Development of a next-generation detector concept to detect astrophysical gamma-rays

Responsables: Ruben Conceição and Bernardo Tomé;

- Matilde Tubal, FCUL at UL;
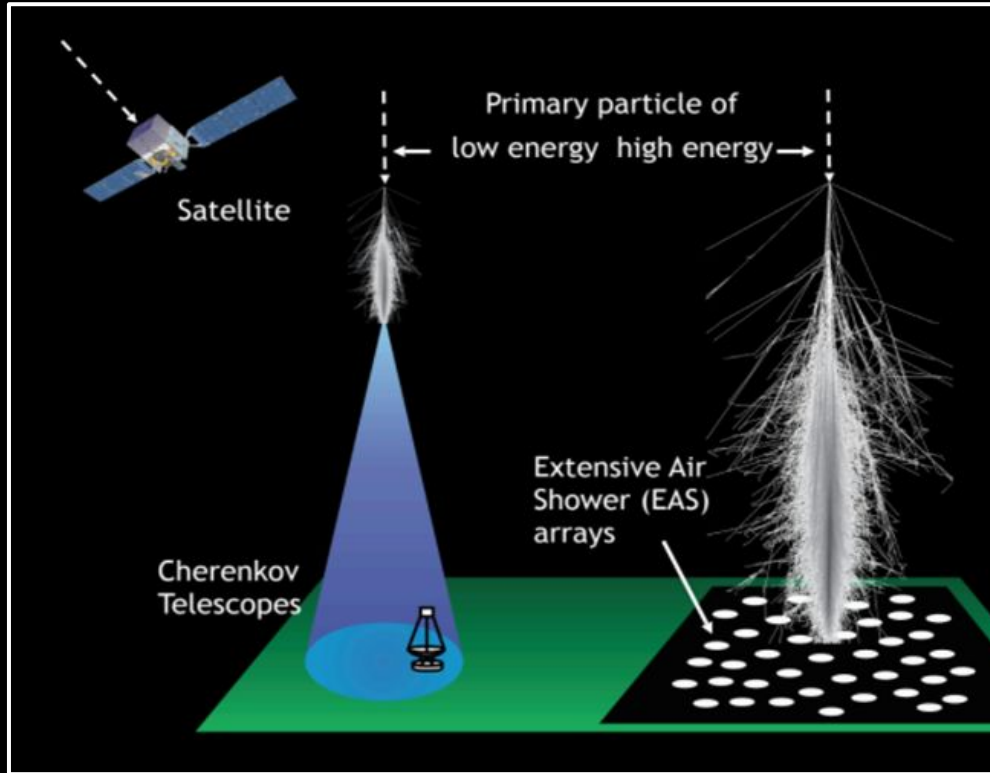- Tatiana Mendes, FCUP at UP.

LIP

How to detect gamma rays?

Fig1: Satellites for high energy gamma-rays and Cherenkov telescopes or EAS arrays for very high energy gamma-rays;
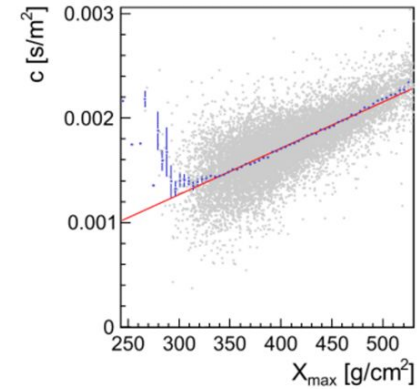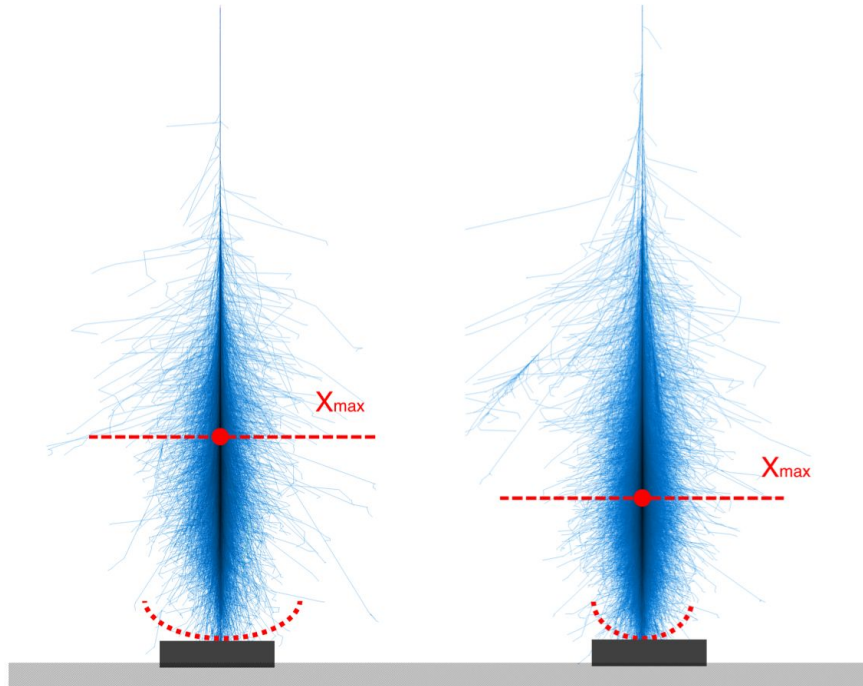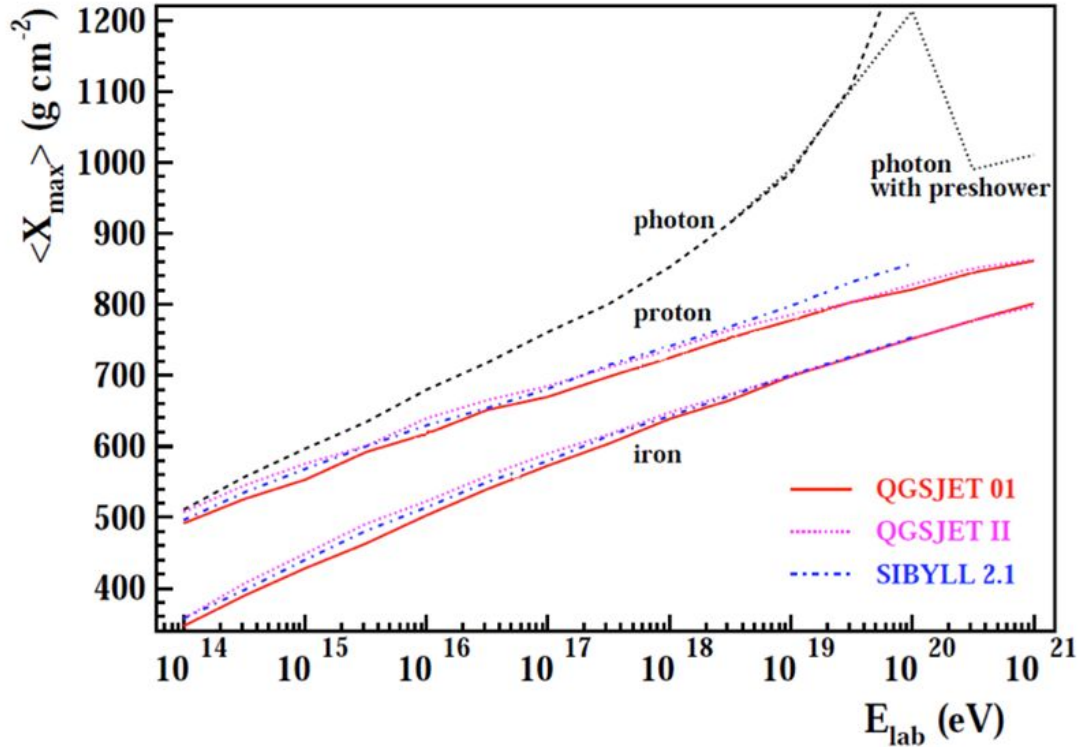
How to measure the Xmax

X_{max}

X_{max}

Fig2: Relation between the Xmax and a constant "c", which measures the shower front plane curvature;

