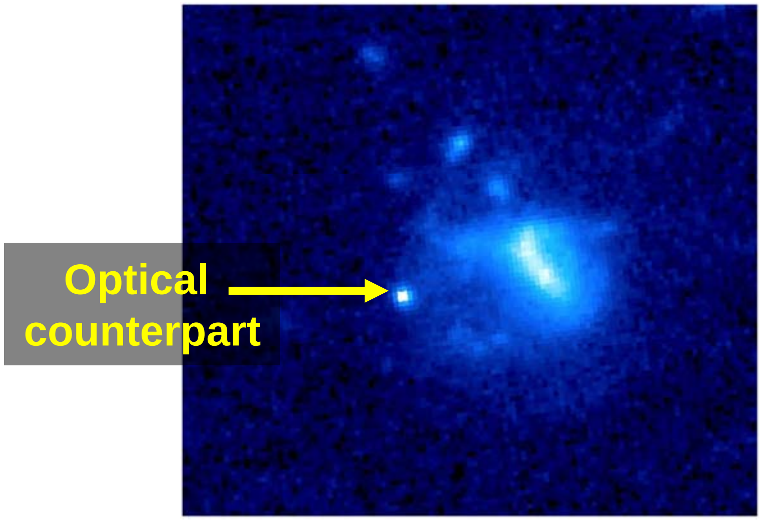
Science Nuggets

Jolien Creighton
University of Wisconsin–Milwaukee

LIGO-G050560-00-Z

Gamma-ray bursts: short and long

Short burst GRB050709



HST Image Credit: Derek Fox

Long burst GRB030329

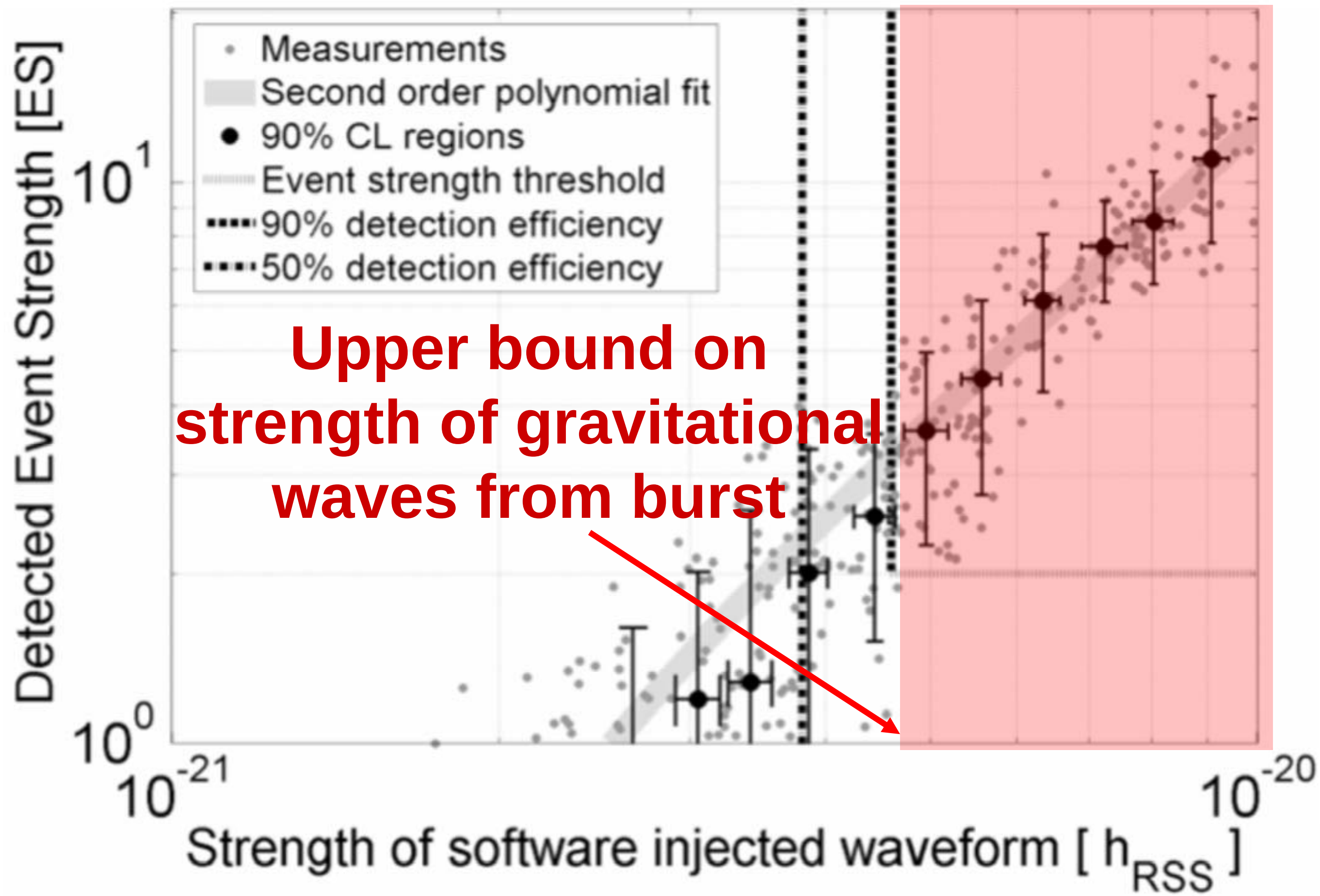
NASA Image

