Status of the High Current Permanent Magnet 2.45GHz ECR Ion Source at Peking University

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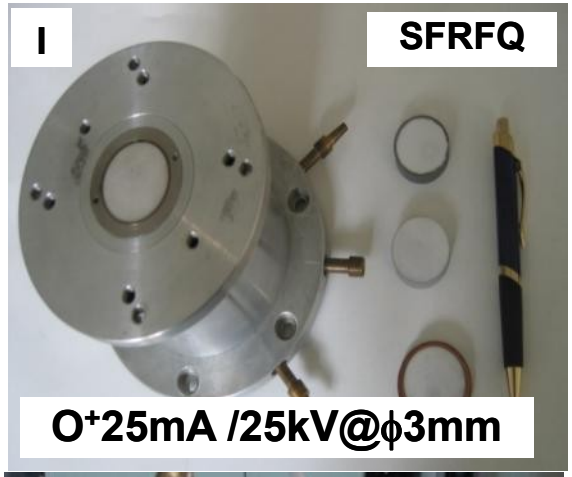
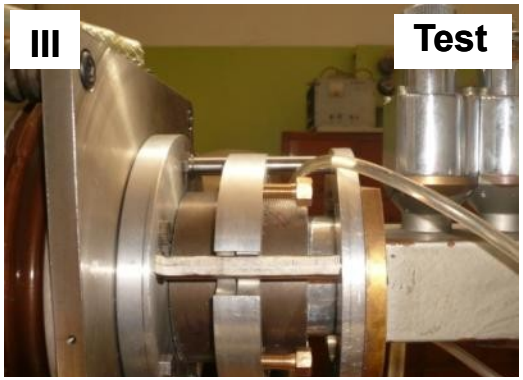
Contents

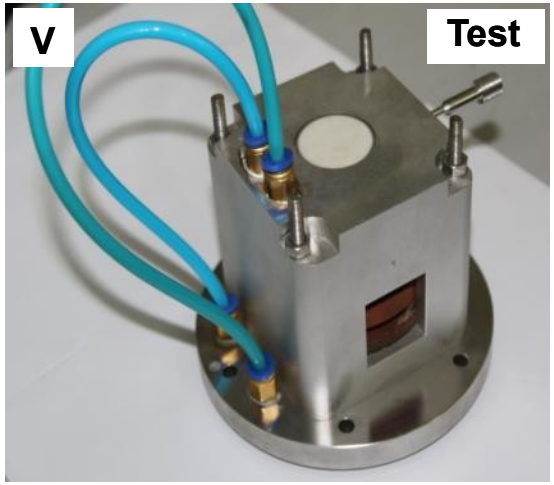
I. Permanent magnet 2.45 GHz ECR ion source at PKU

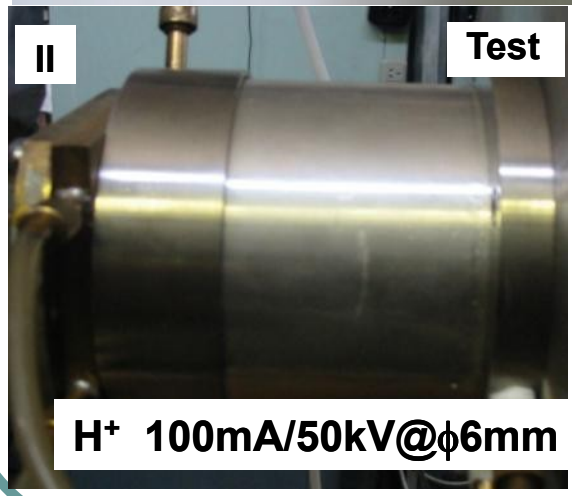


O^+25mA /25kV@ϕ3mm



H^+ 100mA/50kV@ϕ6mm





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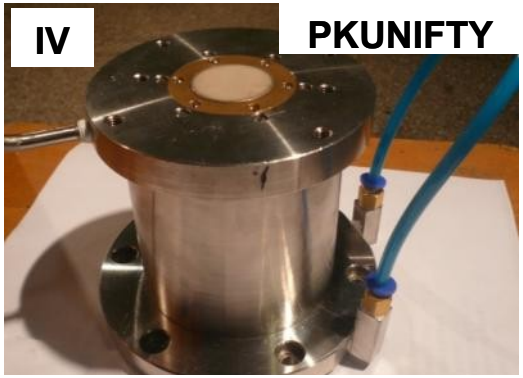
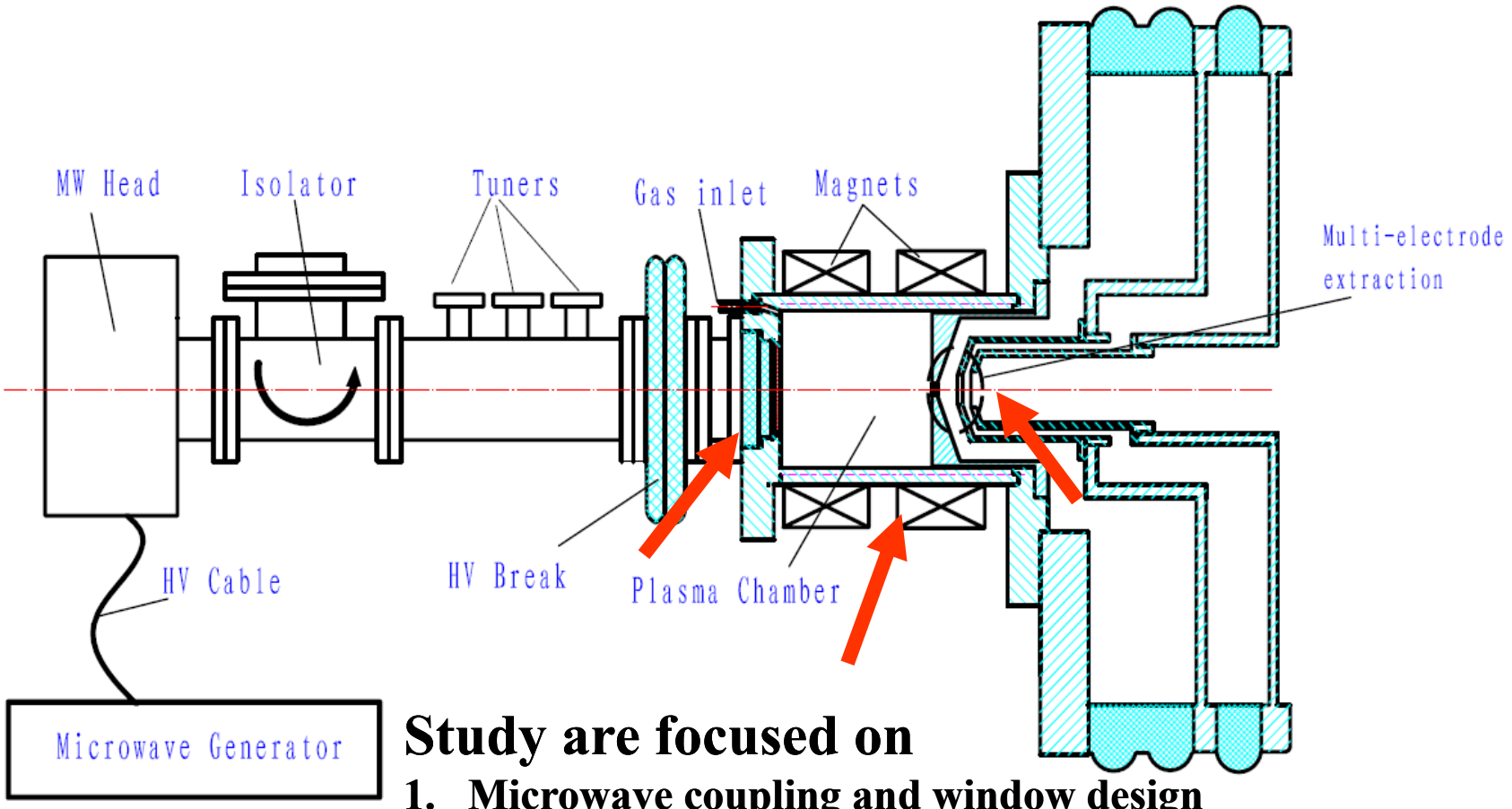


H+ 100mA/50kV@ϕ6mm
D+ 83mA/50kV@ϕ6mm
He+ 40mA/50kV@ϕ6mm

Dimension:

ϕ_{out}: 10 cm/11.5cm
height: 10 cm/11cm
ϕ_{in}: 40 mm/64mm
L: 50 mm/50mm

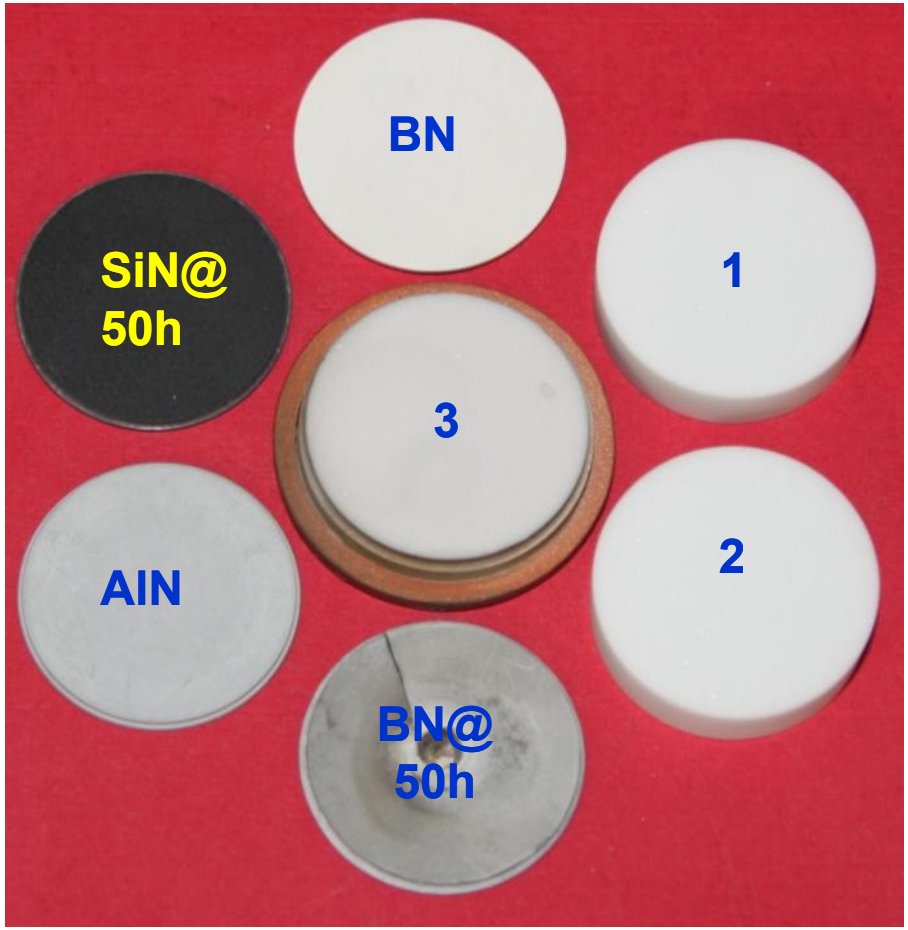
•Structure of PKU Compact Source



Study are focused on

1. **Microwave coupling and window design**
2. **Magnetic field generation and configuration**
3. **Three electrodes extraction system**

