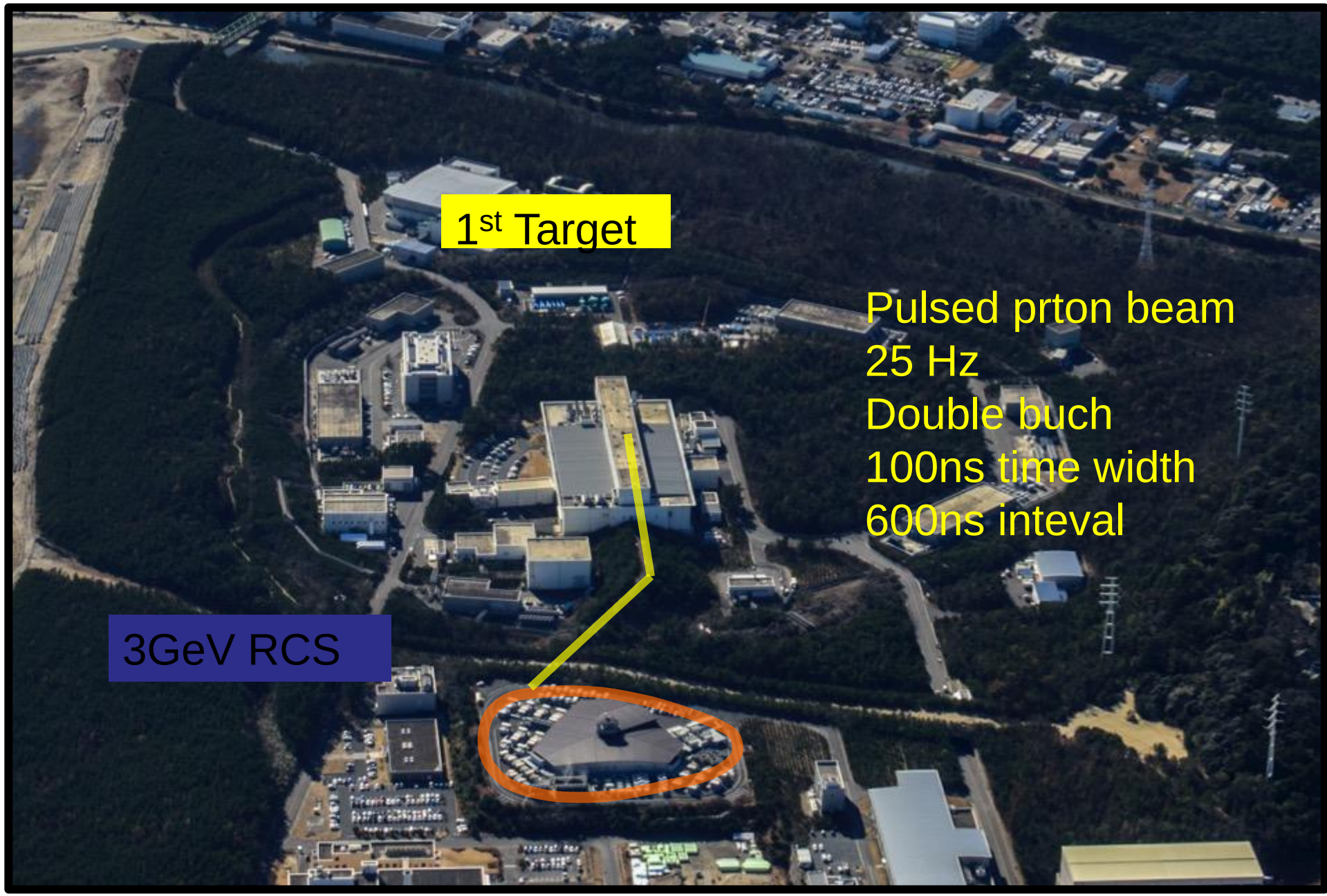
Status of J-PARC MLF MUSE
(MUon Science Establishment)

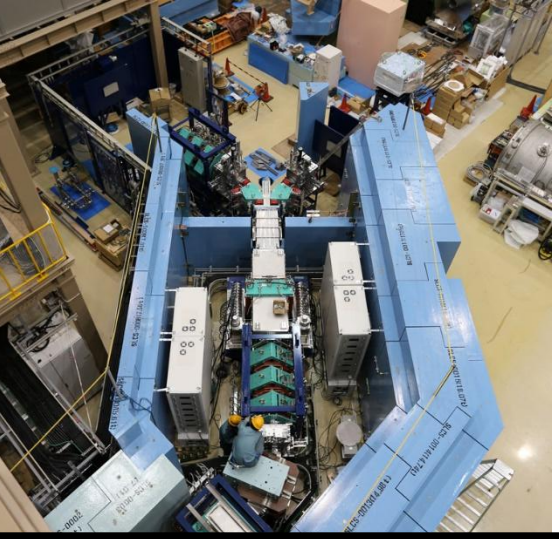
J-PARC MLF Muon Section/KEK IMSS

K Shimomura

Contents

- **MUSE layout**
- **D-Line**
- **U-Line → Ultra slow muon beamline**
- **S-LIne**
- **H-Line**
- **2nd target station**

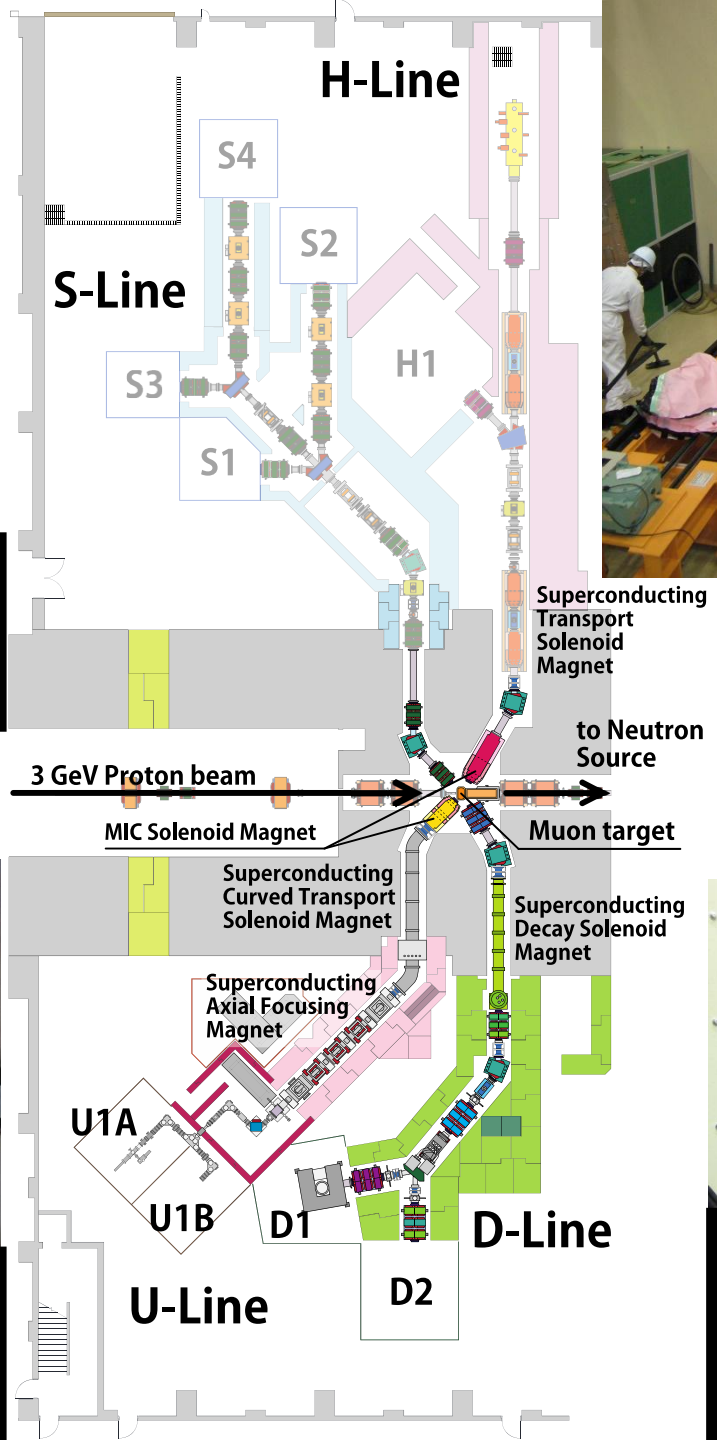

1st Target
Pulsed prton beam
25 Hz
Double buch
100ns time width
600ns inteval
3GeV RCS

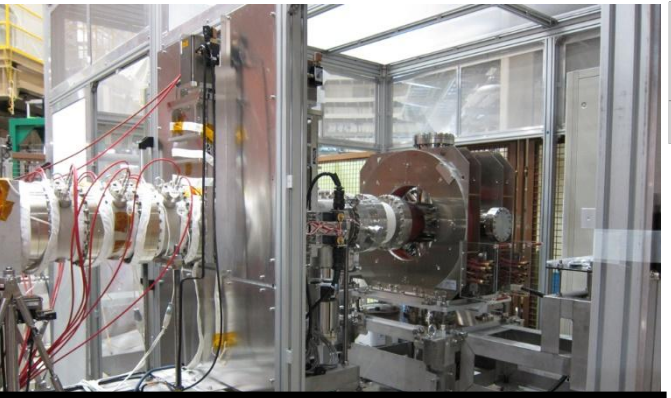


S-Line
Surface μ^+(30 MeV/c) S1 area is ready to extract μ^+ beam.
Hopefully first muon beam is coming soon!

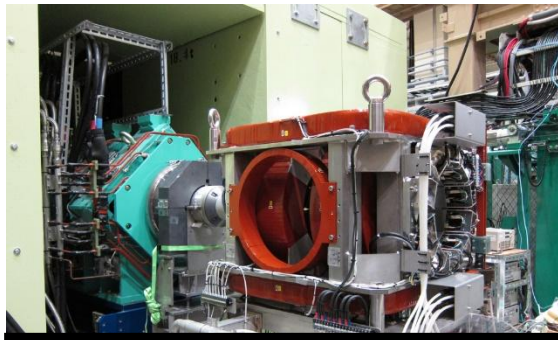
H-Line
Surface μ^+ For Mu-HF, g-2/EDM
e^- up to 120 MeV/c For DeeMe
μ^- up to 120 MeV/c For μCF
Muon Microscopy
Electromagnetic coils in H-Line tunnel were installed.

MUSE Facility @MLF





U-Line
Ultra Slow μ^+ (0.05-60keV)
First Ultra Slow muon beam commissioning will be performed soon.



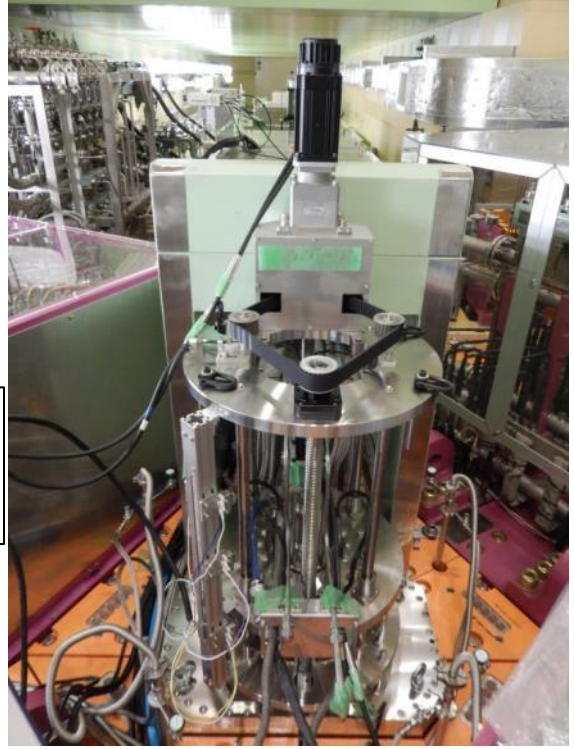
D-Line
Surface μ^+(30 MeV/c)
Decay μ^+/μ^-(5-120 MeV/c)
Trouble in power supply of septum magnet was occurred.

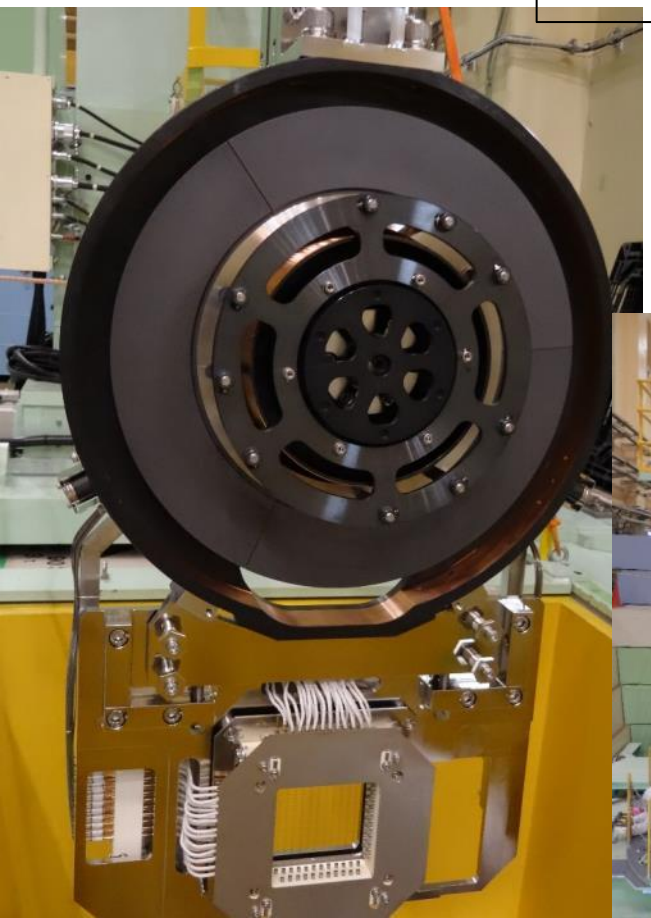
Rotating Graphite Target

Rotating Target was successfully installed on 16th September of 2014.

Now in operation without any trouble!

- Vacuum pressure 10^{-5} Pa
- Control system Confirmed

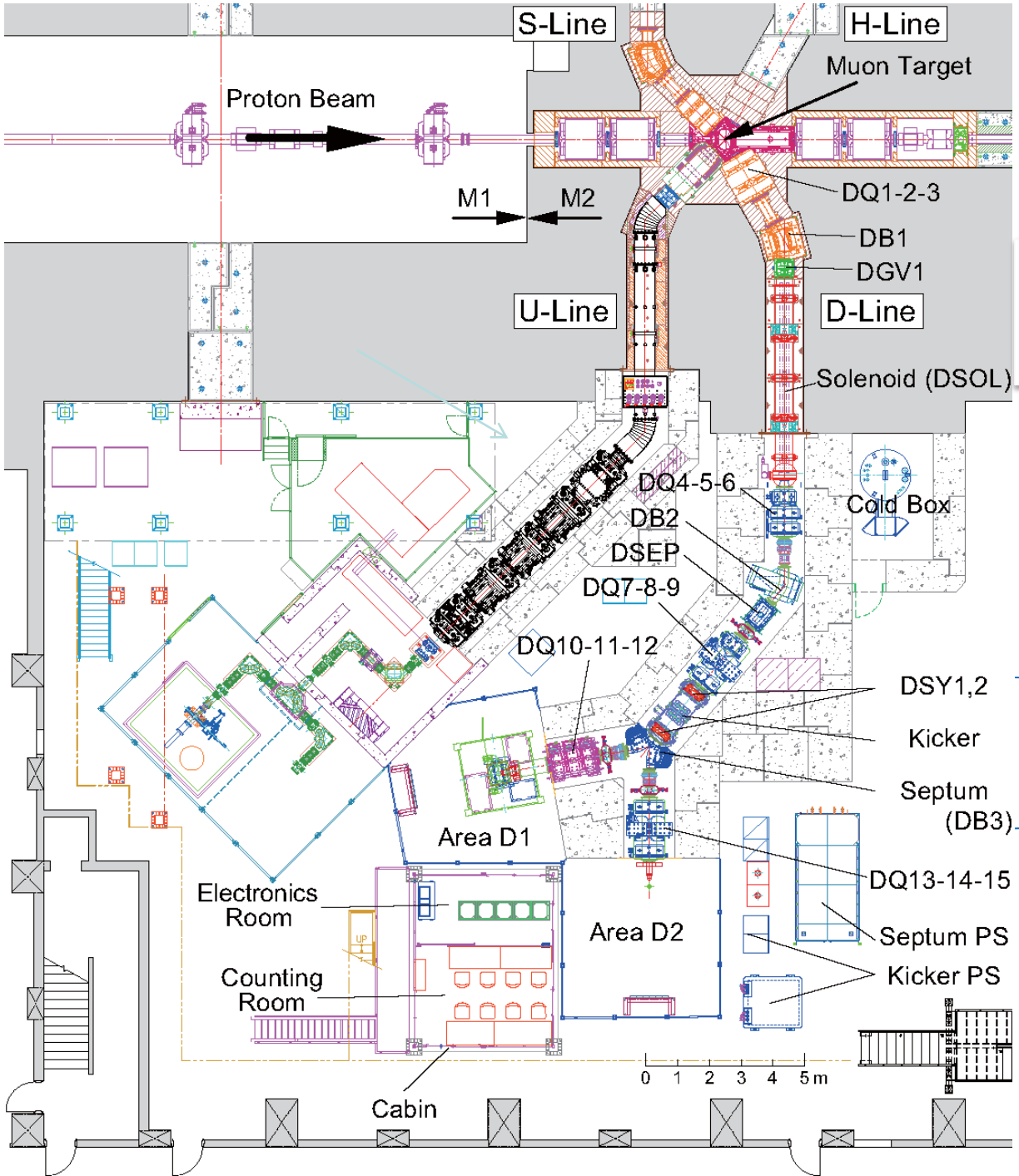




Makimura et al.

