BGS/ChemSep Workshop
at LBNL, 2003

Performance of RIKEN GARIS and Future Plan for Chemistry

(GARIS Parameters and Experimental Program)

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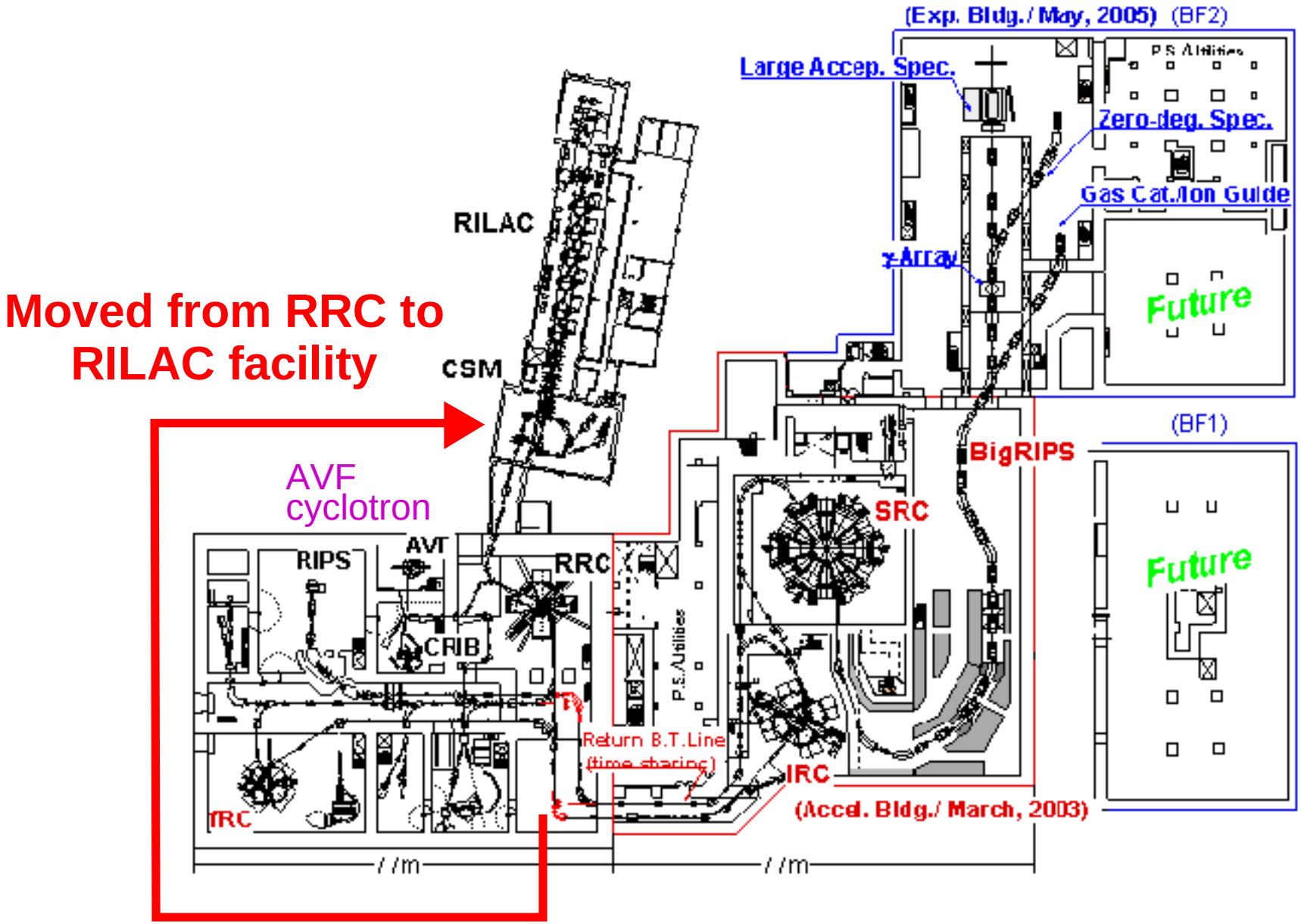
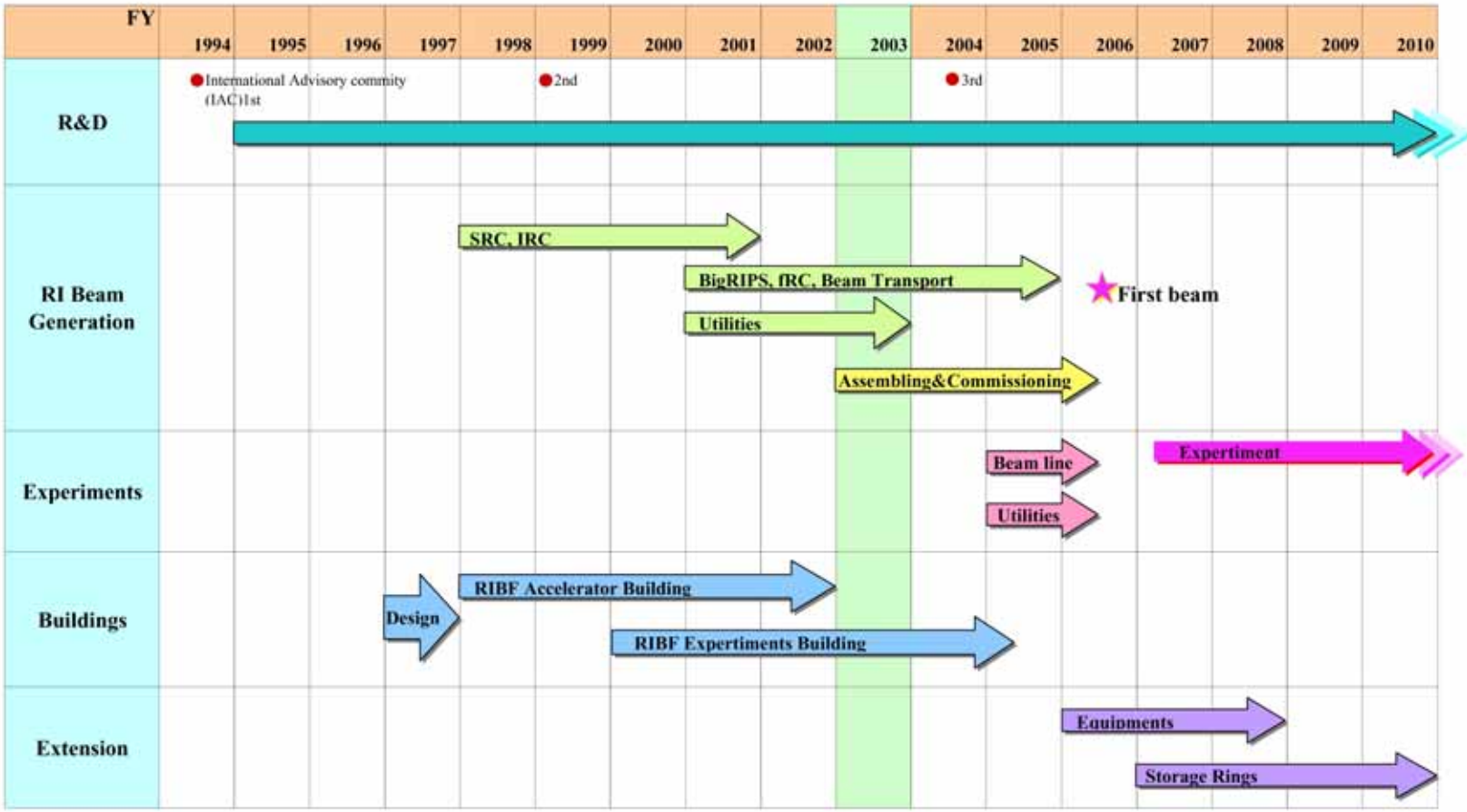
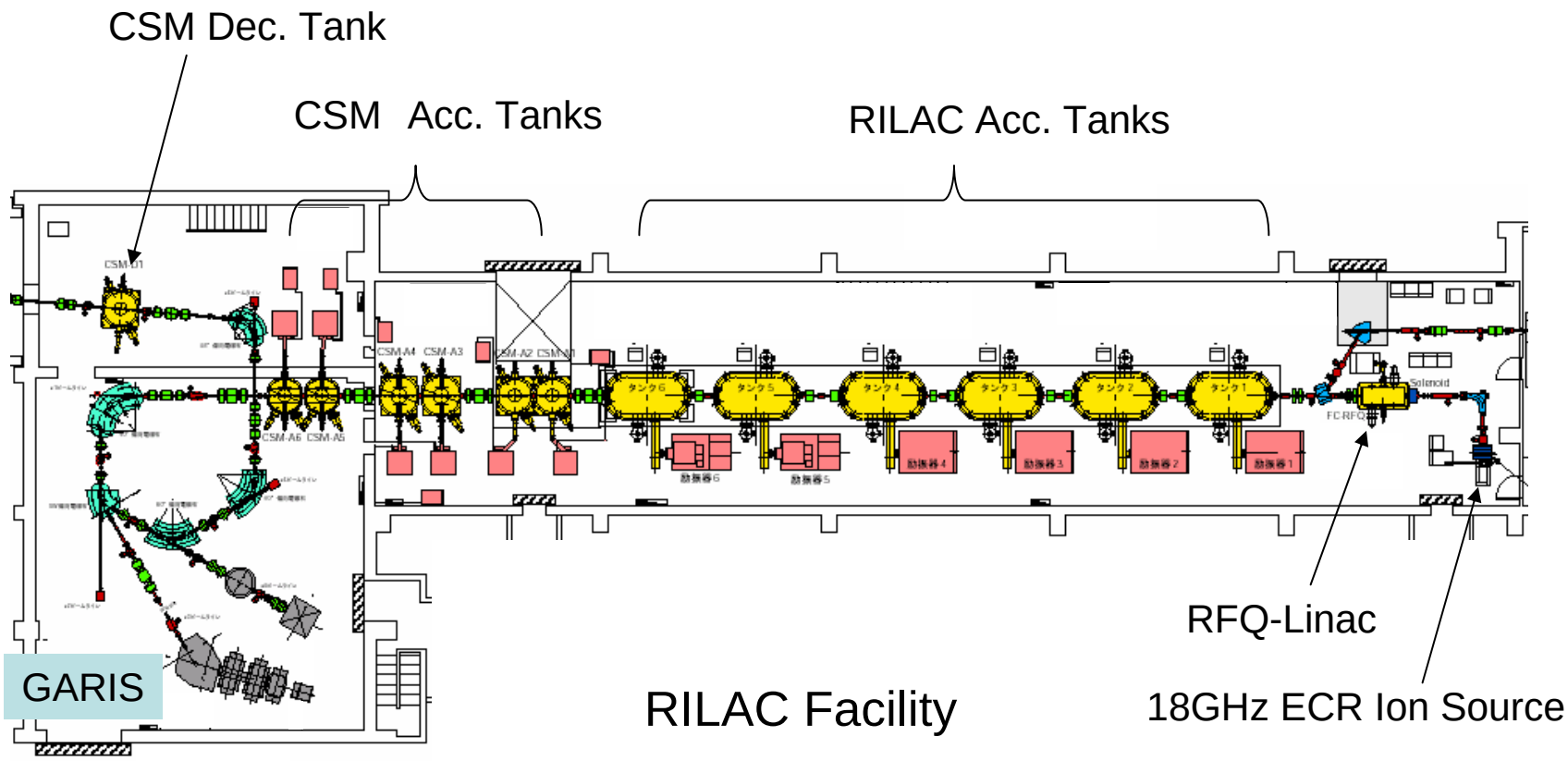
Niigata University

