

The backward end-cap EMC simulations - comparison of tapered & straight crystals

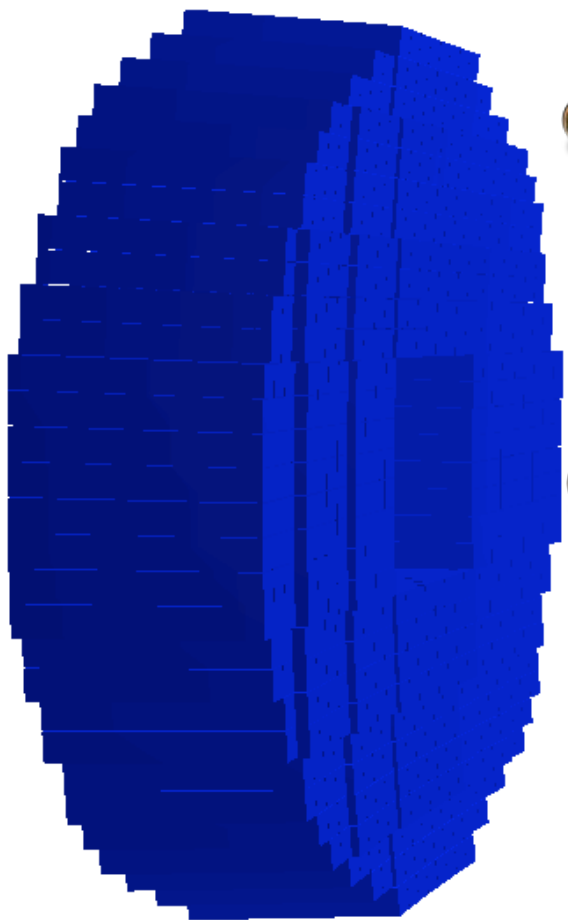
Aleksandra Biegun

PANDA CM, GSI, 2-6 March 2009



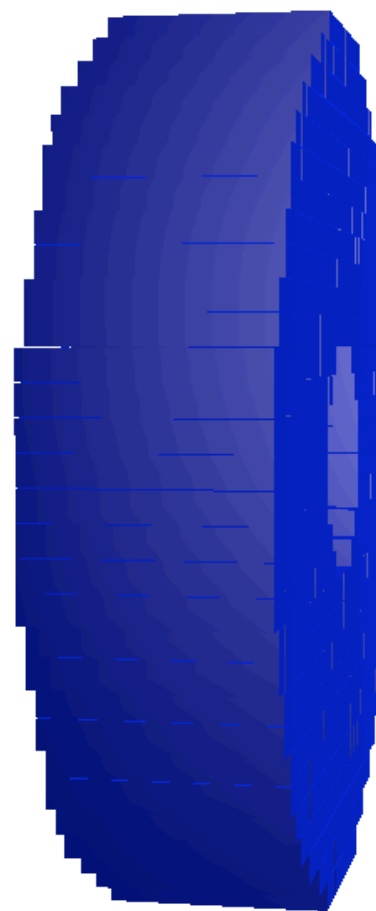
- **The maximum acceptance**
- **Optimization of the energy resolution at the edges**

1) Tapered crystals (Forward EndCap geometry)



- *Crystal size (mm):*
front: 24.4x24.4x200
back: 26x26x200
- *θ range:*
146.1° - 169.5°
- *Diameter (mm)*
front face: 752.85

2) Straight crystals



- *Crystal size (mm):*
26x26x200
- *θ range:*
144.4° - 170°
- *Diameter (mm):*
801.60

- Photon Energy: **0.1 - 5.0 GeV**
- Polar photon angles θ : **145^o - 175^o**

θ bin: size of crystal

Energy bin:

100 MeV - for $E_{\text{photon}} < 1 \text{ GeV}$

500 MeV - for $E_{\text{photon}} > 1 \text{ GeV}$

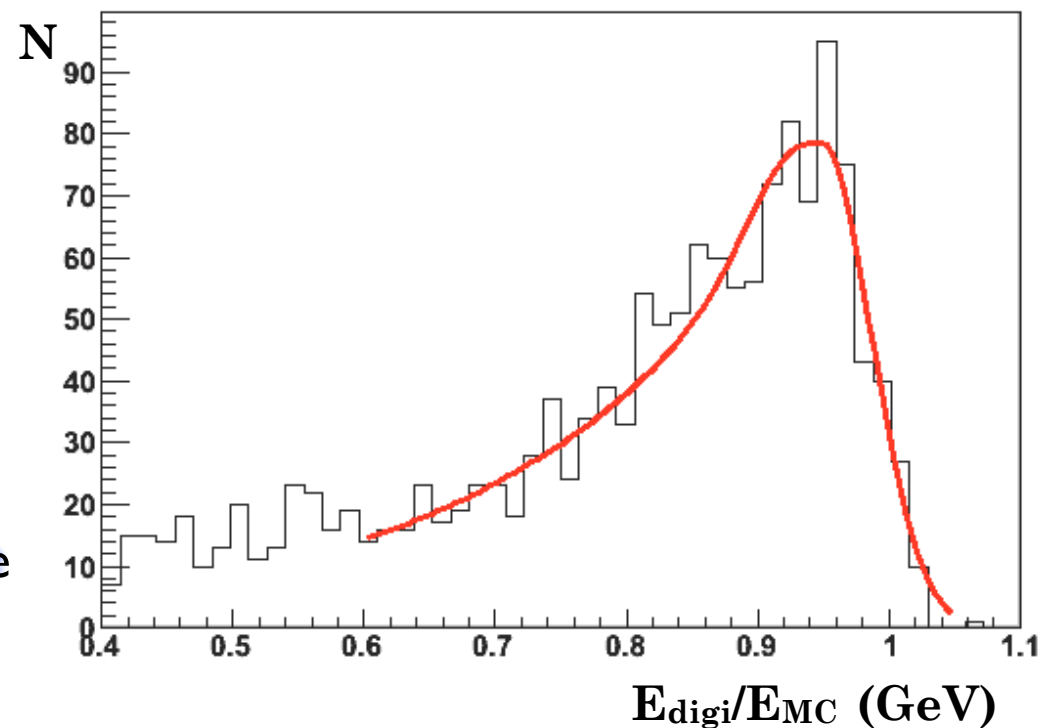
For each θ & energy bin:

$E_{\text{digi}}/E_{\text{MC}}$

E_{digi} - energy summed over all crystals
taking into account electronic response

