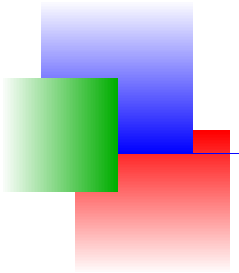
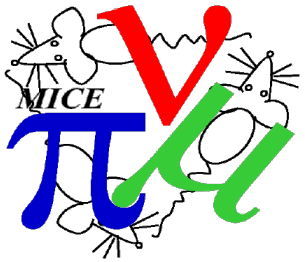


High level analysis



Chris Rogers

MICE CM 20

11-02-08

Off-line and on-line analysis

- Deadlines
  - Would like to be ready for beamline work
  - Would like to be ready before ~June (tracker?)
- Off-line analysis
  - Remaining questions
    - Detector error/Higher moments
    - Statistical error
    - Amplitude (not dealt with here)
- On-line analysis
  - What is needed?
  - Current system

Off-line analysis

- Before we can calculate emittance with an error, need to resolve a few issues
  - Detector error
    - We have an algorithm to do this, but need to understand how to tie this in with the detector calibration
    - We will wish to quote error bounds on momentum-amplitude covariance (3rd moment) and we don't know how to do this
  - Statistical error
    - This is mostly an open question
    - Some subtlety (cf JHC talk)
    - Is there an algorithm to use experimental data to calculate this error?
  - Amplitude
    - We don't know what the errors on amplitude will look like
  - More questions than answers
- I would like to answer these questions by June

Detector error

- We are measuring a distribution width
  - IF detector measurement error is independent of value measured then errors add in quadrature
    - $Var(u_i, u_j) = Var(x_i, x_j) + Var(dx_i, dx_j)$
    - For Var() = covariance
    - Measured position *u*; true position *x*; measurement error *dx*
    - Subscript distinguishes different variables e.g. (x,y,t,px,py,E)
  - In reality error in measured variable is correlated to the true variable and we need something more complicated
    - $Var(u_i, u_j) = Var(x_i, x_j) + Var(dx_i, dx_j) + Var(x_i, dx_j) + {}_{Var}(dx_i, x_j)$
  - This has been checked in monte carlo and shown to be correct
    - cf note from ages ago

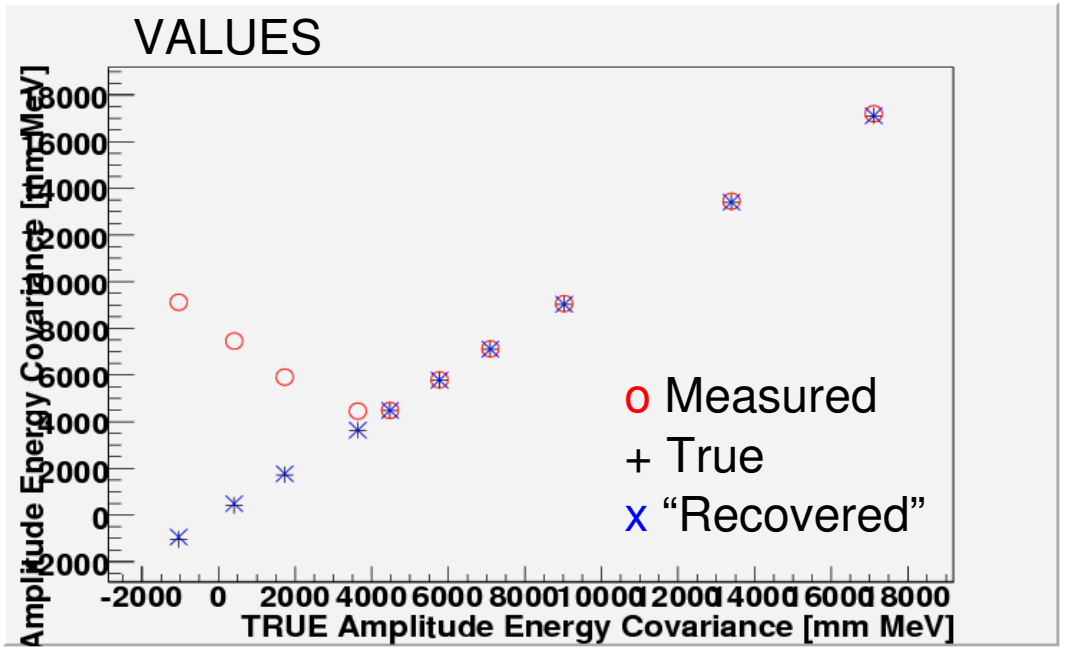
Detector error (3rd moments)

