
# Development Progress of the H+/H- Linear Accelerators at Tsinghua University

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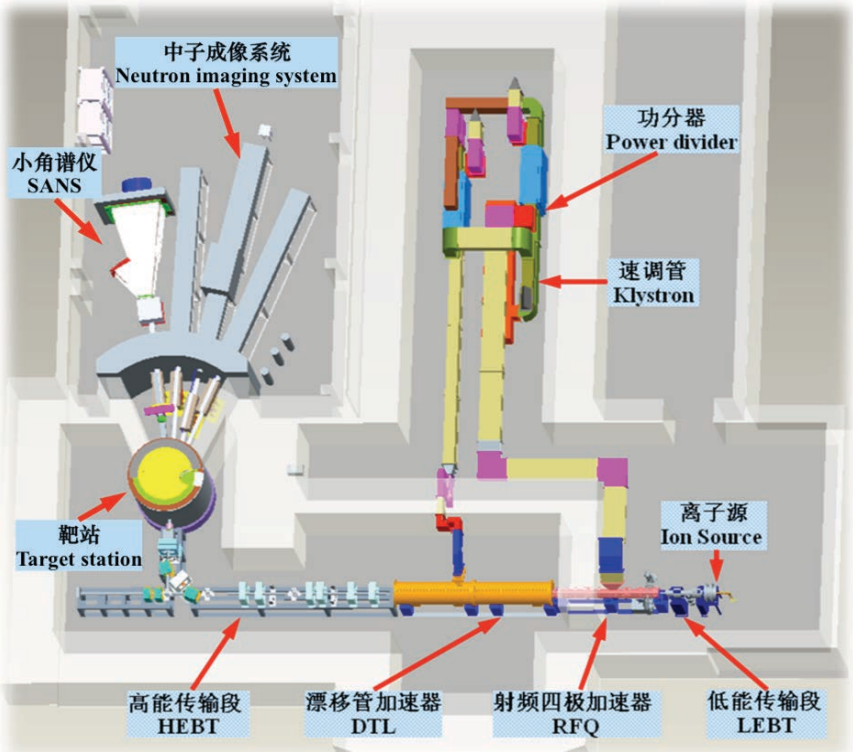
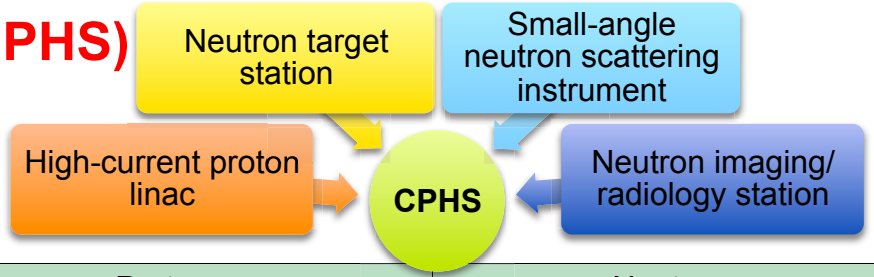
# Content

- 13MeV proton linac for Compact Pulsed Hadron Source (CPHS)
- 7MeV H- linac injector for Xi'an 200MeV Proton Application Facility (XiPAF)

