R&D activities on ADS and Proposal of China Spallation Neutron Source

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ADS R&D

1. Introduction

- **Rapid economic growth demands more power supply in China in future: a factor of 4 or 5 times more than present by 2030, when China steps on the level of a medium-developed country in term of GNP.**

•**Fossil energy resources in the newly-increased power supply must be reduced for environment protection (at present, coal contributes 70% electricity, about Billion ton).**

	CO_2 (million tons)
U.S.	5228.32
China	3006.77
Russia	1546.89
Japan	1150.94
Canada	470.80
France	352.02
Korea	352.10

Prediction for future Energy Require

Need for Energy Source in 2030 in China (Standard Coal in Billion Ton)

Coal	2.7	Hydropower	0.3
Oil	0.17	Nuclear Power	0.5
Gas	0.22	Others	0.1

Total 4.0

- **Nuclear power will play a more important role in China(from the present portion of 1.5% increase to 20%):**

1995	2000	2005	2010	2030
2.1GW	5.3GW	8.7GW	20GW	240GW

- Some critical issues must be solved for large-scale development of nuclear power:

1) Utilization rate of nuclear resources (U-238 and Th-232)

2) Disposal of the nuclear wastes

3) More safety

- For China, nuclear fuel resource is a bottleneck problem because it is far less than what we demand to reach 240GW nuclear power.

- ADS is regarded as a possible solution to these issues.

Uranium Resource Problem

To provide 240GMWt at 2030 we need uranium resource

- 2.58 million ton for PWR
- 0.65 million ton for PWR+FBR(2025)
- 0.20 million ton for PWR+ADS(2030]

Nuclear Waste Accumulated up to 2030 in China

Year	2000	2010	2020	2030
Capacity, GW	6	20	40	(240)
Spent fuel, t			7200	[>50000]
MA, t			4	[>30]
LLFP, t			17	[>120]

ADS is regarded as a possible solution to these issues.

2. Consideration on R&D Program of ADS

- **Development Strategy: Step by step.**

Two-Phase Program

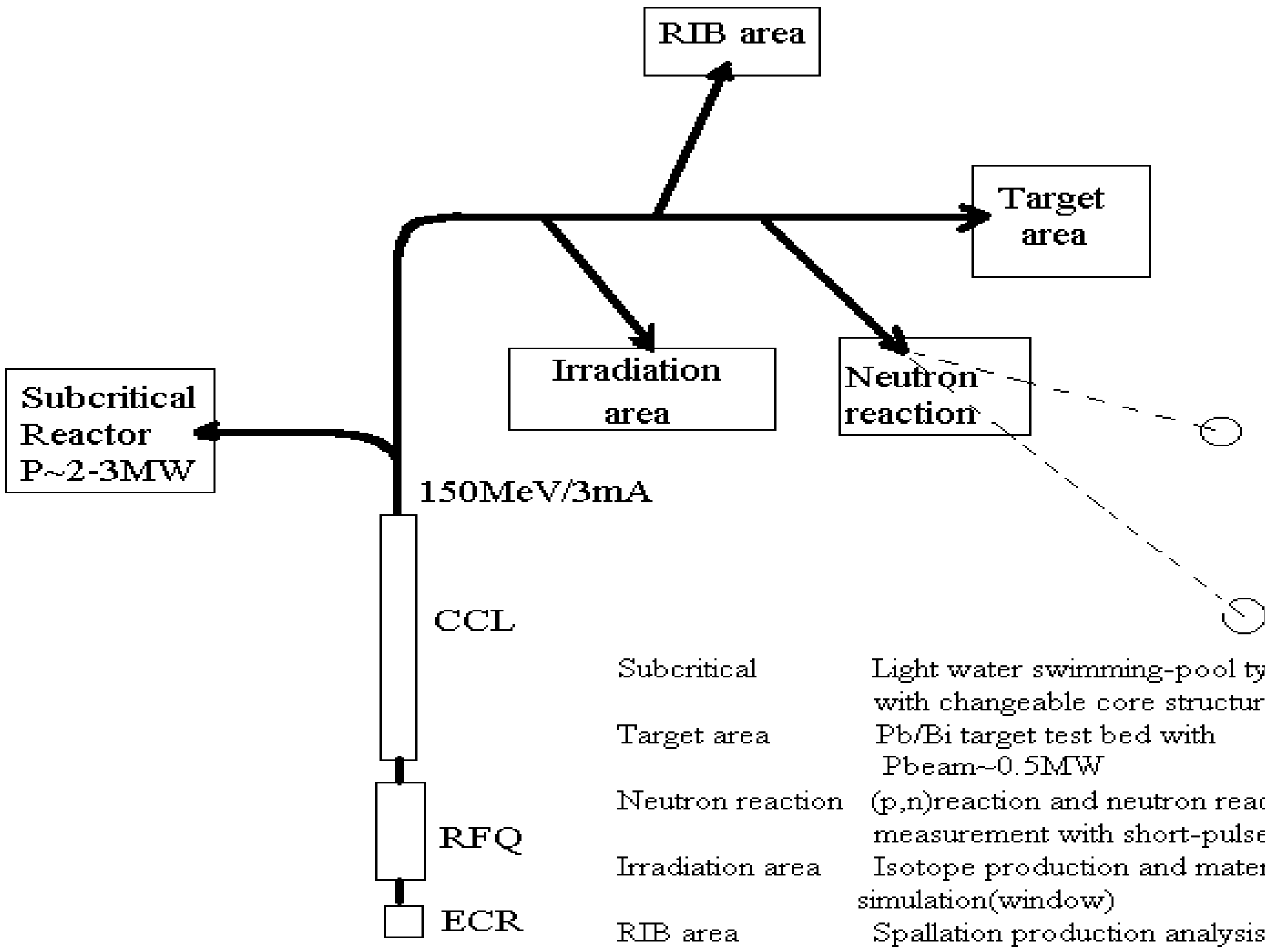
♦ **Phase I -- Principle verification facility(~10 years).**

