The Energy Buncher at the SuperFRS Low Energy Branch

The energy buncher – the principle

Range straggling and resolving power

First tests with a precision degrader

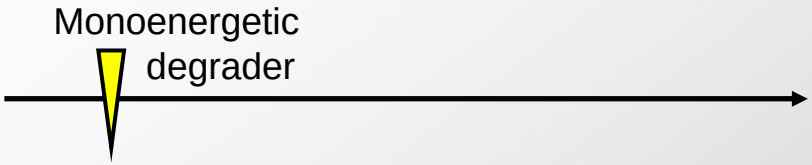
Typical beam properties

Energy buncher: principle and ion-optical layout

Princip

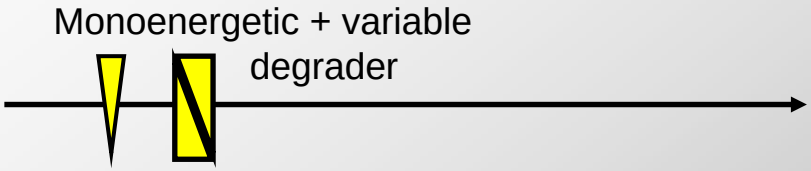
Layou

Experimental opportunities and instrumentation

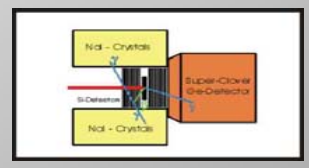


Slow beams
(500...10 MeV/u)

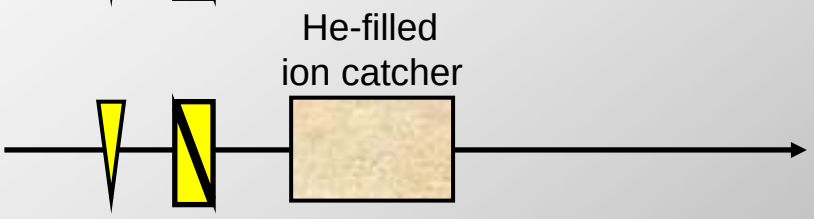
in-beam γ-ray spectroscopy



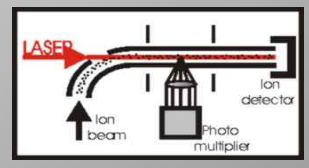
Stopped beams
(~ 25meV)



α, β, γ -decay spectroscopy

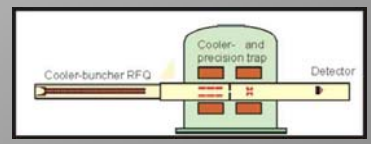


ISOL-type beams
(~10...100 keV)

