Emittance Measurement Simulation Update

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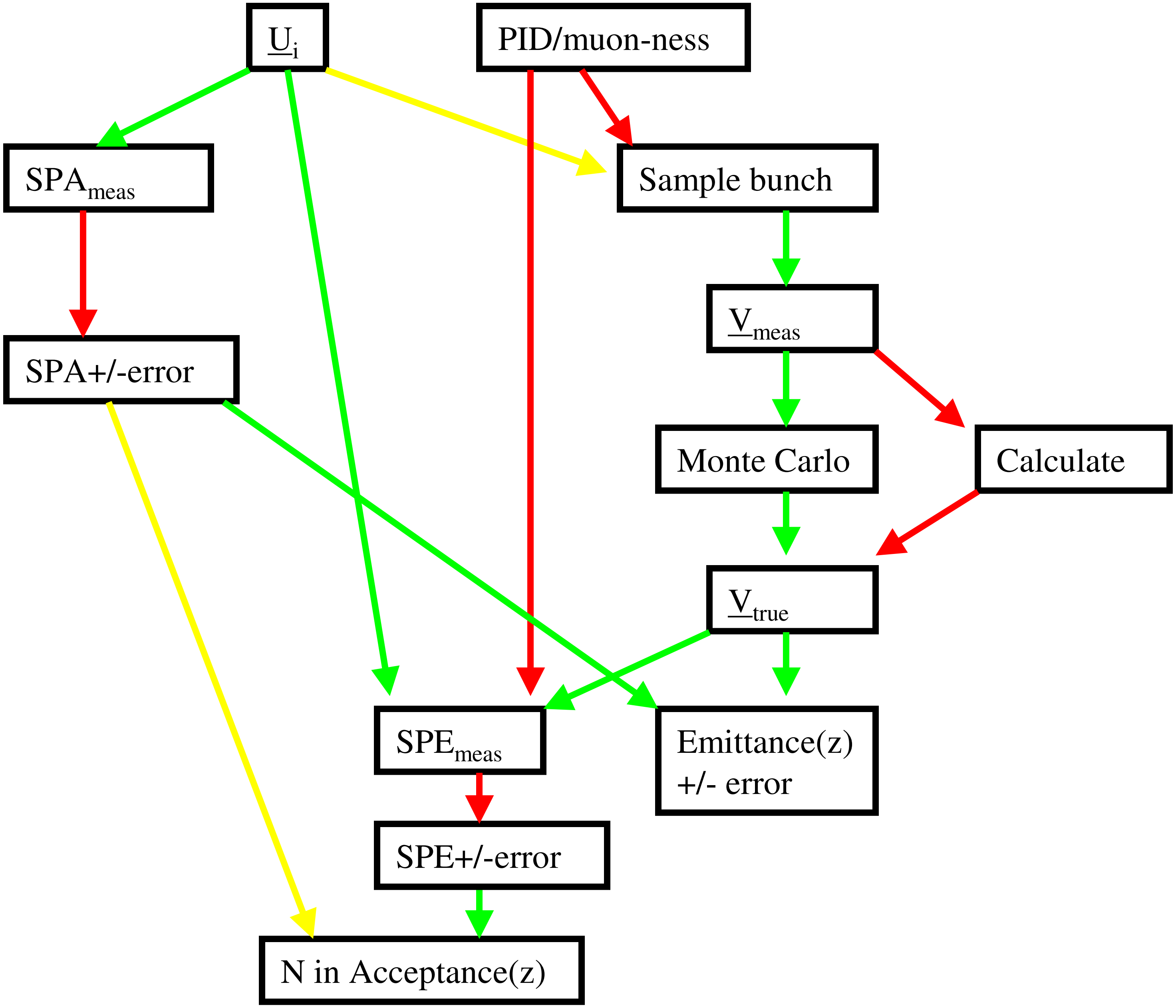
MICE Collaboration Meeting June 05

Analysis Roadmap



V_{meas} vs V_{true}

- Reminder: we can get from the measured covariance matrix to the true covariance matrix if we know our detector response

$$\sigma^2(u_i^{true}, u_j^{true}) = \sigma^2(u_j^{meas}, u_j^{meas}) -$$

$$-\sigma^2(\delta u_i, \delta u_j) - \sigma^2(u_i^{true}, \delta u_j) - \sigma^2(\delta u_i, u_j^{true})$$

- Experimental resolution is dependent on understanding not just the detector resolutions, but also the correlation of the errors in the detector & PID with each other and with the phase space position of the muon.
  - If the resolution/PID gets better/worse at different energies, momenta, or positions we need to know
  - If an error in one coordinate => an error in a different coordinate, we need to know