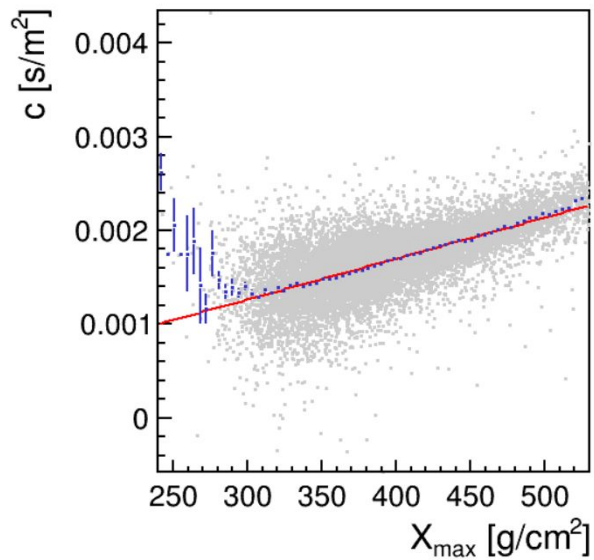$$X^1{}_{max} = B_1 + \gamma_1 c$$

Our goal

1. Calibrate with photon and proton;

2. Reconstruct with photon, proton and iron;
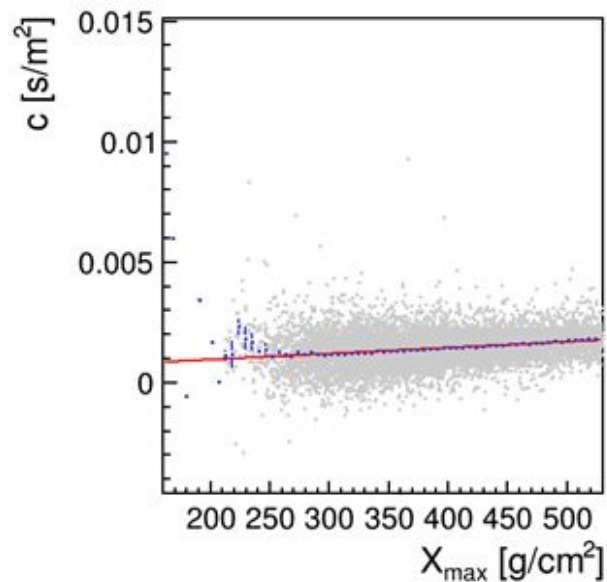
3. Check the results;

4. Conclusion;

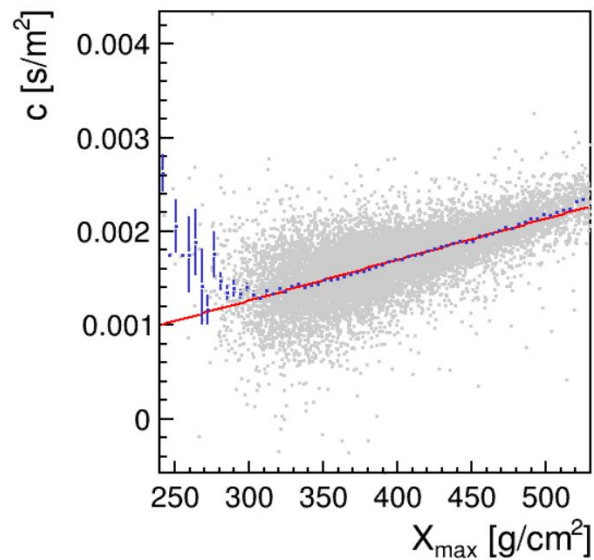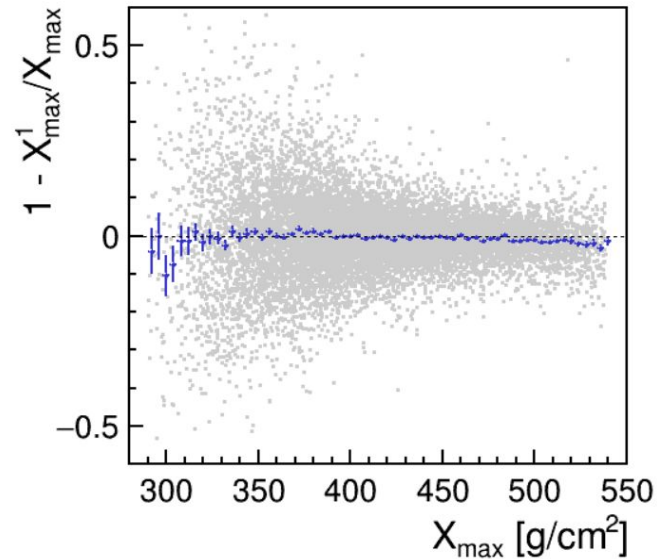# Our results

Calibrations:

- Photon

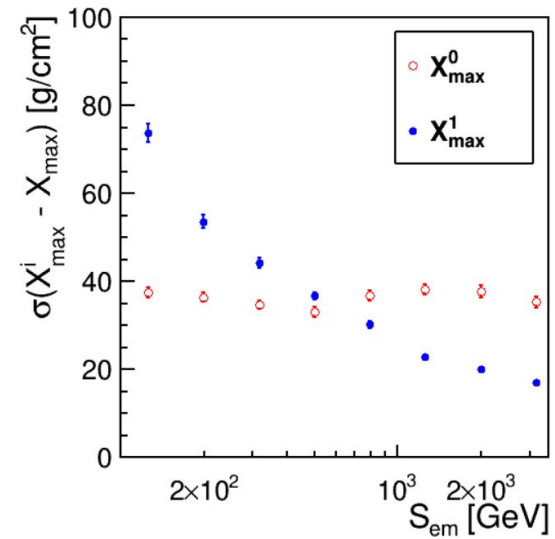- Proton

Our results

photon calibration
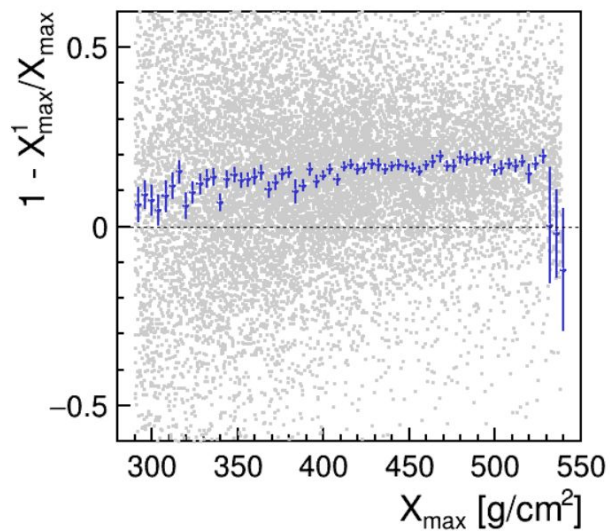
Photon

Xmax Bias vs Xmax:
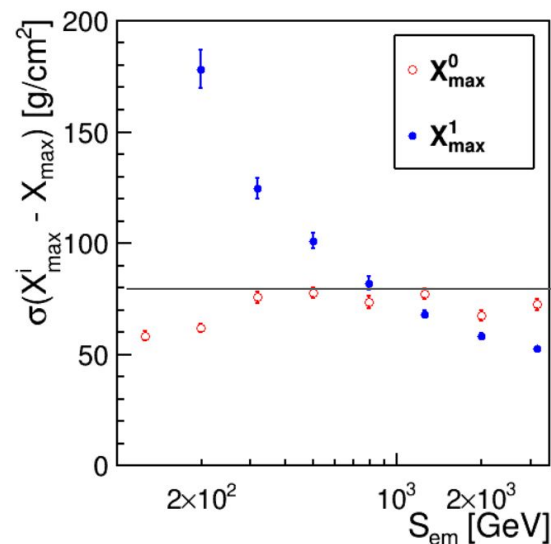
Xmax Resolution vs Sem:

Sem - electromagnetic energy at the ground - proportional to the shower energy
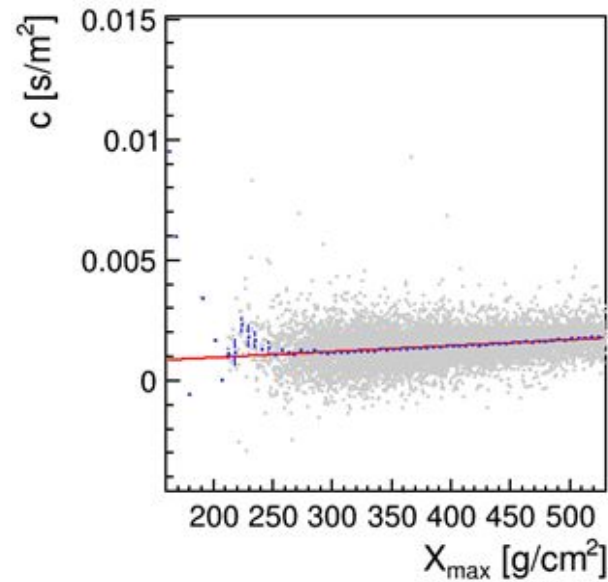
Proton

Xmax Bias:

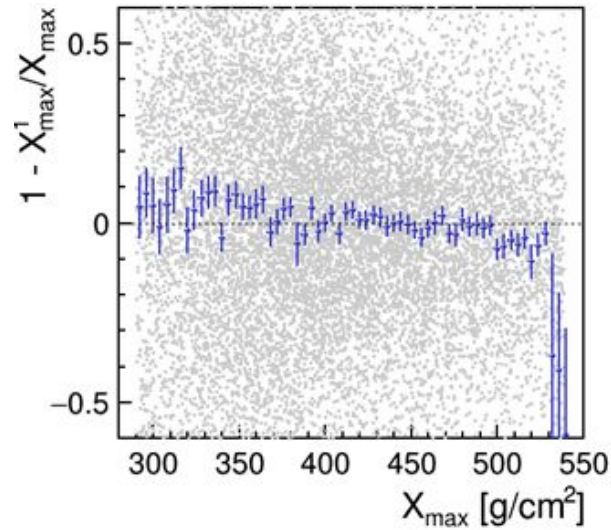Xmax Resolution vs Sem:

Separation between proton and iron
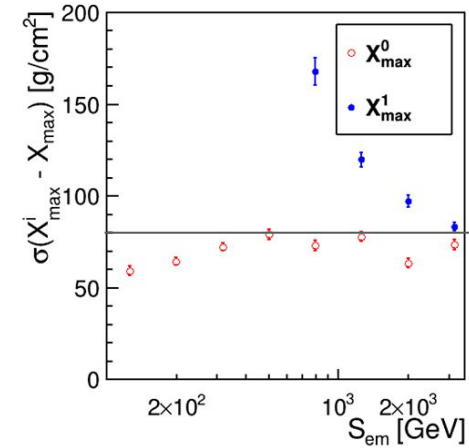
Our results

proton calibration

Proton

Xmax Bias:
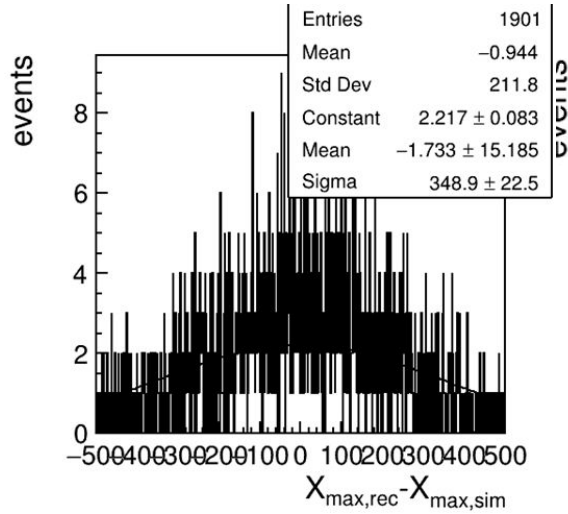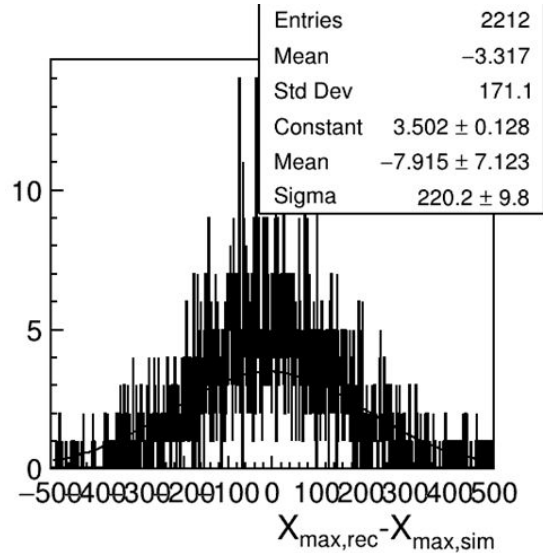
Xmax Resolution vs Sem:

Separation between proton and iron

Proton - Xmax reconstructed distributions

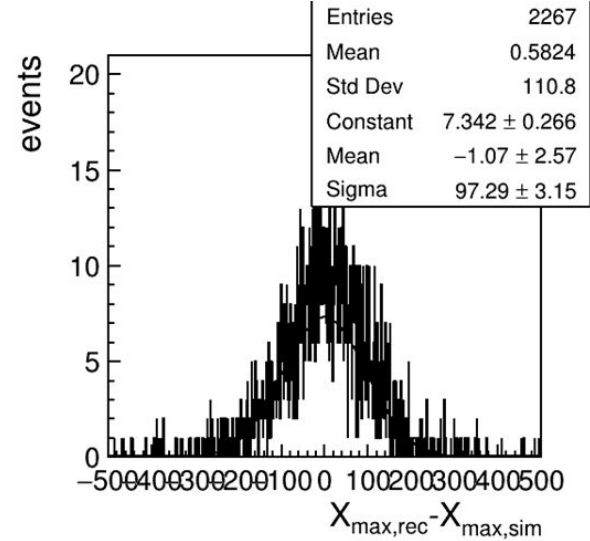Sem=199.526   Sem=501.187   Sem=1995.26

Entries	1901
Mean	−0.944
Std Dev	211.8
Constant	2.217 ± 0.083
Mean	−1.733 ± 15.185
Sigma	348.9 ± 22.5

Entries	2212
Mean	−3.317
Std Dev	171.1
Constant	3.502 ± 0.128
Mean	−7.915 ± 7.123
Sigma	220.2 ± 9.8

| Entries | 2267 |
Mean	0.5824
Std Dev	110.8
Constant	7.342 ± 0.266
Mean	−1.07 ± 2.57
Sigma	97.29 ± 3.15

Summary

- It is possible to correlate the Xmax with the shower curvature (c) not only for photon induced showers but also for hadronic (proton and iron) showers

- The calibration with photon showers cannot be used for proton induced showers
    - A bias on Xmax appears

- The calibration with proton showers removes the bias on Xmax but the obtained resolution is too poor to distinguish between proton and iron showers

- The Xmax reconstructed distributions have an healthy Gaussian shape suggesting that the method is working but the shower curvature reconstruction (c) should be revisited
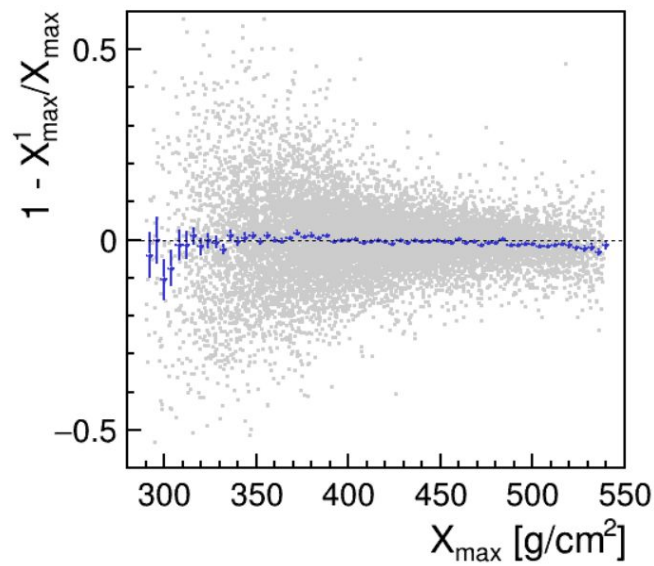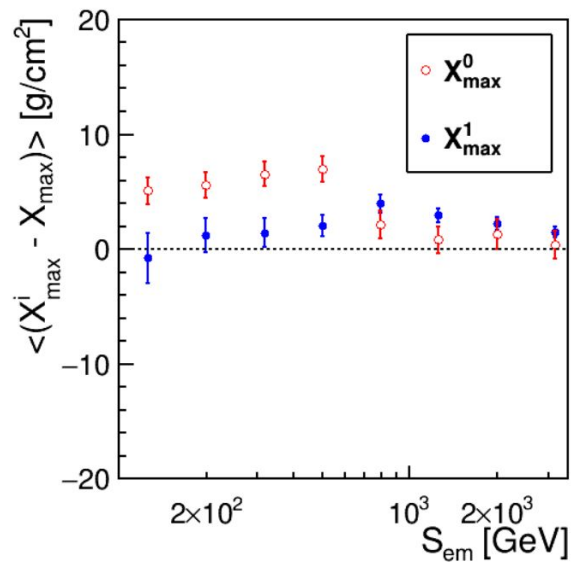
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Backup slides

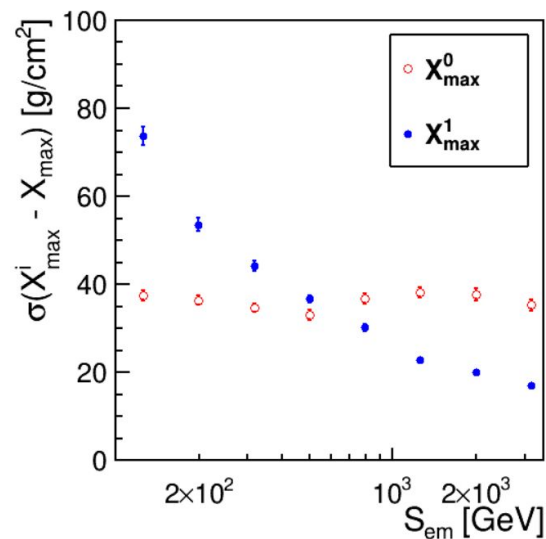# Photon/Photon
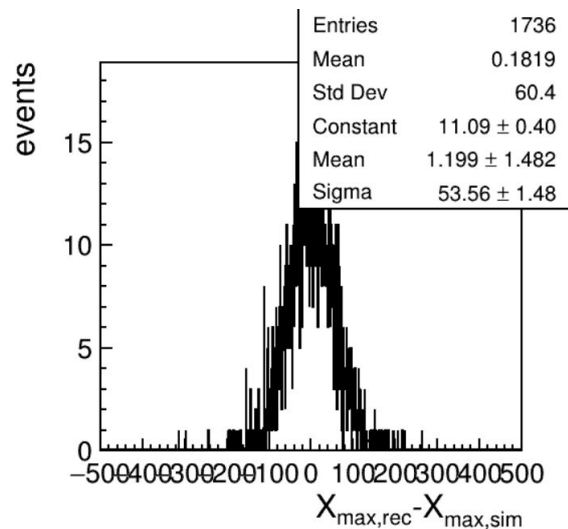
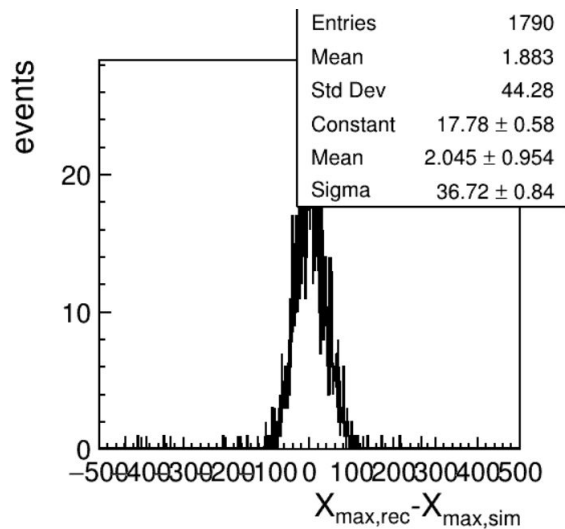Calibration plot:
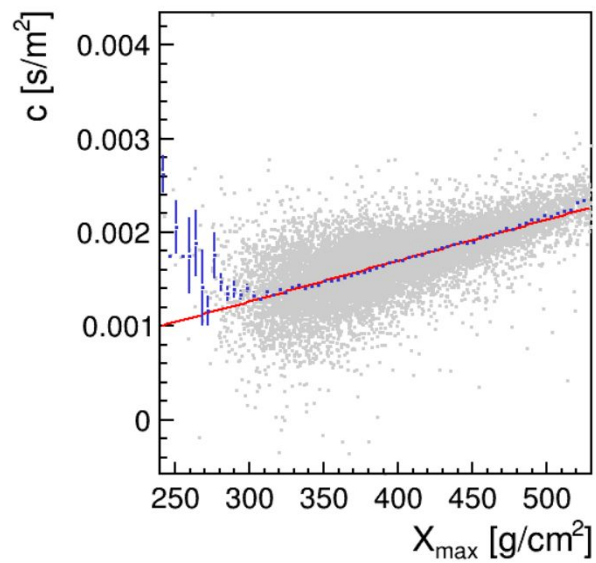
Bias Xmax:

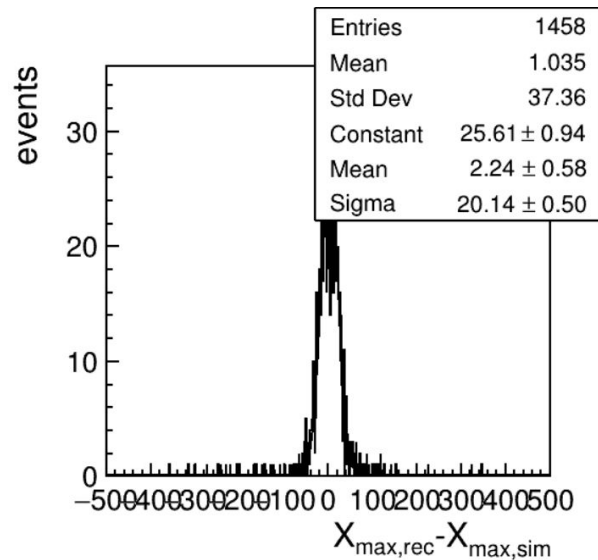# Photon/Photon

Xmax Bias vs Sem:

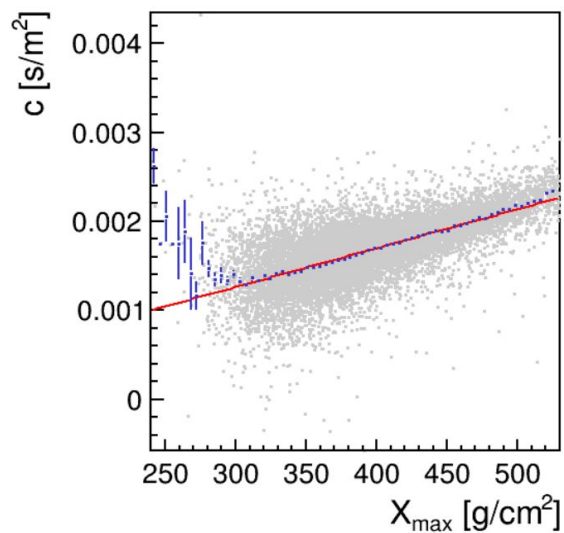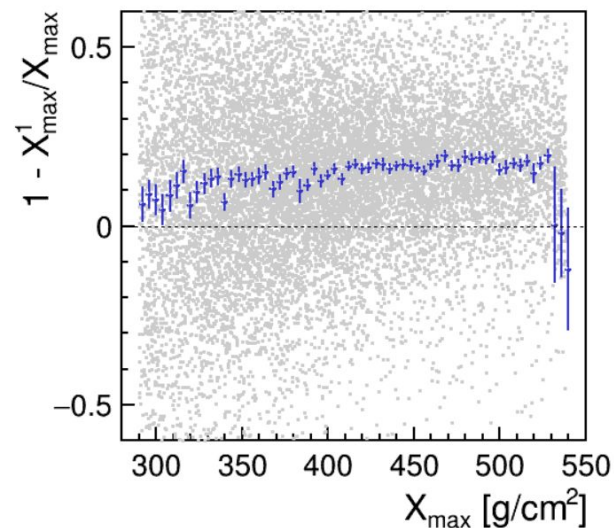Xmax Resolution vs Sem:

Sem = **199.526**   Sem = **501.187**   Sem = **1995.26**

Entries	1736
Mean	0.1819
Std Dev	60.4
Constant	11.09 ± 0.40
Mean	1.199 ± 1.482
Sigma	53.56 ± 1.48

Entries	1790
Mean	1.883
Std Dev	44.28
Constant	17.78 ± 0.58
Mean	2.045 ± 0.954
Sigma	36.72 ± 0.84

