RFQ-cooler and buncher

Ari.Jokinen@cern.ch
PS-OP-ISOLDE
Bat. 8-R-007, Tel. +41-22-7673696

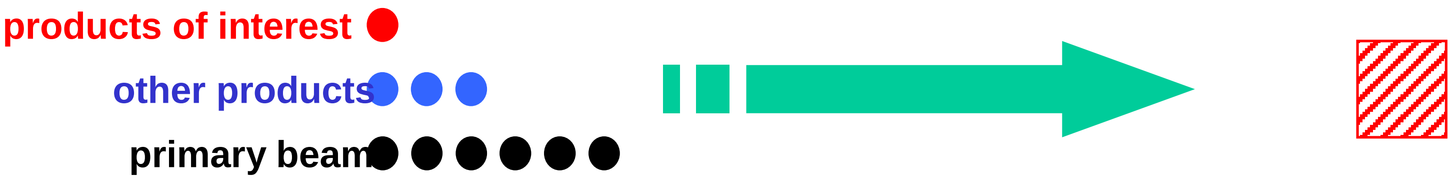
- Introduction: manipulation of ion beams
- Introduction: principle of RFQ with examples from JYFL ion cooler and buncher
- ISOLDE-RFQ: simulations
- Outlook and request for co-operation

ICP-meeting, 16.1.2002

An on-line experiment

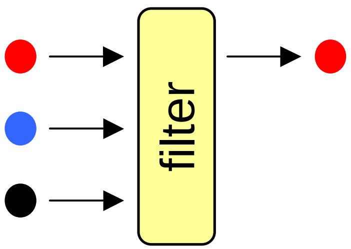
after production target

measurement requires

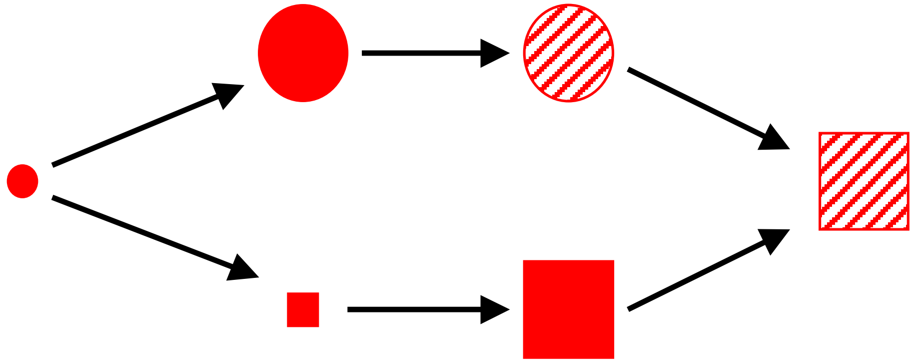


selection &
manipulation

selection



manipulation



Manipulation of radioactive ions

manipulation of ion group properties	*beam, cloud*
• energy	*energy degrading* *stopping, trapping* *acceleration*
• energy spread	*cooling, trapping*
• emittance	*cooling*
• size	*cooling, trapping*
• time structure	*pulsing* *bunching*

“ion beam cooler”
(gas-filled RF quadrupole)

manipulation of ion properties	
• charge state	*ionization*
• ionic/atomic state	
• spin direction	*alignment* *polarization*

“charge breeder”
(ECRIS & EBIS)

Ion beam cooler: principle

- reducing beam size, emittance, energy spread
- storing
- bunching

the output does not depend on the input !

