MuSIC, COMET, and PRISM in Kuno-group, Osaka Univ.

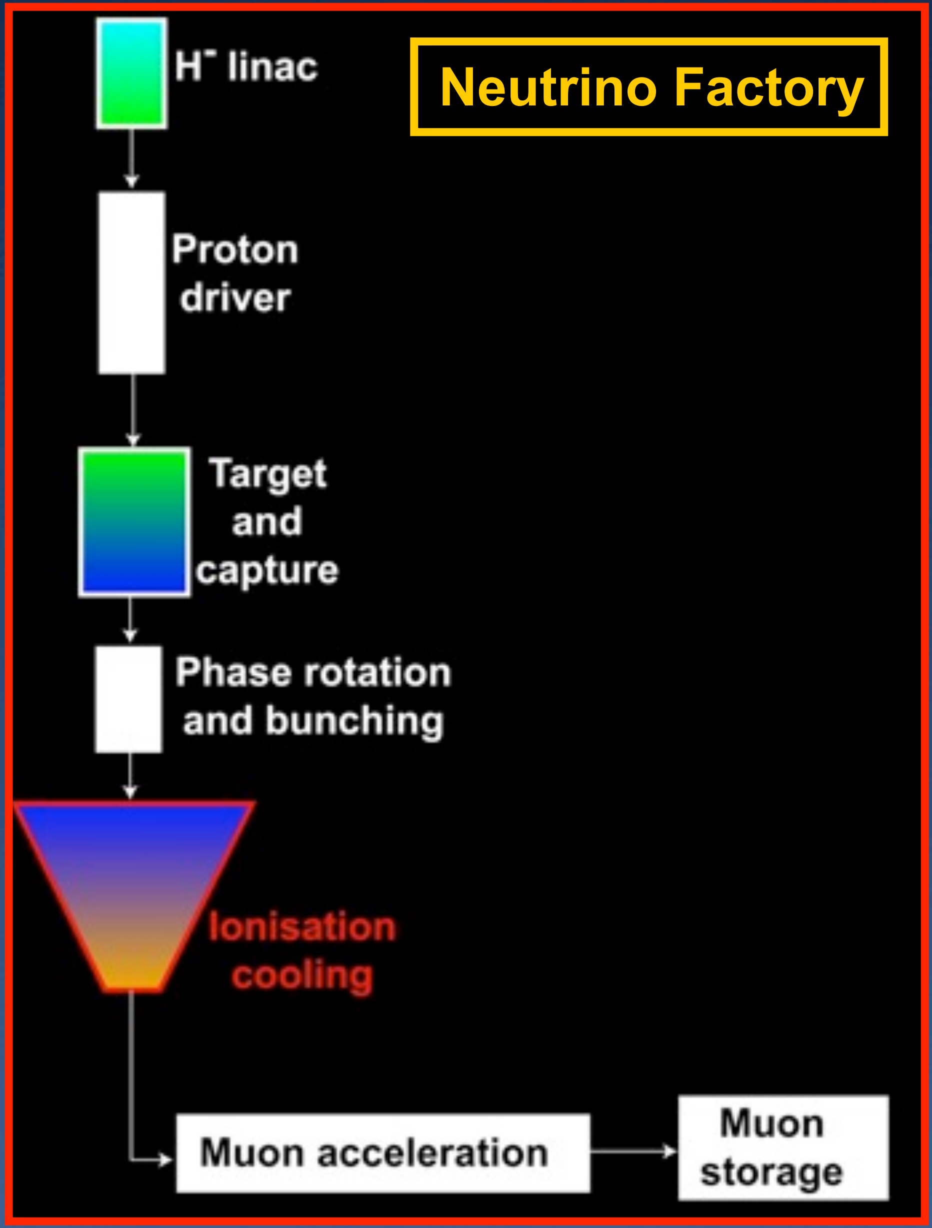
- Synergies between NF/MC and Muon Physics -

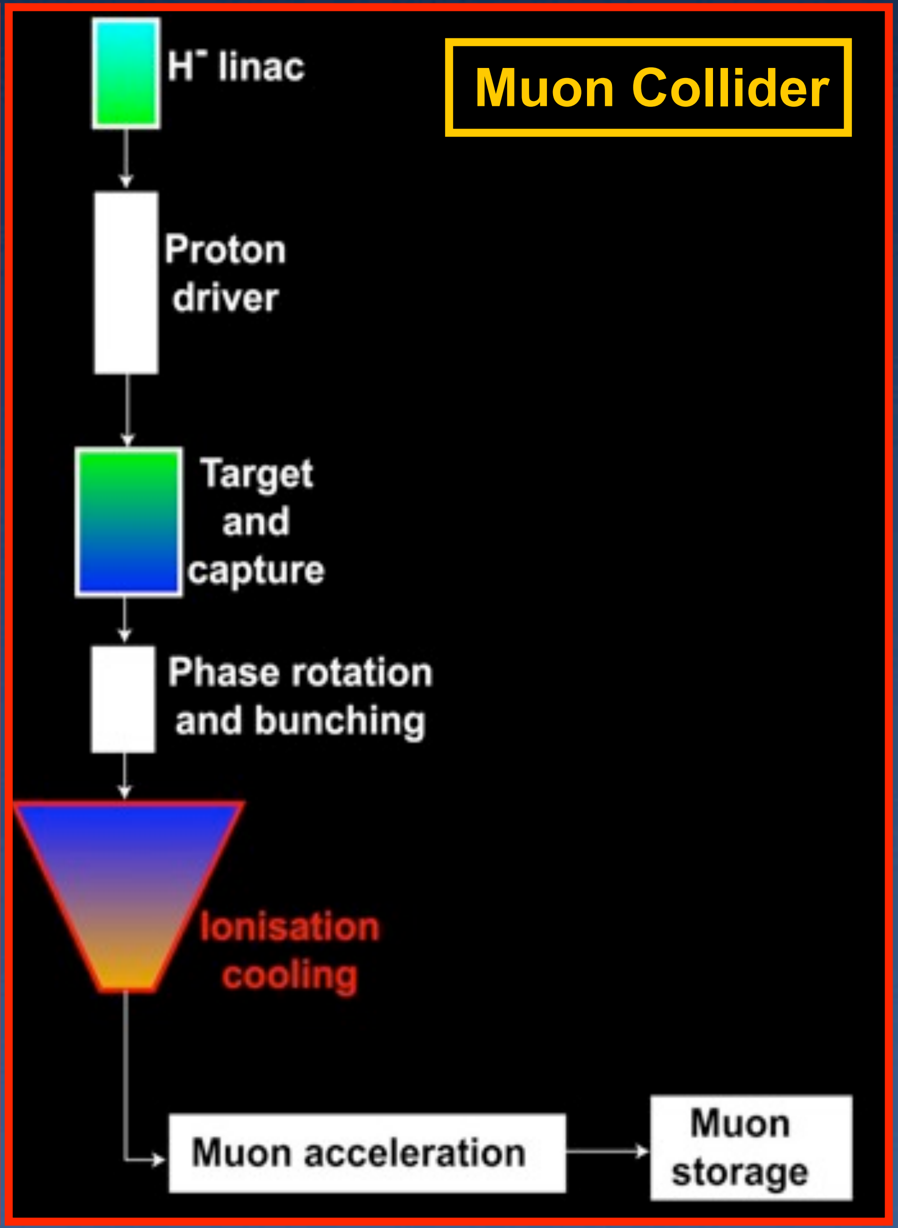
Akira SATO
Department of Physics, Osaka University, JAPAN

2010/10/28,
FFAG10, KURRI, Osaka, JAPAN

Particle Physics Based on Muons

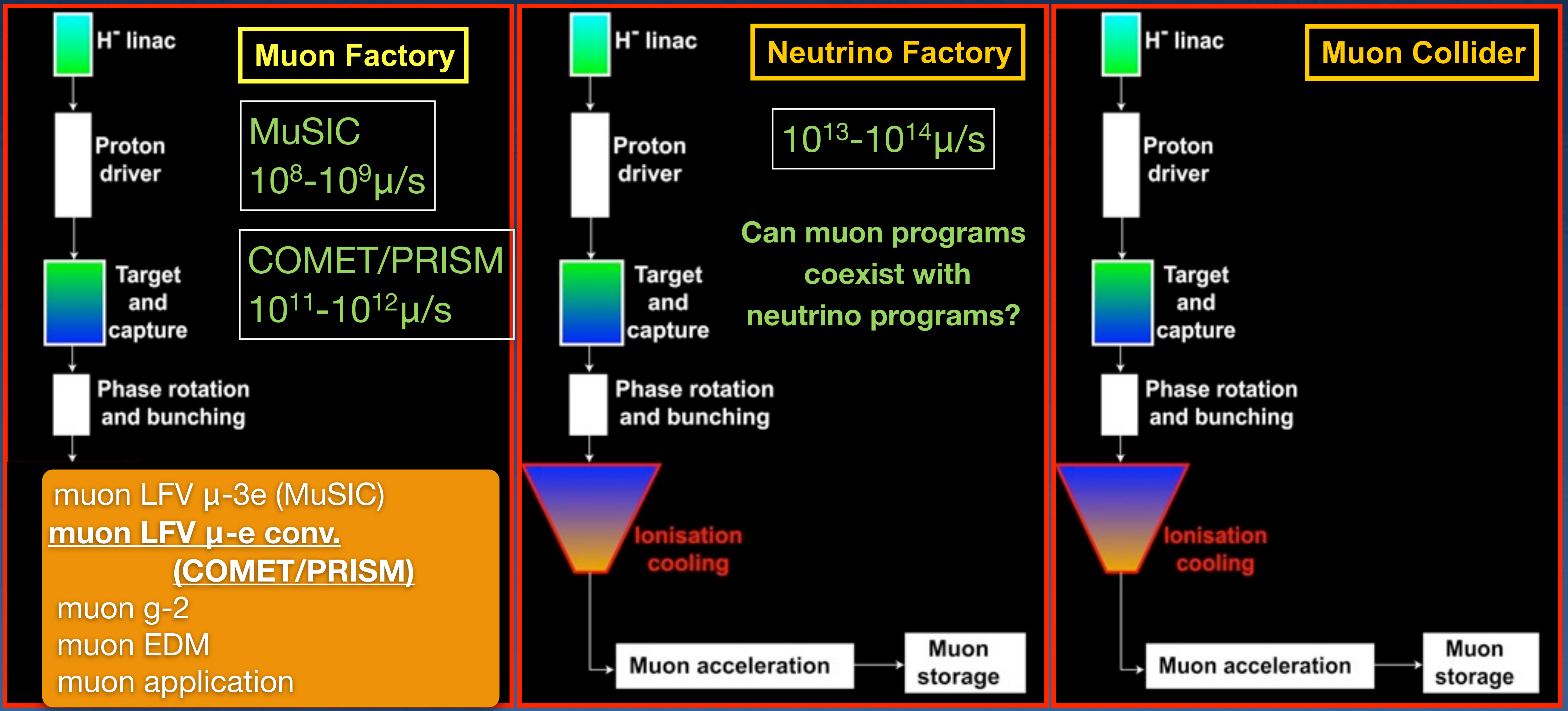
- Muons are a great probe to investigate nature.
  - fundamental physics, material science, μCF, non-destructive element analysis ..
- Muon will be also a key particle in coming decades : NF and MC ...



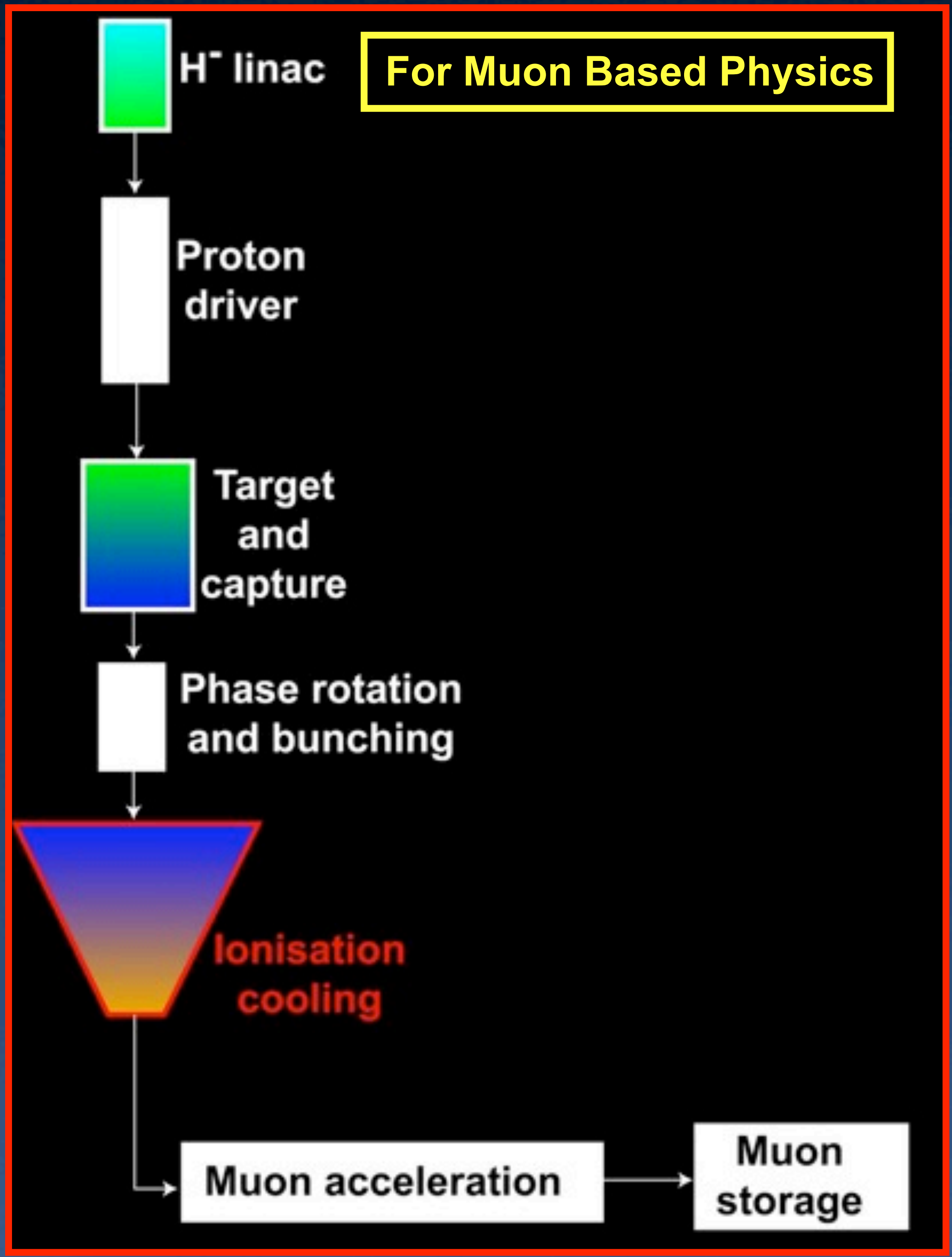


Particle Physics Based on Muons

- There are **excellent synergies** among Muon Factory, Neutrino Factory, and Muon collider on both physics issues and accelerator technologies. Future muon experiments need similar accelerator techniques and devises.
- We need to consider not only the staging scenario from muon factory to neutrino factory but also the co-existence of muon and neutrino programs at the Neutrino Factory facility.



Technological Synergies



- **High power proton driver**
- **Pion production and capture**
  - target system, super-conducting magnet, radiation damage, hadron codes ...
- **Muon beam transport**
  - bend solenoid with a dipole field
- **Phase rotation**
- **FFAGs**
- **Kickers and RF**
- **Techniques in machine design and beam dynamics studies**
- **...**

Studied in MuSIC, COMET and PRISM

Strong relationship b/w NF/MC and muon group is important.

μ-e conversion search is a Hope

- Search for the charged lepton flavor violation (cLFV) is especially promising to probe the TeV-scale physics. In particular, among the cLFV processes, μ-e conversion is attractive to carry out with the future high power proton drivers.
- Comparison between μ→eγ and μ-e conversion (Experimental)

	background	challenge	beam intensity
• μ→eγ	accidentals	detector resolution	limited
• μ-e conversion	beam	beam background	no limitation

  - μ→eγ : Accidental background is given by $(\text{rate})^2$. The detector resolutions have to be improved, but they (in particular, photon) would be hard to go beyond MEG from present technology. The ultimate sensitivity would be about 10^{-14} (with about 10^8/sec) unless the detector resolution is radically improved.
  - μ-e conversion : Improvement of a muon beam can be possible, both in purity (no pions) and in intensity (thanks to neutrino factory and muon collider R&D). A higher beam intensity can be taken because of no accidentals.

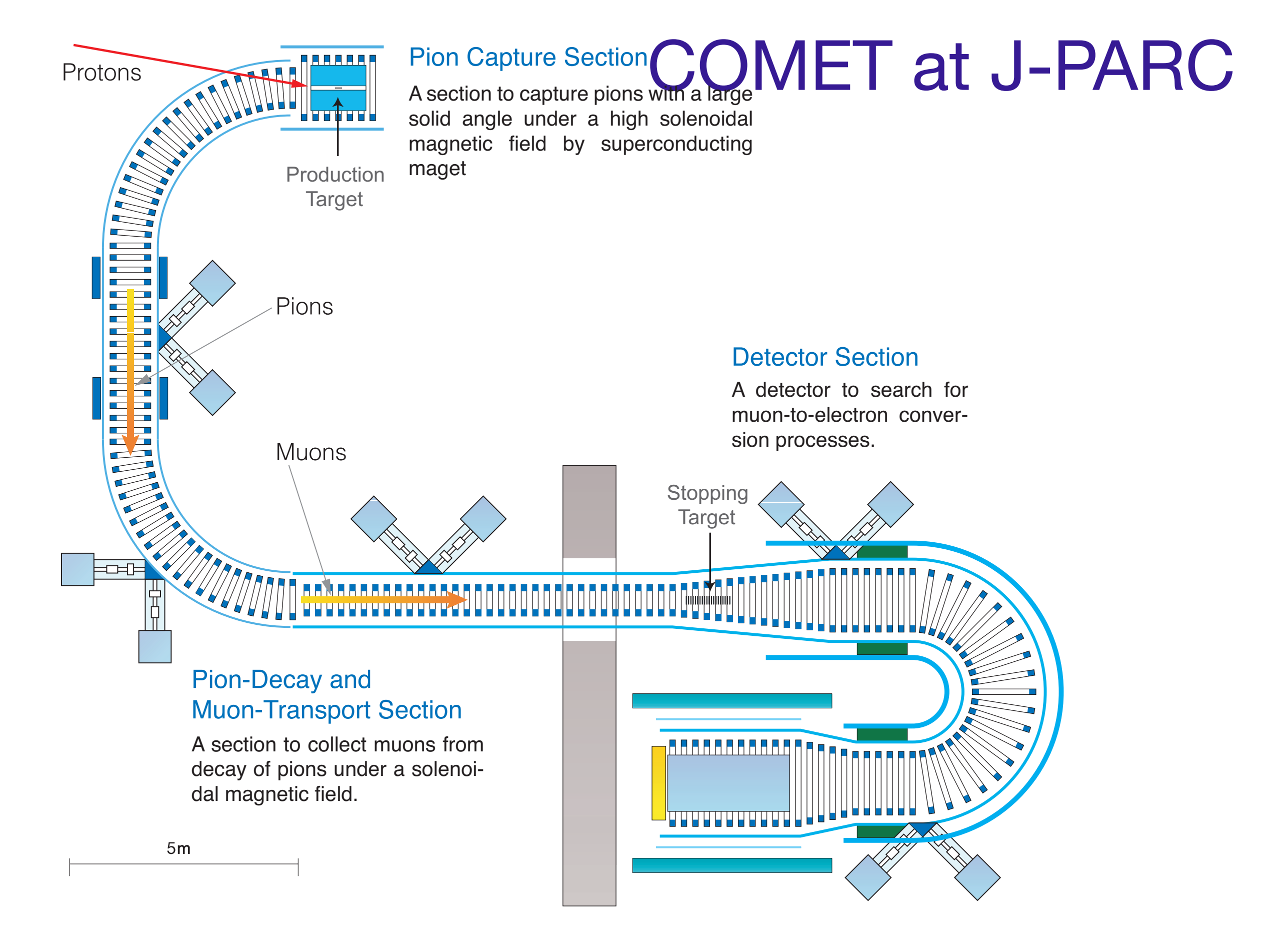
A Next Step should be μ-e conversion

μ-e conv. experiments and R&D programs

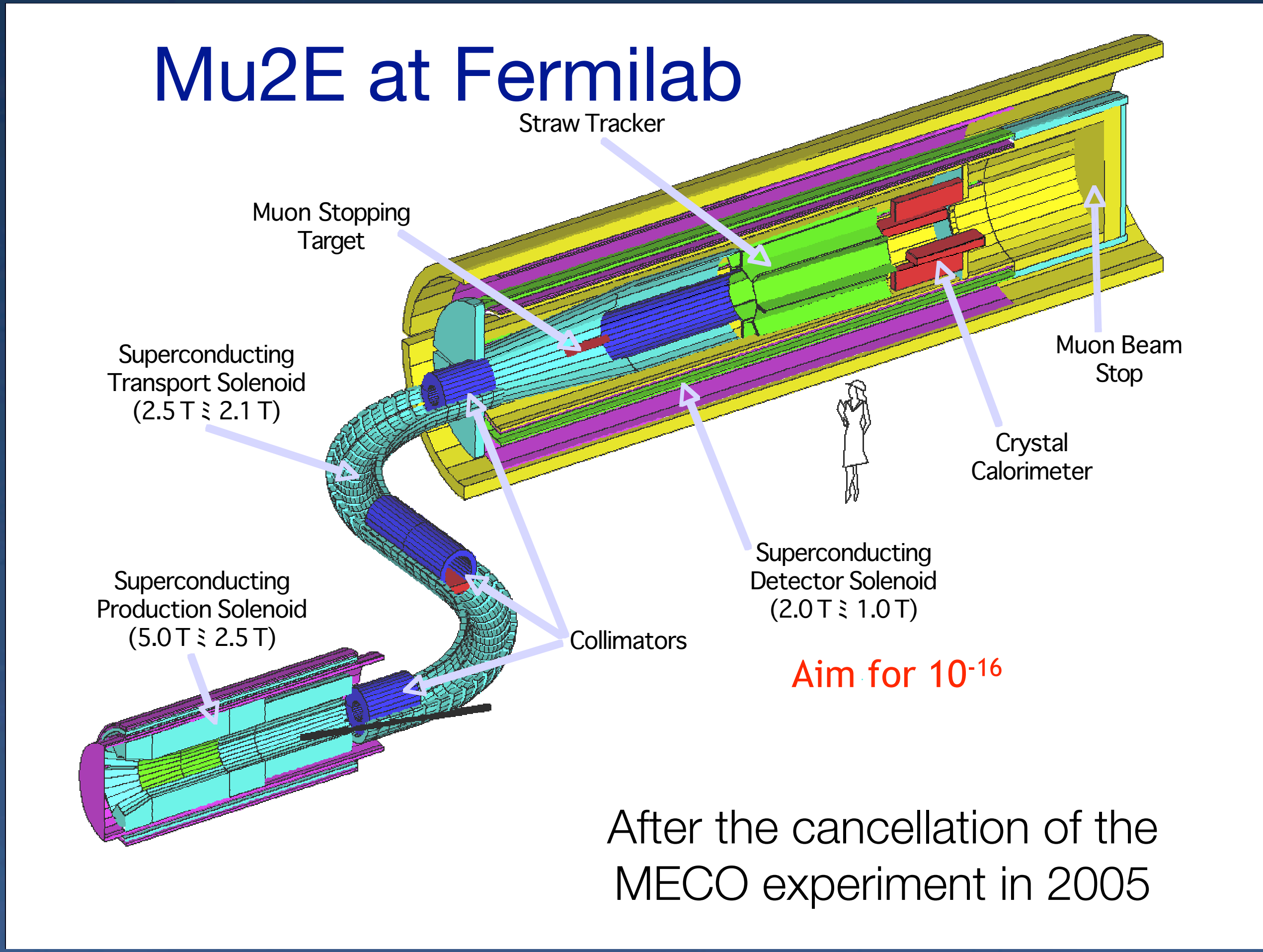
- Proposed experiments
  - COMET at J-PARC and Mu2E at FNAL
  - PRISM at ????
- R&D programs
  - **PRISM-FFAG**
  - **PRISM Task Force**
  - **MuSIC**
  - R&D programs in COMET/Mu2e

COMET and Mu2E: S.E.S.~10^{-16}

- To achieve a single event sensitivity (S.E.S.) of 10^{-16}, we need:
  - High intense muon beam: ~10^{11} μ/sec
  - Pulsed muon beam: for the BG rejection
- Two experiments have been proposed to be carried out around 2016.



Stage-1 approval July 2009 at J-PARC



CD0 approval Nov. 2009 by DOE

Limits of COMET/Mu2E

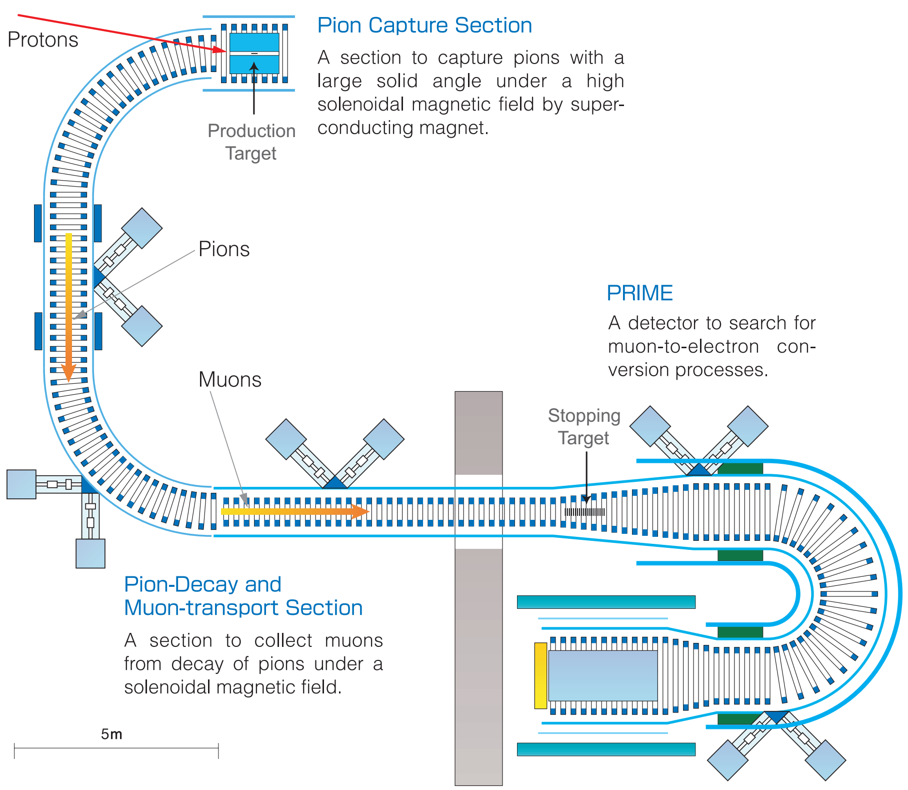
- A single event sensitivity < 10^{-17} would be impossible with the COMET/Mu2E experiments.
  - Signal events can be buried under a large amount of beam related backgrounds, ex. pion radiative decay.
  - A wide energy spread of the muon beam needs a thick stopping target, which makes an insufficient electron energy resolution to separate the signals from backgrounds from muon decay in orbit.
- Measurement efficiency with high-Z stopping targets would be poor.

A mono-energetic and pure muon beam can solve these issues.
The next generation μ-e conversion experiment with PRISM is proposed.

For the detail, please check my presentation of 4th Workshop on Physics with a high intensity proton source, November 9-10 (Monday-Tuesday), 2009
http://indico.fnal.gov/getFile.py/access?contribId=31&sessionId=9&resId=0&materialId=slides&confId=2882

Staging Plan of μ-e conv. in Japan

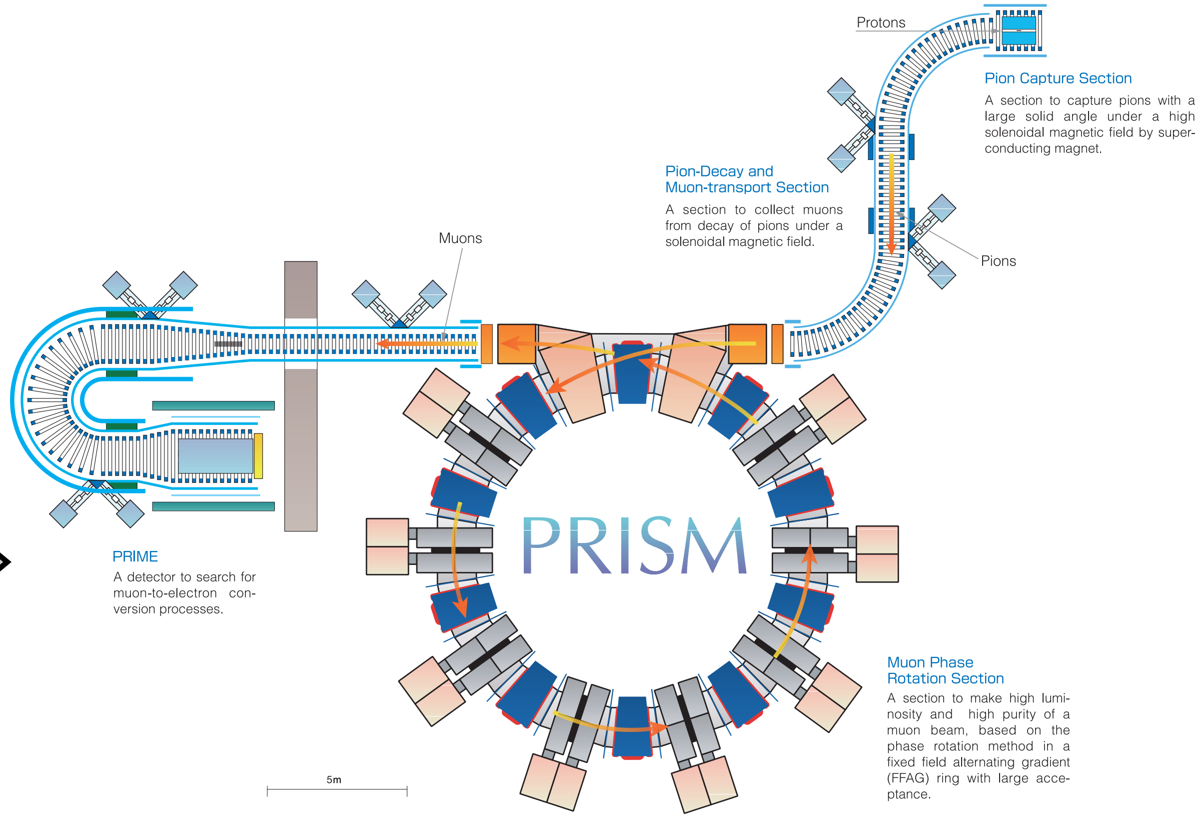
1st Stage : COMET



$$B(\mu^- + Al \to e^- + Al) < 10^{-16}$$

- without a muon storage ring.
- with a slowly-extracted pulsed proton beam.
- doable at the J-PARC NP Hall.
- regarded as the first phase / MECO type
- Early realization

2nd Stage : PRISM/PRIME



$$B(\mu^- + Ti \to e^- + Ti) < 10^{-18}$$

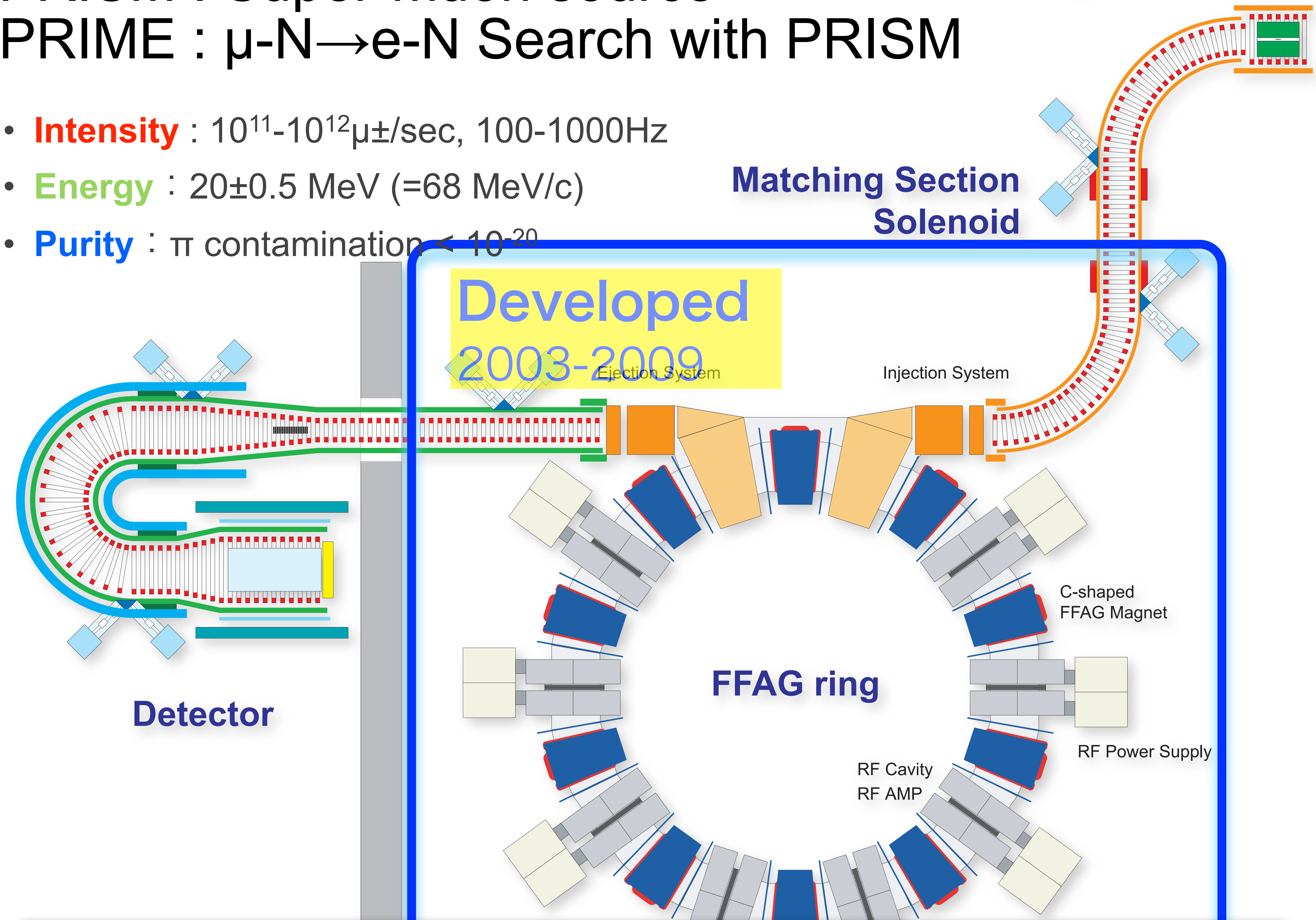
- with a muon storage ring.
- with a fast-extracted pulsed proton beam.
- need a new beamline and experimental hall.
- regarded as the second phase.
- Ultimate search

Staging Programs for the μ-e conversion

	MuSIC	COMET	PRISM/PRIME
Physics	$\mu \rightarrow eee$ nuclear physics material science	BR(μ-e)<10^{-16}	BR(μ-e)<10^{-18}
μ intensity	$10^{8}\mu/s$	$10^{11}\mu/s$	$10^{12}\mu/s$
DC/Pulse	DC	Pulse width<100ns	Pulse width<10ns
Phase Potation?	No	No	Yes
Proton Beam	400W (400MeV, 1μA)	56kW (8GeV, 7μA)	2MW (2-5GeV?)
B_{max} of π Capture Solenoid	3.5 Tesla	5 Tesla	5 Tesla

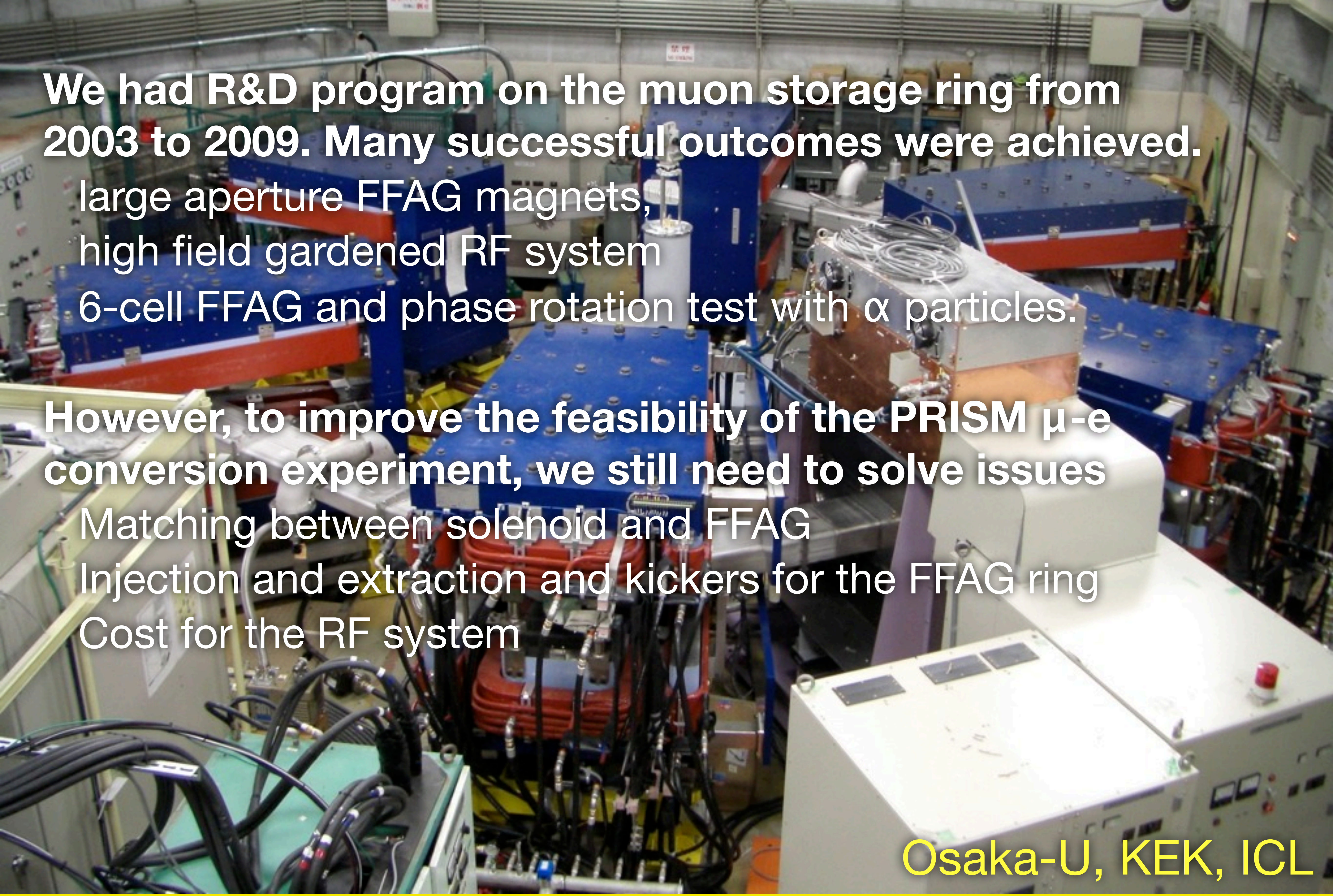
PRISM : Super-muon source
PRIME : μ-N→e-N Search with PRISM

- **Intensity** : 10^{11}-10^{12}μ±/sec, 100-1000Hz
- **Energy** : 20±0.5 MeV (=68 MeV/c)
- **Purity** : π contamination < 10^{-20}



PRISM-FFAG is a key device to achieve the mono-energetic and pure muon beam. Phase rotation is applied in the ring.

6-sector PRISM-FFAG at RCNP, Osaka Univ.



We had R&D program on the muon storage ring from 2003 to 2009. Many successful outcomes were achieved.

- large aperture FFAG magnets,
- high field gardened RF system
- 6-cell FFAG and phase rotation test with α particles.

However, to improve the feasibility of the PRISM μ-e conversion experiment, we still need to solve issues

- Matching between solenoid and FFAG
- Injection and extraction and kickers for the FFAG ring
- Cost for the RF system

Osaka-U, KEK, ICL

6-sector PRISM-FFAG at RCNP, Osaka Univ.

PRISM Task Force

- The PRISM-FFAG Task Force was proposed and discussed during the last PRISM-FFAG workshop at ICL (1-2 July'09).
- The aim of the Task Force is to address the technological challenges in realizing an FFAG based μ-e conversion experiment, but also to strengthen the R&D for muon accelerators in the context of the Neutrino Factory and future muon physics experiments.
- The following key areas of activity were identified and proposed to be covered within the Task Force:
  - - physics of muon to electron conversion,
  - - proton source,
  - - pion capture,
  - - muon beam transport,
  - - injection and extraction for PRISM-FFAG ring,
  - - FFAG ring design including the search for a new improved version,
  - - FFAG hardware R&D for RF system and injection/extraction kicker and septum magnets.
- Studies will continue to obtain a feasible design, aiming on CDR in 2011.

Synergy between PRISM and Neutrino Factory

Members of PRISM Task Force

- **J. Pasternak (contact person)**, Imperial College London / RAL STFC
- L. J. Jenner, A. Kurup, Imperial College London / Fermilab
- Y. Uchida, Imperial College London
- B. Muratori, S. L. Smith, Cockcroft Institute / STFC-DL-ASTeC
- K. M. Hock, Cockcroft Institute / University of Liverpool
- R. J. Barlow, Cockcroft Institute / University of Manchester
- C. Ohmori, KEK/JAEA
- H. Witte, T. Yokoi, JAI, Oxford University
- J-B. Lagrange, Y. Mori, Kyoto University, KURRI
- Y. Kuno, A. Sato, Osaka University
- D. Kelliher, S. Machida, C. Prior, STFC-RAL-ASTeC
- M. Lancaster, University College London

Many young physicists. We are trying to apply our skills, which got thorough the NF related studies, to the muon physics experiment!

Welcome to join us!

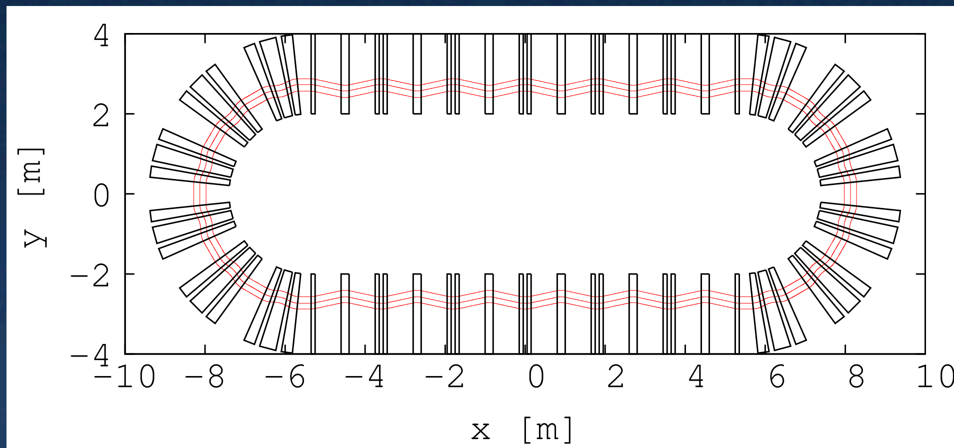
as on IPAC'10 paper

PRISM-TF Design Strategy

- Apply the technologies which studied in the NF related studies to PRISM to solve the issues.
- **Approach 1:**
  - Adopt the original design of PRISM-FFAG and work out injection/ extraction, and hardwares.
- **Approach 2:**
  - Find a new design of the phase-rotator
    - racetrack-scaling FFAG
    - non-scaling FFAG ...
- **Requirements:**
  - High transverse acceptance (at least 38h/5.7v [Pi mm]).
  - High momentum acceptance (at least ± 20% or more).
  - Small orbit excursion.
  - Compact ring size
  - Relax or at least conserve the level of technical difficulties. for hardware (kickers, RF) with respect to the current design.

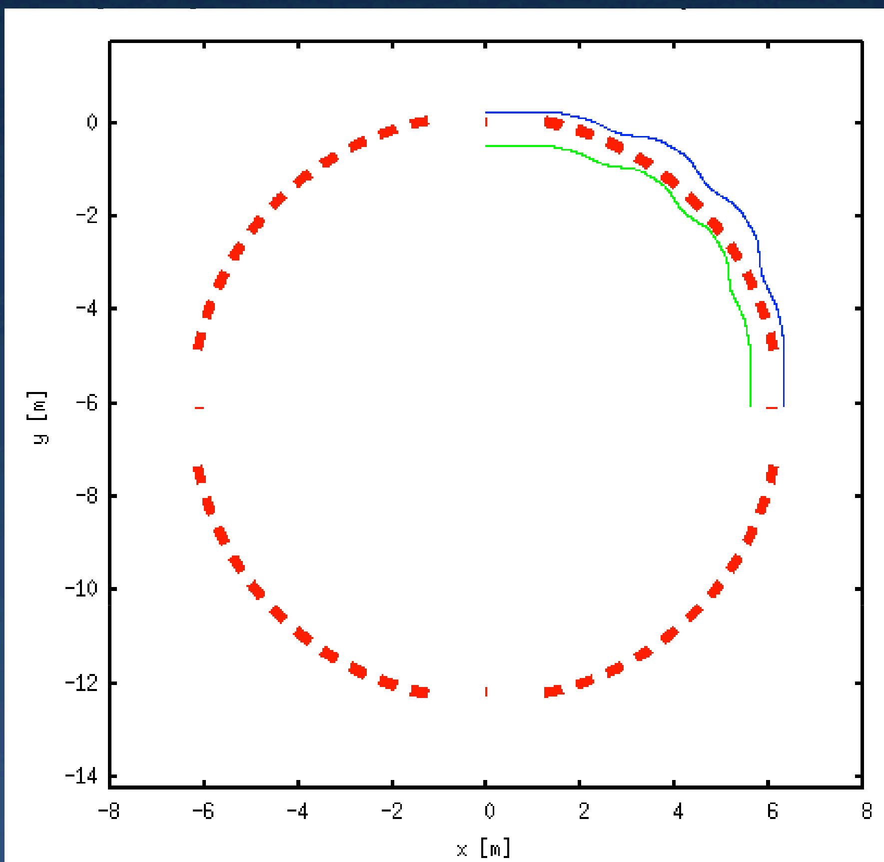
PRISM-TF Progress: Lattice

- One of the issues on the original PRISM-FFAG was injection and extraction.
- New PRISM-FFAG ring designs with longer drifts to install kicker system are proposed.
- Many ideas for scaling and non-scaling FFAGs are being applied to PRISM-FFAG.



Circular section FDF triplet scaling FFAG cell	
k	2.55
Mean radius (at 68 MeV/c)	2.7 m
Horizontal phase advance	60 degrees
Vertical phase advance	90 degrees
Number of circular cells	12
Straight section FDF triplet scaling FFAG cell	
m	1.3 m^{-1}
Cell length	1.8 m
Horizontal phase advance	27 degrees
Vertical phase advance	97 degrees
Number of straight cells	12

Advanced scaling FFAG
(J-B. Lagrange *et al*.)



Scaling FFAG machine law:

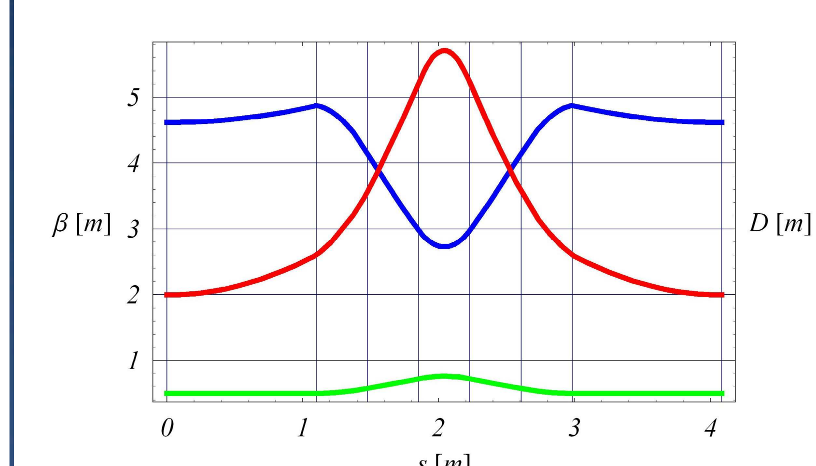
$$B_z = B_{z0}\left(\frac{r}{r_0}\right)^k F(\theta)$$

Super-periodic solution
(S. Machida)

Some parameters:

• Lattice	Symmetric DFD triplet
• N	20
• p_0	68 MeV/c
• Circunference	81.68 m
• (Q_H, Q_V)/cell at p_0	(0.24, 0.155)
• Drif length	2.2 m

•The same geometry as the previous lattice



non-scaling FFAG
(J. Pasternak)

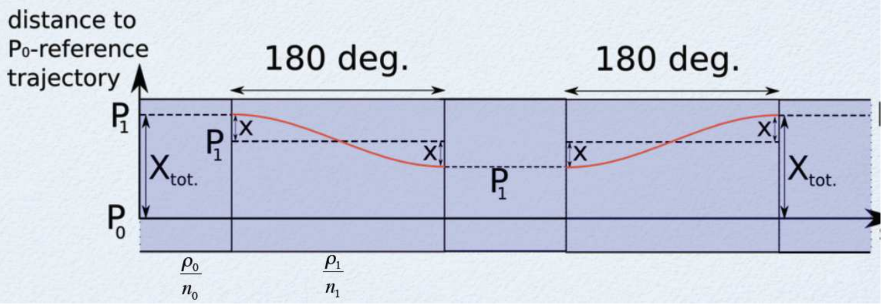
PRISM-TF Progress: Inj./Ext.

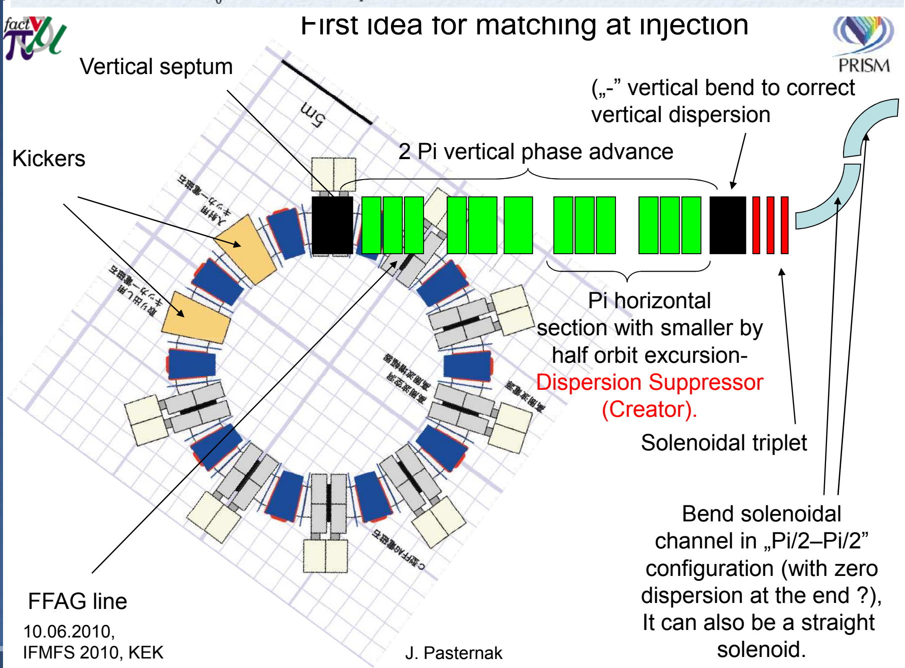
- Matching between the muon transfer solenoid and phase rotator had a difficulty due to a large muon emmitance and dispersion.
- Dispersion suppressor using scaling FFAG magnets and kicker designs based on NF studies are underway.

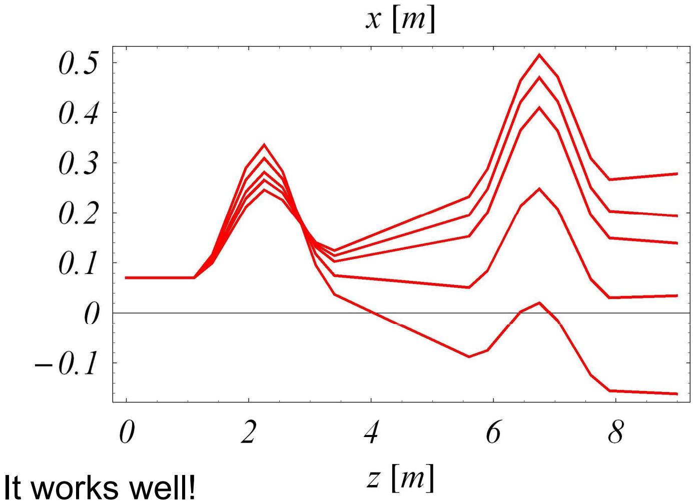
Dispersion suppressor

- Dispersion suppressor (Planche,Lagrange,Mori)
  - successive π-cells in the horizontal plane can suppress the dispersion.

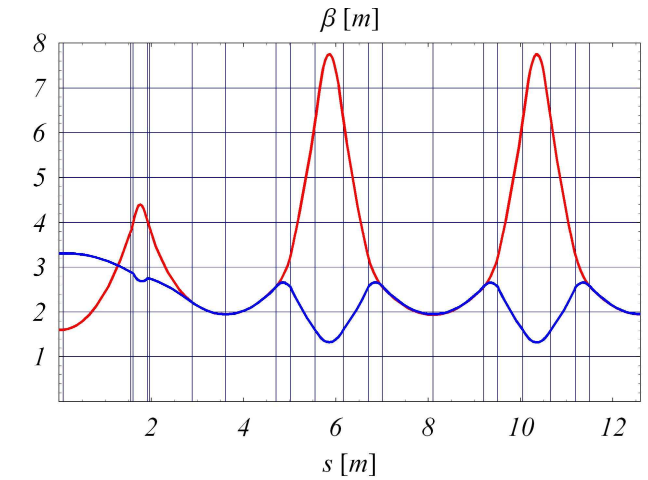
$$X_{tot} = X_1 - X_0 = \frac{1}{n/\rho}\ln\left(\frac{P_1}{P_0}\right) \qquad x = \ln\left(\frac{P_1}{P_0}\right)\left(\frac{\rho_0}{n_0} - \frac{\rho_1}{n_1}\right)$$







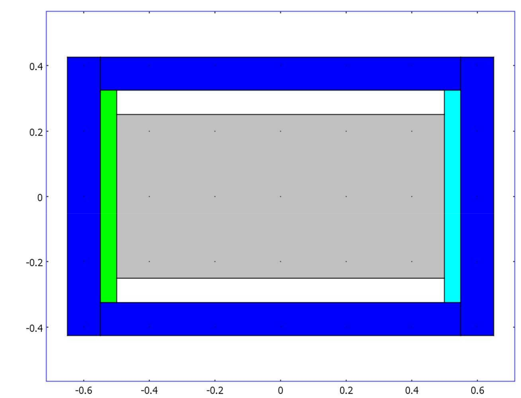
It works well!
The starting position needs to bu adjusted to obtain good results. Here it corresponds to 17 MeV orbit (assuming the periodic condition).



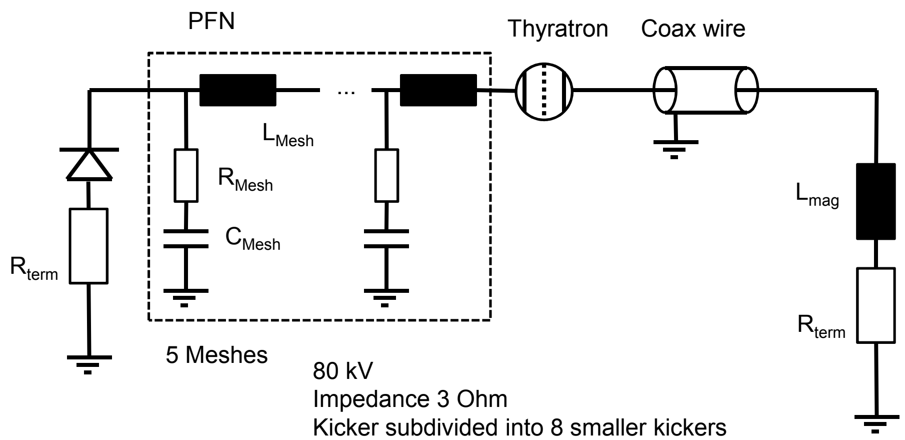
- Dispersion creator is designed and matched to the ring with just one cell.
- Vertical phase advance condition is not rigorously fulfilled (work in progress).

PRISM Kicker, H. Witte

- length 1.6 m
- B vertical 0.02 T
- Aperture: 0.95 m x 0.5 m
- Flat top 40 /210 ns (injection / extraction)
- rise time 80 ns (for extraction)
- fall time ~200 ns (for injection)
- W_{mag}=186 J
- L = 3 uH
- I_{max}=11 kA

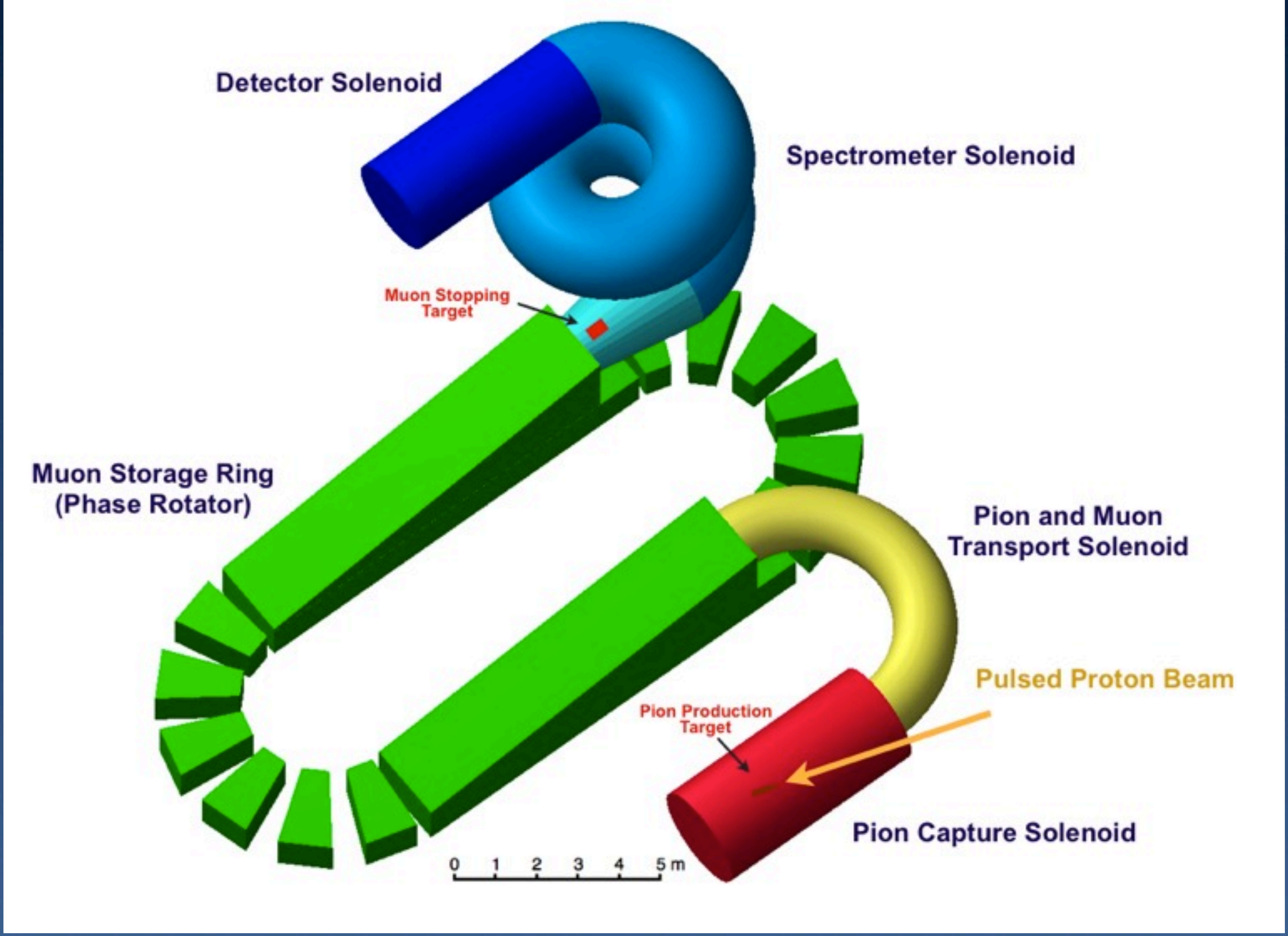


The geometry assumed here corresponds to the horizontal injection, but the kicker parameters for the vertical one will be very similar.