•Microwave window and its protection pieces



We have tested

•Ridged waveguide

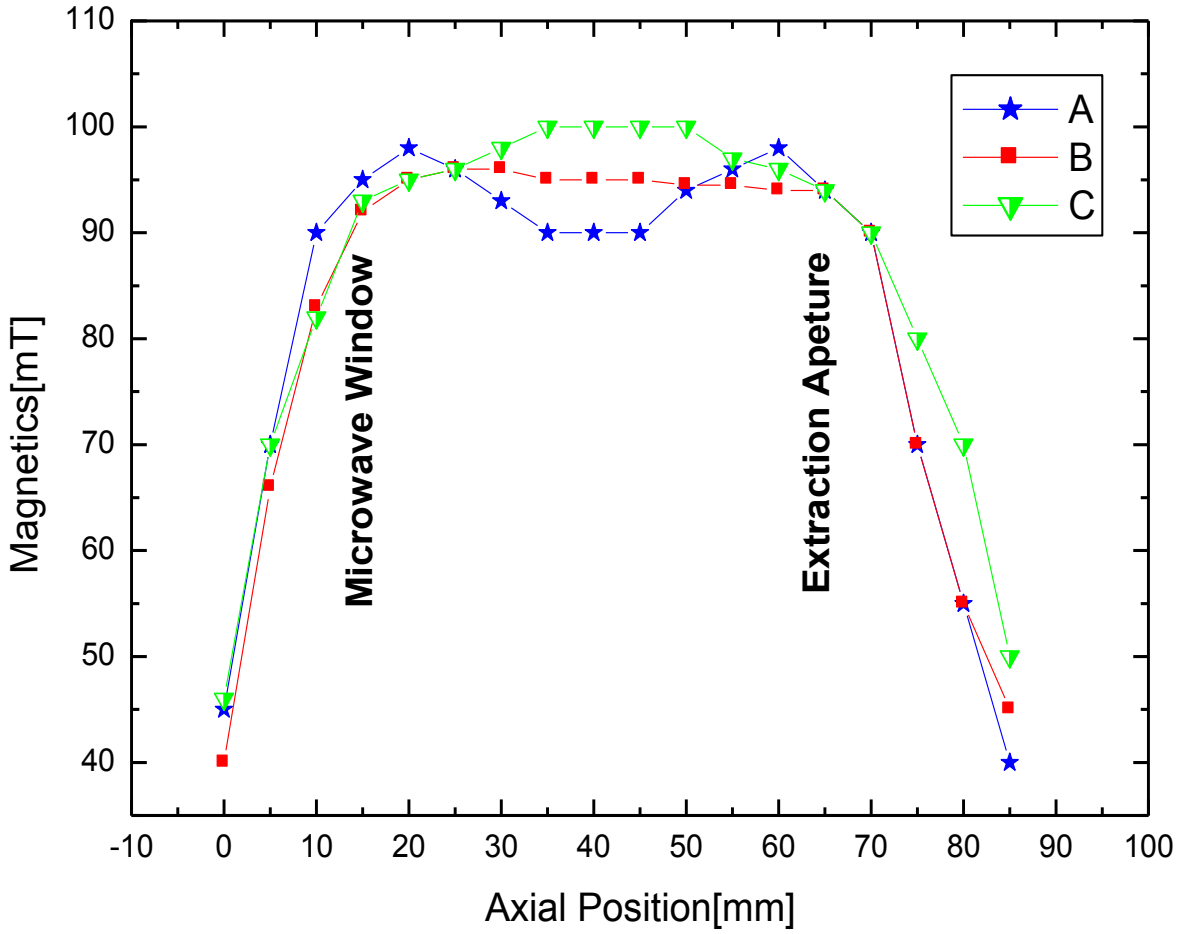
•T-antennae

•Microwave window

Item 1,2,3 form the RF window.

BN, SiN and AlN are used for window protection.

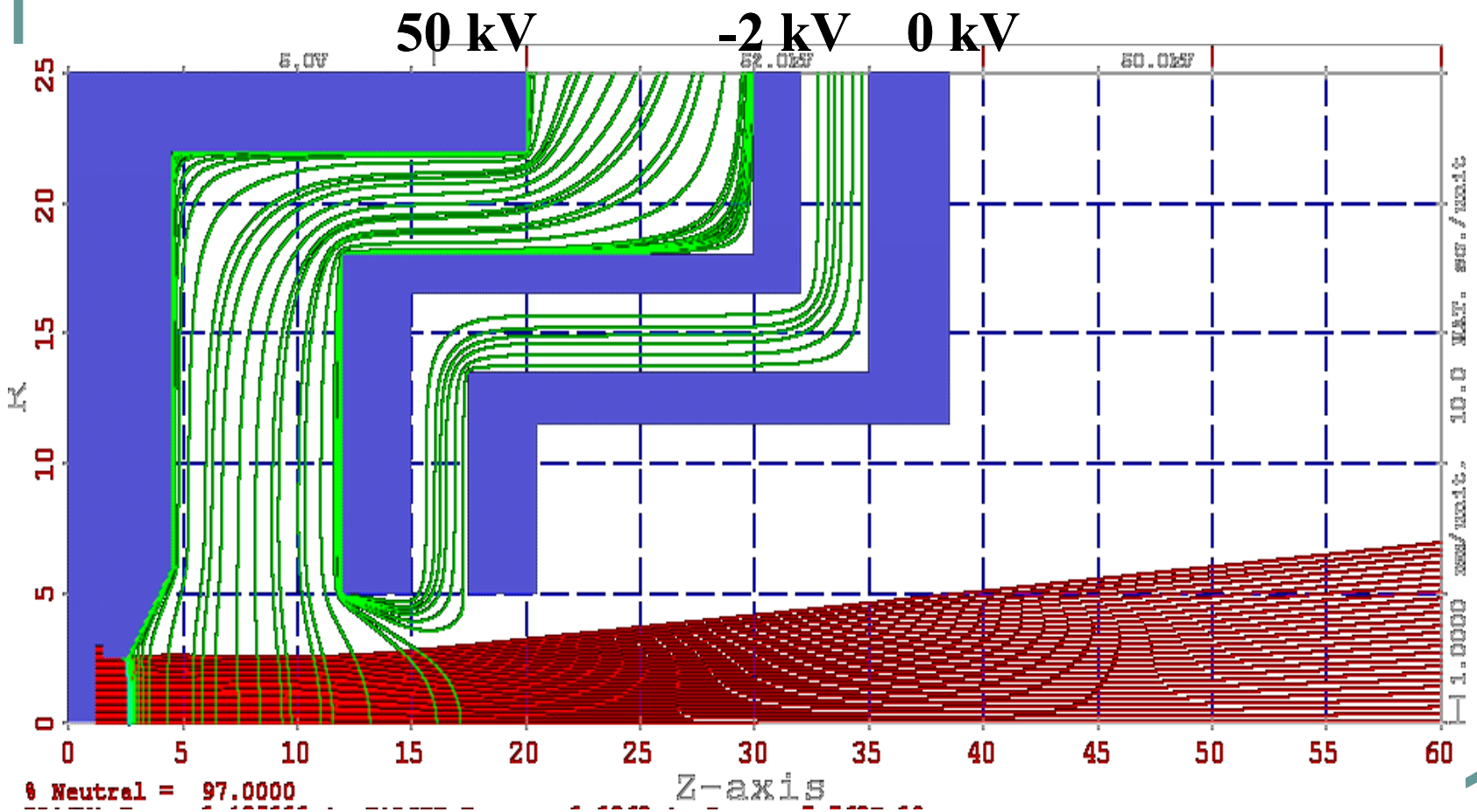
•Magnetic field and its configuration



1. Solenoid
2. Solenoid + Permanent
3. Permanent magnet rings

•Beam extraction system

•Flat (180°) electrodes (original)



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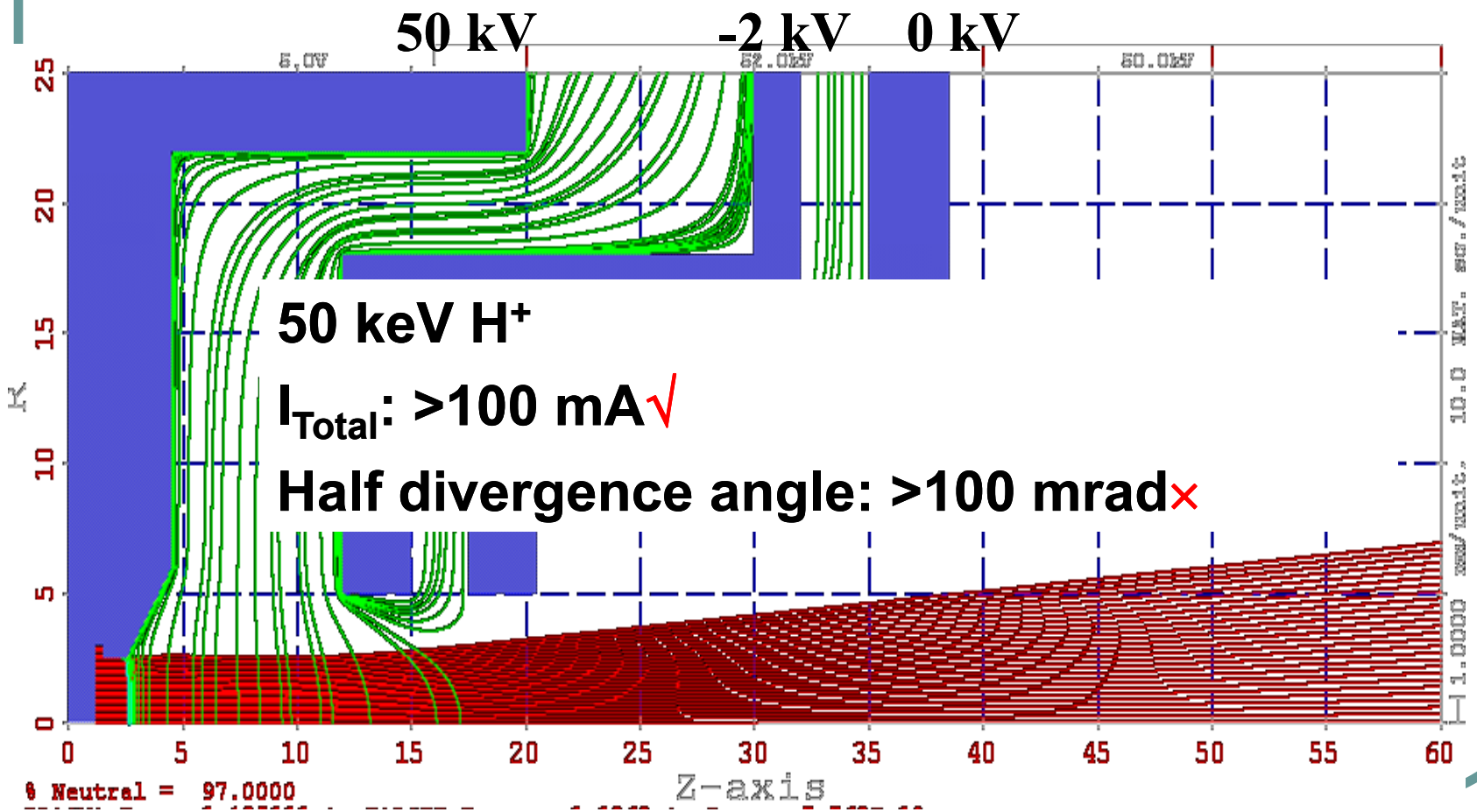

