Conversion electron spectroscopy with Mini-Orange spectrometers (MOS)

Talk for the

Mini-Workshop on Future In-Beam Conversion-Electron Spectroscopy

Bonn, 23-24 January 2003

Edgar Mergel

Overview

- Functionality
- Transmission
- Simulation
- Detectorsystem
- δ–electrons
- MOS Setups
  - ^{240}Pu
  - ^{236}U
  - ^{135}Nd

List of Mini-Oranges and Detectors

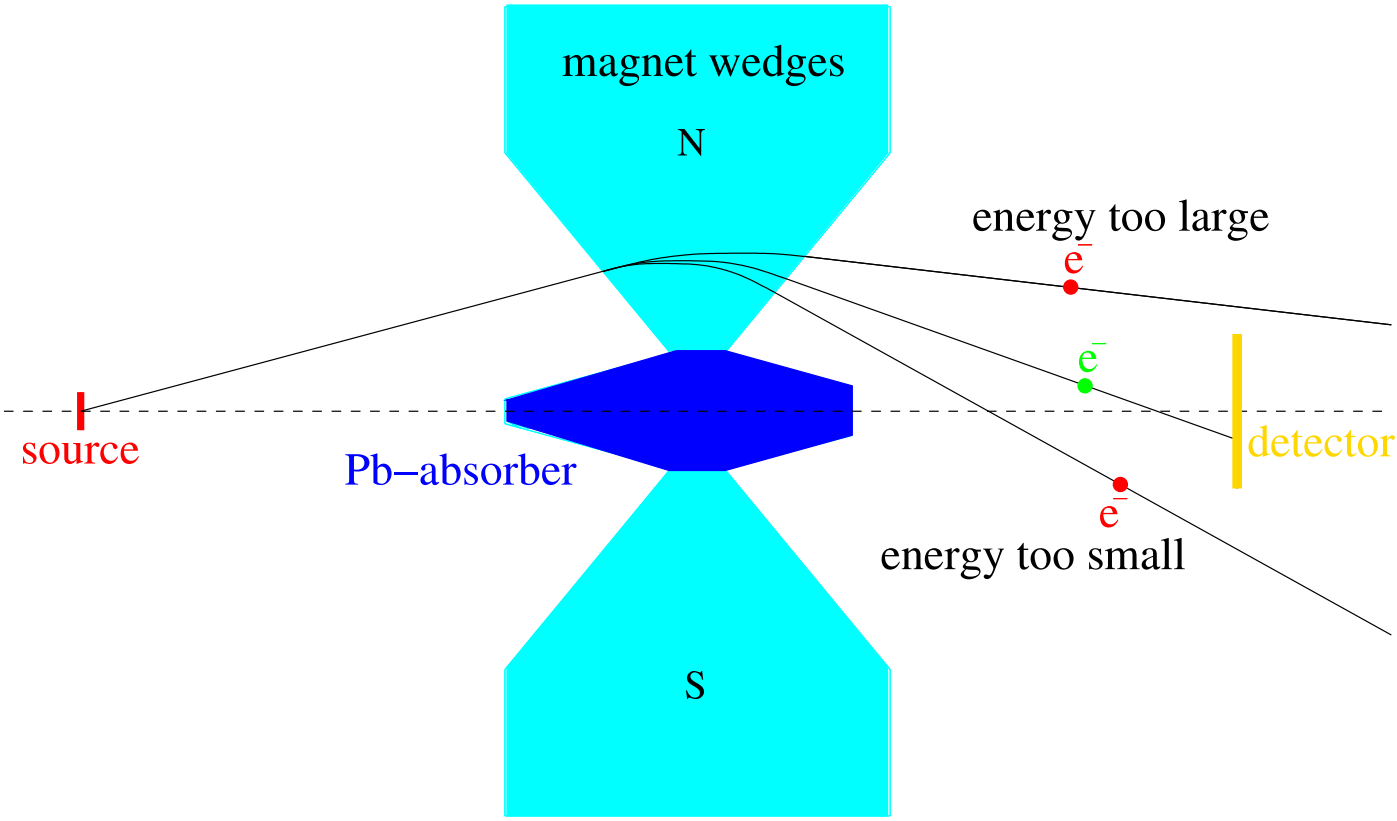
Mini-Oranges:

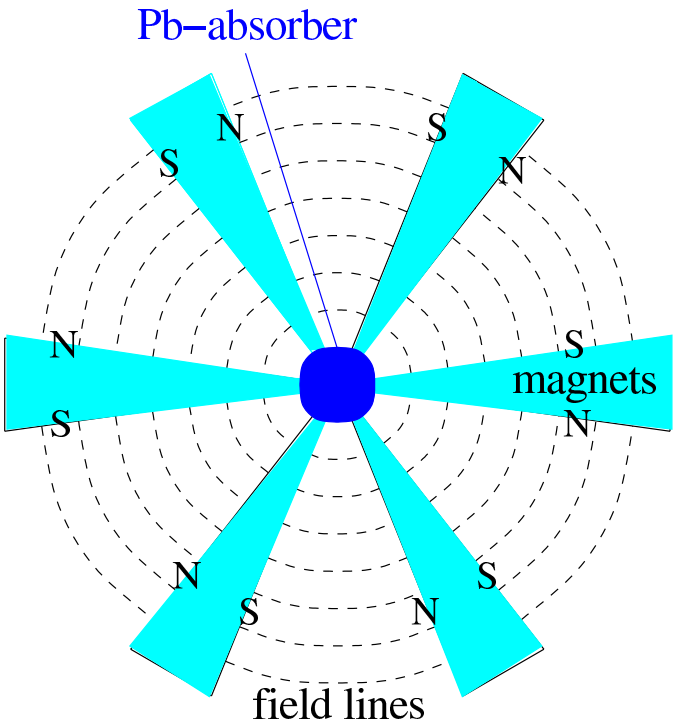
used for experiment on	Material	Wedges [#]	Shape	Transmission [%]	Energy [keV]
^{236}U	$Nd_2Fe_{14}B$	6	asym.	3.5	2700
^{240}Pu	$Nd_2Fe_{14}B$	6	sym.	2.3	650
^{240}Pu	$Nd_2Fe_{14}B$	5	sym.	2.0	450
^{136}Nd	$Nd_2Fe_{14}B$	8	sym.	2.7	1700
^{194}Pb	$Nd_2Fe_{14}B$	6	sym.	2.0	3000
^{135}Nd and ^{188}Pb	$SmCo_5$	6	sym.	1.7	600

Si(Li)–Detectors:

	Thickness [mm]	Area [mm^2]	max. Energy [keV]	Resolution [keV]
5x	3	300	1700	2-3
3x	6	500	3000	3-4
3x	6	300	3000	3

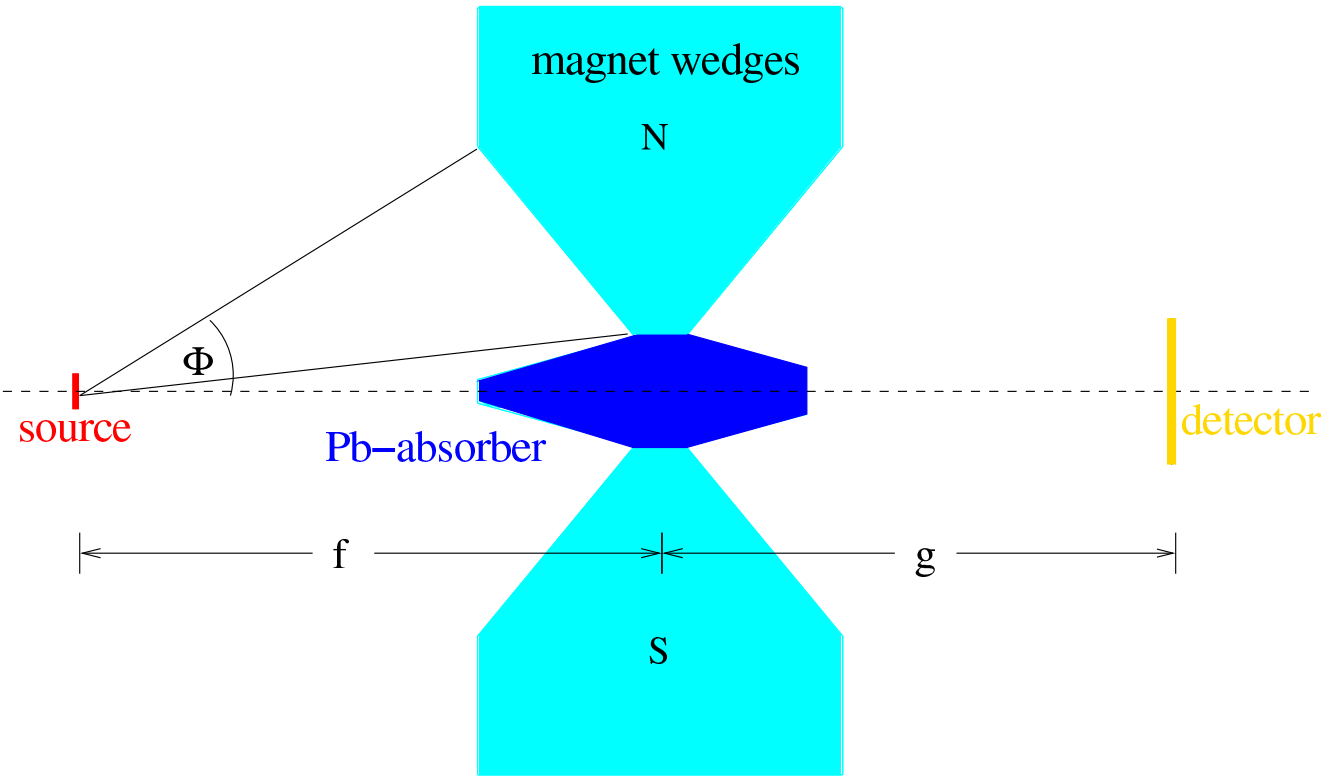
Functionality of a "Mini–Orange" (MO)





- collecting electrons of a specific energy range and large solid angle
- suppression of low energy electrons (delta–electrons)
- direct radiation is blocked by central Pb–absorber (γ–rays, neutrons, etc.)