Possible scenario for short GRBs: neutron star/black hole collision

Credit: Dana Berry/NASA

Search for gravitational wave burst associated with GRB030329

*Physical Review D **72** 042002 (2005)*



Binary Neutron Star Search: LIGO Range

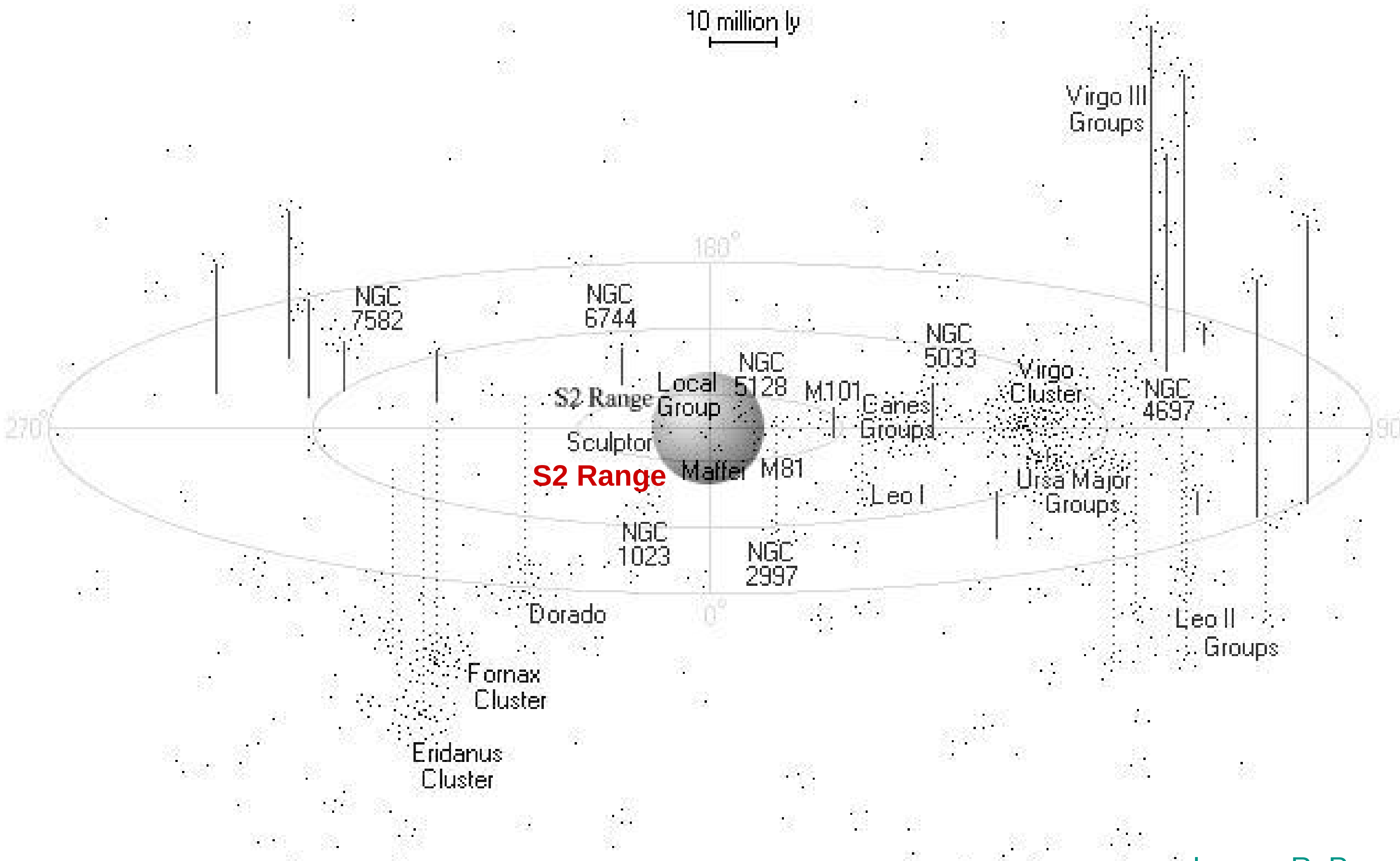
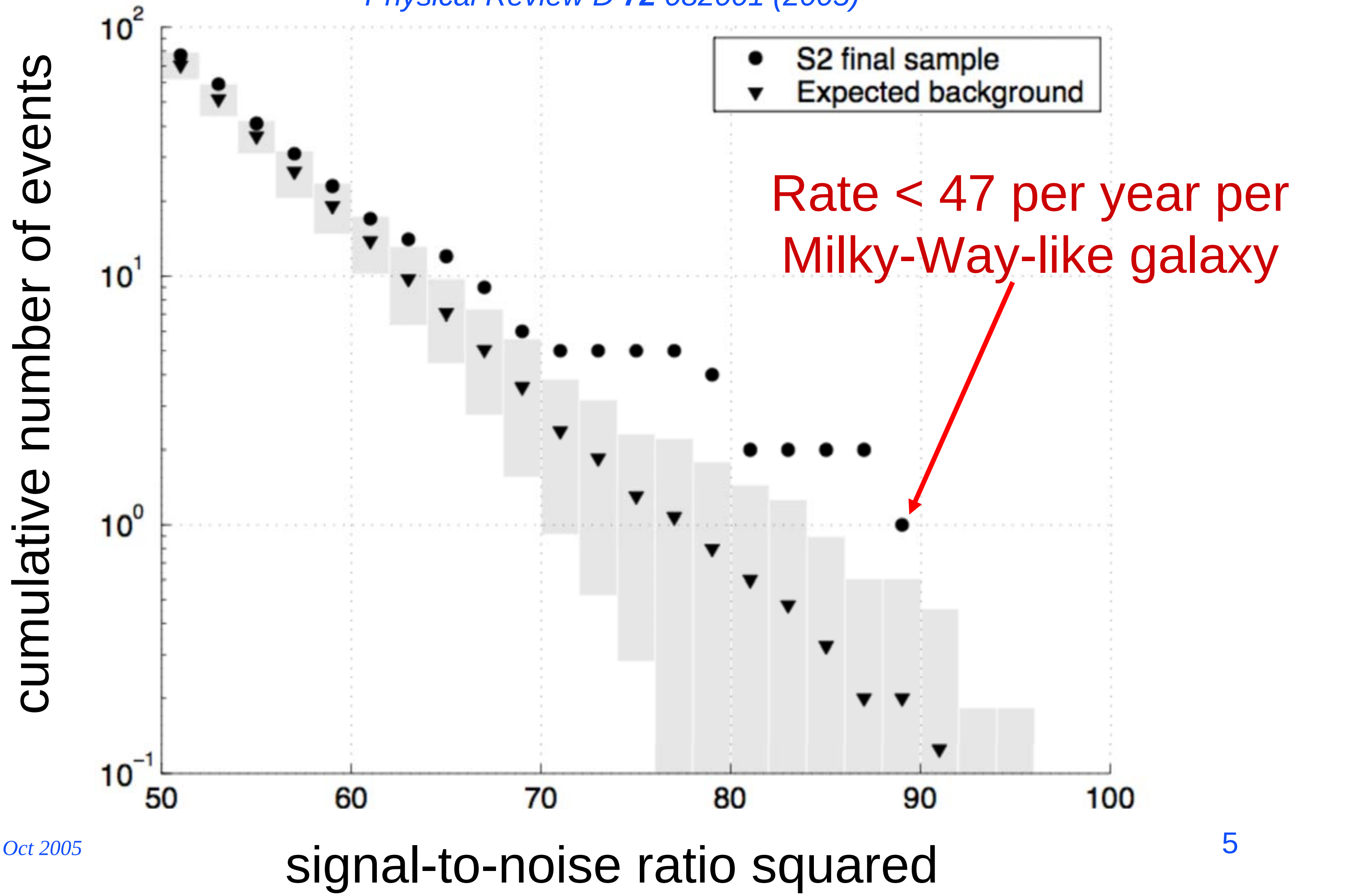


