Kernfysisch Versneller Instituut

university of groningen

Status of the (Super-)FRS cryogenic stopping cell

S411

Peter Dendooven

KVI – University of Groningen

FRS User Meeting - GSI, Darmstadt
8-9 November 2010

Collaboration

Spokesperson:	**P. Dendooven**	**KVI – U Groningen**
Co-spokesperson:	**W.R. Plaß**	**GSI, U Gießen**
GSI contact person:	**S. Purushothaman**	**GSI**
	T. Dickel	**U Gießen**
	H. Geissel	**GSI, U Gießen**
	I.D. Moore	**U Jyväskylä**
	H. Penttilä	**U Jyväskylä**
	M. Ranjan	**KVI – U Groningen**
	D. Schäfer	**U Gießen**
	C. Scheidenberger	**GSI, U Gießen**
	P. Thirolf	**LMU München**
	H. Weick	**GSI, U Gießen**

Kernfysisch Versneller Instituut

university of groningen

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

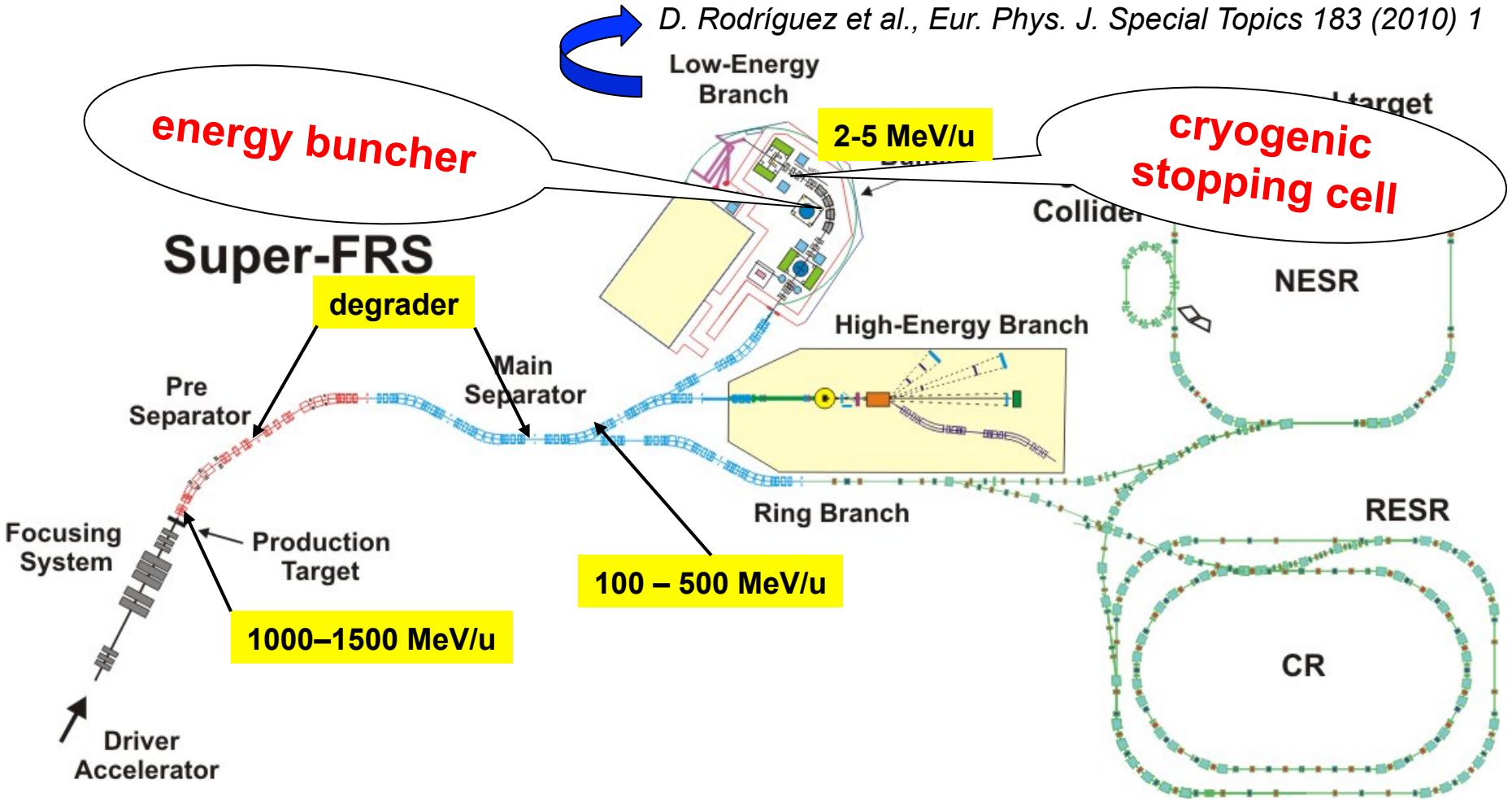
GSI

UNIVERSITY OF JYVÄSKYLÄ

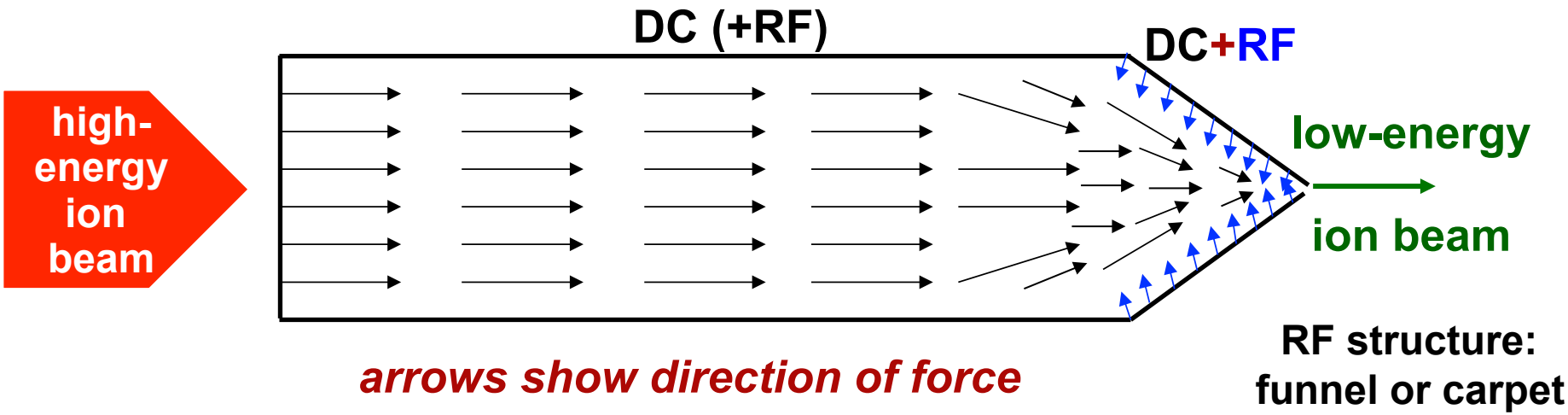
LMU

The Super-FRS Low-Energy Branch

cryogenic stopping cell is part of the ion catcher apparatus transforming the Super-FRS ions into a low-energy ion beam



Stopping cell principles



- high-energy ions stopped in noble gas
- stopped ions transported using DC and RF fields to exit-hole
- extraction by gas flow

Stopping cell requirements

- **from simulations of Super-FRS**
  (Helmut Weick, Chiara Nosiforo)

range: up to 20 mg/cm^2 He
(~1 meter bar at room temperature)

lateral size: 25 x 10 cm^2

ionisation rate density: up to 10^{11} /cm^3 /s for selected beams
(no worry at the moment)

- **need to be efficient** (low production rates)
- **need to be fast** (short half-lives)

S258 vs. S411 (present experiment)

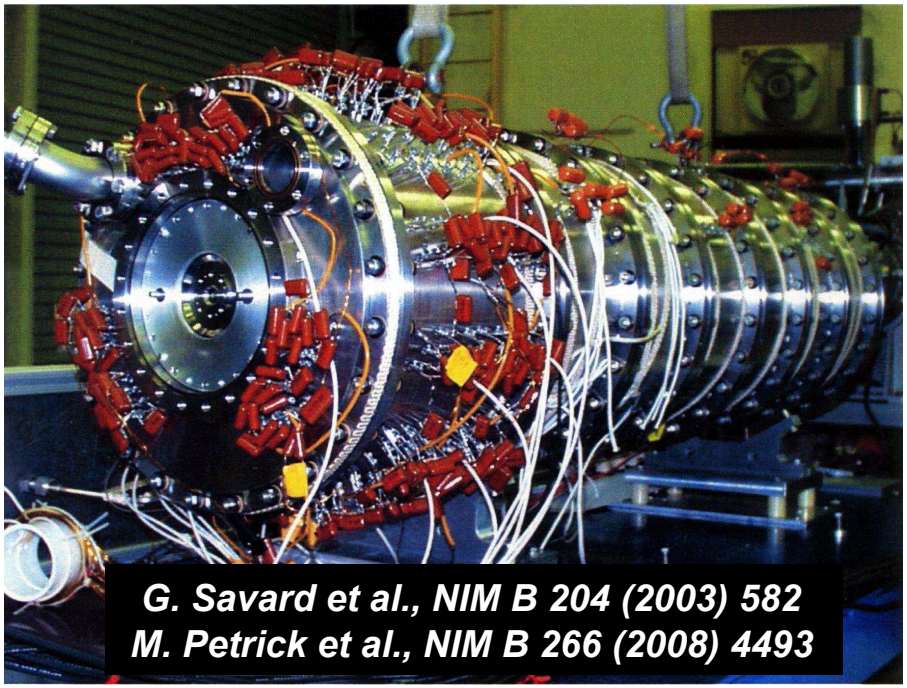
successful proof-of-principle

suffered from:

