TRIUMF

CANADA'S NATIONAL LABORATORY FOR PARTICLE AND NUCLEAR PHYSICS

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Acceleration of Charge Bred Radioactive Ions at TRIUMF

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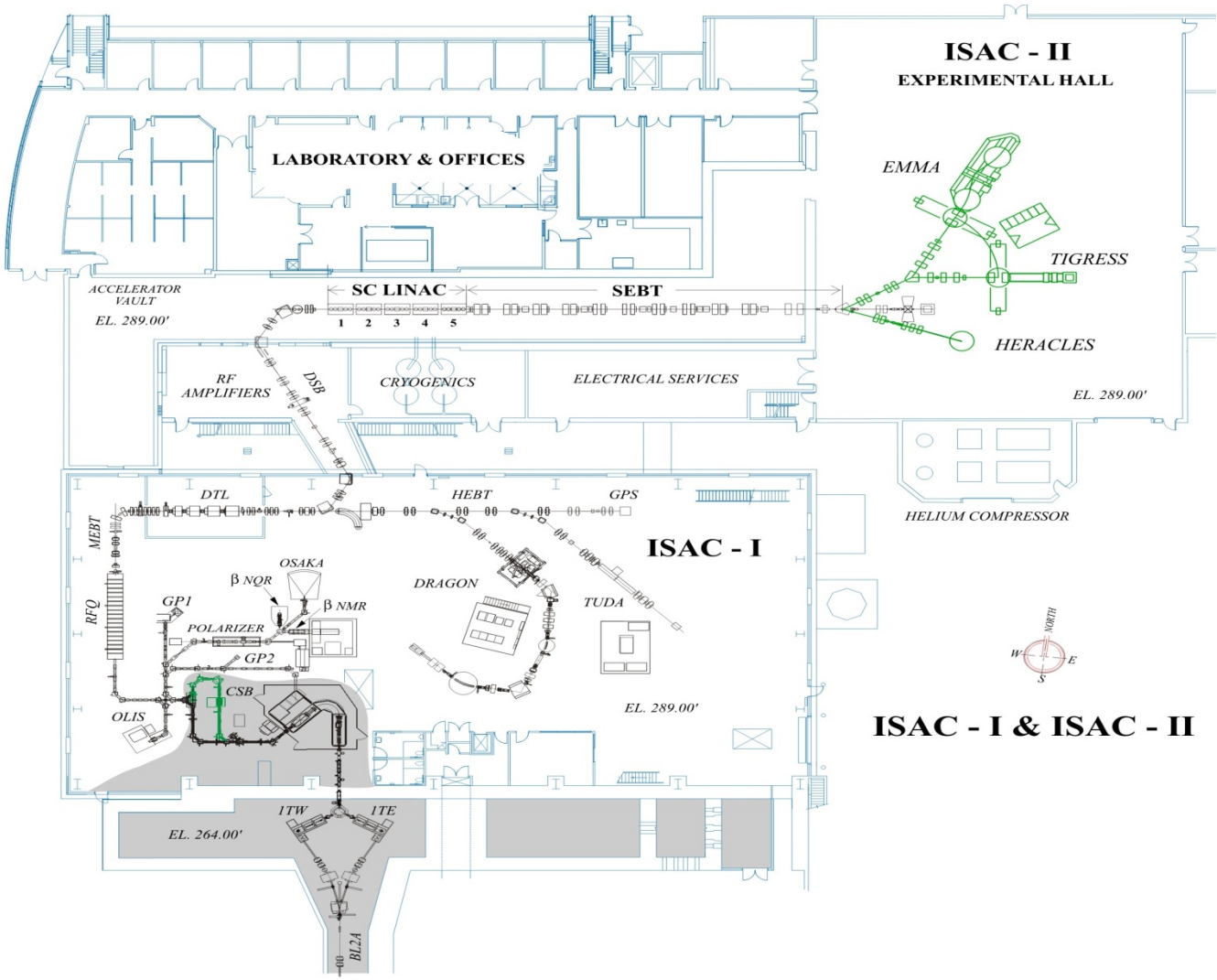
PAC09, Vancouver, May, 2009

LABORATOIRE NATIONAL CANADIEN POUR LA RECHERCHE EN PHYSIQUE NUCLÉAIRE ET EN PHYSIQUE DES PARTICULES

Propriété d'un consortium d'universités canadiennes, géré en co-entreprise à partir d'une contribution administrée par le Conseil national de recherches Canada

