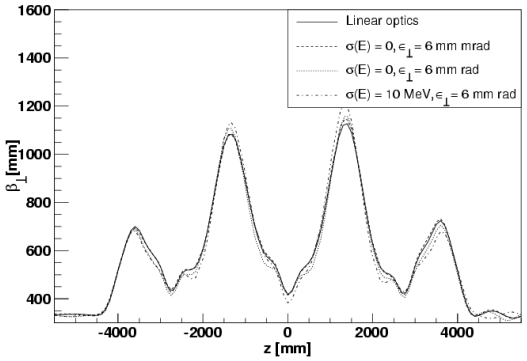
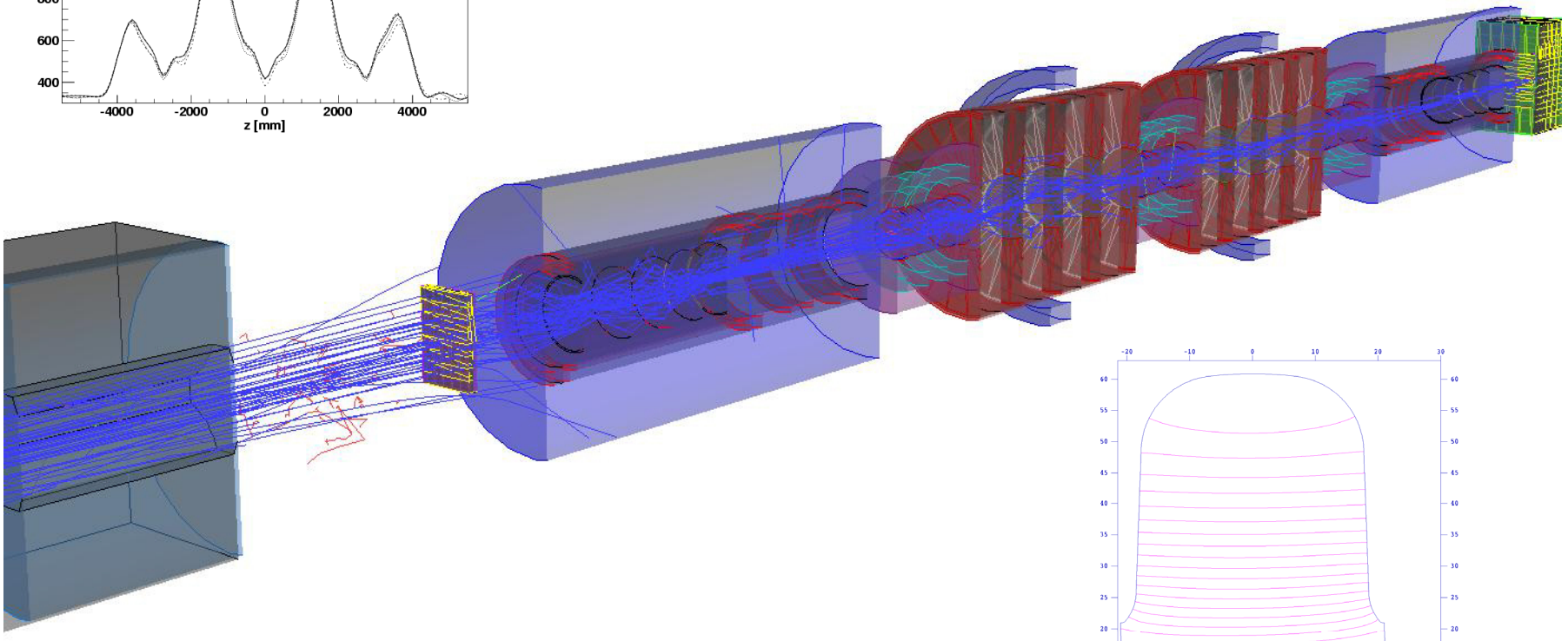
MICE Analysis





Outline

- This talk will attempt to present a taste of two overlapping working groups in MICE:
- Software Group (G4MICE)
  - Simulation of the experiment.
  - Optics tools.
  - Recent progress
  - Current focus
- Analysis Group
  - Optics studies
  - Emittance and Cooling
  - PID Performance
  - PID and Single Particle Emittance
- Conclusions

