# Activities of Superconducting RF Accelerators at Nanjing University

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August 2, 2012

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# Introduction of Nanjing Univerisity

## Proton Linear Accelerator Institute

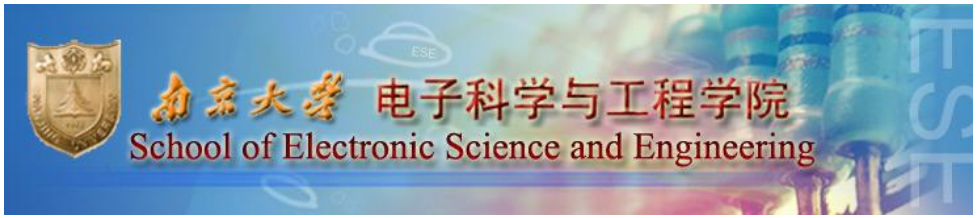
- Nanjing University, one of China`s key comprehensive universities under the direct supervision of the Ministry of Education.
- 1902 : Sanjiang Normal School.
- On August 8, 1949: National Nanjing University.
- In October 1950: Nanjing University (NJU).
- Today`s NJU consists of three beautiful campuses, Gulou, Pukou, and Xianlin. As a top university in China, it boasts advanced teaching and research facilities.


# Introduction of Nanjing Univerisity

## Proton Linear Accelerator Institute

- Presently, NJU is comprised of 21 schools with 59 departments.
- It runs 78 undergraduate programs, 213 master`s programs, 9 professional master`s programs, 147 Ph.D. programs (under 23 primary disciplines), and 23 post-doctoral research stations.
- In addition, NJU has one national laboratory and six national key laboratories, 5 key laboratories of the Ministry of Education, 2 engineering centers of the Ministry of Education, 2 Jiangsu provincial key laboratories, 21 national key disciplines, 24 provincial key disciplines.






# Introduction of Nanjing Univerisity

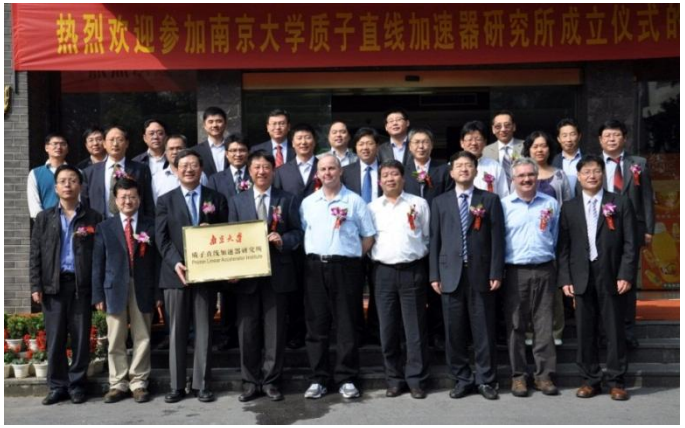
Proton Linear Accelerator Institute

- Among its over 2,000 faculty, there are 716 professors and 649 associate professors , including 27 members of the Chinese Academy of Sciences, 3 members of the Chinese Academy of Engineering, 4 members of the Third-World Academy of Sciences, 1 member of the Russian Academy of Sciences and one fellow of the Royal Society of Canada.
- NJU has made remarkable achievements in student education. Its current student body totals around 43,477 (12,655 undergraduates, 11,030 graduates). NJU students have been demonstrating their cutting-edge competitiveness in various competitions inside and outside of China.
- NJU leads the institutions of higher learning in China. Statistics show that since 1992, the number of research papers by NJU faculty and students on the Science Citation Index (SCI) has ranked the first among universities in Mainland China for seven consecutive years. In the past decade, NJU has won more than 800 national, ministerial and provincial awards, including over 40 National Awards of Natural Sciences, Awards of Science and Technology Progress, and Awards of Innovation. Since 2000, for instance, it has received 11 National Awards of Natural Science (one First Prize, ten Second Prizes) and two of Science and Technology Progress.

# Introduction of Proton Linear Accelerator Institute

## Proton Linear Accelerator Institute

- NJU is lack of the R&D field of the nuclear sciences and engineering, and has decided to develop this area.
- Proton Linear Accelerator Institute (PLAI) of the Nanjing University was established in October of 2011.
- The main R@D field is the superconducting RF accelerator and proton beam utilization.
- We will use a proton linear accelerator as proton beam producer with different energy output.
- The proton beam will be used for the research of the fundamental sciences, medicine, space irradiation, nuclear analysis, spallation neutron source, radio Isotopes, semiconductor injection etc.

# R&D Field

## 1. Cryomodule and SRF Accelrators

- Superconducting RF Cavity for Proton and Electron
- Cryomodule with single or multi-cavity
- Fundamental power and HOM couplers
- Magnetic shielding
- SRF Accelerators
- …

## 2. High-current Proton Accelerators

- Ion source
- Radio-frequency Quadrupole (RFQ)
- Drift Tube Linac (DTL)
- Spoke cavity
- Elliptic SRF cavity
- …

# R&D Field

## 3. Beam Utilization

1. The proton beam with different energy for the fundamental sciences, radio isotopes, medical research (proton therapy), materials, energy & environment, aero-space technology, etc.
2. Neutron Source
3. Accelerator Driven System (ADS)

# Current Status

1. **PLAI has obtained the full support from the Nanjing University.**
2. **Several cutting-edge results have been completed, such as high-power splitter with the variable output ratio, and prototyping a medium-beta superconducting RF cavity, etc.**
3. **PLAI and ADS-SRF have signed a MOU to develop the High-current Proton Superconducting RF Accelerator technology together.**
4. **A R@D team is under recruit.**
5. **PLAI is lack of the funding.**
6. **PLAI has not constructed the test lab building and test facility.**
7. **PLAI needs the help from all of you and collaboration.**

# Purpose to build a proton linear accelerator

Proton Linear Accelerator Institute

Nanjing University has a purpose to build a high-current proton linear accelerator for beam utilization. It will servers for fundamental sciences, radio isotopes, medical research (proton therapy), materials, energy & environment, aero-space technology, etc.

| Parameters | Value |
|---|---|
| Energy | 100~1000 MeV |
| Current | ~ 26 mA |
| Operation Mode | CW or Pulse |
| Operation Frequency | 403MHz, 806 MHz |
| Particle | $H^+$ |
| Accelerating structure | RFQ, DTL, spoke cavity, and elliptical cavity |
| Number of the beam line | 7 or more, depend on the user need. |

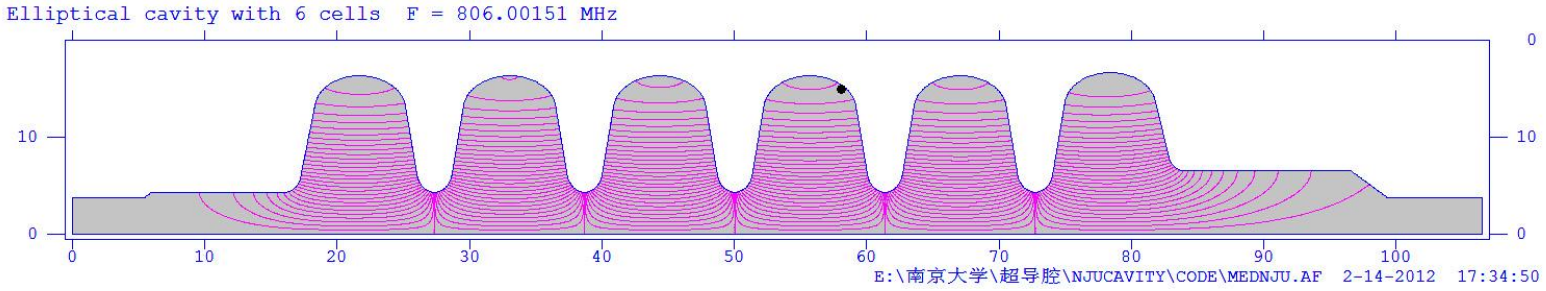
Notice: All the parameters will be decided after the CDR. At present, a CDR is under preparation.

