# Update on VCS simulations

- **Simulations status**

1) My generator and parameters

2) Generated distributions (at generator level)

- **Cross check with Hamza, comparison to proposal distributions**

3) Hamza + Marie cross check status

- **Analysis of reconstructed events**

4) Study of resolution impact on reconstructed kinematics and exclusivity

# 1) My generator, generated distributions and what it provides

• **Generator**: personnal generator, running independently on several process. Added VCS option past December. (see my talk of December Friday meeting)
**Webpage** :https://hallaweb.jlab.org/wiki/index.php/DEEPGen_event_generator
[need to update, I didn't put the executable containing VCS yet]

• **VCS option content:**
- pure phase-space or VCS (for now weighted by BH)
- request invariants and beam energy as input: Ee, Q2, xbj, t. φ (2π).
- input (see next slide). output = root and/or hep files

**Kinematics to study (column 1 bin = my notation, correspond to kin Ia, Ib, IIa... same order):**

| bin | E | thqq | Q2 | P_e | th_e | P_p | th_p | P_g | th_g | s | W | -t | xbj | phi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 4.55 | 155 | 0.33 | 4.035 | 7.688 | 0.893 | 37.359 | 0.158 | 179.277 | 9.419 | 1.232 | 0.670 | 0.341 | 0 |
| 1 | 4.55 | 155 | 0.33 | 4.035 | 7.688 | 0.893 | 51.420 | 0.158 | 91.955 | 9.419 | 1.232 | 0.670 | 0.341 | 180 |
| 2 | 4.55 | 140 | 0.33 | 4.035 | 7.688 | 0.860 | 33.241 | 0.181 | 157.735 | 9.419 | 1.232 | 0.627 | 0.341 | 0 |
| 3 | 4.55 | 140 | 0.33 | 4.035 | 7.688 | 0.860 | 55.538 | 0.181 | 68.956 | 9.419 | 1.232 | 0.627 | 0.341 | 180 |
| 4 | 4.55 | 120 | 0.33 | 4.035 | 7.688 | 0.794 | 28.017 | 0.224 | 131.976 | 9.419 | 1.232 | 0.546 | 0.341 | 0 |
| 5 | 4.55 | 120 | 0.33 | 4.035 | 7.688 | 0.794 | 60.761 | 0.224 | 43.198 | 9.419 | 1.232 | 0.546 | 0.341 | 180 |
| 6 | 4.55 | 165 | 0.45 | 3.971 | 9.052 | 1.010 | 41.029 | 0.139 | 164.004 | 9.419 | 1.232 | 0.826 | 0.414 | 0 |
| 7 | 4.55 | 165 | 0.45 | 3.971 | 9.052 | 1.010 | 48.628 | 0.139 | 106.350 | 9.419 | 1.232 | 0.826 | 0.414 | 180 |
| 8 | 4.55 | 155 | 0.45 | 3.971 | 9.052 | 0.995 | 38.522 | 0.150 | 178.035 | 9.419 | 1.232 | 0.806 | 0.414 | 0 |
| 9 | 4.55 | 155 | 0.45 | 3.971 | 9.052 | 0.995 | 51.135 | 0.150 | 88.378 | 9.419 | 1.232 | 0.806 | 0.414 | 180 |
| 10 | 4.55 | 128 | 0.45 | 3.971 | 9.052 | 0.919 | 32.021 | 0.204 | 137.656 | 9.419 | 1.232 | 0.704 | 0.414 | 0 |
| 11 | 4.55 | 128 | 0.45 | 3.971 | 9.052 | 0.919 | 57.636 | 0.204 | 47.999 | 9.419 | 1.232 | 0.704 | 0.414 | 180 |

**For this work. Generated file:**
very open kinematic cuts to match all kinematics into 1 file and have limits from the detector
• 10M events; free proton P and th; ±25% on electron P and th as input
• $0 < -t < 1.5$ GeV² , $0.1 < Q^2 < 0.75$ GeV², $0 < xbj < 1$ , $0 < y < 1$, $100° < \theta_{\gamma^*\gamma} < 180°$, Ee = 4.55 GeV

## 1) Generated distributions: input

**Input file example**
**file used for this presentations studies with simc**

```
* Energy of the incoming electron
* Eelectron=?
4.55

* Number of events to generate
* NTotEvents =?
10000000

* VCS on Proton (1)
* protonorneutron=?
1

* limits in -t (maximal range:  < -t <  GeV2)
* mt_min=?
0
* mt_max=?
1.5

* limits in xbj (maximal range:  < xbj < )
* xbj_min=?
0
* xbj_max=?
1

* limits in Q2 (maximal range:  < Q2 < GeV2)
* Q2min=?
0.1
* Q2max=?
0.75

* limits in y (not mandatory, for running efficiency 0 to 1)
* ymin
0
* ymax
1

* limits in theta(gg) CM (not mandatory) set 0 180 if no limits
* theta(gg) min
100
* theta(gg) max
180

* Print in ROOT only: 0, ROOT+HEP: 1, HEP only: 2, input for SIMC only: 3, SIMC+ROOT:4
* simc text only, angular and momentum cuts (below): 5
* simc+root, angular and momentum cuts (below): 6
6

* If for SIMC, theta HMS vs beam axis (deg) only with option SIMC (opt 5 or 6) +-25%
* default=0 if not used 37.36
0

* If for SIMC, theta SHMS vs beam axis (deg) only with option SIMC (opt 5 or 6) +(25%)
* default=0 if not used
7.688

* If for SIMC, momentum HMS (opt 5 or 6) +-25%
* default=0 if not used
0

* If for SIMC, momentum SHMS (opt 5 or 6) +-25%
* default=0 if not used
4.035
```

## 1) Generated distributions: output

**Output file content (unweighted events only, more info in case of weighted events)**

ROOT file:
ALV_gamma_out_lab (4-vector arrays)
ALV_gamma_in
ALV_el_in
ALV_Recoil_lab
ALV_el_out
theta_beam (electron out)
phi_beam (random rotation to the reaction plane)
Q2 (few invariants)
yy
WW (squared)
Xbj
tt
Phi_LH ("physics" angle)
CosThetagg (in lab)
CosThetaggCM (in gamma P CM frame)
epsilon (polar)
EventNumber (event index)
TrueEventNumber (total generated over 4 dimensionnal space in $Q^2$, xbj, phi_LH, t)

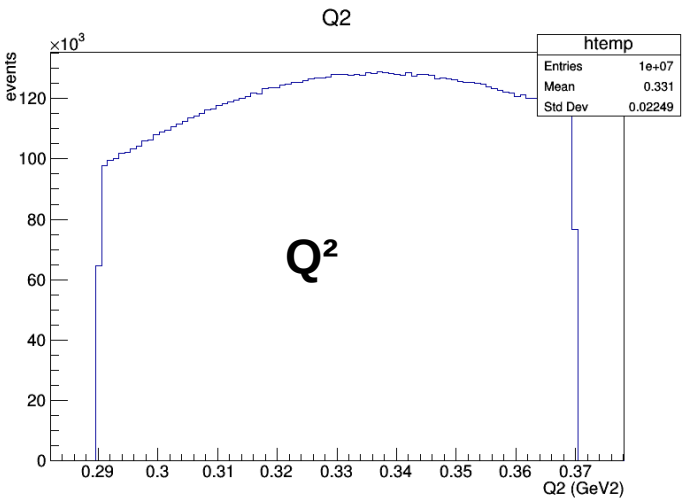
DATA file:
proton 4-vector (hall C frame) ; electron 4-vector (hall C frame) ; various weights (unused here);
CosThetaggCM; W; t; $Q^2$; TrueEventNumber

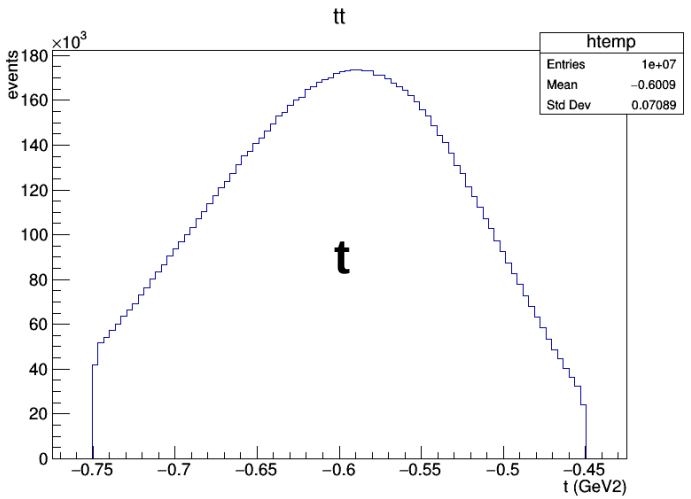
LOG file: normalization info

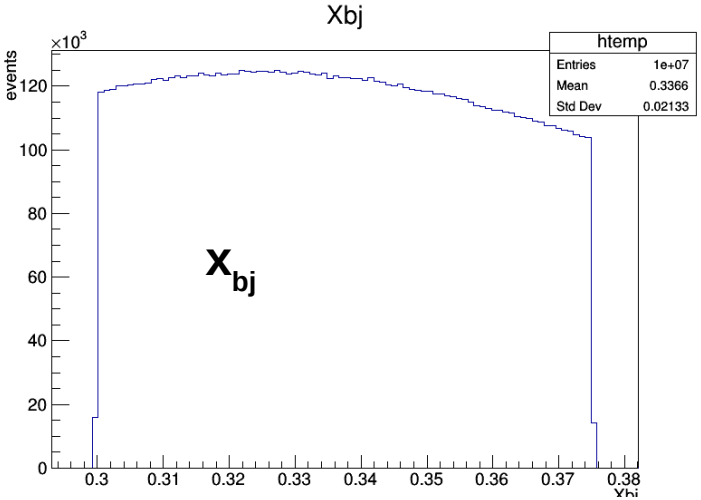
⇒ data file used as input for simc. simc version initialy modified by Sylvester + my additions

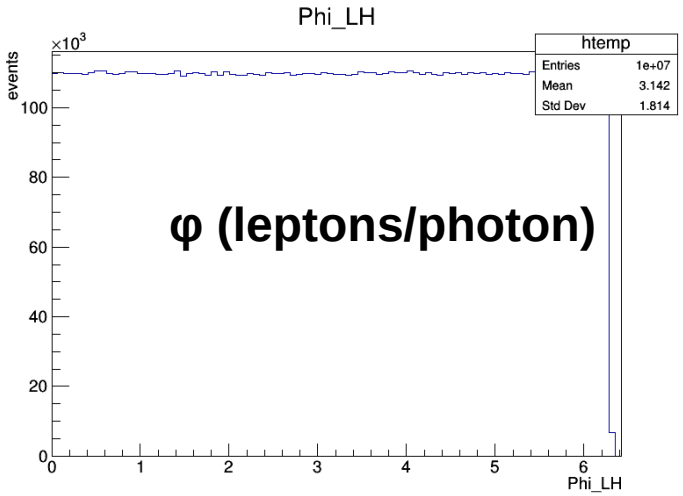
## 2) Generated distributions: shape of generated distributions 1/2 – (more limited than input)

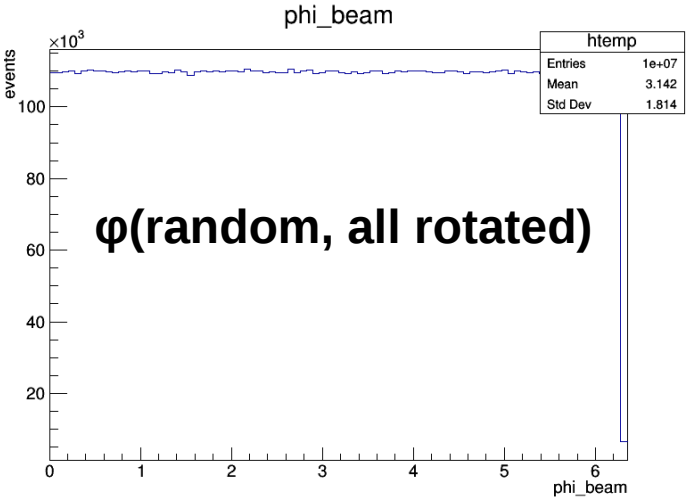
- Generated flat in $Q^2$; t; xbj; phi at fixed Ebeam + flat in arbitrary rotation plane. Kinematic generated distributions are not flat for unweighted events due to accessible phase space
- No physics meaning in the shape of these distributions, just number of generated events
- Below: distributions of what variables are used as input, within full generated range

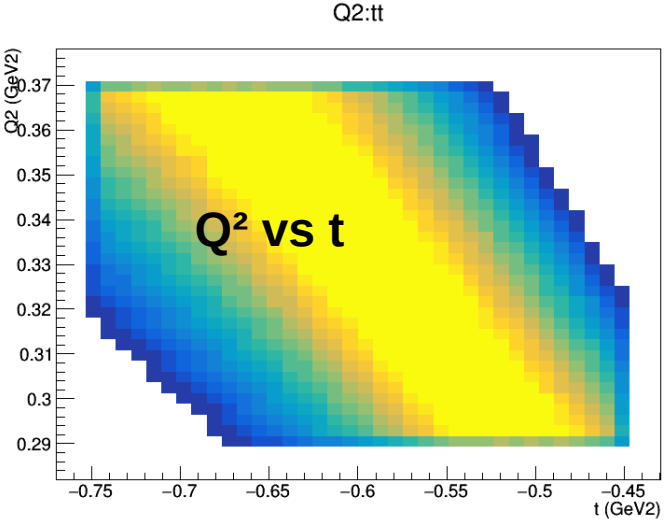


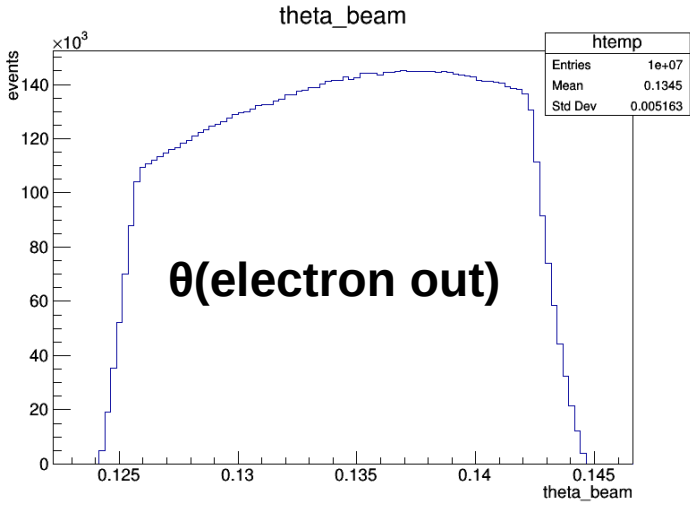



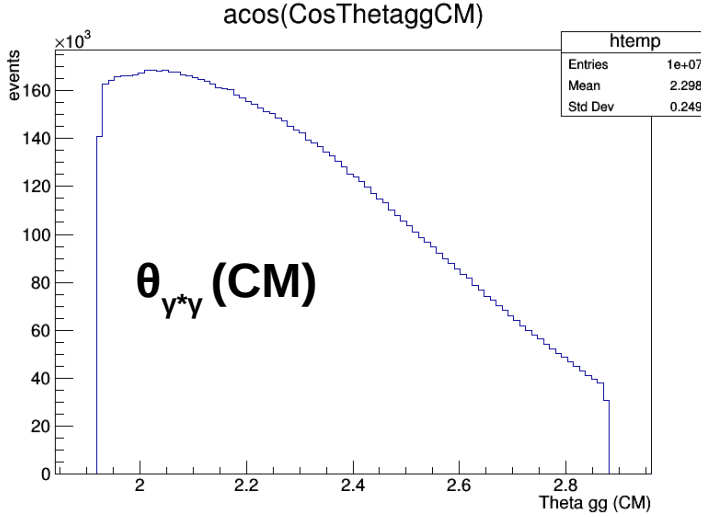



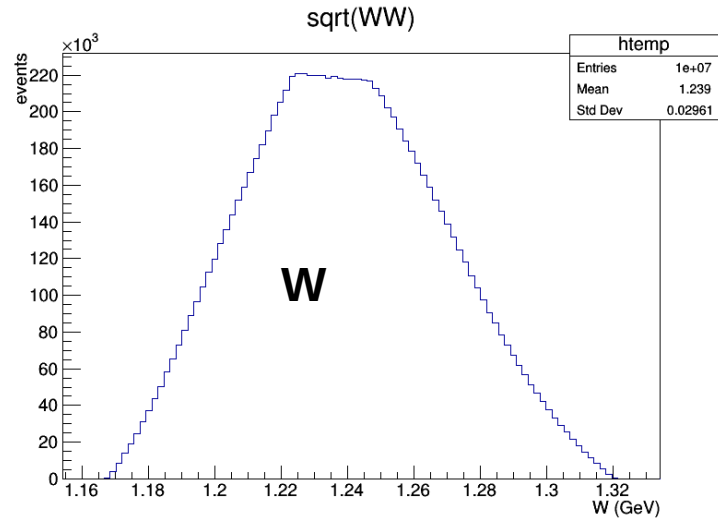

→ reflects probability of falling into accessible kinematics within the cuts of generator

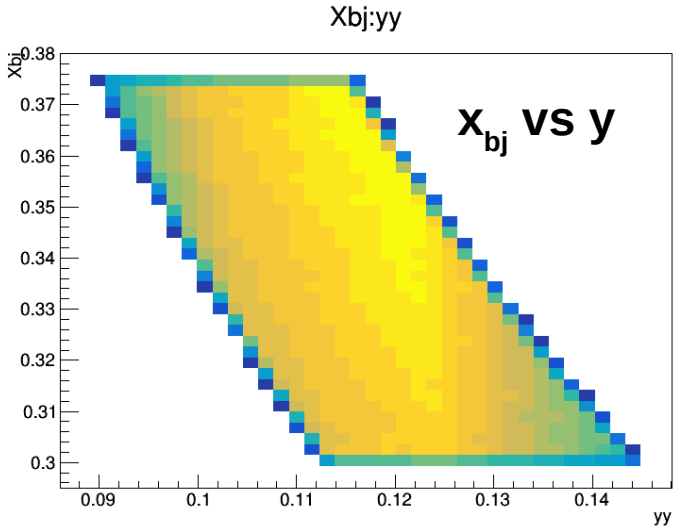
# 2) Generated distributions: shape of generated distributions 2/2 – (more limited than input)

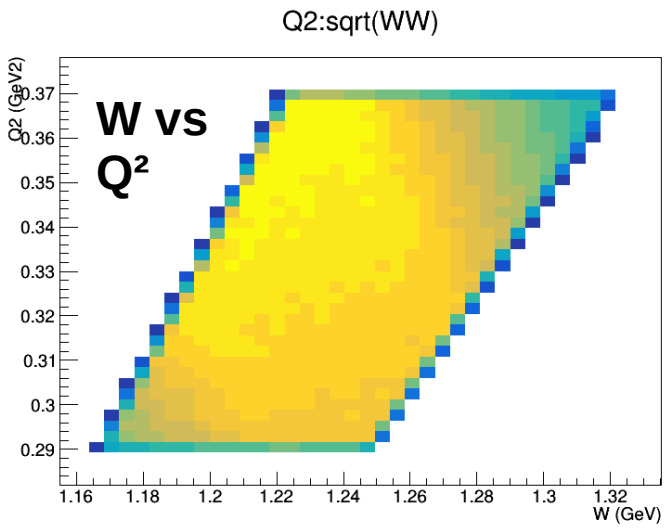
- Below: distributions of kinematic variables calculated from generated ones (no cuts)

