ECRIS12 - Sydney, Australia

LPSC PHOENIX ECR CHARGE BREEDER BEAM OPTICS AND EFFICIENCIES

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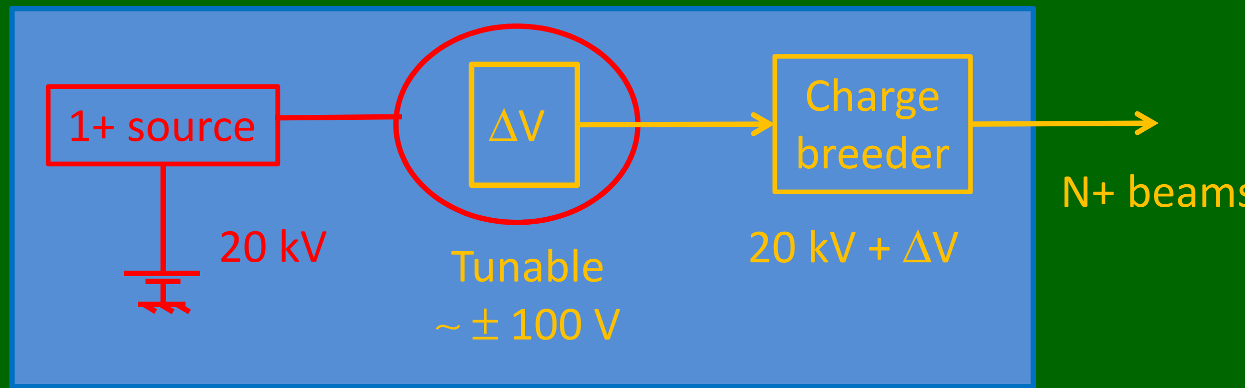
Outline

1. Charge breeders characteristics (LPSC, ANL)
2. LPSC Beam line problem
3. Simulation and technical treatment
4. Benefits of the treatment
5. One question

A few fundamental characteristics

Charge breeder General scheme



N+ intensities ΔV curves

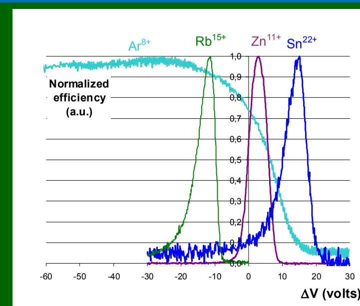


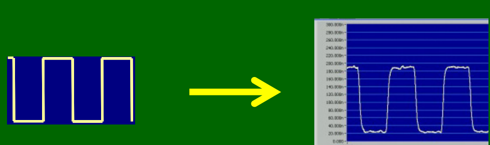
Image of the capture

What we measure

Efficiency : Nb. of ions of a specific charge state relatively to the nb. of 1+ ions injected

Global yield : image of the 1+ beam capture, sum of individual efficiencies

Charge breeding times : How long it takes for a n+ beam to reach its maximum after a 1+ injection



Comparison between ANL and LPSC charge breeders

Laboratory	Ion	Yield (%)	Global yield (%)
ANL	$^{129}Xe^{25+}$	13.4	64
LPSC	$^{132}Xe^{18+}$	6.31	n.c.
ANL	$^{85}Rb^{19+}$	13.7	77
LPSC	$^{85}Rb^{15+}$	6.5	32

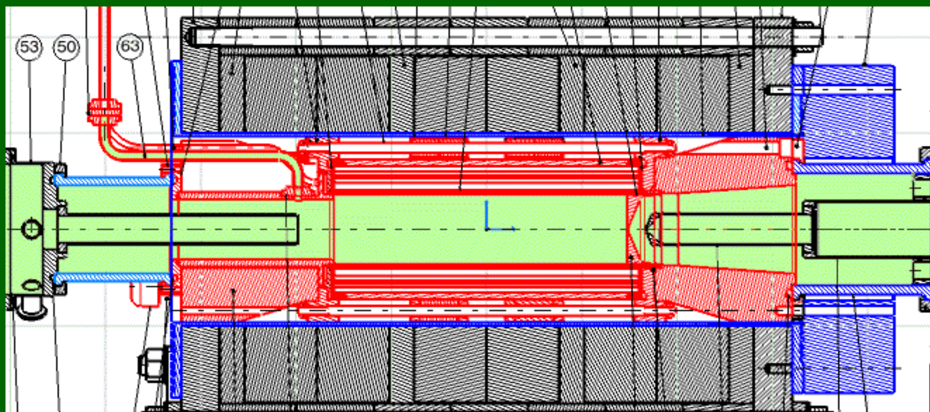
Charge breeding times : lack of systematic data

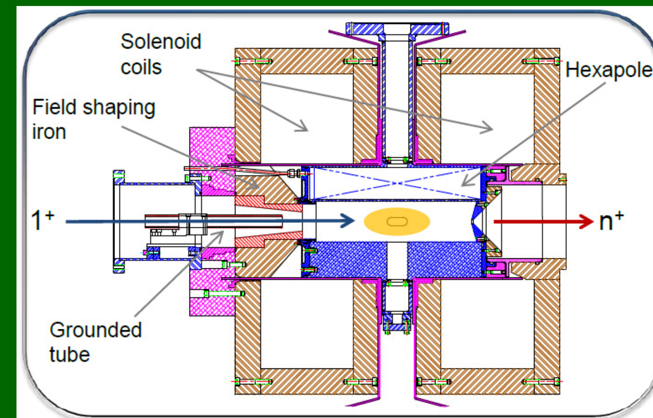
Significant (enormous !) difference in the yields (200 %),why ?

