TRIUMF

CANADA'S NATIONAL LABORATORY FOR PARTICLE AND NUCLEAR PHYSICS

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Status of the ECRIS Charge State Breeding Project at TRIUMF

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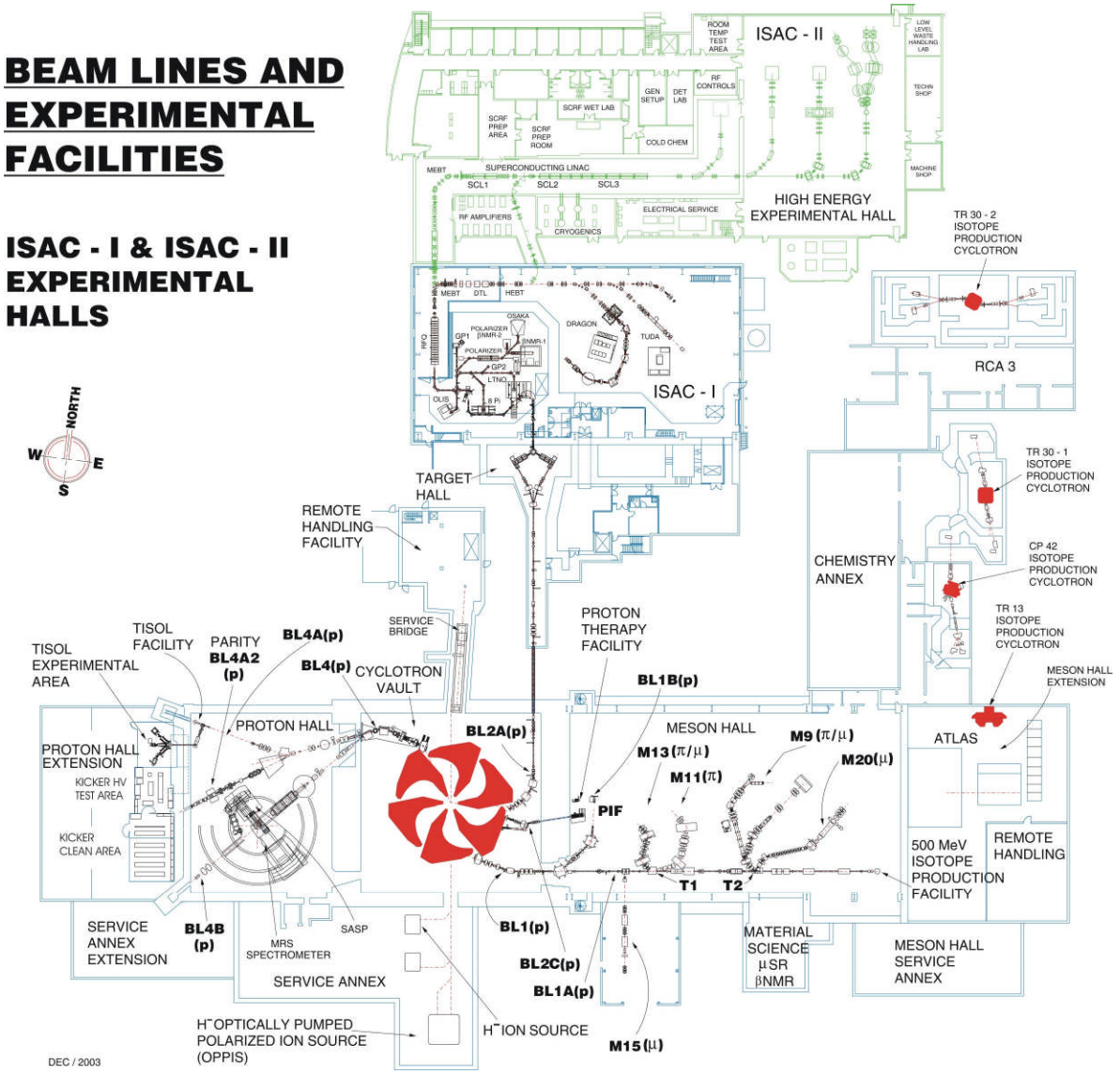
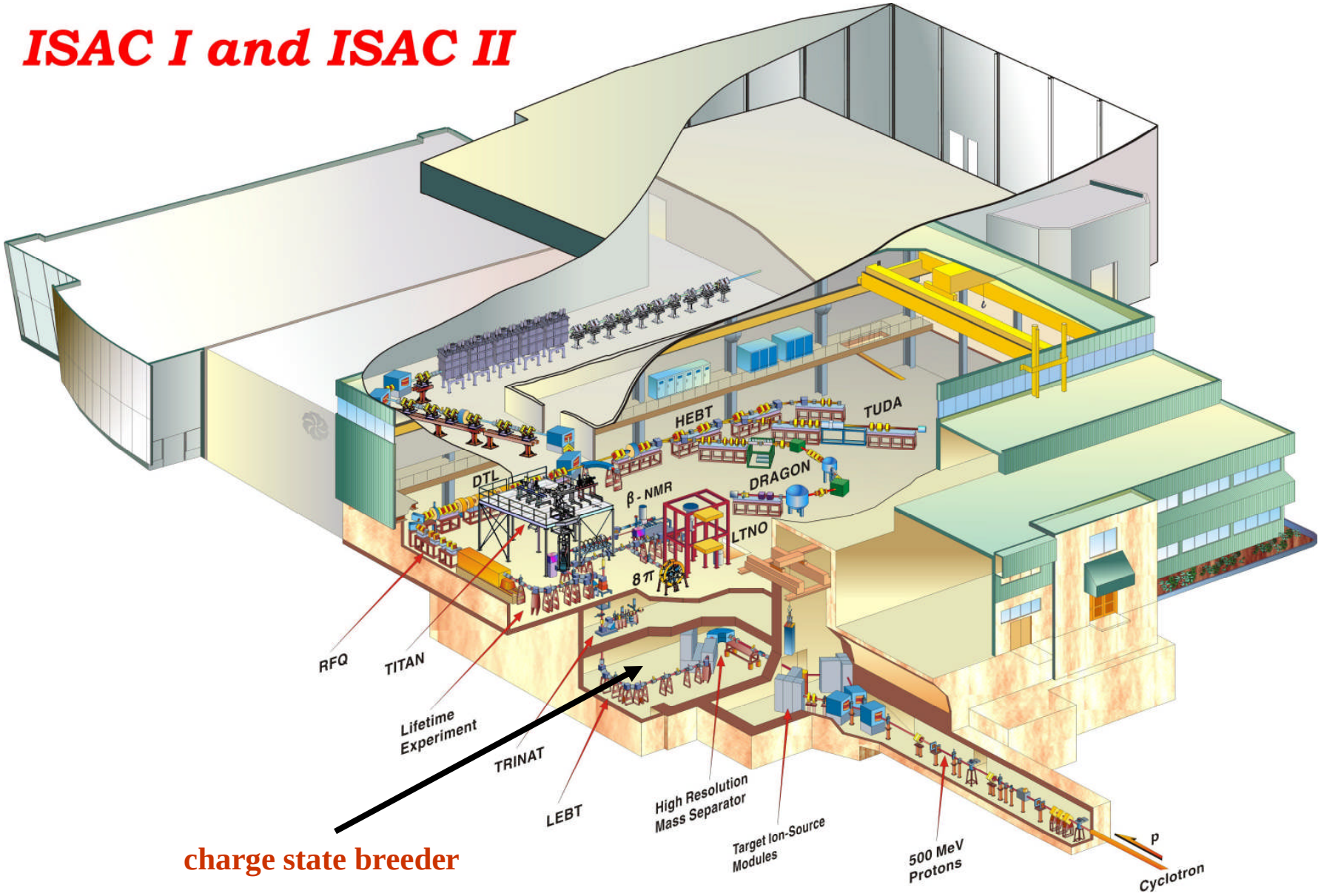
ECRIS08 workshop, Chicago, September, 2008