G4MICE

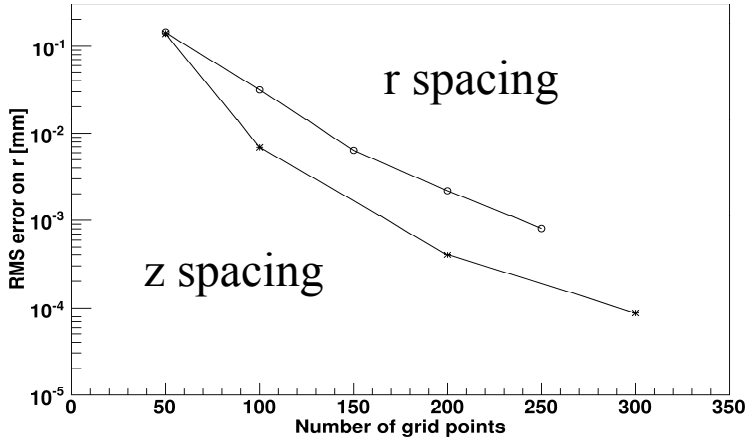
- GEANT4 based simulation of the MICE experiment and beamline.
- Includes reconstruction and analysis tools.
- The last year has been spent going over the existing code and (where possible) implementing the changes foreseen several years ago as part of a design iteration.
- Soon to launch high statistics simulations of a number of configurations and beams as part of a "Data Challenge".
- Overall progress continues to be limited by small amount of skilled mouse-power available for work on the software (also true in Analysis group).

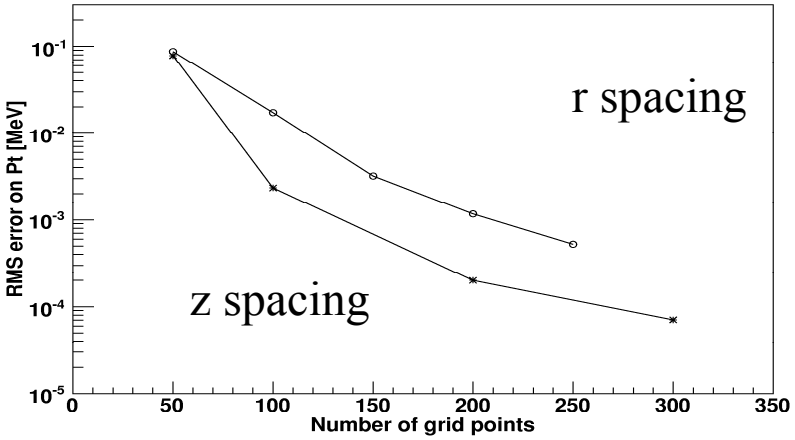
Simulation of MICE

- Simulation includes all beamline elements from the dipole downstream of the decay solenoid as well as the detectors and cooling channel elements.
- Magnetic fields are calculated from solenoid currents.
- Currently unable to calculate effect of iron shields in G4MICE (limited by available developers) so field maps for these are imported from results calculated elsewhere.
- RF cavities are simulated with time varying EM fields.
- Results from SuperFish are imported into G4MICE.
- Thin windows are modeled using the "Polycone" shape in GEANT4.
- New modeling scheme allows the effects of alignments (e.g. tracker inside solenoid, misplaced quadrupole, etc) to be studied.
- Model of X-ray production by RF cavities from lab G will be upgraded once results from the MTA are available.

Optics Tools

- Lot of work on testing the accuracy of tracking in G4MICE to validate its performance.
- GRID spacing in determination of field from thin current sheets can be set to produce desired precision:





- RF tracking accuracy has been similarly checked.
- Working on more control over physics processes to allow a more sophisticated method for setting RF phase from a reference particle.

Recent Progress

- Applications: Added many new applications as part of ongoing analyses (e.g. KEK and Frascati test beams) as well as tools (e.g. matched beams or histogram/NTuple production).
- Tests: Major focus at the moment is the preparation of sufficient tests to cover all aspects of the simulation, digitisation and reconstruction.
- Documentation: Less progress here due to available effort.
- Calorimeter reconstruction using neural network becoming quite advanced.
- First version of the CKOV model is now ready.
- Tools to perform VLPC cassette characterisation and calibration (work in progress).
- Embedded code to keep track of memory usage and tests to detect leaks.

