Atmospheric Neutrino MC

Pat Ward
University of Cambridge

- Status of atmospheric neutrino (and cosmic muon) generation in Cambridge
- Problems encountered
- Future Plans

Atmospheric ν MC

- Atmospheric ν MC samples generated to study event reconstruction and sensitivity to oscillations, particularly charge dependence
- Current studies use GMINOS version of 16/01/02 installed in Cambridge
  (to be updated soon)
- Default far detector geometry and FLS simulation (2 supermodules, with field)
  In January was said to be 'closest we can currently generate' to actual detector
- Atmospheric ν flux file from Peter Litchfield (Soudan)
  100k events, $\nu_{\mathrm{e}}, \overline{\nu}_{\mathrm{e}}, \nu_{\mu}, \overline{\nu}_{\mu}$
- Neutrino interactions using NEUGEN
- Events rerooted and studied using OO reconstruction code

Atmospheric ν MC

- Generated 220k atmospheric ν events
- Also generated cosmic muon events for background studies, using flux histograms from Jim Musser:

  115k events all angles

  500k equivalent with angle cut ($\pm\,10^\circ$ to detector planes)
- Recent developments in offline code have rendered the events obsolete

  $\Rightarrow$ all have to be regenerated
- A few minor problems fixed:

  Reading of flux file

  Array overflow in digitisation

  Fix random numbers to make events reproducible
- Further problem: noticed that generated ν events more strongly peaked in direction of detector axis than expected from flux file

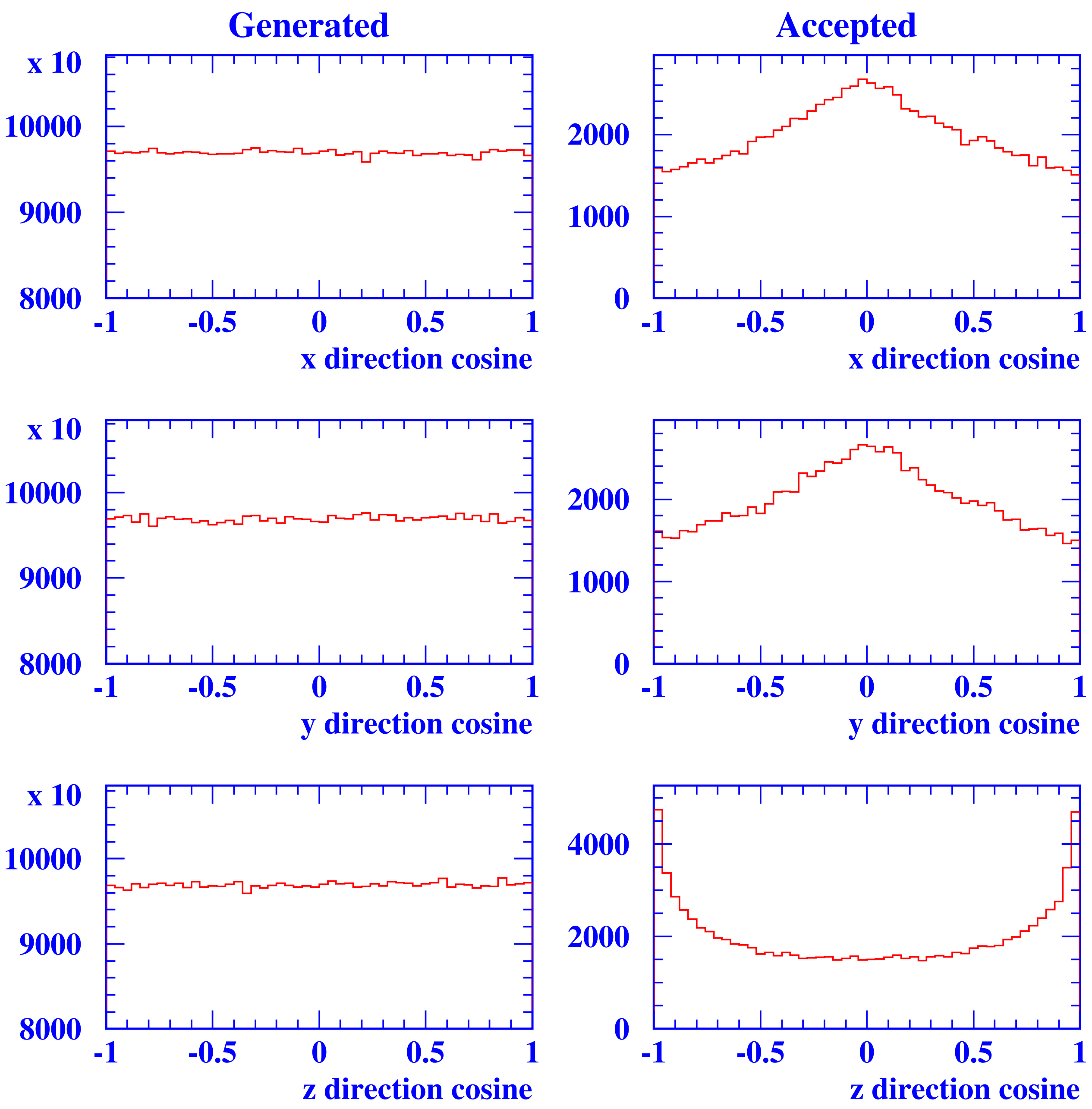
  Angular distribution of ν which interact should be identical to that of incident flux (for given energy, flavour)

