International
MUON Collider
Collaboration

CERN

Synergies

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Synergies

- Synergies:
  - R&D that creates enhanced capabilities to the benefit of:
    - The development of a high energy (multi-TeV) muon collider *and*
    - Another first-rank scientific, innovative, or impactful programme
- Creation of world-class science with intense muon beams
  - As demonstrators, technology test beds, & to create community

Next steps

- Second meeting; engage with Asia:
  - COMET, PRISM, …
- Consolidate places were R&D programme can benefit muon physics activities beyond the muon collider

Last Muon Community meeting conclusions

Our session at the 2nd Muon Community meeting

Timetable

Mon 12/07 | Tue 13/07 | Wed 14/07 | All days

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Session legend

14:00

Synergies in high power and muon beam R&D in China — *Jingyu Tang*
Zoom 14:30 - 14:50

The COMET and PRISM programmes and synergies with muon collider programme — *Akira Sato*
Zoom 14:50 - 15:10

15:00

Target studies for COMET and in the J-PARC Materials and Life Science Facility — *Prof. Shunsake Makimura*
Zoom 15:10 - 15:30

The potential to deliver high quality muon beams could enhance the capabilities of muon sources such as those at PSI,
Prof. Koichiro Shimomura

Synergies in the Korean high-power accelerator programme (TBC) — *Prof. Juhahn Lee*
Zoom 15:50 - 16:10

16:00

Synergies in high-power proton and muon beams in China: Jingyu Tang

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 (∝A)	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

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- CSNS ugrades:
  - Upgrade to 500 kW
    - "Step 1" approved
    - Construction expected to start '22
  - CSNS-II:
    - Approval required for next step
    - Muon experiment included in proposal

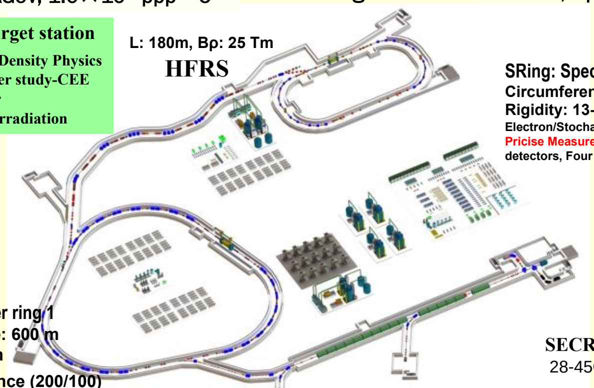
Synergies in high-power proton and muon beams in China: Jingyu Tang

International MUON Collider Collaboration

HIAF Project (Under construction)

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

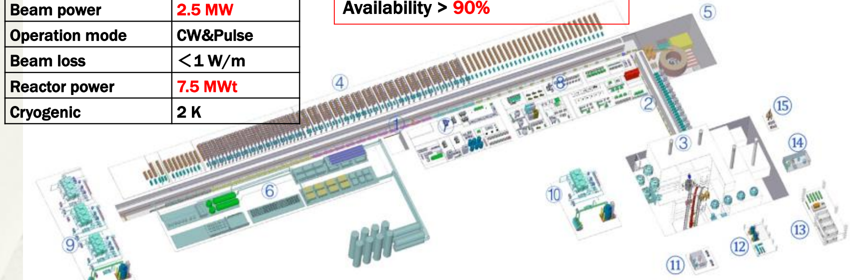
HIAF-I: 2018-2025
Budget: 1.62+1.2 B CNY, approved



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%



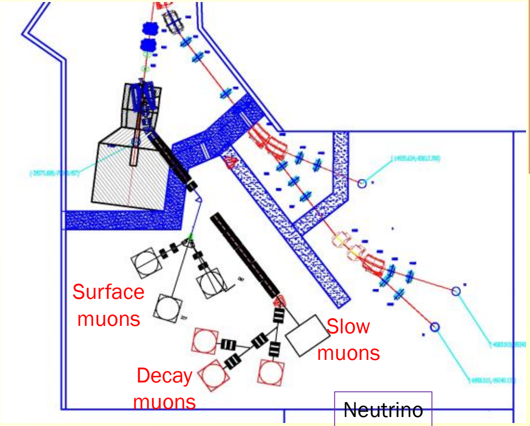
Funding: 3.9 BCNY

Synergies in high-power proton and muon beams in China: Jingyu Tang

Experimental Muon Source (EMuS) at CSNS

- Study on EMuS at CSNS started from 2007, from early time focusing ∝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 ∝SR
  - Baseline scheme: multi-purpose, based on SC solenoids

