P̄ANDA Backward Electromagnetic Calorimeter Studies with BaBar-like framework

María Carmen Mora Espí

Institut für Kernphysik, Johannes Gutenberg Universität, Mainz
and
GSI, Darmstadt

June, 15th - 2010

Outline

Previous simulations

RESULTS FOR:

- Simulation for cabling and supply of STT.
  Results presented in the December 2009 Collaboration meeting. EMC sesion.
- Simulation for cabling and supply of MVD, specific cases.
  Results presented in last Collaboration meeting. Analysis plenary sesion.

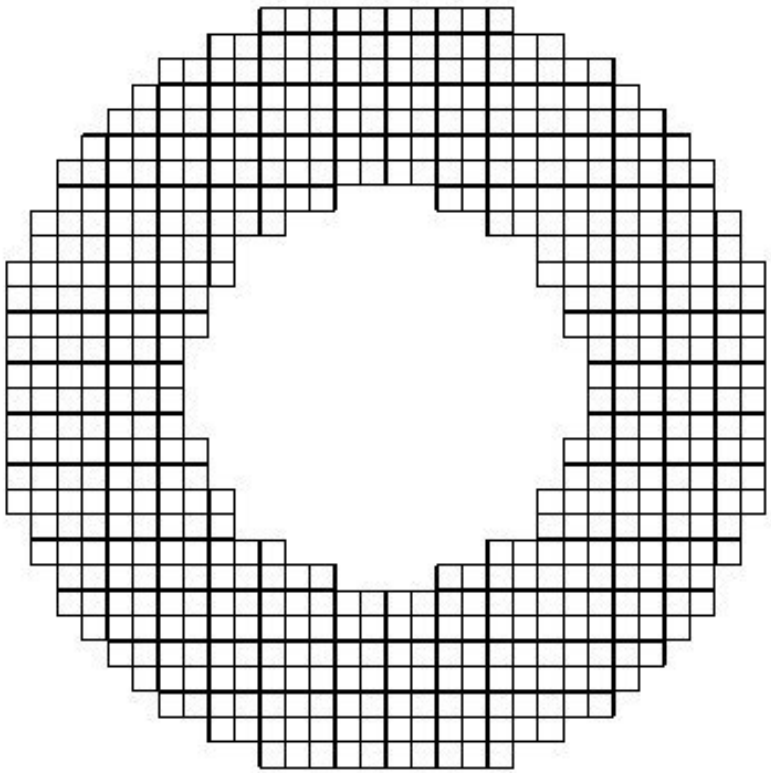
CONCLUSIONS:

- Energy resolution is good in all cases (γ either is lost or reaches the calorimeter) BUT
- Efficiency is not good for only few anglular ranges where a lot of dead material is in the way.

Geometry for simulation

CALORIMETER:

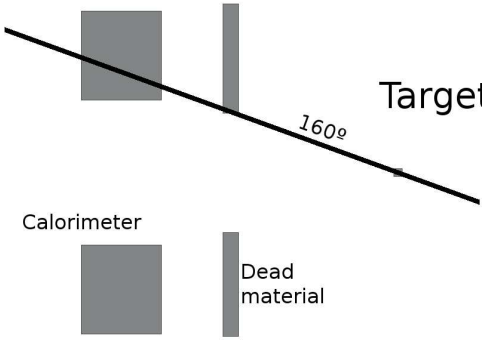
- 20 cm long crystals with a front face $(24.4 \times 24.4)\,\mathrm{mm}^2$.
- $R_{min} = 182\,\mathrm{mm}$, $R_{max} = 406\,\mathrm{mm}$, $z = -594\,\mathrm{mm}$ from target position (0, 0, 0).
- Angular range covered: 146°-167°.



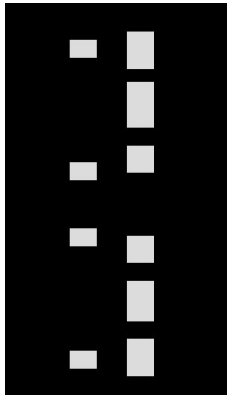
Geometry for simulation

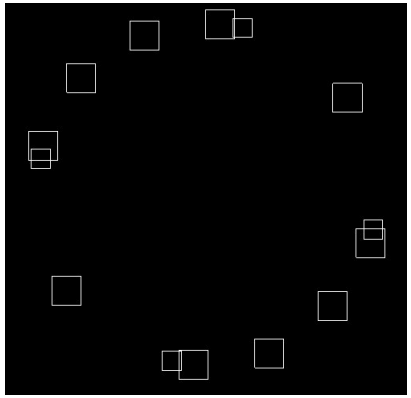
DEAD MATERIAL:

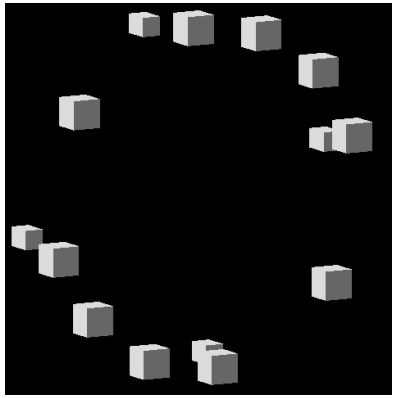
- STT: 2 cm thick Al plate with $R_{min} = 150$ mm, $R_{max} = 418$ mm and z= -400 mm from target $\sim 0.5 \cdot X_0$



- MVD: Estimation done based in the results for dead material by T. Würschig (Dec 09 Collaboration meeting):
  - 4 Cu boxes: $(14.5 \times 14.5 \times 22)\,\mathrm{mm}^3 \sim 1.8 \cdot X_0$
  - 10 Cu boxes: $(21.73 \times 21.73 \times 22)\,\mathrm{mm}^3 \sim 1.8 \cdot X_0$
  - Thin Cu cylinder $\sim 0.5 \cdot X_0$

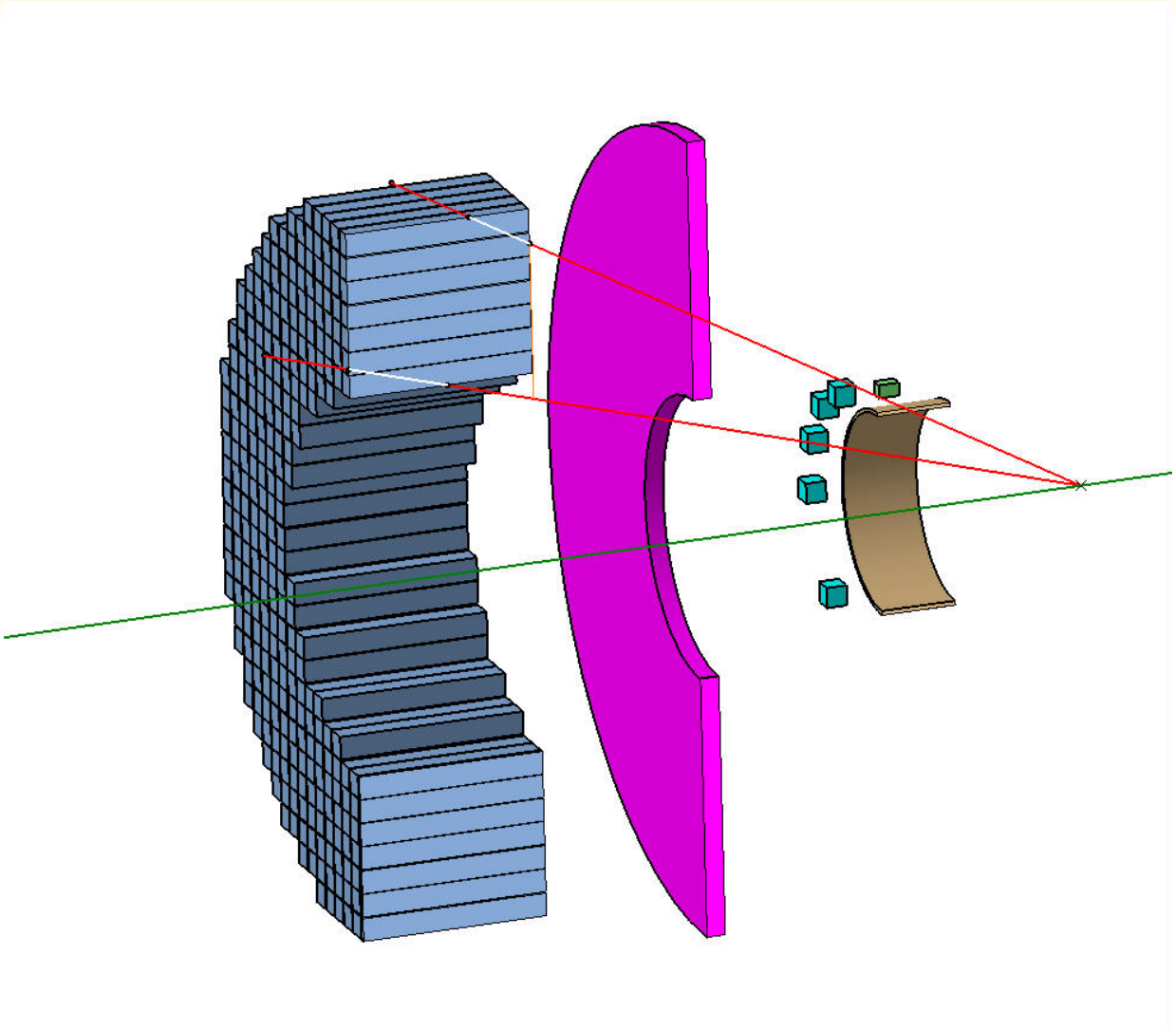






For more information look at my last talk (March 2010)

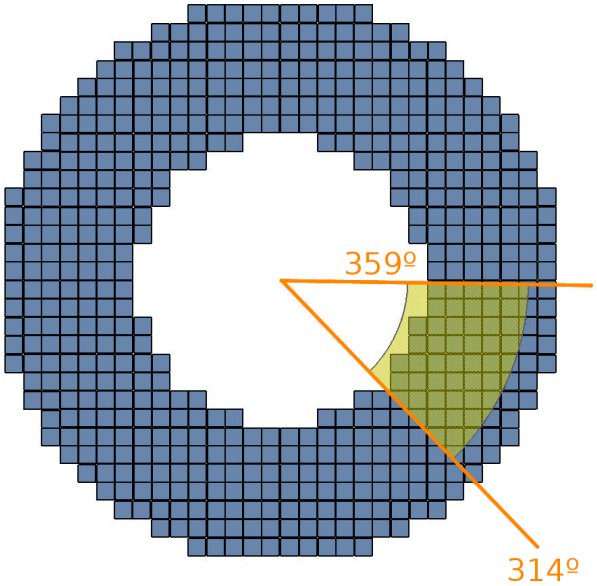
Geometry for simulation

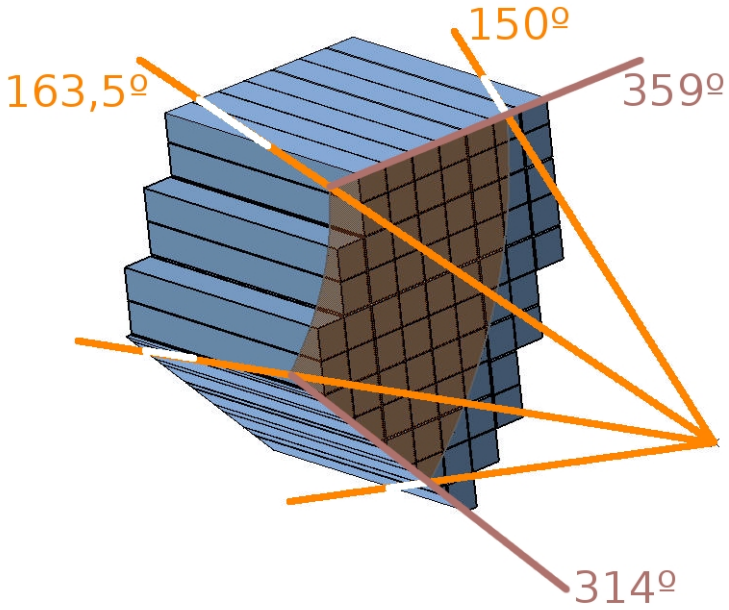


Simulated cases

- E: 30 MeV, 100 MeV, 250 MeV, 500 MeV, 700 MeV
- ϕ: 314°, 319°, 324°, 329°, 334°, 339°, 344°, 349°, 354°, 359°.
- θ: 150°, 151.5°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°.