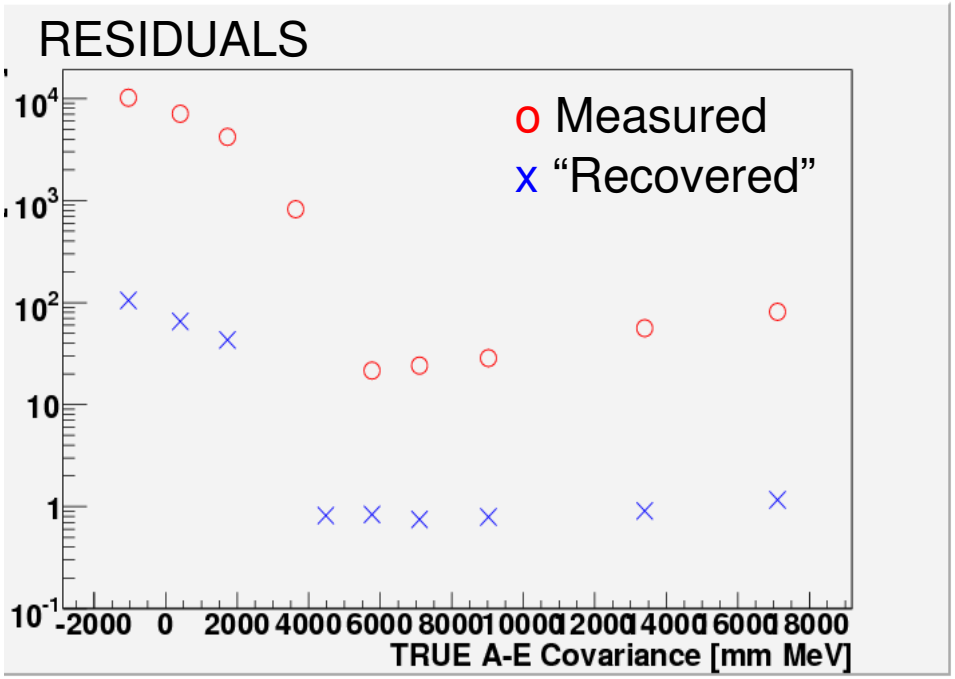
- What does this look like for higher moments?
  - In particular: amplitude-momentum correlation
    - A function of 3rd moments
    - I think error in 3rd moments looks like this:

$$\langle u_i u_j u_k \rangle = \langle x_i x_j x_k \rangle + \langle dx_i x_j x_k \rangle + \langle x_i dx_j x_k \rangle + \langle x_i x_j dx_k \rangle + \langle x_i dx_j dx_k \rangle + \langle dx_i x_j dx_k \rangle + \langle dx_i dx_j x_k \rangle + \langle dx_i dx_j dx_k \rangle .$$

    - Would like to confirm/reject with monte carlo
  - What about other 3rd moments/4th moments?
    - These can be used to understand optical beam heating and so are important

Toy detector





- Use a toy detector for study
  - Insert by hand correlations fitted from monte carlo tracker in the Tracker MICE-note
  - I include the correlation of pz resolution with pt and so on
- There is a very strong systematic effect due to detector
- This can be removed using the formula on the previous slide

