ADS Simulation in MAUS

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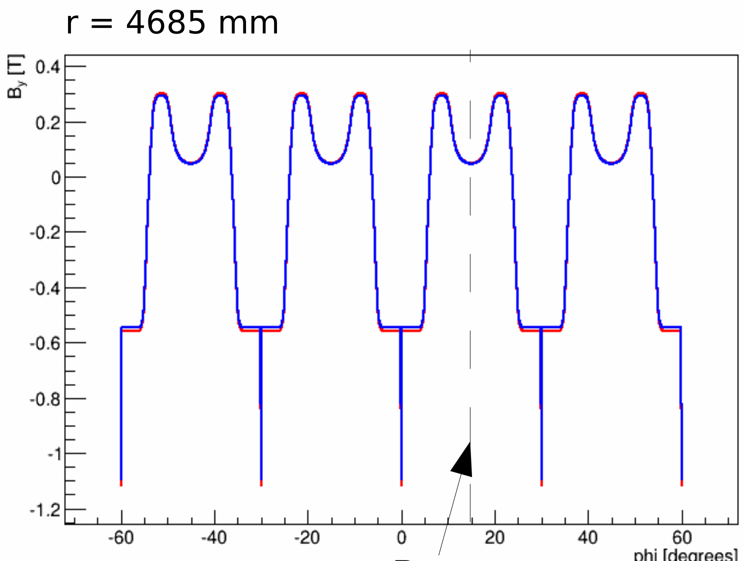
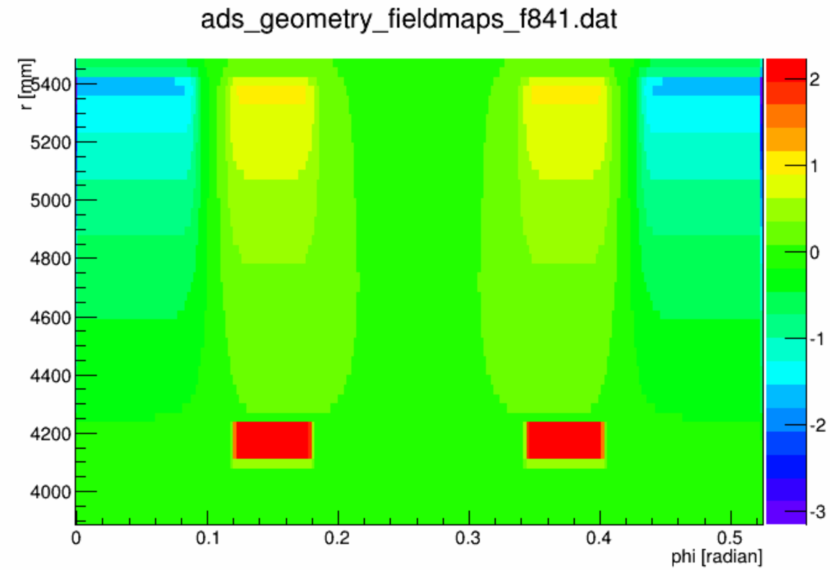
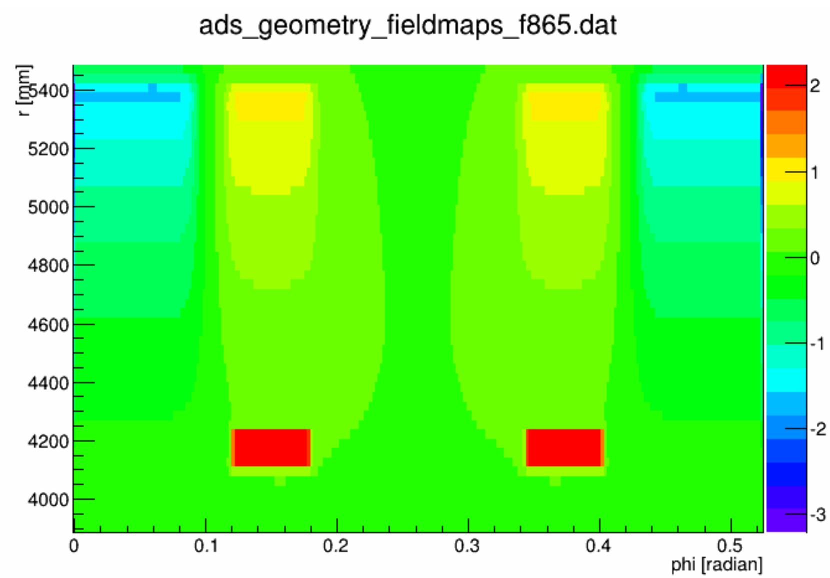
Overview

- Simulation of ADS FFAG in MAUS (GEANT4)
  - Using 3D field maps
  - Convince myself the code is tracking okay
- How does G4 model of multiple scattering and energy loss affect the beam?

