STUDY OF THE ENERGY RESOLUTION FOR DIFFERENT MATERIALS

CaloCube Meeting , Firenze 20th February 2015

Niccolò Daddi

Work made & in progress

Dependence of the energy resolution from:

- **GAP** (proton @1TeV: CsI , BGO)
- **MATERIAL** (proton @1TeV: CsI , BGO , BaF_2 , YAP , LYSO)
- **ENERGY** (proton @ 1, 10, 10^2, 10^3 TeV: CsI, BGO)

	CsI:Tl	BGO	BaF_2	YAP:Yb	LYSO:Ce
density (g/cm^3)	4,53	7,13	4,89	5,50	7,40
interaction lenght (cm)	39,90	22,80	30,50	21,78	20,90
interaction lenght (g/cm^2)	180,75	162,56	149,15	119,79	154,66
radiation lenght (cm)	1,85	1,12	2,03	2,69	1,17
radiation lenght (g/cm^2)	8,39	7,97	9,91	14,81	8,67
R_M (cm)	3,53	2,26	3,12	2,40	2,07
Light Yield (p.e./MeV)	5,4E+04	8,0E+03	1,0E+04	1,8E+04	3,0E+04
refractive index	1,79	2,15	1,47	1,95	1,82
Cube side (cm)	3,60	2,30	3,20	2,40	2,10
Gap (cm)	0,30	0,19	0,27	0,20	0,18
Nside	20	27	22	28	30
Calorimeter side (cm)	78,00	67,23	76,34	72,80	68,40
Total interaction lenght (λ_I)	1,80	2,72	2,31	3,09	3,01
Total radiation lenght (X_0)	38,88	55,54	34,73	24,96	53,75
Nominal GF (m^2sr)	11,47	8,52	10,99	9,99	8,82

MC Simulations - FLUKA based

- Number of crystals → Mass limit **2 ton**

(mechanical structure included, Carbon fiber 1.8 g/cm^3)

- Gap dependence → mechanical structure mass constant

- Material dependence → Gap/CubeSide constant

- Simulated particles: **protons** 1TeV → 1PeV

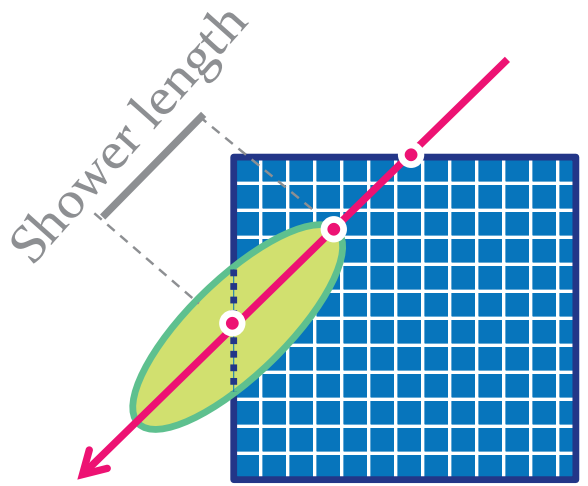
(isotropic generation on the top surface)

Data Analysis

- **20000 Ev** sample
- **1st cut**: non interacting (number of sensors & shower threshold)
- **2nd cut**: maximum point containment
- **3rd cut**: longitudinal containment (shower length)

(fixed efficiency: 100%, 75%, 50%, 25%)

N.B.: light collection (80%) and quantum efficiency of PD (68%) are taken into account

