$\bar{\text{P}}$ANDA Backward Electromagnetic Calorimeter Studies with old framework

Status report

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PANDA Collaboration meeting
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Outline

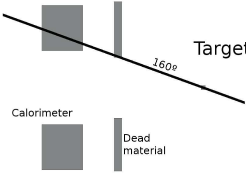
Simulation characteristics: Single gamma.

FIRST SIMULATION:

- Energy range: 0.002 to 0.7 GeV
- Angular range:
  - $\cos\theta$: -0.819 to -0.996
  - θ: 174.87° to 144.98°
- Calorimeter: 20 cm long crystals (2.24 cm×2.24 cm), r_{min} =182 mm, r_{max} =406 mm, at z= -594 mm.
  Full angular range: 145.65°, 167.09°.
- Dead material:
  - Nothing.
  - Low: Al, 4 cm, r_{min} =182 mm, r_{max} =406 mm, at z= -554 mm from the target.
  - High: Al, 8 cm, r_{min} =182 mm, r_{max} =406 mm, at z= -514 mm from the target.

- The dead material was in front of the EMC instead of behind the STT.
- Angular range was calculated wrongly.
- Dimmensions of dead material were also wrong (radii and thickness).

Simulation characteristics: Single gamma.



SECOND SIMULATION:

- Energy: 0.3 GeV
- Angles:
  - θ: 160°
  - ϕ: 0°, 22.5° and 45°
- Calorimeter: 20 cm long crystals (2.24 cm$\times$2.24 cm), r_{min} =182 mm, r_{max} =406 mm, at z= -594 mm.
  Full angular range: 145.65°, 167.09°.
- Dead material:
  - Nothing.
  - Low: Al, 2 cm r_{min} =150 mm, r_{max} =418 mm, at z= -400 mm from the target. Behind STT.
  - High: Al, 4 cm r_{min} =150 mm, r_{max} =418 mm, at z= -400 mm from the target. Behind STT.

Simulation characteristics: Single gamma.

FORESEEN SIMULATIONS:

- Energies: 0.03, 0.1, 0.25, 0.5 and 0.7 GeV
- Angles:
  - θ: 145°, 150°, 155°, 160° and 165°
  - ϕ: 0°, 22.5° and 45°
- Calorimeter: 20 cm long crystals (2.24 cm$\times$2.24 cm), r_{min} =182 mm, r_{max} =406 mm, at z= -594 mm.
  Full angular range: 145.65°, 167.09°.
- Dead material:
  - Nothing.
  - Low: Al, 2 cm r_{min} =150 mm, r_{max} =418 mm, at z= -400 mm from the target. Behind STT.
  - High: Al, 4 cm r_{min} =150 mm, r_{max} =418 mm, at z= -400 mm from the target. Behind STT.

PHYSICS CHANNEL: $\bar{p}p \rightarrow e^+e^-\pi^0$
(Implemented by D. Kahneft for PANDAroot)

Analysed variables

root [1] emepTuple->Show(11)

======>EVENT:11	$\longrightarrow$ Id number of the event
ncnd	$\longrightarrow$ Number of reconstructed candidates
Energy	$\longrightarrow$ Corrected energy of each reconstructed candidate
rawEnergy	$\longrightarrow$ Measured energy of each reconstructed candidate
costh	$\longrightarrow$ Related with the reconstructed angle for the candidate
nmc	$\longrightarrow$ Number of montecarlo true particles
tEnergy	$\longrightarrow$ Energy of each montecarlo true particle
tcosth	$\longrightarrow$ Related with the angle of each montecarlo true particle
lundid	$\longrightarrow$ Particle Id number of each montecarlo true particle (22 for photons)
vtxcause	$\longrightarrow$ Origin of each montecarlo true particle (10 for event generator)
xpos	$\longrightarrow$ X coordinate of the vertex of each montecarlo true particle
ypos	$\longrightarrow$ Y coordinate of the vertex of each montecarlo true particle
zpos	$\longrightarrow$ Z coordinate of the vertex of each montecarlo true particle