Transmission of a "Mini–Orange" (MO)

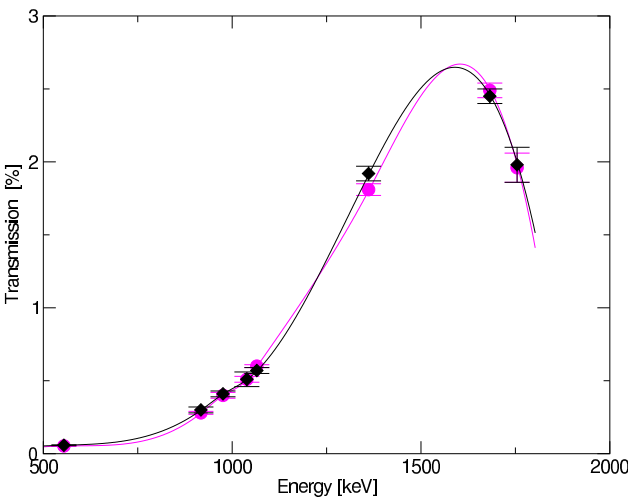


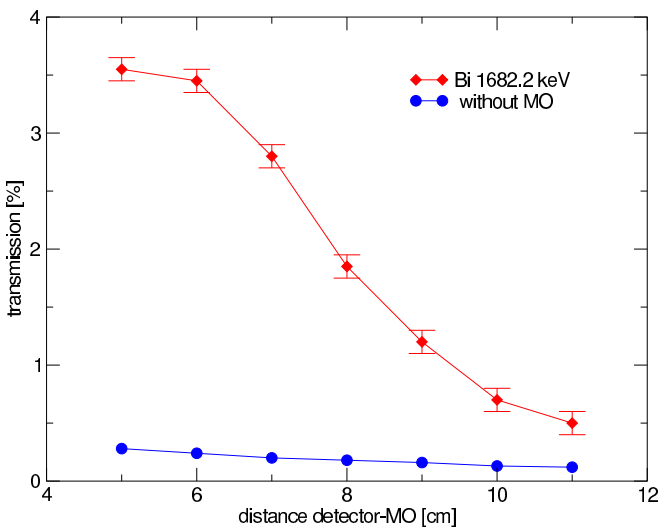
$$T = 1/2(\cos\Phi_{min} - \cos\Phi_{max})(1-b)(1-k)$$

$$= \frac{\text{\# of electrons detected}}{\text{\# of electrons emitted in } 4\pi}$$

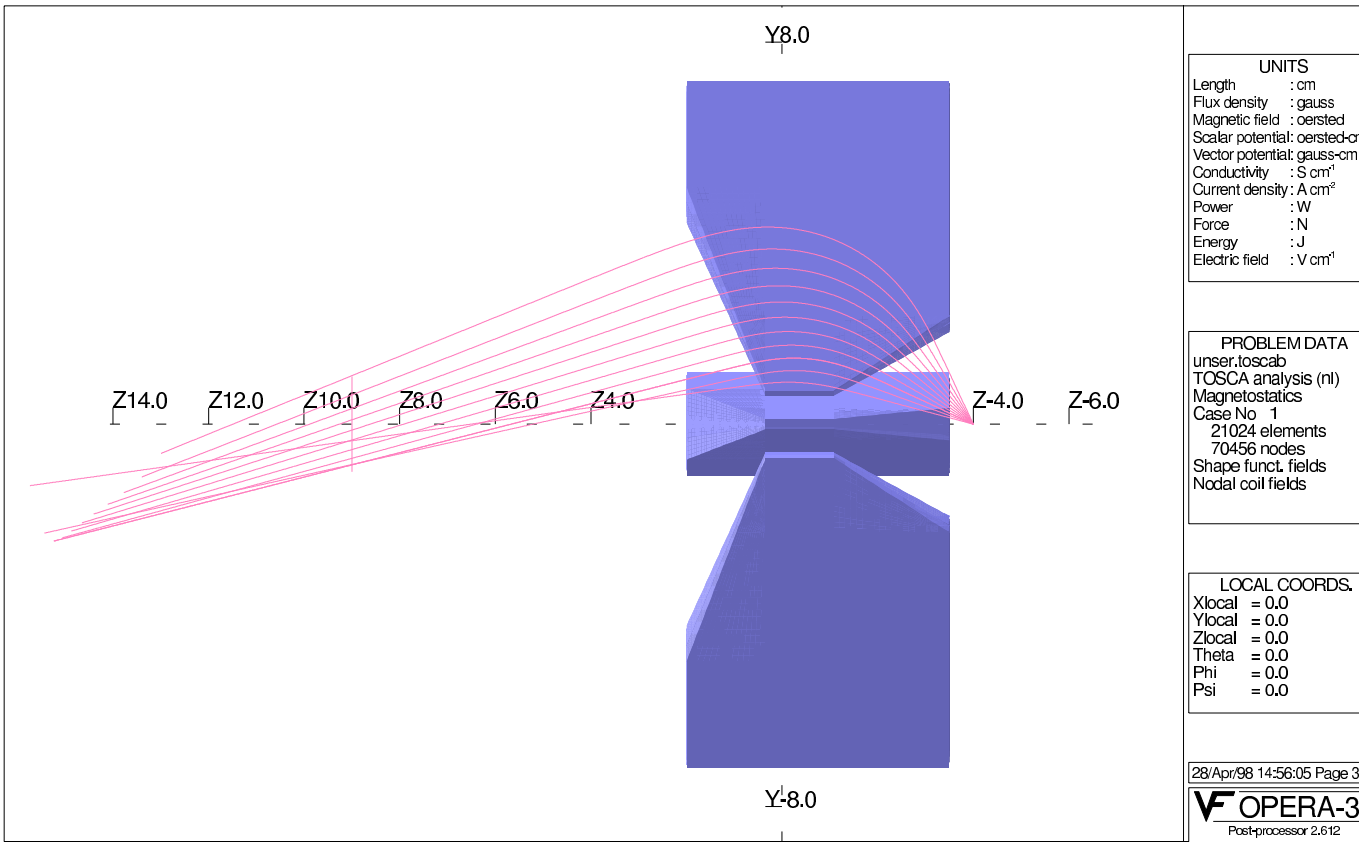
b = blocking factor of the magnet wedges

