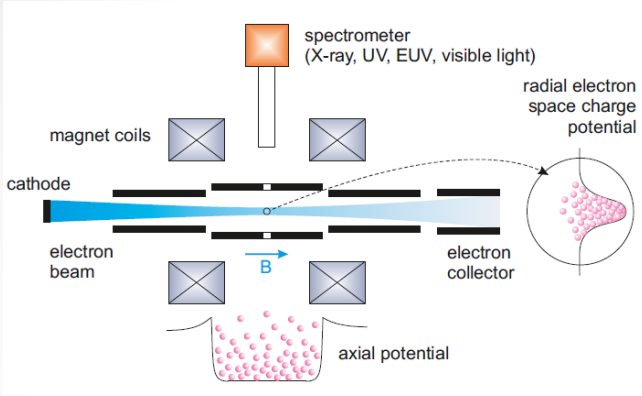
Performances of the EBIS debuncher

P.Ujić, J.F. Cam, P. Delahaye, B-M. Retailleau, E.Traykov, F.J.C. Wenander, Y. Blumenfeld, L. Standylo, J. Choinski

Electron Beam Ion Source (EBIS)



- Charge breeding by electron beam
- Radial confinement of the ions by the electron beam
- Axial confinement by the trapping electrodes
- Magnetic coils for the electron beam confining

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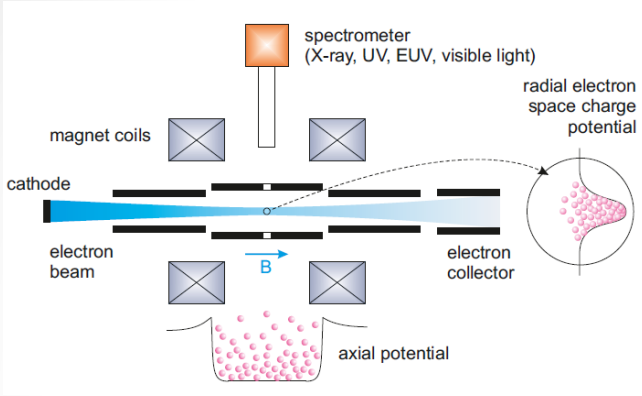

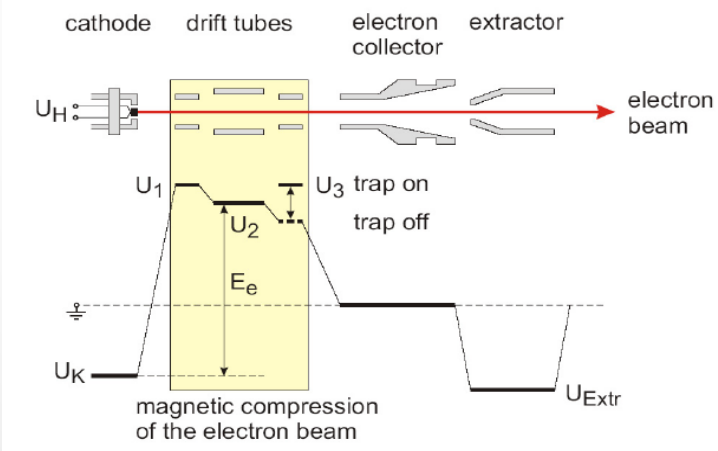

- Charge breeding by electron beam
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arXiv:1411.2445;CERN-2013-007
G.Zschornacka,b, M.Schmidtb and A.Thornb

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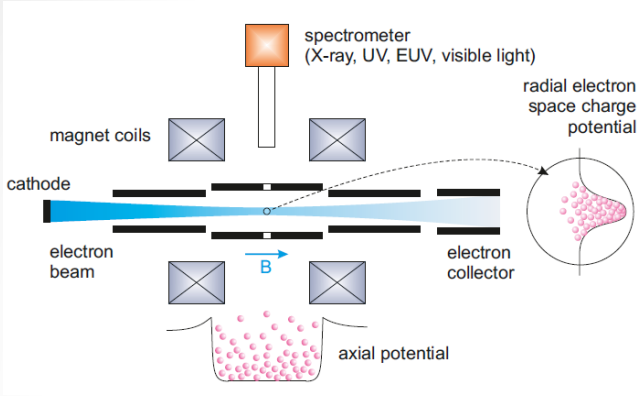
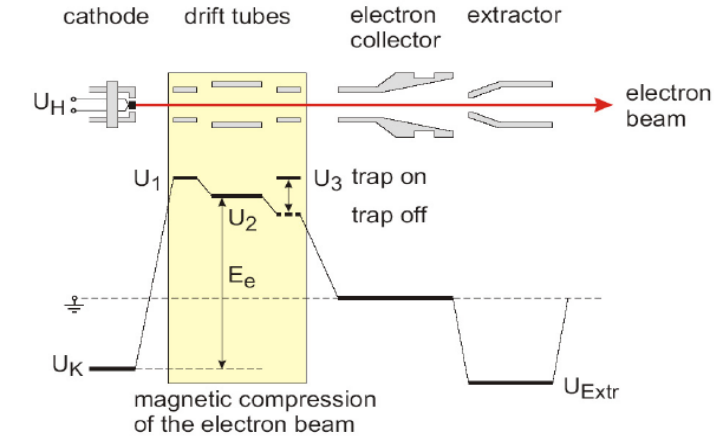




- Charge breeding by electron beam
- Radial confinement of the ions by the electron beam
- Axial confinement by the trapping electrodes
- Magnetic coils for the electron beam confining