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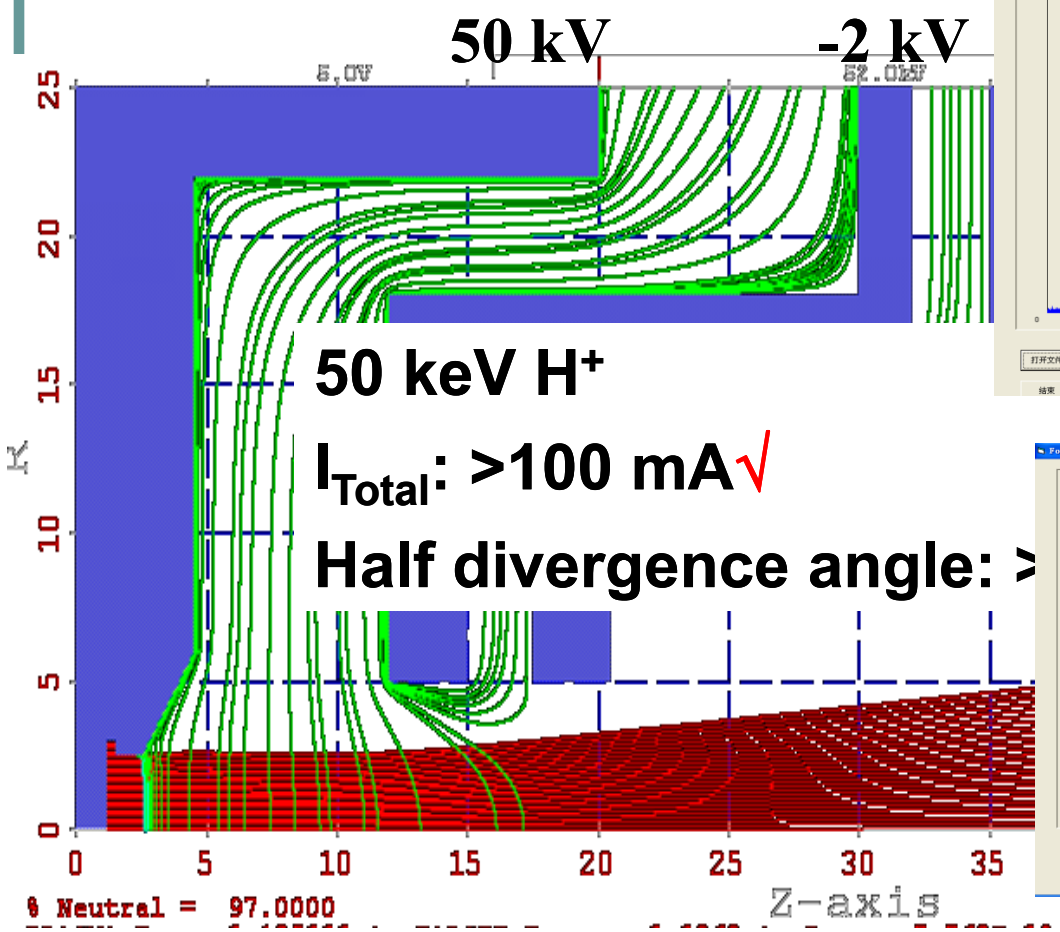
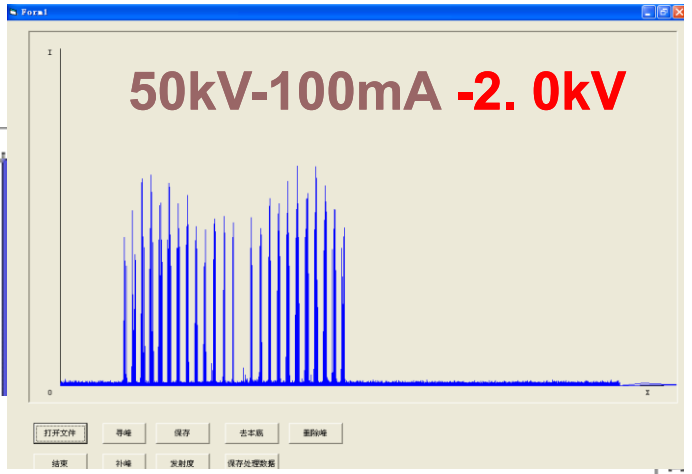
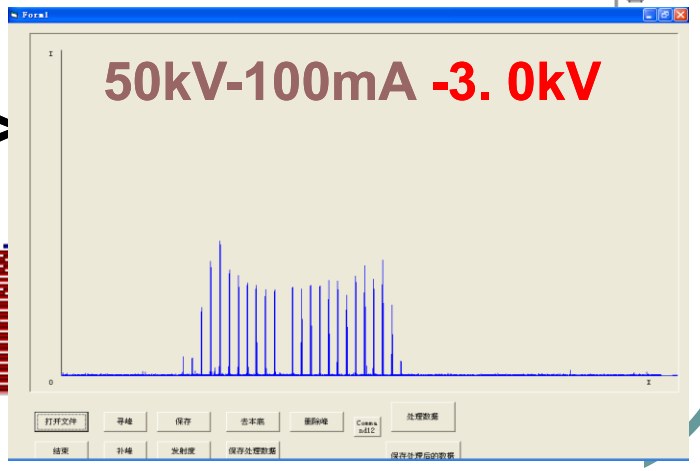
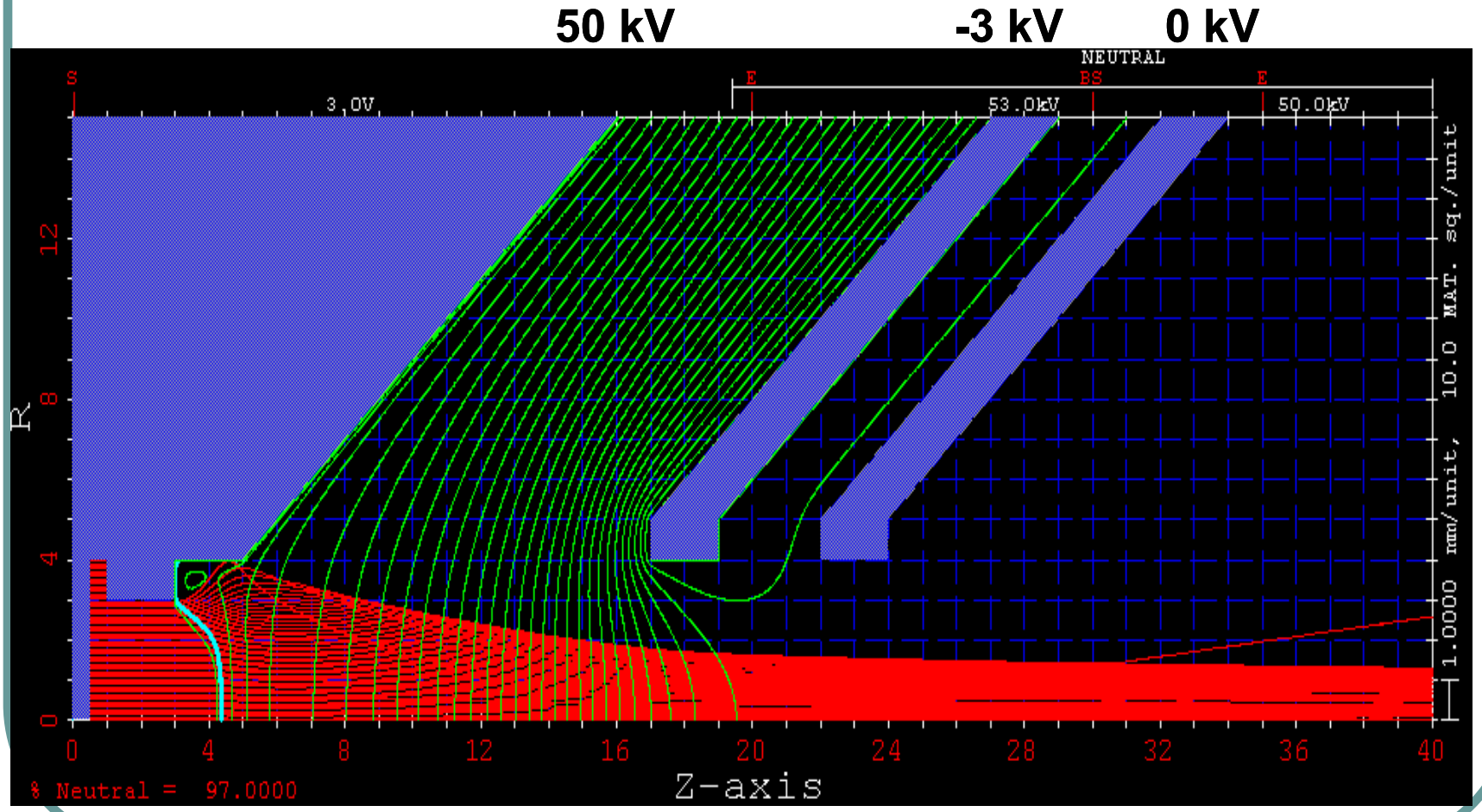






•New 90° electrodes



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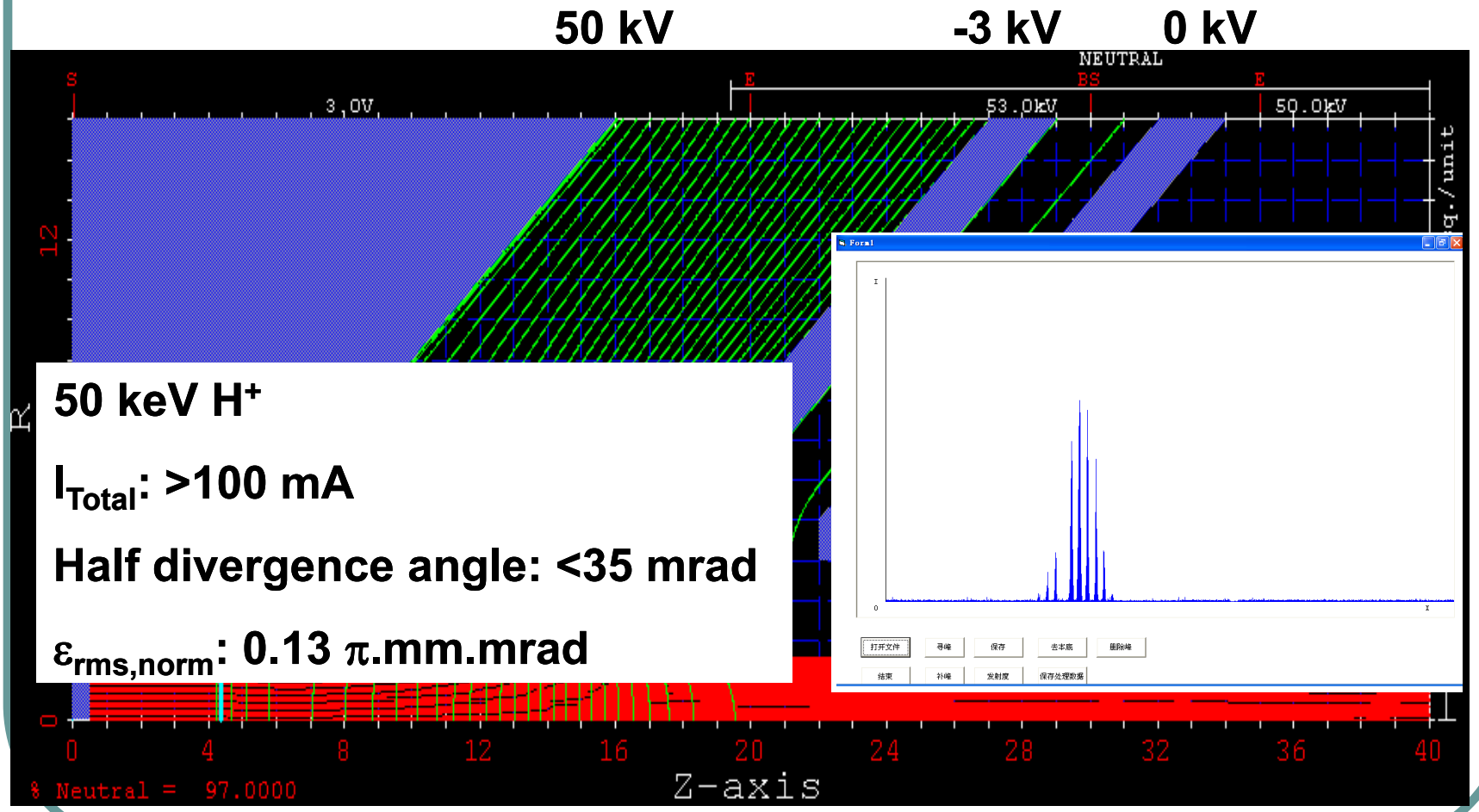