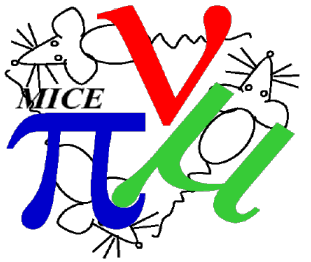
Extracting from data

- How do we get this information from the real MICE data?
  - Calibration in step 2/3
  - But things like <x dx> are beam-dependent
  - We may be able to extract the information nevertheless
- Recpack gives estimate of error covariance matrix for each phase space position measurement
  - Using knowledge of multiple scattering and position resolution
  - Evolved through detector field using linear mapping
  - Then second moment errors look like

$$\langle dx_i dx_j \rangle = \Sigma_{all\ tracks}(dx_i dx_j)$$
$$\langle dx_i x_j \rangle = \Sigma_{all\ tracks}(\sqrt{dx_i dx_i}\, x_j)$$

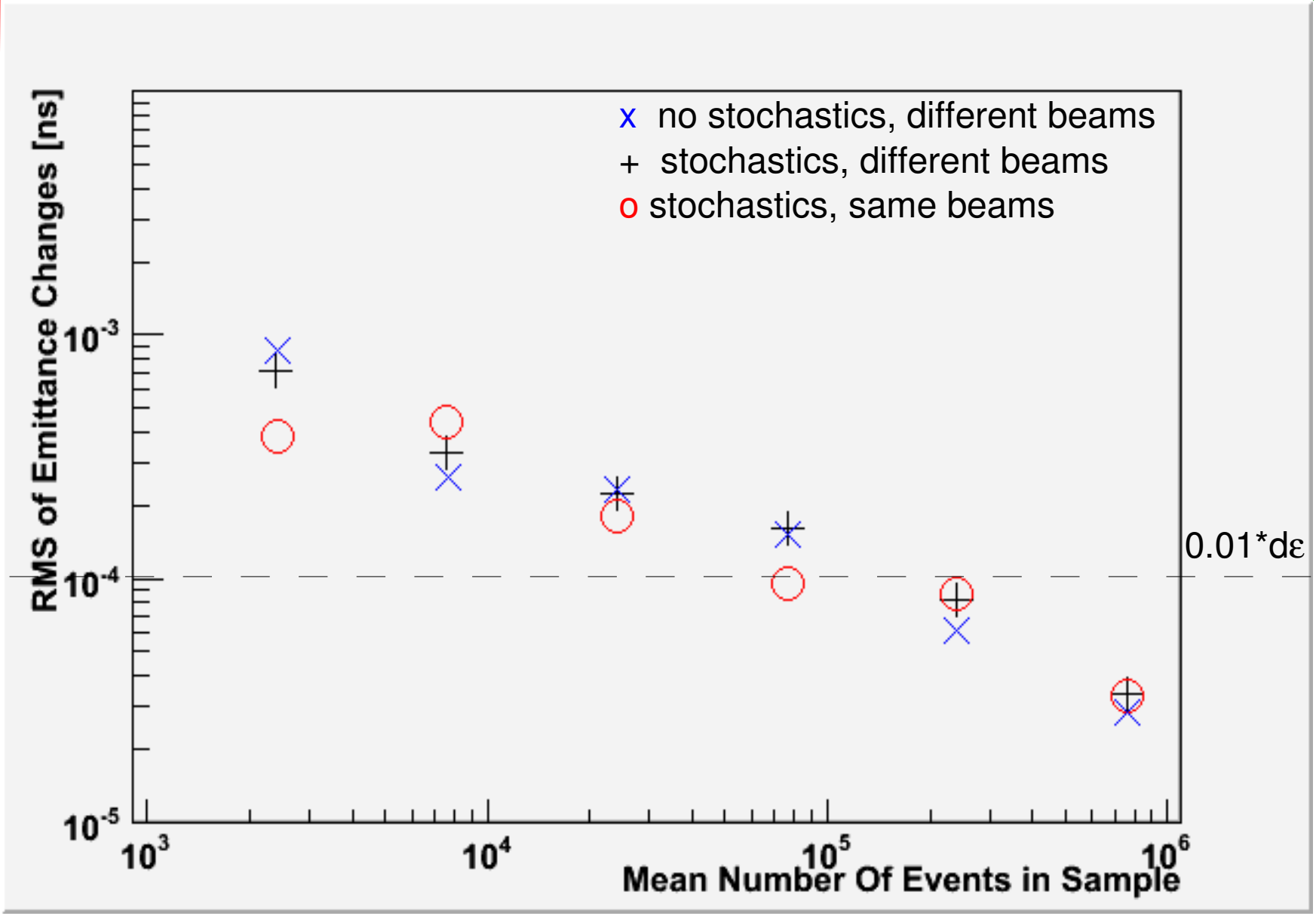
  - This should be in the calibration
- How to do 3rd moments? Can RecPack do this?

