Simulated Moon Shadow

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Method

Important facts:

- For triggered events, the zenith angle is correlated with both energy and angular resolution.
- Azimuth has much weaker correlations.
- Moon's azimuth range is about 185°.
- Monte Carlo events have primary direction drawn from an isotropic distribution.
- The magnetic deflection is determined by the local coordinates (zenith, azimuth) and the Milagro site location.

Procedure

- Read in a Monte Carlo event.
- For θ_{MC} pick ϕ from a set of θ, ϕ pairs from moon data, sampled over 1 year. This forces the correct relation between zenith and azimuth, for the moon.
- Given $\theta_{MC}, \phi_{picked}$, determine the magnetic deflections in the RA and DEC directions, Δ_{α}^{mag}, and Δ_{δ}^{mag}, from a previously computed table. These are for a 1 TeV proton.

- The actual magnetic deflections are then

$$\Delta_\alpha^{mag,actual} = \Delta_\alpha^{mag} 1000 \times (ESF)/Energy(GeV)$$

where ESF is an energy scale factor (=1 for default energy scale).

- The angular deviation for each event is obtained from the fitted and true values of the primary direction.

$$\Delta_\alpha^{ang} = lha_{fitted} - lha_{true}$$

$$\Delta_\delta^{ang} = \delta_{fitted} - \delta_{true}$$

The total deviation is then

$$\Delta_\alpha^{tot} = \Delta_\alpha^{mag} + \Delta_\alpha^{ang}$$

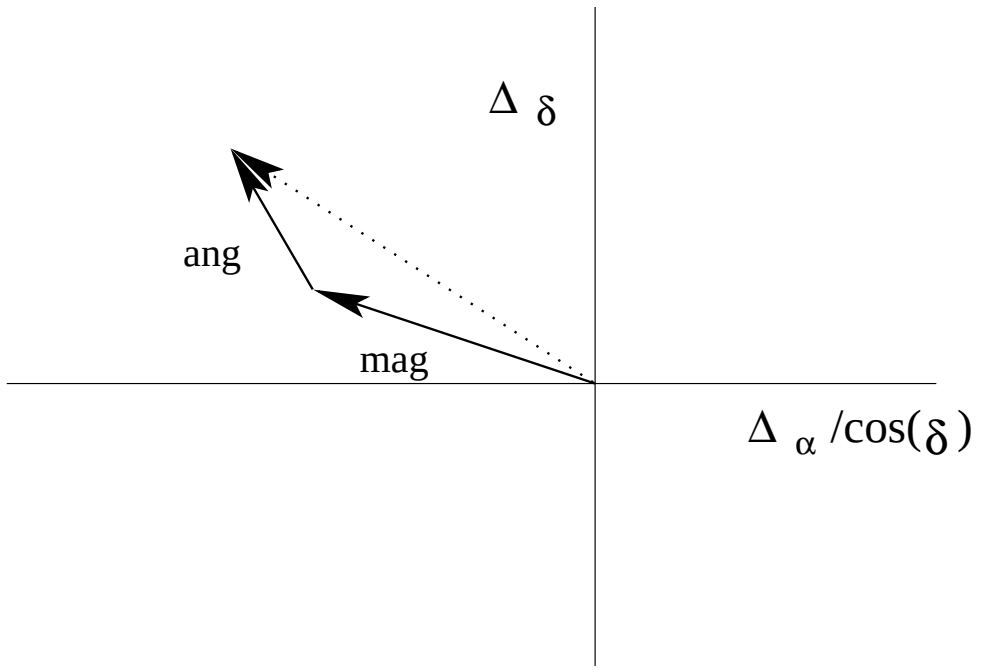

Figure 1: Deviations from moon center due to angular resolution and magnetic deflection.

- The actual moon and MC zenith distributions are different:

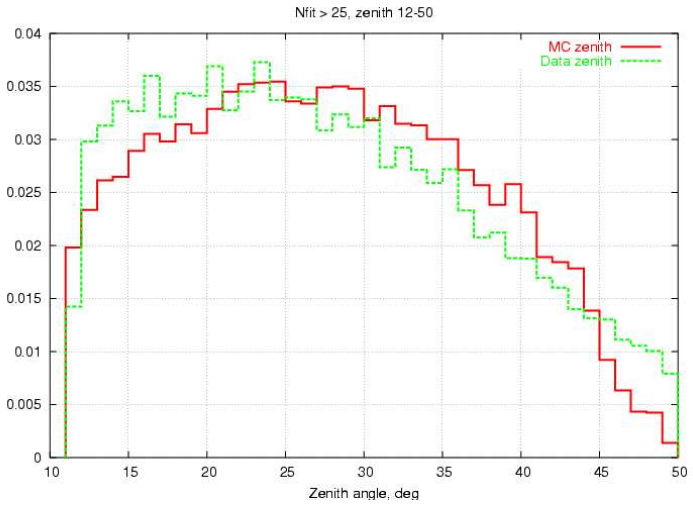

Figure 2: Zenith angle distributions.

The difference is corrected for with a weight factor:

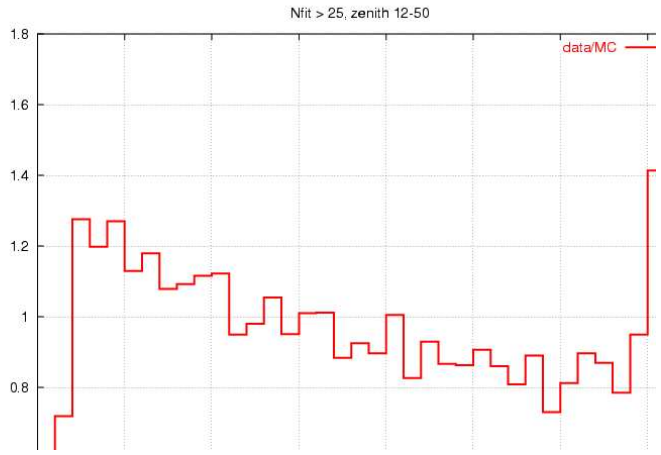

Figure 3: Weight function.

- The Monte Carlo data is currently stored in an Ntuple. It available at **umdgrb.umd.edu/ellswort/moon_shadow_simulation/mc**
- Not yet finished: Inclusion of helium data. Inclusion of .25° finite moon size.

