A study of the 1+n+ scenario with the Phoenix booster at ISOLDE

M. Marie-Jeanne, P. Delahaye, the IS397 and IS458 collaborations

Outline

- Why ECR charge breeding ?
- Results of the 1+n+ studies
- Tentative for beam purification
- Possibilities for future experiments

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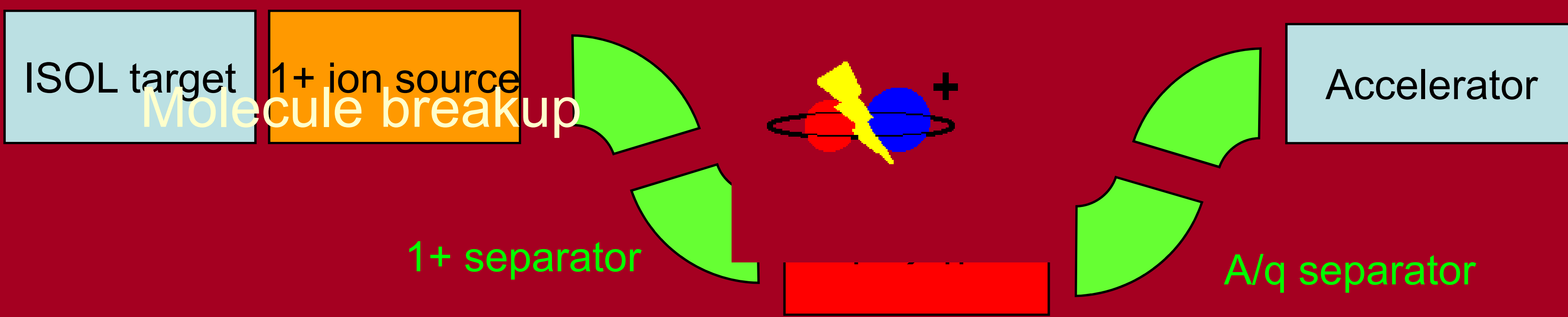
The 1+→n+ scenario