Image: R. Powell

Binary Neutron Star Search Results (S2)

*Physical Review D **72** 082001 (2005)*



Binary Inspiral Search: LIGO Ranges

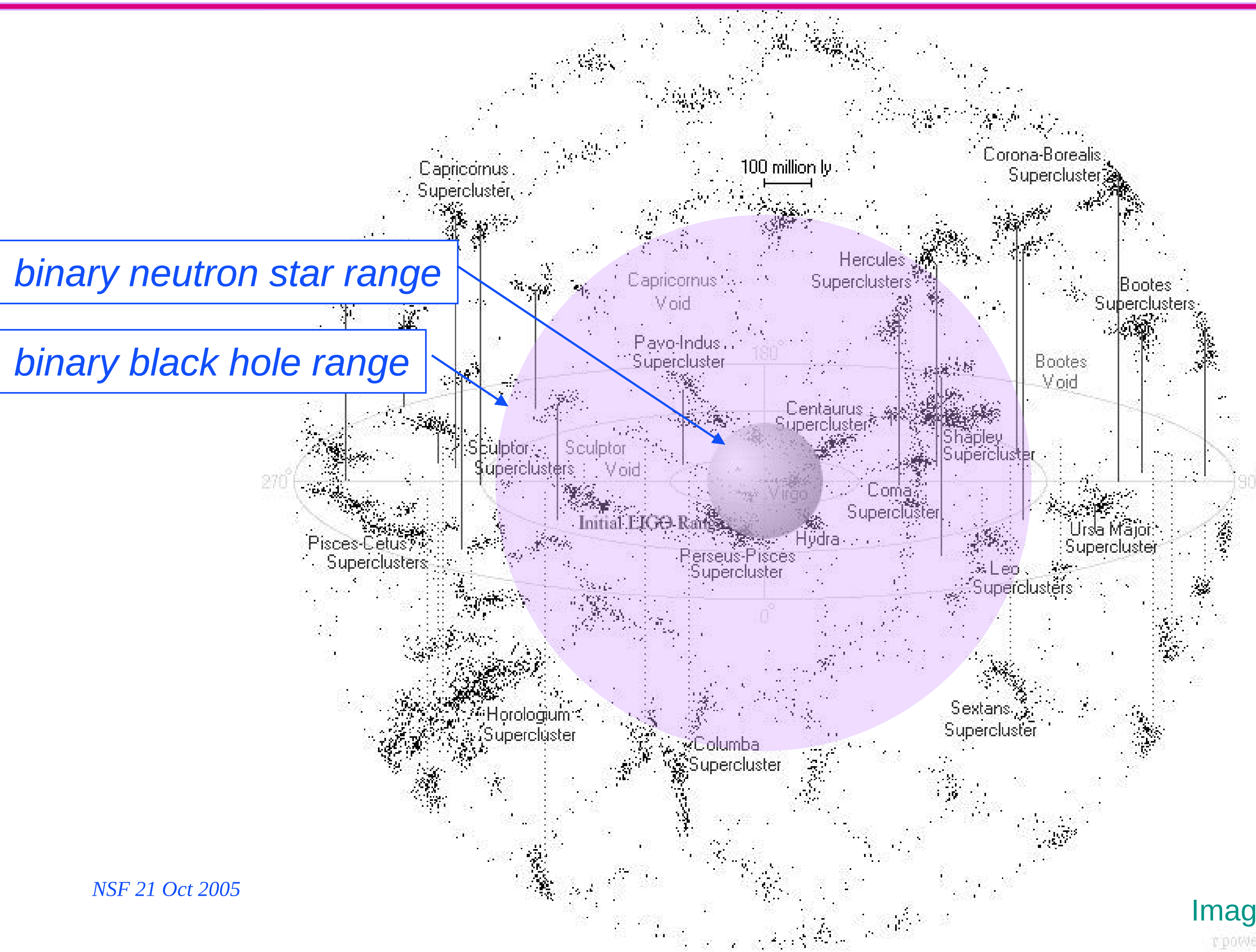
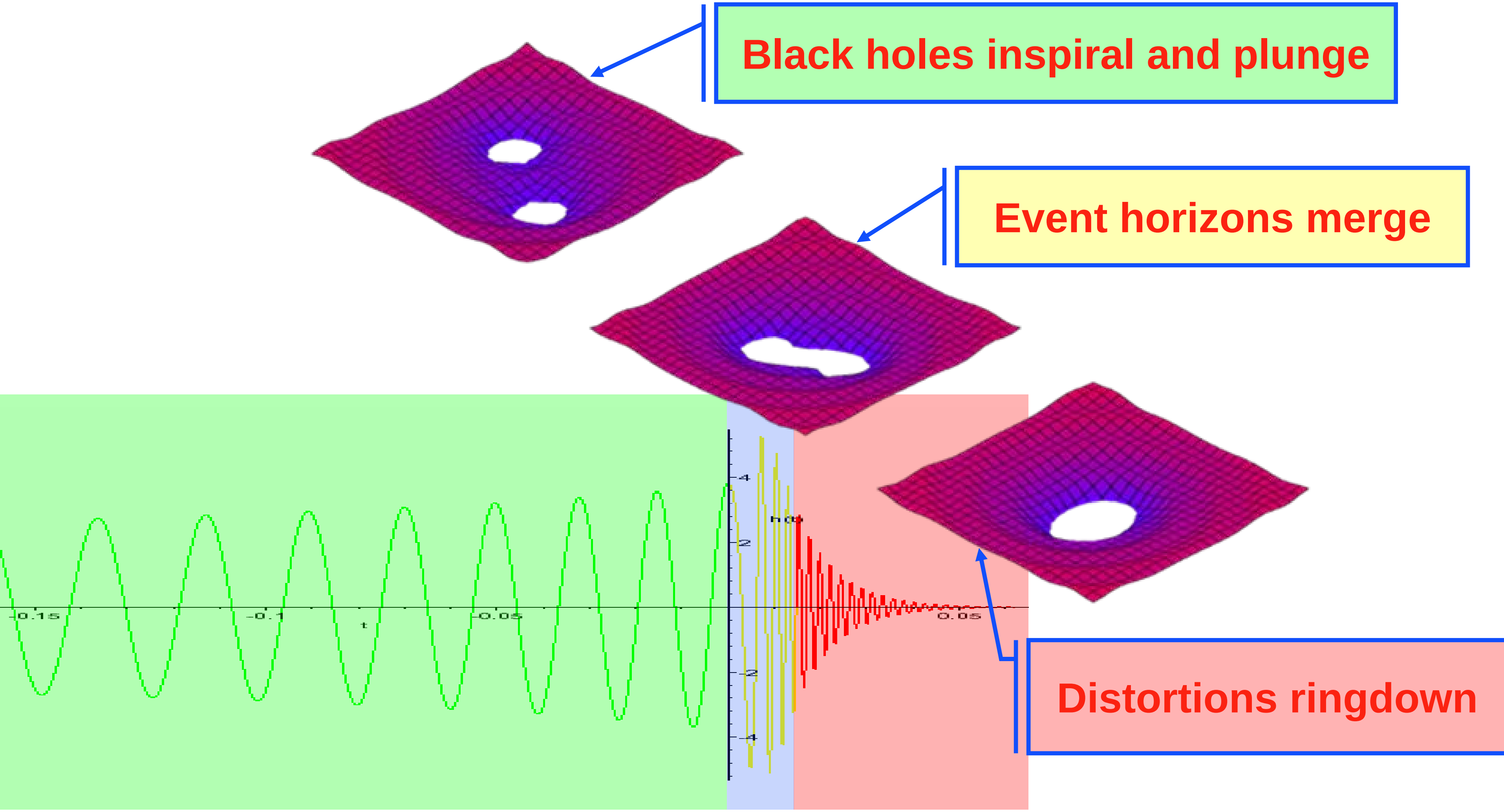


Image: R. Powell

Binary Black Hole Merger Phases



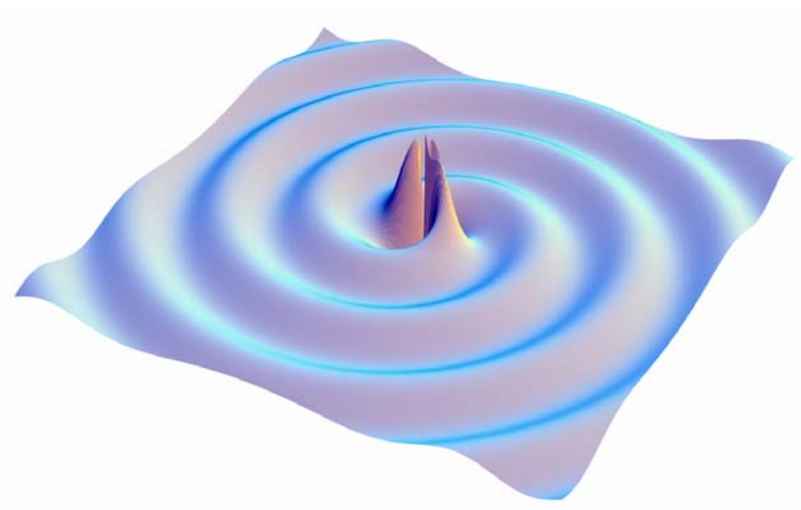
Binary Inspiral Search: Computational Cost

- S2 Binary Neutron Star Search:
  - » Unit of computation:
    3GHz day per day of data
    ~ 10^{14} floating point operations per day
    ~ amount of computer power delivered by one CPU per day
  - » 240 GB of data (~10 days analyzed)
  - » 1000 matched filter templates
  - » 6941 nodes in workflow
  - » 200 Units of computation
- Projection: S5 and beyond …
  - » 10000 templates for binary neutron star search
  - » 600 computational units for binary neutron star search
  - » 6000 computational units for search for primordial binary black holes
  - » More(?) for spinning solar-mass black holes

