Top-down triangulation (Making sky-maps from time series comparisons)

Cal Hewitt // SNEWS Collaboration Meeting // Purdue University // August 4th 2022

Idea and motivation

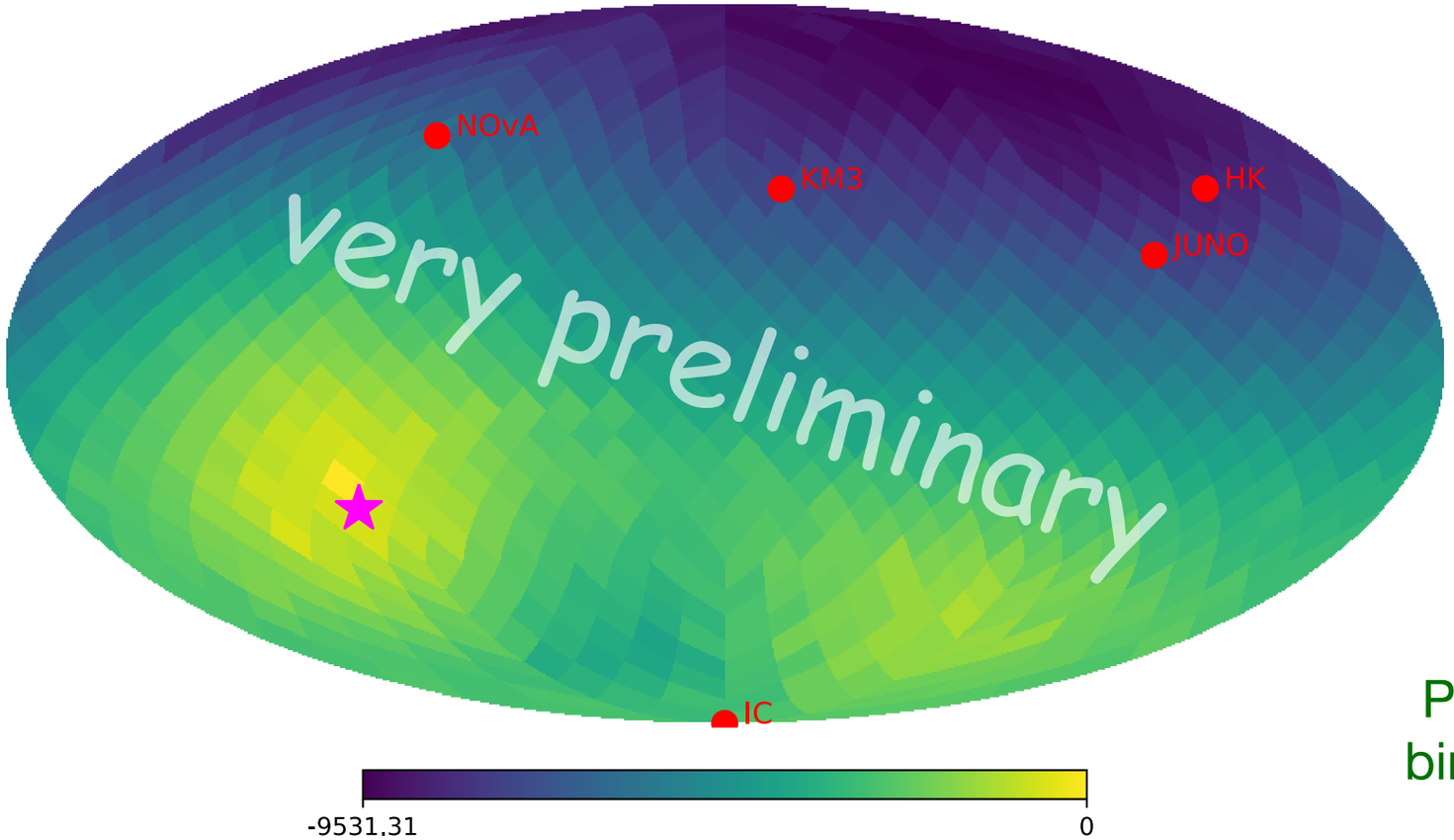
- Pose triangulation as an optimisation over RA/dec rather than a construction from pairwise time differences
- Every point in the sky is a timing hypothesis; test consistency of all time-series at a particular point
- Uses all the information
- Avoids dealing with individual (correlated) uncertainties
- In line with triangulation method used at LIGO/VIRGO (without templating)
- Potential to include other information (pointing from individual experiments?) in the overall likelihood function
- Can trivially produce a list of likelihoods for stars on the candidate list