EMuS Layout and Working Modes



Working modes (indep.):

1. **Surface μ mode**
   a) **Δp/p: <±4%**
   b) **Ref. Pμ=29 MeV/c**
2. **Decay μSR mode**
   a) **Δp/p: <± 5%**
   b) **Ref. Pμ =40-150 MeV/c**
3. **High-momentum μ mode**
   a) **μ imaging, neutrinos**
   b) **Ref. Pπ=200-450 MeV/c**

Special design features:

- Conical graphite target
- Trumpet capture solenoids
- Forward collection
- Multiple working modes
- Muon momentum up to 450 MeV/c

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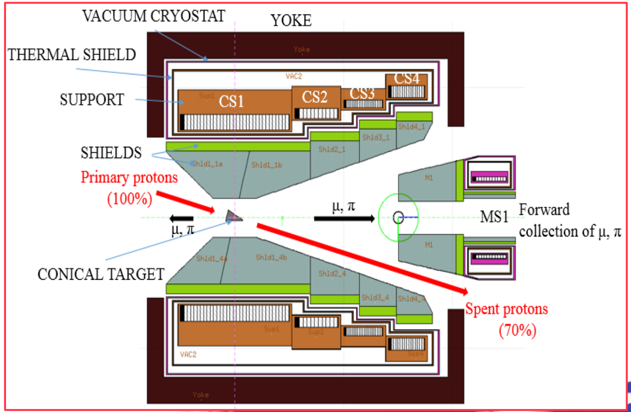
Synergies in high-power proton and muon beams in China: Jingyu Tang

- MOMENT:
  - A muon-decay, medium-baseline neutrino-beam facility
  - Exploit high-power, low-energy linac for ADS studies to deliver high flux muon beam that is used to make a neutrino beam
- Component R&D:
  - EMuS target station

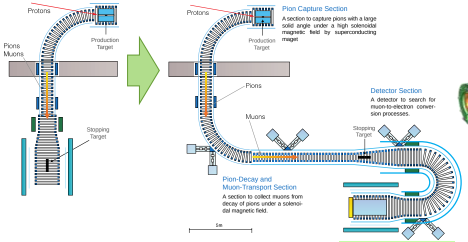


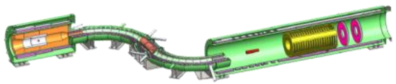
The COMET and PRISM programs and synergies with muon collider program: A. Sato

COMET and Mu2e

PRISM

COMET @J-PARC | **Mu2e @FNAL**





COMET Phase-I : S.E.S. ~ 3 x 10^{-15} on Al Under construction

COMET Phase-II : S.E.S. ~ 3 x 10^{-17} on Al Planed

Mu2e: S.E.S. ~ 3 x 10^{-17} on Al Under construction

Mu2e-II: S.E.S. **~ 3 x 10^{-18}** on Al Under discussion

Features of the Setup

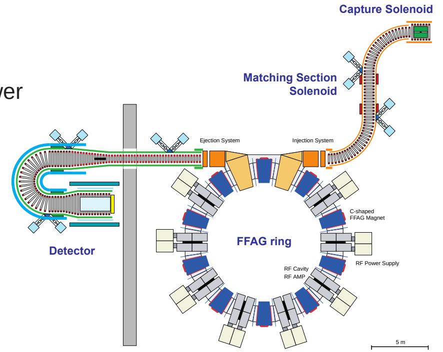
- Solenoid channel
- Stop μ^- at the stopping targets.
- ID single electron from the target and measure its energy precisely.

The COMET/Mu2e type experiments have some limitation on the achievable sensitivity and physics studies.

