Studies of reconstruction algorithms for SPD ECAL

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SPD Physics & MC Meeting

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Side note: ECAL in SPDROOT

ECAL modules: SpdEcalTB2 (barrel) / SpdEcalTEC2 (endcaps)

Examples macros: geometry drawing: macro/geom/ConstructEcalTB2.C (ConstructEcalTEC2.C),

simulation: macro/SimuQsl.C

analysis: macro/analysis/ecalt/CheckEcalTB2Points.C (CheckEcalTEC2Points.C)

Geometry works fine by default; what can be changed:

cell size, absorber/scintillator layer widths, number of layers (barrel);

barrel only flags: force cell size (otherwise optimize), option to trim module length

SPD wiki entry will be written within one week

Please write bugs and questions to andrii.maltsev@cern.ch

SPD ECAL

The following studies were done for Shashlyk

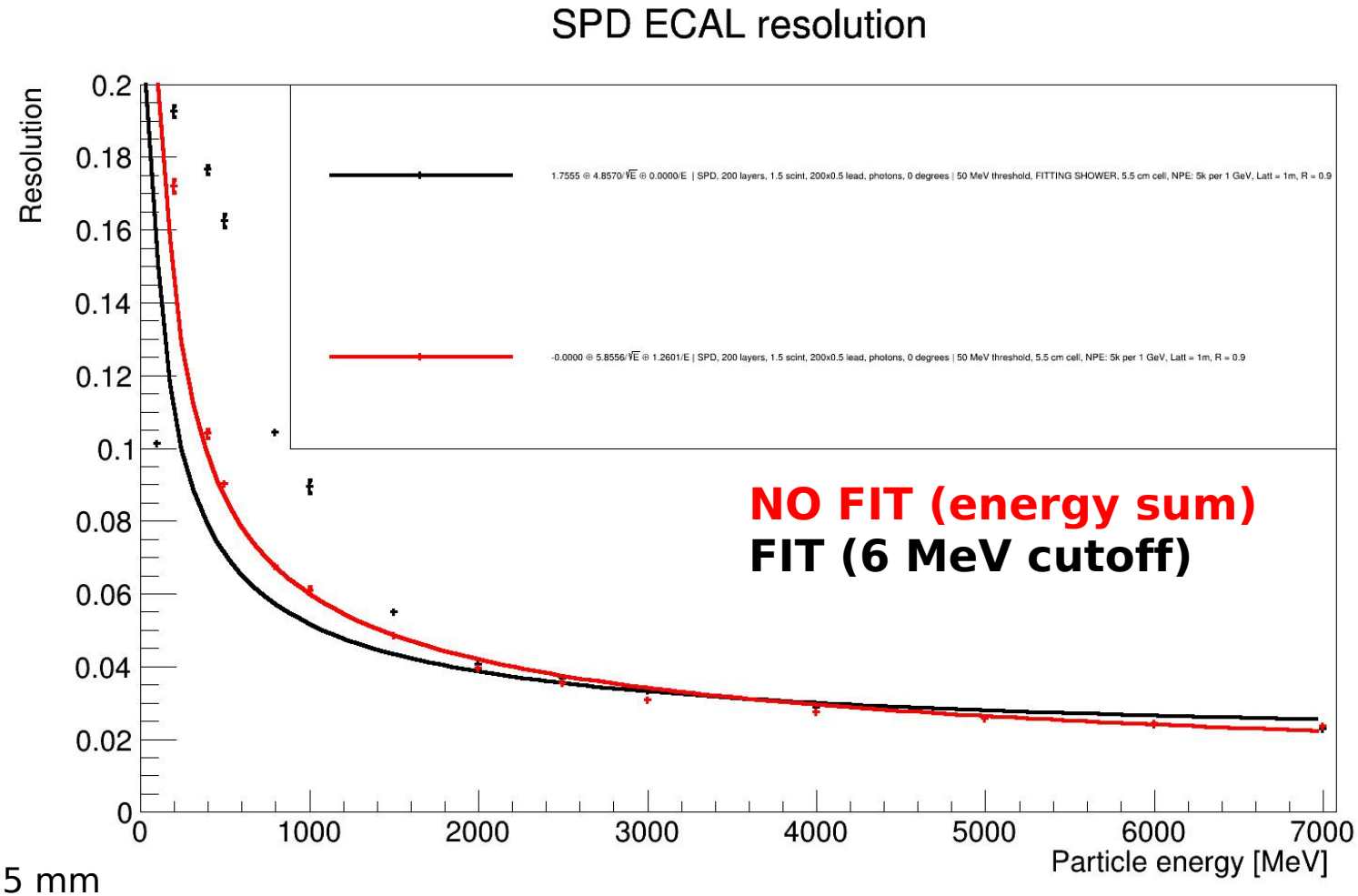
Crystal ECAL: different absolute figures for energy/position resolution, but same algorithms and patterns also apply

Outline:

- Energy resolution: energy sum vs Lednev's shower profile fit
- Position resolution: linear/log weighting vs Lednev's shower profile fit
- Fast ECAL reconstruction: photon detection efficiency/cell multiplicity

Lednev's shower fitting algorithm

- **A.A.Lednev NIM A 366 (1995) 292-297**
- A χ^2 fit with 3 variables to minimize: x,y, energy
- For each cell, difference between predicted (from shower profile) and “measured” energy is calculated
- Using shower profiles from MC (cutting corners a bit: ideally obtained from data)
- Bordering cells are also included in the fit
- Free parameter: cutoff value: energy in cells which border the cluster cells



Resolution with cutoff = threshold/2:

5.5 cm cell size
200 layers: 0.5 mm lead/1.5 mm scintillator, inc. photoelectron statistics and light attenuation

Effect of cutoff cell energy value

1 GeV particle, threshold:

12 MeV in scintillator (~50 MeV total),

6.41% resolution from energy sum

cutoff [MeV]	**resolution [%]**
3.6	6.84
1.2	5.75
0.6	5.71
0.0	5.70

4 GeV particle, threshold:

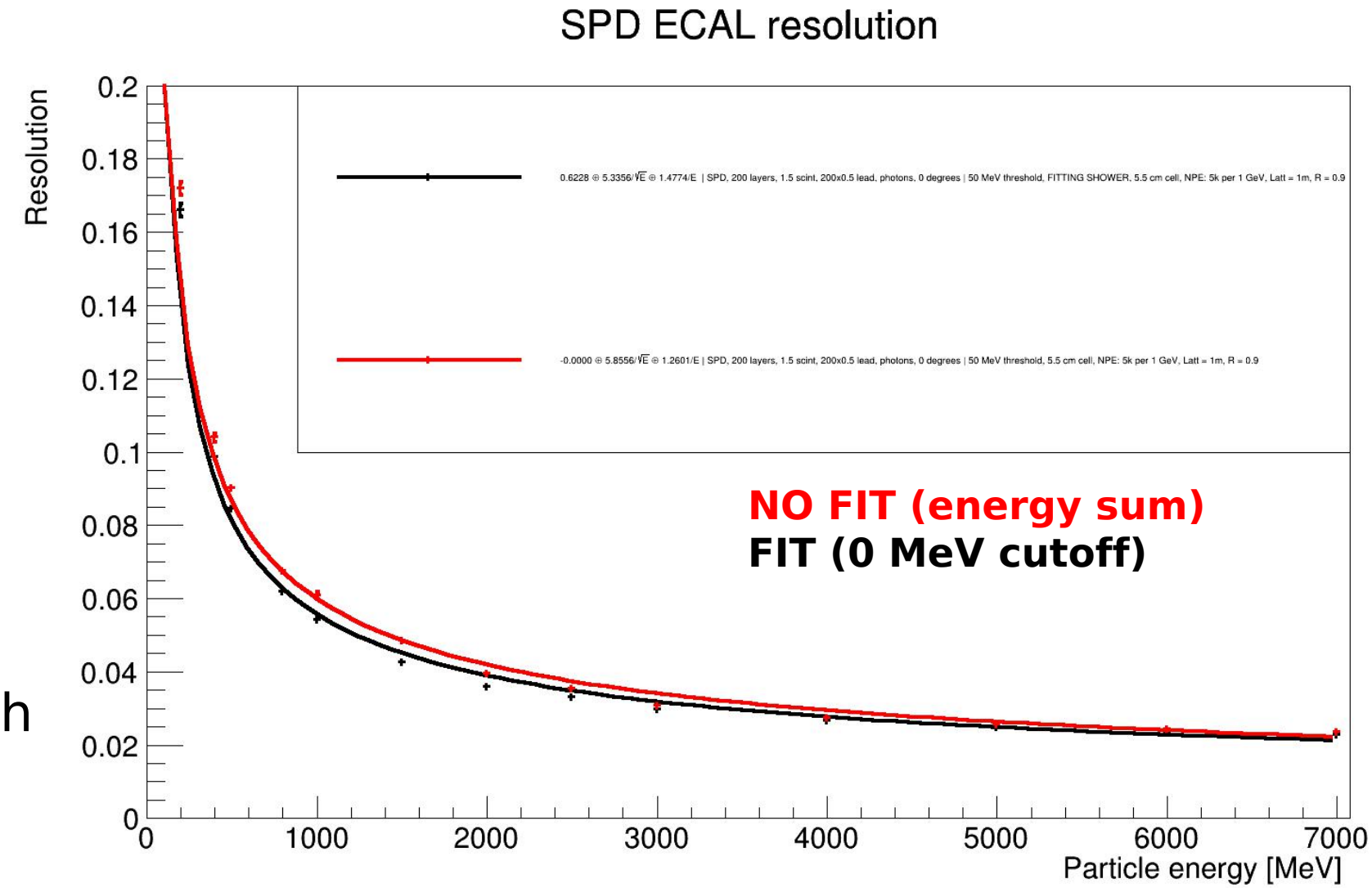
12 MeV in scintillator (~50 MeV total),

2.76% resolution from energy sum

cutoff [MeV]	**resolution [%]**
12	3.58
8.4	3.02
1.8	2.64
0	2.65

using 0 MeV as cutoff value seems reasonable

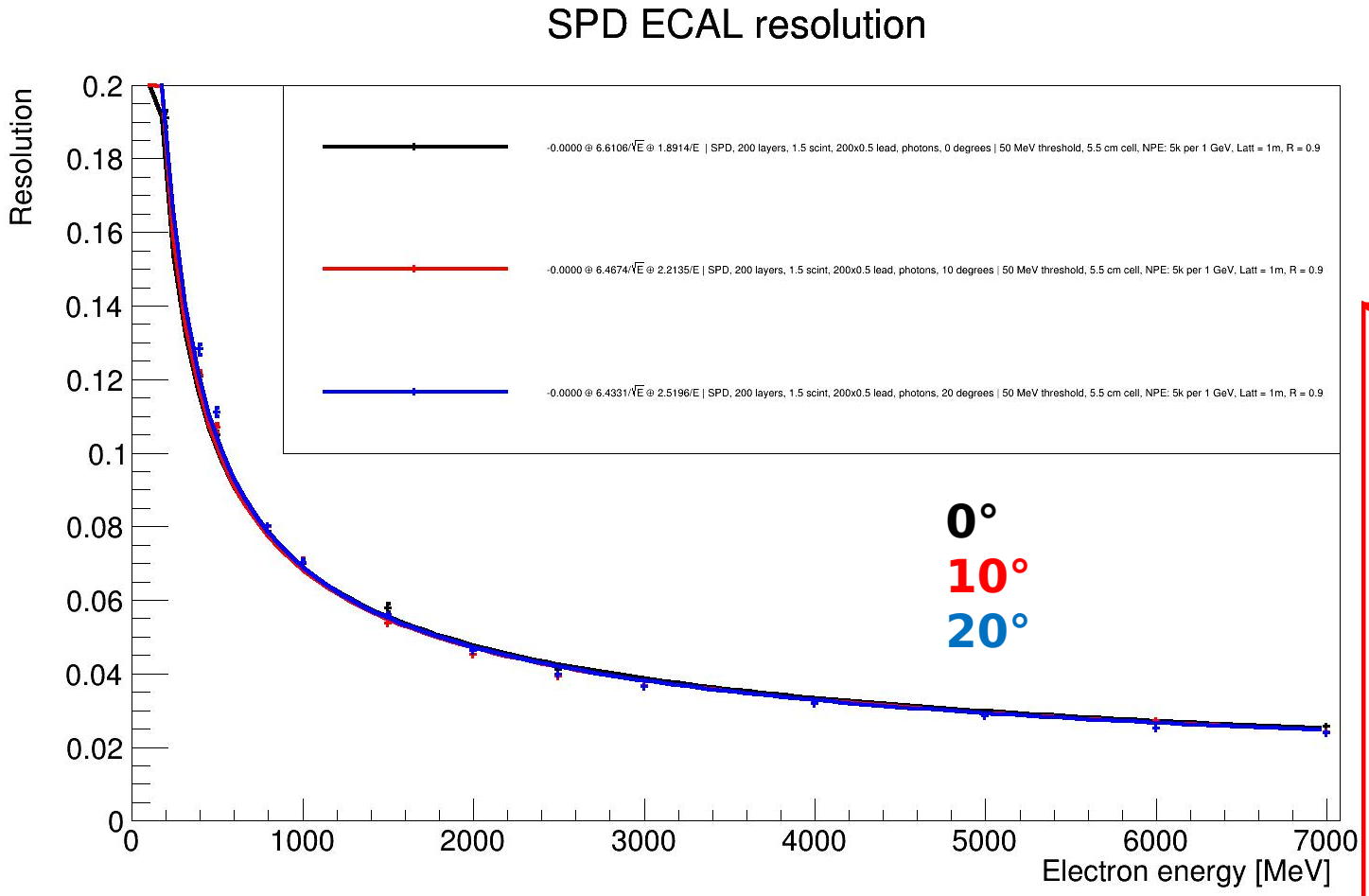
Energy resolution with Lednev's shower profile fit