Magnetic Field



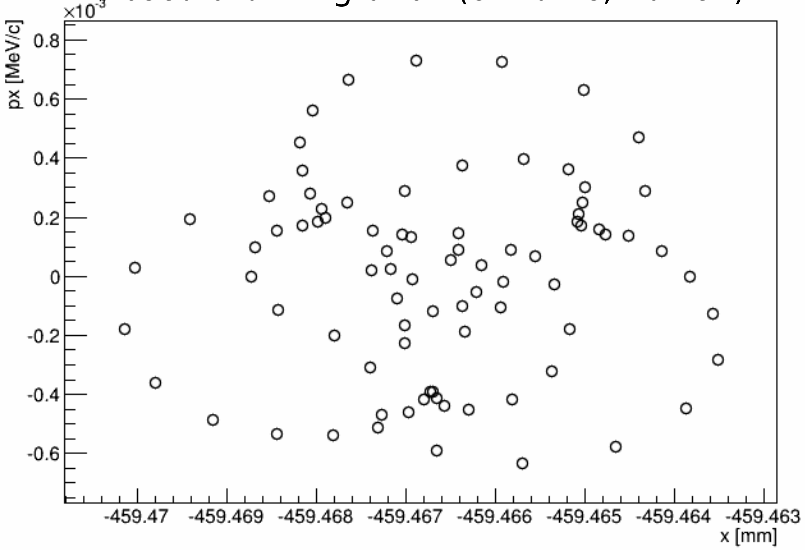




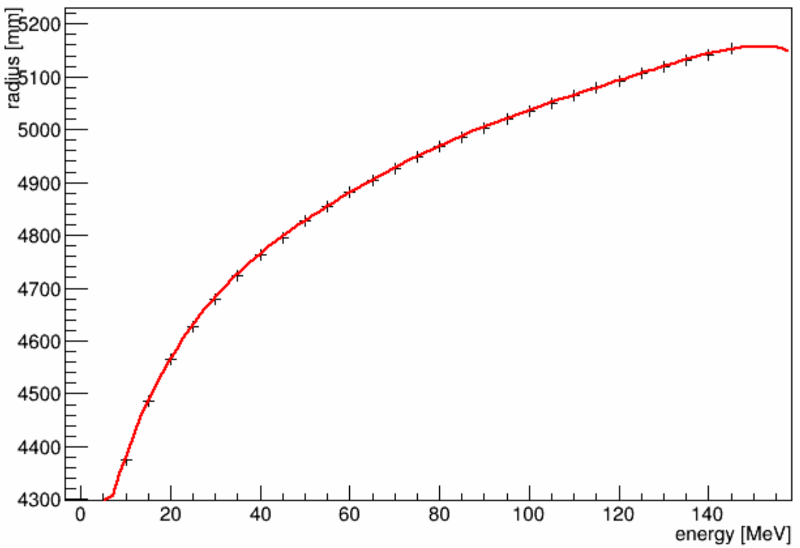
- Two field maps
  - “f865_76-d566_25”
  - “f841_81_d597_04”
  - Presumably coil currents…
- Some overlap between adjacent field maps
  - Overlap region has width < 1 micron
  - May cause some noise in tracking
- Field map has height +/- 15 mm

Closed orbit and tracking stability

Closed orbit migration (84 turns, 10MeV)



