Searching for Signs of a Galactic Excess of Gravitational-Wave Bursts

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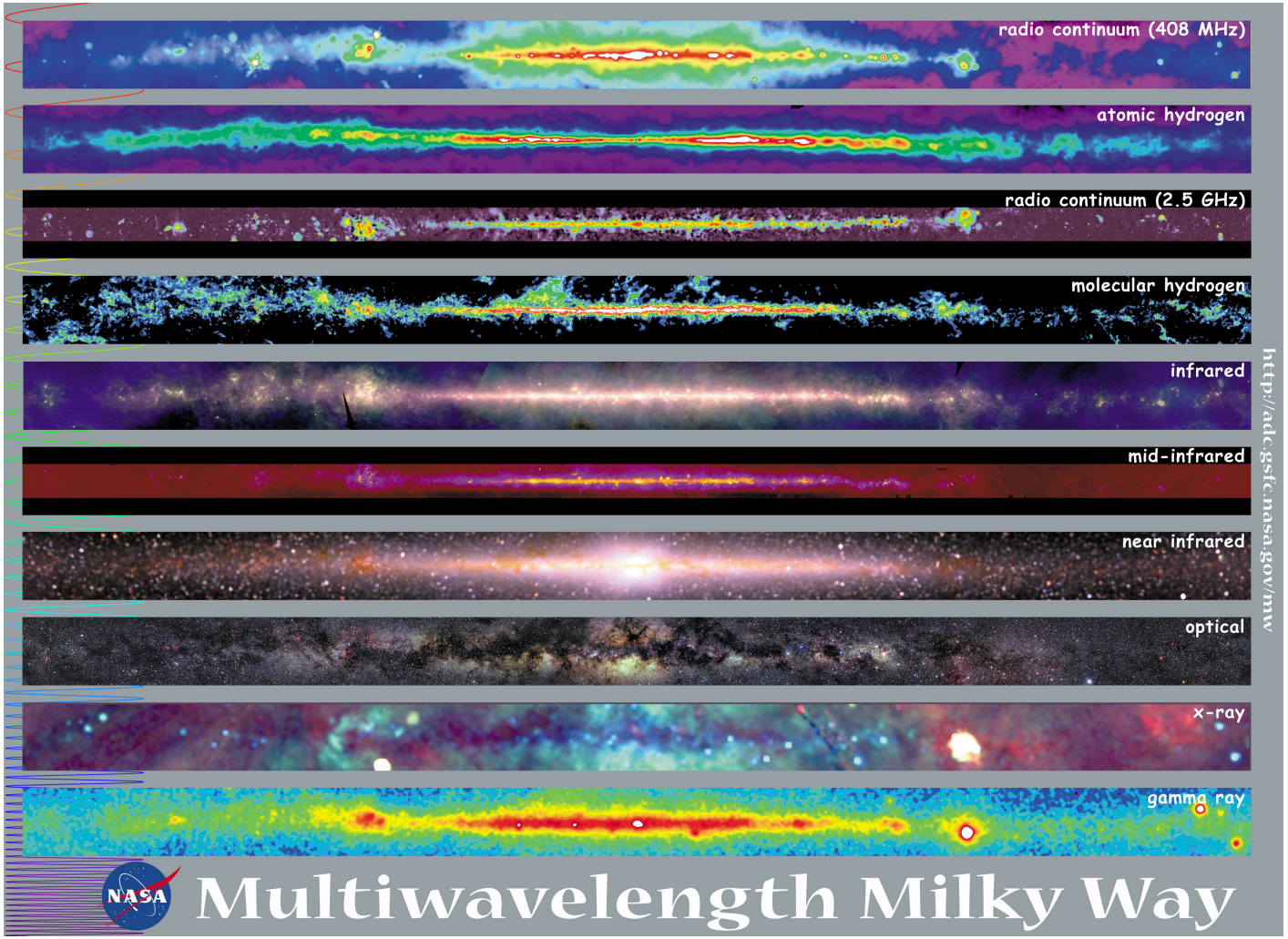
Outline

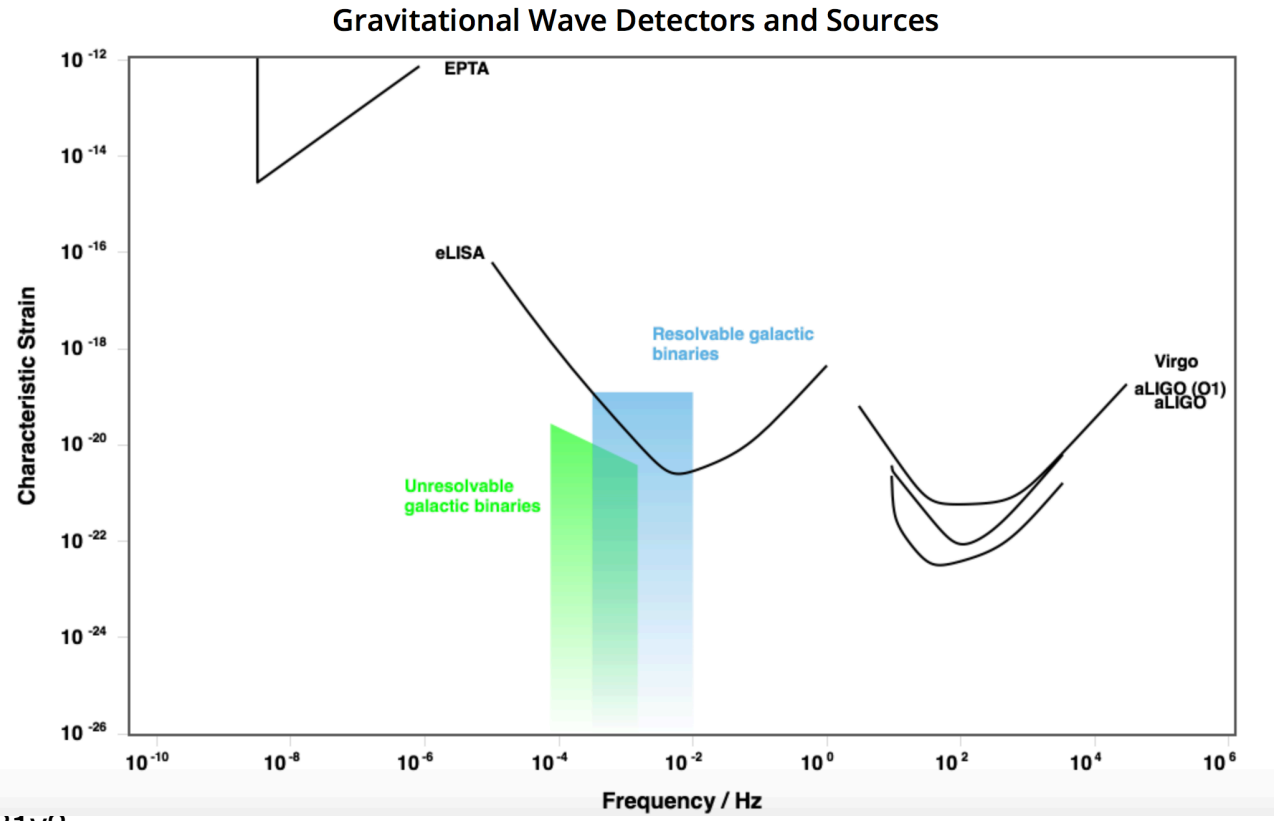
- Galactic Gravitational-Wave Bursts
- Project Details
- Sky Localization and Skymaps
- Simulating and Processing Data
- Results

