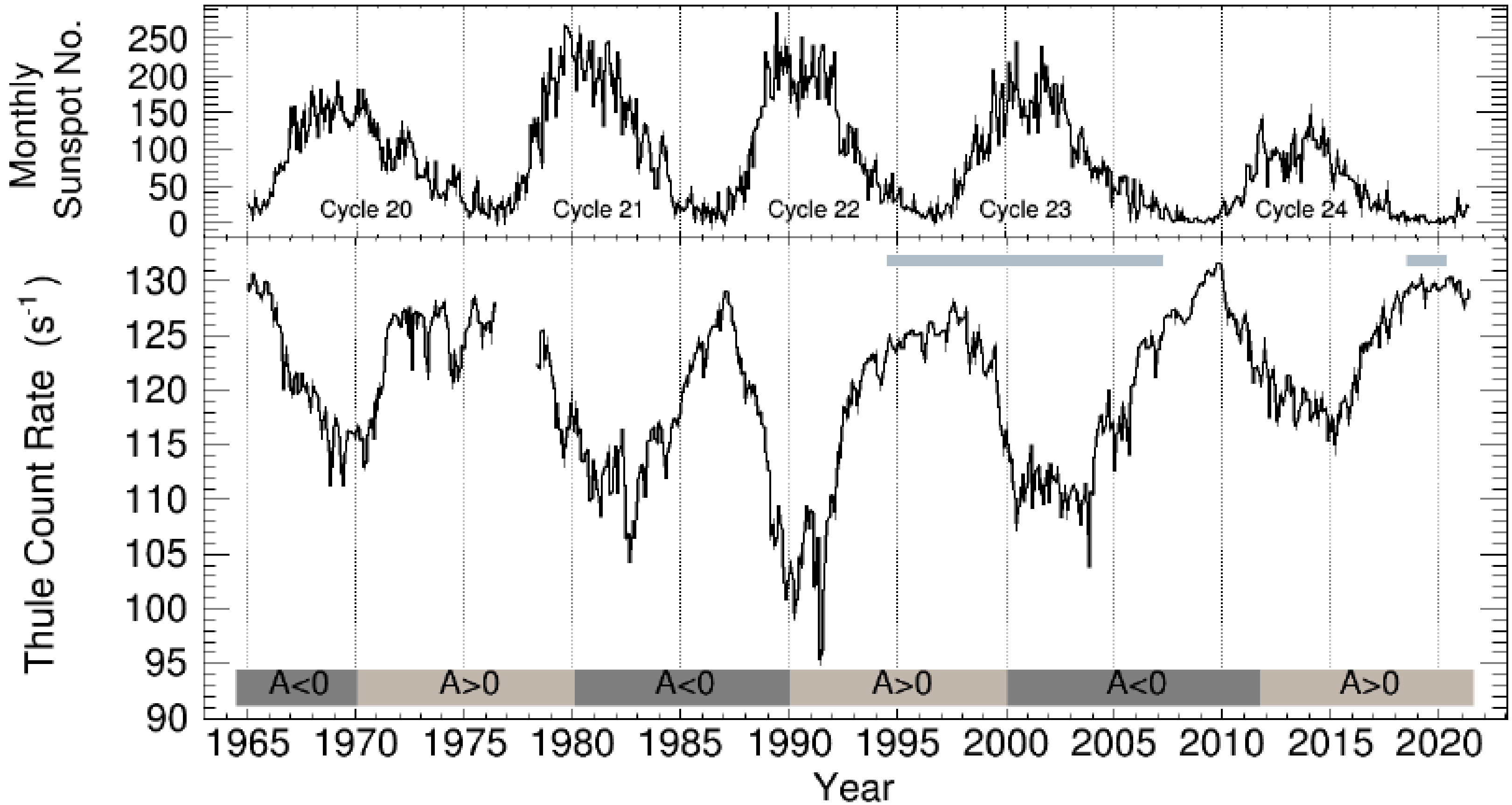
37th ICRC – Berlin 2021

Multiple Particle Detection in a Neutron Monitor

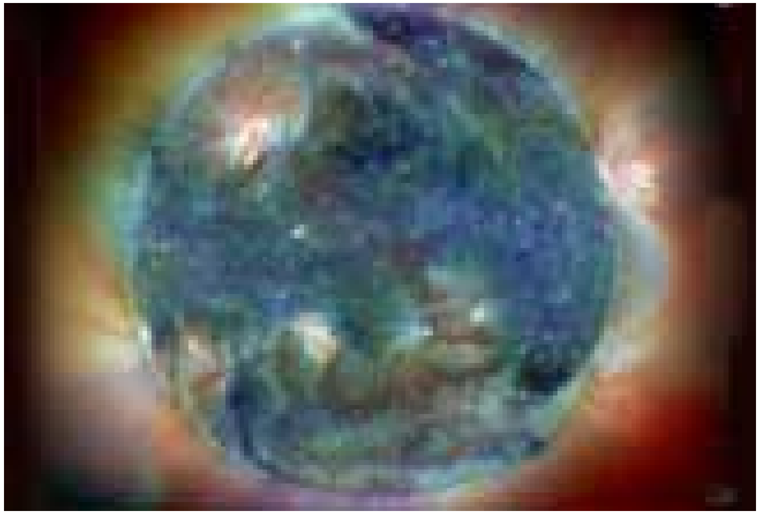
Paul Evenson,[a,*] John Clem,[a] Pierre-Simon Mangeard,[a] Waraporn Nuntiyakul,[d] David Ruffolo,[b] Alejandro Sáiz,[b] Achara Seripienlert[c] and Surujhdeo Seunarine[e]

Since everything is asynchronous, this talk will focus more on the context of our work, while the written paper concentrates more on the technical details

