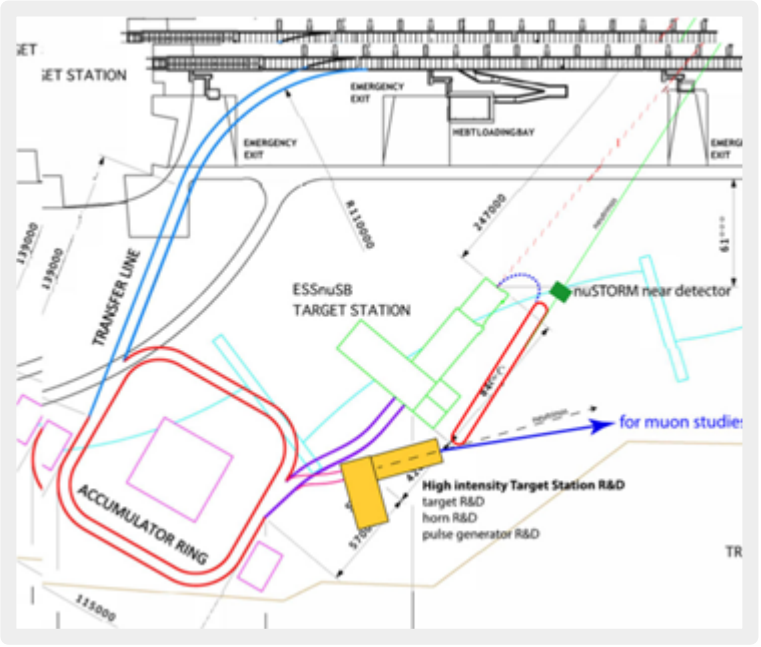
Design of a low energy nuSTORM racetrack ring



