Charge Breeder

OVERVIEW

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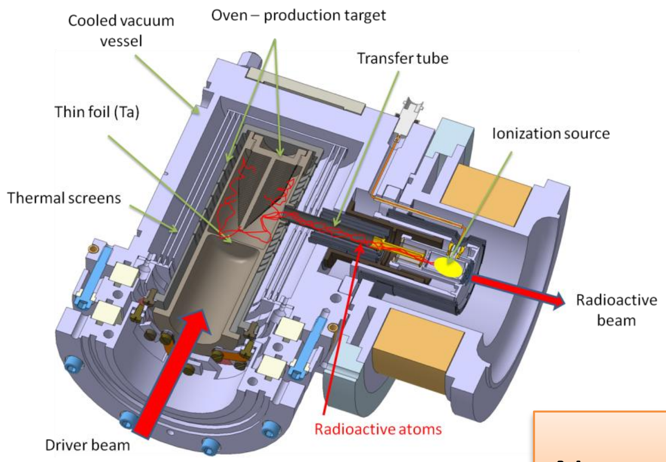
OUTLINE

1 – Why a charge breeder?
2 – Charge breeder modifications
2 – Tests at LPSC Grenoble
- Ar gas
- Kr gas
- Alkali elements
- Pressure influence
- 1+ beam intensity influence
- Transmission through the charge breeder
- Sum up of our results

laboratoire commun CEA/DSM CNRS/IN2P3

Charge breeder WHY?



Low Energy Experiment

New radioactive ion beams but **1+**

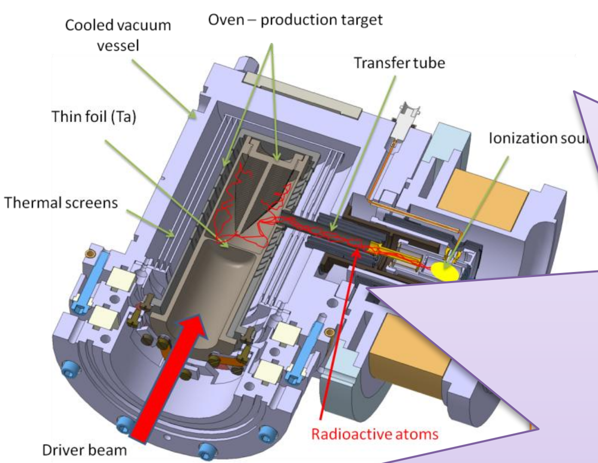
1+

Magic box

N+

High Energy Experiment

Charge breeder WHY?



Magic box

=

Charge breeder

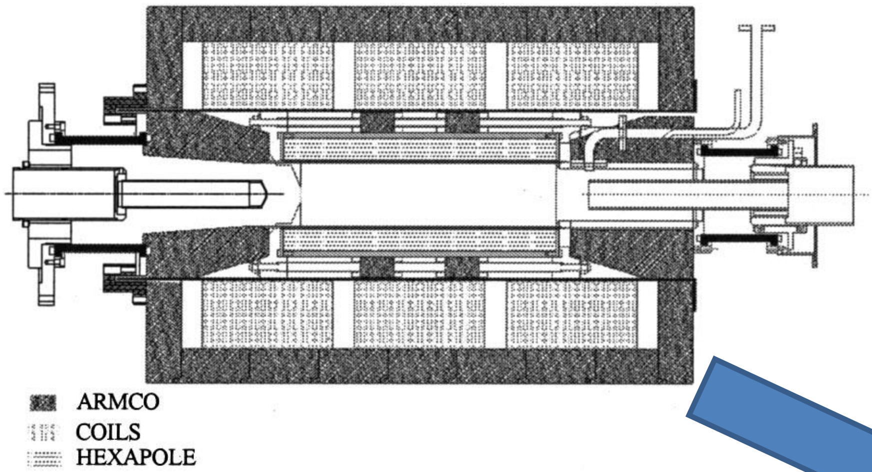
1+

Magic box

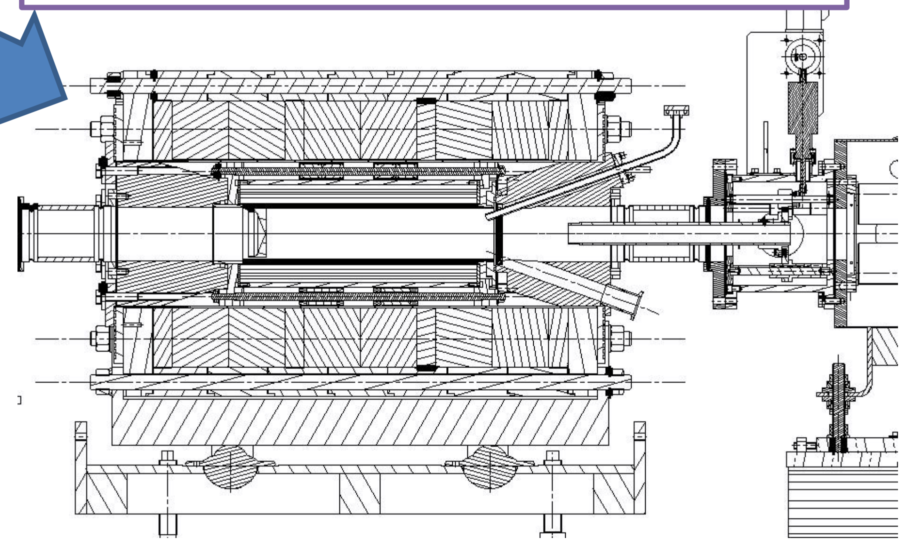
N+

High Energy Experiment

Based on Phoenix booster



- ✓ Two RF ports 14.5 GHz and 8-18 GHz
- ✓ New design of gas and RF injection
- ✓ Symetrisation of the iron plug
- ✓ Movable deceleration tube
- ✓ Plasma chamber made of Al
- ✓ Nickel coating of the iron plug

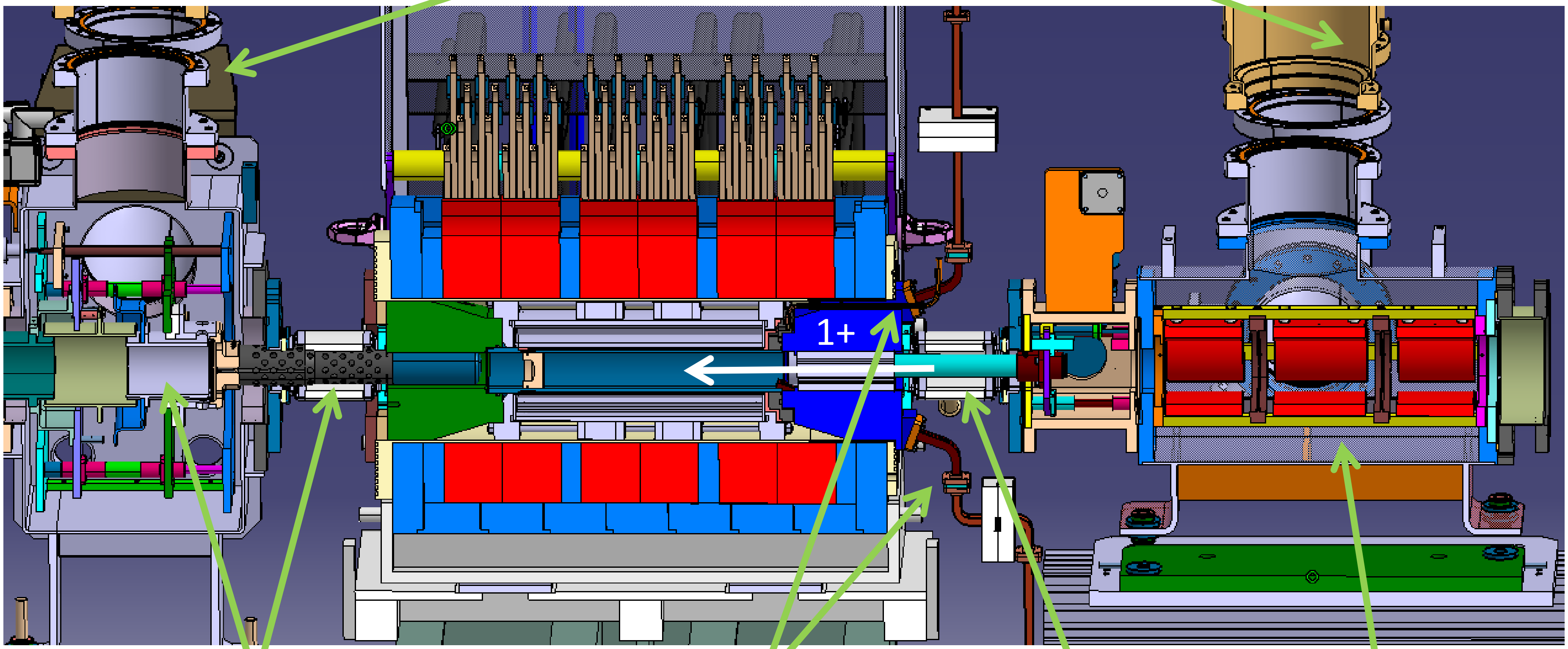


Improvement of our charge breeder according to the feedback of EMILIE collaboration

The research leading to these results has received funding from the European Union's Seventh Framework Programme under grant agreement n°262010

