中国科学技术大学
University of Science and Technology of China

Moving forward

Sites, Facilities and Infrastructures

Jingyu Tang (USTC)

IMCC Annual Meeting 2023 – Synergies Workshop

2023.06.22-23, IJCLab, Paris

Sites, Facilities and Infrastructures

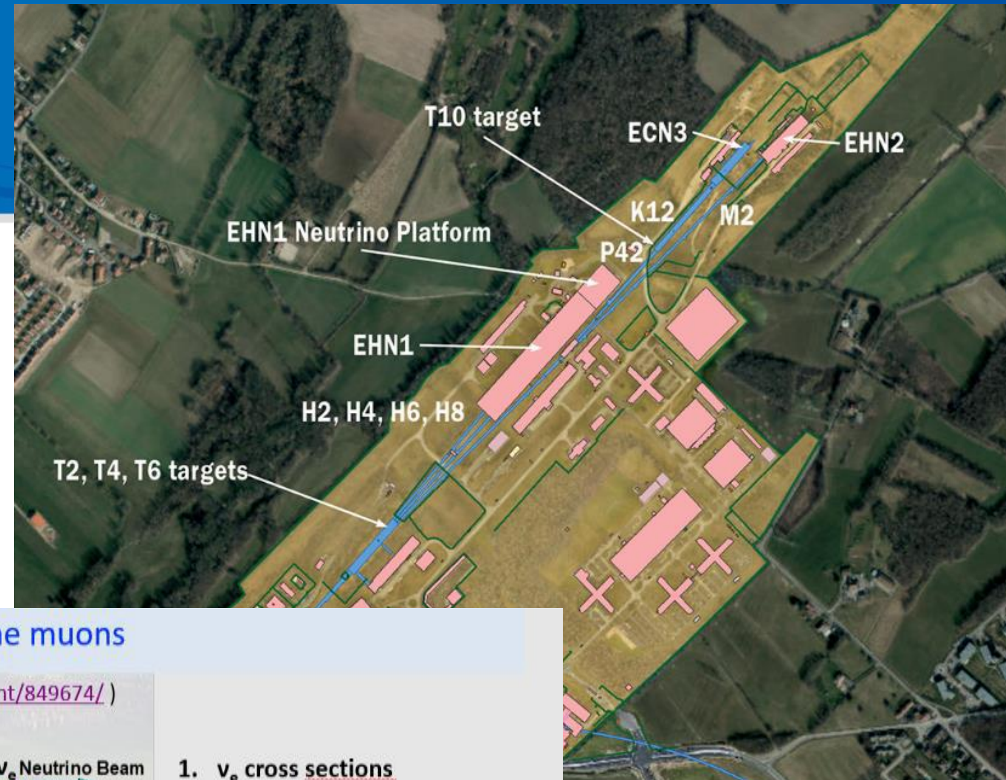
- Try to bring world-wide existing or planned facilities which share similar technologies with MC, could be candidate sites for MC demonstrator, and provide useful infrastructures for potential MC R&D
- High-power proton accelerators, muon sources or beams, neutrino beams, high-power targets, mainly in three continents (Europe, Asia, Nor-Am)

