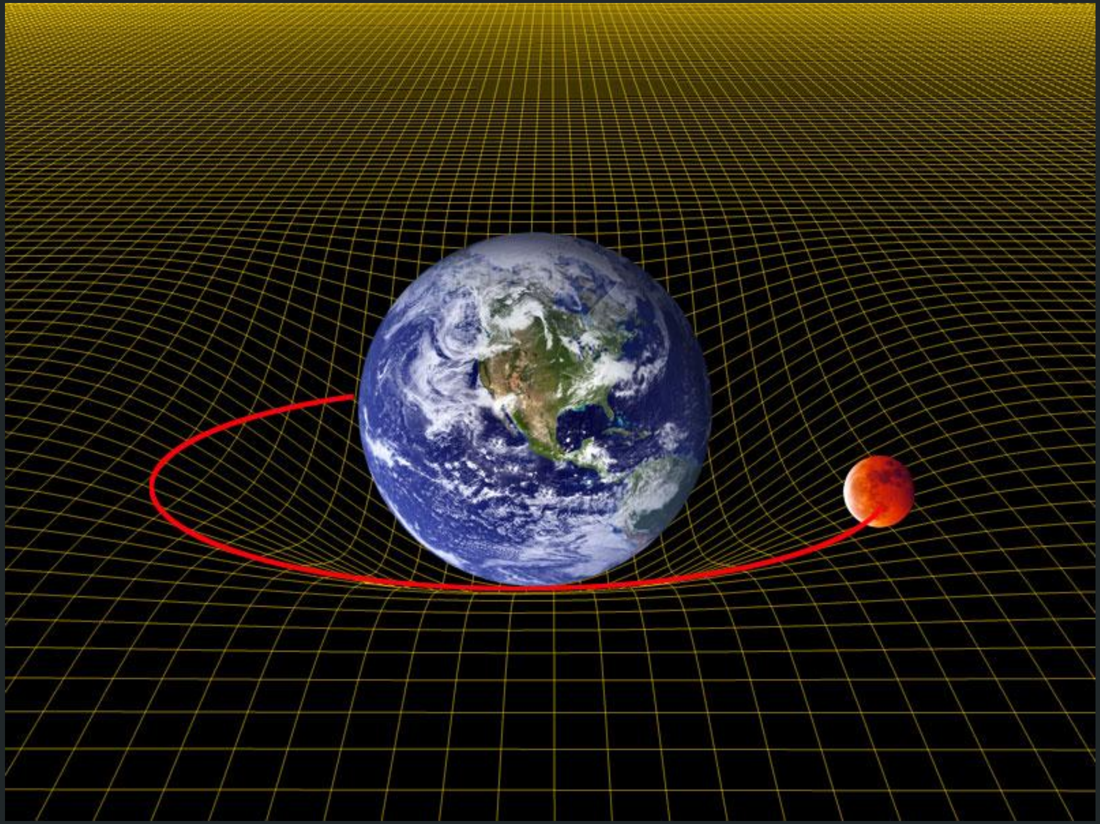
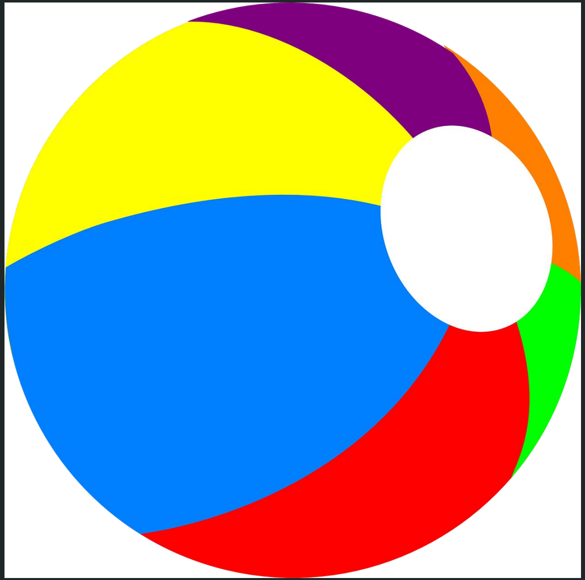
How LIGO Analysis is using HTCondor