Our Galaxy in the EM Spectrum



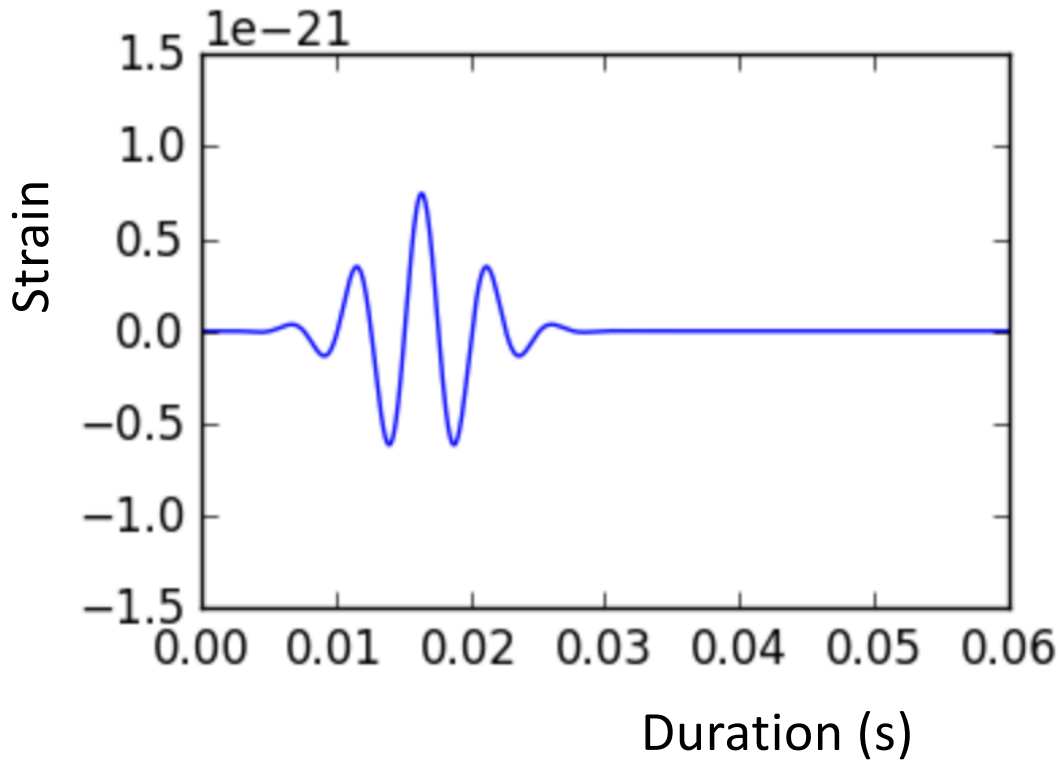
A Galactic Excess

- White dwarf binary systems
  - Radiate at frequencies too low for current detectors



Gravitational-Wave Bursts

- Transient event
- Unknown source
  - Supernovae, glitching neutron stars
- Unmodeled search



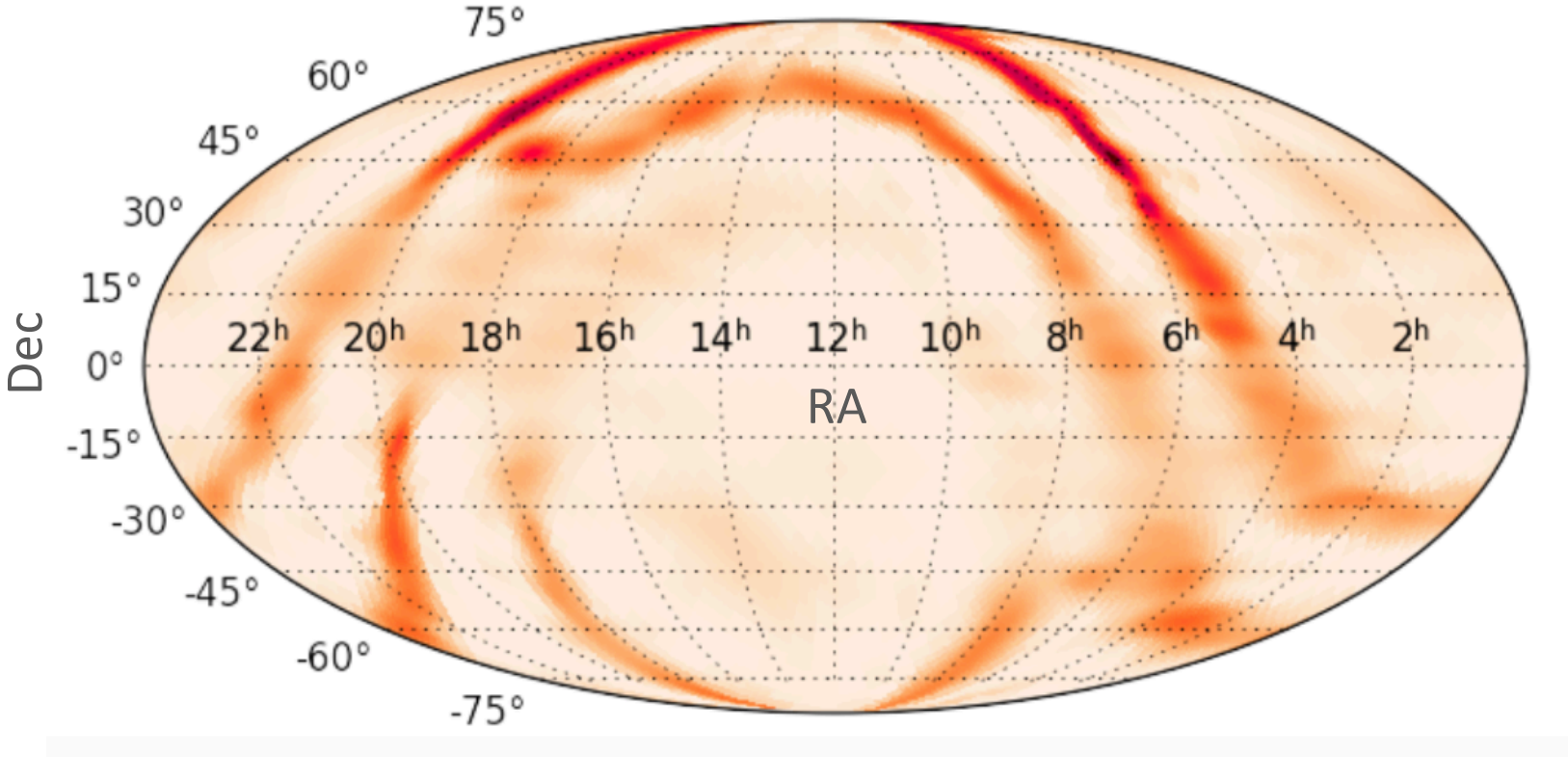
Project Motivation

- Is there a galactic source of gravitational waves radiating in the LIGO frequency band?
  - How can we detect it?
- How can we identify the source of an unknown burst signal?
  - Knowing whether origins are galactic or not will help