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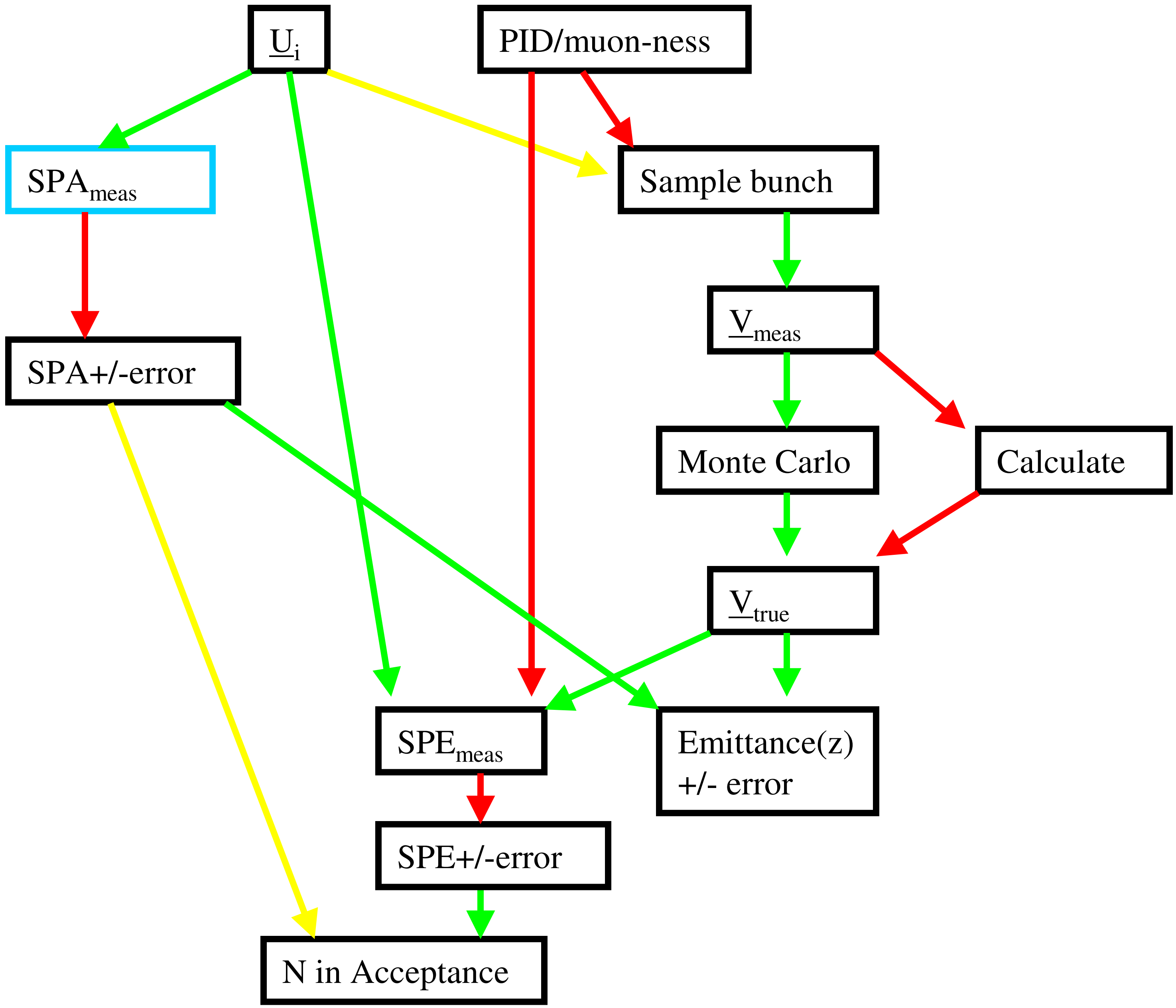
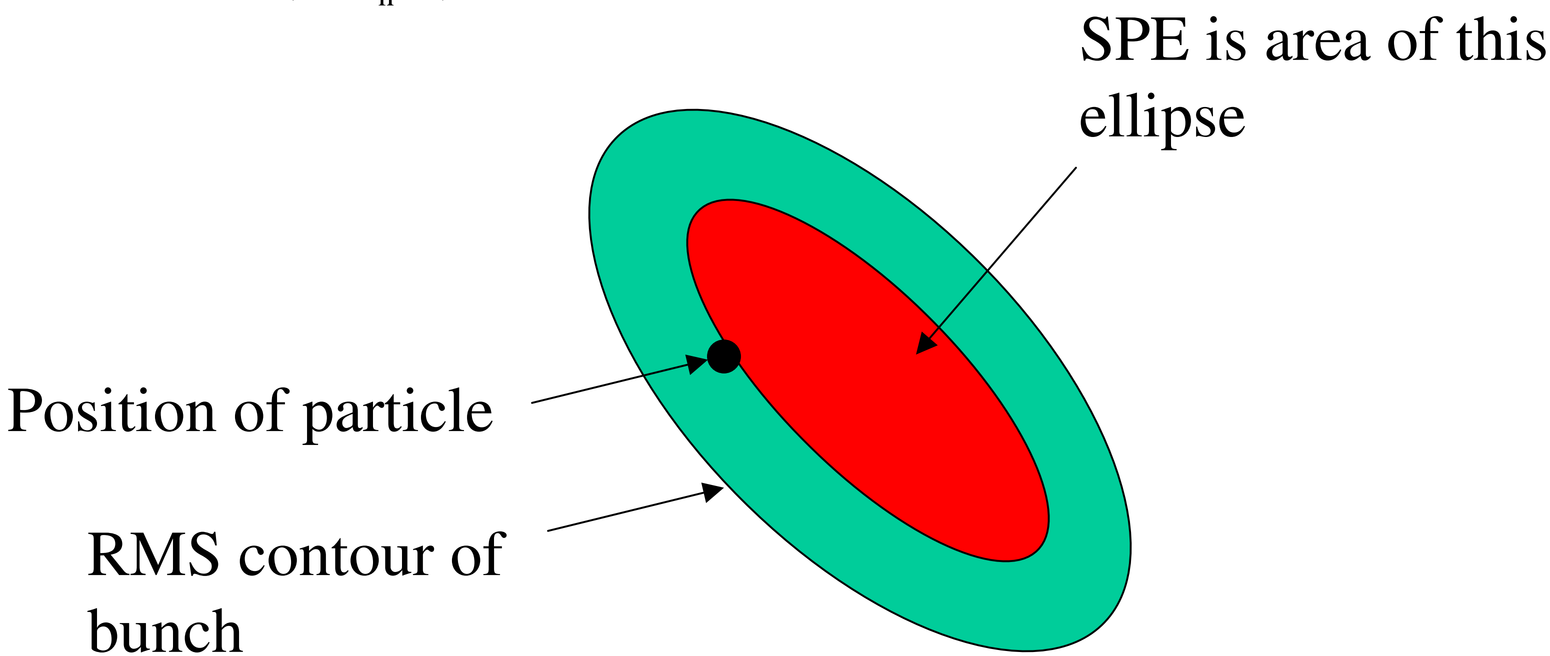