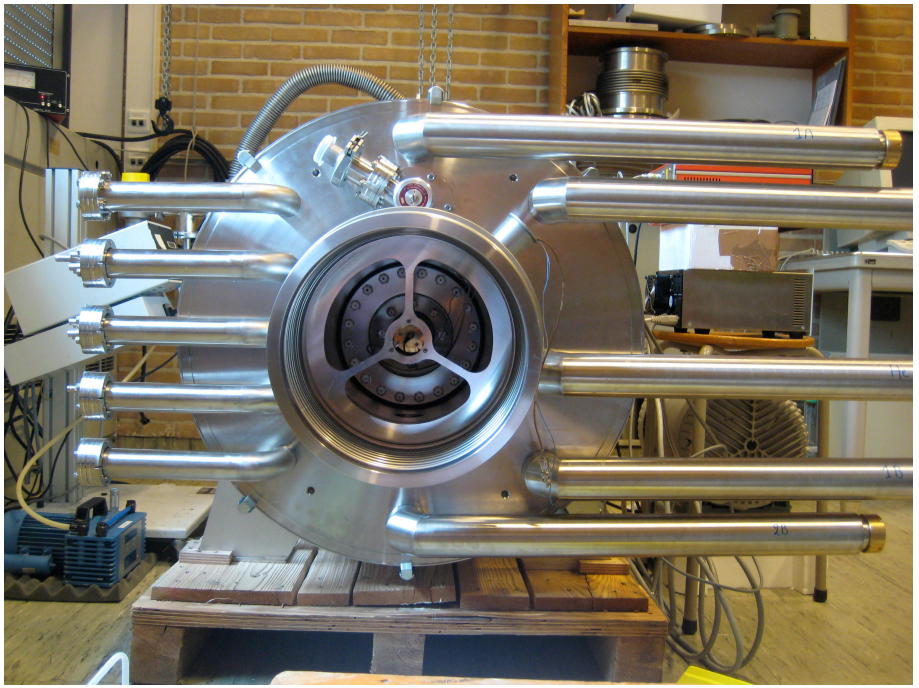
1. **poor stopping efficiency**
2. **presence of impurities**

solutions now implemented:

1. **high-density operation**
2. **cryogenic operation**



G. Savard et al., NIM B 204 (2003) 582
M. Petrick et al., NIM B 266 (2008) 4493



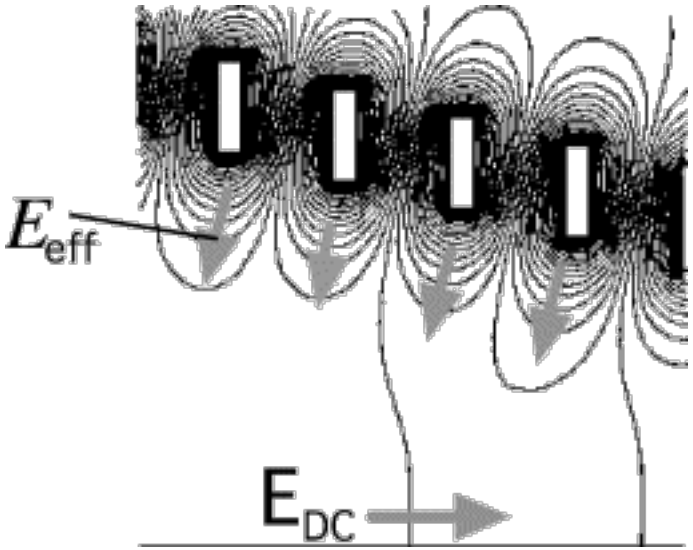
High density is challenging

we aim to extend the operating density of these devices

$$\vec{v} = \mu \vec{E}_{DC} \qquad \overline{F}_{avg} = m\mu^2 \frac{V_{rf}^2}{r_o^3}$$

$$\mu = \mu_o \frac{1}{\rho}$$

$$\vec{v} \propto \frac{1}{\rho} \qquad \overline{F}_{avg} \propto \frac{1}{\rho^2}$$



for high-density operation:

- **large E_{DC}**
- **small r_0, large V_{rf}**

ρ : gas density
μ : ion mobility
r_0 : ½ RF electrode spacing
V_{rf} : RF amplitude (p-p)
m : ion mass

Why cryogenic ?

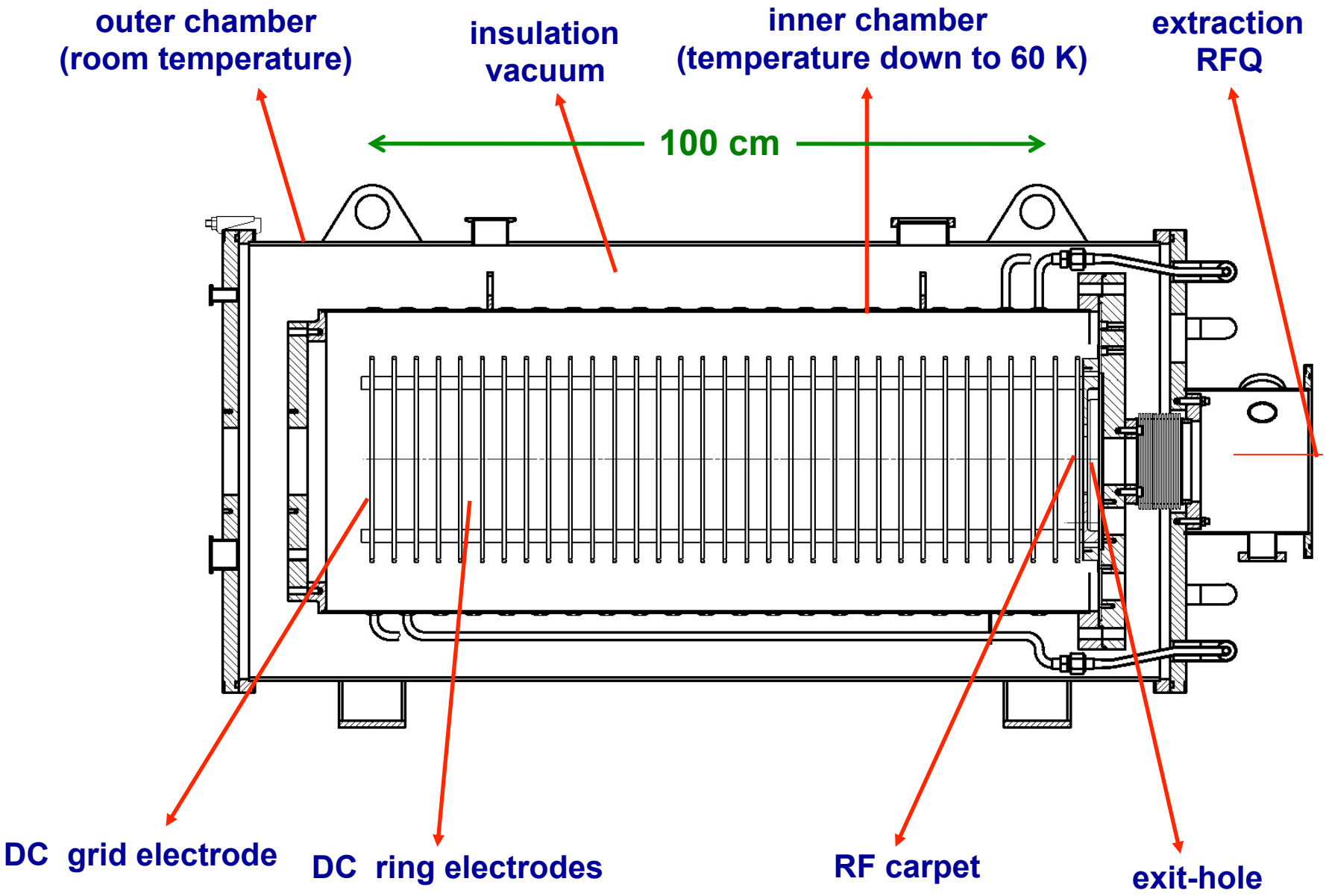
- **Ultra-pure helium: ideal for ion survival**
  P. Dendooven et al., NIM A 558 (2006) 580