Current Focus

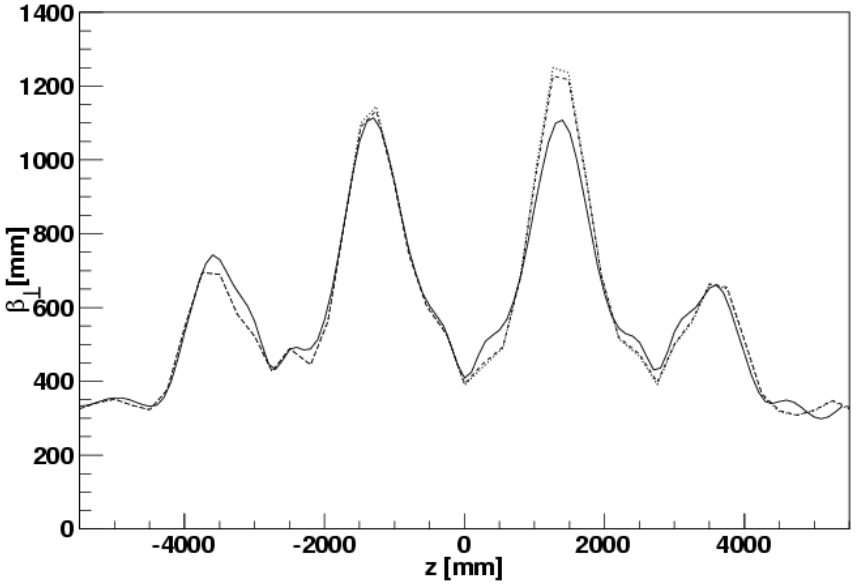
- First priority – tests
  - Unit Test coverage is growing rapidly and as expected are finding issues that are being fixed as quickly as mouse-power allows.
  - Currently working on tests of the performance of the SciFi tracker reconstruction performance.
  - Will move to TOF, Calorimeter and global matching/PID once tracking is validated.
  - Upgrading existing tests to keep track of performance of external packages, in particular GEANT4.
- Second priority – documentation
  - Slowly upgrading web documentation, still very limited.
  - A few volunteers have tried the installation process from a tar ball that is now available for Linux, Cygwin on Windows and Mac OSX.
- Short term goal – Data Challenge
  - Aim to have run non trivial jobs and used output for useful MICE analysis by next collaboration meeting (end of February).

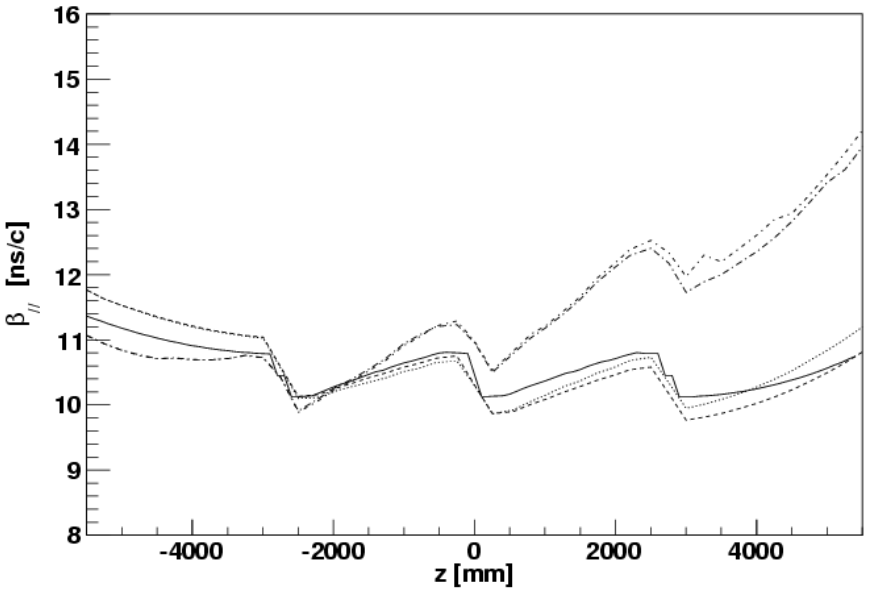
Analysis Group

- Small group (same problem as software tools) with a lot of ongoing tasks:
  - Run plan (understand timescales for changes)
  - TOF measurement and relation to the trigger (& RF phase)
  - Effects of collimation and scraping in the beamline
  - Downstream geometry (sizes of PID detectors and shields)
  - RF induced background in the TOF
  - Beam envelope interference with the spectrometer cryostat
  - Effect of variations in window shape, absorber density, etc
  - Performance indicators (transmission, emittance, phase space density, etc...)
  - Understand longitudinal phase space better
  - RF phasing in G4MICE
  - ...

