ν flux at nuSTORM

D Adey

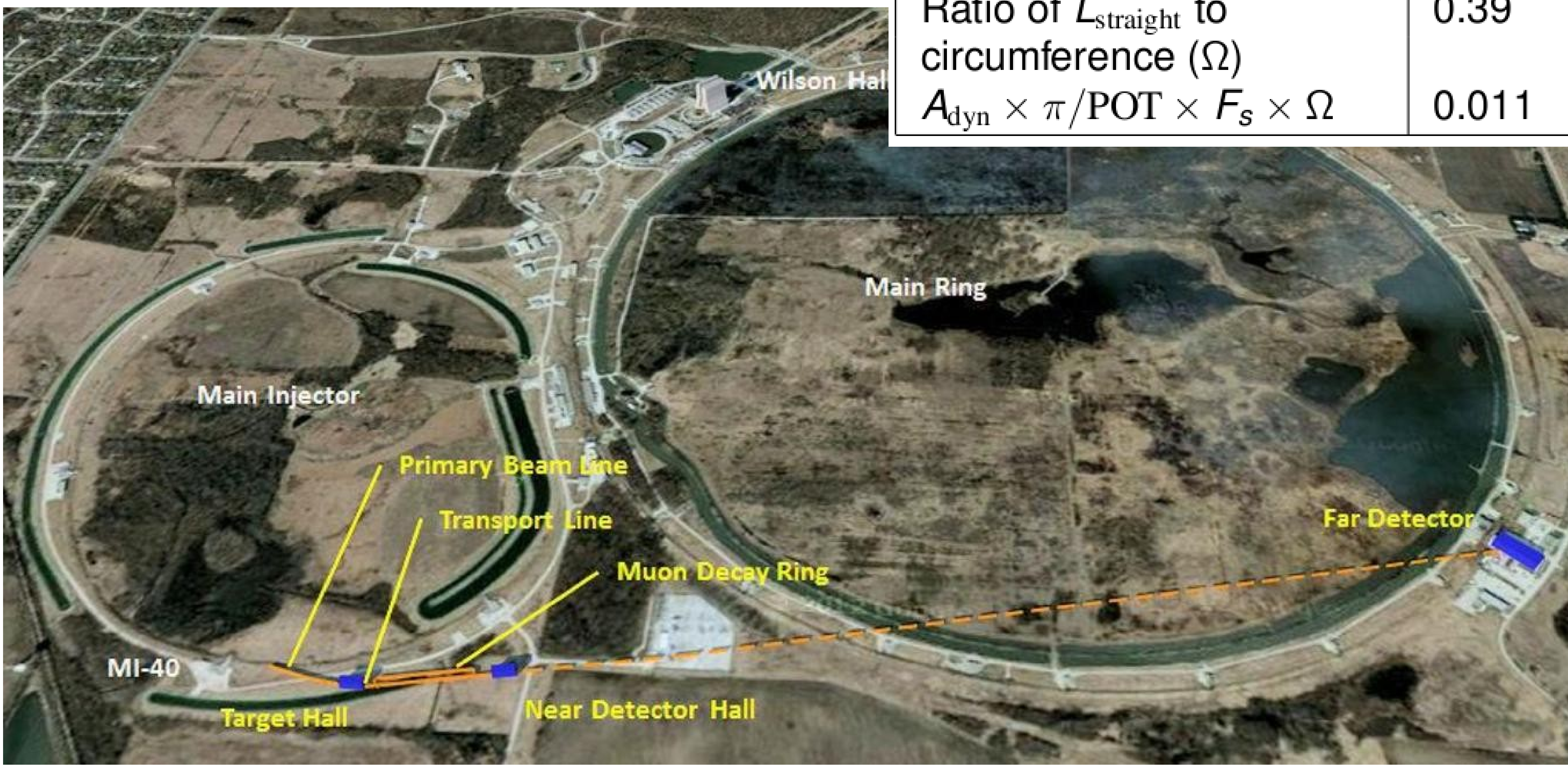
MAP Collaboration Meeting
28th May 2014

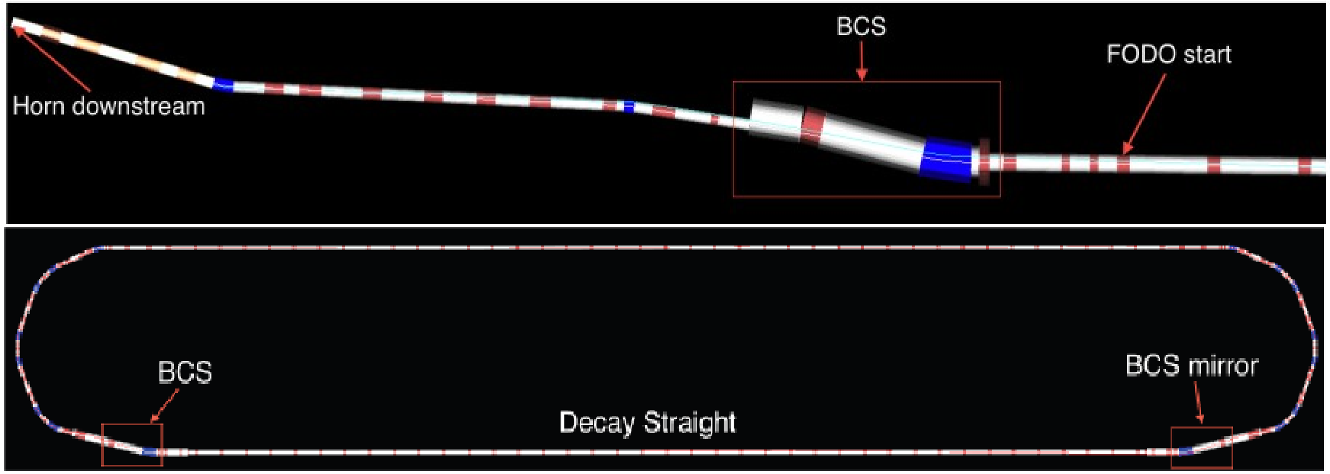
Overview

- Flux features
- Muon-decay flux sampling methodology
- Muon-decay flux at near and far detectors
- Muon-decay flux precision
- Pion-decay flux to near and very far detectors
- Thanks to A Liu, R Bayes, P Coloma

- Protons from Main Injector to new target and horn
- Pion transport line with two ~large angle bends
- Injection into ring with dual optics – 5GeV pions and 3.8GeV muons
- ~180m straights
- Near detector 50m, far detector 2km optimisied for sterile neutrino search

