



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

Results

Summary



Monte Carlo simulations of commissioning experiments for the AGATA Demonstrator

Pär-Anders Söderström

Nuclear Structure Group
Department of Physics and Astronomy
Uppsala University

7th AGATA week
2008-07-08

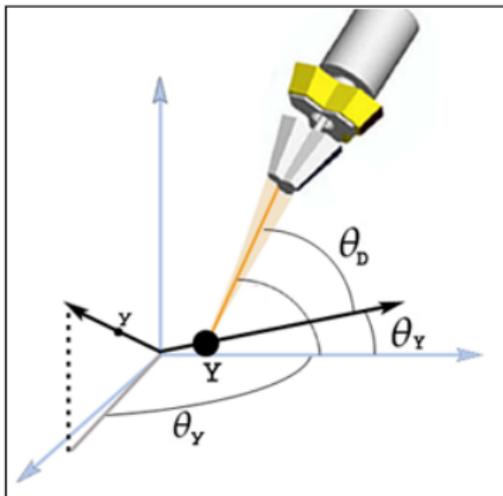


Outline

- 1 Introduction
 - Requirements and Reactions
- 2 Simulations
 - Event generator
 - GEANT4
 - Tracking
- 3 Results
- 4 Summary



Introduction



The aim is to find a suitable reaction for measuring position resolution of one triple cluster in the commissioning phase at LNL. The idea is to compare FWHM of the γ -ray peaks at different distances.

$$W_{\text{tot}}^2 = W_{\text{int}}^2 + W_{\text{rec}}^2 + W_{\Delta\theta}^2$$



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

Summary

Requirements

- High v/c
- High γ -ray energy
- Narrow angular and energy distributions of recoils
- High peak count rate
- Well defined source location - life times of excited states



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

Summary

Requirements

- High v/c
- High γ -ray energy
- Narrow angular and energy distributions of recoils
- High peak count rate
- Well defined source location - life times of excited states



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

Summary

Requirements

- High v/c
- High γ -ray energy
- Narrow angular and energy distributions of recoils
- High peak count rate
- Well defined source location - life times of excited states



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

Summary

Requirements

- High v/c
- High γ -ray energy
- Narrow angular and energy distributions of recoils
- High peak count rate
- Well defined source location - life times of excited states



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

Summary

Requirements

- High v/c
- High γ -ray energy
- Narrow angular and energy distributions of recoils
- High peak count rate
- Well defined source location - life times of excited states



Studied reactions

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Reactions

Simulations

Results

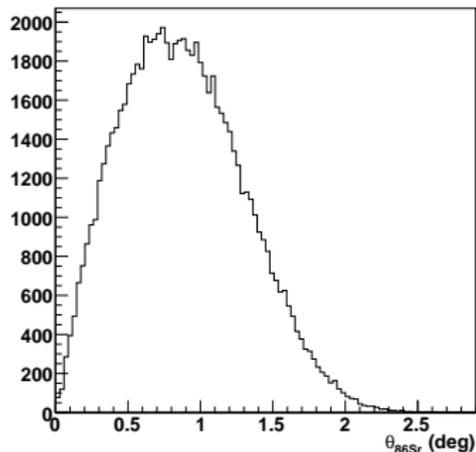
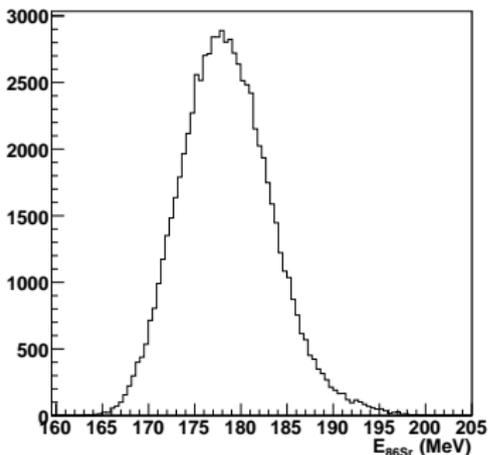
Summary

