The Medium and High resolution mass separators for SPES facility

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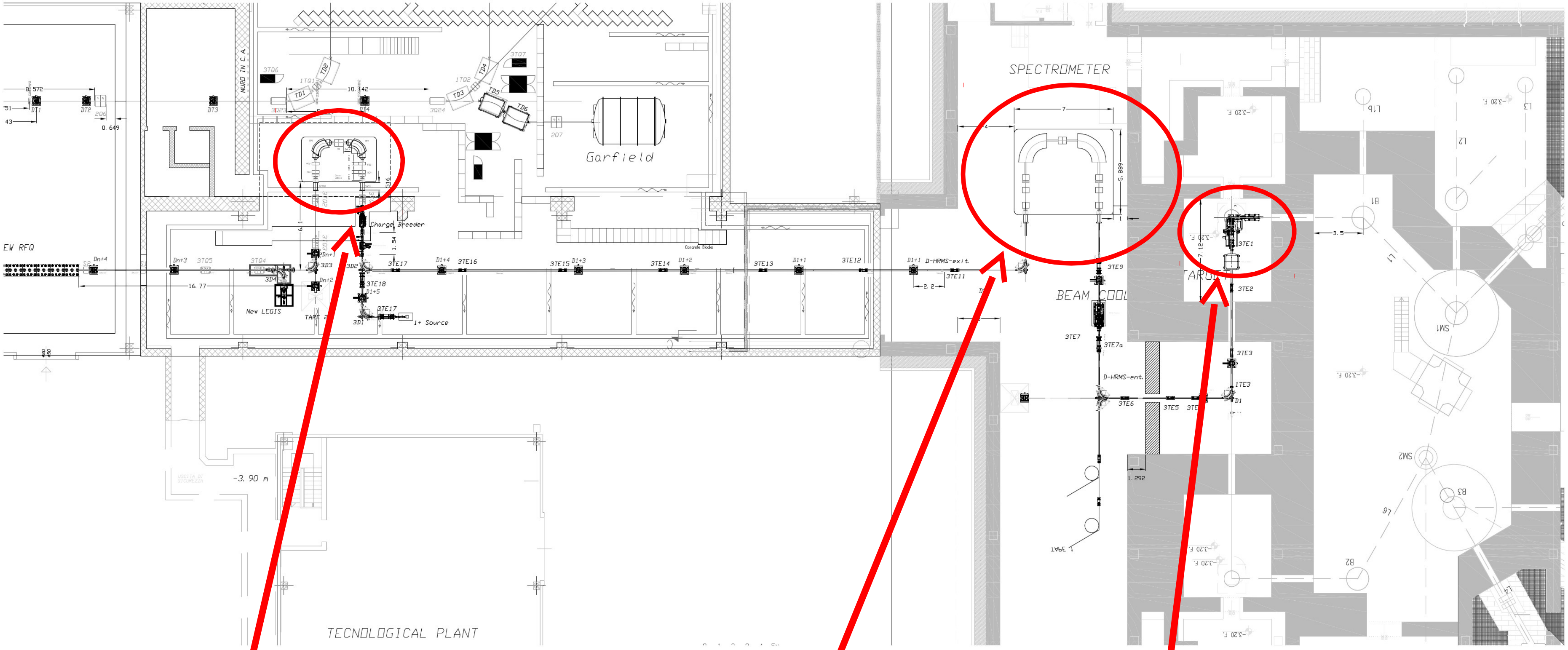
Overview

- SPES Layout
- HRMS design
- MRMS design

SPES Layout



MRMS

HRMS

Ion source

Foreword

To obtain the ions of interest it is necessary :

- To remove isobar ions produced from the source with high resolution mass separator (HRMS)

- Clean up the beam from contaminants introduced by the charge breeder with medium resolution mass separator (MRMS)

Isobaric nuclei table

Beam reference: ^{132}Sn produced by ions source

ΔM/M=1/133

ΔM/M=1/11578

	Z \ A	129	130	131	132	133	134	135
	45							
	46							
	47	128943950	129950700					
	48	128931820	129933940	130940600	131946040	132952850		
In	49	128921805	129924980	130926972	131933000	132938310	133944540	134950050
Sn	50	128913465	129913974	130917045	131917827	132923913	133928682	134934909
Sb	51	128909147	129911662	130911988,8	131914507,7	132915273	133920535,7	134925185
Te	52	128906596,5	129906222,7	130908522,2	131908547	132910969	133911394	134916555,7
I	53	128904984	129906670	130906126,3	131907994	132907797	133909759	134910049
Xe	54	128904780,9	129903509,4	130905084,1	131904155,09	132905910,8	133905394,7	134907228
Cs	55	128906066	129906709	130905465	131906433,9	132905452	133906719	134905977
Ba	56	128908681	129906321	130906941	131905061,1	132906007	133904508	134905688
La	57	128912694	129912369	130910070	131910120	132908220	133905814	134906984
Ce	58	128918100	129914740	130914430	131911464	132911520	133908928	134909161
Pr	59	128925100	129923590	130920230	131919260	132916331	133915697	134913112
Nd	60	128933100	129928510	130927248	131923321	132922350	133918790	134918181

