

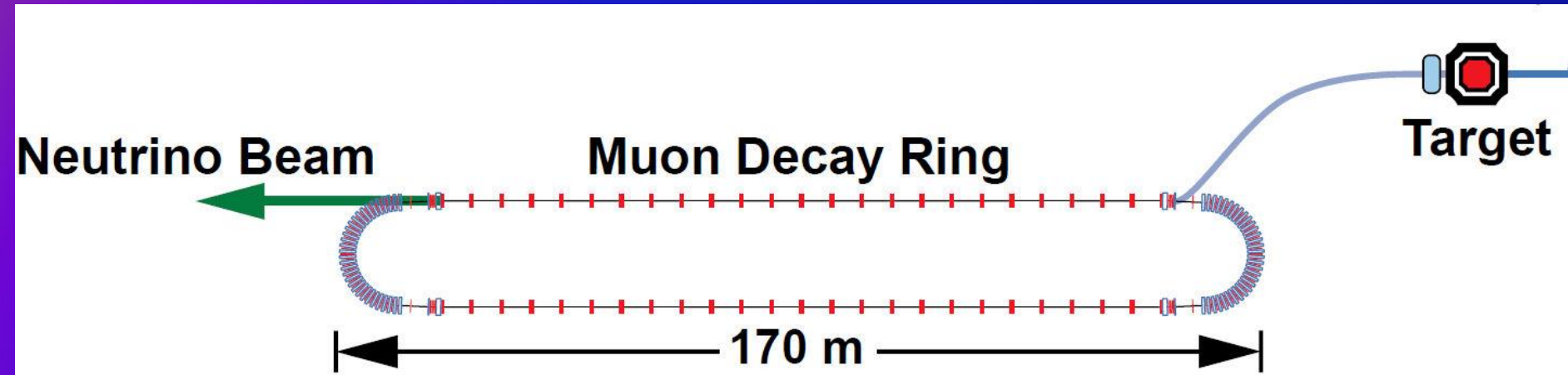
Neutrinos from Stored Muons vSTORM

*A new paradigm for neutrino
physics (& Beyond)?*

Well-understood neutrino source:



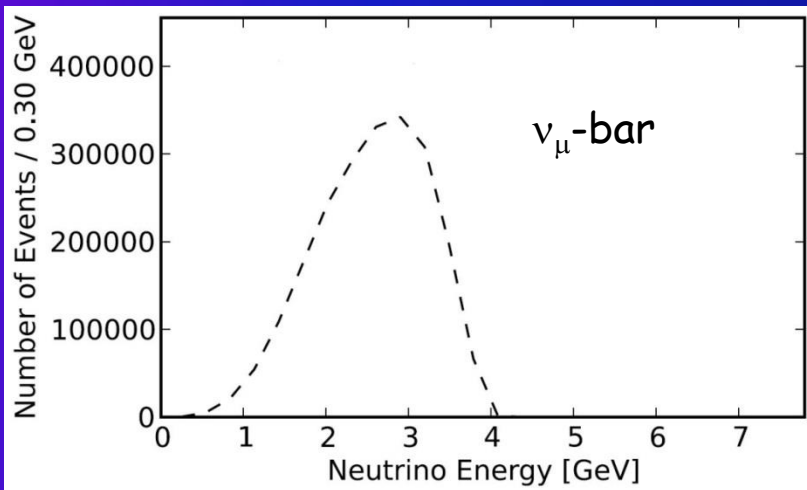
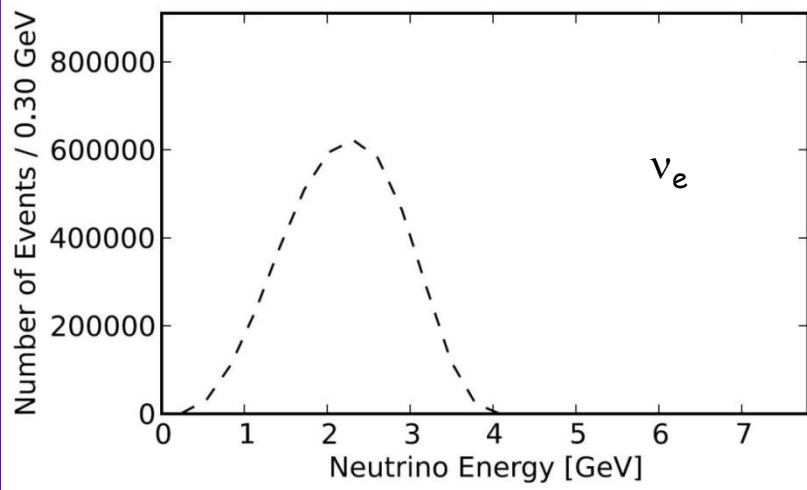
- Flavor content fully known
- “Near Absolute” Flux Determination is possible in a storage ring
 - Beam current, beam divergence monitor, μ_p spectrometer
- Overall, there is tremendous control of systematic uncertainties with a well designed system



