Implantation detector as active stopper

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Rare **Is**otope **In**vestigation at **G**SI

Rakesh Kumar, P. Doornenbal, I. Kojouharov, W. Prokopowicz, H. Schaffner, H.J. Wollersheim

Implantation detector as active stopper

Active catcher for implantation-decay correlations

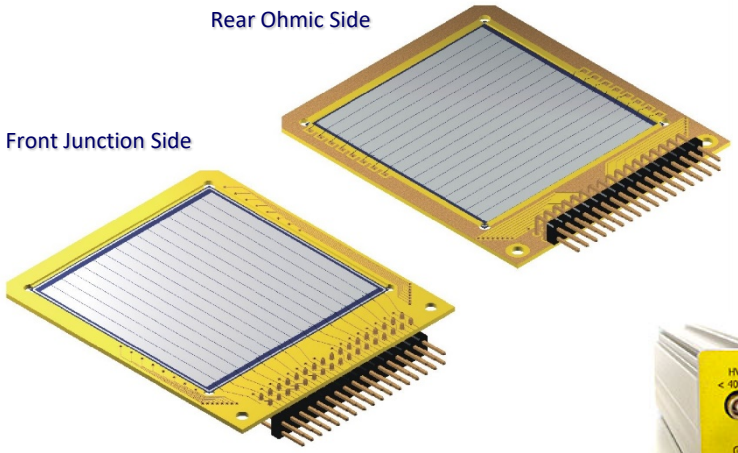
Implantation-decay correlations with large background (half lifes similar to the implantation rate):

- ✓ implantation-decay time correlation: active catcher
- ✓ implantation-decay position correlation: granularity
- ✓ implantation of several ions: thickness and area
- ✓ energy of the implanted ion and the emitted β

3 double-sided silicon-strip detectors

- surface 5x5 cm^2
- thickness 1 mm
- 2 x 16 3.125 mm strips
- manufactured by MICRON

Measurements with a double-sided Si-strip detector



Micron Semiconductor

Nº Junction Elements:	16
Nº Junction Elements:	16
Element Length:	49.5 mm
Element Pitch:	3.1 mm
Element width:	3.0 mm
Active Area:	50x50 mm^2
Thickness:	1000 µm
Price:	5600 €

MPR-32
Charge Sensitive Preamplifier

32 channel compact module
Sensitivity switch, factor 5
Bias voltage up to ±400V

Price: 2790 €

STM-16
16 fold shaper

16 channel NIM module
shaper amplifier
timing filter amplifier
leading edge discriminator

Price: 2x 3415 €

MRC-1
rc master controller
for STM-16

Price: 2200 €

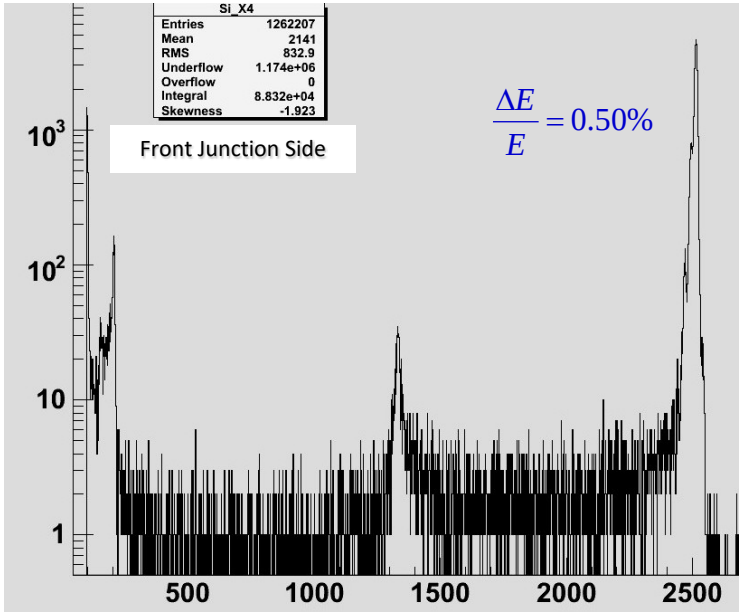
CAEN

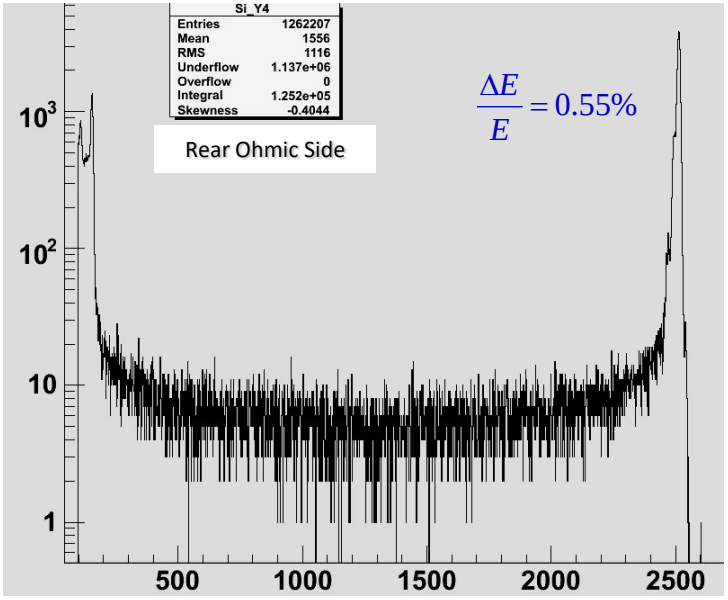
ADC V785AF
32 channel

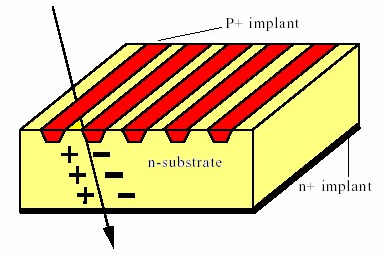
Price: 5094 €

Total cost 22,514.- €

Energy resolution with ^{241}Am source







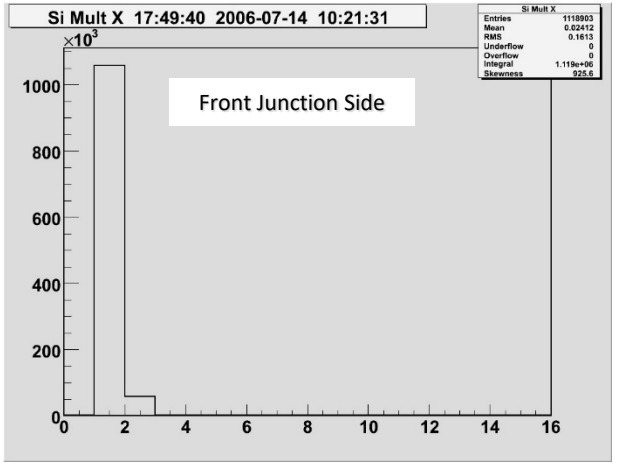
Low energy peak from gap events at about ½ the full pulse height

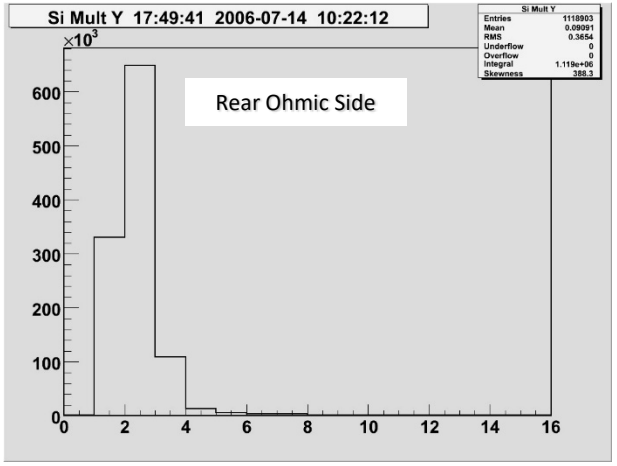
C.Wrede et al. NIM B204 (2003), 619

MICRON #2215-17
Voltage: 200V

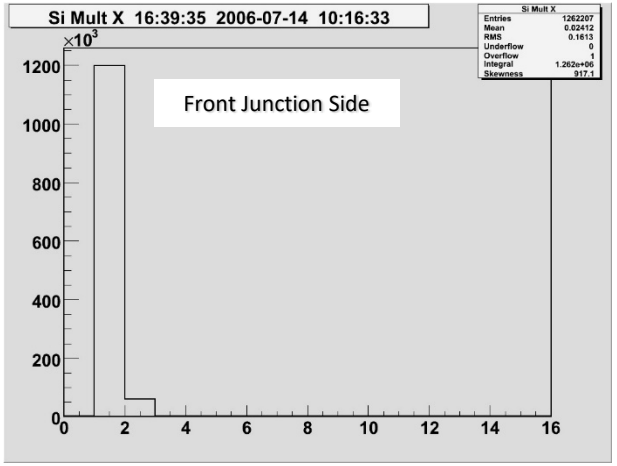
^{241}Am E_α=5.486 MeV
range ~28 µm

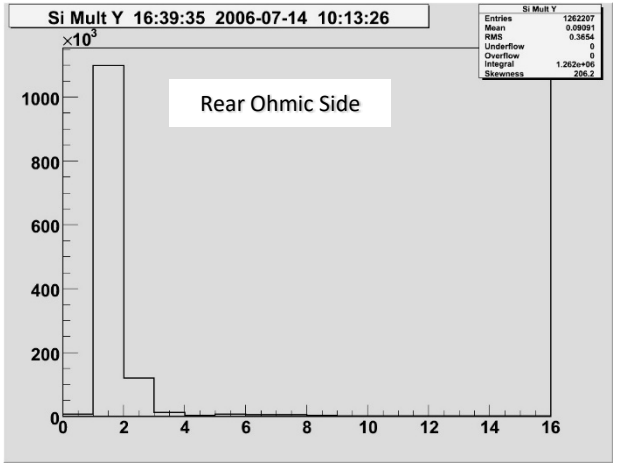
Strip multiplicity with ^{241}Am source





MICRON #2215-17
Voltage: 40V
below full depletion
measurement in vacuum

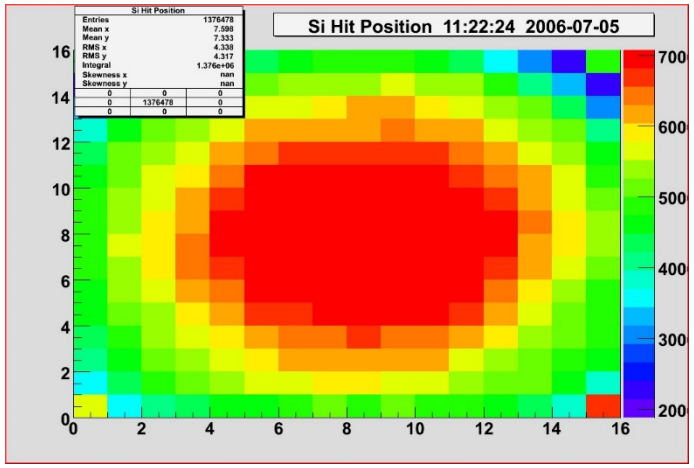




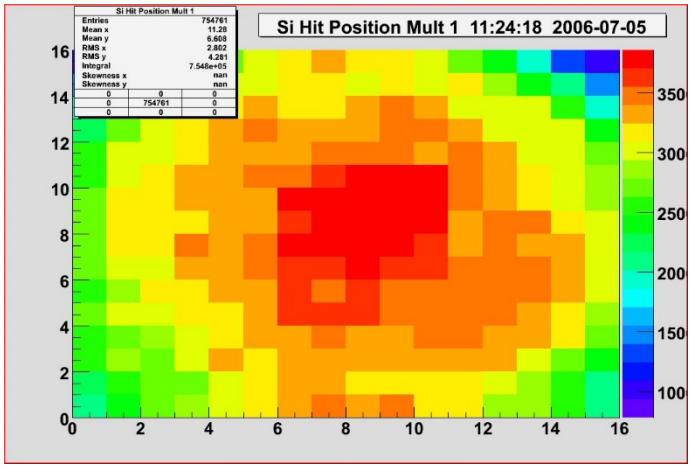
MICRON #2215-17
Voltage: 200V
full depletion voltage
measurement in vacuum

