NuStorm target and facility

D Adey

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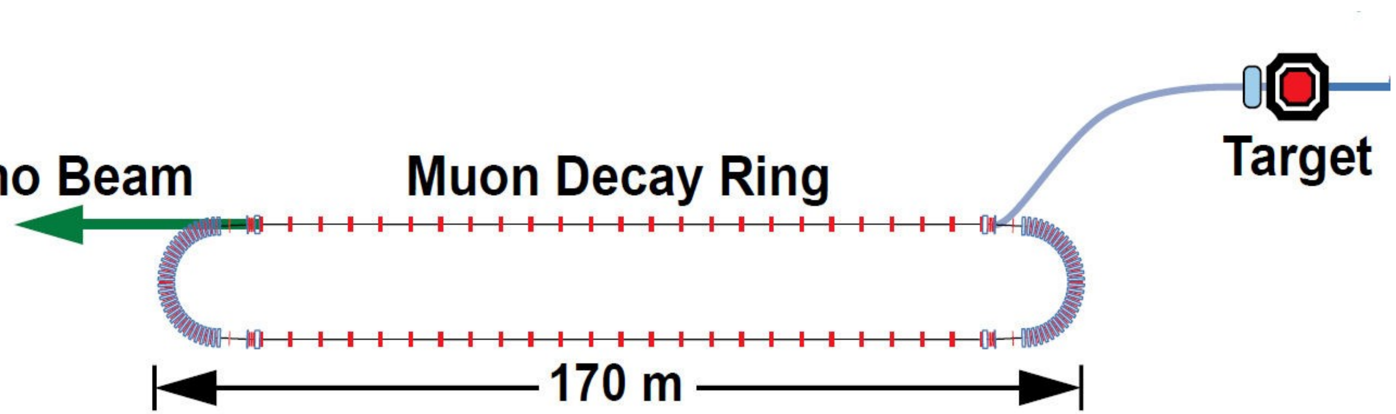
4th April 2013

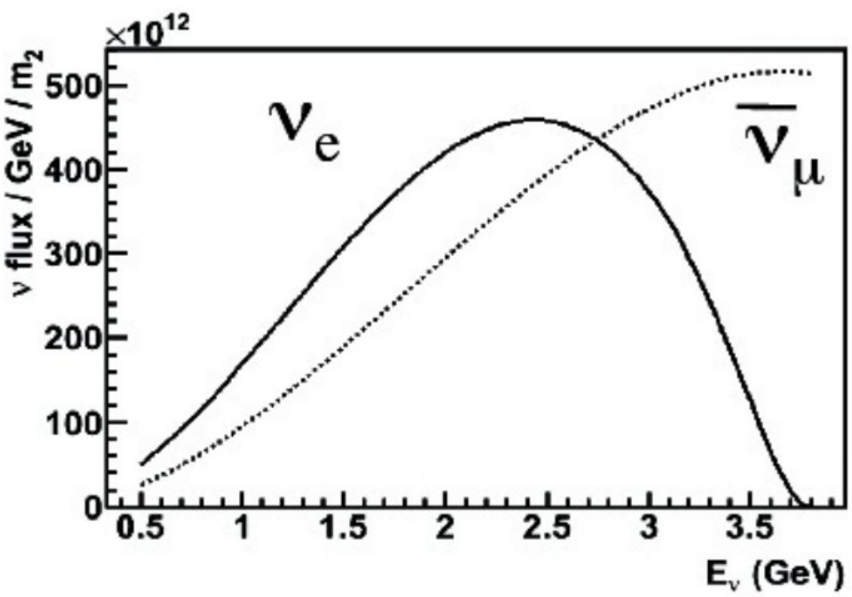
Contents

- 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
- μ storage for ~ 70 turns



$N\mu$ = (POT) X (π/POT) X $\varepsilon_{collection}$ X ε_{inj} X (μ/π) X $A_{dynamic}$ X Ω

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

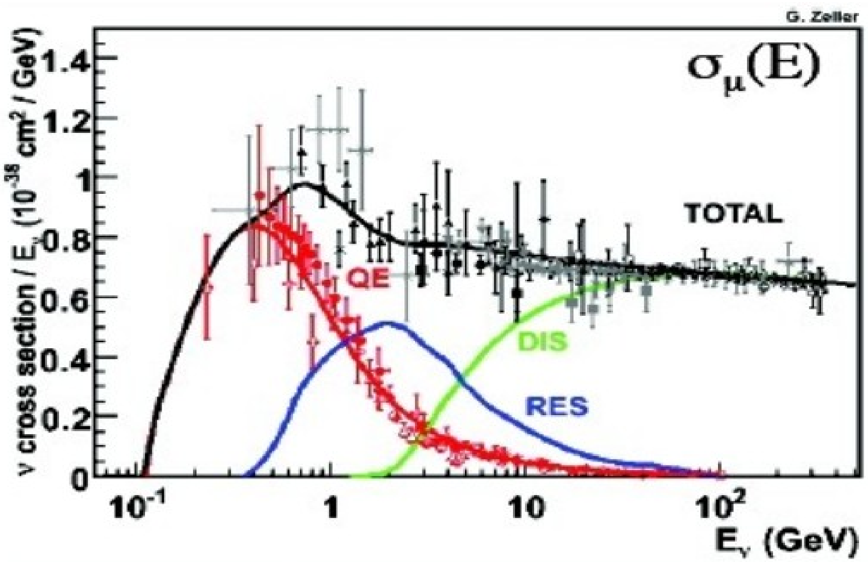
1.7 X 10^{18} useful μ decays

Precise flux with known flavour content

ν physics motivations

Cross sections

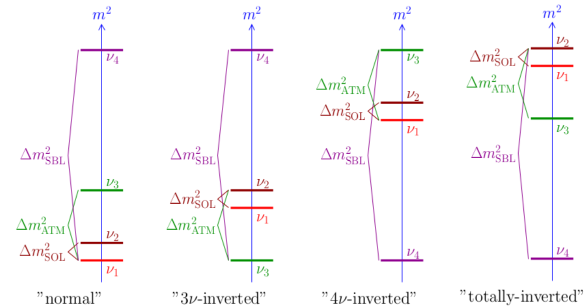
(Boyd)



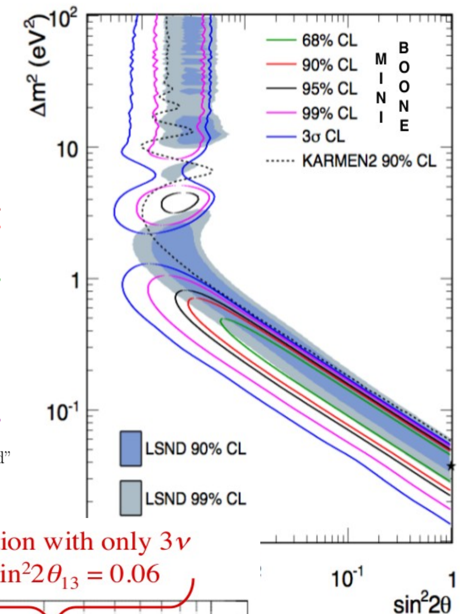
- Cross sections in few GeV range not as well known as low or high energies
- One of the largest systematic errors for oscillation experiments
- No realistic standard candle
- Old data is proving difficult to interpret

