

Synergies in High-power Hadron Beams and Muon Beam R&D in China

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2nd Muon Community Meeting, ZOOM, 2021.07.12-14

Outline

- * High-power hadron accelerator facilities and projects in China
- * Muon-related studies
- * Summary

High-power hadron accelerators

- * China Spallation Neutron Source (CSNS)
 - * Phase-I: 2011.10-2018.3
 - * Operation since 2018.9
 - * Operation at 100 kW: 2019.2
 - * Phase-II: approved in principle by the central government, 2022-2028

	CSNS-I	CSNS-II
Beam Power (kW)	100	500
Repetition rate (Hz)	25	25
Target stations	1	1
Average beam current (μA)	63	313
Protons per pulse (10^{13})	1.56	7.8
Linac output energy (MeV)	80	300
RCS output energy (GeV)	1.6	1.6

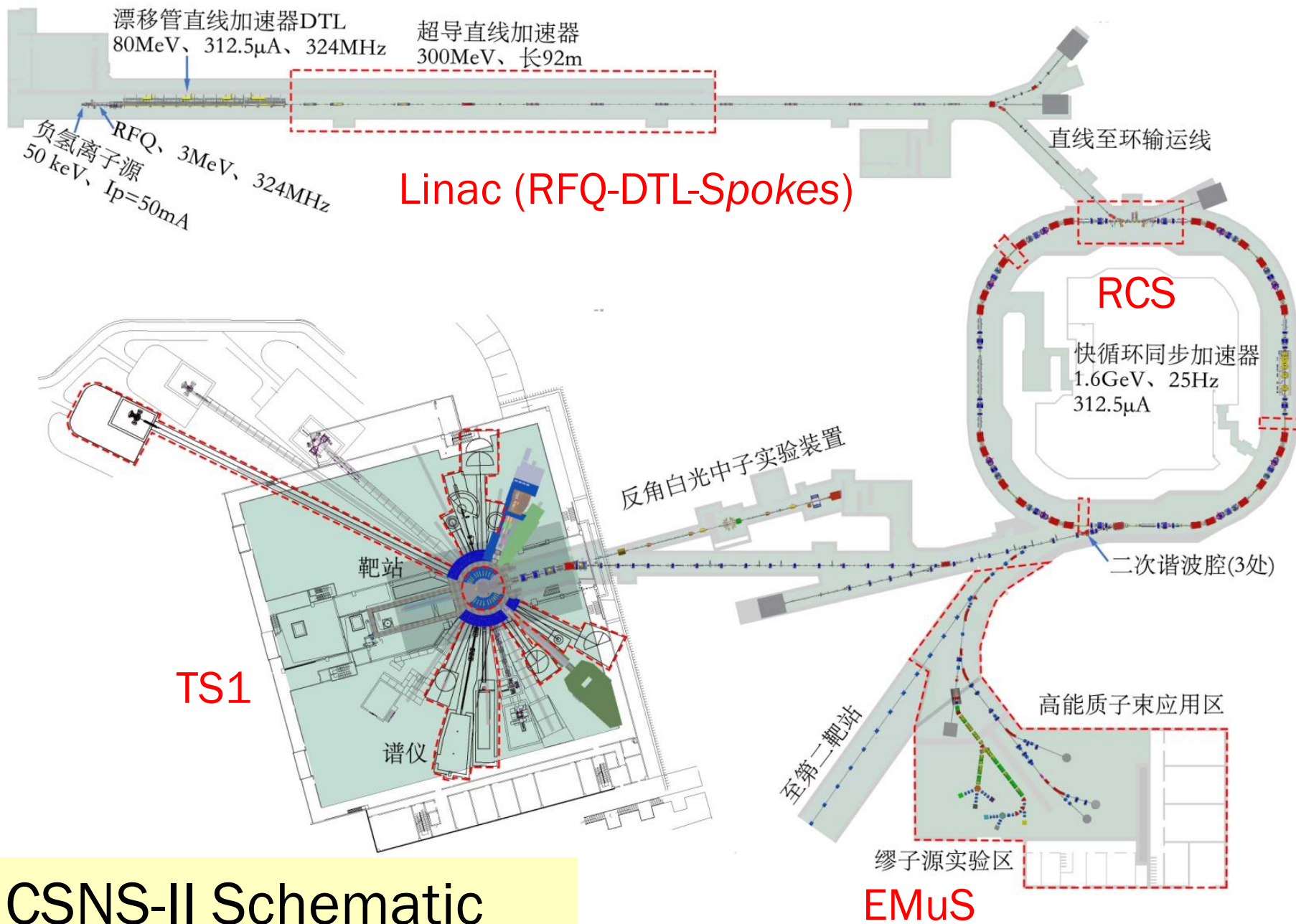
CSNS campus

Eastern part of the
Pearl River Delta



- The site for CSNS is in Dongguan, Guangdong Province.