Energy Distribution

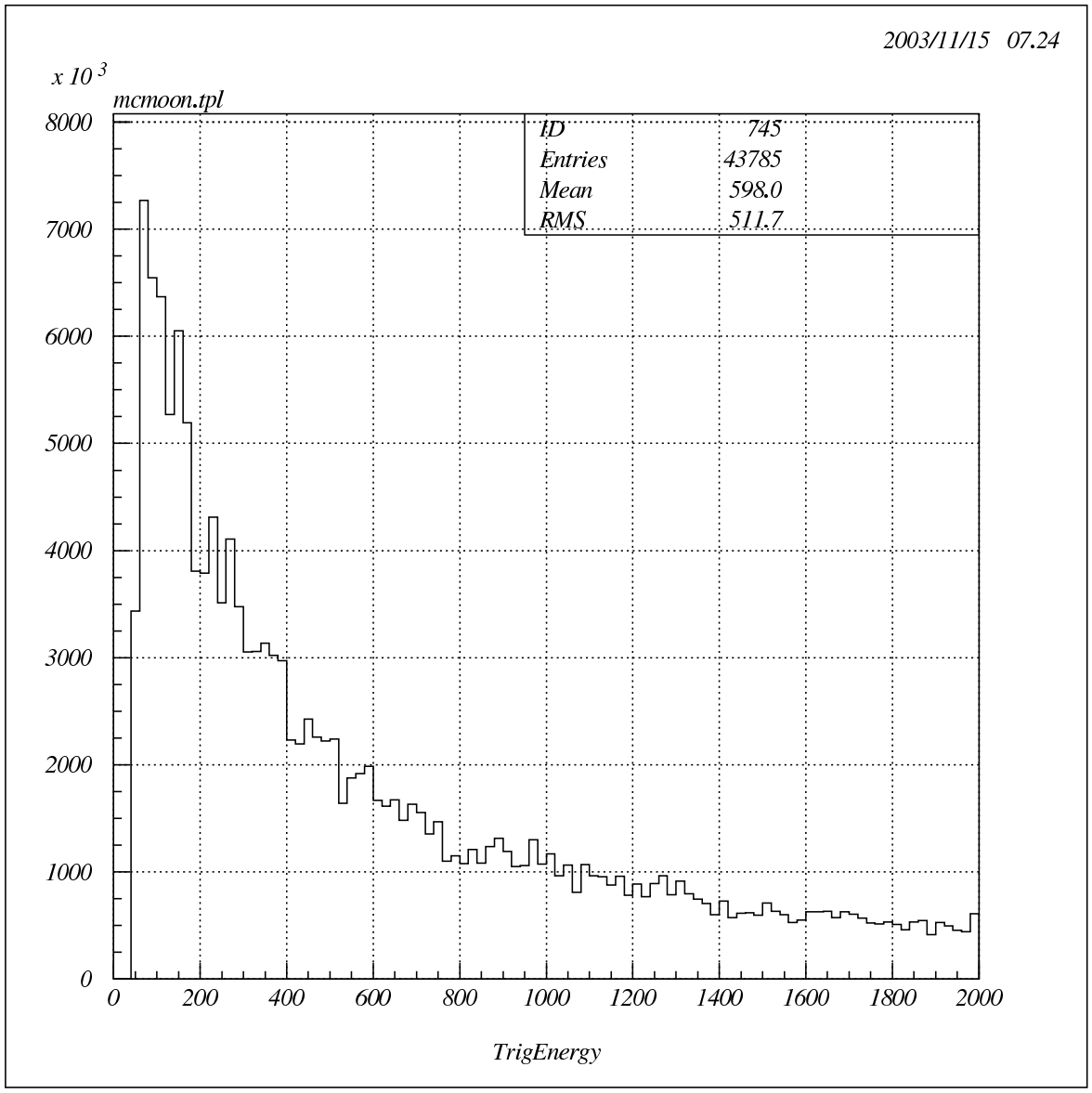

Figure 4: Distribution of energies of triggered events, for $N_{fit} > 25$

Figure 5 shows the magnetic deflections, sampled over 1 year, for 1 TeV protons, as calculated by a previously described method. The vertical axis is the "dec" direction, the horizontal the "ra" direction.

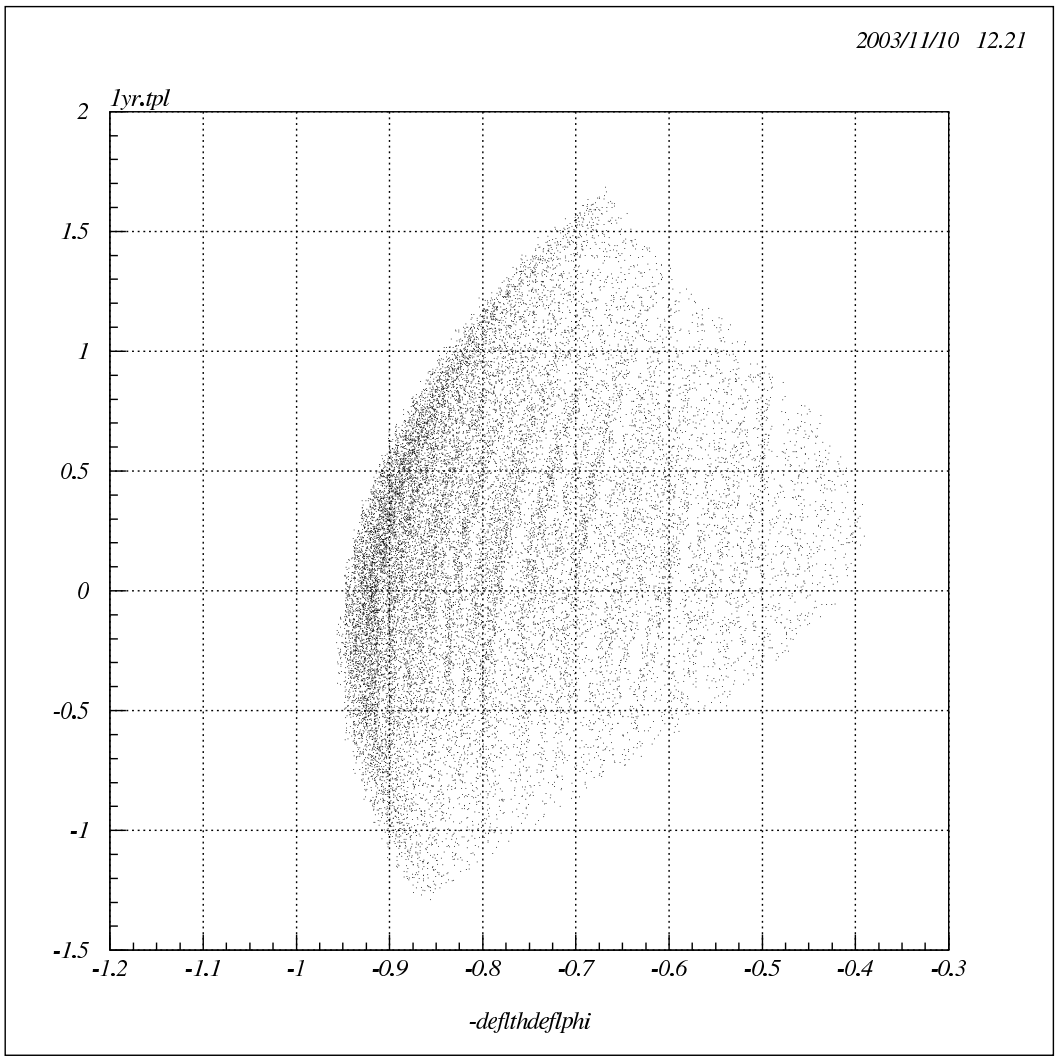

Figure 5: Magnetic deflections, 1 TeV protons.

Figure 6 shows the distribution of the same quantites, obtained from the Ntuple made from the proton Monte Carlo data, with magnetic deflections included. This is a check of the insertion of the magnetic deflections into the program.

