



# RFQ ion guides for in-gas-jet laser spectroscopy studies at KU Leuven

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LA<sup>3</sup>NET Meeting, Paris  
26 Oct 2016



# Outline

Brief introduction to HELIOS

Update on RFQ progress

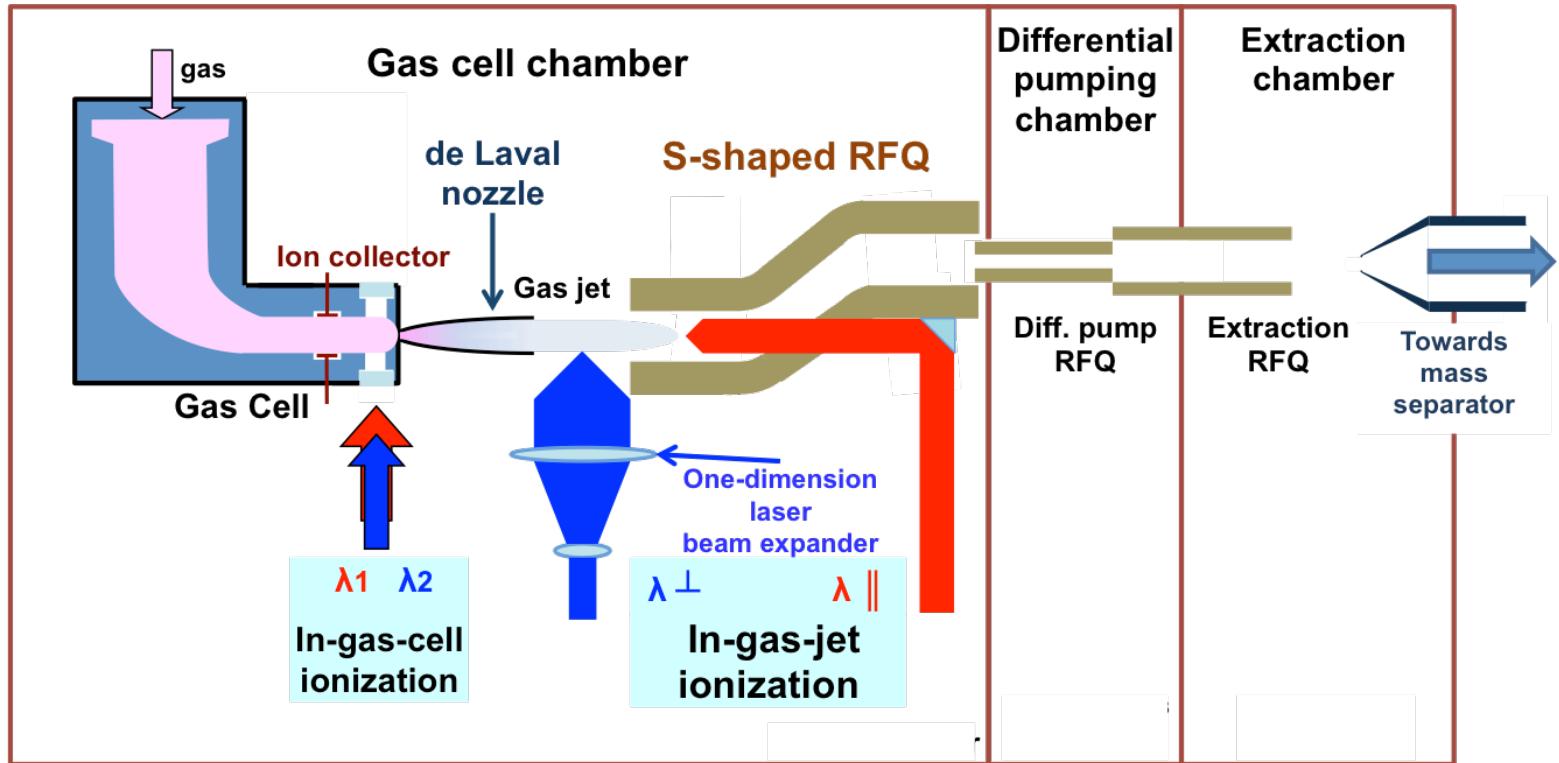
- design
- simulations
- construction
- first tests

Future plans

Conclusions

# Introduction: HELIOS

- Heavy Element Laser Ionization and Spectroscopy  
→ Develop in gas-jet laser ionization technique



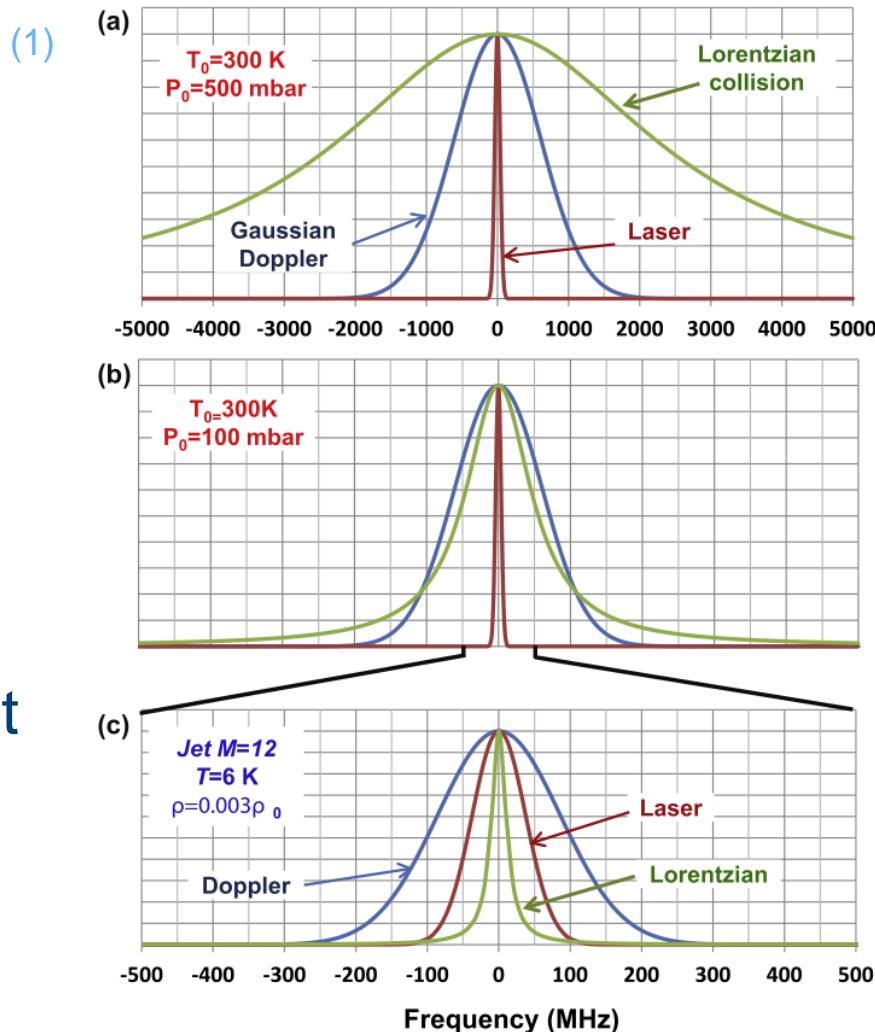
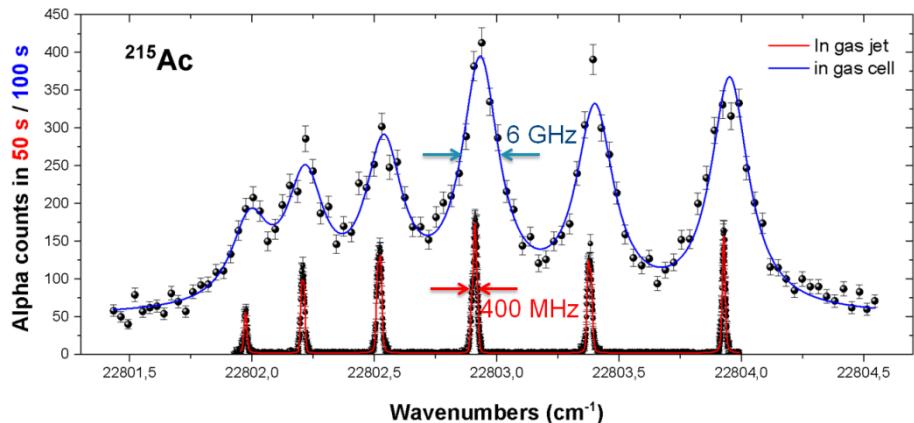


→ Chemically independent product extraction

→ Increased spectral resolution w.r.t gas cell (expected down to ~200MHz)

