Parameters for Muon Programs in ACE

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ACE Workshop

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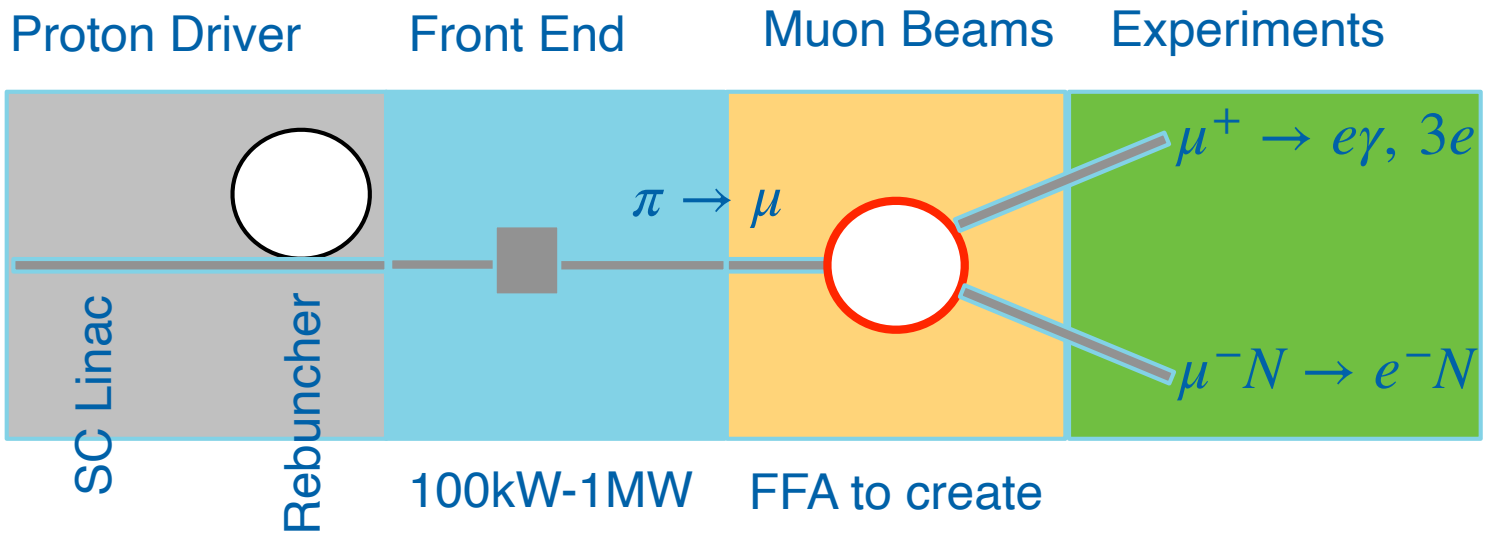
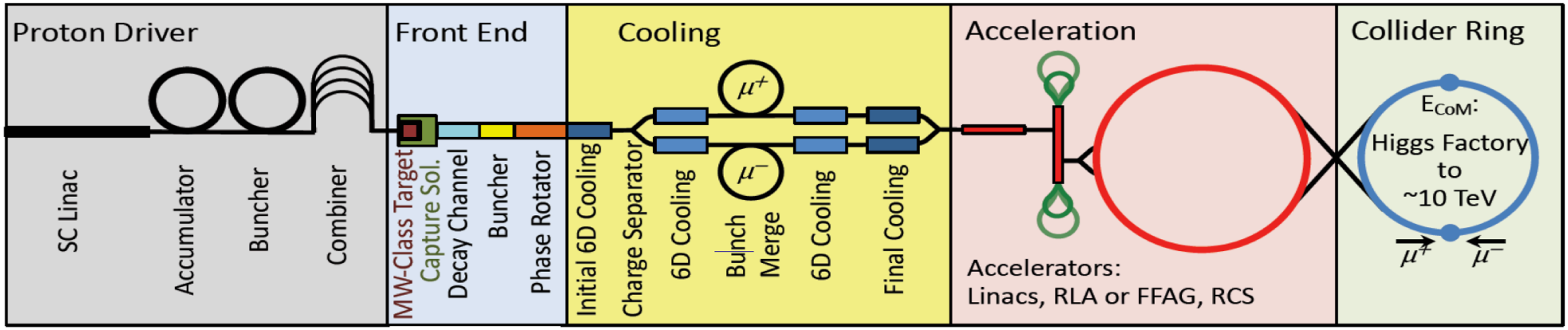
Starting Point



At least at this cartoon level, it looks like there's a lot of overlap. Our goal is to sharpen our intuition.



Some Potential Overlaps

- Proton Source
- Production Solenoid at ~ 1MW
- Compressor Ring to rebunch Linac

in order along the chain

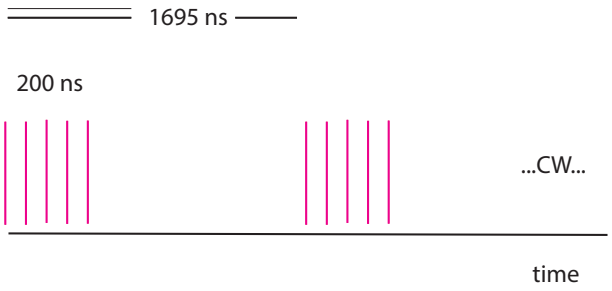
- FFA for a muon storage ring

- *Today: let's write down some numbers and see where it leads.*
  - *don't quote me on any of this as final! this is a workshop!!*