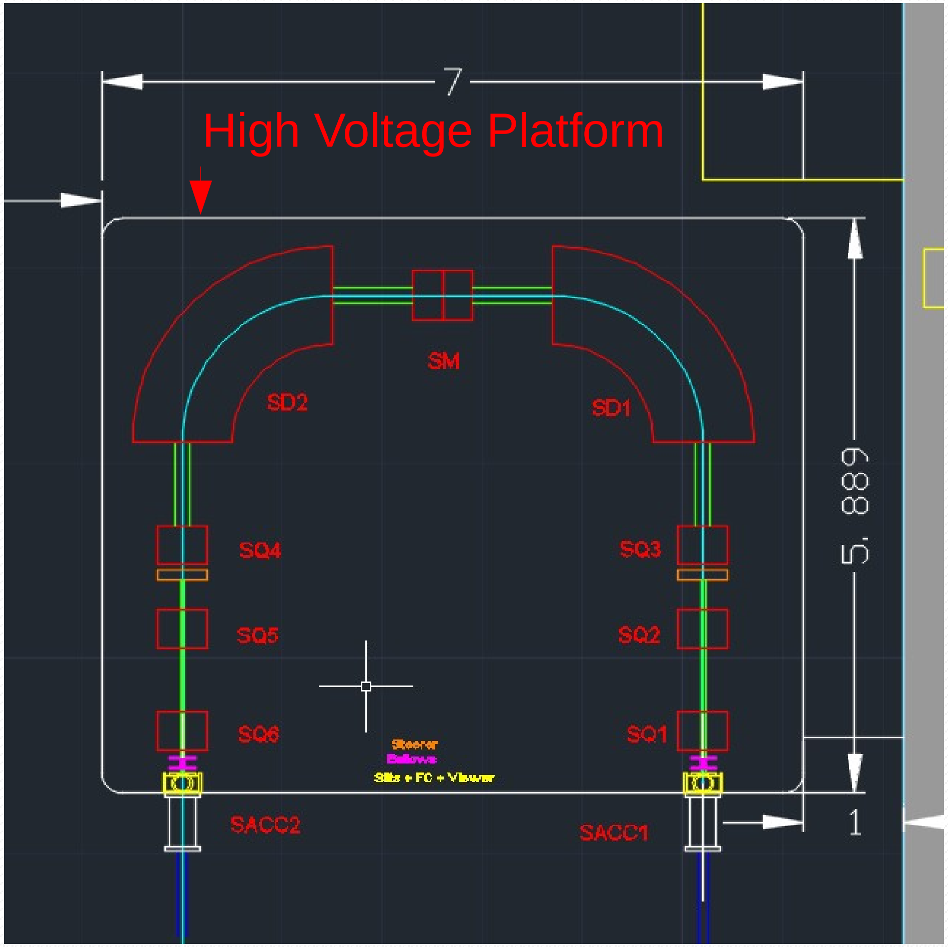
1/200 selected species

HRMS selected species

Nominal beam

A separation in mass of over 1/20000 ensures a “clean selection”, in particular the ^{132}Cs