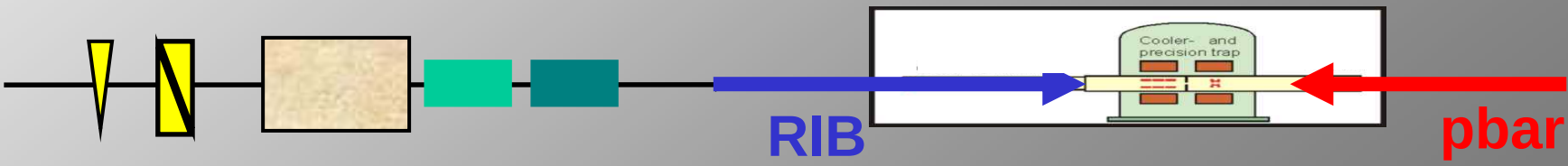


LASER spectroscopy

Highly-charged ions



in-trap ex-periments

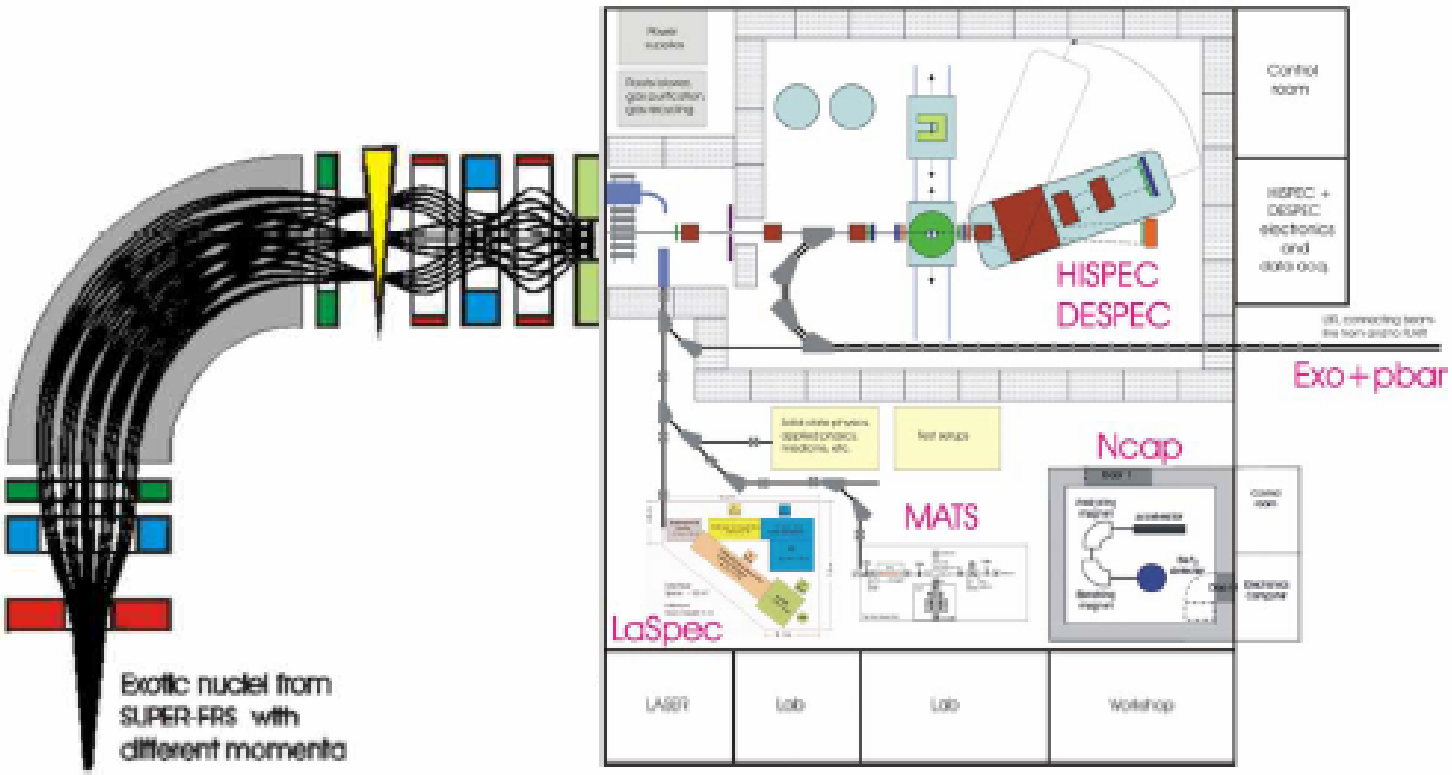


Unique feature: RIBs and pbar at (almost) the same place

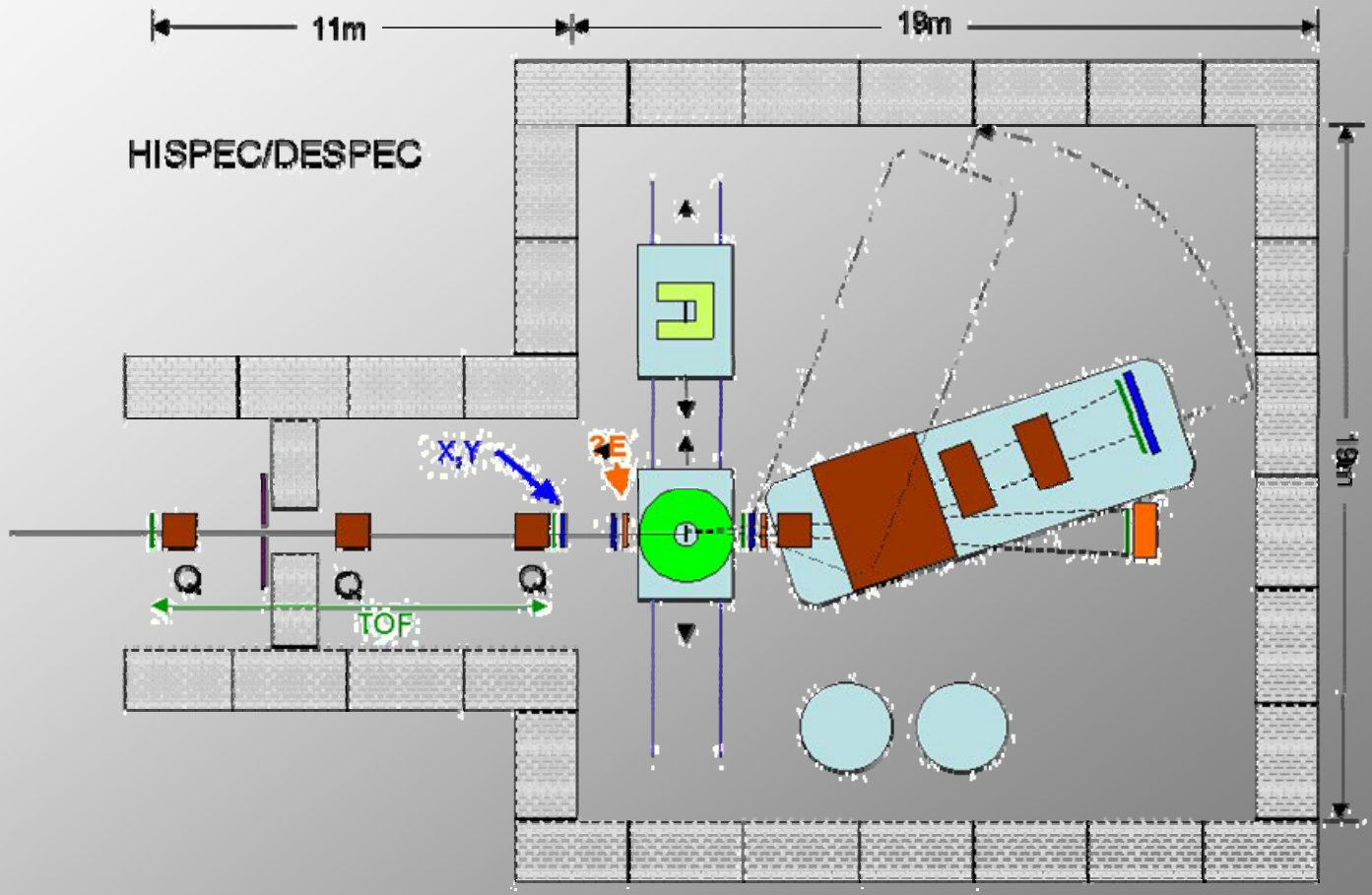
Dissemination: Low-Energy Branch of the Super-FRS

