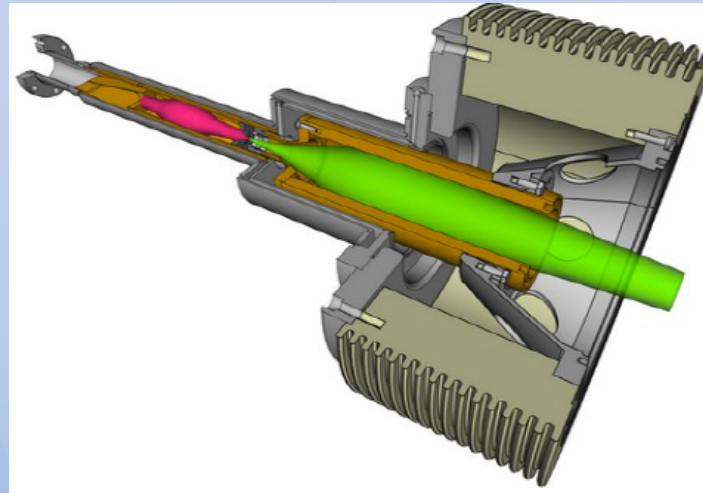
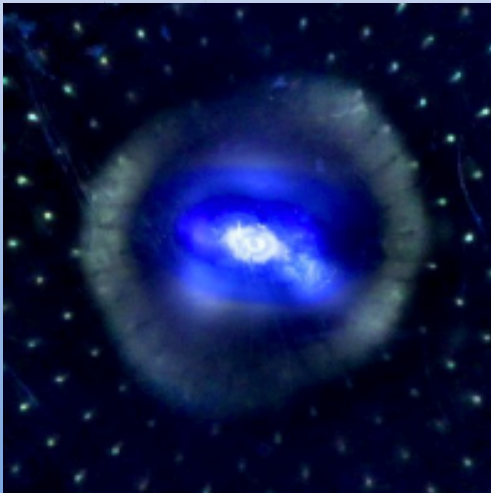


A High Current Pure Proton Beam Source Prototype

Vadim Skalyga, Alexei Bokhanov, Sergey Golubev, Ivan Izotov, Sergey Vybin

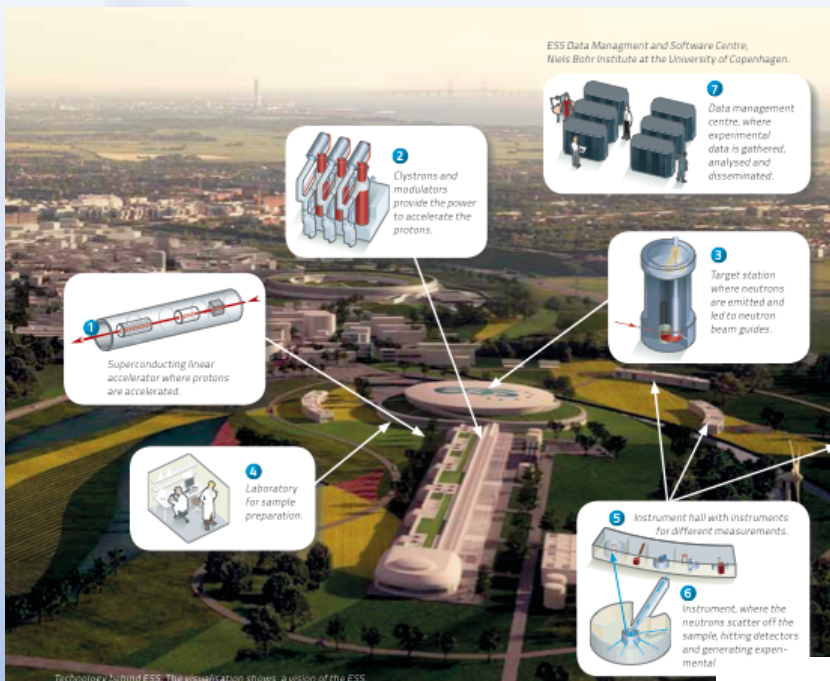
Institute of Applied Physics Russian Academy of Sciences



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Outline

- ❖ Proton injectors for linear accelerators
- ❖ High-frequency ECR ion sources
- ❖ High-current gasdynamic ECR ion sources at the IAP RAS
- ❖ Proton beams formation at SMIS 37 and GISMO
- ❖ New approach for high-current ion beam formation



ESS:

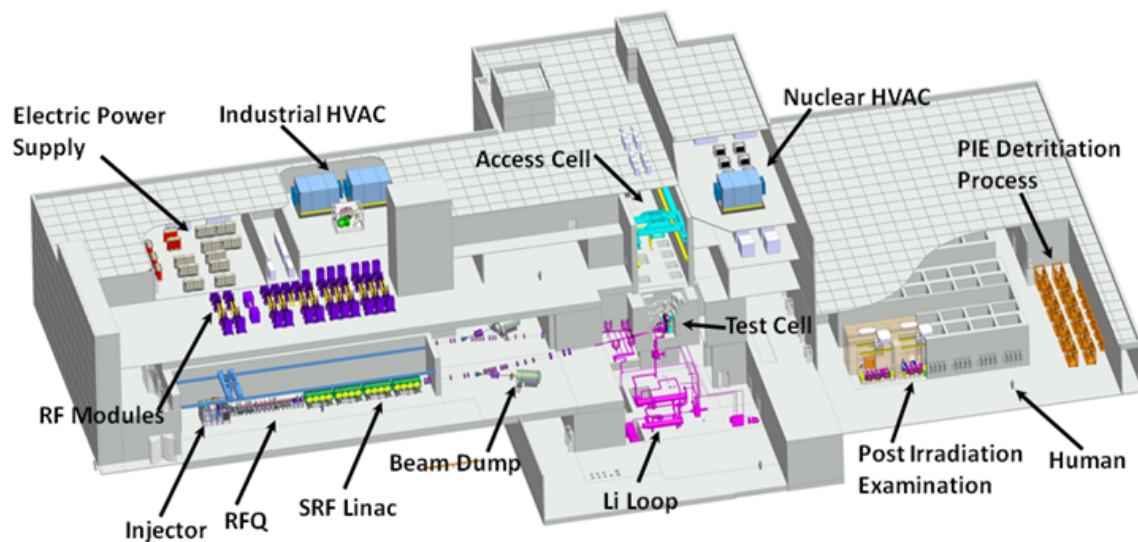
Proton source

H^+ , ECR 2.45 GHz,
90 mA, 75 kV,
14 Hz 3 ms,
 $\epsilon = 0.2 \pi \cdot \text{mm} \cdot \text{mrad}$

IFMIF:

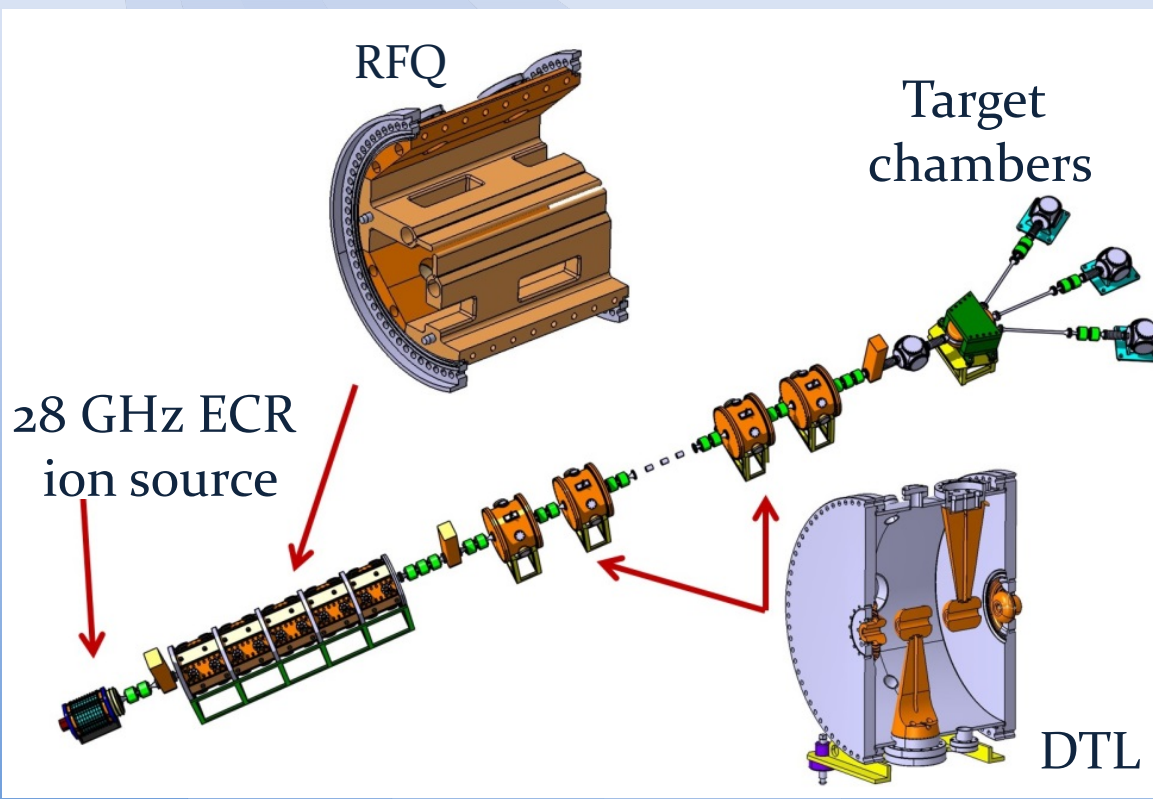
Deuteron source

D^+ , ECR 2.45 GHz
 $2 \times 125 \text{ mA}$, 100 kV, CW
 $\epsilon = 0.2 \pi \cdot \text{mm} \cdot \text{mrad}$