80 kV
Impedance 3 Ohm
Kicker subdivided into 8 smaller kickers
Travelling wave kicker
Each sub-kicker has 5 sections
1 plate capacitor per section

Schematic Layout of New PRISM



Agenda

time	speaker	tentative title
Morning Sessions (Chair: Yoshitaka Kuno)		
Session for Muon Particle Physics at Project X		
09:00 - 09:15	Young-Kee Kim (FNAL)	Welcome and FNAL Future Roadmap
09:15 - 09:45	Steve Holmes (FNAL)	Project X Accelerator Update
09:45 - 10:15	Andre de Gouvea (Northwestern)	Overview of Muon Physics at Project X Era
10:15 - 10:45	Coffee Break	
10:45 - 11:15	Jim Miller (Boston)	Overview of Muon Experimental Programs at Project X
Session for Muon to Electron Conversion Experiment		
11:15 - 11:45	Alejandro Ibarra (TUM, TBC)	Why Muon to Electron Conversion of $<10^{-18}$? (TBC)
11:45 - 13:00	Lunch	
Afternoon Sessions (Chair: Jim Miller)		
13:00 - 13:20	Yoshitaka Kuno (Osaka)	Overview on Muon Storage Ring (PRISM) Option
13:20 - 13:40	Charles Ankenbrandt (Muons. Inc.)	Overview on Cooled RF and Ionization (CRFI) Option
13:40 - 14:10	Keith Gollwitzer (FNAL)	Proton Beam for PRISM
14:10 - 14:40	Eric Prebys (FNAL)	Proton Beam for CRFI
14:40 - 15:10	Coffee Break	
15:10 - 15:40	Jaroslaw Pasternak (Imperial College London)	Muon Beam and FFAG storage ring for PRISM
15:40 - 16:00	Akira Sato (Osaka)	Detector (PRIME)
16:00 - 16:20	Yoshitaka Kuno (Osaka)	Sensitivity and Backgrounds
Session for Synergy of R&D		
16:20 - 16:40	Steve Geer (FNAL)	Synergy with muon collider R&D
16:40 - 17:00	Ken Long (Imperial College London)	Synergy with Neutrino Factory R&D
17:00 - 17:15	Yoshitaka Kuno (Osaka)	Summary

Project-X
5th Workshop on physics,
Muon working group
8th Nov., 2010 at FNAL

Focused on μ-e conv. experiment at SES of 10^{-18}.

PRISM-TF will write a report to show the feasibility of the PRISM based on μ-e conv. experiment.

MuSIC

The world highest intense DC muon beam
in Osaka University

We have build a superconducting pion capture system at RCNP(Research Center of Nuclear Physics), Osaka University, for a new intense DC muon beam line, which is now under construction. **The target muon intensity is 10^8/sec with 400W proton beam!**

Contents

* Pion capture systems for intense muon beams
* Features of MuSIC
* Status and construction schedule
* Design of solenoids
* Expected muon beam
* Conclusions

The first superconducting pion capture system in the world.

This project is referred as ***MuSIC***.

2010.8.2

Muon intensity for the future programs

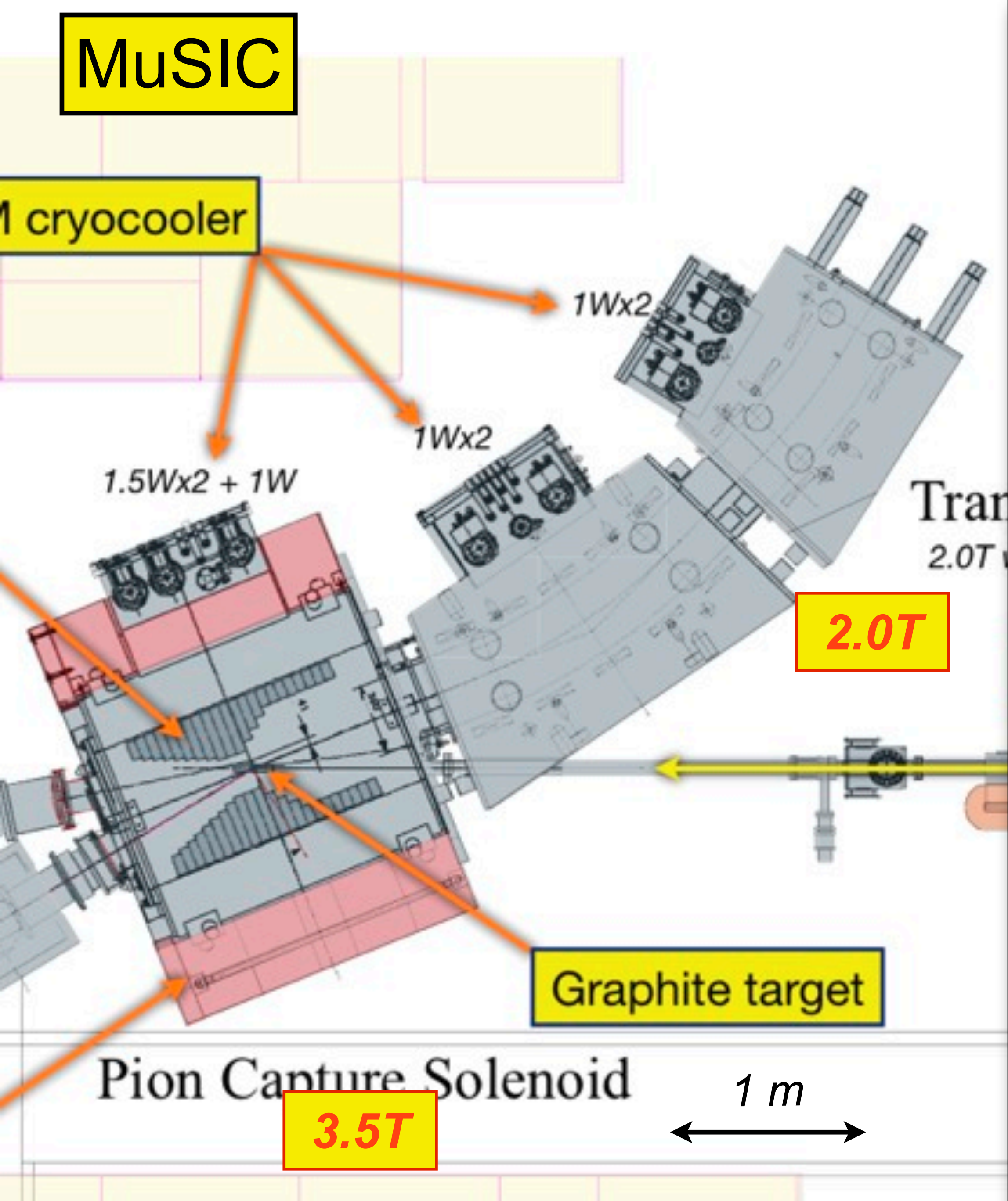
- Future muon related programs under discussion:
  - Searches for the muon to electron conversion in a muonic atom
    - COMET at J-PARC / Mu2e at FNAL: SES ~ 10^{-16}
    - PRISM: SES~ 10^{-18}
  - Neutrino factory: neutrino CP, mass hierarchy, ..
  - Muon collider: high energy frontier
  - ...
- These programs need 10^{11}-10^{14} muons/sec.
- The highest muon intensity available now is 10^{8}muons/sec at PSI
  - Design intensity of J-PARC MUSE is 4×10^{8}muons/sec
- We need 3-6 order of magnitude higher intense muon beam. How?
  - Powerful proton driver ~1GW? impossible.
  - Much more efficient pion collection method. possible.

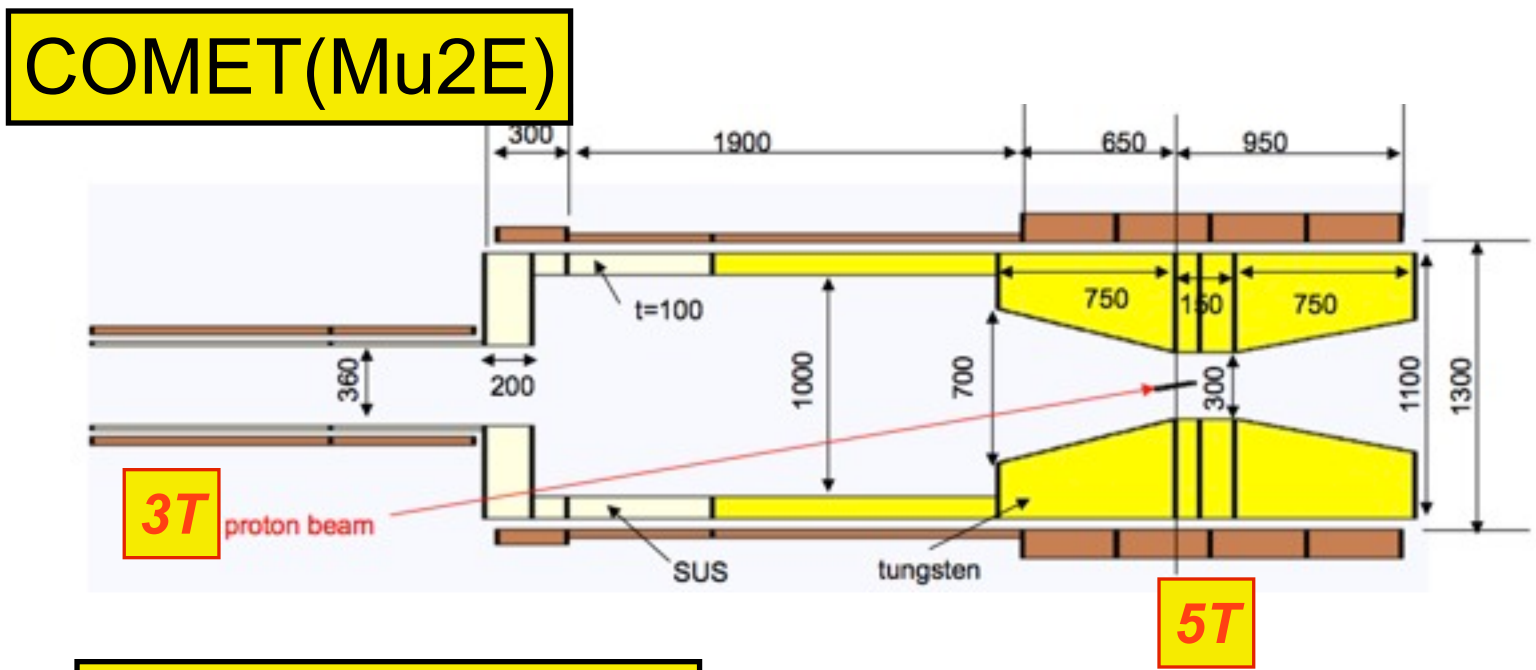
Comparison on the pion capture systems

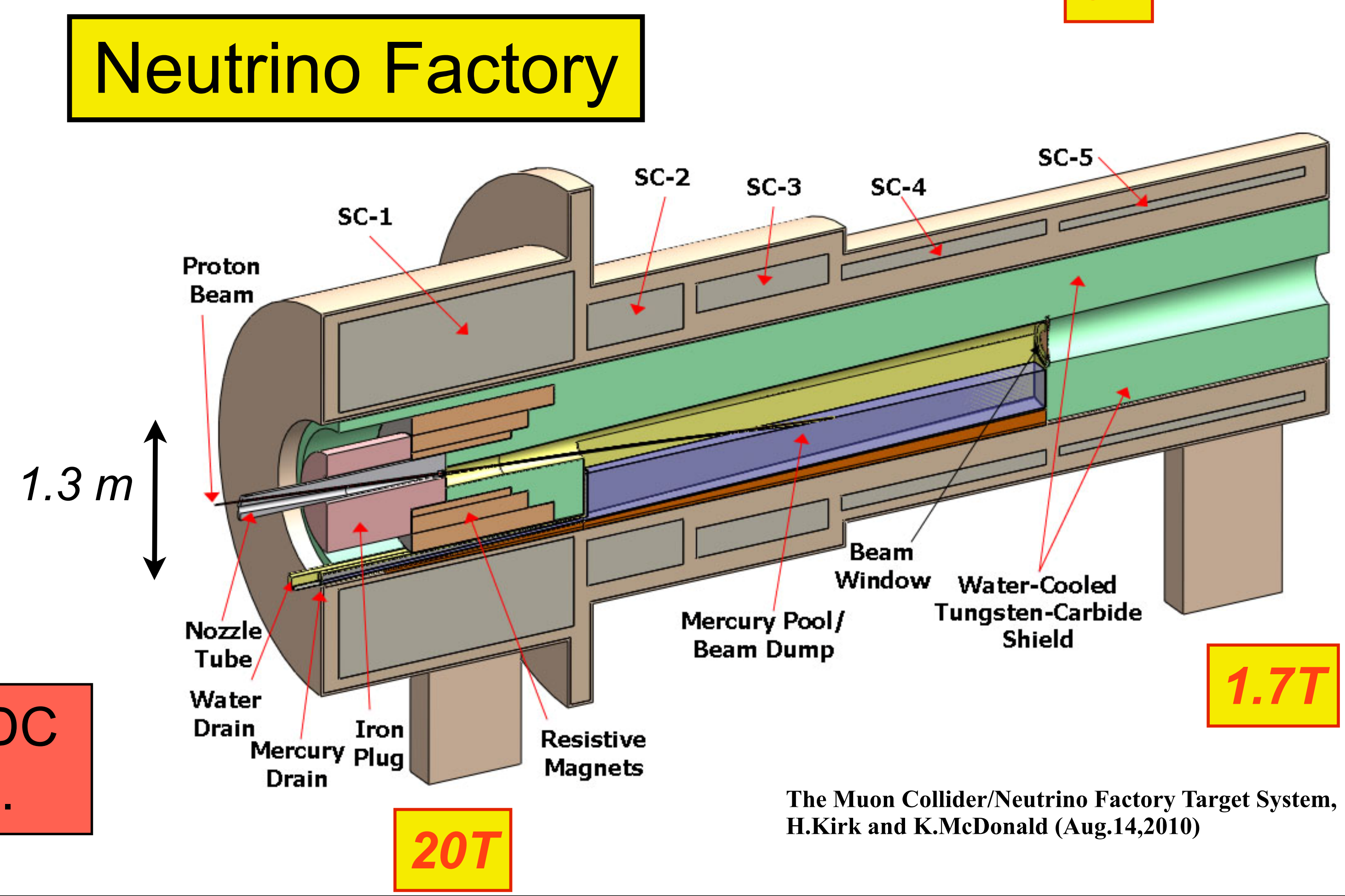
	MuSIC	COMET	NuFact[1]
Muon Intensity	10^8/sec	10^{11}/sec	$10^{12\text{-}13}$/sec
Muon Momentum	20-70 MeV/c (Backward)	20-70 MeV/c (Backward)	170-500 MeV/c (Forward)
Time structure	Continuous	Pulsed	Pulsed
Proton Beam Power	400W (0.4GeV)	56kW (8GeV)	4MW (8GeV)
Production Target	Graphite	Tungsten	Mercury jet
Capture Solenoid Max. Field Strength	3.5 T	5.0 T	20 T
Inner radius of Main SC Coil	0.45 m	0.65 m	0.64 m
Outer radius of Main SC Coil	1.0 m	1.6 m	1.78 m

(1) Based on The Muon Collider/Neutrino Factory Target System, H.Kirk and K.McDonald (Aug.14,2010) and Study-II report

Pion Capture System in MuSIC,COMET, and NuFact







The Muon Collider/Neutrino Factory Target System, H.Kirk and K.McDonald (Aug.14,2010)

MuSIC aims to provide the world intense DC muon beam with the 400W proton beam.

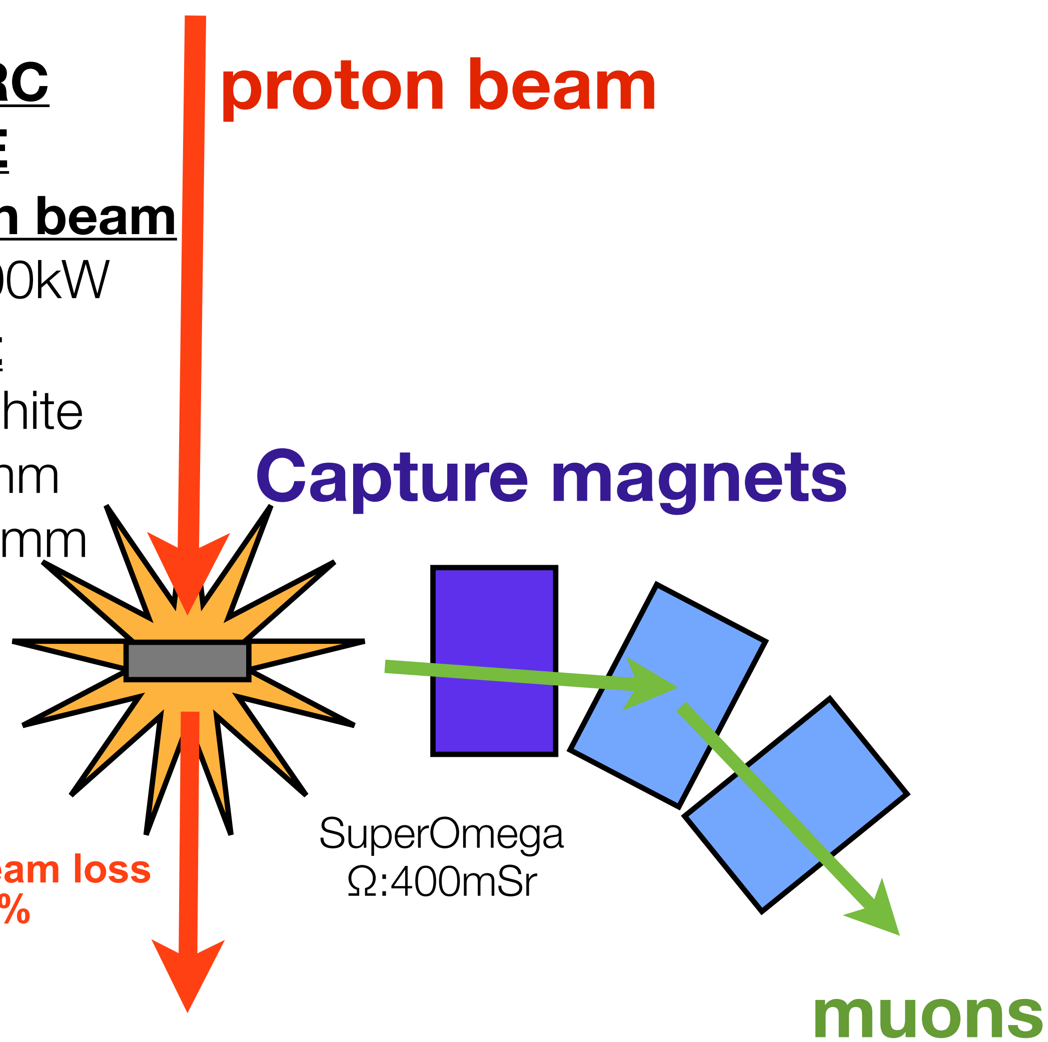
Production and Collection of Pions and Muons

