The development of the Separated Function RFQ accelerator at Peking University

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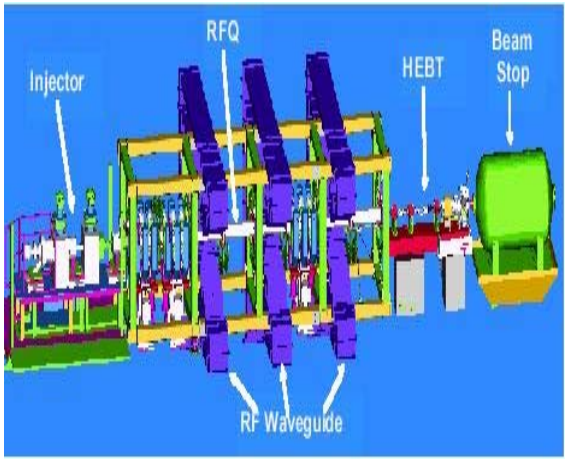
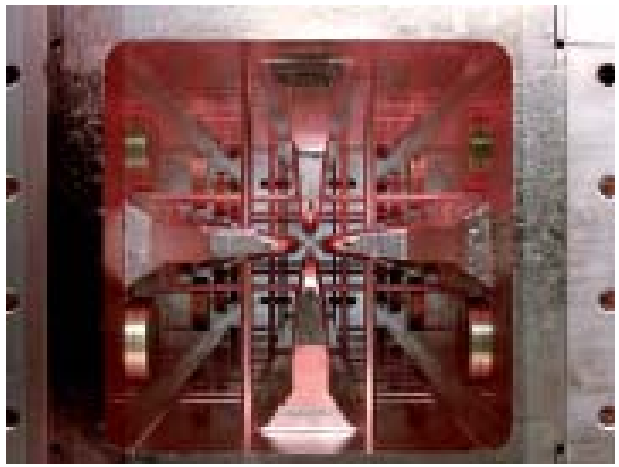
Outline

- What is Separated Function RFQ?
- SFRFQ Prototype cavity
- RF power test
- Preparation for Beam test
- Future plan

RFQ accelerator in the world

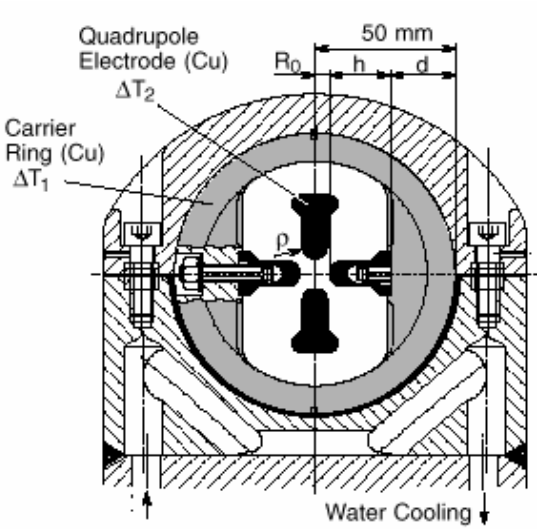


LEDA RFQ

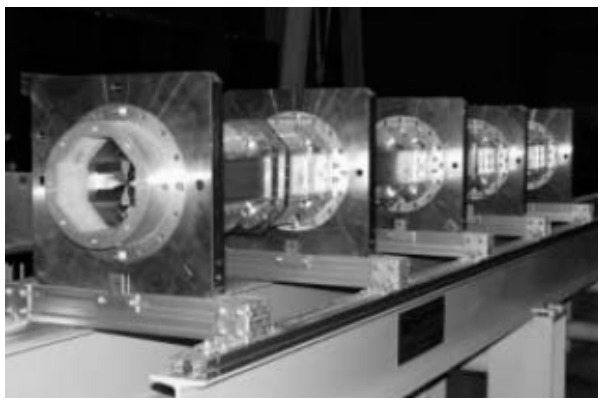


SNS RFQ

ISAC RFQ



IH RFQ



KOMAC RFQ Cold Model

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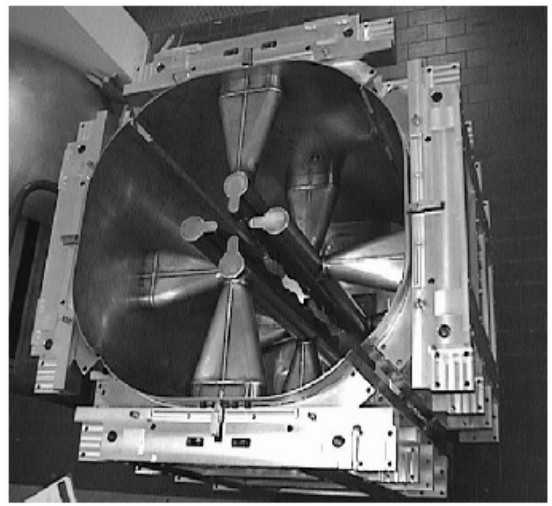


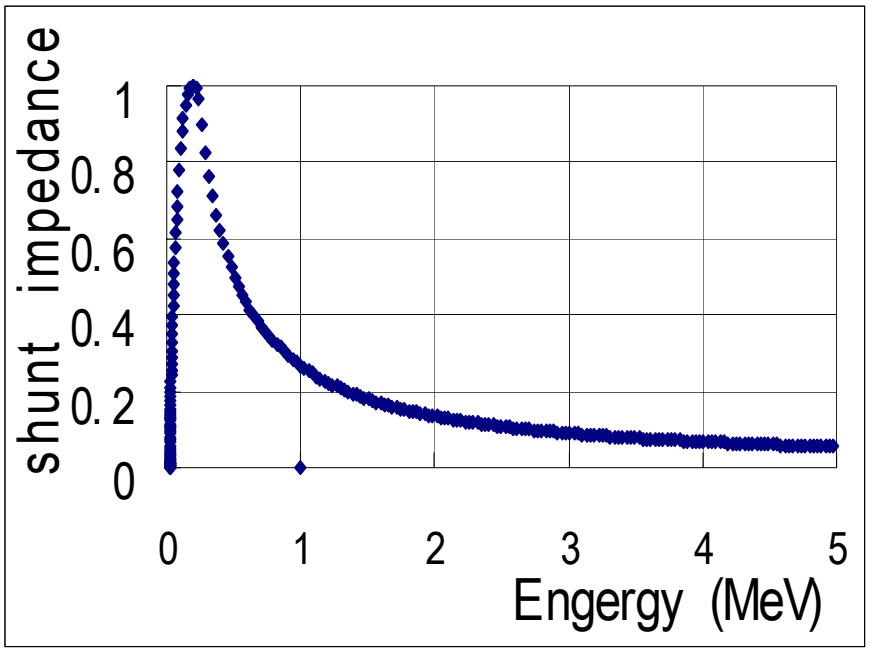
INFN SRFQ2

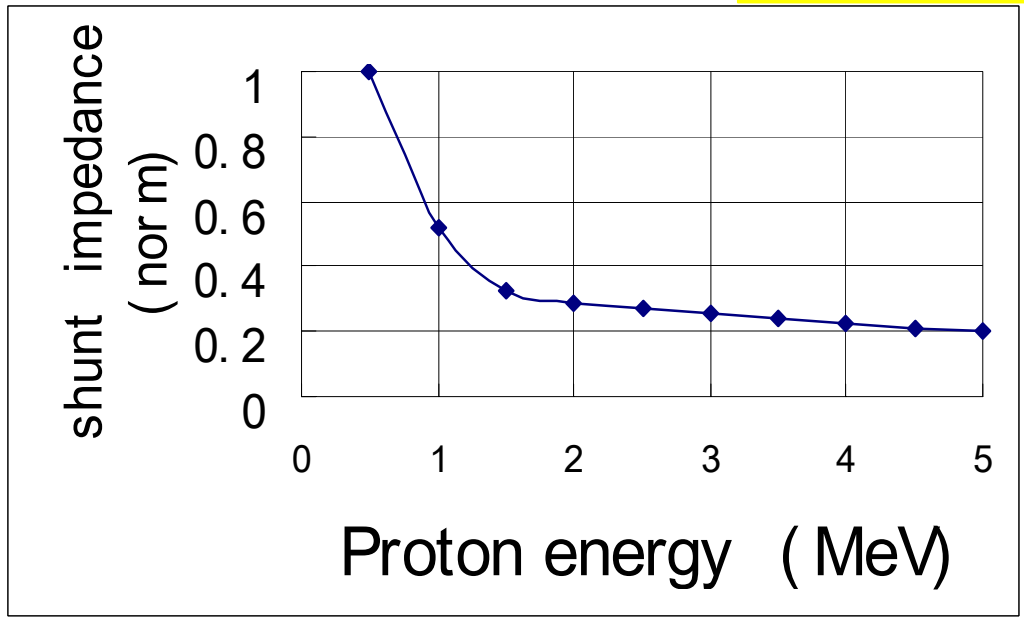
ISR RFQ -1000

Ions	**:**	**N+、O+**
Freq	**:**	**26MHz**
Energy	**:**	**1 MeV**
$I_{peak.}$	**:**	**2mA**
Duty Factor	**:**	**16.7 %**
Q_0	**:**	**3400**
ρ	**:**	**522 kΩ.m**
RF Power	**:**	**24 KW**

