PROTON BEAMS FORMATION FROM DENSE PLASMA OF ECR DISCHARGE SUSTAINED BY 37.5 GHZ GYROTRON RADIATION

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Outline

- Motivation to try proton beams production
- SMIS 37
- Experimental results
- Future plans and ideas

Motivation

Modern accelerators requirements:
hundreds of mA with normalized emittance lower than 1 $\pi \cdot$ mm$\cdot$ mrad

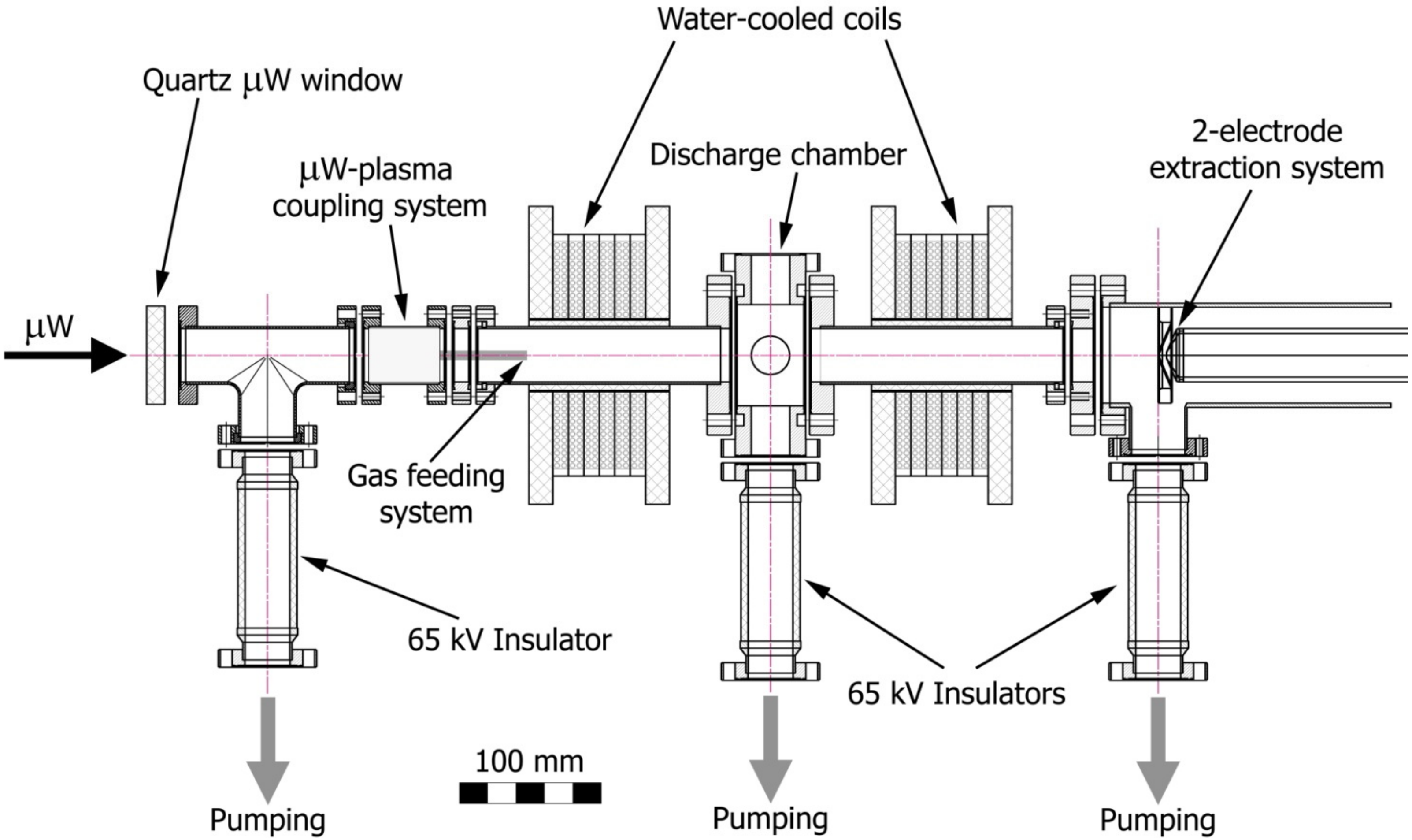
ECRIS has a good emittance and high ionization efficiency

Proton (deuteron) beams with higher current are needed

$\Downarrow$

Lets try high current gasdynamic ECRIS for proton production!