- CSNS is the first large scientific facility in southeastern China, jointly invested by the central government and local government. It aims to promote advanced researches in the economic developed zone of Guangdong-Hong Kong.

Total budget: ~2.2B CNY (or 250M USD)



CSNS-II Schematic

Low-energy high-power accelerators



* ADS test facilities

- * IMP: CW proton front-end, 25 MeV, 10 mA, max: 200 kW, RFQ-HWR-Spoke (162.5 MHz)
- * IHEP: CW proton front-end, 10 MeV, 10 mA, 100 kW, RFQ-Spoke (325 MHz)

* CYCIAE-100 H- cyclotron @CIAE

- * 100 MeV, 500 μ A, max: 50 kW
- * Multi-purpose: ISOL driver for radioactive ion beams, neutron source, isotope production, etc.



HIAF Project (Under construction)

E_{B1} : 0.8 AGeV, 3×10^{10} ppp $^{238}\text{U}^{35+}$
1.75AGeV, 7.5×10^{10} ppp $^{78}\text{Kr}^{19+}$
2.6~3.0AGeV, 1.0×10^{11} ppp $^{16}\text{O}^{6+}$

HIAF-I: 2018-2025

Budget: 1.62+1.2 B CNY, approved

External target station

High Energy Density Physics
Nuclear Matter study-CEE
Hypernuclear
High energy irradiation