Project Description

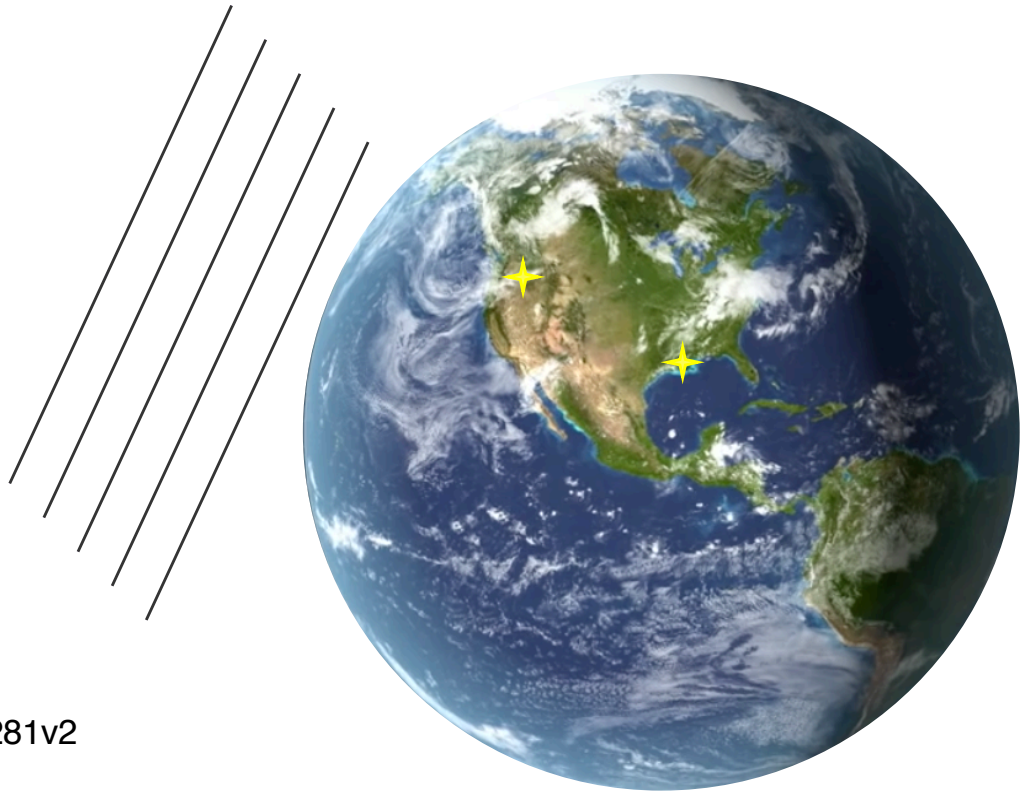
- Create two sets of simulated events
  - Isotropic and galactic
- Inject our two sets into Bayeswave and recover individual injections' sky distributions
- For each set, look at the overall population's distribution and determine if we can tell the difference between our two recovered populations

Skymap: Individual Injection

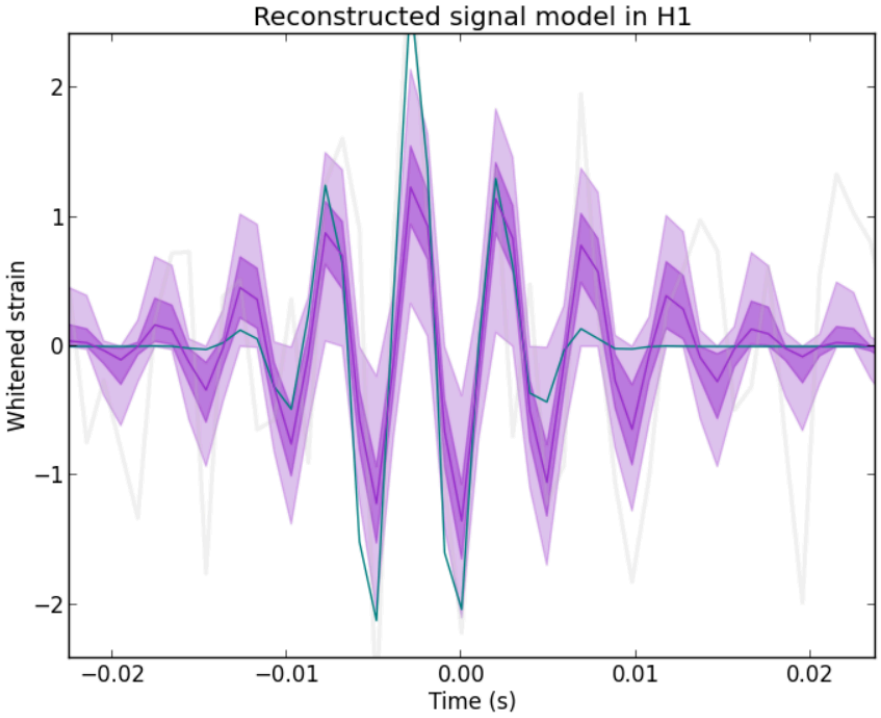


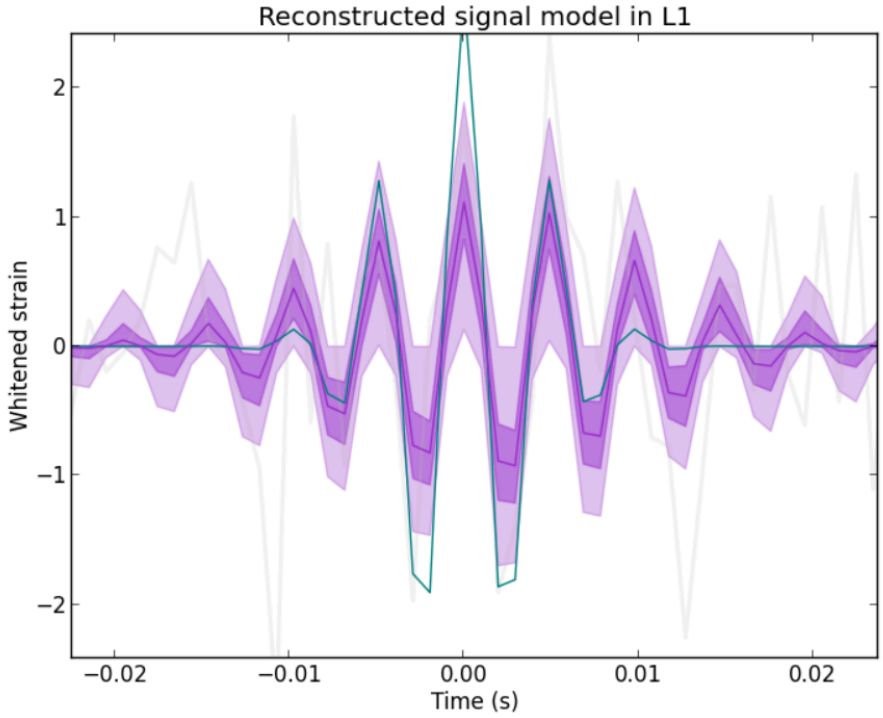
Sky Localizations

- Time delay between the signal's arrival
- Relative amplitude in detectors
  - Different orientations