Gabler function fit

A.R. Gabler et al.,
Nucl. Instr. and Meth. A 346 (1994) 168-176



$$y = N G$$

for $E \geq E_{\text{peak}}$

$$y = N (G + \exp(E - E_{\text{peak}} / \lambda) (1 - G))$$

for $E \leq E_{\text{peak}}$

$$G = \exp(-4 \ln 2 (E - E_{\text{peak}})^2 / \Gamma^2)$$

 **FWHM/Mean**

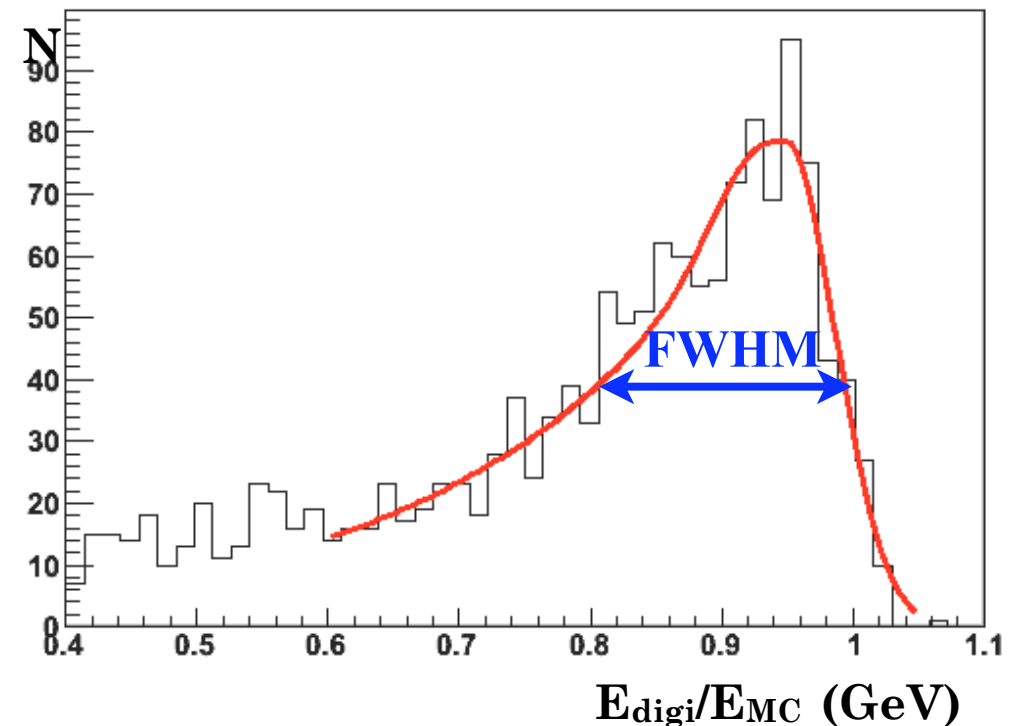
 λ

E_{peak} - most probable energy

N - normalization

λ - FWHM for low energy tail

Γ - FWHM of the Gaussian, describes the high energy side of the peak



$$y = N G$$

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 **FWHM/Mean**

 λ

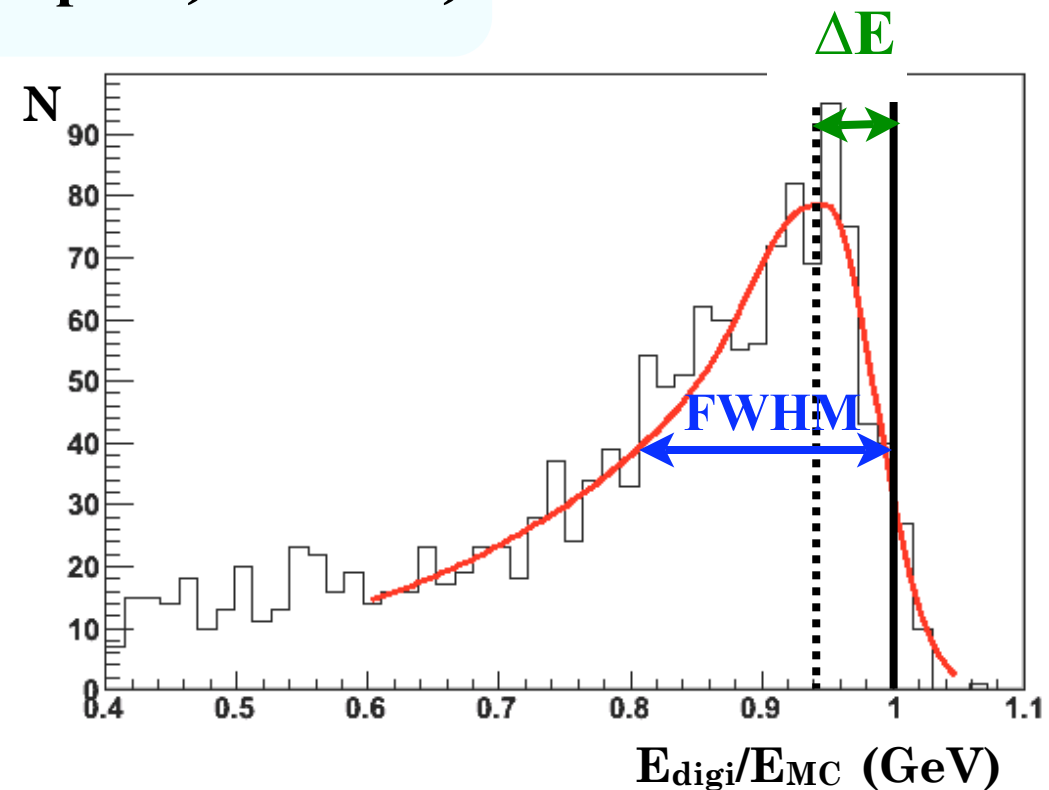
 ΔE

E_{peak} - most probable energy

N - normalization

λ - FWHM for low energy tail

Γ - FWHM of the Gaussian, describe the high energy side of the peak



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FWHM/Mean



λ



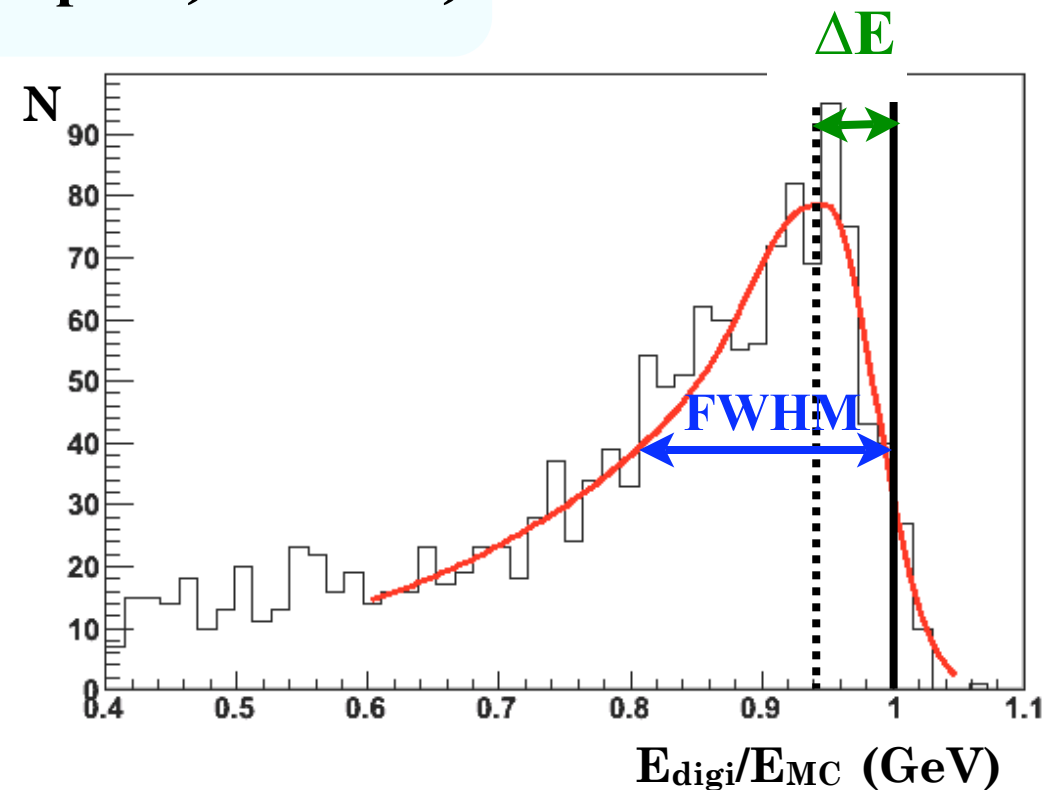
ΔE

E_{peak} - most probable energy

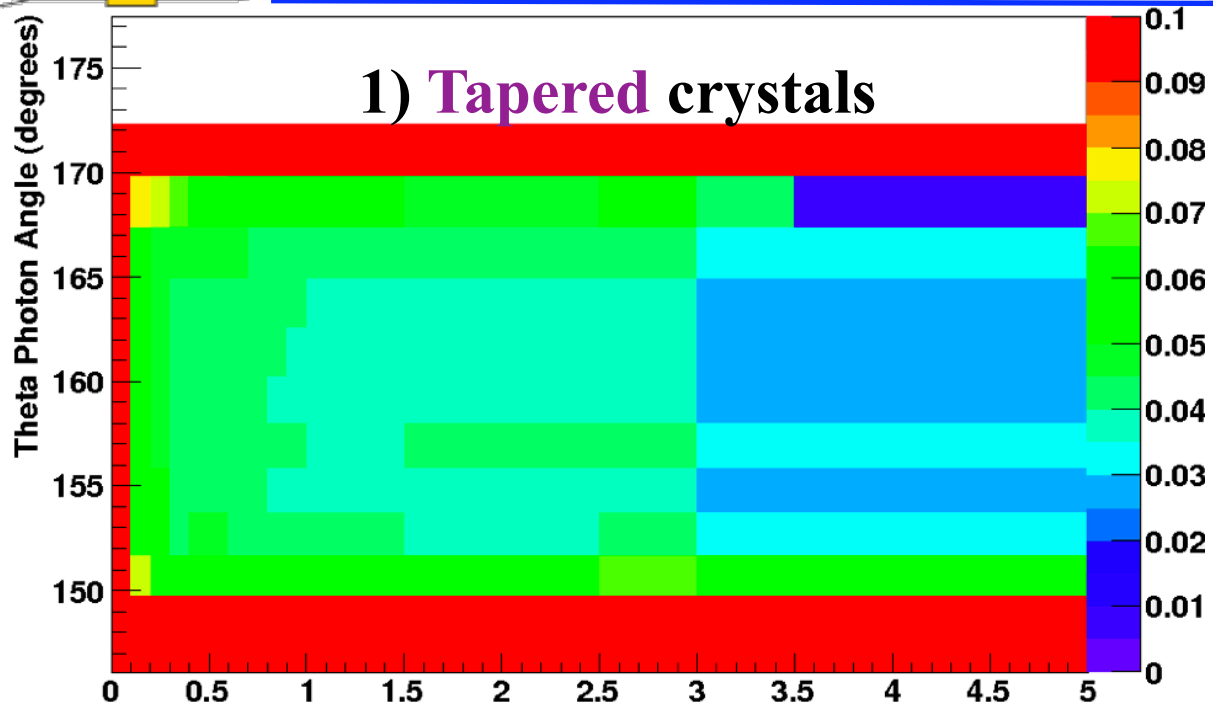
N - normalization

λ - FWHM for low energy tail

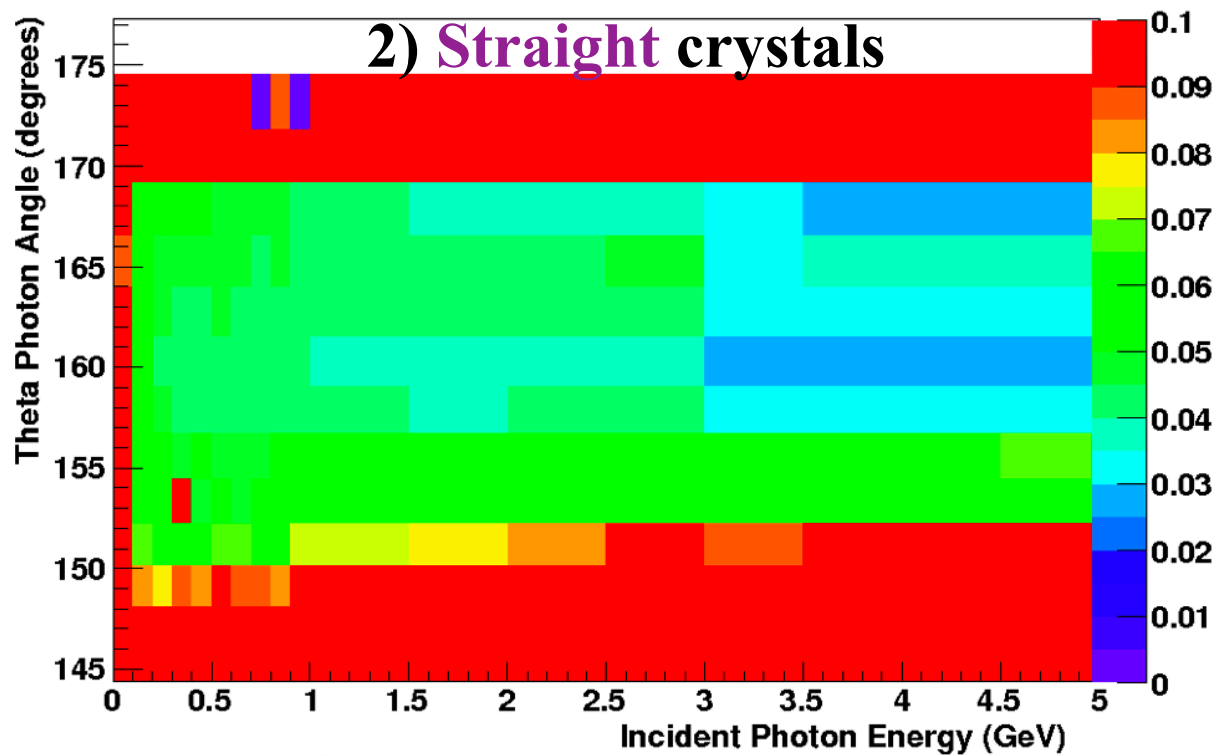
Γ - FWHM of the Gaussian, describe the high energy side of the peak