50.000 events each





Simulation done in the new computer cluster in Mainz

Event selection

CUTS:

- Bump with highest energy per event

Fit function

NOVOSIBIRSK FUNCTION + CONSTANT:

$$f(E) = A \exp\left\{-\frac{1}{2}\left[\frac{\ln^2\left[1+\Lambda\tau(E-E_0)\right]}{\tau^2} + \tau^2\right]\right\} + C$$

with

$$\Lambda = \frac{\sinh\left(\tau\sqrt{\ln(4)}\right)}{\sigma\tau\sqrt{ln(4)}}$$

Energy resolution and efficiency definitions

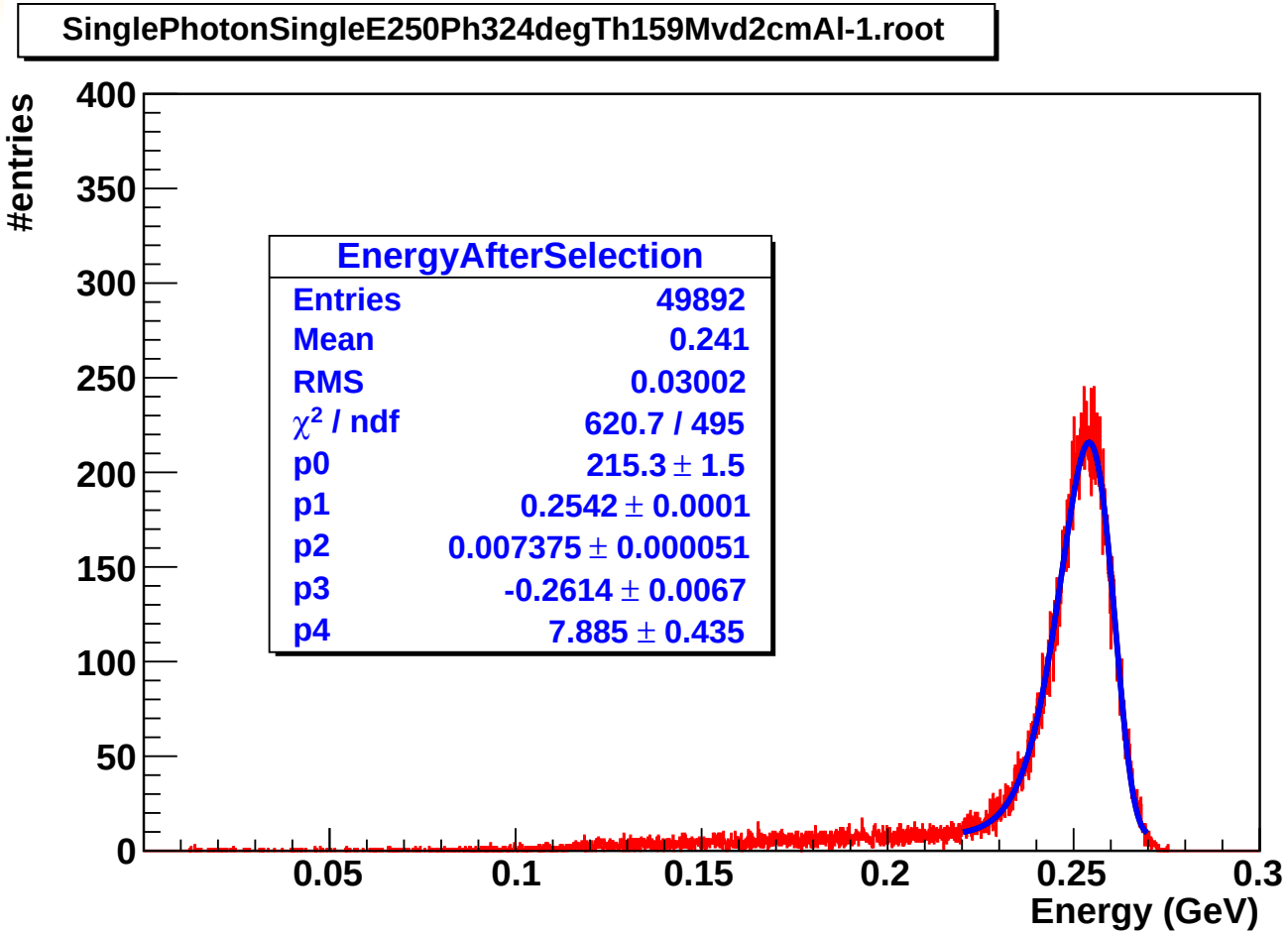
- Energy resolution of the backward end cap:

$$E_{res} = \frac{2.35\sigma}{\mu}$$

- Efficiency of the backward end cap:

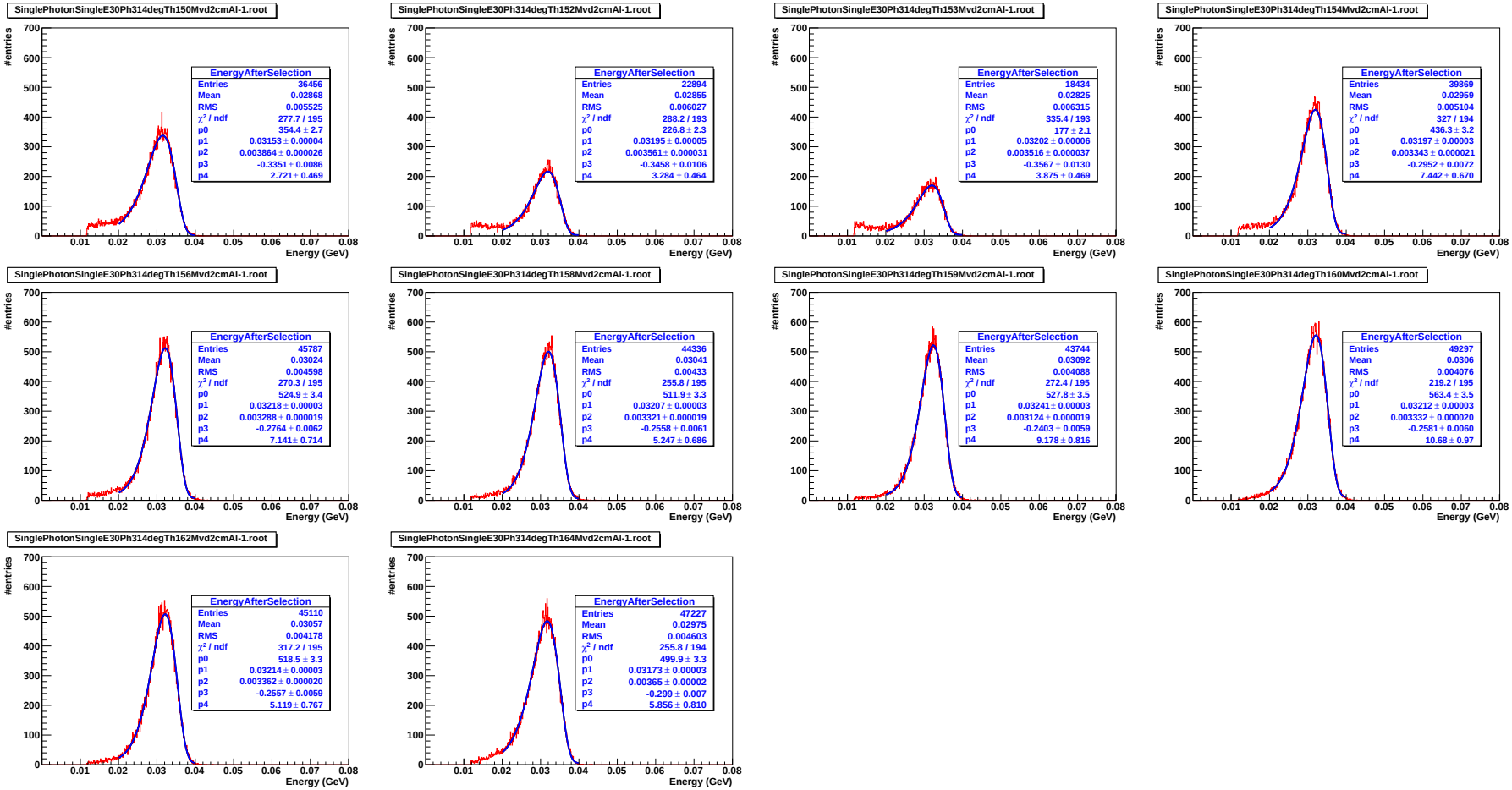
$$Eff = \frac{1}{50000} \int_{\mu-3\sigma}^{\mu+2\sigma} f(E)dE$$

Typical spectrum: E=250 MeV, $\phi = 324°$, $\theta = 159°$

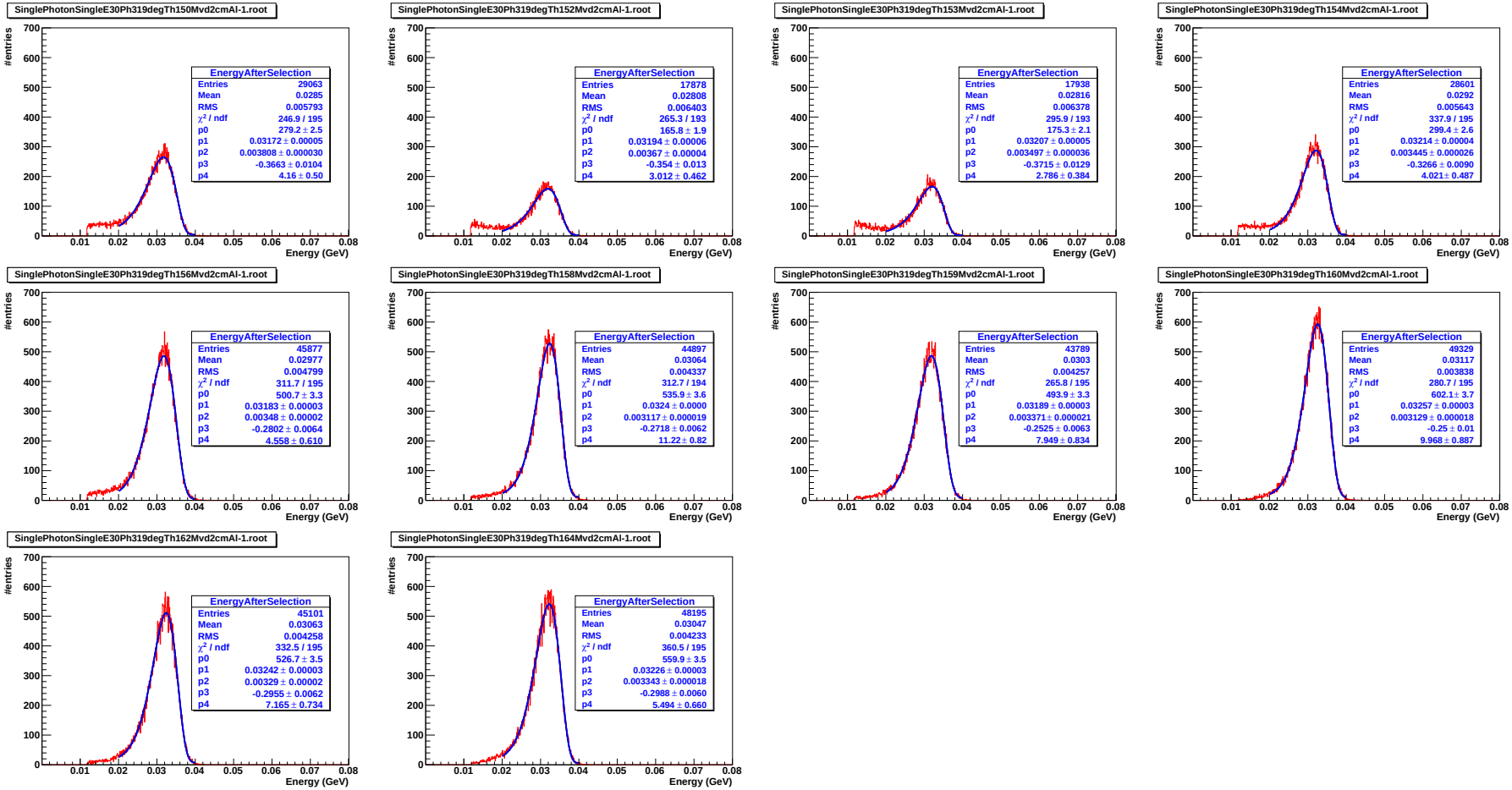


Novosibirsk function plus constant gives better χ^2 results.
Fixed fit range for each energy.

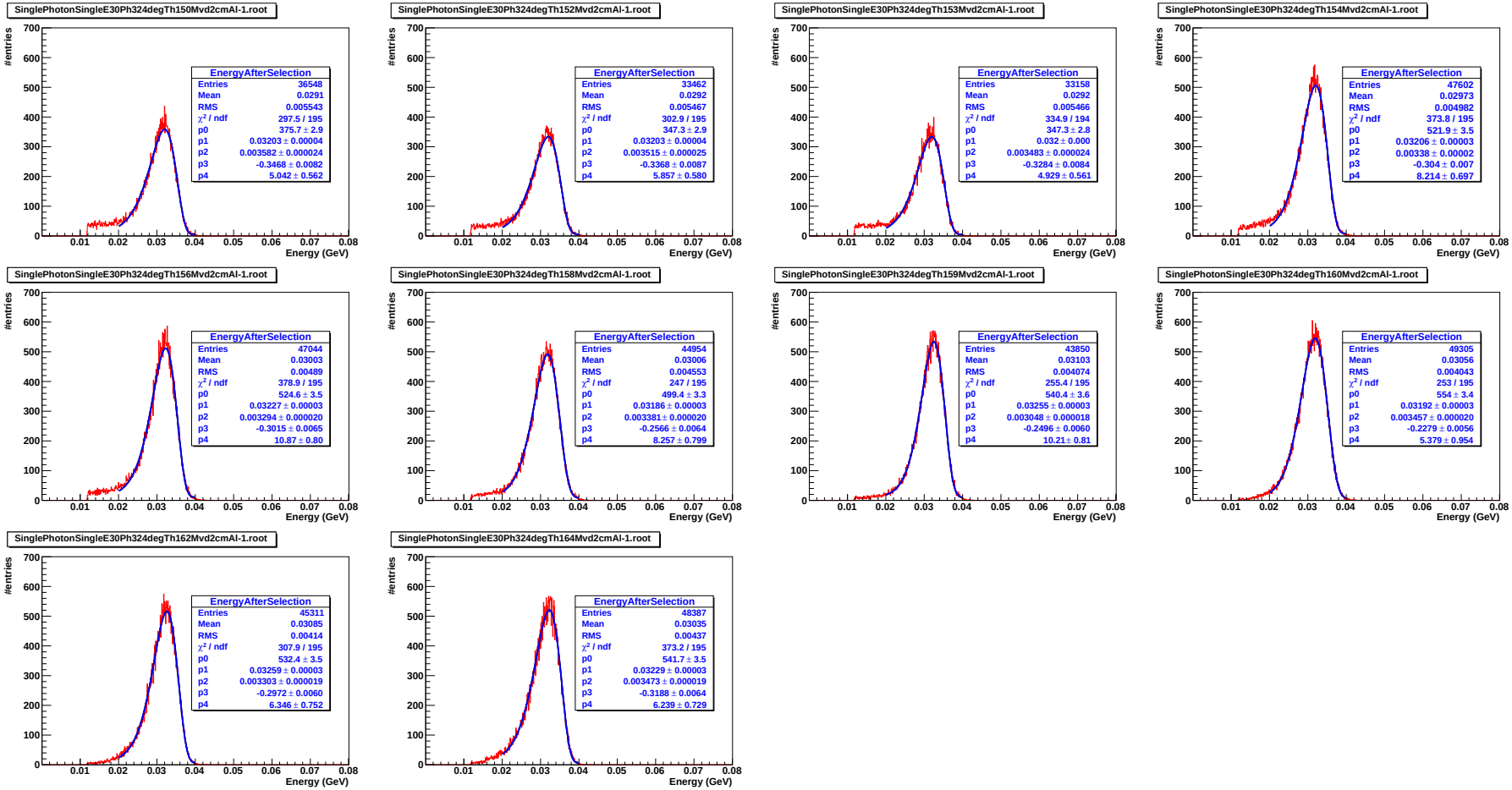
Fits; E=30 MeV $\phi = 314°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