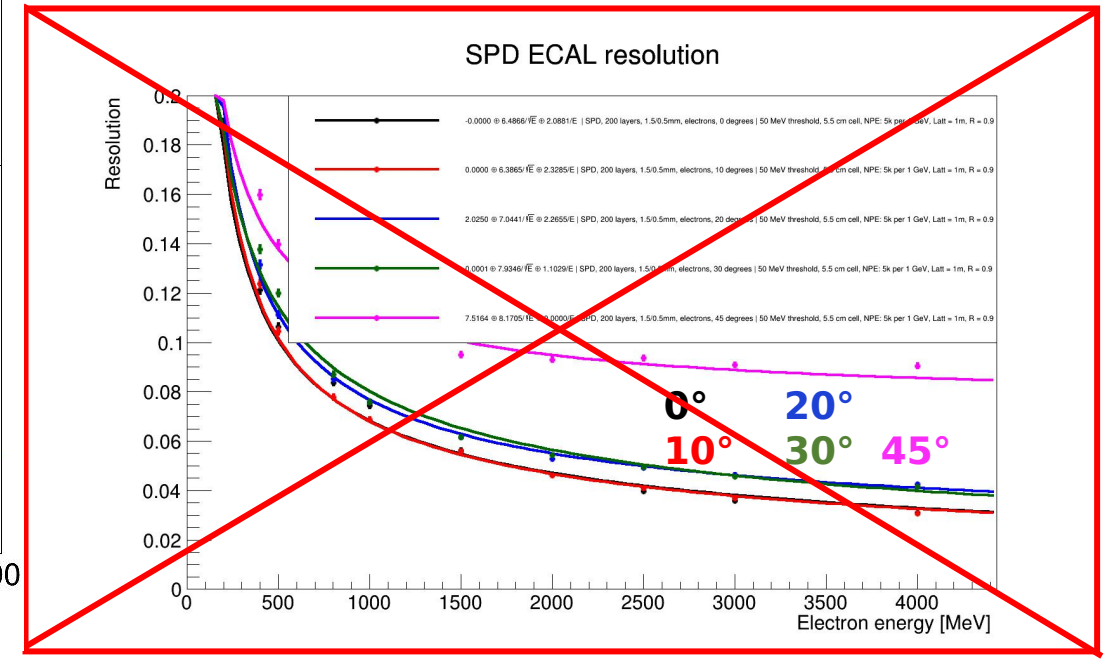


Resolution with 0 MeV cutoff:

the improvement is there, but not significant

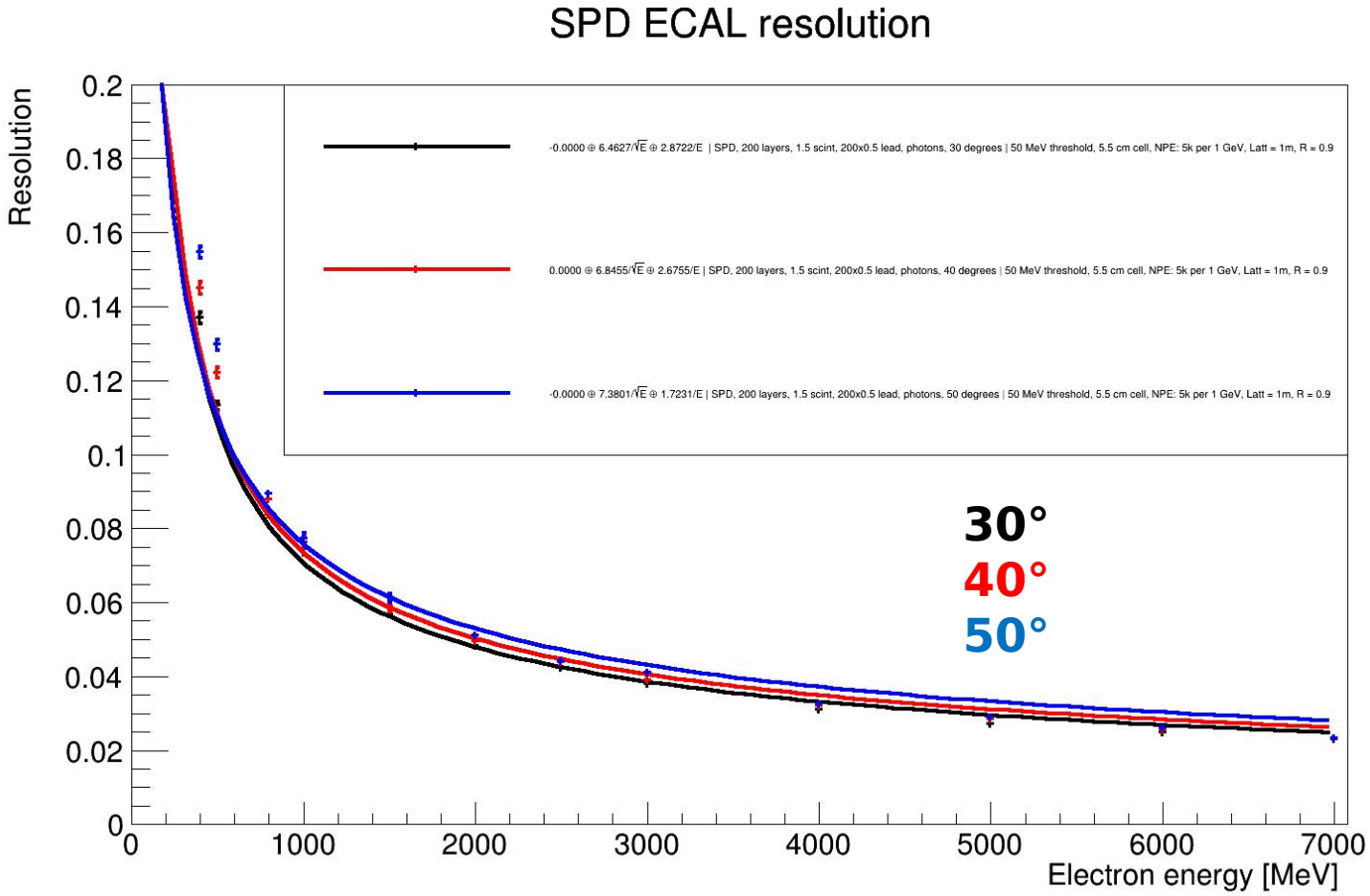
Bug fix: energy resolution for high energies (sum of energies, no fit)

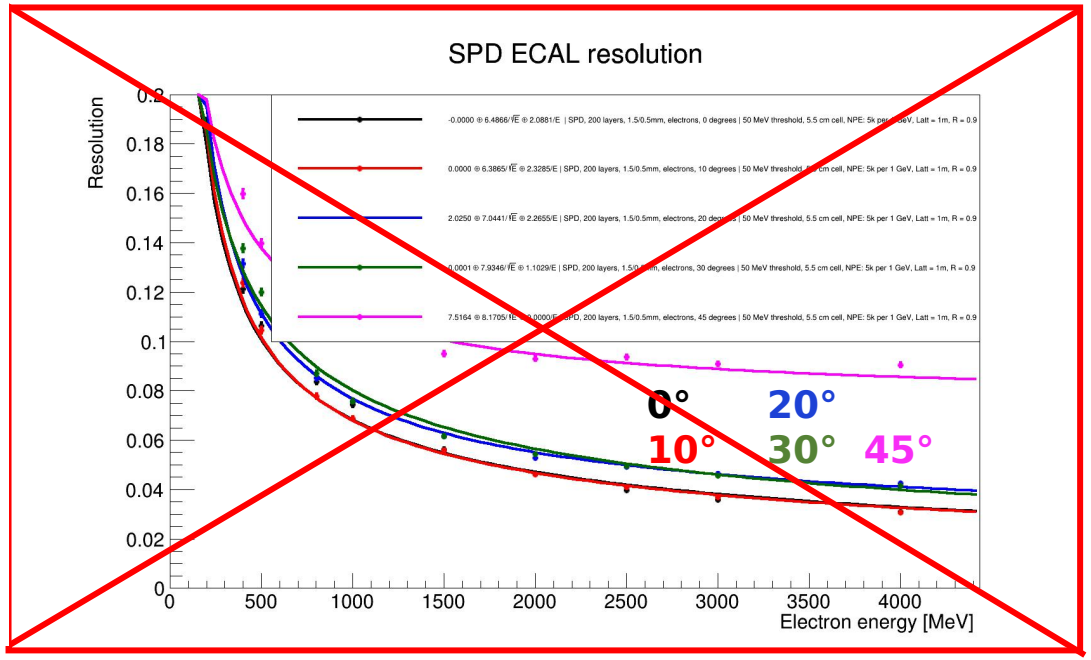




at high angles it's not as bad as was previously thought

Bug fix: energy resolution for high energies (sum of energies, no fit)





at high angles it's not as bad as was previously thought

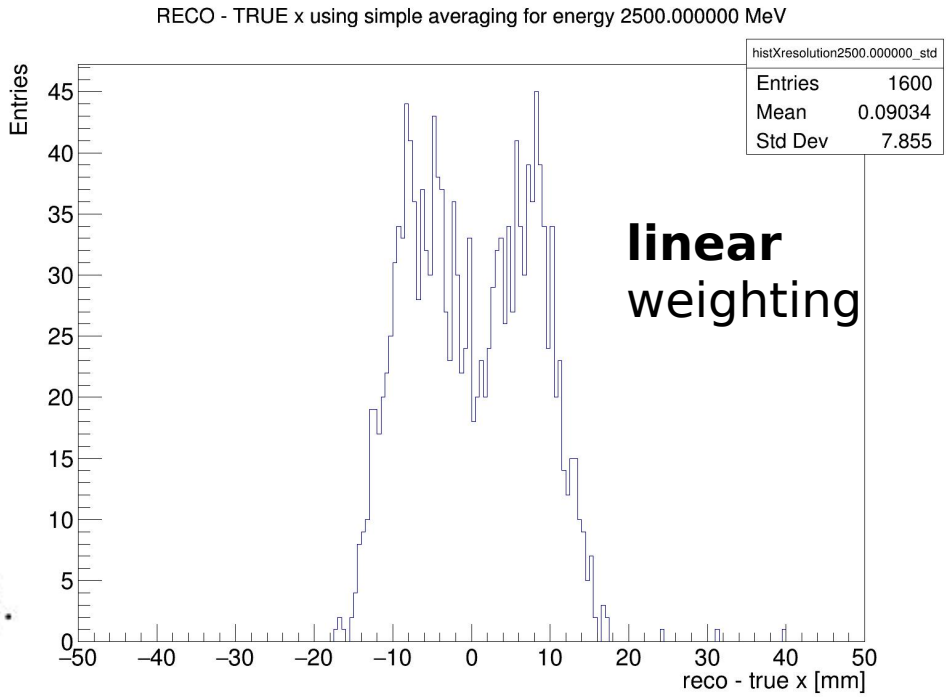
Position resolution

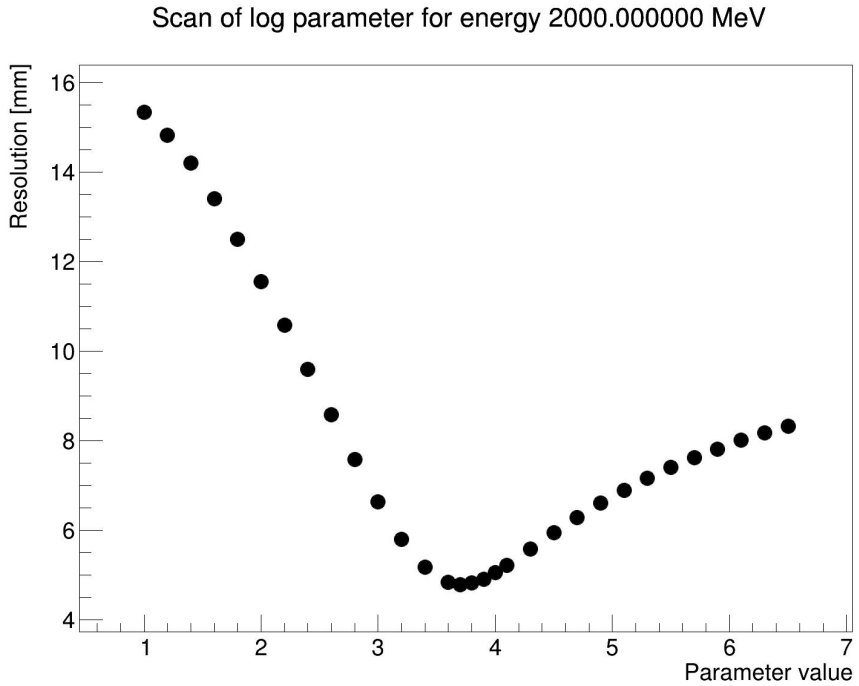
See talk by Adel Terkulov
http://spd.jinr.ru/wp-content/uploads/2020/05/2020-05-13_terkulov.pdf

