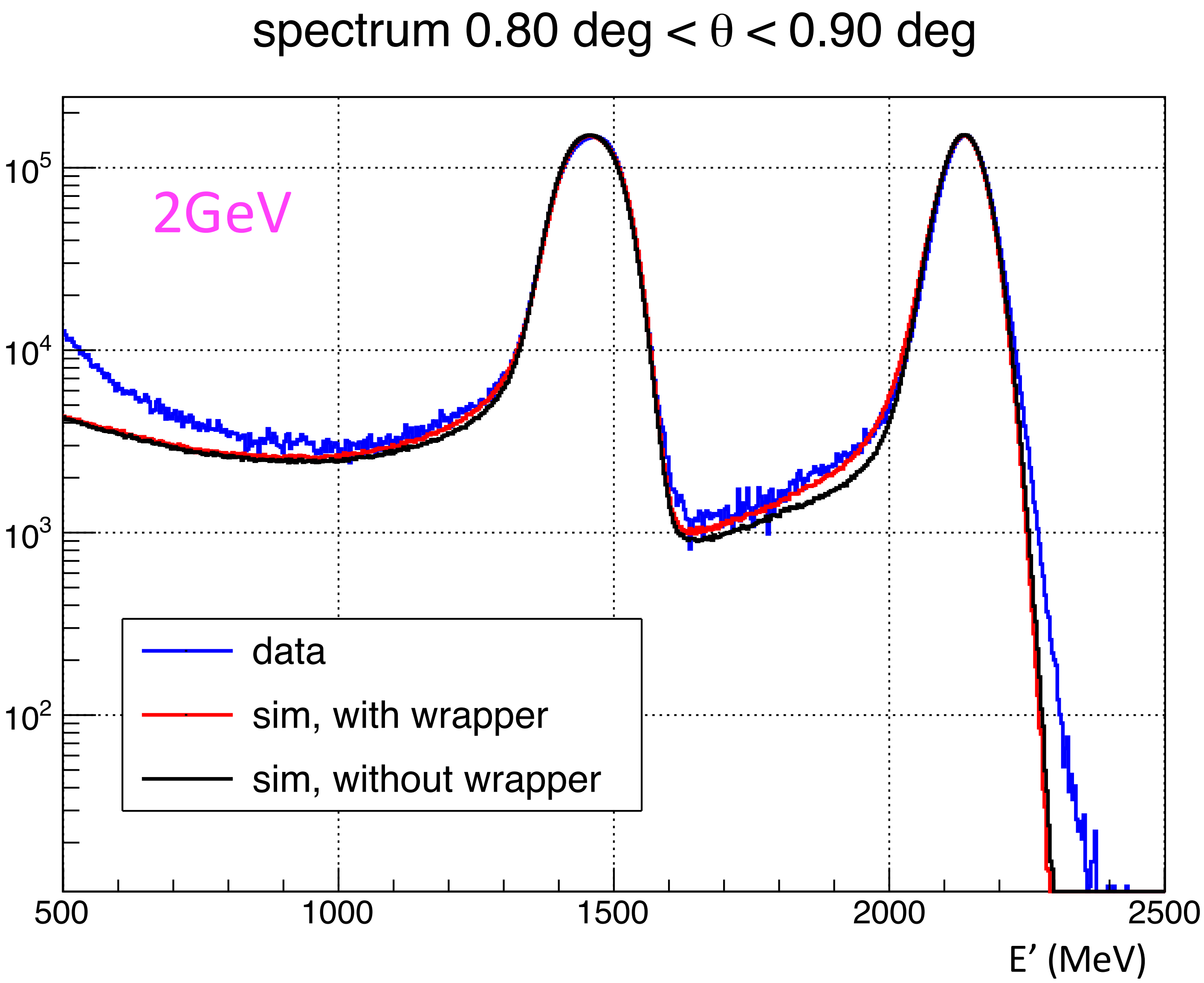
Effect of HyCal Module Wrapper

- For each HyCal module, there is a ~100um wrapper around it (same for PWO and LG)
- These wrappers may introduce some energy leakages, as they creates gaps between modules. This may slightly change the size of the elastic tail
- Larger elastic tail means less yield with a given cut, so it may change the ep/ee ratio
- In the previous study, it has not been put in in the simulation, so we should study its effect now

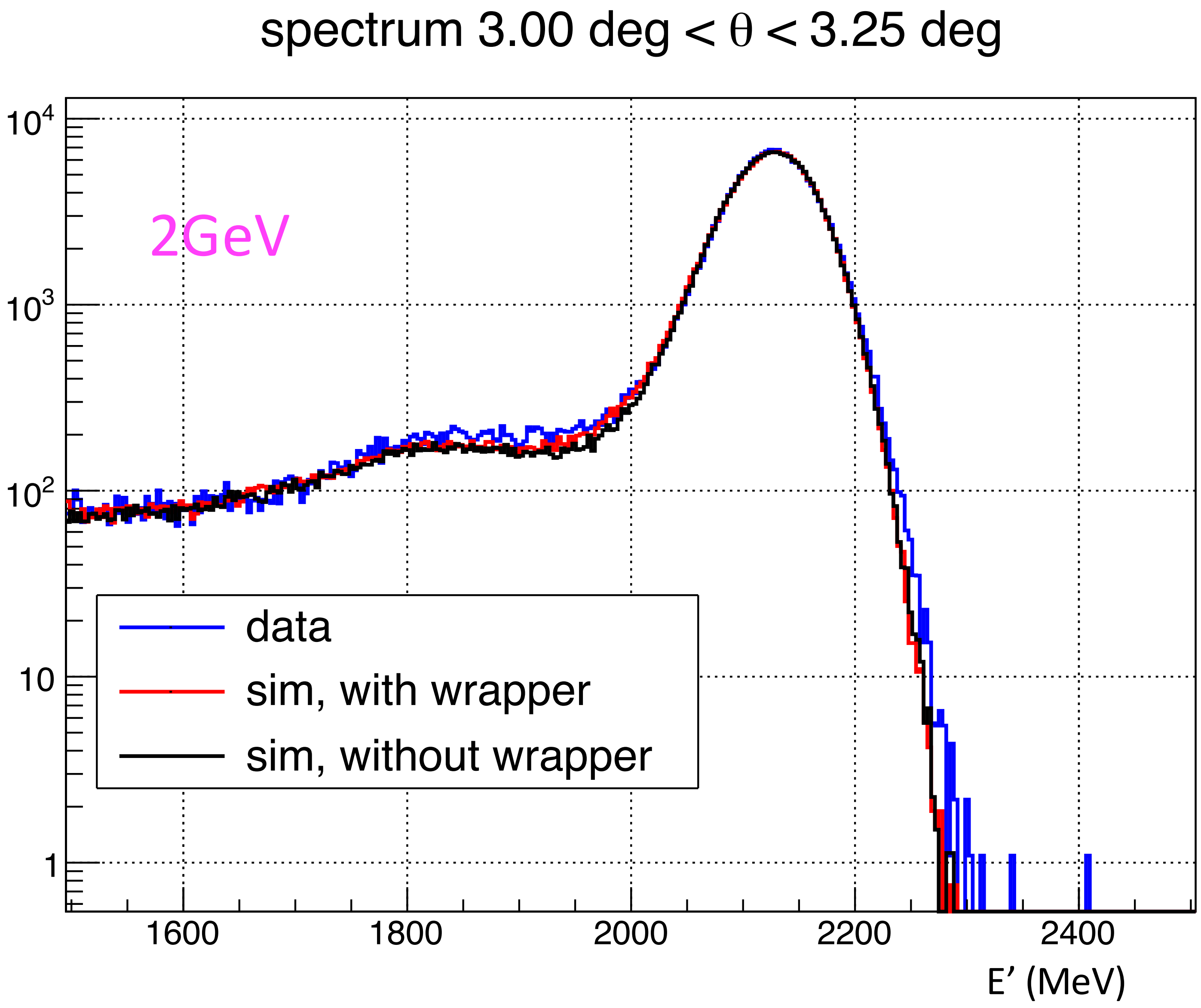
Effect of HyCal Module Wrapper – Energy Spectrum comparison

- At very forward angle, the elastic tail in the data is a bit larger that the simulation without wrapper
- With wrapper, the simulation matches better with the data

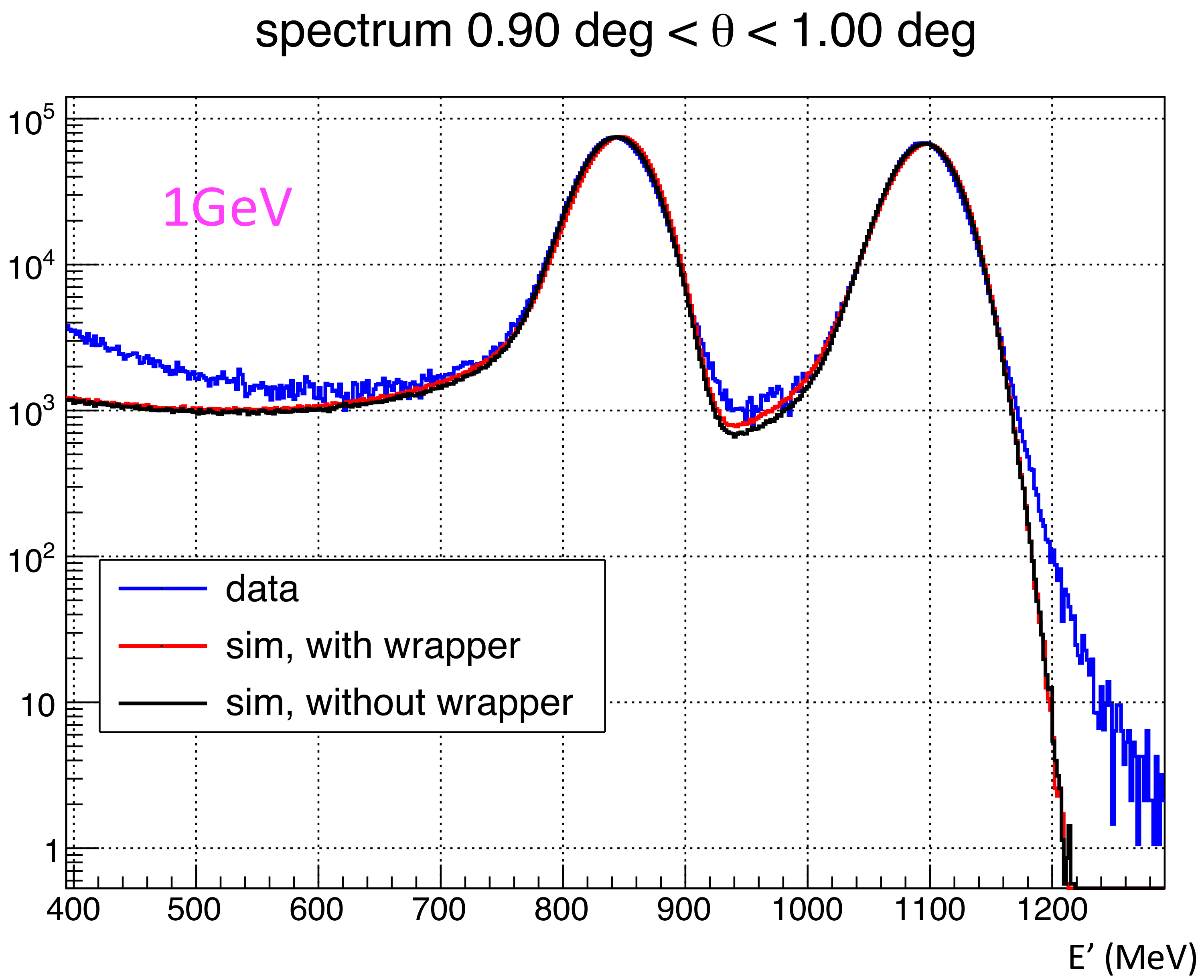


Effect of HyCal Module Wrapper – Energy Spectrum comparison

- At larger angle, the effect of wrapper seems smaller, as the incident particles ”see” less caps between modules
- And also in the LG, since the thickness of wrapper is the same as PWO, the area ratio between wrapper and module is even smaller

