Beam Distributions with Maximal Apertures

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Review of Previous Talk

- Neuffer found significantly worse performance with C compared to Hg
  - Found larger emittance for C
- I looked at emittances at 3 m
  - Various Hg distributions had very different emittances
    - Differences primarily result from different beam pipe apertures
  - Neuffer used the one with the smallest emittance
  - C emittances were larger than Hg
  - C emittances worst with dump no tilt; with dump better with tilt

Review of Previous Talk

- New default for MARS event generator has significant impact on performance
  - Largest impact is total count reduction, less so on spectrum
  - Transverse emittances virtually unchanged
- C energy spectrum peaked at much higher energy than Hg
  - Overall production may be comparable to Hg (about to be proven otherwise…)
  - NBPR design likely very different for Hg and C
  - But Bob argued correctly that capturing flux at higher energies is likely more costly and less efficient

Review of Previous Talk

- C with dump no tilt has signficantly worse production

Maximal Aperture Runs

- Ran both C (at 6.75 GeV) and Hg (at 8 GeV) with
  - 13 cm inner radius to $z = 80$ cm ($z = 0$ at center of target)
  - 23 cm inner radius beyond that
  - $B_{max} = 20$ T (although would run Hg with 15 T)
- Compare distributions at 3 m to results with old apertures
- Emittances are larger, and are identical for Hg and C: emittances determined by apertures!
  - Differences in C apertures based on tilt, *etc.*: likely differences in interaction with aperture

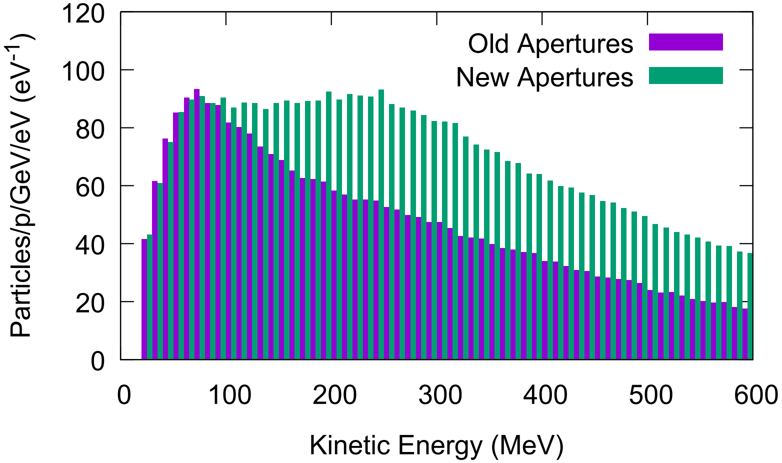
	μ^-+	μ^--	μ^++	μ^+-	π^-+	π^--	π^++	π^+-
Hg old	30.7	13.4	35.2	15.1	21.0	14.4	21.9	15.1
Hg new	60.2	17.5	66.6	18.8	62.8	14.6	64.8	14.8
C old	51.5	22.1	52.7	23.9	36.5	26.0	36.6	27.4
C new	60.7	18.5	64.5	19.4	63.8	15.4	66.1	15.6

μ^-+ means the + eigenemittance for μ^-, "old" means old apertures (different for C and Hg), "new" apertures same for C and Hg.