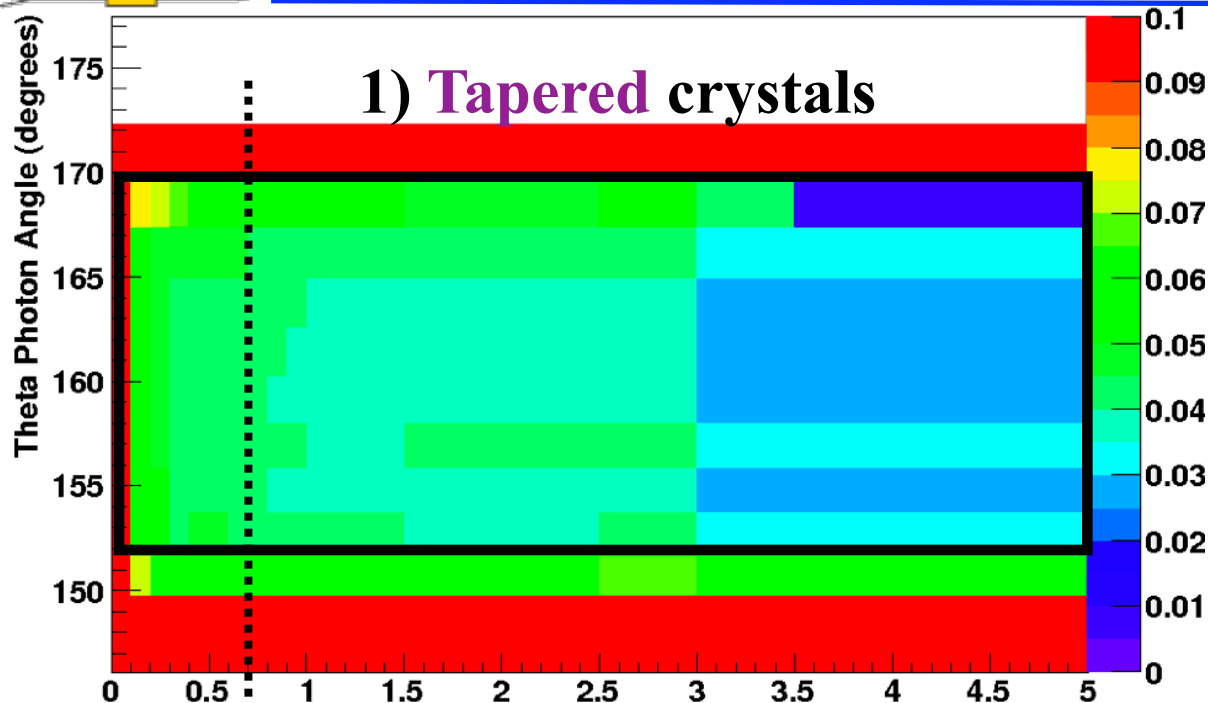
1) Tapered crystals



2) Straight crystals



1) Tapered crystals



The core detection area

G4

similar energy resolution

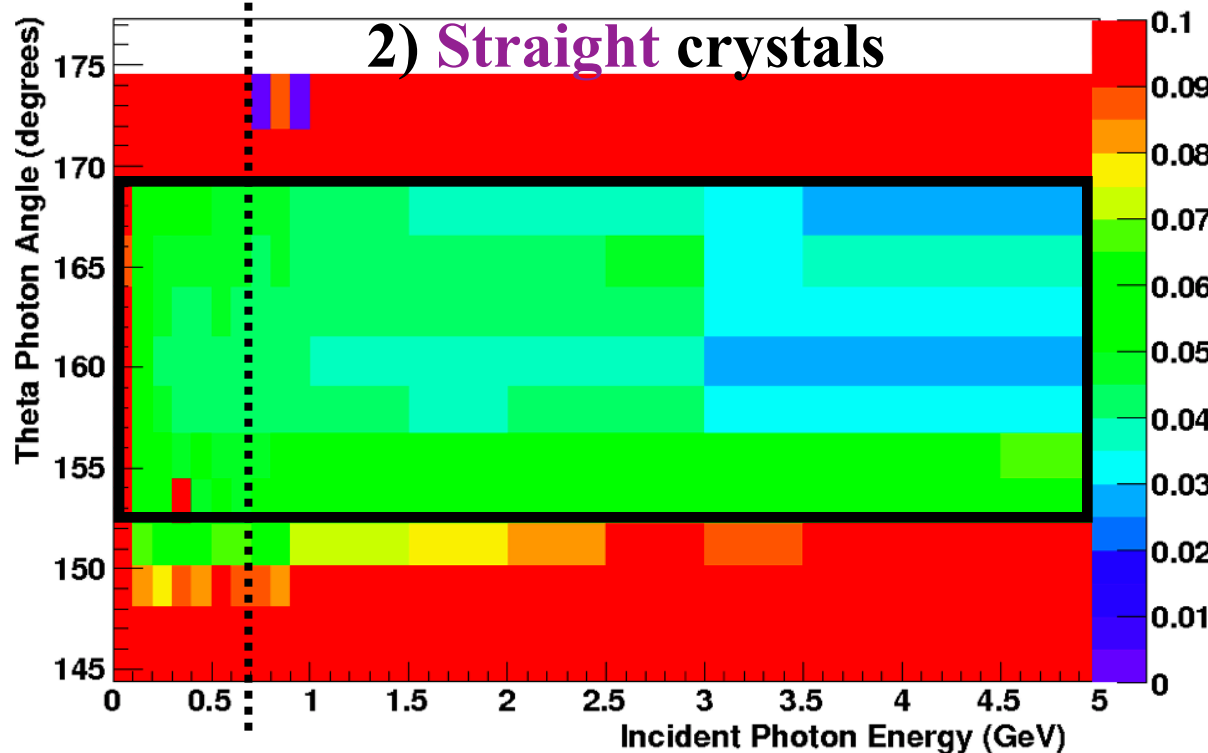
4% - 7%

$E_{\text{photon}} < 700 \text{ MeV}$

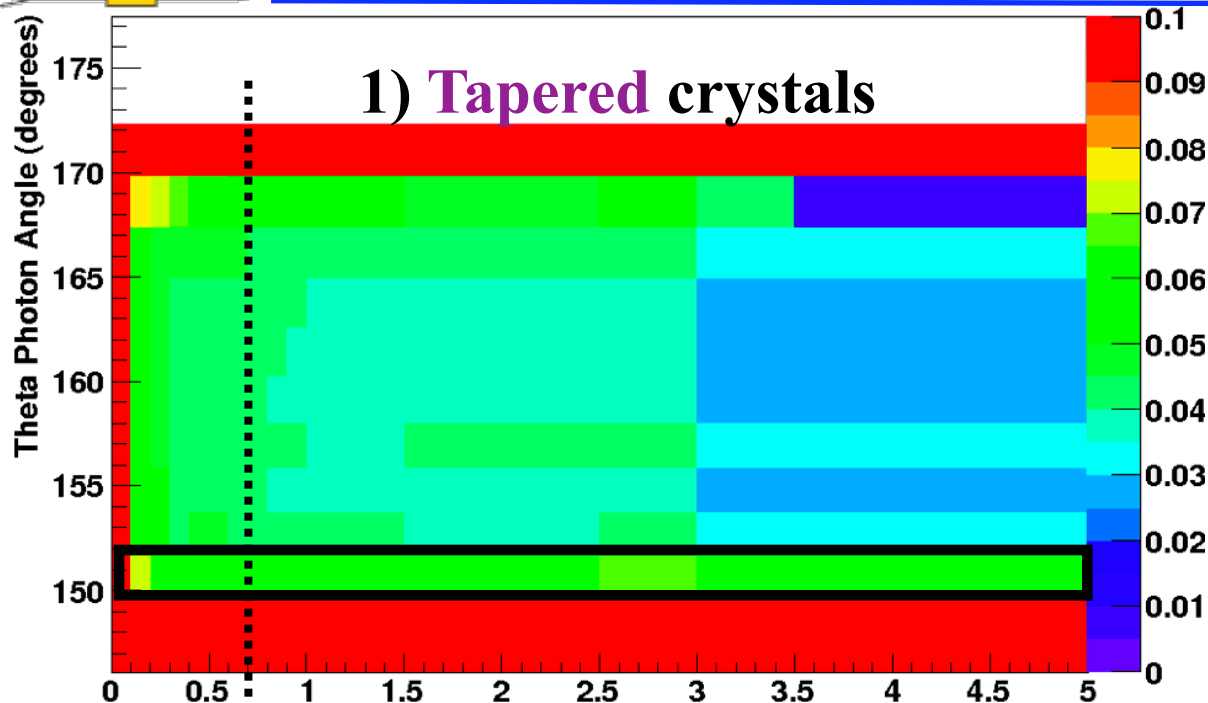
2.5% - 4%

$E_{\text{photon}} > 700 \text{ MeV}$

2) Straight crystals



1) Tapered crystals



The core detection area

similar energy resolution

4% - 7% $E_{\text{photon}} < 700 \text{ MeV}$

2.5% - 4% $E_{\text{photon}} > 700 \text{ MeV}$



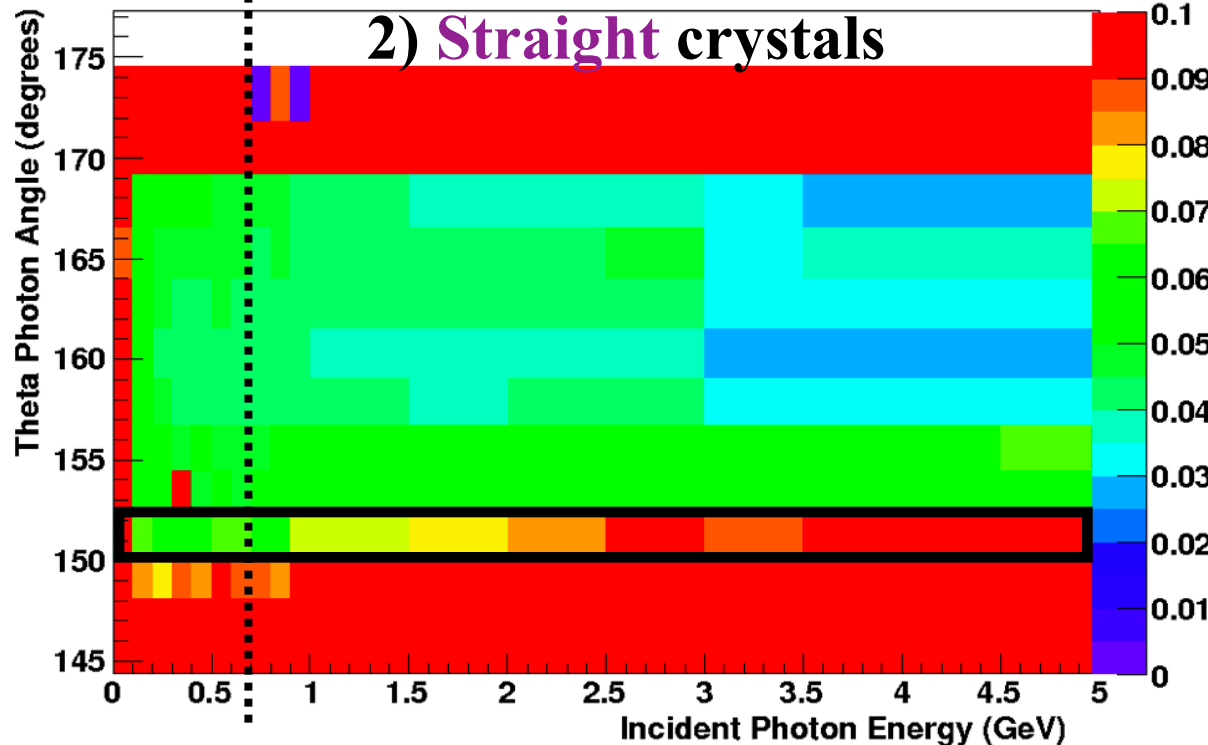
The edge: $\theta \approx 150^\circ$

$E_{\text{photon}} < 700 \text{ MeV}$

tapered: 7%

straight: 7%

2) Straight crystals

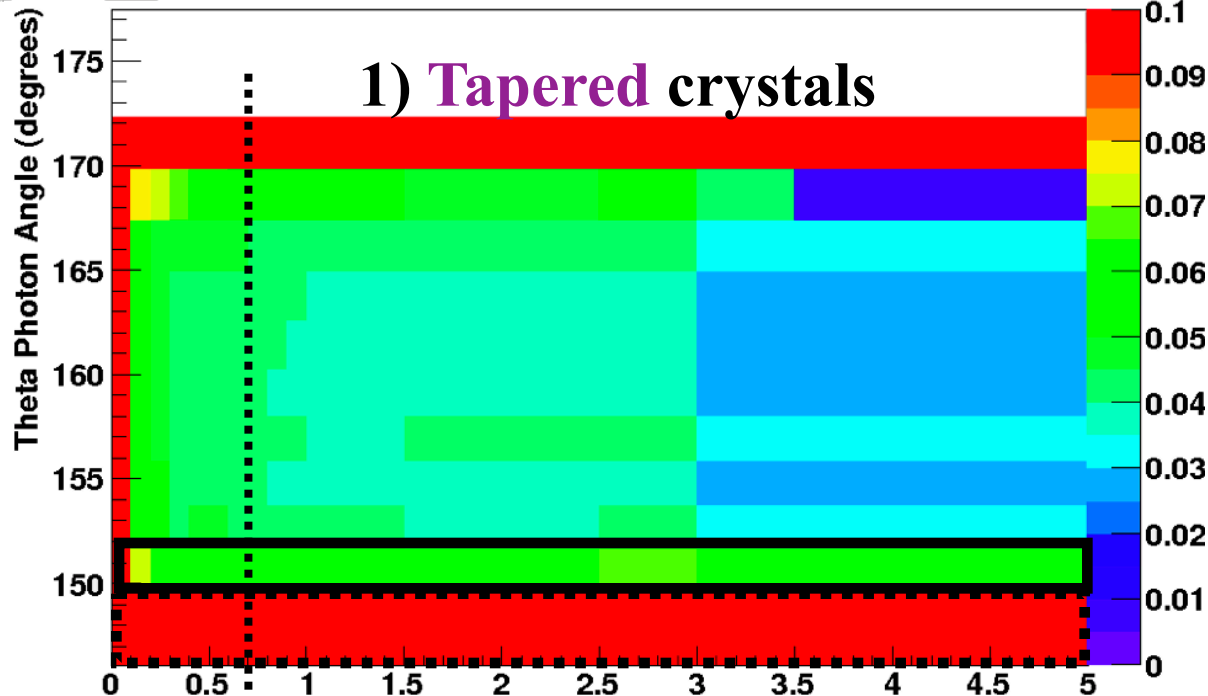


$E_{\text{photon}} > 700 \text{ MeV}$

tapered: 7%

straight: 7-10%

1) Tapered crystals



The core detection area

similar energy resolution