SMIS 37

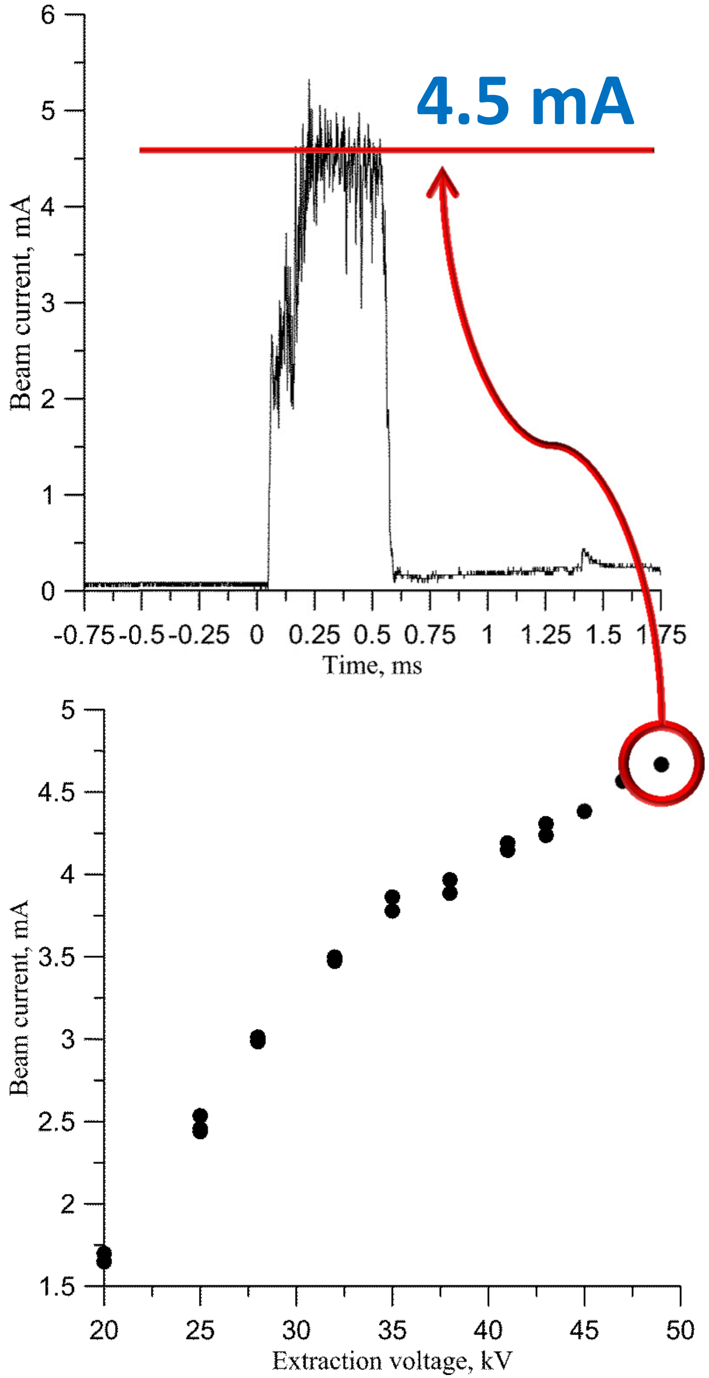


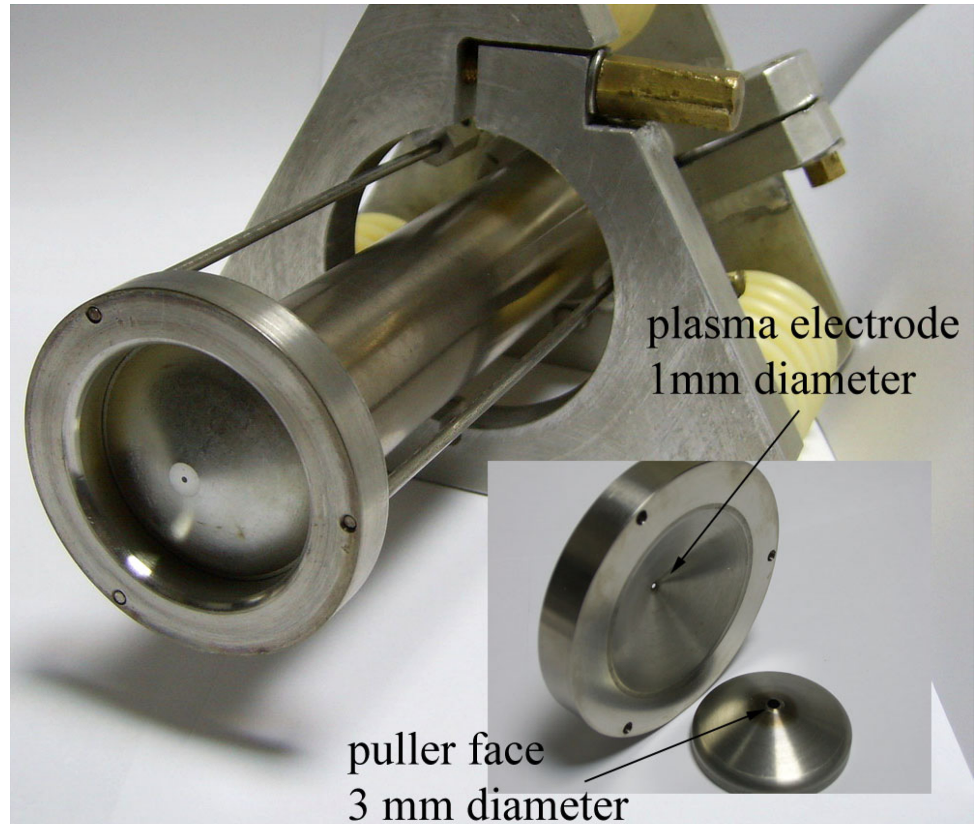
Frequency 37,5 GHz
Power up to 100 kW
Pulse duration 1 ms
Trap magnetic field up to 5 T

