ICOOL

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Ionization Cooling Software Mini-Workshop
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ICOOL Overview

- Software written specifically to model ionization cooling
- Written primarily by Rick Fernow, currently “maintained” by me
  - Available at https://www.cap.bnl.gov/ICOOL/
- Underlying physics model
  - Originally Geant3 plus integration through EM fields, spin
  - Additional models for ionization cooling processes have been added over the years
- Beamline as a sequence of longitudinal regions
  - Radial build within each region

Beamline Layout

- Laid out longitudinally with respect to a “reference particle”
  - Reference can curve, often determined by field
- Sequence of “SREGION”s with specified longitudinal lengths
  - Can be divided into radial sub-regions
- Each region has a
  - Field (can come from neighboring regions as well)
  - Material, possibly with more complex shaping
- Three nested layers of looping possible, sort of

Field Types

- Accelerator magnets (dipole, quadrupole, sextupole, etc.)
  - Different “model”s for handling of ends, etc.
- Numerous ways to get solenoid fields
  - SOL: accelerator-like, field map, expanding from on-axis field
  - COIL: current loop
  - SHEET: cylinder of current
  - BLOCK: annulus with rectangular cross-section
  - BSOL: bent solenoid
- Acceleration (ACCEL): RF cavity or other
- Generic field maps
- A few others…

Interactions

- Average energy loss
  - Bethe-Bloch, possibly with density effect, most probable loss
- Multiple scattering
  - Gaussian, Moliere, Rutherford, Fano, Tollestrup, ELMS, …
- Straggling
  - Gaussian, Landau, Vavilov, ELMS, …
- Decays
- Primitive nuclear interaction, space charge models

Input/Output

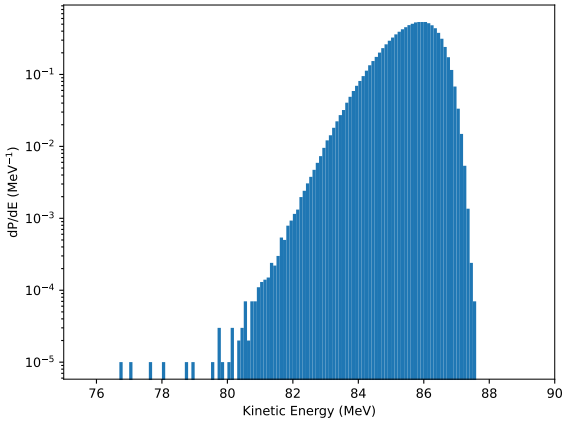
- Initial distribution
  - Can be generated, many models
  - File with particles
- Output
  - File with particles
    - At select locations, each region, steps within regions
    - Included ecalc9f post-processing program
  - Will also process data (histograms, etc.), but not so useful

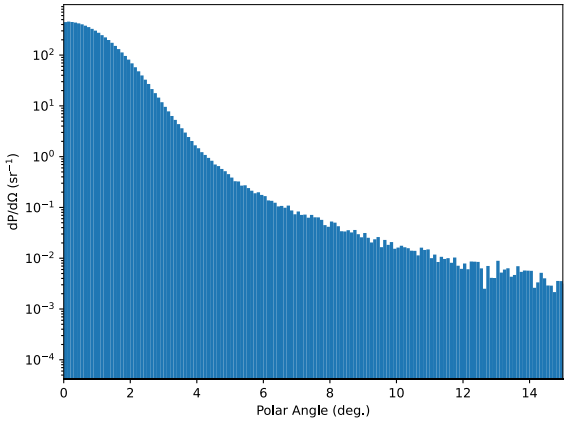
Code Maintenance

- Currently I am the primary “maintainer”
  - But not my day job, no time allocated to this
- I have done some updates to handle evolving Fortran support, fix bugs (new version posted soon)
- Send bug reports, I will try to fix them, and will make a best effort to answer questions. Feature requests will go in the queue…
- There is also an MPI version, ran on NERSC (needs a couple changes to get working again)
- I have a TODO list…

Benchmarking

- Time limits what I am able to get to
- Ran very first example (absorber, LiH, 171.55 MeV/c muons)
  - Default physics model
  - Can’t specify isotopic composition (TODO list…)
- Out of 10^6 particles, 71 decay, 13 going backward
- Default interactions, should compare other models (lots of combinations)





Final Thoughts

- ICOOL is a good code for cooling simulations, used heavily in MAP and earlier design studies
  - Can quickly get many cooling channel (and other beamline) simulations running
- I have limited time to maintain & improve it
  - I have a TODO list, feature suggestions welcome
  - Collaborators are of course welcome
- Doesn’t have a complete physics model behind it like Geant4
  - E.g., modeling of nuclear interactions incomplete (e.g., pion absorption)