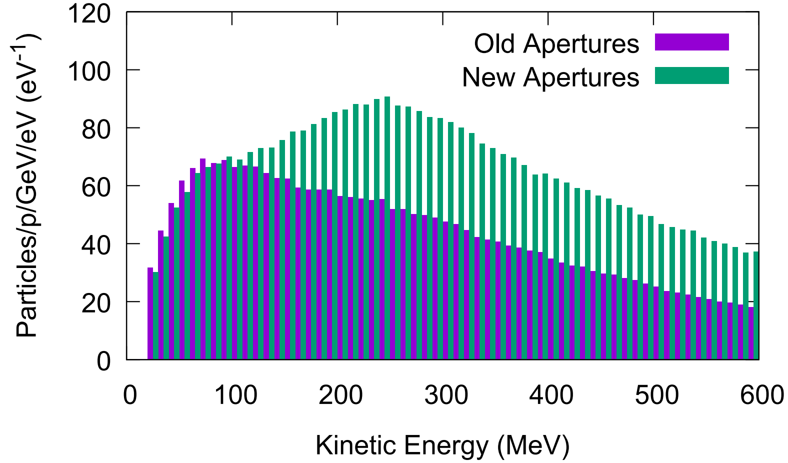
Hg at 3 m

Plots normalized to constant beam power

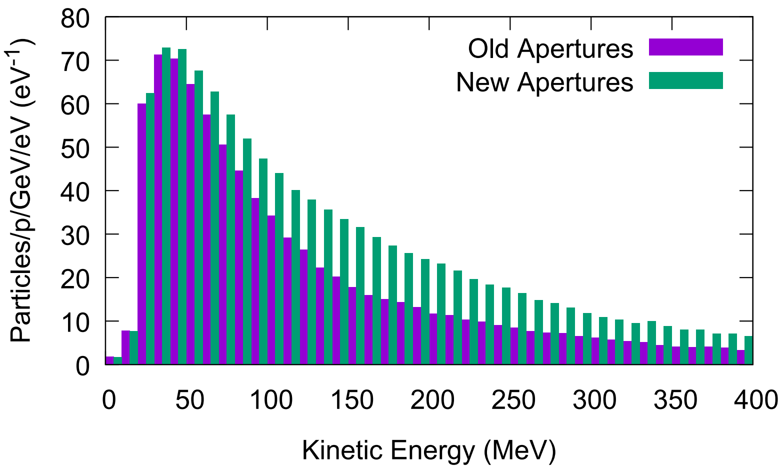
π^-



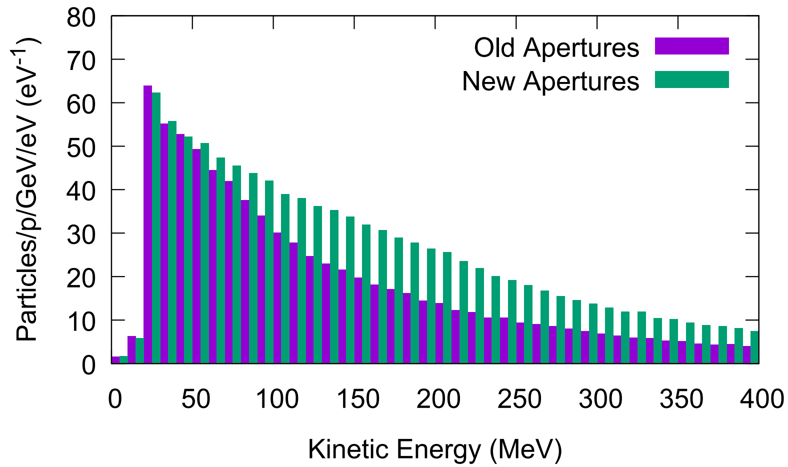
π^+



μ^-



μ^+

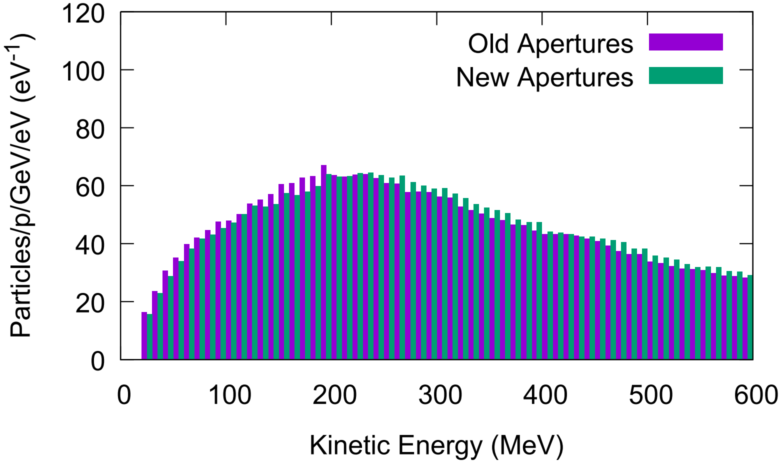


Hg at 3 m

