



中国科学院近代物理研究所

Institute of Modern Physics, Chinese Academy of Sciences



中国科学院
CHINESE ACADEMY OF SCIENCES



中国科学院高能物理研究所

Institute of High Energy Physics Chinese Academy of Sciences



Hefei Institutes of Physical Science
Chinese Academy of Sciences

SRF2015

Progress of Chinese ADS Project

RF Superconductivity

Whistler Conference Centre

September 13-18 2015

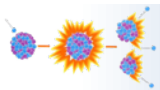
WHISTLER

Yuan He, W.M. Pan

On behalf of ADS Linac Team

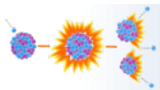
Institute of Modern Physics, CAS

Institute of High Energy Physics, CAS





- **Introduction of ADS Project of China**
- Progress of 325 MHz SRF Linac
- Progress of 162.5 MHz SRF Linac
- Progress of 25-MeV Demo Facility
- Summary

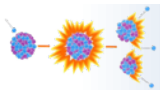




Motivation (NPP in China)

- **To July 2013** (<http://www.iaea.org/NuclearPower/Systems-and-Databases/index.html>)
 - 18 reactors in operation, 13.860GW_e; (6th in the world)
 - 28 reactors under construction, 27.790GW_e; (1st in the world)
- **Estimation for the future (slow down after 2011.3)**
 - **2020**: ~58 GW_e NPP in operation
 - **2030**: ~10% of NP to total power capacity
 - **2050**: 350~400 GW_e, ~20% of NP to total power capacity
→ **almost same as the scale of the total in the world today!**

Nuclear Waste Management is a serious Issues for Sustainable NP Development

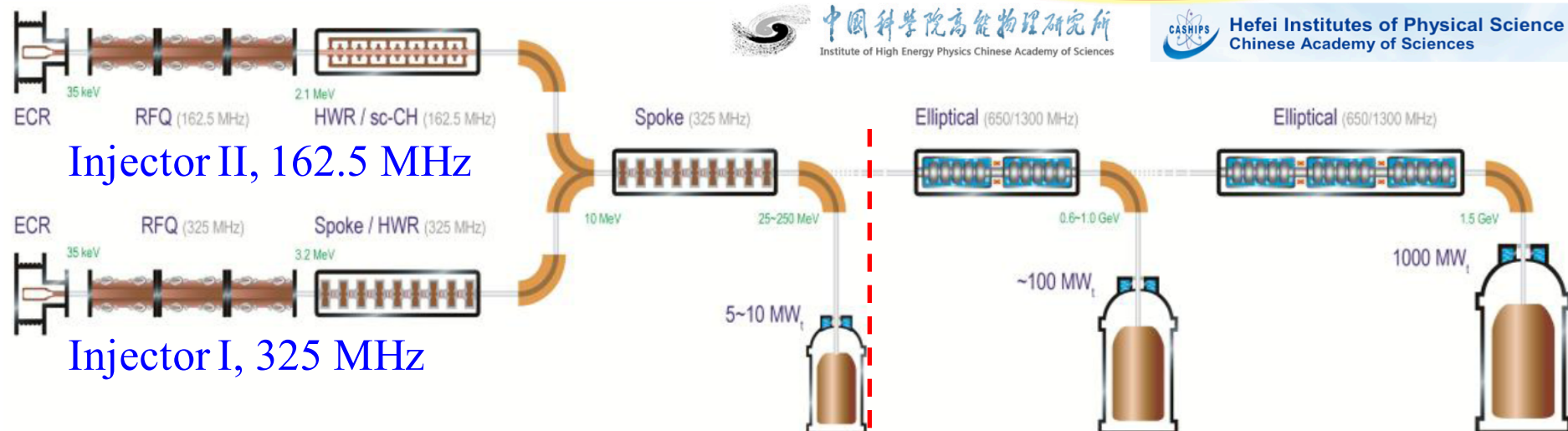




Roadmap of ADS project in China



IMP is the leading institute to carry out the research in cooperation with a number of participants.



Stage 1: Research facility (CIADS)
(250 MeV, 10 mA, 10 MW_t)
Y2017-2022, 1.867 B CNY

Y2011-2016, 1.78 B CNY

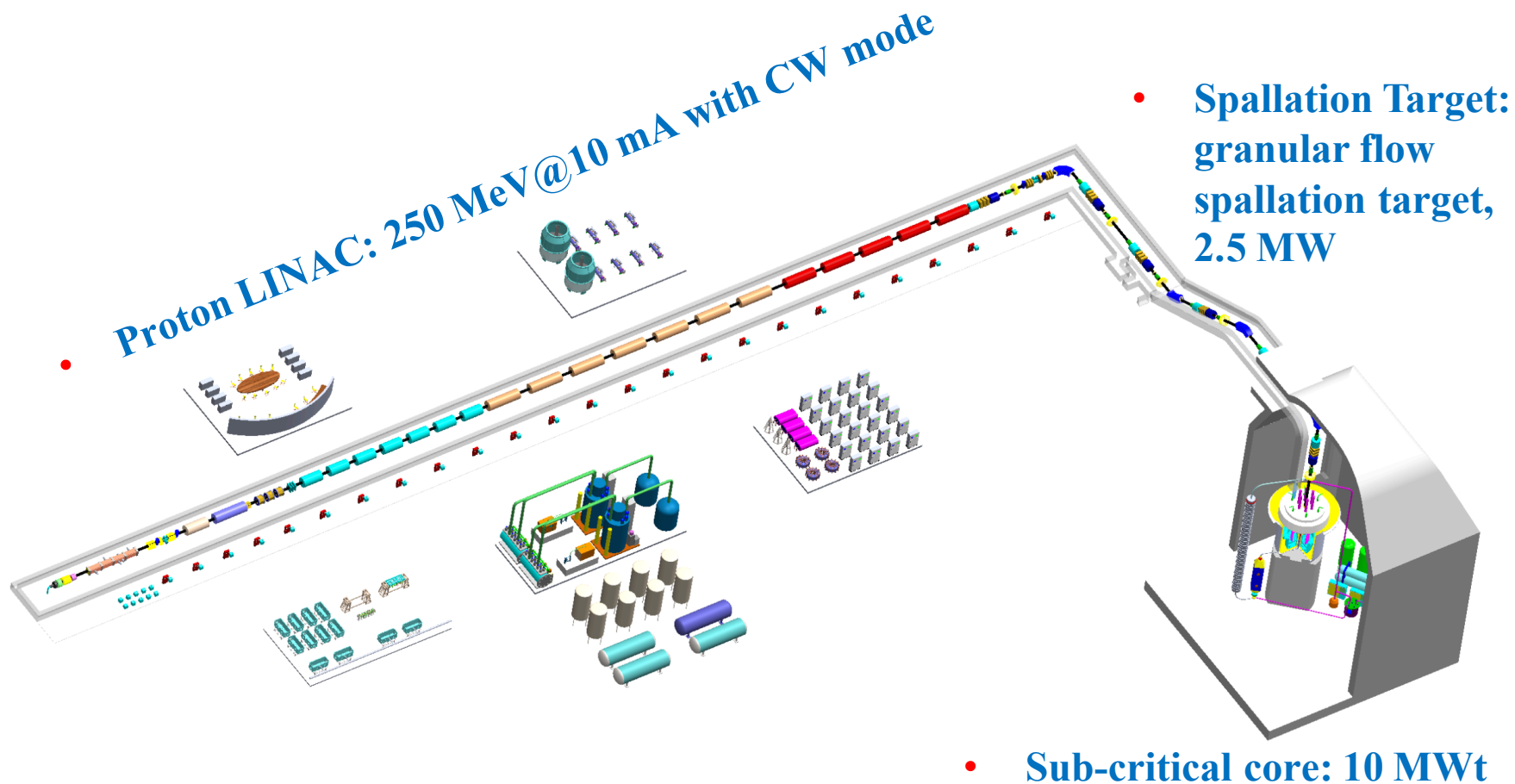
“Strategic Technology Pilot Project” of CAS
Key technology R&D