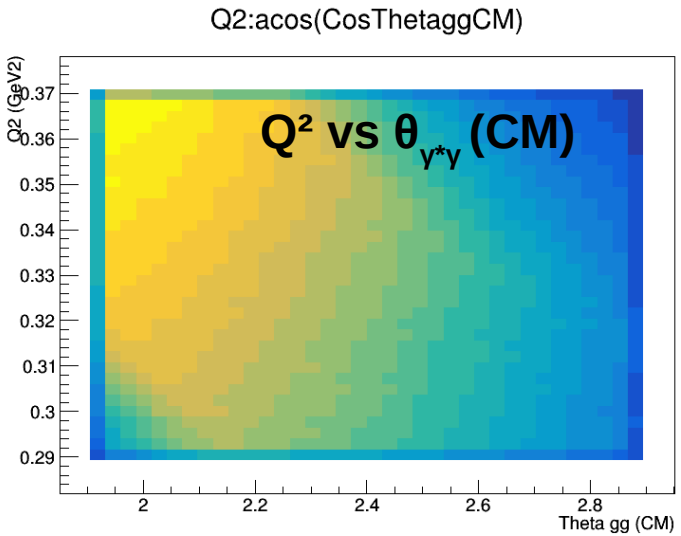



→ reflects what is generated at this level.
No acceptance nor outgoing particle angles consideration

## 3) Hamza + Marie cross check status

kinematics:

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ia: | 4.55 | 155 | 0.33 | 4.035 | 7.688 | 0.893 | 37.359 | 0.158 | 179.277 | 9.419 | 1.232 | 0.670 | 0.341 | 0 |
| Ib: | 4.55 | 155 | 0.33 | 4.035 | 7.688 | 0.893 | 51.420 | 0.158 | 91.955 | 9.419 | 1.232 | 0.670 | 0.341 | 180 |

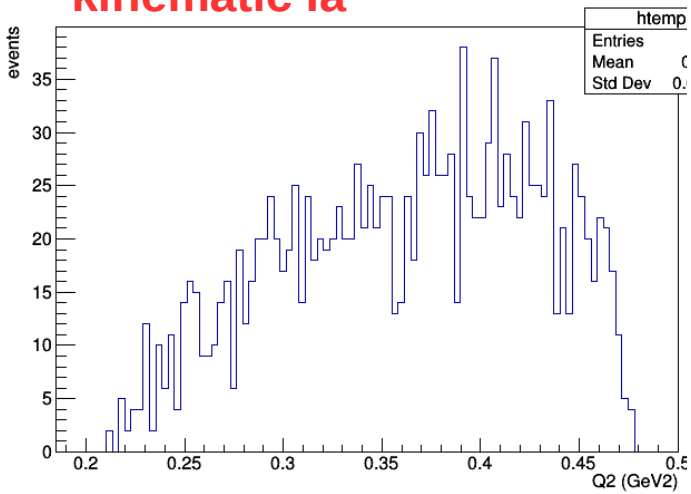
**Next 4 slides:**
showing matching distributions after running generated data out of simc for the 2 above kinematics

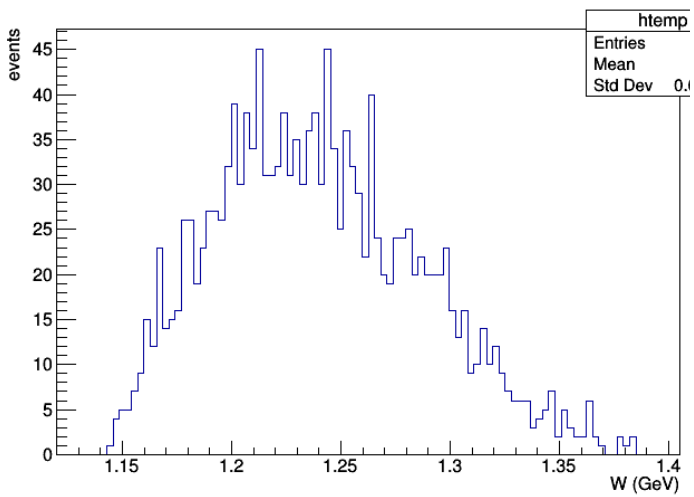
**Conclusion of it:**
- good matching "visually"
- need to go deeper event/event to make sure everything is good + add cuts
- we agree on kinematics (p, θ and invariants)

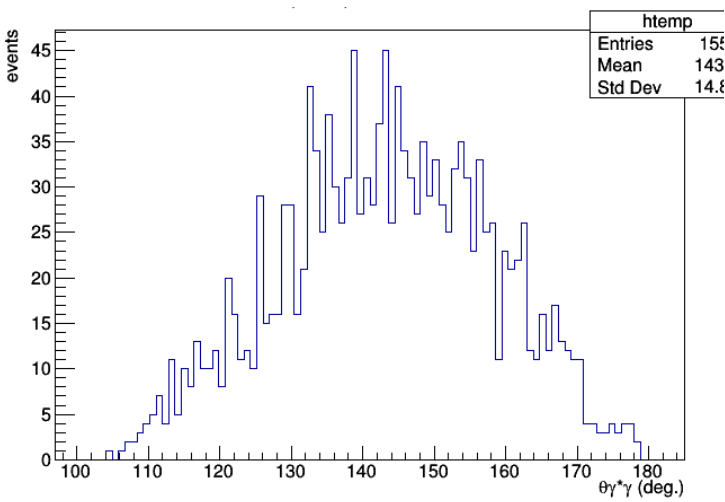
**Remark**:
very different way of generating data: limits can be compared, not the shape as long as events are unweighted

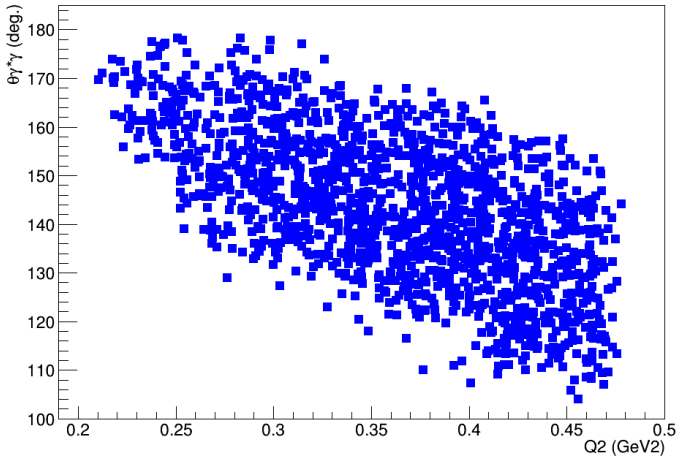
**kinematic Ia**

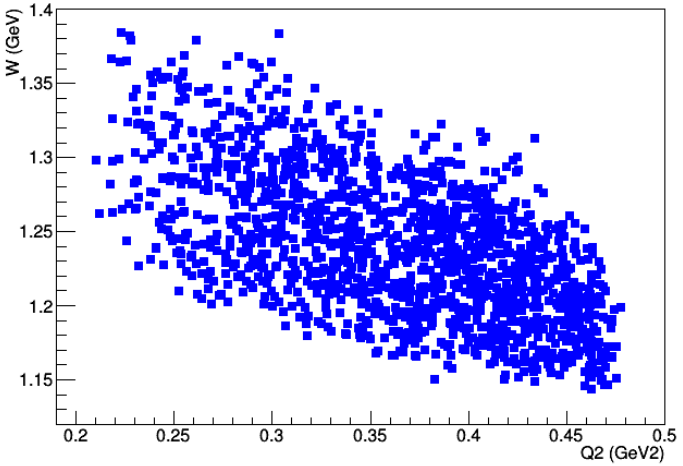
Marie:

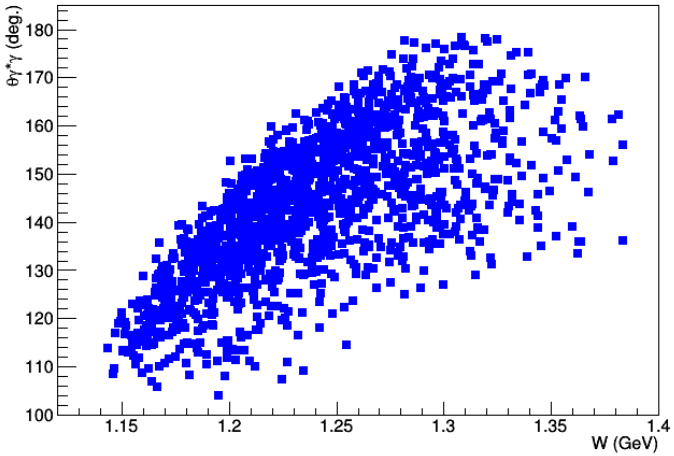


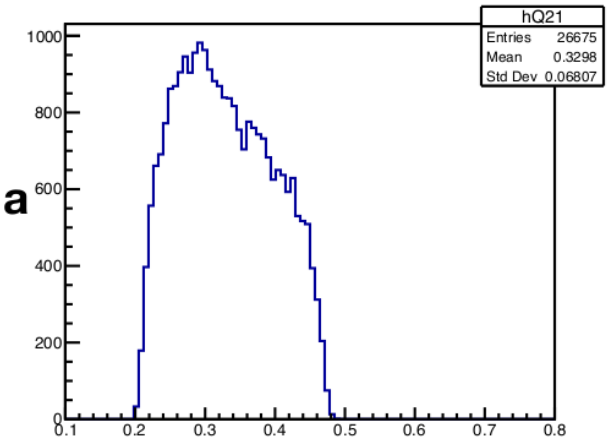



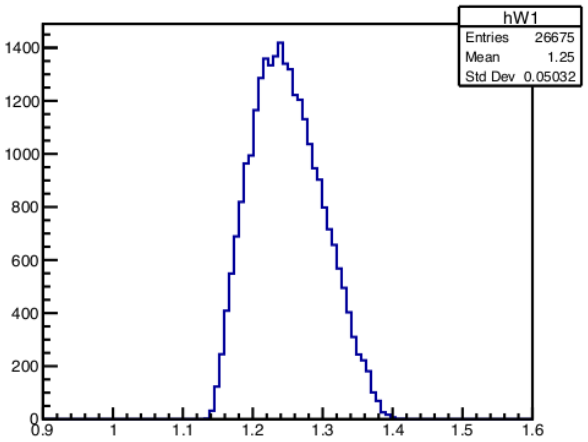



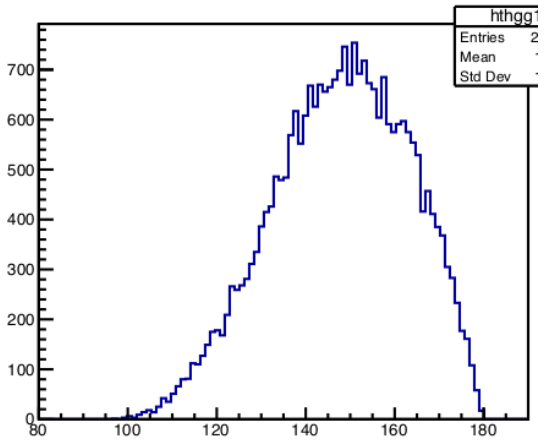




Hamza:

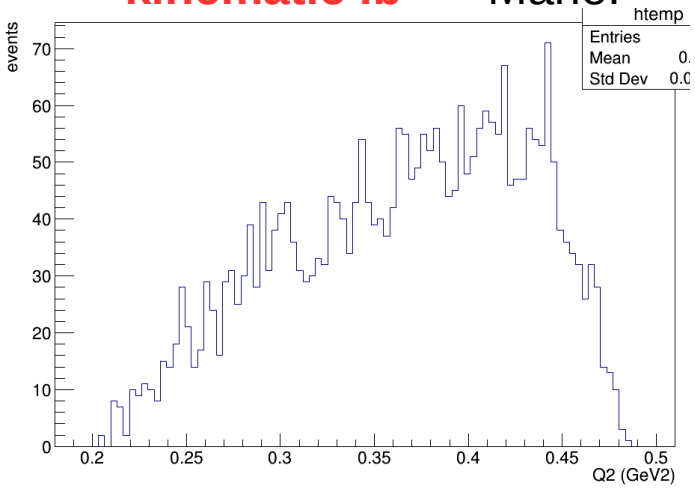


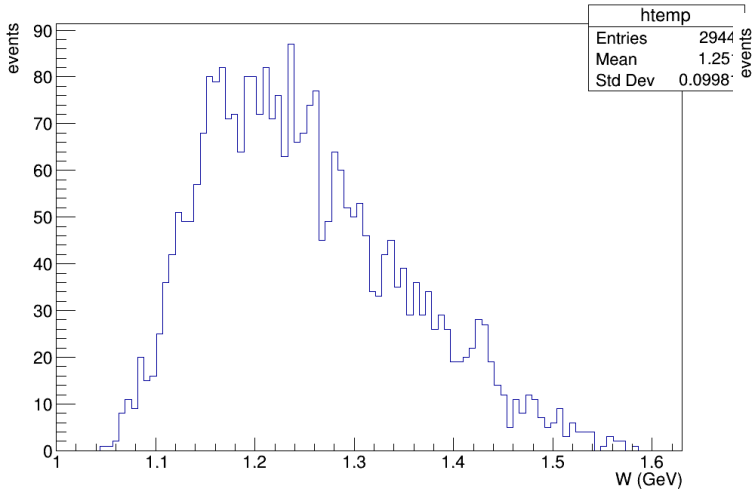



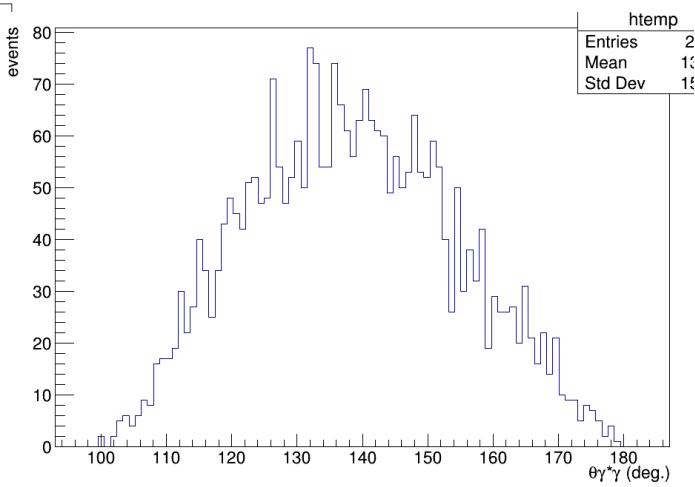



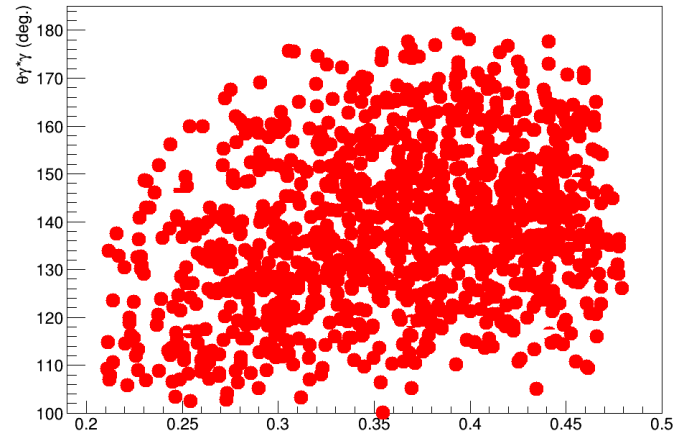
# kinematic Ib

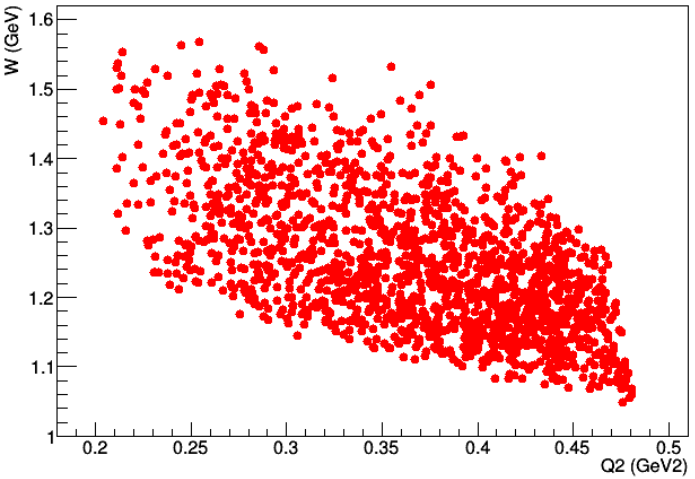
Marie:

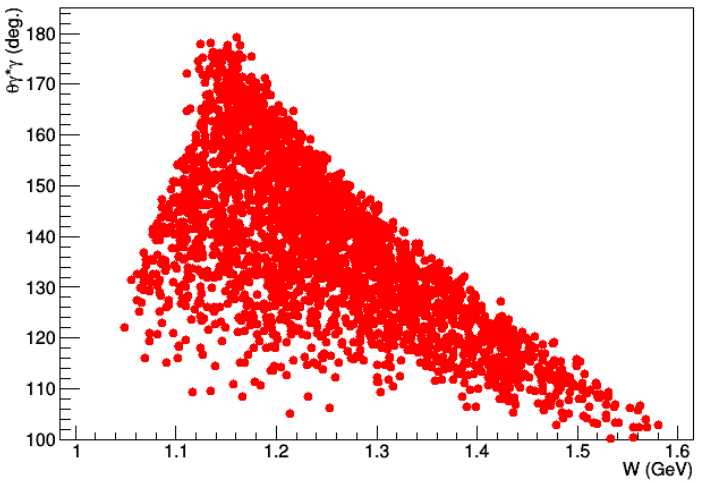


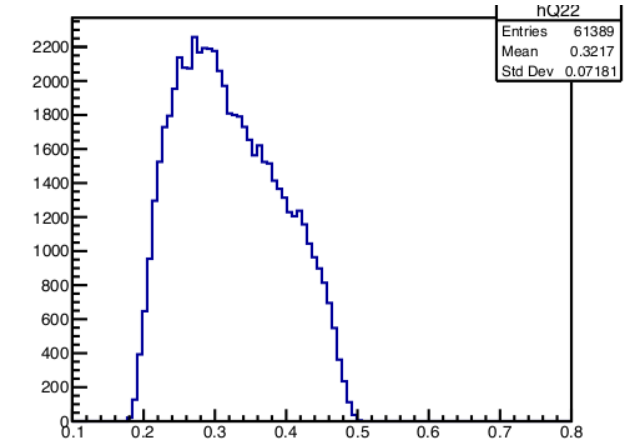



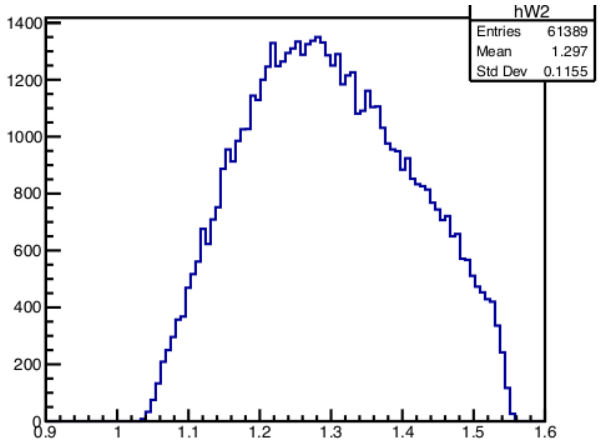



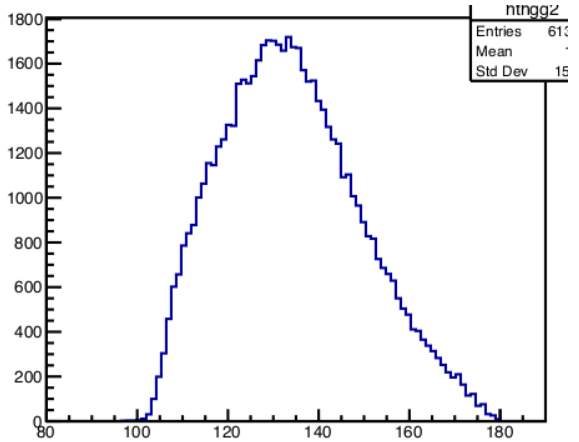

Hamza:




Q2



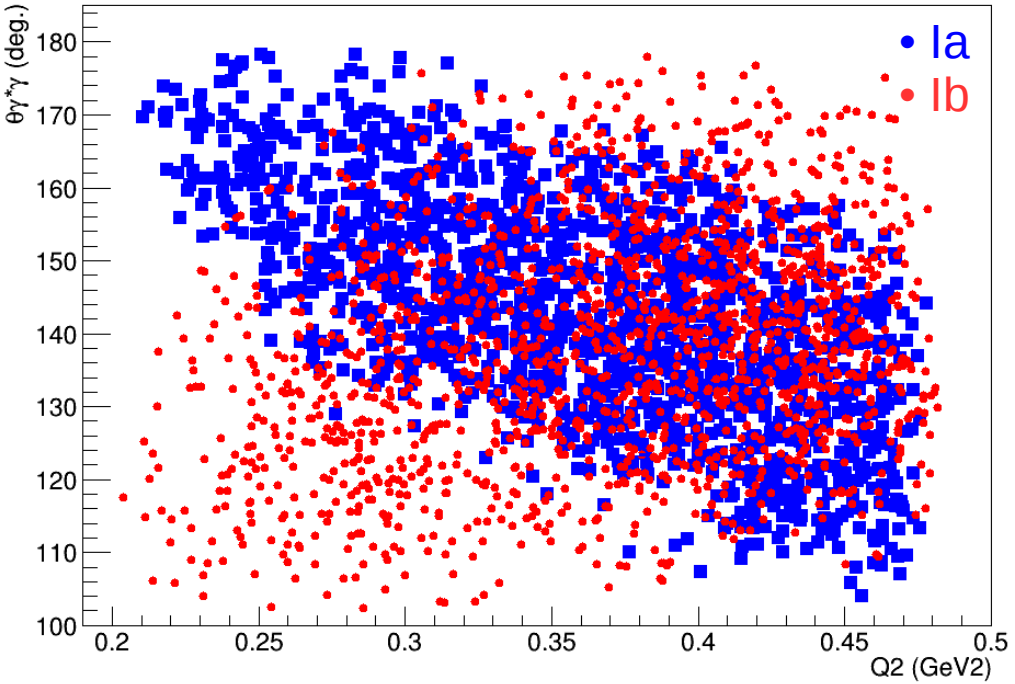

W

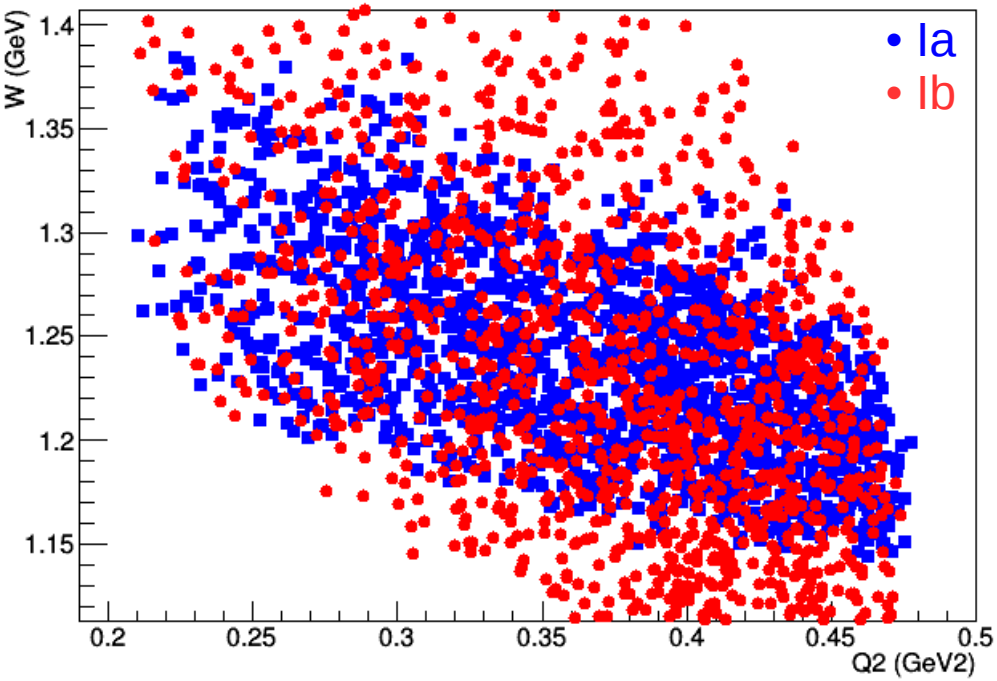



thgg

# kinematics Ia and Ib comparisons

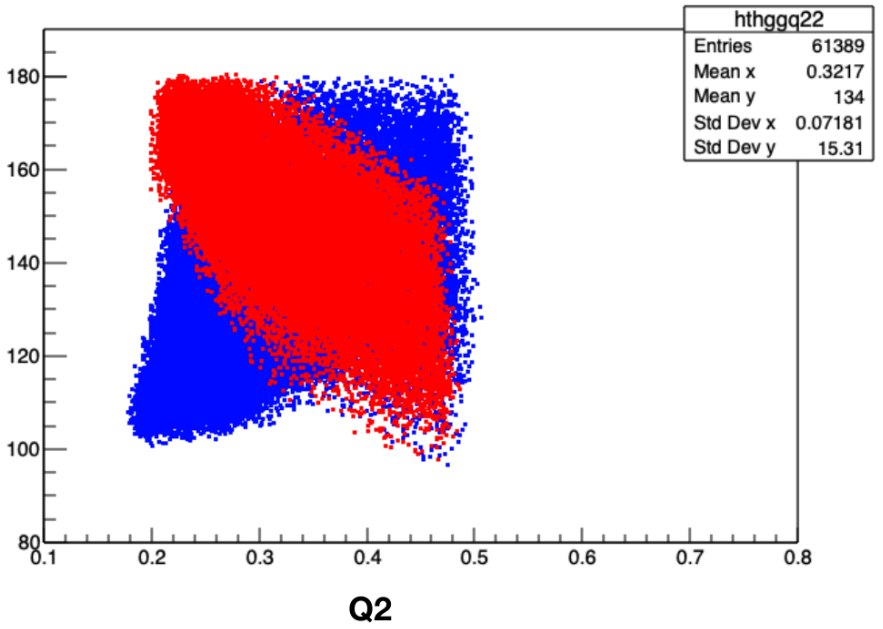
Marie:



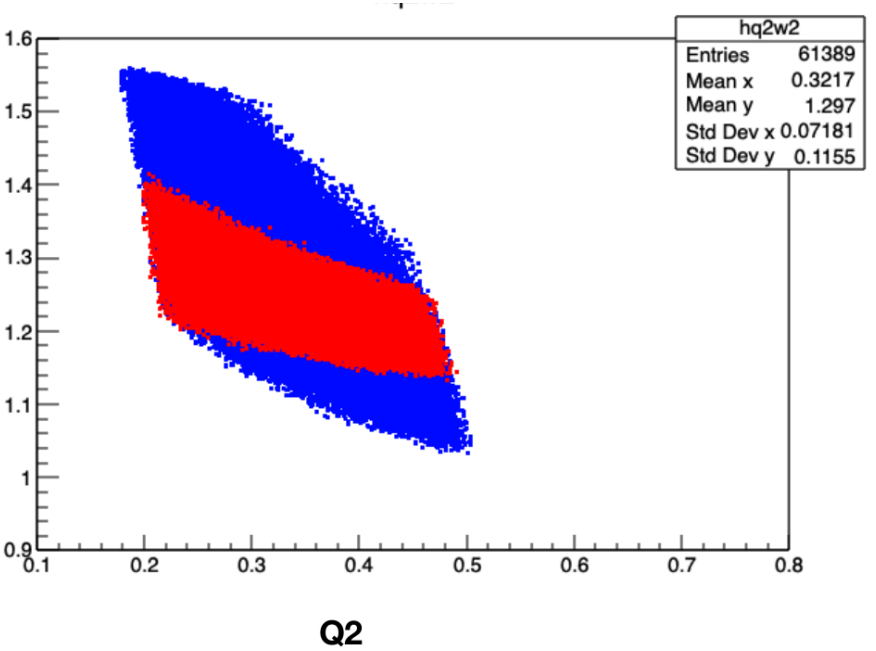




Hamza:

thgg

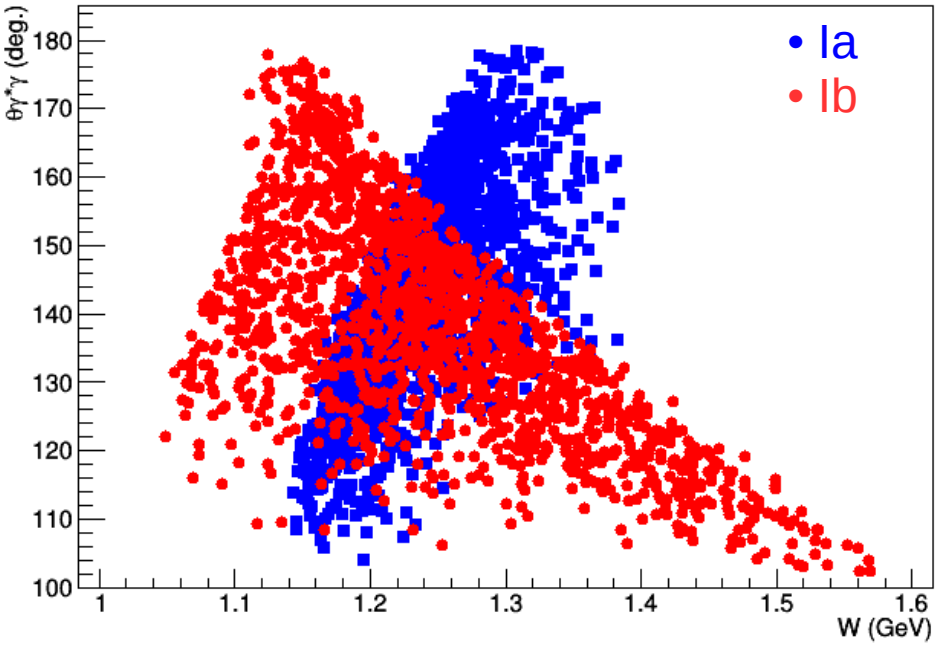



W

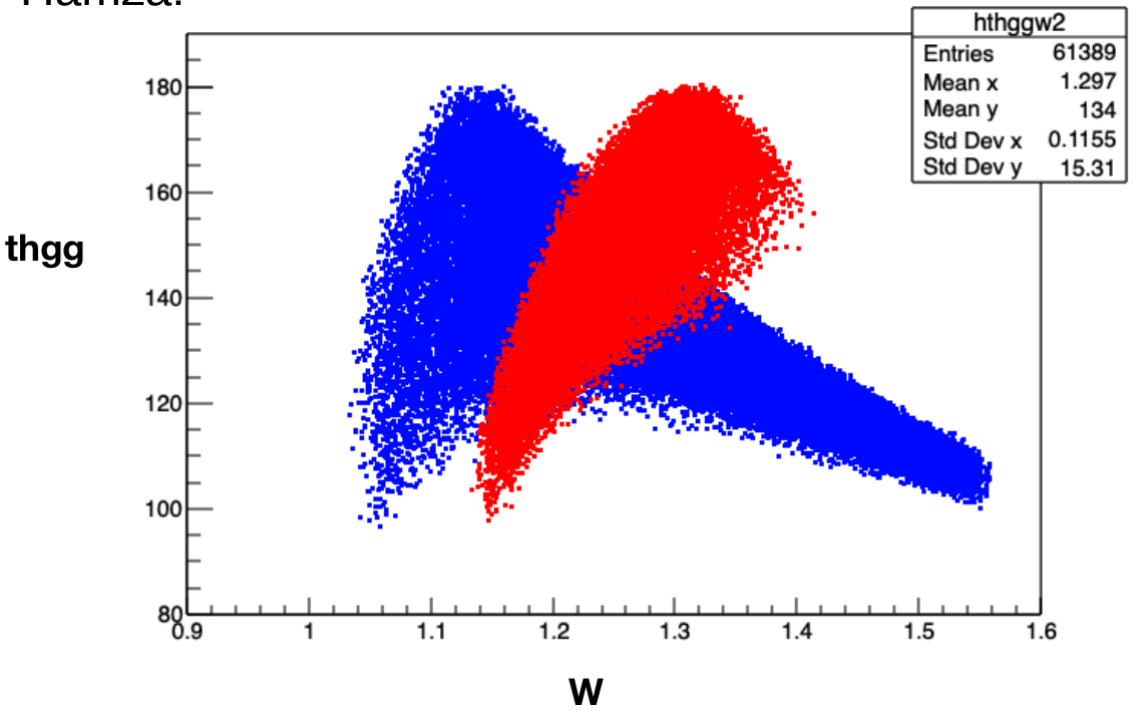


# kinematics Ia and Ib comparisons

Marie:




Hamza:



## 4) Analysis studies  "out of simc"

• compare to before, I use here the values out of simc reconstructed angles and momentum

→ define "generated" + "reconstructed" 4-vectors "as of simc"

→ use these 4-vectors for resolution studies

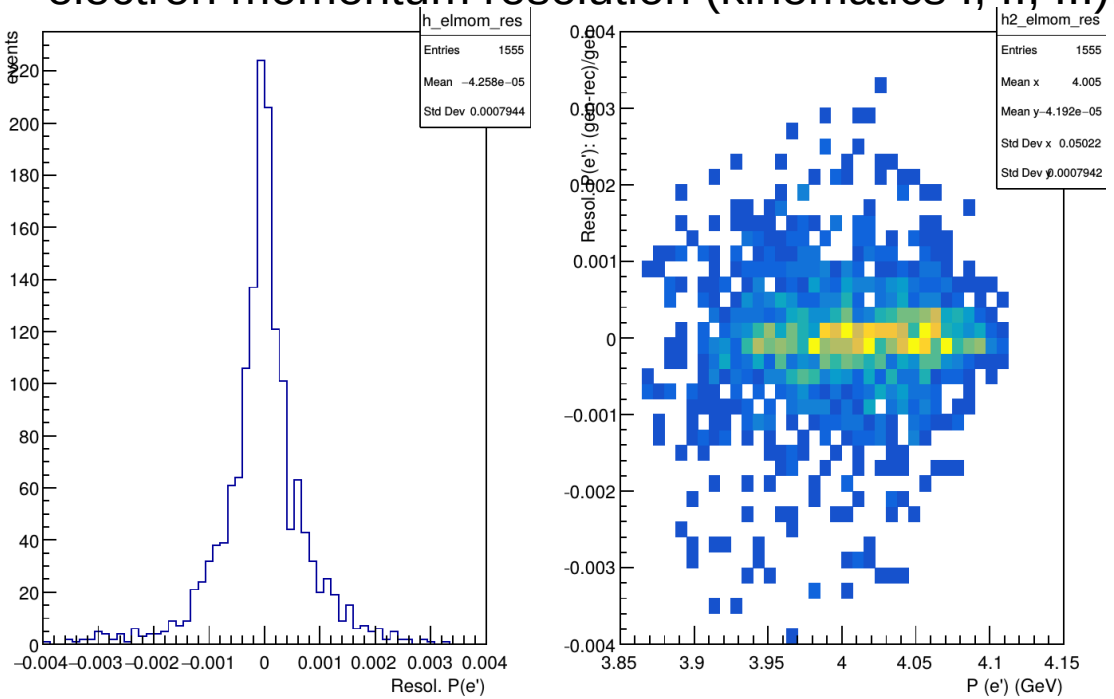
• status:

- work done with unweighted data. in progress, I am checking all variables and if  good match with variables "out of generator".

- next, I plan to look at BH weighted distribution to
check if I can get order of magnitude of counts using same parameters as the proposal

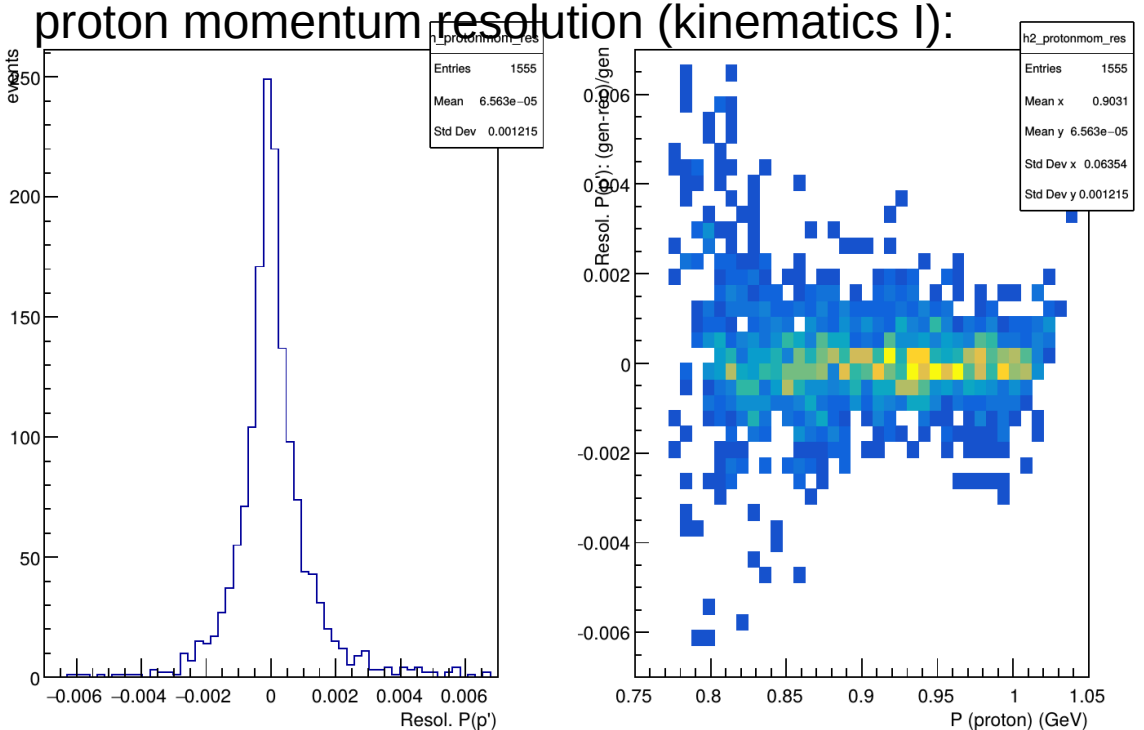
# Momentum resolutions, kinematics I, (II, III)

electron momentum resolution (kinematics I, II, III):




