Seeing with three sites

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Three sites

- In S6/VSR2 (July 09-) we have detectors with comparable (and astrophysically interesting) sensitivity at three widely separated sites
- New opportunities for robustness, pointing and thence multi-messenger astronomy

New capabilities

- Pointing
  - We have enough information to localize a source on the sky to within a few degrees
- Internal consistency
  - Three detectors over-determine the unknown waveform
  - It is possible to reject glitches on the basis of poor consistency across the interferometers
- To exploit these capabilities requires coherent analysis

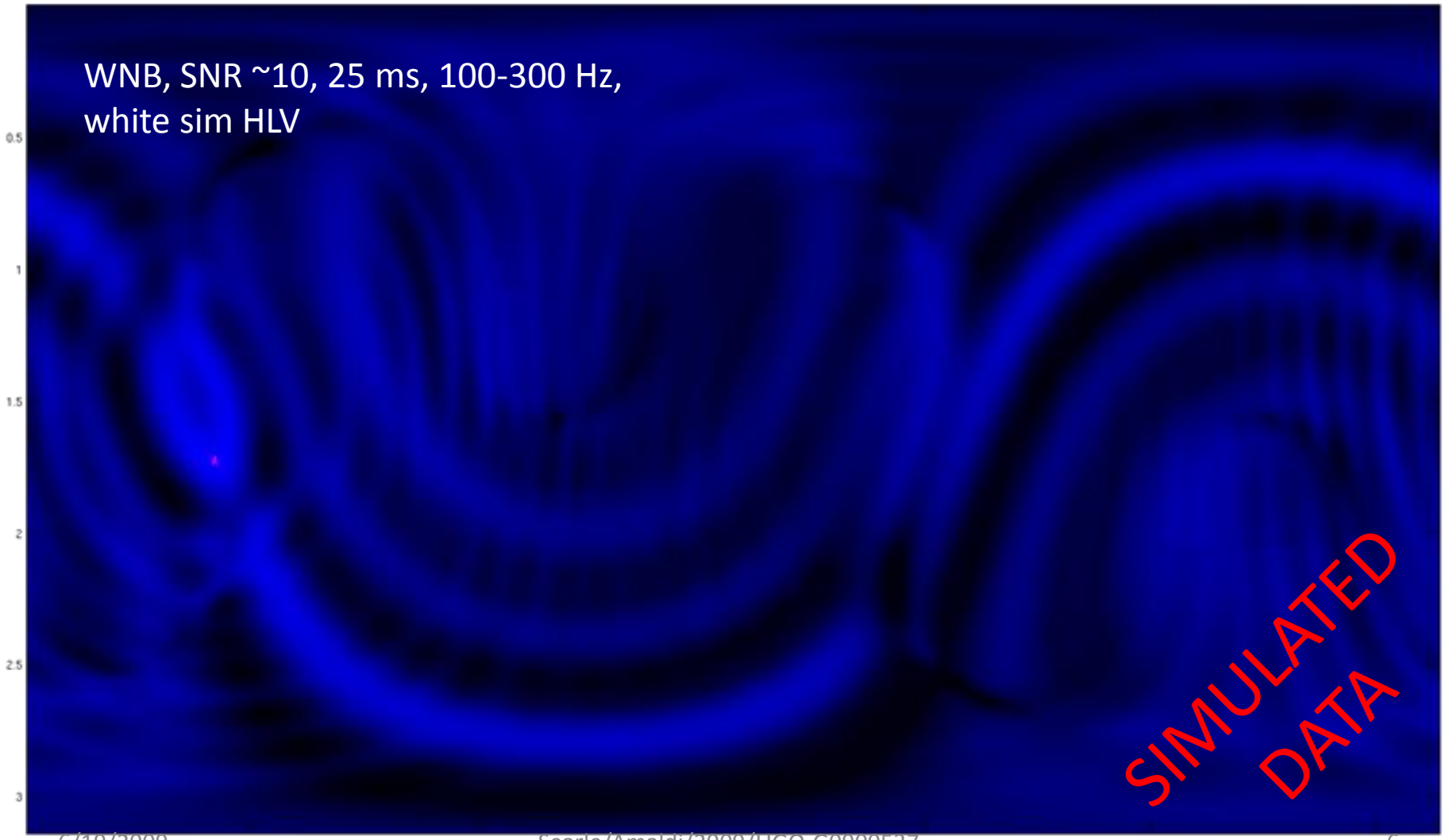
Bayesian framework

- Idea
  - Construct explicit (but *uninfomative*) models for signals and glitches
  - Get back conditional probabilities for the model selection (detection) or pointing problem
- Science
  - First outlined at last Amaldi meeting
  - Searle, Sutton, Tinto & Woan, Class. Quant. Grav. **25** (2008)
  - Searle, Sutton & Tinto, arXiv:0809.2809 (accepted, CQG)
- Implementation
  - Core library in LAL
  - Integrated into Omega and CBC pipelines
  - Outputs parameter probability distributions (like MCMC)
  - Judicious choices of analytically marginalizable priors for some parameters keeps the analysis cheap
  - Fast enough to follow up data around one event per CPU per minute