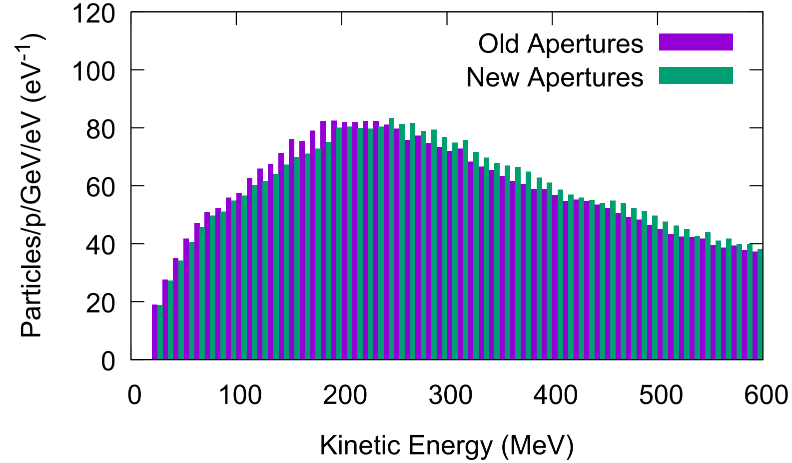
- Hg: widening apertures gives more particles at higher energy
- C: less change seen: only difference is that 13 cm portion got shorter in new version
- Some decrease in low energy pions: pions were losing energy in beampipe?

