Upcoming features in Ptarmigan

Tom Blackburn
Department of Physics, University of Gothenburg

24 March 2025
LUXE Simulation, Analysis and Software

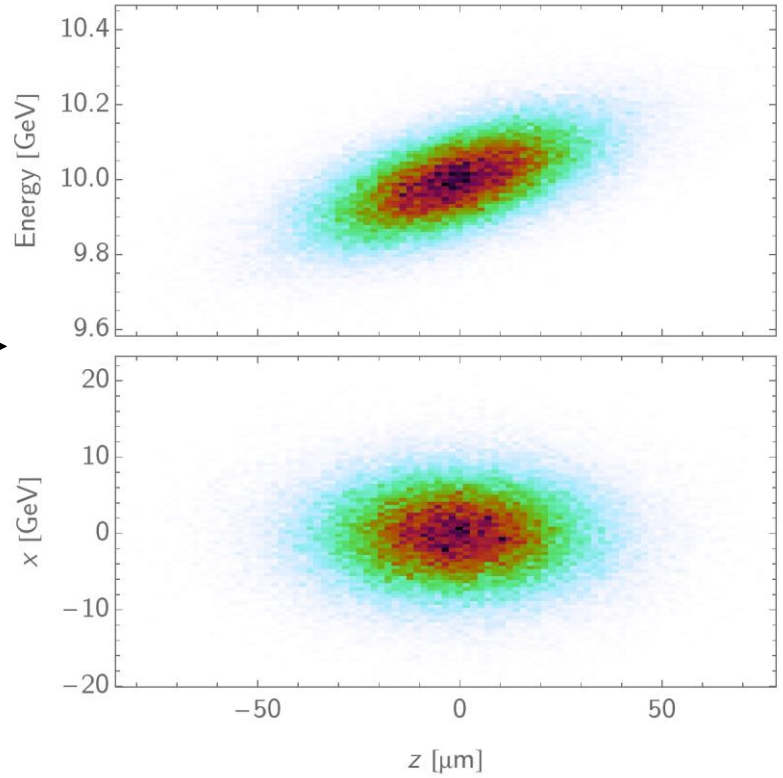
UNIVERSITY OF GOTHENBURG

Ptarmigan v1.5.0

Now: configuring a particle beam

```
beam:
  species: electron
  gamma: 10.0 * GeV / (m * c^2)
  sigma: 100.0 * MeV / (m * c^2)
  radius: 5.0 * micro
  length: 20.0 * micro
  energy_chirp: 0.6
```

→ PRNG sampling →



- As of v1.4.2 (latest), the incident particle can either be generated, assuming Gaussian momentum and spatial distributions, or loaded from an external HDF5 file with specified structure.

