AGATA MC Simulations

for the

fast beam campaign at GSI

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General aspects

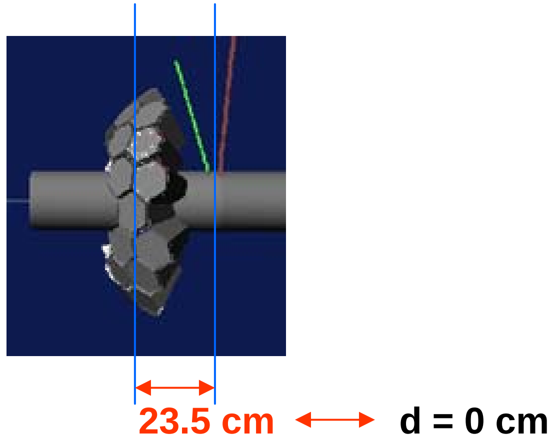
• AGATA Code from Enrico Farnea et al. http://agata.pd.infn.it/ **GEANT4**

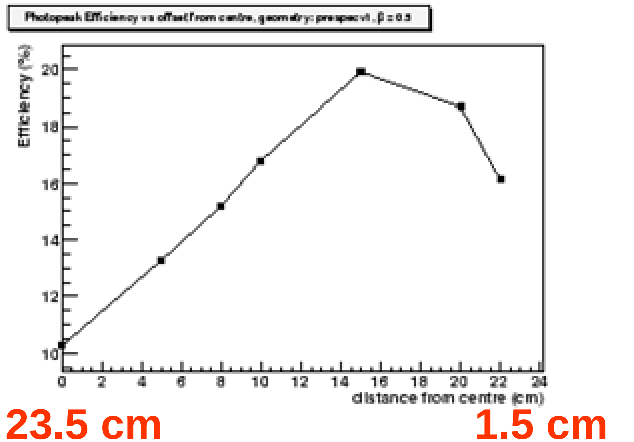
• “Physics case”:

$E_{\gamma,o}$ = 1 MeV $M\gamma$ = 1

Emission source @ β = 0.50

Study several distances sec. target – detector (:= -d), different geometries



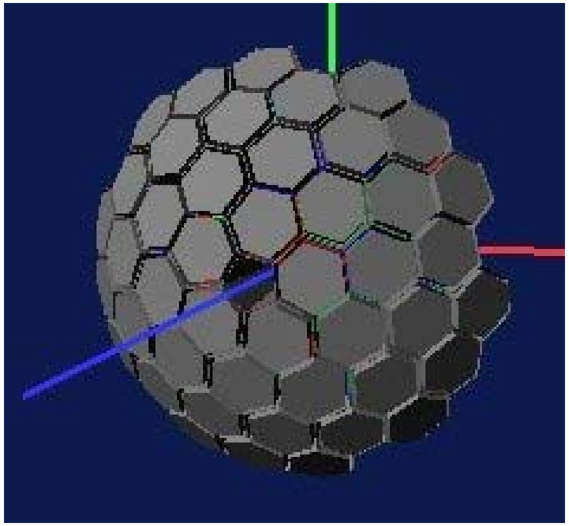


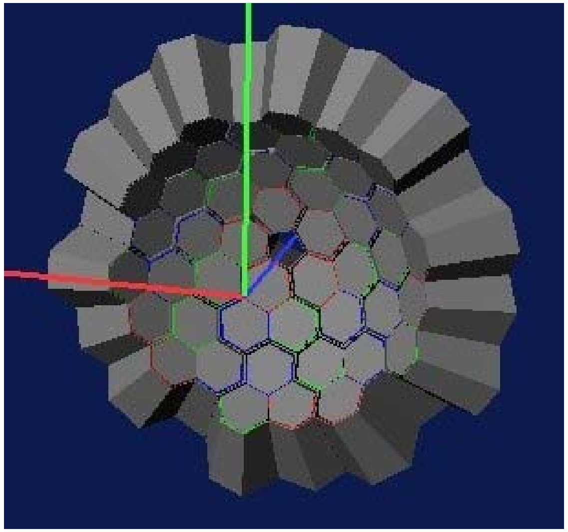
• Data Analysis via ROOT http://root.cern.ch

• Results summary http://www-linux.gsi.de/~cdomingo/agata

Stepwise geometry optimisation

• Ideal geometry = first approach, first step





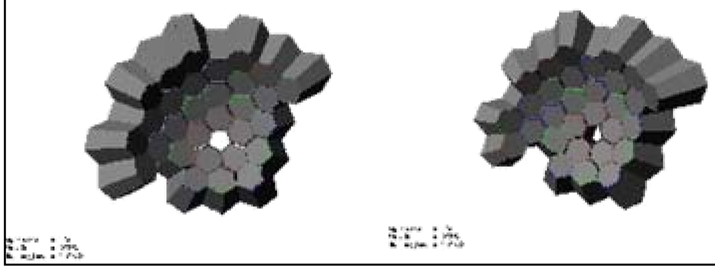
• two main dissadvantages:

1. 15 cluster detectors will not be available yet in 2011/2012
2. The beam hole (pentagonal hole) is too narrow for the GSI beam size

• Geometry constraint: triple clusters (not individual crystals)

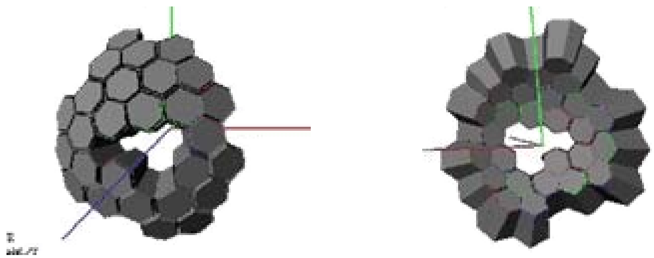
Stepwise geometry optimisation

more realistic



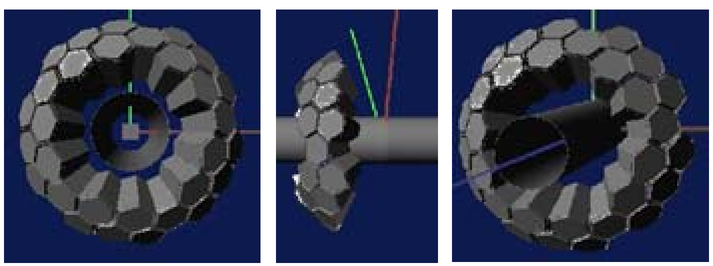
10 Clusters

Hole too small (appx. 4 cm)



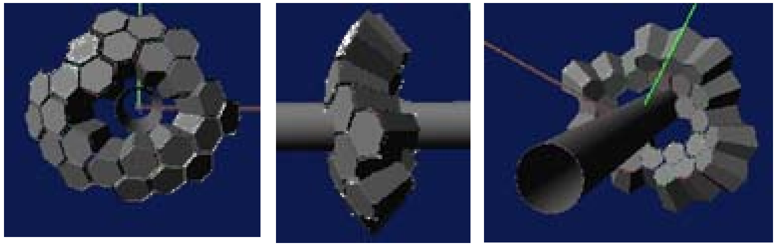
9 Clusters

Hole small (appx. 7 cm)