4% - 7% $E_{\text{photon}} < 700 \text{ MeV}$

2.5% - 4% $E_{\text{photon}} > 700 \text{ MeV}$

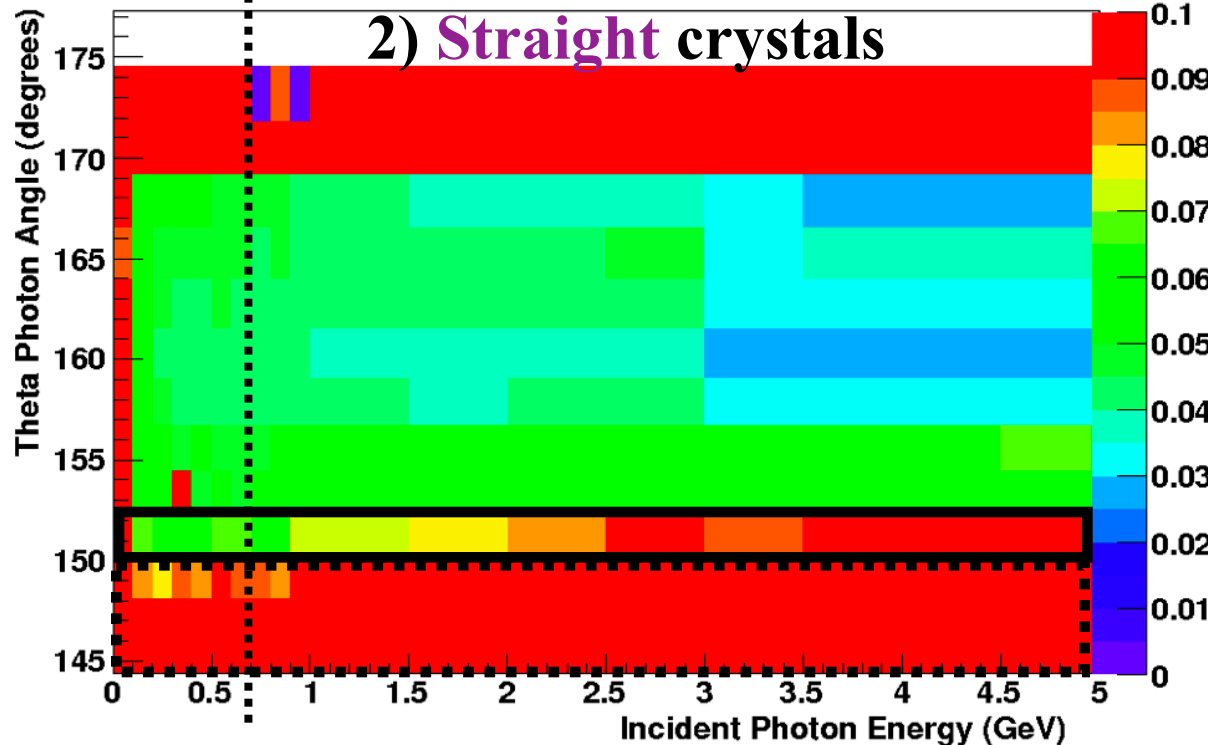
The edge: $\theta \approx 150^\circ$

$E_{\text{photon}} < 700 \text{ MeV}$

tapered: 7%

straight: 7%

2) Straight crystals



$E_{\text{photon}} > 700 \text{ MeV}$

tapered: 7%

straight: 7-10%

The edge: $\theta < 150^\circ$

* bad for both! $> 10\%$

* more straight crystals with bad resolution

$$y = N G$$

for $E \geq E_{\text{peak}}$

$$y = N (G + \exp(E - E_{\text{peak}} / \lambda) (1 - G))$$

for $E \leq E_{\text{peak}}$

$$G = \exp(-4 \ln 2 (E - E_{\text{peak}})^2 / \Gamma^2)$$

 **FWHM/Mean**

 λ bigger $\lambda \rightarrow$ worse **FWHM**

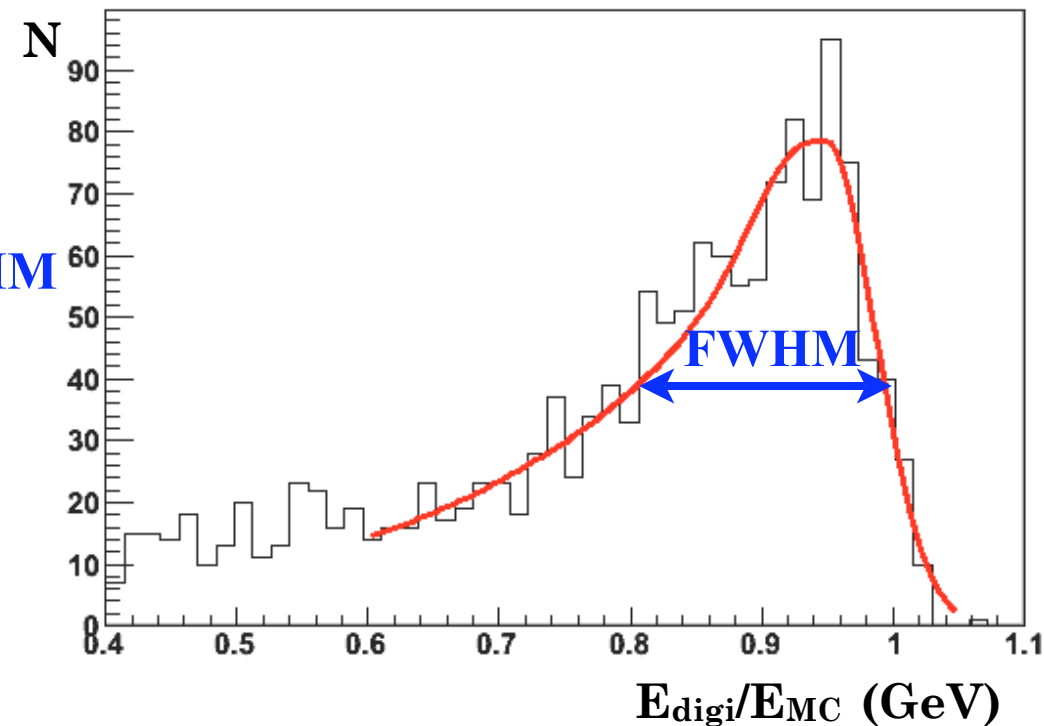
 ΔE

E_{peak} - most probable energy

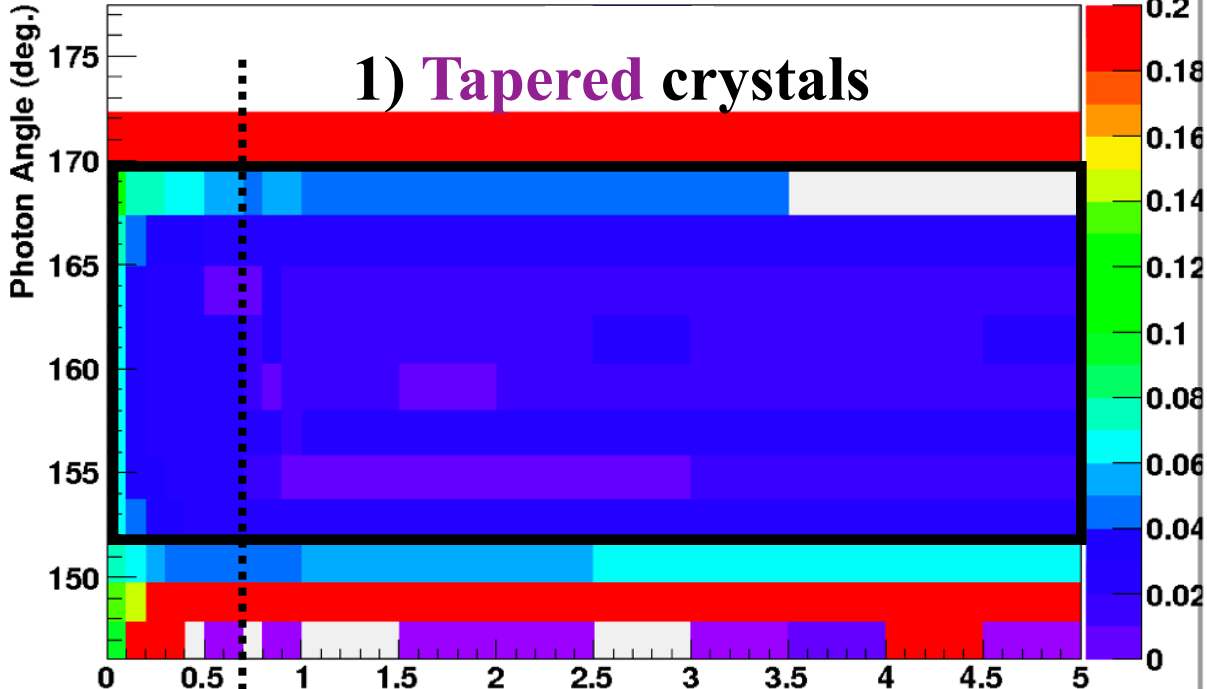
N - normalization

λ - FWHM for low energy tail

Γ - FWHM of the Gaussian, describe the high energy side of the peak



