

PANDA Backward Electromagnetic Calorimeter Studies with old framework

Status report

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05. 06. 2009

Outline

Simulation characteristics

- First simulation

- Second simulation

- Foreseen simulations

Variables

Analysis

- First results

- Last results

Other analysis

- Number of candidates per event

- Conversion probability

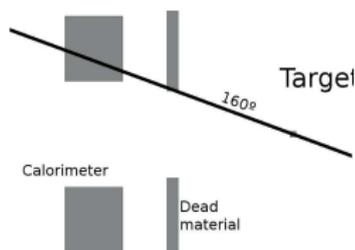
Outlook

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.
- ▶ Dimensions 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 ($2.24\text{ cm} \times 2.24\text{ cm}$), $r_{min} = 182\text{ mm}$, $r_{max} = 406\text{ mm}$, at $z = -594\text{ mm}$.
Full angular range: 145.65° , 167.09° .
- ▶ Dead material:
 - Nothing.
 - Low: Al, 2 cm $r_{min} = 150\text{ mm}$, $r_{max} = 418\text{ mm}$, at $z = -400\text{ mm}$ from the target. Behind STT.
 - High: Al, 4 cm $r_{min} = 150\text{ mm}$, $r_{max} = 418\text{ mm}$, at $z = -400\text{ mm}$ 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    → Id number of the event
ncnd                → Number of reconstructed candidates
Energy              → Corrected energy of each reconstructed candidate
rawEnergy           → Measured energy of each reconstructed candidate
costh               → Related with the reconstructed angle for the candidate
nmc                 → Number of montecarlo true particles