- 100 kW Target Station
 - Assume 60-120 GeV protons (Fermilab PIP)
 - Graphite target
 - Optimization on-going
 - Horn collection after target
- π collection/transport channel π injected into decay ring
- Decay ring
 - Large aperture FODO
 - Instrumentation: BCTs, mag-Spec in arc, polarimeter

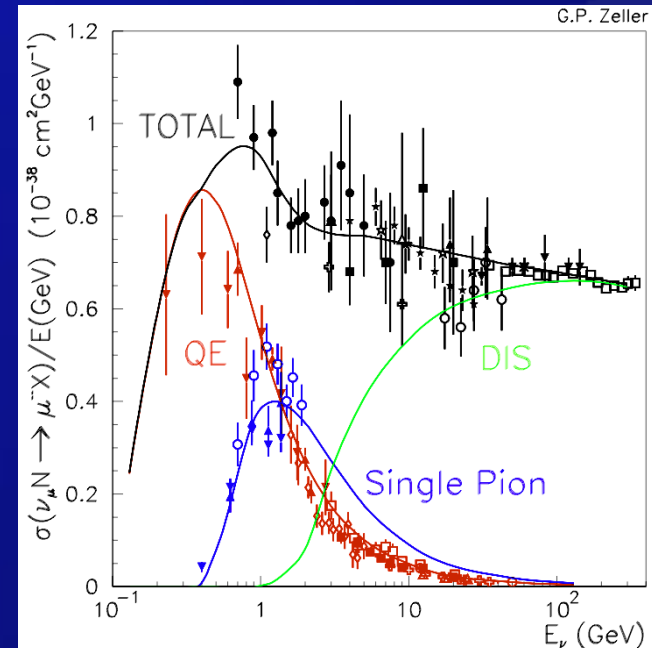
- $N_{\mu} = (\text{POT}) \times (\pi/\text{POT}) \times \epsilon_{\text{collection}} \times \epsilon_{\text{inj}} \times (\mu/\pi) \times A_{\text{dynamic}} \times \Omega$
 - 10^{21} POT in 5 years of running @ 60 GeV in Fermilab PIP era
 - 0.1 π/POT (FODO)
 - $\epsilon_{\text{collection}} = 0.8$
 - $\epsilon_{\text{inj}} = 0.8$
 - $\mu/\pi = 0.08$ ($\gamma\text{ct} \times \mu$ capture in $\pi \rightarrow \mu$ decay) [π decay in straight]
 - $A_{\text{dynamic}} = 0.75$ (FODO)
 - $\Omega = \text{Straight/circumference ratio}$ (0.43) (FODO)
- This yields $\approx 1.7 \times 10^{18}$ useful μ decays