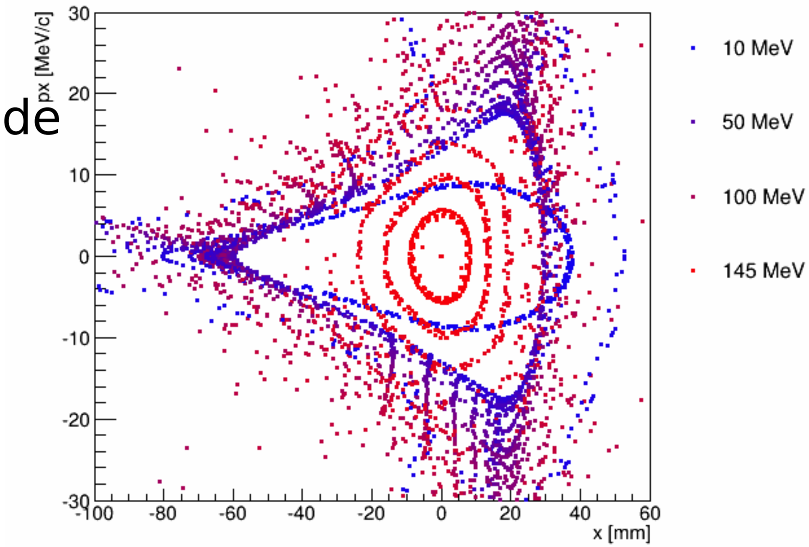
Closed orbit vs energy

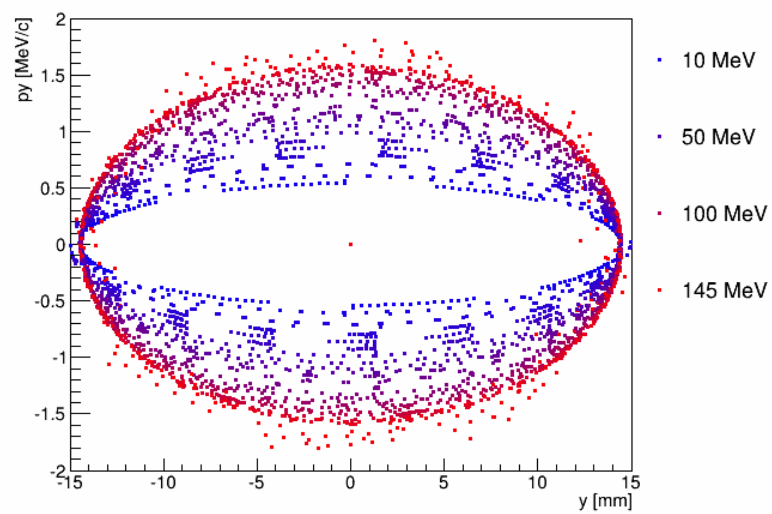


- Choose step size of 10 mm
  - Gives tracking error ~ 4 microns over 80 turns
- Find closed orbits in range 10 MeV – 145 MeV
  - Failed to get a closed orbit at 150 MeV

Aperture

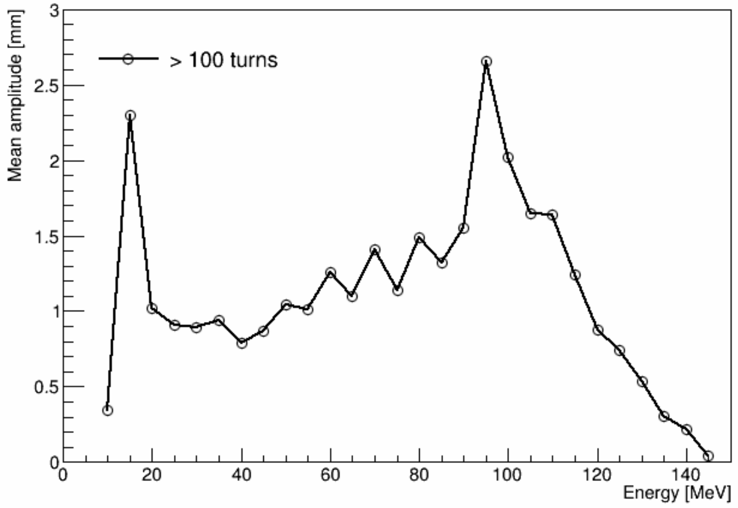
- Aperture
  - Dynamically seek largest amplitude particle that survives 100 turns
  - Plot phase space trajectory for different energies (colours)
- DA in y is limited by scraping
  - Larger at larger energies
  - Beta function is smaller
  - Very clear limit for y < 15 mm
    - Edge of field map

