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DVCS Monte Carlo Simulations

Hall A DVCS collaboration meeting

19-20 December 2013

Old Dominion University

Outline

Geant4: DVCS experimental setup

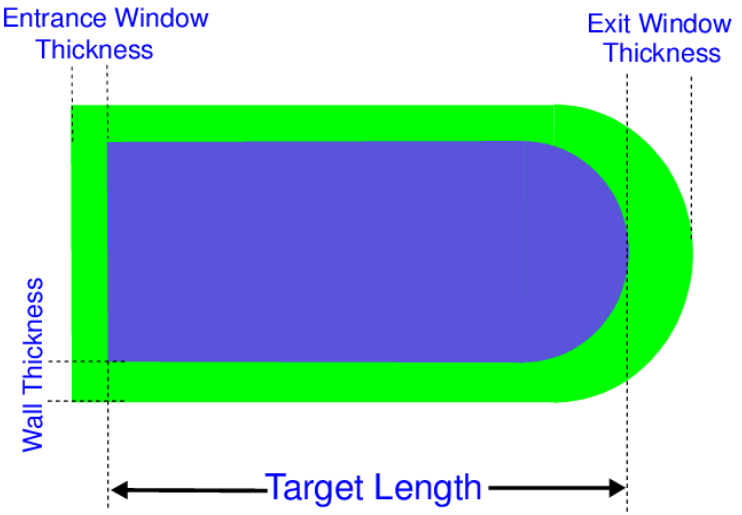
Check of π^0 subtraction technique

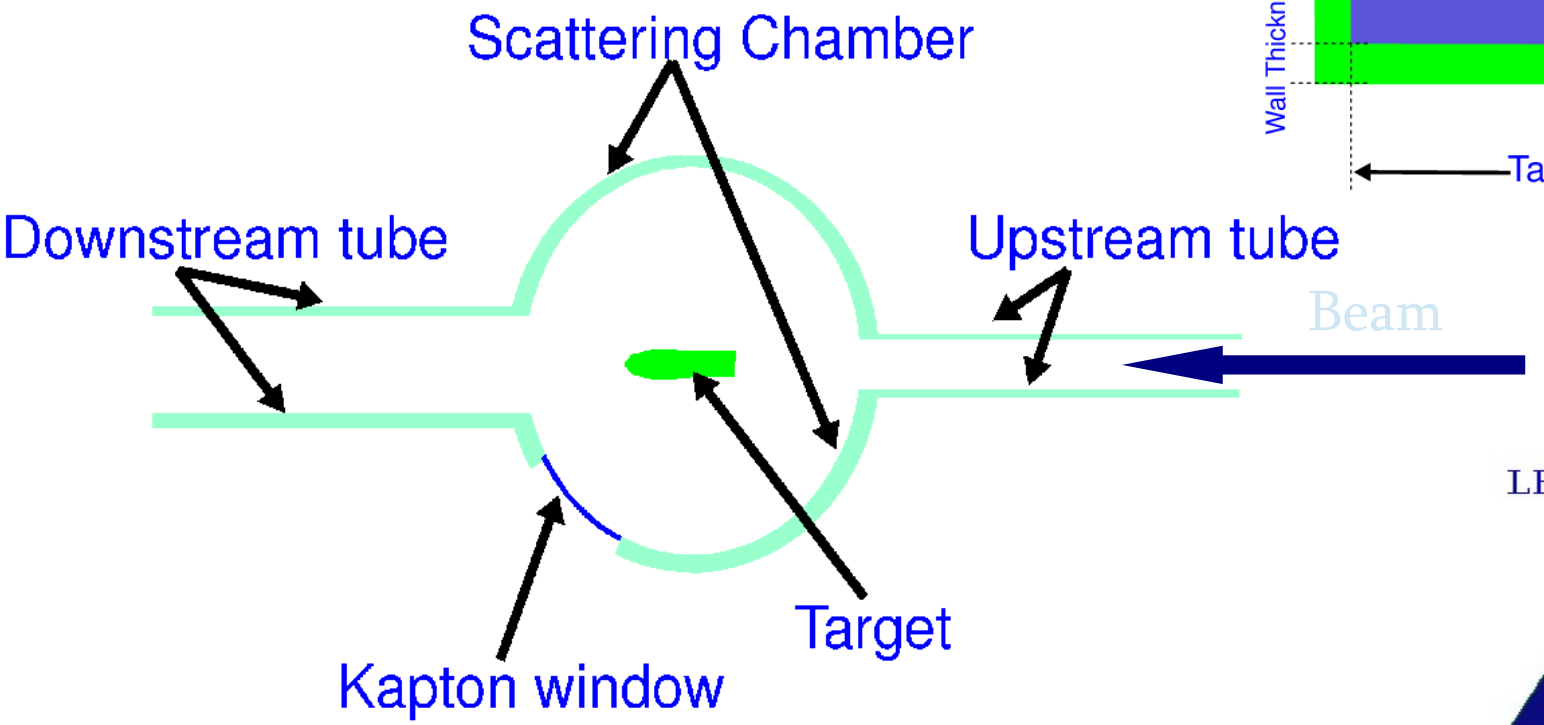
Background effects

Geometry 1

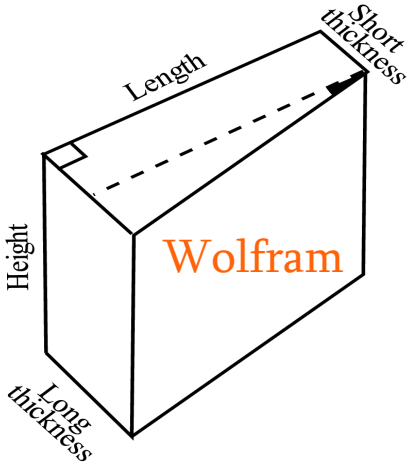
DVCSDetectorConstruction

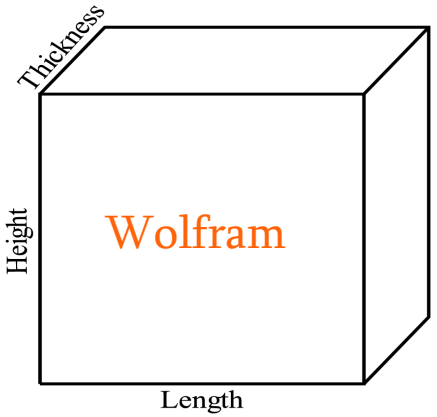
- Geometry
- Materials
- Physical properties of materials

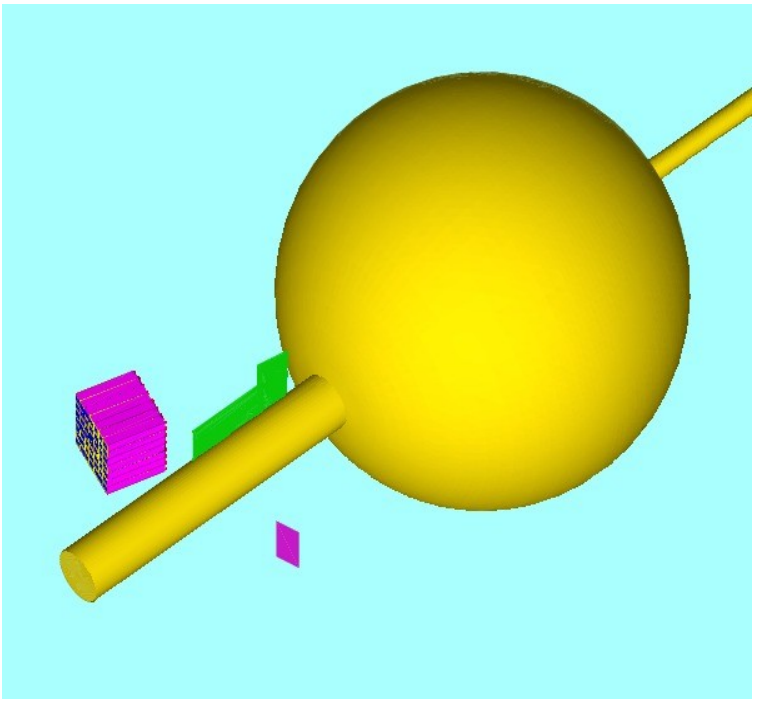




Geometry 2





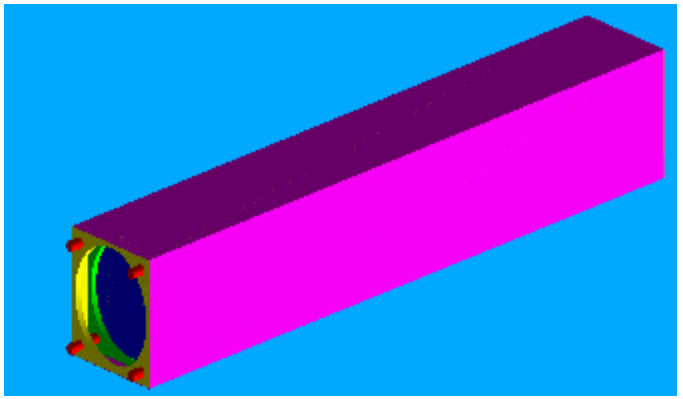


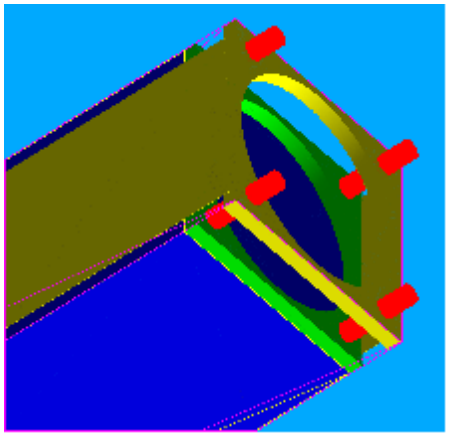
Shieldings

PbF2 block 3x3 cm and 20 rad. length

Totally there are 16x13 blocks

Implemented by Maxime Defurne





Each block is placed according to survey coordinates.

Part 1
G4/G3 comparison

Modifications in the code to reproduce 2004 geometry

- Removal of 4 rows and 2 columns from the calorimeter
- Eliminate Block N-10 in the clustering step
- Removal of nose and beamline shieldings
- Removal of “CH2 shielding” in front of calorimeter
- Target shift to downstream side by 7.8 mm
- Arrange blocks with equal distances from each other