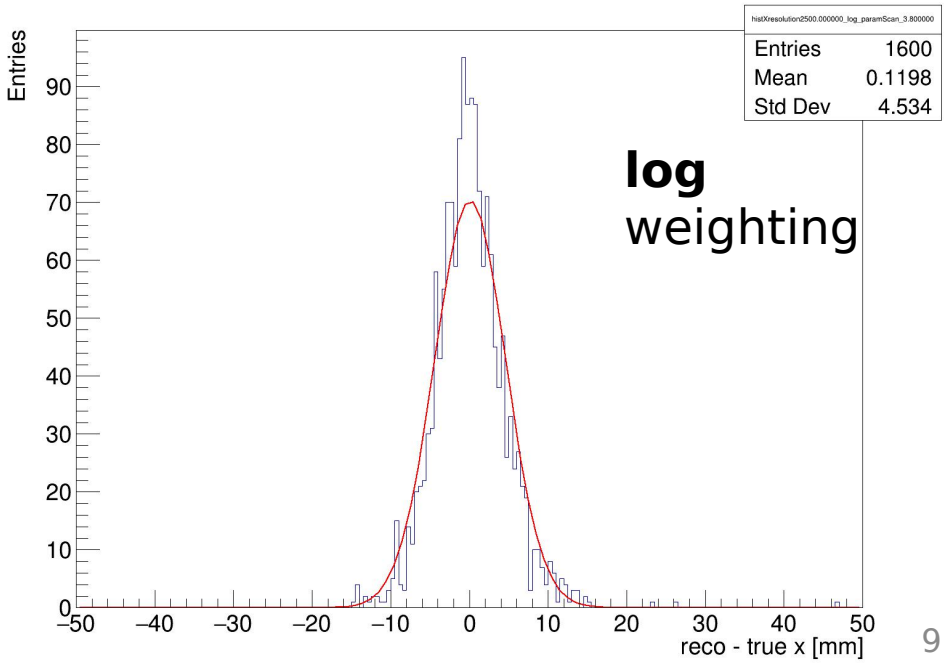
$$x_c = \frac{\Sigma_i W_i(E_i) x_i}{\Sigma_i W_i(E_i)}$$

$$W_i^{(linear)}(E_i) = E_i,$$

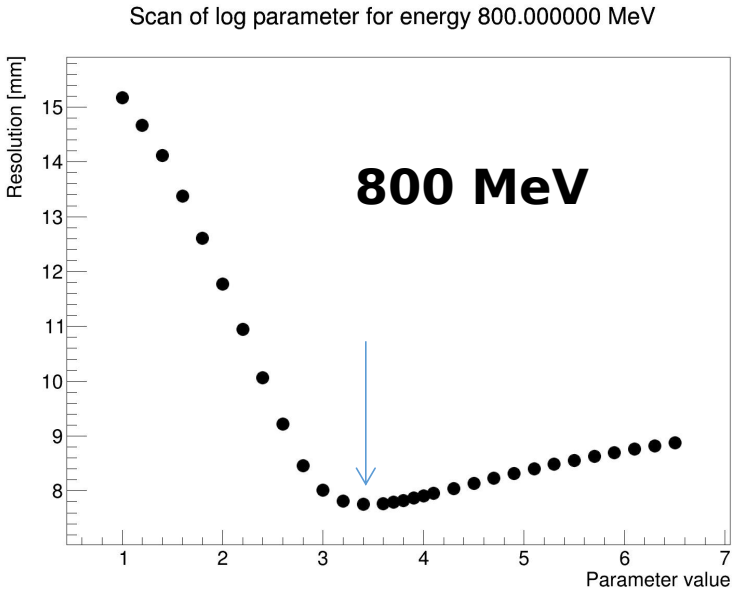
$$W_i^{(log)}(E_i) = Max\{0, a_0 + ln(E_i) - ln(E_{total})\}.$$