^{241}Am E_α=5.486 MeV
range ~28 µm

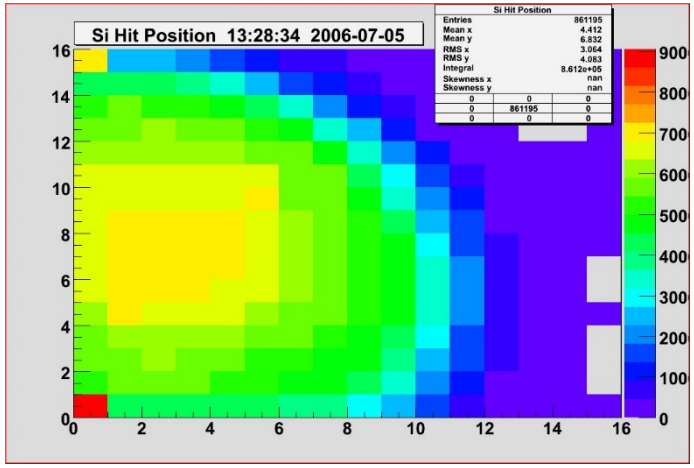
Two dimensional position spectra



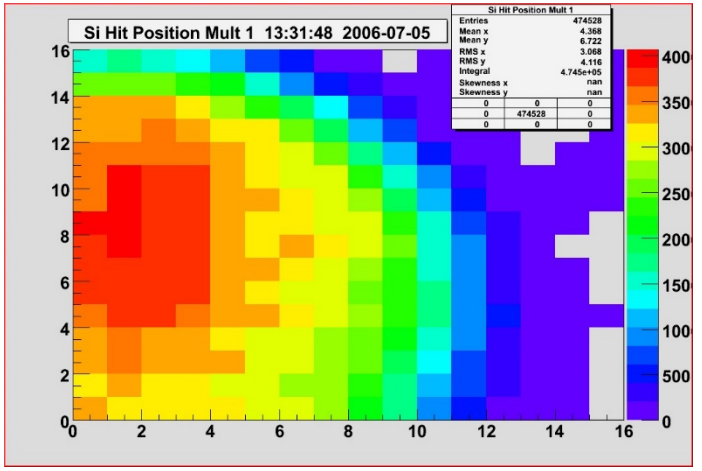
^{241}Am source centered



^{241}Am source centered, strip-multiplicity=1



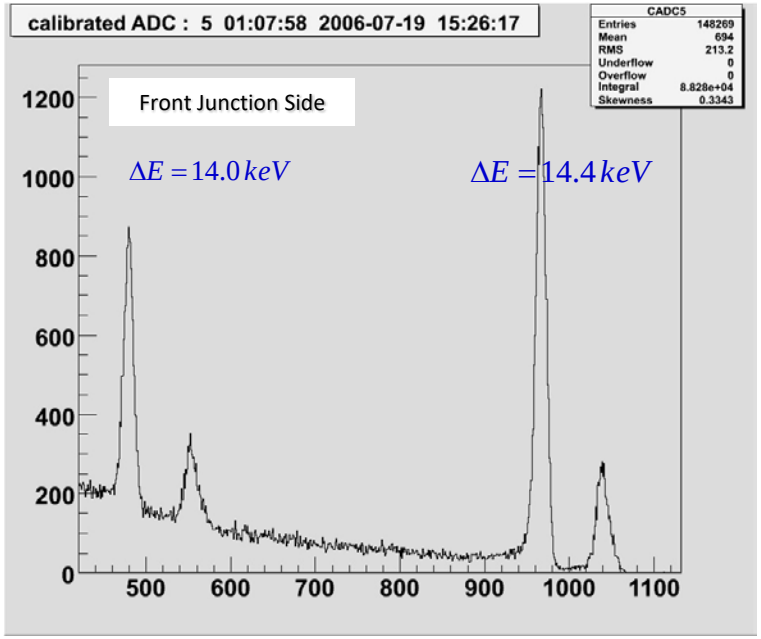
^{241}Am source left

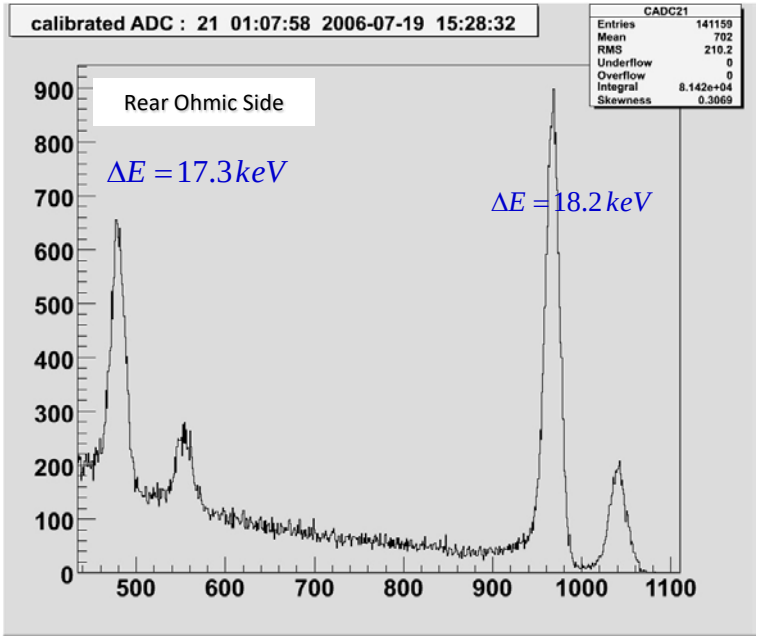


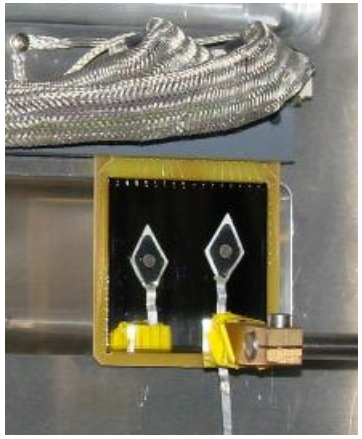
^{241}Am source left, strip-multiplicity=1

MICRON #2243-5 Voltage: 40V, measurement in vacuum

Energy resolution with ^{207}Bi source (in vacuum)





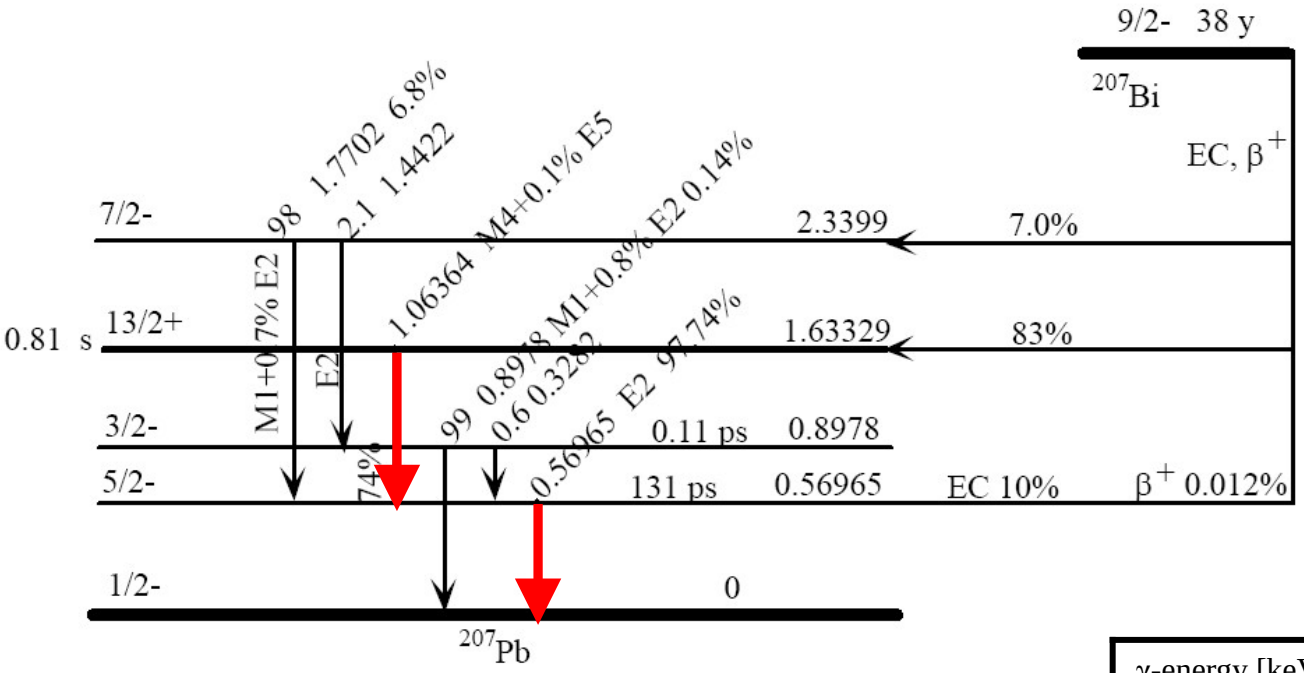


experimental set-up

MICRON #2512-17
Voltage: 200V

^{207}Bi E=482, 976 keV
range 0.94, 2.31 mm (e^-e^- interaction)

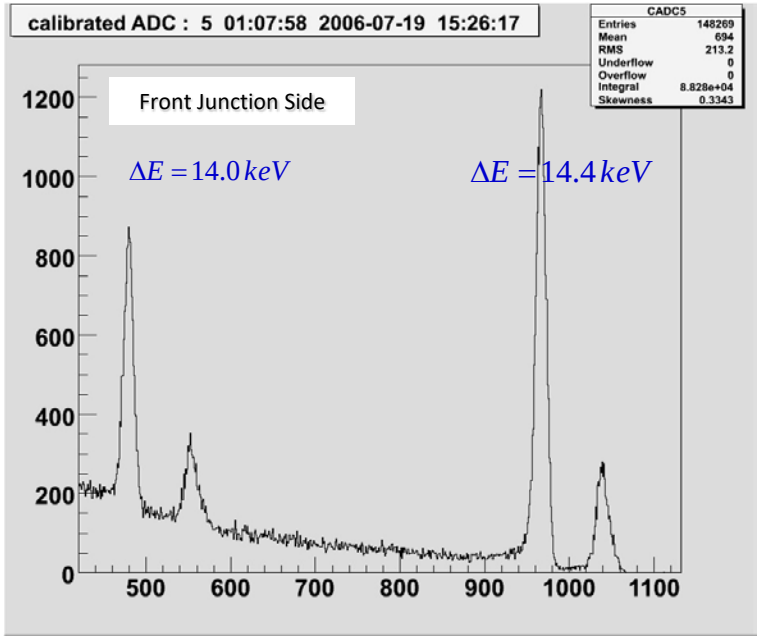
RISING: Test of the active stopper with a ^{207}Bi source