Process

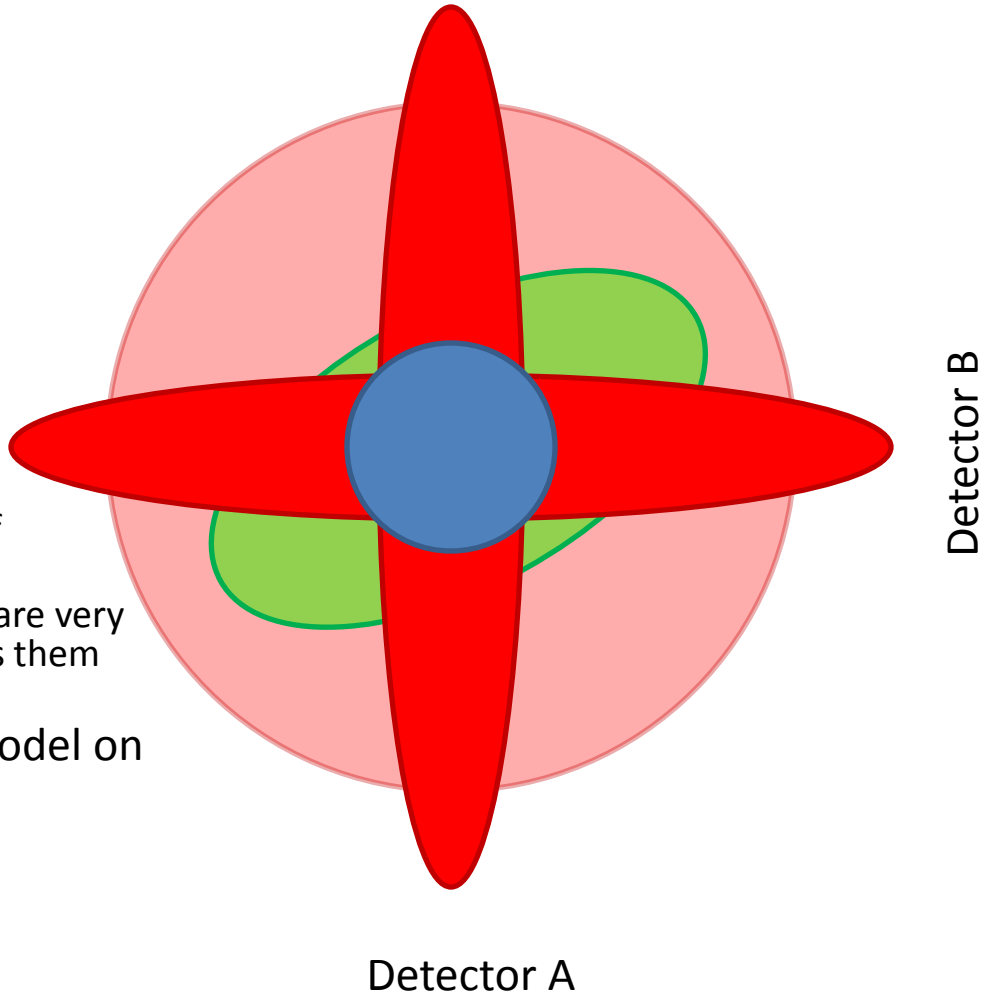
- Given an trigger template and time, we use the matched filter time series z[t] for 1 to 3 sites
  - (i.e. a coincident event found by a regular pipeline; this is a Bayesian followup)
- Produce a conditional posterior probability distribution ("skymap") for the source direction
  - Exactly the right data product for an optical followup
  - Skymaps for orthogonal templates can be combined
    - Cover arbitrary bursts with basis functions
- Produce the conditional posterior probability of a noise burst ("glitch") for each instrument individually

Energy and probability skymaps



Model selection

- The system has *three* states
  - Colored noise
  - Colored noise + signal
  - *Colored noise + glitch*
    - *Coincident glitches*
- Each detector may independently experience a burst of noise
- Uninformative glitch model:
  - Signals and glitches have the same distribution in any single instrument
  - Model selection is then a measure of the inter-site consistency
  - Though the signal and glitch models are very different, Bayesian analysis calibrates them both as probabilities
- In the future, calibrate the glitch model on past observations, like the PSD



Roadmap

- Now:
  - Pointing in Omega and CBC followup pipelines
  - Uninformative glitch model in Omega pipeline
  - Omega online analysis providing pointing to LUMIN
- Soon:
  - Pointing in LLOID
  - Uninformative glitch model in CBC followup pipeline and LLOID
  - Performance studies with SURF students
- Future:
  - Calibrated glitch model