Single Particle Emittance

- Single Particle Emittance ε_i

$$\varepsilon_i = \varepsilon_n \underline{U}\,\underline{\underline{V}}^{-1}\underline{U} = \underline{U}\,\underline{\underline{O}}^{-1}\underline{U}$$

  - V is the matrix of covariances
  - U is particle position
  - O is the matrix of optical functions α, β, etc
    - ($V=\varepsilon_n O$)



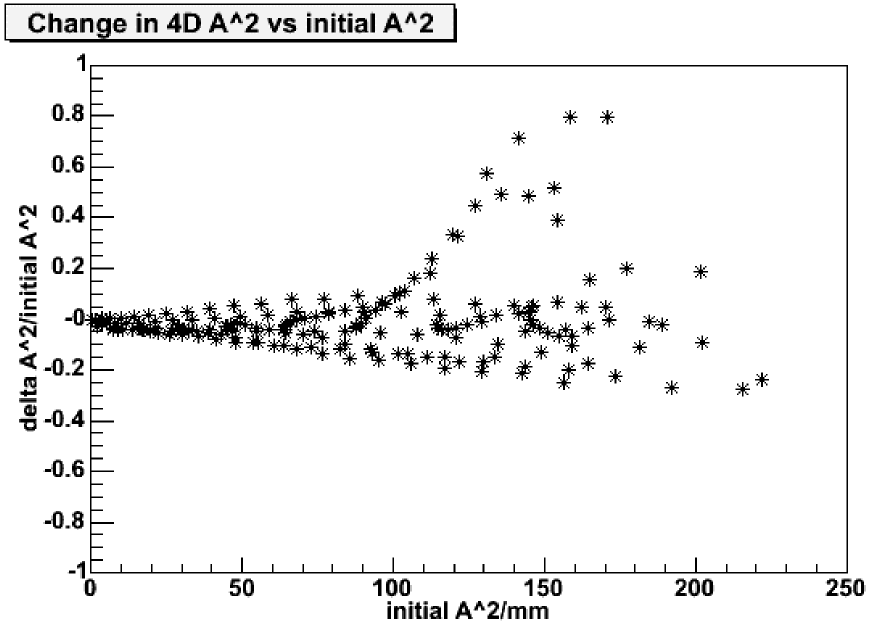
Single Particle Amplitude

- SPA single particle amplitude
  - Use calculated optical functions
  - SPE-like quantity independent of bunch measurement
- One powerful use of this method is to look at a phase space without requiring any bunch
  - Good for simulation
  - Possibly use as an experimental technique?
  - Get much higher statistics in particular regions of phase space
- Get back to "bunch amplitude" ~ bunch emittance
  - Use

$$A^2{}_{bunch} = \frac{< A^2 >}{2n}$$

Example use - nonlinear optics

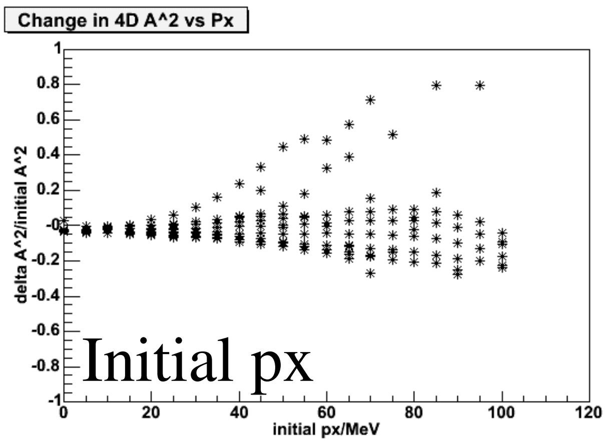
$\Delta A^2/A^2$

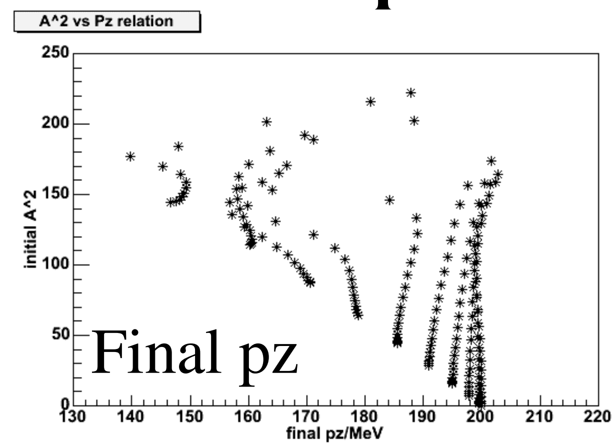


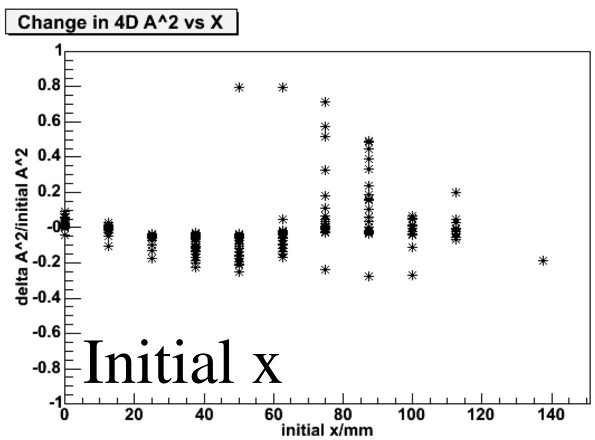
A^2

- Build grid in phase space
- Fire it through MICE magnetic fields
  - Examine change in amplitude upstream vs downstream