Binary Inspiral Search Outlook

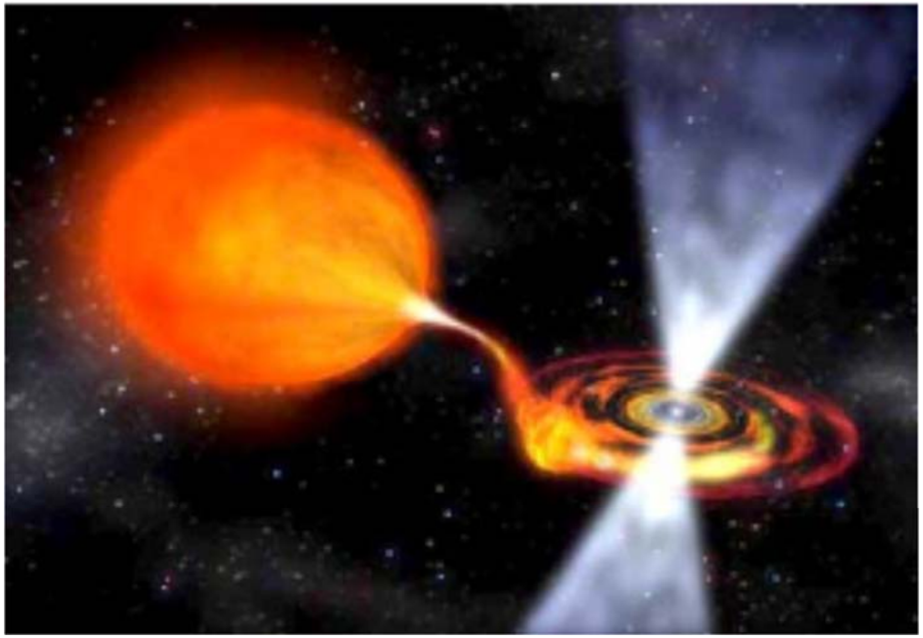
Scientific outlook:

- Look for connection with short gamma-ray bursts
- Insight into neutron star populations … constrain:
  - » Stellar evolution models
  - » Population of faint pulsars
- Insight into neutron star size and equation-of-state
- Probe strong-field gravity
- Detect new classes of objects (binary black holes)