C at 3 m

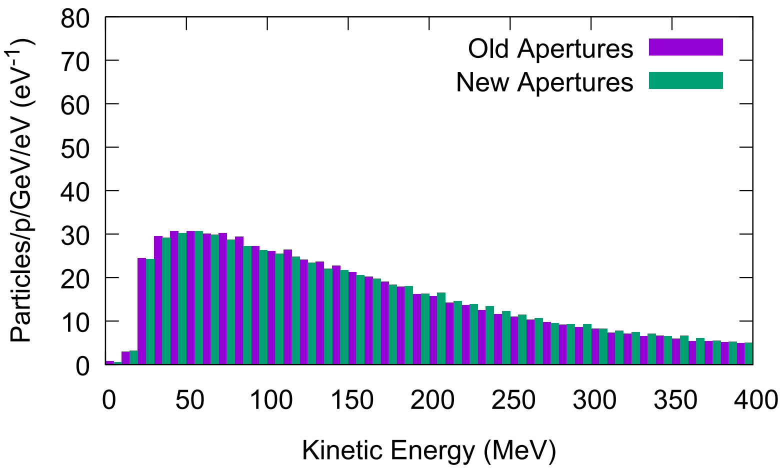
π^-



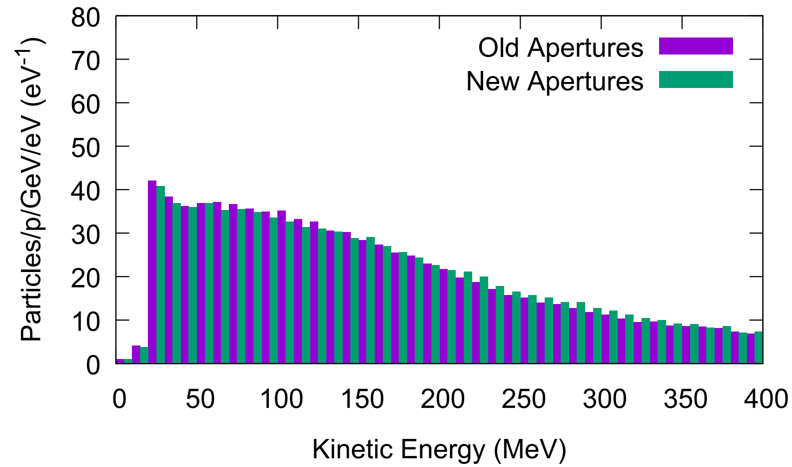
π^+



μ^-

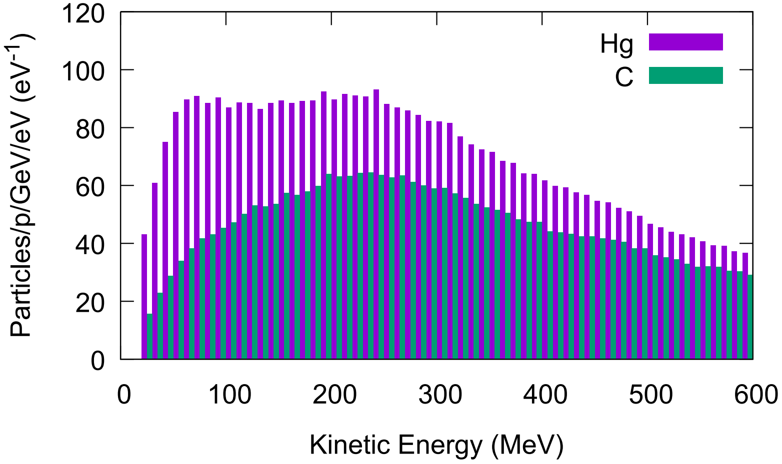


μ^+

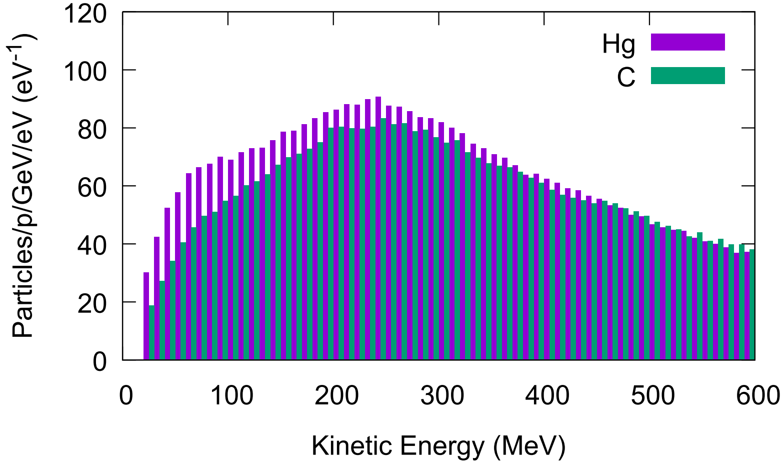


Hg *vs.* C at 3 m

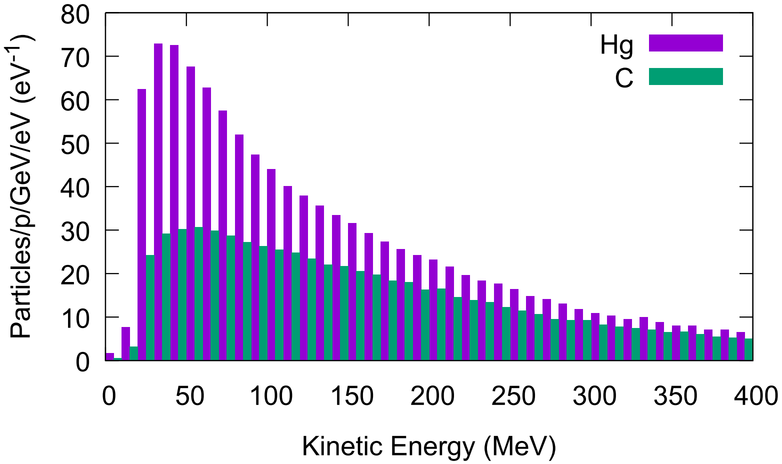
π^-



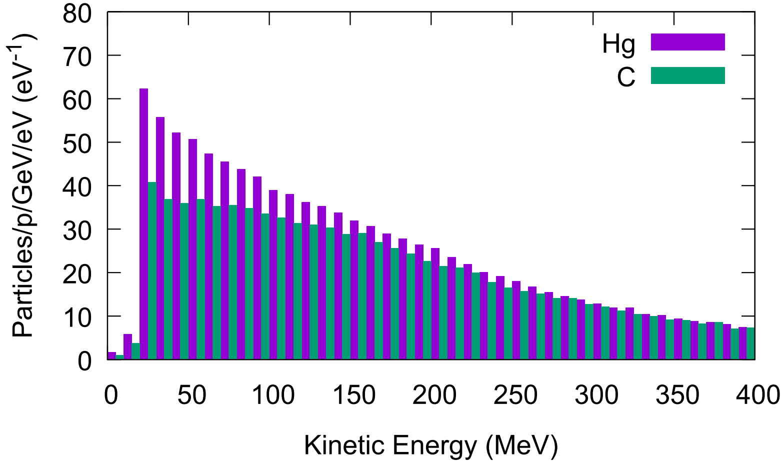
π^+



μ^-



μ^+



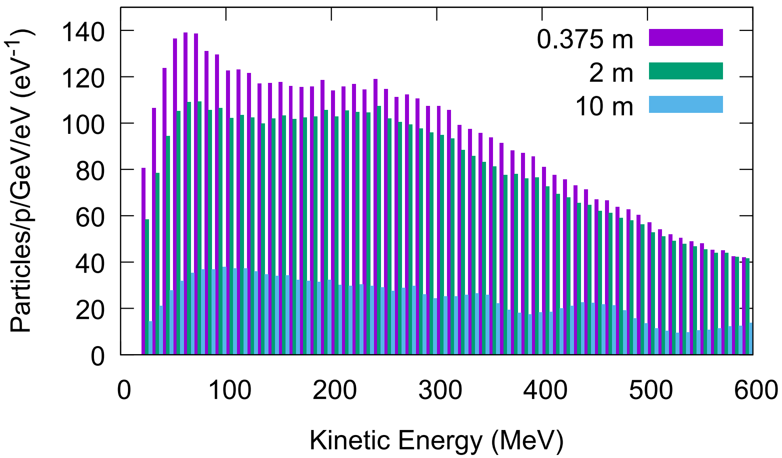
Hg *vs.* C at 3 m

- Hg at 8 GeV production always higher than C at 6.75 GeV for same # of protons