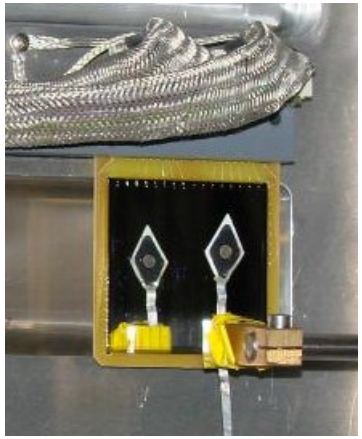


^{207}Bi emits gamma rays and electrons

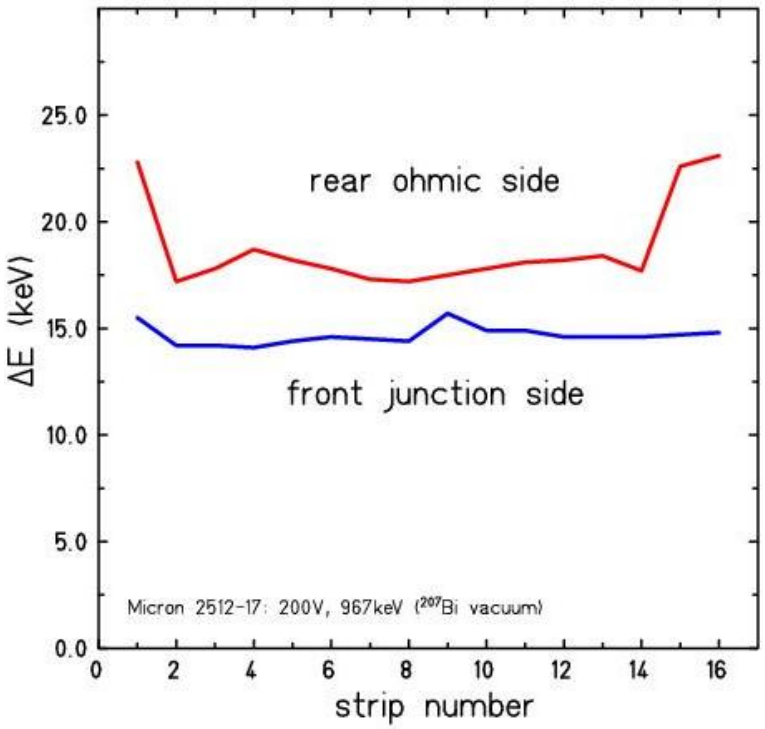
γ-energy [keV]	e⁻-energy
569.6	481.7 [K]
	553.8-556.7 [L]
	565.8-567.2 [M]
1063.7	975.7 [K]
	1047.8-1050.6 [L]
	1059.8-1061.2 [M]

Energy resolution with ^{207}Bi source (in vacuum)





experimental set-up



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Voltage: 200V

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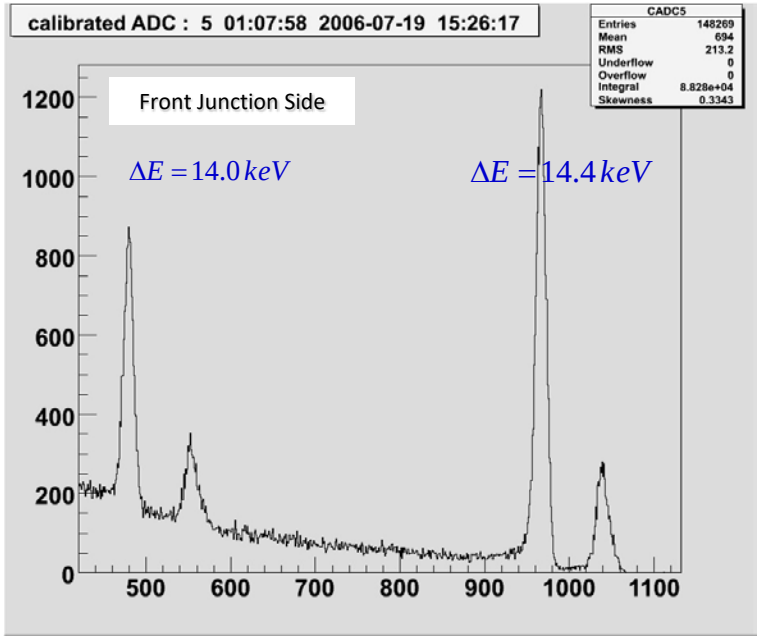
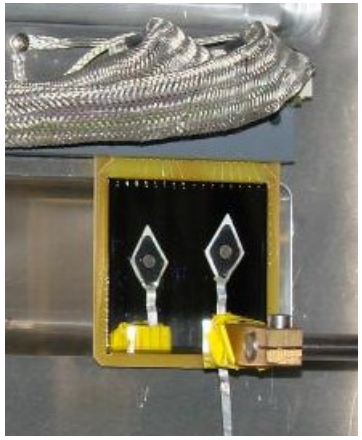
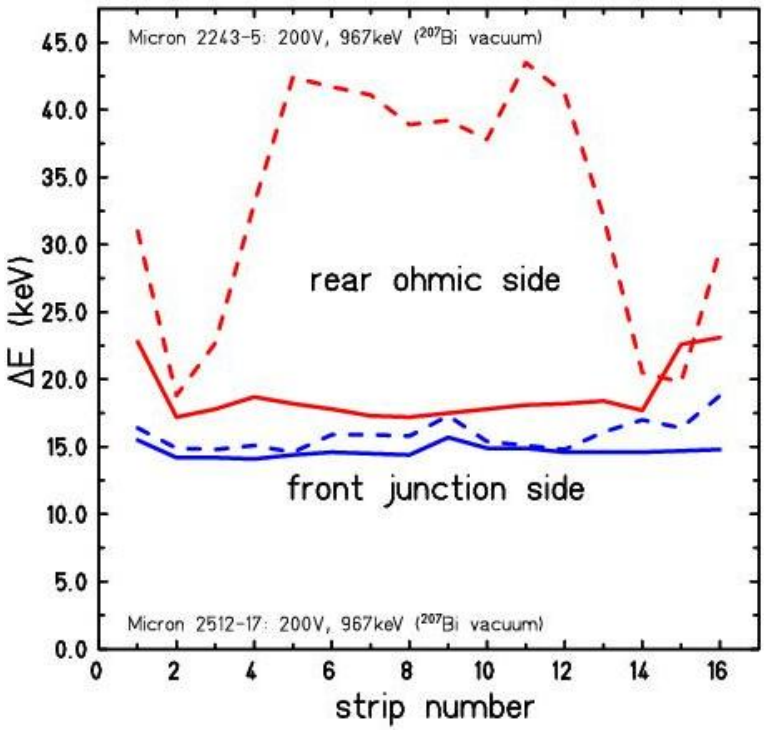
Energy resolution with ^{207}Bi source (in vacuum)





experimental set-up



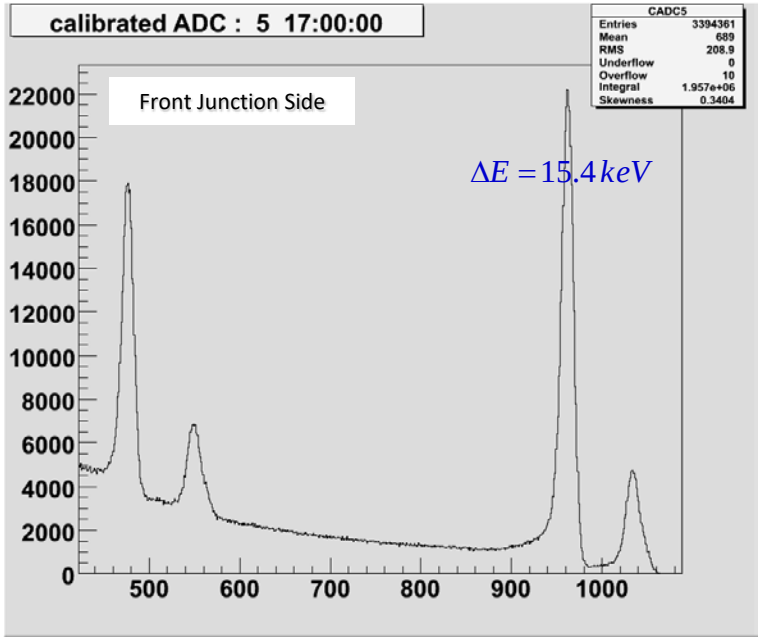
MICRON **#2512-17** (**full lines**)
#2243-5 (**dashed lines**)

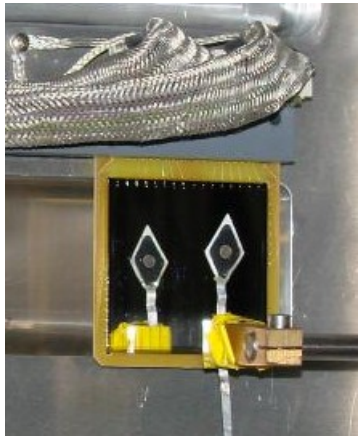
Voltage: 200V

^{207}Bi E=482, 976 keV

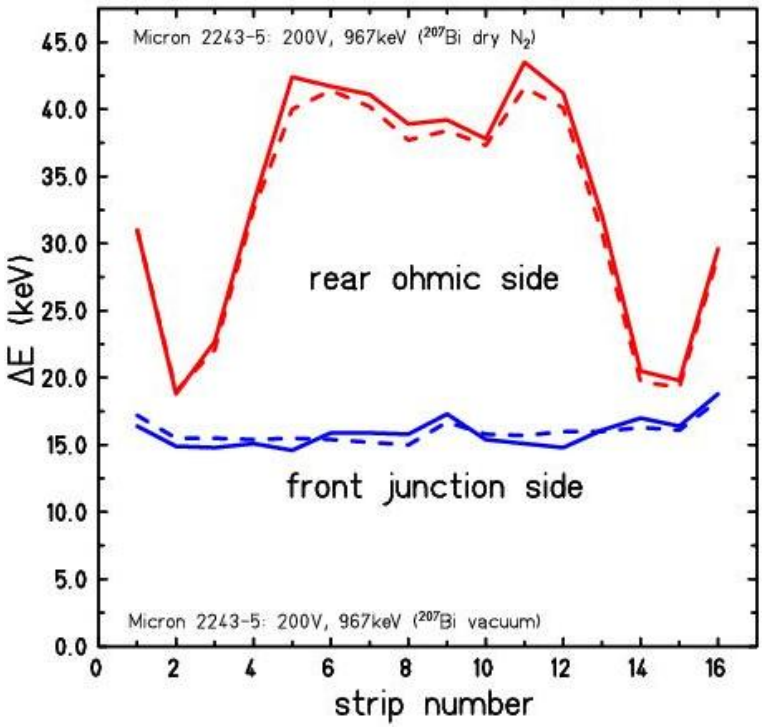
range 0.94, 2.31 mm (e^-e^- interaction)

Energy resolution with ^{207}Bi source (in vacuum and dry N_2)





experimental set-up



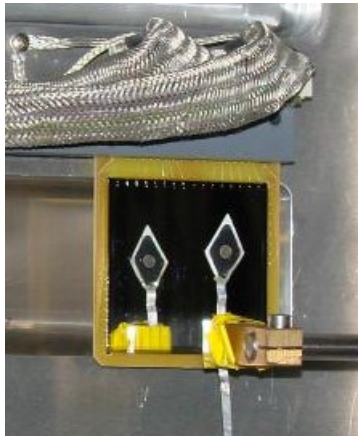
MICRON #2243-5
Voltage: 200V

***conclusion:* measurement in dry N_2**

^{207}Bi E=482, 976 keV
range 0.94, 2.31 mm (e^-e^- interaction)

Energy resolution of the DSSD

MICRON	ΔE (^{241}Am) vacuum	ΔE(^{207}Bi) vacuum	ΔE(^{207}Bi) dry nitrogen
#2243-5	N: 31.3 keV	N: 16.2 keV P: 33.3 keV	N: 16.0 keV P: 32.5 keV
#2243-4	N: 30.2 keV	N: 18.5 keV	
#2243-3	N: 34.0 keV	N: 18.2 keV	
#2243-2	N: 35.7 keV	N: 14.5 keV P: 27.0 keV	
#2512-17	N: 27.4 keV P: 29.7 keV	N: 14.8 keV P: 18.8 keV	