Some more ΔA^2 plots

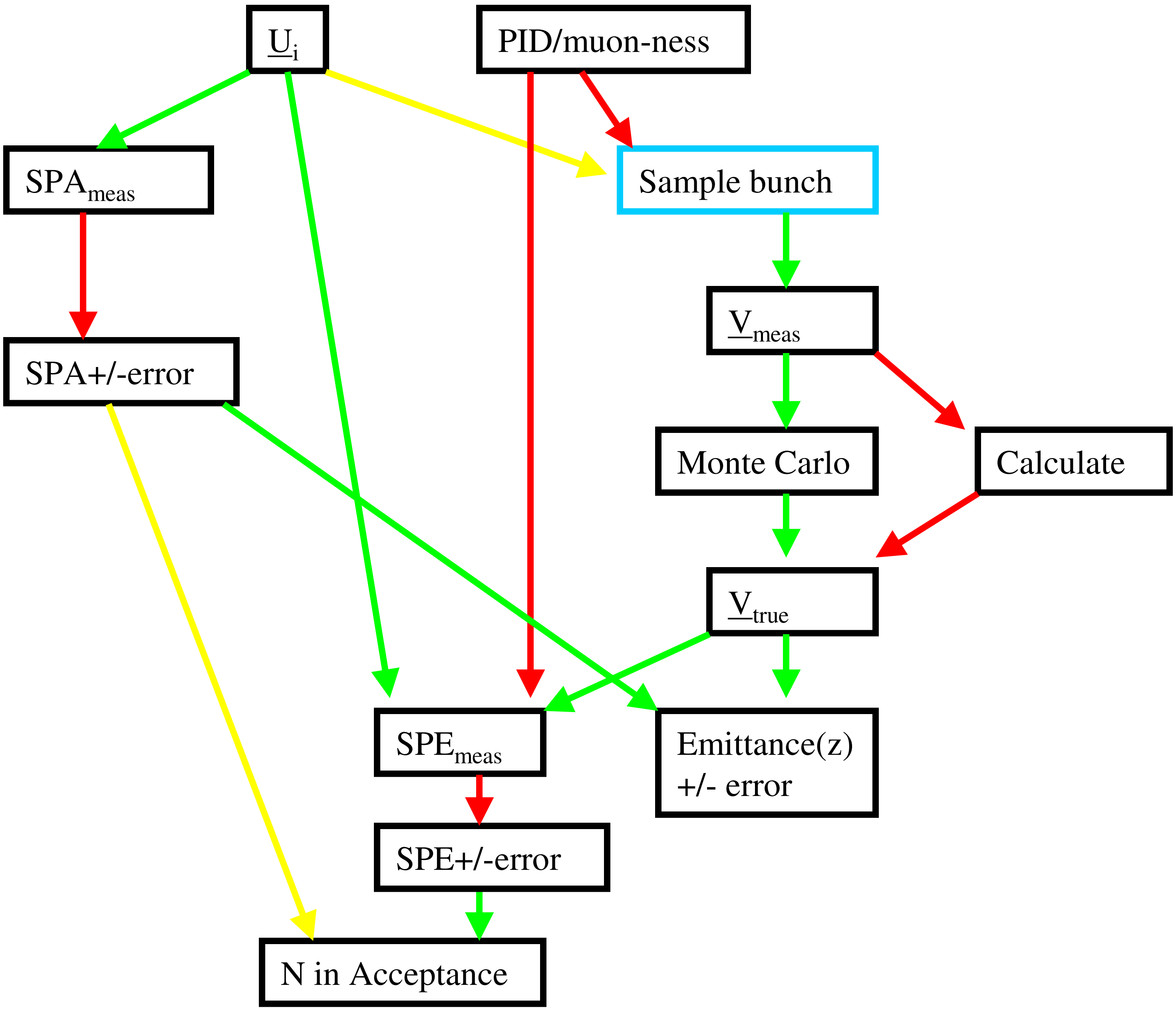






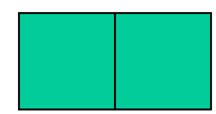
- Show Δ(SPE) independent of the rest of phase space

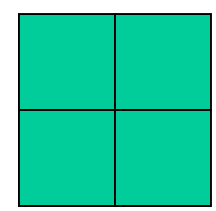
Analysis Roadmap



Sampling a bunch - stupid algorithm

- Stupid algorithm already exists but fails
  - Bin particles
  - Density, $\rho_{bin} = n_{bin}/(\text{bin area})$
  - Apply statistical weight to all particles in bin
    - $W_{bin} = \rho_{required}/\rho_{bin}$
- Fails because number events in each bin goes as $\sqrt[2n]{n_{meas}}$
  - With 10^6 particles and 10 bins/dimension we have ~ 1 particle in each bin
  - Atrocious precision





Sampling a Bunch - clever algorithm

1. Bin ito single particle emittance/amplitude (I.e. 1D)
   - Use the covariance matrix of the desired distribution
2. Then reweight so that the distributions inside each SPE bin are flat in phase space
   - Some ideas on how to do this, but a little difficult

- Not coded yet
- Stage 2 should be easy but I haven't quite worked out the details yet