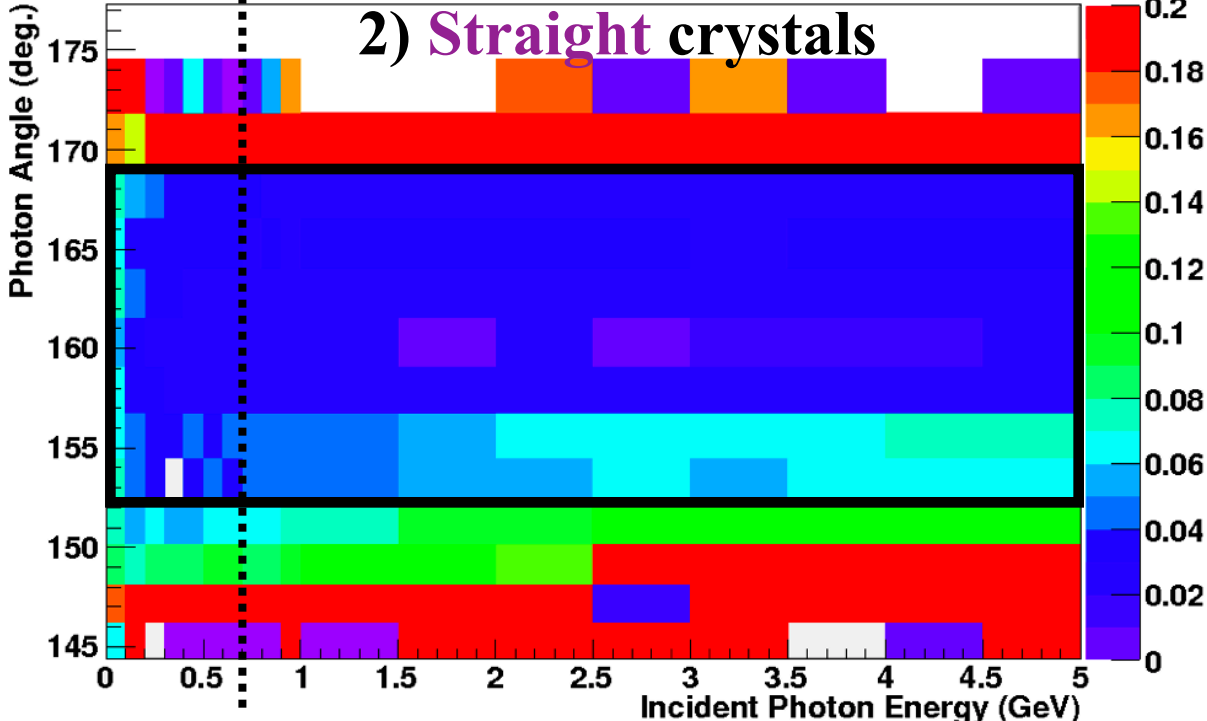
1) Tapered crystals



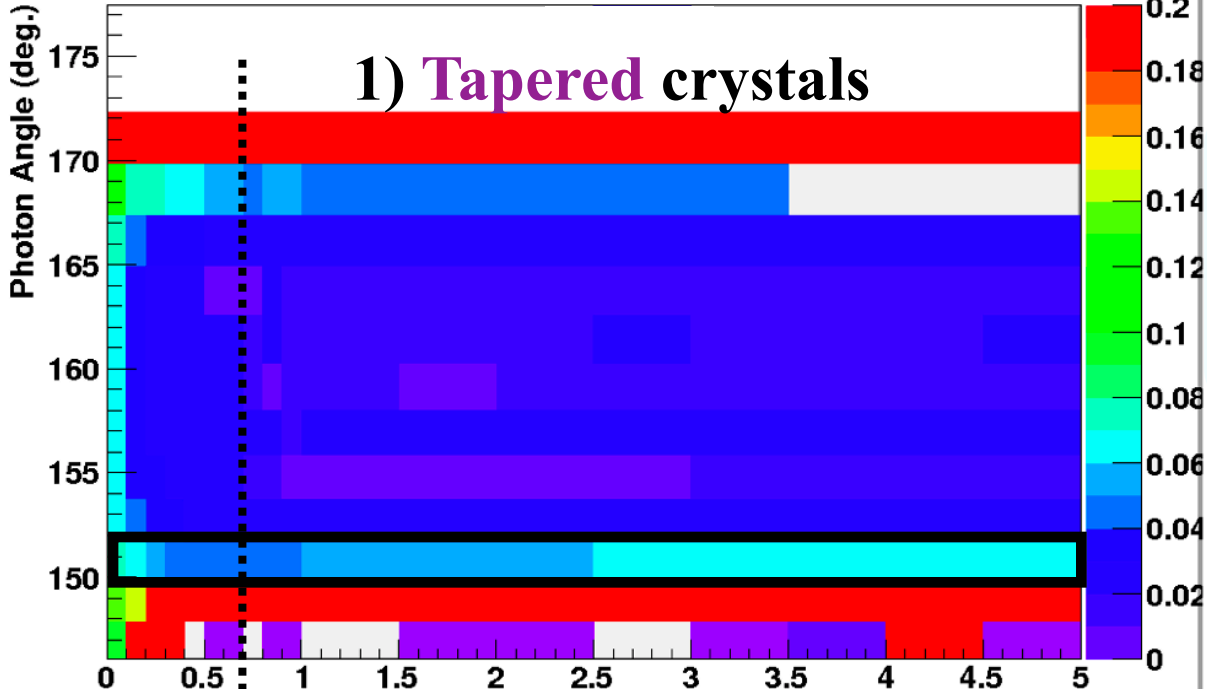
 The core detection area

- * for tapered: 1%-5% (better & more homogeneous)
- * for straight: up to 8%

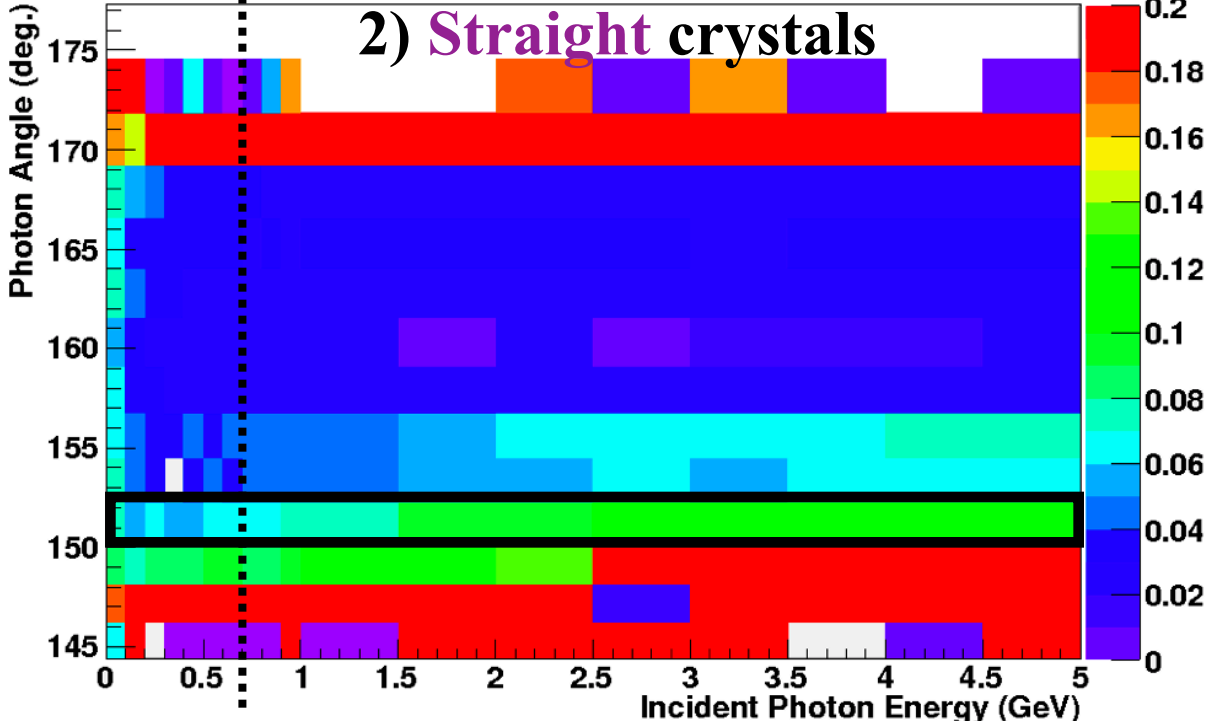
2) Straight crystals



1) Tapered crystals



2) Straight crystals



The core detection area

* for tapered: 1%-5%
(better & more homogeneous)
* for straight: up to 8%

The edge: $\theta \approx 150^\circ$

$E_{\text{photon}} < 700 \text{ MeV}$
tapered: 5-7%
straight: 6-7%

$E_{\text{photon}} > 700 \text{ MeV}$
tapered: 5-7%
straight: 7-10%

The edge: $\theta < 150^\circ$

* bad for both! $> 10\%$

λ confirms FWHM/Mean

$$y = N G$$

for $E \geq E_{\text{peak}}$

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 **FWHM/Mean**

 λ

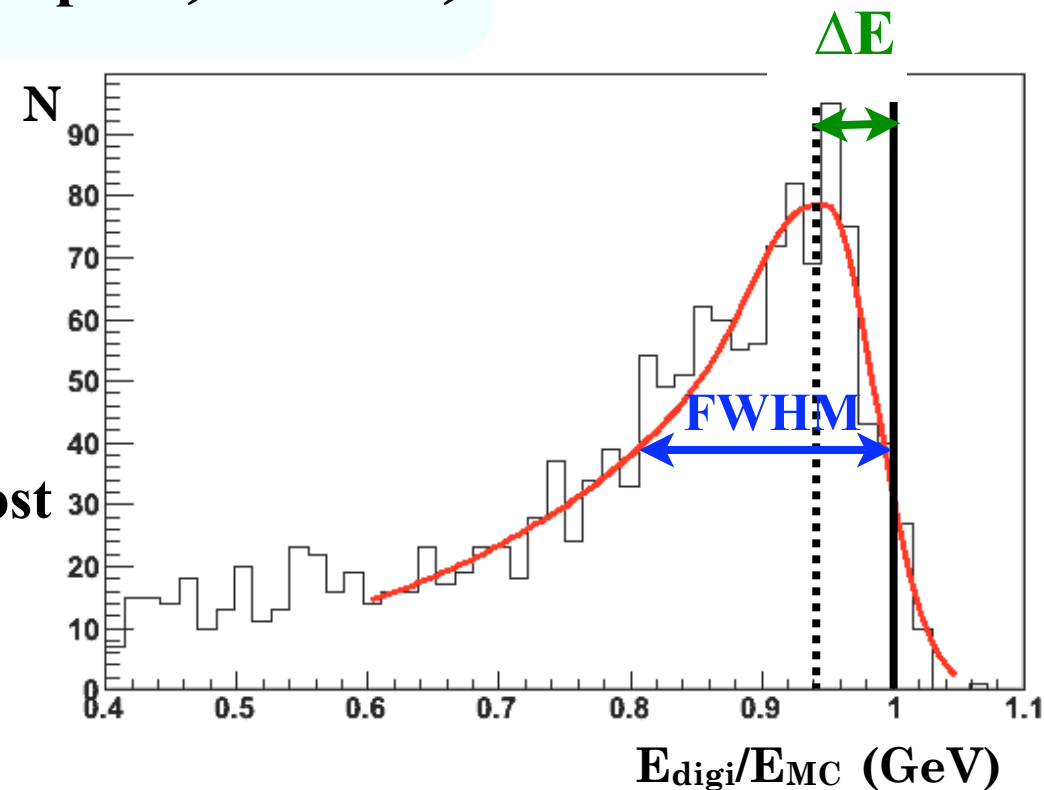
 ΔE bigger ΔE
 → more photons are lost

E_{peak} - most probable energy