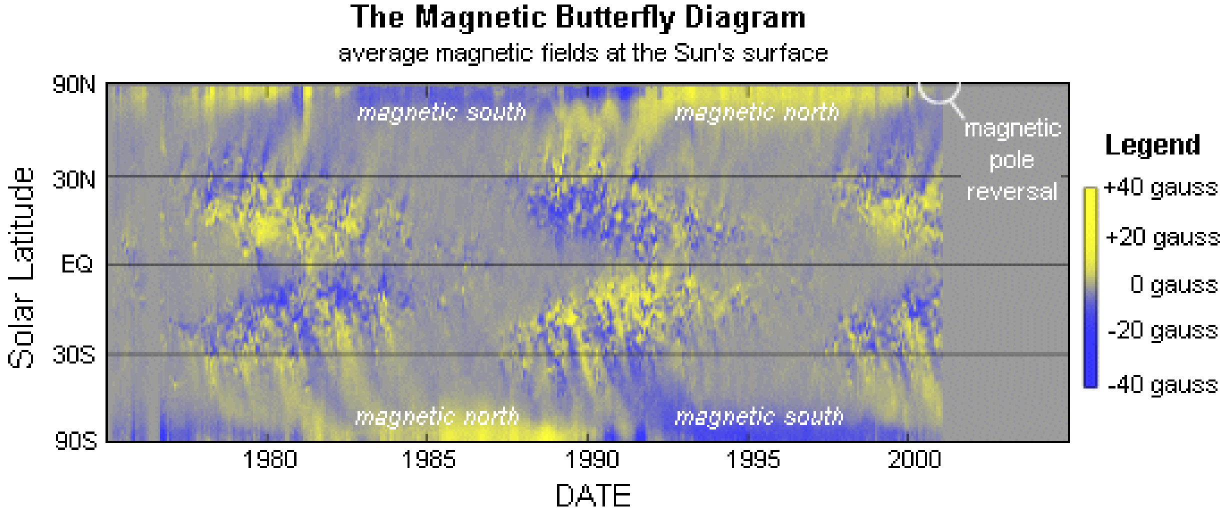
Solar Modulation – A 22 Year Cycle



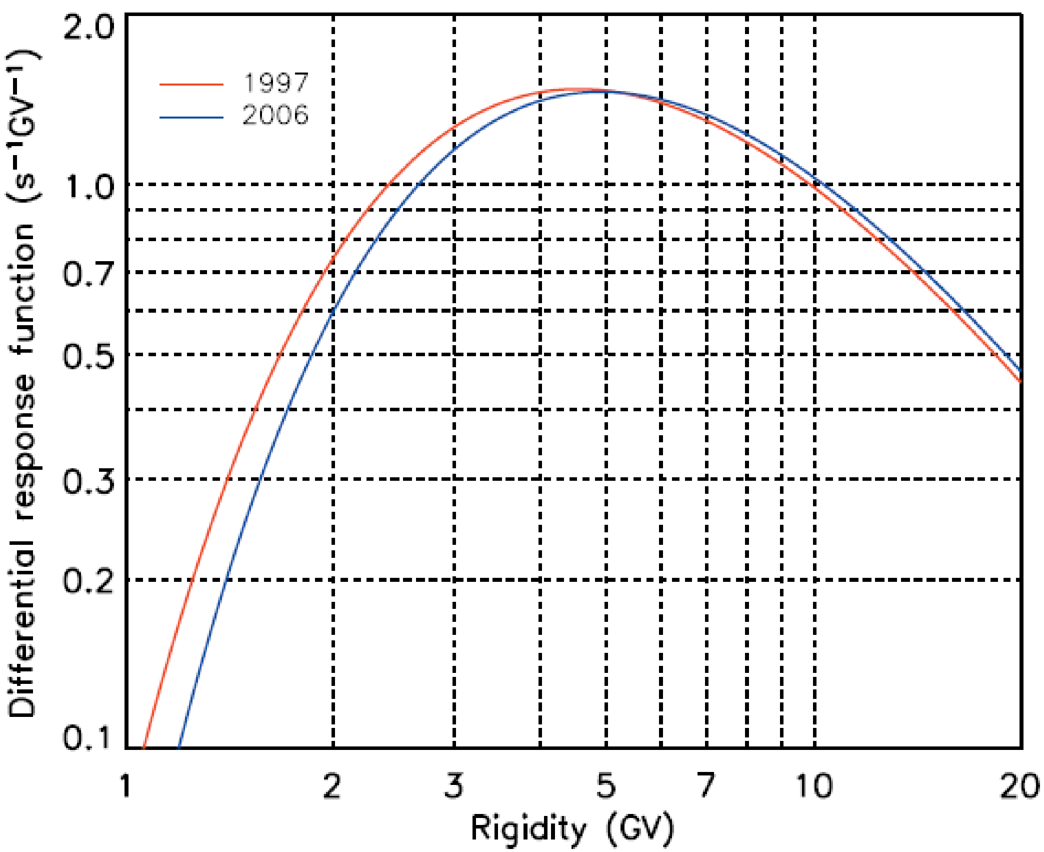
Solar Magnetic Field



- Unlike the earth, the magnetic field of the sun has not yet become nearly a dipole at the surface.
- There is a dipole component, but it takes careful measurement to find it in the surface fields.