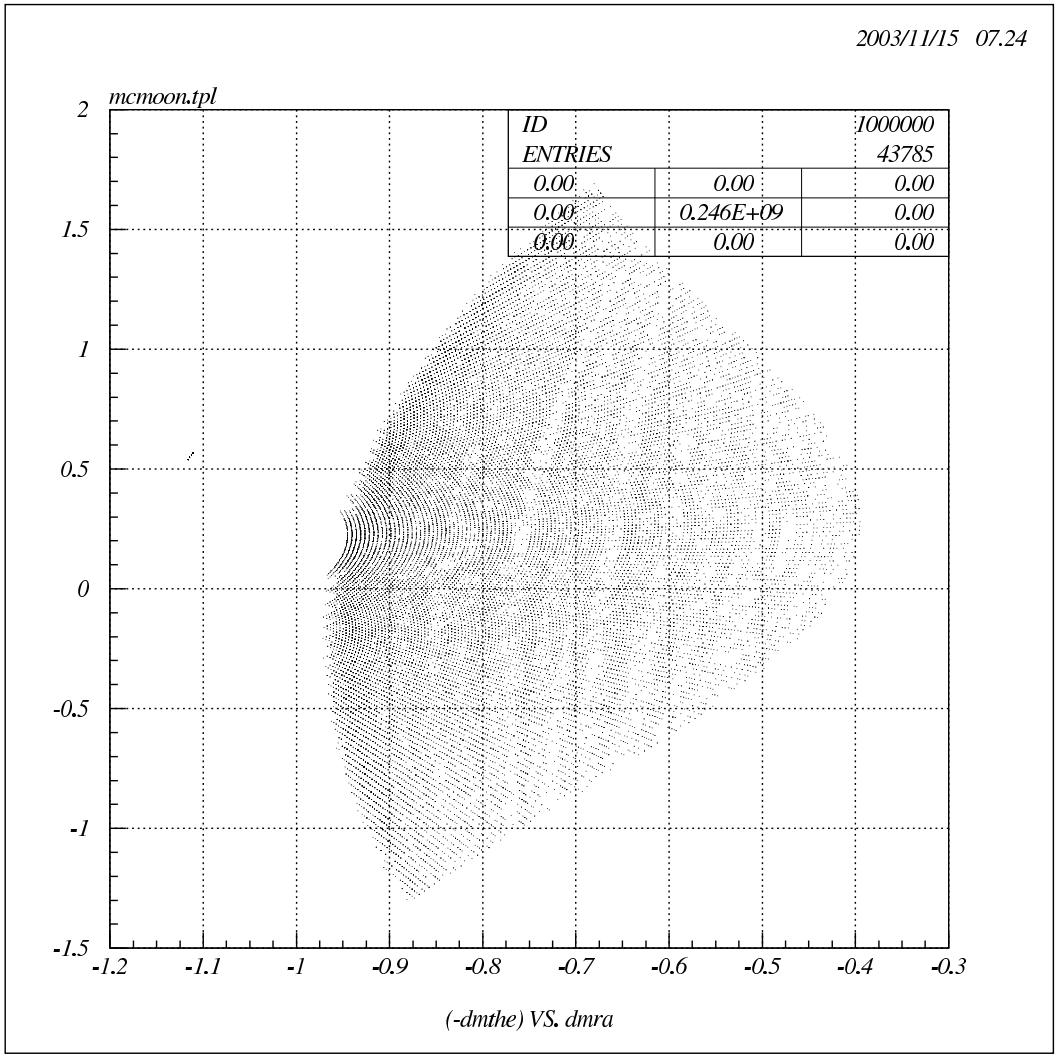

Figure 6: Magnetic deflections, from Ntuple

The distribution of deleo, for the proton Monte Carlo and data taken in July 03.

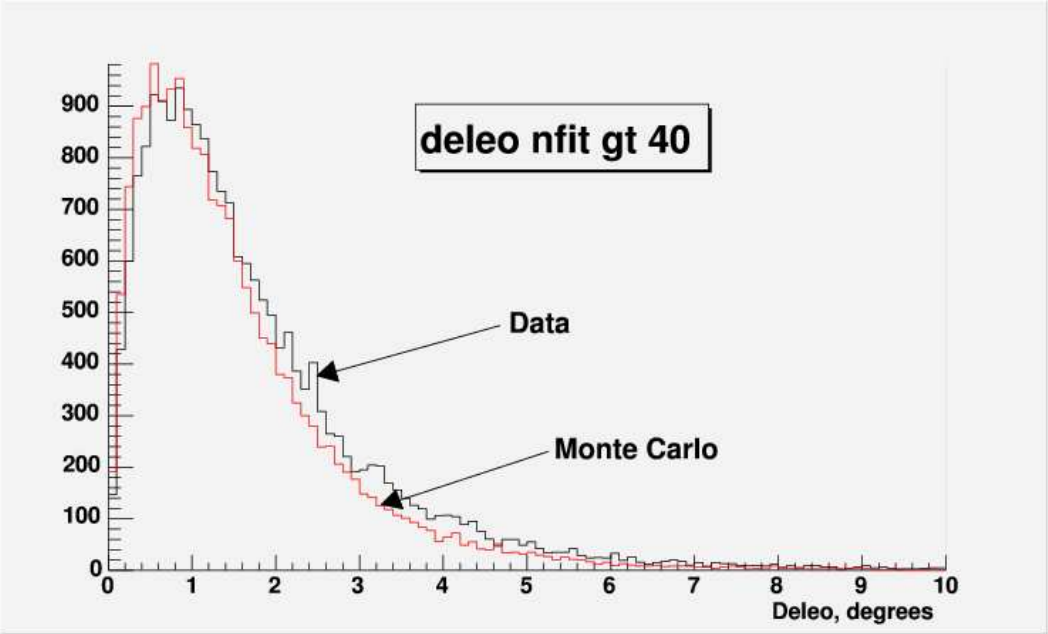

Figure 7:

Figure 8 shows the distribution of the deviation from the Moon center for the simulation, in the "dec" direction, for $N_{fit} > 25$. This includes both magnetic deflection and angular resolution. The colored curves shows the same quantitiy for an energy scale factor shift downward and upward by 2X.