Shunt impedance versus energy

$$Z_0 = \frac{E_0^{\,2}}{\frac{P_{Cu}}{l_T}}$$



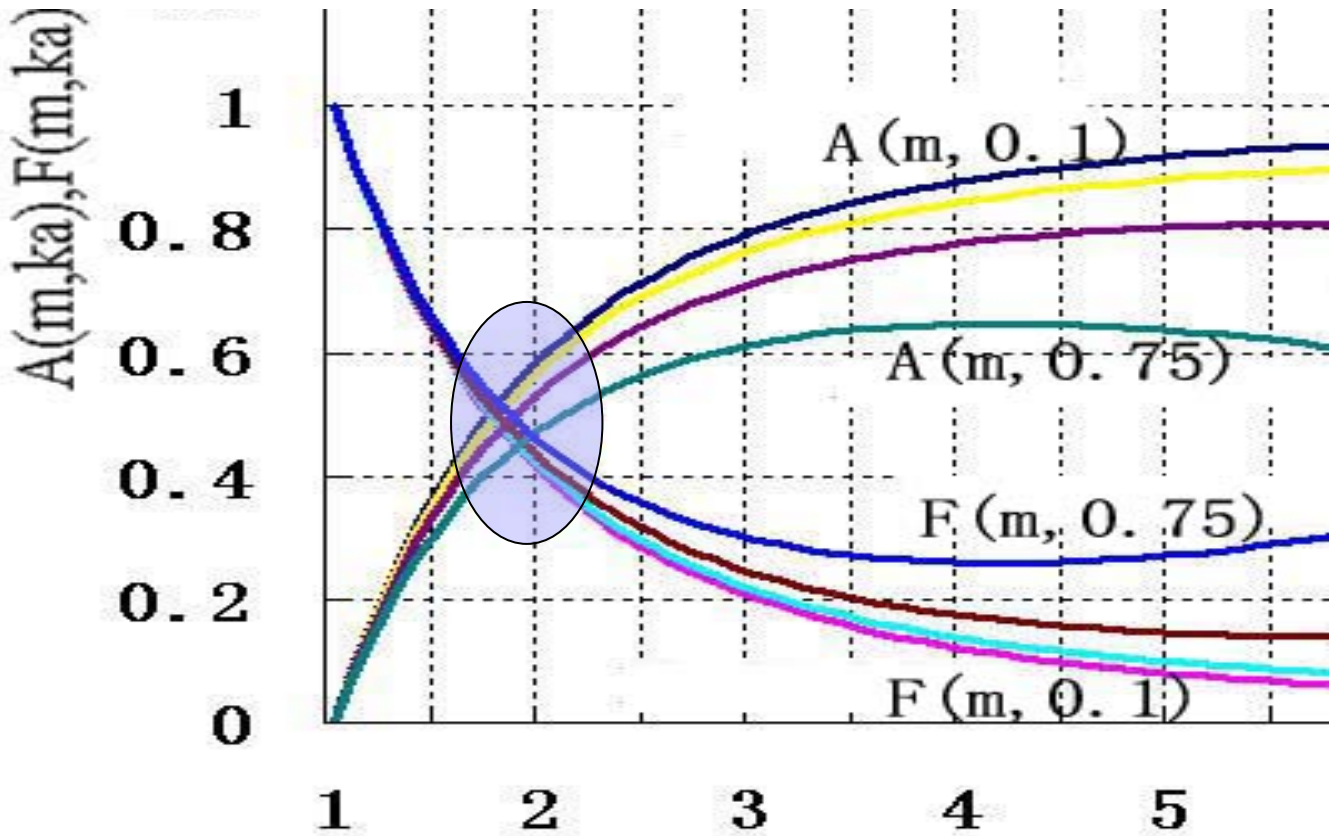


RFQ-1000 operated at 26 MHz

A proton RFQ operated at 600 MHz

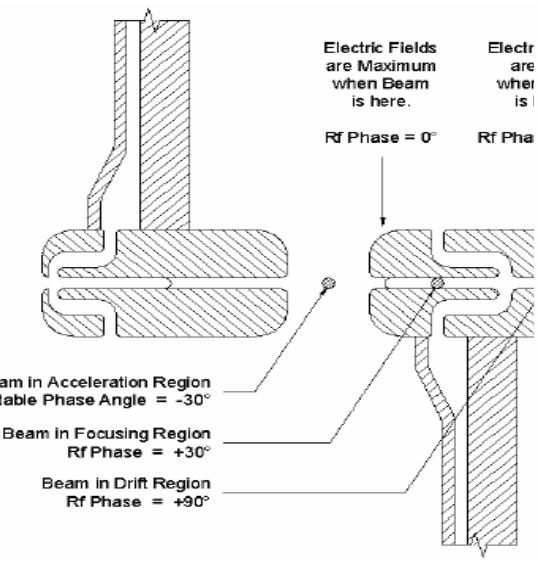
Acceleration efficiency is limited in a RFQ accelerator

- ✓ **A+F ≈1** (A~0.5 , F~ 0.5)

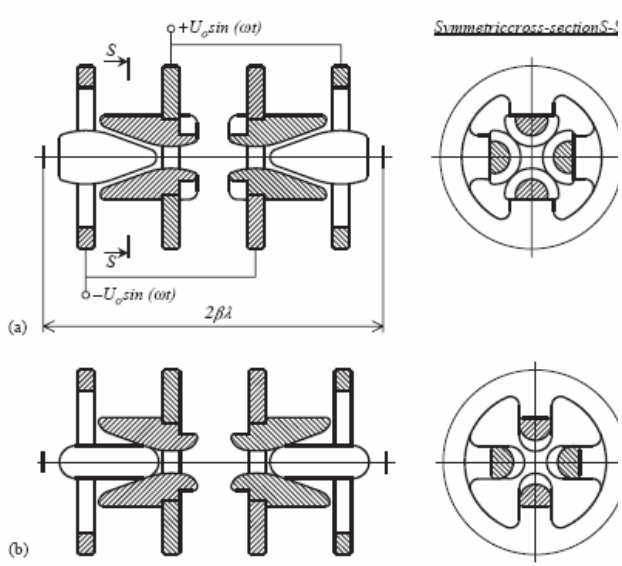


Some novel accelerators

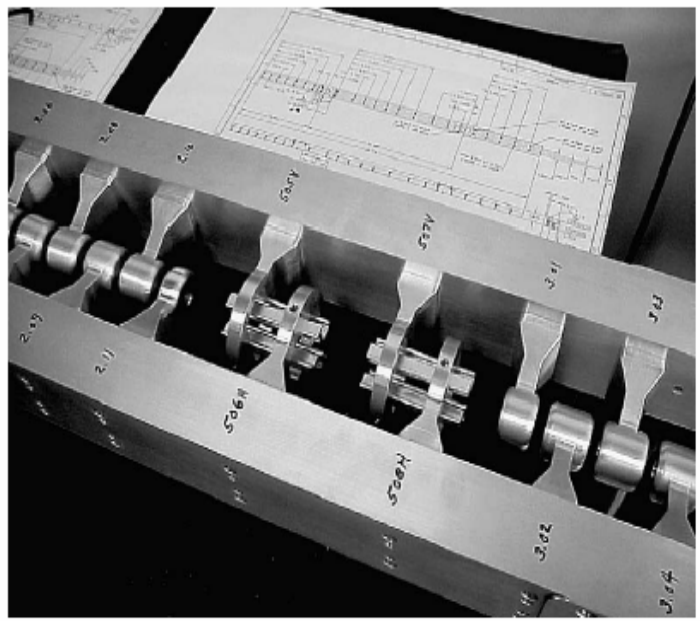
- The drift tube structure has higher acceleration efficiency
- Introducing accelerating gaps into RFQ is attractive for some applications.



