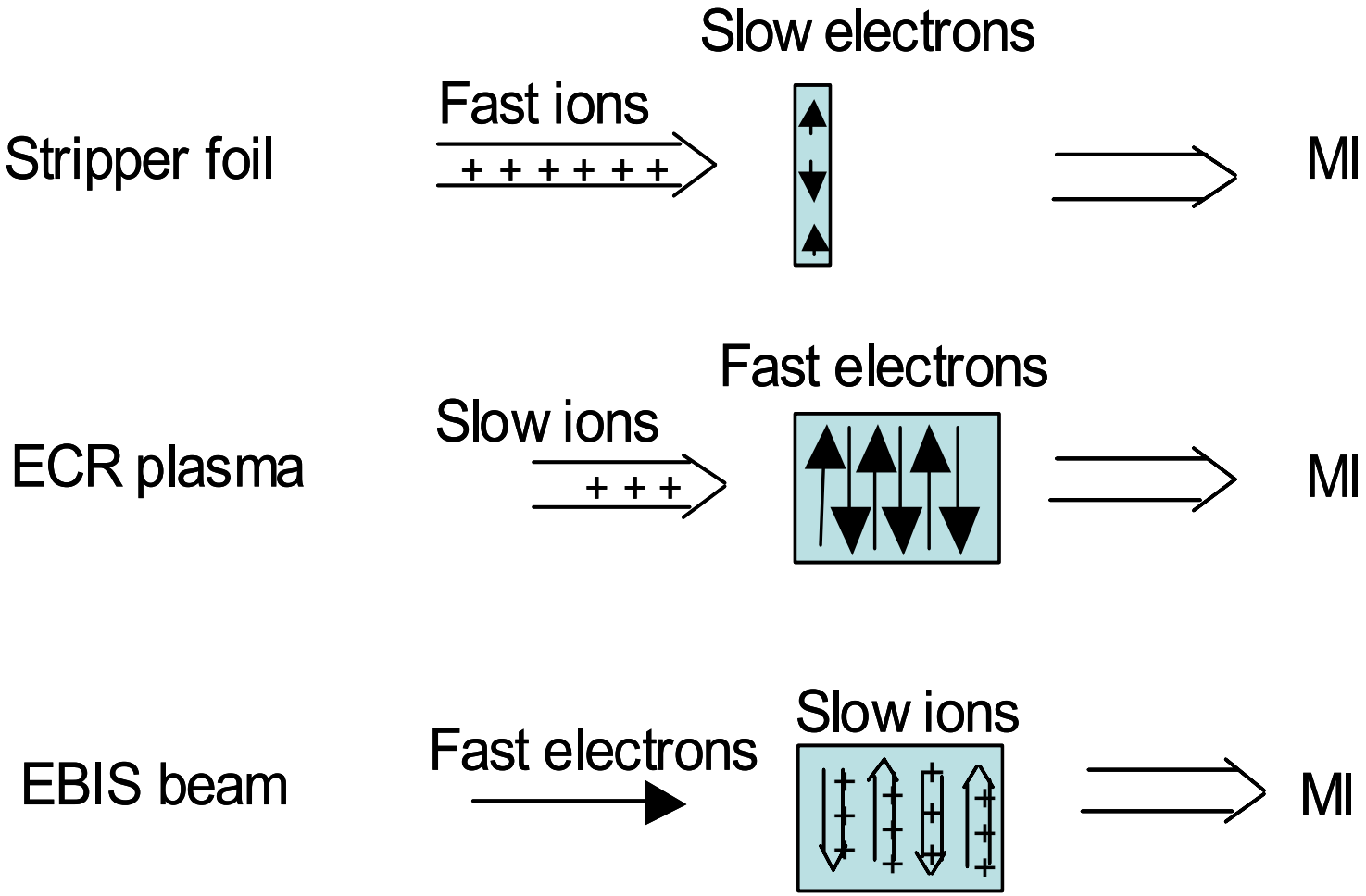
Status of Construction and Commissioning of the GSI HITRAP Decelerator

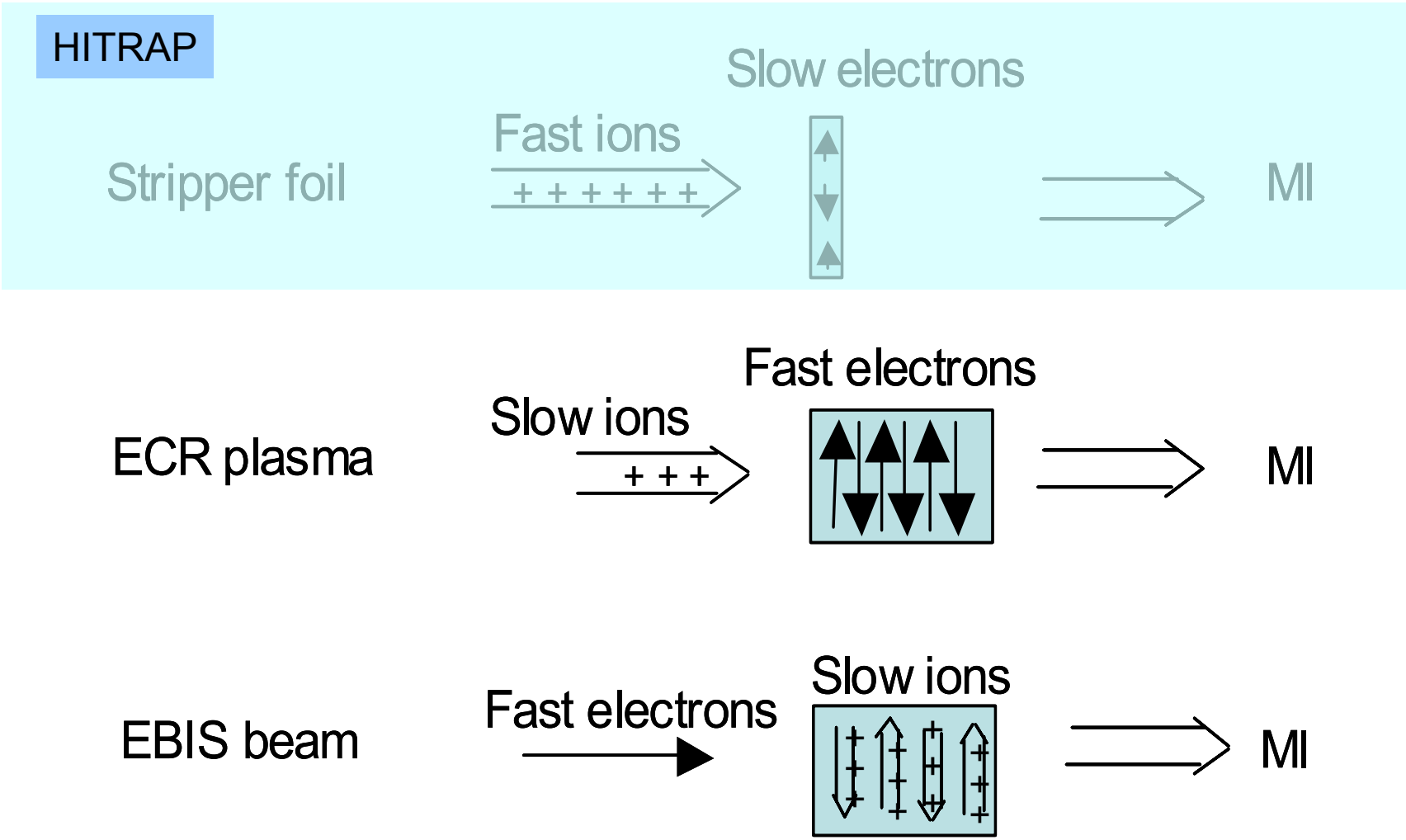
Outline:

- Introduction and motivation
- Beam dynamics issues of the decelerator
- Status of the linac, trap and of the commissioning efforts