Stage 2: Demo facility (CDADS)
(1.0~1.5 GeV, 10~25 mA, 500 MW_t)
Y2030

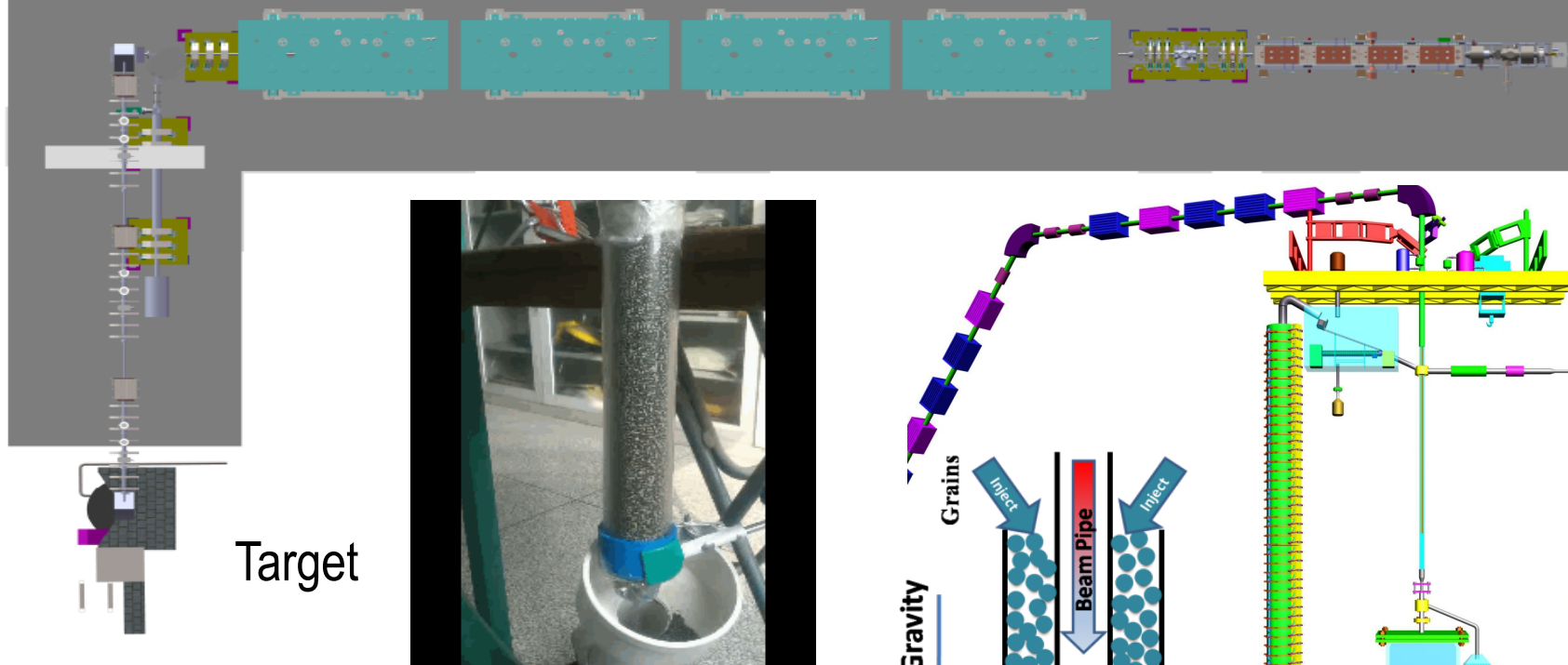
New Project CIADS (2017-2022)

China Initiative Accelerator Driven System

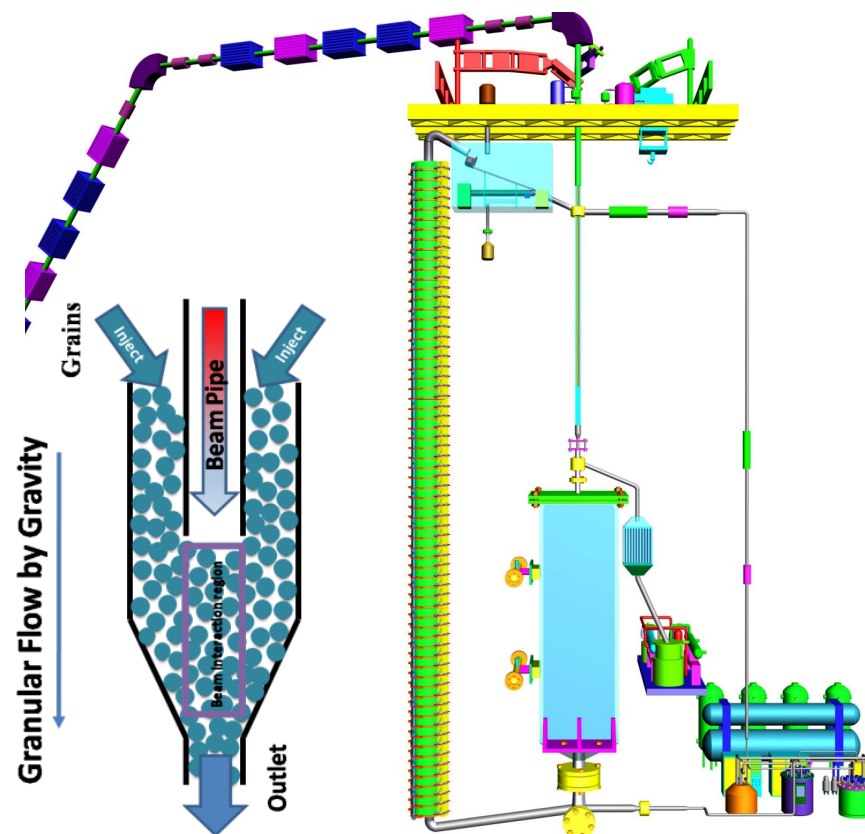
- Budget: ~ 1.867 B CNY
- Location: Huizhou, Guangdong Prov.



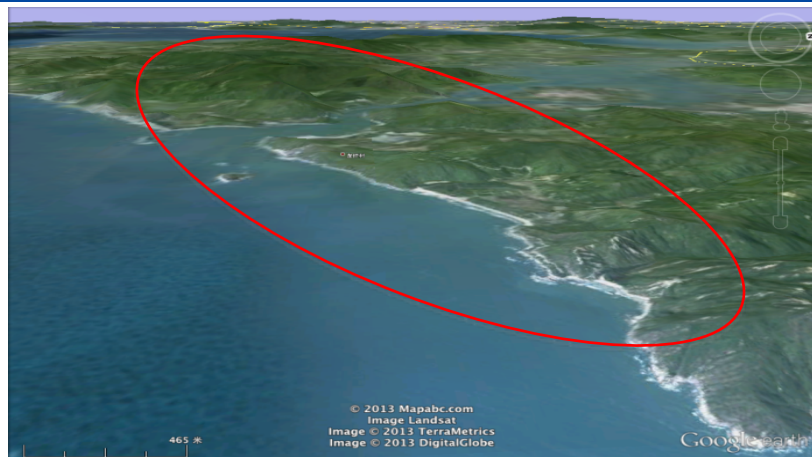
25 MeV/10 mA/CW Proton sc-Linac



Beam: 25 MeV, 10 mA, 250 kW
Target: tungsten granular,
 windowless, vacuum differential
Lifter: mechanical



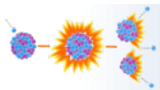
Location of CIADS

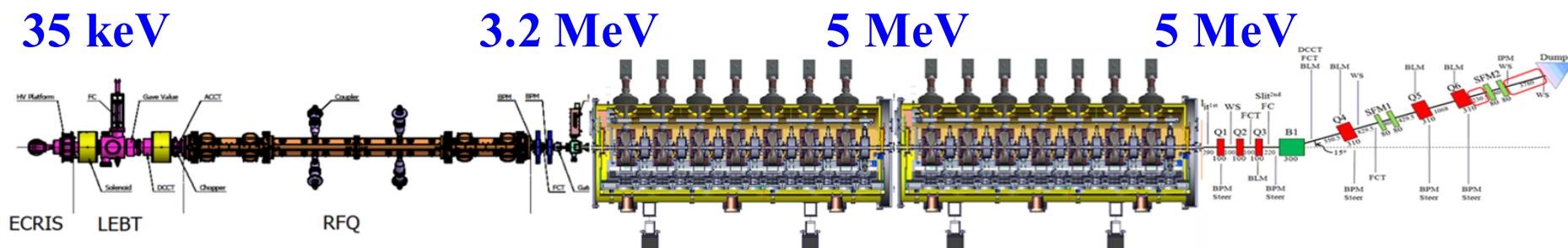


- ❑ A new site, which locates in Huizhou, Guangdong, was selected
- ❑ This new site is nearby the planed Huizhou nuclear power plant