10 Clusters

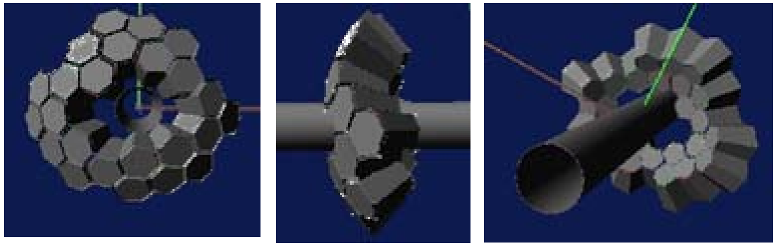
Hole (22.8 cm) beam-pipe 16 cm



8 Clusters

Hole (11.5 cm) beam-pipe 11 cm

8 Clusters Asymmetric Ring Geometry



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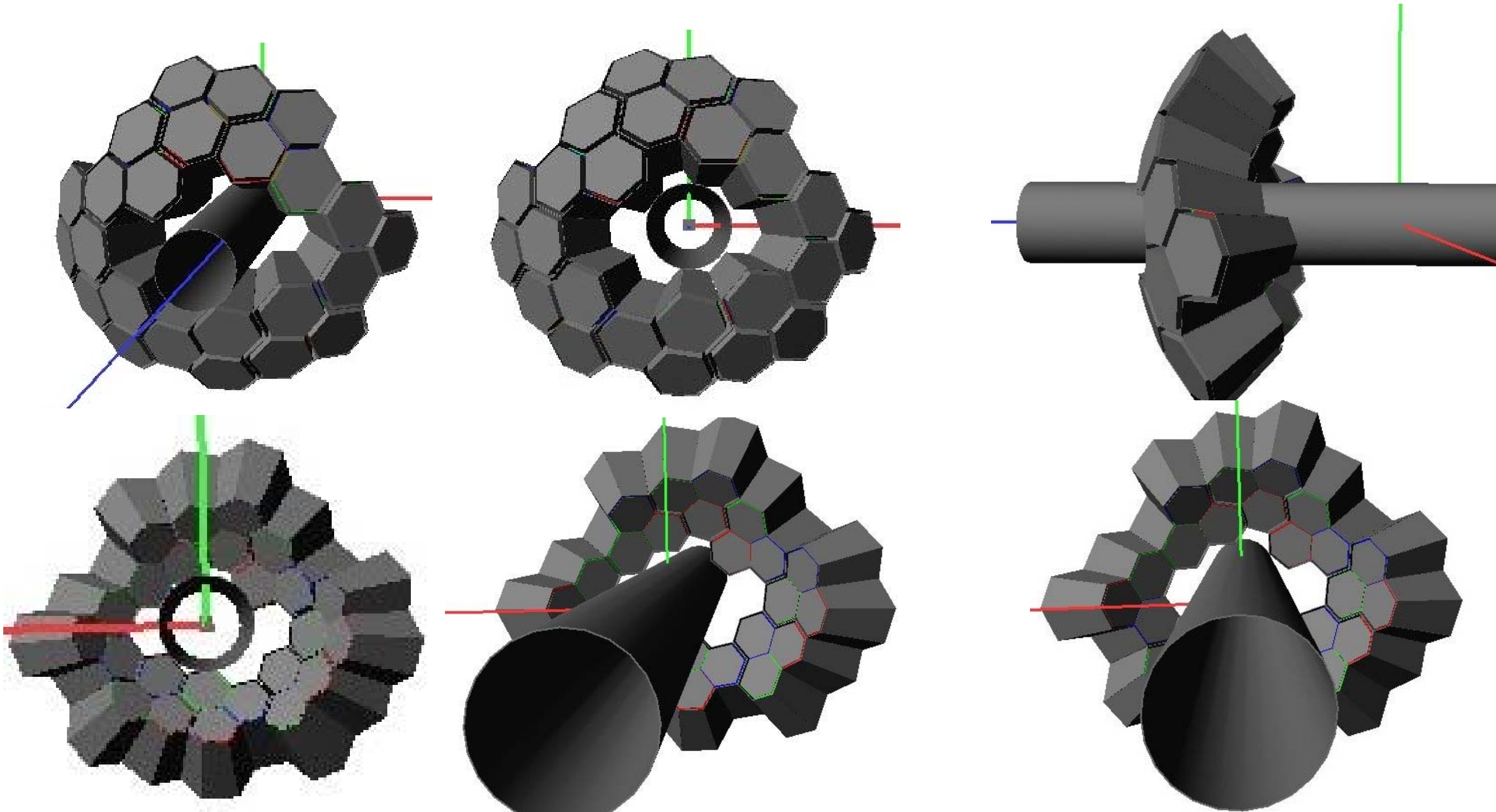

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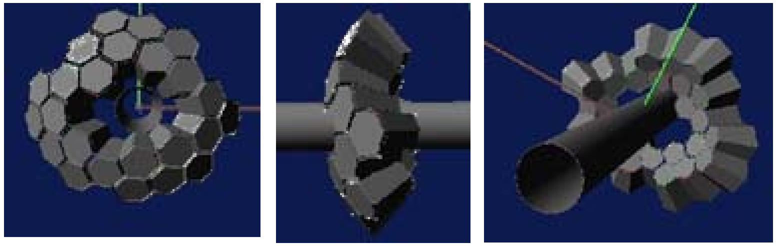

8 Clusters

Hole (11.5 cm) beam-pipe 11 cm

A180euler.list → A180eulerprespecv4.list

```
# The Euler angles (degree)  and shifts (mm) of the 60 clusters
#  cl  cl#     psi(Rz)     theta(Ry)      phi(Rz)        dx           dy           dz
#    0   0    164.302488    21.967863    -5.649422    102.935572   -10.182573   256.432015
.
.
.
#   44   0     42.906217   106.291521   -20.916343    247.916020   -94.750958   -77.567377
    45   0   -156.210622   134.706892    15.424027    189.440679    52.266136  -194.518058
#   46   0    111.584005   131.663878    52.562301    125.572067   164.017668  -183.811468
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    52   0    111.584005   131.663878   -91.437699     -5.182770  -206.502490  -183.811468
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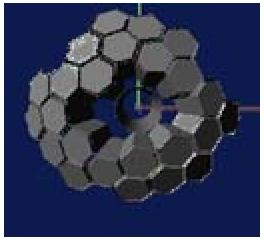
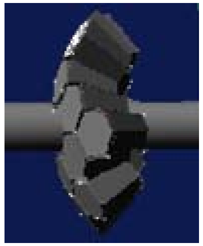
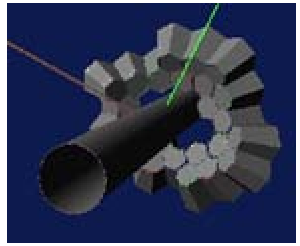

8 Clusters

Hole (11.5 cm) beam-pipe 11 cm

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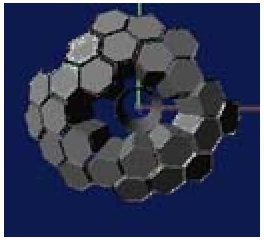
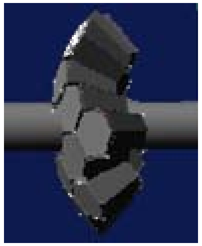
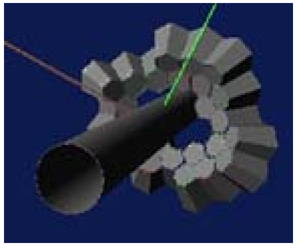
```

8 Clusters Asymmetric Ring Geometry

8 Clusters

Hole (11.5 cm) beam-pipe 11 cm

/Agata/detector/rotateArray   Ry(theta) Rz(phi)

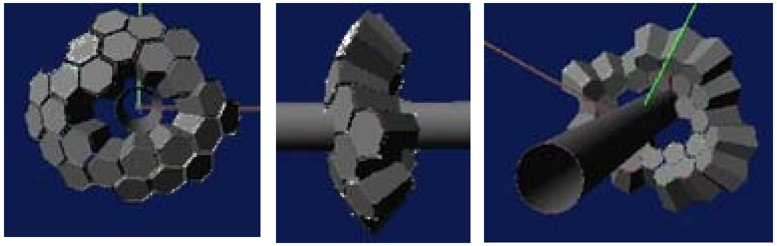
```
radd.rotateY( thetaShift );
radd.rotateZ( phiShift );
```

/Agata/detector/rotateArray   Ry(theta) Rz(phi) Rx(psi)

/Agata/detector/rotateArray   175.0   30.0   -17.0

```
radd.rotateY( thetaShift );
radd.rotateZ( phiShift );
radd.rotateX( psiShift );
```