Layout of the RI Beam Factory (RIBF)



RIBF Schedule

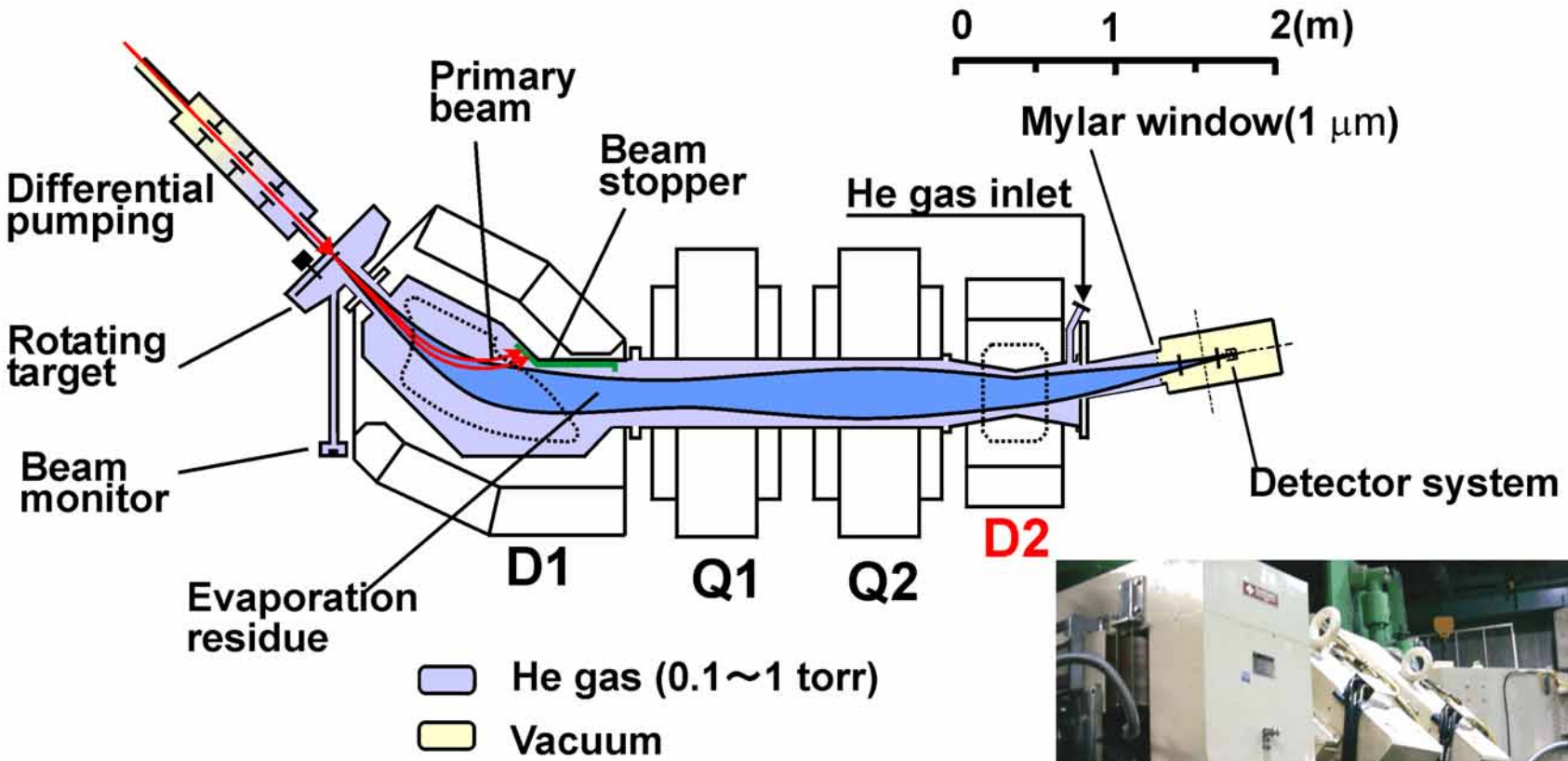




Max. Energy: 5.8 A MeV

ΔE= +/- 0.6 MeV

RIKEN GARIS(Gas-filled Recoil Ion Separator)

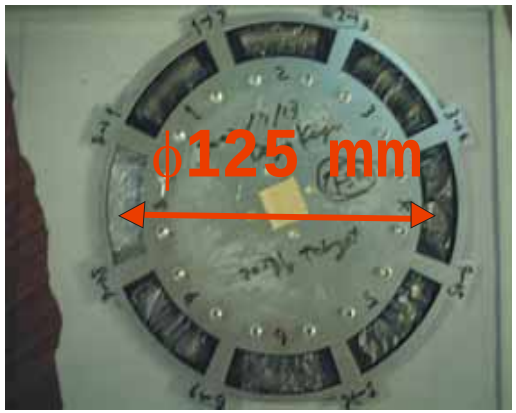


(Original) : K. Morita et al., Nucl. Instr. and Meth. B70, 220(1992)

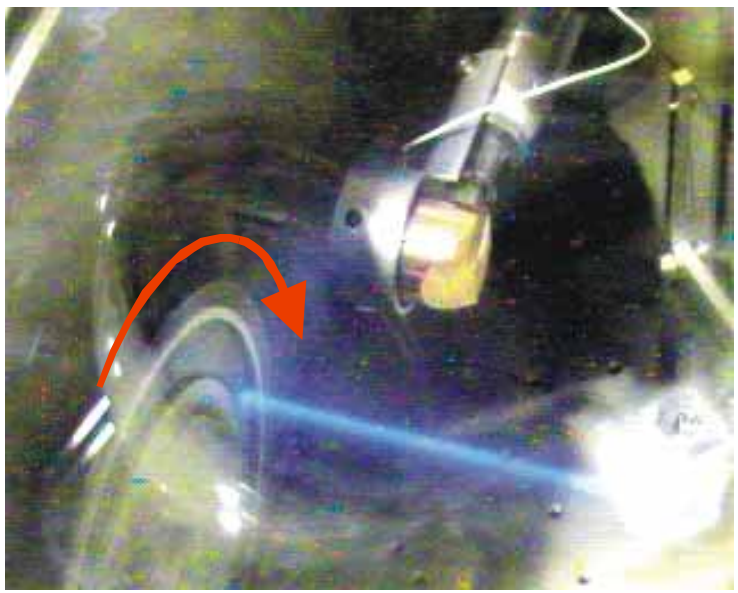
Parameters of GARIS(D1-Q1-Q2-D2)

D1	
Deflecting angle	45 deg
Maximum field	1.54 T
Q1,Q2	
Maximum field gradient	5.2 Tm
D2	
Deflecting angle	10 deg
Maximum field	0.92 T
Solid angle (measured)	12.1 msr
Effective radius (measured)	1.452 m

