# Progress of the COMET Experiment at J-PARC

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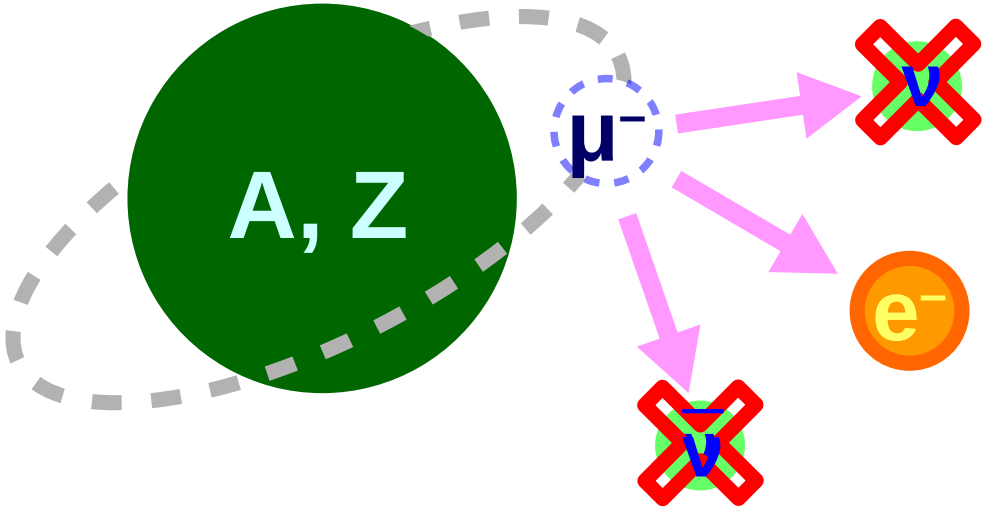
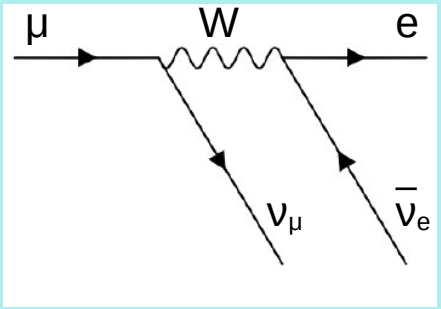
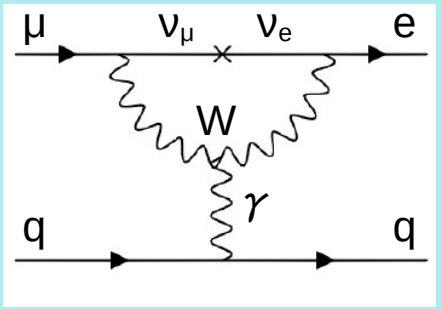
# The μ-e Conversion




- Conversion of a muon to an electron is "Charged Lepton Flavor Violation" process and strongly prohibited in the Standard Model.
- Its discovery is an evidence of the new physics.

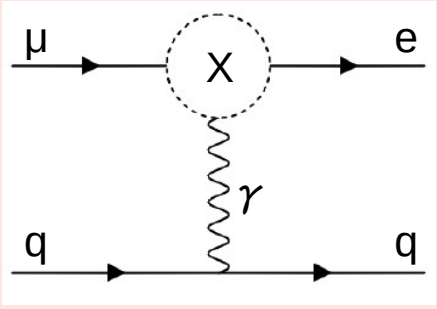
## Standard Model

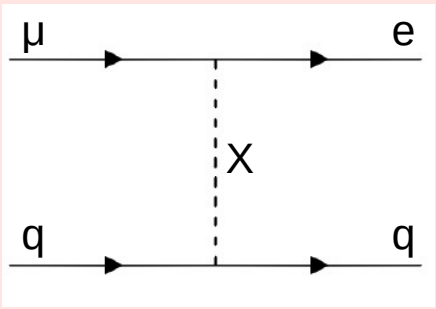



- Muon can decay to electron with neutrinos.
- μ-e conversion via neutrino oscillation is <O($10^{-54}$).