- For RIB development
- For RIB post-acceleration

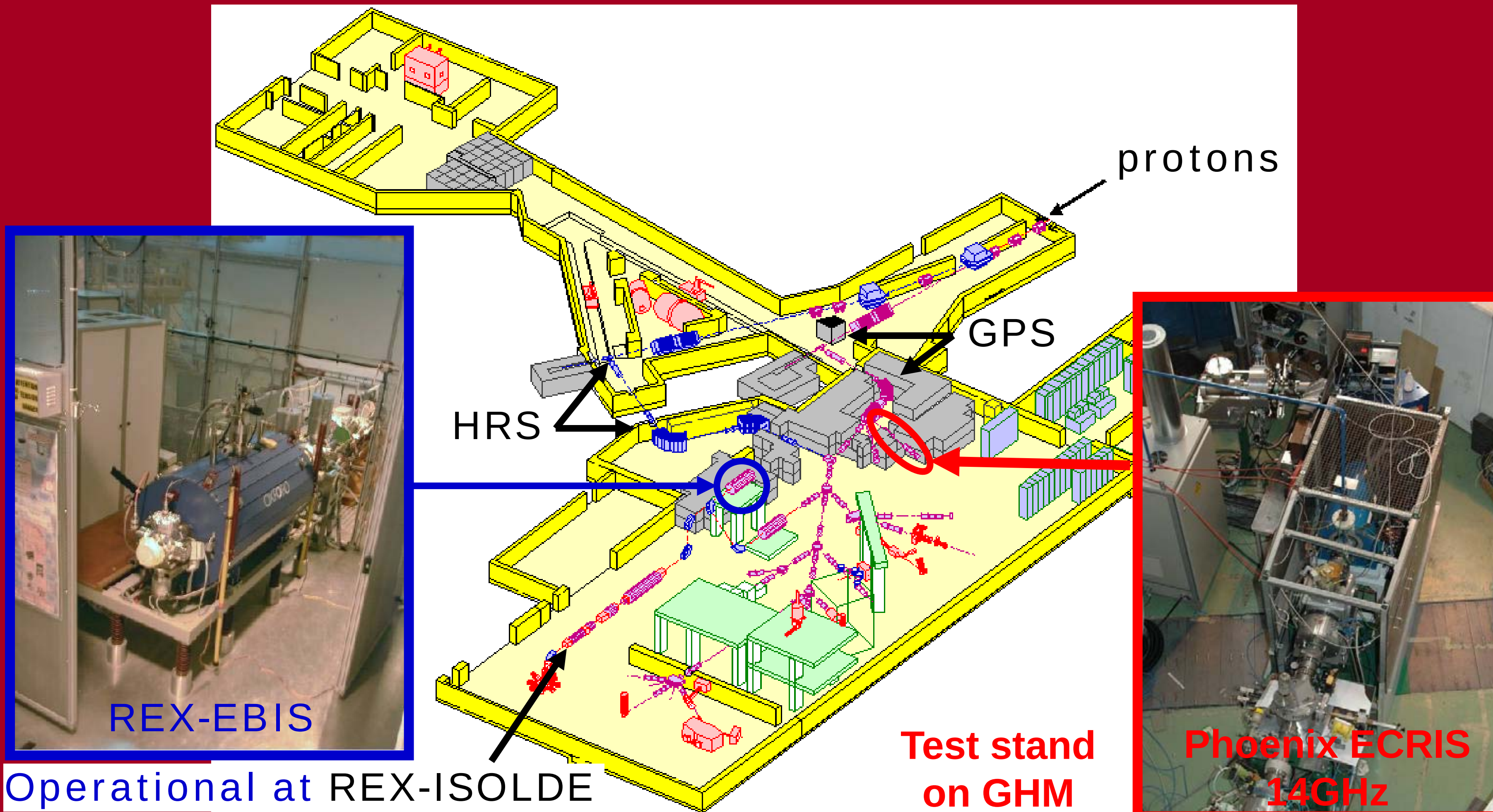


Daughter nuclide trapping

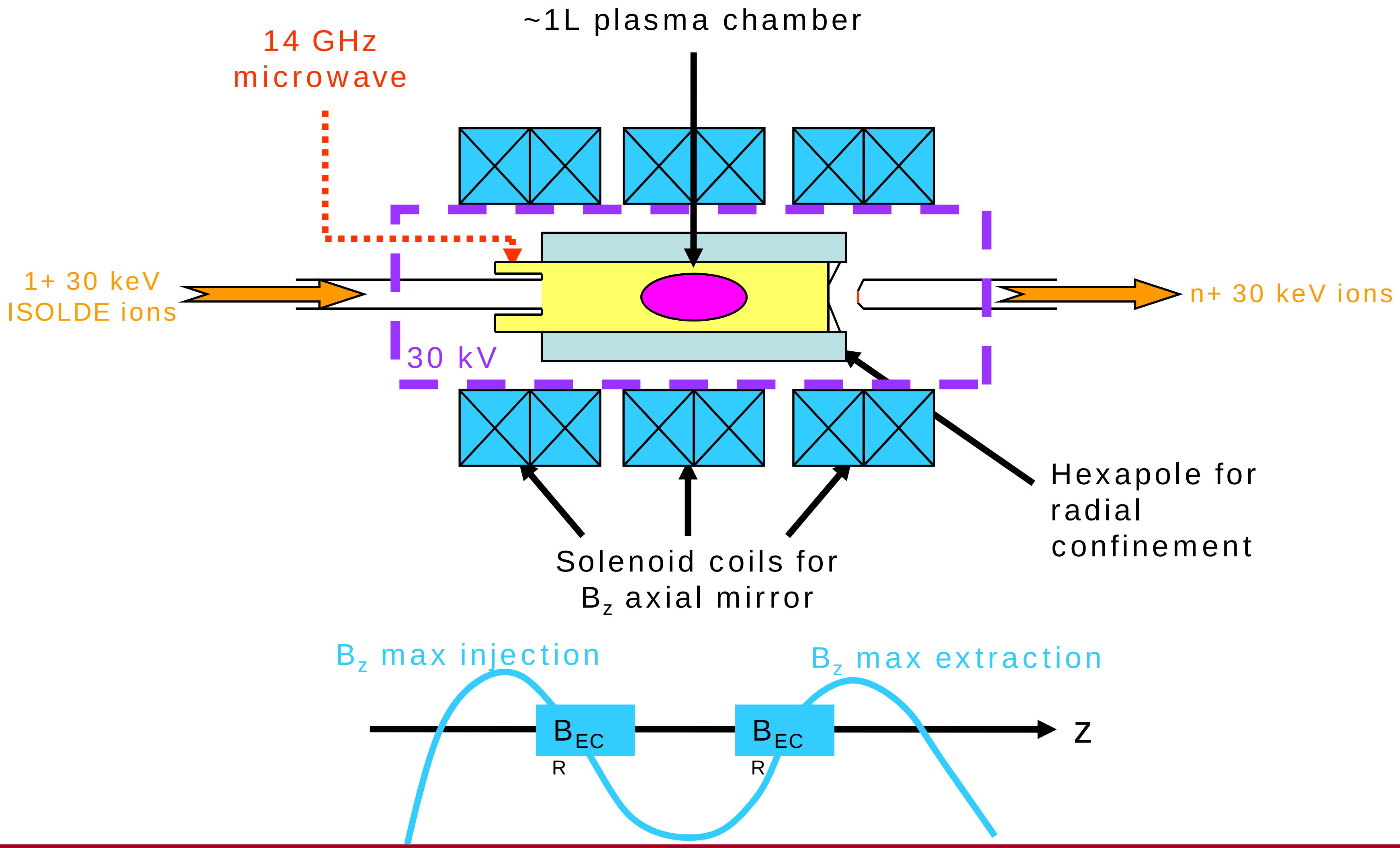
Making more radioactive isotopes available

Matching the A/q acceptance of the post-accelerator

Charge breeding at ISOLDE



The PHOENIX ECR Booster



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Performances with stable ions

All ions for A>20 charge bred

Optimal charge breeding for 4<A/q<8

Continuous mode	Pulsed mode
Efficiency	
2% (alkali)→ 10% (noble gas) Breakup of LaO^{+} --> 3.5% of $^{139}La^{23+}$	Half of the continuous mode
Charge breeding time	
~100ms minimum	~ 20ms minimum *