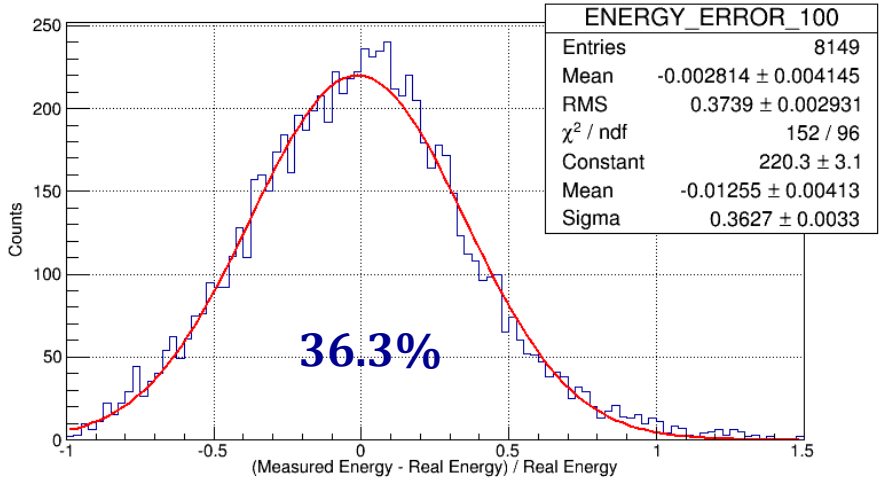


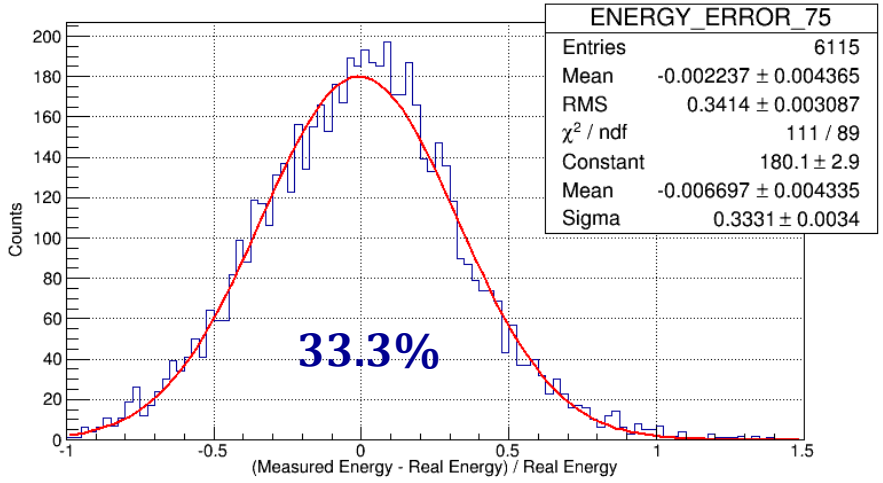
GAP DEPENDENCE

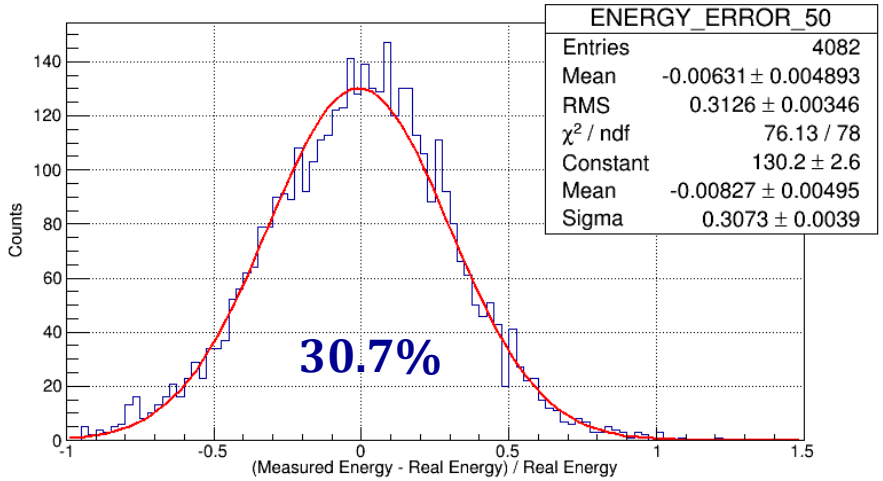
RESULTS

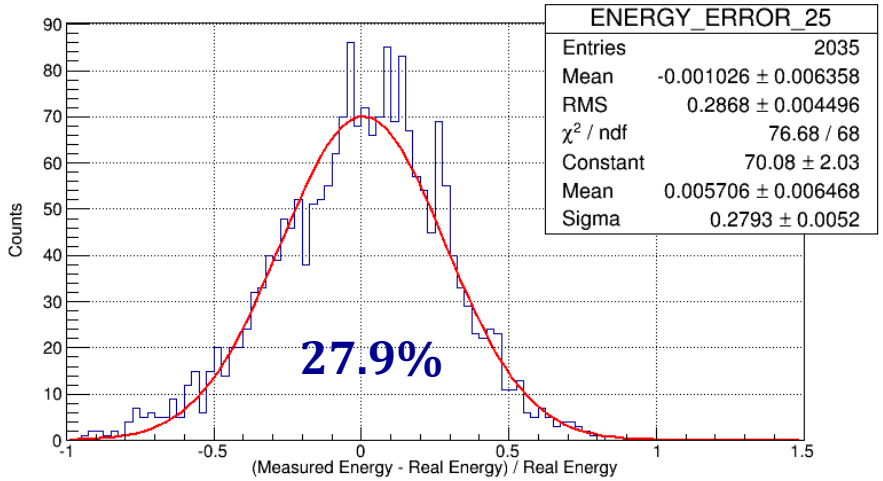
GAP dependence - Proton @1TeV CsI

GAP 1 – 3.0 mm



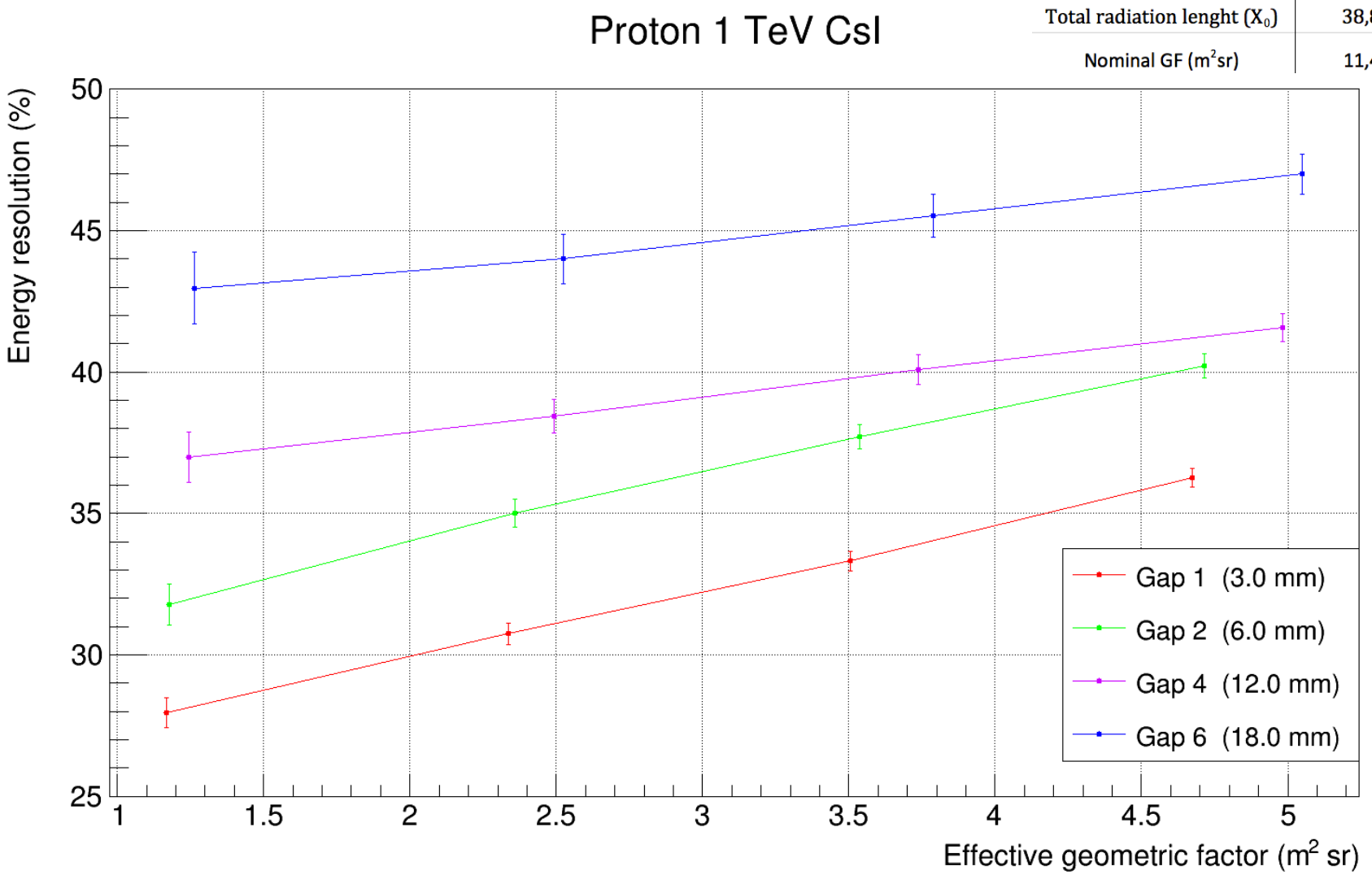






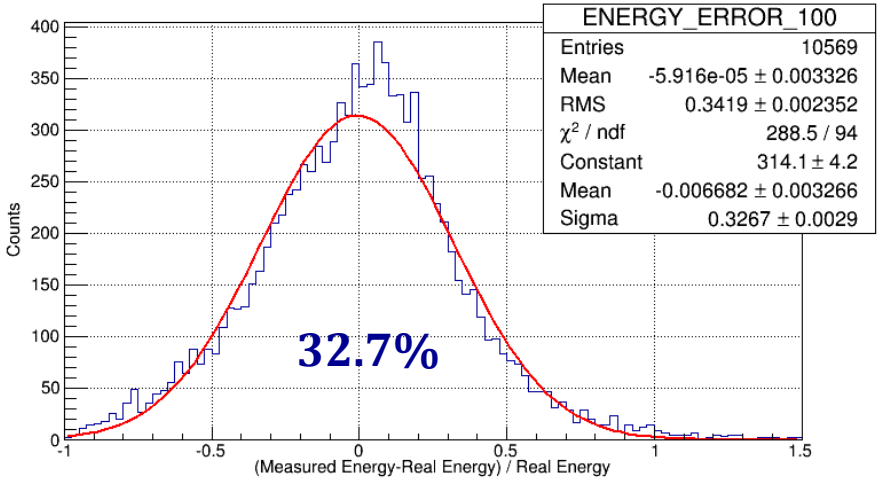
GAP dependence

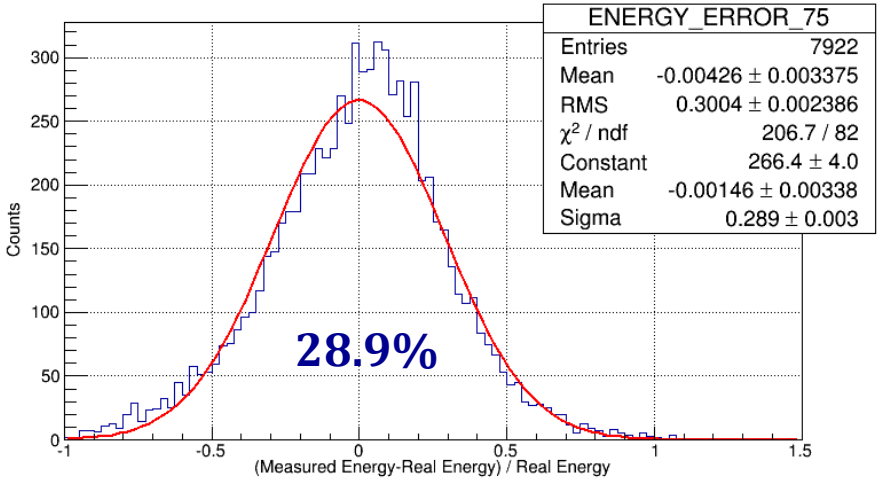
Cube side (cm)	3,60
Gap (cm)	0,30
Nside	20
Calorimeter side (cm)	78,00
Total interaction lenght (λ_I)	1,80
Total radiation lenght (X_0)	38,88
Nominal GF ($m^2 sr$)	11,47