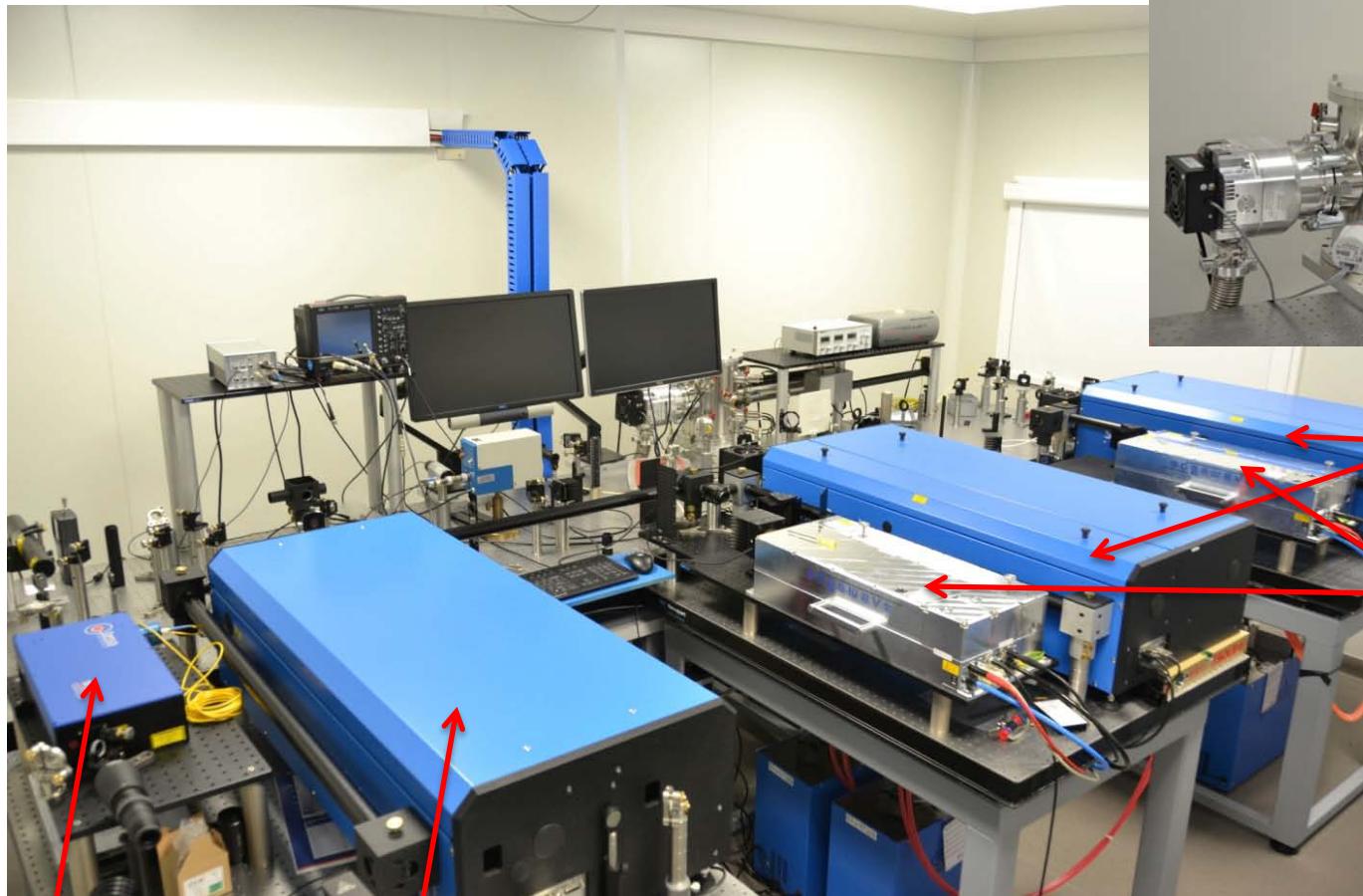
→ Sufficiently fast for Heavy elements(~ 100 ms)

Proven on-line with Ac in-gas-jet VS in-gas-cell experiment



# Laser laboratory : Operational

Atomic beam unit



CW  
diode laser

2-stage dye amplifier

Dye laser

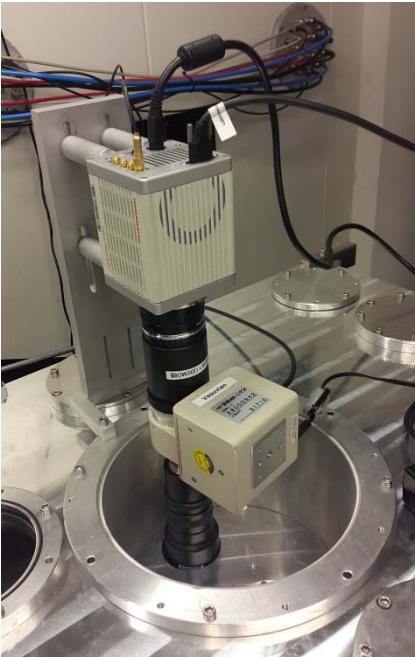
Pump  
laser



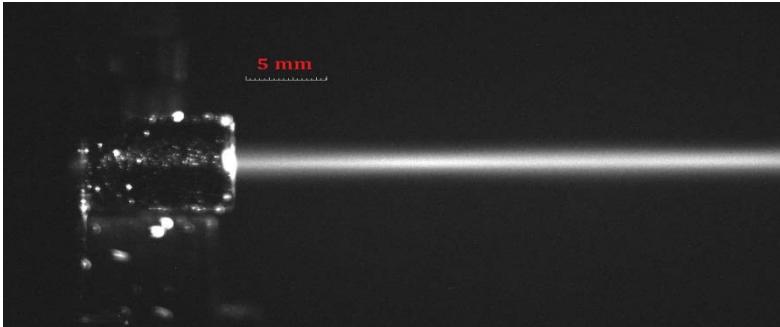
# Jet laboratory

(Talk by S.Zadvornaya)

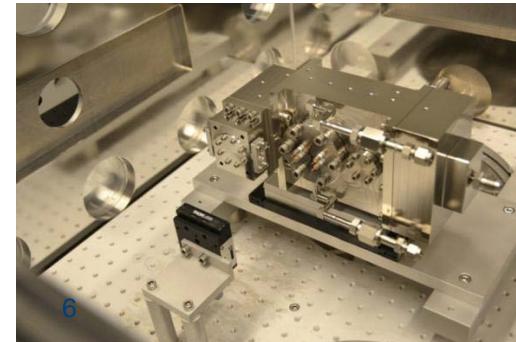
Camera  
and intensifier  
to record jet  
formation using  
PLIF technique



Laser-induced  
fluorescence in  
acetone Jet



Vacuum chamber holding gas cell & RFQ's



Gas cell

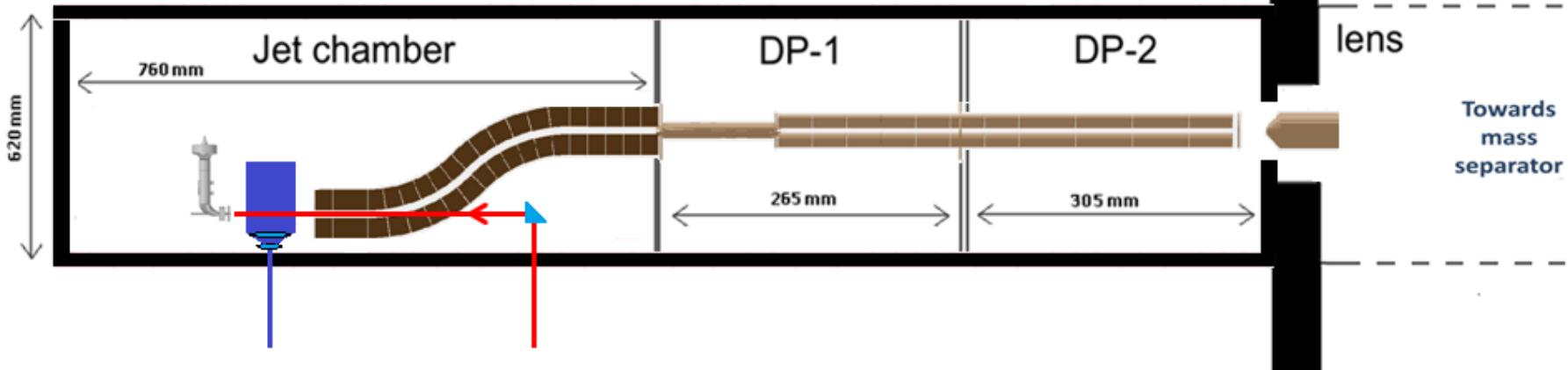


KU LEUVEN

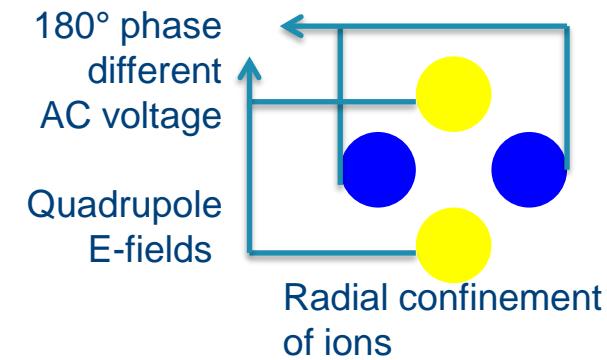


# Goals of the RFQ ion guides

- **Efficient capture** of ions from the gas jet
- **Guide ions** from high-pressure (~0.1 mbar) to low pressure (~ $10^{-6}$  mbar)