Statistical Error

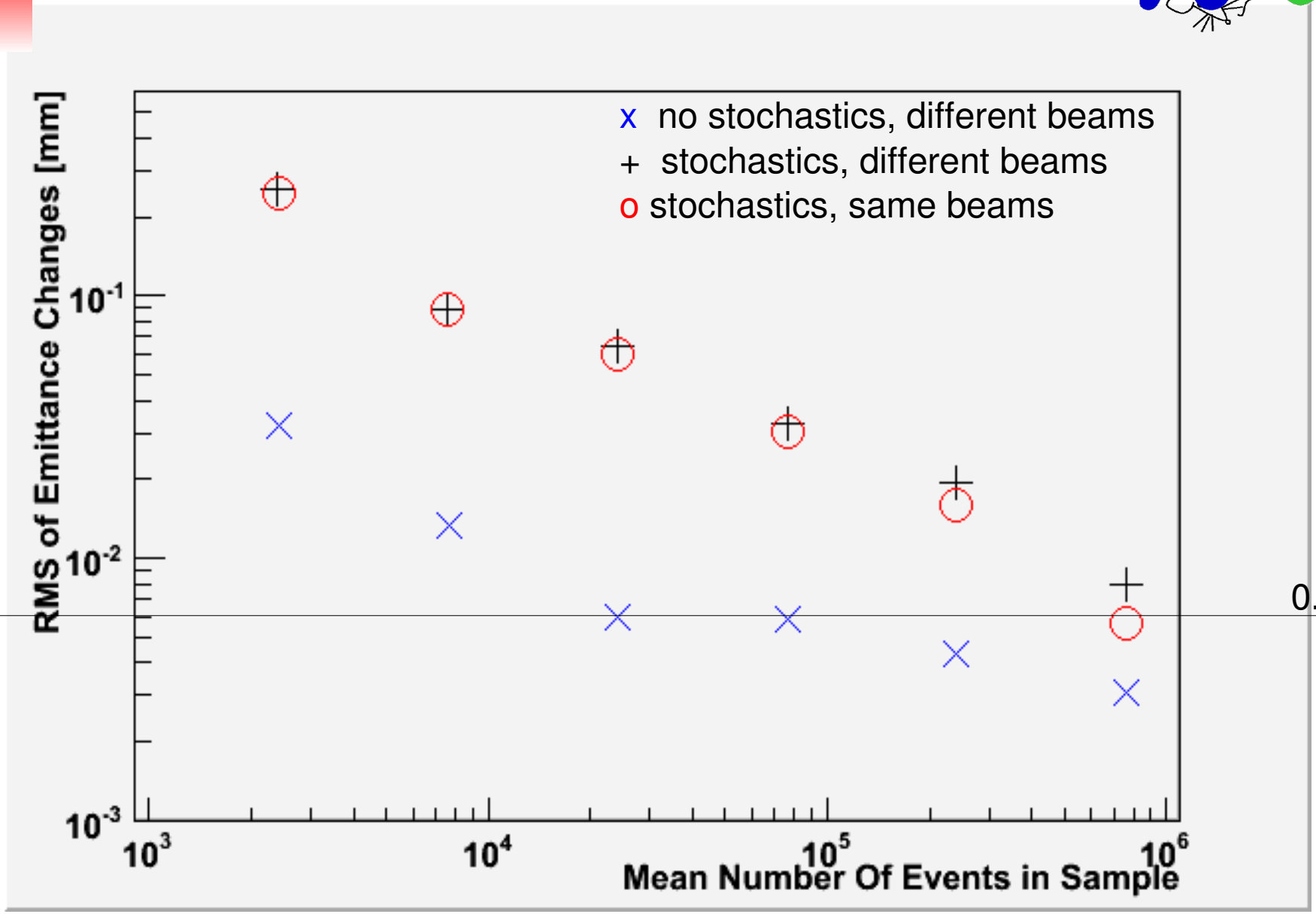


- What is the statistical error in MICE?
  - Two answers
- When we run MICE we are sampling a parent distribution (the input beam)
  - We can seek to measure the statistical error on the cooling of the parent distribution
  - We can seek to measure the statistical error on the cooling of the sample
- Get two different statistical errors
- Track beams through G4MICE Step VI in three cases
  - Track the same input beam 10 times with different random seed
  - Track different samples of the same input parent distribution 10 times with different random seed
  - Track different samples of the same input parent distribution 10 times with no stochastic processes