BEAM LINES AND EXPERIMENTAL FACILITIES

ISAC - I & ISAC - II EXPERIMENTAL HALLS



ISAC I and ISAC II



charge state breeder

TRIUMF

Charge state breeding at ISAC:

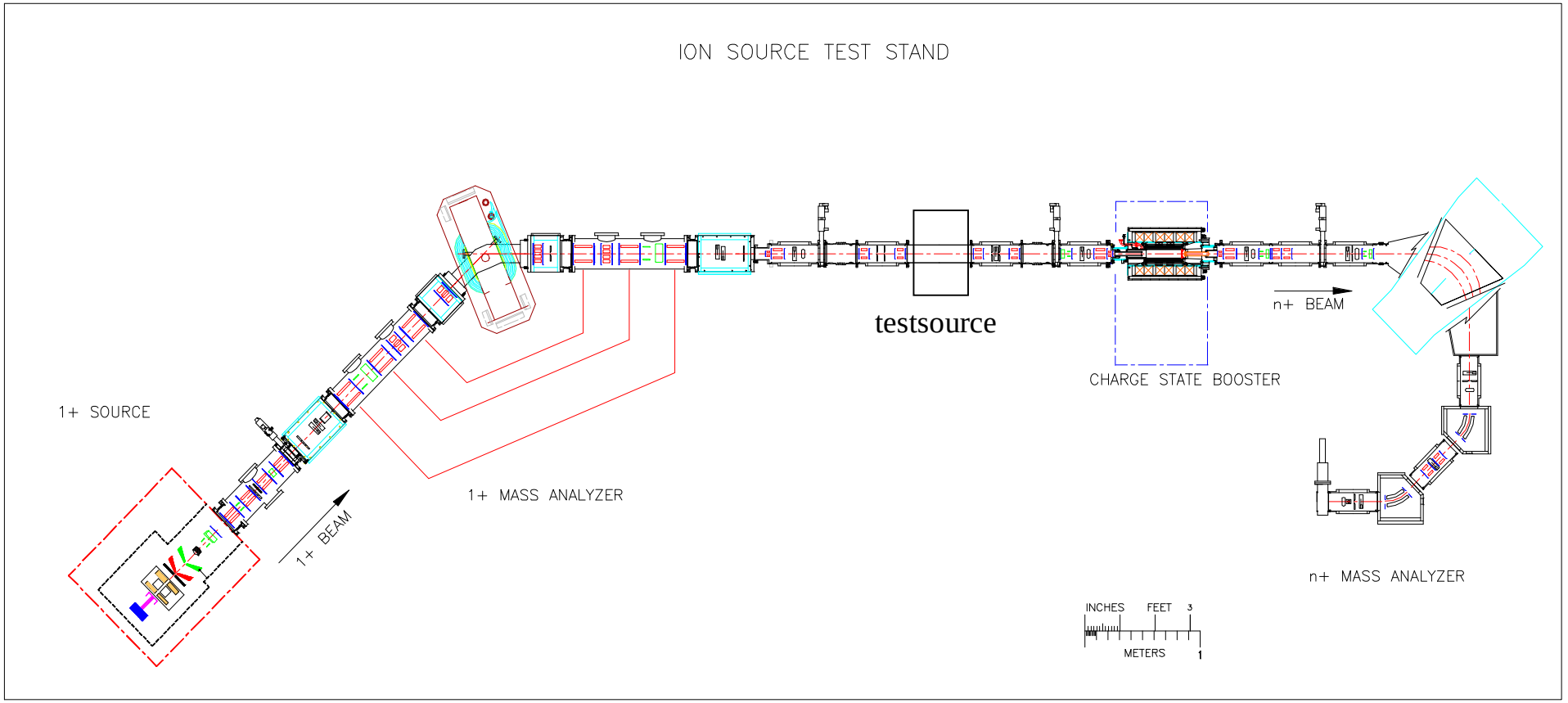
Requirements:

- **M/Q < 30 with additional stripping after first acceleration stage (150 keV/u)**
- **M/Q < (6)7 without additional stripping**
- **ion velocity: 2 keV/u**
- **transversal emittance: ≤ 30 π mm mrad**

•Incoming beam:

singly charged ions continuous beam
typical emittance < 30 π mm mrad @ 30 keV
beam intensity: 1 … > 10^{10} ions/sec