- The dipole component reverses every eleven years or so.



Spectral Shape Changes



All energies modulate, but the amount varies with energy producing a "crossover" in the differential response function.

Two effects combine to produce the crossover.

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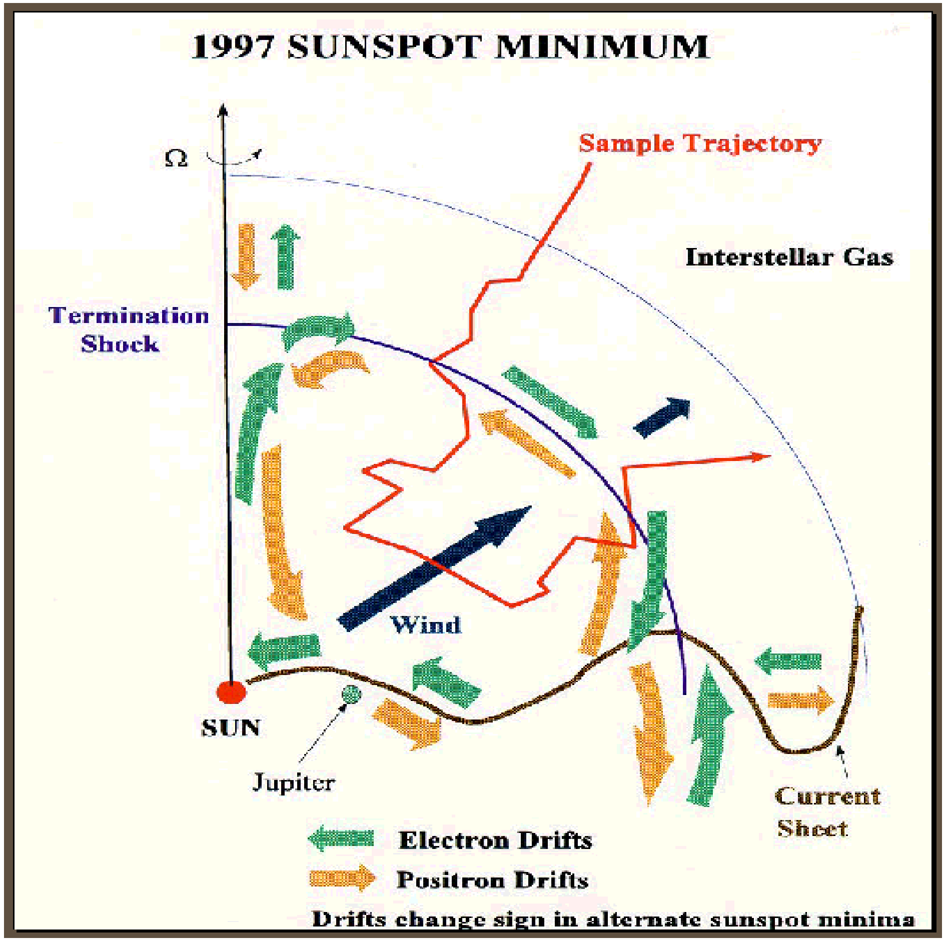
Large Scale Drifts