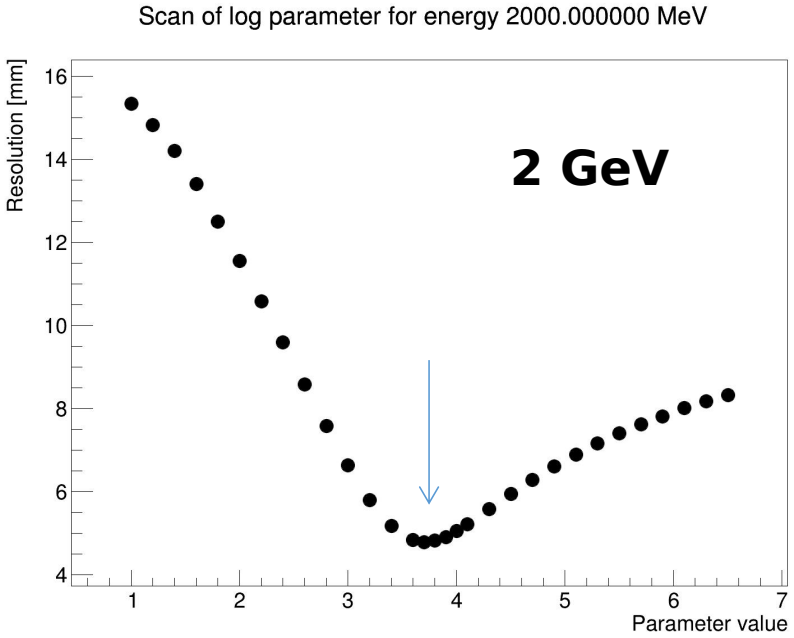


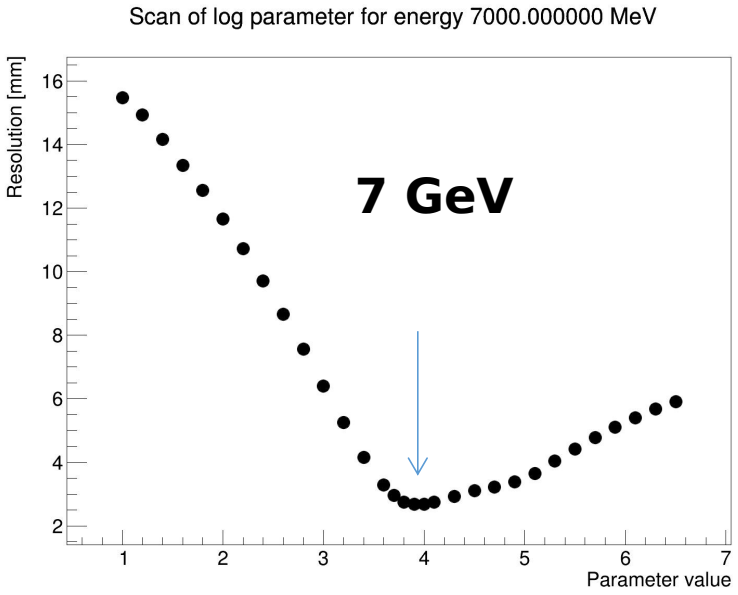




Optimal log.parameter vs energy

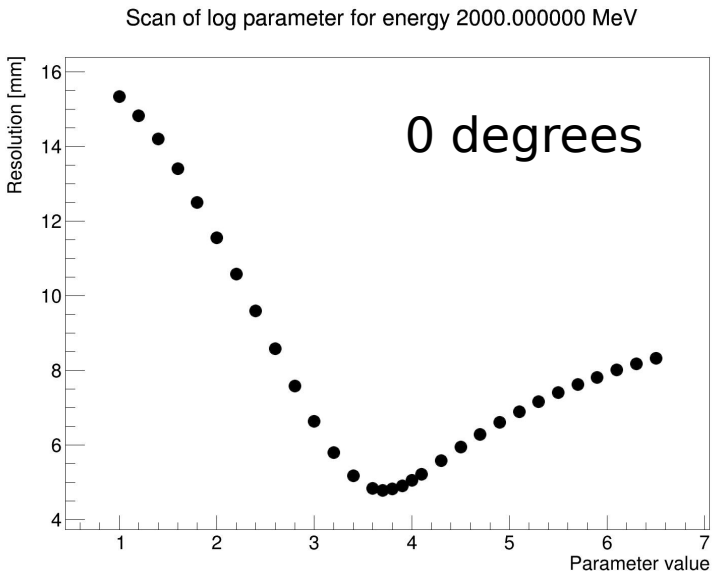


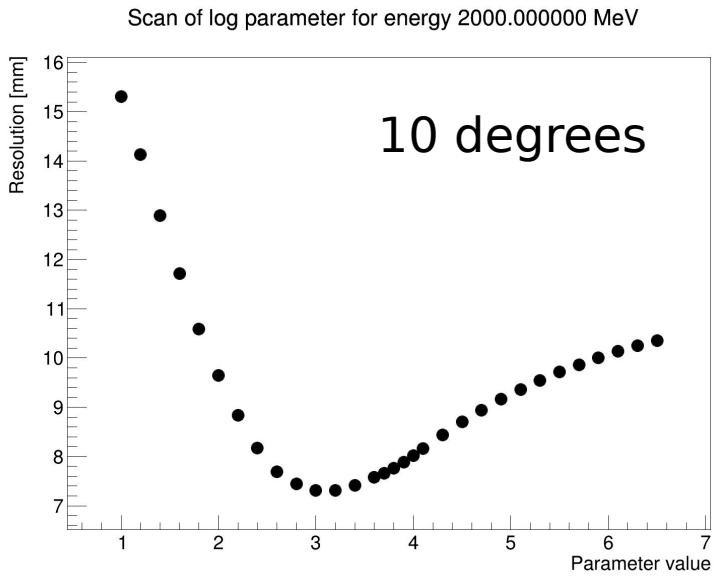


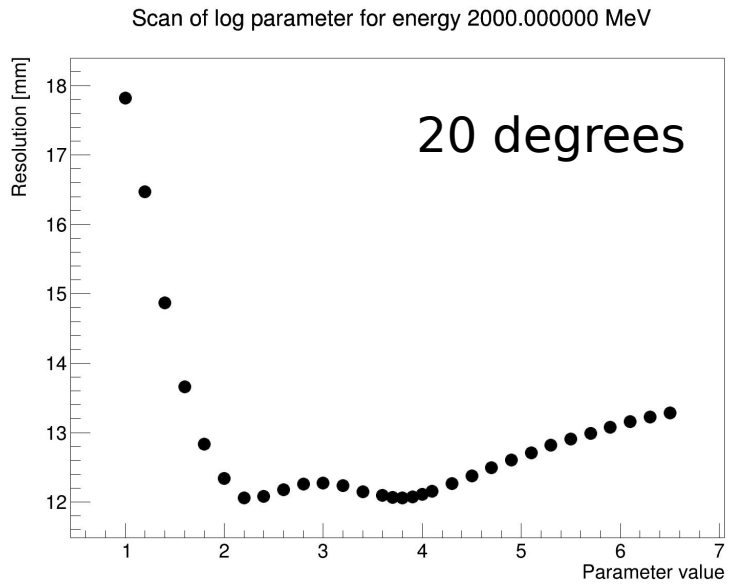


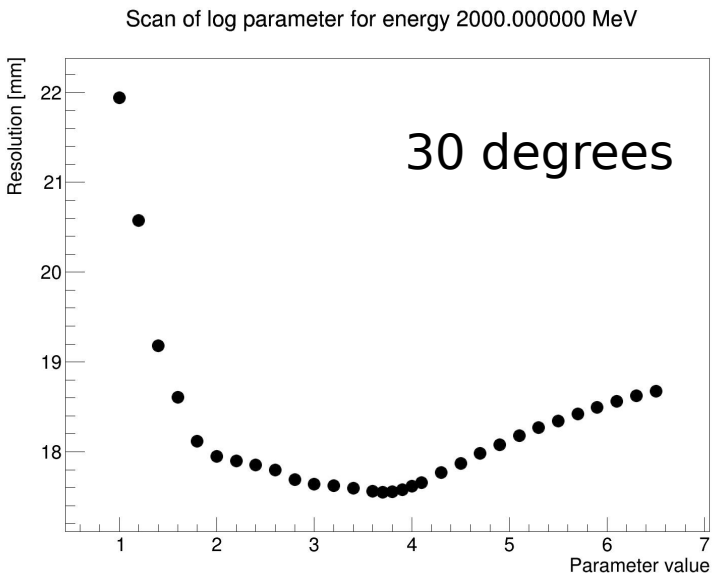
log.parameter also changes with energy

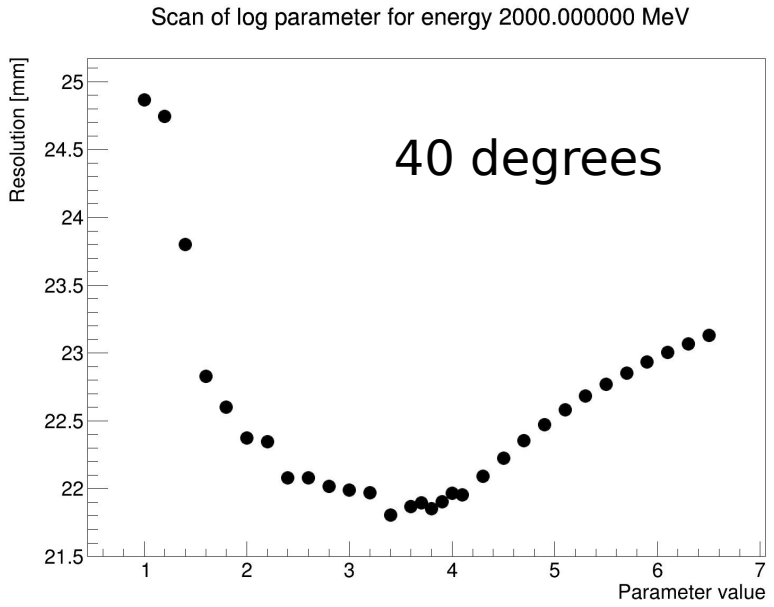
Optimal log.parameter vs energy









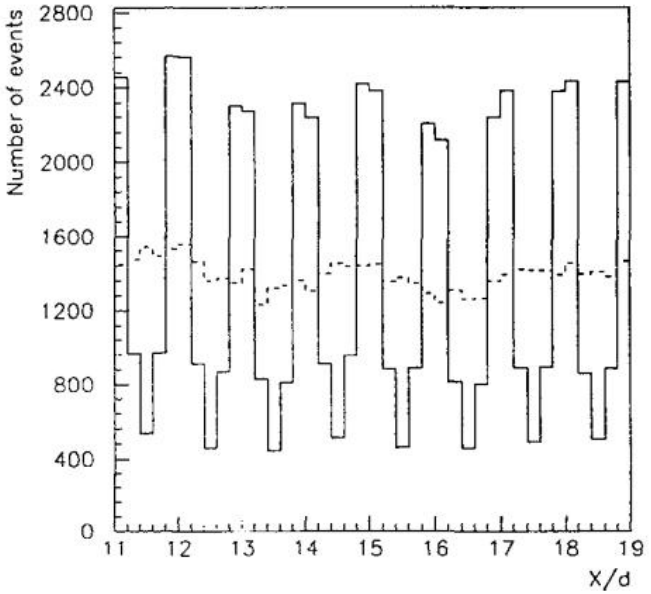


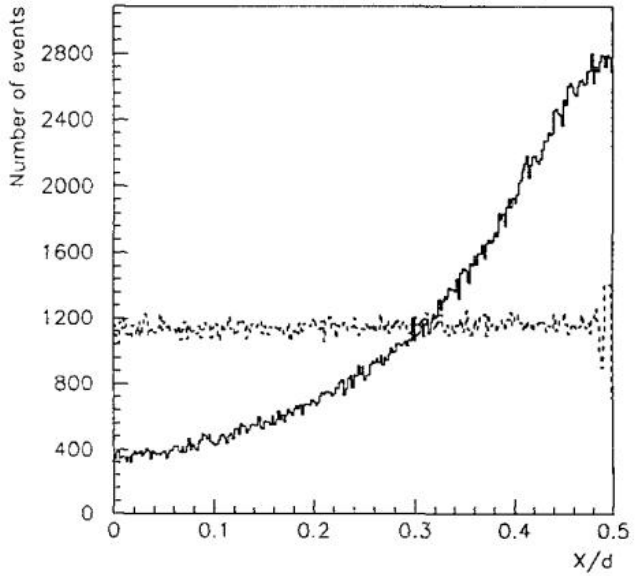
different behaviour and minimum values for different angles

Position resolution using different methods

- Linear weighting
- Log weighting
- Lednev's shower fit
- **Linear weighting + Lednev's correction function:**

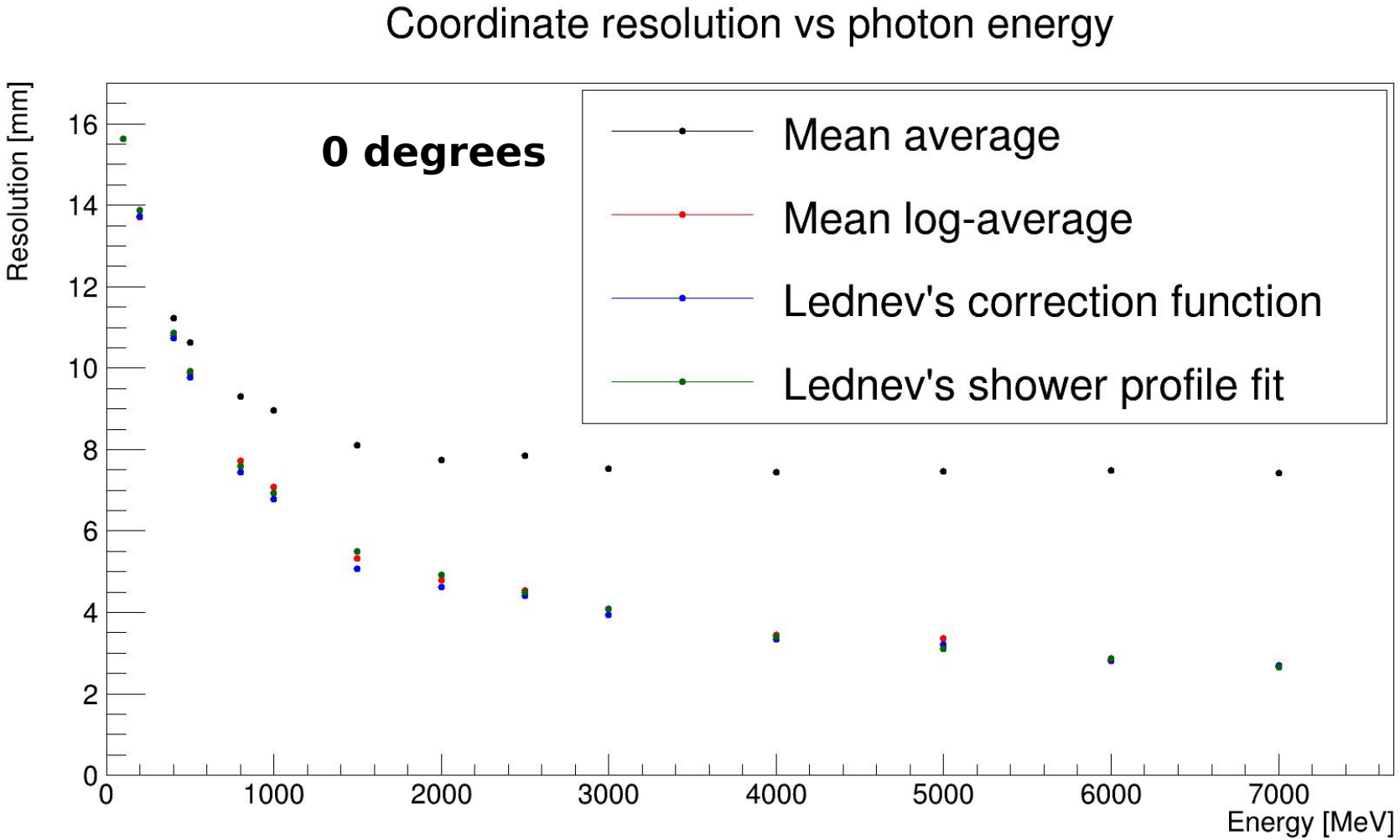
$$\Delta(X_c) = a\, t\, (t^4 + b\, t^2 + c)\, (t^2 - \tfrac{1}{4})\, (t^2 - q)\,,$$



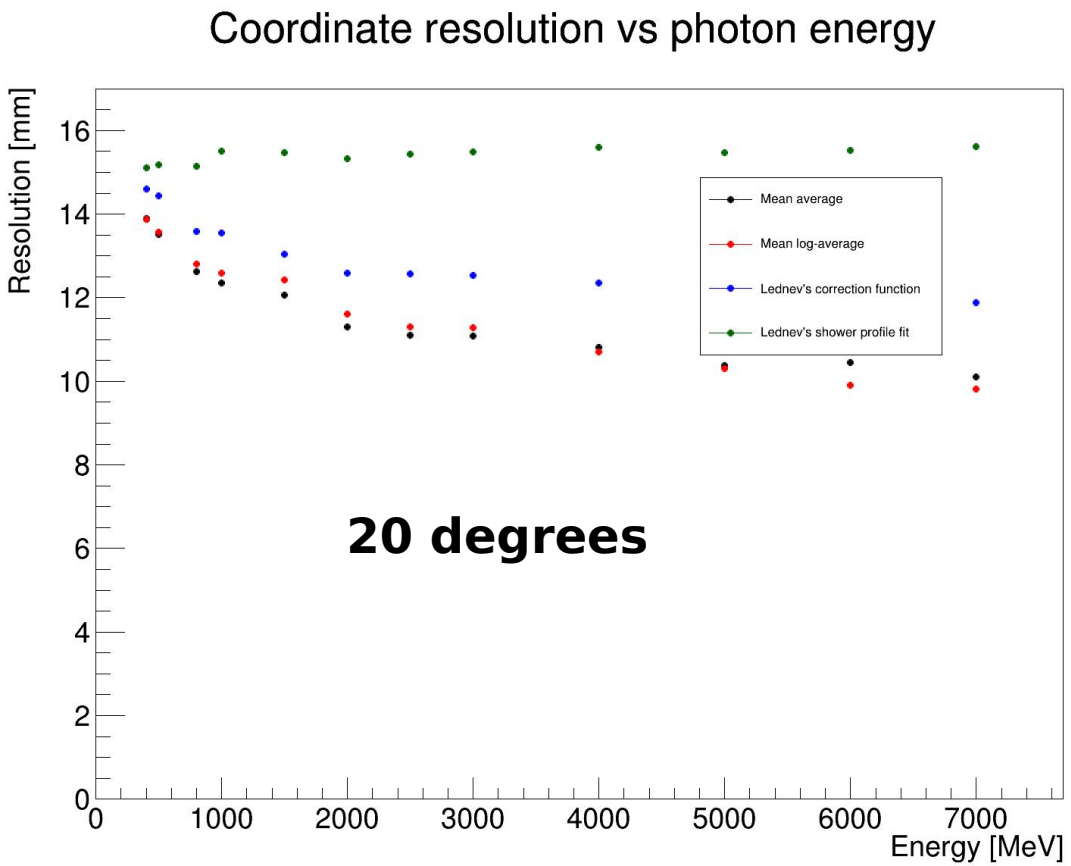


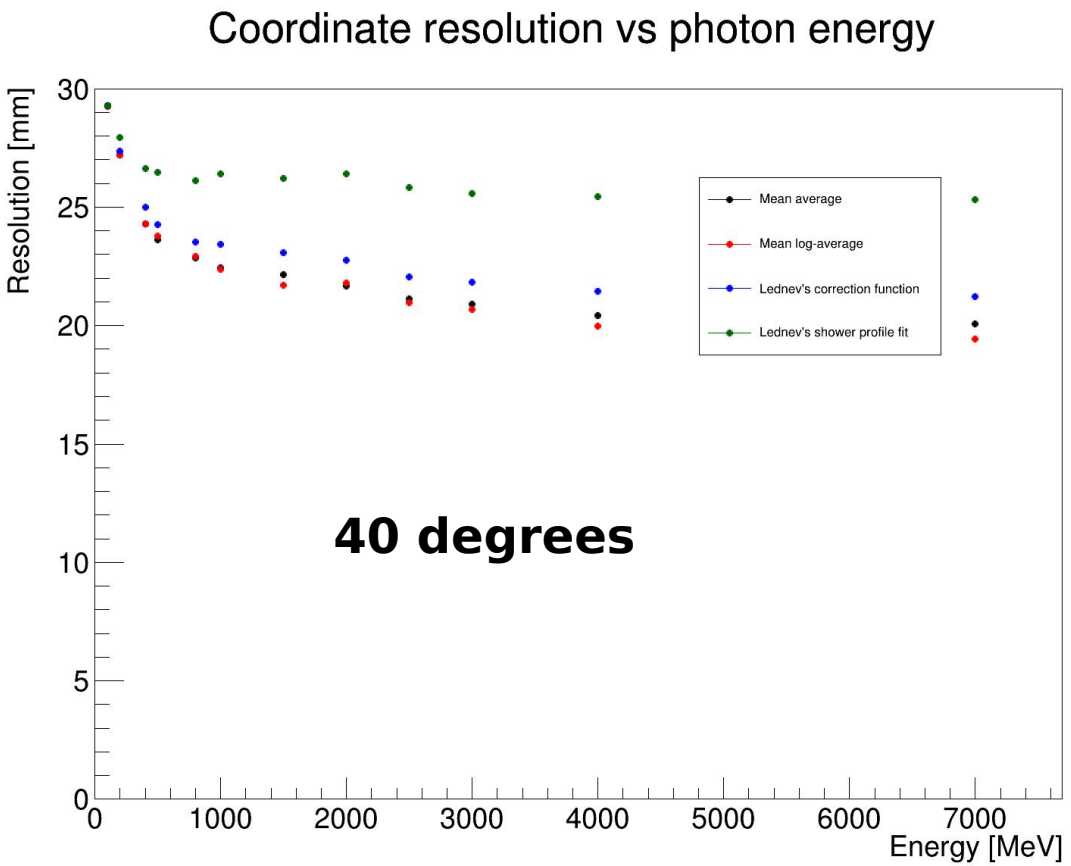
solid: linear weighting
dashed: lin.weighting + correction