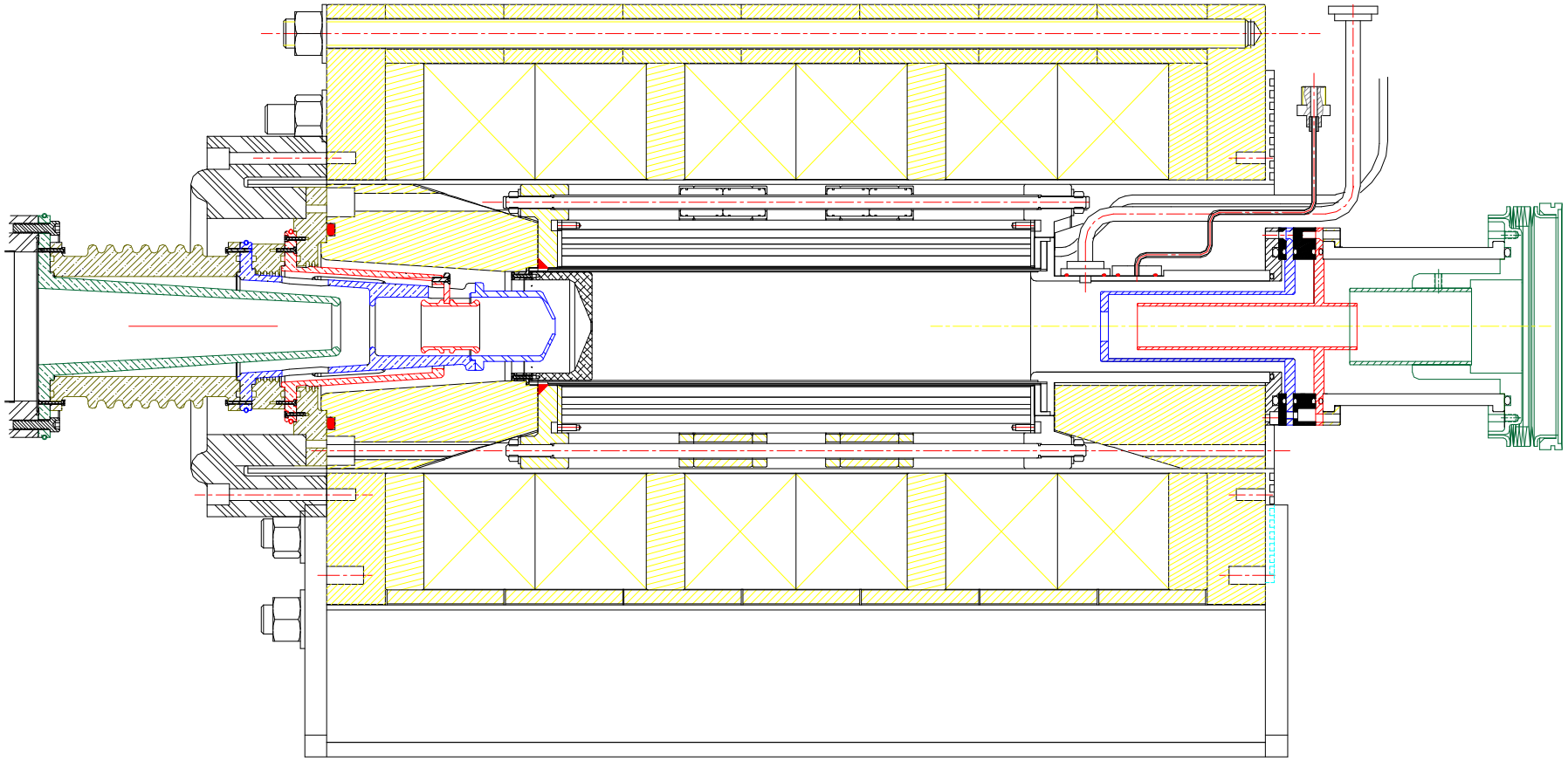
CSB test stand at TRIUMF



14.5 GHz ECR source PHOENIX from Pantechnik

elements measured : Ar, Kr, Xe from ECR ion source

K, Rb, Cs from surface ion source



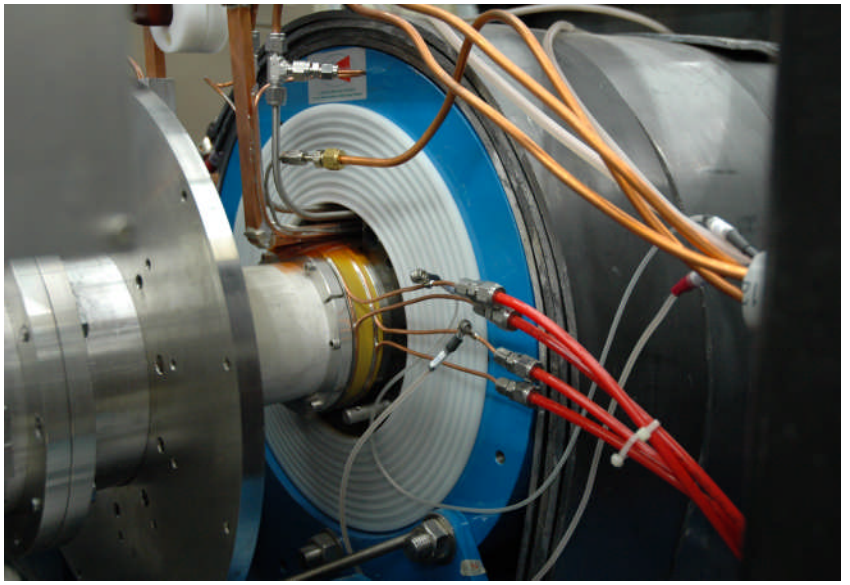
modified PHOENIX source

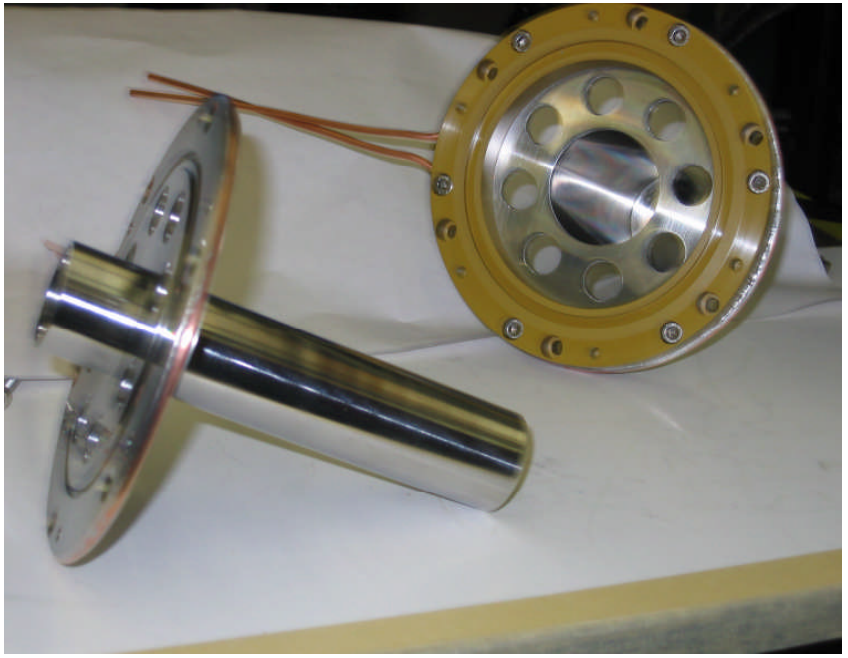
2 step deceleration for the injection of singly charged ions

2 step acceleration scheme + Einzel lens focusing

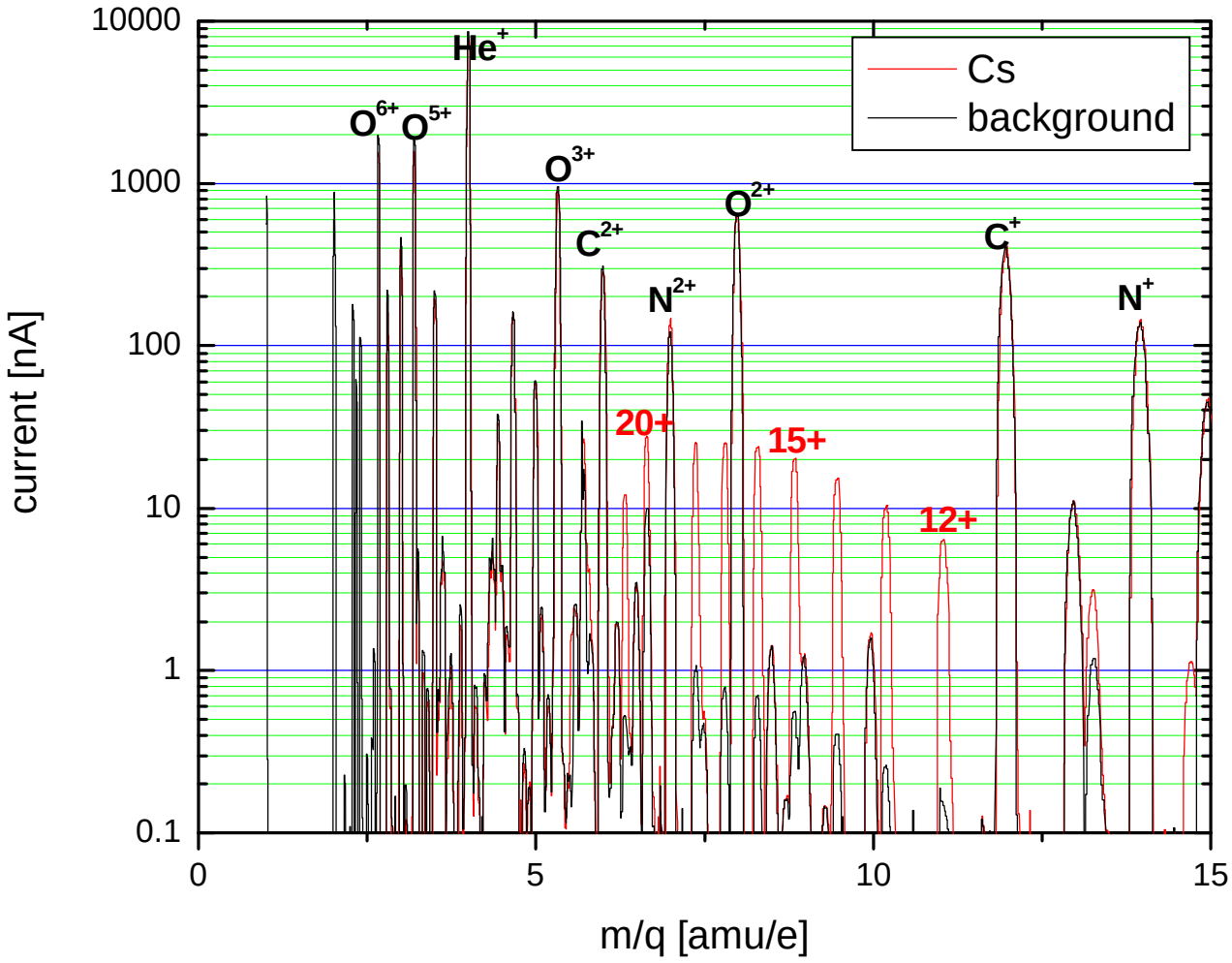
for the extraction of the highly charged ions