SMIS 37 main goals

- Unique plasma parameters
  ($N_e > 10^{13}$ cm^{-3}, $\tau \approx 5 \div 50$ μs, $T_e \approx 50 \div 300$ eV)
- High current density ($j \approx 100 \div 600$ mA/cm^2)
- Low emittance values
- High (unique) flexibility

1-hole extraction



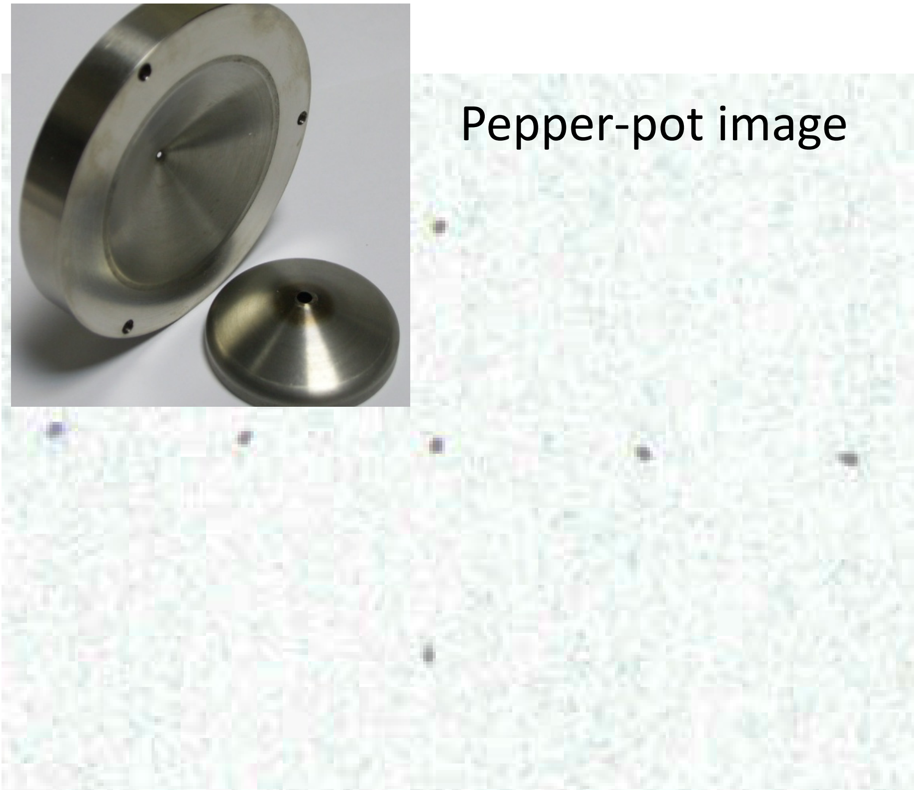


I = 4.5 mA

j = 570 mA/cm^2

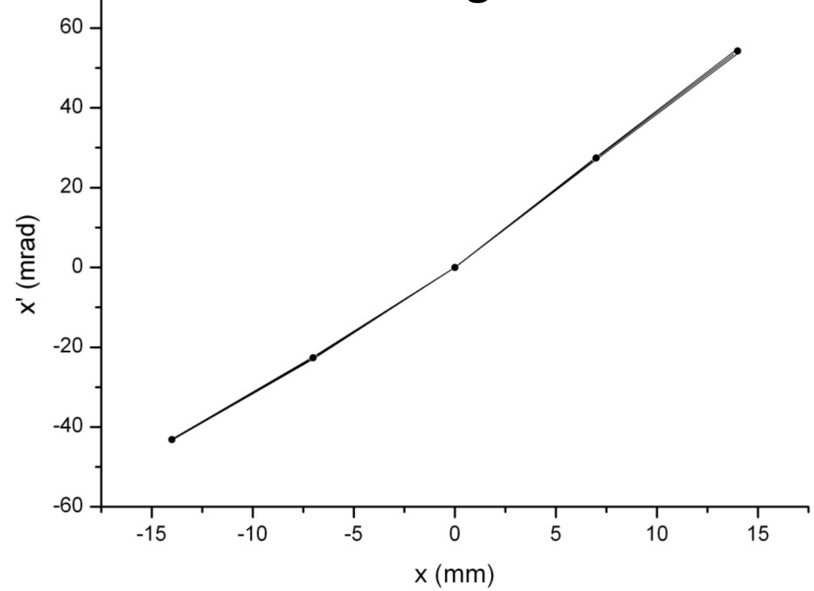
Extractor was placed in 12 cm behind the plug
(magnetic field in extraction area was about 0.2 T)