Parameter	Values
L_{straight} (m)	185
Circumference (m)	480
Dynamic aperture A_{dyn}	0.6
Momentum acceptance	$\pm$ 20%
π/POT in momentum acc.	0.094
Fraction of π decays in straight (F_s)	0.52
Ratio of L_{straight} to circumference (Ω)	0.39
$A_{\text{dyn}} \times \pi/\text{POT} \times F_s \times \Omega$	0.011





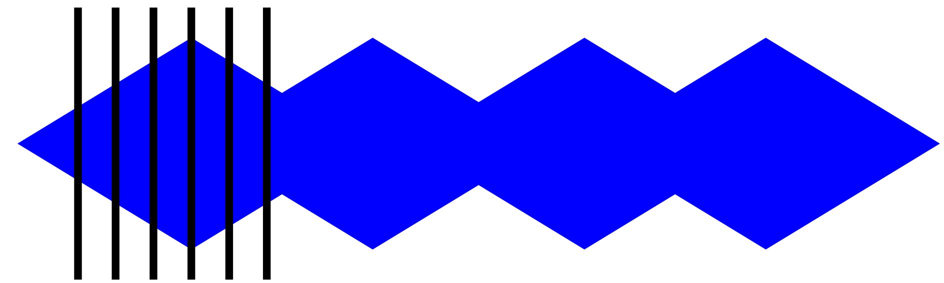
- Assume total exposure of 10^{21} POT
- 2.6×10^{18} “useful” muon decays
- 8.6×10^{19} π + decays

Muon beam tracking approximation

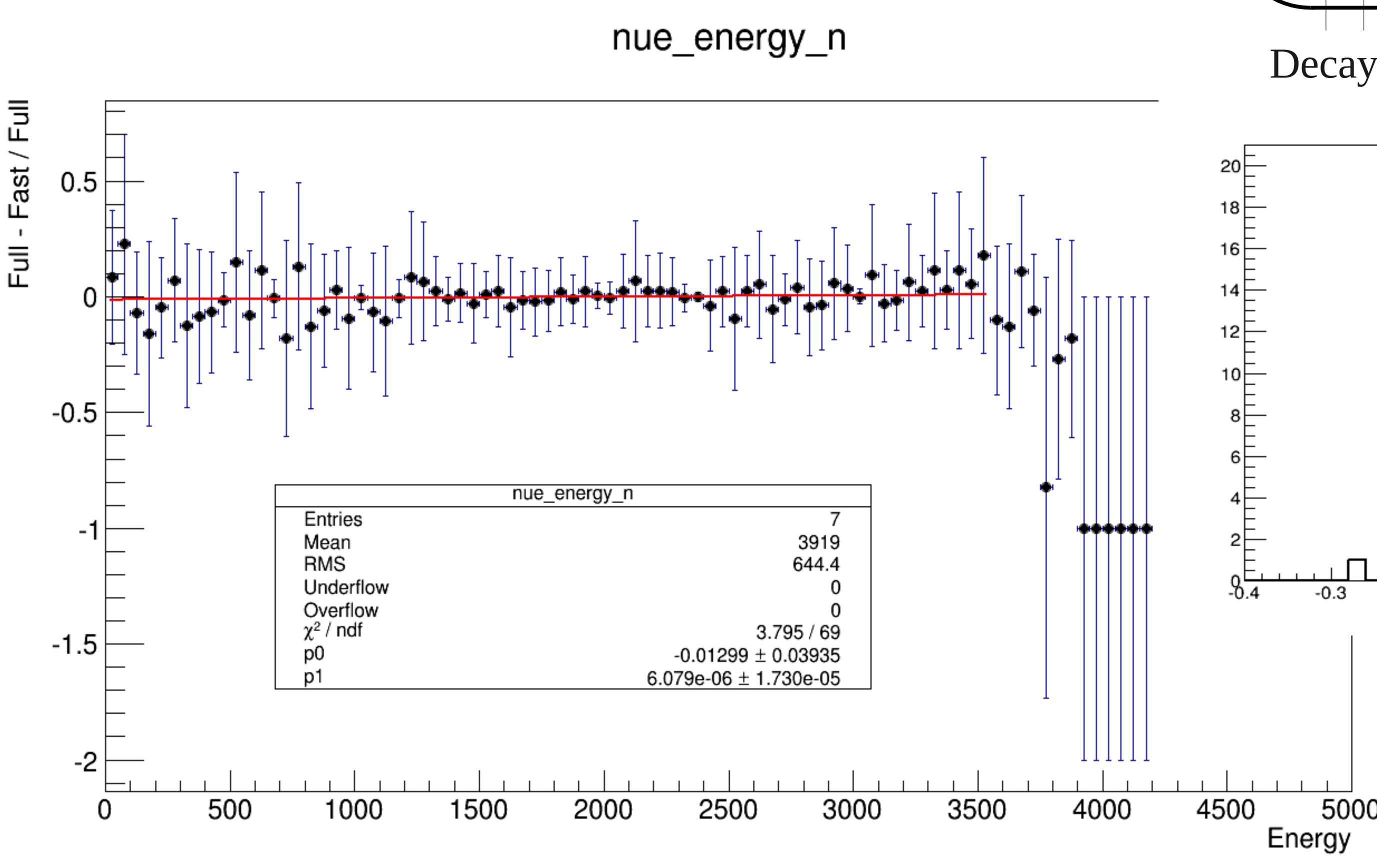
Full Geant tracking of muon beam through decay lattice is computationally intensitve.