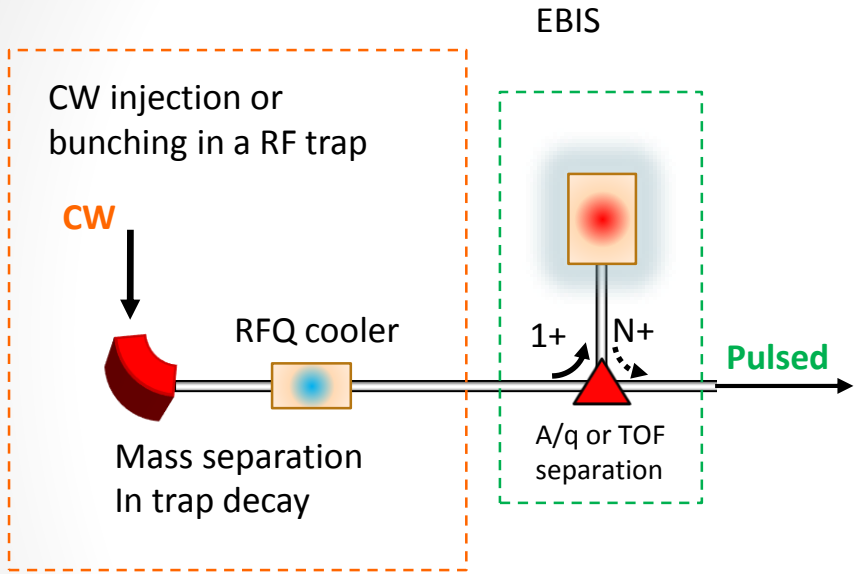
In comparison with ECR ion sources:

- Faster breeding time
- Higher efficiency
- Higher charge states
- ~ Lower beam intensity

→ More convenient for radioactive beams

arXiv:1411.2445;CERN-2013-007
G.Zschornacka,b, M.Schmidtb and A.Thornb

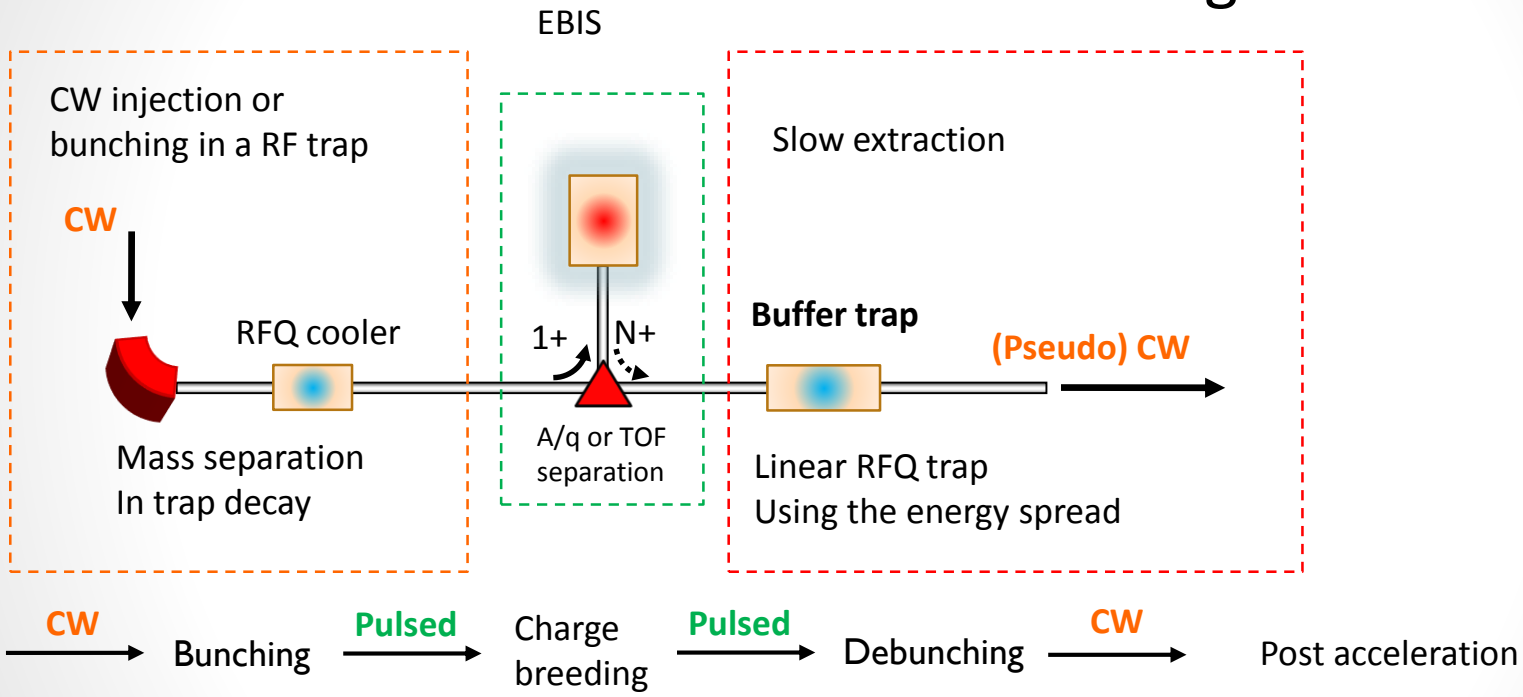
Continuous Wave (CW) EBIS charge breeder



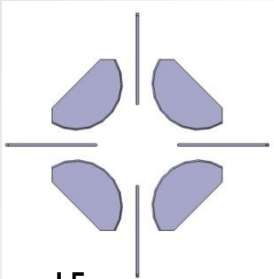
Dead time,
pile-up,
fake coincidences
REX-EBIS and MINIBALL:
DAQ problems with
intensities as low as
10^5-10^6 pps