tEnergy             → Energy of each montecarlo true particle
tcosth              → Related with the angle of each montecarlo true particle
lundid             → Particle Id number of each montecarlo true particle (22 for photons)
vtxcause           → Origin of each montecarlo true particle (10 for event generator)
xpos                → X coordinate of the vertex of each montecarlo true particle
ypos                → Y coordinate of the vertex of each montecarlo true particle
zpos                → 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
```

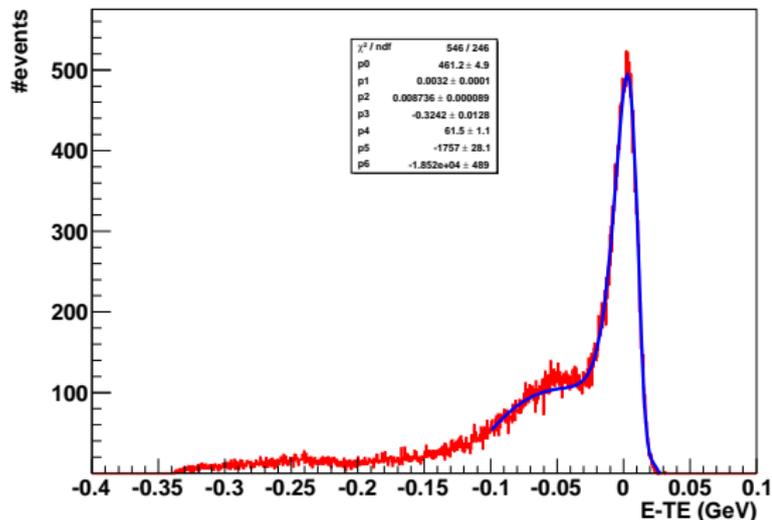
```
root [6]
emepTuple->Show(103)
=====>EVENT:103
ncnd = 2
Energy = 0.0214231,
0.170857
rawEnergy = 0.0163651,
0.156274
costh = -0.795457,
-0.89297
nmc = 2
tEnergy = 0.362898,
0.349363
tcosth = -0.845558,
-0.846095
lundid = 22,
11
vtxcause = 10,
201
xpos = 0,
6
ypos = 0,
13
zpos = 0,
-22
```

Novosibirsk function

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

Energy-Energy

SinglePhotonHighAlMerged.root
 Eff = 28472.8/48150.0 = 59.13
 vtxcause=10&&Energy>0.25&&Energy<0.35&&costh>-0.9659&&costh<-0.9063



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

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

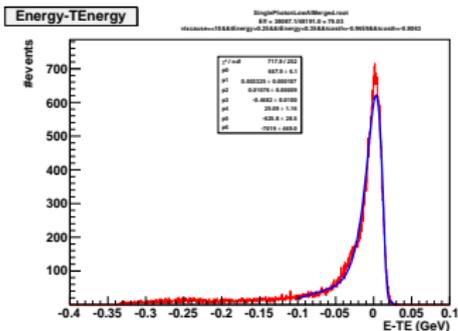
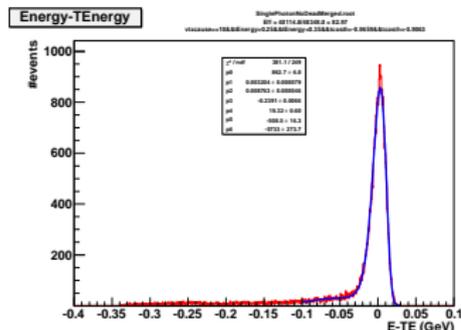
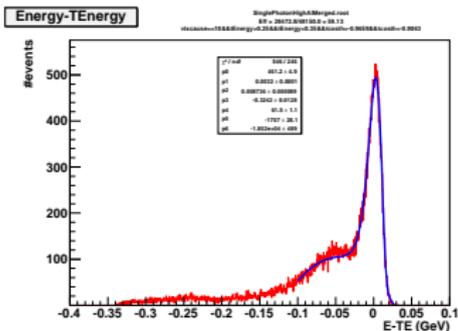