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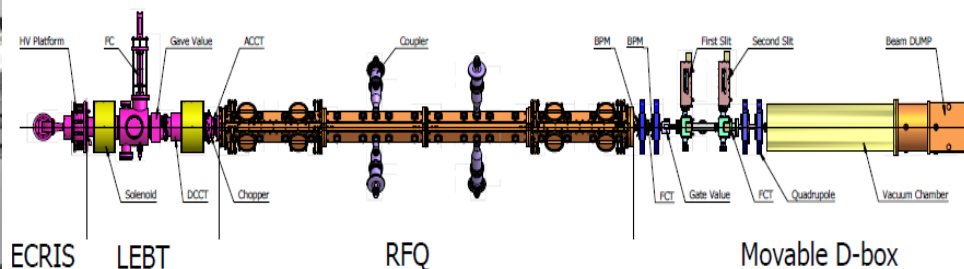




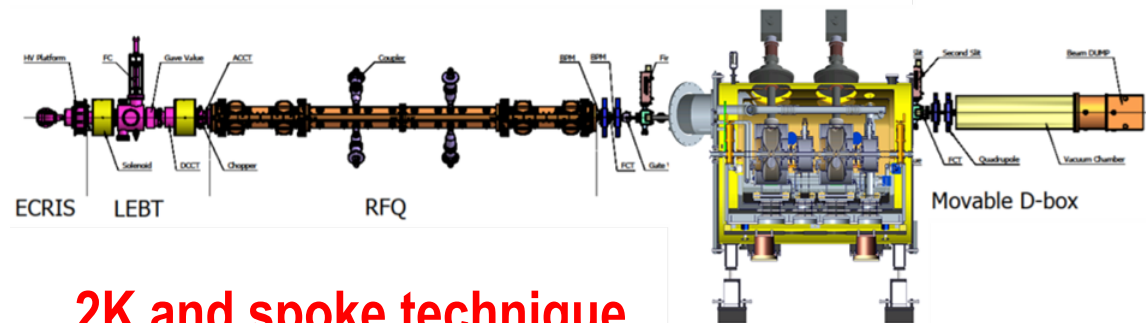
- Ion sources, 35 keV
- RFQ
 - frequency 325 MHz, 3.2 MeV,
 - RF power 280 kW, four couplers
- SRF cryomodules
 - Frequency 325 MHz, 2 K operation
 - Spoke beta=0.12, $E_p=32$ MV/m, $V_{acc}=0.78$ MV
 - 7 Spokes and 7 solenoids per module

Injector I at IHEP

Commissioning of spoke test module



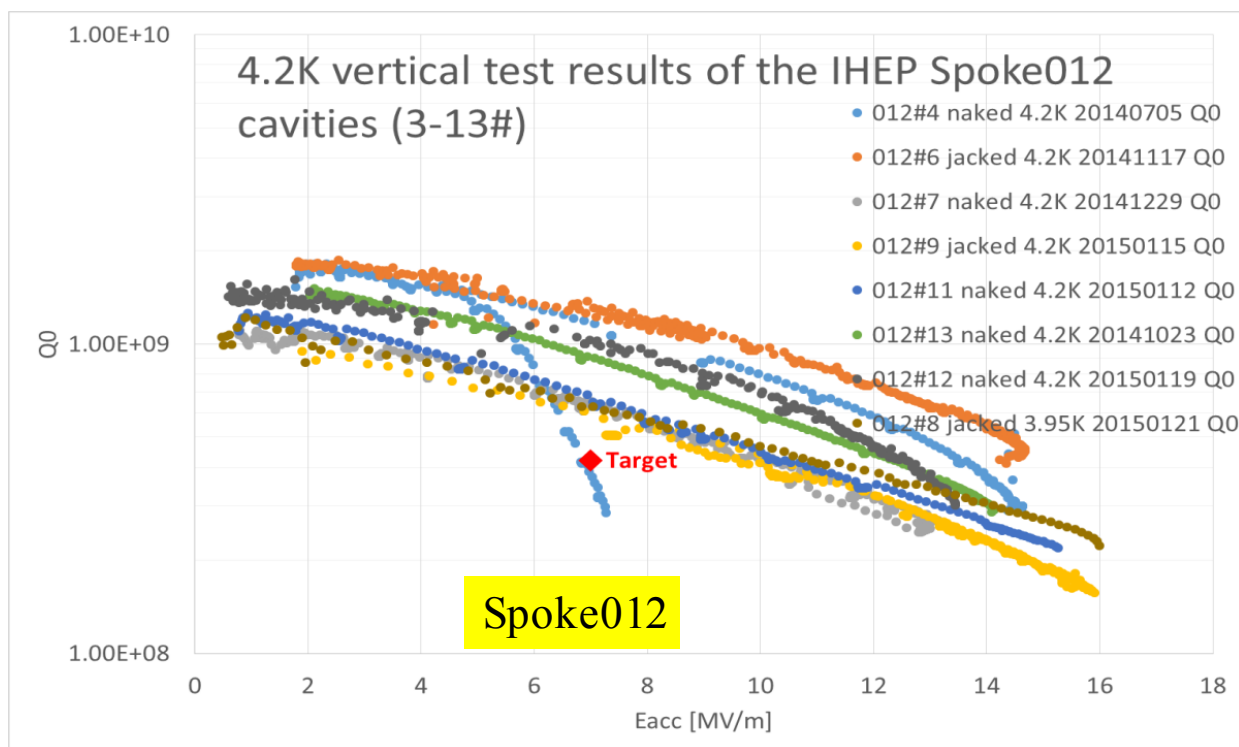
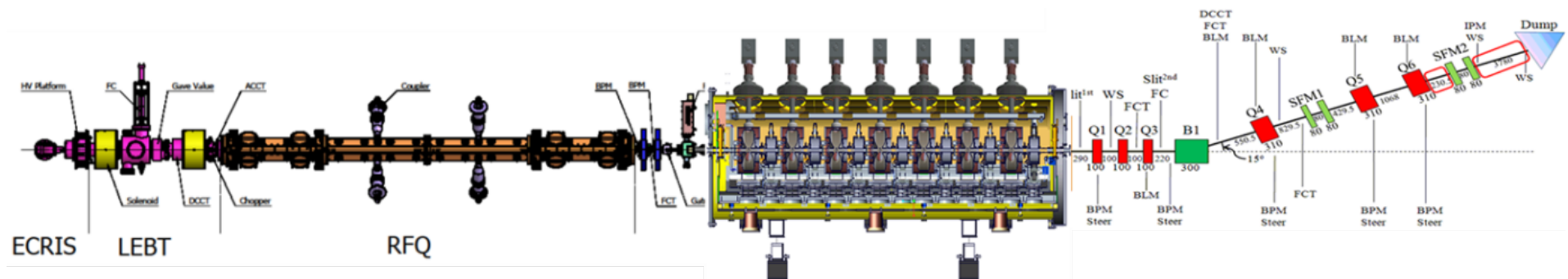
- Pules: 11 mA, 50 Hz, duty factor > 90%
- Efficiency > 97% (duty factor 70%)
- Energy 3.2 MeV, average power > 31 kW



2K and spoke technique

- Two spokes
- Pules: 10 mA, 30~130 us, 1 Hz
- Efficiency > 99.7%
- Energy 3.61 MeV





No.	Eacc [MV/m]	Q ₀ @7MV/m
4#	14.6	1.2e9
6#	14.7	1.3e9
7#	13.4	6.5e8
8#	15.4	5.5e8
9#	15.9	5.9e8
11#	15.3	6.5e8
12#	13.4	1.0e9
13#	14.1	9.0e8

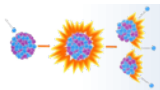


Assembly of Spoke Module of 5 MeV



The first cryomodule of spoke has been installed in tunnel last month. New clean room was employed to install coupler.