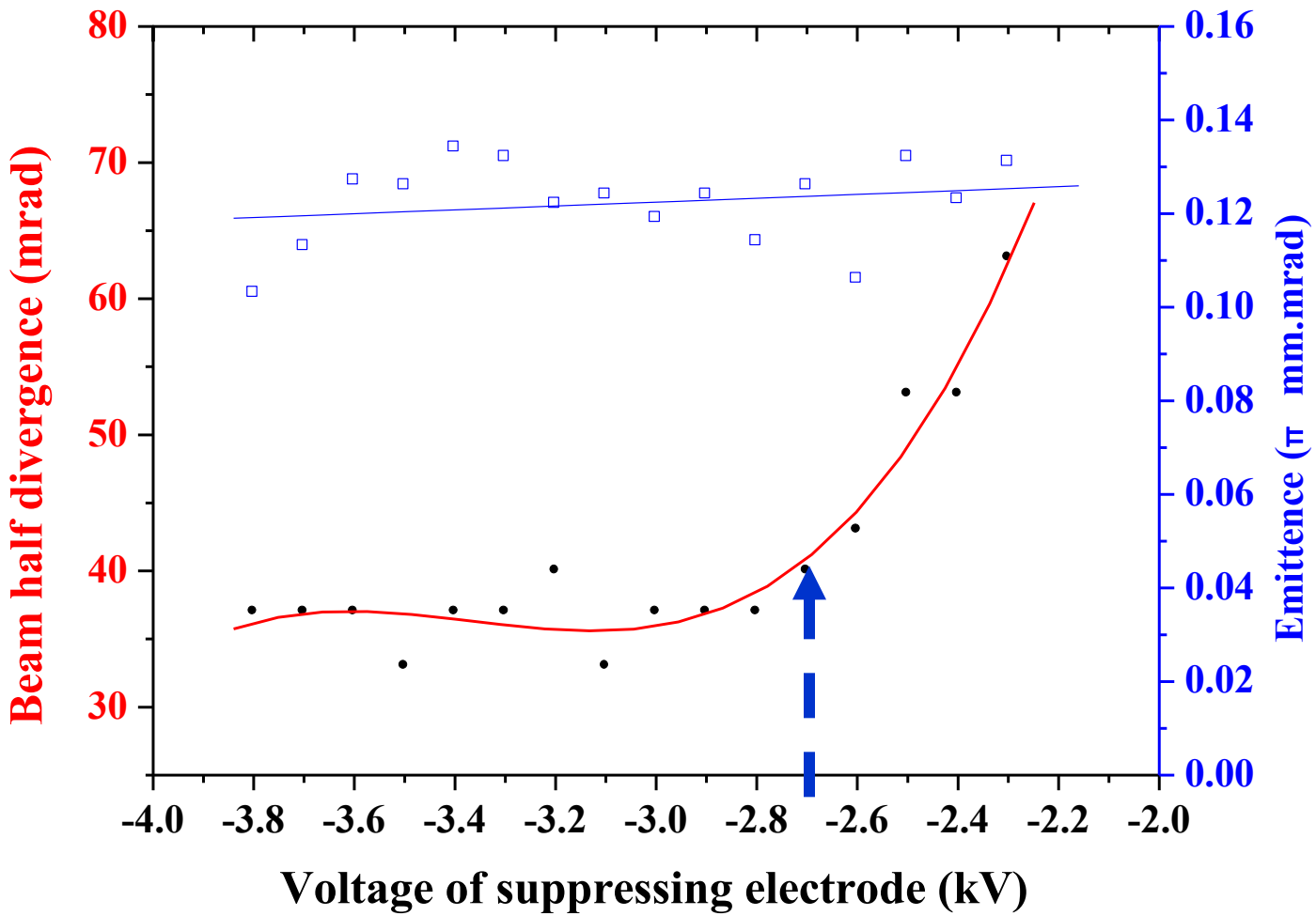
50 keV H^+

I_{Total}: >100 mA

Half divergence angle: <35 mrad

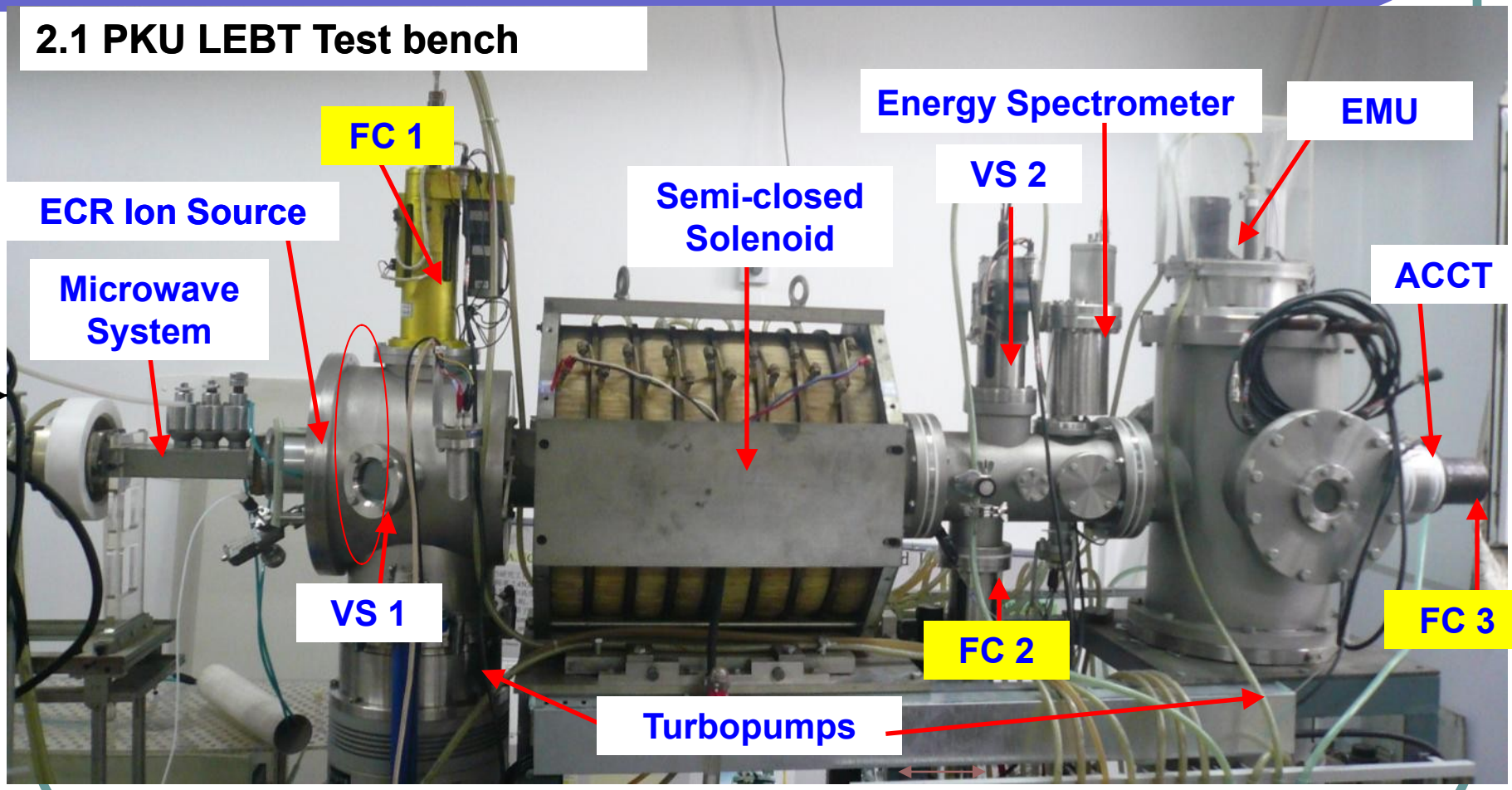
$\varepsilon_{rms,norm}$: 0.13 π.mm.mrad

