

Experiments with the Fragment Separator and their Future

Helmut Weick

MORIOND 03

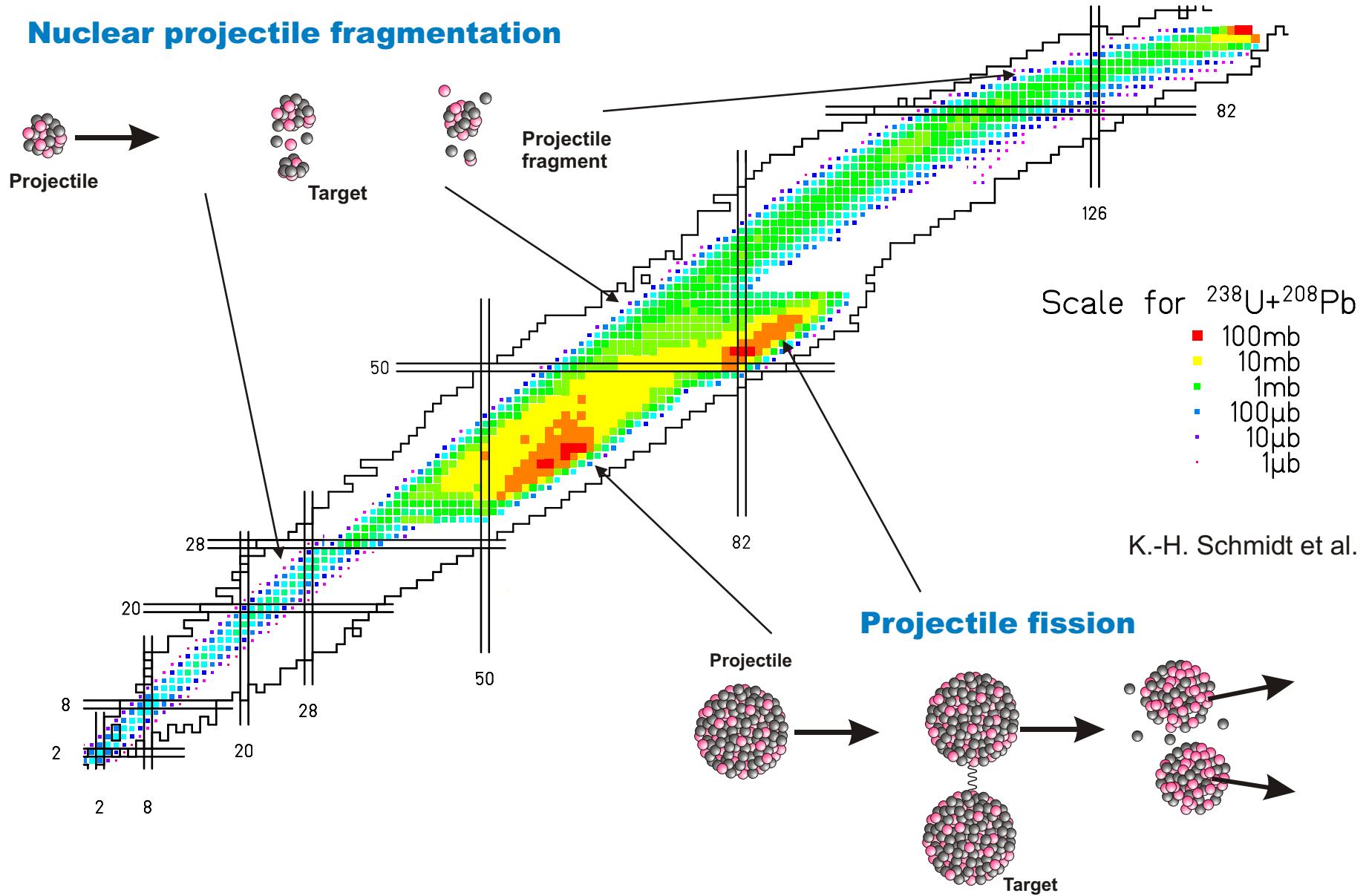
Radioactive Beams for Nuclear Physics and Neutrino Physics

Wednesday, 19.03.2003

- Production and Separation of Radioactive Beams in Flight
- Experiments with Exotic Nuclei
- Future plans
- In-Flight and Neutrinos ?

Fragments produced from ^{238}U

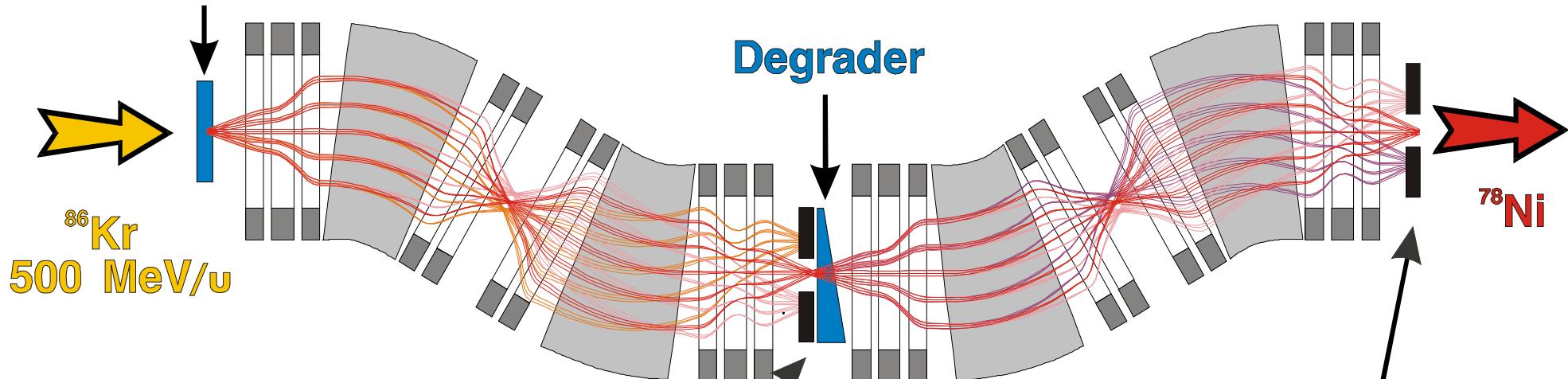
Nuclear projectile fragmentation



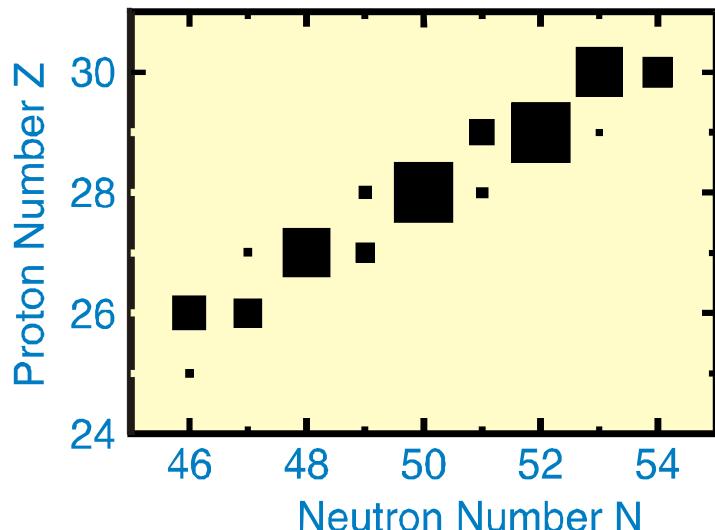
B - E-B - Method of Separation

like ALPHA, LISE, A1900, RIPS, FRS, ACCULINA, RIBBL ...