RECONSTRUCTION
MONTECARLO

Analysed variables

```
root [0] TFile *f=new TFile("SinglePhotonHighAlMerged.root")
```

```
root [1]
emepTuple->Show(11)
======>EVENT:11
ncnd = 1
Energy = 0.491099
rawEnergy = 0.465499
costh = -0.934149
nmc = 1
tEnergy = 0.477832
tcosth = -0.915978
lundid = 22
vtxcause = 10
xpos = 0
ypos = 0
zpos = 0
```

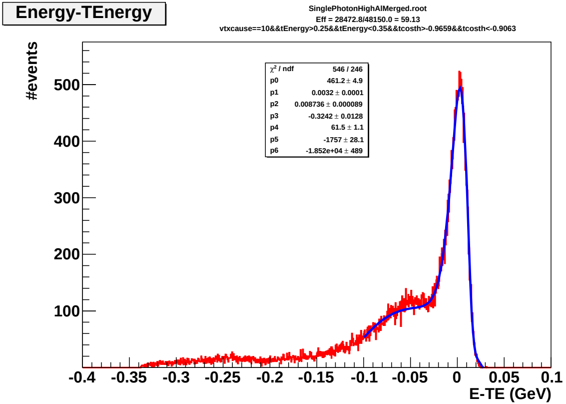
```
root [2]
emepTuple->Show(10)
======>EVENT:10
ncnd = 0
nmc = 1
tEnergy = 0.34764
tcosth = -0.838734
lundid = 22
vtxcause = 10
xpos = 0
ypos = 0
zpos = 0
```

```
root [6]
emepTuple->Show(4)
======>EVENT:4
ncnd = 2
Energy = 0.021131,
0.301479
rawEnergy = 0.0161419,
0.2804
costh = -0.795457,
-0.896427
nmc = 1
tEnergy = 0.389971
tcosth = -0.86105
lundid = 22
vtxcause = 10
xpos = 0
ypos = 0
zpos = 0
```

```
root [6]
emepTuple->Show(103)
======>EVENT:103
ncnd = 2
Energy = 0.0214231,
0.170857
rawEnergy = 0.0163651,
0.156274
costh = -0.795457,
-0.89297
nmc = 2
tEnergy = 0.362898,
0.349363
tcosth = -0.845558,
-0.846095
lundid = 22,
11
vtxcause = 10,
201
xpos = 0,
6
ypos = 0,
13
zpos = 0,
-22
```

Novosibirsk function

$$y = A \cdot \exp\left\{ -\frac{1}{2}\left[\frac{\ln\left(1 + \frac{x-\mu}{\sigma}\cdot\frac{\sinh(\tau\cdot\sqrt{\ln 4})}{\tau\cdot\sqrt{\ln 4}}\cdot\tau\right)}{\tau}\right]^2 + \tau^2 \right\}$$



p0: A = Normalization
p1: μ = Mean value
p2: σ = Width parameter
p3: τ = Tail parameter
p4, 5, 6: Parabolic background

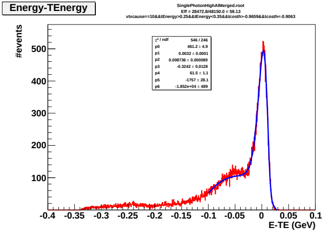
$$Eff = \frac{Integral(\mu - a\sigma, \mu + b\sigma)}{Entries}$$

Eff 3-2: a=3, b=2
Eff 5-3: a=5, b=3

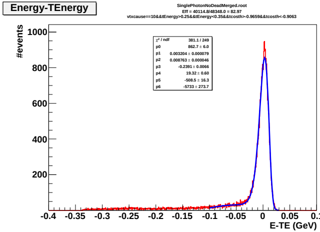
First simulation.