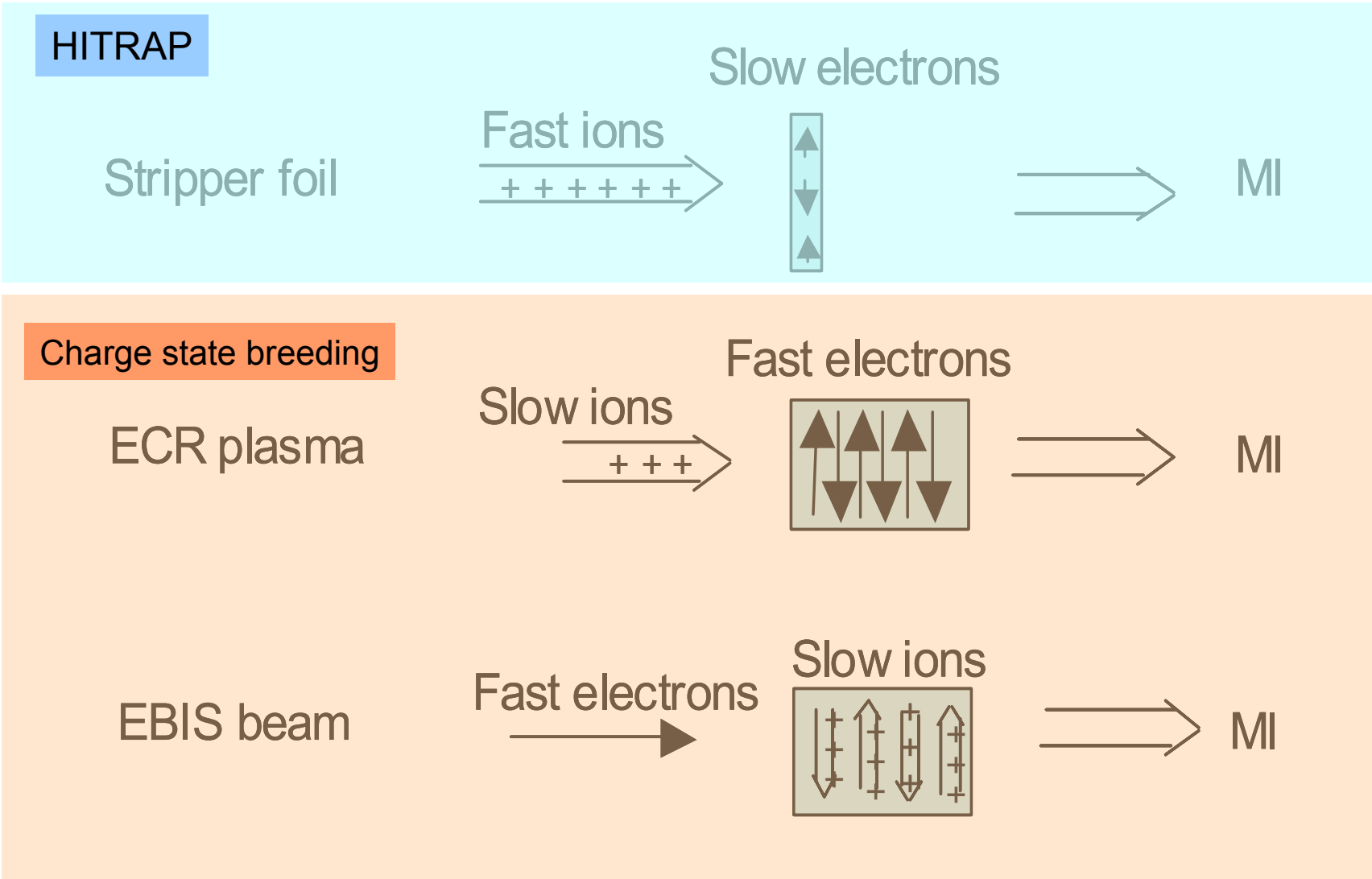
Production of multi-charged ions



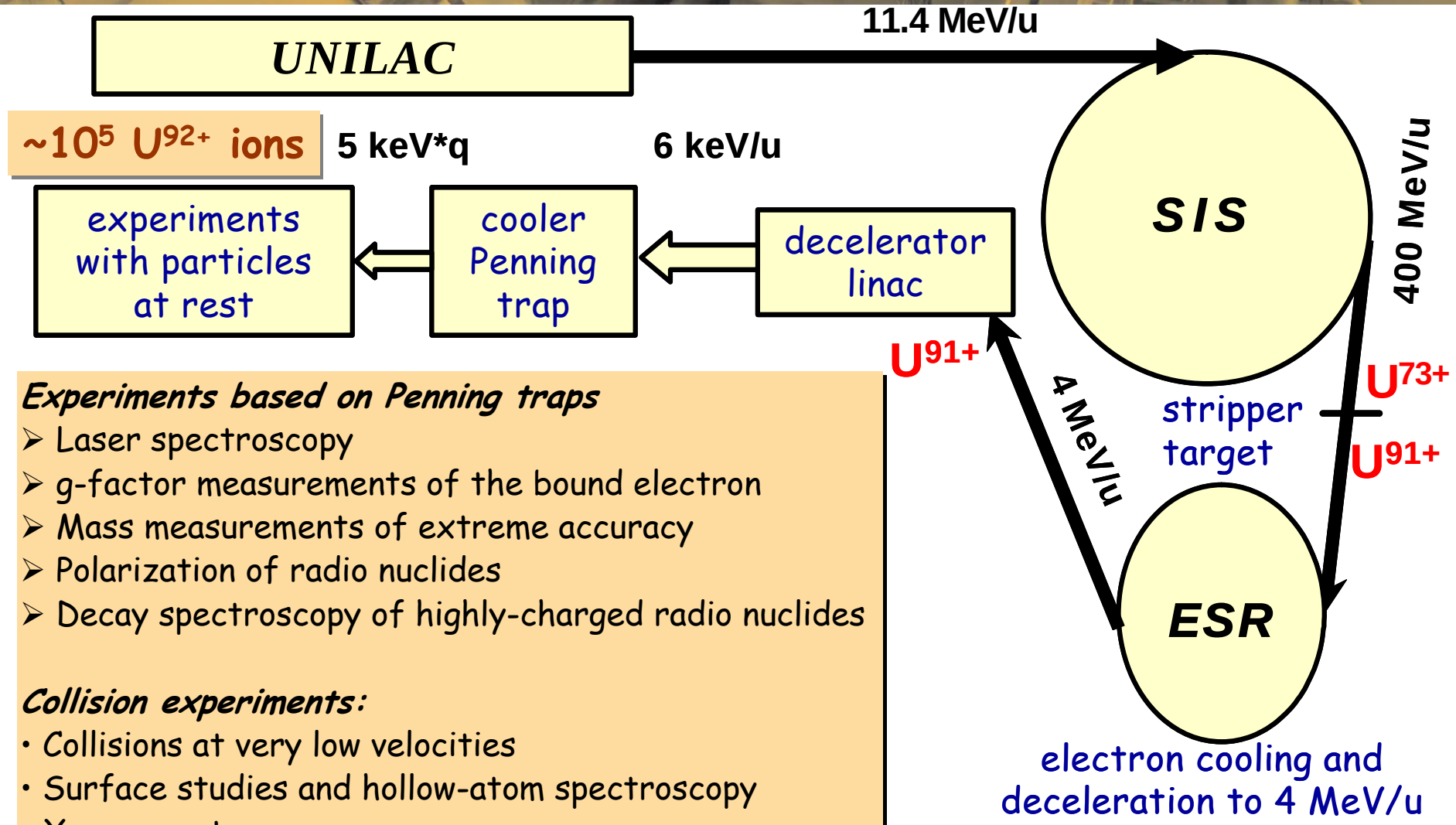
Production of multi-charged ions



Production of multi-charged ions



HITRAP schematic overview



Experiments based on Penning traps

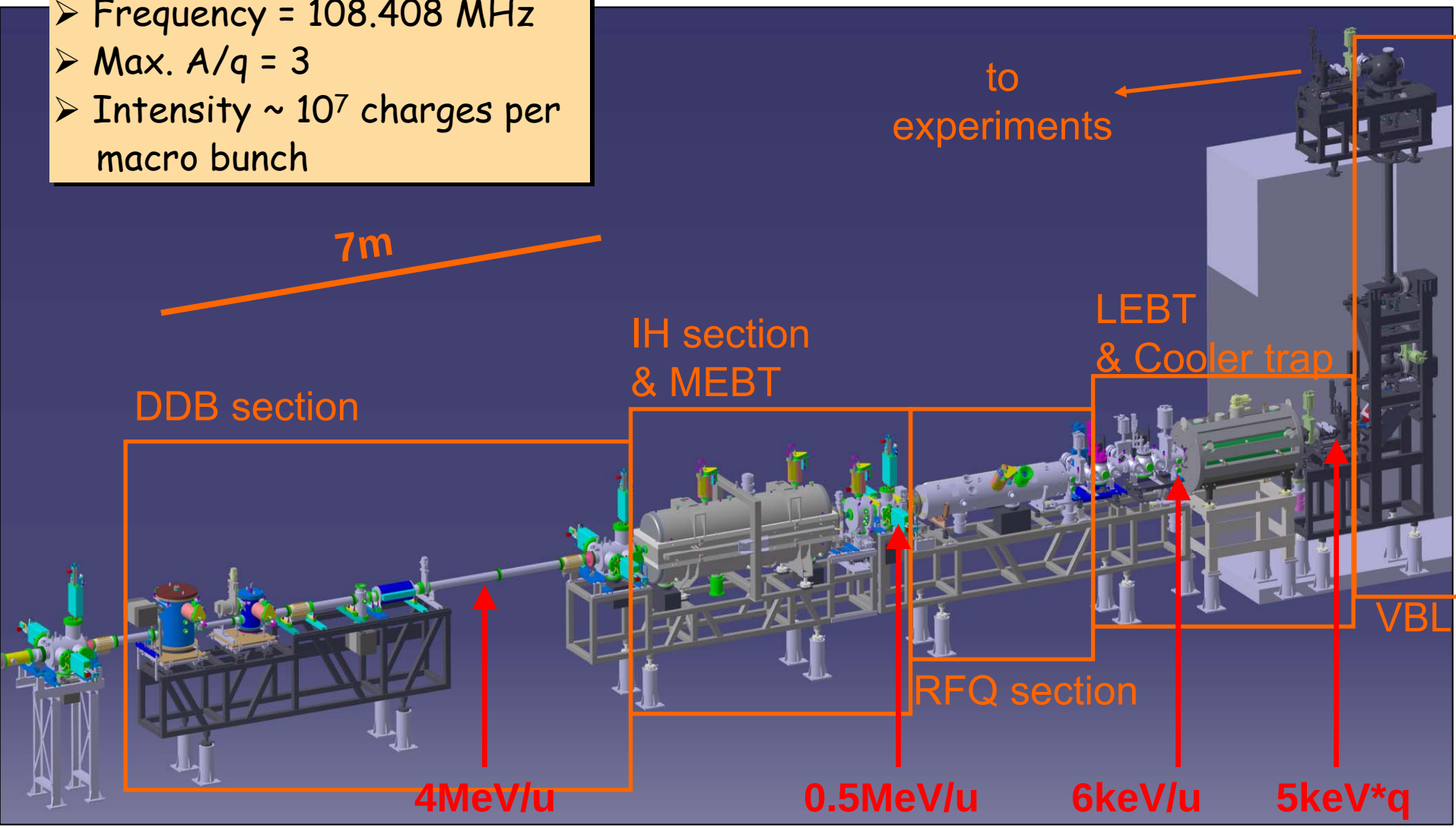
- Laser spectroscopy
- g-factor measurements of the bound electron
- Mass measurements of extreme accuracy
- Polarization of radio nuclides
- Decay spectroscopy of highly-charged radio nuclides

Collision experiments:

- Collisions at very low velocities
- Surface studies and hollow-atom spectroscopy
- X-ray spectroscopy

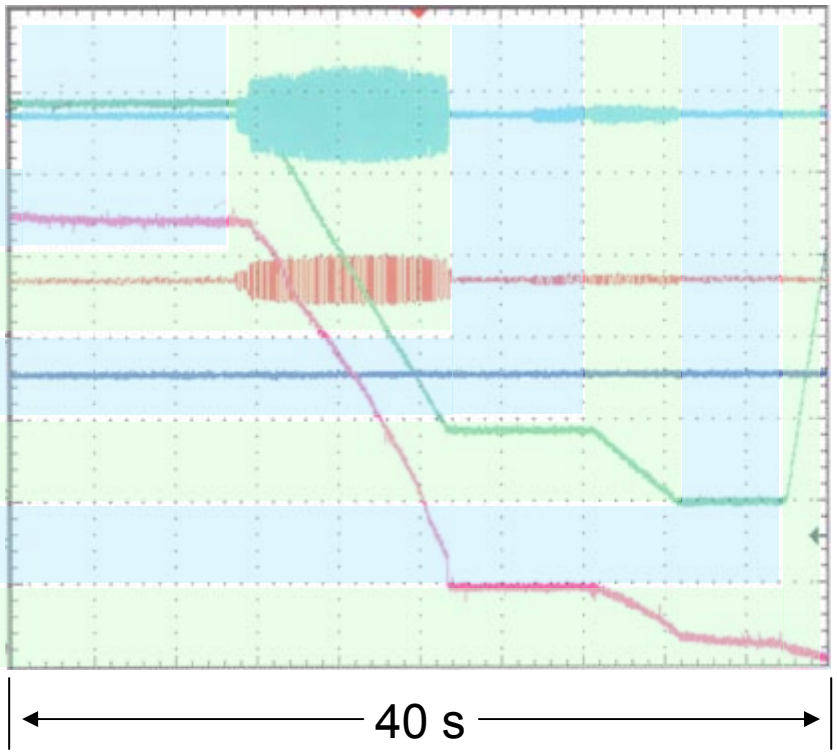
HITRAP linac overview

- Frequency = 108.408 MHz
- Max. A/q = 3
- Intensity ~ 10^7 charges per macro bunch



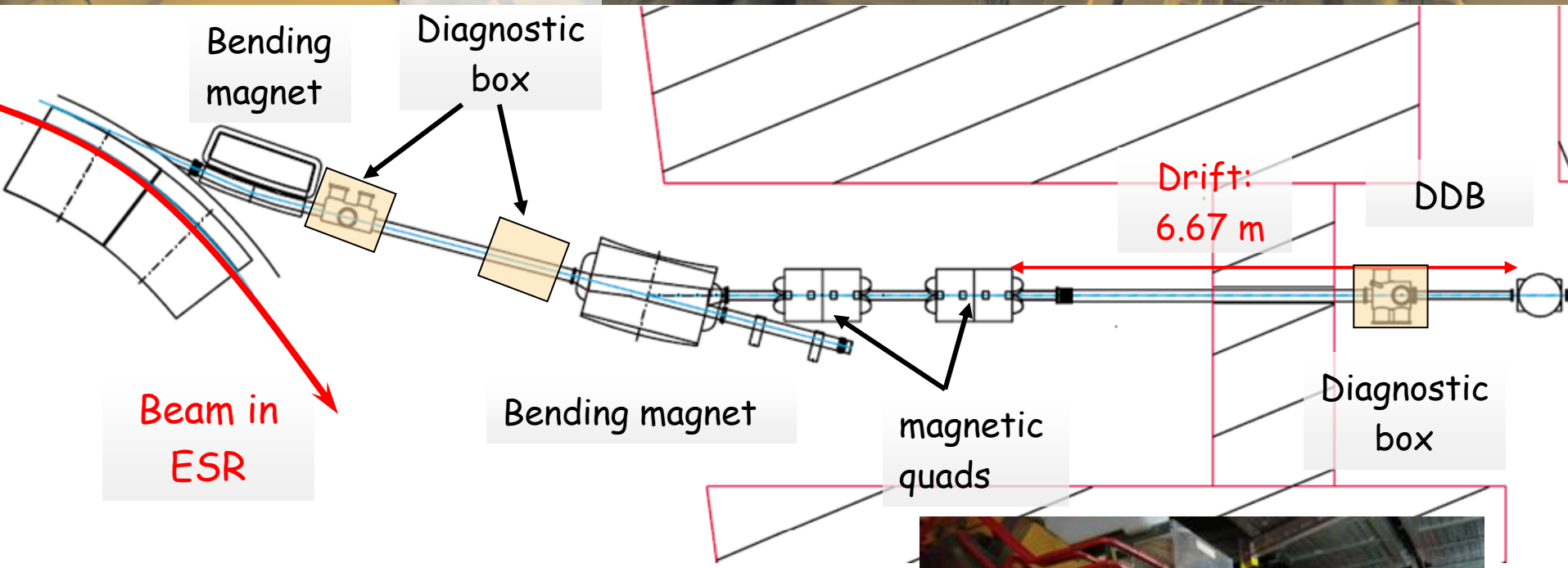
ESR deceleration – From 400 to 4 MeV/u

time (s)	ESR cycle during recent experiment
5..20	injection, stoch. cooling
3..10	deceleration 400 – 30 MeV/u
2..6	e^- cooling, rebunching
2..5	deceleration 30 – 4 MeV/u
2..5	e^- cooling, ejection
3	reset magnets



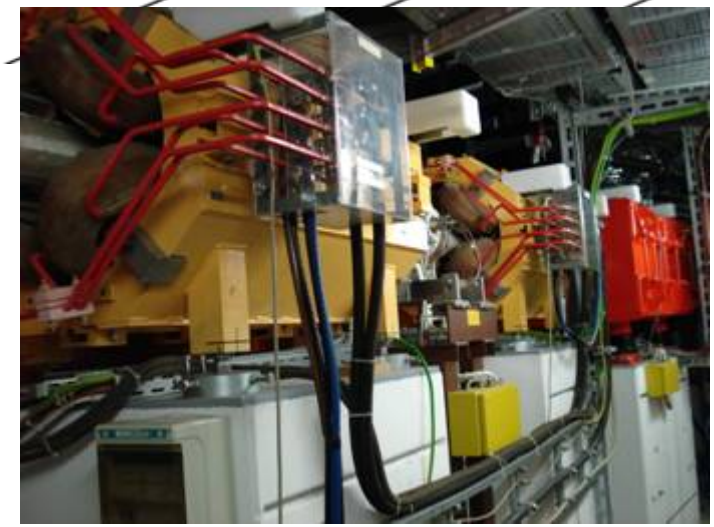
- stochastic cooling at injection energy implemented
- electron current for final cooling at 4 MeV/u increased

Transport of the ions from the ESR to the DDB

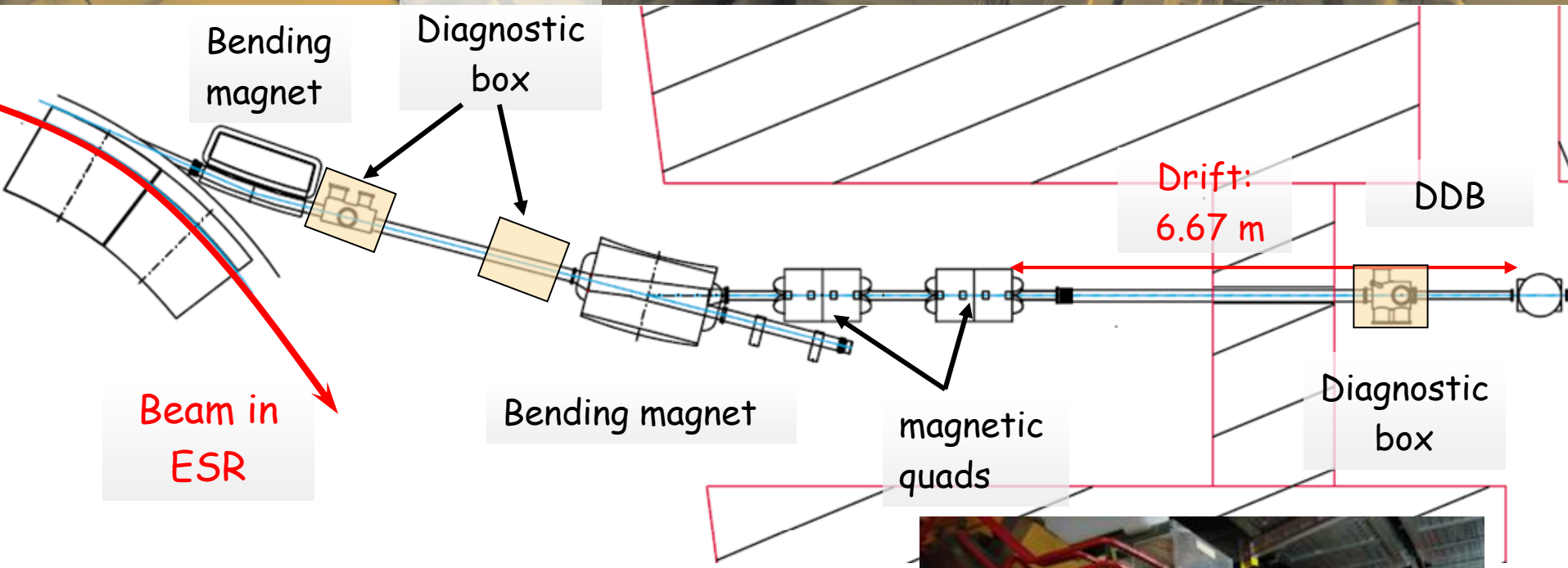


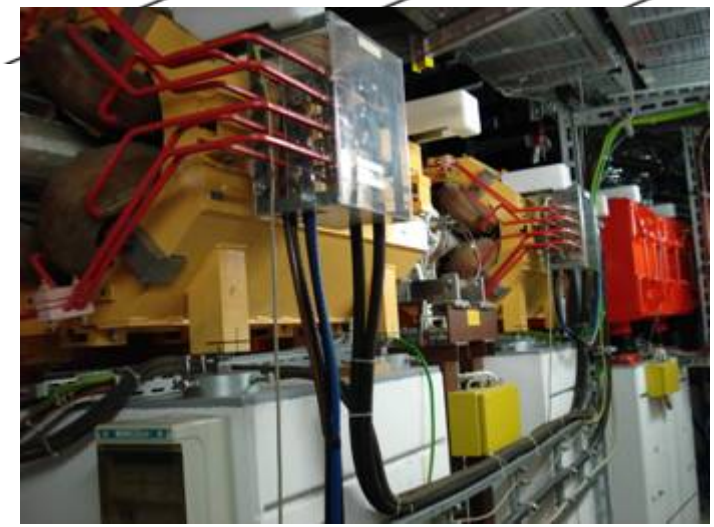
Diagnostic used in high energy section:

- Faraday cups
- Profile grid
- Scintillator screens (YAG)