L: 180m, Bp: 25 Tm

HFRS

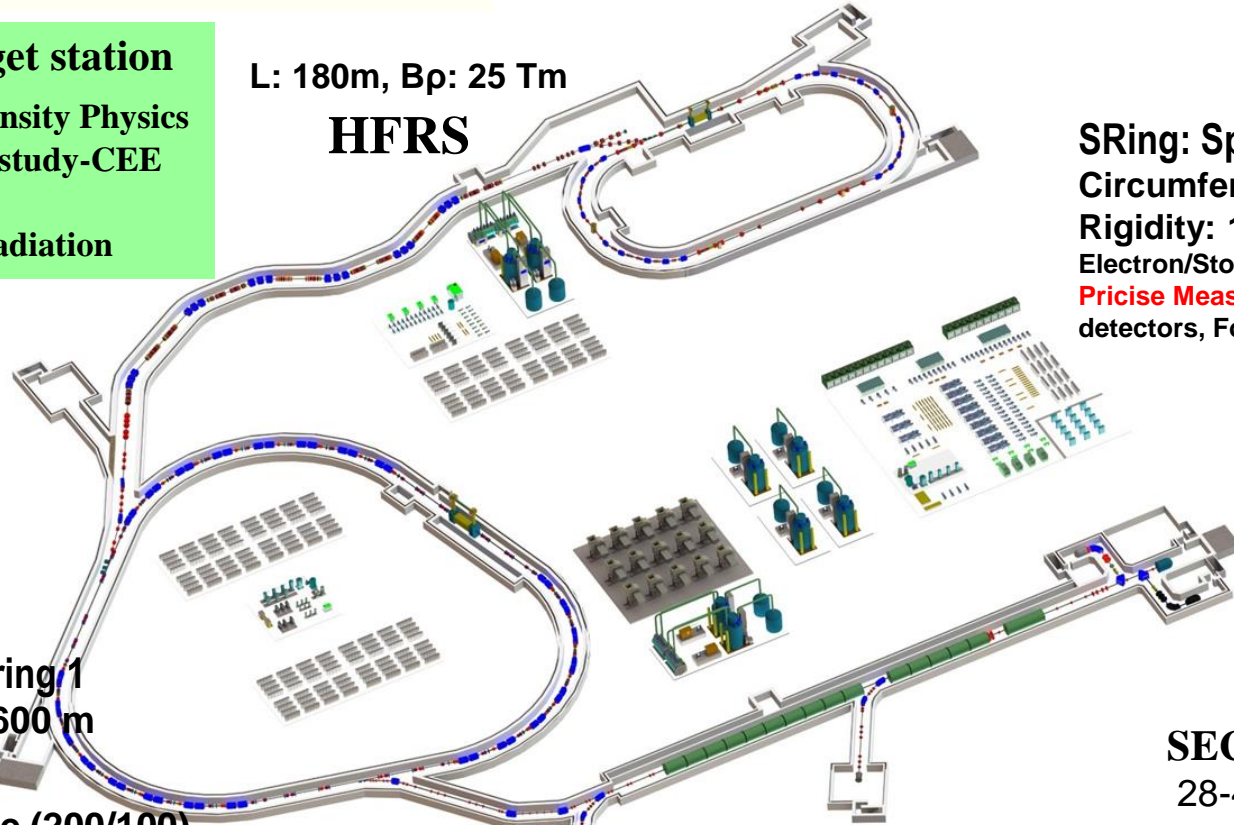
SRing: Spectrometer ring

Circumference: 273m

Rigidity: 13-15 Tm

Electron/Stochastic cooling

Precise Measurement by Two TOF detectors, Four operation modes



BRing1: Booster ring 1

Circumference: 600 m

Rigidity: 34 Tm

Large acceptance (200/100)

Two planes painting injection

Fast ramping rate (5-10Hz)

iLinac: Superconducting linac

Length: 100 m

Energy: 17~22 MeV/u($\text{U}^{35+} \sim 46+$)

Low energy nuclear structure terminal

SECRAL and FECR

28-45GHz, 1.0emA(U^{35+})

