Muon Production - Lasers vs Accelerator Rings

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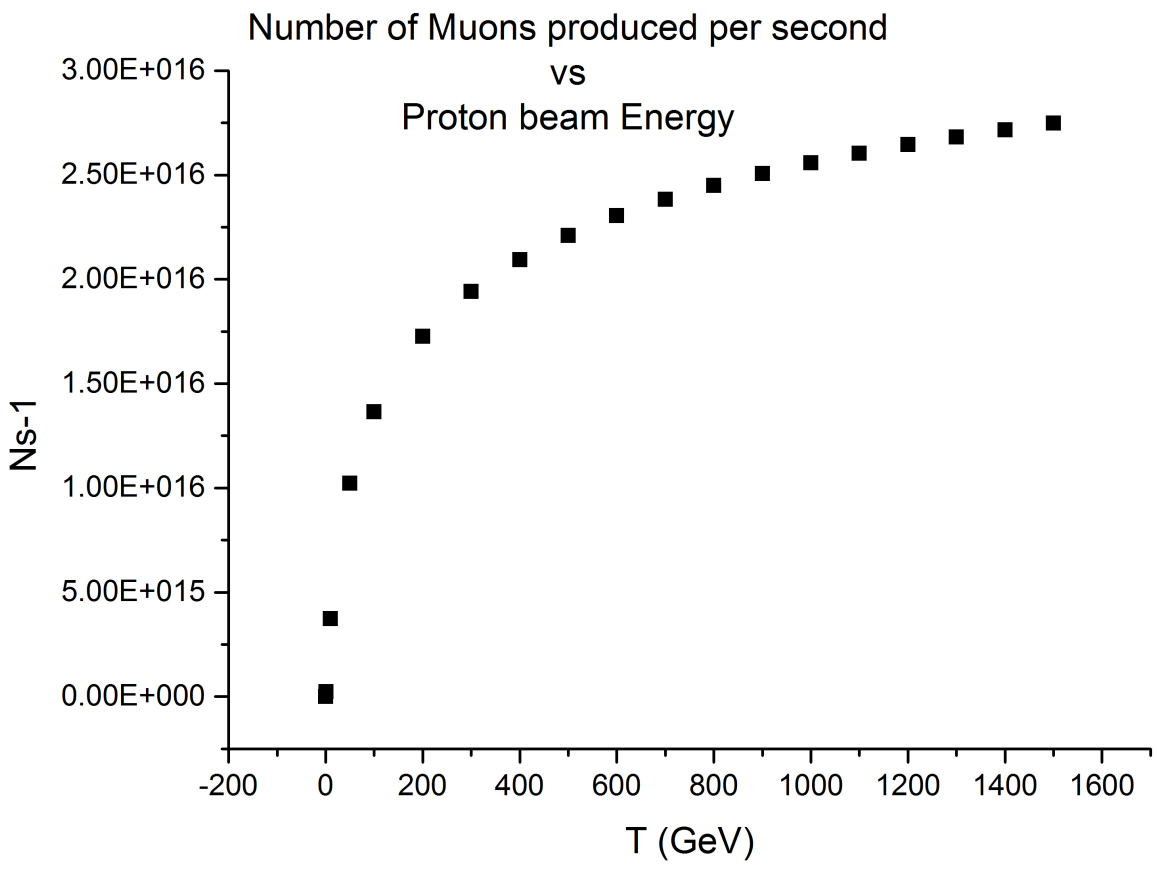
Outline

Protons to Pions to Muons

$$p + p \rightarrow 3\pi + X \rightarrow 3\mu + 3\bar{\nu} + X \tag{1}$$

Muon Numbers



Requirements[1]

- >500kW proton beam, ie. 1mA at 500MeV proton energy, or 0.5mA at 1GeV
- operating at 25kHz (!!)
- around 30ns proton pulse length duration
- small area of proton beam, of the order of mm^2