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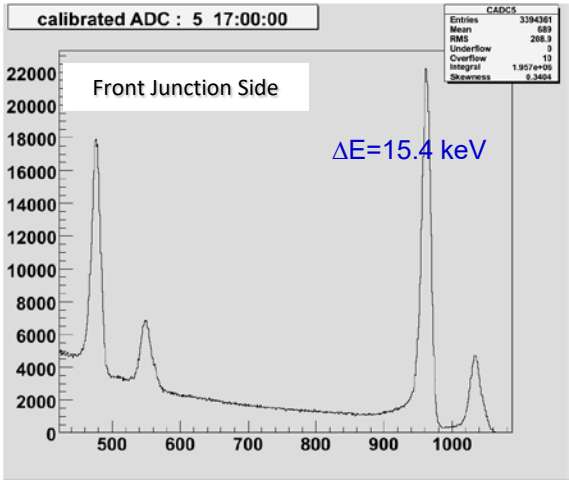
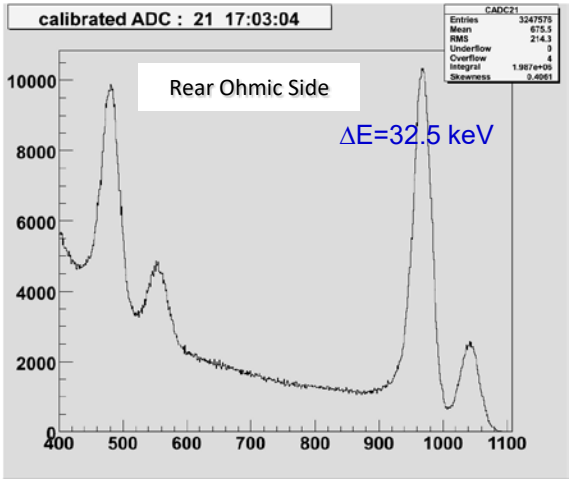
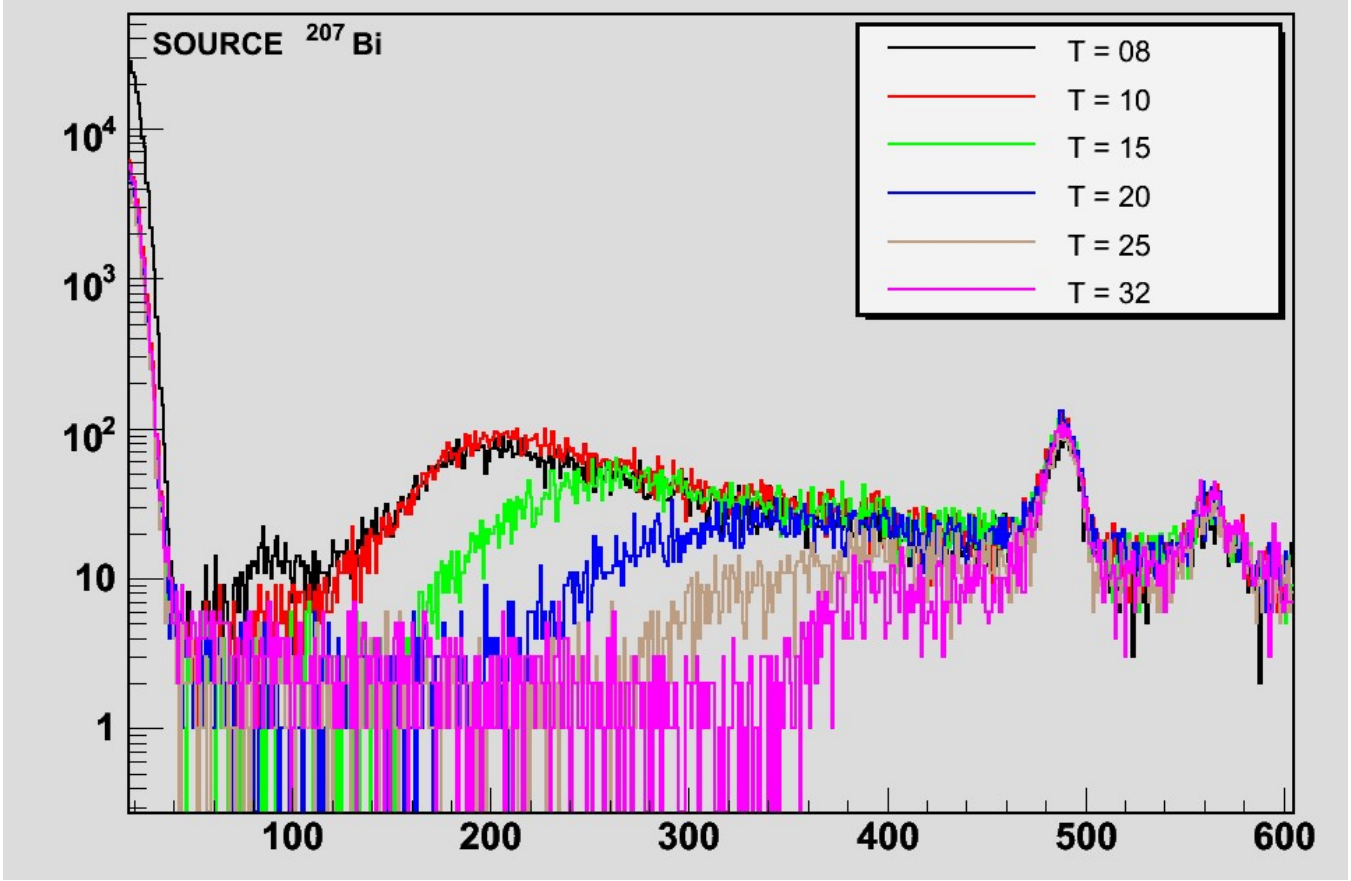
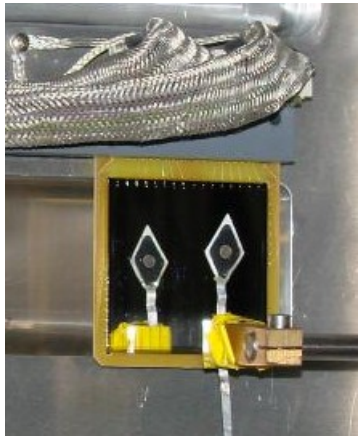




^{207}Bi E_e=976 keV ; ^{241}Am E_α=5.486 MeV

Energy threshold of the DSSD





experimental set-up

^{207}Bi	E_e=482, 976 keV

Measurements with a double-sided Si-strip detector

Micron Semiconductor

multichannel systems

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Element Length:	49.5 mm
Element Pitch:	3.1 mm
Element width:	3.0 mm
Active Area:	50x50 mm^2
Thickness:	1000 µm
Price:	5600 €

CPA-16
Charge Sensitive Preamplifier

16 channel compact module
2 output stages with different gains
Bias voltage up to ±500V

Price: 2x 2250 €

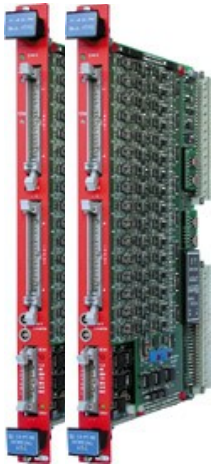
CAEN

Amplifier N 568BC

16 fold shaper

Price: 2x 3481 €

CAEN

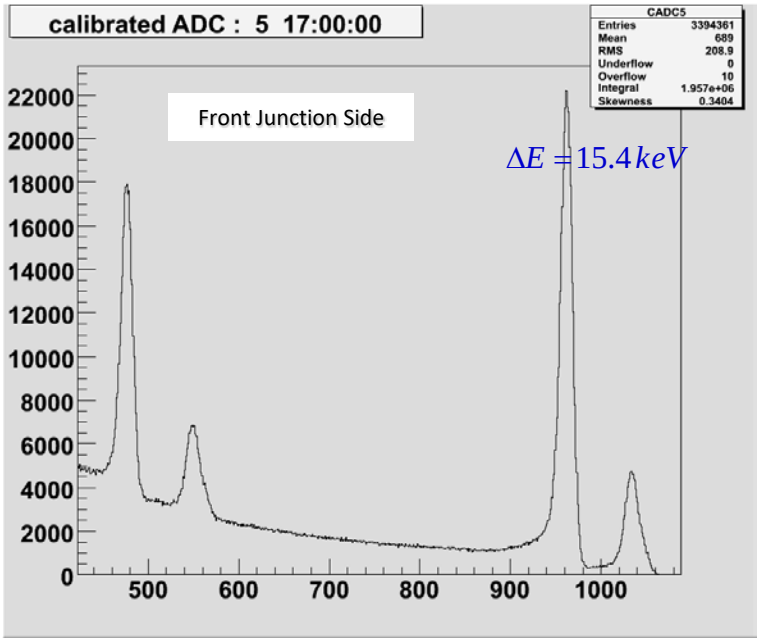


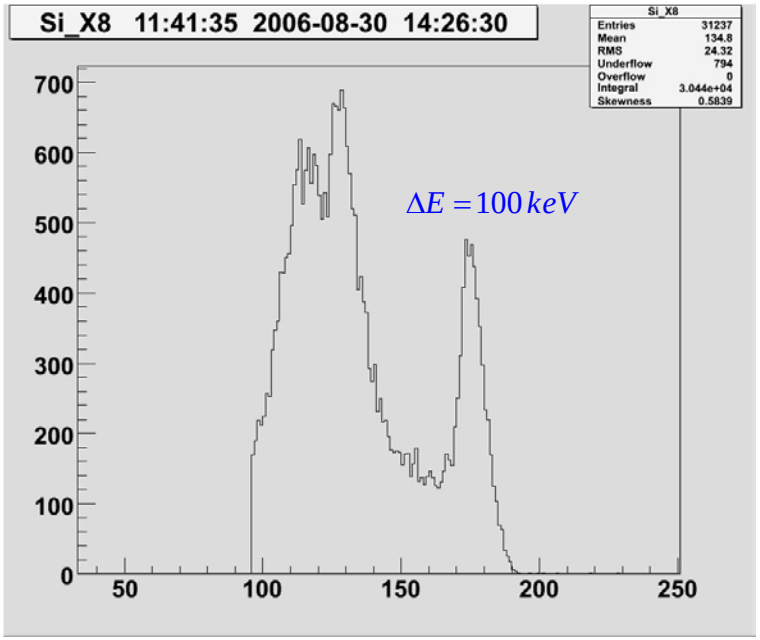
ADC V785AF
32 channel

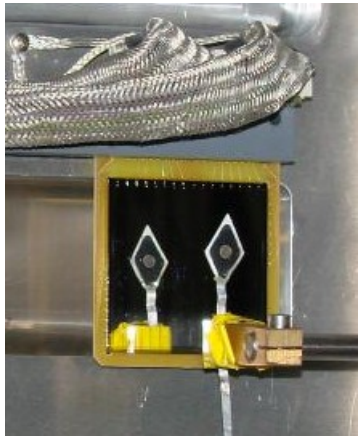
Price: 2x 5094 €

Total cost 27,250.- € (discriminator not included)

Energy resolution with ^{207}Bi source (Mesytec and Multichannel Systems)





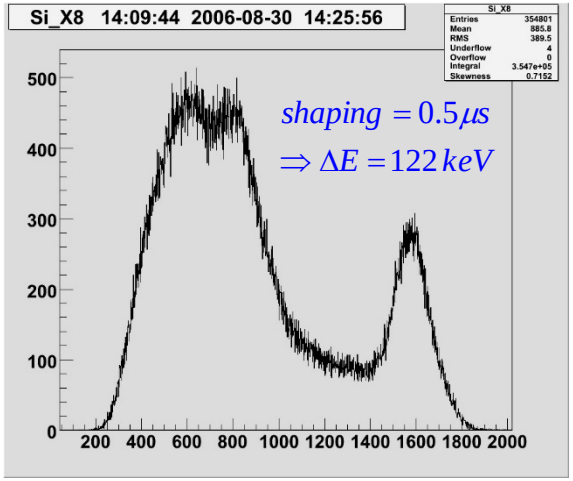


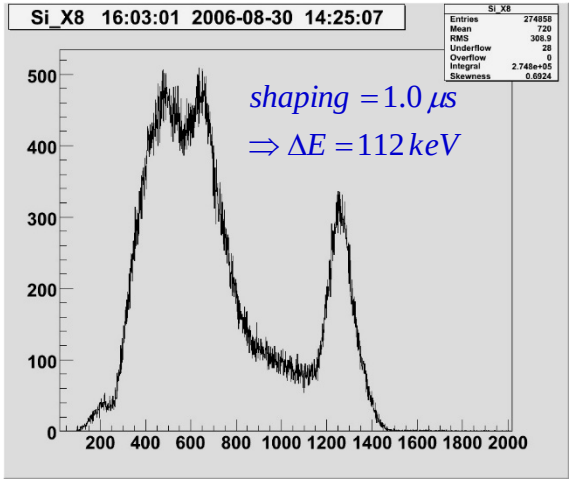
experimental set-up

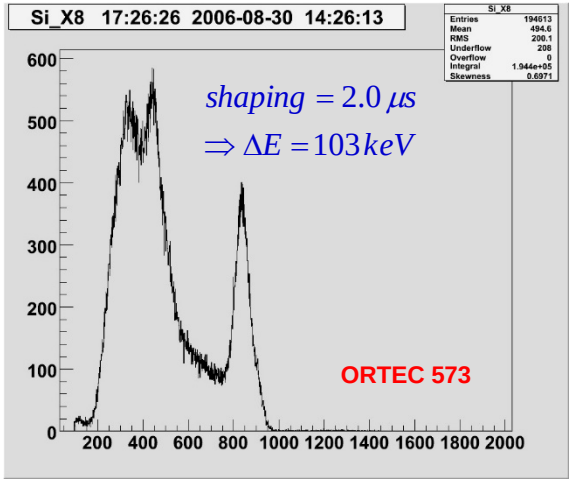
MICRON #2243-5
Voltage: 200V
measurement in vacuum