Clever algorithm - cartoon

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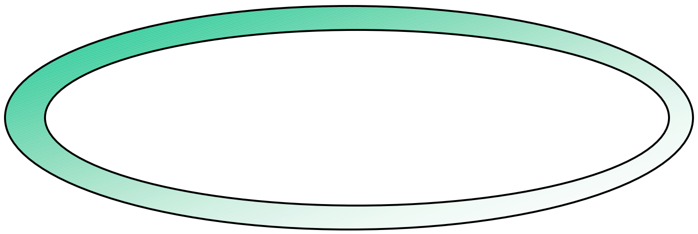

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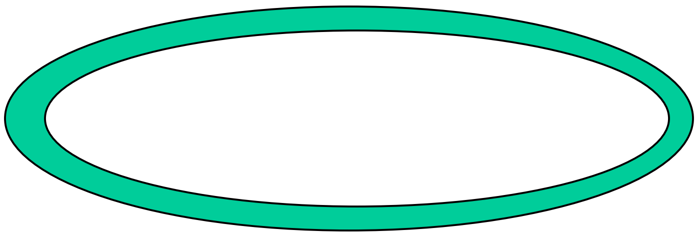

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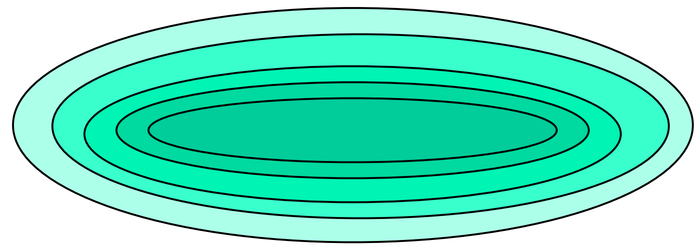
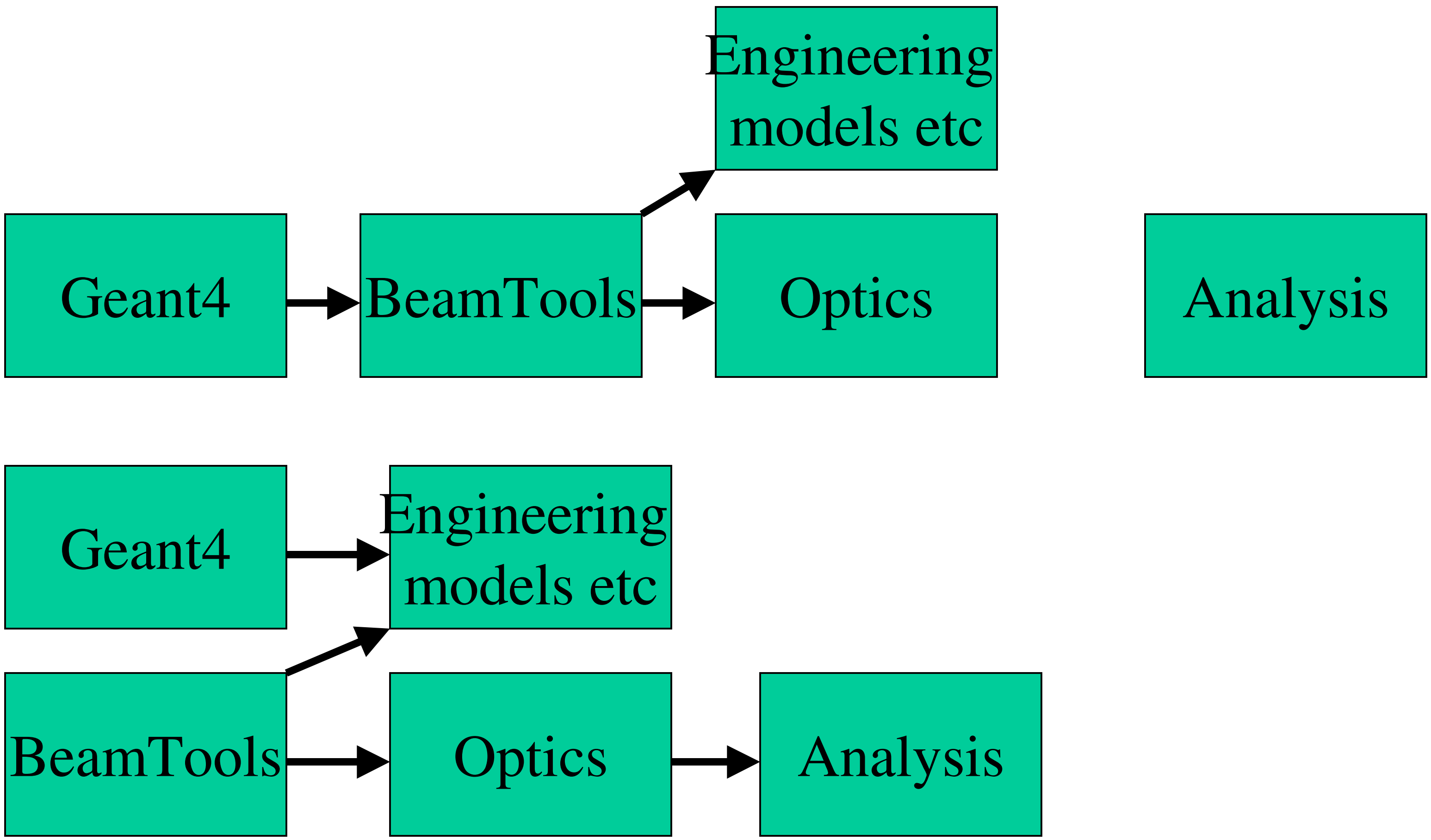


