Heavy Elements from Transfer → Present Status

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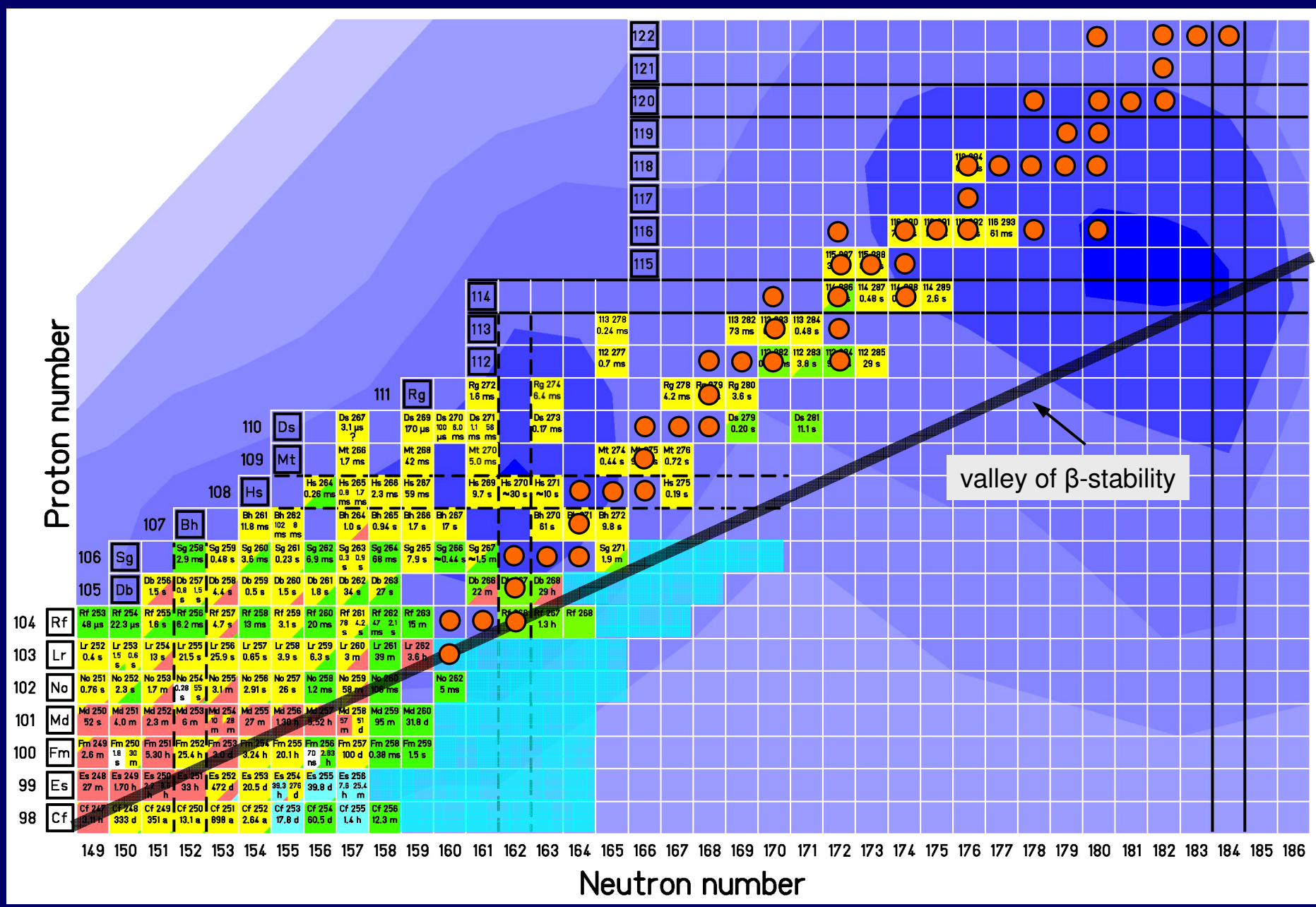
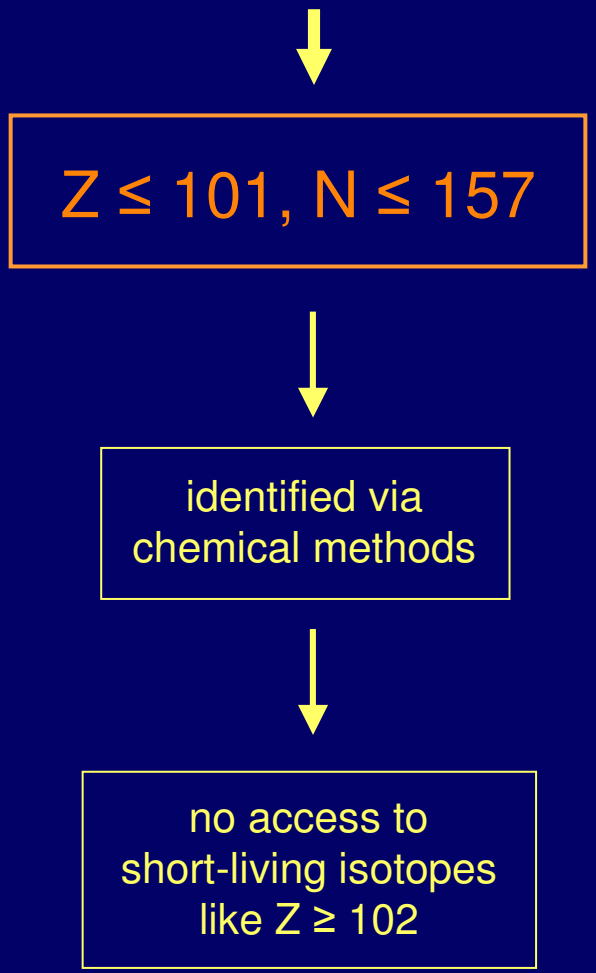
SHIP