# 13MeV proton linac for CPHS

## ➢ Compact Pulsed Hadron Source (CPHS)

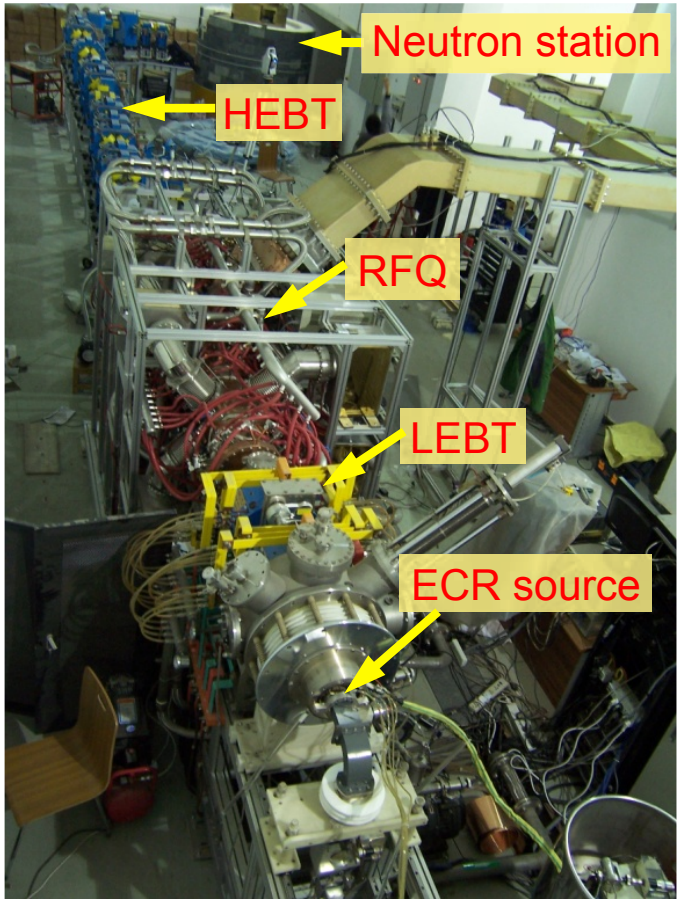


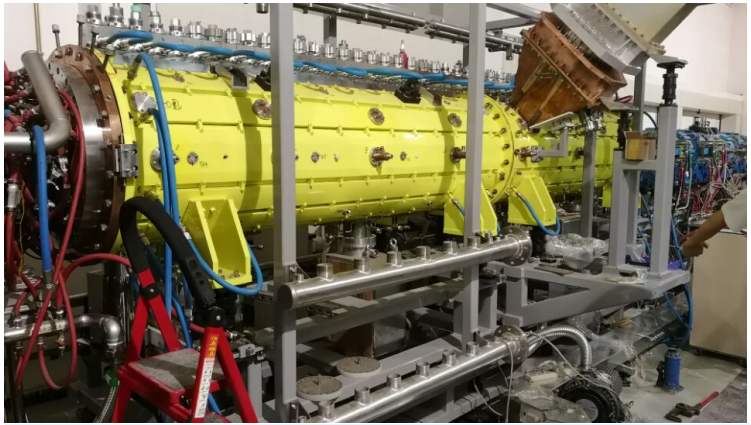

| Protons | | Neutrons | |
|---|---|---|---|
| Beam power on target | 16 kW | Target for ~6 cm x 6cm proton beam | |
| Output energy | | Material | Be ~1.2 mm thick |
| DTL | 13 MeV | Coolant | Chilled water |
| RFQ | 3 MeV | Moderator | |
| Ion source | 50 KeV | Material | Solid $CH_4$ ~20 K |
| Average beam current | 1.25 mA | *n*-emitting surface | 10 cm x 10 cm |
| Pulse repetition rate | 50 Hz | Reflector | Water |
| Pulse length | 0.5 ms | Pulse length | ~1 ms |
| Peak beam current | 50 mA | Neutron yield (est.) | ~5 x $10^{13}$ /s |
| Protons per pulse | 1.56 x $10^{14}$ | | |
| RF frequency | 325 MHz | | |

# 13MeV proton linac for CPHS

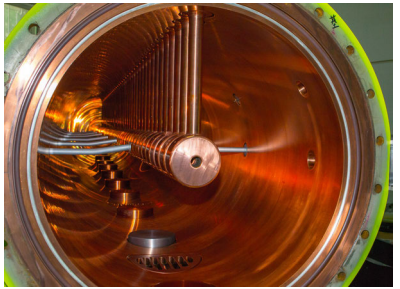
## ➢ CPHS linac

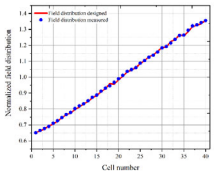


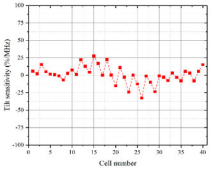

- Microwave ECR H+ source without Cs
- Four-vane RFQ with ramped inter-vane voltage
- Alvarez-type permanent-magnet DTL
- No MEBT between the RFQ and DTL
- RFQ and DTL powered by one klystron