extraction electrodes

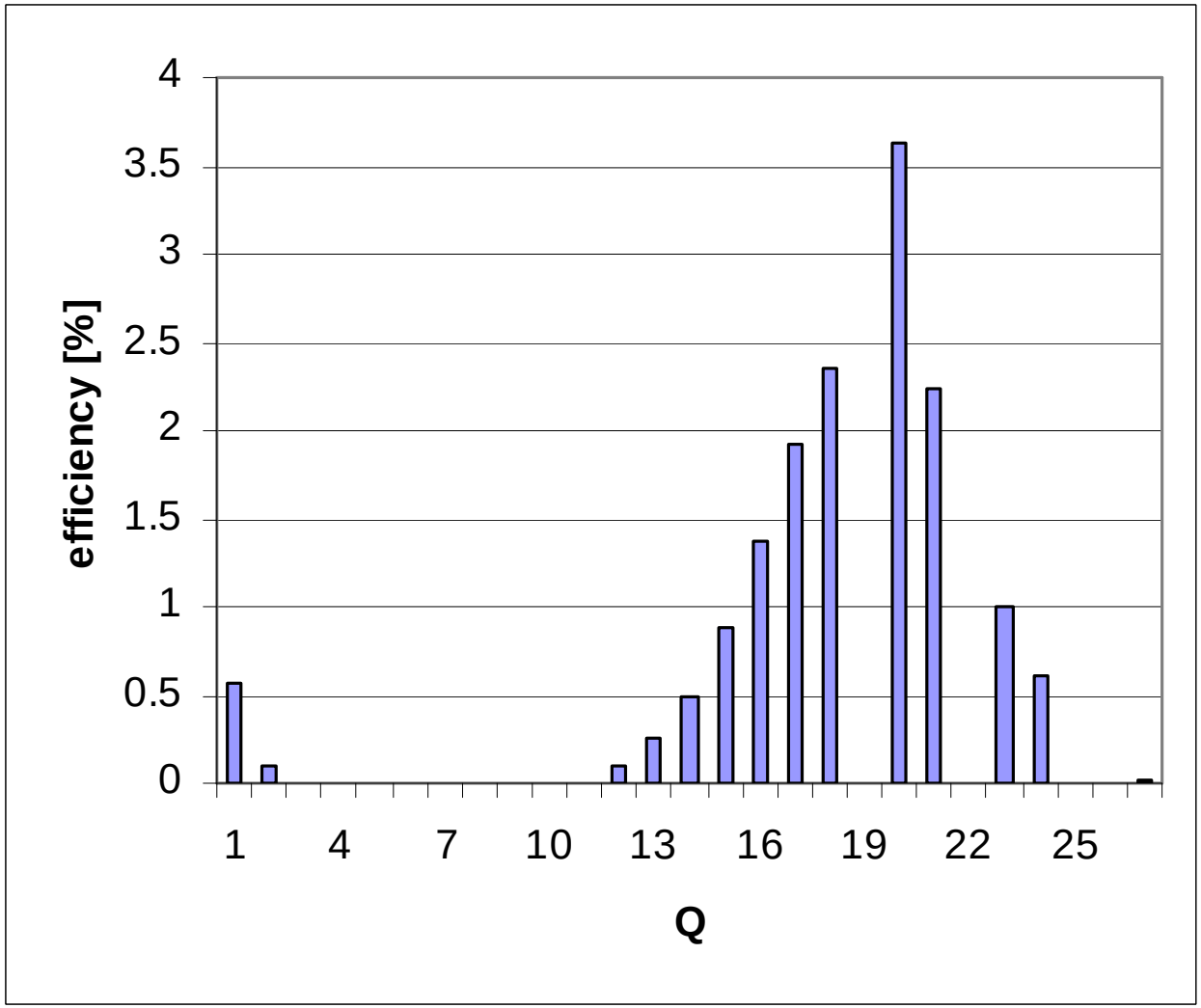




injection electrodes



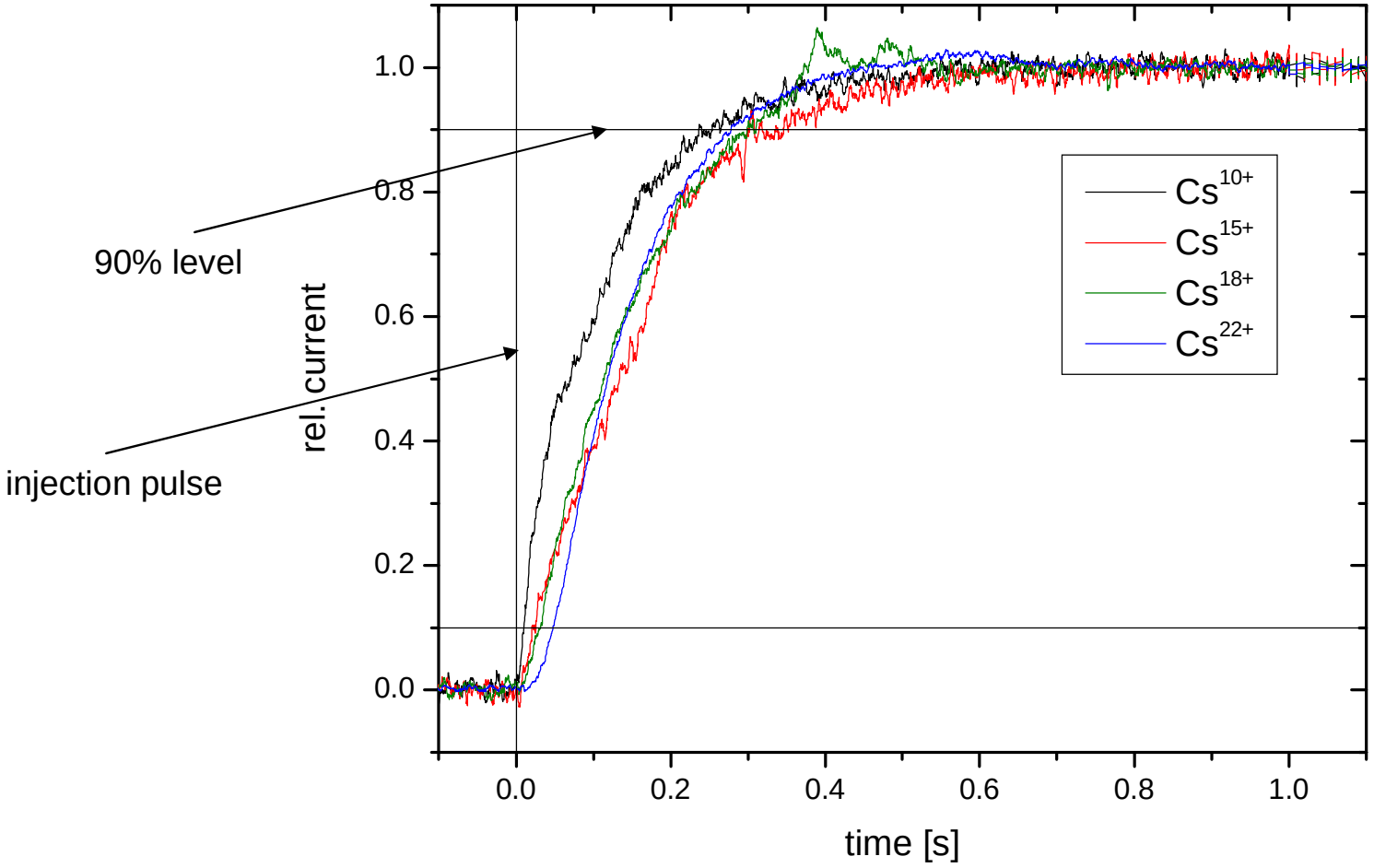
mass spectrum with and without Cs^+ injection (500 W rf power)



charge state distribution of Cs 15 nA Cs^{1+} injected
total efficiency >20%

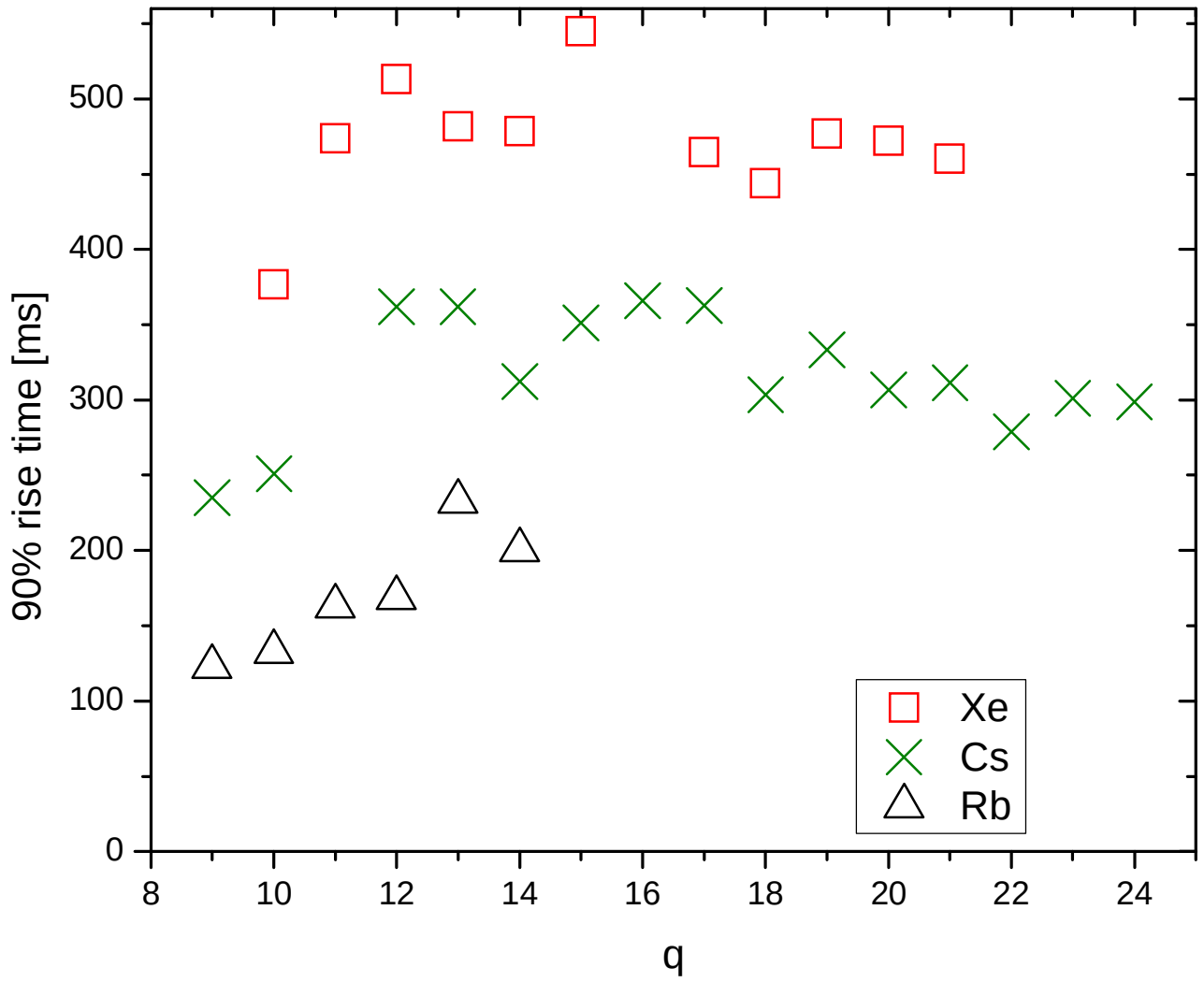
breeding time

pulsed injection of 1+ ions
signal as function of time



signal rise time for different Cs charge states (10,15,18,22)

Xe, Cs and Rb breeding time



rise time
injection pulse to 90%

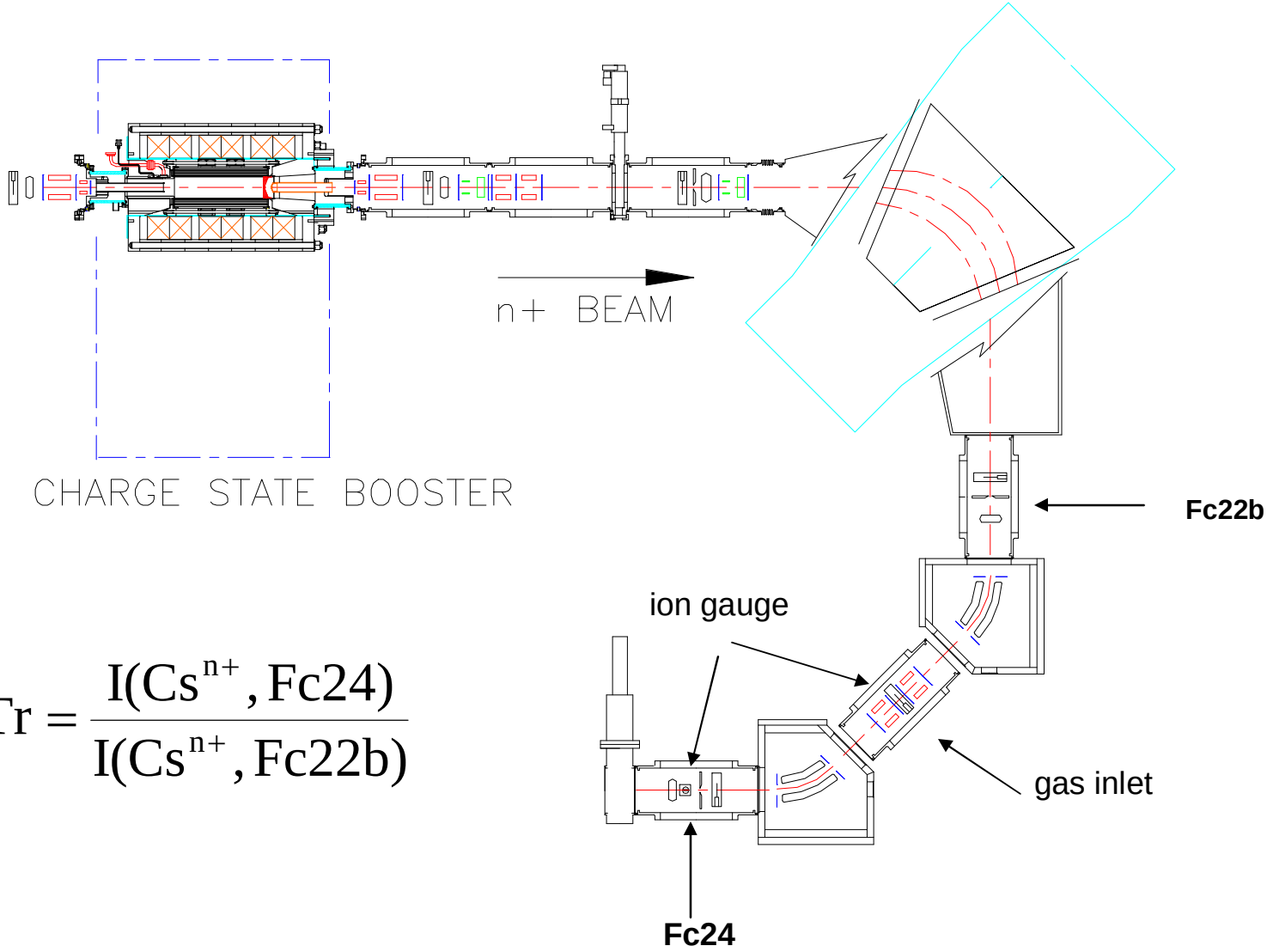
charge breeder results from the test stand