Transport of the ions from the ESR to the DDB

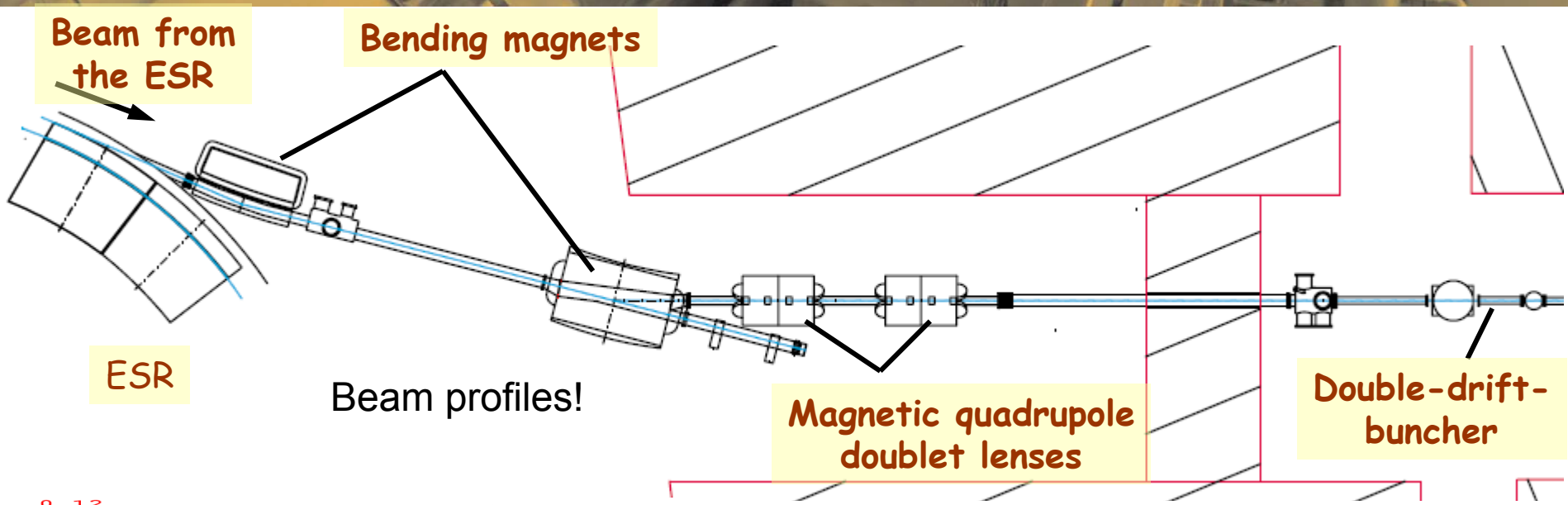


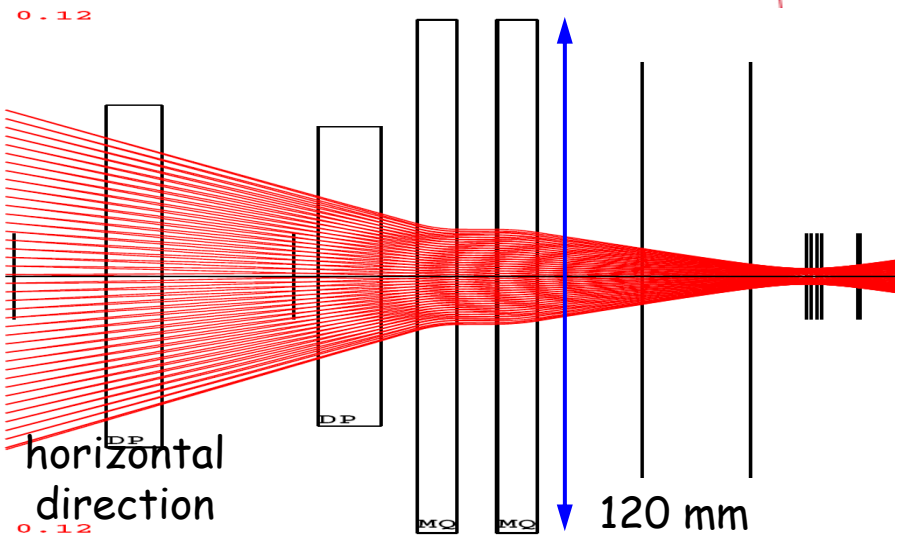


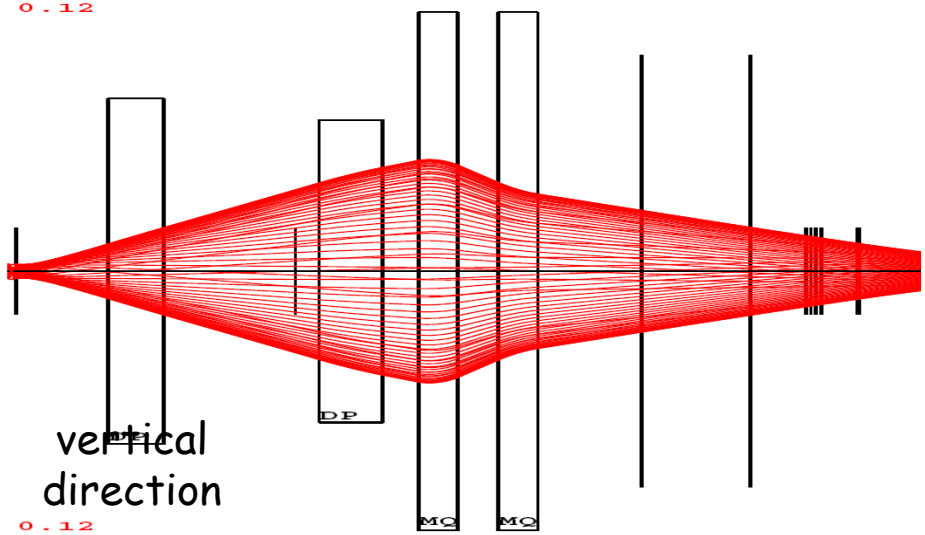
Expected beam properties:

- Bunch length of 1 μs
- Cooled beam with transverse emittance of ~1 mm mrad at 4 MeV/u
- Energy spread ~0.01%