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Part 1

G4/G3 comparison

Modifications in the code

* R
* E
* R
* R
* T
* A

11	23	35	47	59	71	83	95	107	119	131
10	22	34	46	58	70	82	94	106	118	130
9	21	33	45	57	69	81	93	105	117	129
8	20	32	44	56	68	80	92	104	116	128
7	19	31	43	55	67	79	91	103	115	127
6	18	30	42	54	66	78	90	102	114	126
5	17	29	41	53	65	77	89	101	113	125
4	16	28	40	52	64	76	88	100	112	124
3	15	27	39	51	63	75	87	99	111	123
2	14	26	38	50	62	74	86	98	110	122
1	13	25	37	49	61	73	85	97	109	121
0	12	24	36	48	60	72	84	96	108	120

orimeter

eter

other

Some distributions and fiducial cuts

$E_b = 5.7572\ GeV$

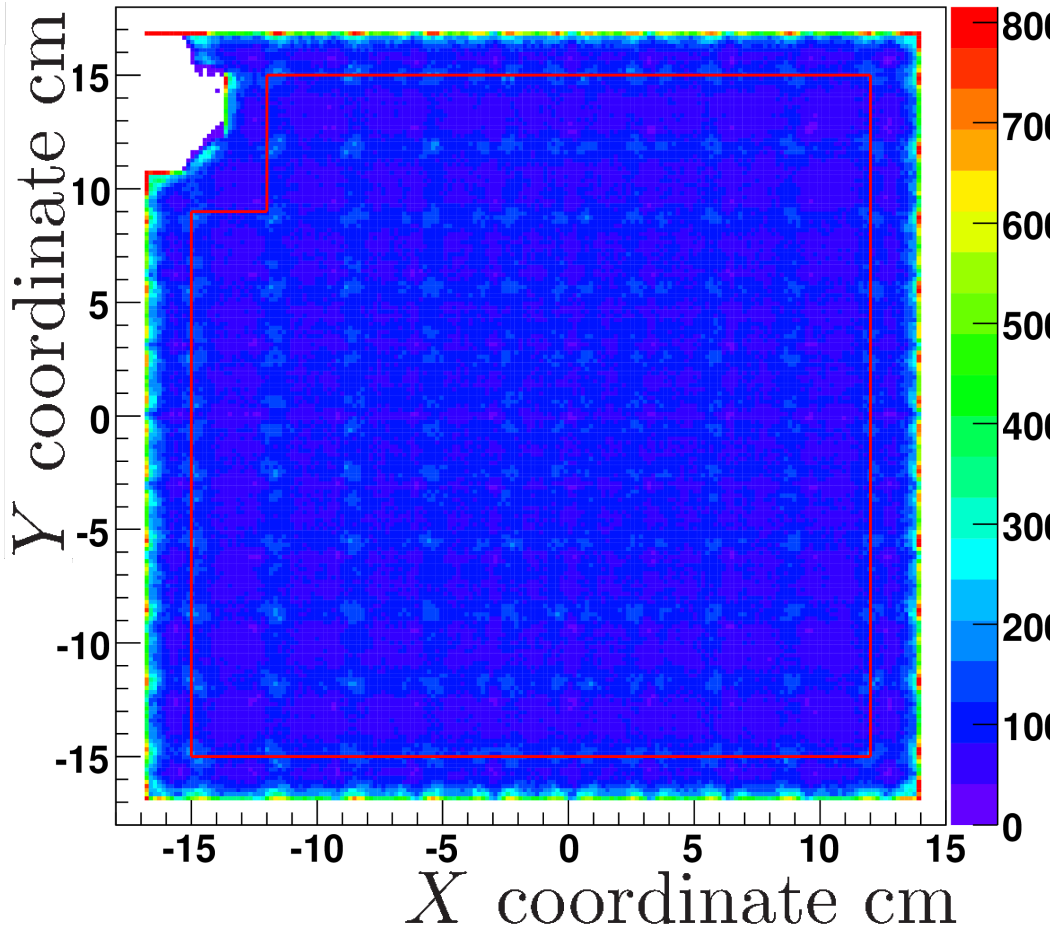
$d_{Calo} = 112\ cm$

$P_{HRS} = 2.35\ GeV$

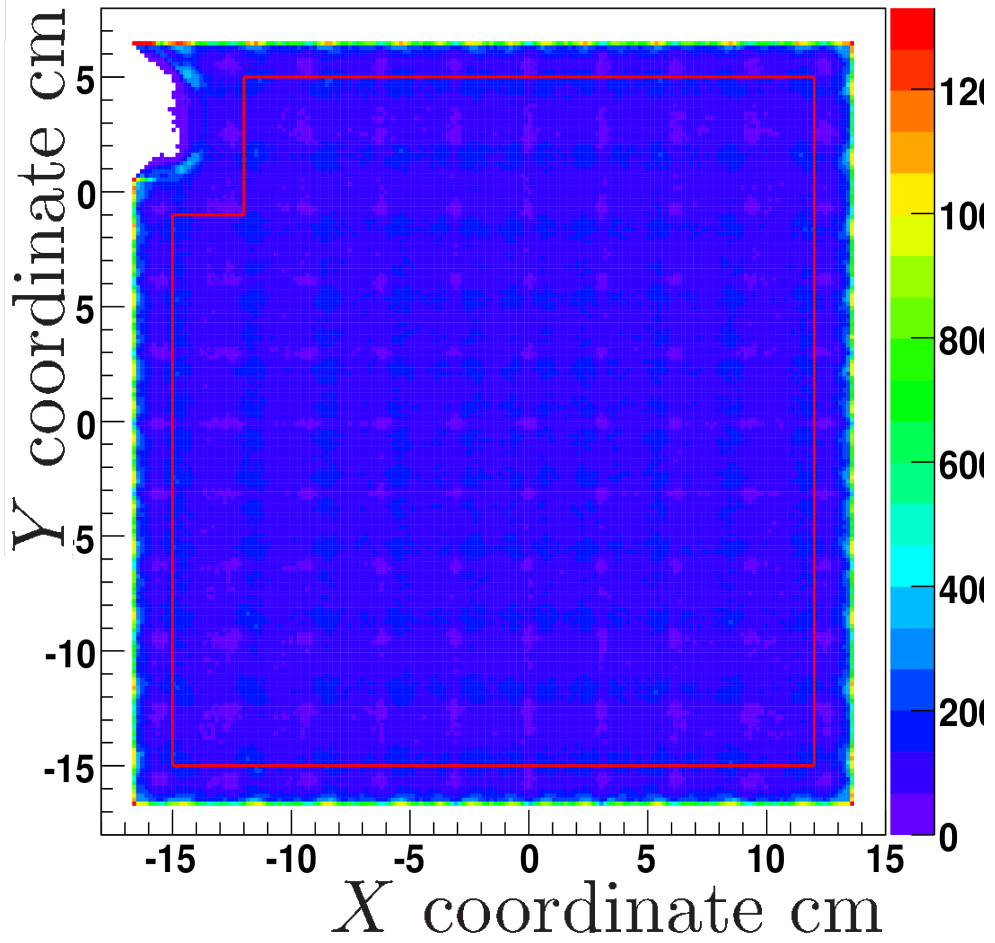
$\theta_{Calo} = 14.803°$

$\theta_{HRS} = 23.91°$

Geant 3



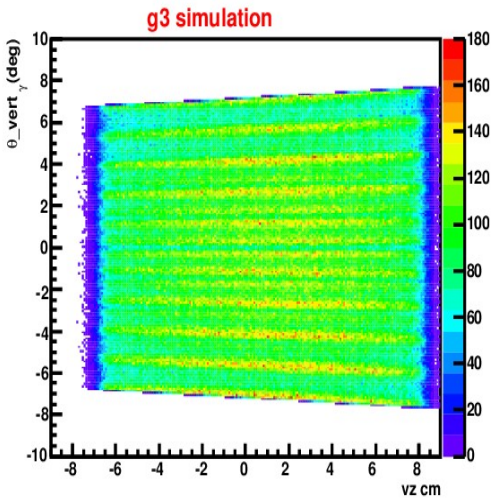
Geant 4

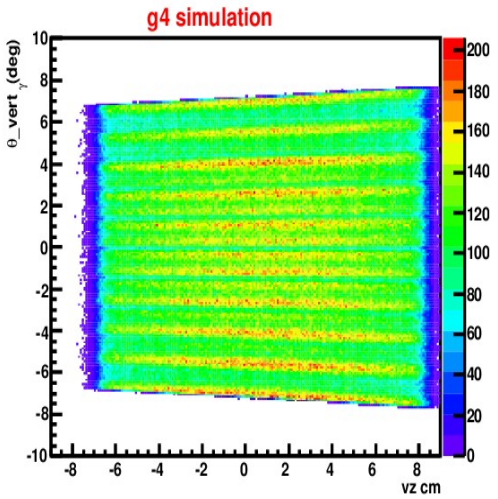


Some distributions and fiducial cuts

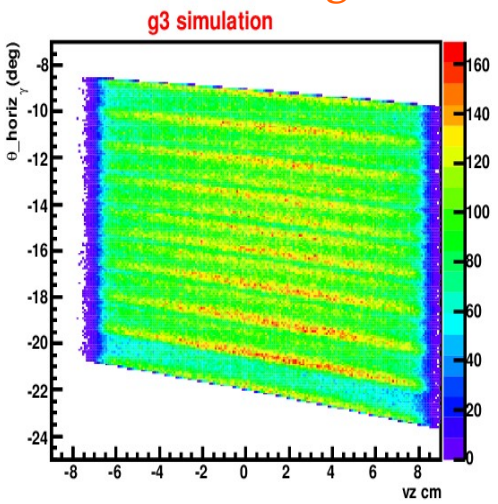
Calorimeter

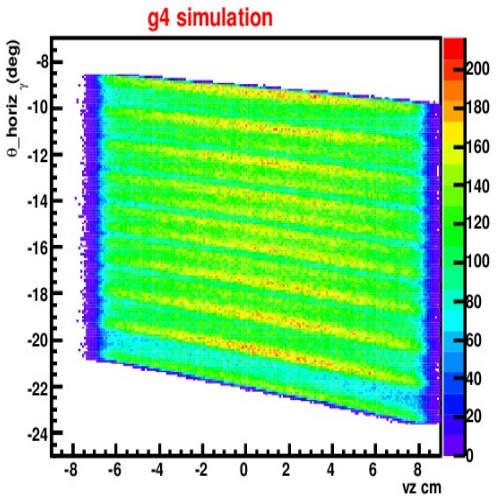
Vertical angle