•The suppressing voltage



II. PKU PM source results

2.1 PKU LEBT Test bench



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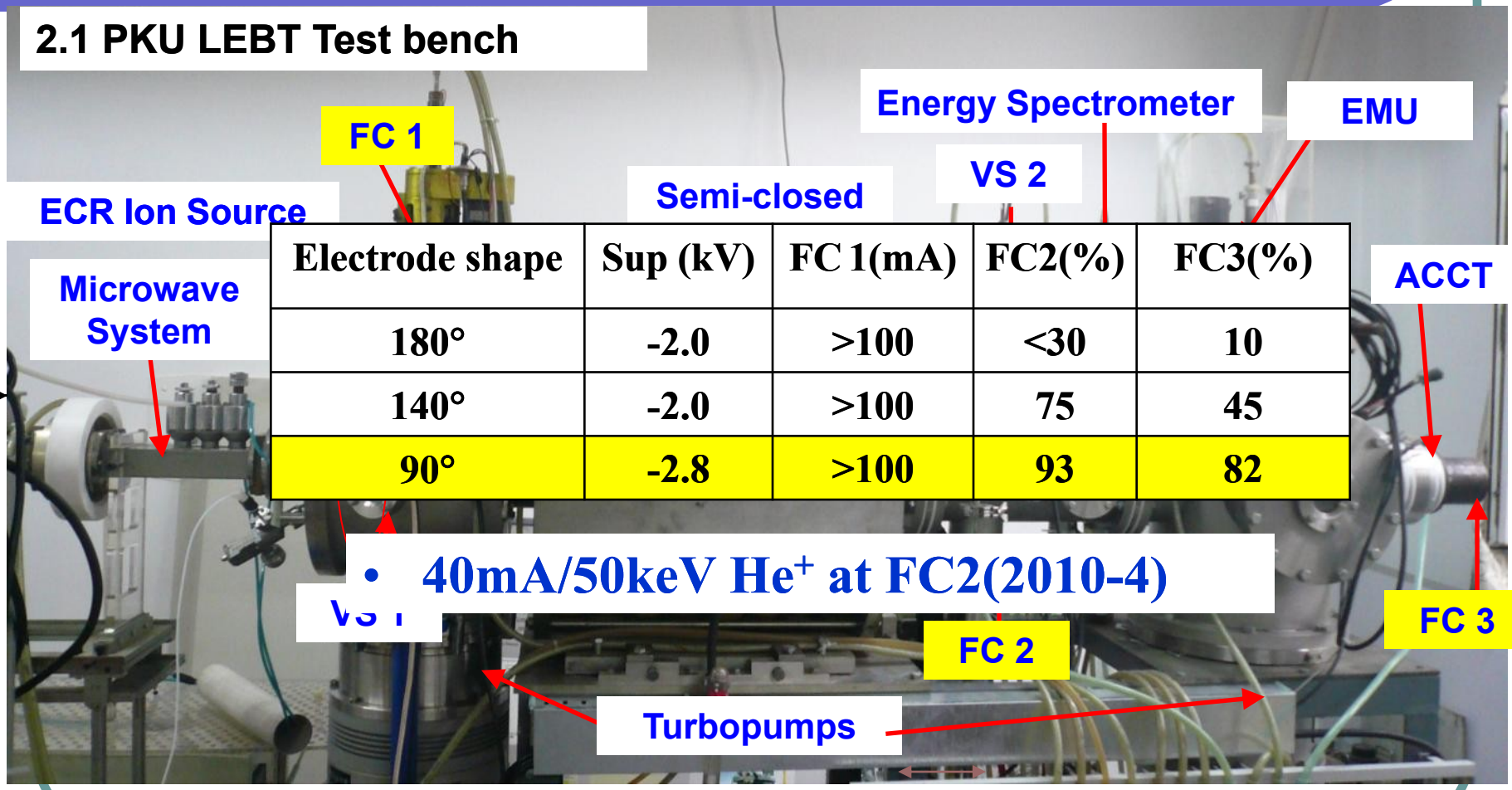
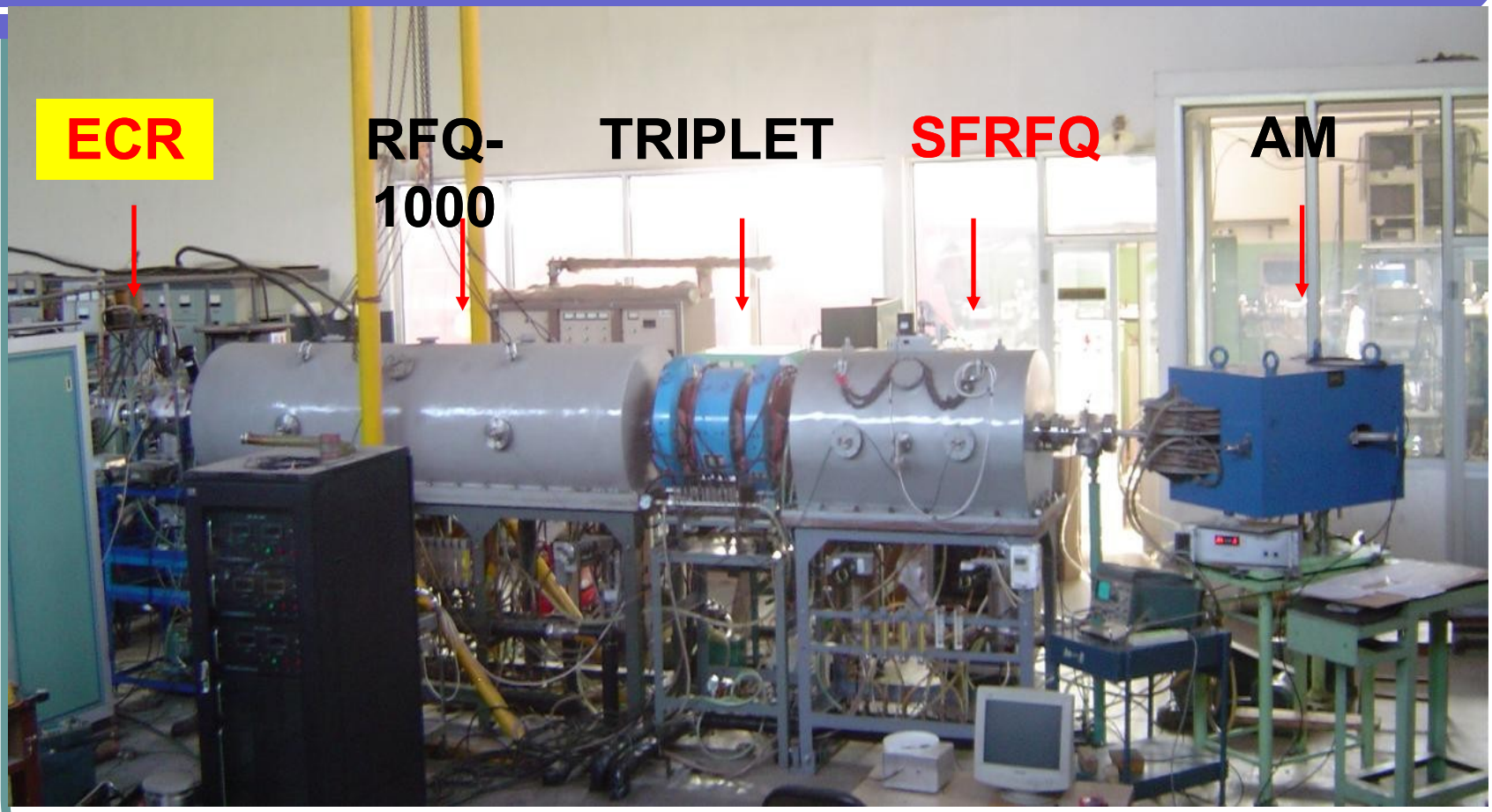


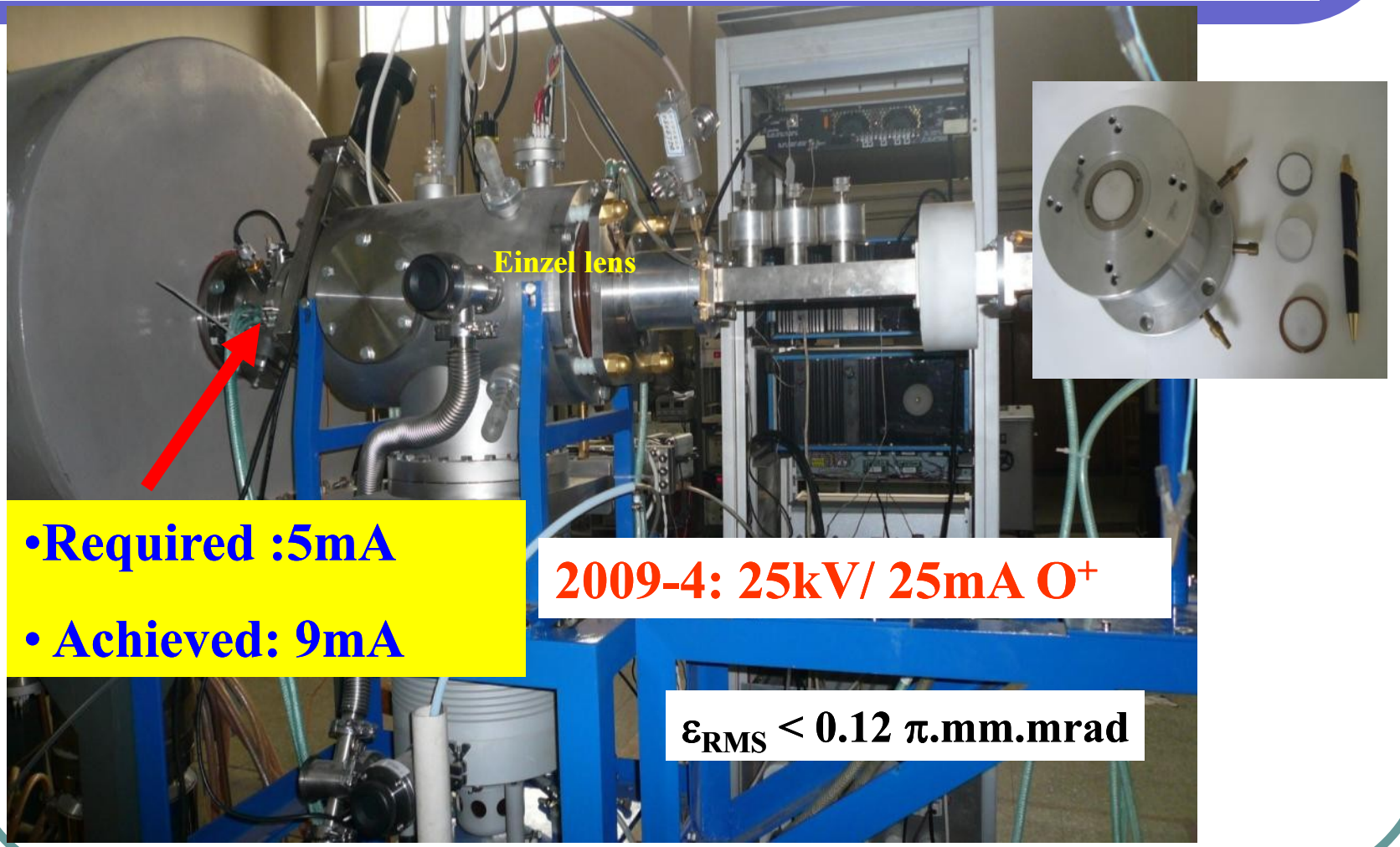
Electrode shape	Sup (kV)	FC 1(mA)	FC2(%)	FC3(%)
180°	-2.0	>100	<30	10
140°	-2.0	>100	75	45
90°	-2.8	>100	93	82

- 40mA/50keV He^+ at FC2(2010-4)