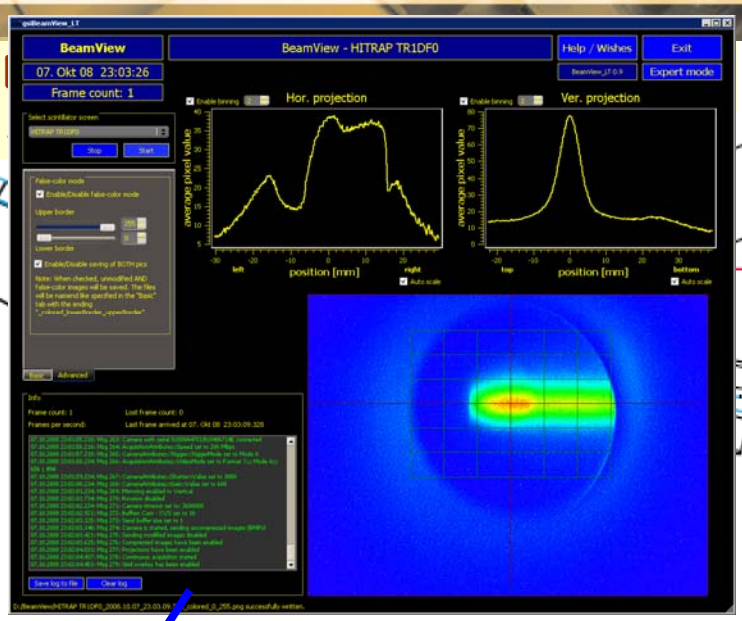
Transverse beam focusing

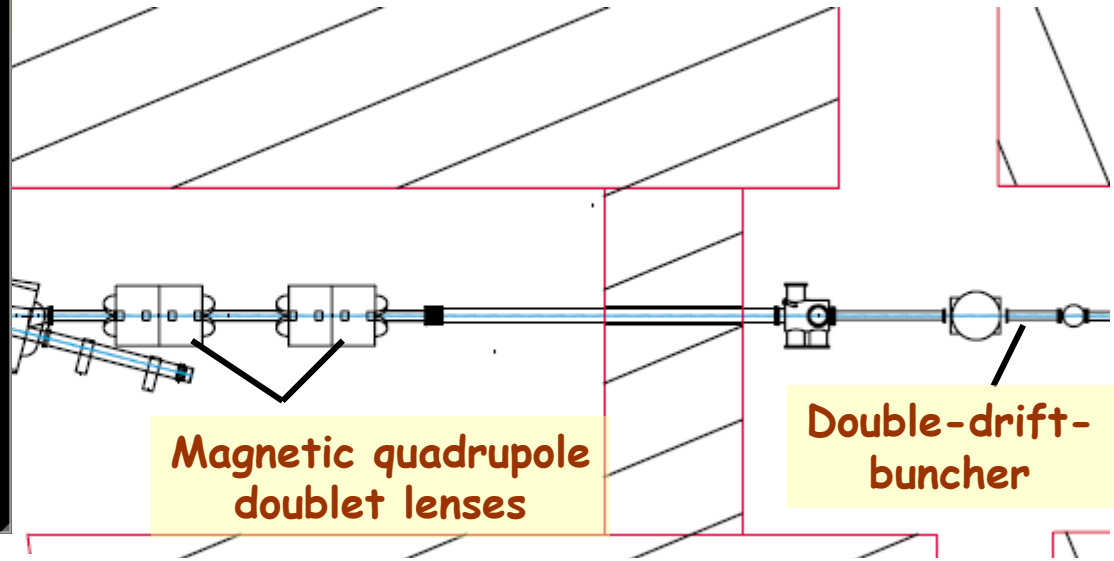






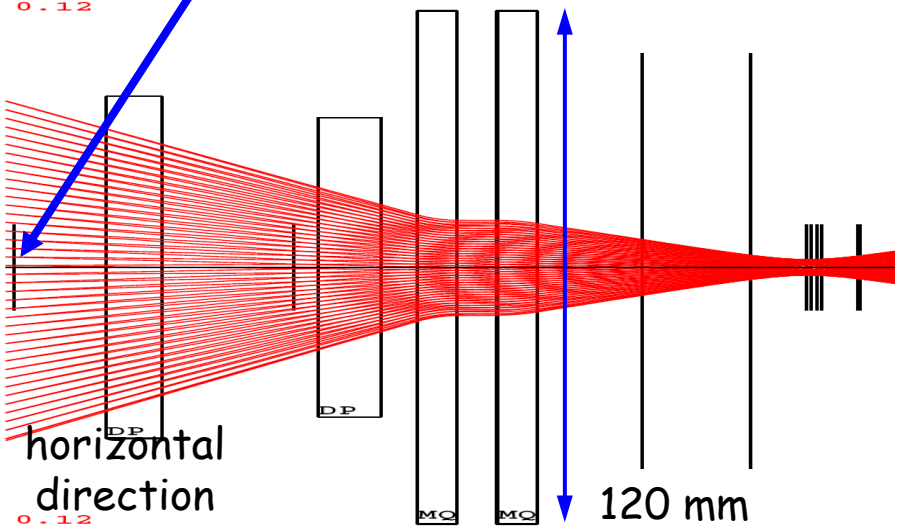
Transverse beam focusing



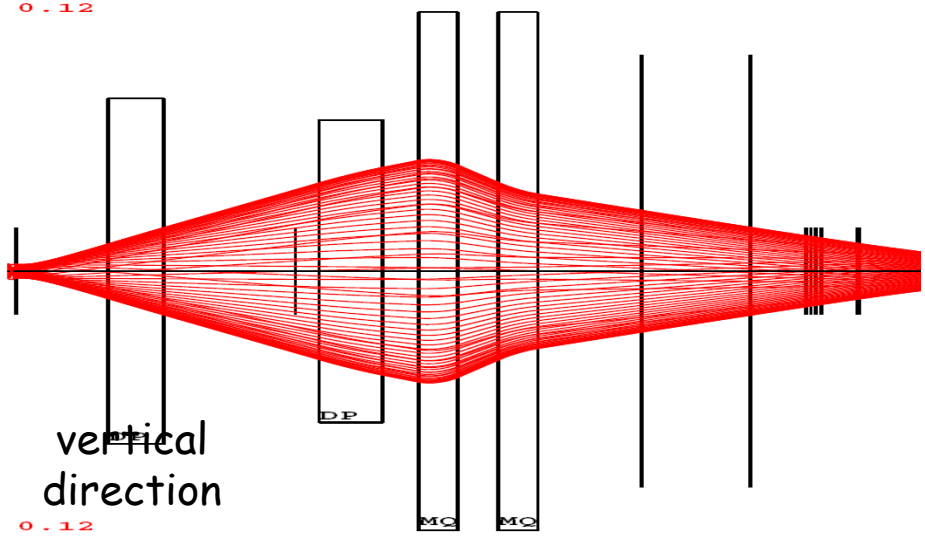


Magnetic quadrupole doublet lenses

Double-drift-buncher

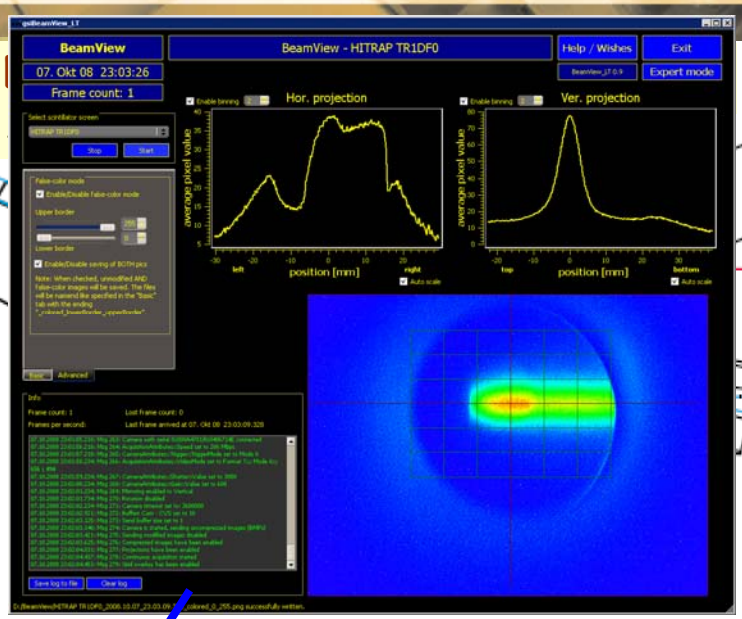


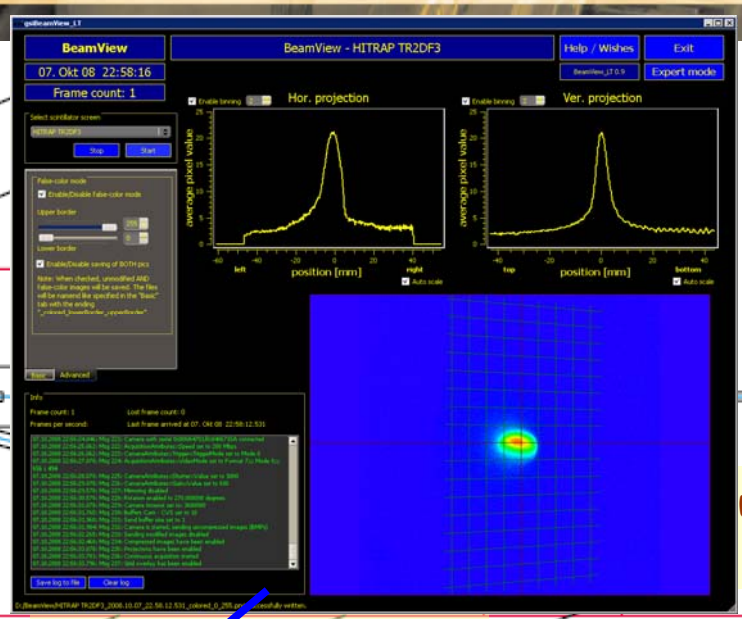
horizontal direction



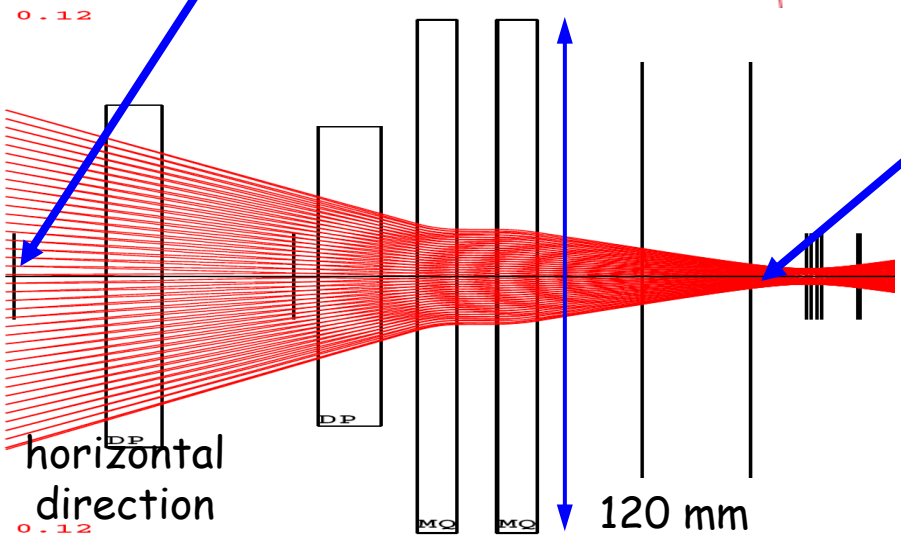
vertical direction

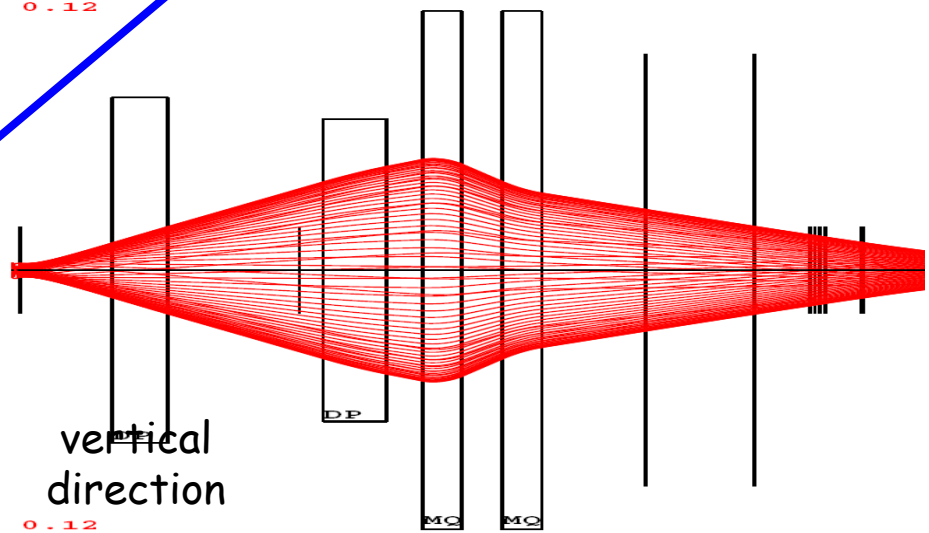
Transverse beam focusing



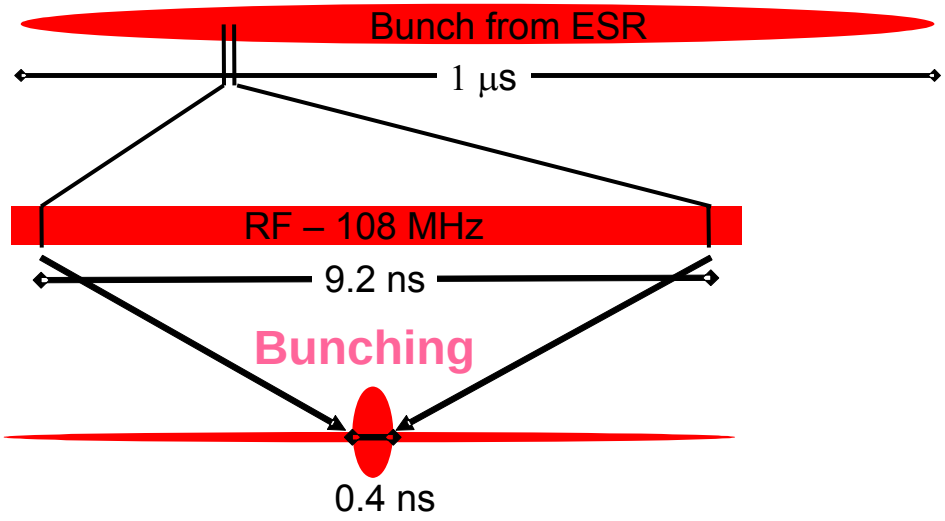


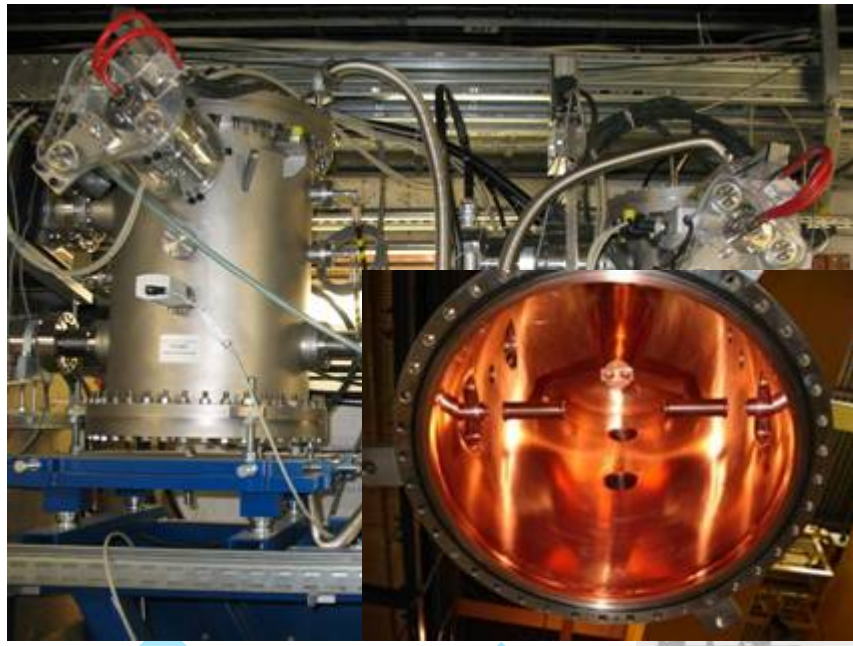
uble-drift-
buncher





HITRAP – Double Drift Buncher





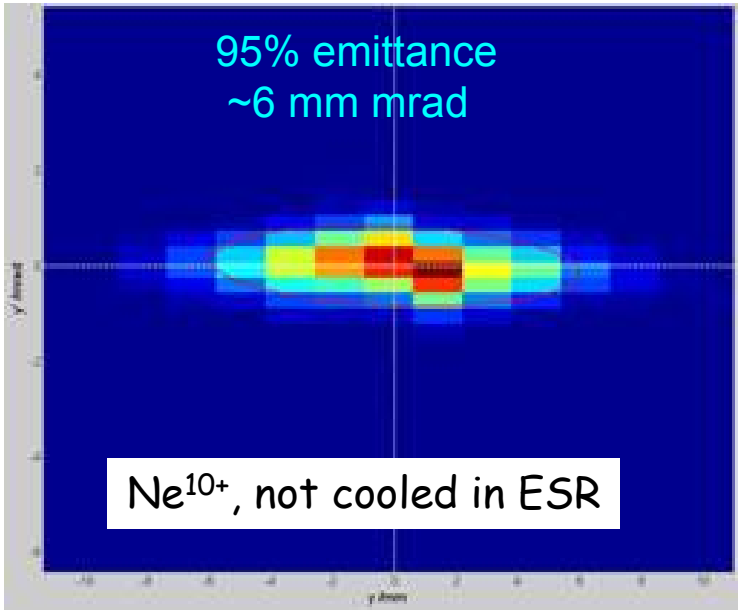
- Two coaxial resonators
- 108.408 MHz cavity (4 gaps)
- 216.816 MHz cavity (2 gaps)