Injected Signal





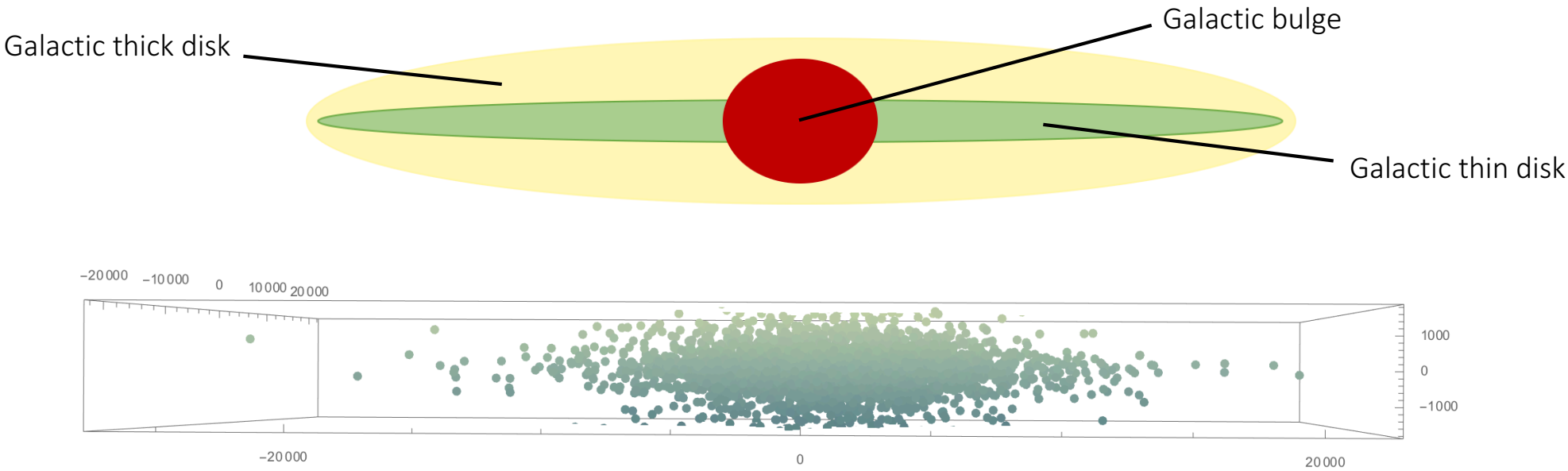
Injection Sets

- 2 sets: isotropic and galactic sky distribution
- Generated 2000 random sky locations according to given distribution model
- Created simulated GW burst events associated with each generated location
  - Sine-Gaussian signals, low quality factor
- 2000 injections, total duration spanning the length of a sidereal day

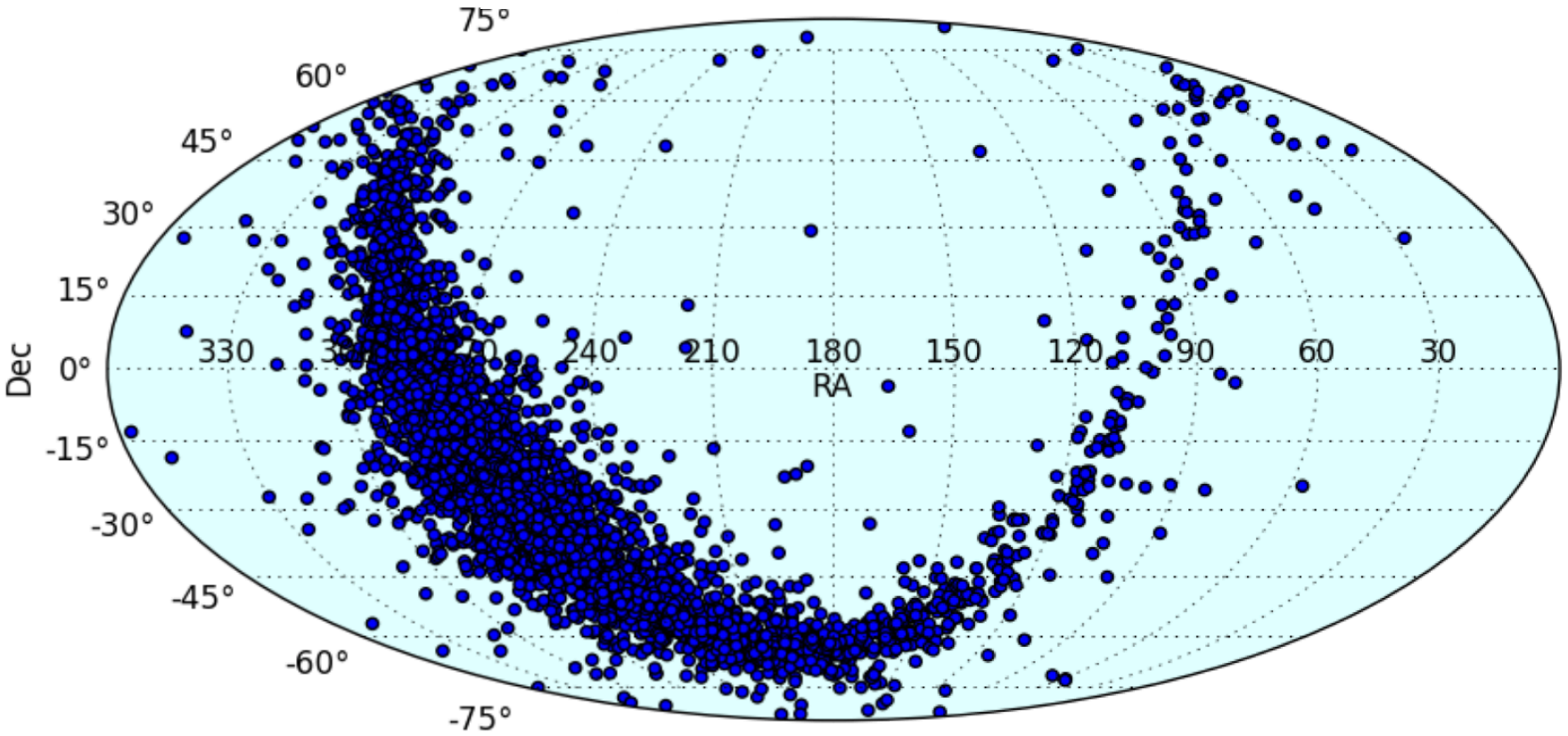
Galactic Distribution Model

- Empirical stellar number density function:

$$n(z,r) = n_0 \left(e^{-z/z_{\text{thin}}} + 0.085 e^{-z/z_{\text{thick}}} \right) e^{-r/h_R}$$

