Ion test bench : linear spectrometer design for low-medium mass

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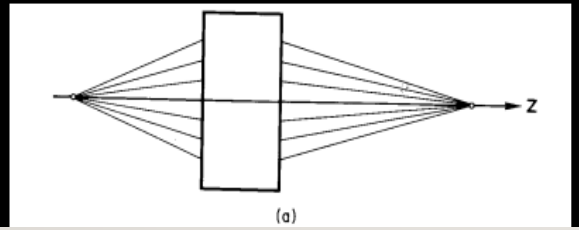
BASIC OPTICS OF A SEPARATOR

creates an image size in x that is independent of the incident angular distributions

- Point to point



$(x/a) = 0$

Transfer matrix

$$\begin{bmatrix} & x & a & y & b & l & \delta \\ x & (x/x) & (x/a) & 0 & 0 & 0 & (x/\delta) \\ a & (a/x) & (a/a) & 0 & 0 & 0 & (a/\delta) \\ y & 0 & 0 & (y/y) & (y/b) & 0 & (y/\delta) \\ b & 0 & 0 & (b/y) & (b/b) & 0 & (b/\delta) \\ l & (l/x) & (l/a) & (l/y) & (l/b) & 1 & (l/\delta) \\ \delta & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Dispersion (D) = $(x/\delta) = \left(\frac{x}{\Delta p/p}\right)$

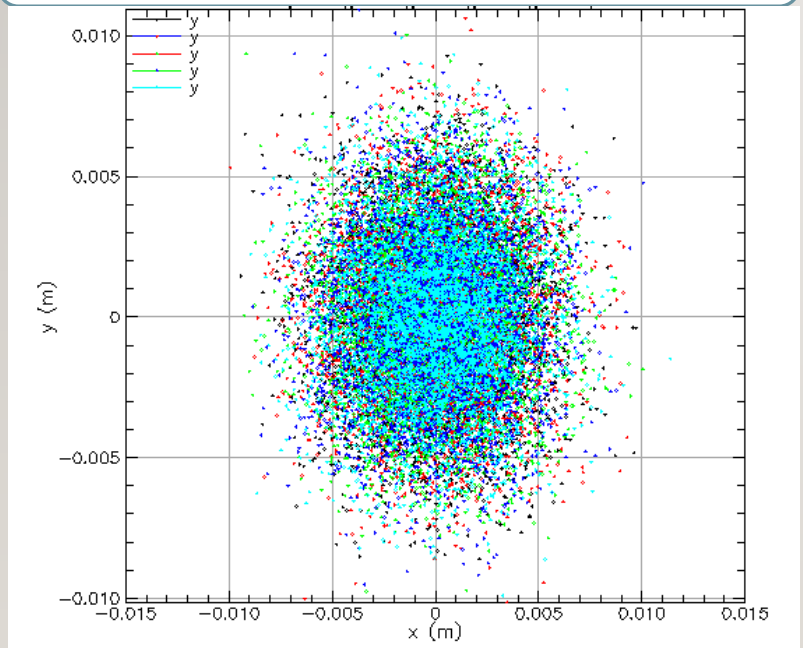
Magnification (M) = $(x/x) = \left(\frac{\sigma(x)_{fp}}{\sigma(x)_{ini}}\right)$

Beam size = $2 \cdot \sigma(x)_{ini}$

Resolving power = $R_p = \frac{p}{\Delta p} = \frac{D}{M \cdot 2 \cdot \sigma(x)_{ini}}$

DETAILS OF INPUT BEAM PARAMETERS

Input beam= 5 isotopes of Li^{+2}



Beam	$^{9}Li^{+2}$	$^{68}Ni^{+16}$
energy	10 Mev/u	10 MeV/u
Beam spot (rms)	5 mm	5 mm
Emittance (x ,y)	2.5 mm.mrad	2.5 mm.mrad
Beam rigidity	1.74 Tm	1.95 Tm

Simulation code: Bmad

- Open-source toolkits(software libraries)
- Cornell University

LATTICE DETAILS AND LAYOUT

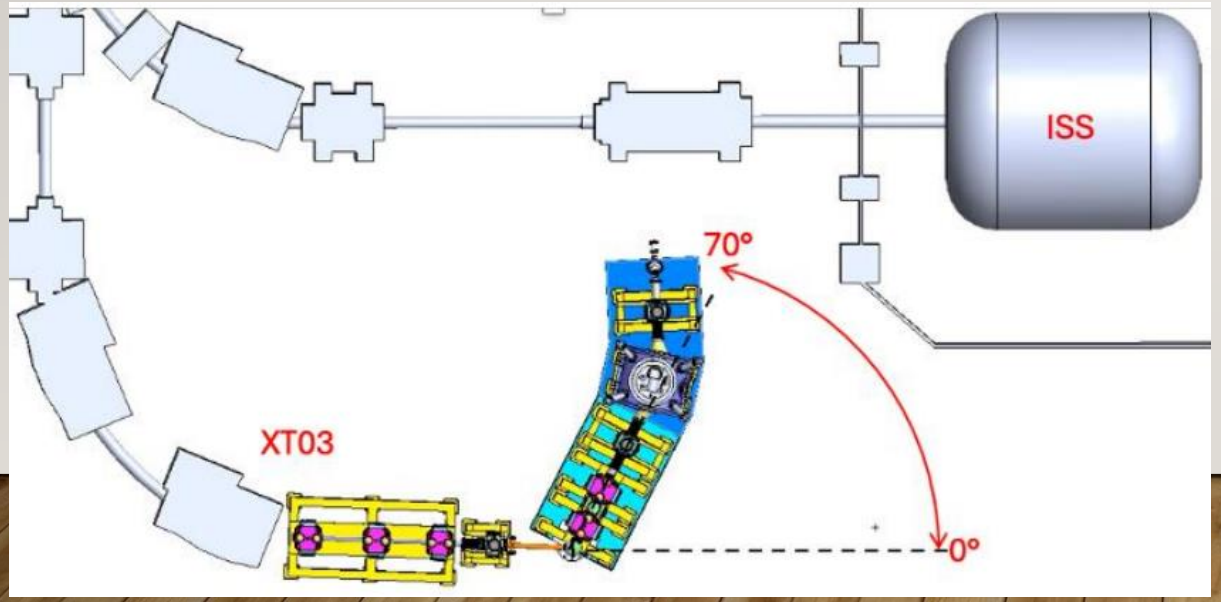
	Effective length	Gradient strength	B-field	Bend
Quadrupole 1	180 mm	2.7944 T/m	-	-
Quadrupole 2	180 mm	-18.5603 T/m	-	-
CCT	580 mm	5.9874 T/m	1.7812 T	30 deg

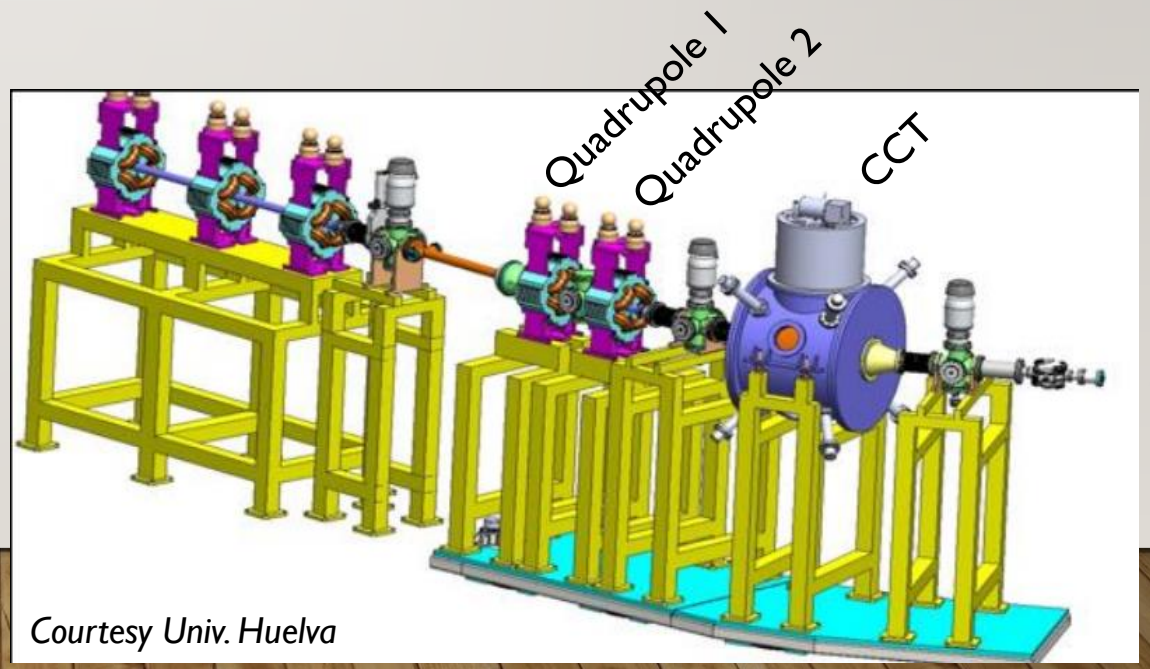
Magnification (M)