Can we scientifically explain such differences ?

What are the schemes for these two charge breeders ?

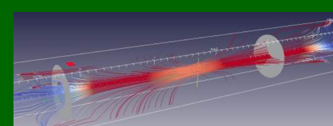
Fundamental parameters





Initial LPSC charge breeder

ANL charge breeder
Movable transfer tube



B_{inj} = 1.21T **(too low !)**
B_{min} = 0.42T
B_{ext} = 0.82T

Similar magnetic fields

B_{inj} = 1.16 T
B_{min} = 0.27 T
B_{ext} = 0.83T.

14 or 18 GHz, 2 kW
Sum of the two

Different HF frequencies
Frequency mixing
Good at ANL
Not efficient at LPSC

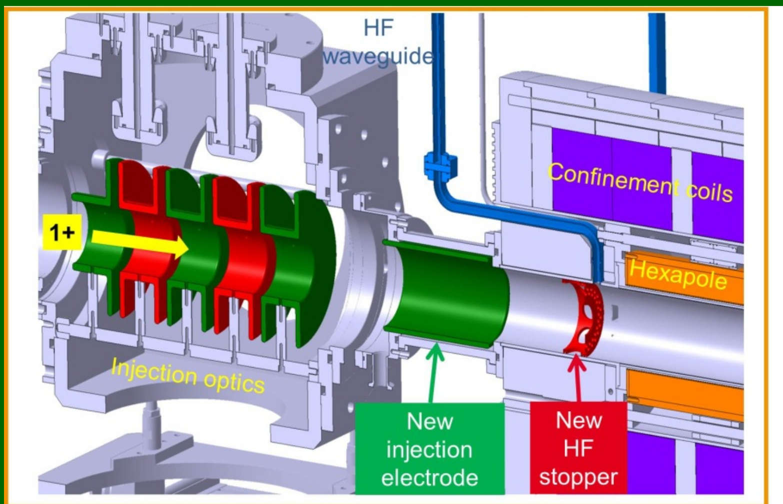
10.44 GHz, 2 kW
11 to 13 GHz, 0.5 kW

$6x10^{-7}$ mbar

One decade better at ANL

$7x10^{-8}$ mbar

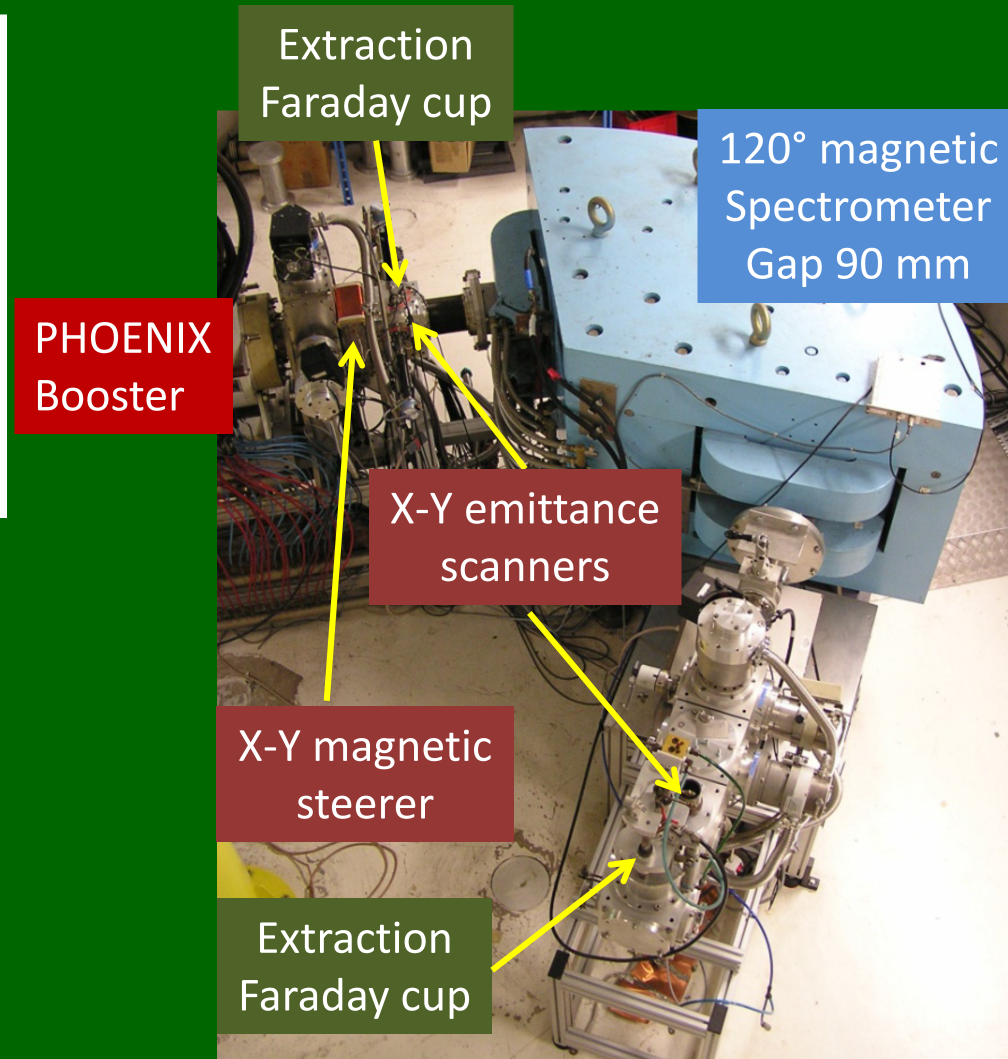
Last LPSC improvement



	Rb^{15+} yield (%)	P_{hf} (W)
Before	3.6	634
After	6.5	365

- ✓ **Higher efficiency**
- ✓ **Better HF coupling**
- ✓ **Better stability**

Beam line