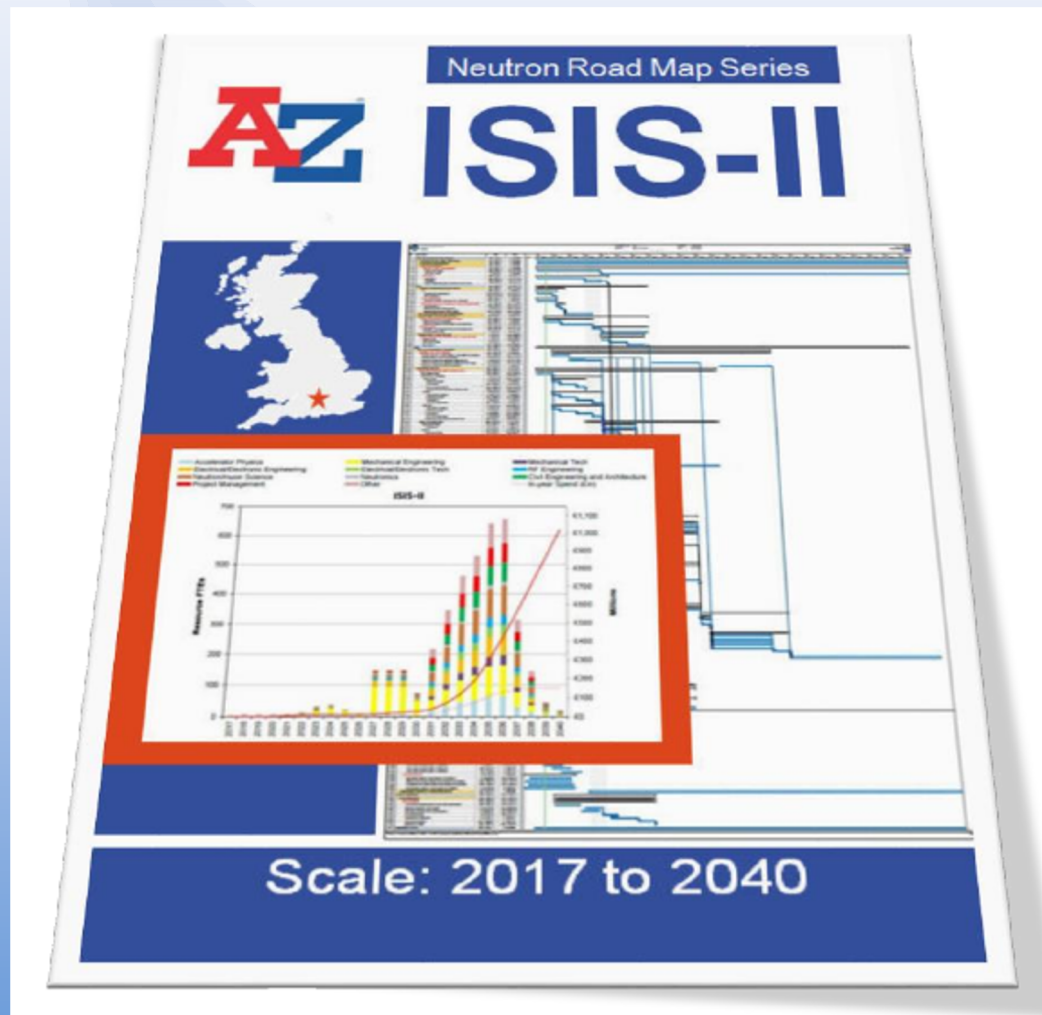


neutron source Dedicated to Applied Research and Industrial Applications



Ions: protons
Beam energy: 13 MeV
Target: Beryllium

Operation: pulsed
Current: 80-100 mA
Pulse duration: 100 μ s
Rep. rate: 100 Hz



If protons would be chosen for acceleration:

H⁺ current: 250 mA

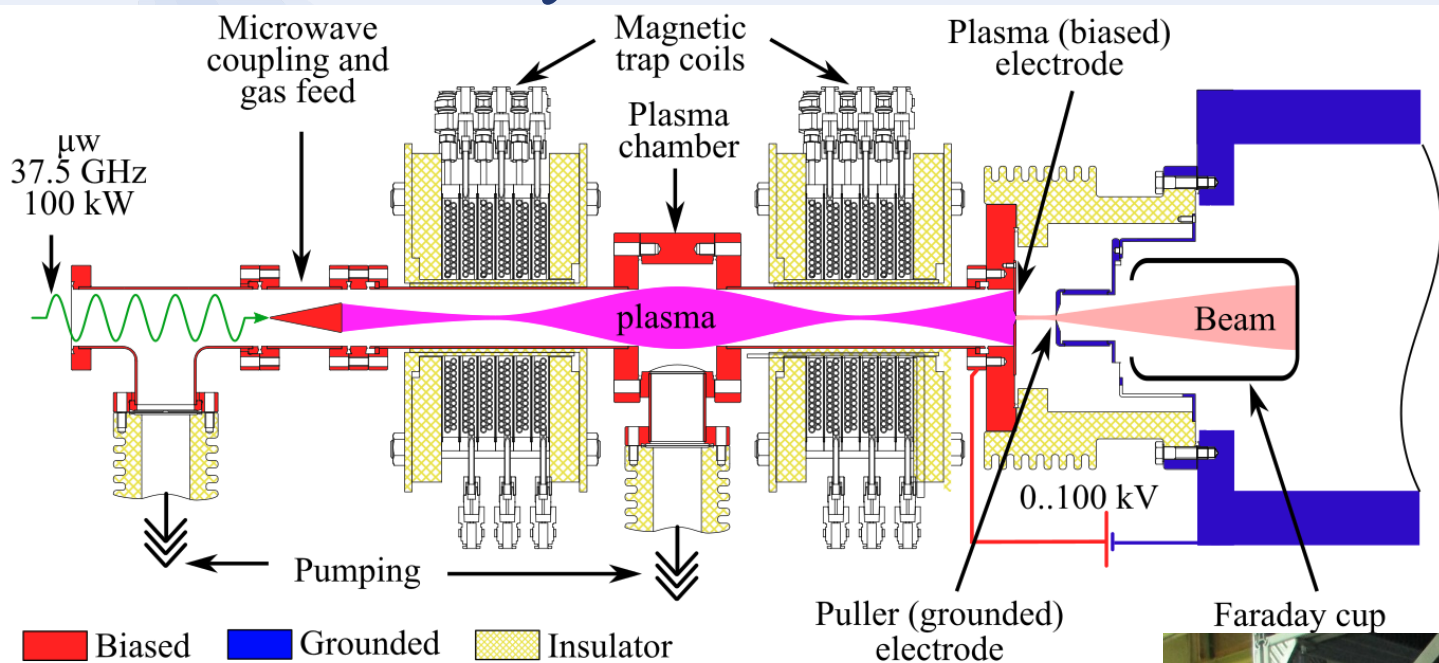
Pulse duration: 1 ms

Rep. rate: 100 Hz

Normalized RMS

emittance: $0,1 \pi \cdot \text{mm} \cdot \text{mrad}$

SMIS 37 Gasdynamic ECR ion source



Microwave power: 100 kW

Heating frequency: 37.5 GHz

Maximum B_{\max} value = 4T

Pulse duration - 1ms

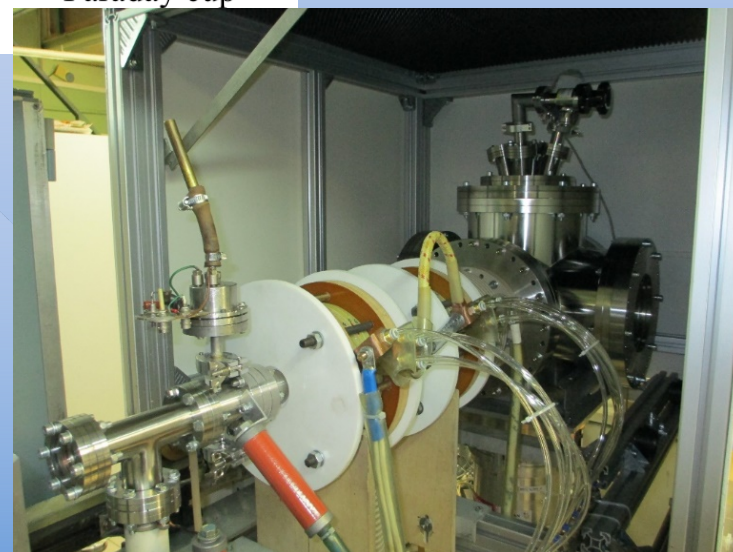
Extraction: up to 100 kV

Plasma parameters:

($N_e > 10^{13} \text{ cm}^{-3}$, $\tau \approx 5 \div 50 \text{ } \mu\text{s}$, $T_e \approx 50 \div 300 \text{ eV}$)

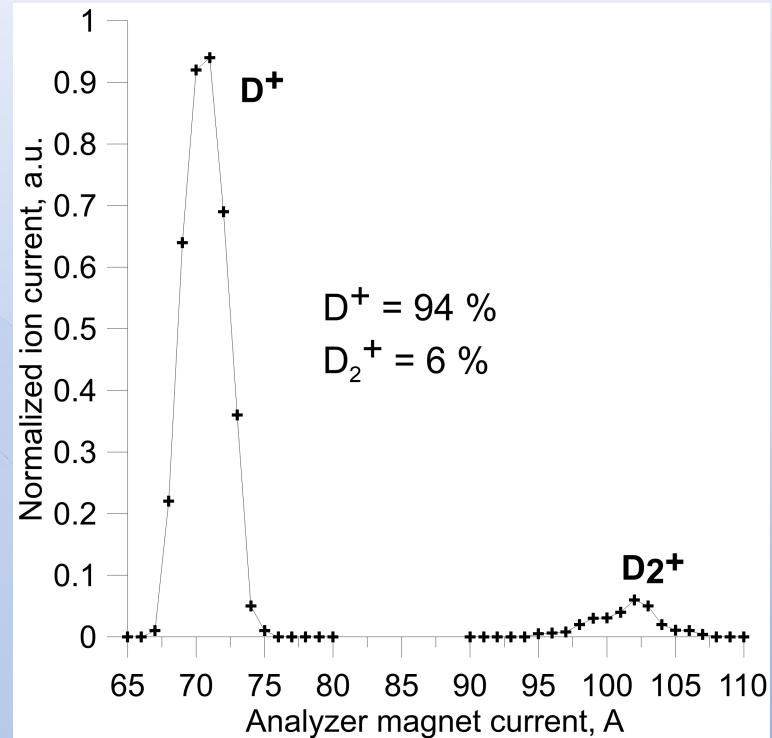
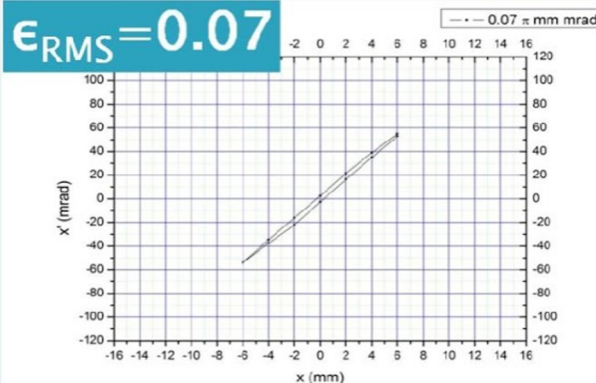
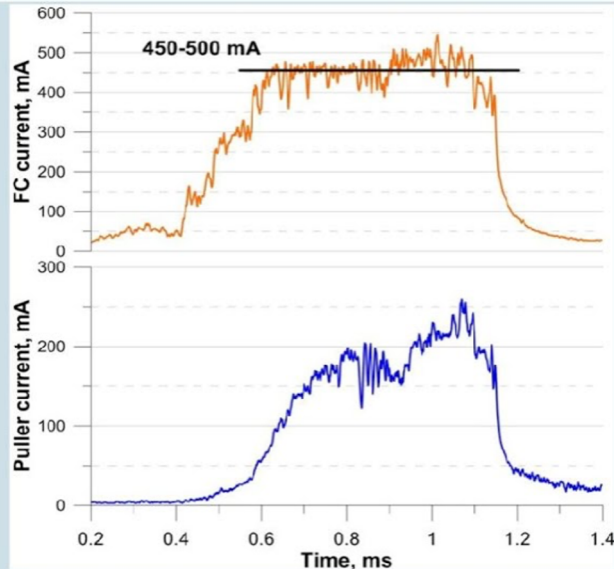
Record ion beam current ($j \approx 100 \div 1200 \text{ mA/cm}^2$)