- **Possible survival as 2+ ions**
  faster extraction

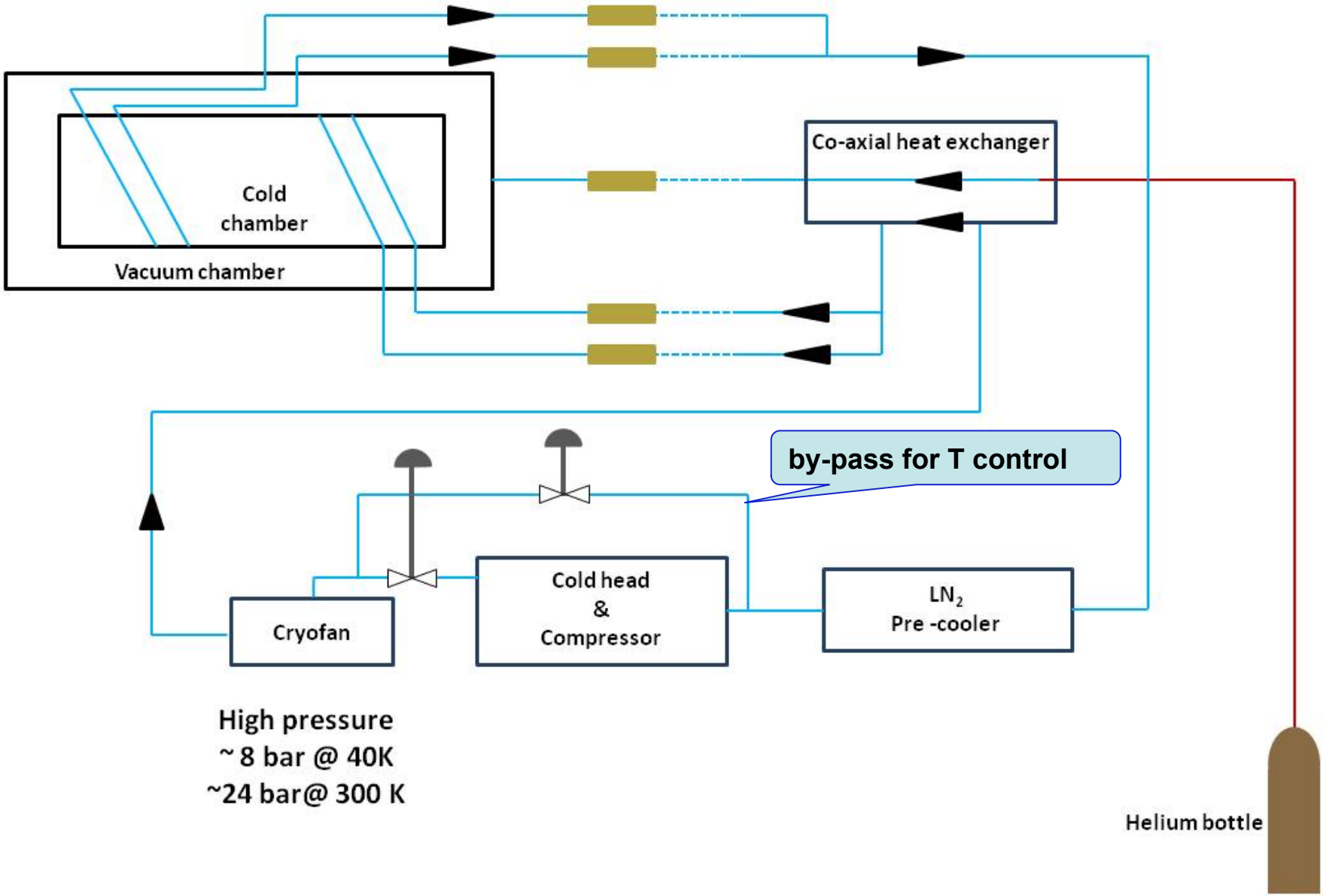
- **Ultra-high vacuum standard not required**
  easier, more flexible construction