Optics

- Some Hamiltonian mechanics (transfer matrices).
- Updated optics code (beta function calculation).
- Need to understand longitudinal phase space
- Optimise phasing?





Emittance

- Already demonstrated calculation of emittance from a virtual bunch (tracker validation, reconstructed cooling curve matched simulated after correction).
- Single particle measurement in MICE, so can measure amplitudes of individual muons

- $A = \gamma x2 + 2\,\alpha xx' + \beta x'2$

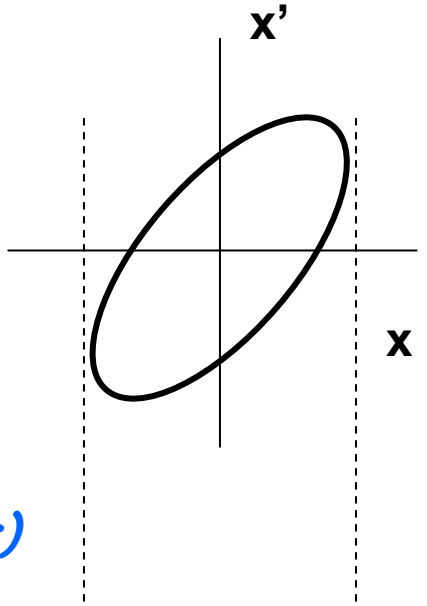
  α, β, γ are *optical (Twiss) parameters*

- At *focus* or in *uniform field:*

  $A = x^2/\beta + \beta x'^2$

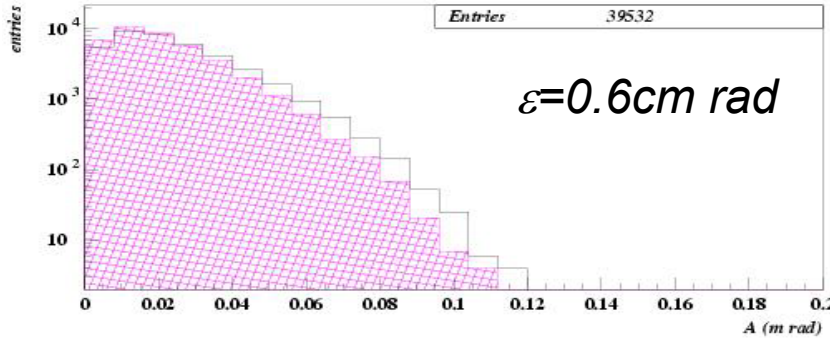
  $An = (p/mc)\,A = p\,x^2/(\beta\,mc) + pt^2\,\beta/(p\,mc)$