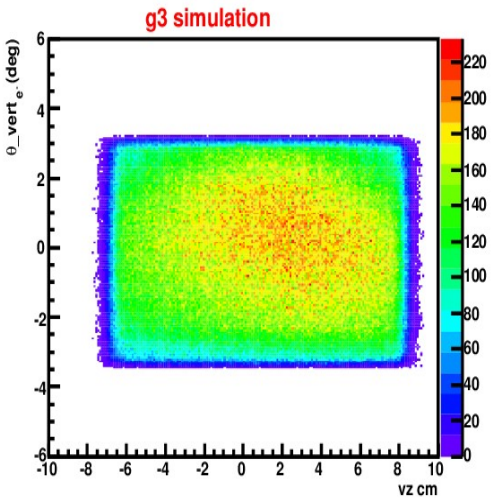
Horizontal angle

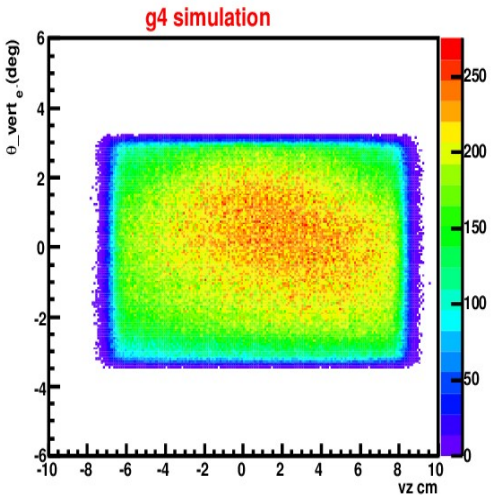




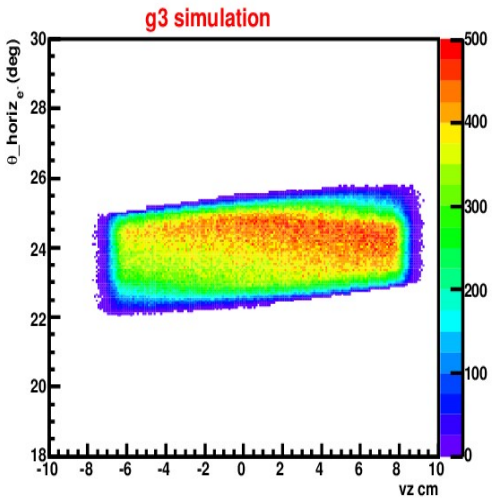
HRS

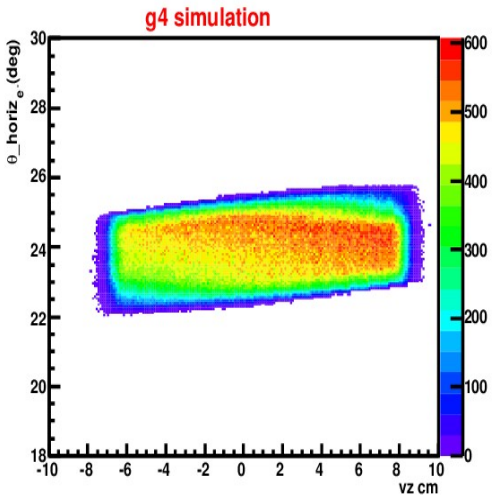
Vertical angle





Horizontal angle





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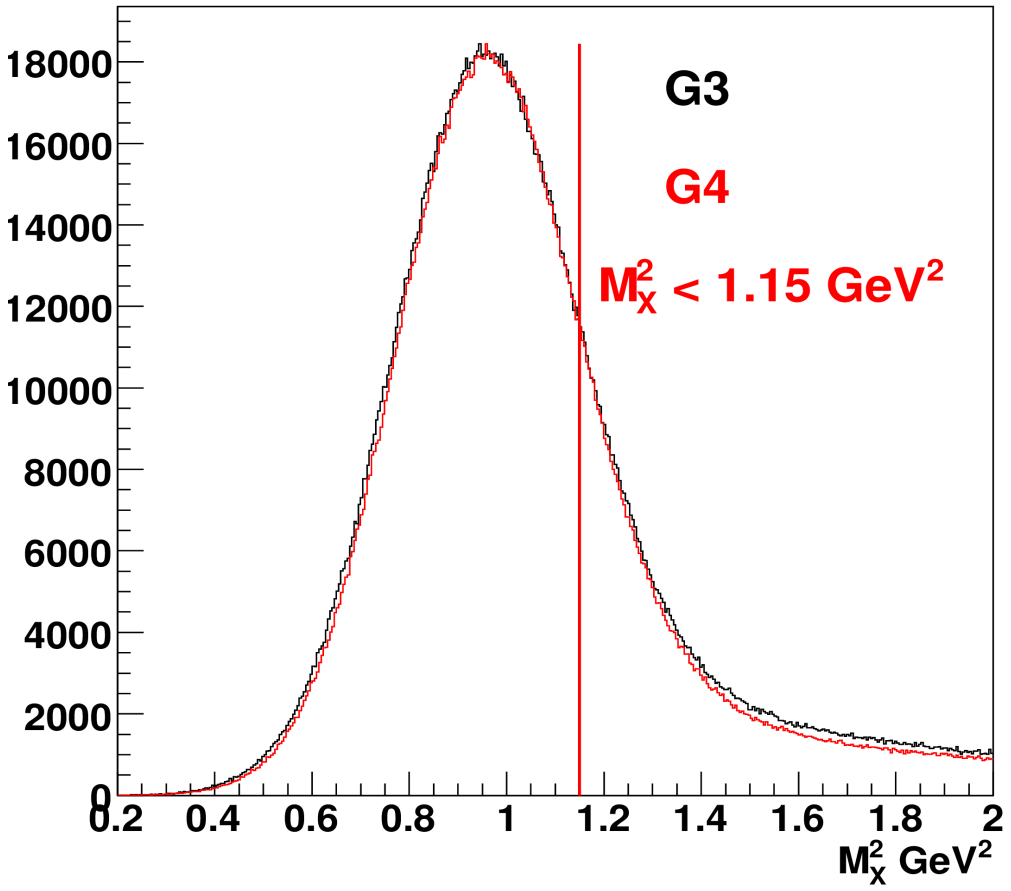
mm2 distribution



G3 distribution scaled to match G4

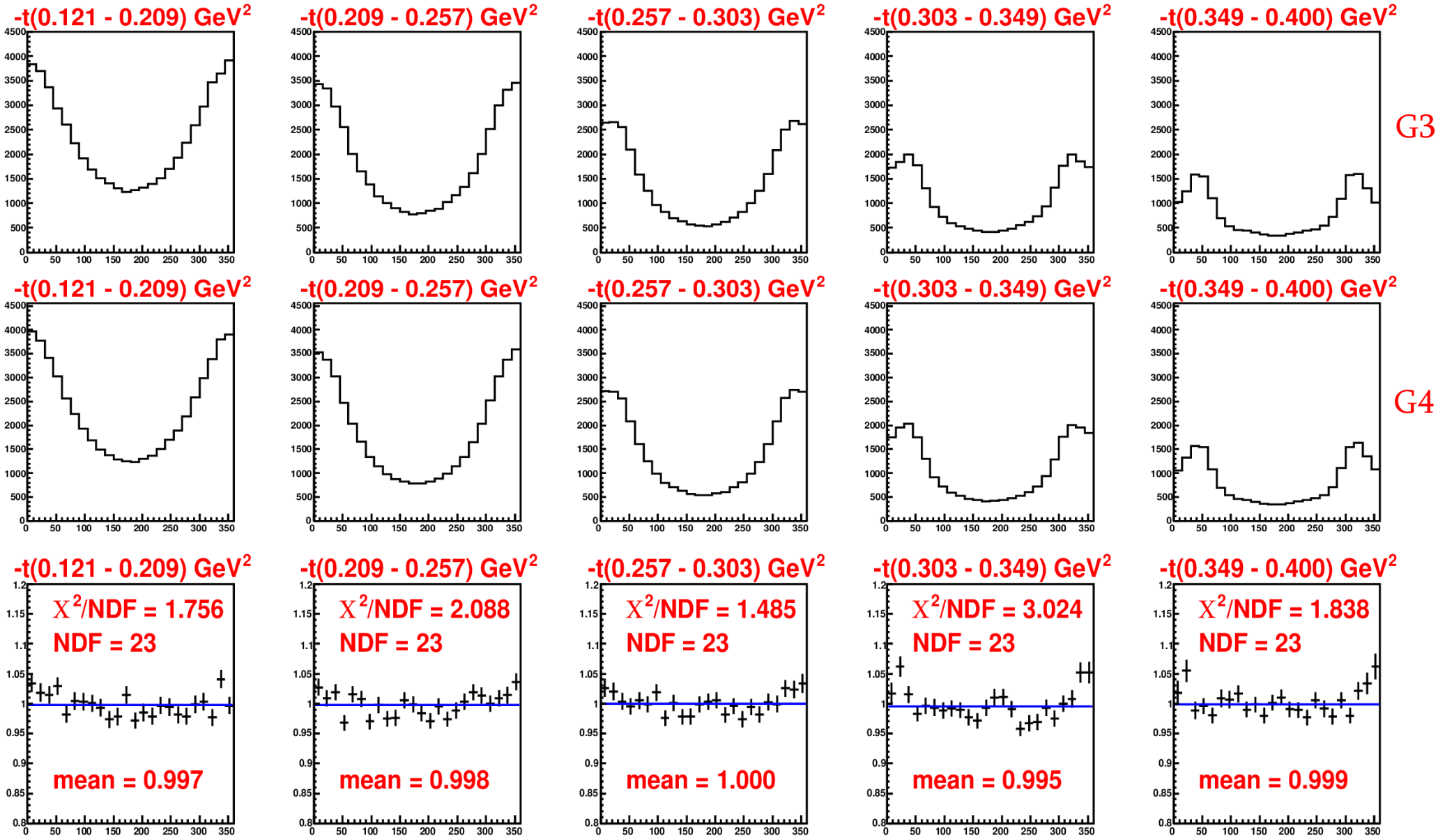
Looks not bad

Rates Depend on:

- Luminosity (Same value)
- Process cross section (Same model)
- Acceptance

$$N = \frac{1}{N_0 \mathcal{L}} \sum_i ps f^i \sigma^i$$

Rates/Comparison



Available executables

- dvcs_2004: experimental setup of 1st DVCS experiment in HallA
- dvcs_2010: experimental setup of 2nd DVCS experiment (2010) in Hall A
- pi0_2010: ep->eπ^0p for 2nd DVCS experimental setup in HallA
- dvcs_HallC: experimental setup for DVCS in HallC
- dvcs_addup_bgr_2010: Background studies
- + some additional versions for various needs e.g. pi0 subtraction tests

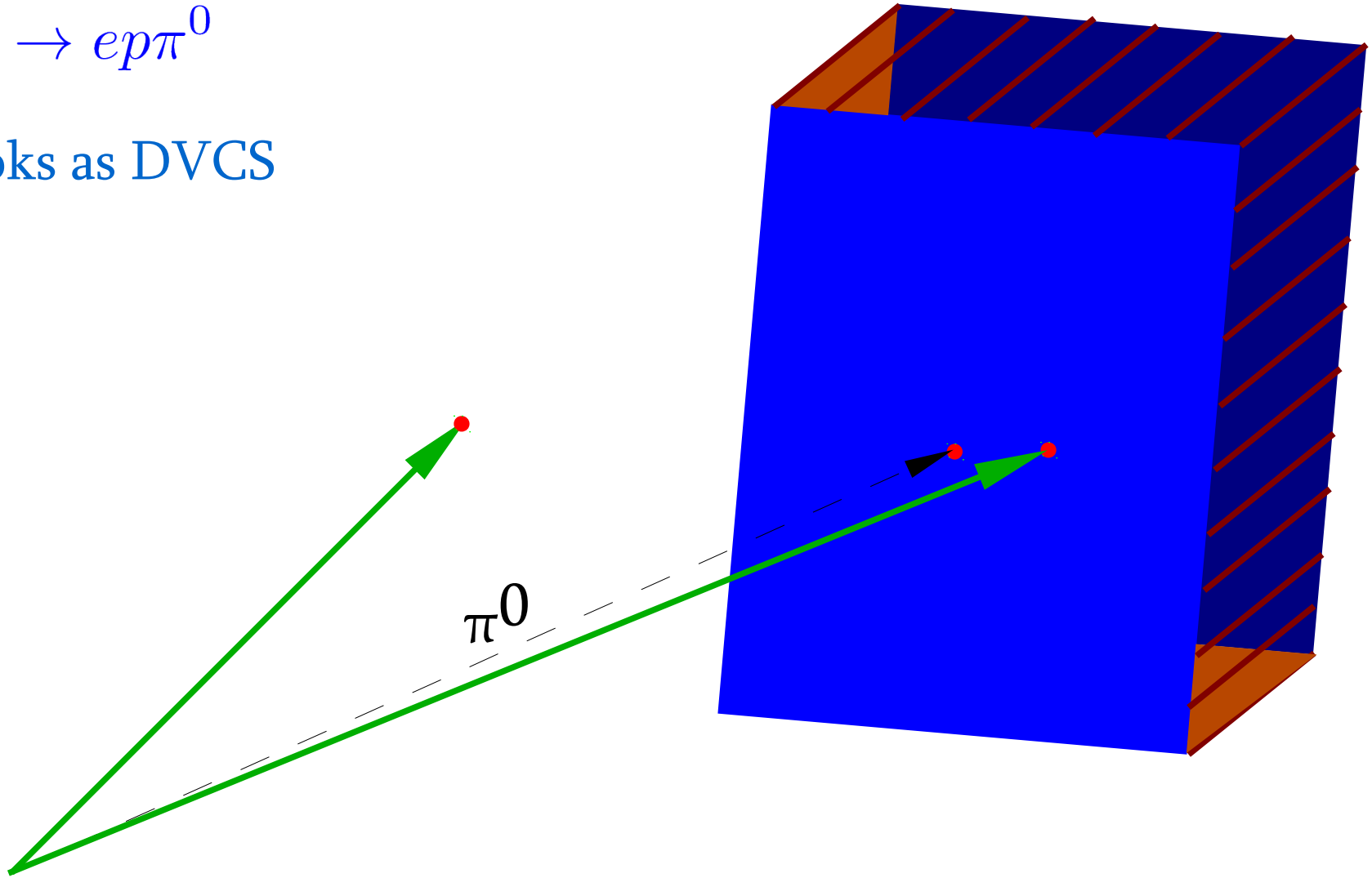
Available in Lyon machines ccage.in2p3.fr