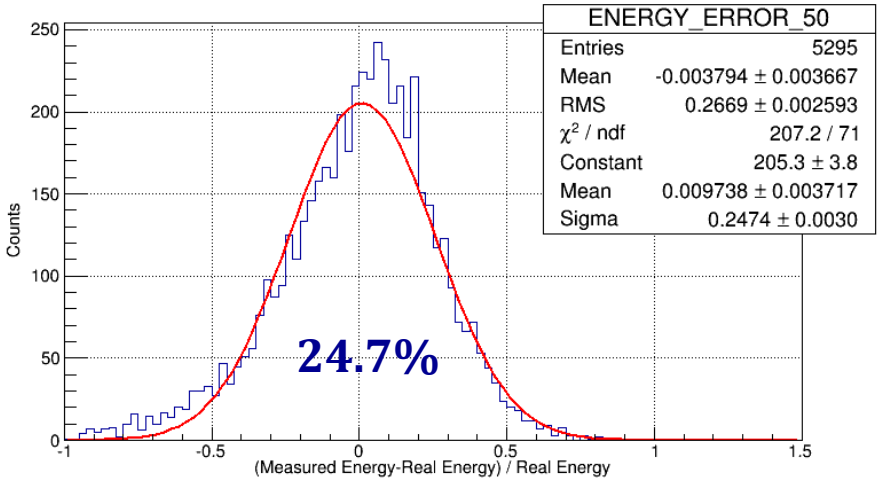


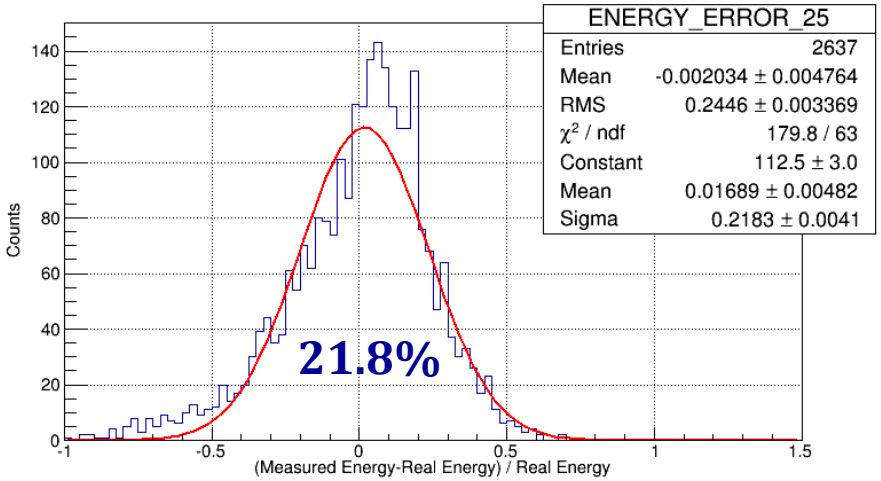
GAP dependence - Proton @1TeV BGO

GAP 1 – 1.9 mm



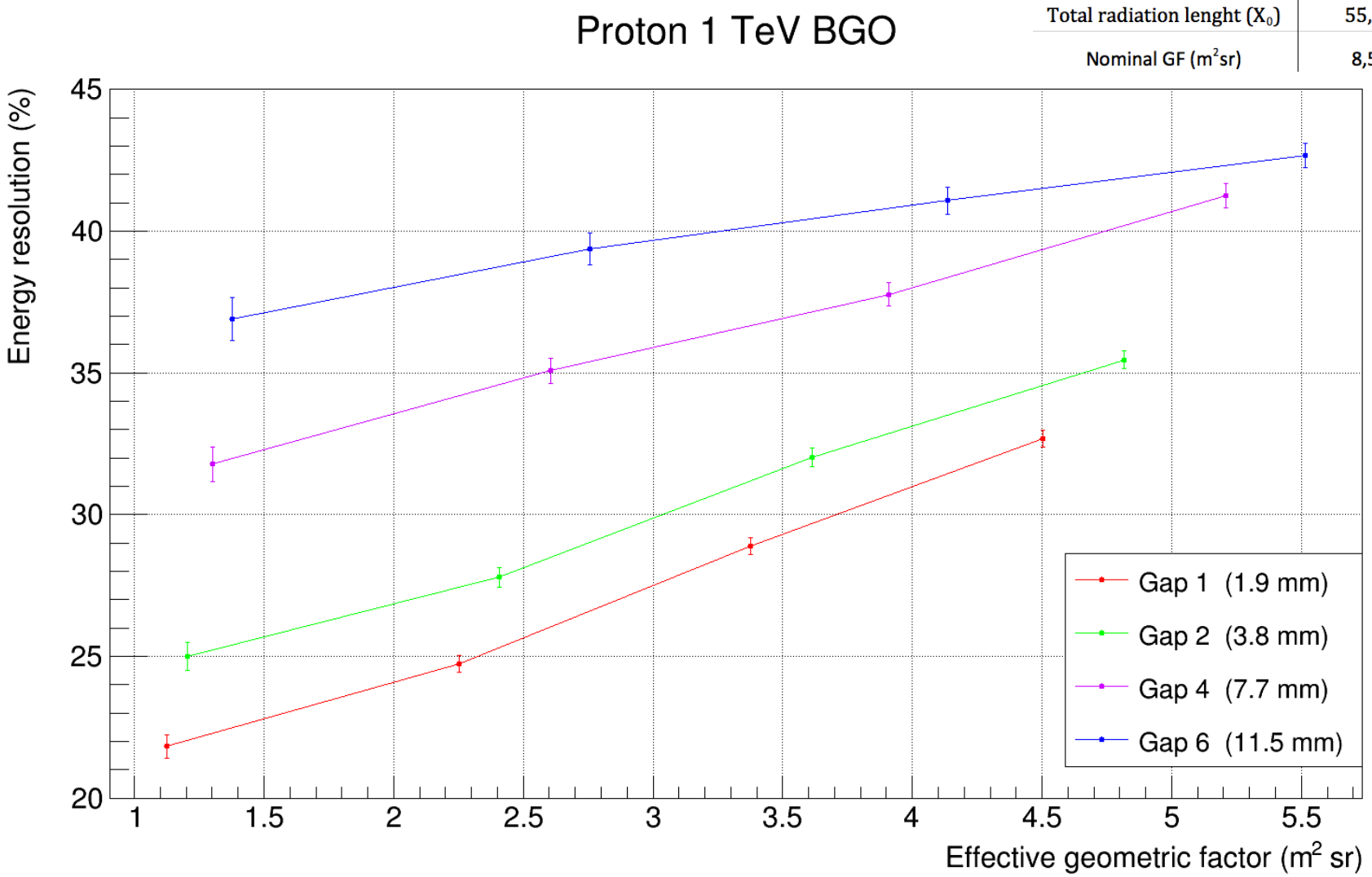






GAP dependence

Cube side (cm)	2,30
Gap (cm)	0,19
Nside	27
Calorimeter side (cm)	67,23
Total interaction lenght (λ_I)	2,72
Total radiation lenght (X_0)	55,54
Nominal GF ($m^2 sr$)	8,52



GAP dependence - Conclusions

The energy resolution is worse with increasing gap.

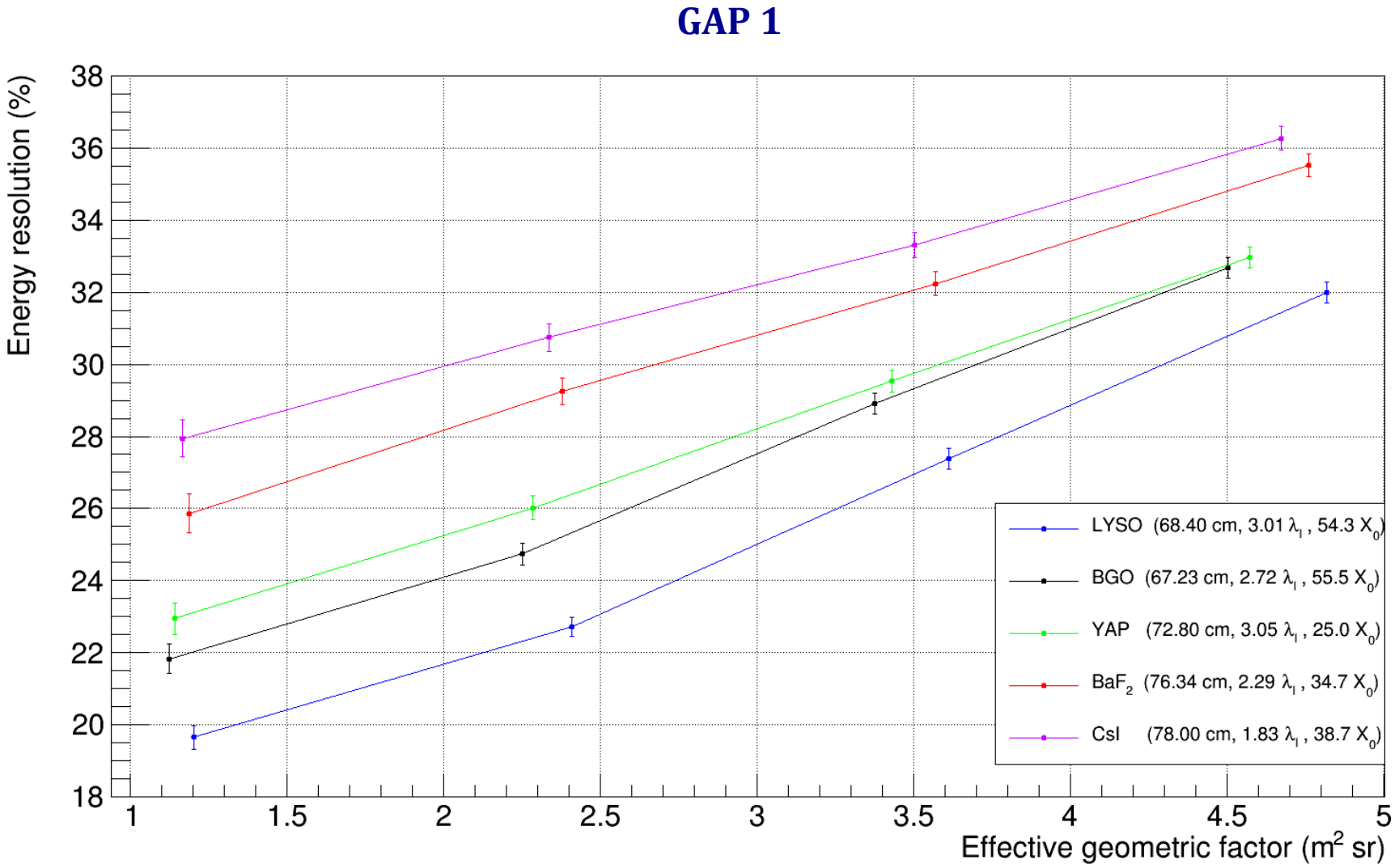
Gap as small as possible!

(consistent with mechanical requirements)

MATERIAL DEPENDENCE

RESULTS

MATERIAL dependence - Proton @1TeV



MATERIAL dependence - Conclusions

LYSO is the best … but it is radioactive!

High density materials are, in general, better.

Which is the minimum energy resolution required to identify the “knee” in the cosmic rays spectrum?

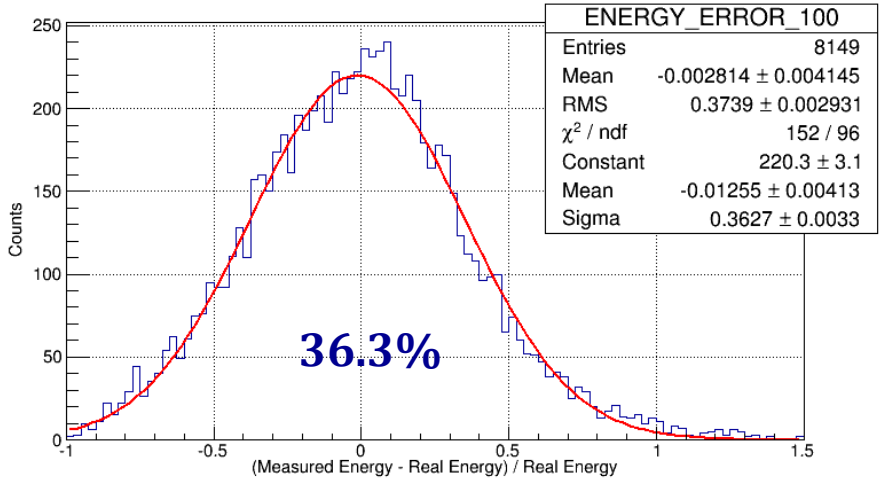
Maybe CsI has a sufficient energy resolution…