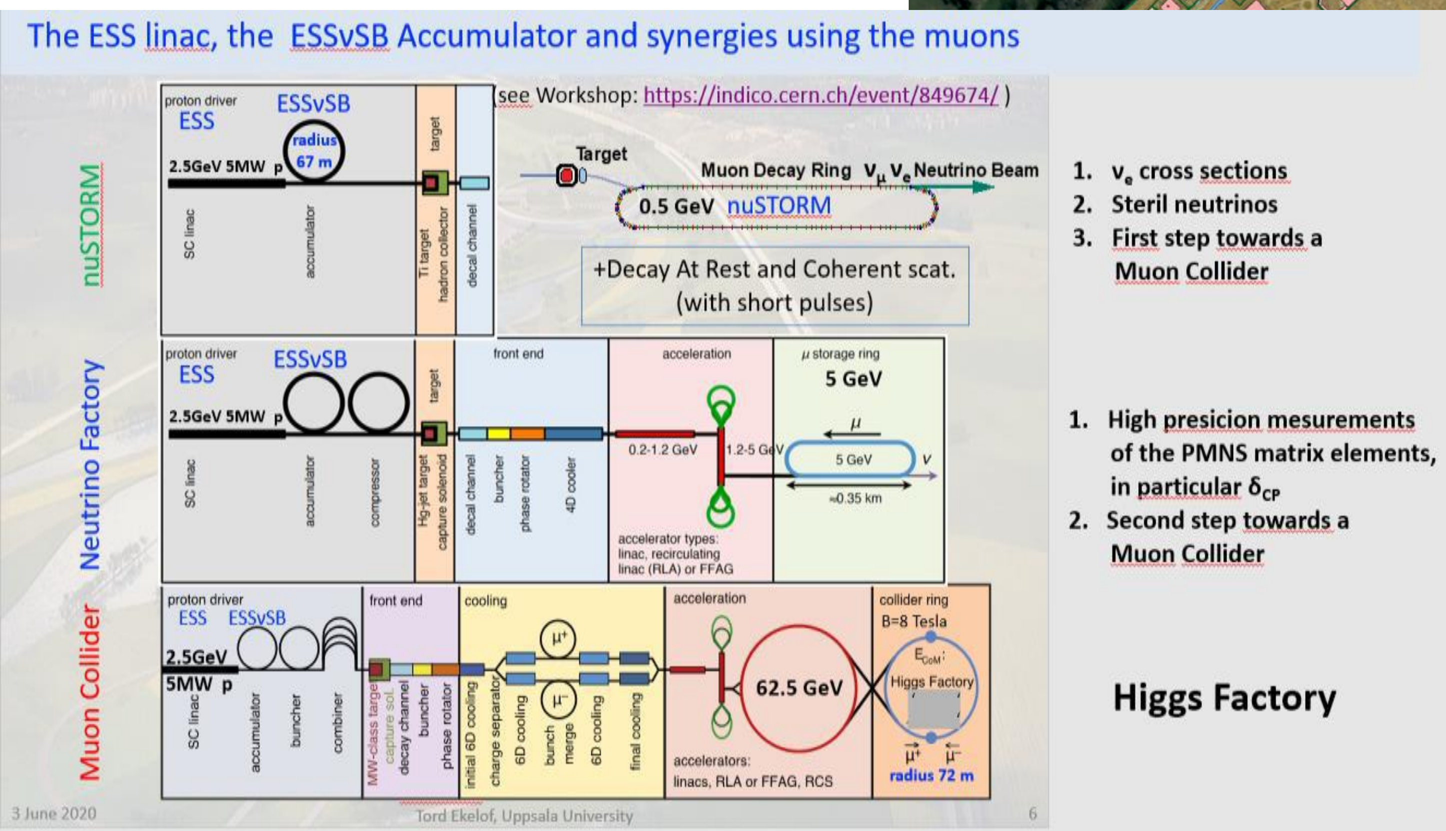
Talks in the session

- Nicholas Evans (ORNL): SNS for Muon Collider Proton Driver R&D
- Katsuya Yonehara (Fermilab): US Strategy for Muon Collider Targetry R&D Based on Fermilab Accelerator Complex Evolution Plan
- Rhea Stewart (UKRI): Muon Facilities Beyond Particle Physics
- Yuan He (IMP): Proton Facilities and Muon Plans in China
- Masashi Otani (KEK): Proton and Muon Applications in Japan
- Nikolaos Charitonidis (CERN): Protons in Europe : Possible synergies with the Muon Collider

Highlights - Proton sources in Europe

- CERN:
  - PS: T08/09/10, n-TOF, ISOLDE
    - Possible for MC demonstrator
  - SPS: H2/H4/H6/H8, M2, HiRadMat
- PSI:
  - SμS: Muon/pion beamlines
  - SINQ: neutron beamlines
- GSI:
  - SIS18 Synchrotron & HEST beam lines
- ISIS:
  - Muon beamlines, neutron beamlines
- Future
  - CERN HI ECN3, ESS (&ESSnuSB), ENUBET & NuSTORM


T10 target
ECN3
EHN2
K12
M2
EHN1 Neutrino Platform
P42
EHN1
H2, H4, H6, H8
T2, T4, T6 targets