2.2 O^+ LEBT for SFRFQ (Separation function RFQ)



O^+ LEBT

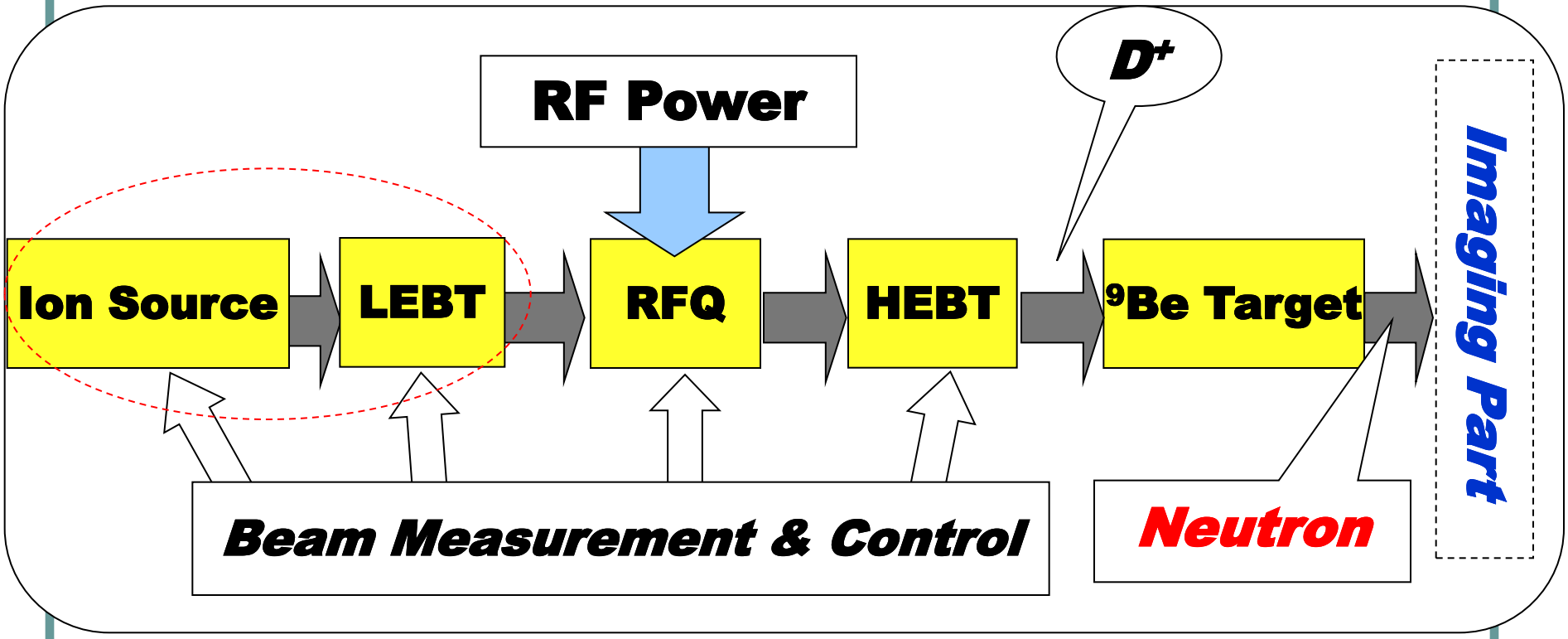


- Required :5mA
- Achieved: 9mA

2009-4: 25kV/ 25mA O^+

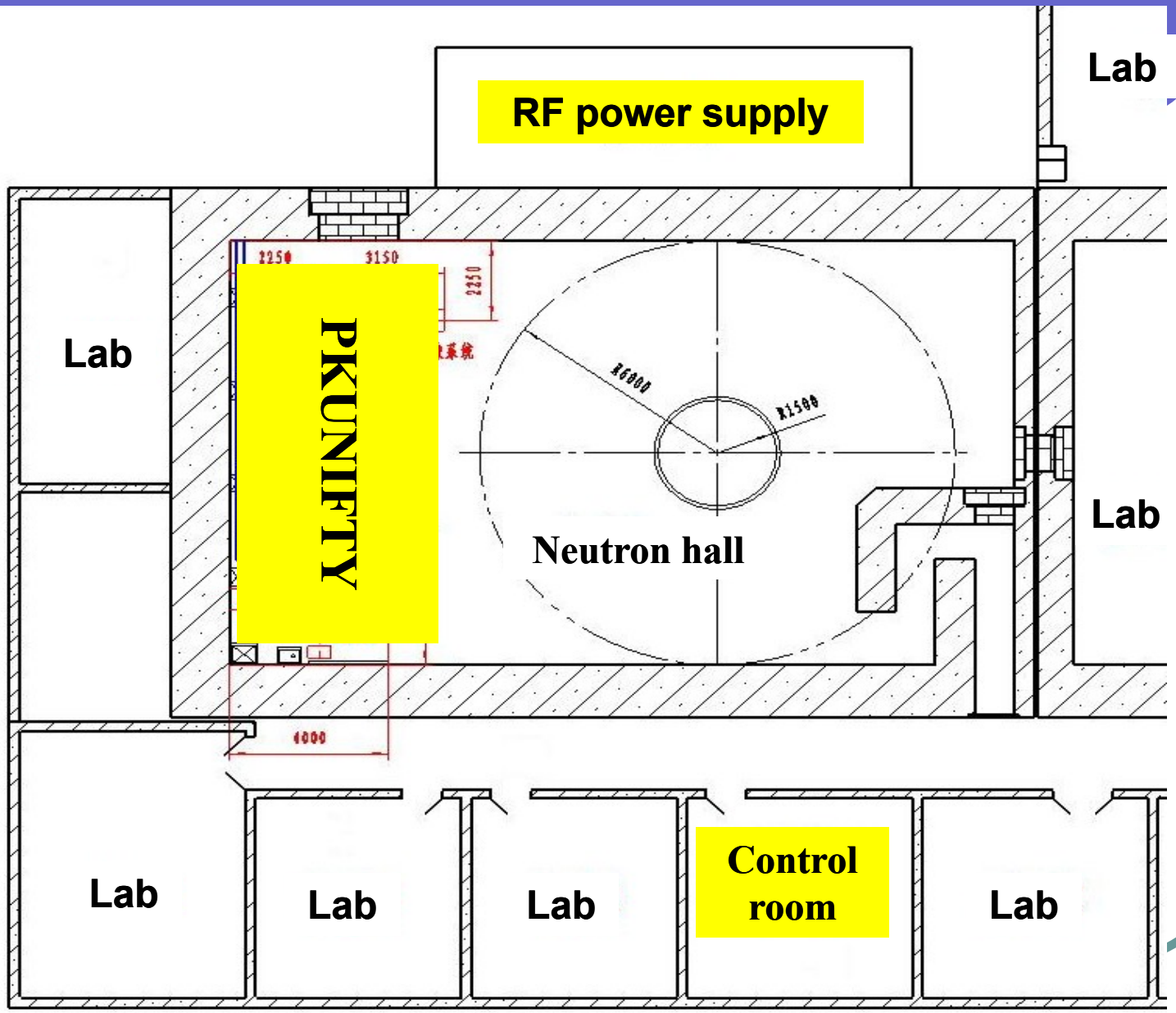
$\varepsilon_{RMS} < 0.12$ π.mm.mrad

2.3. D^+ Injector for PKUNIFTY

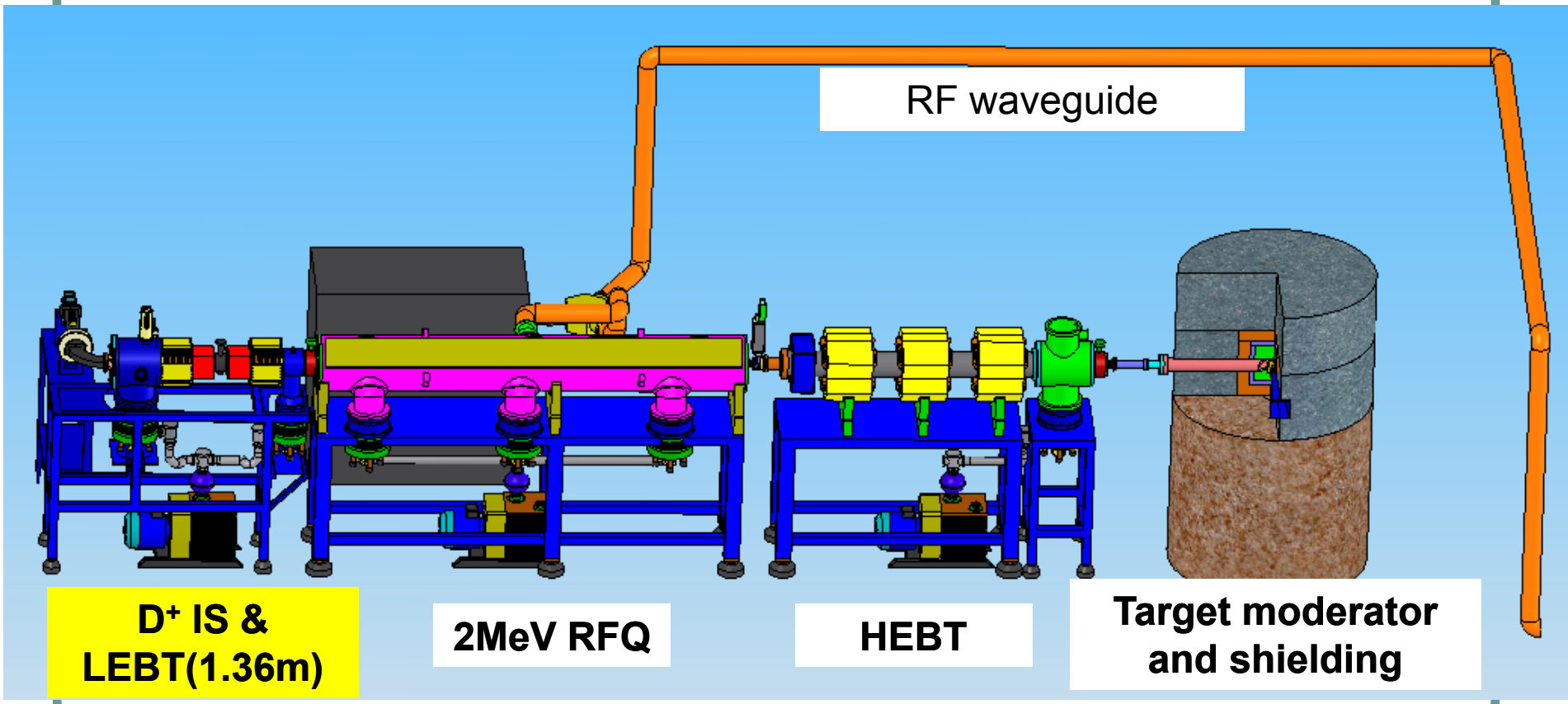


Schematic diagram of PKU 2MeV accelerator-driven neutron source

•Plan view around neutron hall

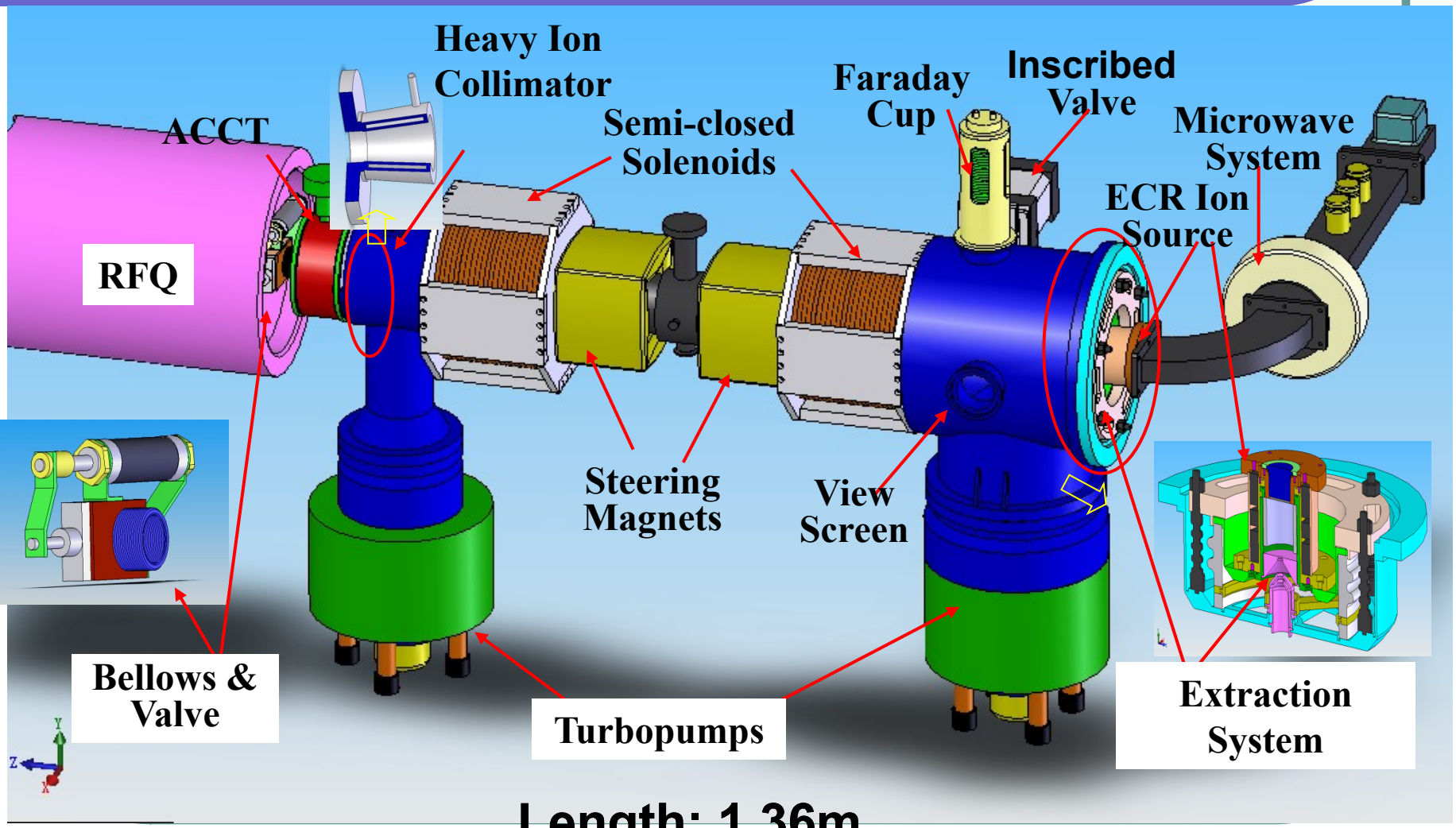


Three-D Schematic diagram of PKUNIFTY



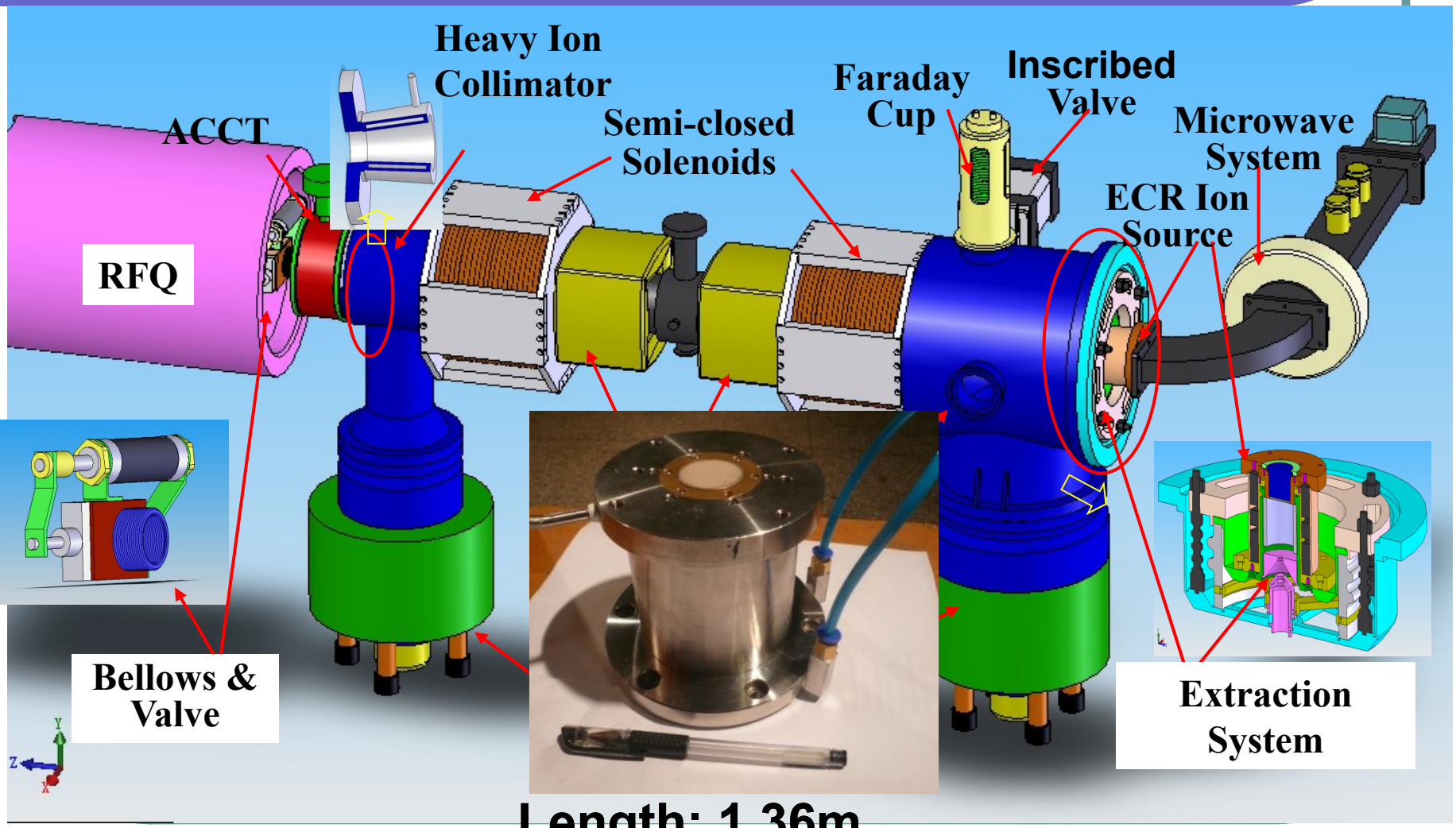
Total length: 8m.

D^+ injector of PKUNIFTY



Length: 1.36m

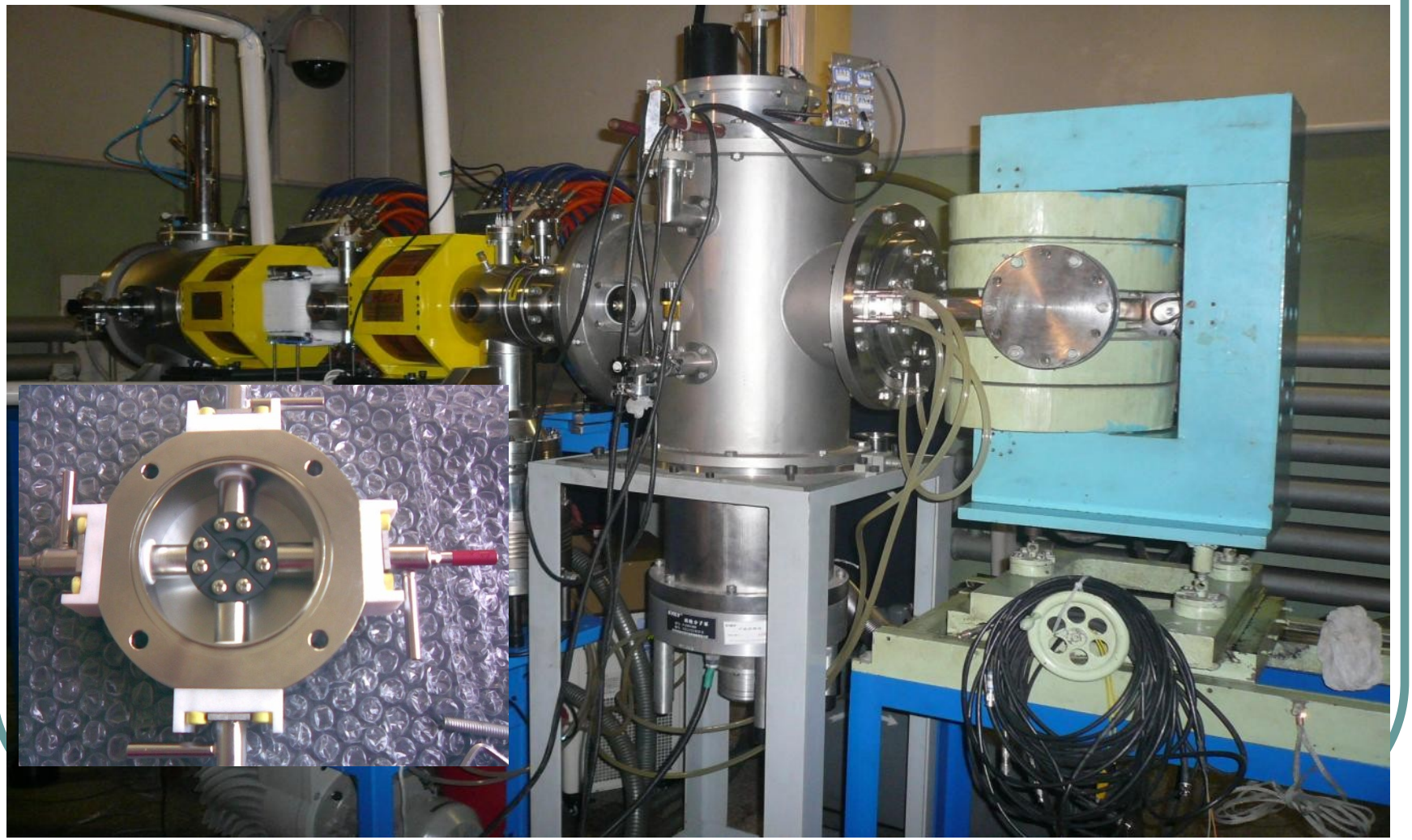
D^+ injector of PKUNIFTY



Length: 1.36m

A photograph of D+ LEBT (from source)