Muon Beam Line, where either Surface Muon or Decay Muon can be extracted!

@D-Line



D-line

Multi purpose muon beam line

Kicker System

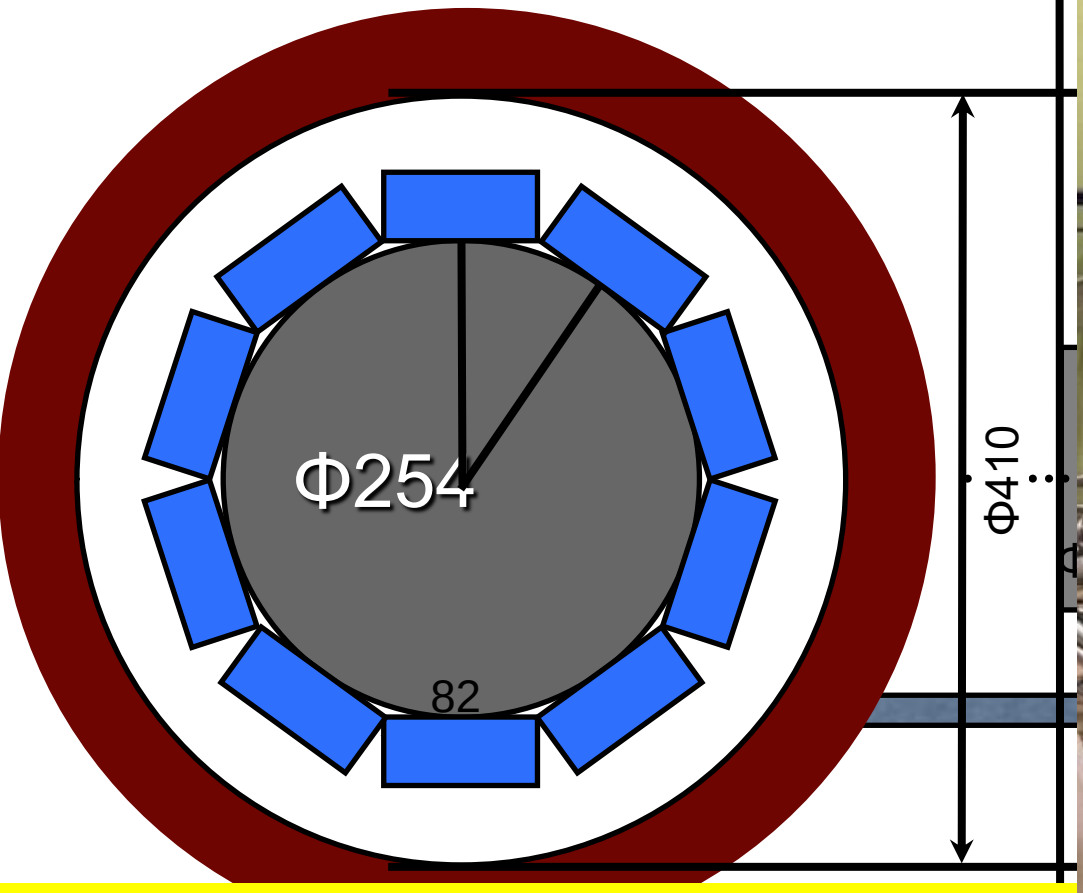
D1 Spectrometer

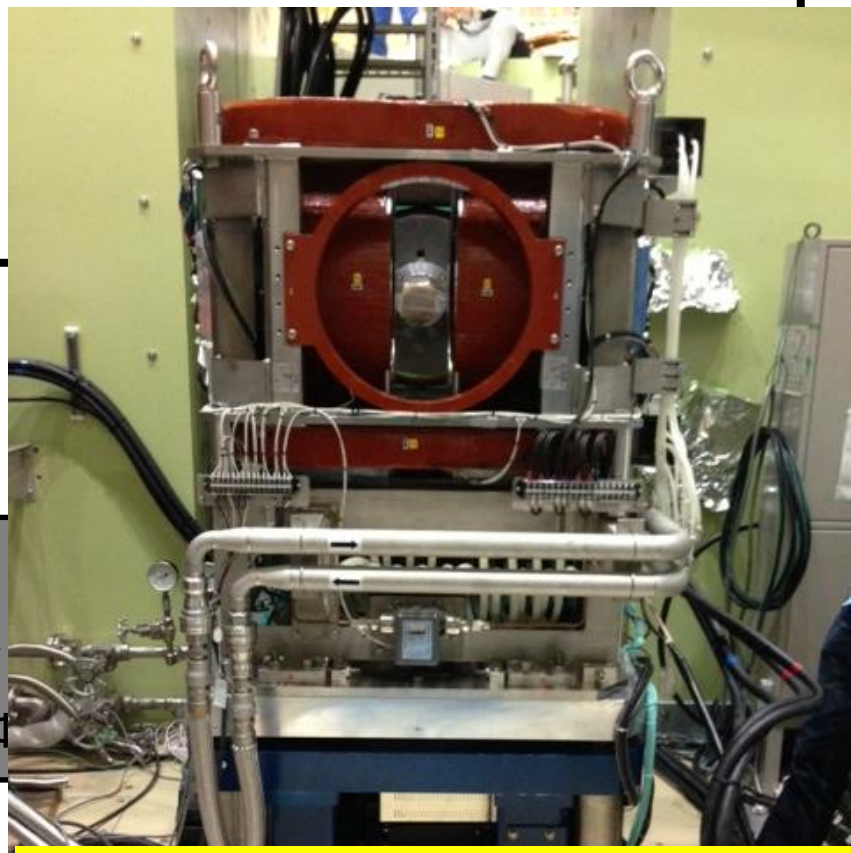
KALLIOPE
KEK Advanced Linear and Logic board
Integrated Optical detector for Position and Electrons

magnet inner bore : Φ410
magnet gap : 135mm
vacuum duct diameter : Φ254→10 sets/round
32ch × 40 = 1280channels
Solid angle total: (0.523+0.646) × 10 × 2=23.4%

LF up to 4kG
GAP 135mm
Can be inserted up to Φ254

Kojima et al.





200 M of coincidence e^+ events/h for 15 x 15 mm² with a 20 mm collimator.

Solid Angle 23.4 %/7% ~ 3.3 times compared with DΩ1

D1-μSRSpectrometer

K. M. Kojima *et al*, J. Phys: Conf. Ser.,

諸元	DΩ-1 J-PARC	New D1 J-PARC	ARGUS RIKEN-RAL	CHRONUS RIKEN-RAL
Field (kG)	1.5	4	4	4
Solid Angle Channels	8%/128pair PMT	23%/640pair MPPC	25%/192 PMT	26%/606 MAPMT
Data Acquisition	20-40M/h for15x15mm	100-200M/h for15x15mm	40M/h for 25x25mm	86M/h for unknown size

データ収集レートが５～６倍

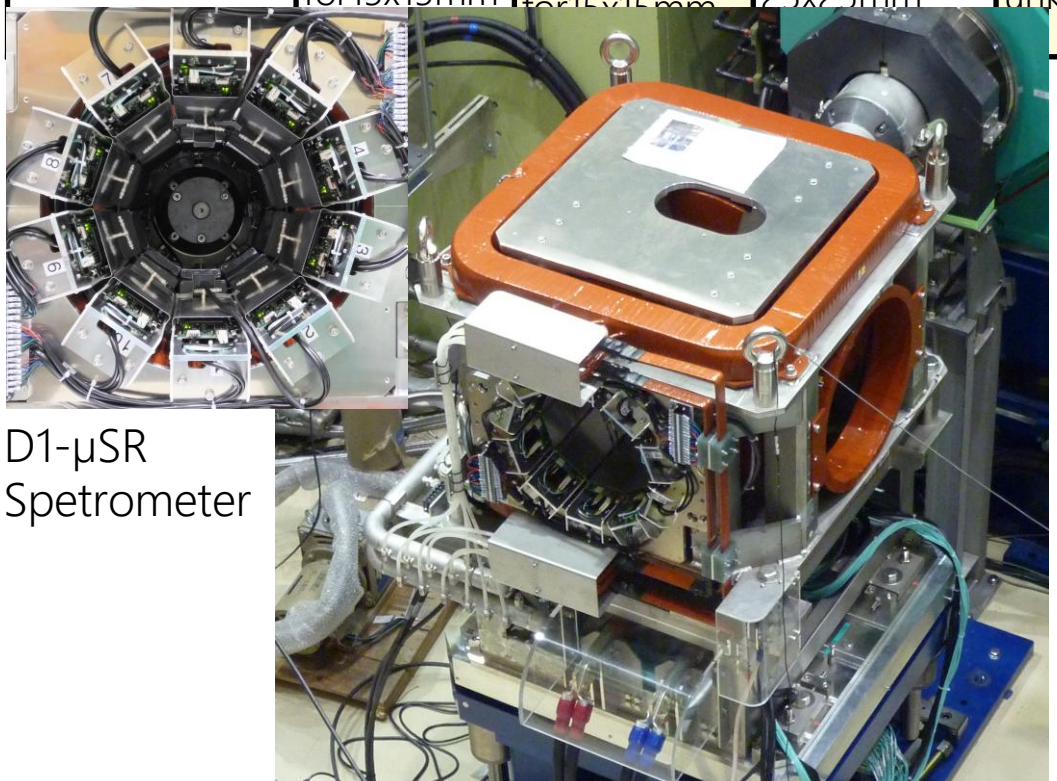
１測定３０分→５分

新たな問題

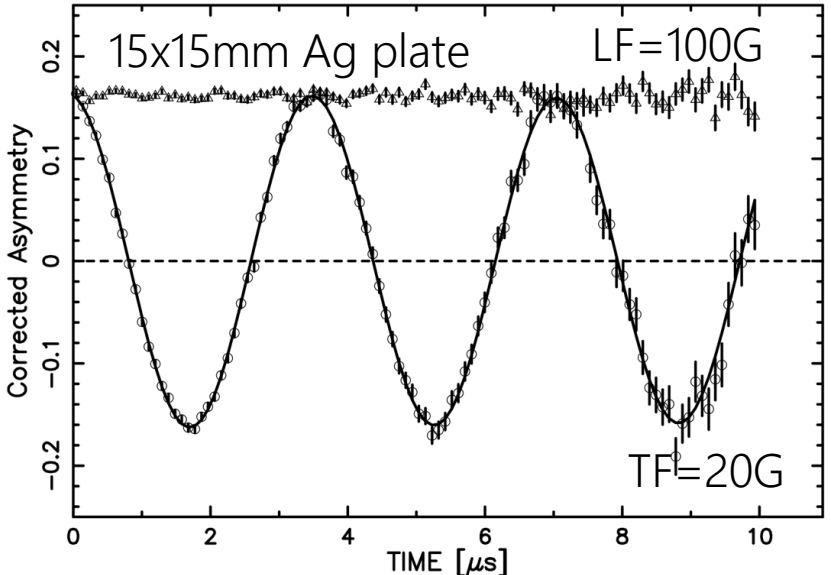
どう解析するか？

→自動解析？前人未到の領域

S1実験エリアに同じデザインの分光器を設置済み。2015年新年のビームコミッショニング待ち



D1-μSR Spetrometer



New Dilution Refrigerator for μSR at D1

For investigation of magnetic ground state, superconducting state or nove quantum phenomena, μSR experiment below 1K is quite important.

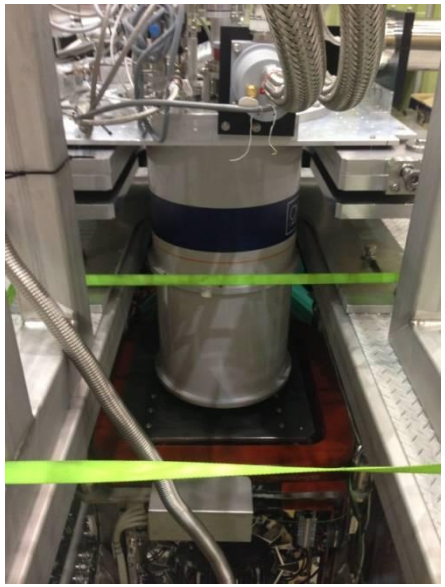
We have installed new dilution refrigerator at MUSE D1. Operation has been started from 2014B.

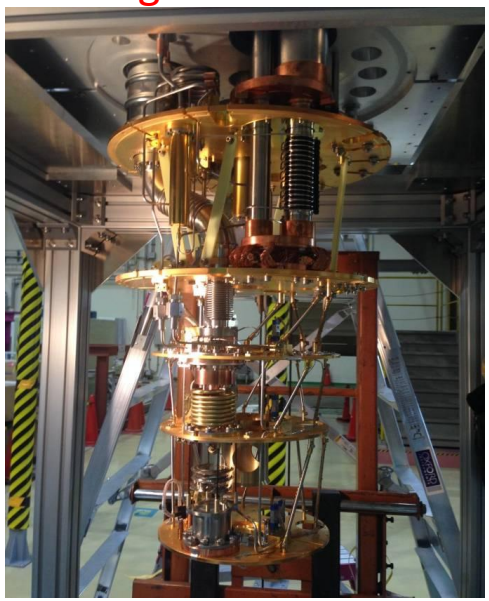
Features

Automatic cooling system →Cooling can be done within 1.5days without manpower.

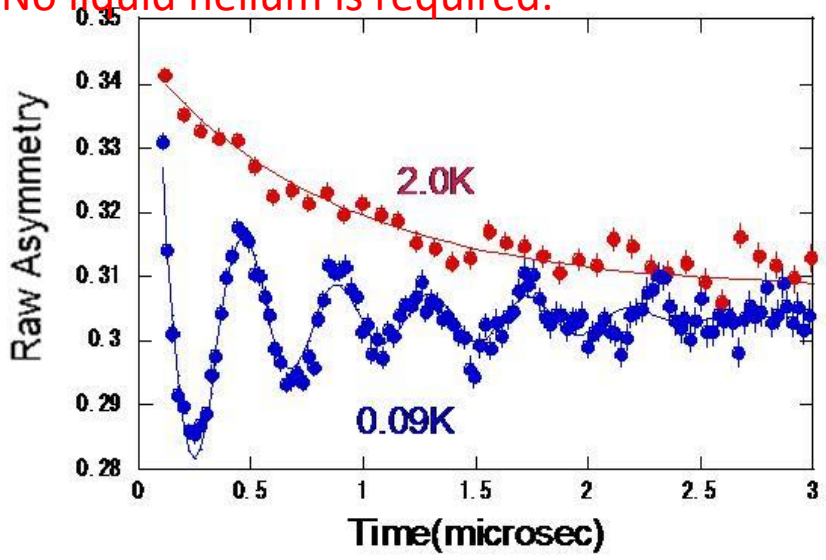
Top loading → Sample can be quickly changed.

Pulsetube refrigerator is used → No liquid helium is required.