High Resolution Mass Separator

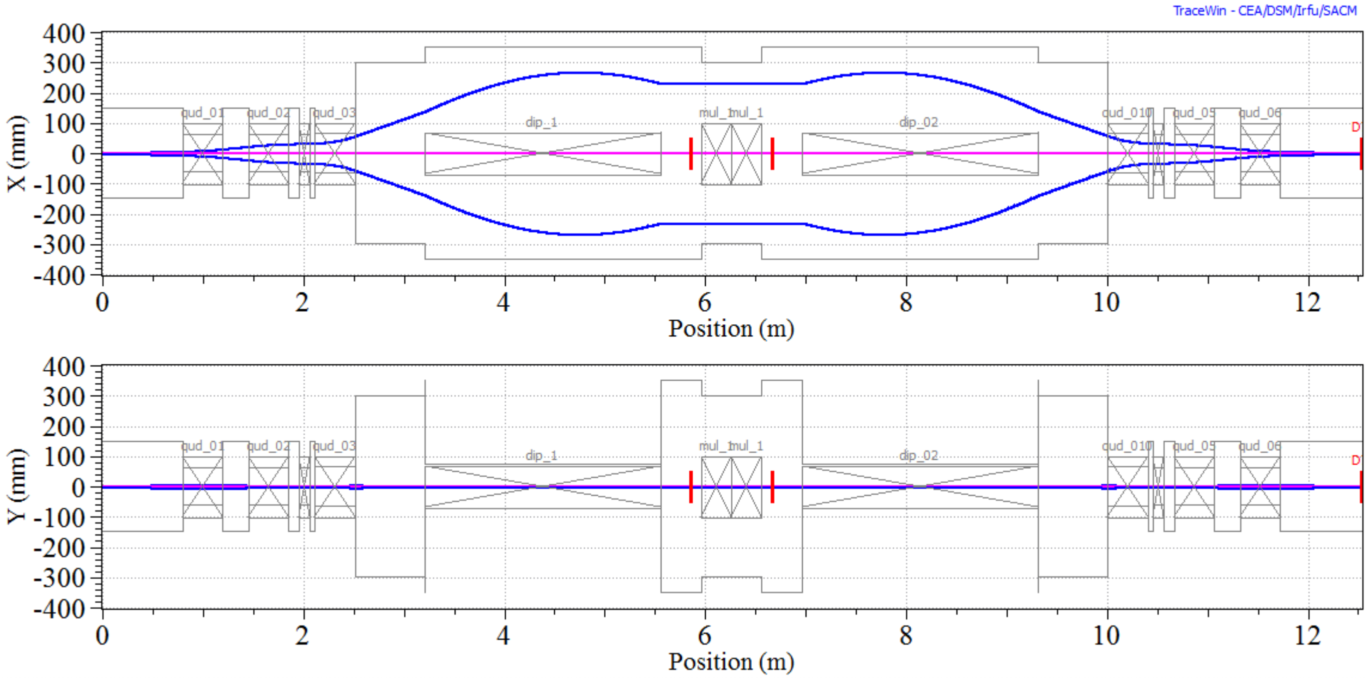


A Scaled up version of the separator designed by Cary Davids for CARIBU project, Argonne

Parameters	CARIBU	SPES-LNL
Bending radius	500 mm	1500 mm
Beam Energy	50 keV	260 keV
Magnetic field A=20	2.9 kGauss	**2.2 kGauss**
Magnetic field A=200	9.1 kGauss	6.9 kGauss
Bending angle	60°	90°
Entrance/exit angle	23	28.4°
Pole gap	80 mm	<80 mm
Pole width	620 mm	<640 mm

First order SPES optics

First order simulation: mass resolving power and beam envelope

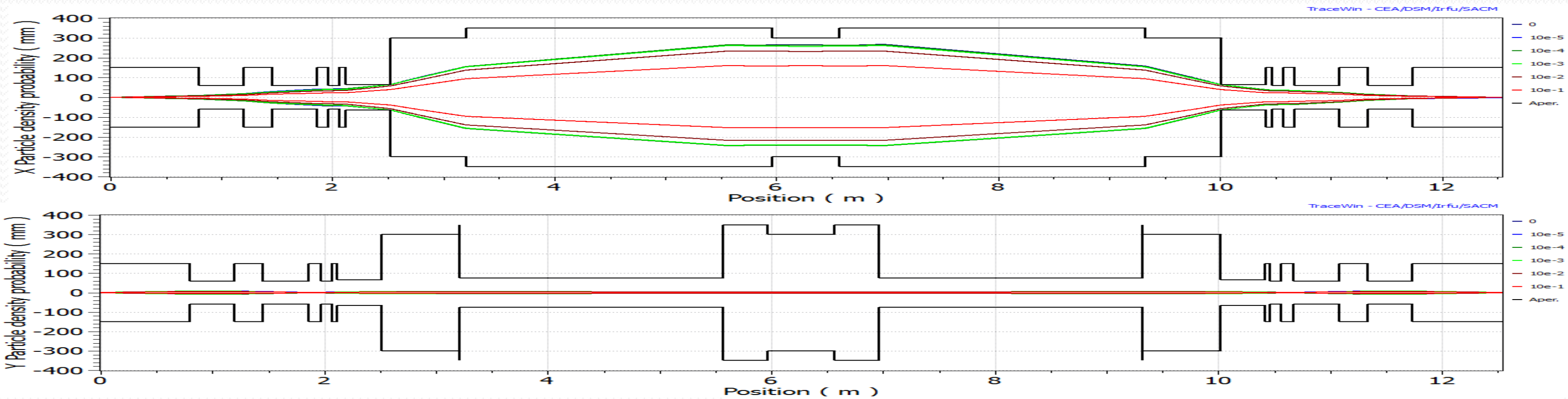


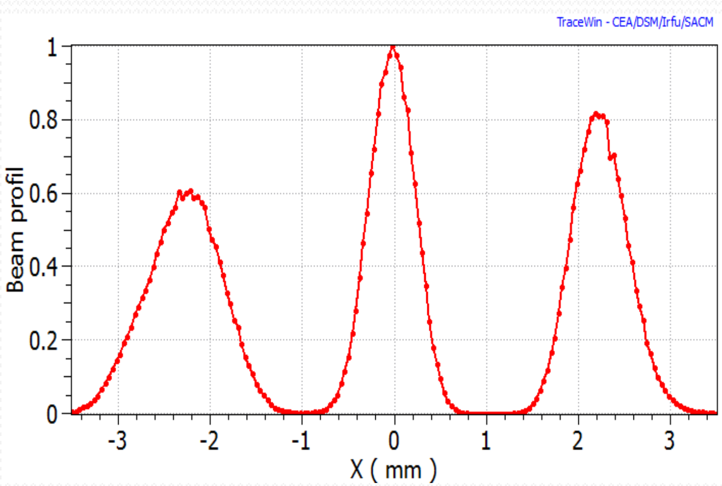
No aberrations included in the calculation