Ao Liu
Fermilab/UI

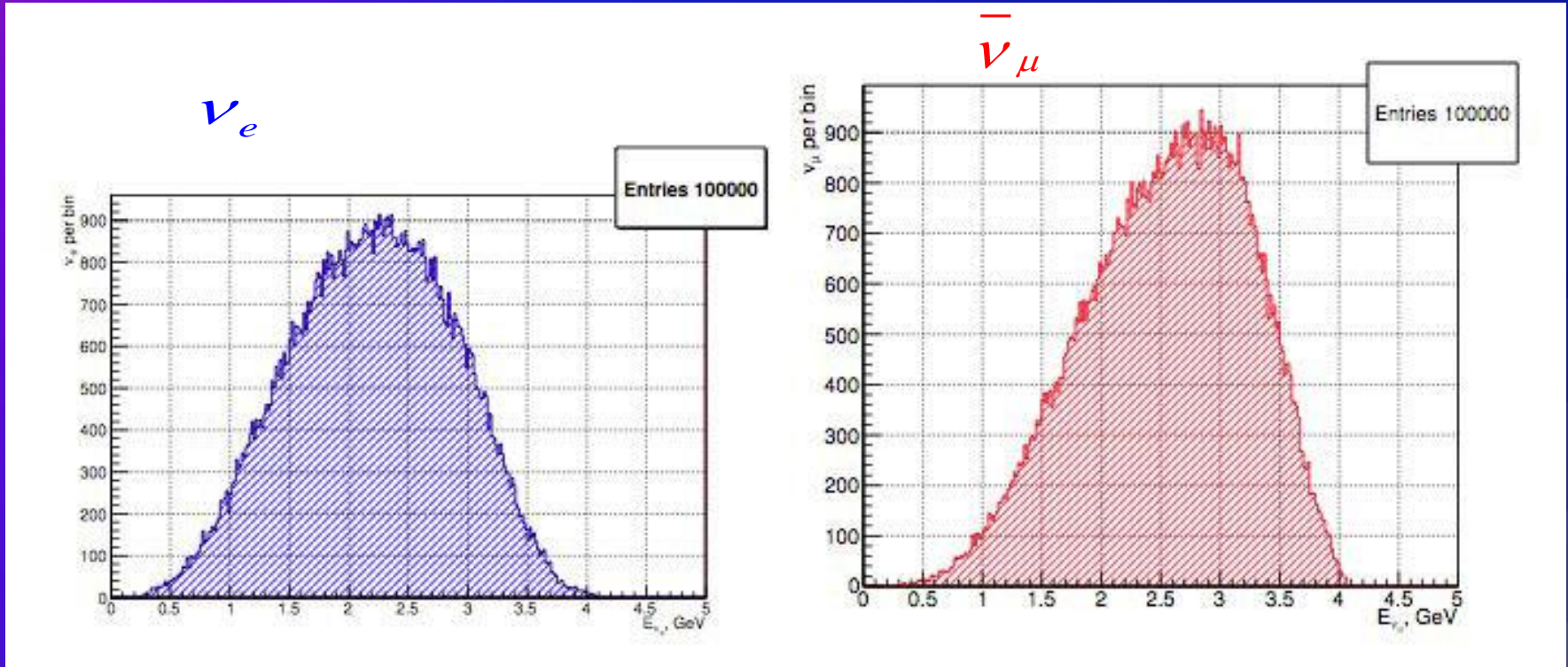


Event rates/100T
at ND hall 50m
from straight with
 μ^+ stored

Channel	N_{evts}
$\bar{\nu}_\mu$ NC	844,793
ν_e NC	1,387,698
$\bar{\nu}_\mu$ CC	2,145,632
ν_e CC	3,960,421



E_ν spectra (μ^+ stored)



Integrated over the 150 m straight at a position 50m from the end of the straight with 3m diameter detector

NOTE: The transport line and ring could be re-tuned for 2 GeV/c μ and move these spectra lower by » a factor of two with some drop in μ production efficiency