RF conditioning is ongoing and the beam commissioning will be in September.

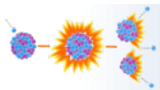




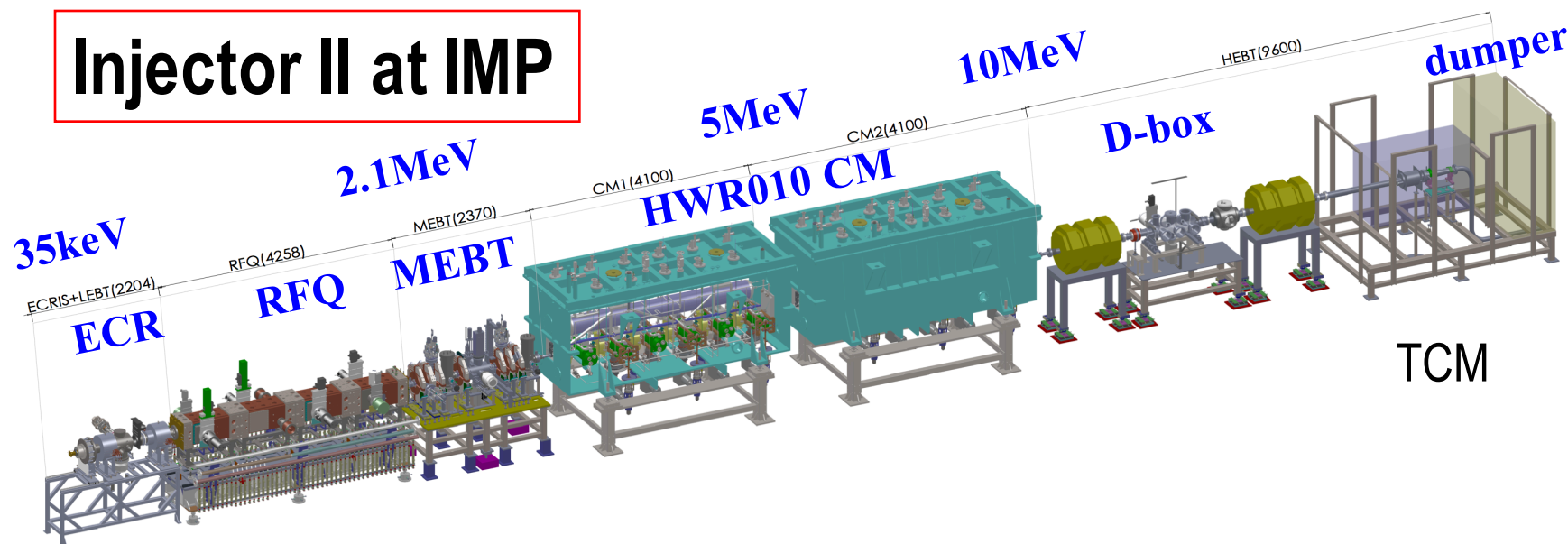
- Air Liquid, 1000W/4.5K
- FSD571 main compressor
- Recycle compressor
- Purifier + Analyzer
- LN2 tank
- Gas Helium buffers



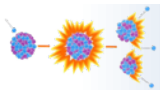
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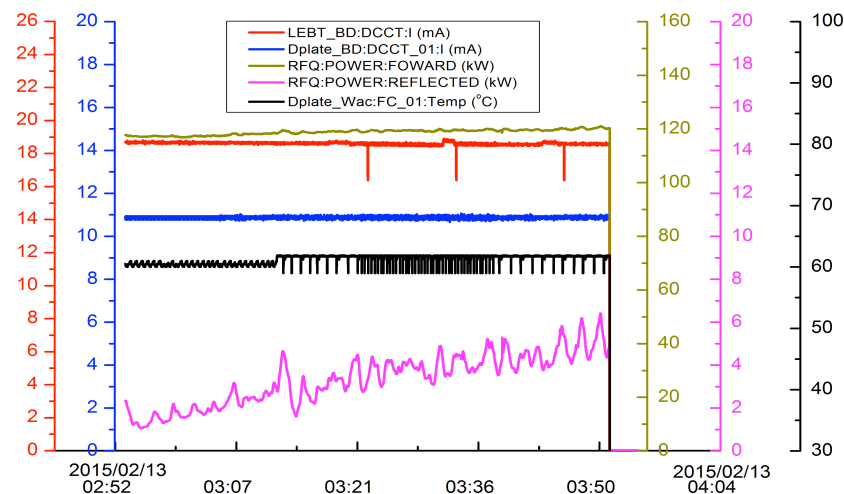
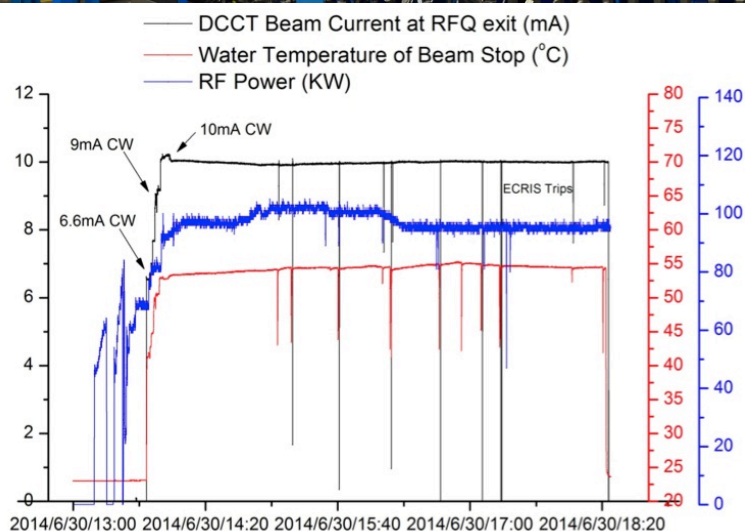
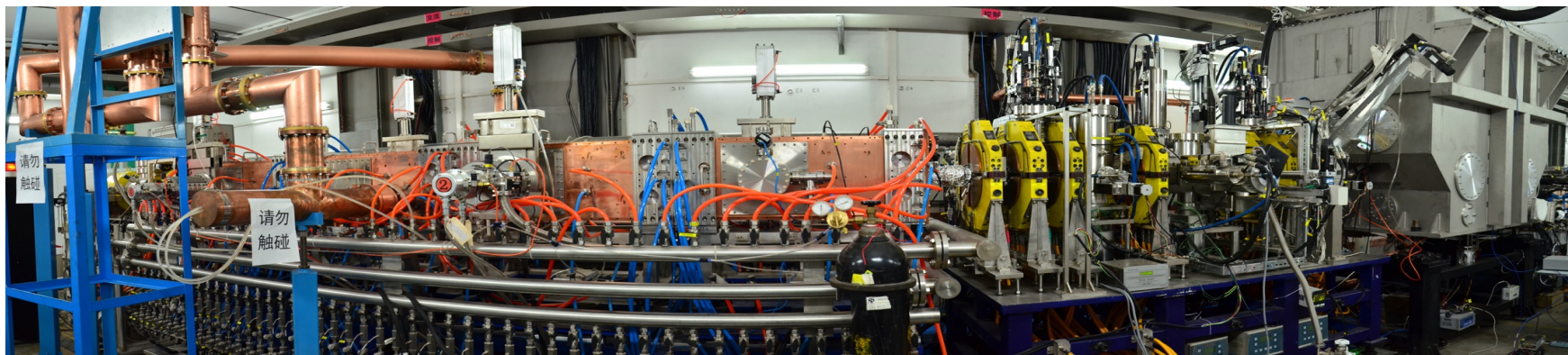


Injector II at IMP



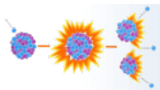
- **RFQ**
 - frequency 162.5 MHz, 2.1 MeV,
 - RF power 100 kW, 2 couplers
- **SRF cryomodules**
 - Frequency 162.5 MHz, 4.5 K
 - HWR beta=0.1, $E_p=25$ MV/m, $V_{acc}=0.78$ MV
 - 6 HWRs and 6 solenoids per module

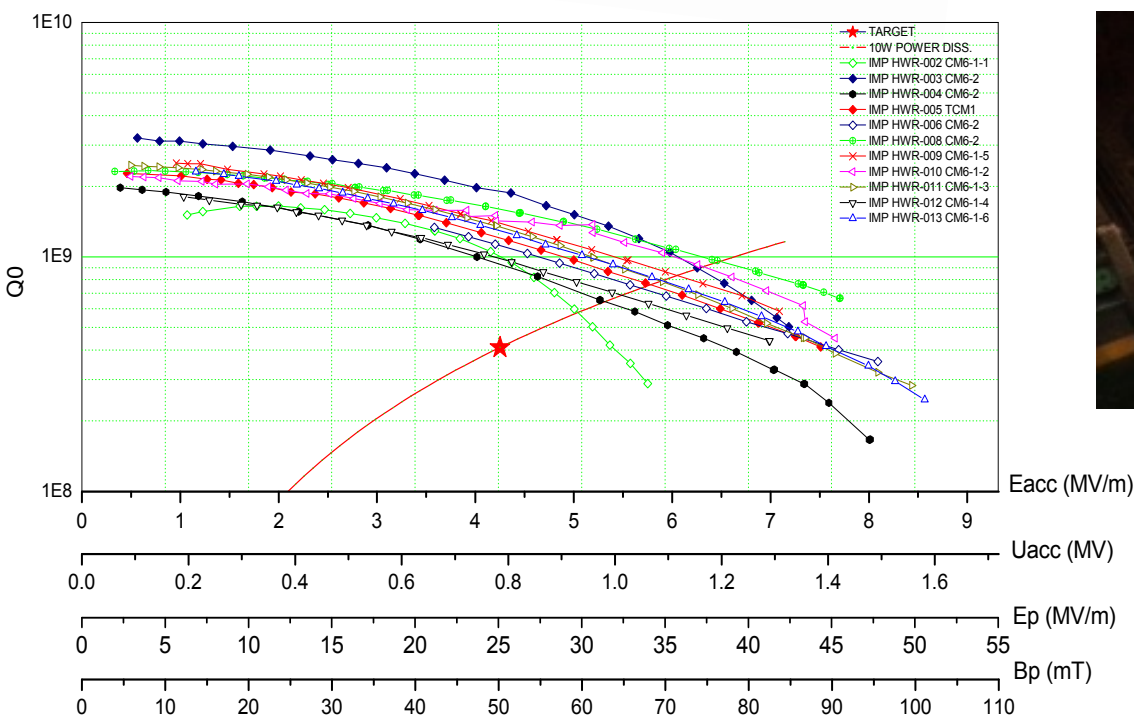
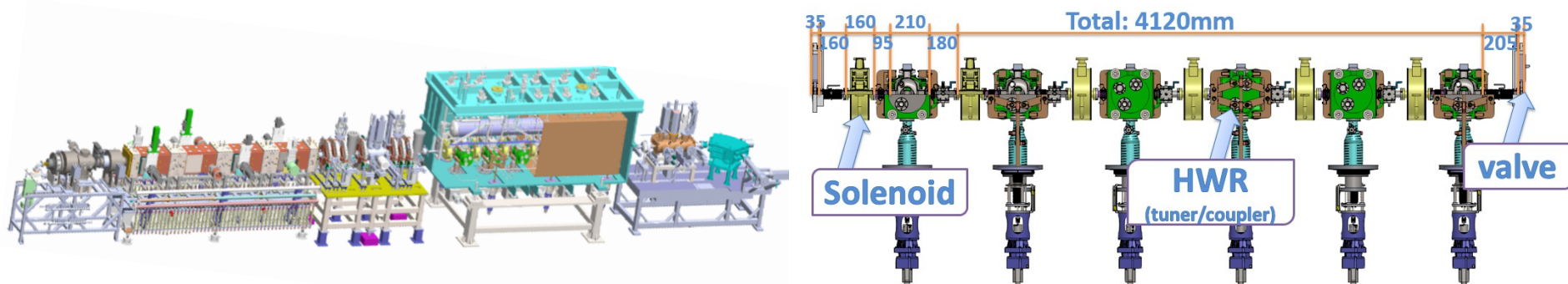




- June 6th, 2014, the first beam, 2.16 MeV
- June 30th, 10 mA, CW, 21 kW, 4.5 hrs
- Operation > ~1000 hours by now
- Non-trip operation ~220 hrs

- Oct. 1st, 2014, first beam, 2.6 MeV, 2.3 mA
- Nov.25th, first CW, 3.4 mA around 6 hours.
- Feb. 23rd, 2015, 2.55MeV/~11mA/28kW, 1 hour
- Total operation time was ~200 hours.

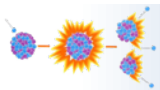
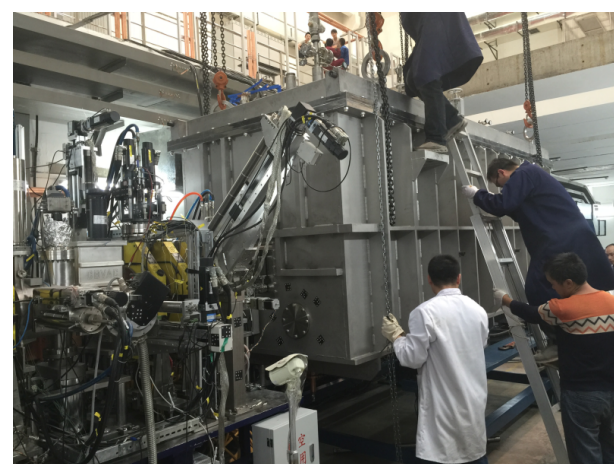
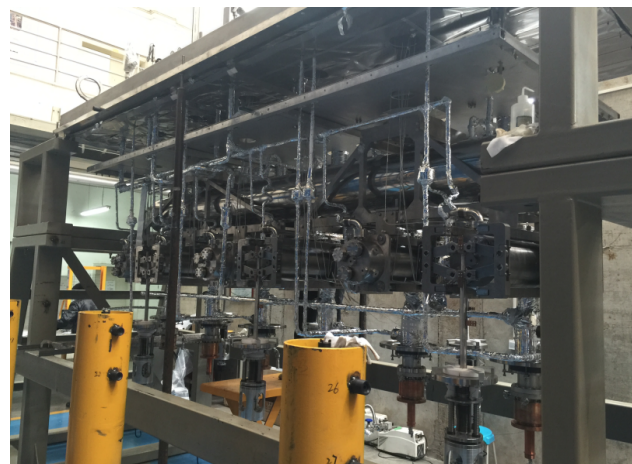
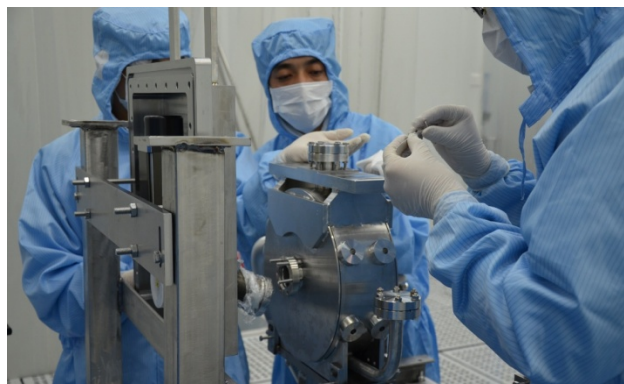




Vacc(MV)	0.78
Bpeak(mT)	50
Epeak(MV/m)	25
Eacc(MV/m)	4.7
β_{opt}	0.10
Q0	4.0E08



Assembly of HWR module of 5 MeV



Chemistry Lab



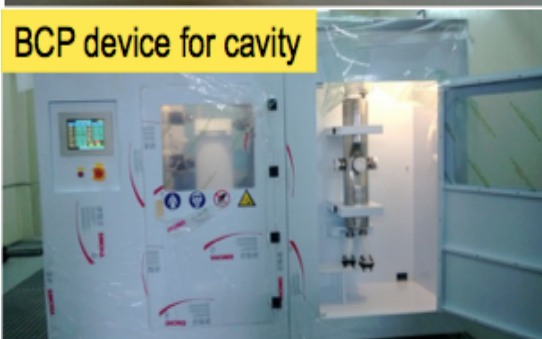
BCP Device for Parts



Hands-on BCP



BCP device for cavity



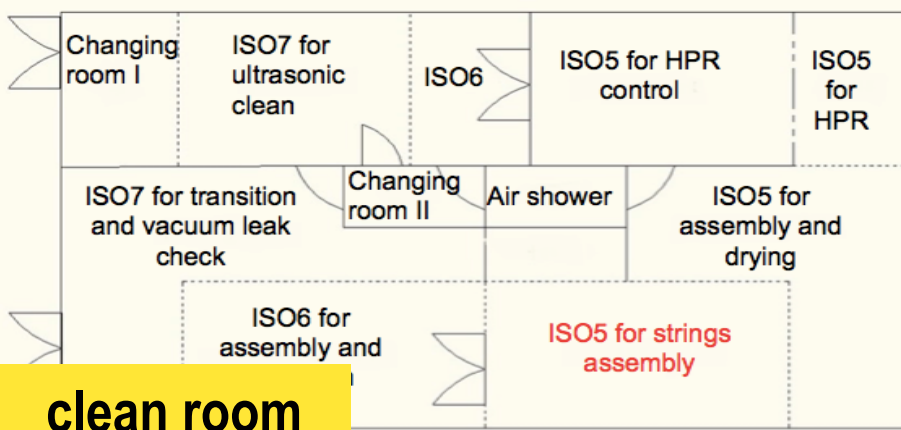
Acids mixing system



HPR



CM String assembly area

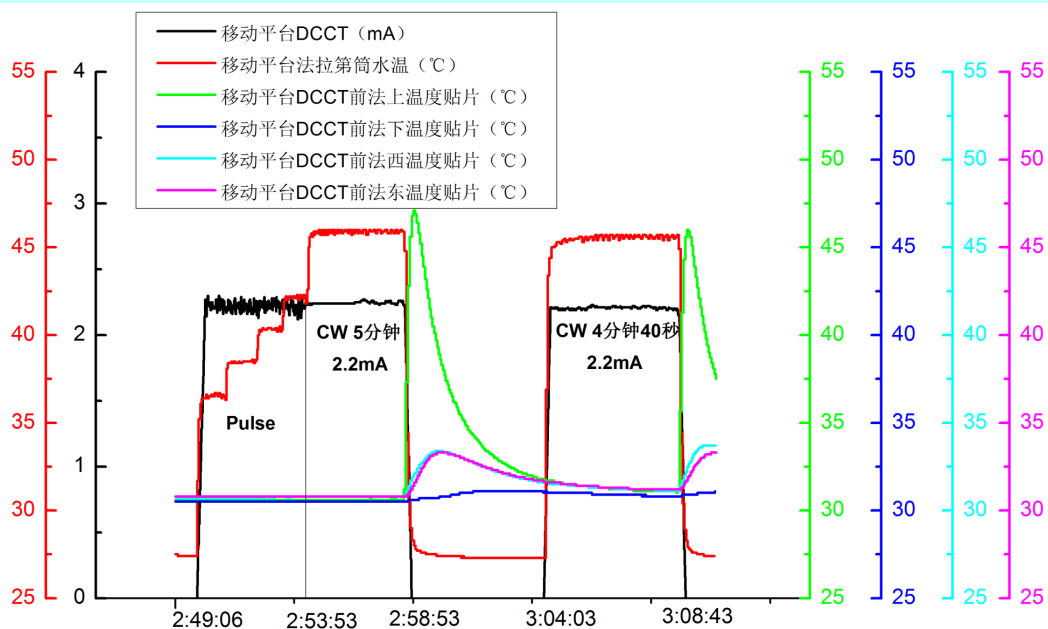
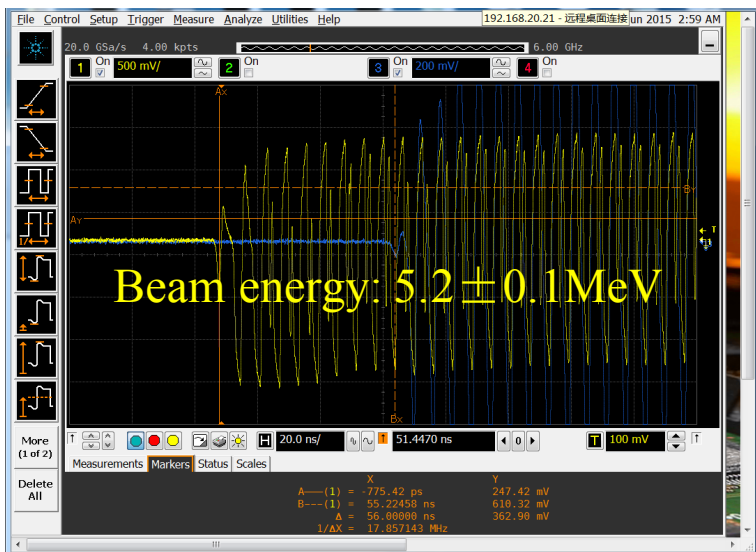




- Linde L280, 850W/4.2K
- FSD571 main compressor
- DS85 recovery compressor
- Recovery compressor, 15MPa/40m³*4
- HP He purifier, 15MPa/100m³
- HP He tank, 15MPa, 8000m³
- Gas bags, 25m³*2
- Purity analyzer on line

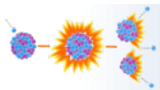


- June 6th, 2015, **5.2 MeV, 10.2 mA**, short pulse, 100us@1Hz; MPS upgrade
- June 12th, 2015, **5.1 MeV, 2.7 mA**, 100ms@1Hz ; **radiation protection upgrade**
- June 24th, 5.3 MeV, 2.7 mA, CW, 5 min, MPS upgrade
- Beam trips due to loss of phase lock
- The next turn of commissioning starts soon

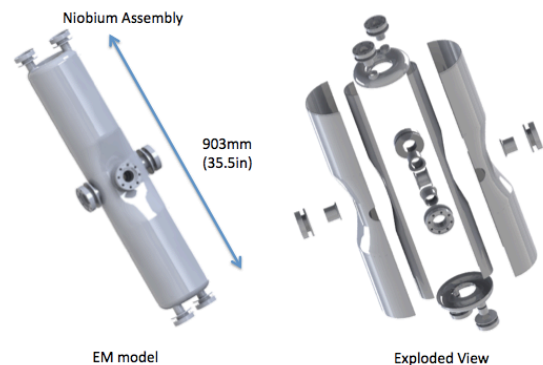




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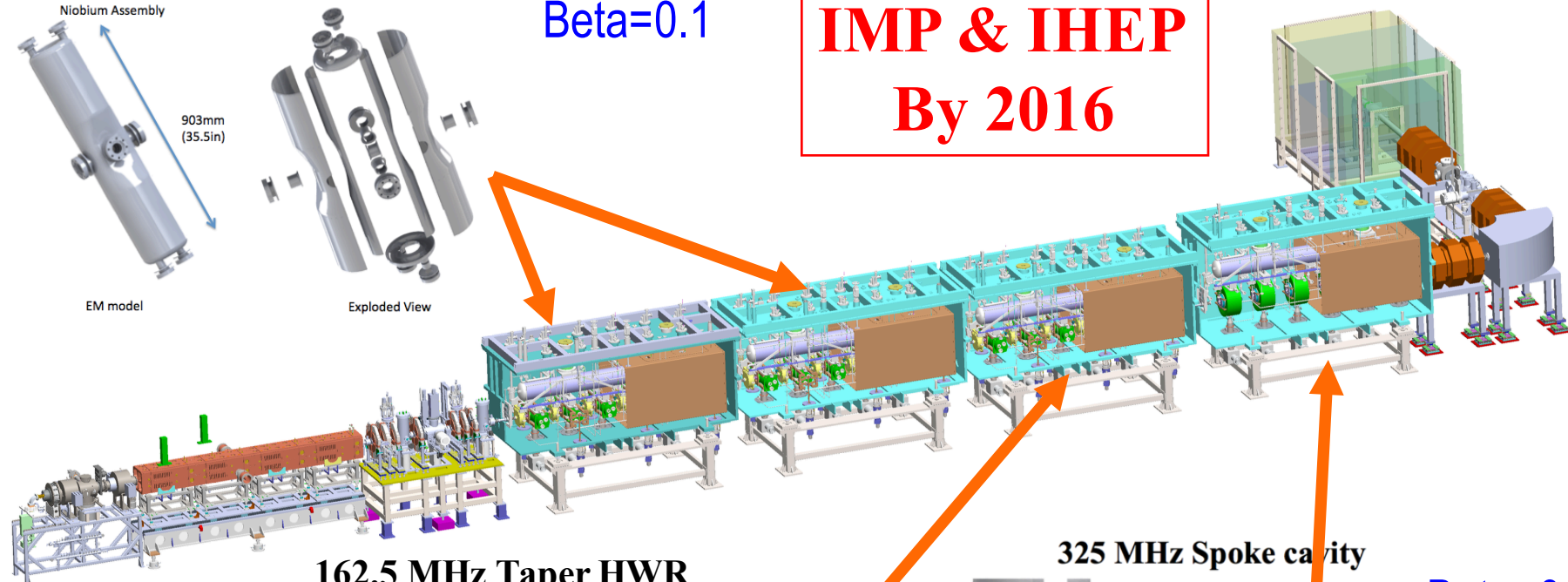