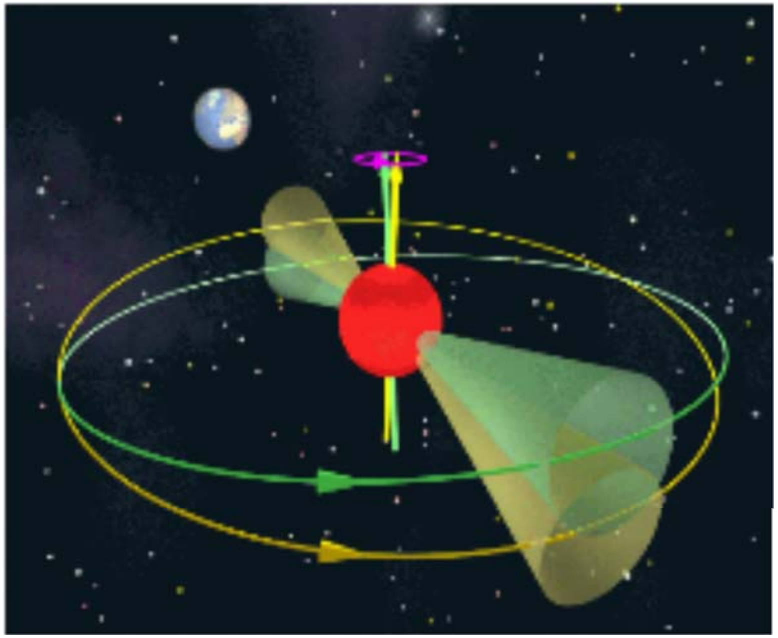
Pulsars: target sources

Accreting Neutron Stars

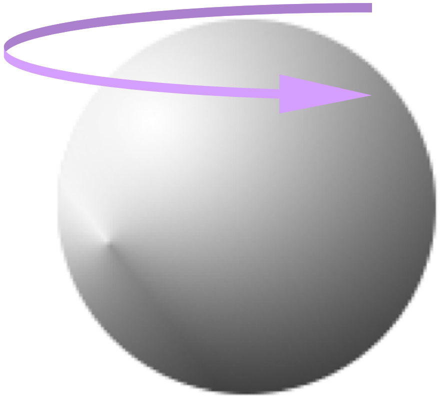


Credit: Dana Berry/NASA

Wobbling Neutron Stars