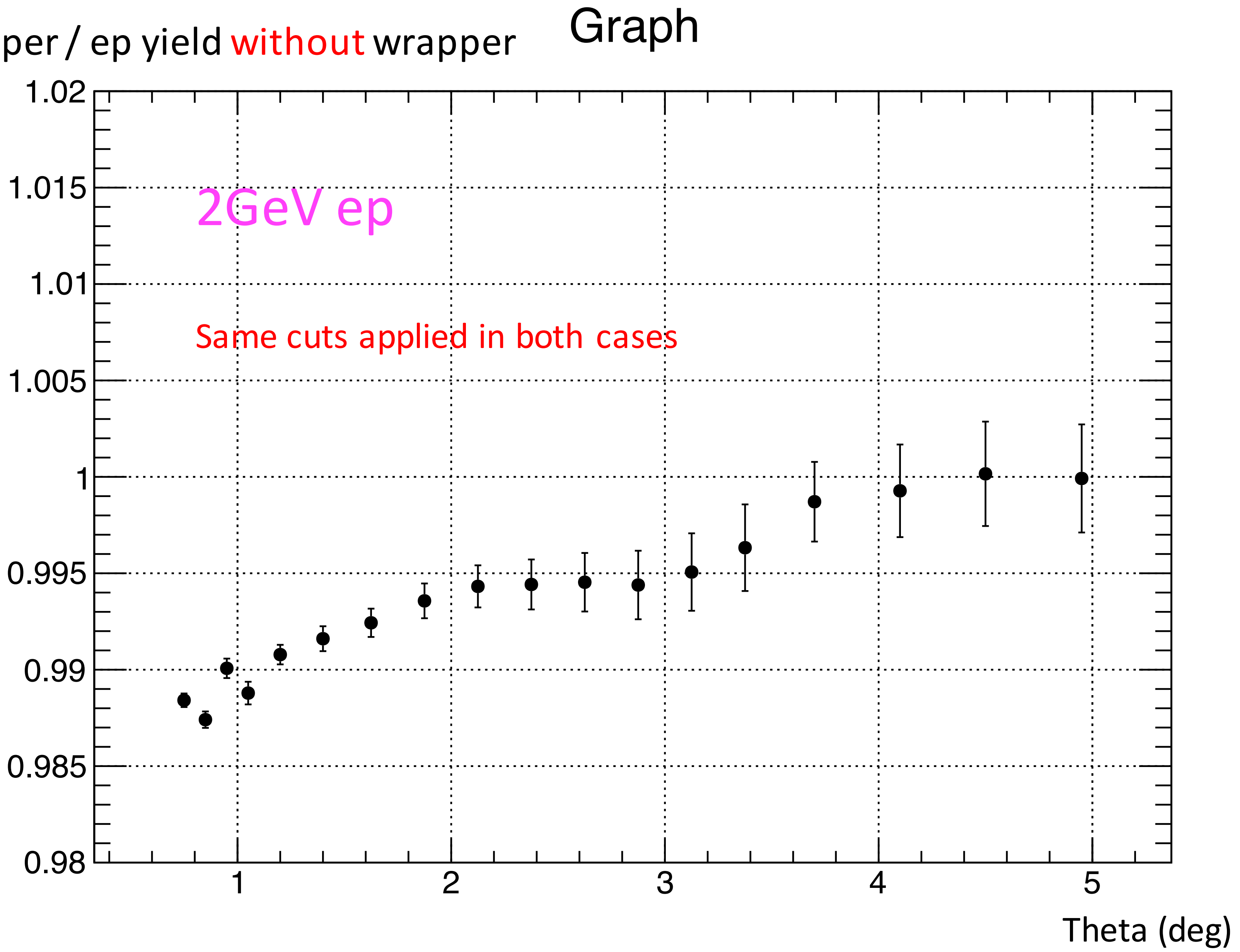


Effect of HyCal Module Wrapper – Energy Spectrum comparison

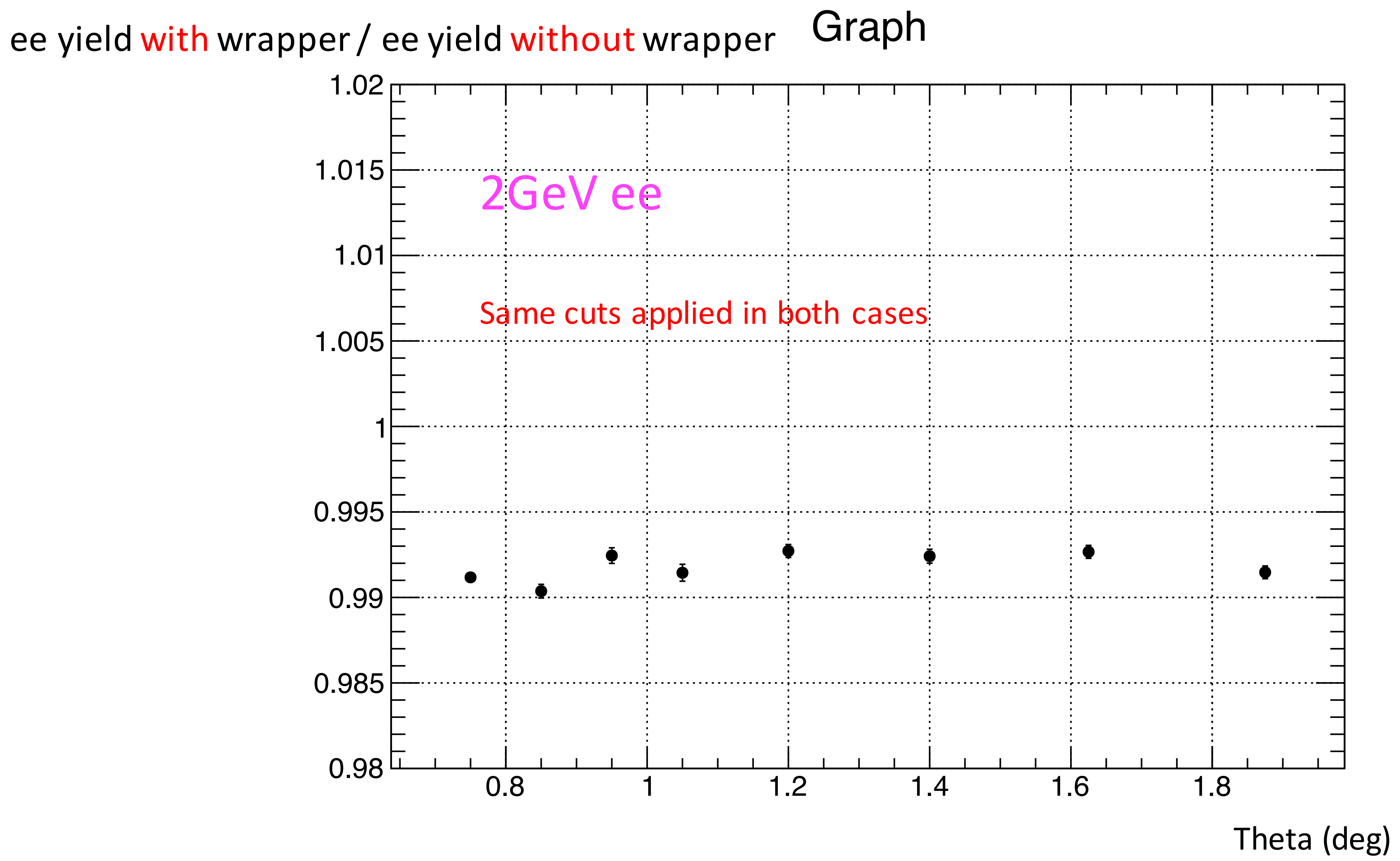


Effect of HyCal Module Wrapper – Yield ratio

ep yield with wrapper / ep yield without wrapper

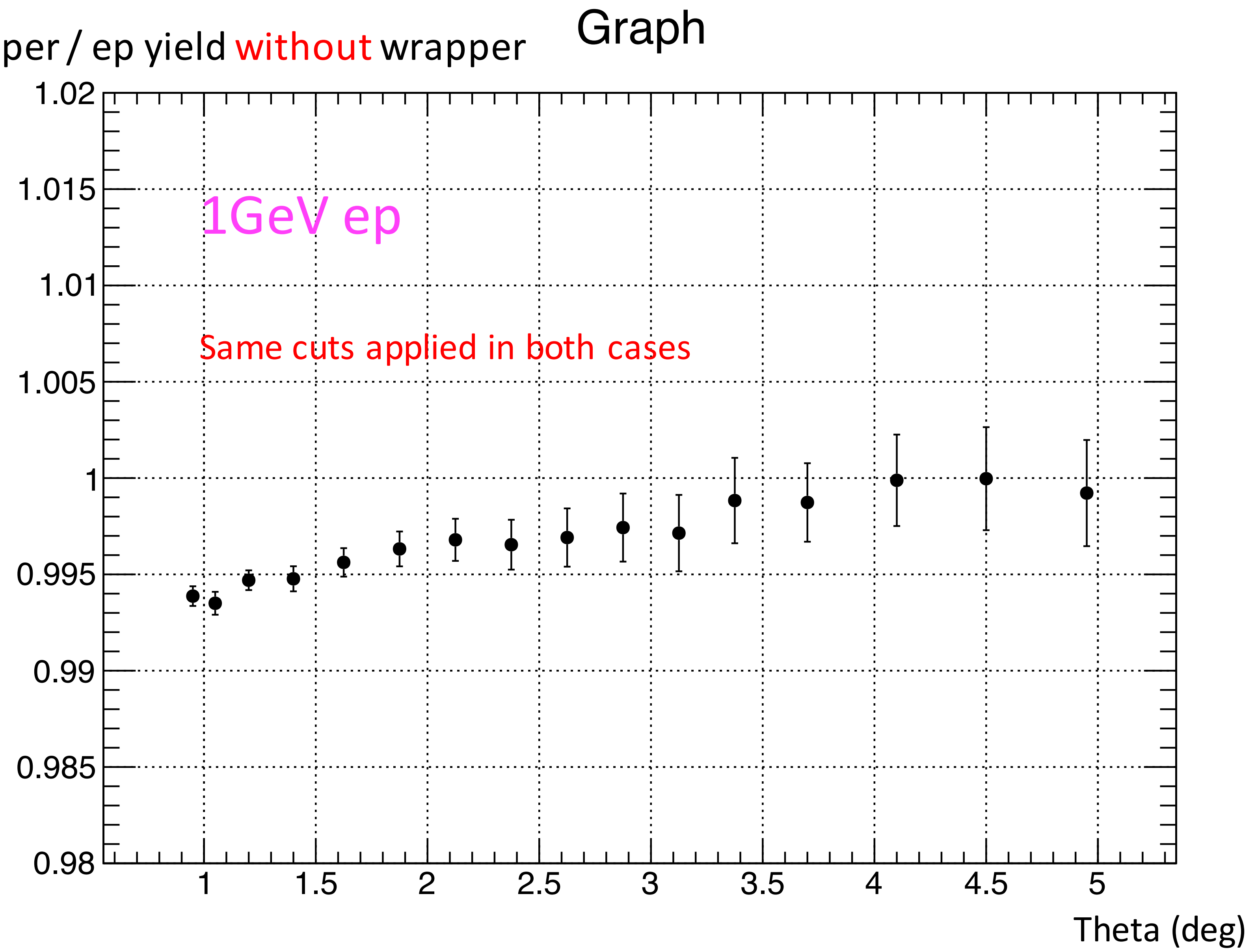


Effect of HyCal Module Wrapper – Yield ratio



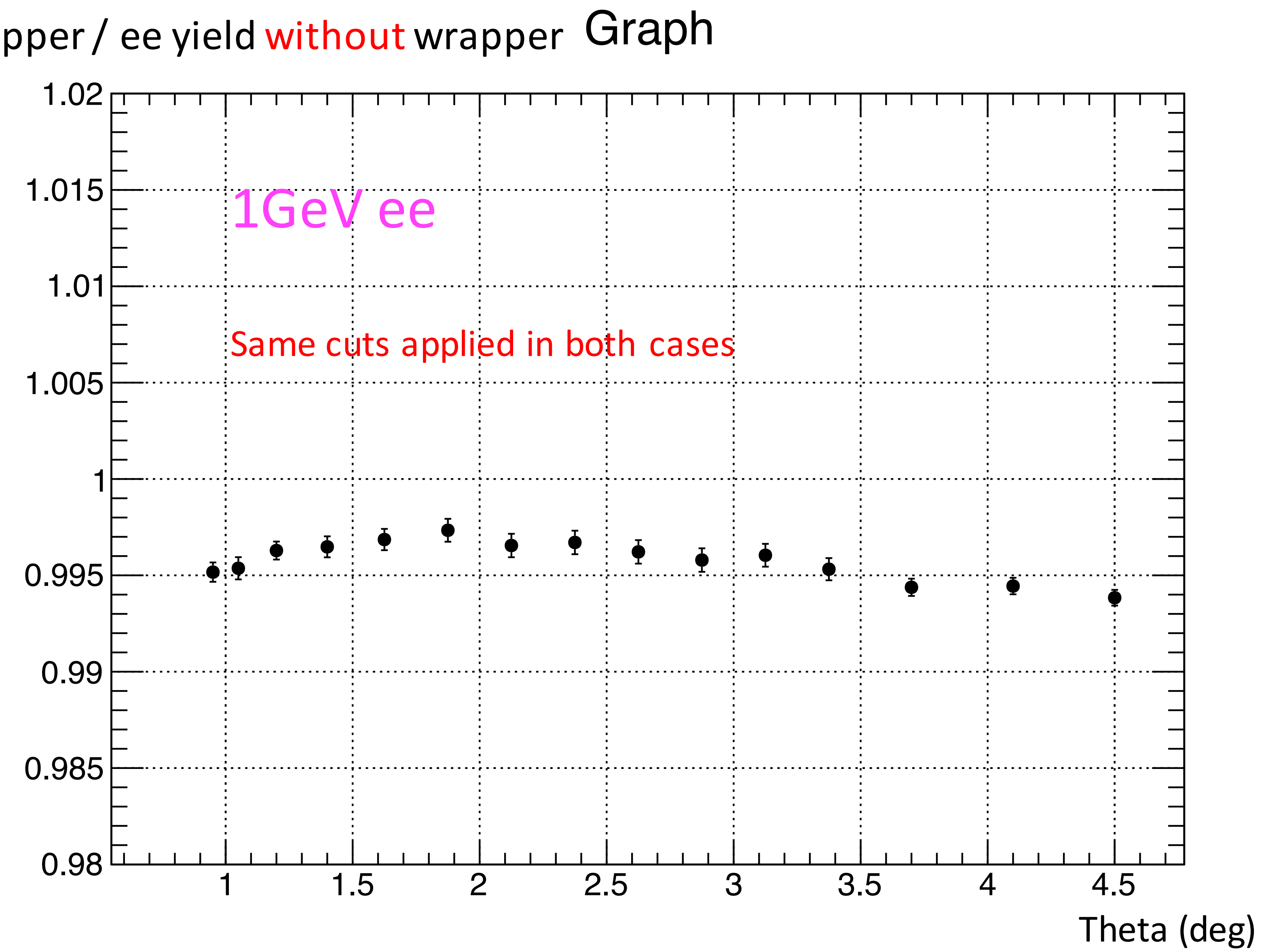
Effect of HyCal Module Wrapper – Yield ratio