Measurements with ions from standard ISAC ion sources

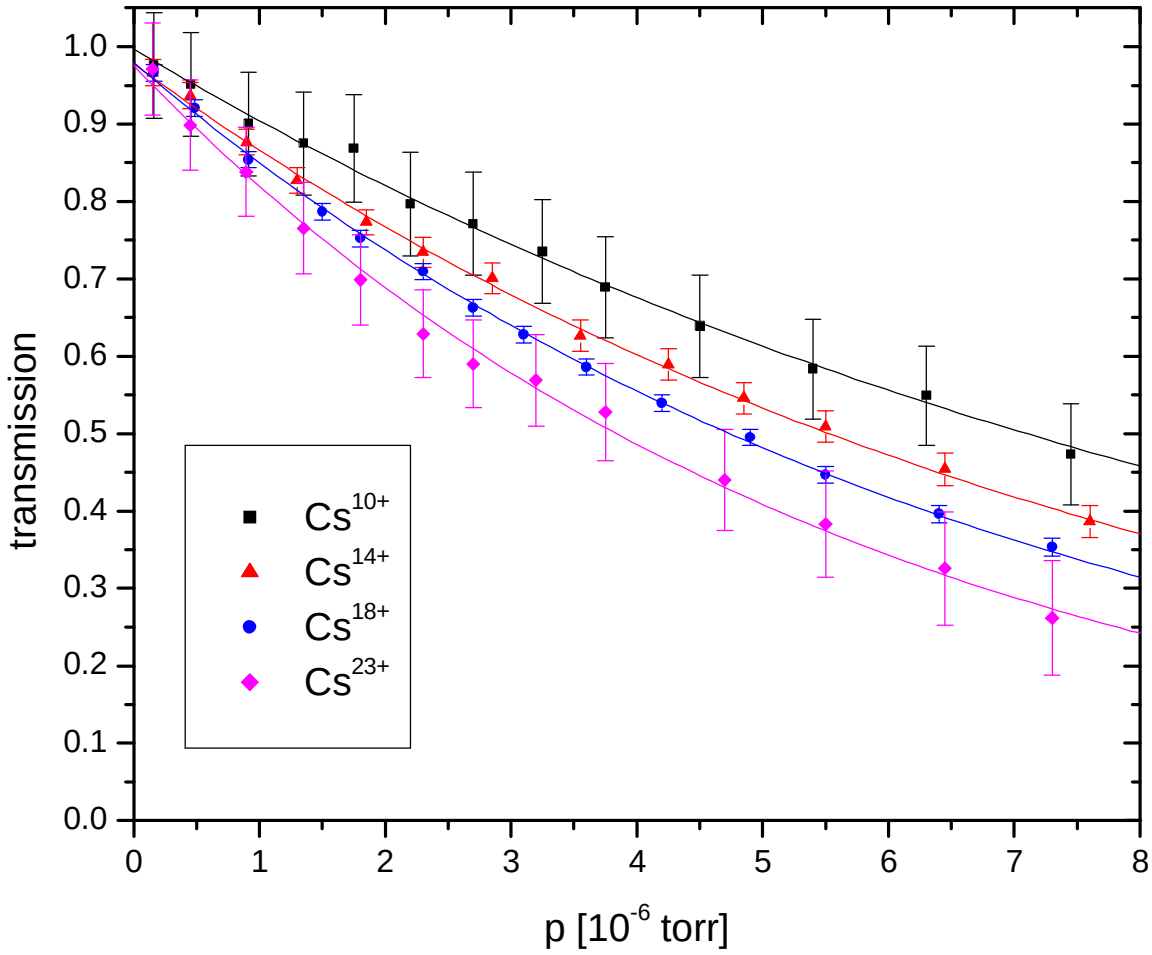
Element	Mass	Charge state with maximum efficiency (A/Q)	Efficiency (%)	rise time (90%) for charge state with maximum efficiency (ms)	1+ ion source
Ar	40	8+ (5)	5.5	102	ECR
Kr	84	12+ (7)	6.3	401	ECR
Xe	129	17+ (7.6)	4.8	432	ECR
K	39	9+ (4.3)	2.1		surface
Rb	85/87	13+ (6.5)	3	230	surface
Cs	133	20+ (6.7)	3.5	300	surface + testsource

- emittance of Cs^{n+} measured < 20 π mm mrad @ 15q keV

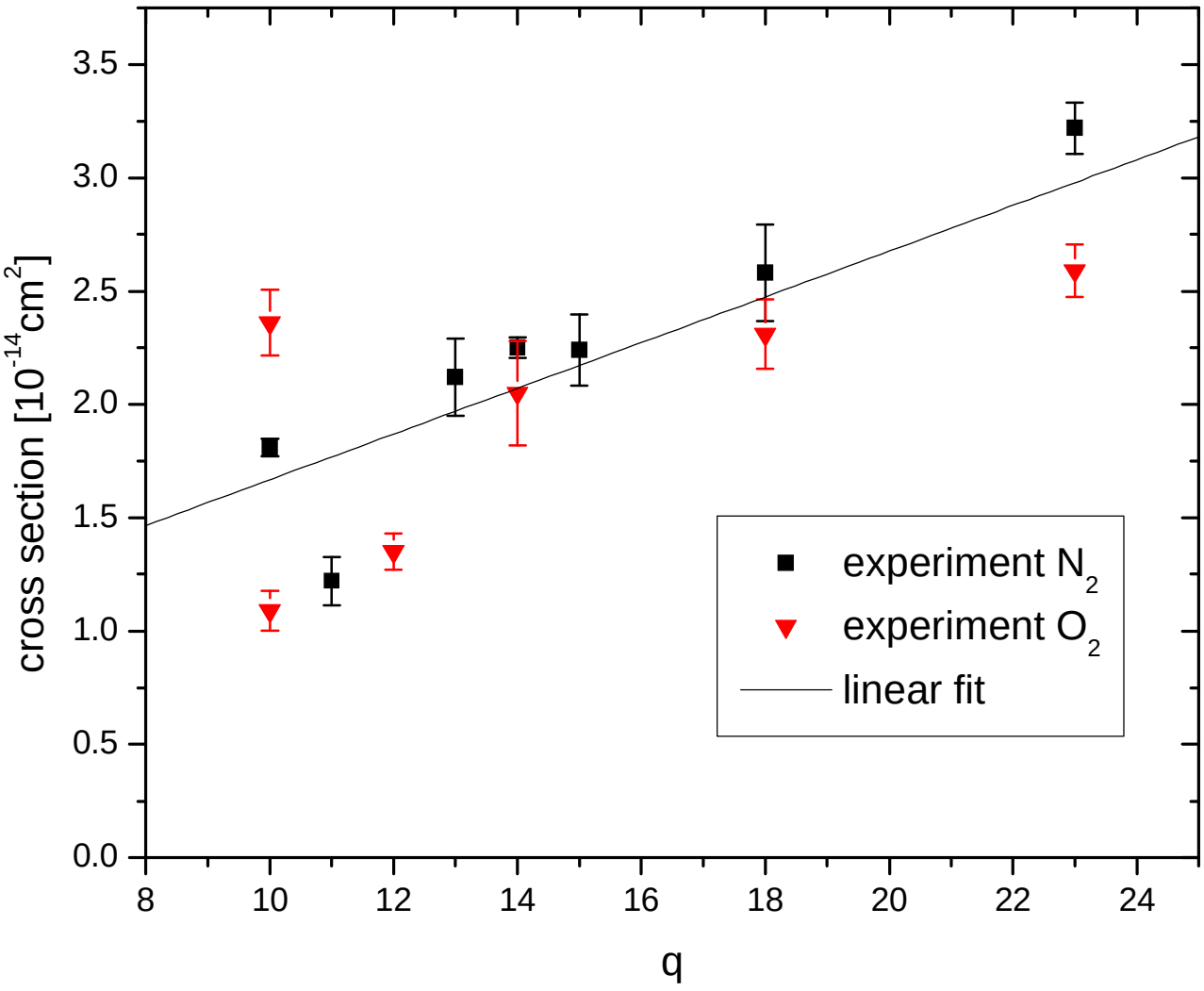
measurement of charge exchange cross sections