Statistical Error

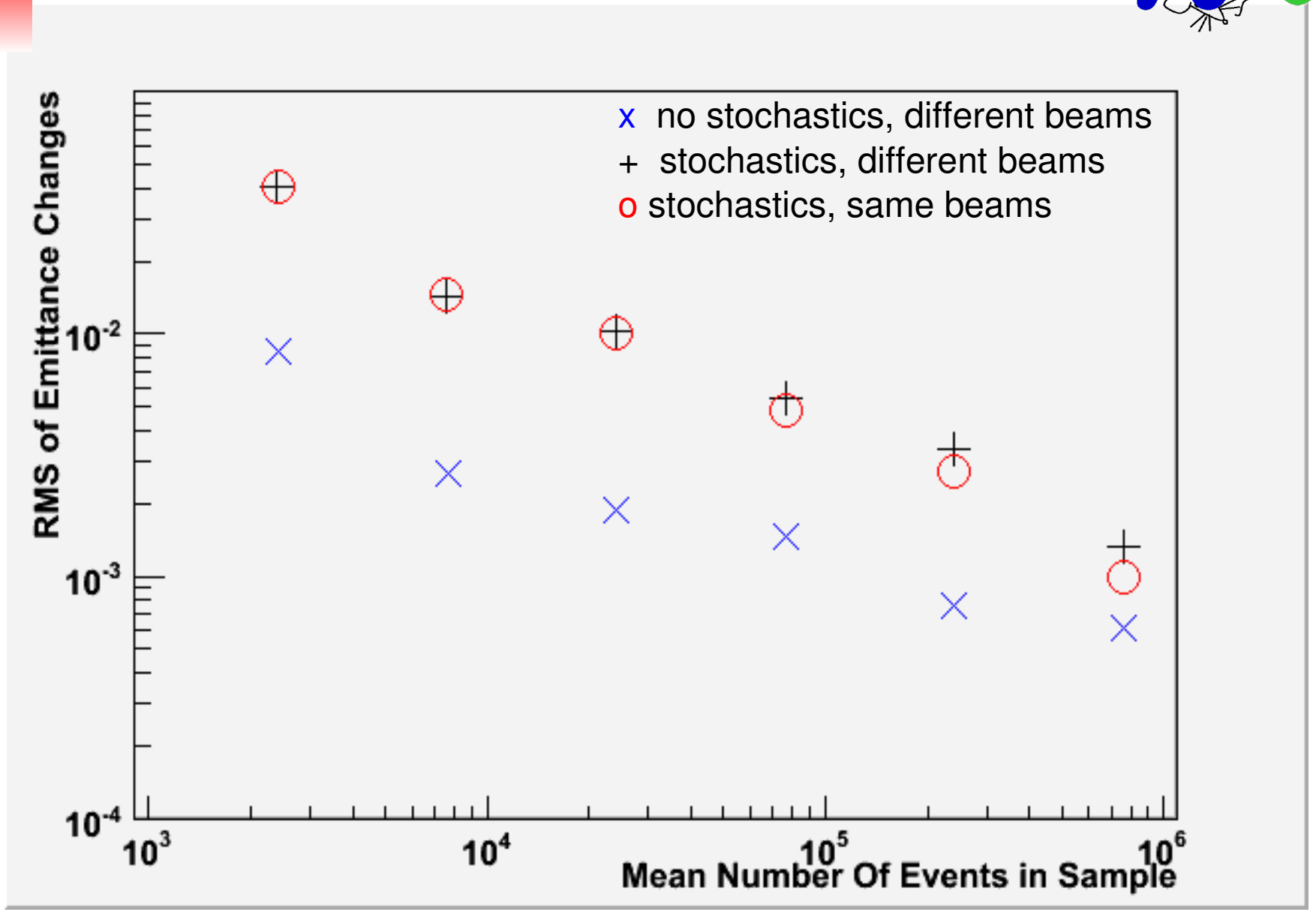


Statistical Error



0.01*dε

Statistical Error



Statistical Error