  $\beta = p / (150\ [MeV]\ B\ [T])$ in uniform field

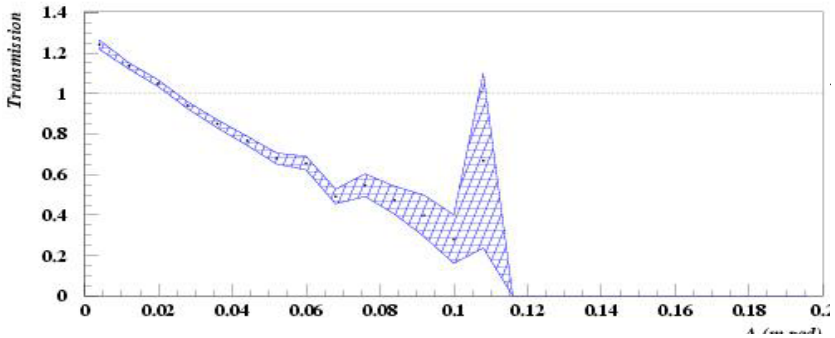


$x_{max} = \mathrm{sqrt}\,(\beta A)$

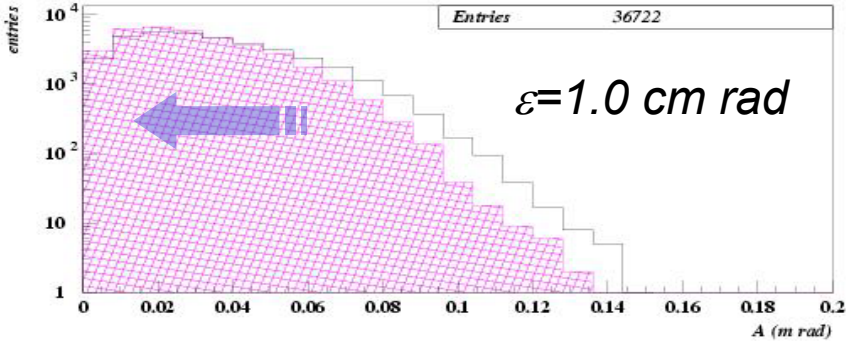
Cooling



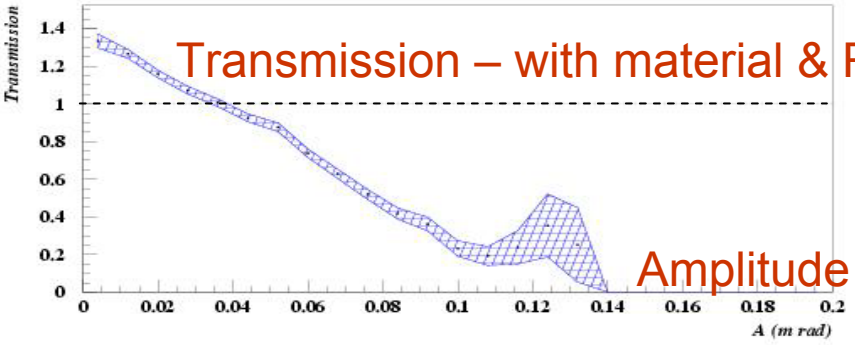
ε=0.6cm rad



P_Z=200 MeV/c, β_{abs}=42 cm



ε=1.0 cm rad



Transmission – with material & RF

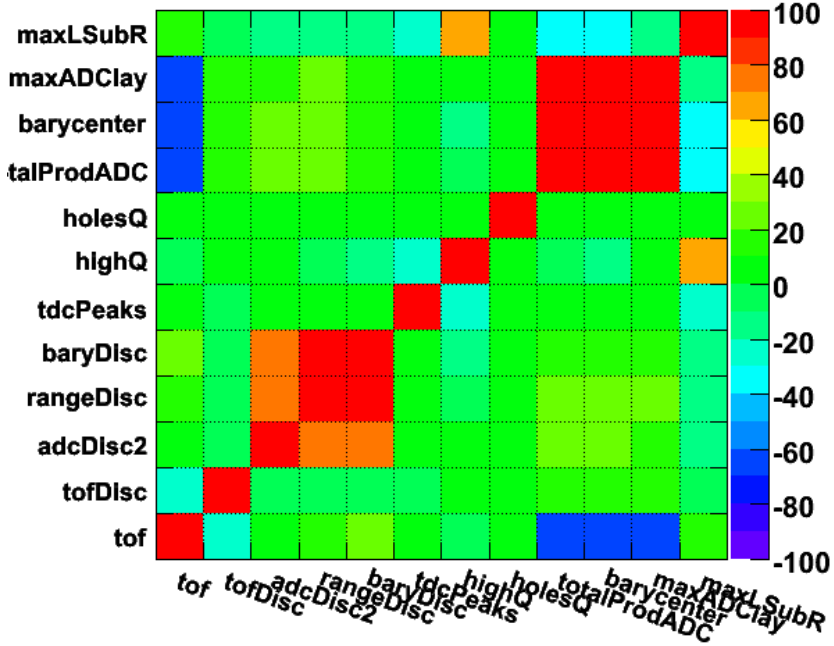
Amplitude

Can see cooling as ***increase in central phase space density*** by using amplitude

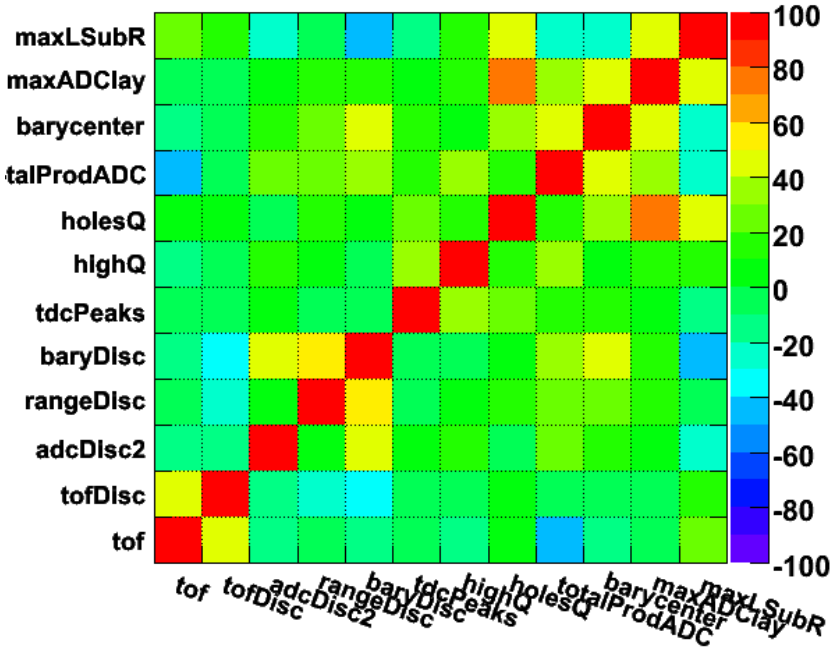
MICE can measure Amplitude

PID Performance

Correlation Matrix (signal)



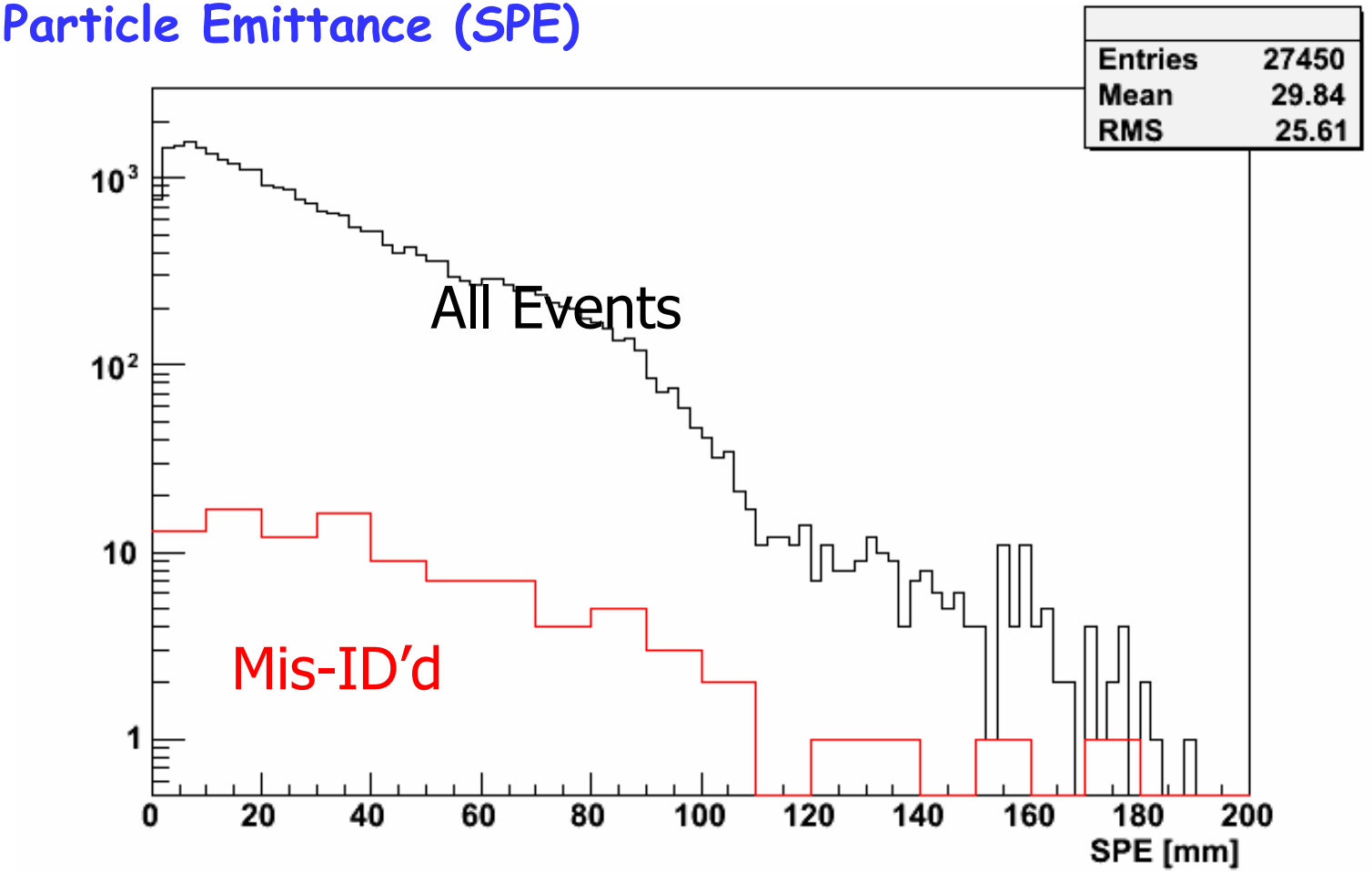
Correlation Matrix (background)