Alvarez-type DTL mounted on the beam line, Sep. 8, 2018



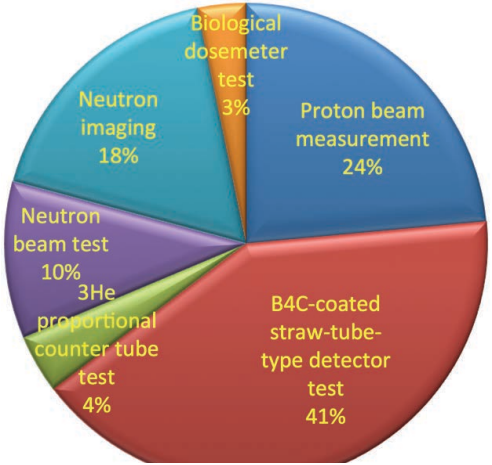




Field error：<1.6%
Tilt sensitivity: within ±33%/MHz

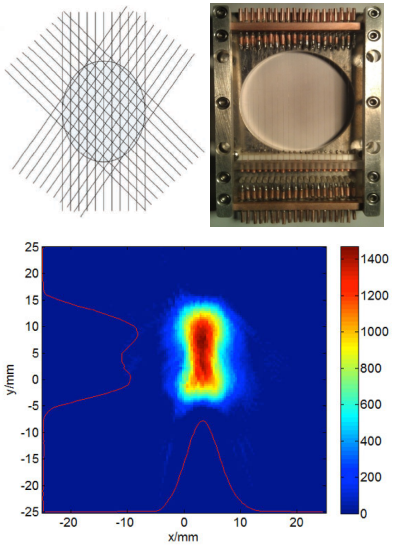
# 13MeV proton linac for CPHS

## ➢ CPHS operation

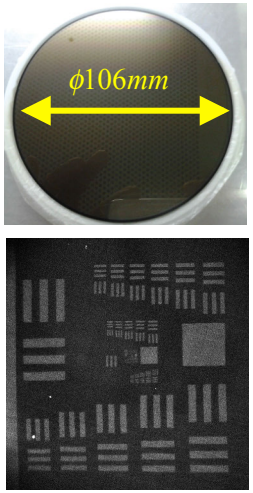



Total operation time: ~2000 hrs

| Parameter | Designed Value | Present Value (mid-term) |
|---|---|---|
| Beam Energy | 13 MeV | 3 MeV |
| Peak Current | 50 mA | 28 mA |
| Beam Pulse Width | 500 μs | 100 μs |
| Repetition Rate | 50 Hz | 20 Hz |

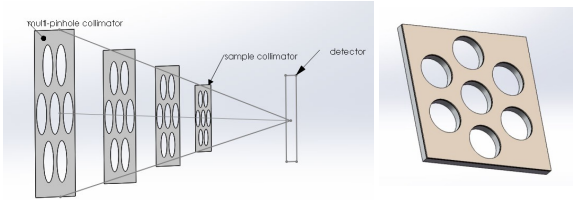



2D profile measurement of the proton beam by the rotatable multi-wires

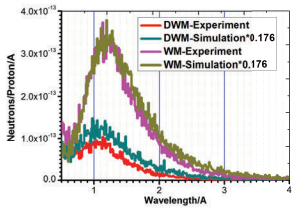



Neutron imaging from Gd-doped Multi-channel plate detector@CPHS

$B_4C$-Coated Straw-Tube-Type Detector



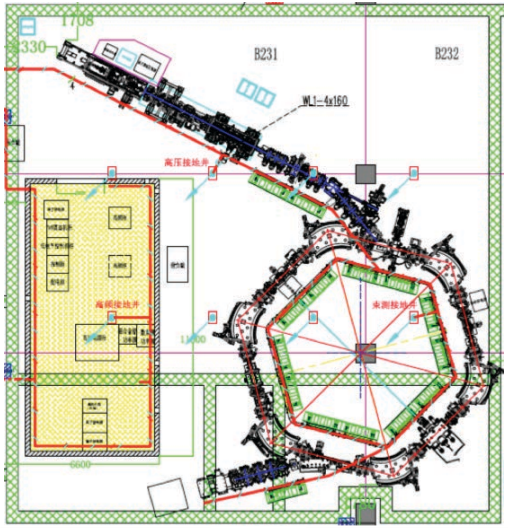

multi-pinhole collimator for SANS instrument




Neutron wavelength spectrum for the decoupled moderator ( collaborating with CSNS)

# 7MeV H- linac injector for XiPAF

## ➢ Xi'an 200MeV Proton Application Facility (XiPAF)

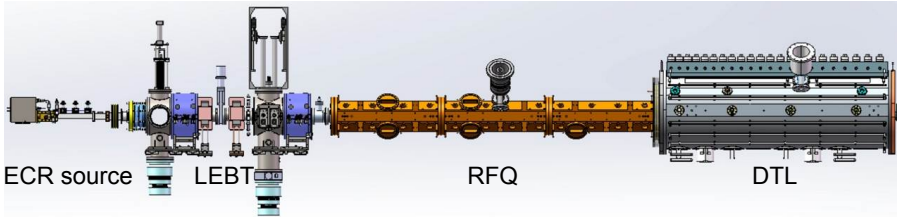



| Parameter | Linac Injector | Synchrotron |
|---|---|---|
| Particle | H- | Proton |
| Output energy | 7 MeV | 60 MeV~200 MeV |
| Operation frequency | 325MHz | 1.18~5.78 MHz |
| Peak current | 5 mA | - |
| Max. repetition frequency | 0.5 Hz | 0.5 Hz |
| Beam pulse width | 40 μs | 1-10 s |
| Average current | 100nA | 30 nA |
| Flux density | - | $10^5$~$10^8$ p/cm$^2$/s |

- 7MeV H- linac
- Synchrotron with six-folded symmetrical structure
- H- Charge exchange injection
- Air-cooled magnetic alloy RF cavity
- Third-order resonant extraction

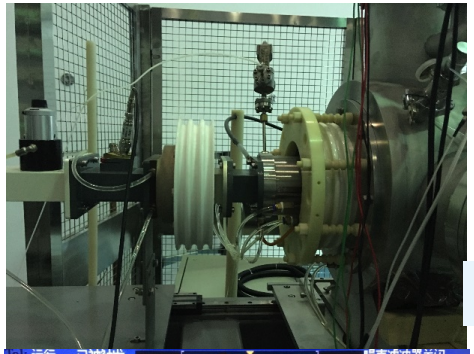
# 7MeV H- linac injector for XiPAF

## ➢ Linac injector for XiPAF

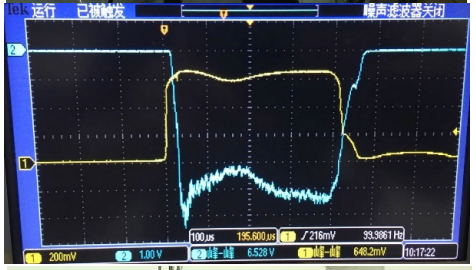



| Parameter | Value | Unit |
|---|---|---|
| Ion type | $H^-$ | |
| Beam energy | 7 | MeV |
| Peak current | 5 | mA |
| Maximum repetition rate | 0.5 | Hz |
| Beam pulse width | 10~40 | μs |
| Normalized RMS emittance | <0.24 | π mm•mrad |