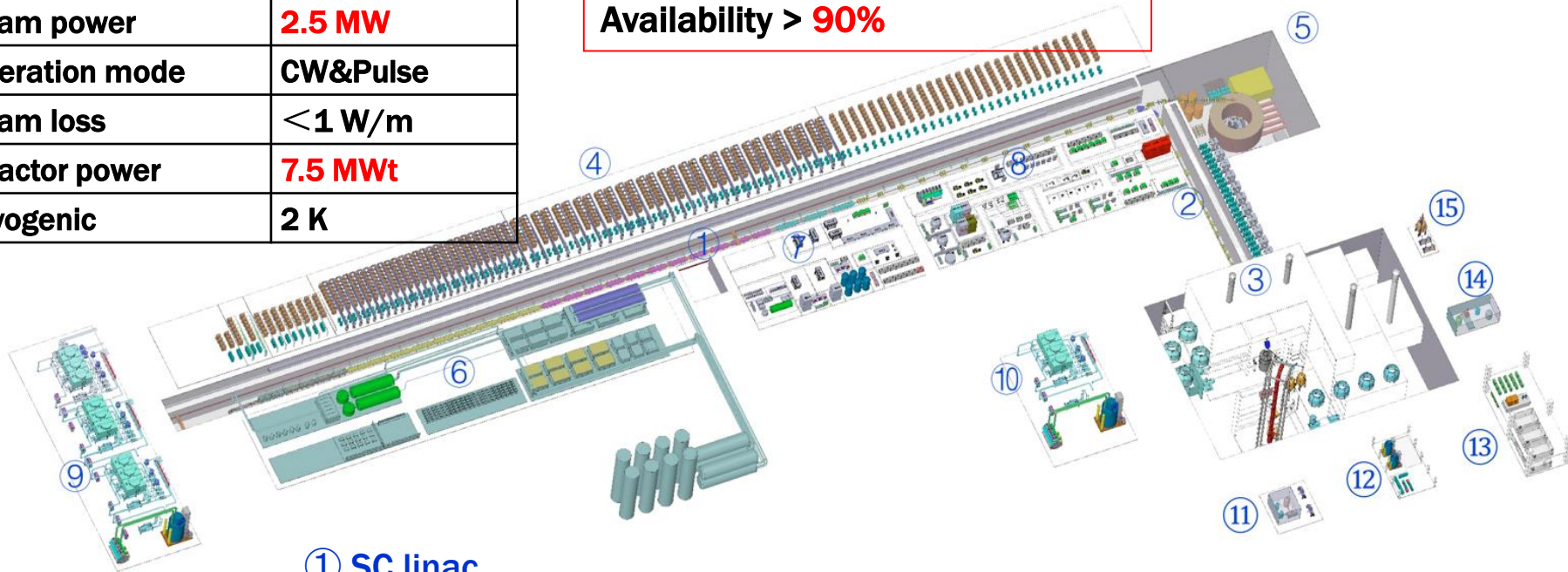
CiADS (Construction: 2021-2027)

Design Particle	proton
Energy	500 (250) MeV
Beam current	5 (10) mA
Beam power	2.5 MW
Operation mode	CW&Pulse
Beam loss	<1 W/m
Reactor power	7.5 MWt
Cryogenic	2 K

Beam trips goal:

<10s, -
10s~5min, 2500/y
>5min, 300/y

Availability > 90%



- ① SC linac
- ② Coupling transport
- ③ Target and reactor hall
- ④ Accelerator equ. hall