RFI/RFD

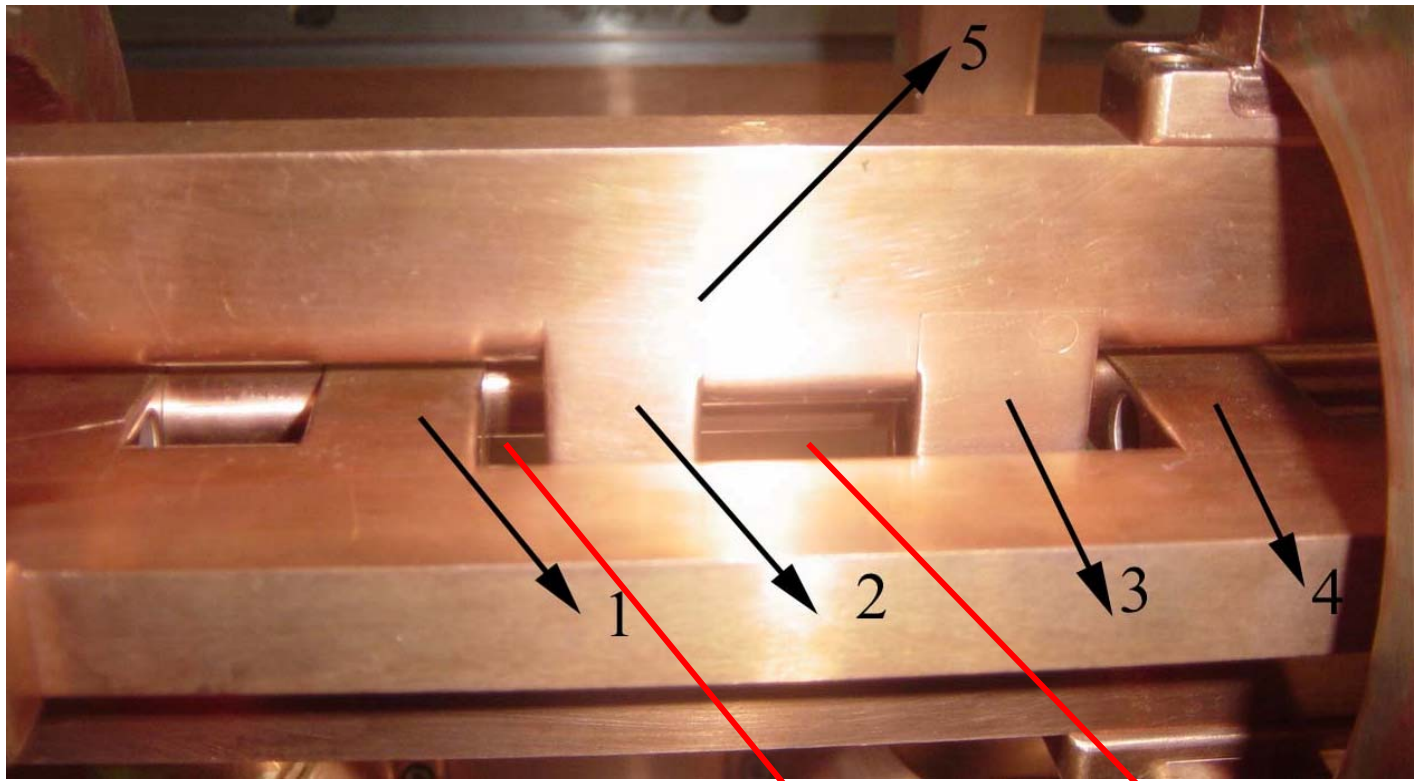


SP-RFQ



H-RFQ in ANL

Seperated Function RFQ(SFRFQ)

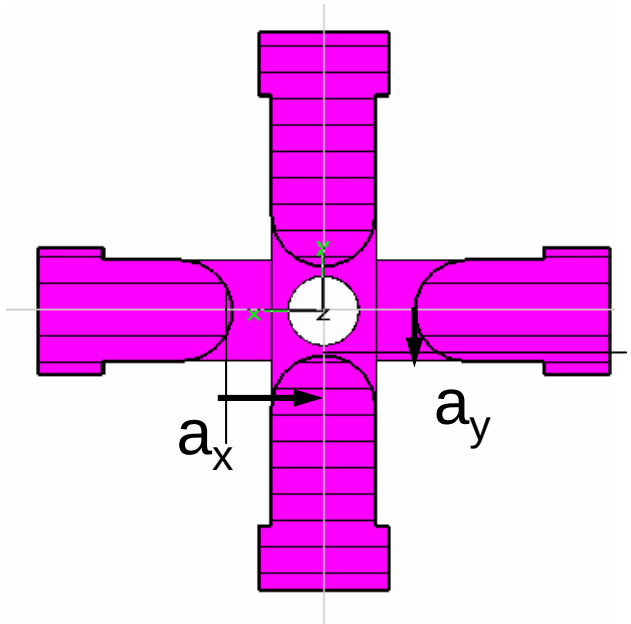


(1,2,3&4 diaphragms, 5 RFQ electrode)

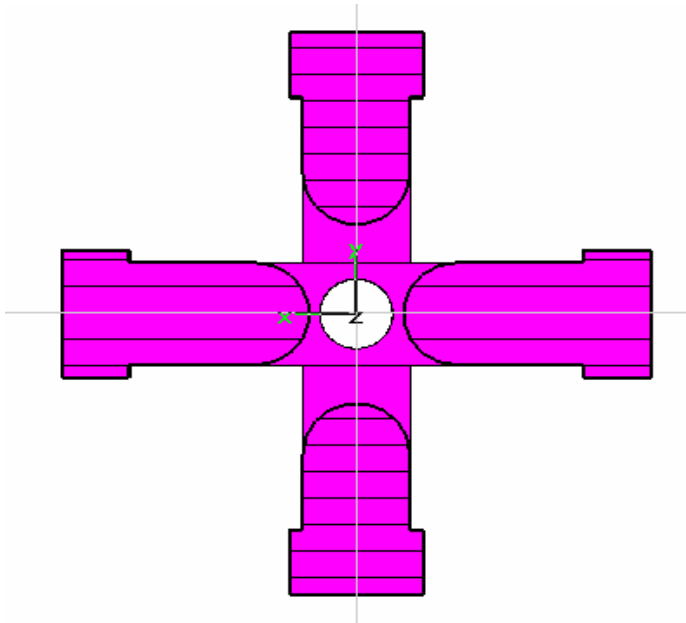
Acceleration gap Quadruple

Field sparking is a Challenge

- Asymetrical quadruple



$a_x > a_y$

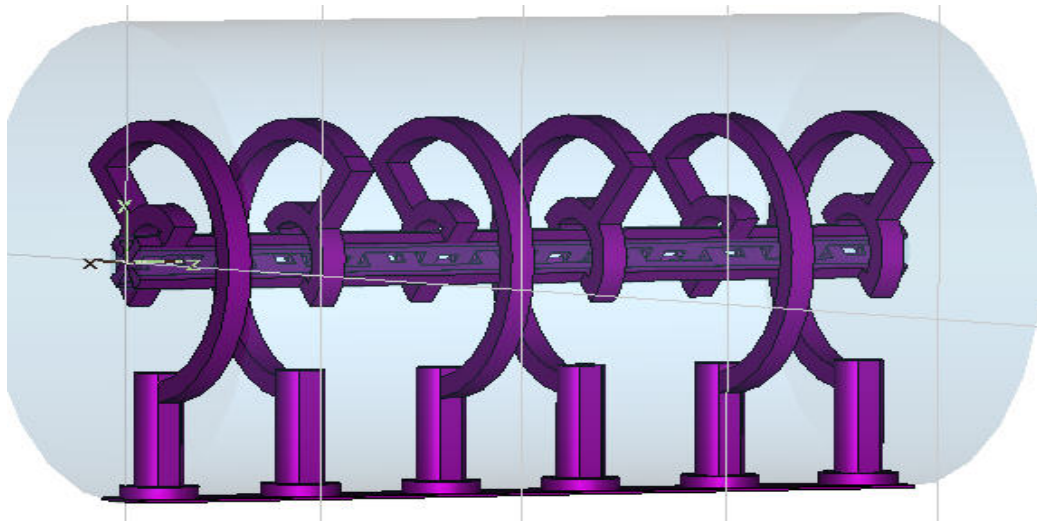


$a_y > a_x$

SFRFQ prototype

- The prototype cavity will be tested as a post-accelerator for RFQ-1000

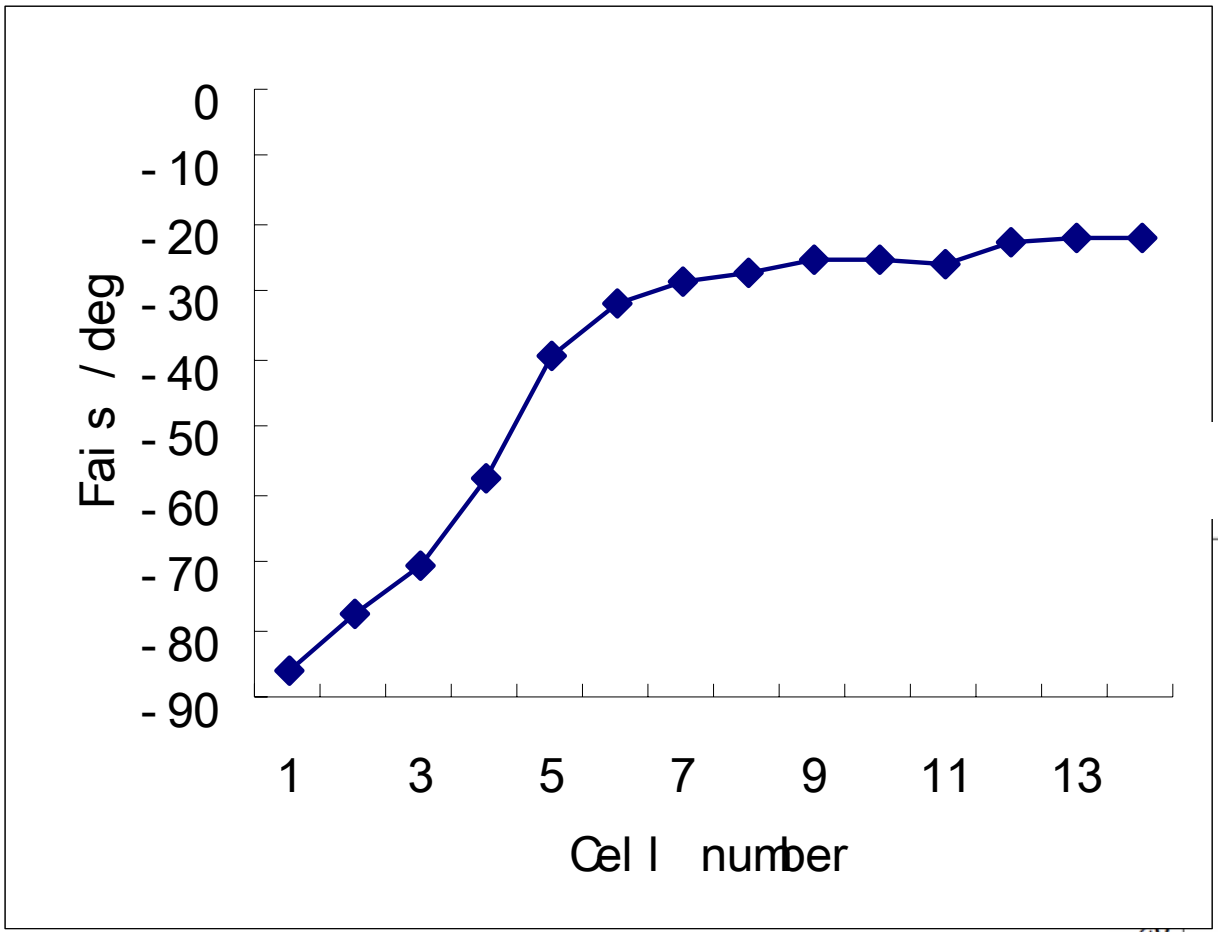
- Accelerate ~ mA O^+ from 1MeV to 1.6MeV.



Principal parameters of prototype

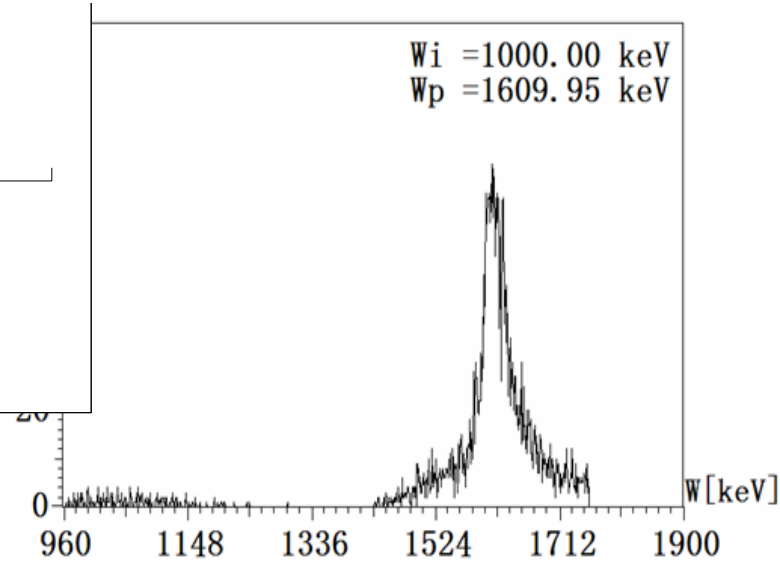
	SFRFQ Prototype
Ion species	O^+
F(MHz)	26.07
W_{in}(keV)	1000
W_{out}(keV)	1620
Length(cm)	105
Diameter(cm)	70
V_o(kV)	70
Duty factor	1ms/6ms