- ANN method (TMIpANN) chosen as best performing of three studied.
- Studied purity of particle ID, require 99.93% as a safety margin to avoid mis ID having a strong bias on the reconstructed emittance.

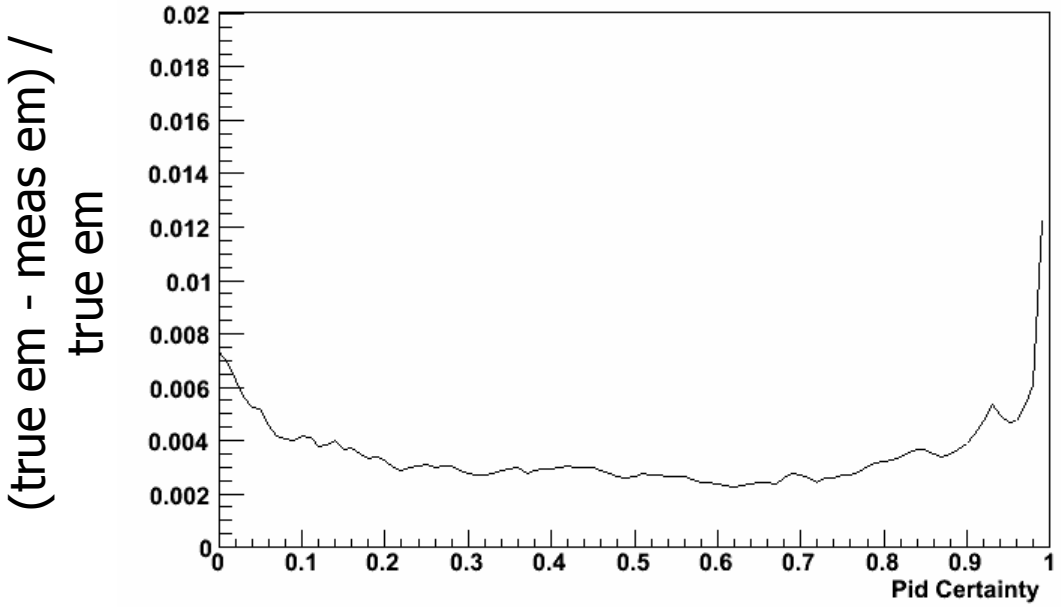
PID and SPE

- Discard events with PID certainty < 0.5 and look at Single Particle Emittance (SPE)



Emittance vs PID cut

- Fractional offset of emittance as a function of PID cut.
  - ~30k events
  - ~100 mis-identified events (depends on cut value)
- Not getting < 0.001
  - This is absolute emittance, not delta emittance



Conclusions

- Slow but steady progress on Software Tools and Analysis side.
- Data Challenge will push forward testing and debugging of software tools by developers and exploitation by analysis group.
- Still limited by small number of workers.
- Lots of important issues still need to be addressed before first beam later on this year!