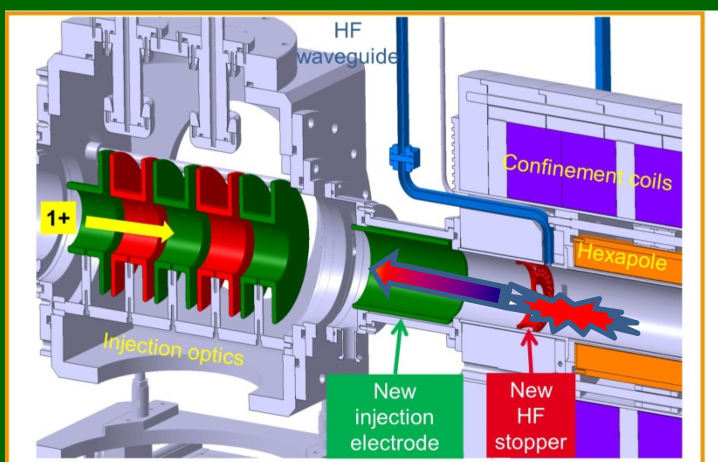


Problematics

A too high high voltage drain current with respect to the sum of the n+ beams analyzed by the spectrometer

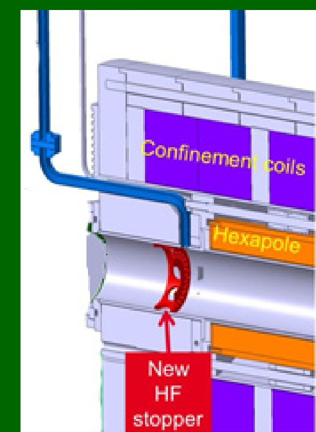
Looking for the origin of this current

- 1+ source ? — Disconnected, current still too high
- Electrons produced at the extraction ?
- Excessive plasma leak at the opened injection side ?



Never accurately measured

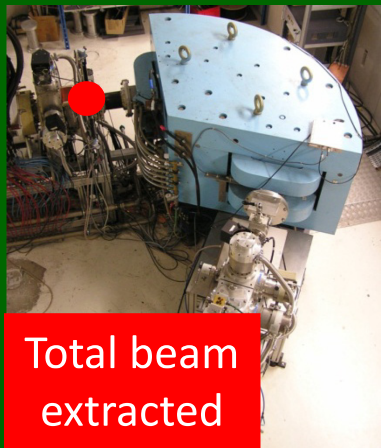
To get rid of it:
Close the charge breeder

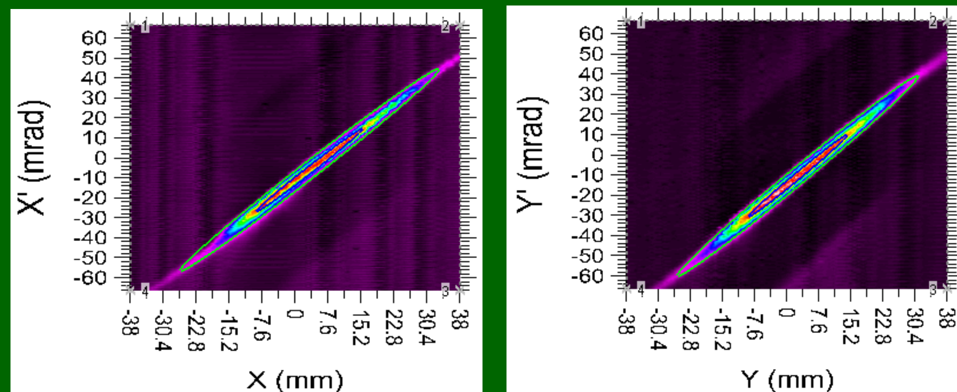


Transmission problem between the ion extraction and the n+ faraday cup ?

$$T_{glob} = \frac{\sum_i I_i}{I_{HV}} = 0.32$$!!, but booster not high charge states optimized

Extracted beam characterization

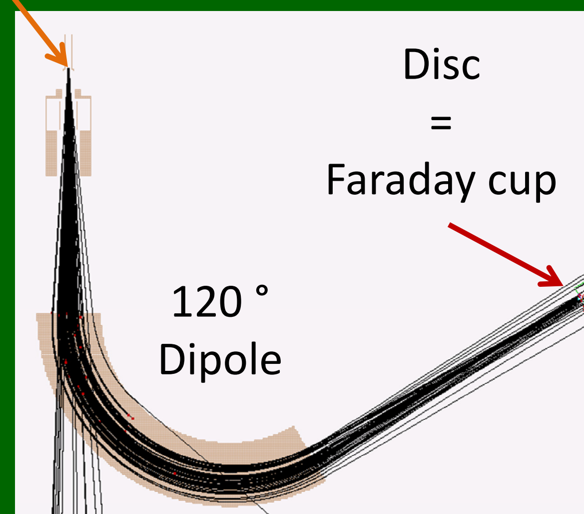




Horizontal and vertical emittances
25 π.mm.mrad (RMS)