Conventional muon beam line

J-PARC MUSE

proton beam
-1000kW

target
graphite
t20mm
φ70mm



proton beam loss
< 5%

to the neutron facility

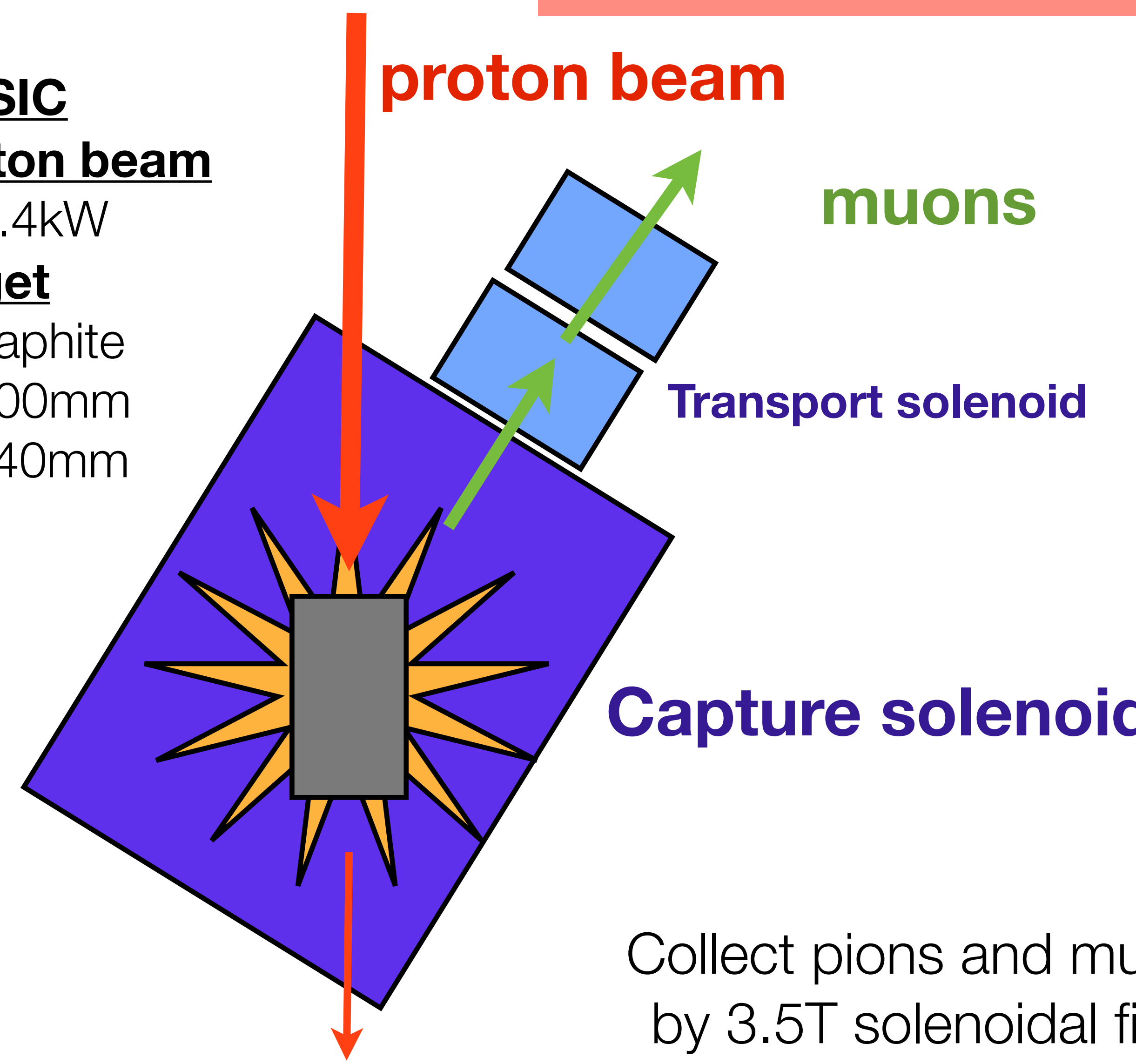
Much efficient

MuSIC,COMET,PRISM,
Neutrino factory,
Muon collider

MuSIC

proton beam
-0.4kW

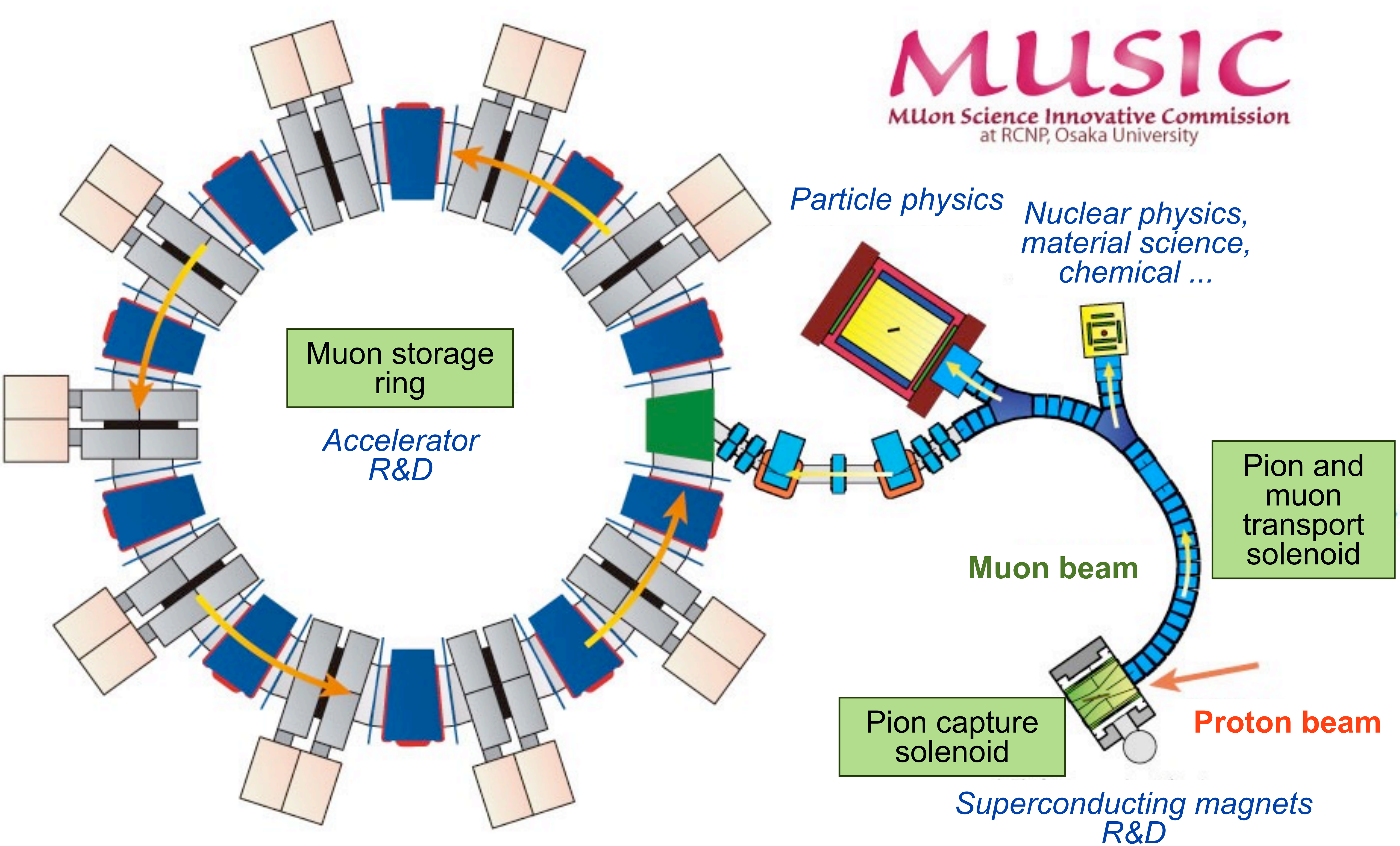
target
graphite
t200mm
φ40mm



Collect pions and muons
by 3.5T solenoidal field

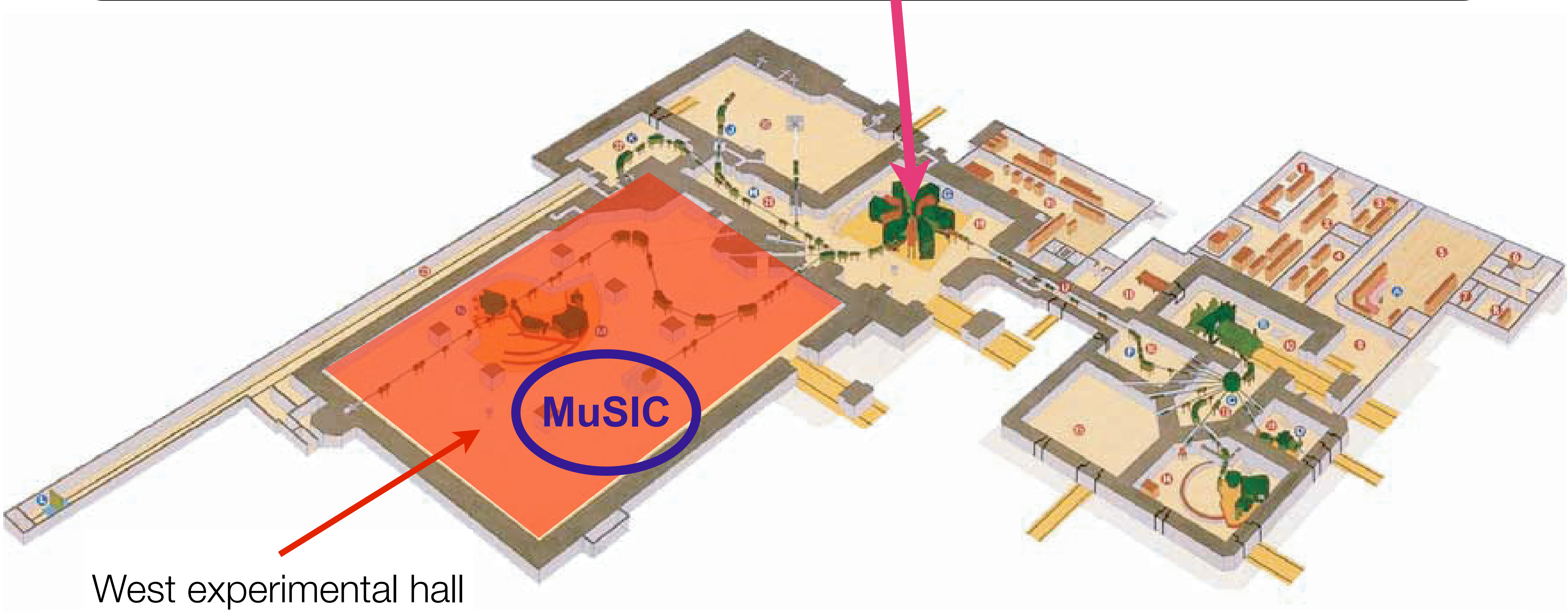
to a beam dump

Large solid angle & thick target


MUSIC
MUon Science Innovative Commission
at RCNP, Osaka University
Particle physics
Nuclear physics,
material science,
chemical ...
Muon storage
ring
Accelerator
R&D
Pion and
muon
transport
solenoid
Muon beam
Pion capture
solenoid
Proton beam
Superconducting magnets
R&D

MuSIC at RCNP, Osaka University

Research Center for Nuclear Physics (RCNP), Osaka University has a cyclotron of 400 MeV with 1 microA . The energy is above pion threshold.



The beam current would be upgraded to 5 microA in future.

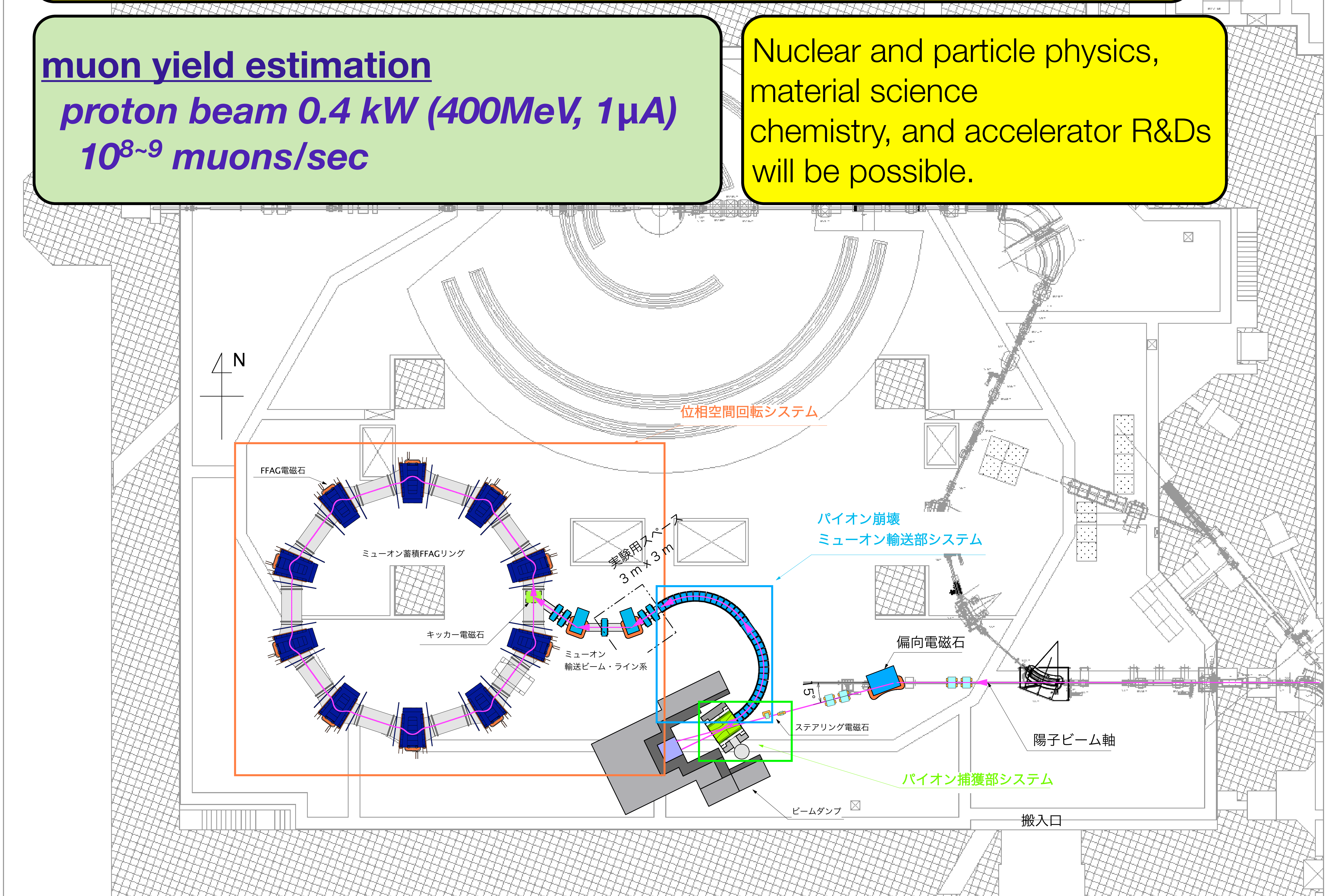
MuSIC (=MUon Science Innovative Commission)

<u>**muon yield estimation**</u>

proton beam 0.4 kW (400MeV, 1μA)

$10^{8\sim9}$ muons/sec

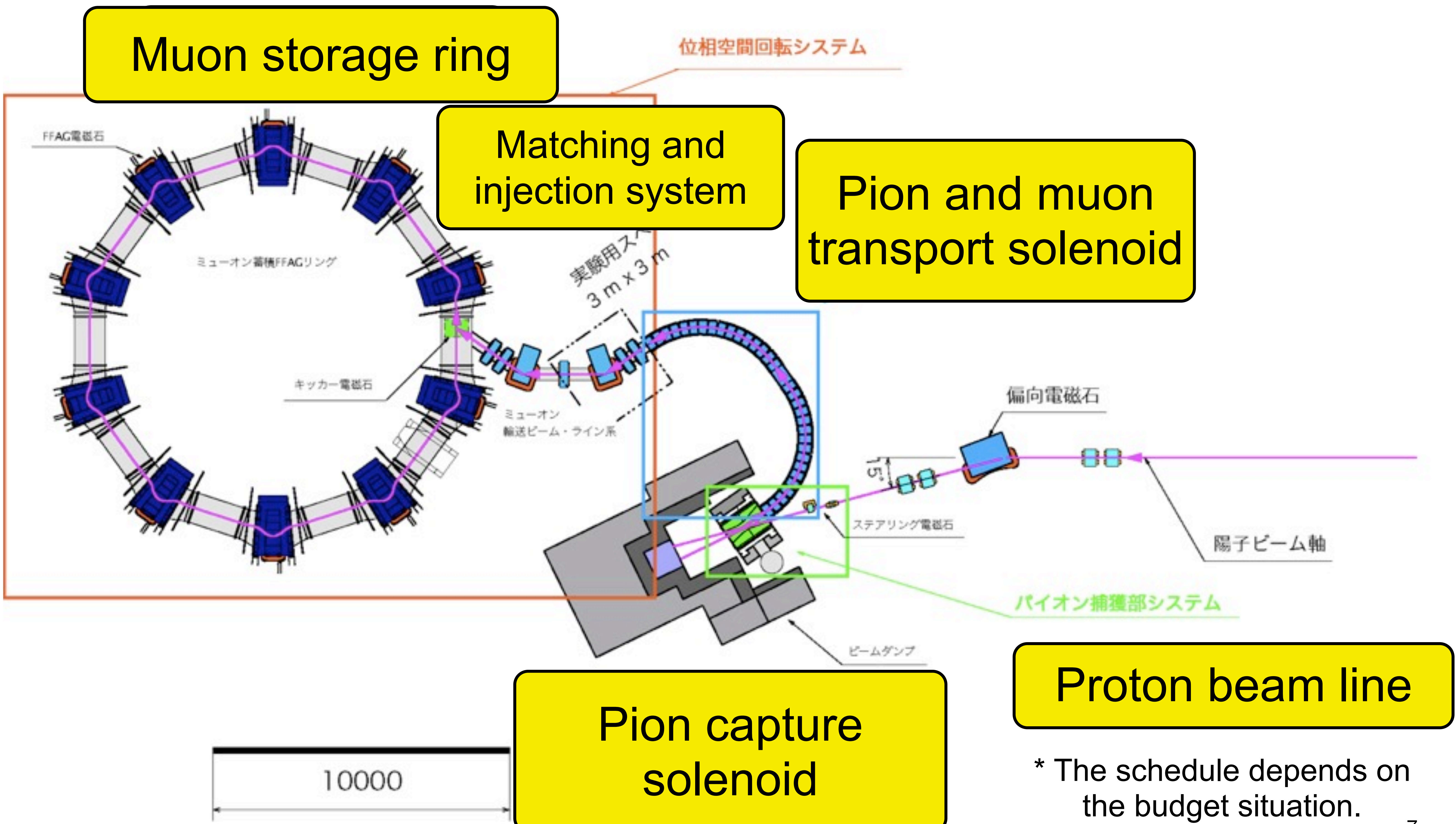
Nuclear and particle physics, material science chemistry, and accelerator R&Ds will be possible.



A final layout plan of the MuSIC in the W-hall, RCNP, Osaka Univ.

Construction Status and Schedule

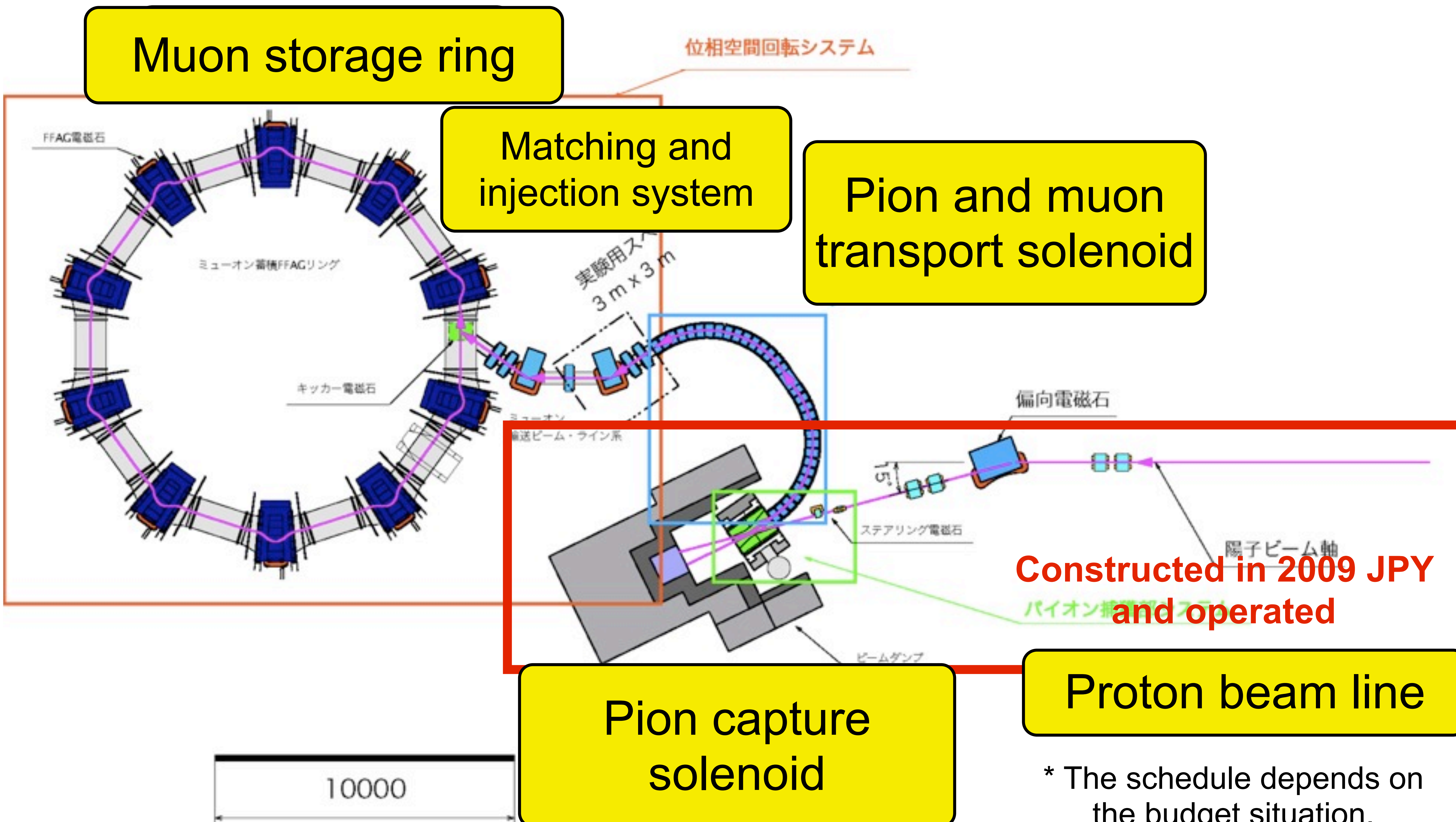
The construction has started at 2009, and will be finished in 5 years.



* The schedule depends on the budget situation.