ep yield with wrapper / ep yield without wrapper

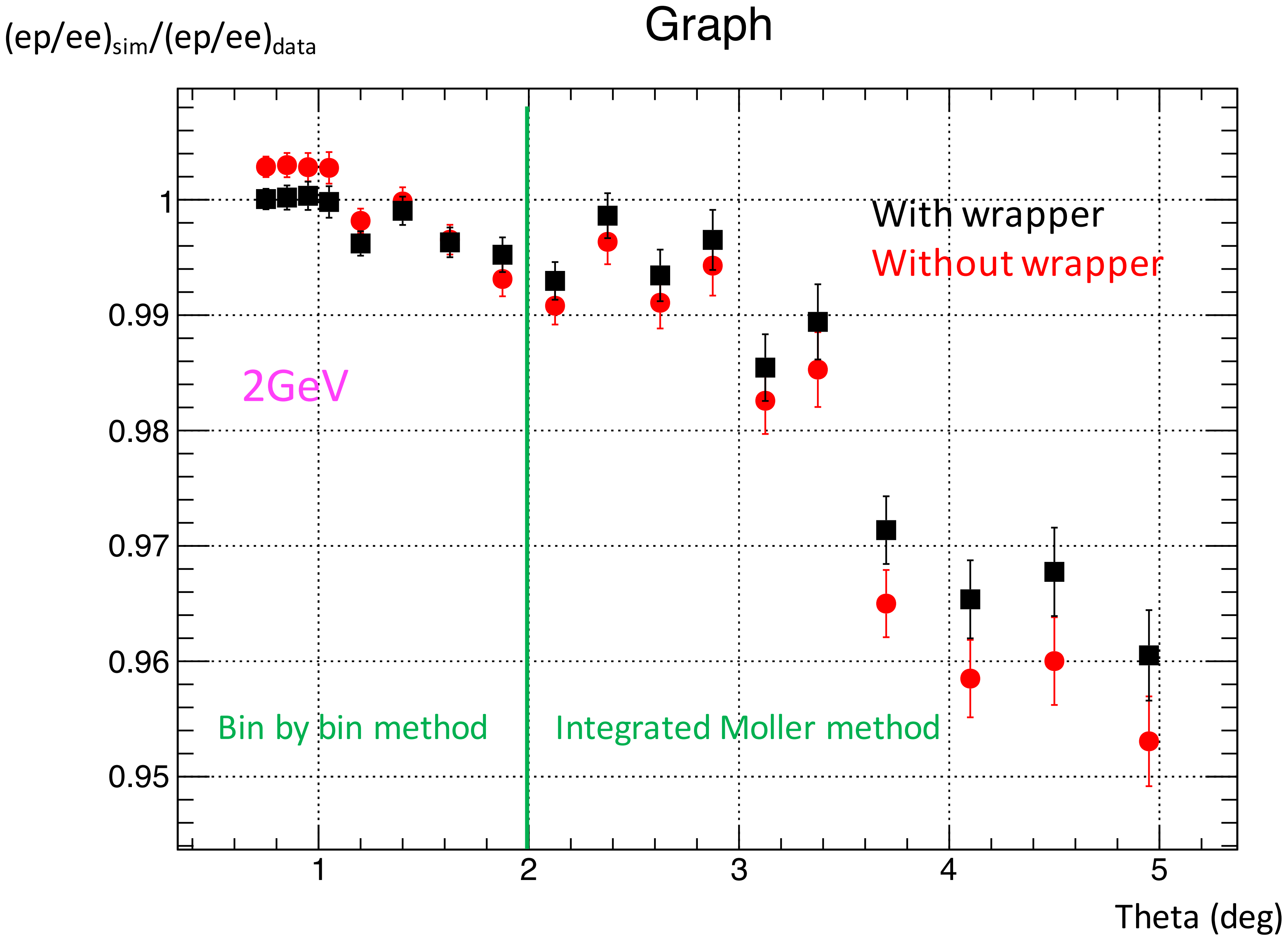


Effect of HyCal Module Wrapper – Yield ratio

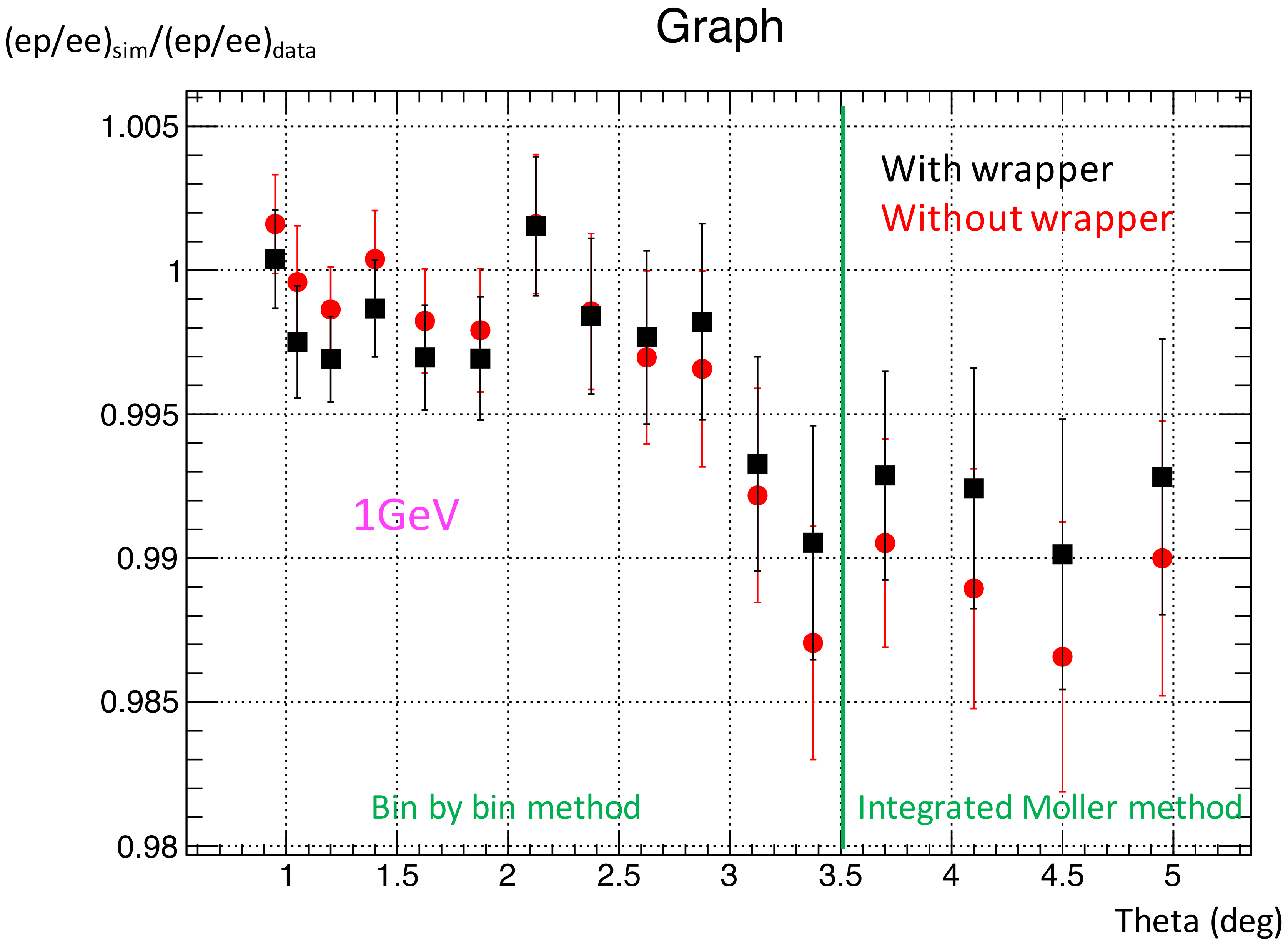
ee yield with wrapper / ee yield without wrapper



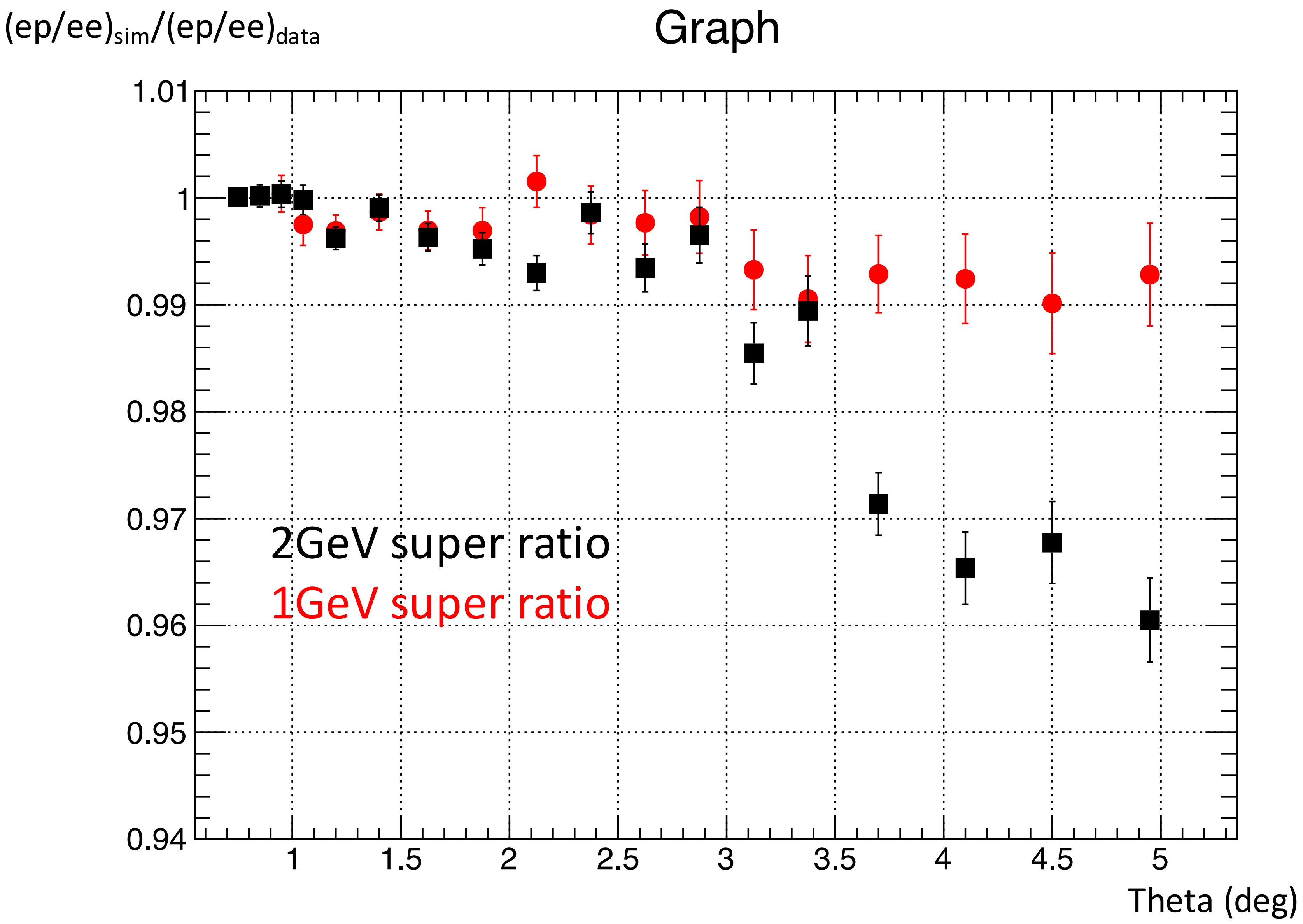
Effect of HyCal Module Wrapper – super ratio



