Muon channel at RCNP: the MUSIC project

Makoto Yoshida, Osaka Univ.

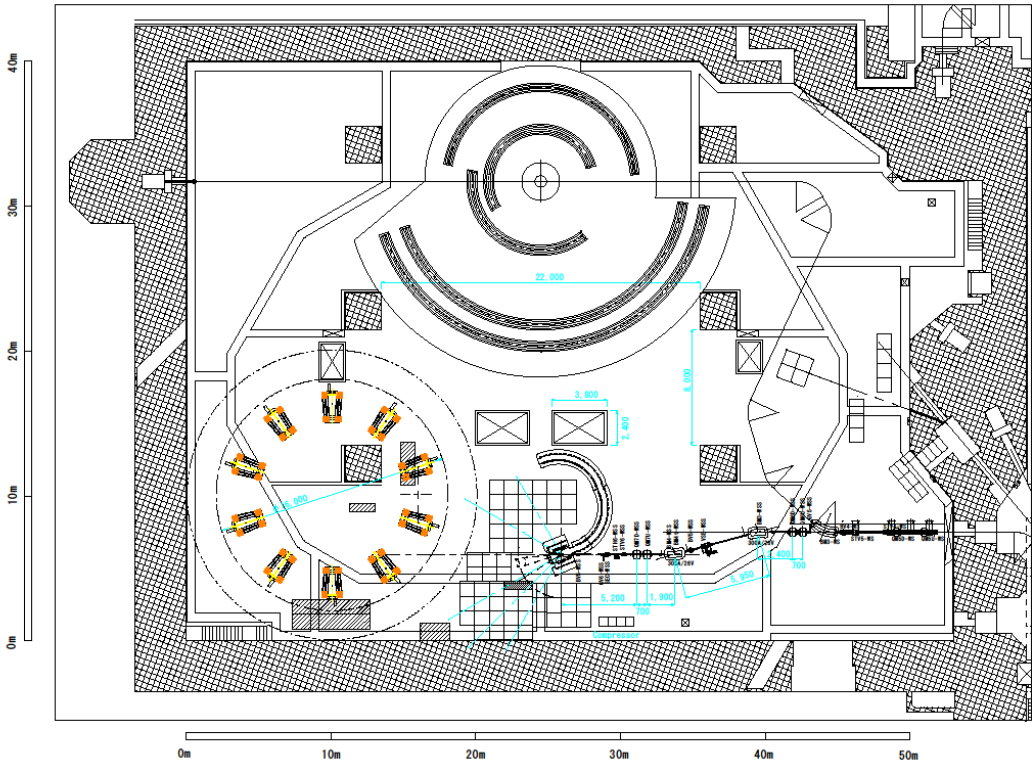
NuFact09, Chicago
22 July, 2009

The MUSIC project

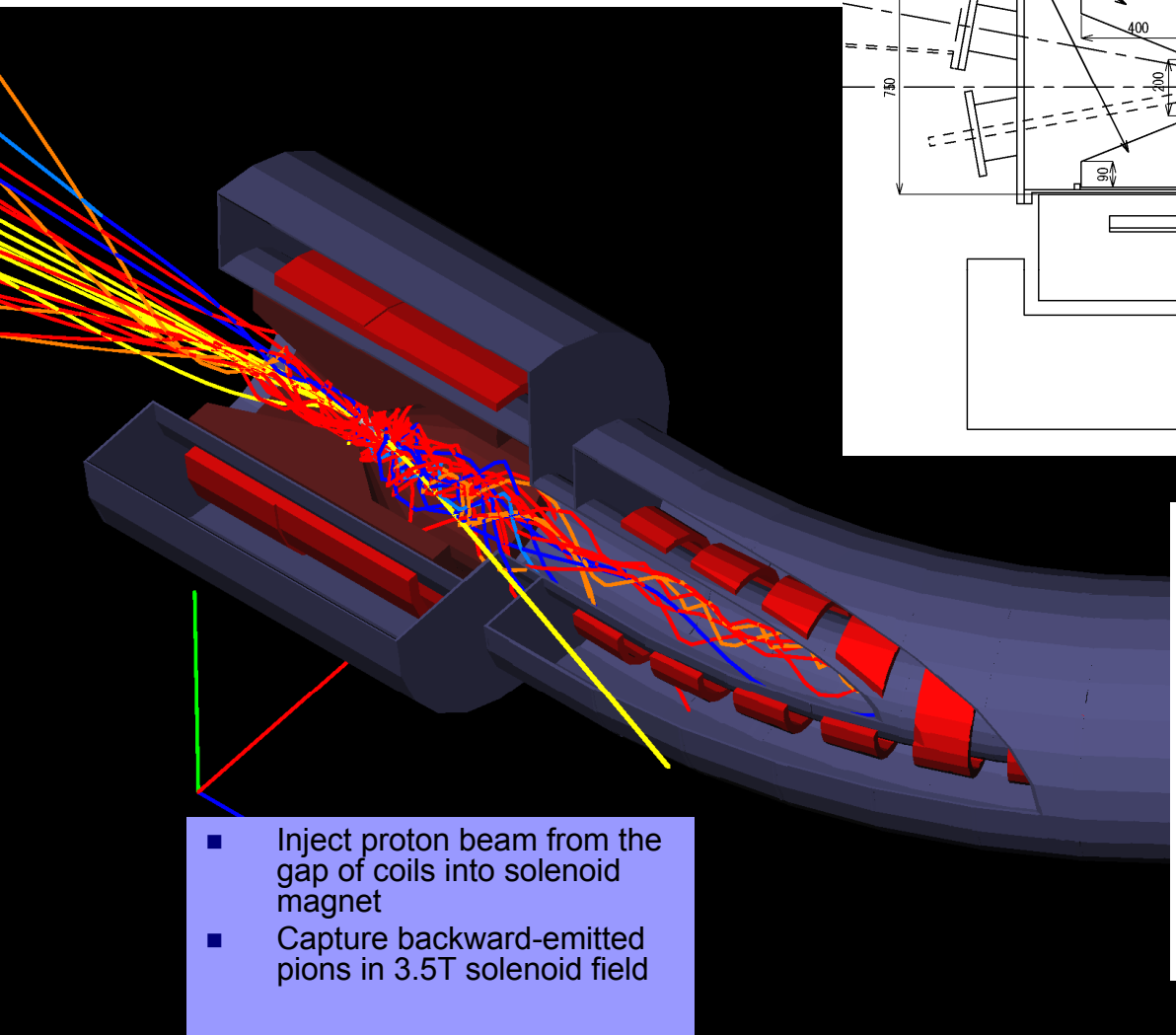
- MUon Science Innovative Commission
- Muon channel at RCNP, Osaka Univ.
- Science using muons
  - Material science
  - Muon physics
  - R&D on muon accelerator
- Cyclotron proton beam produce pions in graphite target
- Large pion-capture solenoid surrounding target can collect pions in large solid angle
- Long bent transport solenoid can select charge and momentum, and also reduce background
  - Provide positive and negative muons on demand by flipping correction field
- All the superconducting solenoid magnets are cooled by cyocooler for easy operation

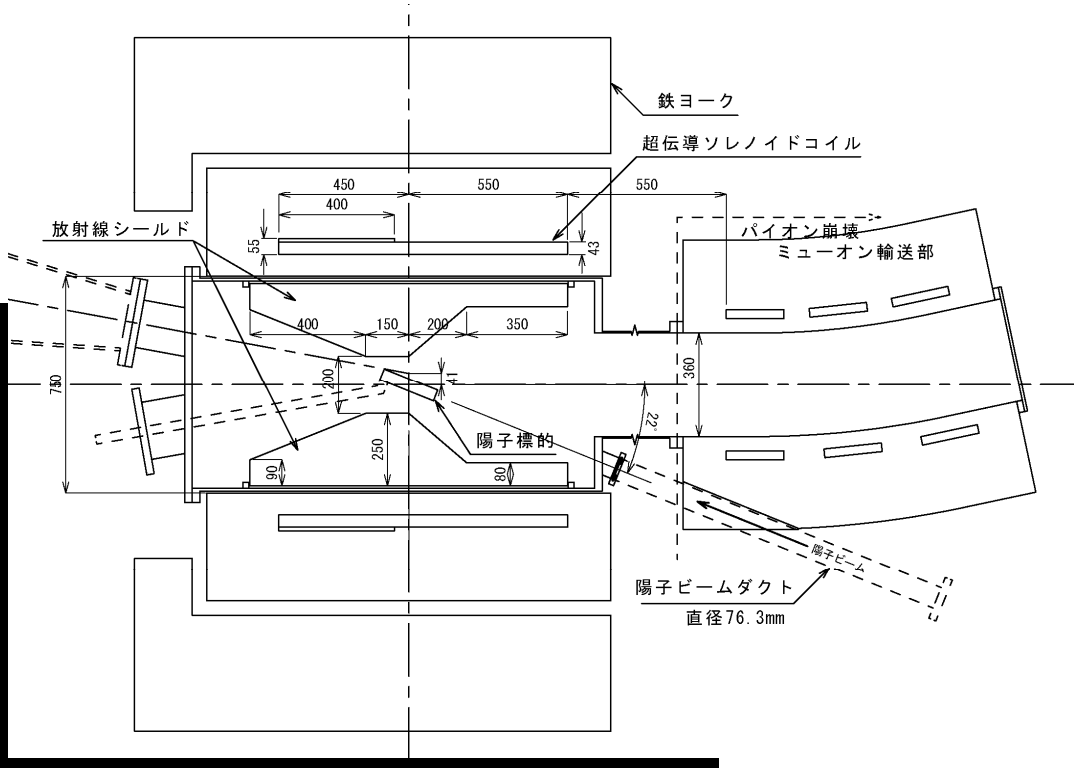
MUSIC at RCNP

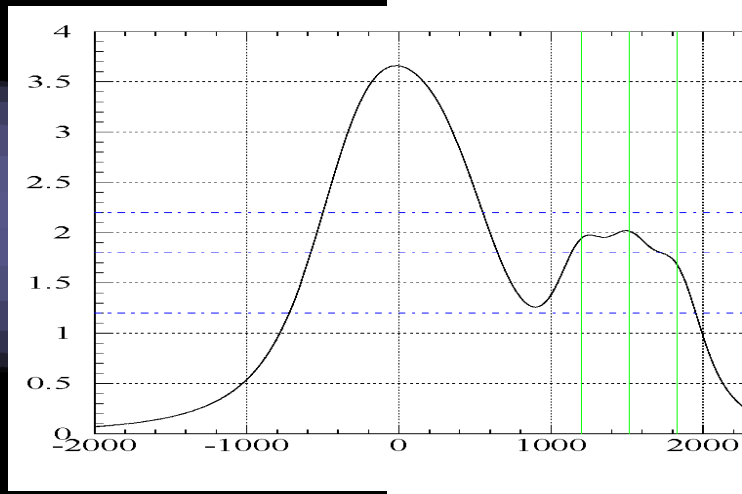
- Proton beam
  - 400 MeV cyclotron
  - 1microA DC
- Pion production target
  - Graphite
  - 40mm dia. x 200mm len.
  - rad. cooling; temp. rise ~300K
- Pion capture solenoid
  - 3.5T superconducting solenoid
  - Cu-stabilized NbTi wire
  - Coil aperture ~ 900mm dia.
  - 27cm-thick radiation shield insic
- Transport solenoid
  - 2T superconducting solenoid
  - additional dipole coils
- Phase rotator
  - PRISM-FFAG
  - Compress momentum spread



Pion Capture System



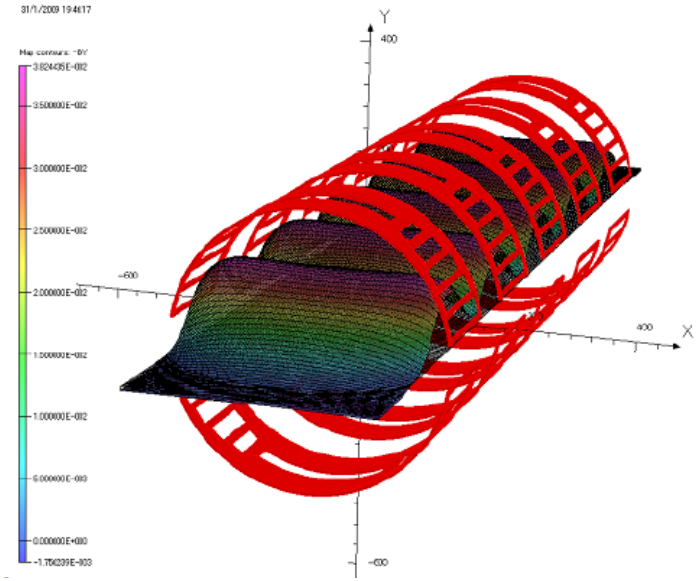




- Inject proton beam from the gap of coils into solenoid magnet
- Capture backward-emitted pions in 3.5T solenoid field

Vertical dipole field in transport solenoid

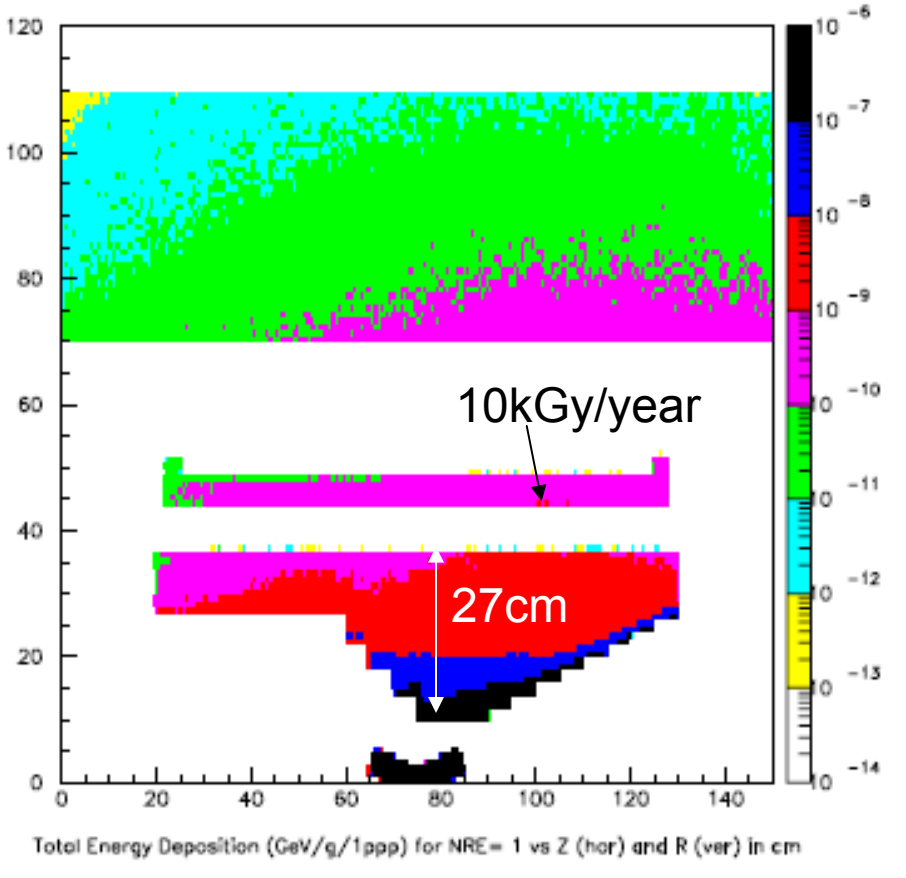
- Correct drift of helical trajectory in toroidal solenoid magnet.
- Dipole coil can reverse vertical field
  - can select opposite sign particles
- Dipole coil can control field strength
  - can select target momentum
- Dipole SC coil is installed together with each coil element of transport solenoid

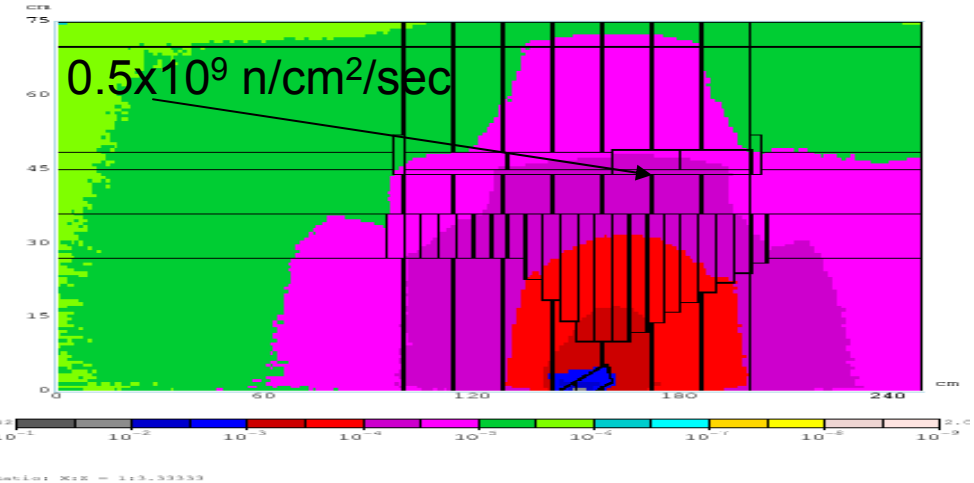


Radiation on pion-capture system

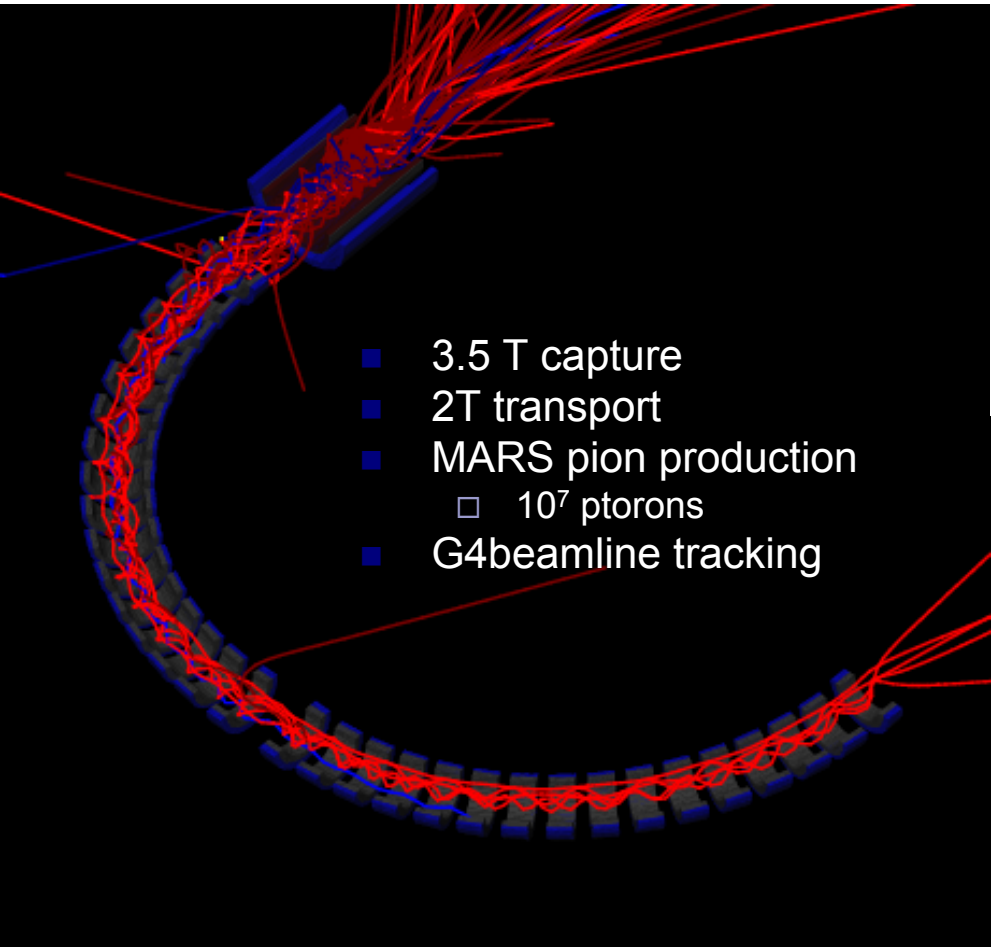
- MARS calculation for 400MeVx1microA proton beam
- 27cm SUS shielding
- 0.6W heat deposit in cold mass
  - 0.4W in coil (~1ton)
  - 0.2W in coil support
- 100W in target (Graphite)
- 50W in radiation shield (SUS)
- Radiation dose ~10kGy/year

- Neutron fluence
  - 0.5×10^{18} neutrons/m^2/day
  - possible degradation of RRR can be recovered by thermal cycle to room temperature
  - matches yearly maintainance of cryocooler

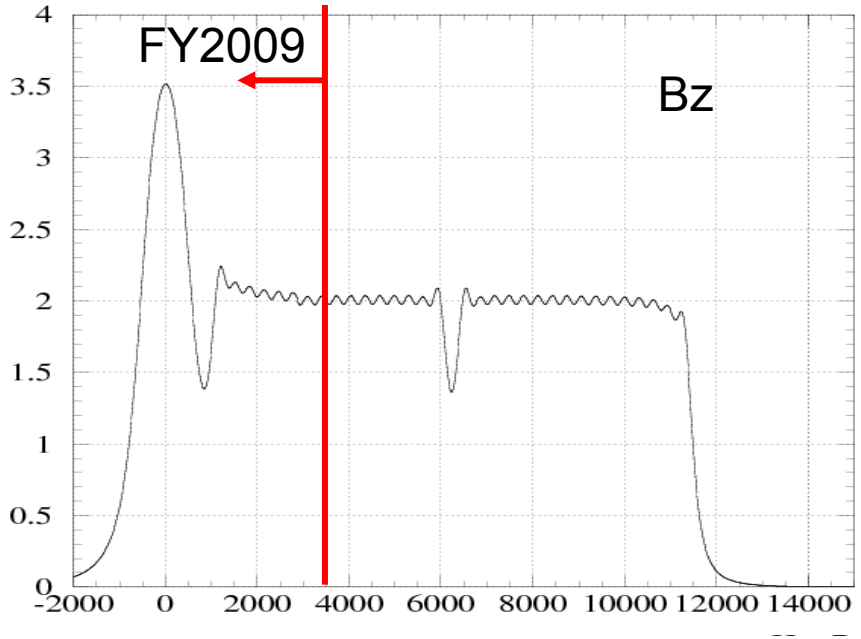


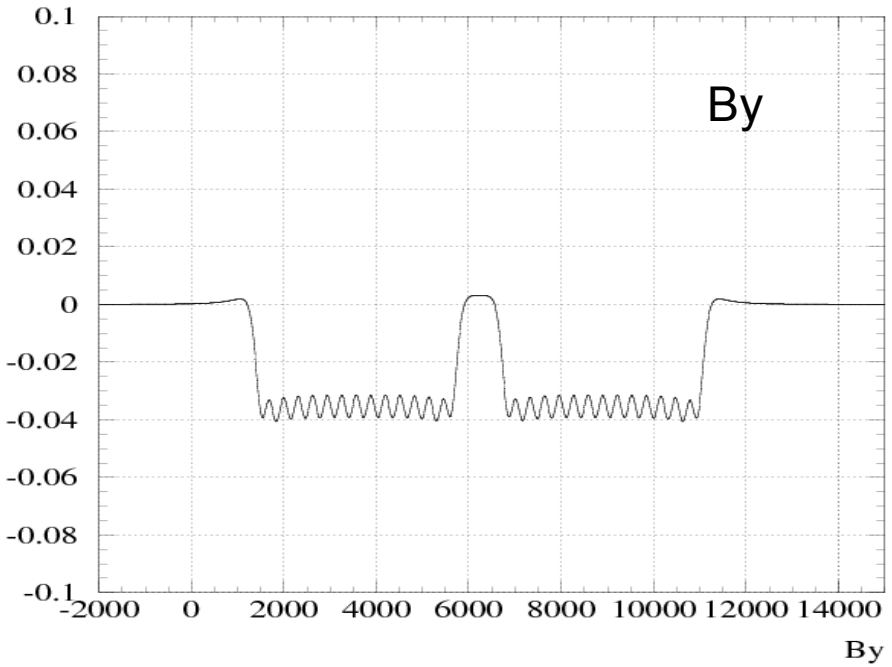


Muon beam simulation

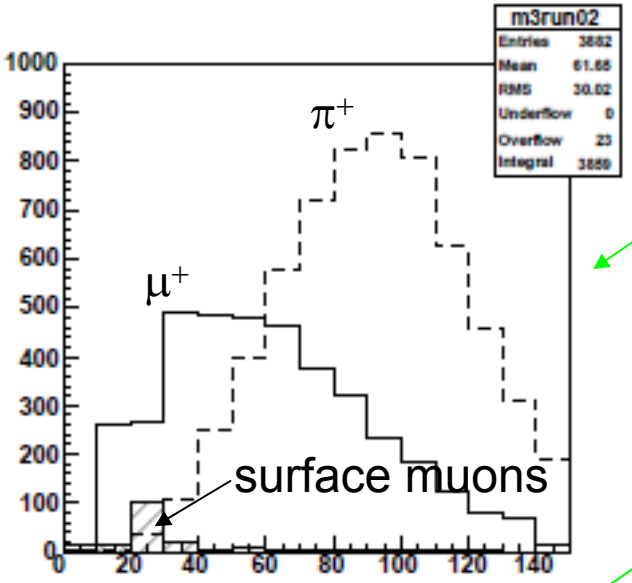


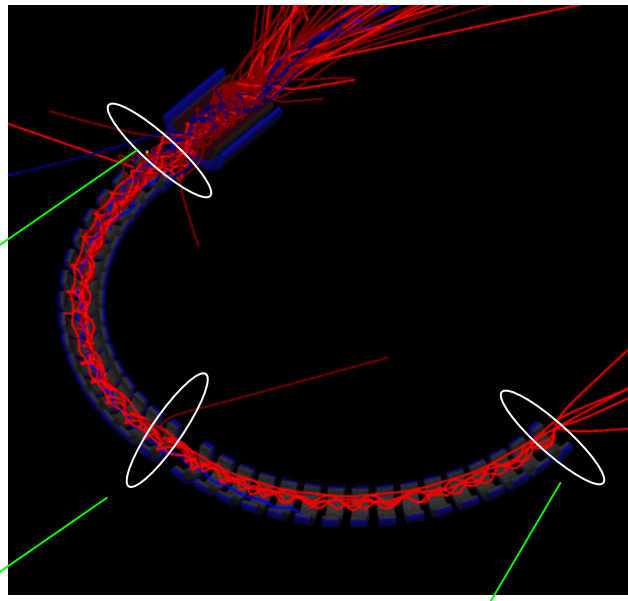
- 3.5 T capture
- 2T transport
- MARS pion production
  - 10^7 ptorons
- G4beamline tracking

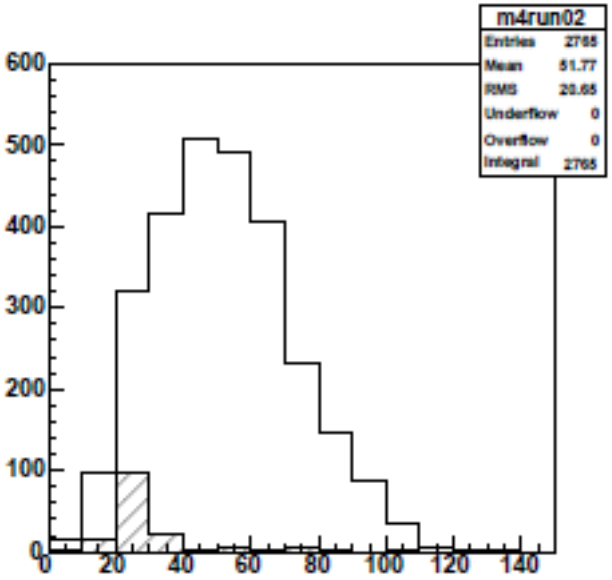


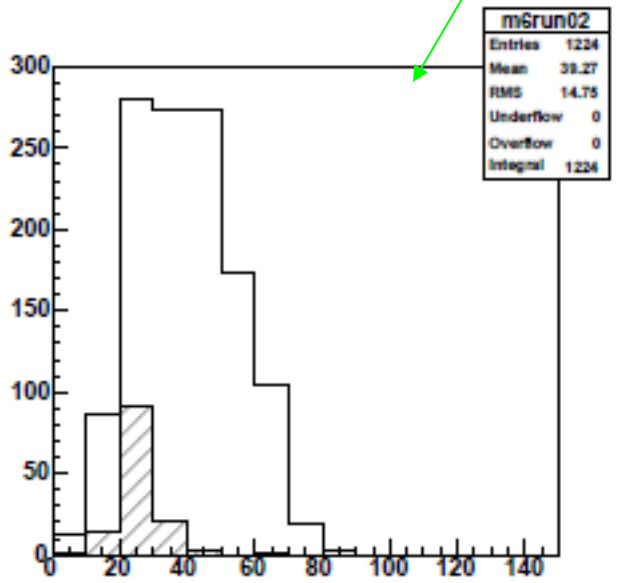


Muon momentum distribution in transport solenoid





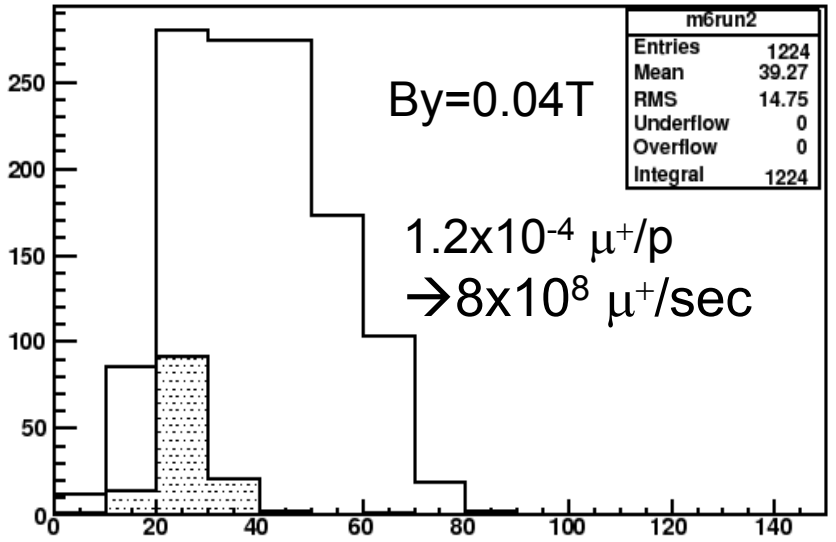


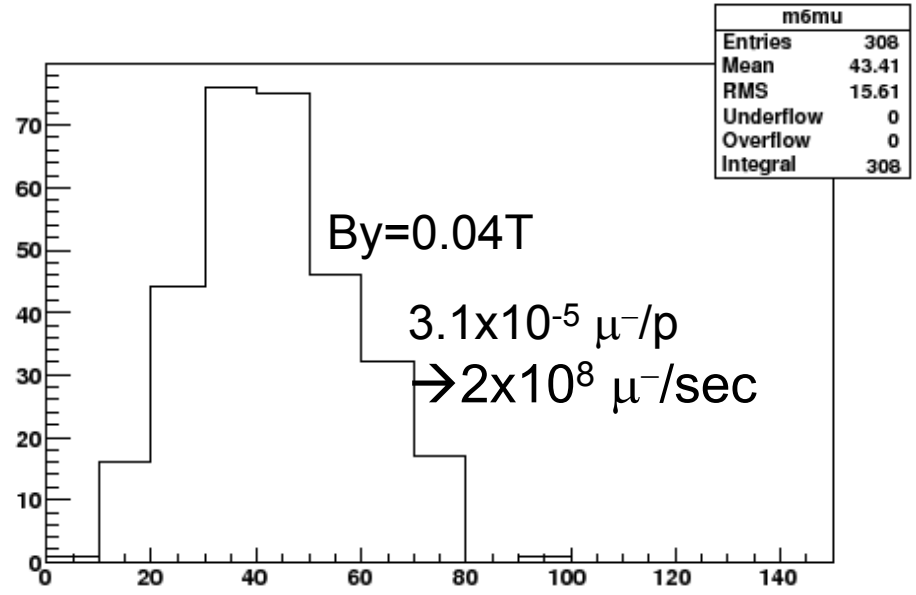


Muon beam intensity

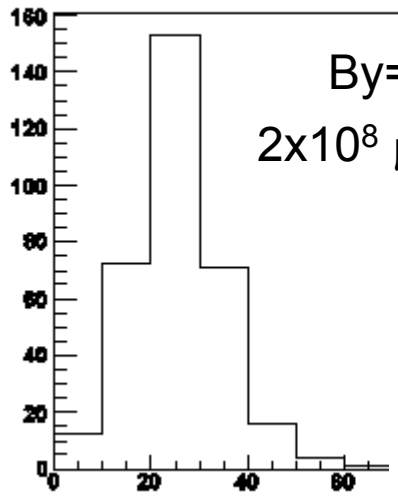
- 8×10^{8} μ^{+}/sec with By=0.04T
  - surface muons of 8×10^{7} μ^{+}/sec
- 2×10^{8} μ^{+}/sec with By=0

- 2×10^{8} μ–/sec with By=0.04T
- 5×10^{7} μ–/sec with By=0



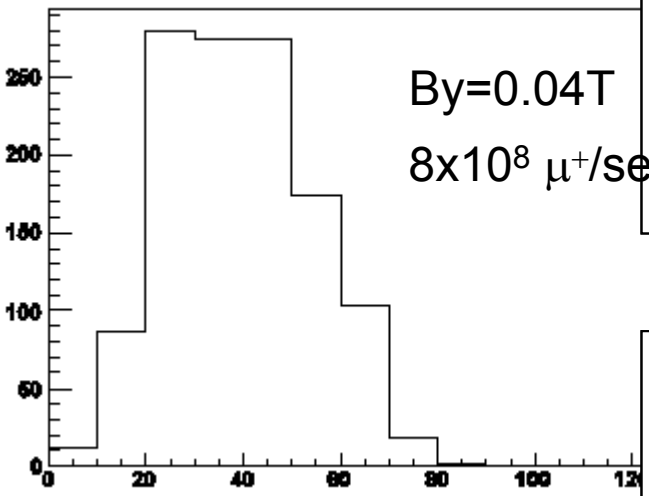


Momentum selection



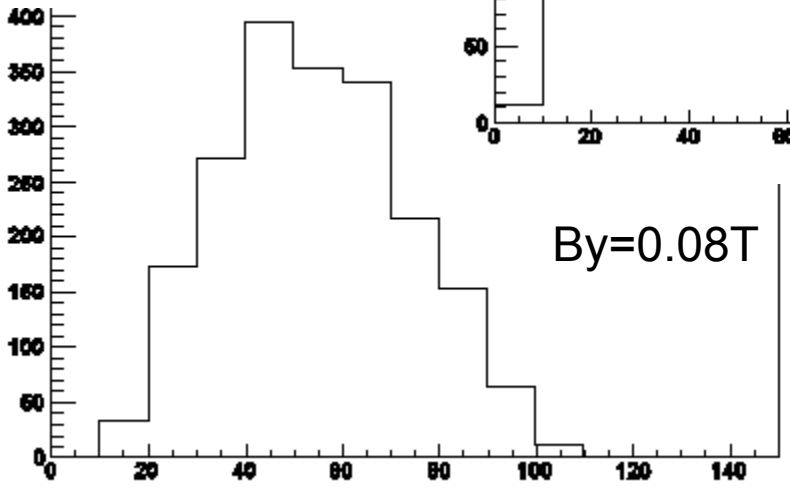
By=0

$2x10^8$ μ^+/sec

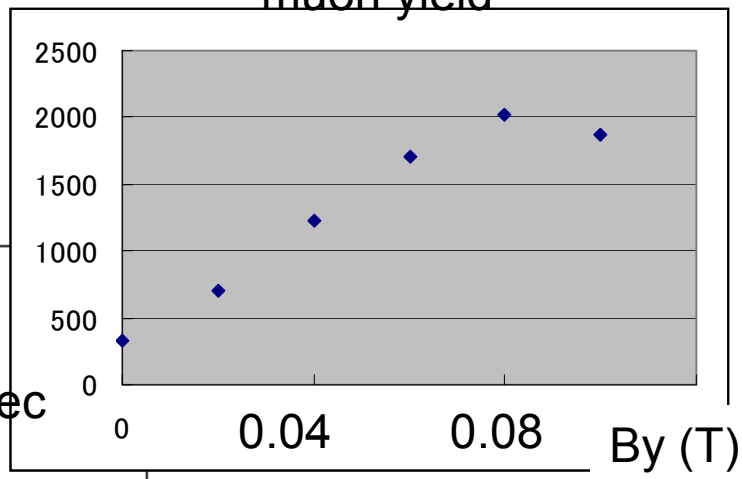


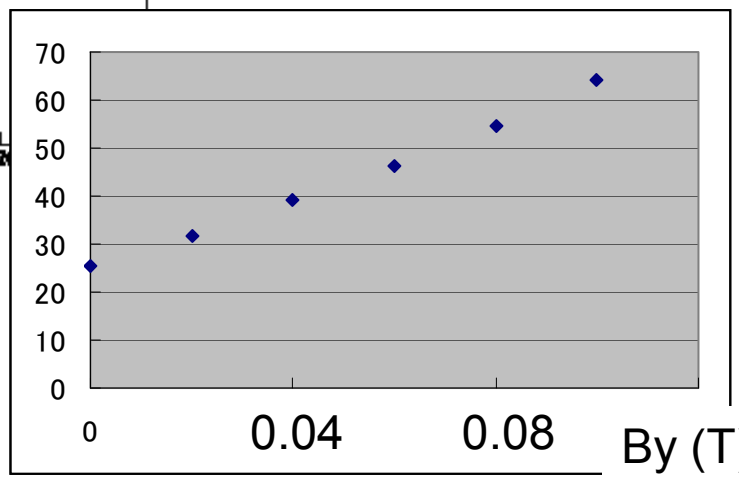
By=0.04T

$8x10^8$ μ^+/sec



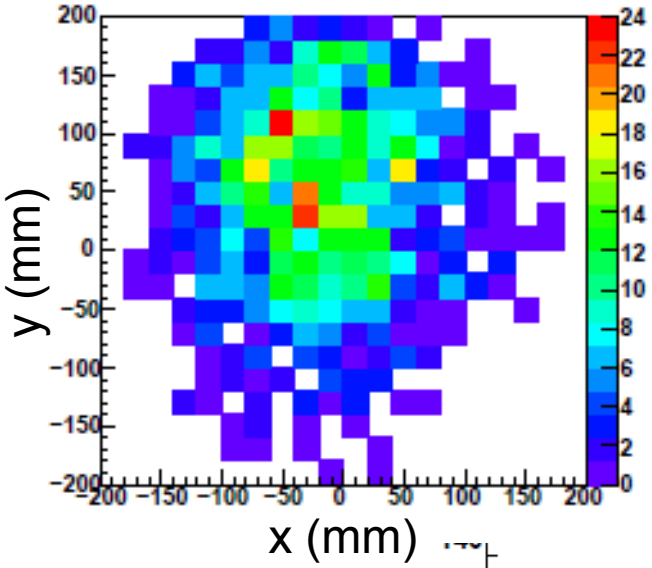
By=0.08T

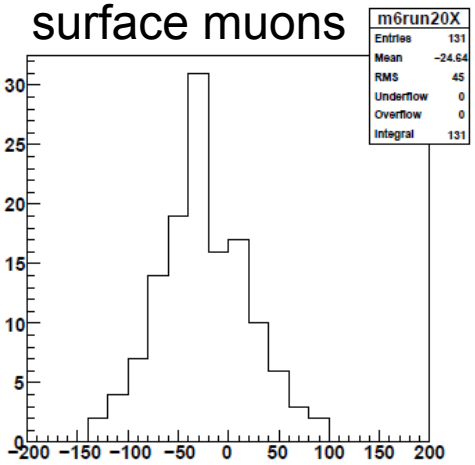


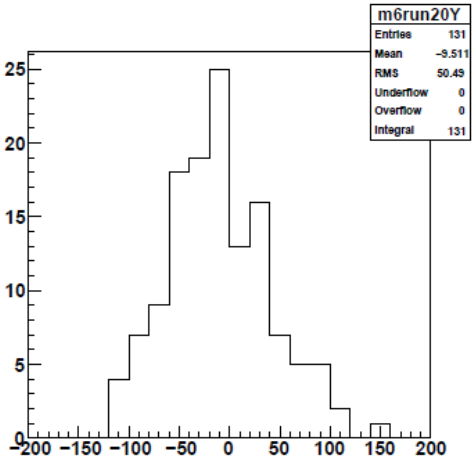


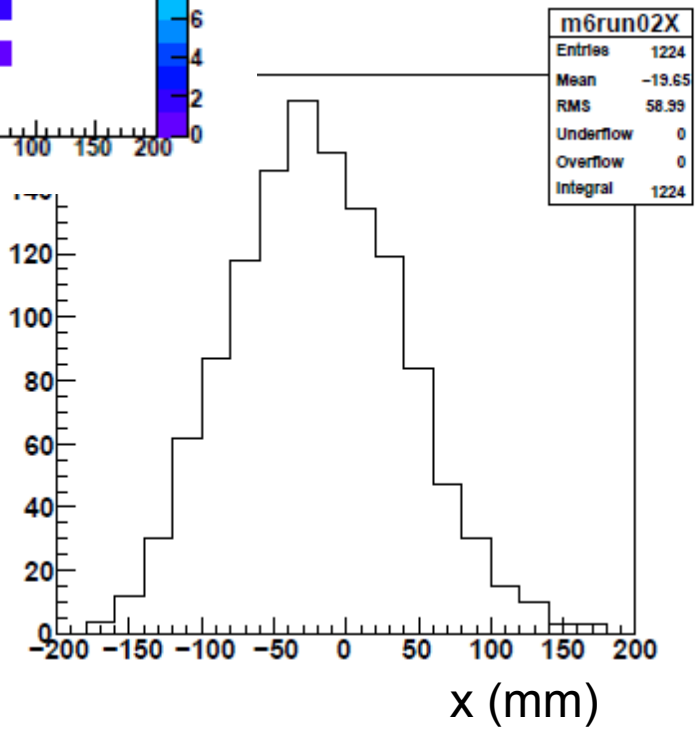
Muon profile

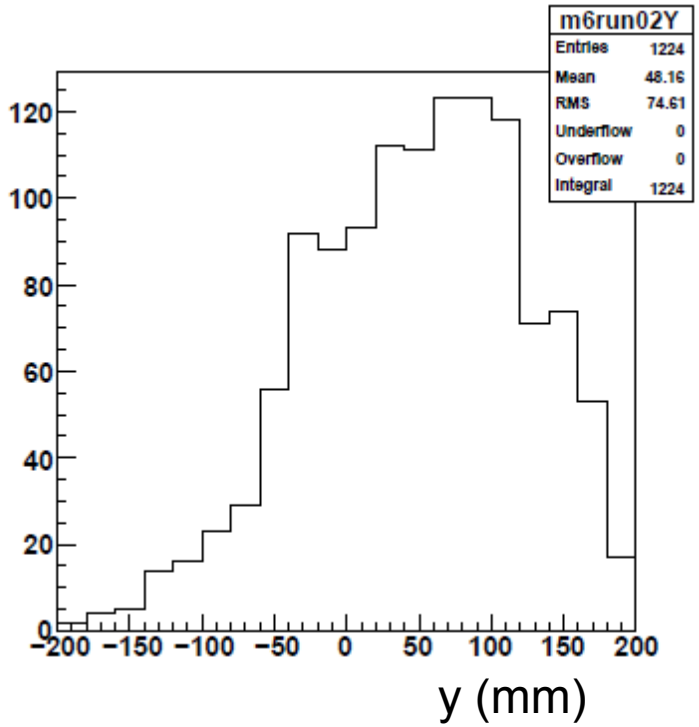
surface muons











MUSE at J-PARC vs. MUSIC at RCNP

	MUSE	MUSIC
Location	J-PARC	RCNP
Beam power	1000kW	0.4kW
	Surface muons	Surface + Decay
Intensity	10^8/sec	10^7-10^8/sec
Time structure	Pulsed (25Hz)	Continuous
Beam polarization	High	Medium
Multiple use	Many channels	Only one channel

Summary

- Muon channel, MUSIC, is going to be constructed at RCNP, Osaka Univ.
- The first of solenoid capture scheme on proton beam
- MUSIC can provide intense positive and negative muon beam using 400MeV x 1microA proton beam.
- Pion Capture System for MUSIC with a few meter transport solenoid will be constructed at RCNP in FY2009
- Commissioning with proton beam next year