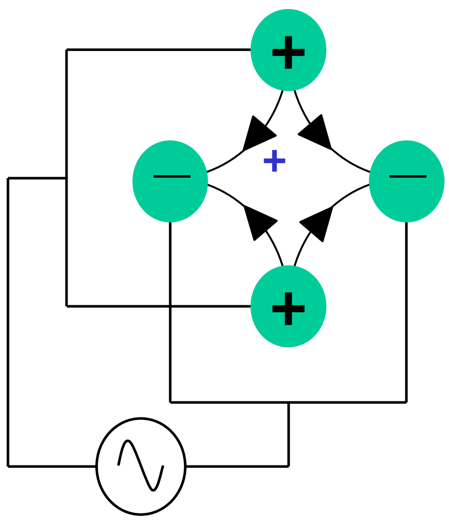
<u>principle</u>

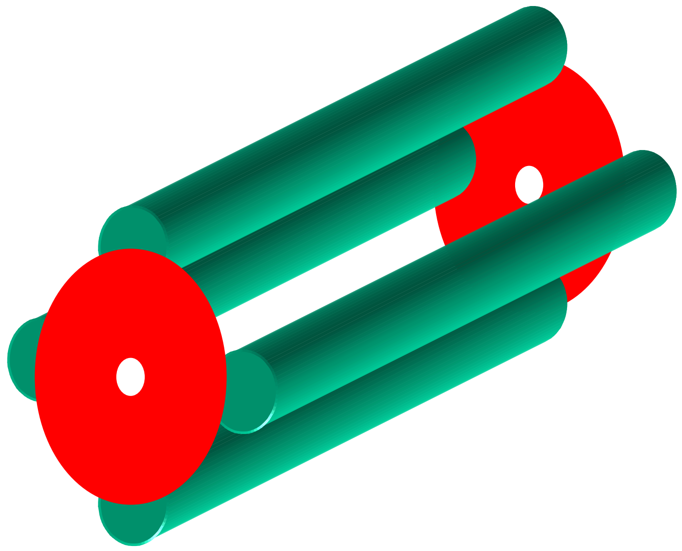
reducing energy spread:

thermalization in (helium) gas

confinement by electric fields

- RF multipole
- end electrodes



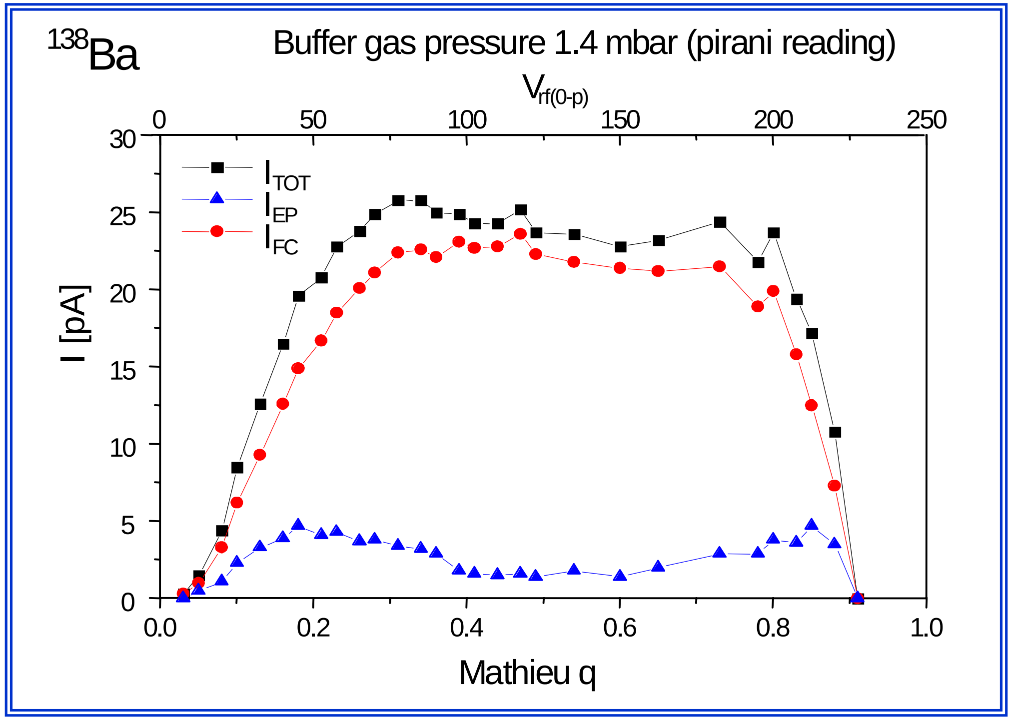


Ion beam cooler: RF confinement

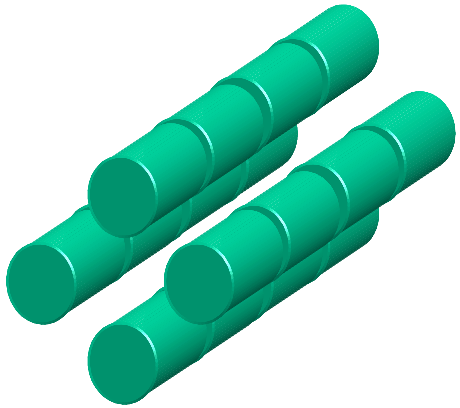
Mathieu parameter