More modifications…

More pumping speed => 3000 l/S



Mobile puller & electrostatic lens

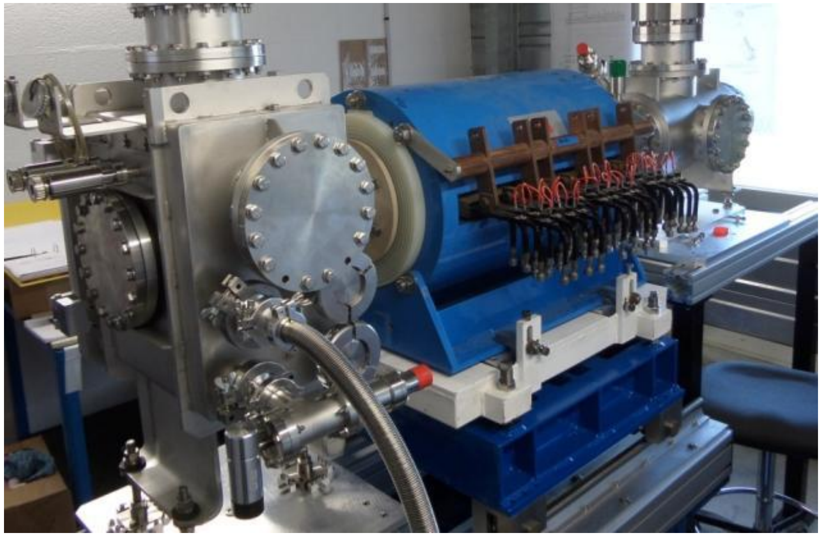
HF : 14,5GHz + 8/18GHz

Mobile Ground tube

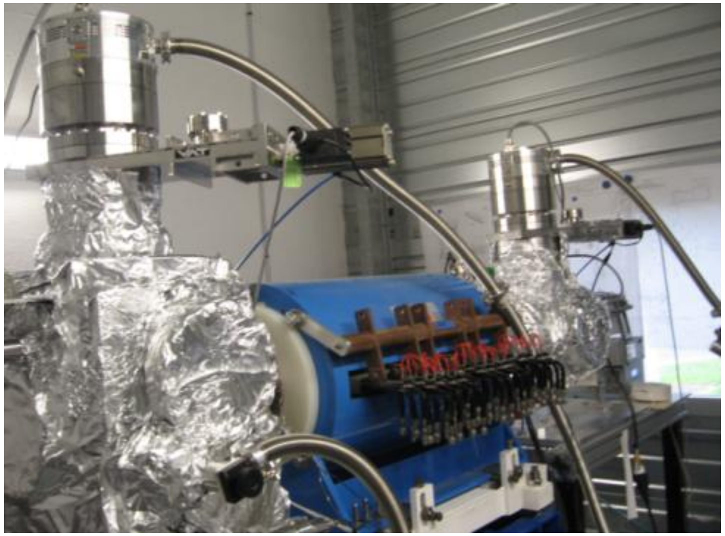
Electrostatic QPole Focussing/steering

Vacuum pressure tests - GANIL

Mechanical assembly at GANIL

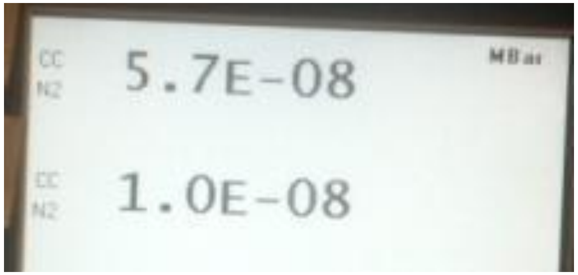


UHV Baking



Extraction side

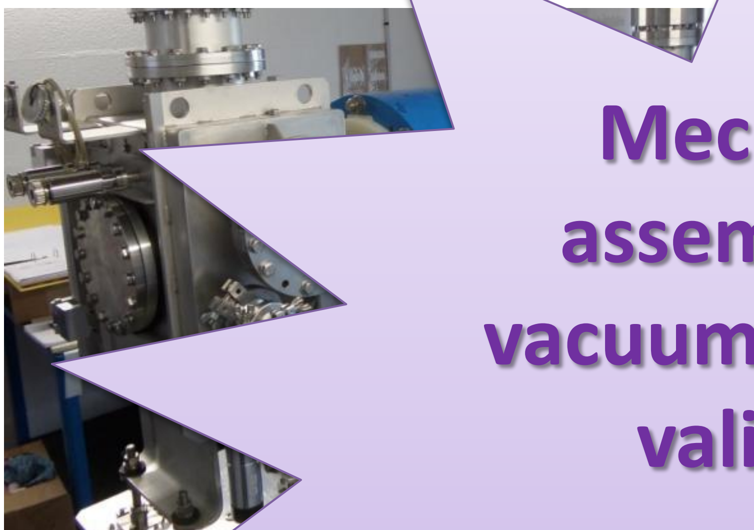
Injection side



Vacuum pressure tests - GANIL

Mechanical assembly at GANIL

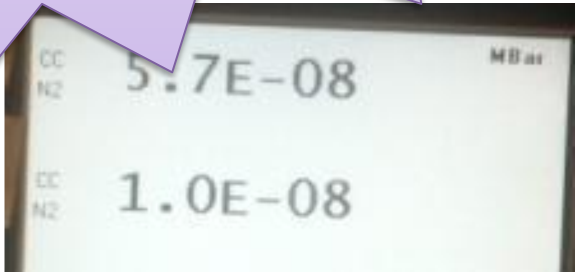
UHV Baking



Mechanical assembly and vacuum pressures validated

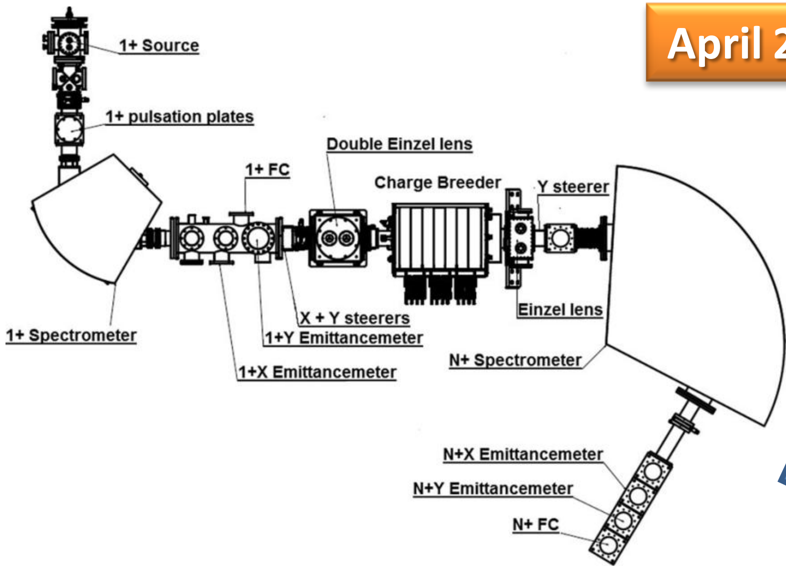
...ion si...

