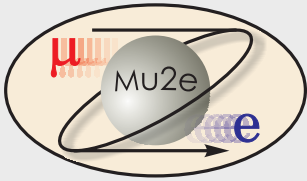


FFA Sessions Summary

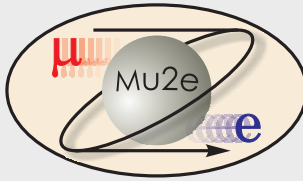
R. Bernstein

Future Muon Program at Fermilab Workshop

Caltech

29 March 2023

What is an FFA

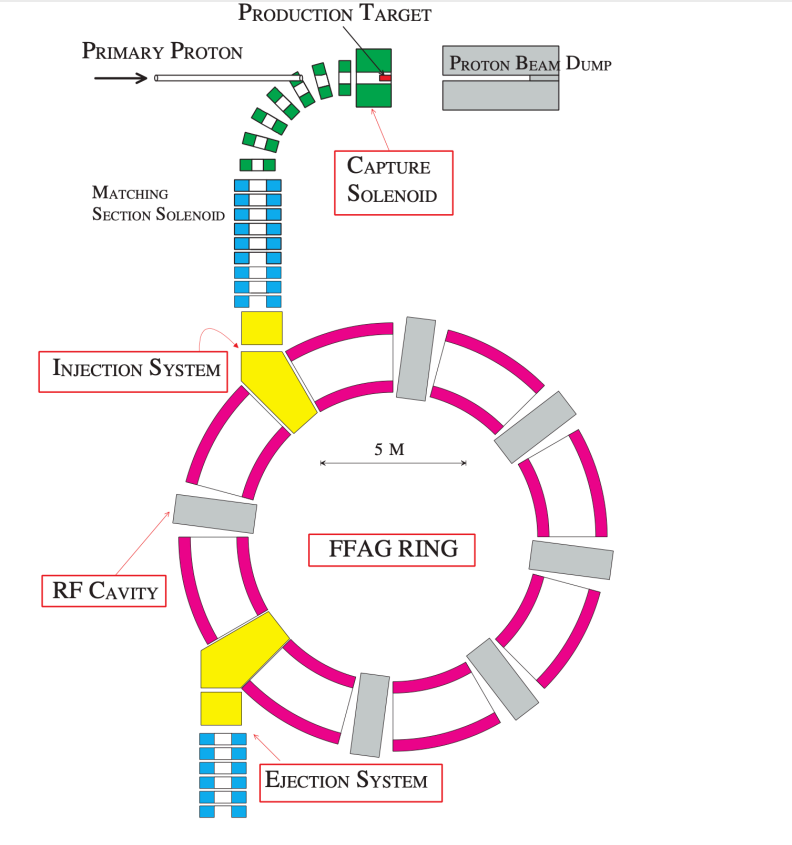


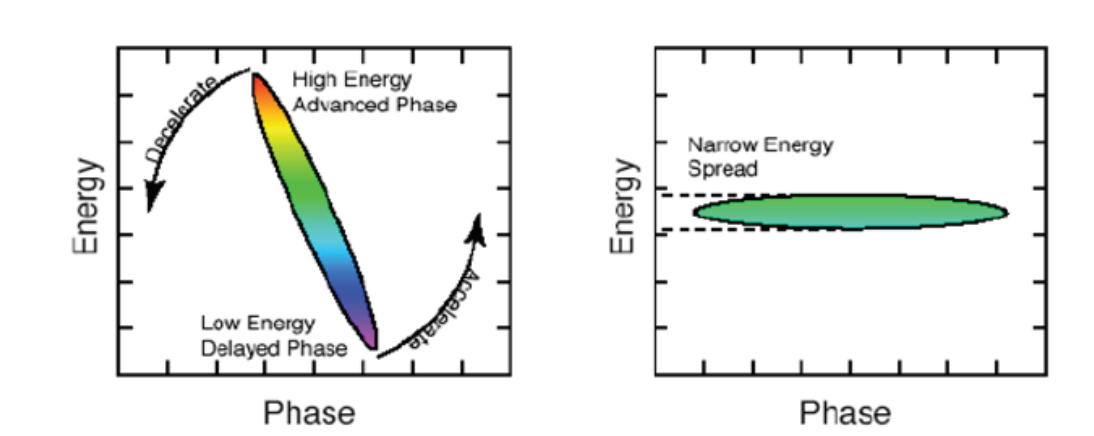
- Fixed Field Alternating Gradient Synchrotron
- large momentum acceptance, wide transverse acceptance with strong focusing, and synchrotron oscillation
- there are scaling FFAs and non-scaling FFAs and DFD and FDF and many other types
- we want this for phase rotation: trade momentum spread for time spread: cool, mono-energetic muon beam.
- phase rotation performed with RF: high field gradients
  - in about 6 turns, 1.5 μsec, 30 m circumference ring