$$q = \frac{4\ Q\ V_{RF}}{m\ r_0^2\ \Omega_{RF}^2}$$

Ion motion is stable when $0 < q < 0.91$

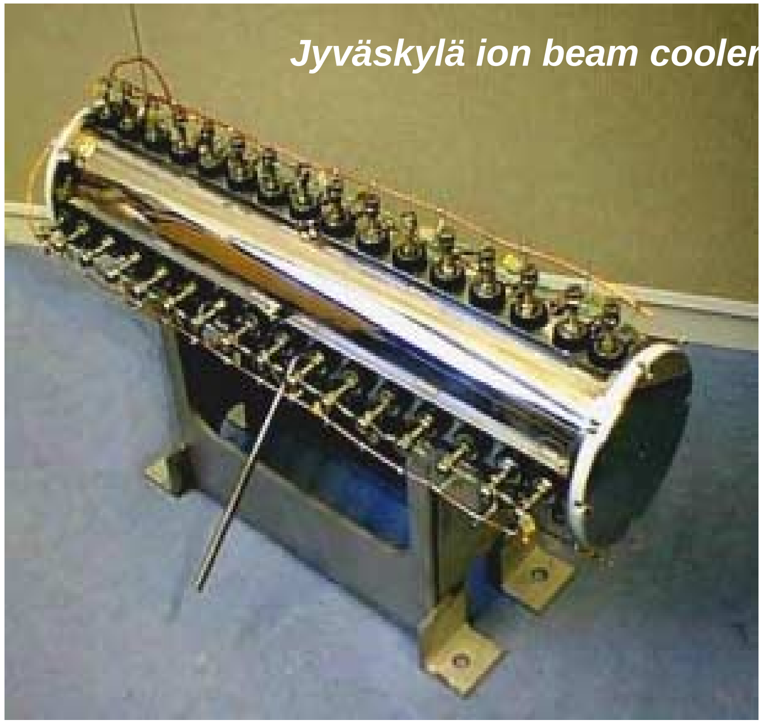


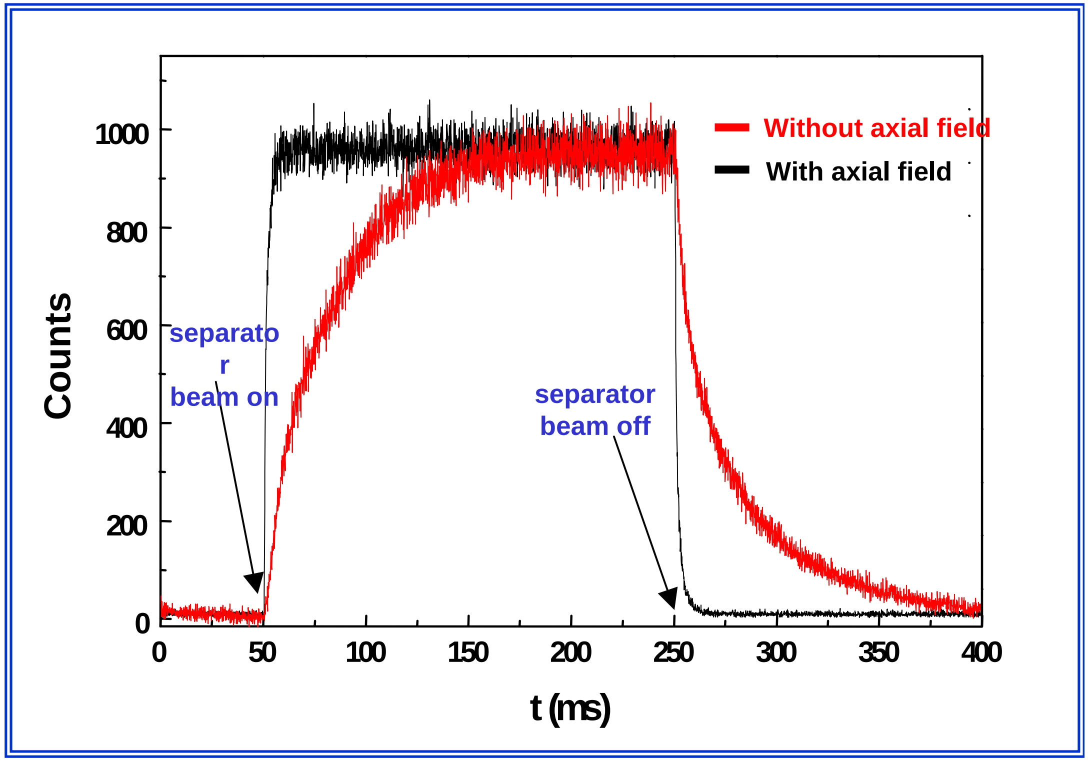
Ion beam cooler: axial field



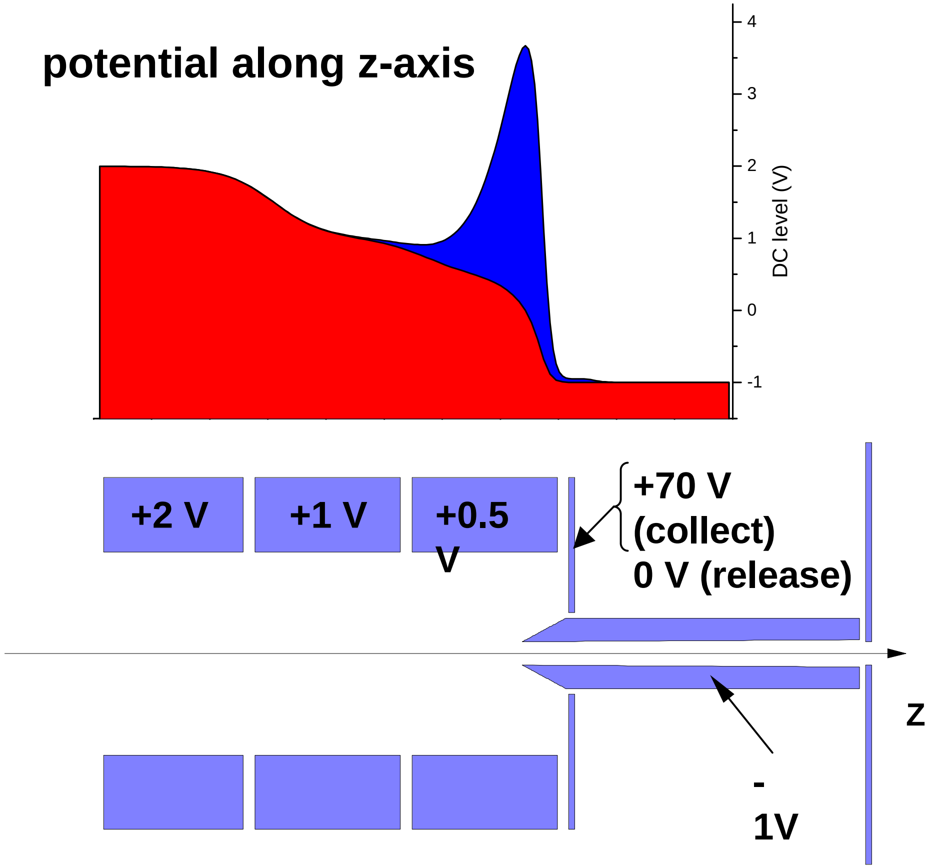
axial field due to segmentation of quadrupole rods

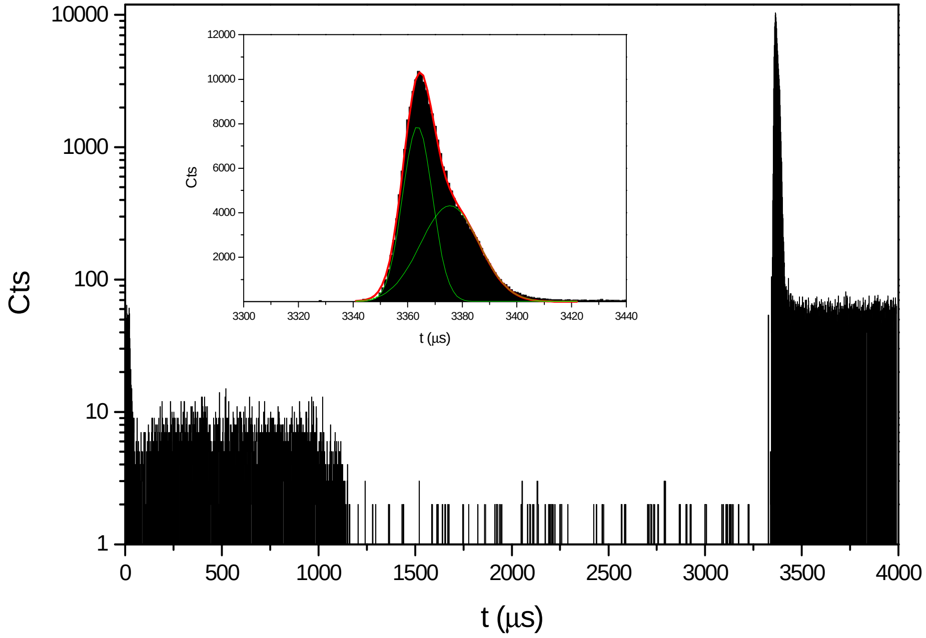
- speeds up transmission
- allows storing and bunching





Ion beam cooler: storing and bunching





- separator beam on: t = 0 - 1000 µs
- cooler end plate voltage down t: = 3300-4000 µs