Eff 3-2: a=3, b=2

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



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

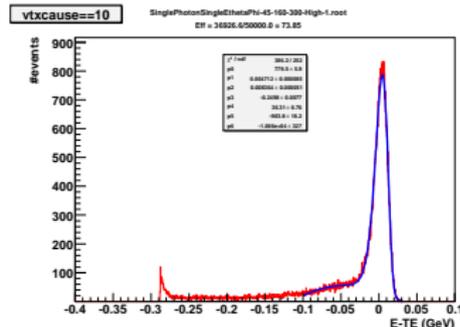
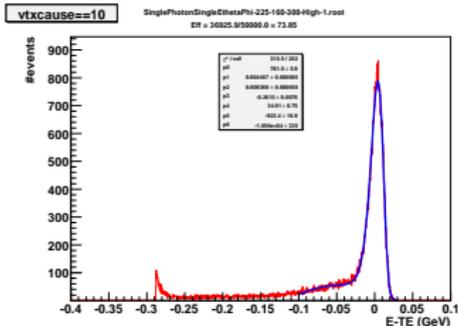
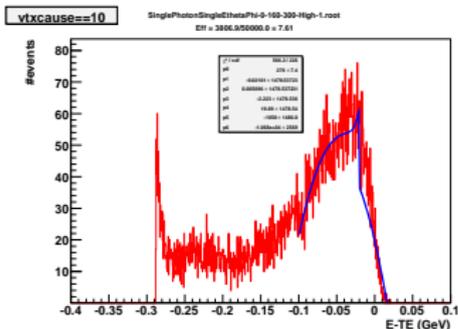
$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

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

Second simulation. Results High material.

CUT: $vtxcause=10$; $tEnergy = 0.25$; $costh=160^\circ$

SIMULATED EVENTS: 50000



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

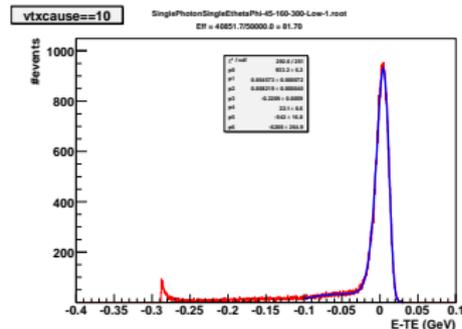
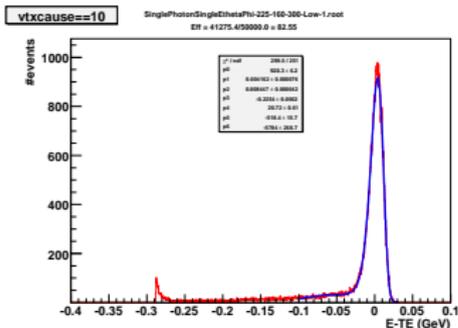
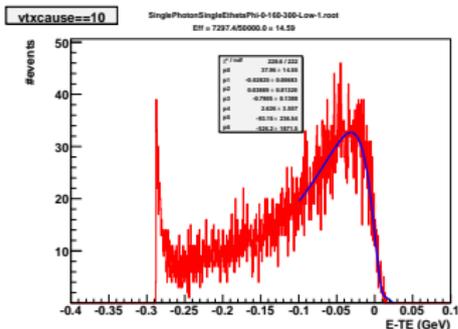
$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

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

Second simulation. Results Low material.

CUT: $vtxcause=10$; $tEnergy = 0.25$; $costh=160^\circ$

SIMULATED EVENTS: 50000



Simulation	Entries	σ GeV
45°	50000	0.008219 ± 0.000040
22.5°	50000	0.008447 ± 0.000042

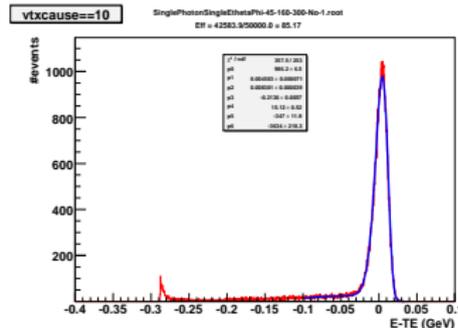
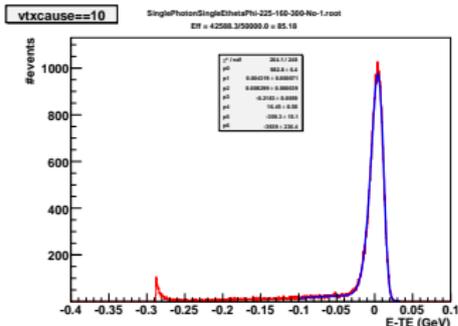
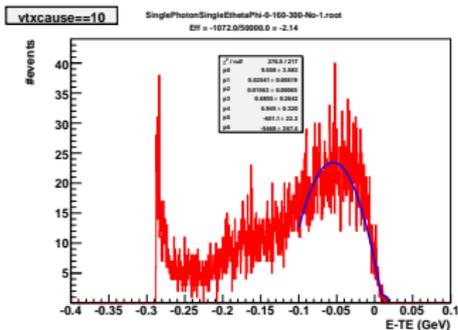
Simulation	Integral	Eff 3-2	Integral	Eff 5-3
45°	38994.7	77.99	40851.7	81.70
22.5°	39422.4	78.84	41275.4	82.55

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

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

Second simulation. Results No dead material.