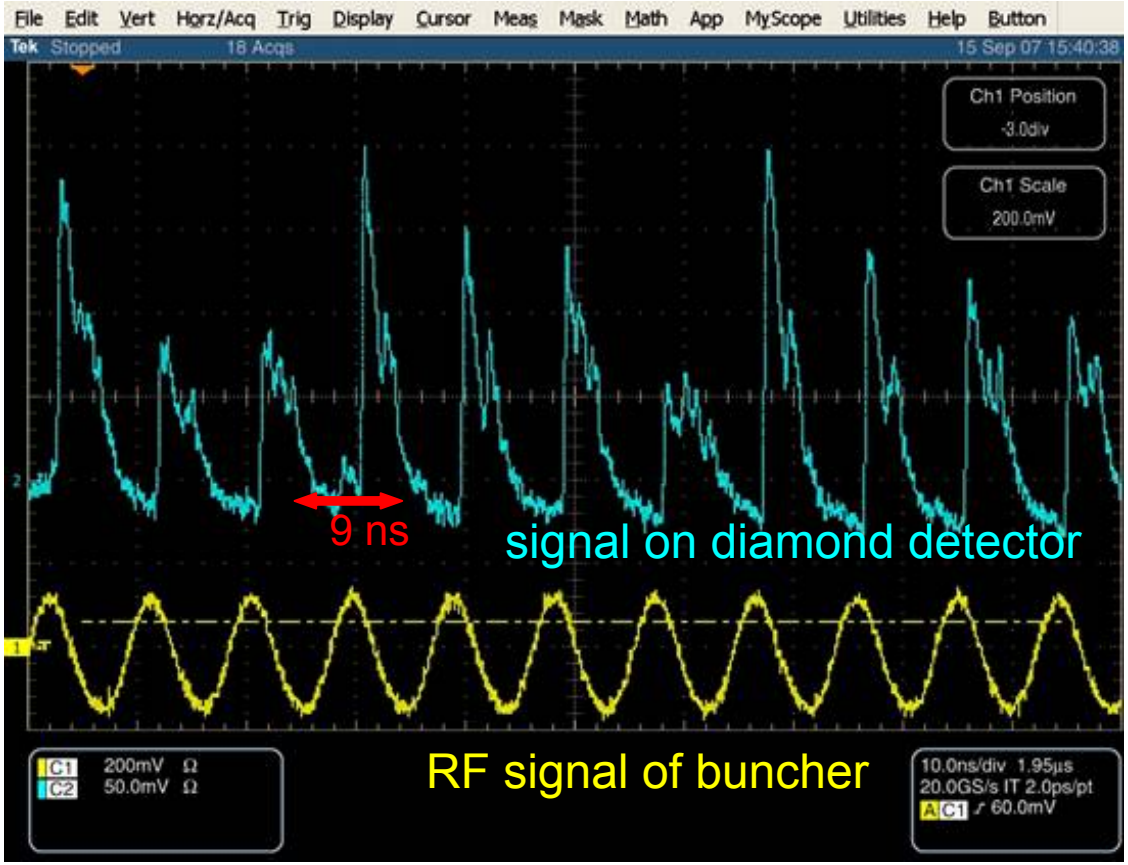
4 MeV/u

0.5 MeV/u

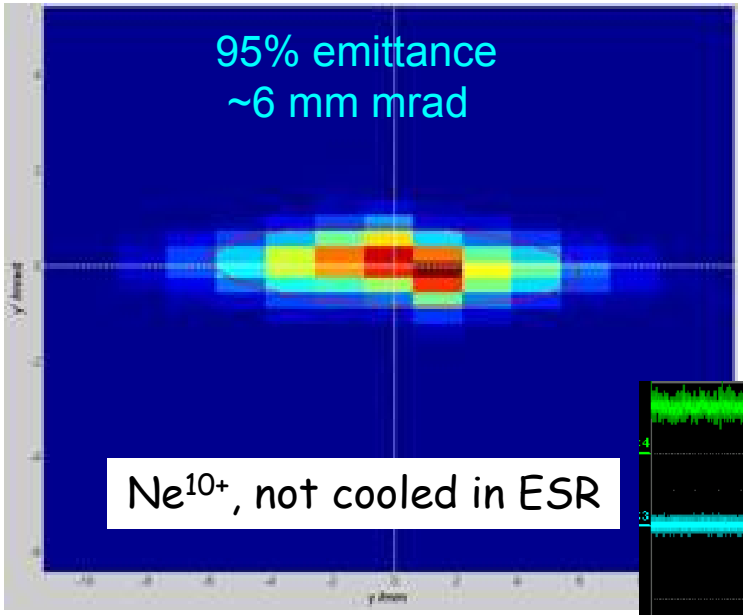
6 keV/u

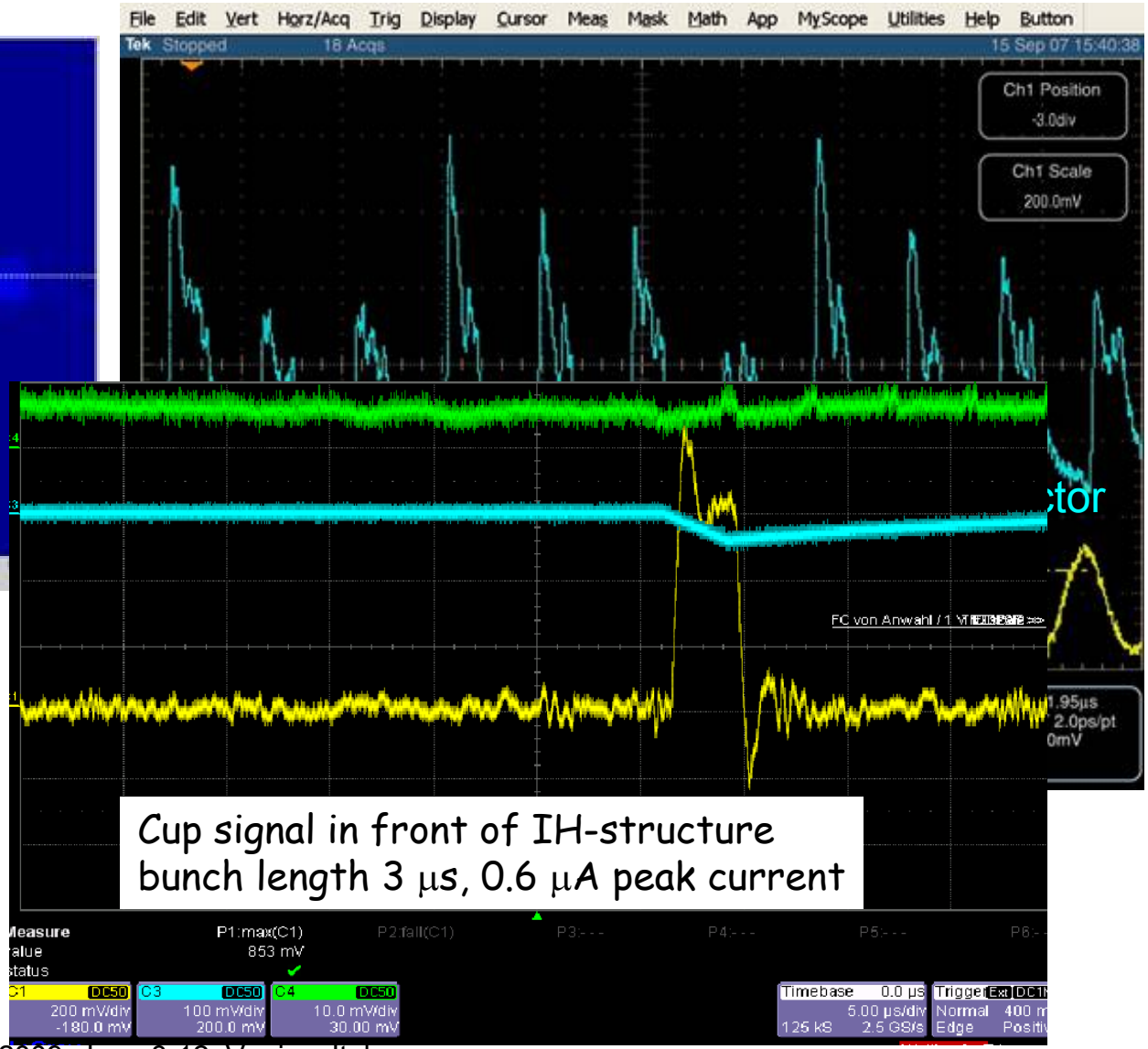
Bunched Ions from the DDB



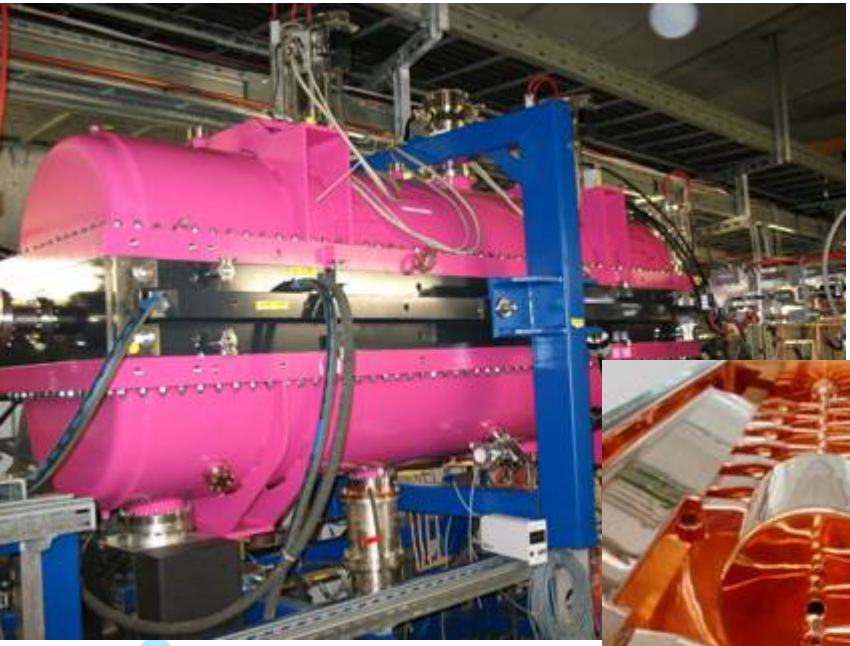


Bunched Ions from the DDB





The HITRAP – IH Structure



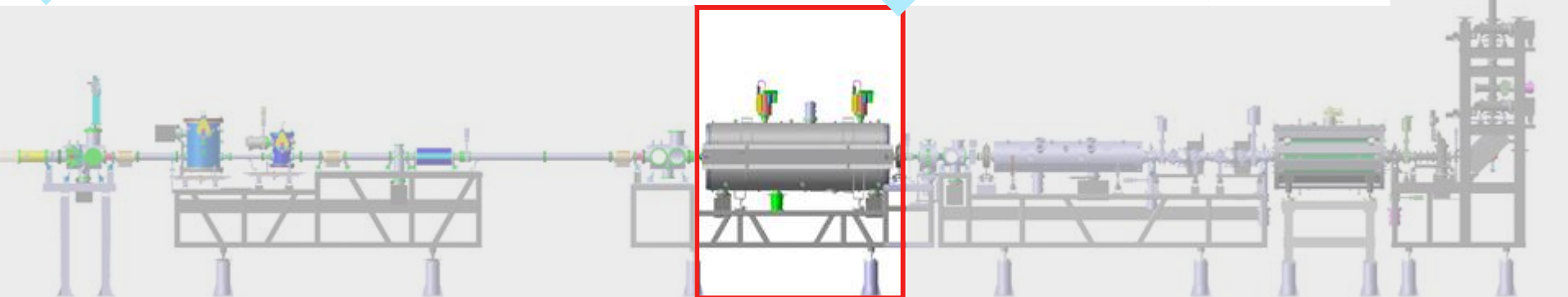
- 25 gaps
- Max. 10.5 MV eff. acc. voltage
- Shunt impedance 290 MΩ/m
- 1 inner tank lens (magn. triplet)

For beam measurements:
pepper pot emittance meter
diamond detectors

4 MeV/u

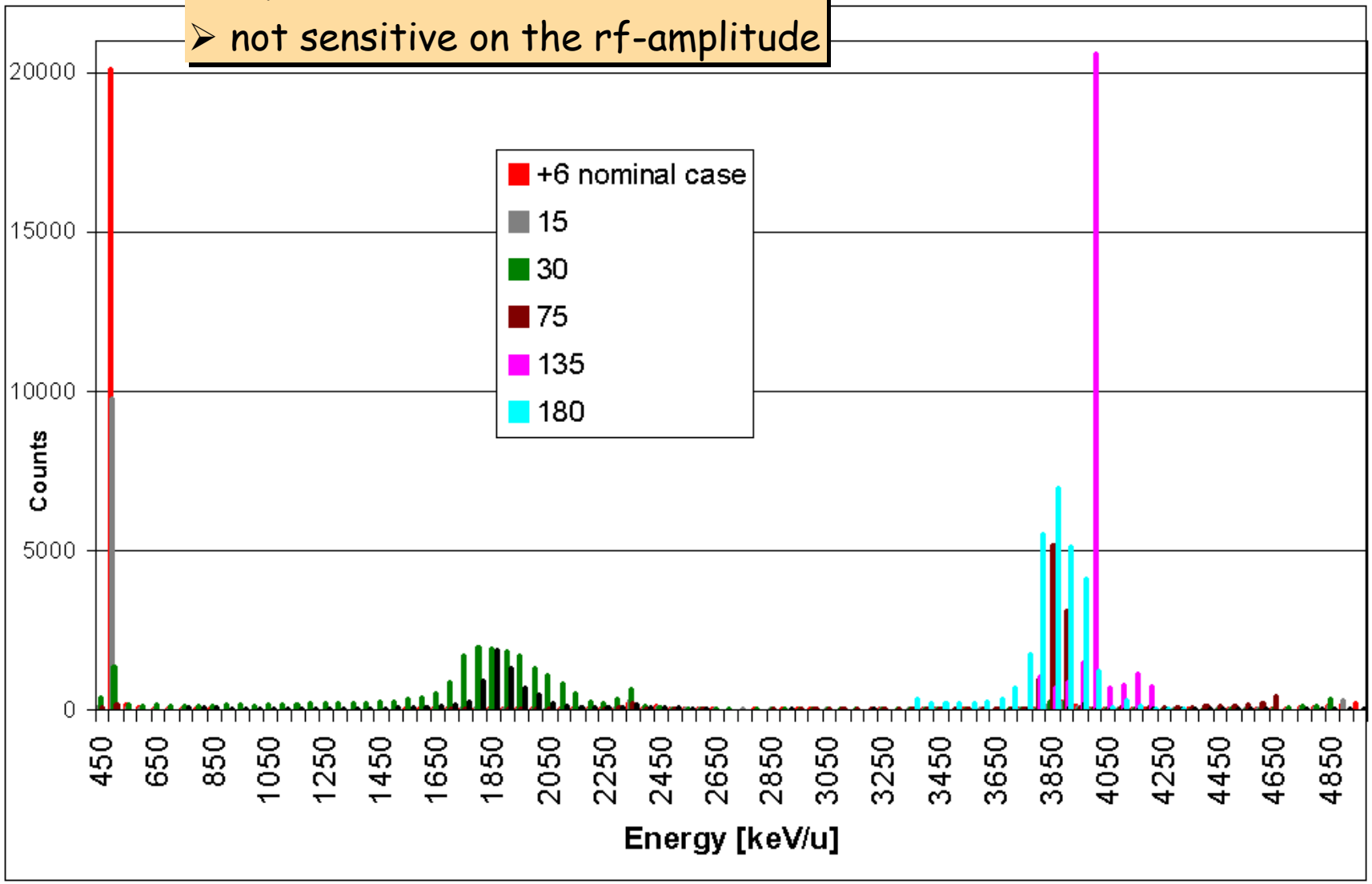
0.5 MeV/u

6 keV/u



IH Structure – Energy Spectrum (LORASR)

- Phase sensitive
- not sensitive on the rf-amplitude



G. Clemente

IH Structure – Energy Spectrum (LORASR)

- Phase sensitive
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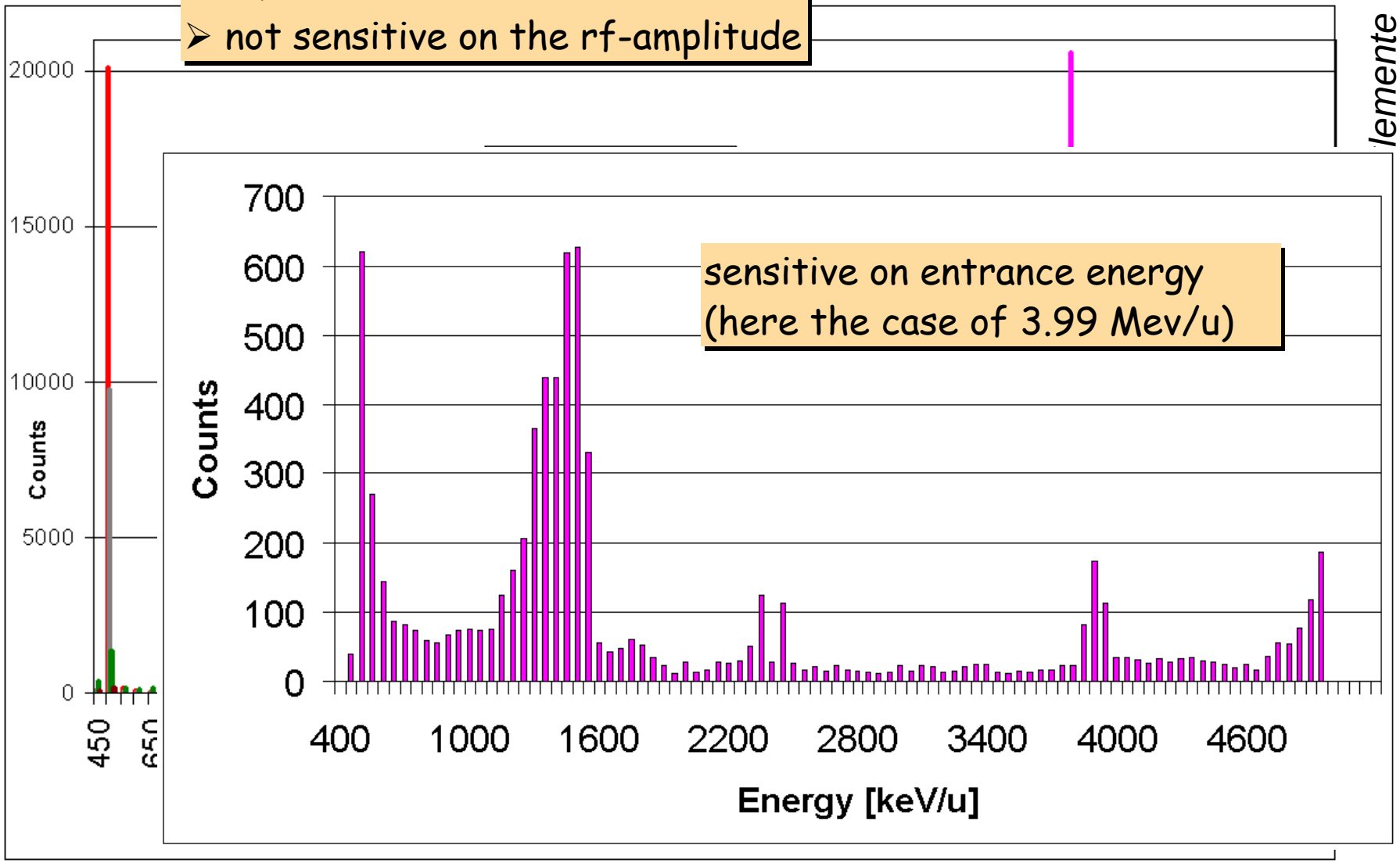
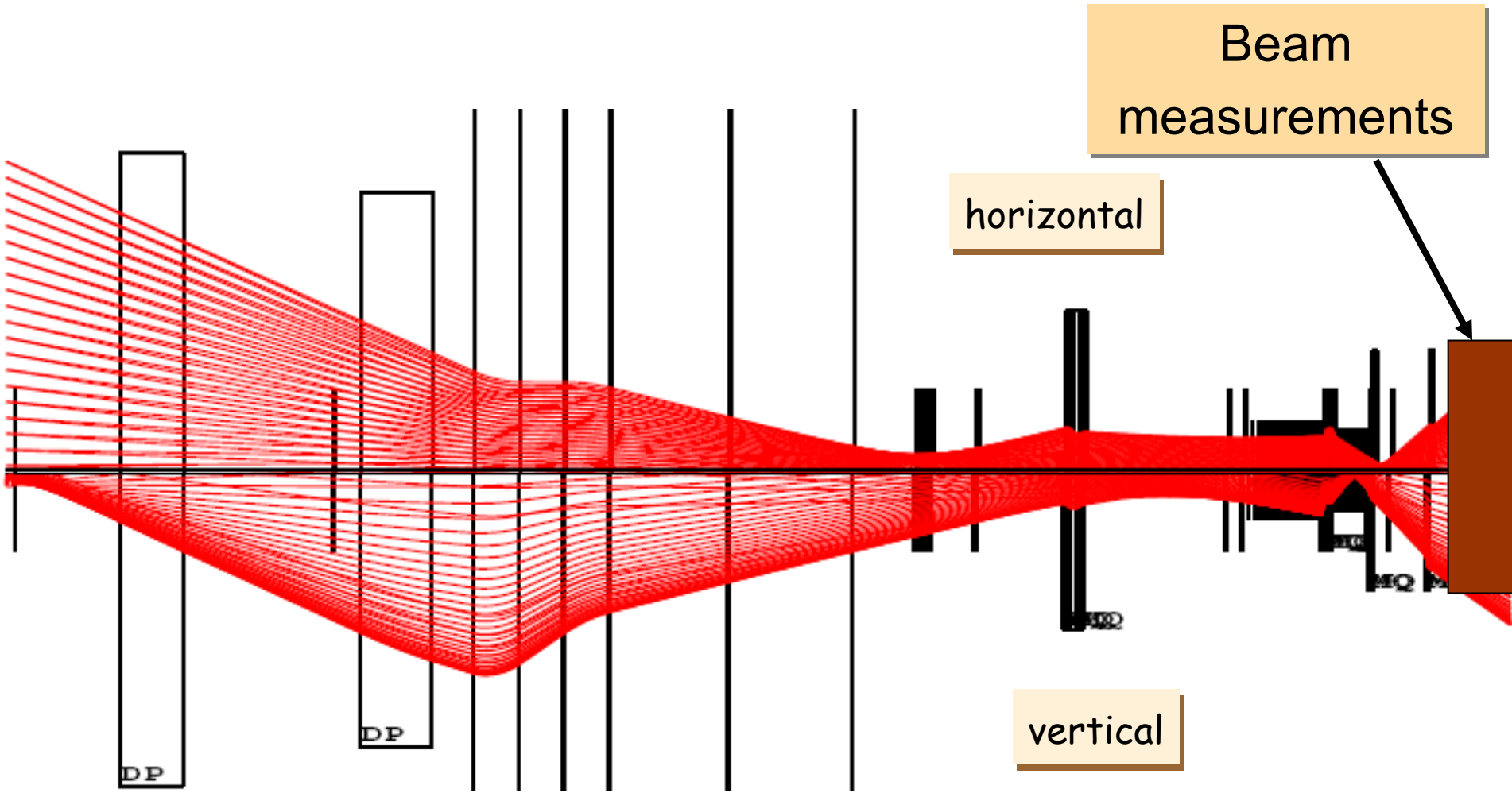
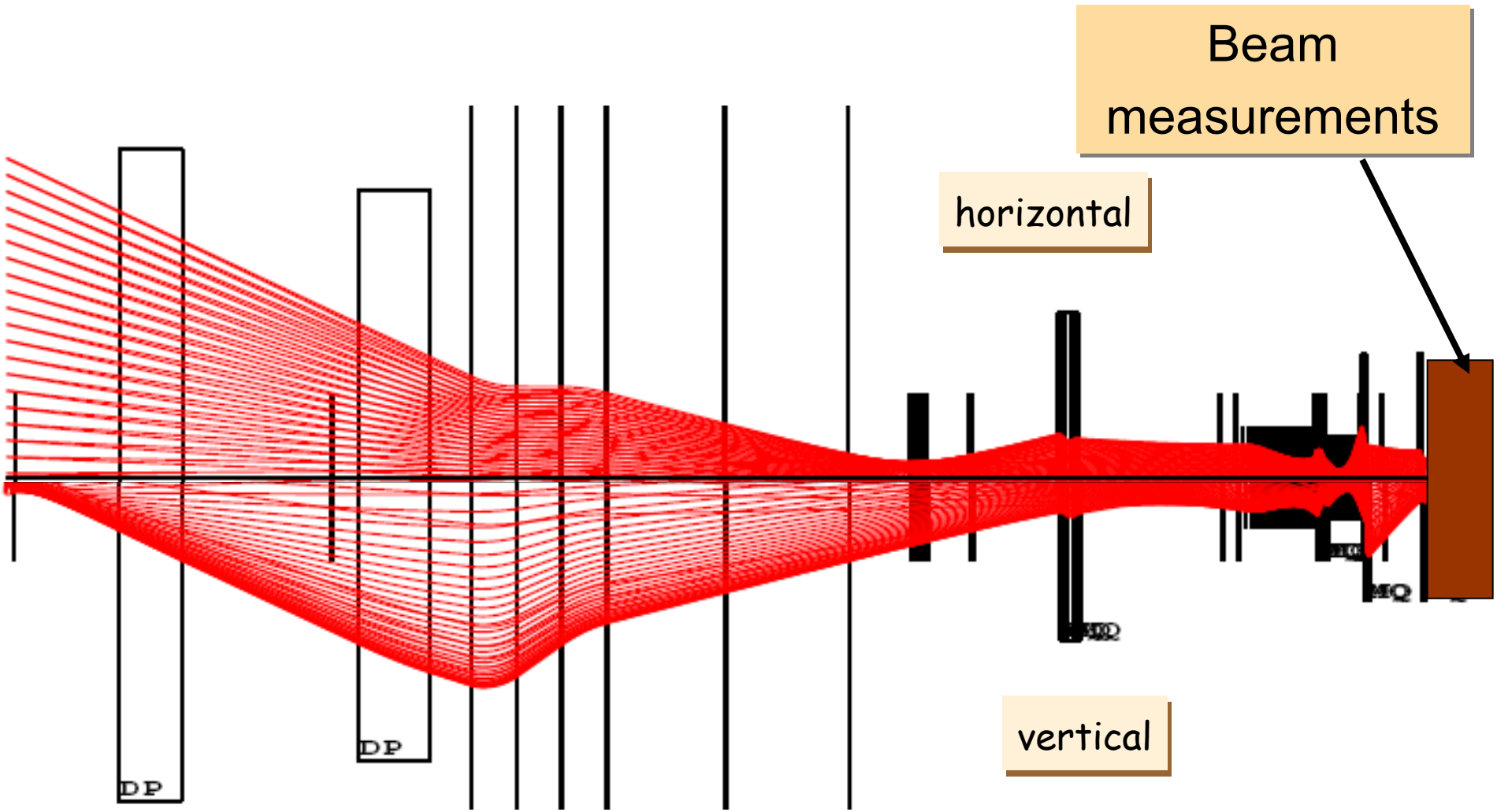