Looking Forward: To the Higgs Factory *Friends in High Places*

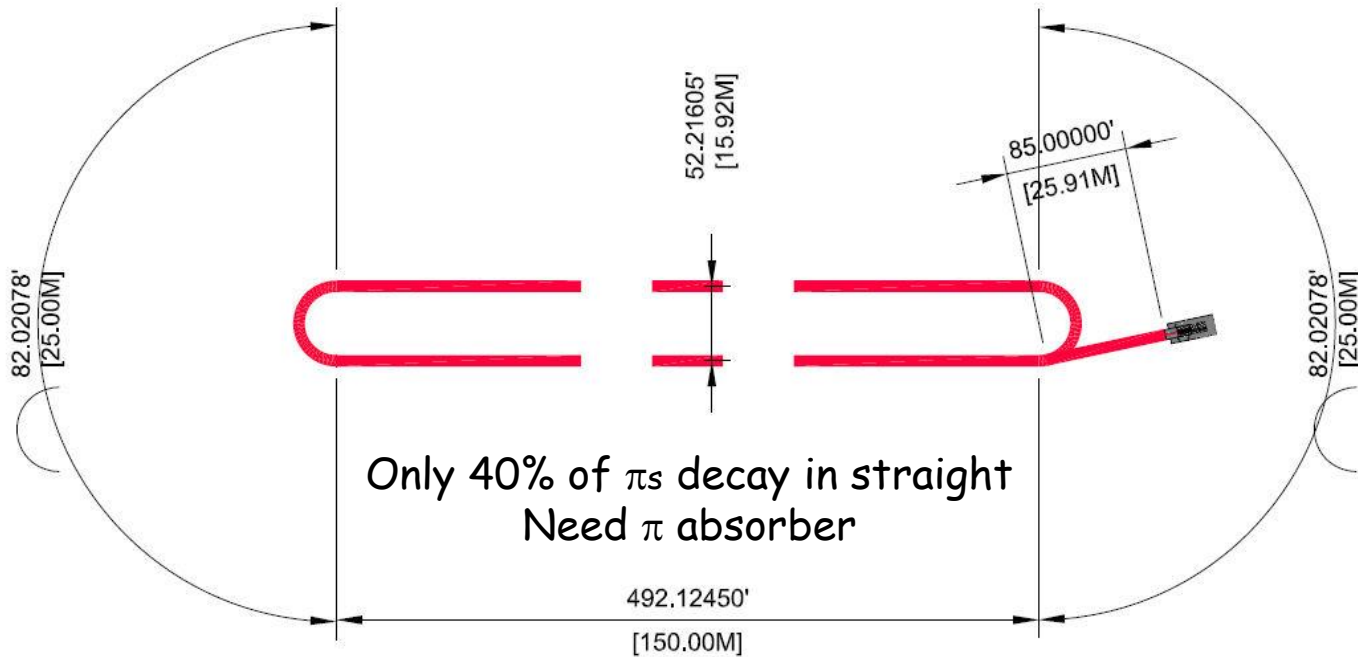
Conclusions (cont)

- The recent discovery of the Higgs particle of 125 GeV at CERN has brought in also the additional requirement of a remarkably small longitudinal emittance.
- The unique feature of the direct production of a H^0 scalar in the s-state is that the mass, total width and all partial widths of the H^0 can be directly measured with remarkable accuracy.
- The main innovative component could be the practical and experimental realization of a *full scale cooling demonstrator*, a relatively modest and low cost system but capable to conclusively demonstrate "ionization cooling" at the level required for a Higgs factory and eventually as premise for a subsequent multi-TeV collider and/or a long distance ν factory
- The additional but conventional facilities necessary to realize the facility with the appropriate luminosity should be constructed *only after the success of this "initial cooling experiment" has been conclusively demonstrated.*