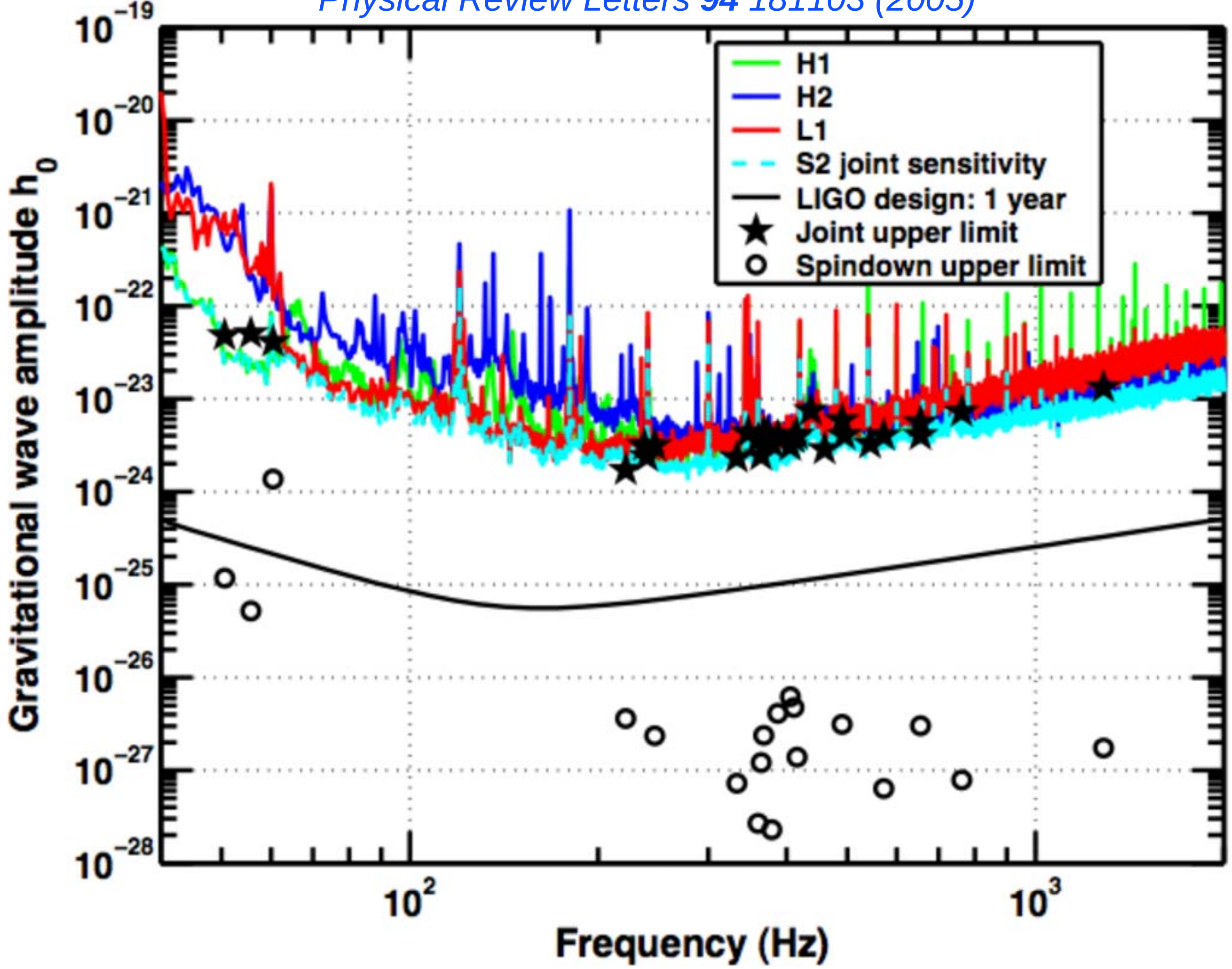
Credit: M. Kramer



Bumpy Neutron Star

Search for Known Pulsars (S2)

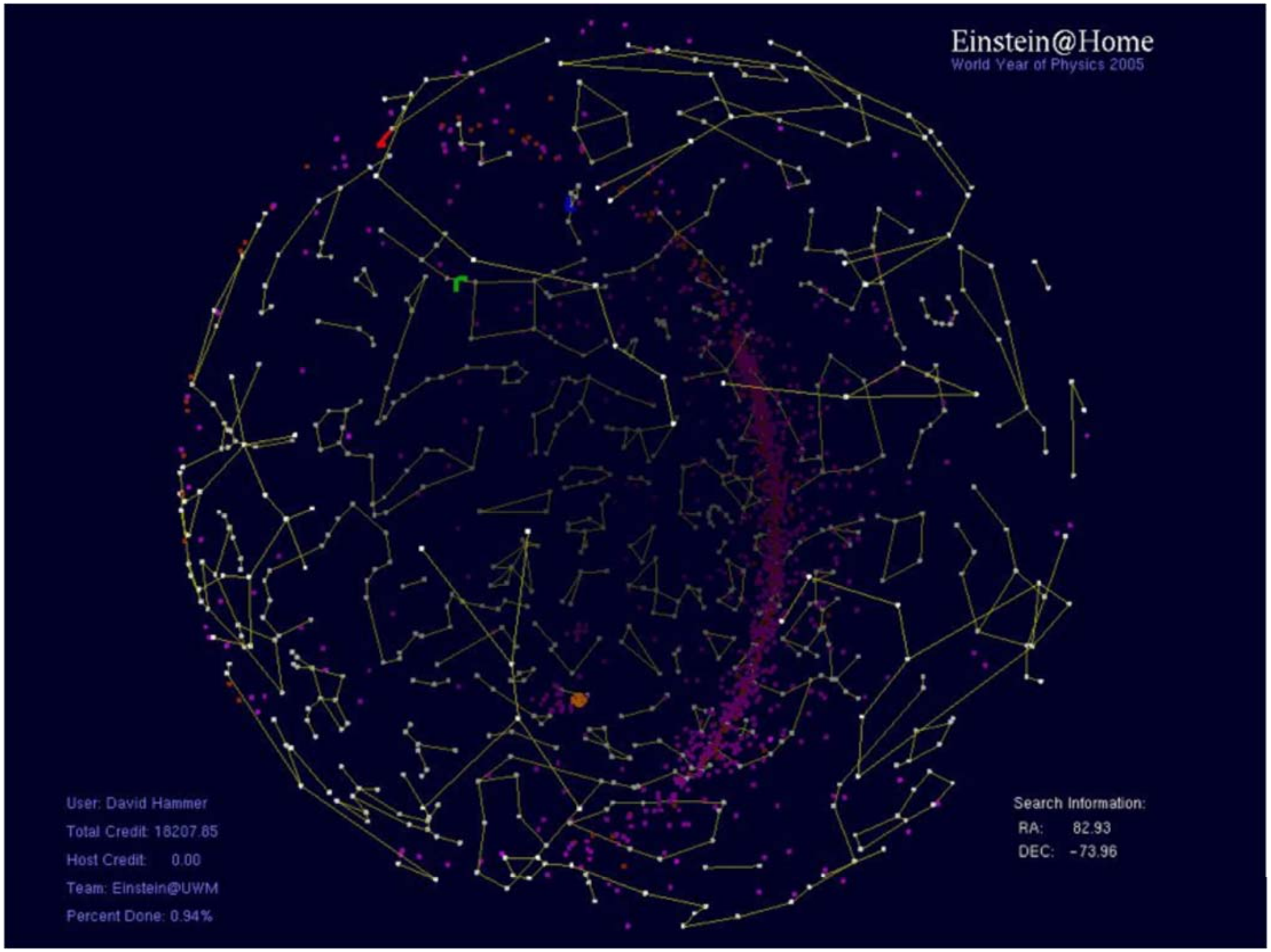
Physical Review Letters ***94*** *181103 (2005)*