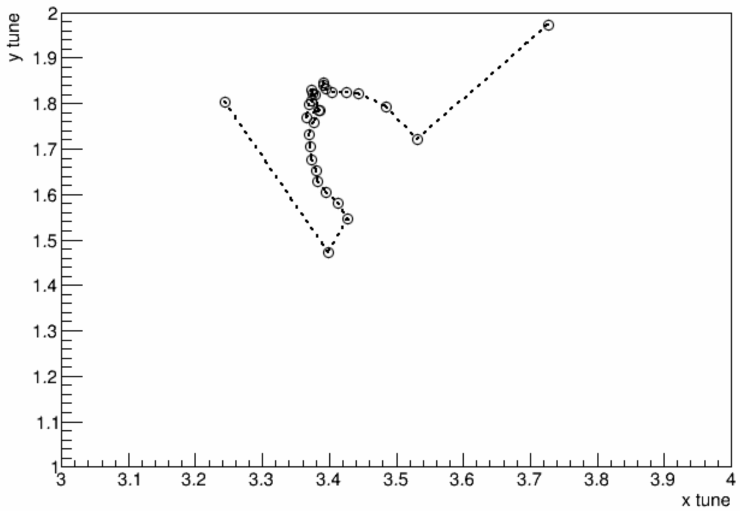




Tune vs DA

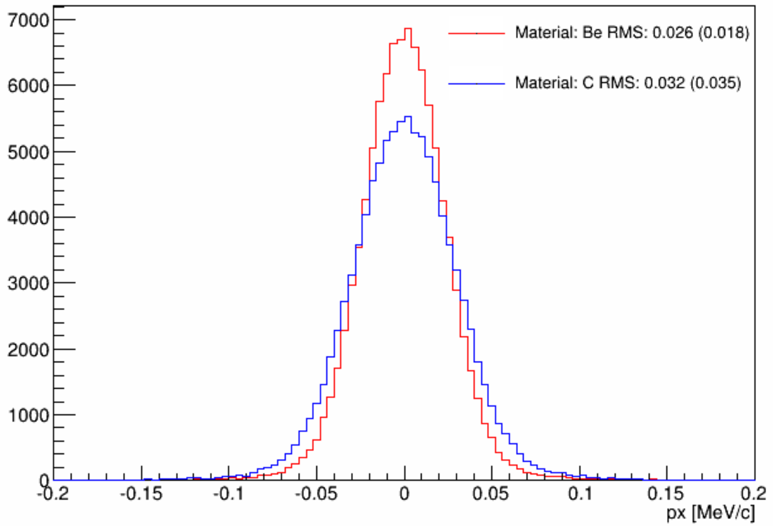
- Calculate acceptance vs energy
  - Fit ellipse to tracking data for largest amplitude surviving particle
  - Calculate mean amplitude of the orbit against this ellipse
  - Acceptance looks very good until the top energy
- Calculate (ring) tune using FFT technique
  - Particle with initial offset in x/y of 1 mm from co
  - A lot of tune variation at low and high energies