Energy buncher

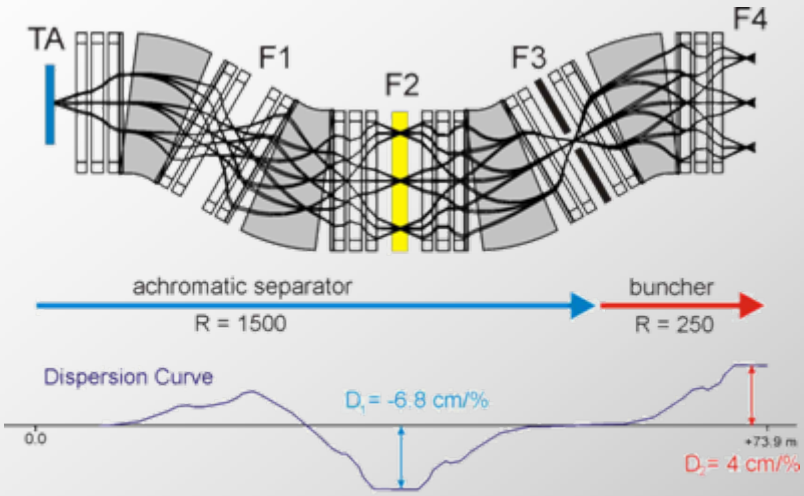
Experimental area



Experimental Area at the Low-Energy Branch of the Super-FRS



Tests and developments @ the FRS

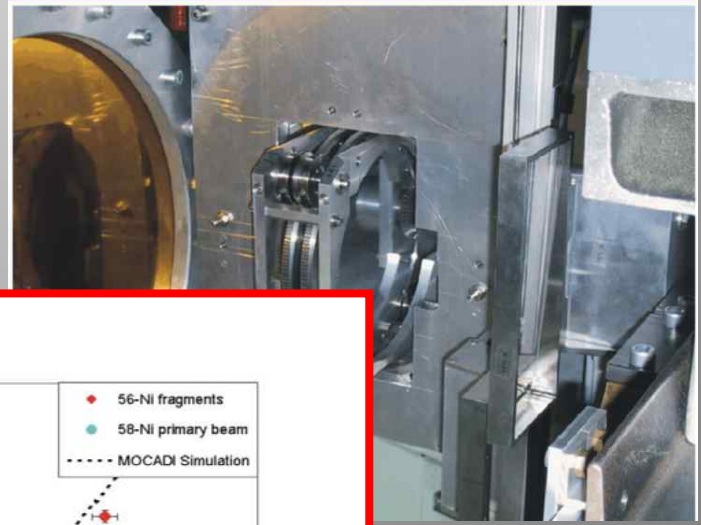


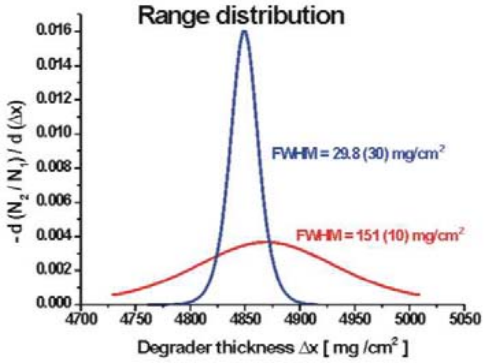
Achromatic condition: $D_1 M_2 * \delta_1 + D_2 * \delta_2 \stackrel{!}{=} 0$

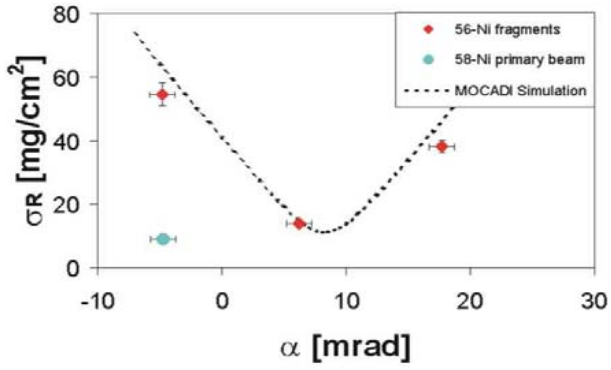
achieve by $(\delta_2 = \kappa\, \delta_1)$ with $\kappa = 1.90 \sim p_{in}/p_{out}$