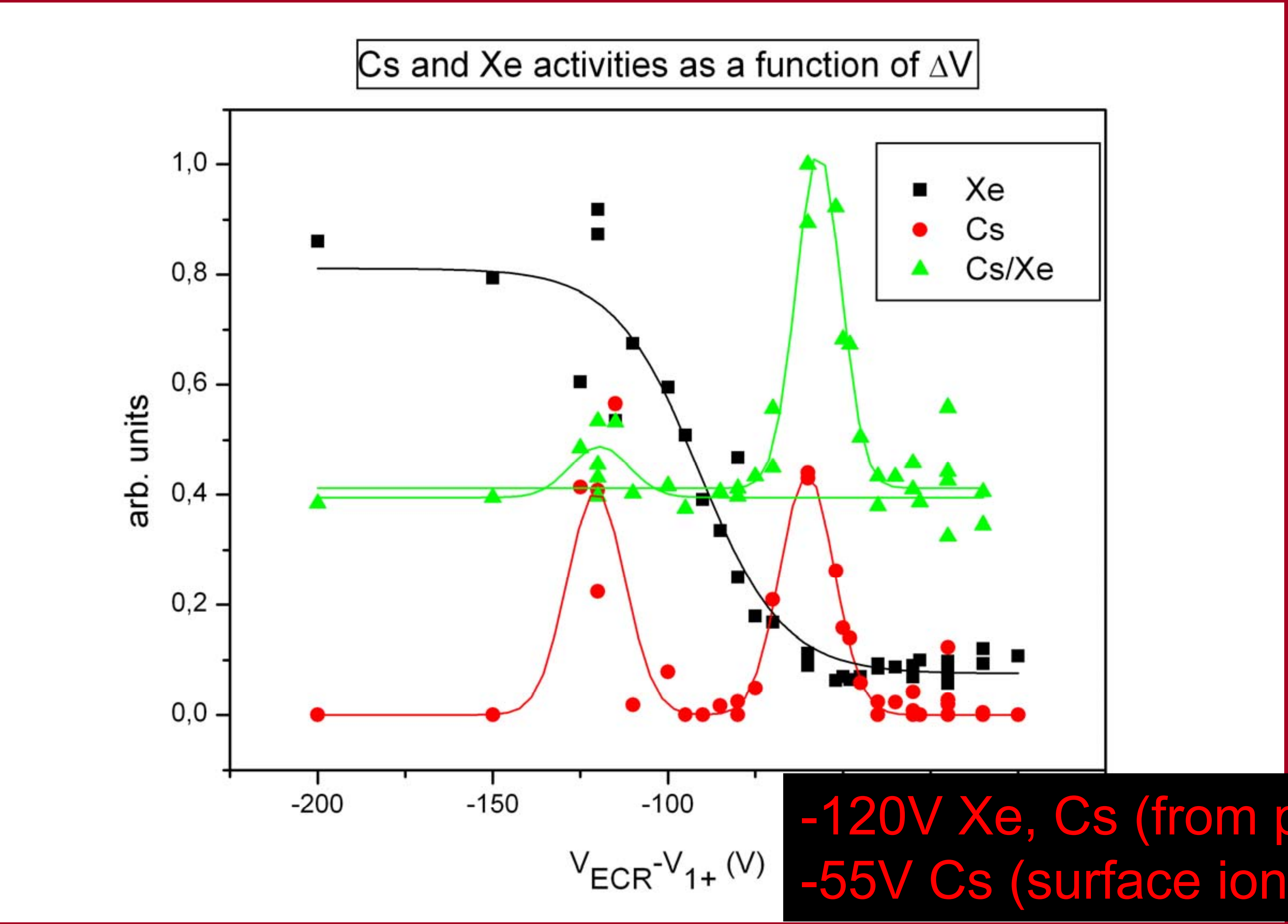
* P. Sortais et al., Rev. Sci. Instrum. **71**, 617 (2000)

Results with radioactive ions

CW-mode:

- ✓ Measurement of injection conditions confirms results with stable beams
  - same ΔV to inject a given mass for a given 1^+ source
  - many beam energies if surface ionization in 1^+ source

Mass 142 cocktail beam



-120V Xe, Cs (from plasma)
-55V Cs (surface ionized)

Results with radioactive ions

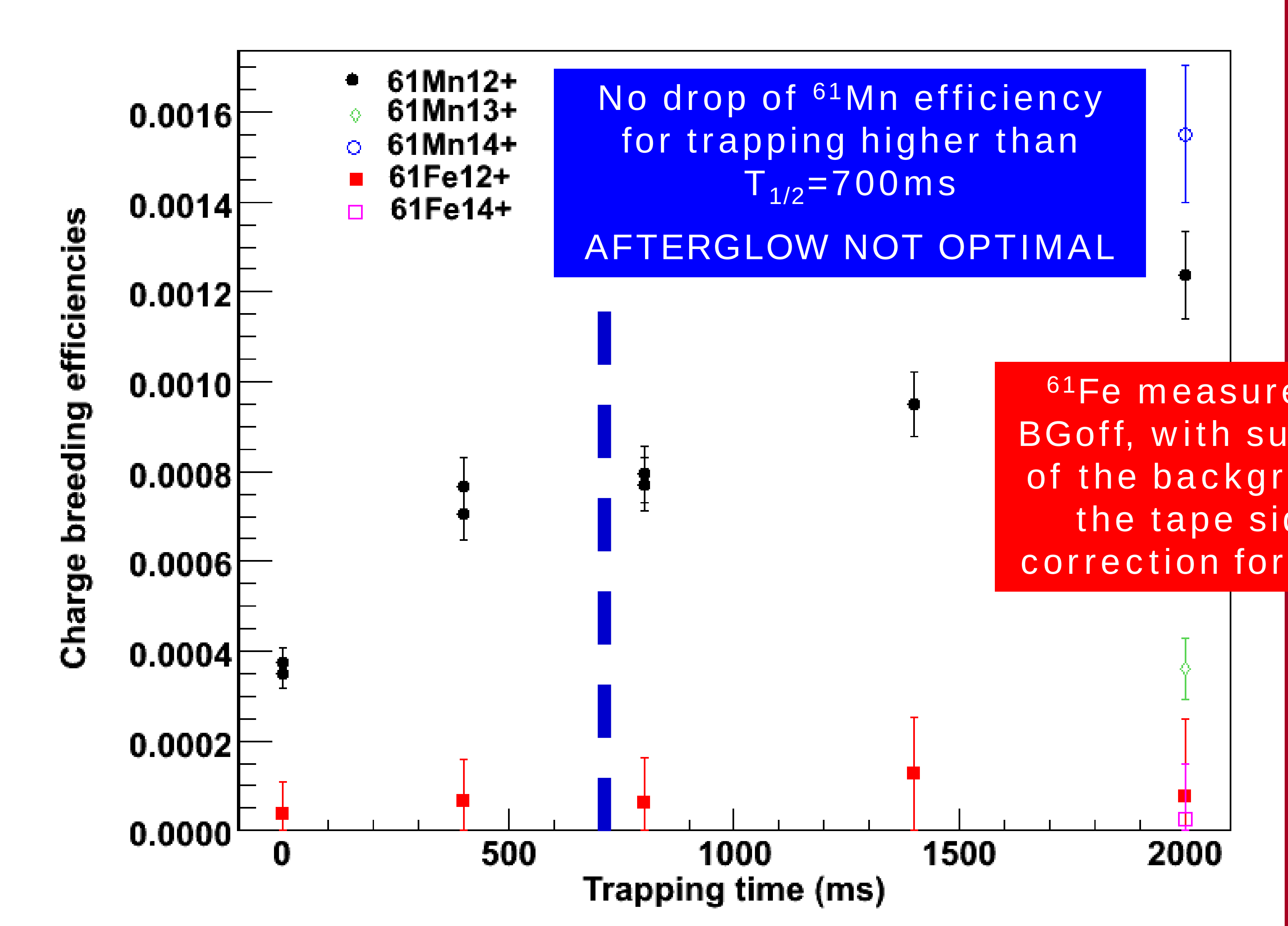
CW-mode:

- ✓Measurement of injection conditions confirms results with stable beams
  - ➢same ΔV to inject a given mass for a given 1^{+} source
  - ➢many beam energies if surface ionization in 1^{+} source

Pulsed-mode:

- ✓Trapping of daughter nuclides not conclusive
  - ➢afterglow configuration not optimal
  - ➢Is Fe trapped or recycled from the walls ?

Charge breeding of daughter nuclides



No drop of ^{61}Mn efficiency for trapping higher than $T_{1/2}$=700ms

AFTERGLOW NOT OPTIMAL

^{61}Fe measured during BGoff, with substraction of the background from the tape sides and correction for the decay

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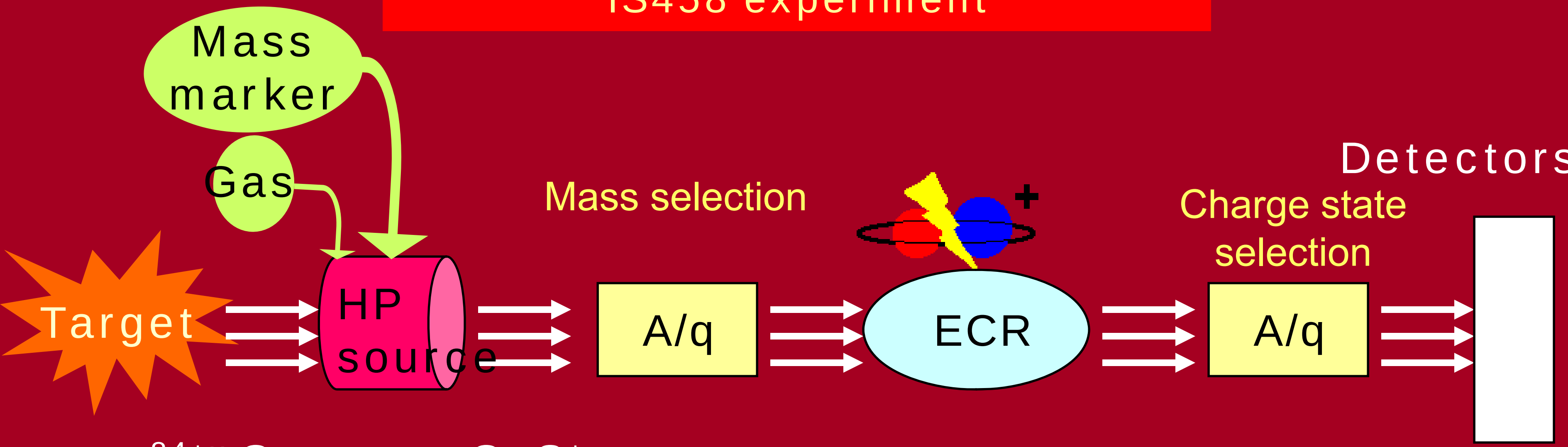
Purification of RIB by molecule breakup