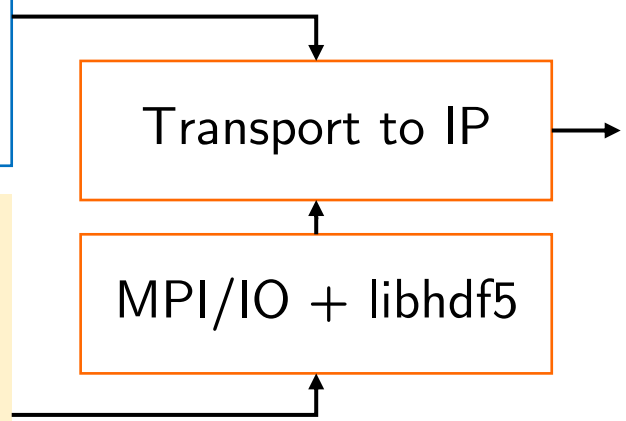
UNIVERSITY OF GOTHENBURG

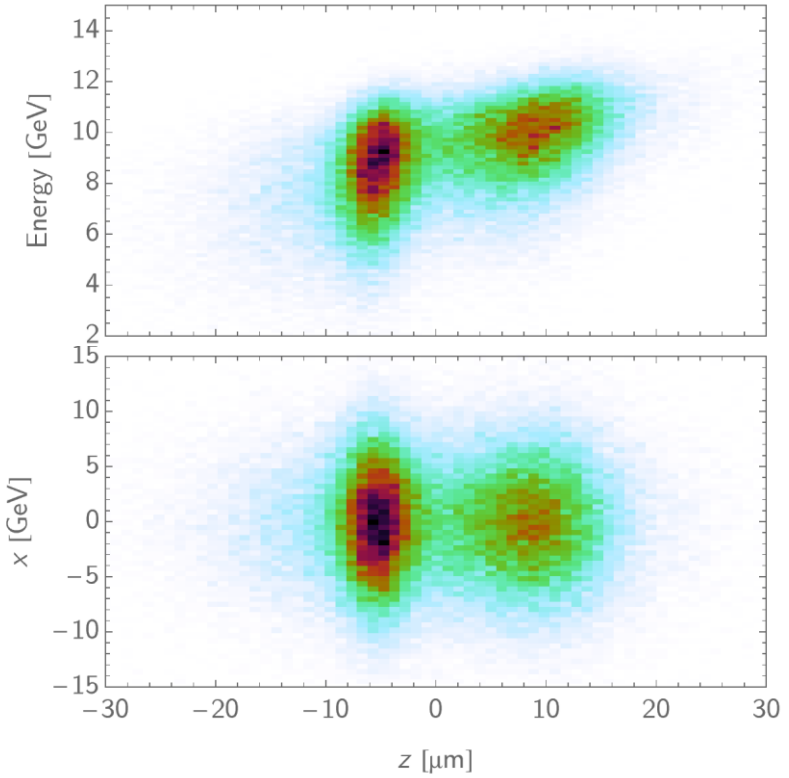
Ptarmigan v1.5.0

Now: configuring a particle beam

```
beam:
  species: electron
  from_hdf5:
    file: incident_beam.h5
    distance_bt_ips: 0.0 # ok
```

```
final-state/electron/momentum:
{{12.3, 0.3, 0.2, 12.2}, …}
final-state/electron/position:
{{0.0, 4.0, -0.6, 10.0}, …}
final-state/electron/weight:
{1.0e-5, …}
beam_axis: “+z”
config/unit/momentum: “GeV/c”
config/unit/position: “um”
```





- As of v1.4.2 (latest), the incident particle can either be generated, assuming Gaussian momentum and spatial distributions, or loaded from an external HDF5 with specified structure.

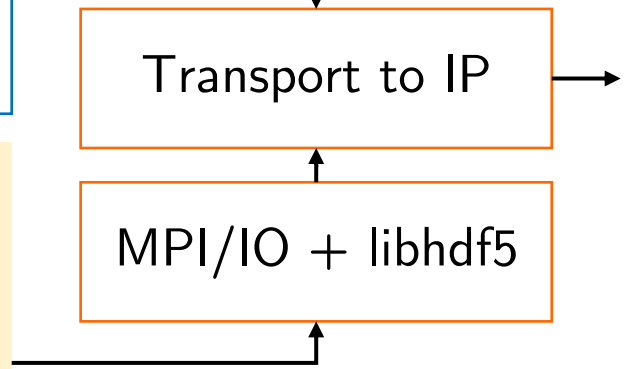
UNIVERSITY OF GOTHENBURG

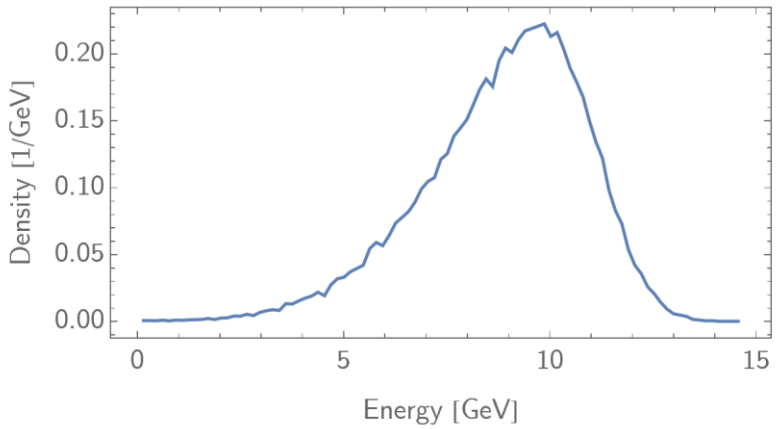
Ptarmigan v1.5.0

Now: configuring a particle beam

```
beam:
  species: electron
  from_hdf5:
    file: incident_beam.h5
    distance_bt_ips: 0.0 # ok
```

```
final-state/electron/momentum:
{{12.3, 0.3, 0.2, 12.2}, …}
final-state/electron/position:
{{0.0, 4.0, -0.6, 10.0}, …}
final-state/electron/weight:
{1.0e-5, …}
beam_axis: “+z”
config/unit/momentum: “GeV/c”
config/unit/position: “um”
```





- As of v1.4.2 (latest), the incident particle can either be generated, assuming Gaussian momentum and spatial distributions, or loaded from an external HDF5 with specified structure.