CUT: $vtxcause=10$; $tEnergy = 0.25$; $costh=160^\circ$
 SIMULATED EVENTS: 50000



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		
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

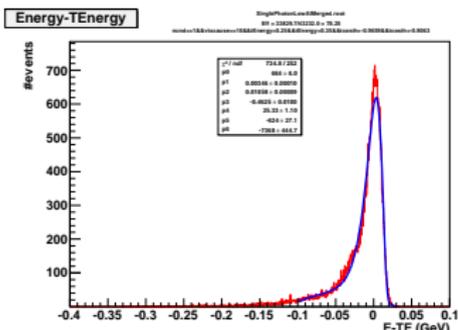
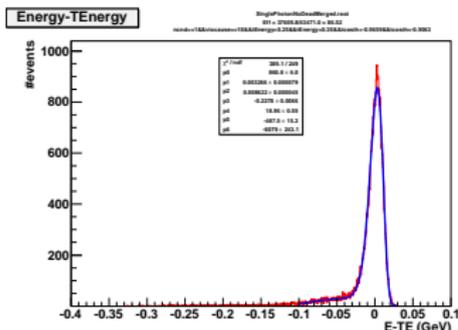
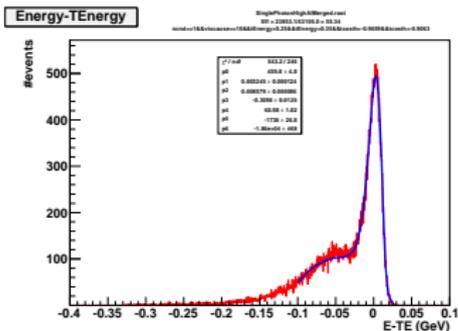
Second simulation, only vtxcause cut:

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: $n_{\text{cnd}}=1$; $\text{vtxcause}=10$; $0.35 > t_{\text{Energy}} > 0.25$; $-0.9063 > t_{\text{costh}} > -0.9659$

SIMULATED EVENTS: 1000000



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

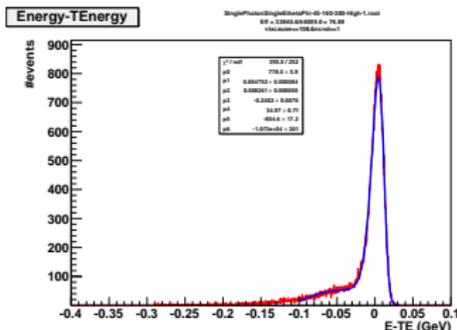
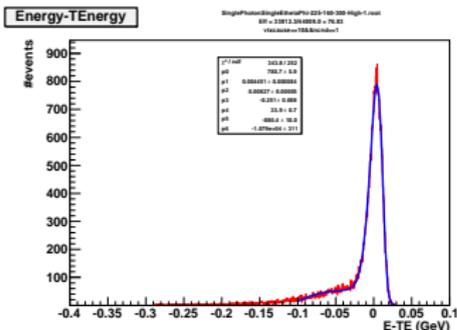
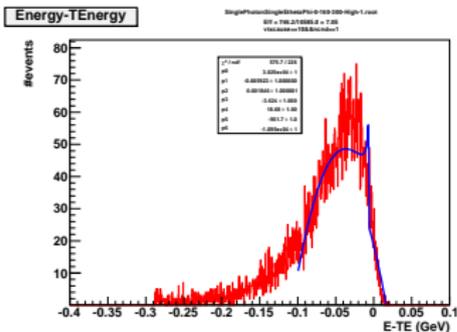
$$\text{Eff} = \frac{\text{Integral}(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{\text{Entries}}$$

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

Second simulation. Results High material.

CUT: $n_{cd}=1$; $vt_{xcause}=10$; $tEnergy = 0.25$; $costh=160^\circ$

SIMULATED EVENTS: 50000



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

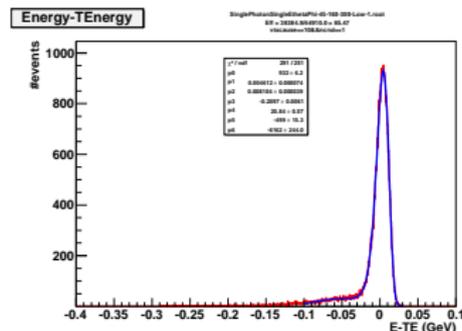
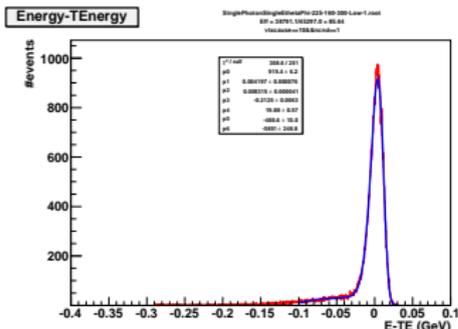
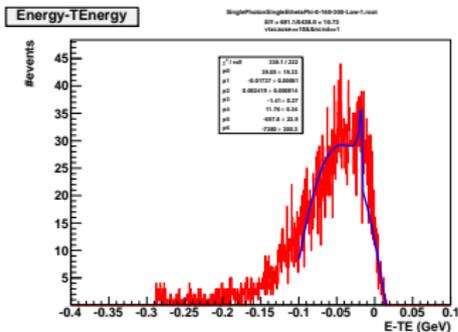
$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

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