Layout of the ISAC facility at TRIUMF



Charge state breeding at ISAC:

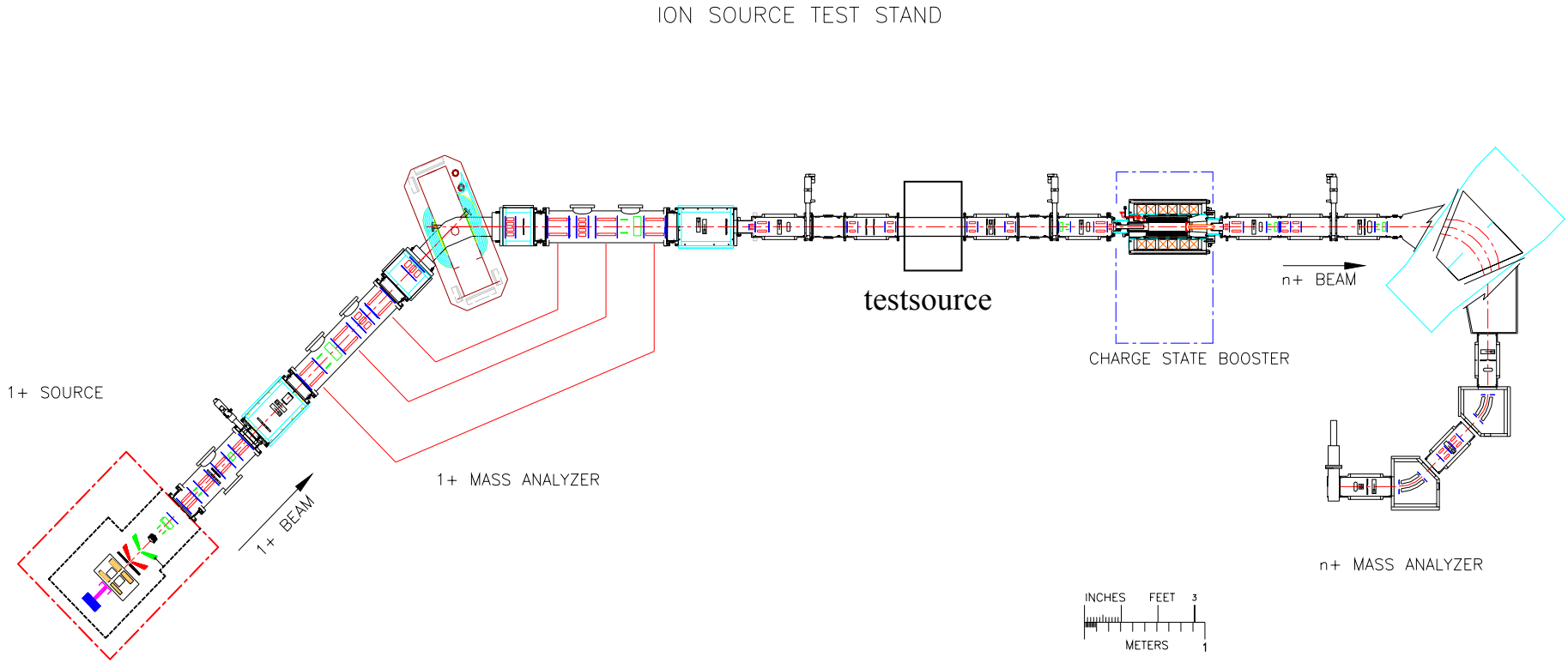
Requirements:

- **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

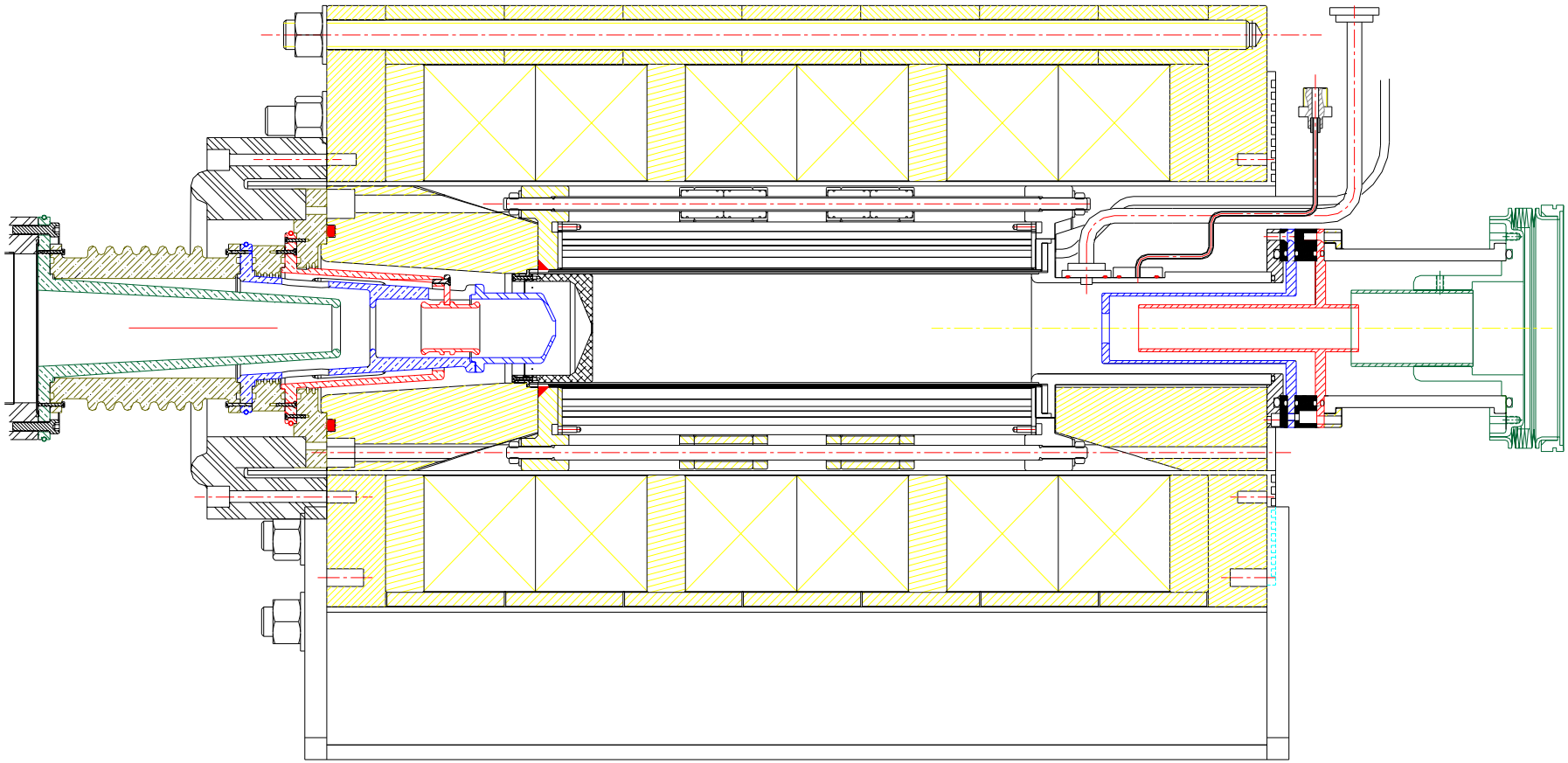
CSB test stand at TRIUMF



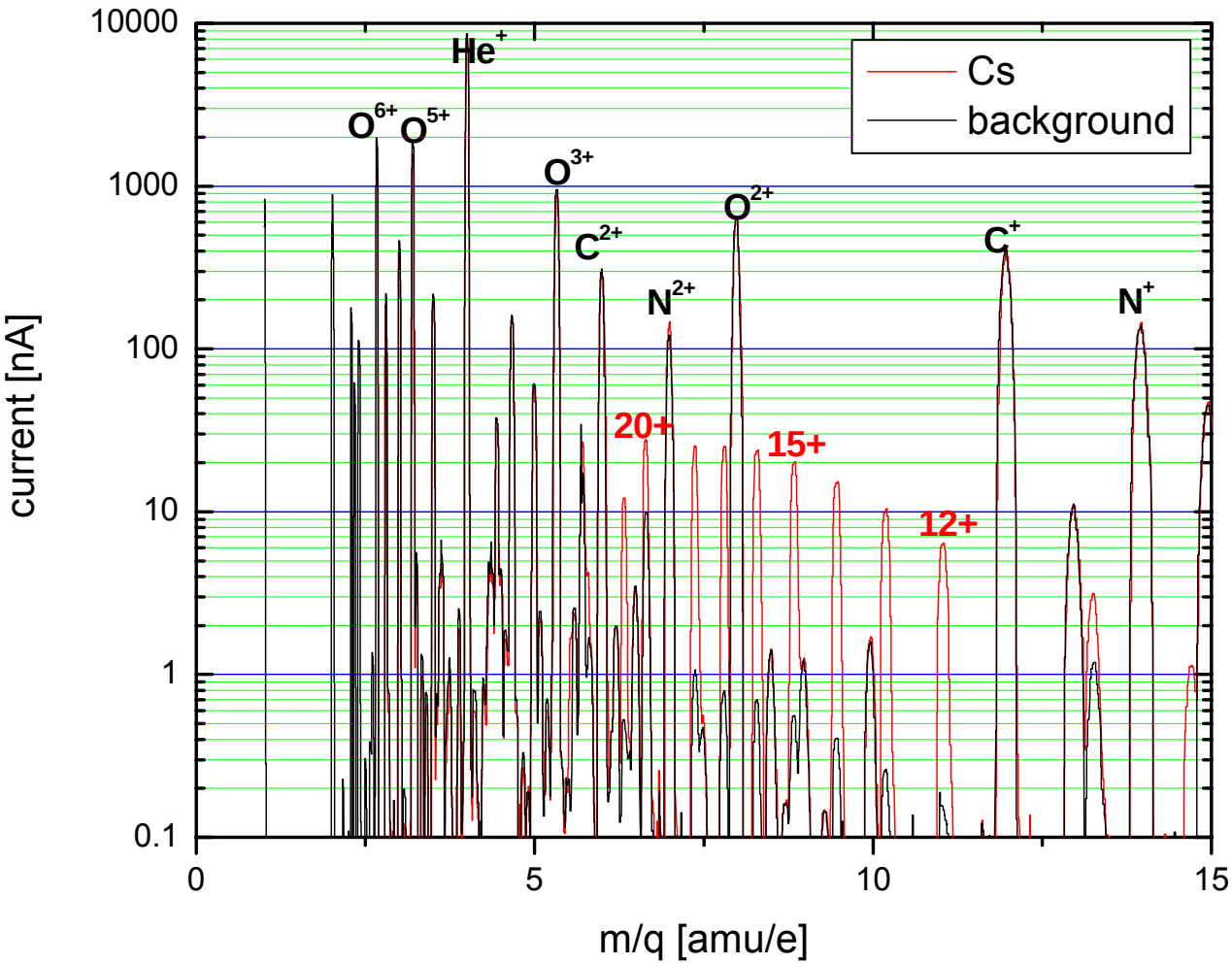
14.5 GHz ECR source PHOENIX from Pantechnik, injection and extraction modified

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



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

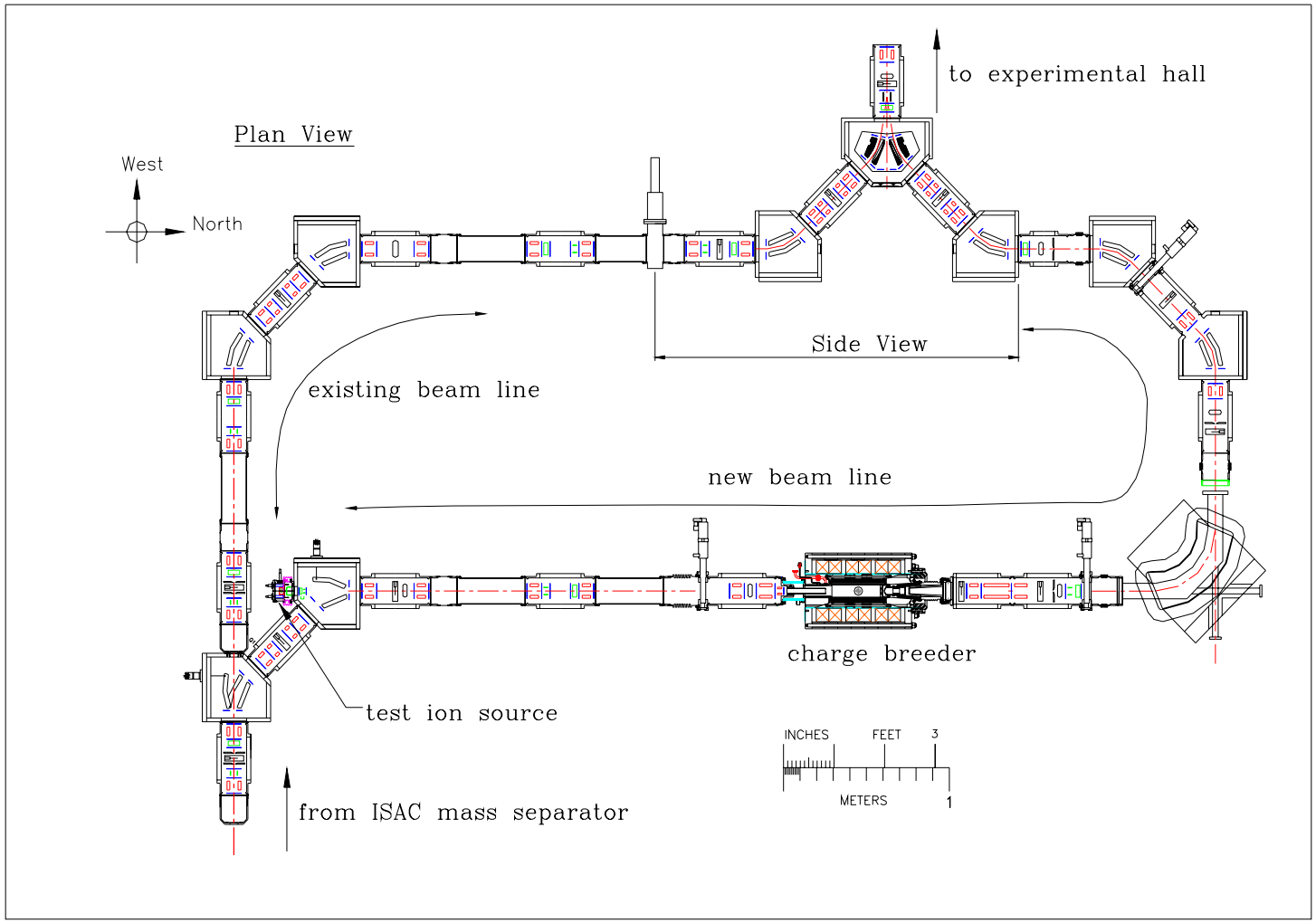
charge breeder results from the test stand

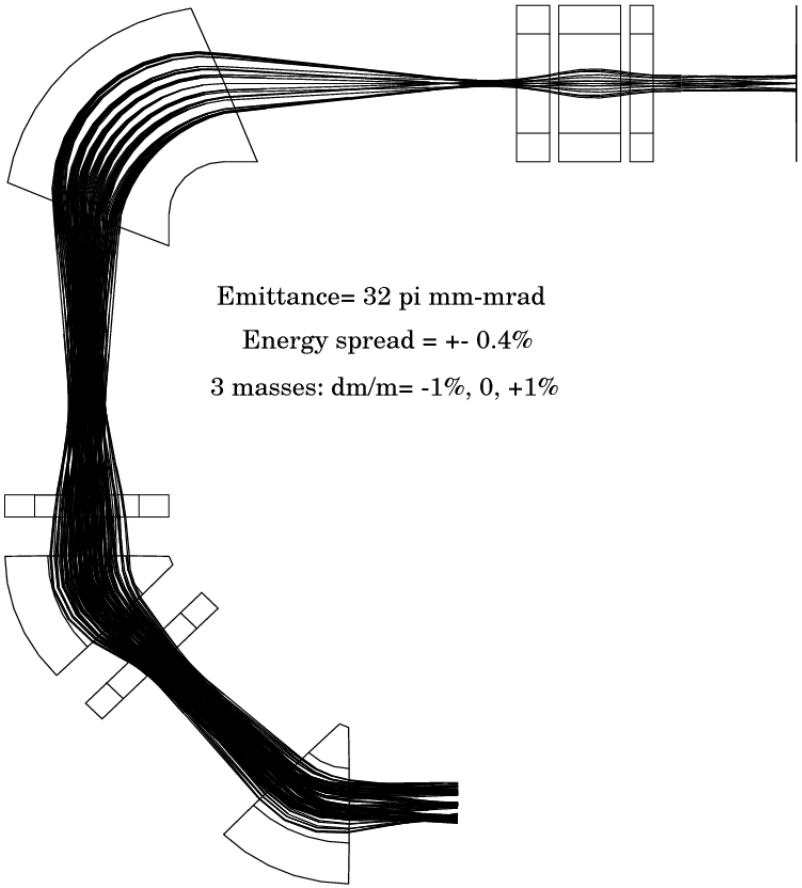
Measurements with ions from standard ISAC ion sources

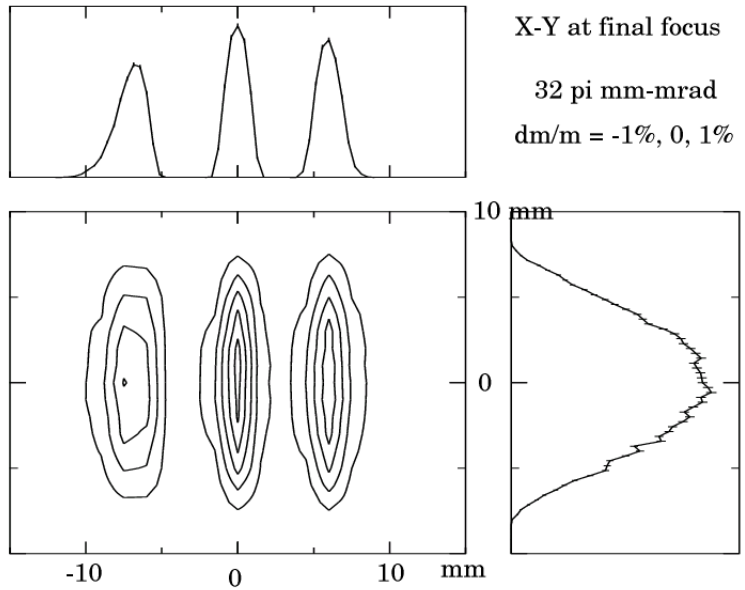
Element	Mass	Charge state with maximum efficiency (A/Q)	Efficiency (%)	rise time (90%) for charge state with maximum efficiency (ms)	1+ ion source
Ar	40	8+ (5)	5.5	102	ECR
Kr	84	12+ (7)	6.3	401	ECR
Xe	129	17+ (7.6)	4.8	432	ECR
K	39	9+ (4.3)	2.1		surface
Rb	85/87	13+ (6.5)	3	230	surface
Cs	133	20+ (6.7)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