Rotating target



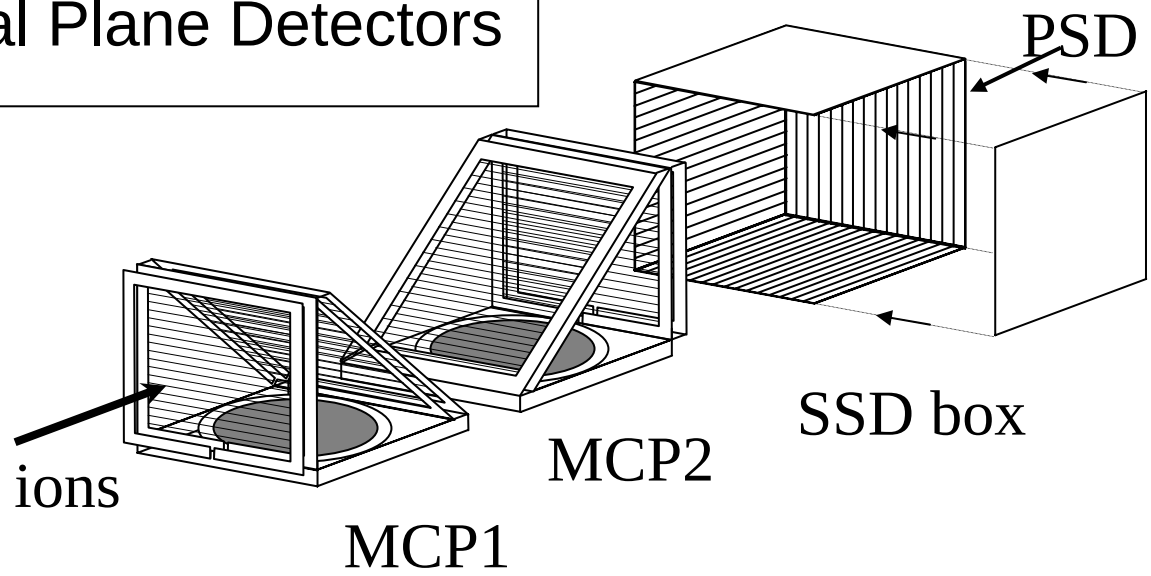
ϕ = 125 mm, ω = 1000 rpm

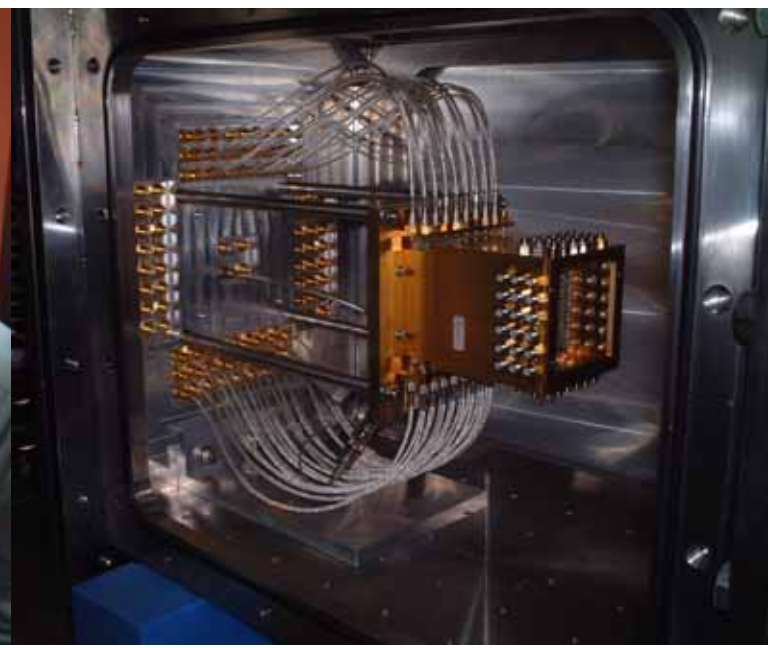


New Rotating Target

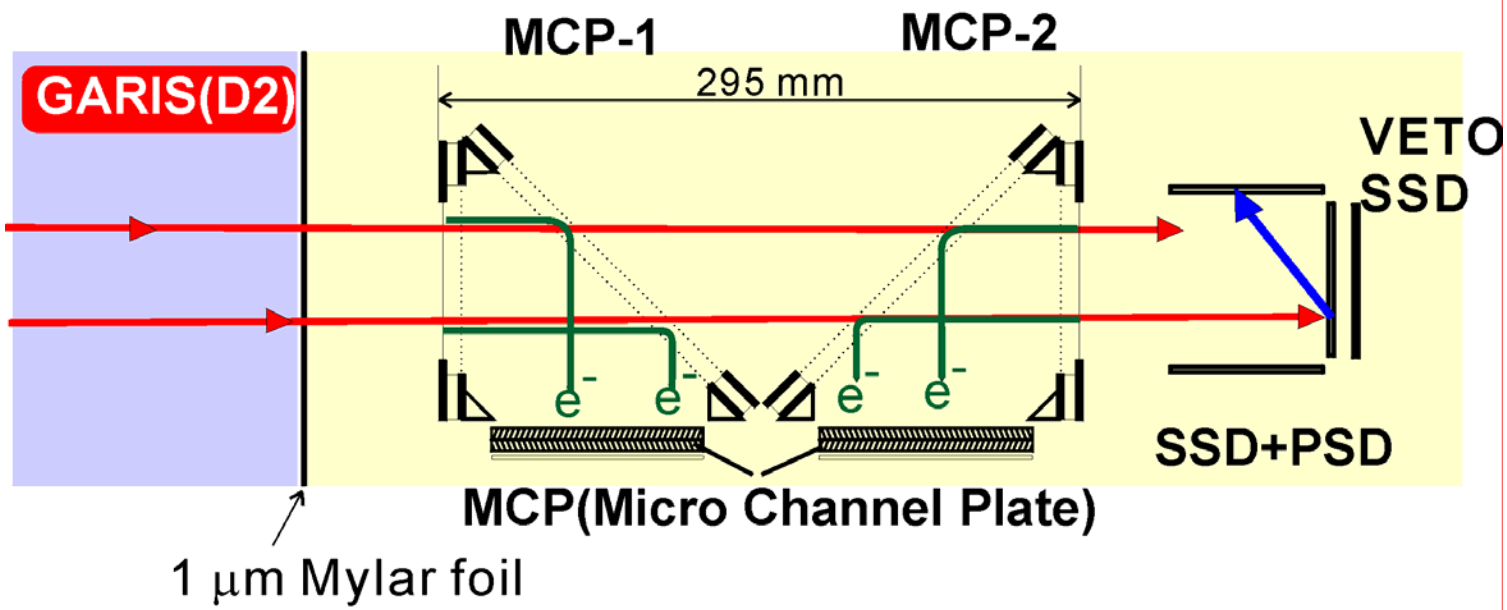
ϕ = 300 mm, ω = 2000 rpm

Focal Plane Detectors





Focal plane detectors



MCP
- Transmission: 94%
- Timing resolution: 500 ps (FWHM)

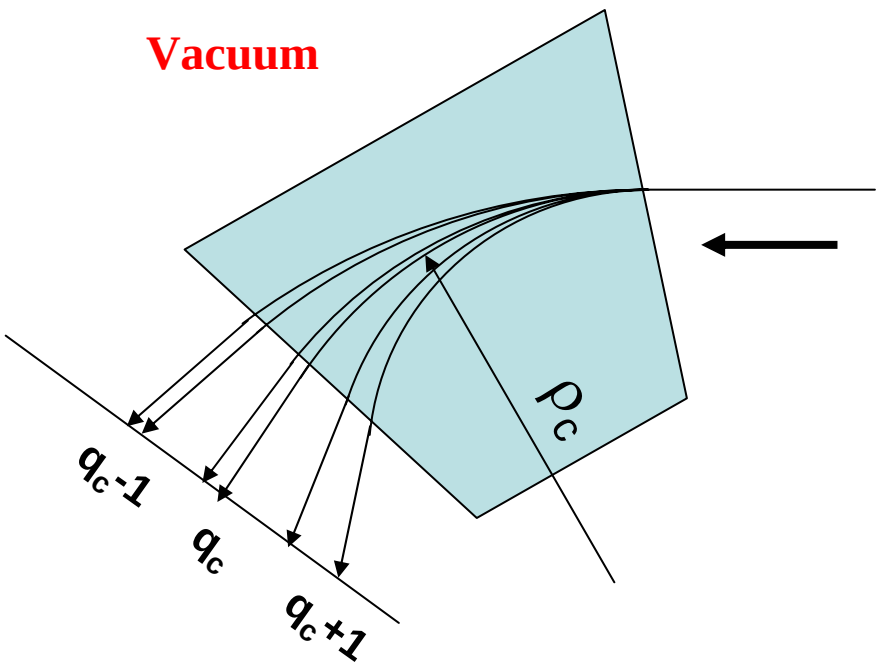
PSD
- 16-strip(3.75 mm x 60 mm) silicon detector
- Position resolution: 1 mm (FWHM)
- Energy resolution: 35 keV (FWHM)
- (For escaped events: 70 keV)

Principle of Operation for Gas Filled Recoil Separator-I

Reaction Products
With
Δv & Δq

Magnetic Field

Vacuum



$B\rho = mv/qe$

$= 0.0227A(v/v_0)/q$ [Tm]