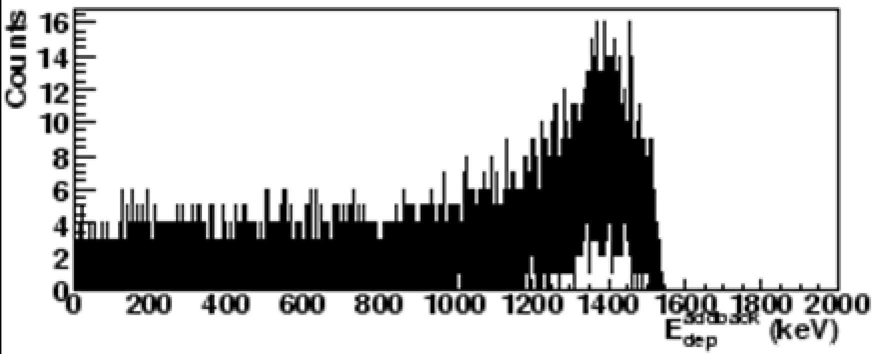
8 Clusters Asymmetric Ring

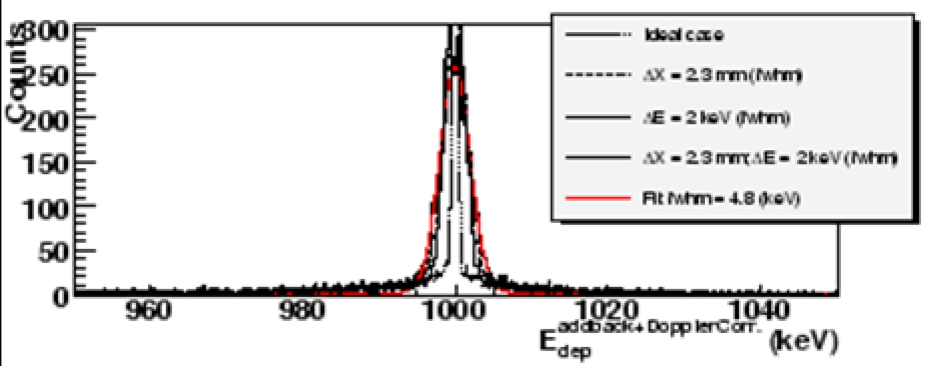


8 Clusters

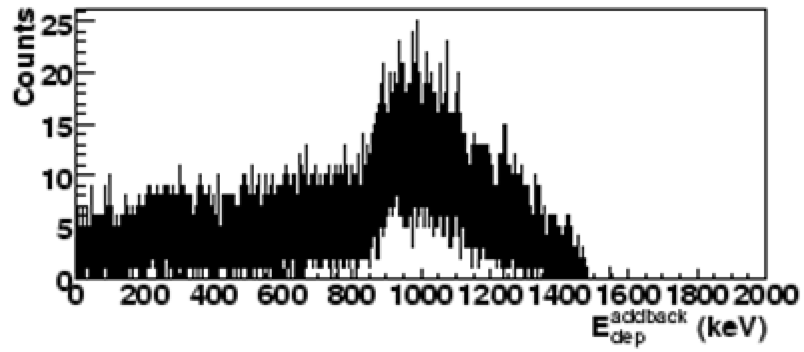
Hole (11.5 cm) beam-pipe 11 cm

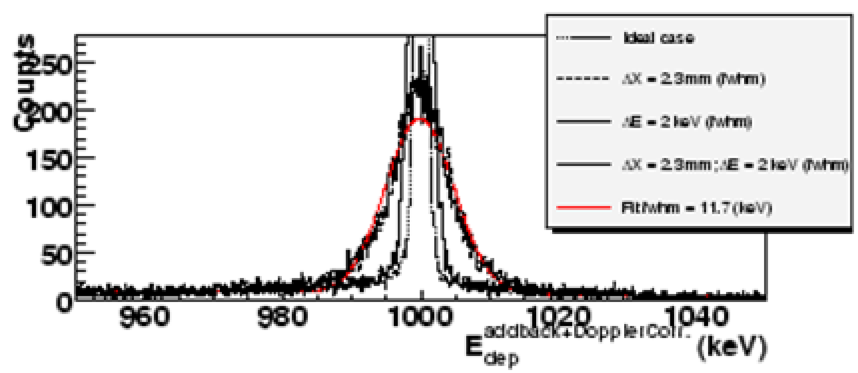
d = 23.5 cm





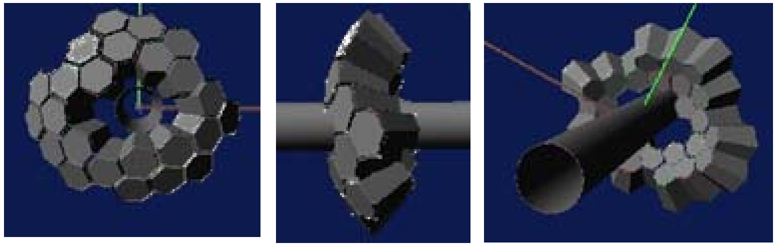
d = 1.5 cm





ΔE = 2 keV (fwhm) @ E_γ = 1 MeV; Δx = 4 mm

8 Clusters Asymmetric Ring



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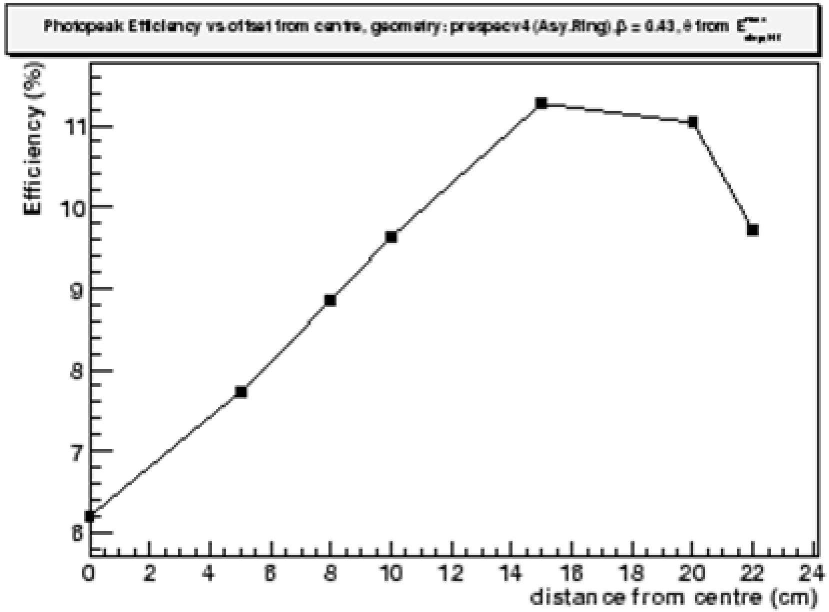
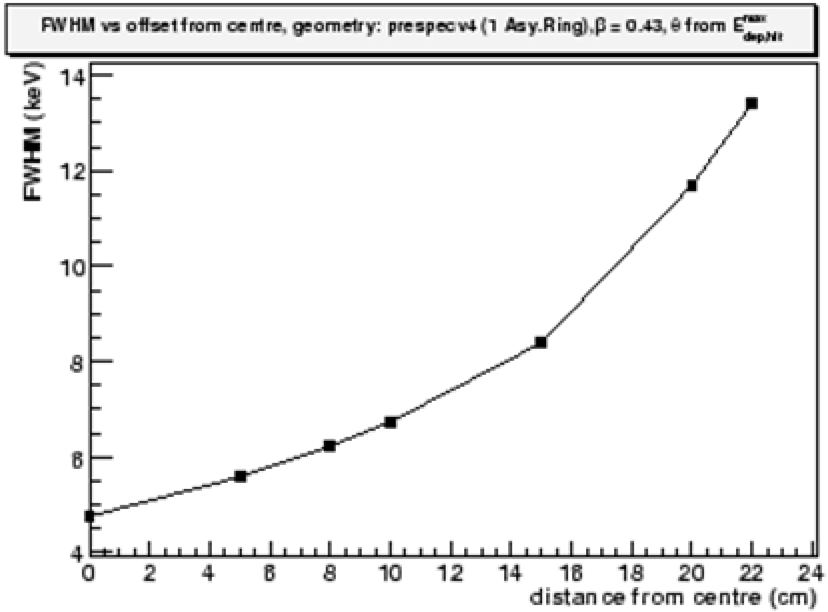
Hole (11.5 cm) beam-pipe 11 cm

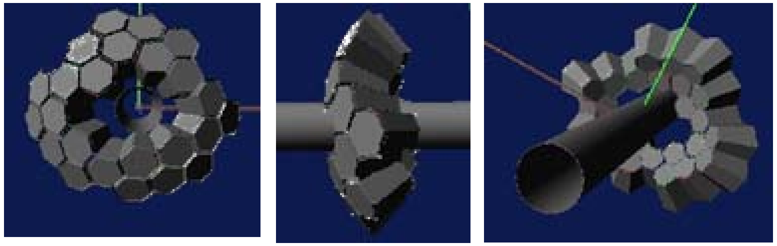




23.5 cm   1.5 cm   23.5 cm   1.5 cm

ΔE = 2 keV (fwhm) @ $E\gamma$ = 1 MeV; Δx = 4 mm

8 Clusters Asymmetric Ring



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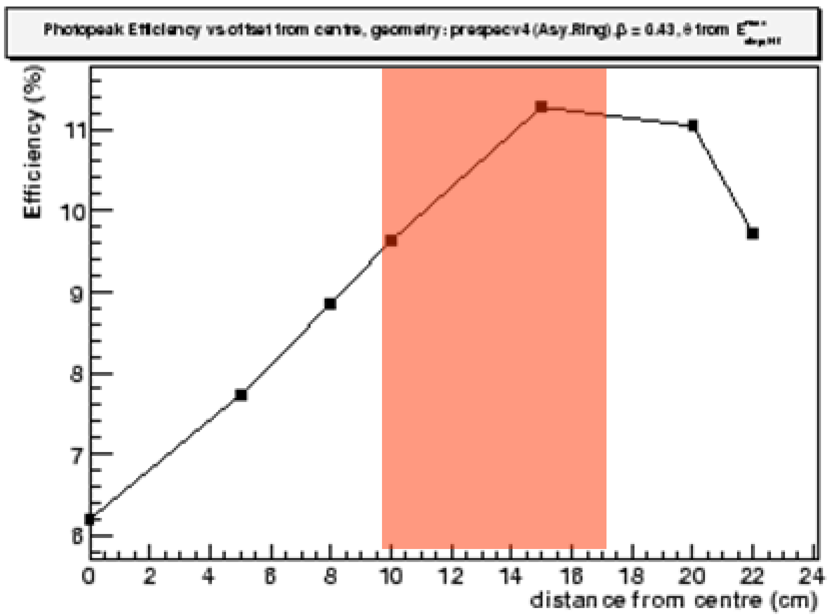
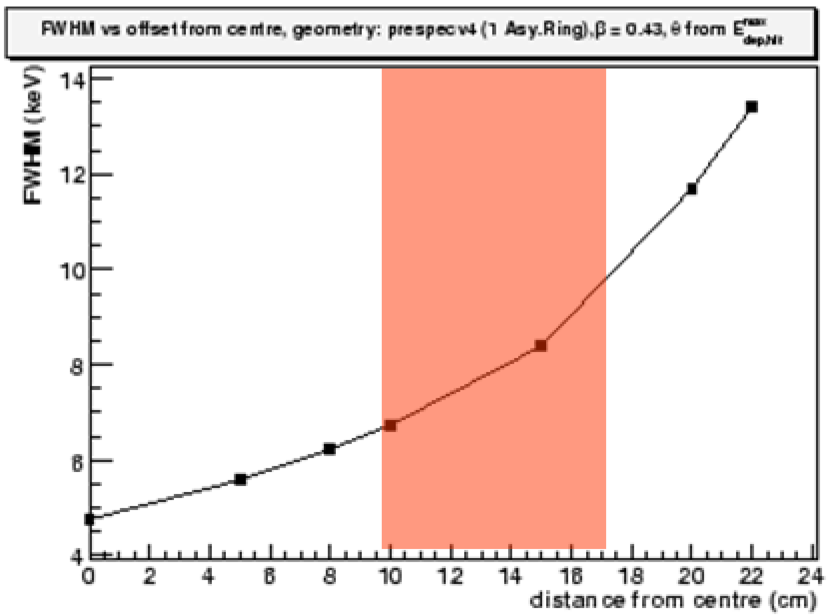




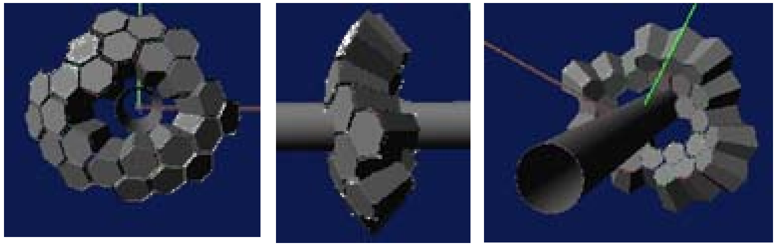
23.5 cm 1.5 cm 23.5 cm 1.5 cm

Efficiency = 10-11%

FWHM = 6-8 keV

ΔE = 2 keV (fwhm) @ $E\gamma$ = 1 MeV; Δx = 4 mm

8 Clusters Asymmetric Ring



8 Clusters

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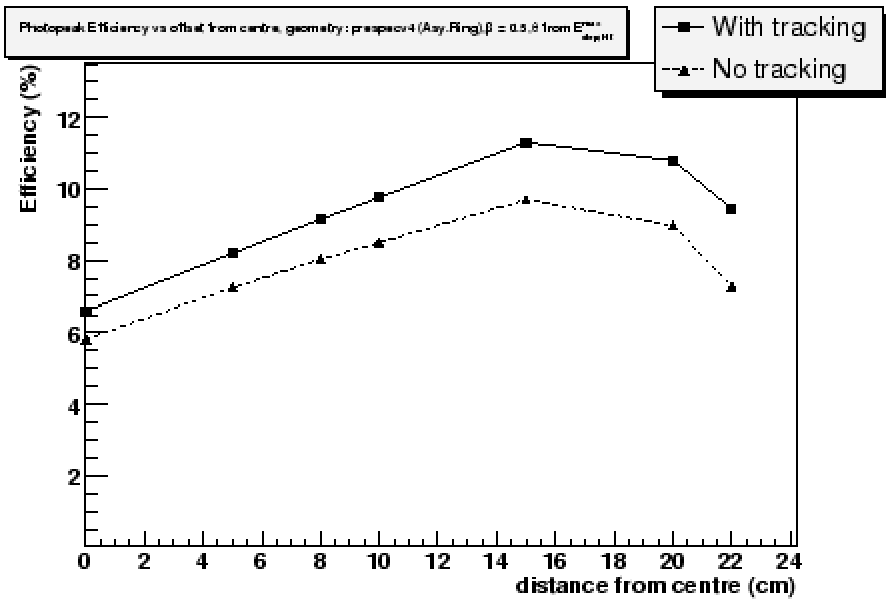
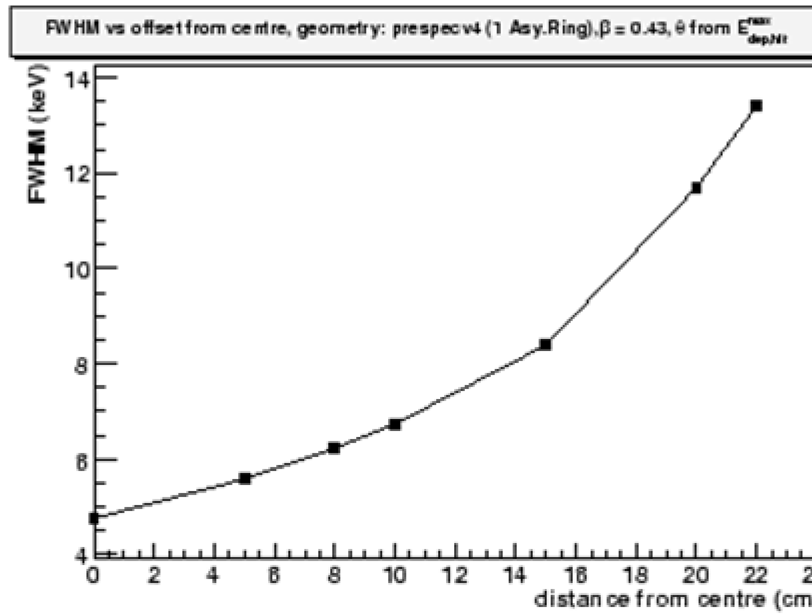


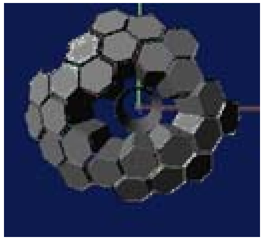
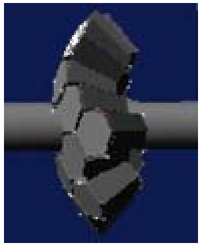
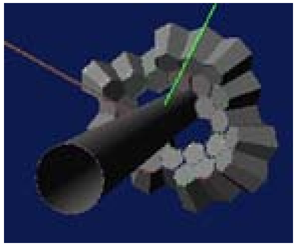


23.5 cm 1.5 cm

23.5 cm 1.5 cm

ΔE = 2 keV (fwhm) @ $E\gamma$ = 1 MeV; Δx = 4 mm

Conclusion / Comparison

8 Clusters

Hole (11.5 cm) beam-pipe 11 cm

$E_{\gamma,o}$ = 1 MeV M_γ = 1

Emission source @ β = 0.50

AGATA@GSI

Efficiency = 10 %

Resolution = 7 keV (FWHM)

RISING

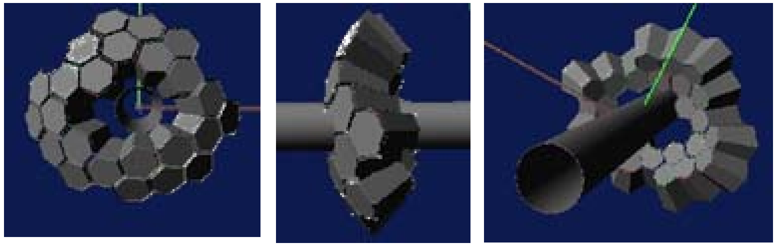
Efficiency = 3 %

Resolution = 20 keV (FWHM)

About one order of magnitude improvement in sensitivity!

Ersatzfolien

8 Clusters Asymmetric Ring



8 Clusters

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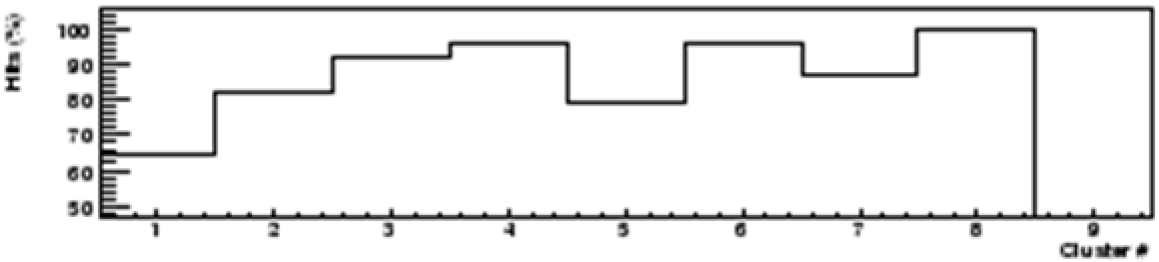

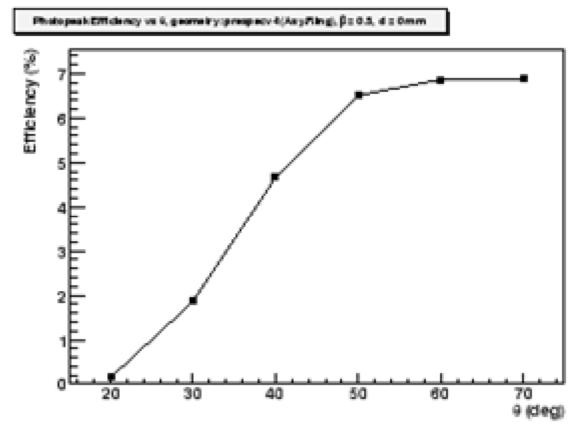

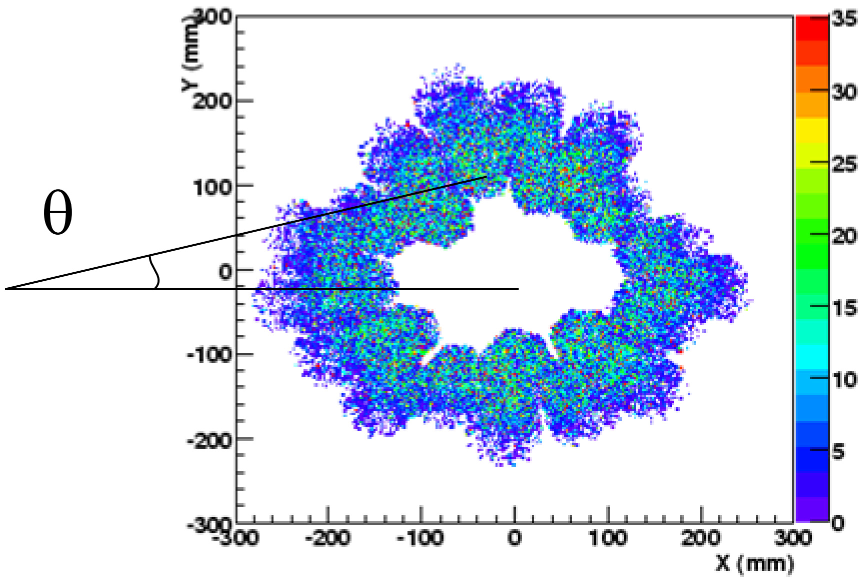

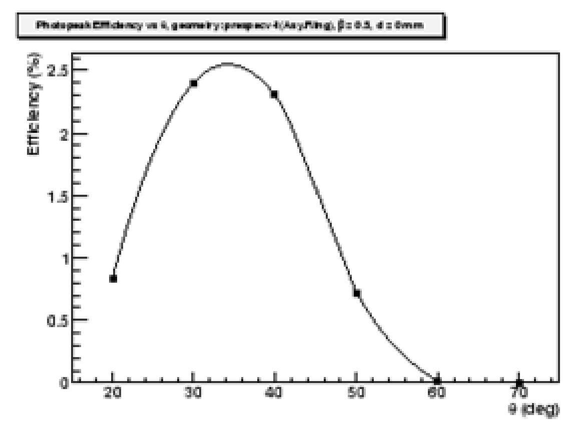

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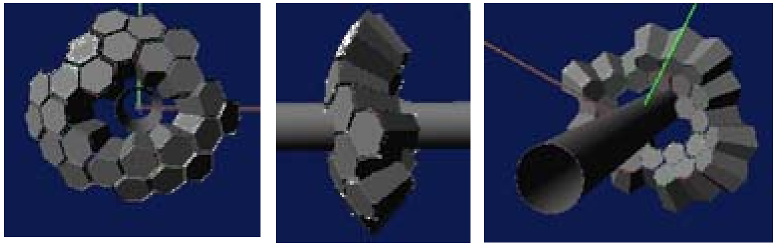

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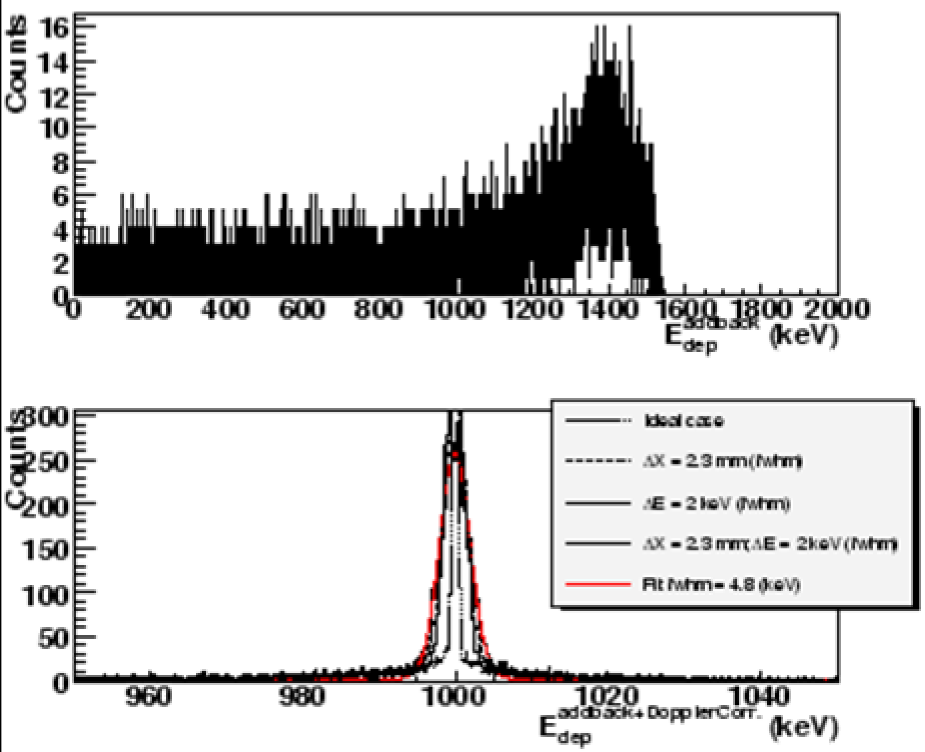
Hole (11.5 cm) beam-pipe 11 cm

d = 23.5 cm



$$E_{\gamma o} = E_{\gamma} \frac{1-\beta\cos\vartheta_{\gamma}}{\sqrt{1-\beta^{2}}}$$