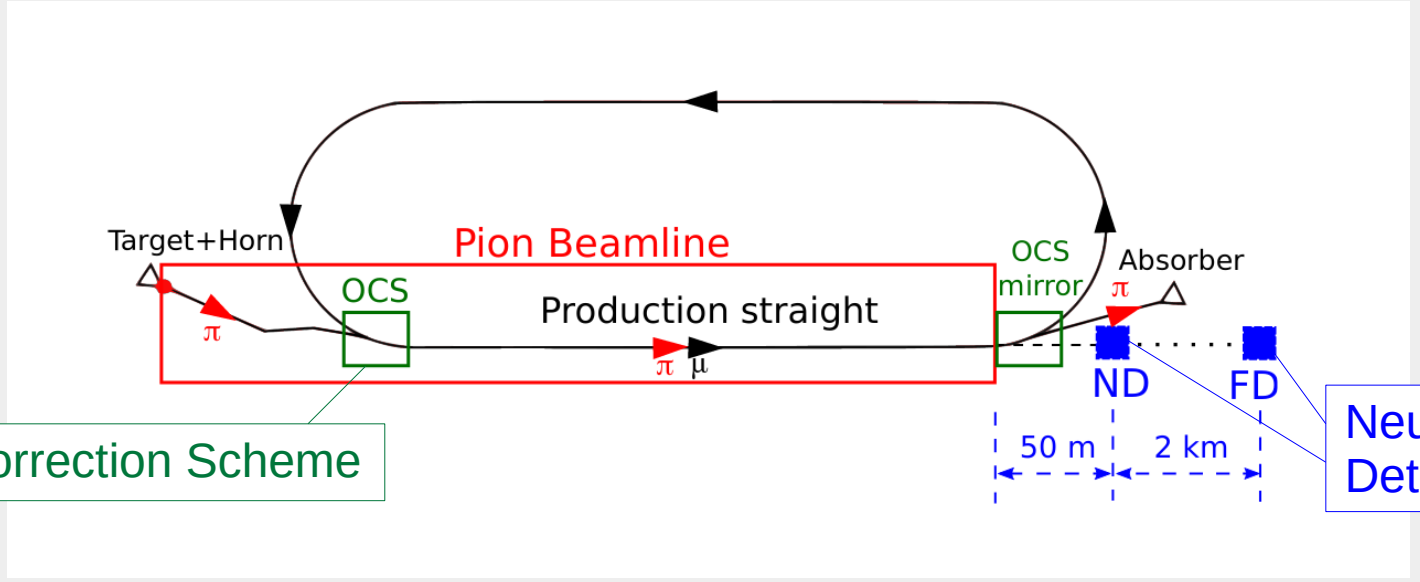
Maja Olvegård, Uppsala University

Funded by the Horizon 2020 Framework Programme of the European Union

ESS NEUTRINO SUPER BEAM

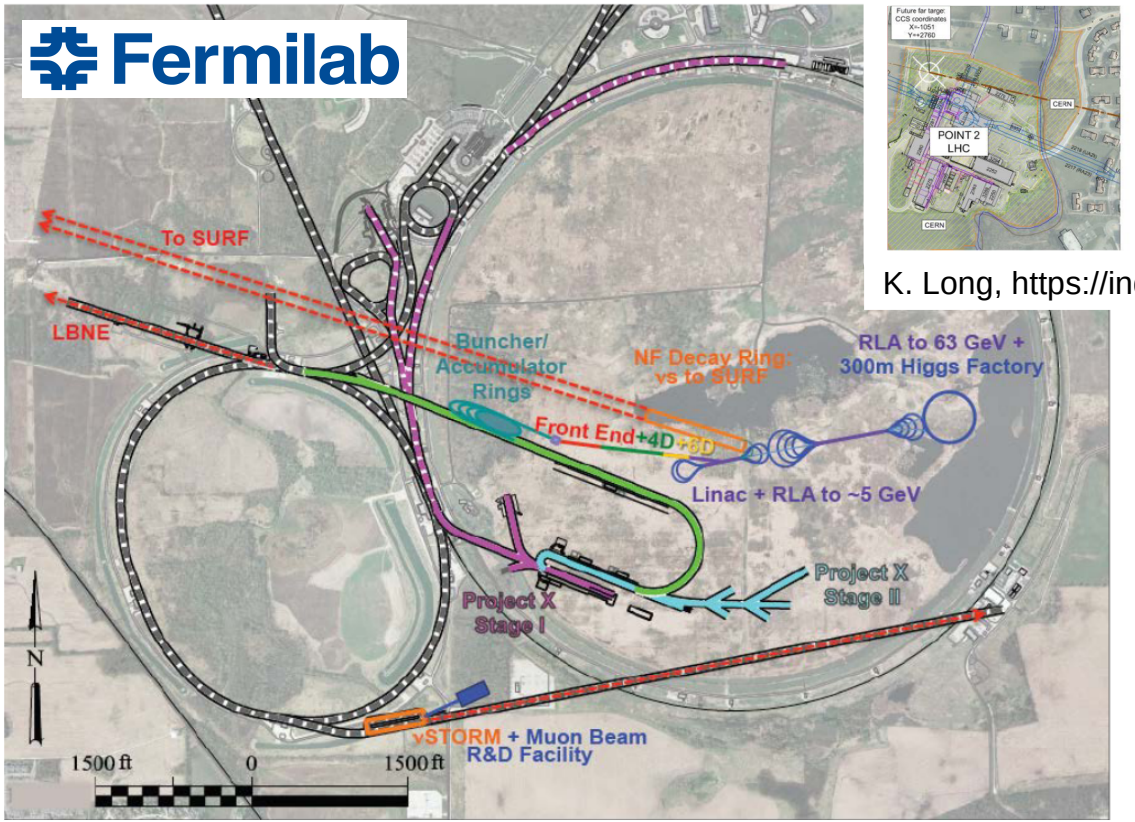
Decay ring for nuSTORM

nuSTORM racetrack at FNAL:

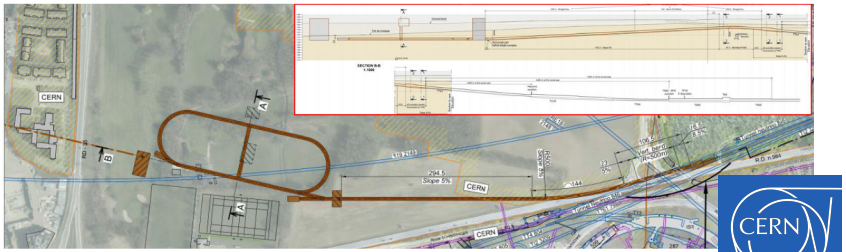


A. Liu et al., https://iopscience.iop.org/article/10.1088/1748-0221/12/07/P07018

nuSTORM at FNAL & CERN



J.-P. Delahaye, https://arxiv.org/abs/1308.0494



K. Long, https://indico.cern.ch/event/768000/contributions/3275092/

Decay ring: Important features

Short arcs

- Strong magnets in arcs
- Compact arc lattice

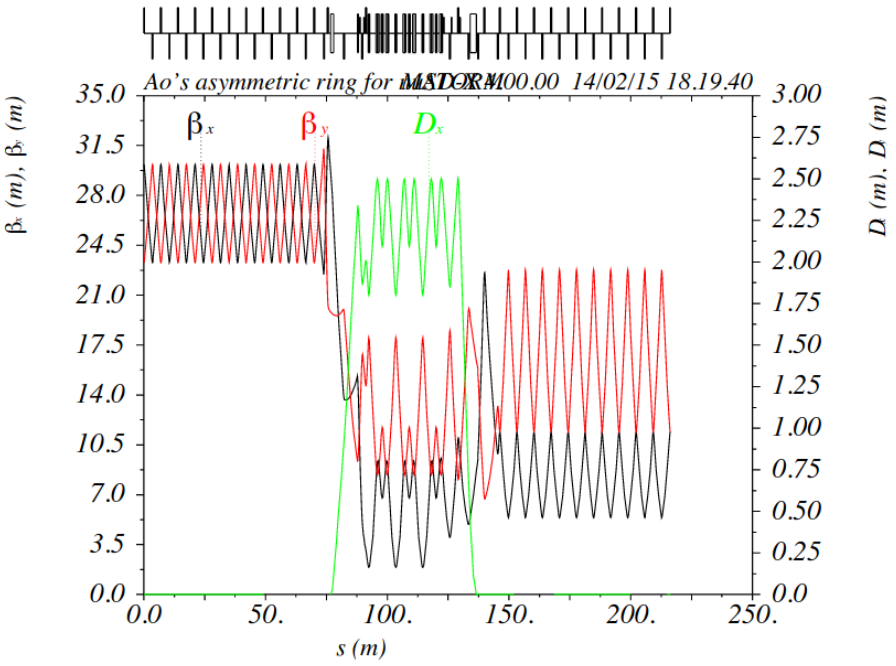
Injection

- Stochastic
  - Dispersive Optical Correction Scheme
- Kicker
  - Rise time affects ring length

- Large momentum acceptance
  - Large magnet bores
  - Special lattice, like FFAG
- Large emittance acceptance
  - Large magnet bores
- Chromatic compensation