(Small-scale) **Construction of an accelerator (150MeV, 3-5mA) to drive a subcritical reactor.**

♦ **Phase II -- Demonstration facility(5-10 years).**

(Full-scale) **An accelerator (1GeV, 20mA) and a subcritical reactor (1000MWt).**

The Principle Verification Facility



Subcritical	Light water swimming-pool type with changeable core structure
Target area	Pb/Bi target test bed with Pbeam~0.5MW
Neutron reaction	(p,n)reaction and neutron reaction measurement with short-pulse mode
Irradiation area	Isotope production and material test simulation(window)
RIB area	Spallation production analysis and extraction, Transmutation of MA

First five years R&D program of phase one

A five years (2000-2004) R&D program has been launched under the support of MOST, China.($ 3.5M/5 years). Because of the limitated support, so the works for HPPA and ADS is limited in a basic concept study, critical technology and the key components development. CIAE and IHEP undertake the task supported

Purposes in 2000-2004

- To develop the related technology of a high current proton linac (especially the low-energy part of the proton linac).
- To get the experience of high reliable and stable operation.
- To verify different concepts of the blanket (Neutronics, hydrodynamics, safety and flatten of power distribution).
- To simulate the material property of the different concepts (target, window,etc.)

The basic study covers

1) Subcritical reactor optimization

Subcritical reactor physics

Related nuclear data base

2) Material for target and window

3) Intense-beam proton linac

ECR ion source (75KeV)

3.5 MeV RFQ and linac design.

SC cavity technology.

3. Progress in Research:

1. Accelerator

Current Status of the ECR ion Sources

Design Parameters of Ion Source

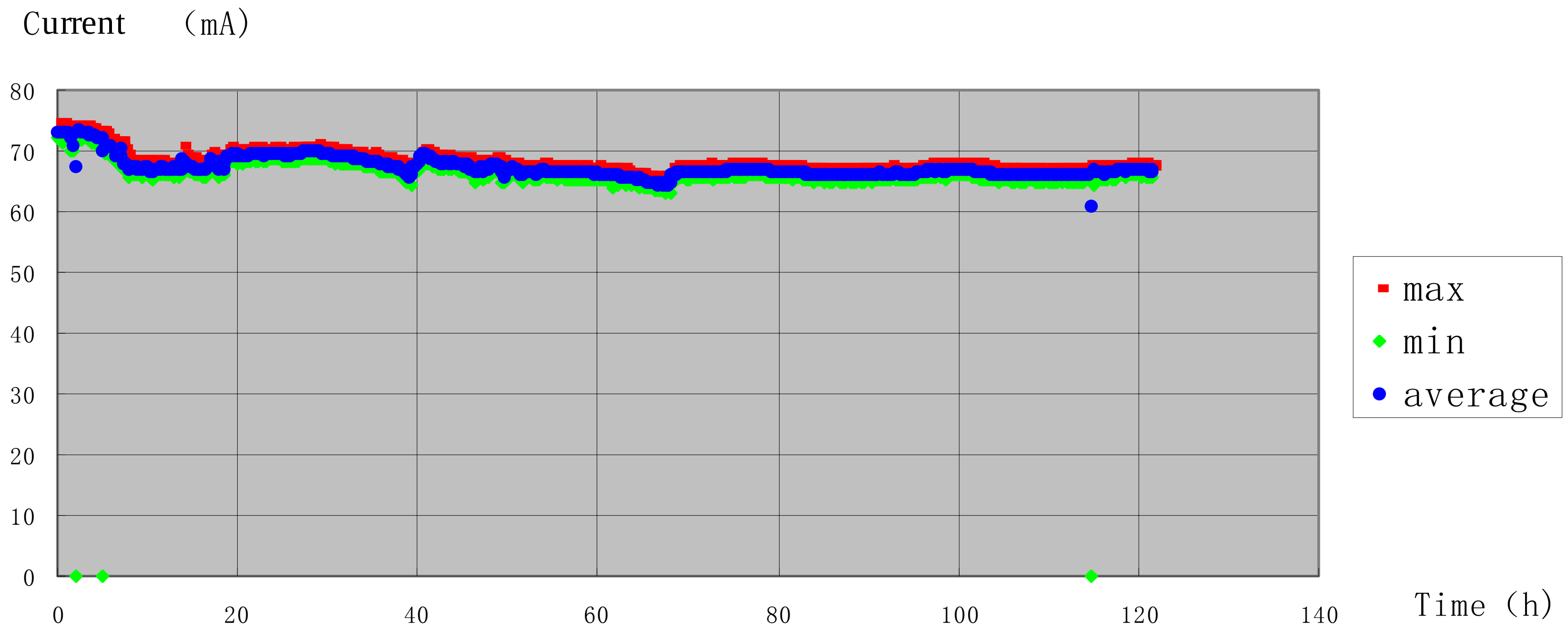
Extraction Voltage	75	kV
Microwave power	1	kW
Beam current	70	mA
Vacuum pressure	1×10^{-3}	Pa
Aperture in diameter	7.3	mm
proton ratio	90%	

Results of ECR ion source

Current mA	70, ϕ 6.5, 100, ϕ7.5
Energy keV	75
Rms emittance π mm mrad	0.129 @60mA, 60 keV
Proton ratio %	>80
operation time (hours)	121
trips	3
Mean time of recovery (mins)	1
Longest uninterrupted time(Hrs)	110
Reliability %	99.9

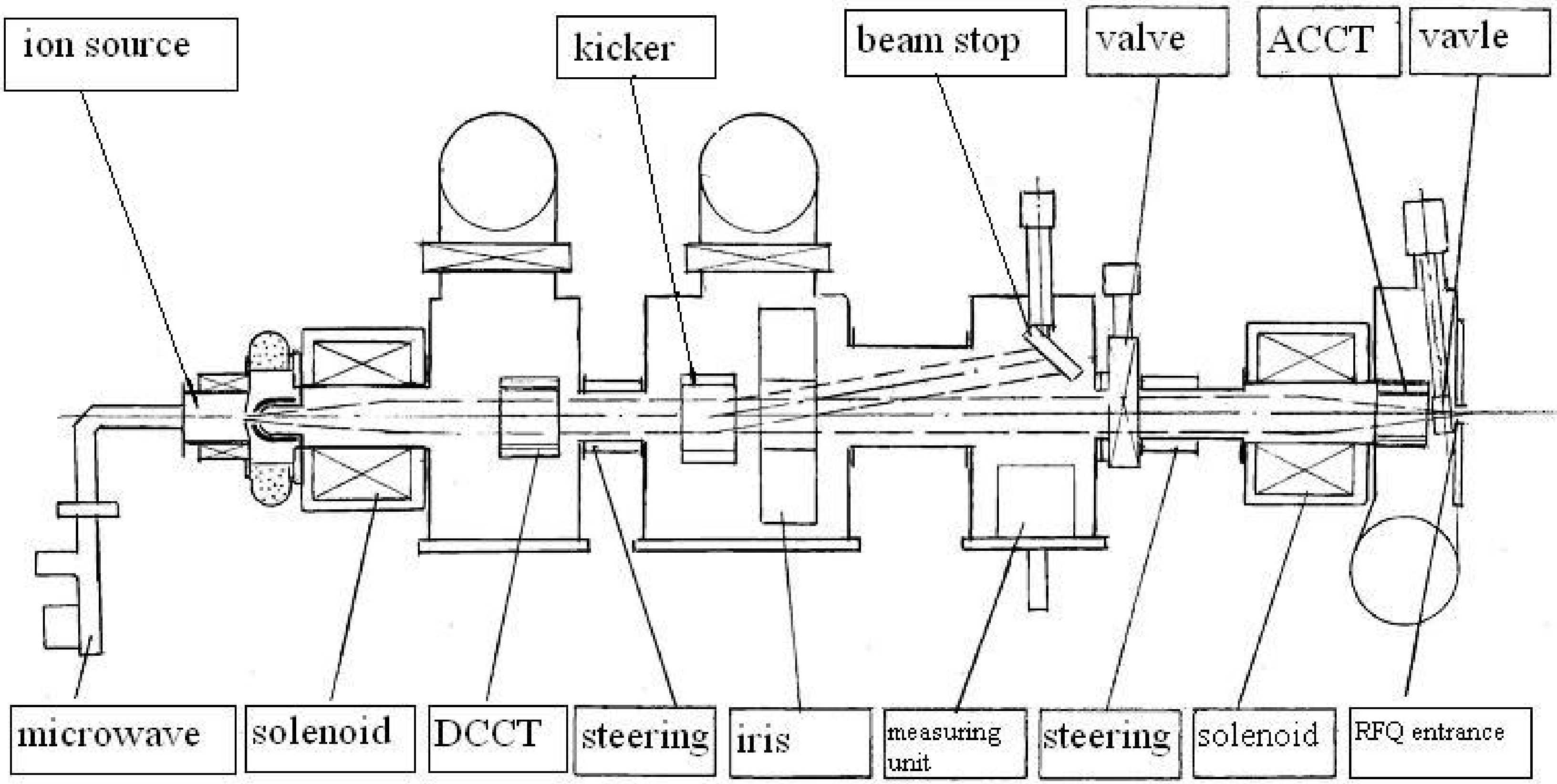
ECR ion Sources

Reliability test of the source



120 hours reliability test run

LEBT Layout



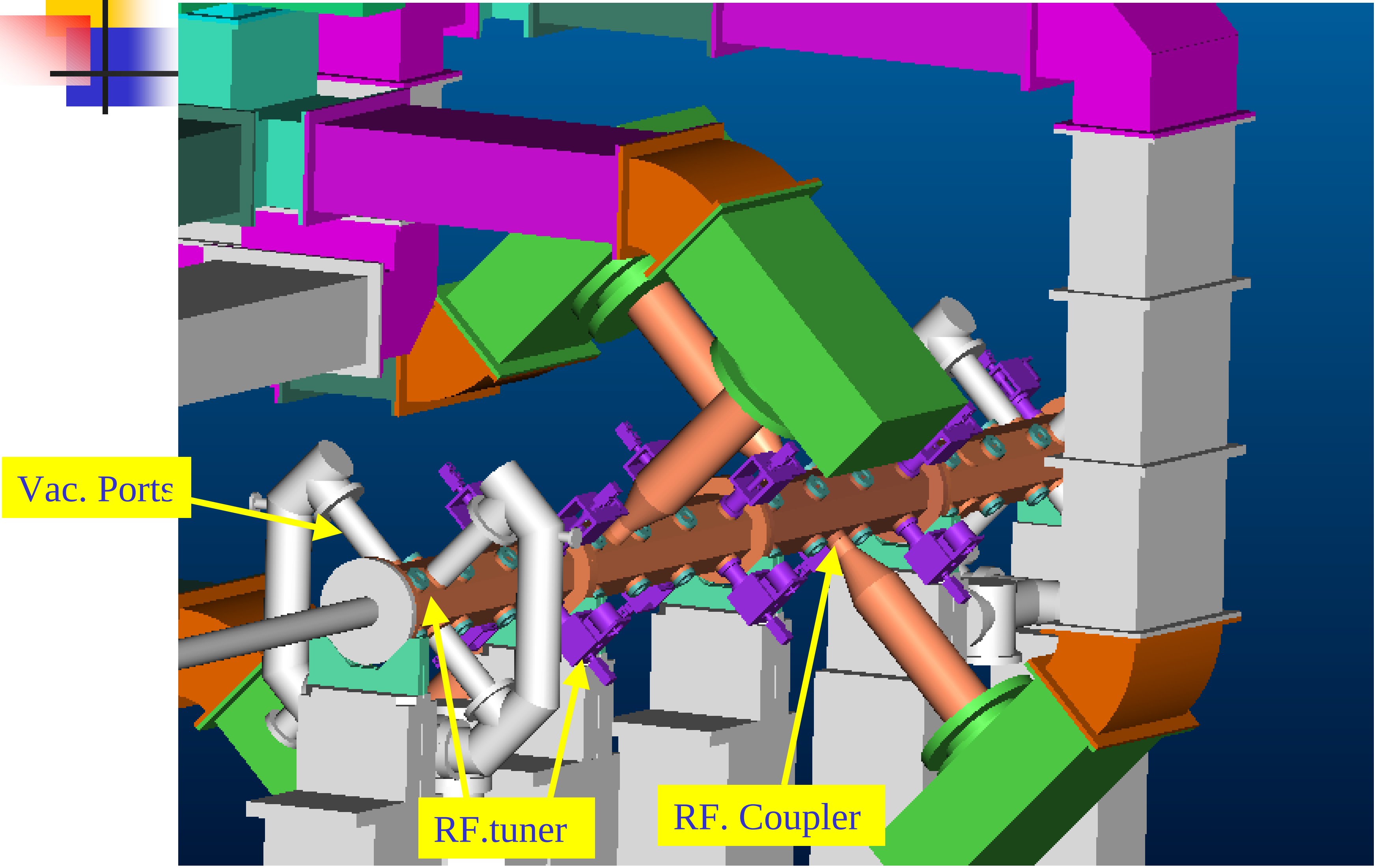
ion source
kicker
beam stop
valve
ACCT
vavle
microwave
solenoid
DCCT
steering
iris
measuring unit
steering
solenoid
RFQ entrance

Current status of RFQ

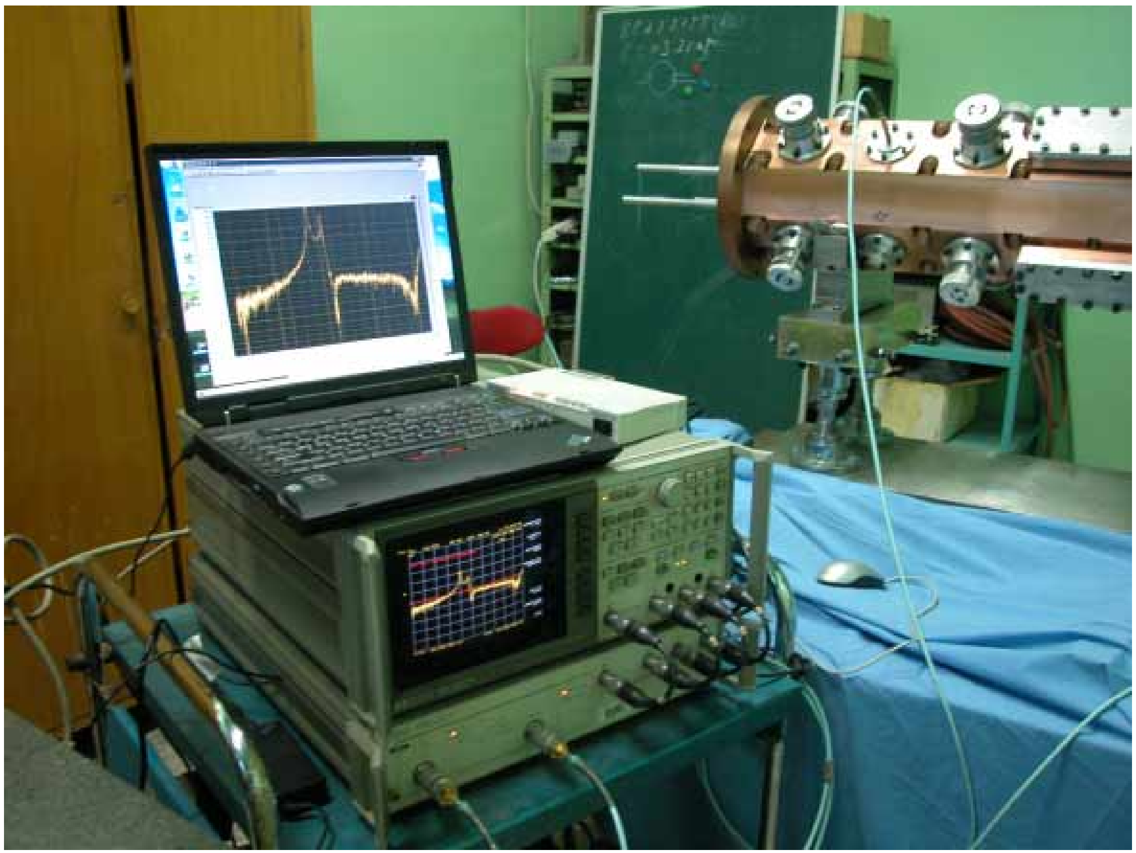
Main Parameters for Our RFQ

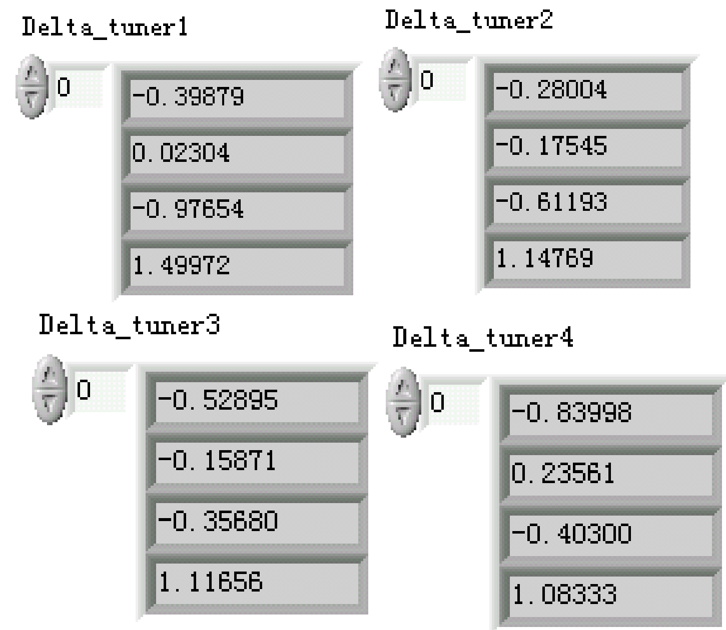
Structure	4 vanes
Particle	Proton
Input Energy	75 keV
Output Energy	3.5 MeV
Peak Current	50 mA
Duty Factor	6 %
Frequency	352 MHz
Total Length	4.75 m

RFQ accelerator



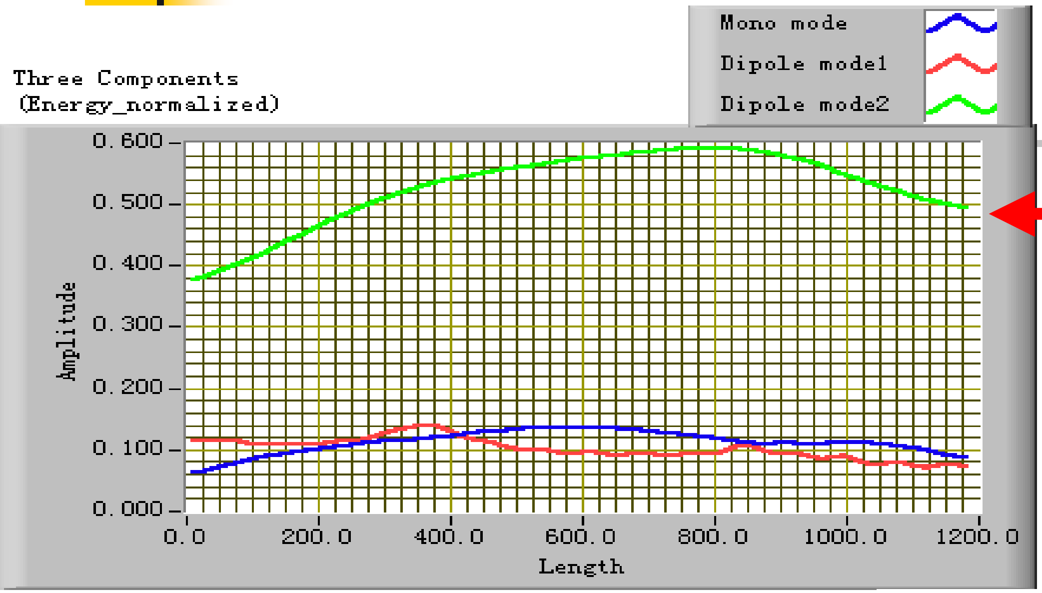
A cold model RFQ section has been fabricated and some RF measurements have been made.





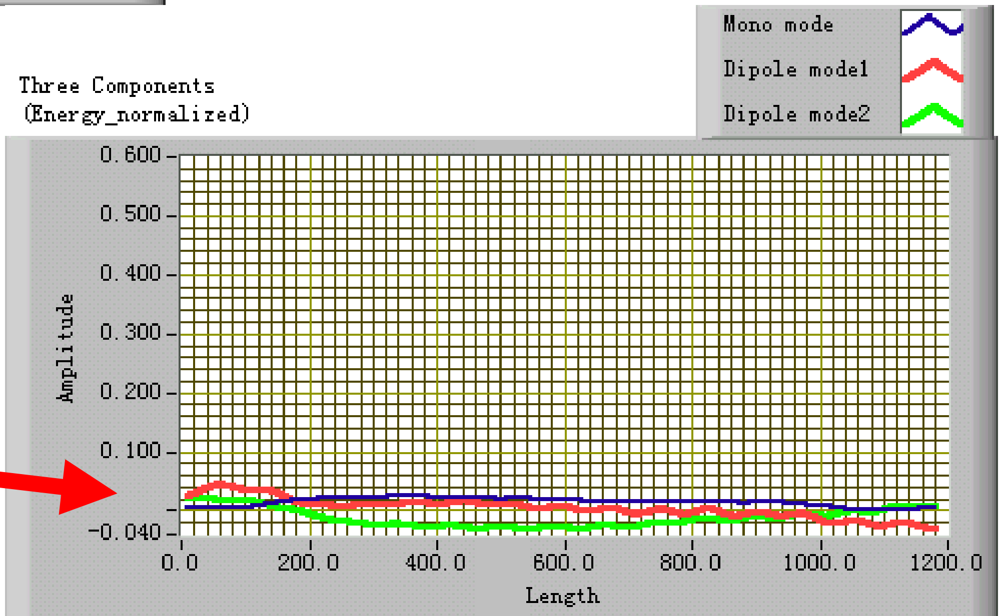
LabView code suggests a new tuner insertion according to the field distribution measured by bead-pulling method.

The original dipole component has been greatly reduced.

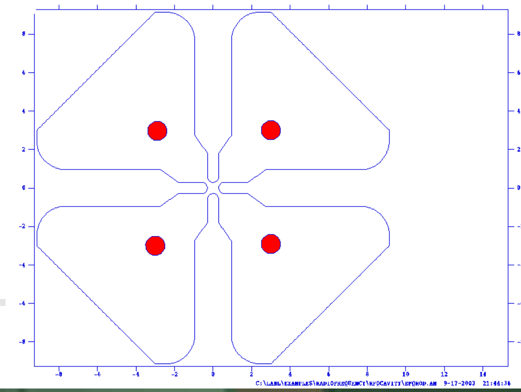


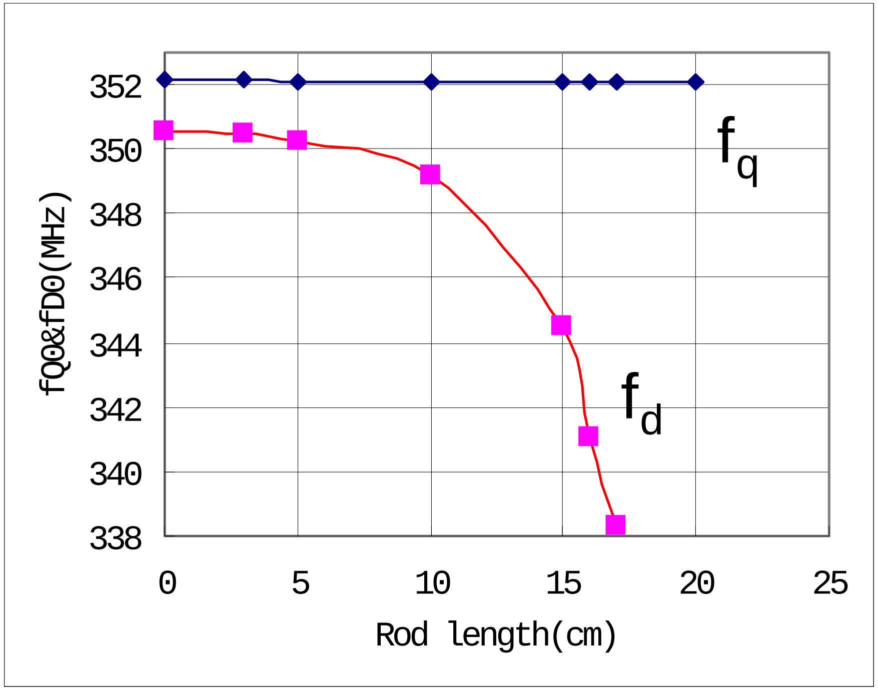
One dipole component is very large before tuning.

The dipole component is tuned to become much smaller



Dipole rod test





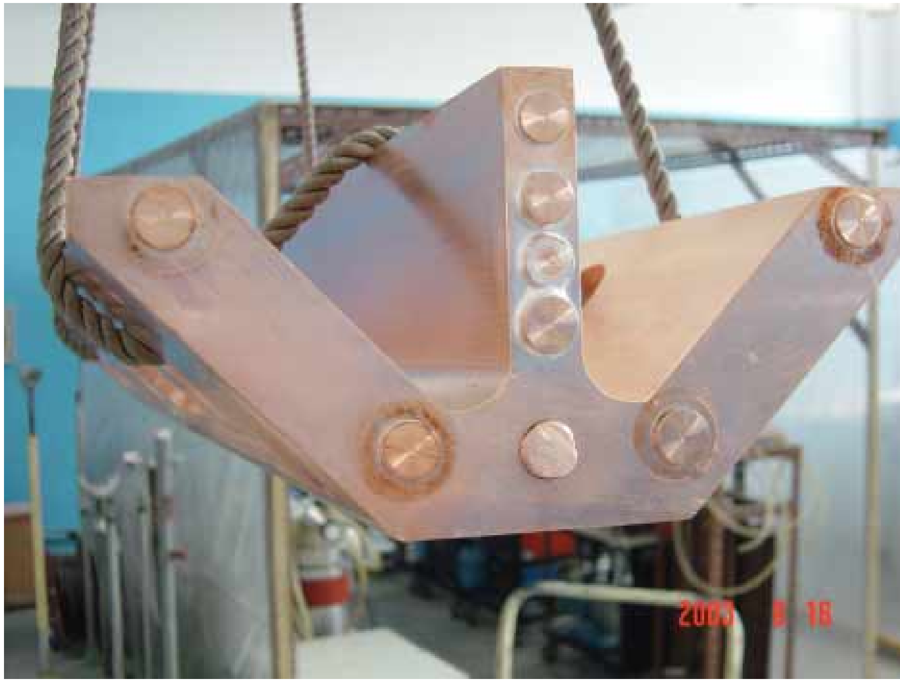
Dipole rods are inserted which lower the dipole mode frequency sharply and keep quadrupole mode unchanged.

RFQ technology model

A short technological model with the modulations is machining and will be measurement.

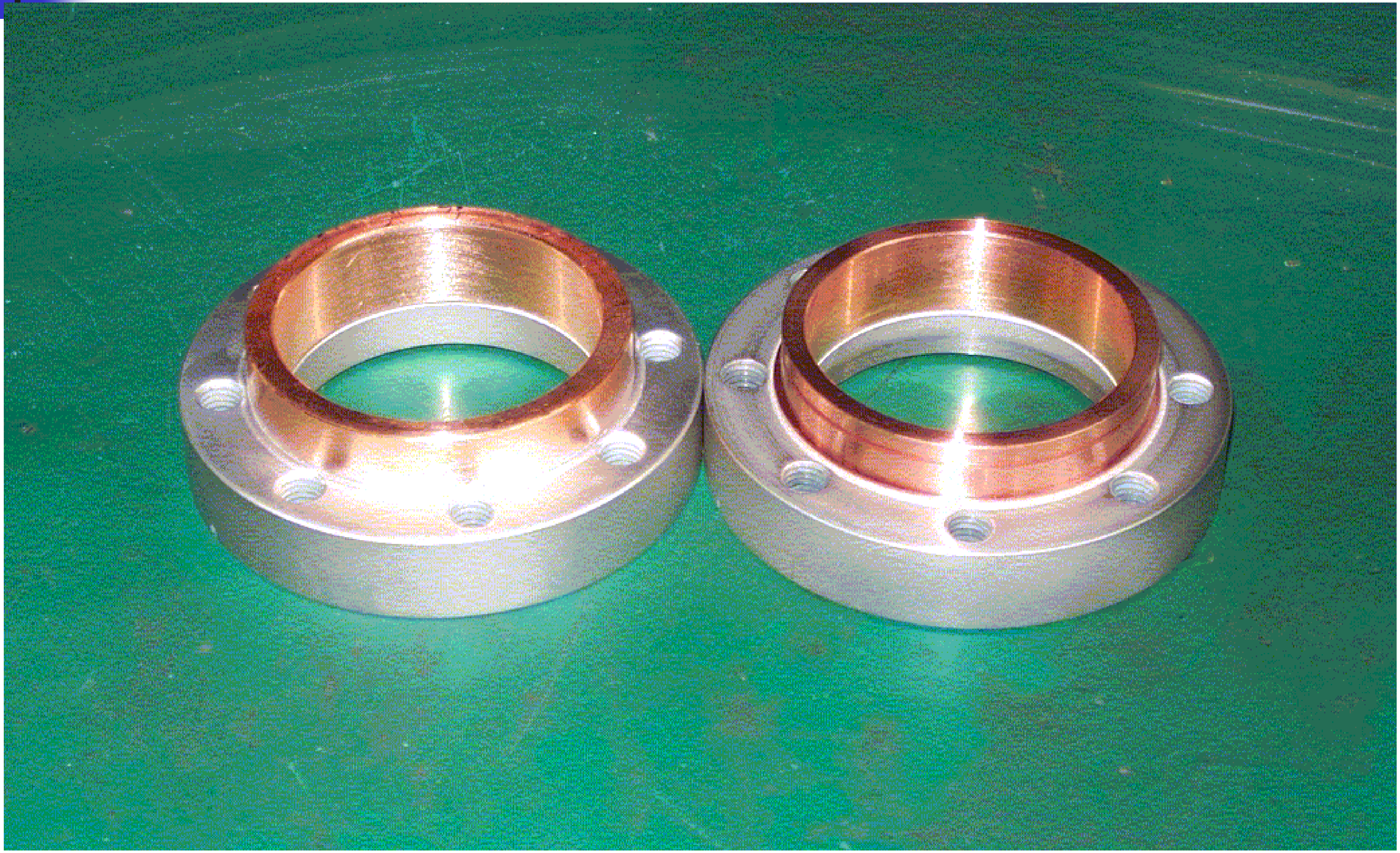
RFQ construction

The RFQ cavity has been drilled with deep holes of 1.2m long .The diameter of the hole is 11mm and the accuracy is ±0.3mm.