Search for Unknown Pulsars: Computational Issues

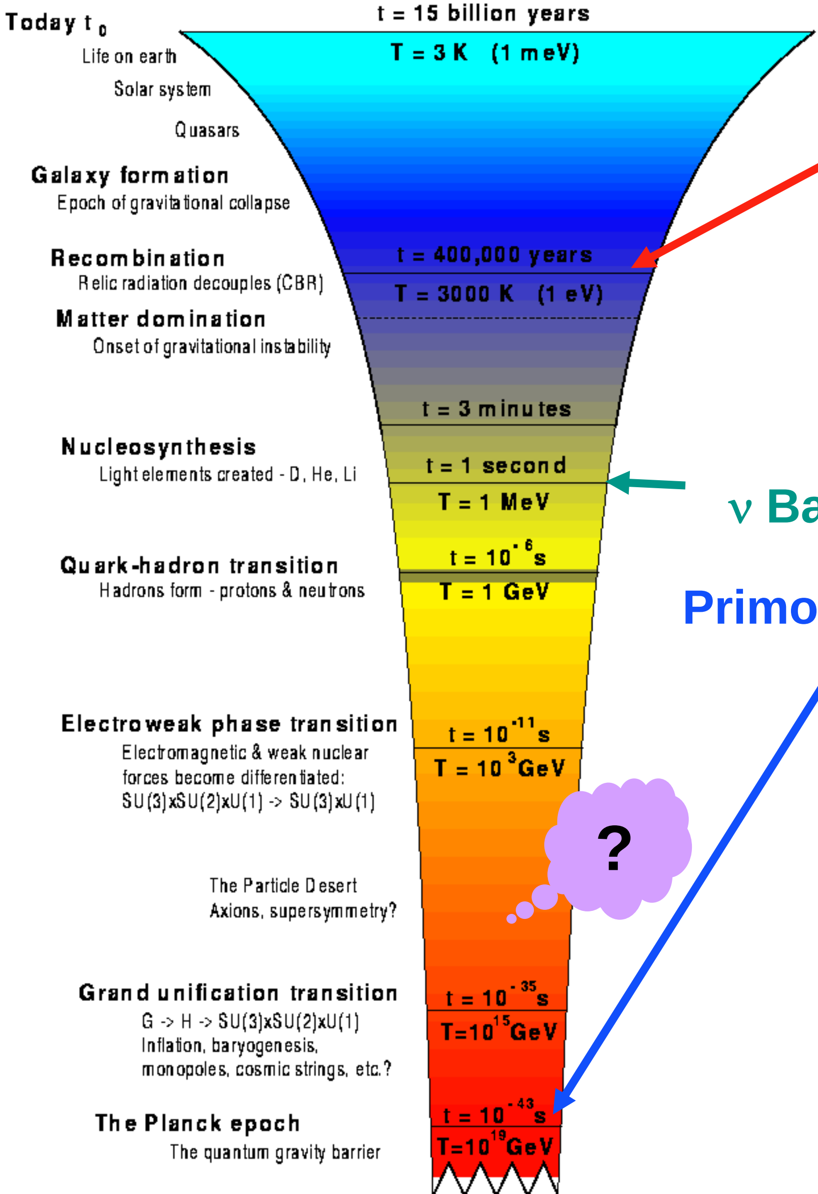
- Sensitivity improves with longer integration
- As more data is analyzed, frequency resolution increases
- As frequency resolution increases, more sky positions resolved
  - » 1 day of data: 100000 points on the sky
  - » 1 week of data: 10^7 points on the sky
  - » 1 year of data: 10^{12} points on the sky
- As more sky positions are resolved, more templates are needed
- Therefore: amount of time analyzed limited by amount of computer power available!
  - » 1 day: $\sim 10^{19}$ floating-point operations = $\sim 10^5$ computational units
  - » 1 week: $\sim 10^{23}$ floating-point operations = $\sim 10^9$ computational units
  - » 1 year: $\sim 10^{32}$ floating-point operations = $\sim 10^{18}$ computational units