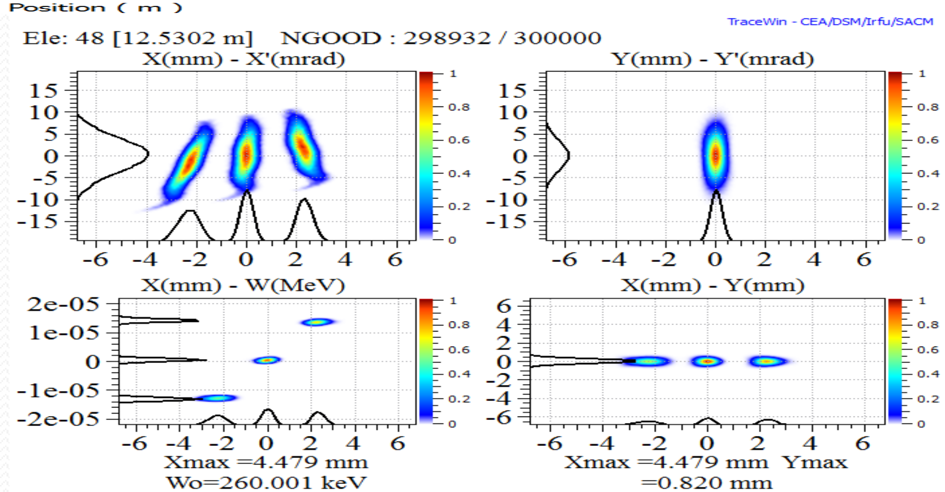
Resolving Power = 95000

Multiparticle simulation

1/20000 in mass



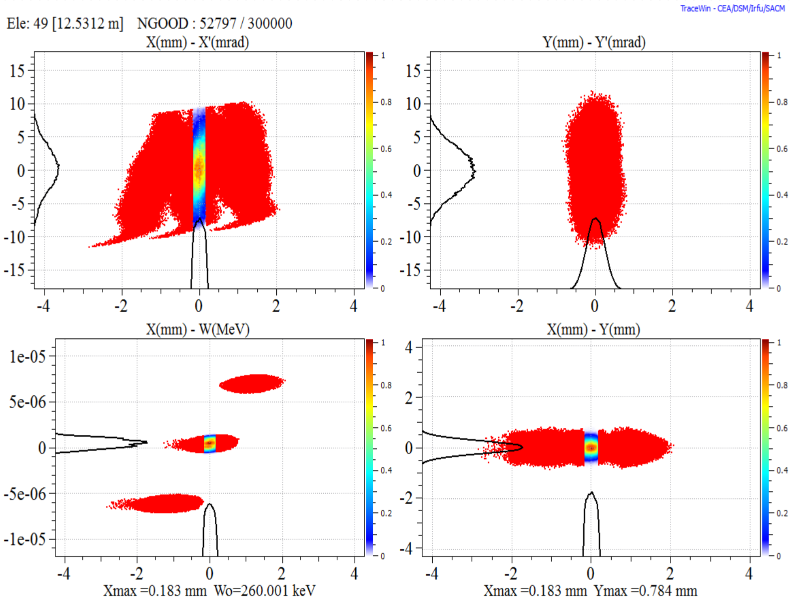




Transverse Gaussian distribution in the phase spaces, truncated at 3 , while uniform in the longitudinal phase space with a 1 ev energy spread

Separation of 1/40000 with 1 eV energy spread

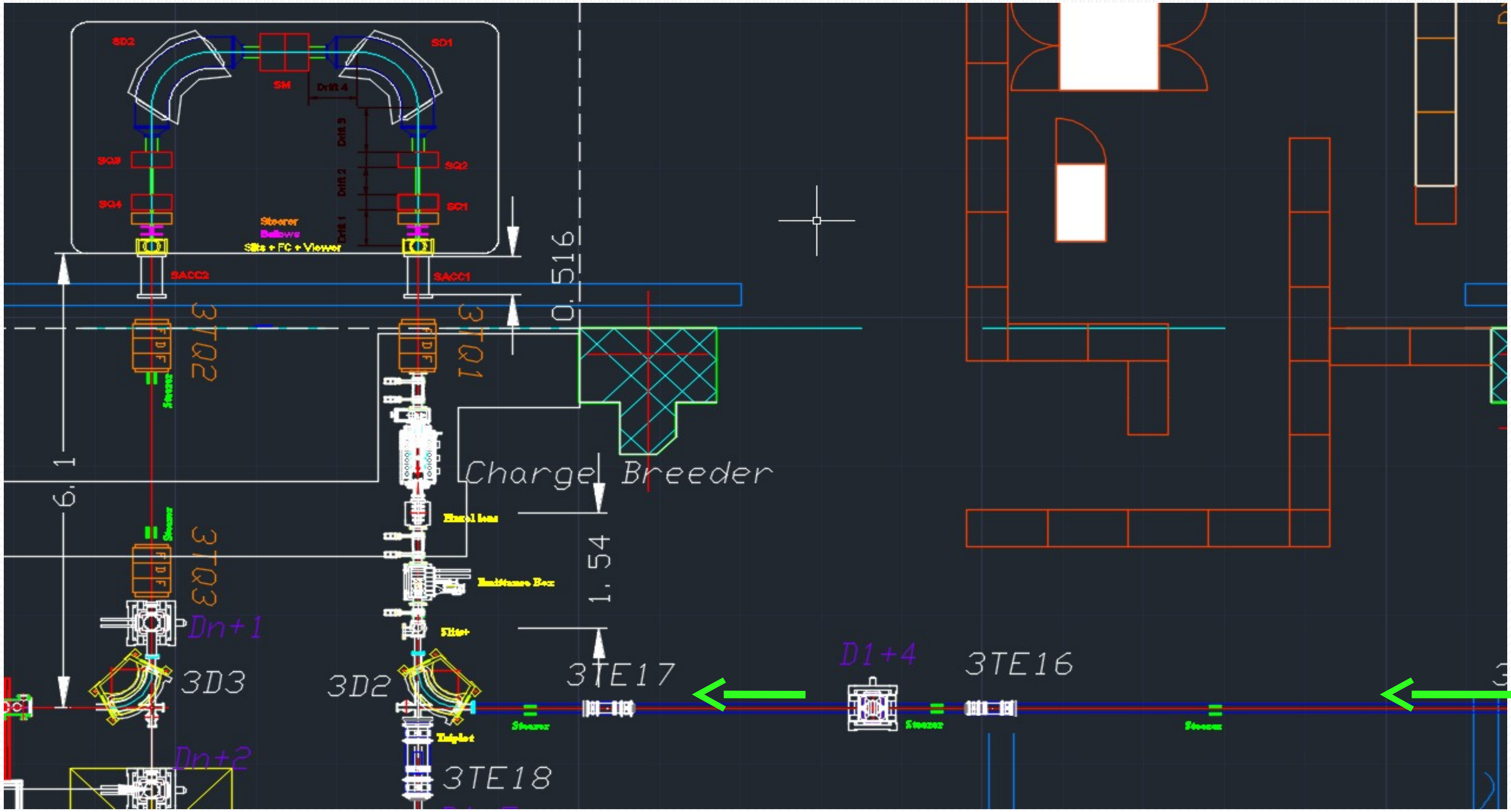
It is possible to obtain a resolution equal to 1/40000 if the slit at the of system will be close. The percentage of nominal beam which assure a clean beam is 53%.