Low ion beam emittance



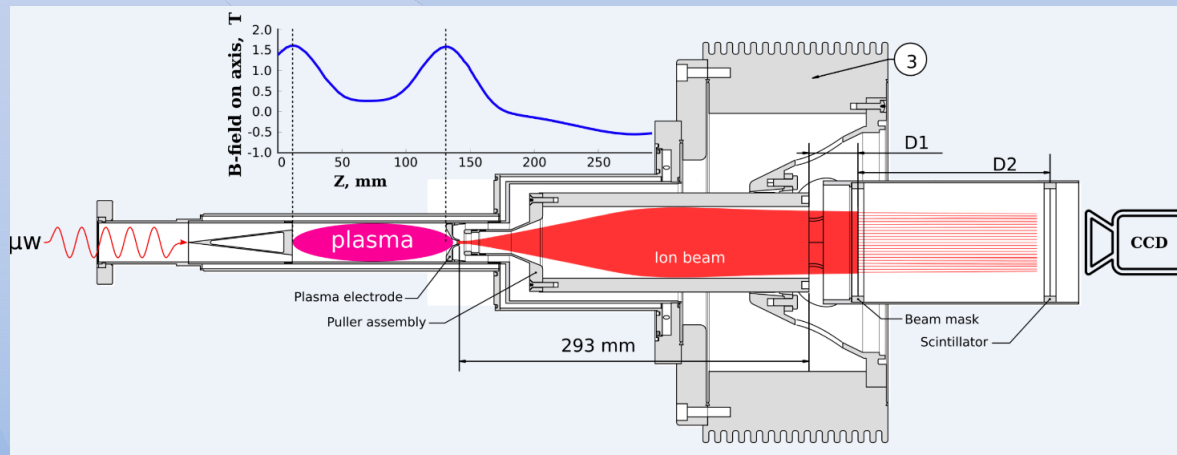
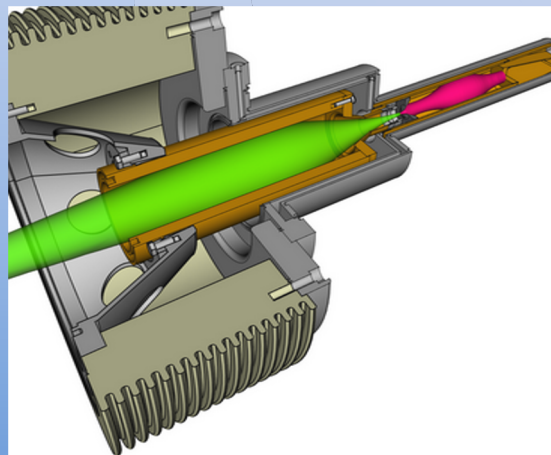
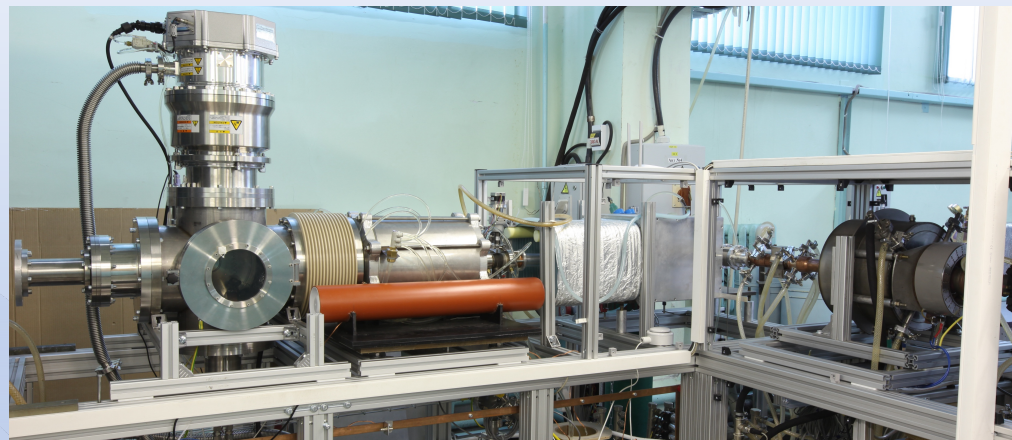
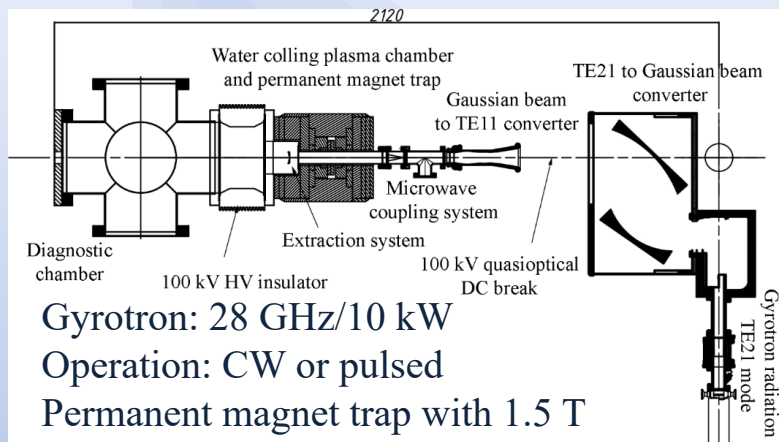
Proton beam production at SMIS 37