Effect of HyCal Module Wrapper – super ratio

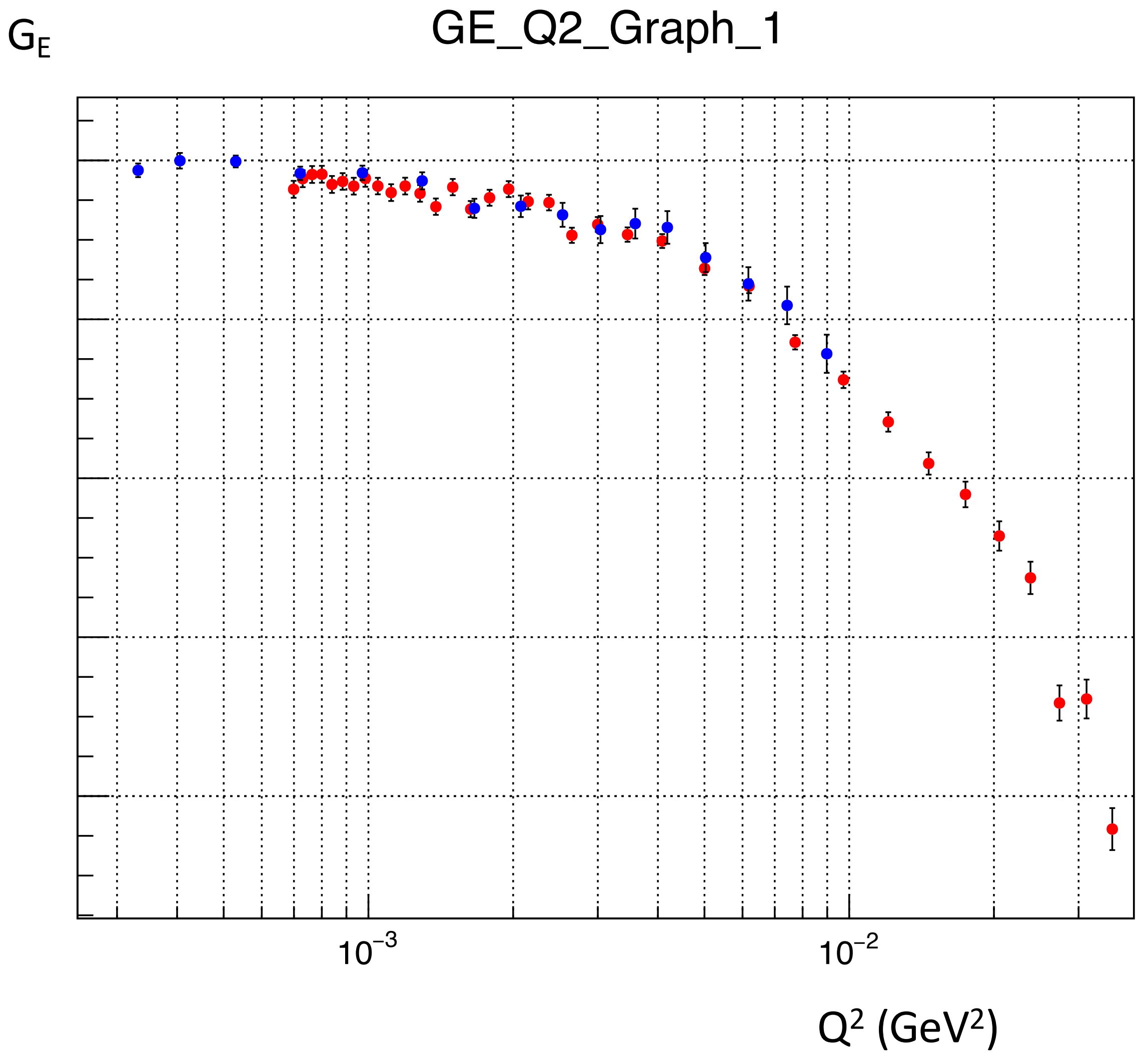


Effect of HyCal Module Wrapper – super ratio

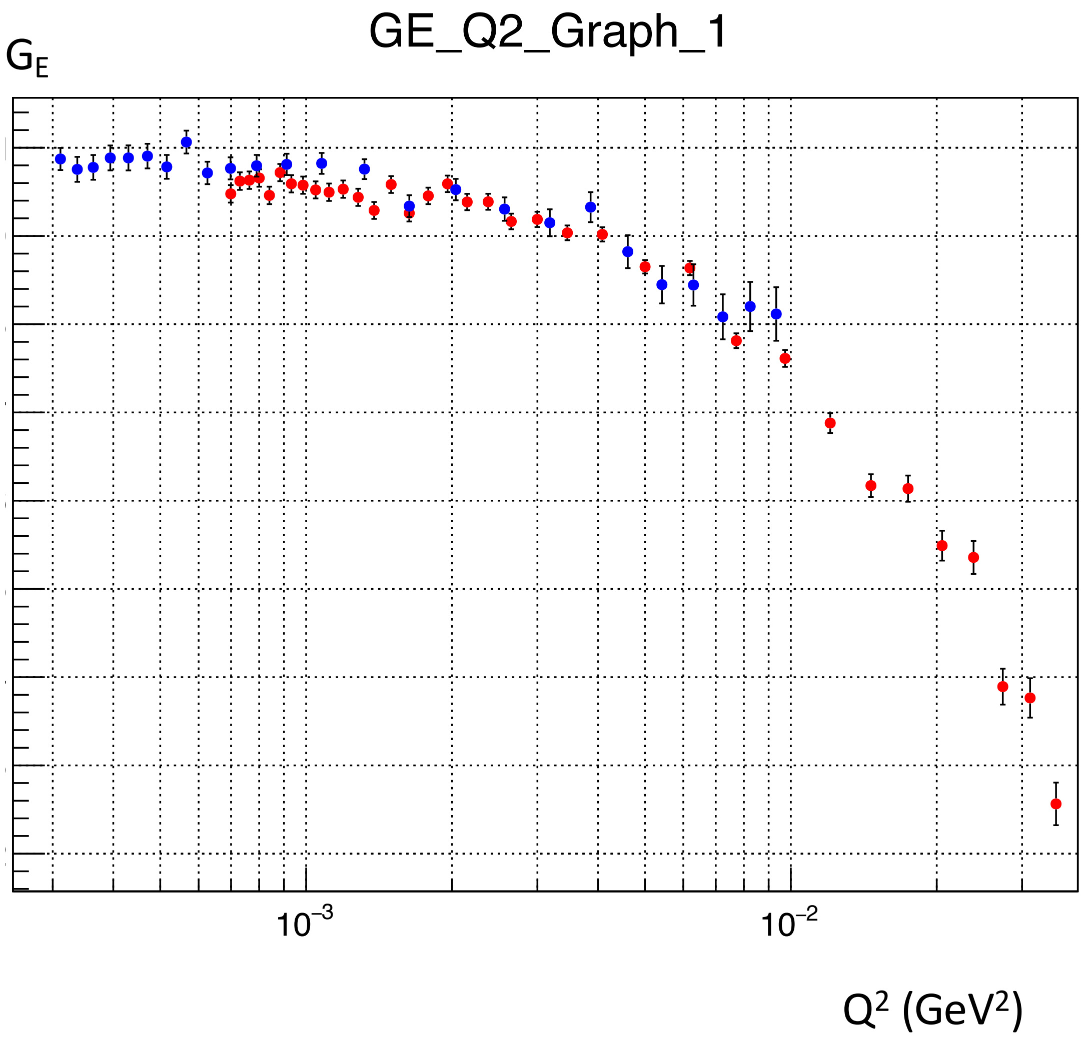


Effect of HyCal Module Wrapper – G_E

With wrapper



Without wrapper



Systematic uncertainty table

items	Uncertainty on cross section (or possible solution)
Background subtraction	??
simulation	~0.5% to 1%
Cosmic contamination for GEM eff	~< 0.2 %
GEM efficiency correction error	~0.2% to 0.5%
Rad correction for ep	~0% (using difference between the two generators)
Rad correction for ee	?? (using difference between the two generators)
Inelastic contribution	(using difference between generators)
HyCal trigger efficiency	??
Detector position	<0.1%
Beam energy	?? (using the nominal uncertainty)

GEM efficiency correction error

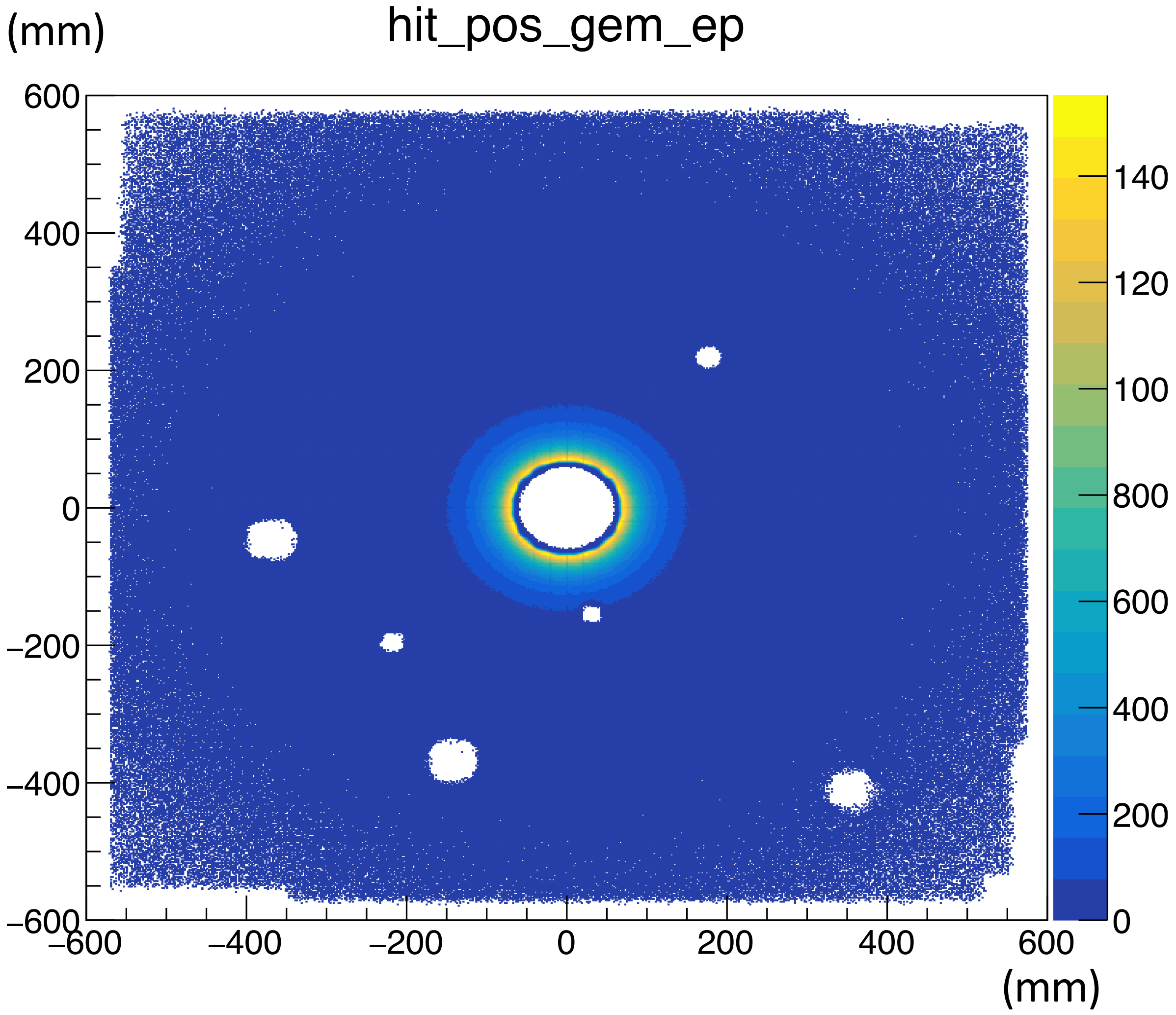
- If we know the true averaged GEM efficiency for ep and ee in a given theta ring, then true ep/ee ratio should be:

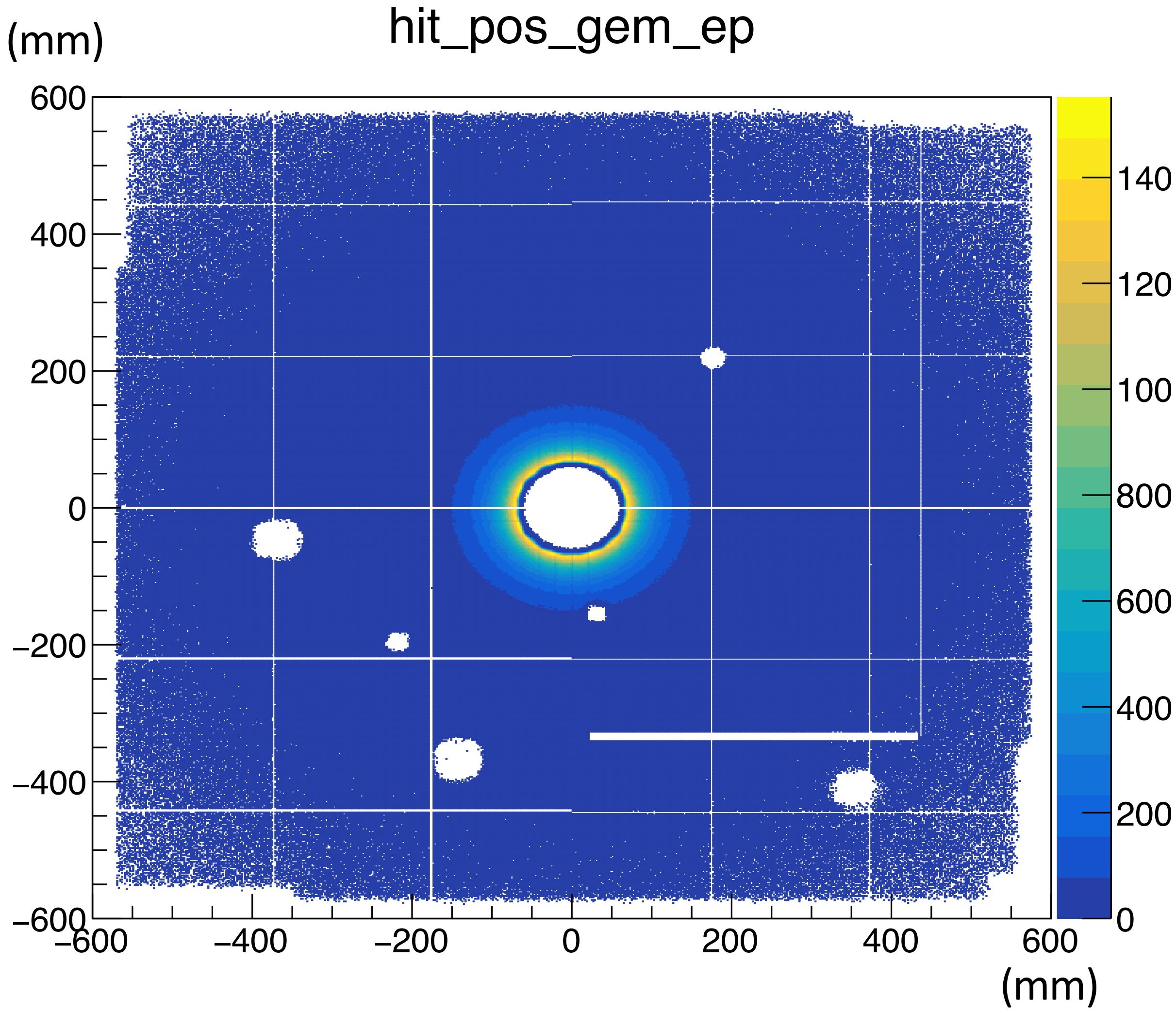
$$\frac{Yield_{ep}/\varepsilon_{ep}}{Yield_{ee}/\epsilon_{ee}}$$