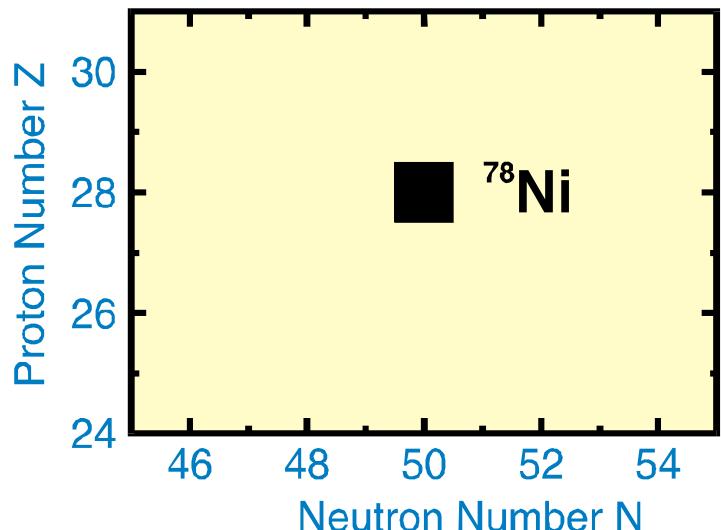
Production Target



First Selection

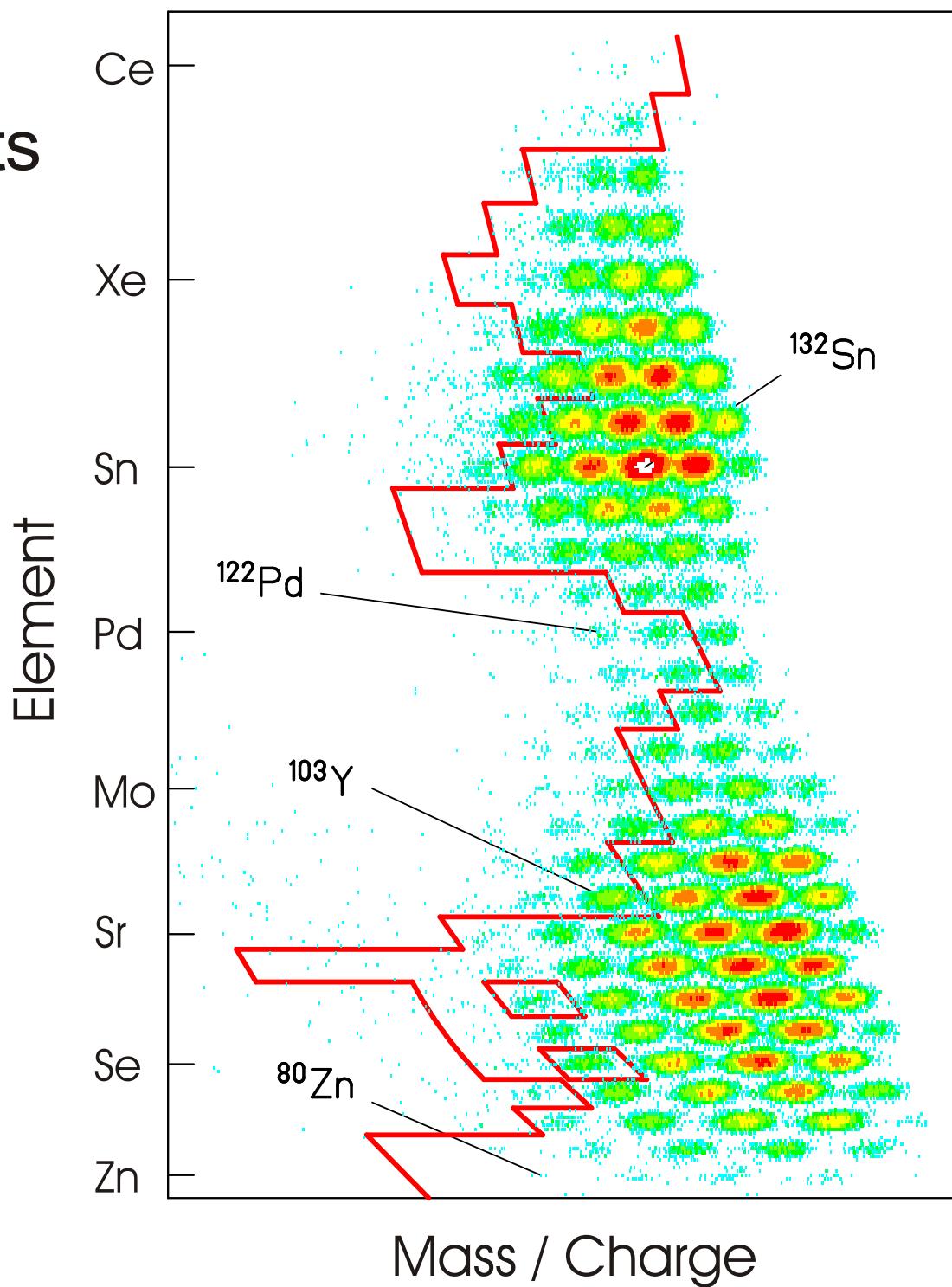


First and Second Selection

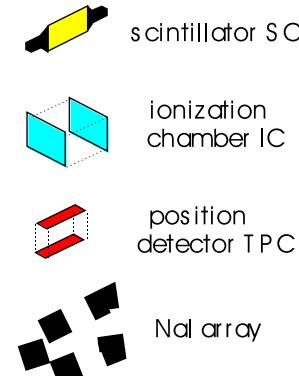
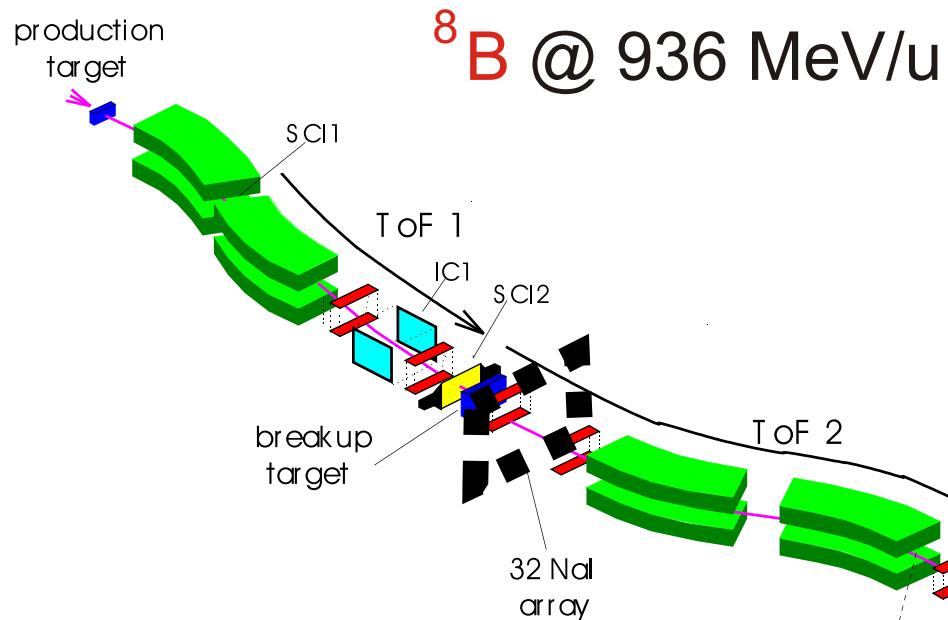


Fission Fragments

identified in-flight
with TOF, dE

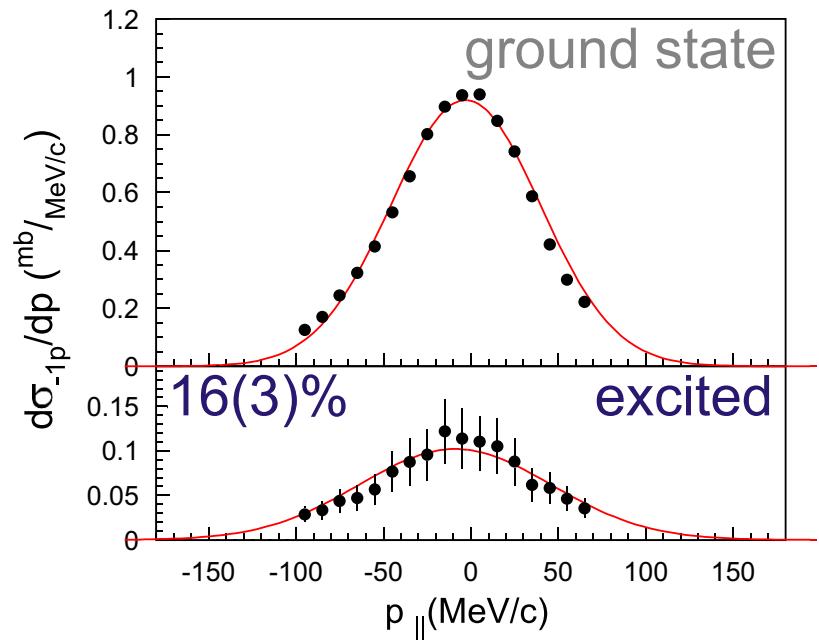
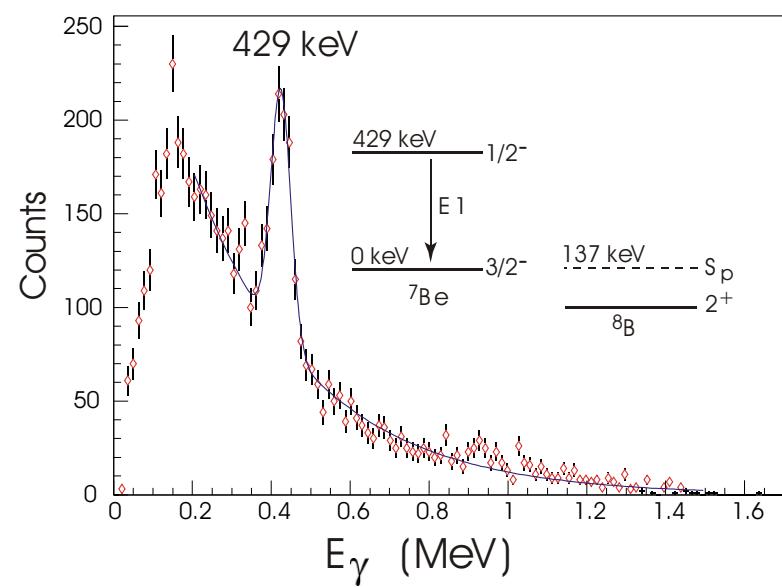