In Jlab: dvcs_2010 and dvcs_HallC

π^0 detection

$ep \rightarrow ep\pi^0$

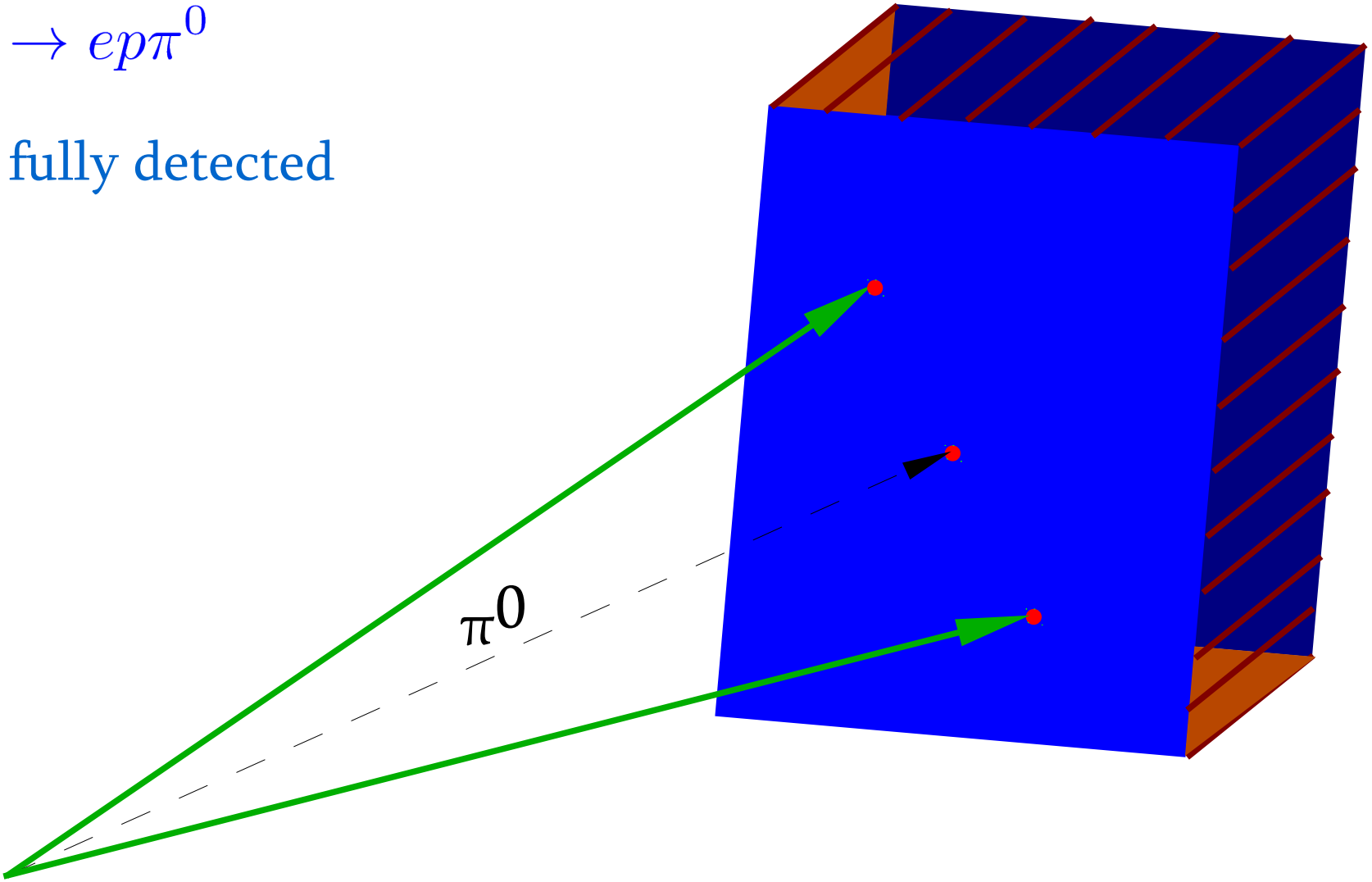
Looks as DVCS



π^0 detection

$ep \rightarrow ep\pi^0$

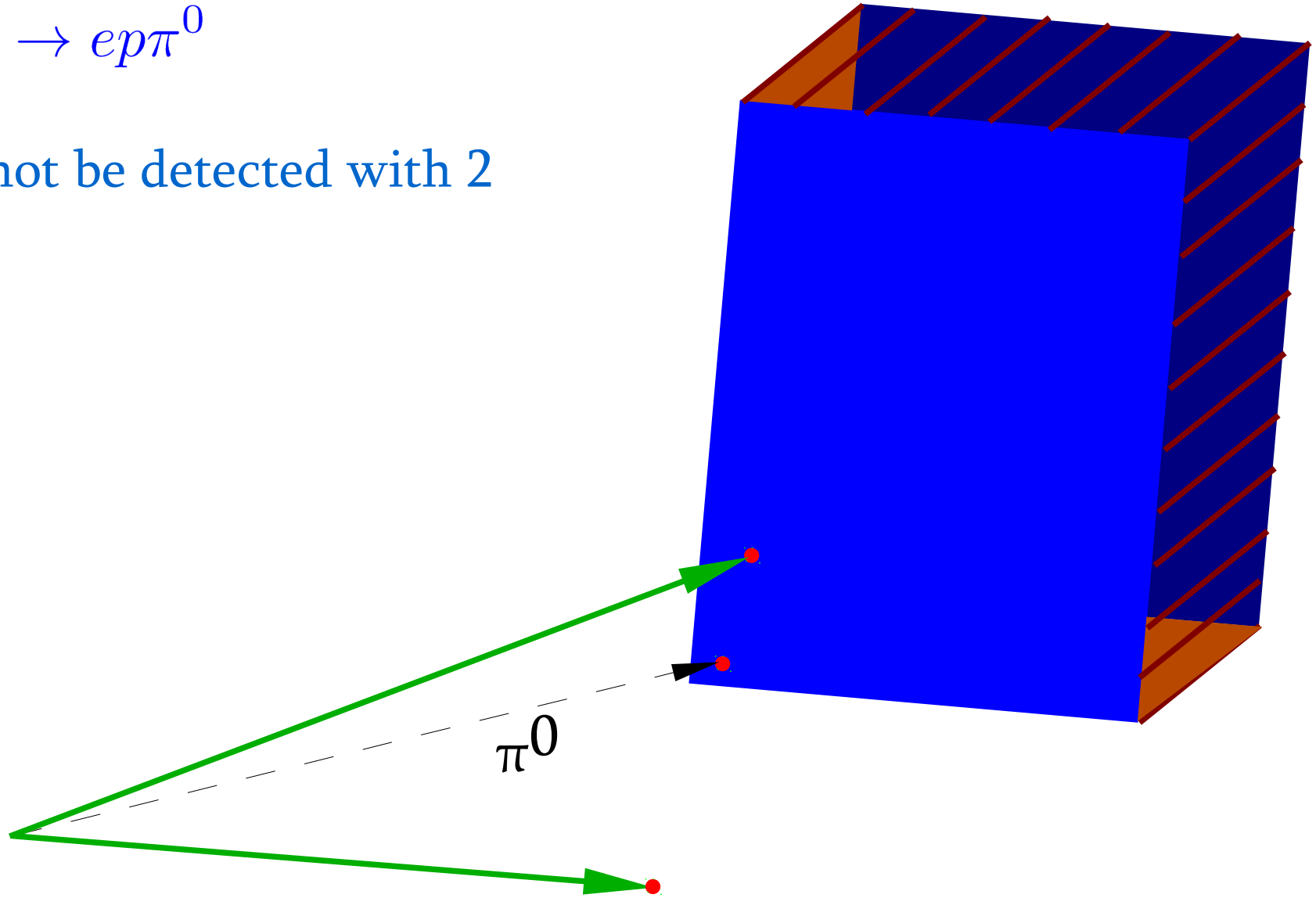
π^0 is fully detected



π^0 detection

$$ep \rightarrow ep\pi^0$$

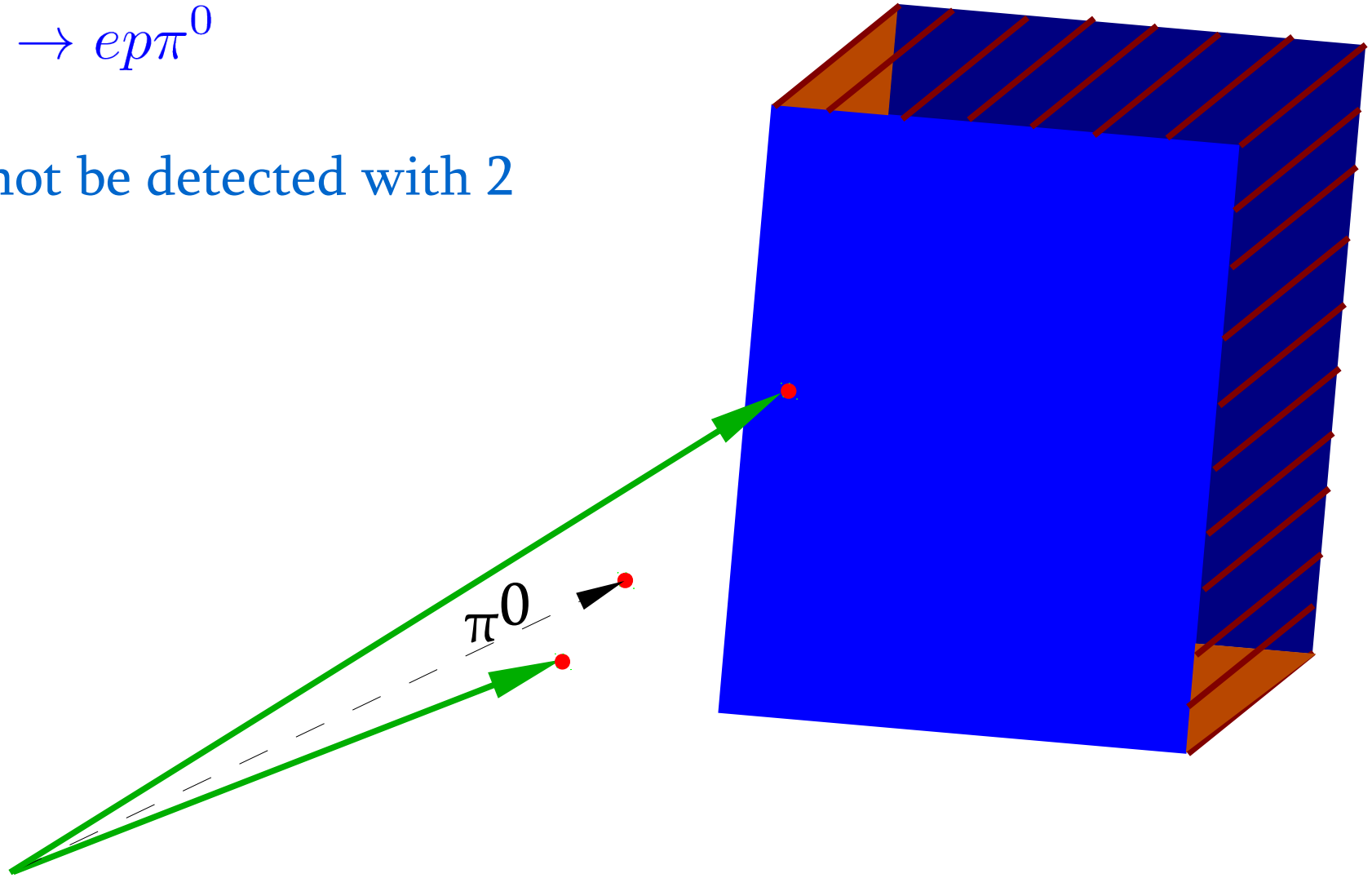
π^0 can not be detected with 2 photons



π^0 detection

$$ep \rightarrow ep\pi^0$$

π^0 can not be detected with 2 photons



π^0 Subtraction technique

$5\mathrm{K}\ \pi^0 \rightarrow \gamma\gamma$ isotropic decays

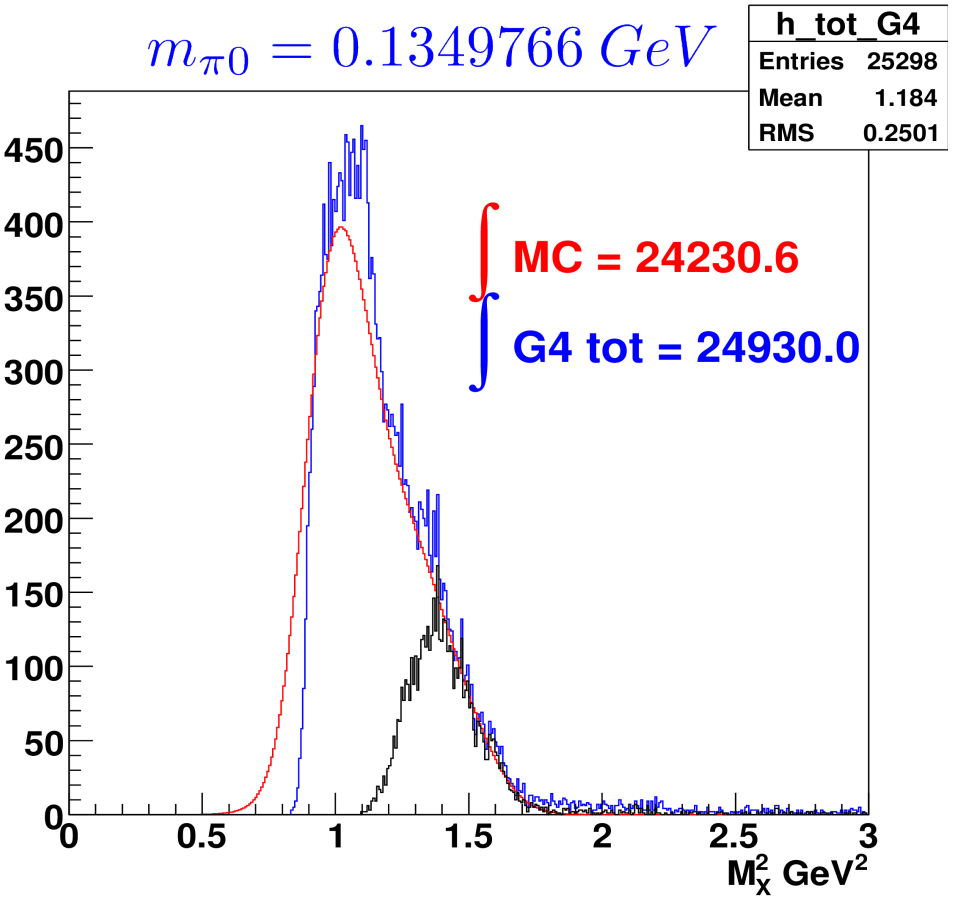
Boost to the lab frame

Determine proportion of 1 Photon and 2 photon events

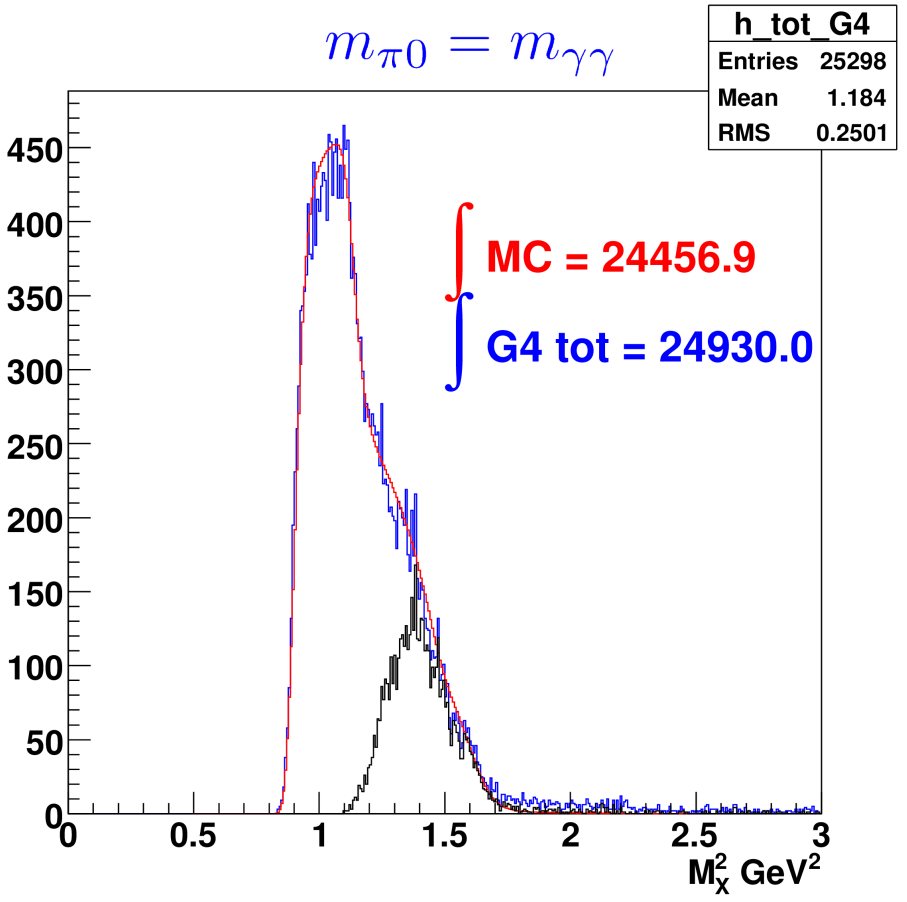
$m_{\pi 0} = 0.1349766\ GeV$

$m_{\pi 0} = m_{\gamma\gamma}$

$m_{\pi 0} = 0.1349766\ GeV$



$m_{\pi 0} = m_{\gamma\gamma}$



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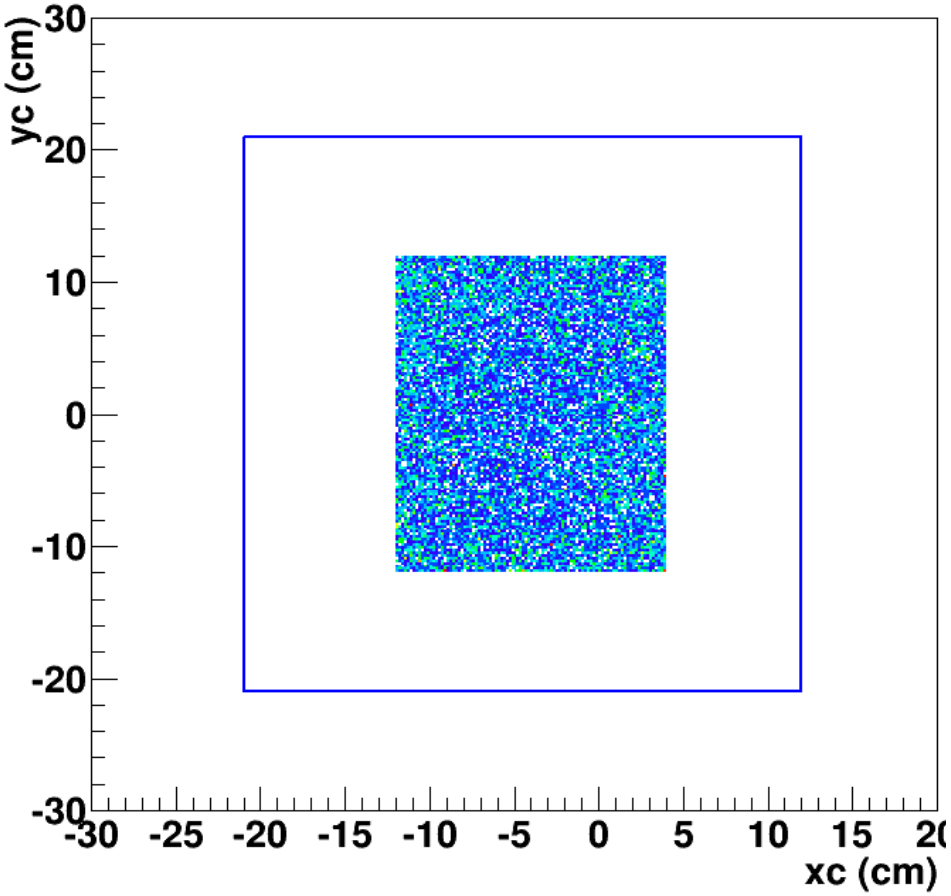
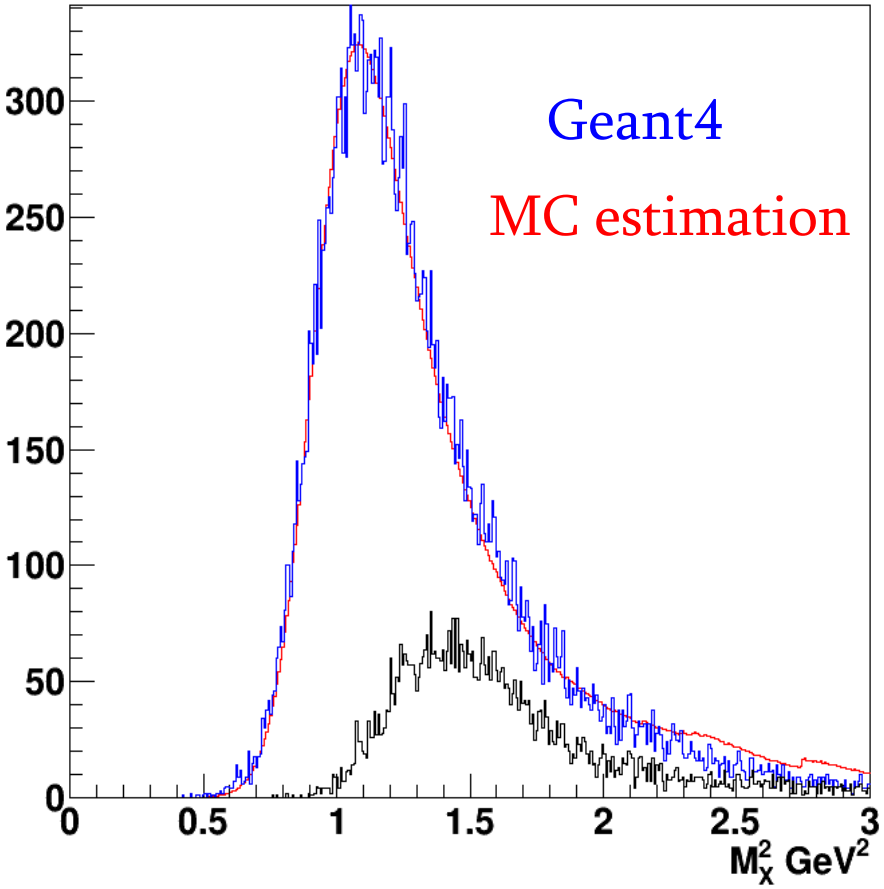
π^0 Subtraction

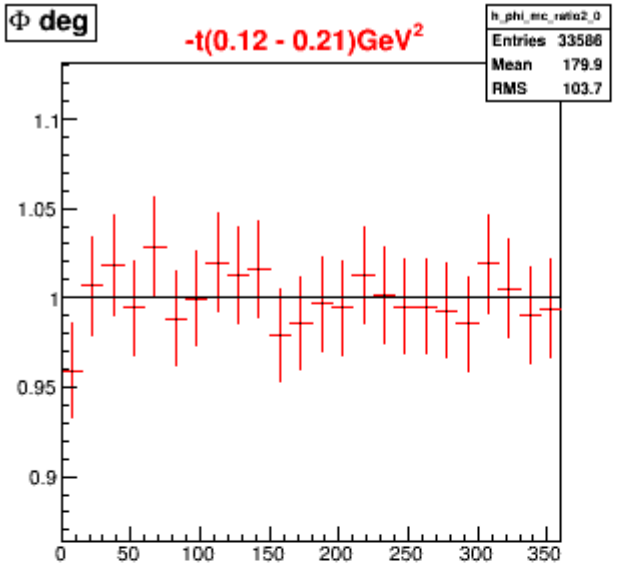
All π^0s are deep inside the calorimeter

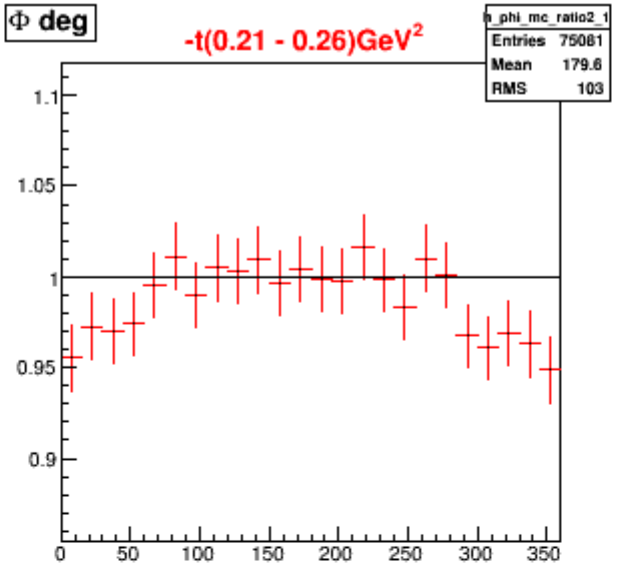


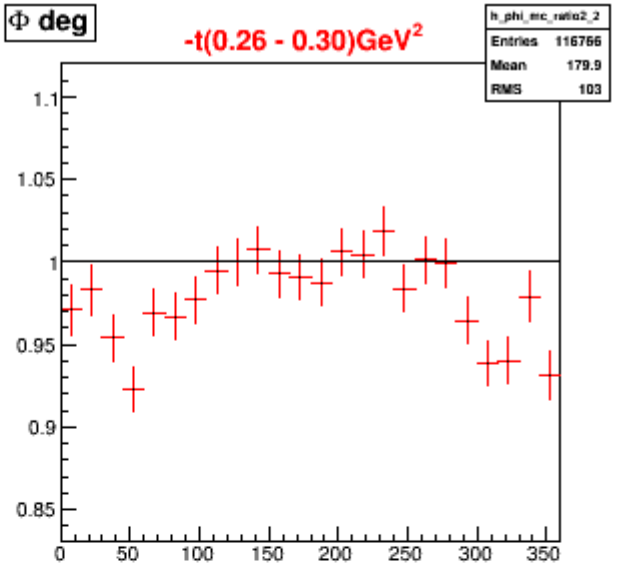


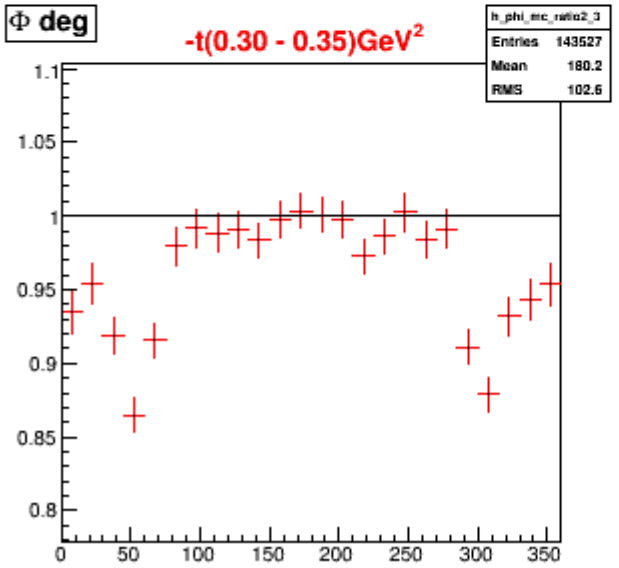
π^0 Estimation works well, when π^0 footprint is deep inside the calo

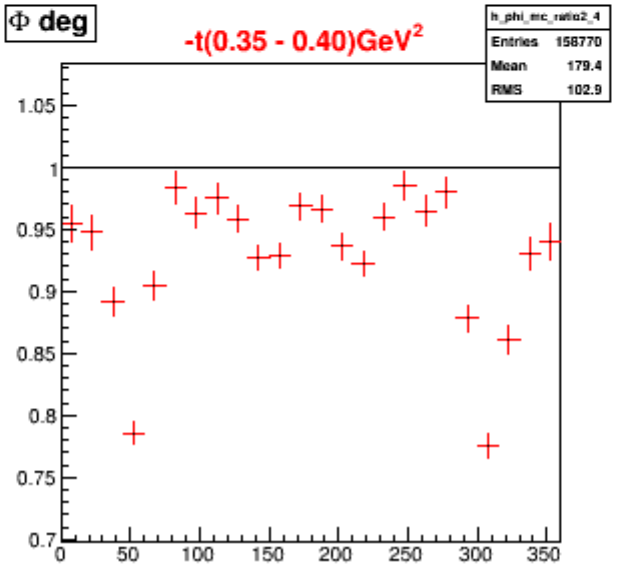
π^0 Subtraction











Φ(0-360)deg

1st t bin: π^0s properly estimated

With the increase of t corners of calo. become more inefficient

Cross Check with M. Defurne

This is 2004 calorimeter, should be better with 2010

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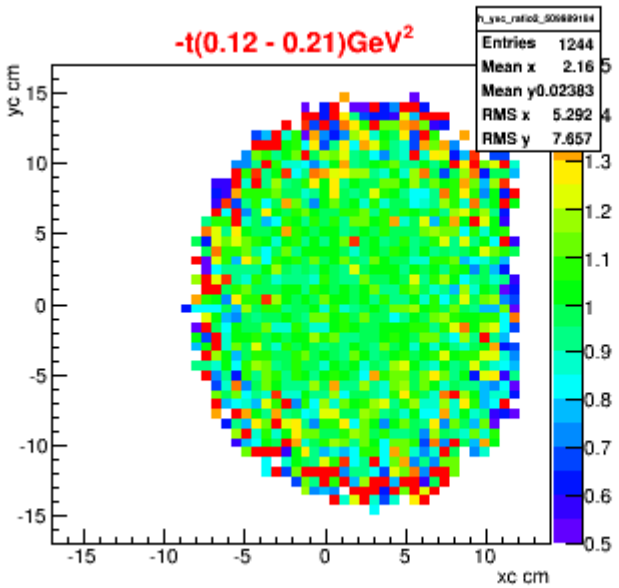
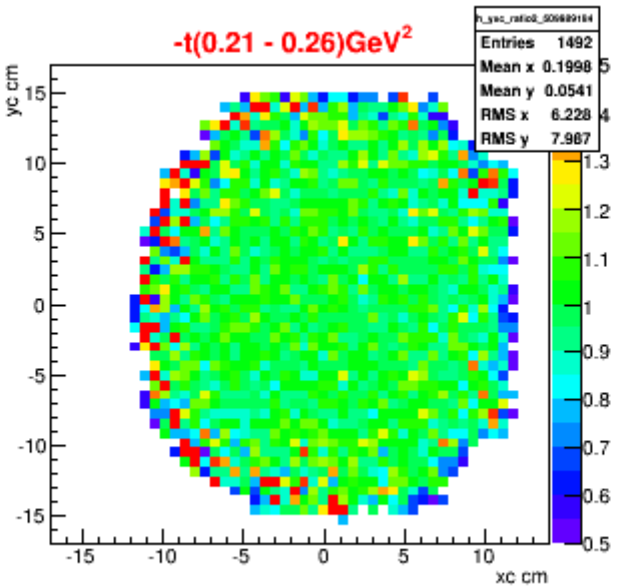
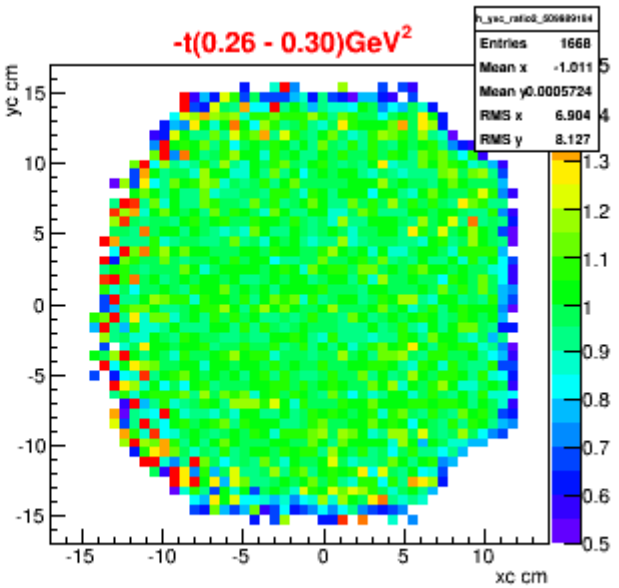
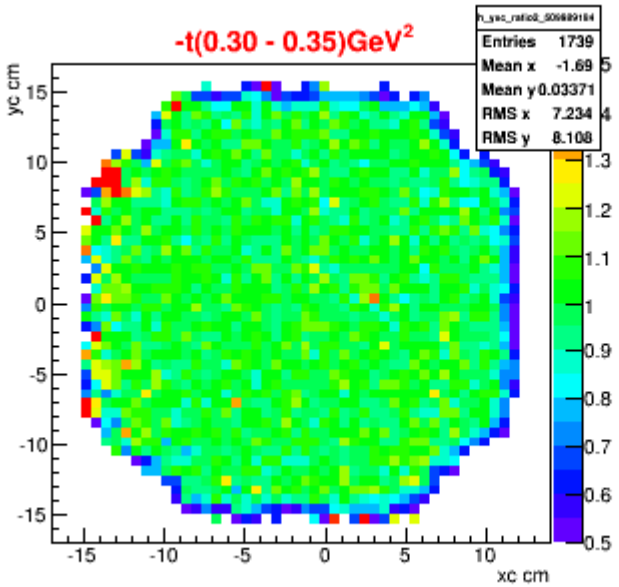
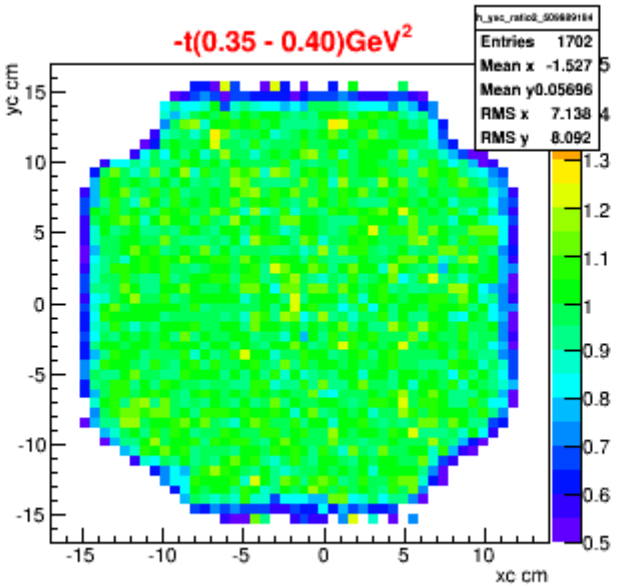
π^0 Subtraction











Possible solution is to not use corners in the analysis

This is 2004 calorimeter, should be better with 2010

Background influence on mm2

Energy resolution: Energy deposition, block photo-statistic, background, noise in electronics…

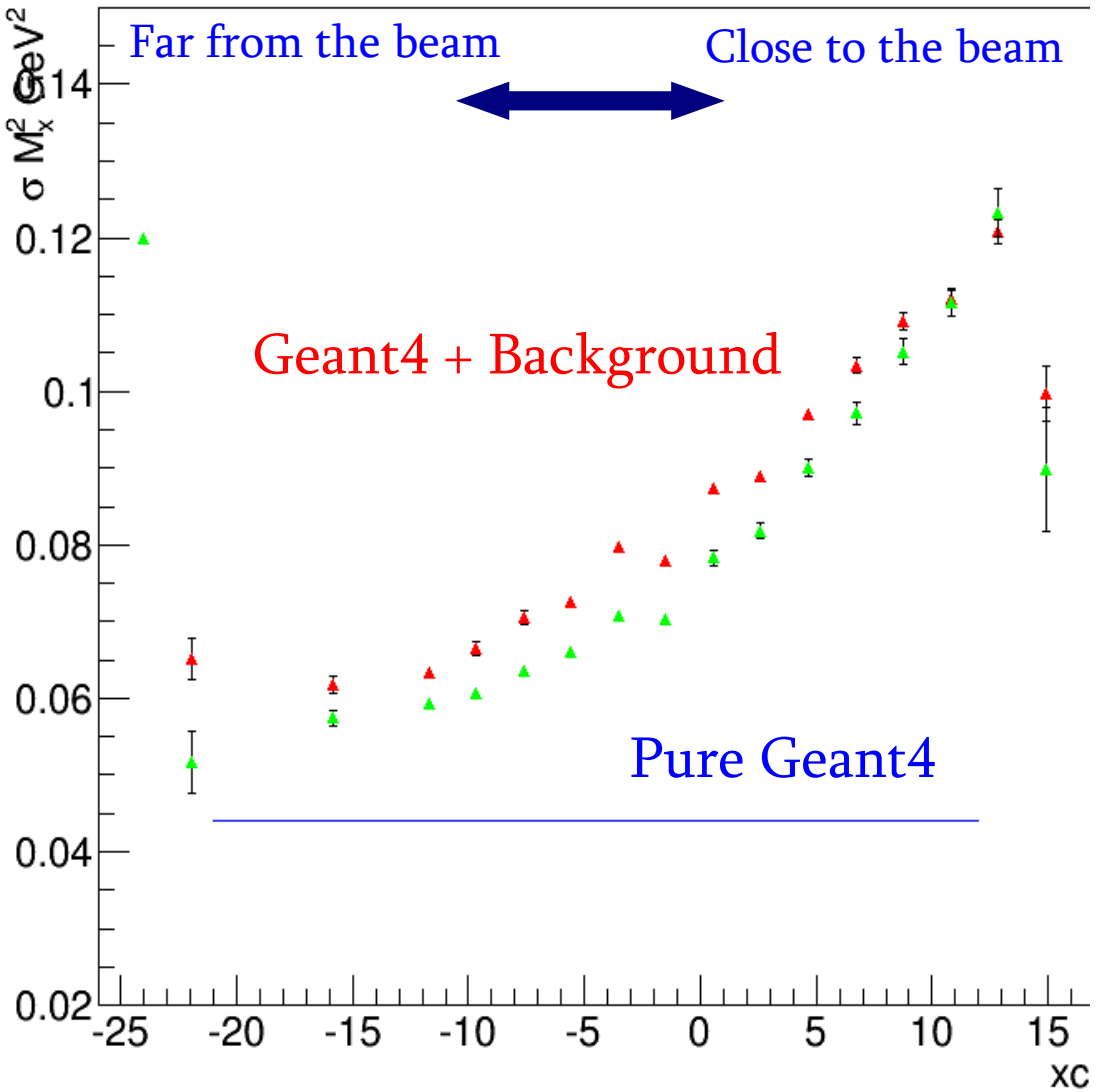
Energy deposition: Pure Geant4

Background influence: Adding background events into Geant4

Block photo-statistic: Using elastic runs

Combine all of them and compare with the data

Background influence on mm2



How much background affects into mm2?

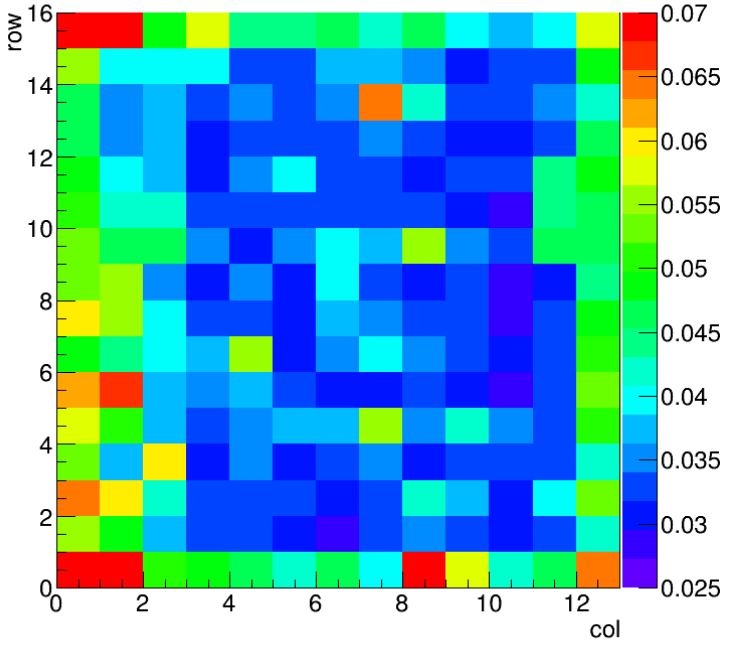
Background events added into Geant4

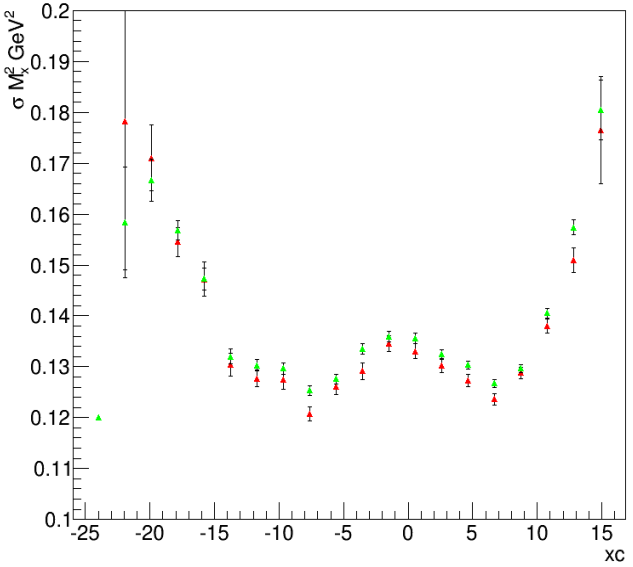
Yes. Background makes larger sigma!

Gives expected trend, however small w.r.t. Data ≈0.17 GeV2

Elastic events

Block resolution





Old blocks:

		16	19								2	
			27	15								
7	19	11	11	11	10	10	10	9	9	9	8	8
	17	12										
20	18	12		5	5	4	4	4	4	3	8	
66	18	13		5							7	
60	20	14		5		0	-1	-2	2		7	
53	20	14		6		0			2		7	
44	21	14		6		1			2		7	
44	20	14		6		1	2	2	2		7	
36	19	14		6							7	
31	18	13		6	6	6	6	6	6	6	6	
30	17	12										
29	17	11	11	11	11	10	10	10	9	9	8	8
29	17	16	16	15								
	28	27	25	25	24	24	24	23	23	23	23	23

Big number-> big Change of calibration coefficient

New blocks

	3			-10	-10	12	10	3	1	0		4
1	1	3			-10	-10	-10	-10	-10	-10	-10	10
2			3	2	2	2	2	2	2	2		11
			2									10
			2		1	0	0	0	0	2		10
			3		1					2		9
			3		1			0	0	2		8
			3		1			0	0	2		7
			3		1					1		7
			3		1	1	1	1	1	1		6
			3									6
			4	4	4	4	5	5	5	5	5	6
					-10	-10	-10	-10	-10	-10	-10	-10

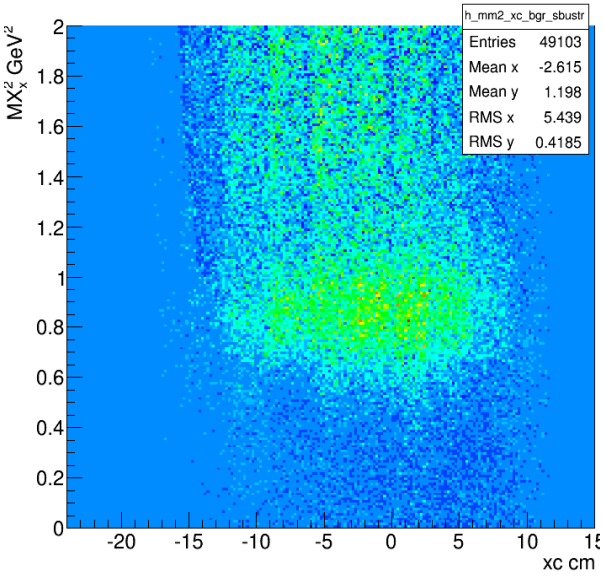
Big number-> big Change of transparency

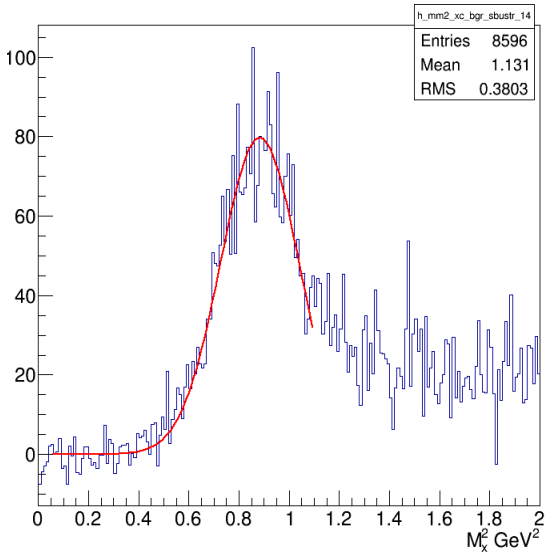
Energy of each block in Geant4 smeared by coefficients obtained from elastic runs.

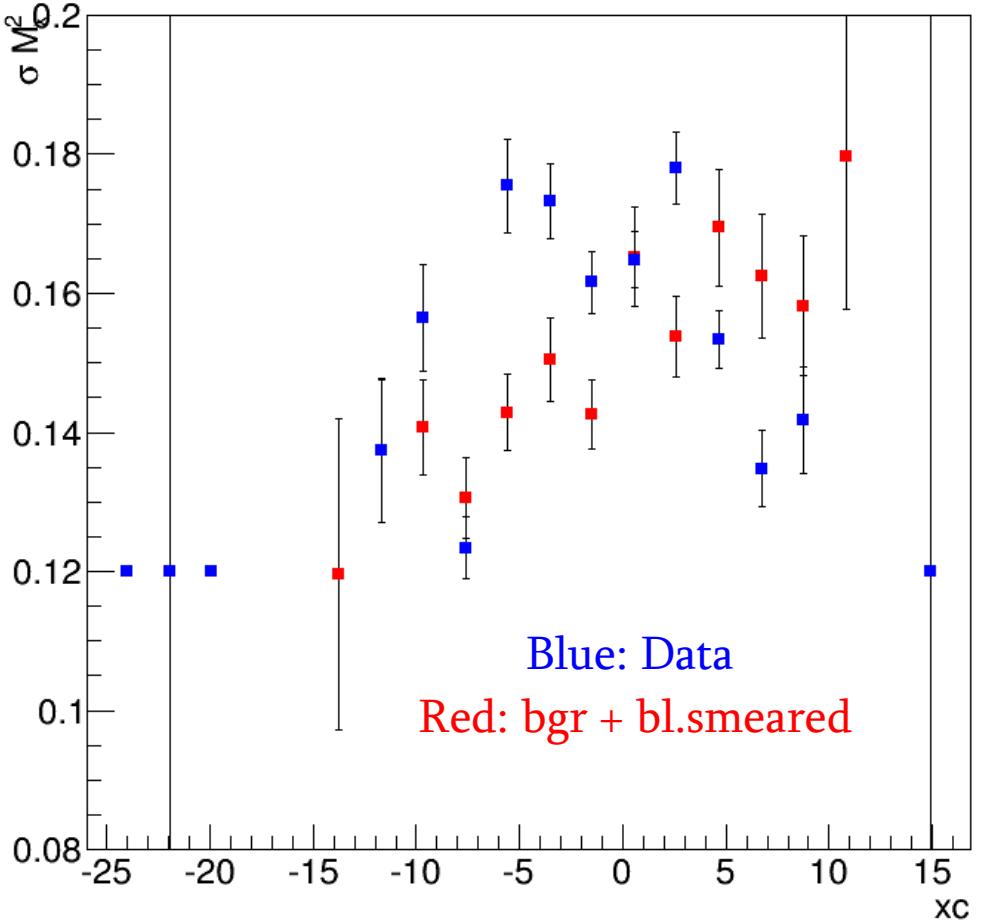
Almost flat, and again small w.r.t. data resolution.