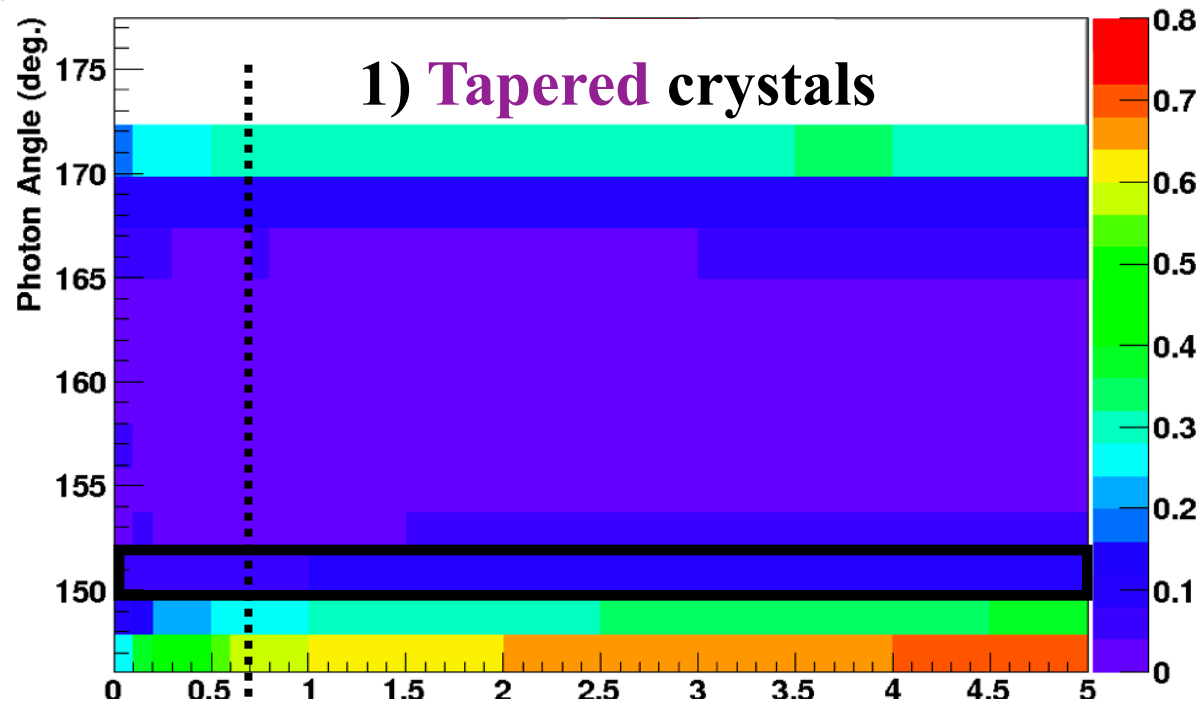
N - normalization

λ - FWHM for low energy tail

Γ - FWHM of the Gaussian, describe the high energy side of the peak



1) Tapered crystals



The core detection area

* similar behaviour



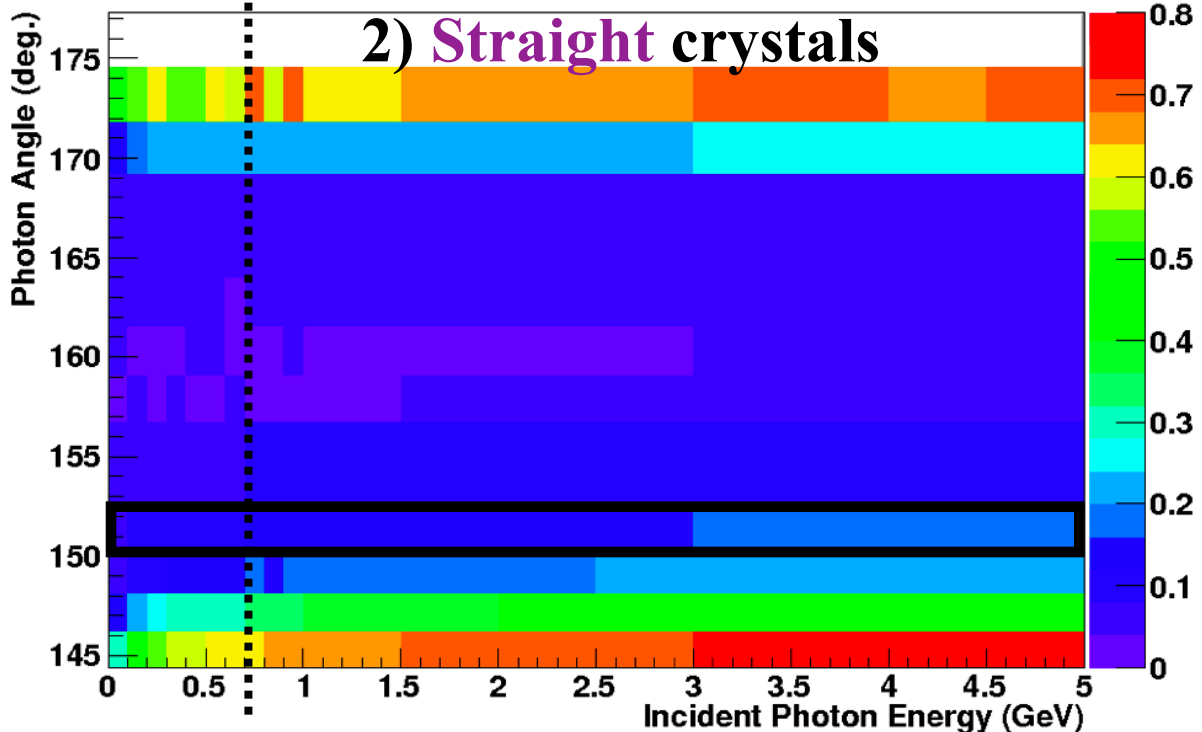
The edge: $\theta \approx 150^\circ$

$E_{\text{photon}} < 700 \text{ MeV}$

tapered: 10%

straight: 10%

2) Straight crystals



$E_{\text{photon}} > 700 \text{ MeV}$

tapered: 10%

straight: 15-20%



The edge: $\theta < 150^\circ$

* bad for both!

tapered: up to 60% <700 MeV

straight: up to 65% <700 MeV

The two geometry of Backward End-Cap EMC have been compared - **tapered** & **straight** crystals

The energy resolution:

in the core detection area is *similar* for both geometries

at the edge:

$$\theta \approx 150^\circ$$

$$E_{\text{photon}} < 700 \text{ MeV}$$

the same values for both: **7%**

$$E_{\text{photon}} > 700 \text{ MeV}$$

worse response for **straight** crystals: **up to 10%**

Straight crystals give slightly more θ coverage (about 2°), but the energy resolution is low below $\theta < 150^\circ$

Tapered crystals show more homogeneous performance in energy resolution

Mounting of **tapered** crystals could be the same like for FwEndCap

More studies need to be done:

(*position resolution*, material in the front, shorter crystals)

 Backward - **old** version: **straight crystals** *crystal size:* 20 x 20 x 200 mm³ *θ range:* 151° - 173° *diameter:* 744 mm

→ Existing
in the PandaRoot

Backward - **new**: straight crystals

 *crystal size*: 26 x 26 x 200 mm³

 *θ range*: 144.7° - 170°

 *diameter*: 780 mm

Backward - **new**: FwEndCap geometry

 *crystal size (front)*: 24.4 x 24.4 x 200 mm³

(back): 26 x 26 x 200 mm³

 *θ range*: 146° - 169.7°

 *diameter*: 740 mm (*front face*)