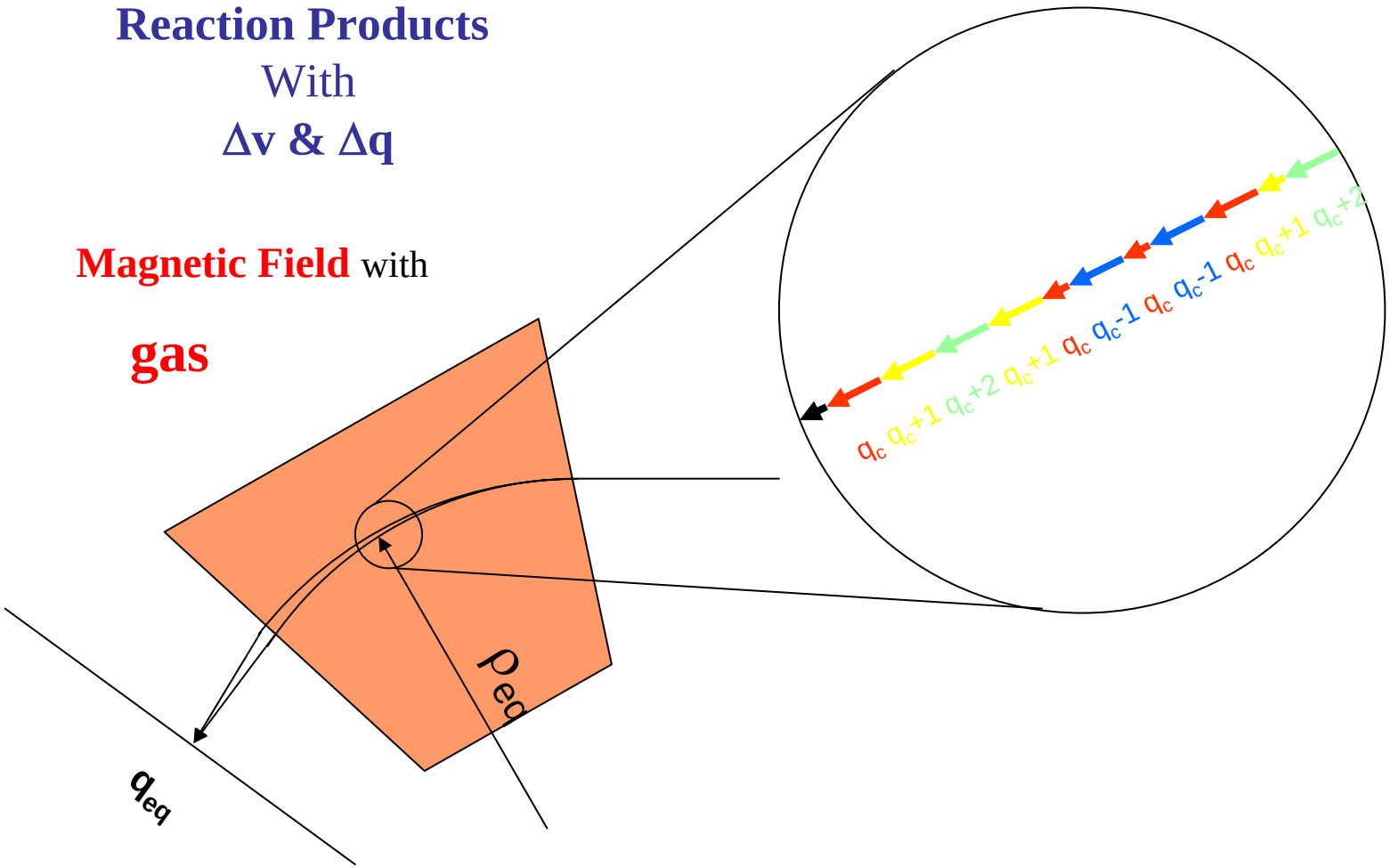
A: mass number
v: velocity of ion
v_0: Bohr velocity c/137