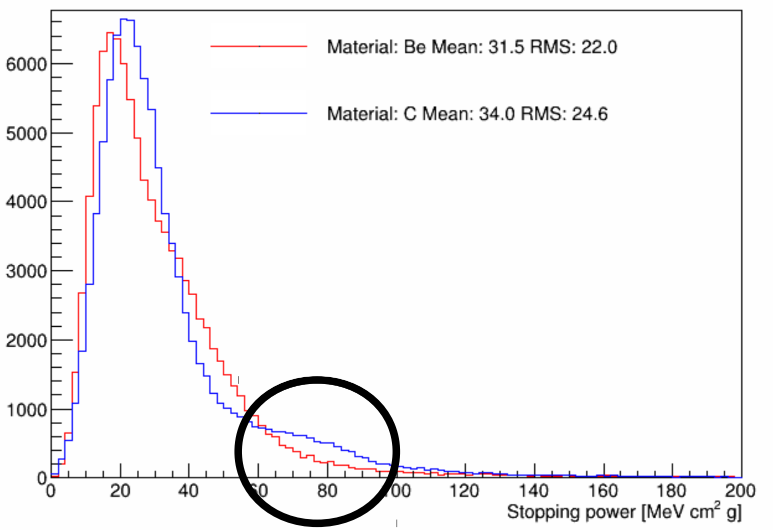




Energy Loss and Scattering in Foil

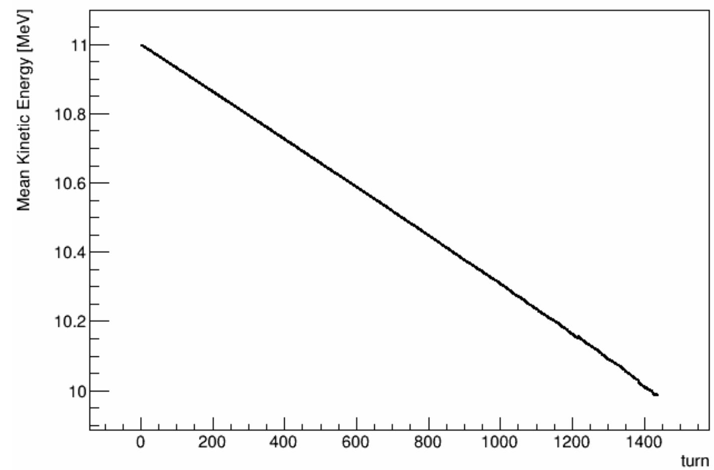
- Look at effect of foil
  - 11 MeV protons
  - Single pass
- MCS distribution (p_0 144 MeV/c)
  - Number in parenthesis is PDG value for MCS
  - 10% discrepancy for C
  - 50% discrepancy for Be
- Energy loss distribution
  - PDG/NIST gives mean stopping powers @ 11 MeV
    - Carbon 37.58
    - Beryllium 34.89
  - Agreement to 10 % level
    - Note suspicious bulge in tail

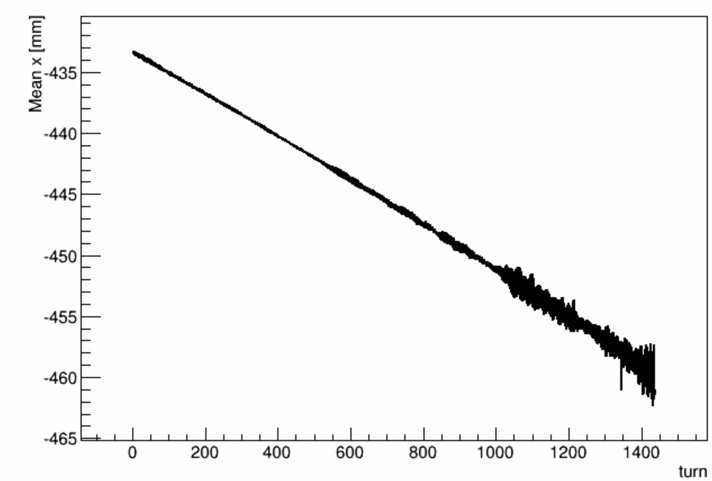




Beam orbit migration

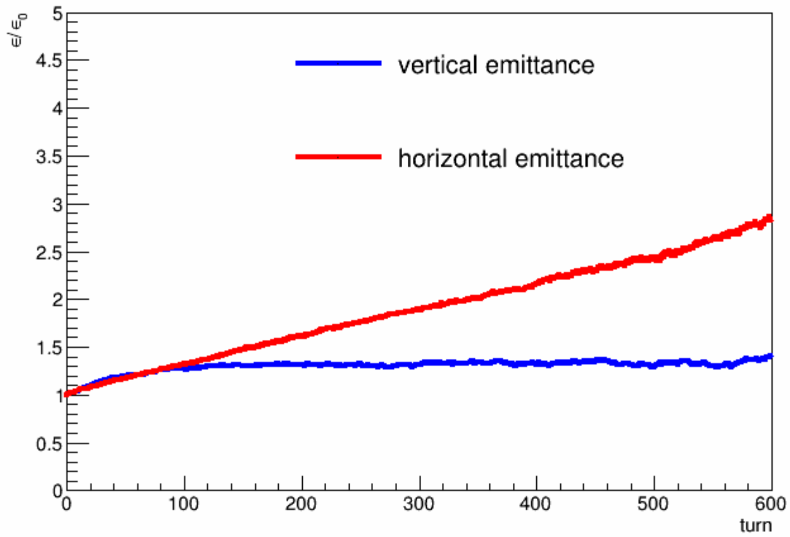
- How does foil affect beam energy and closed orbit?
  - No RF
  - 20e-6 g/cm^2 Carbon
  - Over 1400 turns, get ~ 1 MeV of energy loss
  - Closed orbit migrates by ~ 25 mm
- Not much statistics by 1400 turns