Injection side

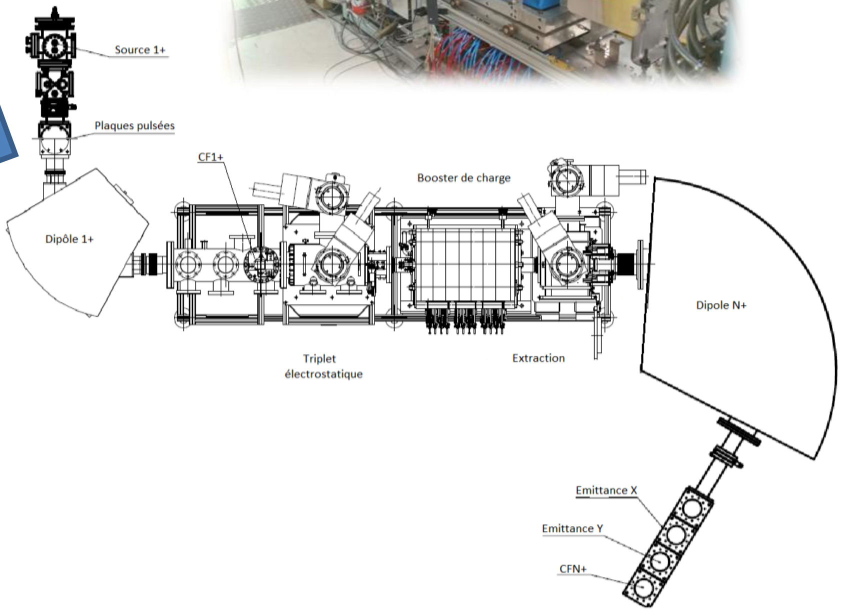


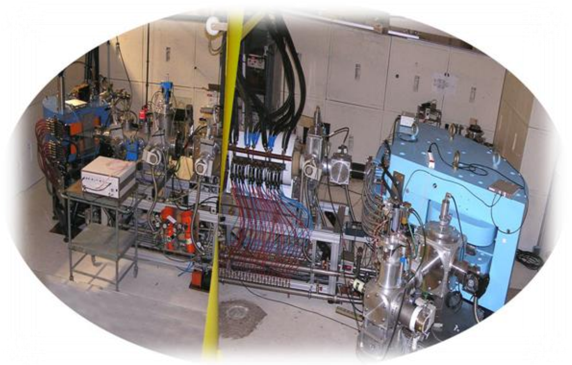
Tests at the LPSC 1+/N+ test bench

April 2015 => December 2015

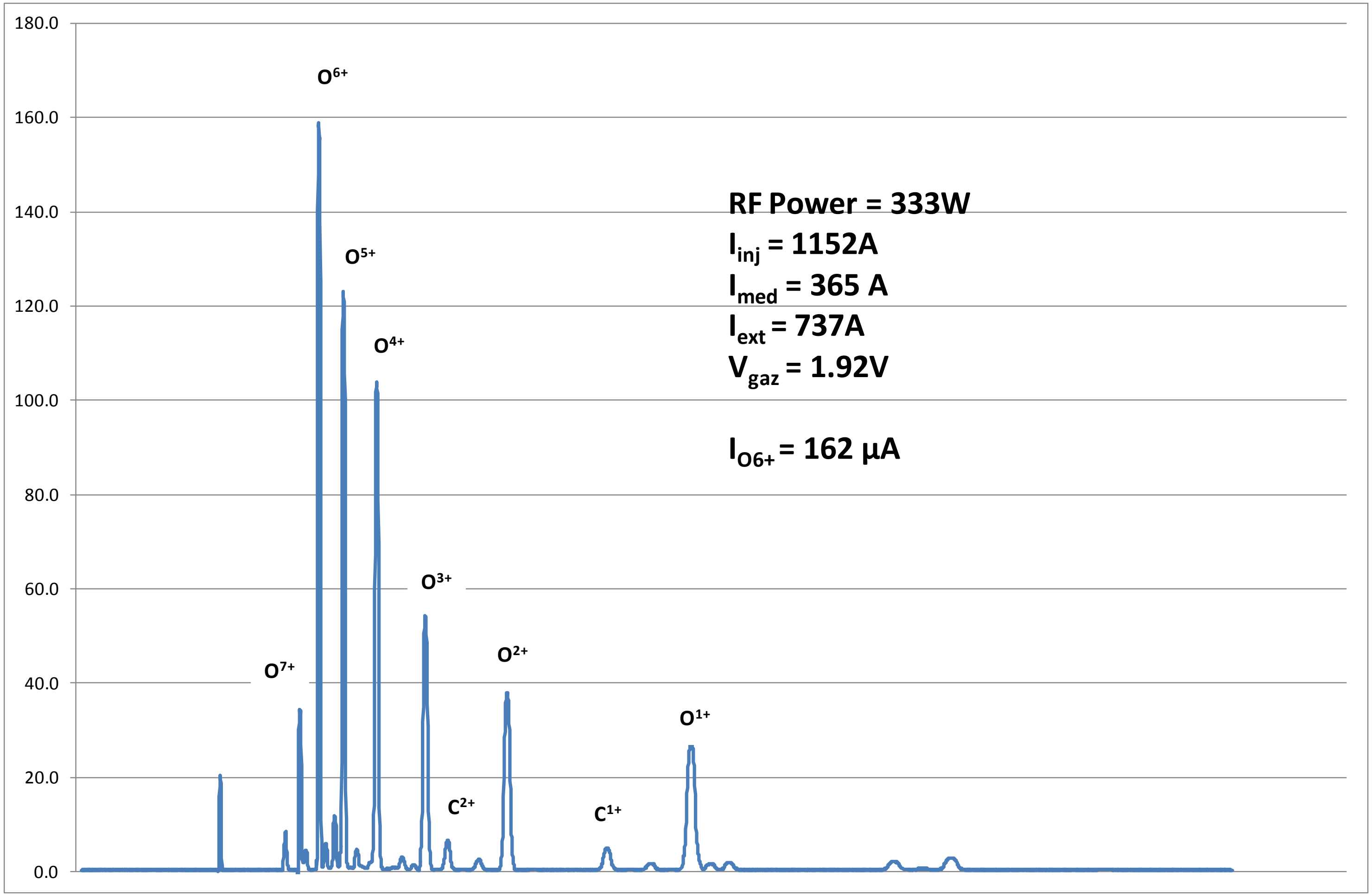


Beam line changes

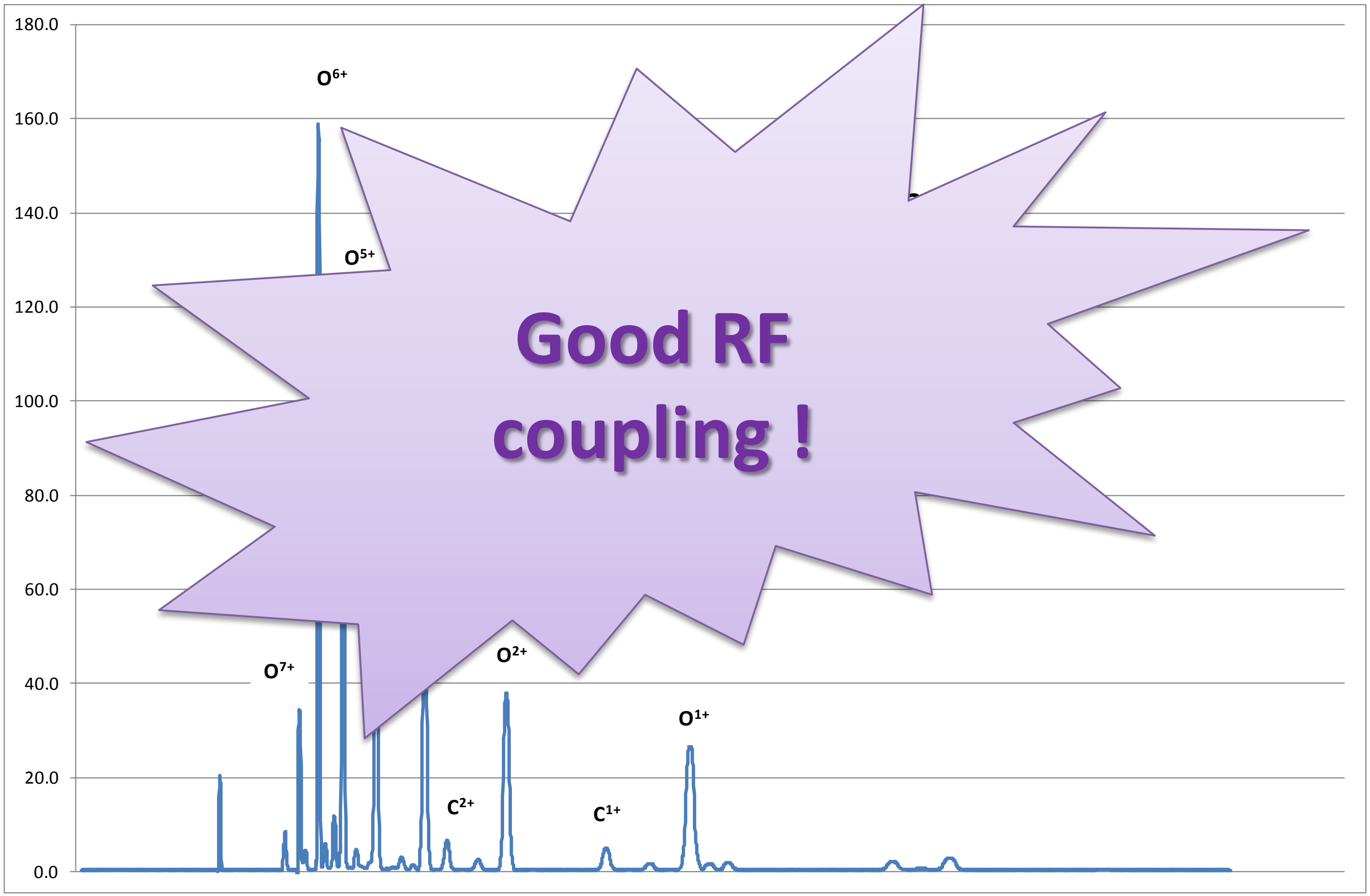




Typical spectrum



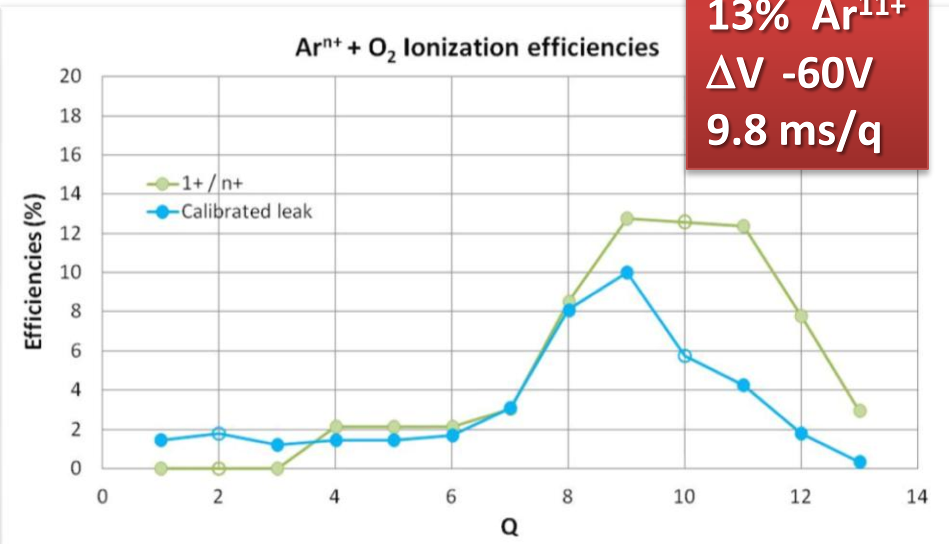
Typical spectrum



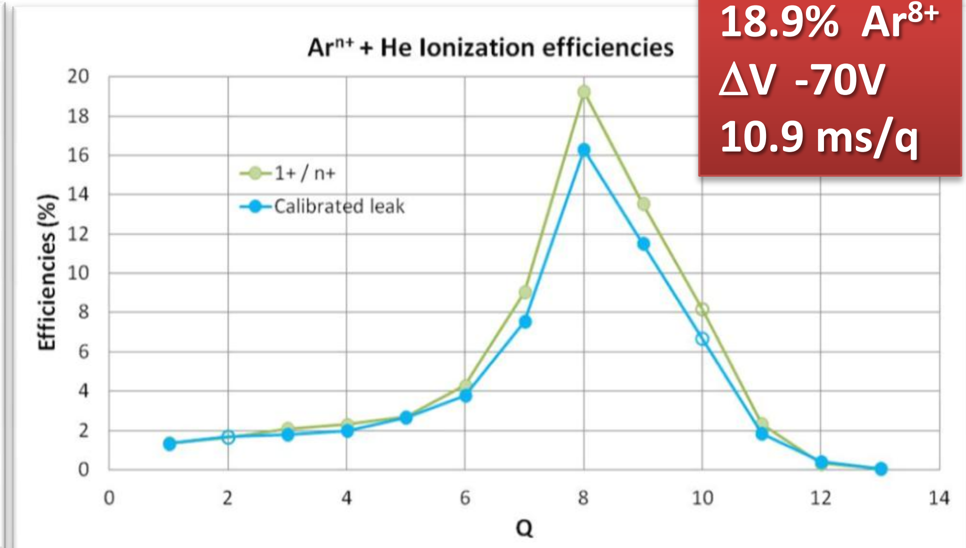
Ar gas

Comparison of direct ionization with 1+/n+ method

13% Ar^{11+}
ΔV -60V
9.8 ms/q



18.9% Ar^{8+}
ΔV -70V
10.9 ms/q



$\Sigma(Ar^{n+})_{1+/n+} \sim 66\%$