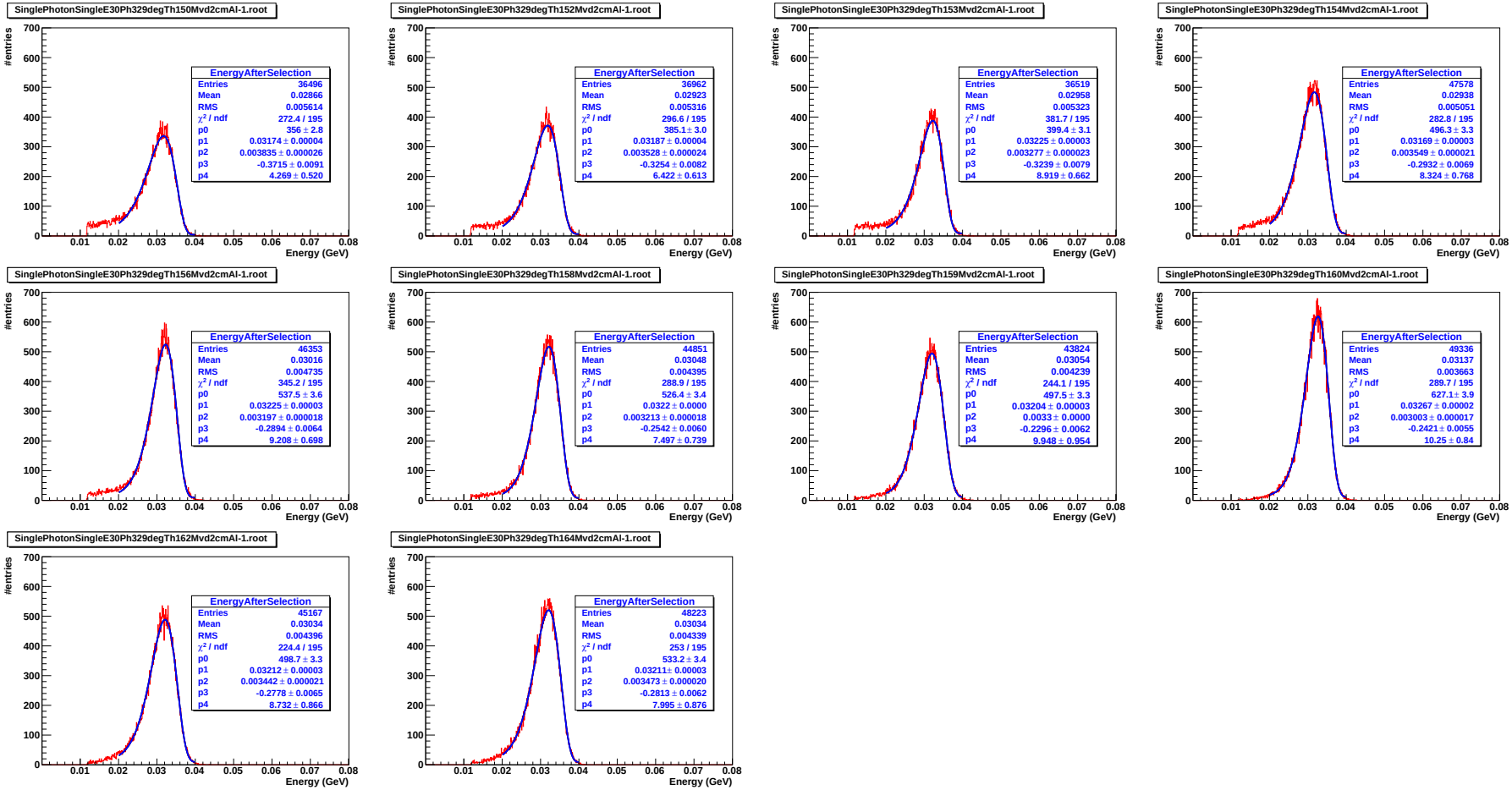
Fits; E=30 MeV $\phi = 319°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



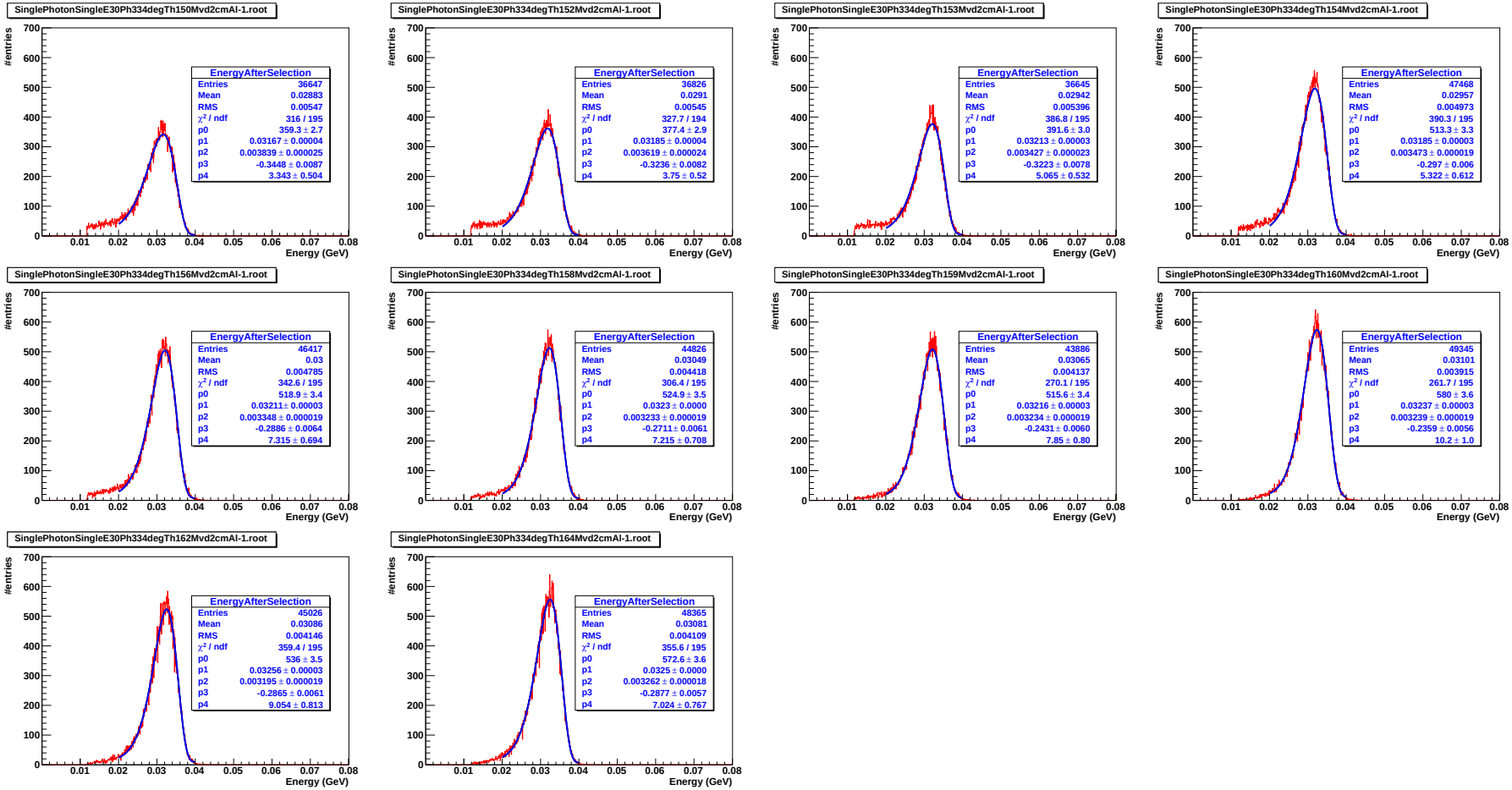
Fits; E=30 MeV $\phi = 324°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



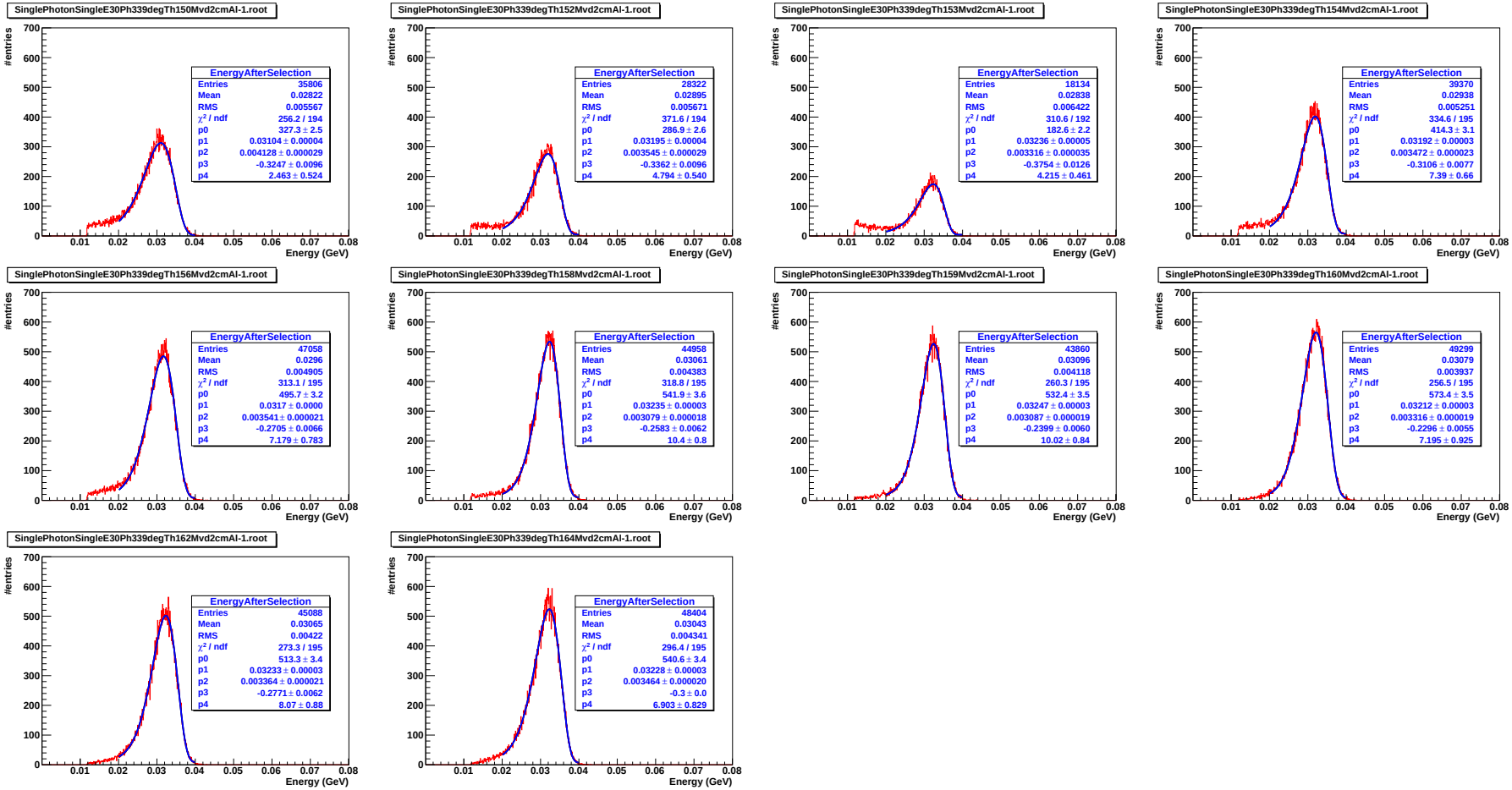
Fits; E=30 MeV $\phi = 329°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



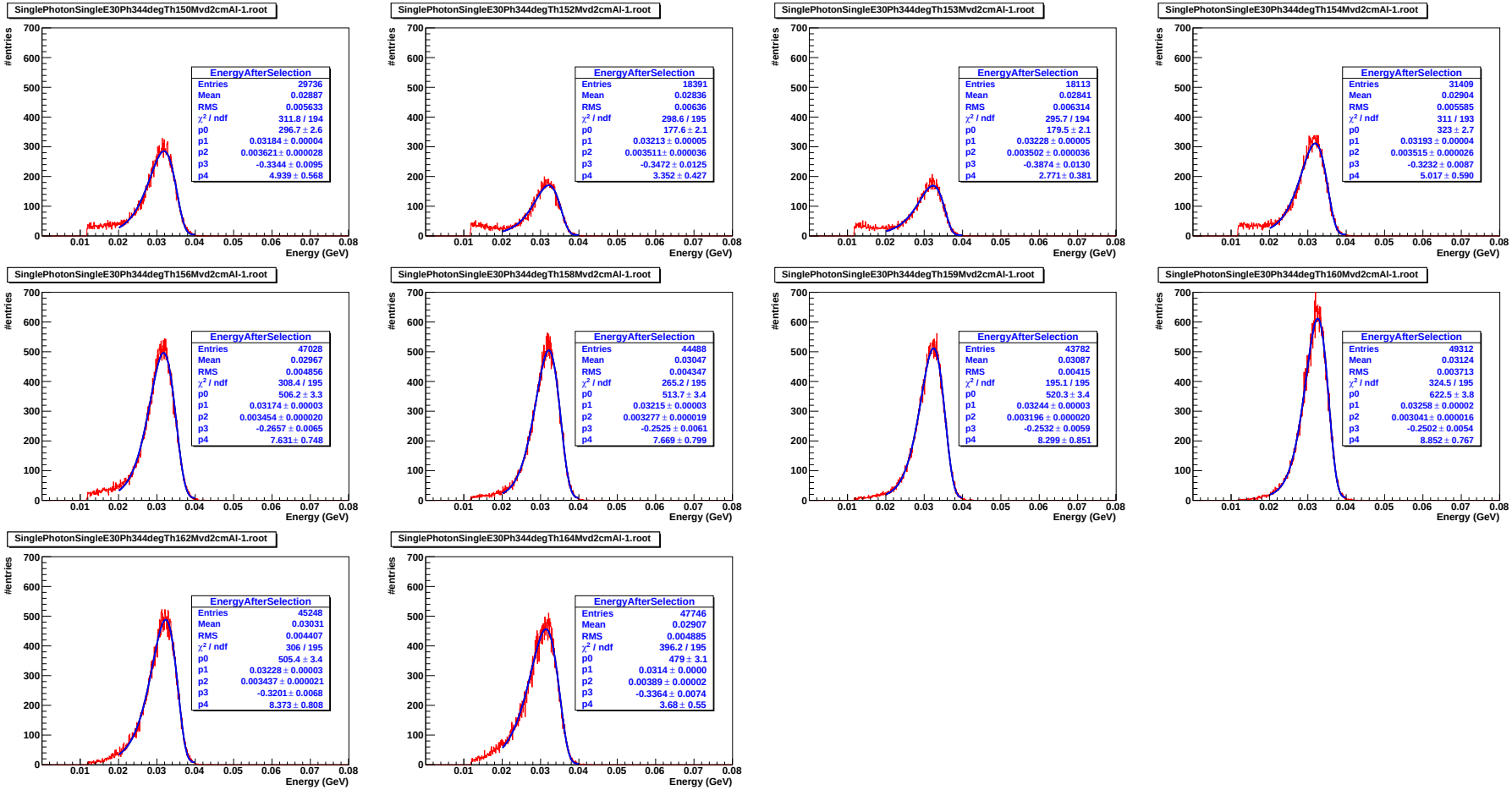
Fits; E=30 MeV $\phi = 334°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