The ESS linac, the ESSνSB Accumulator and synergies using the muons
(see Workshop: https://indico.cern.ch/event/849674/)
nuSTORM
proton driver
ESS
ESSνSB
radius 67 m
2.5GeV 5MW p
SC linac
accumulator
target
Ti target hadron collector
decal channel
Target
Muon Decay Ring νμ νe Neutrino Beam
0.5 GeV nuSTORM
+Decay At Rest and Coherent scat. (with short pulses)
1. νe cross sections
2. Steril neutrinos
3. First step towards a Muon Collider
Neutrino Factory
proton driver
ESS
ESSνSB
2.5GeV 5MW p
SC linac
accumulator
compressor
target
Hg-jet target capture solenoid
front end
decal channel
buncher
phase rotator
4D cooler
acceleration
0.2-1.2 GeV
1.2-5 GeV
accelerator types: linac, recirculating linac (RLA) or FFAG
μ storage ring
5 GeV
≈0.35 km
1. High presicion mesurements of the PMNS matrix elements, in particular δCP
2. Second step towards a Muon Collider
Muon Collider
proton driver
ESS ESSνSB
2.5GeV
5MW p
SC linac
accumulator
buncher
combiner
front end
MW-class target
capture sol.
decay channel
buncher
phase rotator
cooling
initial 6D cooling
charge separator
6D cooling
bunch merge
6D cooling
final cooling
acceleration
62.5 GeV
accelerators: linacs, RLA or FFAG, RCS
collider ring
B=8 Tesla
Higgs Factory
radius 72 m
Higgs Factory
3 June 2020
Tord Ekelof, Uppsala University
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Highlights - Proton sources in China

- CSNS:
  - Proton beam: 1.6 GeV/140 kW, 25 Hz
  - CSNS-II (2023-2028): 500 kW
  - MELODY Muon beam
- HIAF:
  - High intensity heavy-ion beam and proton beam, 34 Tm
  - Muon beam: muon applications, muon ionization cooling
- CiADS:
  - CW linac: 500 MeV/2.5 MW, flexible time structure
  - Muon beam: muon applications

USTC NSRL

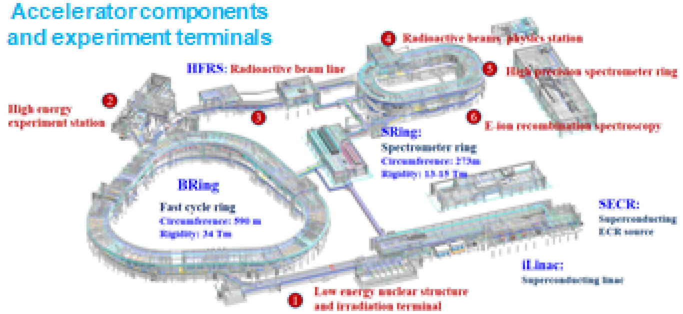
HIAF & CiADS

HIAF Project

- **Very high-intensity & high energy ion beams from proton to uranium.**
- High intensity: 10^{13} ppp for p and 10^{11} ppp for U^{35+}
- Fast ramping rate: 12T/s, 3Hz
- Wideband and high-field RF
- Dynamic vacuum

Courtesy Yang, Jiancheng

Accelerator components and experiment terminals



	iLinac	BRing		SRing	
Length / circumference (m)	114	569		277	
Final energy of U (MeV/u)	17 (U^{35+})	835 (U^{35+})	9300 (p)	800 (U^{92+})	3500 (p)
Max. magnetic rigidity (Tm)	---	34		15	
Max. beam intensity of U (ppp)	28 pμA	2×10^{11}	$(1\text{-}3)\times10^{13}$	$(0.5\text{-}1)\times10^{12}$	$(1\text{-}3)\times10^{13}$
Operation mode	CW or pulse	Fast ramping (12T/s, 3Hz)		DC, deceleration	
Emittance or Acceptance (H/V, π·mm·mrad, dp/p)	5 / 5	200/100, 0.5%		40/40, 1.5% (normal mode)	