γ gated longitudinal momentum distributions

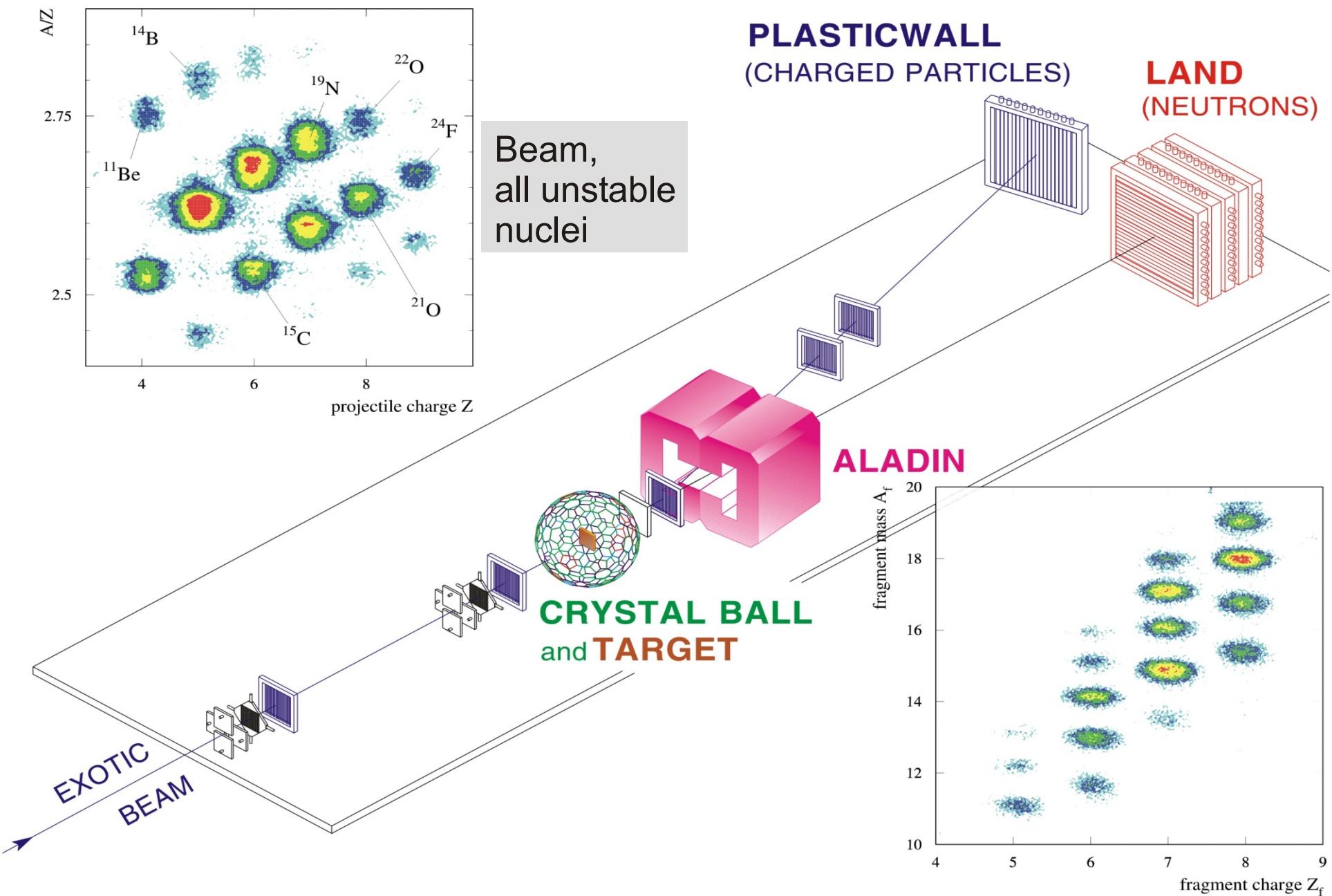


D. Cortina-Gil et al.
PLB, 529 (2002) 36

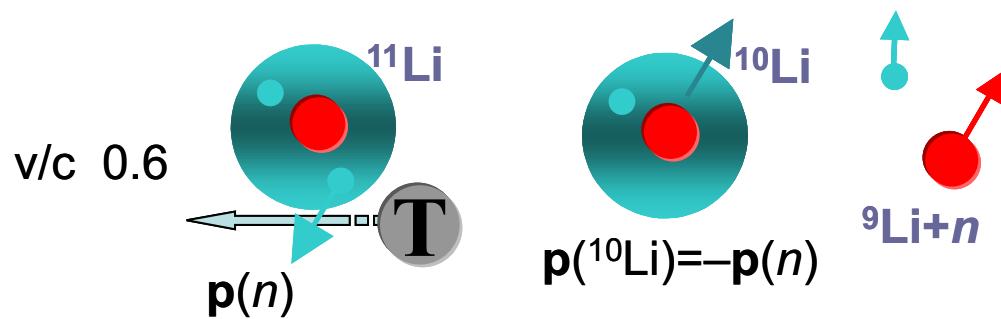
$$|^{8}\text{B}\rangle = (|^{7}\text{Be}\rangle \oplus |^{7}\text{Be}^*\rangle) \circledast |\text{p}\rangle$$