CERN INTC proposal 225 (2007)
IS458 experiment

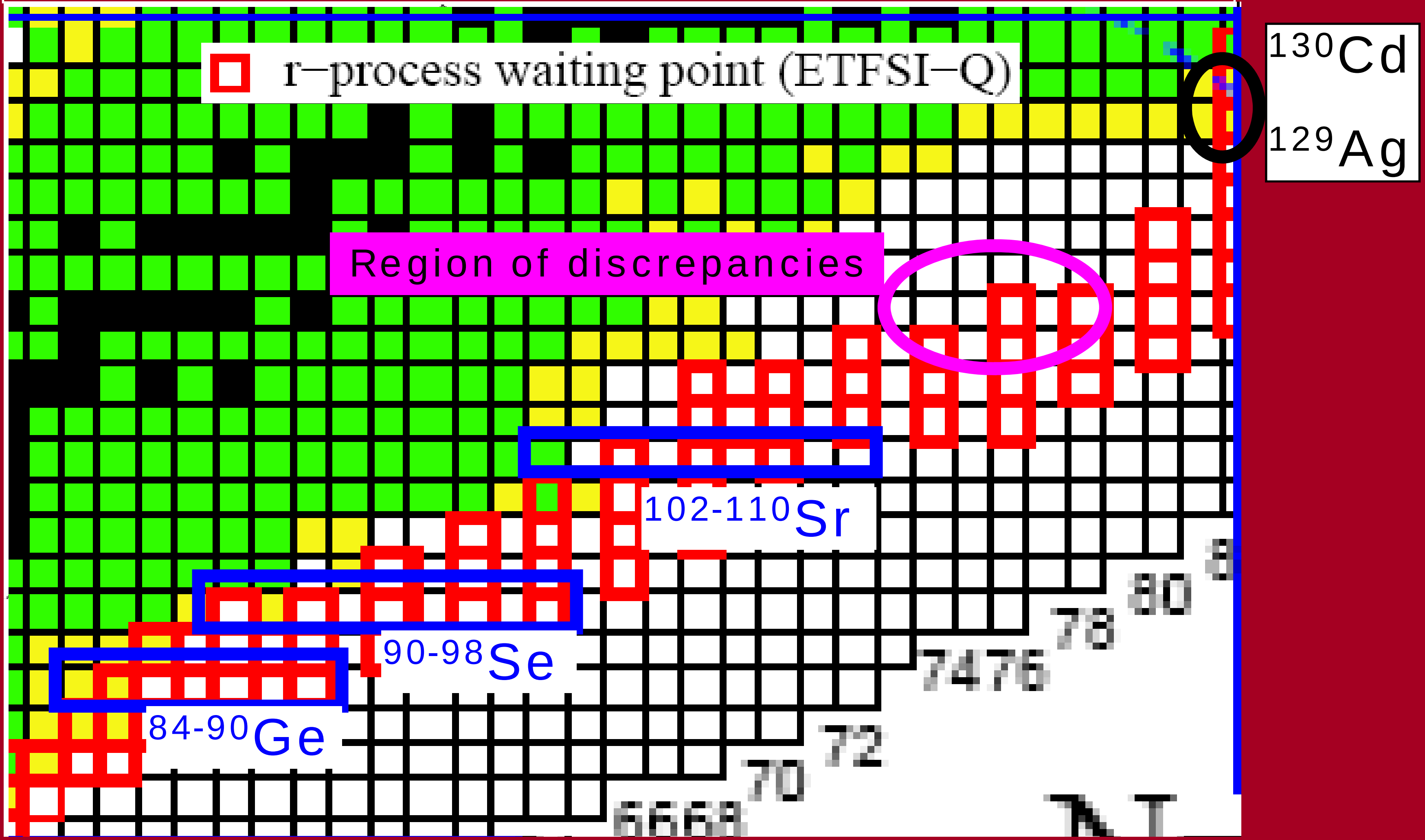


$^{84+x}$Ge	GeS^{+}	Ge^{n+}	Ge^{n+}
$^{90+x}$Se	$SeCO^{+}$	Se^{n+}	Se^{n+}
$^{102+x}$Sr	SrF^{+}	Sr^{n+}	Sr^{n+}

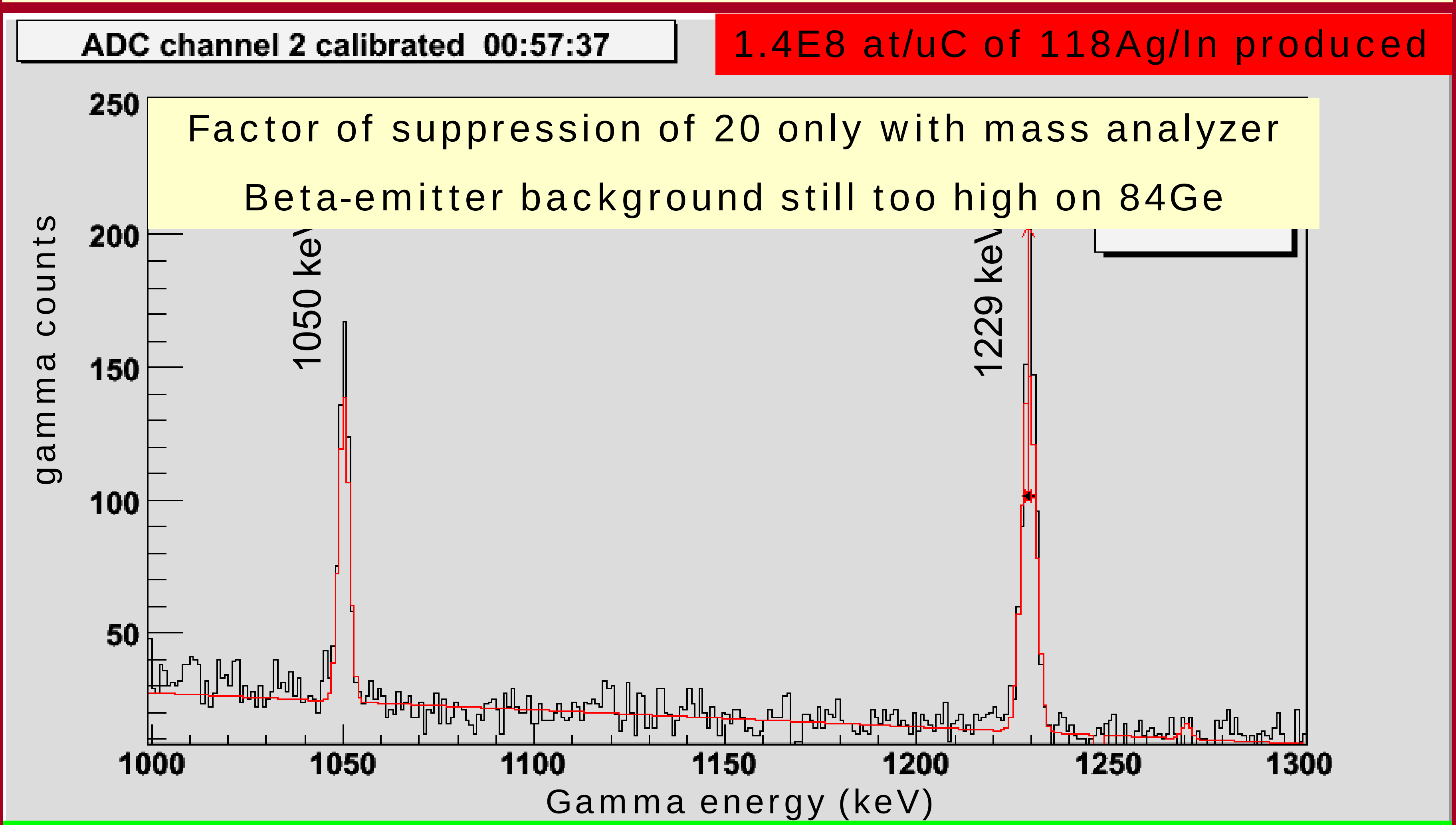
+ Fission fragments ...