CUT: vtxcause=10; 0.35>tEnergy>0.25; -0.9063>tcosth>-0.9659
SIMULATED EVENTS: 1000000

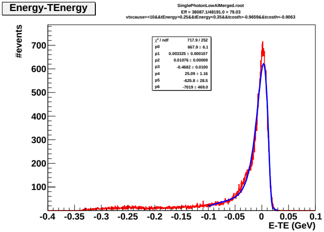
High



No



Low



Simulation	**Entries**	σ GeV
No dead	48348	0.008763 $\pm$ 0.000046
Low	48191	0.01076 $\pm$ 0.00009
High	48150	0.008736 $\pm$ 0.000089

Simulation	**Integral**	**Eff 3-2**	**Integral**	**Eff 5-3**
No dead	38255.3	79.12	40114.8	82.97
Low	34497.5	71.59	38087.1	79.03
High	24313.6	50.50	28478.2	59.13

$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

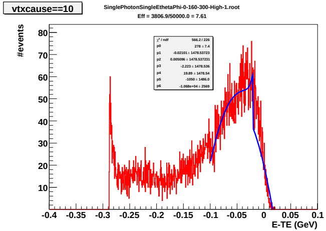
$$Eff = \frac{Integral(\mu - 5 \cdot \sigma, \mu + 3 \cdot \sigma)}{Entries}$$

Second simulation. Results High material.

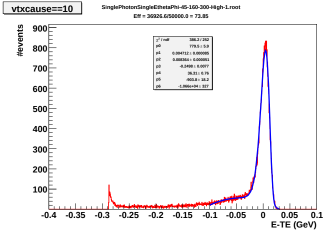
CUT: vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

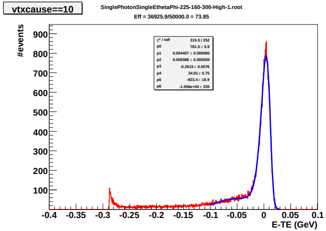
0°



45°



22.5°



Simulation	Entries	σ GeV
45°	50000	0.008364 ± 0.000051
22.5°	50000	0.008388 ± 0.000051

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	34340.8	68.68	36926.6	73.85
22.5°	34333.9	68.67	36925.9	73.85

$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

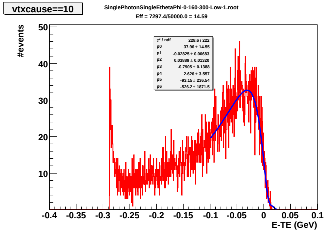
$$Eff = \frac{Integral(\mu - 5 \cdot \sigma, \mu + 3 \cdot \sigma)}{Entries}$$

Second simulation. Results Low material.

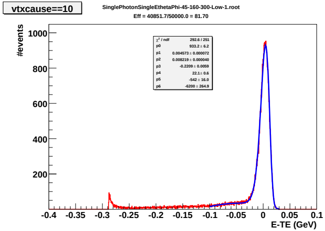
CUT: vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

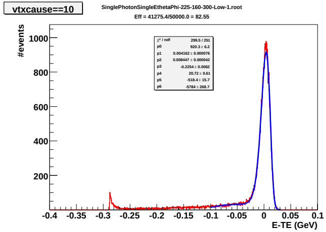
0°



45°



22.5°



Simulation	Entries	σ GeV
45°	50000	0.008219 $\pm$ 0.000040
22.5°	50000	0.008447 $\pm$ 0.000042

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	38994.7	77.99	40851.7	81.70
22.5°	39422.4	78.84	41275.4	82.55

$$Eff = \frac{Integral(\mu - 3\cdot\sigma, \mu + 2\cdot\sigma)}{Entries}$$

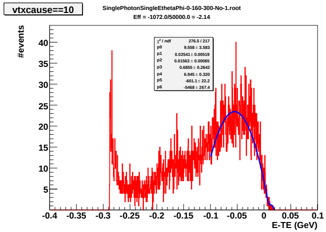
$$Eff = \frac{Integral(\mu - 5\cdot\sigma, \mu + 3\cdot\sigma)}{Entries}$$

Second simulation. Results No dead material.