- When using the bin by bin method, we simply take $\text{Yield}_{\text{ep}}/\text{Yield}_{\text{ee}}$, or we implicitly assume that $\boldsymbol{\varepsilon}_{\text{ep}} = \boldsymbol{\varepsilon}_{\text{ep}}$, which is only approximately true
  - Matching between GEM and HyCal is energy dependent (multiple scattering and HyCal position resolution…)
  - Angular Event distribution is very different for ep and ee (ep piles-up more at small angle)
- When calculate the absolute value of the GEM matching efficiency, we use HyCal, which doesn’t have enough resolution to resolve GEM spacers and gaps between HV sectors

GEM efficiency correction error

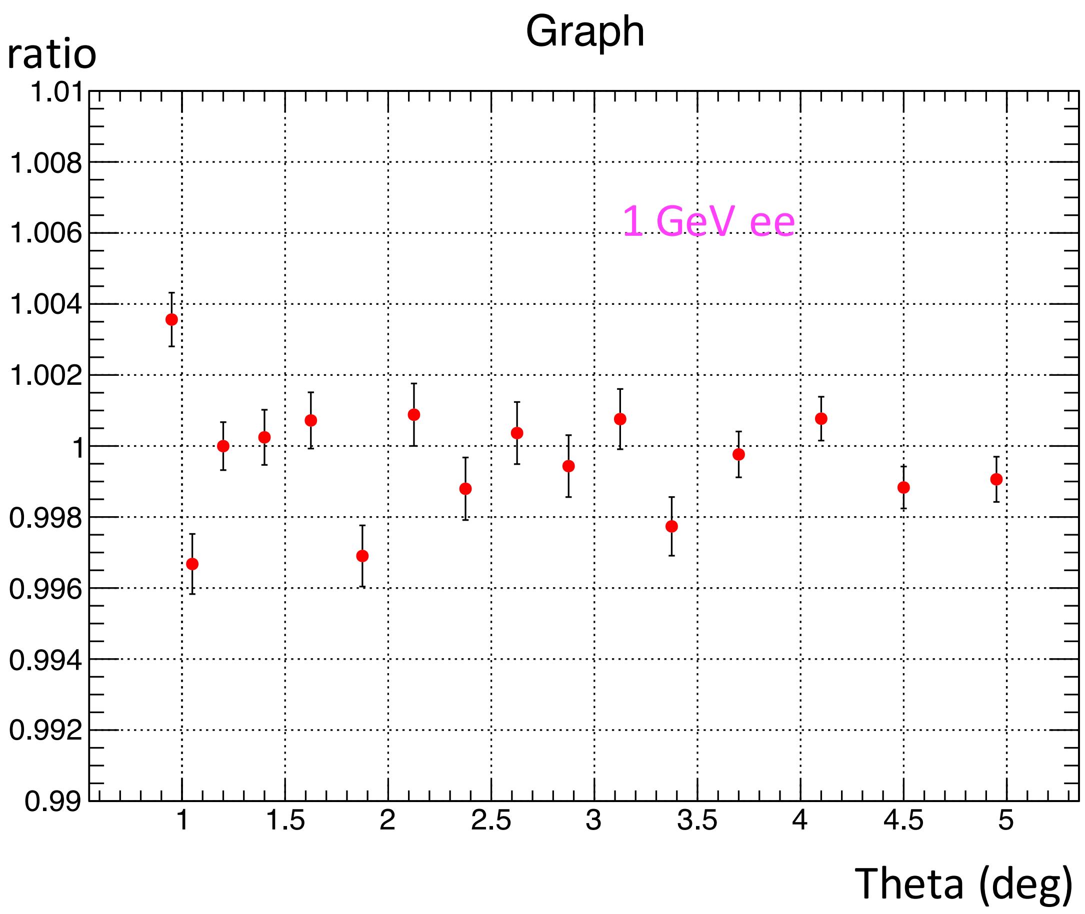
Simulation

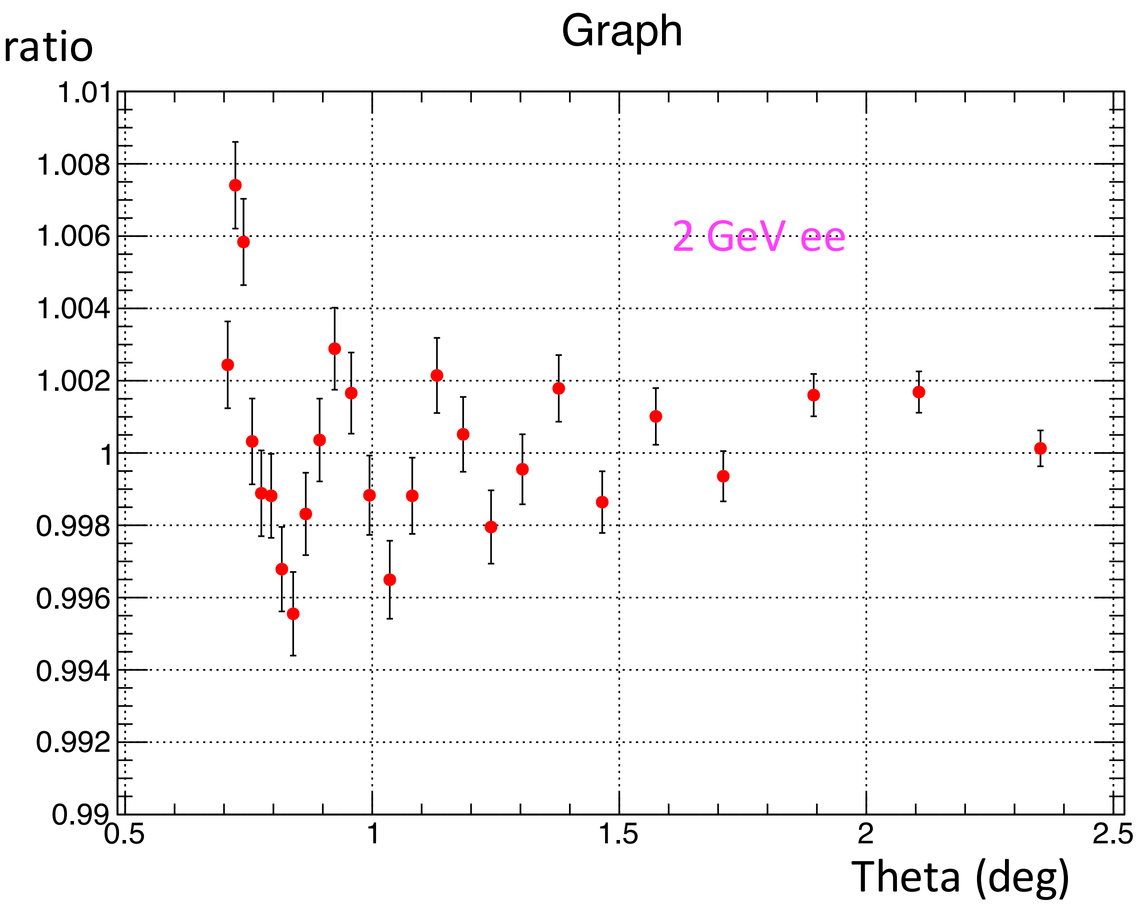




GEM efficiency correction error

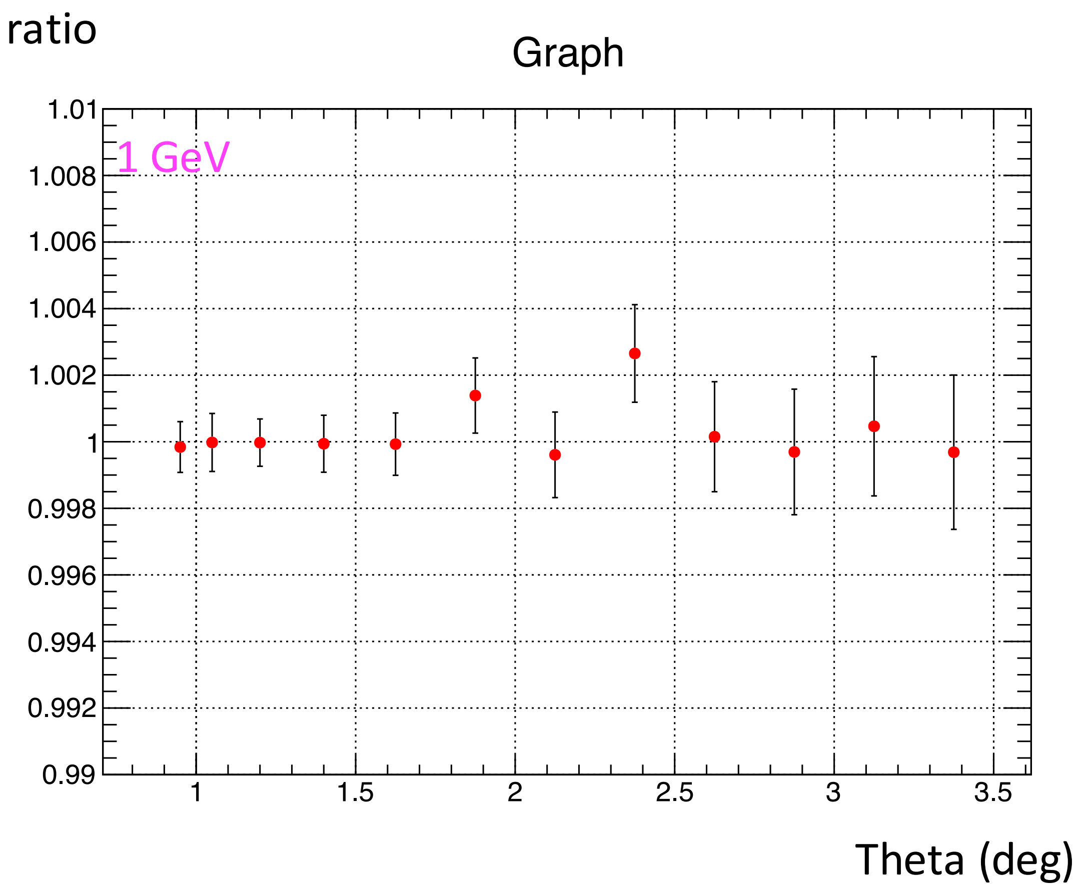
- Same data set run through the two cases (with and without GEM spacer removal)
- Two sets of GEM matching efficiencies are calculated, and used to correct for the yields
- Take the ratio between the yields to see if the correction is perfect