$\Sigma(Ar^{n+})_{calibrated\ leak} \sim 42\%$

Flux of the calibrated leak ~ 15 µAp

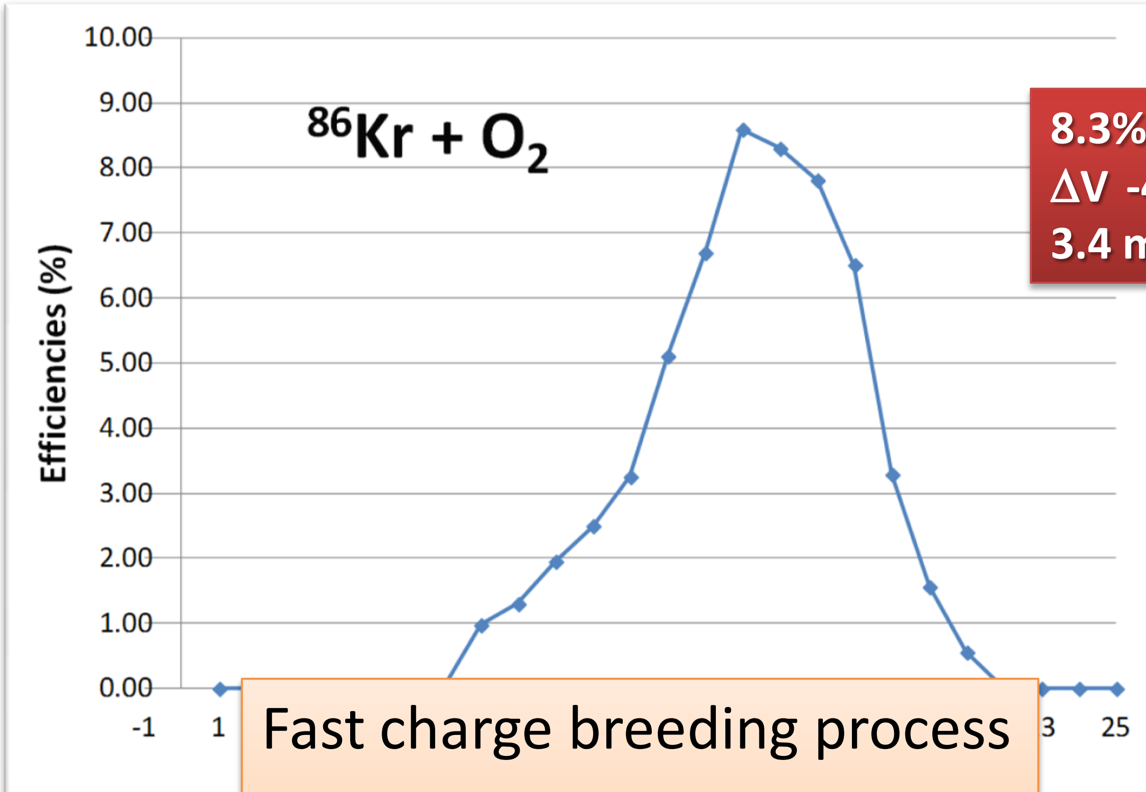
$\Sigma(Ar^{n+})_{1+/n+} \sim 67\%$

$\Sigma(Ar^{n+})_{calibrated\ leak} \sim 55\%$

Flux of the calibrated leak ~ 15 µAp

•$^{86}Kr^{10+}$ => 3.1ms/q
•$^{86}Kr^{15+}$ => 3.4 ms/q
•$^{86}Kr^{20+}$ => 3.4 ms/q

Kr gas



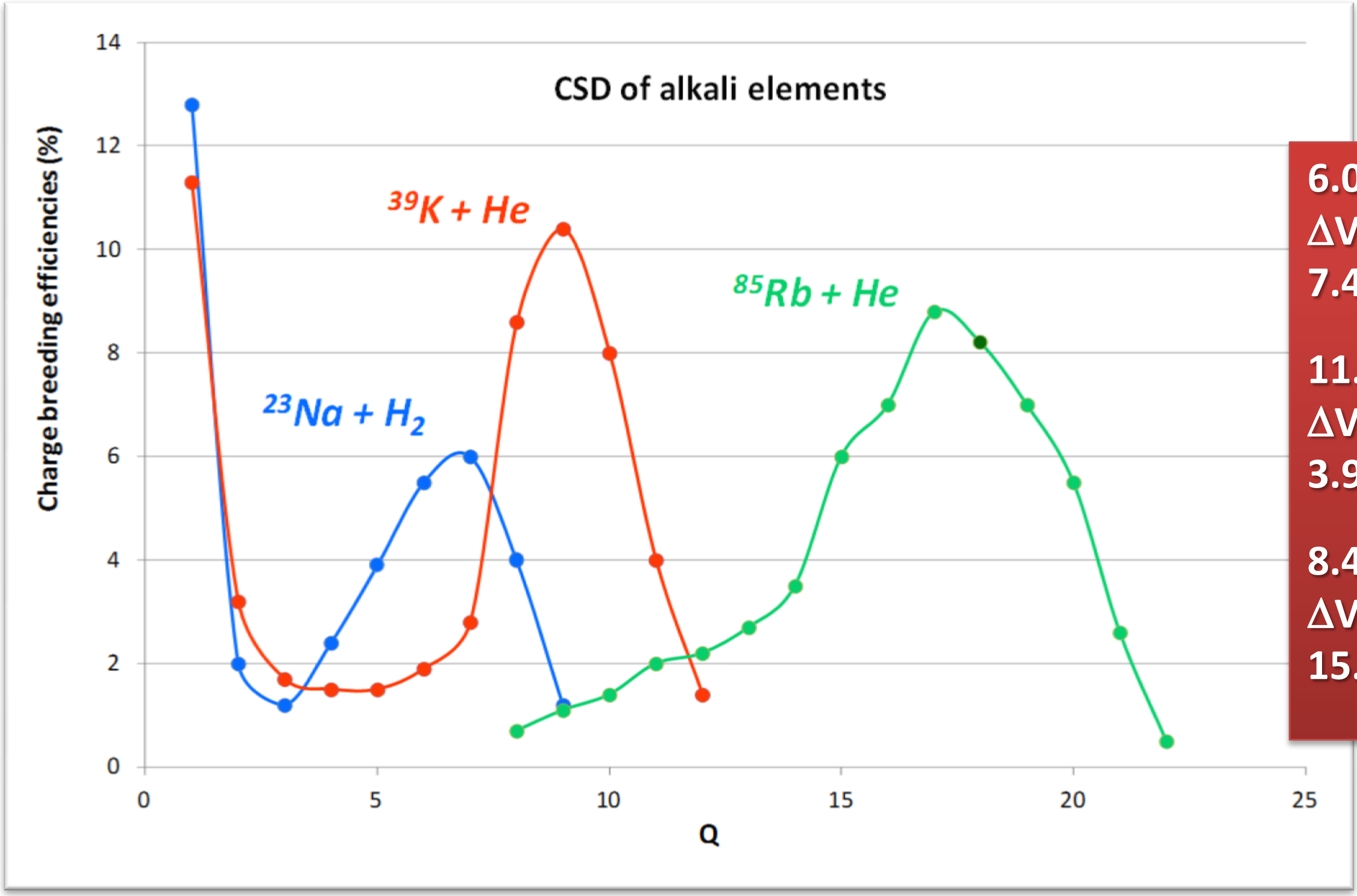
8.3% $^{86}Kr^{15+}$
ΔV -40V
3.4 ms/q

Fast charge breeding process

$^{86}Kr^{10+}$ => 3.1 ms/q
$^{86}Kr^{15+}$ => 3.4 ms/q
$^{86}Kr^{20+}$ => 3.4 ms/q