Beam emittance (single hole)



Pepper-pot image

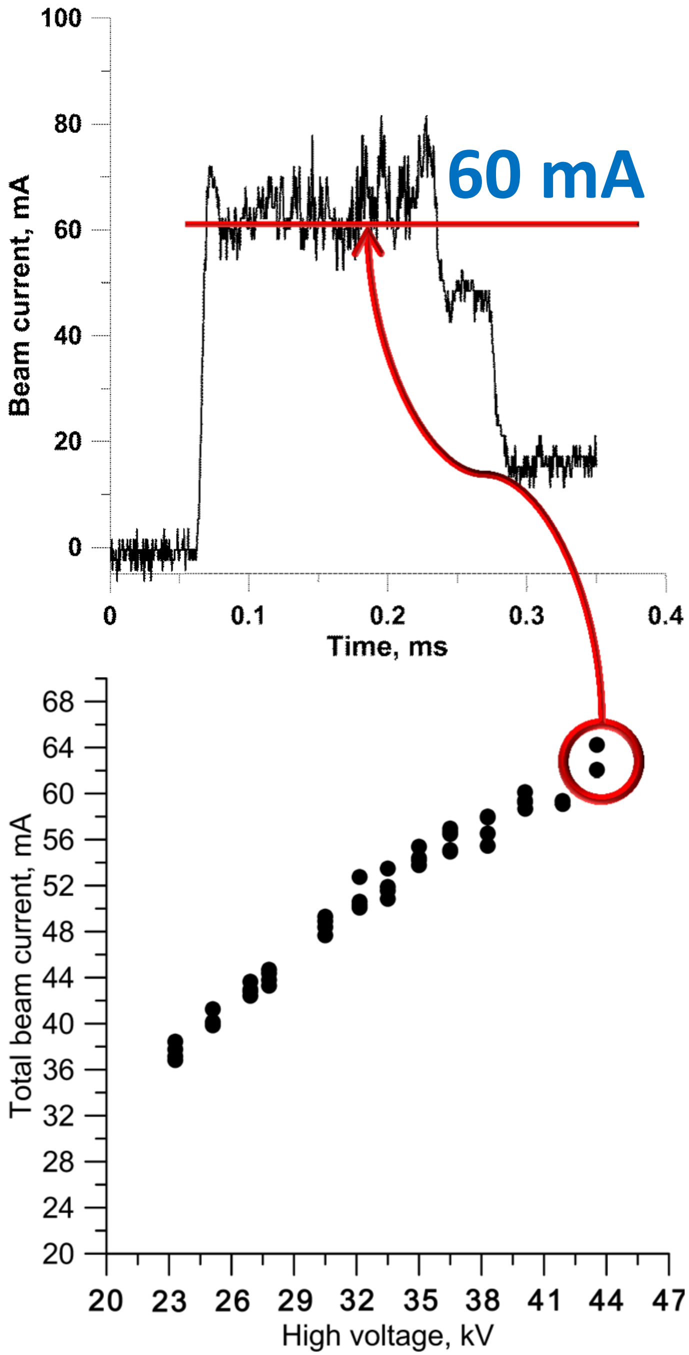
Emittance diagram

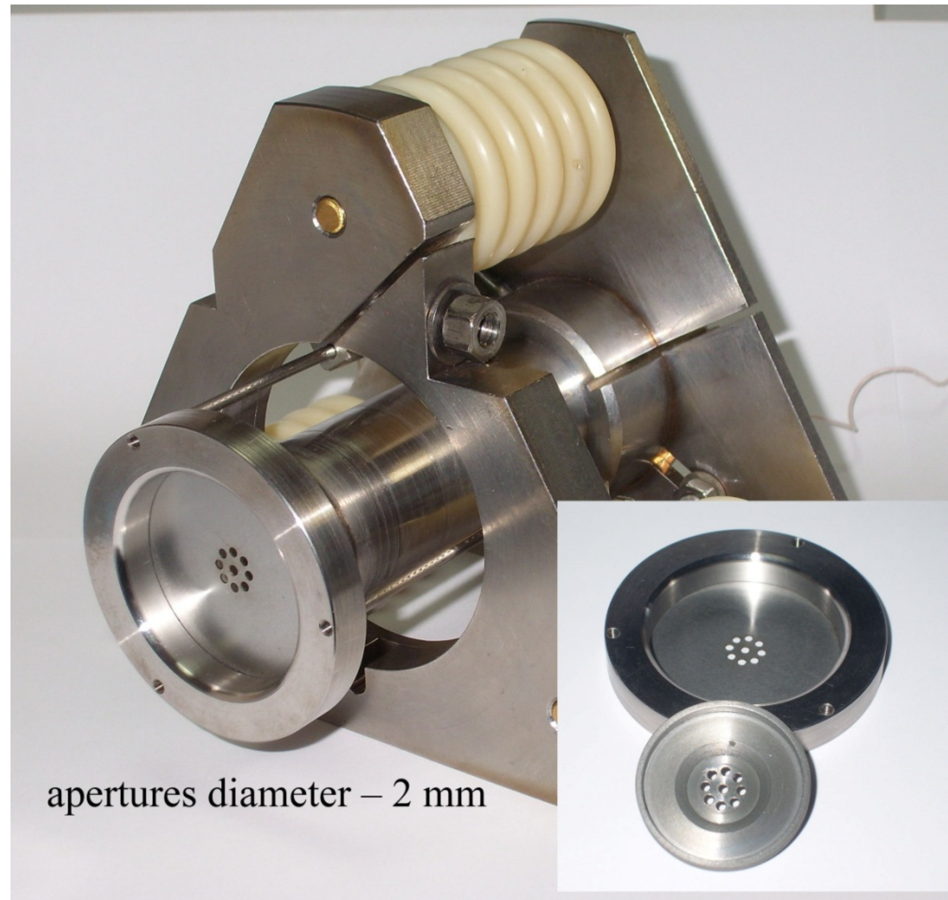


$\varepsilon_n = 0.03\ \pi\cdot \text{mm}\cdot \text{mrad}$

$B_n = 5\ \text{A}/(\pi\cdot \text{mm}\cdot \text{mrad})^2$