Beam dynamics design

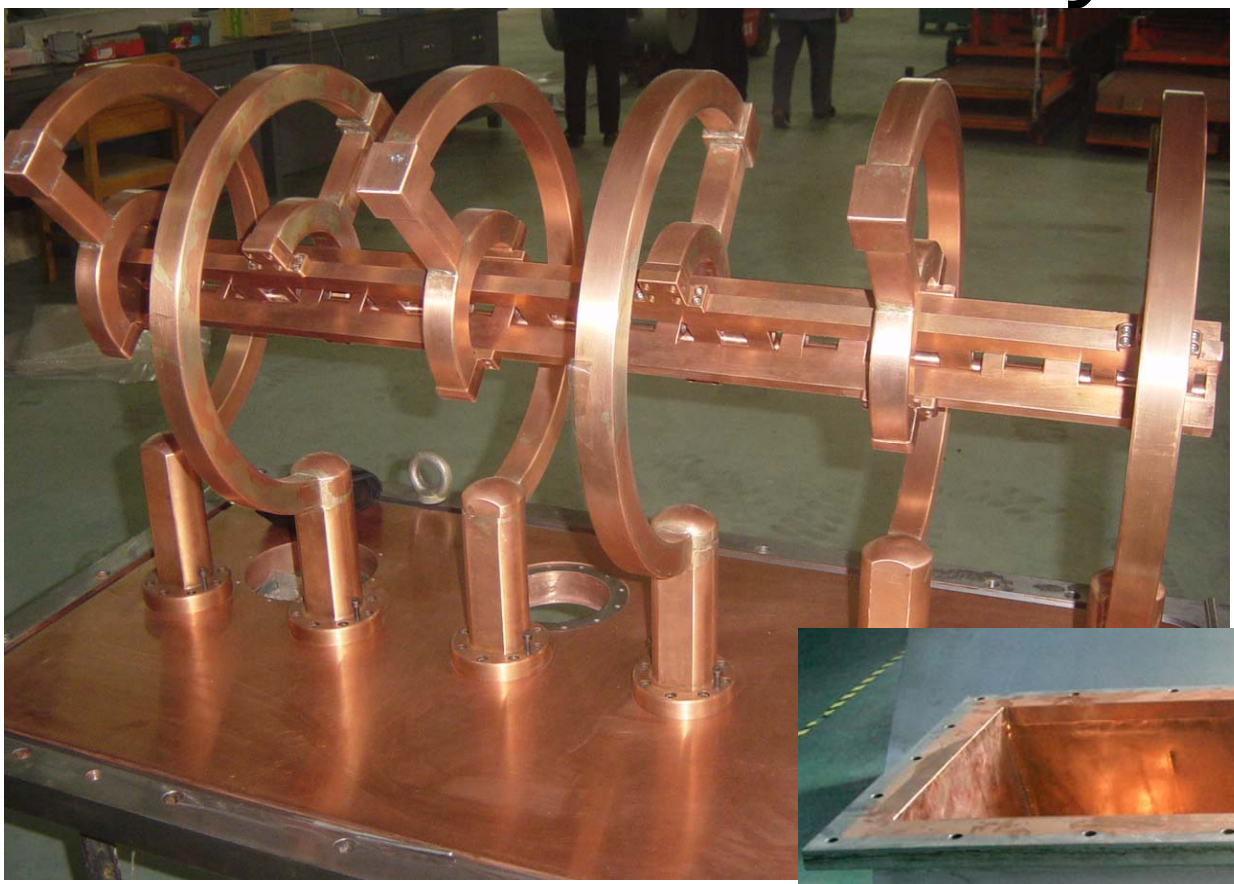


Synchronous phase

Energy spectrum

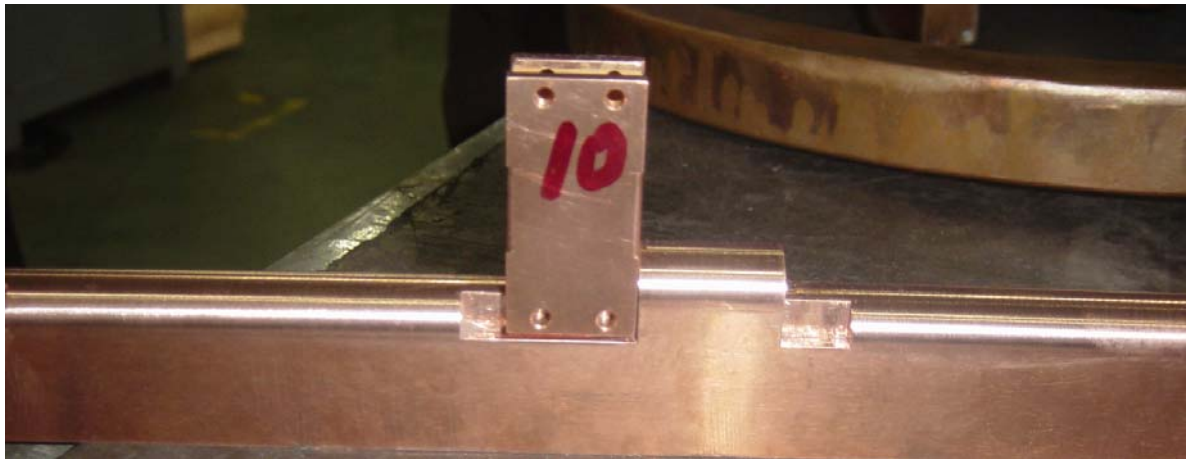


Assembly



Prototype cavity

Tank cover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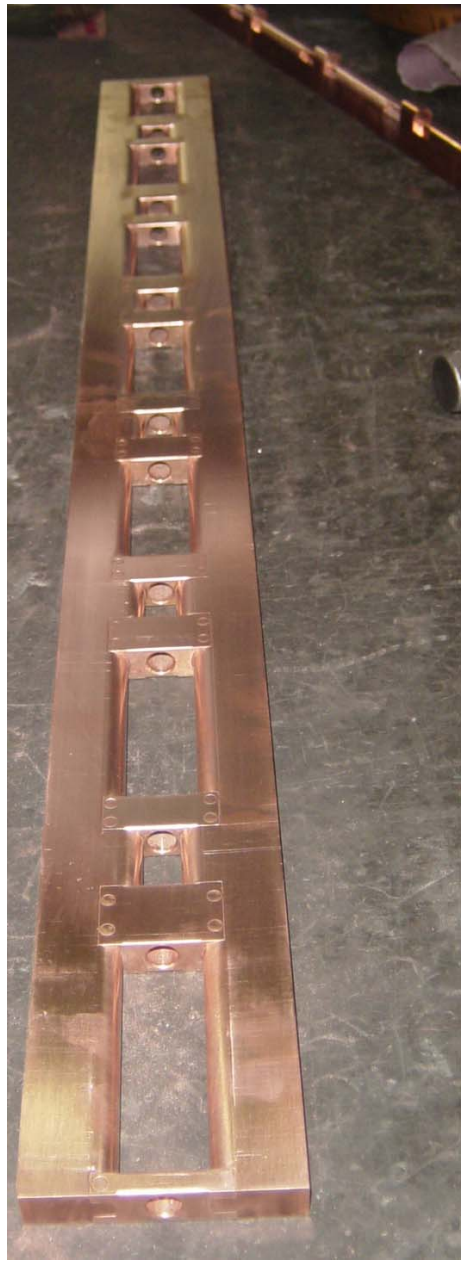
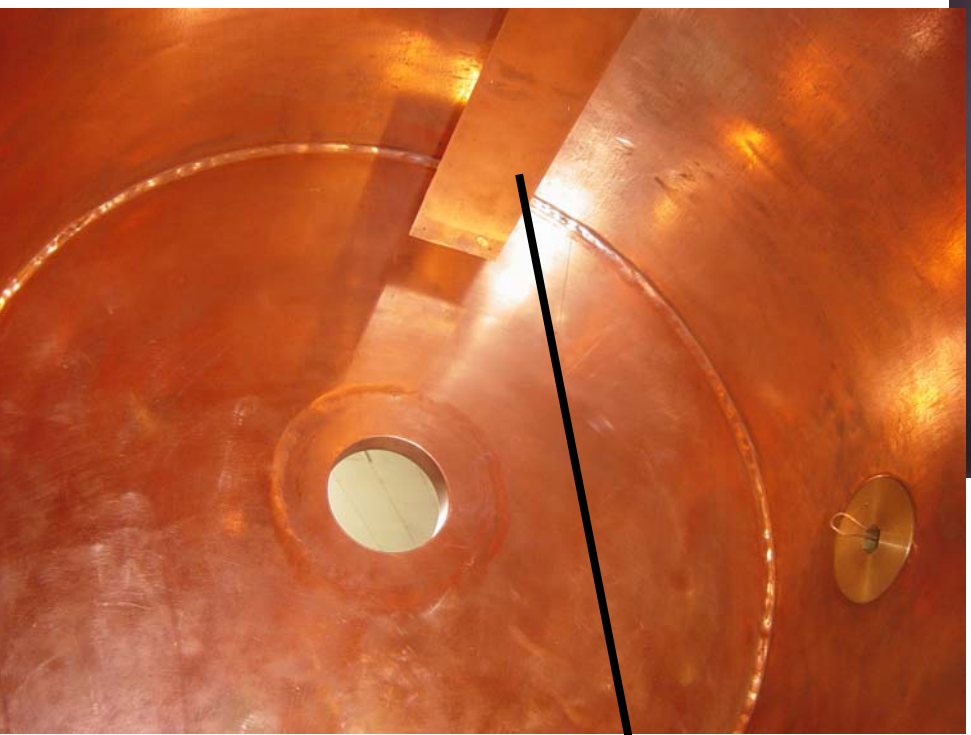
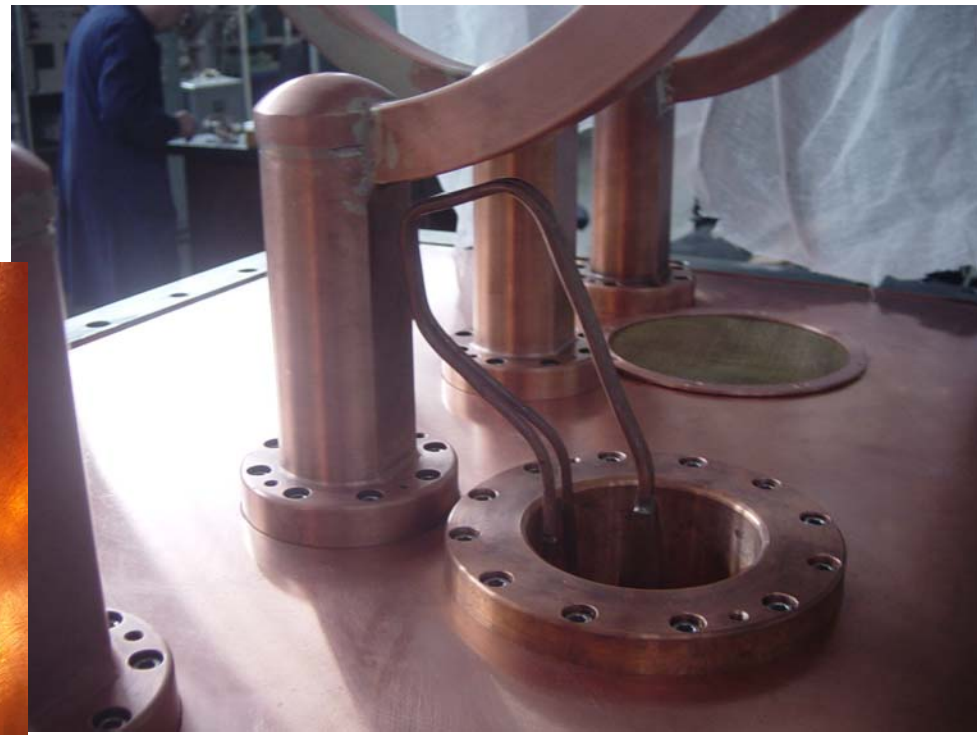
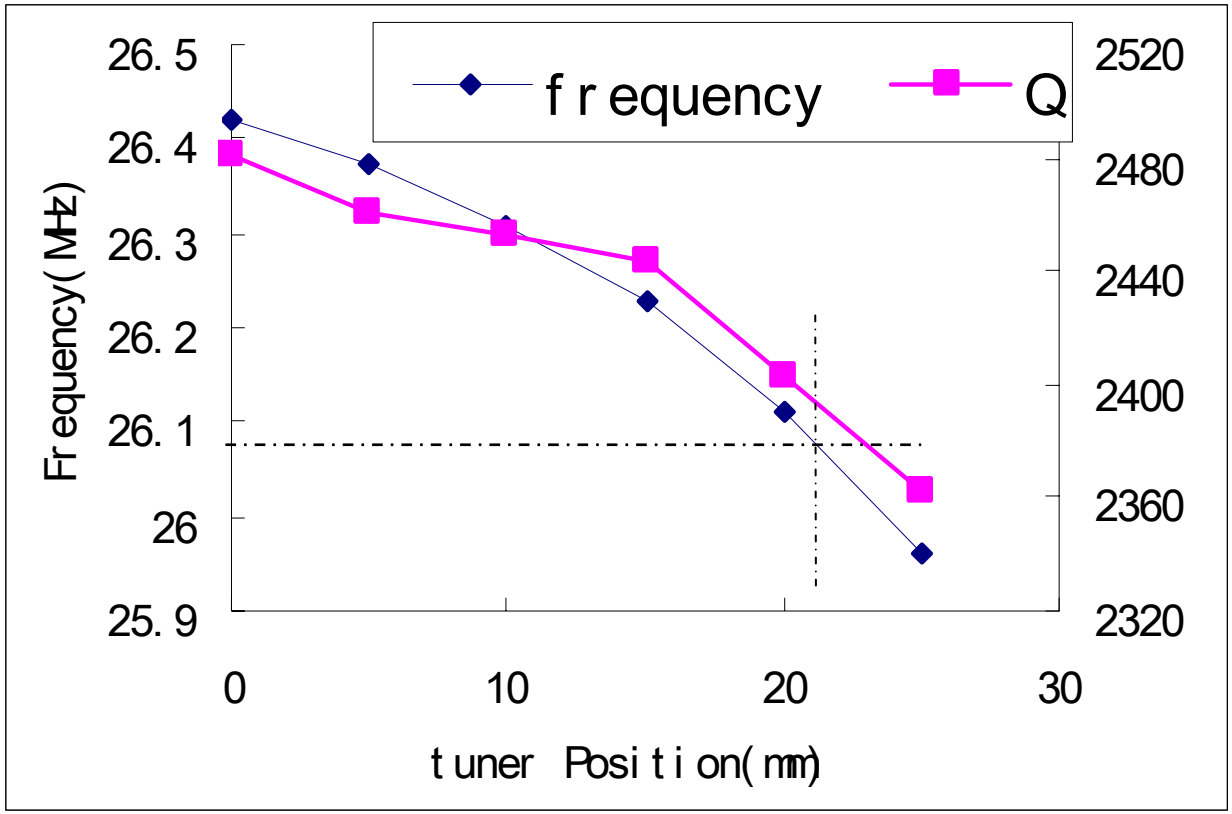