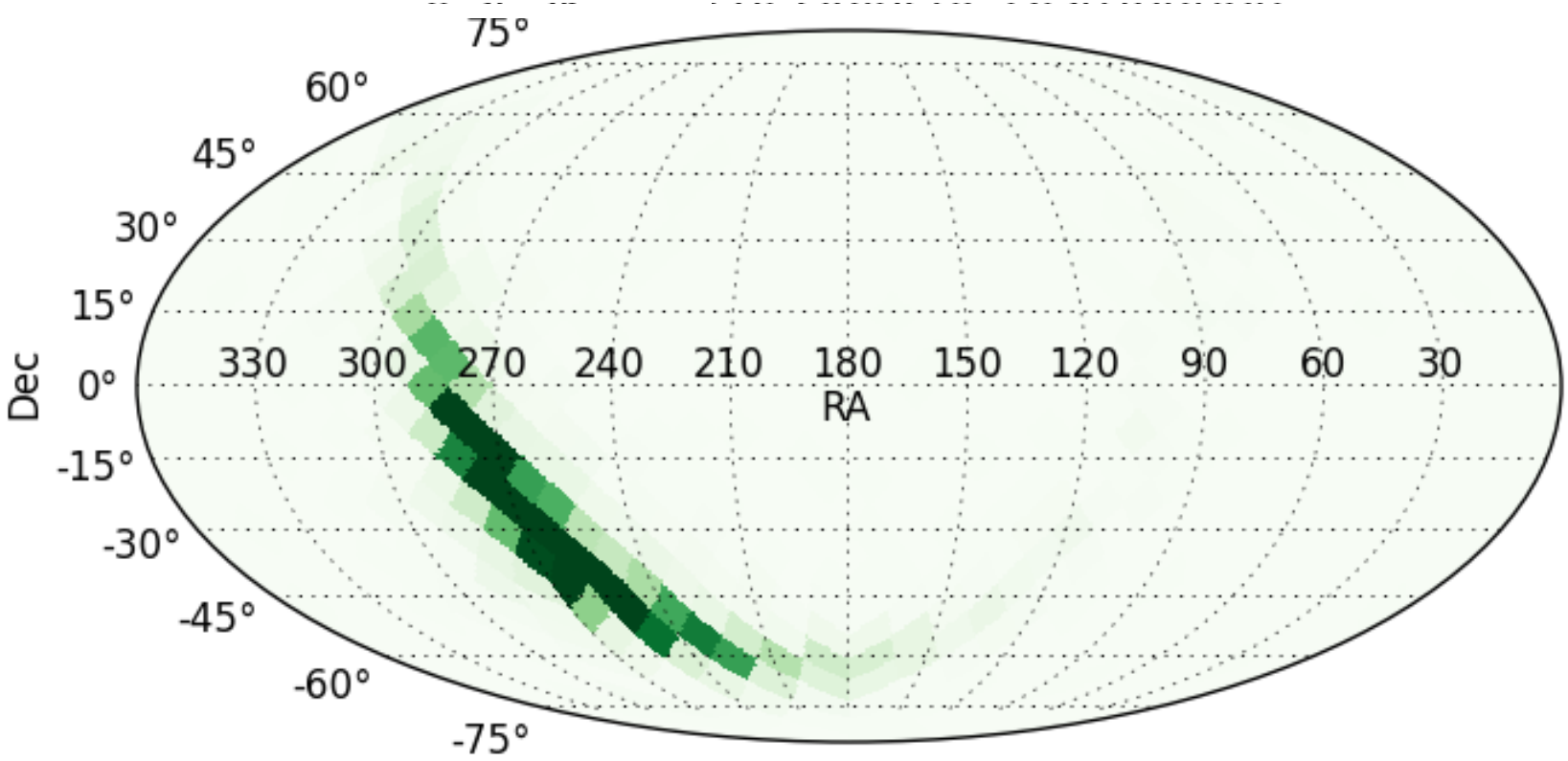


Galactic Distribution

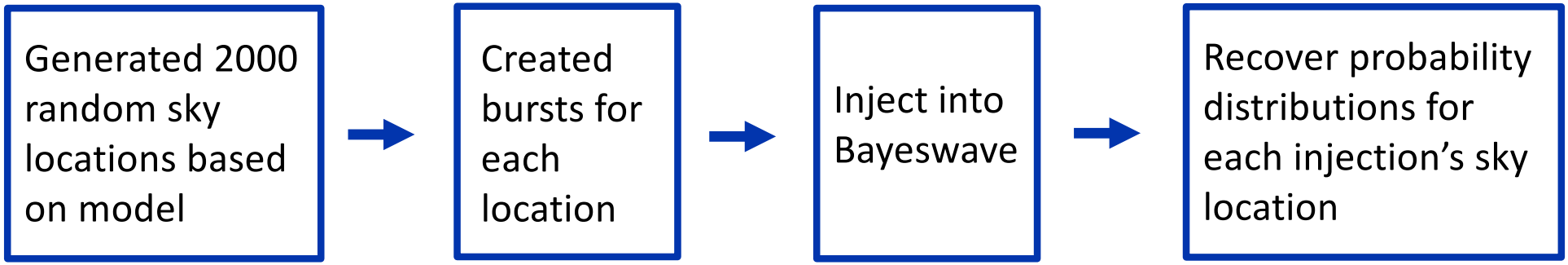


Galactic Distribution - HEALPix

- Equal area bins - pixels



Data Processing

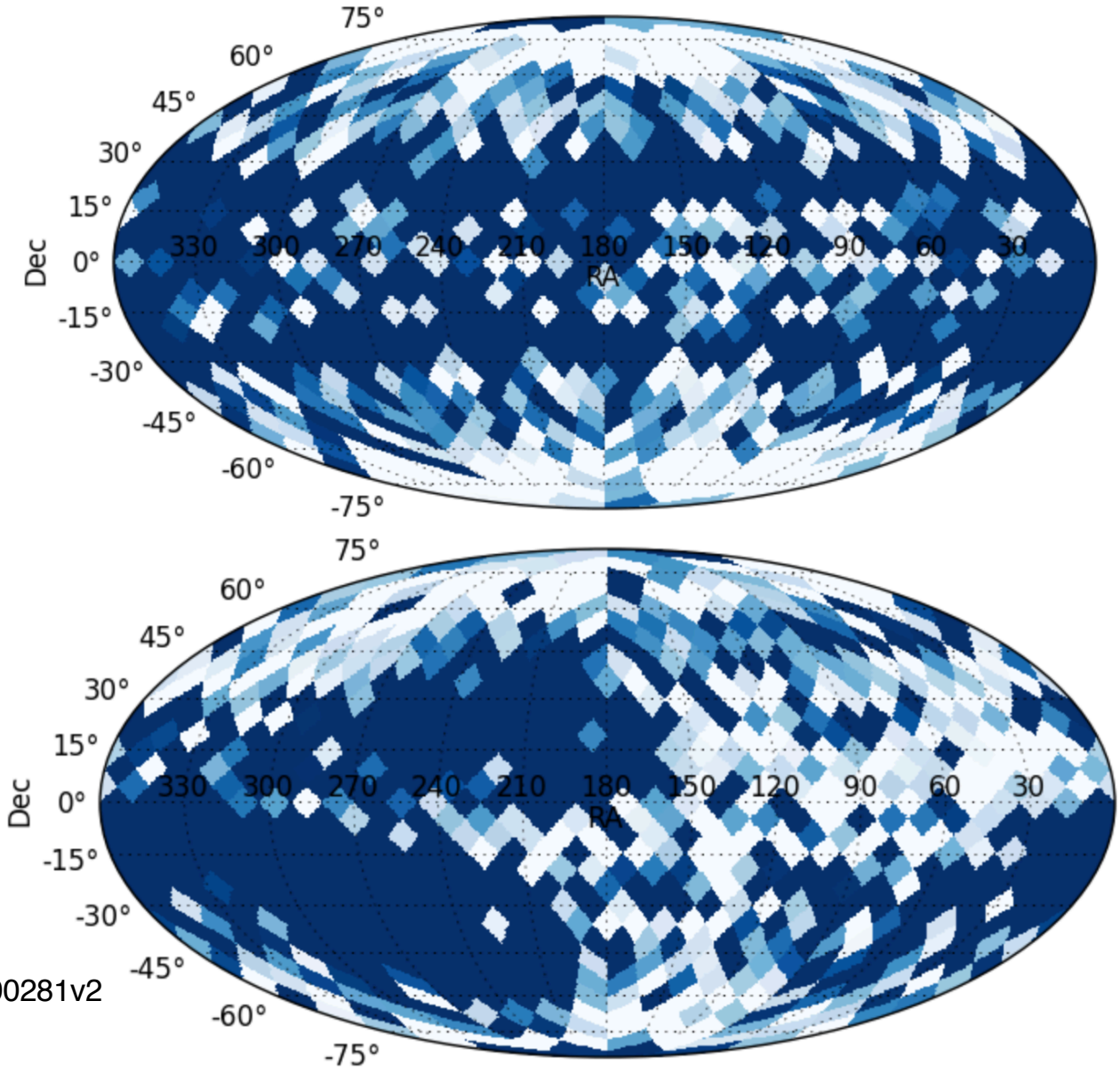


- Must combine the individual distributions of both the isotropic and galactic injections into a composite map of each population's overall sky distribution

Maximum Pixel Probability