- **Operational reliability !**

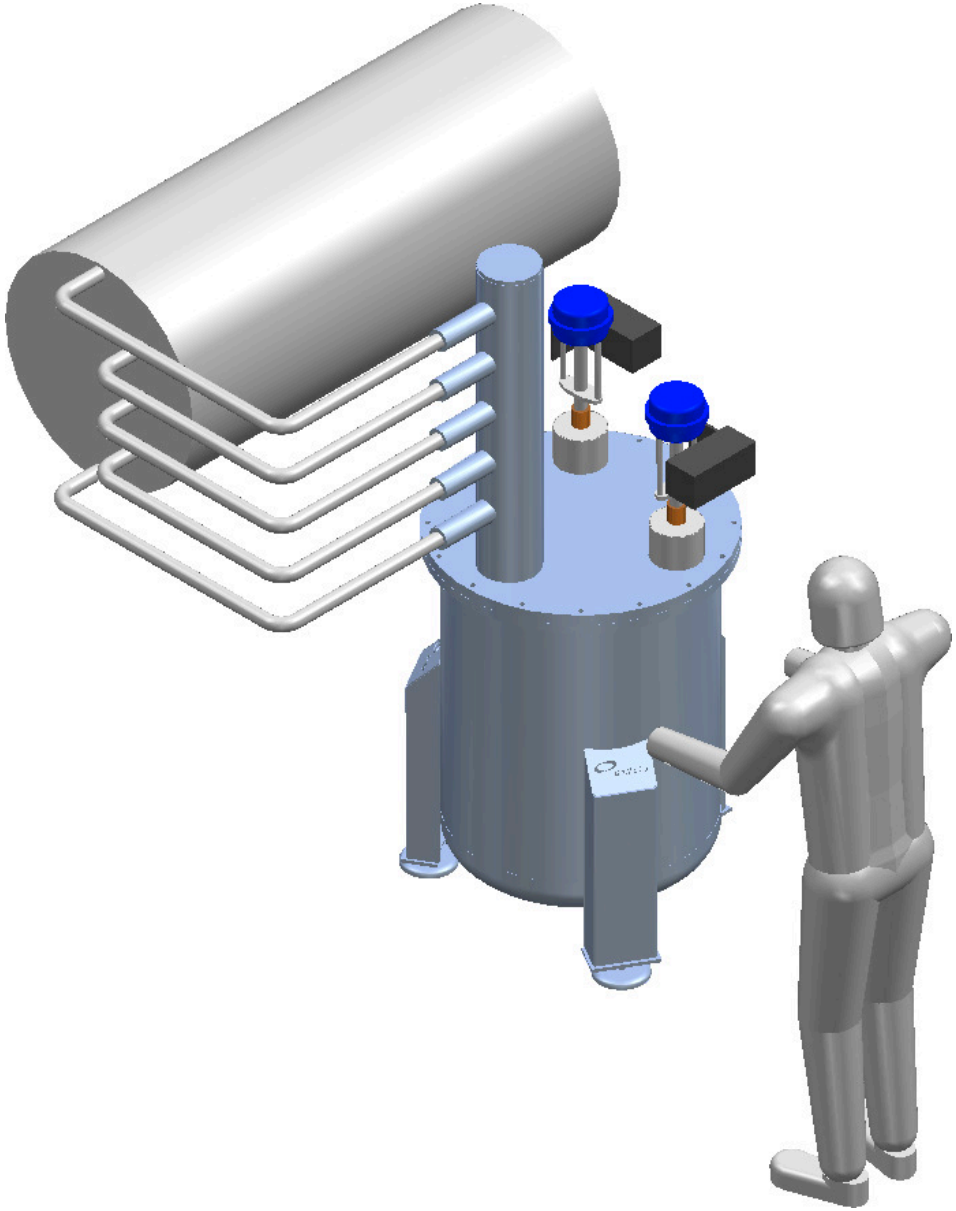
Cryogenic stopping cell design



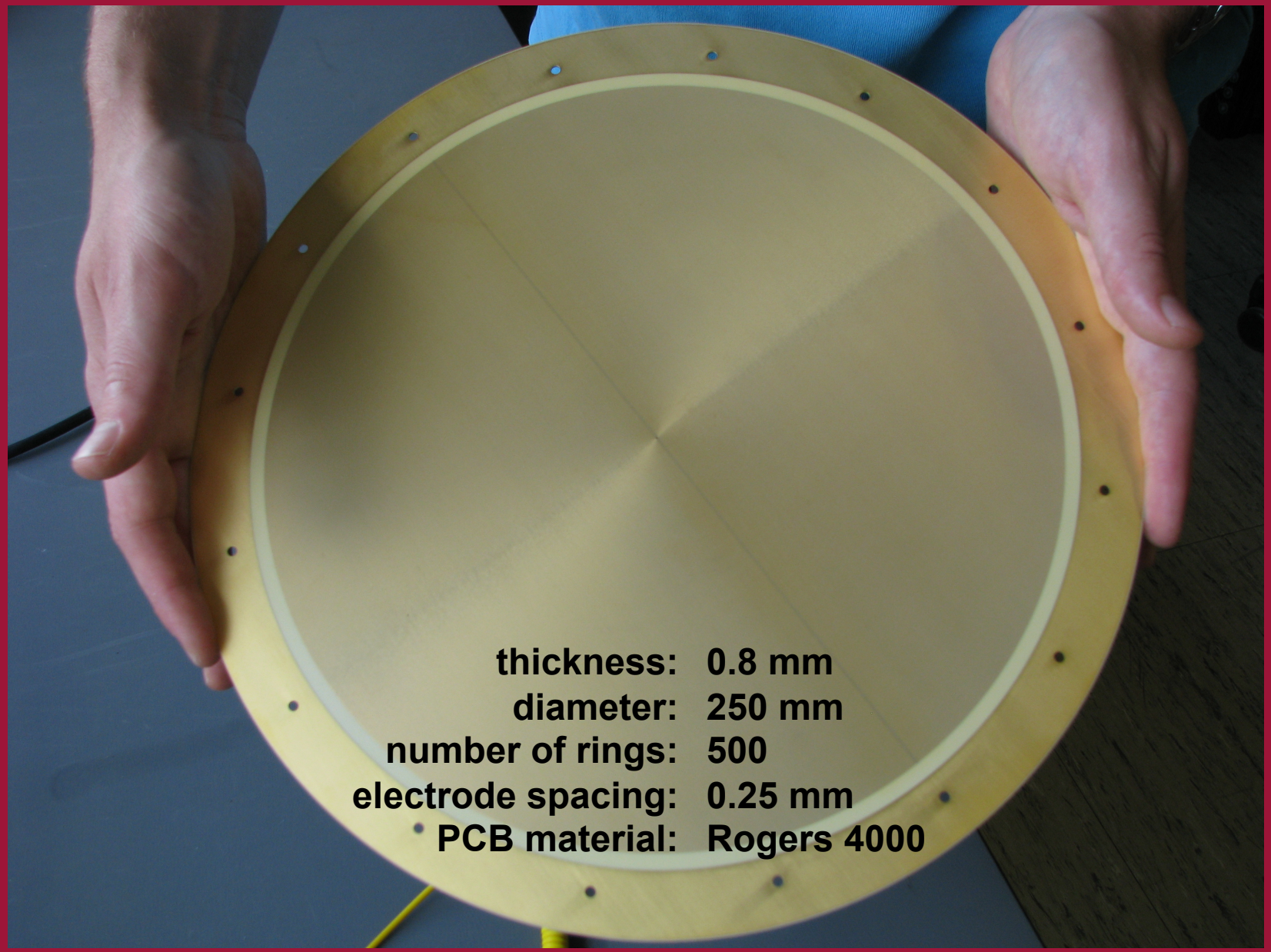
Cooling system schematic



Stopping cell + cooling system

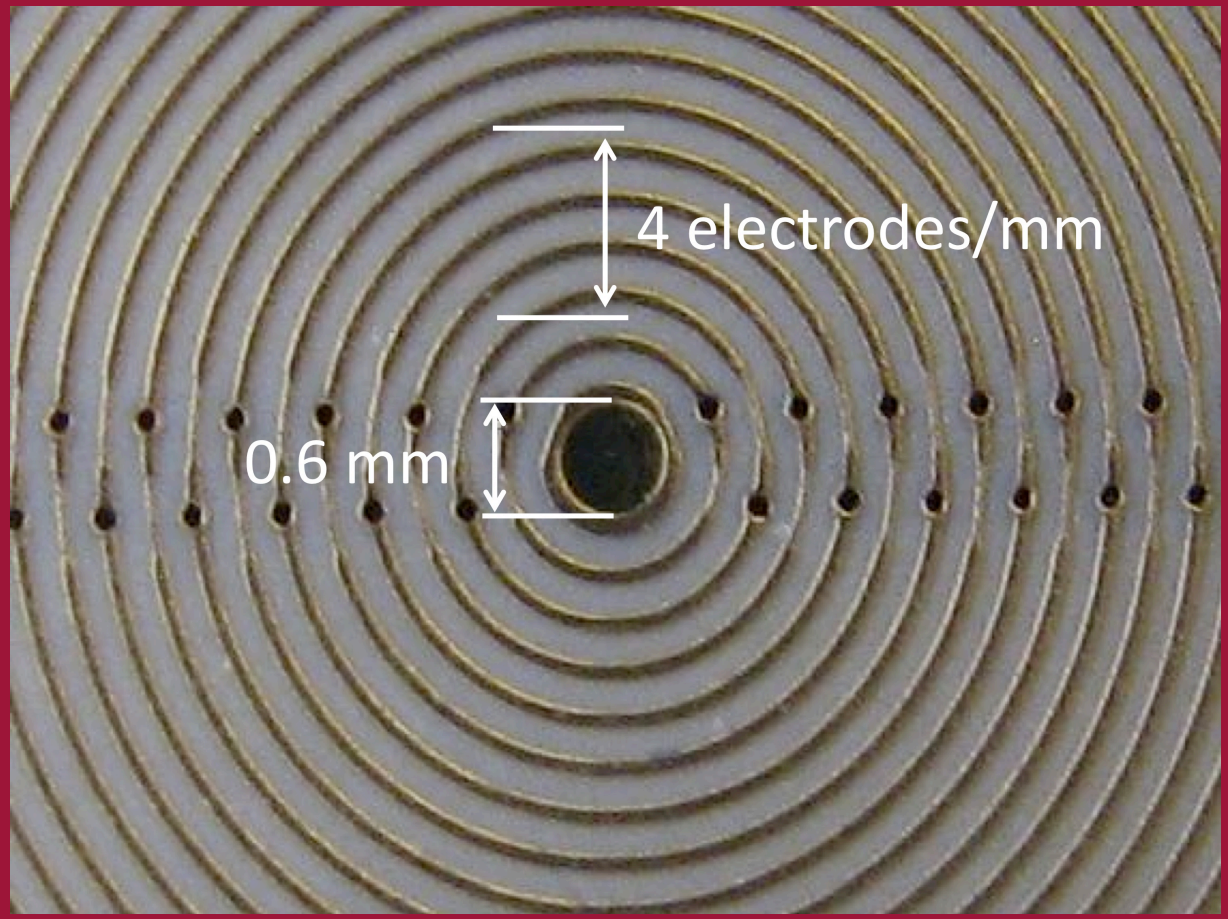


The RF carpet

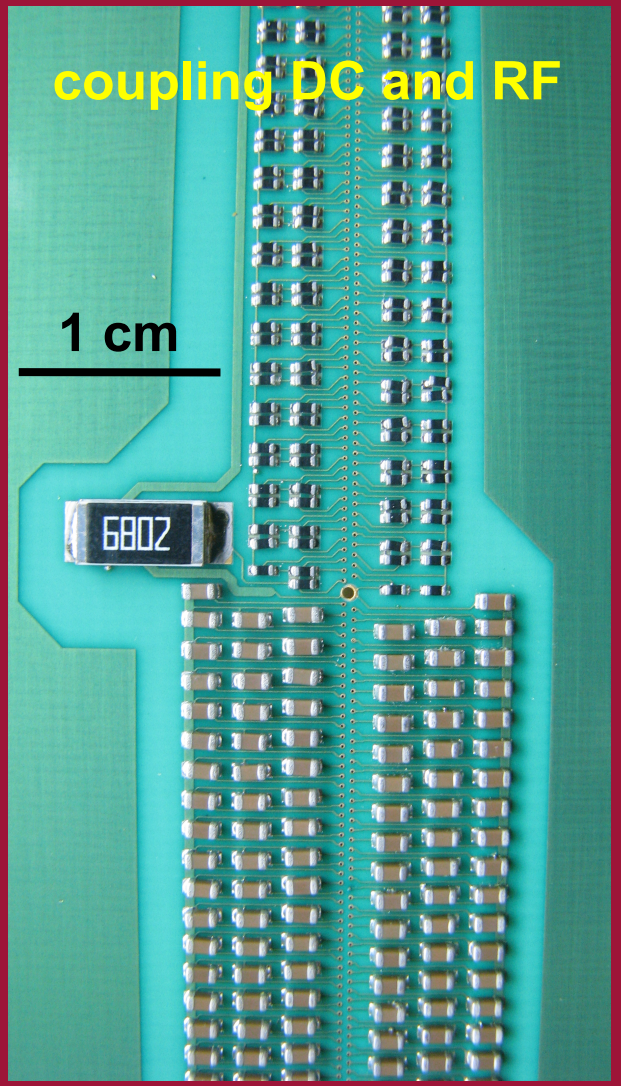


The RF carpet close-up

front side