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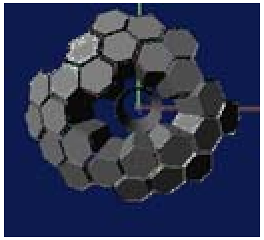
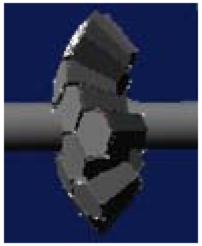
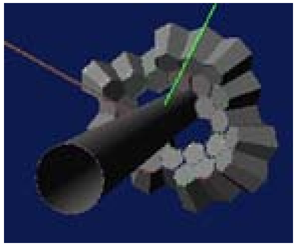
8 Clusters Asymmetric Ring Geometry

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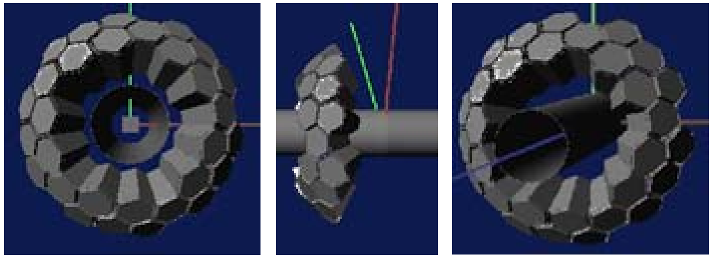
```

Event reconstruction



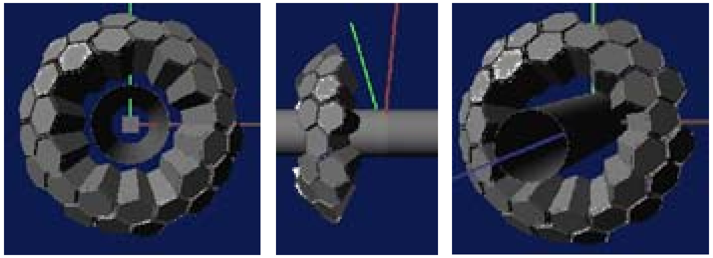
10 Clusters

Hole (22.8 cm) beam-pipe 16 cm

```
GAMMA 1
1000.0000
RECOIL   0.5000  0.0000  0.0000  0.0000  1.0000  0.0000
SOURCE       0      0    0.0000    0.0000    0.0000
$
  -1   1401.723 -0.43045  0.48009  0.76434 0
  29    73.617 -142.729  141.623  234.825 52     1.053
  29    39.475 -143.302  150.765  245.890 52     1.129
  29   148.895 -151.199  143.686  236.472 51     1.083
  29   155.373 -151.207  143.675  236.479 51     1.083
  29   251.516 -129.956  144.860  230.891 41     1.007
  29   166.208 -129.833  144.792  230.981 41     1.008
  29   163.364 -129.791  144.692  230.949 41     1.008
  29   132.162 -129.764  144.711  230.911 41     1.008
  29    86.873 -129.765  144.716  230.913 41     1.008
  -1   1627.135  0.23197 -0.26644  0.93552 1
   1   126.640  125.339  -75.549  240.008 34     1.154
   1   334.250  120.598  -82.006  265.573 43     1.065
   1    71.117  120.608  -81.984  265.633 43     1.065
   1   160.091  120.600  -81.997  265.637 43     1.065
   1    11.067  120.642  -81.972  265.678 43     1.065
   1    45.200  120.643  -81.971  265.679 43     1.065
  -1   1087.822 -0.71426 -0.56881  0.40778 2
  -1   1257.962 -0.08354  0.77764  0.62313 3
  24   129.869  -24.004  192.131  156.311 05     0.836
  24    30.817  -34.318  197.026  157.088 15     0.874
.
.
.
.
.
```

Simulation output

Event reconstruction



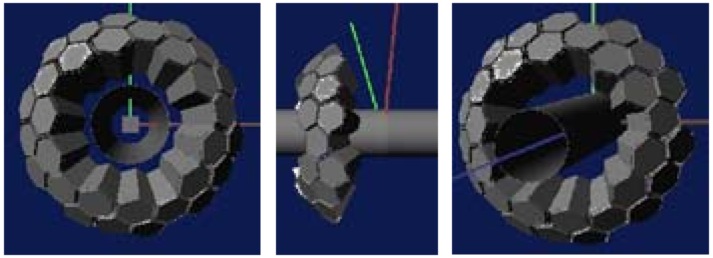
10 Clusters

Hole (22.8 cm) beam-pipe 16 cm

```
GAMMA 1
1000.0000
RECOIL   0.5000  0.0000  0.0000  0.0000  1.0000  0.0000
SOURCE      0      0    0.0000    0.0000    0.0000
$
  -1   1401.723 -0.43045  0.48009  0.76434 0
  29    73.617 -142.729  141.623  234.825 52     1.053
  29    39.475 -143.302  150.765  245.890 52     1.129
  29   148.895 -151.199  143.686  236.472 51     1.083
  29   155.373 -151.207  143.675  236.479 51     1.083
  29   251.516 -129.956  144.860  230.891 41     1.007
  29   166.208 -129.833  144.792  230.981 41     1.008
  29   163.364 -129.791  144.692  230.949 41     1.008
  29   132.162 -129.764  144.711  230.911 41     1.008
  29    86.873 -129.765  144.716  230.913 41     1.008
  -1   1627.135  0.23197 -0.26644  0.93552 1
   1   126.640  125.339  -75.549  240.008 34     1.154
   1   334.250  120.598  -82.006  265.573 43     1.065
   1    71.117  120.608  -81.984  265.633 43     1.065
   1   160.091  120.600  -81.997  265.637 43     1.065
   1    11.067  120.642  -81.972  265.678 43     1.065
   1    45.200  120.643  -81.971  265.679 43     1.065
  -1   1087.822 -0.71426 -0.56881  0.40778 2
  -1   1257.962 -0.08354  0.77764  0.62313 3
  24   129.869  -24.004  192.131  156.311 05     0.836
  24    30.817  -34.318  197.026  157.088 15     0.874
```

Crystal# Edep X Y Z Segment# time

Event reconstruction



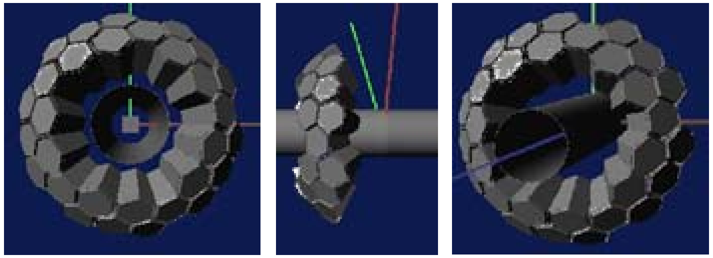
10 Clusters

Hole (22.8 cm) beam-pipe 16 cm