Point to point

Dispersion(D)

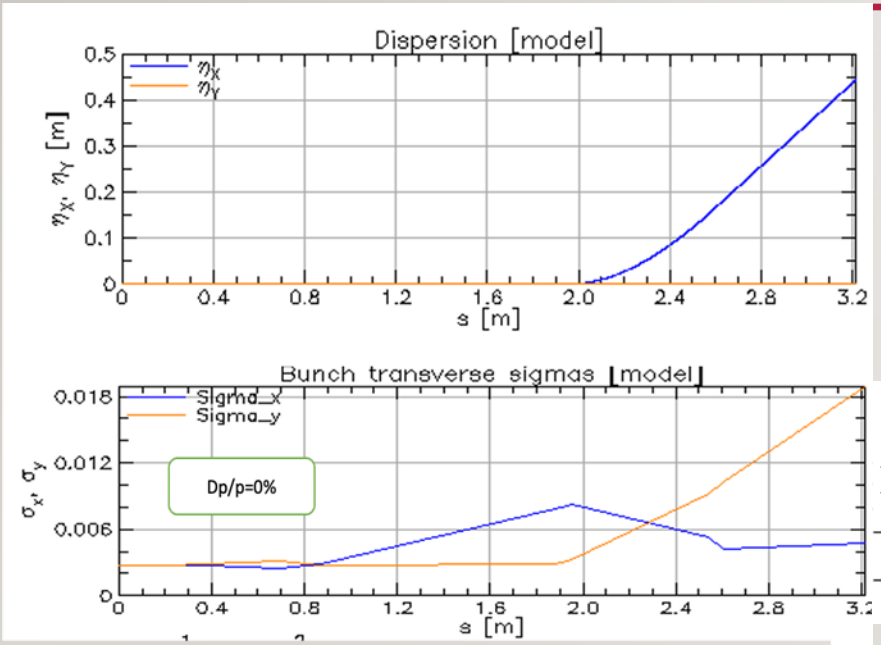
-0.18938045	0.07953877	0.00000000	0.00000000	0.00000000	0.44336663
-3.01725078	-4.01314702	0.00000000	0.00000000	0.00000000	0.44968829
0.00000000	0.00000000	-4.09697242	0.90888738	0.00000000	0.00000000
0.00000000	0.00000000	-3.07180765	0.43737839	0.00000000	0.00000000
-1.25258615	-1.81506314	0.00000000	0.00000000	1.00000000	3.12490872
0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000