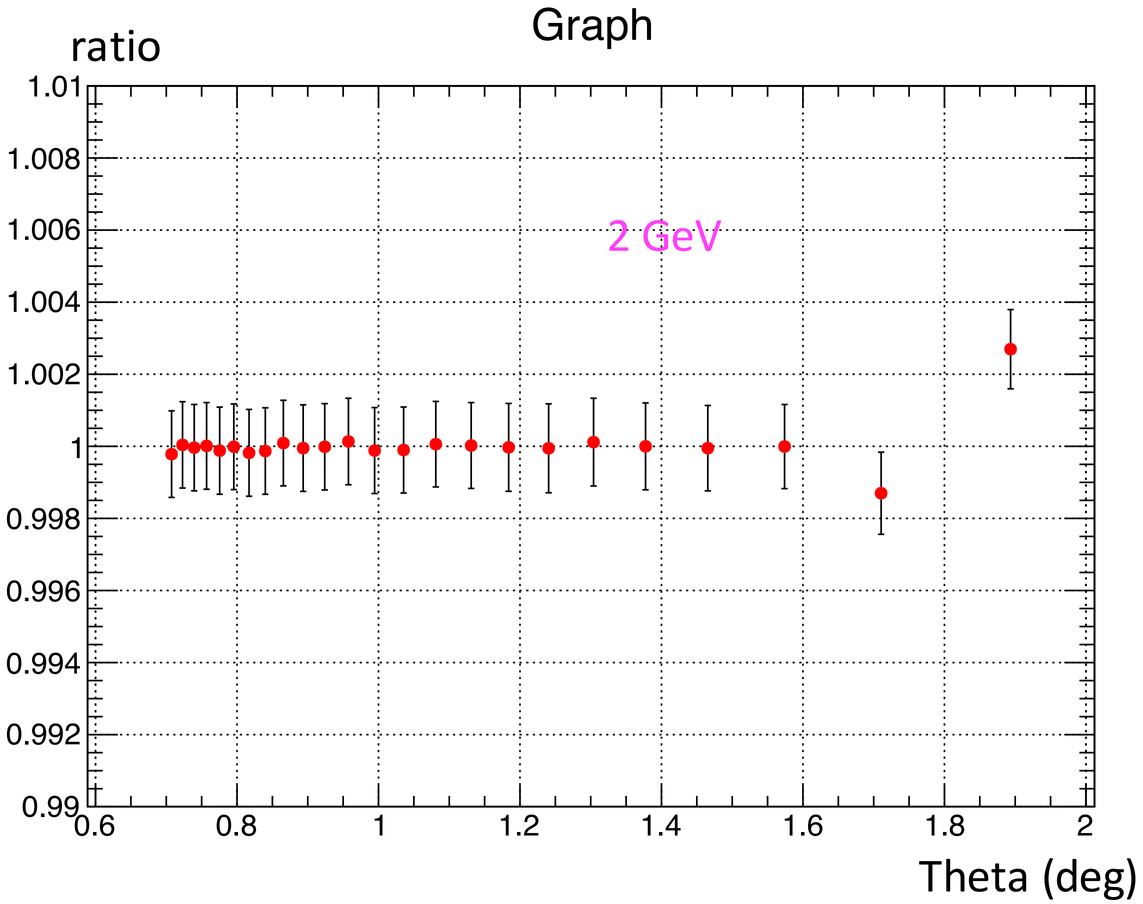




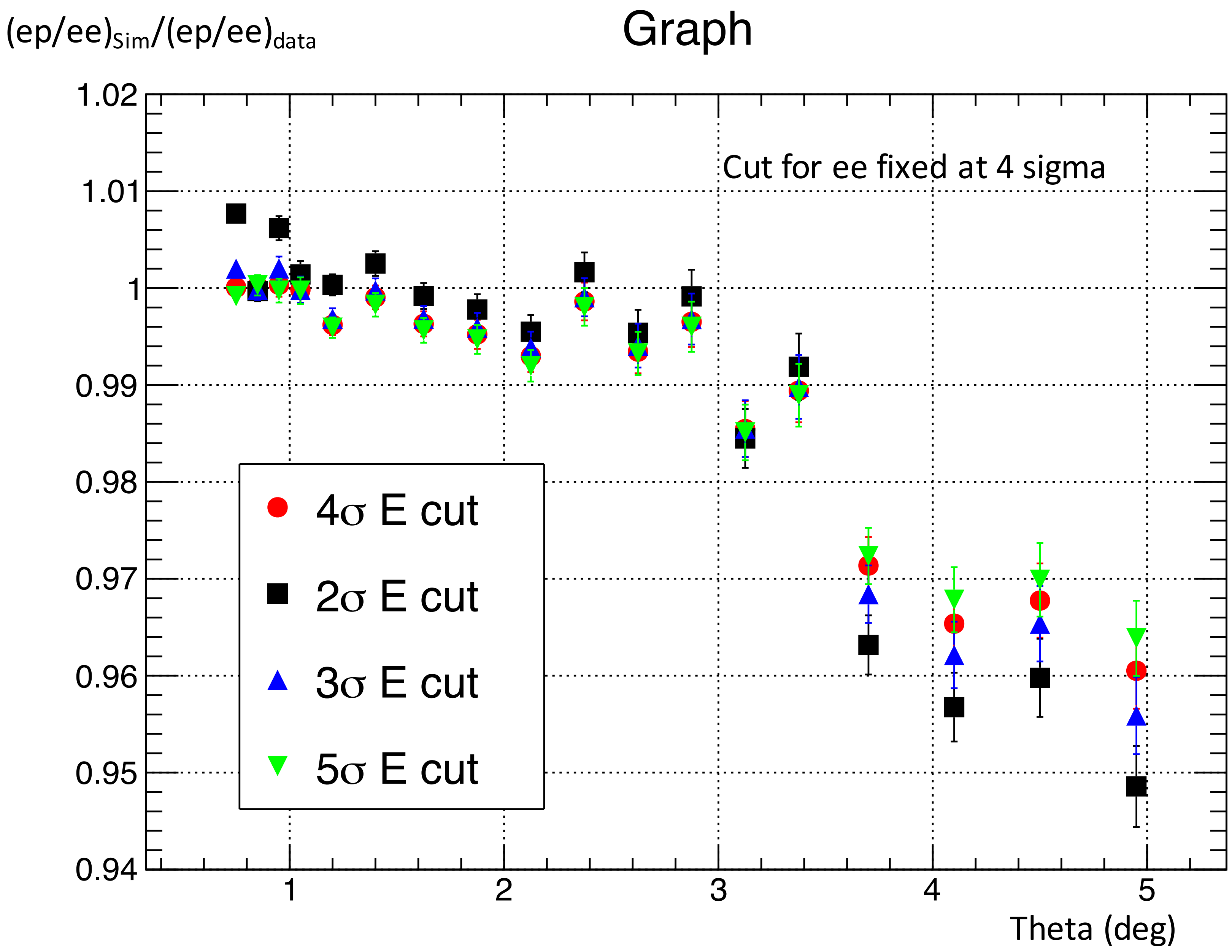
GEM efficiency correction error

- Same data set run through the two cases (with and without GEM spacer removal)
- Take the ep/ee ratio separately within each case
- Take the super ratio see if the GEM efficiency drops out