Atmospheric ν MC

- Problem appears to arise from algorithm used to generate interactions from flux file. As far as I can see, this appears to be:
  - Read ν (p_x, p_y, p_z, p) from flux file
  - Choose random point in rectangular box surrounding detector
  - Track ν back from this point to find intersection with box
  - From box entry point and ν direction, calculate total material traversed through detector $\Rightarrow$ interaction probability $\Rightarrow$ decide if interaction
  - If ν interacts, choose nucleus, interaction point etc and generate event
  - Otherwise read next event from flux file
- This algorithm produces bias in angular distribution

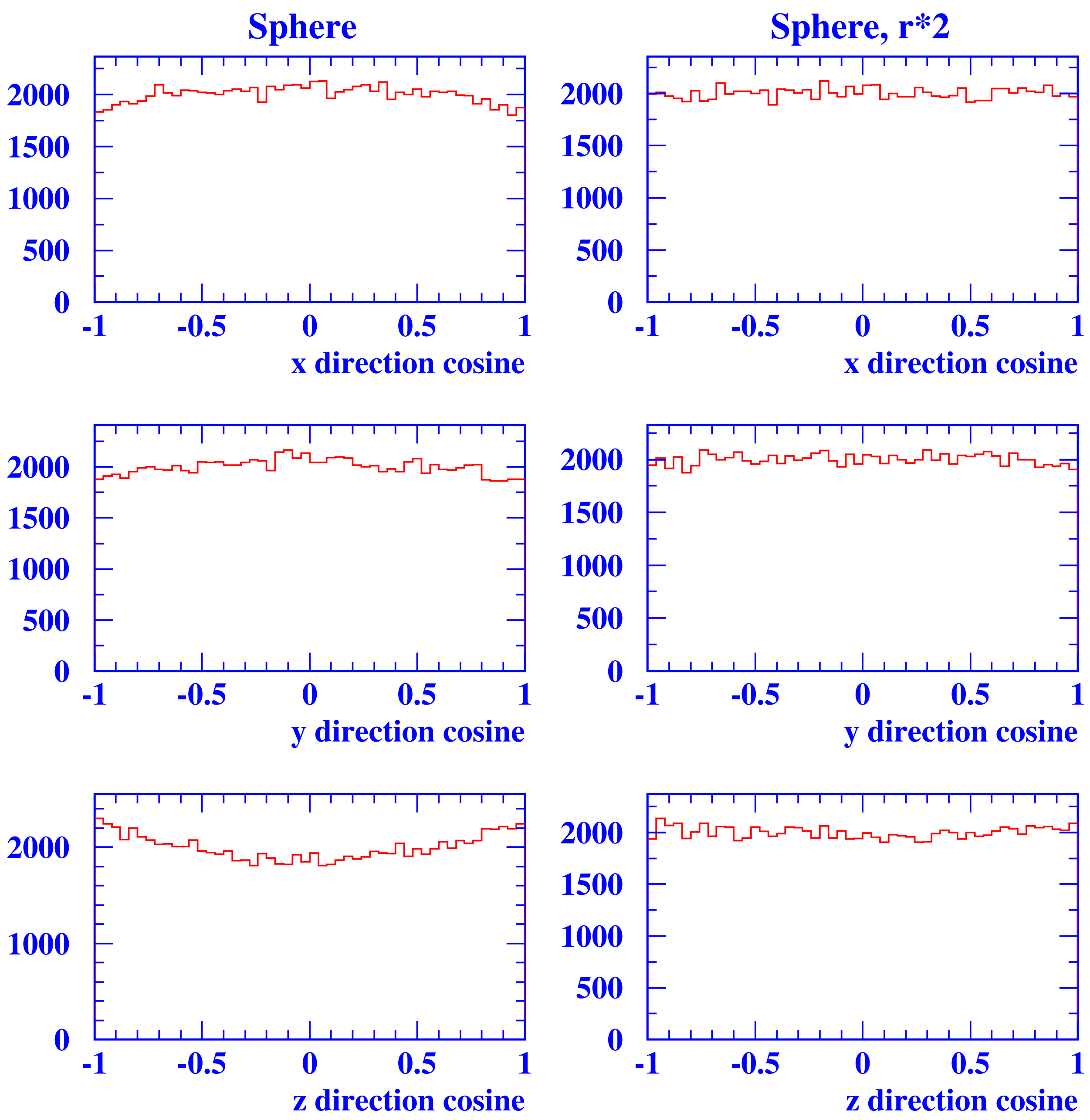
Atmospheric ν MC

Test by generating isotropic distribution of 1 GeV ν_μ events, and compare generated angular distribution with that of events accepted.



