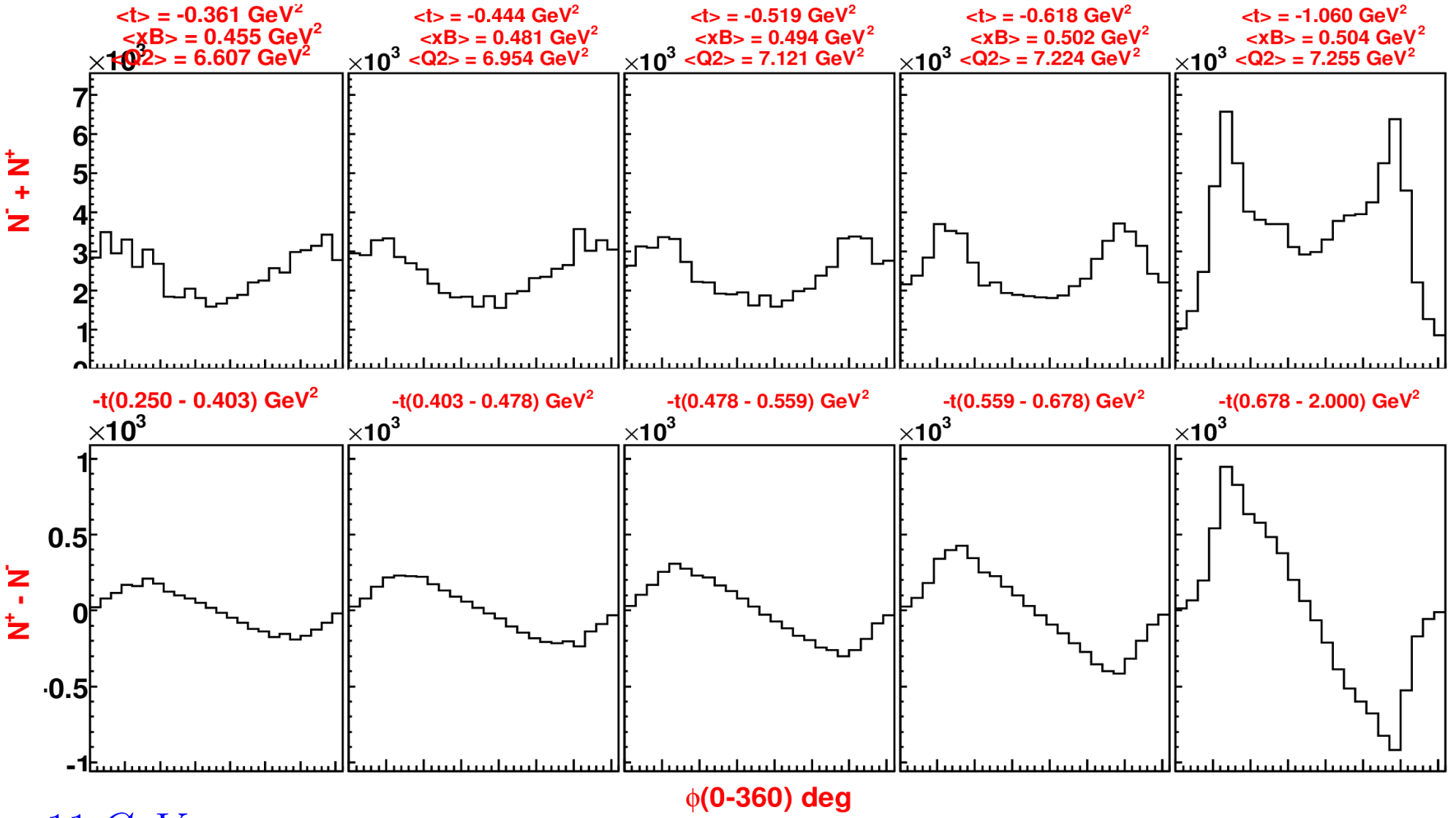


11 kinematic settings from proposal

5 t bins in each kinematic setting

PR12-06-114, http://arxiv.org/abs/nucl-ex/0609015

Estimated rates



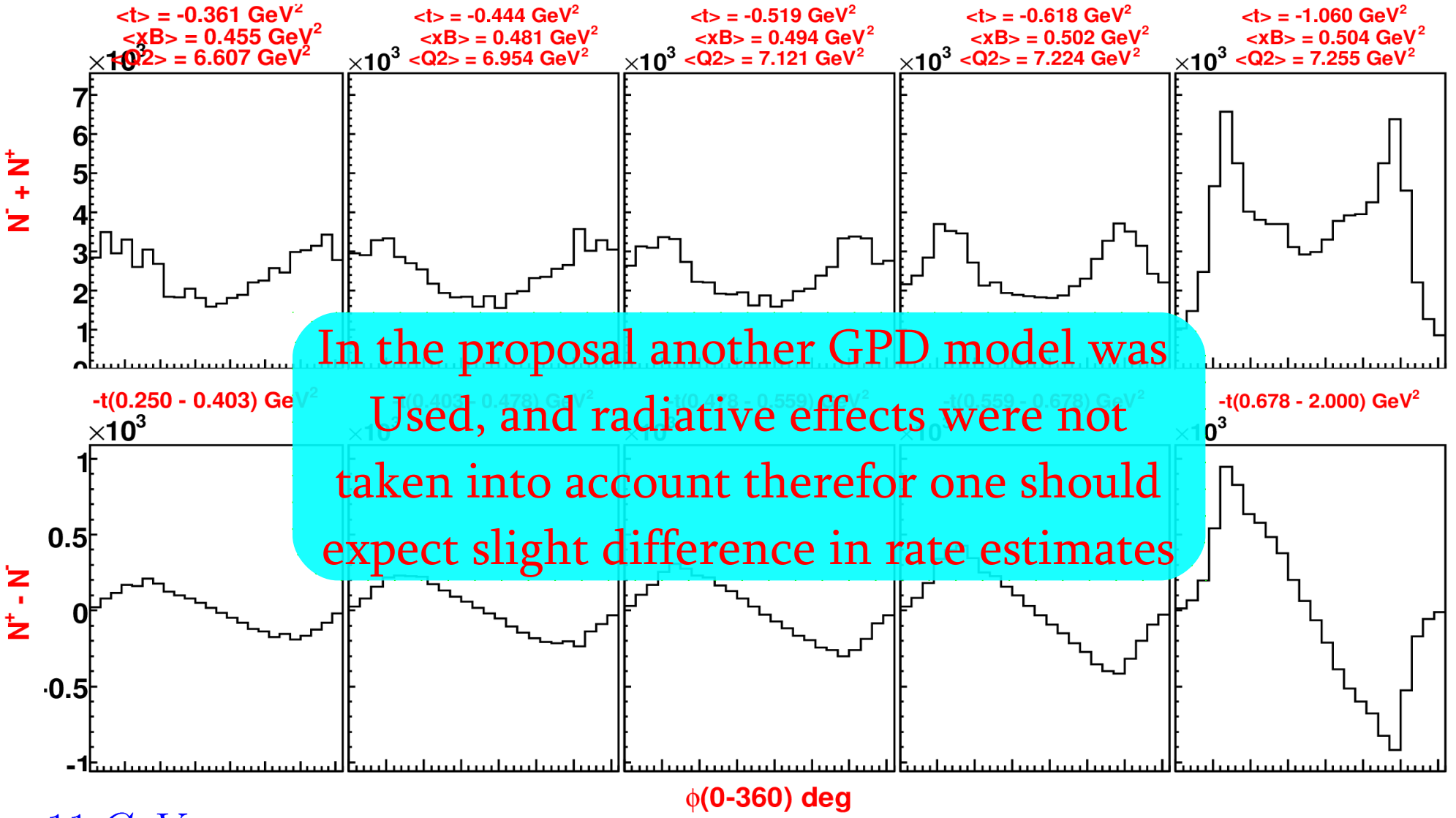
$k = 11\ GeV$

$d = 2.5\ m$ $\quad L = 2 \times 10^{38} cm^{-2} s^{-1}$ $\quad \theta_{HRS} = 25.6\ deg$

$\theta_{calo} = 10.42\ deg$ $\quad$ beam time $= 168h$ $\quad P_{HRS} = 3.32\ GeV$

$$N = \frac{L}{N_0} \sum_i \sigma_i (psf)_i$$

Estimated rates



In the proposal another GPD model was Used, and radiative effects were not taken into account therefor one should expect slight difference in rate estimates