Error in simulation



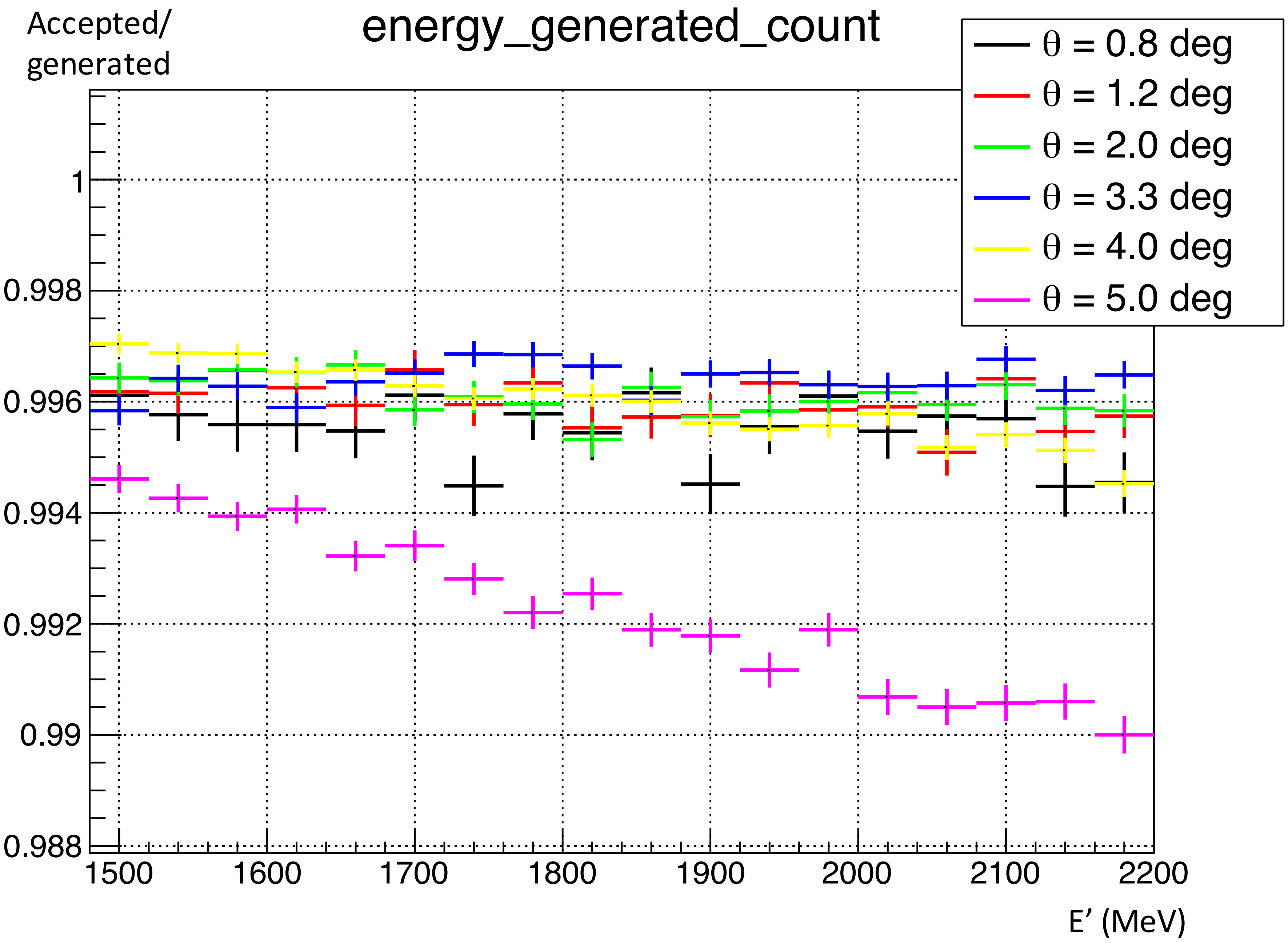
Error in simulation

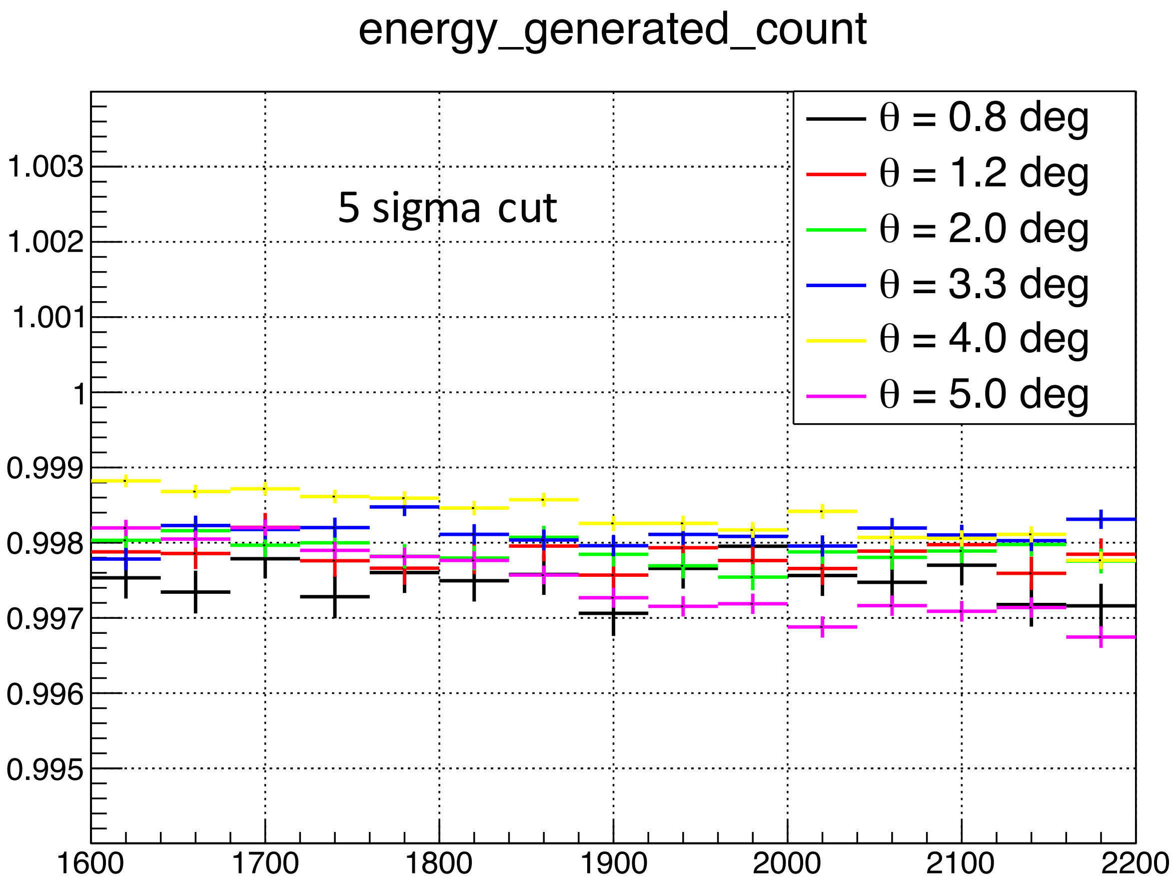
- Possible source of systematic error from simulation
  - MC calibration (mean and width of the elastic peak matching between data and simulation)
  - Energy leakage (caps between modules, transition region)
  - Effect of background (cluster overlap)
  - S-shape effect in simulation and data not identical
  - ……

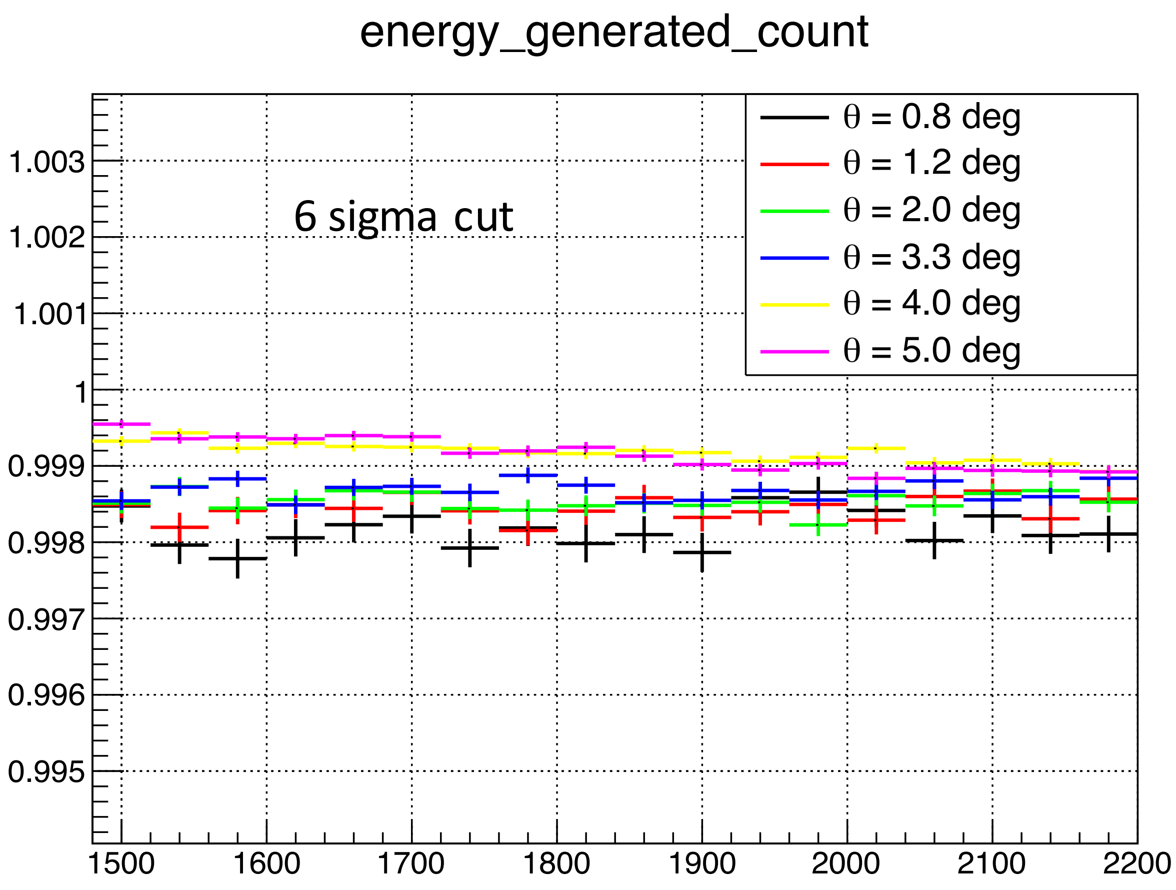
Checking the simulation

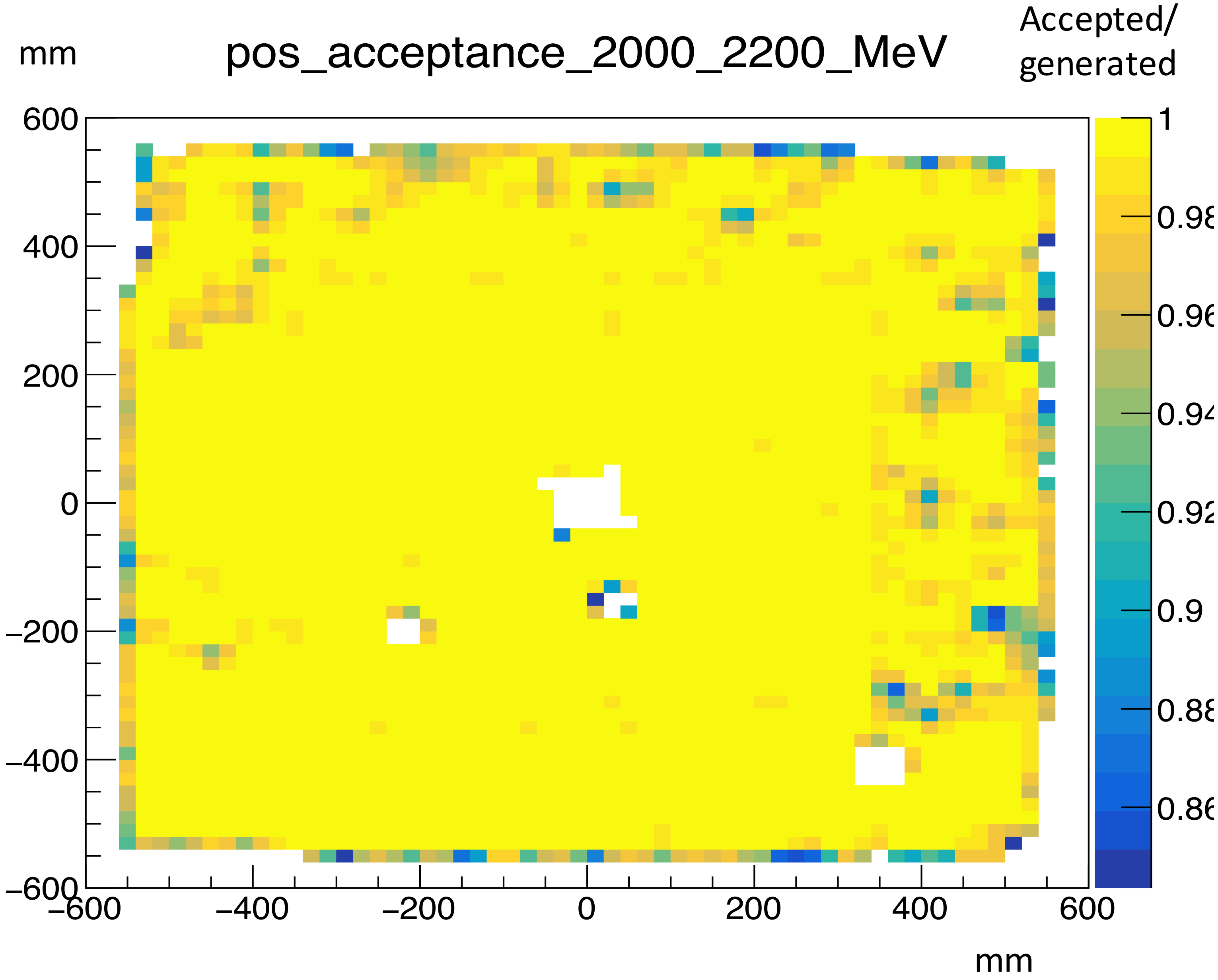
- use uniform distributed electrons in x and y and energy from 1000 to 2200 MeV and check the acceptance

- Condition of acceptance:
  - Reconstructed energy within 4 sigma (HyCal energy resolution) agreement with the vertex momentum
  - Reconstructed position within 6 sigma (HyCal position resolution) agreement with the projected hit position


energy_generated_count
Accepted/
generated
θ = 0.8 deg
θ = 1.2 deg
θ = 2.0 deg
θ = 3.3 deg
θ = 4.0 deg
θ = 5.0 deg
1
0.998
0.996
0.994
0.992
0.99
0.988
1500
1600
1700
1800
1900
2000
2100
2200
E’ (MeV)


energy_generated_count
5 sigma cut
θ = 0.8 deg
θ = 1.2 deg
θ = 2.0 deg
θ = 3.3 deg
θ = 4.0 deg
θ = 5.0 deg
1.003
1.002
1.001
1
0.999
0.998
0.997
0.996
0.995
1600
1700
1800
1900
2000
2100
2200


energy_generated_count
6 sigma cut
θ = 0.8 deg
θ = 1.2 deg
θ = 2.0 deg
θ = 3.3 deg
θ = 4.0 deg
θ = 5.0 deg
1.003
1.002
1.001
1
0.999
0.998
0.997
0.996
0.995
1500
1600
1700
1800
1900
2000
2100
2200


mm
pos_acceptance_2000_2200_MeV
Accepted/
generated
600
400
200
0
−200
−400
−600
−600
−400
−200
0
200
400
600
mm
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86