Reaction	E_{beam}	E_{γ}	v/c	σ
${}^2\text{H}({}^{37}\text{Cl}, n){}^{38}\text{Ar}$	75 MeV	2168 keV	6.4 %	300 mb
${}^2\text{H}({}^{51}\text{V}, n){}^{52}\text{Cr}$	100 MeV	1434 keV	6.4 %	150 mb
${}^9\text{Be}({}^{80}\text{Se}, 3n){}^{86}\text{Sr}$	220 MeV	1077 keV	6.9 %	300 mb
${}^2\text{H}({}^{81}\text{Br}, n){}^{82}\text{Kr}$	240 MeV	1044 keV	7.8 %	80 mb
${}^9\text{Be}({}^{136}\text{Xe}, 3n){}^{142}\text{Ce}$	470 MeV	641 keV	8.1 %	10 mb



Event generator

Event-by-event Monte Carlo data is obtained from the program evapOR (PACE). Fusion-evaporation code that evaporates particles up to ${}^6\text{Li}$ with monoenergetic and Doppler shifted γ -rays added.



Example of the the recoil energy and angular distributions in the reaction ${}^9\text{Be}({}^{80}\text{Se}, 3n){}^{86}\text{Sr}$.



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

GEANT4

MGT

Results

Summary

GEANT4 simulation

AGATA demonstrator simulation with Enricos GEANT4 program.

One triple cluster positioned at 90 degrees from the beam direction.

Four different distances to front face of the detector: 40 mm, 120 mm, 140 mm and 235 mm.



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

GEANT4

MGT

Results

Summary

GEANT4 simulation

AGATA demonstrator simulation with Enricos GEANT4 program.

One triple cluster positioned at 90 degrees from the beam direction.

Four different distances to front face of the detector: 40 mm, 120 mm, 140 mm and 235 mm.



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

GEANT4

MGT

Results

Summary

GEANT4 simulation

AGATA demonstrator simulation with Enricos GEANT4 program.

One triple cluster positioned at 90 degrees from the beam direction.

Four different distances to front face of the detector: 40 mm, 120 mm, 140 mm and 235 mm.



MGT

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

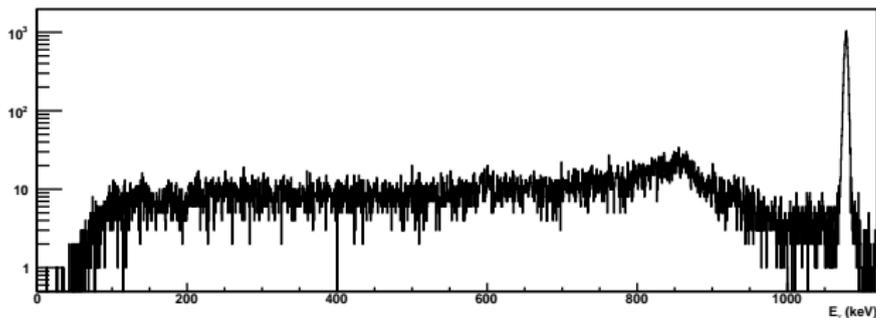
GEANT4

MGT

Results

Summary

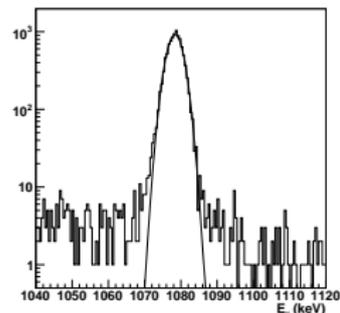
9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm



Tracking done with MGT, intrinsic energy resolution assumed to be a FWHM of 2 keV at 1.33 MeV and 1 keV FWHM for noise.

No ancillary detectors gives recoils in 0 degrees and average v/c for each event.

9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm





MGT

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

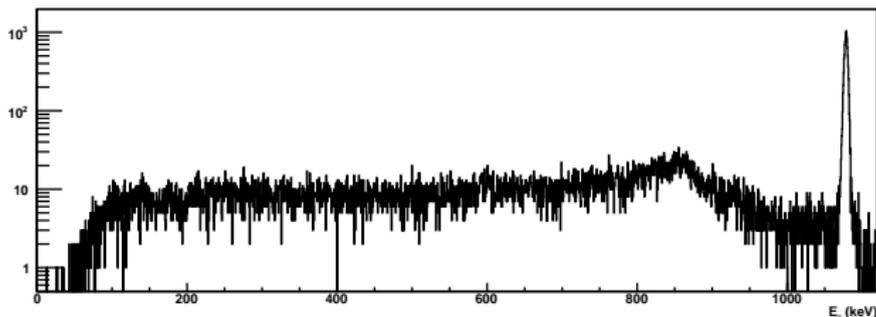
GEANT4

MGT

Results

Summary

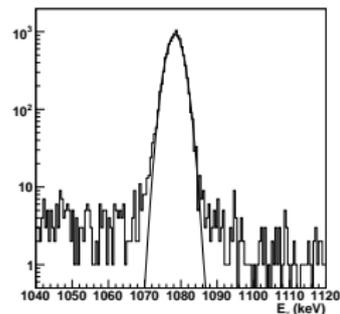
9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm



Tracking done with MGT, intrinsic energy resolution assumed to be a FWHM of 2 keV at 1.33 MeV and 1 keV FWHM for noise.

No ancillary detectors gives recoils in 0 degrees and average v/c for each event.

9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm





MGT

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

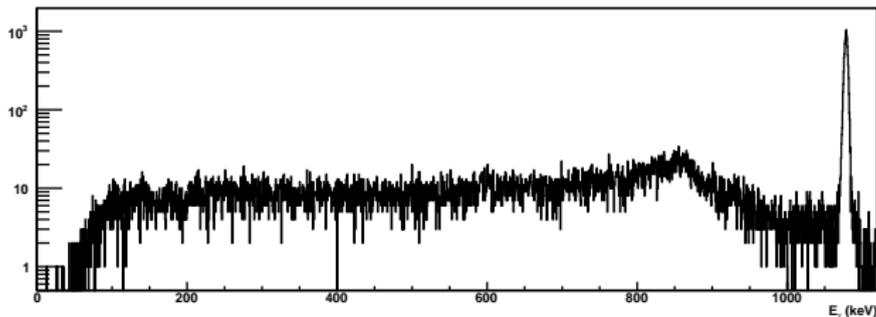
GEANT4

MGT

Results

Summary

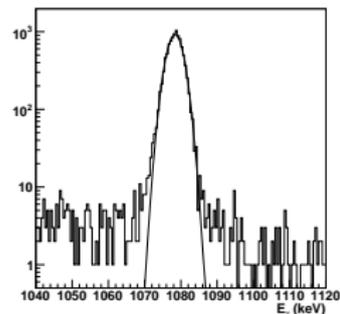
9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm



Vary position smearing parameter from 1 mm to 10 mm in steps of 0.5 mm. Same value for packing.

Energy dependent smearing turned off.

9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm





MGT

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

evapOR

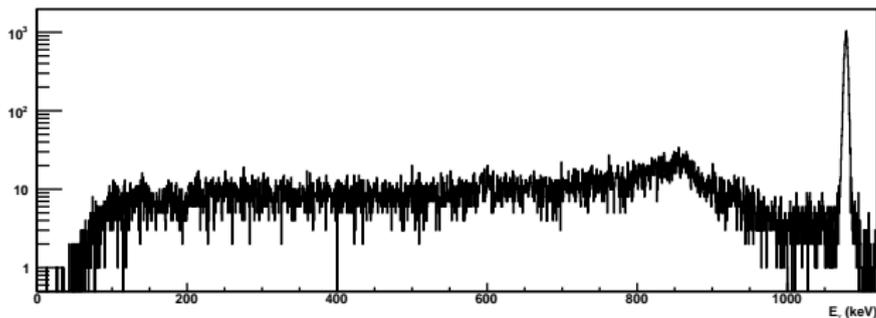
GEANT4

MGT

Results

Summary

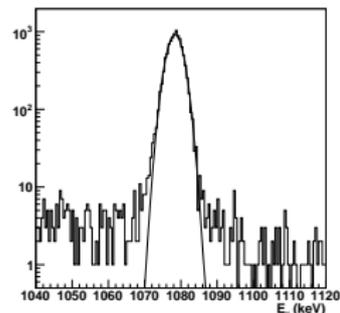
9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm



Vary position smearing parameter from 1 mm to 10 mm in steps of 0.5 mm. Same value for packing.

Energy dependent smearing turned off.

9Be(80Se,3n)86Sr @ 40 mm, Smearing 5 mm





Estimation of position resolution

$$p^2 = \frac{1}{k^2} (\Delta E_{\text{close}}^2 - \Delta E_{\text{far}}^2) \left(\frac{1}{d_{\text{close}}^2} - \frac{1}{d_{\text{far}}^2} \right)^{-1} \quad (1)$$

(See previous talk by A. Gadea)

Position resolution only dependent on measured FWHM, no Monte Carlo dependence.