$$Tr = \frac{I(Cs^{n+}, Fc24)}{I(Cs^{n+}, Fc22b)}$$



transmission for different Cs charge states in nitrogen
exponential fit



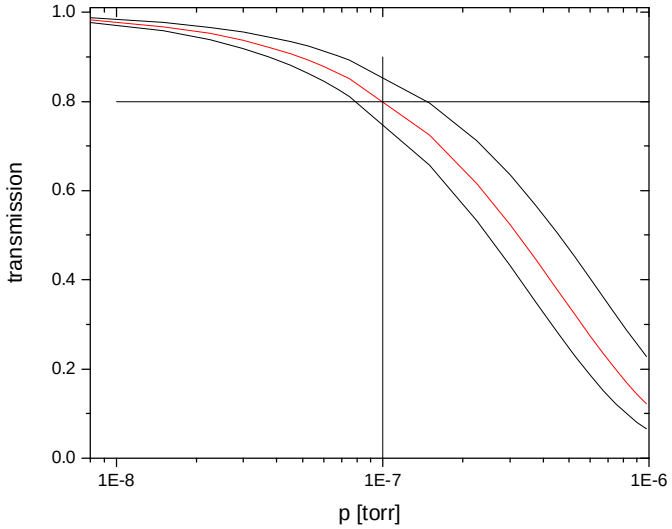
cross sections for highly charged Rb and Cs ions in O_2 and N_2
error bars: statistical error from fit of exponentials

cross section for charge exchange with residual gas measured

$$\sigma = ((6.58 \pm 0.89)\cdot 10^{-19} + (1.01 \pm 0.06)\cdot 10^{-19}\cdot q)\ m^2$$

q = 20

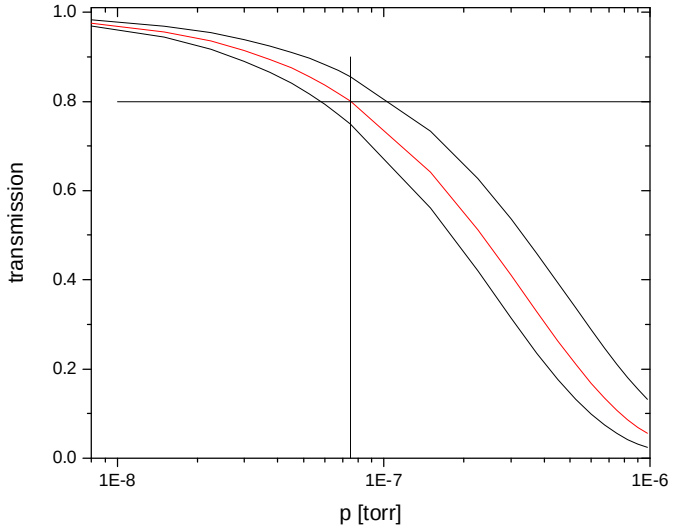
$\sigma = (2.7 \pm 0.8)\cdot 10^{-18}\ m^2$



$p(80\%) = 1\cdot 10^{-7}$ torr

q = 30

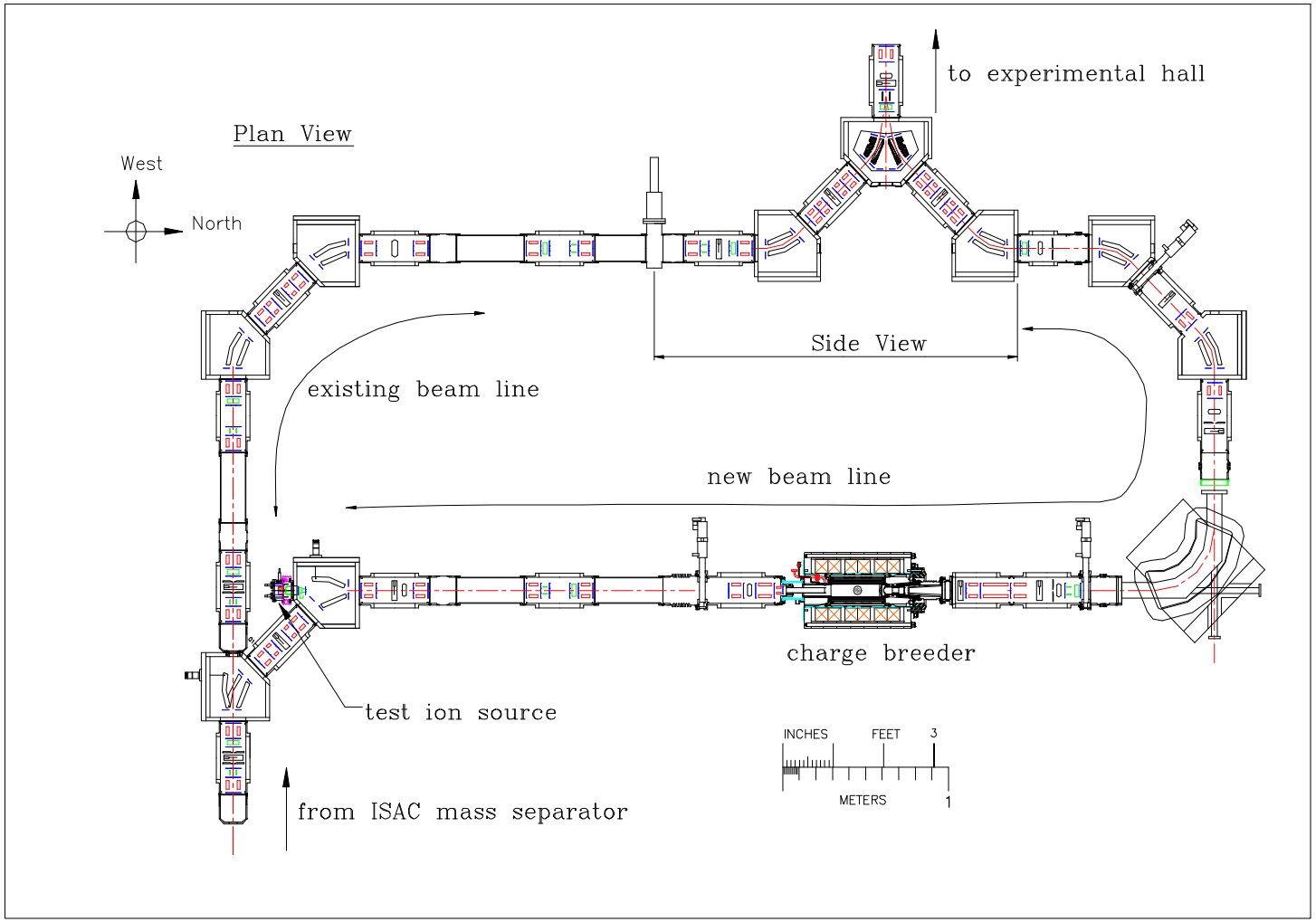
$\sigma = (3.7 \pm 1.1)\cdot 10^{-18}\ m^2$