- In each injection's HEALPix map, determine the pixel with the most probability
- Assume the signal did come from that pixel and add value to the corresponding pixel in the overall map

Maximum Pixel Probability



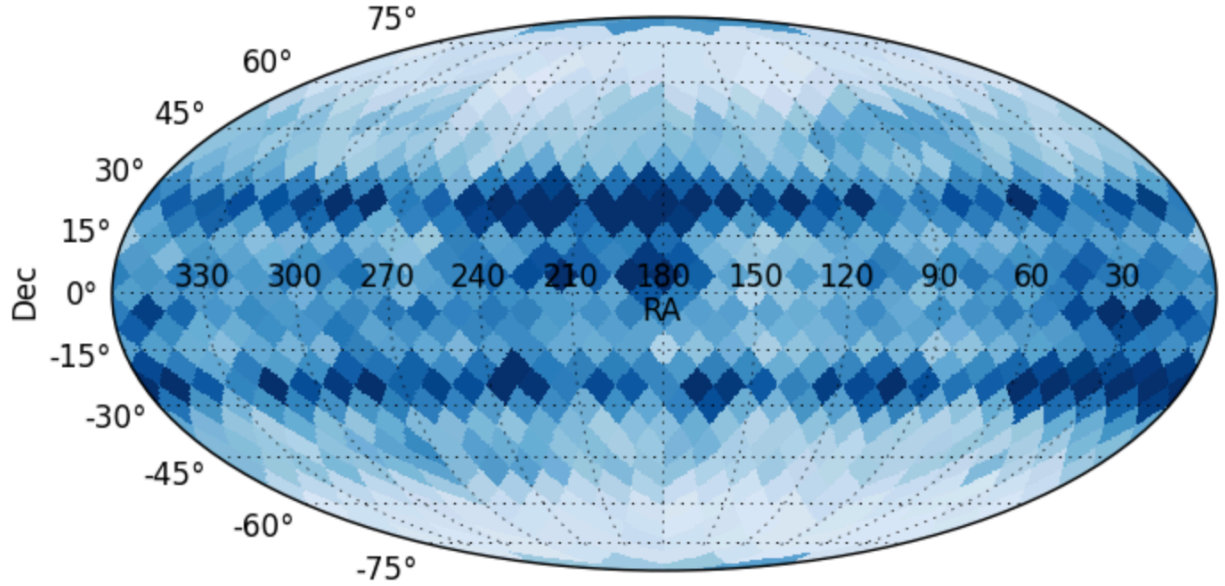
Isotropic

Galactic

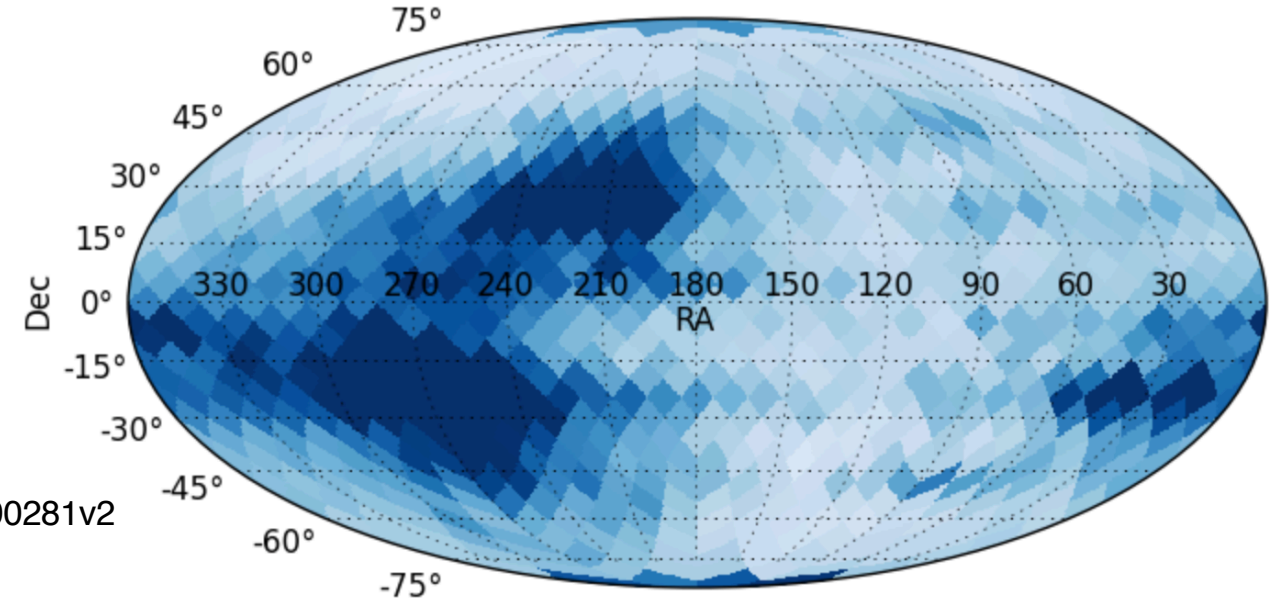
Averaging the Maps

- Normalize each individual injection's HEALPix map
- Sum all the 2000 individual injection's values at every pixel and scale up by some factor