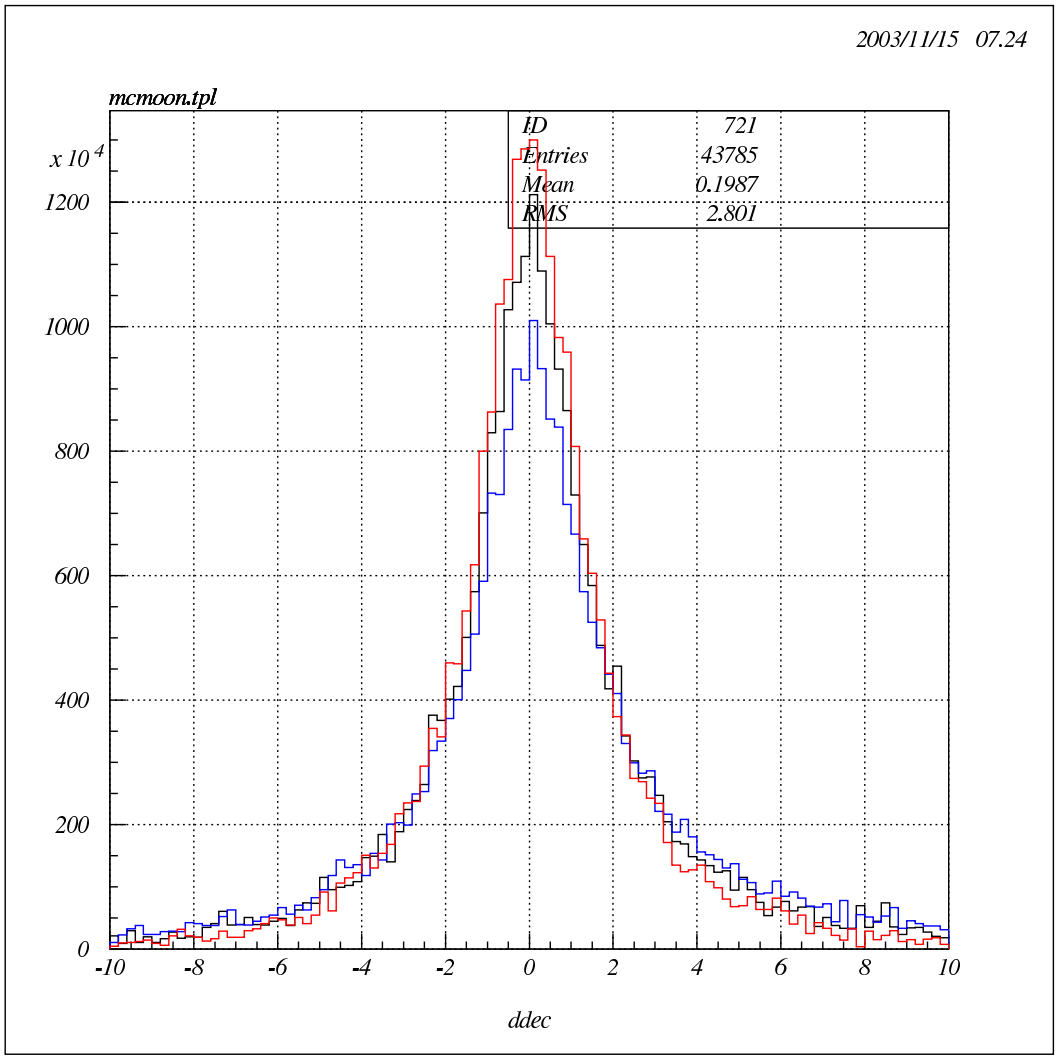

Figure 8: Total deviation, dec direction.

The same, but for the “ra” direction.

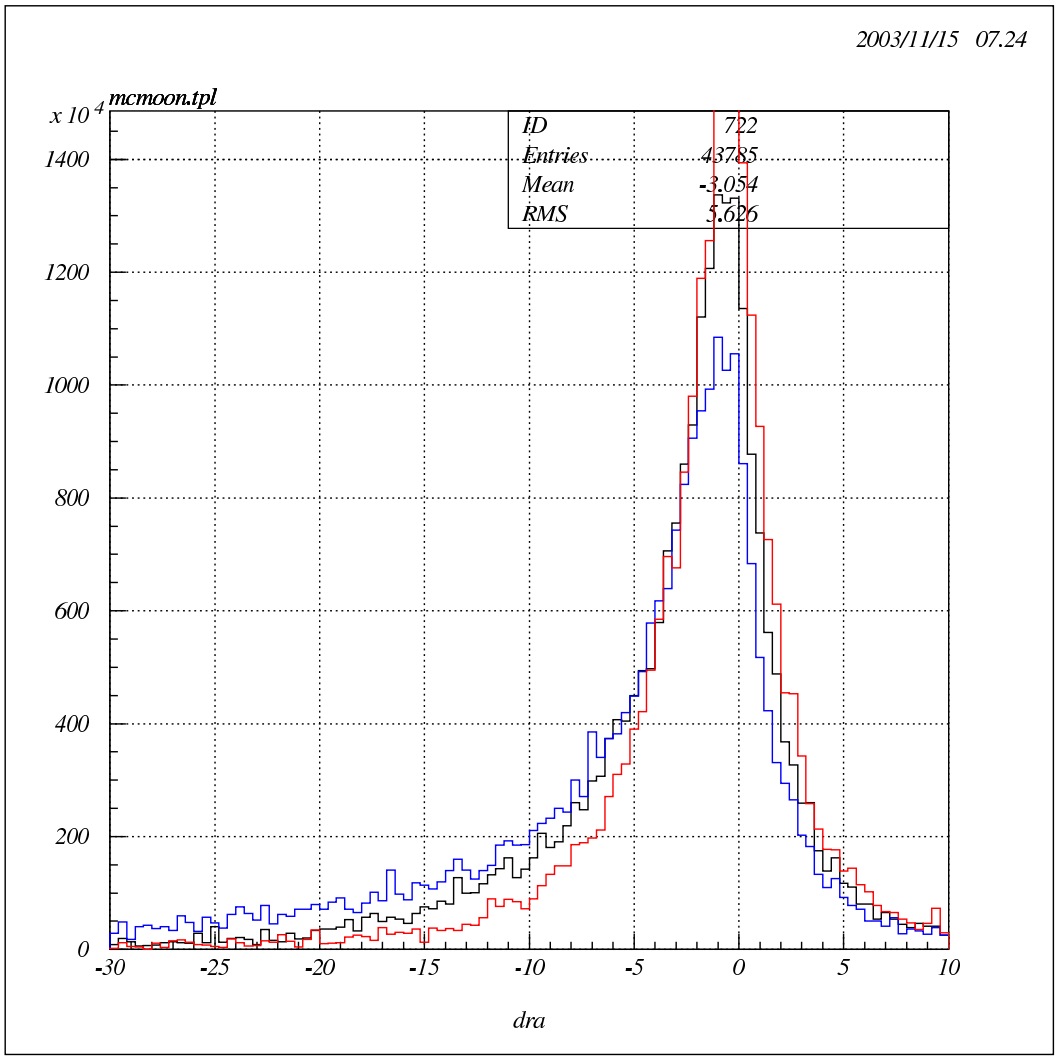

Figure 9:

The same, again the "ra" direction, but for $N_{fit} > 100$.