```
GAMMA 1
1000.0000
RECOIL   0.5000  0.0000  0.0000  0.0000  1.0000  0.0000
SOURCE       0      0    0.0000    0.0000    0.0000
$
  -1   1401.723 -0.43045  0.48009  0.76434 0
  29    73.617 -142.729  141.623  234.825 52     1.053
  29    39.475 -143.302  150.765  245.890 52     1.129
  29   148.895 -151.199  143.686  236.472 51     1.083
  29   155.373 -151.207  143.675  236.479 51     1.083
  29   251.516 -129.956  144.860  230.891 41     1.007
  29   166.208 -129.833  144.792  230.981 41     1.008
  29   163.364 -129.791  144.692  230.949 41     1.008
  29   132.162 -129.764  144.711  230.911 41     1.008
  29    86.873 -129.765  144.716  230.913 41     1.008
  -1   1627.135  0.23197 -0.26644  0.93552 1
   1   126.640  125.339  -75.549  240.008 34     1.154
   1   334.250  120.598  -82.006  265.573 43     1.065
   1    71.117  120.608  -81.984  265.633 43     1.065
   1   160.091  120.600  -81.997  265.637 43     1.065
   1    11.067  120.642  -81.972  265.678 43     1.065
   1    45.200  120.643  -81.971  265.679 43     1.065
  -1   1087.822 -0.71426 -0.56881  0.40778 2
  -1   1257.962 -0.08354  0.77764  0.62313 3
  24   129.869  -24.004  192.131  156.311 05     0.836
  24    30.817  -34.318  197.026  157.088 15     0.874
```

Maximum Edep-Hit determines θ for Doppler correction

Event reconstruction

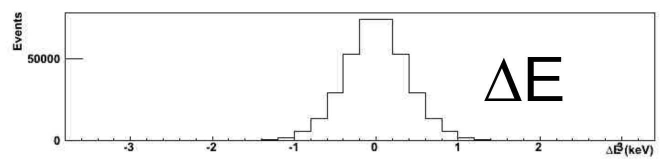


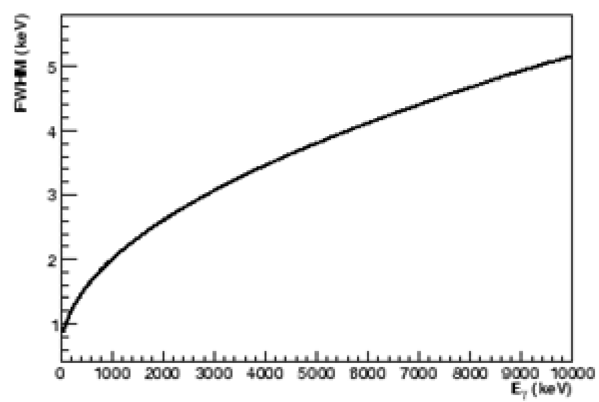
10 Clusters

Hole (22.8 cm) beam-pipe 16 cm

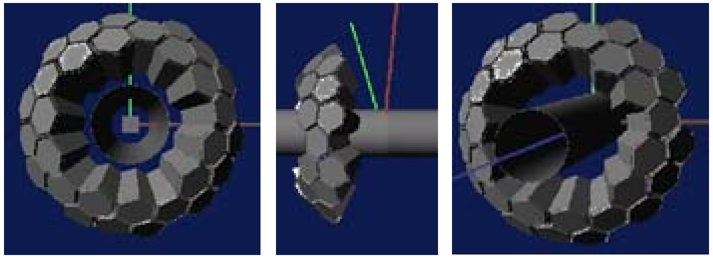
```
GAMMA 1
1000.0000
RECOIL   0.5000  0.0000  0.0000  0.0000  1.0000  0.0000
SOURCE      0      0  0.0000    0.0000    0.0000
$
  -1   1401.723 -0.43045  0.48009  0.76434 0
  29    73.617 -142.729  141.623  234.825 52     1.053
  29    39.475 -143.302  150.765  245.890 52     1.129
  29   148.895 -151.199  143.686  236.472 51     1.083
  29   155.373 -151.207  143.675  236.479 51     1.083
  29   251.516 -129.956  144.860  230.891 41     1.007
  29   166.208 -129.833  144.792  230.981 41     1.008
  29   163.364 -129.791  144.692  230.949 41     1.008
  29   132.162 -129.764  144.711  230.911 41     1.008
  29    86.873 -129.765  144.716  230.913 41     1.008
  -1   1627.135  0.23197 -0.26644  0.93552 1
   1   126.640  125.339  -75.549  240.008 34     1.154
   1   334.250  120.598  -82.006  265.573 43     1.065
   1    71.117  120.608  -81.984  265.633 43     1.065
   1   160.091  120.600  -81.997  265.637 43     1.065
   1    11.067  120.642  -81.972  265.678 43     1.065
   1    45.200  120.643  -81.971  265.679 43     1.065
  -1   1087.822 -0.71426 -0.56881  0.40778 2
  -1   1257.962 -0.08354  0.77764  0.62313 3
  24   129.869  -24.004  192.131  156.311 05     0.836
  24    30.817  -34.318  197.026  157.088 15     0.874
```

Deposited energy folded with a Gauss distribution to introduce energy resolution (2 keV @ Eγ=1 MeV)





Event reconstruction

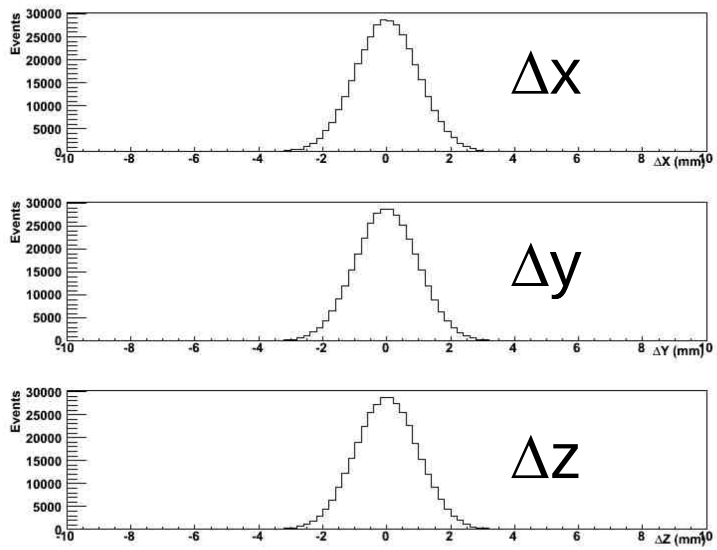


10 Clusters

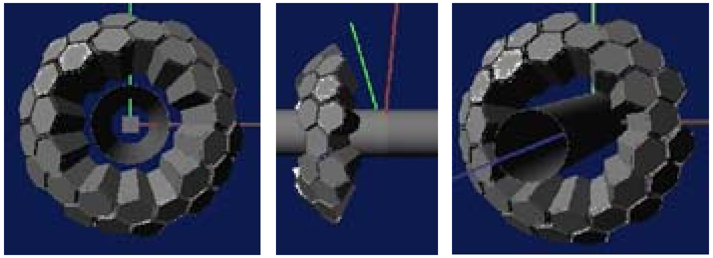
Hole (22.8 cm) beam-pipe 16 cm