Allow trajectories simulations with realistic data (for O^{3+})
SIMION

39 % *of the ions reach the disc*
Ttr = 0.39

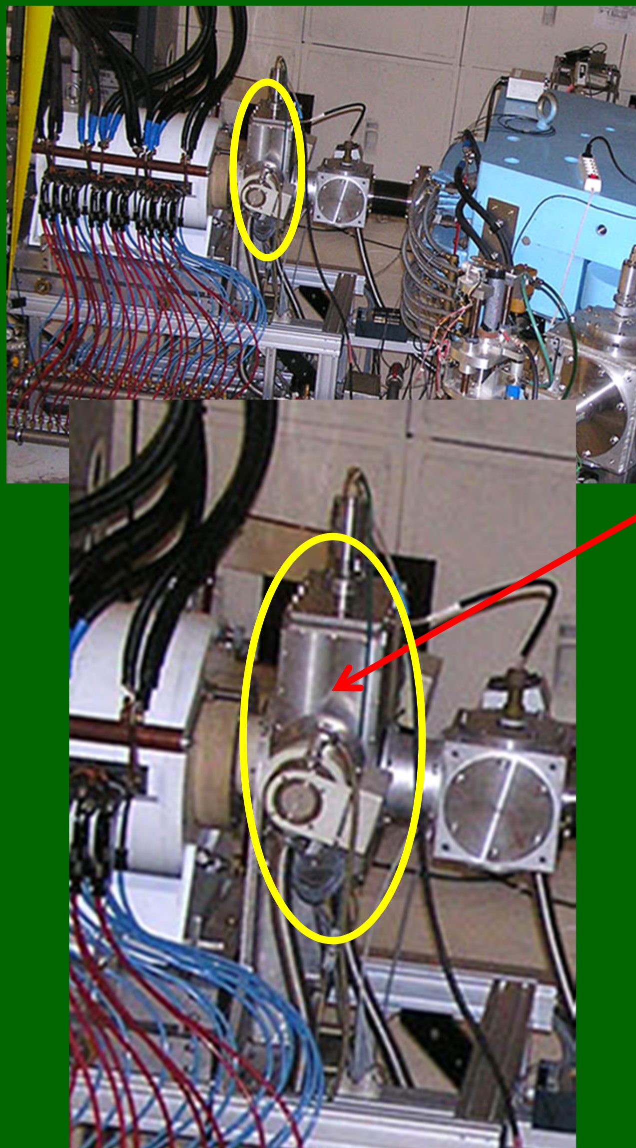


The simulation gives a result very close to the measurement

Most of the ions are lost in the vertical plane of the dipole

Nota:
The ***TRANSPORT*** code gave the same result

Improve the transmission of the beam line...!

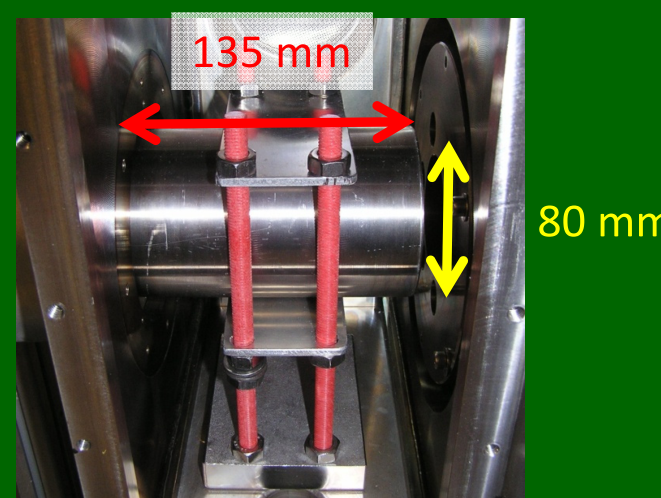


Where to put a Glazer lens... ?
With another power supply...

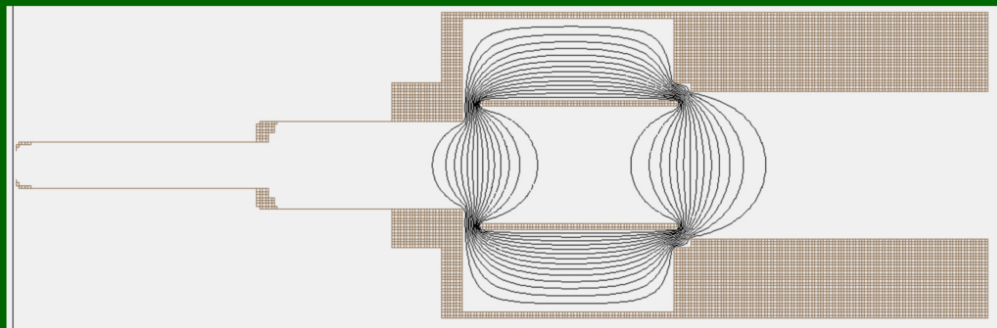
Let's try an Einzel lens...
Why not here ?

And we have a tube of the right size...

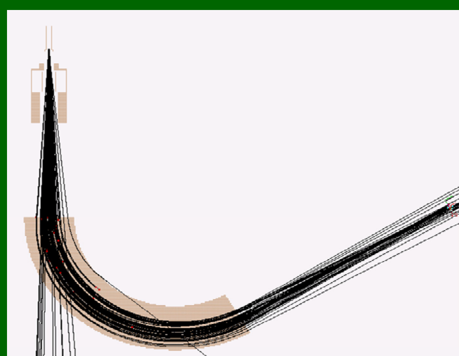
Uhhhmm...

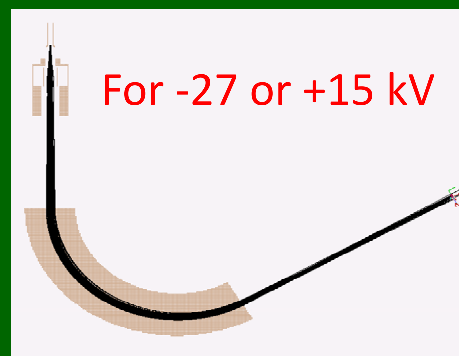


SIMION simulation of the « Einzel lens » effect

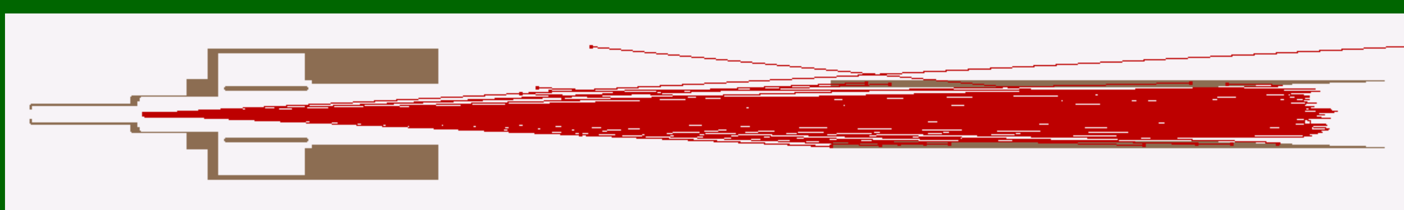


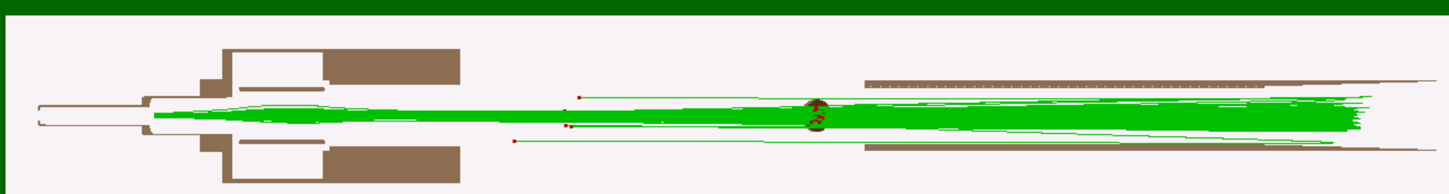
OK,
It’s not a perfect Einzel lens...
It will have to be improved,
But...



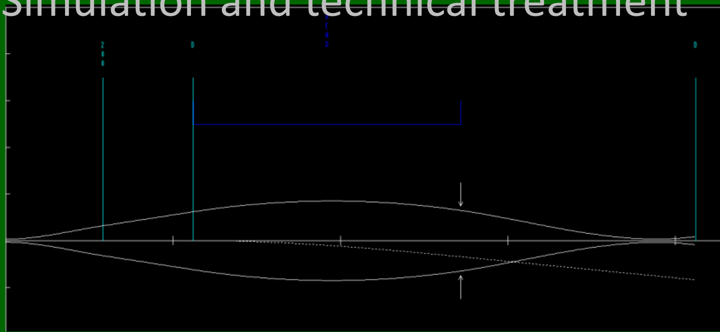


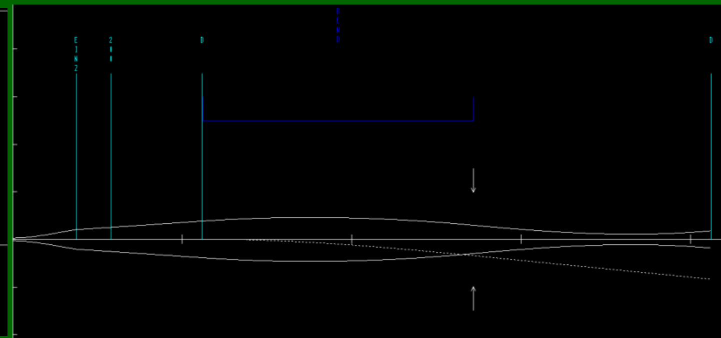
$$T_{tr} = \frac{\sum_i I_i}{I_{axis}} = 0.97$$