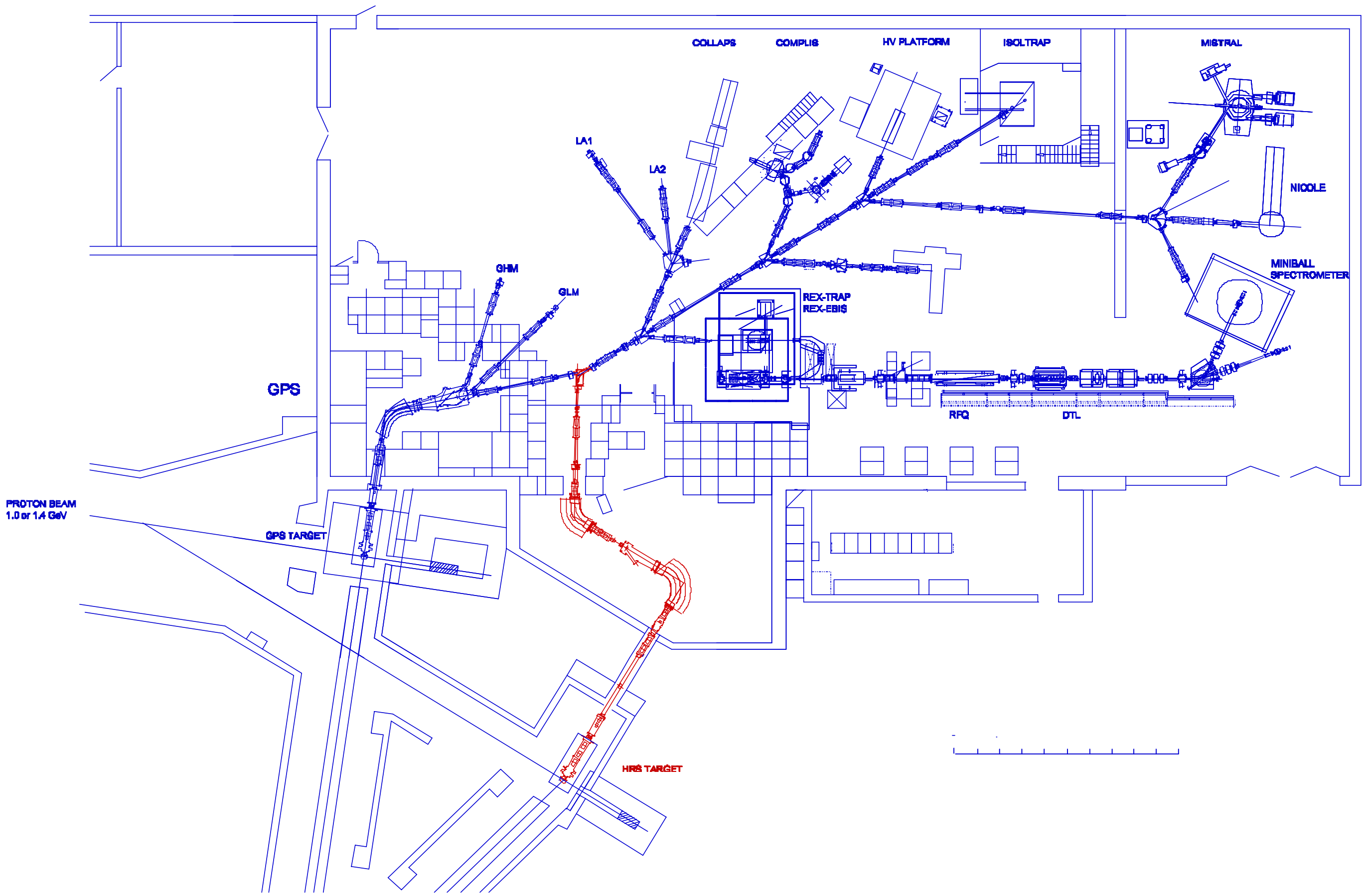
Existing RFQ's in numbers

- Injection energy 100 eV $\rightarrow$ HV-platform
- Pressure 0.1 mbar $\rightarrow$ differential pumping
- Length (rods) 0.5 m, distance of rods 2 cm
- V_{RF} = 200 V, f_{RF} = 1 MHz
- Transmission efficiency 60 %
- Energy spread < 1 eV
- Transverse emittance few πmmmrad
- Trapping time 10 ms - 10 s
- Bunch length 1-10 μs
- Intensities: 5 nA (3E10), sim. 1 μA (6E12)

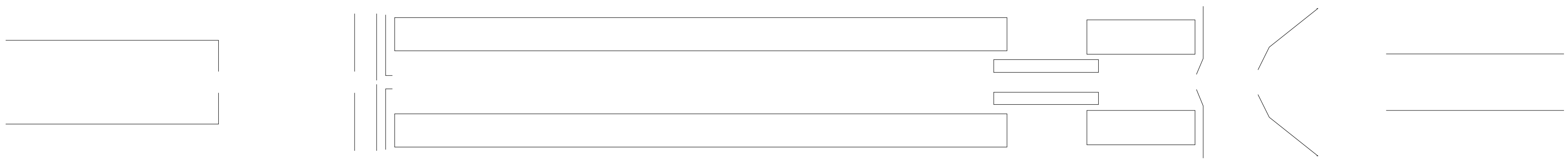
A. Nieminen et al., NIM A469 (2001)
F. Herfurth et al., NIM A469 (2001)
A. Kellerbauer et al., NIM A469 (2001)