- ⑤ Beam dump and granular target exp.
- ⑥ Cryogenic plant
- ⑦ SRF hall

Funding: 3.9 BCNY

Campus for HIAF and CiADS

2020.11: Site preparation completed

2020.12: HIAF civil construction started

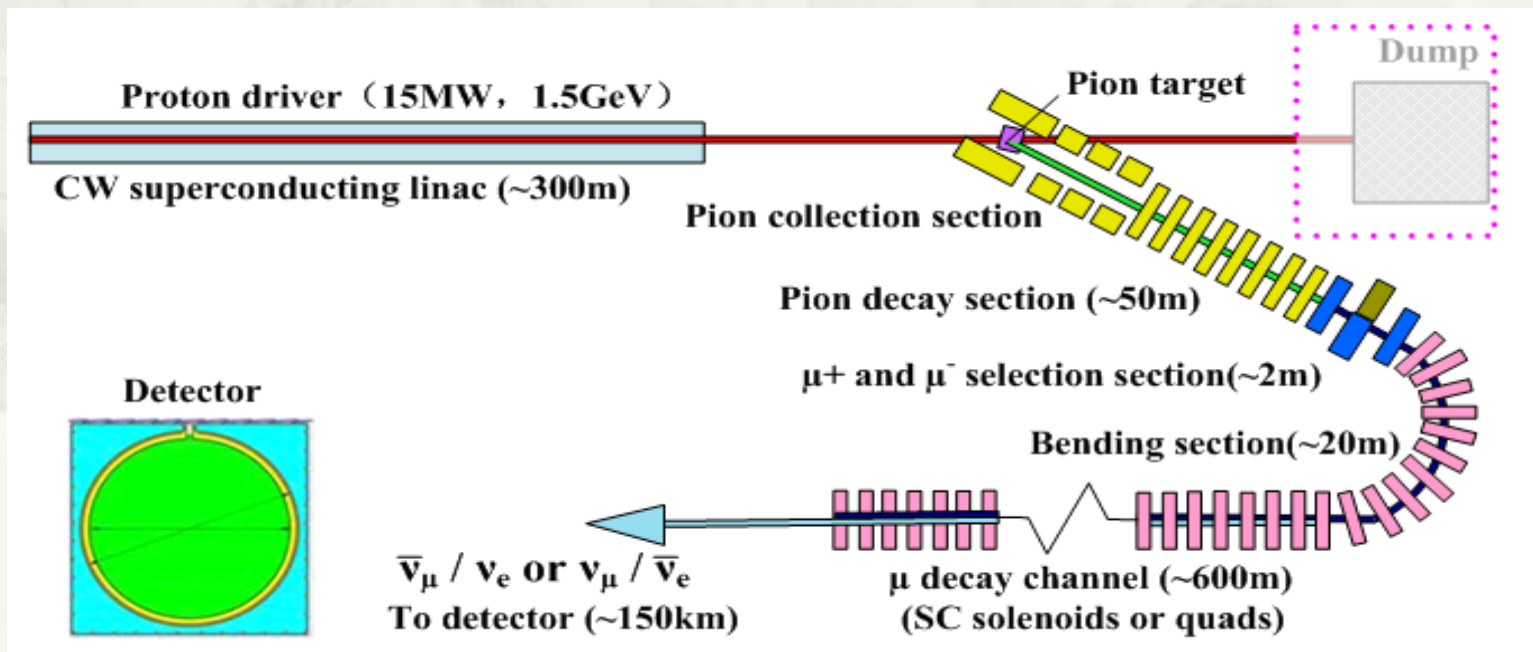




Muon related studies

MOMENT: a muon-decay medium-baseline neutrino beam facility

- * Based on ADS-type accelerator, muon decayed neutrinos (200-300 MeV), for LCPV and other neutrino physics
- * Study since 2013, as a part of the neutrino program in China
 - * Studies: proton driver, target station, muon channels, detector and physics



* Proton linac

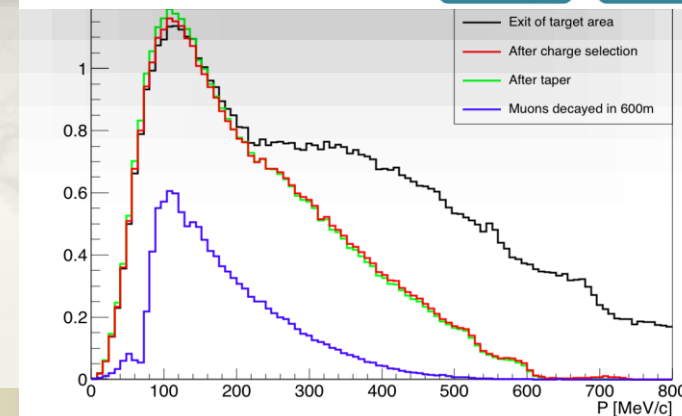
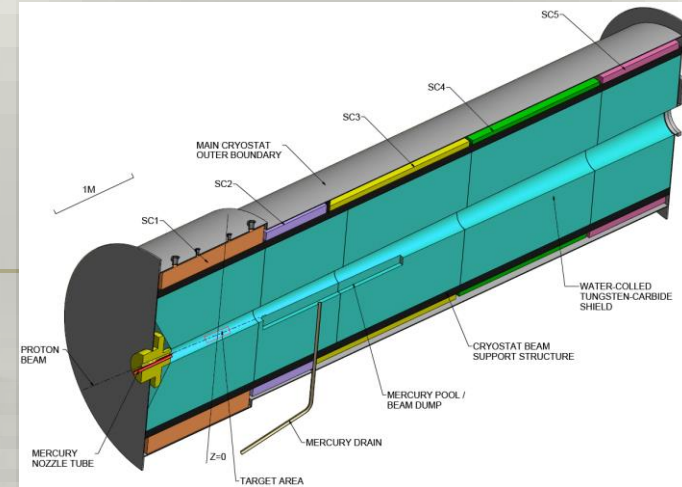
- * CW, 1.5 GeV, 15 MW, synergy with China-ADS study