```
GAMMA 1
1000.0000
RECOIL   0.5000  0.0000  0.0000  0.0000  1.0000  0.0000
SOURCE       0      0   0.0000    0.0000    0.0000
$
  -1   1401.723 -0.43045  0.48009  0.76434 0
  29    73.617 -142.729  141.623  234.825 52     1.053
  29    39.475 -143.302  150.765  245.890 52     1.129
  29   148.895 -151.199  143.686  236.472 51     1.083
  29   155.373 -151.207  143.675  236.479 51     1.083
  29   251.516 -129.956  144.860  230.891 41     1.007
  29   166.208 -129.833  144.792  230.981 41     1.008
  29   163.364 -129.791  144.692  230.949 41     1.008
  29   132.162 -129.764  144.711  230.911 41     1.008
  29    86.873 -129.765  144.716  230.913 41     1.008
  -1   1627.135  0.23197 -0.26644  0.93552 1
   1   126.640  125.339  -75.549  240.008 34     1.154
   1   334.250  120.598  -82.006  265.573 43     1.065
   1    71.117  120.608  -81.984  265.633 43     1.065
   1   160.091  120.600  -81.997  265.637 43     1.065
   1    11.067  120.642  -81.972  265.678 43     1.065
   1    45.200  120.643  -81.971  265.679 43     1.065
  -1   1087.822 -0.71426 -0.56881  0.40778 2
  -1   1257.962 -0.08354  0.77764  0.62313 3
  24   129.869  -24.004  192.131  156.311 05     0.836
  24    30.817  -34.318  197.026  157.088 15     0.874
```

x, y, z folded with a Gauss distribution to introduce spatial resolution of 4 mm FWHM (actually 5 mm)



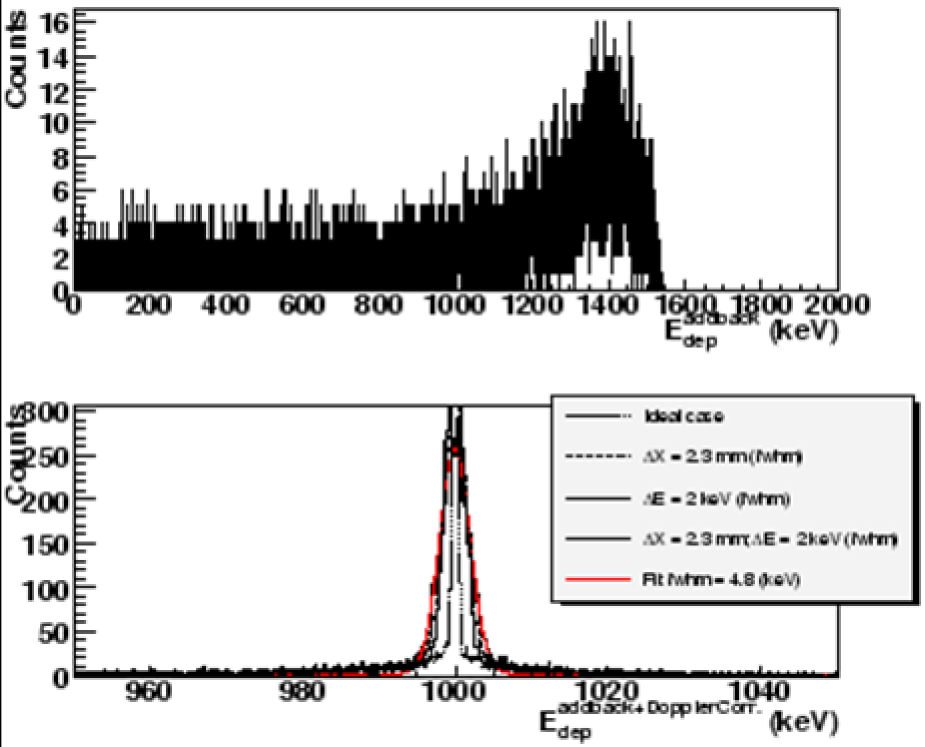
8 Clusters Asymmetric Ring



10 Clusters

Hole (22.8 cm) beam-pipe 16 cm

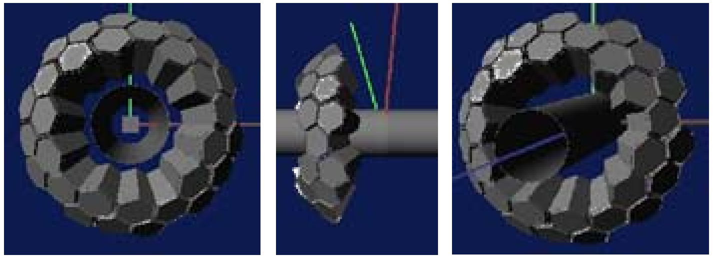
d = 23.5 cm



$$E_{\gamma o} = E_{\gamma} \frac{1-\beta\cos\vartheta_{\gamma}}{\sqrt{1-\beta^{2}}}$$

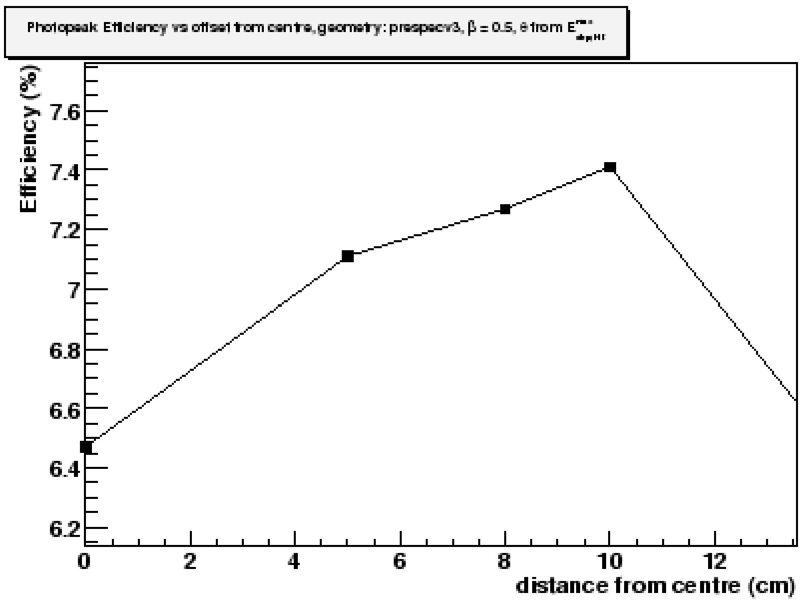
ΔE = 2 keV (fwhm) @ Eγ = 1 MeV; Δx = 4 mm

Efficiency results for 10 Cluster Ring



10 Clusters

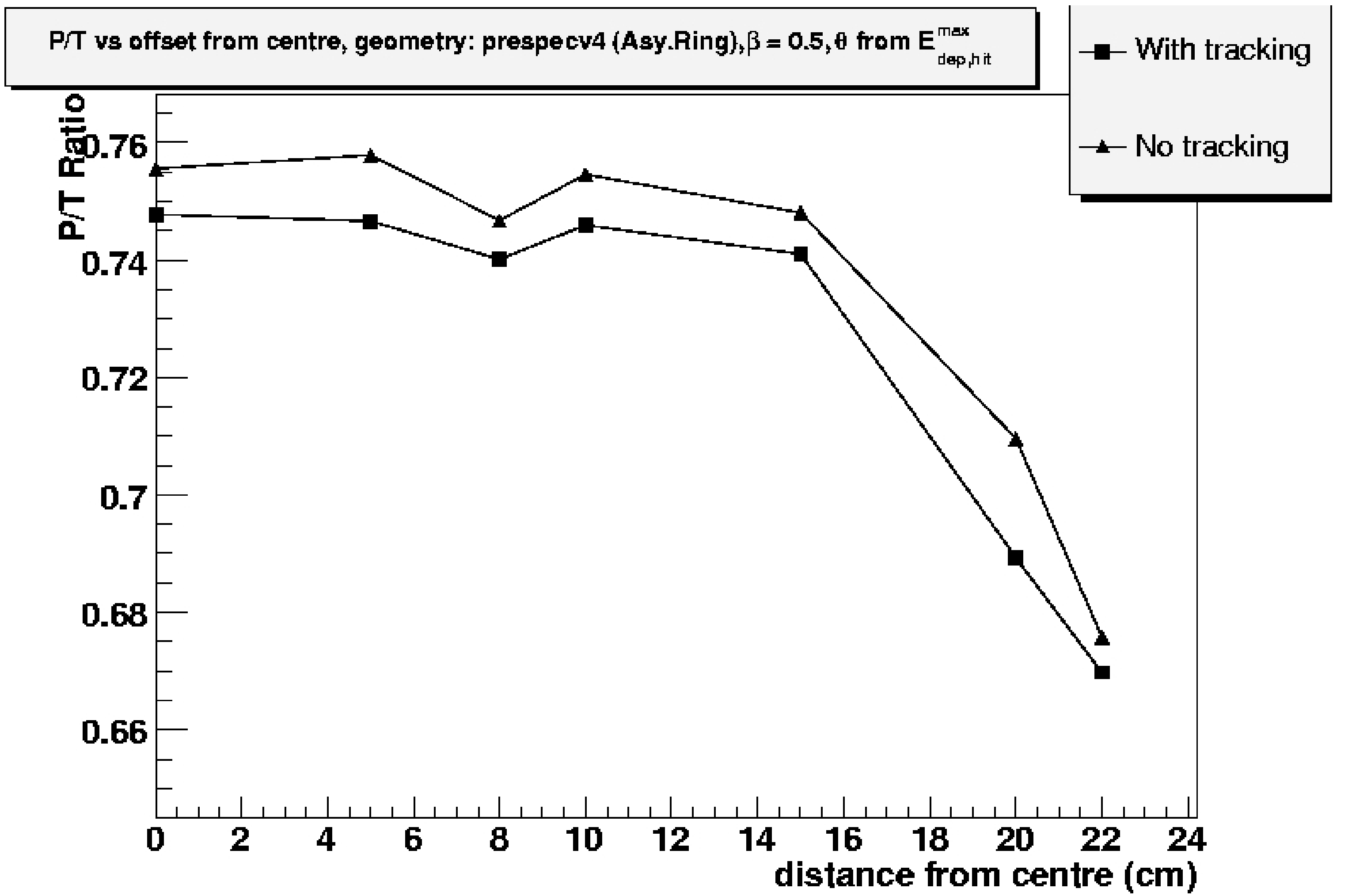
Hole (22.8 cm) beam-pipe 16 cm



23.5 cm

13.5 cm

Peak/Total (?)


P/T vs offset from centre, geometry: prespecv4 (Asy.Ring), β = 0.5, θ from $E^{max}_{dep,hit}$
With tracking
No tracking
P/T Ratio
0.76
0.74
0.72
0.7
0.68
0.66
0
2
4
6
8
10
12
14
16
18
20
22
24
distance from centre (cm)