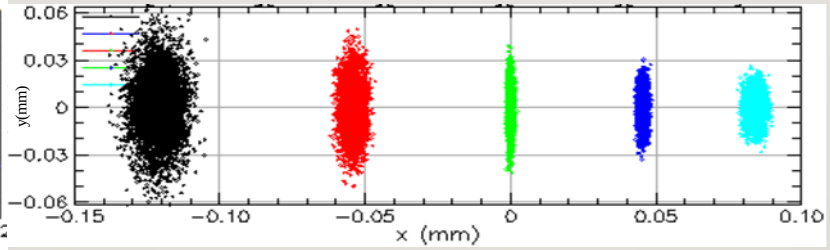


Courtesy Univ. Huelva

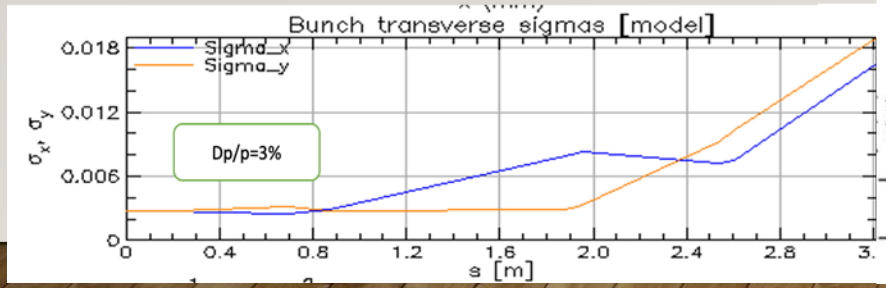
TRANSPORT BEAM AT DIFFERENT MOMENTUM SPREADS FOR $^{9}Li^{+2}$

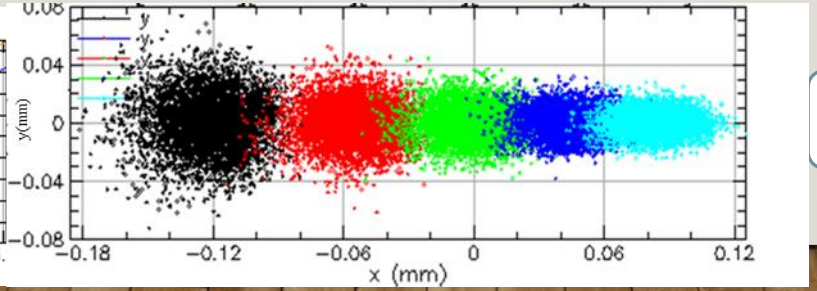


$^{7}Li^{+2}$ $^{8}Li^{+2}$ $^{9}Li^{+2}$ $^{10}Li^{+2}$ $^{11}Li^{+2}$



Δp/p = 0%



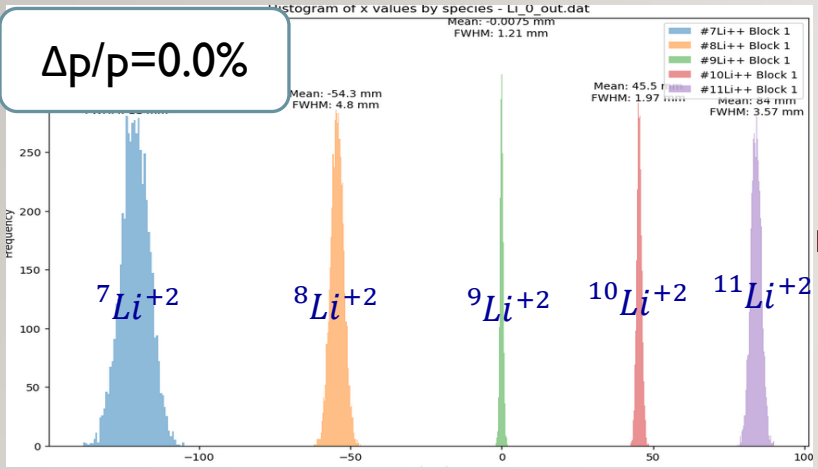


Δp/p = 3%

Dispersion (D)	0.443
Magnification(M)	0.19
beam spot(2*σ)	5 mm
Resolving power	466

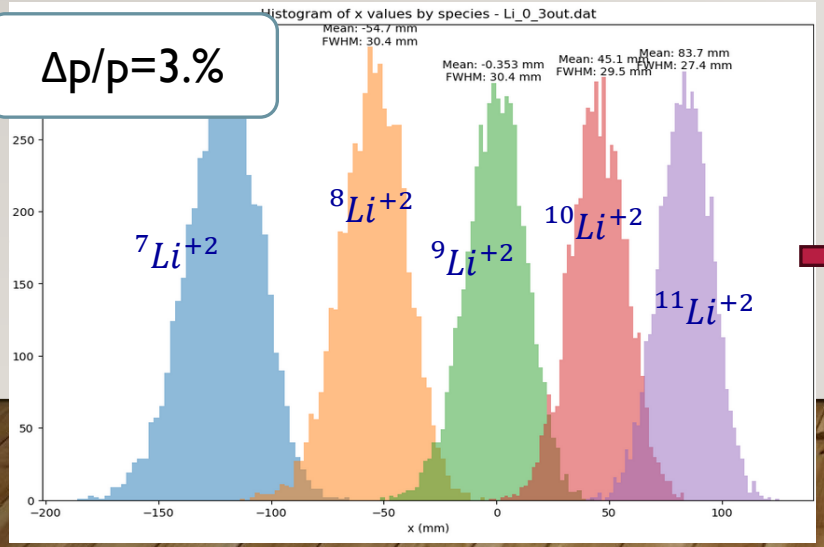
CALCULATION FIGURE OF MERIT (FOM) FOR $^{9}Li^{+2}$