**In order to confirm the main technology, Nanjing University is to develop the elliptical cavity at the first. A prototype Nb cavity has been fabricated at Andeson Superconducting RF Accelerator Technology Inc. (ADS-SRF).**

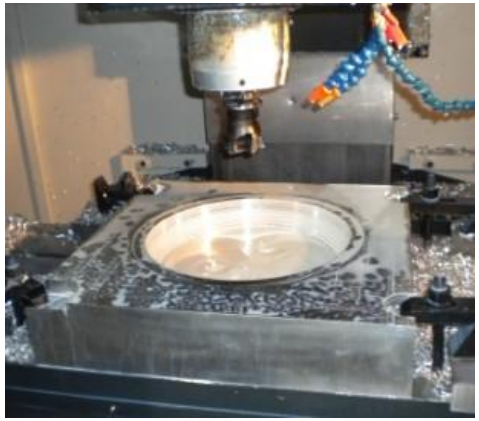
## 1. Cavity design

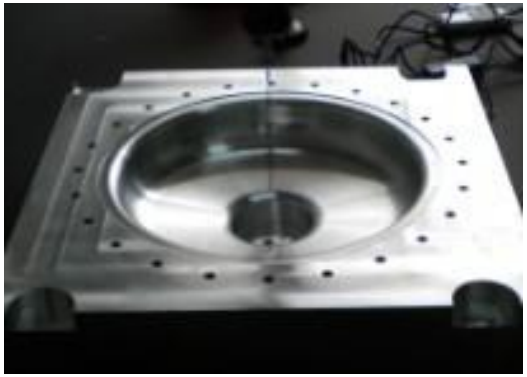
Parameters of the NJU SRF medium beta Cavity

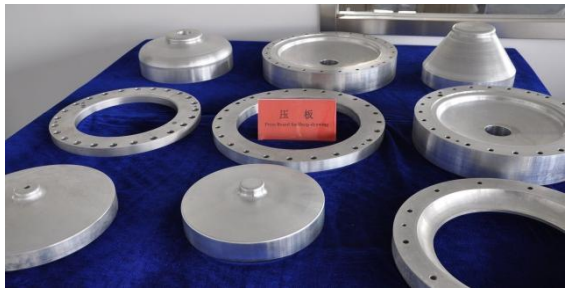
| Parameter | Value | | Parameter | Value |
|---|---|---|---|---|
| Frequency (MHz) | 806 | | Operation Mode | TM010 $\pi$ |
| $\beta_g$ | 0.61 | | $E_{pk}/E_{acc}$ | 2.72 |
| Number of cell | 6 | | $B_{pk}/E_{acc}$ [mT/(MV/m)] | 5.79 |
| Cell-to-cell coupling factor (%) | 1.61 | | $R/Q$ (Ohm) | 278.55 |
| Cavity length (cm) | 106.5 | | G (Ohm) | 176.55 |

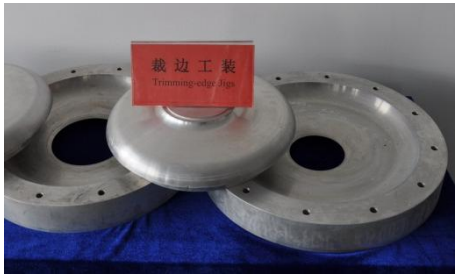


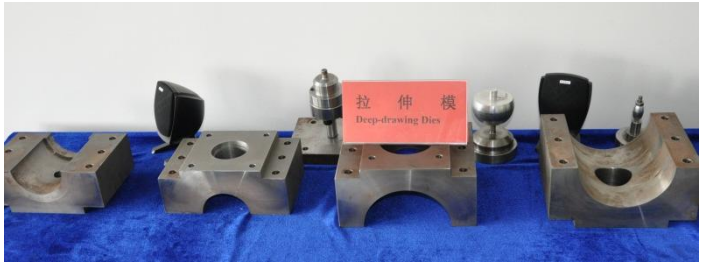
## 2. Cavity fabrication





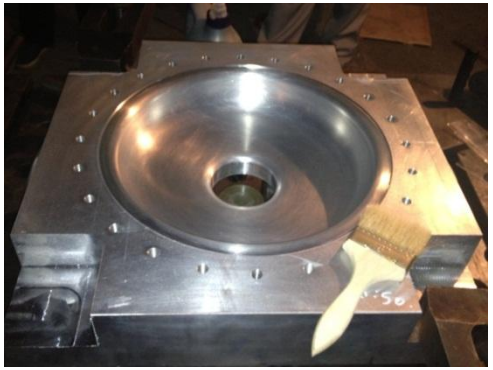
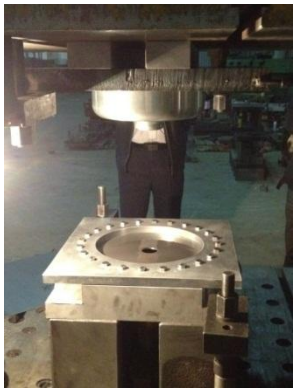





Fabrication of deep-drawing dies and trimming fixtures.