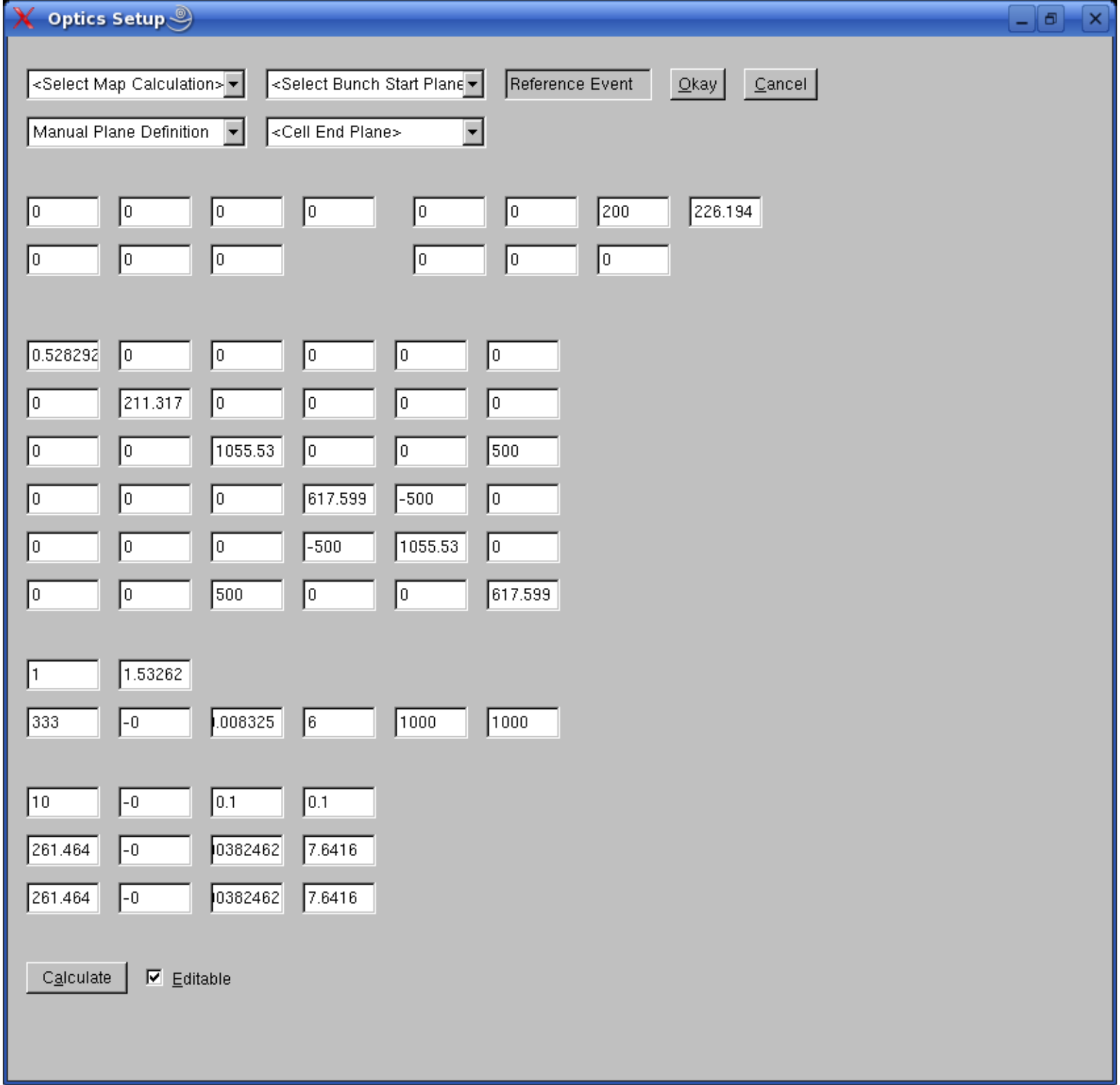
- This is an important question that needs detailed analytical and monte carlo study
- Something I don't have time for