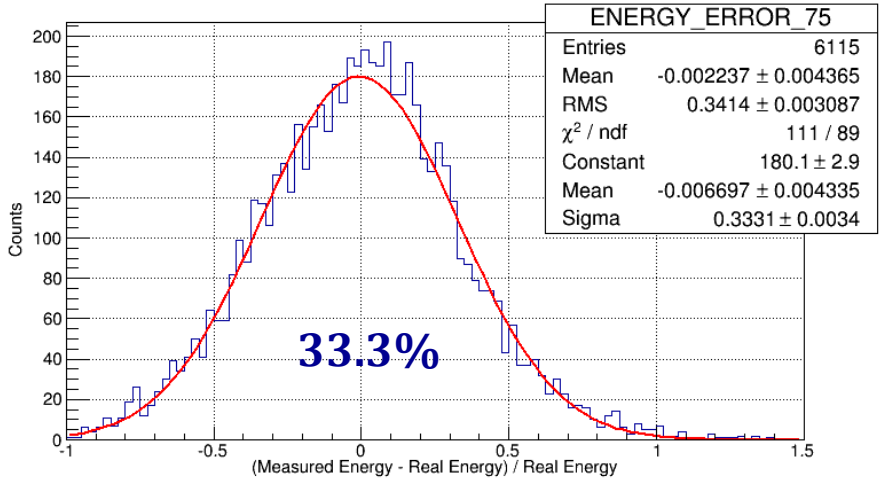
ENERGY DEPENDENCE

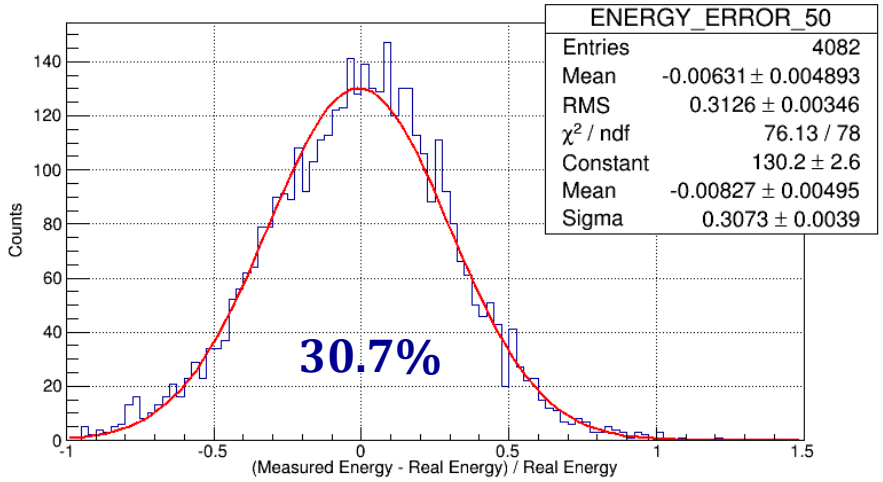
RESULTS

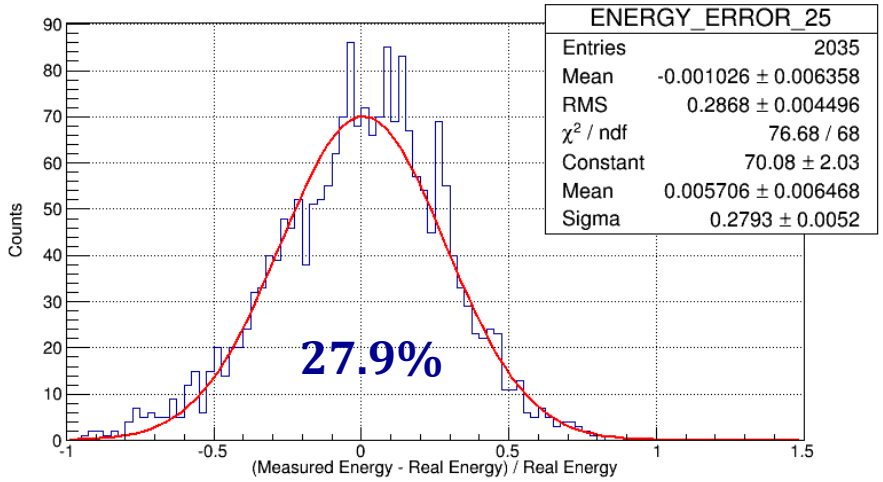
ENERGY dependence - Proton @1TeV CsI

GAP 1



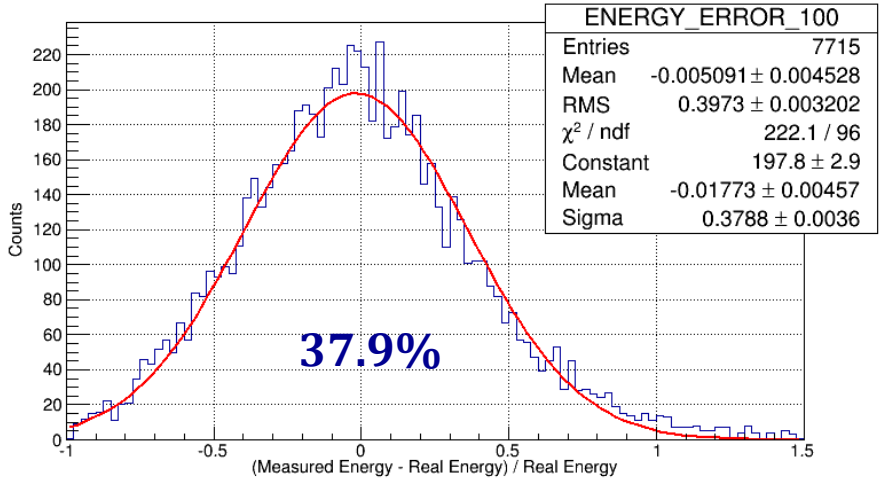