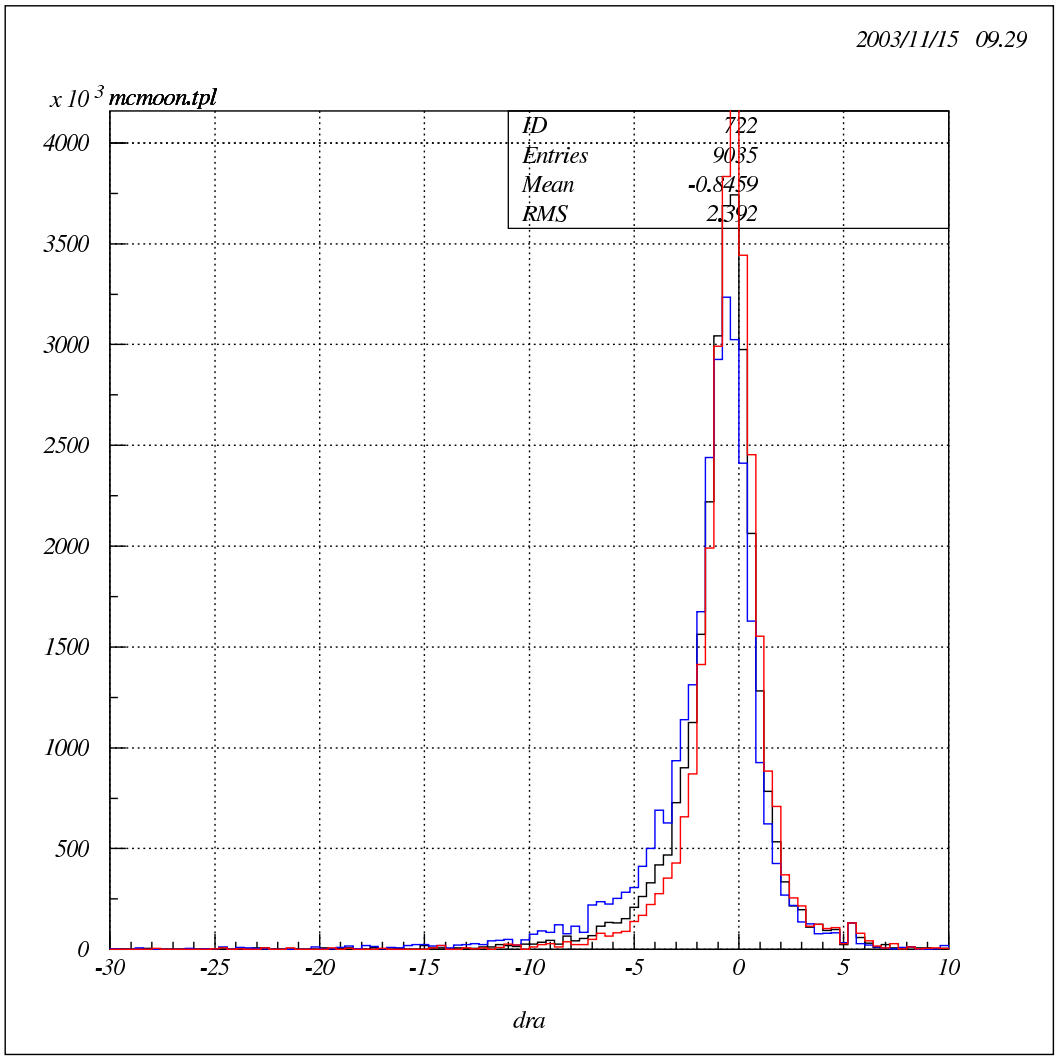

Figure 10:

A color map of the shadow, which shows fits to a 2-D Gaussian.

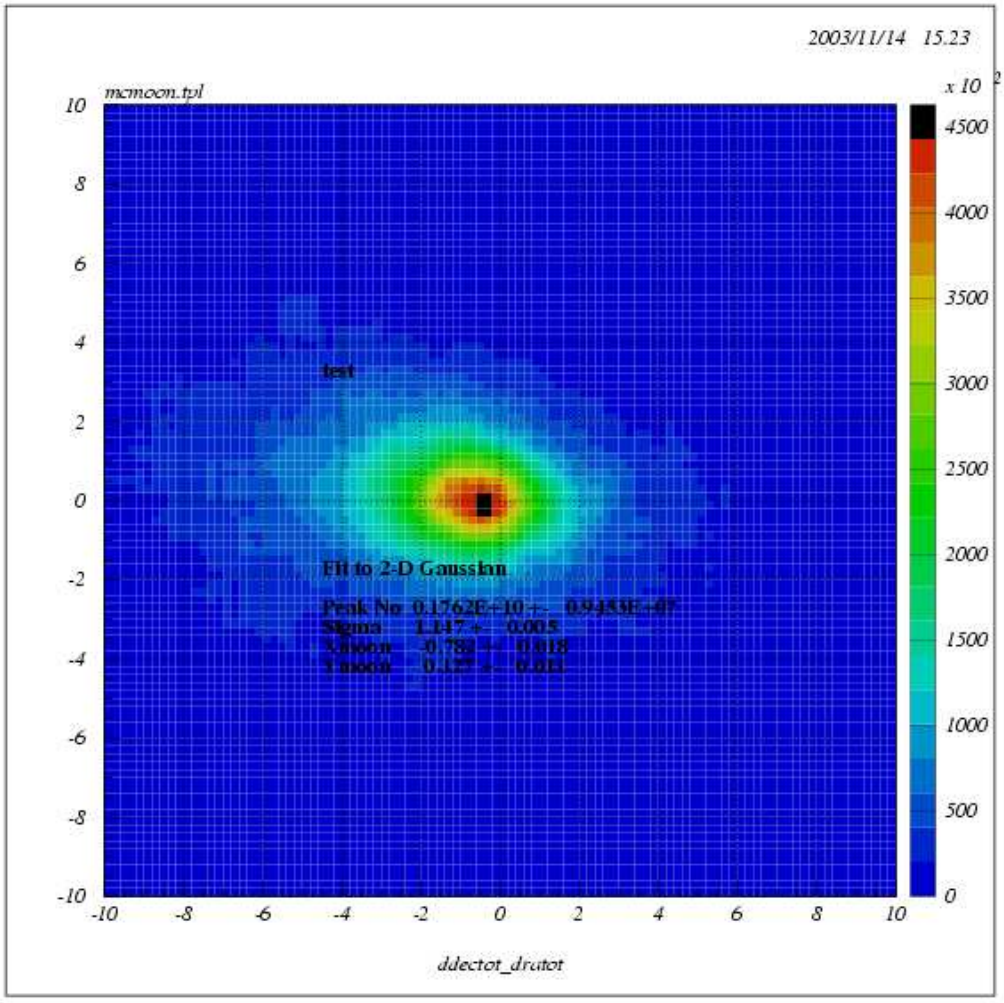

Figure 11:

Here is a contour map of the same distribution:

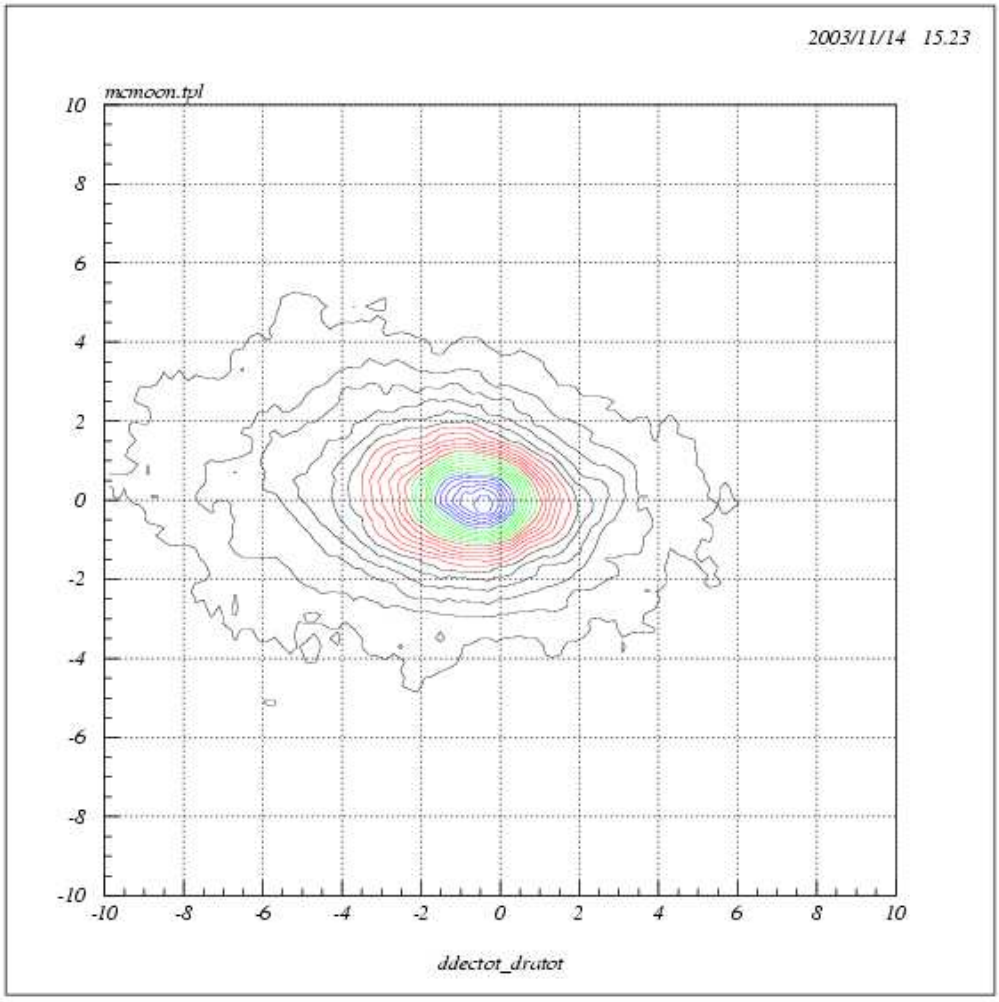

Figure 12:

Deficits obtained by Frank Samuelson.

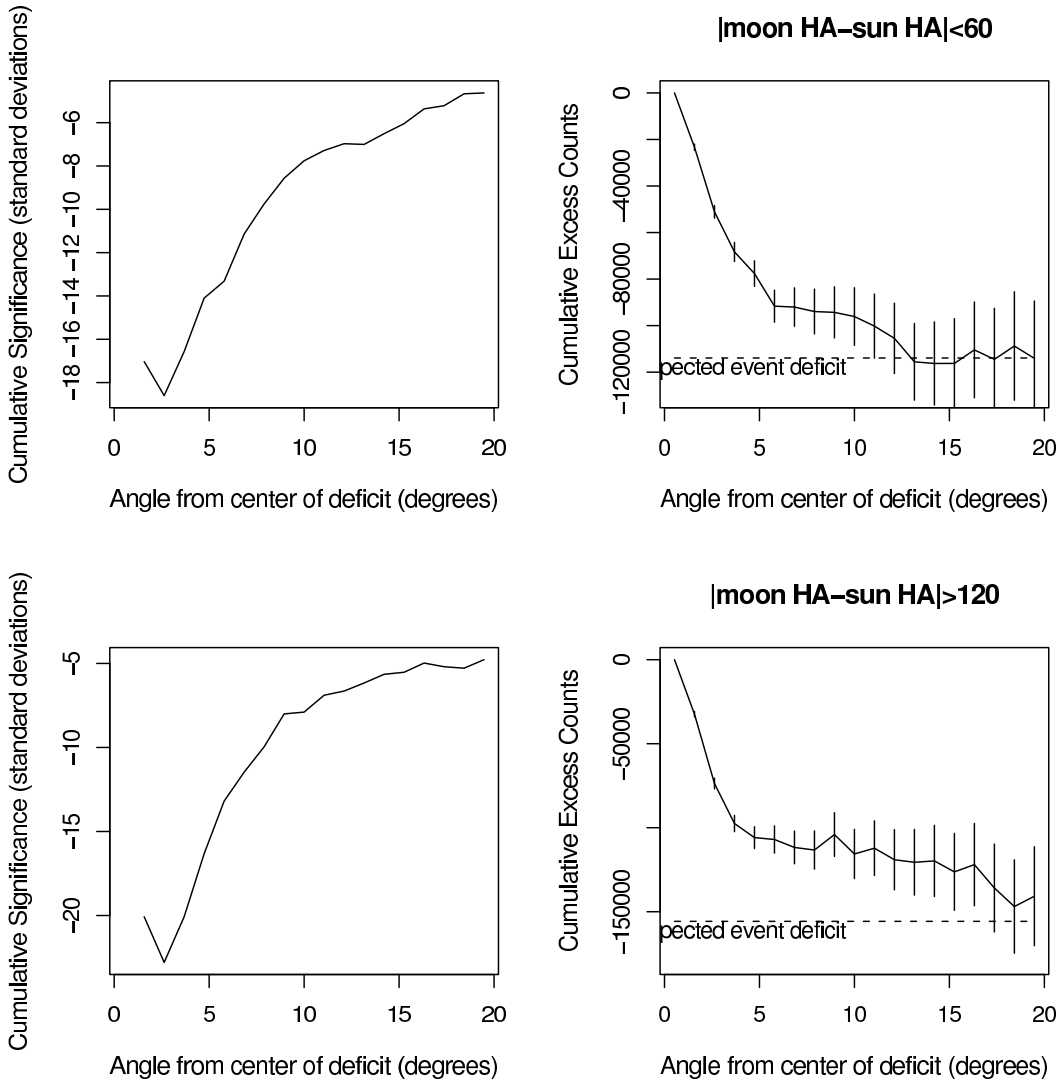

Figure 13:

Rotation of Coordinates

For both Monte Carlo and data, for each event, the direction of the magnetic deflection is known. It is possible to calulate the deviation from the moon center in directions parallel and perpendicular to the magnetic deflection. Figure 14 shows the distribution parallel to the deflection direction (positive is along this direction.) This is for $N_{fit} > 25$