Experimental data

$-t < 0.25\ GeV^2$





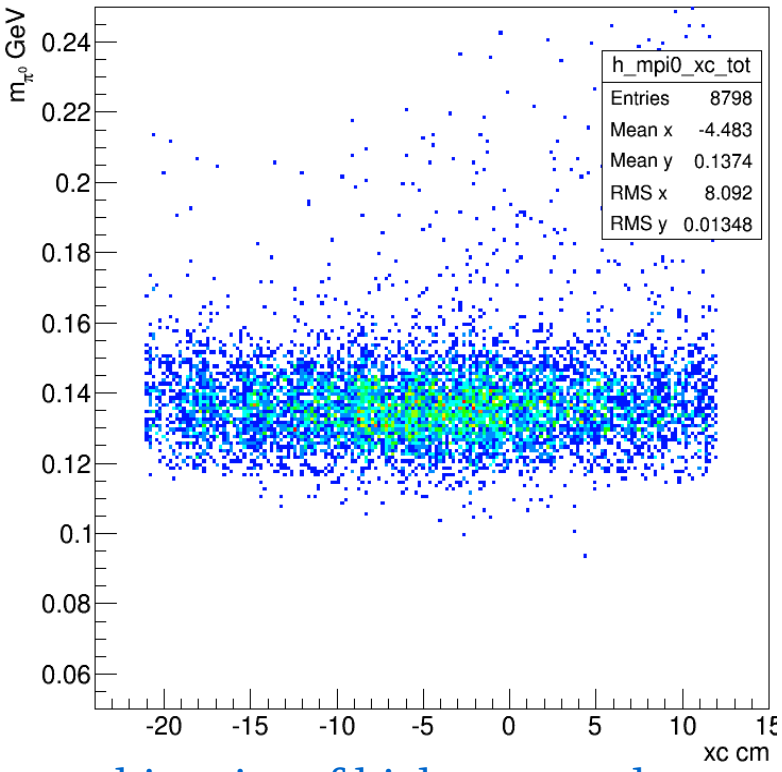


G4: bl. Energy smeared + background shows position dependent energy resolution

Data doesn't behave as we thought!

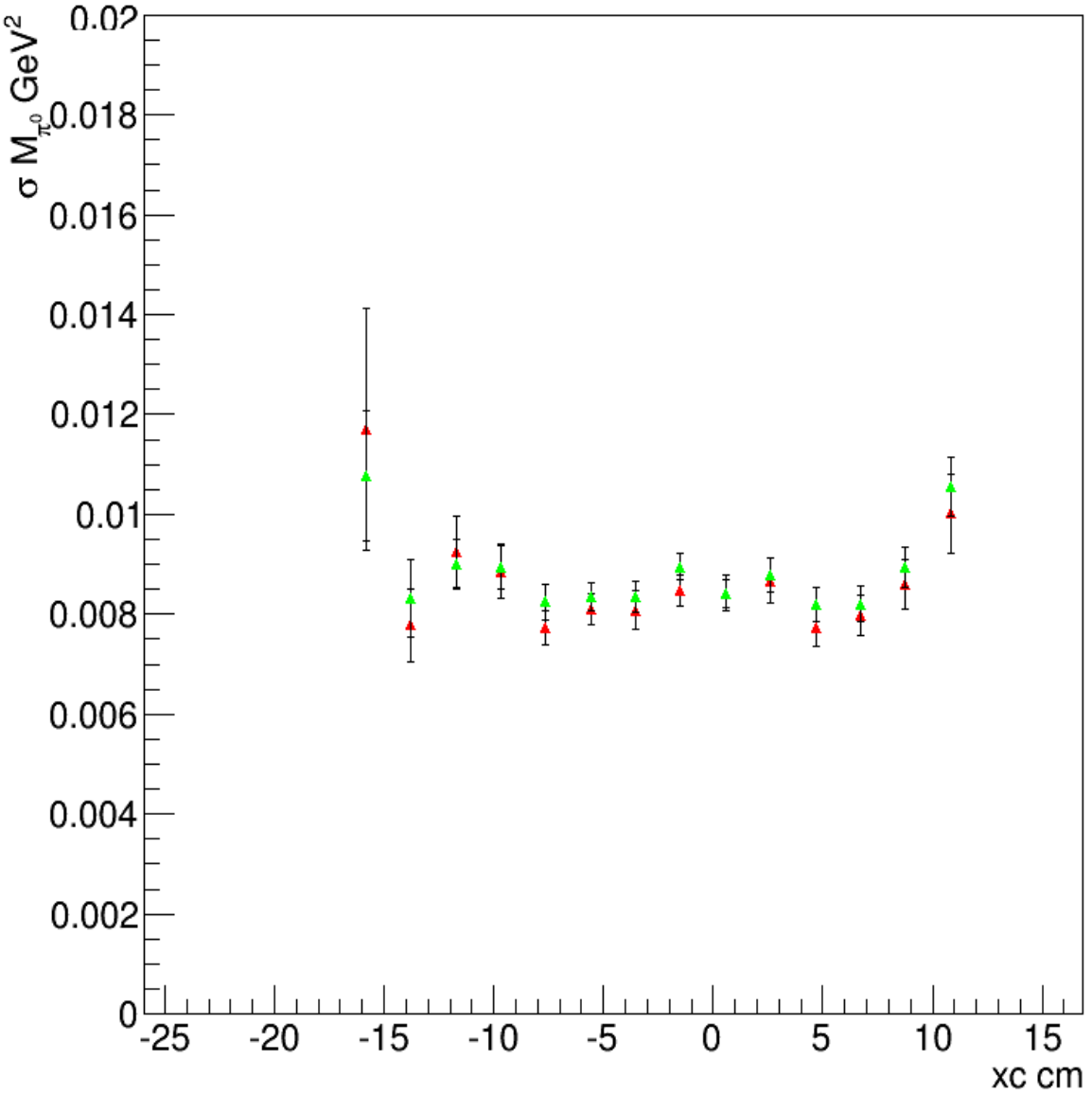
Experimental data for π^0

$E_{\gamma 1}/E_{\gamma 2} > 2$



xc: hit point of high energy photon

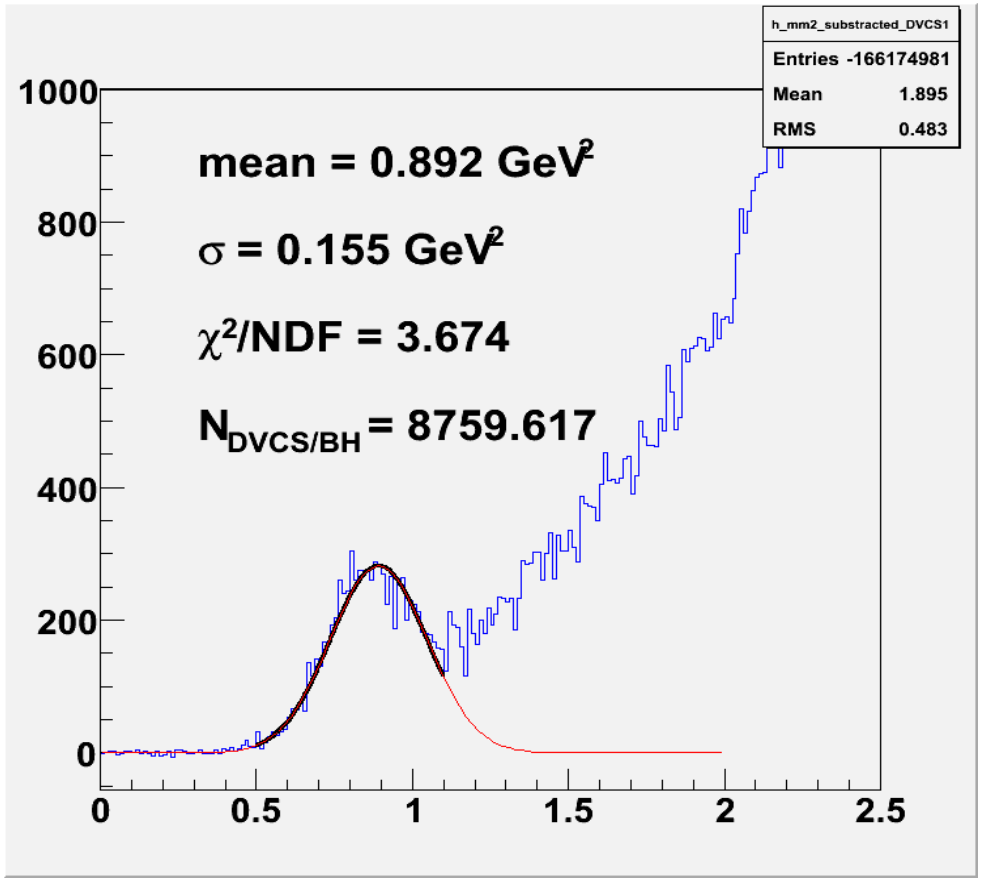
Data on π^0 also doesn't show x dependence of sigma



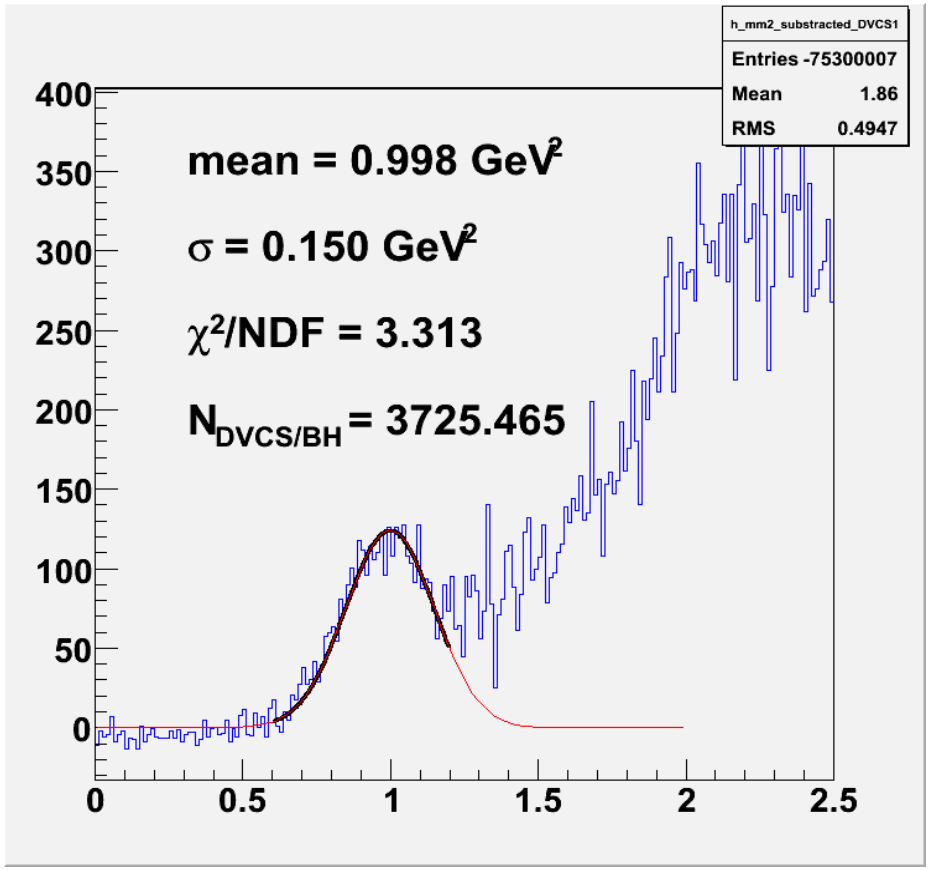
Different beam currents

Kin1high $\theta_{calo} = 19.3067°$ $\theta_{calo}^{edge} = 19.533°$

$1\mu A$



$10\mu A$



Open question: What is the optimum luminosity to chose to run the next DVCS experiment?

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Summary

- Experimental setup for different DVCS experiments in Hall A is developed by Geant4, and is validated by comparing with Geant3
- Using Geant4 package validity of pi0 subtraction technique is studied.
- Influence of background on the mm2 resolution was also studied with Geant4, however data doesn't behave as predicted by Geant4
- Open question: What is the optimum luminosity to chose to run the next DVCS experiment?

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