Possible source of error: How to estimate $d = d(\theta, E_\gamma)$?

Two sources of uncertainties in d . Geometrical uncertainties and interaction depths.



Estimation of position resolution

$$p^2 = \frac{1}{k^2} (\Delta E_{\text{close}}^2 - \Delta E_{\text{far}}^2) \left(\frac{1}{d_{\text{close}}^2} - \frac{1}{d_{\text{far}}^2} \right)^{-1} \quad (1)$$

(See previous talk by A. Gadea)

Position resolution only dependent on measured FWHM, no Monte Carlo dependence.

Possible source of error: How to estimate $d = d(\theta, E_\gamma)$?

Two sources of uncertainties in d . Geometrical uncertainties and interaction depths.



Estimation of position resolution

$$p^2 = \frac{1}{k^2} (\Delta E_{\text{close}}^2 - \Delta E_{\text{far}}^2) \left(\frac{1}{d_{\text{close}}^2} - \frac{1}{d_{\text{far}}^2} \right)^{-1} \quad (1)$$

(See previous talk by A. Gadea)

Position resolution only dependent on measured FWHM, no Monte Carlo dependence.

Possible source of error: How to estimate $d = d(\theta, E_\gamma)$?

Two sources of uncertainties in d . Geometrical uncertainties and interaction depths.



Estimation of position resolution

$$p^2 = \frac{1}{k^2} (\Delta E_{\text{close}}^2 - \Delta E_{\text{far}}^2) \left(\frac{1}{d_{\text{close}}^2} - \frac{1}{d_{\text{far}}^2} \right)^{-1} \quad (1)$$

(See previous talk by A. Gadea)

Position resolution only dependent on measured FWHM, no Monte Carlo dependence.

Possible source of error: How to estimate $d = d(\theta, E_\gamma)$?

Two sources of uncertainties in d . Geometrical uncertainties and interaction depths.



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

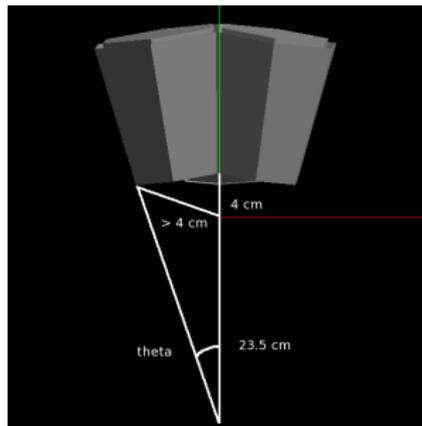
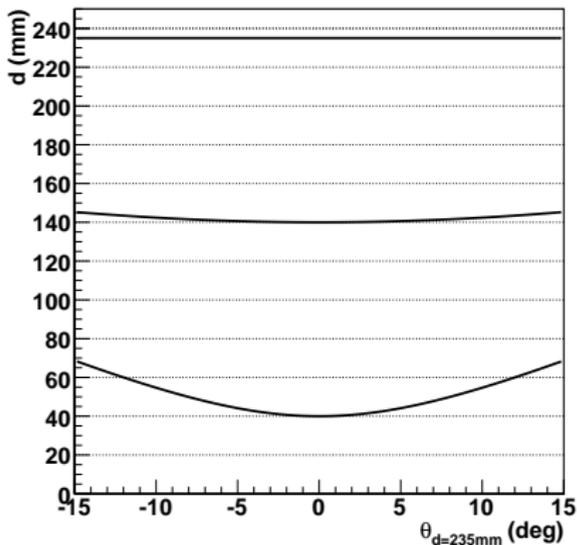
Introduction

Simulations

Results

Summary

Geometrical uncertainties



The curvature radius of the clusters is designed for $d = 235$ mm. If the front face of the detector is closer to the source, the distance can vary a lot.