by transfer
fusion (reachable compound nuclei with ^{248}Cm targets)
Proton number
Neutron number
valley of β-stability
Rf
Lr
No
Md
Fm
Es
Cf
Db
Sg
Bh
Hs
Mt
Ds
Rg
149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186
98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122

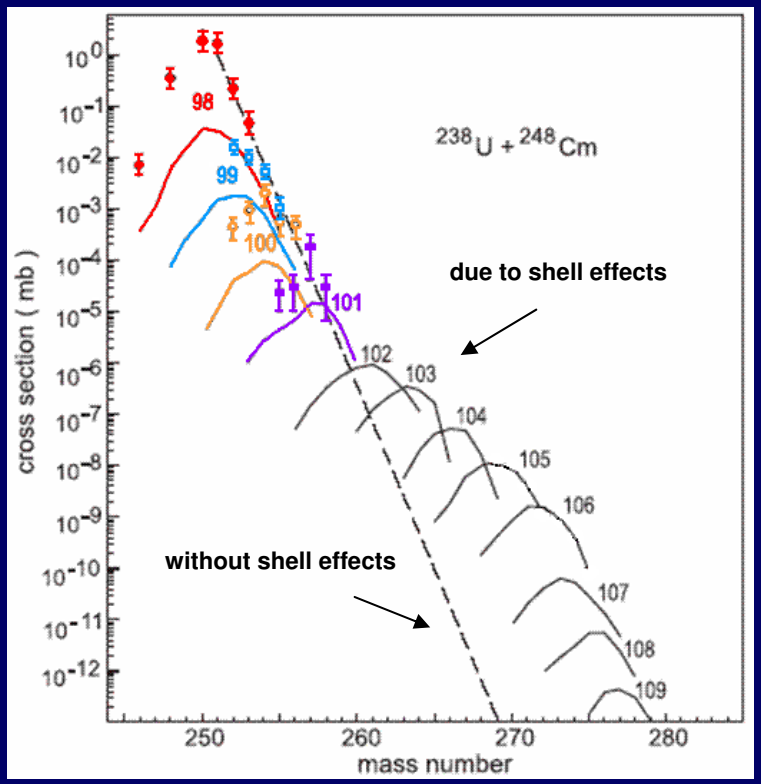
Status

Heaviest isotopes reached so far by transfer



M. Schädel, A. Türler, ...
Ca + U, U + Cm, ...

Z ≥ 102 → so far only theoretical predictions

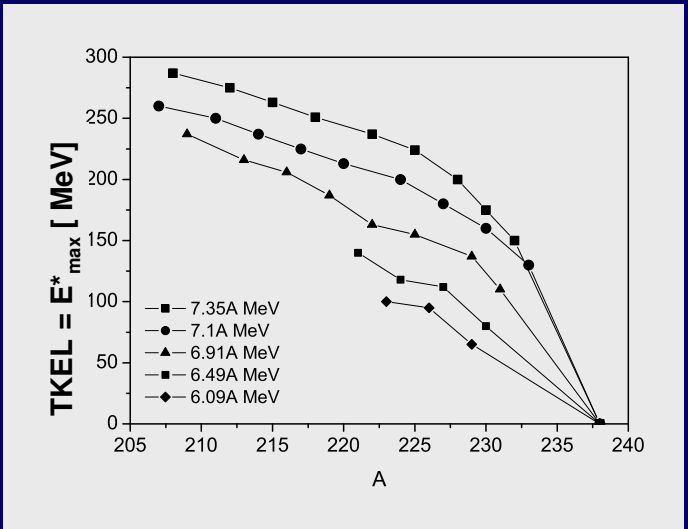


	U + Cm shell effects	U+Cm no shell effects	Ca + Cm
total cross section	≤ 1 nb	≤ 50 pb	≤ 50 pb
Z = 102 N = 159	50 / d	2 / d	20 / d
Z = 104 N = 161	2 / d	1 / 400 d	20 / d
Z = 106 N = 164	1 / 20 d	1 / 5000 y	20 / d

→ single event identification is necessary

calculations: U + Cm: V. Zagrebaev and W. Greiner, Phys. Rev. C 78, 034610 (2008)
Ca + Cm: G.G. Adamian et al., PR C 71034603 (2005)
experiment: M. Schädel et al., Phys. Rev. Lett. 48, 852 (1982)

Recent Experimental Results



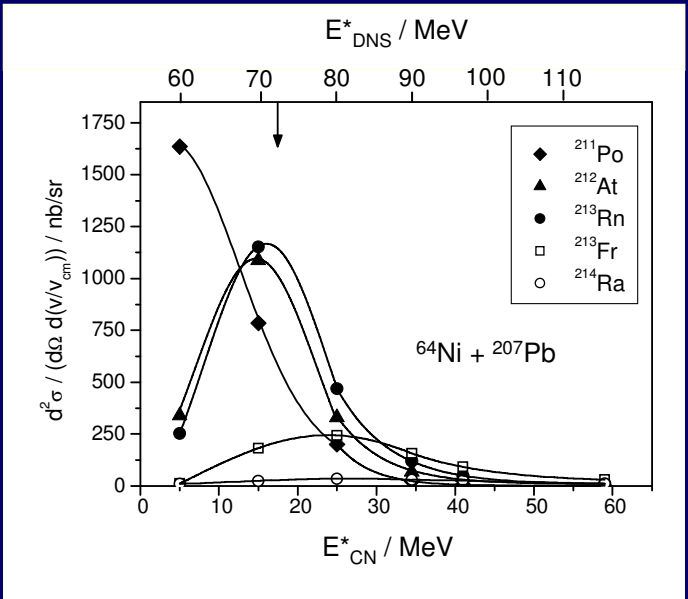
$^{238}U + ^{238}U$

April 2006 (VAMOS spectrometer, GANIL)

→ no hint for shell effects

→ massive transfer at sub- and near barrier energies

→ further experiments planned



$^{64}Ni + ^{207}Pb$

November 2008 (SHIP)

→ massive transfer at sub- and near barrier energies

Optimum Beam Energy ?