- Distributions get very similar at high energy, especially for positive charges
- Pion production peak at 250 MeV shows up in Hg as well as C
  - This peak may be related to geometry: higher fields may move this to higher energy
- Still holds that C and Hg will require different NBPR, but less so than I initially thought
  - Note that NBPR will function differently for both signs (more so in Hg): must be a compormise, designed simultaneously for both signs

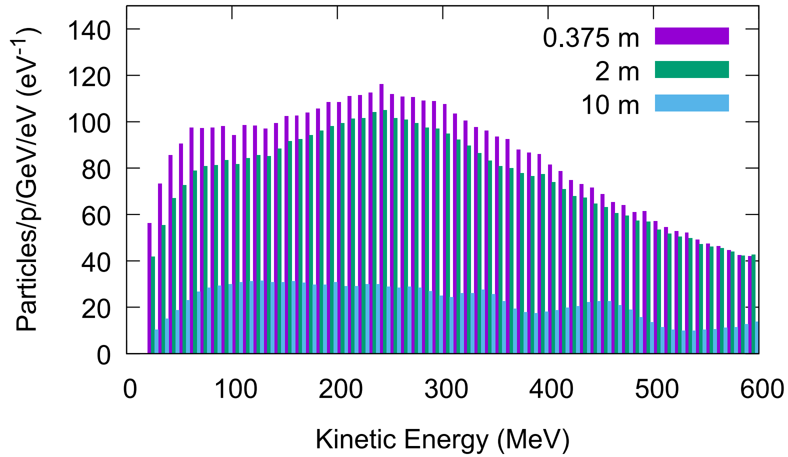
Spectrum *vs.* Distance (Hg, MARS)

