Cost Benefits of Low Longitudinal Emittance

- Effect on dynamics
  - Smaller longitudinal emittance
    - Accelerate closer to crest
  - Shorter bunch
    - Higher frequency
  - Smaller energy spread
    - More turns/easier switchyard
    - Easier arcs

- Cost scalings
  - Linac:
    - ⋆ Proportional to linac length
    - ⋆ Different for different frequencies
      - ➢ 200 MHz: 38 Nrb/GeV
      - ➢ 400 MHz: 27 Nrb/GeV
  - Arcs:
    - ⋆ Proportional to max energy (length)
    - ⋆ Proportional to dp/p
      - ➢ Aperture size increases (dispersion)
      - ➢ Greater quad density needed to control chromaticity
      - ➢ Switchyard size
    - ⋆ Study 1 costs:
      - ➢ RLA1 was 0.27 Nrb/half arc/GeV/%
      - ➢ RLA2 was 0.09 Nrb/half arc/GeV/%
    - ⋆ Maybe should consider beam size
      - ➢ Scaling with energy
      - ➢ Puts floor as $dp/p \to 0$
    - ⋆ Choose 0.18 Nrb/half arc/GeV/%
  - Design study 1:
    - ⋆ RLA1 + RLA2 ≈ 500 Nrb
    - ⋆ Total machine ≈ 1000 Nrb

Results

- Example: 3-20 GeV RLA
- Observations
  - Closer to crest with small ϵ_L, but so close to start with, irrelevant
  - More turns possible, so linac costs drop
  - Arc costs decrease, but more arcs with more turns
  - 400 MHz worse:
    - Further off crest, more GeV of linac
    - Energy spreads increase
  - Number of turns gets large for small emittance
    - Decay losses
    - FFAG?
    - Fixed turns, still better. Saturates for smaller emittances.
  - Should decrease $\epsilon_\perp$ for small ϵ_L
    - Transverse size determines aperture
    - Switchyard complexity
  - Magnet edges in switchyard
    - Limit number of turns
    - Maybe limit as low as 10