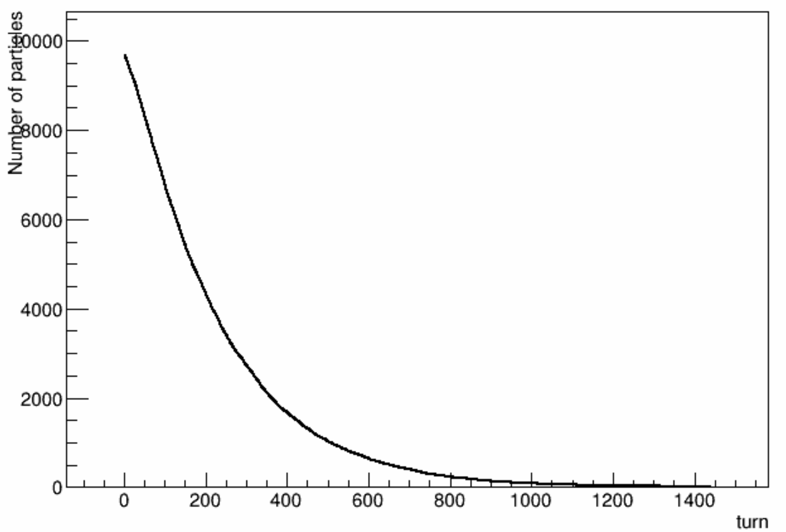




Transmission and emittances

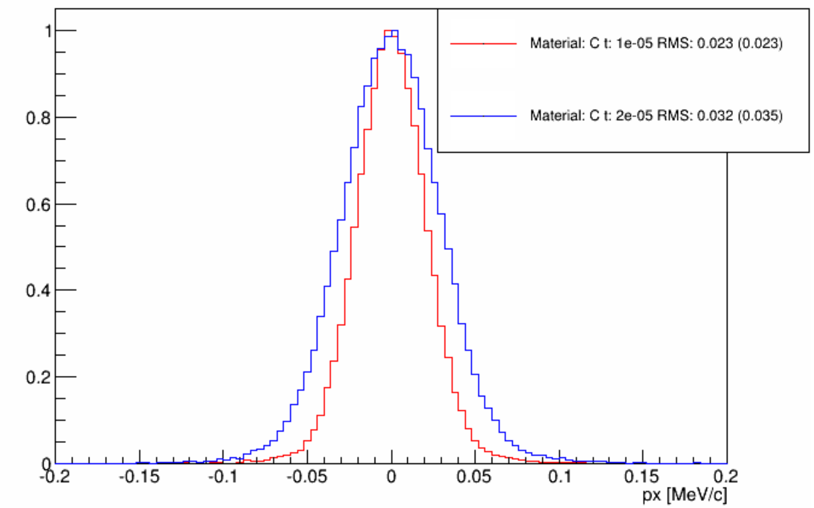
- Look at effect of foil on beam emittance
  - No RF
  - Inject 8 micron geometric emittance
  - Lose 50% of beam in first 200 turns
  - Injection cycle is ~ 160 – 1200 turns
    - (Uesugi, FFAG 13, slide 8)
- Is 15 mm real aperture?
  - Or just edge of field map…