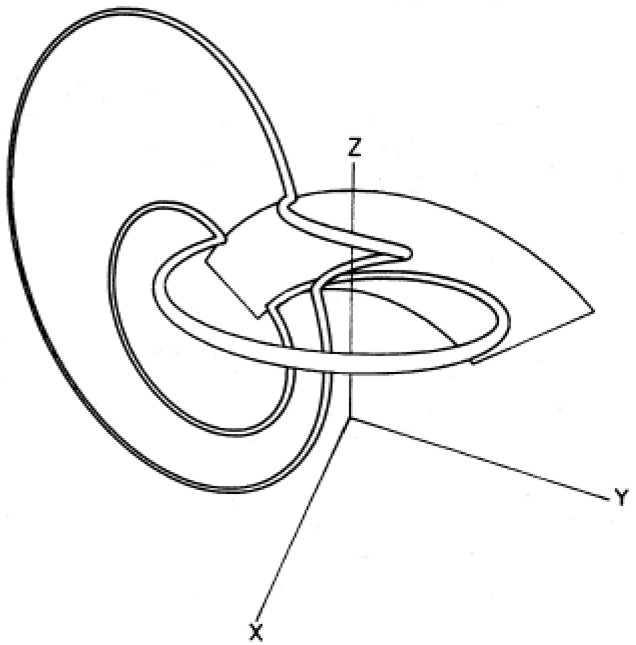


The Parker Spiral field is not axially symmetric.

Large scale "gradient and curvature" drifts of particles in opposite directions can occur.

Jokipii, Levy & Hubbard (Astrophys. J. 213,861-868, 1977) showed that, coupled with energy changes in the expanding solar wind, this can result in different modulation levels for different solar polarity.

Small Scale Helicity



Using interplanetary magnetic field data acquired at 1 AU, Bieber, Evenson and Matthaeus (GRL 14, 864-867, 1987) showed that the distribution of magnetic helicity in the solar wind is asymmetric about the current sheet.

Asymmetric helicity cause systematically different diffusion coefficients for oppositely directed magnetic field.

Coupled with energy changes in the expanding solar wind this can result in different modulation levels.

Summary

In positive solar polarity:

- Drifts bypass diffusion.
- Helicity decreases diffusion coefficients.

The implication of the “crossover” is that drifts dominate at low energy and helicity dominates at high energy.

Extending spectral measurements above what can be attained by latitude surveys is vital – it is unlikely that AMS will still be active on a 22 or 44 year timescale.