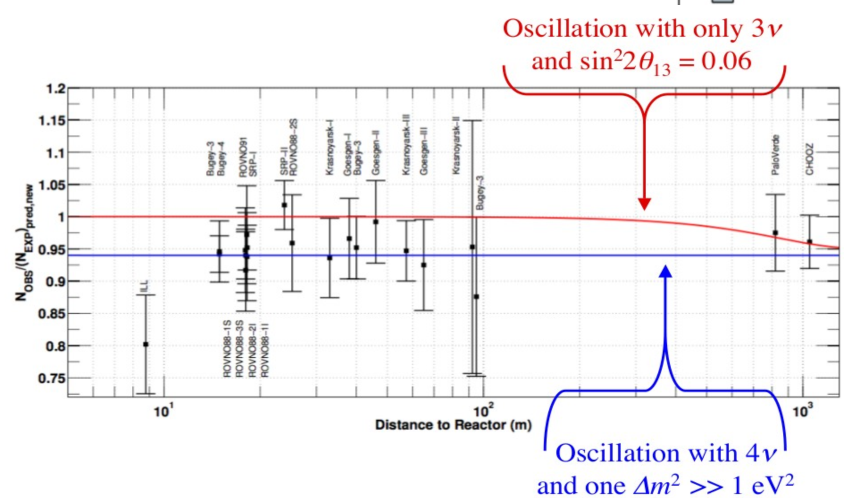
Sterile neutrinos

(Parke)



Giunti arXiv:1106.4479

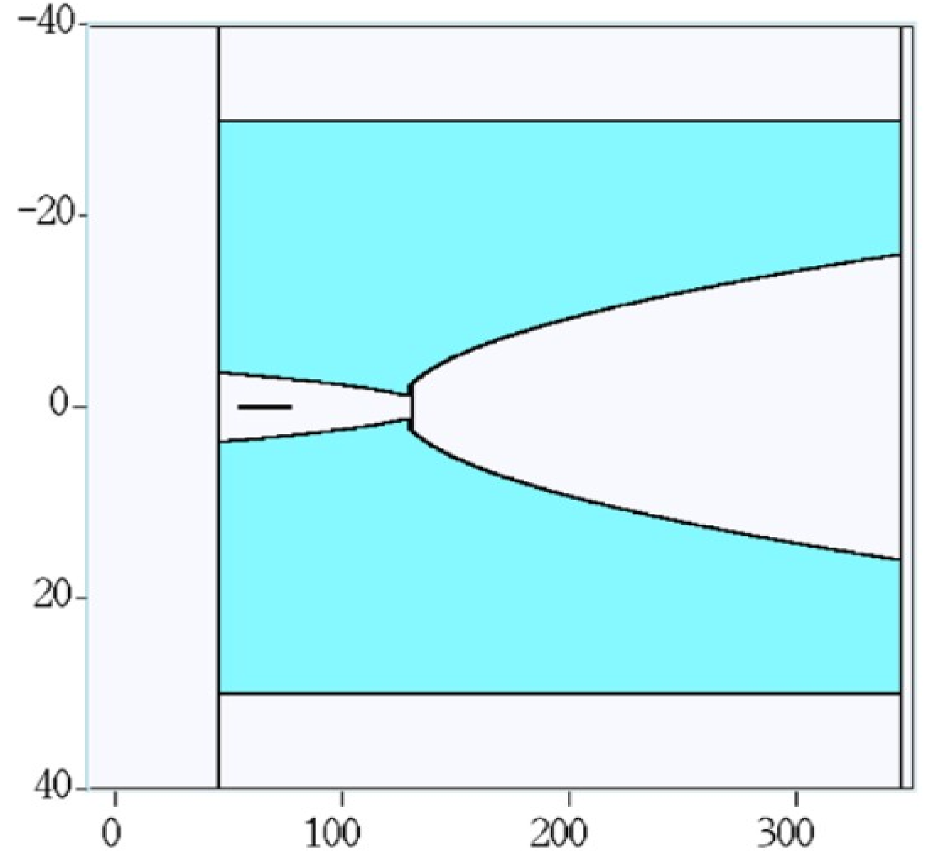




- Gallium: 2.7σ evidence for ν_e disappearance
- LSND: 3.8σ evidence for $\bar{\nu}_e$ appearance
- MiniBooNE: 3.8σ evidence for ν_e and $\bar{\nu}_e$ appearance
- Reactor: 3.0σ evidence for $\bar{\nu}_e$ disappearance
- LEP limits to 3 light, interacting neutrinos
- Short baseline experiment

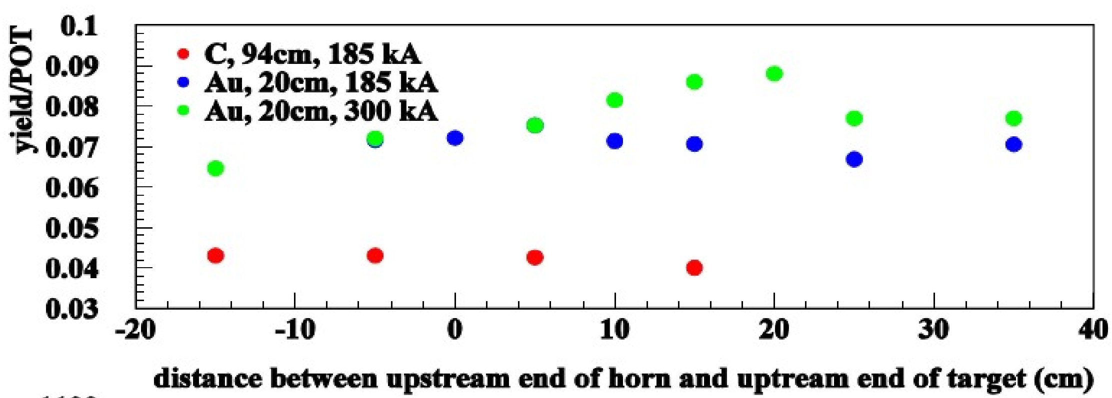
Target
(Striganoff)

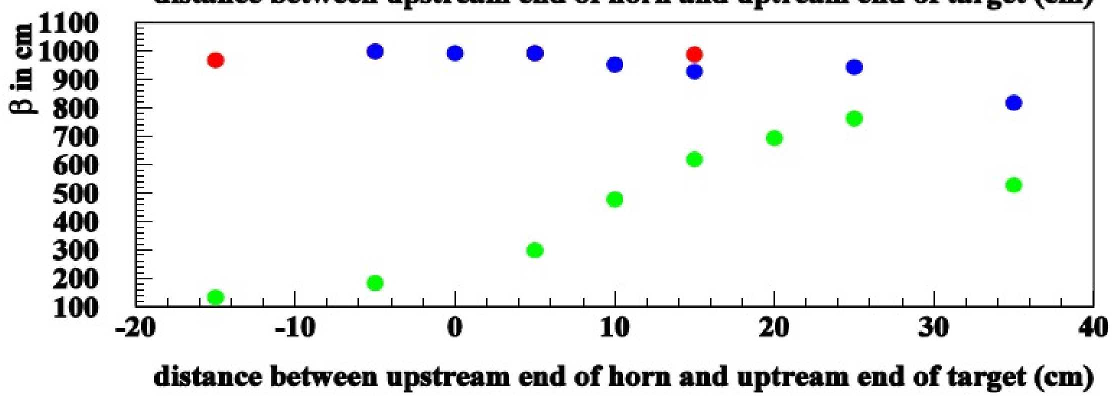
- 100KW (prepare for 400KW) 60GeV from main injector
- Graphite target within NuMI-like horn
- Li lens would be beyond state of art
- MARS studies suggest 0.1 pions / POT
- Significant irradiation of first quadrupoles in transport line

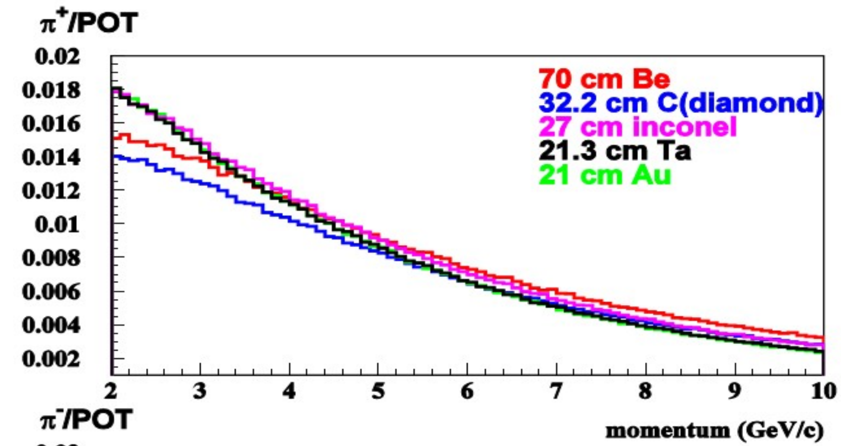


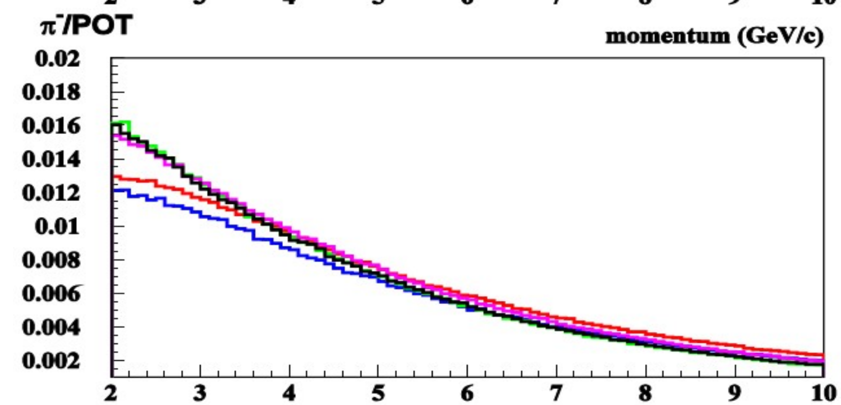
Magnet Name	Length (mm)	Distance to horn (From End of Magnet, mm)	Strength (T/m)	Beam pipe radius (mm)	Estimated pole-tip field (T)
Q1	500	700	6.09	200	1.22
Q2	900	1800	-10.18	200	2.04
Q3	900	2900	15.37	200	3.07
Q4	500	3716	-14.77	200	2.95
Q6	500	7600	-12.06	200	2.41
B1	2400	6884	-	width=400	1.213
QI1	900	8700	10.27	200	2.05
B2	800	9715	-	width=400	2.00
QI4	900	12041	-9.70	200	-1.94
QI5	900	13141	9.67	200	1.93
Q7A	500	16074	-10	200	2
B1	2400	18724	-	width=400	1.213
Q9	250	19224	10	200	2

material	momentum (GeV/c)	±15%	±10%	±5%	target length (cm)	density (g/cm^3)
Carbon	3	0.085	0.056	0.028	27.3	3.52
Carbon	5	0.099	0.067	0.033	32.2	3.52
Inconel	3	0.131	0.087	0.044	19.2	8.43
Inconel	5	0.136	0.091	0.045	27.0	8.43
Tantalum	3	0.164	0.109	0.054	15.3	16.6
Tantalum	5	0.161	0.107	0.053	21.3	16.6
Gold	3	0.177	0.118	0.059	18.0	19.32
Gold	5	0.171	0.112	0.056	21.0	19.32



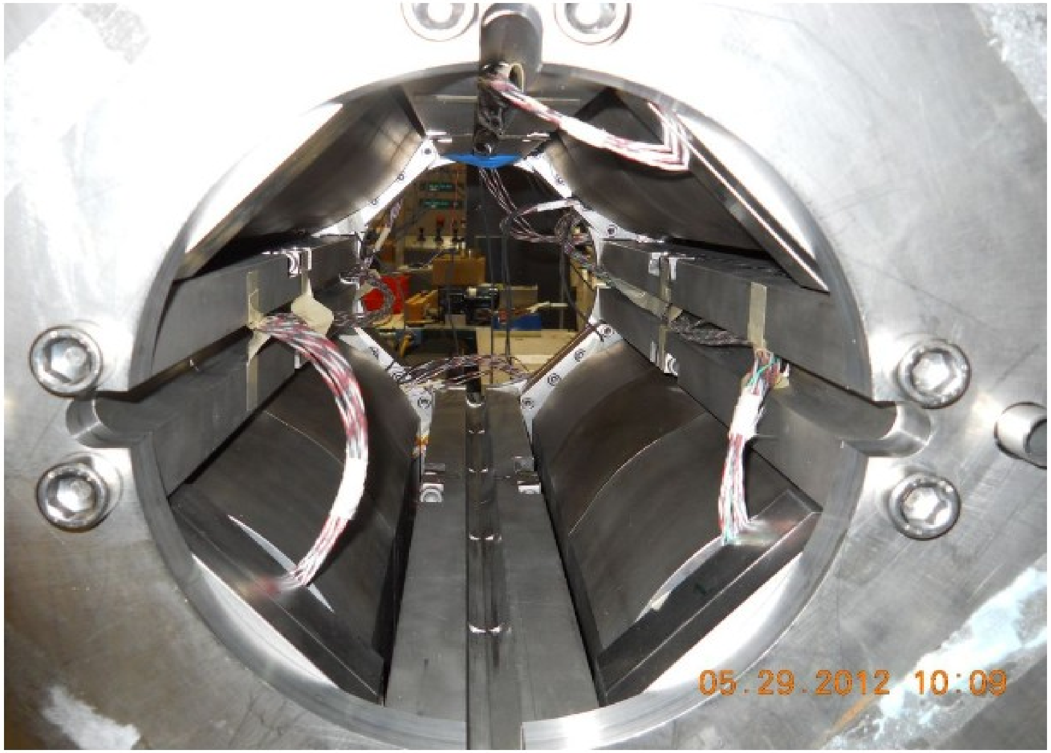


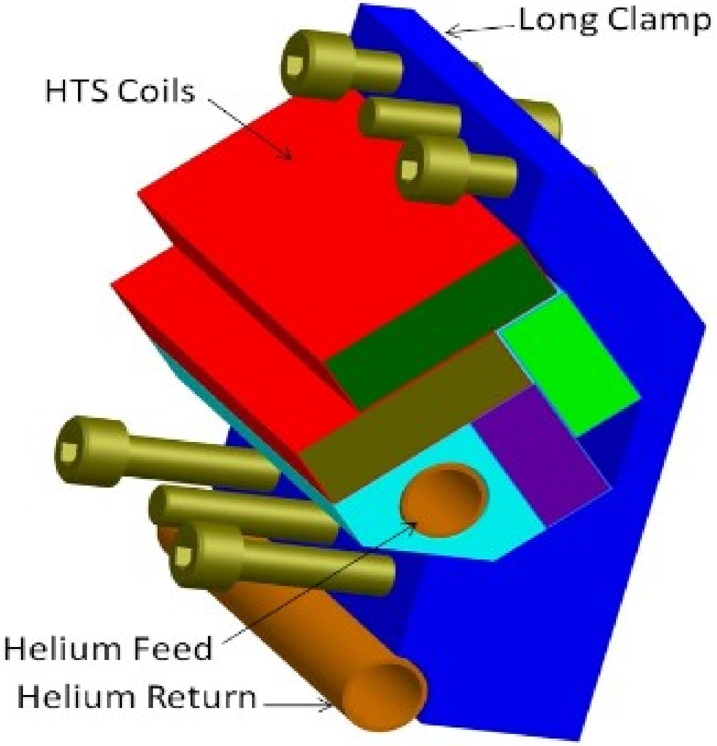




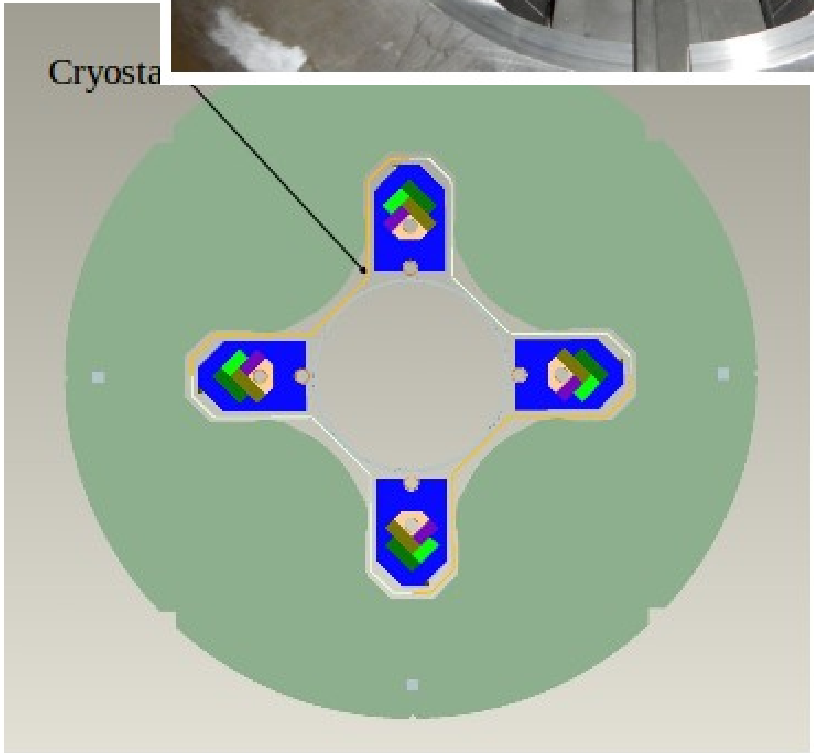
Radiation hard magnets
(Cozzolino - BNL)

- High temperature and radiation tolerant quadrupoles under investigation at Brookhaven





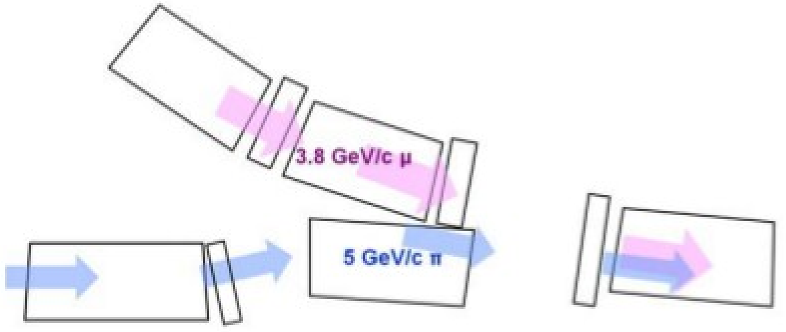
Partial View of Clamped Coil

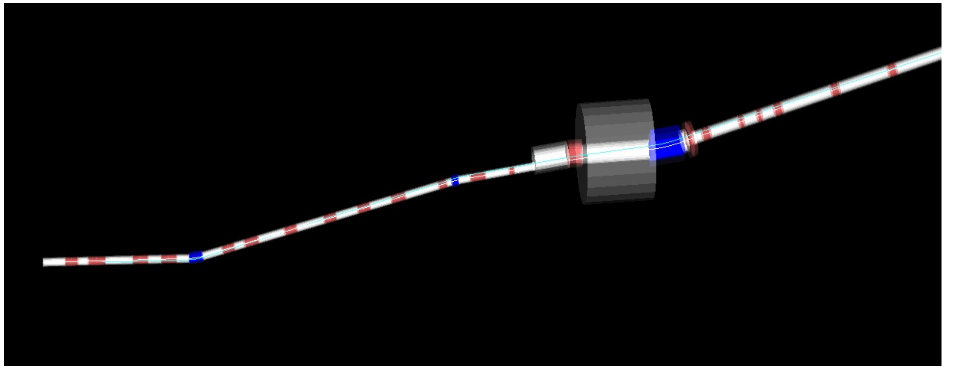


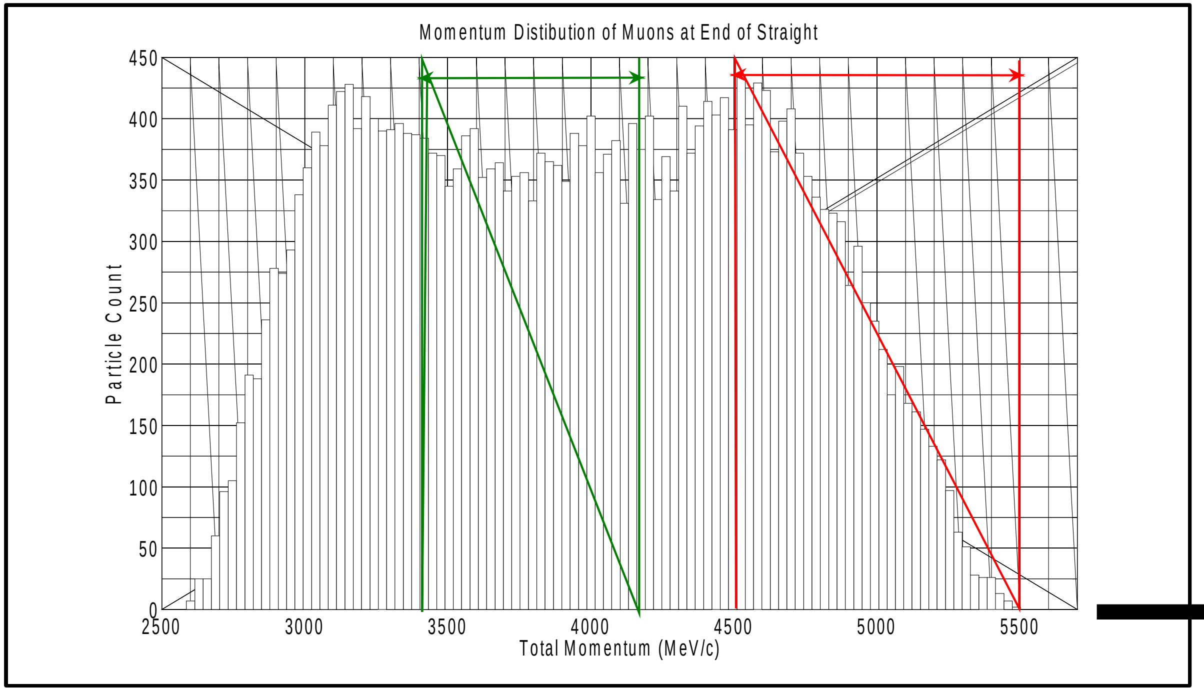
Magnet Cross-Section

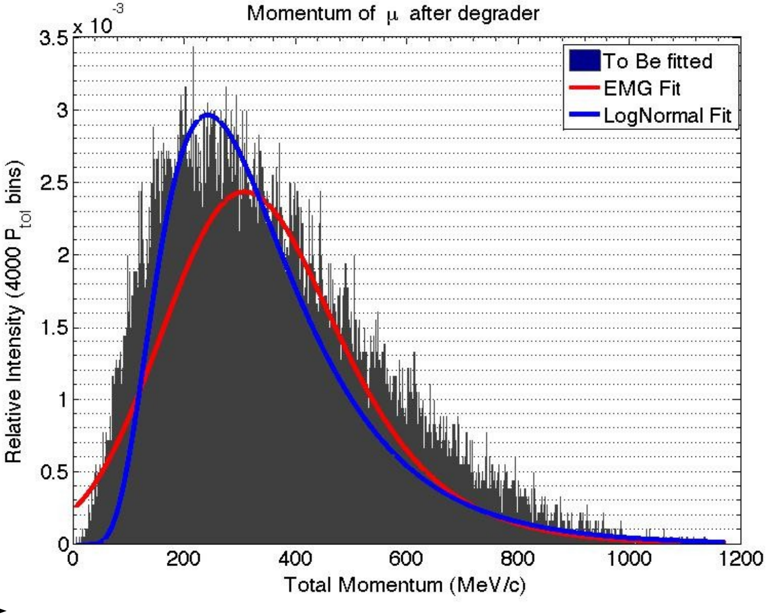
Capture and injection
(Liu)

- 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



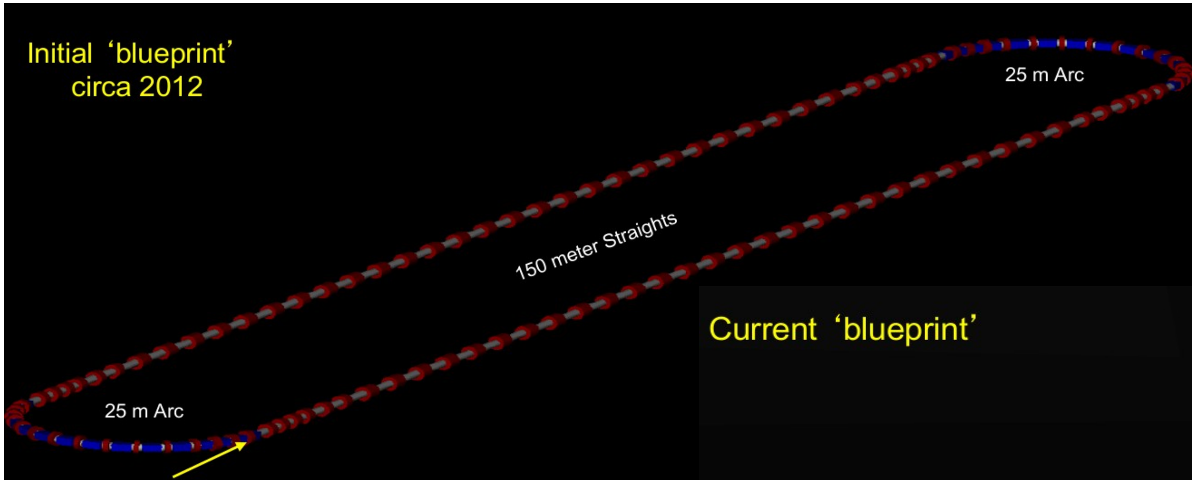


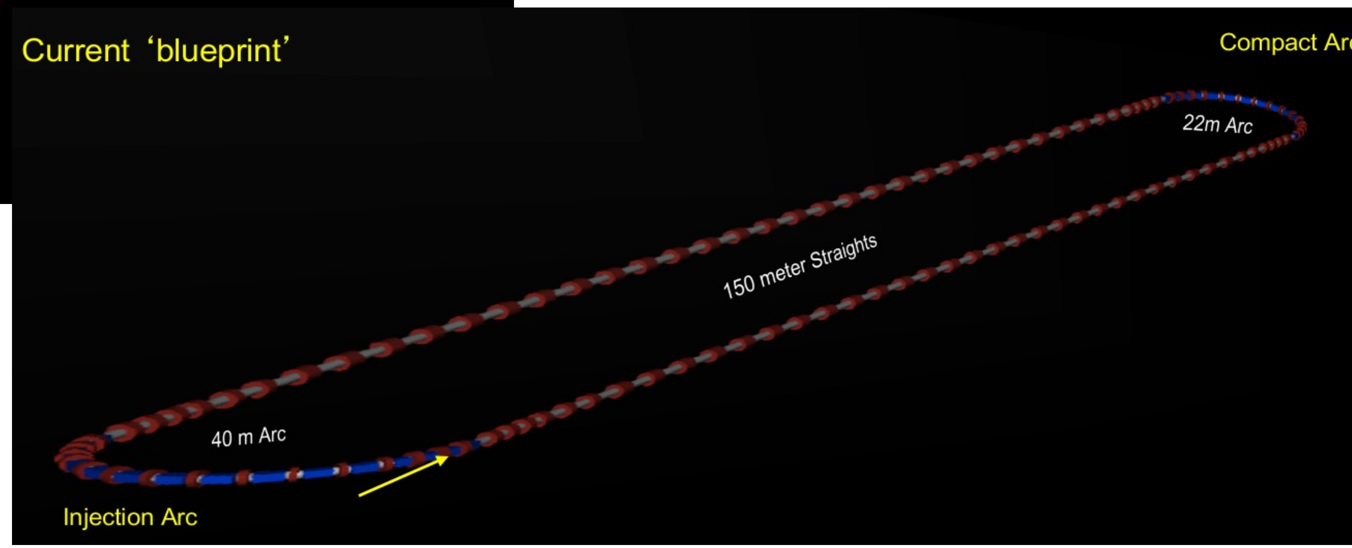




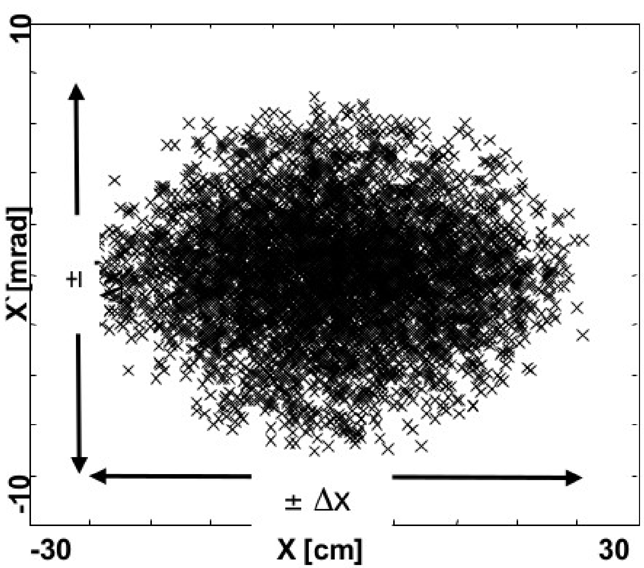
Low E muon beam through degrader

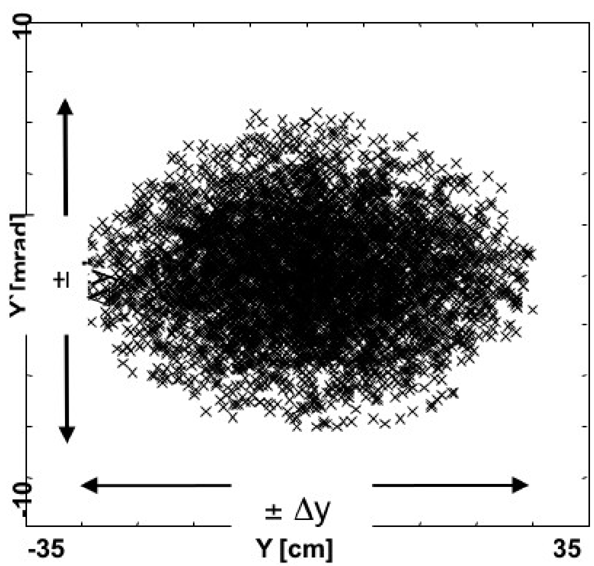
Decay ring
(Bogasz)



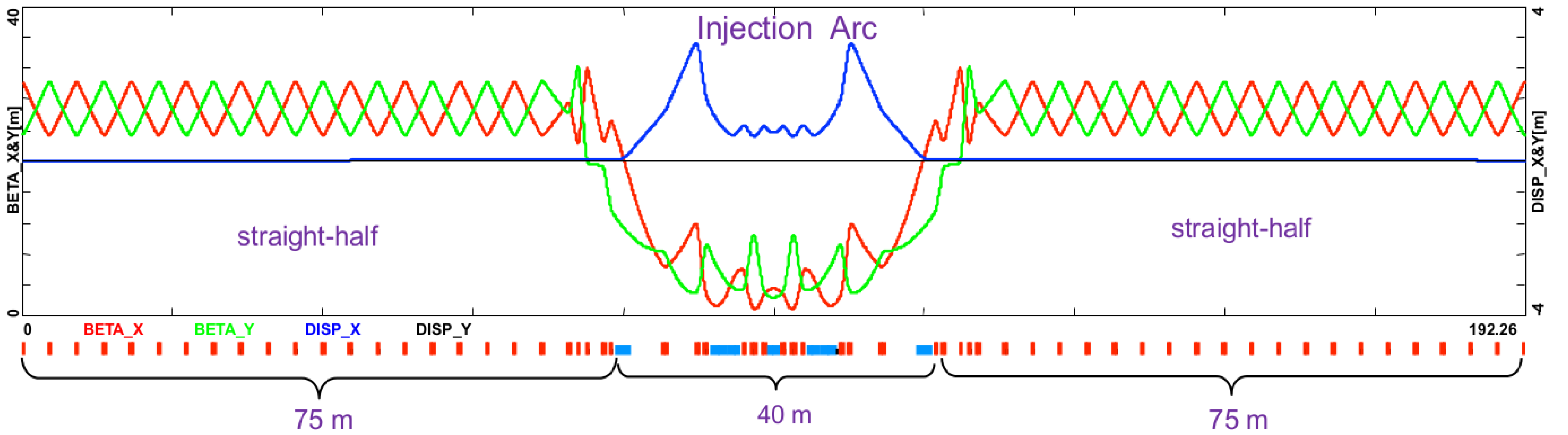


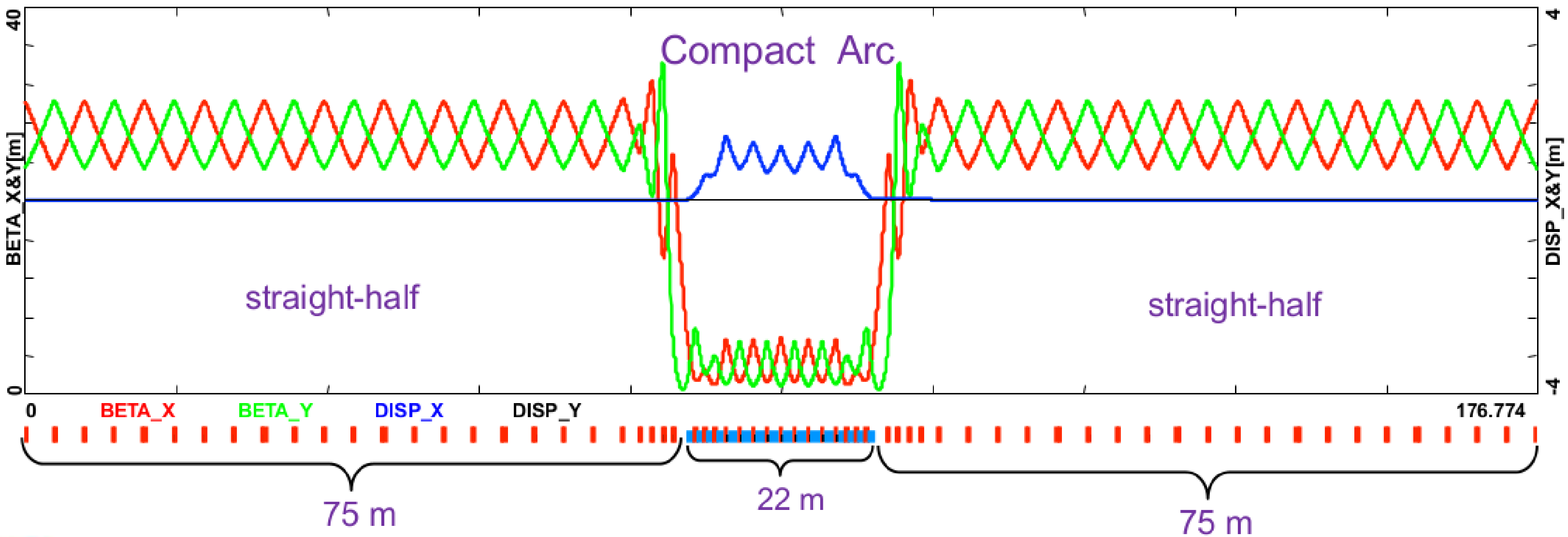
- Different arc lengths for injection and return arcs
- 150m non-parallel straights





- $\beta\gamma \approx 37 \rightarrow A_N = A\,\beta\gamma =$ 74 mm rad
- Momentum: $\sigma\Delta p/p = 0.08$
- 35% dynamic lost after 70 turns (no decays)


Injection Arc
BETA_X&Y[m]
DISP_X&Y[m]
40
0
4
-4
straight-half
straight-half
0
BETA_X
BETA_Y
DISP_X
DISP_Y
192.26
75 m
40 m
75 m

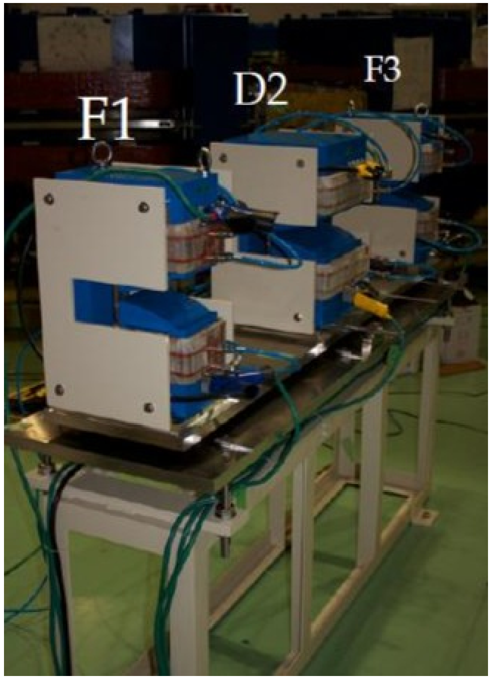

Compact Arc
BETA_X&Y[m]
DISP_X&Y[m]
40
0
4
-4
straight-half
straight-half
0
BETA_X
BETA_Y
DISP_X
DISP_Y
176.774
75 m
22 m
75 m

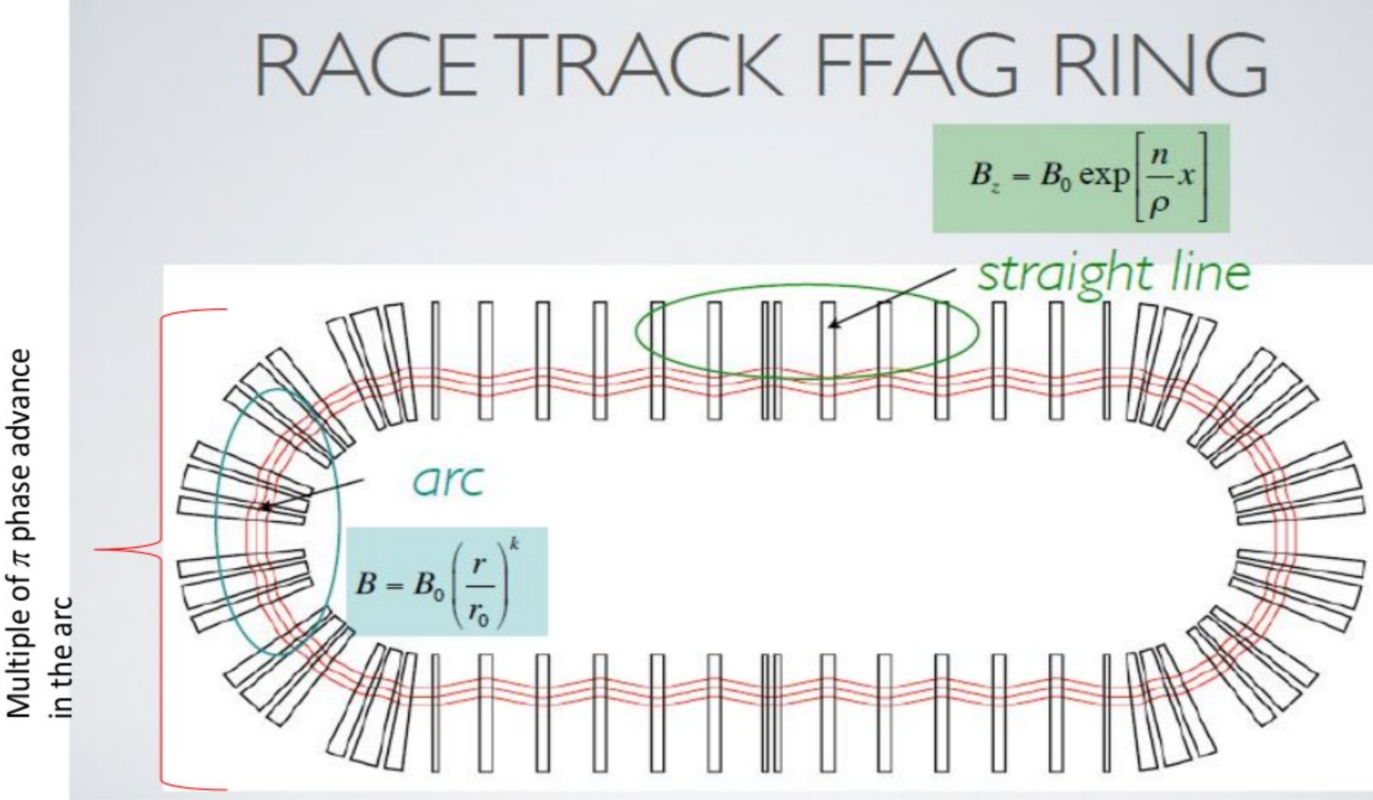
FFAG decay ring
(Pasternak)

Simulation studies for FFAG decay ring, suggest:

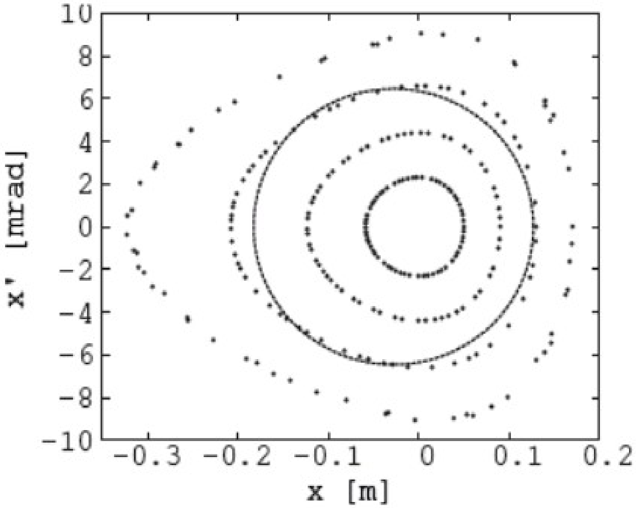
- 1mmrad non-normalised acceptance
- 26% momentum spread achievable
- 0.7% losses after 60 turns

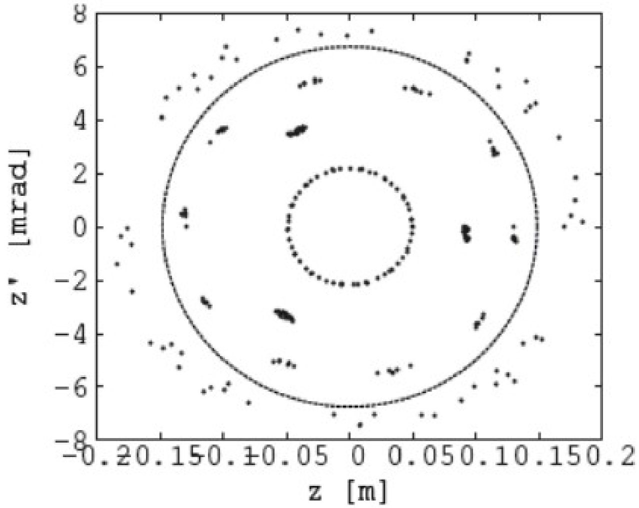
Experimental tests of straight FFAG at KURRI





Small scallop will have a negligible effect on the neutrino flux

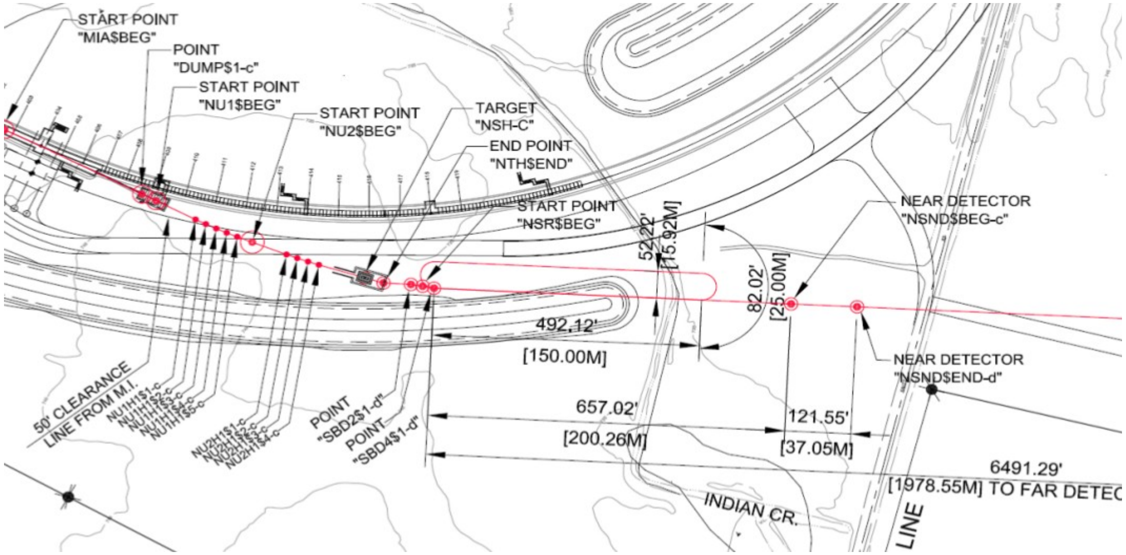


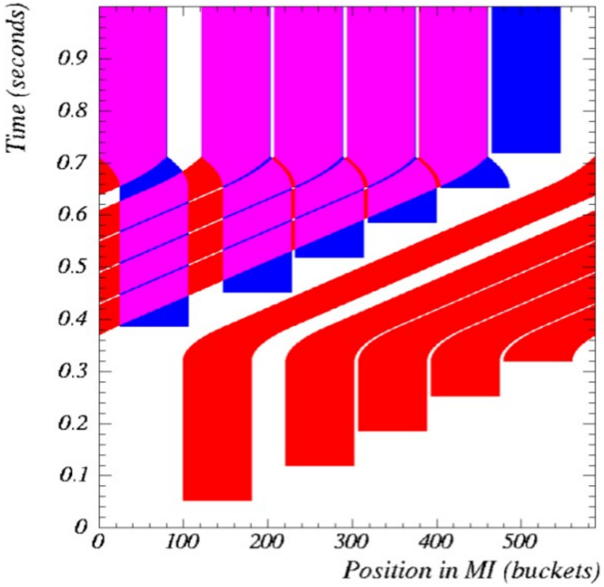


Implementation at Fermilab

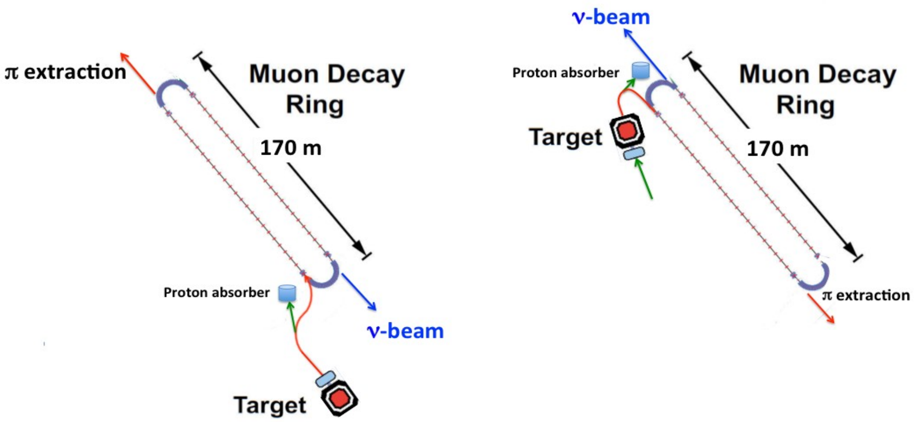
(Geelhoed)

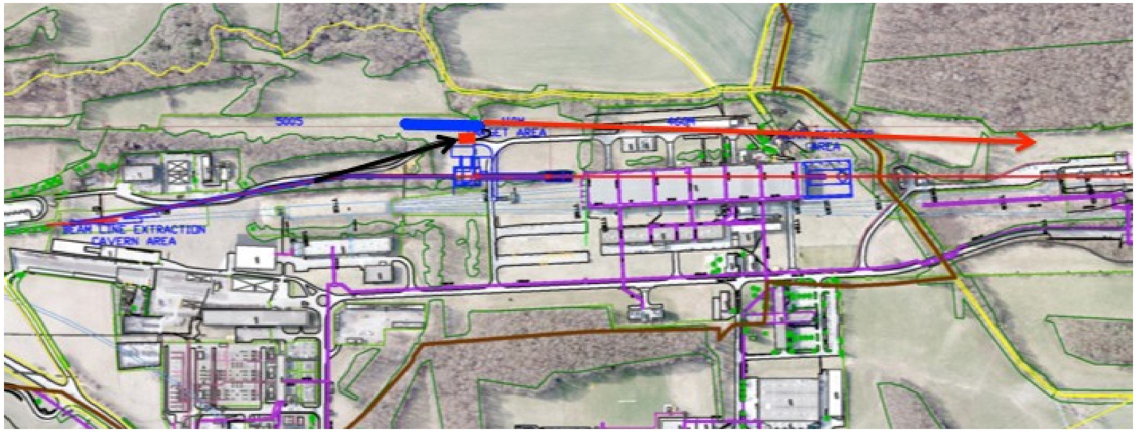
- Use MI abort line
- Far detector hall in D0 assembly building
- Beamline layout, costing, component search, safety planning
- Integration with MI cycle

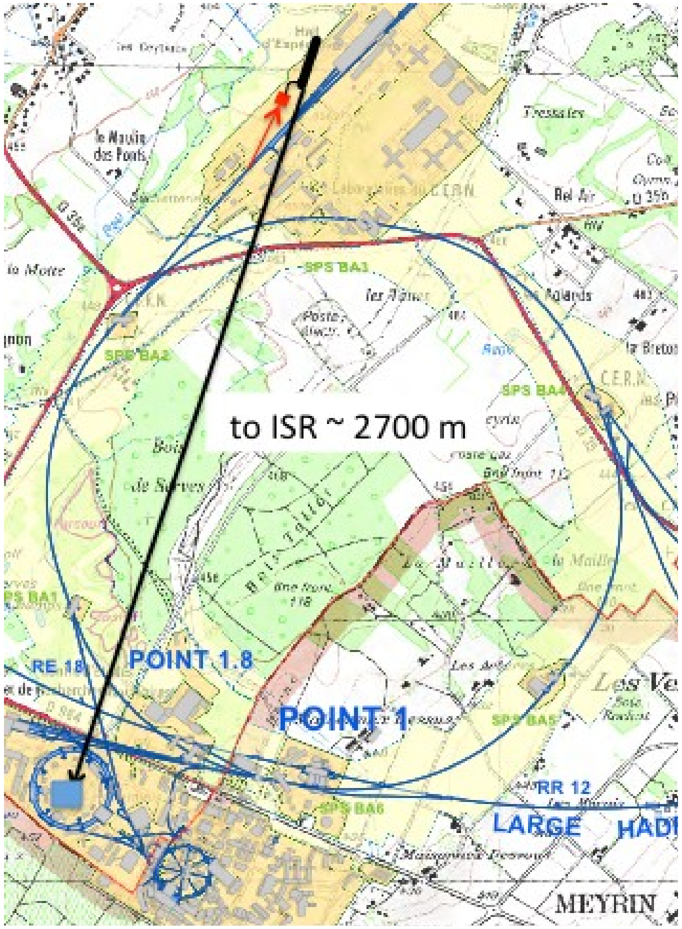


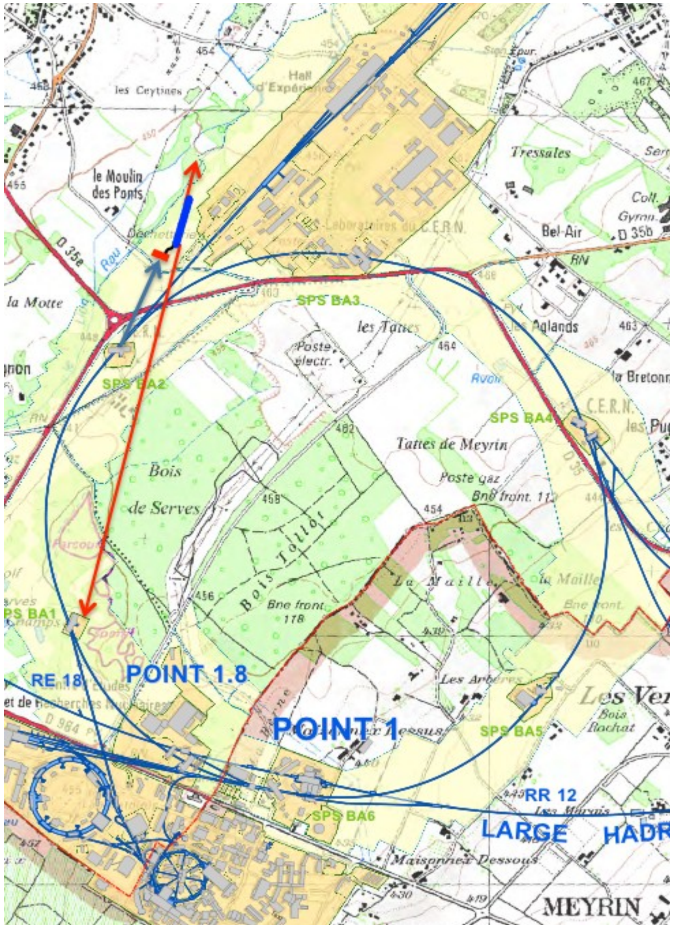


Implementation at CERN
(Wildner)









- 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?