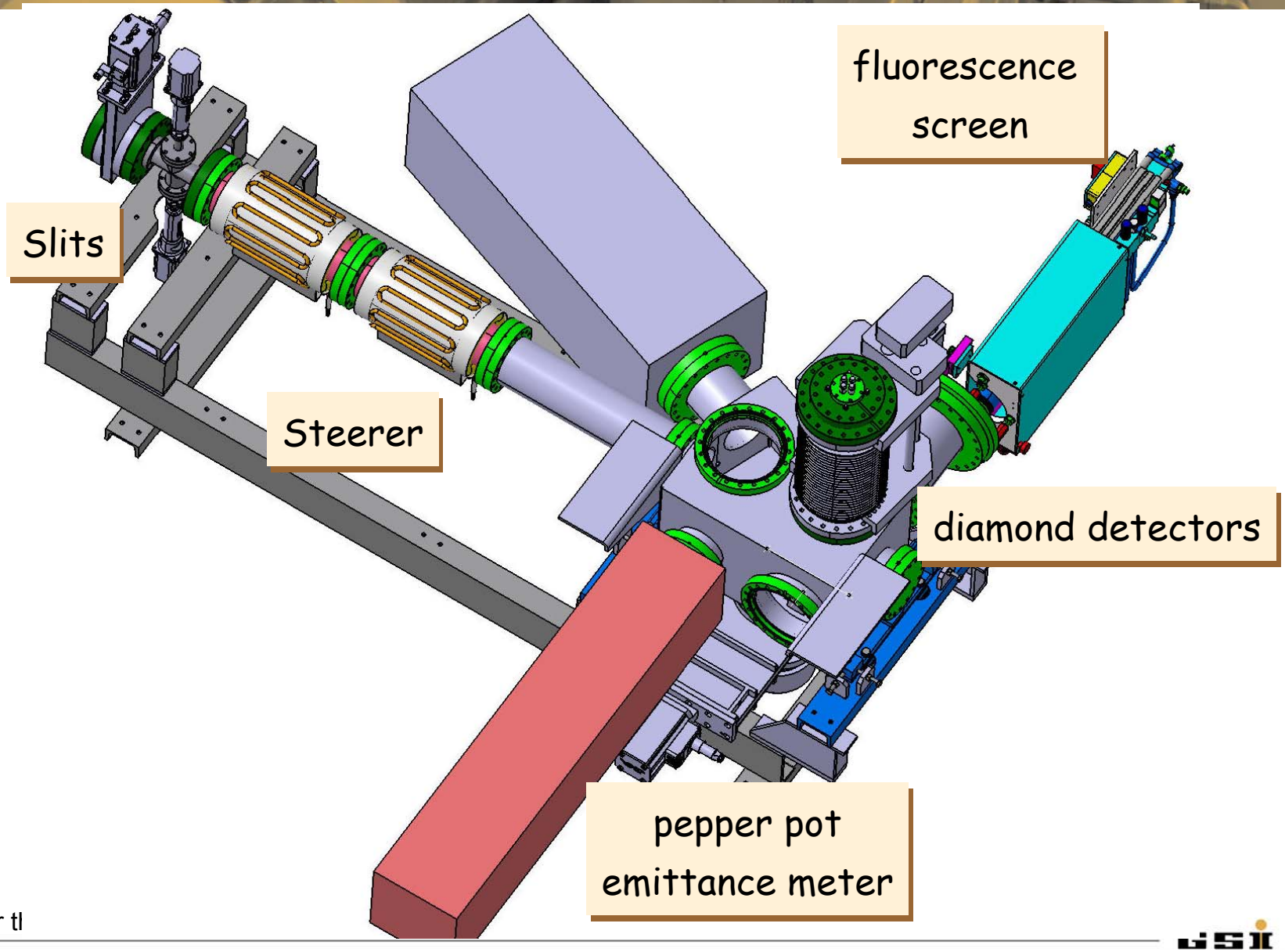
Beam dynamics for 4 MeV/u beam



Beam dynamics for a decelerated beam (0.5 MeV/u)

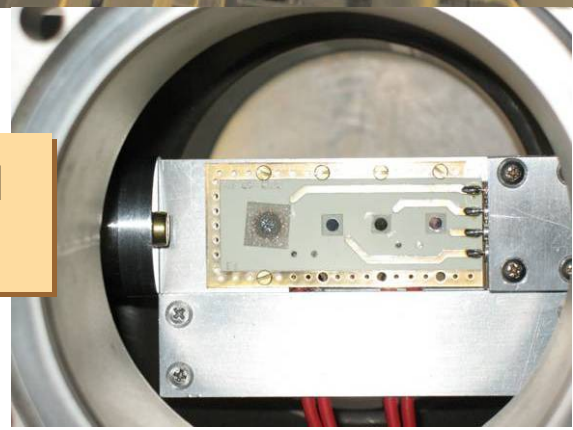


Setup for beam measurement of beam properties



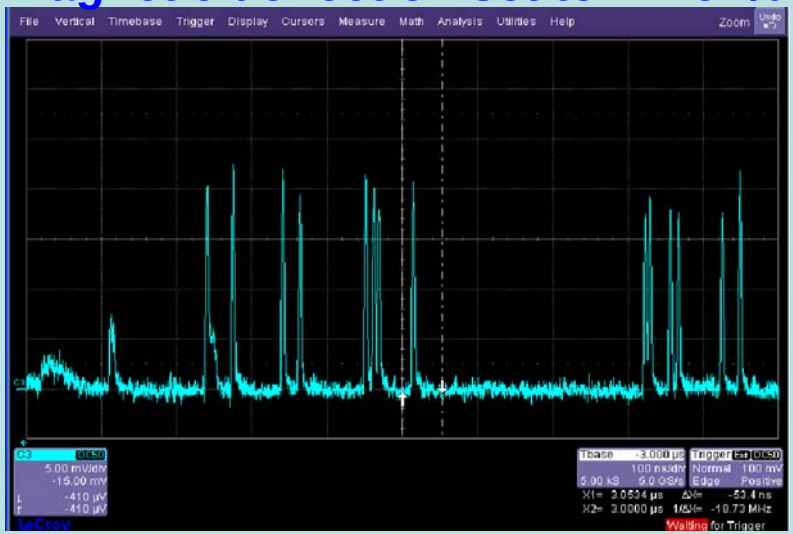
From 4 MeV/u to 0.5 MeV/u

- IH commissioning: deceleration from 4 MeV/u to 0.5 MeV/u
- Energy signal on single crystal diamond detector:



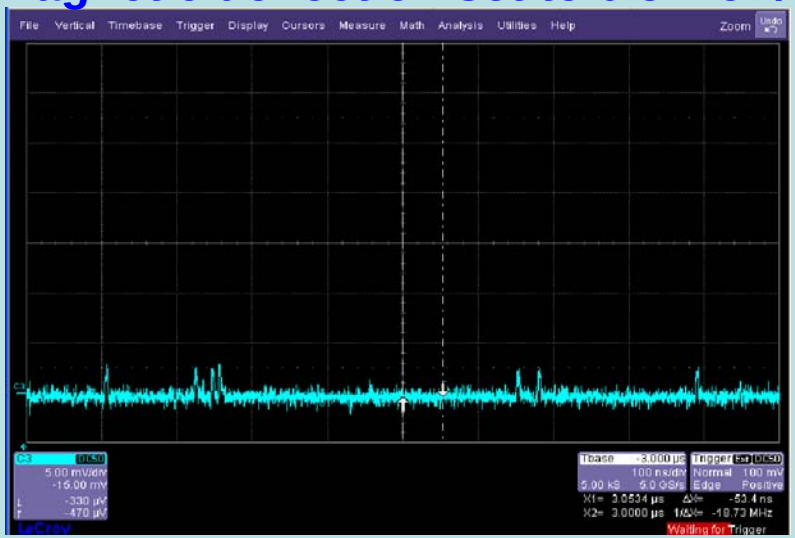
Diamond detector

Magnetic deflection set to 4 MeV/u

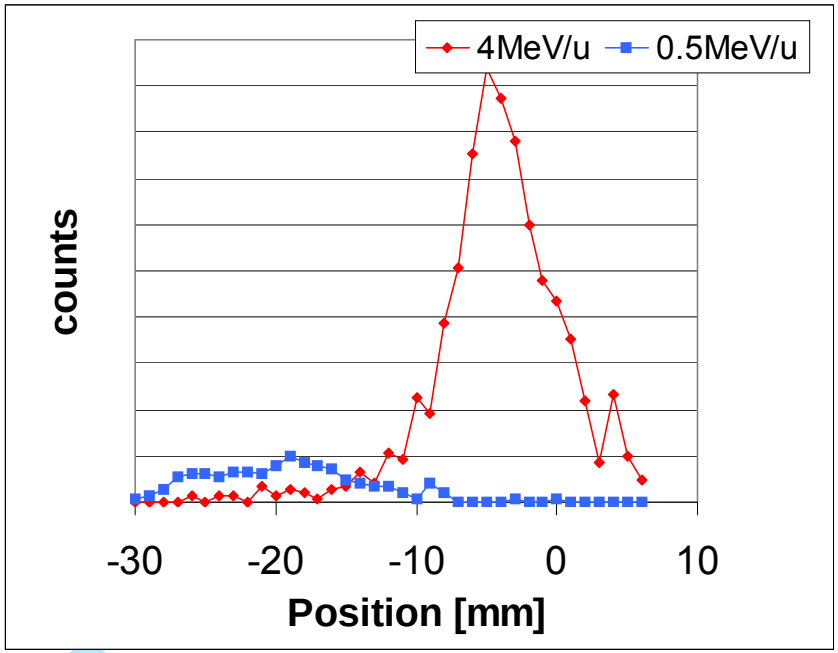


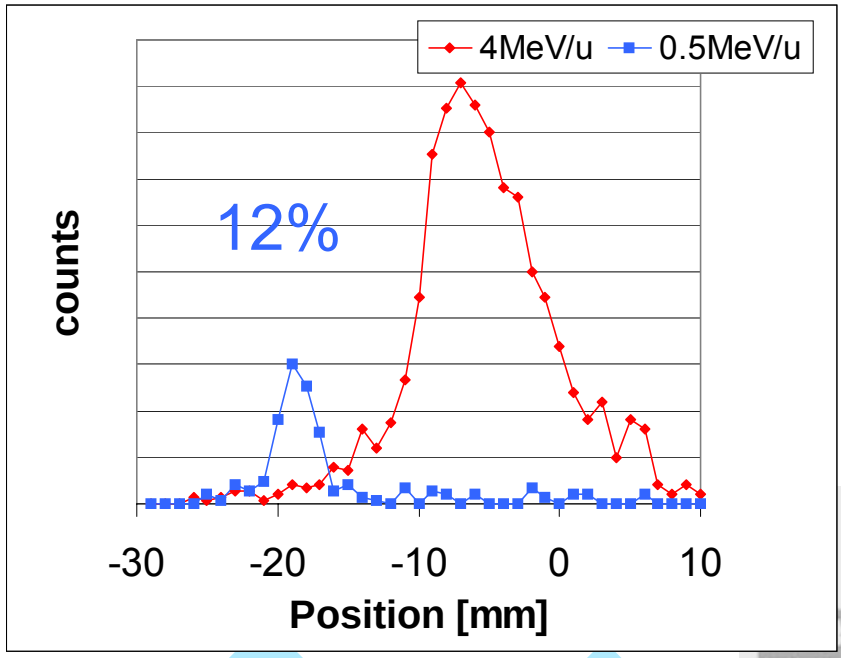
MeV/u
4
0.5
0

Magnetic deflection set to 0.5 MeV/u



HITRAP – Decelerated Ions



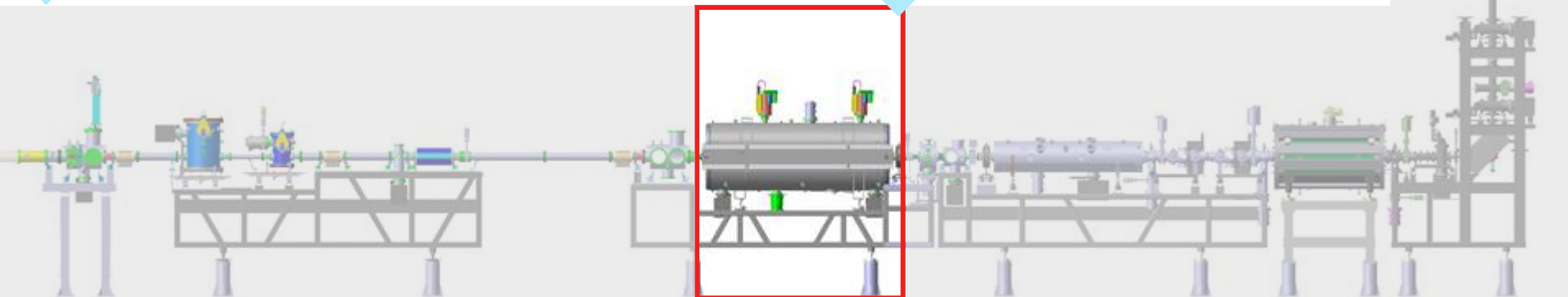


beam profile on diamond

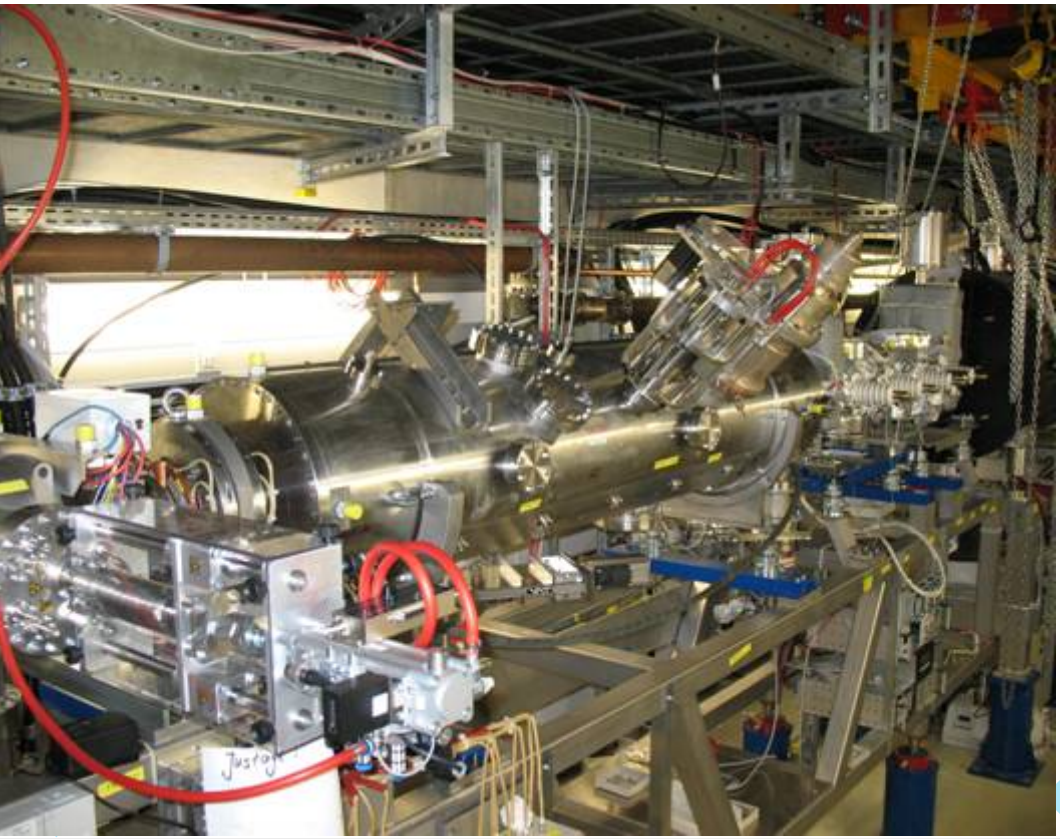
4 MeV/u

0.5 MeV/u

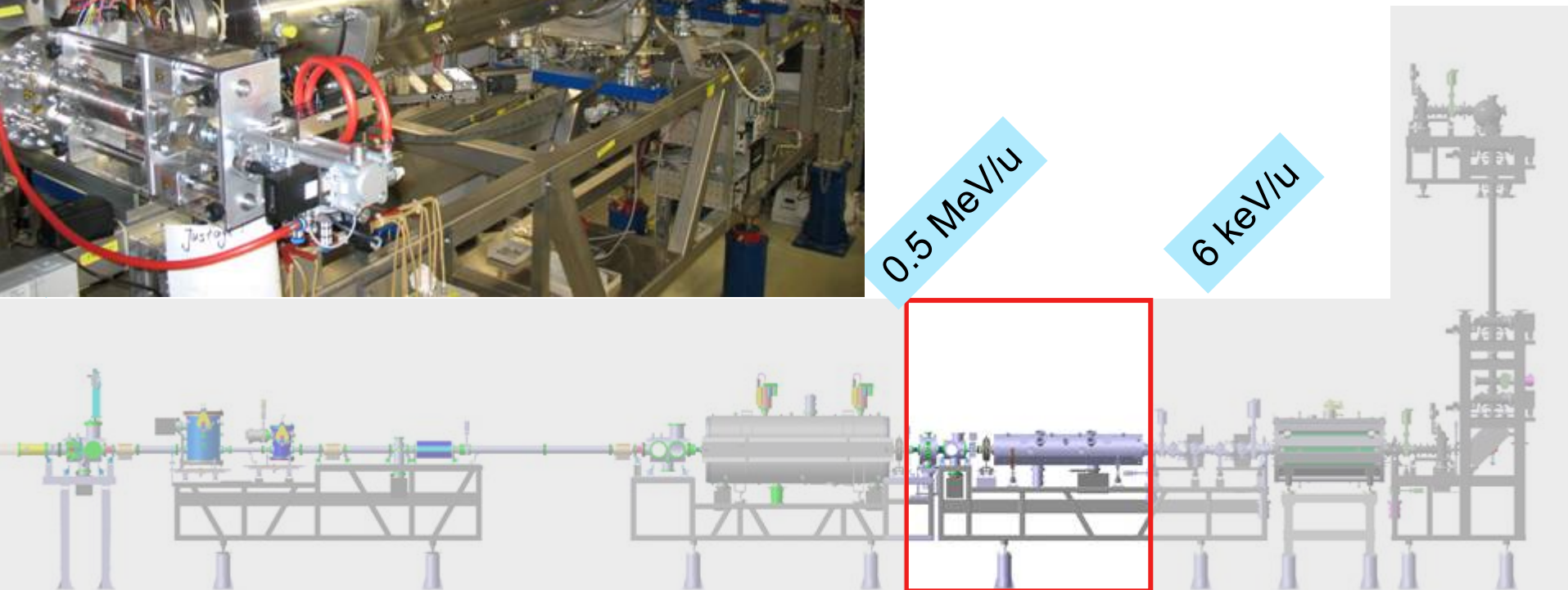
6 keV/u



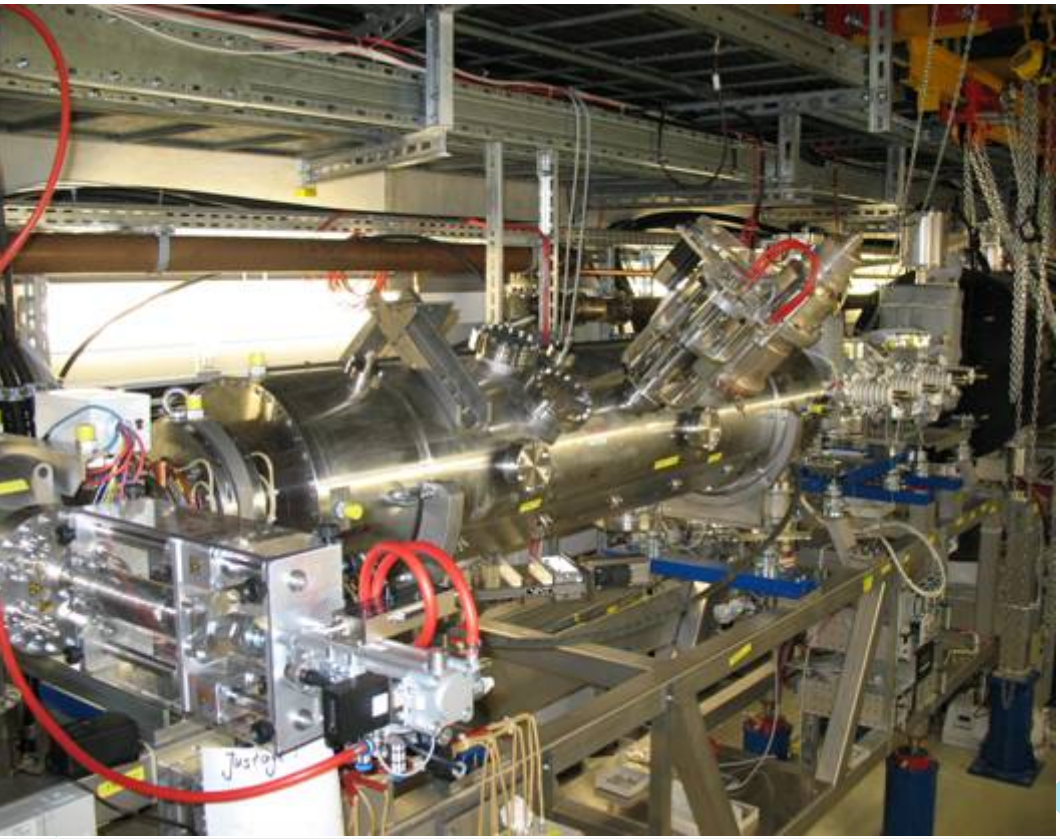
HITRAP – ReBuncher & RFQ



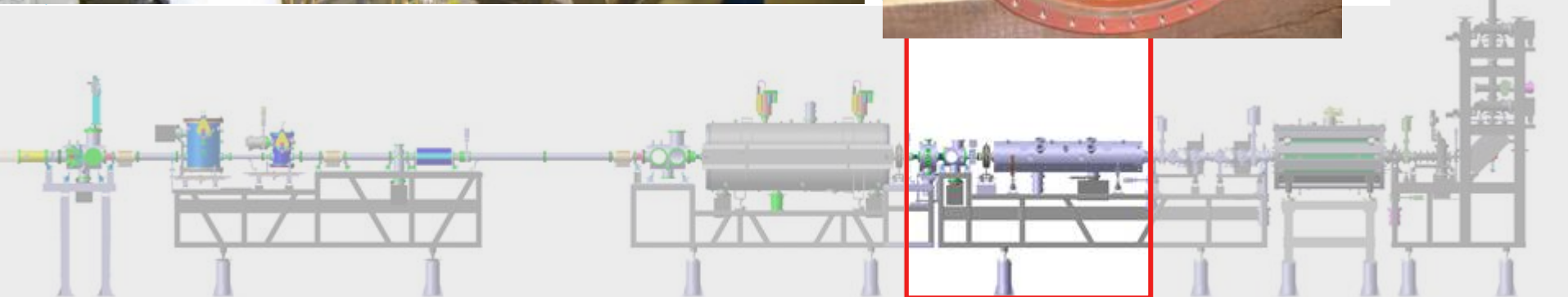
- 4-rod RFQ and 2 gap spiral re-buncher
- Last deceleration stage
- rod voltage 77.5 kV
- length = 2m



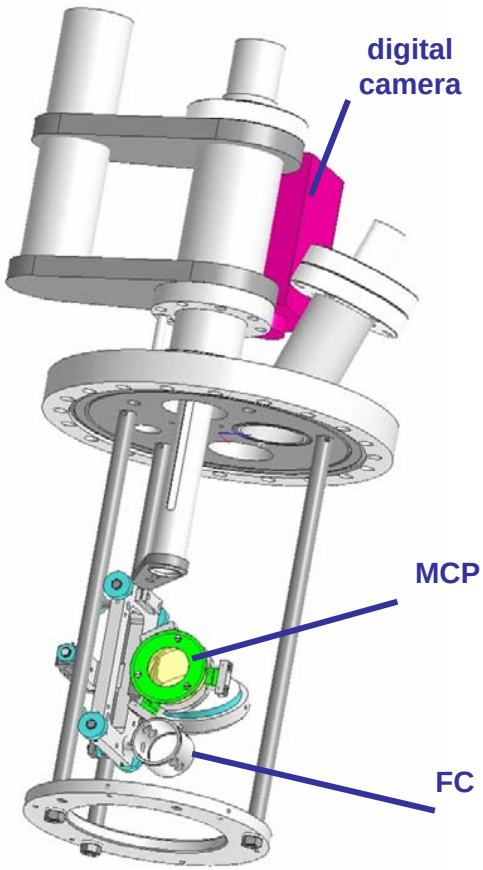
HITRAP – ReBuncher & RFQ



- 4-rod RFQ and 2 gap spiral re-buncher
- Last deceleration stage
- rod voltage 77.5 kV
- length = 2m