Position resolution using different methods



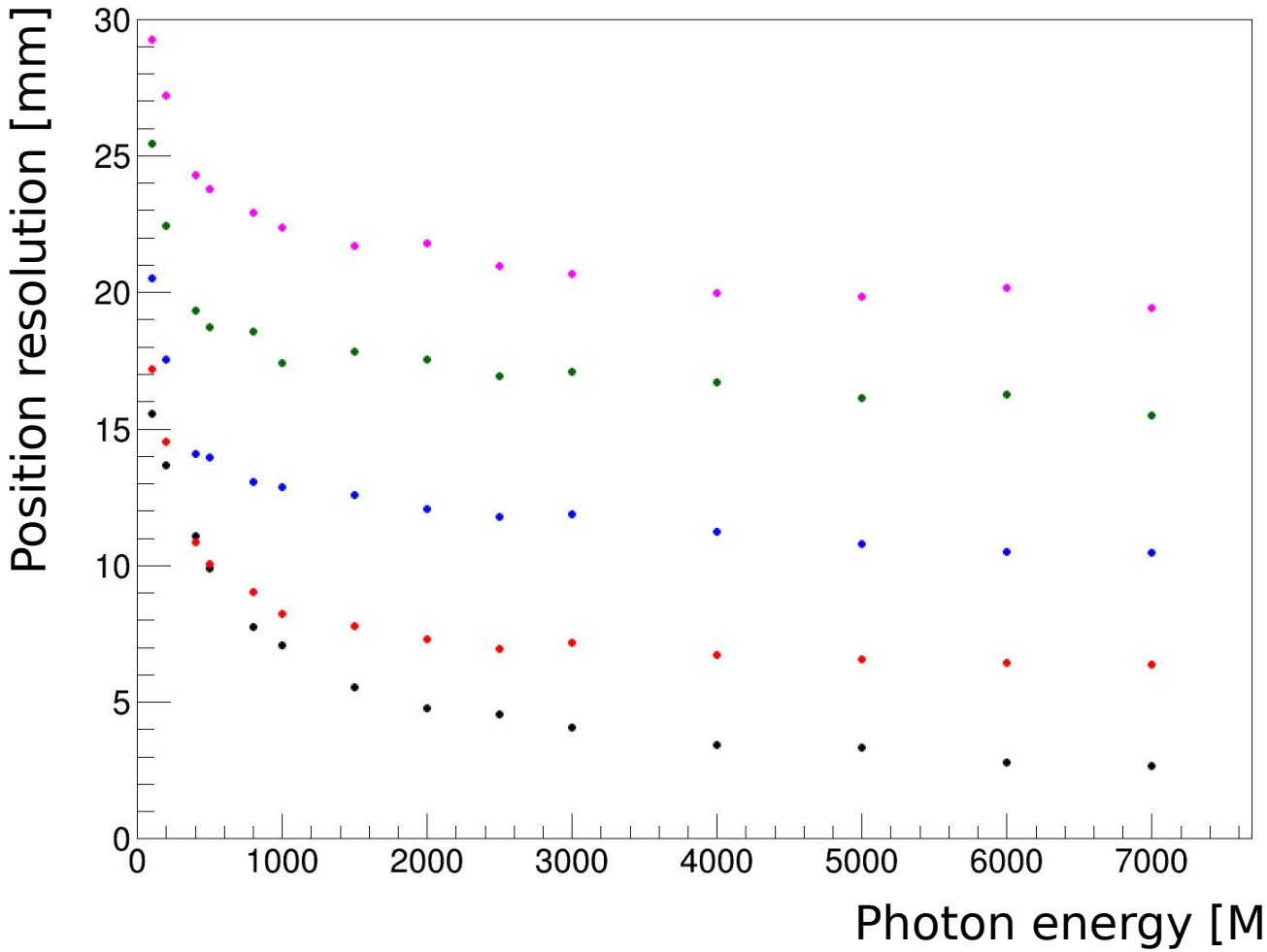
Position resolution using different methods





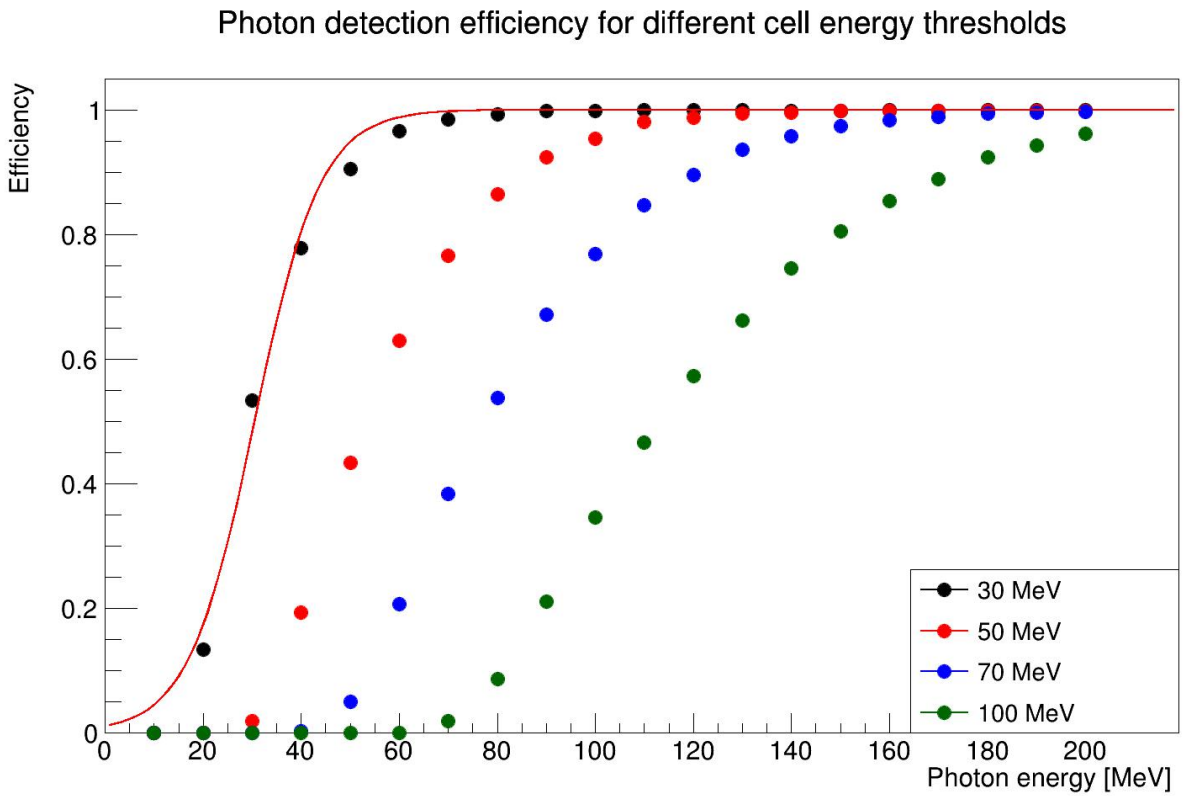
for large angles, log average and mean average yield best resolutions

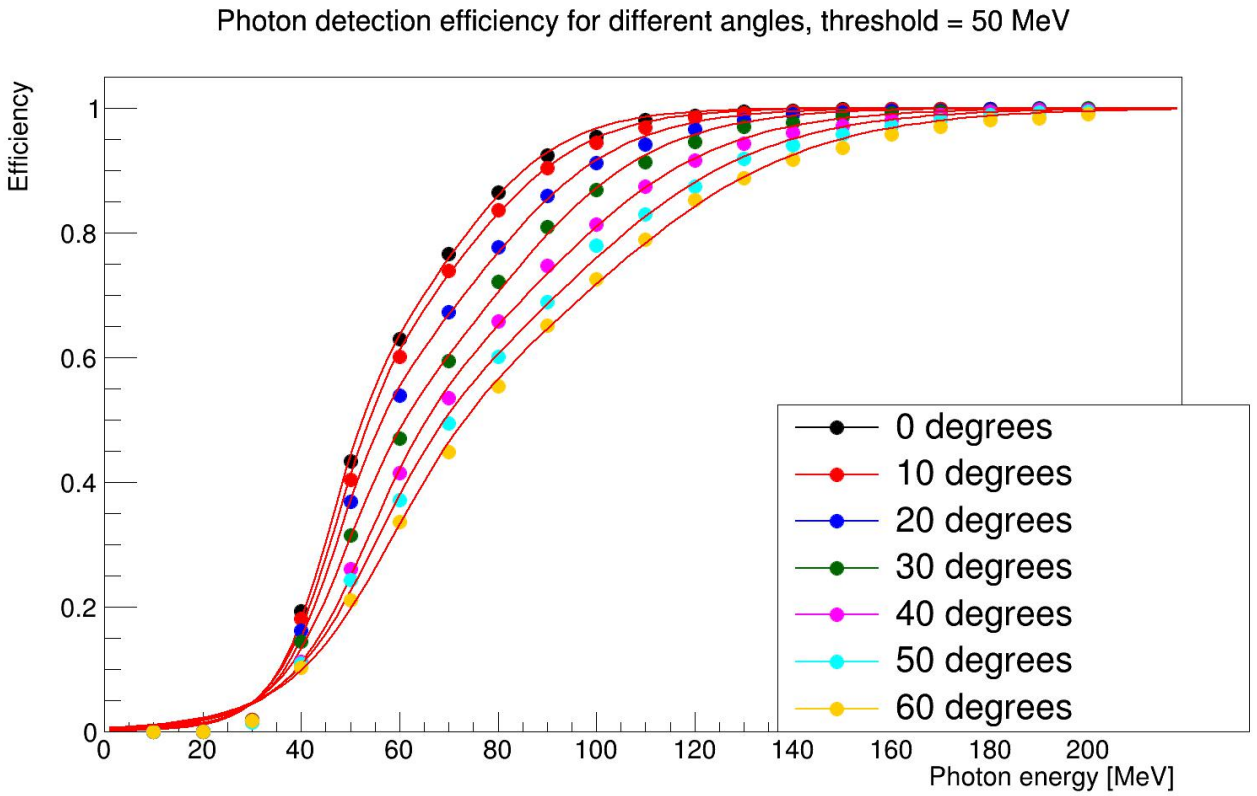
Position resolutions for log weighting method



0 degrees
10 degrees
20 degrees
30 degrees
40 degrees

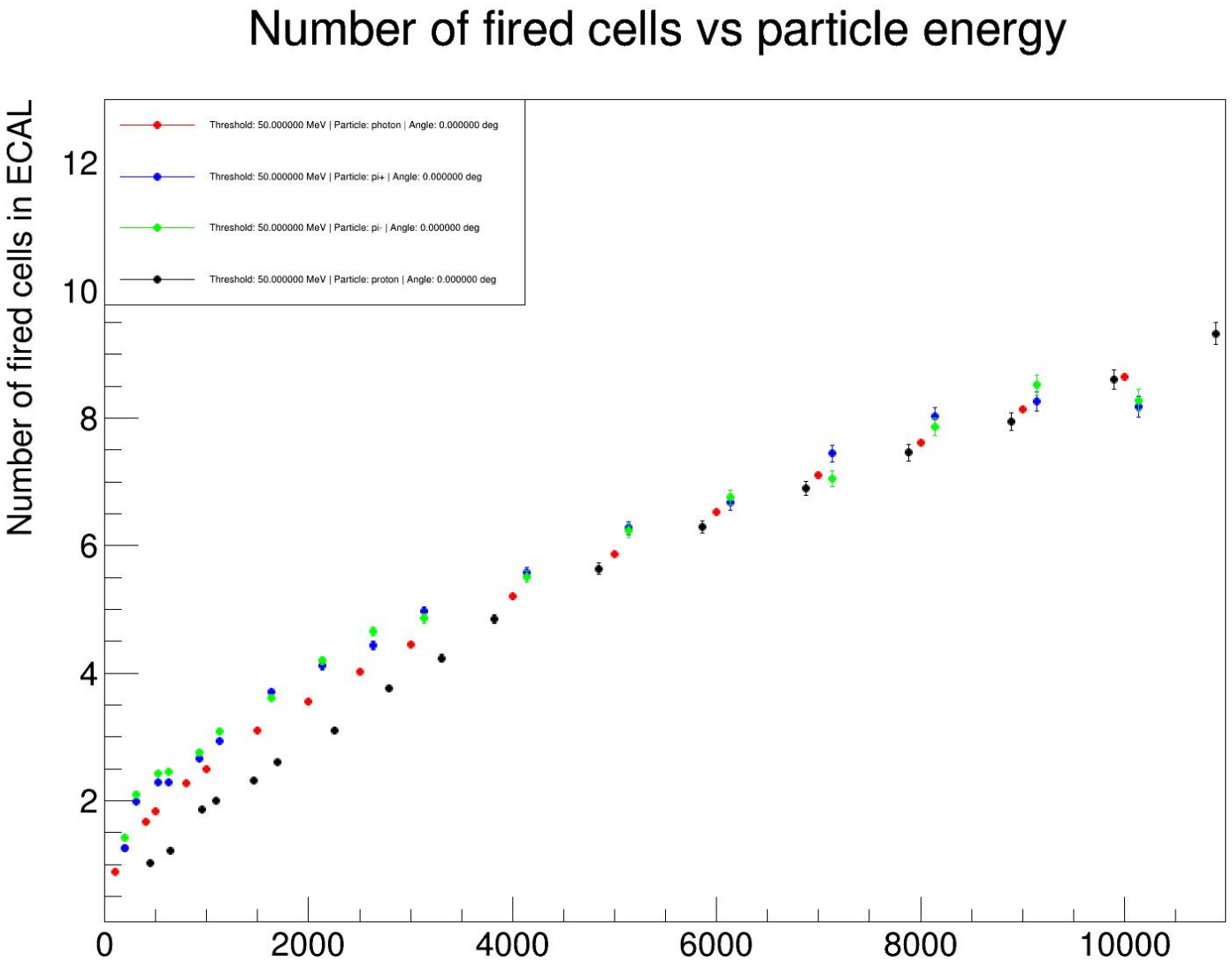
Fast reconstruction: photon detection efficiency