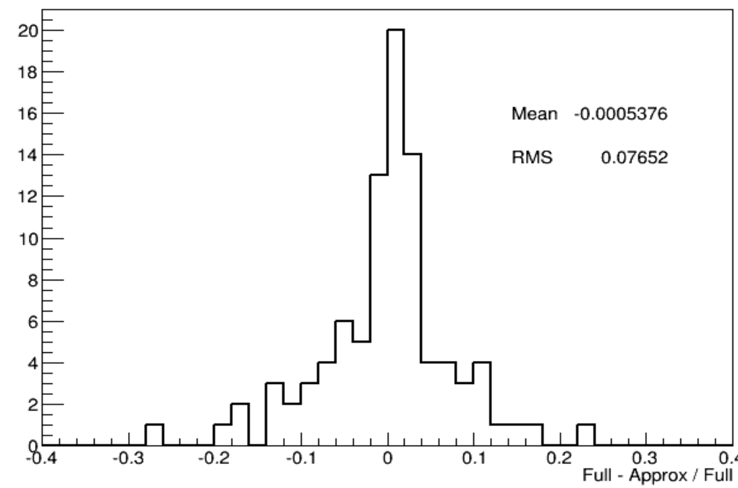
Beam was sampled a) with a single FODO cell b) over the entire straight and this sample used at decay points along the straight