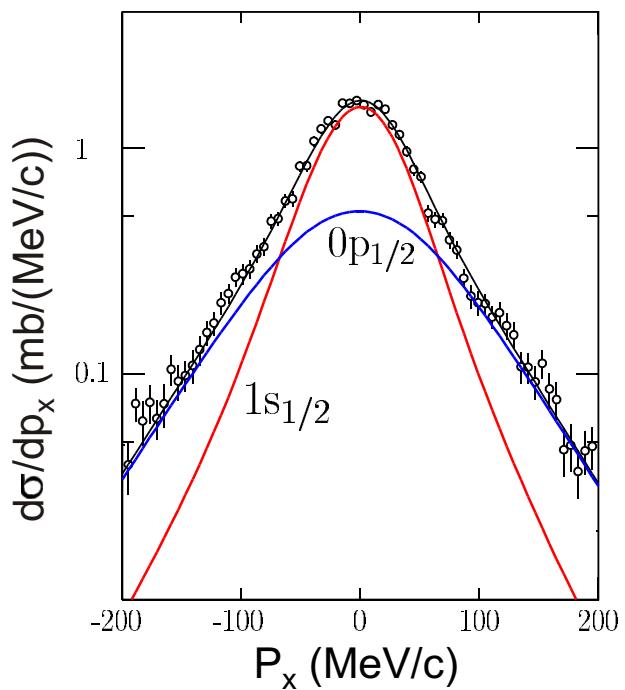
Experimental Scheme: Setup LAND@GSI



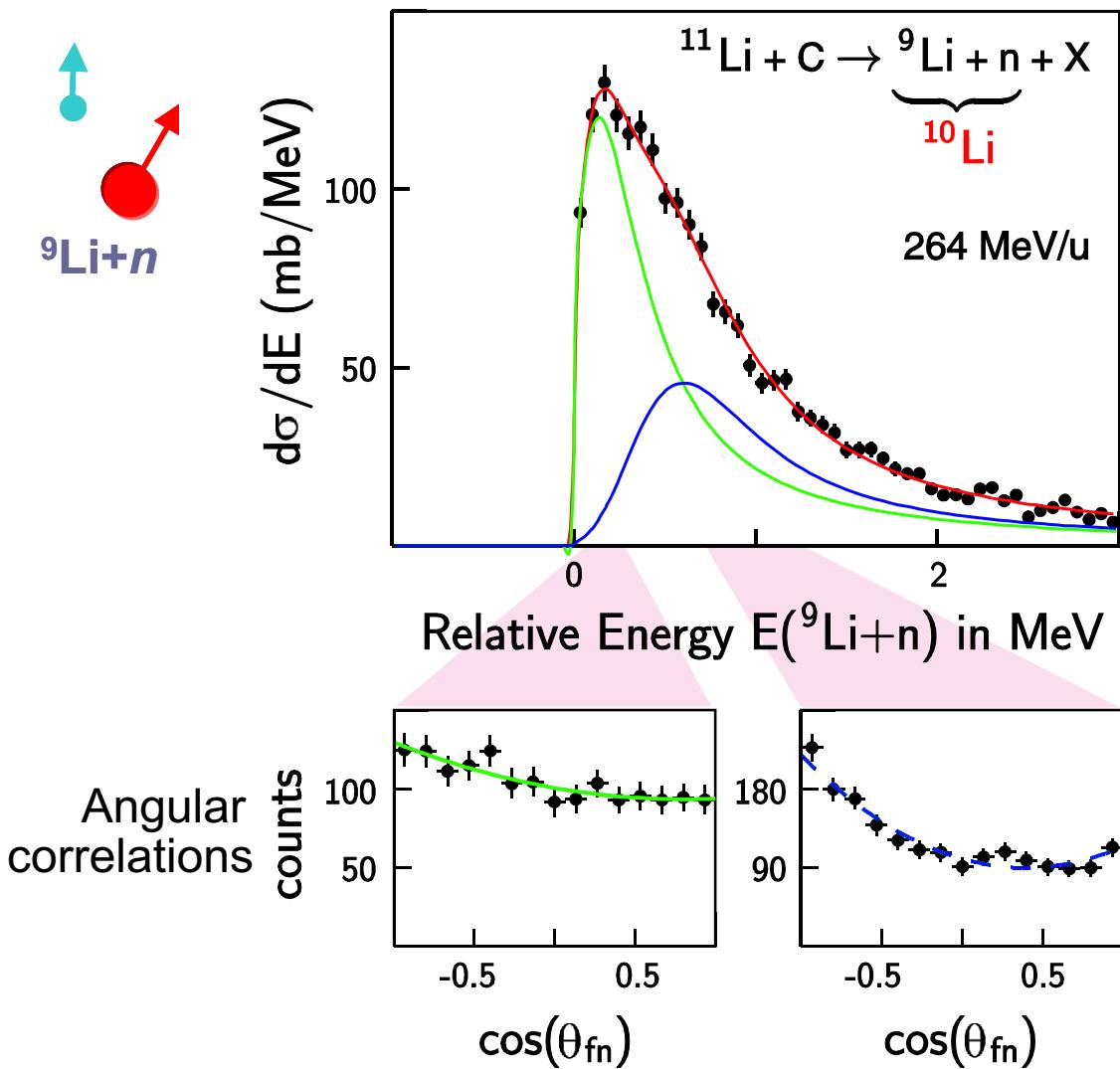
The Halo of ^{11}Li : s and p Waves



Momentum distribution ^{10}Li



Data: LAND-FRS@GSI, H. Simon et al.,
Phys. Rev. Lett. 83 (99) 496

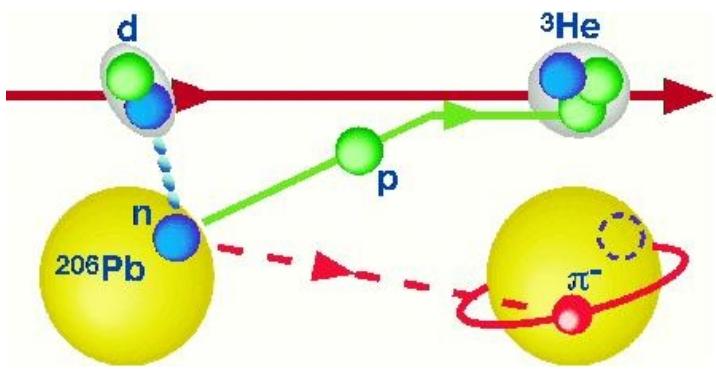


Strong s -wave admixture

$$(s_{1/2})^2 / (p_{1/2})^2 \sim 1$$

Investigation of Pionic Atoms

Reaction:



Real pion is located inside nuclear matter.
In-medium properties of pion can be measured.

$$U_{\text{opt}}(r) = \dots + V_s(r) \quad [\text{Local (s-wave) part}]$$

$$V_s(r) \propto b_0 \rho(r) + b_1 \Delta \rho(r) + \varepsilon_2 B_0 \rho^2(r)$$

Isoscalar Isovector

Pionic ^{123}Sn , ^{119}Sn , ^{115}Sn

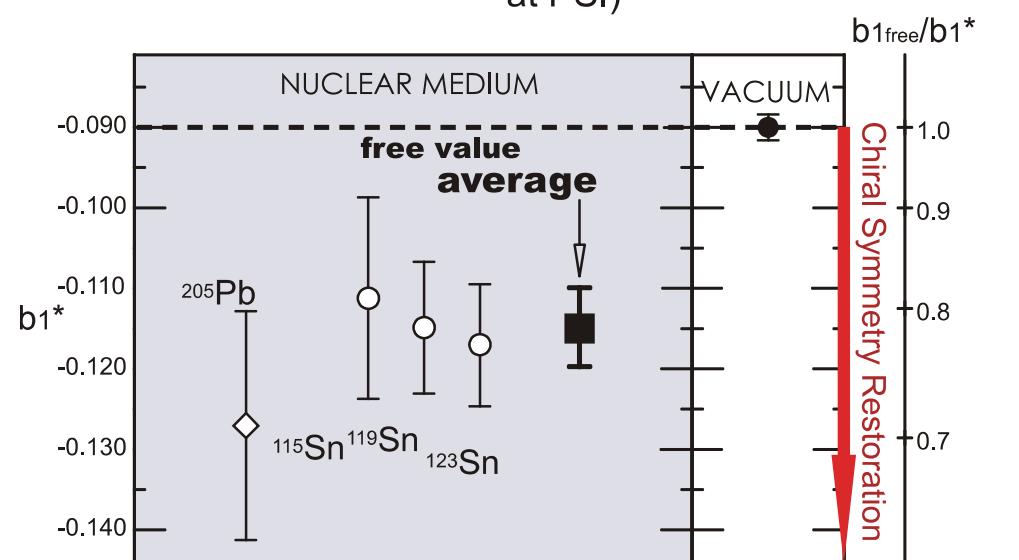
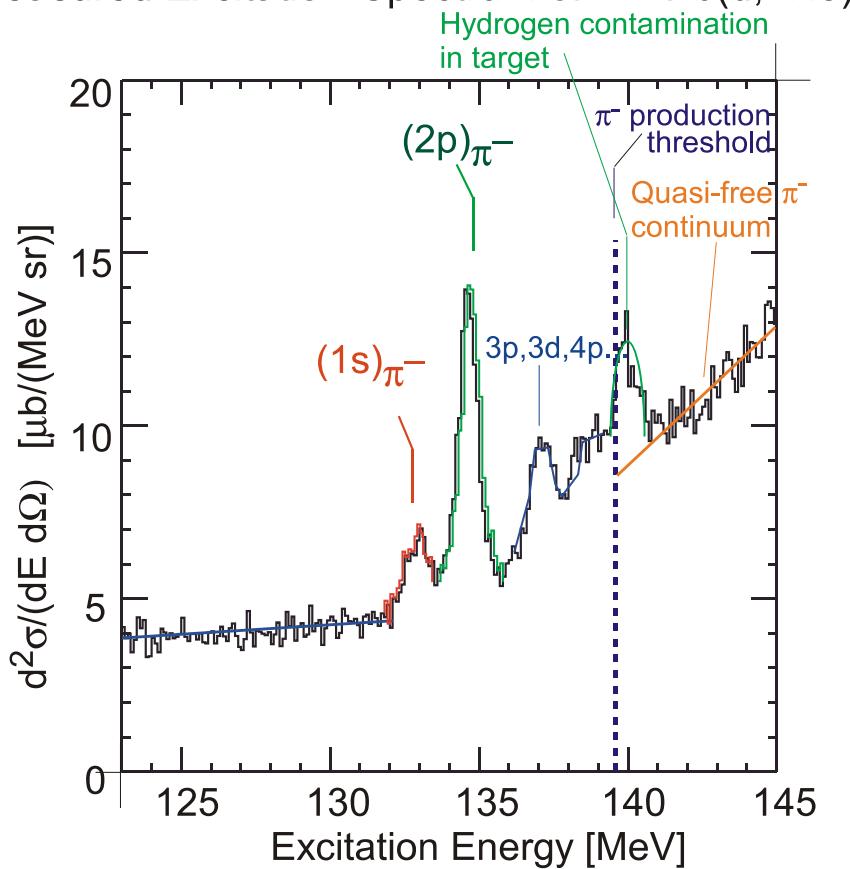


Unknown isovector part interaction.

in-medium b_0 , b_1 values

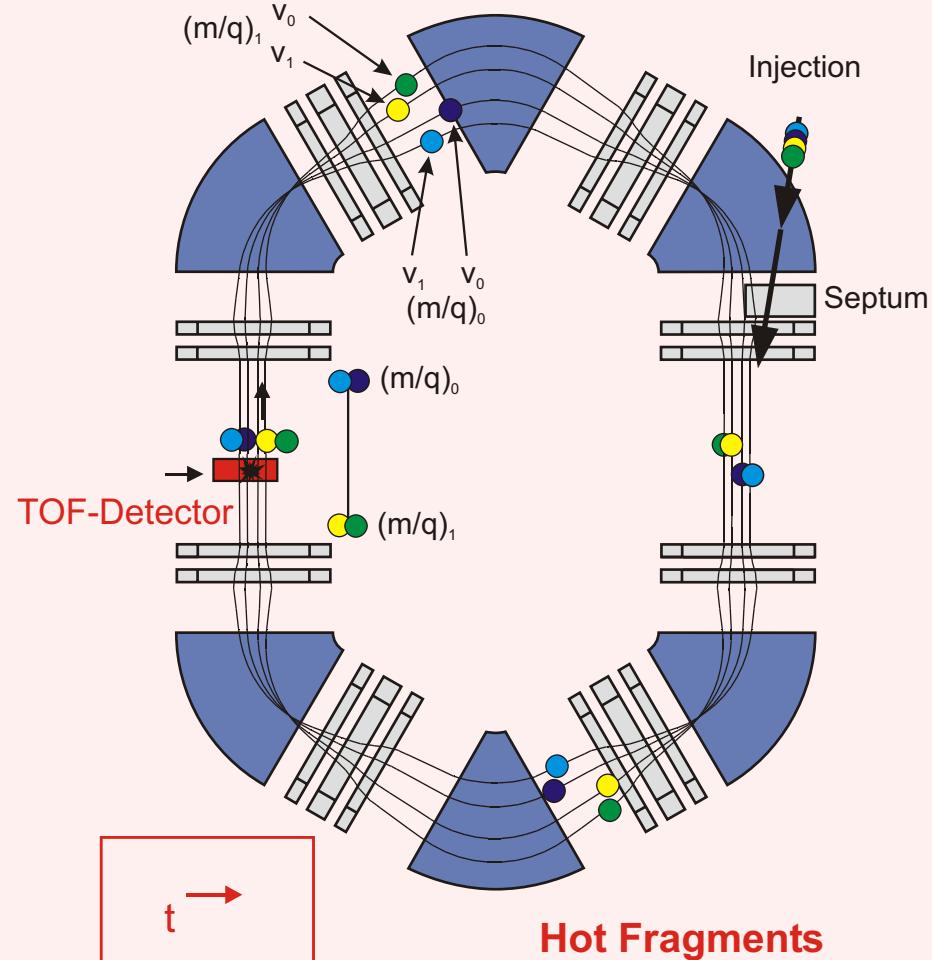
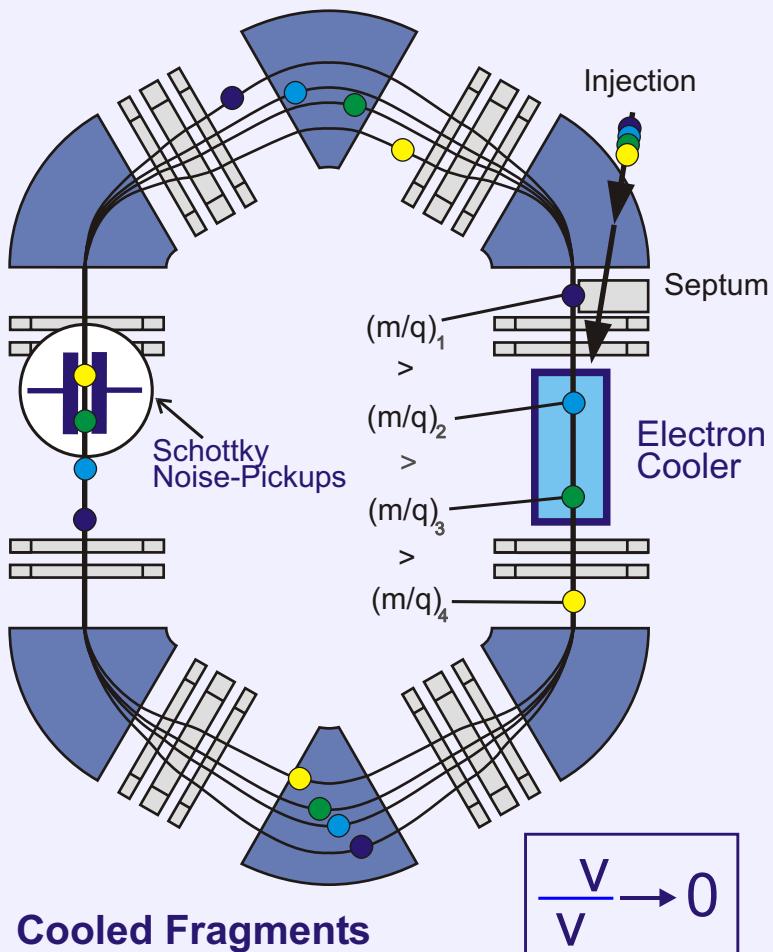