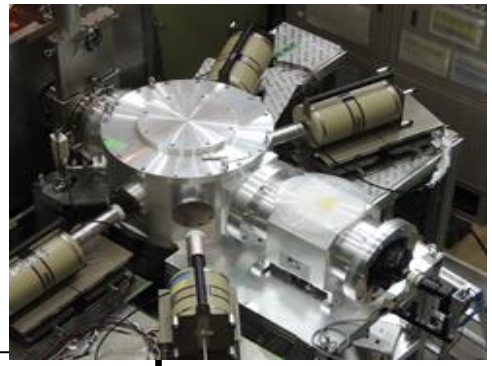


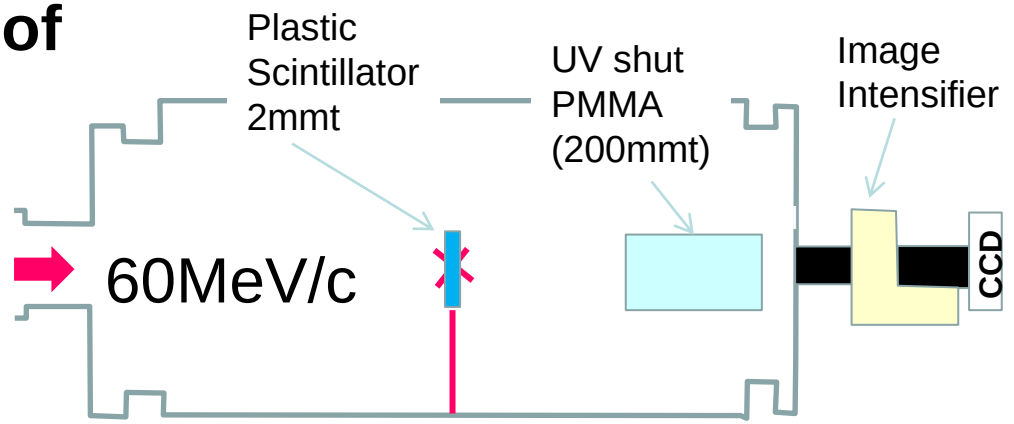
Dilution refrigerator installed on the top of D1 spectrometer

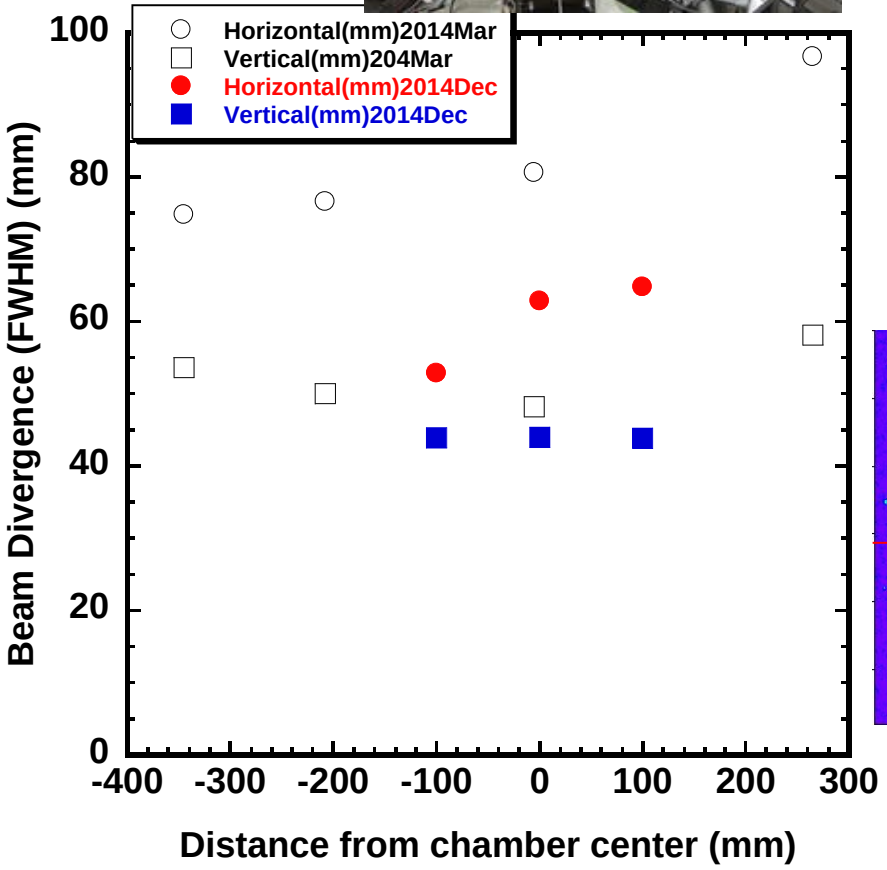


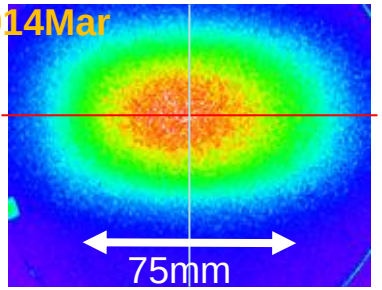
Example of the μSR measurement in the new dilution refrigerator.

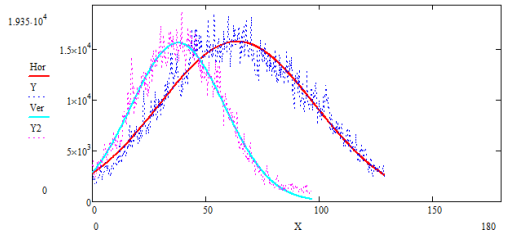
μ- Beam Focusing with use of Rotating Target!



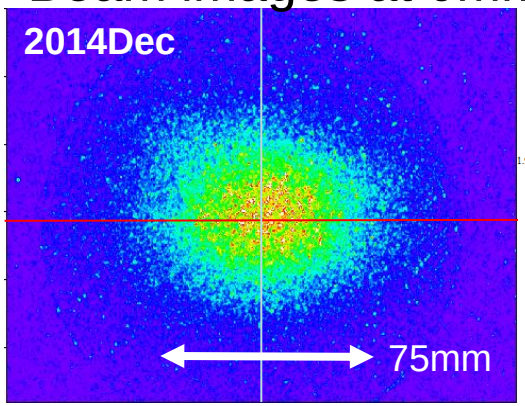




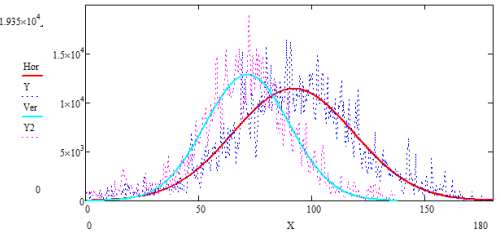




Beam images at 0mm



Fitting with Gaussian profiles



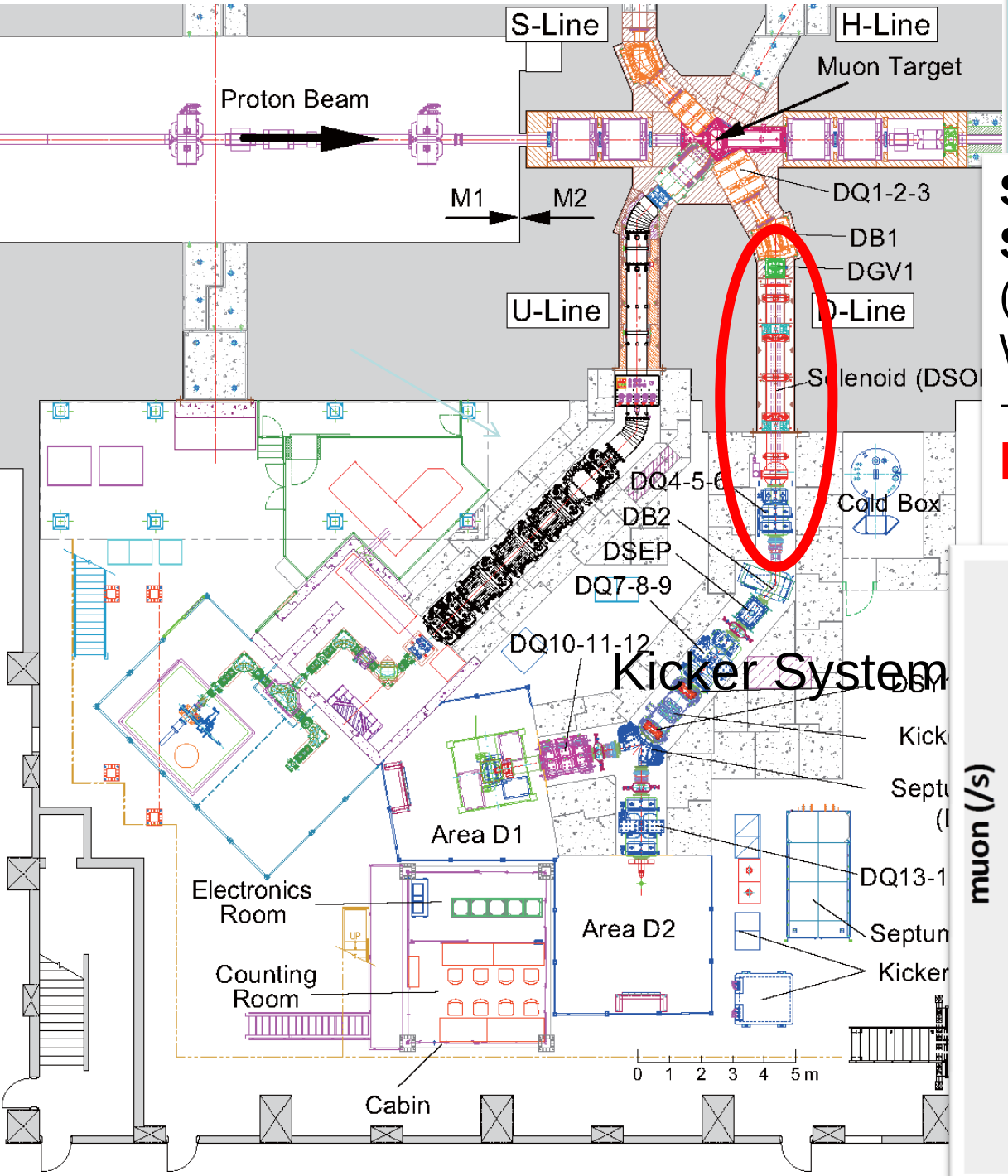
Narrower beam divergence has been obtained than before

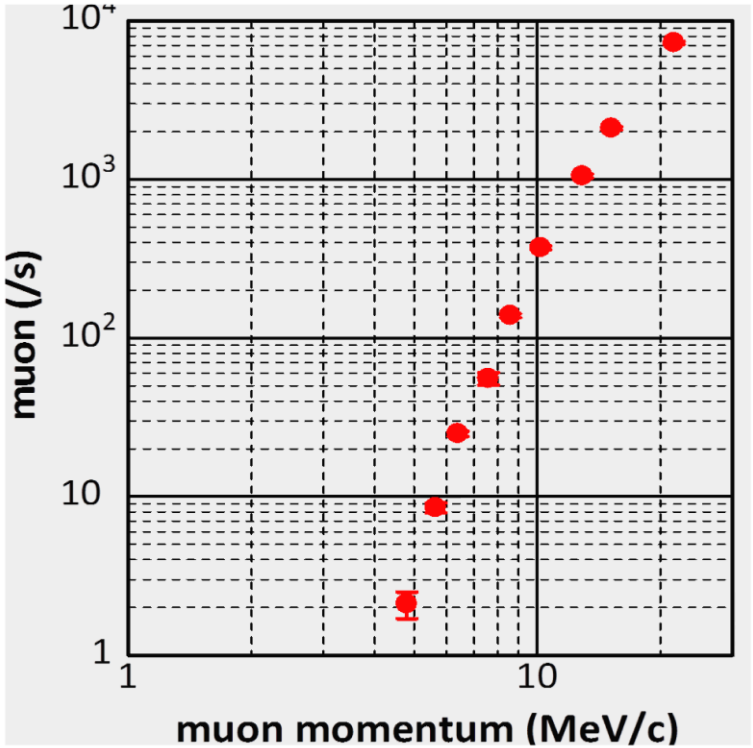
D-line upgrade

Funded!

Superconducting Decay Solenoid with Larger Bore
(12cm→24cm)
Warm Bore（No Window）
→ more low energy muons

More muons from 50keV to 100MeV





U-Line

Dedicated to Ultra Slow Muon

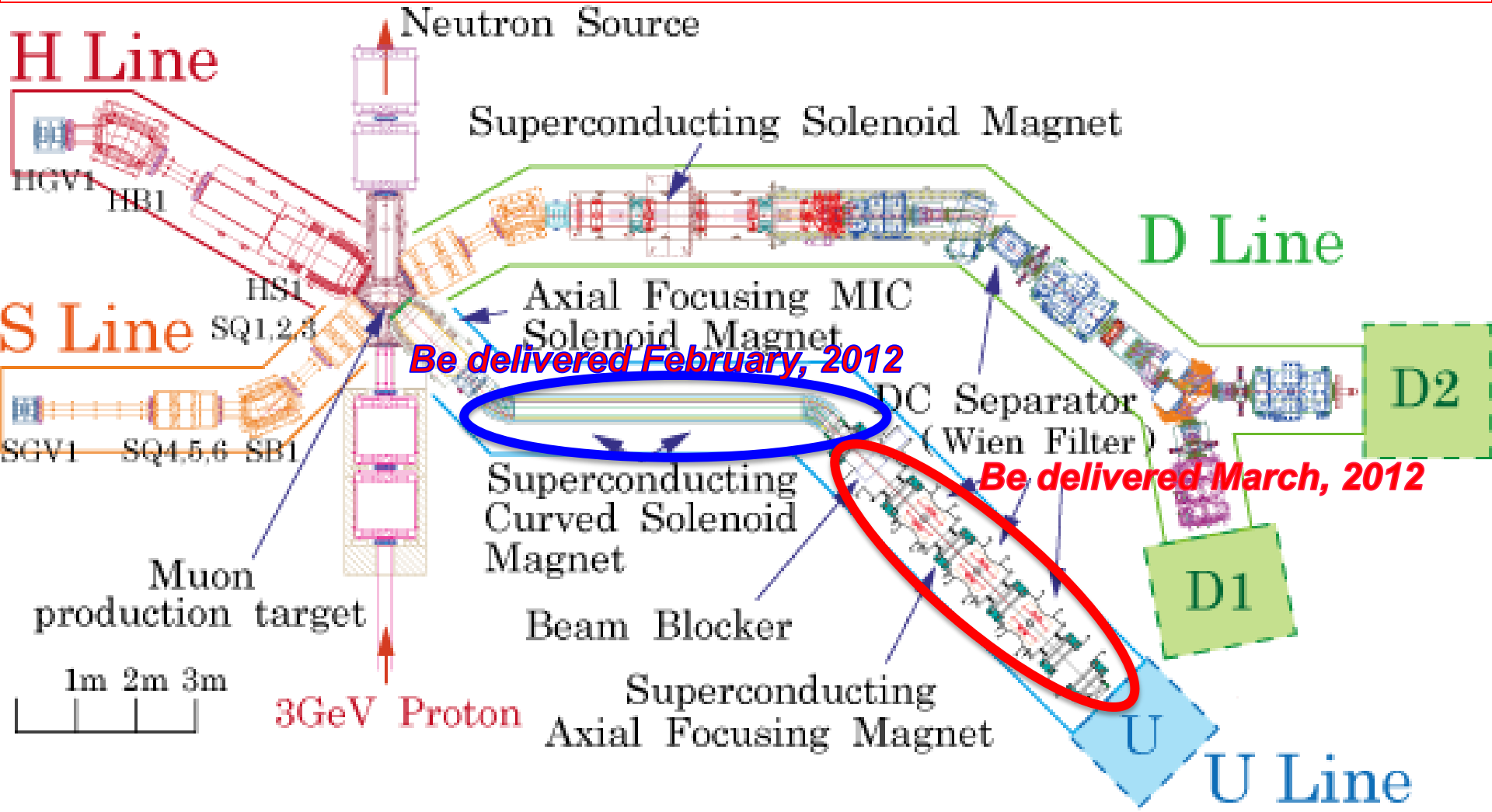
more than 10 times intense than D-Line

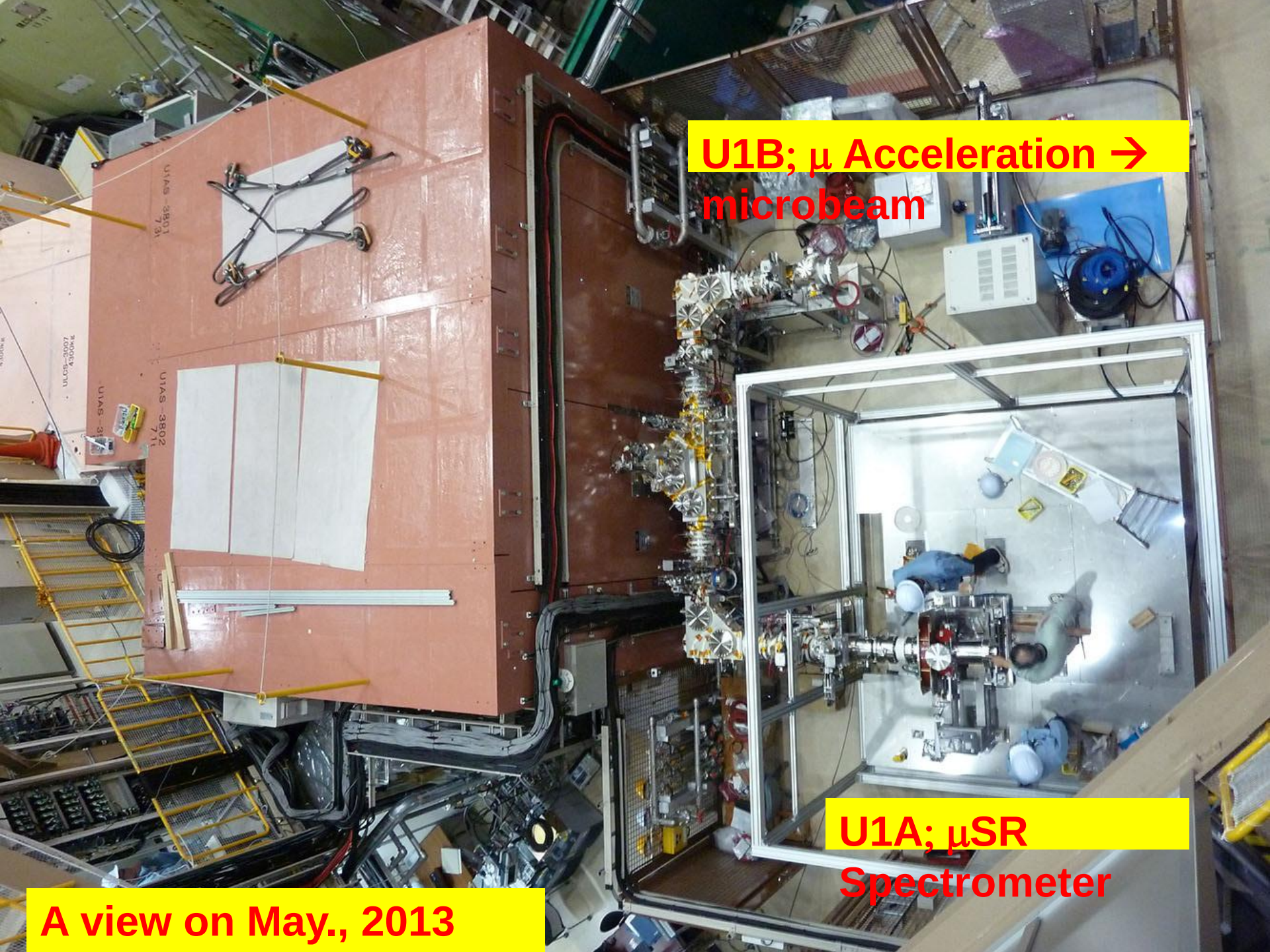
First goal of U-Line:
Surface muon source that produce Ultra Slow muon
(E= 0.05 eV – 30 keV) with high intensity and
high luminosity.

U-Line

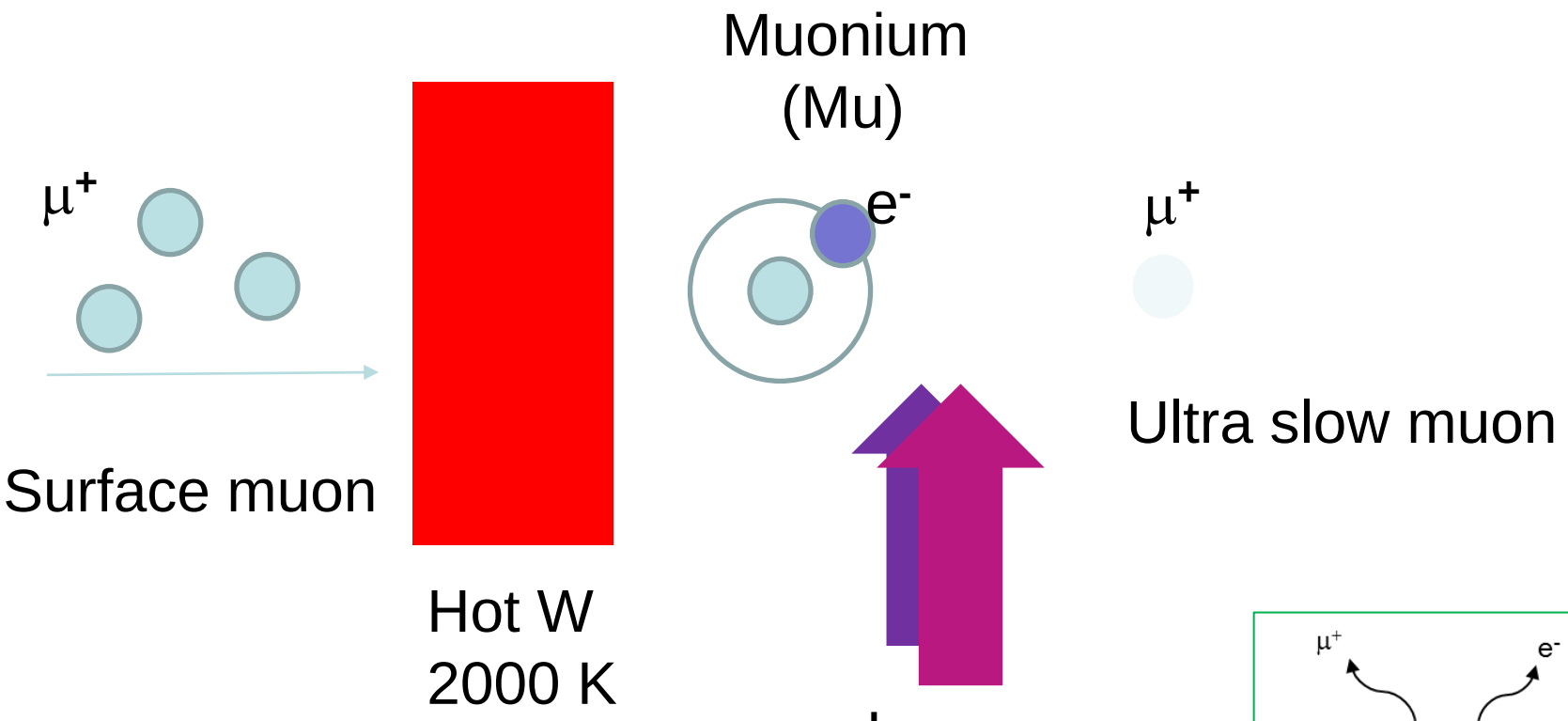
5.0 x 10^8 /s surface muons, 20 times more intense than D-line which is the strongest at present!

Dedicated beam line to produce Ultra Slow muon (E= 0.05 – 30 keV) with high intensity and high luminosity.

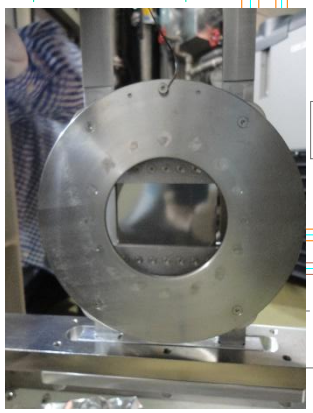



U1B; μ Acceleration → microbeam
U1A; μSR Spectrometer
A view on May., 2013

Introduction: generation of USM

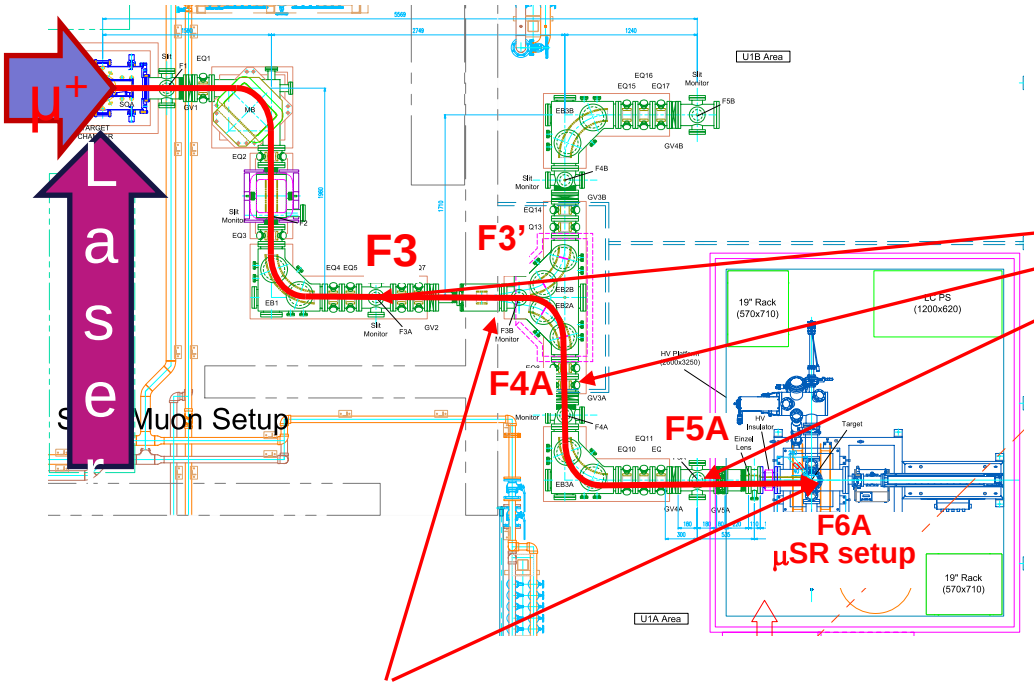


Extraction of USM

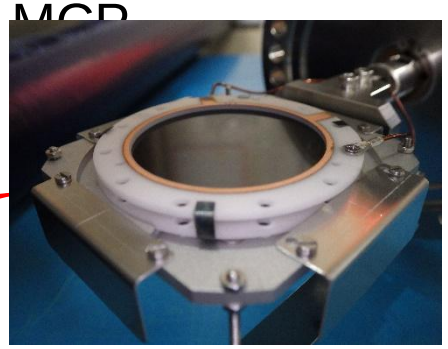


W target through S1 of SOA lens

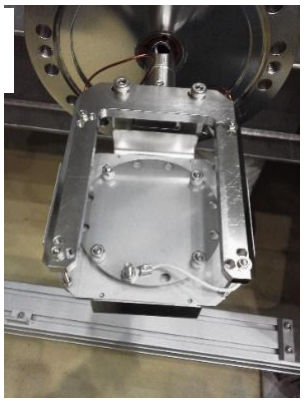
Beam detector: MCP (micro channel plate)



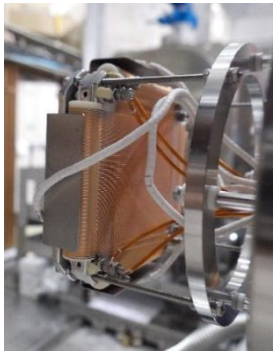
Single Anode MCP



MCP



Single Anode

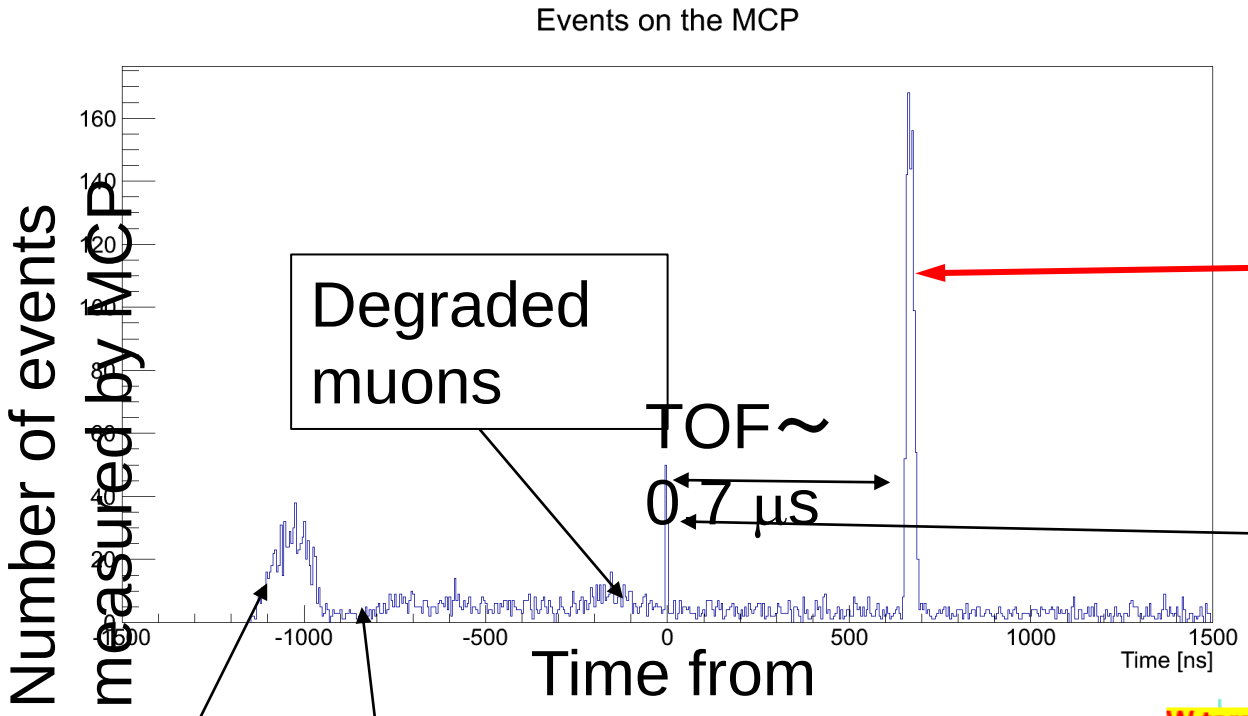


Delay-line Anode

Method: Destructive (Put into beamline to use)

Count number of

Measurements: USM observation



Degraded muons

TOF～0.7 μs

Ultra Slow Muon

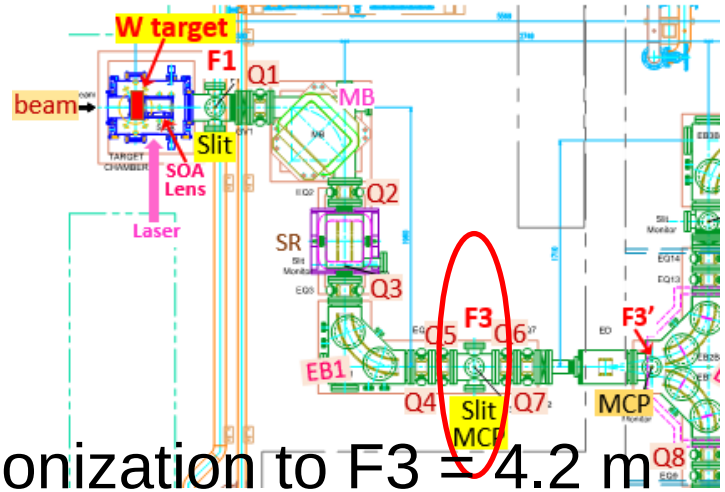
A part of the laser hit detector directly.