Alkali elements

Charge state distributions for Na, K and Rb



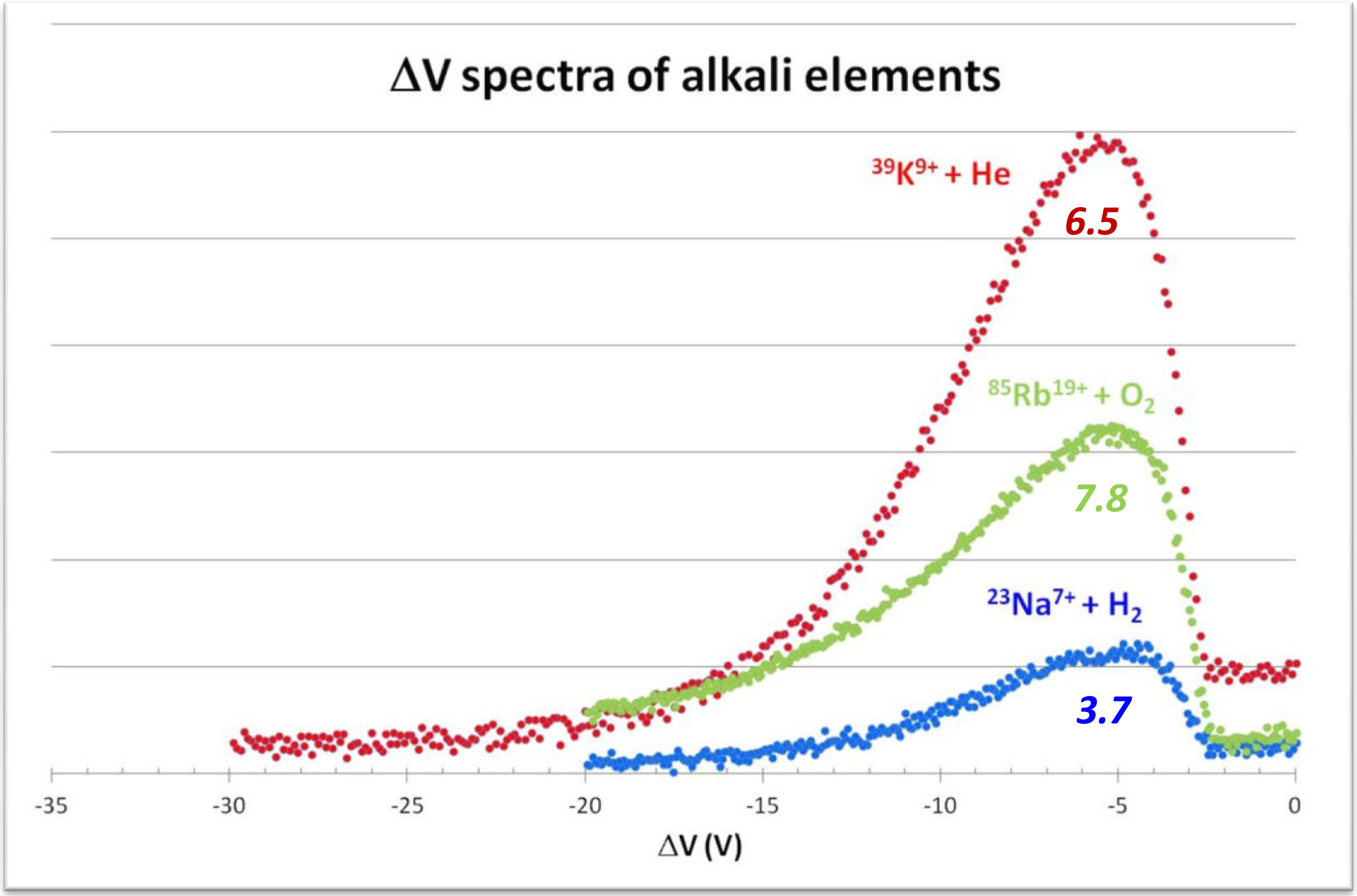
6.0% $^{23}Na^{7+}$
ΔV -5.3V
7.4 ms/q

11.7% $^{39}K^{9+}$
ΔV -5.5V
3.9 ms/q

8.4% $^{85}Rb^{19+}$
ΔV -5.3V
15.8 ms/q

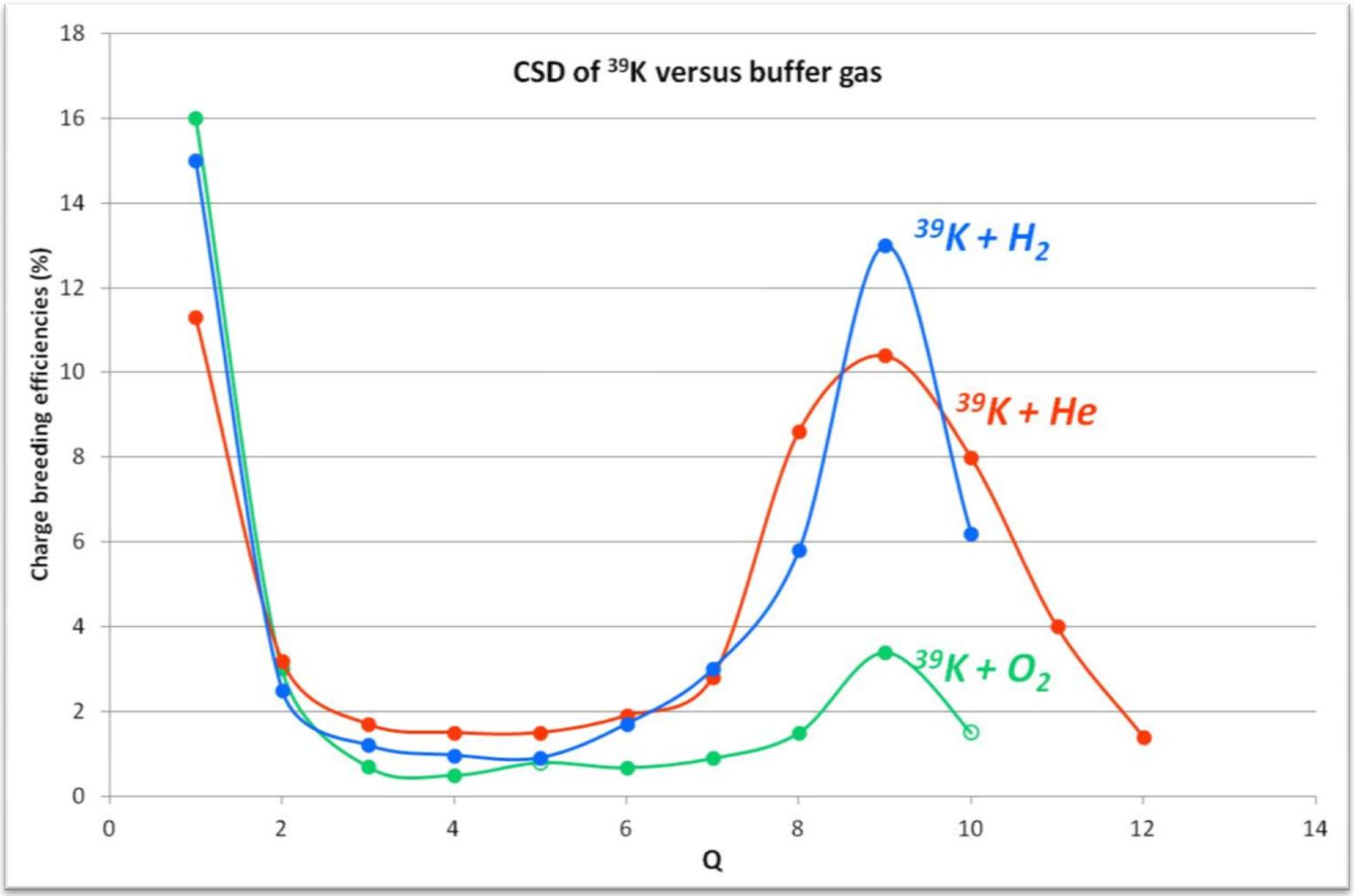
Alkali elements

Similar ΔV spectra with FWHM of ~7.5V



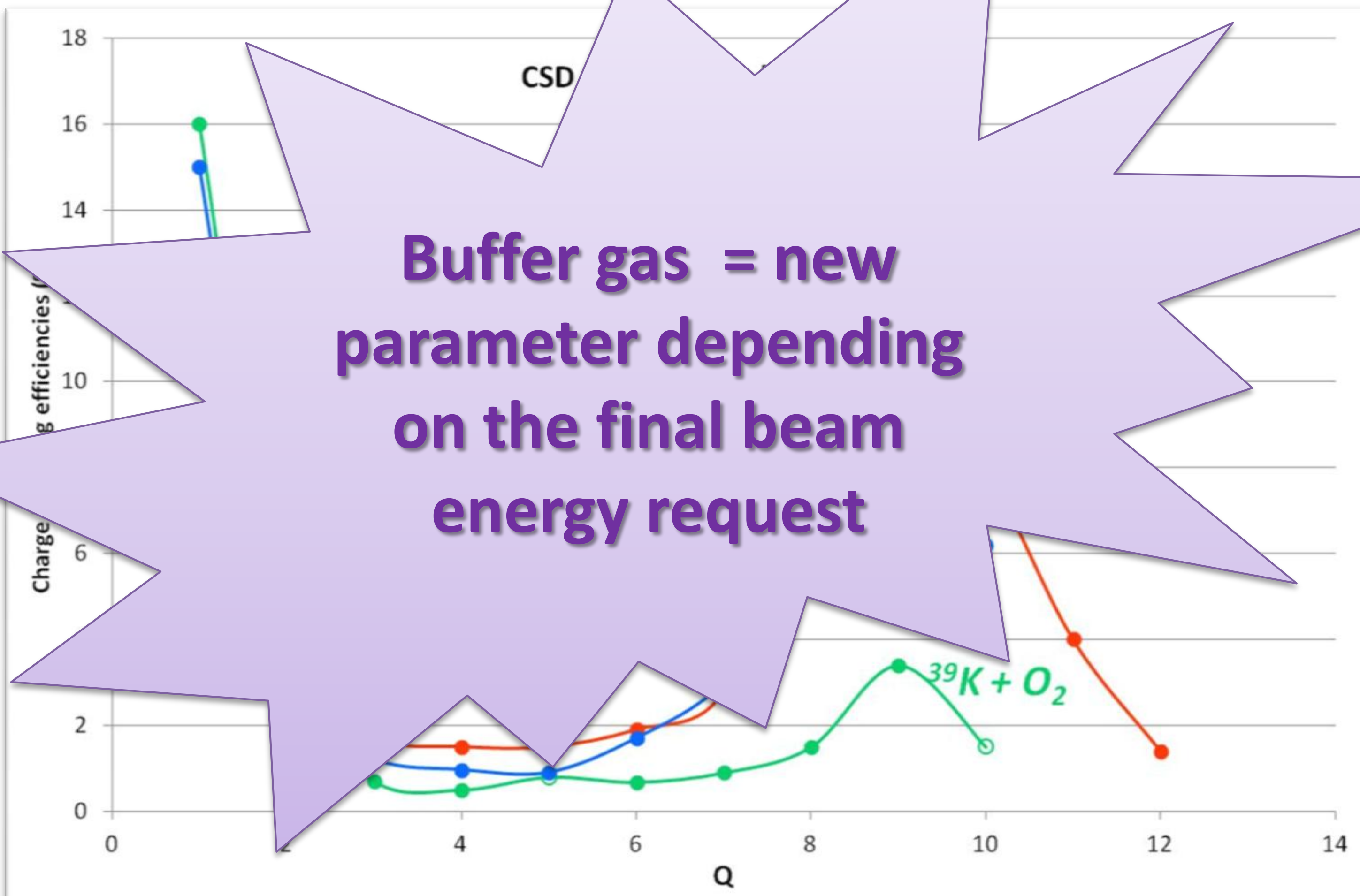
Alkali elements

Higher charge breeding efficiency with lighter buffer gas for $^{39}K^{9+}$



Alkali elements