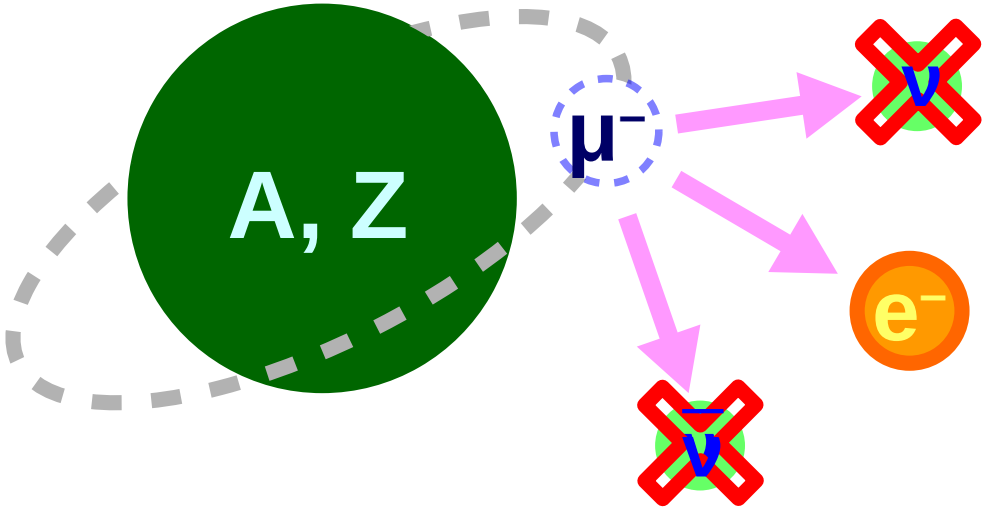
## New Physics



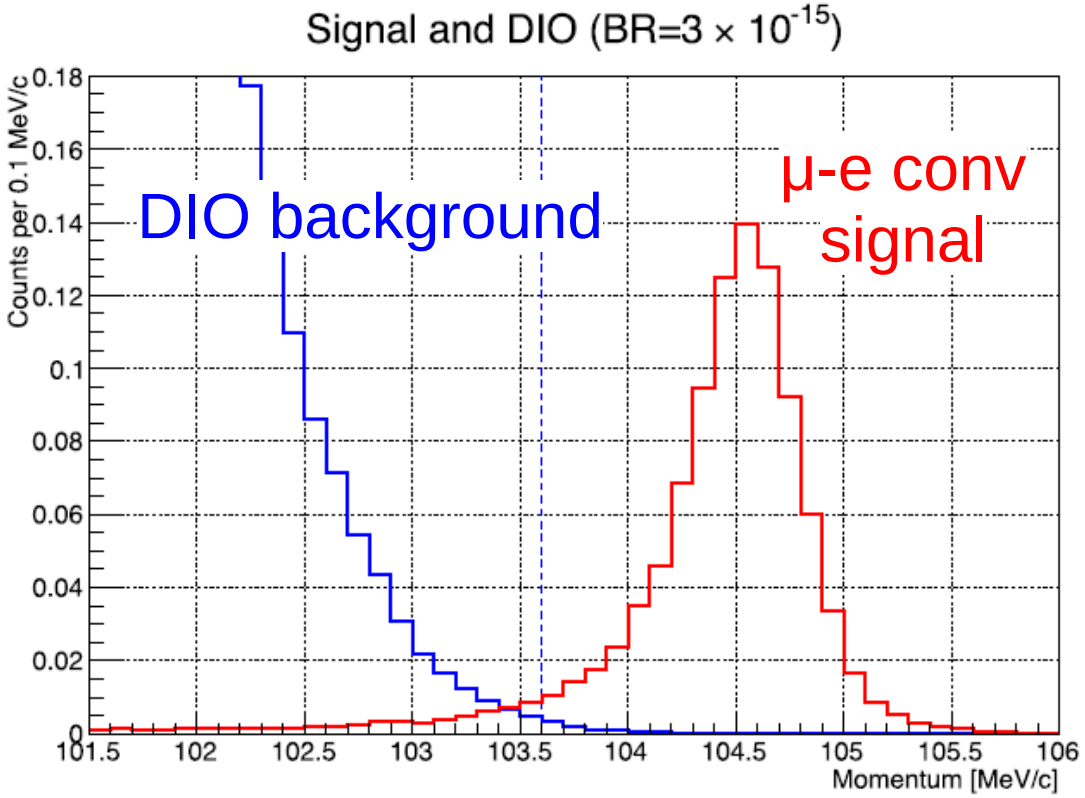




- Sensitivity for the new physics scale is >1000TeV.
- μ-e conversion has sensitivity to both photonic and non-photonic interaction.

# The μ-e Conversion

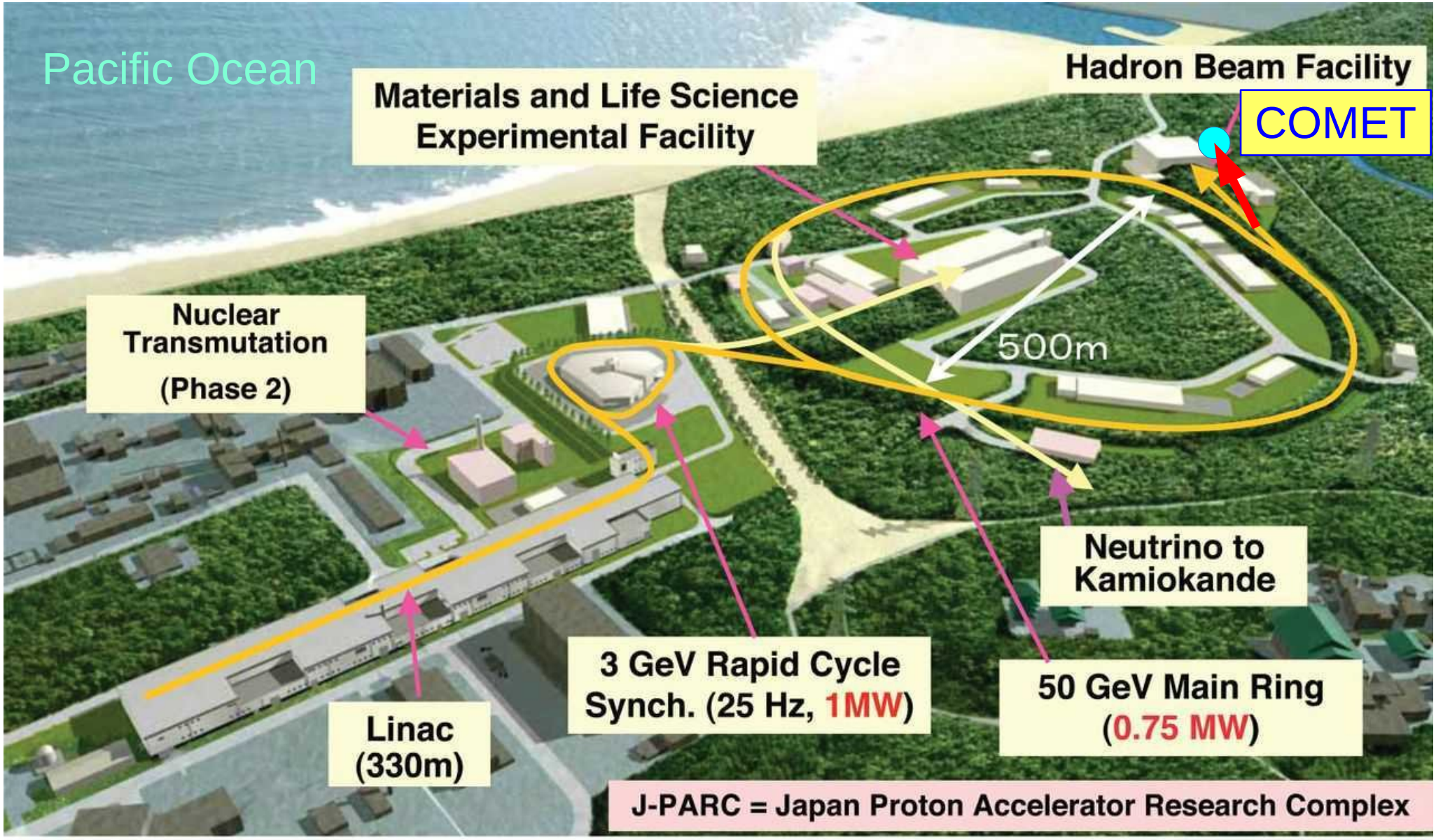



- Current world record of the μ-e conversion is $7 \times 10^{-13}$ by SINDRUM-II experiment. The COMET experiment aim to reach $O(10^{-17})$ at Phase-II.