Application to nuclear astrophysics

H. Grawe et al., Reports on Progress in Physics 70, 1525-1582 (2007)



Problem of background suppression

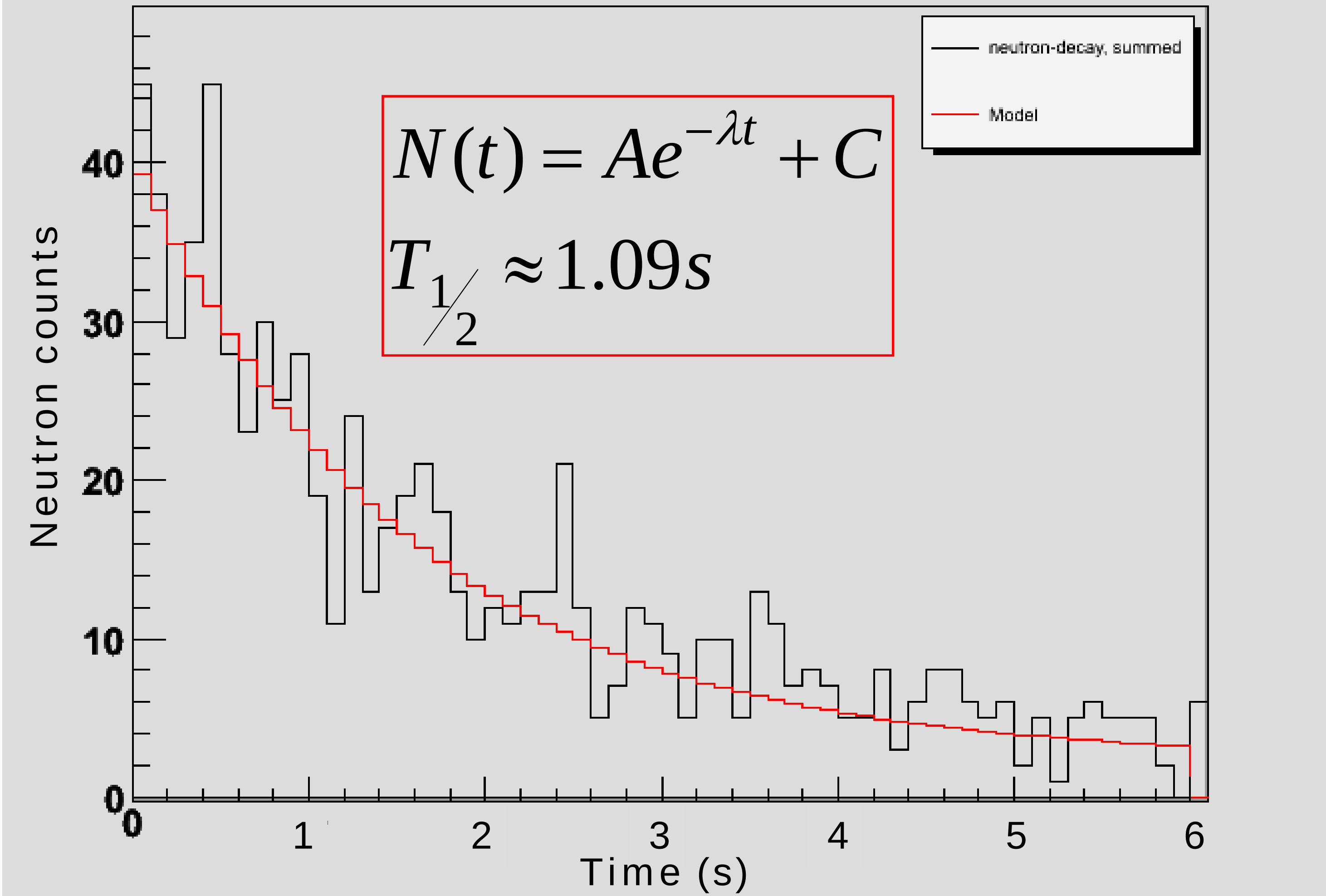


84Ge11+ CS (A/q=7.64) measurement after the ECR for 2h27min

Detection setup

Method validated

$^{134}Sn^{34}S$ broken in the ECR, $^{134}Sn^{21+}$ neutrons detected



$$N(t) = Ae^{-\lambda t} + C$$

$$T_{1/2} \approx 1.09s$$

Nucl... C)

^{134}Sn...

^{140}I(...