Entries	1458
Mean	1.035
Std Dev	37.36
Constant	25.61 ± 0.94
Mean	2.24 ± 0.58
Sigma	20.14 ± 0.50

$X_{max,rec} - X_{max,sim}$

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Photon/Proton

Calibration plot:
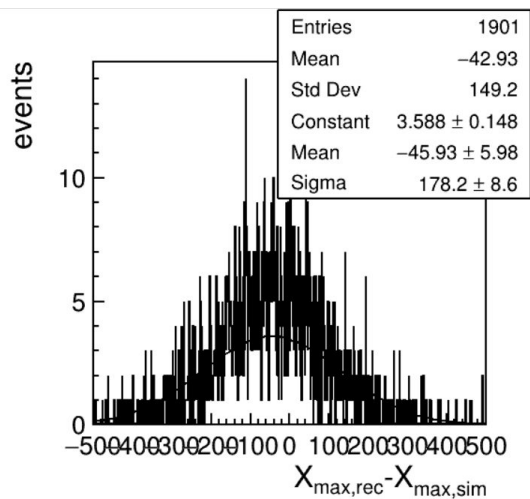
Bias Xmax:

Photon/Proton
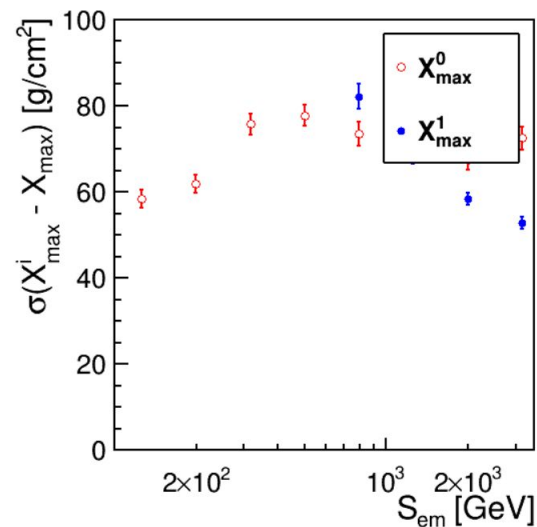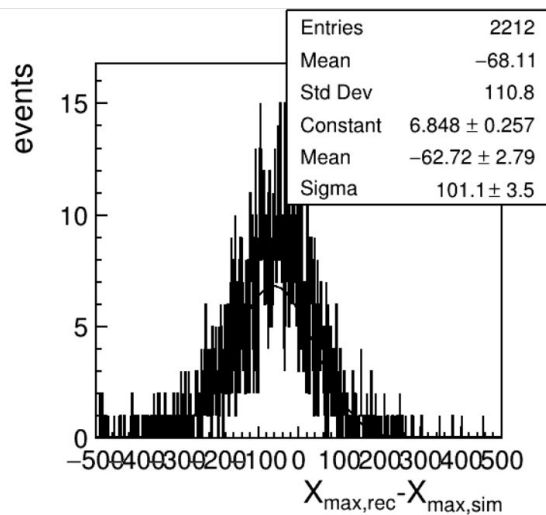
Bias Sem:

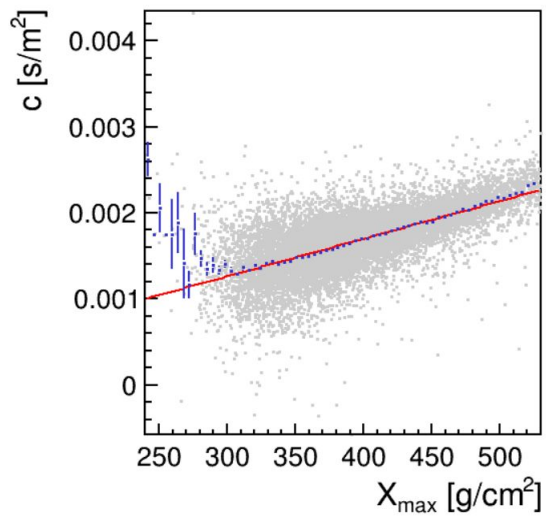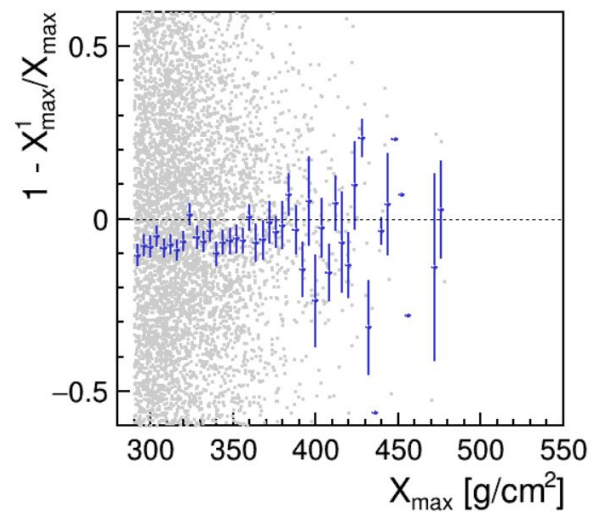Resolution Sem, (0-200):
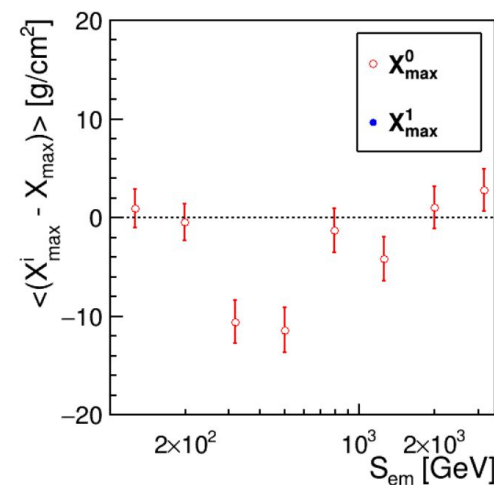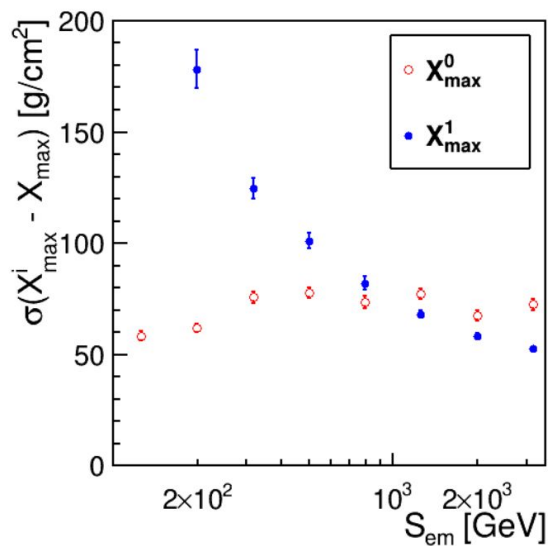
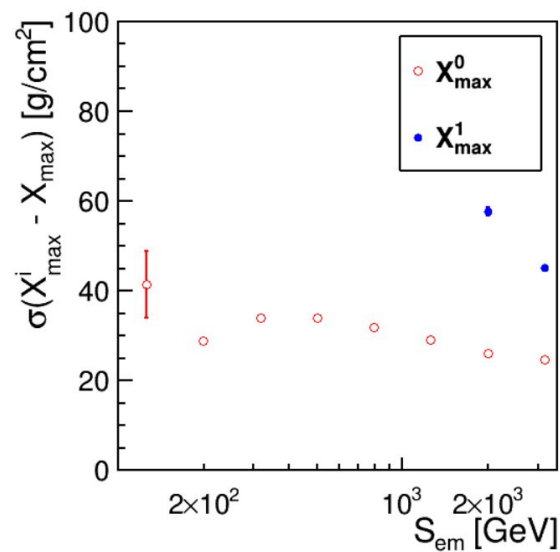Sem = **199.526**   Sem = **501.187**   Sem = **1995.26**
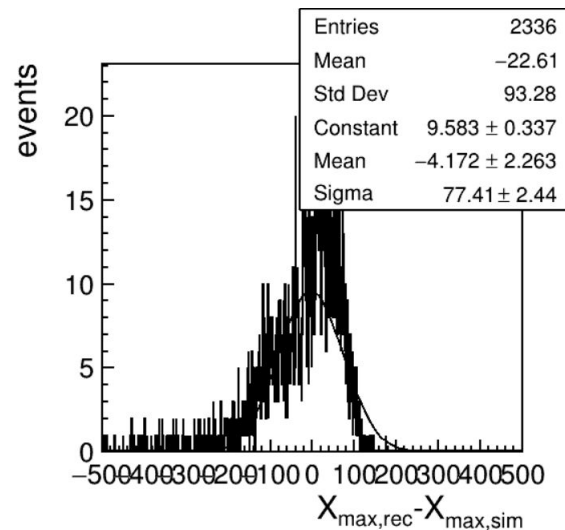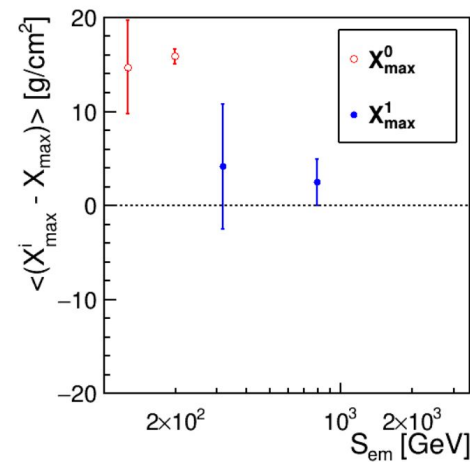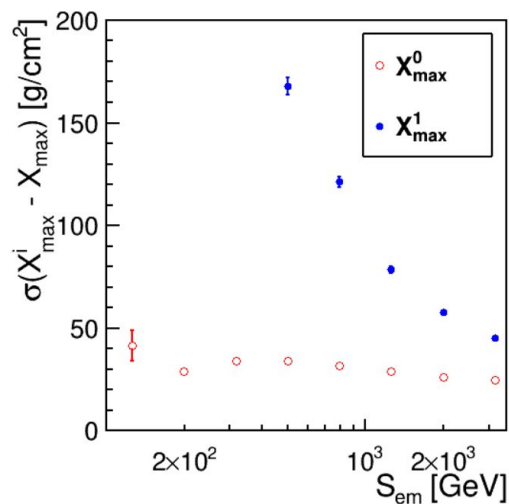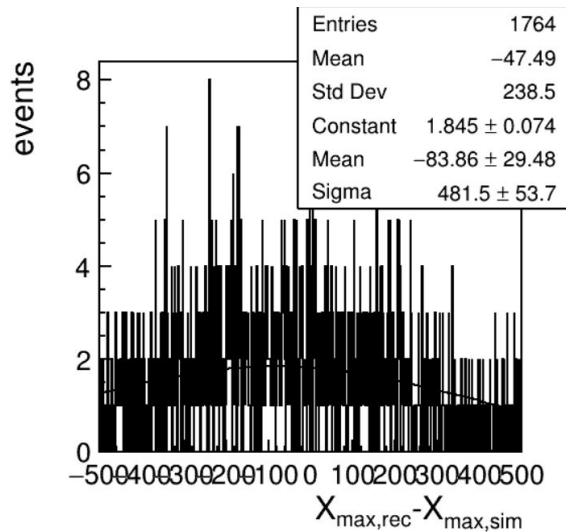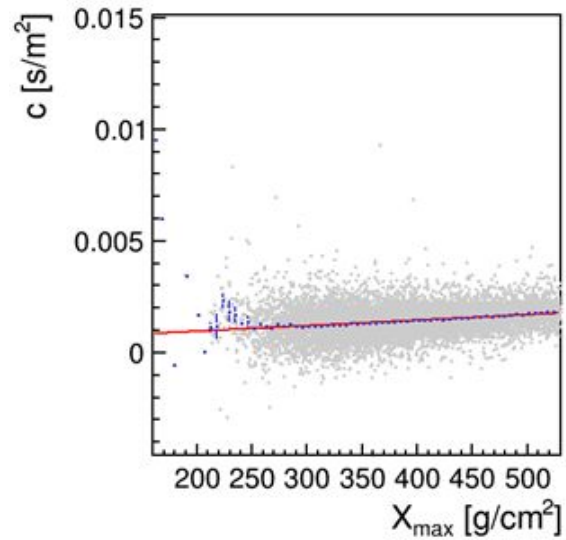
Photon/Iron