- **Maximize efficiency** of transport
- Suitable beam quality: **cooling / emittance**

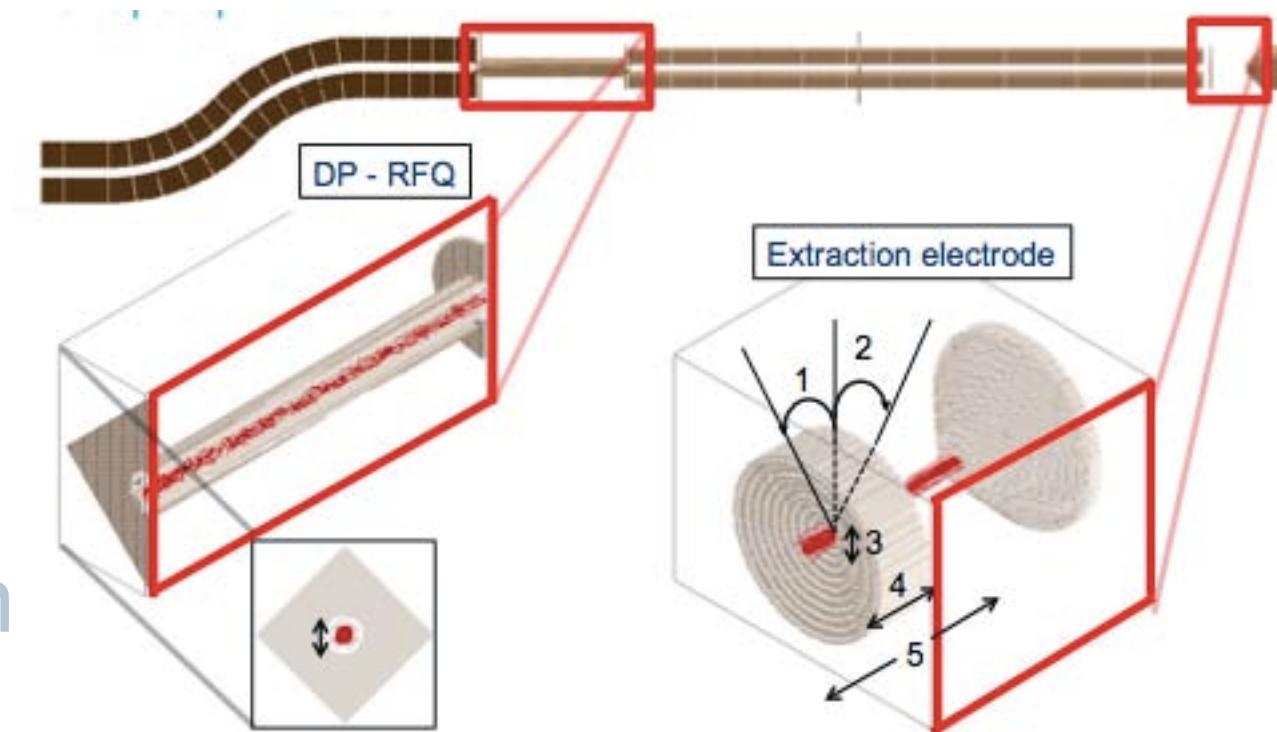


# RFQ - different stages

Design

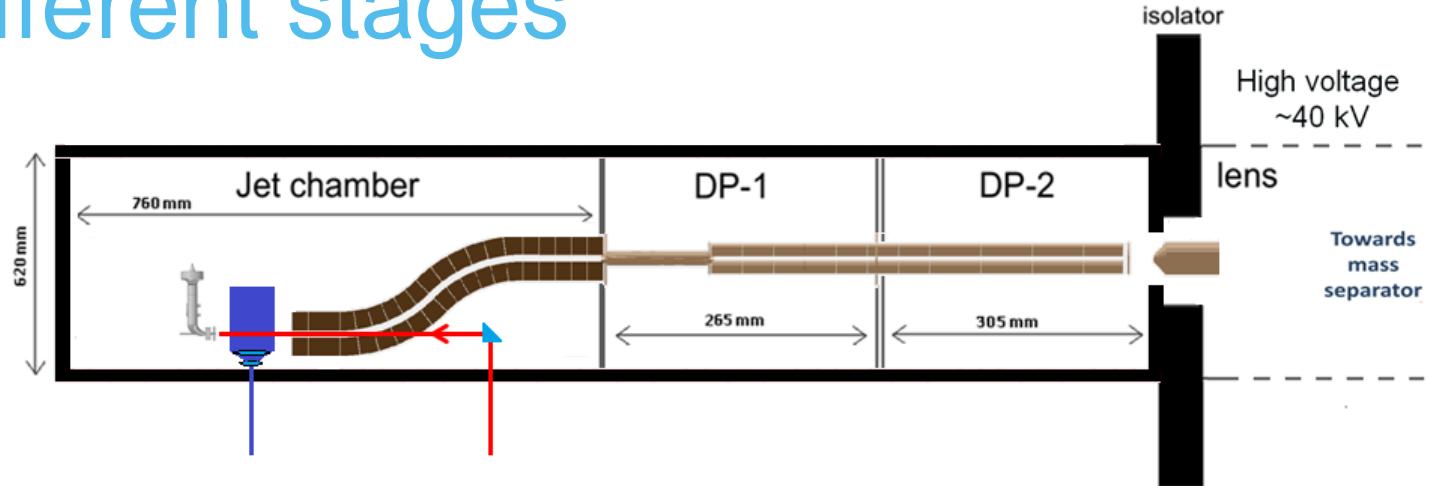
Simulation

Construction



# RFQ - different stages

## Design



Shape constraints

Vacuum constraints

Voltage constraints

Few examples...

- Several stages of differential pumping  
→ 3 different RFQ structures
- S-shape chosen for
  - Collinear (and direct) laser and jet overlap
  - Not directing gas jet through DP
  - allows for potential later upgrades

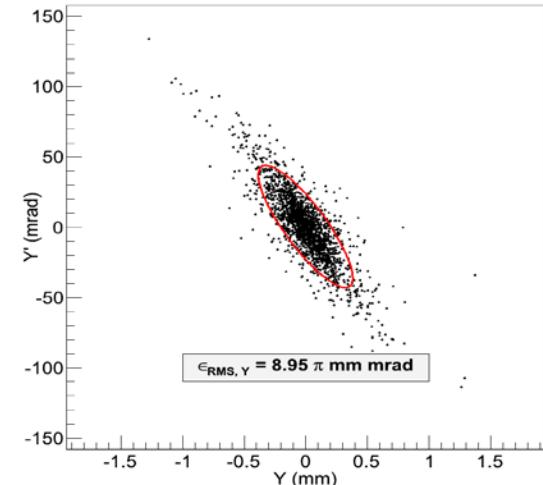
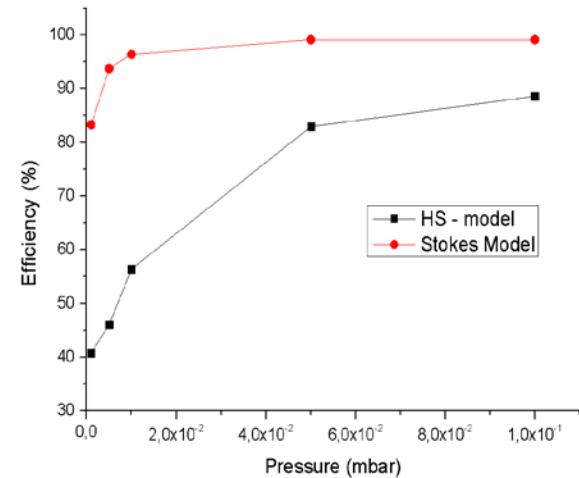
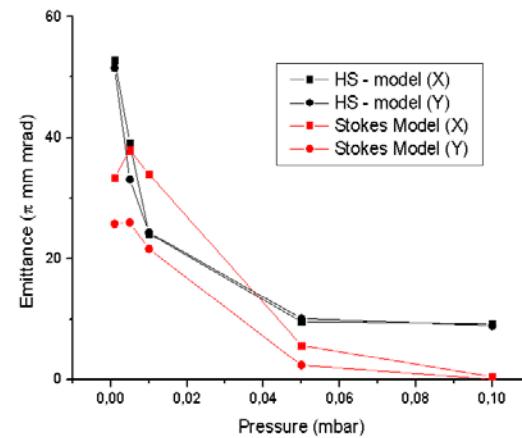