* Target station

- * Basic: Capture SC solenoids (14 T), Hg jet, Forward collection + extracting spent protons
- * Fluidized granular target (waterfall target)

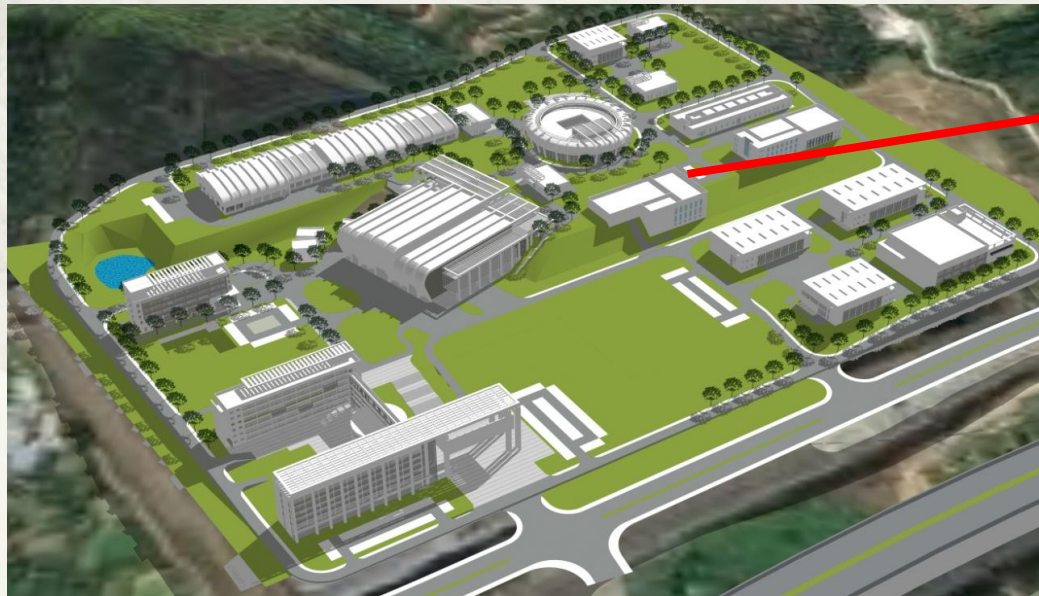
* Muon channels

- * Charge selection by curved solenoids
- * Wide spectrum transport (stopband)
- * Low-divergent muon decay channel

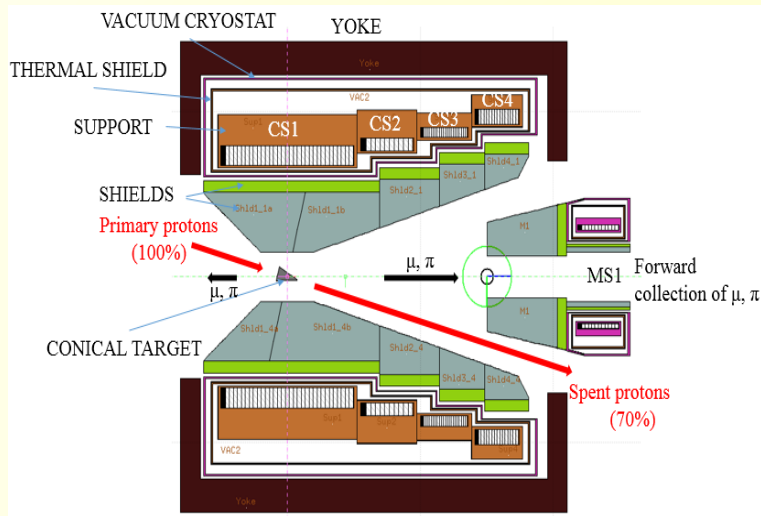


Experimental Muon Source (EMuS) at CSNS

- * Study on EMuS at CSNS started from 2007, from early time focusing μ SR applications to later multi-purpose muon facility
 - * Proton beam at CSNS-II : 1.6 GeV, 500 kW, 25 Hz
 - * Proton beam for EMuS: 1.6 GeV, 25 kW, 2.5 Hz, standalone
- * Phased construction:
 - * Simplified scheme (included in CSNS-II): surface muons for μ SR
 - * Baseline scheme: multi-purpose, based on SC solenoids