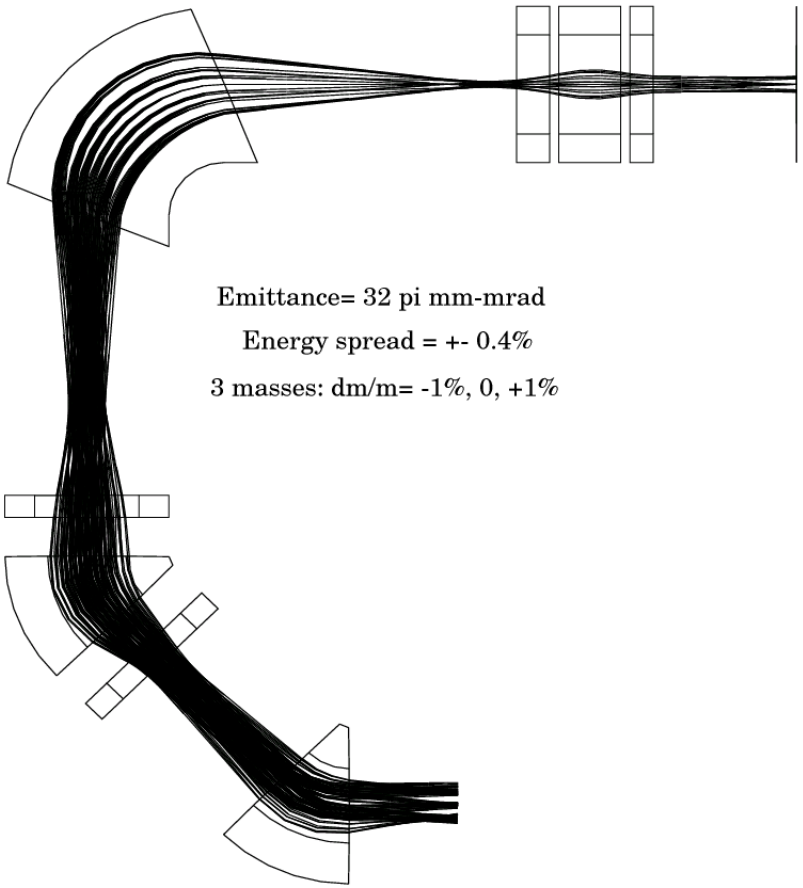


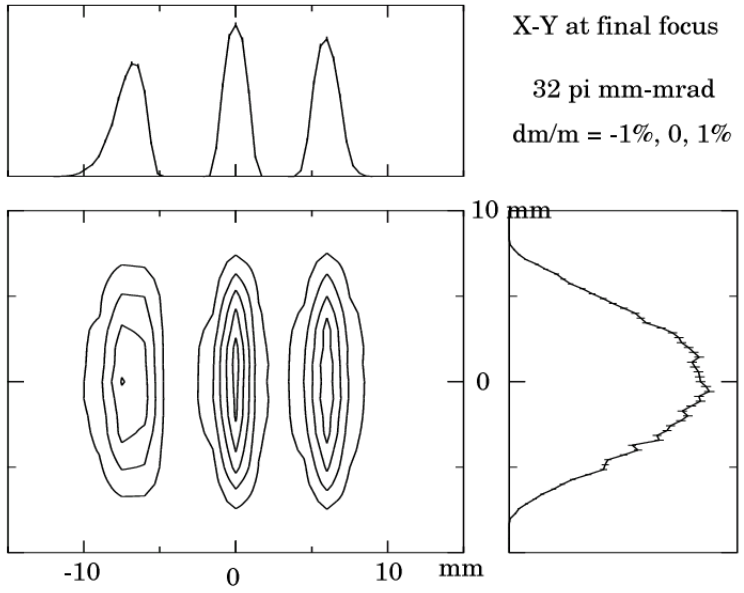
$p(80\%) = 7.5\cdot 10^{-8}$ torr

transmission after 25 m as function of pressure

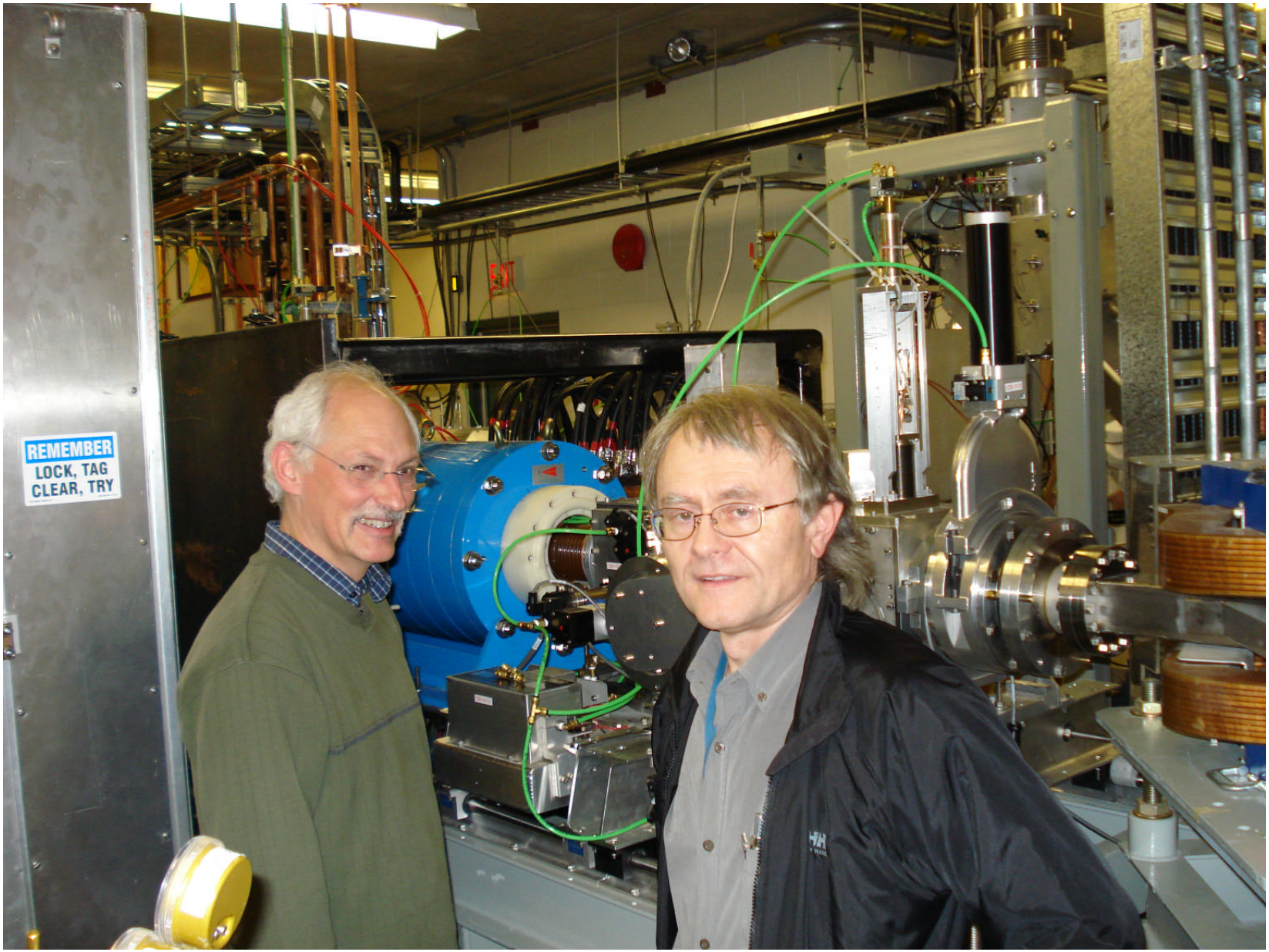
installation of the charge state breeder at ISAC







ion optical simulation for mass resolution after charge state breeding


REMEMBER
LOCK, TAG
CLEAR, TRY

Summary and Outlook

- charge breeding has been studied with stable ions
- mass to charge ratio A/q = 4.3 ($^{39}K^{9+}$) to A/q = 6.7 ($^{133}Cs^{20+}$)
  higher for higher masses
- efficiency ≈>3 %
- breeding time x 100 ms
- high background from residual gas ions
  can be separated in most cases
- charge exchange rates for 10-20 q keV (q<23) measured
- for q ≈> 10 cross section only depends on q

- on line installation finished commissioning ongoing

- first beam scheduled for November 2008

thank you

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