162.5 MHz Half-wave Cavity



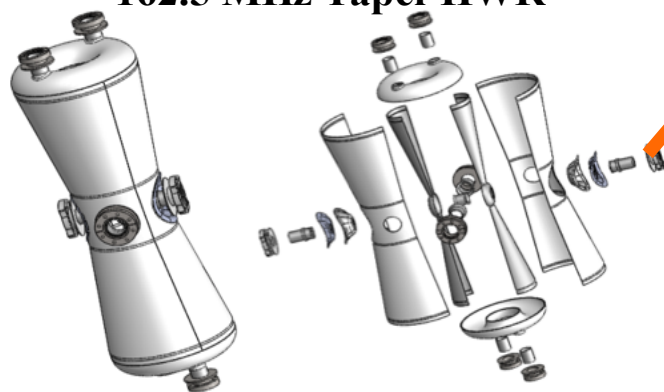
Beta=0.1

IMP & IHEP
By 2016



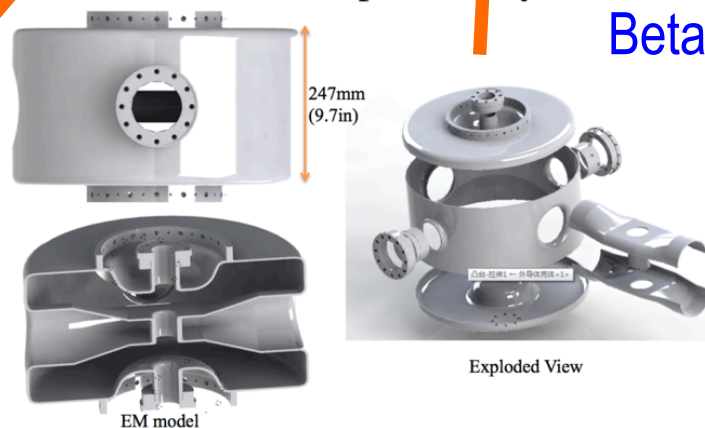
162.5 MHz Taper HWR

Beta=0.15

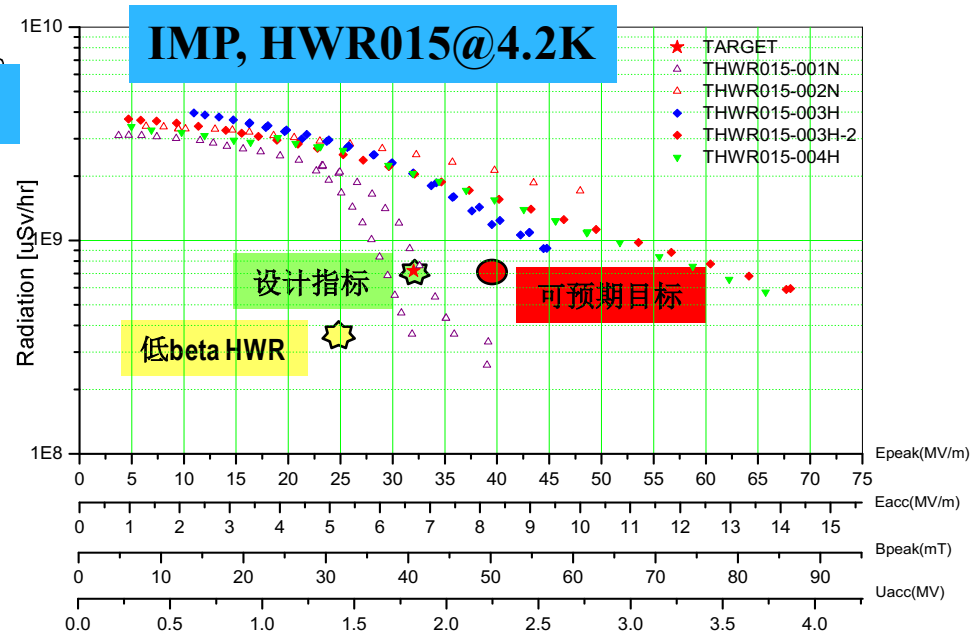
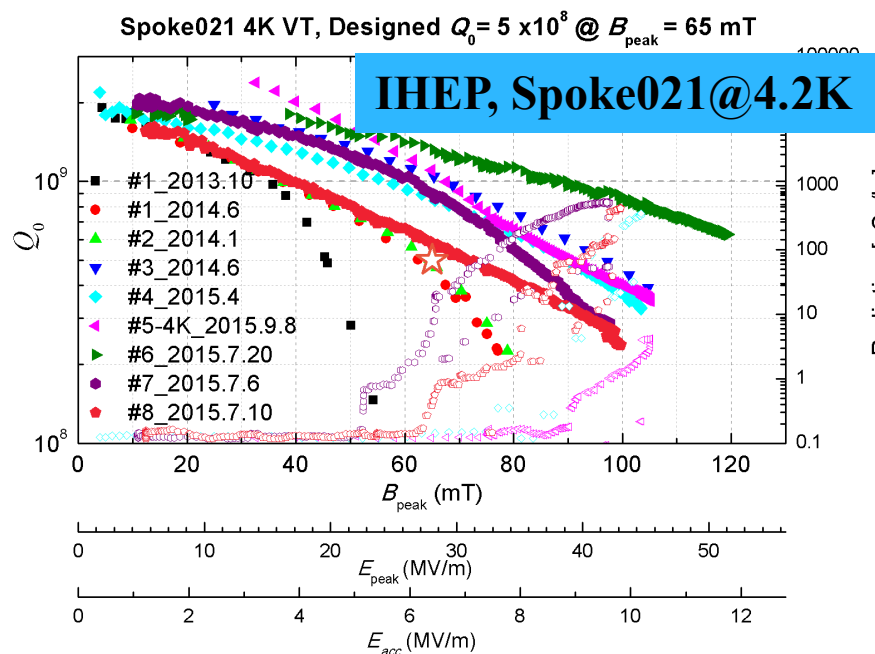