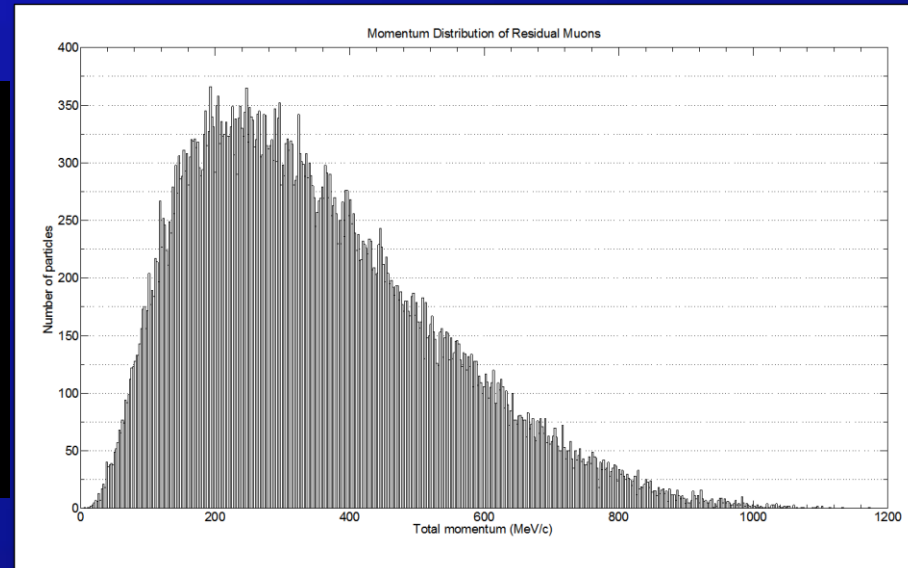
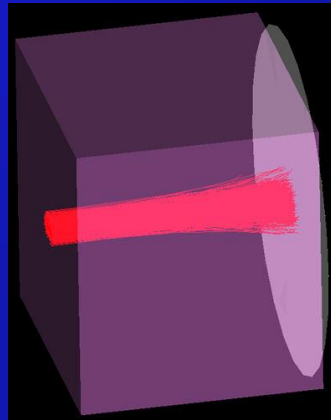
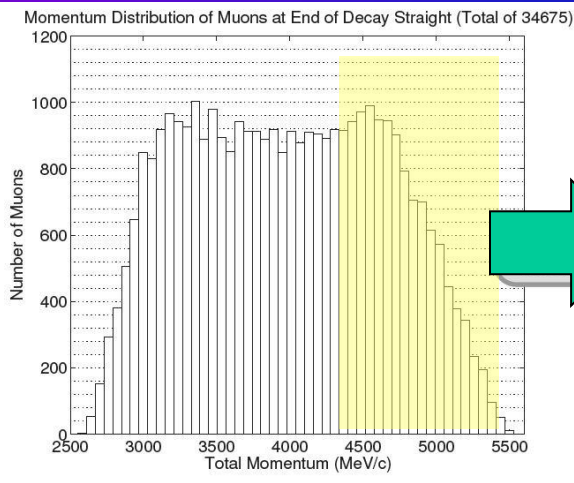
Venice_March2013

Slide# : 38

C. Rubbia, Neutrino Telescopes 2013



DECAY RING - PLAN

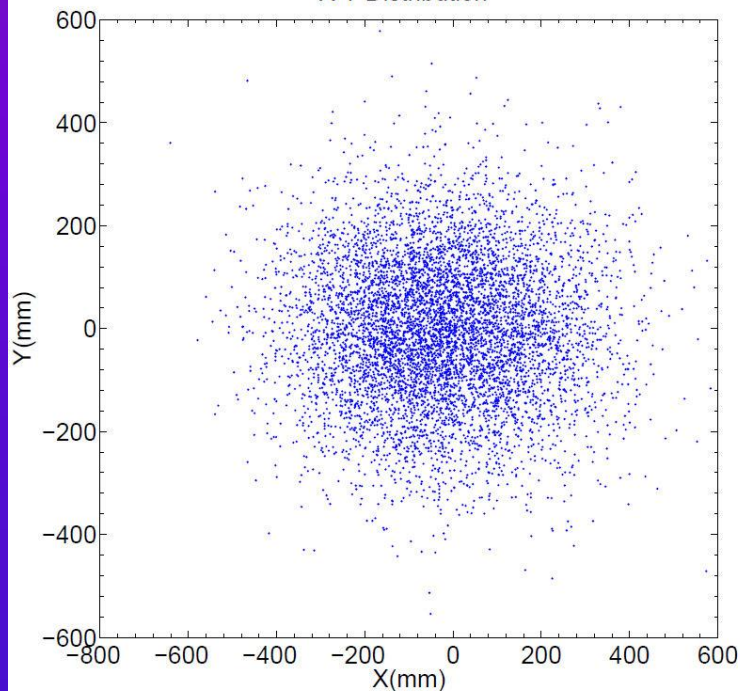


At end of straight we have a lot of π s, but also a lot of μ s with $4.5 < P(\text{GeV}/c) < 5.5$