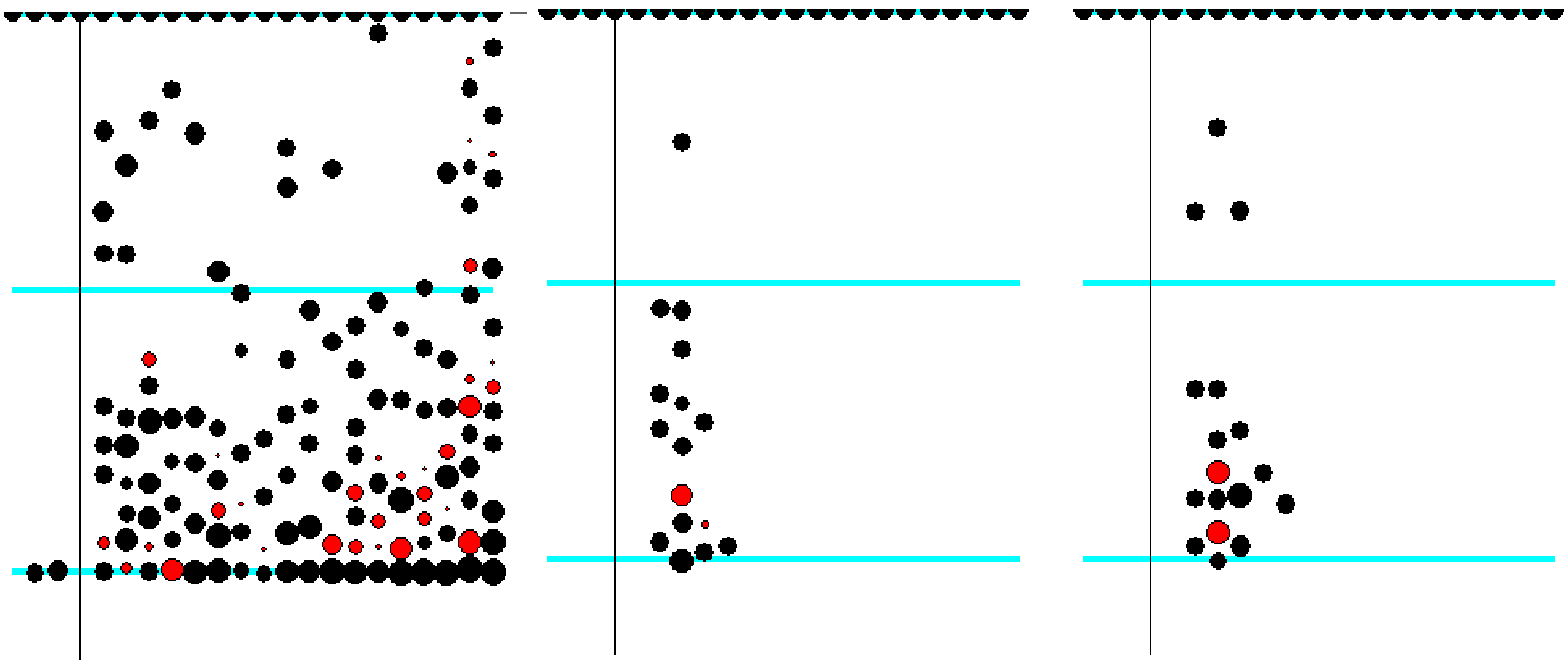
Our Approach

Develop techniques to use “multiplicity” at the high altitude (2,565 m), high cutoff (17 GV) Princess Sirindhorn Neutron Monitor to measure changes in the cosmic ray spectrum with time.