Construction Status and Schedule

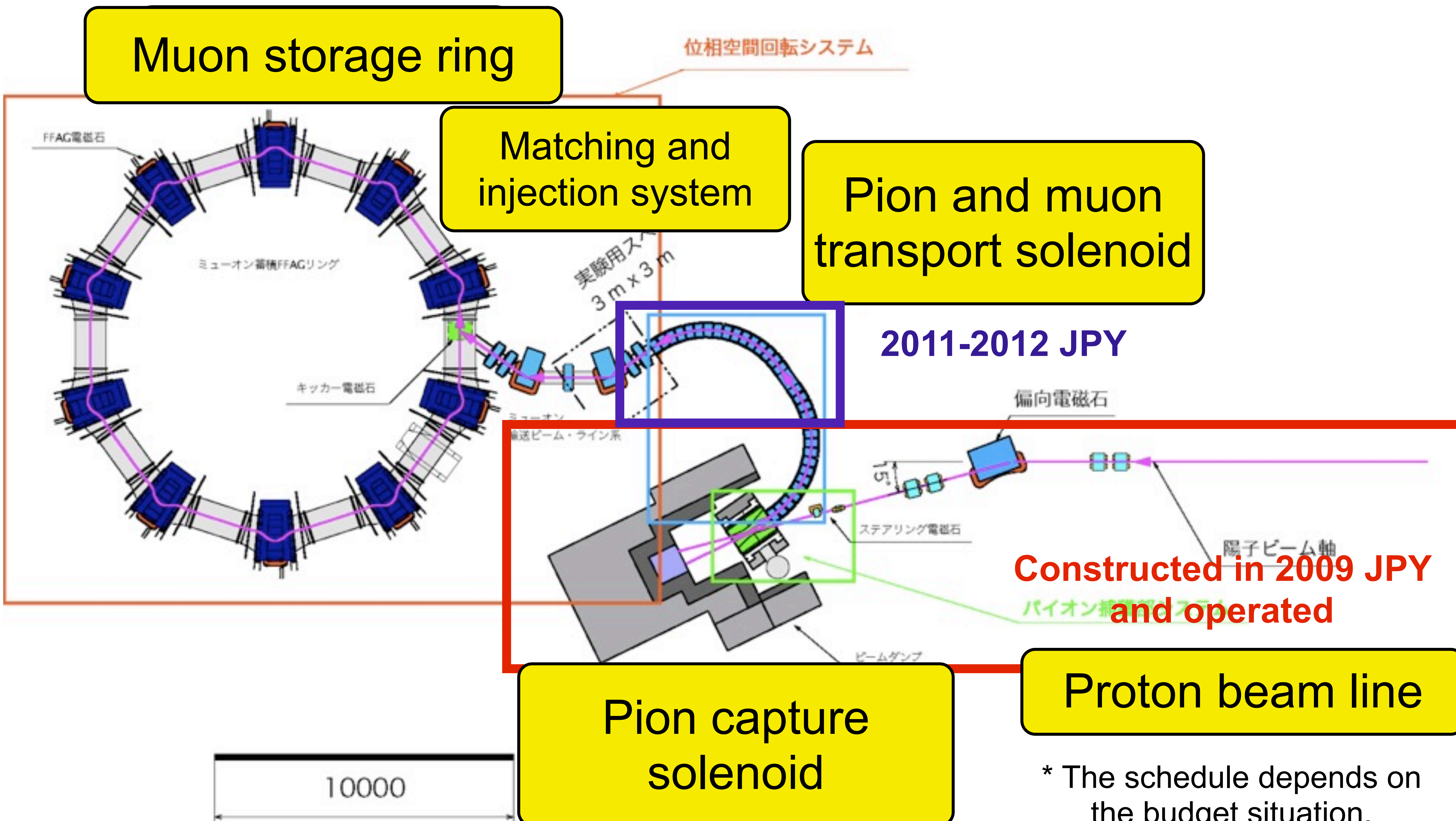
The construction has started at 2009, and will be finished in 5 years.



* The schedule depends on the budget situation.

Construction Status and Schedule

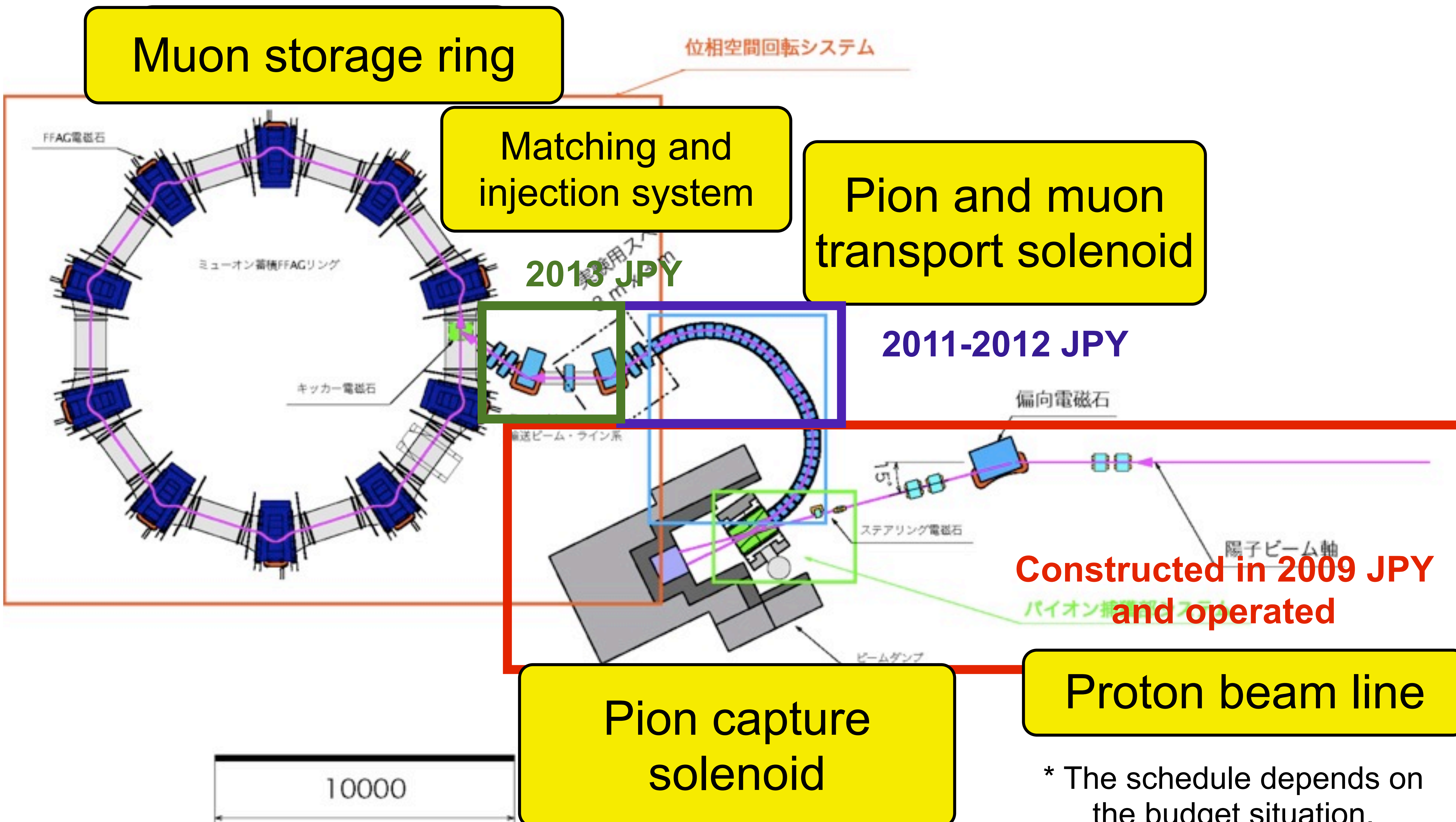
The construction has started at 2009, and will be finished in 5 years.



* The schedule depends on the budget situation.

Construction Status and Schedule

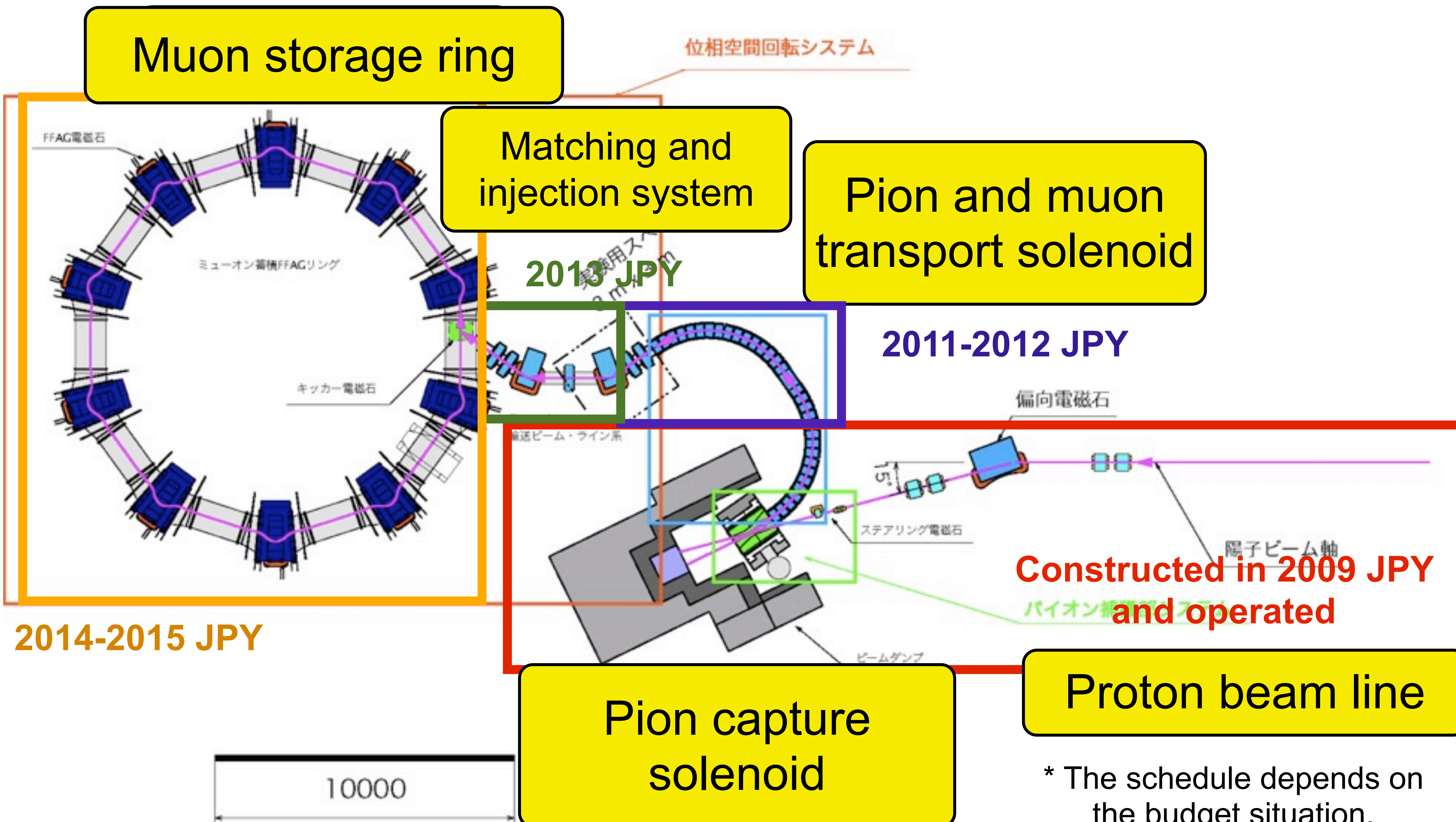
The construction has started at 2009, and will be finished in 5 years.



* The schedule depends on the budget situation.

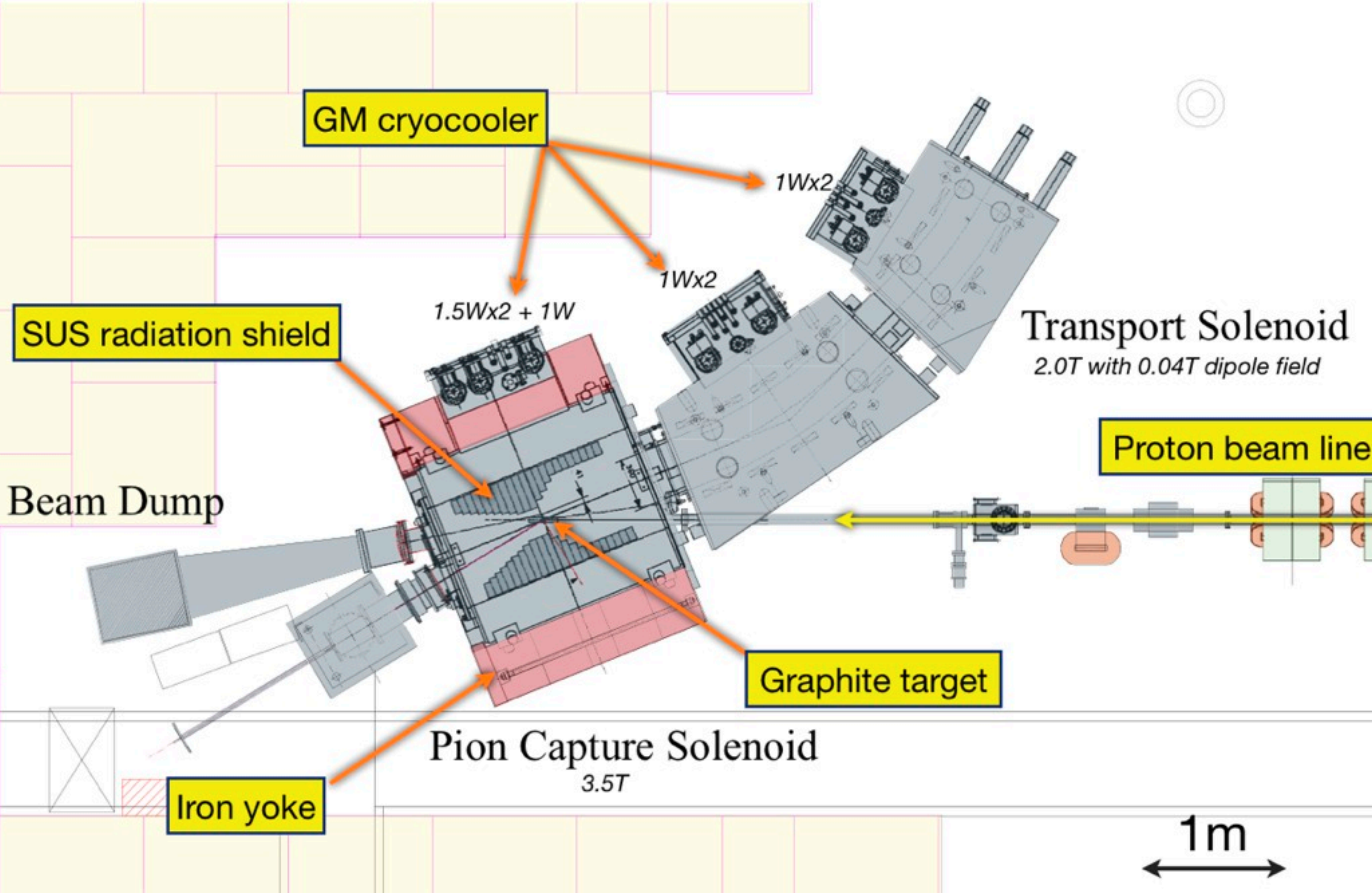
Construction Status and Schedule

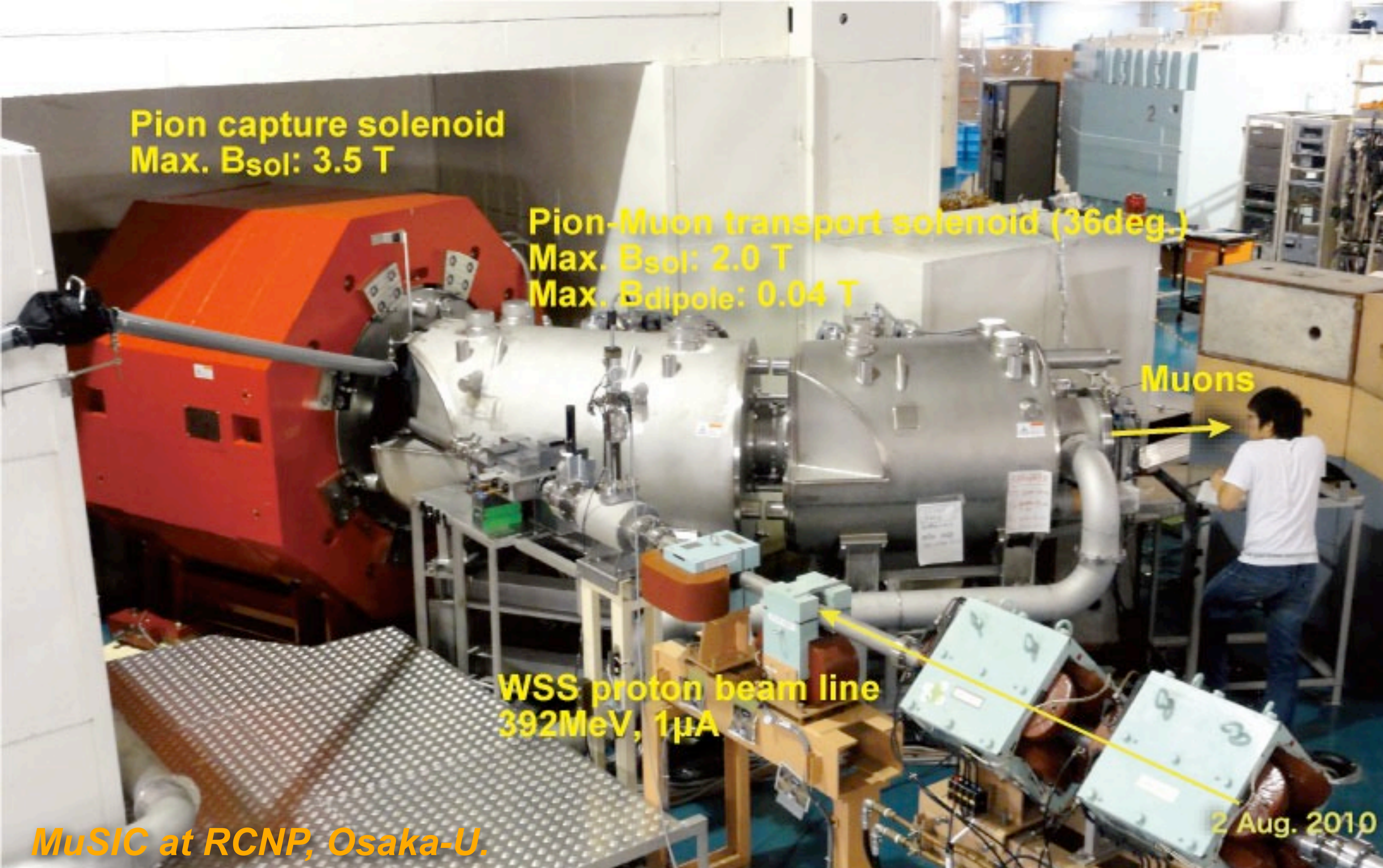
The construction has started at 2009, and will be finished in 5 years.



* The schedule depends on the budget situation.