50 MeV threshold

Fast reconstruction: cell multiplicities (for data flow estimates)



0 deg | 50 MeV threshold

photons

π+

π-

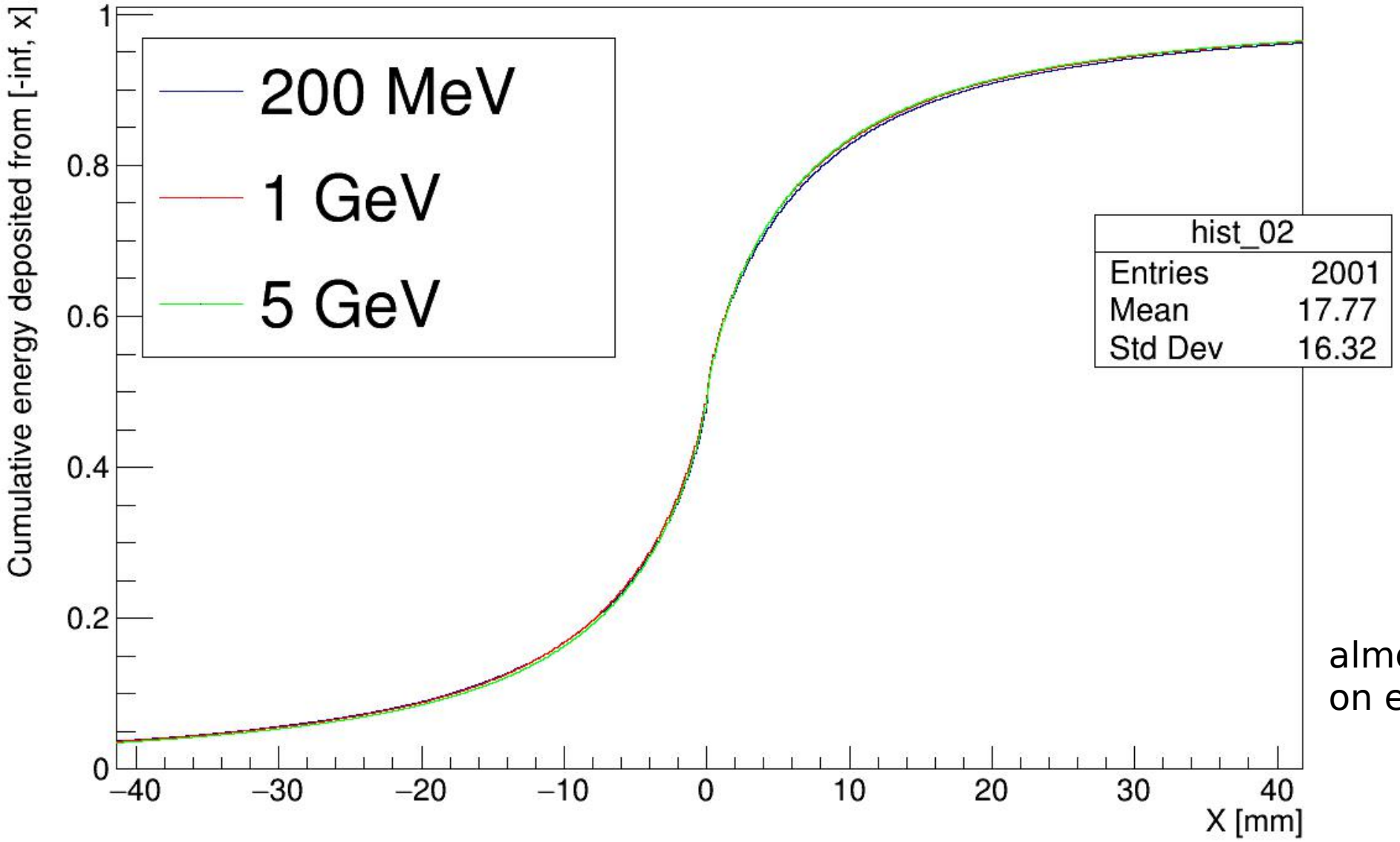
protons

Conclusions and outlook

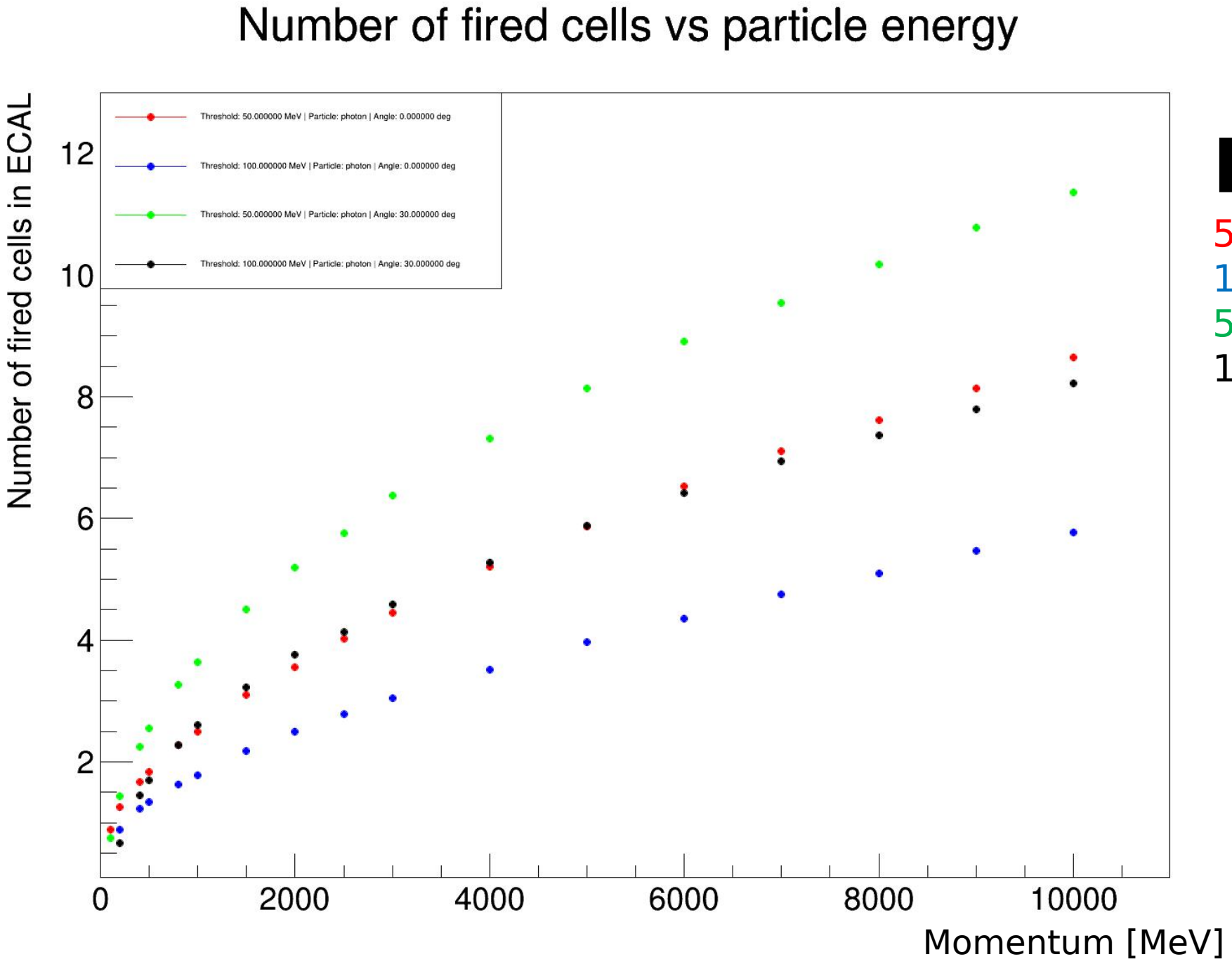
- Lednev's shower fitting algorithm doesn't improve energy resolution significantly with present ECAL setup at low energies
- Energy resolution doesn't depend significantly on the particle angle (except for angles > 40 degrees and energies < 0.8 GeV)
- Log. weighting algorithm yields position resolutions similar to Lednev's algorithm
- Due to requests of multiple people, fast(pseudo-)recontruction of ECAL is in development and will be available soon (next week)