10 mm, H⁺



Pulsed proton beams were demonstrated
with current **100 – 500 mA**
and current density up to **800 mA/cm²**

New *GISMO* (Gasdynamic Ion Source for Multipurpose Operation)



$$N_e \sim 10^{13} \text{ cm}^{-3}$$

$$V_p \sim 40 \text{ cm}^3$$

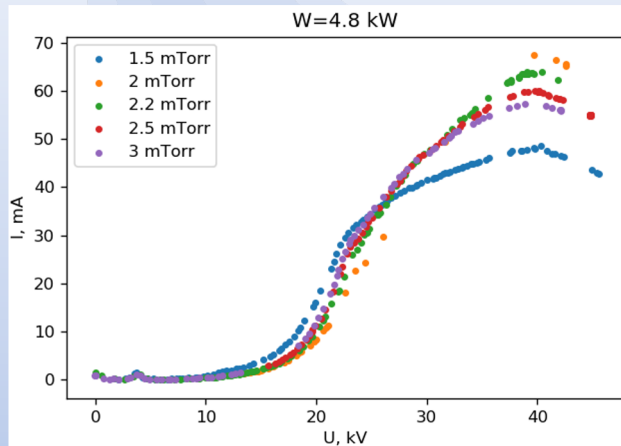
$$Q \sim 250 \text{ W/cm}^3$$

$$T_e \sim 50\text{-}300 \text{ eV}$$

$$\tau_e \sim 10 \text{ } \mu\text{s}$$

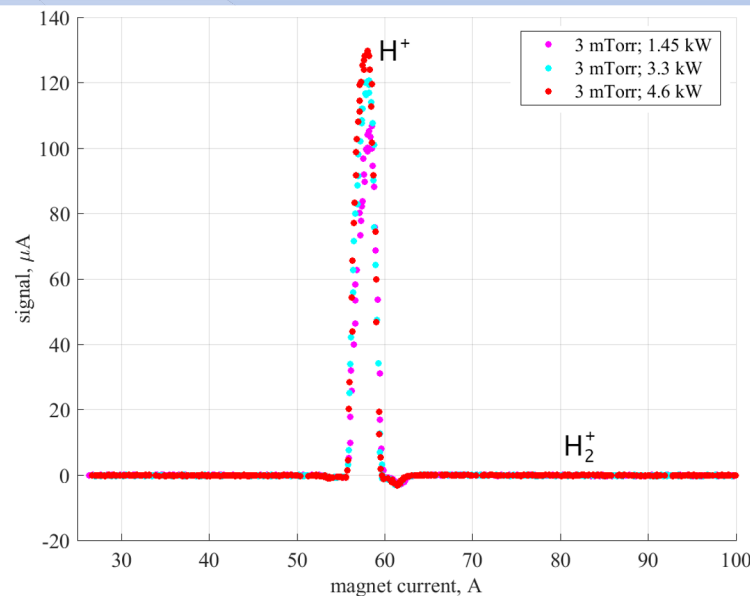
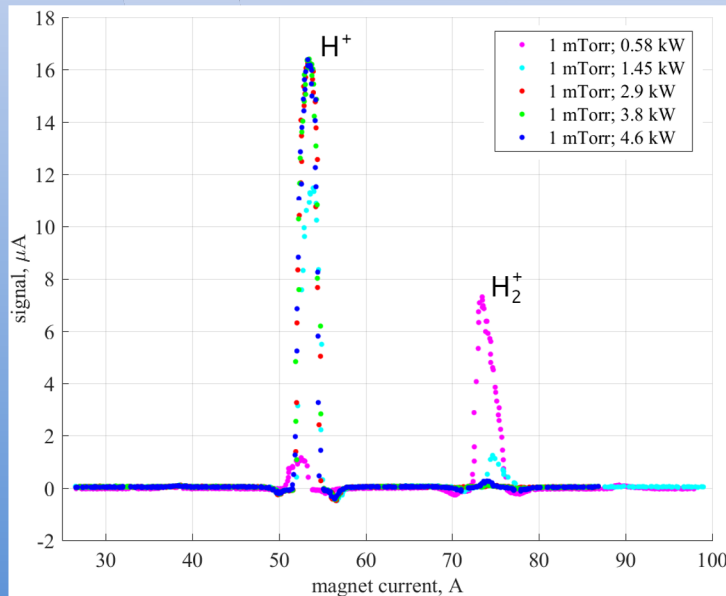
$$J \sim 1.5 \text{ A/cm}^2$$

Proton beams production at GISMO



70 mA of pure protons was extracted
using 3 mm extraction aperture

(almost 1 A/cm² of ion beam current density
with high beam quality)



Emittance measurements with ITEP Accelerator Department team

T.V. Kulevoy, G.N. Kropachev, A.L. Sitnikov

DARIA requirements:

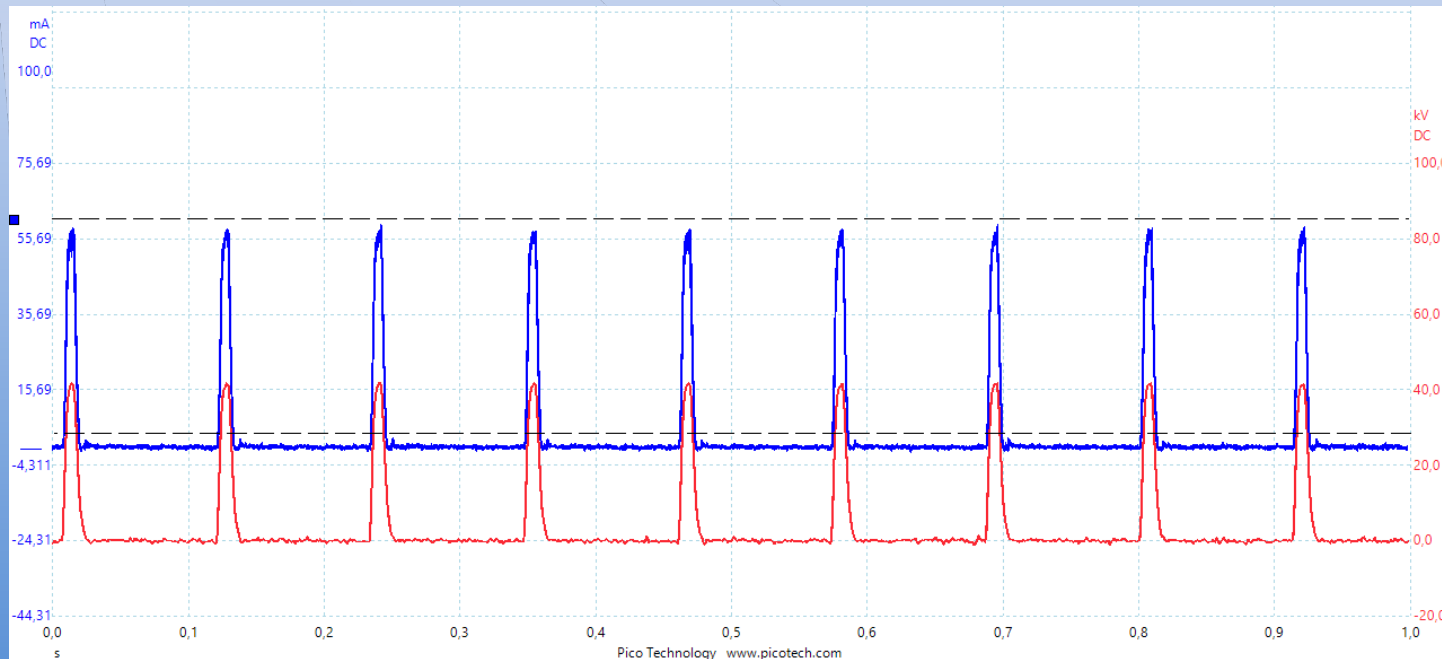
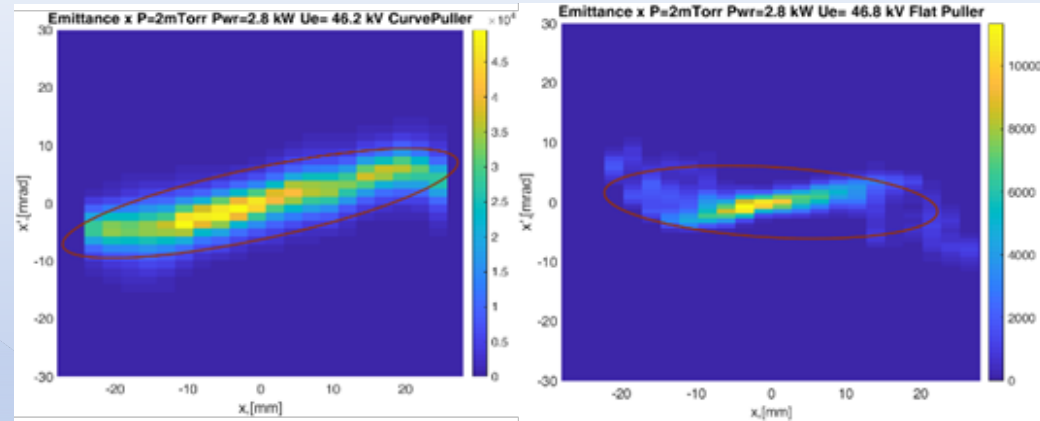
Beam current 70-100 mA