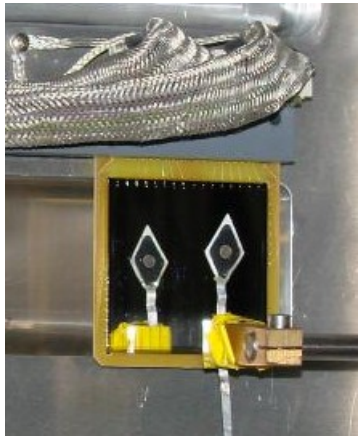
ORTEC 572
shaping time 0.5 µs ΔE=122 keV
1.0 µs ΔE=112 keV
2.0 µs ΔE= 103 keV

Energy resolution with ^{207}Bi source (Multichannel Systems)



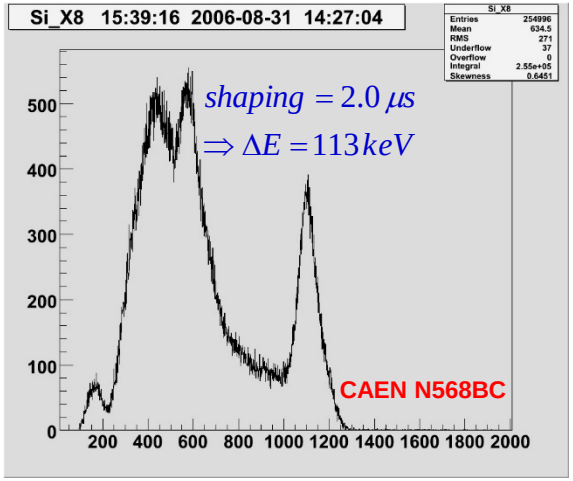






MICRON #2243-5
Voltage: 200V
measurement in vacuum

experimental set-up



Implantation detector as active stopper

Active catcher for implantation-decay correlations

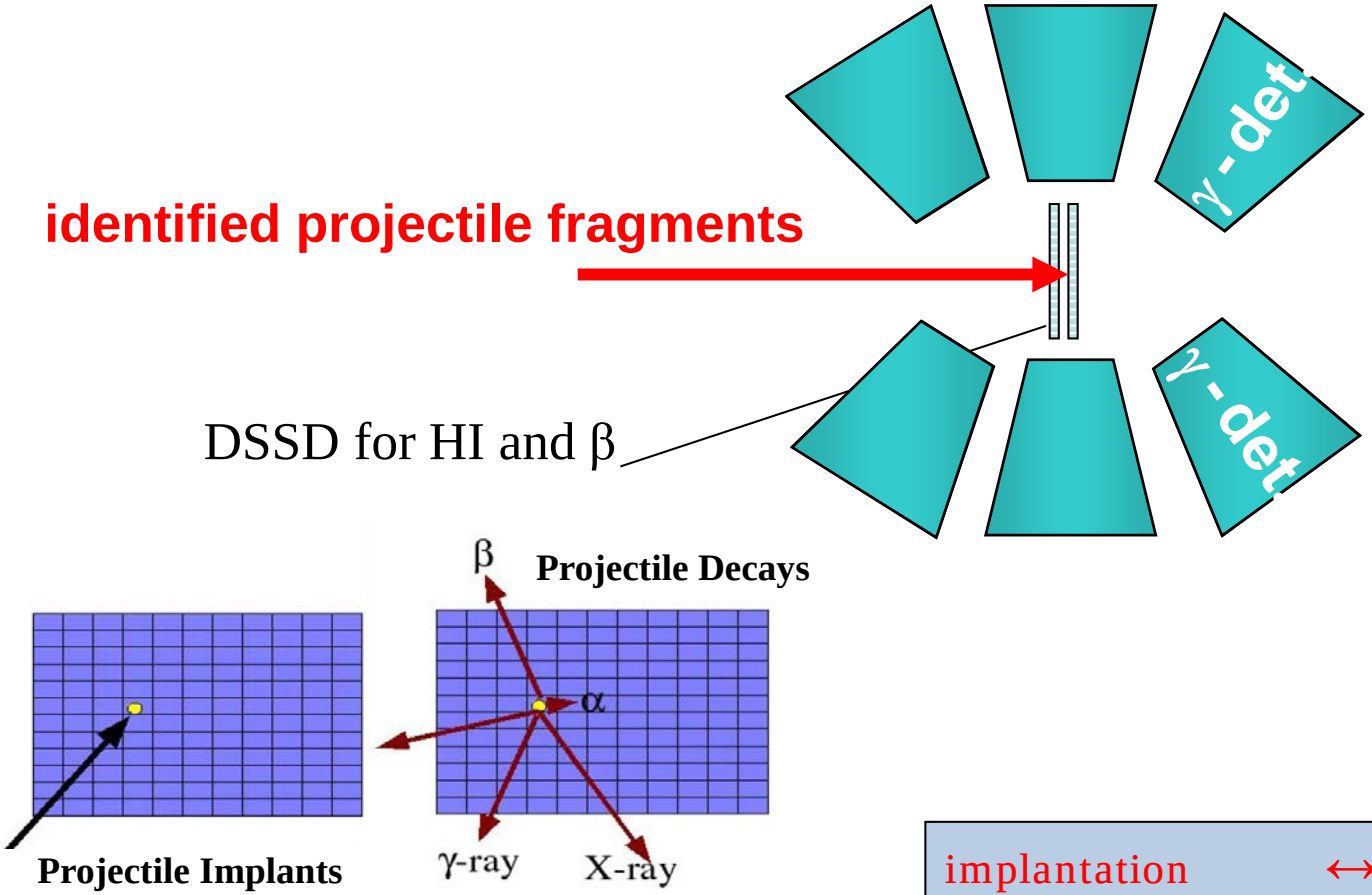
Implantation-decay correlations with large background (half lifes similar to the implantation rate):

- ✓ implantation-decay time correlation: active catcher
- ✓ implantation-decay position correlation: granularity
- ✓ implantation of several ions: thickness and area
- ✓ energy of the implanted ion and the emitted β

3 double-sided silicon-strip detectors

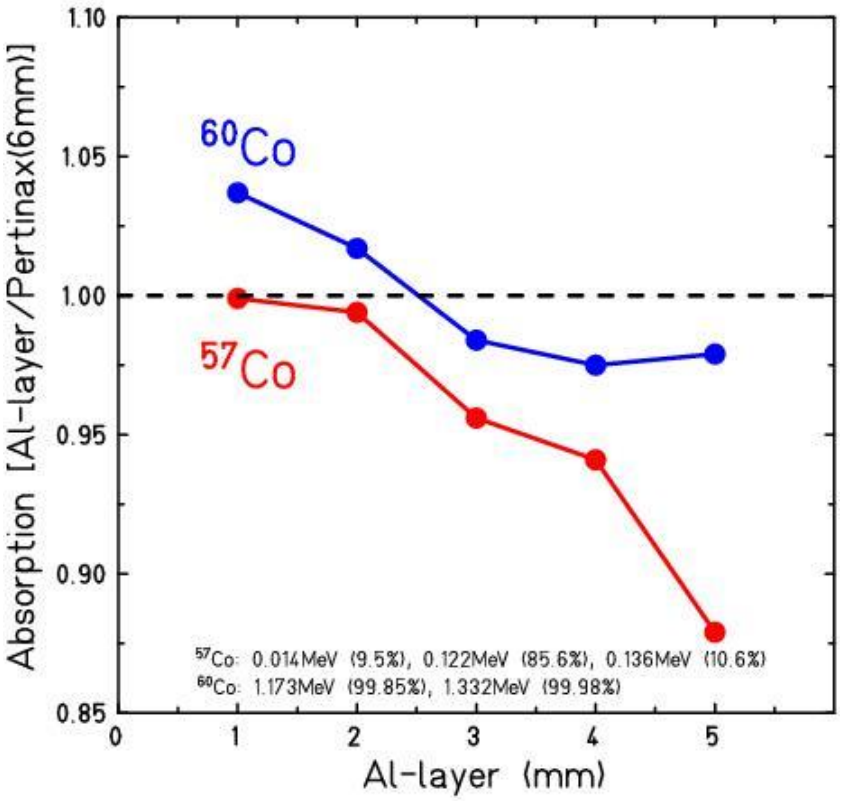
- surface 5x5 cm^2
- thickness 1 mm
- 2 x 16 3.125 mm strips
- manufactured by MICRON

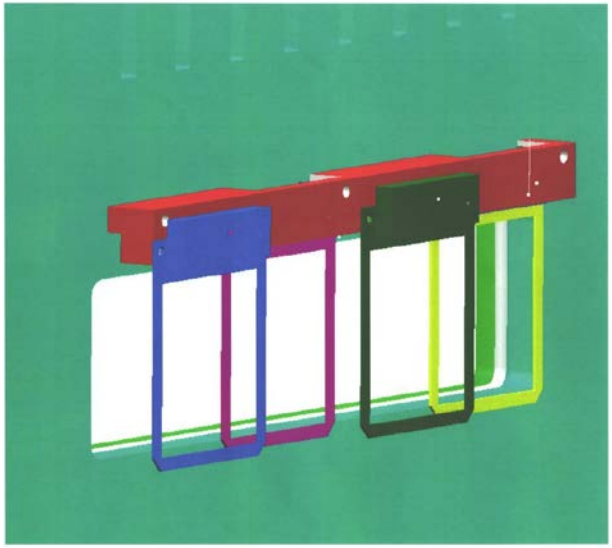
Spectroscopy at stopped beams



implantation	↔ range focusing
position correlation	↔ high garnularity
time correlation	↔ dedicated electronics

Chamber for active stopper (dry N_2)





result:

6mm Pertinax ≈ 2mm Al

2mm Pertinax for active stopper chamber

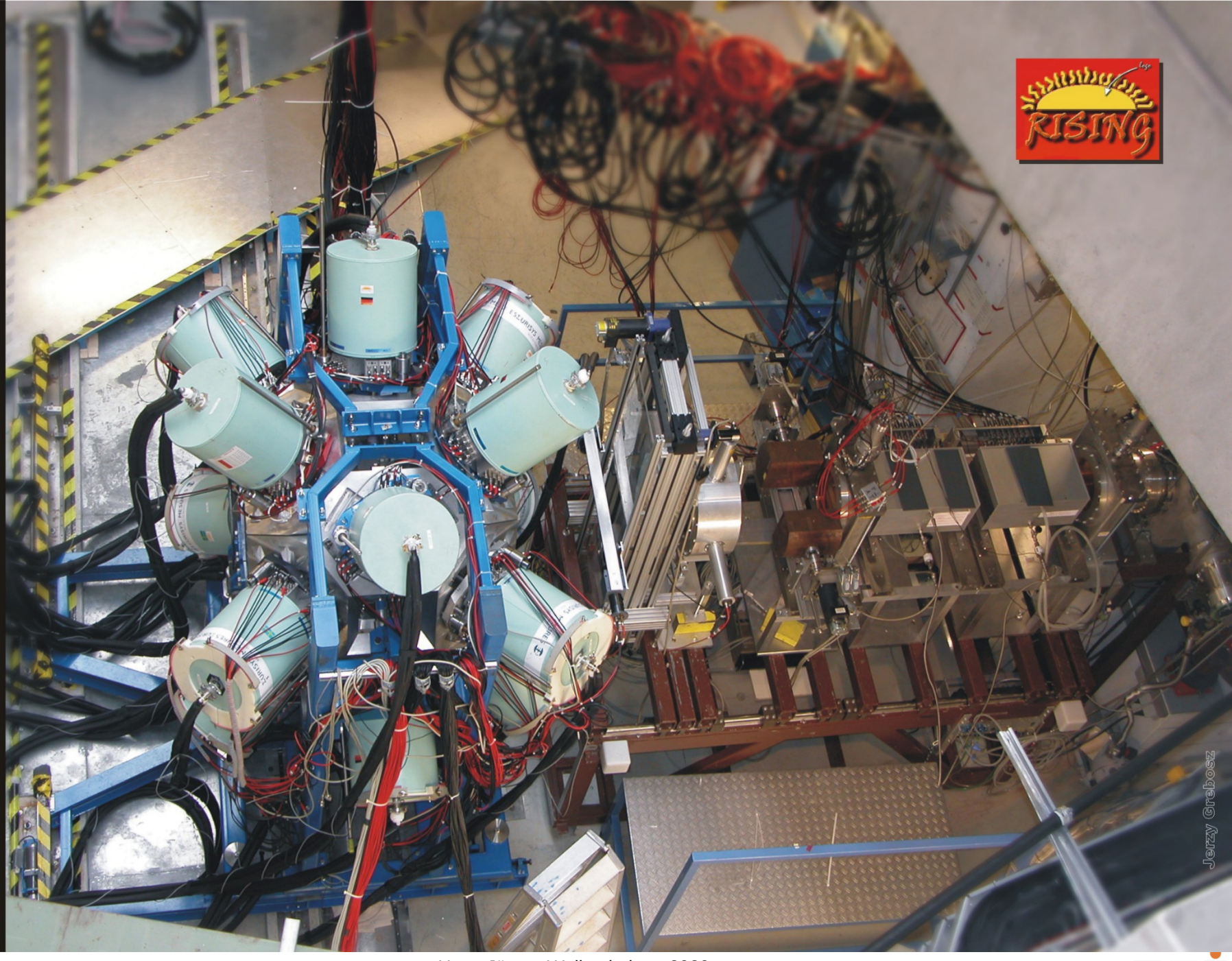
Pertinax

phenolic-formaldehyd cellulose-paper

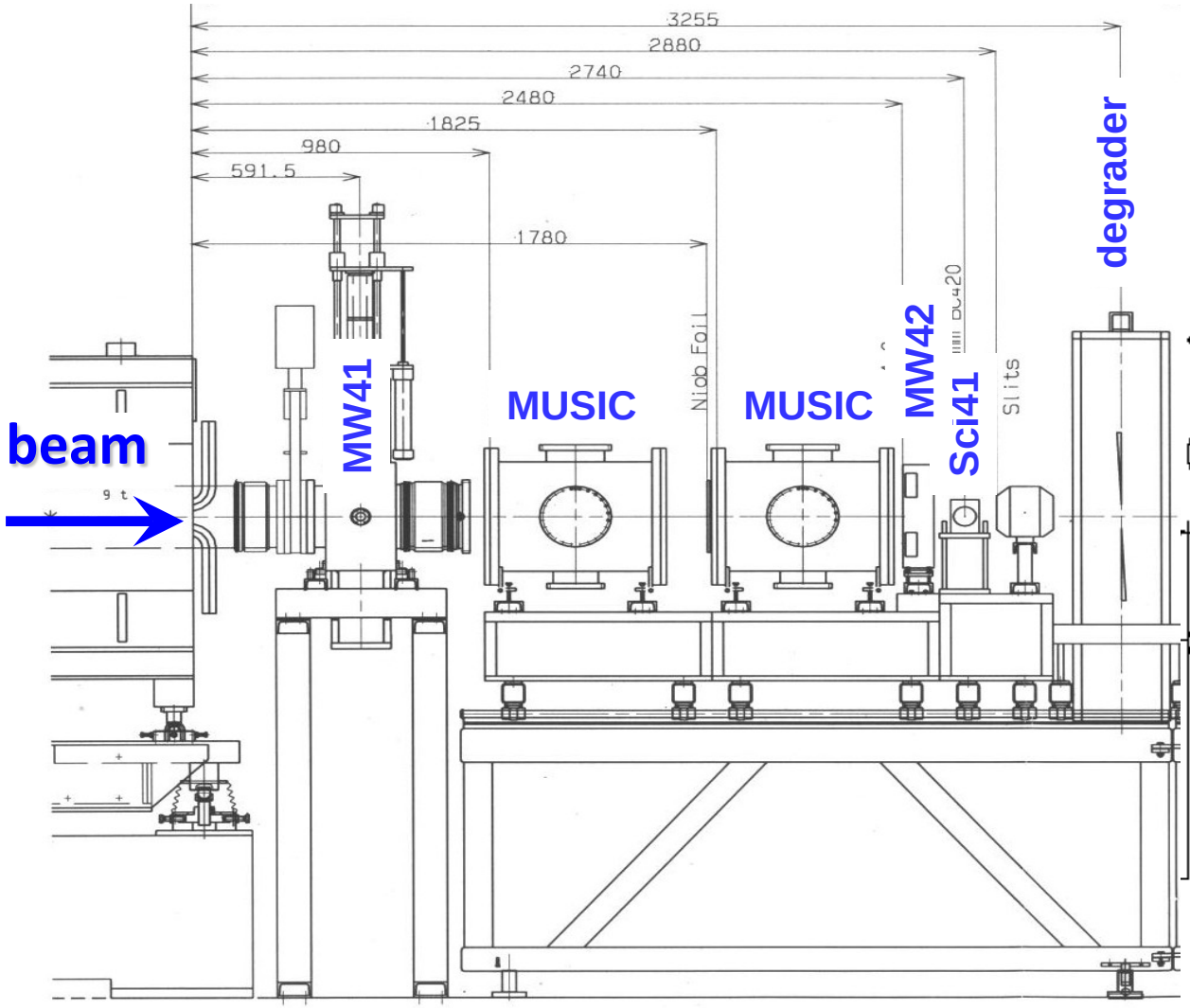
PF CP 2061

Stopped RISING Array: 15*7 element CLUSTERs with DSSD

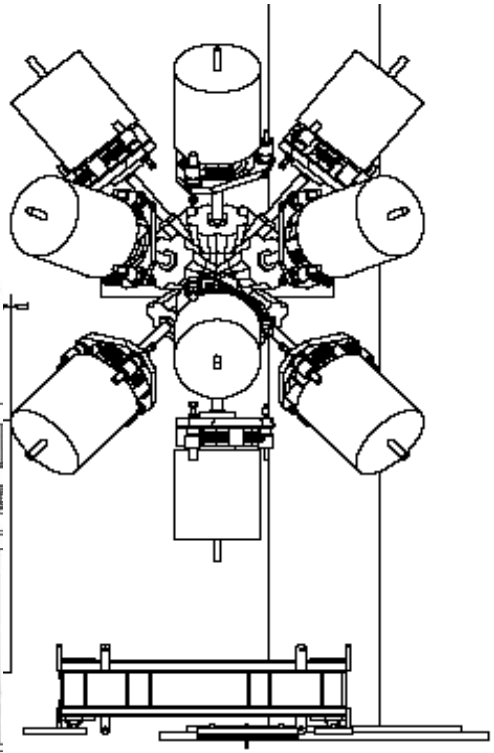
stopped beam setup



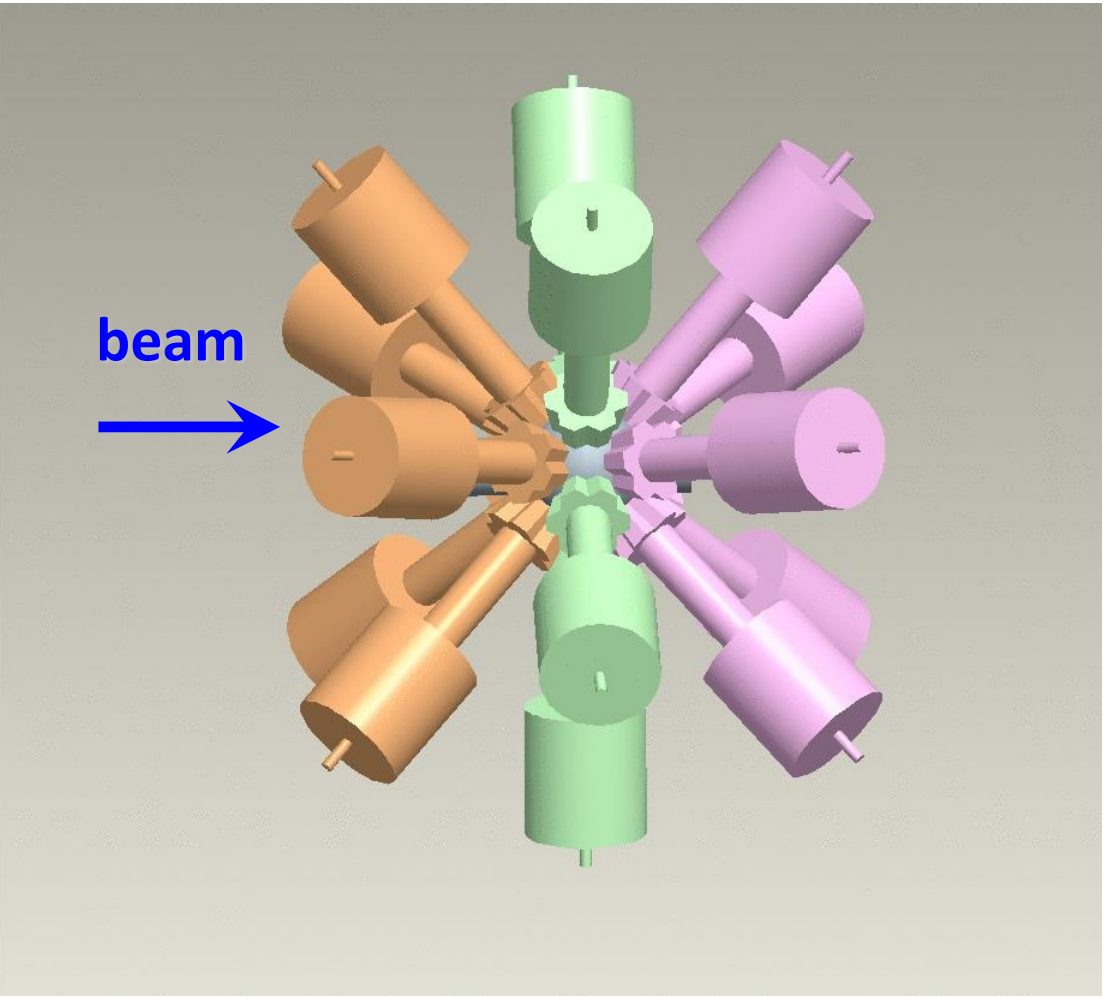
RISING setup with stopped beams



RISING Ge Cluster Array



RISING setup with stopped beams

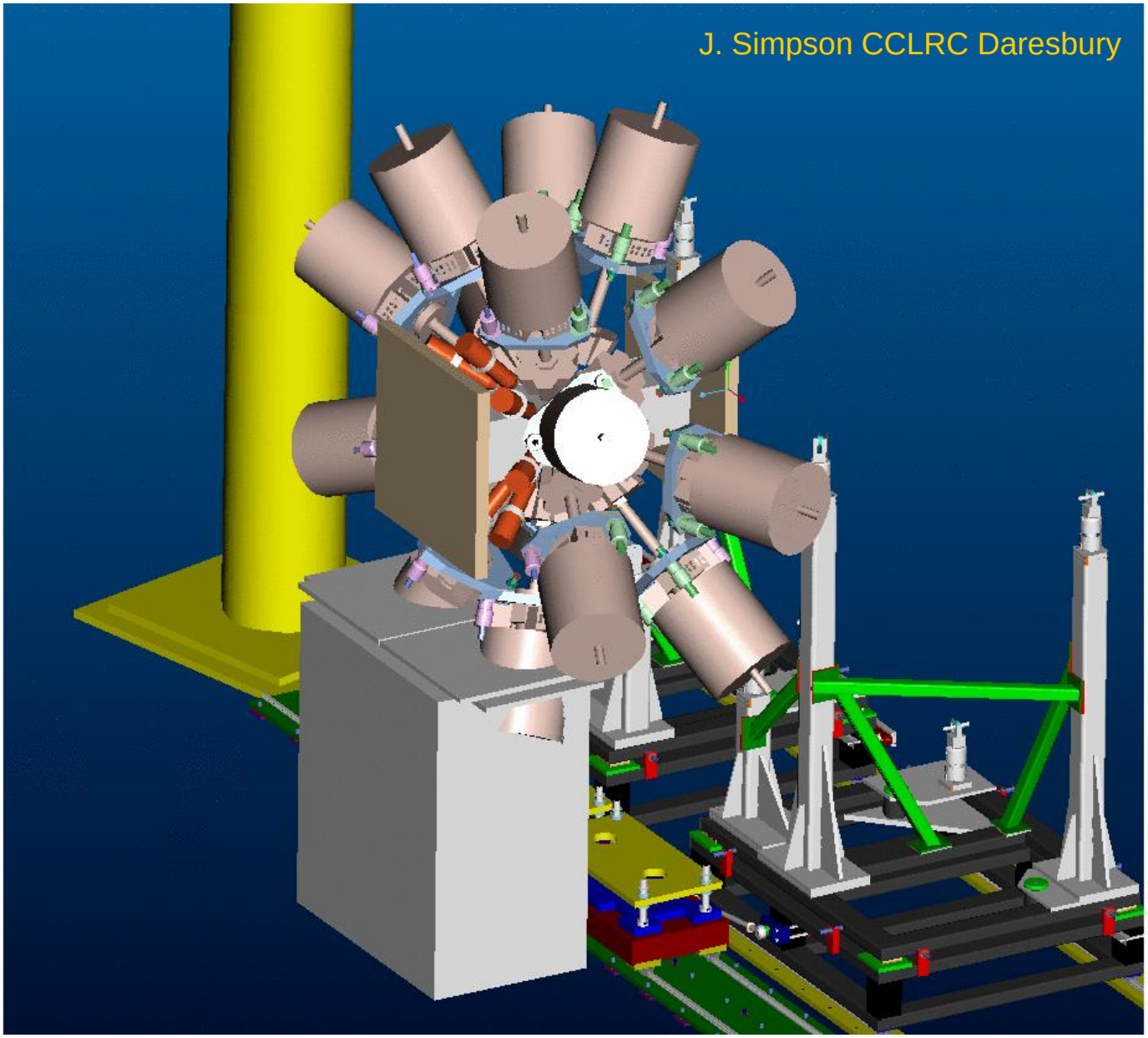


no. of Clusters	angle	distance to target
5	50^0	210+10mm
5	90^0	210+20mm
5	130^0	210+10mm

photopeak efficiency: 18.2%

