

# RFD simulations

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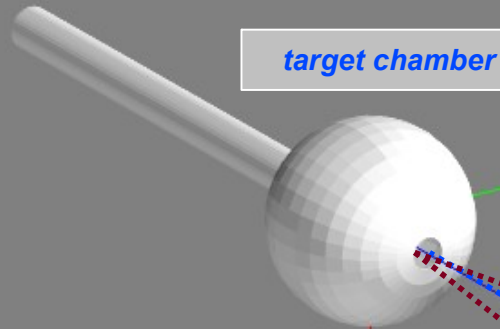
et al.

*EGAN 2012 Workshop, 25-28 June, Orsay*

# Introduction to RFD

## construction and performance

*Ion guide*



*target chamber*

*gamma detector*



Identification of recoils,  
using pulsed beam, by their:

- time-of-flight
- the pulse height

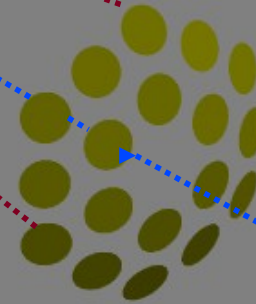
In coincidence with gamma spectroscopy,  
allows filtering out:

- scattered beam
- other reaction products

**recoils**

*mylar foils*

**recoils**



**beam**

# Introduction to simulations

„some history”

Simulations started by G. Jaworski in GEANT4 and COMPA:

Simulation of a beam

Simulation of desired recoil

Continued with application of CASCADE:

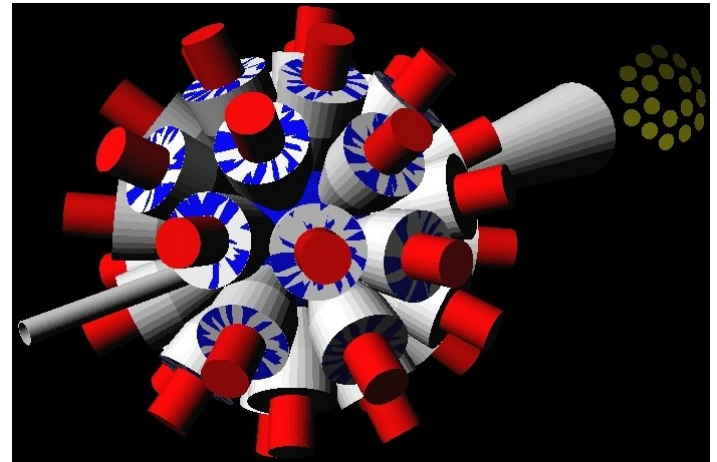
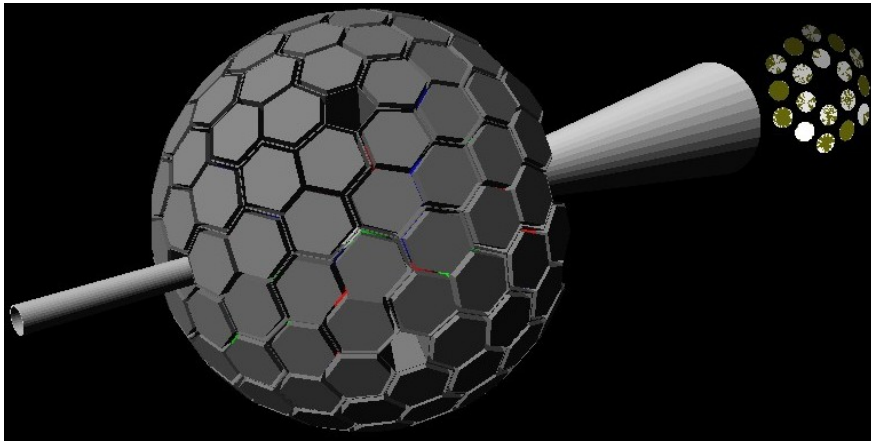
Simulation of all types of recoils for given reaction

Inclusion of fission products (pre-phase)

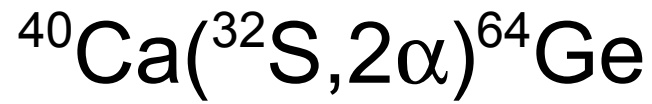
Application of GEMINI++

Inclusion of symmetric and asymmetric fission products

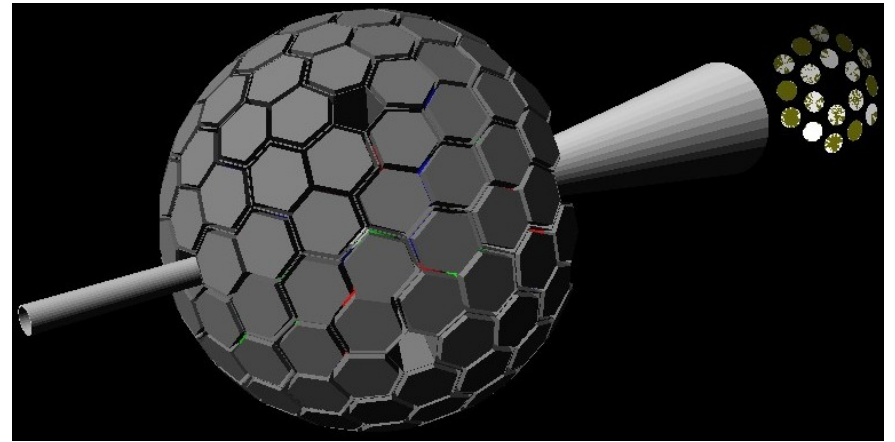
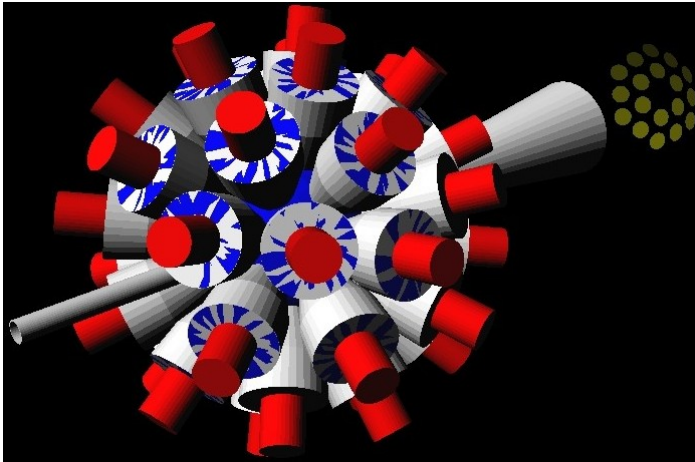
# Simulations of lifetime measurements with RFD, AGATA and GASP



shown during AW in Uppsala, July 2008



$$\epsilon_{\text{RFD}} = 24\%$$



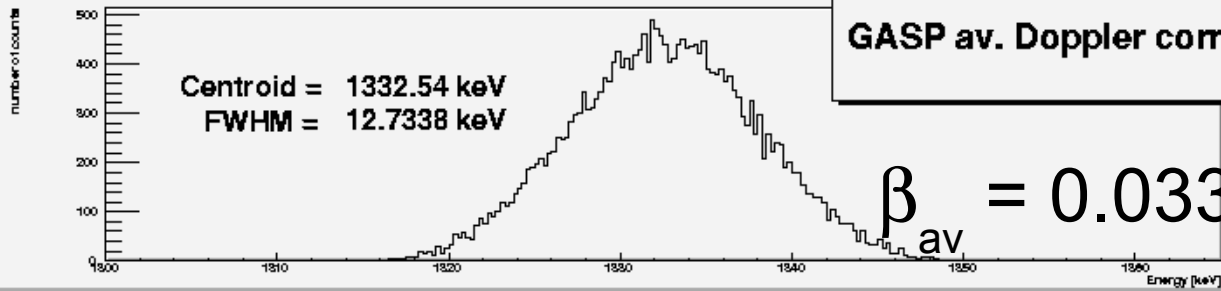
$$\epsilon_{\text{GASP}} = 5.0\%$$

$$P/T = 0.71$$

$$\epsilon_{3\text{PI}} = 22\%$$

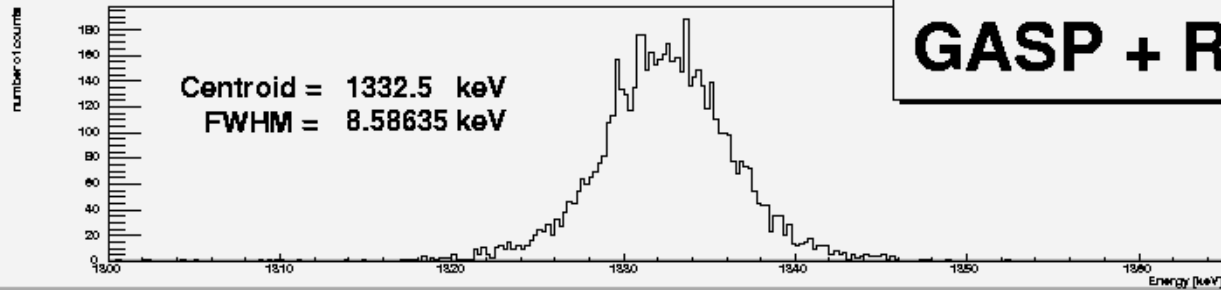
$$P/T = 0.67$$

FWHM = 2.4 keV @ 1.3 MeV



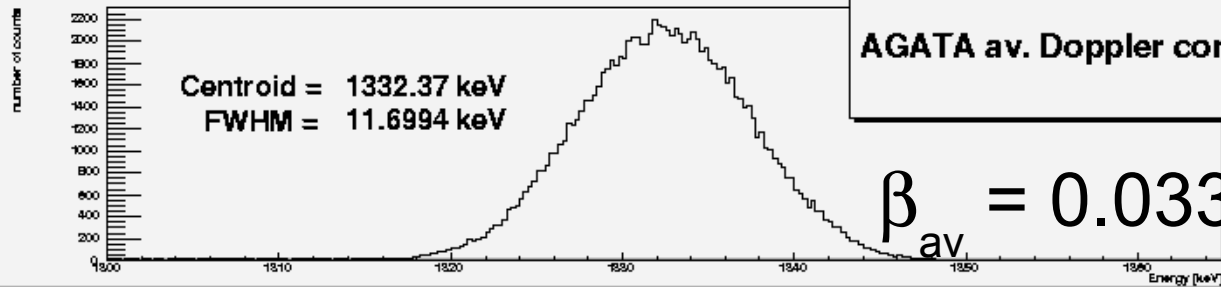
GASP av. Doppler correction

$$\beta_{av} = 0.0335$$



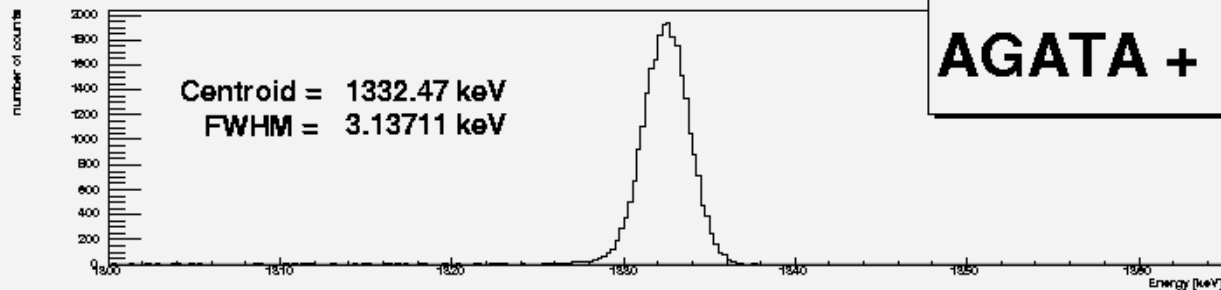
GASP + RFD

$\gamma$   
emission  
after  
passing  
through  
the target



AGATA av. Doppler correction

$$\beta_{av} = 0.0335$$



AGATA + RFD

# AGATA

120-180°

lifetime determination:  
P.Bednarczyk et al.  
EPJA 20(2004)45

prompt  $\gamma$  emission

$\tau = 0.01$  ps

$\tau = 0.05$  ps

$\tau = 0.1$  ps

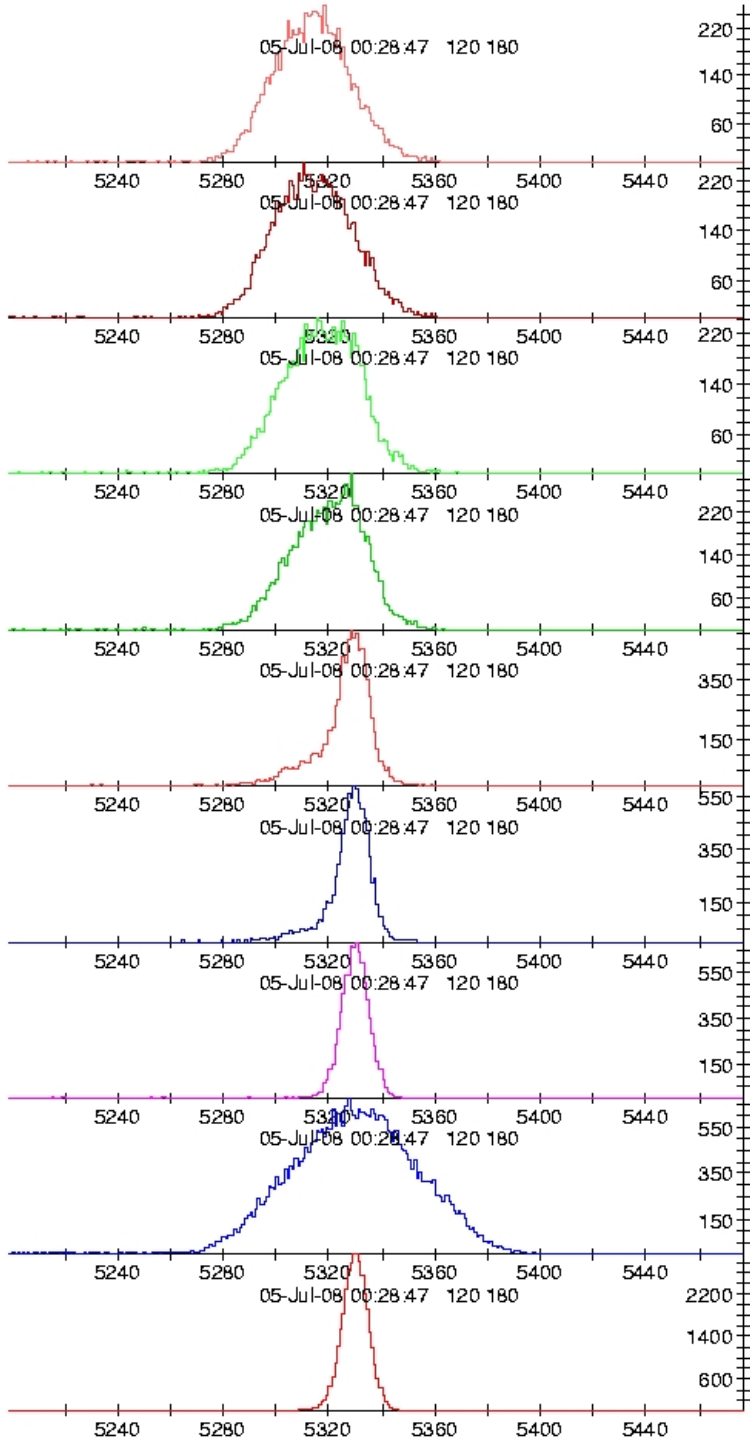
$\tau = 0.5$  ps

$\tau = 1.0$  ps

$\gamma$  emission outside the target

average Doppler correction

stopped source



# Aim of simulations radioactive beams, inverse kinematics

## „Study of collective modes of excitations in the neutron-rich Ba region via fusion-evaporation reactions”

*Spiral2 Day1 – Phase2 Lol*

Adam Maj (Kraków), Silvia Leoni (Milano) – spokespersons

Christell Schmitt – GANIL Liaison et al

### Proposed reaction:

- Radioactive beam:  $^{90}\text{Kr}$ ,  $E = 388 \text{ MeV}$
- Target:  $^{48}\text{Ca}$ ,  $1 \text{ mg/cm}^2$

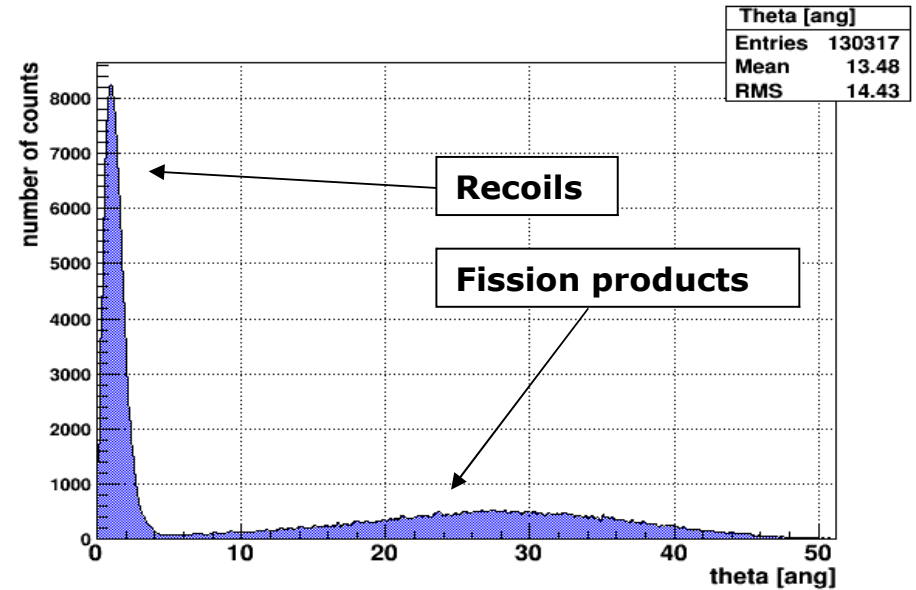
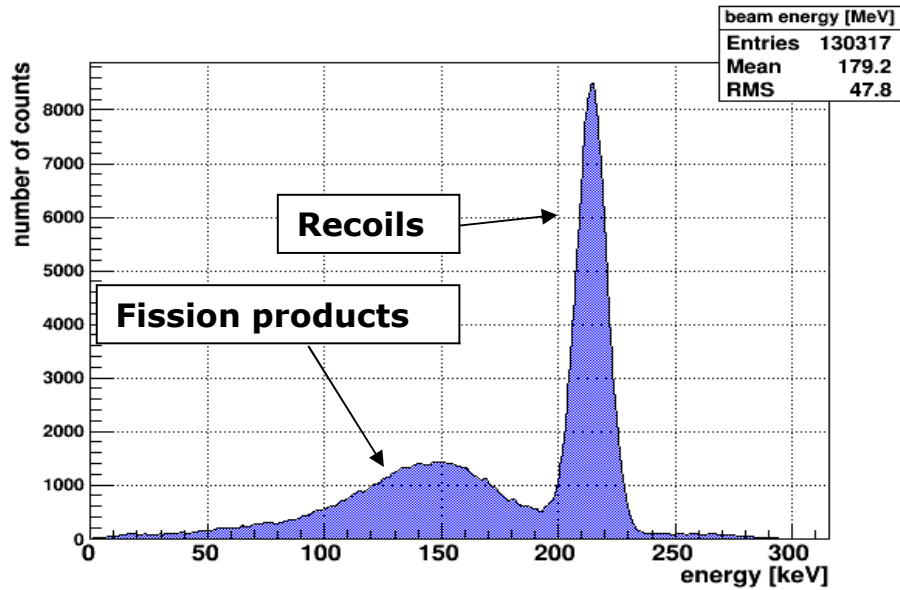
### Possible application of RFD

- Doppler shift correction
- elimination of fission products – *essential in this kind of reaction*



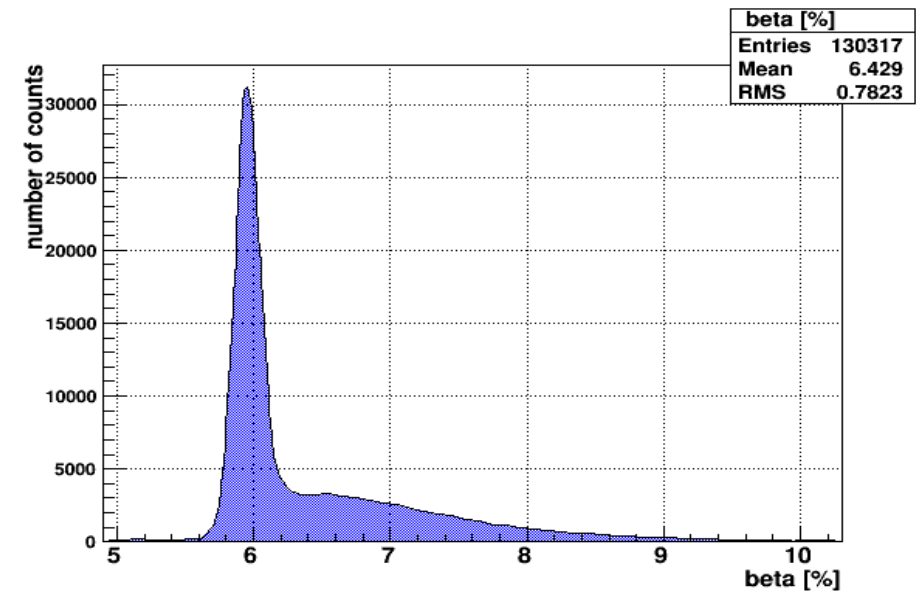
# Results

## reaction products



388 Mev  $^{90}\text{Kr}$  beam passing  $1\text{mg}/\text{cm}^2$   $^{48}\text{Ca}$  target

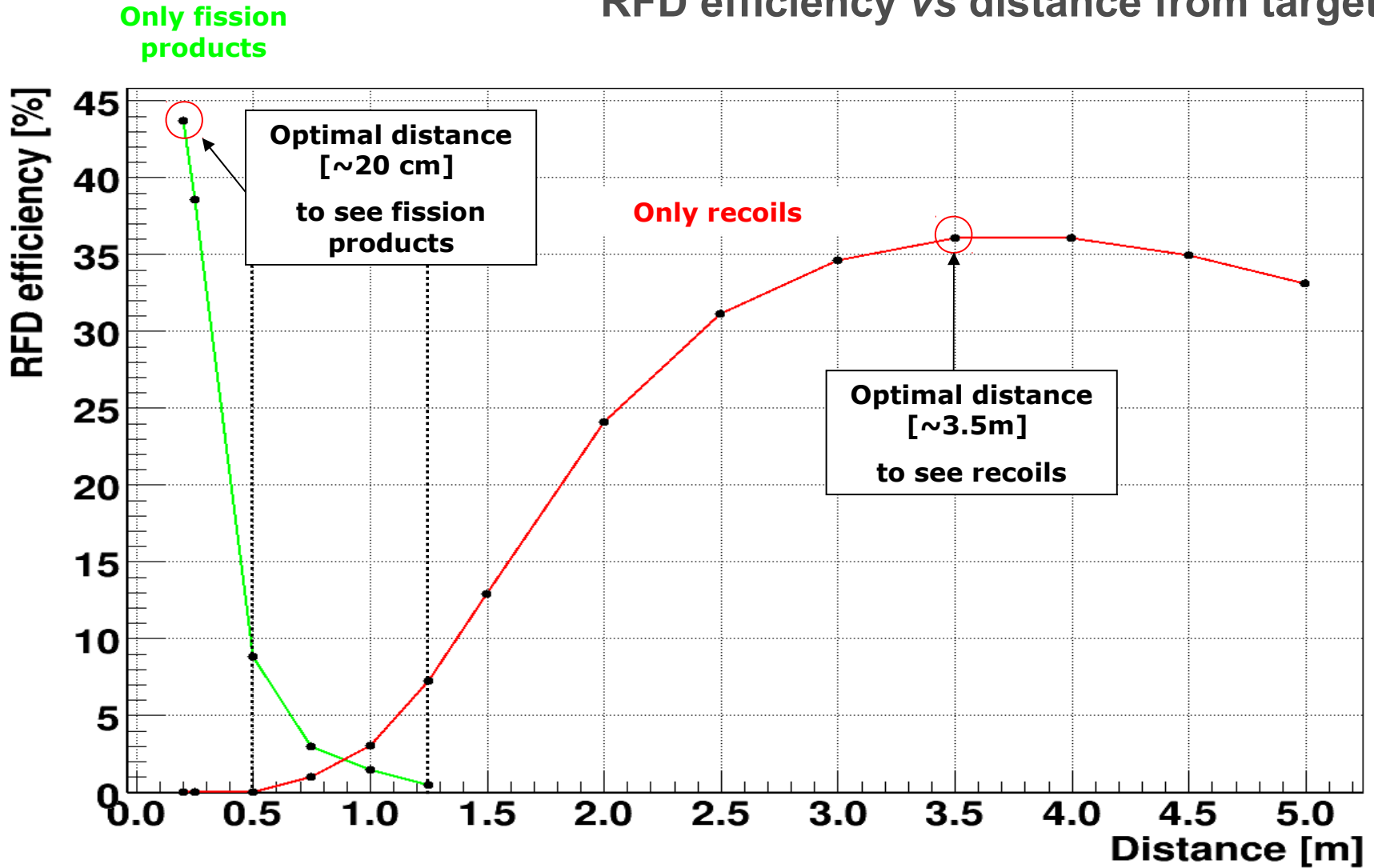
calculated with Geant4.9.2 + Gemini+



Energy, angular and beta distributions  
of  
reaction products that leave target

# Results

## RFD efficiency vs distance from target

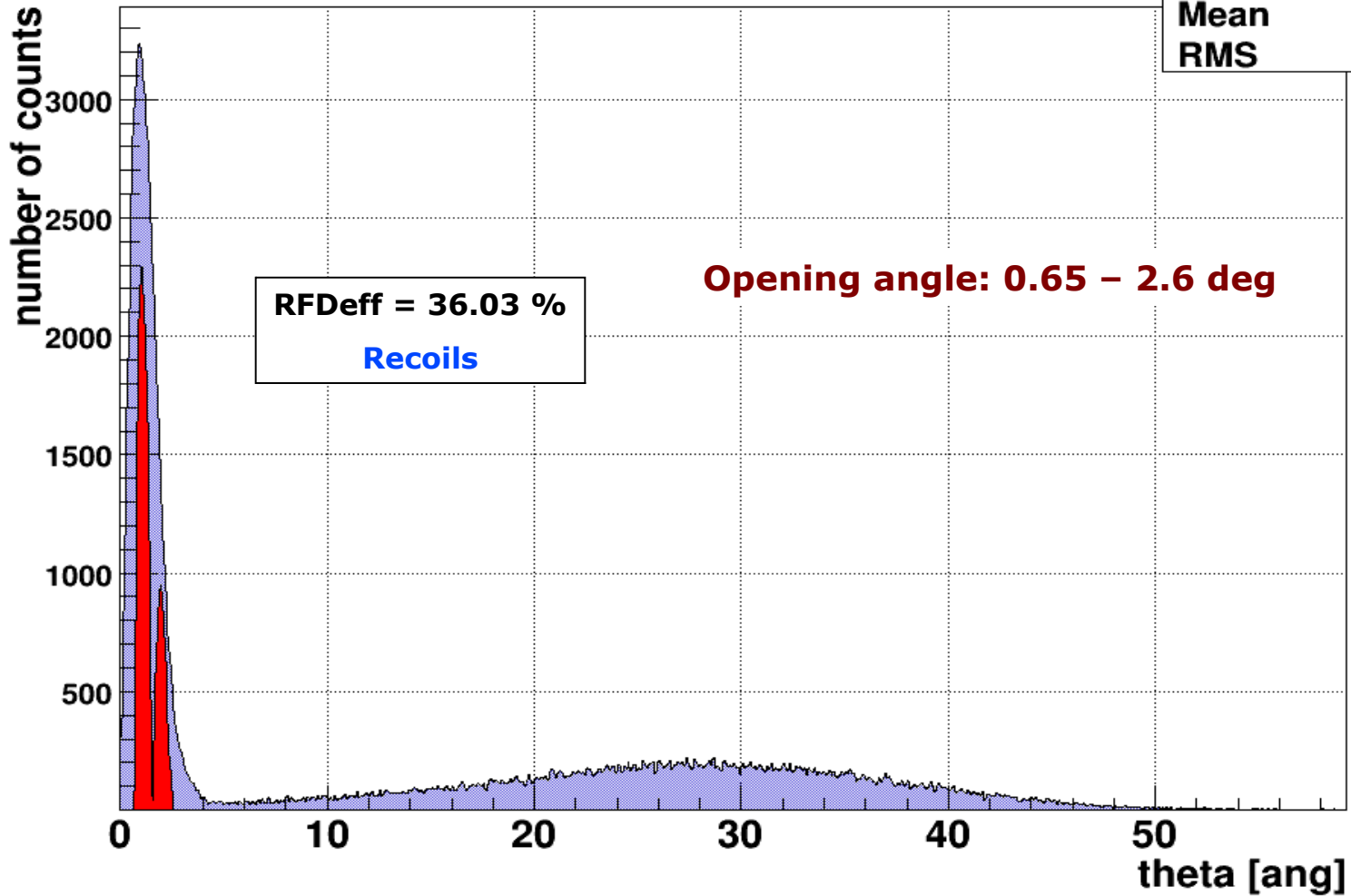


# Results

## RFD efficiency vs distance

RFD efficiency at the distance of 3.5 m

Theta [ang]	
Entries	99916
Mean	13.56
RMS	14.56

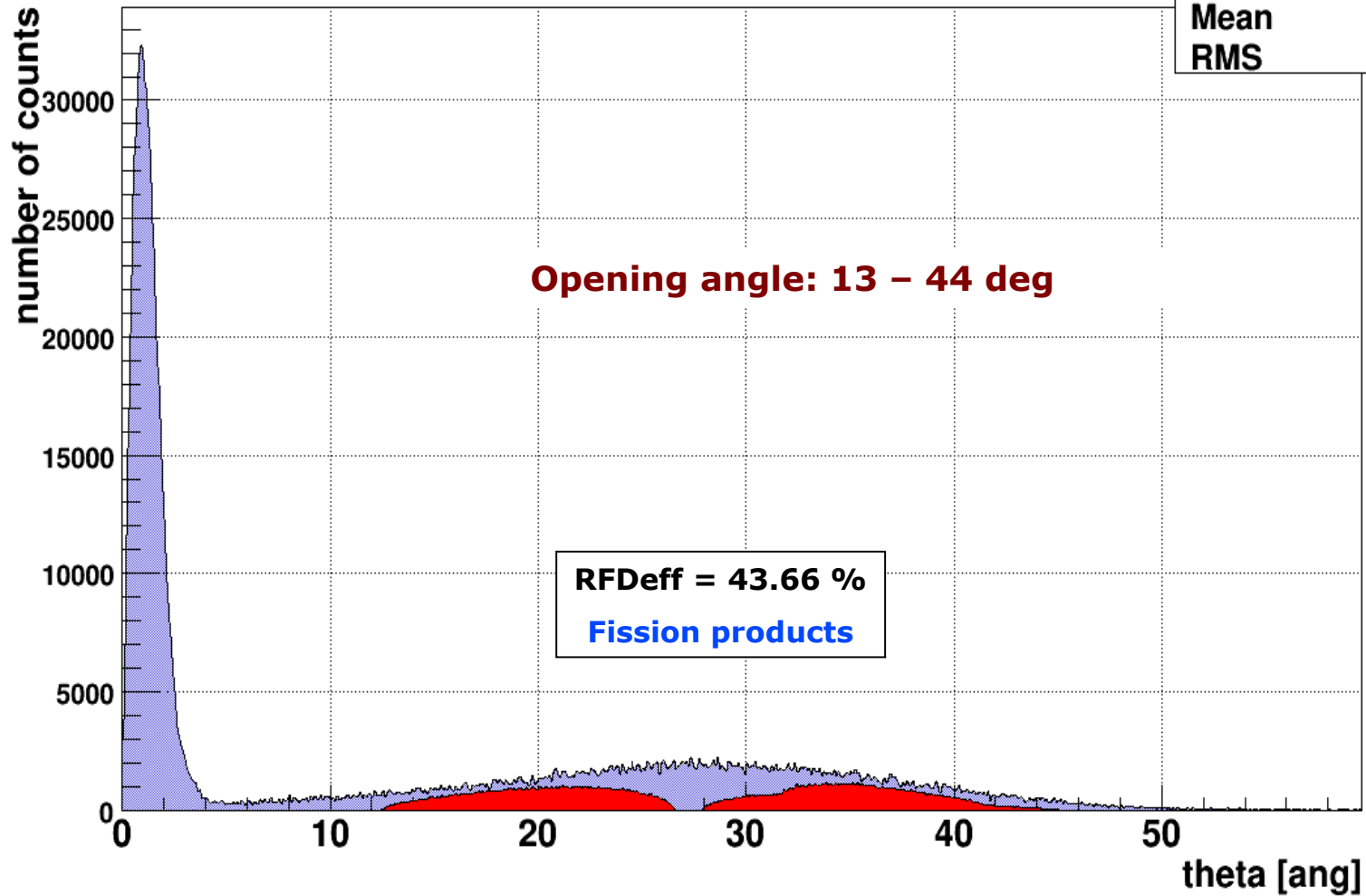


# Results

## RFD efficiency vs distance

### RFD efficiency at the distance of 20cm

Theta [ang]	
Entries	99916
Mean	13.56
RMS	14.57



# Results

## deposition of nuclei in RFD elements

Only 0.4% of recoils and 0.01% of beam nuclei leaving target chamber are implemented in RFD cone –  
*might not be necessary to make it removable*

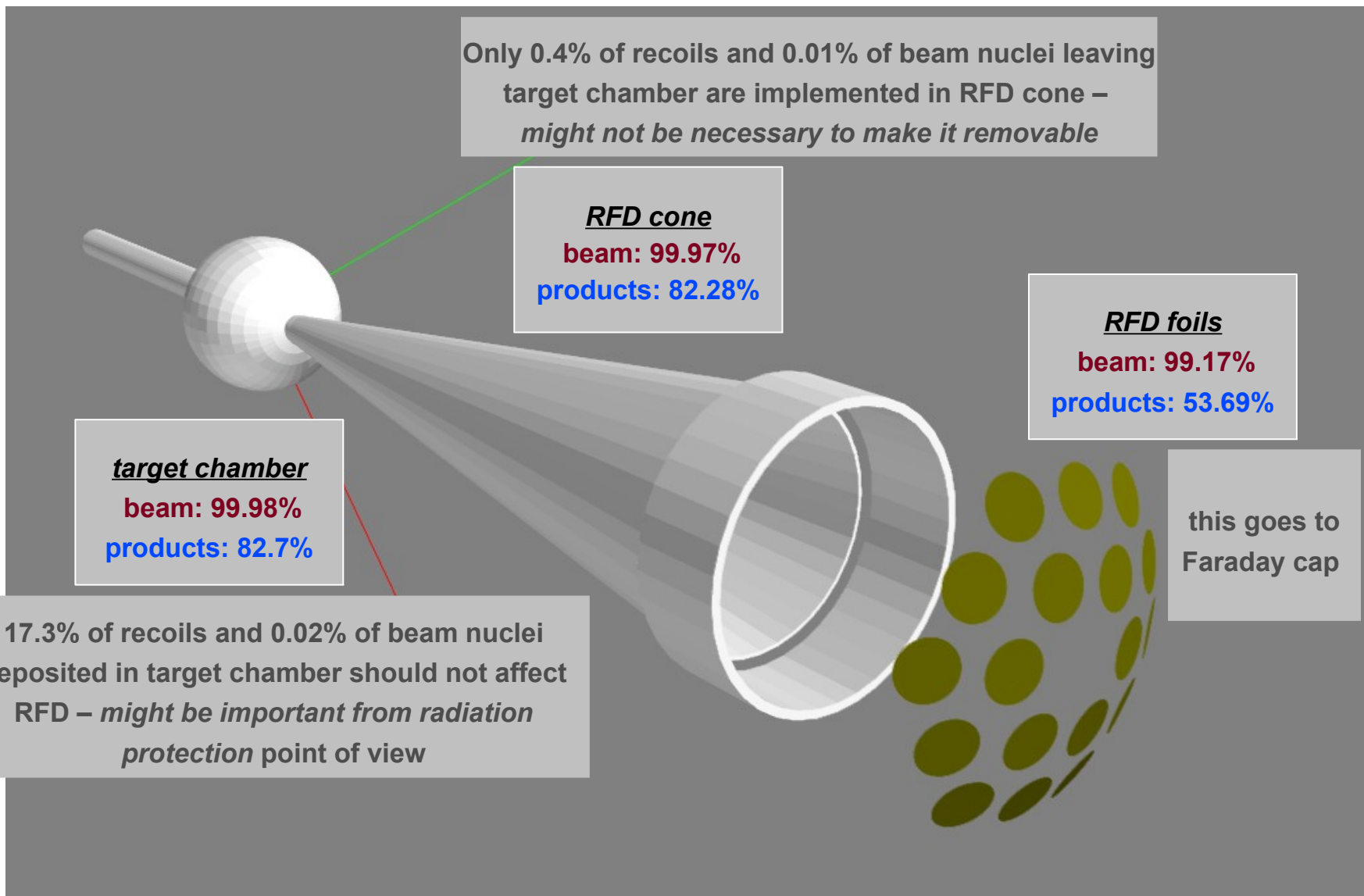
**RFD cone**  
beam: 99.97%  
products: 82.28%

**RFD foils**  
beam: 99.17%  
products: 53.69%

**target chamber**  
beam: 99.98%  
products: 82.7%

this goes to  
Faraday cap

17.3% of recoils and 0.02% of beam nuclei deposited in target chamber should not affect RFD – *might be important from radiation protection point of view*



# Summary

- experiments with RFD: widths of the  $\gamma$  lines just due to Ge det. opening angle;
- complete simulations of GASP+RFD and AGATA+RFD performed (with COMPA);
- AGATA+RFD setup sensitive to lifetimes in the range 0.01-1.00 ps;
- new design of RFD for RIB ongoing;
- CASCADE and GEMINI employed

## Simulations „to do list”

General „improvements”:

Point vs non point-like (finite size of the spot) beam

Broadening of initial beam energy

Further study on possible application to detect fission products:

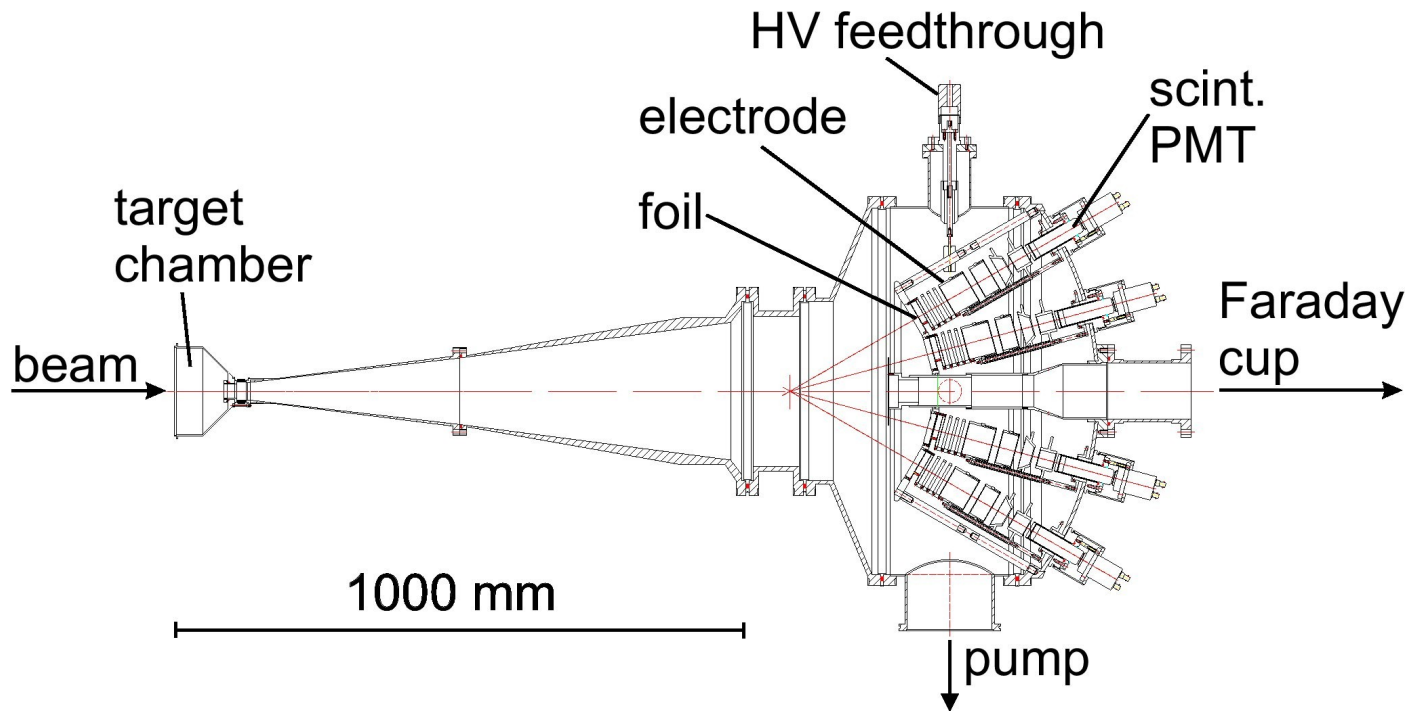
Angular resolution

Doppler shift correction

Further study on nuclei deposition in RFD construction:

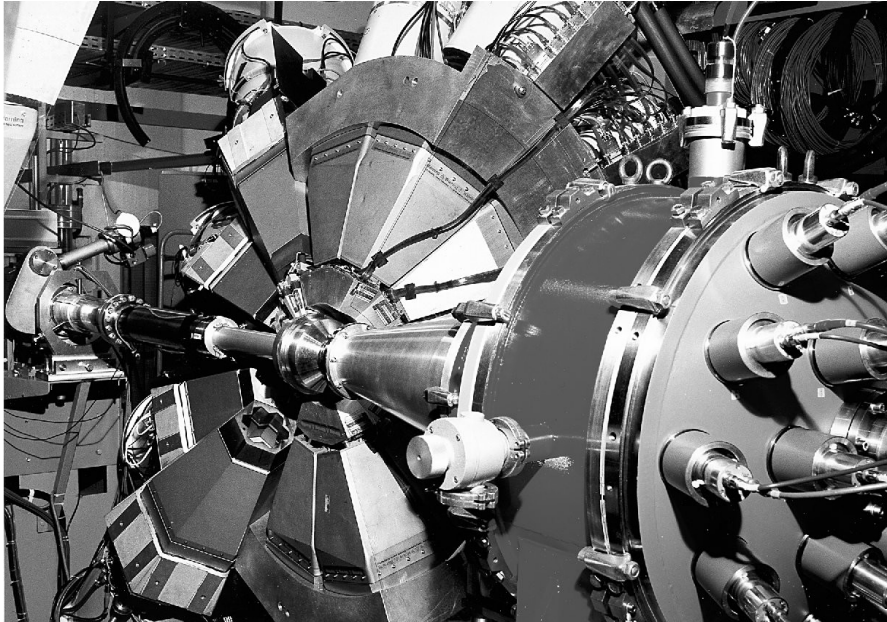
Detailed identification of nuclei and its quantity – estimation of dose deposition

# The RFD detector



W.Męczyński et al. - NIM A580, 1310(2007)

# The RFD detector



W.Męczyński et al. - NIM A580, 1310(2007)



W.Męczyński et al.  
NIM A580, 1310(2007)