Averaging the Maps

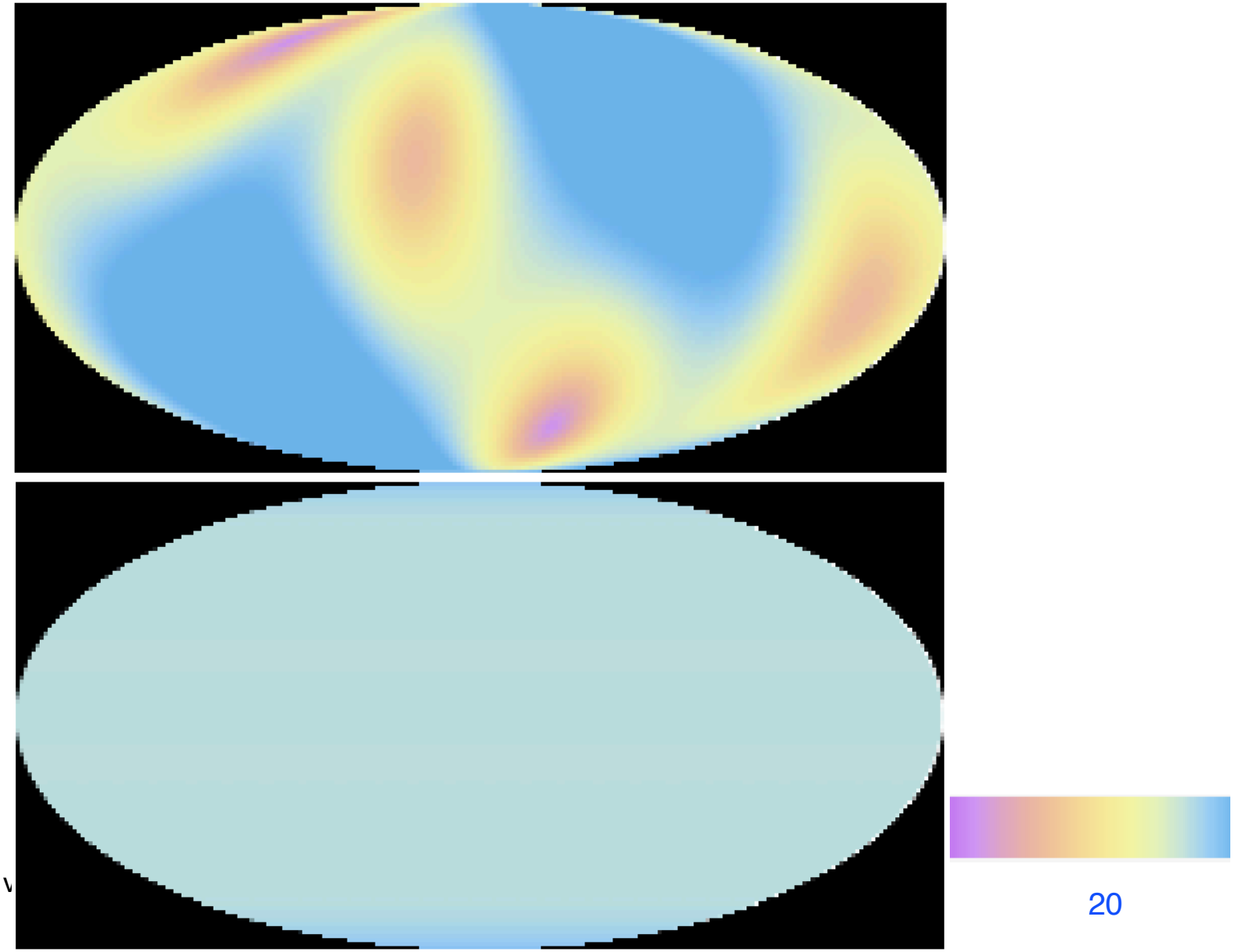


Isotropic

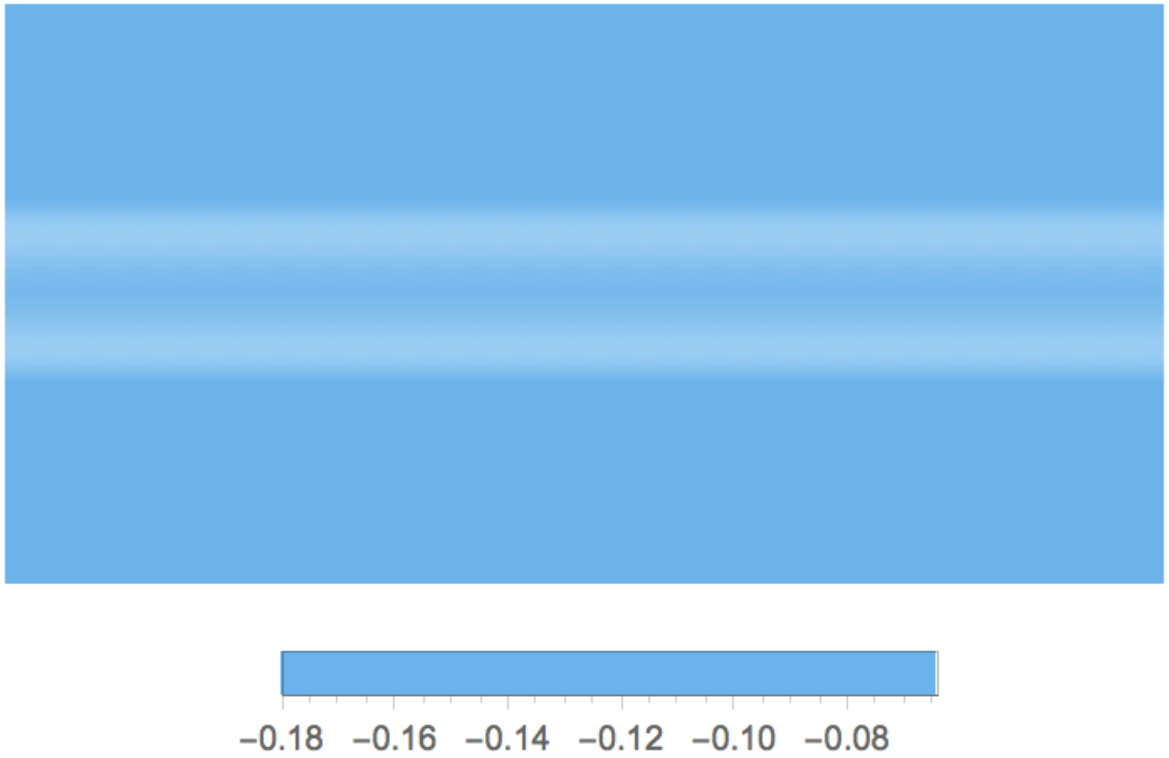


Galactic

Antenna Pattern



Antenna Pattern



Conclusion

- Goal: to develop a method of mapping the sky distribution of a population of unmodeled gravitational-wave bursts and be able to distinguish galactic set
- In our resultant skymaps, we can clearly see a difference between the recovered isotropic and galactic sets

Future Work

- Removing potential antenna pattern effects
- Factoring in Virgo
- Processing using a sampling algorithm with a high resolution
- Taking glitches and noise into consideration
- Using O1, O2 data

Acknowledgements

- Tom
- LIGO SURF Program
- The NSF
- LIGO Data Grid!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The following users have consumed
more than 10k SU with the
explore.test tag over the past
month

  * serena.moseley
65,928
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The following users have consumed
more than 10k SU with the
explore.test tag over the past
month