Calibration plot:

Bias Xmax:

Photon/Iron

Bias Sem:

Resolution Sem, (0-200):

Sem = 199.526

Entries	1764
Mean	−47.49
Std Dev	238.5
Constant	1.845 ± 0.074
Mean	−83.86 ± 29.48
Sigma	481.5 ± 53.7

Sem = 501.187

Entries	3492
Mean	40.85
Std Dev	164.4
Constant	6.873 ± 0.192
Mean	33.09 ± 3.56
Sigma	167.9 ± 4.2

Sem = 1995.26

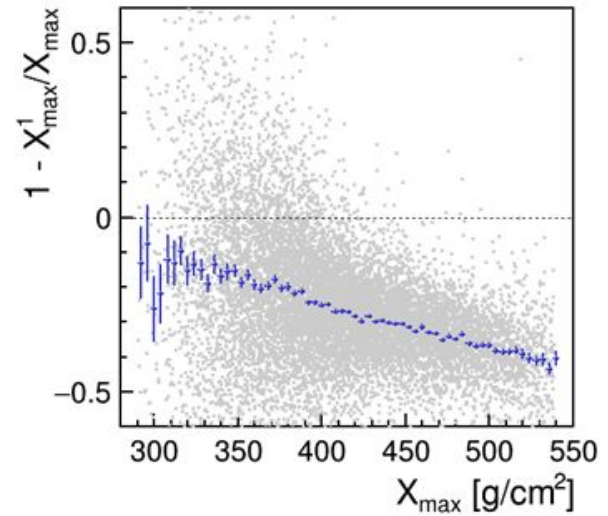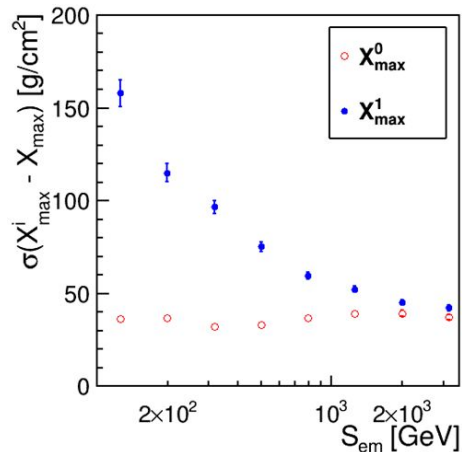| Entries	3469
Mean	−62.19
Std Dev	60.82
Constant	21.76 ± 0.51
Mean	−62.51 ± 1.07
Sigma	57.77 ± 0.94