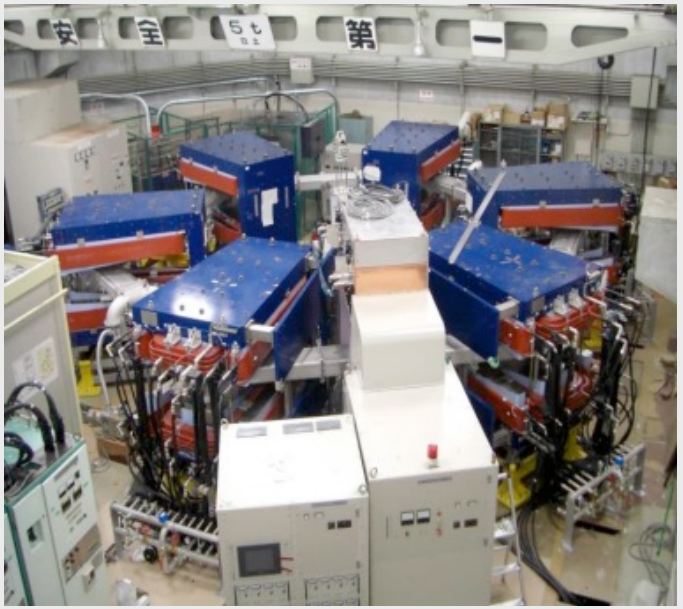
https://accelconf.web.cern.ch/e04/PAPERS/MOPLT070.PDF

FFA

- PRISM (Phase Rotated Intense Source of Muons) (arXiv:1310.0804 [physics.acc-ph])







6 cell demonstrator at Osaka

FFA is not what we're used to

- Phase space is enormous!
- Values like $35{,}000\pi$ mm·mrad horizontal and 3000π mm·mrad in the vertical. The beams that come out are not 5-6 cm wide like Mu2e or COMET
- Kickers for injection and extraction are complicated
- FFA serves another purpose as a muon storage ring to let π's decay, hence no RPC for conversion experiments