9-hole extraction



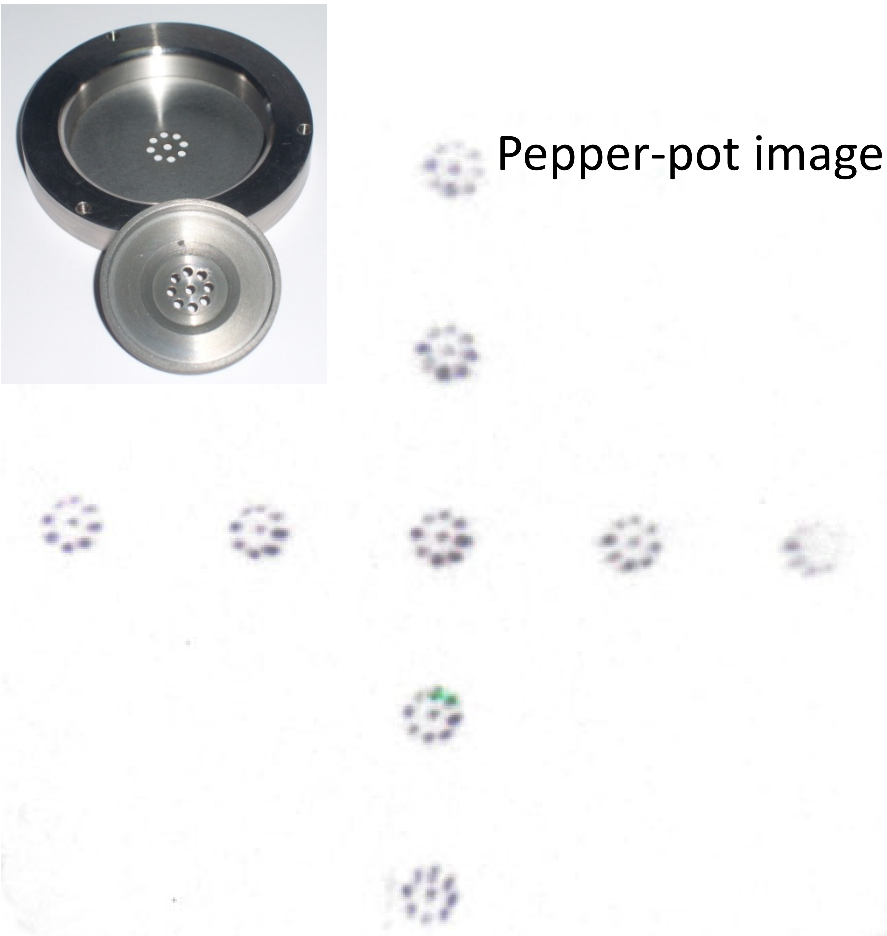


I = 60 mA

j = 200 mA/cm^2

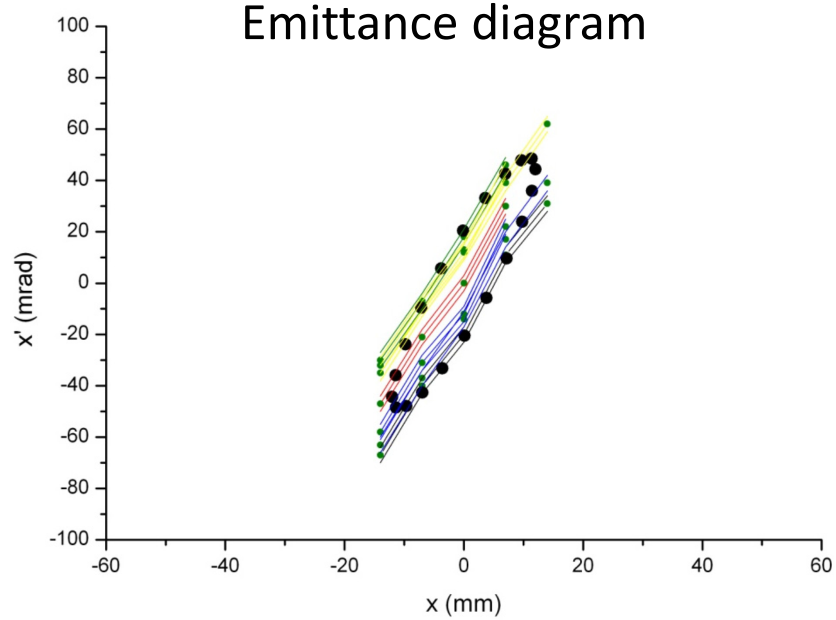
Extractor was placed in 22 cm behind the plug
(magnetic field in extraction area was about 0.03 T)

Beam emittance (9-hole)