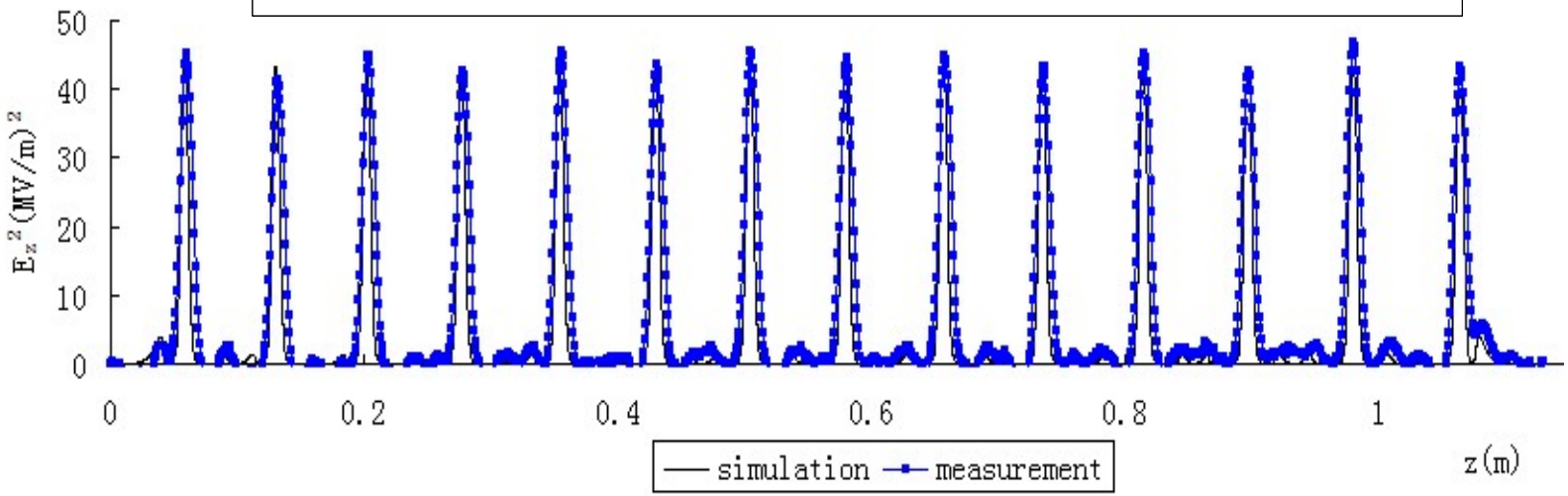


Capacitance tuner

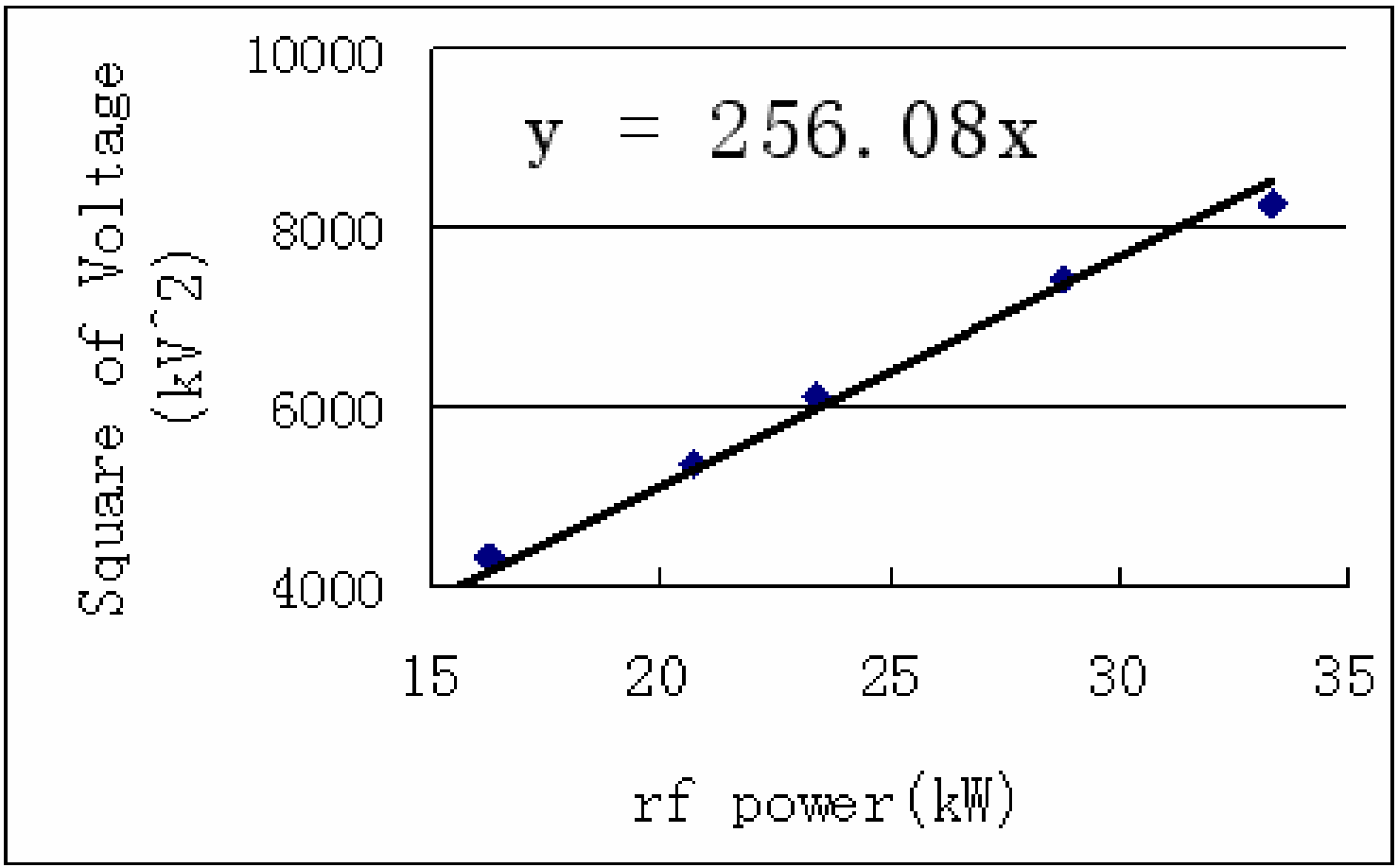


Power coupler

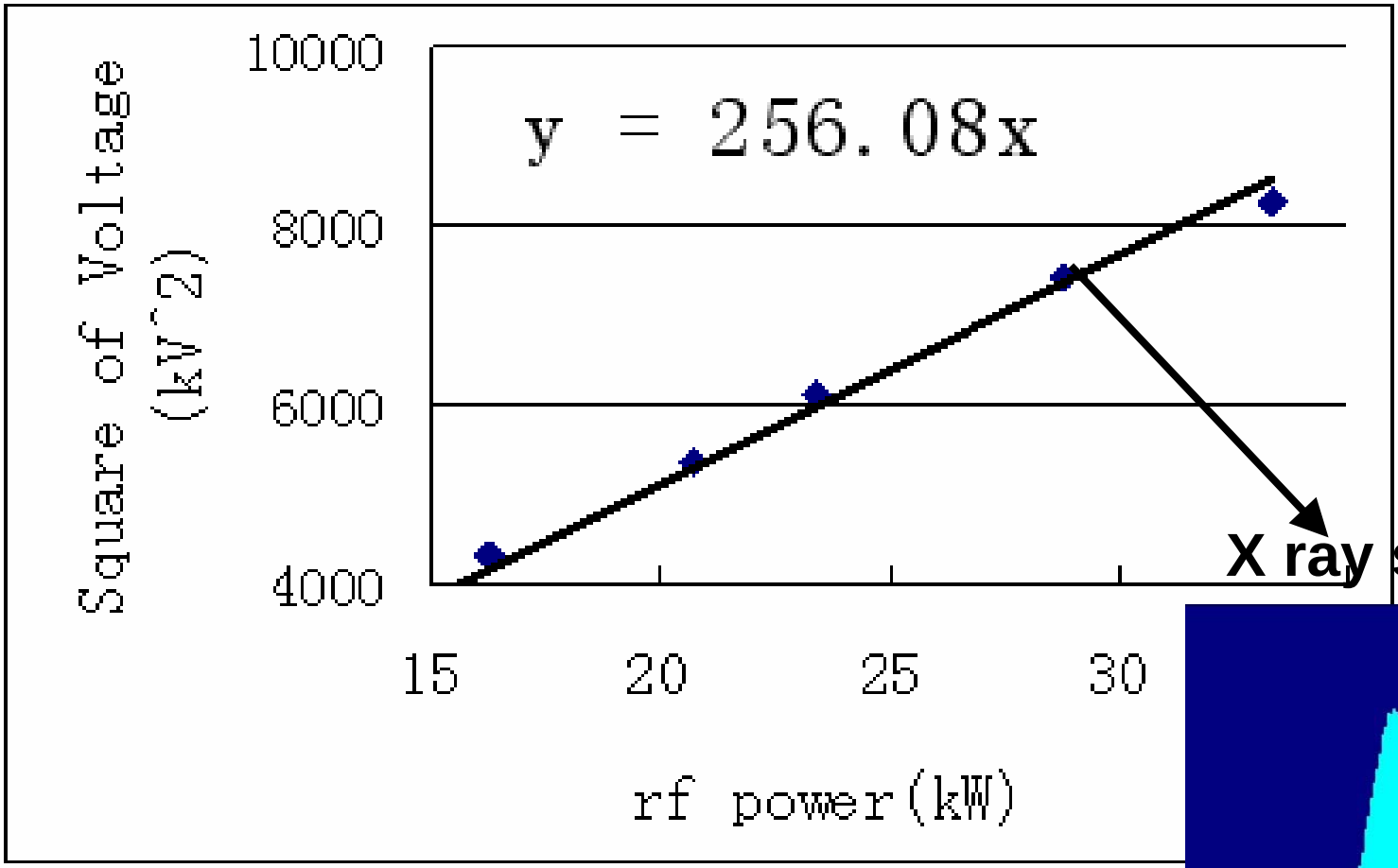

frequency
Q
Frequency(MHz)
26.5
26.4
26.3
26.2
26.1
26
25.9
2520
2480
2440
2400
2360
2320
0
10
20
30
tuner Position(mm)


E_z^2(MV/m)^2