MuSIC in 2010





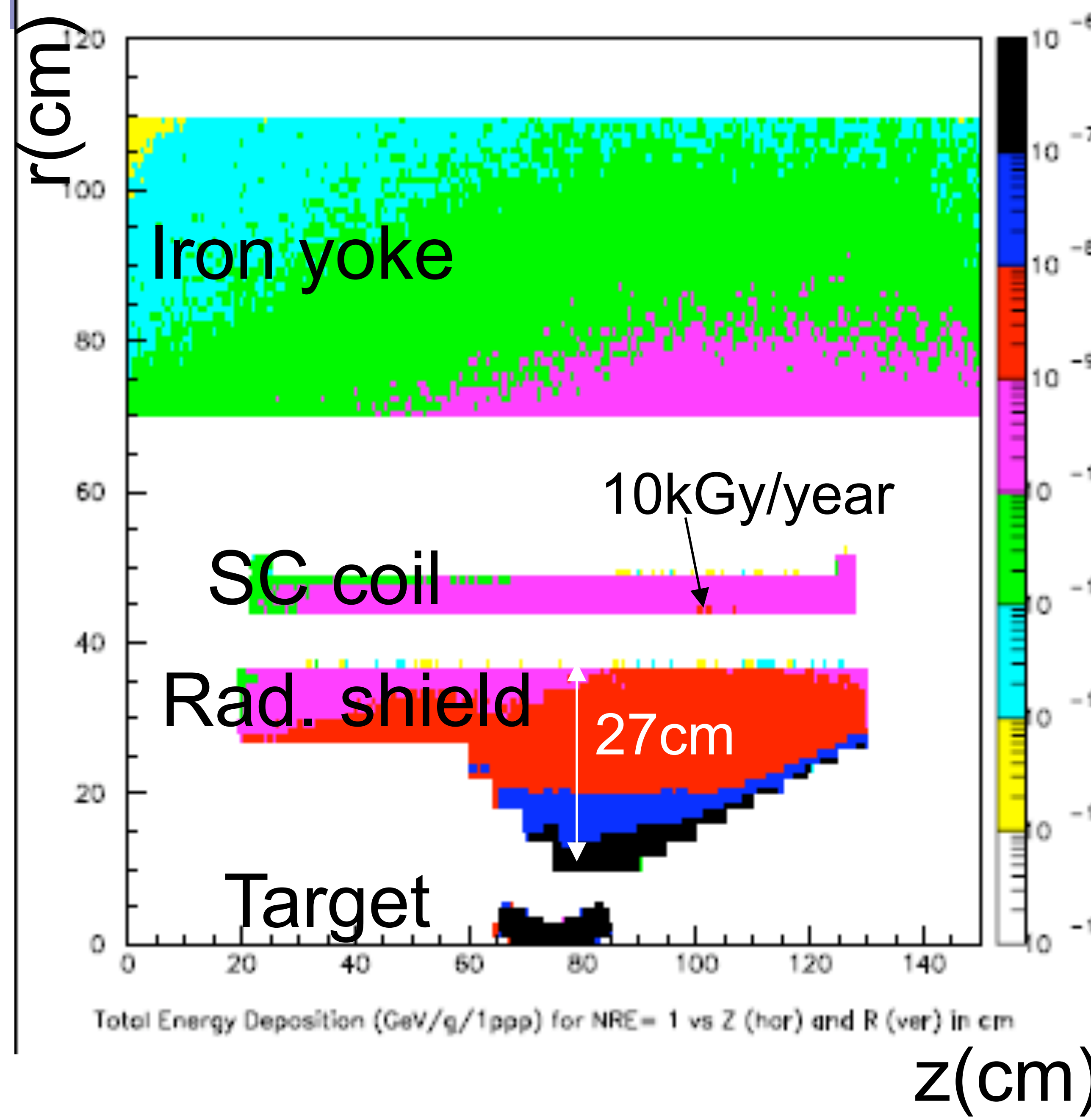
The 1st beam test has been performed at 29-30 July, 2010.
The 2nd beam test will be in January 2011.

Requirements to the superconducting solenoids

- Strong magnetic field on the pion production target
  - Trap pions in 3.5 T
    - Superconducting coils surrounding the target
- Long solenoid transport channel with a big aperture
  - Pions decay out and muons transported in 2T solenoid
  - ~10m long
  - 360mm dia. bore
  - Correction dipole field for momentum and charge selection
- LHe free refrigeration
  - Conduction cooling by GM cryocoolers
    - Heat deposit on the coils < 1W
    - Dose < 1MGy
      - for insulator, glue ...
    - Neutron flux < 10^{20}n/m^2
      - avoid degradation of the stabilizer of SC wires

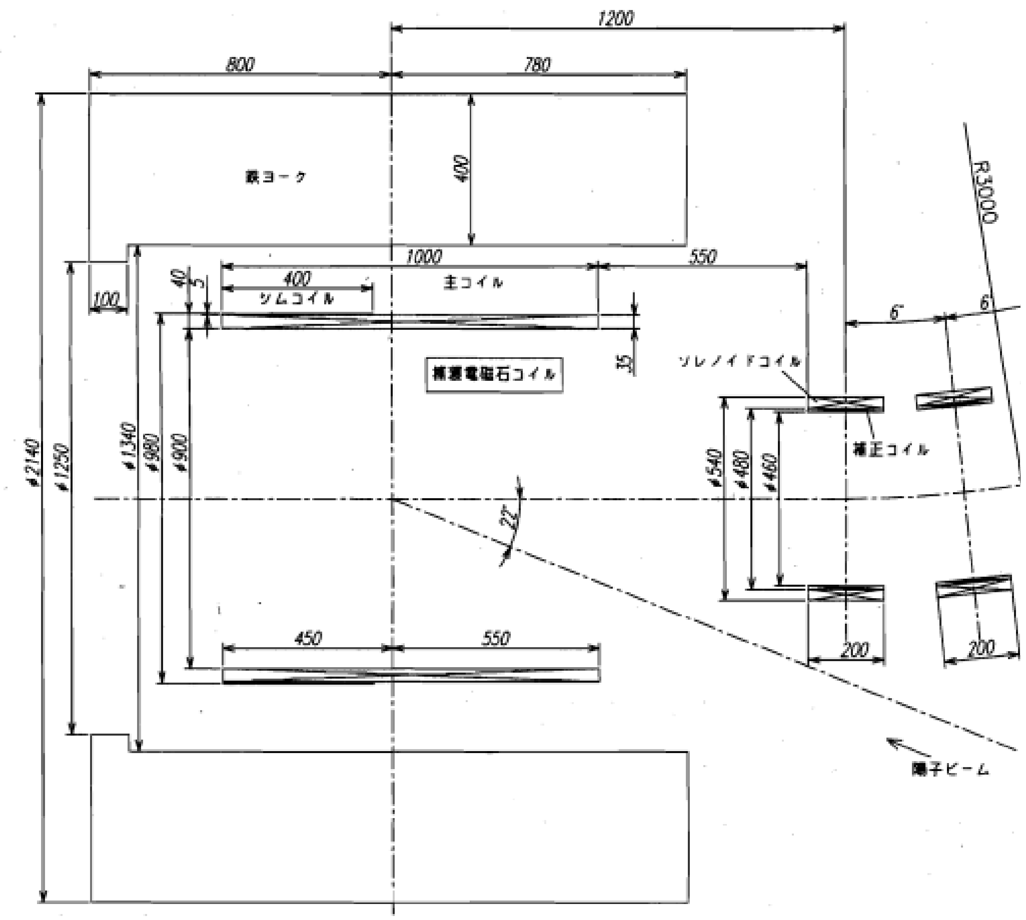
Pion capture solenoid: radiation issue

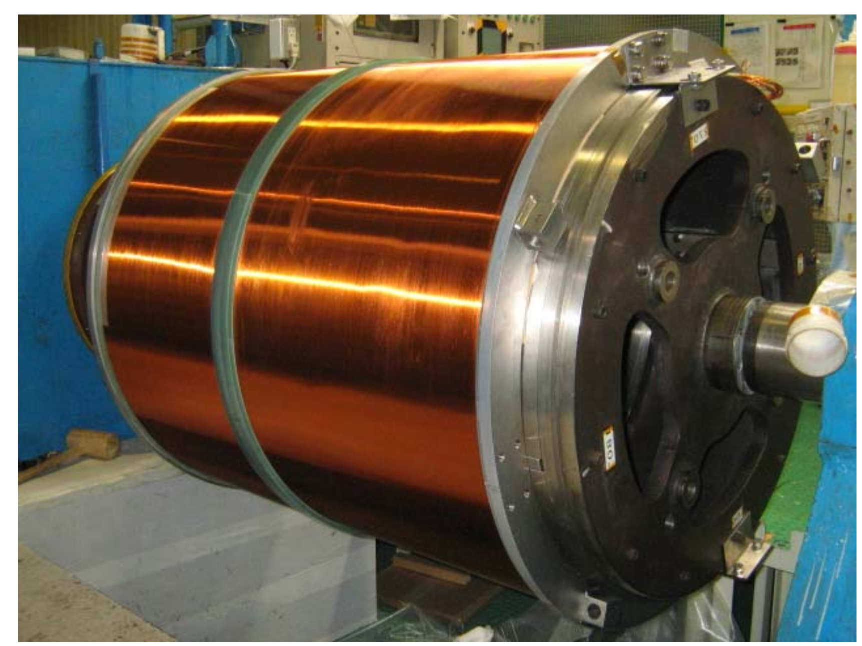
- Radiation shields (27cm thick stainless steels) are installed b/w the target and the coils.
- MC simulation by MARS (M.Yoshida)
  - Heat deposit: 0.6W
    - 0.4W in the coils(~1ton)
    - 0.2W in the coil supports
  - Dose on the coils < 10kGy/year
  - Heat load
    - 100W on the target
    - 50W on the rad. shields
  - Neutron flux: 5×10^{18}n/m^2/year
    - no degradation is expected



Pion capture solenoid: parameters

Conductor	Cu-stabilized NbTi
Cable diameter	ϕ1.2mm
Cu/NbTi ratio	4
RRR (R293K/R10K at 0T)	230-300
Operation current	145A
Max field on axis	3.5T
Bore	ϕ900mm
Length	1000mm
Inductance	400H
Stored energy	5MJ
Quench back heater Cu wire	1.2mm dia. ~1Ω@4K



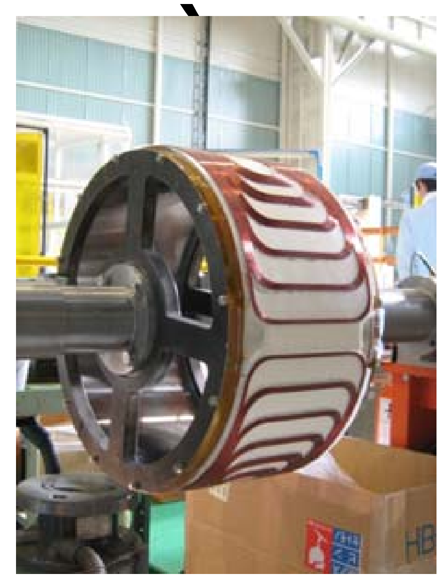


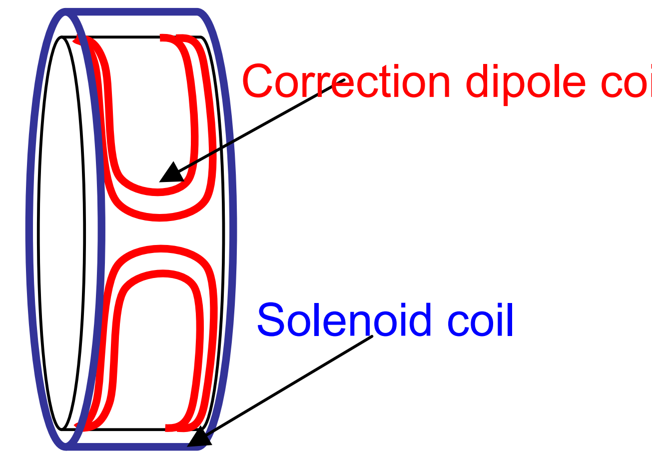
Transport solenoids

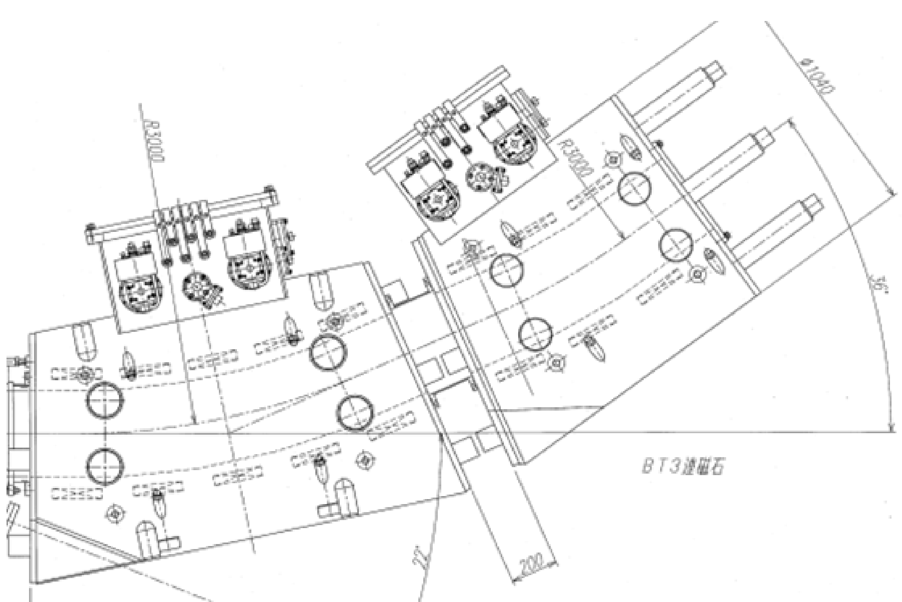
The world first working beam line which adopts cosθ winding dipole coils

Solenoid coils

Operation current	145A
Field on axis	2T
Bore	ϕ480mm
Length	200mm x8Coils
Inductance	124H
Stored energy	1.4MJ
Quench back heater Cu wire	1.3mm dia. ~0.05Ω/Coil@4K







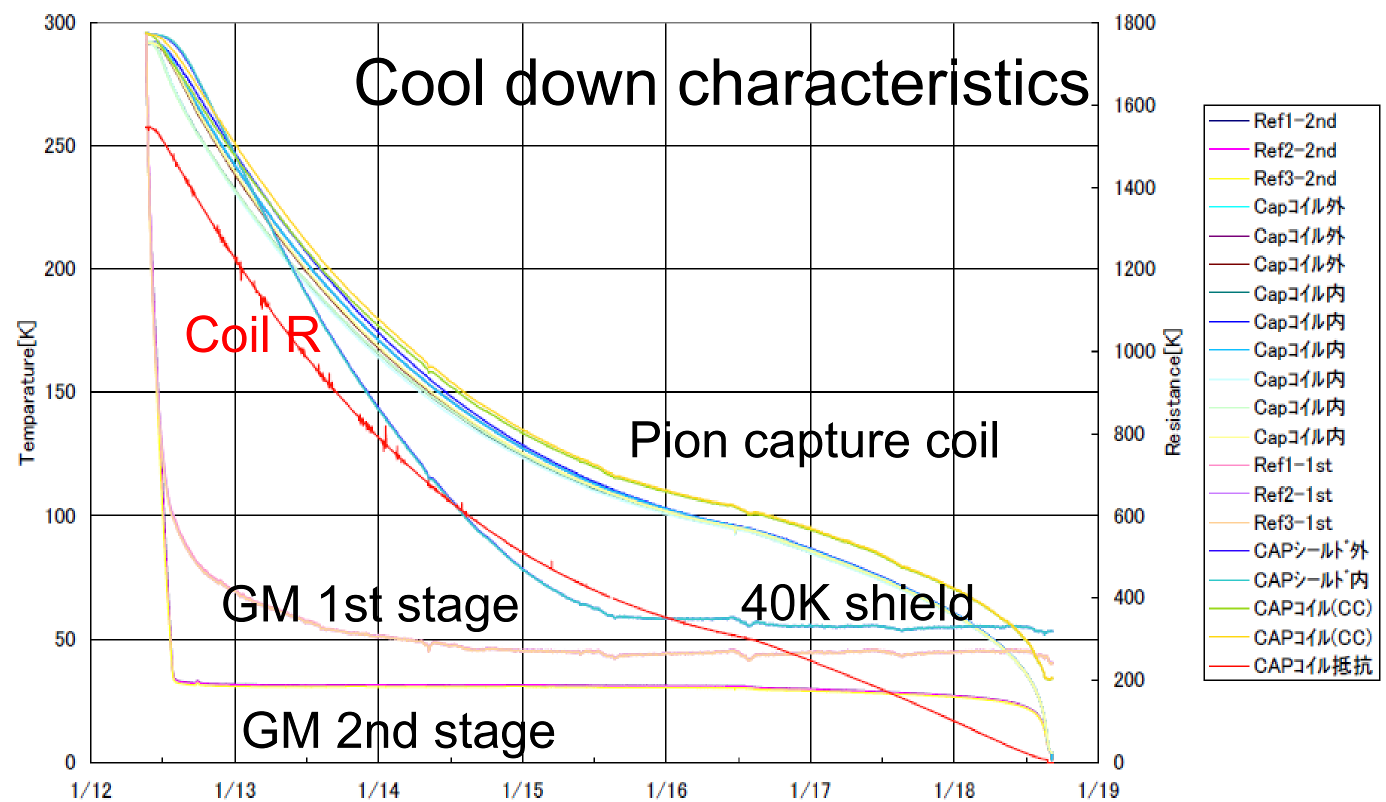
Correction dipole coils

Coil layout	Saddle shape dipole
	6 layers
	528 turns (1 set)
Current	115A (Bipolar)
Field	0.04T
Aperture	ϕ460mm
Length	200mm
Inductance	0.04H/Coil
Stored Energy	280J/Coil

Refrigeration

- Conduction cooling by GM cryocoolers
- Can be cooled down within 1 week with pre-cooling by LN2

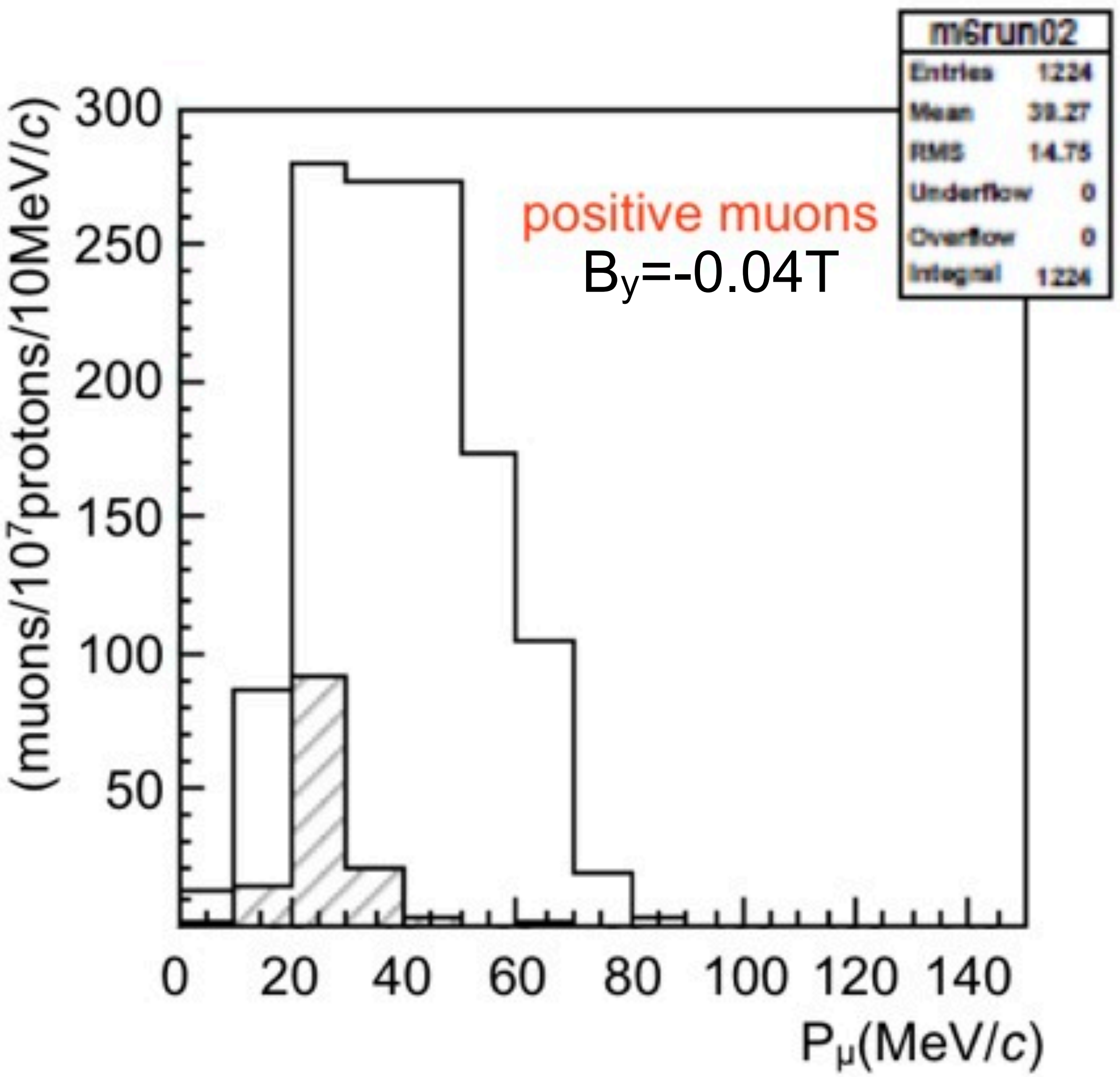
- Pion capture solenoid
  - 4K: 1W+nucl. heating 0.6W
  - 300K→40K: 50W
    - GM 1st stage
  - 3 x GM cryocoler
    - 1.5Wx2+1Wx1 @4K
    - 45Wx2+44W @40K
- Transport solenoid
  - 4K: 0.8W
  - 300K→40K : 50W
    - GM 1st stage
  - 2 x Cryocoolers on each cryostat (BT5,BT3)
    - 1Wx2 @4K
    - 44Wx2 @40K