[1] ref:Cywinski R. et al., 2009

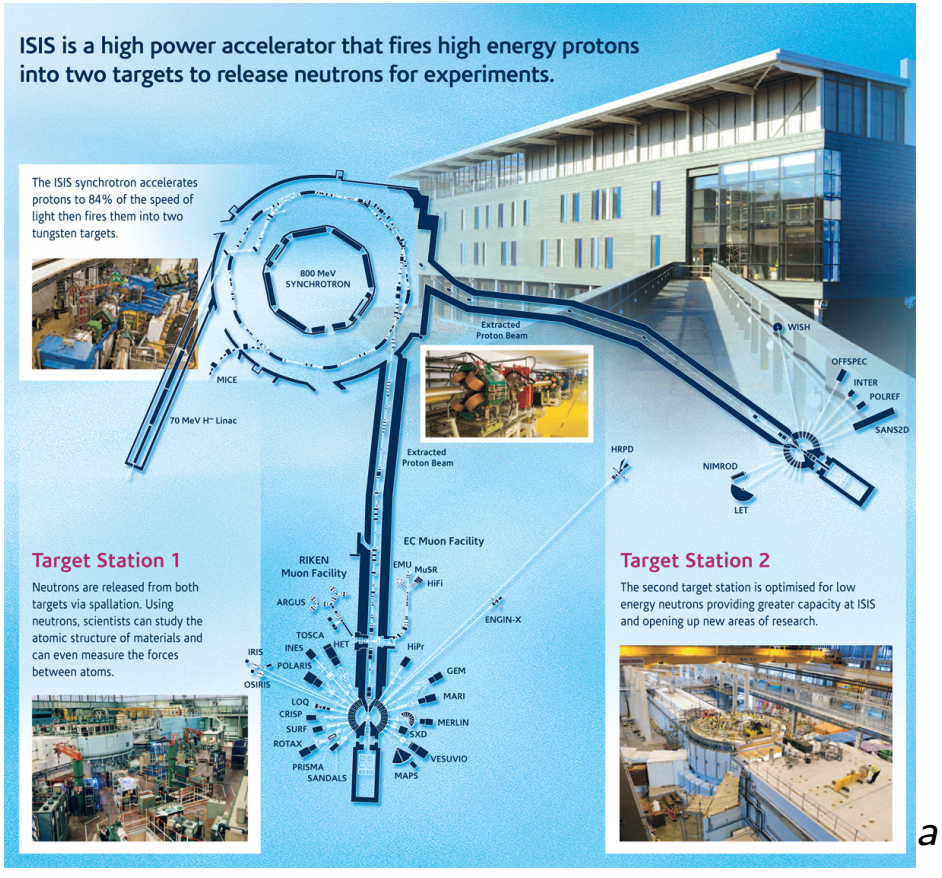
Current Muon Facilities

[2]

"One Ring to rule them all" [3]

[2] picture from www.blueskydisney.com
[3] ref: Tolkein, J. R. R., The Lord of the Rings

ISIS



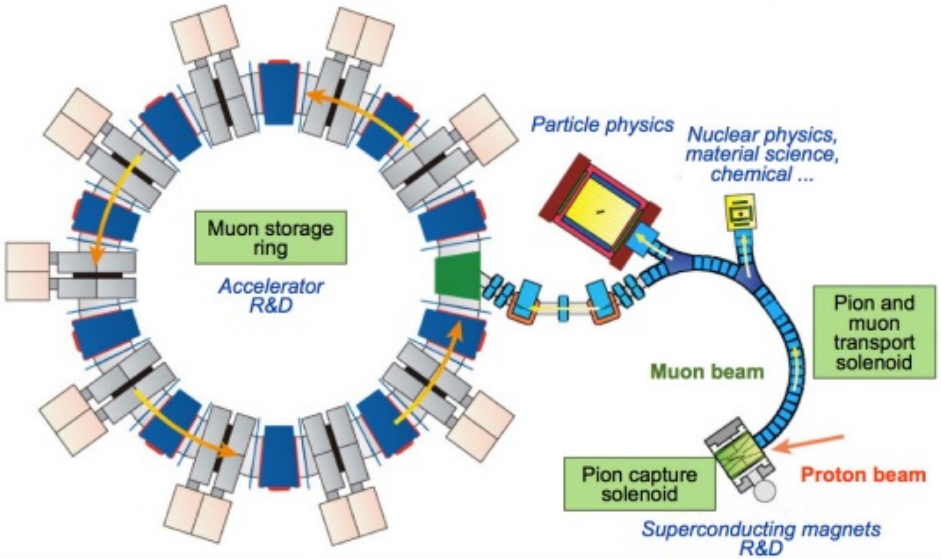
[a]

$10^4 \mu s^{-1}$

[a] picture from www.isis.stfc.ac.uk

MuSIC

$10^8 \mu s^{-1}$



[a]