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
z(m)
simulation
measurement

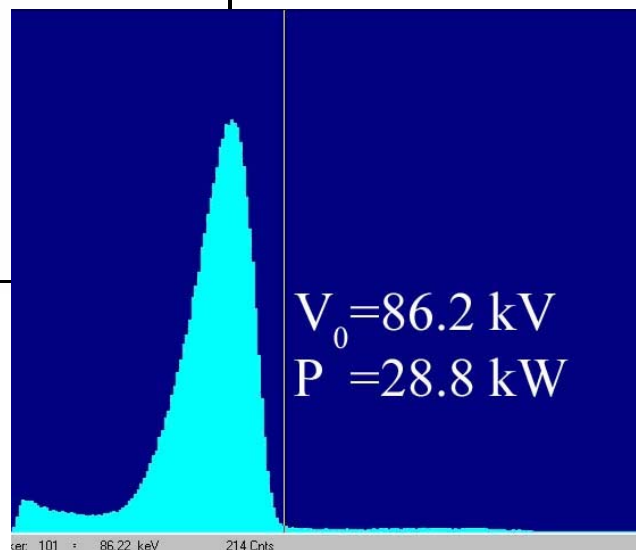
RF Power test

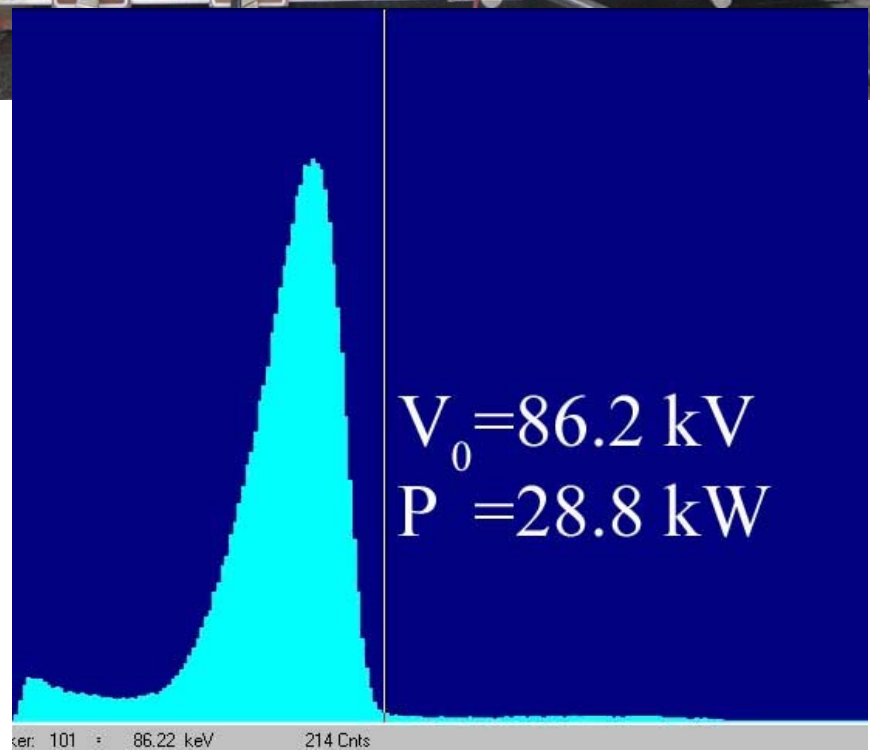


RF Power test



X ray spectrum





HP Ge(germanium) Detector

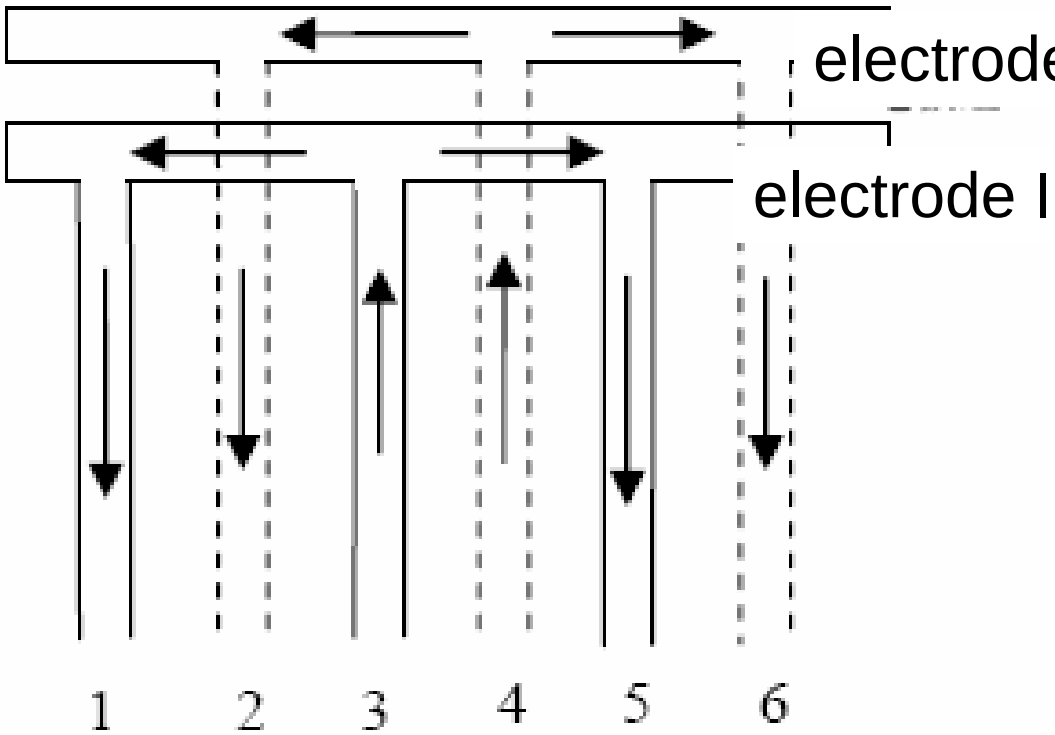
two standard γ rays of ^{241}Am 59.5keV and ^{137}Cs 661.661keV

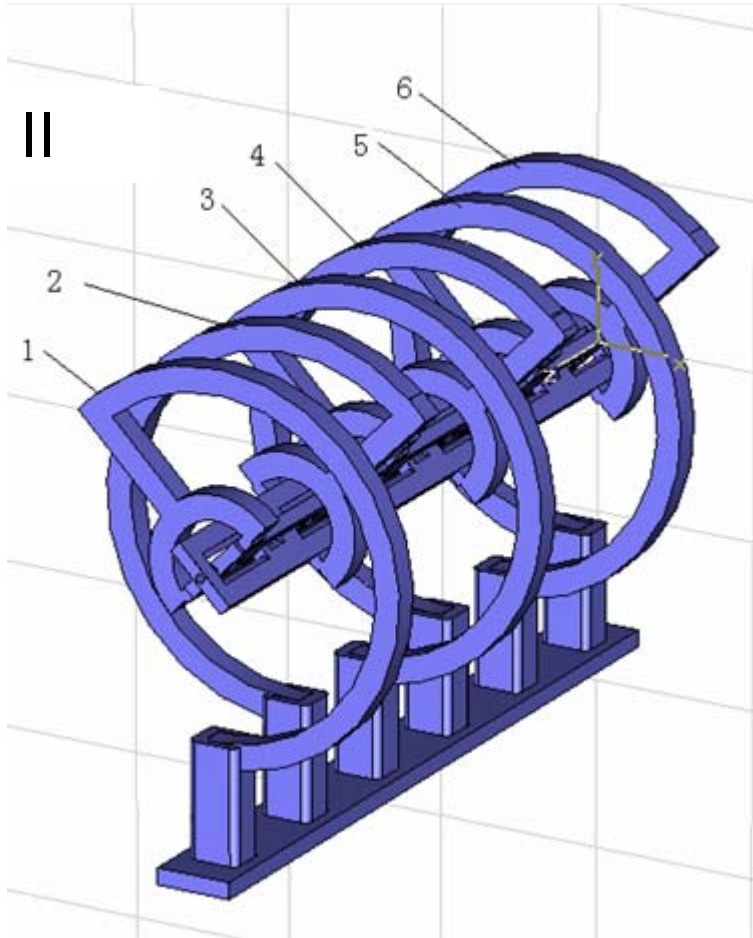
RF power test results

Power kW	V_o kV	ρ kΩ m
16.2	65.81	276.2
20.7	73.16	265.7
23.4	78.06	269.8
28.8	86.22	266.6
33.3	**91.02**	257.1

Maximum surface electric field is about 2.1 Kilpat

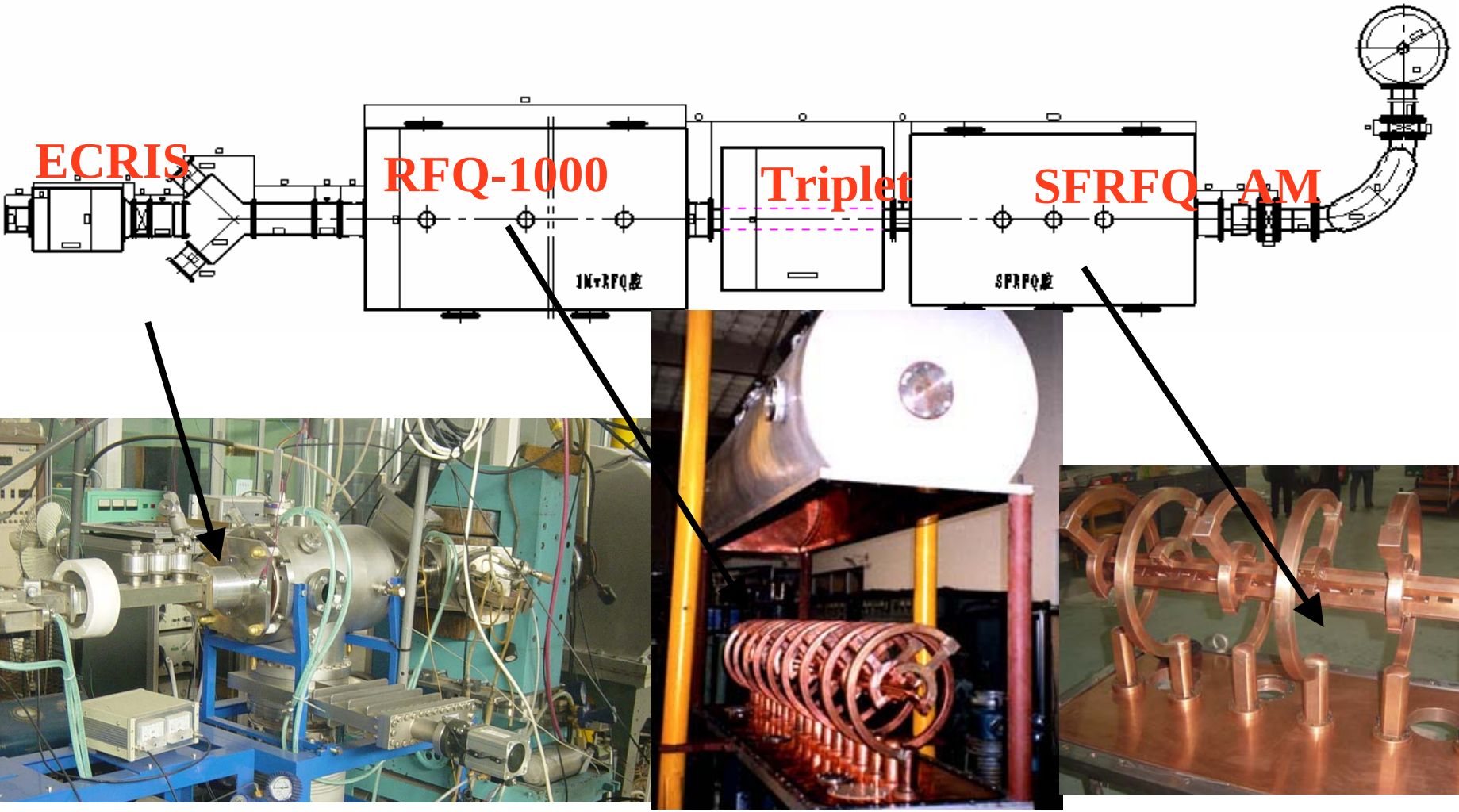
Cooling





1~6 are support rings

Preparation for the beam test



5mA Oxygen ECR IS

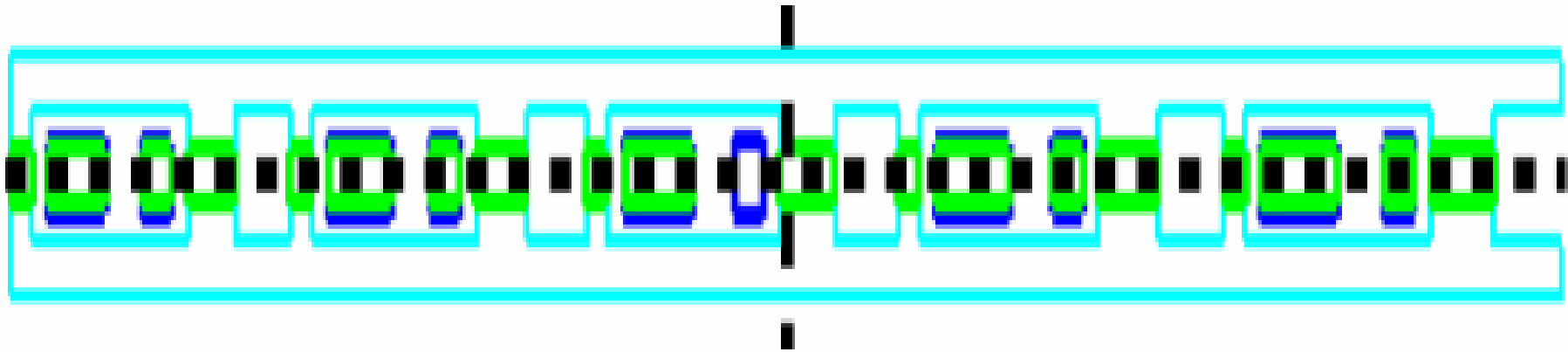
Summery

- full RF power test proved the feasibility of SFRFQ structure.
- The RF efficiency is not optimized for the prototype cavity: ρ=270 kΩ m ;it's effective shunt impedance is about 26MΩ/m.
- Both RFQ and SFRFQ can be excited by the similar structure (Split Ring), so they can be coupled and excited inside one cavity.

Future plan:

- Beam test
- Upgrade RFQ-1000

RFQ+SFRFQ combined Injector



SFRFQCODEv1.0

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