events

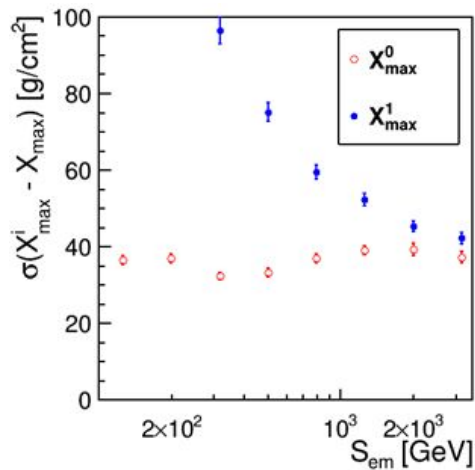$X_{max,rec} - X_{max,sim}$

Proton/Photon
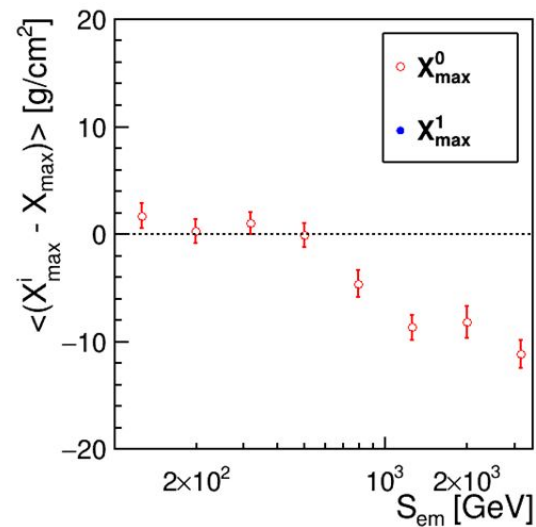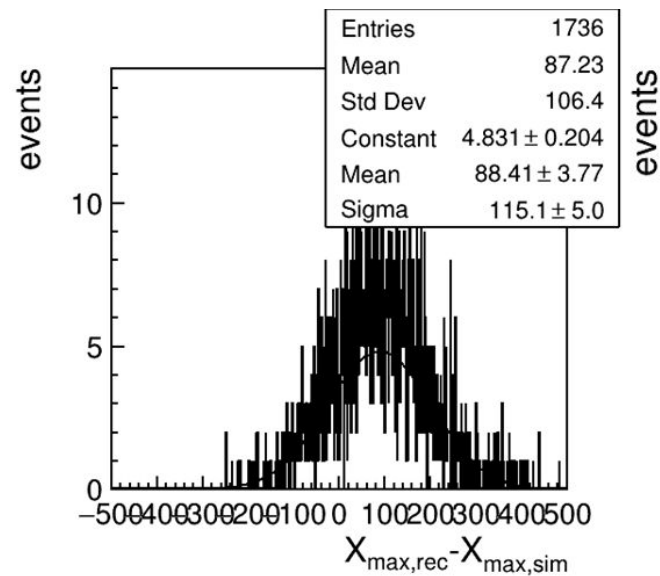
Calibration plot:

Bias Xmax:

Proton/Photon

Bias Sem:

Resolution Sem:

Proton/Photon

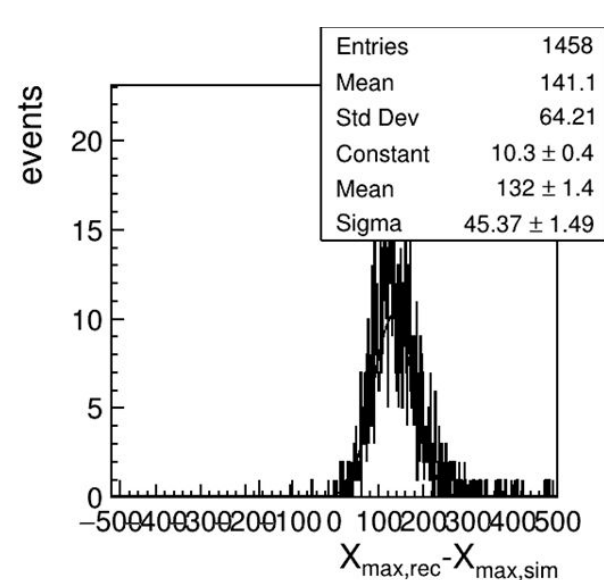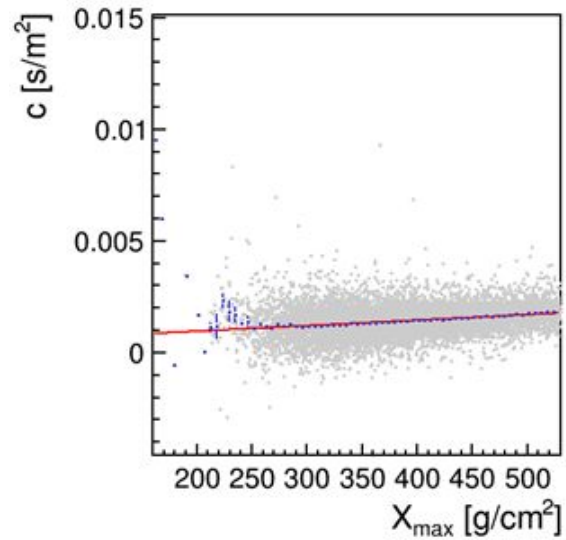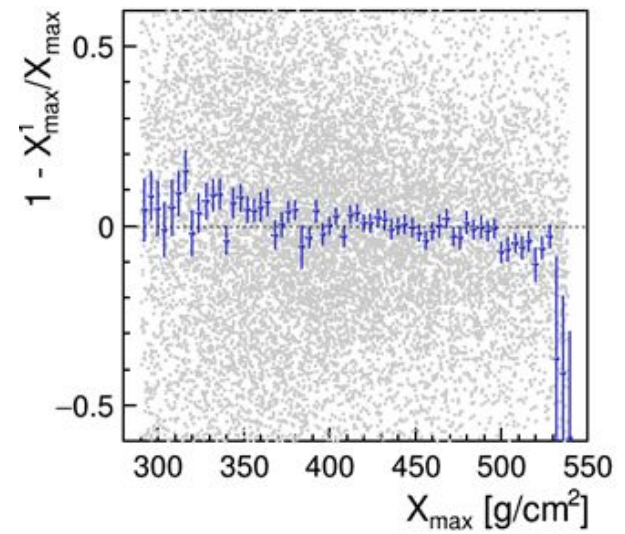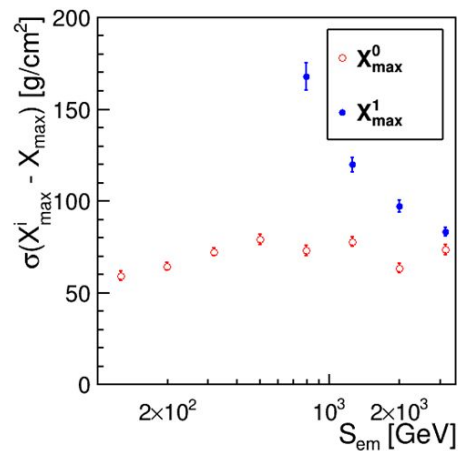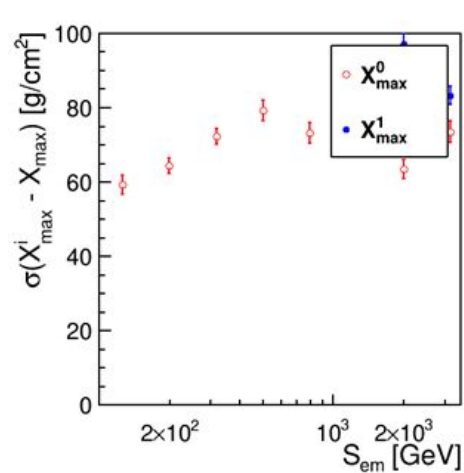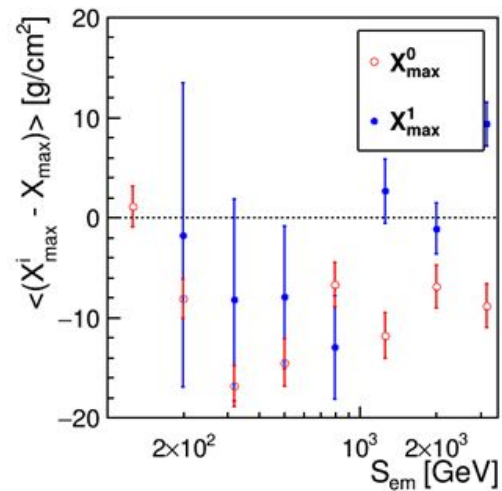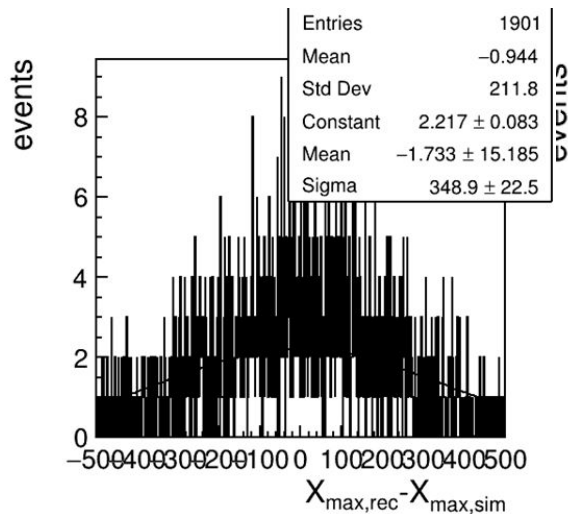Sem=199.526

Sem=501.187

Sem=1995.26

Entries	1736
Mean	87.23
Std Dev	106.4
Constant	4.831 ± 0.204
Mean	88.41 ± 3.77
Sigma	115.1 ± 5.0

Entries	1790
Mean	108.6
Std Dev	83.46
Constant	8.008 ± 0.296
Mean	104.9 ± 2.2
Sigma	75.22 ± 2.36