Atmospheric ν MC

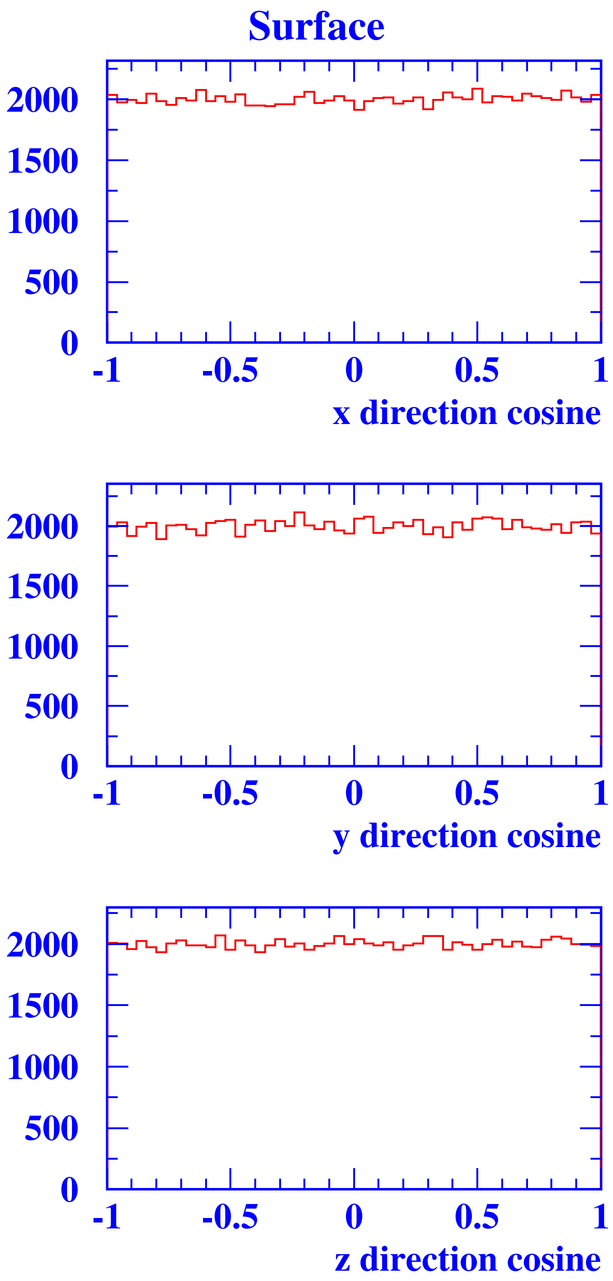
- Consider ways of removing (or reducing) bias, e.g. use sphere instead of box (reduce directionality)



- Better, but still some bias with sphere just enclosing detector, need radius $>$ twice half-length of detector

Atmospheric ν MC

- Alternative algorithm: choose random point on SURFACE of box surrounding detector, and reject according to angle θ between neutrino direction and normal to surface, i.e. reject if $r > |\cos\theta|$ where r is random number uniform in $[0, 1]$



- Actually tried cube for simplicity
- This algorithm seems fine
- Should change code to use something like this

Future Plans

- Update GMINOS and regenerate all event samples...
- Decide on, and implement, best flux algorithm
- Add new flux calculations (Hugh Gallagher)
- Generate even more events...