On-line Analysis

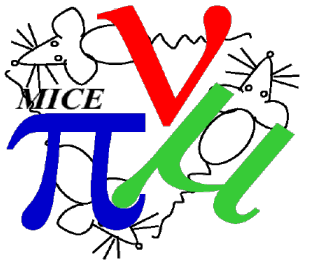
- So much for off-line analysis
- What about on-line analysis
- What high level analysis tools are needed in MICE LCR?
  - Emittance calculation?
  - Beta function calculation?
  - Histogramming?
  - Optimising/trend reporting?
  - I seek requests
- At the moment there is an ever growing generic accelerator "analysis" interface
  - Focussed on code optimising some generic cooling channel/accelerator
  - Not focussed on MICE
- In addition to the functionality reported at the last CM:

Optics

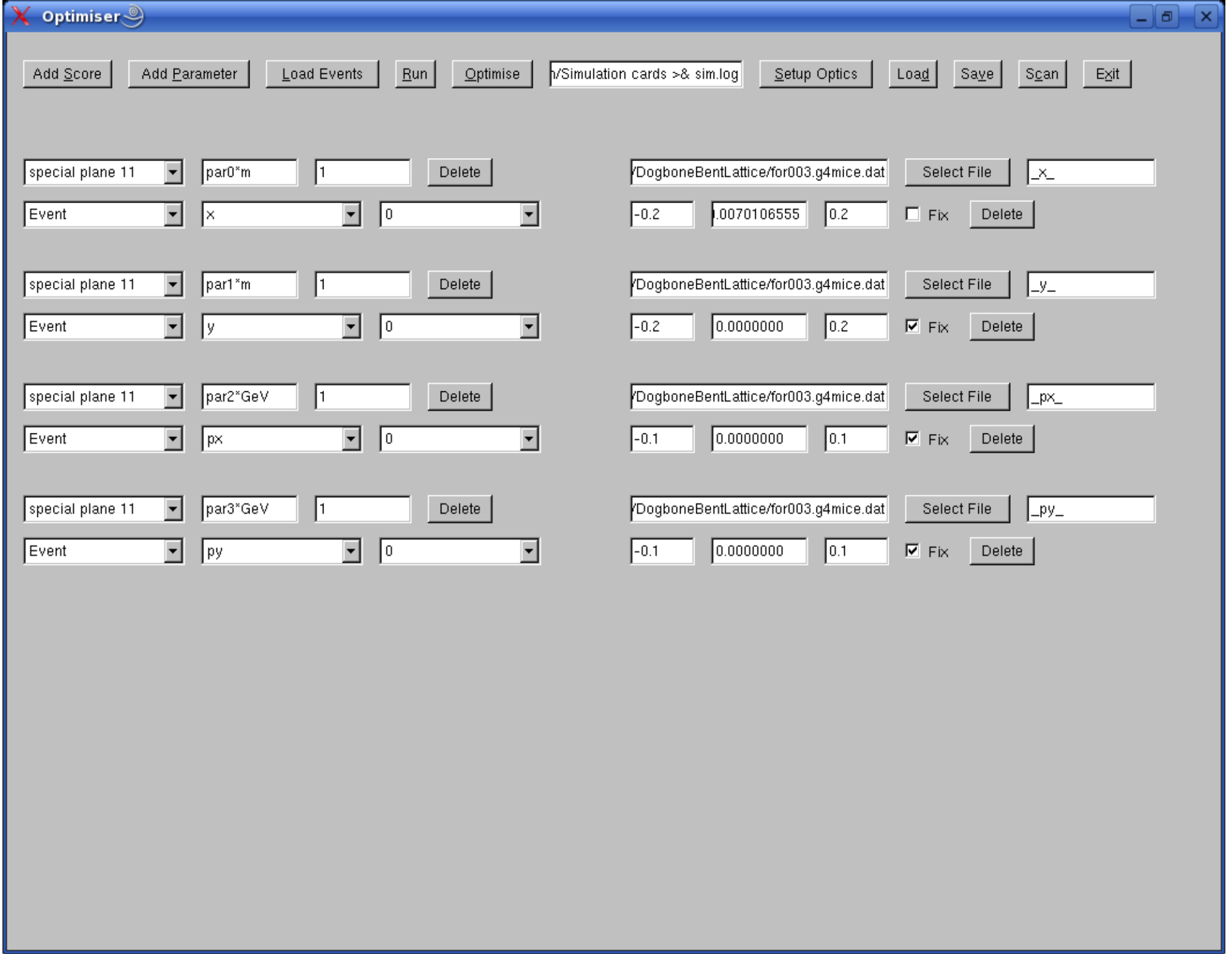
- Optics window has options to set up optics calculation
- Transfer maps based on tracking in your favourite tracking code
  - G4MICE, G4BL, ICOOL supported
  - Need to track ONLY 7 particles to extract dynamic information of the magnetic lattice to some approximation
- Select input covariance matrix either
  - manually
  - from some file input
  - using automatic beam matcher to find a matched solution
- Can then look at evolution of covariance matrix
- Quick!
- Magic!