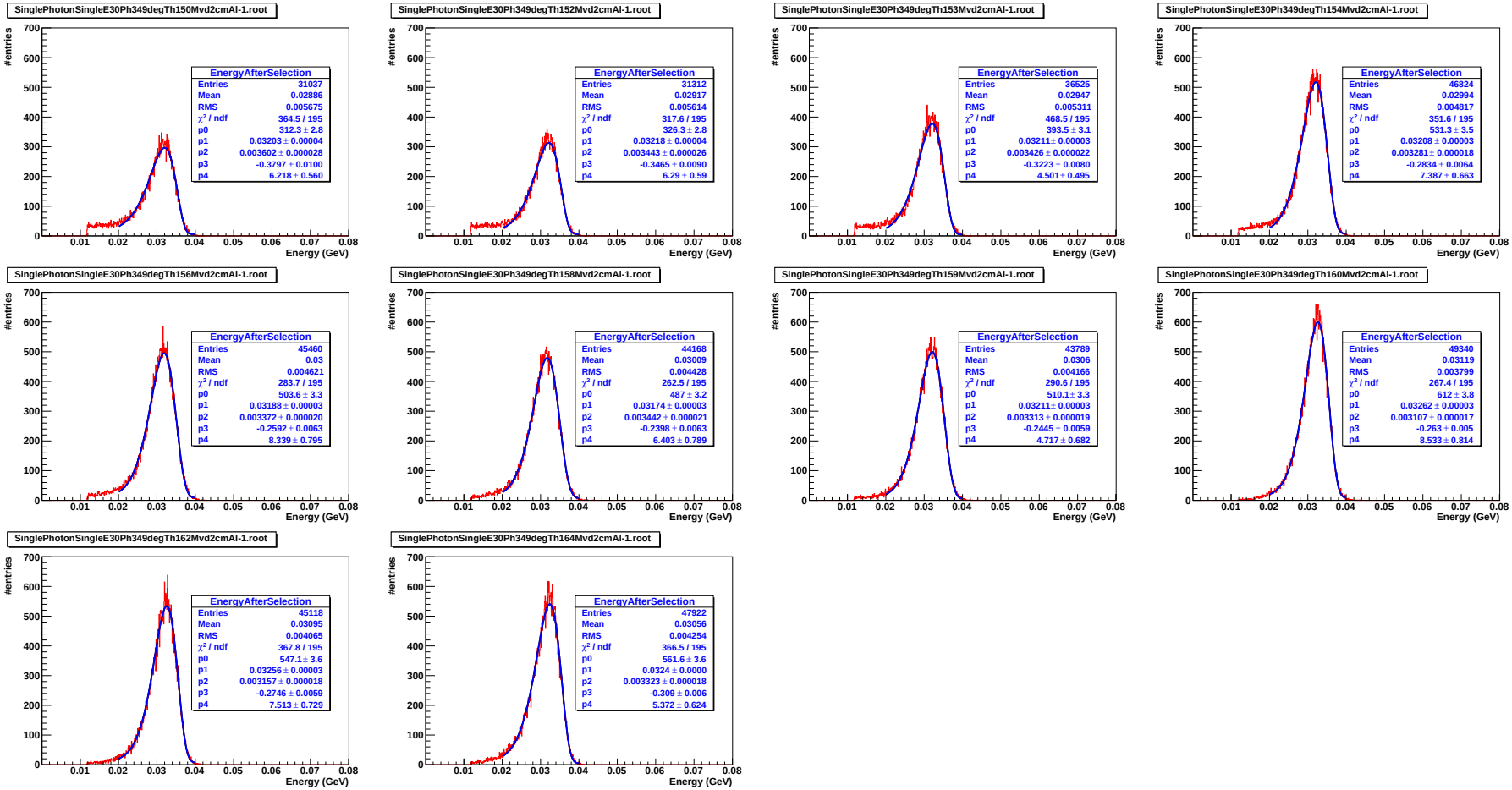
Fits; E=30 MeV $\phi = 339°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



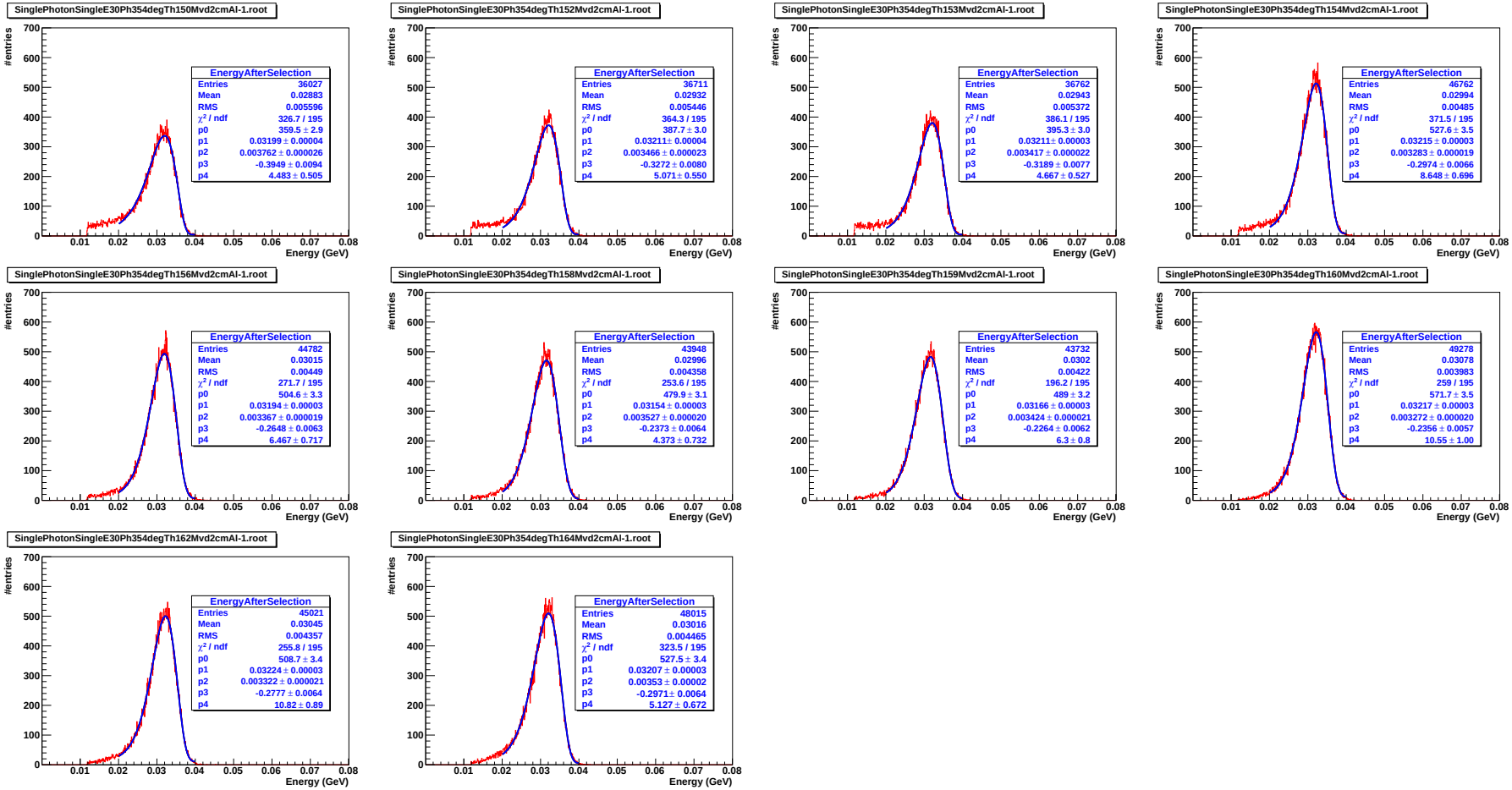
Fits; E=30 MeV $\phi = 344°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



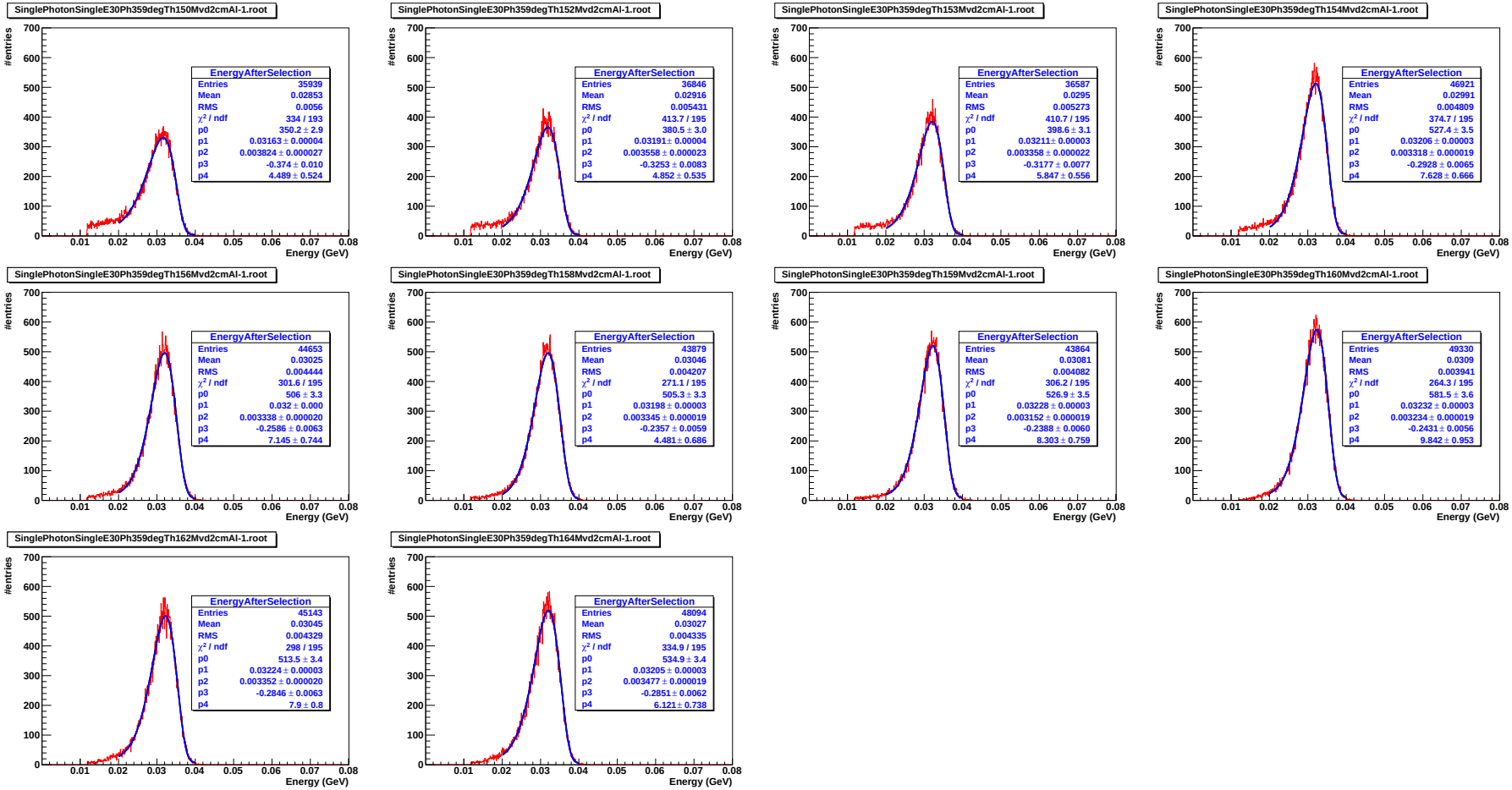
Fits; E=30 MeV $\phi = 349°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



Fits; E=30 MeV $\phi = 354°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



Fits; E=30 MeV $\phi = 359°$; $\theta = 150°$, 151.1°, 153°, 154.5°, 156°, 157.5°, 159°, 160.5°, 162°, 163.5°