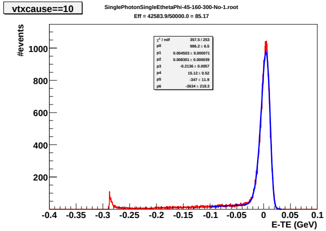
CUT: vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

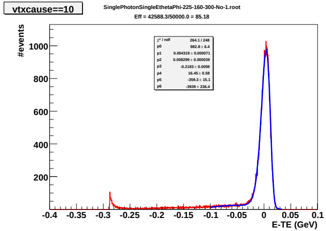
0°



45°



22.5°



Simulation	Entries	σ GeV
45°	50000	0.008301± 0.000039
22.5°	50000	0.008299± 0.000039

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	41043.3	82.09	42583.8	85.17
22.5°	40971.9	81.94	42588.3	85.18

$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

$$Eff = \frac{Integral(\mu - 5 \cdot \sigma, \mu + 3 \cdot \sigma)}{Entries}$$

Comparison results.

First simulation, only vtxcause cut:

Simulation	Entries	σ GeV
No dead	48348	0.008763 ± 0.000046
Low	48191	0.01076 ± 0.00009
High	48150	0.008736 ± 0.000089

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Second simulation, only vtxcause cut:

Simulation	Entries	σ GeV
45°No dead	50000	0.008301 ± 0.000039
22.5°No dead	50000	0.008299 ± 0.000039
45°Low	50000	0.008219 ± 0.000040
22.5°Low	50000	0.008447 ± 0.000042
45°High	50000	0.008364 ± 0.000051
22.5°High	50000	0.008388 ± 0.000051

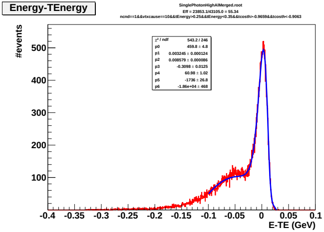
Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°No dead	41043.3	82.09	42583.8	85.17
22.5°No dead	40971.9	81.94	42588.3	85.18
45°Low	38994.7	77.99	40851.7	81.70
22.5°Low	39422.4	78.84	41275.4	82.55
45°High	34340.8	68.68	36926.6	73.85
22.5°High	34333.9	68.67	36925.9	73.85

First simulation.

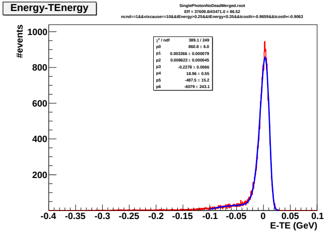
CUT: ncnd=1; vtxcause=10; 0.35>tEnergy>0.25; -0.9063>tcosth>-0.9659

SIMULATED EVENTS: 1000000

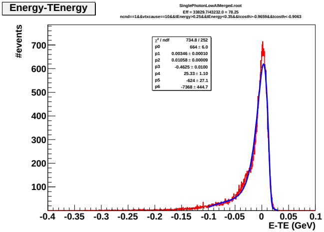
High



No dead



Low



Simulation	**Entries**	σ GeV
No dead	43471	0.008622 ± 0.000045
Low	43232	0.01058 ± 0.00009
High	43105	0.008579 ± 0.000086

Simulation	**Integral**	**Eff 3-2**	**Integral**	**Eff 5-3**
No dead	37609.8	86.52	39350.7	90.52
Low	33829.7	78.25	37303.9	86.29
High	23853.1	55.34	27852.6	64.82

$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

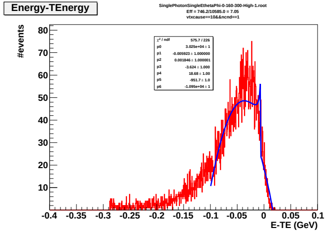
$$Eff = \frac{Integral(\mu - 5 \cdot \sigma, \mu + 3 \cdot \sigma)}{Entries}$$

Second simulation. Results High material.