## 2. Cavity fabrication

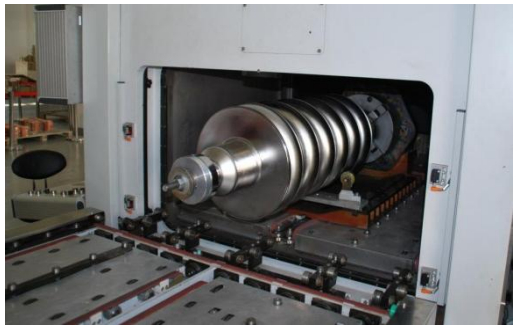

Deep-drawing of the cavity parts

## 2. Cavity fabrication



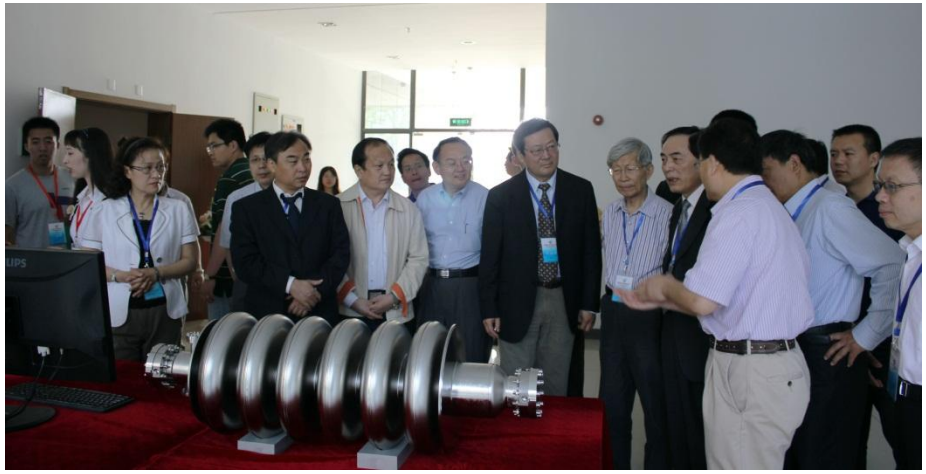
BCP



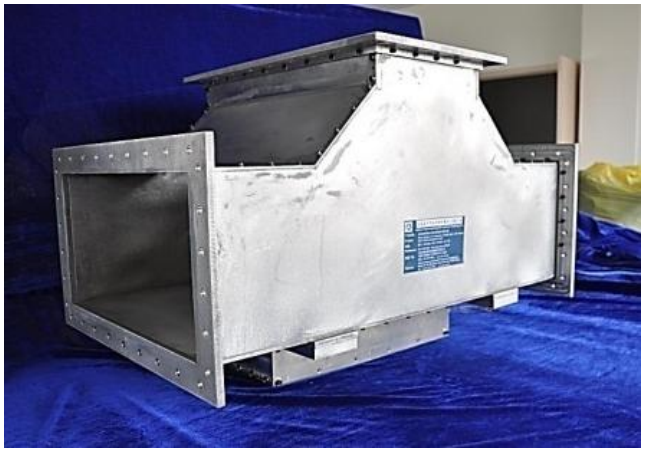


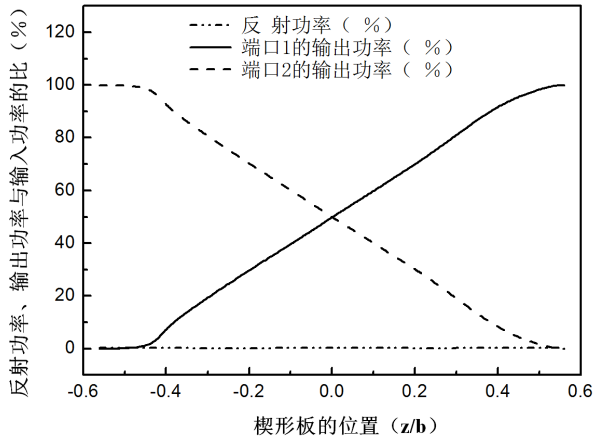
Electron beam welding.

## 2. Cavity fabrication



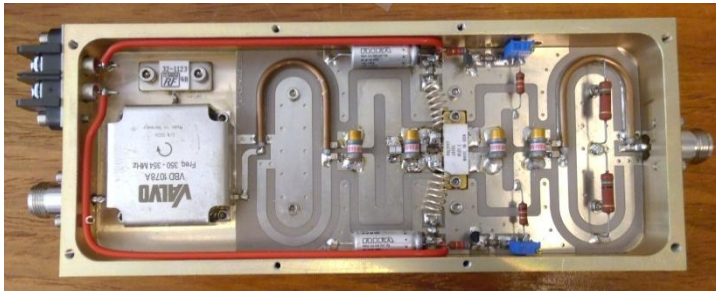
## 3. RF component fabrication






Power splitter with a variable output radio between two output ports.

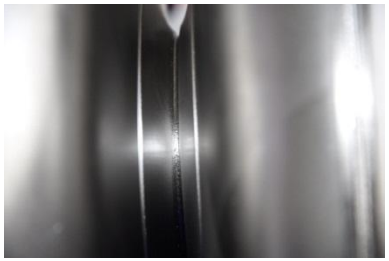
BPM for IHEP.

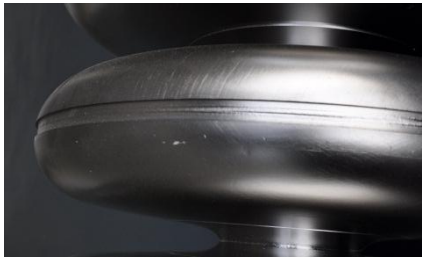


Solid State Amplifier.

## 4. Lessons

Uncertified pipes can not be used!





Enough EB testing is necessary for the good EBW quality!

# Future Plan

Proton Linear Accelerator Institute

1. Prototyping of the medium beta cavity
2. Vertical test of the prototype cavity
3. Cryomodule fabrication and test facilities
4. Prototyping of the medium beta cryomodule
5. Concept design report (CDR) of the proton beam utilization platform
6. Technology design report (TDR) of the proton beam utilization platform
7. Obtain the budget to build the proton beam utilization platform
8. Construction and commissioning of the proton beam utilization platform

# Summary

Proton Linear Accelerator Institute

1. Proton Linear Accelerator Institute (PLAI) at Nanjing University has been established, and under development.
2. Fabrication of the first 6-cell medium beta cavity has been completed, but its quality needs to be improved and tested.
3. A medium beta cryomodule will be developed at Nanjing University
4. Cryomodule fabrication and test facilities will be constructed at Nanjing University.
5. A proton beam utilization platform project is under consideration
6. PLAI needs your kind help and cooperation

Thank You
for Your Attention
and Help!