BACKUP

sidenote: MC shower profiles

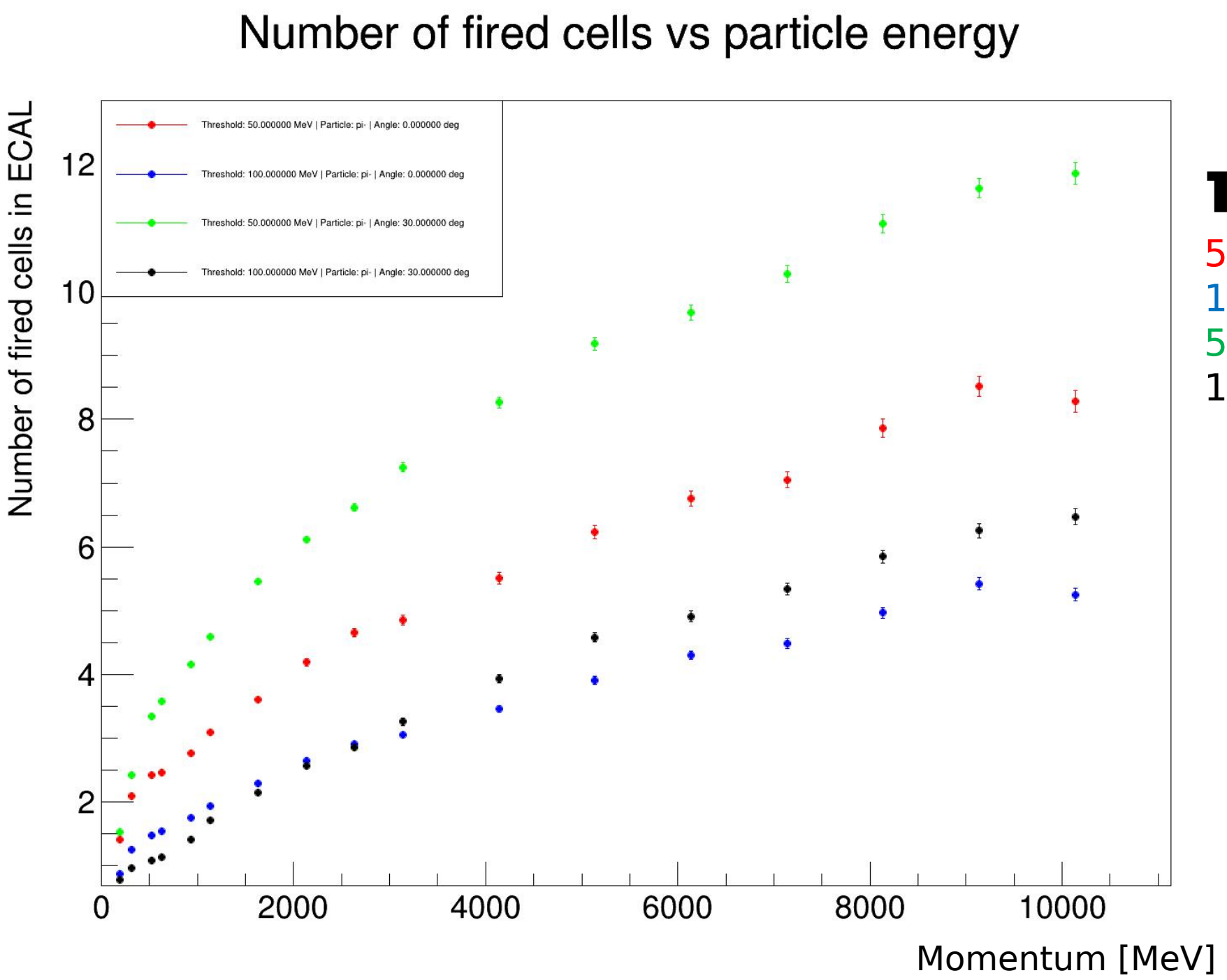


almost no dependence on energy



PHOTONS

50 MeV threshold | 0 deg
100 MeV threshold | 0 deg
50 MeV threshold | 30 deg
100 MeV threshold | 30 deg



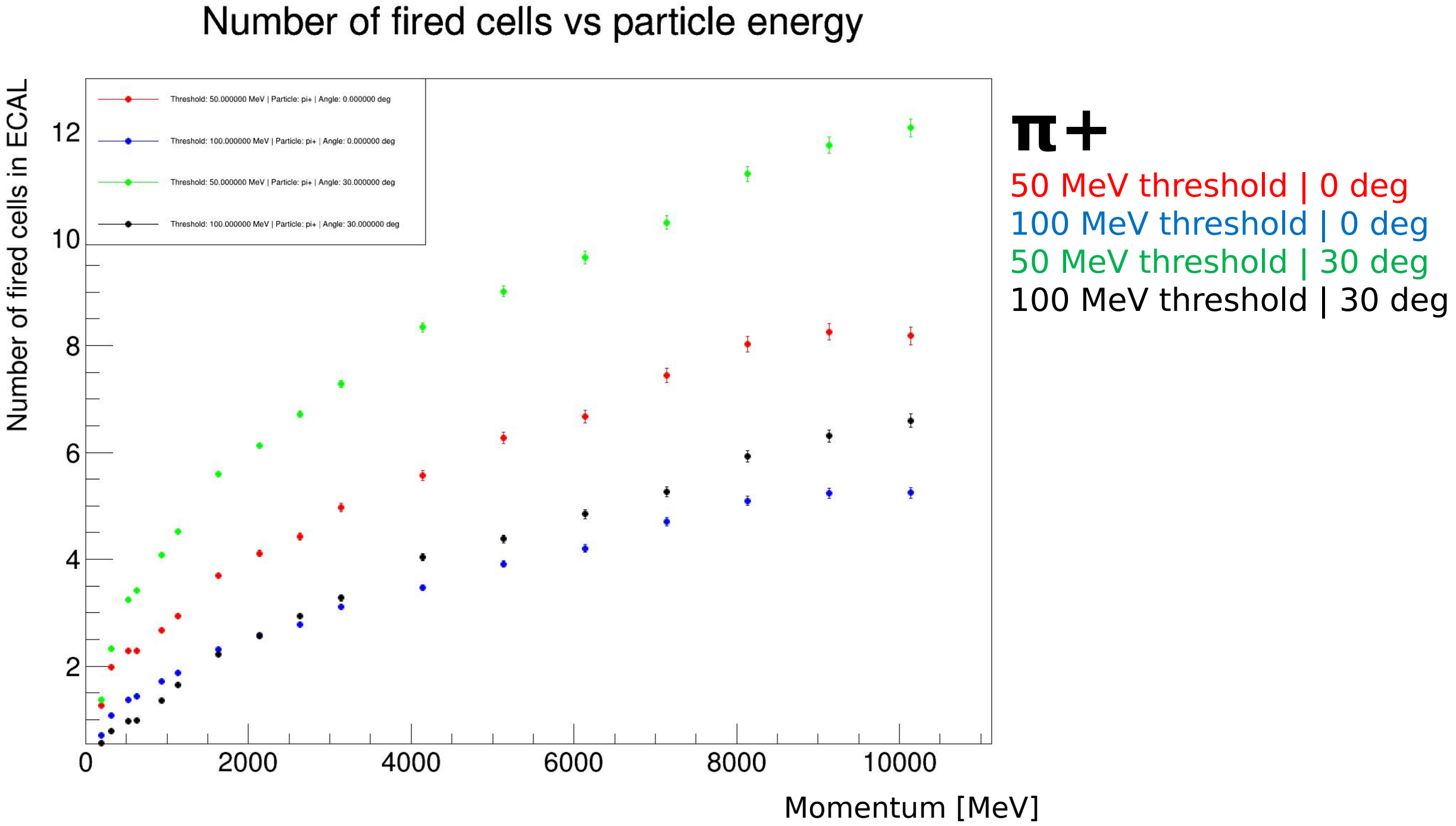
π-

50 MeV threshold | 0 deg

100 MeV threshold | 0 deg

50 MeV threshold | 30 deg

100 MeV threshold | 30 deg



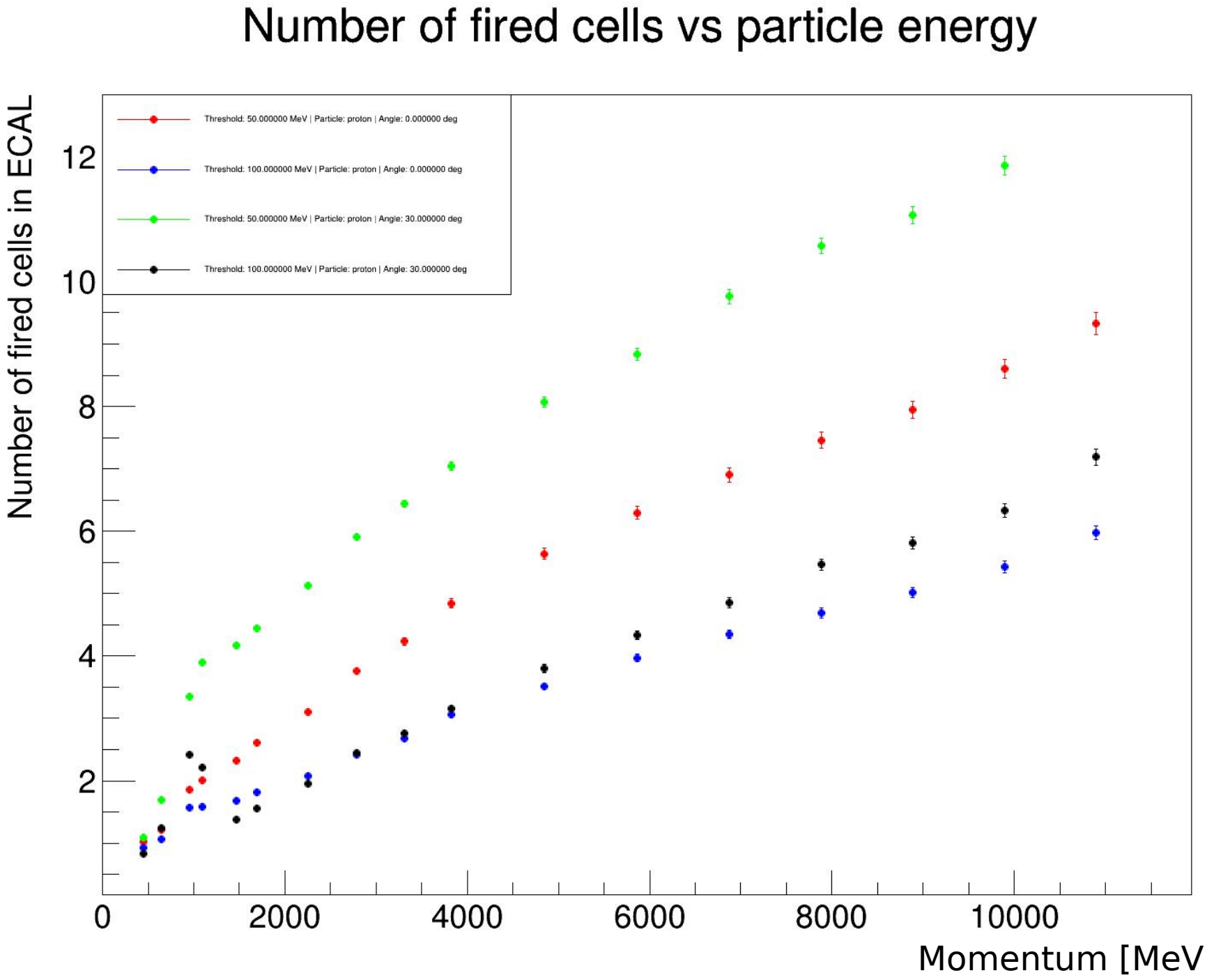
π+

50 MeV threshold | 0 deg

100 MeV threshold | 0 deg

50 MeV threshold | 30 deg

100 MeV threshold | 30 deg



PROTONS

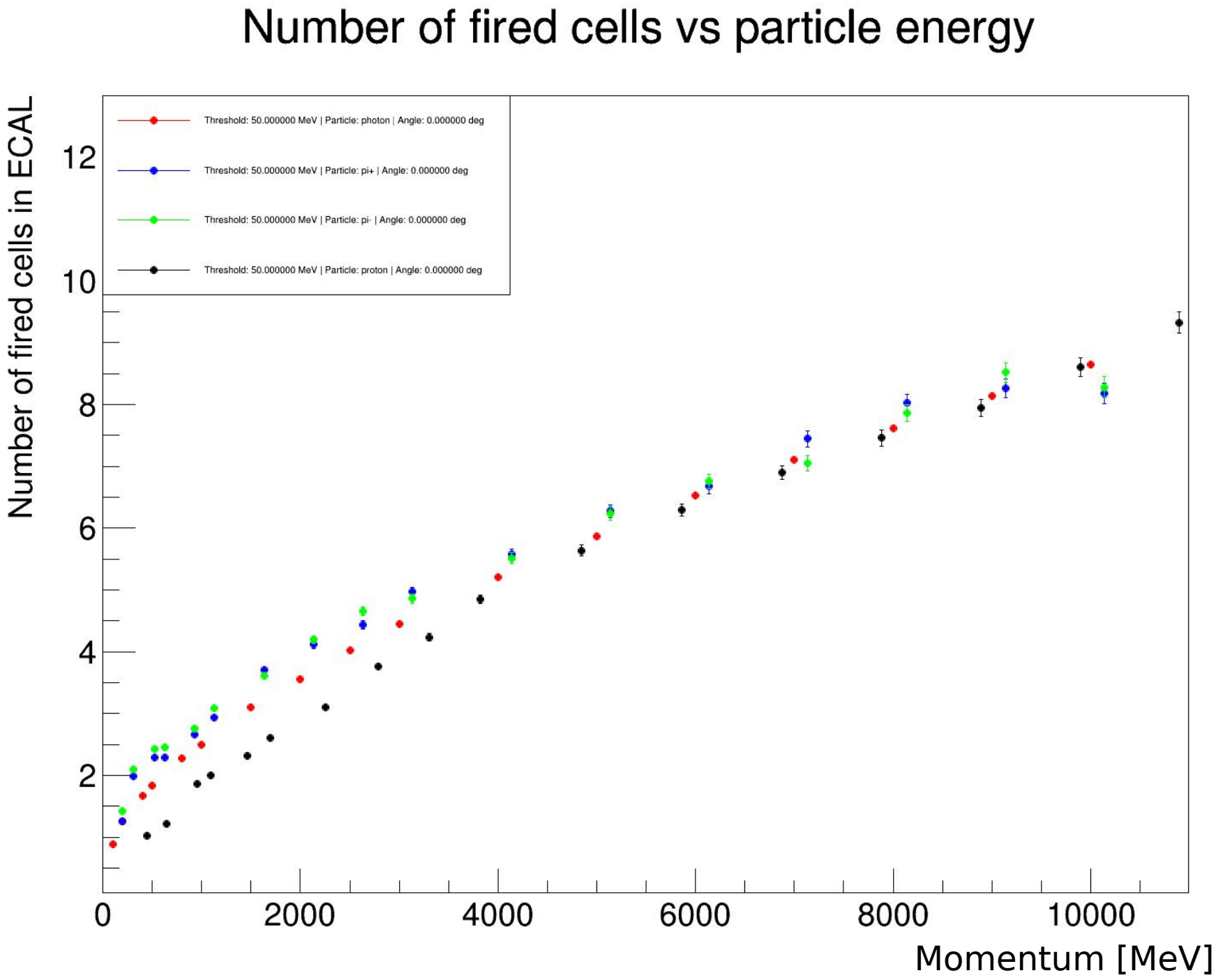
50 MeV threshold | 0 deg

100 MeV threshold | 0 deg

50 MeV threshold | 30 deg

100 MeV threshold | 30 deg

Momentum [MeV]