- Fusion reactions

$\sigma_{ER}(E_{cm}, J) = \sigma_{capture} \times P_{CN} \times P_{survival}$

→ largest yields of ER for energies at the barrier

$E^*_{CN} = E_{cm} + Q$

- Transfer reactions

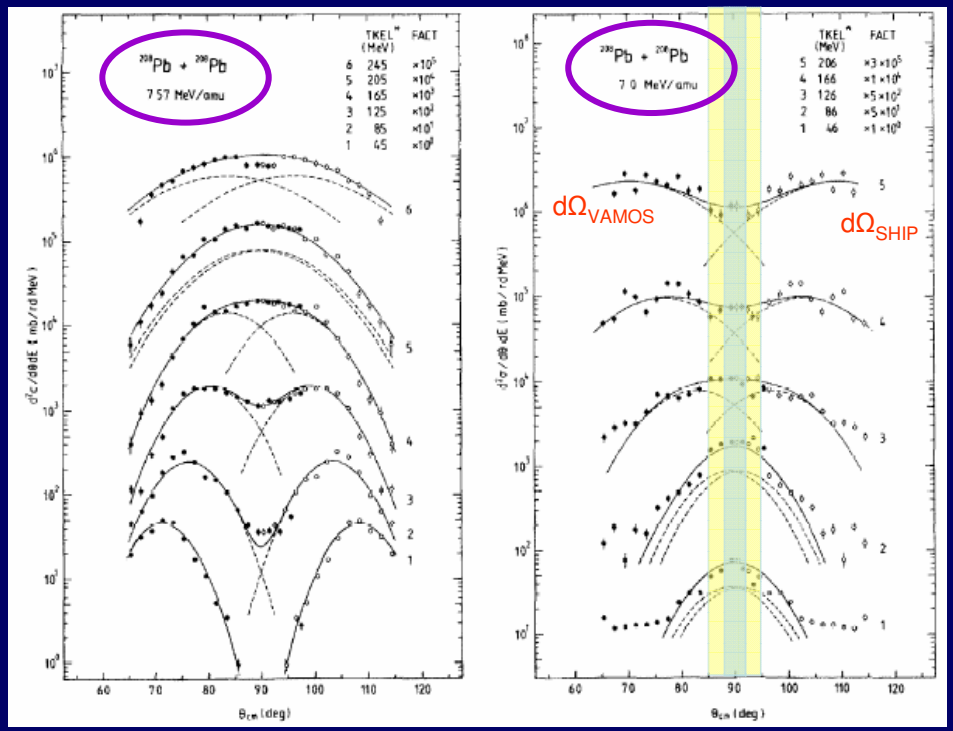
$\sigma_{TR}(E_{cm}, J) = \sigma_{capture} \times P_{transfer} \times P_{survival}$

→ largest yields of certain transfer products for energies at the barrier ?