PRISM Specifications

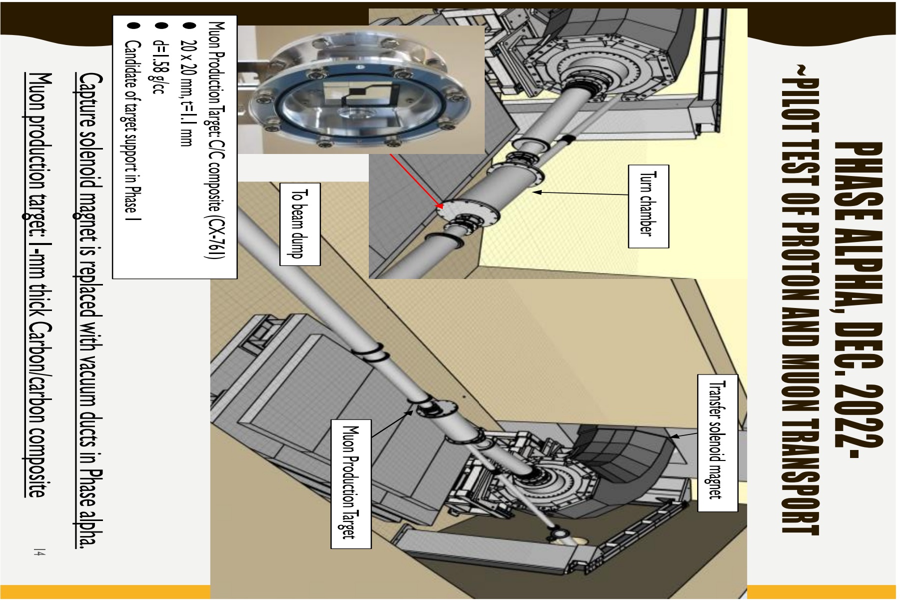
PRISM

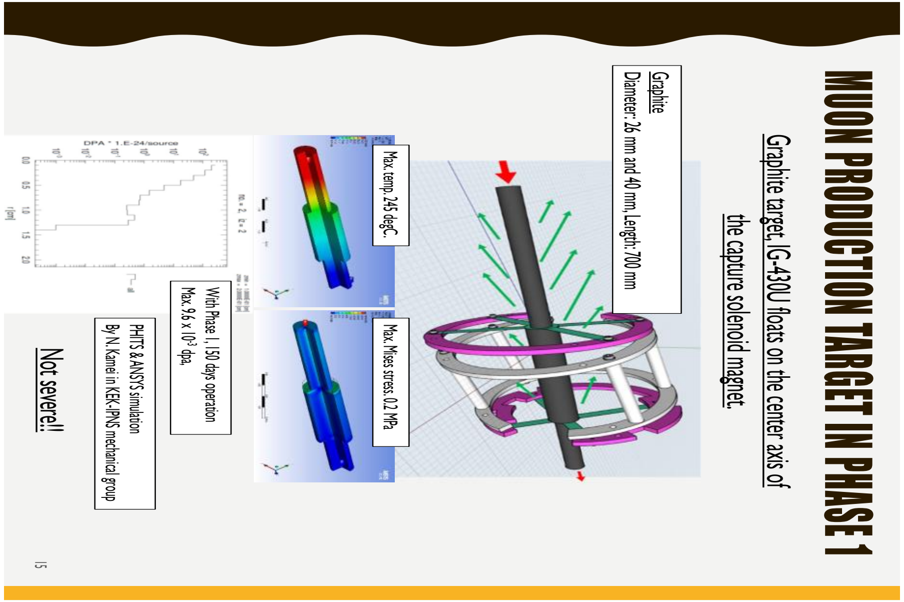
- **Intensity :**
  - 2×10^{12} muons/sec.
  - for multi-MW proton beam power
- **Central Momentum :**
  - 40 MeV/c
- **Momentum Spread :**
  - phase rotation
  - ±3% (from ±30%)
- **Beam Repetition :**
  - 100 - 1000 Hz
  - due to repetition of kicker magnets of the muon storage ring.
- **Beam Energy Selection :**
  - 40 MeV/c ±3%
  - at extraction of the muon storage ring.



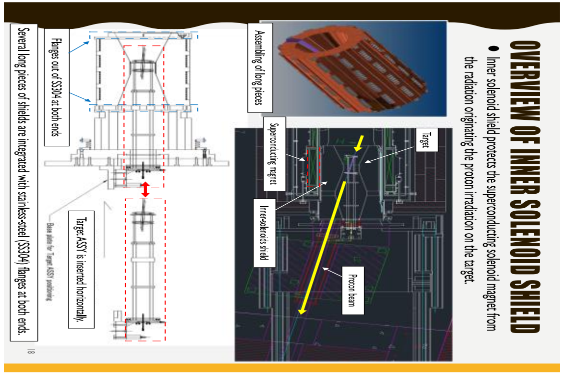
Discussed at MC1: clear synergies with MC programme

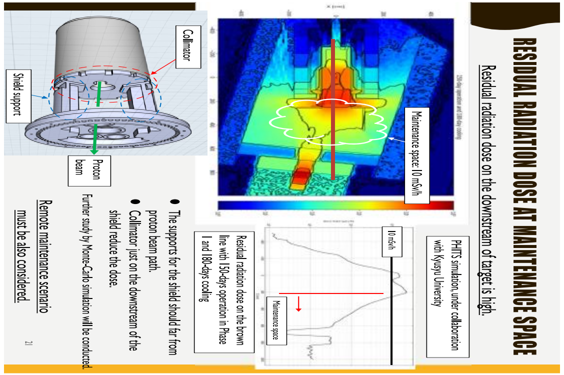
Muon production at J-PARC (and MLF target): S. Makimura