325 MHz Spoke cavity

Beta=0.21

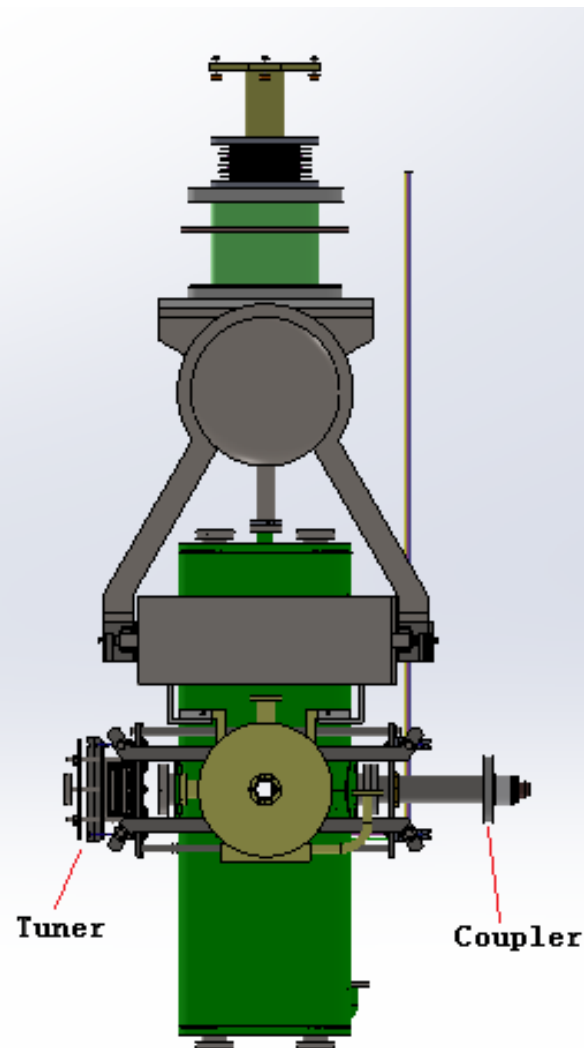
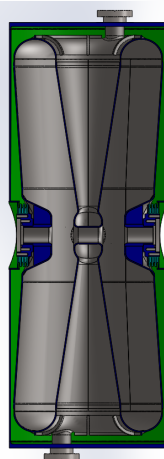
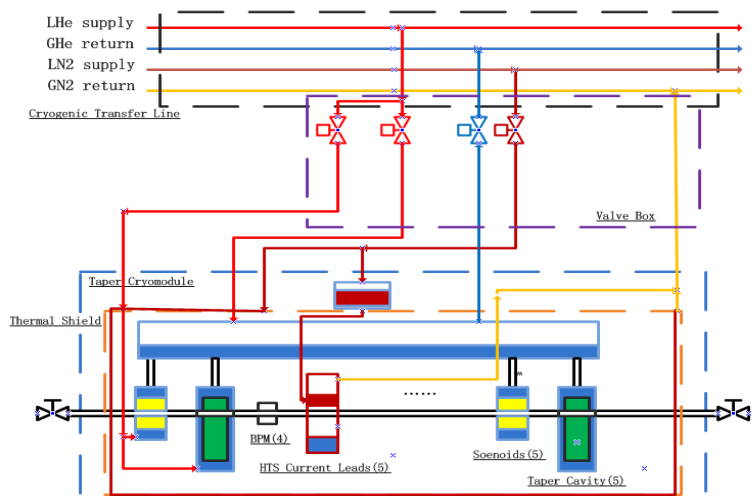
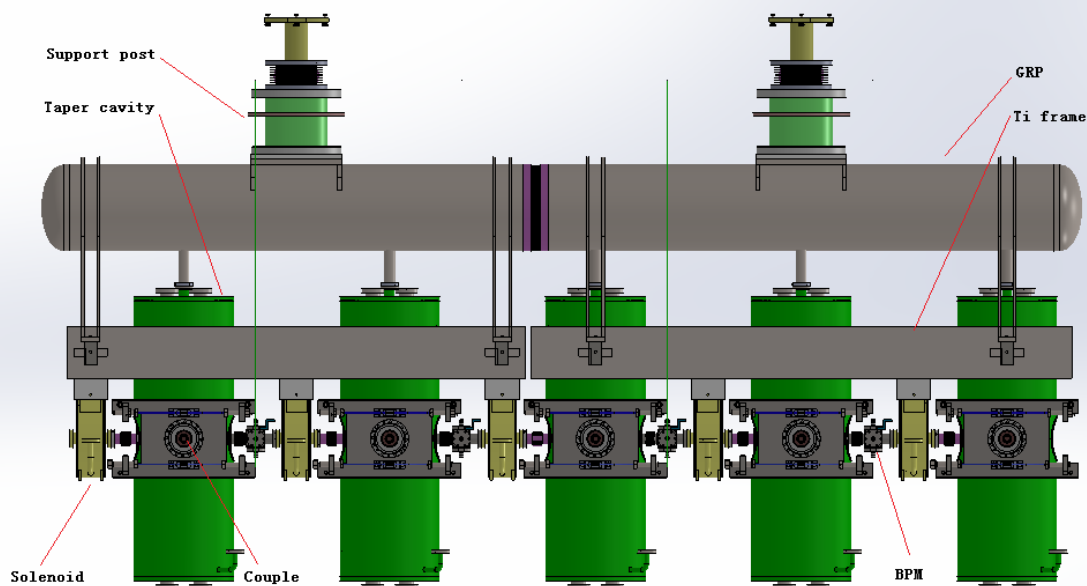


Status of Resonators for 10~25 MeV



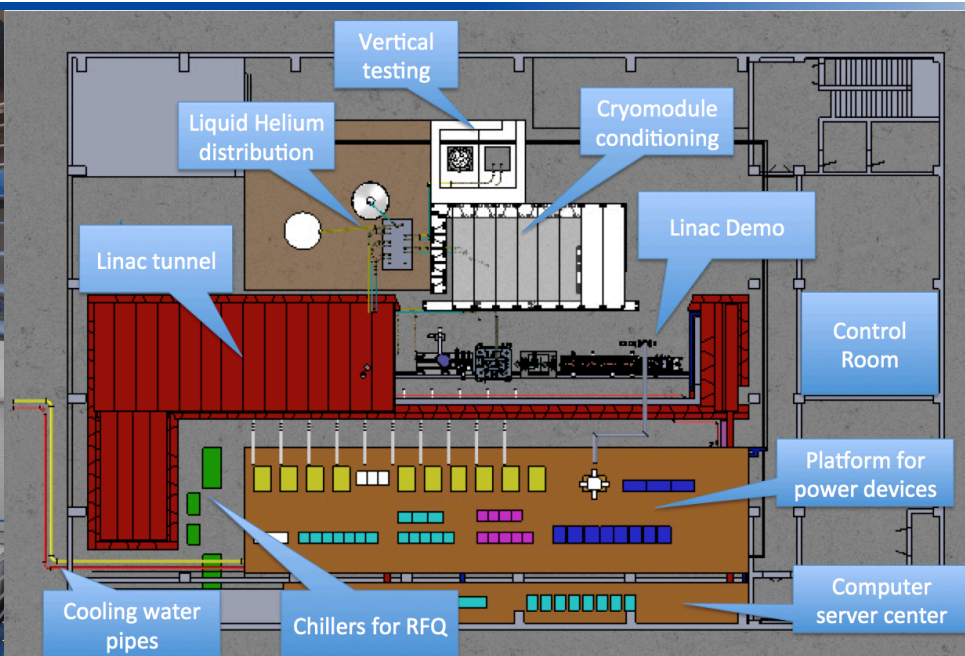
- ✓ 8 Spokes were tested
- ✓ $H_p = 98$ mT @ $Q_0 = 5e8$
- ✓ 4 T-HWR were tested
- ✓ $H_p = 85$ mT @ $Q_0 = 5e8$







Vertical testing



Power supply



Liquid Helium distribution



Beam diagnostic



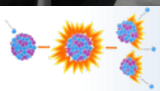
LLRF



Solid state AMP

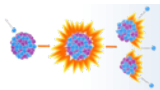


Amplifier of RFQ





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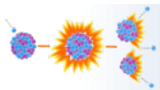




Summary



- ▶ The prototypes of Spoke and HWR are commissioned. One has achieved 11 mA, CW proton beam.
- ▶ 5 MeV of HWR Linac has been commissioned and got 10 mA pulse beam. The first attempt to CW was succeeded and lasted 5 min. The LLRF need to be upgraded to keep the stability.
- ▶ The demo SRF linac with 25 MeV/10 mA/CW will be build in 2016 and coupled with granular target.
- ▶ Chinese Initiative ADS project (CIADS) will be approved soon. 250 MeV SRF proton linac, Granular target and 10 MWt subcritical LBE FR are chosen.





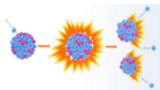
More details about SRF resonators for Chinese ADS

- ▶ **Presentation WEBA01**

by Dr. Feisi HE on Wednesday Morning

- ▶ **Posters**

THPB-015, TUPB097, TUPB017, THPB087, THPB101





Acknowledgements



Thanks for your attention

&

Linac Team of China ADS

Thanks for the helps

from **LBNL**, **J-Lab**, **TRIUMF**, ANL, MSU/FRIB, ORNL, FNAL,
RIKEN, CEA/Saclay, IPN/Orsay, IAP, KEK,

HIT, PKU, SINAP,.....

Welcome Collaboration!