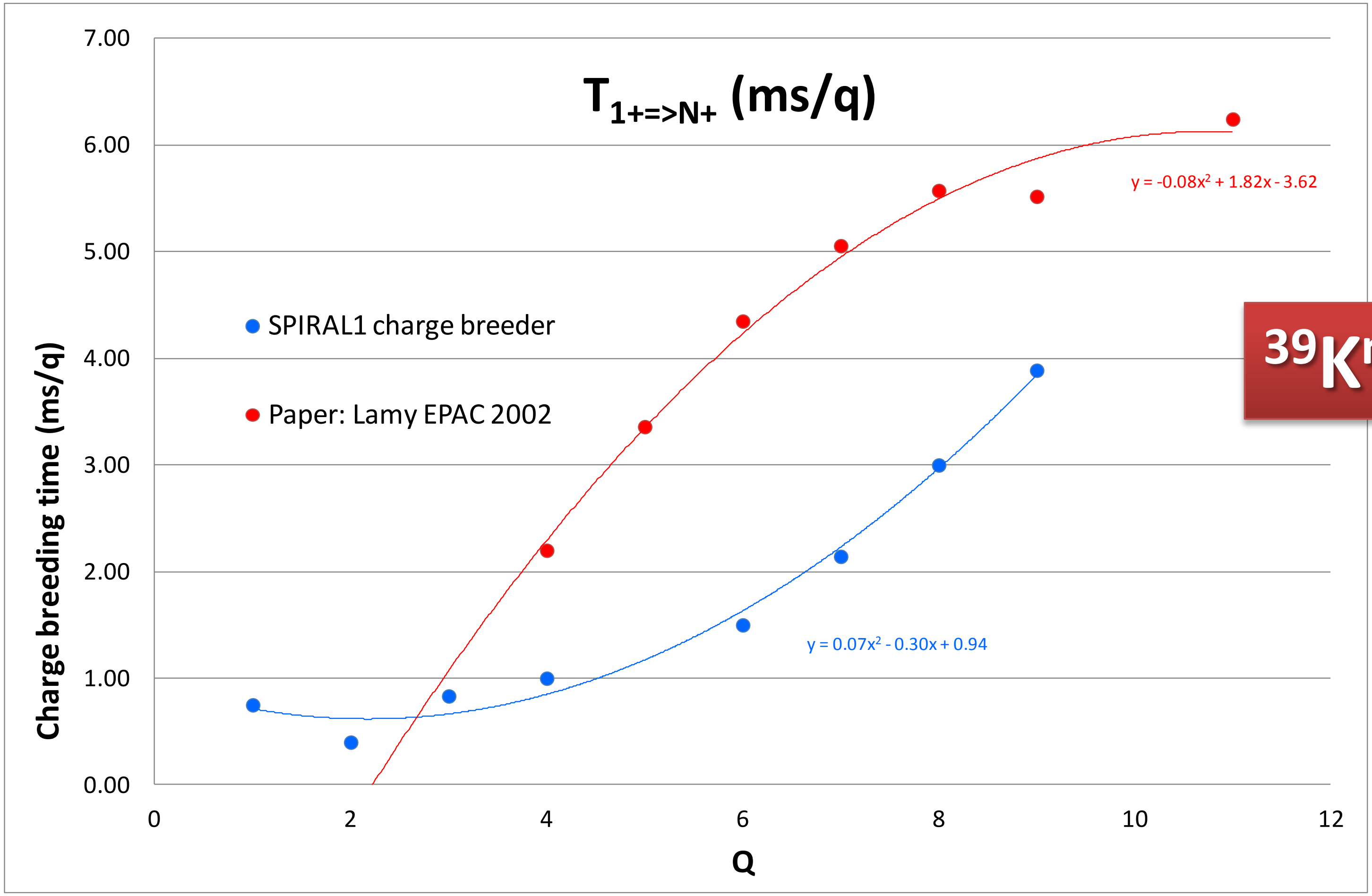
Higher charge breeding efficiency with lighter buffer gas for $^{39}K^{9+}$



Buffer gas = new parameter depending on the final beam energy request

Alkali elements

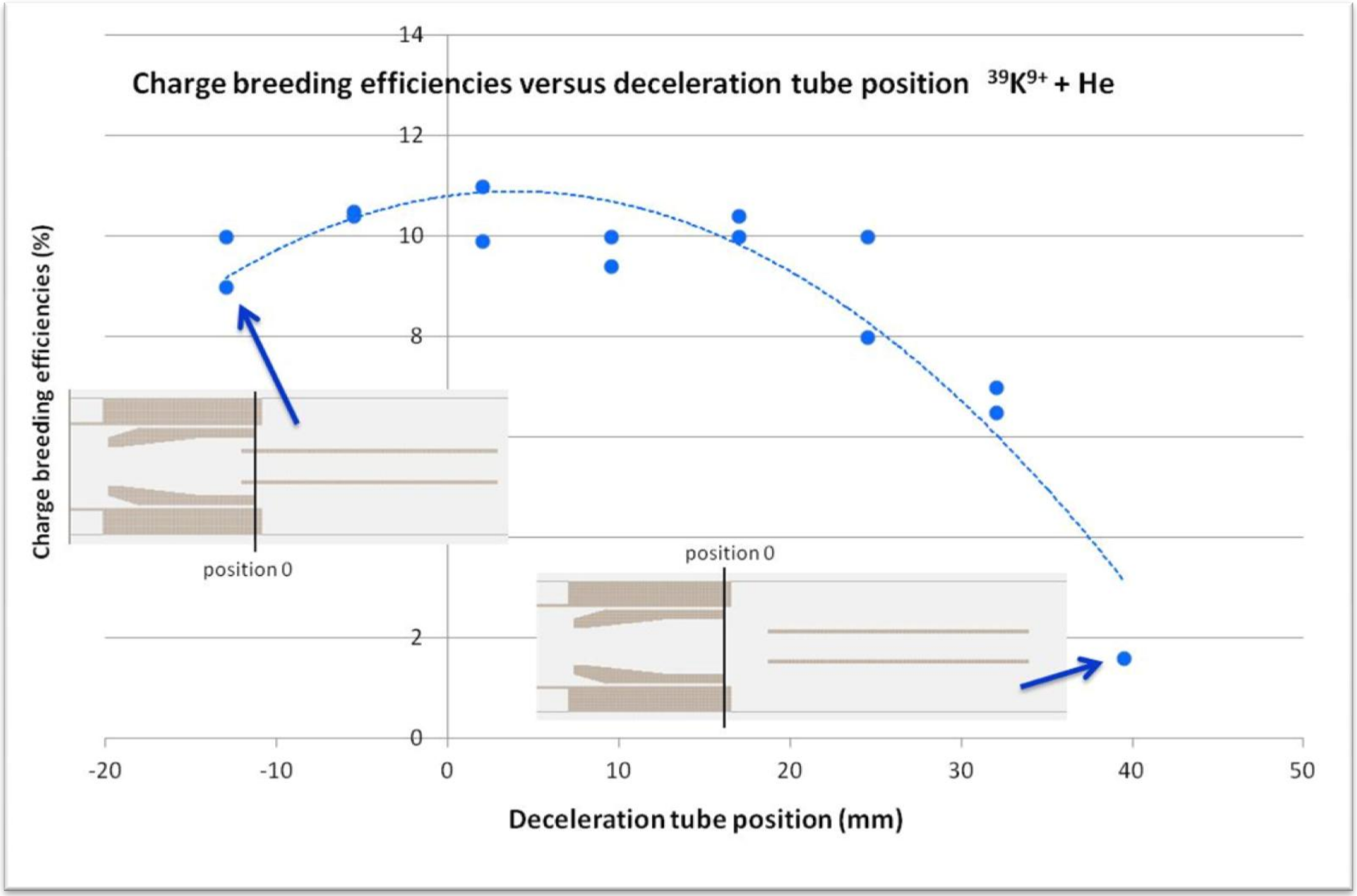
Charge breeding time increases with charge state



$^{39}K^{n+}$

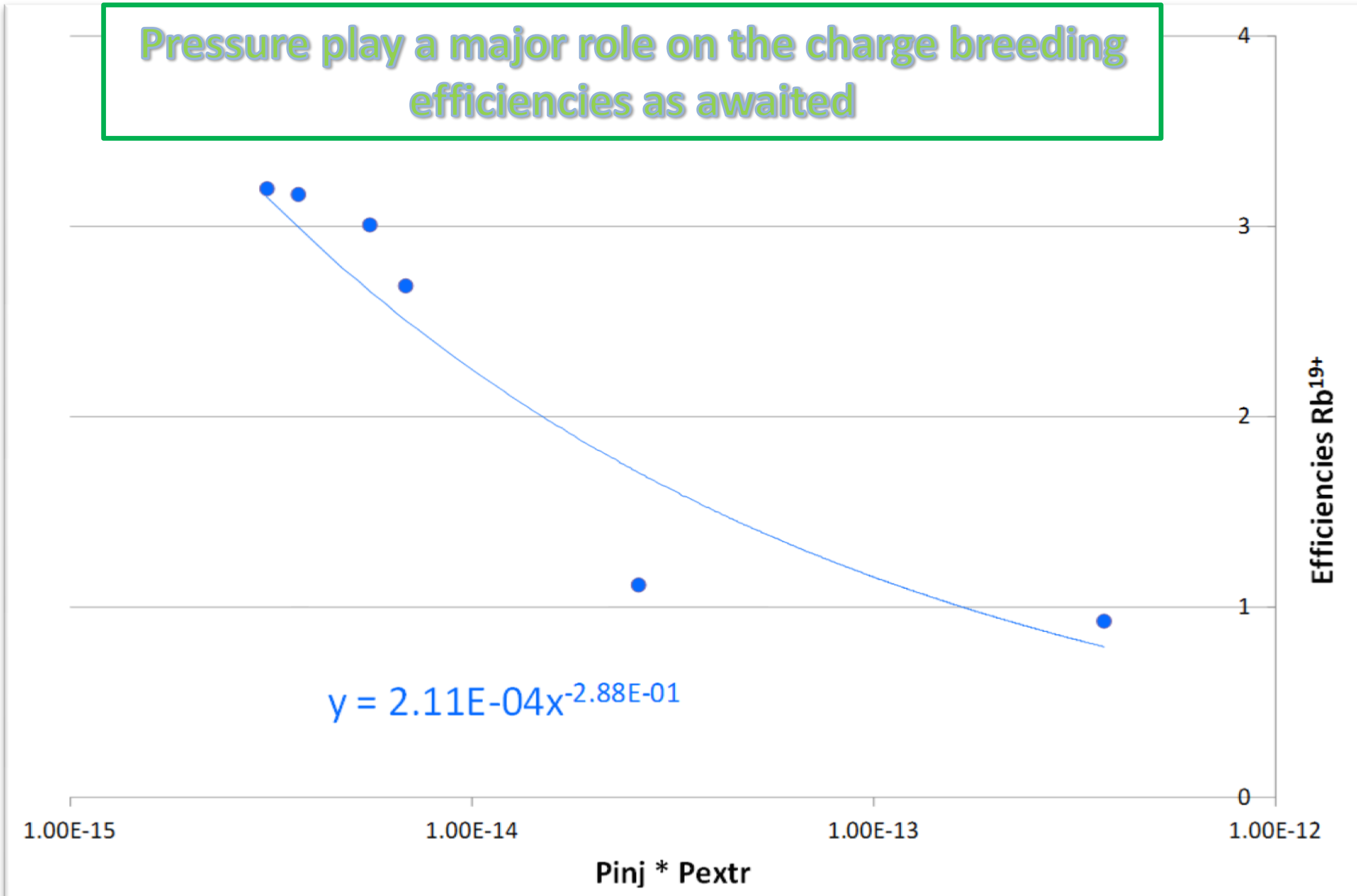
Alkali elements

Charge breeding efficiency has a slight evolution with the position of the deceleration tube