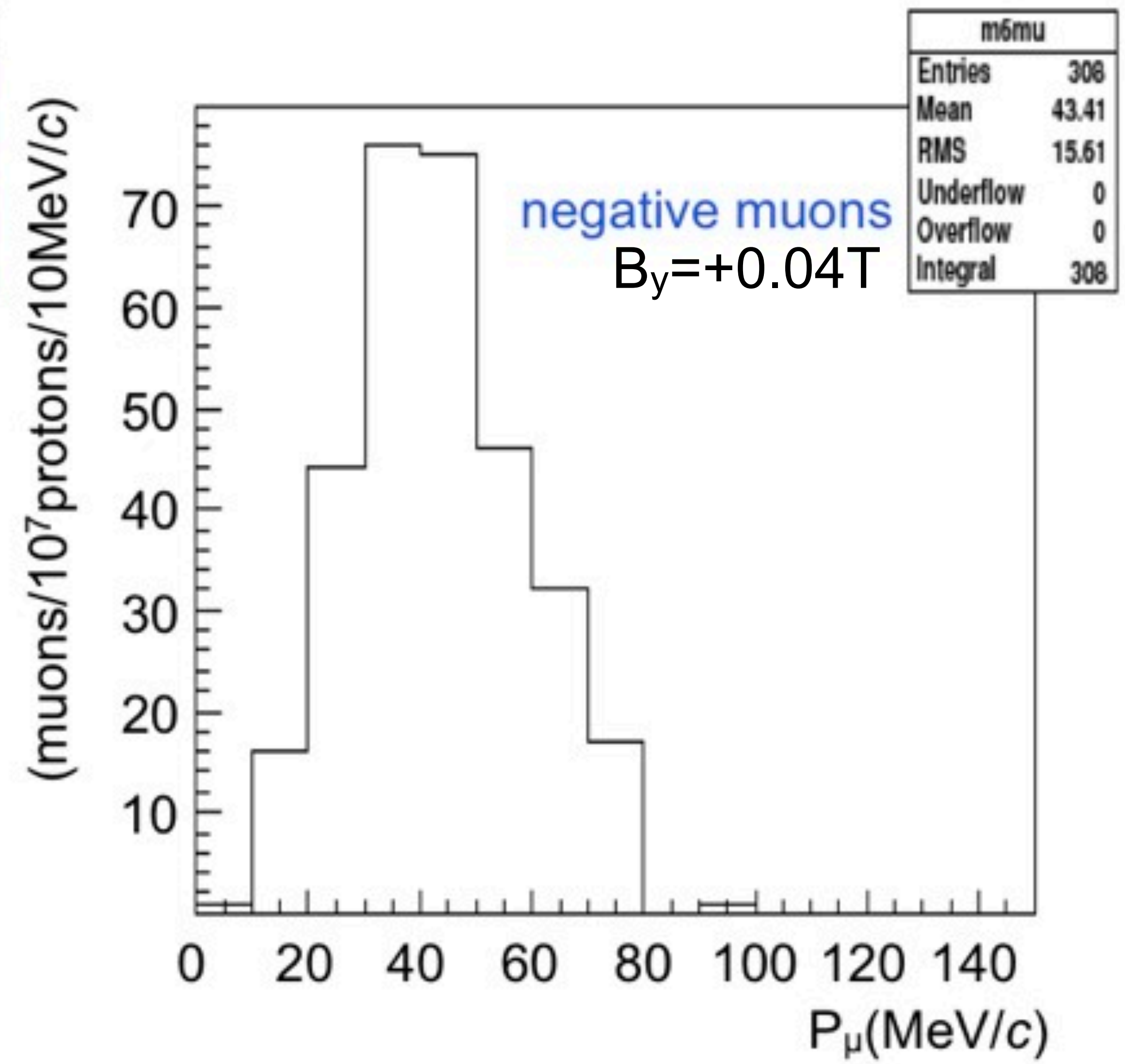


- Achievable temperature
  - Pion capture solenoid : 3.7K
  - Transport solenoids : 4.2K-4.5K(BT3), 4.5K-5.8K(BT5)

Simulation results for B_y=±0.04T

This is just an example. We need to optimize the beam characteristic for various experiments using collimators, DC separators, and so on.





$8\times10^8\ \mu^+$/sec
for 400MeV, 1 μA proton beam

$2\times10^8\ \mu^-$/sec
for 400MeV, 1 μA proton beam

- At the end of the transport solenoid (180 deg.)
- Charge of the muons can be selected by changing the direction of the dipole field.

Charged Particle Trajectory in Curved Solenoids

- A center of helical trajectory of charged particles in a curved solenoidal field is drifted by

$$D = \frac{p}{qB}\theta_{bend}\frac{1}{2}\left(\cos\theta + \frac{1}{\cos\theta}\right)$$

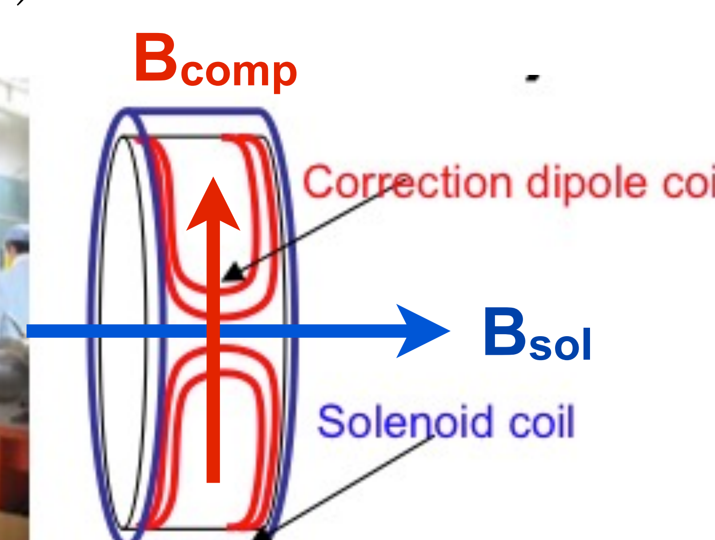
D : drift distance
B : Solenoid field
θ_{bend} *: Bending angle of the solenoid channel*
p : Momentum of the particle
q : Charge of the particle
θ *: atan(*P_T/P_L*)*

- This effect can be used for charge and momentum selection.

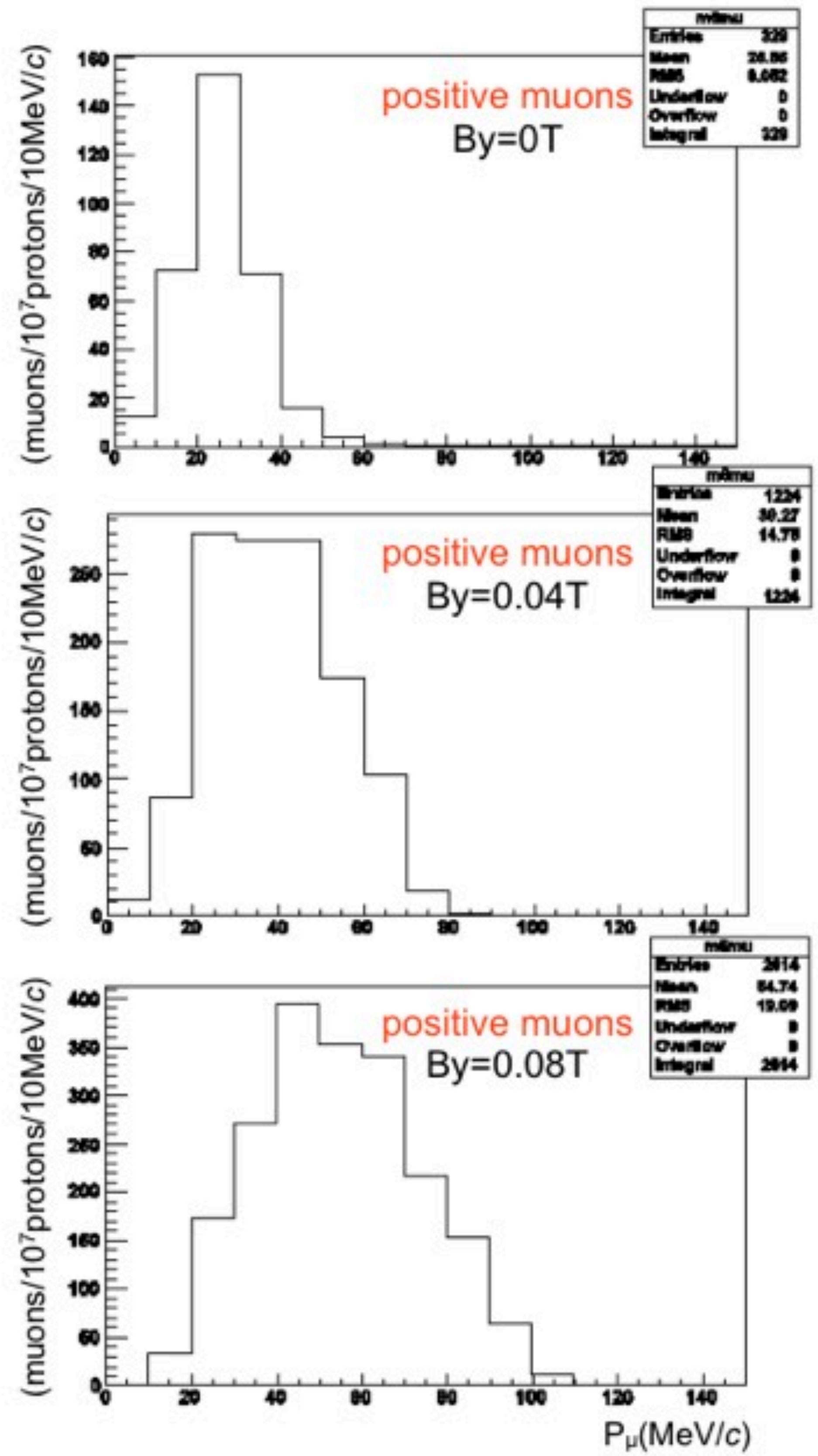
- This drift can be compensated by an auxiliary dipole field parallel to the drift direction given by

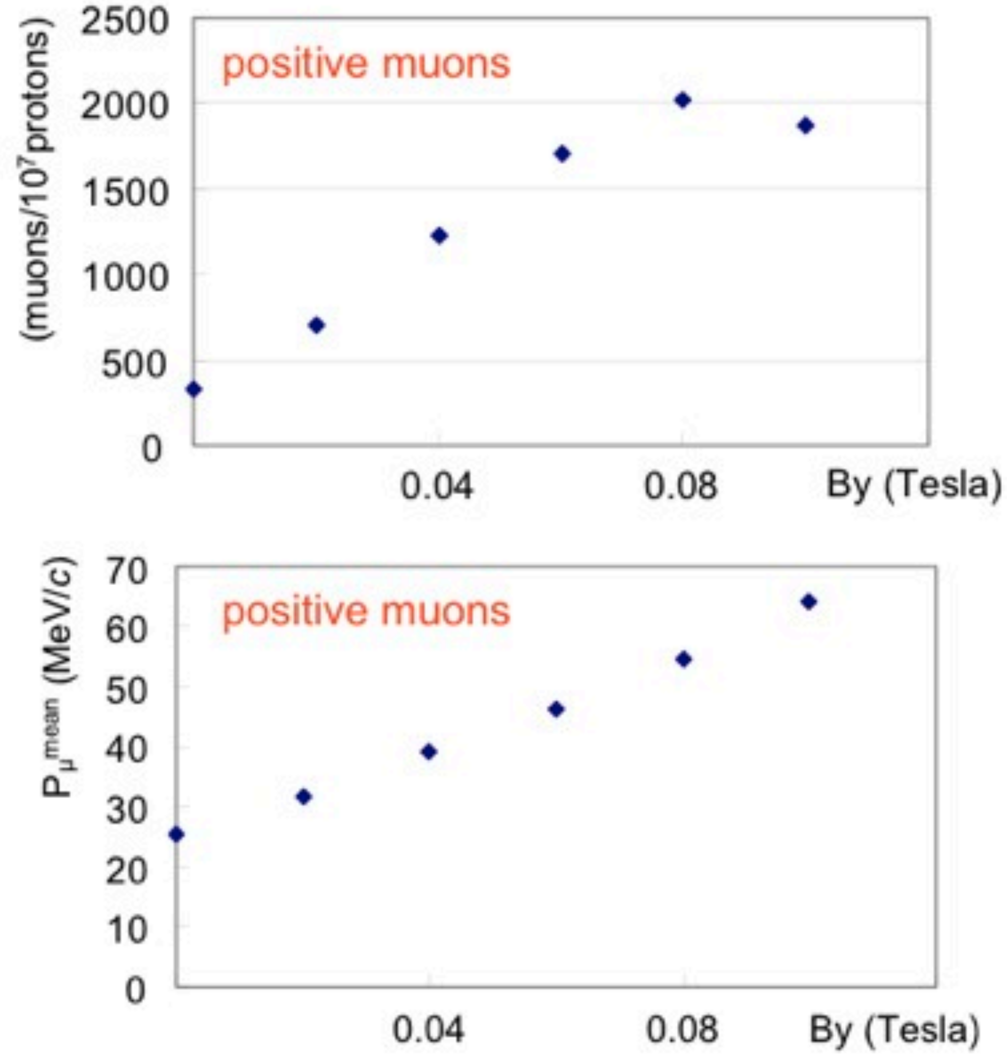
$$B_{comp} = \frac{p}{qr}\frac{1}{2}\left(\cos\theta + \frac{1}{\cos\theta}\right)$$

p : Momentum of the particle
q : Charge of the particle
r : Major radius of the solenoid
θ *: atan(*P_T/P_L*)*



Momentum vs Dipole field B_y

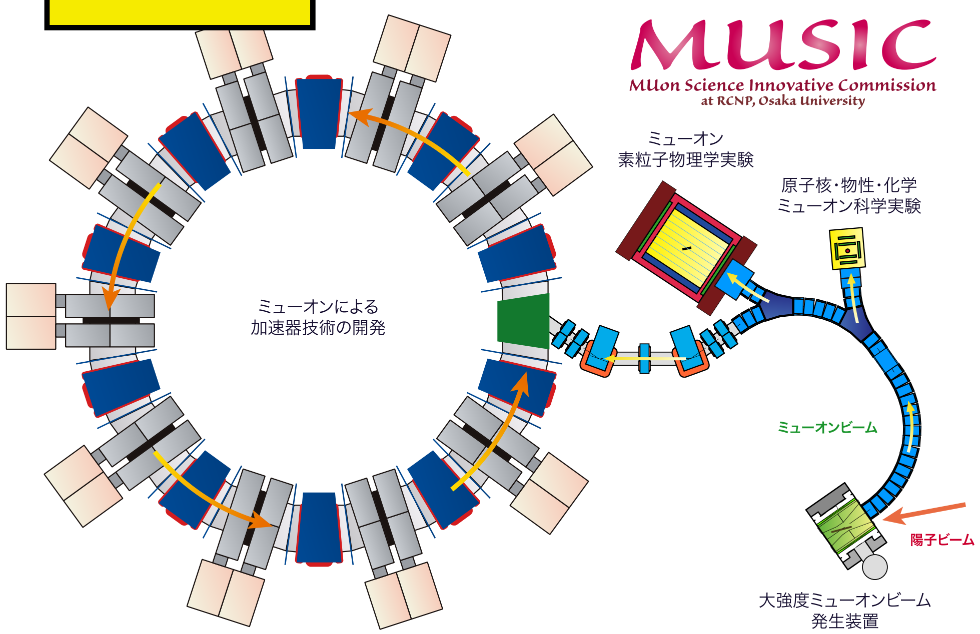




Wishful Staging Scenario

2009-2016

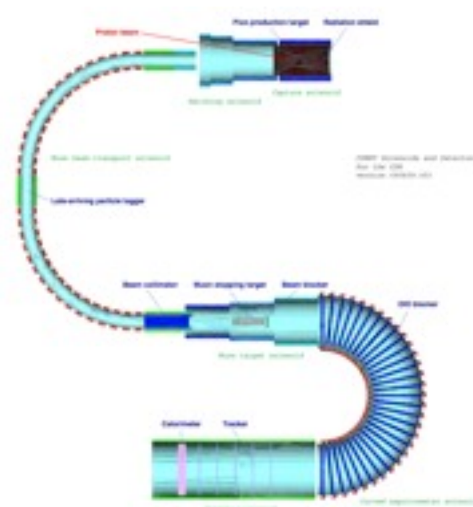
MuSIC



Proton beam:0.4kW
DC muon:10^8/s

2017-

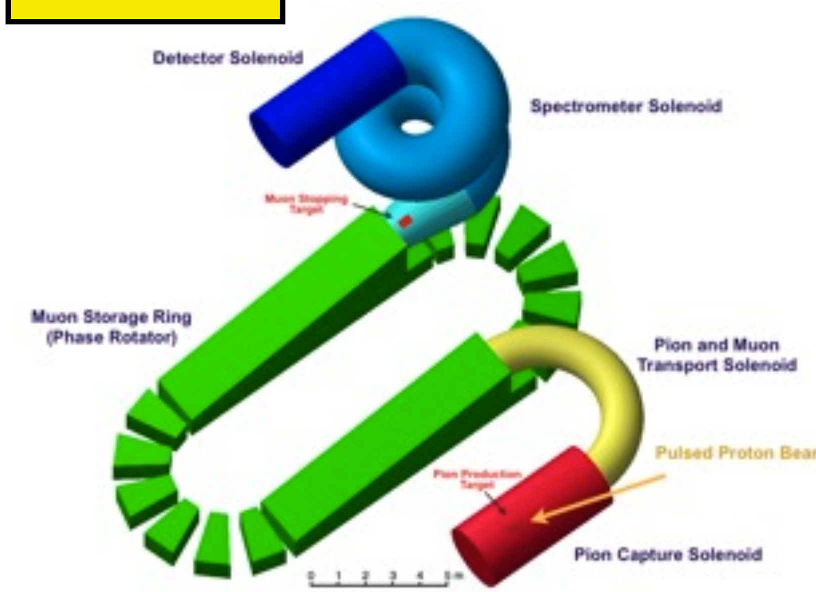
COMET/Mu2e



Proton beam:56kW
pulsed muon:10^{11}/s

2020?

PRISM



Proton beam:1000-4000kW
pulsed muon:10^{12-13}/s

μ-eee search
Solenoid R&D → **μ-e conv. search** → **The ultimate μ-e conv. study**
Accelerator R&D → **The ultimate μ-e conv. study**

↓

2019?? **Neutrino factory**
Muon collider

pulsed muon:10^{13-14}/s

MuSIC is a very important step
for the future muon programs.

Relationship among the programs

towards the ultimate μ-e conversion study

COMET/Mu2E 2016~?
S.E.S.<10^{-16},
for early realization

Test results of π capture and transport solenoid

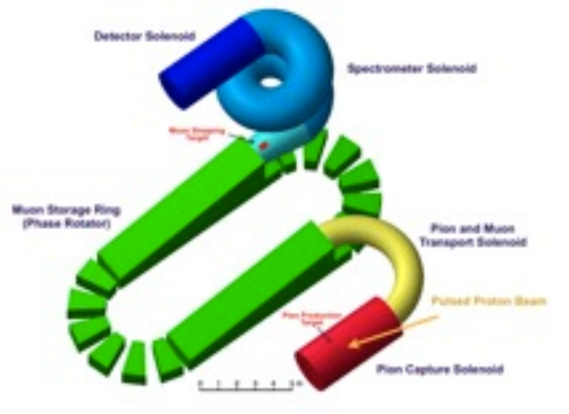
upgrade

PRISM FFAG
The ultimate μ-e Study,
S.E.S.<10^{-18},
Target dependence

FFAG **MuSIC** 2010~
super-conducting solenoid,
μ phase rotation,
tests of new ideas

Solenoid, backgrounds, detectors

New design and results of feasibility studies



FFAG magnets, RF system

FFAG design

Test results of new ideas with muon beam

PRISM-FFAG R&D ~2009 FFAG
large FFAG magnets,
high field grad. RF system,
phase rotation demo. α

Study results

PRISM-TF 2009~ FFAG
Reconsideration of PRISM design,
lattice, matching, inj./ext., kicker ...

Technological Synergy

FFAG **Neutrino Factory and Muon Collider R&Ds**

Study results

FFAG **Neutrino Factory/ Muon Collider**

Physics Beyond the SM

Summary

- Search for the charged lepton flavor violation (cLFV), in particular μ-e conversion search, can be a promising probe to the TeV-scale physics in a Neutrino Factory era. We can draw the staging scenario from muon factory to neutrino factory, we need also to consider the possibilities for the co-existence of muon and neutrino programs at the Neutrino Factory facility.
- Neutrino factory and μ-e conversion experiments have a lot of common issues. Therefore, a strong relation ship between neutrino factory groups and muon groups is important to make synergies. PRISM-TF is a very nice example of the good relationship.
- R&D programs for the μ-e conversion are underway. PRISM-FFAG, COMET, PRISM-TF, and MuSIC. Many people from the neutrino factory study join the programs.
- PRISM-TF will make a report on the new PRISM based μ-e conversion experiment in a year. Dellp discussion will be made in comming project-X workshop om muon physics.
- **You are also welcome to join us!!!**