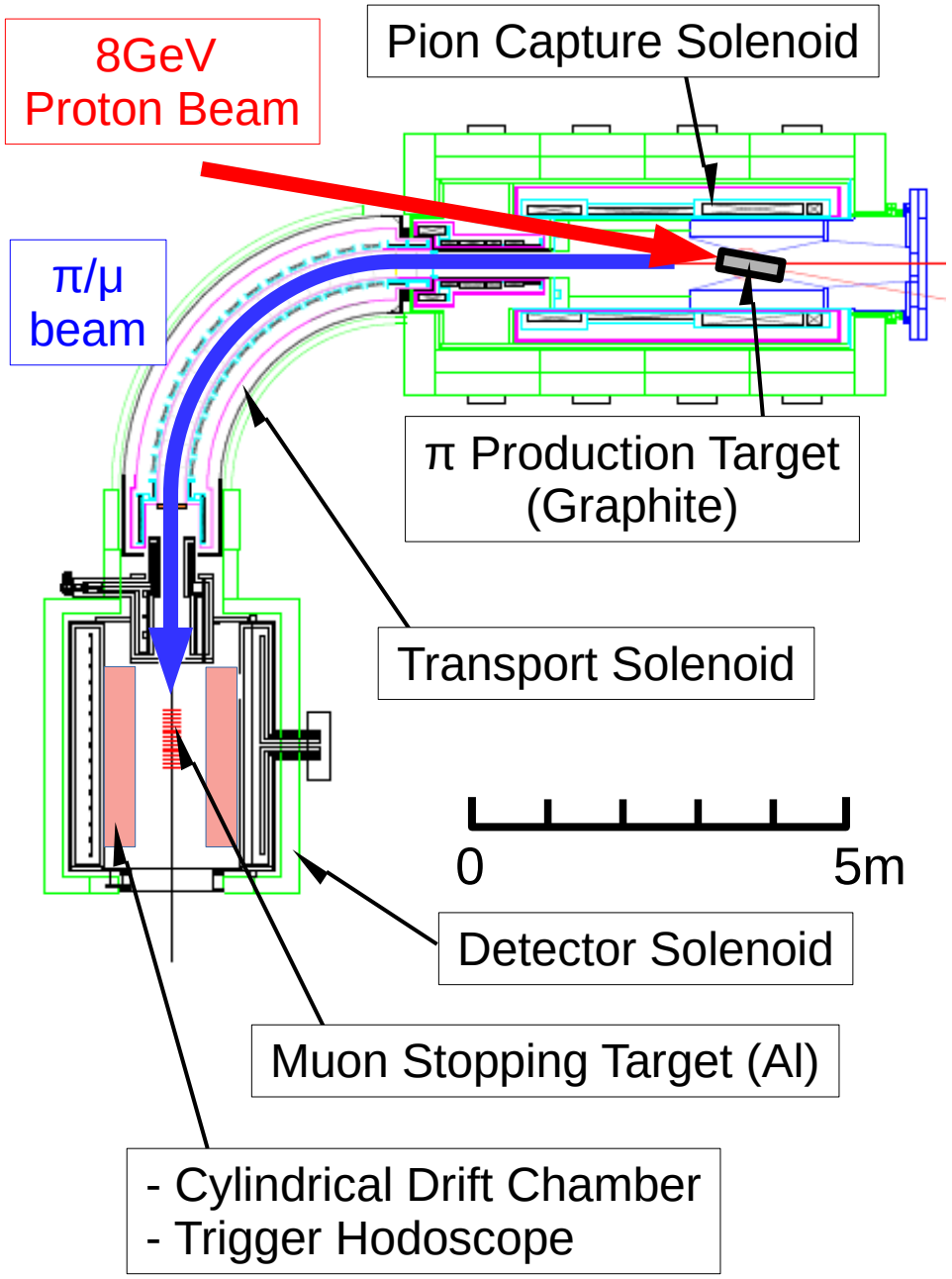



- The signal of μ-e conversion is single electron with energy of about muon mass.
- Electrons from muon decay-in-orbit (DIO) is a major background. It emits a high-energy electron due to recoil of a nucleus.

# COMET in J-PARC

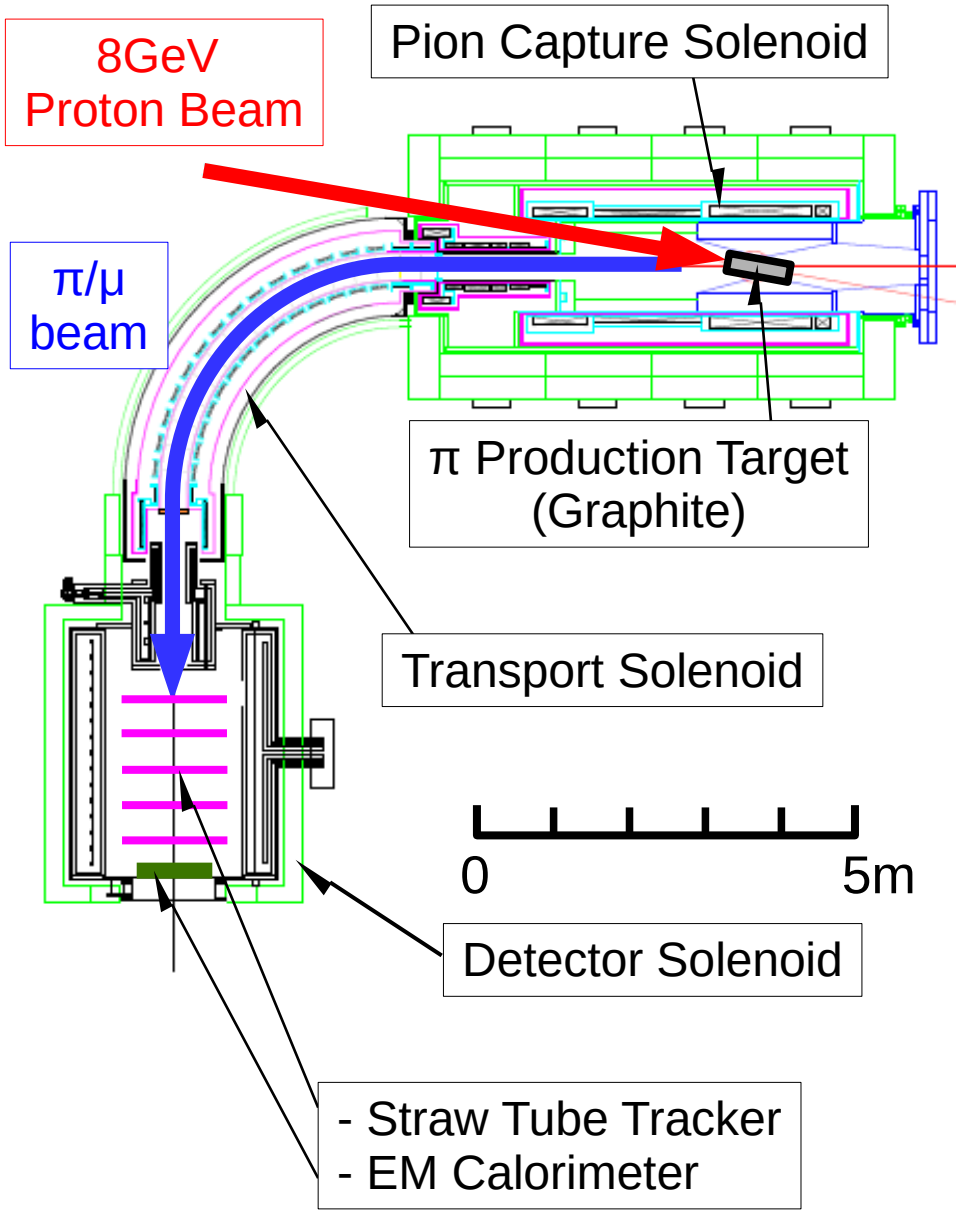


# COMET Phase-I : Physics Run

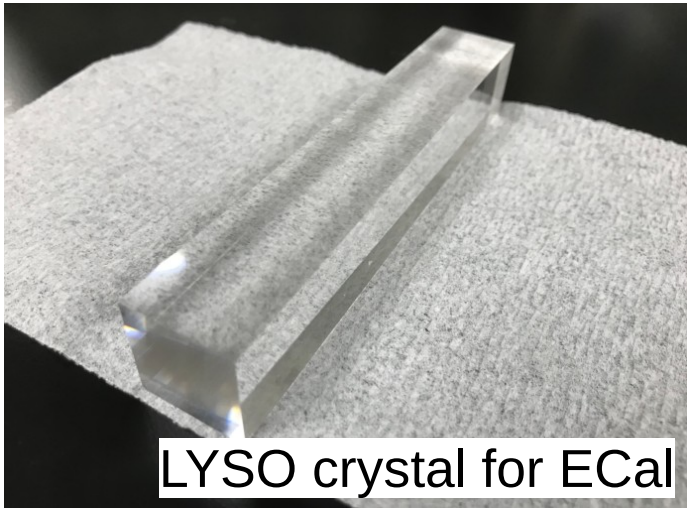



1. J-PARC 8GeV proton beam is injected to Pion Production Target (700mmL graphite), which is installed inside Pion Capture Solenoid.
2. Pions decay to muons during transportation in Transport Solenoid.
3. Muon are stopped at the aluminum stopping target. Momentum of decay electrons are measured by Cylindrical Drift Chamber.
4. Expected sensitivity at COMET Phase-I is $7\times10^{-15}$.