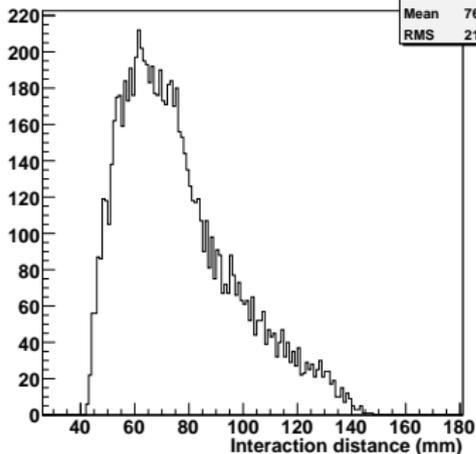


First interaction point

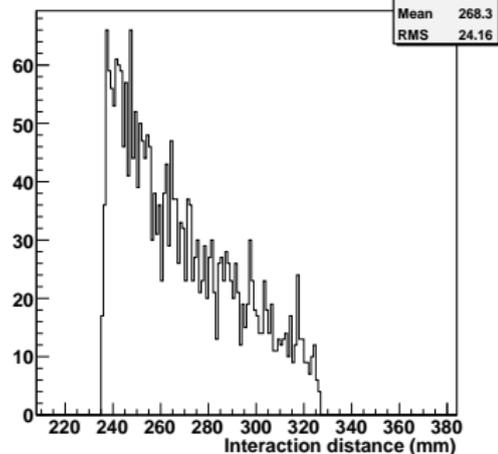
Histograms from the GEANT4 output.

Includes both the geometrical uncertainties and uncertainties due to the interaction depth.

9Be(80Se,3n)86Sr @ 40 mm



9Be(80Se,3n)86Sr @ 235 mm



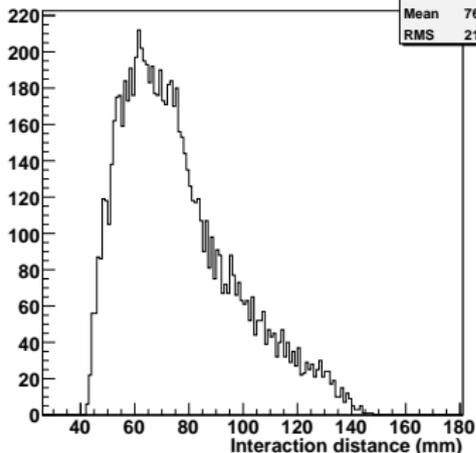


First interaction point

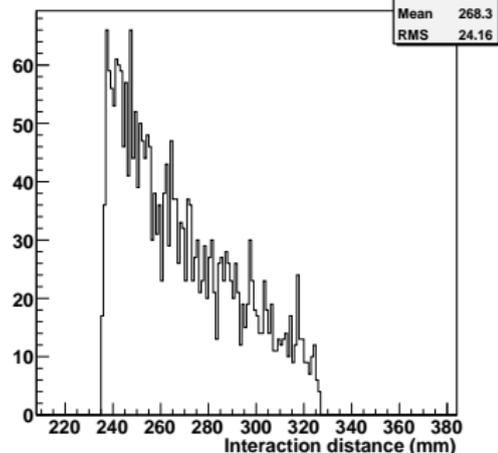
Histograms from the GEANT4 output.

Includes both the geometrical uncertainties and uncertainties due to the interaction depth.

9Be(80Se,3n)86Sr @ 40 mm



9Be(80Se,3n)86Sr @ 235 mm





FWHM vs. smearing

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

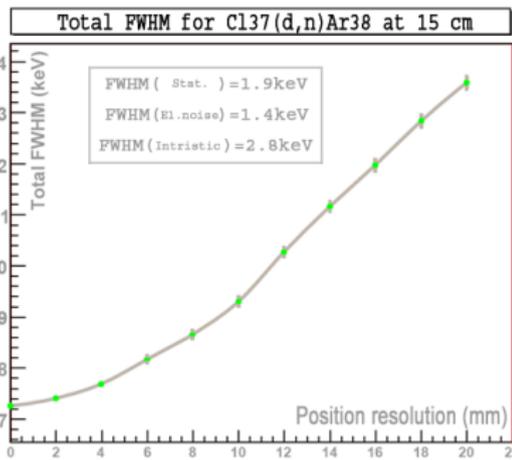
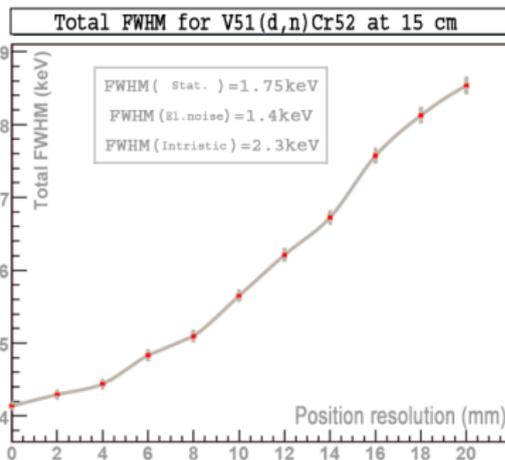
P.-A. Söderström