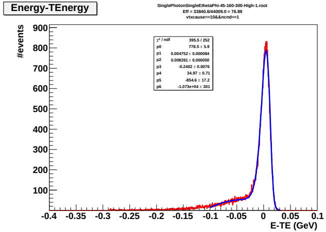
CUT: ncd=1; vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

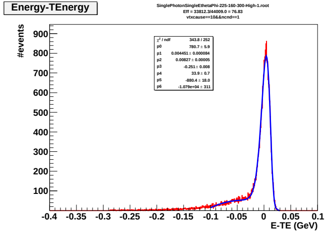
0°



45°



22.5°



Simulation	Entries	σ GeV
45°	44009	0.008261 ± 0.000050
22.5°	44009	0.00821 ± 0.00005

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	33840.6	76.89	36267.8	82.41
22.5°	33812.3	76.83	36248.2	82.37

$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

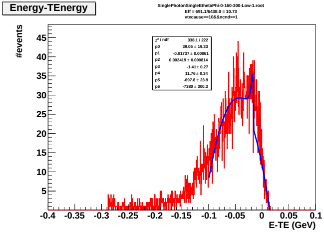
$$Eff = \frac{Integral(\mu - 5 \cdot \sigma, \mu + 3 \cdot \sigma)}{Entries}$$

Second simulation. Results Low material.

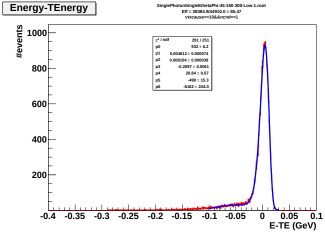
CUT: ncd=1; vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

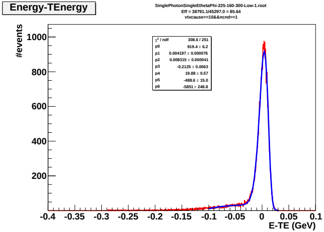
0°



45°



22.5°



Simulation	Entries	σ GeV
45°	44910	0.008104 $\pm$ 0.000039
22.5°	45297	0.008315 $\pm$ 0.000041

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	38384.9	85.47	40100.0	89.29
22.5°	38791.1	85.64	40512.5	89.44

$$Eff = \frac{Integral(\mu - 3\cdot\sigma, \mu + 2\cdot\sigma)}{Entries}$$

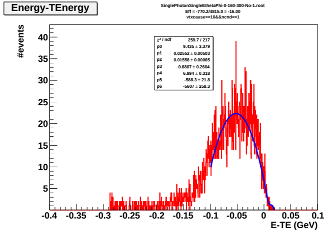
$$Eff = \frac{Integral(\mu - 5\cdot\sigma, \mu + 3\cdot\sigma)}{Entries}$$

Second simulation. Results No dead material.

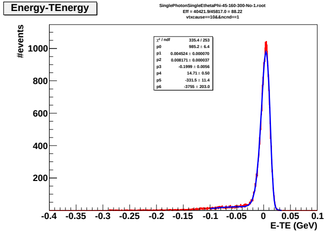
CUT: ncd=1; vtxcause=10; tEnergy = 0.25; costh=160°

SIMULATED EVENTS: 50000

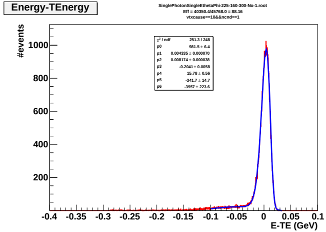
0°



45°



22.5°



Simulation	**Entries**	σ GeV
45°	45817	0.008171 ± 0.000038
22.5°	45768	0.008174 ± 0.000038

Simulation	**Integral**	**Eff 3-2**	**Integral**	**Eff 5-3**
45°	40421.9	88.22	41864.8	91.37
22.5°	40350.4	88.16	41855.6	91.45

$$Eff = \frac{Integral(\mu - 3\cdot\sigma, \mu + 2\cdot\sigma)}{Entries}$$

$$Eff = \frac{Integral(\mu - 5\cdot\sigma, \mu + 3\cdot\sigma)}{Entries}$$

Comparison results.