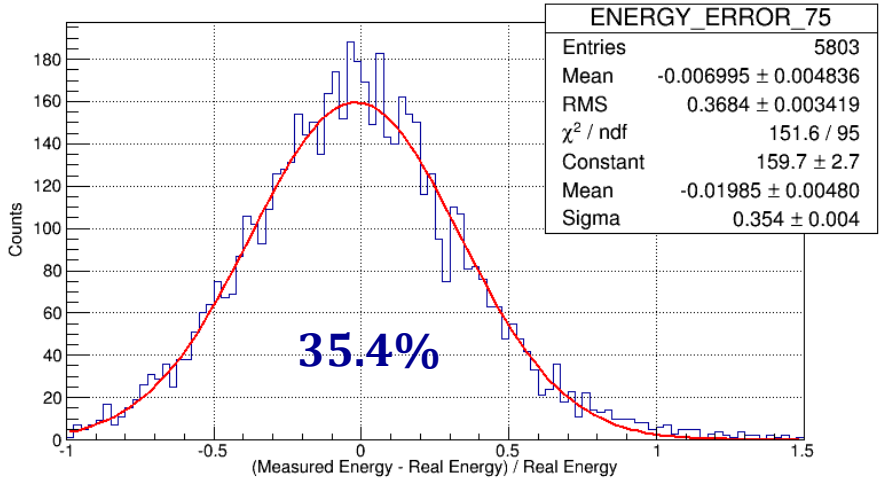


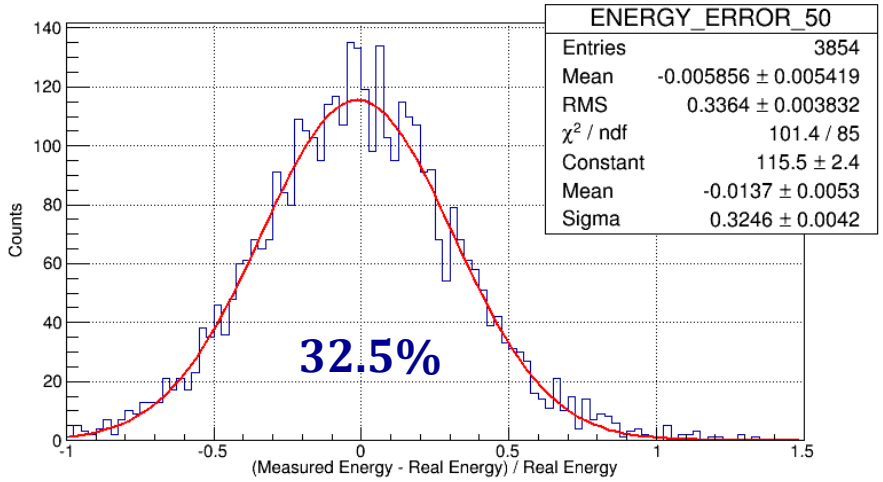


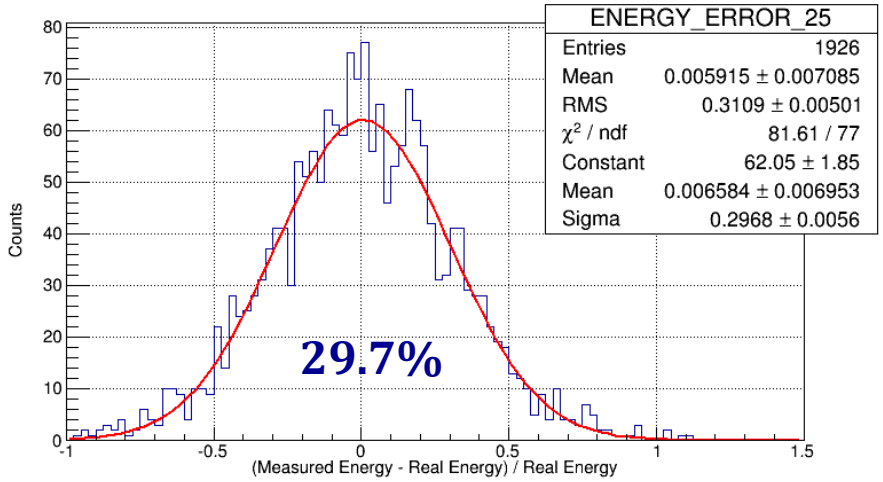
ENERGY dependence - Proton @10TeV CsI

GAP 1



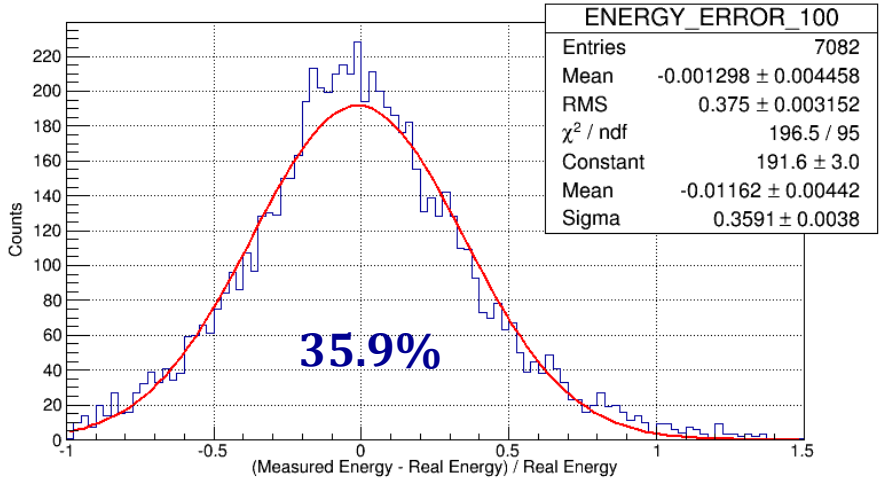


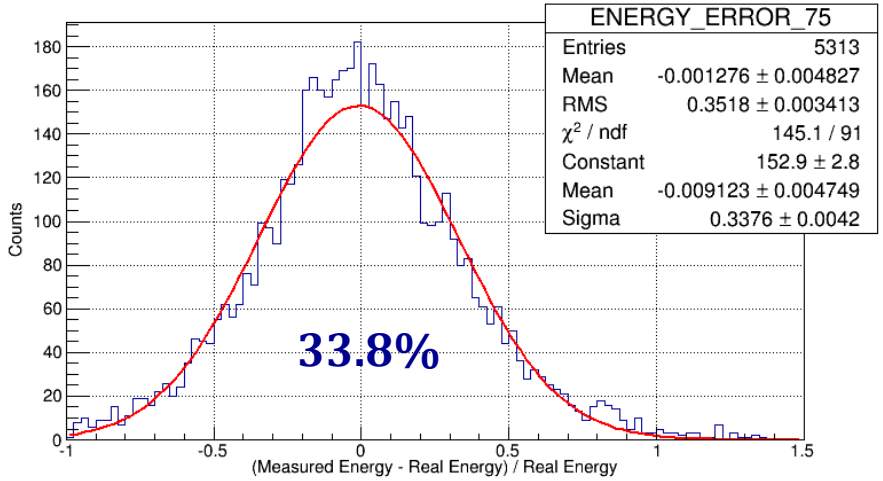