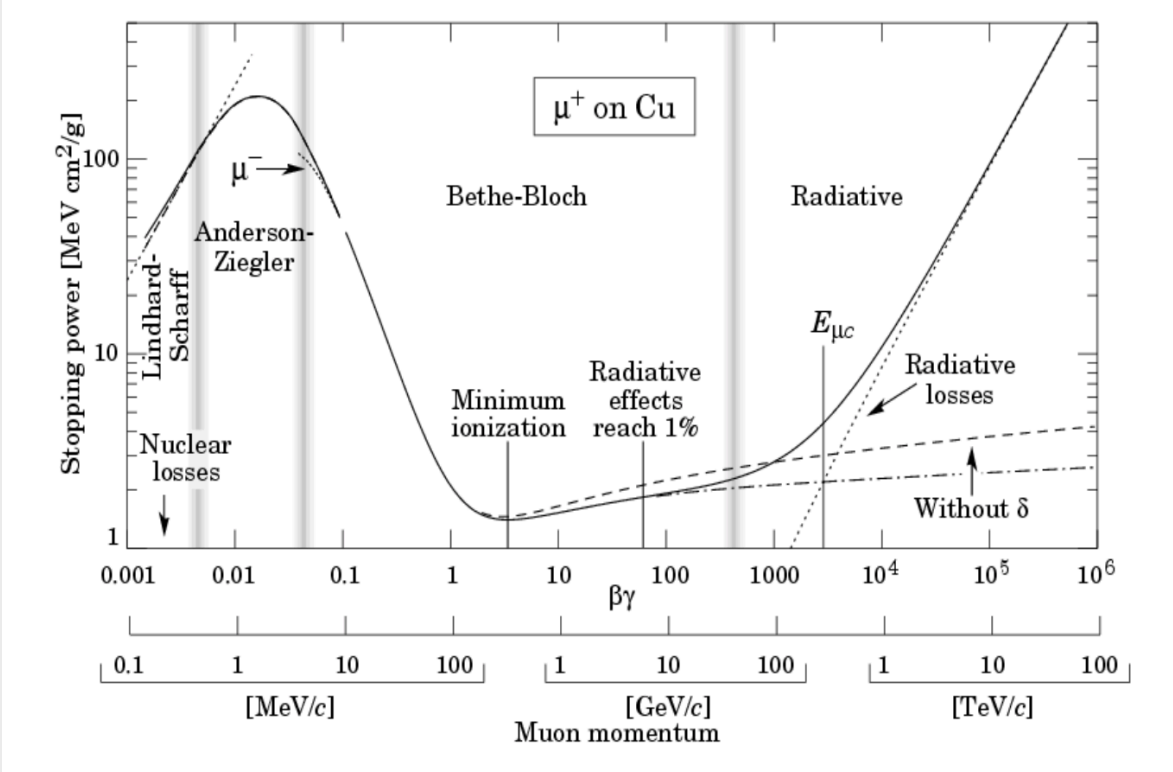
New Things We Talked About

- *We would like to do both conversion and decay experiments in one facility: FFA needs both signs $\mu^+\mu^-$, preferably simultaneously*
  - Mèot told us this can be done; general agreement this can be done
  - injection/extraction more complicated
- *Many of FFA designs have central momenta ~ 50 MeV/c or more*
  - Contrast to surface muon beam at 29.8 MeV/c, or Mu2e/COMET beams with momentum at stopping target ~ similar number
  - Ability to stop in a small, well-defined volume degrades rapidly
  - important for resolution in BOTH conversion and decay expt's
- *We want central momentum $\leq$ 30 MeV/c*

https://indico.fnal.gov/event/6248/contributions/95160/attachments/62042/74395/SurfaceMuonBeams_ANL_IF_Meeting_April2013.pdf

What Should the Central Momentum Be?

- Fighting (or taking advantage of) Bethe-Bloch
- small changes in momentum produce large changes in stopping distance and range straggling



Agreed Here

- We want to try for the lowest central momentum we can reasonably achieve
  - otherwise, we need to slow the muon beam externally, which seems complicated, difficult, and expensive
- We want both signs simultaneously
- Kickers (extraction is the bigger problem) run at most at about 100 kHz. Mu2e runs at 625 kHz so we lose x6 or so in rate
  - we need to look for designs where we can extract as rapidly as possible and as easily

Summaries of what we heard

- Meot: history of FFAs and careful consideration of different designs
- Pasternak: PRISM design, central momentum at 68 MeV/c. Detailed discussion about matching from production solenoid to FFA
- JB Lagrange: interesting discussion of “egg-shaped” FFA with longer straight sections perhaps making injection/extraction easier

Goals

- Find out what we are injecting into FFA from Fermilab or JPARC
- Decide on an FFA design given the constraints we've outlined
- Start designing kickers

FFA Plans

- Collect questions from previous slide and write up a brief document
- Estimate number of people required to go to next level of design subject to constraints we discussed: lower central momentum, both signs, 100 kHZ, …
- Start looking for funding!