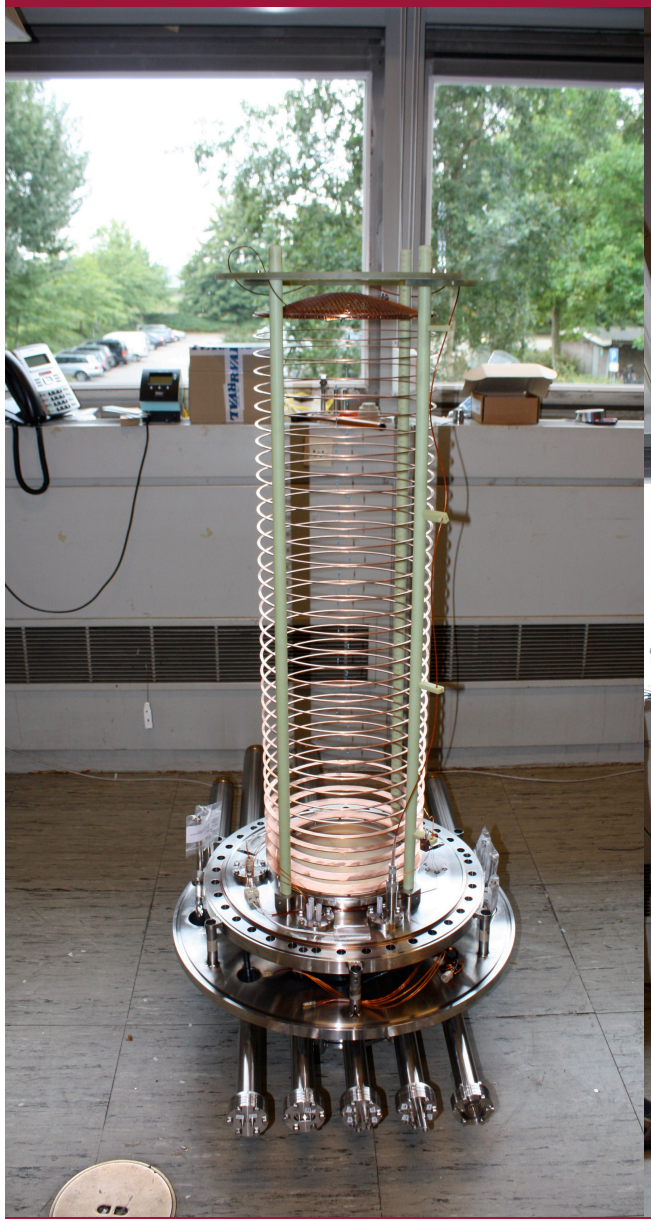


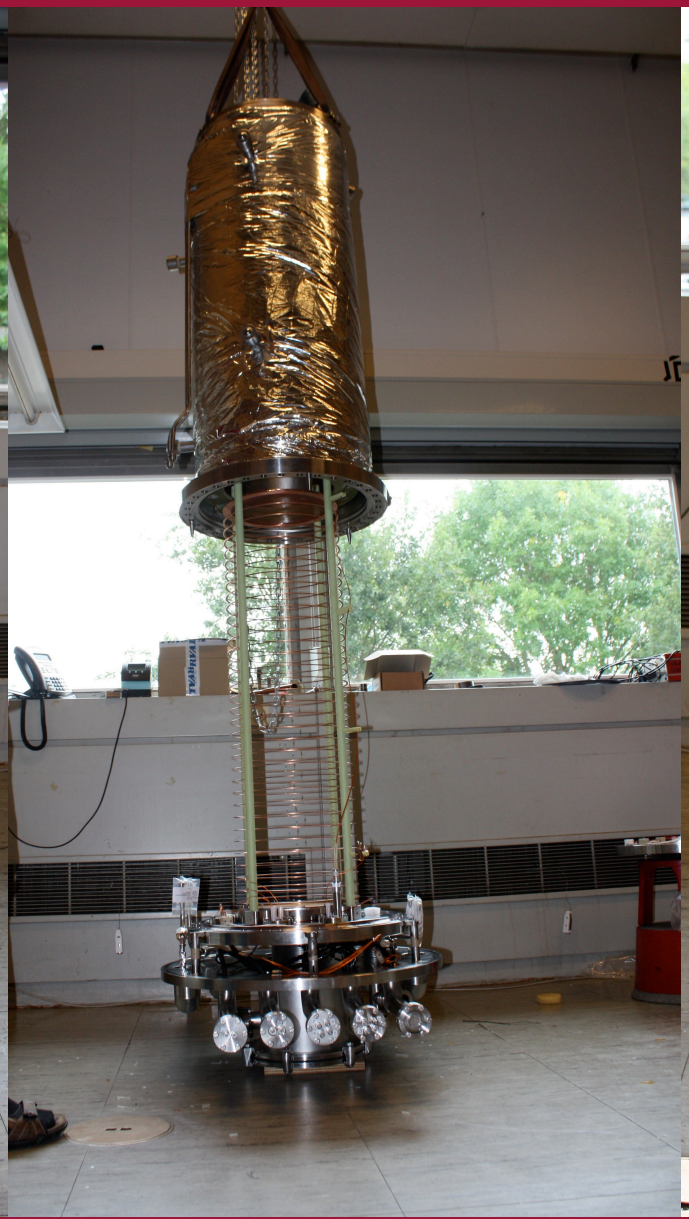
back side



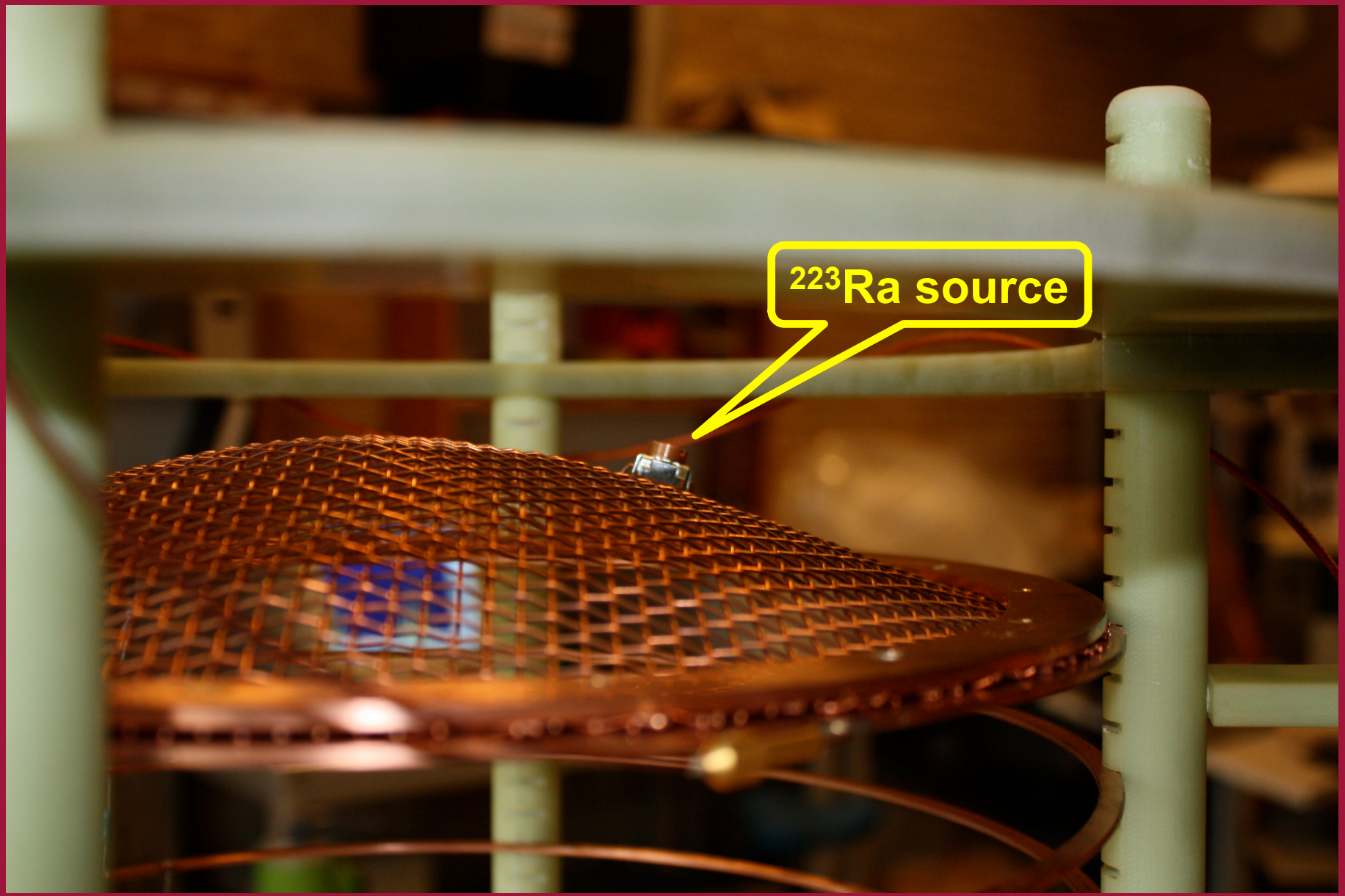
Off-line assembly

Assembly

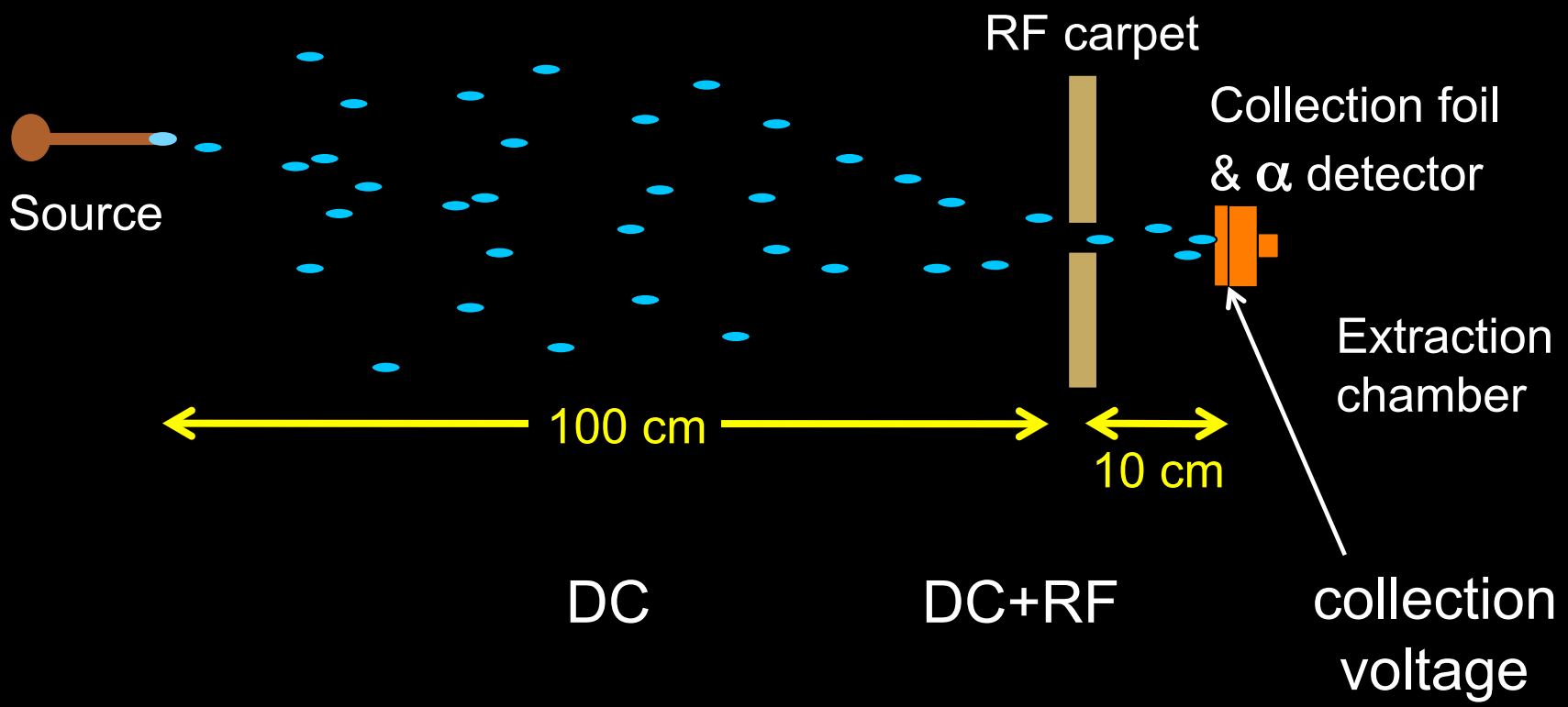




Off-line ions: alpha decay recoils

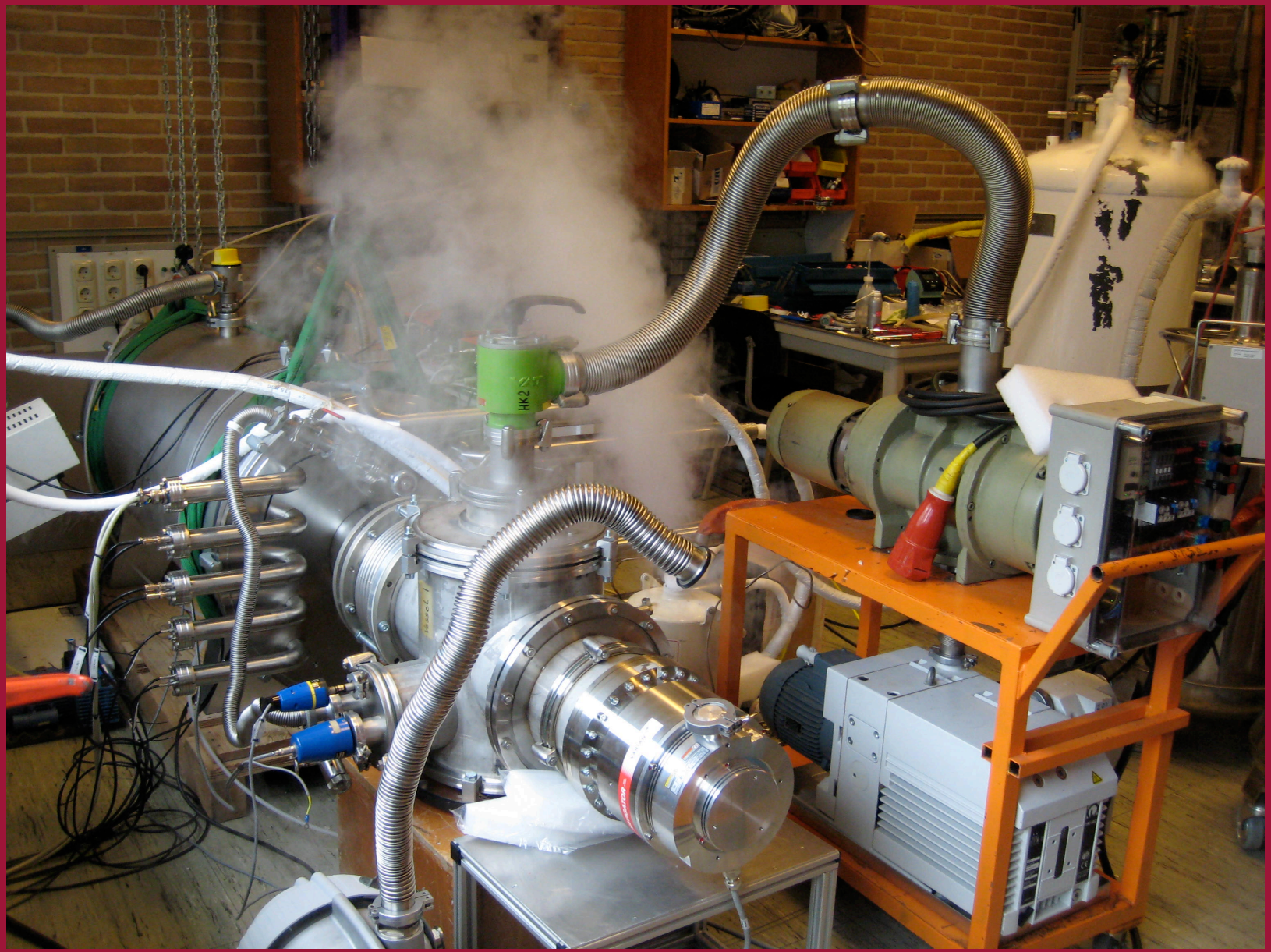


The off-line test: schematic

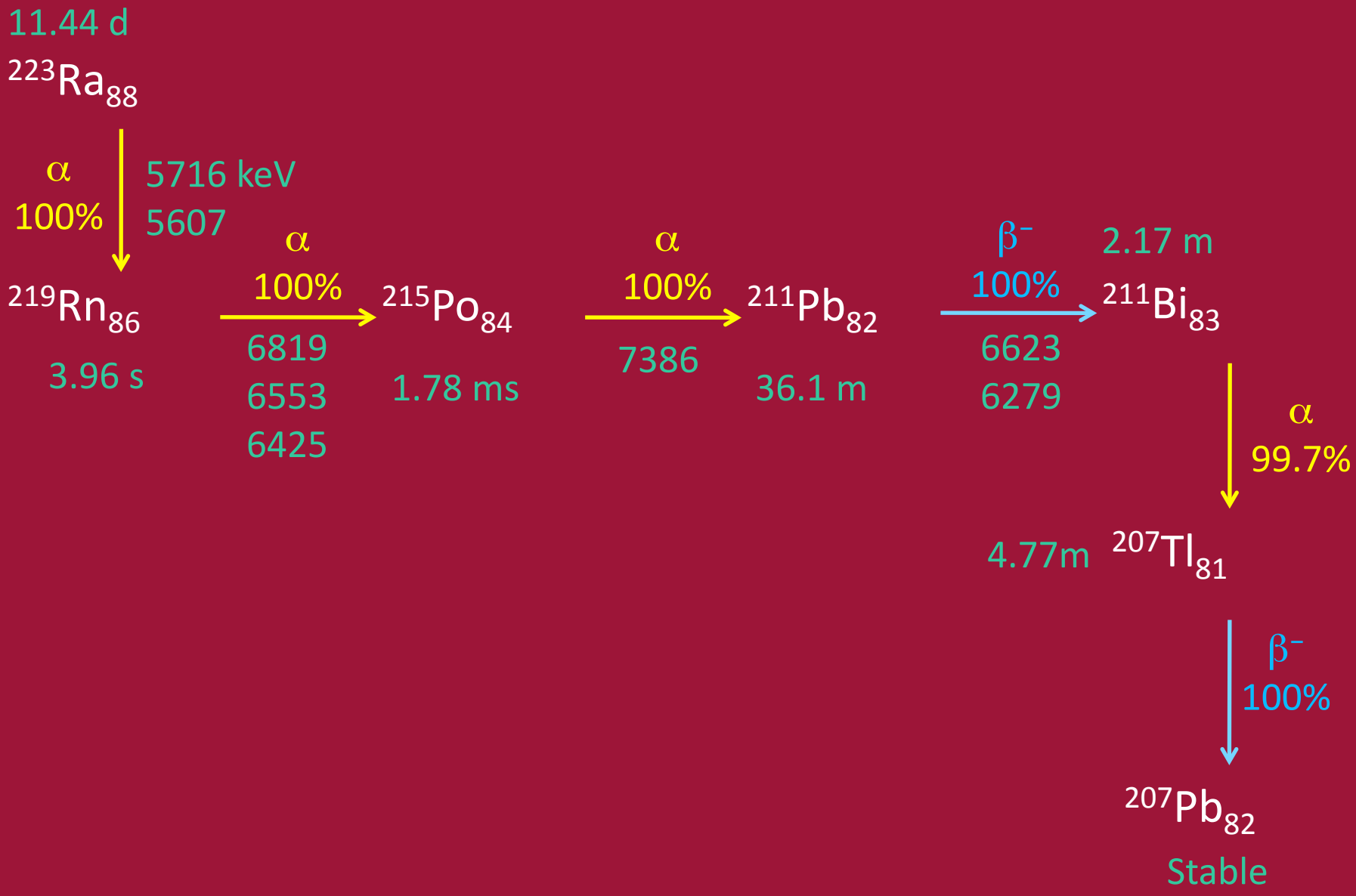