Book Keeping

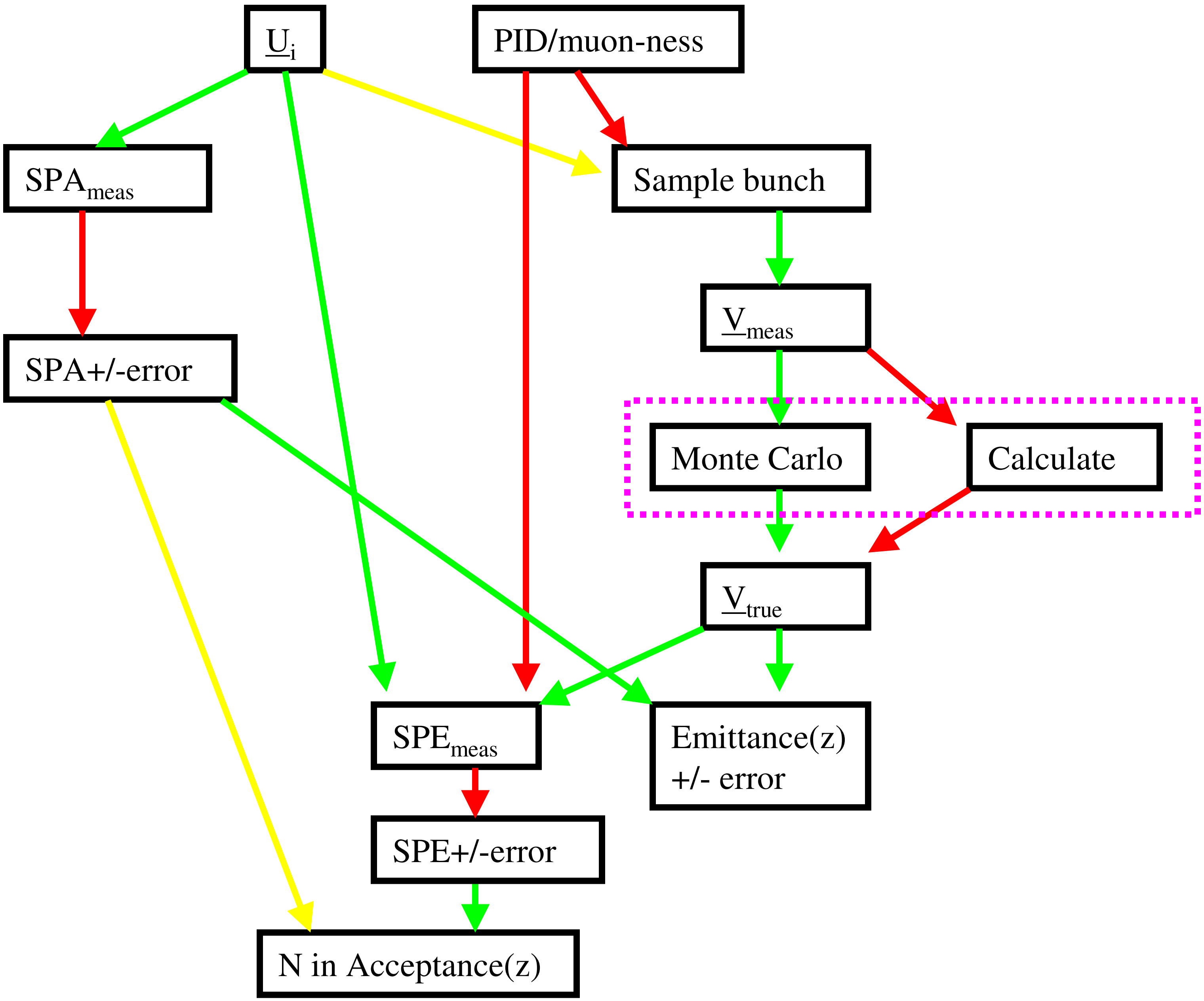
- Code clean up
  - New file io algorithm ~ halves processing time
  - Some other areas tidied up
- Easier "just works" interface
  - See documentation
  - "Easy to do easy things"
- Falling behind on testing…
  - Submitted a bug report last week on "just works" interface