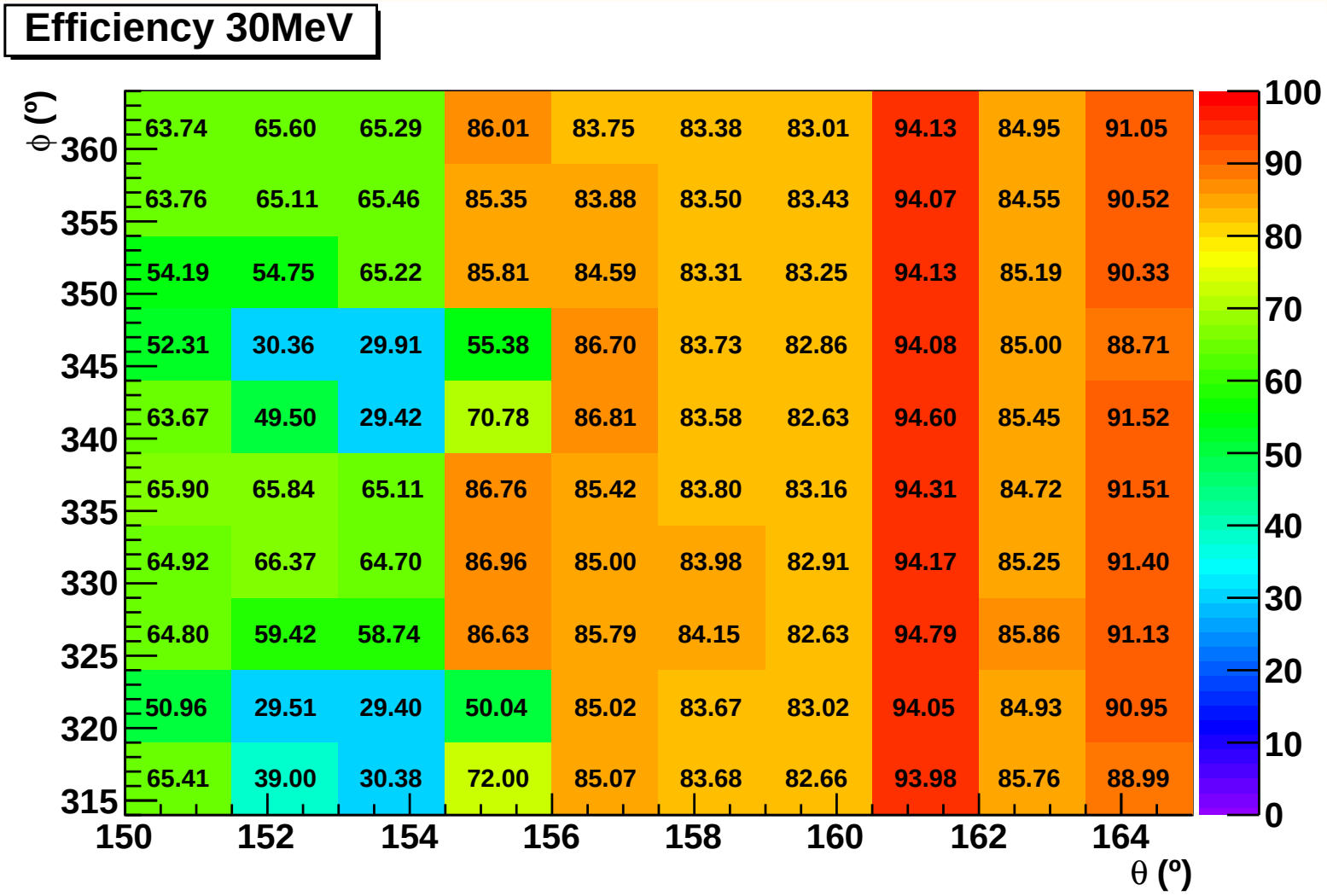
30 MeV

Energy resolution 30 MeV

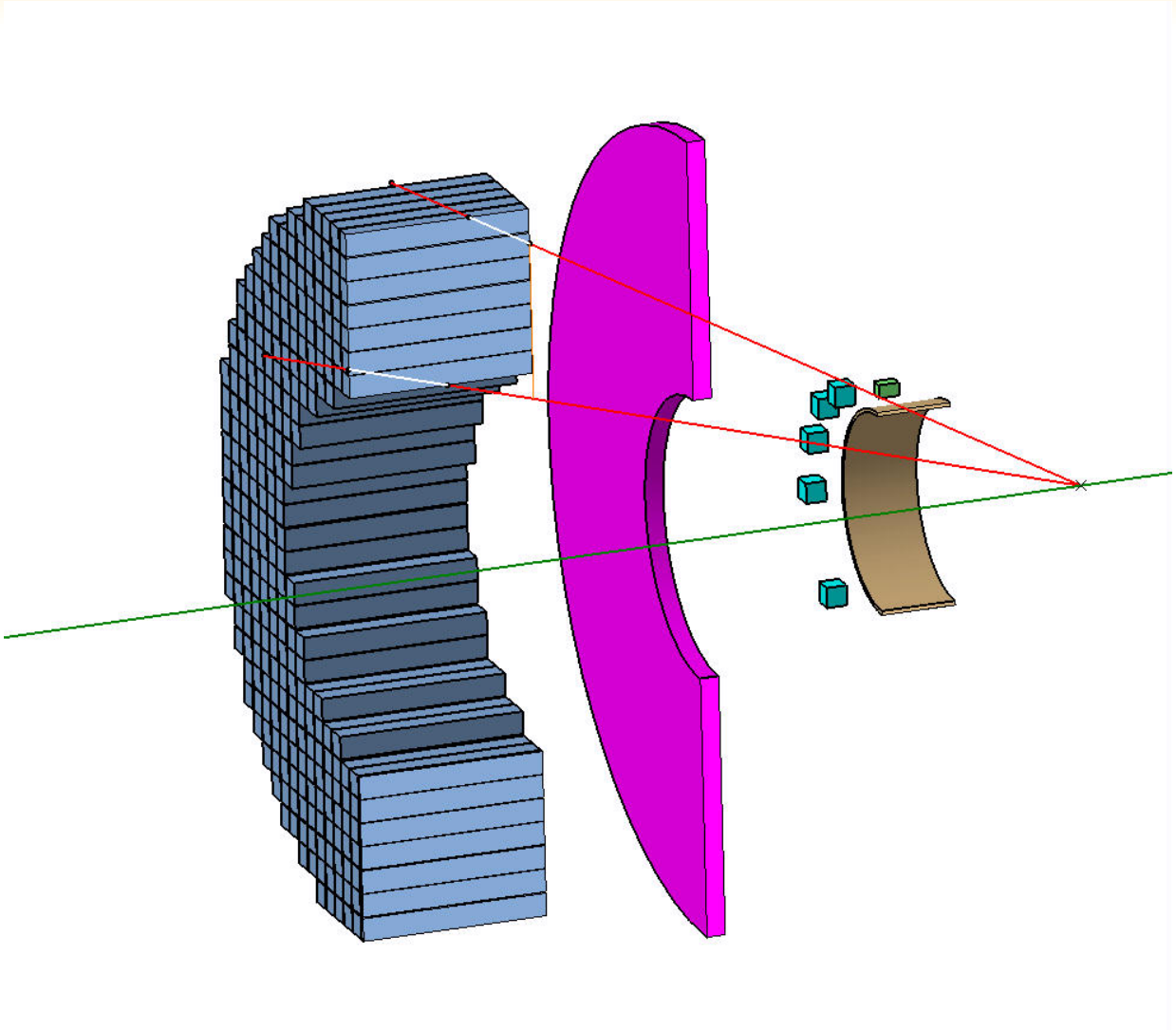
Eresolution 30MeV

ϕ (°) \ θ (°)	150	152	154	156	158	160	162	164
360	28.41 ± 0.21	26.20 ± 0.18	24.58 ± 0.16	24.32 ± 0.14	24.52 ± 0.15	24.59 ± 0.14	22.95 ± 0.14	23.52 ± 0.14	24.43 ± 0.15	25.50 ± 0.14
355	27.63 ± 0.20	25.36 ± 0.17	25.01 ± 0.16	24.00 ± 0.14	24.77 ± 0.15	26.28 ± 0.15	25.42 ± 0.16	23.90 ± 0.14	24.22 ± 0.15	25.87 ± 0.14
350	26.42 ± 0.21	25.14 ± 0.19	25.07 ± 0.16	24.04 ± 0.13	24.86 ± 0.15	25.48 ± 0.15	24.24 ± 0.14	22.39 ± 0.12	22.78 ± 0.13	24.10 ± 0.13
345	26.73 ± 0.21	25.68 ± 0.27	25.49 ± 0.26	25.88 ± 0.19	25.58 ± 0.15	23.96 ± 0.14	23.15 ± 0.14	21.94 ± 0.12	25.03 ± 0.15	29.11 ± 0.17
340	31.26 ± 0.22	26.07 ± 0.21	24.08 ± 0.26	25.56 ± 0.17	26.25 ± 0.16	22.37 ± 0.13	22.34 ± 0.14	24.26 ± 0.14	24.45 ± 0.15	25.22 ± 0.15
335	28.48 ± 0.19	26.71 ± 0.18	25.06 ± 0.17	25.62 ± 0.14	24.50 ± 0.14	23.52 ± 0.14	23.63 ± 0.14	23.52 ± 0.14	23.05 ± 0.14	23.58 ± 0.13
330	28.40 ± 0.20	26.01 ± 0.18	23.87 ± 0.17	26.32 ± 0.16	23.30 ± 0.13	23.45 ± 0.14	24.20 ± 0.16	21.61 ± 0.12	25.19 ± 0.16	25.41 ± 0.15
325	26.28 ± 0.18	25.79 ± 0.19	25.58 ± 0.18	24.78 ± 0.14	23.99 ± 0.15	24.94 ± 0.15	22.00 ± 0.13	25.45 ± 0.15	23.81 ± 0.14	25.28 ± 0.14
320	28.21 ± 0.23	27.00 ± 0.29	25.63 ± 0.26	25.19 ± 0.19	25.69 ± 0.14	22.61 ± 0.14	24.84 ± 0.15	22.57 ± 0.13	23.85 ± 0.14	24.35 ± 0.13
315	28.80 ± 0.19	26.20 ± 0.23	25.80 ± 0.28	24.57 ± 0.16	24.01 ± 0.14	24.33 ± 0.14	22.66 ± 0.14	24.38 ± 0.15	24.59 ± 0.15	27.03 ± 0.16