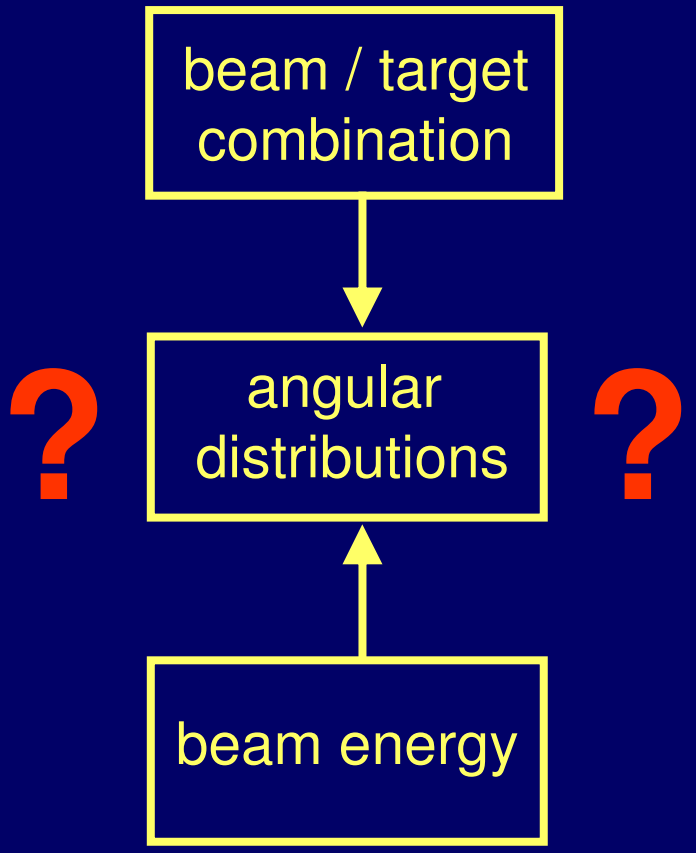
$E^*_{DNS} = E_{cm} + Q - TKE$

Angular distribution of transfer products

- deep inelastic transfer → broad angular distributions, up to isotropic
- quasielastic transfer → peaked around the grazing angle