Plots normalized to constant beam power

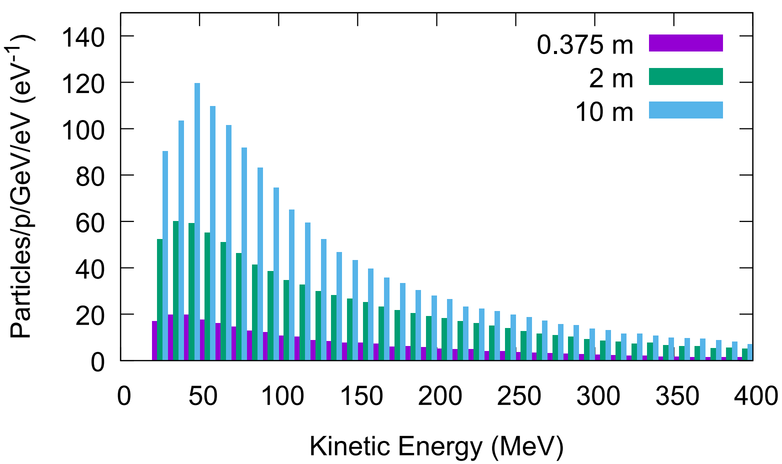
π^-



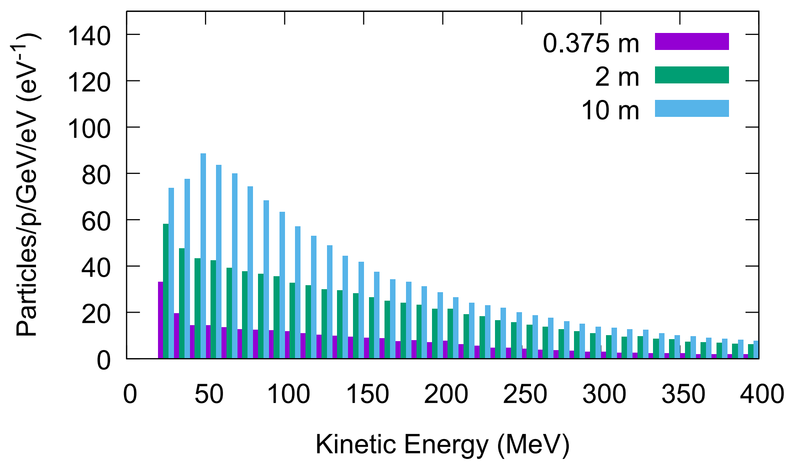
π^+



μ^-

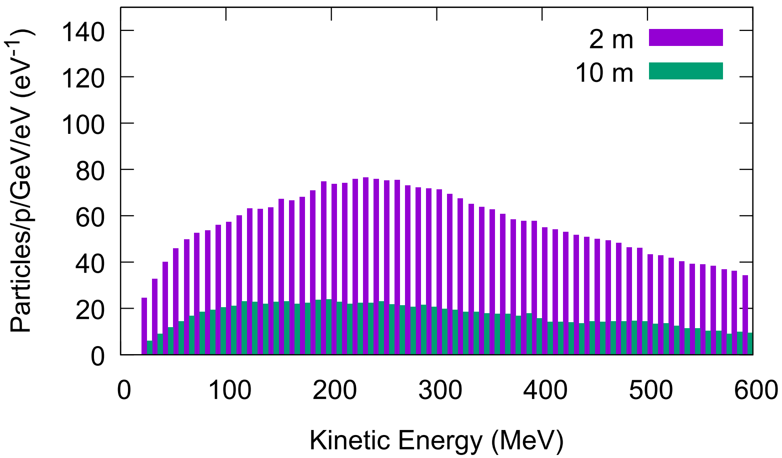


μ^+

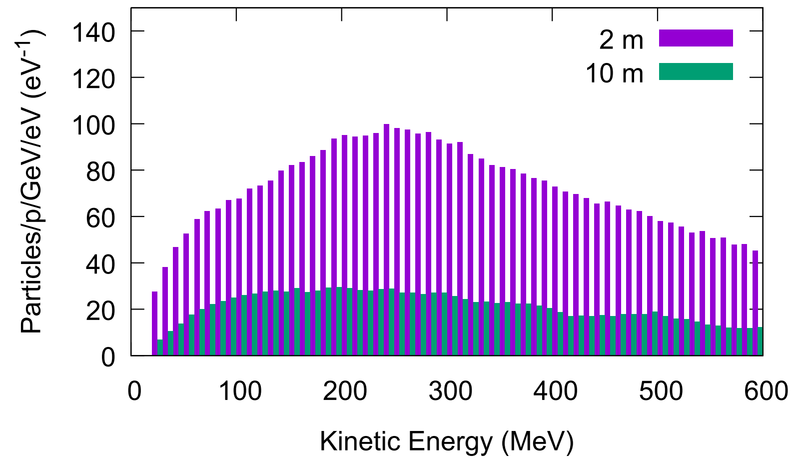


Spectrum *vs.* Distance (C, MARS)