Δp/p=0.0%



$FWHM_1$	1.21 mm
$FWHM_2$	1.97 mm
Mean distance	45.5 mm
FoM	4.18

Δp/p=3.%



$FWHM_1$	29.5 mm
$FWHM_1$	30.4 mm
Mean distance	45.1 mm
FoM	0.75

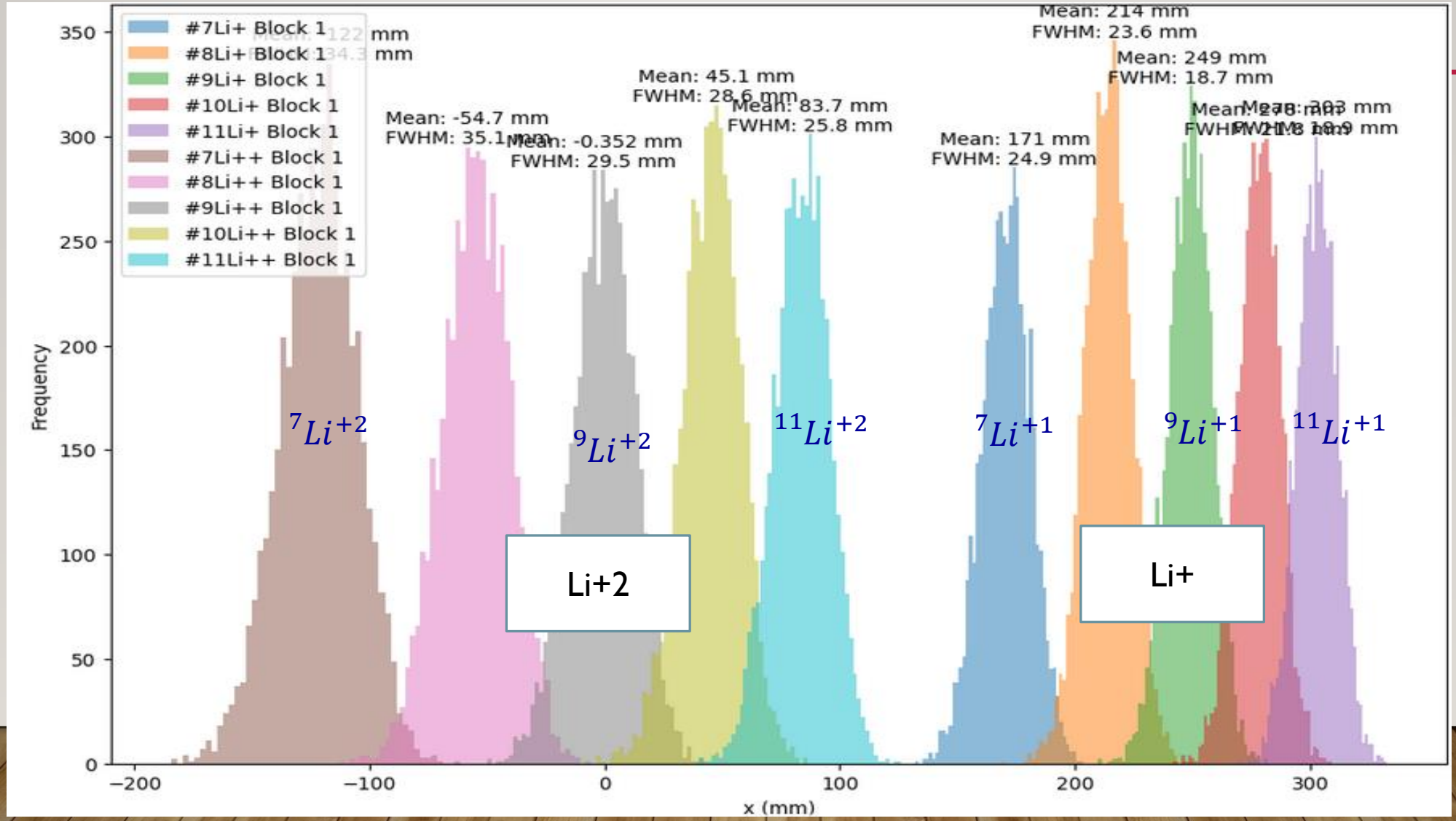
The quality of the mass discrimination achieved be a particle detector system can be accounted for by using the figure of merit (FoM) , as defined in :

$$\text{FoM} = \frac{\Delta x}{FWHM_1 + FWHM_2}$$

Being Δx the spatial separation between the two adjacent peaks, and FWHM the corresponding full widths at half-maximum .