CW → Bunching → Pulsed → Charge breeding → Pulsed → Post acceleration

Continuous Wave (CW) EBIS charge breeder



Debuncher prototype design



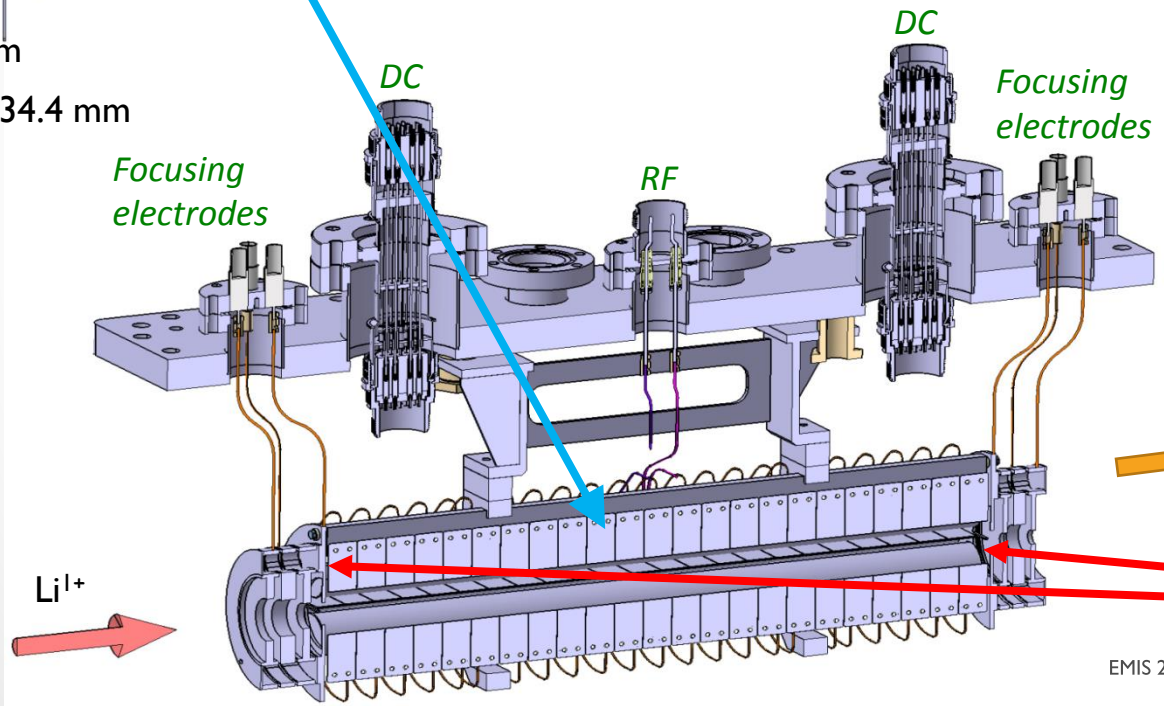
DC segments

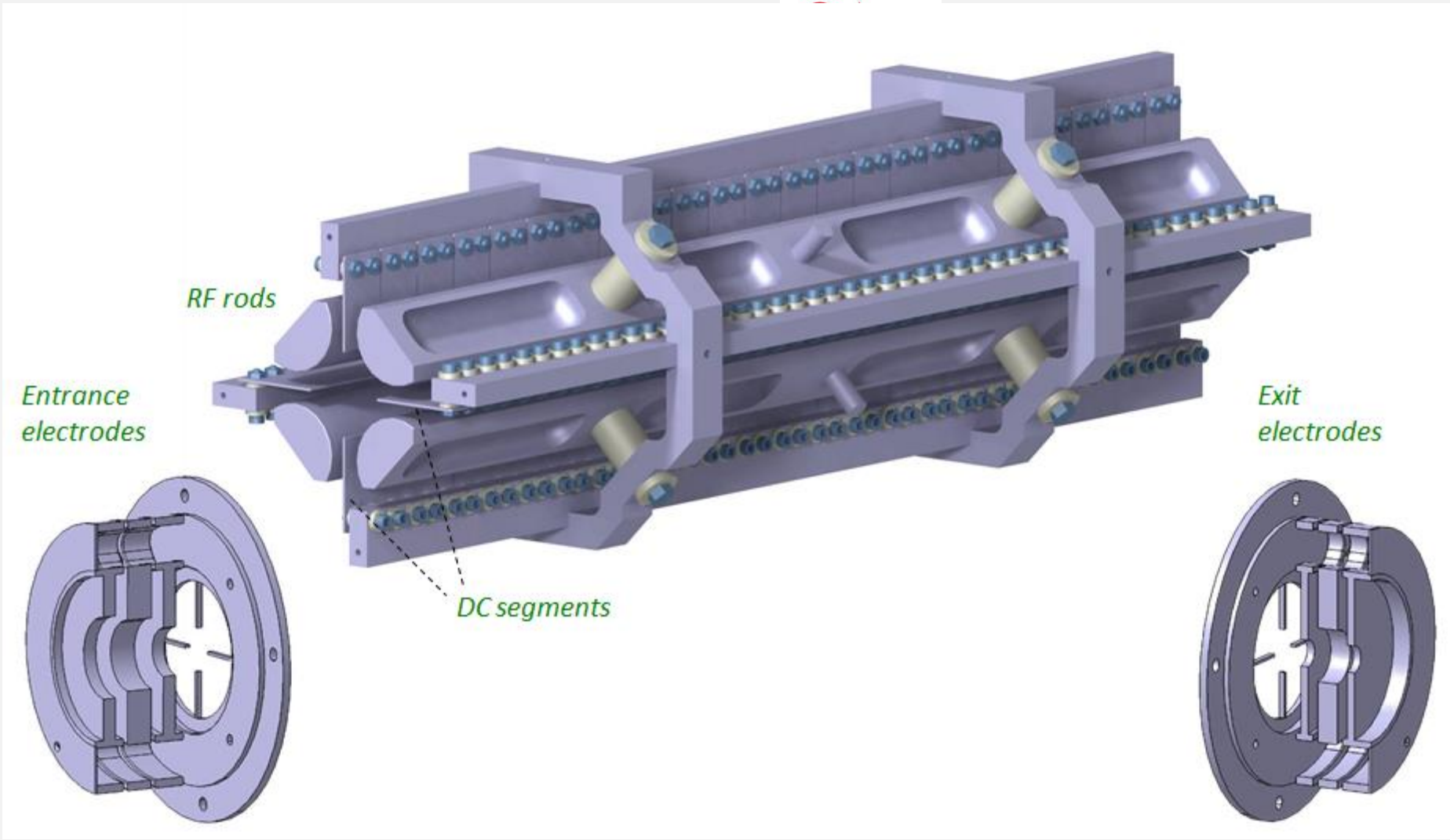
R_0 = 15 mm

RF rods Ø34.4 mm

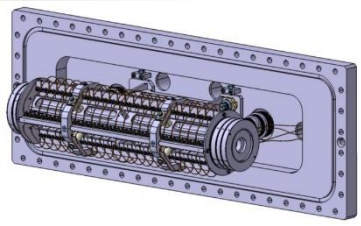
Completed in 2012 at LPC

Y. Merrer
P. Desrues

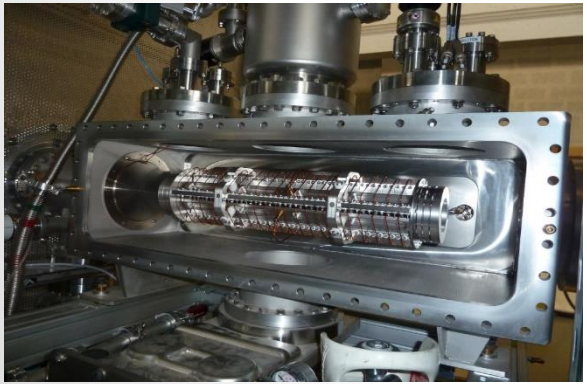



RF rods
Entrance electrodes
DC segments
Exit electrodes

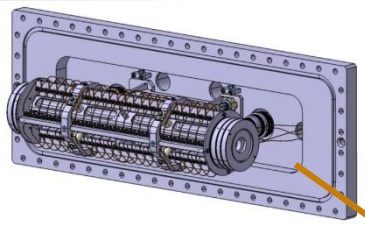
Experimental Setup



Emilie debuncher on the adaptation flange



Experimental Setup



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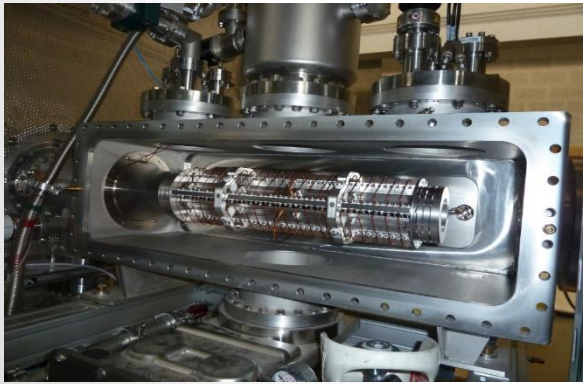
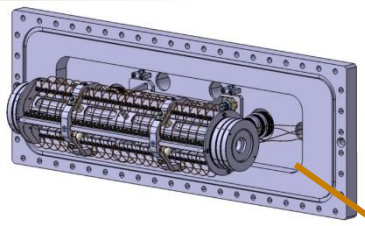


Emilie debuncher on the test bench

Experimental Setup



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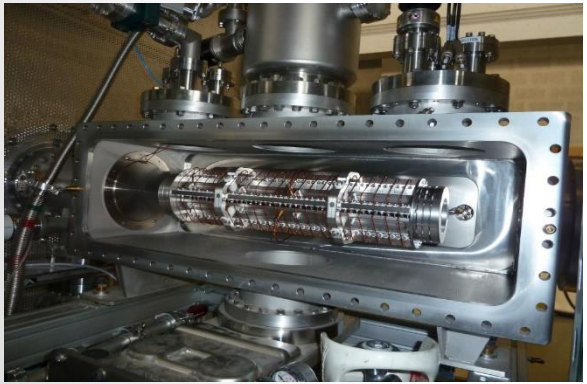

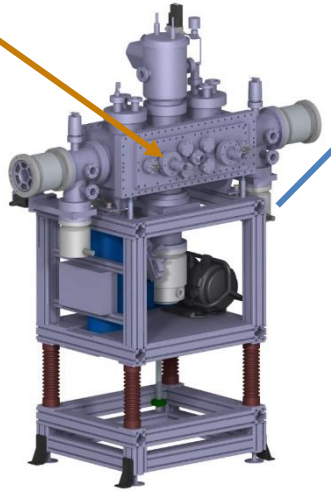

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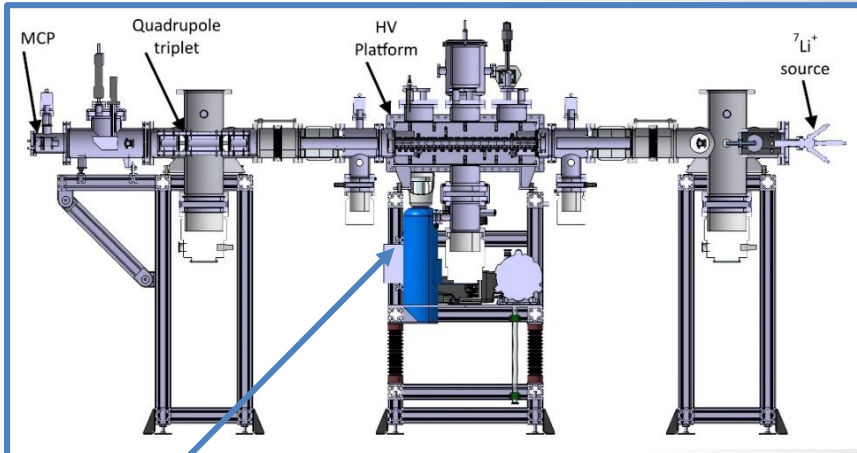
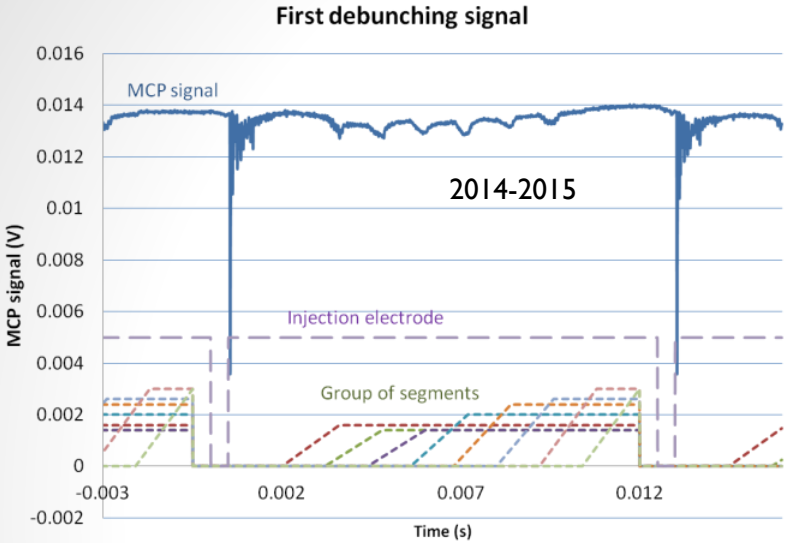
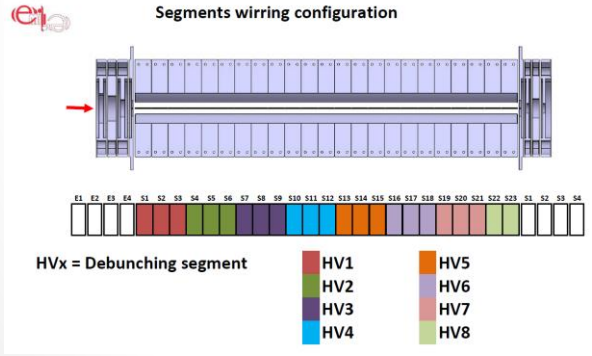


SPIRAL2 high intensity RFQ cooler demonstrator (SHIRaC) at LPC CAEN

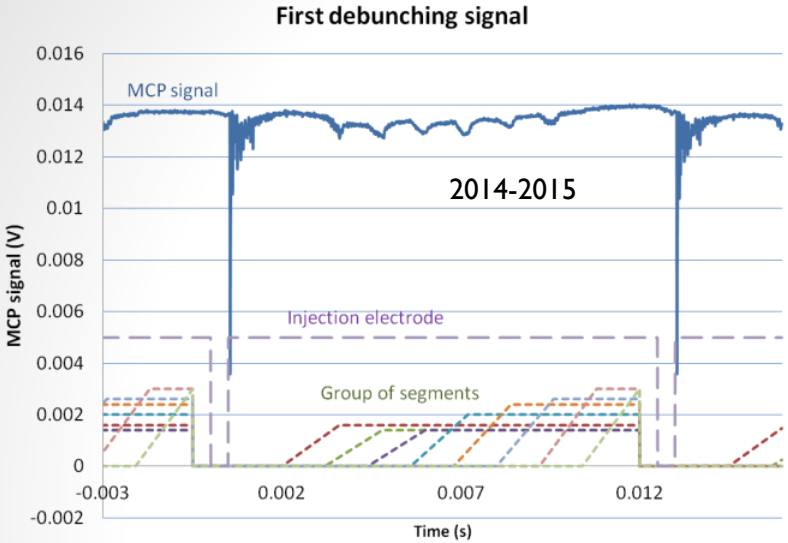
Ion extraction

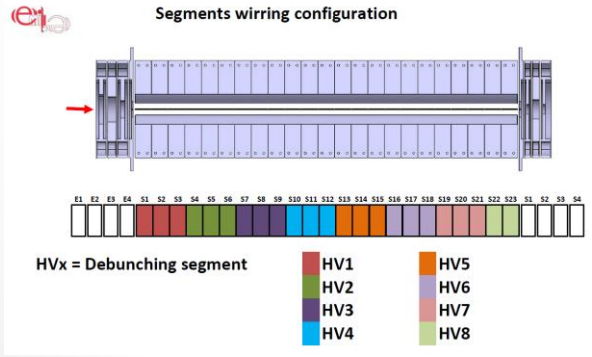




Application of successive linear ramps on electrode groups of segments

Ion extraction





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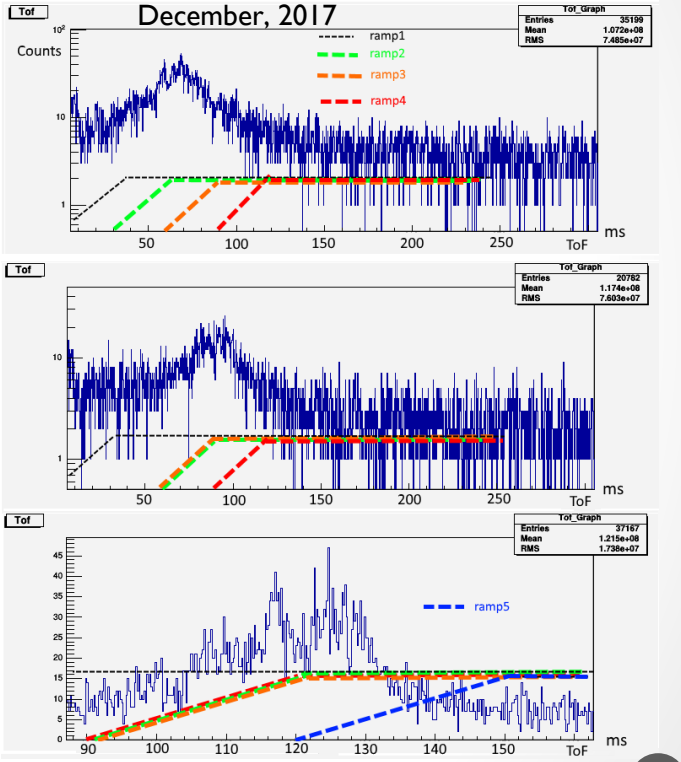
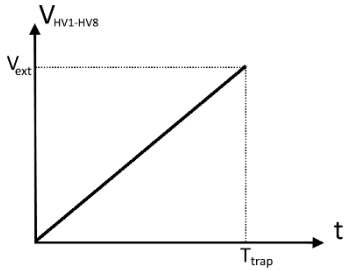


„Inverse function“ method

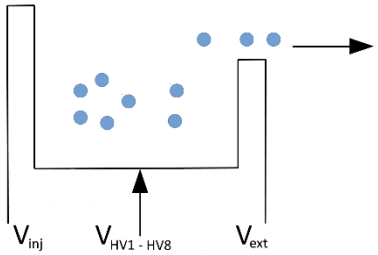
The idea is to apply a potential function which make uniform extraction of given energy density distribution

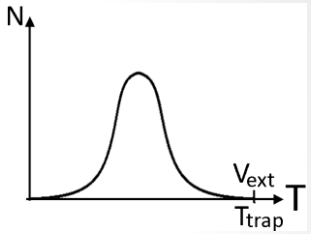
STEPS:

1) Find the energy distribution



Ramp potential applied to all segments





Distribution in time (potential) domain

„Inverse function“ method

The idea is to apply a potential function which make uniform extraction of given energy density distribution

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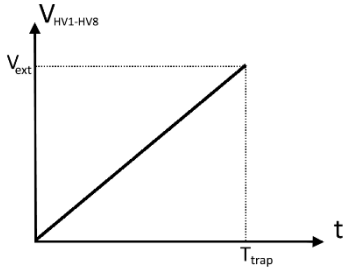
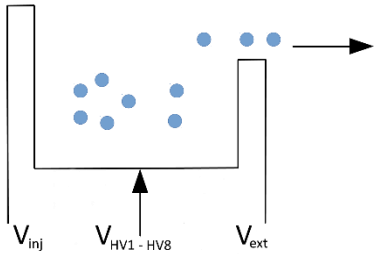
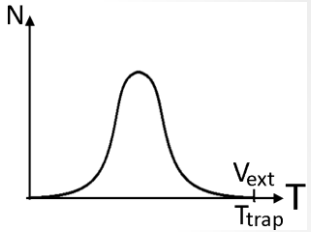