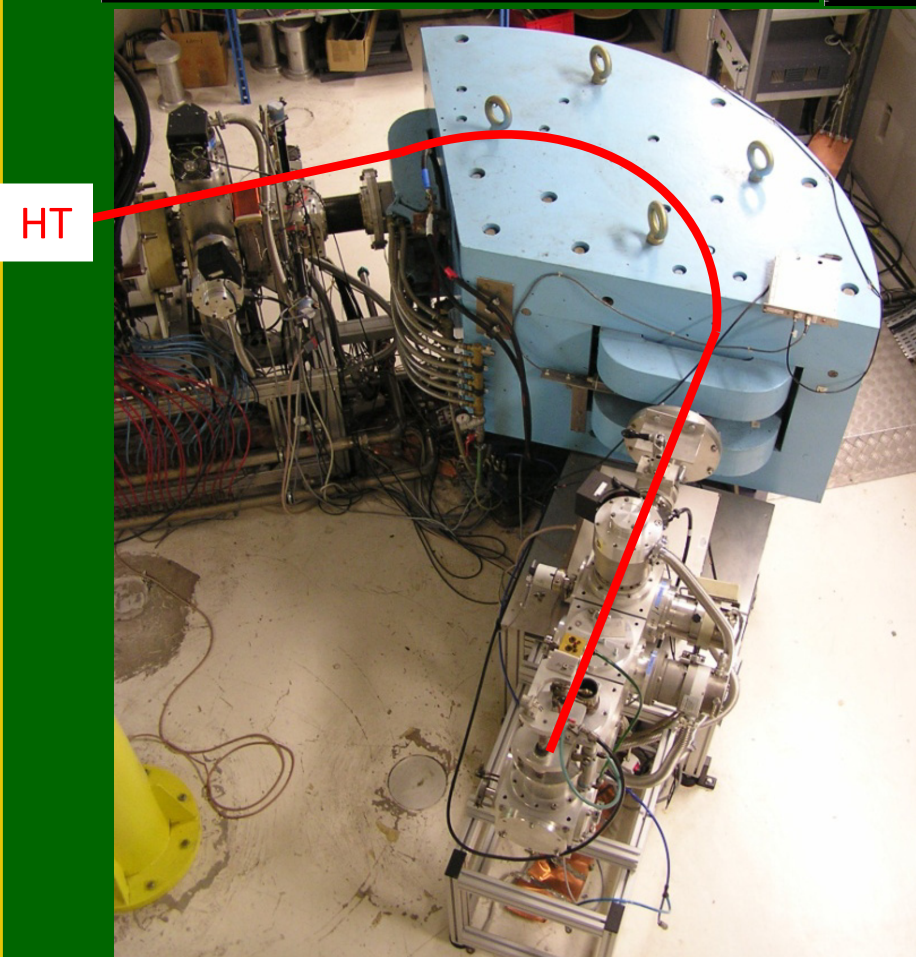


3. Simulation and technical treatment





TRANSPORT Code Same trend



In the real world

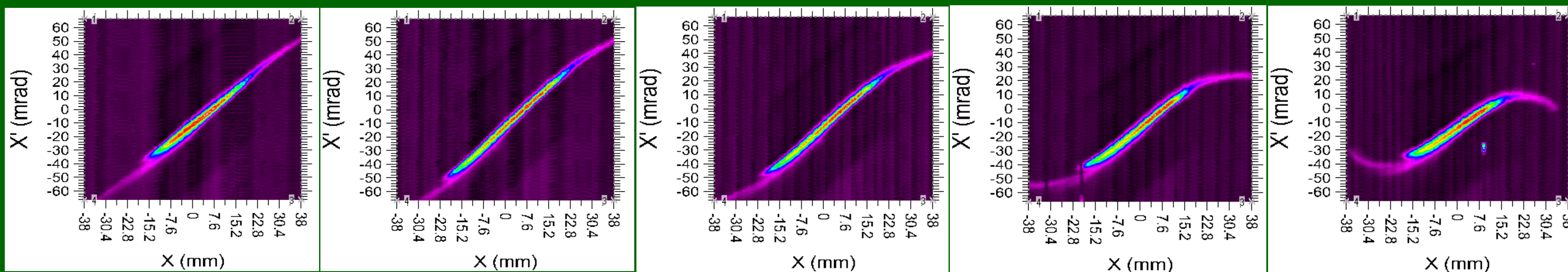
$$T_{glob} = \frac{\sum_i I_i}{I_{HV}} = 0.75$$

$+$ *steerer magnétique* : 0.82

Automated steerer : 0.84

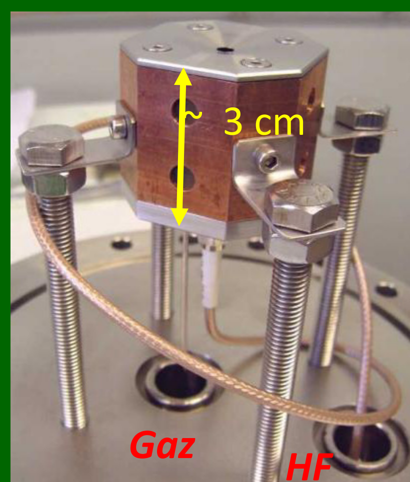
$$T_{tr} = \frac{\sum_i I_i}{I_{axis}} = 0.92$$

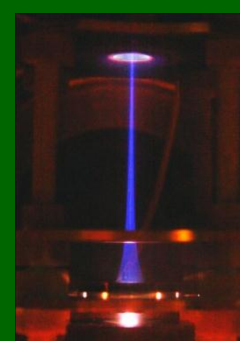
Einzel lens effect : total beam emittances