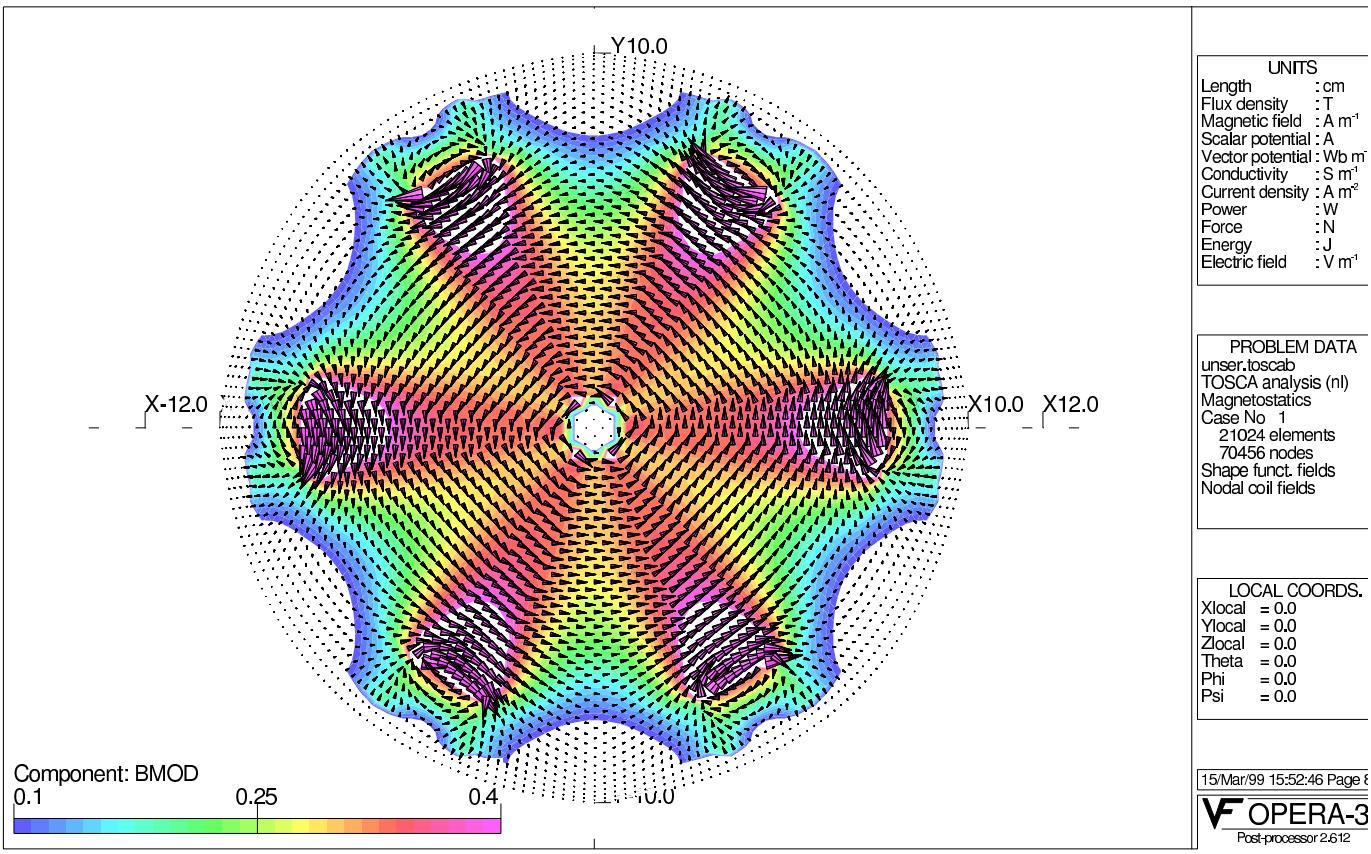
1–k = peak efficiency



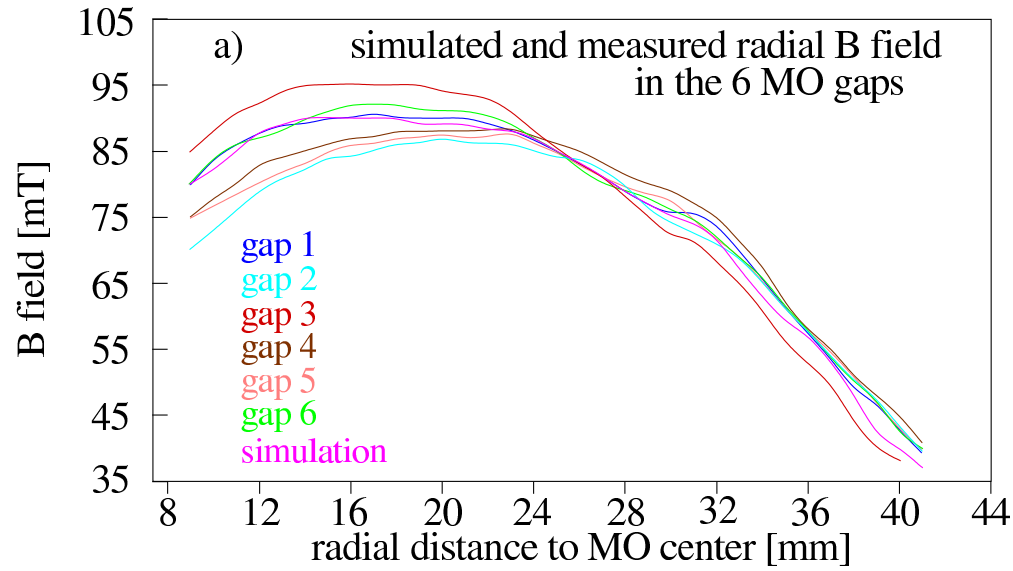


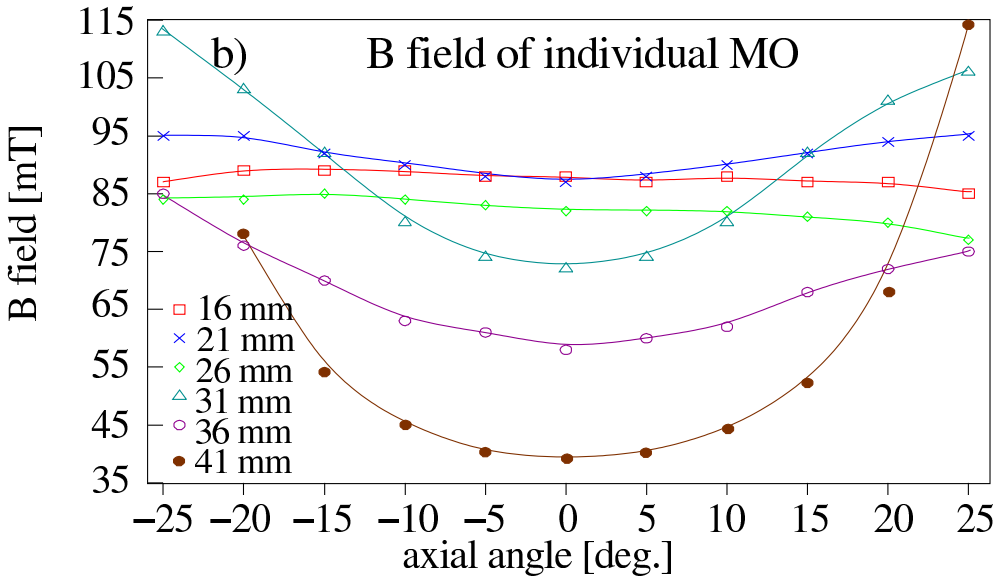
Simulation with OPERA 3D

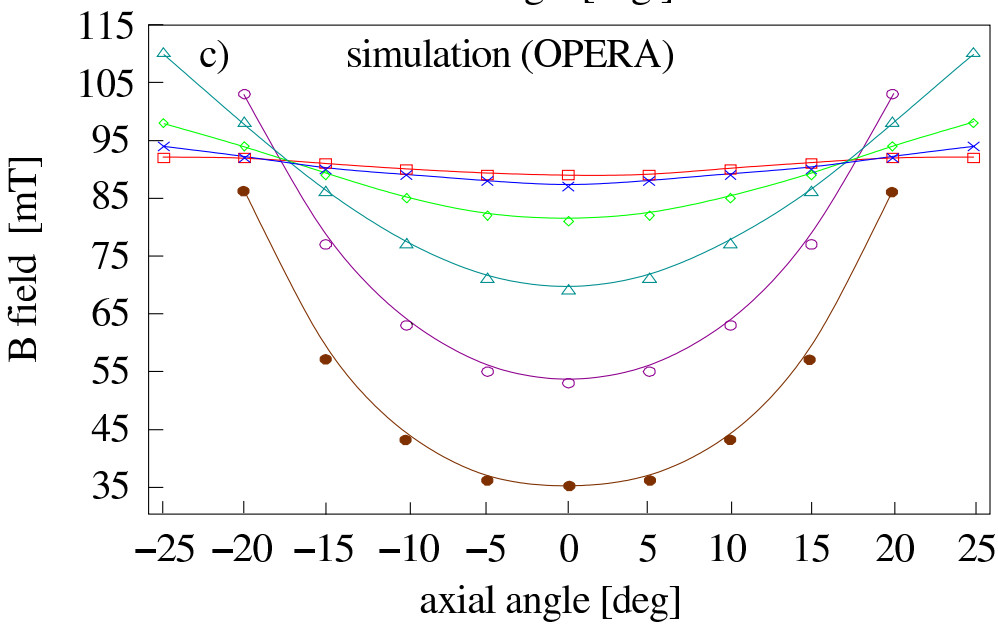




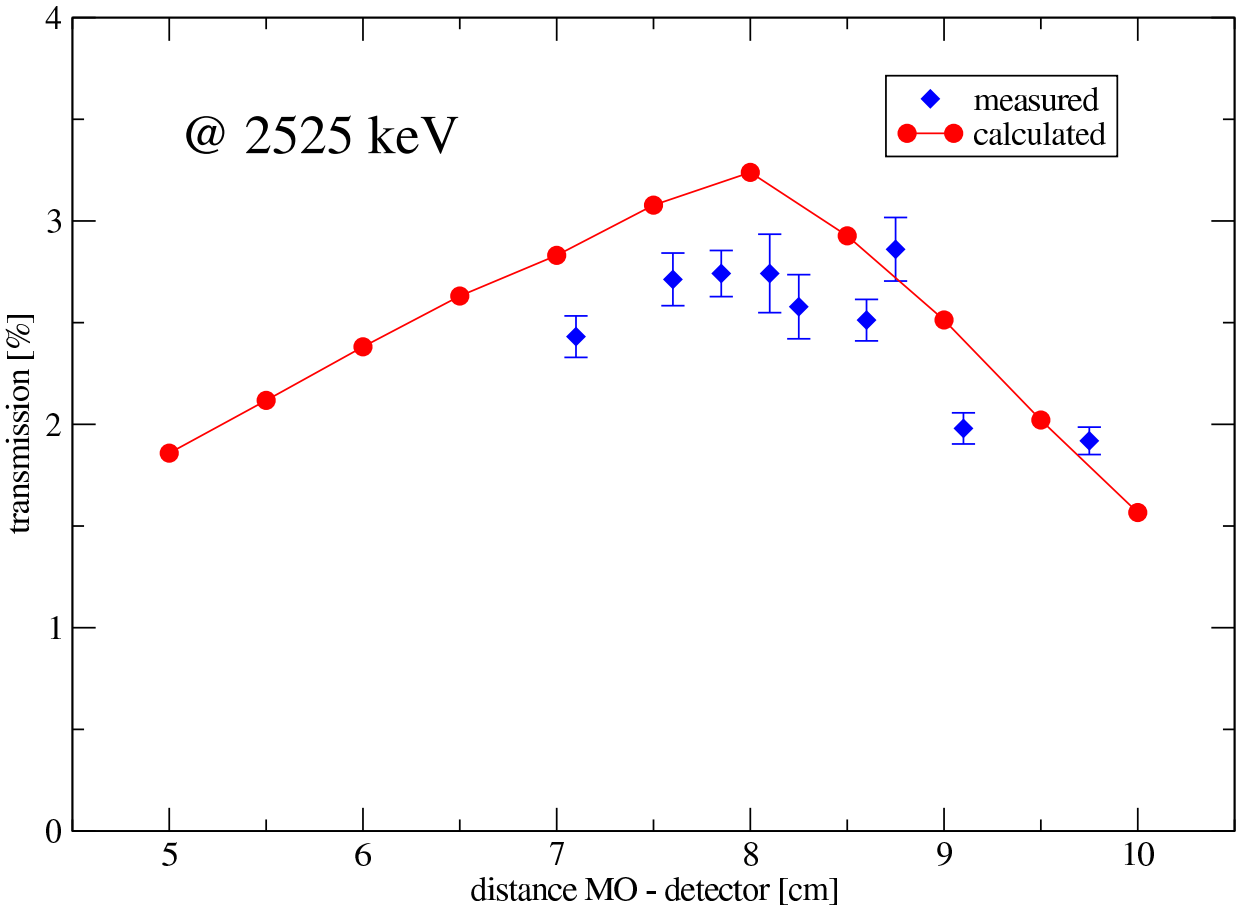
Comparing Simulation and Measurement



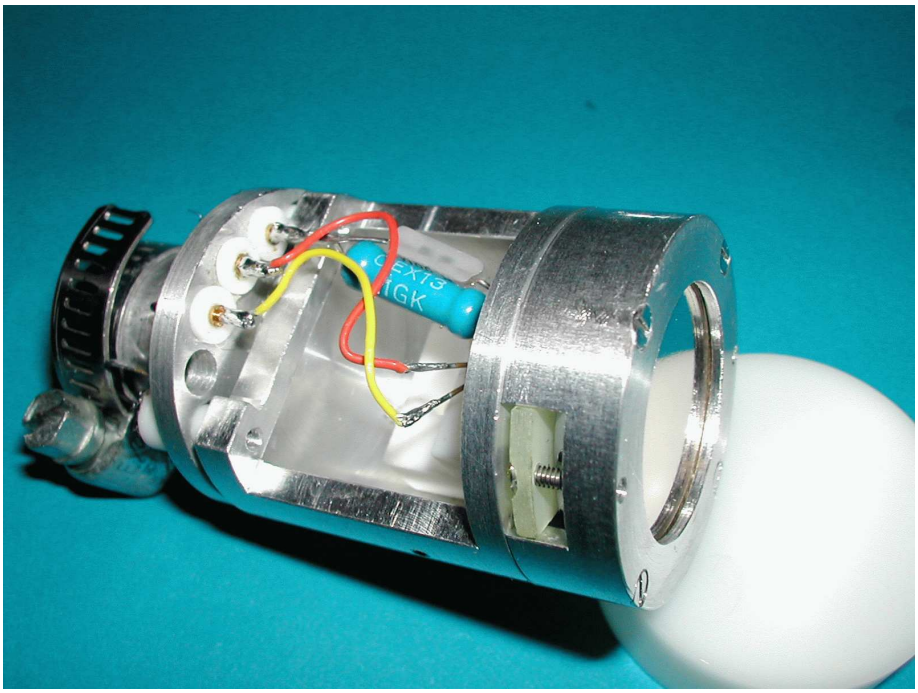




Calculated Transmission



Si(Li)-Detectors and Tentacles



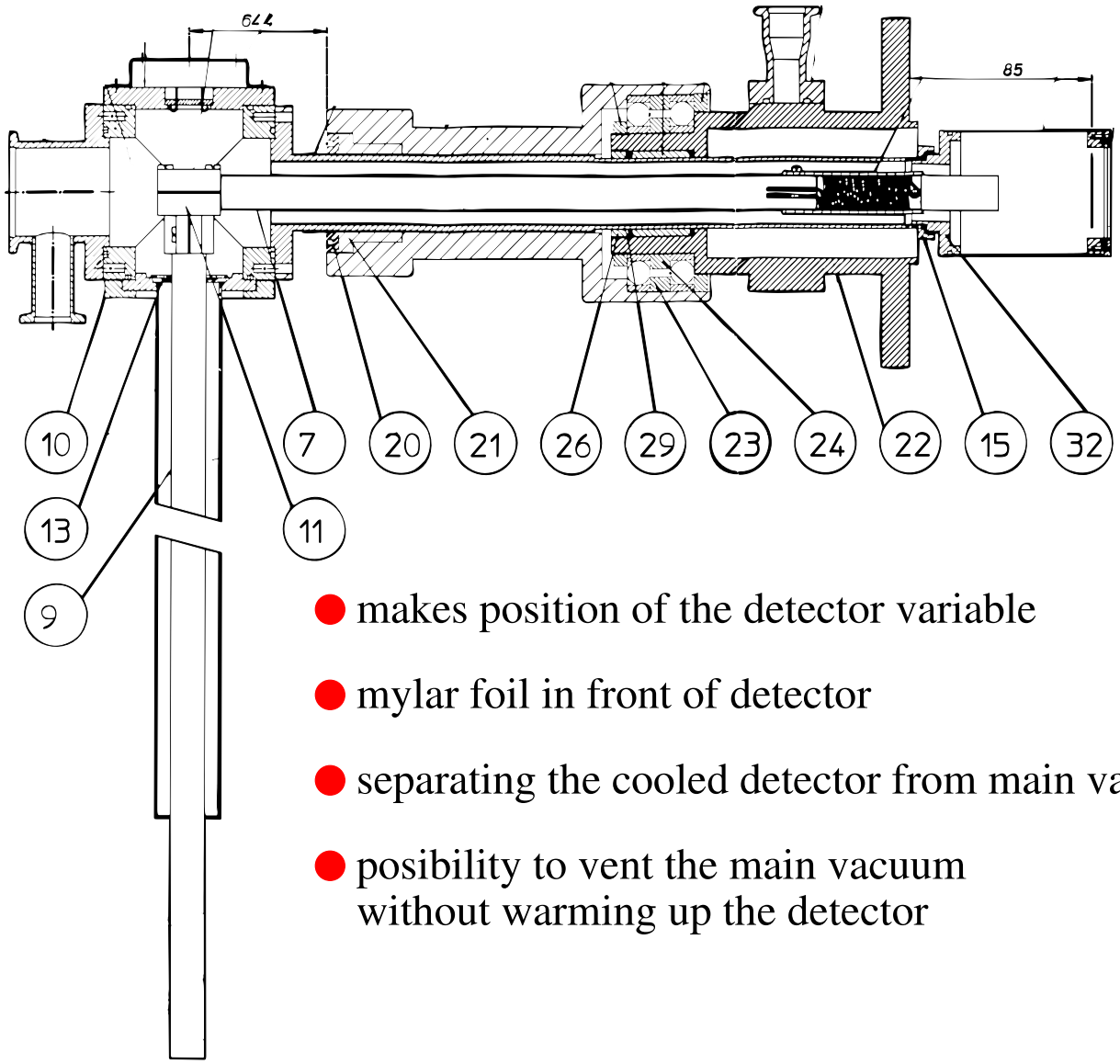
surface: 300-500 mm^2

thickness: 3-6 mm

