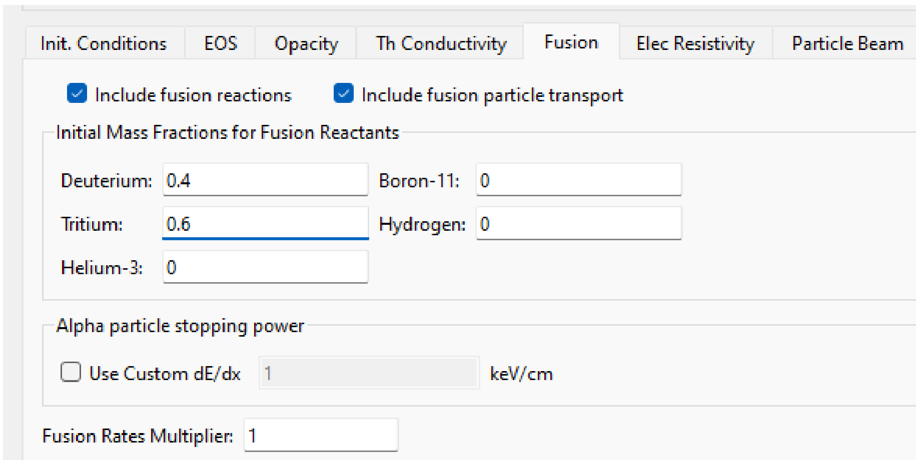
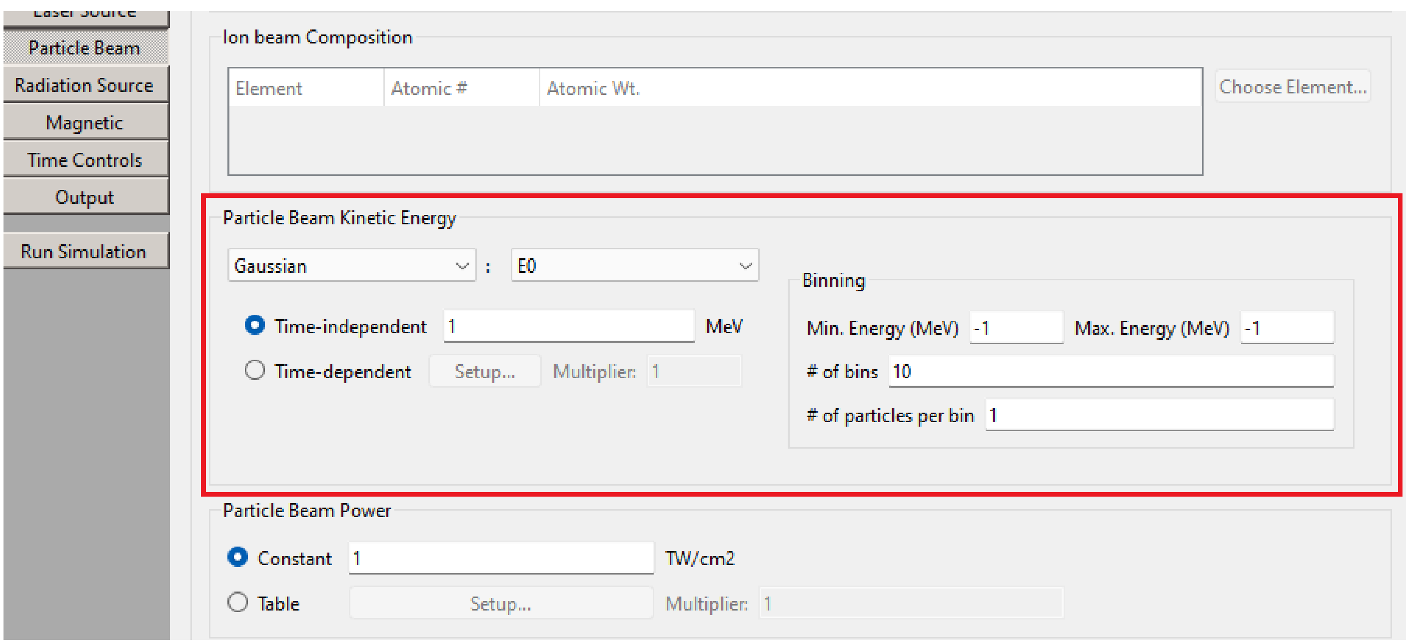
Revisions for HELIOS: 10.1.0

- Updates related to fusion burn physics:
  - Implemented algorithm for reducing the amount of available fusion fuel for burning plasma simulations.
  - Improved cross-sections for p+B11 reactions (based on Alessandro Tentori and Fabio Belloni 2023 Nucl. Fusion 63 086001).
  - Implemented scaling parameter for fusion rates.



- Multi-threaded implementation of particle transport.
- Improved algorithm for integrating particle trajectories within a zone and for computing deposited energy.
- Particle Beam kinetic energy (KE) can now be entered as a distribution, with multiple options for its input.