Pepper-pot image

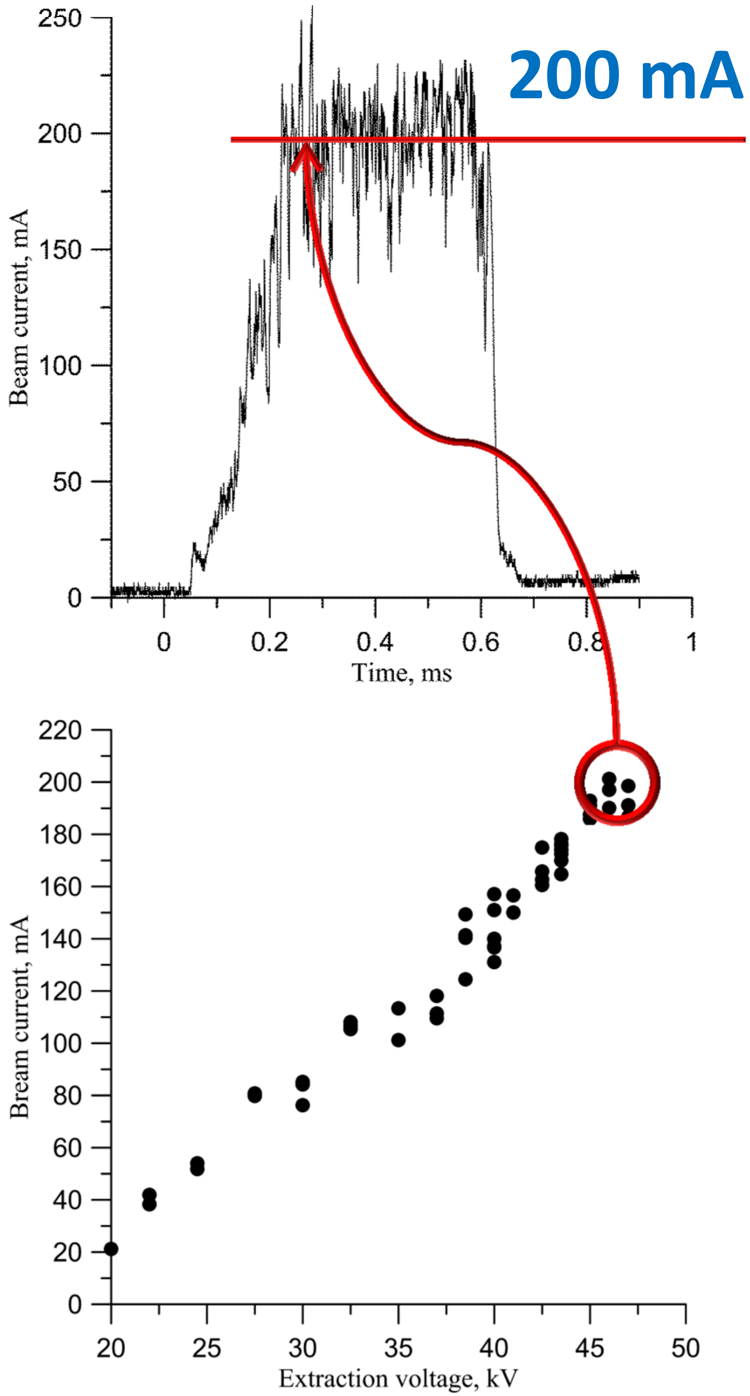
Emittance diagram



$\varepsilon_n = 0.5\ \pi \cdot \mathrm{mm} \cdot \mathrm{mrad}$

$B_n = 0.24\ \mathrm{A}/(\pi \cdot \mathrm{mm} \cdot \mathrm{mrad})^2$

13-hole extraction