Implementation

- Grid-search over whole sky quick enough with vectorized bin comparisons in Python
- Need a ~likelihood-valued consistency metric
- Poisson statistics in uniform bins is the simplest
  - Take average time series as the most likely (data-based expectation)
  - Performance depends on binning. Promising preliminary results from dynamic *non*-uniform binning (Bayesian Blocks)
  - Can use other metrics, eg. η from Josh Wang's thesis (χ^2-like, emphasising rapid changes)

Implementation status

- **Work in progress**
- Proof of concept using yields from SNEWS white paper, subtracted background of 3840^2 at IceCUBE, 0 elsewhere

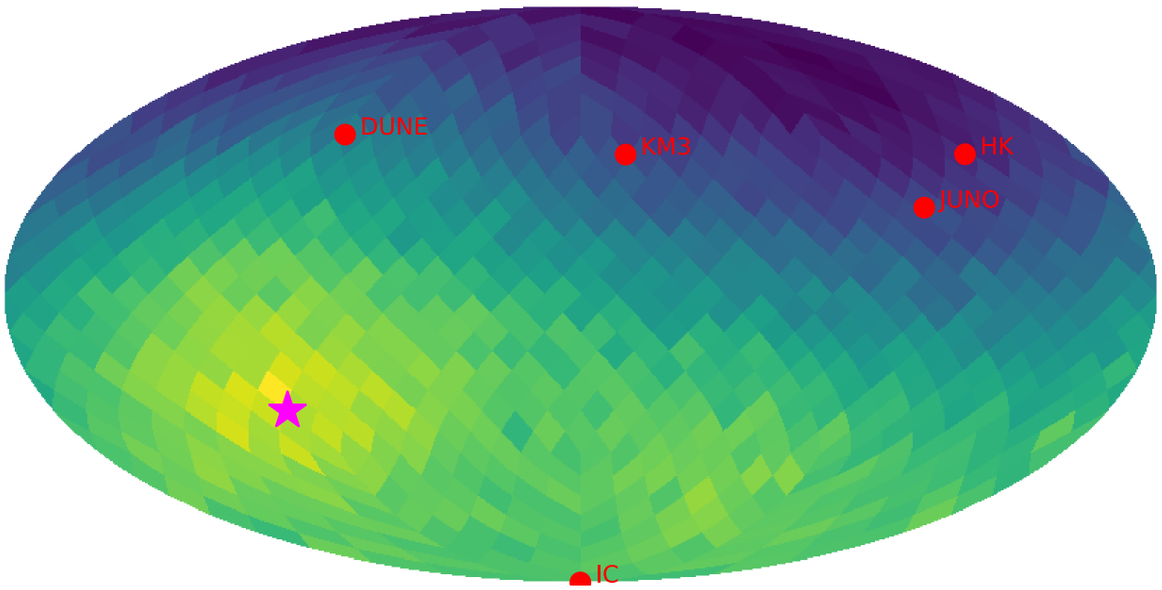


27 $M_\odot$; LS220 equation of state; anti-ν_e only

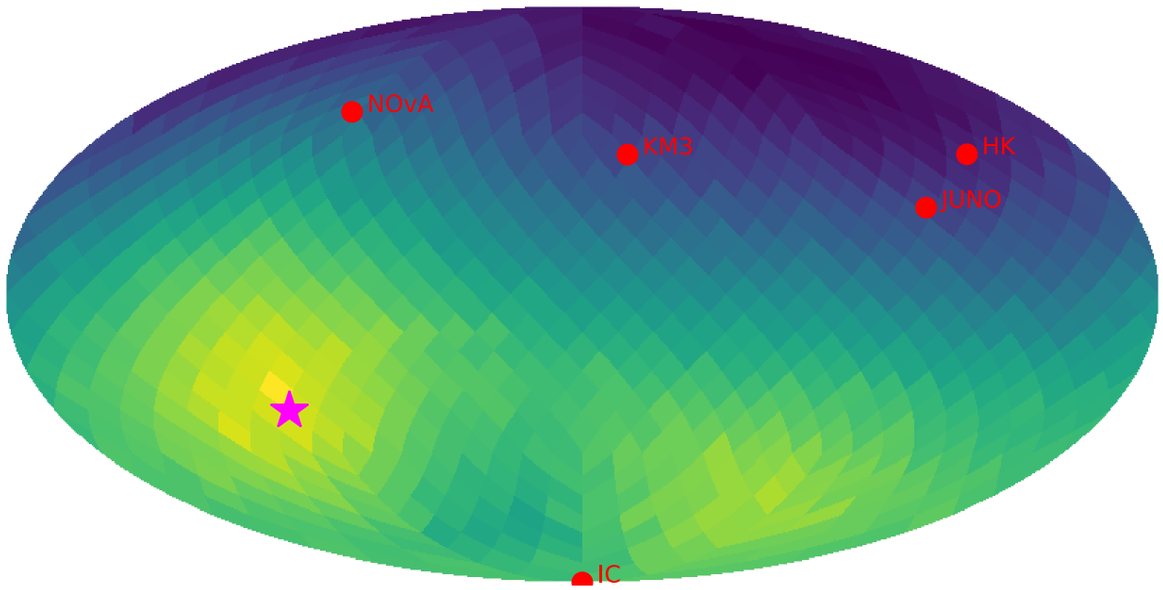
Plotting sum of log(LH) over bins. Confidence levels go as ~the exponential of this