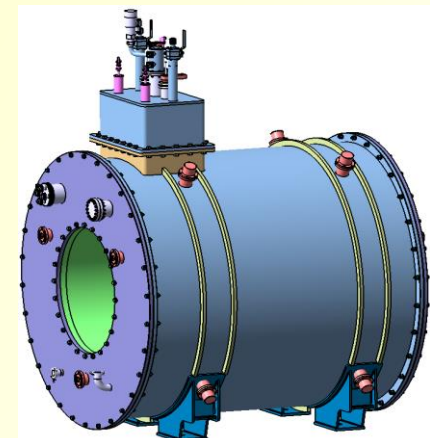
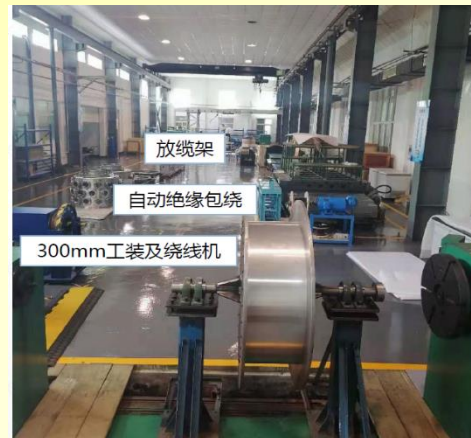
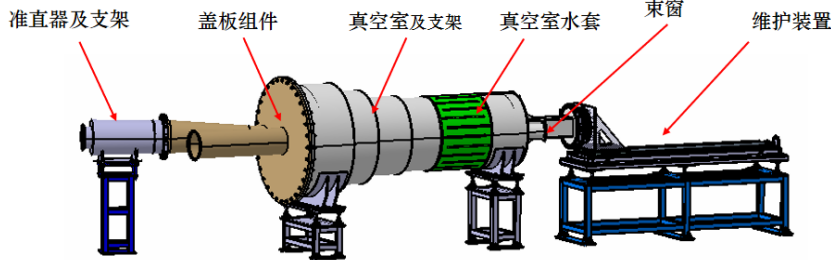
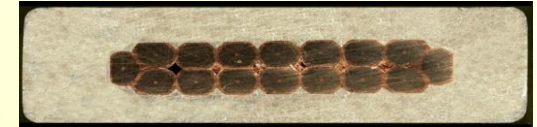


R&D and prototyping of EMuS target station



EMuS target station
(Baseline scheme)

- Target assembly prototype
- Al-stabilizer NbTi cable
- Capture solenoid prototype



Possible Muon Facilities at CiADS/HIAF

@CiADS

- * CW/pulsed beam: 500-600 MeV, Max: 2.5 MW (CW)
- * A possible muon facility in the application hall (project: to a subcritical reactor)
- * μ SR, muon physics

@HIAF

- * Pulsed intense heavy-ion beams for production of pions/muons
- * 1-3 Hz, 1-5 GeV/c, 10^{15} nucleon/pulse
- * Possible muon experiments: μ -e conversion, μ g-2, Kaon rare decay etc.



Summary

- * Design studies on different muon beams have been working in China: MOMENT, EMuS@CSNS, muons@CiADS/HIAF
- * R&D and prototypes for EMuS almost completed
- * Different studies profit from the synergies on design concepts, key technologies, simulation tools, etc.

Thanks for your attention!