Time from Laser

Muon arrive at target

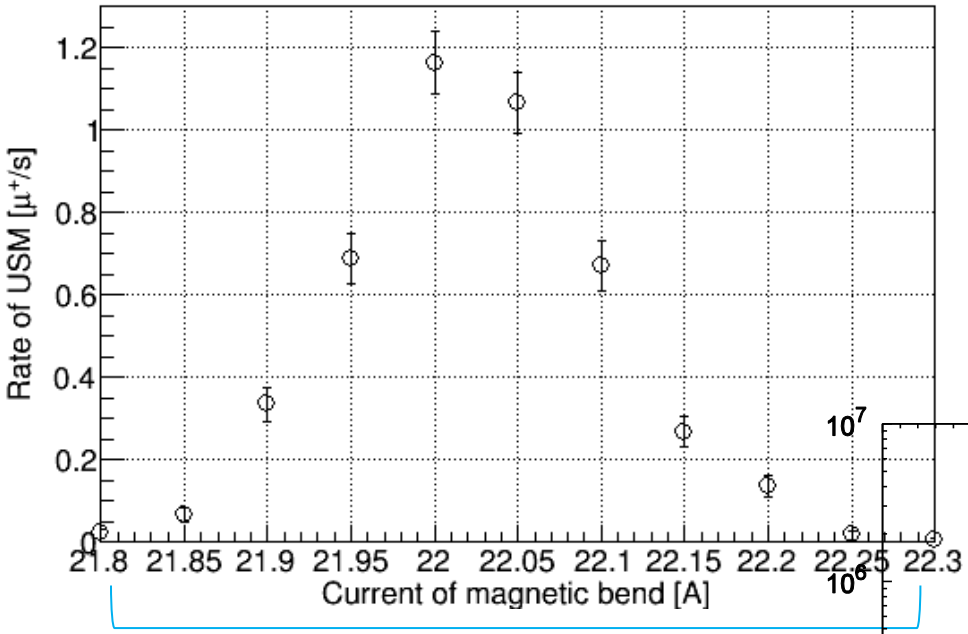
Primary positrons

From T. Adachi

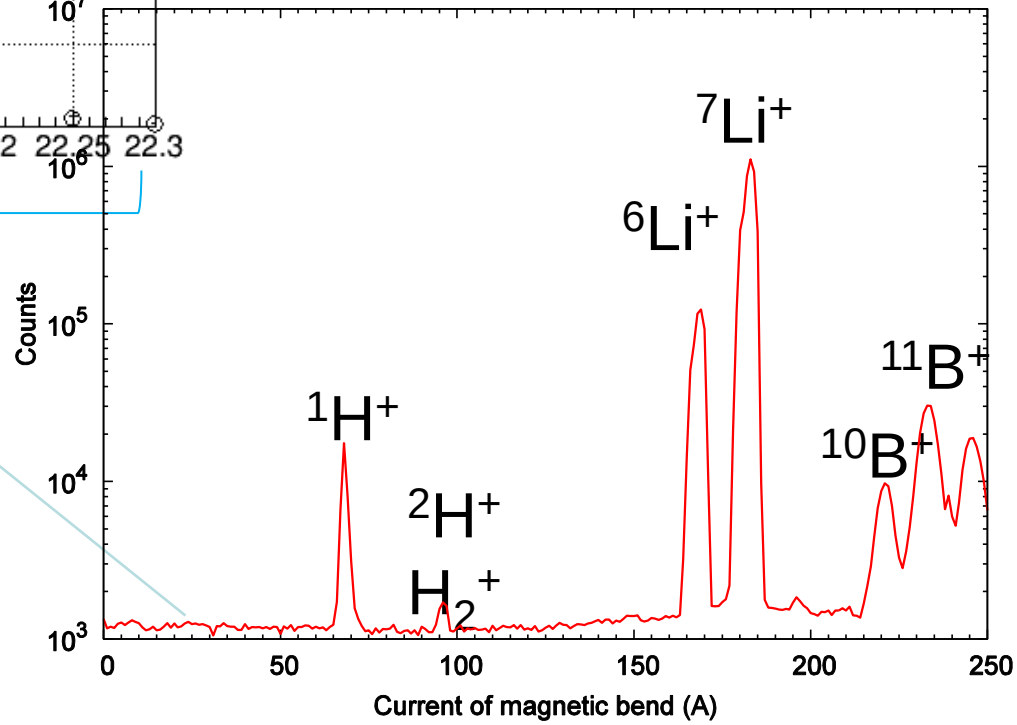


Ionization to F3 = 4.2 m

Measurements: USM observation



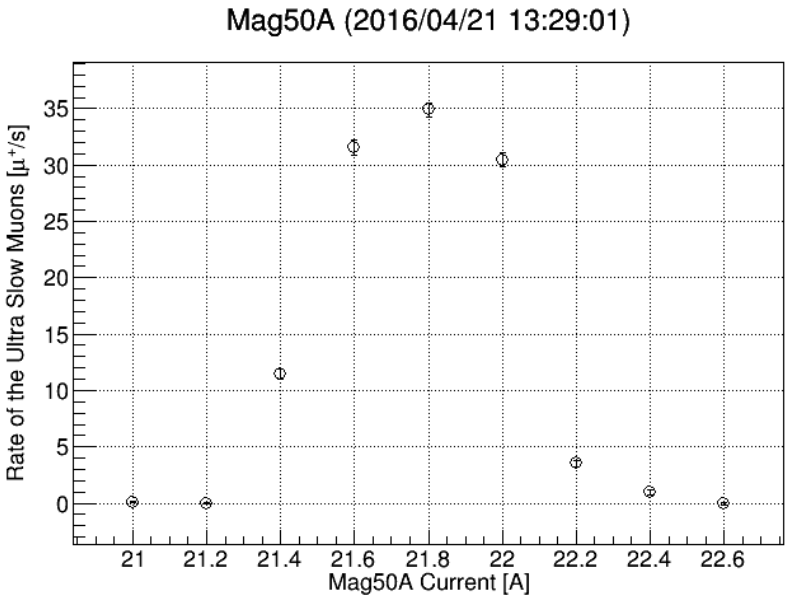
Charge/mass of muon



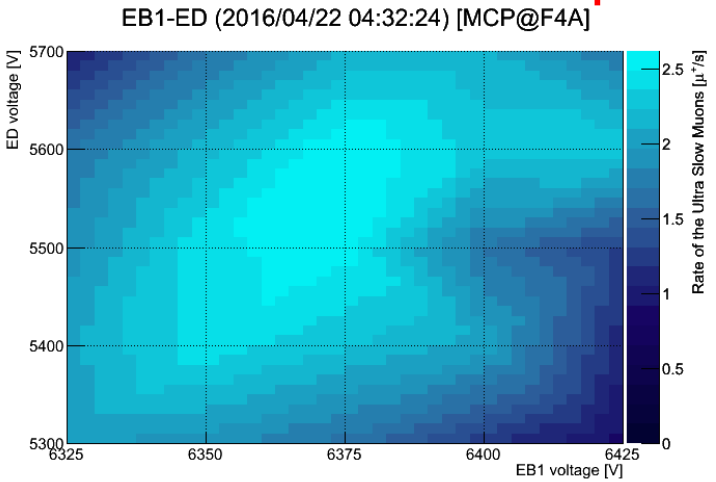
USM observation: confirmed

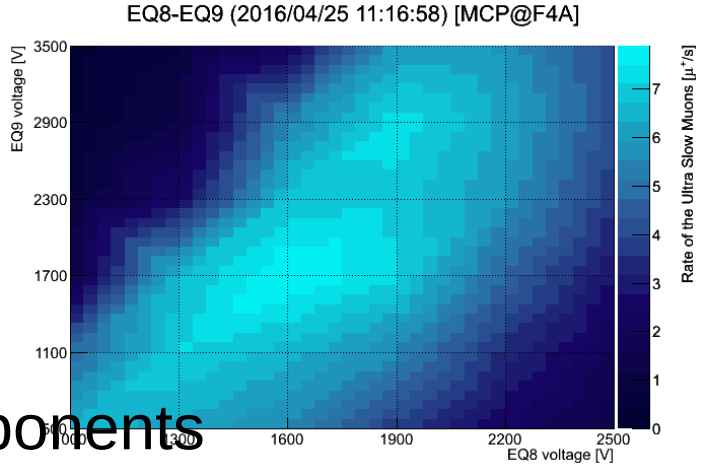
Beam commissioning: Technique

Component scanning



2D scan
Relation between components

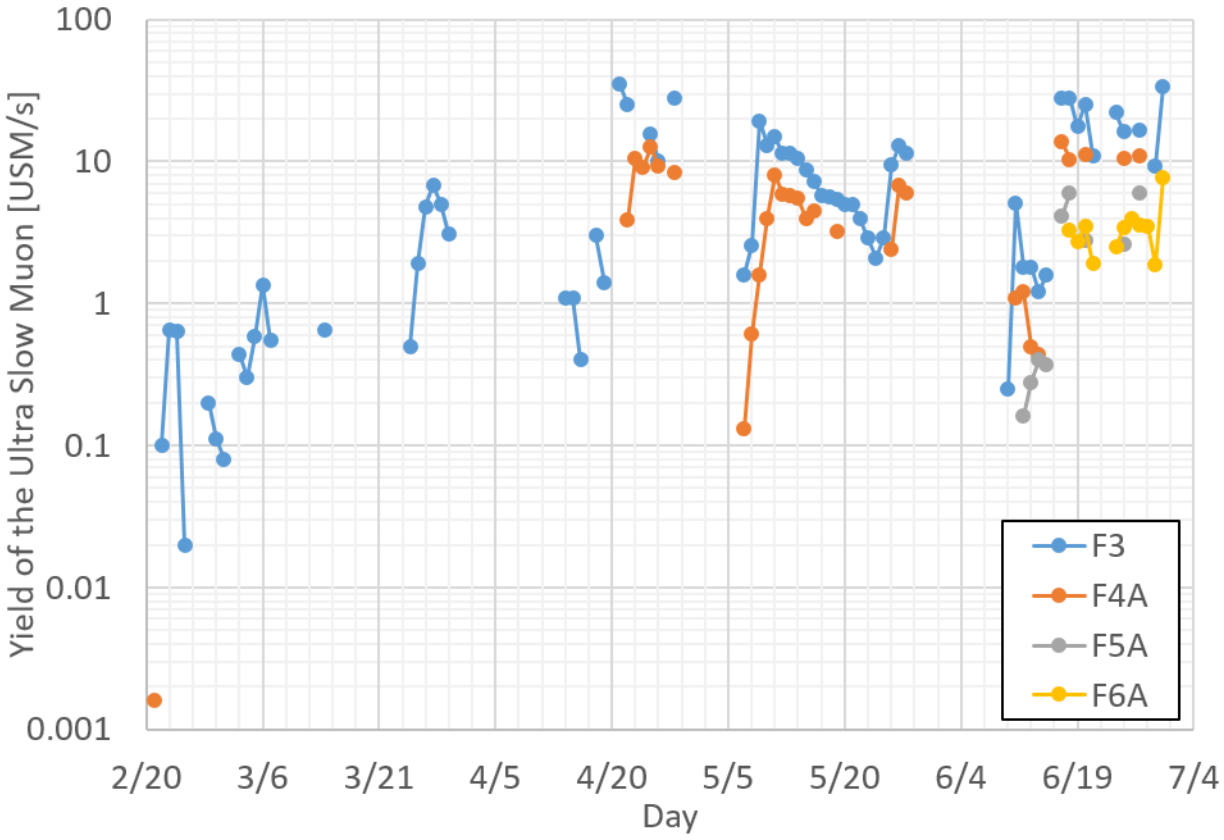




Optimization of components

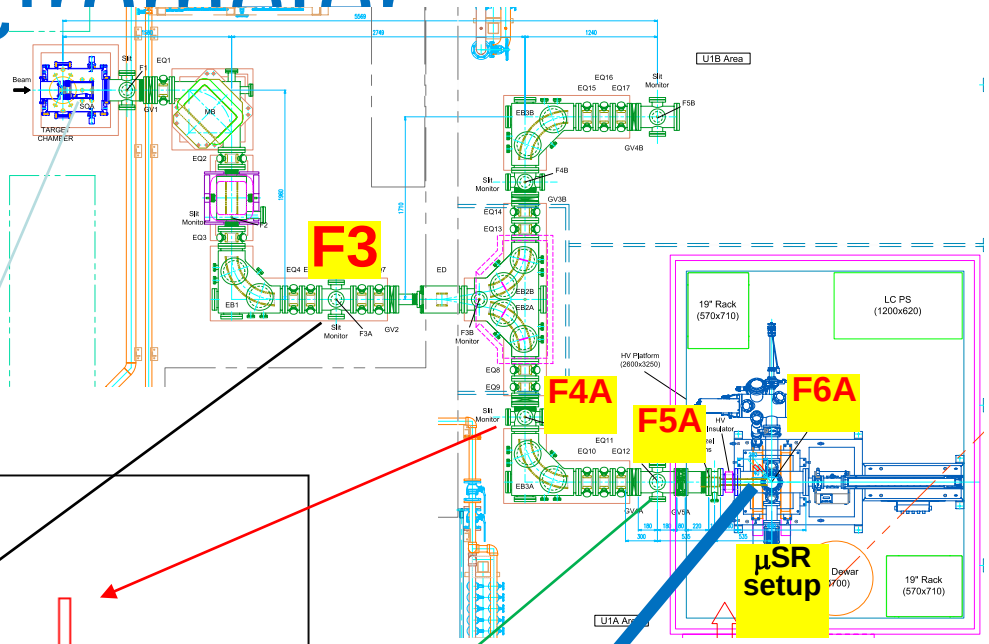
- Varying current/voltage of components
- collect USM by MCP