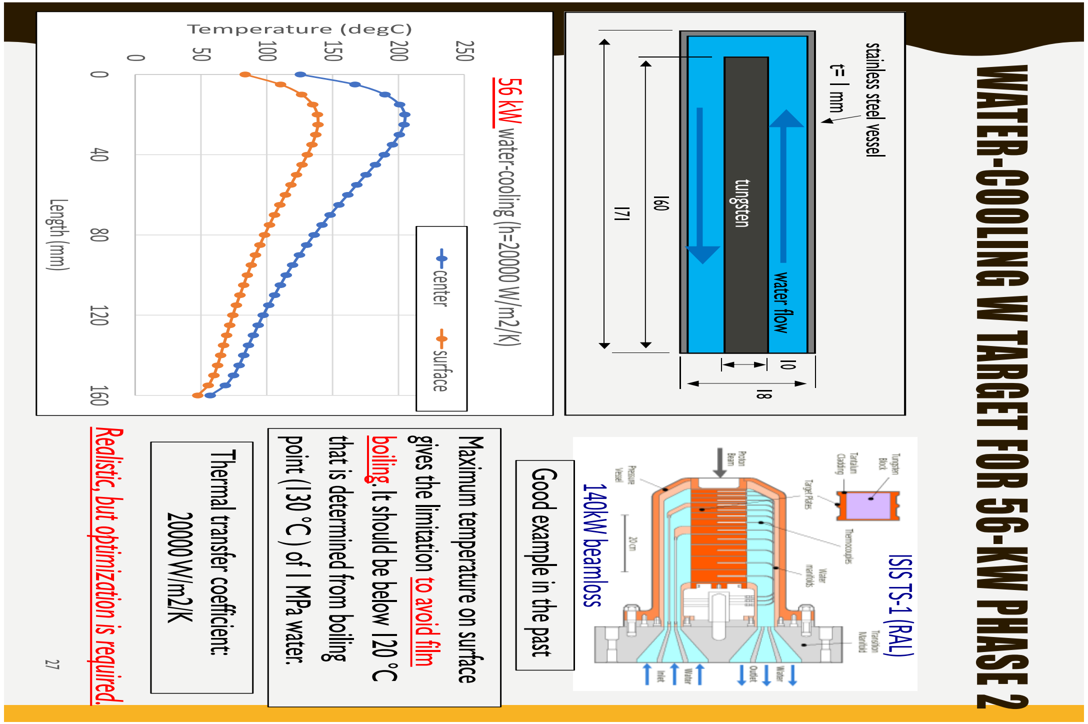




Muon production at J-PARC (and MLF target): S. Makimura



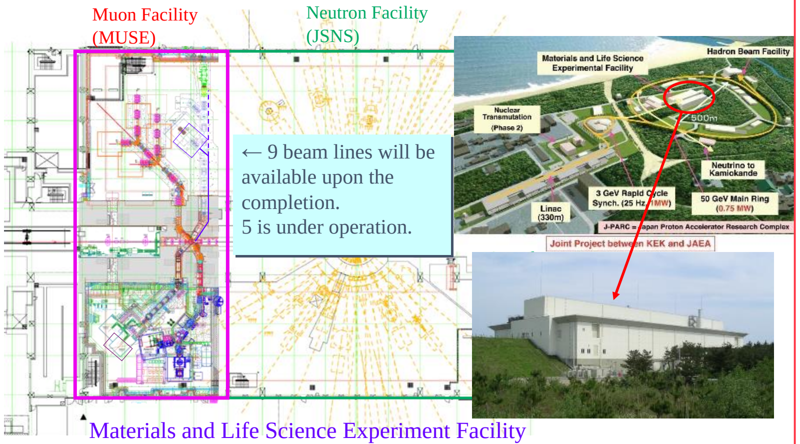




Synergies in high-power and muon programmes in Japan: K. Shimomura

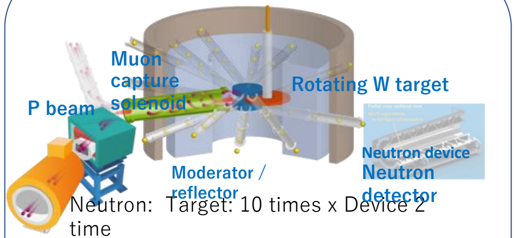
Muon Facility @J-PARC

MUSE="Muon Science Establishment"