J. Simpson CCLRC Daresbury

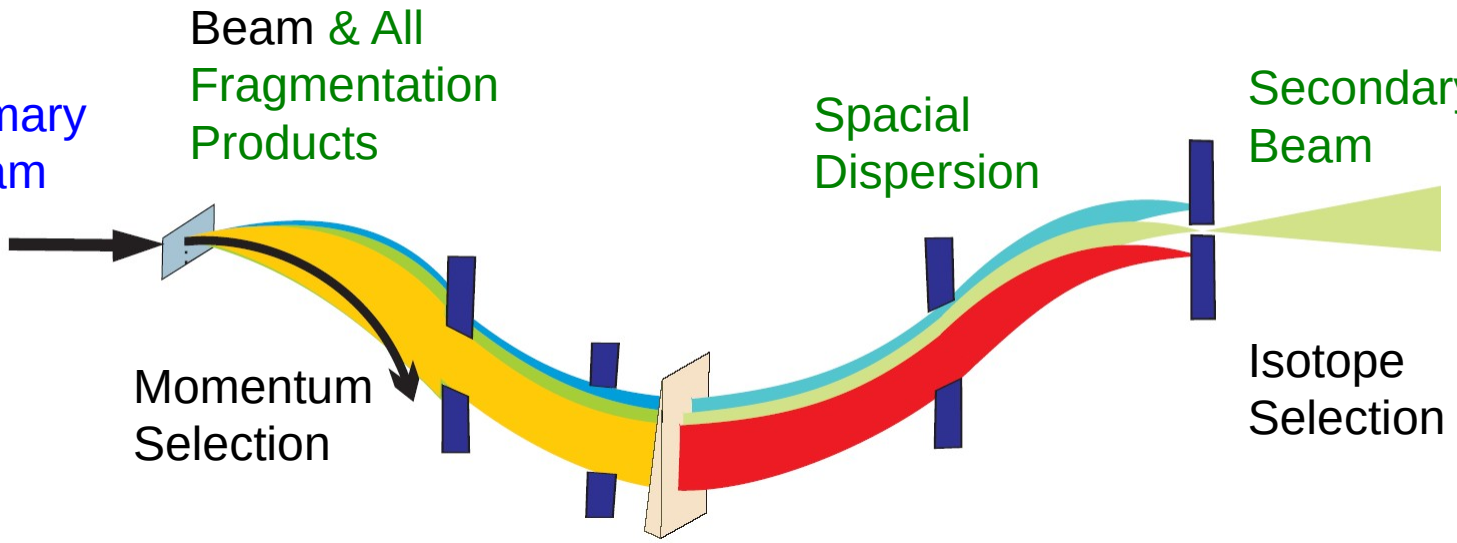
RISING setup with stopped beams



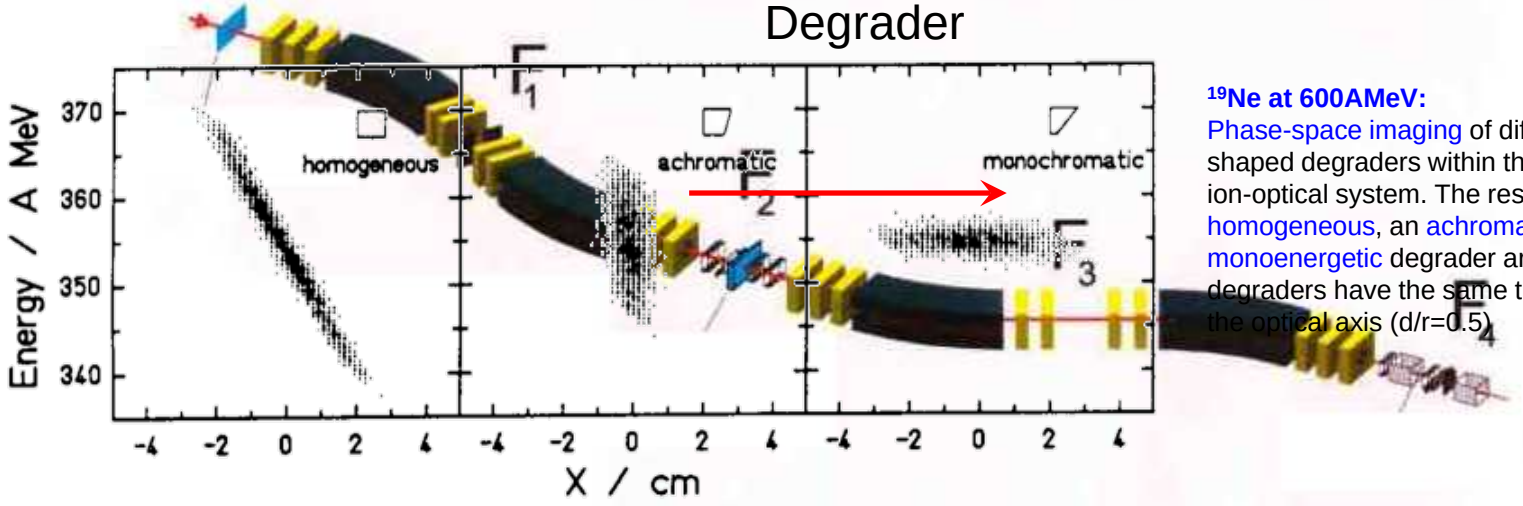
Count rate limitations with active stopper

- 3 x 16 x 16 = 3 x 256 = 768 total pixels.
  - Assume upper limit for β-half-life of ~30 seconds
  - Each pixel hit every 5 half-lives (150 secs)
- Max. rate of ~768/150 = 5 per sec (= 50 per 10s spill).
- Rate increases directly with decreasing half-life
- (e.g., $T_{1/2}$ = 10 seconds -> 150 per 10 s spill cycle)
- Dual gain pre-amps on DSSSD to get energies of
- implanted ion and β-particle
- All events time stamped with MHz clock.