# RFQ - different stages

Design

Simulation

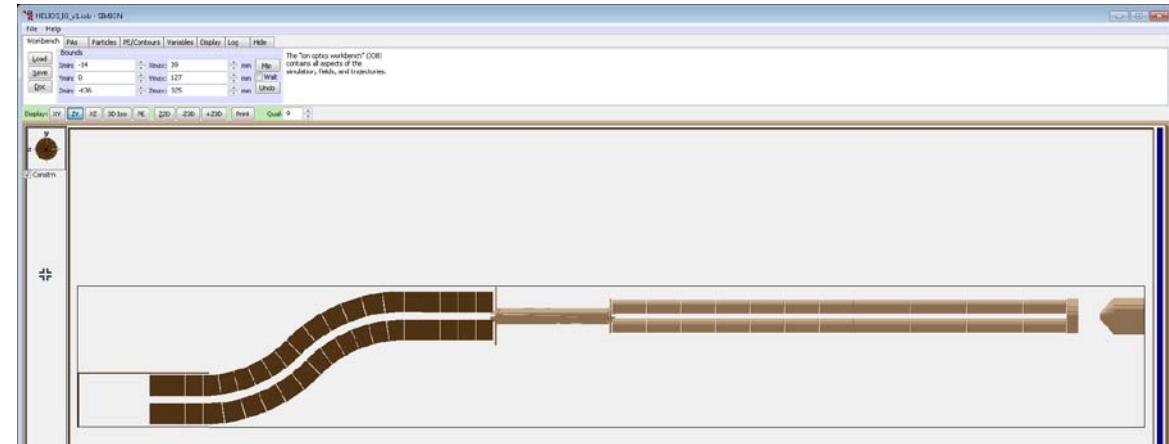
Construction



# RFQ - different stages

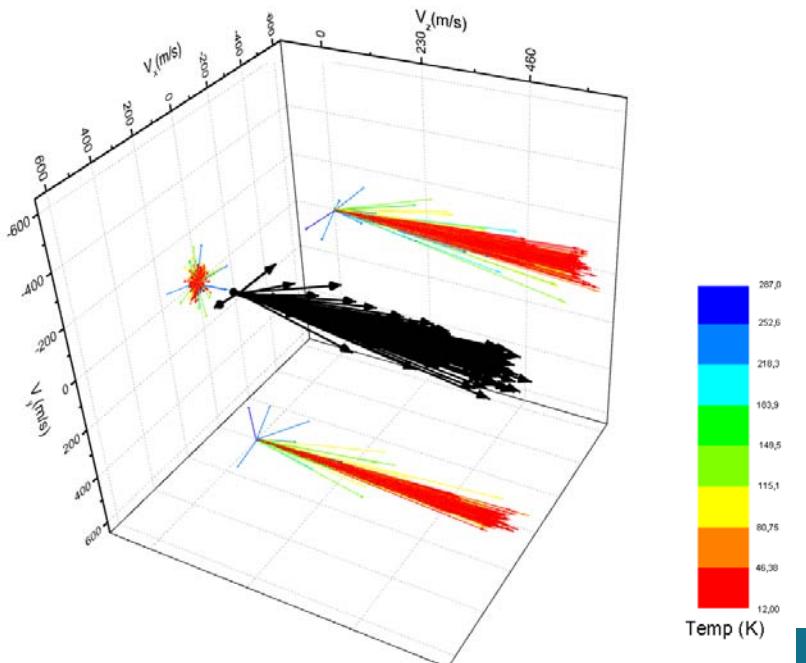
## Simulation

Simion® software:  
Calculation of  
E-fields and  
ion trajectories



Initial ion conditions  
provided by COMSOL  
CFD simulations of gas cell

- Velocities/angles
- Spatial distribution
- Temperature

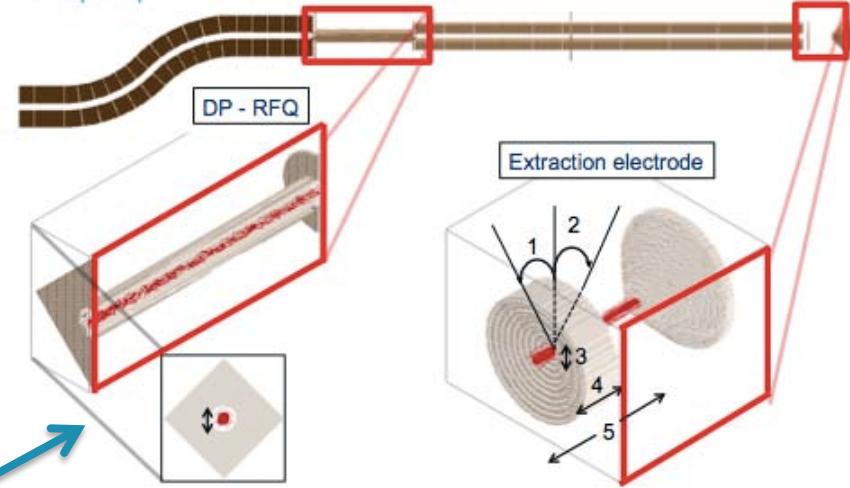


# RFQ - different stages

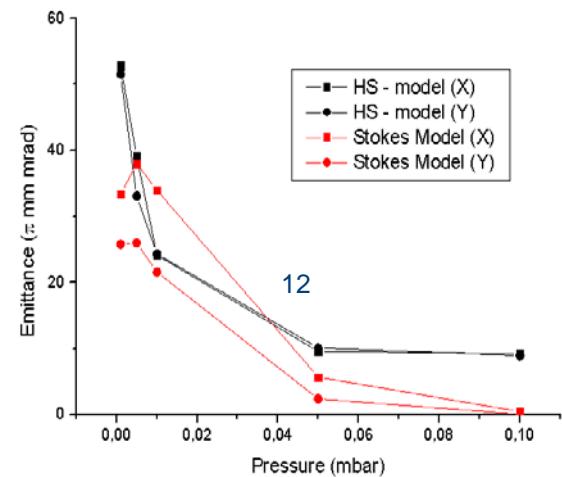
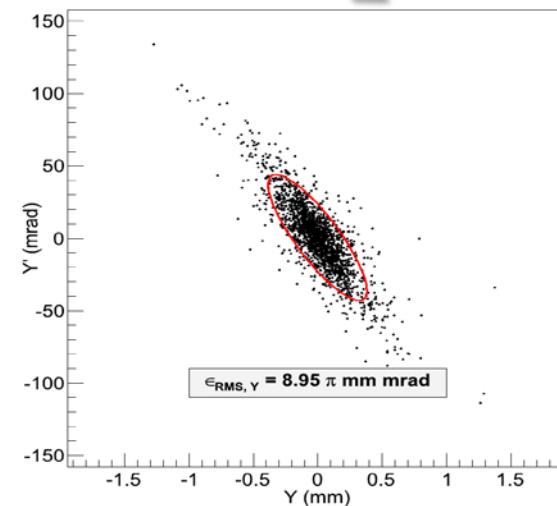
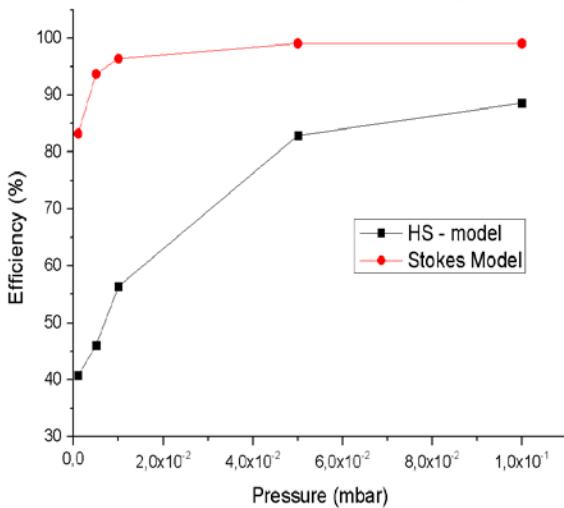
## Simulation

Few examples...