Materials and Life Science Experiment Facility

TS2; A unified Target for neutron and muon production



Neutron: Target: 10 times x Device 2 time

→ Aiming to more than 20 times brilliance

Muon: Target 10 times x Capture solenoid 5 ~10 times

→ Aiming to 50~100 times intensity

Accelerator upgrad

Effective utilization of long wave neutron

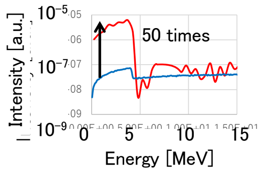
Beam power 1 MW → 1.5 MW (TS1:1MW, TS2: 0.5MW)

Repetition 25 Hz → 25 HZ (TS1:17Hz, **TS2: 8Hz**)

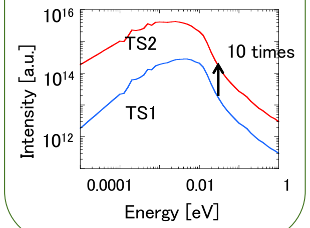
		1 MW operation	1.5 MW operation
Ion source current	[mA]	50	62.5
Pulse width	[ms]	500	600
Repetition	[Hz]	25	25
Average current	[∝A]	333.3	500
LINAC	[MeV]	400	400
RCS	[GeV]	3	3

Neutron・muon intensity

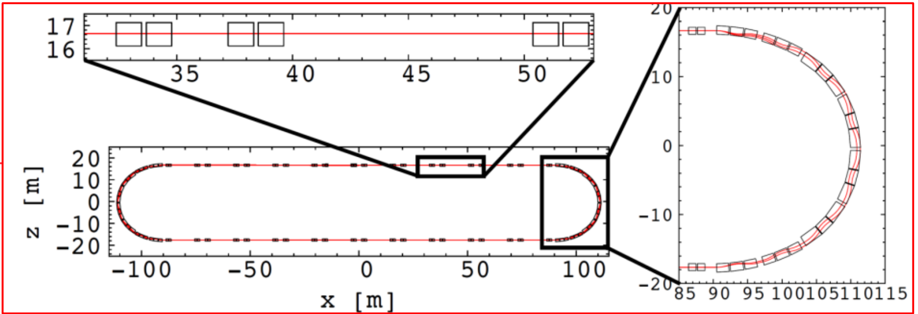
Muon beam



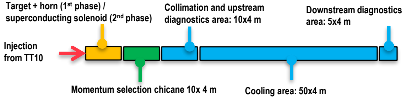
Neutron beam



Conceptual layout of MUC test facility: R. Franqueira Ximenes

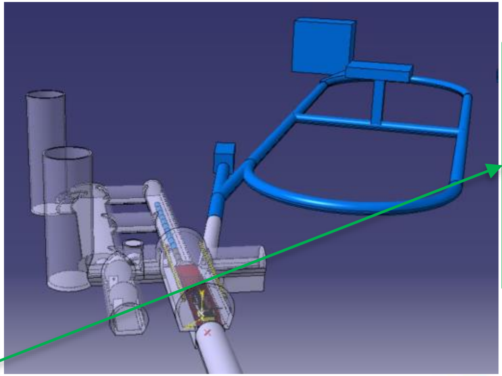


Conceptual layout



MUC Demonstrator

- The Facility is flexible enough to accommodate other experiments.
- nuSTORM and potentially ENUBET could be branched from the MUC Demonstrator Facility.
- The same target complex would be used profiting from its shielding and general target systems infrastructure, utilities, and accesses.
- The double deflection of the beamline could reduce radiation streaming towards the nuSTORM ring.
- Synergies between experiments would reduce costs on both sides.
- Is the 26 GeV/c beam from the PS appropriate for these two experiments?



Yes:

- **28 GeV can give "sufficient" pion flux in phase-space of interest**
- **SPS solution chosen in PBC study owing to civil-engineering constaints**

Next steps

- Clear synergies in high-power proton and muon development programmes in Asia
  - Conclusion as for the N/A and European contributions from last time

- Need further discussion to understand programmes by which to enhance scientific o/p with R&D work done in support of muon collider development

- nuSTORM-4-MUC test facility:
  - nuSTORM synergies as part of MUC test facility discussed last time
  - Pion yield in phase space of interest sufficient
    - Will now include in nuSTORM discussions