A photograph of D+ LEBT (from RFQ)



On site test on 9th Spet,2009

•Ion Source Commissioning Results

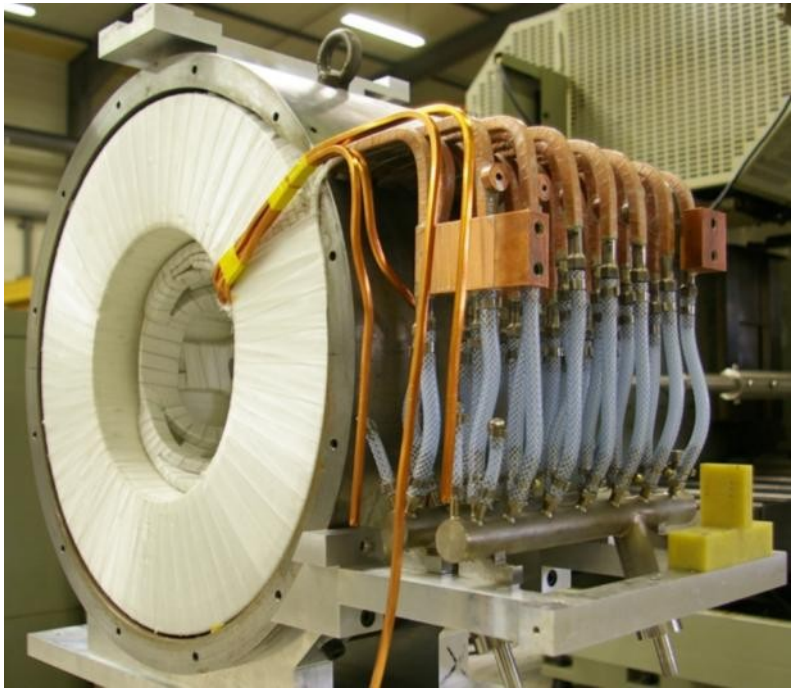
U_{ex}=50 kV, time schedule: τ= 1 ms, f=100 Hz

Ion type	Gas flow (Sccm)	V_{Sup} kV	RF (W)	I_{Total} (mA)	X^+ %	X_2^+ %	X_3^+ %	$\alpha_{1/2}$ mrad	$\varepsilon_{RMS,\ norm.}$ π.mm.mrad
H	1.5	-2.6	170	80	89.7	8.7	1.6	42	0.17
D	1.8	-2.9	210	83	81	13.2	4.2	70	0.18

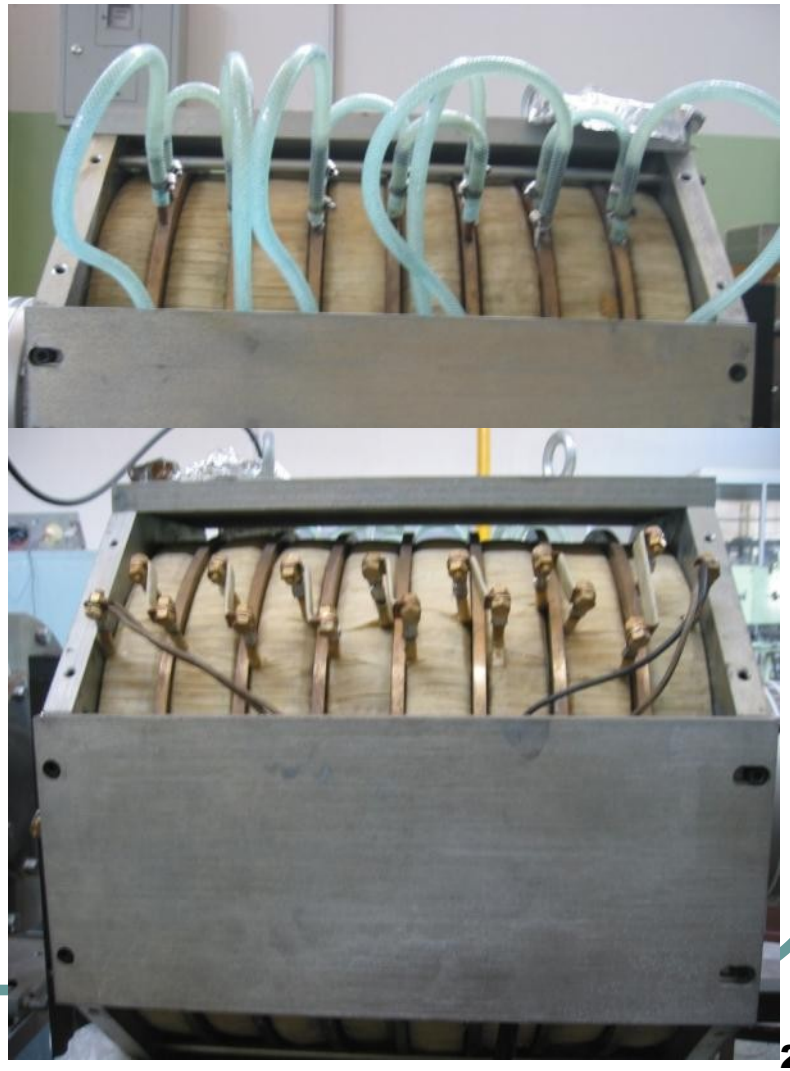
LEBT commissioning

- **Vacuum:** < 10^{-5}Pa after 0.5h
- $I_{RFQ,D+}$: 56mA
- $\varepsilon_{norm,\ RMS}$: 0.12-0.16 πmmmrad
- **Waist shift:** -10mm ~ 10mm
- **Species factor** : D^+: 99.5 %, D_2^+: 0.2 %, others : 0.3 %
- **Neutron flow 0.6m away from the target**: 15μSv/h

Some words on LEBT solenoid

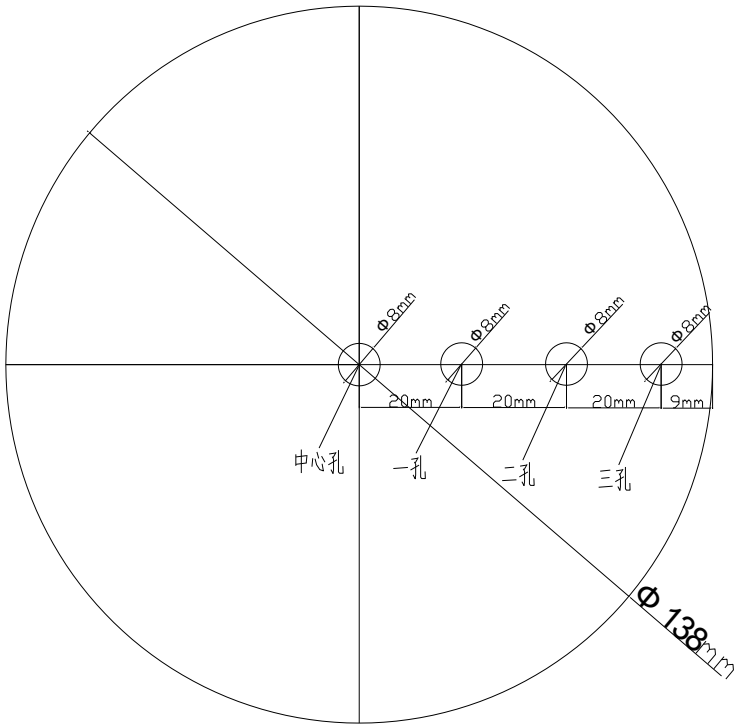


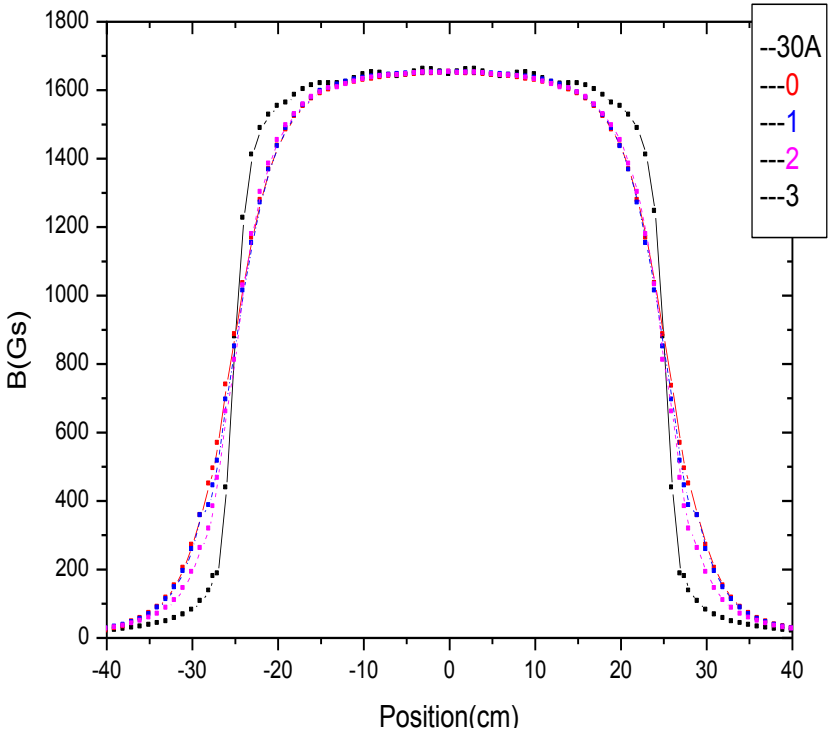
Full-closed type(CEA/Saclay)



Semi-closed type

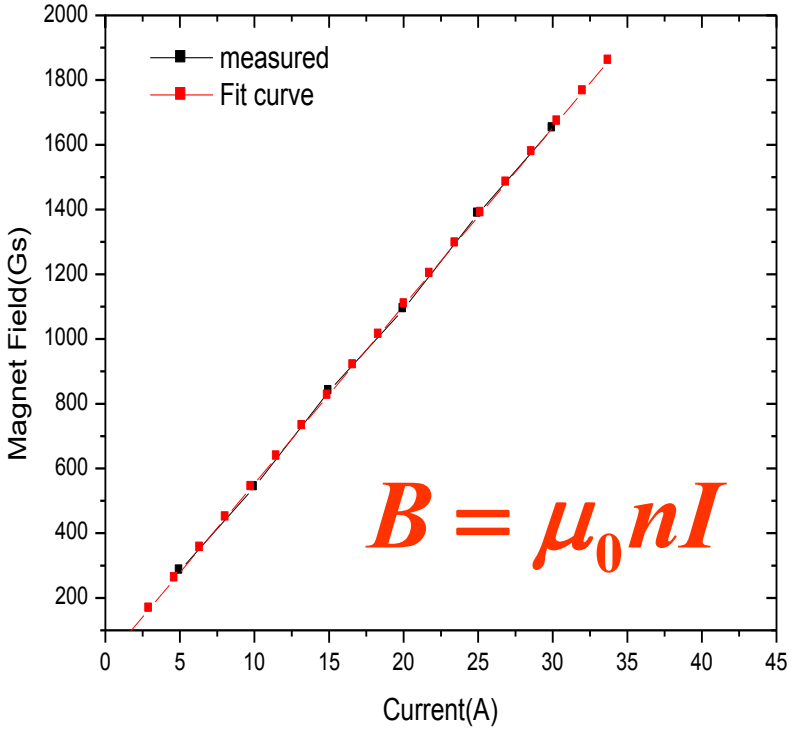
Measurement results

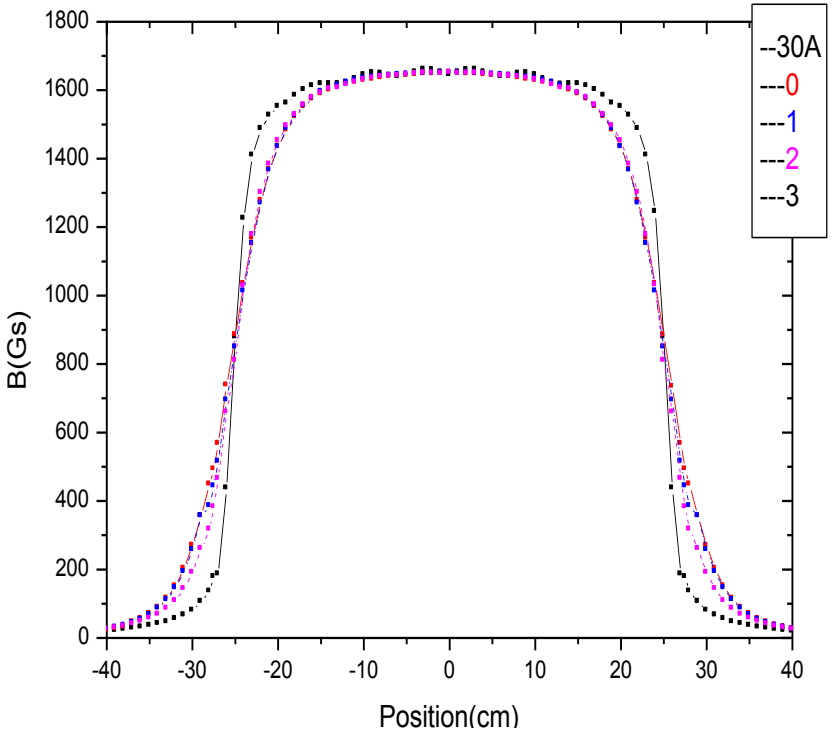




Shixiang Peng, Jifeng Yan, Jinxiang Yu, and Zhiyu Guo, A simple ferromagnetic circuit for a solenoid lens. *Meas. Sci. Technol.* **18** (2007) ：N5–N8

Measurement results





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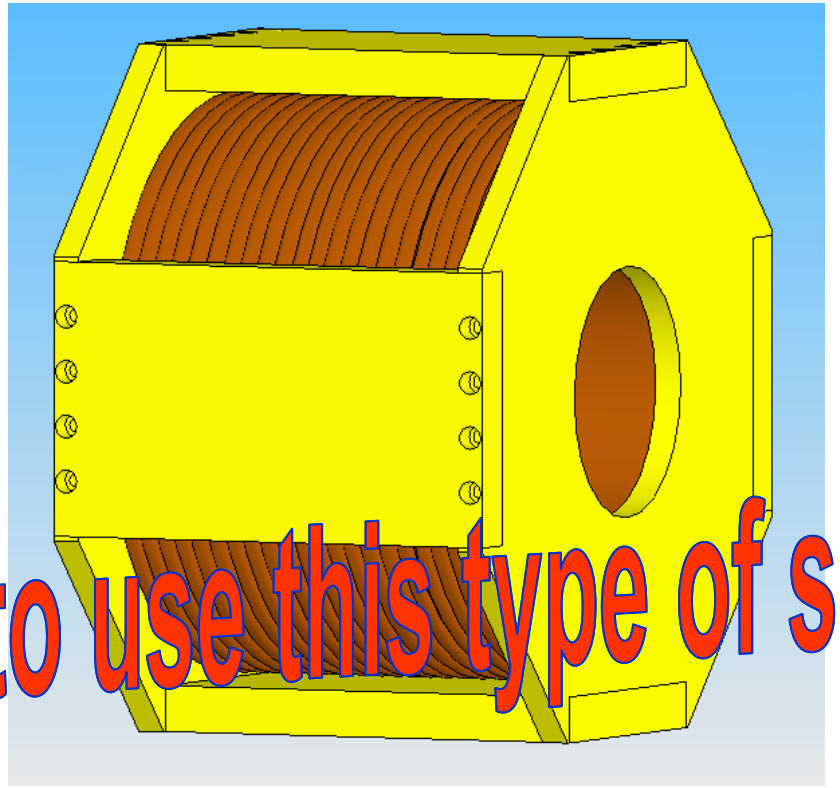
•Solenoids for PKUNIFTY

L: 200mm

ϕ_{in}: 110mm

ϕ_{out}: 300mm

B_{max}: 0.65 T



Please try to use this type of solenoid!

•Simple structure, easy to fabrication and Cost lower!!

III. Conclusion

1. The PKU ECR ion source is focused on compact Permanent magnet type without ridged waveguide.
2. Currently 100 mA of H^+ ion, 40 mA of He^+ ion, 10 mA of N^+ ion were produced for several years with good performance in term of reliability, stability, beam noise, emittance in pulsed mode on the test bench.
3. More than 25 mA/25 keV O^+ ion was delivered to 1MeV RGQ for SFRFQ project.
4. Up to know more than 83 mA/50 keV D^+ was produced for PKUNIFTY project.

To conclude, the compact permanent magnet ECR mono-charged ion sources are really powerful and efficiently fit in with the high current accelerators requests.

Thank you for you attention!

感谢您的关注！

Je vous remercie de votre attention ！