- Influence of electrode shapes and size
- Expected optimal Transport
- Expected emittance



Different pressure models  
Hard sphere  
Stokes viscous drag  
+ IONCOOL (soon)

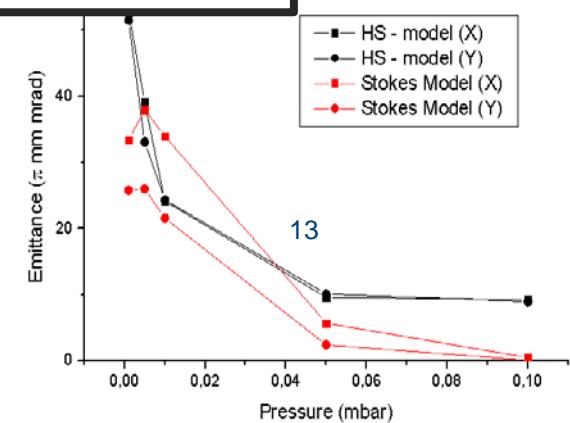
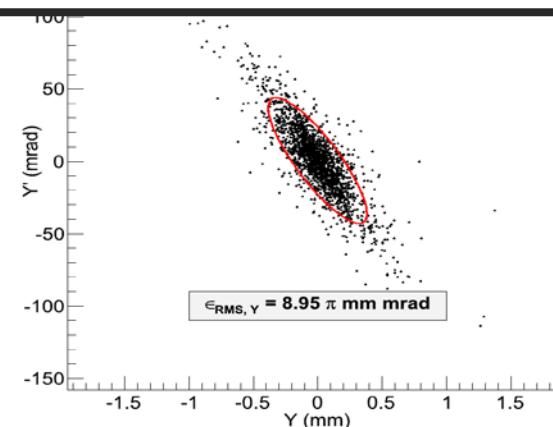
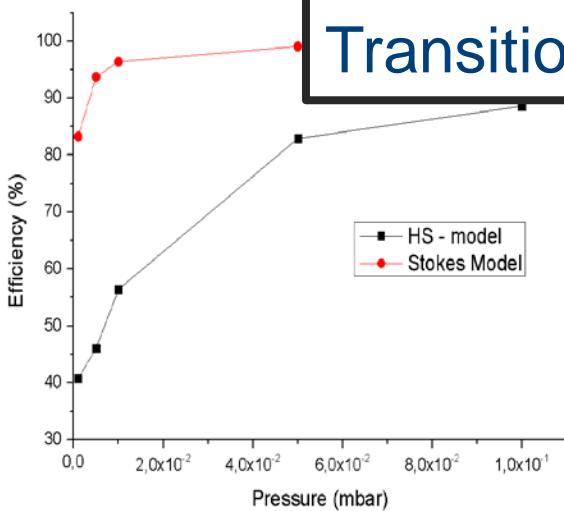
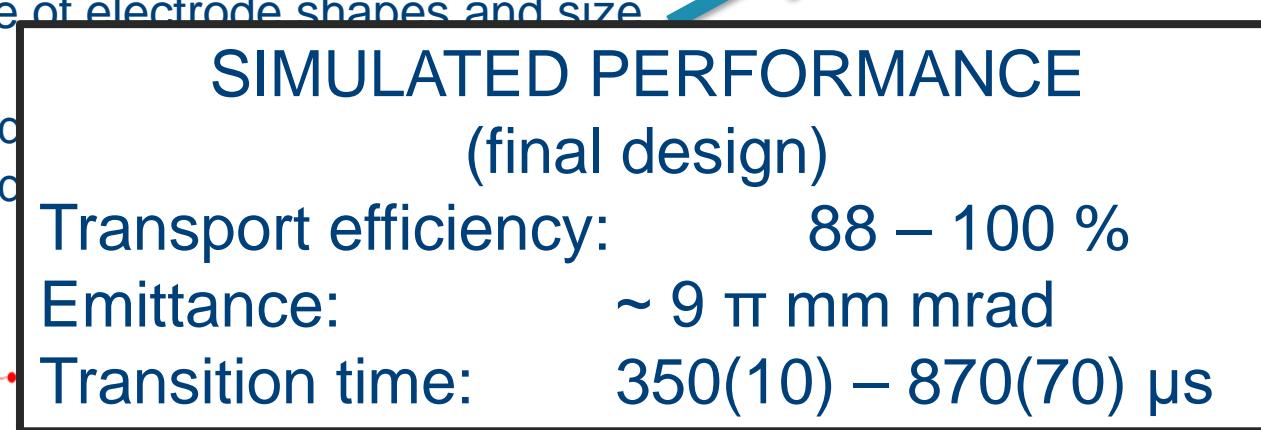
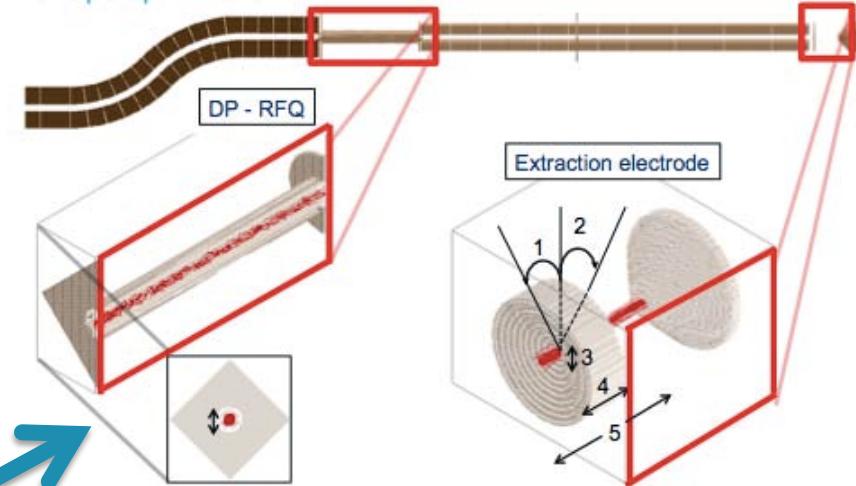


# RFQ - different stages

## Simulation (SIMION)

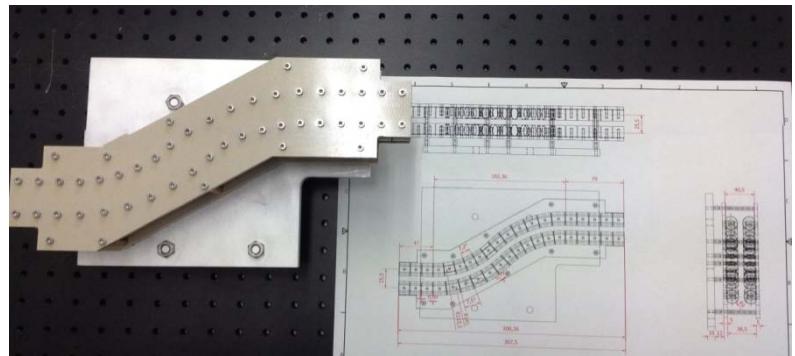
Few examples...