RFQ at ISOLDE-hall

Straight section after final focus of HRS



SCHEMATIC LAYOUT OF ISOLDE-RFQ



Deceleration

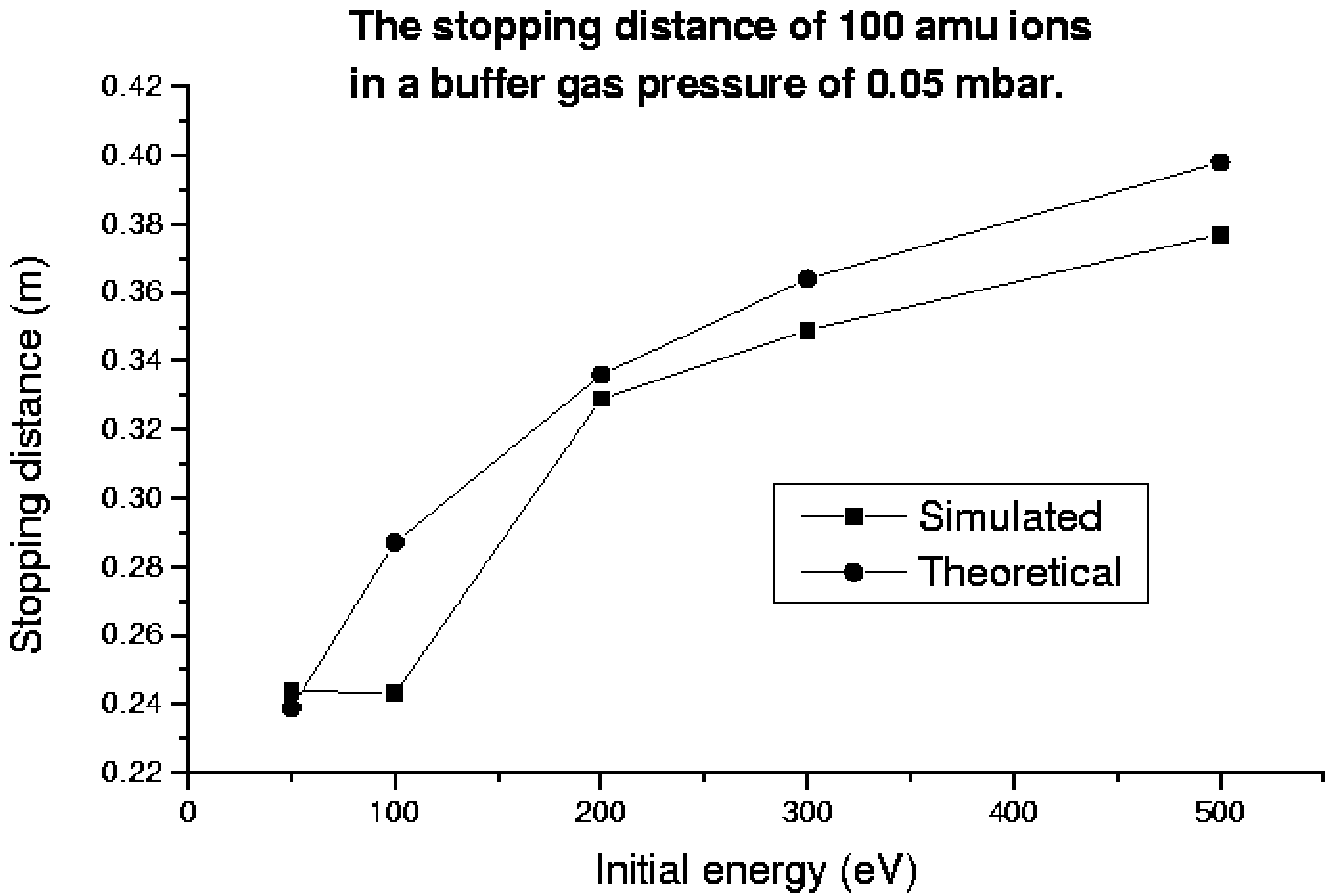
Cooling RFQ

Buncher

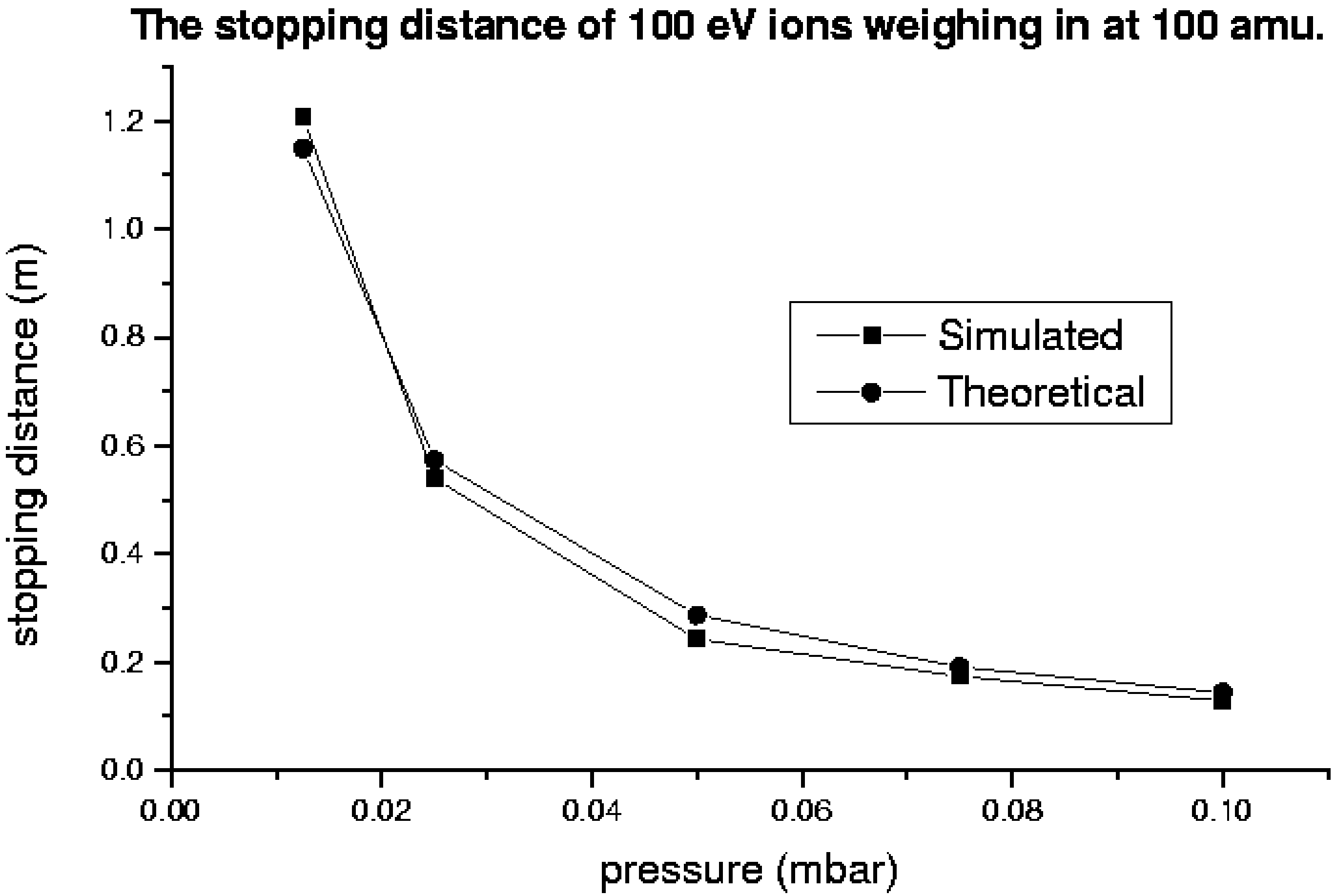
Extraction (and pulse-down)