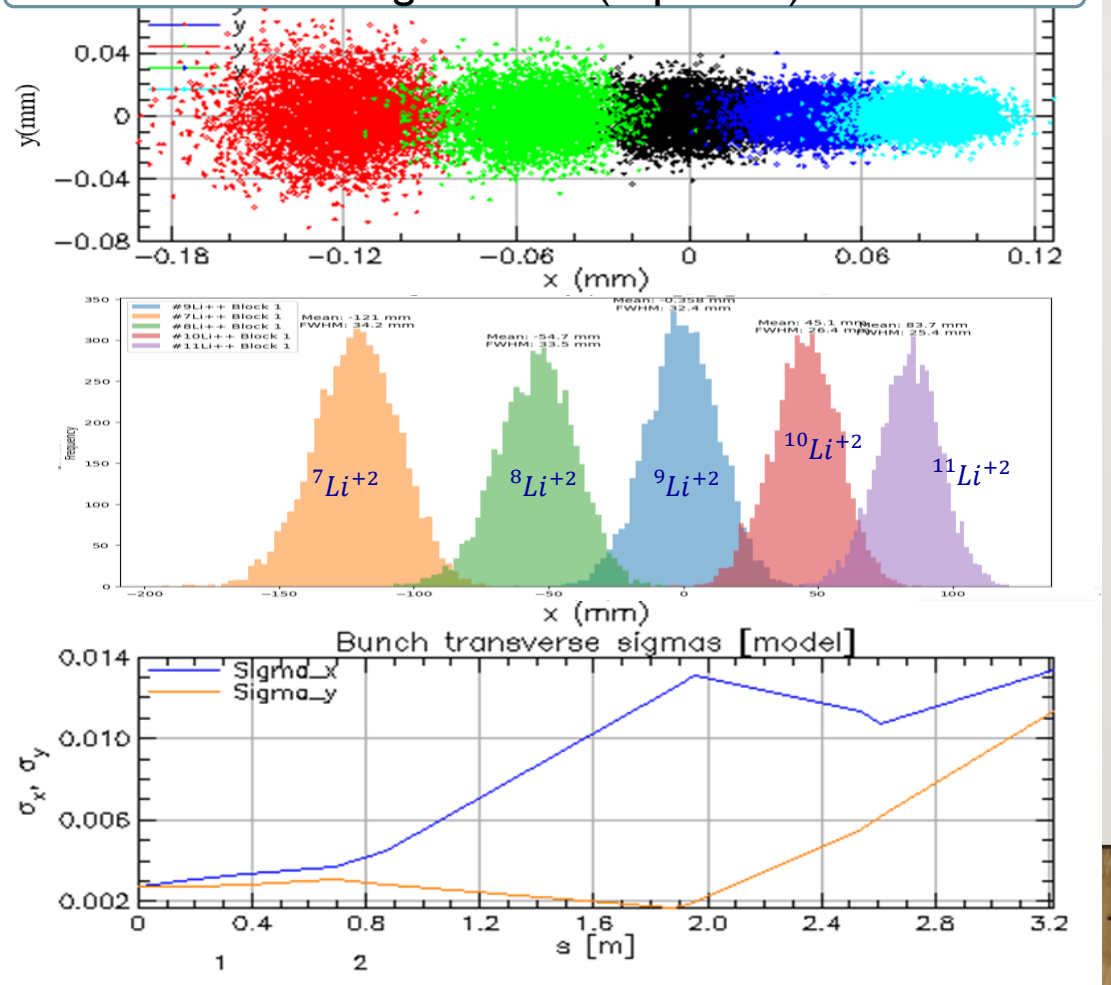
A detector system will exhibit good identification capability when FoM>0.7