Introduction

Simulations

Results

Summary



FWHM against MGT smearing for ^{37}Cl and ^{51}V beams at 11 cm. Target effects, cross sections and similar carefully studied by Ali Al-Adili and under control. See his masters thesis (in preparation) for details.



FWHM vs. smearing

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

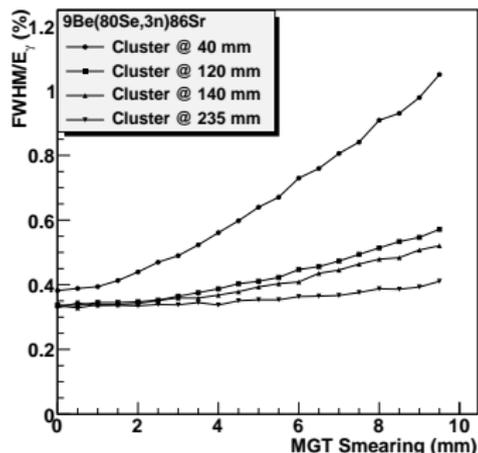
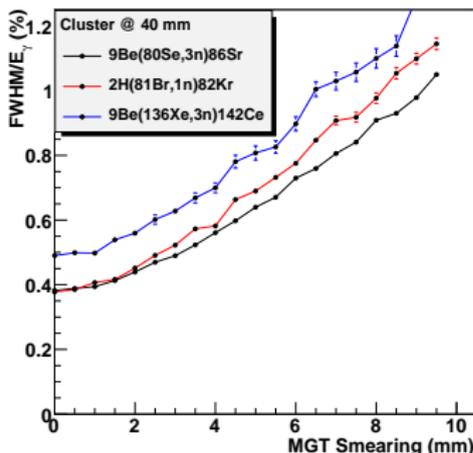
P.-A. Söderström

Introduction

Simulations

Results

Summary



The three reactions looks qualitatively very similar.

Example with MGT smearing of 5 mm:

${}^{80}\text{Se}$ gives $W_{\text{rec}} \approx 3.74$ keV, $W_{\text{int}} \approx 1.86$ keV

${}^{136}\text{Xe}$ gives $W_{\text{rec}} \approx 2.89$ keV, $W_{\text{int}} \approx 1.39$ keV.

As expected, slope change with d . Why do they not meet at 0?
Because of packing of 1 mm?



FWHM vs. smearing

UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

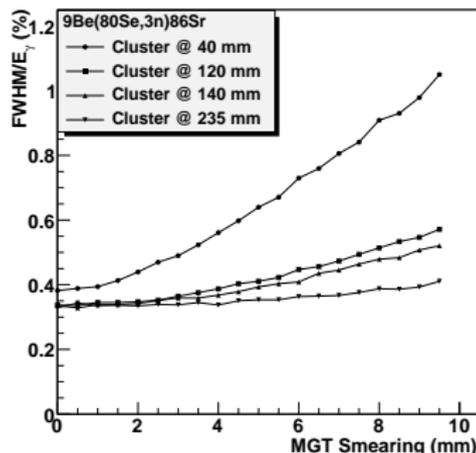
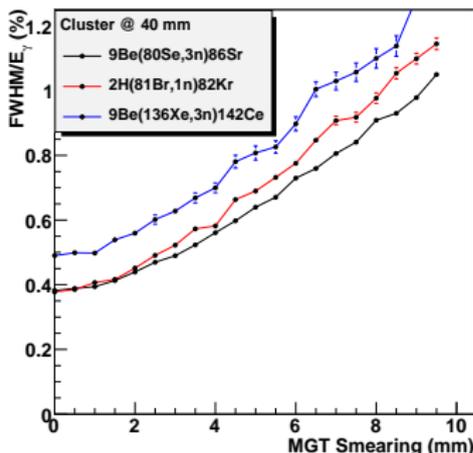
P.-A. Söderström

Introduction

Simulations

Results

Summary



The three reactions looks qualitatively very similar.

Example with MGT smearing of 5 mm:

${}^{80}\text{Se}$ gives $W_{\text{rec}} \approx 3.74$ keV, $W_{\text{int}} \approx 1.86$ keV

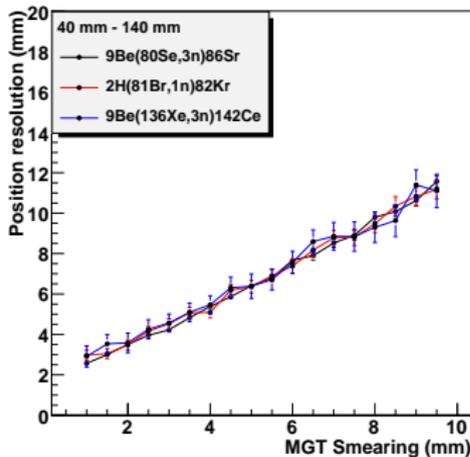
${}^{136}\text{Xe}$ gives $W_{\text{rec}} \approx 2.89$ keV, $W_{\text{int}} \approx 1.39$ keV.

As expected, slope change with d . Why do they not meet at 0?
Because of packing of 1 mm?

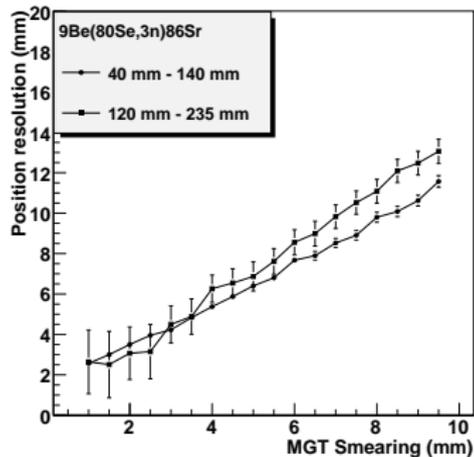


Position resolution vs. smearing

Graph



Graph



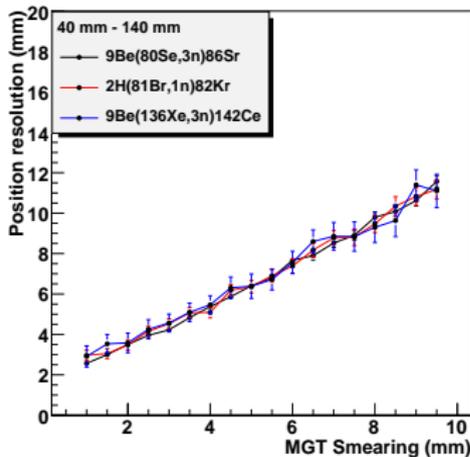
The good news: The three different reactions give the same position resolution when run at the same distance.

The bad news: The two different distances do not give same position resolution for the same reaction. Possibly related to uncertainties in d ?

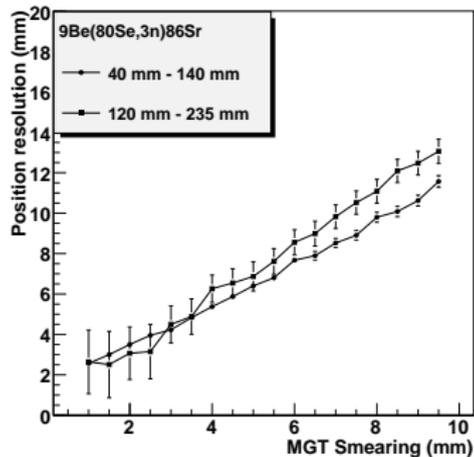


Position resolution vs. smearing

Graph



Graph



The good news: The three different reactions give the same position resolution when run at the same distance.

The bad news: The two different distances do not give same position resolution for the same reaction. Possibly related to uncertainties in d ?



UPPSALA
UNIVERSITET

Monte Carlo
simulations of
commissioning
experiments for the
AGATA Demonstrator

P.-A. Söderström

Introduction

Simulations

Results

Summary

Summary

- The method proposed by F. Recchia seem to work with Monte Carlo simulations
- Necessary to find a way to determine d with good accuracy
- Reaction rate example: ^{80}Se , 1 pA, 1 mg/cm², 300 mb gives about 500 Hz in peak
- Requirements - OK