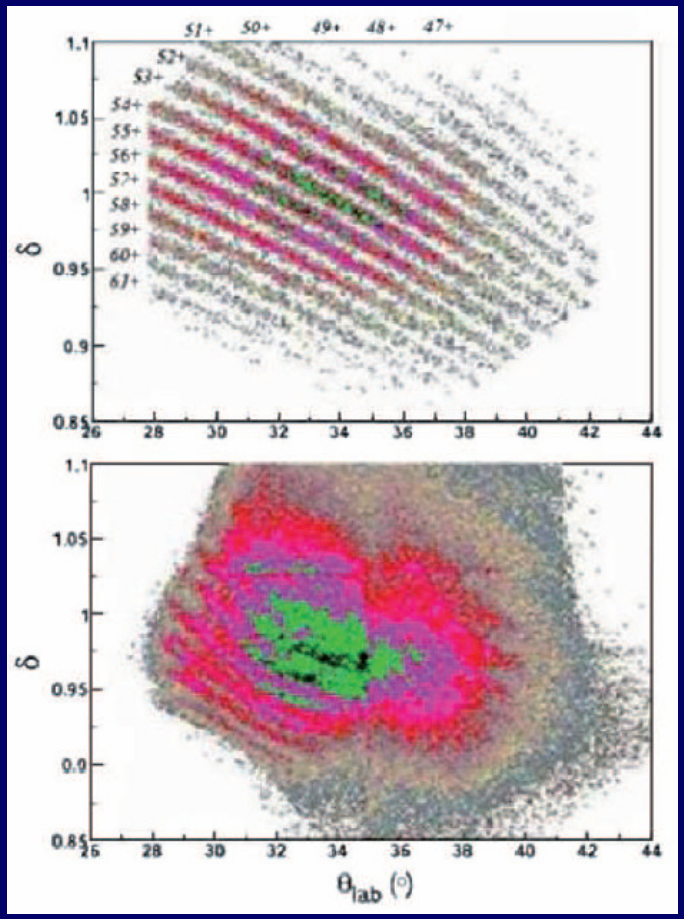


example: Pb + Pb collisions, T. Tanabe et al., Nucl. Phys. A 342 (1980) 194



Electronic charge state distributions