CHARGE STATES FOR DIFFERENT ISOTOPES OF $^{9}Li^{+2}$ AT ΔP/P=3%

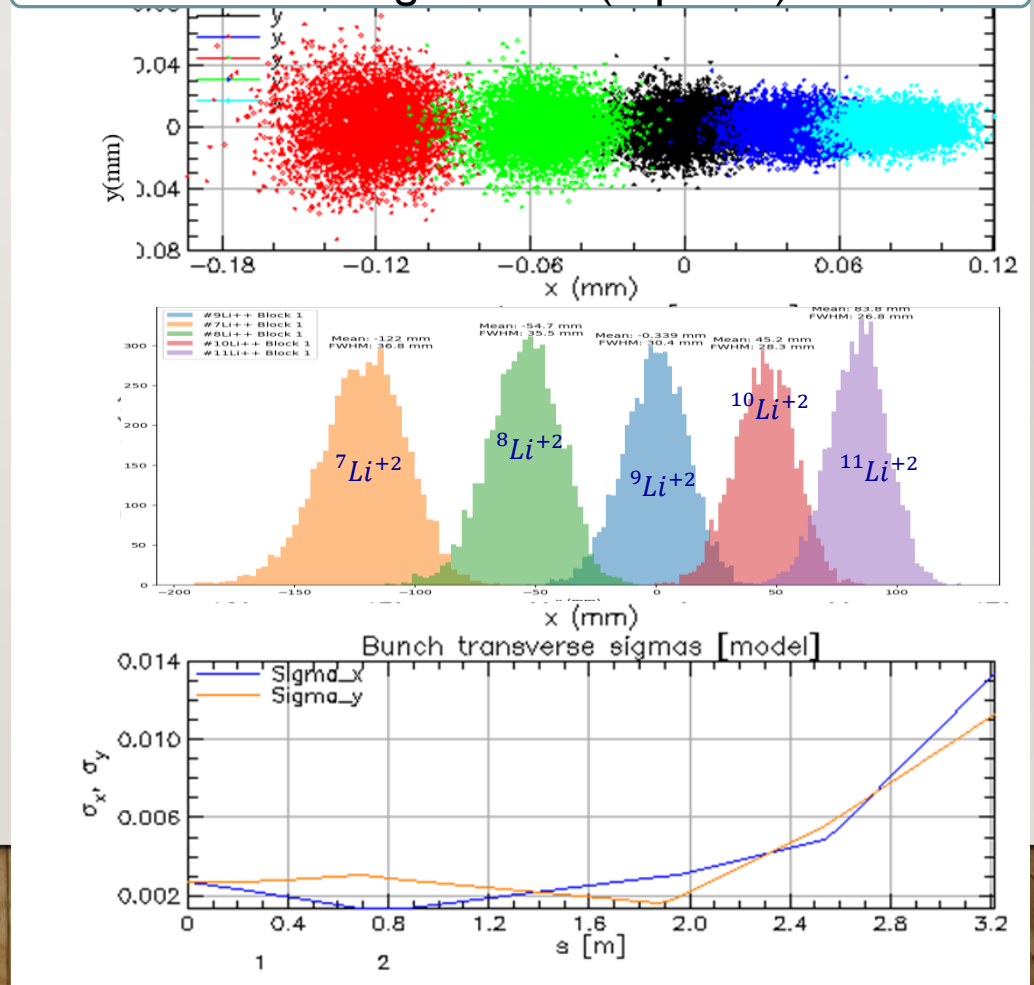


IMPACT OF BEAM CONVERGENCE AND DIVERGENCE OF $^{9}Li^{+2}$ ISOTOPES AT ΔP/P=3%

Divergent beam(Alpha=-2)

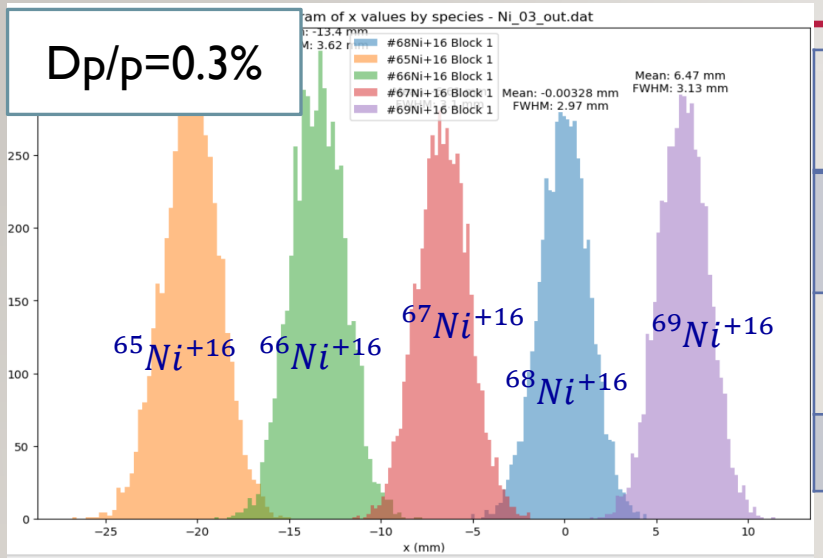


Convergent beam(Alpha=2)