$k = 11\ GeV$
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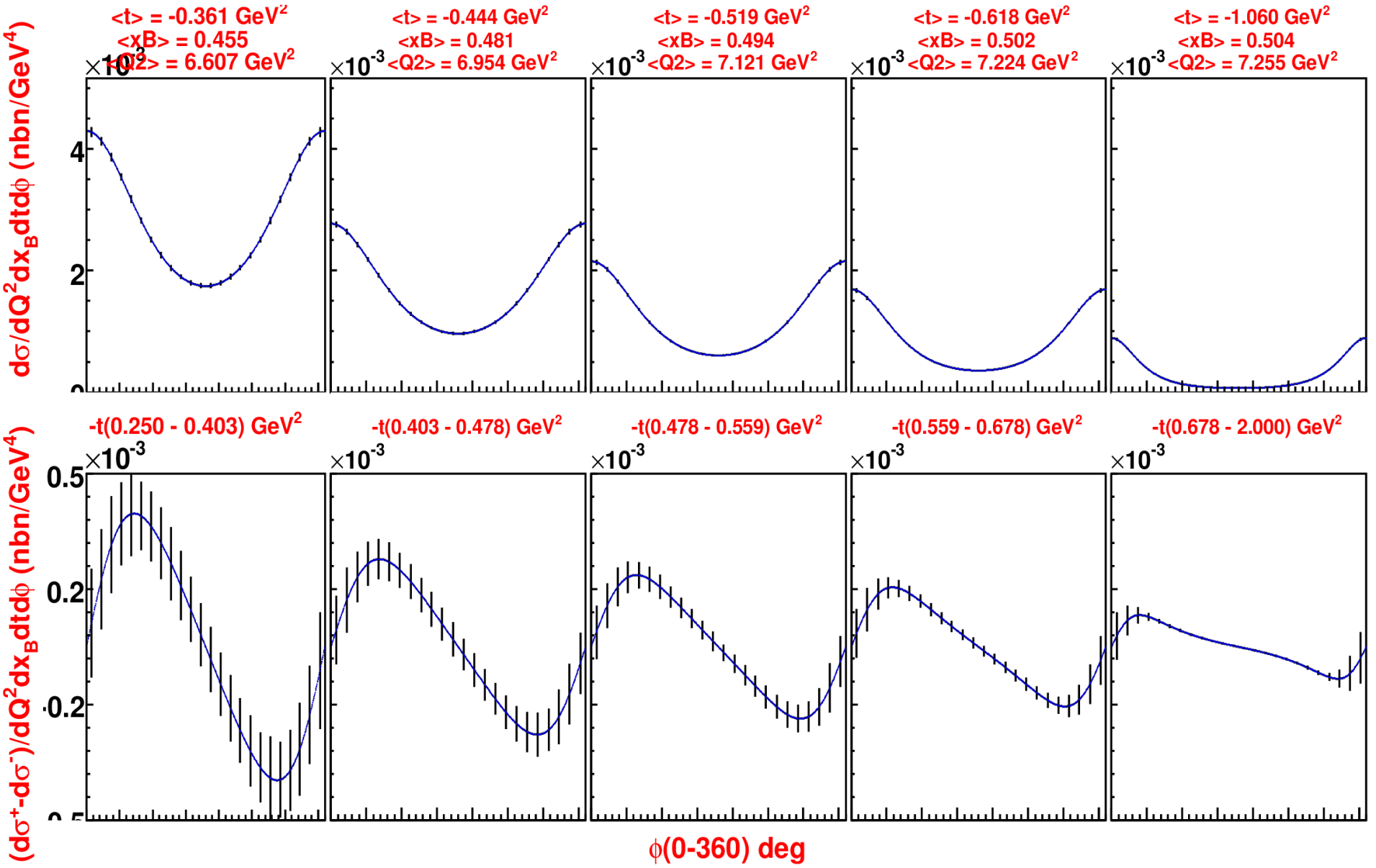
$$N = \frac{L}{N_0} \sum_i \sigma_i (psf)_i$$

Estimated Error bars



Summary

- Experimental setup implemented in Geant4 code
- Calorimeter angular (coordinate) and energy resolutions were studied, which are consistent with previous Geant3 results.
- As an application of the code, DVCS rates were estimated.
- Next step is to compare with previous DVCS Geant3 simulation i.e. reanalyze previous cross-section data with the new simulation (and hopefully find consistent results)