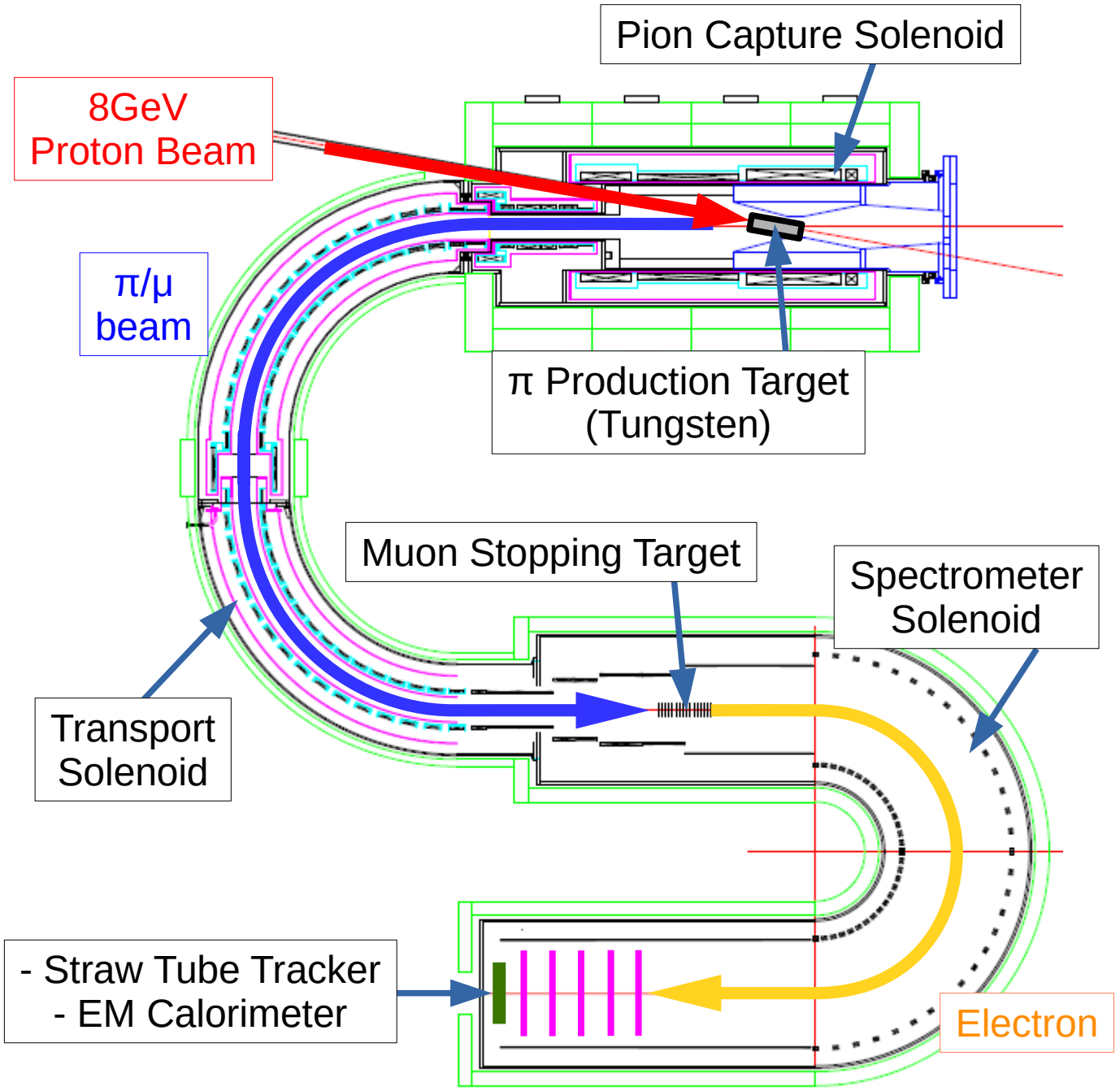
# COMET Phase-I : BG Study




- Another program at Phase-I is to study secondary beam itself to evaluate background at Phase-II.
- Muon stopping target and CDC is removed. Instead, Straw Tube Tracker and EM Calorimeter are used.
- Same detector as Phase-II will be used for this study.



