Comparison of muon beam facilities

Y. Arimoto

April 28, 2012

Abstract

Performances of muon beam facility are compared. The performances are compared about μ^- and decay muon. It is should be noted that a brightnesses in this note are not normalized by a power of a proton beam.

1 TRIUMF

Parameters of muon source

Proton beam	Energy	500 MeV
	Current	$200\mu A$
	Power	1 kW
	Repetition	23 MHz
Muon beam	Beam Line	M9B
	μ^- flux (x1000/sec)	1400[1]
	Momentum bite	3.4% [1]
	Pion contamination	0.2% [2]
	Muon momentum	60 MeV/c [2]

Calculation of Brightness

$$B = F/(\Delta p) = 3.43 \times 10^5 \text{ muons/s/(MeV/}c\text{)} \quad (1)$$

$$\Delta p = 2 \times 0.034 \times 60\text{MeV}/c = 4.08\text{MeV/}c \quad (2)$$

$$B\text{:Brightness} \quad (3)$$

$$F\text{:Muon flux} \quad (4)$$

2 PSI

Parameters of muon source

Proton beam	Energy	600 MeV
	Current	1.7 mA
	Power	1.02 MW
Muon beam	Beam Line	μE4
	Channel Length	17.3 m
	μ^- flux (sec^{-1})	$\sim 10^7$[3]
	Full momentum band	$\pm$3% [3]
	Muon Momentum	28 MeV[3]

$$B = F/\Delta p = 1 \times 10^7/1.686 = 5.931 \times 10^6 \text{ muons/s/(MeV/}c\text{)} \quad (5)$$
$$\Delta p = 2 \times 0.03 \times 28\text{MeV/}c = 1.68 \text{ MeV/}c \quad (6)$$
$$B\text{:Brightness} \quad (7)$$
$$F\text{:Muon flux} \quad (8)$$

Calculation of Pion Contamination

$$N^{\pi}_{survival} = \exp\left\{-\frac{L}{L_\pi}\right\} \quad (9)$$
$$= 1.589 \times 10^{-5} \quad (10)$$
$$L_\pi = c\beta\gamma\tau_\pi \quad (11)$$
$$= c \text{ [m/s]} P\text{[MeV/}c\text{]}\tau_\pi\text{[s]}/m_\pi \text{ [MeV]} \quad (12)$$
$$= 0.05592P \text{ [m]} \quad (13)$$
$$= 1.566 \text{ [m]} \quad (14)$$
$$P = 28\text{[MeV/}c\text{]} : \text{Pion Momentum} \quad (15)$$
$$L = 17.3 \text{ [m]} : \text{Channel Length} \quad (16)$$
$$m_\pi = 139.57 \text{ MeV} : \text{Pion mass} \quad (17)$$
$$\tau_\pi = 2.6033 \times 10^{-8} \text{ sec} : \text{Pion life time} \quad (18)$$

3 KEK-MSL

Parameters of muon source

Proton beam	Energy : 500 MeV	
	Current : 9.6 μA	
	Power : 4.8 kW	
	Repetition : 20 Hz	
Muon beam	Beam Line	Superconducting Muon Beam Channel
	Channel Length	12 m[4]
	μ^- flux (sec^{-1})	2000*
	Full momentum bite	10$\sim$15% [5]
	Muon Momentum	30$\sim$100 MeV/c[5]

$*$: μ^- flux $= 100/\text{spill} \times 20$Hz[5].

Calculation of Brightness

$$B = F/\Delta p = 2000/9.75 = 205.2 \text{ muons/s/(MeV/}c\text{)} \quad (19)$$
$$\Delta p = 0.15 \times 65\text{MeV/}c = 9.75 \text{ MeV/}c \quad (20)$$
$$B\text{:Brightness} \quad (21)$$
$$F\text{:Muon flux} \quad (22)$$

Calculation of Pion Contamination

$$N^{\pi}_{survival} = \exp\left\{-\frac{L}{L_{\pi}}\right\} \tag{23}$$
$$= 0.03684 \tag{24}$$
$$L_{\pi} = c\beta\gamma\tau_{\pi} \tag{25}$$
$$= c\ [\mathrm{m/s}]P[\mathrm{MeV}/c]\tau_{\pi}[\mathrm{s}]/m_{\pi}\ [\mathrm{MeV}] \tag{26}$$
$$= 0.05592P\ [\mathrm{m}] \tag{27}$$
$$= 3.635\ [\mathrm{m}] \tag{28}$$
$$L = 12\ [\mathrm{m}] : \text{Channel Length} \tag{29}$$
$$P = 65\ \mathrm{MeV/c} : \text{Pion Momentum} \tag{30}$$

4 PRISM

Parameters of muon source

Proton beam	Energy : 50 GeV	
	Current : 20 μA	
	Power : 1 MW	
Muon beam	μ^- flux (sec^{-1})	1×10^{12}[6]
	Momentum width	$\pm2\%$ [6]
	Muon Momentum	68 MeV/c[6]
	Pion contamination	10^{-17}[6]

Calculation of Brightness

$$B = F/\Delta p = 1\times10^{12}/2.72 = 3.68\times10^{11}\ \text{muons/s/(MeV/}c\text{)} \tag{31}$$
$$\Delta p = 2\times0.02\times68\text{MeV/}c = 2.72\ \text{MeV/}c \tag{32}$$
$$B\text{:Brightness} \tag{33}$$
$$F\text{:Muon flux} \tag{34}$$

References

[1] S. Kreitzman, *et al.*, "μSR Facility Users Guide", TRIUMF, 44(1999) or http://musr.org/equip/mubeamlines/node1.html

[2] Stocki, *et al.*, Phys. Rev. **A 697**, 55(2002).

[3] F. Foroughi, *et al.*, Hyper. Inter. **138**, 483(2001).

[4] http://msl.kek.jp/shisetsu/lab1/index_en.html

[5] http://msl.kek.jp/shisetsu/lab1-3/index_en.html

[6] PRISM working group, "The PRISM Project –A Muon Source of the World-Highest Brightness by Phase Rotation", *A Letter of Intent to The J-PARC 50 GeV Proton Synchrotron Experiments*.