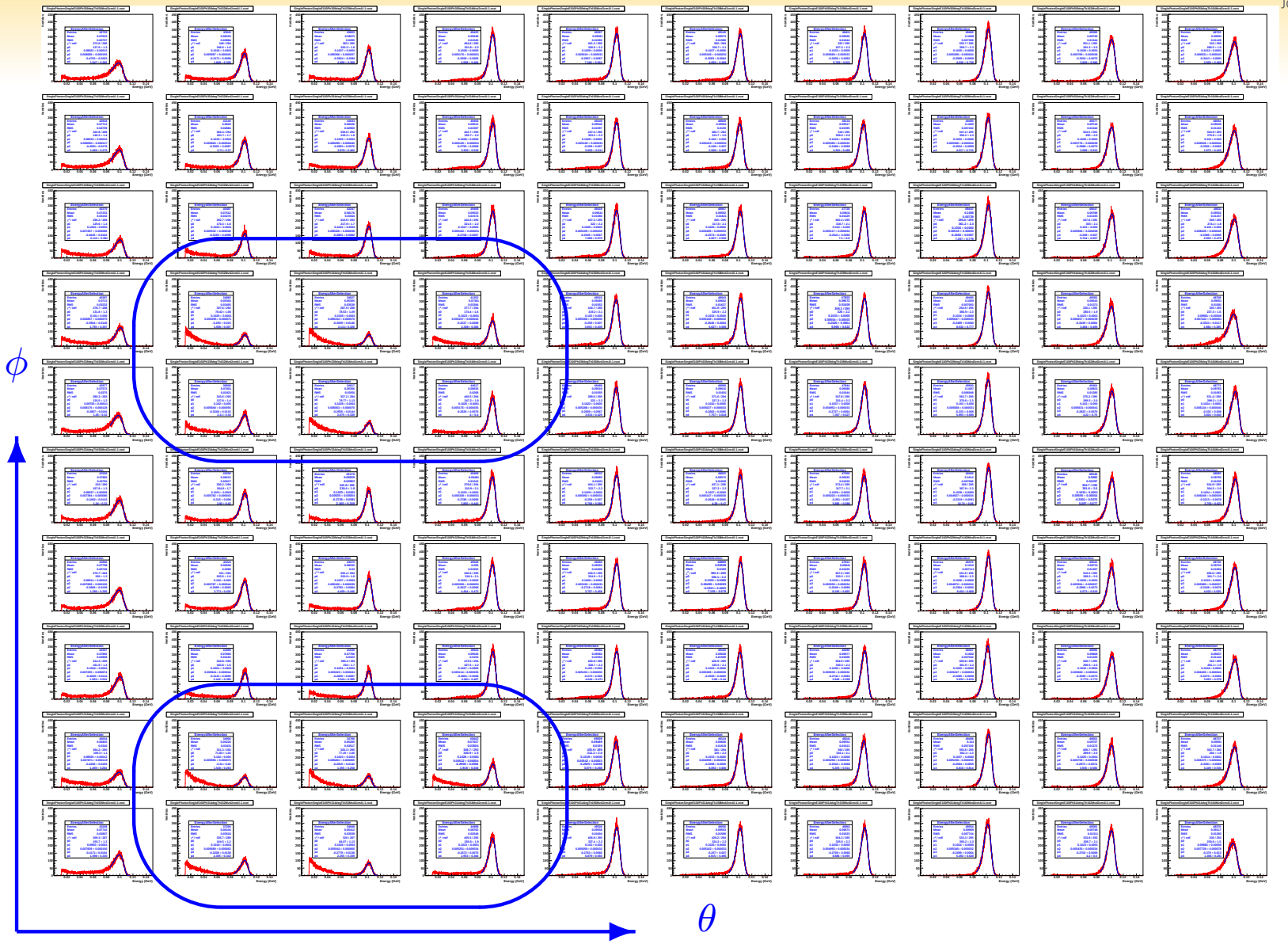
Efficiency 30 MeV



Efficiency



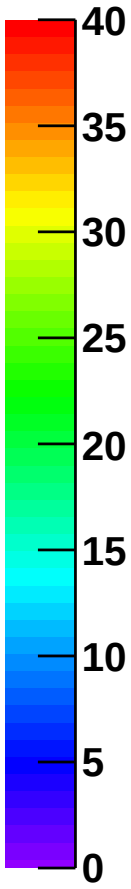
100 MeV



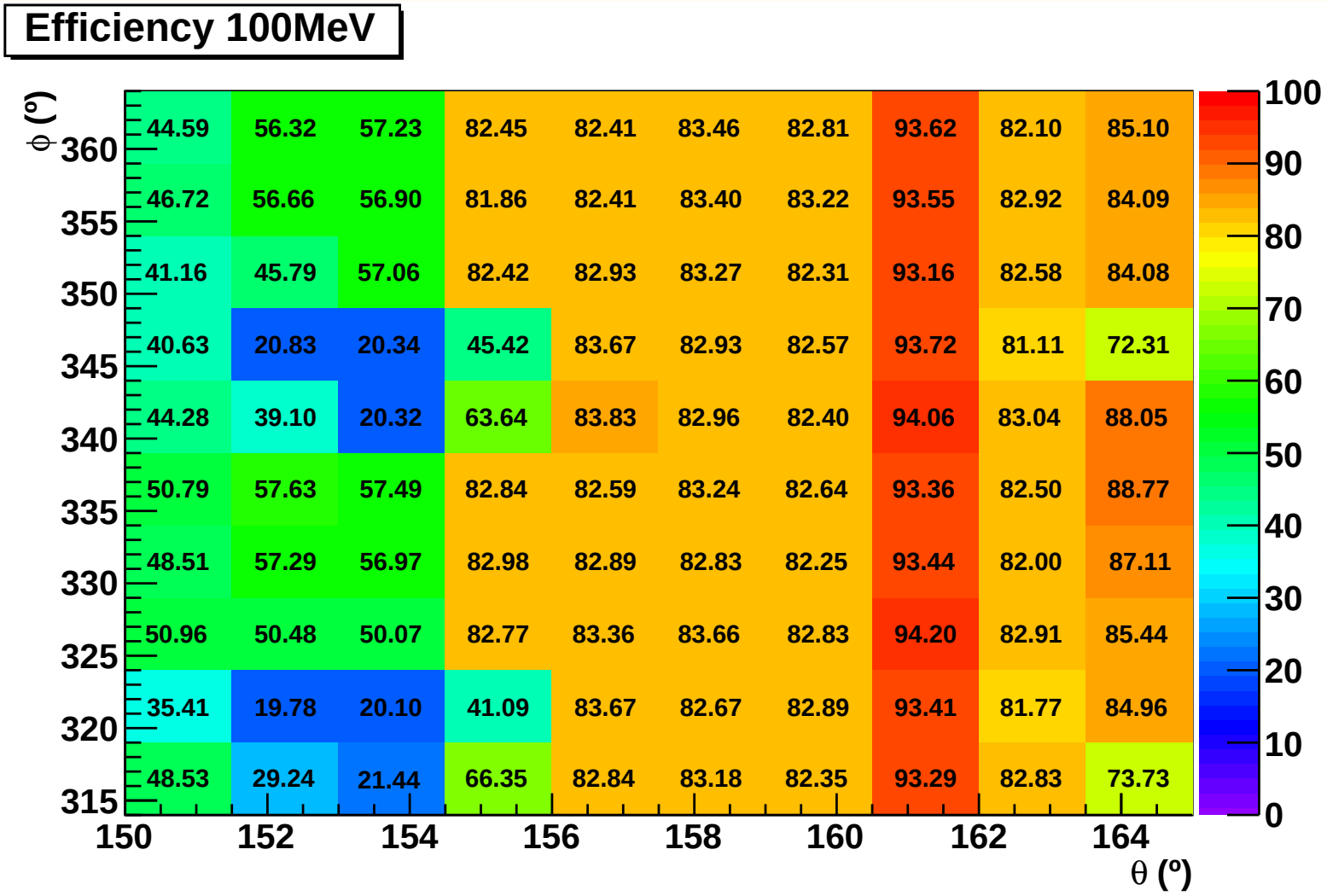
Energy resolution 100 MeV

Eresolution 100MeV

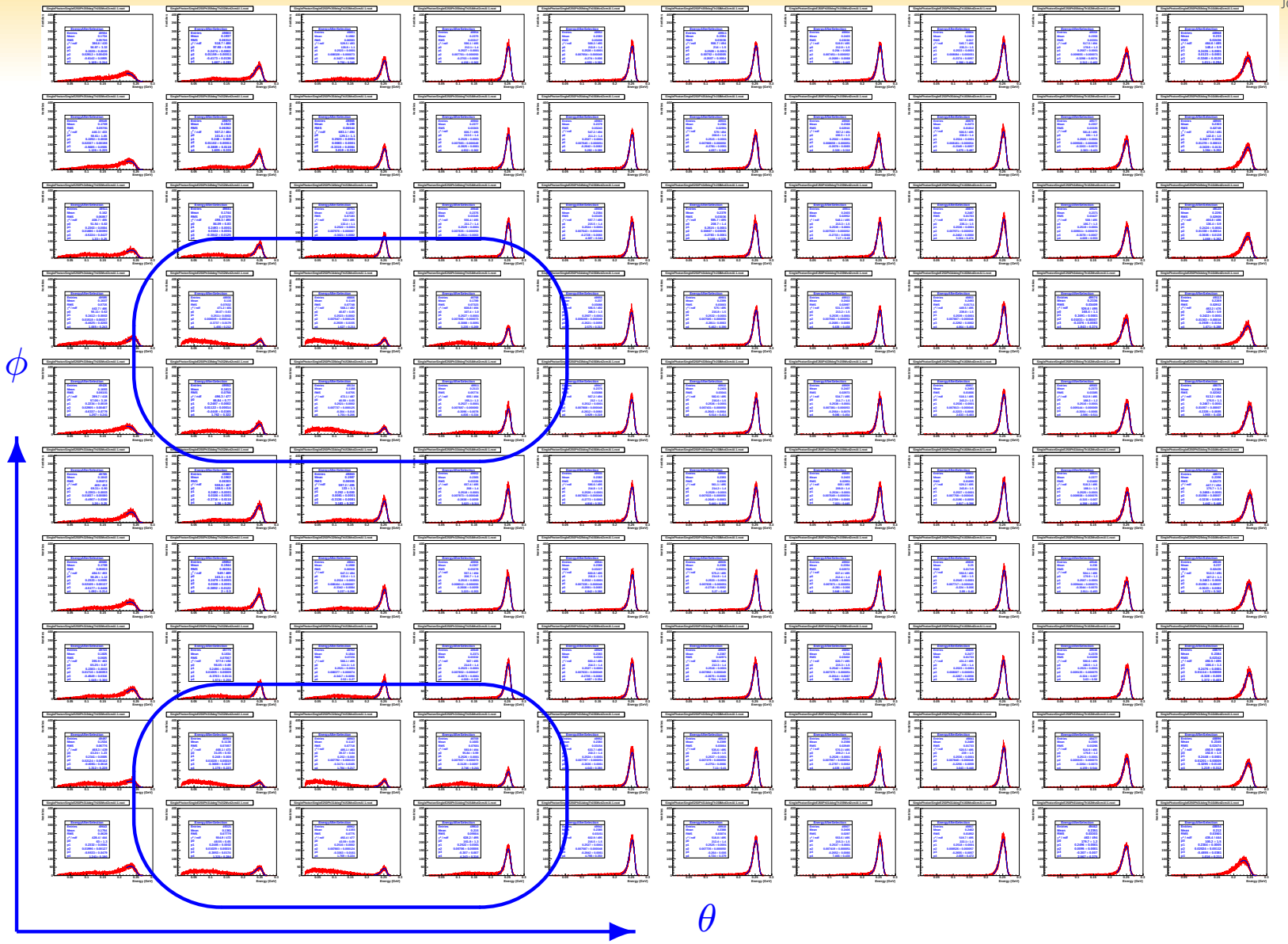
ϕ (°) \ θ (°)	150	152	154	156	158	160	162	164
360	20.79 ± 0.37	13.88 ± 0.10	12.15 ± 0.09	11.83 ± 0.07	11.46 ± 0.07	11.82 ± 0.07	11.53 ± 0.07	11.96 ± 0.08	13.21 ± 0.09	15.17 ± 0.10
355	19.17 ± 0.28	13.43 ± 0.10	12.15 ± 0.09	11.72 ± 0.07	11.72 ± 0.07	12.49 ± 0.07	12.47 ± 0.07	12.08 ± 0.08	13.23 ± 0.09	15.44 ± 0.10
350	17.02 ± 0.20	12.71 ± 0.11	12.22 ± 0.09	11.81 ± 0.07	11.70 ± 0.07	12.07 ± 0.08	11.68 ± 0.08	11.69 ± 0.08	12.56 ± 0.09	15.45 ± 0.11
345	15.95 ± 0.18	12.14 ± 0.16	11.78 ± 0.16	12.08 ± 0.10	12.23 ± 0.07	11.63 ± 0.07	11.46 ± 0.08	11.47 ± 0.08	13.91 ± 0.09	17.00 ± 0.14
340	19.64 ± 0.31	13.48 ± 0.13	11.57 ± 0.16	11.86 ± 0.08	12.16 ± 0.07	11.45 ± 0.08	11.23 ± 0.07	11.57 ± 0.07	12.84 ± 0.09	14.07 ± 0.09
335	17.49 ± 0.19	13.30 ± 0.10	12.29 ± 0.09	12.28 ± 0.07	11.63 ± 0.07	11.77 ± 0.07	11.89 ± 0.08	11.16 ± 0.08	12.65 ± 0.09	13.88 ± 0.09
330	18.51 ± 0.24	13.34 ± 0.10	11.82 ± 0.09	12.11 ± 0.07	11.85 ± 0.07	11.38 ± 0.07	11.53 ± 0.08	11.28 ± 0.08	12.61 ± 0.08	13.80 ± 0.09
325	16.98 ± 0.17	12.94 ± 0.10	11.98 ± 0.09	11.70 ± 0.07	11.76 ± 0.07	12.19 ± 0.07	11.43 ± 0.07	12.03 ± 0.07	12.89 ± 0.09	14.89 ± 0.10
320	18.63 ± 0.28	12.81 ± 0.17	12.10 ± 0.15	11.93 ± 0.10	12.50 ± 0.07	11.37 ± 0.08	12.08 ± 0.07	11.69 ± 0.08	13.20 ± 0.09	14.78 ± 0.10
315	18.53 ± 0.24	13.09 ± 0.14	11.55 ± 0.15	12.07 ± 0.08	11.54 ± 0.07	11.83 ± 0.07	11.32 ± 0.08	12.27 ± 0.07	12.49 ± 0.08	18.41 ± 0.19