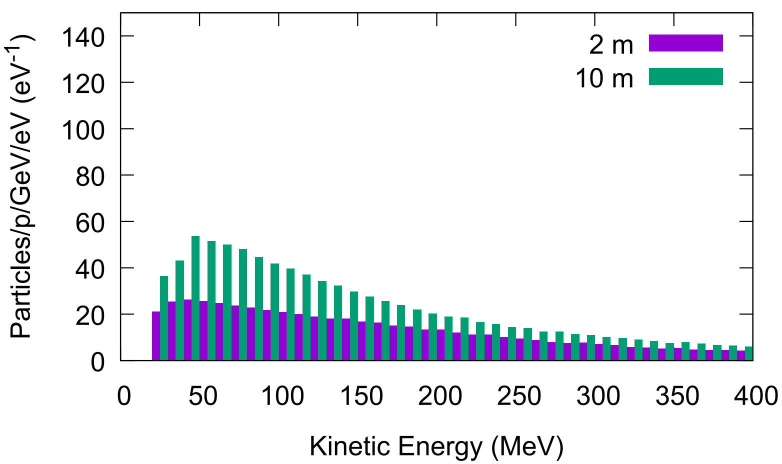
π^-



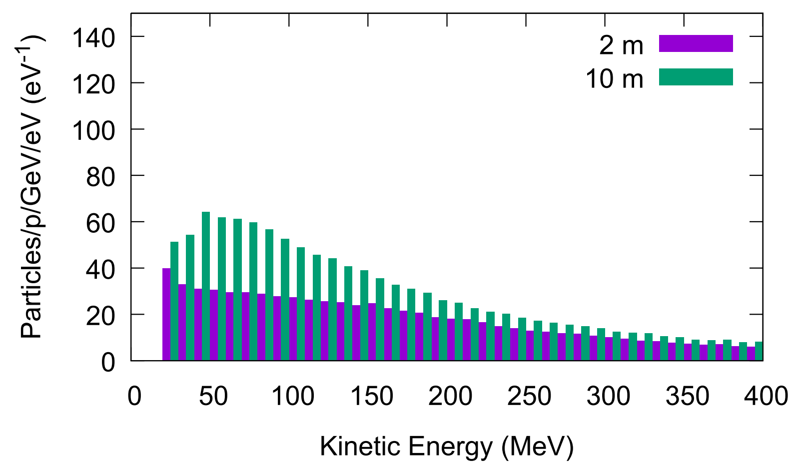
π^+



μ^-



μ^+

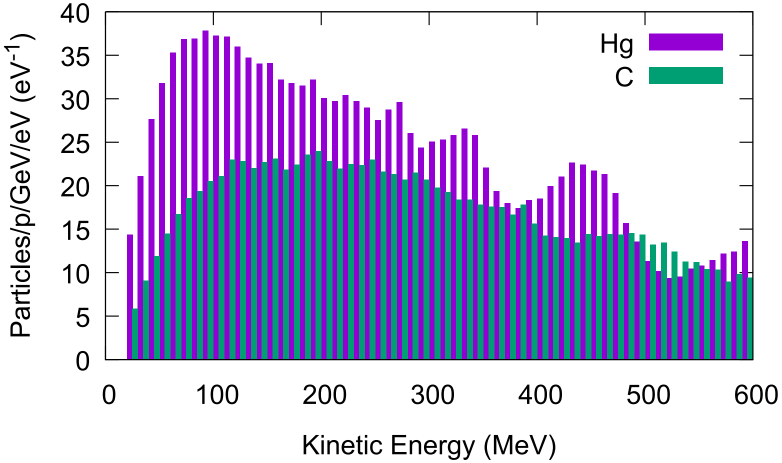


Spectrum *vs.* Distance

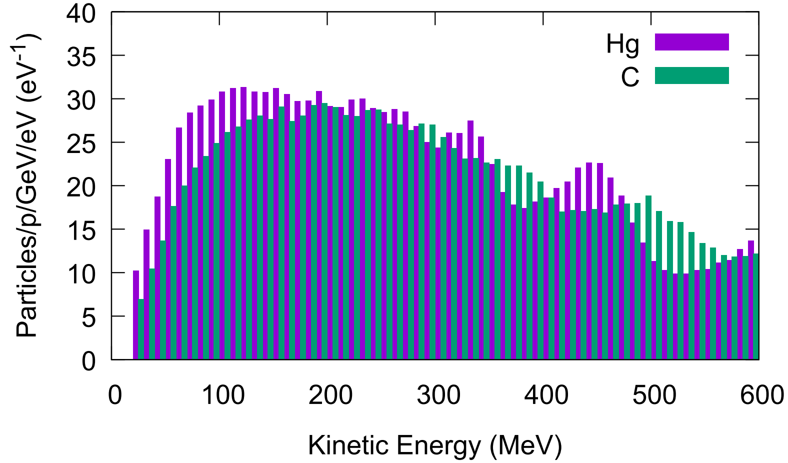
- Going down to 10 m, many more pions lost than muons created
- Peak at 250 MeV goes away
- Conclusion: many pions (and maybe some decay muons) lost on apertures
- High energy spectrum oscillates for Hg
  - Longer betatron period for high energies
  - Expect to eventually flatten out
  - Less so for C: production over larger longitudinal range?
- Transmission would be improved by higher fields
  - Consistent with Hisham's results
  - Spectrum would be weighted toward higher energy

