NuStorm target and facility
D Adey

2nd PASI meeting, Rutherford Appleton Laboratory
4th April 2013
Contents

• Concept
• Motivations/Benefits
• Accelerator complex
• Implementation
• Material taken from NuStorm workshops at Fermilab (Sept 12), Imperial college (Nov 12) and CERN (Mar 13)
Neutrinos from STOREd Muons

- 60-120 GeV POT
- Pion capture
- Transport line and injection
- $\pi \rightarrow \mu$ decays in ring
- $\mu$ storage for ~ 70 turns

$$N\mu = (\text{POT}) \times (\pi/\text{POT}) \times \varepsilon_{\text{collection}} \times \varepsilon_{\text{inj}} \times$$
$$\frac{\mu}{\pi} \times A_{\text{dynamic}} \times \Omega$$

- $10^{21}$ POT in 5 years of running @ 60 GeV in Fermilab PIP era
- 0.1 $\pi$/POT
- $E_{\text{collection}} = 0.8$
- $E_{\text{inj}} = 0.8$
- $\mu/\pi = 0.08$ (yct $\times \mu$ capture in $\pi \rightarrow \mu$ decay) [$\pi$ decay in straight]
- $A_{\text{dynamic}} = 0.75$ (FODO)
- $\Omega = $ Straight/circumference ratio (0.43) (FODO)

1.7 X $10^{18}$ useful $\mu$ decays

Precise flux with known flavour content
v physics motivations

Cross sections (Boyd)

- Cross sections in few GeV range not as well known as low or high energies
- One of the largest systematic errors for oscillation experiments
- No realistic standard candle
- Old data is proving difficult to interpret

Sterile neutrinos (Parke)

- Gallium: $2.7\sigma$ evidence for $\nu_e$ disappearance
- LSND: $3.8\sigma$ evidence for $\bar{\nu}_e$ appearance
- MiniBooNE: $3.8\sigma$ evidence for $\nu_e$ and $\bar{\nu}_e$ appearance
- Reactor: $3.0\sigma$ evidence for $\bar{\nu}_e$ disappearance
- LEP limits to 3 light, interacting neutrinos

Giunti arXiv:1106.4479

Oscillation with only $3\nu$ and $\sin^2 2\theta_{13} = 0.06$

Oscillation with $4\nu$ and one $\Delta m^2 \gg 1\text{ eV}^2$
Target
(Striganoff)

- 100KW (prepare for 400KW) 60GeV from main injector
- Graphite target within NuMI-like horn
- Li lens would be beyond state of art
- MARS studies suggest 0.1 pions / POT
- Significant irradiation of first quadrupoles in transport line

<table>
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<th>Magnet Name</th>
<th>Length (mm)</th>
<th>Distance to horn (From End of Magnet, mm)</th>
<th>Strength (T/m)</th>
<th>Beam pipe radius (mm)</th>
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![Graph 1](image1)

![Graph 2](image2)
Radiation hard magnets (Cozzolino - BNL)

- High temperature and radiation tolerant quadrupoles under investigation at Brookhaven
Capture and injection

(Liu)

- Stochastic injection of pions into decay ring
- Dual optics for 5GeV pions and 3.8GeV muons
- High energy muons can be passed through a degrader to provide a low energy muon beam for further use
• Different arc lengths for injection and return arcs
• 150m non-parallel straights

\[ \beta \gamma \approx 37 \rightarrow A_N = A \beta \gamma = 74 \text{ mm rad} \]
• Momentum: \( \sigma \Delta p/p = 0.08 \)
• 35% dynamic lost after 70 turns (no decays)
FFAG decay ring
(Pasternak)

Simulation studies for FFAG decay ring, suggest:
● 1mmrad non-normalised acceptance
● 26% momentum spread achievable
● 0.7% losses after 60 turns

Experimental tests of straight FFAG at KURRI
Implementation at Fermilab
(Geelhoed)

• Use MI abort line
• Far detector hall in D0 assembly building
• Beamline layout, costing, component search, safety planning
• Integration with MI cycle
Implementation at CERN (Wildner)

- Use SPS at 60GeV
- 10μs pulse (compared to 2μs at FNAL)
- Use North area
- Proportion of preparatory work not site specific
Summary

- Work on sterile search and cross section physics potential
- Proton source, target, capture, injection and decay ring work
- Implementation at sites at Fermilab and CERN
- LOI submitted to Fermilab, EOI in preparation for CERN
Questions?