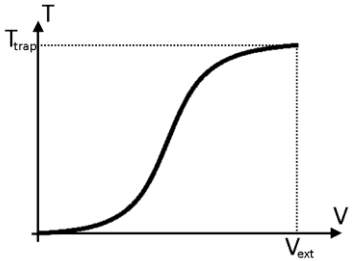
Ramp potential applied to all segments





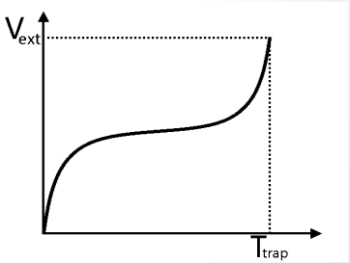
Distribution in time (potential) domain

2) Calculate inverse cumulative energy distribution



Cumulative distribution function

exchange axes



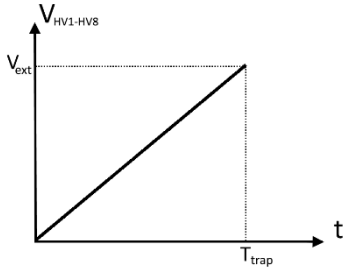
Inverse cumulative distribution function (inversed function)

„Inverse function“ method

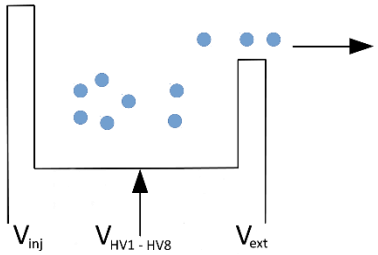
The idea is to apply a potential function which make uniform extraction of given energy density distribution

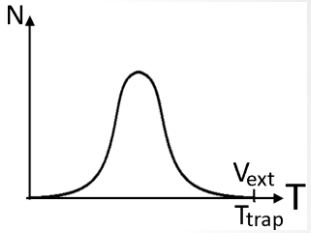
STEPS:

1) Find the energy distribution



Ramp potential applied to all segments





Distribution in time (potential) domain

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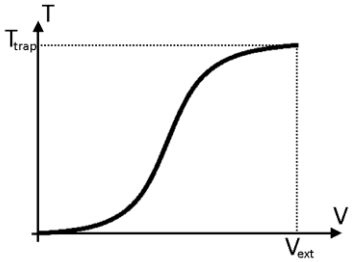
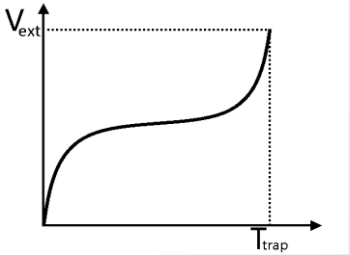


Cumulative distribution function

exchange axes



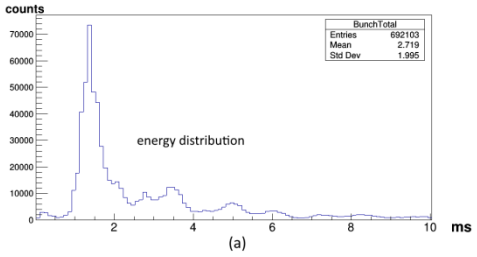
Inverse cumulative distribution function (inversed function)

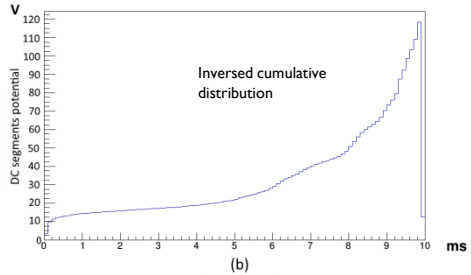
3) Apply inverse function instead of ramp potential

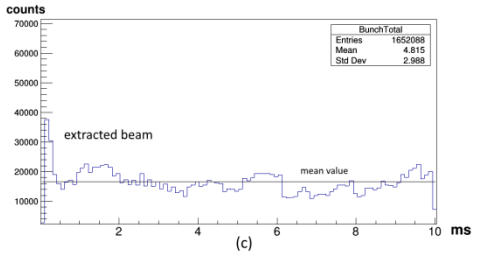
Uniform beam extraction

„Inverse function“ method

10 ms debunching







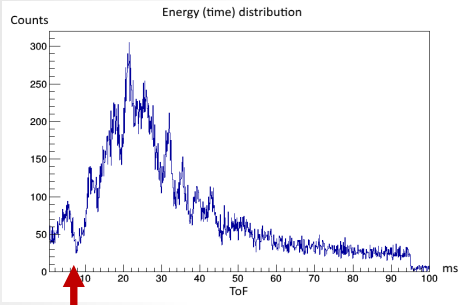
Ions extracted by linearly increased voltage on all segments simultaneously
0 – 120 V in this case

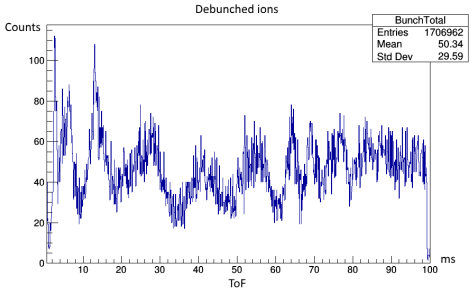
Calculation of the Inversed cumulative distribution (numerically in this case)

Applying the „inversed function“ instead of the linear ramp to get uniform extraction