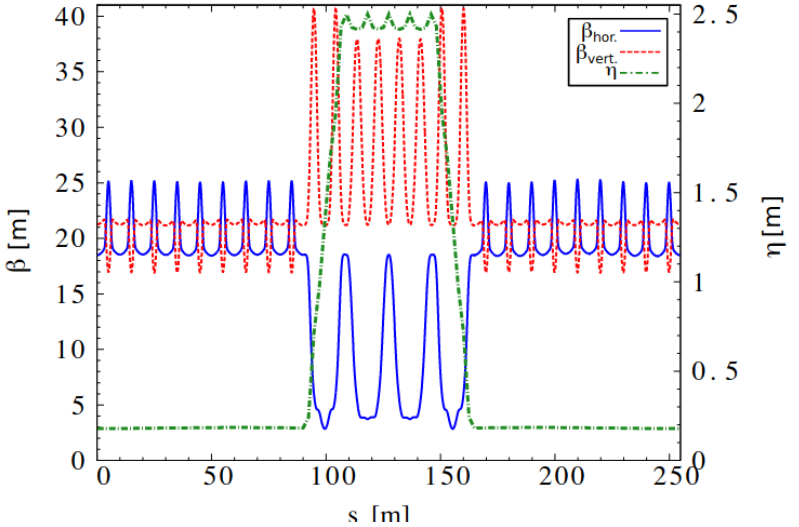
Decay ring lattice: FODO

- Normalconducting or superconducting combined-function magnets in the arcs
  - Compact
  - Strong field
- Very large bores
  - 60 cm diameter
- Dispersion-free straight sections
- Large losses even within momentum acceptance
  - Resonance crossings

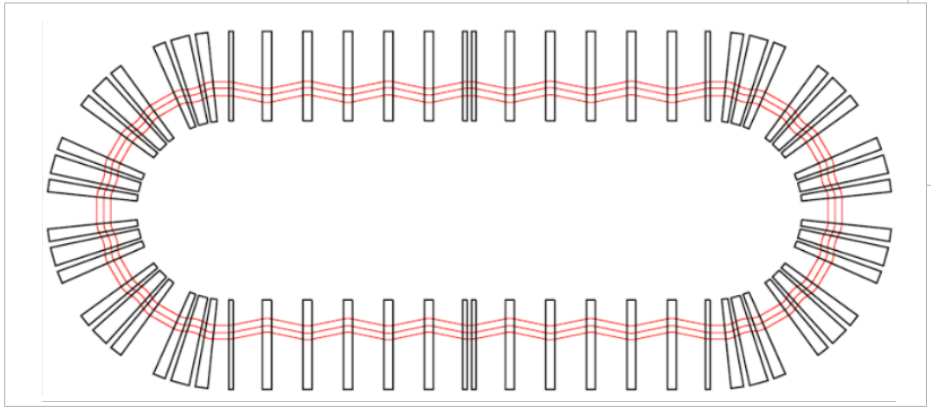


Decay ring lattice: FFAG

- Inherently large momentum acceptance
- “Wriggle” in straight sections
  - Lowers neutrino flux by 20%
- Slightly lower losses
- Reduced pion capture efficiency



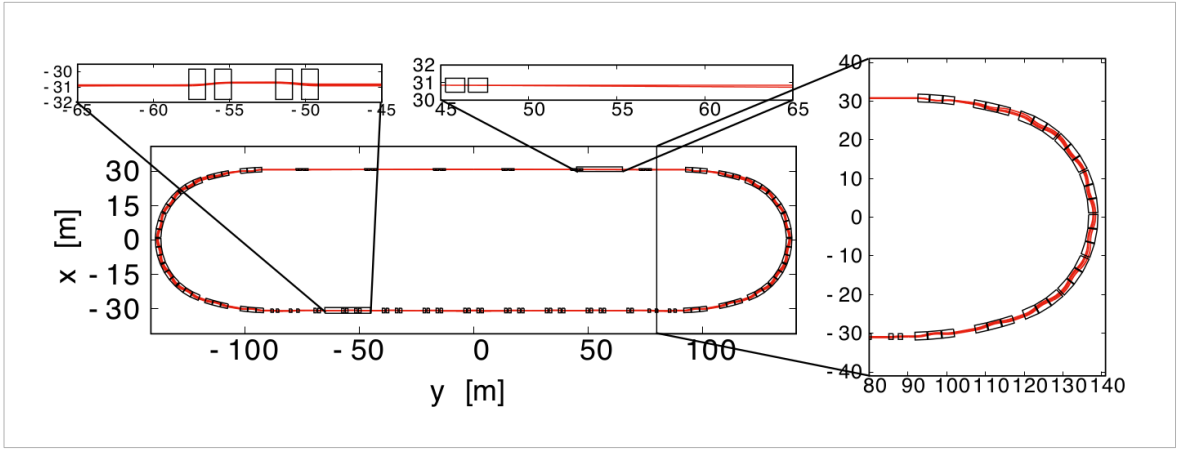
J.-B. Lagrange et al., https://arxiv.org/pdf/1806.02172.pdf