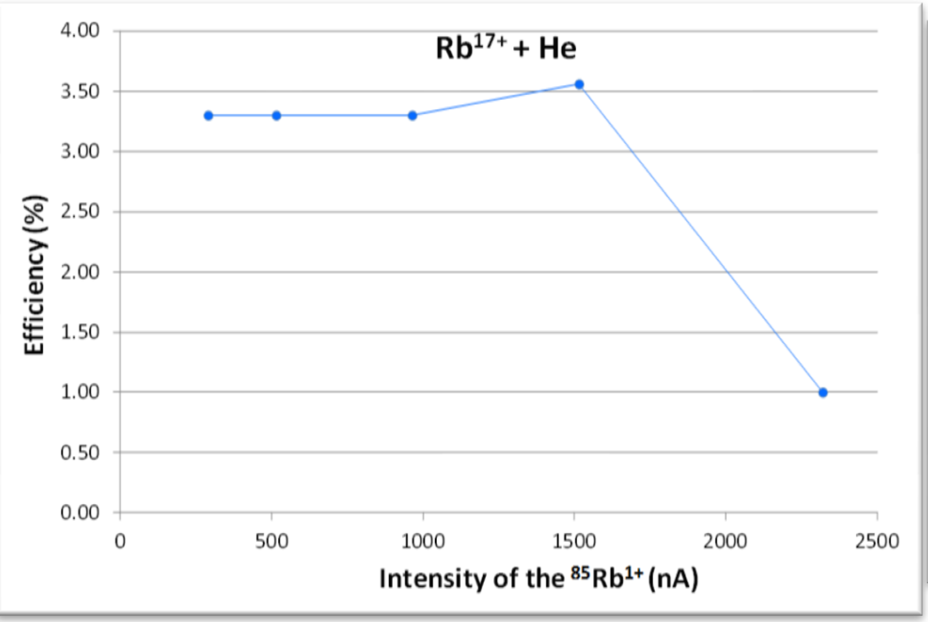
Pressure influence

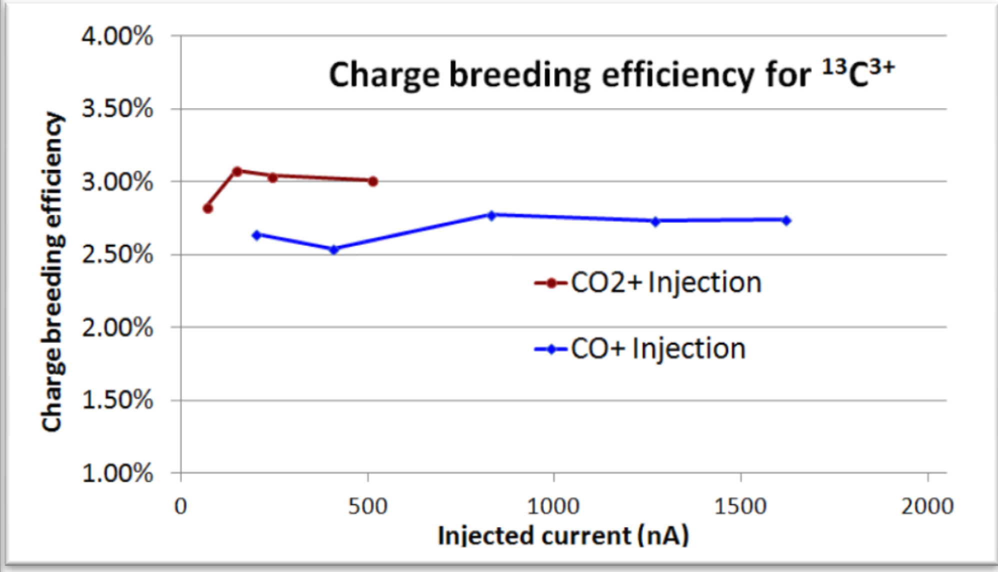
Pressure play a major role on the charge breeding efficiencies as awaited



1+ beam intensity influence

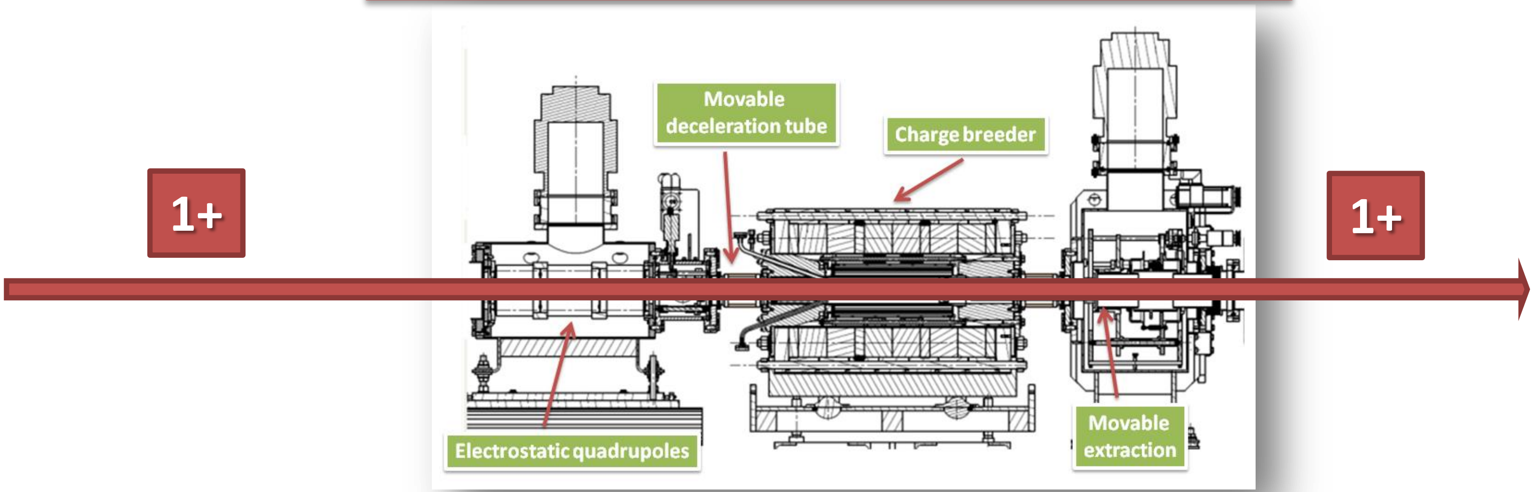
Charge breeding efficiency is a plateau over a decade





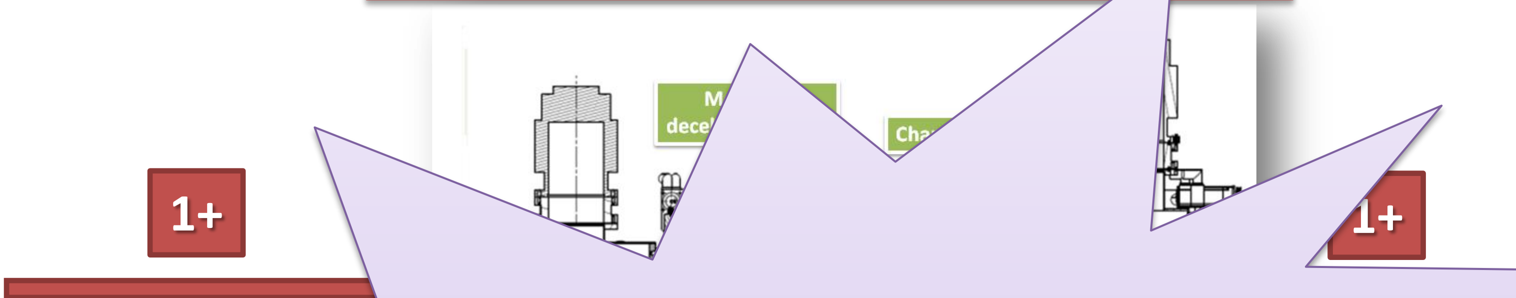
L. Maunoury, RSI, **85** 02A504 (2014)

Going through mode



Haute Tension (kV)	Etat HT	Na^{1+}	K^{1+}	Rb^{1+}	ΔV
10	OFF			55	-
20	OFF			65	-
20	ON			30	-5
20	ON		37		-10
20	ON	48			-15