First simulation, cuts on vtxcause and ncnd:

Simulation	Entries	σ GeV
No dead	43471	0.008622 $\pm$ 0.000045
Low	43232	0.01058 $\pm$ 0.00009
High	43105	0.008579 $\pm$ 0.000086

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
No dead	37609.8	86.52	39350.7	90.52
Low	33829.7	78.25	37303.9	86.29
High	23853.1	55.34	27852.6	64.82

Second simulation, cuts on vtxcause and ncnd:

Simulation	Entries	σ GeV
45° No dead	45817	0.008171$\pm$ 0.000038
22.5° No dead	45768	0.008174 $\pm$ 0.000038
45° Low	44910	0.008104 $\pm$ 0.000039
22.5° Low	45297	0.008315 $\pm$ 0.000041
45° High	44009	0.008261 $\pm$ 0.000050
22.5° High	44009	0.00821 $\pm$ 0.00005

Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45° No dead	40421.9	88.22	41864.8	91.37
22.5° No dead	40350.4	88.16	41855.6	91.45
45° Low	38384.9	85.47	40100.0	89.29
22.5° Low	38791.1	85.64	40512.5	89.44
45° High	33840.6	76.89	36267.8	82.41
22.5° High	33812.3	76.83	36248.2	82.37

Other fit functions

GABLER FUNCTION

$$y = N \exp\left(-\frac{4\ln 2(E - E_{Peak})^2}{\Gamma^2}\right), E \leq E_{Peak}$$

$$y = N\left\{\exp\left[-\frac{4\ln 2(E - E_{Peak})^2}{\Gamma^2}\right] + \exp\left[\frac{E - E_{Peak}}{\lambda}\right]\left[1 - \exp\left(-\frac{4\ln 2(E - E_{Peak})^2}{\Gamma^2}\right)\right]\right\}$$

A.R. Gabler et al. /Nucl. Instr. and Meth. in Phys. Res. A 346 (1994) 168-176

A4-COLLABORATION FIT FUCTION

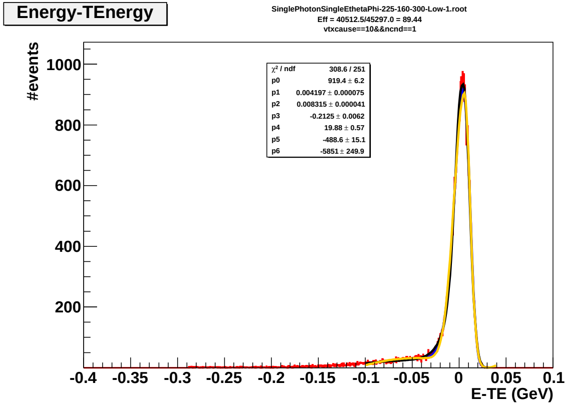
$$y = C \cdot \left\{\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma_L}\right)^2\right] + \exp\left[\frac{x-\mu}{\lambda}\right] \cdot \left(1 - \exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma_L}\right)^2\right]\right)\right\}, x < \mu$$

$$y = C \cdot \exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma_R}\right)^2\right]$$

S. Baunack PhD thesis
http://wwwkph.kph.uni-mainz.de/A4//schriften/doktor/baunack.diss.pdf

Different fit results

New simulation, 22.5°, Low



Novosibirsk
Gabler
A4-Collaboration

- From the point of view of χ^2 is better the Novosibirsk function
- Frome the point of view of the Efficiency is better the Gabler function, but probably because the σ is bigger
- First values for energy resolution ($FWHM/E$) are of the order of 6%
- More analysis needed

Outlook

- Results of first and second simulation are comparable.

- Calculate the energy resolution in detail for the different fit functions as:

$$E_{res} = \frac{FWHM}{E}$$

- Simulation of other energies and angles:
  - Energies: 0.03, 0.1, 0.25, 0.5 and 0.7 GeV
  - Angles:
    - θ: 145°, 150°, 155°, 160° and 165°
    - ϕ: 0°, 22.5° and 45°
- Implementation of aditional dead material:
  - MVD supplies.