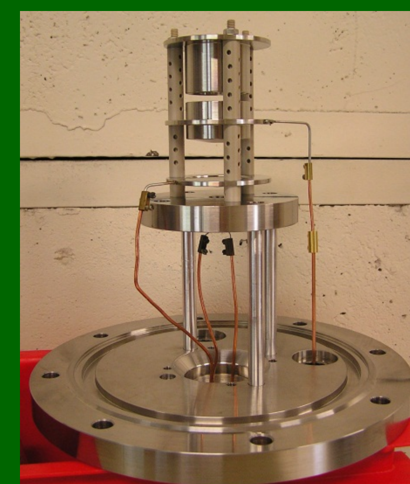
Charge breeding efficiencies after the treatment

Ion sources for 1+ beams



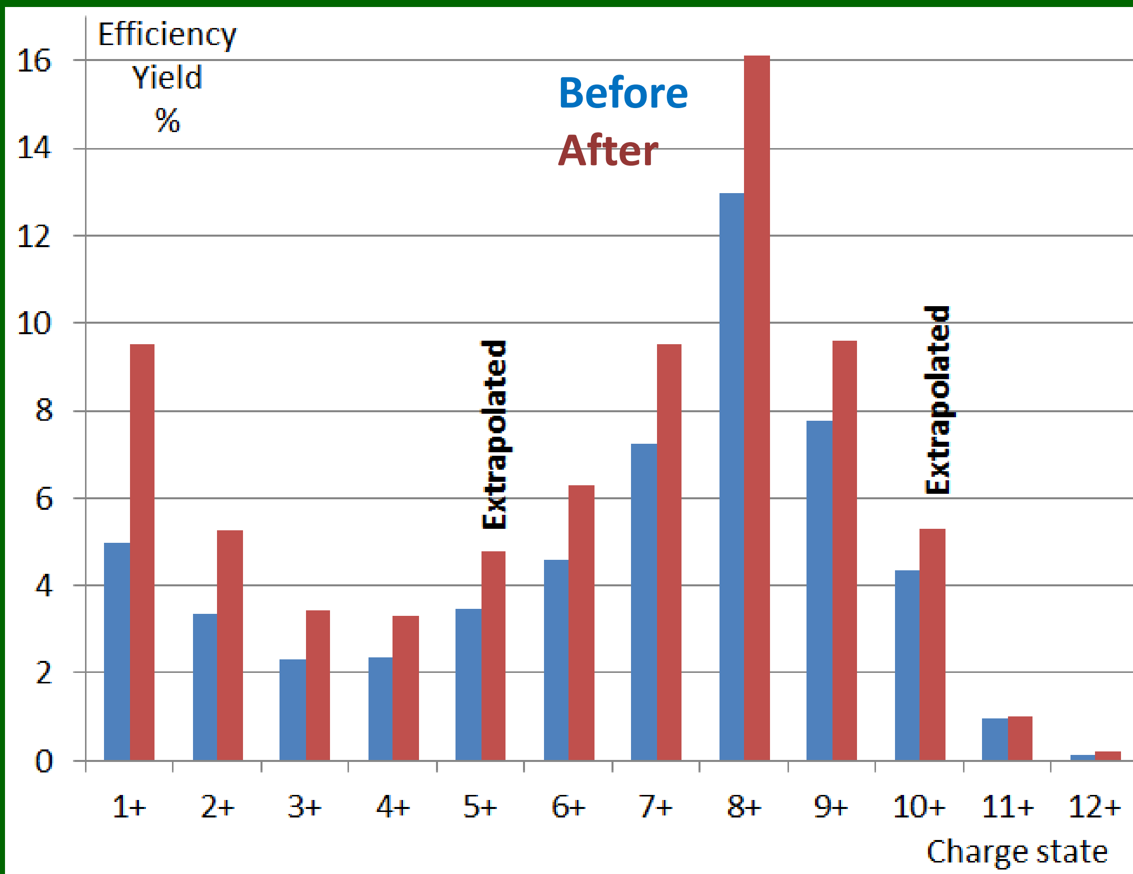


1 µA argon or Xe
COMIC source



300 nA Rb
Heatwave gun (Loan P. Jardin GANIL)
J. Angot LPSC optics

Gaseous ion beams charge breeding



$Ar^{1+} \rightarrow Ar^{8+}$ 16.2%
17% increase

Charge breeding time 78ms
(about 10ms per charge)