  * serena.moseley
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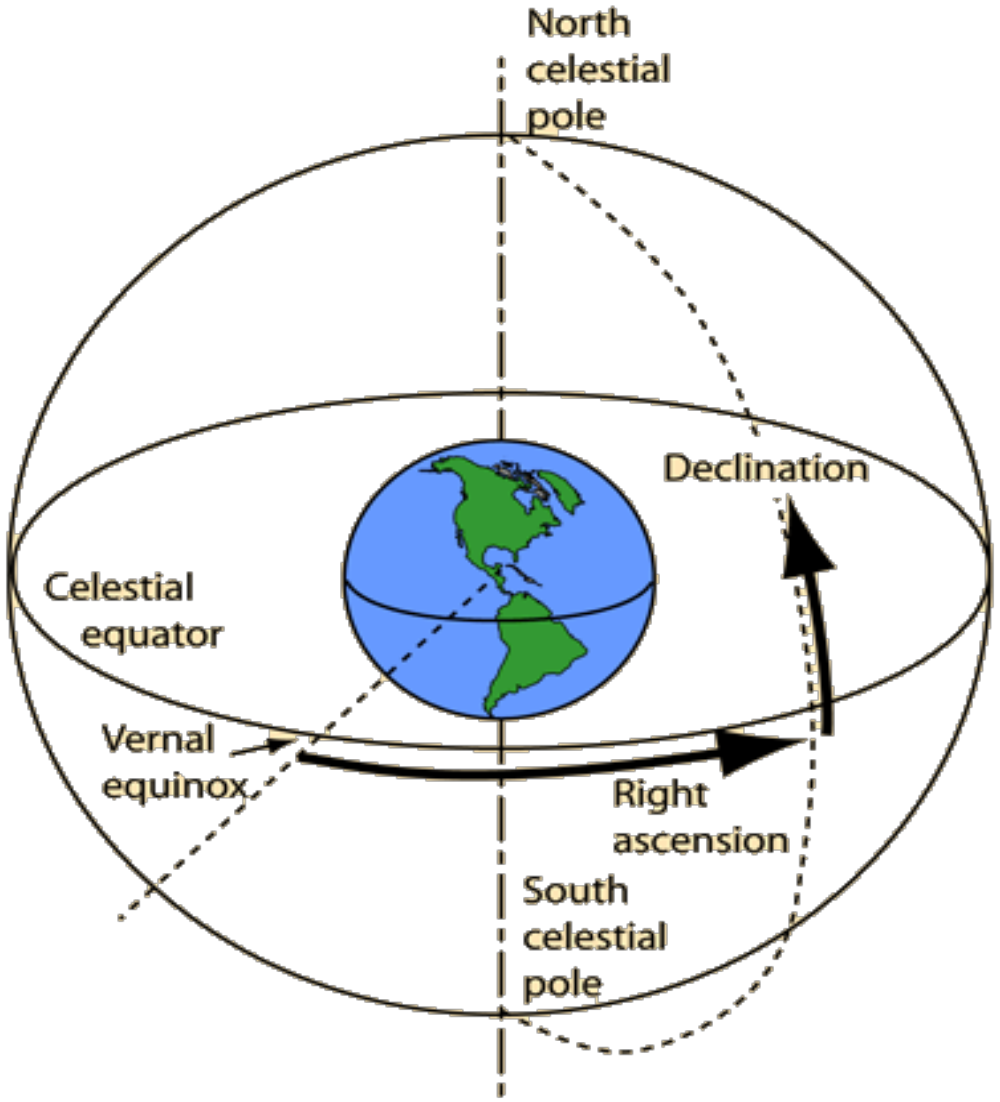
Back-up slides

Equatorial Coordinates



Multinest

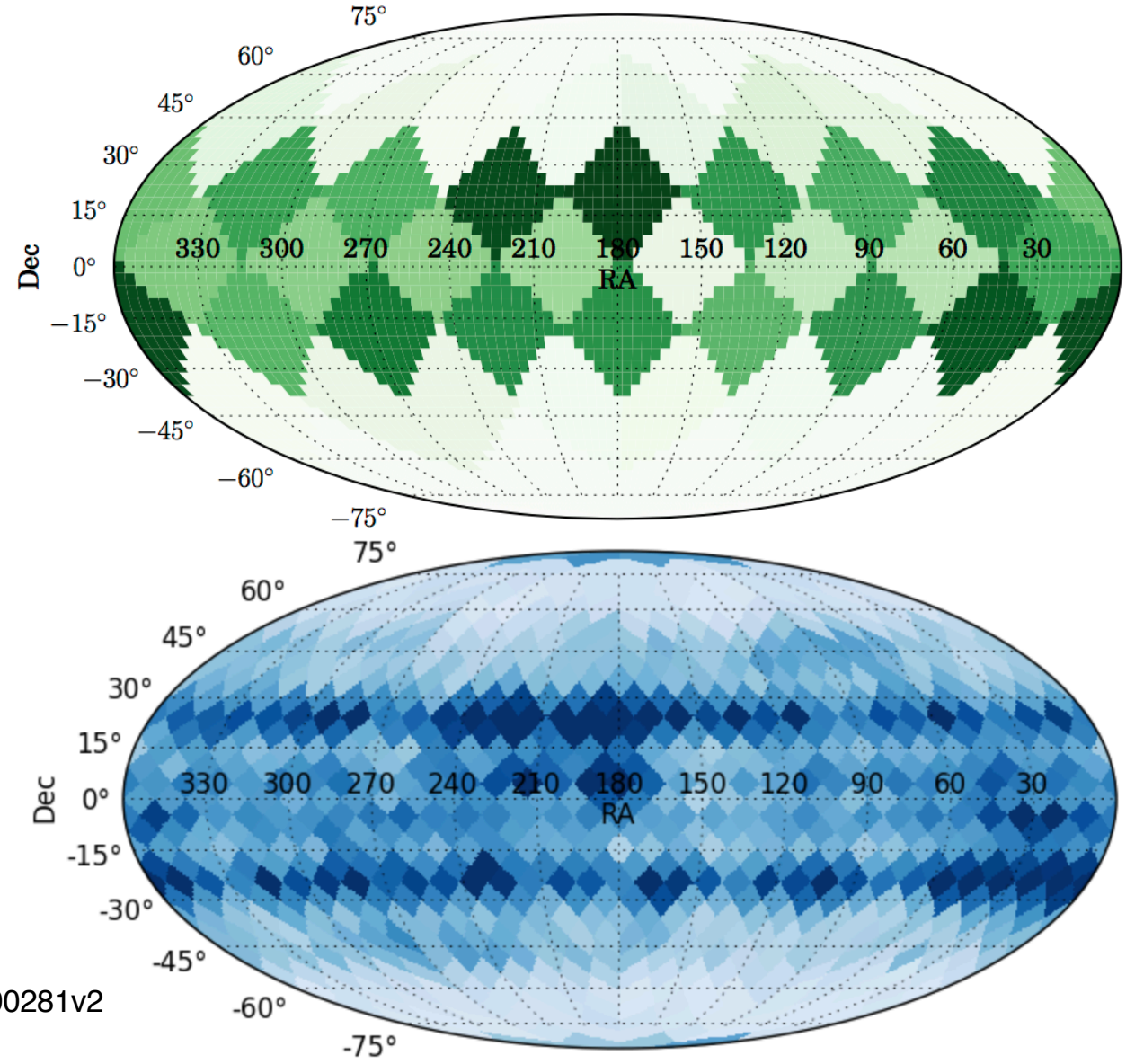
- More correct, but computationally intensive

$$p(\vec{c} \mid d) = \vec{P} \cdot \vec{c}$$

$$p(\vec{c} \mid \{d\}) \propto \prod_{d_i} \vec{P}_i \cdot \vec{c}$$

- c: fraction of events coming from a specific direction
- d: skymap
- P: set of pixel heights for each map
- Gives the probability of a certain c, given the skymaps we have for our two injection sets

Multinest - Isotropic



Multinest - Galactic