Binning

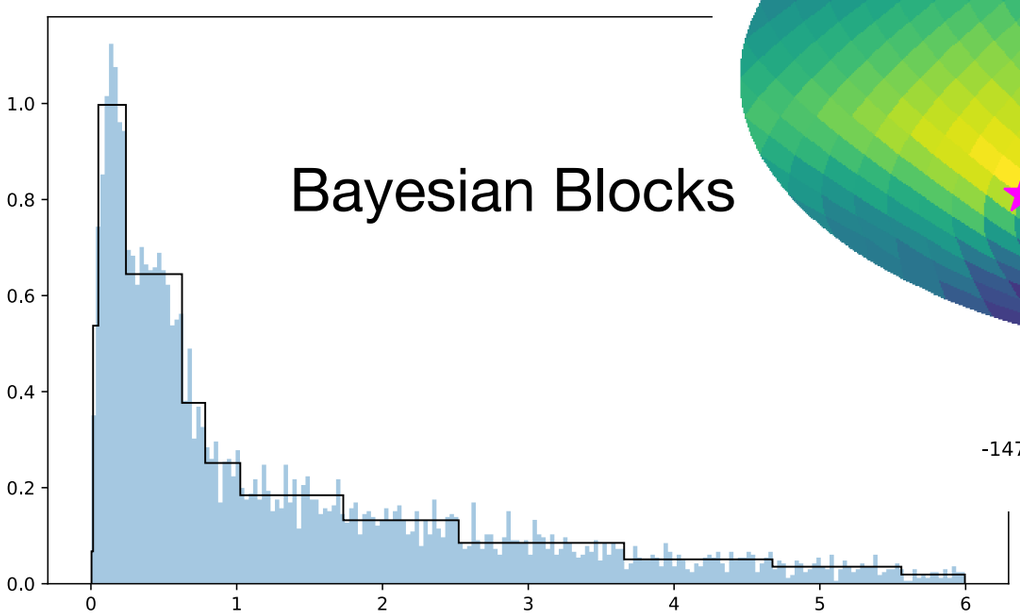
Uniform: 0.1ms

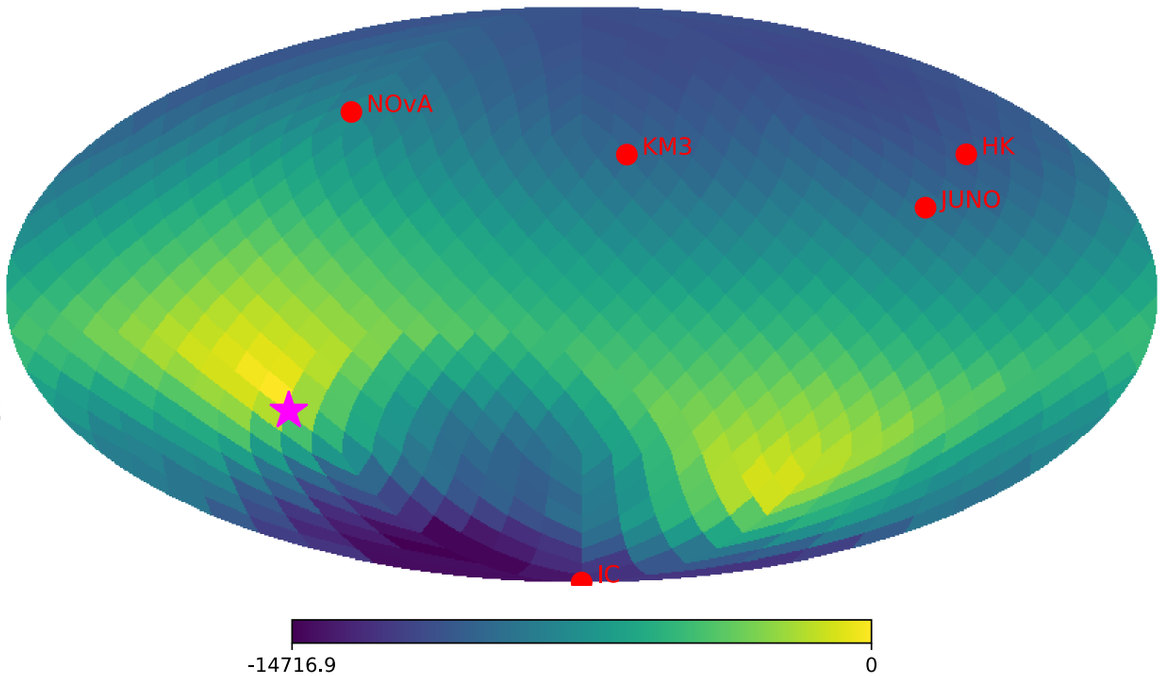


Uniform: 1ms

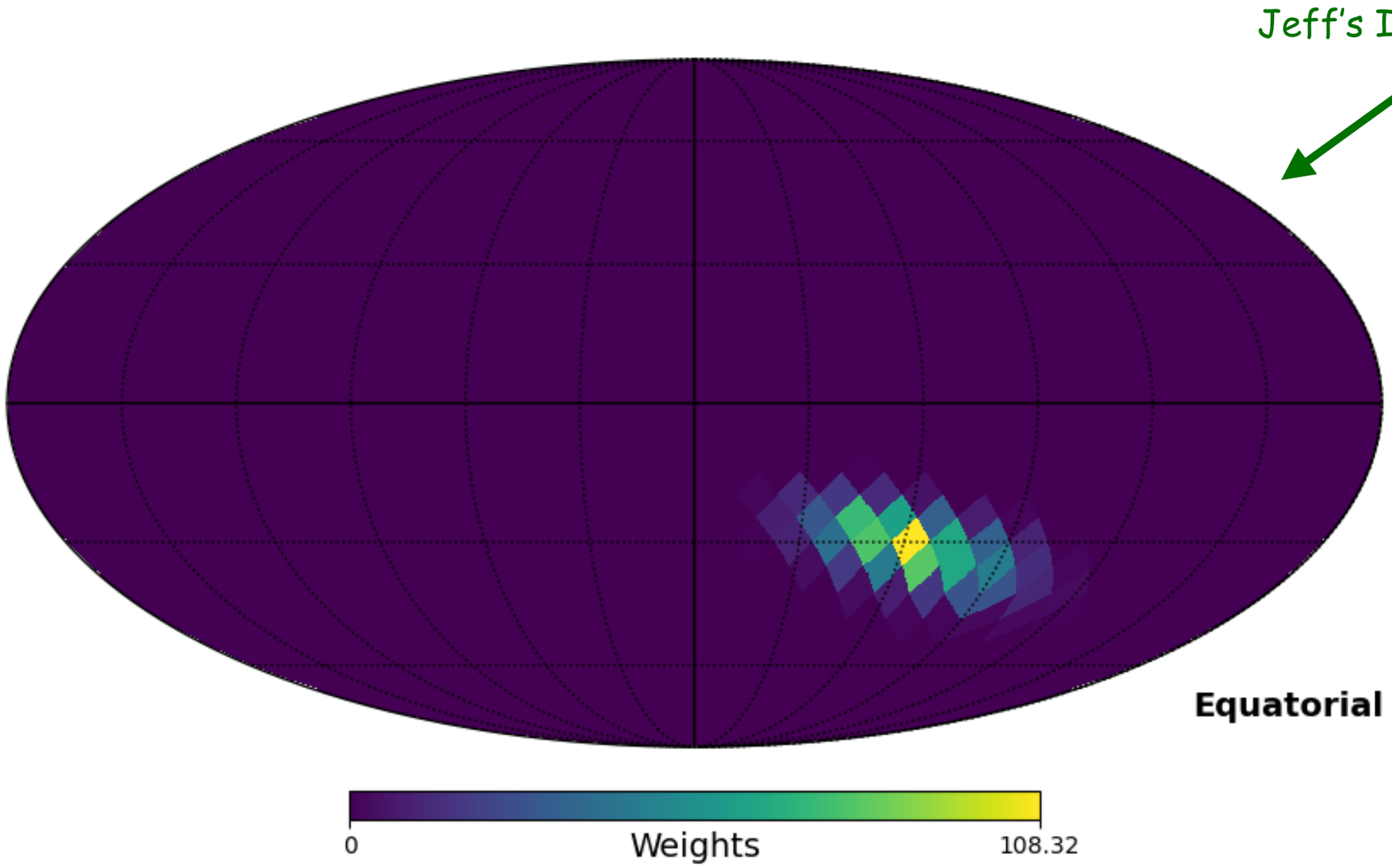


Bayesian Blocks





Conversion to probability



Sum of probability maps for 1000 MC trials
NOvA/SK/IceCube/KM3NET/JUNO
$27M_{\odot}$; yields from white paper
IceCUBE and KM3NET derated to model background

The work continues…

- More realistic test cases
    - Backgrounds
    - Detection channels
- Rigorous characterisation of resolution
    - Comparison of binning schemes and metrics
    - Comparison to ‘bottom-up’ method
- Uniting implementations and integrating into snewpdag