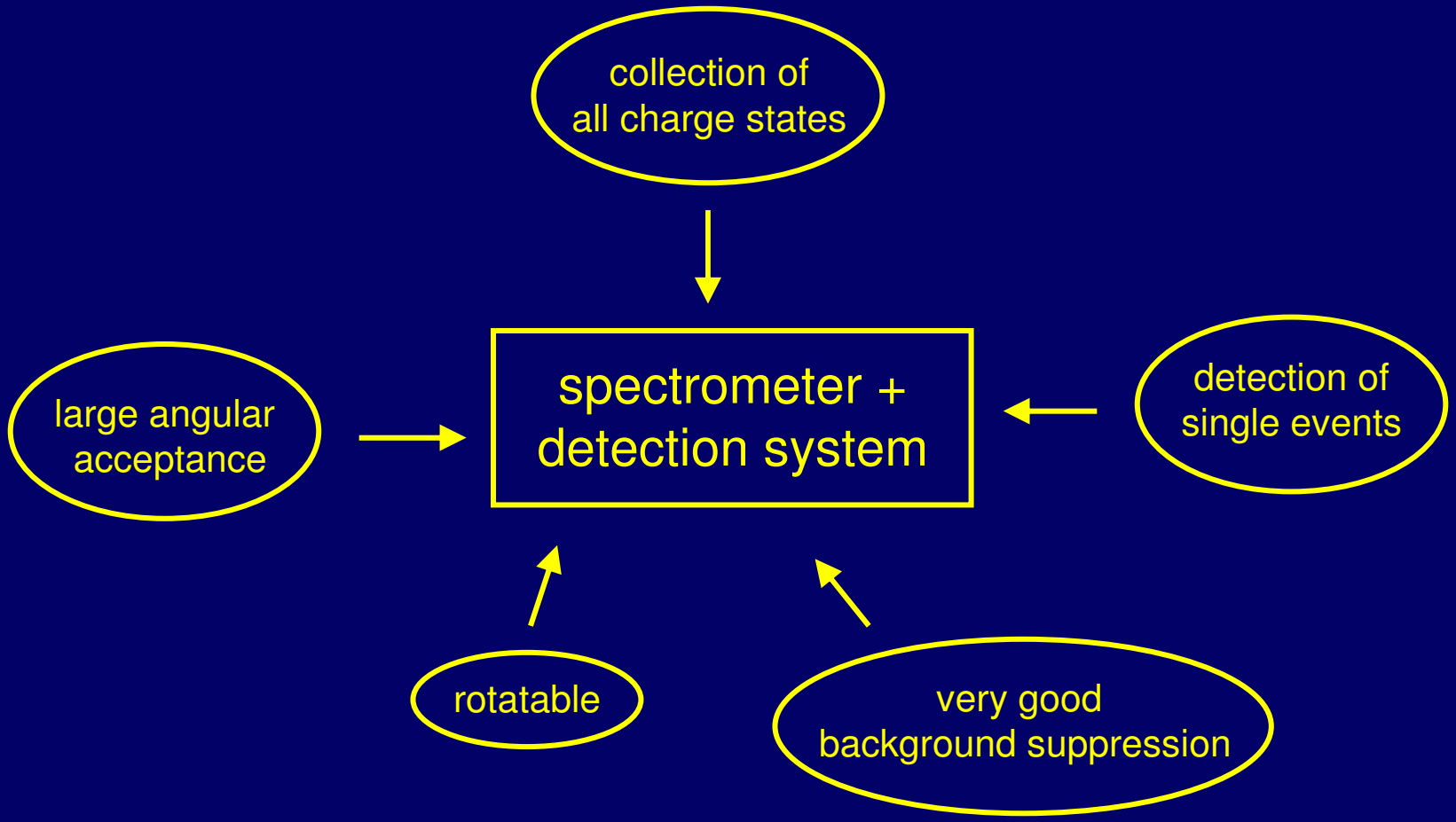
example: U + U, VAMOS spectrometer, GANIL



simulation

measurement

Requirements on the spectrometer / detection system



Choice of spectrometer ?