[a] picture from *The first muon beam from a new highly-intense DC muon source, MuSIC*, AIP Conference Proceedings 1441, 652 (2012)

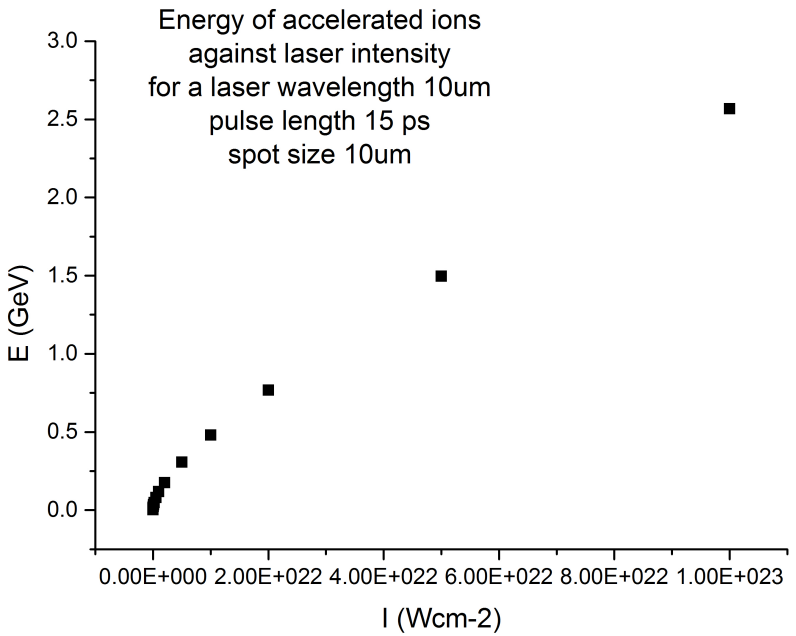
Ion Acceleration

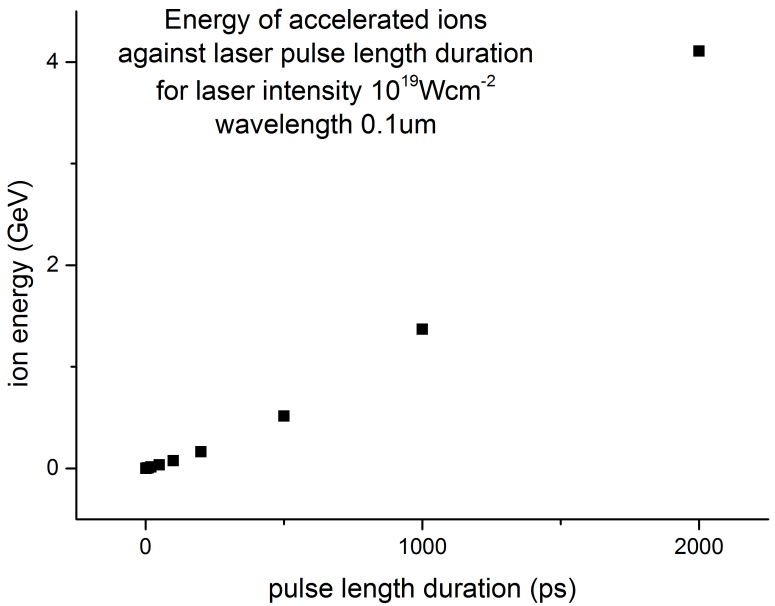
- Target Normal Sheath Acceleration
- Radiation Pressure Acceleration
- Shockwave Acceleration