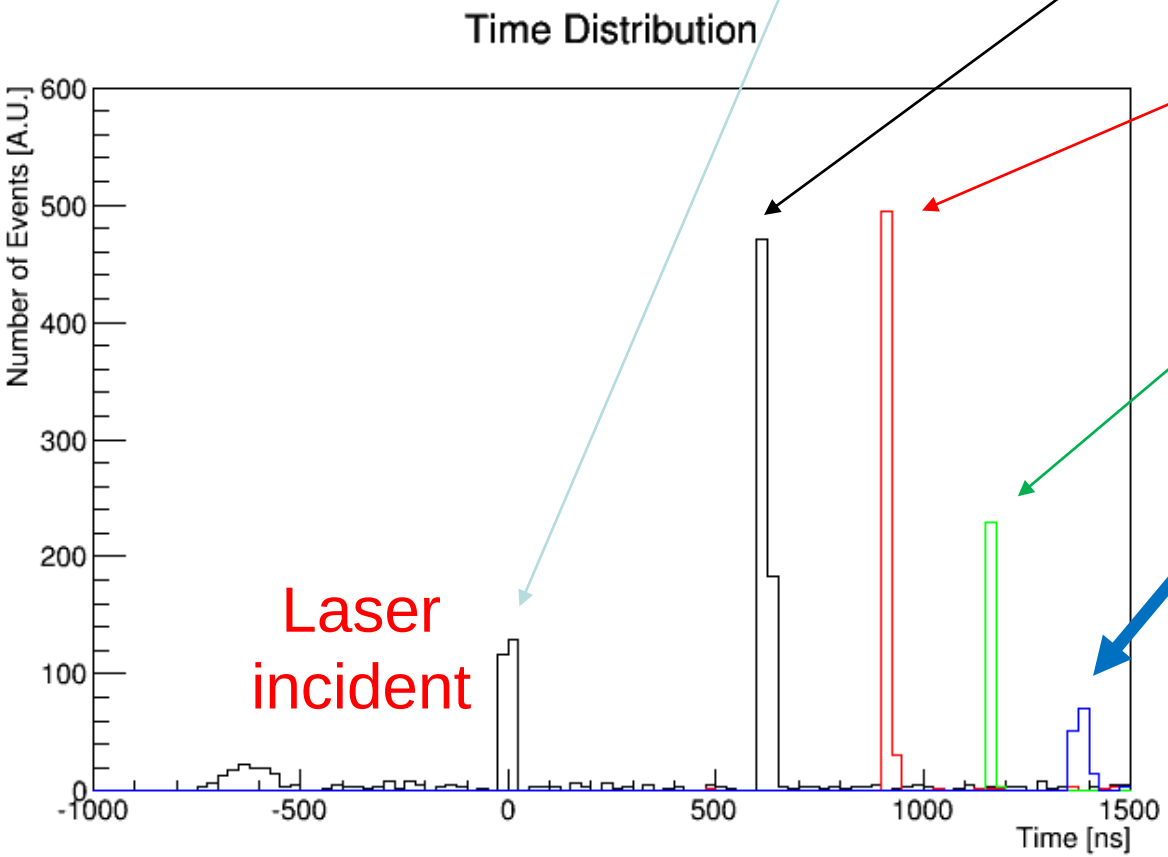
Rate of USM day by day



Date (2016)	USM/s
2/21	0.001
2/23	0.6
3/06	1.4
3/28	6.8 ± 0.1
4/21	36.7 ± 0.7

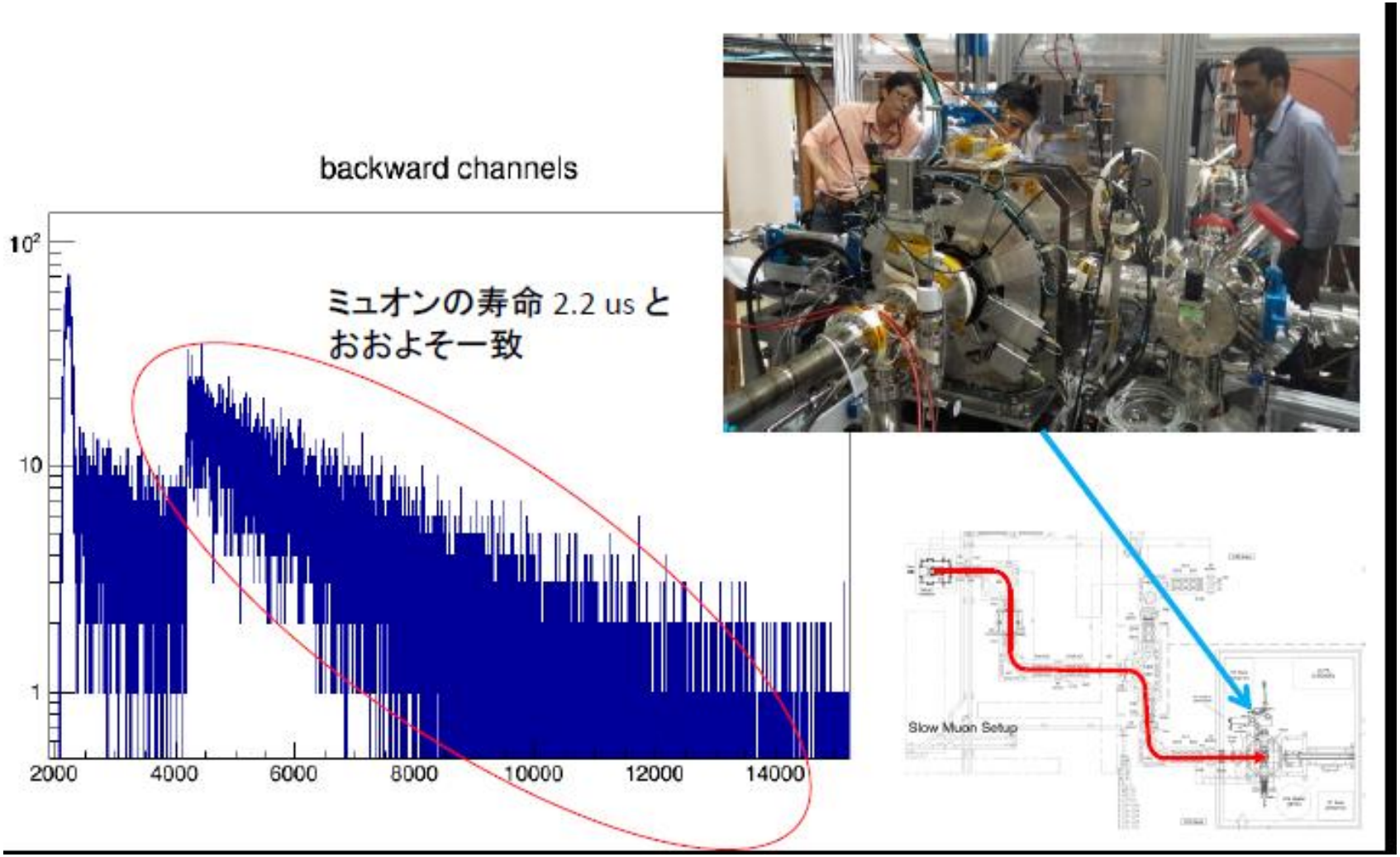
Transport USM @ μSR spectrometer



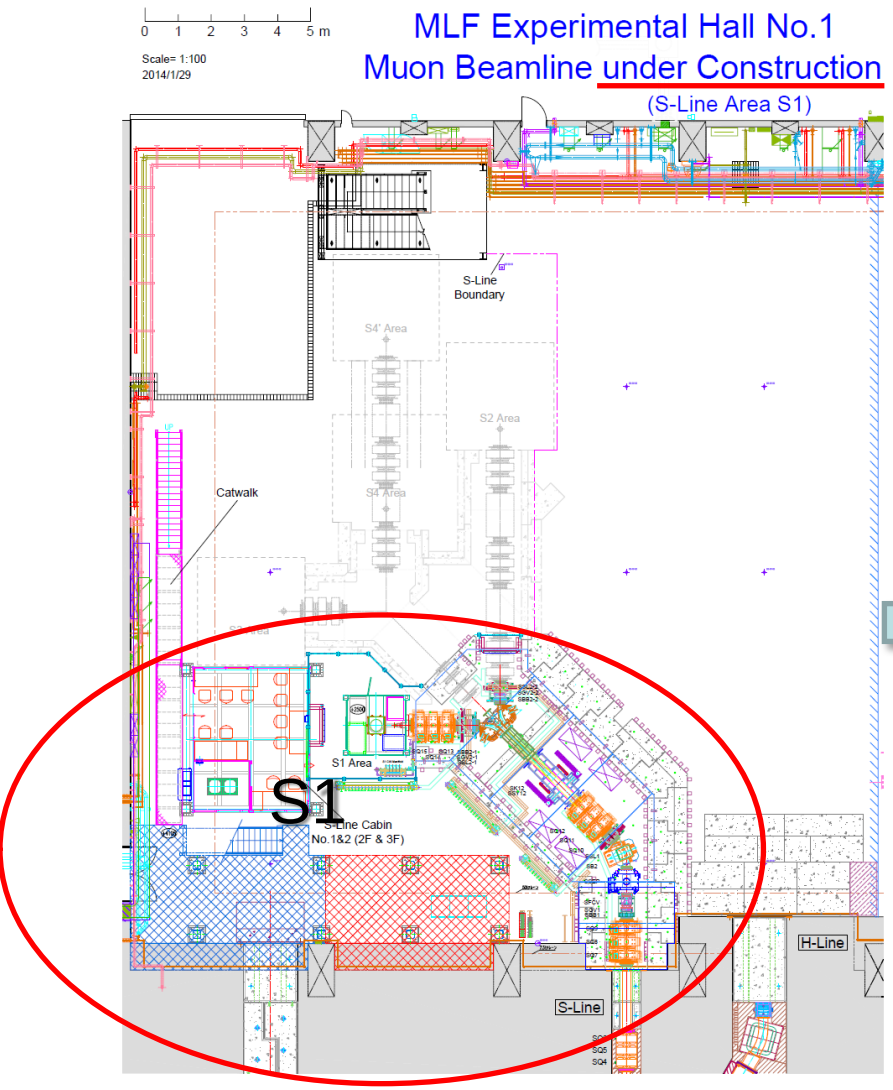


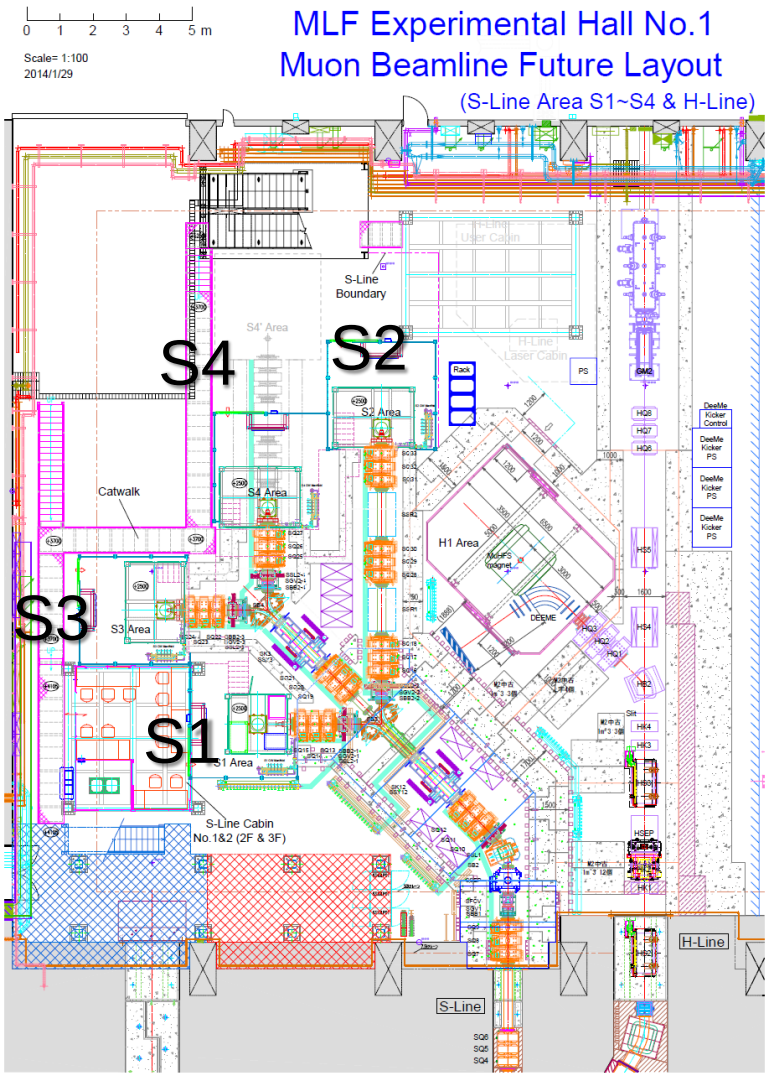
From T. Adachi

Transport USM @ μSR spectrometer

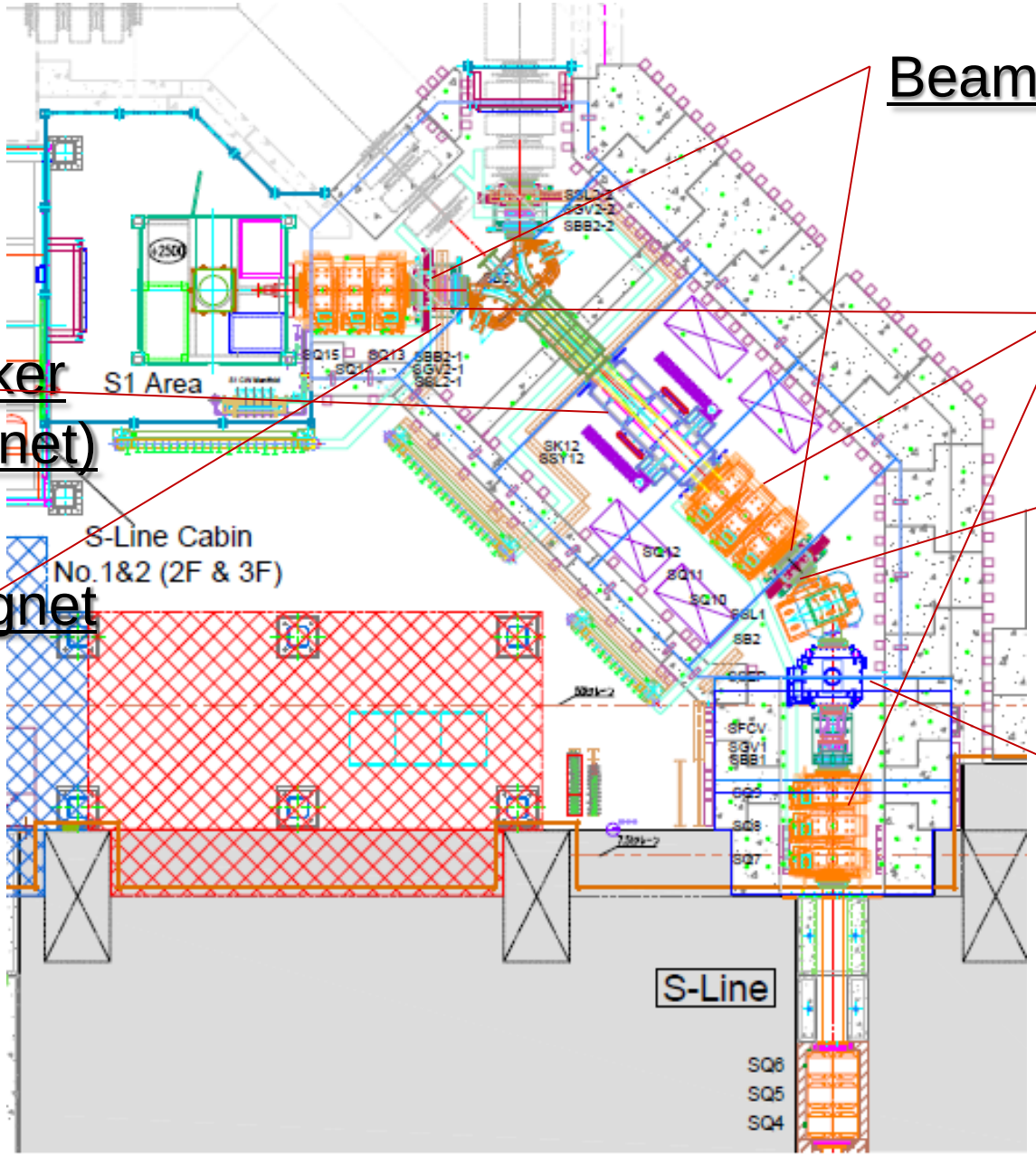


S-line construction plan

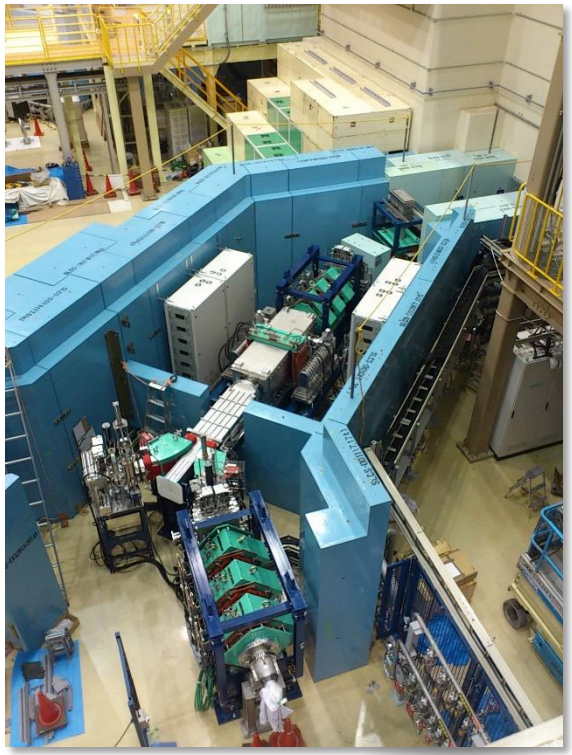




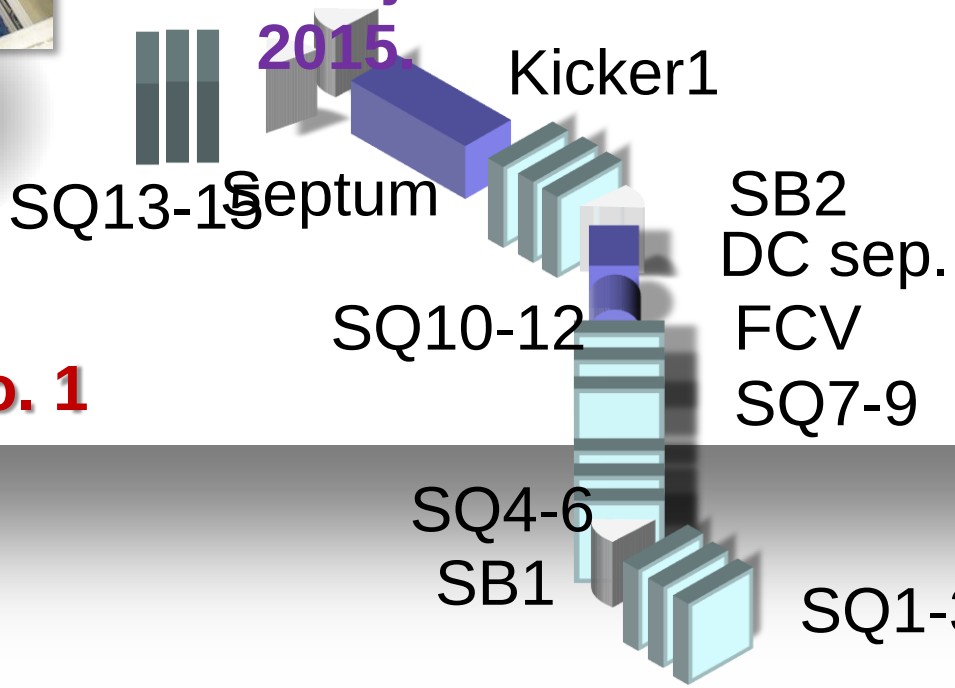
S-line

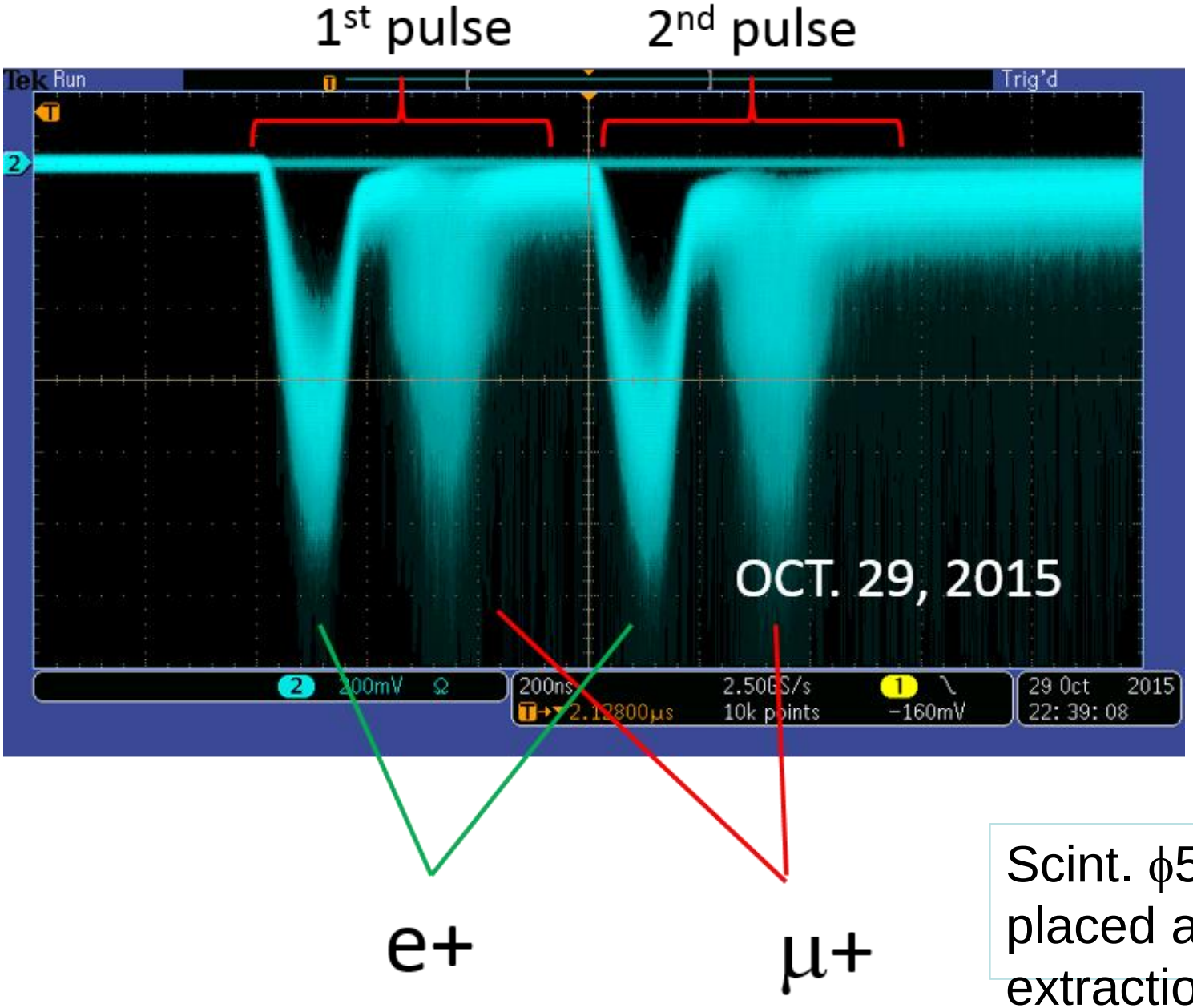

Beam Slit
Triplet-Qma
Electric Kicker
(w/ SY Magnet)
S1 Area
Bending Mag
S-Line Cabin
No.1&2 (2F & 3F)
Septum Magnet
DC Separa
S-Line
SQ6
SQ5
SQ4

S-Line: Phase 1



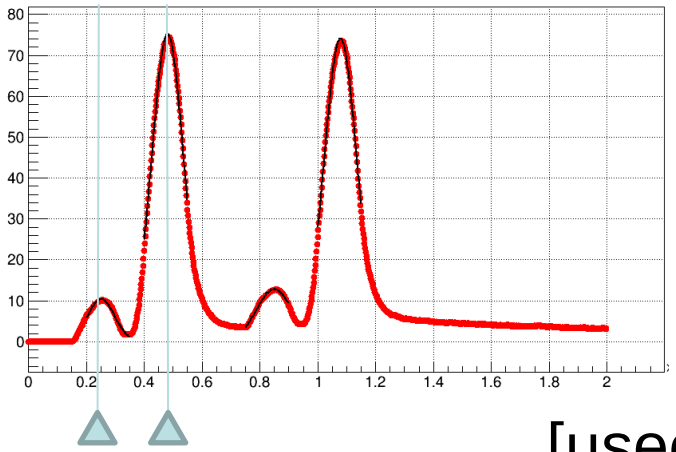
The beamline construction to extract muon beam at one of four experimental areas, S1, was completed in Nov. 2014.
The beam commissioning has just started in Oct. 2015.