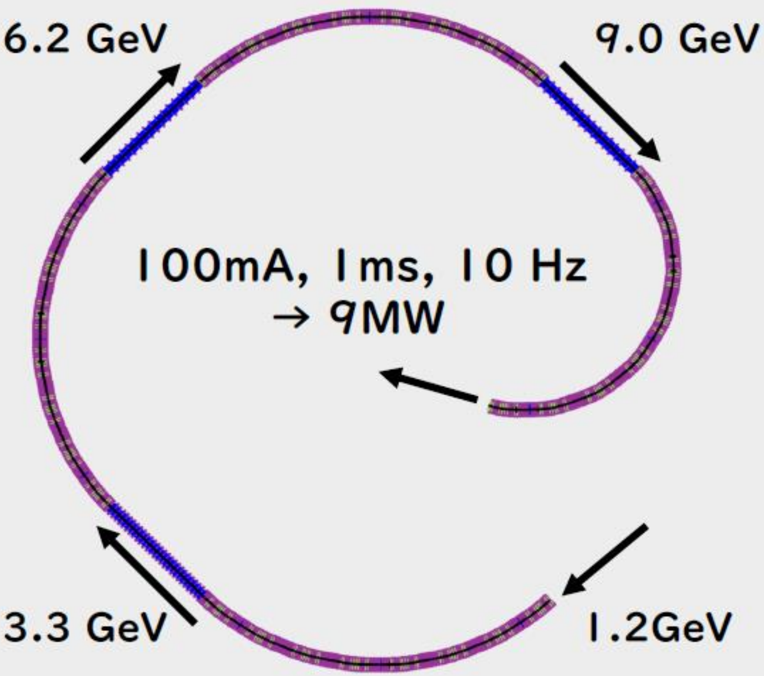
Highlights - Proton sources in Japan

- J-PARC:
  - Current: 400 MeV linac, 3 GeV RCS (1 MW), 30 GeV MR (750 kW)
  - Muon beams: MUSE, COMET
- KEK-Tsukuba:
  - SC-linac based multi-MW proton driver
- Unique technologies and scenario:
  - μ+ cooling and acceleration (MUSE)
  - Capture solenoid for μ-e conversion (@MuSIC, COMET)
  - FFAG accelerators (KEK, Kyoto U, Osaka U)

Multi-MW proton driver@Tsukuba

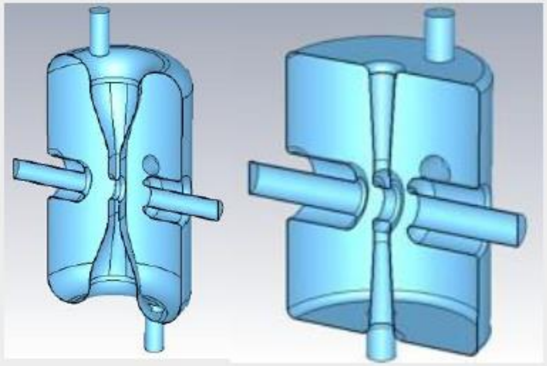
- SC linac based multi-MW proton driver has been investigated.

@SuperKEKB tunnel



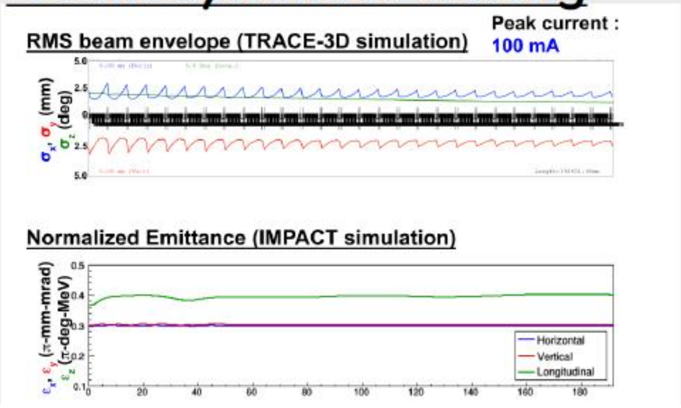
G.T. Park et al., WEOM07 PASJ2016.
T. Maruta et al., JPS Conf. Proc. 8 (2015) 011013.