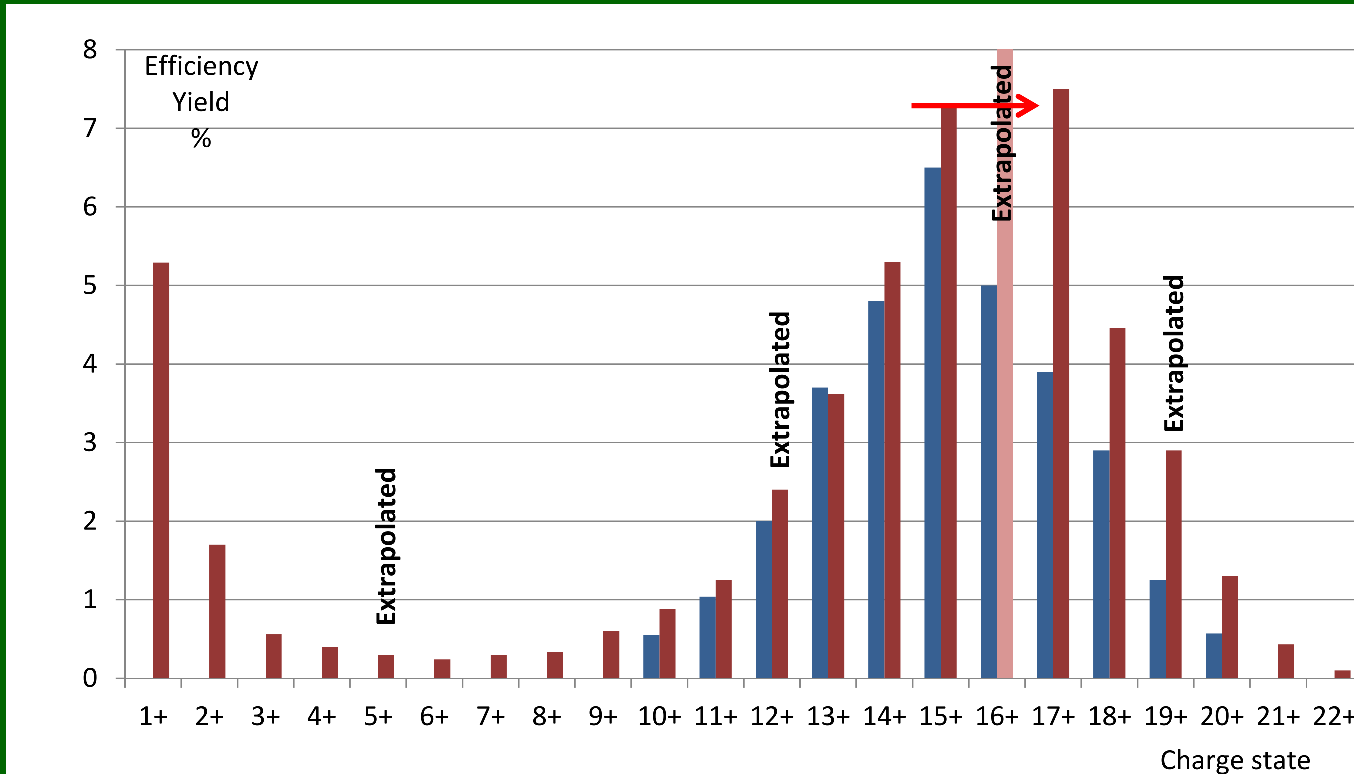
Global capture 75%

$^{132}Xe+ \rightarrow {}^{132}Xe^{20+}$ 10.9%

Charge breeding time 252ms (Xe^{21+})
(about 12 ms per charge).

Global capture 80%

Rubidium ion beam charge breeding



$^{85}Rb^{+} \rightarrow {}^{85}Rb^{17+}$ 7.5% (16+ 8% ?)

Charge breeding time 226 ms
(about 13 ms per charge)

Global capture about 55%

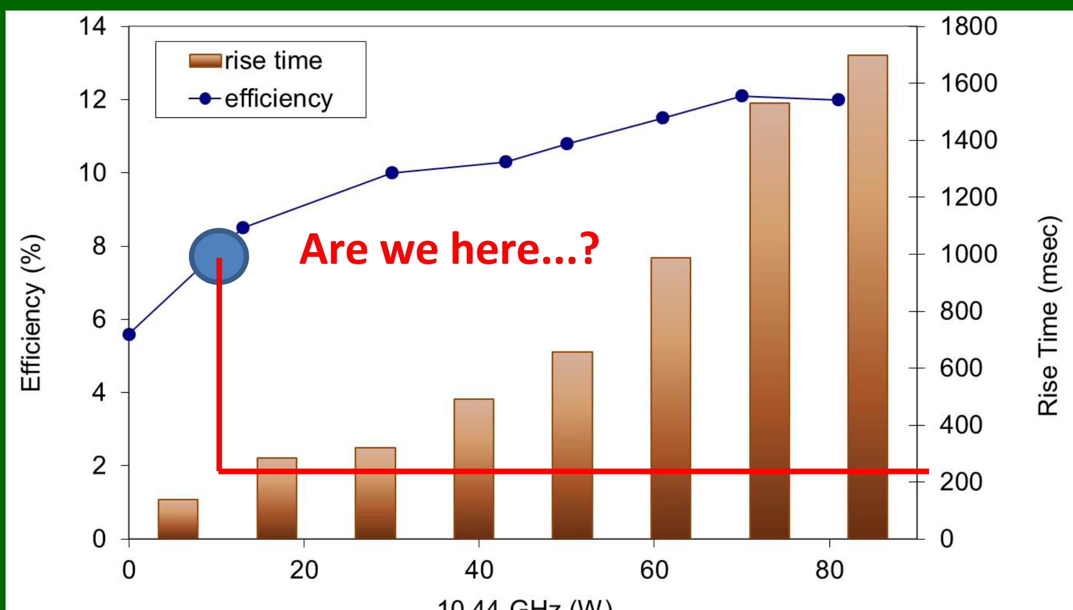
Mixed effect
better transmission
And better vacuuma

Conclusions

We improved the **measured** efficiency of 15 % for gases and alkali

For background and impurities, ECRIS people are still dirty ones

I still dream of a 10^{-9} mbar ECRIS where we could accurately master the pressure and the cleanliness
At least, better vacuum should shift the CSD and may improve the efficiencies (sharpness)



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