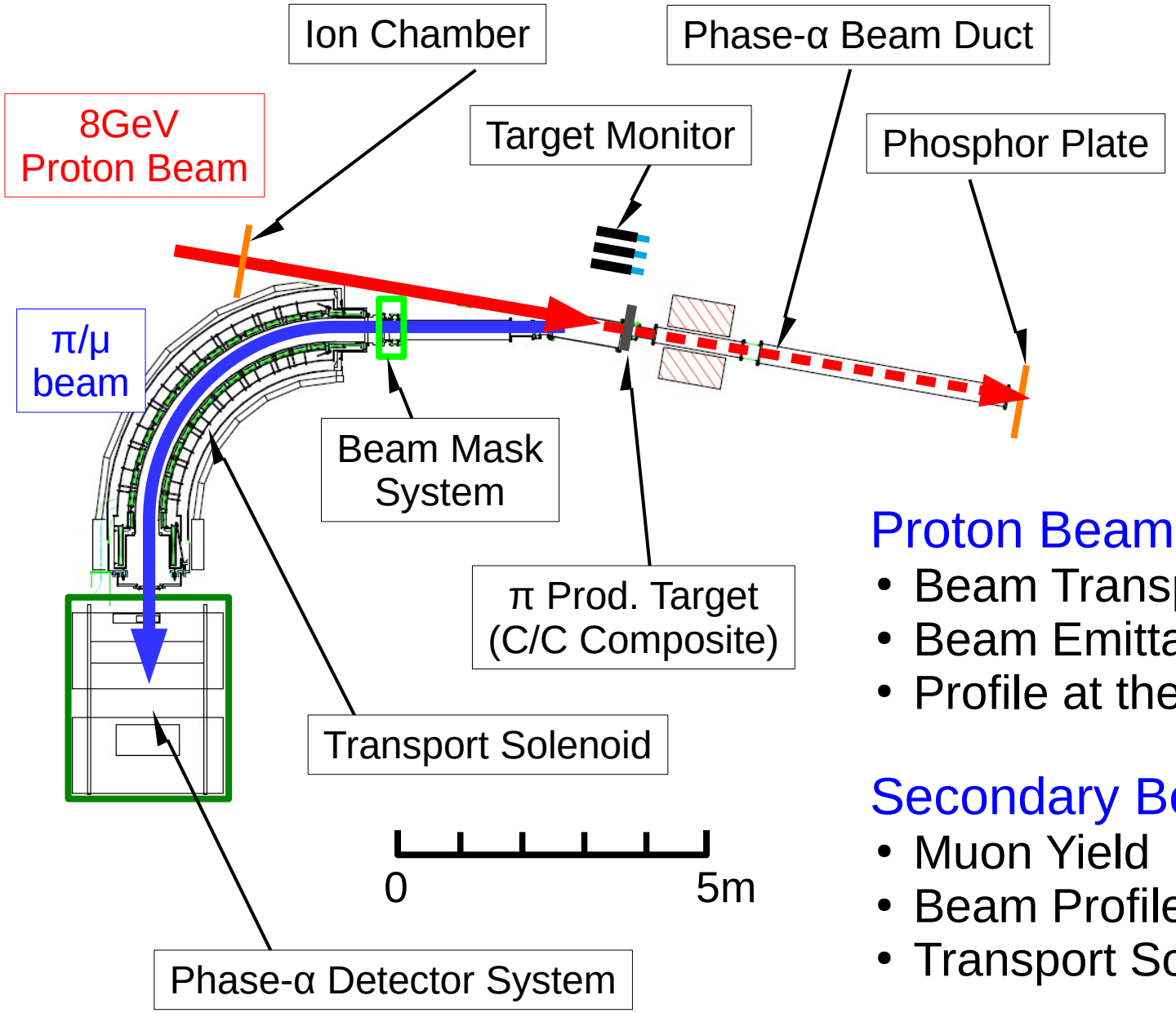
# COMET Phase-II : Final Setup




After Phase-I completed, significant upgrade is planned to achieve further sensitivity of a factor of 100.

1. Proton beam intensity will become 20 times higher.
2. Production target will be replaced to tungsten.
3. Transport Solenoid will be extended twice longer.
4. Electron spectrometer will be installed.
5. Straw tube tracker with EM calorimeter will be installed.

# COMET Phase-α : Pilot Run



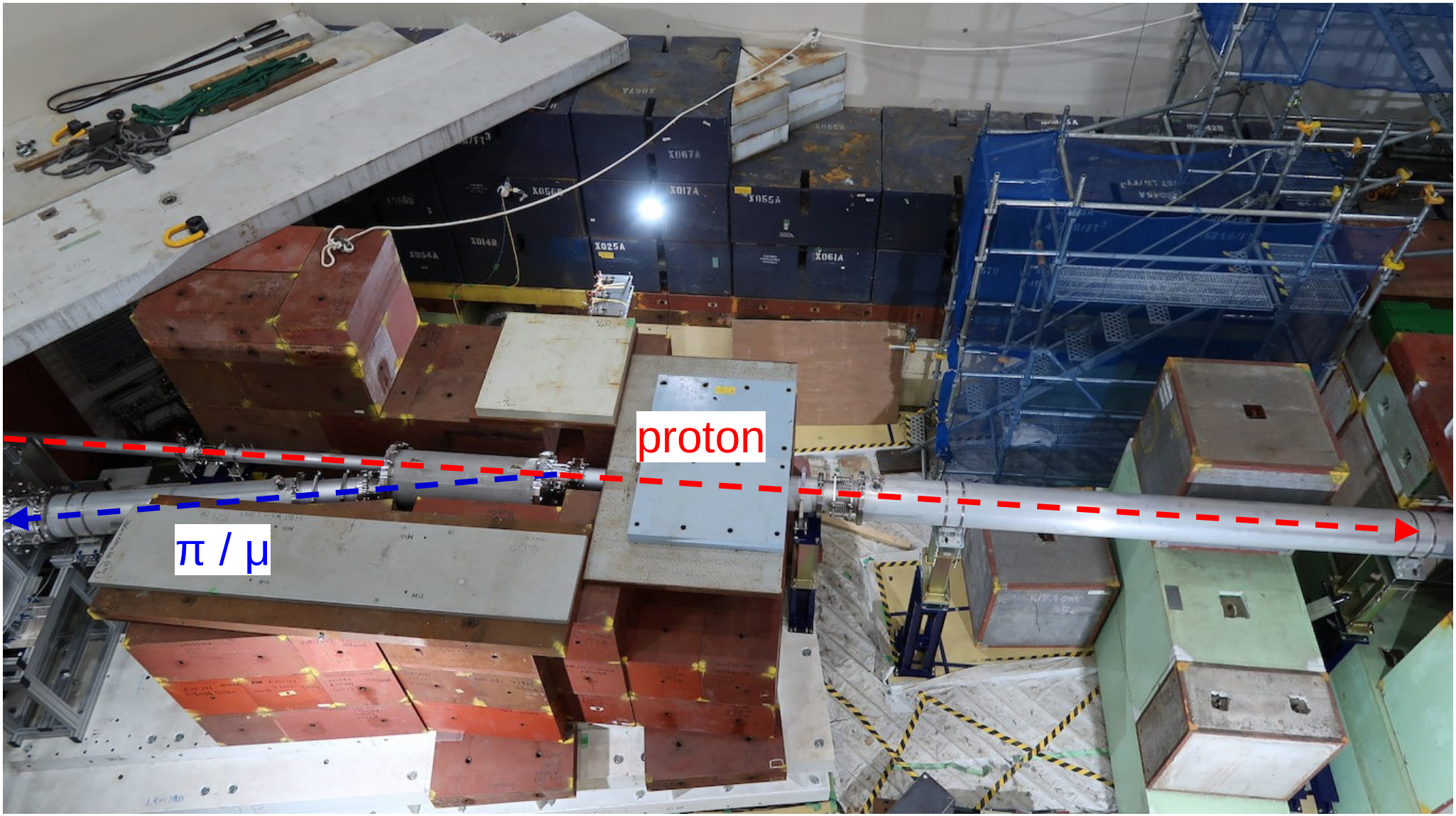

## Proton Beam Commissioning

- Beam Transportation
- Beam Emittance
- Profile at the Target

## Secondary Beam Commissioning

- Muon Yield
- Beam Profile
- Transport Solenoid Performance

# Proton Beam Commissioning



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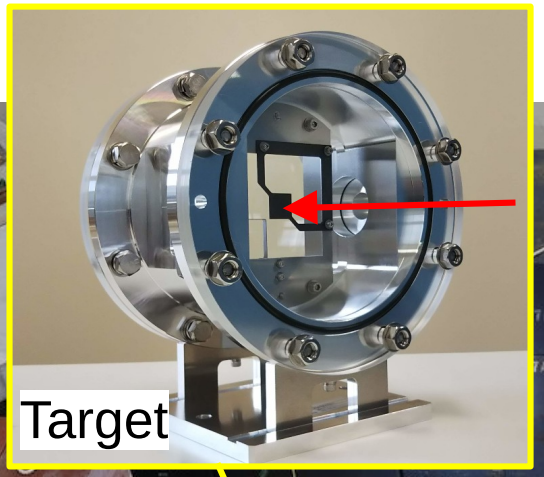
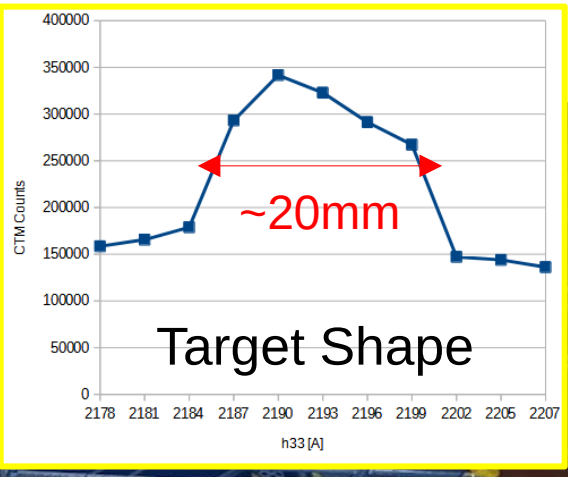
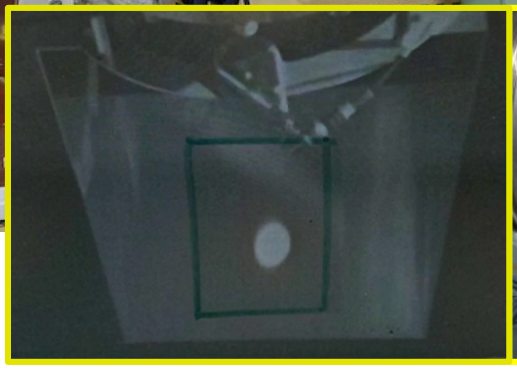