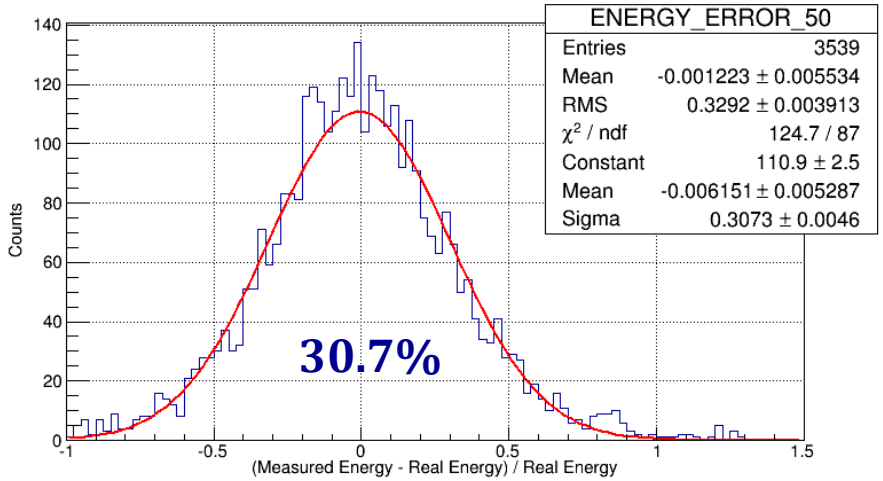


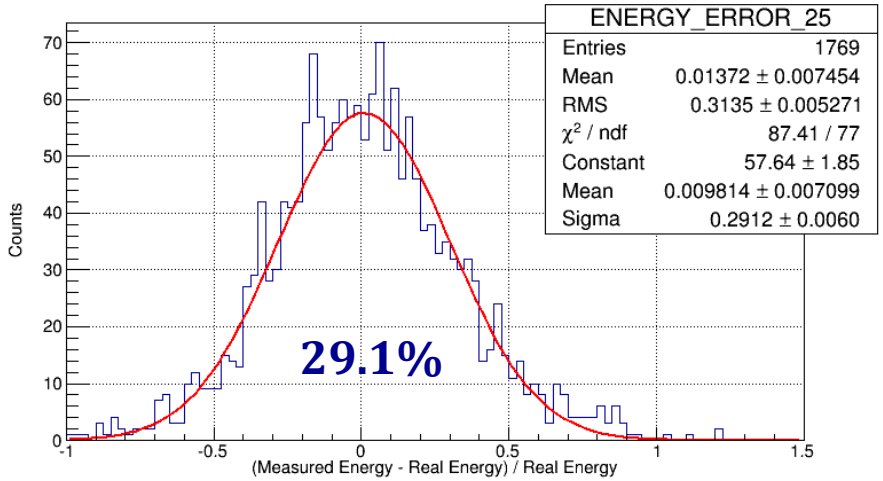
ENERGY dependence - Proton @100TeV CsI

GAP 1

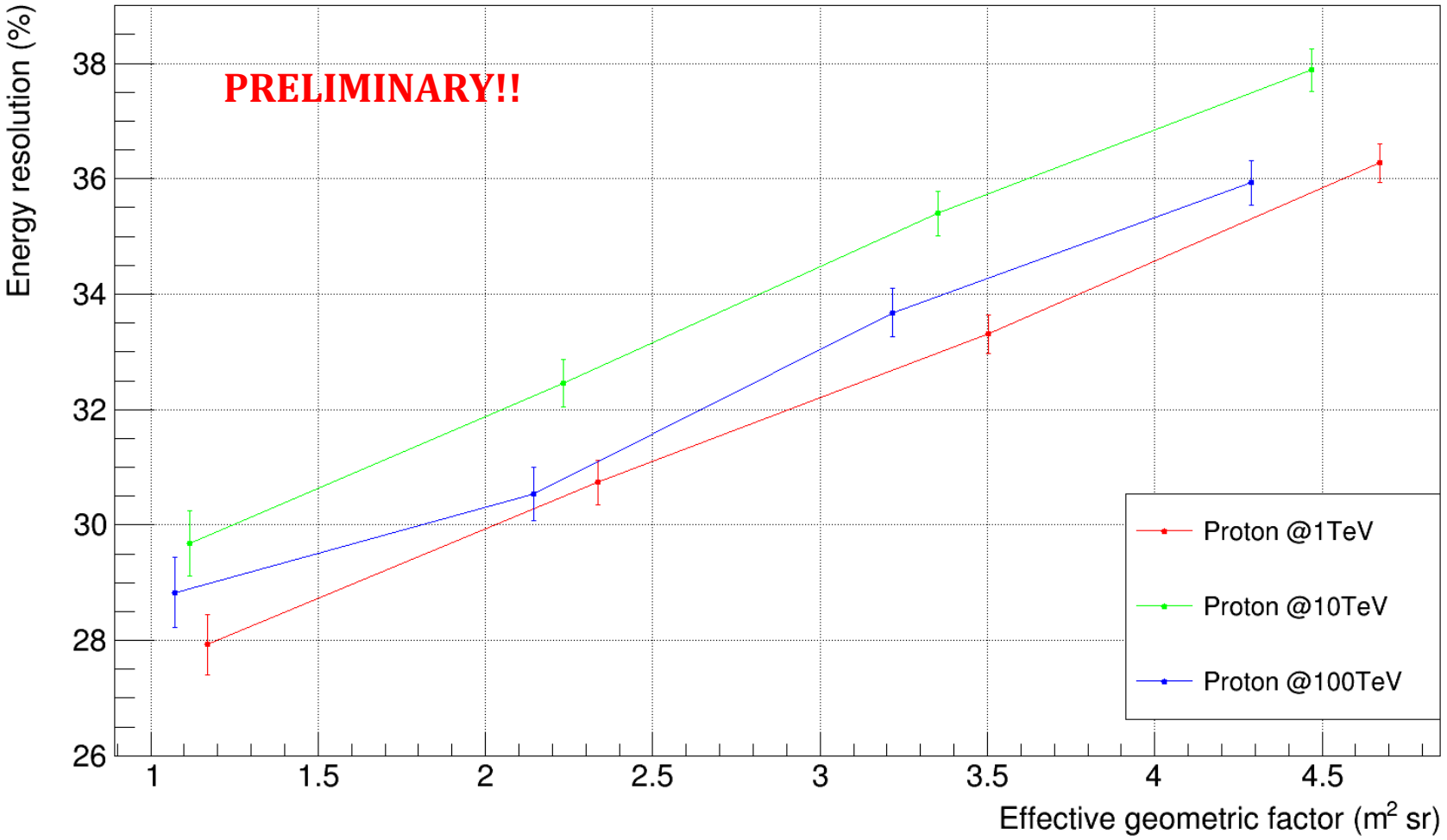








ENERGY dependence - Proton CsI (20x20x20 GAP 1)



Correction with Shower Length