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

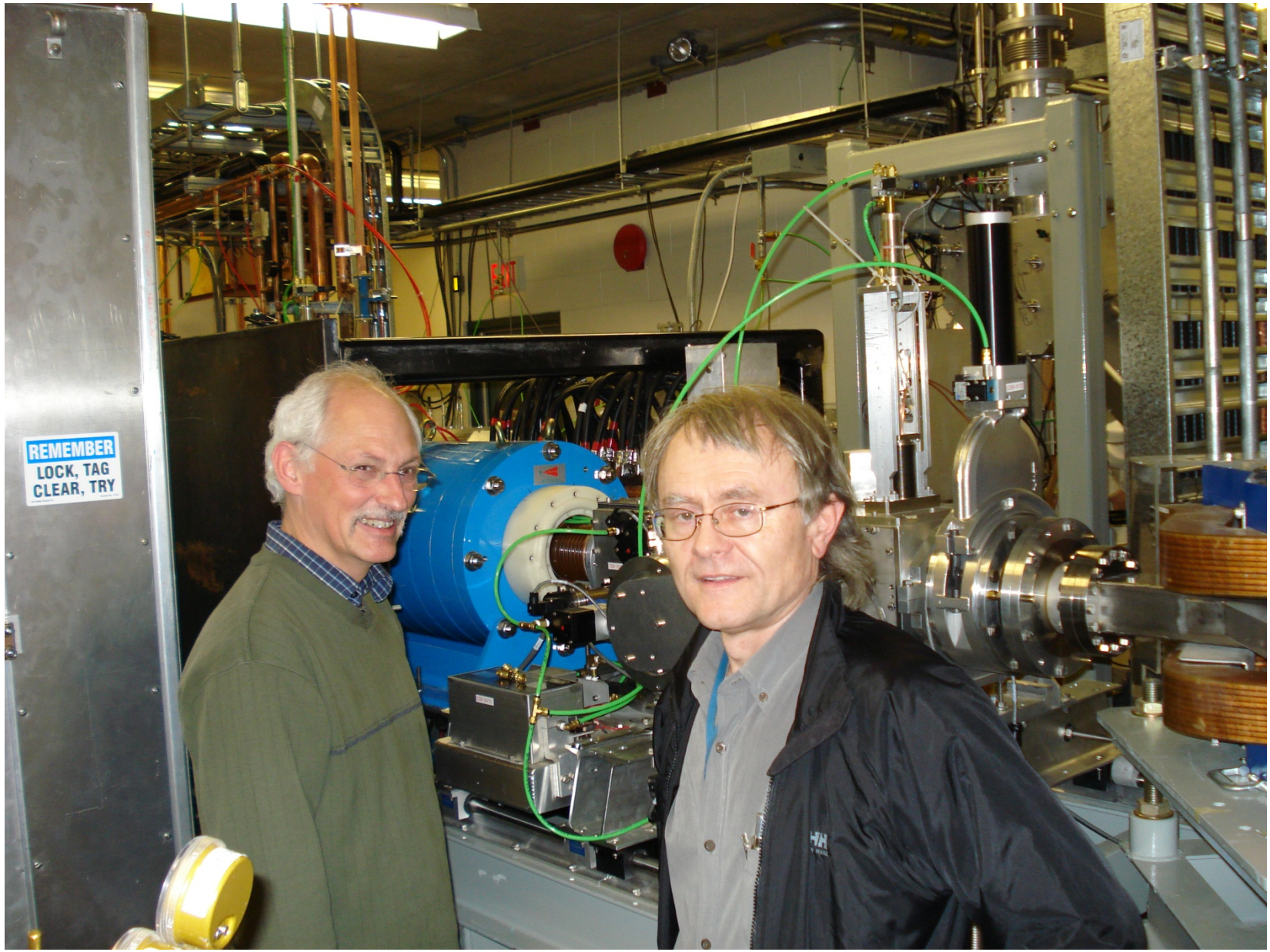
installation of the charge state breeder at ISAC



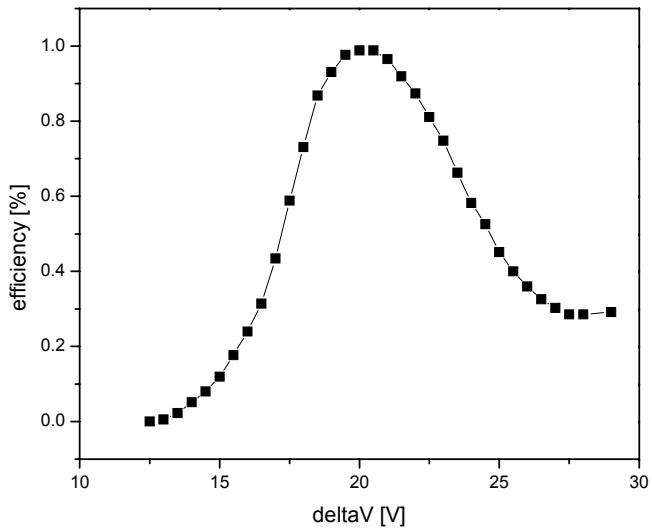




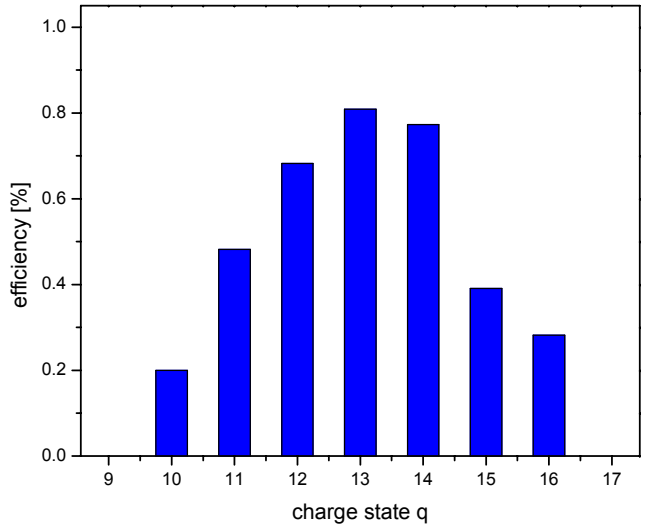
ion optical simulation for mass resolution after charge state breeding