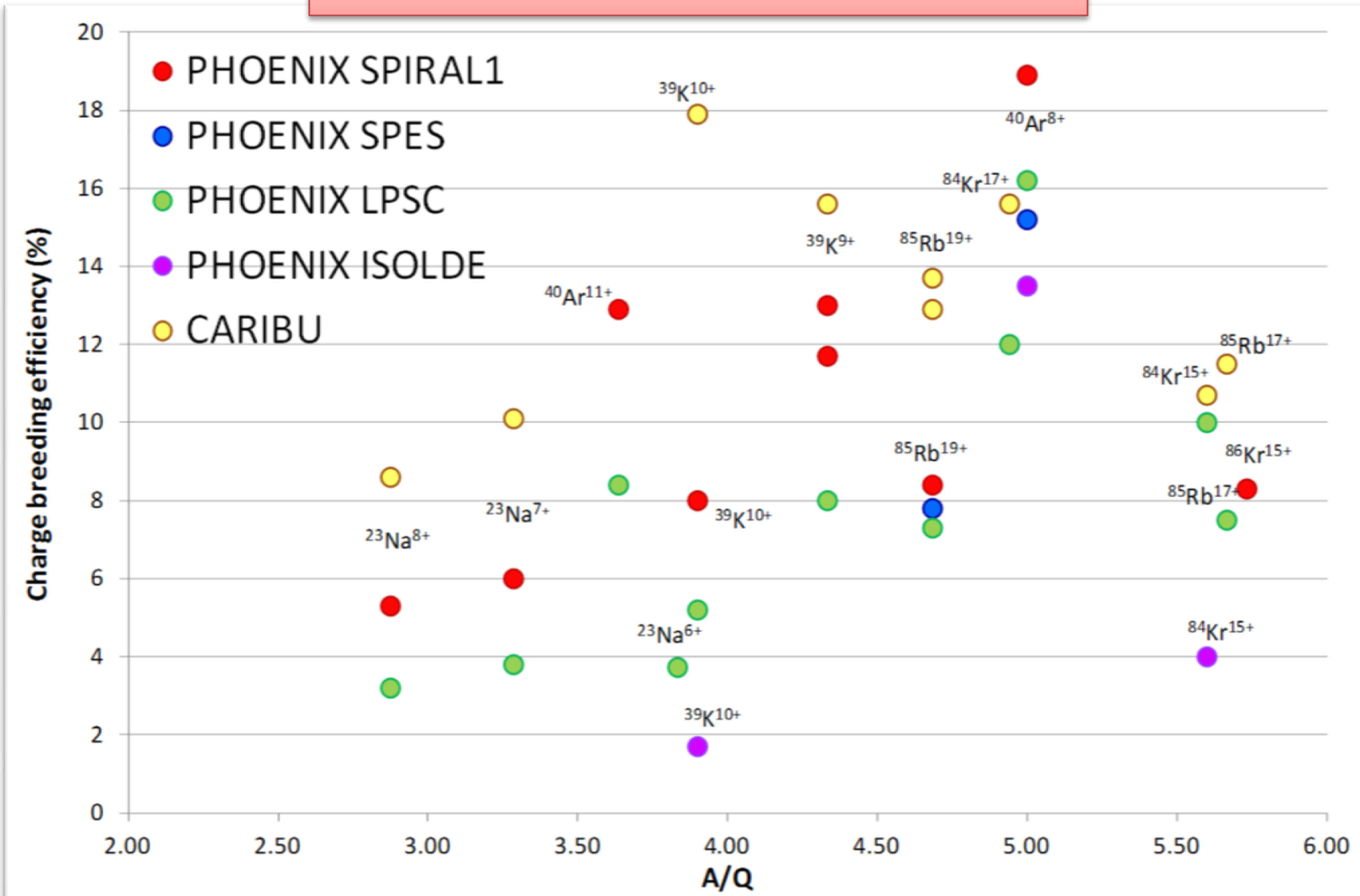
Going through mode



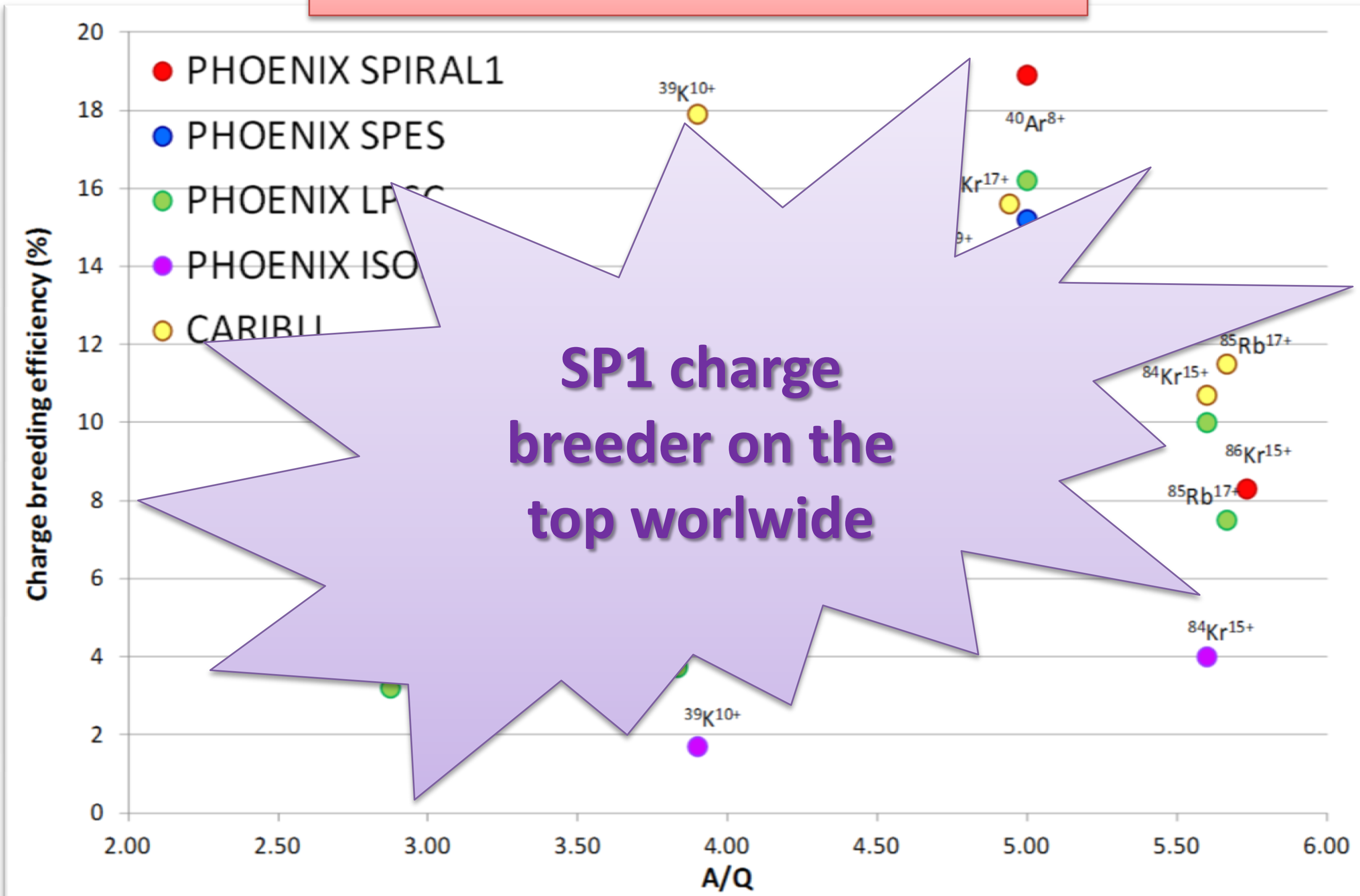
Results to be confirmed for NanoganIII more optic parameters but higher emittance

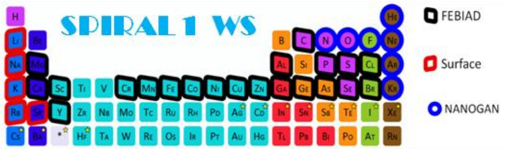
Haute					ΔV
10				55	-
				65	-
20				30	-5
20	N		37		-10
20	ON	48			-15

Sum up of the results



Sum up of the results





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Sum up of the results

	Ion	A/Q	SPIRAL1 Efficiency (%)	SPIRAL1 Charge Breeding Time (ms / q)	SPES Efficiency (%)	SPES Charge Breeding Time (ms / q)	CARIBU Efficiency (%)	CARIBU Charge Breeding Time (ms / q)	LPSC Efficiency (%)	LPSC Charge Breeding Time (ms / q)	ISOLDE Efficiency (%)	ISOLDE Charge Breeding Time (ms / q)
	$^{23}Na^{6+}$	3.83							3.7	6.0		
	$^{23}Na^{7+}$	3.29	6.0	7.4			10.1		3.8	7.4		
	$^{23}Na^{8+}$	2.88	5.3				8.6		3.2	8.8		
50%	$^{39}K^{9+}$	4.33	13.0	13	+ H_2		15.6	16.7	8	5.4		
50%	$^{39}K^{9+}$	4.33	11.7	3.9	+ He							
	$^{39}K^{10+}$	3.90	8.0				17.9	15.7	5.2	6.0	1.7	10
	$^{40}Ar^{8+}$	5.00	18.9	10.9	15.2	9.1			16.2	9.8	13.5	
	$^{40}Ar^{11+}$	3.64	12.9	9.8					8.4			
	$^{84}Kr^{15+}$	5.60					10.7		10.0		4.0	
	$^{84}Kr^{17+}$	4.94					15.6		12.0	8.5		
	$^{85}Rb^{17+}$	5.67					11.5	10.6	7.5	13.3		
56%	$^{85}Rb^{19+}$	4.68	8.4	15.8	7.8	28.2	13.7	77.9	7.3	12.0		
	$^{85}Rb^{19+}$	4.68					12.9	12.1				
	$^{86}Kr^{15+}$	5.73	8.3	3.4								

Sum up of the results

Ion	A/Q	SPIRAL1 Efficiency (%)	SPIRAL1 Charge Breeding Time (ms / q)	SPES Efficiency (%)	SPES Charge Breeding Time (ms / q)	CARIBU Efficiency (%)	CARIBU Charge Breeding Time (ms / q)	[illegible]PSC Efficiency (%)	[illegible]PSC Charge Breeding Time (ms / q)	ISOLDE Efficiency (%)	ISOLDE Charge Breeding Time (ms / q)
$^{23}Na^{6+}$	3.83										
$^{23}Na^{7+}$	3.29	[illegible]									
$^{23}Na^{8+}$	2.88	[illegible]									
$^{39}K^{9+}$	4.33	13.0									
$^{39}K^{9+}$	4.33	11.7									
$^{39}K^{10+}$	3.9									1.7	*10*
$^{40}Ar^{8+}$	5.00	[illegible]								[illegible].5	
$^{40}Ar^{11+}$	3.64	12.9									
$^{84}Kr^{15+}$	5.60									4.0	
$^{84}Kr^{17+}$	4.94					15.6		12.0	*8.5*		
$^{85}Rb^{17+}$	5.67					11.5	*10.6*	7.5	*13.3*		
$^{85}Rb^{19+}$	4.68	8.4	*15.8*	7.8	*28.2*	13.7	*77.9*	7.3	*12.0*		
$^{85}Rb^{19+}$	4.68					12.9	*12.1*				
$^{86}Kr^{15+}$	5.73	8.3	*3.4*								

50%

56%

Not only charge breeding efficiency but also charge breeding time

Coming back to GANIL

April 2015

January 2016

Ready for the CB return

And now…

- ✓ **Charge breeder is back home**
  March 2016
- ✓ **Assembly in the Low Energy Beam Line of SPIRAL1**
  May – July 2016
- ✓ **Vacuum pressure validation**
  July 2016
- ✓ **Commissioning with stable 1+ beams**
  November 2016 – 1st trimester 2017
- ✓ **Commissioning with radioactive 1+ beams**
  2nd trimester 2017