Principle of Operation
for Gas Filled Recoil Separator-II

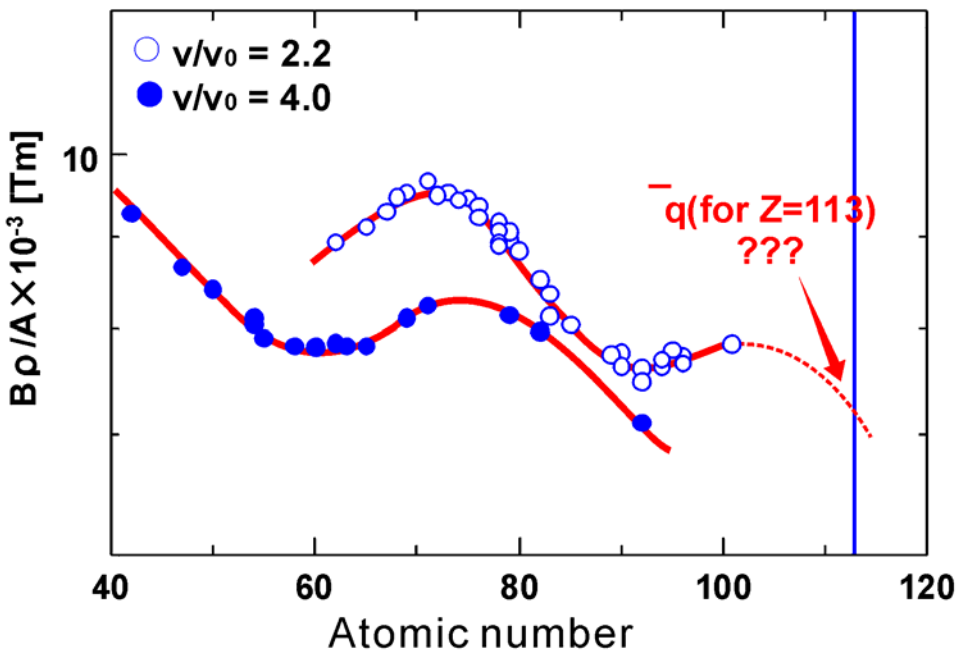
Reaction Products
With
Δv & Δq

Magnetic Field with

gas



Equilibrium charge in He gas



A. Ghiorso et al., Nucl. Instr. and Meth. A269, 192-201(1988)

$^{169}Tm(^{40}Ar,5n)^{204}Fr$

$^{169}Tm(^{40}Ar,6n)^{203}Fr$

$^{169}Tm(^{48}Ca,5n)^{212}Ac$

$^{208}Pb(^{40}Ar,3n)^{245}Fm$

$^{208}Pb(^{48}Ca,2n)^{254}No$

$^{209}Bi(^{48}Ca,2n)^{255}Lr$

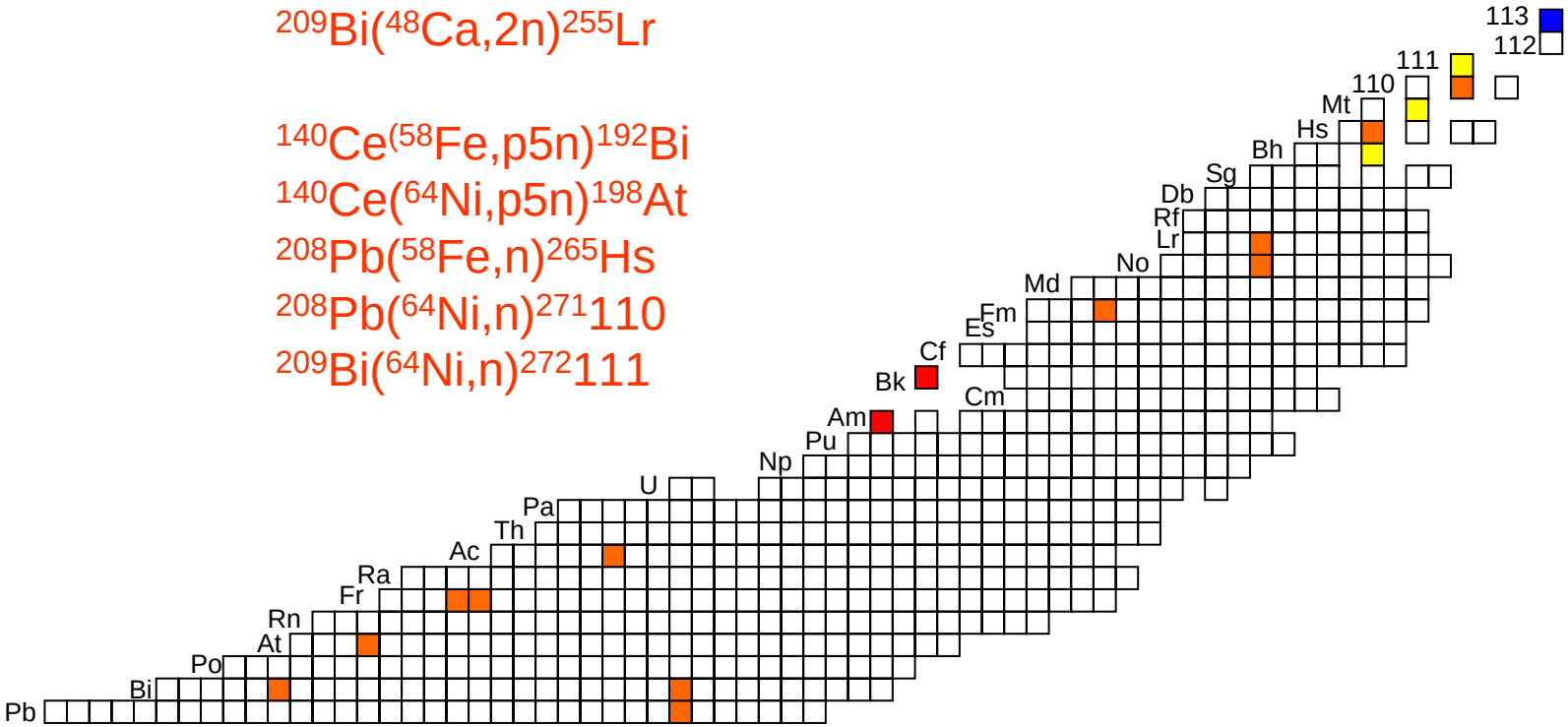
$^{140}Ce(^{58}Fe,p5n)^{192}Bi$

$^{140}Ce(^{64}Ni,p5n)^{198}At$

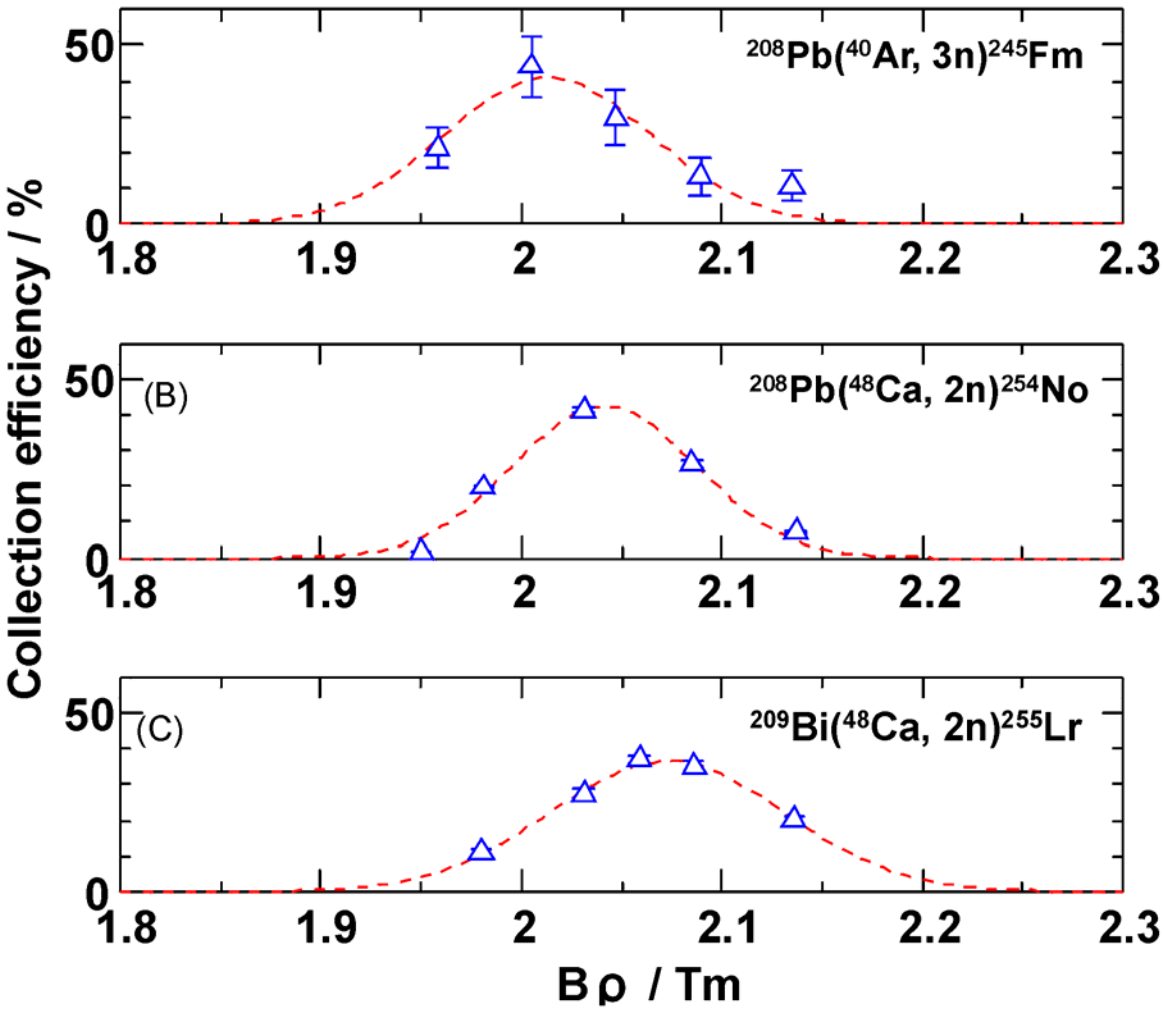
$^{208}Pb(^{58}Fe,n)^{265}Hs$

$^{208}Pb(^{64}Ni,n)^{271}110$

$^{209}Bi(^{64}Ni,n)^{272}111$

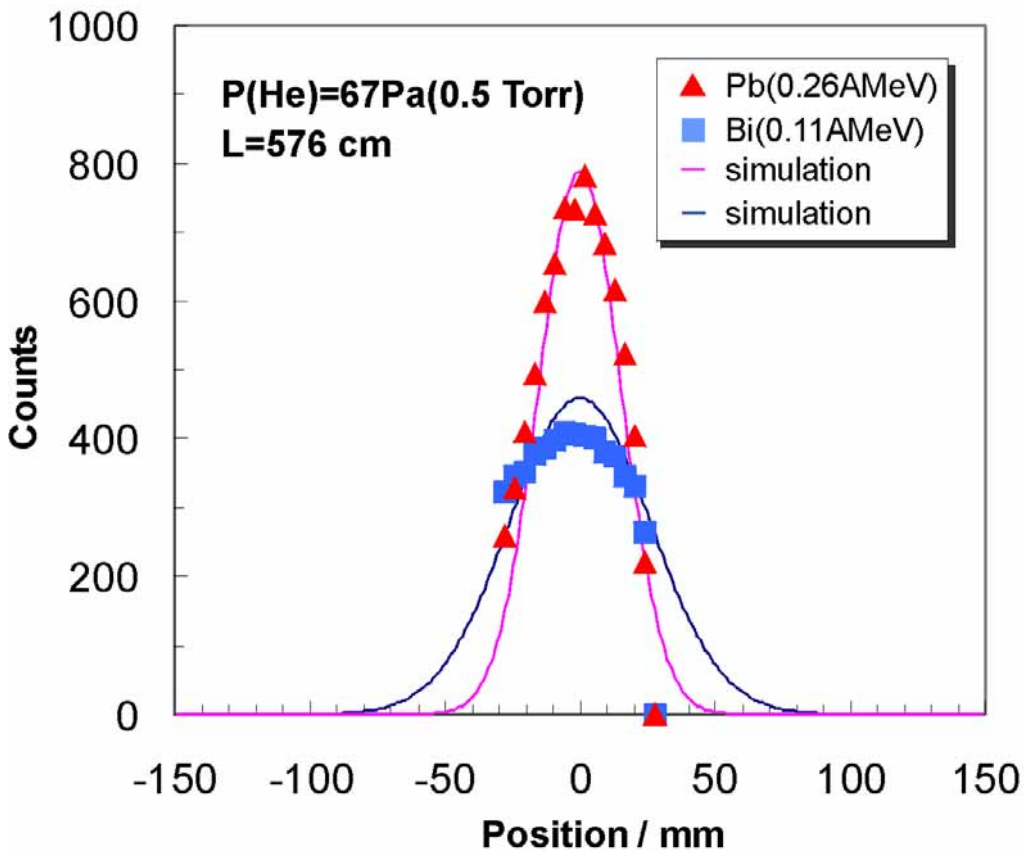


Bρ distribution of ^{245}Fm, ^{254}No and ^{255}Lr



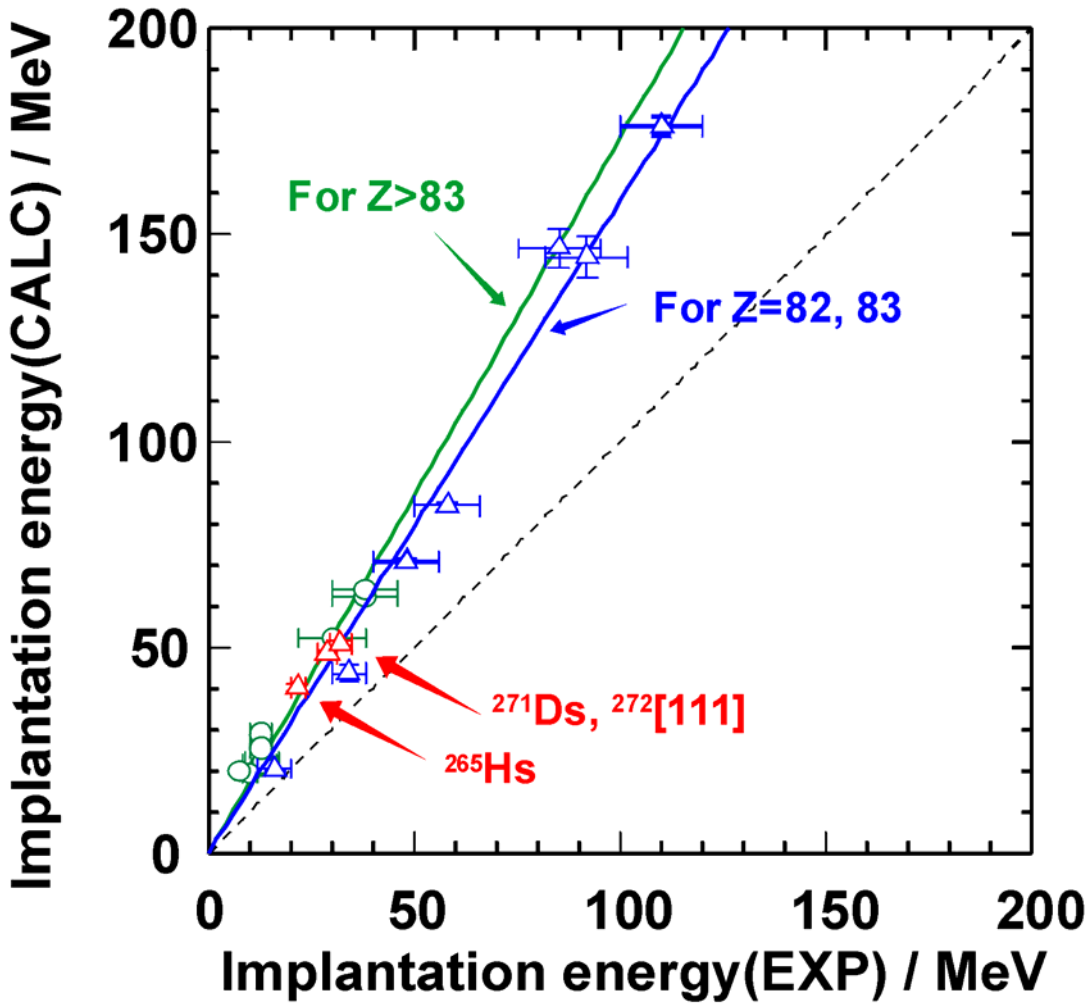
$$\overline{q} = \frac{0.0227 \times A \times (v/v_0)}{B\rho}$$

