Hi Eric -

Here is a draft abstract. It is much too long, but I suppose I can edit it later!

With thanks for your organizing efforts, Alanna

PS I think you were right about the importance of involving statisticians and engineers with the solar data. On Monday I kept having the feeling in my gut that we were there at the beginning of something fundamentally important.

Measuring What We "See" in Poisson Images, or, Is That a Bridge over the Milky Way?

Alanna Connors et al.

Some of the interesting and challenging measurements of high energy astronomy have come not from detailed analyses of point sources, but from viewing and modelling the diffuse emission including: 1/ diffuse X-ray and gamma-ray glow from the plane of our Milky Way galaxy 2/ interesting structures such as jets or wind nebulae around particular point-sources such as black holes, or pulsars; and/or 3/ more local diffuse glow from nearby star-forming regions.

Understanding this diffuse emission presents a number of challenges.
It can span the sky, yet has detailed structure. We have a remarkable understanding of much of the physics (e.g. in the Galactic plane, one can model the X-ray/Gamma-Ray glow as due to supernovae remnants, plus clouds of gas and a 'sea' of low-energy photons lit up and boosted to high energies by energetic cosmic ray particles from the plane of our Milky Way Galaxy), yet key pieces remain unknown or uncertain (e.g. what is the true spectrum of cosmic ray electrons, protons, etc?). The gamma-ray (and X-ray) glow should correspond to detailed maps of the sky (from other wavelengths), but we don't know exactly how. Astrophysicists have tried a combination of detailed physical modelling as well as non-parametric methods, with some good success but also tough challenges. It is an intrinsically Poisson regime, where, to paraphrase B. Dingus and David van Dyk at SAMSI06, "each photon is a source".

To ilustrate these, we go through a 'simple' example of the question the existence or non-existence of a faint but broad "bridge" in >GeV gamma-rays seen in all-sky CGRO/EGRET data above the plane of the Milky Way (roughly following and updating Dixon et al 1998). Our simplifying assumptions include: 1/ we can ignore instrument smearing (i.e. image bin size > EGERT PSF); we ignore energy information (use only E > GeV); we assume our physics models (for galactic diffuse emission and catalog of point sources) are perfectly known. Then we use a Haar-wavelet-like multiscale model for the remaining diffuse glow (i.e a multiscale smoothing "prior"; Esch et al., van Dyk et al., Roy et al.). Under these assumptions, do we detect a "bridge" over the Milky Way? At what significance do we detect this feature? What can we say abot the uncertainty of its shape and extent? What happens if we relax some of our assumptions (model uncertainty; instrument smearing, etc)?

We use this example to put into context a sampling of other methods, from physics-based Bayesian to more frequentist non-parametric methods for sparse data (e.g. Rice, SAMSI06). How can these help us in understanding hard-to-model structures in our sky images?