Ion extraction

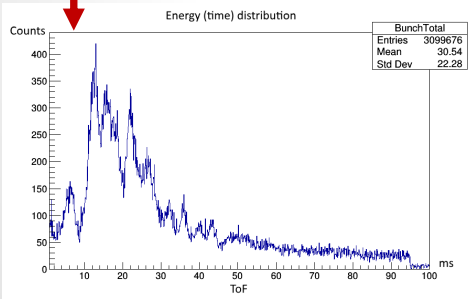
100 ms extraction

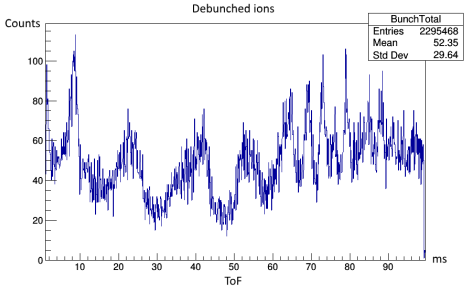




High noise and a lot of parasitic peaks in the distribution

25 min difference

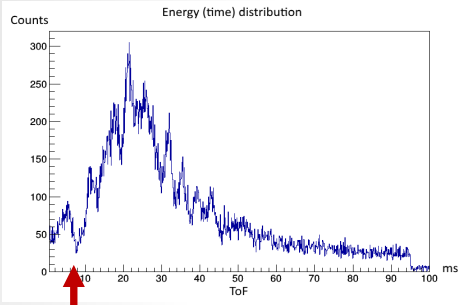


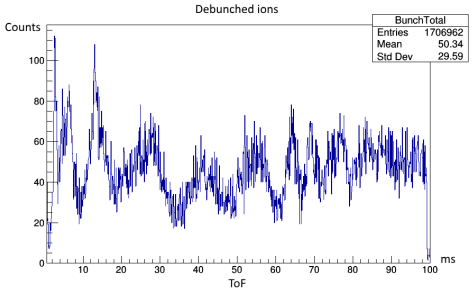


Instabilities caused poor reproducibility
– impossible to remove the peaks

Ion extraction

100 ms extraction





High noise and a lot of parasitic peaks in the distribution

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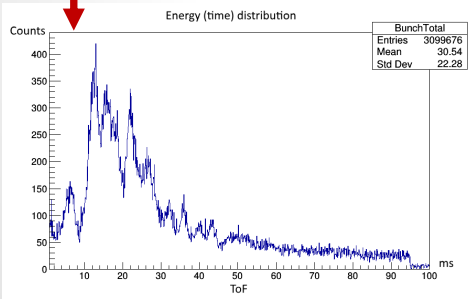
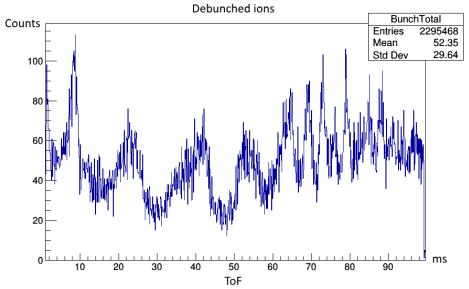
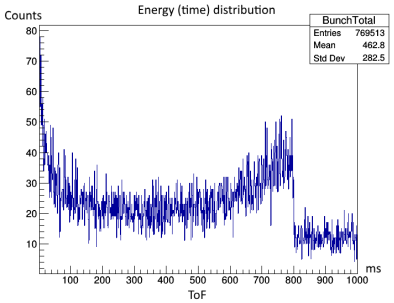
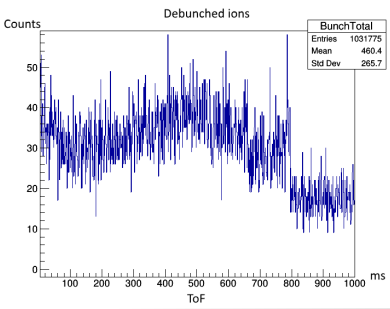




Instabilities caused poor reproducibility
– impossible to remove the peaks

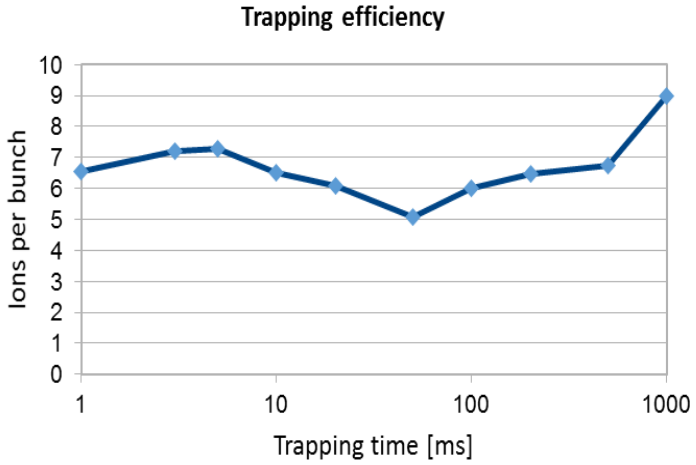
800 ms extraction



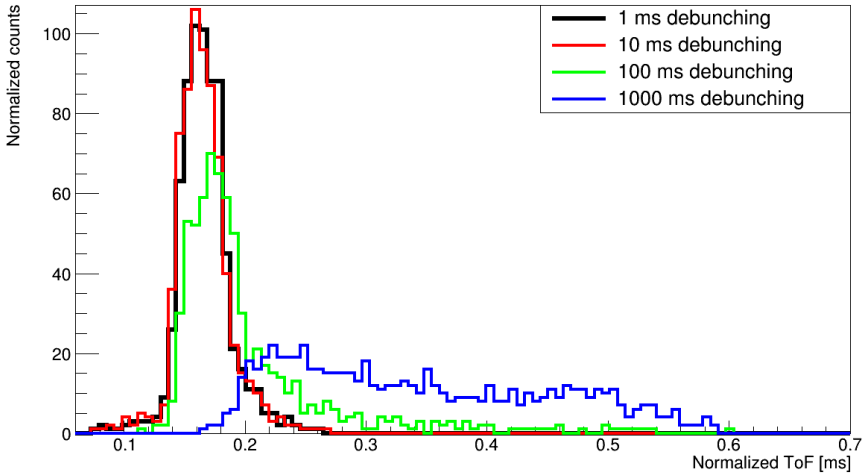


Flatten distribution due to the cooling effect
→ The vacuum was not sufficient ~10^{-7} mbar