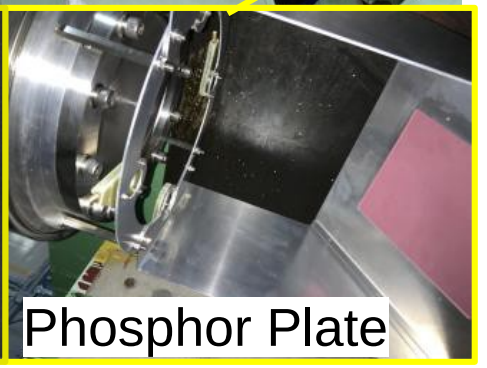




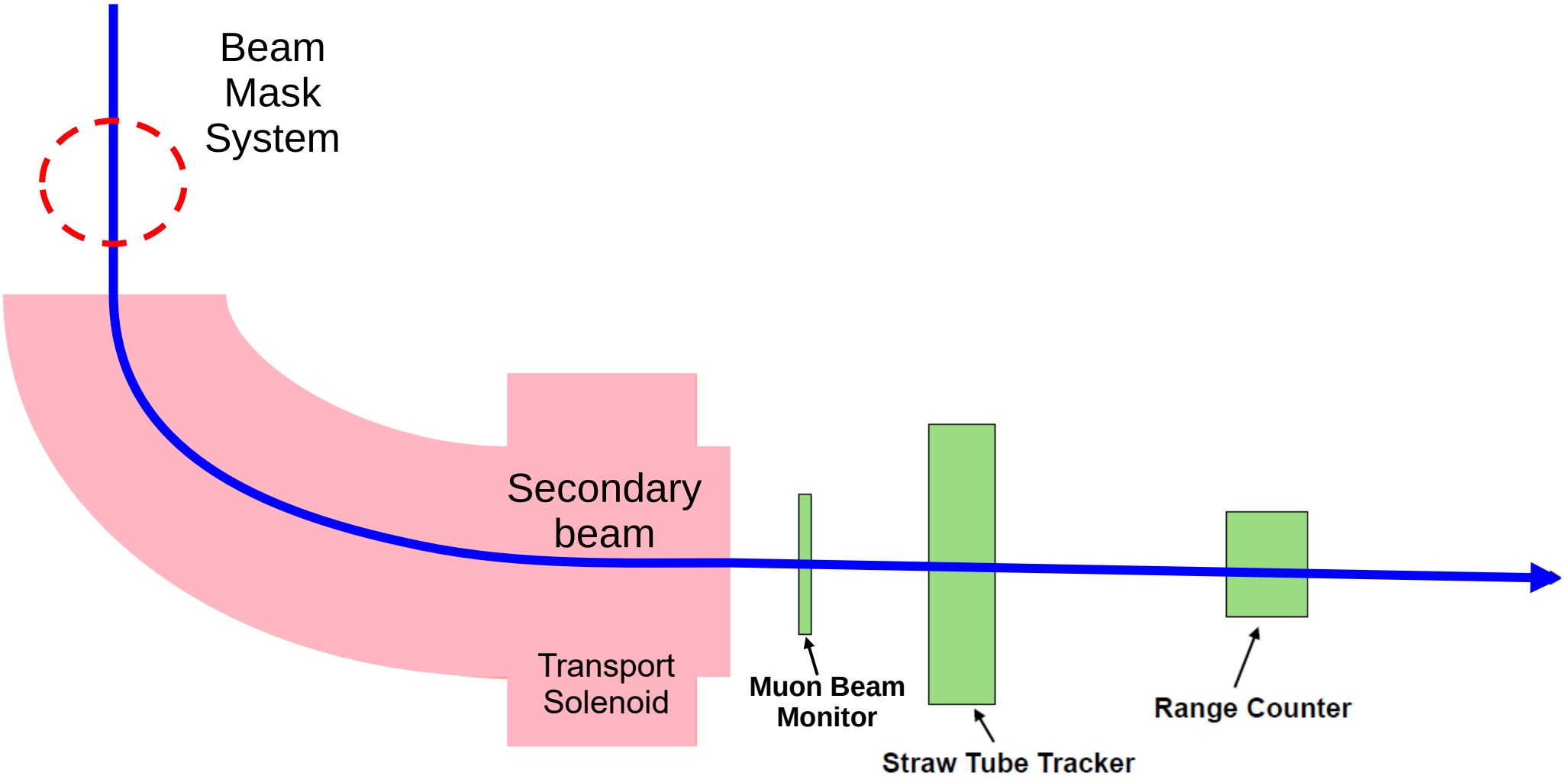

proton

π / μ



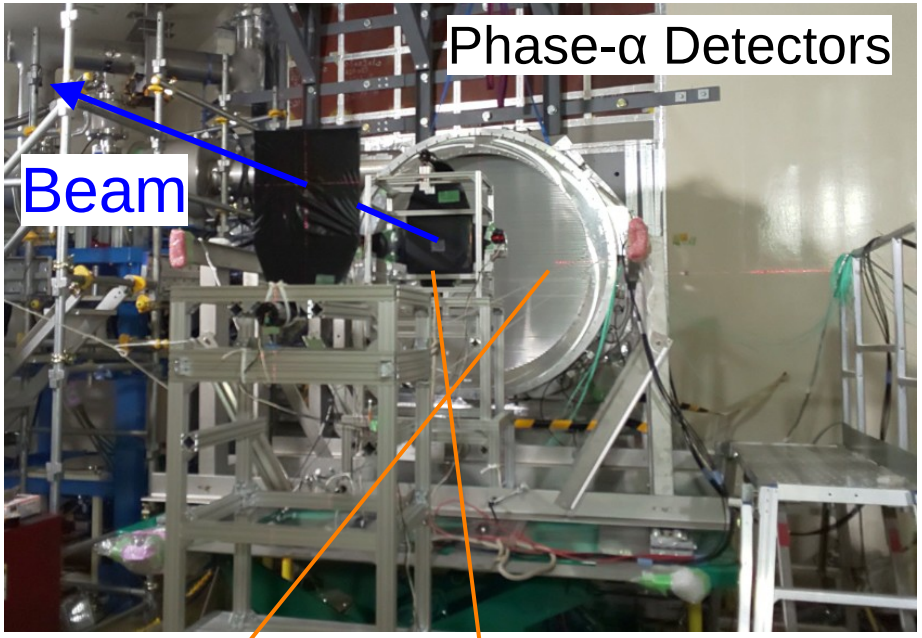
# Muon Beam Measurements

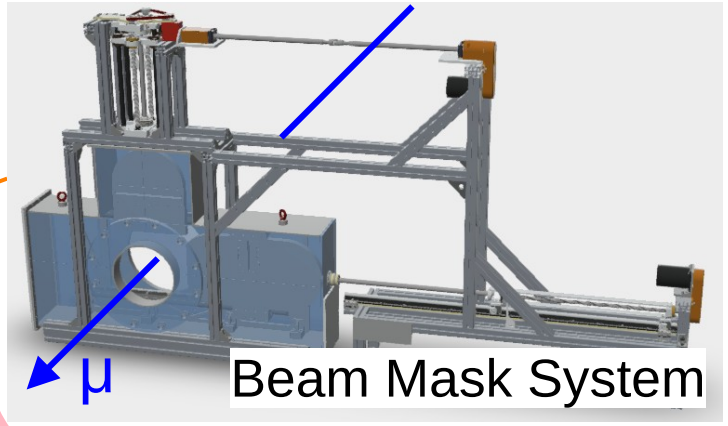



The detector commissioning was performed for ~14 days from 2/10 to 3/15.