<0.3% resolution in electron momentum

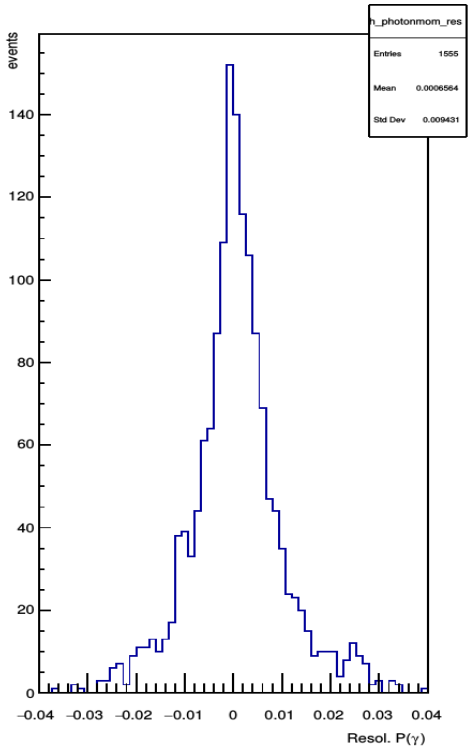
proton momentum resolution (kinematics I):

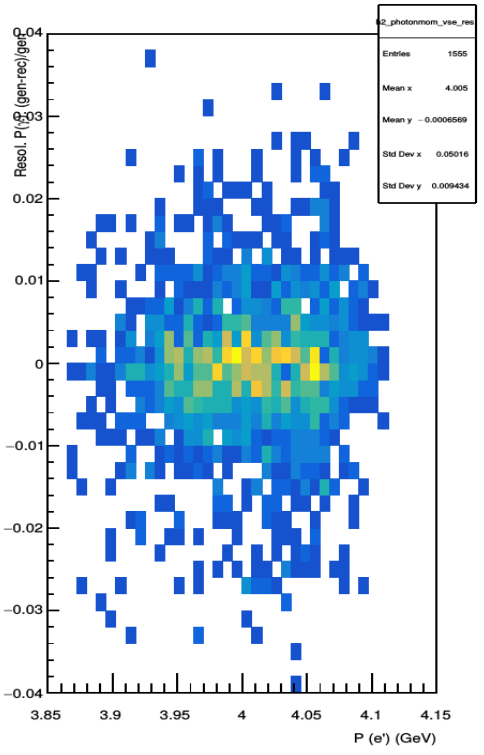


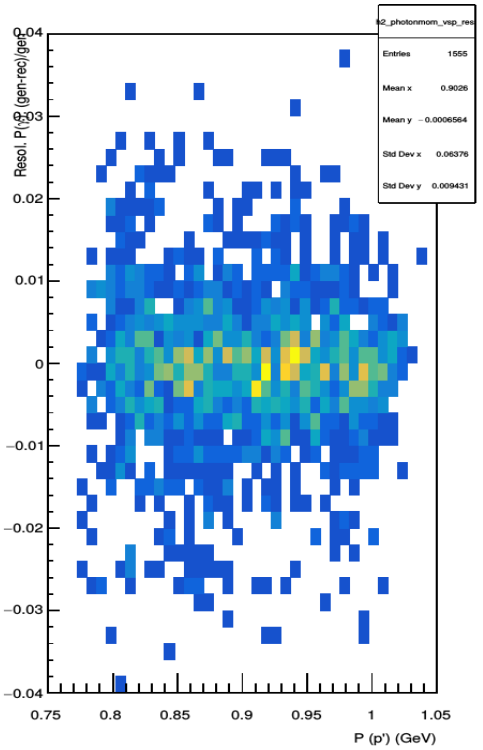

below % level but get worse for lower P
→ will check for other kinematics at lower proton momentum if no problem

# Momentum resolutions: impact on reconstructed kinematics, kin. I, (II, III)

missing particle resolution (≡ photon) – using kinematic I

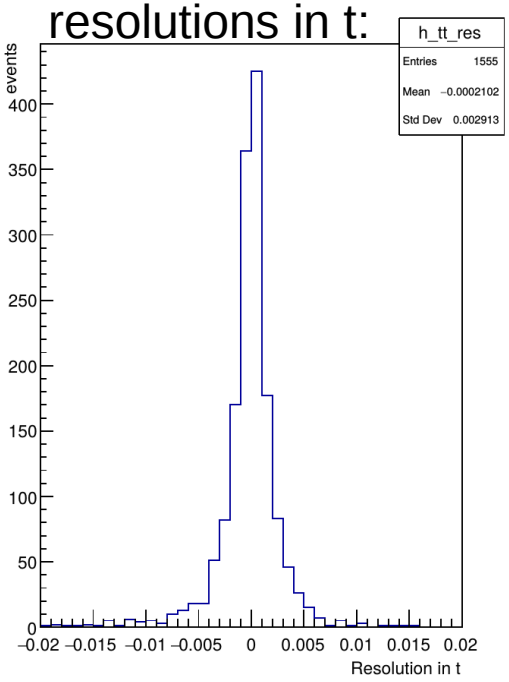


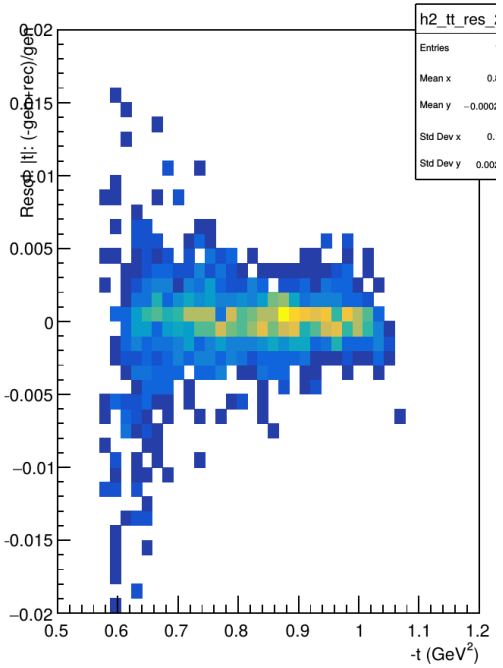




<5%,
seems independent
of P' and e' momentum
at first order

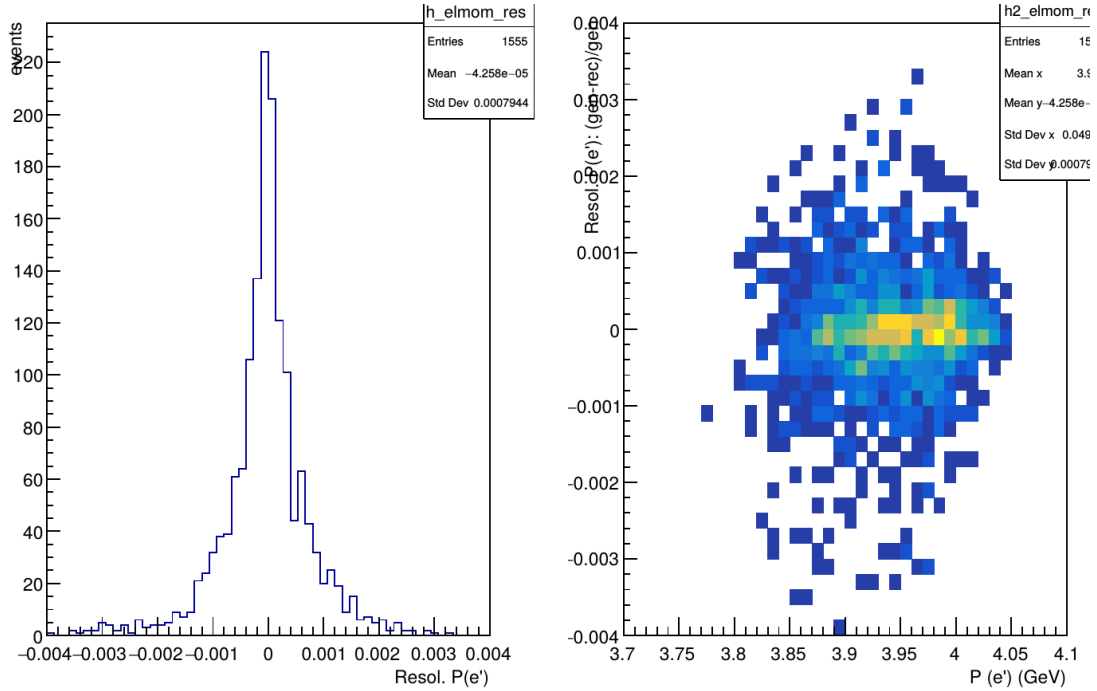
resolutions in t:



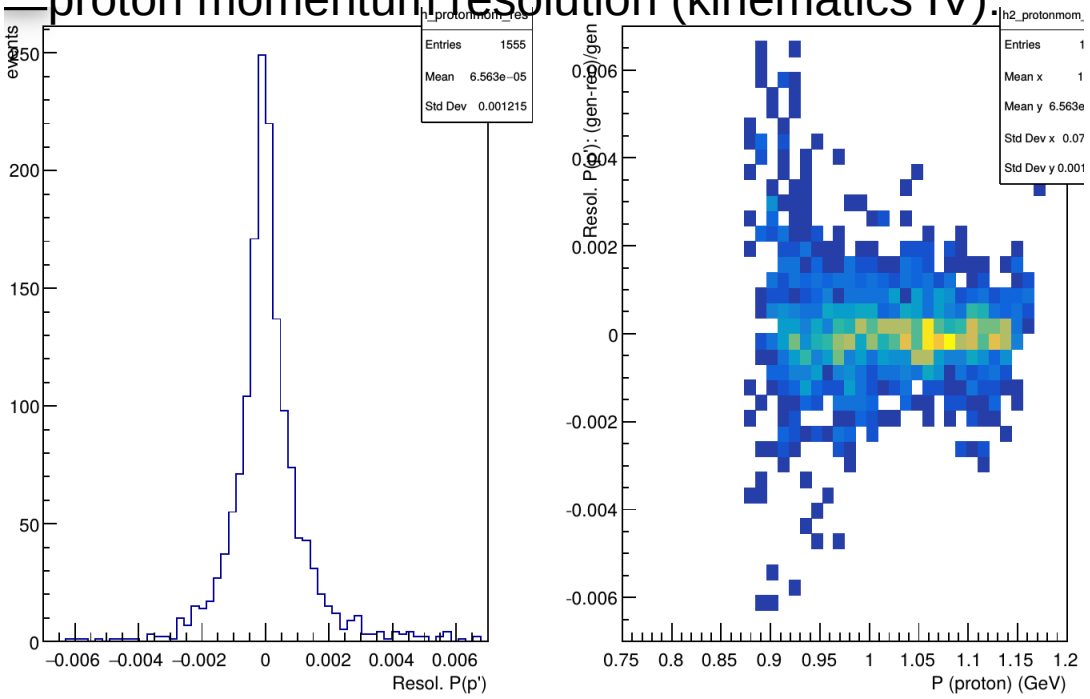
# Momentum resolutions, kinematics IV, (V, VI)

electron momentum resolution (kinematics IV, V, VI):




<0.4% resolution in electron momentum

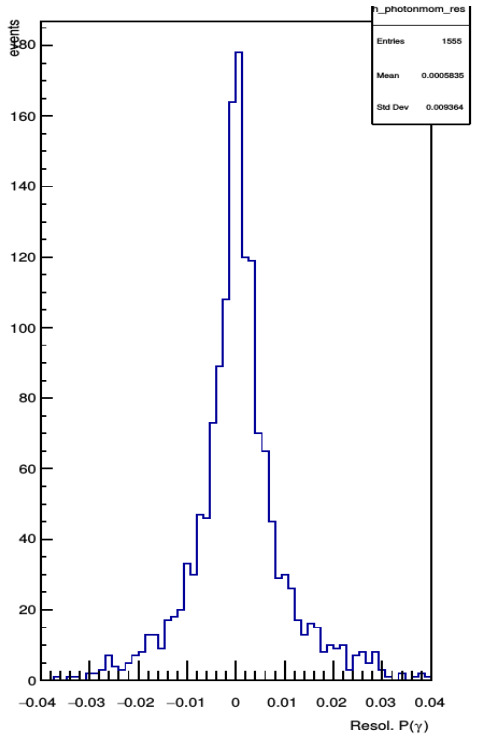
proton momentum resolution (kinematics IV):

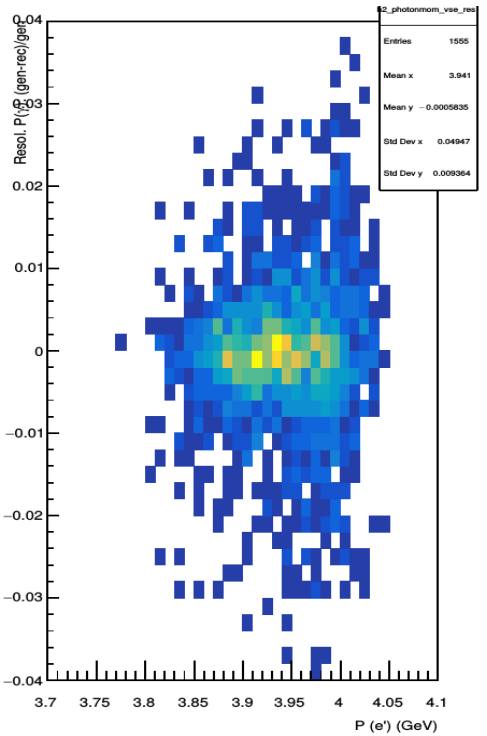


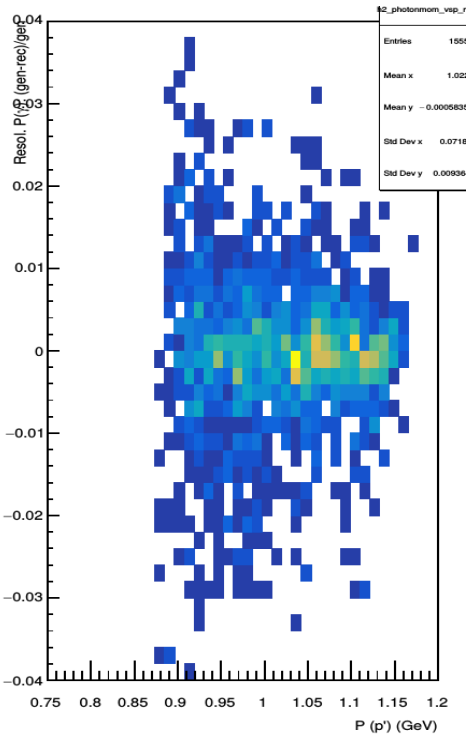

below % level but get worse for lower P
This kinematics has one of the largest P momentum. Narrower than kin I on the other slide

# Momentum resolutions: impact on reconstructed kinematics, kin. IV, (V, VI)

missing particle resolution (≡ photon) – using kinematic I

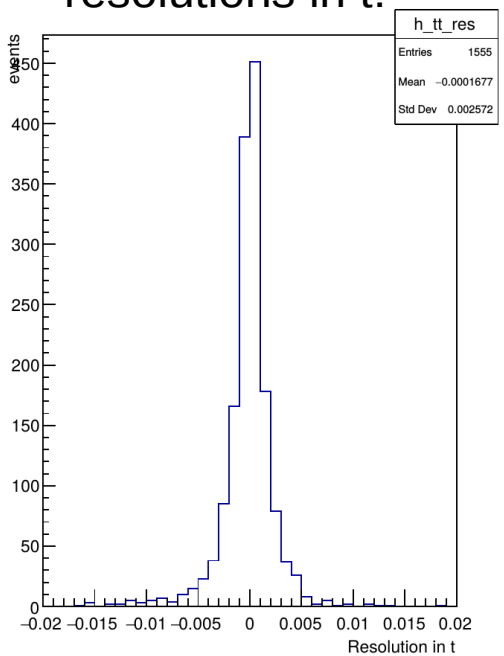


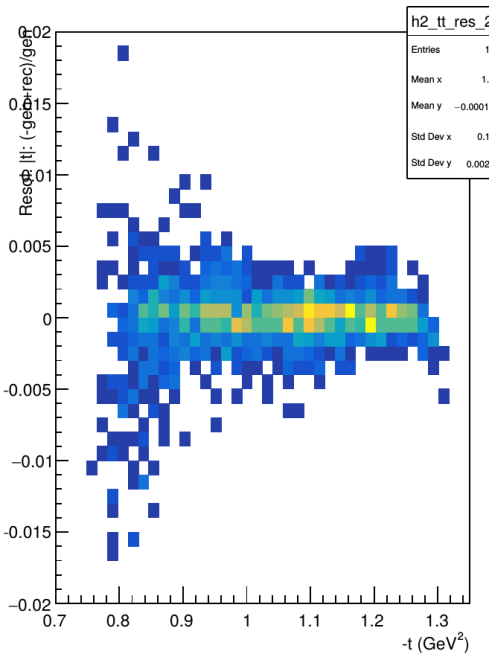




<5%,
seems independent
of P' and e' momentum
at first order

resolutions in t:



# Summary

**WHAT IS DONE**

- Independent BH-weighted VCS generator running well. Provides ROOT+HEP files

- HEP files through simc match with unweighted Hamza's results "visually": need to match Px, Py... values, and weights in a second step to make sure we are getting same things

- Reconstructed values, exclusivity. Study of some effects in resolution "as of simc"

- Running well with weighted events as well but need some optimizations

**TO DO LIST:**

- systematic studies on resolutions in momentum & angle for all kinematics + impact on other variables + exclusivity → see if no problem for lowest proton momenta (kin III by instance)

- weighted events, check if matching expected cross sections and counts/ starting with BH only

- optimize speed for weighted simulations

- optimizations in reconstruction (very basic code for now)

- finalize cross check with Hamza

**REQUEST**:

my event weighting = "pure" BH cross section

→I really need B. Pasquini code to include VCS: the sooner the better due to I may have to do major modifications in my generator depending what format it is

→I would like to perform studies: asym vs kinematics, x-sec vs angles... Also, sooner the better!