max. energy:
1.7 - 3 MeV

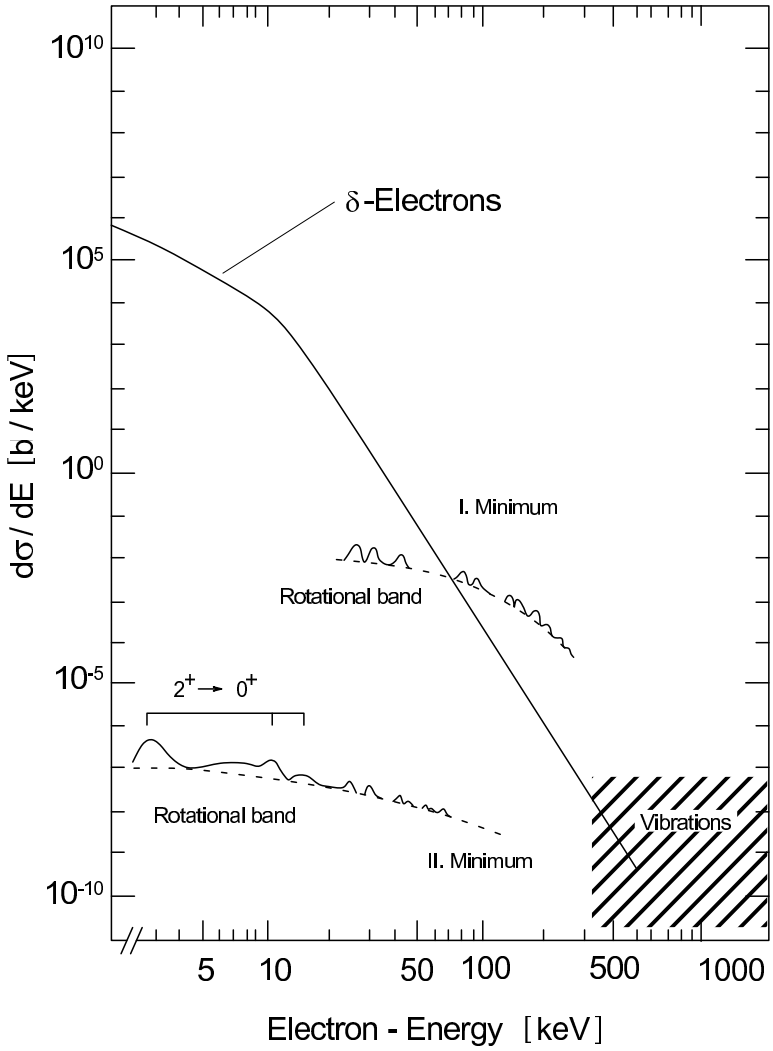
temperature: 77 ^{o}K

resolution: 2 - 3 keV
@ 1 MeV

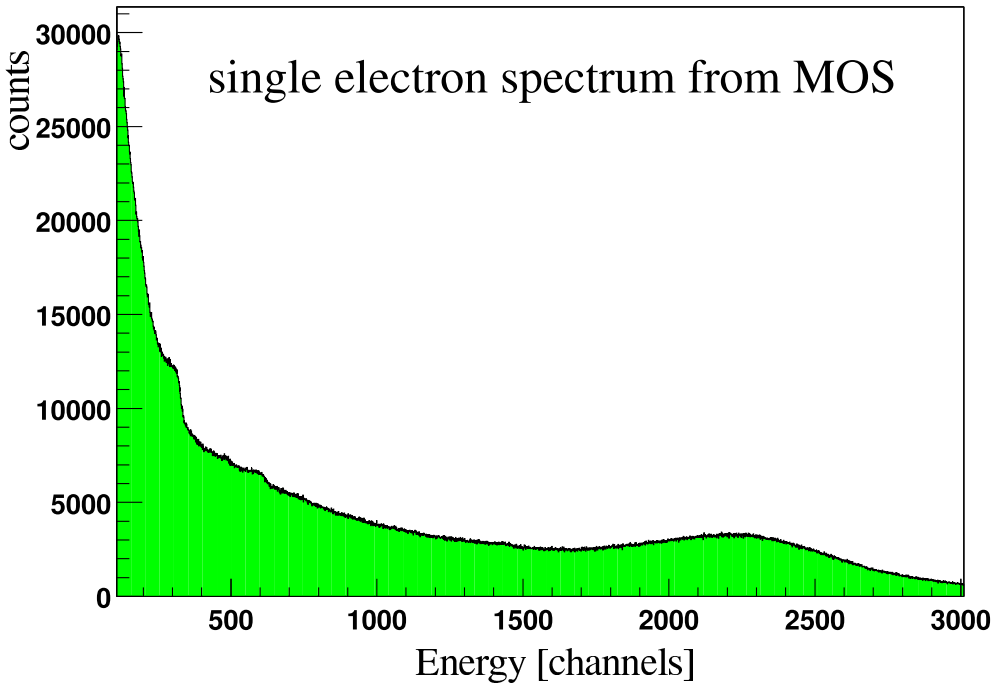


- makes position of the detector variable
- mylar foil in front of detector
- separating the cooled detector from main vacuum
- posibility to vent the main vacuum without warming up the detector

δ – *electrons*

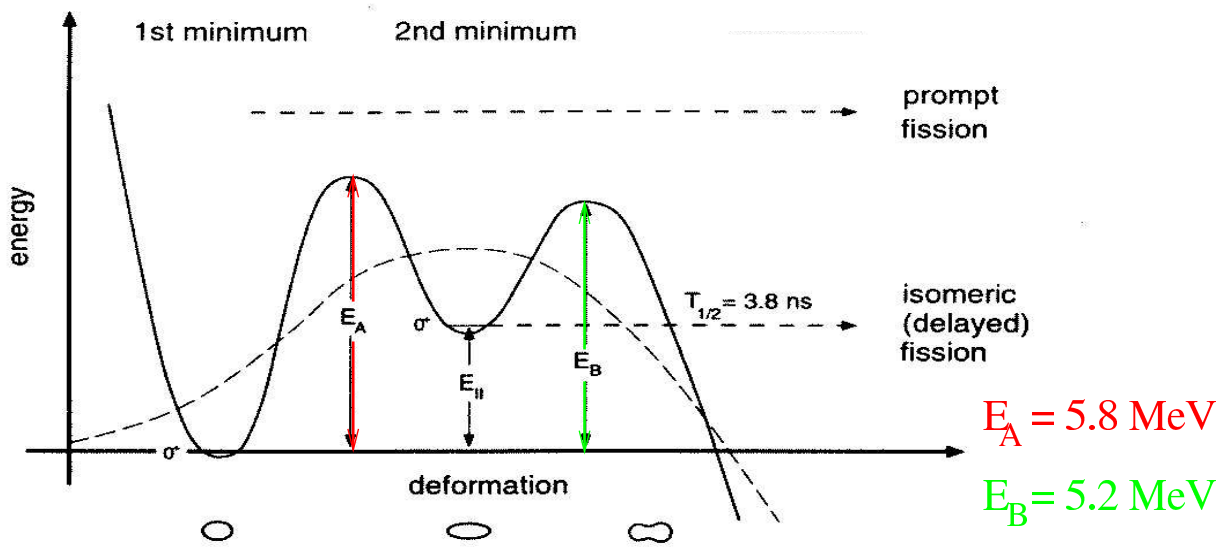


$$\frac{\delta - \text{electrons}}{\text{conversion electrons}} \sim 10^{12}$$