- Muon beam profile / yield, background particles
- Transfer matrix of the Transport Solenoid

# Muon Beam Measurements





Secondary beam

Transport Solenoid

Muon Beam Monitor

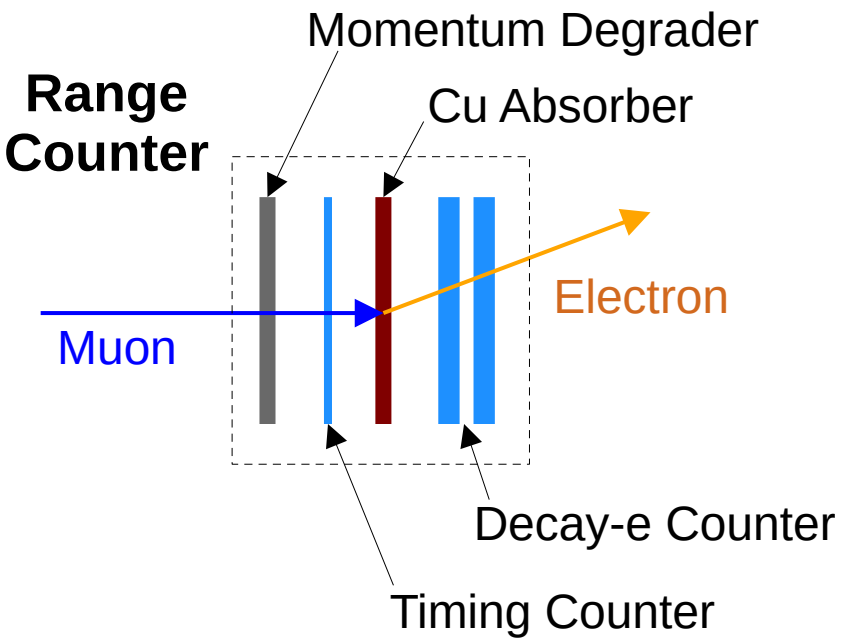
Straw Tube Tracker

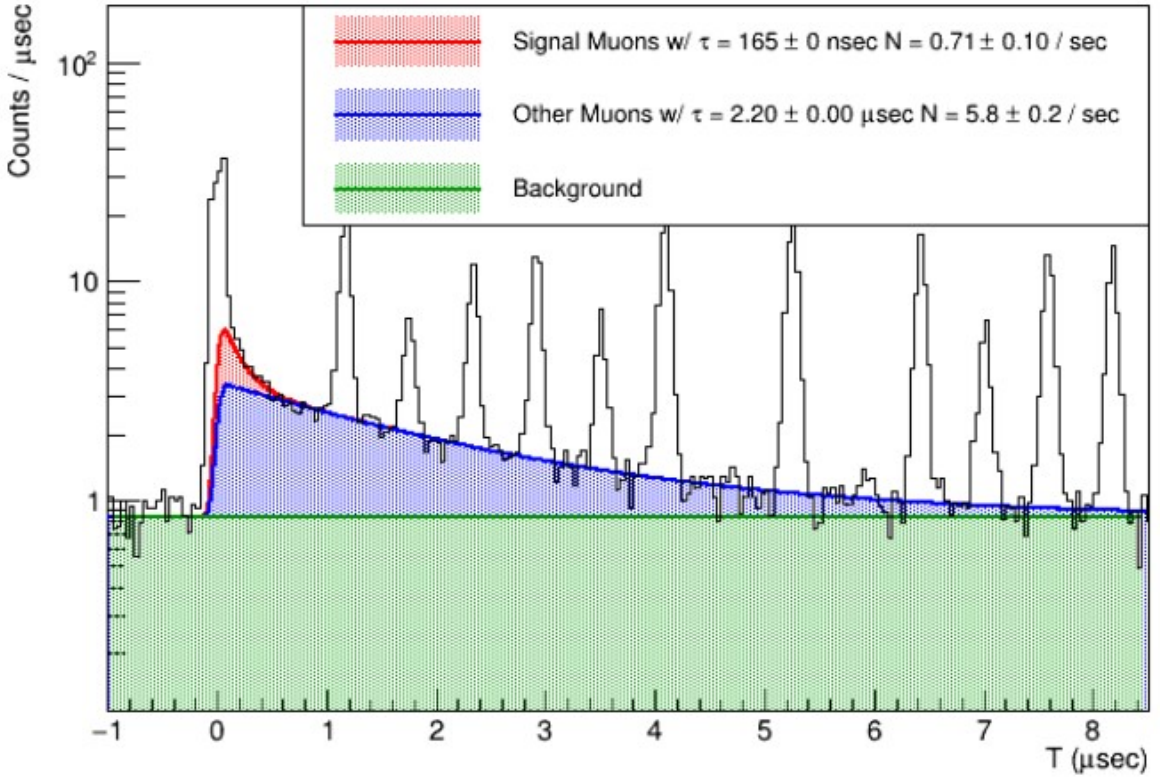
Range Counter

The detector commissioning was performed for ~14 days from 2/10 to 3/15.

- Muon beam profile / yield, background particles
- Transfer matrix of the Transport Solenoid

# Preliminary Muon Distribution



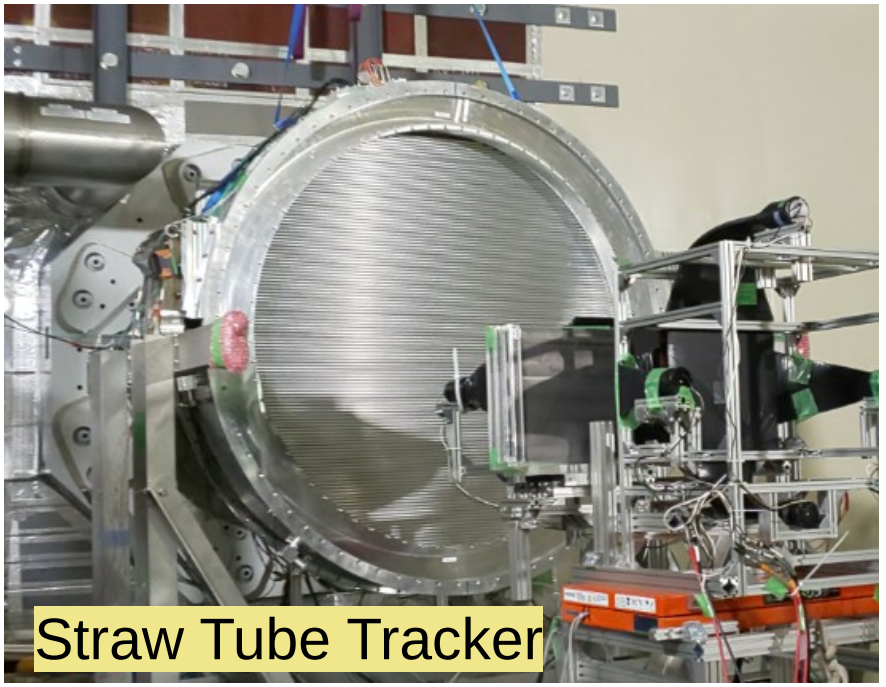




Two components of muon decay time by Range Counter appear.
- Red : Decay in Cu Absorber (~165ns)
- Blue : Decay elsewhere (~2usec)