Hg vs. C at 10 m

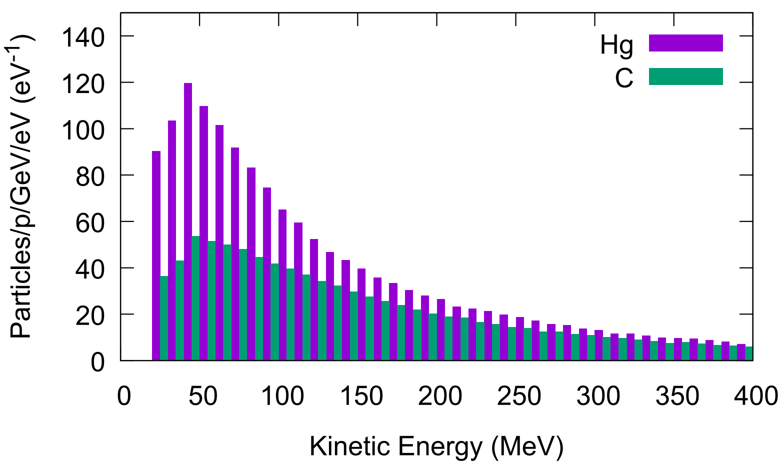
π^-



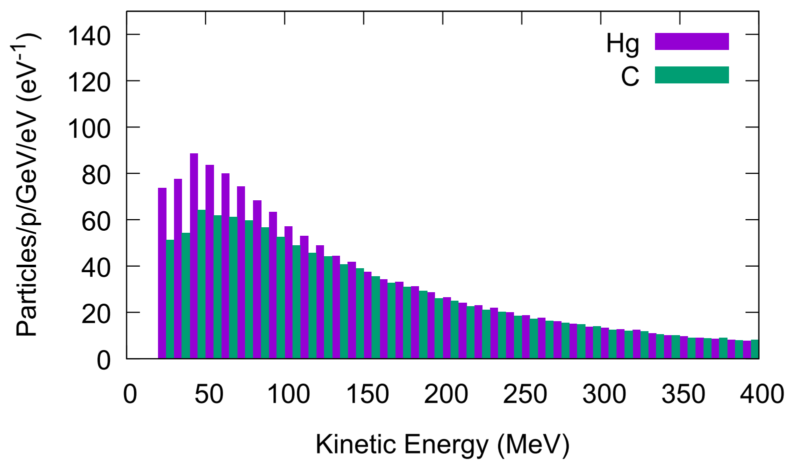
π^+



μ^-



μ^+



Hg vs. C at 10 m

- Similar to 3 m, especially for muons
- Main difference is disappearance of pion peak at 250 MeV

Conclusions

- Emittances are determined primarily by apertures; Hg and C are the same
- High energy portion of spectrum clipped by apertures as well
- Spectrum shape differs for different signs
- Positive production similar for Hg and C
- Negative production differs significantly at low energy (< 150 MeV for μ^-)
- Higher fields would increase number of captured particles, but likely raise energy of spectrum

Distribution Availability

- Distributions available at
  https://pubweb.bnl.gov/~jsberg/150201-Distributions/
- ICOOL for003.dat input, as well as raw MARS output
- At 2 m and 10 m for both Hg and C, also 0.375 m for Hg
- At 10 m, also have charged pions, kaons, and muons, plus same separated by charge signs
- MARS input files also available

Next Steps

- What does the N_{euffer}B_{uncher}P_{hase}R_{otator} optimized for these distributions look like?
  - What portion of the distribution does it use?
  - What is the best compromise for both signs?
    - Is this different for collider and ν factory optimization?
  - Is there a significant difference for C and Hg?
- How does chicane change things?
- How does raising the field change things?
- Would an early absorber help?