Normalized RMS emittance $< 0.4 \pi \cdot \text{mm} \cdot \text{mrad}$

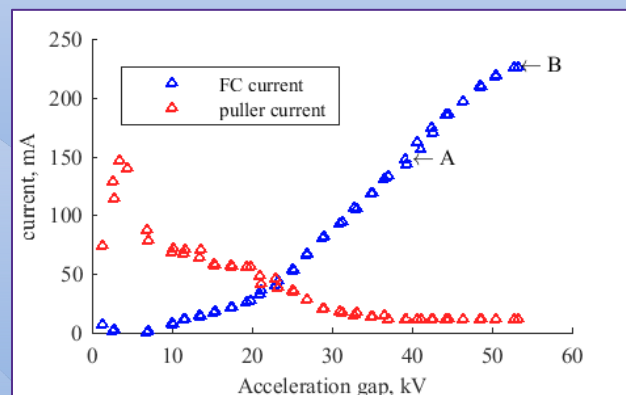
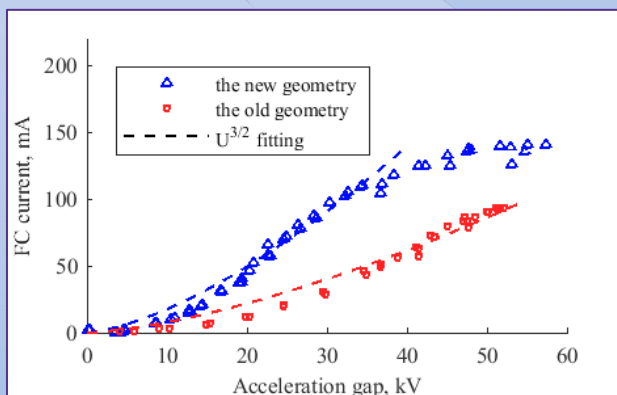
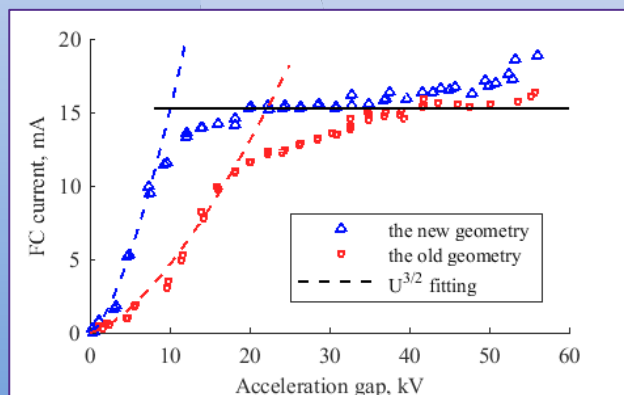
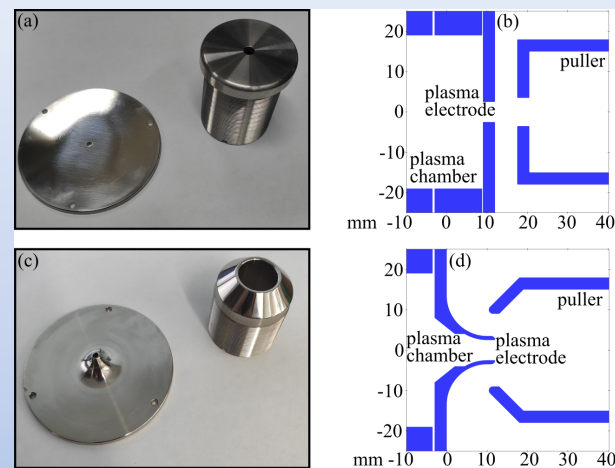
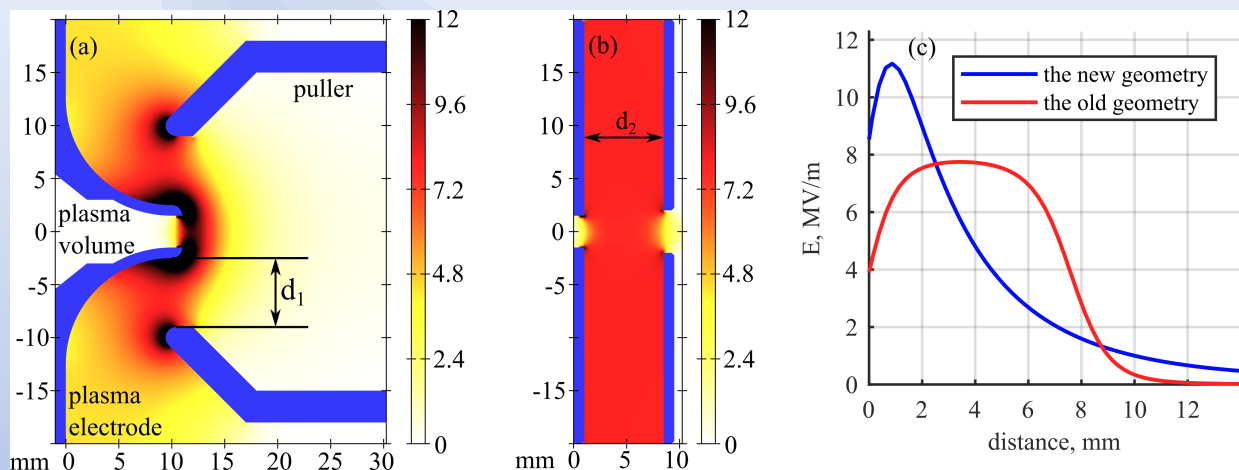
Pulse duration 100 μs

Repetition rate 100 Hz

Have been almost fulfilled at GISMO already



New approach for high-current ion beam formation



Optimal extraction voltage have been reduced 2 times

1.1 A/cm² have been reached!

Conclusions

- ✓ Pure proton beam extraction from the 28 GHz ECR discharge plasma was demonstrated
- ✓ Beam current densities above 1 A/cm^2 have been achieved
- ✓ New extraction system for high-current density beams was proposed and tested
- ✓ Prototype of proton injector is under final design

Thank you for your attention!