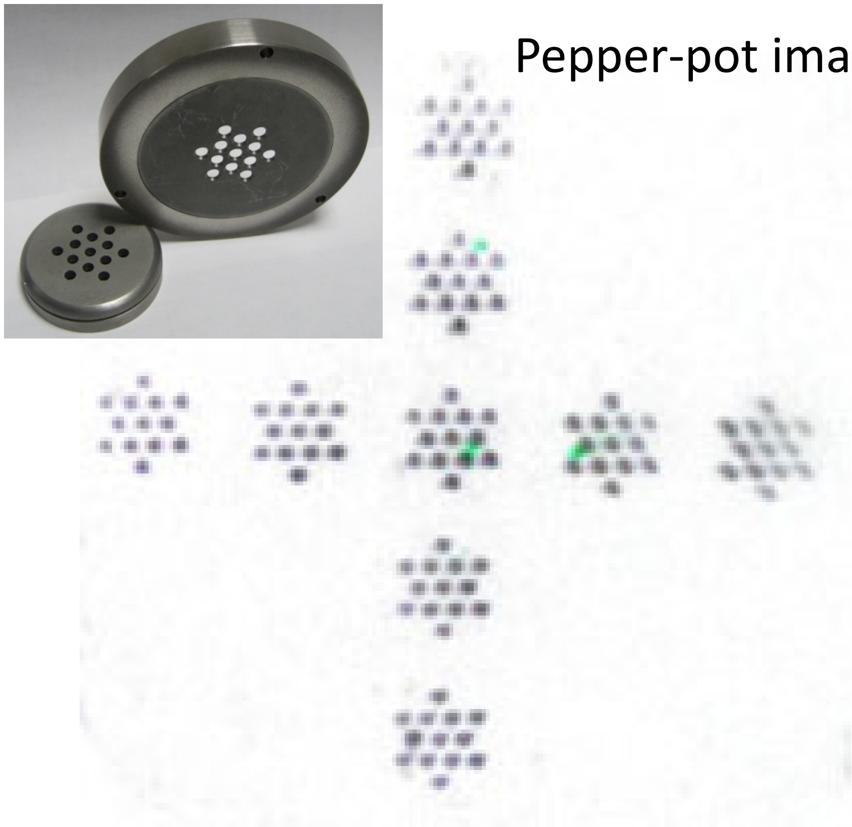


I = 200 mA

j = 220 mA/cm^2

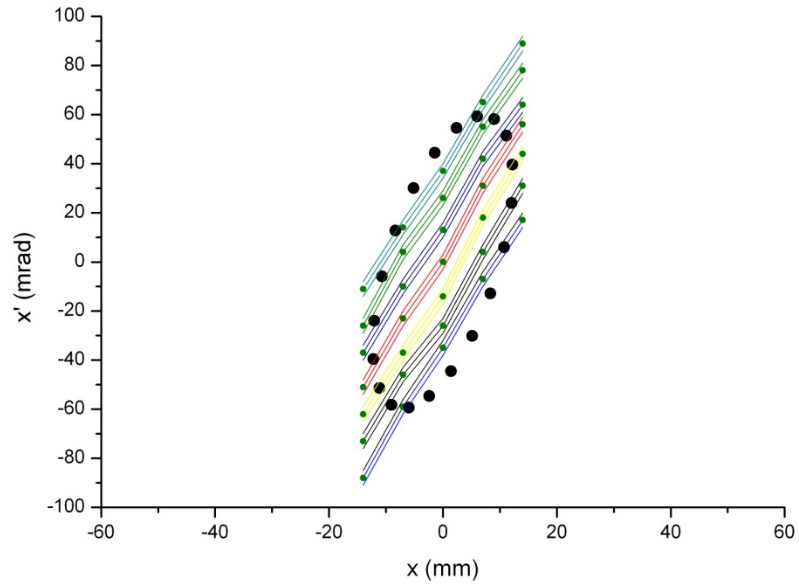
Extractor was placed in 20 cm behind the plug (magnetic field in extraction area was about 0.03 T)

Beam emittance (13-hole)