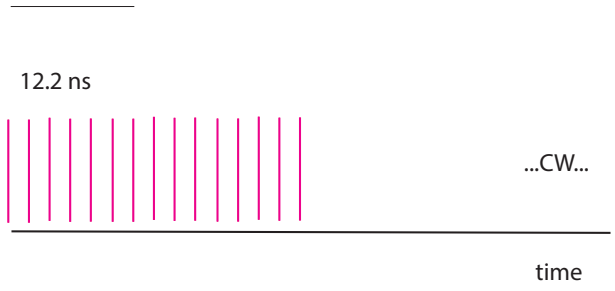
Proton Source

Proton Source	Mu2e-II	AMF	Muon Collider
bunch length	~200 nsec	short	1-3 ns
bunch spacing	~1695 ns	12.2 ns	5-10 Hz
macrostructure	CW	CW	Pulsed
beam energy	800 MeV	800 MeV–4 GeV	5–15 GeV
beam power	100 kW	1MW	2–4 MW

Mu2e-II



AMF



see Eldred def'n of CW (this workshop)

Compressor Ring

Proton Source	*AMF*	*Muon Collider*
bunch length	*10 ns*	*1–3 ns*
bunch spacing	*100 Hz*	*5–15 Hz*
protons/bunch	*78 x 10^{12} - 78 x 10^{13}*	*3 x 10^{14}*
macrostructure	*CW*	*Pulsed*
beam energy	*800 MeV–4 GeV*	*5–15 GeV*
beam power	*1MW*	*2–4 MW*

This is the output; input is PIP-II proton source

FFA

- Note: phase rotation occurs before cooling in the MuCol. Be careful about "cartoons."

Proton Source	*AMF*	*Muon Collider*
dp/p	*~1%*	*Factor of 2 energy gain*
central momentum	*20 MeV/c*	*Few GeV – 4 TeV*
macrostructure	*100Hz - 1kHz*	*5 Hz, 2 counter-rotating bunches*
beam power	*1MW*	*30 kW – 12 MW*

Production Solenoid

Proton Source	*Mu2e-II*	*AMF*	*Muon Collider*
bunch length	*<200 nsec*	*<200 nsec*	*1–3 ns*
bunch spacing	*~1695 ns*	*10 msec (100 Hz)*	*5 – 10 Hz*
macrostructure	*CW*	*CW*	*Pulsed*
beam energy	*800 MeV*	*800 MeV–4 GeV*	*5 – 15 GeV*
beam power	*100 kW*	*1MW*	*2 – 4 MW*

this is probably the most obvious overlap. Mu2e-II works here too.

Questions From P5: AMF Answers

- How does the experiment make use of the ACE beam?
  - Uses 2 GeV Spigot (CW) and Pulsed for muonium-antimuonium oscillations
- Is the experiment uniquely enabled by the ACE upgrades?
  - Having a higher energy (1-3 GeV vs 800 MeV) has some benefits. The Booster Replacement is *not* necessary. The 2 GeV accumulator ring could be designed to be the compressor ring required for AMF.
- Can this experiments be performed elsewhere?
  - It is possible that J-PARC could use their RCS and MR but much of what is proposed for AMF would have to be built there. PSI only has a CW beam at 51 MHz. Although PSI's target is at 1 MW, only about a percent at most is available for the HEP program, so it could do the decay experiments (albeit not as the statistical power of FNAL) but not the conversion experiment.
- What particular accelerator components or capabilities are necessary?
  - compressor for rebunching PIP-II protons, production solenoid and pion production target, FFA for muons that can deliver pulses for conversion or "continuous" for decay experiments, then injection/extraction components.

Questions from P5 (2)

- What proton energies are needed?
  - 800 MeV to a few GeV

- What proton quantities are needed?
  - $\mathcal{O}(10^{26})$ (SES of 10^{-20} x 10% detector acceptance x $10^{-3}\mu/p$ x 1% transfer efficiencies)

- What time structure is needed? (bunch length, train structure)
  - depends on where you are in the chain. The PIP-II proton source works as a start.

- Can the experiment be performed with 800 MeV protons from PIP-II?
  - Yes. 2-3 GeV is better but this is partly dependent on the Production Solenoid magnetic field. AMF wants to stay below antiproton threshold at 5 GeV if possible.

Common Questions

- With these sets of parameters, what can be used from Mu2e-II or AMF as R&D for the Muon Collider?

  - Production Solenoid
    - how much are the production solenoid designs similar?
    - what can we learn about targeting?
    - what can we learn about protecting a superconductor
    - are the superconductors for both the same?

  - FFA
    - is there common technology for phase rotation?
    - is a racetrack FFA acceptable for both?
    - how can we extract μ^- with one time structure (every 1000 ns or so) for conversion and μ^+ with another (as constant as possible) from the FFA? Is such a ring still useful for the MuCol?

  - Compressor Ring
    - what is the physics purpose of the current 2 GeV ring? Does it make sense to turn it into a compressor ring for AMF? Or do we need two rings?

Today: Mu2e-II, AMF and MuC are in this together

- Overlap in Production Solenoid/Target Station:
  - build a team
  - learn about megawatt class targets
  - validate engineering estimates:
    - *effort at Mu2e-II and AMF will inform MuC design*
  - does it make sense to just build MuC solenoid for AMF?
    - No. Aperture is very expensive.
  - is using forward production in AMF sensible? Maybe.

- Overlap in Compressor Ring
  - build a team
  - code validation
  - similar at a broad scale but parameters about x10 different; some things easier, some harder
    - again, validating engineering estimates

- Overlap in FFA
  - not that much overlap, but a lot of good discussion about design