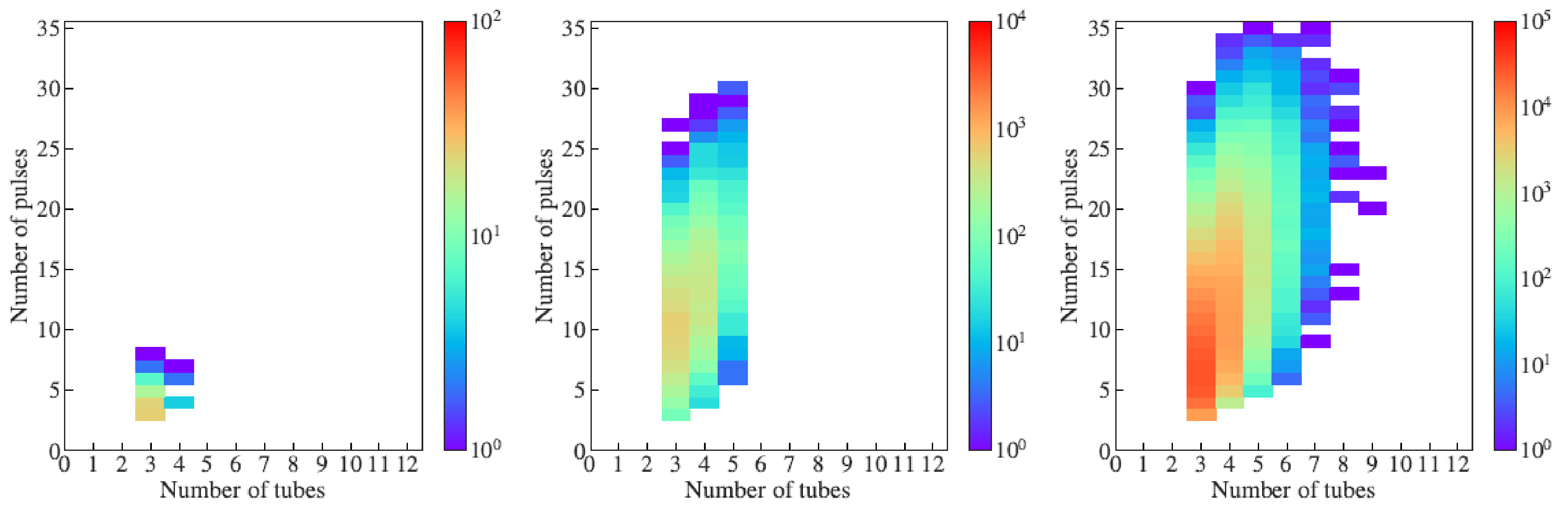
Here we present initial results using interaction patterns in multiple detectors.

PSNM Interaction Histories

Actual air shower core (left) and two simulated 100 GeV neutrons. Time runs upward; blue lines are one millisecond apart.