Transmission=53%

Medium Resolution Mass Separator

The beam exit the HRMS is injected in the charge breeder, It increases the beam charge state and some contaminants are introduced.
The MRMS is required to clean up the beam.



Beam

Medium Resolution Mass Separator

Analysis of contaminants introduced by the charge Breeder. Purple cells show the critical resolution value. A resolution of 0.1 % is sufficient.

CONTAMINANTS			element	C	N	N	Ar	Ar	Kr	Kr	Kr	Kr	Kr
			mass	13,003355	14,003074	15,000109	36,967546	39,962383	77,920397	79,916375	81,913483	77,920397	79,916
RADIOACTIVE IONS			charge	2+	2+	2+	5+	6+	11+	11+	11+	12	12
			M/q	6,5016774	7,001537	7,5000545	7,3935091	6,6603972	7,0836725	7,265125	7,4466803	6,4933664	6,6596
element	mass	charge state	M/q	Resolution (%)									
Sn	125,90765	18	6,9948696	7,5856146	-0,095228	-6,735749	-5,39175	5,0218091	-1,253627	-3,7199	-6,067276	7,7233158	5,0328
Sn	126,91036	18	7,0505756	8,442408	0,7003969	-5,993009	-4,638306	5,8581848	-0,467228	-2,953142	-5,319212	8,5812059	5,8692
Sn	127,91054	18	7,1061409	9,2970396	1,4940139	-5,252142	-3,886763	6,6924502	0,317187	-2,188318	-4,573035	9,4369313	6,7036
Sn	128,91348	18	7,16186	10,154035	2,2898256	-4,509227	-3,133142	7,5290228	1,1037713	-1,42138	-3,824795	10,295023	7,5403
Sn	129,91397	18	7,2174426	11,008931	3,0836886	-3,768131	-2,381366	8,3635467	1,8884294	-0,656319	-3,078387	11,151014	8,3749
Sn	130,91198	18	7,2728879	11,861715	3,8755902	-3,028866	-1,631448	9,1960088	2,6711488	0,1068514	-2,333824	12,00489	9,2074
Sn	132,92383	18	7,3846572	13,5808	5,4719444	-1,538619	-0,119725	10,874127	4,2489933	1,6452879	-0,832895	13,726175	10,885
Sn	133,92829	18	7,4404606	14,439091	6,2689599	-0,79458	0,6350359	11,711965	5,0367673	2,4133866	-0,083523	14,585564	11,723
Sn	131,91782	18	7,3287676	12,721181	4,6736959	-2,283809	-0,875654	10,034993	3,4600005	0,8760008	-1,583427	12,865455	10,046
Sn	125,90765	19	6,6267186	1,9232138	-5,353374	-11,64439	-10,37113	-0,505655	-6,450805	-8,787274	-11,0111	2,0536676	-0,495
Sn	126,91036	19	6,6794926	2,7349129	-4,599624	-10,94075	-9,657342	0,2867014	-5,705795	-8,060871	-10,30241	2,8664056	0,2972
Sn	128,91348	19	6,78492	4,3564539	-3,093849	-9,535057	-8,231397	1,8696005	-4,21748	-6,609728	-8,886648	4,490022	1,8802
Sn	129,91397	19	6,8375772	5,1663558	-2,341769	-8,832966	-7,519189	2,6602022	-3,474119	-5,884934	-8,179525	5,3009606	2,6709
Sn	130,91198	19	6,8901043	5,9742567	-1,591546	-8,13261	-6,80874	3,4488504	-2,732596	-5,16193	-7,474149	6,1098955	3,4597
Sn	131,91782	19	6,9430429	6,788487	-0,835446	-7,426767	-6,092725	12,68873	-10,89569	-1,985263	-4,433262	-6,763246	-7,888
Sn	132,92383	19	6,9959911	7,6028631	-0,079211	-6,720797	-5,376582	5,0386466	-1,237796	-3,704464	-6,052217	7,7405864	5,0496
Sn	133,92829	19	7,0488574	8,4159812	0,6758567	-6,015918	-4,661545	5,8323877	-0,491484	-2,976792	-5,342285	8,5547452	5,8435
Sn	128,91348	20	6,445674	-0,861369	-7,939157	-14,0583	-12,81983	-3,22388	-9,006606	-11,27924	-13,44232	-0,734479	-3,213
Sn	129,91397	20	6,4956984	-0,091962	-7,22468	-13,39132	-12,14323	-2,472808	-8,300414	-10,59069	-12,77055	0,0359125	-2,462
Sn	130,91198	20	6,5455991	0,6755438	-6,511969	-12,72598	-11,4683	-1,723592	-7,595966	-9,903834	-12,10044	0,8044007	-1,713
Sn	132,92383	20	6,6461915	2,2227199	-5,07525	-11,38476	-10,10775	-0,213286	-6,175906	-8,519241	-10,74961	2,3535571	-0,202
Sn	133,92829	20	6,6964145	2,9951821	-4,357936	-10,71512	-9,428468	0,5407684	-5,466909	-7,827952	-10,07517	3,1270079	0,5513
Sn	131,91782	20	6,5958908	1,4490627	-5,793674	-12,05543	-10,78809	-0,968507	-6,886	-9,211599	-11,42508	1,5789096	-0,958
Sn	125,90765	21	5,9956025	-7,783759	-14,36734	-20,05921	-18,90721	-9,981306	-15,36025	-17,4742	-19,48624	-7,665729	-9,971
Sn	126,91036	21	6,0433505	-7,049365	-13,68537	-19,42258	-18,26141	-9,264413	-14,6862	-16,81698	-18,84504	-6,930395	-9,254
Sn	127,91054	21	6,090978	-6,316823	-13,00513	-18,78755	-17,61723	-8,549328	-14,01384	-16,16142	-18,20546	-6,196916	-8,539