Positional distribution at focal plane



	E / AMeV	v/v0	Trans.(exp)	Trans.(calc)
^{208}Pb	0.26	3.21	84 %	92 %
^{209}Bi	0.11	2.07	33 %	36 %

Pulse height defect



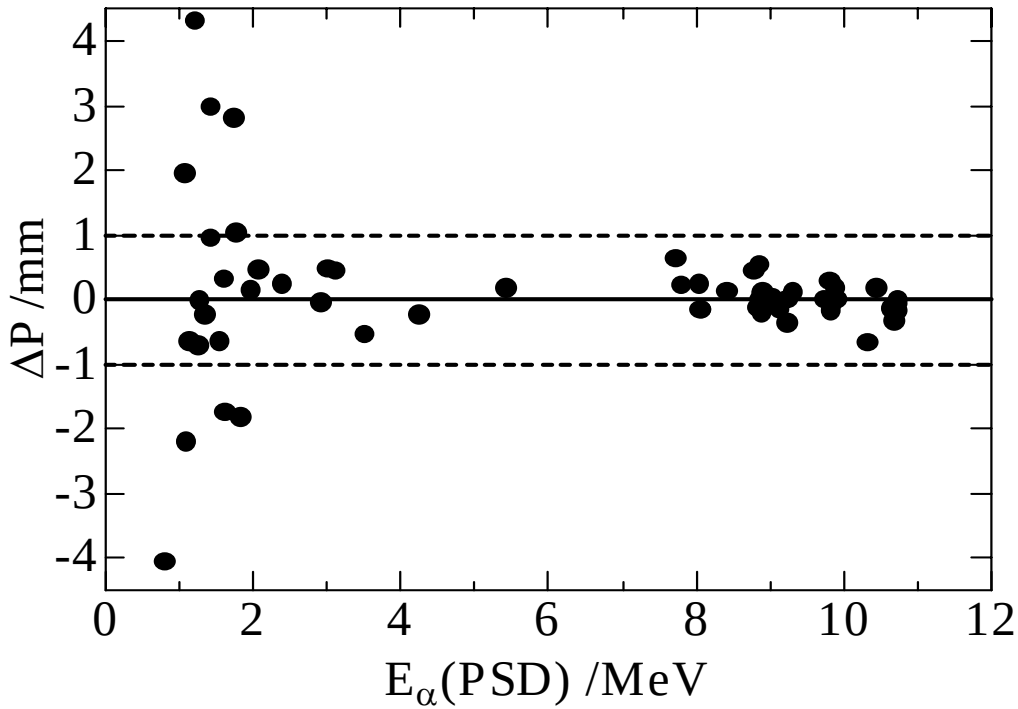
Ecorr = 1.73 × Eexp [For Z>83]

$^{208}Pb(^{64}Ni, n)^{271}Ds$

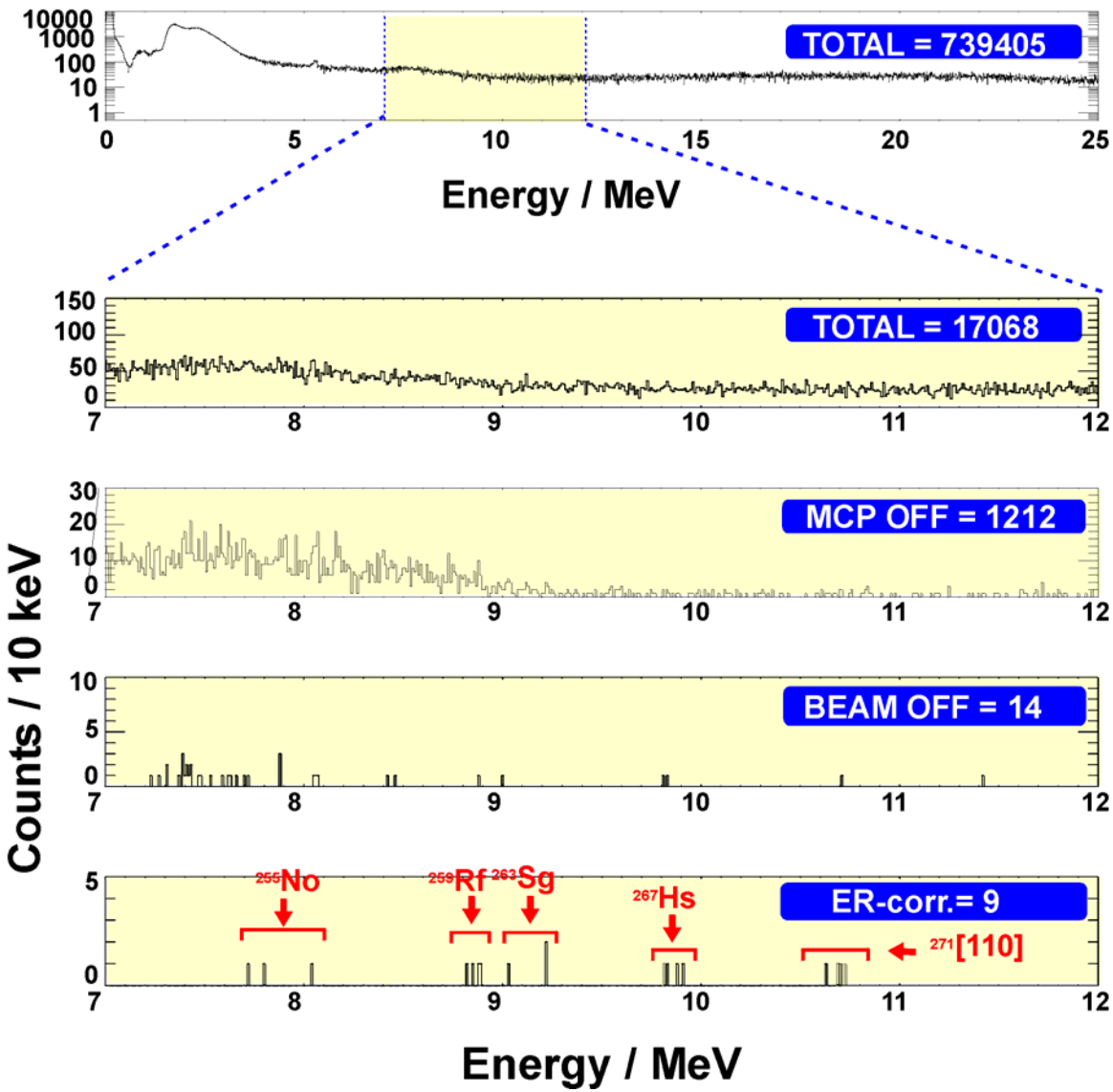
Experimental conditions

Beam	^{64}Ni	0.4 - 1 pμA
Total dose	4.0×10^{18}	
Target	^{208}Pb	190 - 250 μg/cm² (98% enriched) evaporated on 30 μg/cm² C covered by 10 μg/cm² C
Bρ (GARIS)	2.05	Tm
P (GARIS)	75	Pa
Counting rate	1 - 20	cps

Position difference (ER vs α)



Energy spectrum @ PSD



Target : 230 μg/cm² ^{208}Pb

Beam energy : 316.3 MeV

Beam dose : 1.2x10^{18} ions (ave.0.4 pμA)