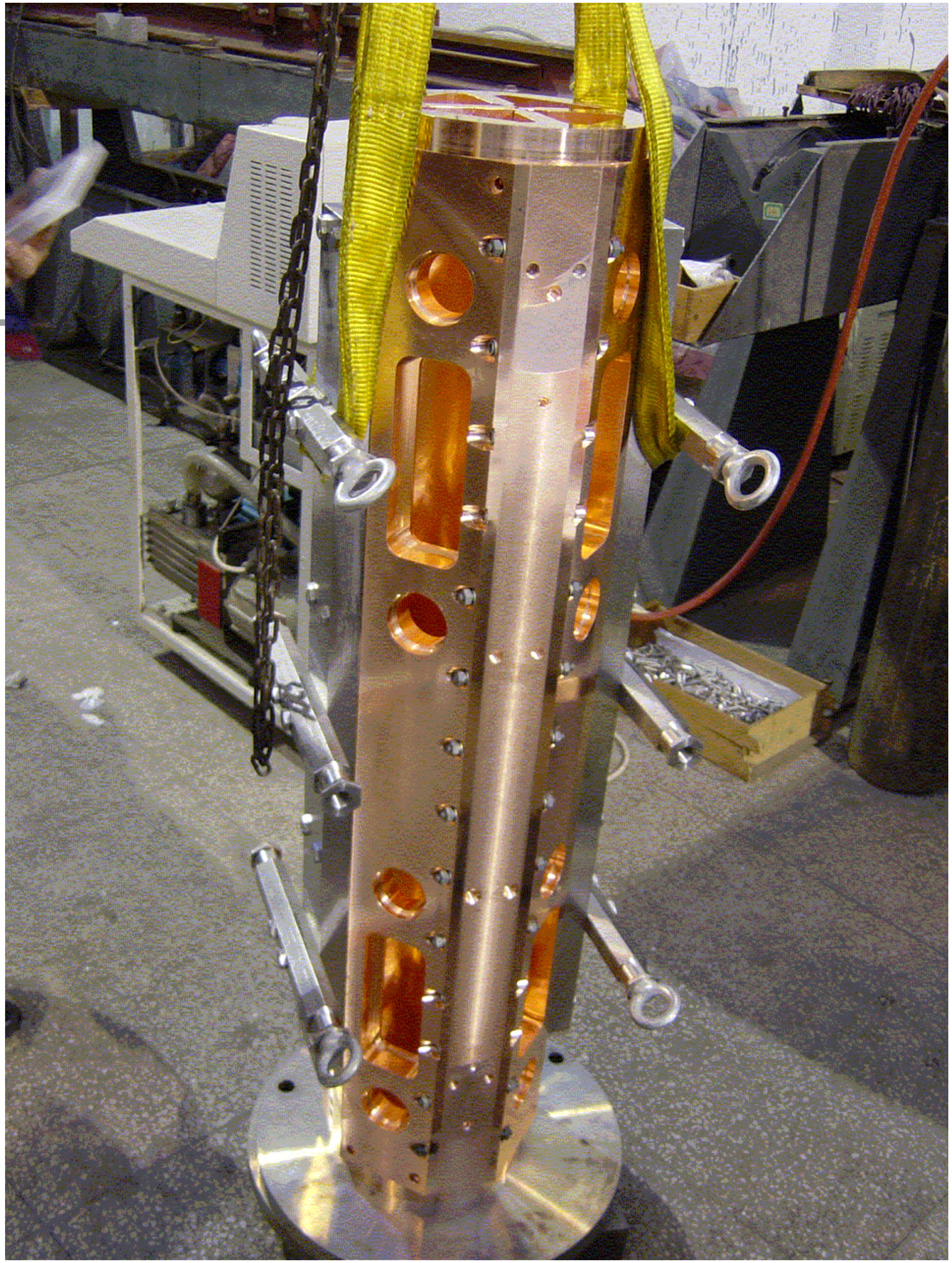


The holes are covered by braze.

The flange of the RFQ (copper brazed with stainless steel)

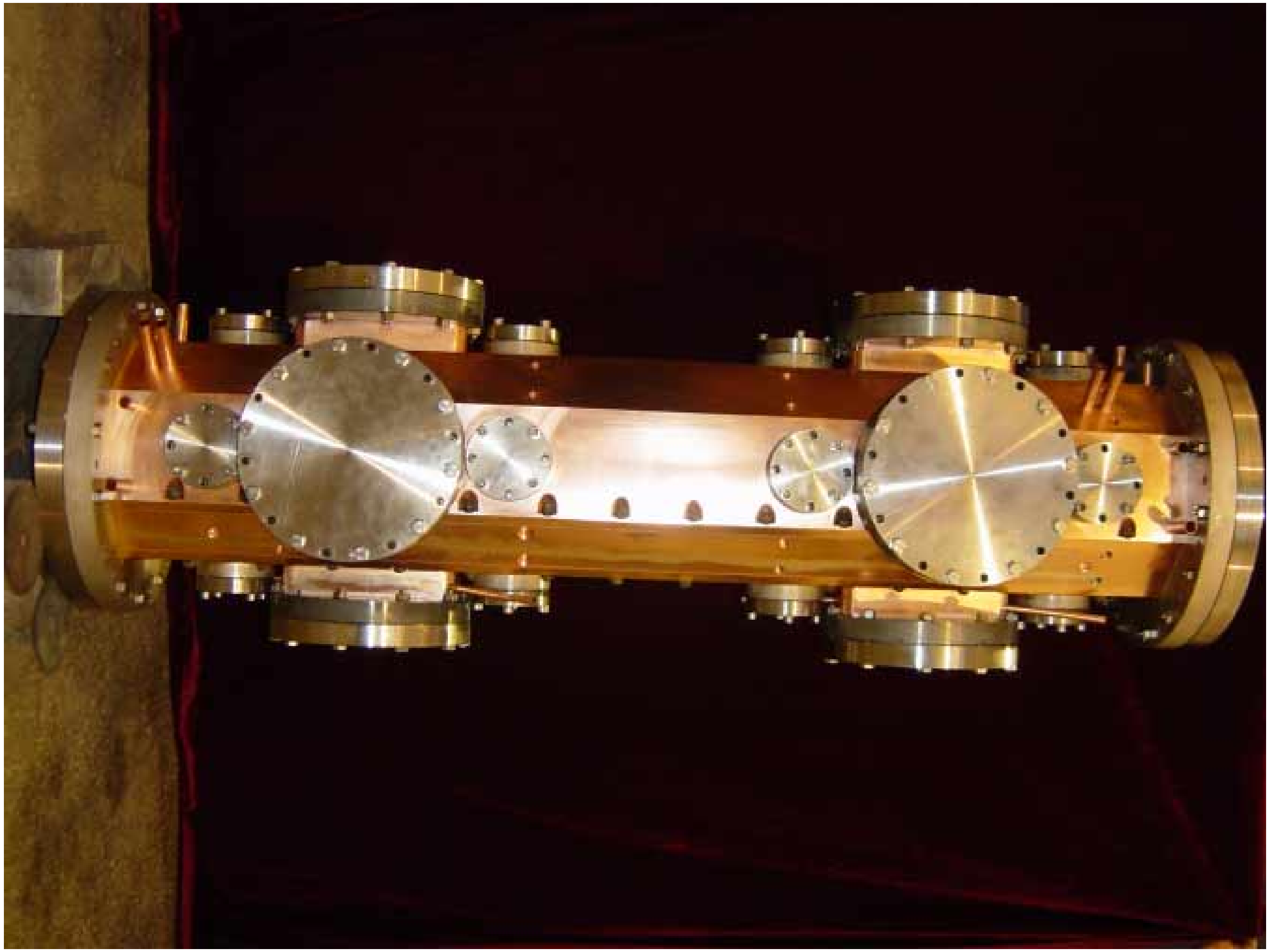


The clamp for RFQ brazing



The RFQ test module
is ready for brazing,before putting in to hydrogen vessel.

Cavity and all flanges are also brazed on the cavity without vacuum leakage.



The Test module of RFQ without modulation) has been completed ,and the vacuum test result reached 10^{-10} bar/sec