Nominal beam

Courtesy of Alessio Galatà

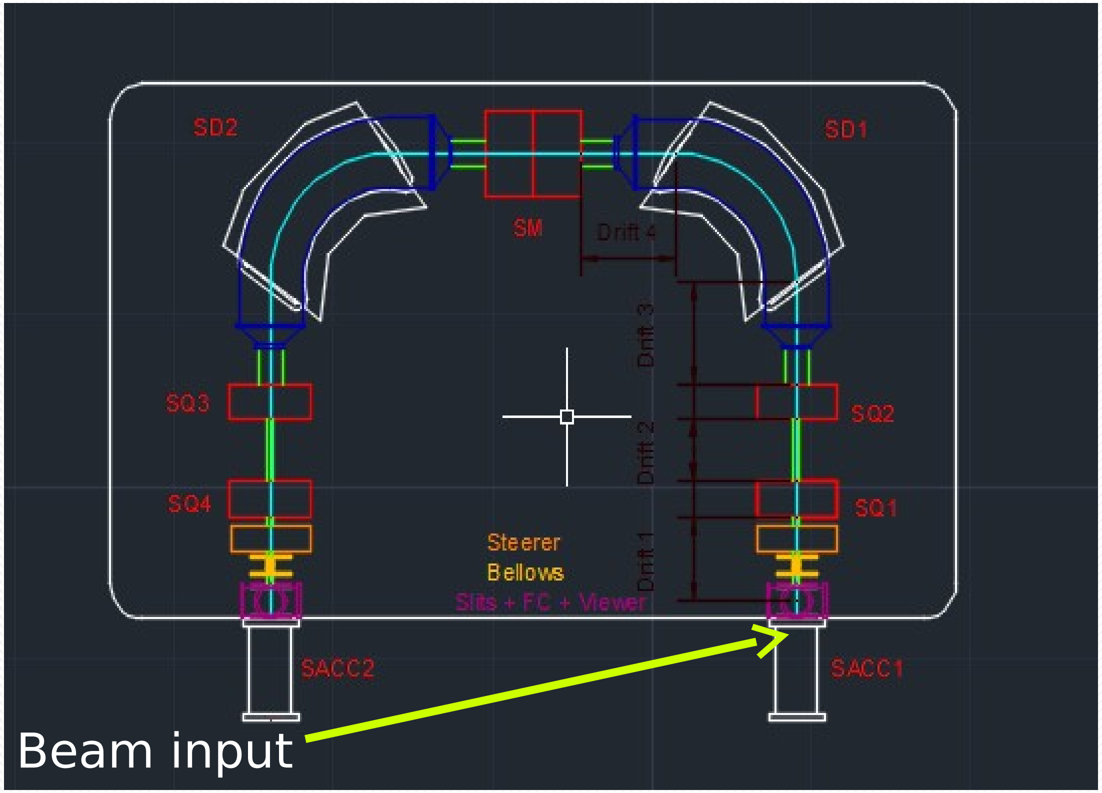
Medium Resolution Mass Separator

Characteristics of the nominal beam at the entrance of the platform

MRMS Project requirement — Mass resolving power 0.1%

Nominal beam => 132Sn19+@3.04 Mev (40KV+120KV , extraction + platform voltage);
Norm. Emittance in x-x'=0.1 π*mm*mrad;
Norm. Emittance in y-y'=0.1 π*mm*mrad;