SC cavity designs



2 HWR, SSR, and and 3 TESLA types

Beam dynamics deisng

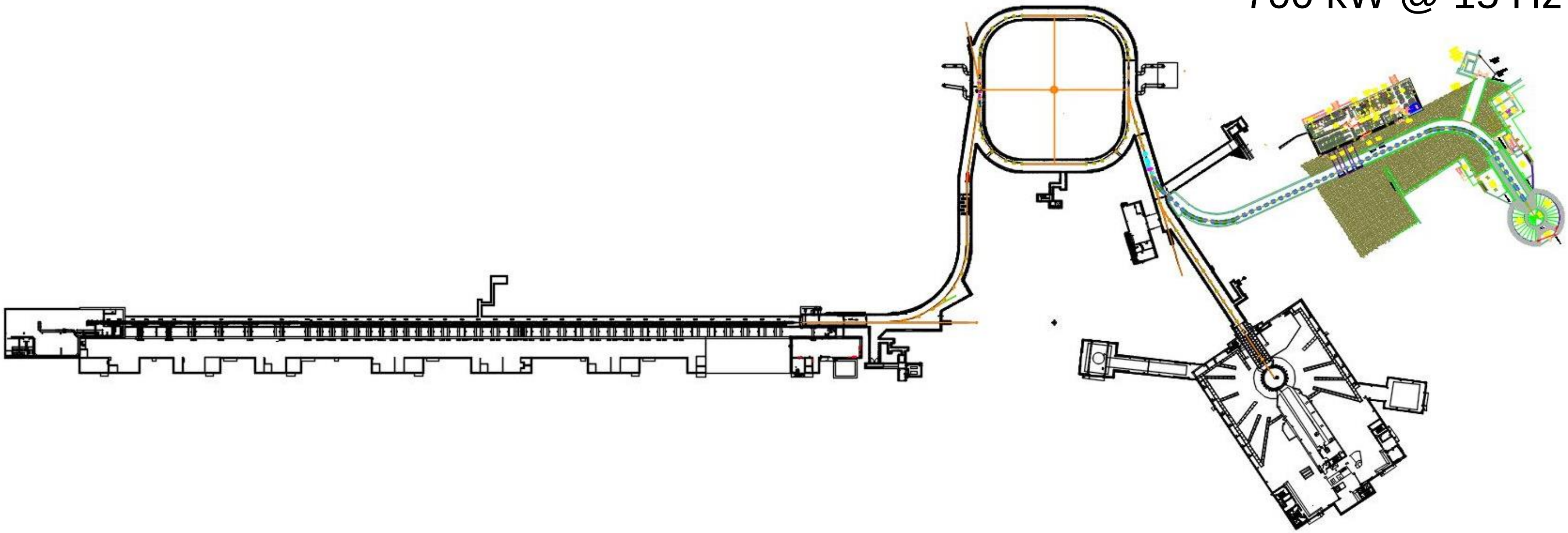


Highlights - Proton source at SNS

- SNS accelerator complex
  - Current: 1 GeV linac, 1 GeV accumulator ring (1.4 MW)
  - Proton Power Upgrade: 1.3 GeV (2.8 MW)
  - Idle power: PPU, 0.8 MW to be defined (before 2nd TS, middle 2030)
- Techniques
  - Bunch compression, RF barrier
  - Laser assistant stripping injection

Idle beam power after PPU:
for MC proton driver R&D?