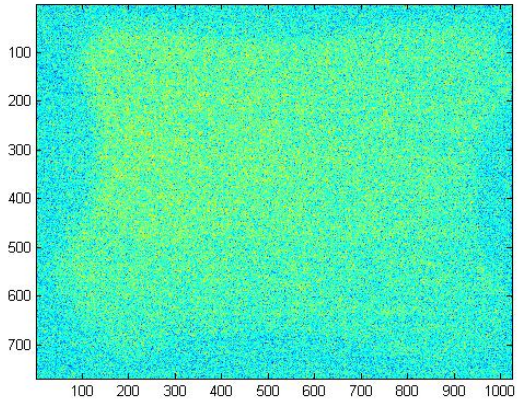


First Beam behind RFQ

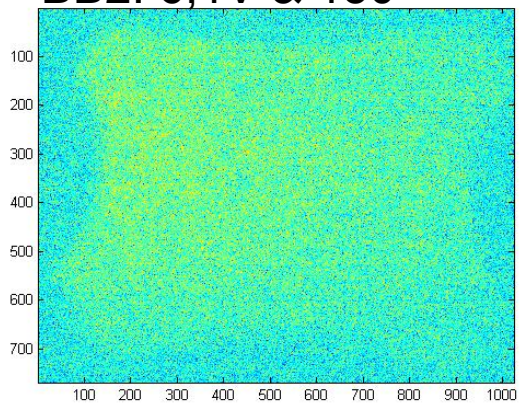


low energy, low intensity
MCP-based imaging detector

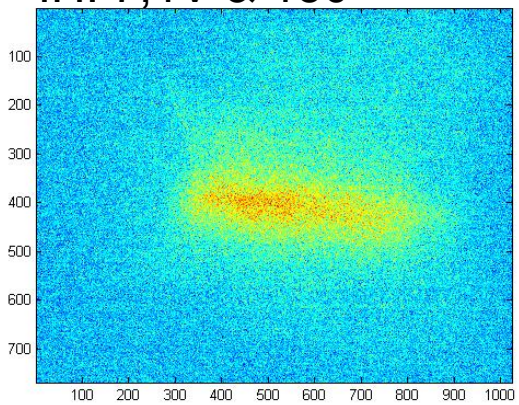
all RF off



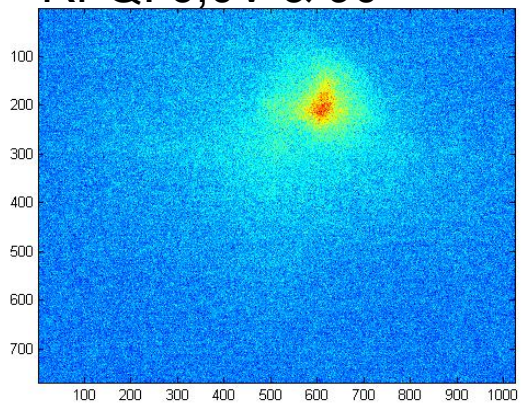
BB1: 8,5V & 0°
BB2: 6,1V & 150°



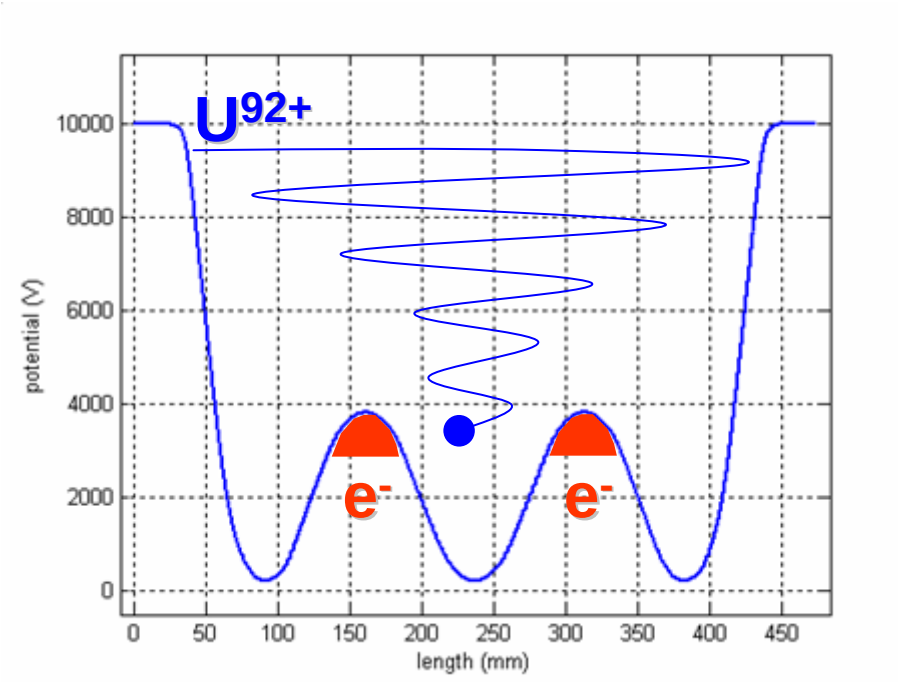
BB1 & BB2
IH: 7,1V & 150°



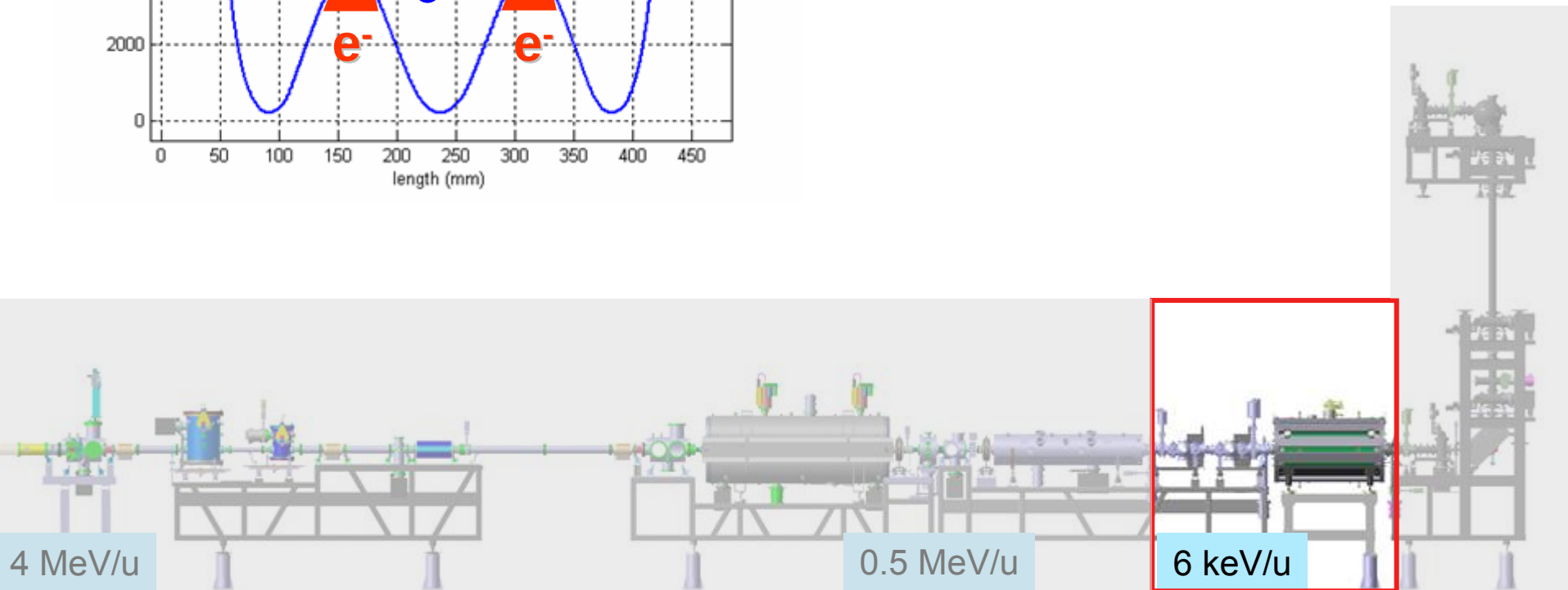
BB1, BB2 & IH
RFQ: 6,0V & 90°



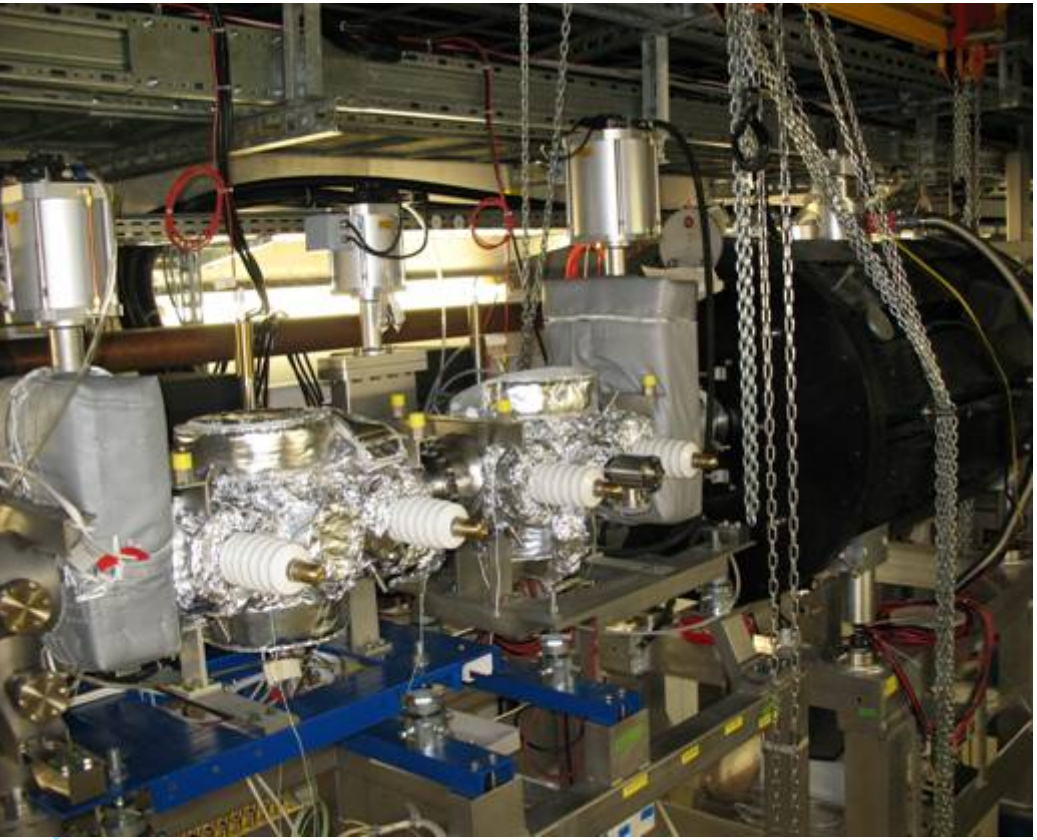
HITRAP – LEBT & Cooler Trap



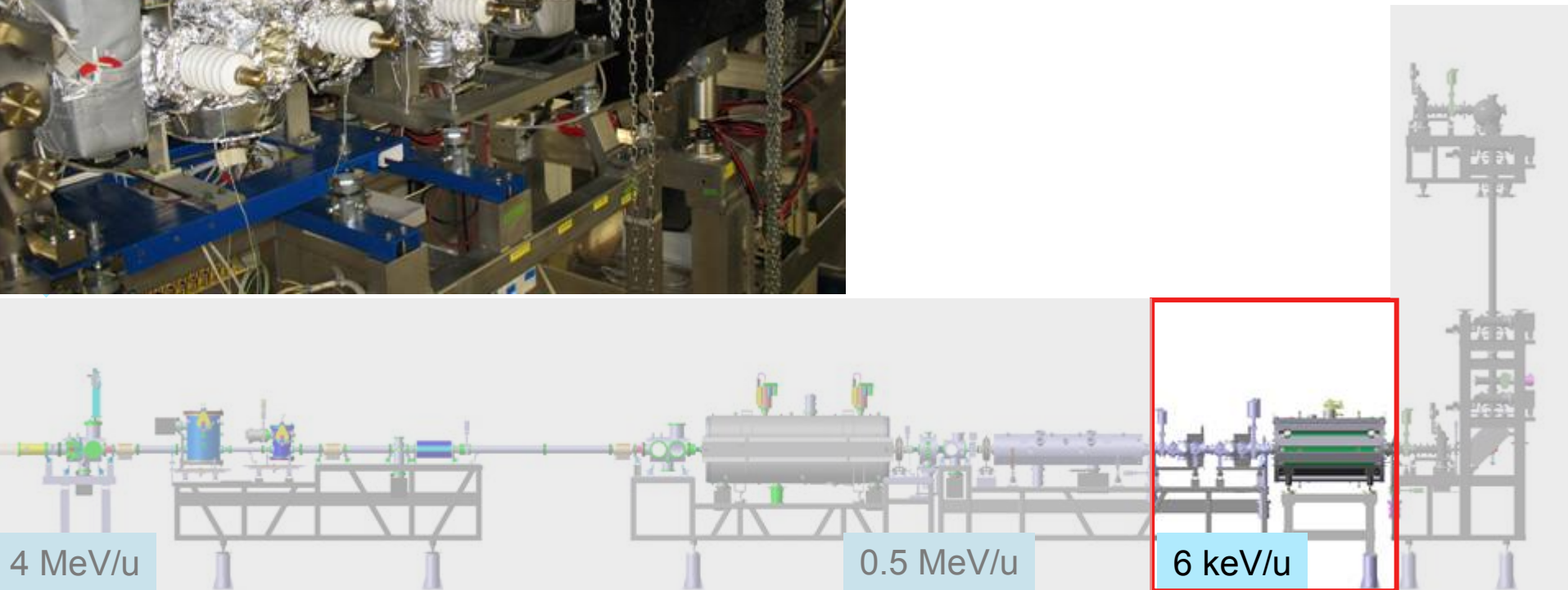
- catch the ions in flight
- cool them with combined electron and resistive cooling to ~ 4 Kelvin



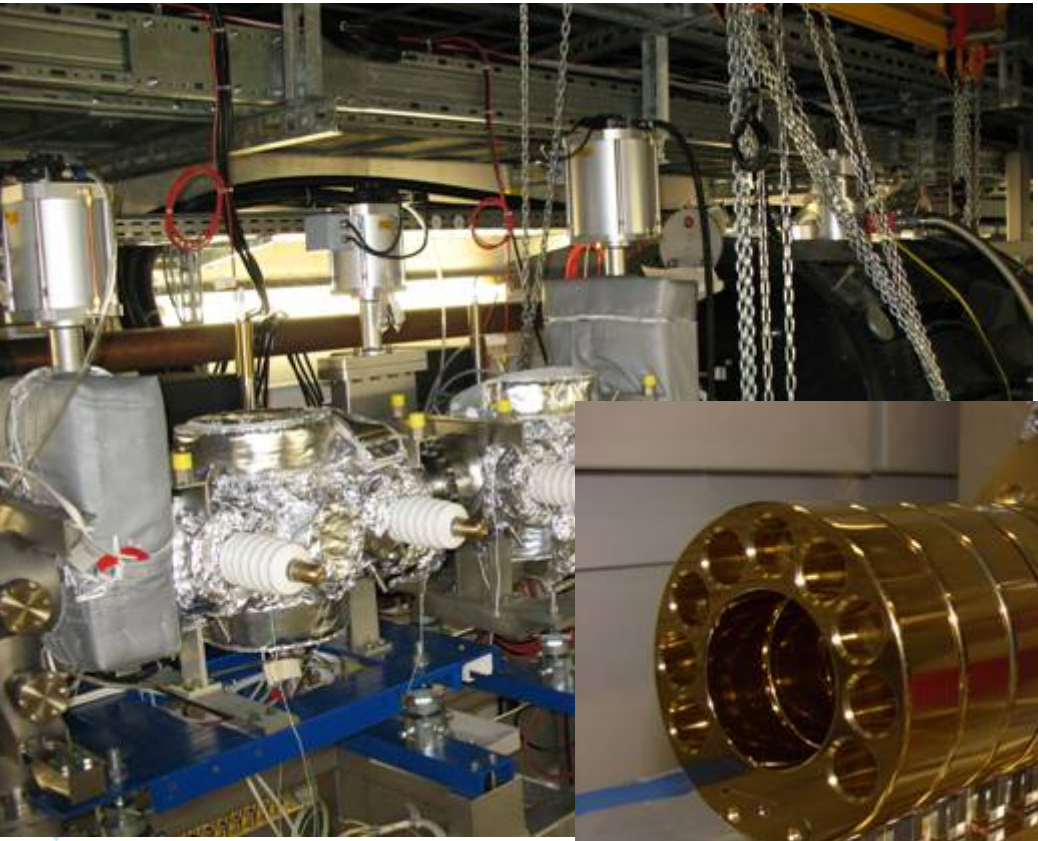
HITRAP – LEBT & Cooler Trap

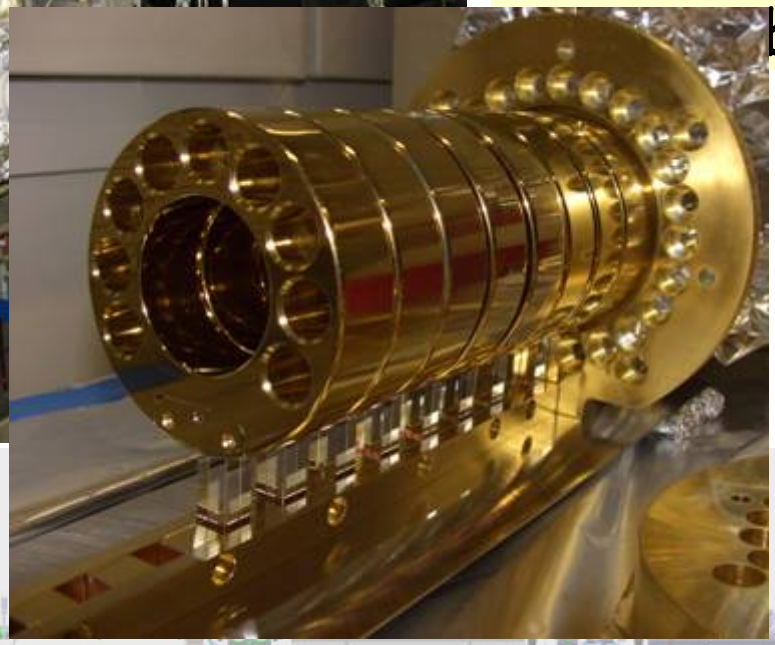


- LEBT installed, trap magnet installed and tested
- trap electrodes ready, assembly in progress



HITRAP – LEBT & Cooler Trap





- LEBT installed, trap magnet installed and tested
- trap electrodes ready, bly in progress

Summary

- Installation of the LINAC and low energy transport completed
- Offline tests of HITRAP cooler trap (are about to start)
- Commissioning of linac ongoing
- Identification of the ion energy is essential
- Compact identification of particle energy is required

HITRAP Collaboration

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The GSI pepper pot emittance meter

- matrix of 15x15 holes
- diameter 100µm
- spacing 1.6mm
- drift length 150mm
- 10-bit cooled CCD
- $\delta\phi$ 0.3mrad