General case: deflection by E or B field

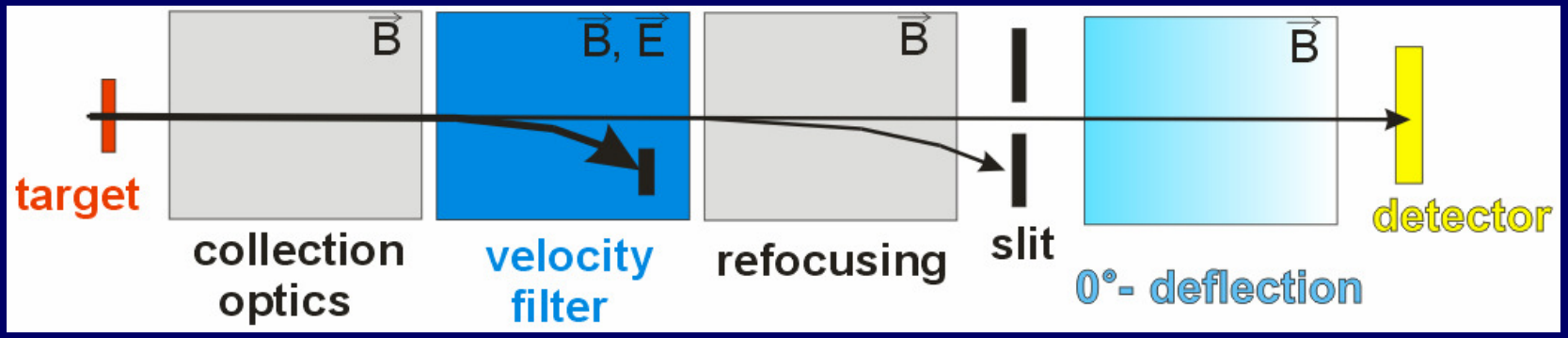
$E\rho = mv^2/q$

$B\rho = mv/q$

for every velocity a combination of E and B must be found such that $F_m = F_e$ ($F_{res} = 0$)

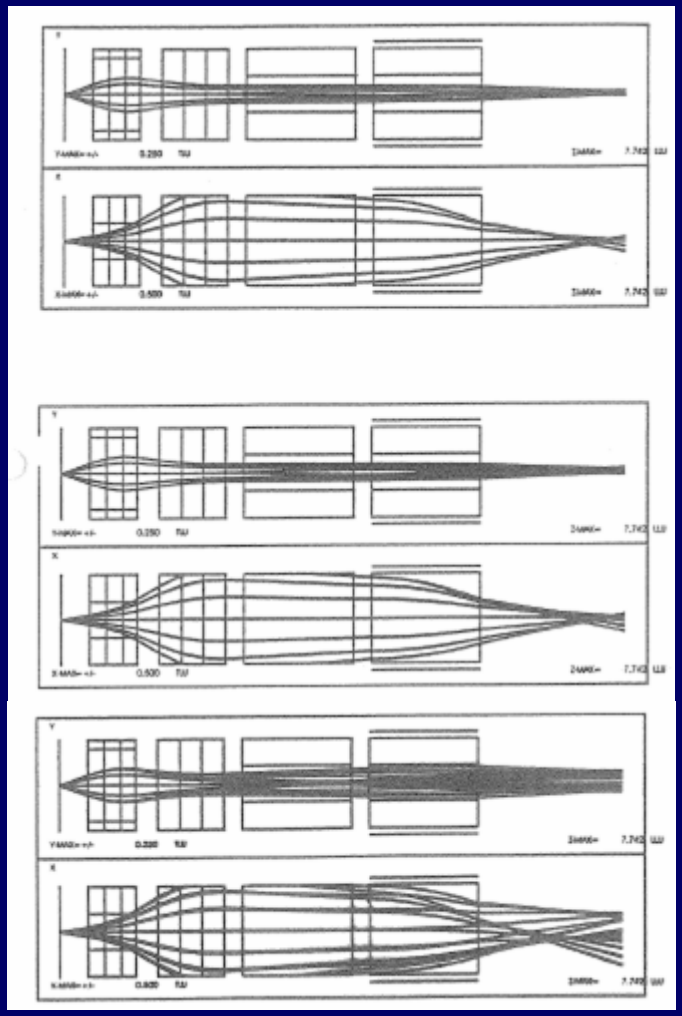
→ velocity filter → larger acceptance at SHIP

→ alternatively: gas-filled separator



large angles collected after target
with doublet similar to VAMOS
or with superconducting solenoid

chromatic aberrations (VAMOS spectrometer)



0%

1%

10%