All Sky Search: Einstein@Home

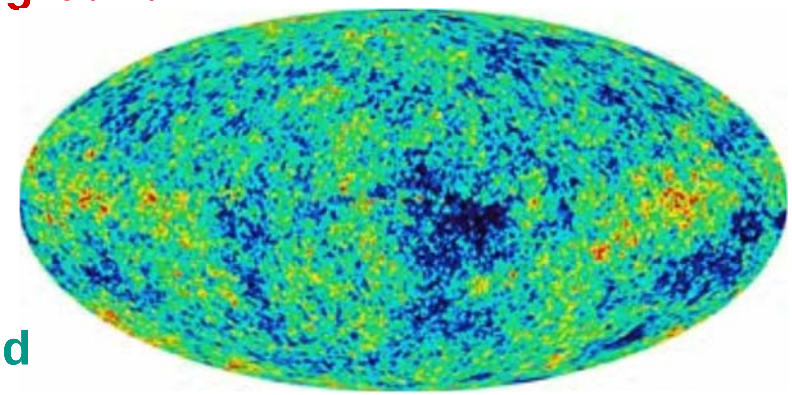


LIGO

Stochastic Background

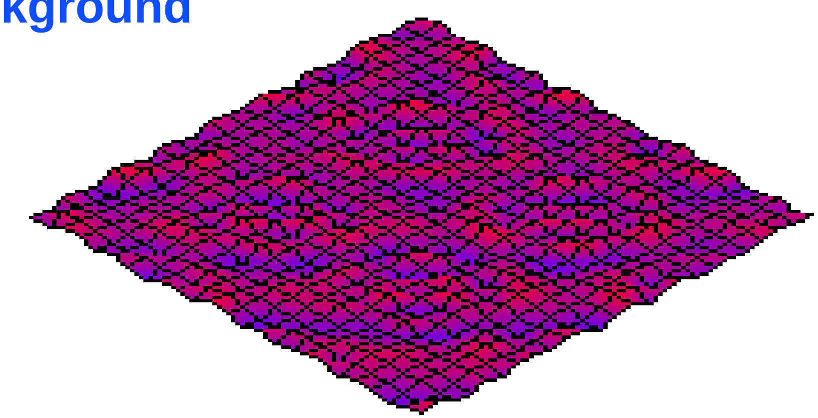


Cosmic Microwave Background



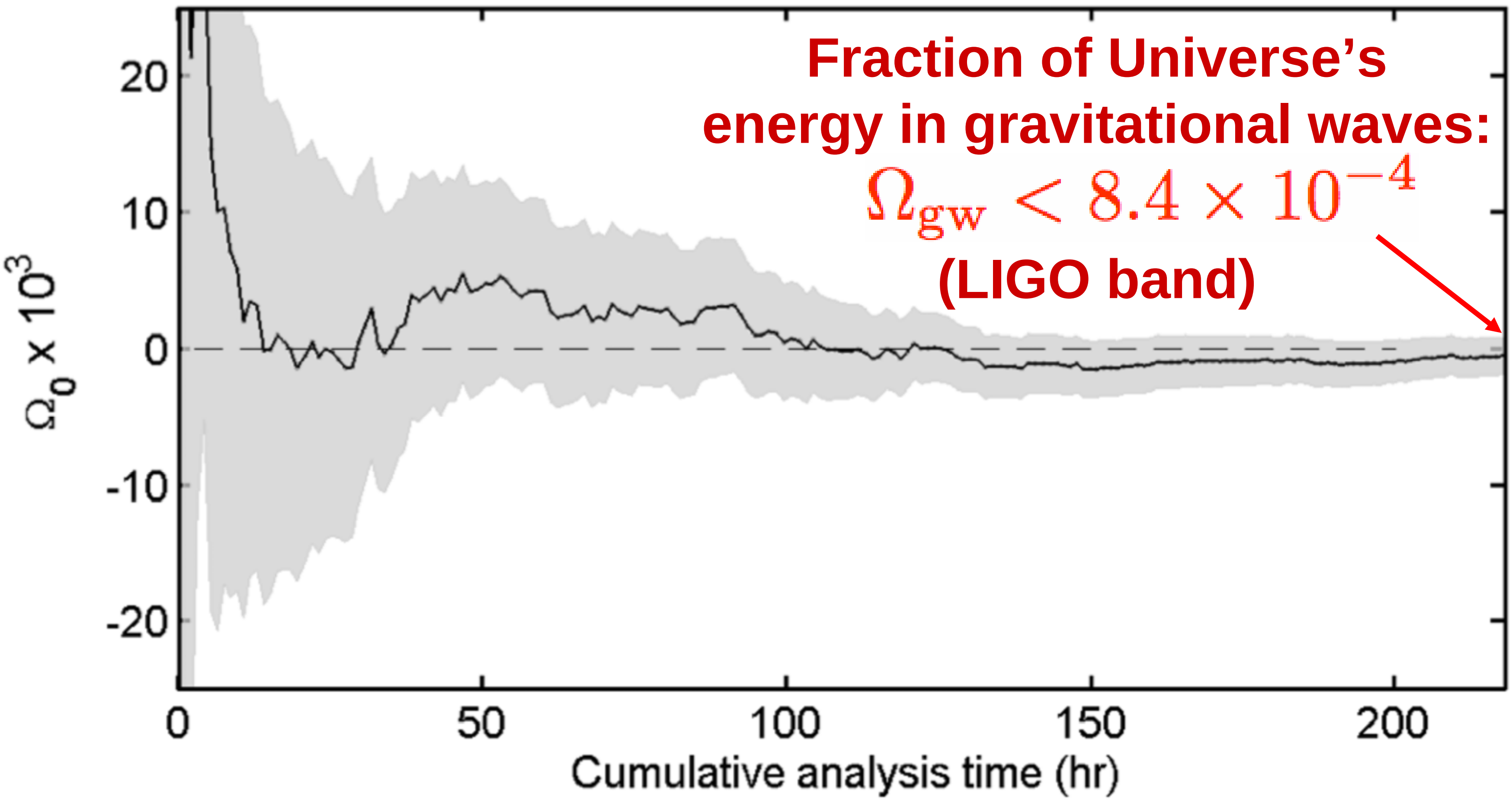
ν Background

Primordial Gravitational-Wave Background



Stochastic Background Search (S3)

Physical Review Letters, In Press



Stochastic Background Search Goals

Scientific Goals:

- Bound gravitational-wave contribution to total energy in the universe
- Produce a map of gravitational wave stochastic background across the sky
- Probe the universe as it was just after inflation
- Search for background of unresolved gravitational wave bursts