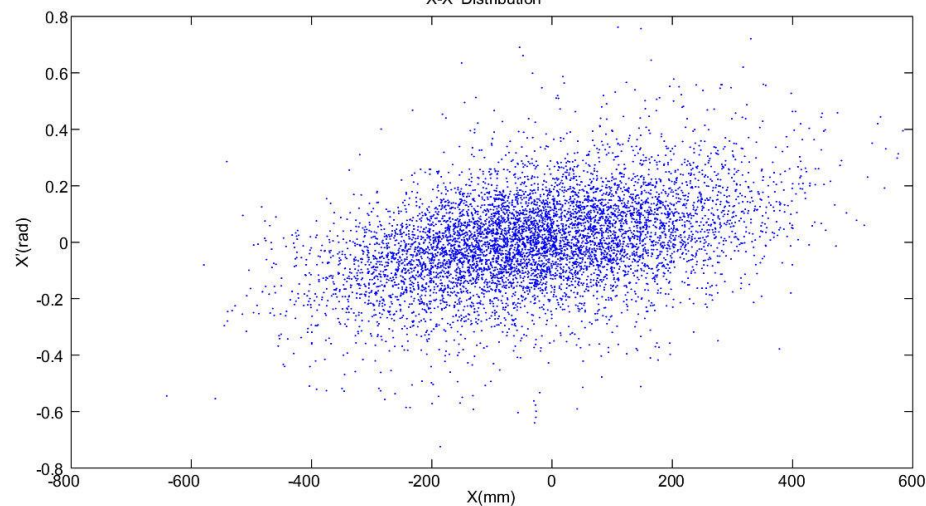
After 3.48m Fe, we have $\approx 10^{10}$ μ /pulse in $100 < P(\text{MeV}/c) < 300$

Input beam for some future 6D μ cooling experiment(s)

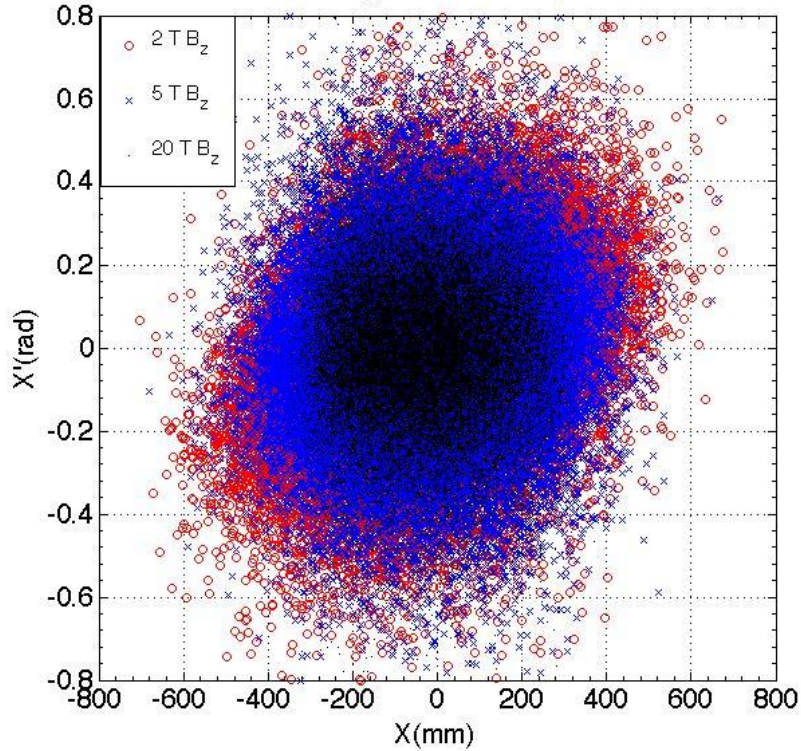
X Y Distribution



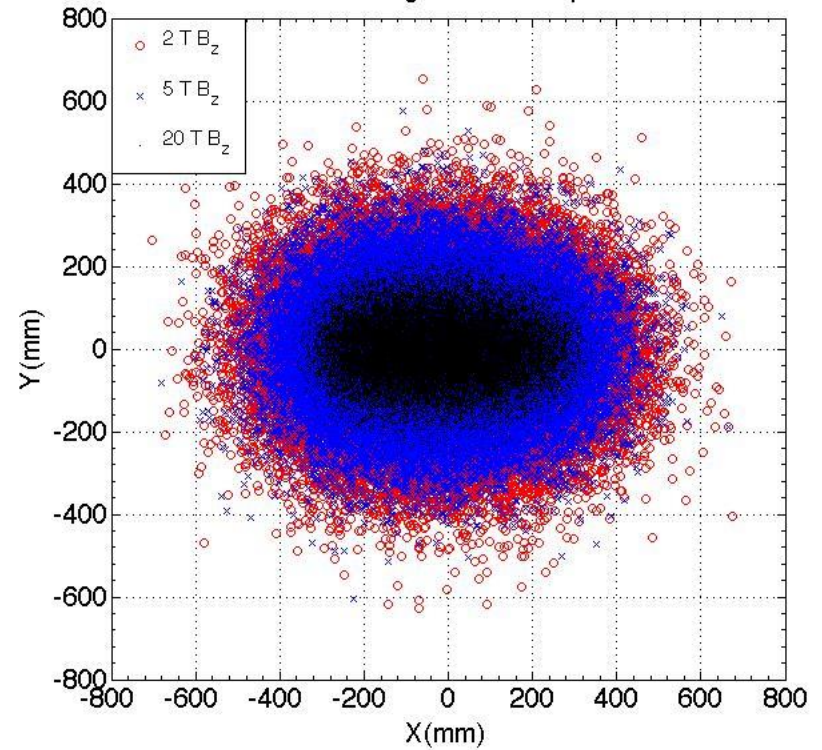
X-X' Distribution



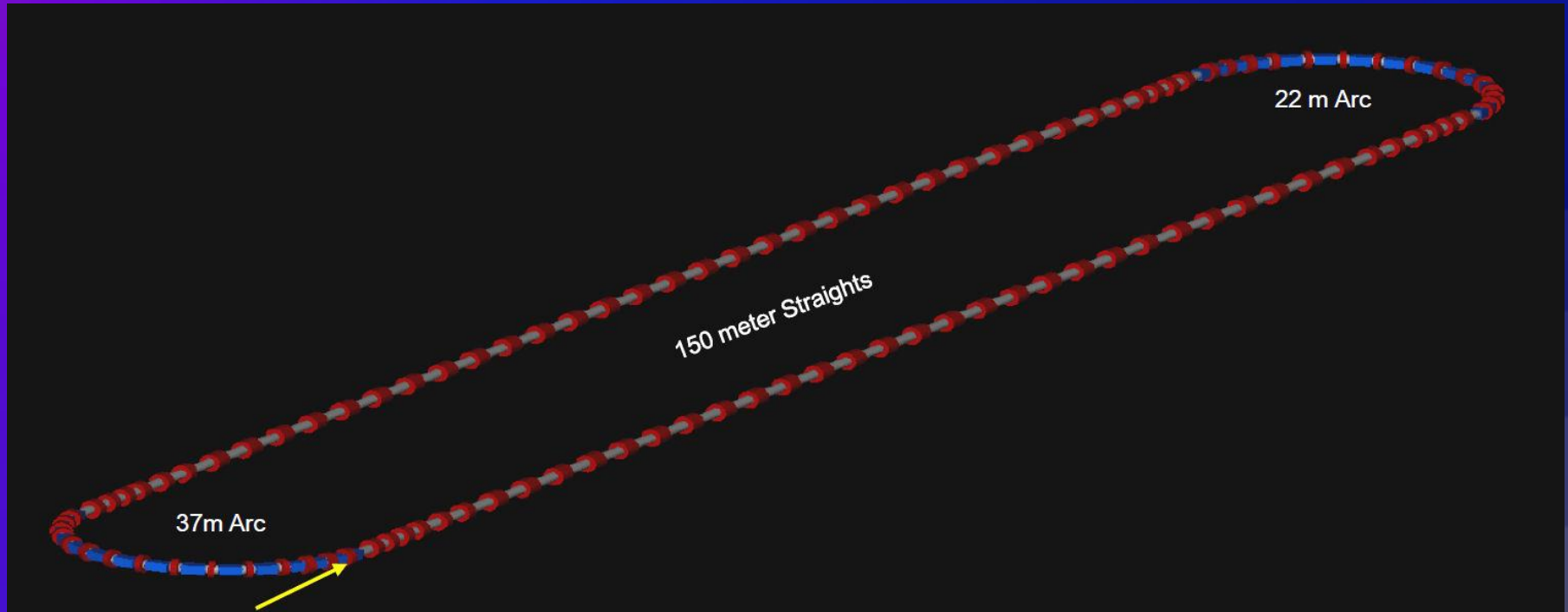
Muons after Degraders-Phase Space Plot



Muons after Degraders-Real Space Plot



Decay-Ring Instrumentation



$3.8 \text{ GeV}/c \pm 10\%$ momentum acceptance, circumference = 350 m

- NF goal has been to measure circulating muon flux to 0.1%
- nuSTORM goal < 1%

Utilize:

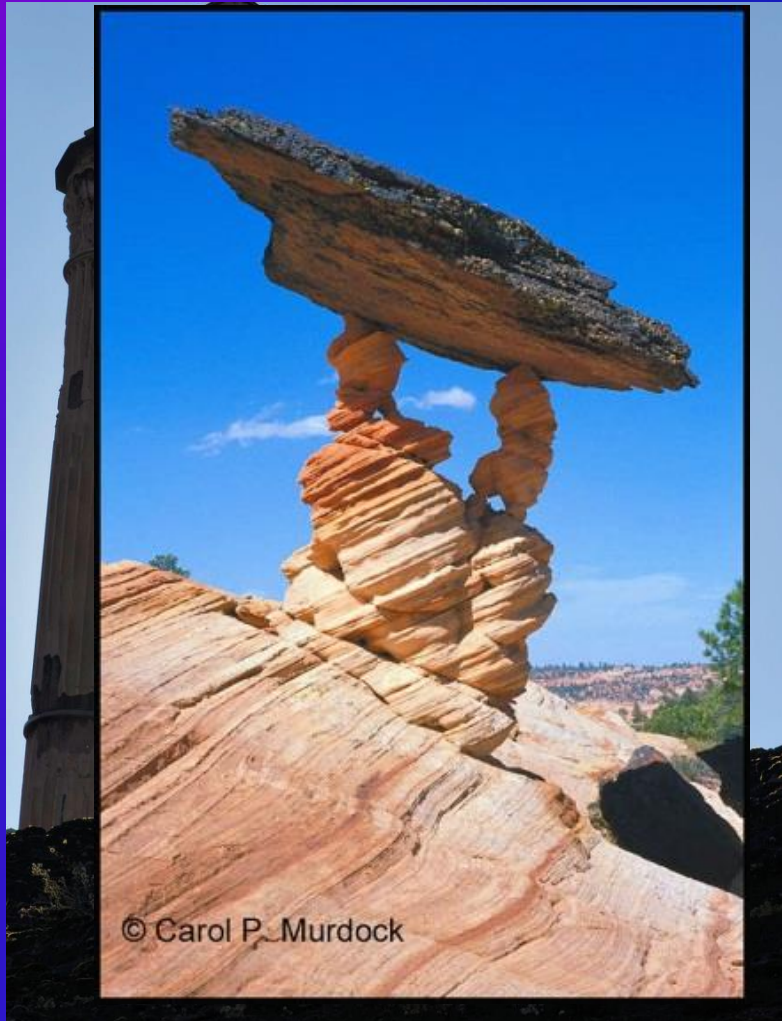
- Beam position monitors
- Beam current transformers
- Loss monitors
- Polarimeter(s)
- Magnetic spectrometer (multi-wire chamber) in arcs

- New challenges due to the large size of the beam (up to $r=30$ cm)
- First implementation in this type of ring.

The Facility:

- Presents very manageable extrapolations from **existing technology**
 - But can explore new ideas regarding beam optics and instrumentation
- Offers opportunities for extensions
 - Add RF for bunching/acceleration/phase space manipulation
 - Provide μ source for 6D cooling experiment with intense pulsed beam
- Move P_{μ} to 5 GeV/c & set stage for LBL program?
- And, presents a new direction in ν physics

Three Pillars of nuSTORM



- Delivers on the physics for the study of sterile ν
 - Offers a new approach to the detection of ν beyond a 10σ benchmark to confirm/exclude LSND/MiniBooNE
- Can add significantly to our knowledge of ν interactions, particularly for ν_e
 - ν "Light Source"
- Provides an accelerator & detector technology test bed