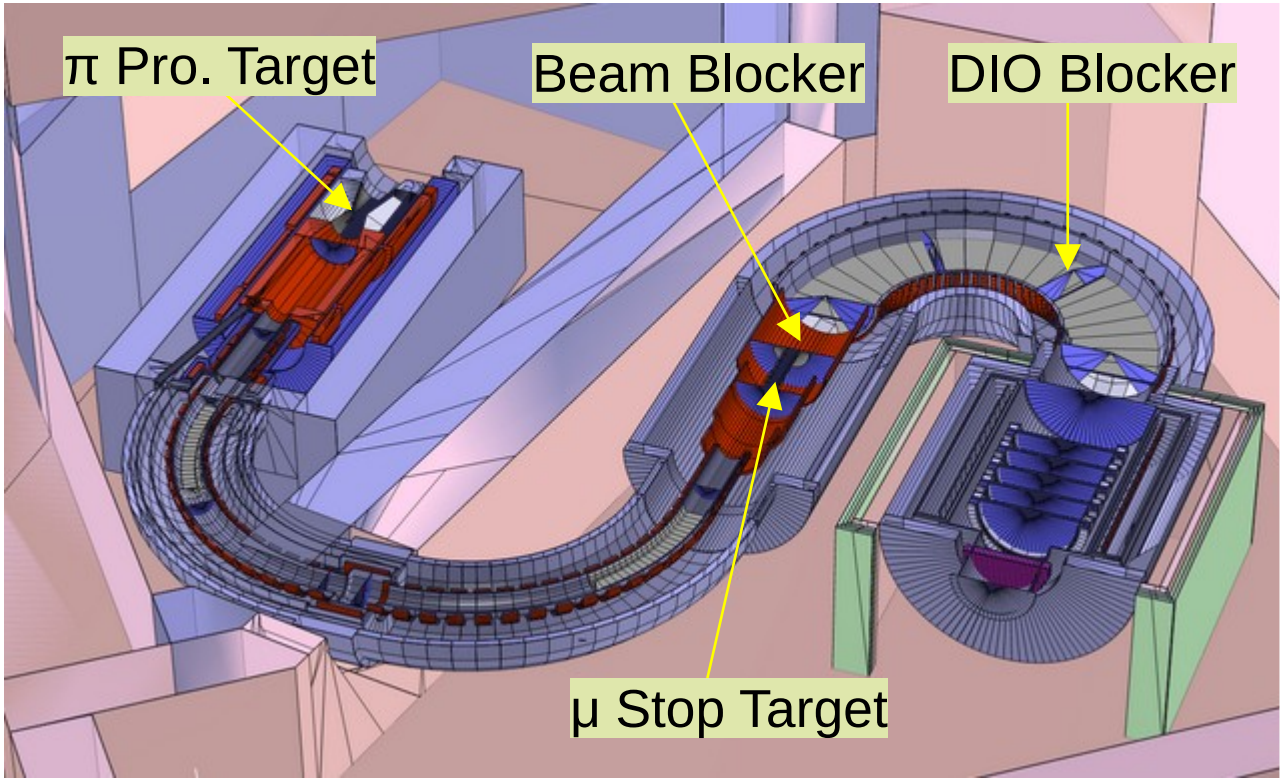
(Peaks are generated by prompt beam-related particles)

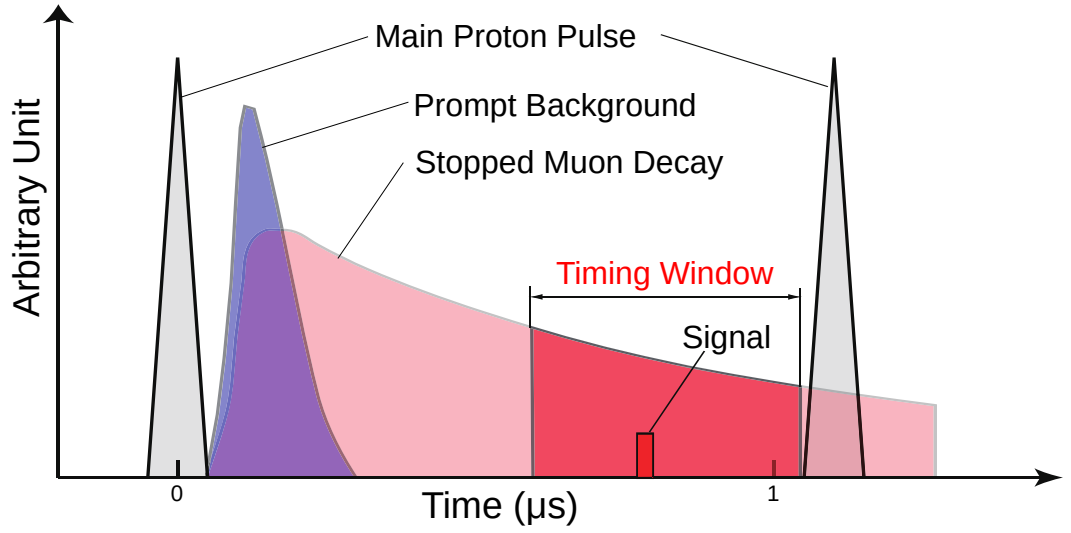
# Other Progress towards Phase-I


5T large-aperture super-conducting magnet is used to capture pions from target. Manufacturing is ongoing in a company.

# Refinement of COMET Phase-II




- Original estimation of the Phase-II sensitivity was $O(10^{-17})$. A simulation study to achieve $O(10^{-18})$ is ongoing.
  - ➔Optimize the pion production target and muon stopping target.
  - ➔Improve the geometrical acceptance of the electron spectrometer.
  - ➔Optimize timing window of the measurements.
  - ➔Keep background sufficiently low.

# Summary

- Construction of the COMET experiment is ongoing in the J-PARC Hadron Facility. COMET aims to search for the μ-e conversion that is an evidence of the new physics.
- The pilot run, Phase-α, has performed from 2/15 to 3/14 for the commissioning of the proton beam and the secondary beam.
- Development of the Phase-I Detectors are ongoing. Cylindrical Drift Chamber is in commissioning at J-PARC. The 1$^{st}$ station of the Straw Tube Tracker was installed for the Phase-α.
- Simulation study for Phase-II is ongoing to optimize the experimental setup and to obtain further sensitivity.