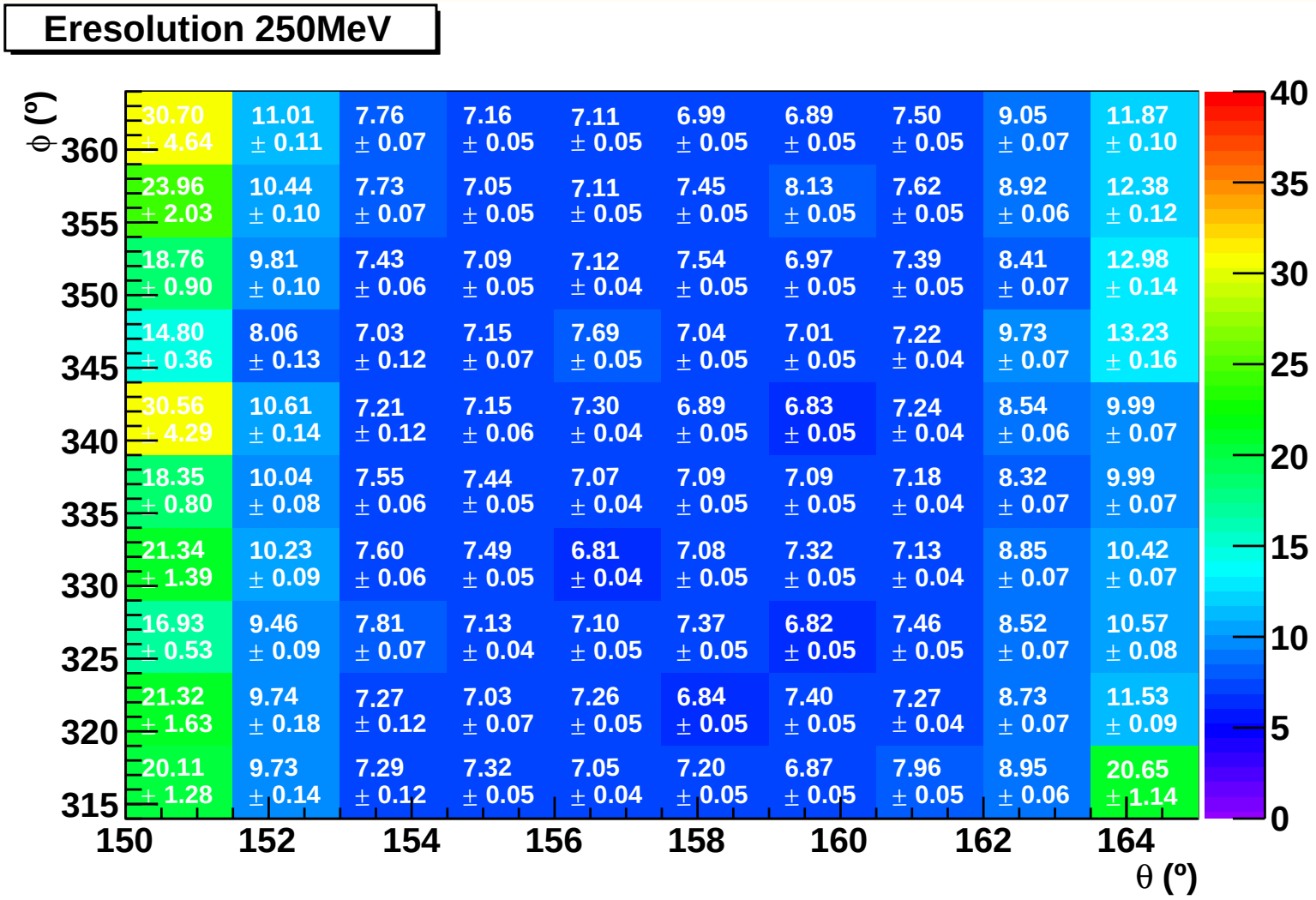
Efficiency 100 MeV



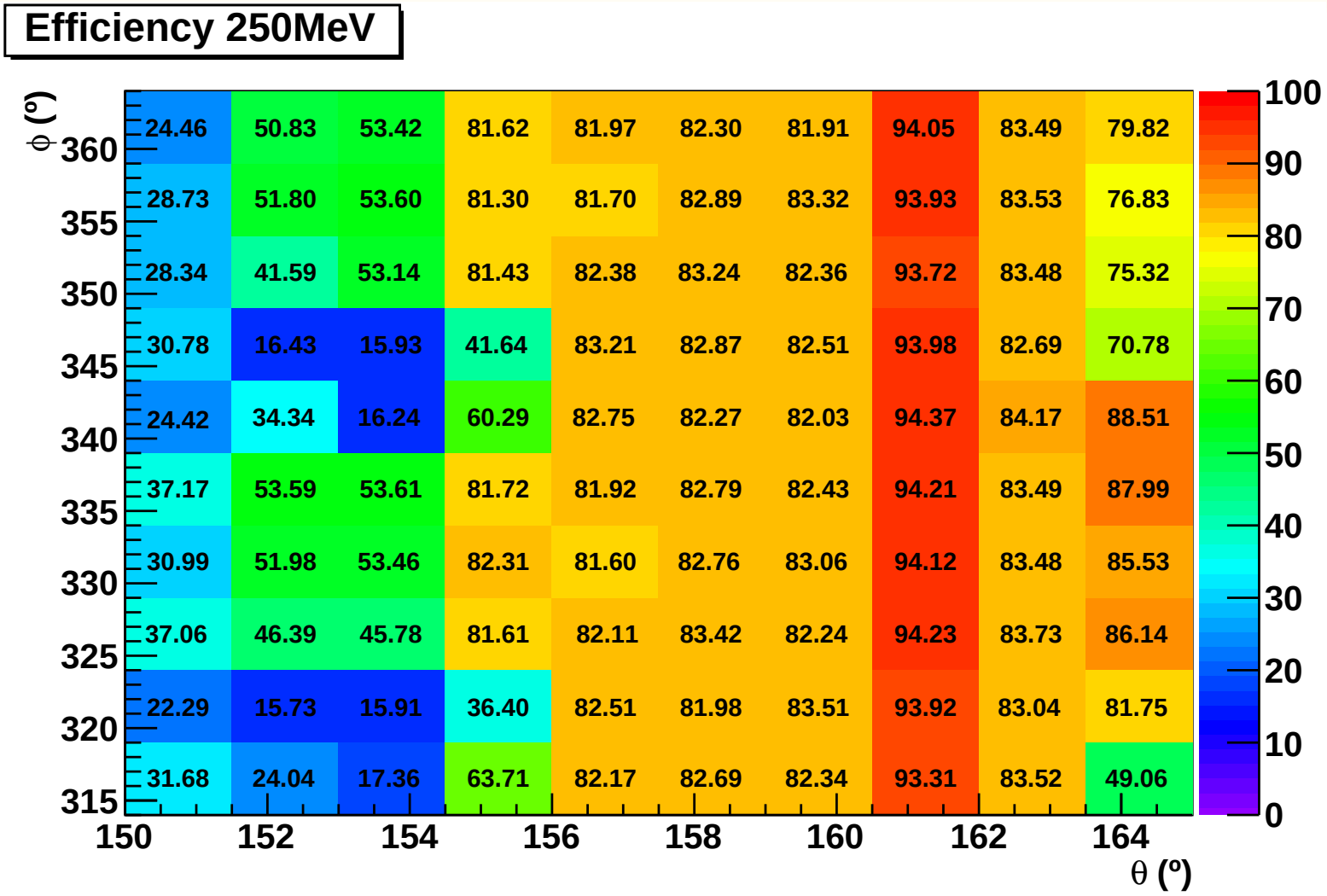
250 MeV



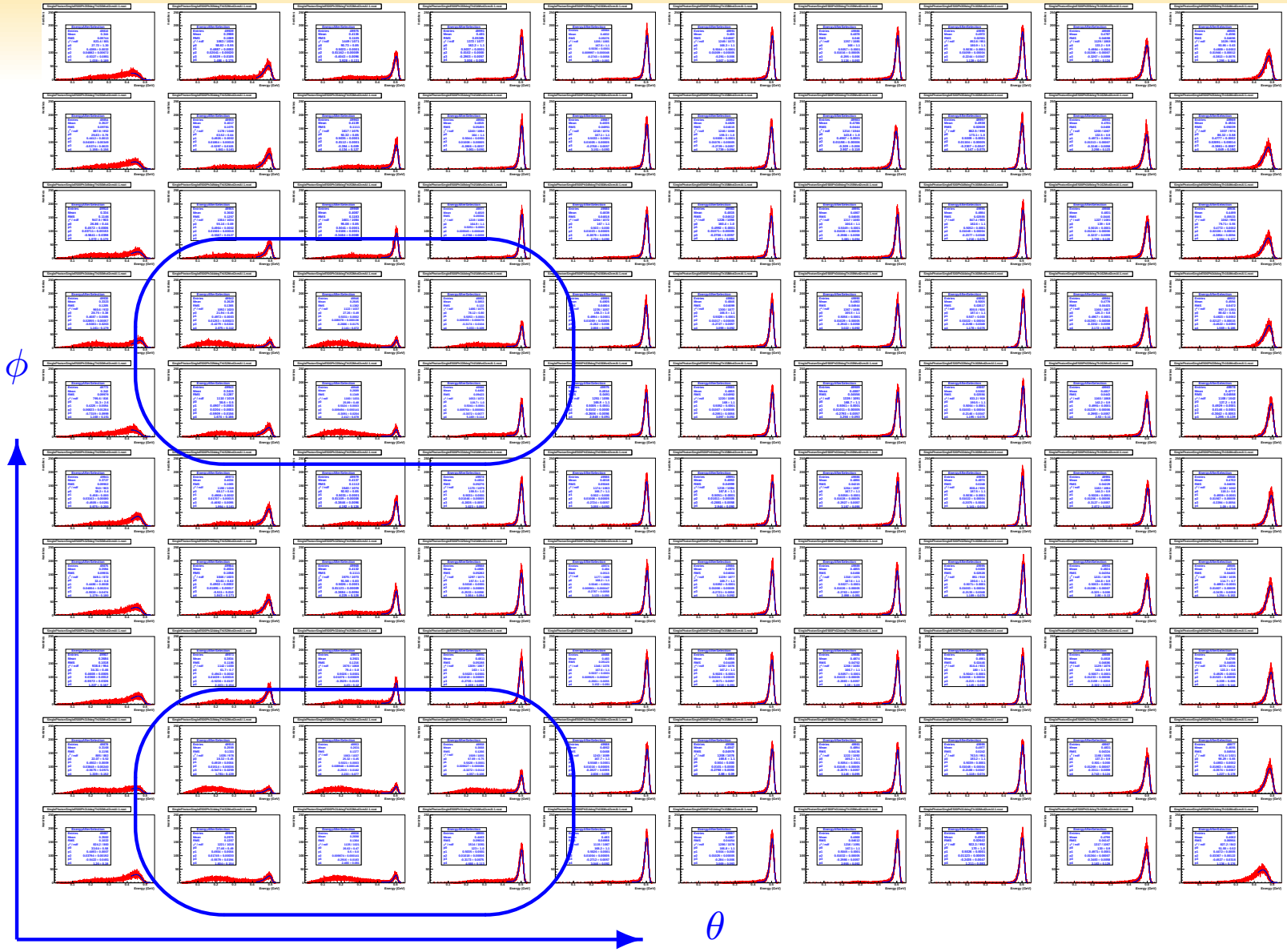
Energy resolution 250 MeV



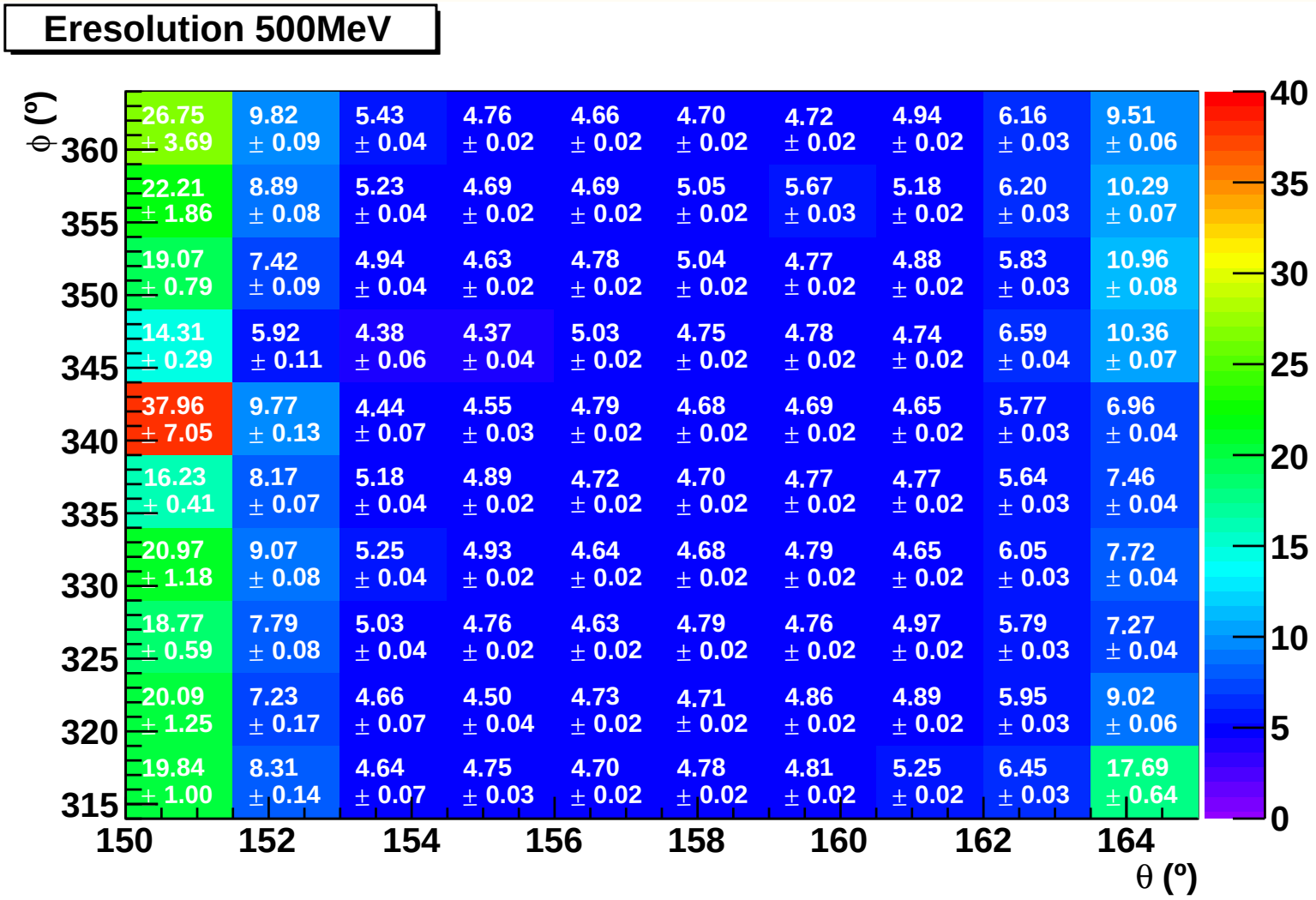
Efficiency 250 MeV



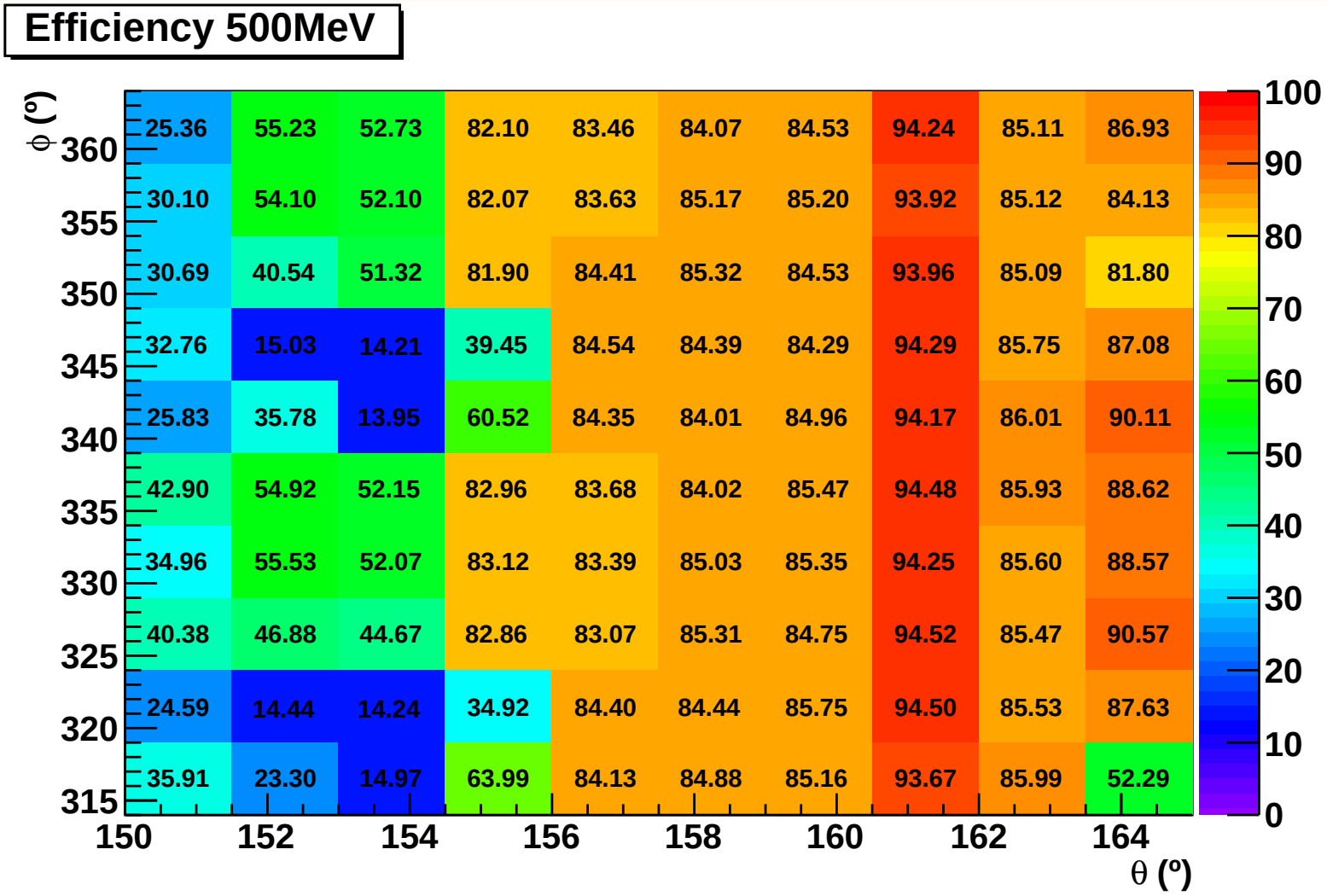
500 MeV



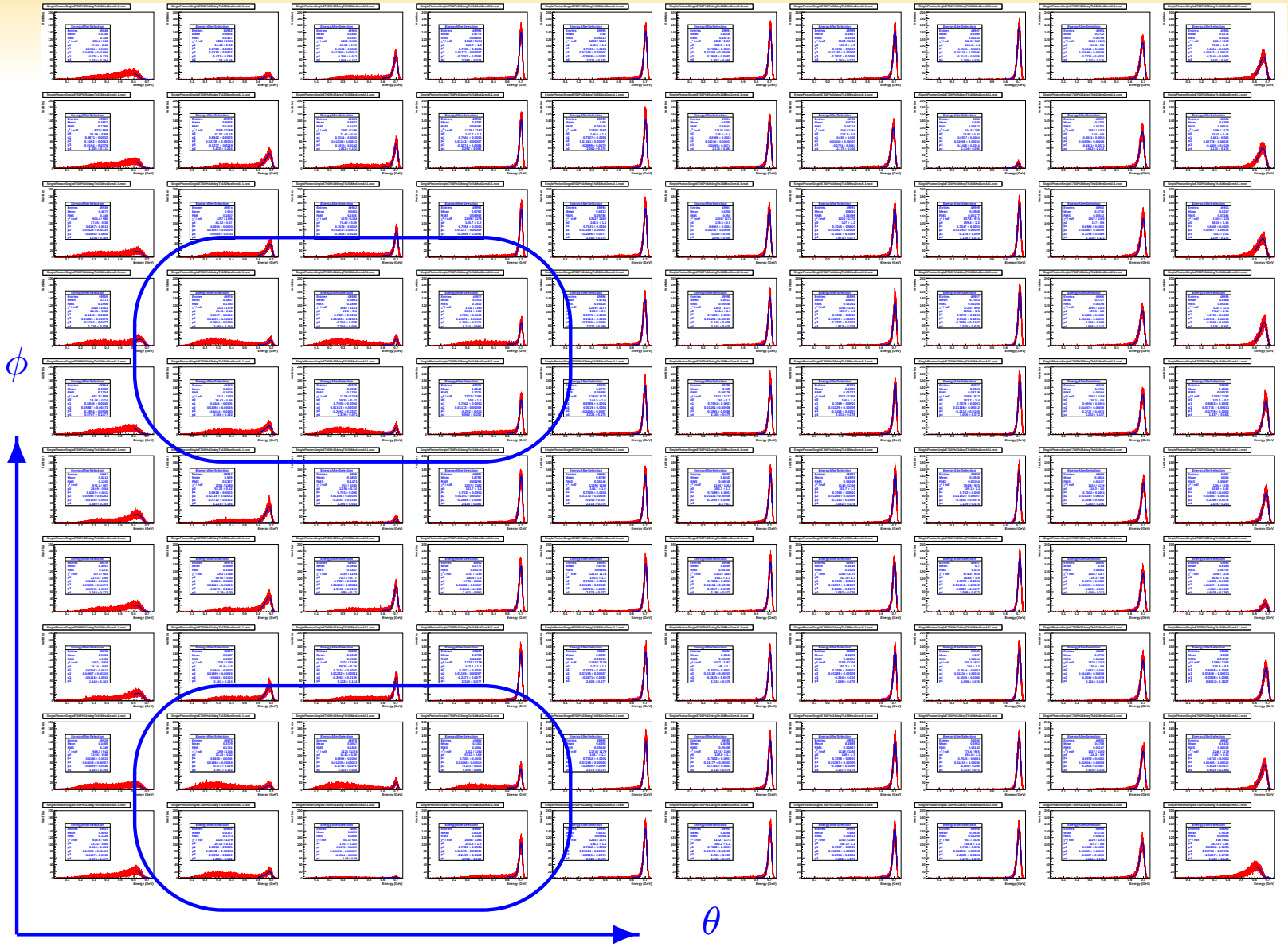
Energy resolution 500 MeV



Efficiency 500 MeV



700 MeV

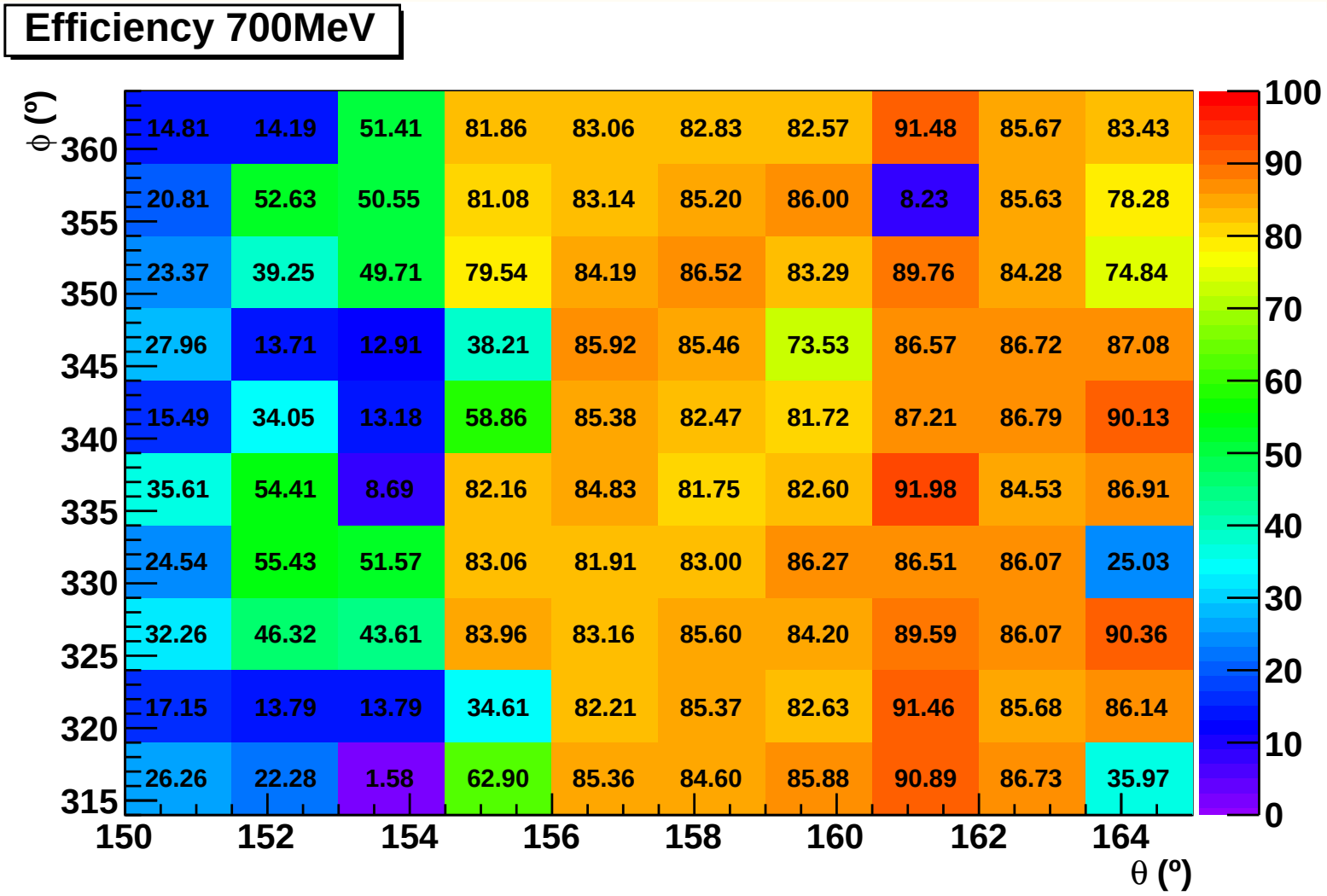


Energy resolution 700 MeV

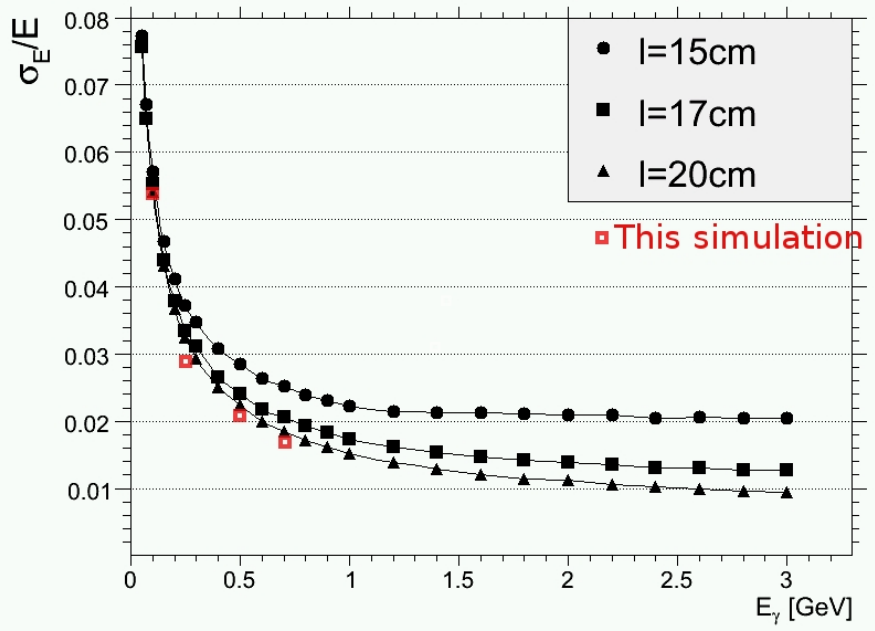
Eresolution 700MeV

ϕ (°) \ θ (°)	150	152	154	156	158	160	162	164
360	19.56 ± 6.30	7.48 ± 0.23	4.69 ± 0.04	3.91 ± 0.02	3.90 ± 0.02	3.84 ± 0.03	3.93 ± 0.03	4.07 ± 0.03	5.24 ± 0.03	8.86 ± 0.06
355	42.52 ± 2.54	8.02 ± 0.11	4.48 ± 0.04	3.81 ± 0.02	3.88 ± 0.02	4.19 ± 0.02	4.77 ± 0.02	3.70 ± 0.08	5.28 ± 0.03	9.88 ± 0.08
350	16.56 ± 1.25	6.65 ± 0.10	4.19 ± 0.04	3.82 ± 0.03	3.91 ± 0.02	4.20 ± 0.02	3.97 ± 0.03	3.97 ± 0.03	5.00 ± 0.03	10.55 ± 0.10
345	14.89 ± 0.64	5.08 ± 0.11	3.78 ± 0.07	3.59 ± 0.04	4.18 ± 0.02	3.99 ± 0.02	3.86 ± 0.03	3.82 ± 0.04	5.58 ± 0.03	8.80 ± 0.06
340	24.07 ± 1.90	8.93 ± 0.16	3.87 ± 0.07	3.72 ± 0.03	4.00 ± 0.02	3.84 ± 0.03	3.75 ± 0.03	3.87 ± 0.04	4.92 ± 0.03	6.09 ± 0.04