Precision degrader system

Material:	Suprasil 2 (SiO_2)
Surface roughness:	less than 10 nm
Maximum shape deviation:	less than 1μm
Material homogenity:	better than 10^{-4}
Areal weight homogenity:	better than 0.2 mg/cm^2
Minimum thickness steps:	180 μg/cm^2



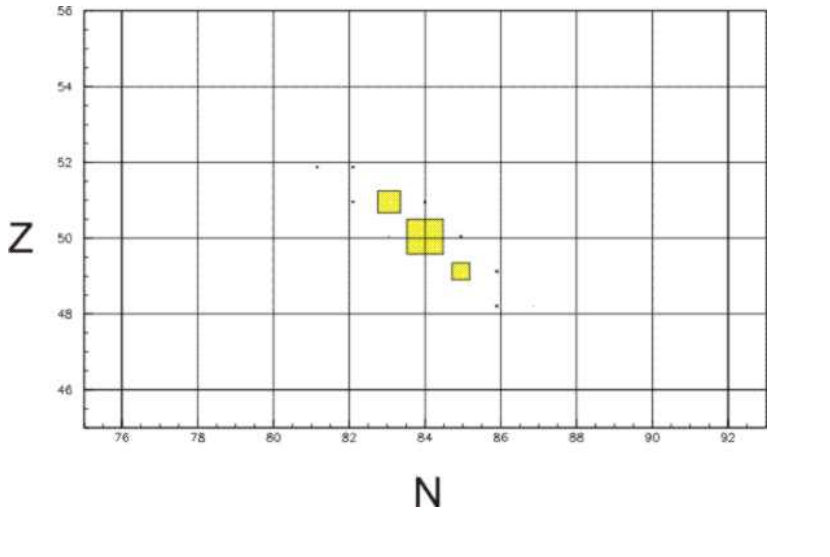


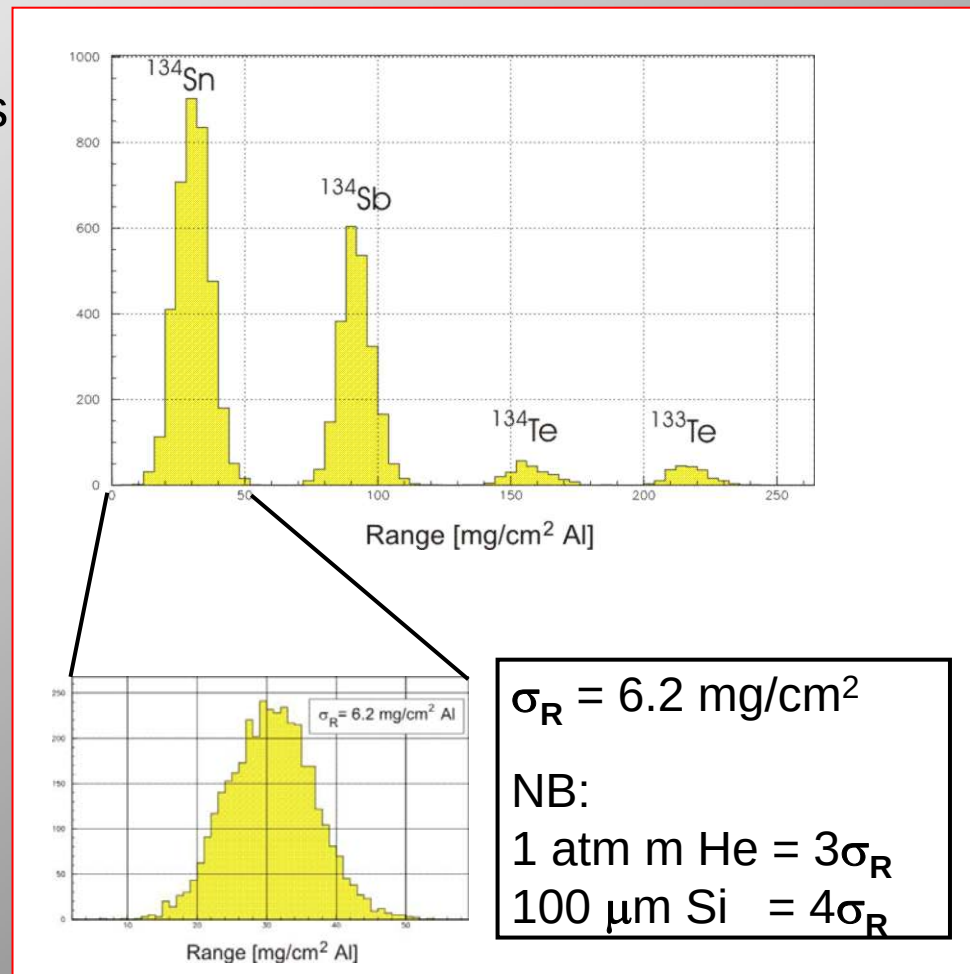


Separation characteristics and performance: purity of stopped beams

Example:

* Separation of ^{134}Sn fission fragments
* Range focusing with E-buncher (p/Δp=600)