Parameters	
Bending radius	750 mm
Beam Energy	3.04 MeV
Magnetic field A=132 q=19+	2 kGauss
Bending angle	90°
Entrance/exit angle	33,35°
Pole gap	70 mm
Pole width	400 mm



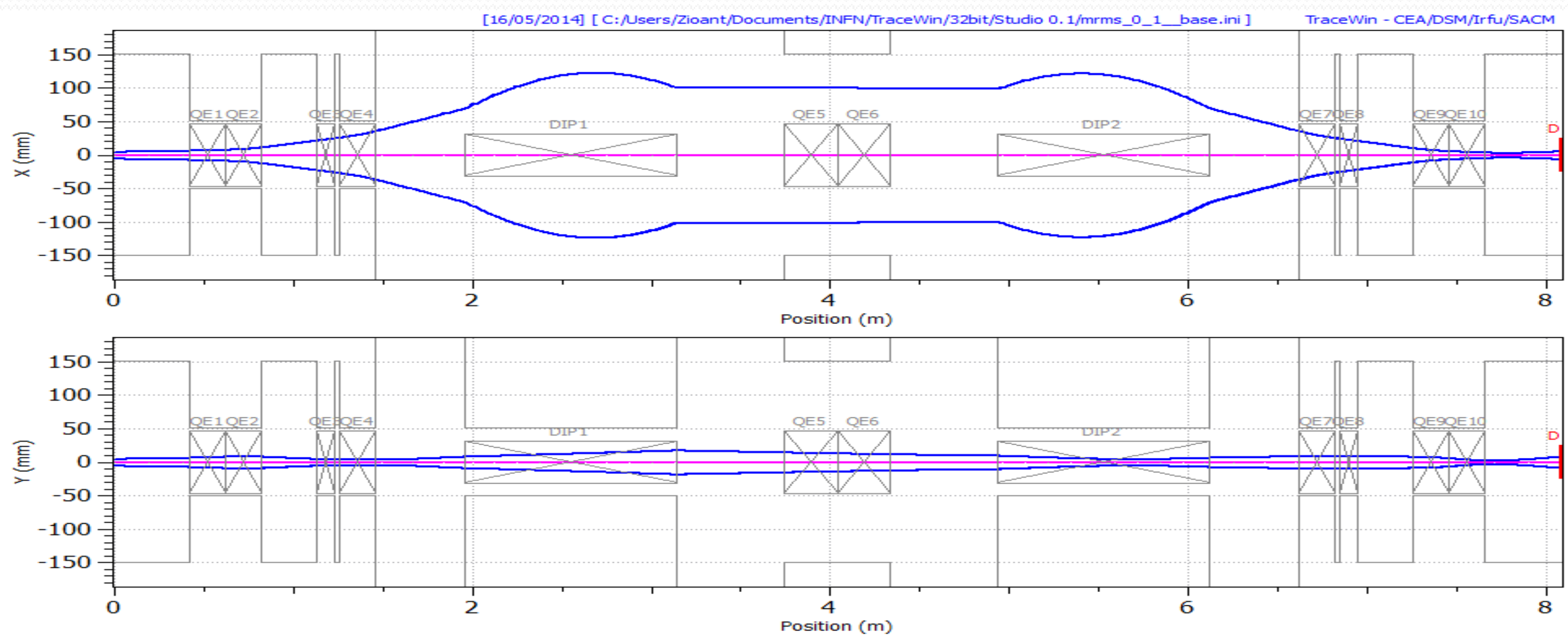
Medium Resolution Mass Separator

Longitudinal beam dynamics

First order simulation: mass resolving power and beam envelope

$$\frac{\Delta p}{p} = \left|\frac{2X_0 M_{11}}{M_{16}}\right| \cong \frac{1}{4400}\% = 0.022\% \Rightarrow \frac{\Delta M}{M} \cong \frac{1}{2200}$$