The Equation

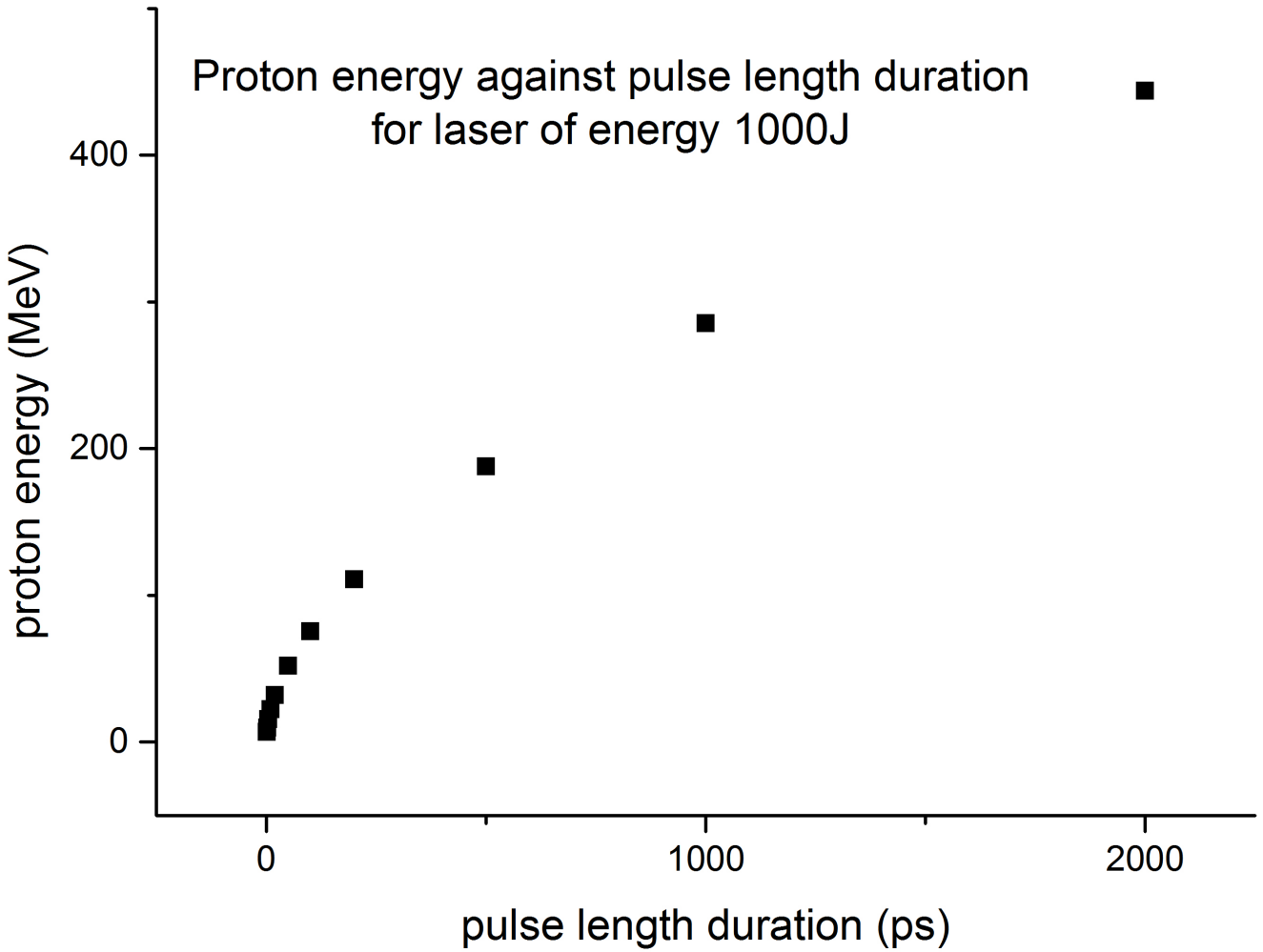
$$\epsilon_{ions}[MeV] = 2M^2 T_e + M\frac{t_{acc}(2T_e)^{1.5}}{L\frac{m_i}{m_e}^{0.5}} + \frac{T_e^2}{\frac{m_i}{m_e}}[(\frac{t_{acc}}{L})^2 + 4M] \quad (2)$$

Predictions





Predictions



Vulcan

- E = 2.6kJ
- τ = 1ns
- $\rightarrow I = 2.6 \times 10^{18}$
- $E_{ion} = 0.53 GeV$
- $N_\mu = 8.63 \times 10^4$ per pulse

$\rightarrow 72 \mu s^{-1}$ (on average)

DiPOLE

- $I = 10^{16} Wcm^{-2}$
- τ=ns
- E_{ion}=22MeV

What if...?

- Vulcan had a longer pulse length?
- DiPOLE could fire at 340J?

Summary

- fewer muons per second
- but shorter pulses, more intense
- more compact sources

ISIS	MuSIC	Vulcan (2500ps)	DiPOLE (340J)
$10^4 \mu s^{-1}$	$10^8 \mu s^{-1}$	$500 \mu s^{-1}$	$10^5 \mu s^{-1}$

Thank you

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