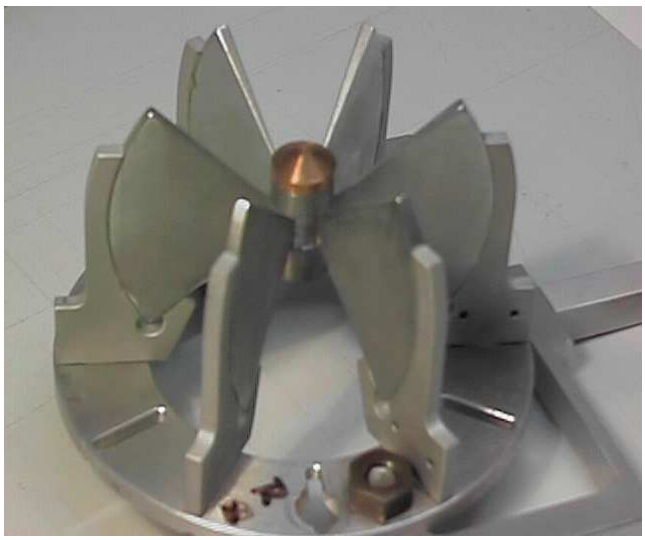
=>
gating needed

^{240}Pu



- Search for decays within the 2nd minimum
- Interesting energy range is known from previous experiments
- ^{238}U (α , 2n) ^{240}Pu @ 25 MeV (Munich)
- current: ~ 300 enA

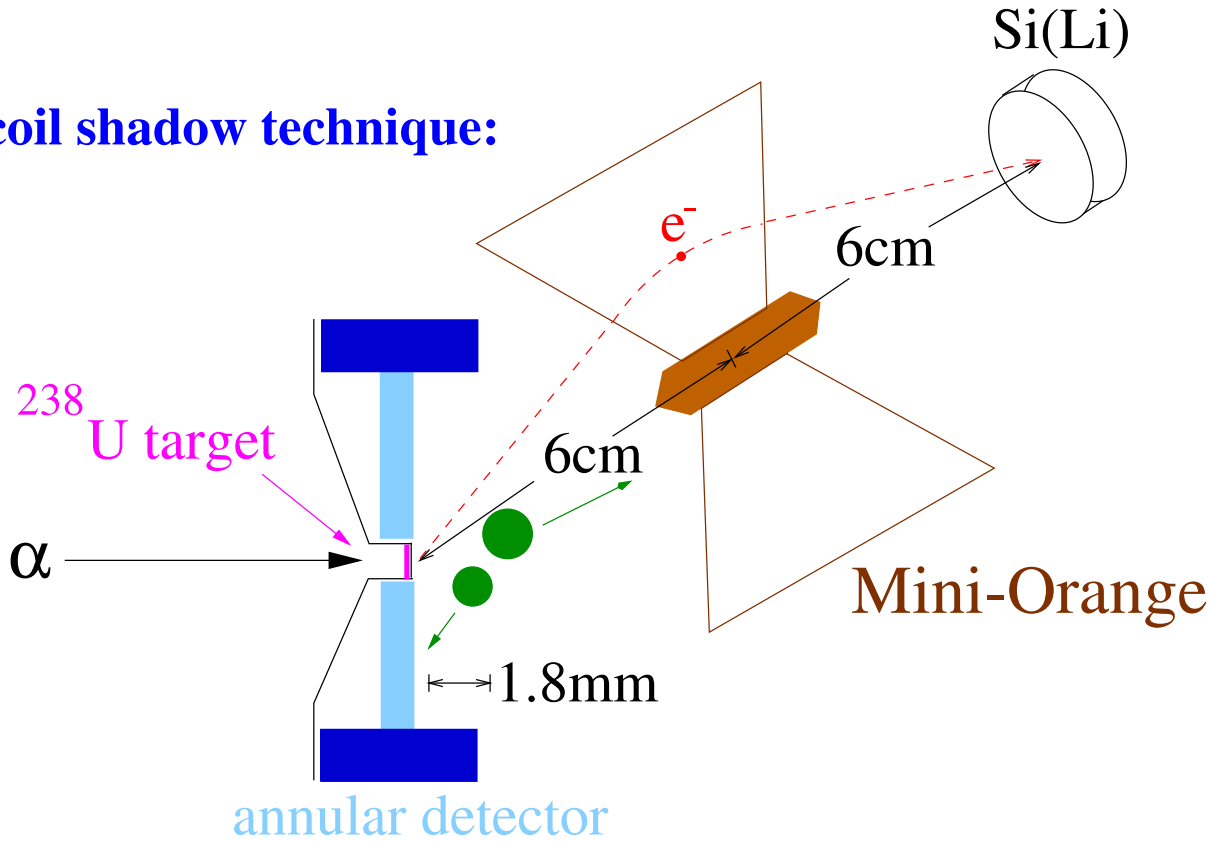
Experimental Setup



Mini-Orange:

- 6 (5) permanent magnets (NdFeB)
- transmission function optimized for 500-700 keV (400-600 keV)
  B ≈ 90 mT
- transmission: 2.3 % (at 626 keV)