Second simulation. Results Low material.

CUT: $n_{cd}=1$; $vt_{xcause}=10$; $tEnergy = 0.25$; $\cosh=160^\circ$

SIMULATED EVENTS: 50000



Simulation	Entries	σ GeV
45°	44910	0.008104 ± 0.000039
22.5°	45297	0.008315 ± 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

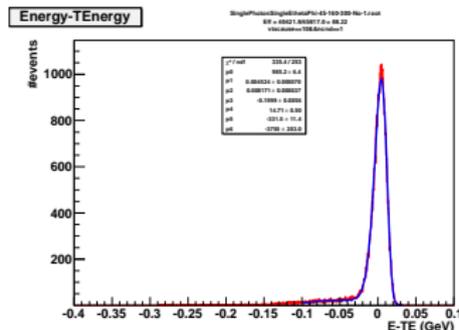
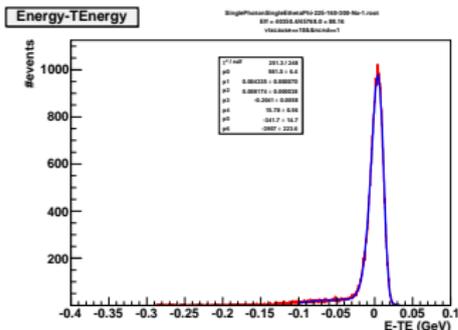
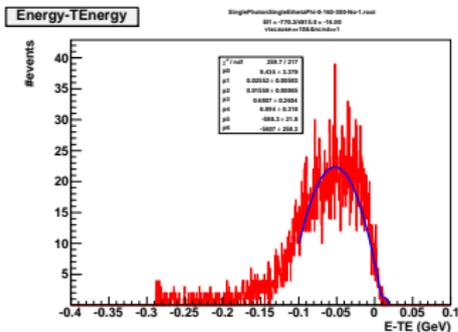
$$Eff = \frac{Integral(\mu - 3 \cdot \sigma, \mu + 2 \cdot \sigma)}{Entries}$$

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

Second simulation. Results No dead material.

CUT: $n_{cd}=1$; $vt_{xcause}=10$; $t_{Energy} = 0.25$; $costh=160^\circ$

SIMULATED EVENTS: 50000



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 ncmd:

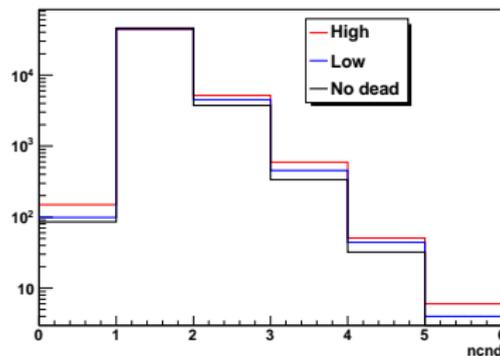
Simulation	Entries	σ GeV		
No dead	43471	0.008622 \pm 0.000045		
Low	43232	0.01058 \pm 0.00009		
High	43105	0.008579 \pm 0.000086		
Simulation	Integral	Eff 3-2	Integral	Eff 5-3
No dead	37609.8	86.52	39350.7	90.52
Low	33829.7	78.25	37303.9	86.29
High	23853.1	55.34	27852.6	64.82

Second simulation, cuts on vtxcause and ncmd:

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

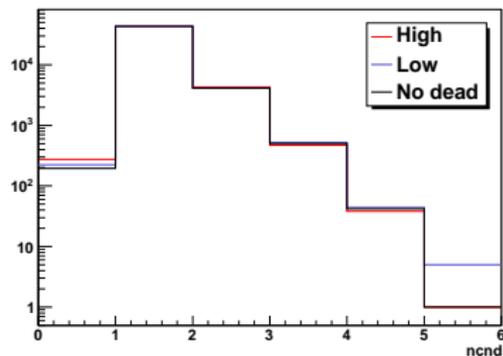
Number of candidates per event

$\phi = 45, \theta = 160, E = 300 \text{ MeV}$



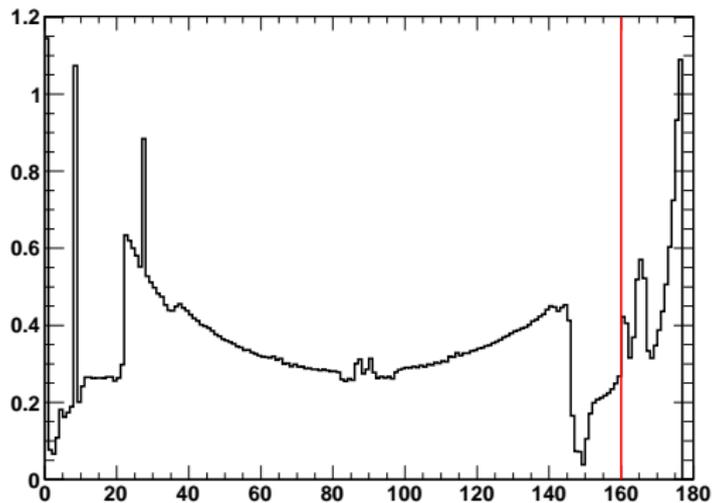
Candidates	No dead	Low	High
0	86	99	150
1	45817	44910	44009