- Influence of electrode shapes and size
- Expected
- Expected

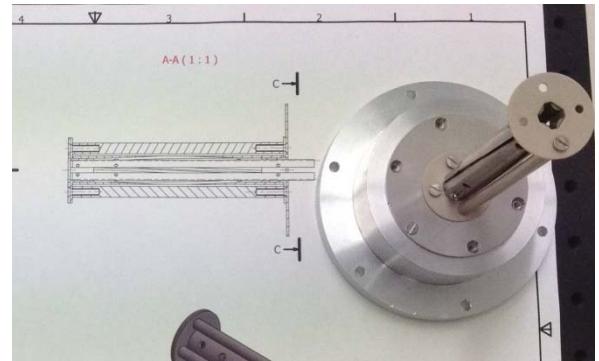


# RFQ - different stages

Design



Simulation



Construction

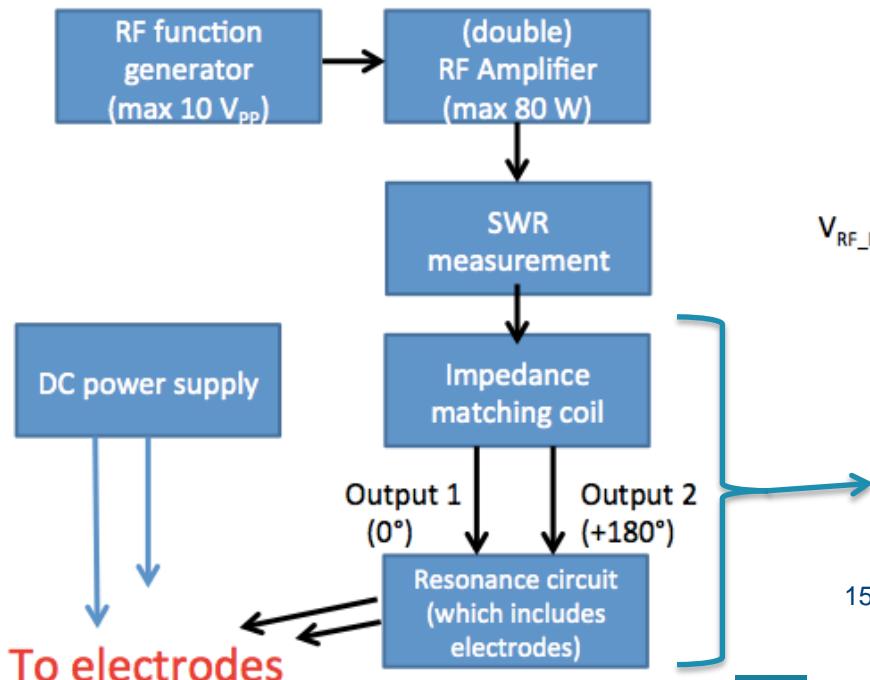


# RFQ - different stages

Mechanical

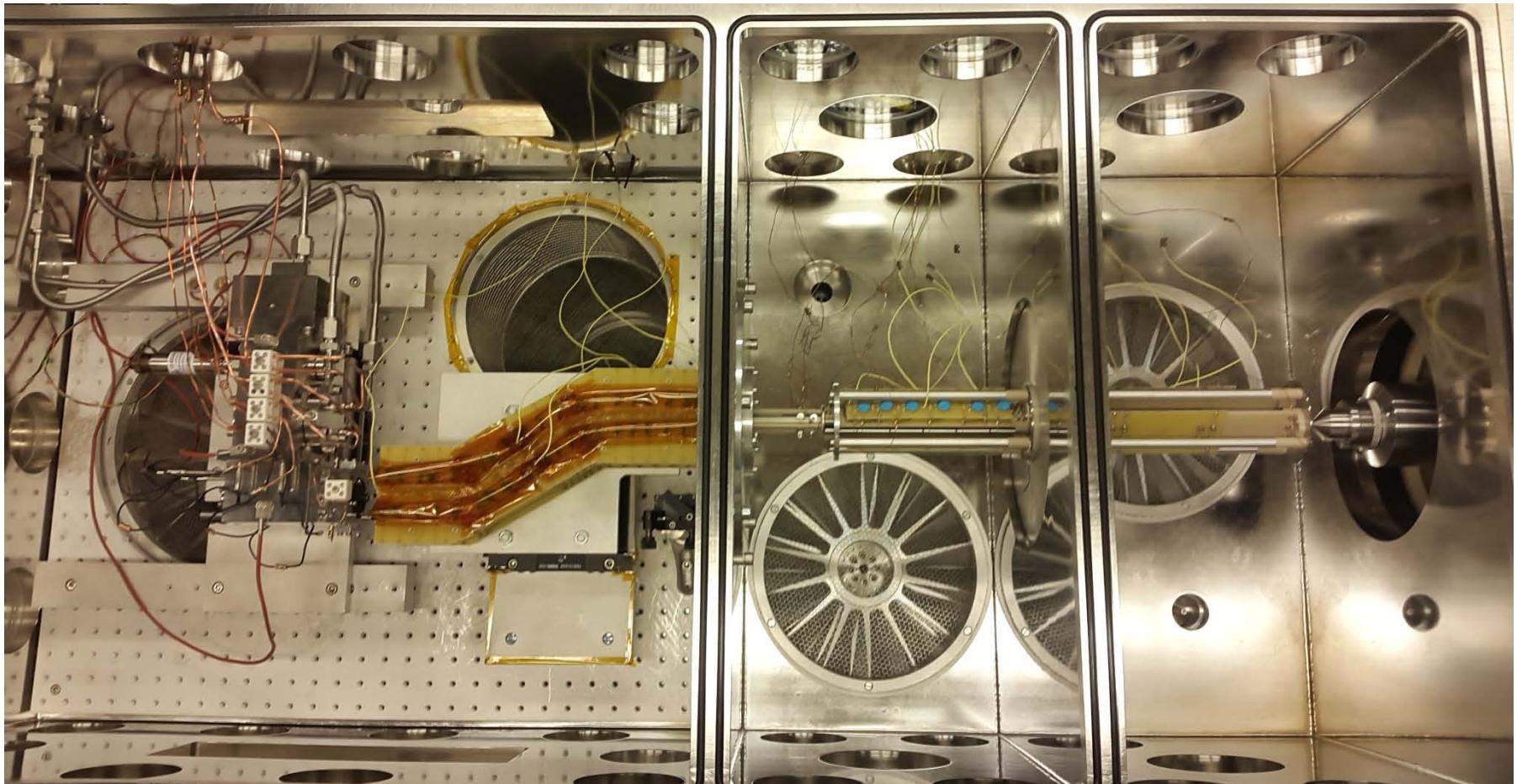
## Construction

Electronic



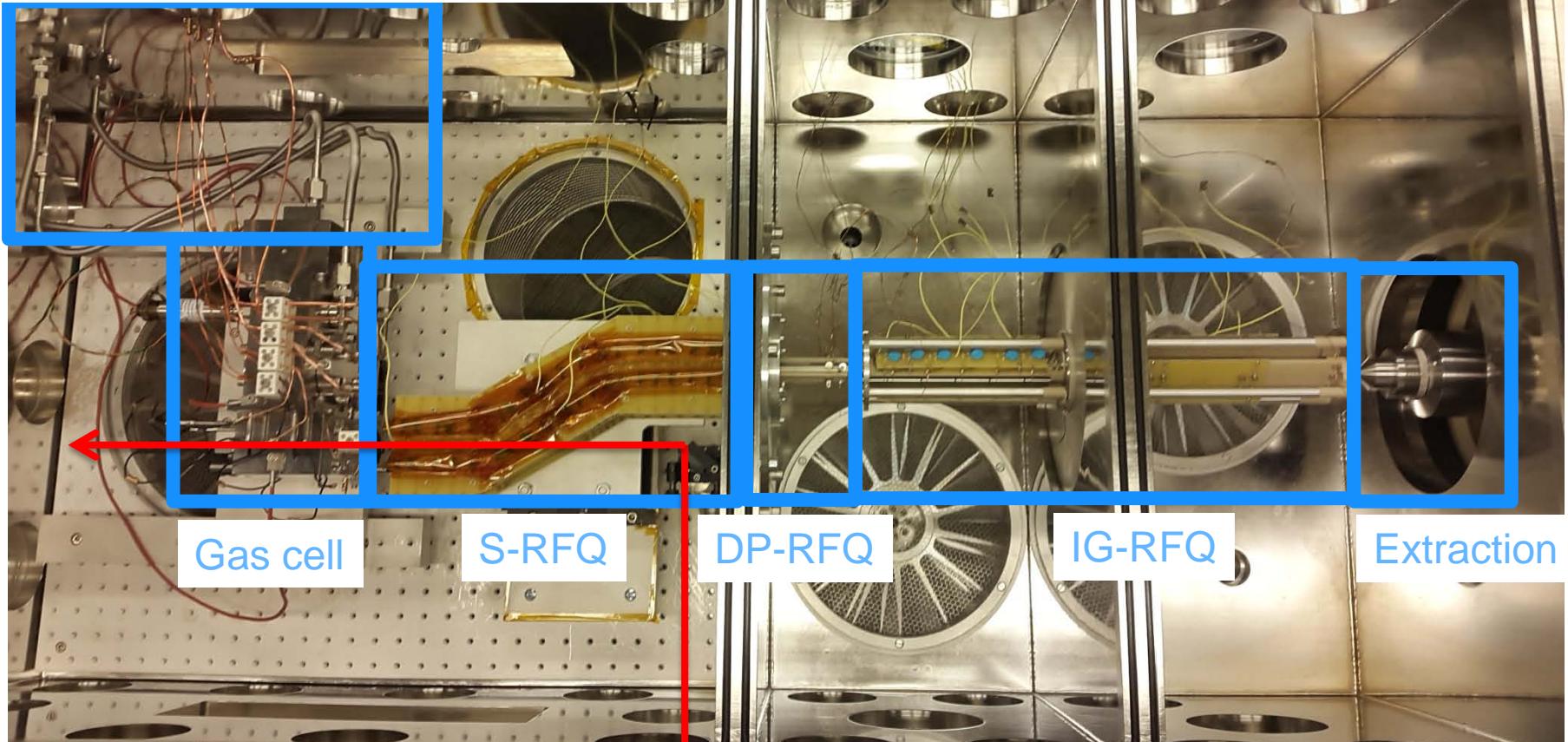
LEUVEN

# Current status – First tests



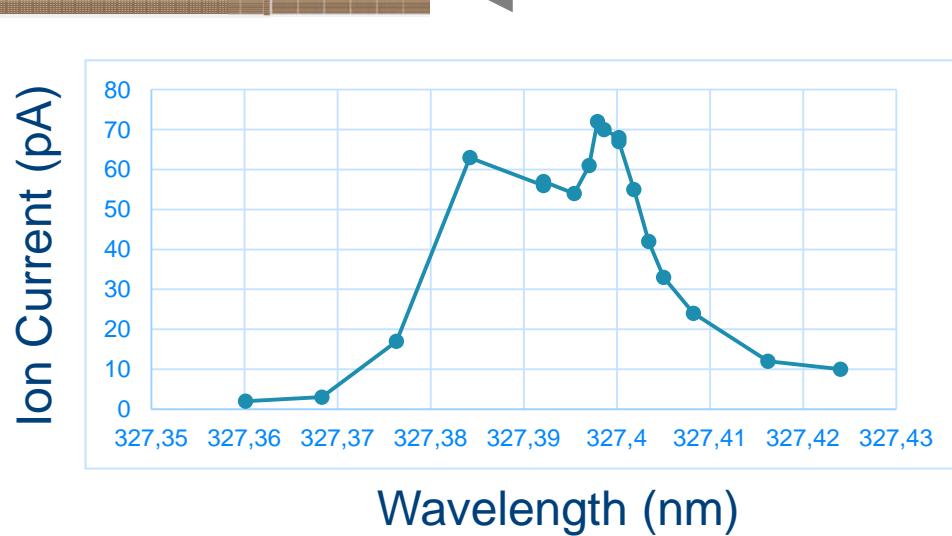
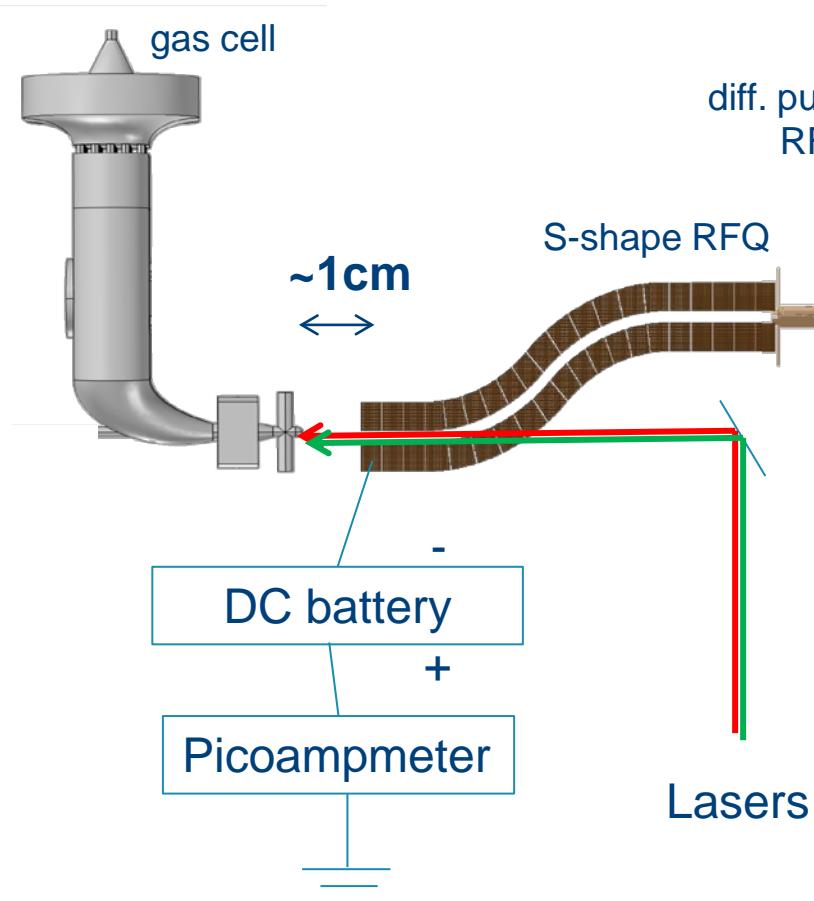
# Current status – First tests

Power cables, water cooling, gas flow