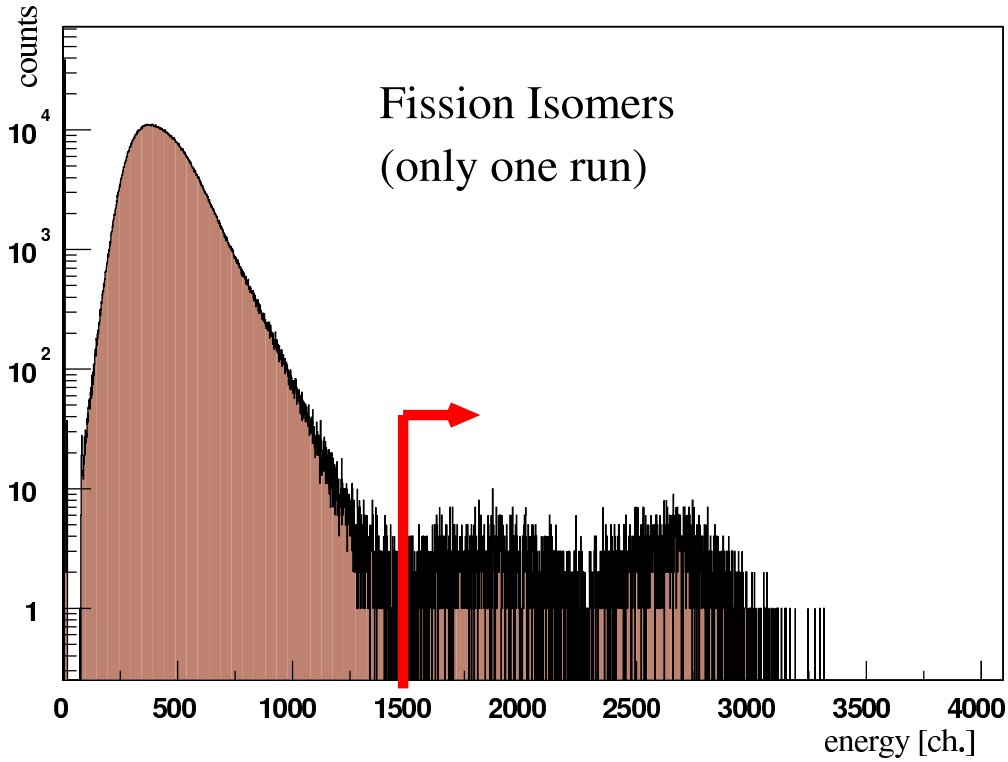
recoil shadow technique:

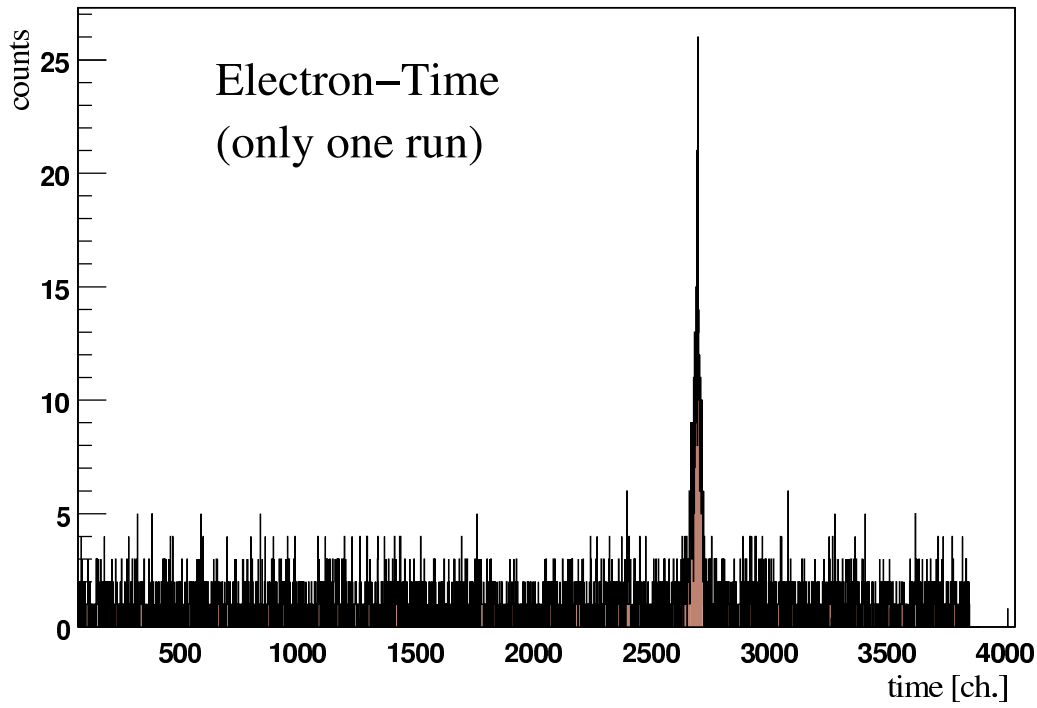


- **10^4 - 10^5 more prompt fission**

Spectra from ^{240}Pu

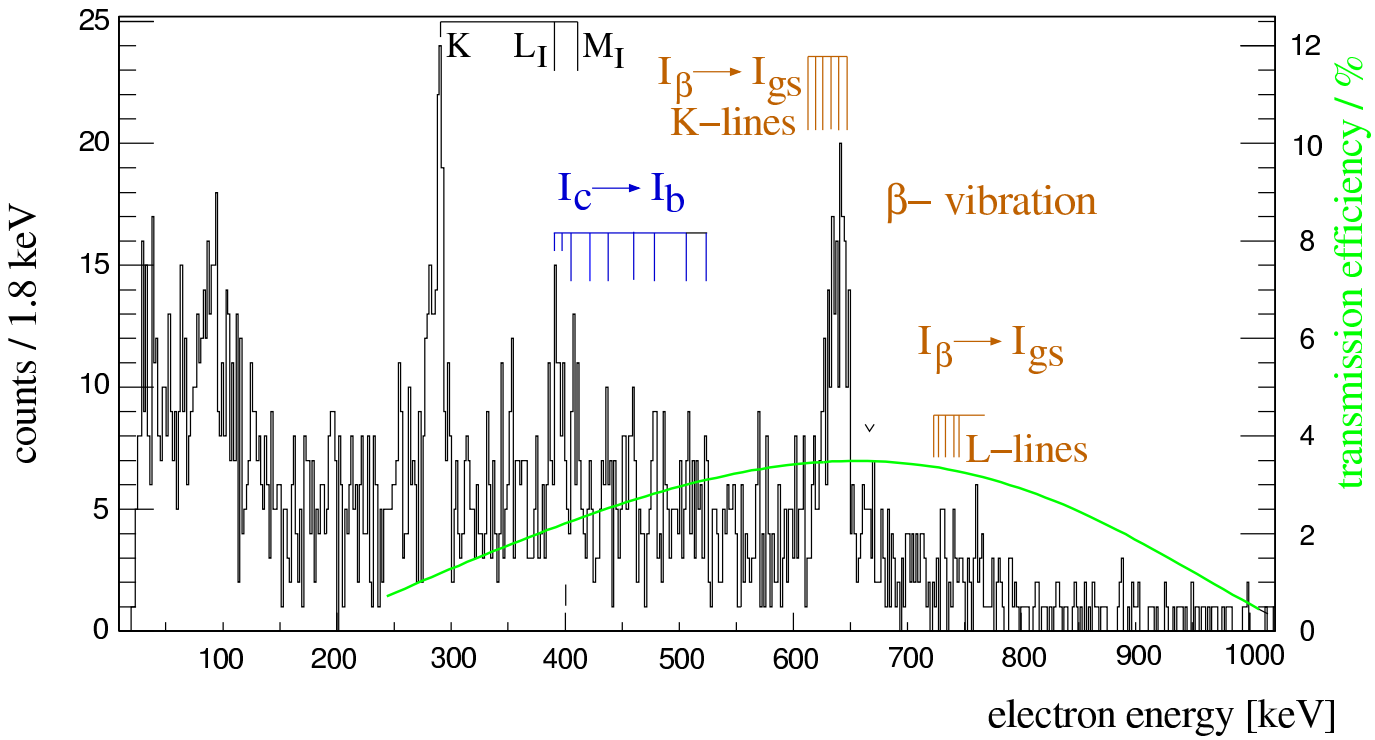
300000 isomeric fission fragments in 540 h