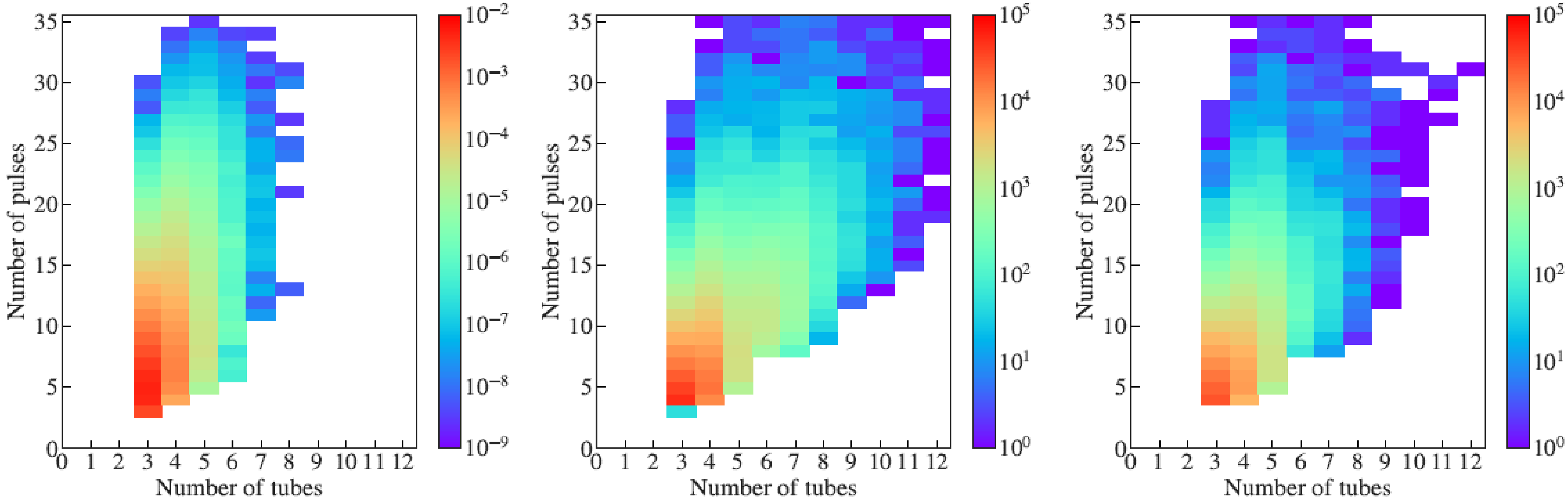


PSNM Simulations



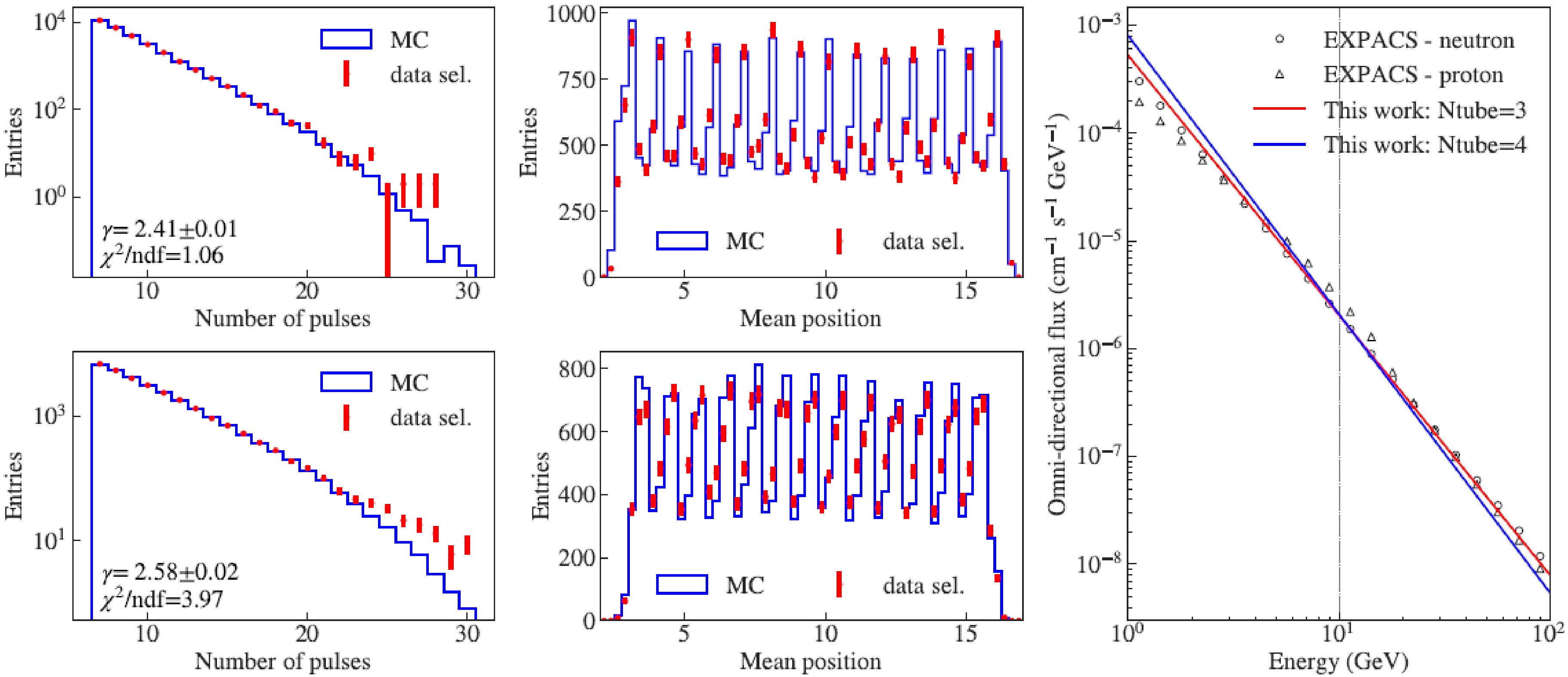
In each case the number of detectors hit is plotted horizontally, while the total number of hits is plotted vertically. Left: 1 GeV neutron pencil beam. Center: 100 GeV. Right: 1 to 100 GeV, E^{-1} spectrum distributed in location and incident direction.

PSNM Simulation and Data



Left: Simulation re-weighted to $E^{-2.5}$. Center: Two days of actual data. Right: Data selected for a single, contiguous span of hit detectors with no hits in the end detectors.

Analysis Compared to EXPACS



By adjusting the weighting we can produce good fits (normalized for now) to EXPACS calculations of the expected secondary spectrum

Conclusions:

- With a relatively simple analysis we can measure the spectrum of secondary particles at PSNM over a wide energy range with high statistics on a daily basis.
- Future work:
  - Better deconvolution and background rejection.
  - Atmospheric variability corrections.
  - Relate the secondary spectrum to primary spectrum
- We are taking data to span the next polarity reversal