Optics Setup
<Select Map Calculation>
<Select Bunch Start Plane
Reference Event
Okay
Cancel
Manual Plane Definition
<Cell End Plane>
0 0 0 0 0 0 200 226.194
0 0 0 0 0 0
0.528292 0 0 0 0 0
0 211.317 0 0 0 0
0 0 1055.53 0 0 500
0 0 0 617.599 -500 0
0 0 0 -500 1055.53 0
0 0 500 0 0 617.599
1 1.53262
333 -0 .008325 6 1000 1000
10 -0 0.1 0.1
261.464 -0 0382462 7.6416
261.464 -0 0382462 7.6416
Calculate
Editable

Optimiser/Scanner



- Perform optimisation based on arbitrary parameter set
  - Substitute text parameters into input file
    - e.g. set arbitrary coil currents in some input files by substituting every instance of some key words for the desired coil currents
  - Run some executable e.g. icool, g4mice, g4bl, shell script
  - Seeks to minimise sum of squares of some user-defined variables
    - e.g. seek to minimise sum of (beta_perp-333)^2+(alpha_perp-0)^2
- Some additional features
  - Interfaces with optics routines to make a very fast optimiser
  - Parameter scanning to plot scores vs some set of parameters
  - Functional recognition accepts functions of parameters in other parameters and scores


Optimiser
Add Score
Add Parameter
Load Events
Run
Optimise
h/Simulation cards >& sim.log
Setup Optics
Load
Save
Scan
Exit
special plane 11
par0*m
1
Delete
/DogboneBentLattice/for003.g4mice.dat
Select File
_x_
Event
x
0
-0.2
.0070106555
0.2
Fix
Delete
special plane 11
par1*m
1
Delete
/DogboneBentLattice/for003.g4mice.dat
Select File
_y_
Event
y
0
-0.2
0.0000000
0.2
Fix
Delete
special plane 11
par2*GeV
1
Delete
/DogboneBentLattice/for003.g4mice.dat
Select File
_px_
Event
px
0
-0.1
0.0000000
0.1
Fix
Delete
special plane 11
par3*GeV
1
Delete
/DogboneBentLattice/for003.g4mice.dat
Select File
_py_
Event
py
0
-0.1
0.0000000
0.1
Fix
Delete

Conclusions

- Still some work to do on offline analysis
  - Understand errors and how to calibrate against them
- Deadline is June 08
- Online analysis is useful for me
- I don't get enough feedback to make it useful for anyone else!
- Work continues...