Counting rate @ PSD : 2.1 cps

^{271}[110]-corr. event : 9

gate
position +/- 1.0 mm
time 10 s

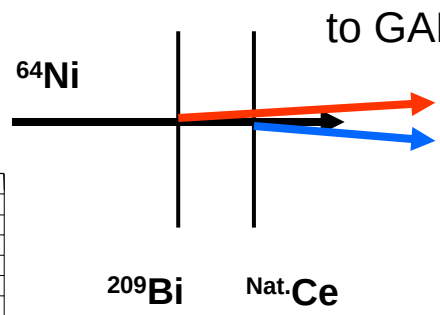
$^{209}Bi\ (^{64}Ni\ ,n)^{272}111$

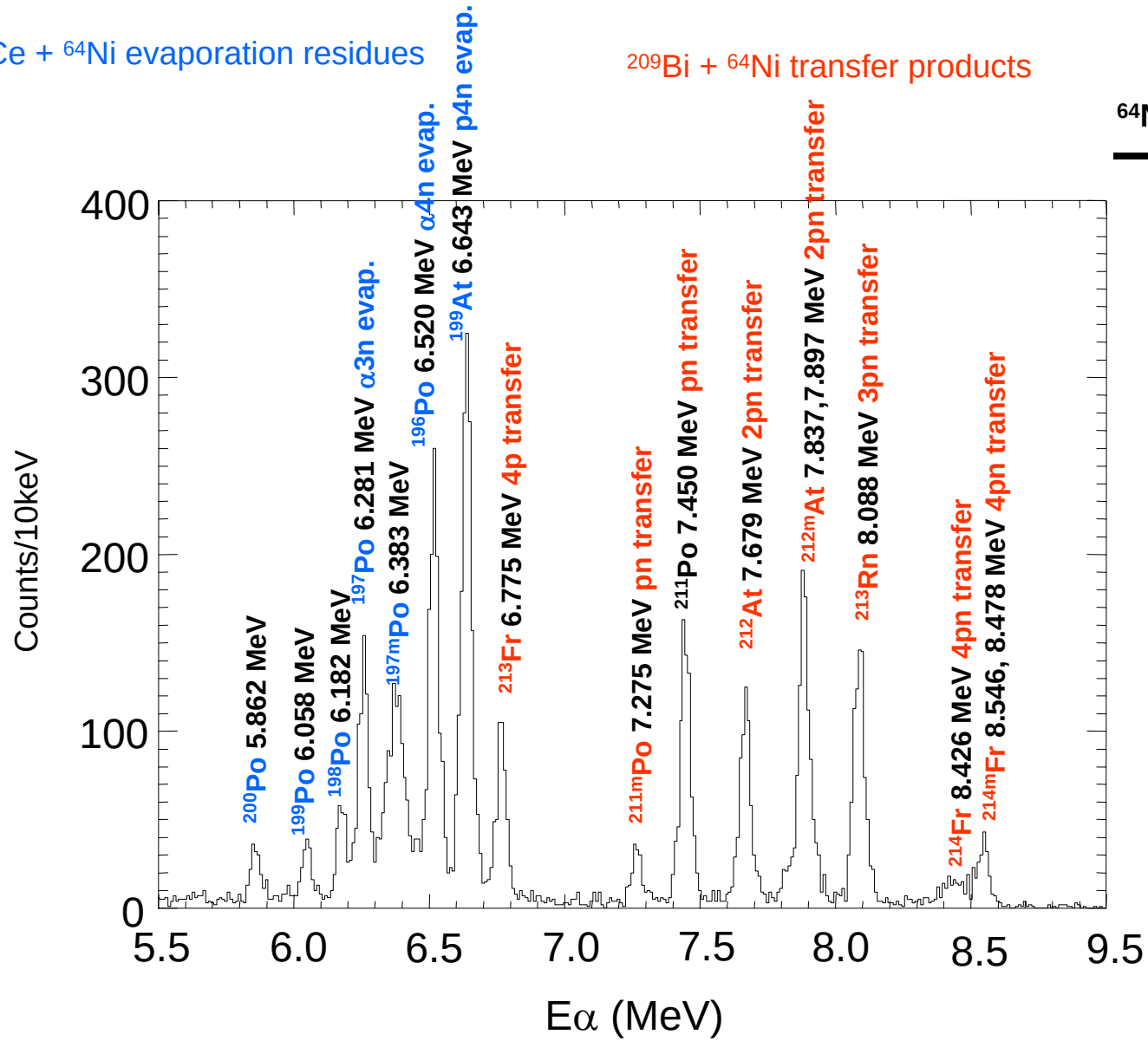
Experimental conditions

Beam	^{64}Ni	0.7 - 1.8 pμA
Total dose	**1.30×10^{19}**	
Target		210～310 μg/cm² evaporated on 30 μg/cm² C covered by 10 μg/cm² C
Bρ (GARIS)	2.05	Tm
P (GARIS)	75	Pa
Counting rate	**2 - 10**	**cps**

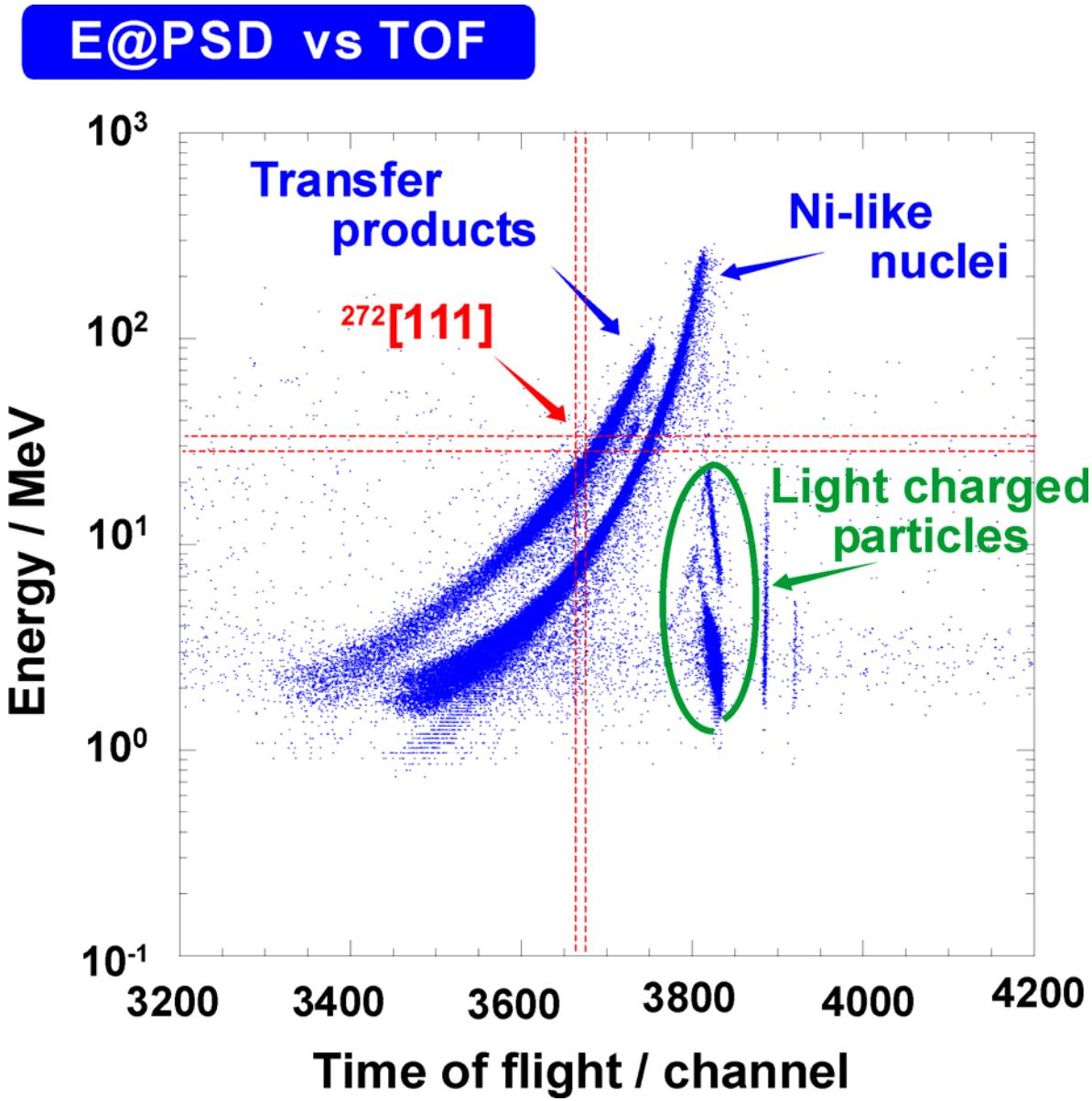
^{140}Ce + ^{64}Ni evaporation residues

^{209}Bi + ^{64}Ni transfer products



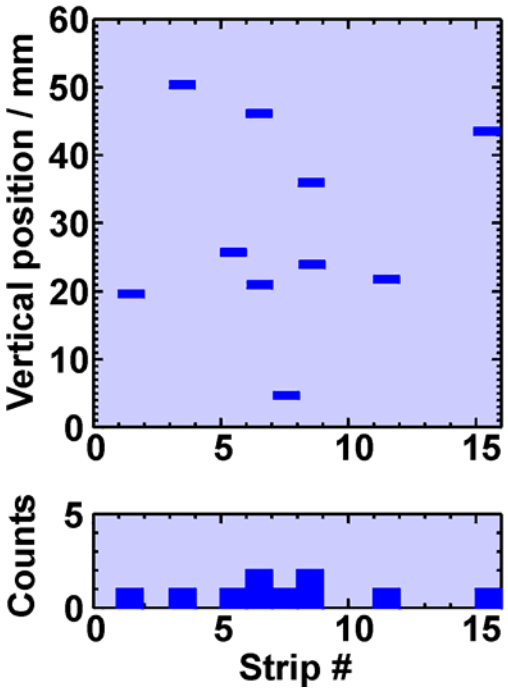


system check &
energy calibration

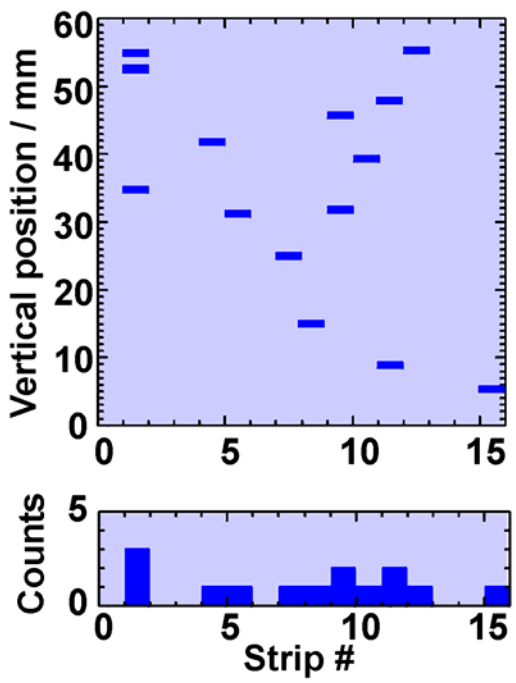

E@PSD vs TOF
Transfer products
Ni-like nuclei
272[111]
Light charged particles
Energy / MeV
Time of flight / channel
10^3
10^2
10^1
10^0
10^-1
3200
3400
3600
3800
4000
4200

