Beam Selections Tools
Coming Soon To MAUS

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Contents

1. Beam Selection Routines

   Basic Algorithm

   What's Been Tested

2. Implementation In MAUS

   New Classes/Functions

   Configuration and Use

3. Further Developments

4. Conclusions

Accept-Reject Method

1. Construct the parent distribution

   This is vital. In order to select the correct fraction from each bin, the total number of events per bin must be calculated.

2. Calculate the daughter distribution

   A probability distribution, normalised to the pre-calculated parent distribution is required such that the algorithm is as efficient as possible.

3. Iterate through all events individually and calculate:
   - The probability of finding that event in the parent distribution $p(\mathrm{parent})$
   - The probability of finding that event in the daughter distribution $p(\mathrm{daughter})$
   - A random, uniformily distributed variable u

4. If $p(\mathrm{daughter})/p(\mathrm{parent}) \leq u$ the event is accepted.

Accept-Reject Method

Notes:

- Selections can be performed in parallel. Each criteria is simply *AND*ed with the others.

- However, selections are best performed in series, not parallel. One selection criteria can quite easily change the parent distribution which would not be correctly modelled.

- This can therefore be quite time consuming involving multiple analyses: e.g. Parent calculations, momentum selection and finally beam selection.

- The selections can be difficult to tune. The leading difficulty is correctly normalising the daughter distribution to the parent distribution.

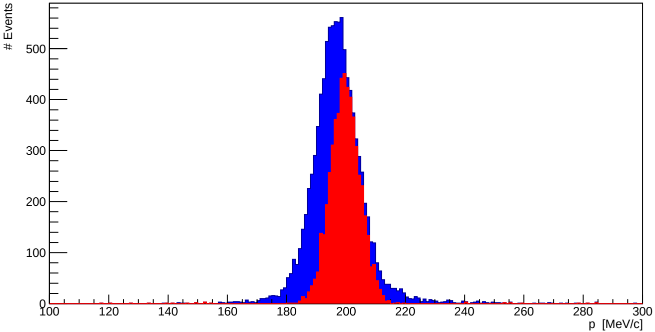
Current Developments

So far I have tested and/or have experience with:

- Analtical Routines
- Square window momentum selection
- Gaussian Momentum Selection ← Implemented in MAUS
- 2D x-y beam selection using histograms
- 2D x-p_x and y-p_y beam selections using histograms
- 4D x,p_x,y,p_y beam selection using 2D projections
- 1D Single Particle Amplitude Selection ← Implemented in MAUS

Current Developments
Momentum Selection Example

Start a beam at TOF1, 200MeV/c.
Select a beam with 200MeV/c, Gaussian distribution at the upstream reference plane.



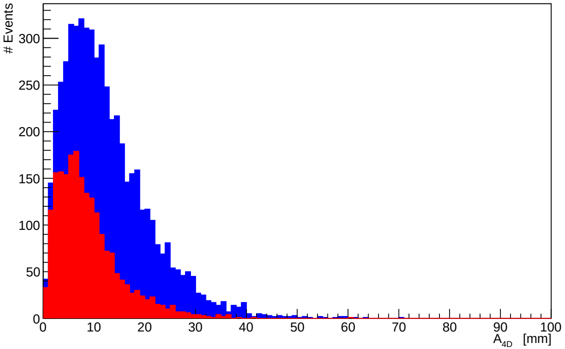
This will be availble in the next version of MAUS.

Current Developments

Single Particle Amplitude Example

Start a beam at TOF1, 3 mm transverse emittance.

Select a beam with 2mm transverse emittance, at the upstream reference plane.



This will be availble in the next version of MAUS.

Changes to MAUS

In the next minor release of MAUS several new classes and components will be added:

- ReduceCppEmittanceReconstruction

  A reducer that can simply be turned on and will automatically reconstruct the phase-space distributions at any selection of tracker planes.

- MapCppBeamSelection

  The Mapper that uses Misha's Cut storage and management framework to apply `cut_beamSelection` to selected events.

- src/common_cpp/BeamSelection/

  A new directory that contains a `Selector_base` class and two derived selection classes: `GaussianMomentum` and `IdealTransverseAmplitude`.

Changes to MAUS

Continued. . .

- src/common_cpp/Maths/ProbabilityDensityFunctions/

  Purely for convenience. There is a class for fast calculations of ideal Gaussian and Chi-Squared distributions.

- Recon/Emittance/

  The power behind the mapper. One class for inline calculation of covariance matrices and one for creating plots of phase-space distributions.

Unfortunately documentation is still to follow. . .

Configuration and Use

Simply include the ReduceCppEmittanceReonstruction reducer and two files named :

- `EmittanceReconstruction.-1.root` and
- `EmittanceReconstruction.1.root` will be created.

ID `-1` refers to the upstream tracker reference plane and `1` the downstream tracker reference plane.

These include the calculated phase-space distributions, in addition to the 4D covariance `TMatrixD` and a vector of scalar values (mean p, emittance, alpha, beta, etc).

Configuration and Use

Advanced configuration is possible and indeed encouraged! For example:

Provide parent distributions to the emittance reconstruction

```
EmittanceReconstruction_FileName = "test_helicals_amplitude_selected_recon"
EmittanceReconstruction_ReconstructionPlanes = [ -1, 1 ]
EmittanceReconstruction_ParentFileNames=[\
  { "plane" : -1, "filename" : "test_helicals_selected_recon.-1.root") },\
  { "plane" :  1, "filename" : "test_helicals_selected_recon.1.root") }
]
```

Perform a transverse amplitude selection,

```
BeamSelection_Configuration = [ \
{
  "parent_file" : "test_helicals_selected_recon.-1.root"),
  "routine" : "transverse_amplitude",
  "plane" : -1,
  "emittance" : 2.0
} ]
```

My To-Do List

1. Remove all my debugging statements, exessive checks and asserts.
2. Make some components more robust against incorrect inputs or unusual situations.
3. Documentation. . .
4. Offline reconstruction requirements
5. Additional selection routines (Ideas?)
6. Routine optimisation to ensure high efficiency
7. Finish tying the system into the global data structure.

Conclusions

- A lot of new features have been added - so expect a “burning-in” period.
  And please let me know if there are any bugs or errors, or if it doesn’t do what you expect.
- I suggest that the reference plane emittance calculations are turned on by default - maybe even in OnRec!
  Still need to benchmark the performance to ensure that it’s viable.
- I will produce 1-2 scripts for OffRec, so that the basic beam selection routines can be performed as standard.
  This will probably work in parallel with the developments from Misha for the creation of optimal datasets as standard.
- Requests and questions are welcome. There are more selection routines to consider, and optimisations in terms of efficiency.
  Efficiency is still a weak area.