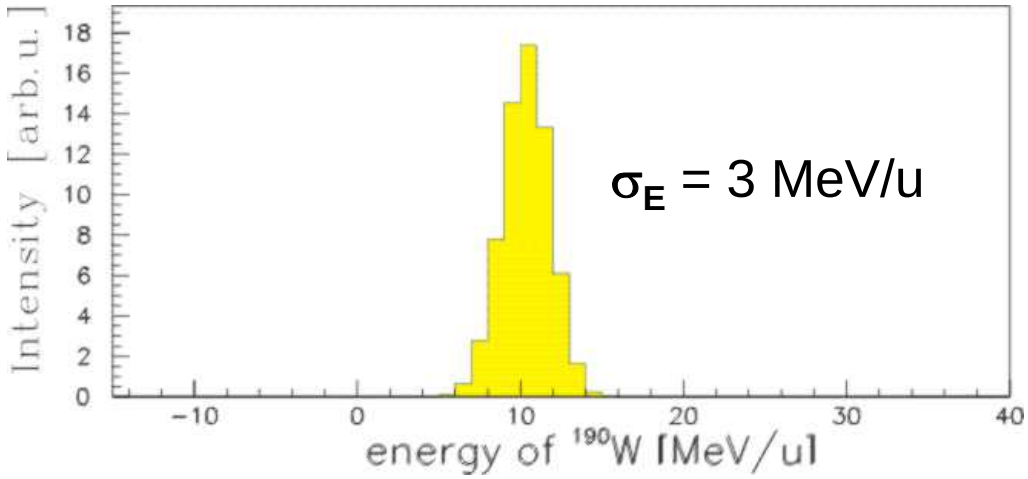
σ_R = 6.2 mg/cm^2

NB:

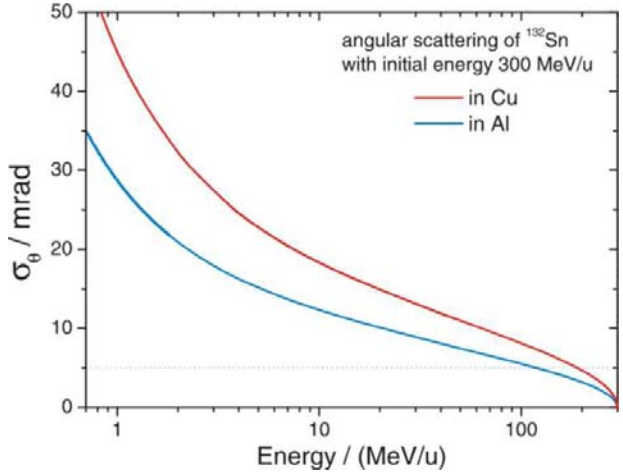
1 atm m He = $3\sigma_R$

100 μm Si = $4\sigma_R$

Characteristics of low-energy beams: energy and angular spread



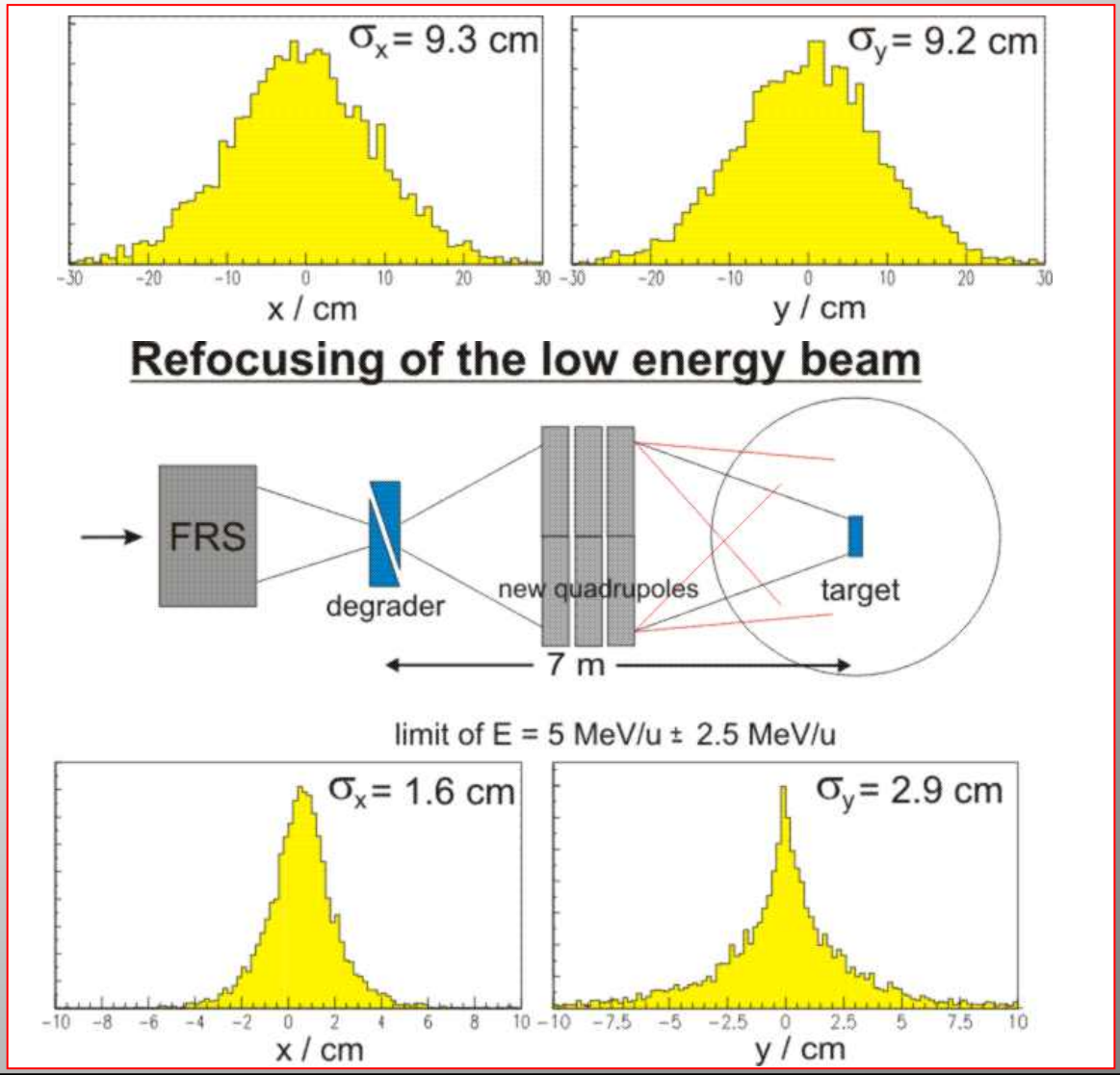
σ_E = 3 MeV/u



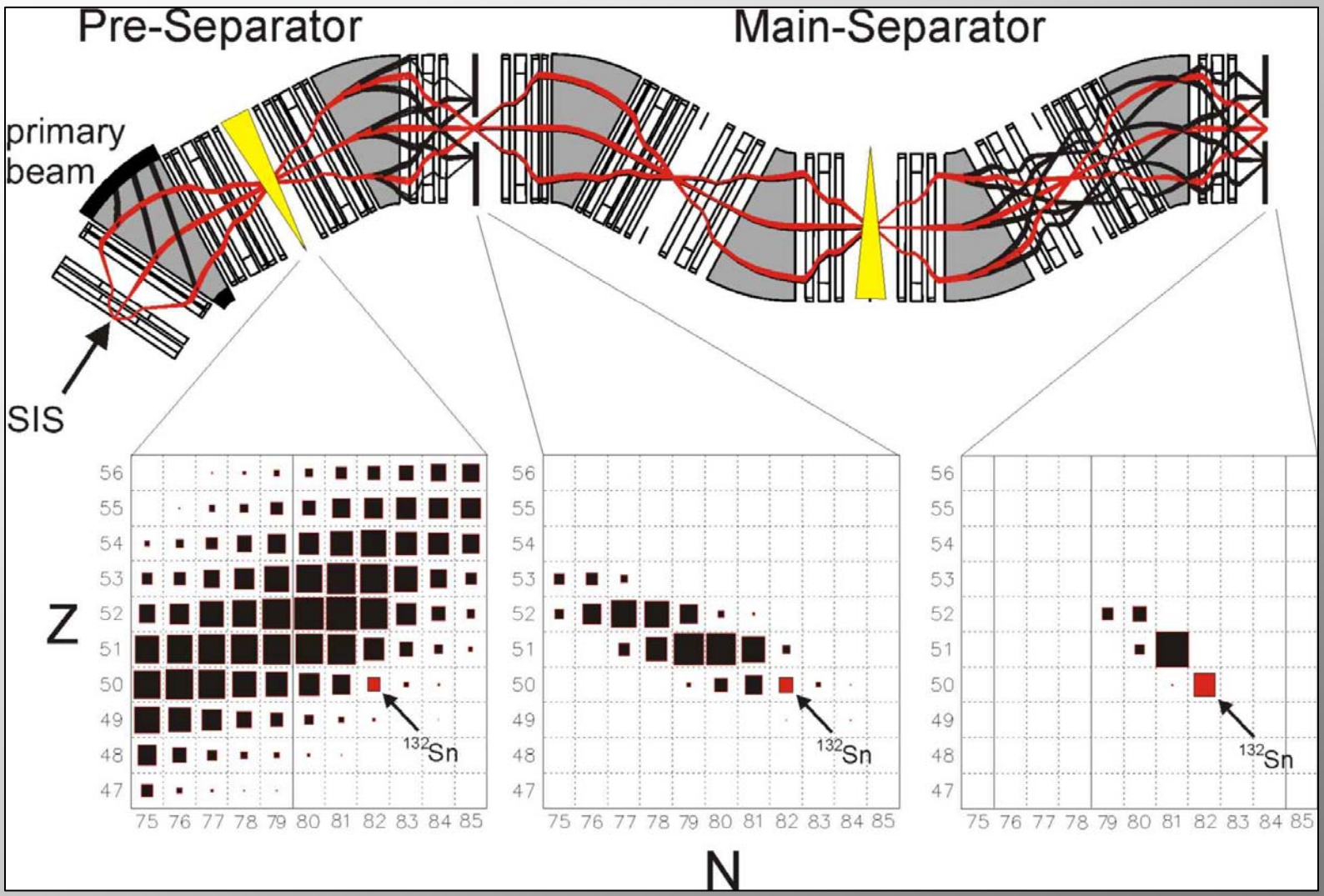
Typical numbers:

300 MeV/u:	σ_E ~ 0.3 MeV/u	σ_α ~ 5 mrad
5 MeV/u:	σ_E ~ 3 MeV/u	σ_α ~ 20 mrad

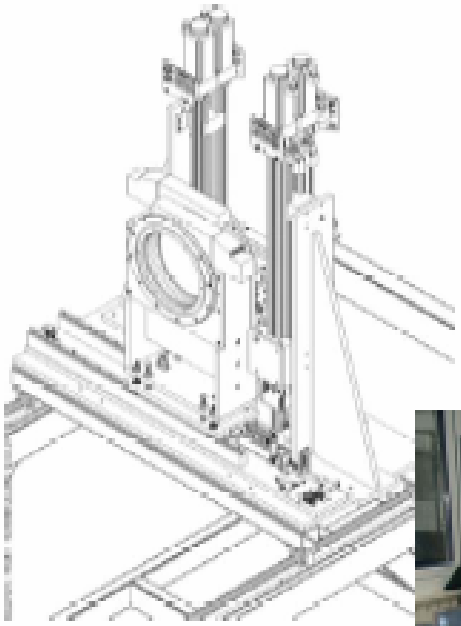
Refocusing system

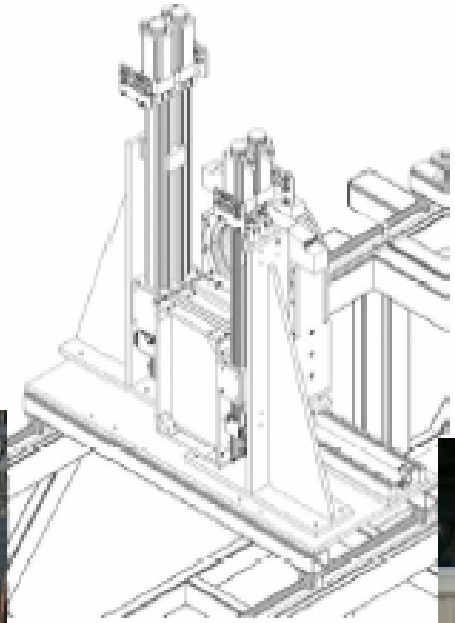


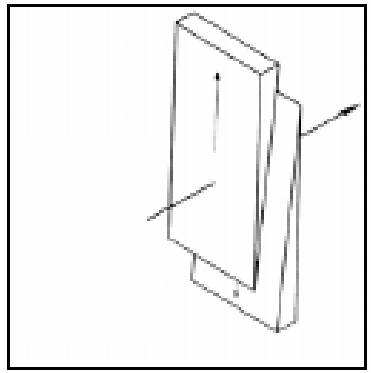
Layout and Separation Properties



Design and assembly of the degrader system