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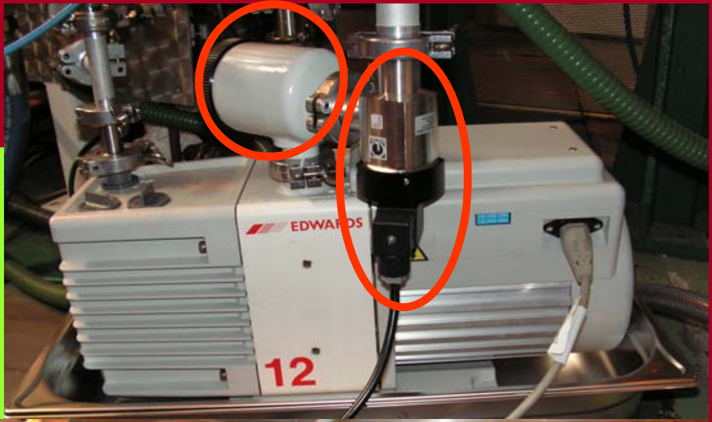
An upgraded Phoenix Booster

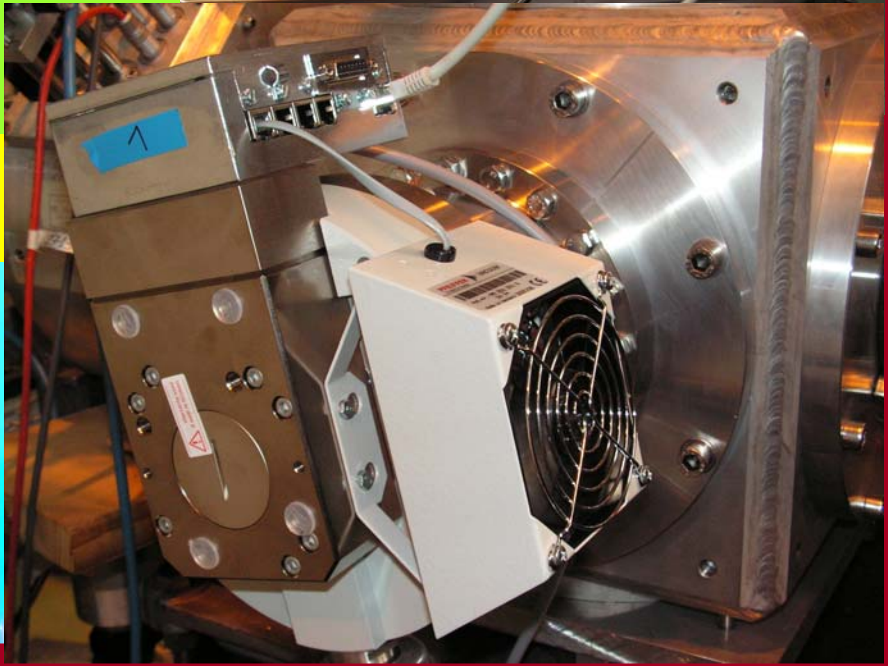
2007: vacuum improvements

- conductance for injection side
- 3 x Edwards rotary backing pumps
- 5 x 500L Pfeiffer turbopumps
- electromagnetic valves
- foreline traps

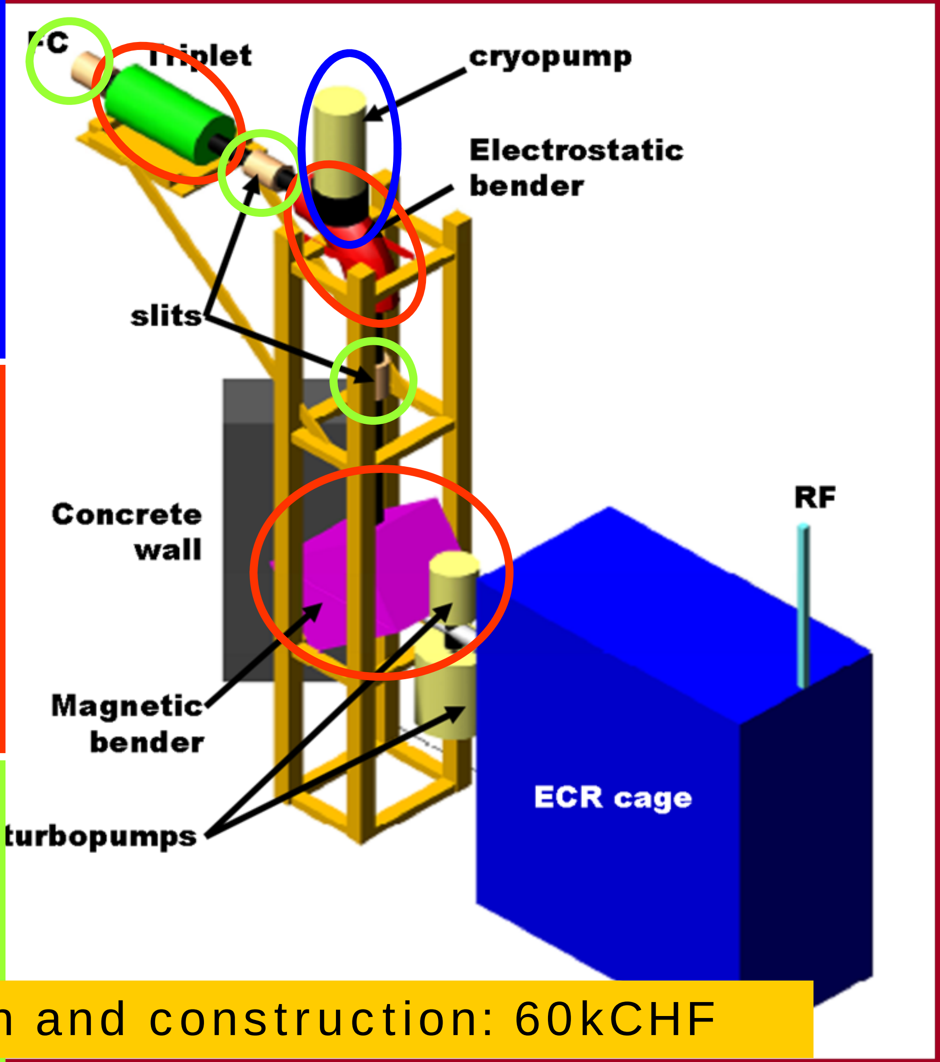
for

P_{inj} =1.10^{-6} mbar → 1.10^{-7} mbar



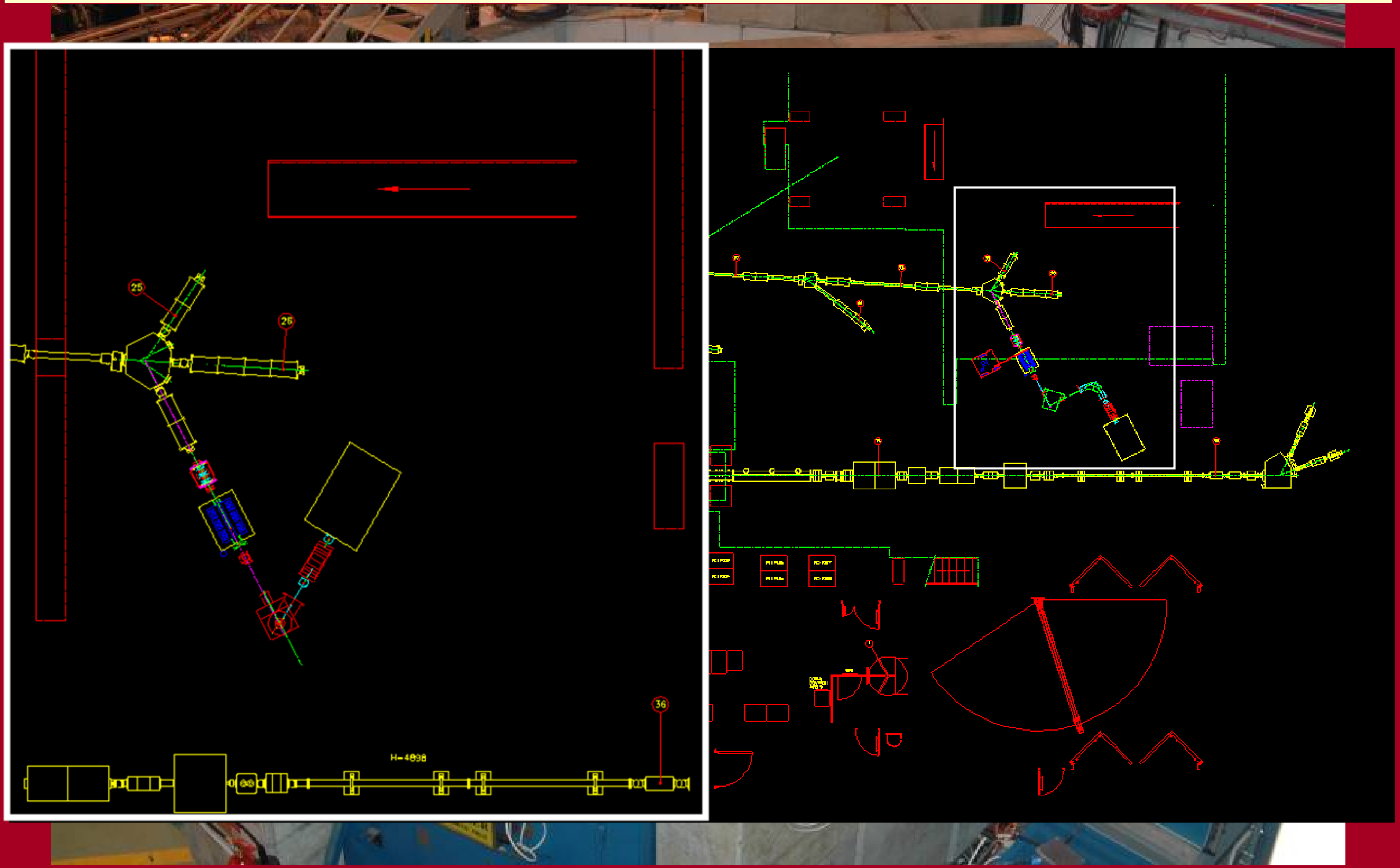


A new isotopic separator



Supporting structure design and construction: 60kCHF

More space ?



Conclusion

ECR charge bred beams for postacceleration:

- of high intensity – high emittance beams
- to feed a CW LINAC or a cyclotron

ECR charge bred beams for experiments:

- suppression of isobaric contamination
- outlook: new mass and energy separator to suppress contamination from intense neighbouring peaks

Acknowledgments

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the IS397 collaboration:

Charge Breeding of Radioactive Ions in an Electron Cyclotron Resonance Ion Source(ECRIS) at ISOLDE

C. Barton[1], P. Butler[2], K. Connell[3], P. Delahaye[2], T. Friticoff[4], D. Habs[5], C. Hill[2], O. Kester[6], H. Koivisto[7], P. Jardin[8], T. Lamy[9], R. Leroy[8], M. Lindroos[2], P. Sortais[9], P. Suominen[7], G. Transtromer[10], A. Villari[8], D.D. Warner[3], F. Wenander[2]

the IS458 collaboration:

Measurement of ground state properties of neutron-rich nuclei on the r-process path between the N=50 and N=82 shells

Carmen Angulo[1], Charles Barton[2], Joakim Cederkall[3], Pierre Delahaye[3], Ulli Köster[4], Mélanie Marie-Jeanne[3], Gabriel Martinez-Pinedo[5], Alberto Mengoni[3,6], Karsten Riisager[3], John Simpson[7], Olof Tengblad[8]