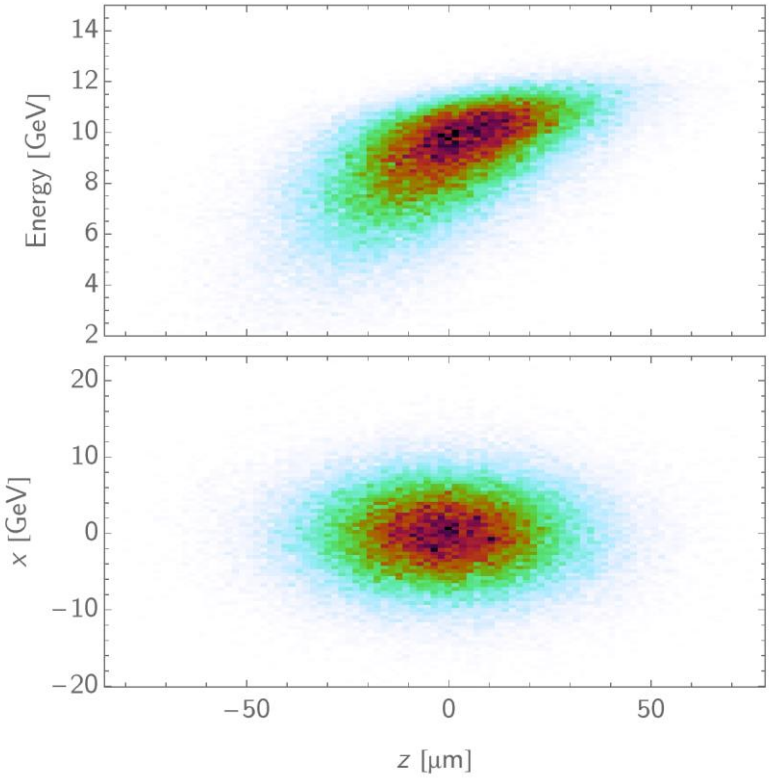
UNIVERSITY OF GOTHENBURG

Ptarmigan v1.5.0

New: custom energy spectra

```
beam:
  species: electron
  spectrum:
    function: >
      gauss(gamma, mu, sigma) *
      (1.0 + erf(
      alpha * (gamma - mu) / sigma
      ))
    min: 1.0 * GeV / (m * c^2)
    max: 15.0 * GeV / (m * c^2)
  radius: 5.0 * micro
  length: 20.0 * micro
  energy_chirp: 0.6
```

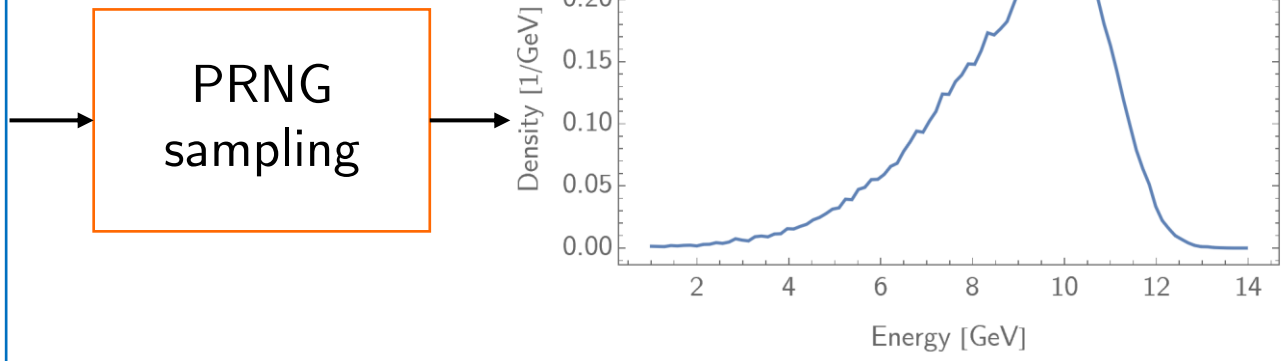
PRNG sampling



- Allow energy spectrum to be defined by a custom function…
- Argument must be “gamma”, other variables can be defined in the constants block.

New: custom energy spectra


```
beam:
  species: electron
  spectrum:
    function: >
      gauss(gamma, mu, sigma) *
      (1.0 + erf(
      alpha * (gamma - mu) / sigma
      ))
    min: 1.0 * GeV / (m * c^2)
    max: 15.0 * GeV / (m * c^2)
  radius: 5.0 * micro
  length: 20.0 * micro
  energy_chirp: 0.6
```



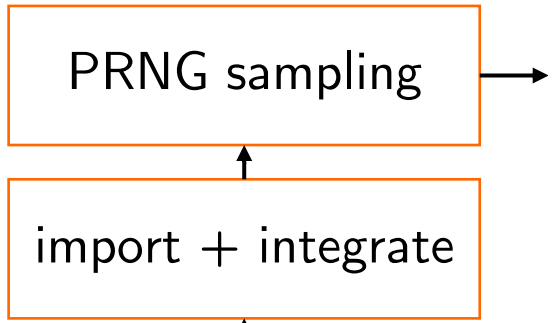
- Allow energy spectrum to be defined by a custom function…
- Argument must be “gamma”, other variables can be defined in the constants block.