REMEMBER
LOCK, TAG
CLEAR, TRY

on-line charge breeding results



Efficiency for the production of Cs^{17+} as function of the potential difference between the singly charged ion source and the charge breeder



Efficiency for the production of high charge states of ^{80}Rb

charge bred radioactive ions

^{80}Rb

^{122}Cs

^{124}Cs

acceleration of charge bred $^{80}Rb^{14+}$

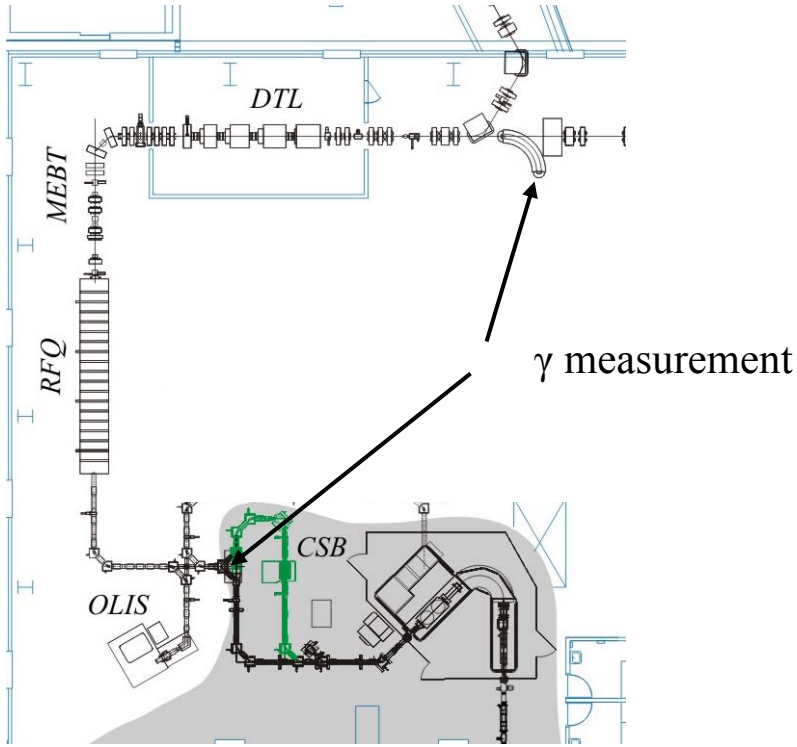
determine $^{80}Rb^{14+}$ intensity after charge breeding
by measuring γ radiation
⇒1.1 10^5 ions per sec (1% efficiency)

radioactive beam is accompanied by ~100 nA $^{40}Ar^{7+}$

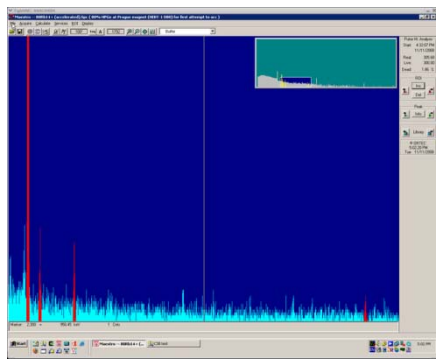
inject beam into RFQ,
accelerated to 150 A keV,
drifted through DTL,
energy analyzed with magnet

transmission for $^{40}Ar^{7+}$ 33%

determine $^{80}Rb^{14+}$ intensity after acceleration
by measuring γ radiation
⇒3.5 10^4 ions per sec (32%)



γ spectrum
after acceleration



Summary and Outlook

- charge breeding with stable ions
- mass to charge ratio A/q = 4.3 ($^{39}K^{9+}$) to A/q = 6.7 ($^{133}Cs^{20+}$)

- efficiency ≈>3 % higher for noble gases
- breeding time x 100 ms

- charge breeding with radioactive ions
- test beam time November 2008
- first acceleration of radioactive charge bred $^{80}Rb^{14+}$ ions

- continue commissioning with radioactive ions from different elements
- further optimization of breeding efficiency
- and accelerator transmission

thank you

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