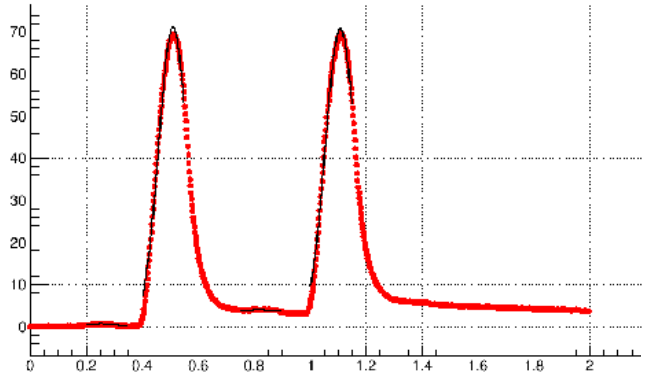
Scint. ϕ50x1.5m
placed at the be
extraction windo

Evaluation of the momentum distribution by measuring TOF (Y. Nakatsugaw



[μsec]

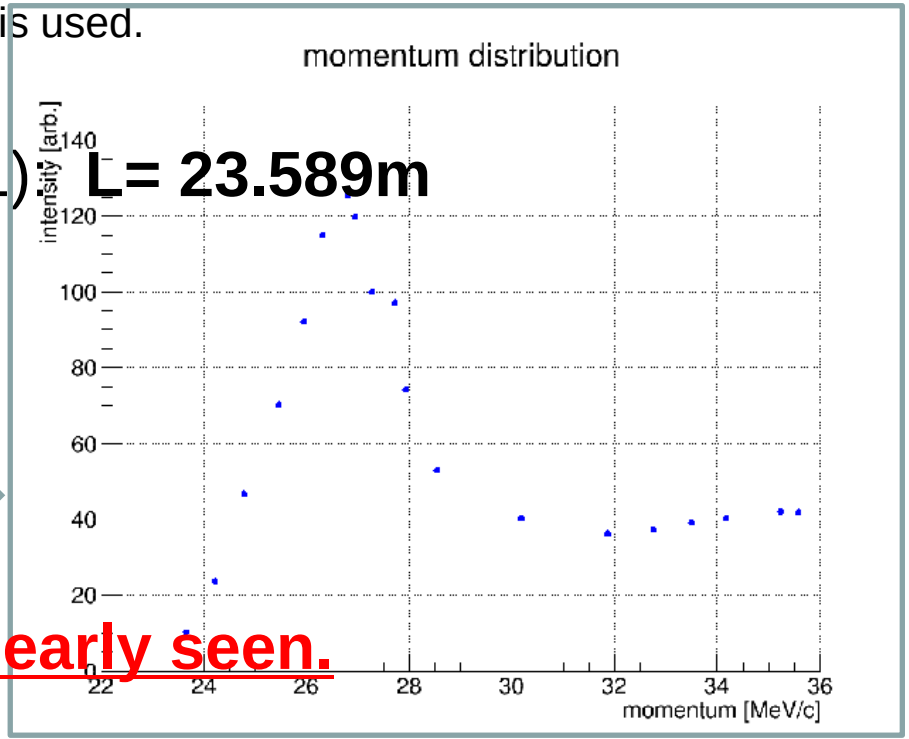
A waveform (accumulated for 100~200pulses) is analyzed by Gaussian fitting to determine the arrival time, Te^+ and$T\mu^+$.



[μsec]

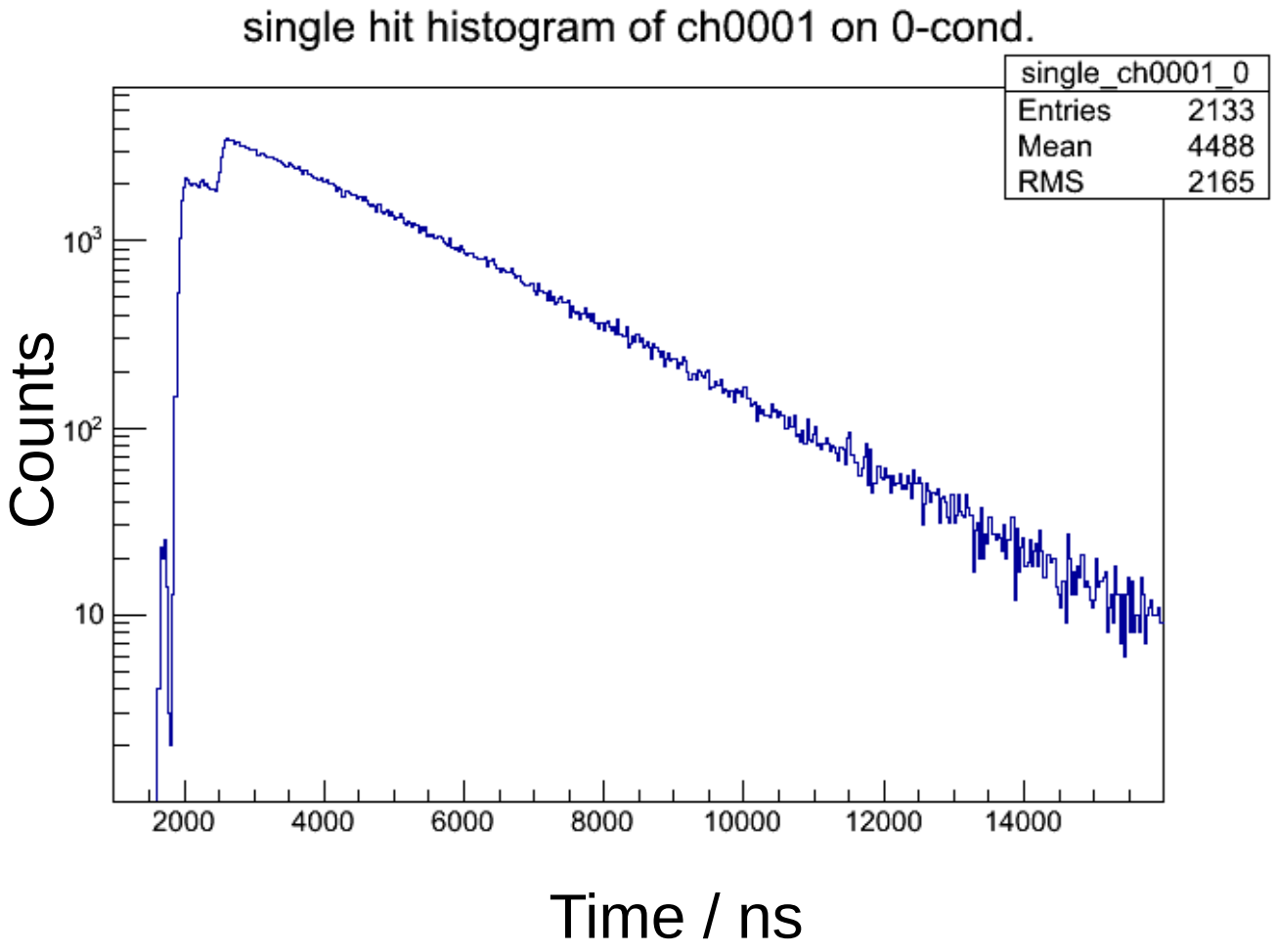
In the case that only a subtle peak corresponding to e+ is seen, an averaged Te^+ is used.

- Beamline length (Target <-> S1): **L= 23.589m**
- $TOF\mu^+ = L/c + (T\mu^+ - Te^+)$
- $P\mu^+ = \beta\gamma M_\mu$
- The peak height is potted against the estimated momentum.

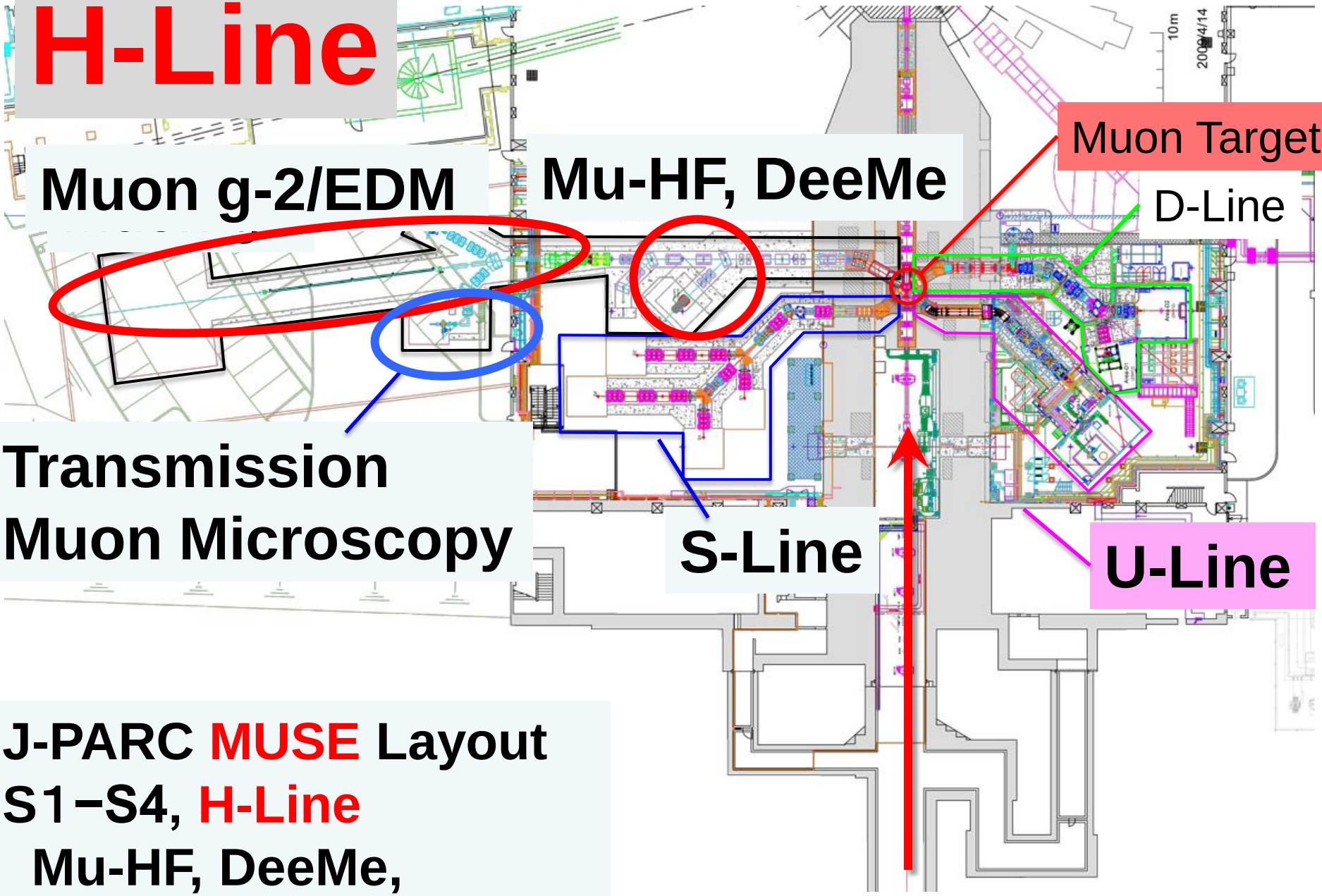


The surface muon edge is clearly seen.

μ^+-e^+ decay histogram obtained at S1



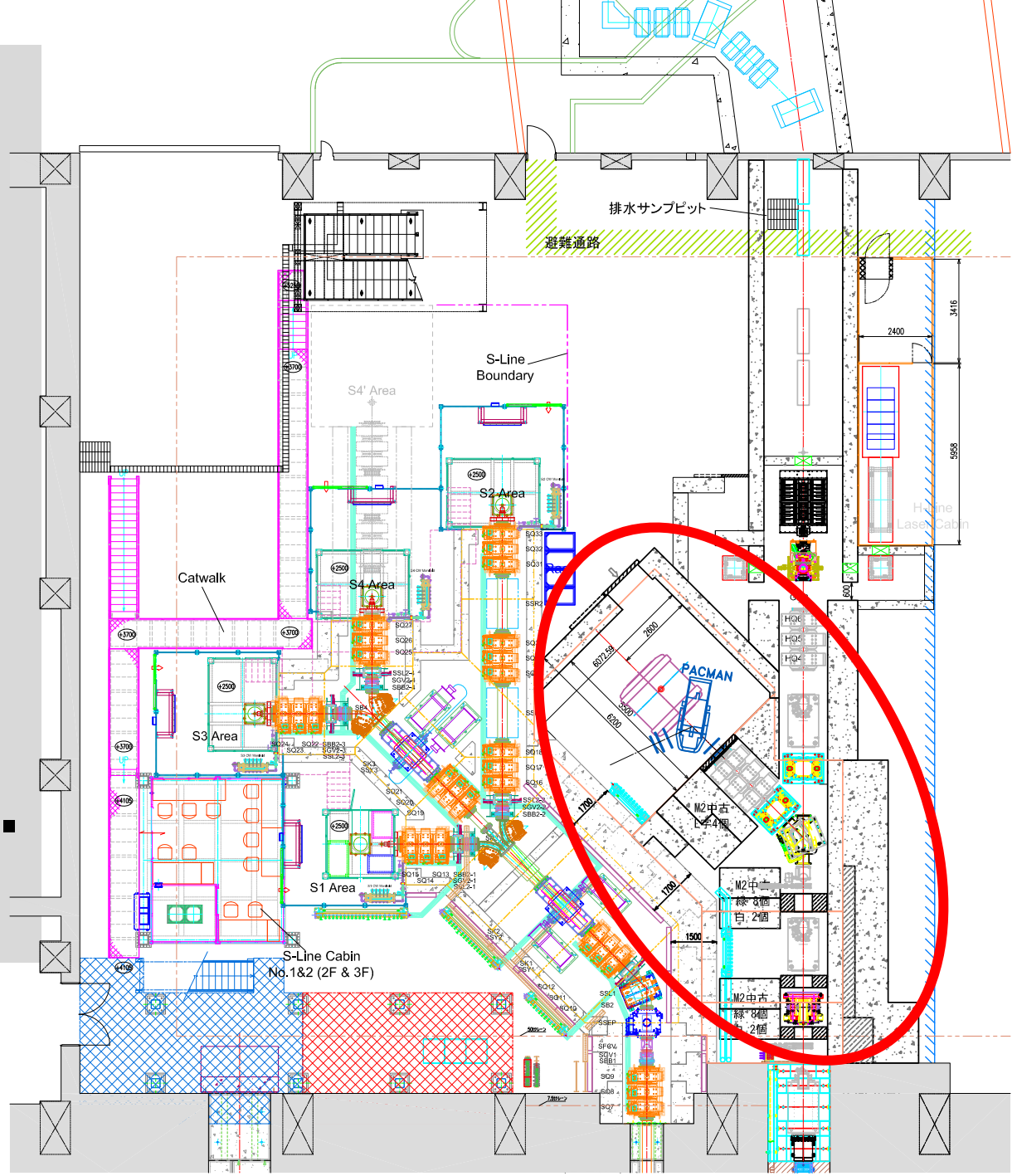
H-Line



J-PARC MUSE Layout
S1−S4, H-Line
Mu-HF, DeeMe,
g-2, Muon Microscopy

H-Line

Planning to complete H1Area For DeeMe & Mu-HF exs. In 2015!