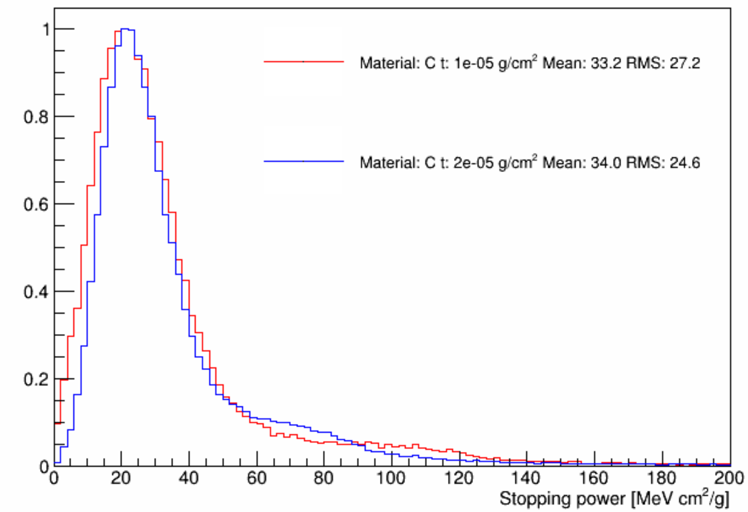




Foil thickness

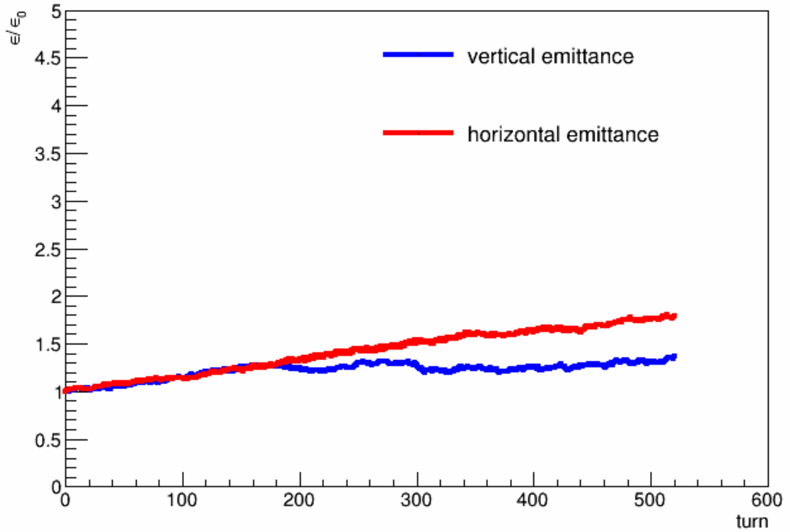
- MCS is reduced with thinner foil
  - Not linear with thickness
- Look at effect of foil thickness
  - Stopping power is pretty independent of thickness as expected

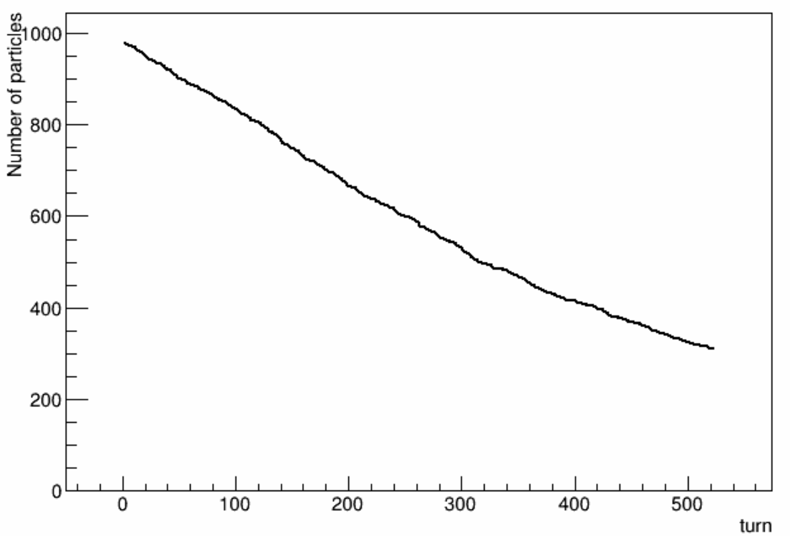




10e-6 g/cm² thickness

- For a 10e-6 g/cm² foil
  - No RF
  - Inject 8 micron geometric emittance
  - Lose 50% of beam in around 300 turns





Future Plans

- Would be great to generate these field maps
  - Use real aperture
  - Vary coil currents in a physical way
  - I think it is OPERA? What is the geometry file?
    - We have a licence to run it at RAL
- Would be great to add RF
  - Need to code in variable RF frequencies
- And space charge…
  - Integrate with OPAL