Positional distribution@PSD

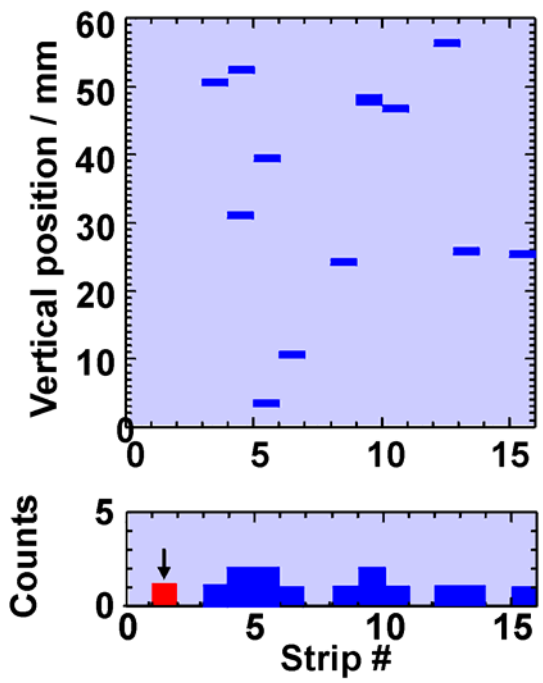
$^{208}Pb(^{58}Fe, 1n)^{265}Hs$



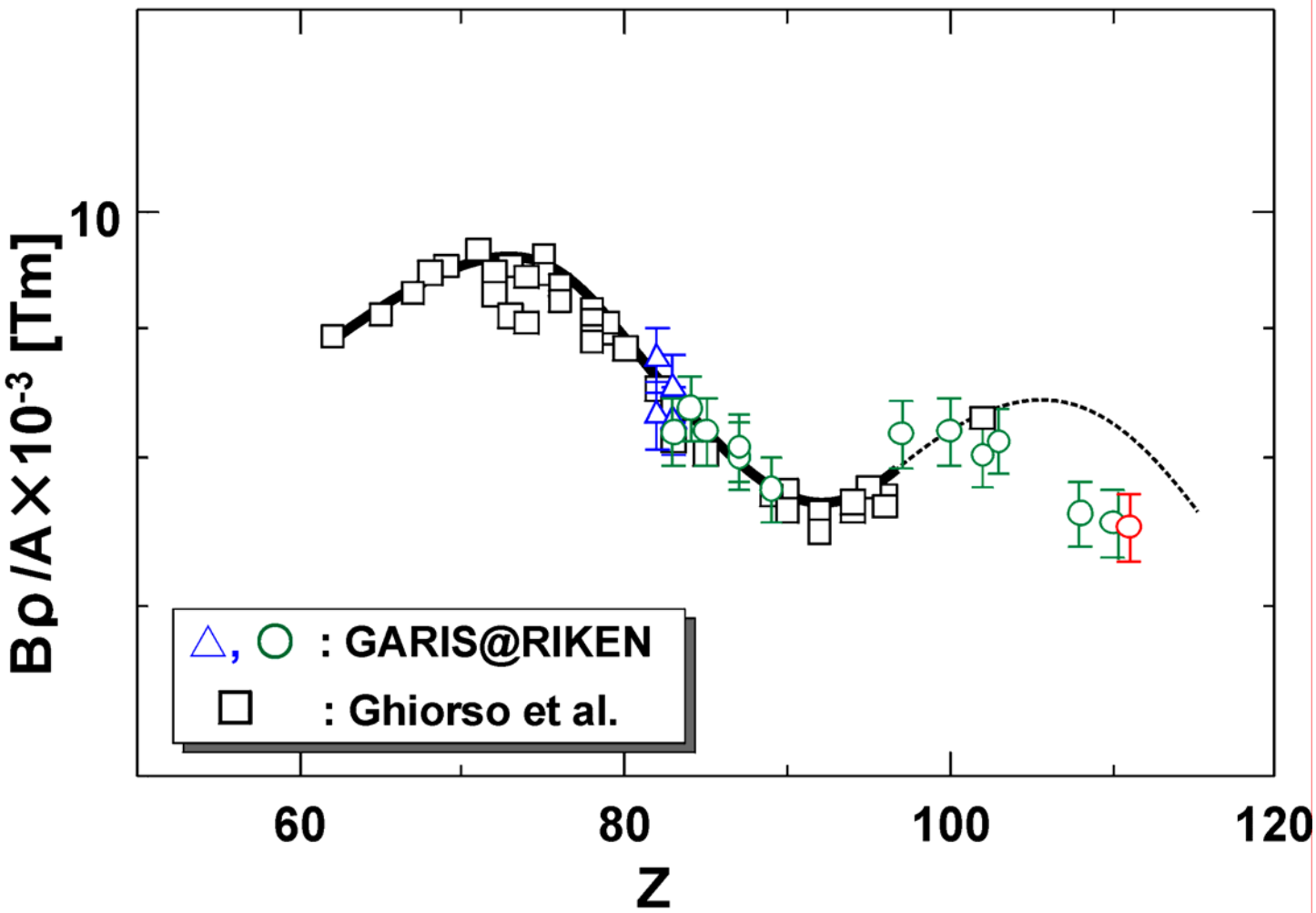
$^{208}Pb(^{64}Ni, 1n)^{271}Ds$



$^{209}Bi(^{64}Ni, 1n)^{271}111$

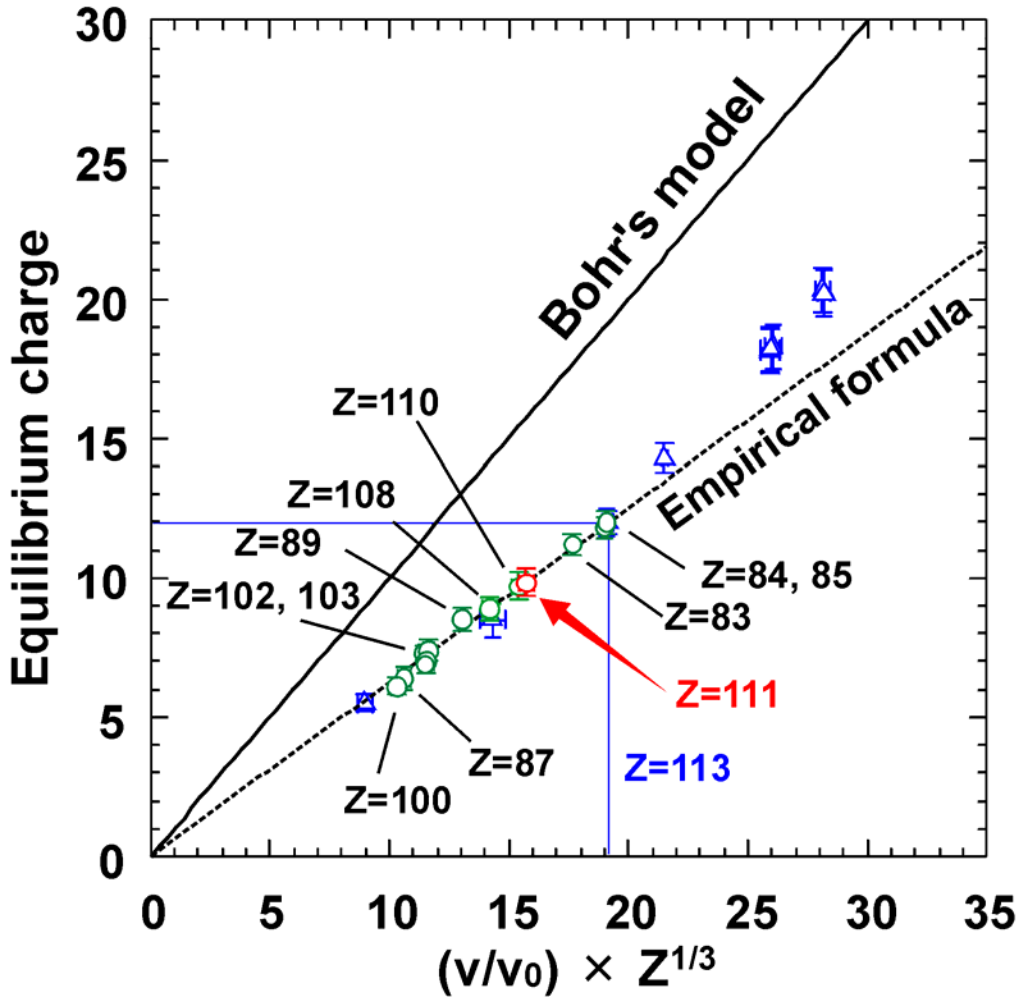


Z-dependence of $\bar{q}$



$B\rho/A = 0.0227 \times (v/v_0)/\bar{q}$ [Tm]

Empirical formula based on Bohr model



$\bar{q} = 0.625 \times (v/v_0) \cdot Z^{1/3}$

$[8 \leqq (v/v_0) \cdot Z^{1/3} \leqq 20,\ Z \geqq 82]$

Future plan for chemistry at RIKEN

GARIS + Gas-jet + (Gas-phase) Chemistry

$^{208}Pb(^{50}Ti,n)^{257}Rf$, ^{209}Bi (^{50}Ti, n) ^{258}Db

AVF cyclotron + ^{248}Cm target