Sampling

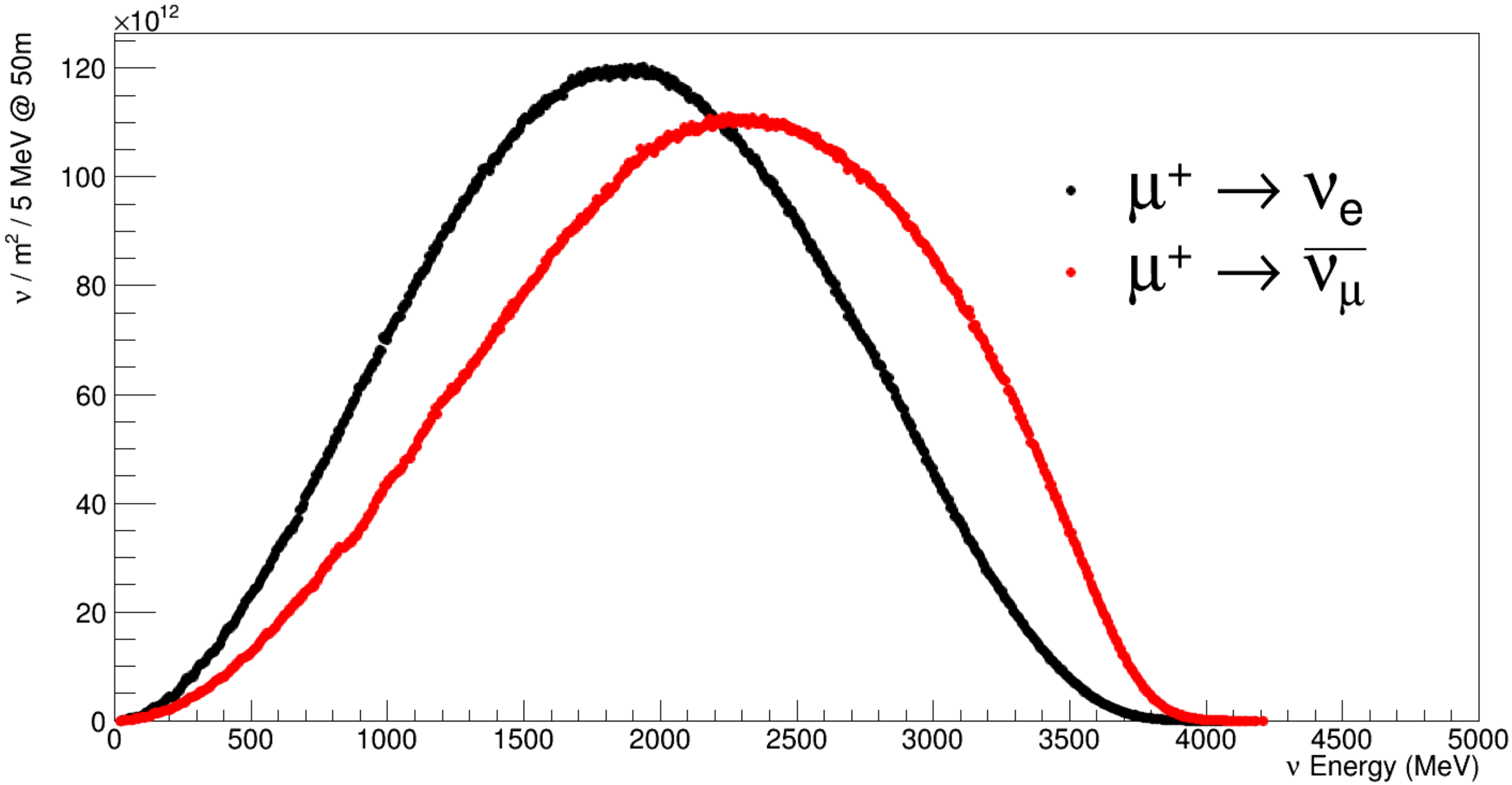


Decay points



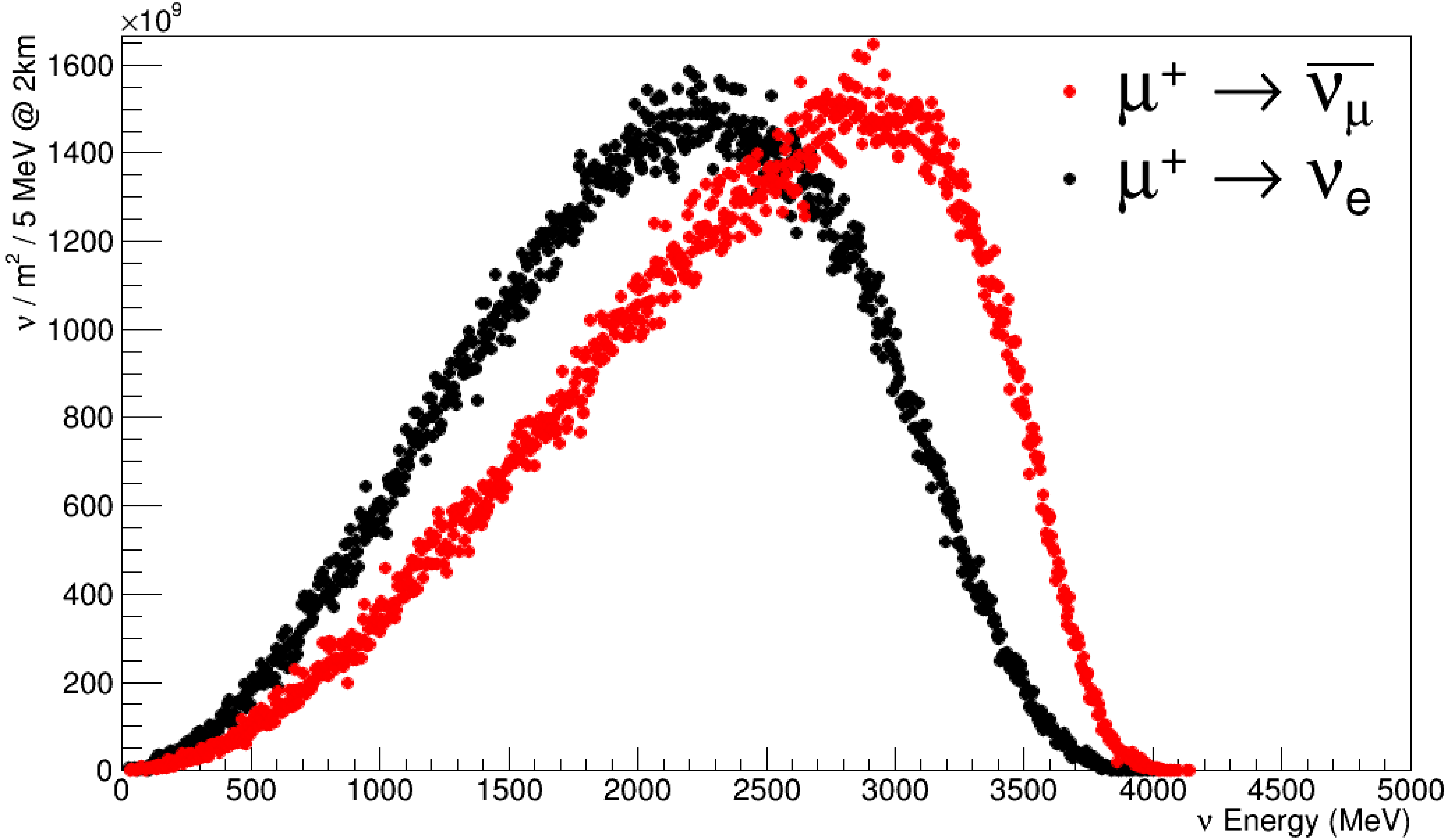


Flux at a near detector 50m from the end of the decay straight with a 3m radius



Rates / 100T for 10^{21} POT

	μ+		μ-
$\overline{\nu_\mu}$ NC	1,174,710	$\overline{\nu_e}$ NC	1,002,240
νe NC	1,817,810	νμ NC	2,074,930
$\overline{\nu_\mu}$ CC	3,030,510	$\overline{\nu_e}$ CC	2,519,840
νe CC	5,188,050	νμ CC	6,060,580



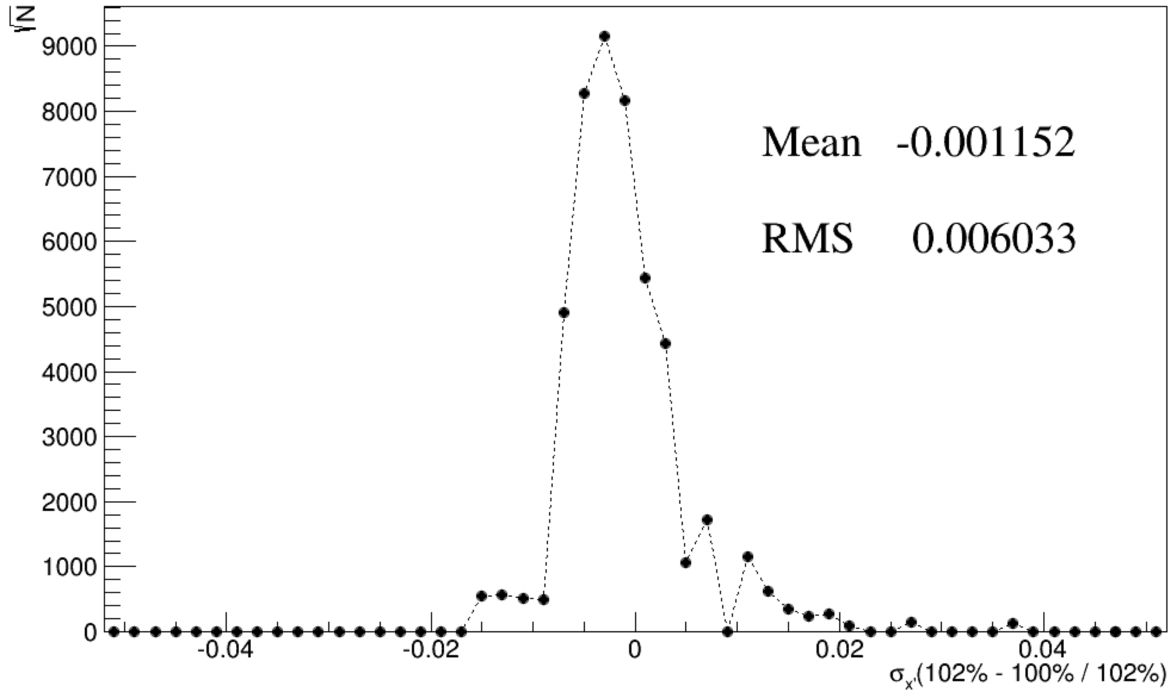
Flux at a fr detector 2km from the end of the decay straight
with a 3m radius – full muon simulation and decays

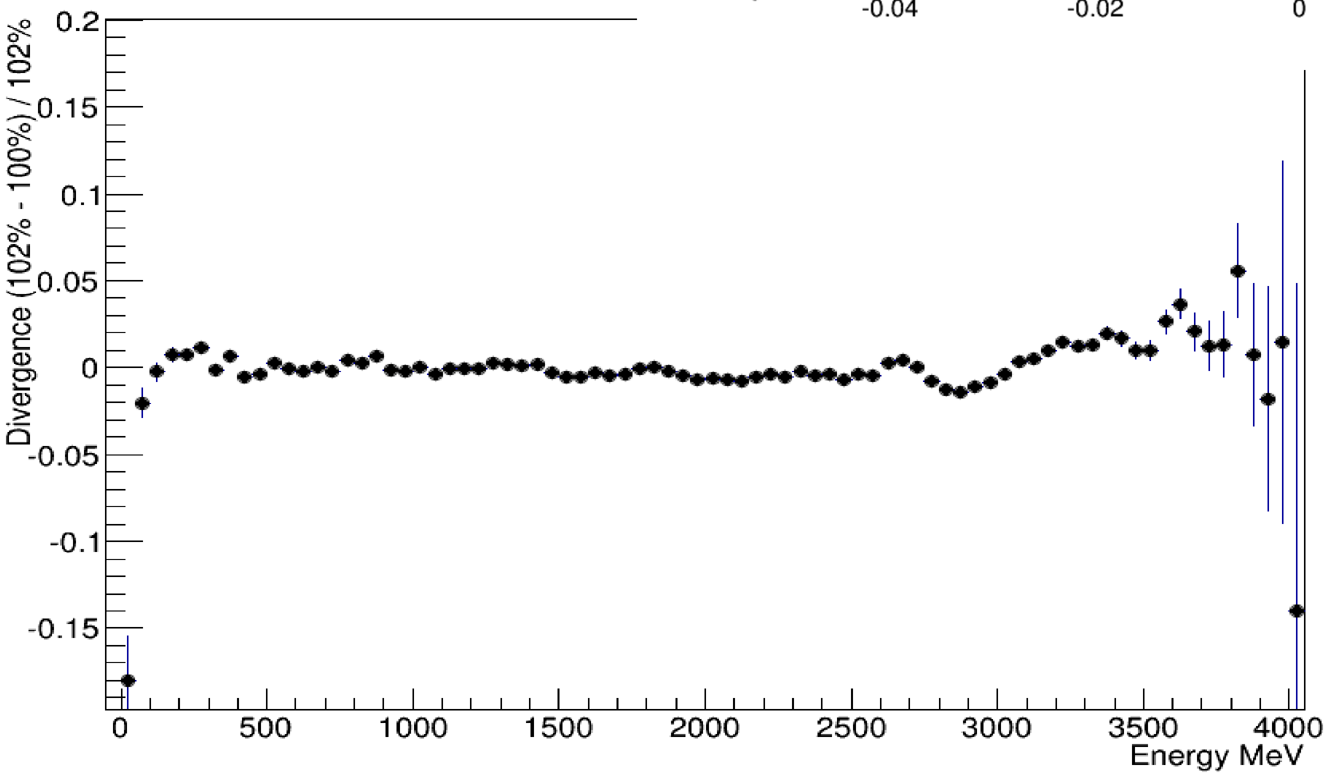
* far detector performance for sterile neutrino searches documented:
Light sterile neutrino sensitivity at the nuSTORM facility Phys. Rev. D 89, 071301(R)

Beam divergence errors

Muon beam divergence inflated by 2% and compared with nominal case – less than 1% bin errors

Divergence resolution of 1% achievable with diagnostics





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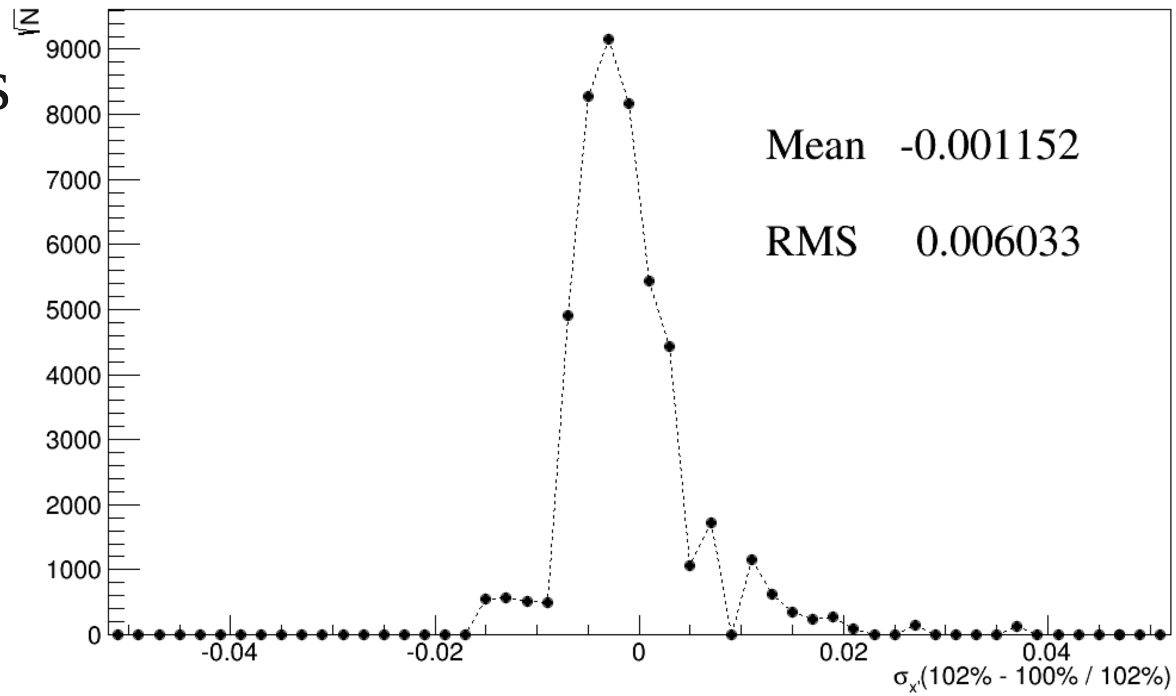
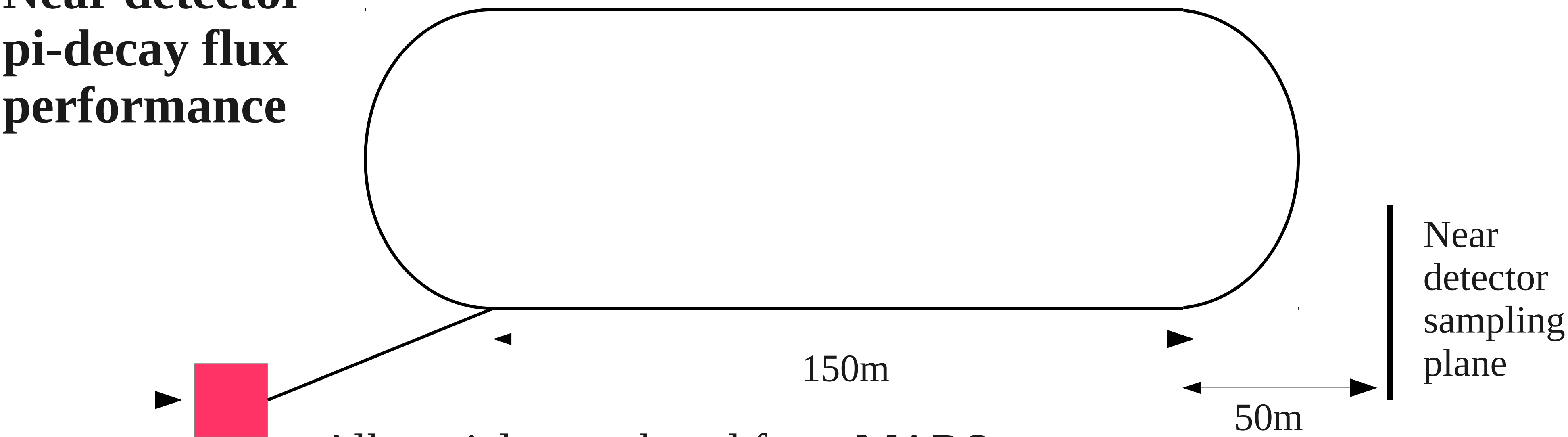


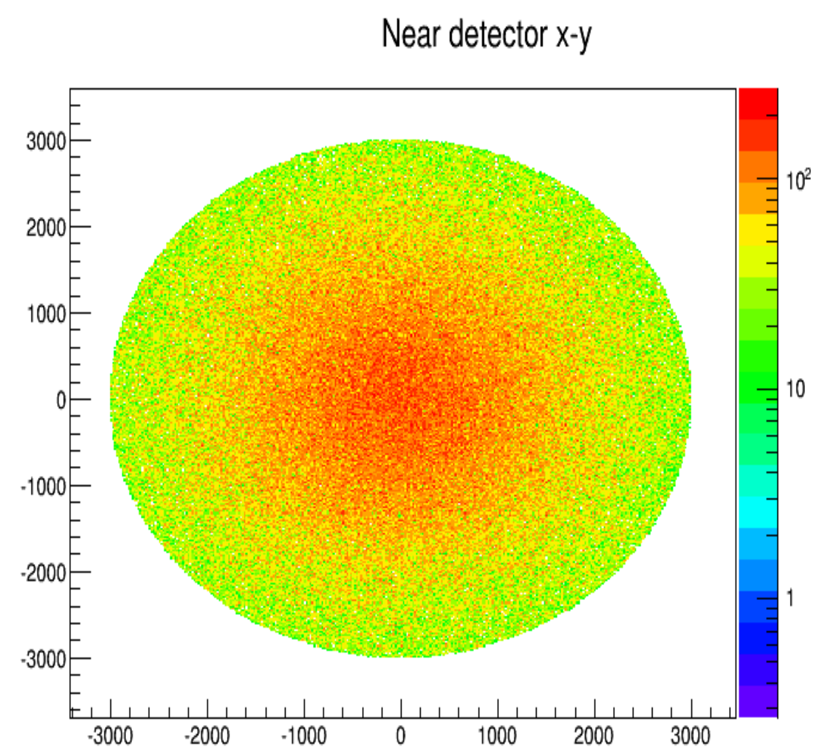
Quantity	Planned Detectors	Comment
Intensity	Beam Current Transformer	0.1% resolution realistic
Beam Position	Button BPM	1 cm resolution expected
Beam Profile	Scintillating screens	Destructive, 1 cm resolution
Energy	Polarimeter	
Energy Spread	Beam Profile measurement in Arcs	order of 0.1% resolution
Beam loss	Ionization or Diamond Detectors	

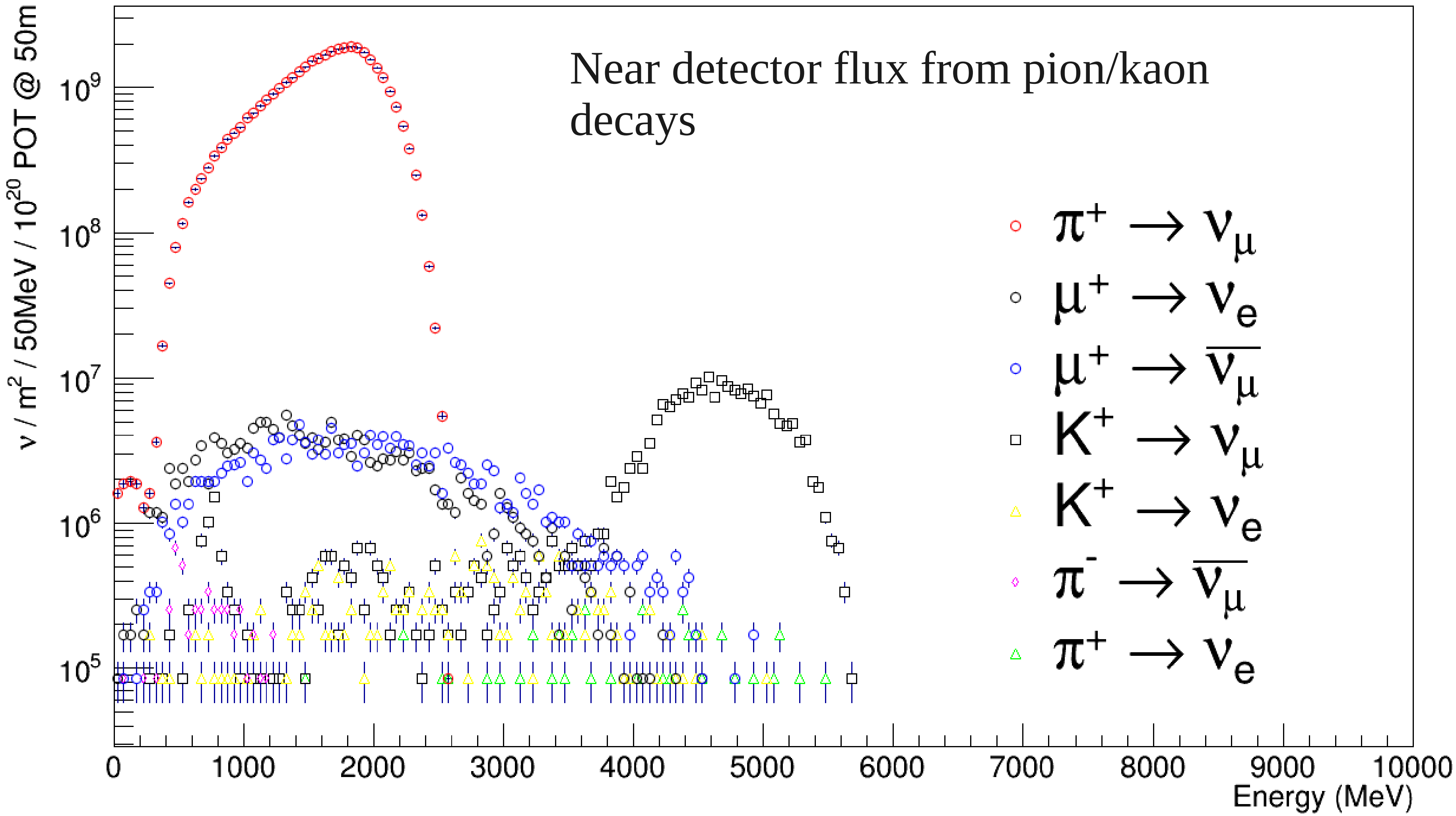
Near detector pi-decay flux performance



All particles produced from MARS target simulation tracking to end of decay straight, with decays enabled

- Flux from pion decay ~10 times larger
- Contributes to near detector physics studies
- Straight large fraction of baseline to near detector
- At near detector full simulation has been completed
- Extremely large statistics generated for cross-checks

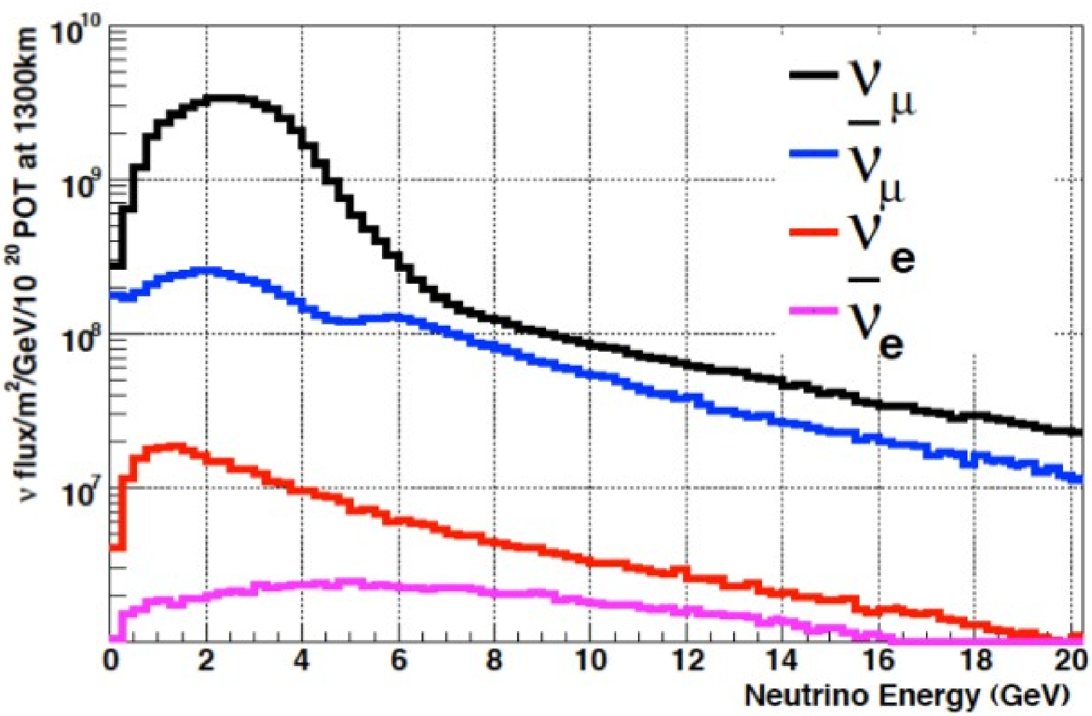


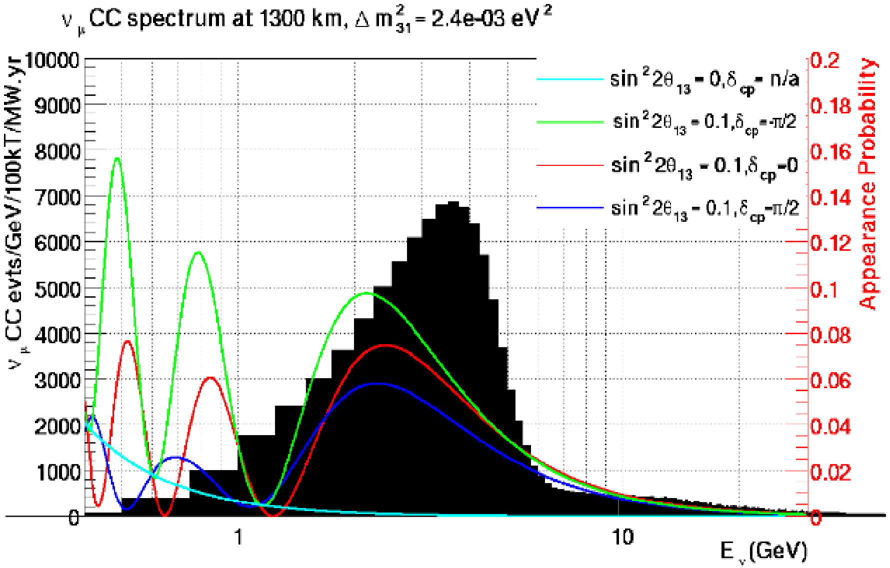


Rates / 100T for 10^{21} POT

	π+		π-
νμ NC	14,384,192	νμ NC	6,986,343
νμ CC	41,053,300	νμ CC	19,939,704

LBNE

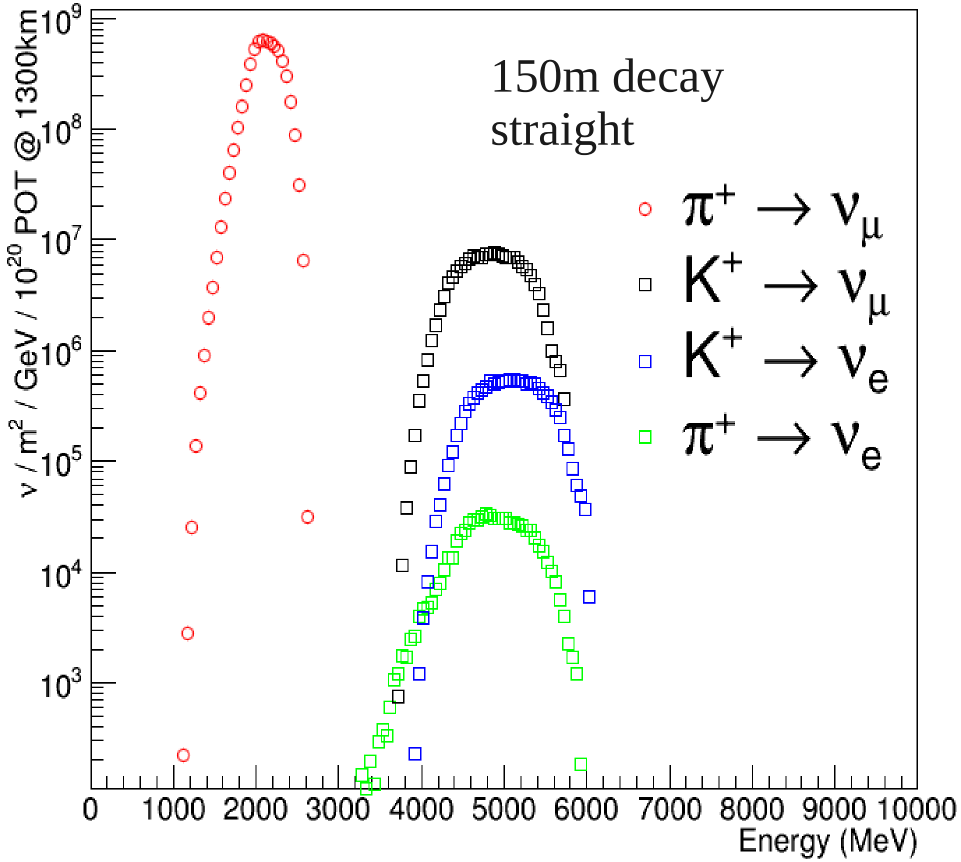


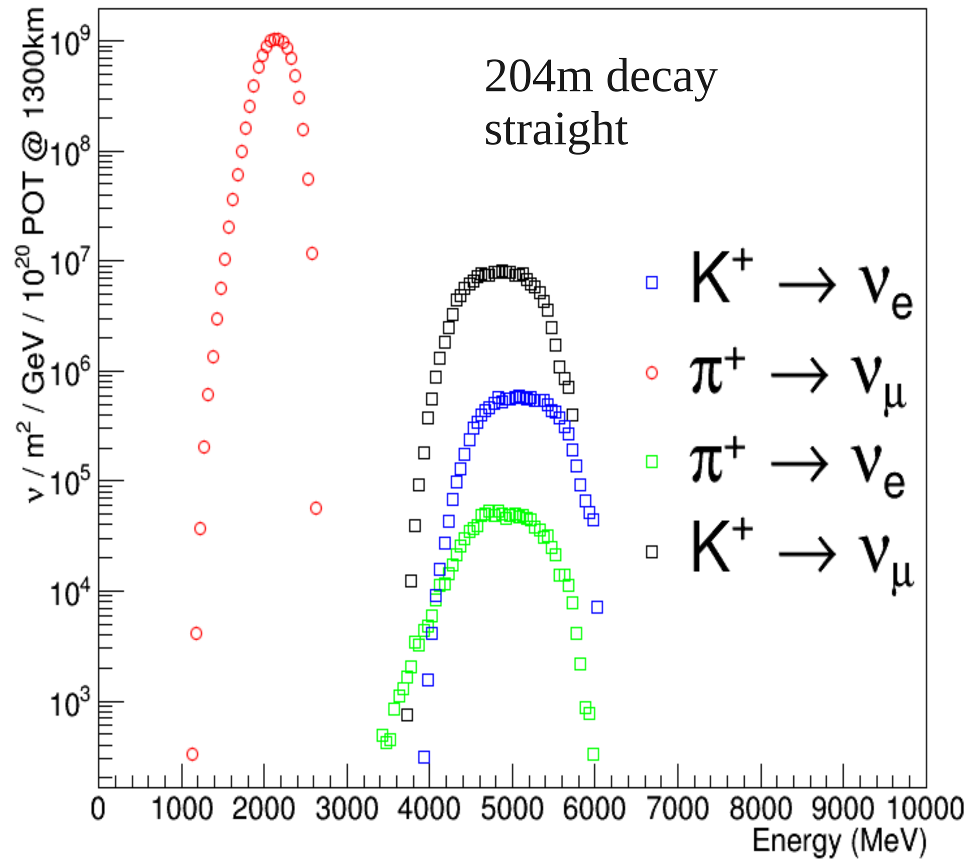


Consider using nuSTORM pion decay beam with LBNE

- Sign selection removes wrong-sign background
- Momentum selection removes high energy NC background
- (Tunable) narrow-band momentum beam
- Hybrid neutrino source – pi-decay and mu-decay

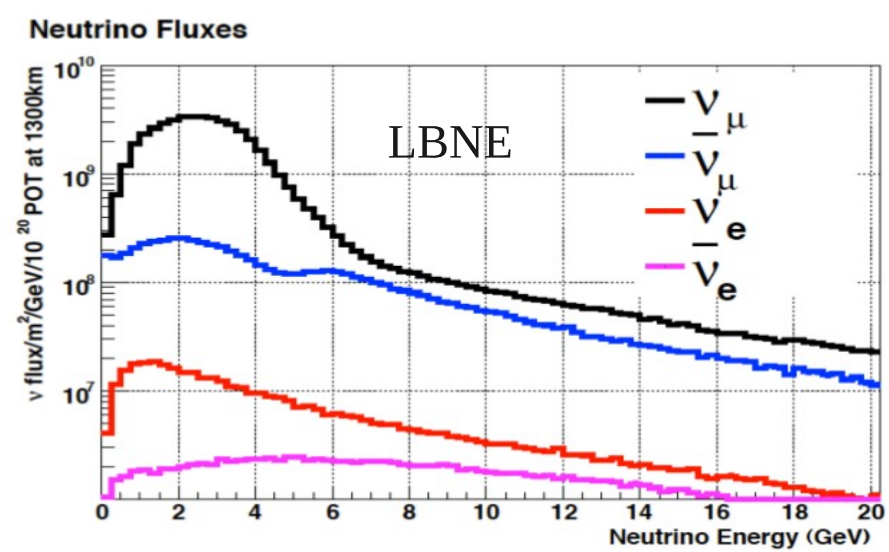
Very far detector pion decay





Full simulation of target (MARS) and horn, transport line and decay straight from 2.4×10^7 POT provides pion/kaon distributions.

Neutrino flux calculation from these distributions at 1300km, scaled to 10^{20} POT and / GeV.



- Neutrino flux from muon-decay expected to be precise to less than 1% bin-to-bin
- Performance of muon-decay neutrinos documented
- Much larger flux from initial pion-decay “flash”
- Plausible to move the nuSTORM pi-decay peak to the 2nd oscillation maximum – what would be the benefits – comparable flux, fewer interactions, low energy detector effects
- Fully optimised pi-decay beam would inhibit muon-decay physics
- FFAG flux under investigation at Imperial

Thank you