335	17.18 ± 1.06	7.29 ± 0.08	3.91 ± 0.08	3.98 ± 0.02	3.93 ± 0.02	3.77 ± 0.03	3.88 ± 0.03	3.99 ± 0.02	4.74 ± 0.03	6.46 ± 0.05
330	22.40 ± 5.30	8.36 ± 0.09	4.42 ± 0.04	4.13 ± 0.02	3.90 ± 0.03	3.78 ± 0.03	4.01 ± 0.02	3.83 ± 0.04	5.12 ± 0.03	6.41 ± 0.09
325	18.44 ± 1.21	6.84 ± 0.09	4.13 ± 0.04	3.97 ± 0.02	3.86 ± 0.02	3.96 ± 0.02	3.96 ± 0.03	4.12 ± 0.03	4.87 ± 0.03	6.33 ± 0.04
320	17.54 ± 2.12	6.83 ± 0.20	4.16 ± 0.08	3.55 ± 0.03	3.86 ± 0.03	3.93 ± 0.02	3.95 ± 0.03	4.06 ± 0.03	5.06 ± 0.03	8.39 ± 0.07
315	17.37 ± 1.89	7.69 ± 0.18	3.36 ± 0.74	3.94 ± 0.03	3.90 ± 0.02	3.92 ± 0.03	3.98 ± 0.03	4.32 ± 0.03	5.45 ± 0.03	22.31 ± 2.87

Efficiency 700 MeV



Expected values from simulation



[1]

Energy (MeV)	$\frac{\sigma}{E}\|_{MySim}$	$\frac{\sigma}{E}\|_{EMC-TDR}$
0.03	0.110	?
0.1	0.051	0.054
0.25	0.029	0.032
0.5	0.021	0.022
0.7	0.017	0.018

[1] Plot 9.4 from EMC - TDR

Conclusions

- Best approximation of MVD dead material to reality with Babar framework.
- Dead material structures of MVD and STT can be recognized in the Efficiency map.
- Good efficiency except for specific ϕ and θ angles.

EFFICIENCY AND ENERGY RESOLUTION ARE GOOD ENOUGH TO DO PHYSICS WITH THE BACKWARD END CAP CALORIMETER!!