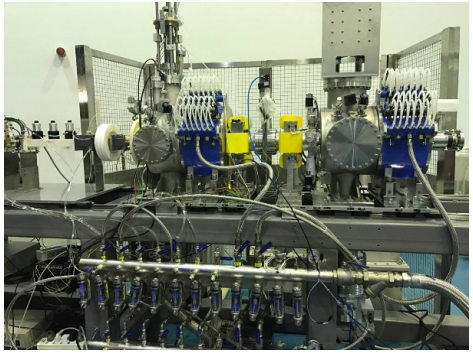
- Microwave ECR H- source without Cs
- Four-vane RFQ with ramped inter-vane voltage
- Inter-digital H mode DTL
- Tetrode-based RF power system



ECR H- source



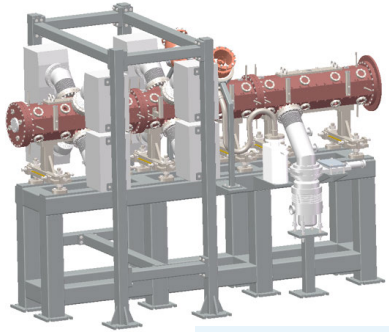
Maximum current of 5.8 mA (@50 kV) has been measured by the Faraday cup at the exit of the source.



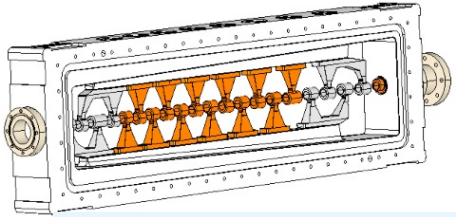
IS & LEBT

# 7MeV H- linac injector for XiPAF

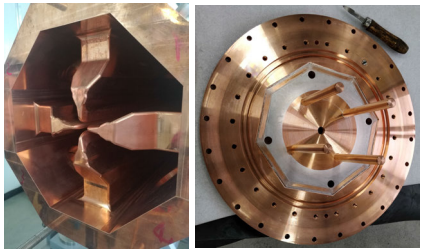
## ➢ Linac injector for XiPAF



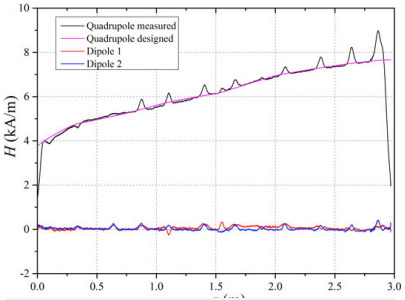
Assembled RFQ cavity



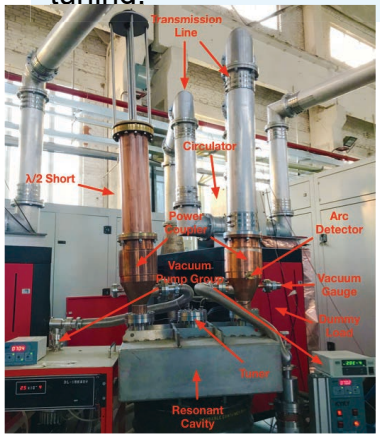
Central frame of the IH-DTL cavity. The cavity is under tuning.



Undercuts and dipole-mode stabilizer rods




Relative error of the quadrupole: <2.7%
Dipole component: within ±1.9%




4616V4 tetrode amplifiers commissioned: 500kW/150μs/1Hz for 8 hrs

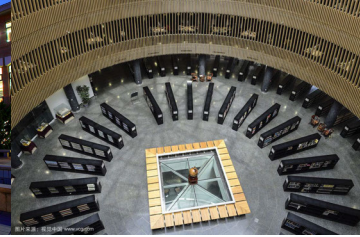
Tetrode-based RF system at site

# Conclusion

- Beam conditioning of the 13MeV/50mA proton linac for CPHS, and 7MeV/5mA H- linac injector for XiPAF, will be performed in the second half of this year
- Construction of CPHS/XiPAF: achieve reliable, stable and safe experimental platforms
- Cooperation home and aboard: promote various applications based on proton accelerators







# Thank you for your attention

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