Surface Muons for Project X

*Conceptual Discussion*

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Surface Muons and Project X

• Project X is a flexible, staged, linac for the next generation of Intensity Frontier Experiments.
• Large pricetag – also has a lot of 1 GeV beam which is not used for Mu2e or neutrino programs.
• Surface, and other, muon applications clearly need to be investigated.
• We began our investigations focusing on applications – but always with fundamental physics in our minds as well.
Disclaimers

• I am a neutrino physicist. Before that I was a collider physicist.
• Very new to muon beam physics.
• The studies so far are very rough.
  – Aimed at providing resource materials for this meeting.
  – No time yet for real design or simulations.
  – Aimed at building collaboration with material scientists.
• Relying heavily on communications with experts.
• In the current case – this means you!
Project X Site Layout

Area under discussion in this talk

- Stage 1: 0-1 GeV
- Stage 2: 1-3 GeV
- Stage 3: 3-8 GeV
- Existing Beamline Enclosure
All beam line components are surrounded by iron shielding.

Beam line from Target E to beam dump (side view)

Significant Infrastructure Required – PSI Example

Concrete shielding

Working platform

Beam dump
160 MHz Chopper in Project X Front End Beam Transport (2.1 MeV)

Allows the bunch structure programmability which is the signature feature of Project X
Example of RF Filtering

The diagram illustrates the filtering of RF pulses, with different filters applied at certain frequencies and time intervals. The filters are labeled as $f_0/2$ and $f_0/4$, indicating the cutoff frequencies for the filters.

- **Spallation**
- **Muon Area/Booster**
- **µSR Target**

The pulses are spaced every 24 ns, with additional filtering for high and low power applications.

- For high power applications:
  - Pulses spaced every 24 ns,
  - Repeats every 5 μS.

- For low power applications:
  - Pulses spaced every 24 ns,
  - Repeats every μS.

The diagram also notes that the pulses extend to 3 GeV.
Possible Beamline Layout

Select endstations using fast kickers. Simultaneous operation.
Modifications for more surface muons, I

Modify Integrated Target Station
Modifications for more surface muons, II

Create new shared beamline

- Project X Protons
- LEM target
  - μSR target
  - Protons to Spallation
  - LEM 1
  - LEM 2
  - Protons to Muon/Booster
  - Low Energy Muons for μSR

New dedicated surface muon target
The Challenge

Compatible Concepts?

Or should a new target station be considered?
Rate Estimate

• In $\mu$SR study for Project X, we estimated, for each PX bunch/20 $\mu$s:
  – $1.3 \times 10^6$ surface muons/sec

• For this study, the relevant beam is basically CW
  – Correct by factor $20 \, \mu$S $\times 40\, \text{bunch/} \mu\text{s} = 800$
  – Additional factor of 10 for total absorption in target.
    (Surface “skim” targets typically use 10%).

• Estimate $1.0 \times 10^{10}$ muons/s

• Comparable to PSI.

• Still need to further examine how much affected by 1 GeV proton energy.
Pushing the Envelope

• Current at 1 or 3 GeV is limited by the total RF power installed.
• People are interested in a muon storage ring beam for LBNE – NuMAXX
• This might generate the need for some more current at 3 GeV, stage II. Maybe 30% more.
• It is not (I think) outlandish to consider a stage II request for additional 1 GeV RF in the same spirit.
• However – no guarantees – that is for sure.
Figure II-10: Footprint of neutrino-factory and muon-collider facilities, including an initial muon collider Higgs factory, on the Fermilab site.
Conclusions

• Project X has a high current beam, which can be used for “slow” muon physics.
• There are design and operational constraints.
• There is a reasonable timing structure.
• This dialog should remain open as we proceed further with the physics options.
• Thank you for inviting me!