Entries	1458
Mean	141.1
Std Dev	64.21
Constant	10.3 ± 0.4
Mean	132 ± 1.4
Sigma	45.37 ± 1.49

$X_{max,rec} - X_{max,sim}$
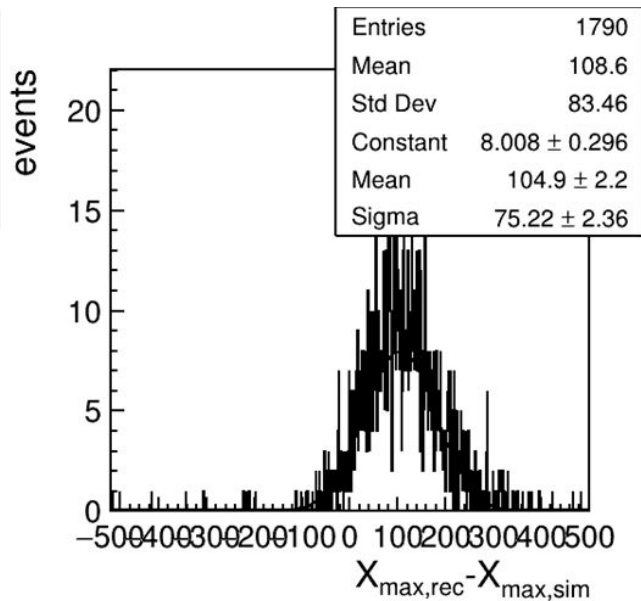
Proton/Proton

Calibration plot:

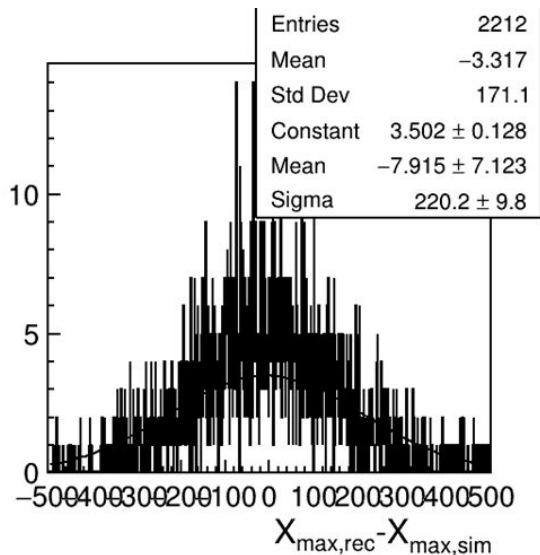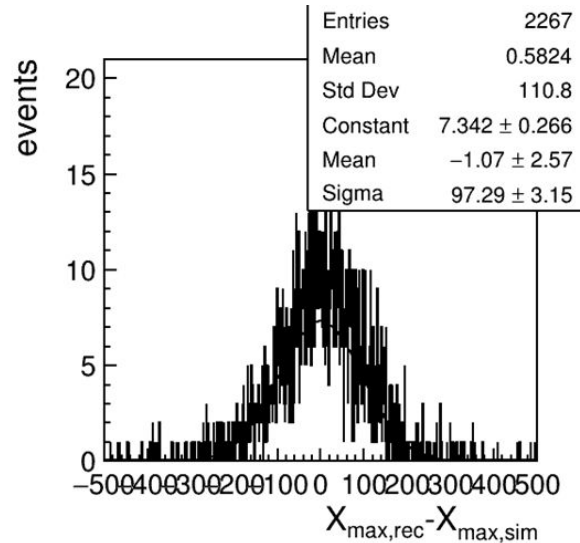Bias Xmax:

Proton/Proton

Bias Sem:

Resolution Sem:
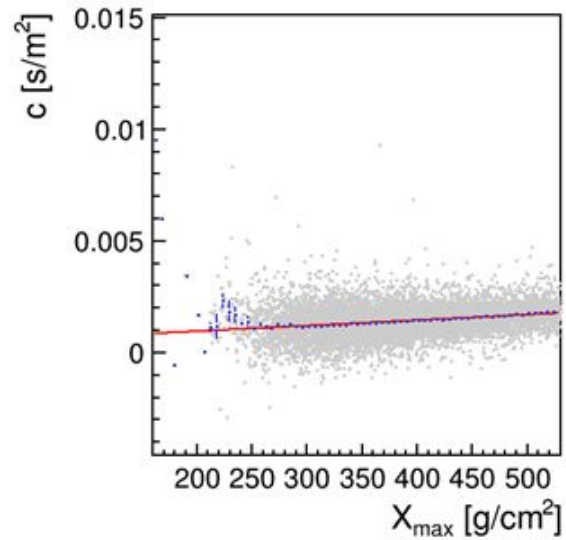
Proton/Proton

Sem=199.526

Sem=501.187

Sem=1995.26

Proton/Iron

Calibration plot:

Bias Xmax:
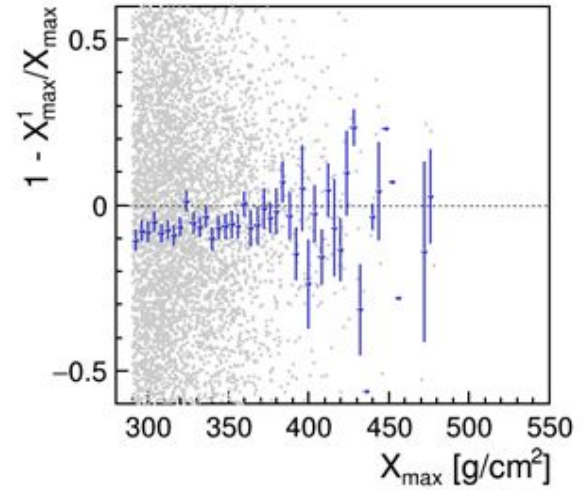
Proton/Iron

Bias Sem:
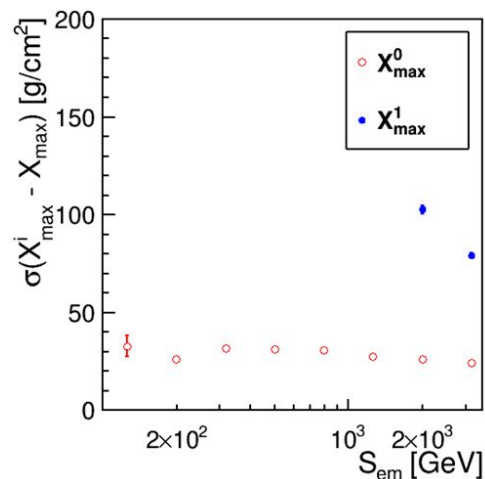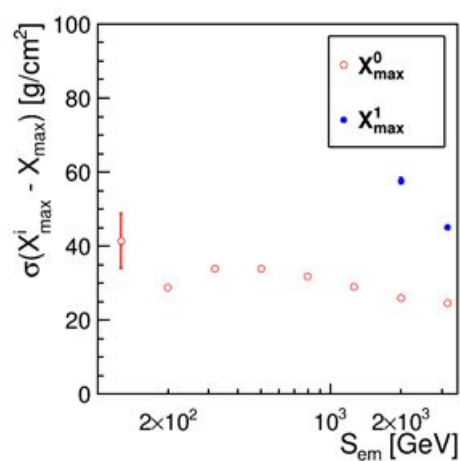
Resolution Sem:
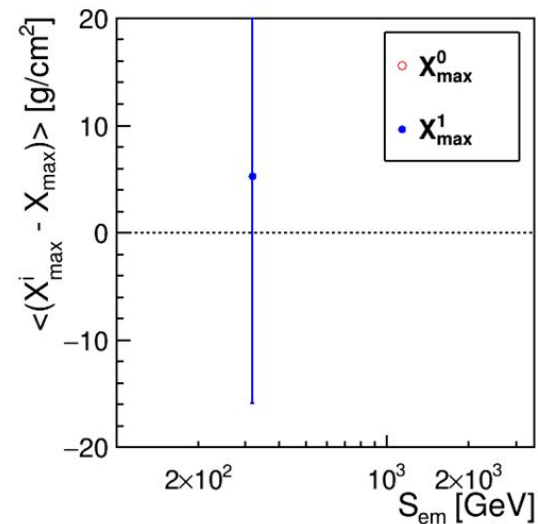
Proton/Iron

Sem=199.526   Sem=501.187   Sem=1995.26