In FWHM



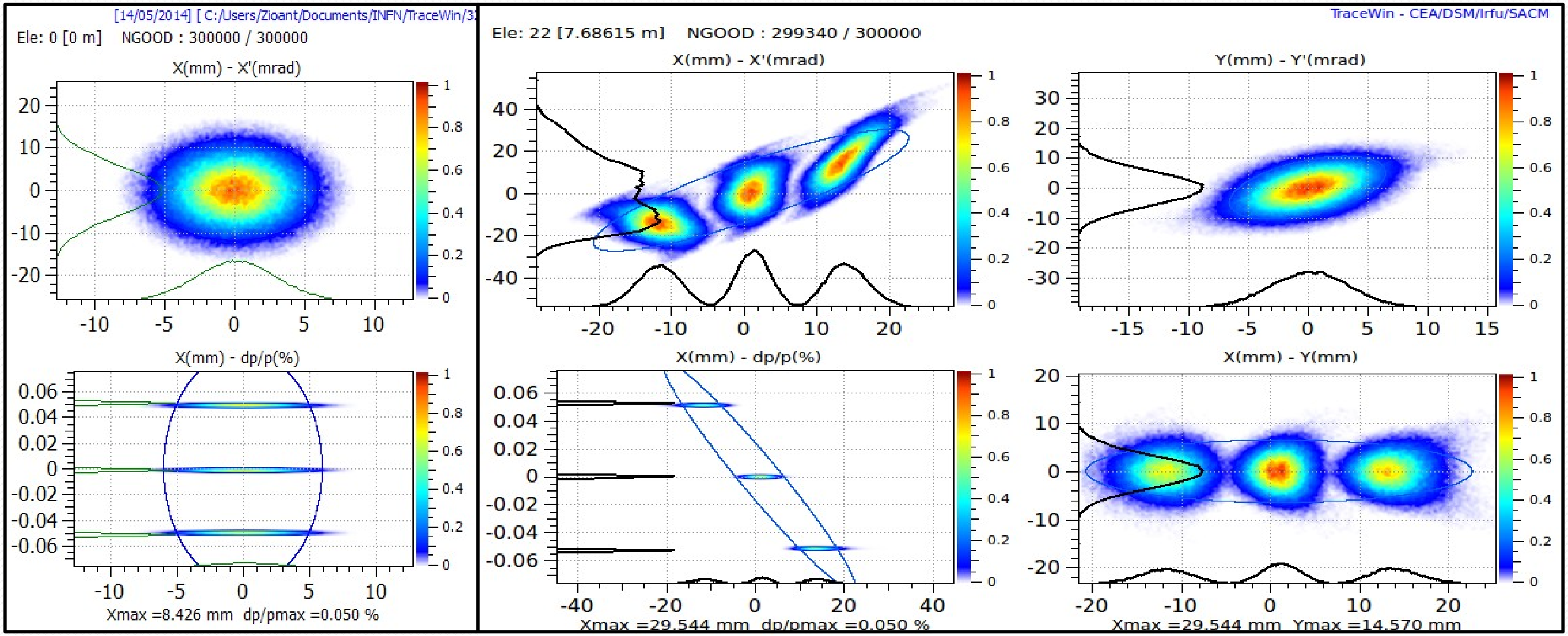
Resolving power

Transverse beam dynamics

Simulation of a beam with ΔM/M= 0.1%

Input

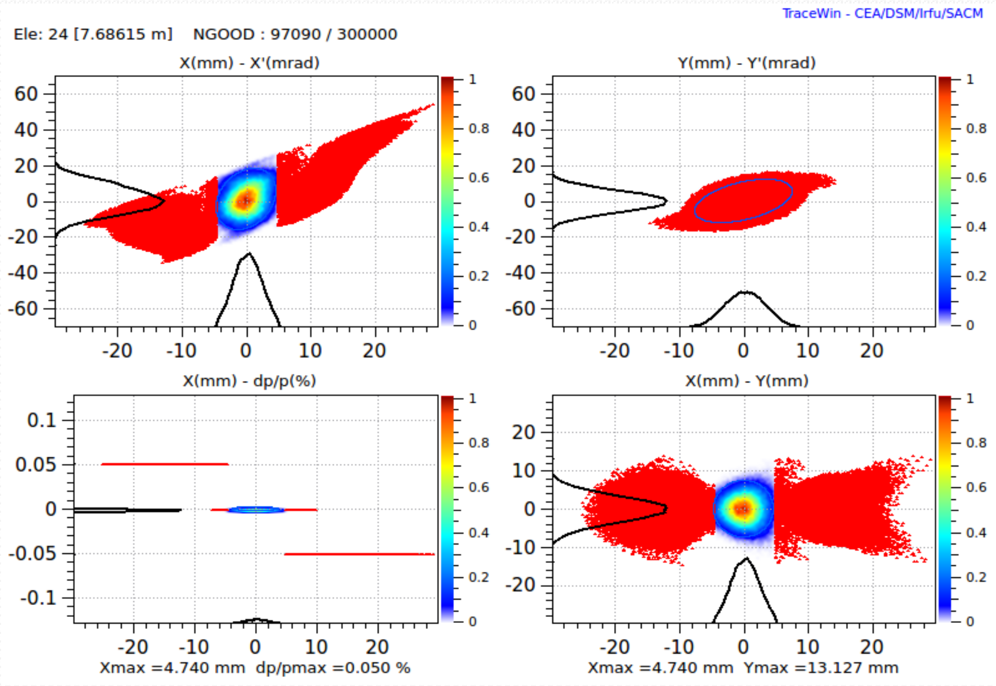
Output



Resolving power >1/1000

Resolving power

Transverse beam dynamics



Using a slit size equal to the 94 % of maximum beam size the particles loss are 1 %

Contaminants with $\Delta M/M=\pm 1/1000$ are ≈ 0% of the selected beam

Conclusions

- **MRMS Dipoles are commissioning;**
- **The study and design of MRMS was preparatory to the HRMS study;**
- **This kind of system are very sensitive to external variable, the errors study has been done, we are confident about the separator.**