2	3275	4486	5189
3	337	456	595
4	32	44	51
5	2	4	6
6	1	1	0
Total	50000	50000	50000
1cand/Total	91.63%	89.82%	88.01%
Eff 5-3	91.41%	89.37%	82.39%

First simulation with cuts

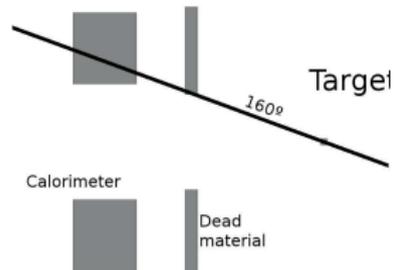


Candidates	No dead	Low	High
0	195	223	276
1	43471	43232	43105
2	4133	4163	4262
3	505	524	468
4	42	44	38
5	1	5	1
6	1	0	0
Total	48348	48191	48150
1cand/Total	89.91%	89.71%	89.52%
Eff 5-3	90.52%	86.29%	64.82%

Radiation lengths

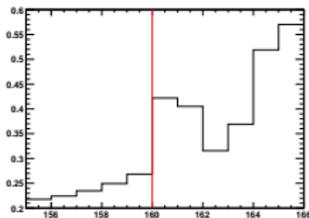
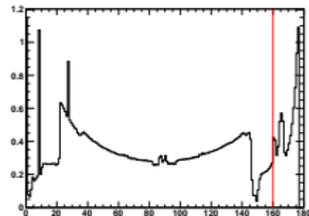


X axis: $\theta(^{\circ})$; Y axis: Radiation lengths
 160° : Angle of simulation.

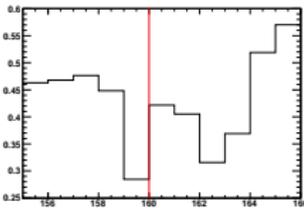
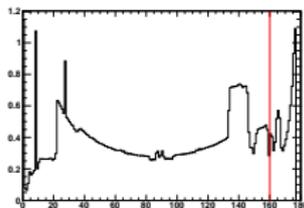


Radiation lengths

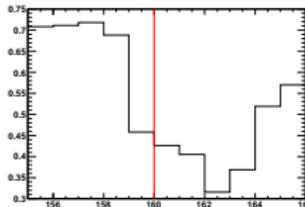
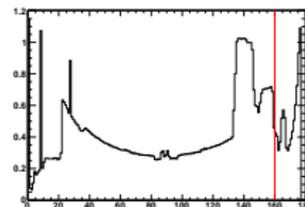
No dead:



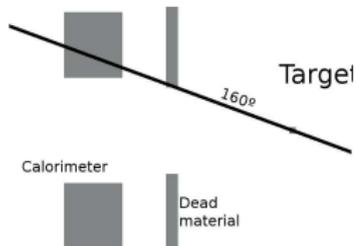
Low:



High:



Material	bin left	bin right	mean
No dead	0.27	0.42	0.345
Low	0.29	0.42	0.355
High	0.46	0.43	0.445



Outlook

- ▶ Results of first and second simulation are comparable.
- ▶ Calculate the energy resolution from the value of the fit σ .
- ▶ Test other fit functions (Gabler fit function, A4 fit function).
- ▶ Calculate the conversion probability according to the dead material and compare it with the results.
- ▶ 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 additional dead material.
 - MVD supplies.