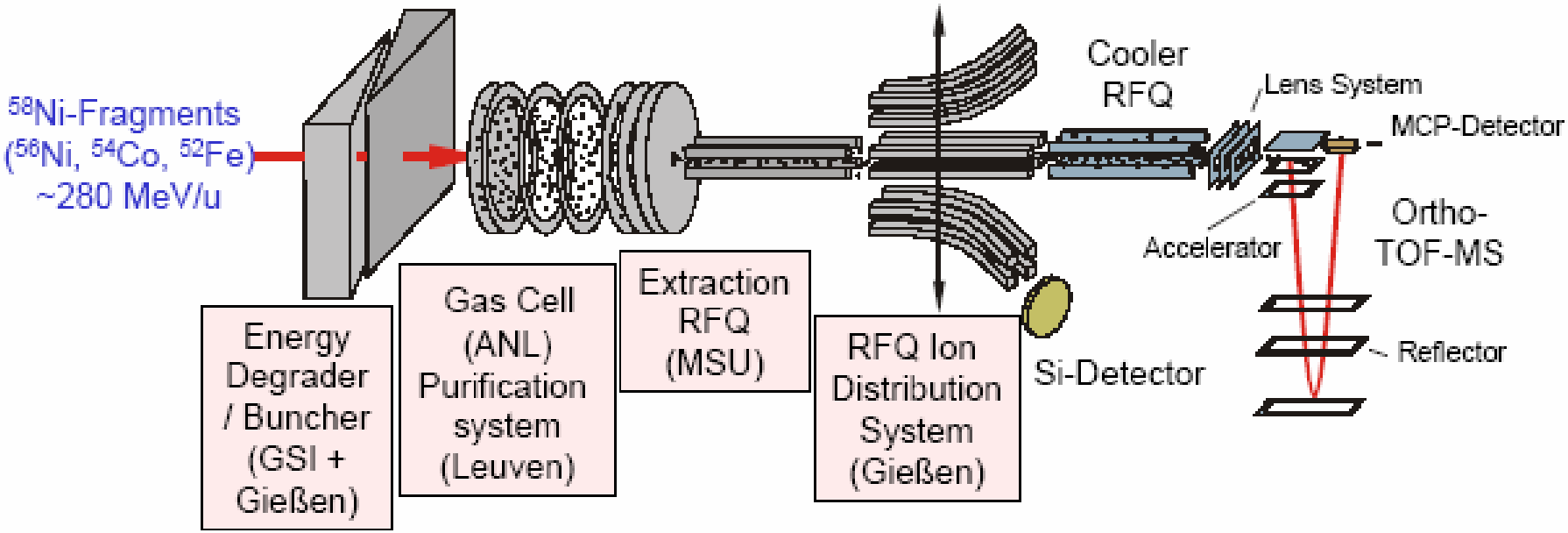




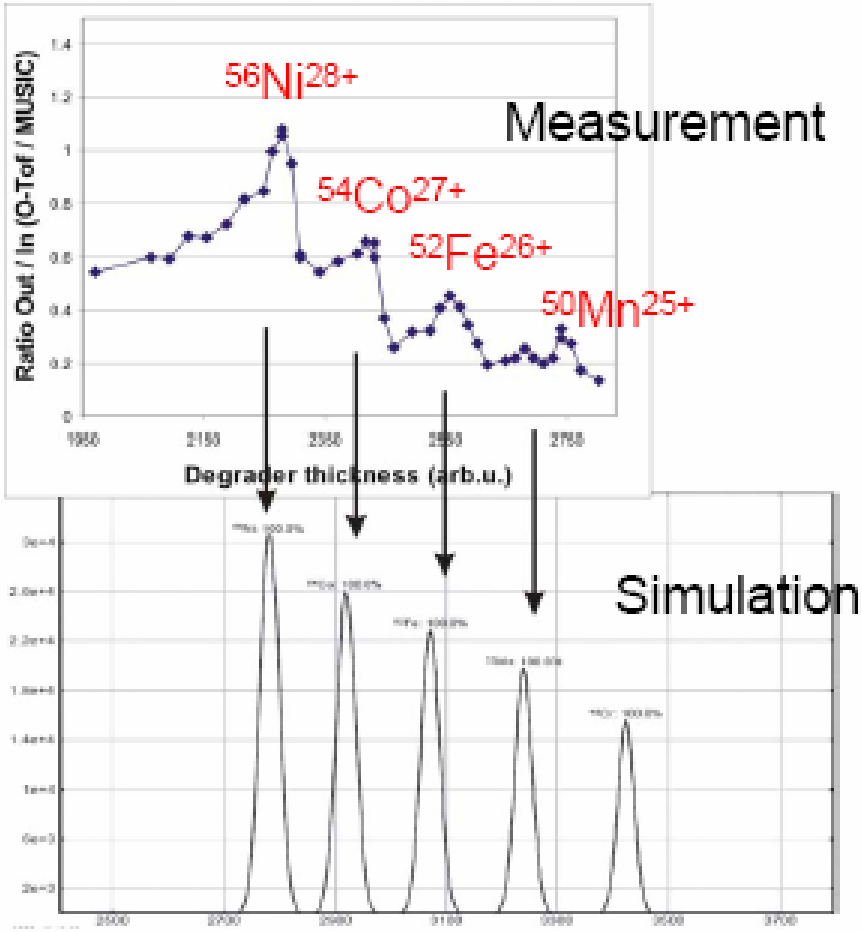
Linear drives
(quasi-continuous
thickness variation)

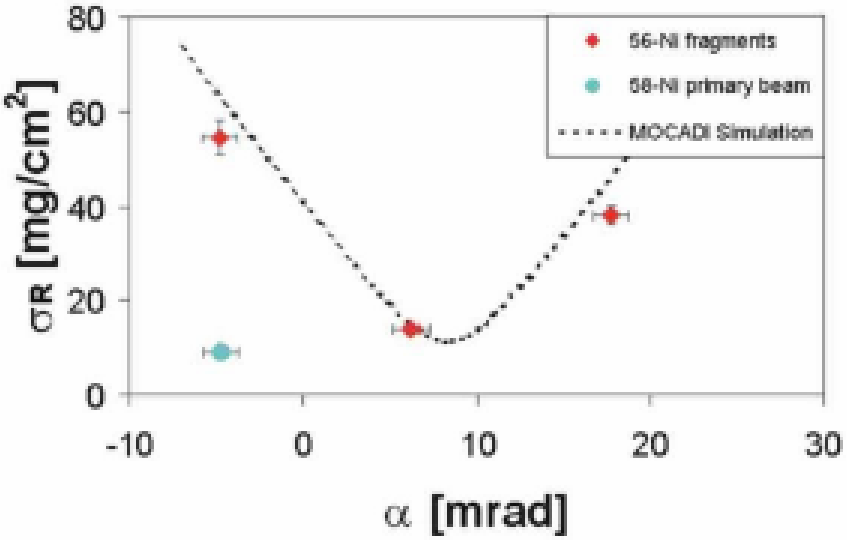
Rotational stages
(wedge angle)

Schematic view of setup



Measurement of range distributions





$\sigma_R \approx 10...13$ mg/cm^2

Gas cell: ~ 2 mg/cm^2