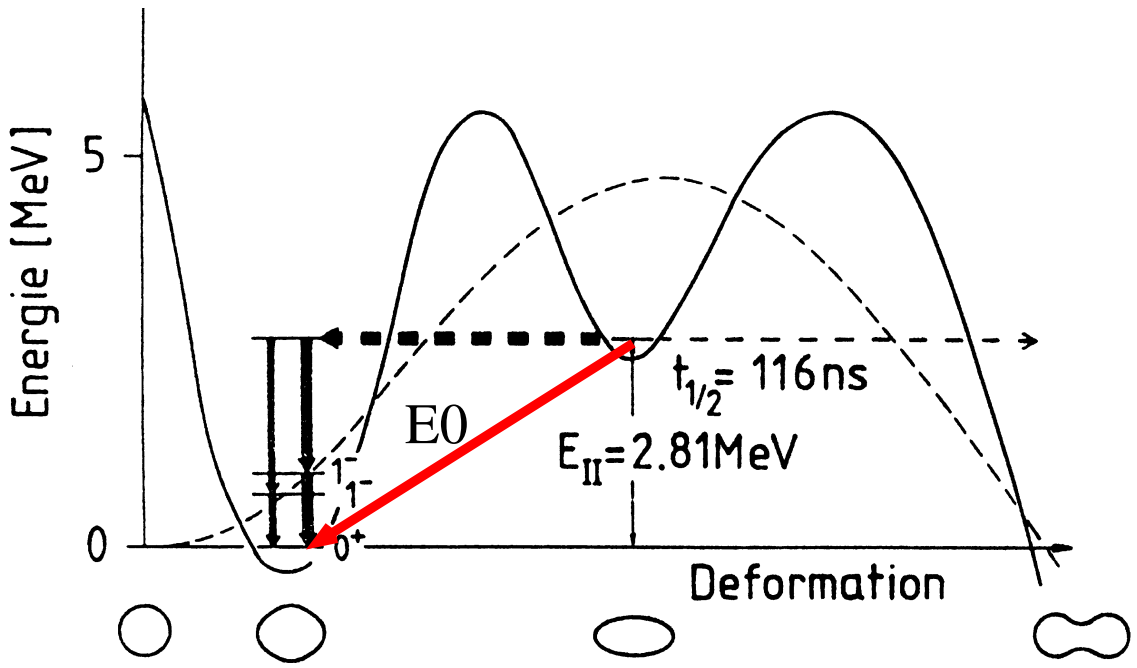
=> ~2500 "good" electrons

Conversion Electrons of ^{240f}Pu

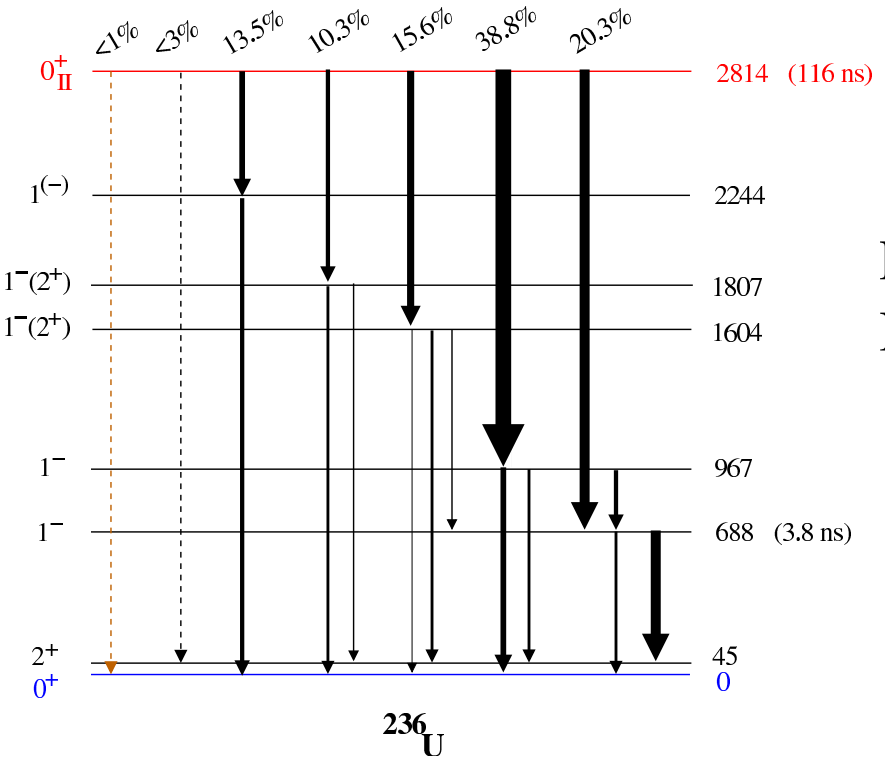


- Electrons in delayed coincidence with fission fragments

^{236}U

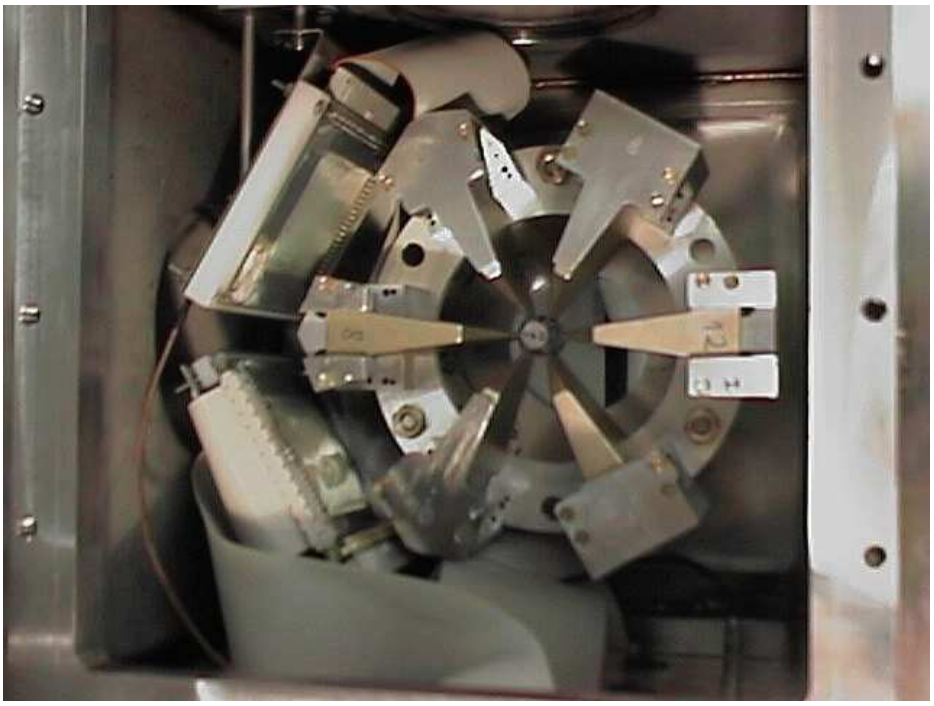


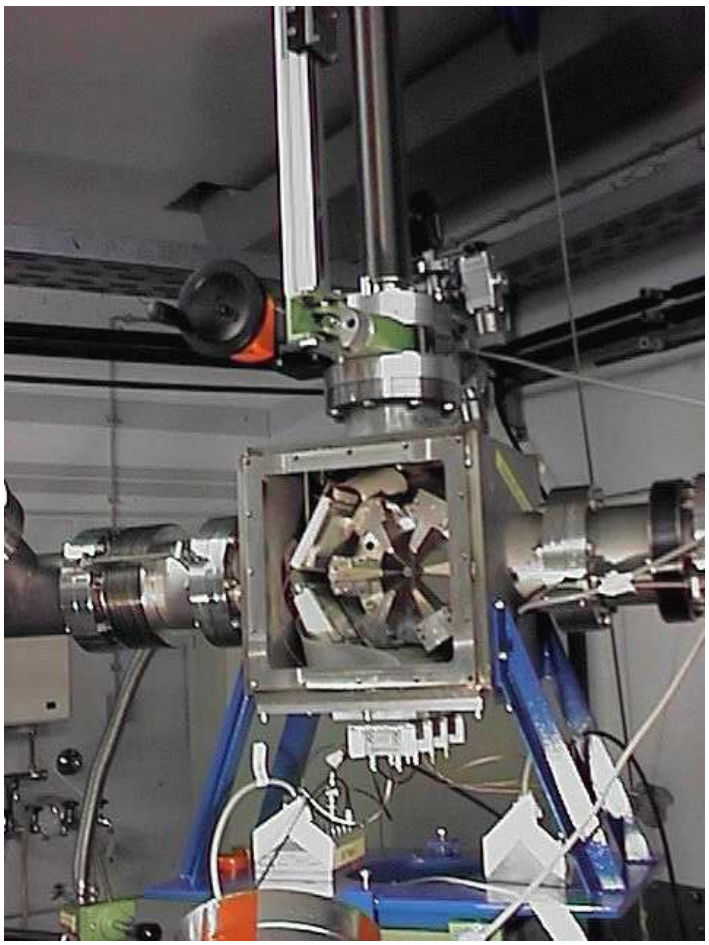
- Search for back decay from the 2nd to the 1st minimum
- $^{235}U\,(d,p)\,^{236}U$ @ 10 MeV Munich
- known γ back decay through five E1 cascades