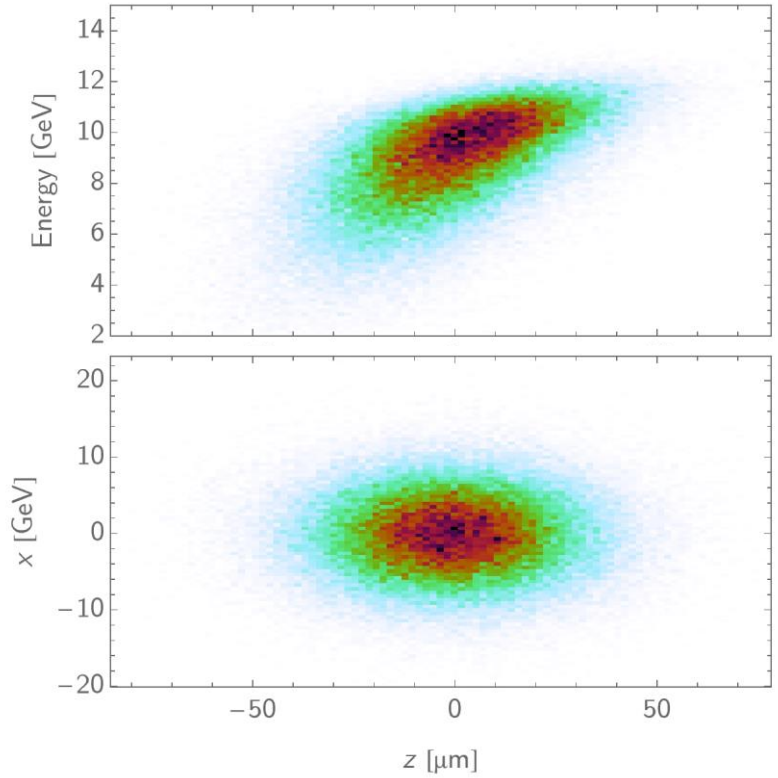
Ptarmigan v1.5.0

New: custom energy spectra

```
beam:
  species: electron
  spectrum:
    file: custom_spectrum.dat
    min: 1.0 * GeV / (m * c^2)
    # either
    max: 15.0 * GeV / (m * c^2)
    # or
    step: 0.1 * GeV / (m * c^2)
```

```
...
0.150472
0.155788
0.161096
...
```



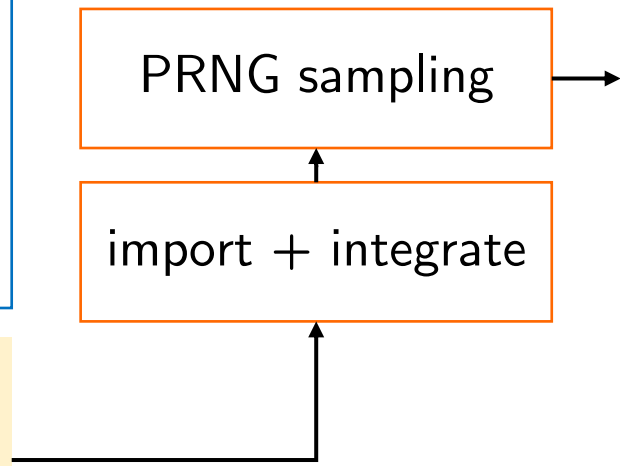


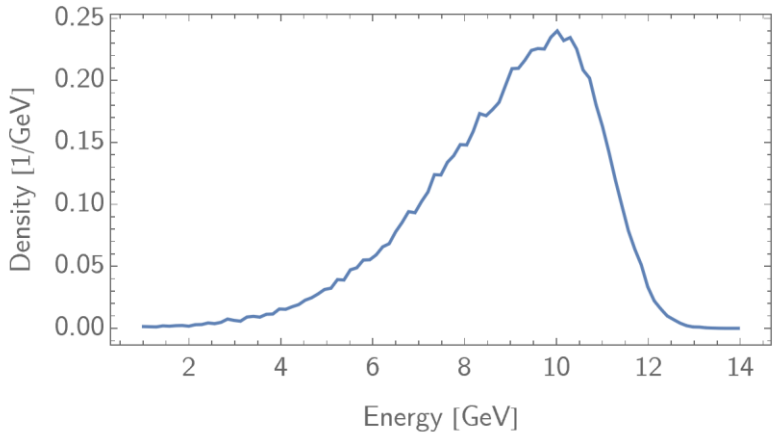
- Allow energy spectrum to be defined by a custom function or imported from a file.
- Plain-text, evenly spaced points, normalisation not required.