INJECTION OF IONS

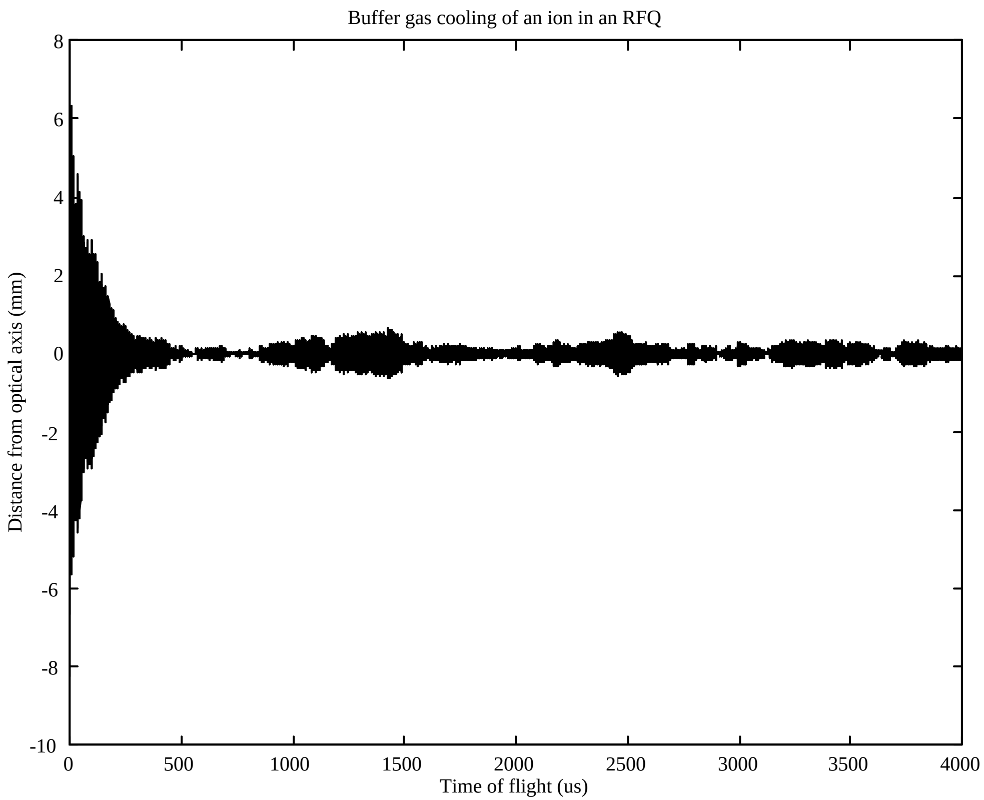
Stopping distance vs. E_{inj}



Stopping distance vs. pressure



Simulated cooling of ions in ISOLDE-RFQ



ISOLDE-RFQ in numbers

- $A = 100$
- $R_o = 20$ mm
- $R_m = 3.5$ mm
- $W = 2\pi f = 2$ MHz
- V(RF) = 200 V
- $\phi = 5$ mm
- $\varepsilon = 40\ \pi$ mm mrad
- $E_{inj} = 200$ eV

- $q = 0.48$
- $D = 24.1$ eV
- $E_{tr} = 15.4$ eV
- $\theta = 4.8$ degrees
- $D_m = 0.74$ eV

CAPACITY
6 cm long, 2 mm radius ion cloud
2.5E6 ions
2.5E9 ions/s (1000 m/s)
2.5E7 ions/bunch (100 ms bunch)

VACUUM
Flow rate of the order of 100 mbar l/s

Outlook 1

- Smaller focus into an experiment
- Better energy definition of the ion beam
- Bunched beam
- New starting point of the ion transport
- Stability and independence of ion beam properties against changes in the front-end
  - Mechanical, pressure or temperature variations
  - Ion source type
- Shorter stable beams sessions, better transmission
- Route for calculated ion optics or ABS ?

Outlook 2

- Solid State Physics
  - Soft-landing experiments
  - Any high dose, small size implantations
  - Channeling experiments ?
- Nuclear Spectroscopy
  - Correlation studies
  - Tagging experiments
- Laser Spectroscopy
  - Better overlap of ion beam and laser
  - Bunch-gating

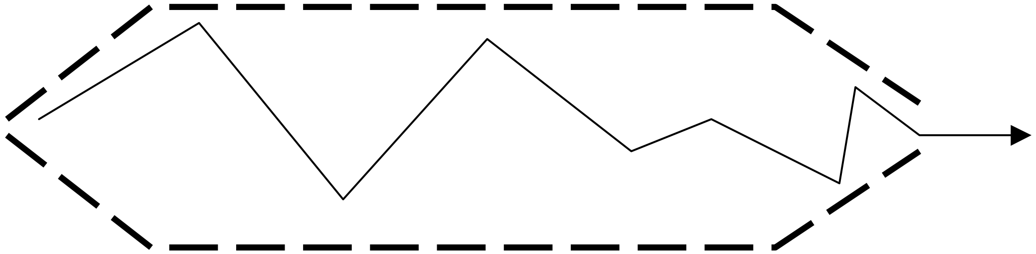
Outlook 3

- NICOLE
  - Higher injection efficiency
- REX-ISOLDE
  - Simplified and more efficient capture to REXTRAP
- MISTRAL
  - Higher transmission
- WITCH-Project, ECR, …

OPEN QUESTIONS

- Gryogenic cooling
- Switch to conventional quadrupole
- Funnel-structure
- Fast extraction

FUNNEL ?



Square well potential – higher capacity
Simple construction, in principle
Does it work ?

Co-operation 2002-2004

Support is asked in following topics:

- Mechanical structure (ideas, technical design, …)
- Vacuum (components, materials, suppliers for CERN, …)
- Electronics (power supplies, feedthroughs, cables, …)
- RF-techniques (design of RF-amplification and tuning scheme, components, …)
- Control system (ISOLDE compatibility)
- Construction, testing, diagnostics, …