Efficiencies



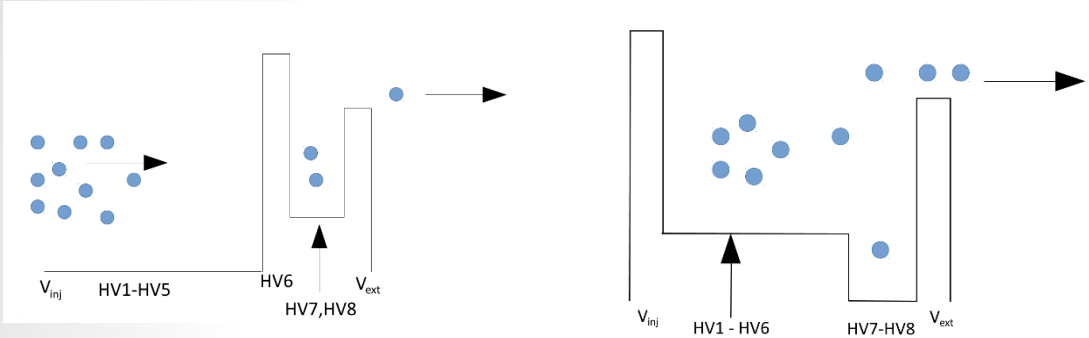
„Cooling" effect



- No measurable losses up to ~1 s trapping time !
- Injection efficiency 20-30 %

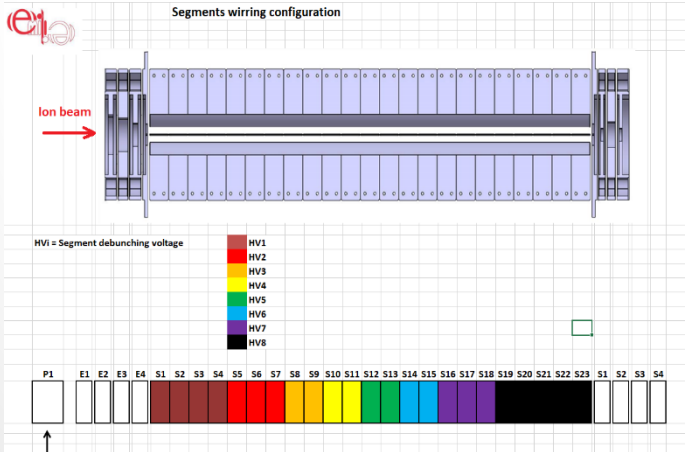
Buffer method

(fully continuous extraction)



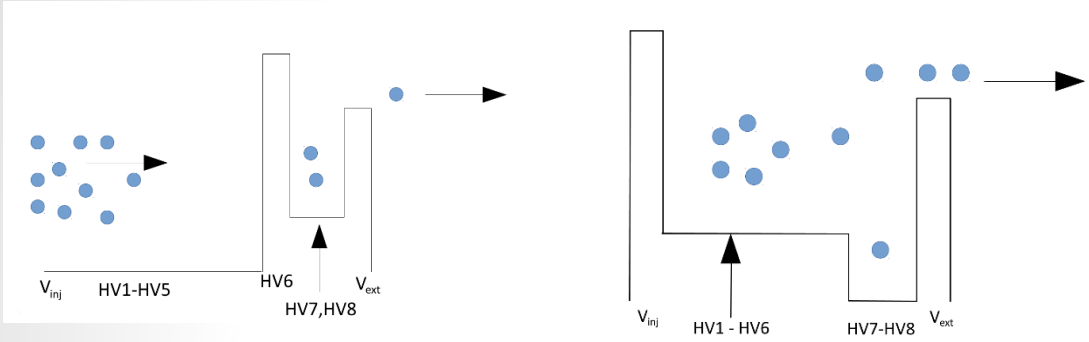
- Injection in main buffer
- Extraction of auxilary buffer

- Extraction of main buffer
- Trapping in auxilary buffer



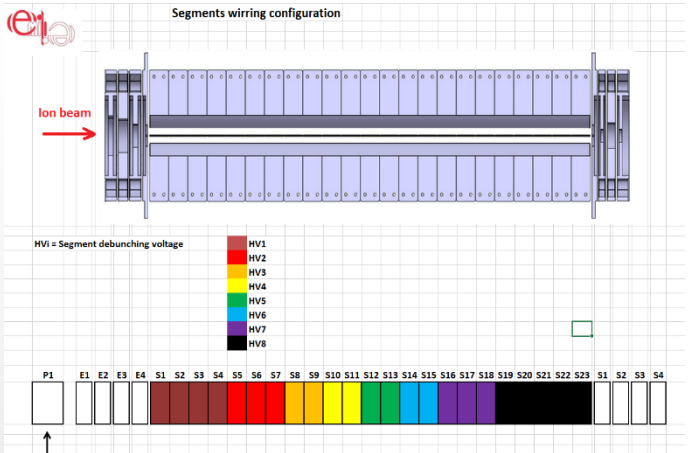
Buffer method

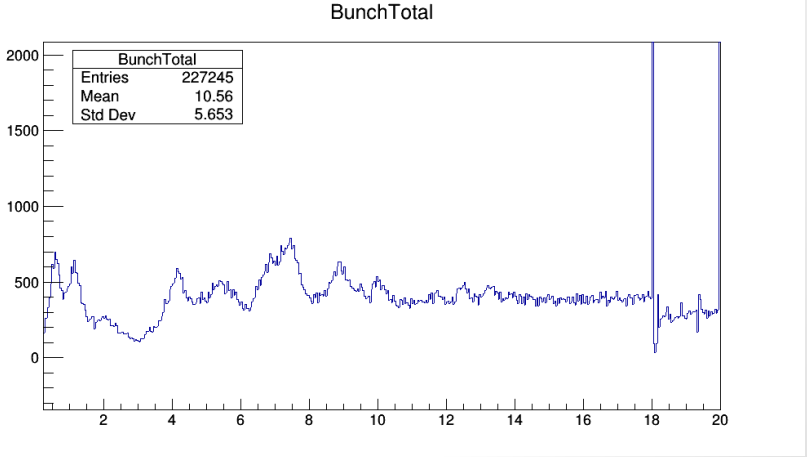
(fully continuous extraction)



- Injection in main buffer
- Extraction of auxilary buffer

- Extraction of main buffer
- Trapping in auxilary buffer





Conclusions

- **Uniform ion extraction for trapping times up to ~1 s**
- **Ultra high vacuum level (<10^{-11}mbar) necessary for the manipulation of high charge state ions**
- **An optimized ion optics are needed**
- **Projections for the use of such device with an operational EBIS, i.e. for HIE-ISOLDE or for a future EBIS at GANIL, are therefore encouraging**

Thank you for your attention !