Pepper-pot image

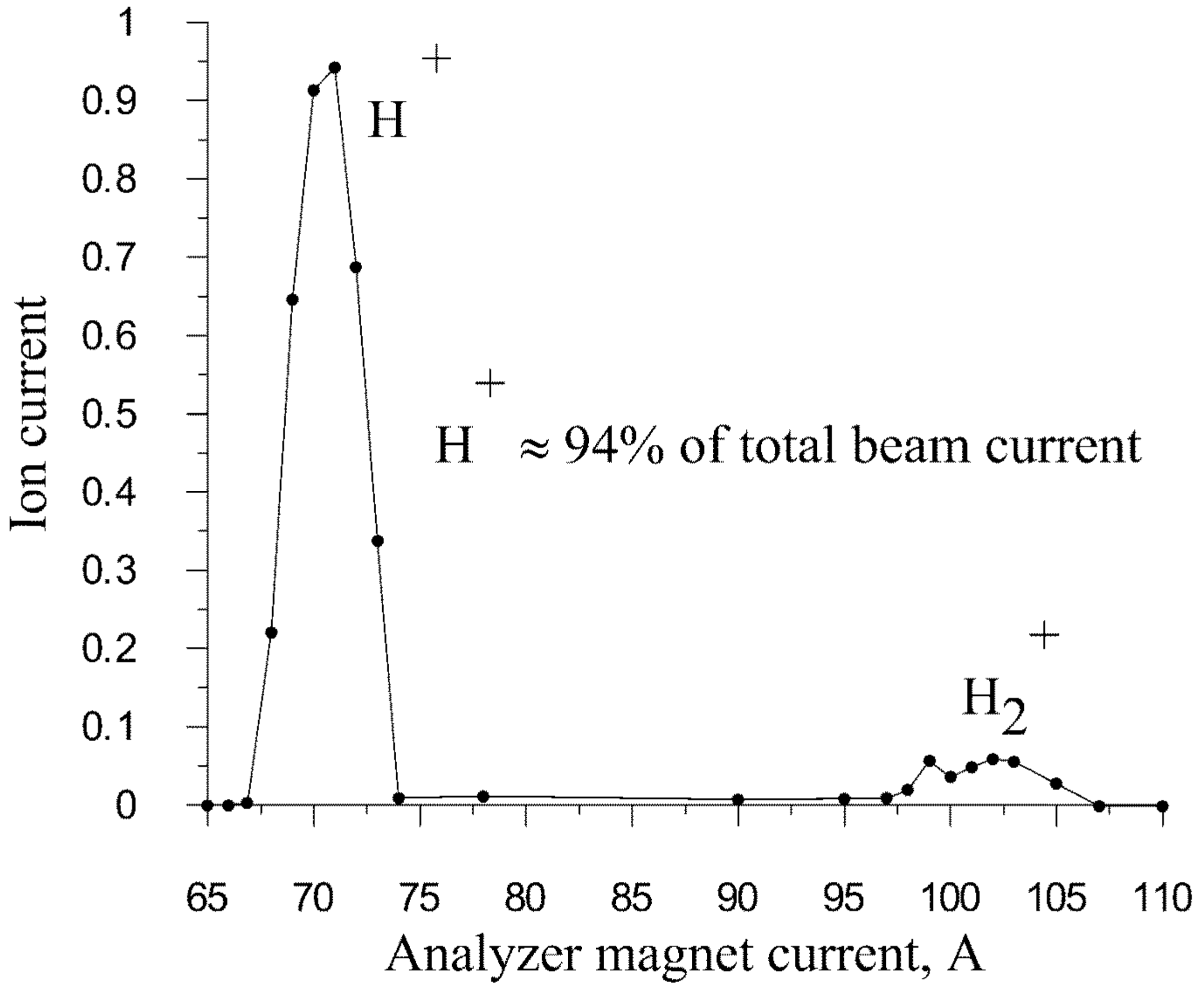
Emittance diagram



$\varepsilon_n = 1.1\ \pi\cdot\text{mm}\cdot\text{mrad}$

$B_n = 0.17\ \text{A}/(\pi\cdot\text{mm}\cdot\text{mrad})^2$

Ion spectrum



$H^+ > 94\ \%$
$H_2^+ < 6\ \%$

Results summary

Extraction system	Faraday cup current, mA	Puller current, mA	Normalized emittance, $\pi \cdot$mm$\cdot$mrad	Extraction voltage, kV	Normalized brightness, A/($\pi \cdot$mm$\cdot$mrad)^2
1 hole (d = 1 mm)	4.5	2	0.03	50	5
9 holes (d = 2 mm)	60	30	0.5	45	0.24
13 holes (d = 3 mm)	200	250	1.1	45	0.17

$H^+ > 94$ %
$H_2^+ < 6$ %

Future plans

- Higher voltage
- New extractors design
- 24 GHz CW source

Thank you for your attention!