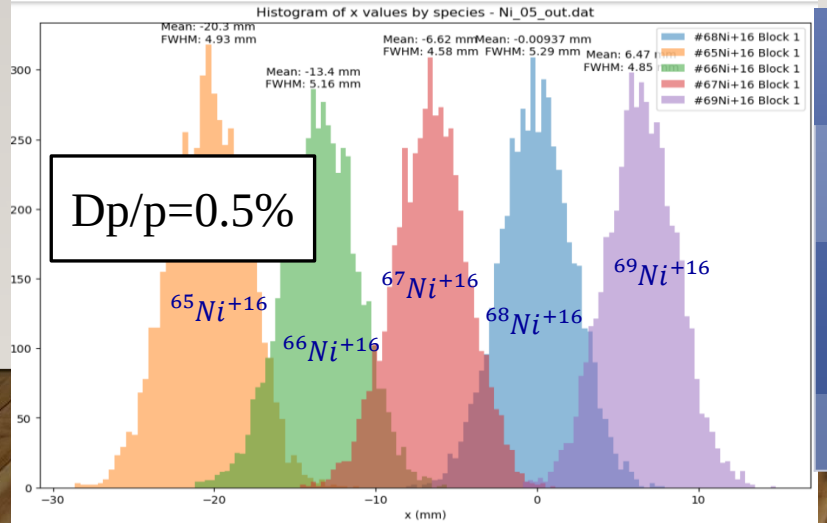
$^{68}Ni^{+16}$ AT DIFFERENT ΔP/P

Dp/p=0.3%



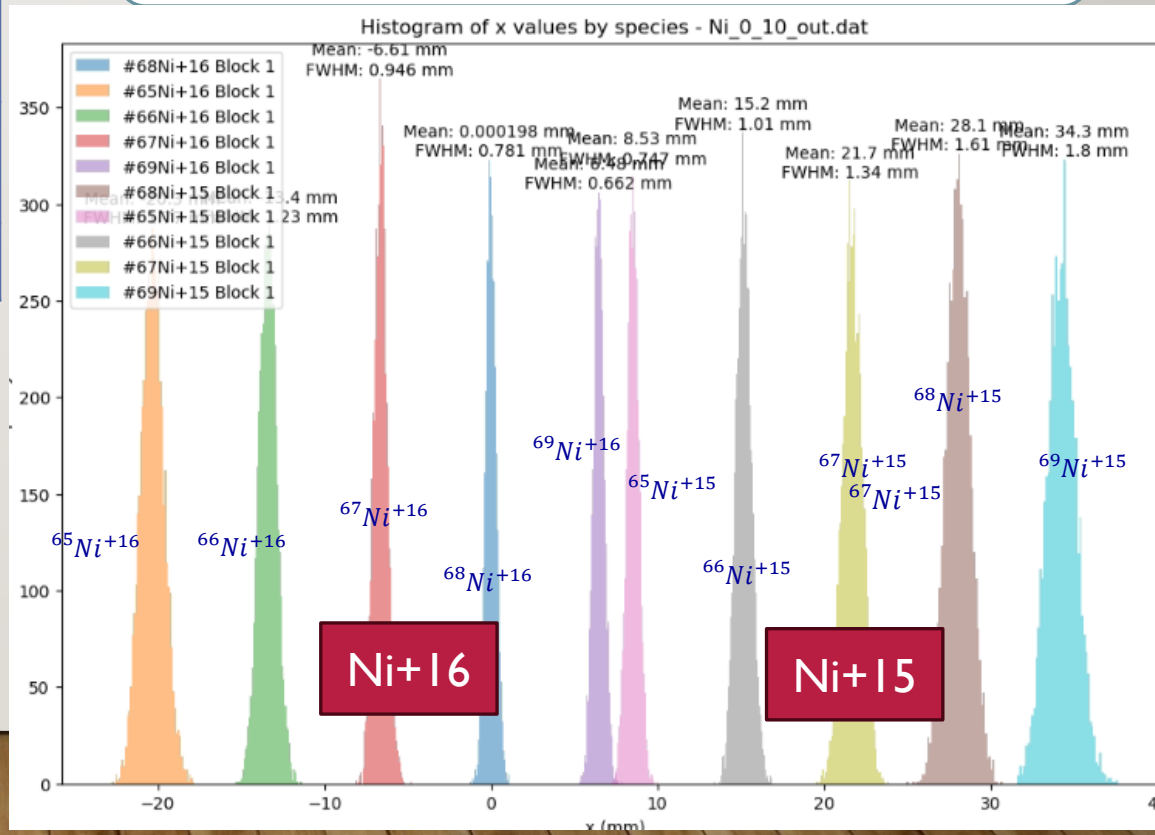
$FWHM_1$	3.13 mm
$FWHM_2$	2.97 mm
Mean distance	6.47 mm
FoM	1.02

Dp/p=0.5%



$FWHM_1$	5.29 mm
$FWHM_2$	4.58 mm
Mean distance	6.62 mm
FoM	0.68

Charge state $^{69}Ni^{+16}$ for Δp/p=0 %



Thanks for your attention

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