P. Reiter, PhD Thesis, Heidelberg 1993

New Setup for ^{236}U

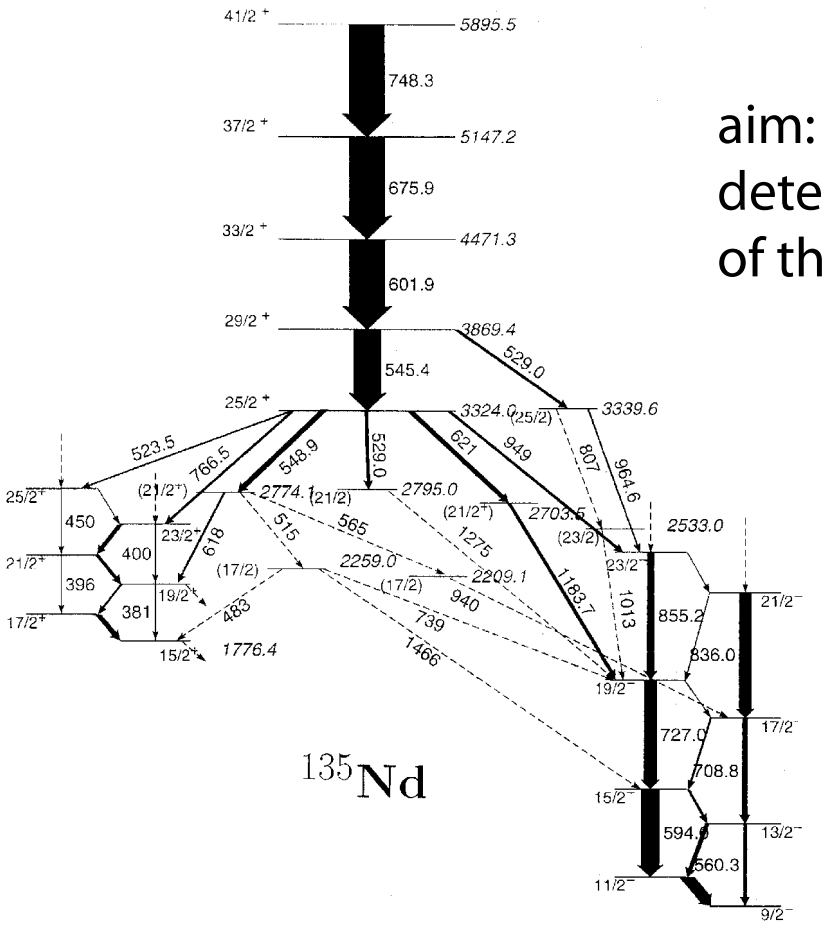




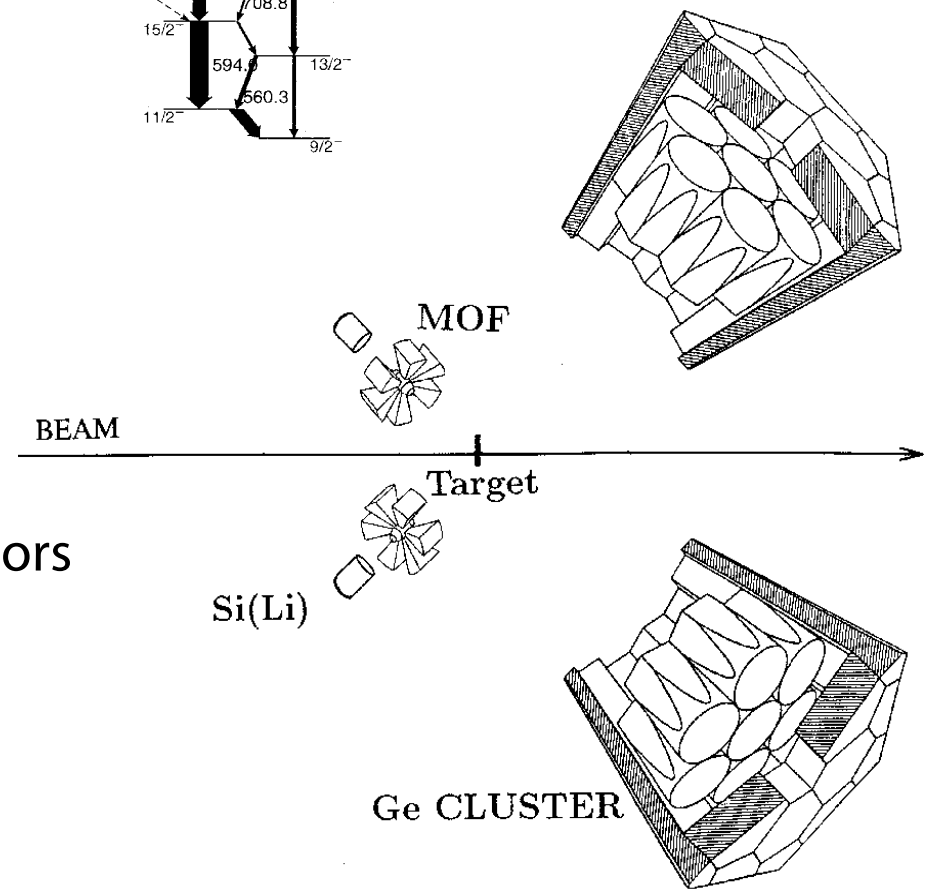
Improvements:

- double efficiency for electron detection
- lower rate in proton detector => higher beam current

^{135}Nd

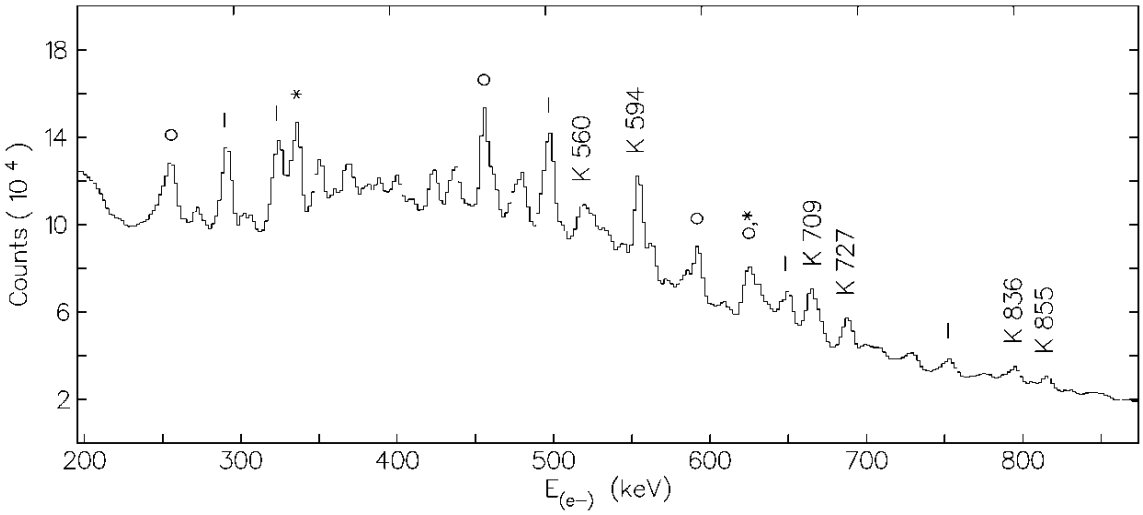


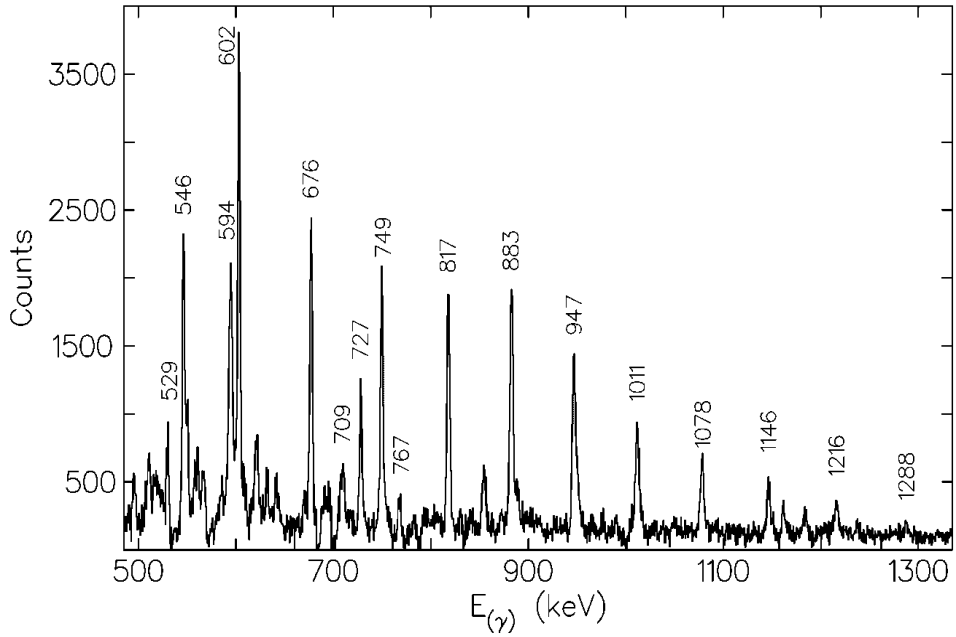
aim:
determine character
of the linking transitions

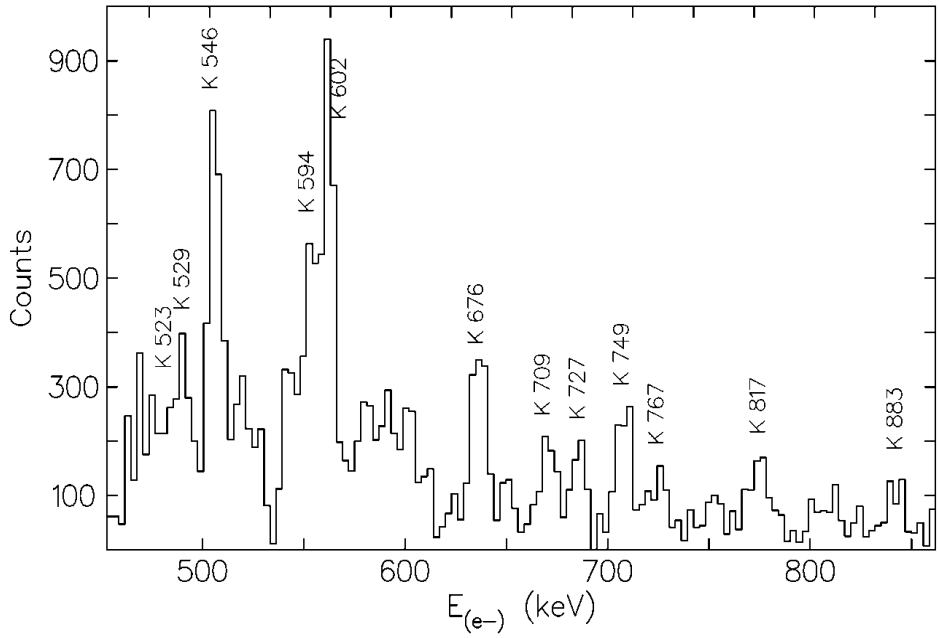


4 Cluster detectors
3 MOS

^{135}Nd


Counts (10 4)
E(e−) (keV)
K 560
K 594
K 709
K 727
K 836
K 855


Counts
E(γ) (keV)
529
546
594
602
676
709
727
749
767
817
883
947
1011
1078
1146
1216
1288


Counts
E(e−) (keV)
K 523
K 529
K 546
K 594
K 602
K 676
K 709
K 727
K 749
K 767
K 817
K 883

ICEMOS - Setup