New: custom energy spectra


```
beam:
  species: electron
  spectrum:
    file: custom_spectrum.dat
    min: 1.0 * GeV / (m * c^2)
    # either
    max: 15.0 * GeV / (m * c^2)
    # or
    step: 0.1 * GeV / (m * c^2)
```

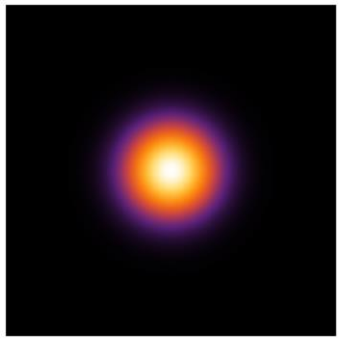
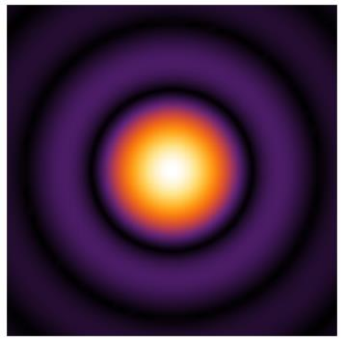
```
...
0.150472
0.155788
0.161096
...
```





- Allow energy spectrum to be defined by a custom function or imported from a file.
- Plain-text, evenly spaced points, normalisation not required.

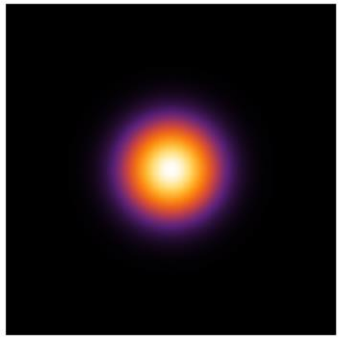
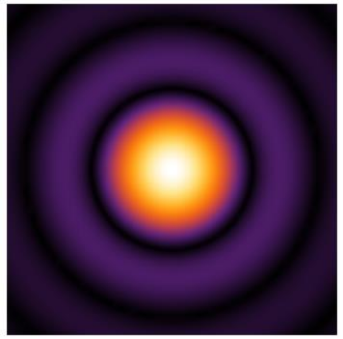
Next: laser transverse profiles

	Gaussian	Airy
Waist	$2\,\mathrm{f}\,\lambda\,/\,\pi$	$2.584\,\mathrm{f}\,\lambda\,/\,\pi$
Peak intensity	$\pi P_0\,/(2\,\mathrm{f}^2\lambda^2)$	$\pi P_0\,/(4\,\mathrm{f}^2\lambda^2)$*
Profile		

*As in the CDR

- Currently Ptarmigan assumes focused laser pulses have Gaussian spatial structure.
- More realistic treatment of focusing increases waist (radius at which intensity is $1/e^2$ of its central value) and decreases peak intensity at fixed f-number and power P_0.
- Easiest approach: fix waist and peak intensity to match measured profile.

Next: laser transverse profiles

	Gaussian	Airy
Waist	$2\,\mathrm{f}\,\lambda\,/\,\pi$	$2.584\,\mathrm{f}\,\lambda\,/\,\pi$
Peak intensity	$\pi P_0\,/(2\,\mathrm{f}^2\lambda^2)$	$\pi P_0\,/(4\,\mathrm{f}^2\lambda^2)$*
Profile		

*As in the CDR

- Ambition is to include a simplified model for focusing of a beam with a flat-top profile in the far field (i.e. an Airy disk in the focal plane).
- ... and then represent an arbitrary profile in the focal plane as a linear combination of Hermite/Laguerre-Gauss modes.

UNIVERSITY OF GOTHENBURG

Ptarmigan v1.5.0
Overview

- More customisation options for the incident particle beam: choose your own energy spectrum using either a function or a data file.
- "Restart" simulations:

```
beam:
  species: electron
  from_hdf5:
    file: previous_output.h5
    auto_timing: false
    distance_bt_ips: 0.0
```

- Available on development branch:
  - `> git fetch --tags`
  - `> git checkout v1.5.0-alpha`
  - Recompile
- Next: custom laser profiles.