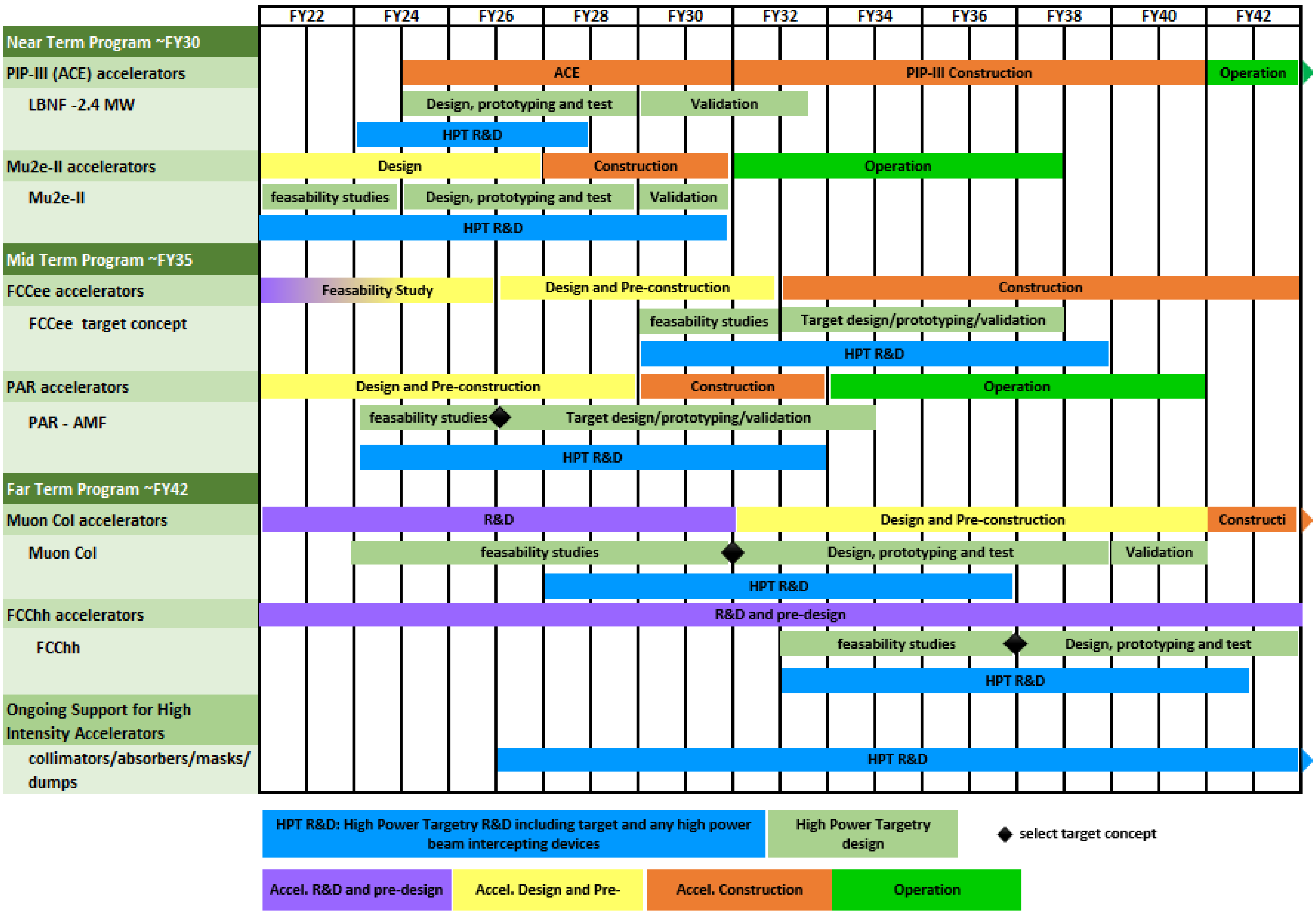
700 kW @ 15 Hz



Highlights – Targetry R&D in US

- Fermilab Accelerator Complex Evolution (ACE) + Booster Replacement plan
  - ACE: 2+ MW
  - Booster replacement options: potential as MC proton driver
- Targetry R&D
  - Support LBNF/DUNE at 2.4 MW, Mu2e-II at 100 kW
  - MuC targetry R&D (GARD)