Fragment Separator FRS

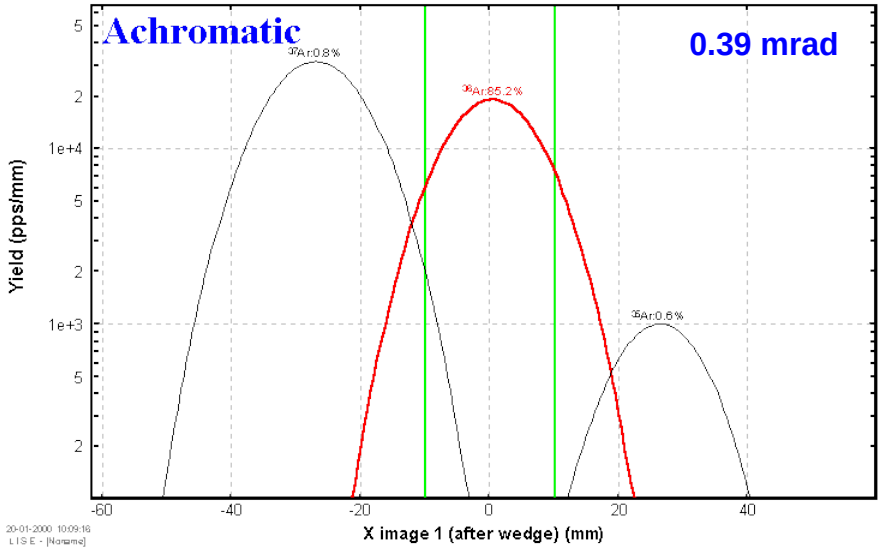


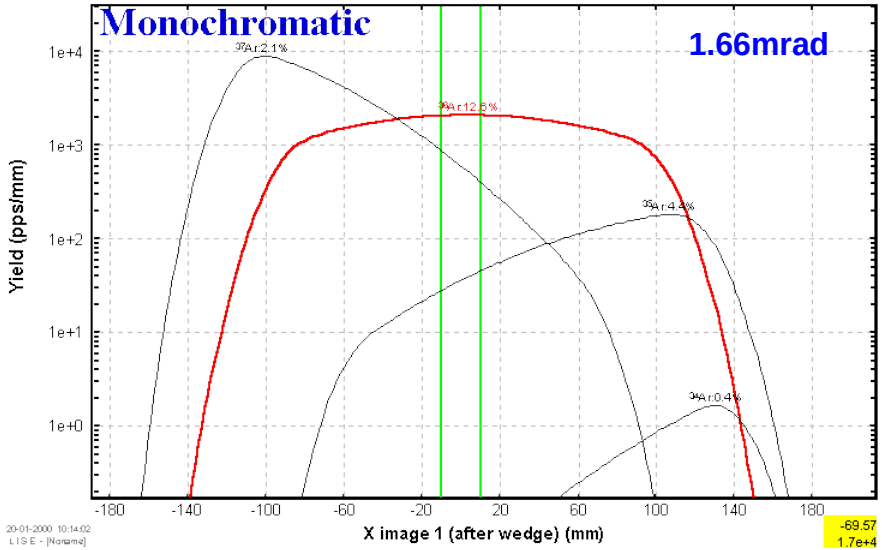
Wedge-shaped Degrader

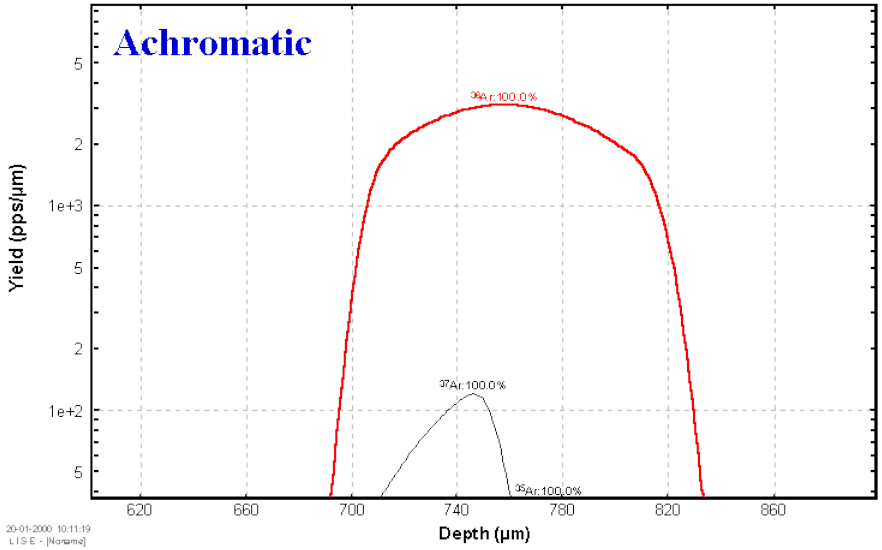


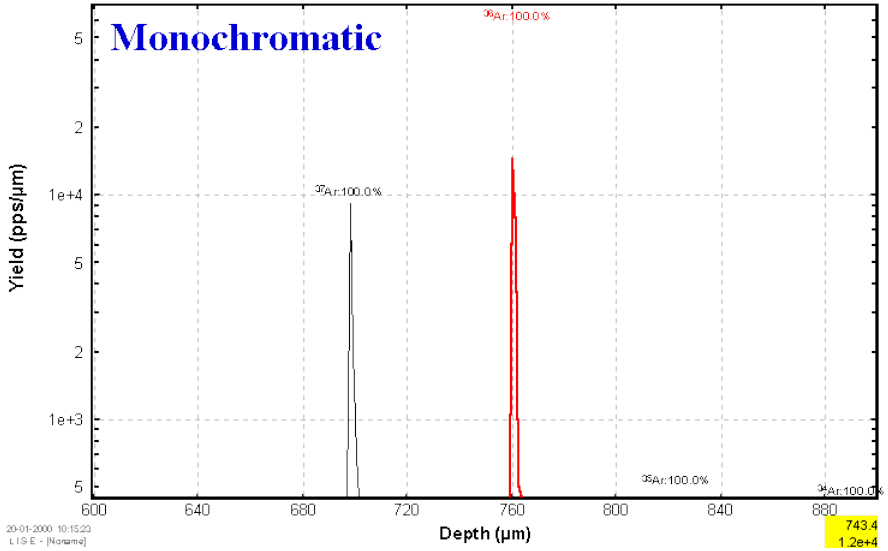
^{19}Ne at 600AMeV:
Phase-space imaging of differently shaped degraders within the achromatic ion-optical system. The results for a homogeneous, an achromatic, and a monoenergetic degrader are given. All degraders have the same thickness on the optical axis (d/r=0.5)

Fragment Separation (^{40}Ar 50 MeV/u + Ta (100µm), wedge shaped Al (200µm) degrader)

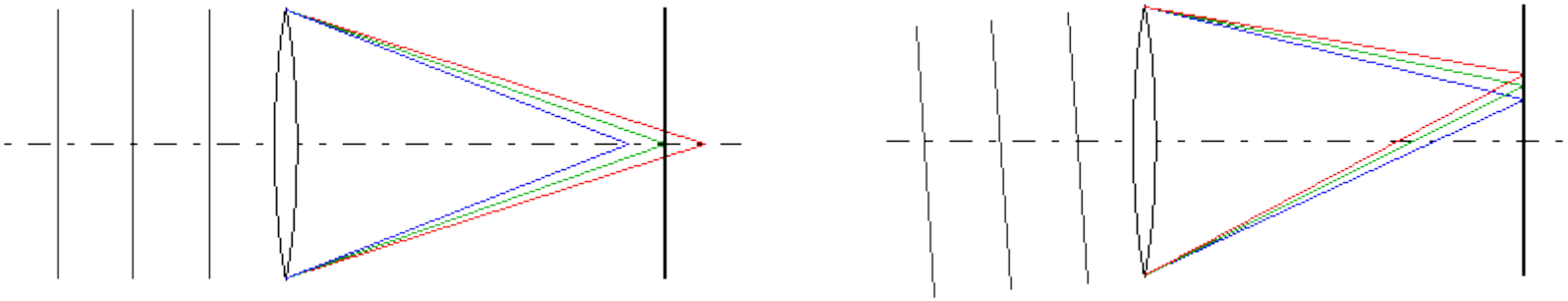








Chromatic Aberration



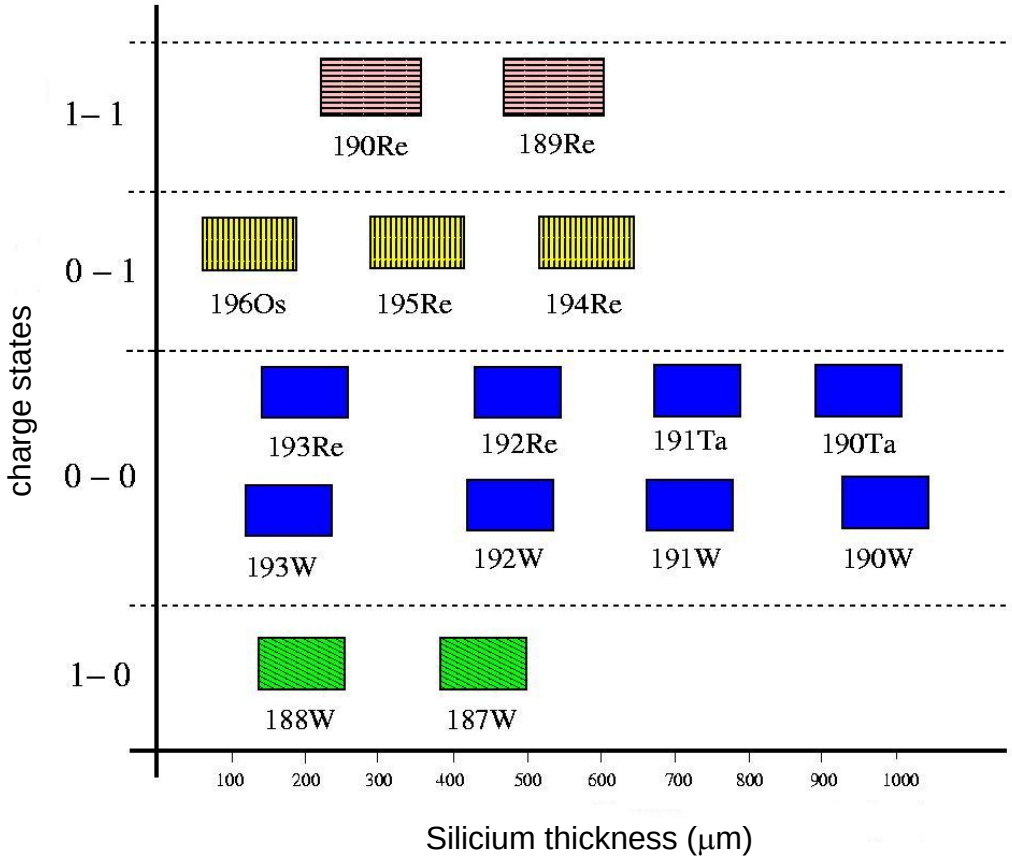
When different colors of light propagate at different speeds in a medium, the refractive index is wavelength dependent. This phenomenon is known as dispersion.

Longitudinal (axial) chromatic aberration:
The focal planes of the various colors do not coincide.

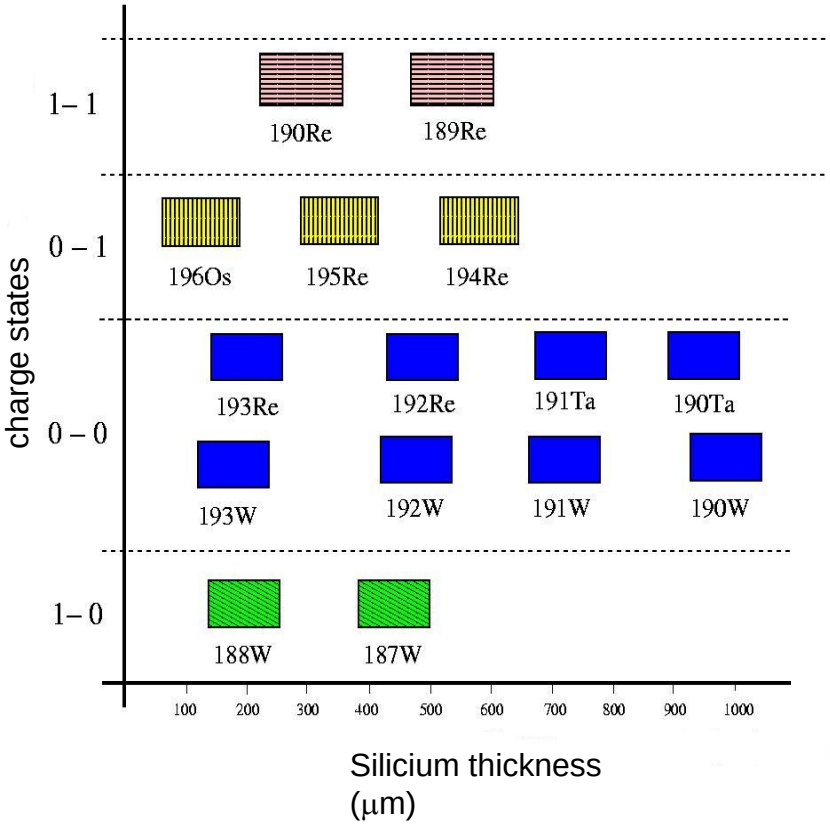
Transverse (lateral) chromatic aberration:
The size of the image varies from one color to the next.

Implantation range

Estimated implanted isotopes for a setting centered on ^{192}W
in 1 mm thickness silicon with a **monoenergetic degrader at S2**

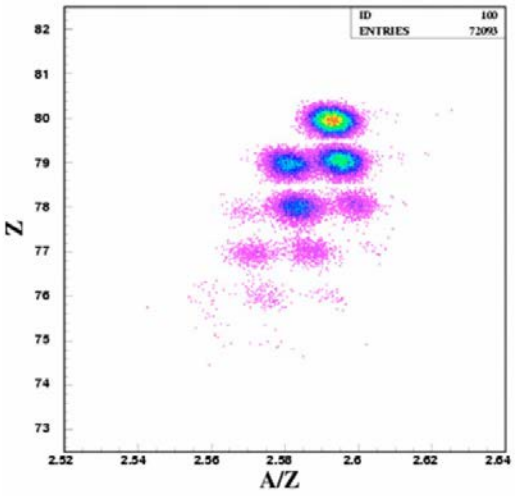


Estimated implanted isotopes for a setting centered on ^{192}W in 1mm thickness silicon with a monoenergetic degrader at S2

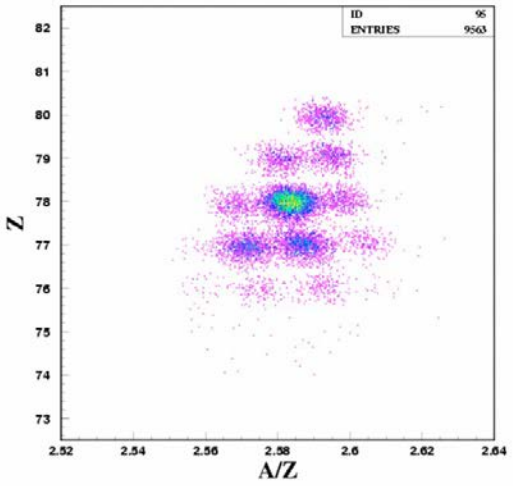


Setting centered on ^{198}Ir

Produced



Implanted



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