free b_0 , b_1 values (Pionic H precise measurement at PSI)



SCHOTTKY MASS SPECTROMETRY

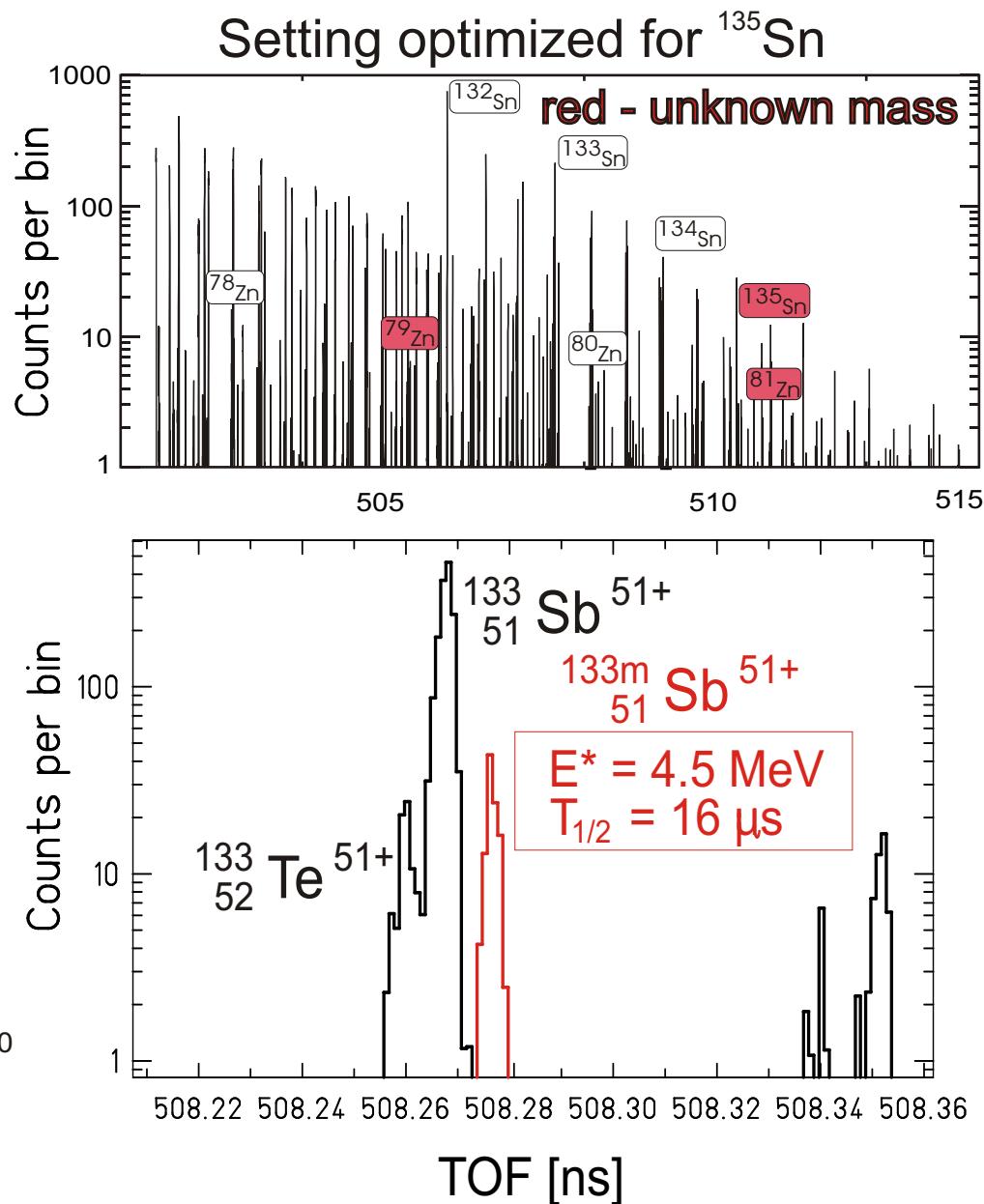
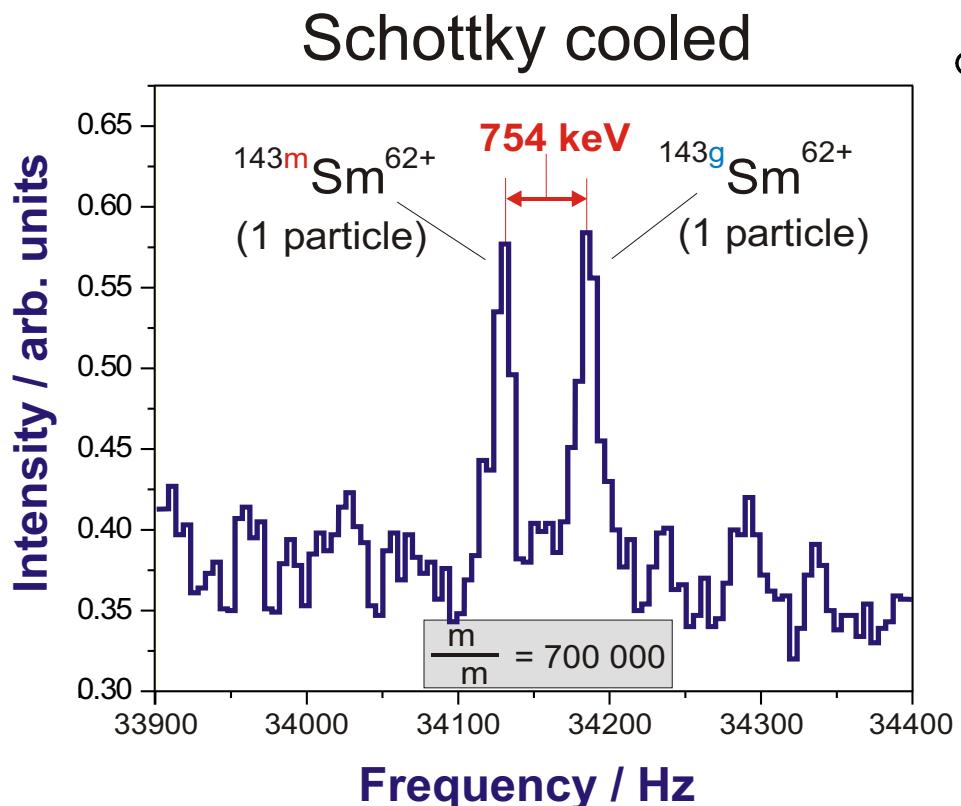
ISOCHRONOUS MASS SPECTROMETRY



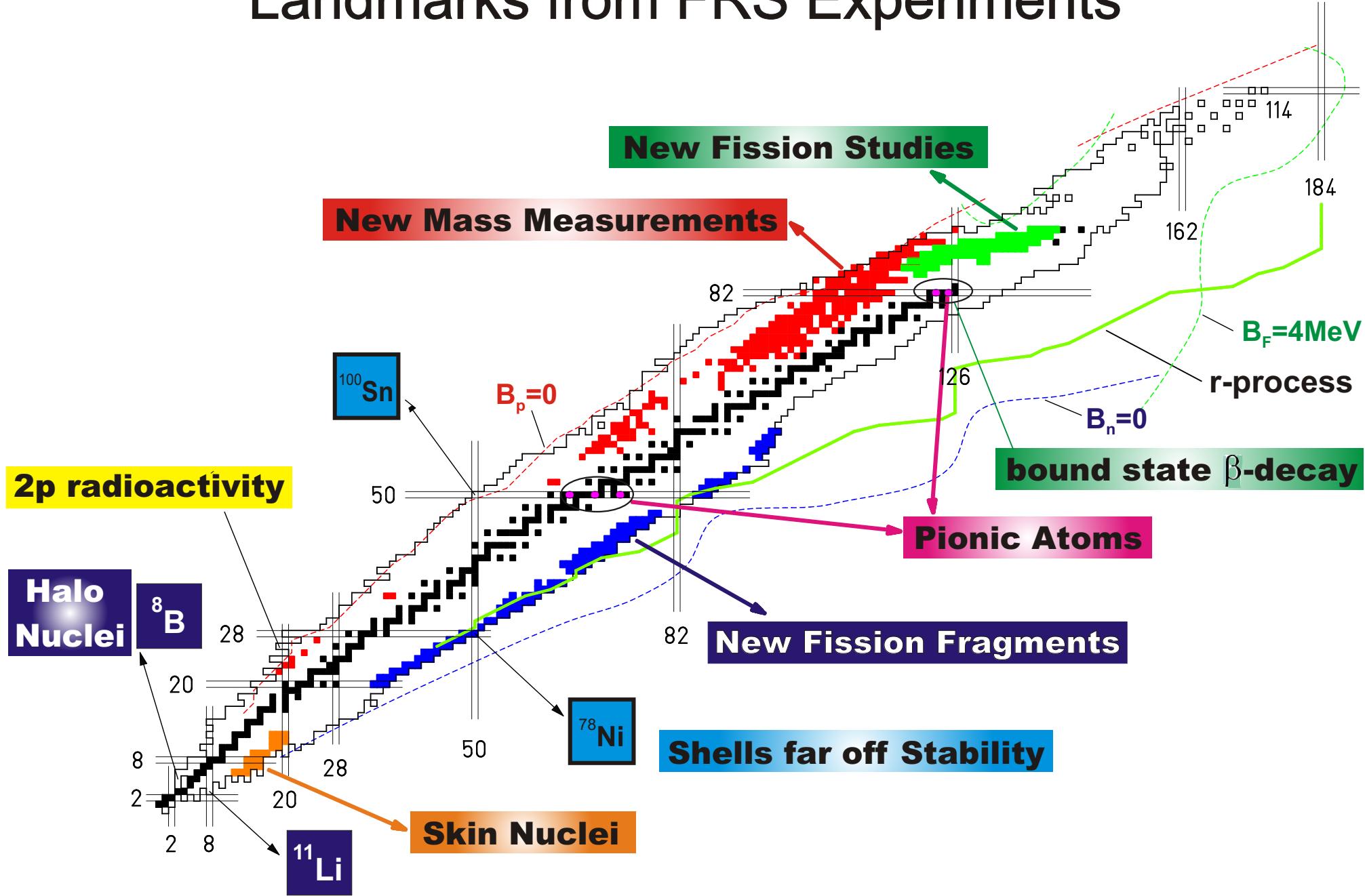
$$\frac{f}{f} = -\frac{1}{t^2} \frac{(m/q)}{m/q} + \frac{V}{V} \left(1 - \frac{2}{t}\right)$$

Measured Mass Spectra

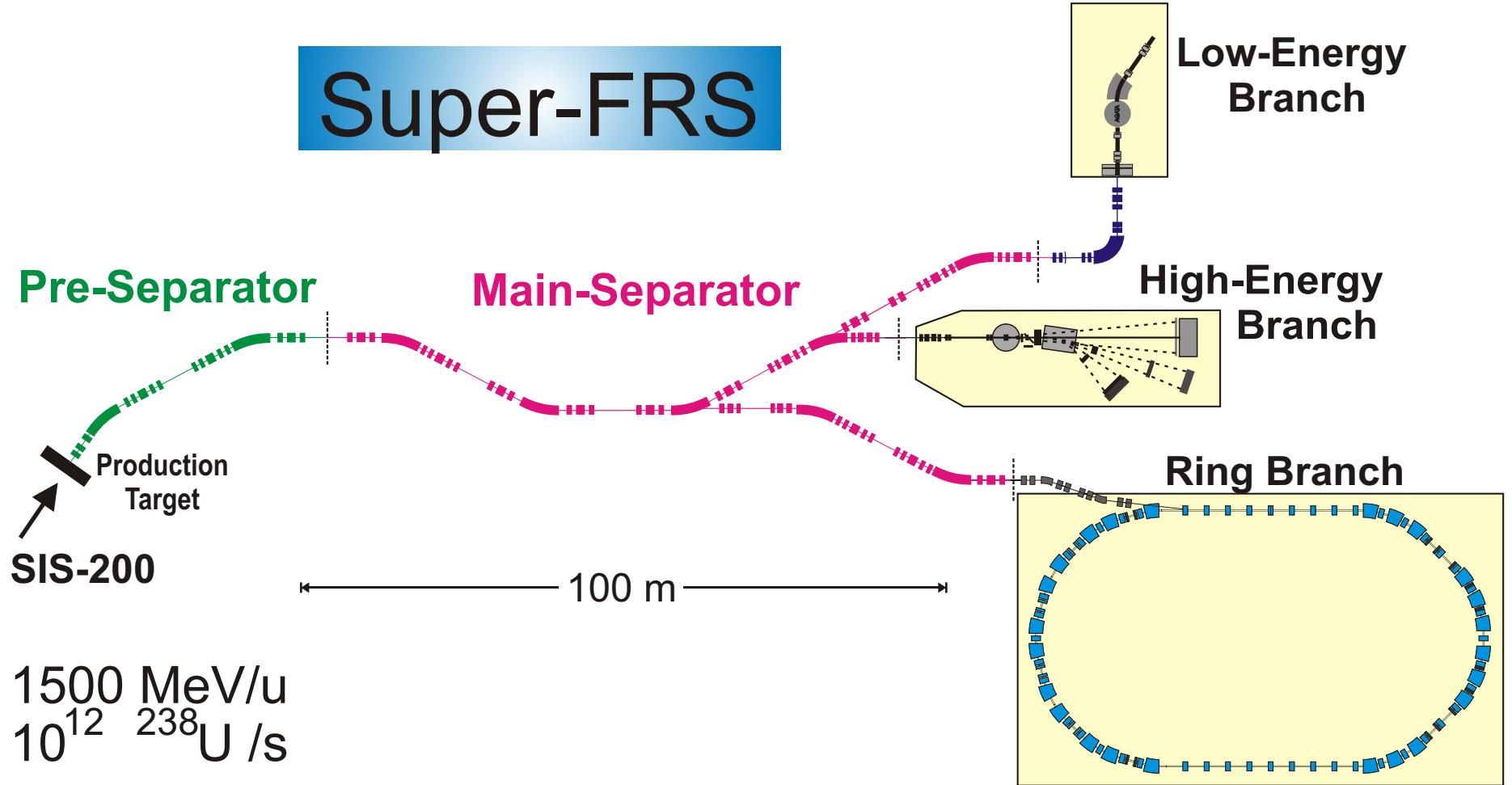
TOF isochron



Landmarks from FRS Experiments

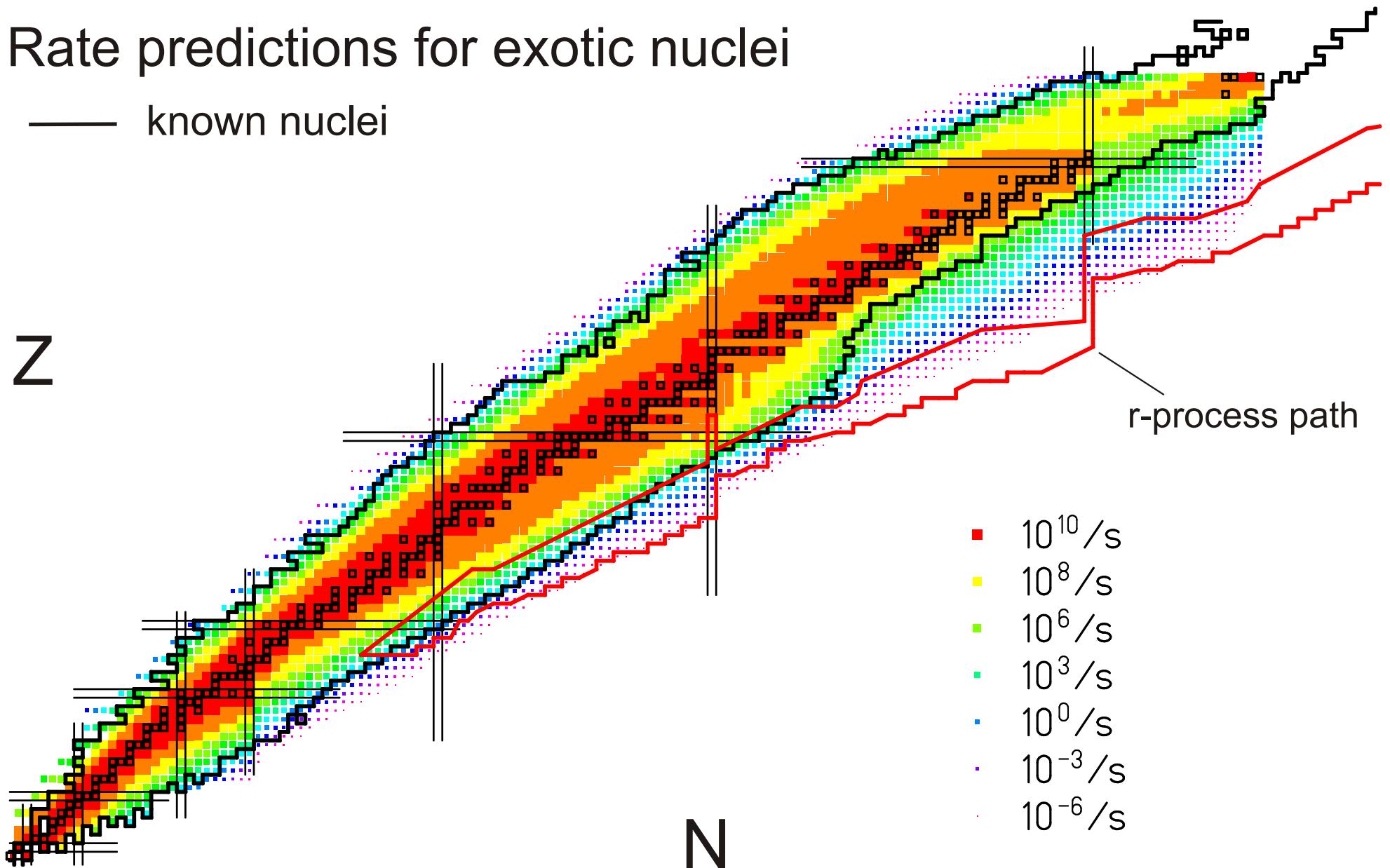


Super-FRS



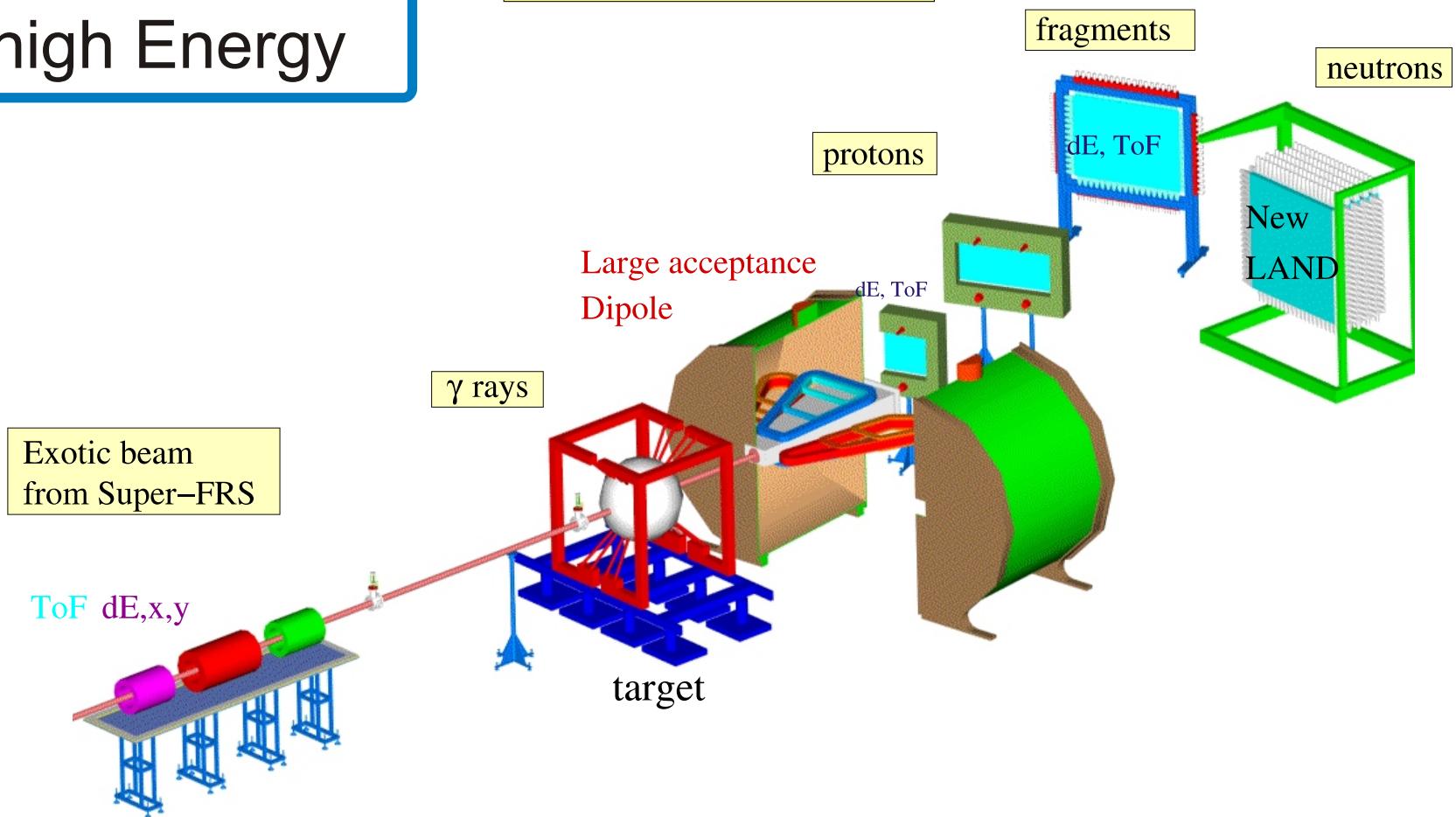
Rate predictions for exotic nuclei

— known nuclei



Reaction Studies at high Energy

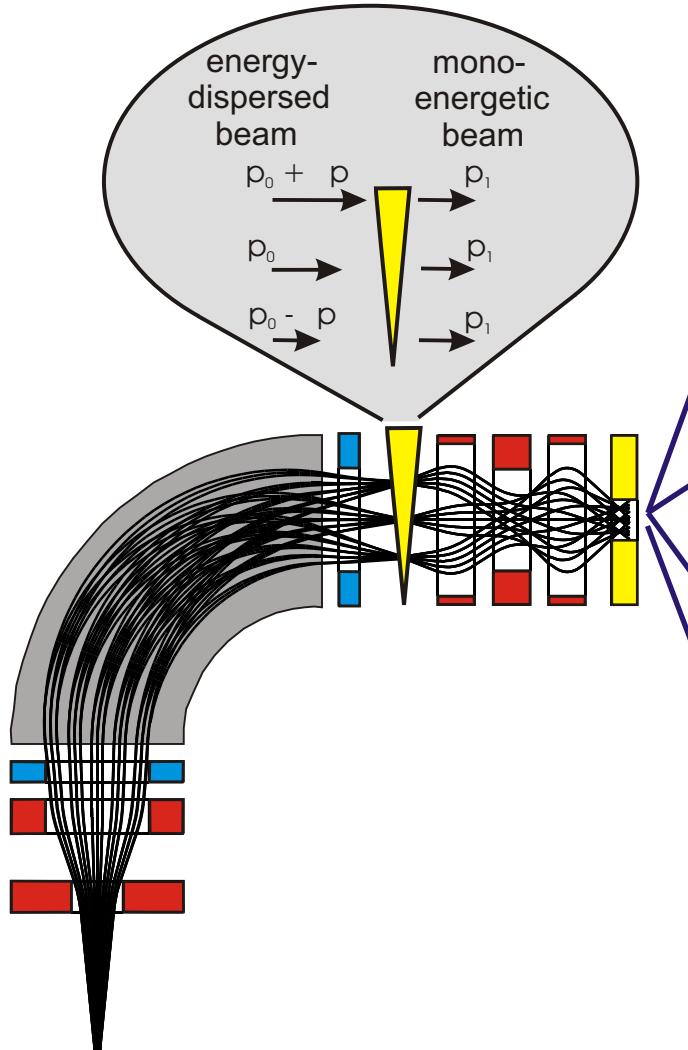
Experimental Setup



Knockout, Electromagnetic Excitation, Fission, Fragmentation,
Quasifree Scattering, Spallation

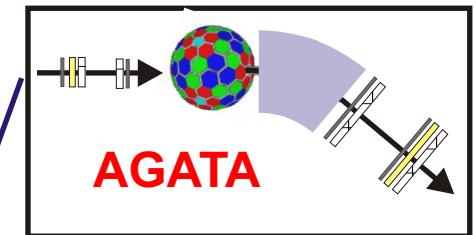
Single particle structure, nucleon-nucleon (cluster) correlations, excitations,
soft modes, matter distribution

Low Energy Experiments

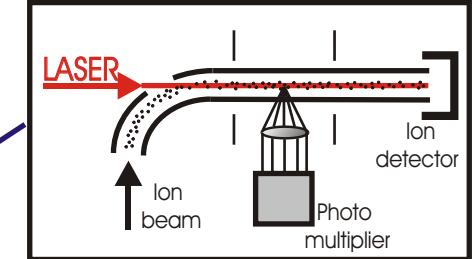


Range bunching with a
monoenergetic degrader

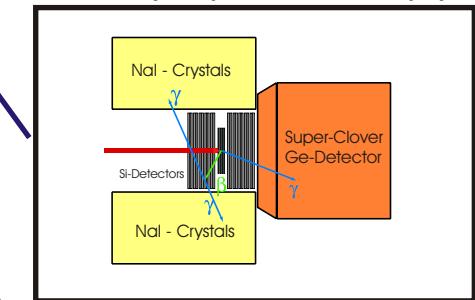
γ -ray spectroscopy



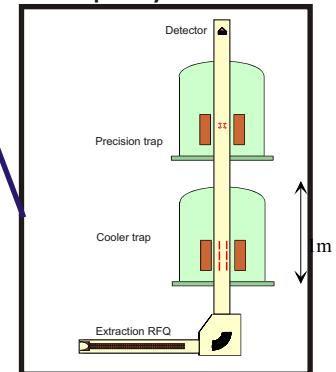
LASER spectroscopy



Decay spectroscopy



Trap system

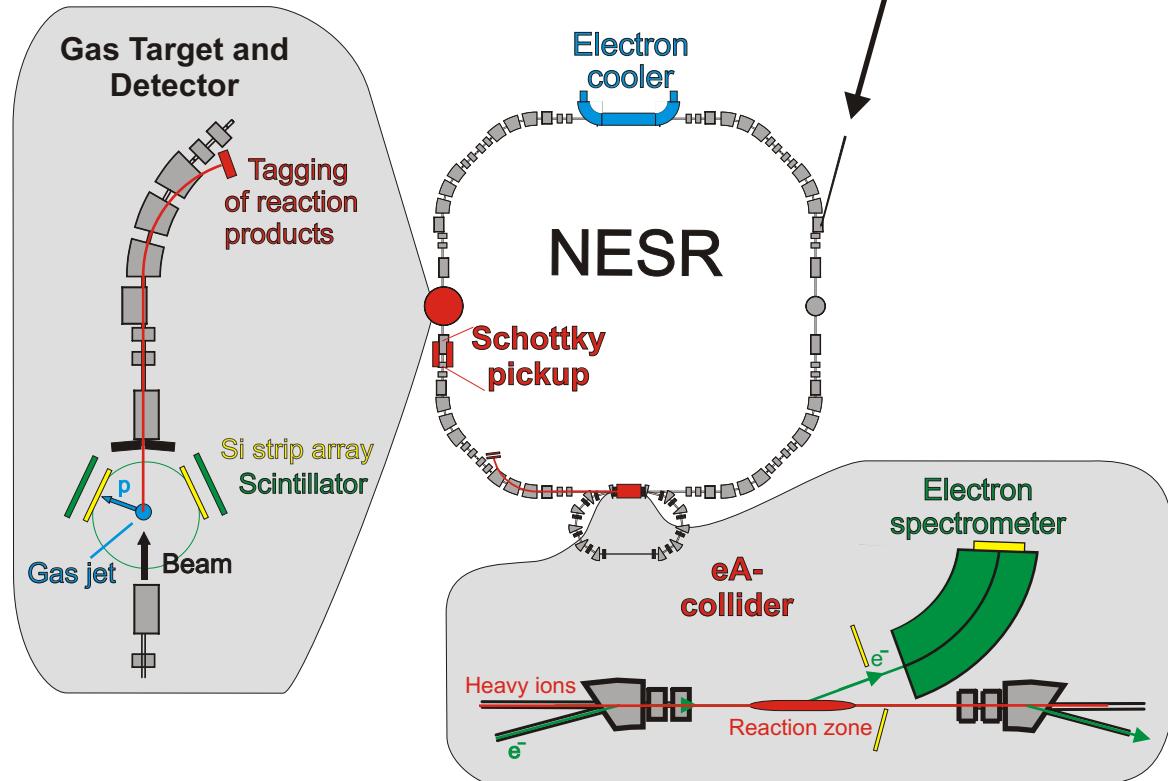
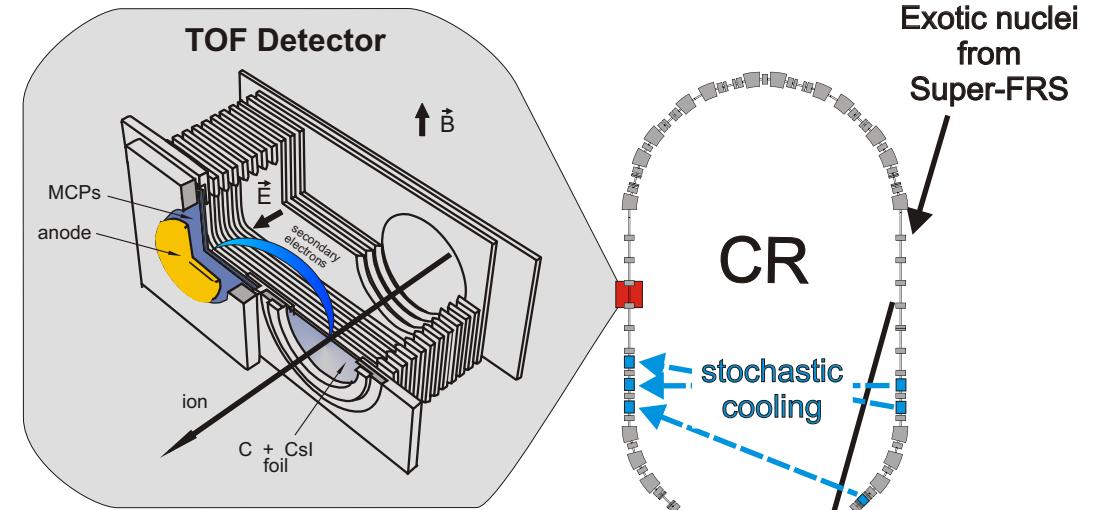


Experiments in the storage rings

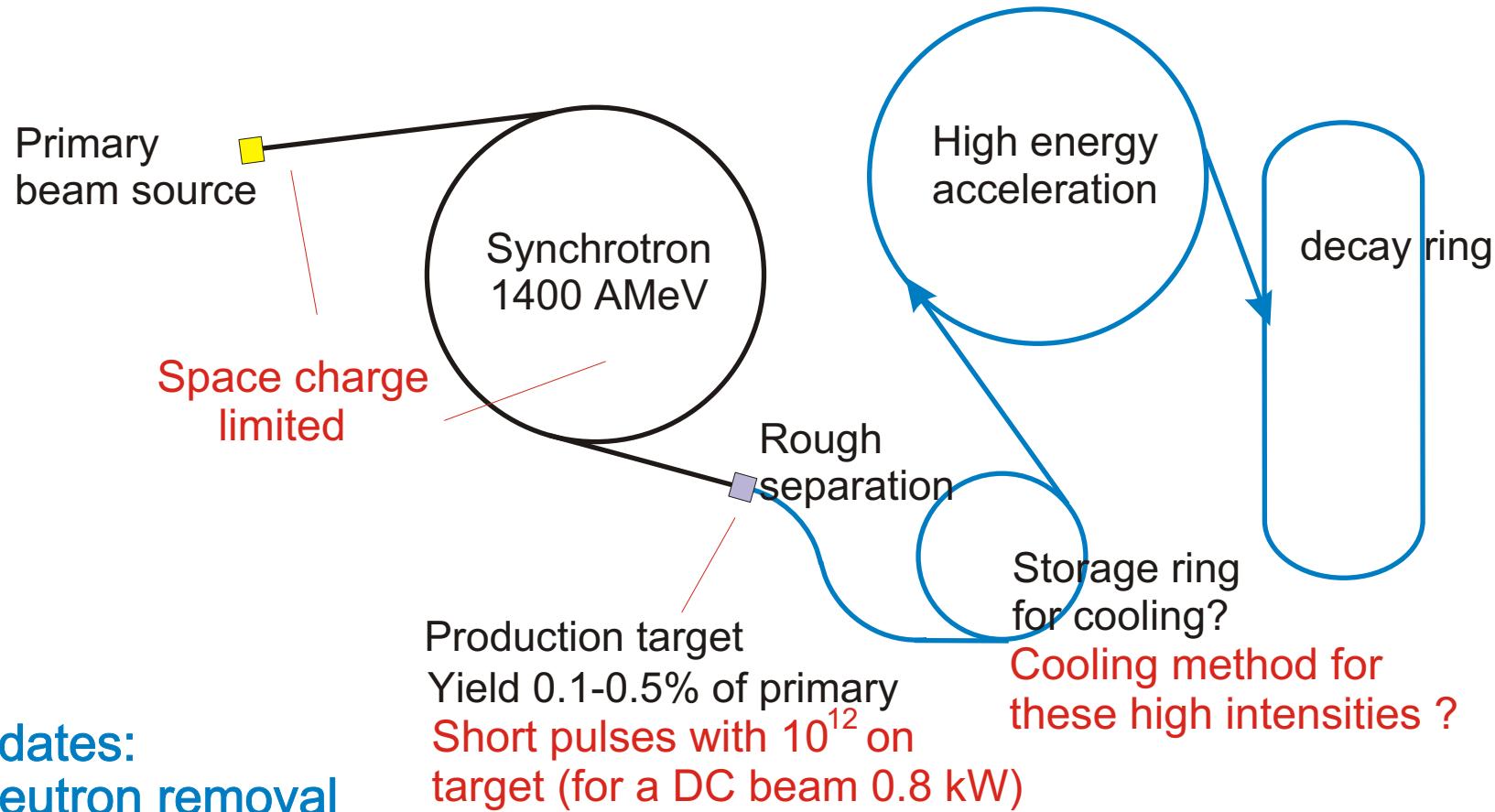
Mass and Lifetime measurements

Scattering in inverse kinematics (H, He on RIB)

Electron Scattering on RIBs



Neutrino beam from a RIB produced in-flight ?



Candidates:
one neutron removal

^{35}Ar (1.78 s)
 ^{34}Cl (1.53 s)
 ^{31}S (2.6 s)

high cross section, small phase space, no cooling necessary

At present (cf. CDR GSI future project)
 10^{12} primary ions/s are foreseen
-> 10^9 neutrinos emitted /s.

HESR B = 50 Tm, =6.3
SIS B = 300 Tm, =48