The off-line test set-up at KVI

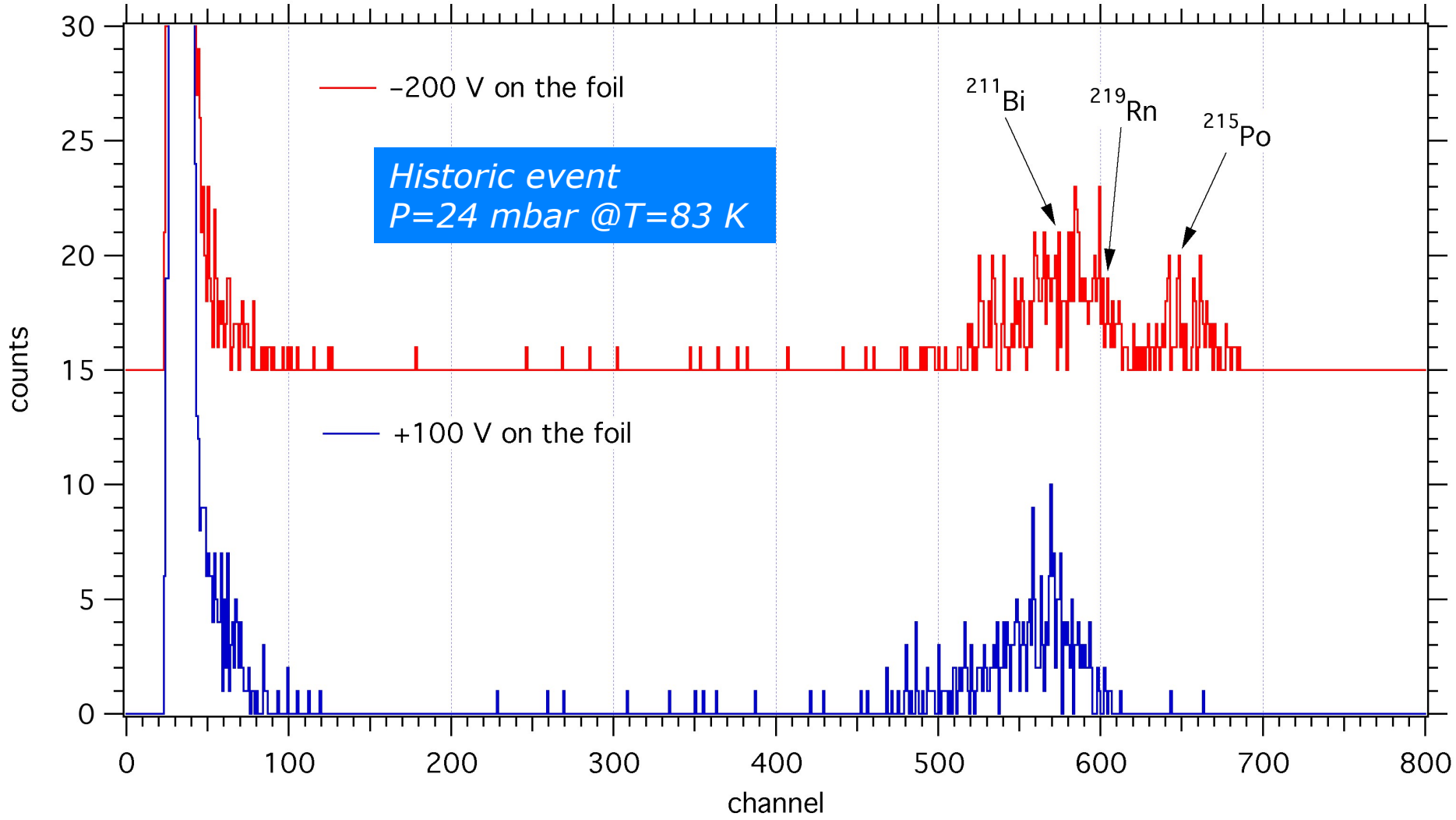
The off-line test in progress



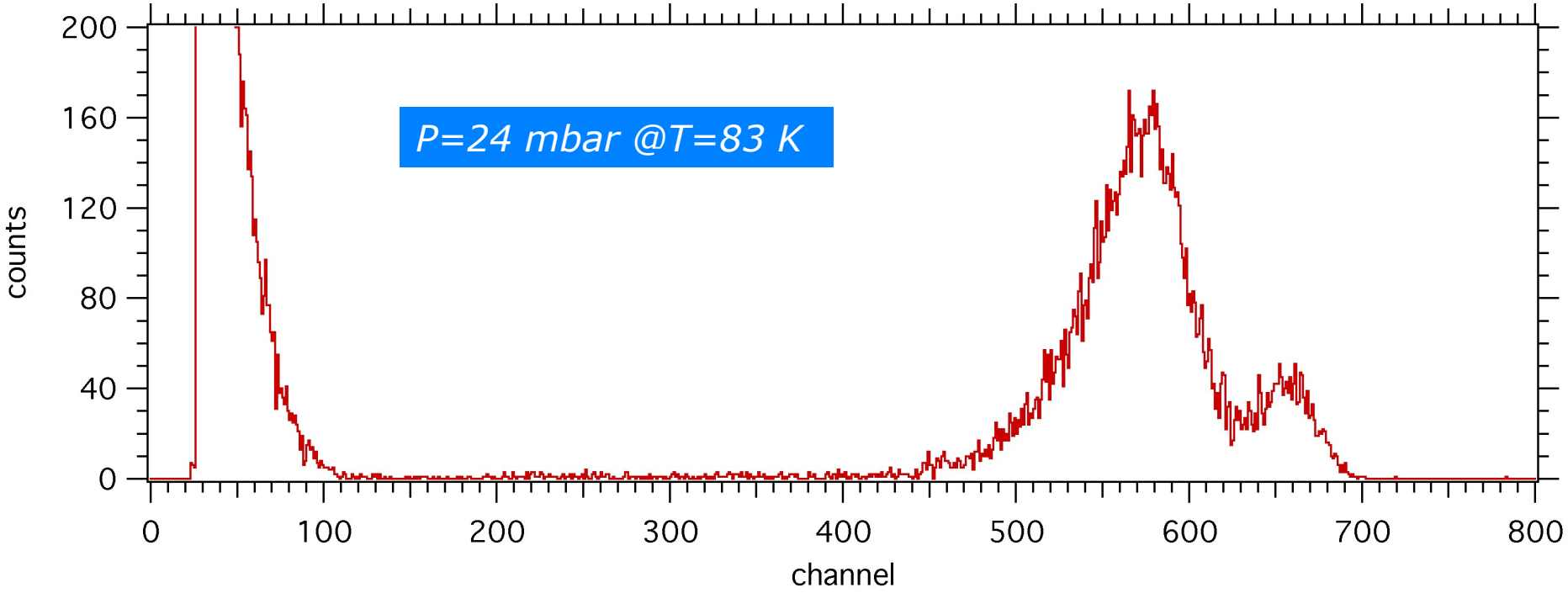
The ^{223}Ra decay chain



Proof of ion extraction



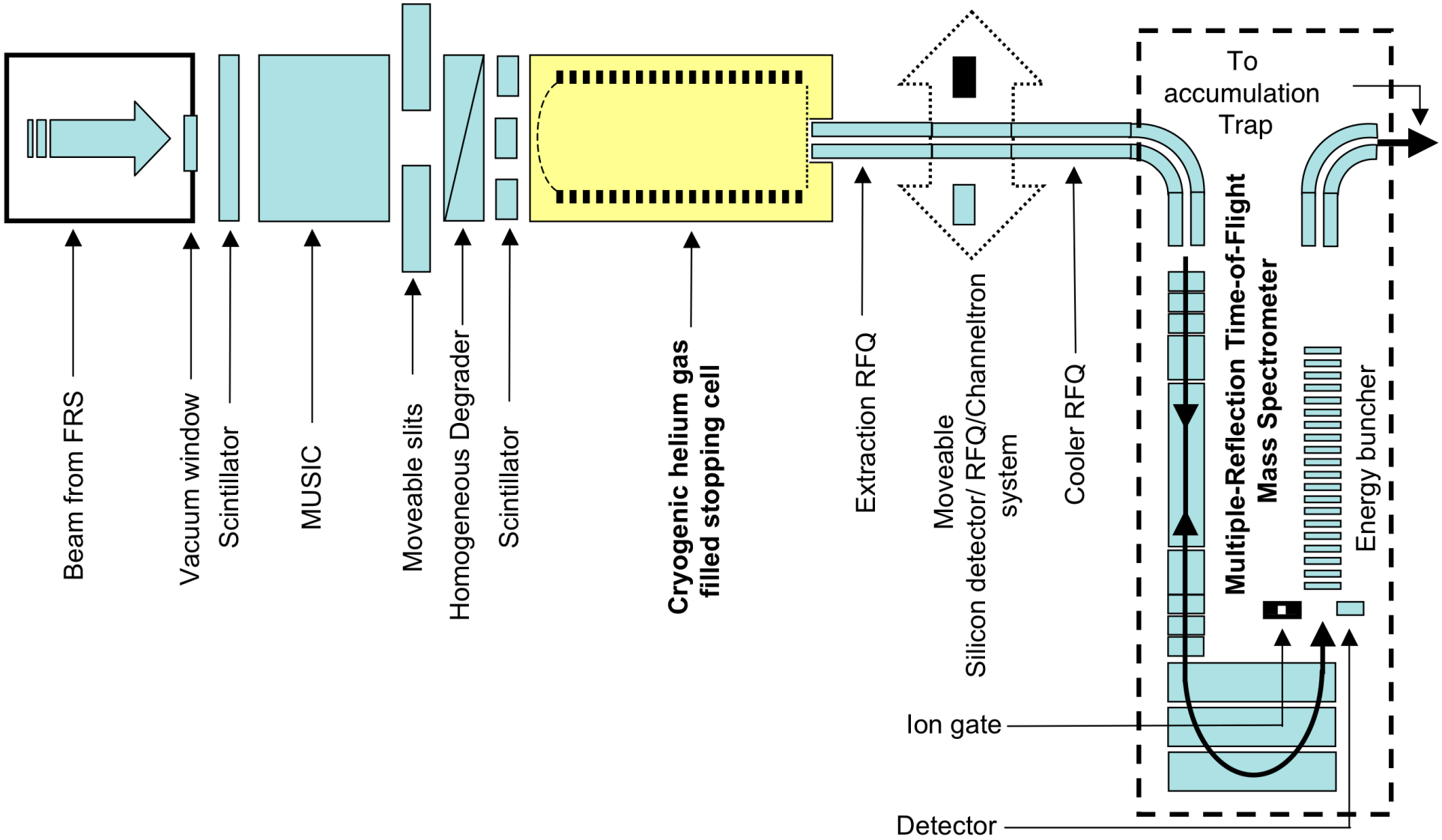
Status off-line commissioning



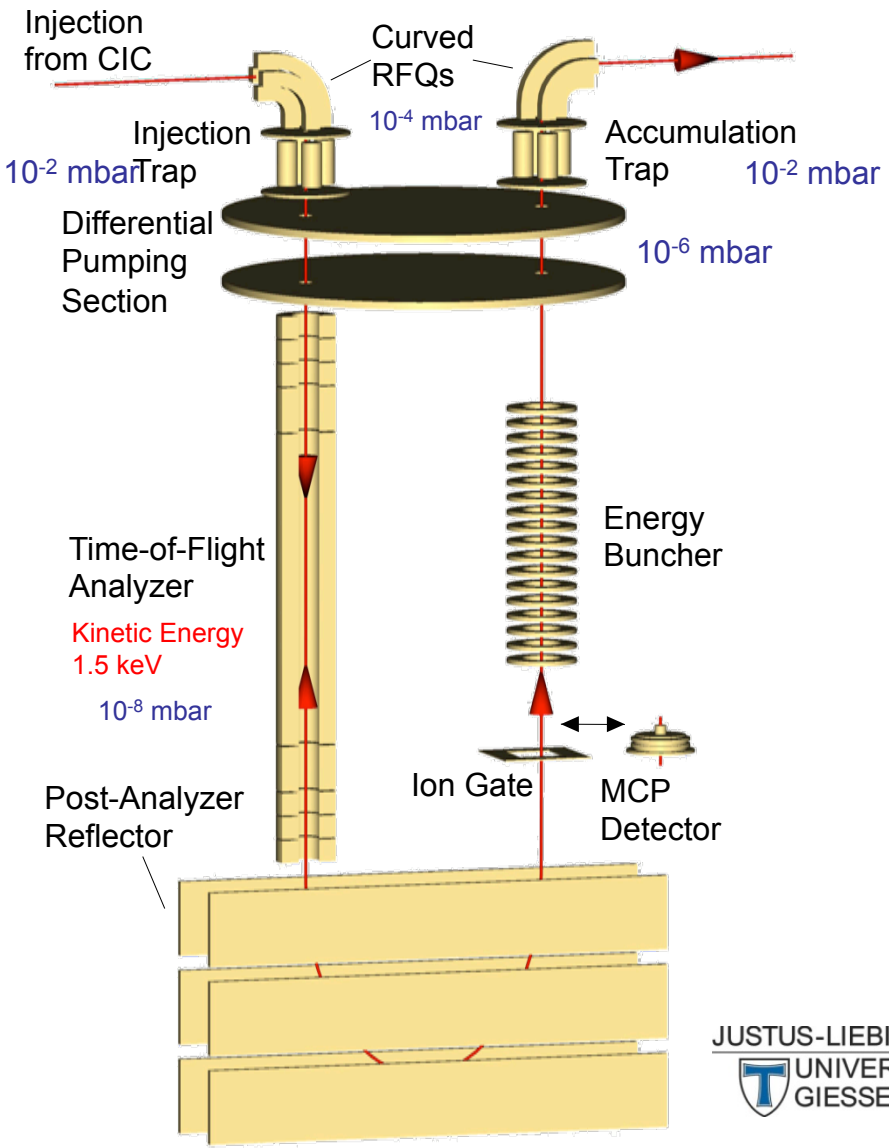
→ extraction efficiency: 2.8 %