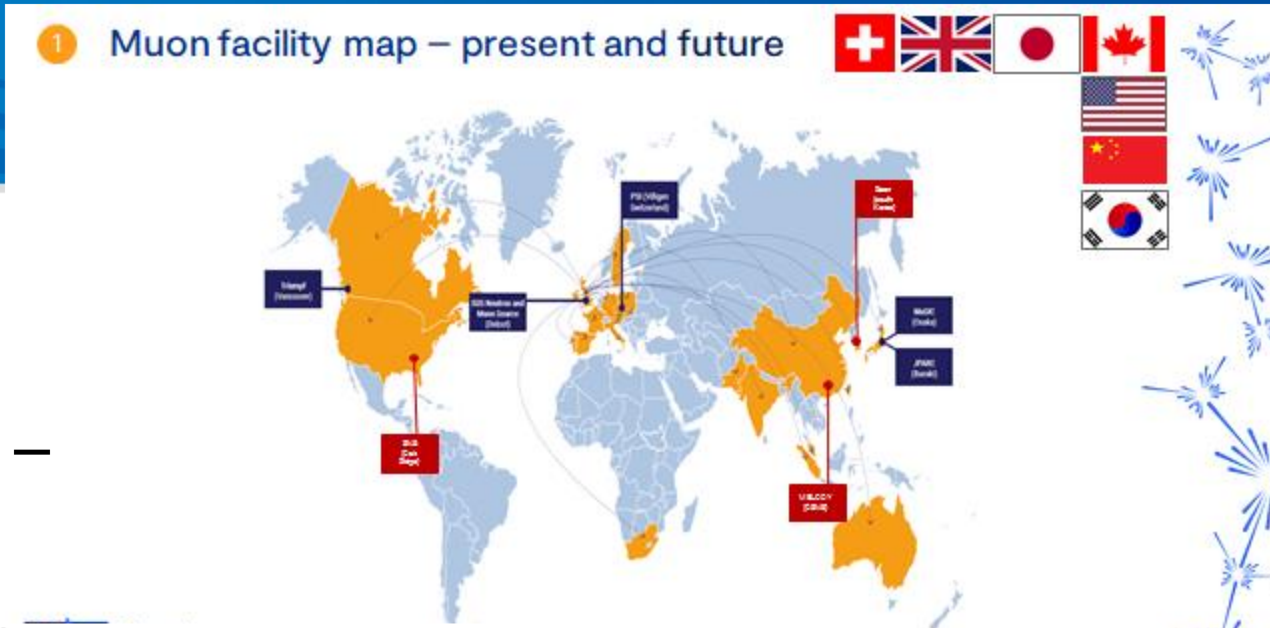
Proposed Roadmap of Targetry R&D

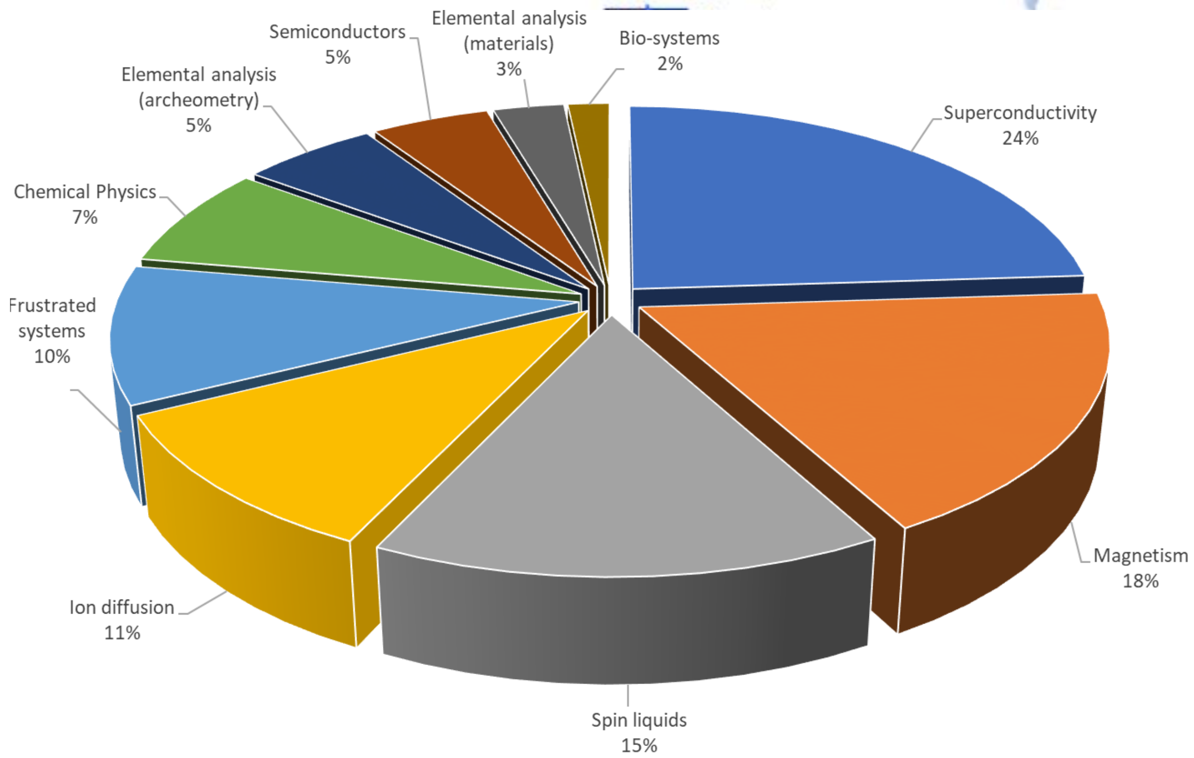


Highlights – Multi-disciplinary App. of Muon Beams

- Worldwide muon user facilities
  - Existing and planned
- Wide fields
  - Core: condensed matter with μSR.
  - Energy ranges: low energy: (0.5 - 30) keV, surface: ~4MeV, and decay: (15 – 60) MeV
  - Muon beam types: Continuous beams and pulsed beams
- ISIS muon facility
  - Techniques and science
  - Future development

Science highlights – science supported





Next?

- Welcome international partners to contribute the study and R&D of Muon Collider
- Share the technologies, infrastructures
- Win-win synergy efforts

Many thanks to all the speakers and the other conveners!

Thanks for attention!