Development of high intense surface muon beam using a large solid angle axial focusing channel.

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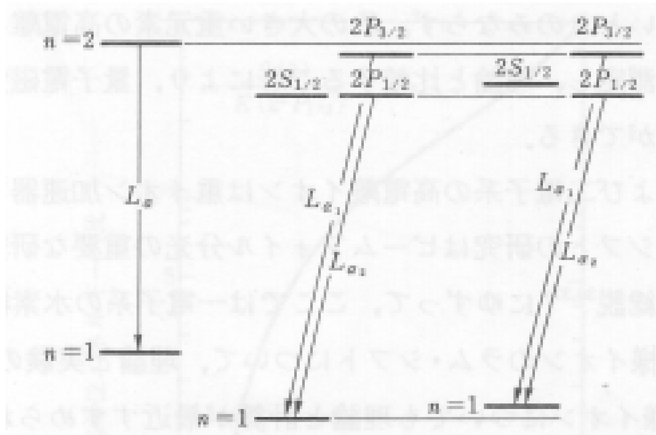
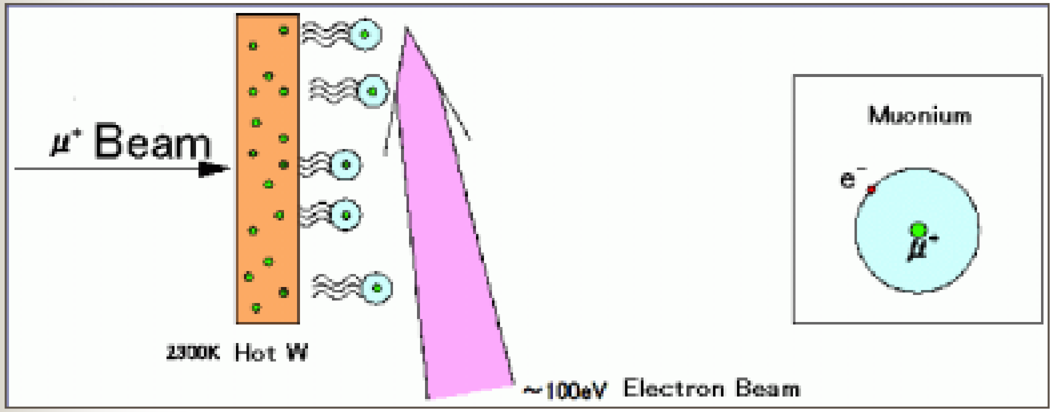
Why High Intensity Muon Beam?

Muon beam: Meson Factories dotted over the world

Muonium 2S-2P Lamb Shift Measurement
Calculated value:1047.490MHz
Experimental results: 1042(20)MHz LAMPF
1075(15)MHz TRIUMF
Mu^* by Beam Foil Method





Mu^* by Electron Impact Method

100eV 10mA e^- gun

·1S-2S Cross Section ($5x10^{-18}cm^2$)
Low energy high intense muon beam is essential.

Surface Muon

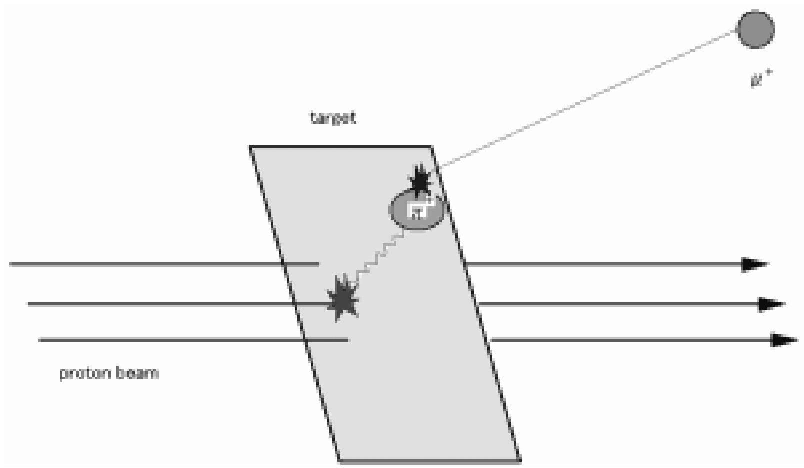
Surface Muon

μ^+ from π^+ decay at the production target.

Low Energy 4MeV (30MeV/c)

100% spin polarization

Suitable for mSR spectroscopy.



High Intensity Surface Muon Beam

Upgrading of primary proton acceralator

KEK:2.5x10^5μ^+/sec (500MeV, 5μA)

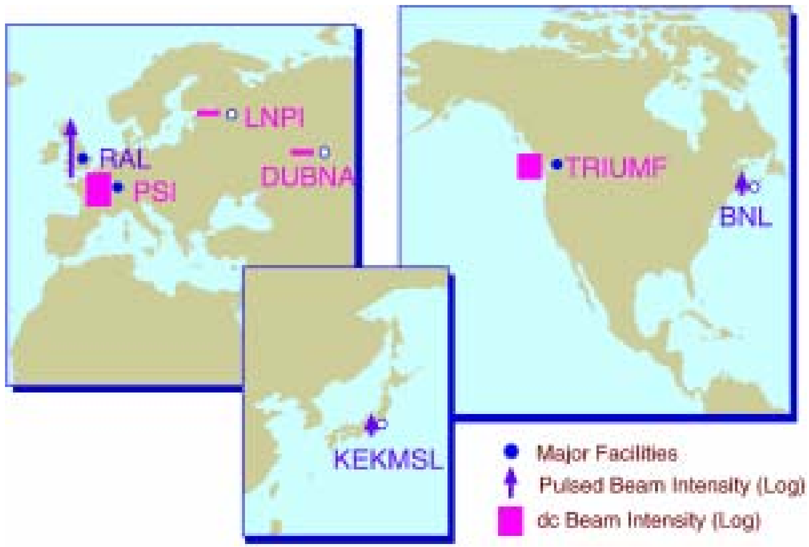
RAL:~10^6μ^+/sec (800MeV, 200μA)

J-PARC:3x10^7μ^+/sec (3GeV, 333μA)

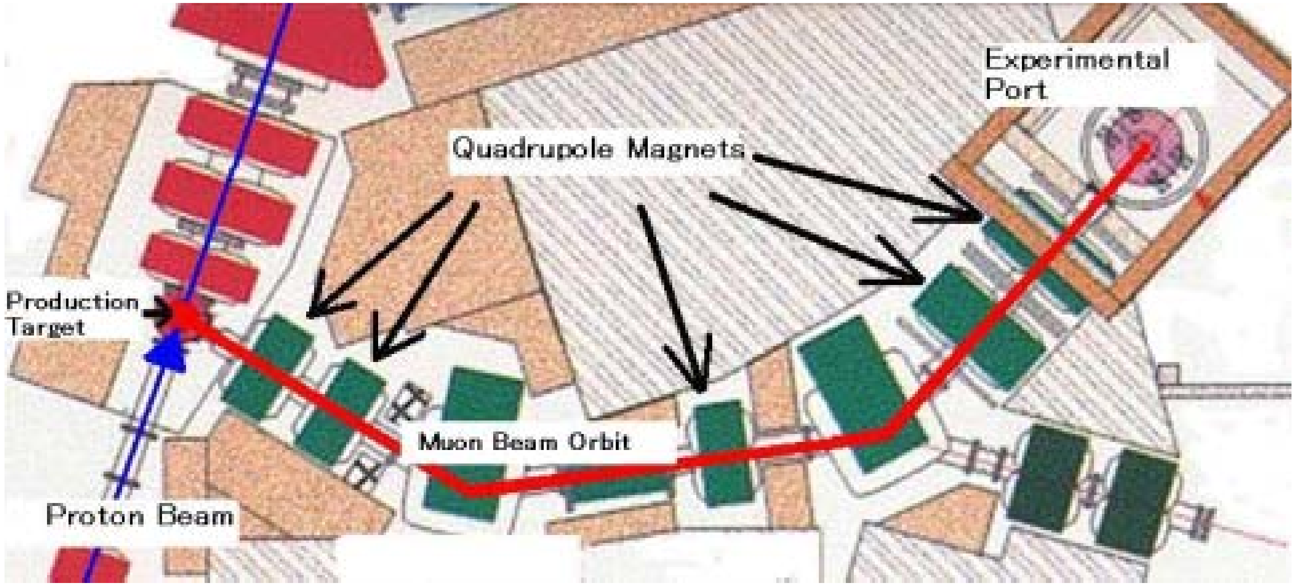
Upgrading of acceptance of muon channel

Solid angle acceptance of conventional muon channel ~50msr

Less than 1% of produced surface muon is transported.



Conventional Surface Muon Channel at KEK-MSL I



Quadrupole: Focus

Bending Magnet: Momentum selection

Electric Separator

Transportation Efficiency: 1% (~50msr)

Large Solid Angle Axial Focusing Superconducting Surface Muon Channel, Dai Omega

Large Solid Angle:

Large aperture Superconducting Coil

80cm diameter

#1 coil is placed 20cm from the production target.

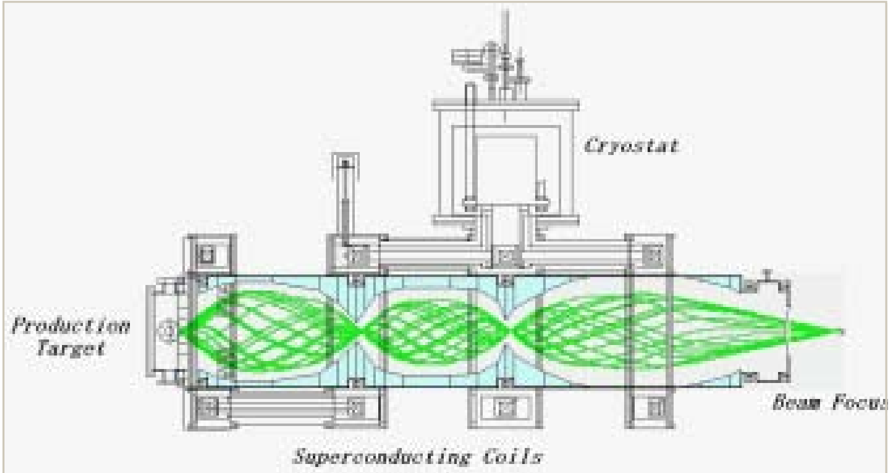
Axial Focusing Channel:

Axially symmetric beam course using symmetric magnetic field of coils.

Beam focus is located 360cm from the production target.

Momentum [MeV/c]	Acceptance [msr]
31	754
30	1382
29	565
28	314
27	188

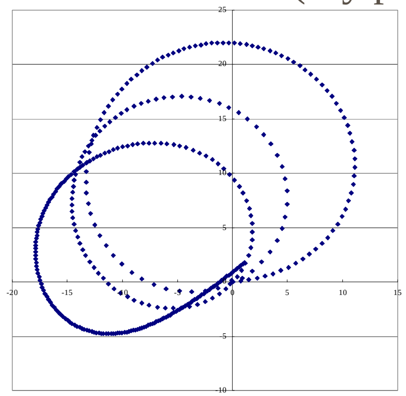
Solid angle acceptance is 20 times larger than conventional muon channel.



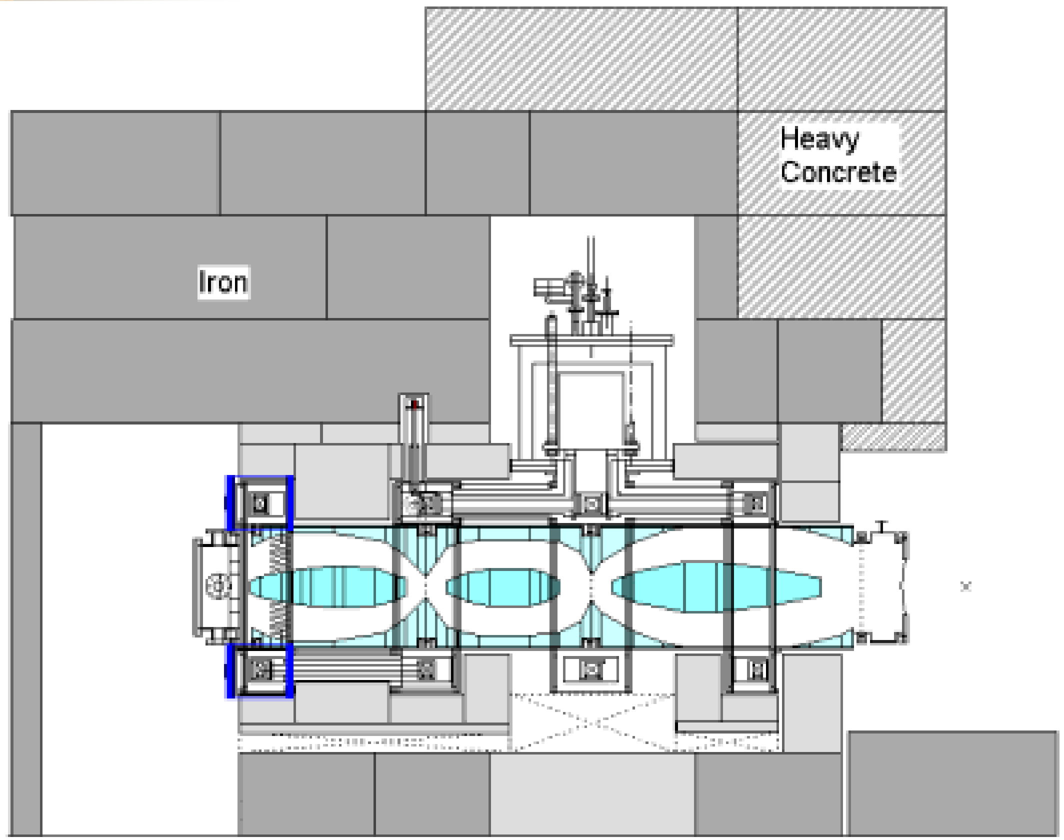
Dai Omega

Point Source to Point Focus Optics

Muon beam course (x-y plane)



Radiation Shield



Radiation level estimation

(MCNP)

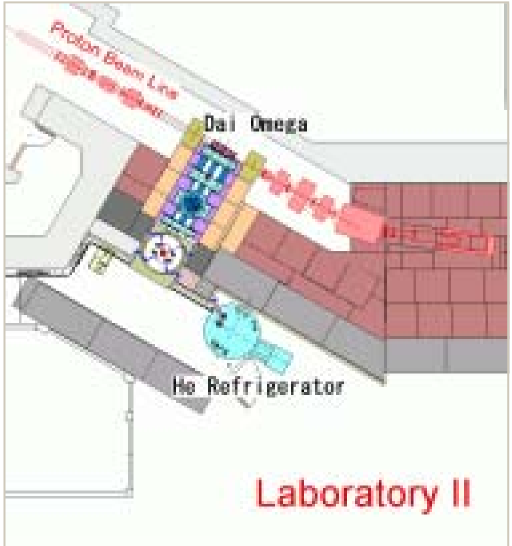
30μSv/h at experimental port

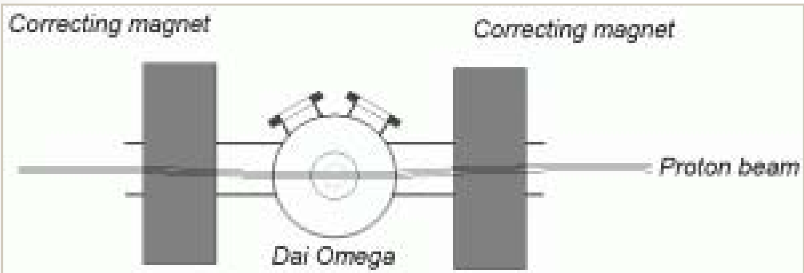
Correction of magnetic field

Magnetic forces between coils and radiation shields

(TOSCA + Geant)

Dai Omega at KEK-MSL II





Superconducting coils are cooled by pool boiling liquid helium, which is provided by an on-line liquid-helium refrigerator.

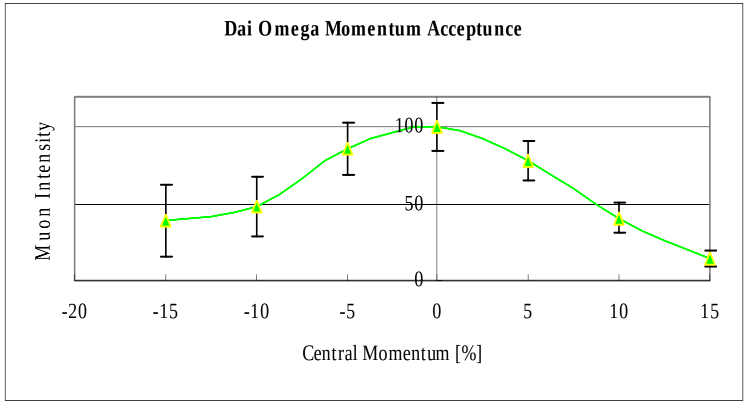
We started operation of Dai Omega in December 2001.

Beam Intensity

Detection of μ-e decay positron from the stopping target.
Telescope counter of moderate solid angle selection.

2 x $10^4 \mu^+$/pulse!

Momentum Acceptance of Dai Omega

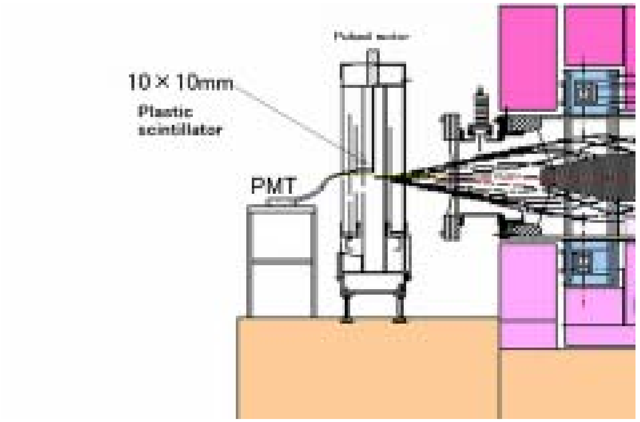


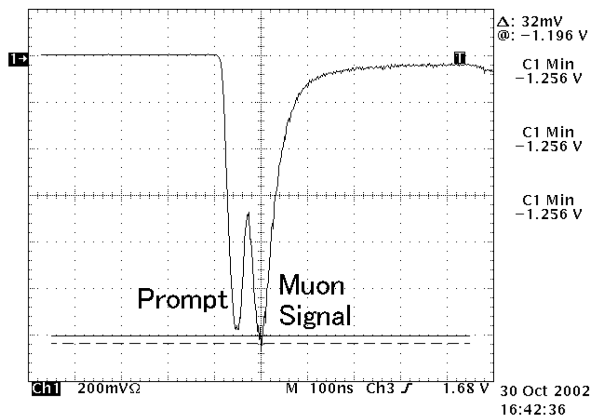
Comparison with other muon facilities

	Proton Current	Target Thickness	Muon Intensity	μ^+ / pulse
Dai Omega	500MeV 5 μA	4mm	4 x $10^5 \mu^+$ / s	2 x 10^4
KEK-MSL I	500MeV 5 μA	30mm	2.5 x $10^4 \mu^+$ / s	1.3 x 10^3
RAL	800MeV 200μA	10mm	~$10^6 \mu^+$ / s	~2 x 10^4

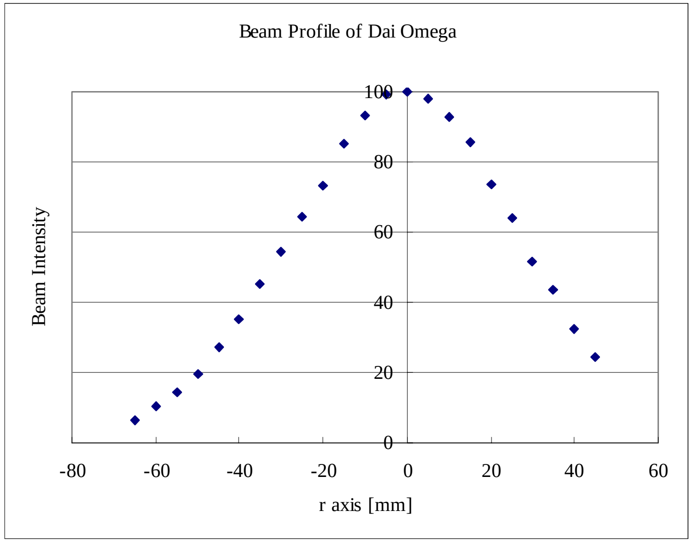
Beam Profile Measurement

The muon beam size at the focus was measured by moving the beam monitor which consist of plastic scintillator of 10mm square connected to photo multiplier via optical fibers.





Prompt and muon signal observed at oscilloscope



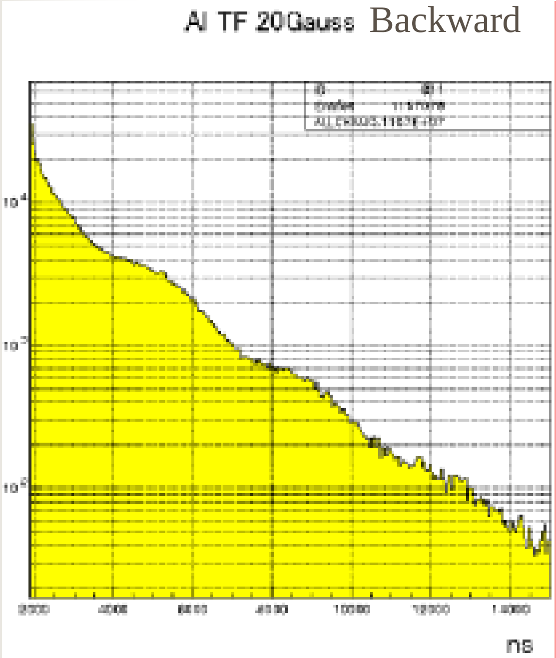
Beam size ϕ50(FWHM)
Calculated value ϕ40

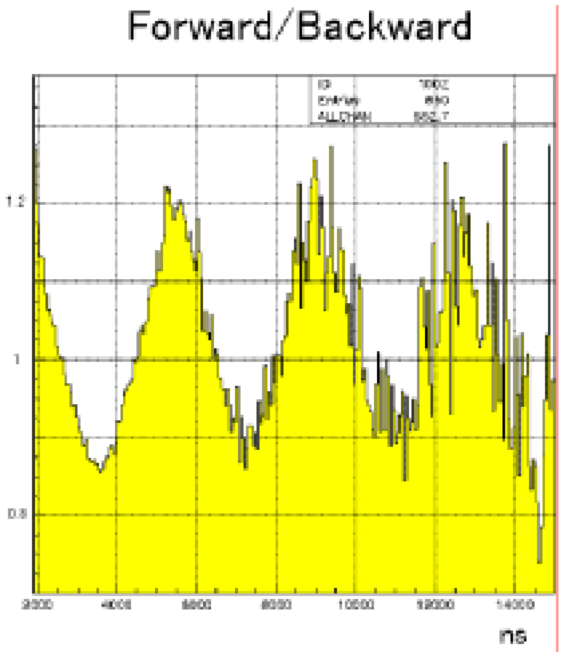
Dai Omega μSR Detecting System

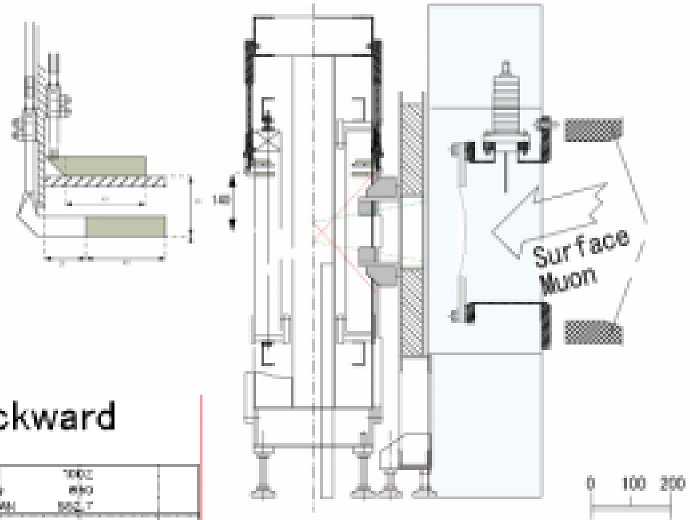
Dai Omega μSR detection system consists of 128 coincidence counters connected to the multi anode photo multiplier via optical fibers.

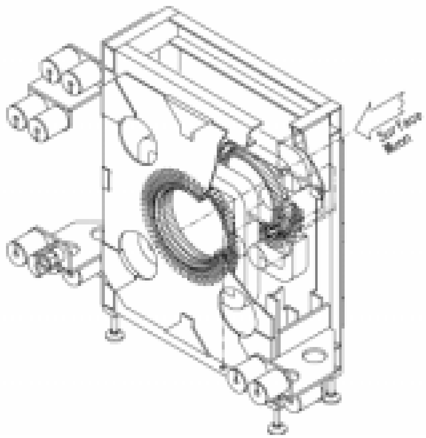
5% acceptance.

36M event / hour was achieved with this detection system.

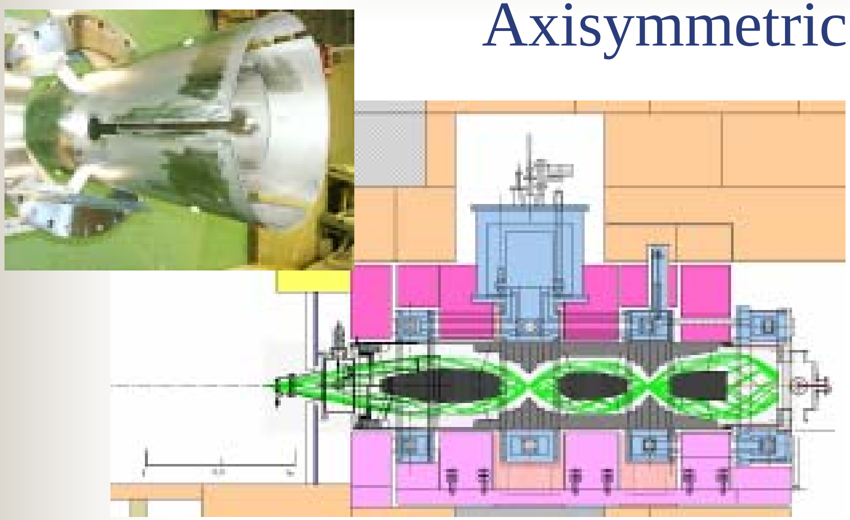




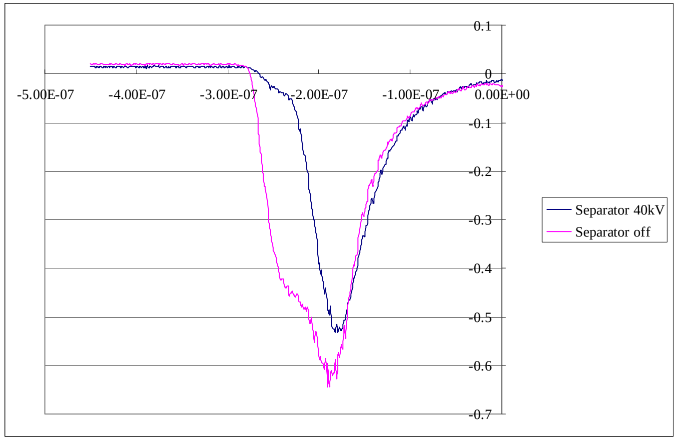




Axisymmetric Particle Separator

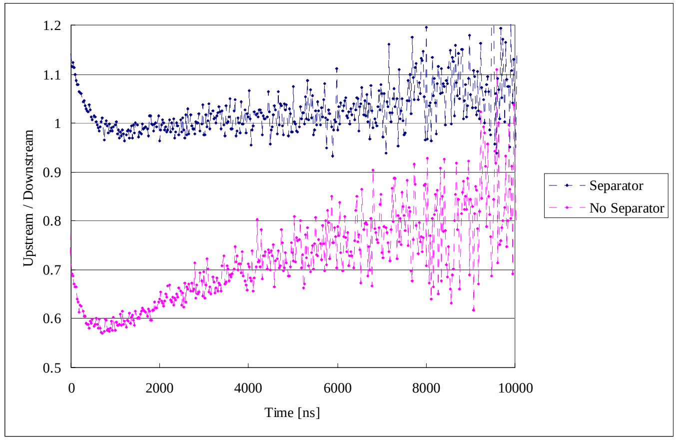


Electrode is placed at the exit of Dai Omega
60cm length, 70mm gap, 120kV.



Beam Monitor

“Muon kick” optics (SIMION simulation)
100% Spin polarization



µSR Asymmetry (Ho Target)

Summary

The beam tuning tests that we have carried out confirmed that Dai Omega can collect half of the muons of the defined momentum emitted towards the direction of the coils. Dai Omega improved the solid angle acceptance by more than one order of magnitude compared with the conventional muon channels.

The results of our present studies suggest that the surface muon beam intensity of Dai Omega at KEK-NML (500 MeV, 5 μA) can be comparable with that of RAL (800 MeV, 200 μA); Dai Omega produces the world's most intense pulsed surface muon beam.

μSR detection system was installed, and data rate of 36Mevents/hour was achieved.

Axisymmetric electric separator was also successfully installed.

Dai Omega

Beam intensity 4 x $10^5 \mu^+$/sec, Momentum acceptance 6% (FWHM), Beam size ϕ50(FWHM).