https://ffa20.triumf.ca/wp-content/uploads/2020/11/lagrange_nustorm.pdf

Decay ring lattice: Hybrid

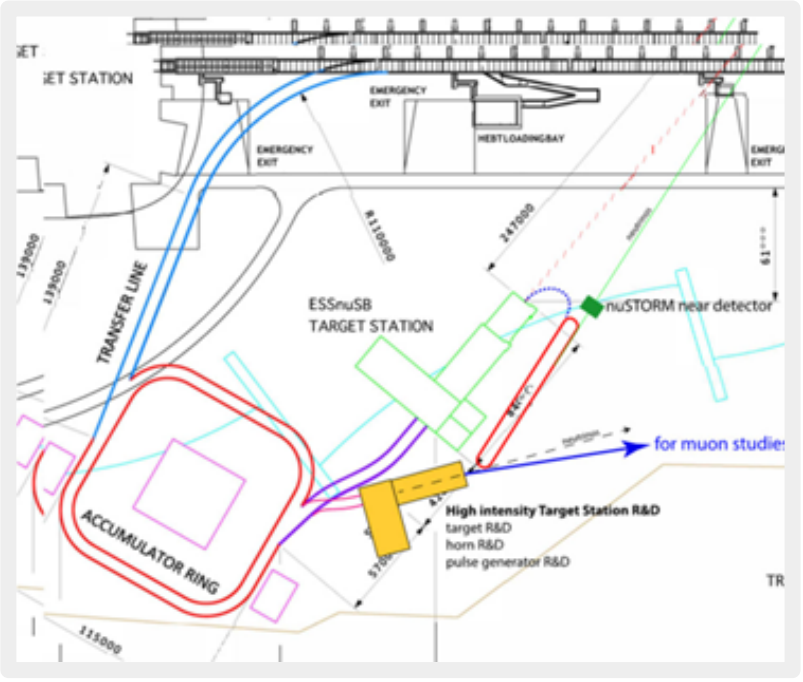
- FFAG arcs
  - Large acceptance
- FODO in straight sections
  - Higher capture efficiency
  - Higher neutrino flux



- Slightly reduced 6D acceptance compared to full FFAG solution
- No magnet R&D needed

J.-B. Lagrange https://ffa20.triumf.ca/wp-content/uploads/2020/11/lagrange_nustorm.pdf

ESS based nuSTORM



- Pions from separate target or muons from ESSnuSB decay tunnel?
  - Capturing of muons directly, with kicker magnets
  - Less efficient?
  - No need to transport two species simultaneously.
- Low energy muons
  - Can or should have a smaller ring and/or shorter arcs
  - Wide angle neutrino source
- Fewer turns?
  - Less losses
  - Lower flux control?

Decay ring comparison

	FNAL FODO	CERN FFAG	ESS
Proton energy	120 GeV/c	100 GeV	2.5 GeV
Pion energy	5 GeV/c	5 GeV/c	?
Muon momentum	3.8 GeV/c	3.8 GeV/c	0.45 GeV/c
Momentum acceptance	±10%	±16%	
Emittance acceptance	2π mm rad	1π mm rad	
Length of decay straight	181	180	
Circumference	490	510	60-300 m *
Mean distance traveled	24 km	24 km	2.8 km
	~ 50 turns	~ 50 turns	10-50 turns *
Muon flux			

Focusing
O (vacuum)
Defocusing
O (vacuum)

Fixed
Field
Alternating
Gradient

* J.-B. Lagrange, http://dx.doi.org/10.14989/doctor.k16846