→ ~10% of the maximum achievable efficiency (30%)

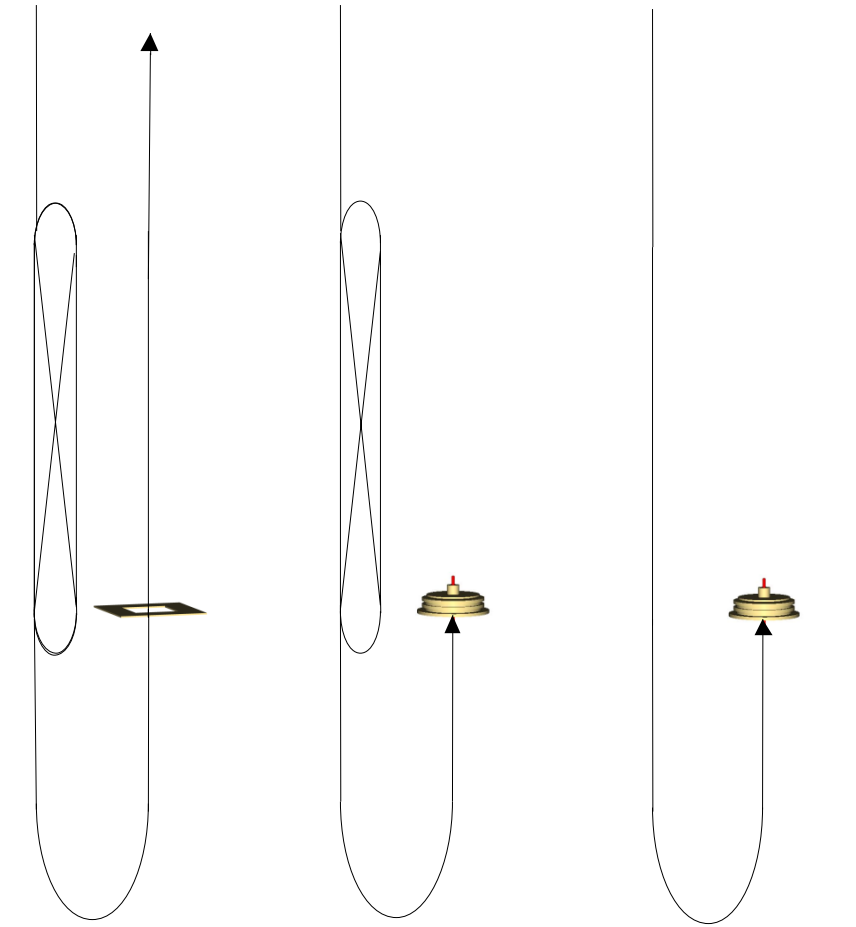
next:
→ continue efficiency optimization vs. p, DC, RF
→ pulsed source for transport time measurements

Experimental setup at the FRS



MR-TOF-MS as diagnostic tool





JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

W.R. Plaß et al., NIMB 266 (2008) 4560

W. Plaβ

Status and outlook

- off-line commissioning at KVI is ongoing
  - ✓ 2.8 % efficiency reached (unoptimized)
- cooling system has been ordered
- installation at FRS is being prepared at Gieβen/GSI

Aim:
performance tests and on-line characterization
of a *new device* based on a *new concept*
(worldwide the first cryogenic stopping cell that is used on-line?!)