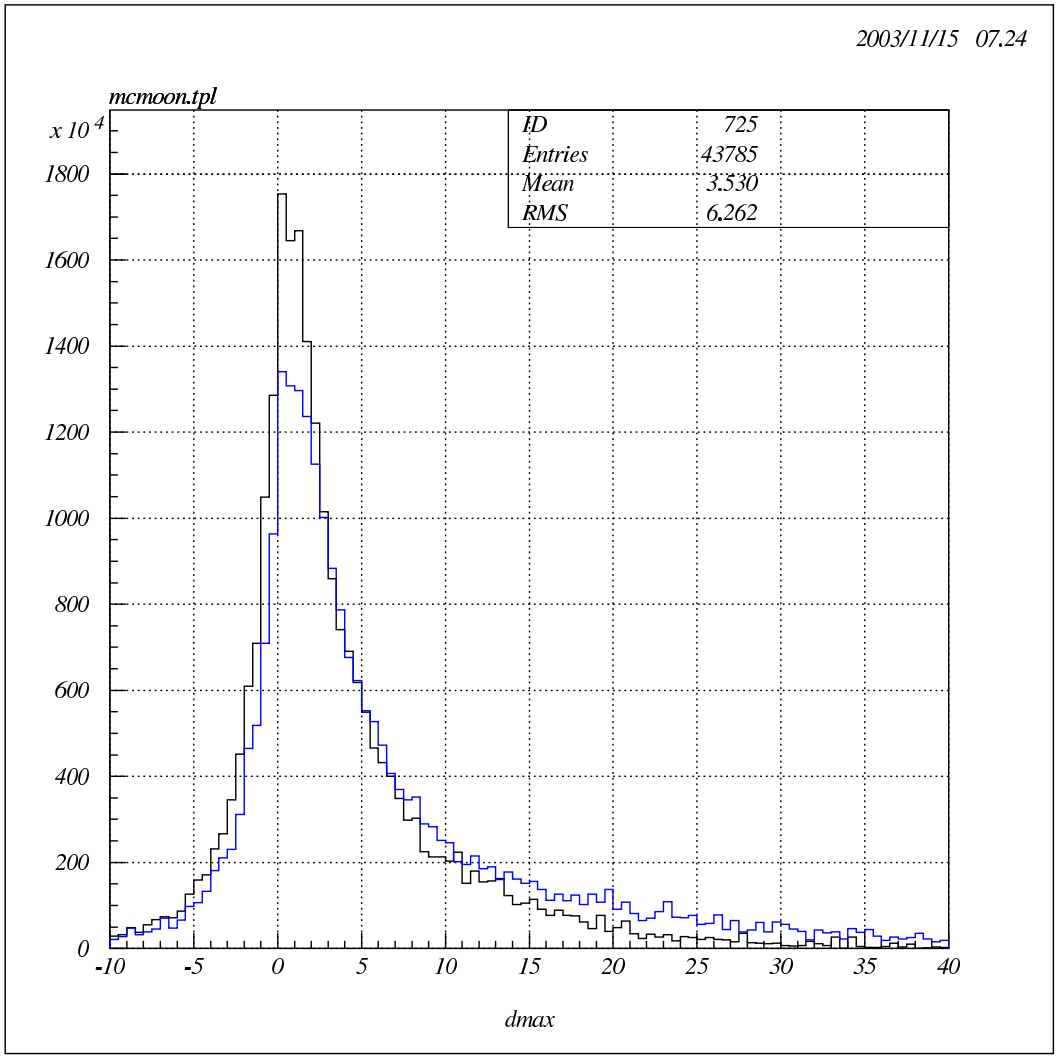

Figure 14: Maximum deflection, $N_{fit} > 25$

Here is the component in the perpendicular direction:

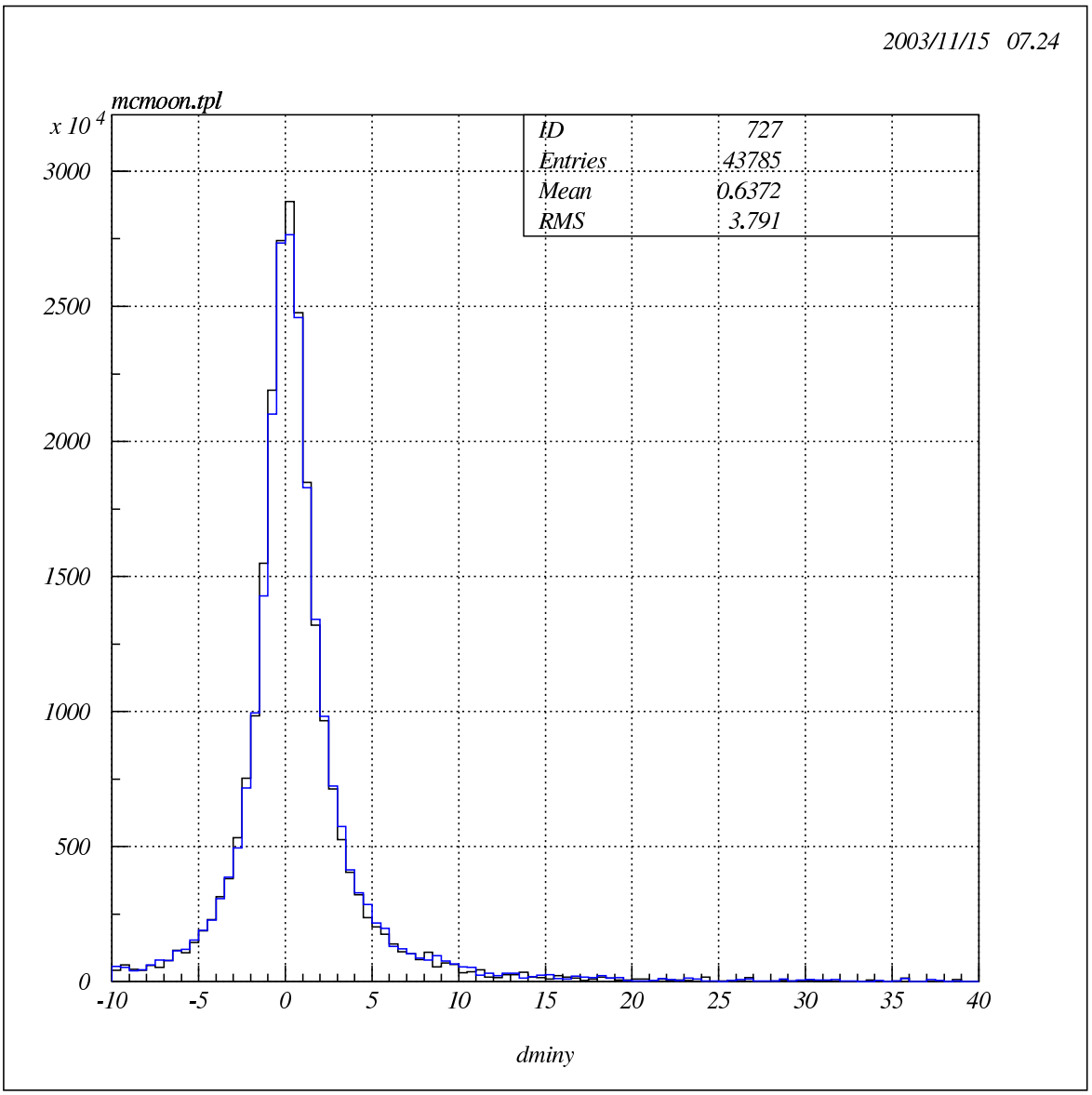

Figure 15: Perpendicular direction, $N_{fit} > 25$

The above two distributions are now **subtracted** from each other, after normalizing them so that the negative deflections have the same total number. The result is:

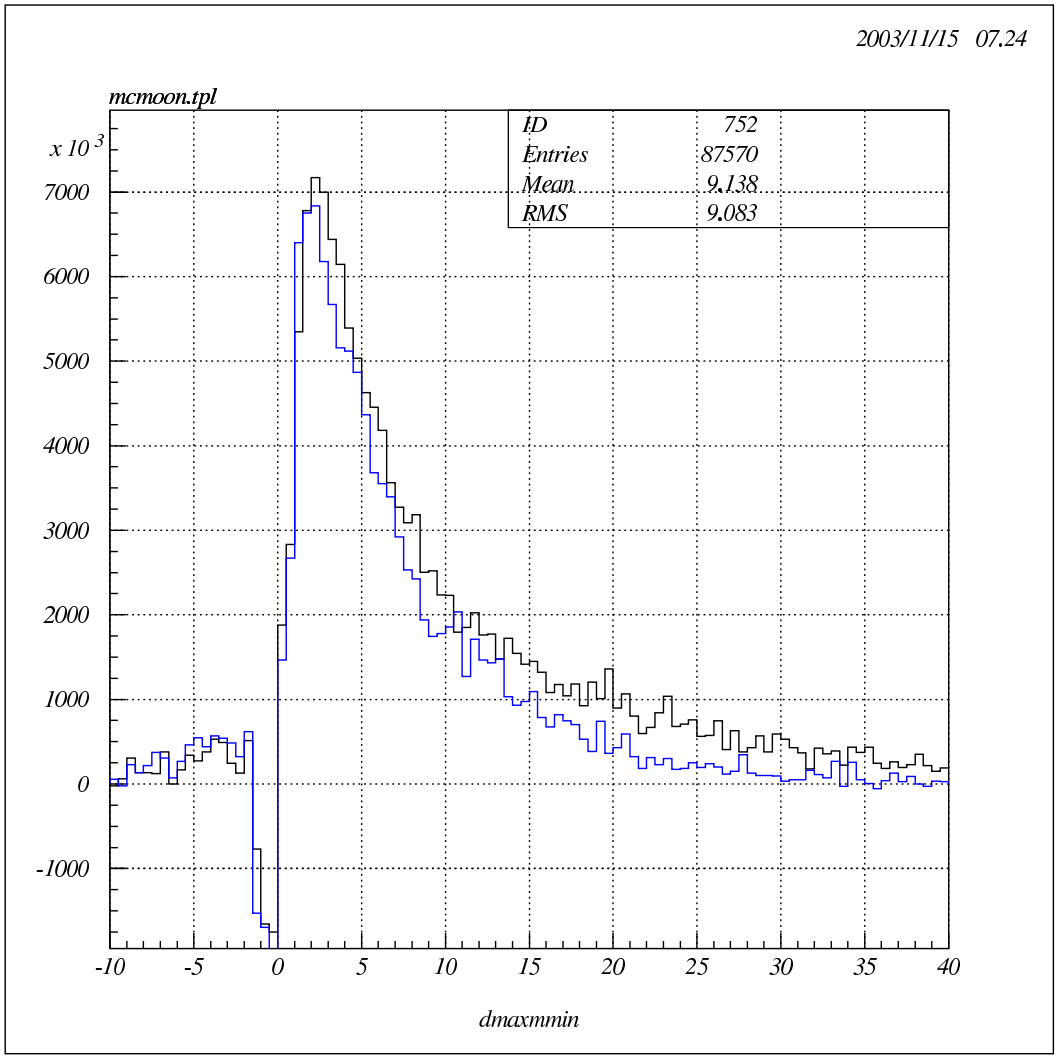

Figure 16:

The same, for $N_{fit} > 100$.

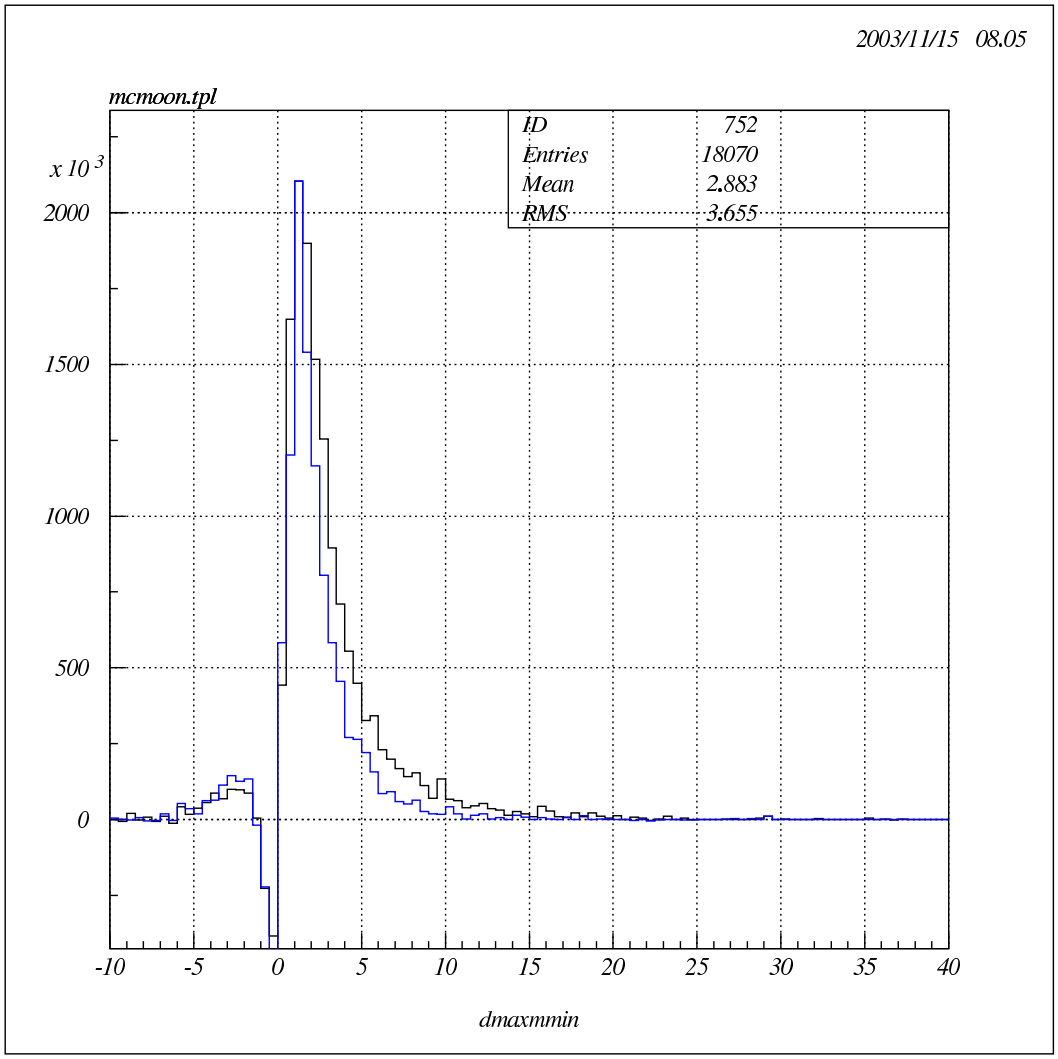

Figure 17: