Muon Beam for COMET/PRISM

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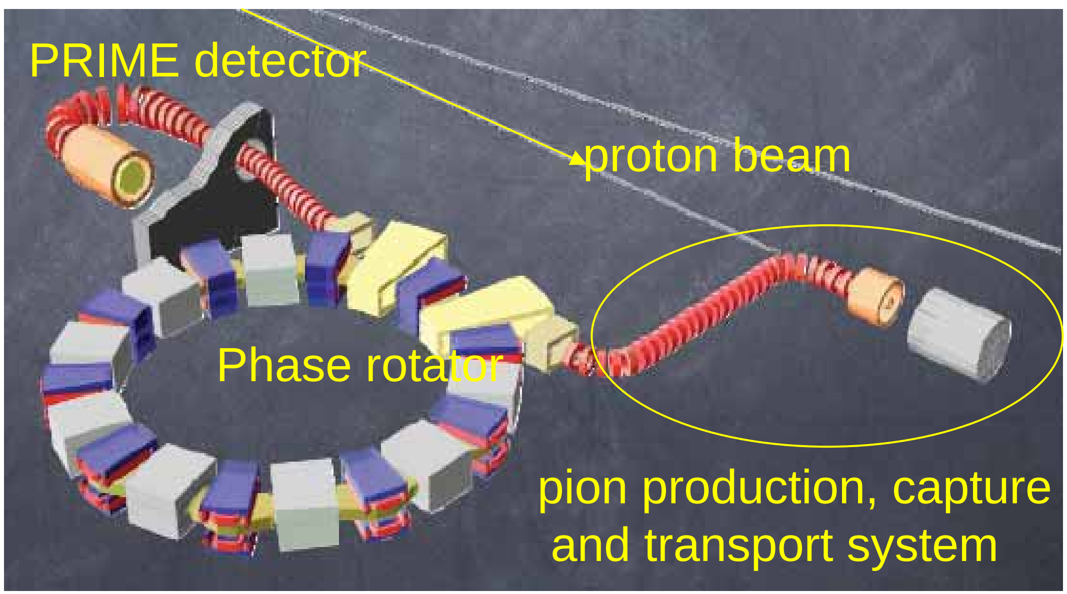
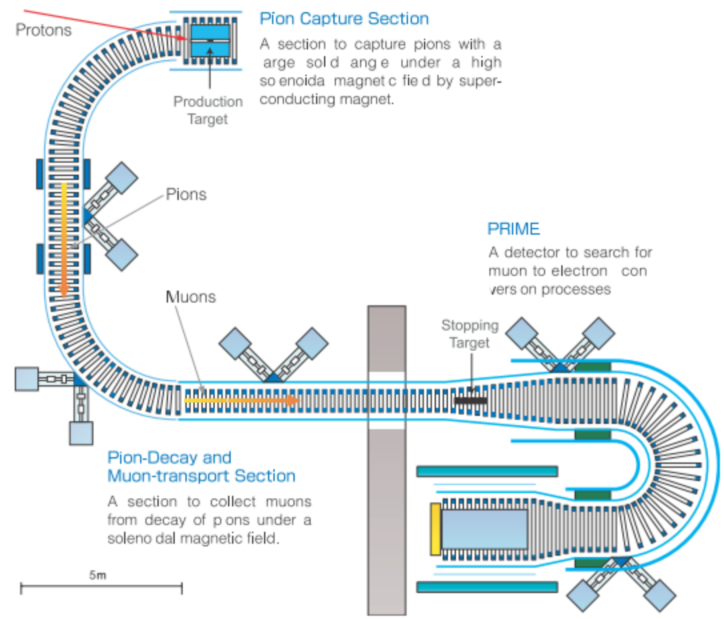
PRISM/COMET project

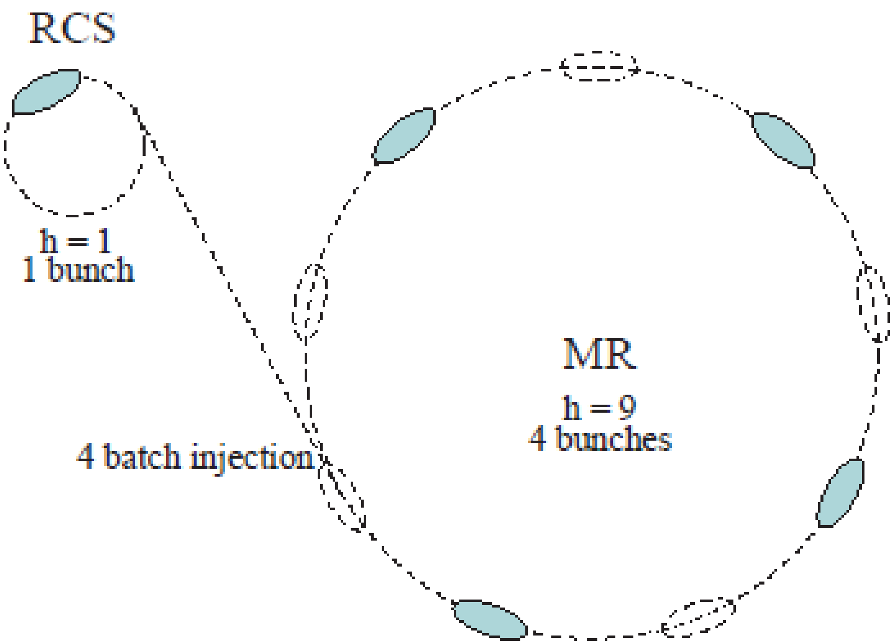
- PRISM stands for Phase Rotated Intense Slow Muon source
- Proposal of COMET was submitted to J-PARC PAC in Jan. 2008 aiming for 10^{-16} sensitivity
- Collect 68MeV/c μ^-





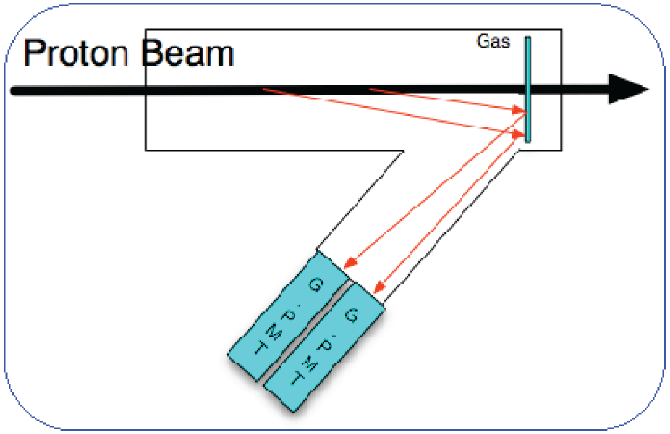
Proton Beam

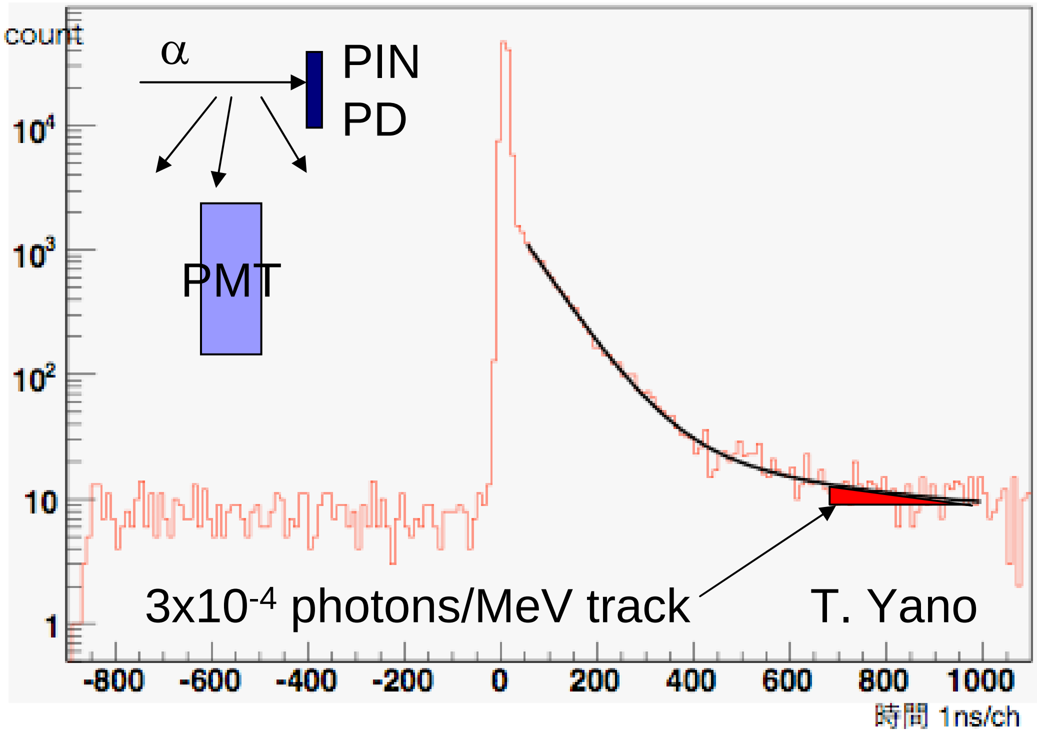
- Pulsed beam from slow extraction.
- 8GeV x 7microA
  - Total beam power is 56 kW
  - ~1/8 of the JPARC full beam power of 450 kW (30 GeVx15 microA)
- 8×10^{20} protons in total
  - 2×10^{7} sec running for a single event sensitivity $< 10^{-16}$.
- Need proton extinction by 10^{-9}
  - AC dipole in Main Ring
  - Proton monitor after extraction
  - R&D in US-Japan program



Extinction Monitor R&D

- Gas Cherenkov detector
- Monitor off-time protons in between bunches
- C2H6 (1atm) has been investigated to have enough low scintillation tail in Signal Time Window.
- R&D underway
  - High pressure situation, necessary to produce Cherenkov for 8GeV protons
  - Gating PMT
  - …



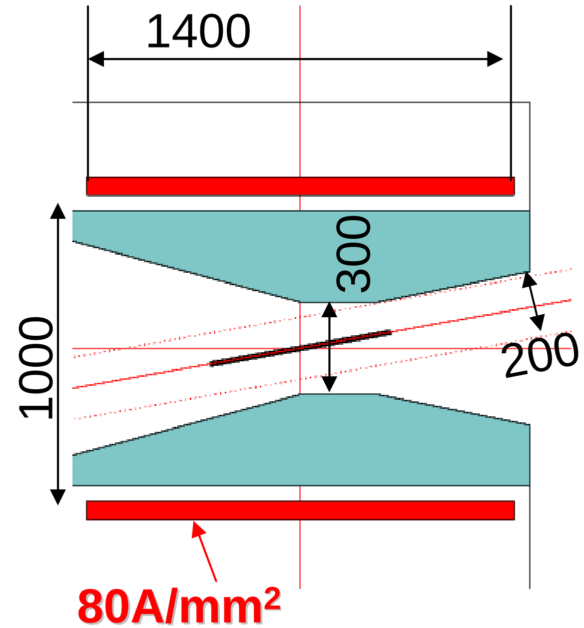


Concepts of pion capture/transport system for COMET

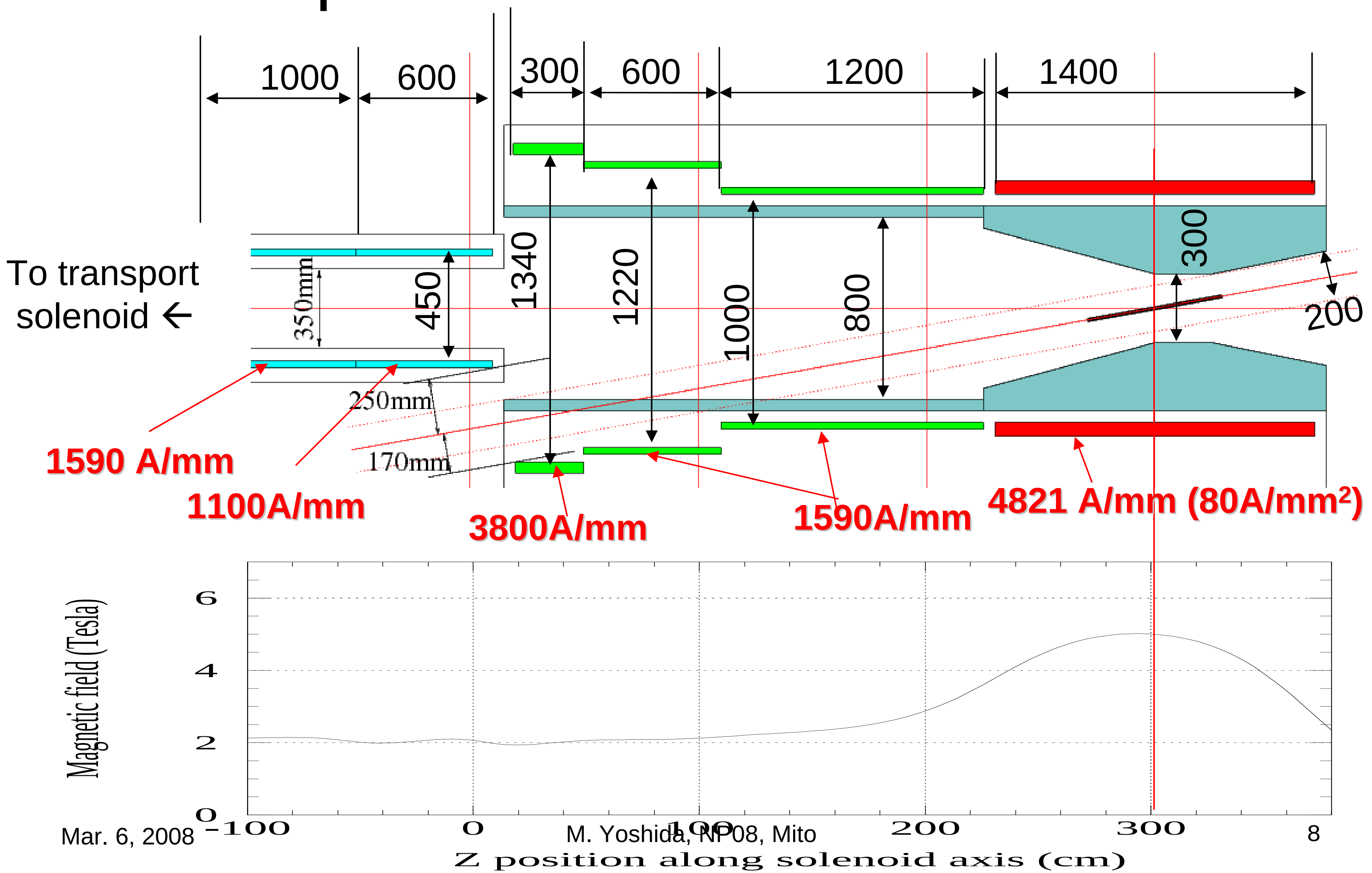
- Capture low-energy pions with 5T solenoid field
  - Low-Z material
    - Graphite
    - to avoid absorption LE pions in the target
    - large diameter can be chosen for beam steering/ support structure
  - High-Z material target
    - Tungsten
    - Large production cross section; 2 times or more yields
    - Small diameter to avoid absorption
    - Need precise proton beam steering
    - Need careful study on cooling
  - Collect backward pions from the target
  - Tilt target by 10 deg. to implement proton beam pipe
  - Energy deposit on superconducting coil of capture solenoid << 100W
  - Al-stabilized SC coil to reduce cold mass
- Transport pions+muons in long 2T solenoid channel
  - Bent solenoid channel
    - Target should be off-site from experimental area
    - Reduce background by wiping out higher energy particles

Pion Capture Solenoid

- Radiation Shield
  - need thick shield to reduce radiation on SC conductor
  - 30cm-thick Tungsten around the target
  - keep 20cm space along beam axis
    - beam steering
    - HE particles escape forward
- Dimensions
  - Coil should have enough length for large bore
  - Length: 1.4m
  - Coil Diameter: 1m
  - 1-ton coil mass
- Achieve 5T on Target
  - by stacking only 2 layers of SC conductor
  - 80 A/mm^2 with 60 mm thickness
  - Load line ratio = 0.63
- Stored energy = 12 MJ

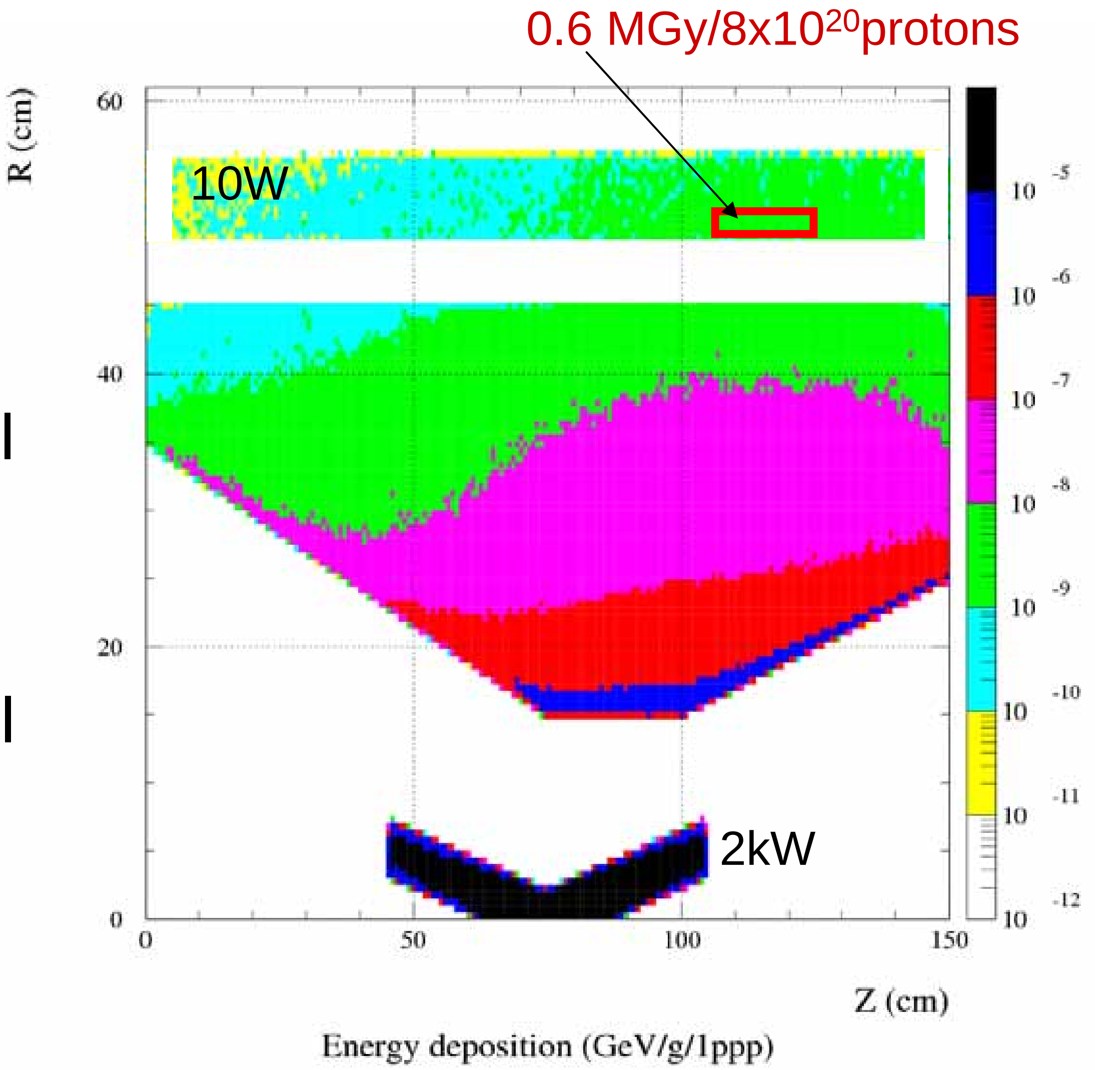


Pion Capture Solenoid

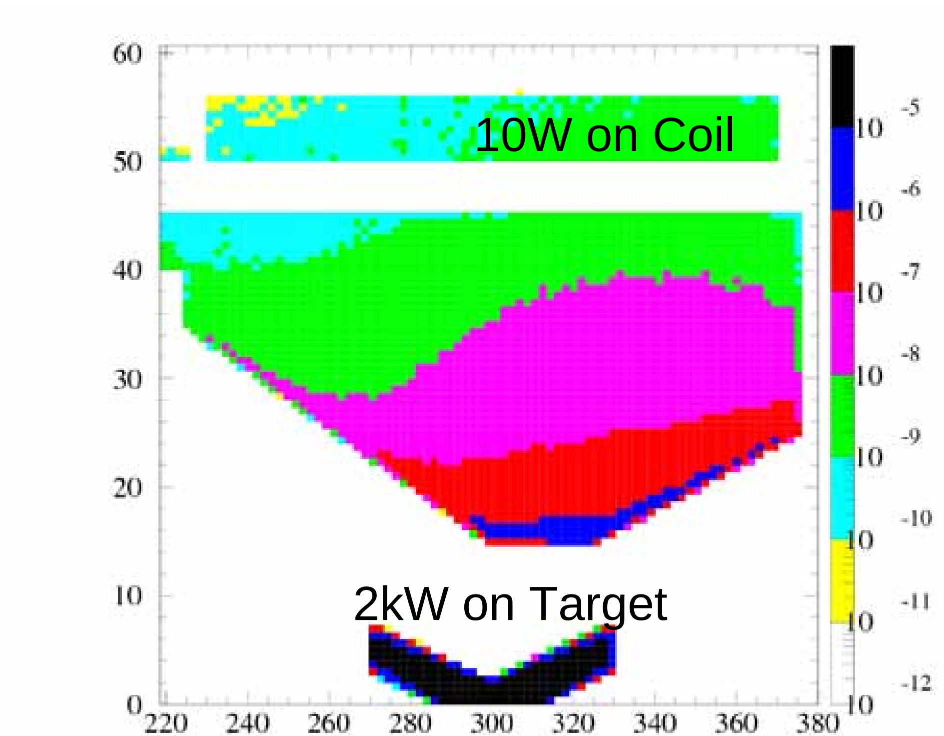


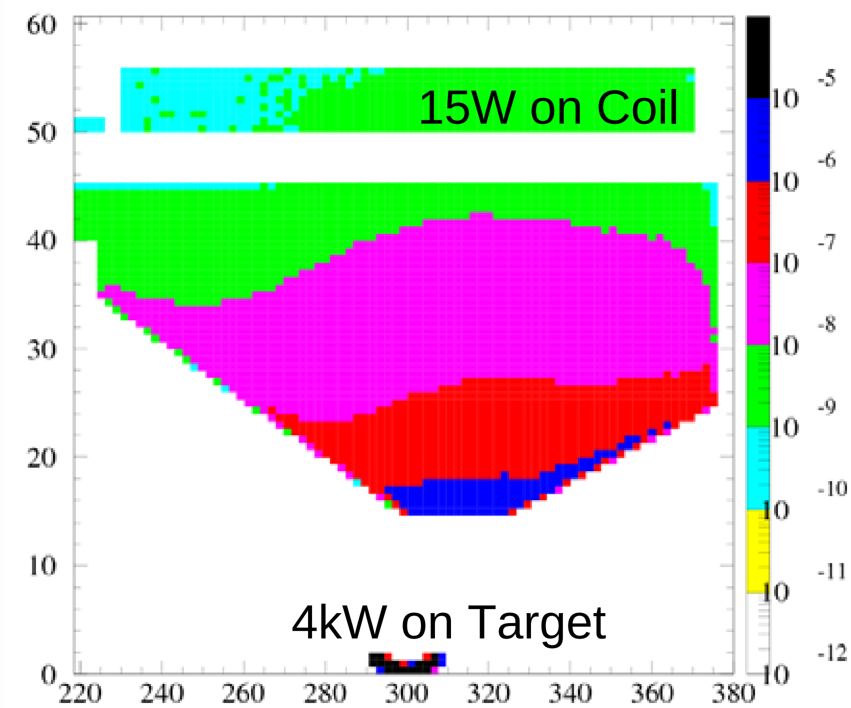
Heat load on capture solenoid

- Superconducting coil
  - Density: 4g/cm^3
  - 6cm thick (50cm<R<56cm)
- Energy deposit on coil
  - 2x10^{-5} W/g for 8GeV x 7microA
  - 10 W in total
- Radiation dose on coil
  - 0.3 MGy for 4x10^{20} protons



Heat Load with Tungsten Target

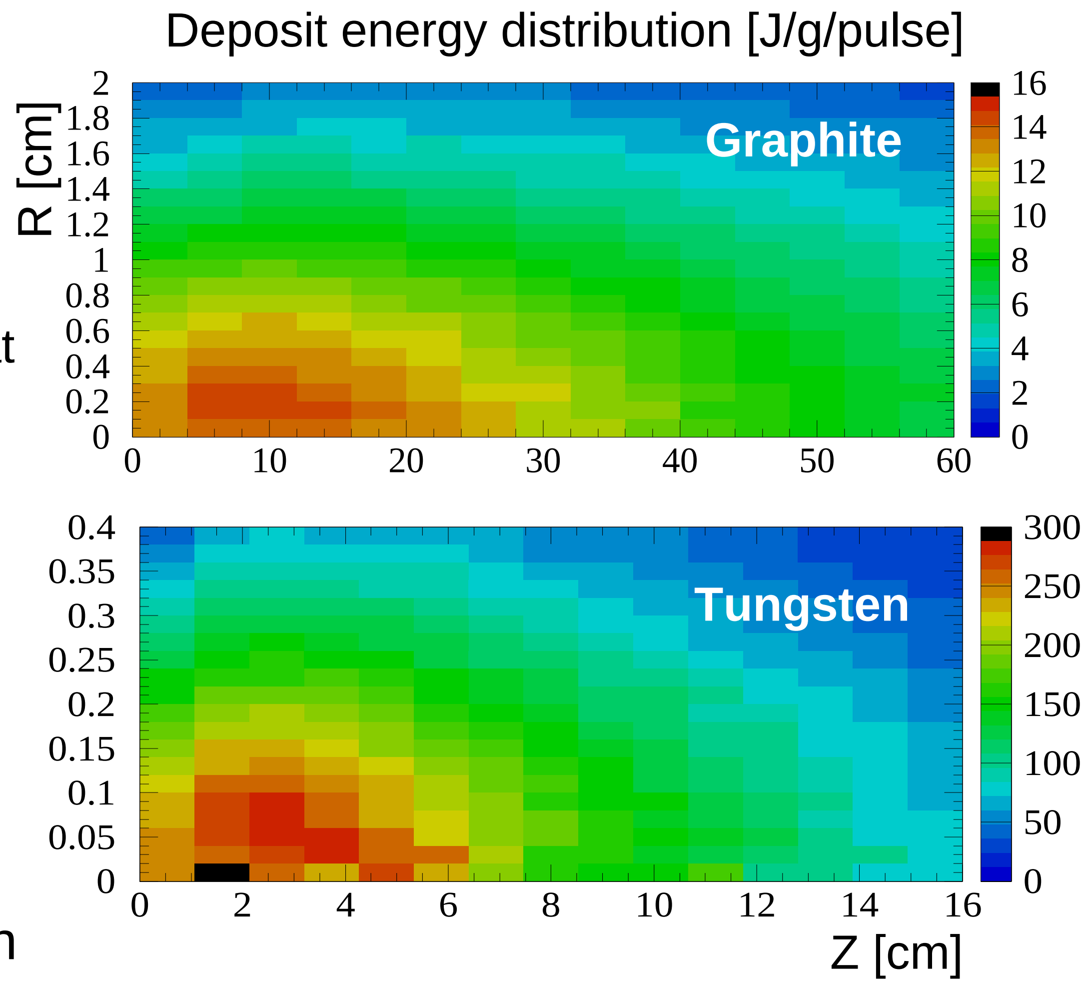




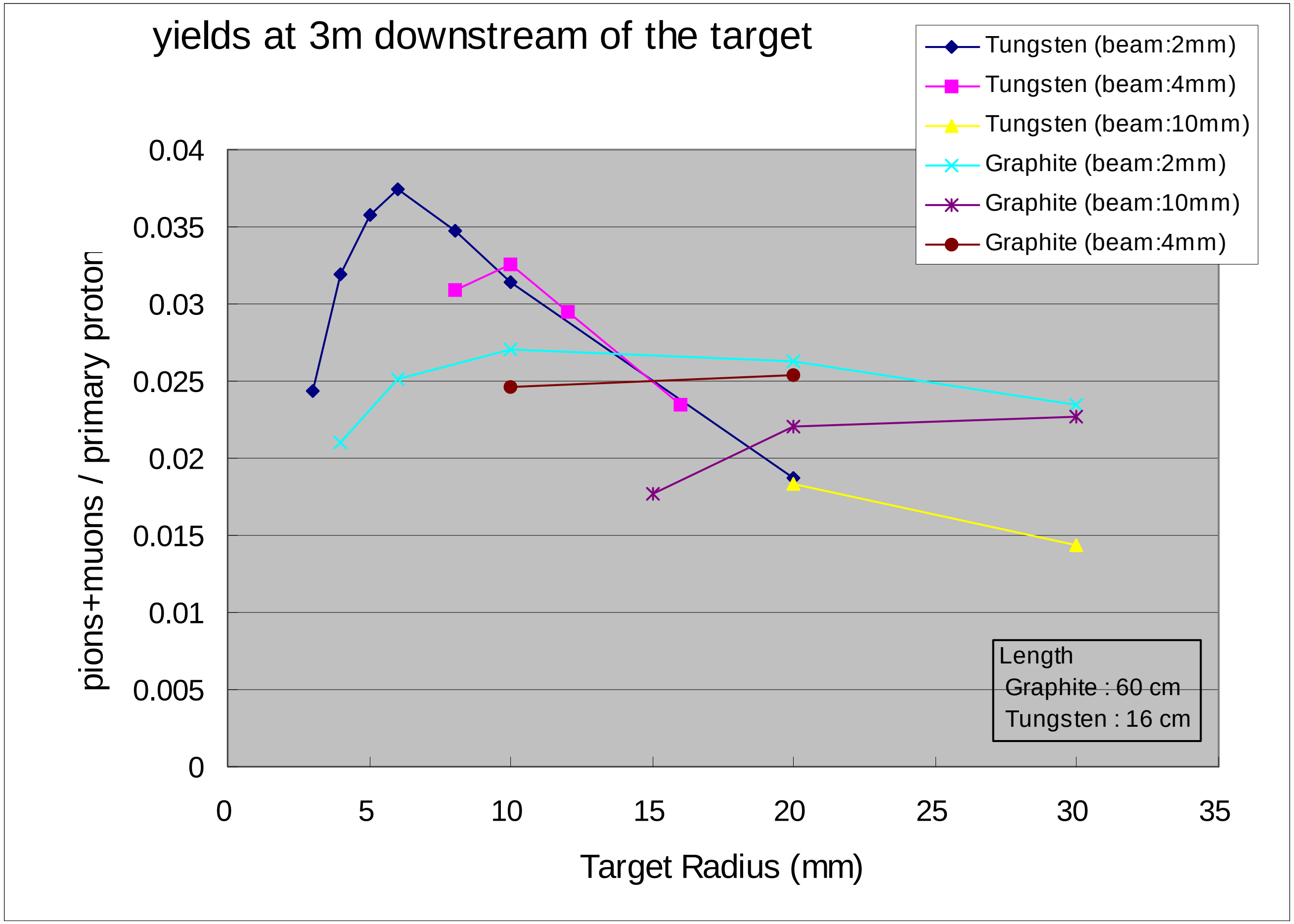
- No significant difference on Coil

Temperature Rise in Target

- Graphite target
  - Length: 60cm
  - Diameter: 4cm
  - Maximum : 15 [J/g]
    - DT = 23 K, if no heat transfer
  - Gas He cooling
- Tungsten target
  - Length: 16cm
  - Diameter: 0.8cm
  - Maximum : 280 [J/g]
    - DT= 2200 K , if no heat transfer
  - Need careful calculation and design cooling mechanism

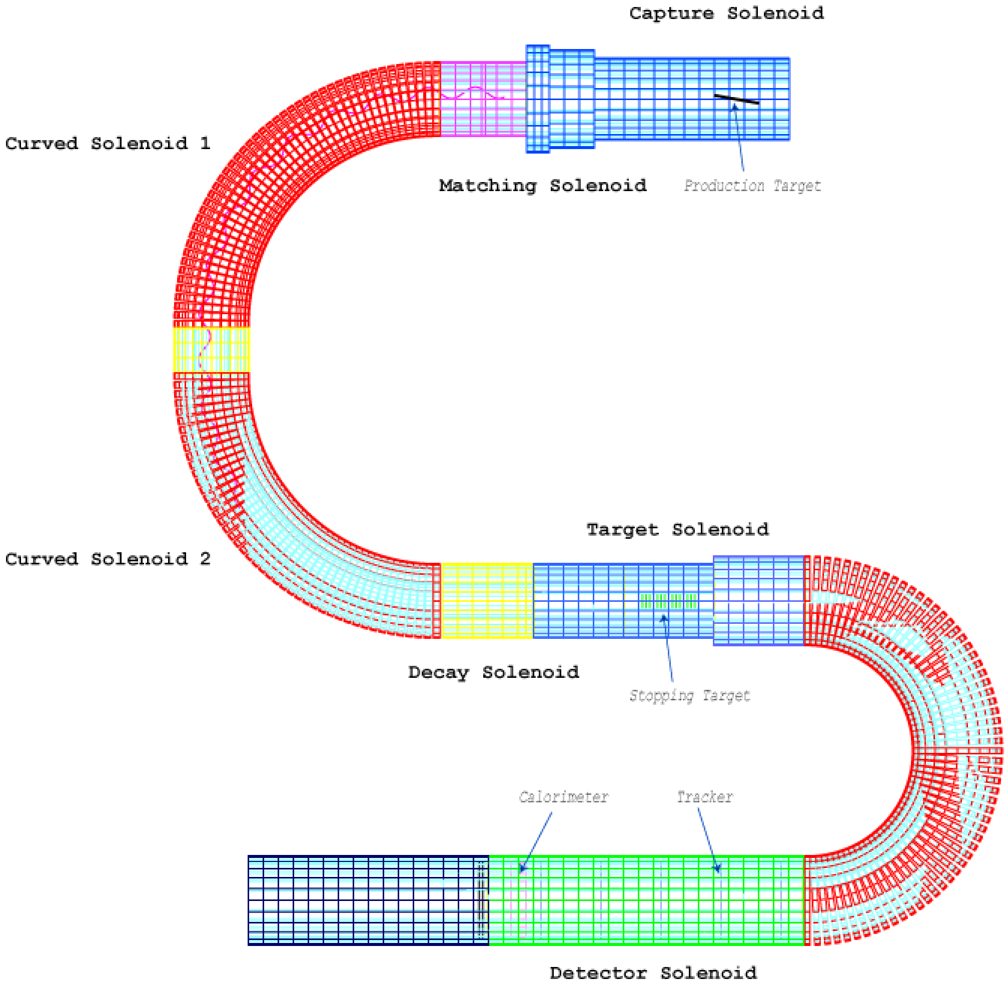


Yields at Capture Solenoid Exit

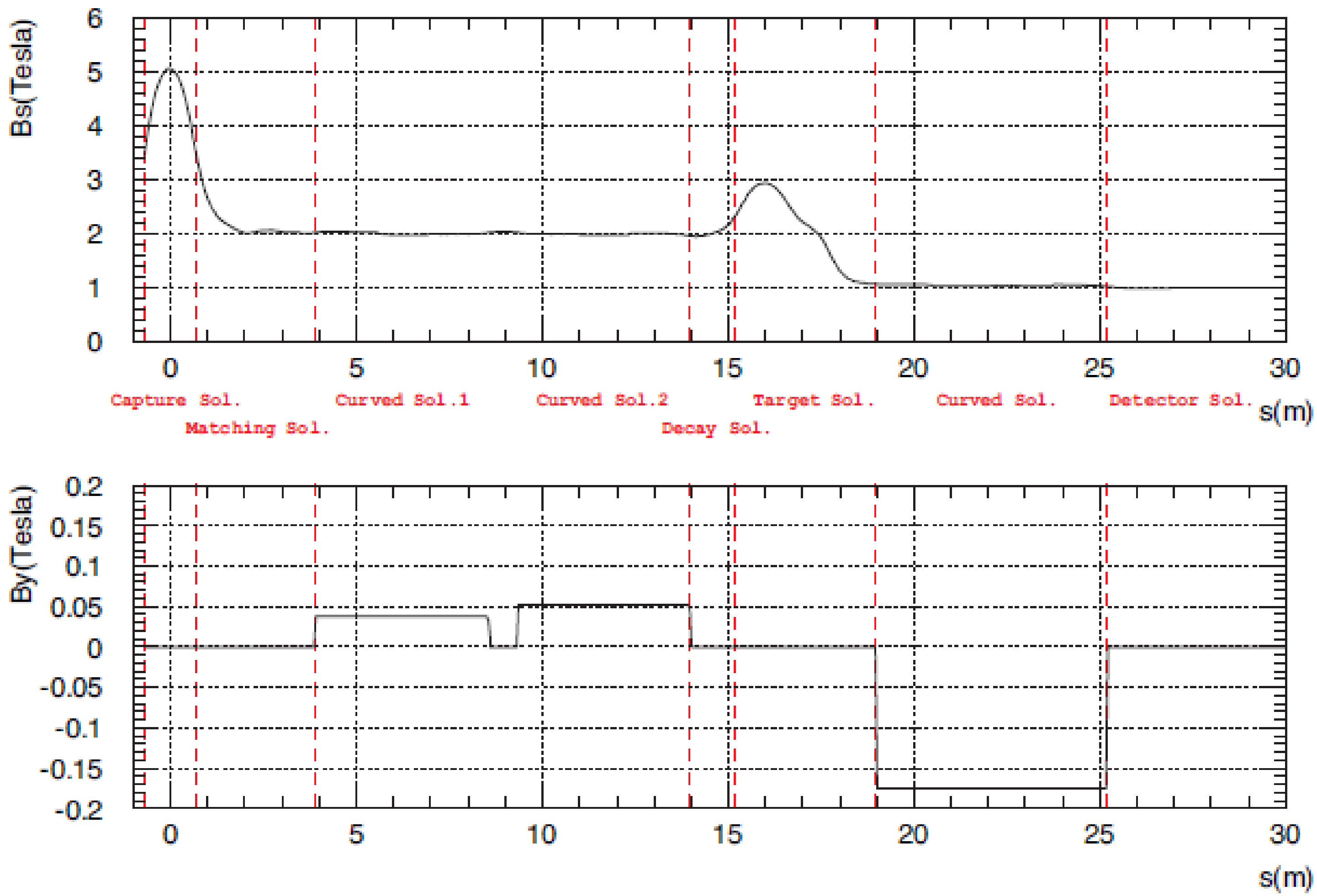


Superconducting Solenoid System

- Long enough for pions to decay to muons
  - 20 meters => Psurvive=$2x10^{-3}$
- high transport efficiency
  - inner bore = 35cm
  - $P\mu \sim 40$ MeV/c
- Negative charge selection
- Low momentum selection
  - $P\mu<75$ MeV/c

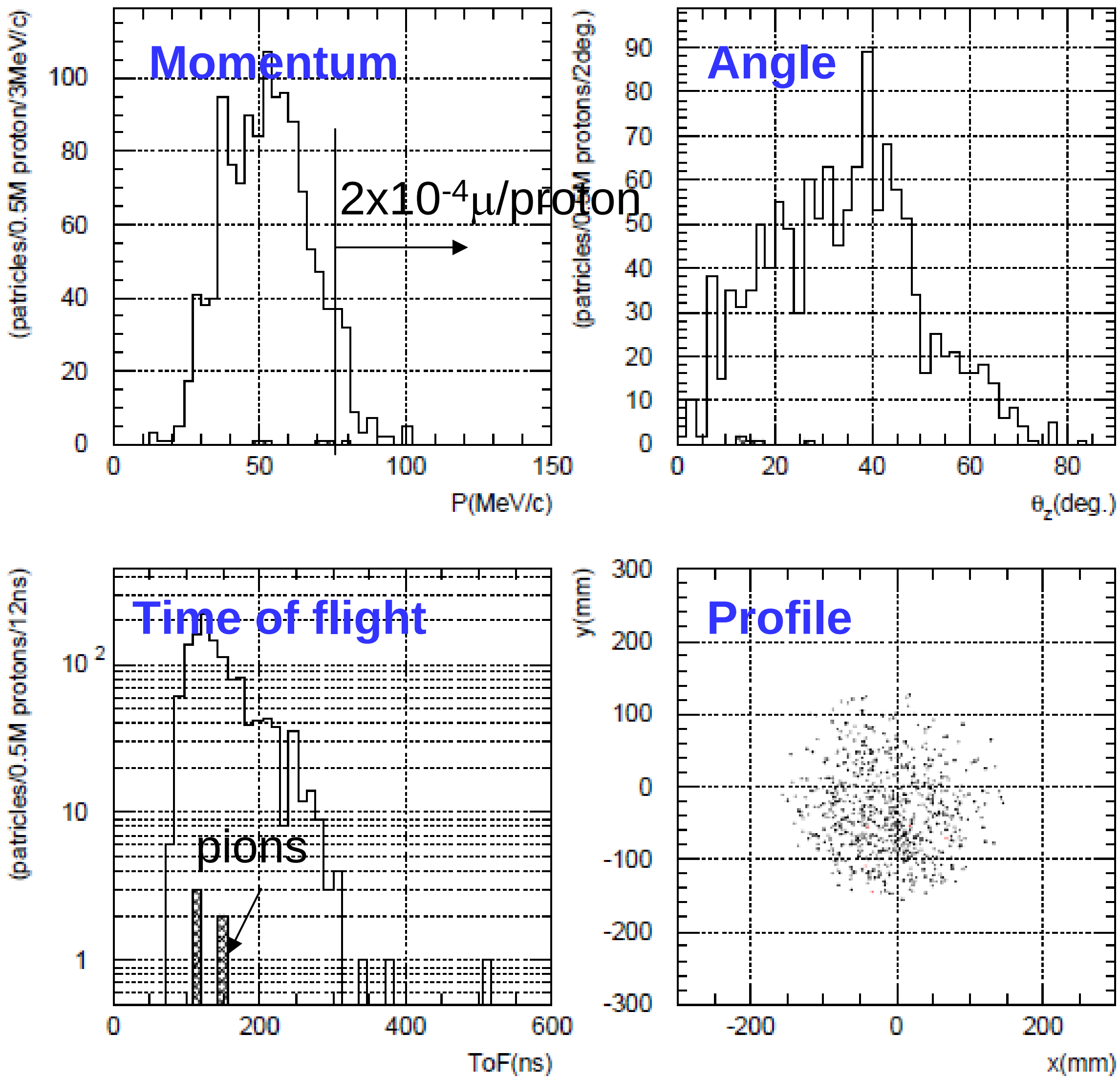


Magnetic field profile



Muons at the end of decay solenoid

- Graphite target case
  - # stopping muons / proton = 0.0007
  - 5.6×10^{17} muons for 8×10^{20} protons
- Tungsten target case
  - # stopping muons / proton = 0.0018
  - 1.4×10^{18} muons for 8×10^{20} protons



Summary

- Preliminary design study of pion capture solenoid and transport bent solenoid for PRISM Phase-I is presented.
- Capture solenoid can be constructed with Al-stabilized superconducting coil
  - 5 Tesla
  - Large bore with thick radiation shield inside
  - Heat deposit on coils can be reduced to 10 W-15W, at 8 GeV proton injection, with 56kW beam power
- Long decay/transport solenoid is designed
  - 2 Tesla, >15meters
  - Bent to reject high energy muons --> slant coil winding
  - keep high transport efficiency for low energy muons
- Temperature rise of target is estimated
  - Graphite target can be cooled by He gas flow
  - Need R&D on Tungsten target
- We will continue to make studies for realistic target cooling mechanism and maintenance scheme.