A brief technical note

- Some of these ideas need access to the optical functions - a fair amount of work:



Future Plans



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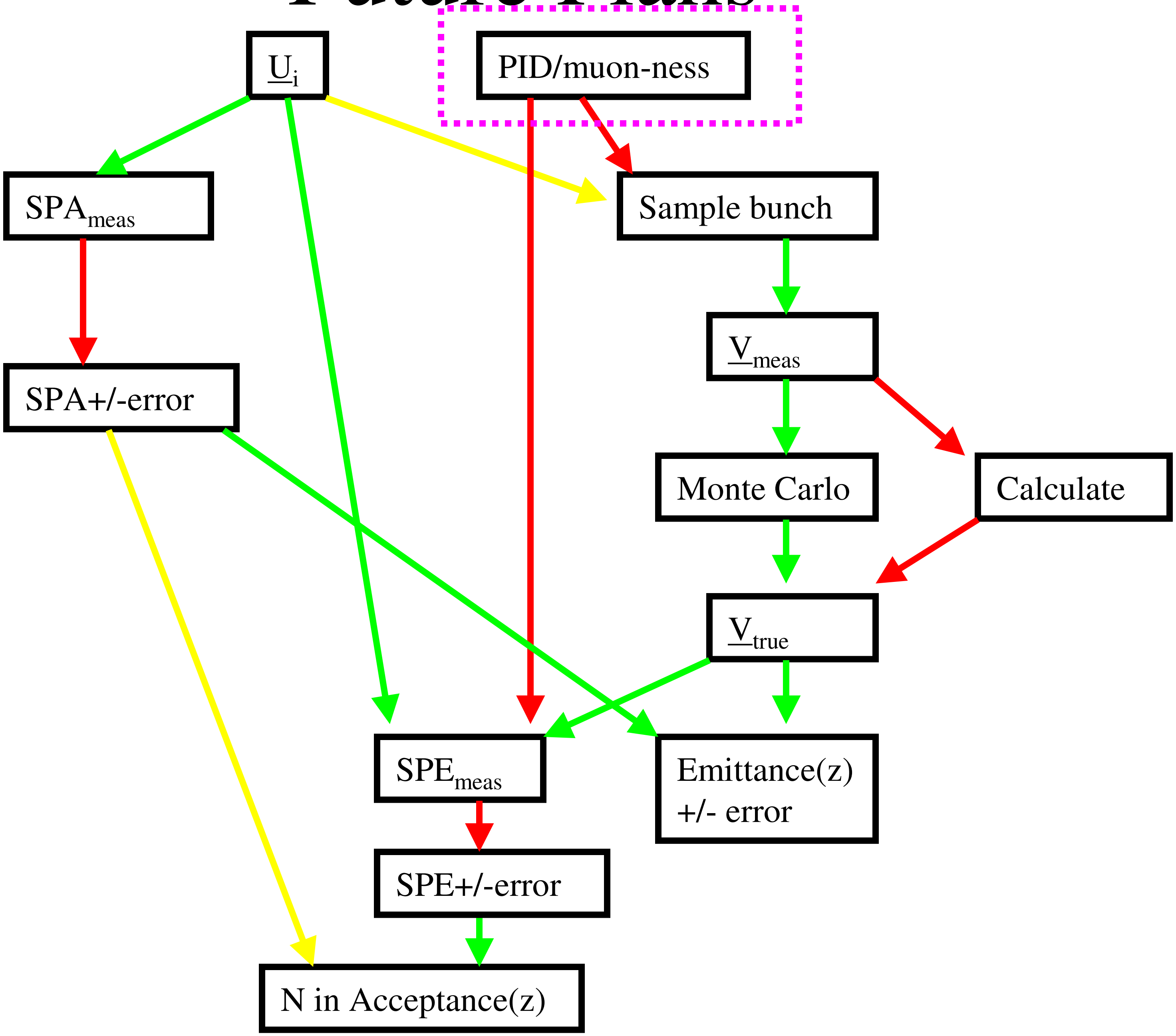

Future Plans