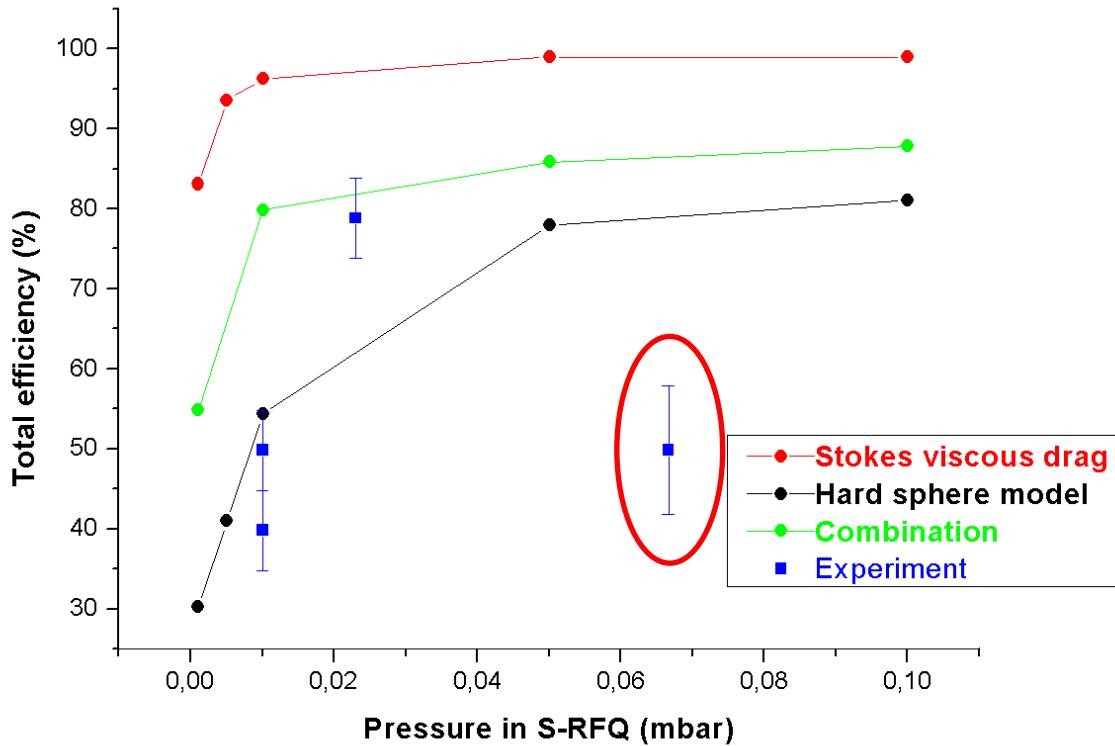
# First tests

Gas cell – S-RFQ in close configuration:



# First tests

## Transport vs. pressure



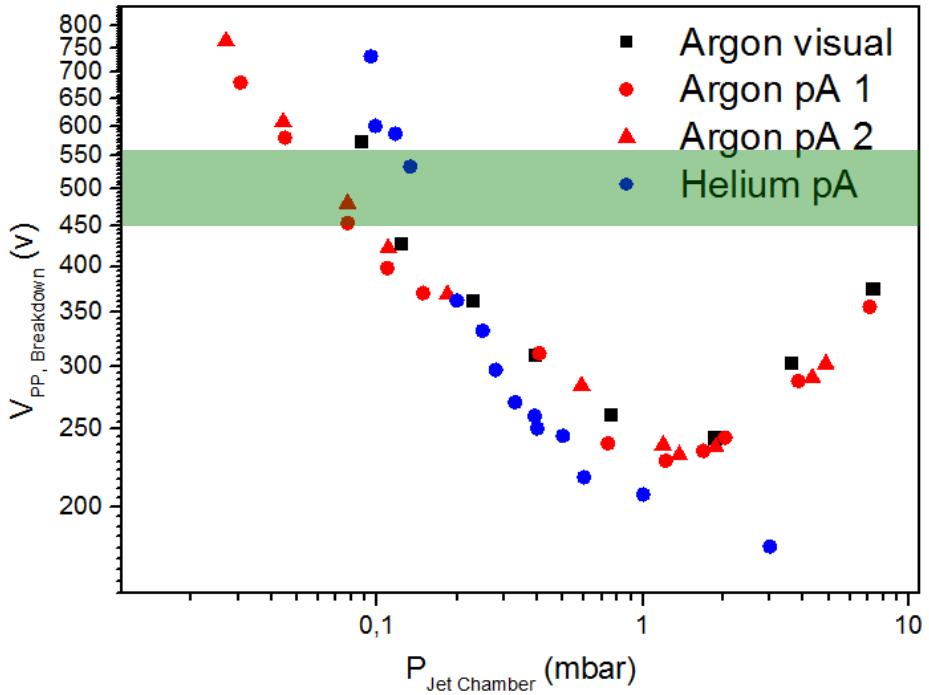
## Results of first tests

- Able to guide ions through full setup at first tests
- At low pressures: Agreement with SIMION
- Problem: efficiency drop at high pressure (Electrical Discharges)

## Issues during tests:

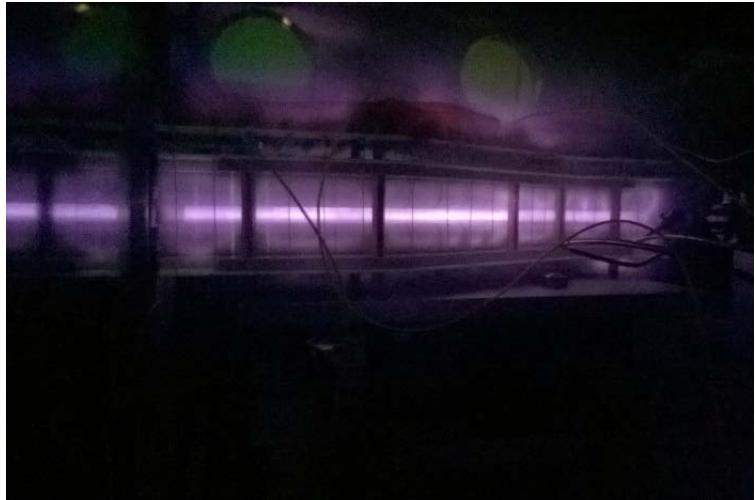
- Sparks (discharges at higher pressure)
- Reproducibility and stability of ion current (meter?)

