WG1: Neutrino, Rare Muon and Kaon Physics summary

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Workshop on Applications of High Intensity Proton Accelerators October 19-21, 2009

Motivation: Physics beyond the Standard Model

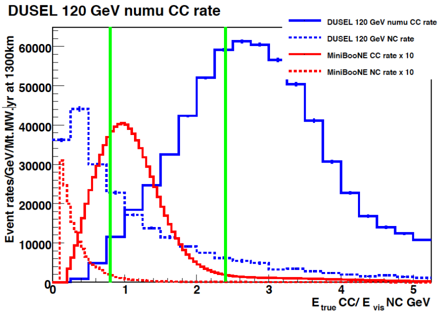
Process	Prediction	Measurement
ν oscillations (CP violation, etc.)		
$\mu^+ \to e^+\gamma$	$\mathcal{B}_{SM} \sim 10^{-54}$	$< 1.2 \times 10^{-11}$
$\mu^- N \to e^- N$	$\mathcal{B}_{SUSY} \geq 10^{-18}$	$< 4.3 \times 10^{-12}$ (Ti)
$g_\mu - 2$	$a_\mu^{exp} - a_\mu^{SM} = (27.6 \pm 8.1) \times 10^{-10}$	
μ EDM	0 SUSY $\sim 10^{-24}\ e \cdot cm$	$< 2 \times 10^{-19}\ e \cdot cm$
$K^+ \to \pi^+\nu\bar{\nu}$	$\mathcal{B}_{SM} = (8.5 \pm 0.7) \times 10^{-11}$	$(17.3^{+11.5}_{-10.5}) \times 10^{-11}$
$K_L^0 \to \pi^0\nu\bar{\nu}$	$\mathcal{B}_{SM} = (2.5 \pm 0.4) \times 10^{-11}$	$< 6.7 \times 10^{-8}$

LBNE MI ν beam (M.Bishai)

Long-baseline neutrino program

- 1280 km baseline to Homestake
- 20-year program
- $0.5 < E_\nu < 10$ GeV to address most ν oscillation questions. Lower E_ν not easily accessible due to Fermi motion.
- 700 kW @ 120 GeV (pre-ProjectX) with capability of 2MW @ 60 - 120 GeV(ProjectX)
- Further design & optimization of target, focussing, decay region can improve sensitivity
- Fast-extracted beam
- Low-energy ν beam option? (next slide)

Conventional ν beam (M.Bishai)



Green lines are oscillation maxima at 1300 km baseline.
MiniBoone 8 GeV beam($\times 10$) compared to 120 GeV MI beam

- Can increase MiniBoone 8 GeV ν flux by $\times 2-3$ with more efficient focussing, longer decay pipe
- Water Č det. efficiency increases at low energy
- NC background smaller
- Is it possible to run 8 GeV beam interleaved with 120 GeV MI beam in LBNE beamline?
- Need detailed sensitivity calculation

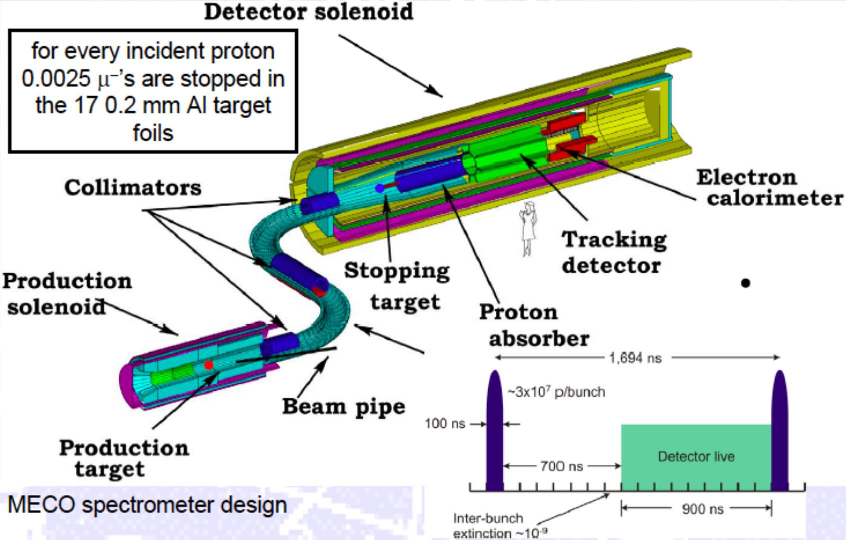
Muons

- $\mu^+ \to e^+\gamma$: Current experiment (MEG @ PSI) limited by detector resolution, not beam intensity. Difficult to see how to improve on PSI μ^+ production.
- $\mu^- N \to e^- N$: Limited by beam background, so improvements in purity and intensity of μ^- could improve sensitivity
- $g_\mu - 2$: Improvements on BNL/CERN "magic momentum" technique possible.
- μ EDM is zero in SM. Second-generation sensitivity to new sources of CPV. Copious μ source (and thus proton source) required.

mu2e Muon Beam and Detector

C. Dukes

for every incident proton 0.0025 μ^-'s are stopped in the 17 0.2 mm Al target foils



MECO spectrometer design

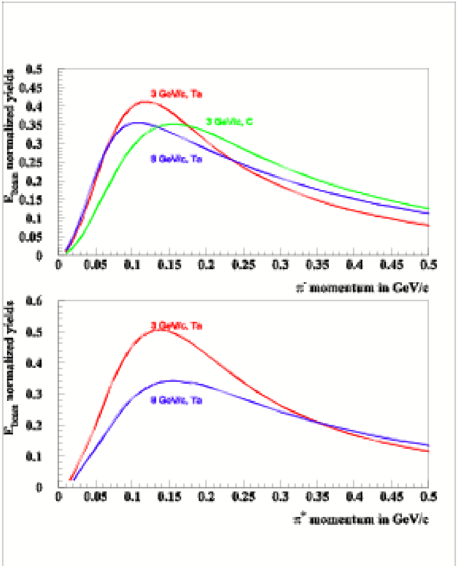
September 11th 2009. R. Tschirhart - Fermilab

$\mu^- N \rightarrow e^- N$ at ProjectX

- Beam time structure: Pulsed
- Proton beam energy: 2-5 GeV
- Beam pulse width: $< 10 - 30$ ns
- Beam pulse interval 0.3 - 2μs
- Extinction (proton + muon beam): 10^{-11}
- Beam power: > 0.2 (2) MW
- $B(\mu^- N \rightarrow e^- N)/B(\mu^- N \rightarrow \nu N) < 10^{-17}$ ($< 10^{-18}$) sensitivity

Beam pulse interval depends on Z of capture target and details of beam line.
Advances in μ cooling techniques would be beneficial to this measurement.

Pion yields (S.Striganov, MARS15)



- Low energy π^- yield from Ta larger than C at $P_p = 3$ GeV/c
- Normalized low energy π^+ yield larger at $P_p = 3$ GeV/c than 8 GeV/c

muon $g-2$ (BNL method at magic momentum)

- Beam time structure: Pulsed
- Muon (magic) momentum: 3 GeV/c
- Proton beam energy: 8 GeV
- Beam pulse width: < 50 ns
- Beam pulse interval: 1ms
- Extinction: $< 10^{-4}$
- Beam power: > 0.2 MW
- Backward muon beam? Less background, need 5 GeV π
- Reduce storage ring aperture to reduce unc. in average B field at cost of stored beam intensity

Beam pulse interval driven by 64μs muon lifetime at 3 GeV/c. Measure muons for 10 lifetimes.

Muon EDM

- Beam time structure: Pulsed
- beam pulse width: < 50 ns
- beam pulse interval: $\sim 10\mu$s
- beam extinction: 10^{-9}
- Muon momentum < 700 MeV/c
- Beam power: > 2 MW to reach 10^{-25} $e \cdot cm$ (guess)

$K \to \pi\nu\bar{\nu}$ at Project X

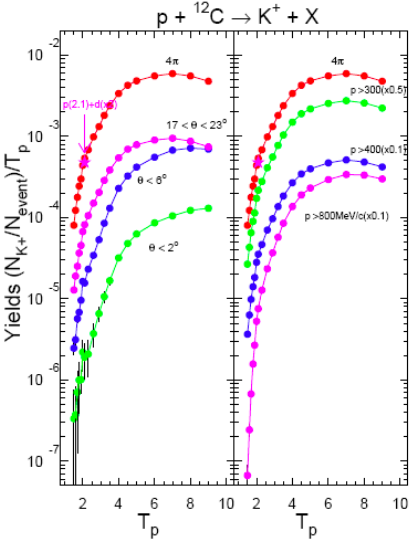
	$K^+ \to \pi^+\nu\bar{\nu}$	$K_L^0 \to \pi^0\nu\bar{\nu}$
Beam time structure	DC	pulsed (25 MHz)
Proton beam energy	2.6-6 GeV	2.6-6 GeV
Beam pulse width	NA	$<$ 50 ps
Beam pulse interval	NA	$\sim$40 ns
Extinction	NA	10^{-3}
Beam power	2 MW	2 MW

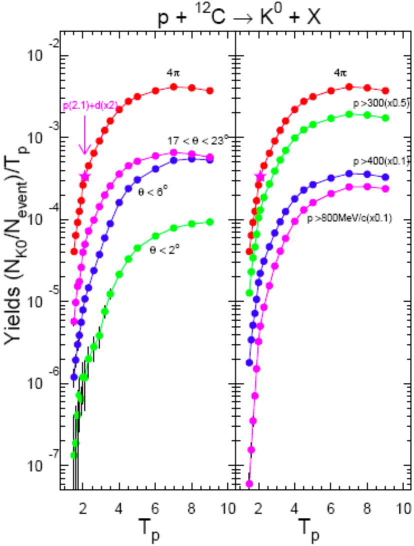
Both experiments prefer ICD-2.

Maximum power would allow reduction of phase space of kaon beams for higher beam purity, detection efficiency.

Kaon production (K.Gudima, MARS15-LAQGSM)

Optimal production rate at $T_p \geq 4$ GeV is 8-10$\times$ rate at $T_p = 2$ GeV





Considerations for kaon beams at ProjectX

- K^+ experiment uses stopped beam.
  - At low energy $T_p = 2.6$ GeV K^+ stopping rate is 180× AGS, kaon production is not optimal and π^+/K^+ is 6× worse than at 6 GeV.
  - Requires improved separation. Perhaps RF separation is superior to electromagnetostatic separation (P.Cooper).
- Neutral kaon experiment uses TOF technique.
  - At $T_p = 2.6$ GeV K_L^0 flux would be 25× KOPIO proposal, K_L^0/neutron is 4 times worse than KOPIO.
  - At $T_p = 6$ GeV, K_L^0/watt would be 3× higher still.
  - Need detailed optimization of target, neutral beam and detector.

Potential problem: Destruction of production target at 2 MW.