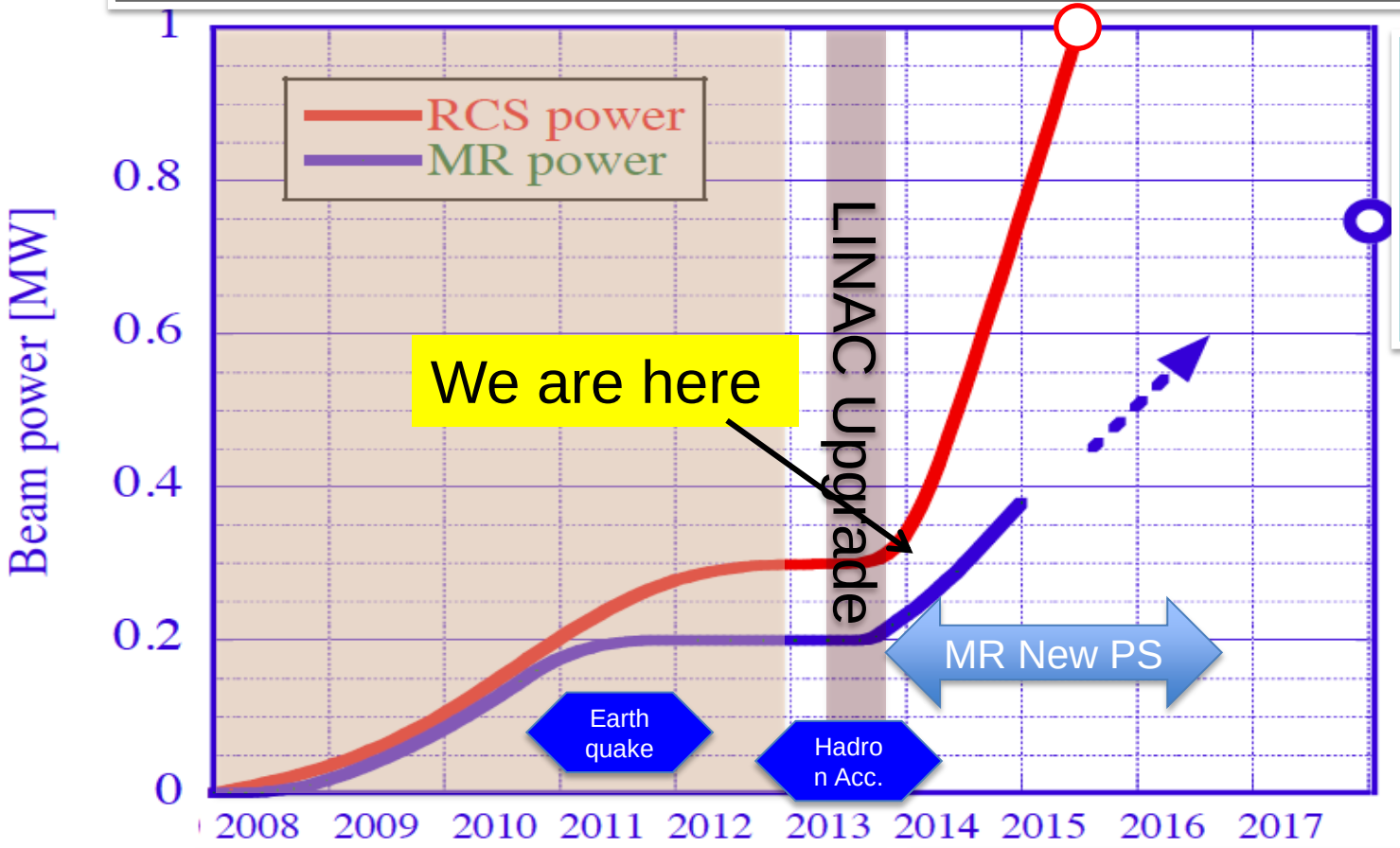


Kawamura et al.

Schedule for Power Upgrade

1 MW（RCS)was successfully achieved Last December, 2014!

FY2013: Linac 400MeV, FY2015: RCS MW

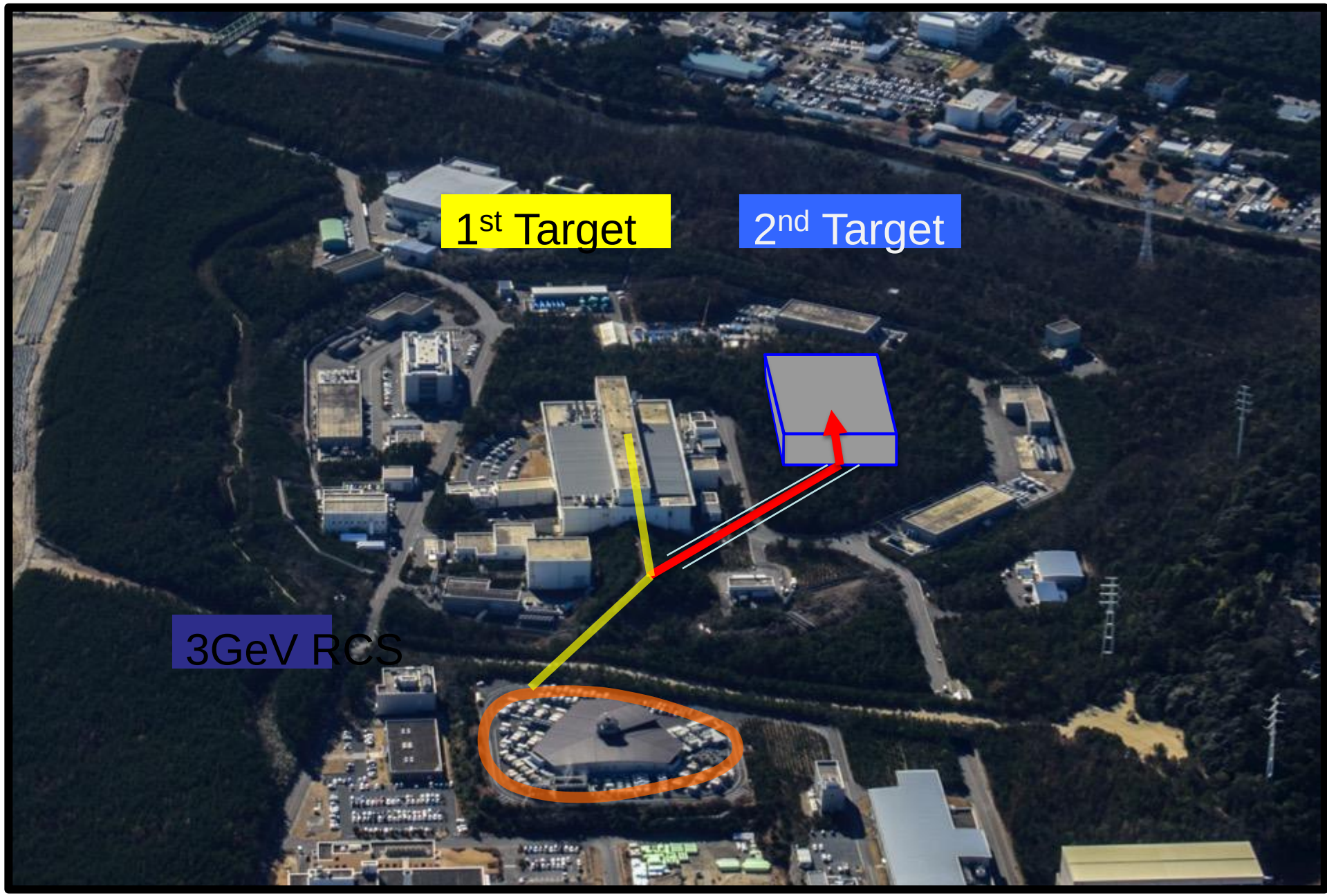


Issues for MR
- PS
- High gradient Cavity
- High repetition
- Shielding

Linac 181MeV

Linac 400 MeV

2nd Target Station


1st Target
2nd Target
3GeV RCS

2nd target station

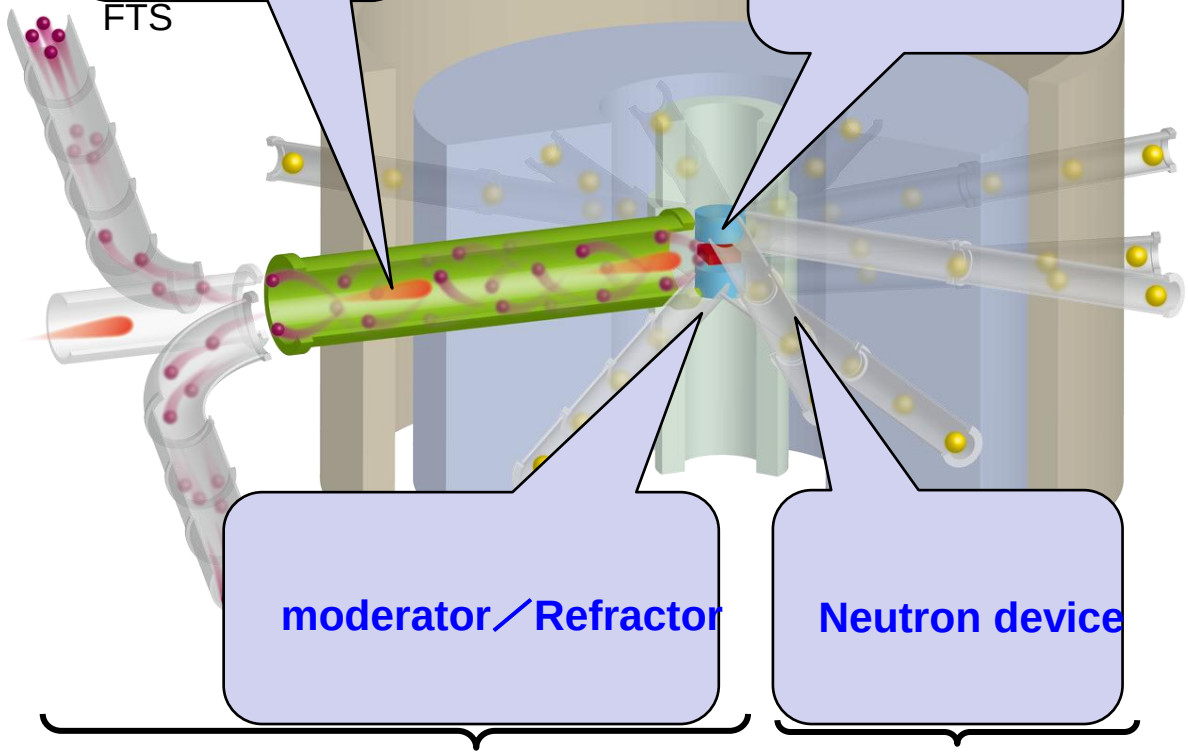
Muon Int.: 10 times × 5 times

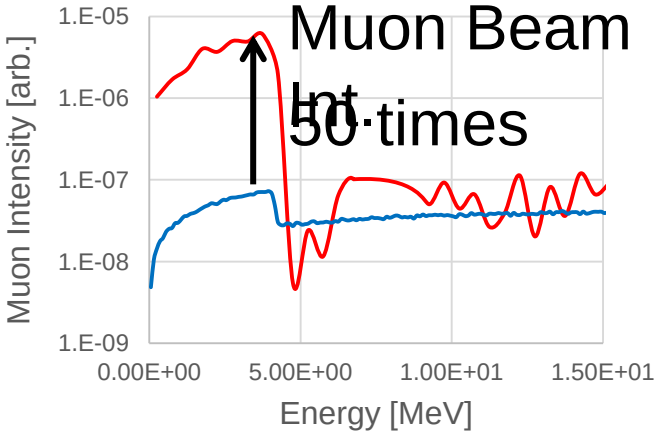
Proton Beam
Current density: >5 times than FTS

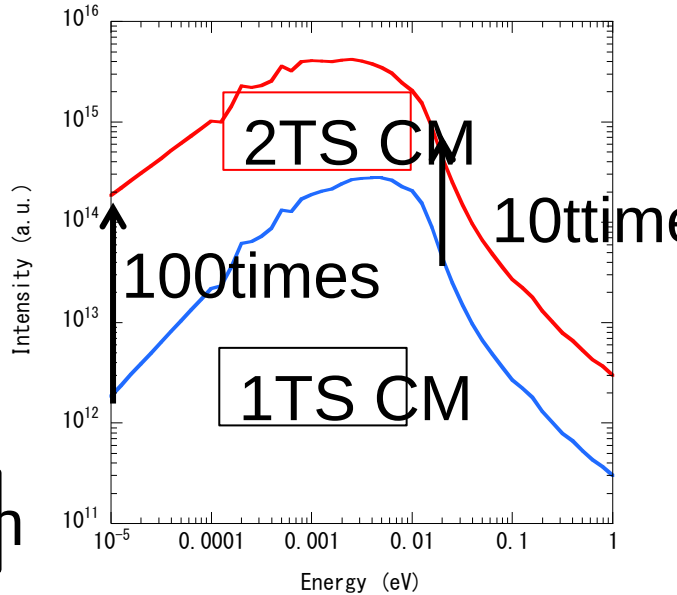
Target
Compact
W target?

Target
Same target
For neutron

Beam LIne
Solenoid capture





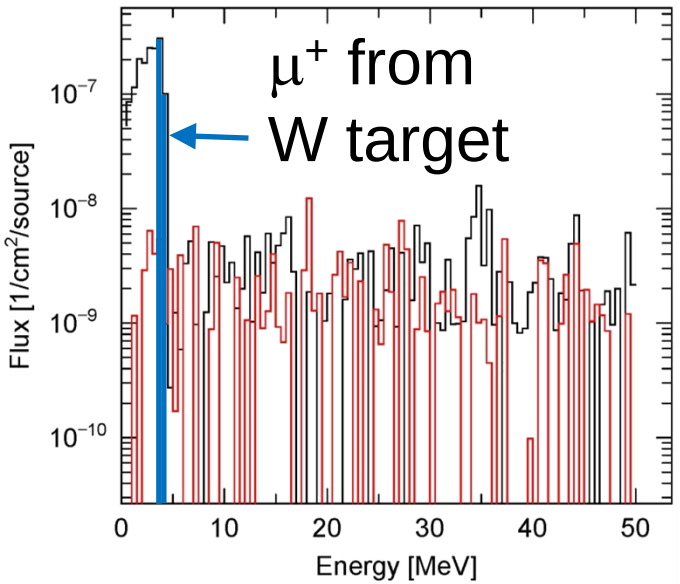


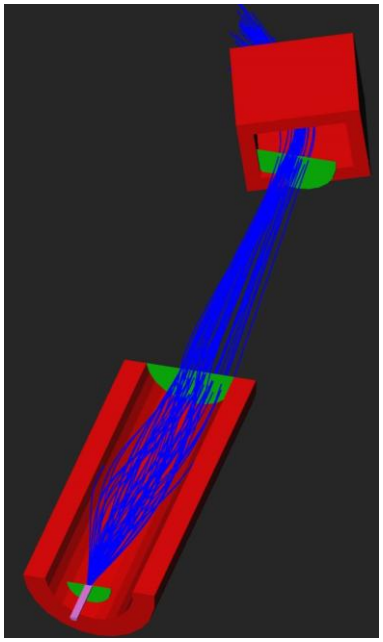
Neutron: 5 times × 2 times

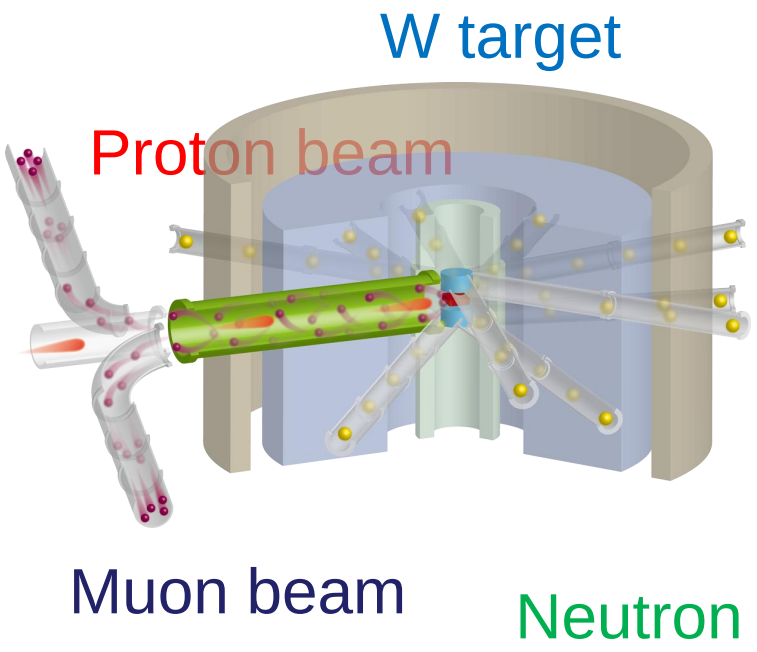
More than 10 times of Netron and Muon

Ultra high intensity muon beam Stroboscope
Muon beam from 2nd Neutron target

- Muon intensity ~100 times larger than U line.
- Stroboscopic μSR and muon imaging will become possible.







Master plan 2017

Summary

- **Rotating Graphite Target is in operation!**
- **D-Line, User's Runs have been going on!**
  - **Upgade's budget funded!**
- **U-Line Construction (**Completed!**)**

  → Broken **thermal shield was fixed!**

  → **Ultra slow muon beamline (**Completed!**)**
- **S-LIne (S1 Completed**!**)**

  → Muon Beam at S1 is now available.
- **H-Line** → Budget request for the **MEXT**!
- **2nd target station** → now in design.