# Sparking



Green band = optimal Cu guiding voltage according to Simion

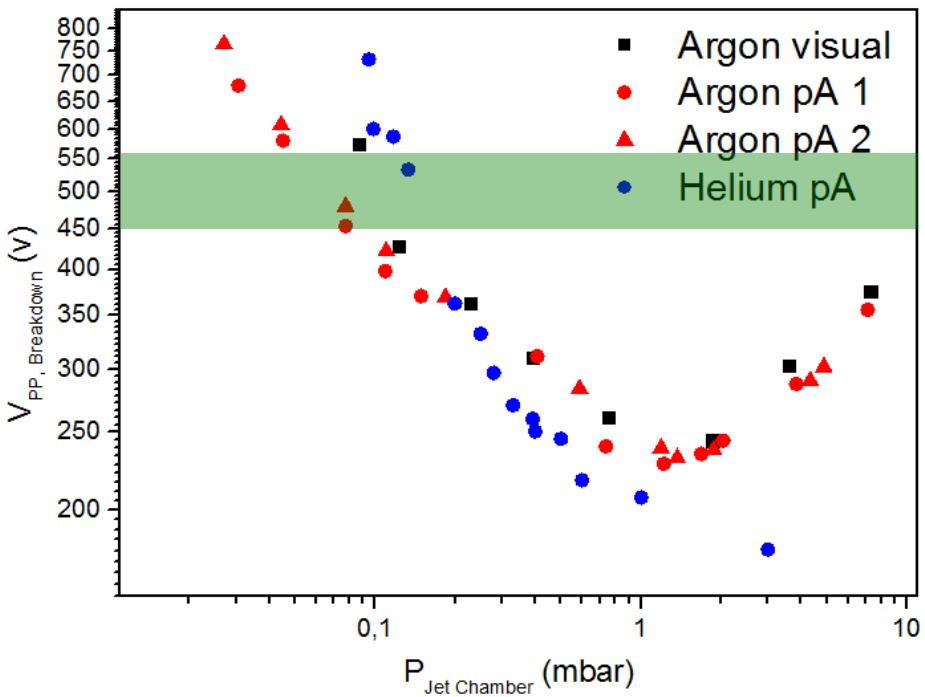
20



# Sparking

## Tried :

- Shielding all close-by possible grounding points
  - Covering bare electronics on top (close to camera-cover lit)
  - Removing metal spacers and replacing with peak posts
- Not solved by these precautions



Green band = optimal Cu guiding voltage according to Simion

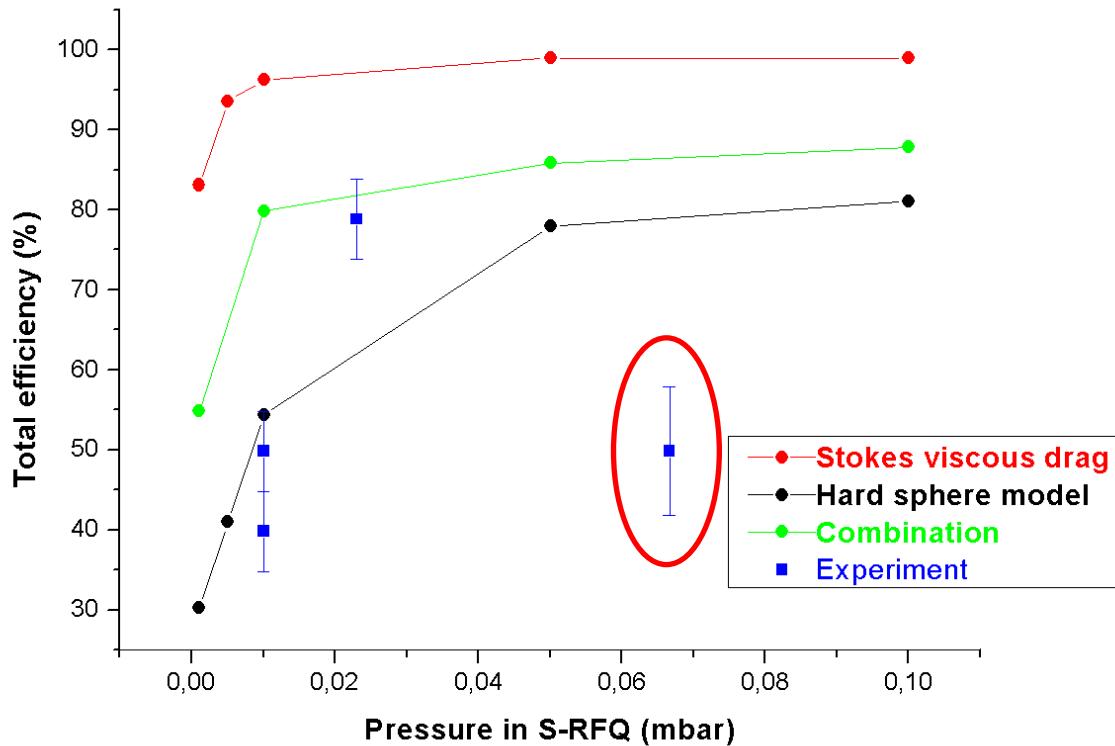
## Possible solutions

Reduce RF frequency and maximize transport with voltages < 200 V<sub>pp</sub>

Remove ion guides from high-pressure environment

Last resort:  
Redesign S-RFQ ion guide

# First tests - checklist



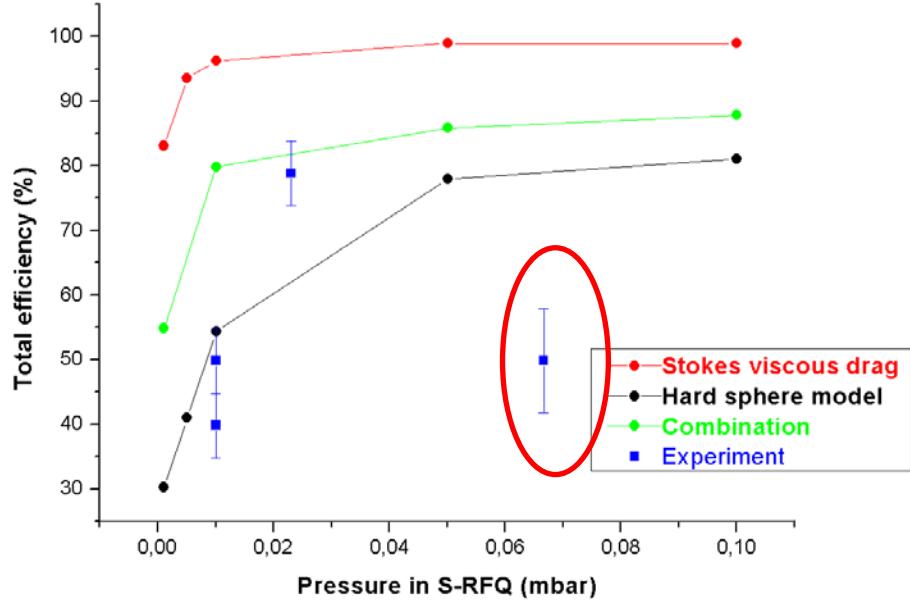
**Checklist :**

**Improve diagnostics stability**

**Check setup:  
alignment, electronics,  
transition between  
RFQ's...**

**Verify measurements**

# First tests - checklist



## Checklist :

### Improve diagnostics stability

- Picoampmeter ✓
- Camera for filament stability (color calibration) ✓

### Check setup:

alignment, electronics..

- Alignment tools + HeNe laser ✓
- 1 MHz electronics checked ✓
- 500 kHz electronics (ongoing)
- Transition between RFQ's adapted ✓

### Verify measurements (currently)

# Conclusion

## RFQ status

- Ion guides installed and first tests ongoing
- First tests show ion guiding with 80%
- Working on current sparking and transport issues

## RFQ future plans

- Install 500 kHz electronics to avoid sparking  
(Backup plans as well if needed)
- Perform full characterization of ion guides
- Beam quality verification
- Resonance ionization spectroscopy in gas jet
- Ionization vs Fluorescence spectroscopy

# Thank you for your attention

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