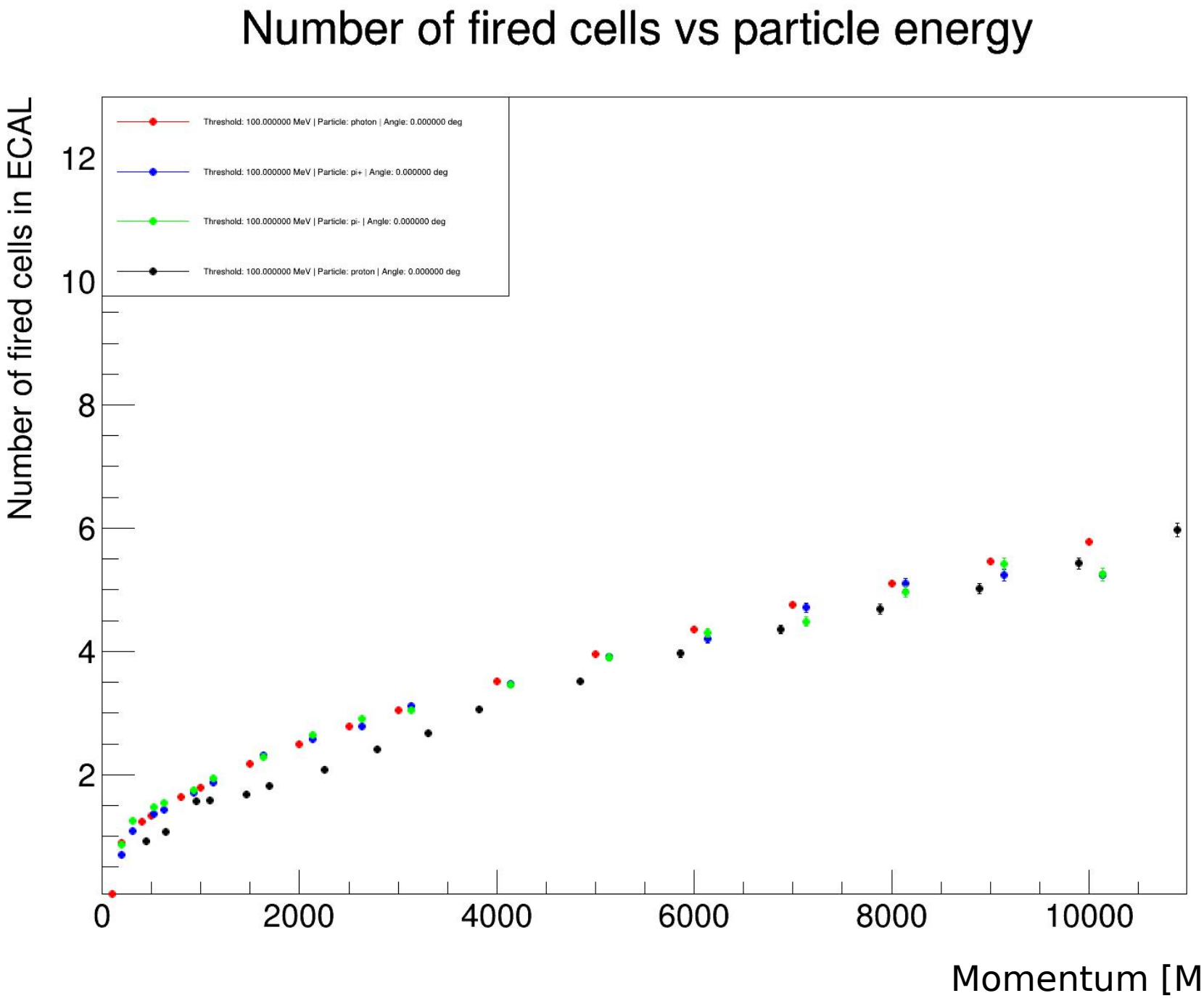
0 deg | 50 MeV threshold

photons

π+

π-

protons



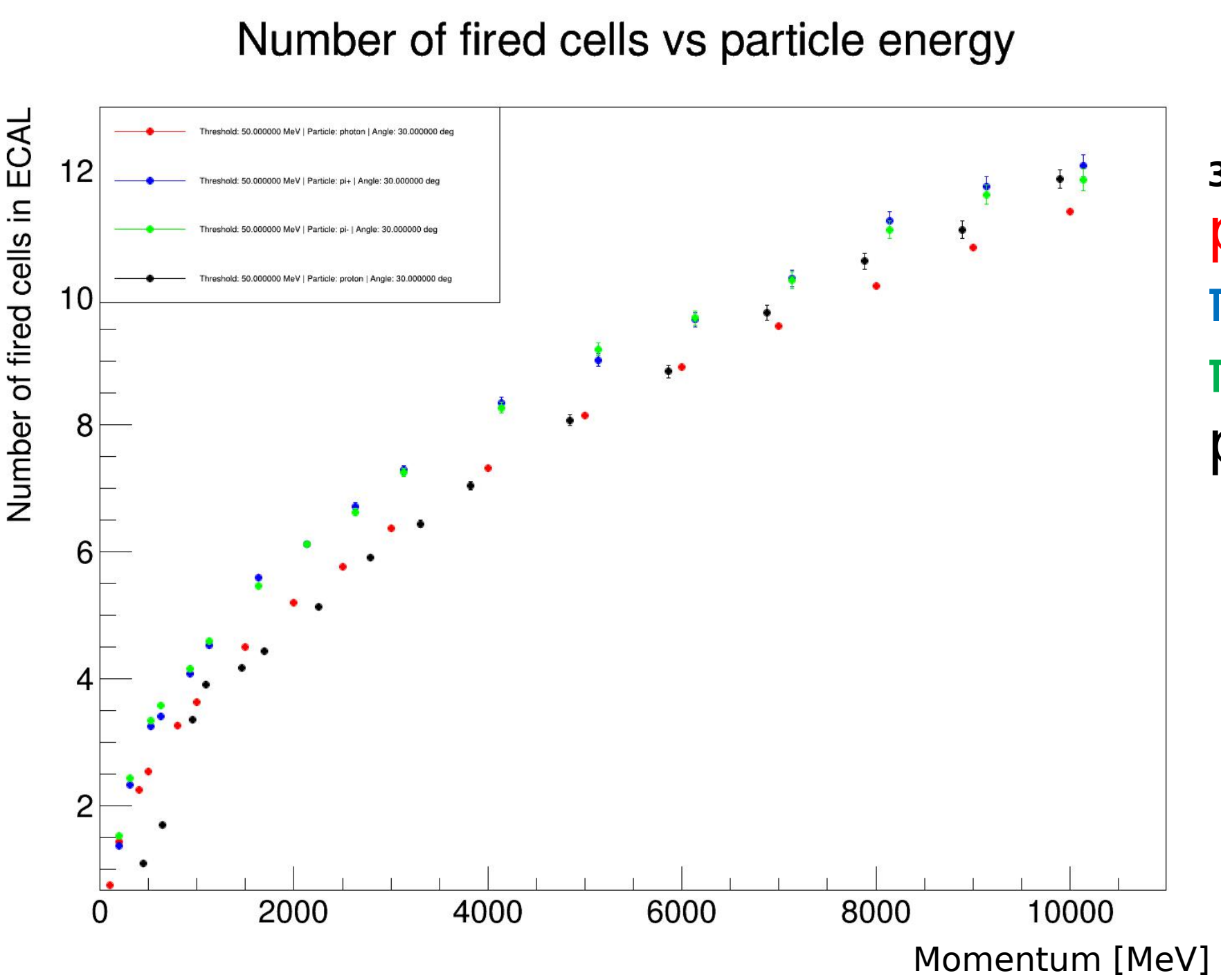
0 deg | 100 MeV threshold

photons

π+

π-

protons



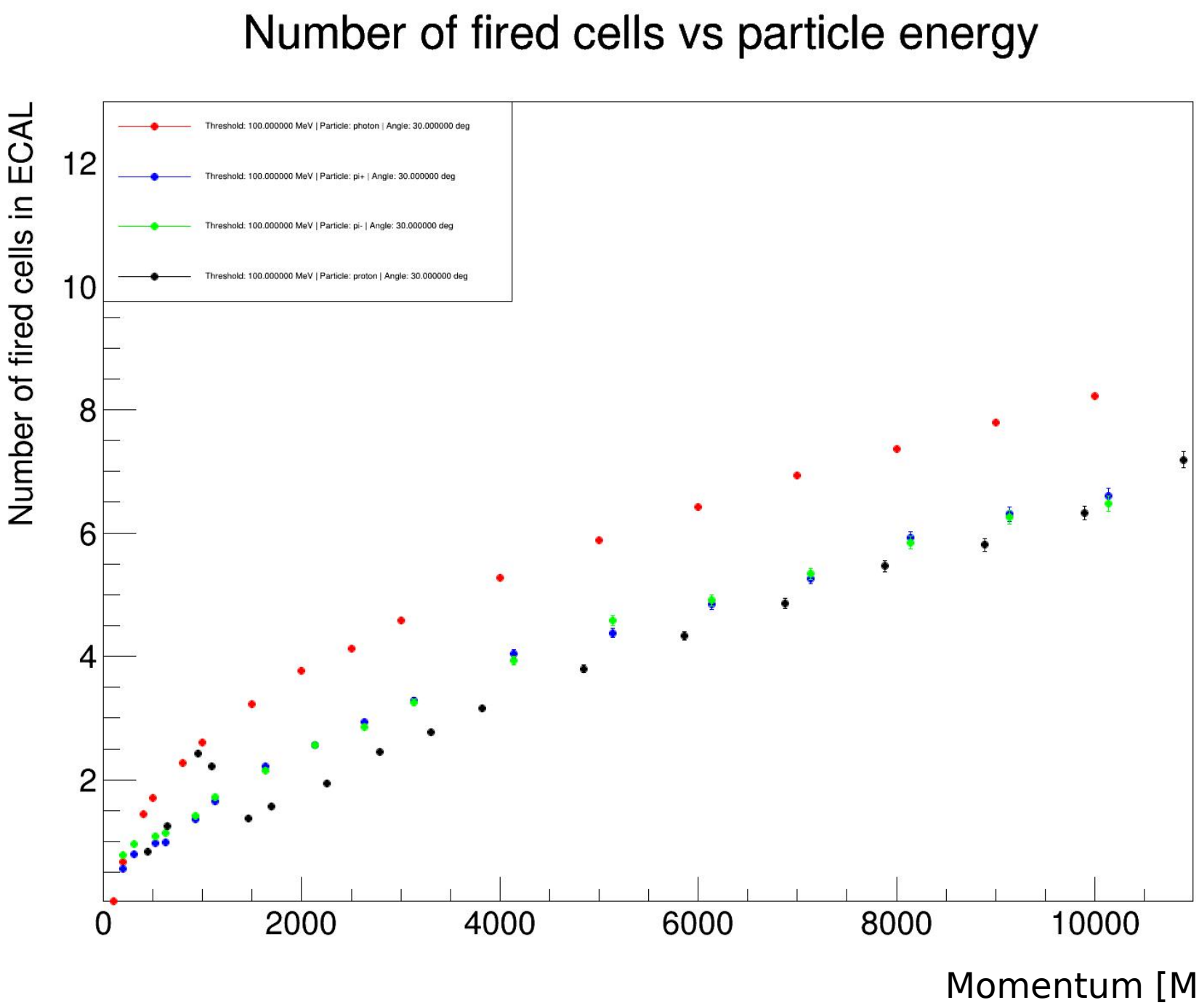
30 deg | 50 MeV threshold

photons

π+

π-

protons



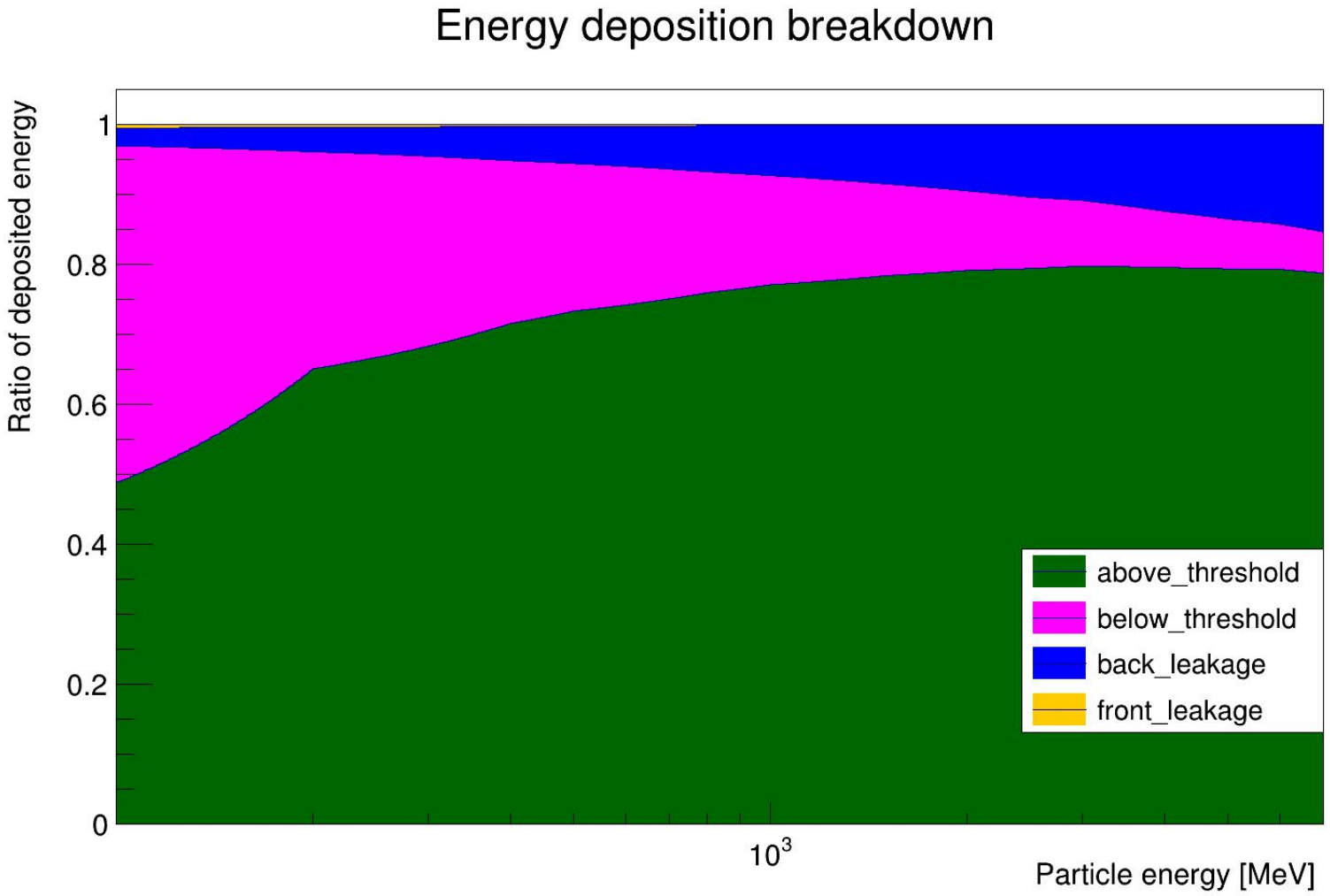
30 deg | 100 MeV threshold

photons

π+

π-

protons



	0.2 GeV	1 GeV	5 GeV
back leakage	4%	7%	14%
front leakage	0.5%	0.2%	0.1%
below threshold	30%	16%	7%
above threshold	65.5%	77%	79%