The distribution option (e.g. Gaussian) appears in the first combo-box. For each distribution option (except Tabulated), the distribution is defined by one or more parameters. The parameter being specified appears in the second combo-box. Each parameter can be either time-independent or time-dependent.

Normalization: the distributions only define the shape. When running the simulation, *Helios* will normalize the distributions such that the integral of the distribution, *between the Binning Min. and Max. Energy*, equals the Power at that time, which is defined in the Particle Beam Power section of the page. Note that the times do not need to match. Linear interpolation will be done in the case where time values do not match.

Additionally, if there are hydro times which are before the lowest input time, the value at the lowest input time will be used. Similar treatment will be done for hydro times beyond the highest input time.

Input options:

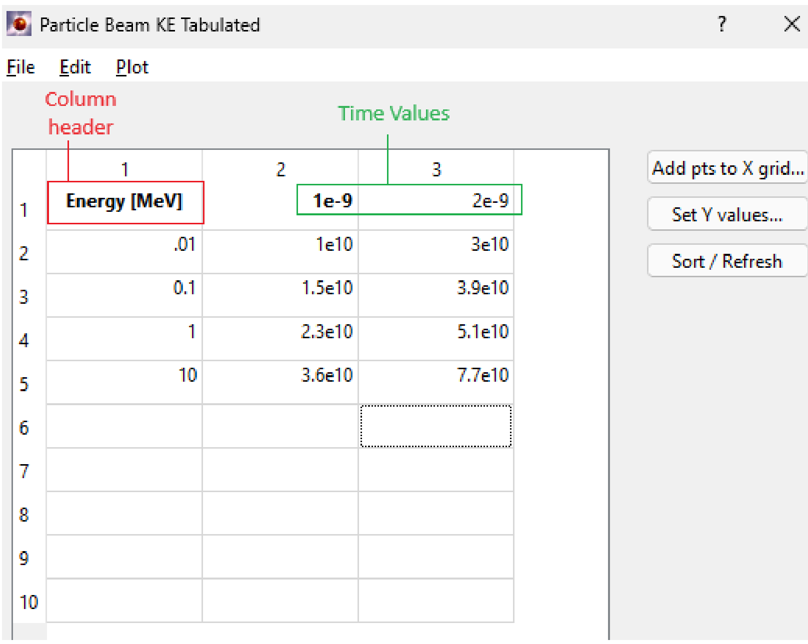
- *Mono-energetic:*

  All particles have the same KE, thus "Energy" is the only entry in the combo-box.

- *Tabulated:*

  This option uses a multi-column table for input for KE distributions. The first cell should not be edited--it is the title for the first column (energies). The remaining entries of the first row are time values (s). If your KE distribution is constant in time, you can leave this as having just one time column. Each remaining cell is then the dN/dE value for that energy and time. If the distribution is time-dependent, add an additional column (Edit > Add Column), and put its time value in the first cell of the column.

  Here is an example of a table of distributions for two times:



  The *Table File* option can be used by browsing for a text file with the following format. This would enter the same values as the table above:

  [table format=1]: Tabulated Particle beam KE:
  # table rows = 4
  # table cols = 3
  Energy [MeV]
  1.00000e-02 1.00000e-01 1.00000e+00 1.00000e+01
  1e-9
  1.00000e+10 1.50000e+10 2.30000e+10 3.60000e+10
  2e-9
  3.00000e+10 3.90000e+10 5.10000e+10 7.70000e+10

- *Maxwellian:*

  The distribution will be a Maxwell-Boltzmann given by temperature "T" in MeV, i.e. the mean KE will also be "T" in MeV. Thus "T" is the only entry in the combo-box.

- *Power Law:*

  The distribution will be *E*^-*k* where *E* is the KE, and *k* is dimensionless. Thus "k" is the only entry in the combo-box.

- *Gaussian:*

  The distribution will be Gaussian with central KE given by "E0" and standard deviation"sigma". The combo-box thus has an entry for both "E0" and "sigma".

Binning:

The min. and max. energies define the range of the distribution, and should thus likely be chosen to contain the significant part of the distribution . E.g., E0-5*sigma to E0+5*sigma for a Gaussian, or 0.1*T to 10*T for a Maxwellian. For Tabular input, the min.-max. should generally match the table range, unless only part of the table is desired. Outside this binning range, the beam power will be zero.

As noted above, the binning min. and max. energies also define the integration region for normalizing the energy distribution to the particle beam power.

The number of particles created per time step will be the number of bins times the number of particles per bin. It is recommended to use 25 - 100 total particles. The number of particles created with energy distributions will be a factor of n_bins*np_per_bin more than in the mono-energetic beam.

- Added functionality to control continuum lowering models for CR calculations (*Atomic Processes -> Advanced -> Dense plasma*) and to include dense plasma shifts. FAC CL option and dense plasma shifts require *.es atomic data files. The data will be distributed to all Helios-CR users.