Backward - **new**: off-pointing geometry

 *crystal size (front)*: 20.53 x 20.53 x 200 mm³

(back): 26 x 26 x 200 mm³

 *θ range*: 151° - 169.7°

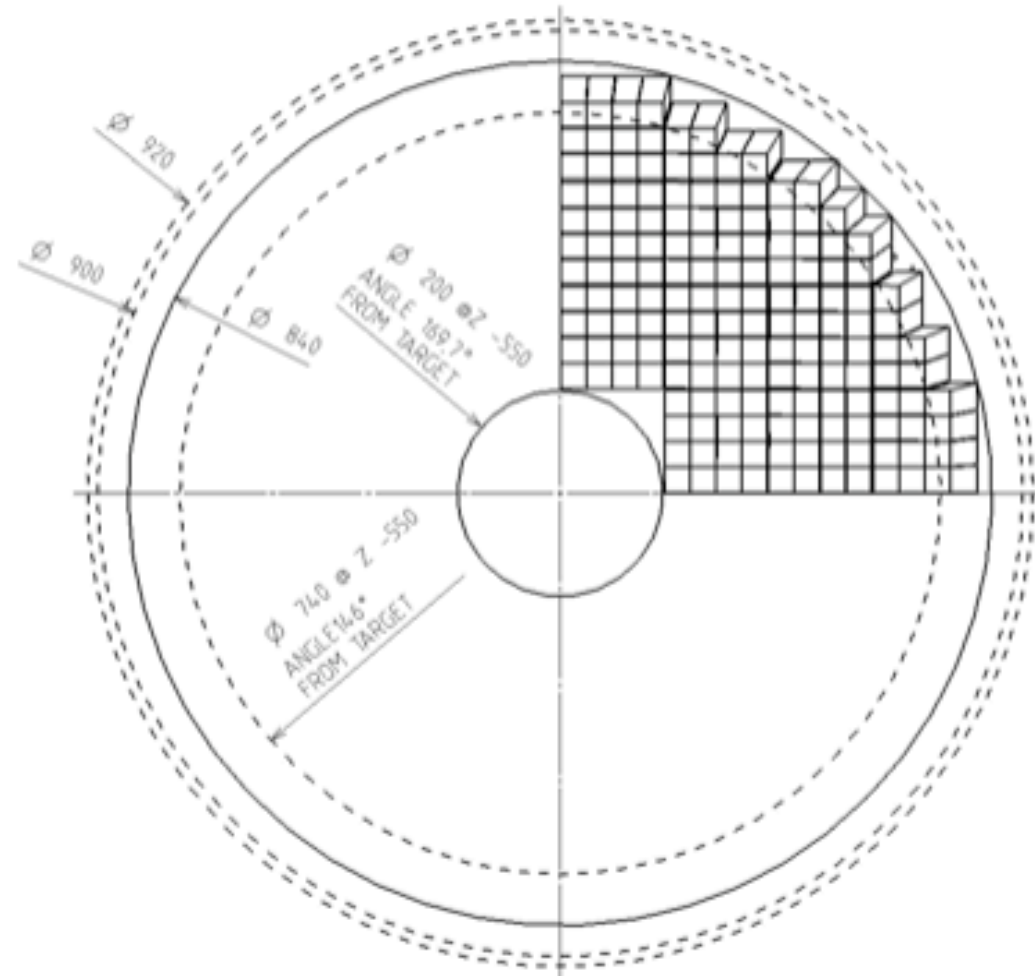
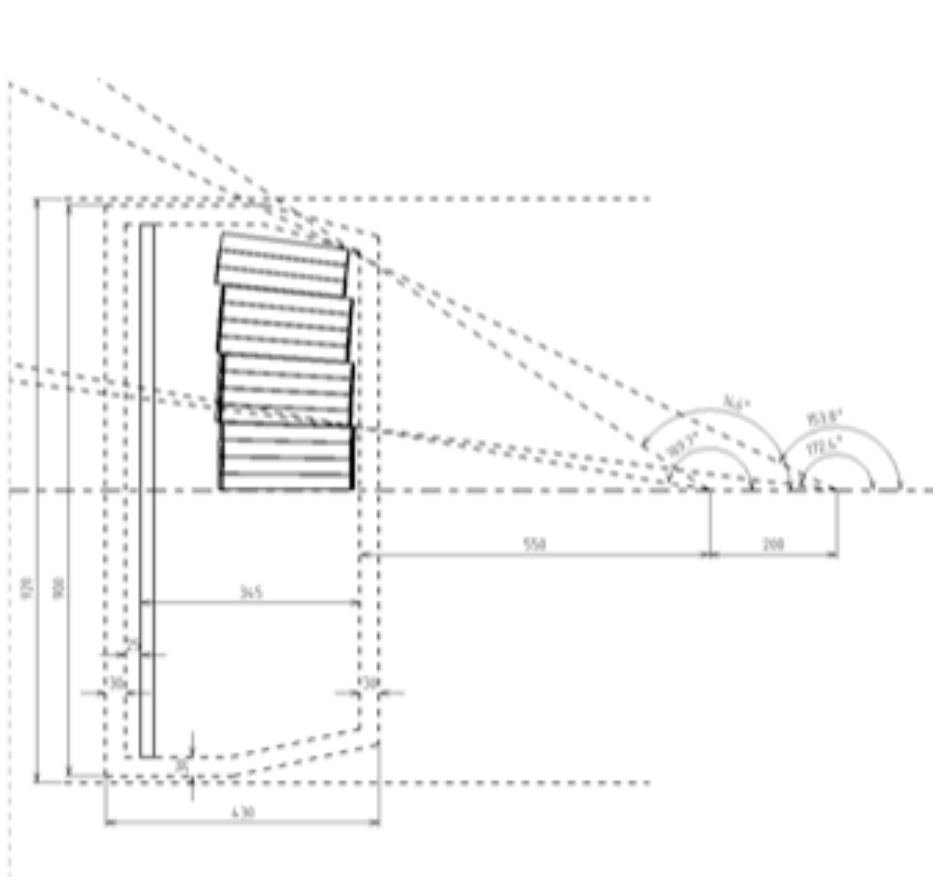
 *diameter*: 600 mm (*front face*)

← Not presented

BwEndcap with FwEndcap geometry

(24.4x24.4x200 mm³) - front side

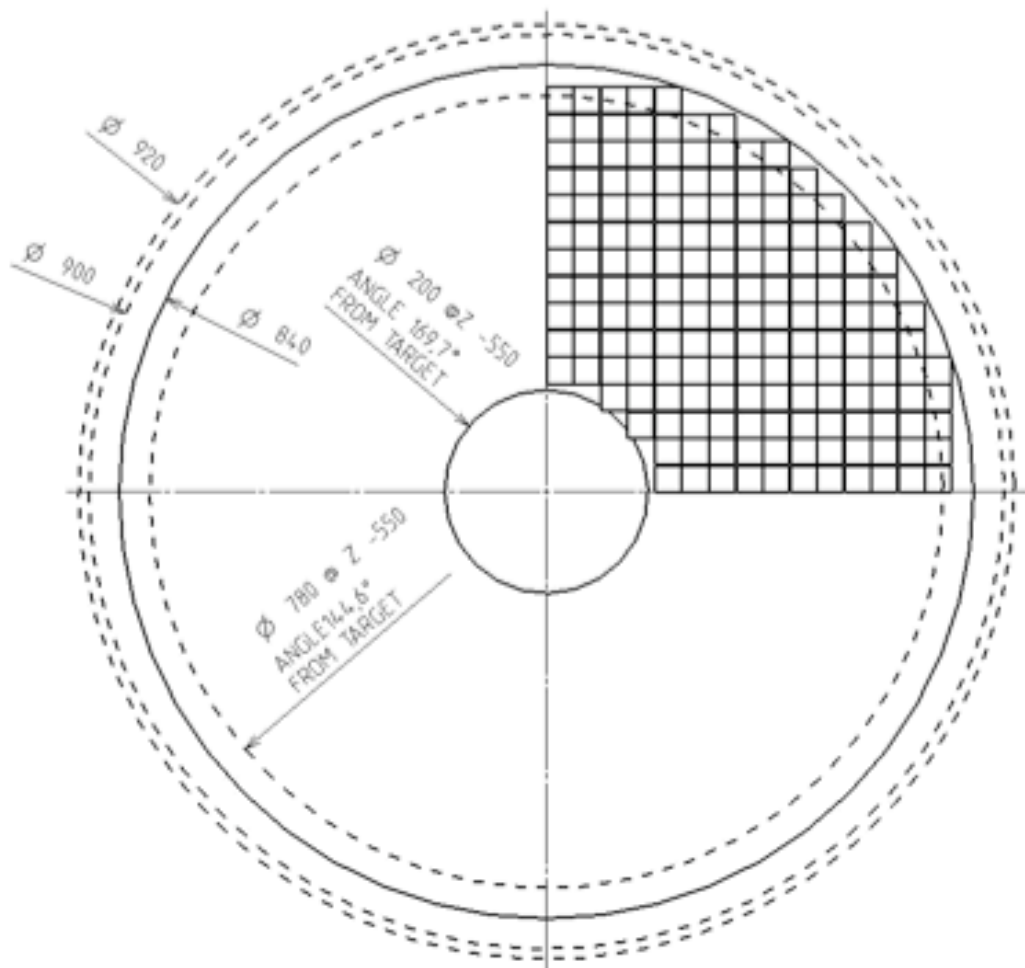
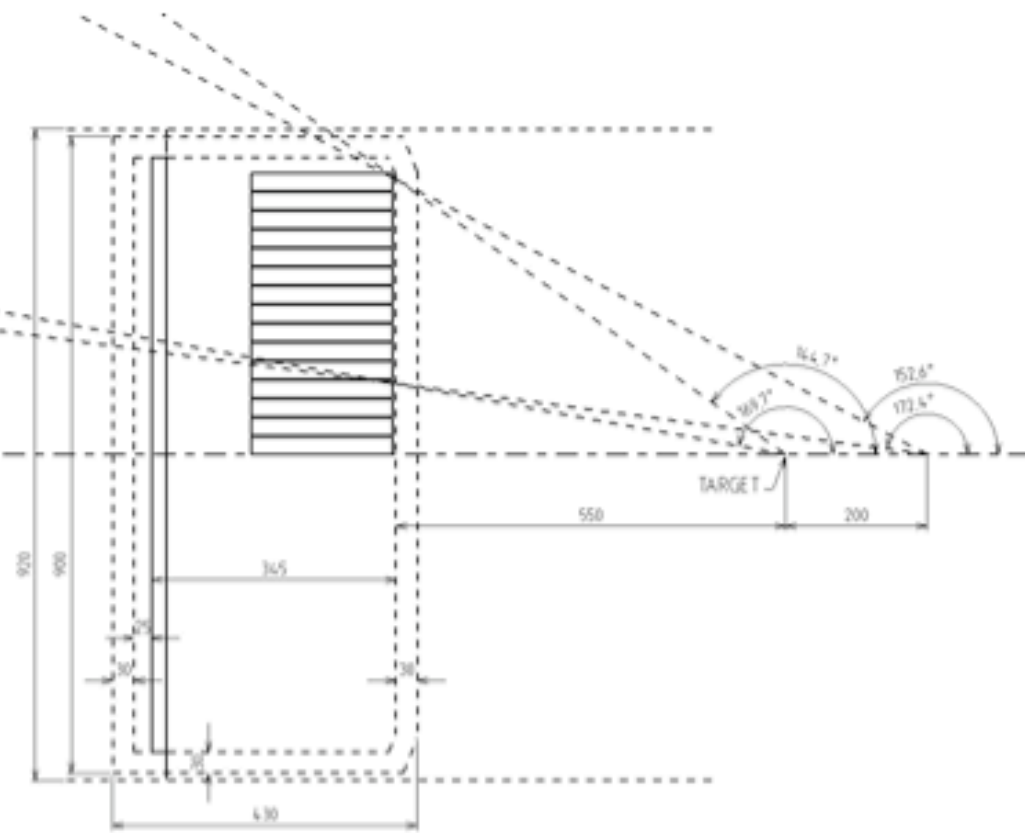
(26x26x200 mm³) - back side





BwEndcap straight geometry

(26x26x200 mm³)



BwEndcap off-pointing geometry

(20.5x20.5x200 mm³) - front side

(26x26x200 mm³) - back side