Cody Messick

General Relativity

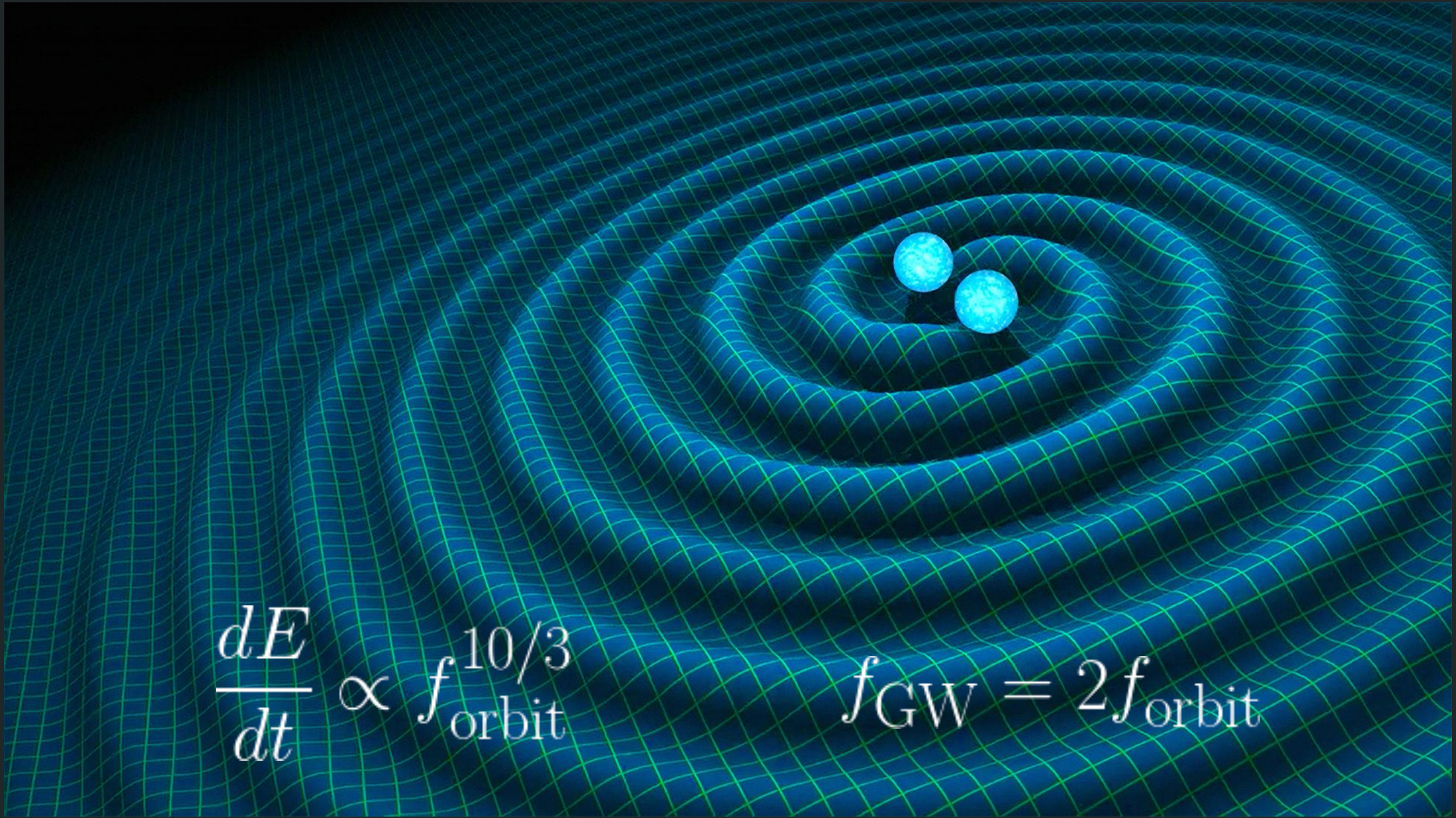


Gravitational Waves

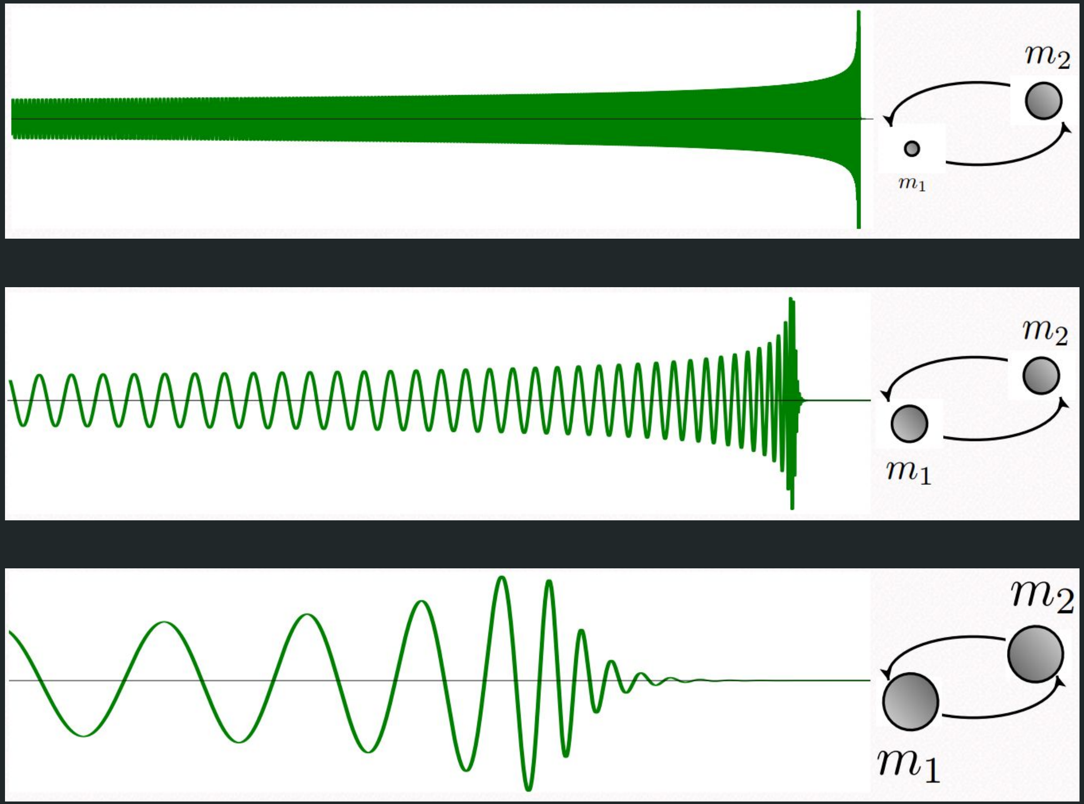


- *Tiny* ripples in space-time curvature
- Travel at speed of light
- Stretch/compress space
- Predicted 1915, but not detected until 2015
- Generated by accelerating non-spherically symmetric massses

Compact Binary Mergers

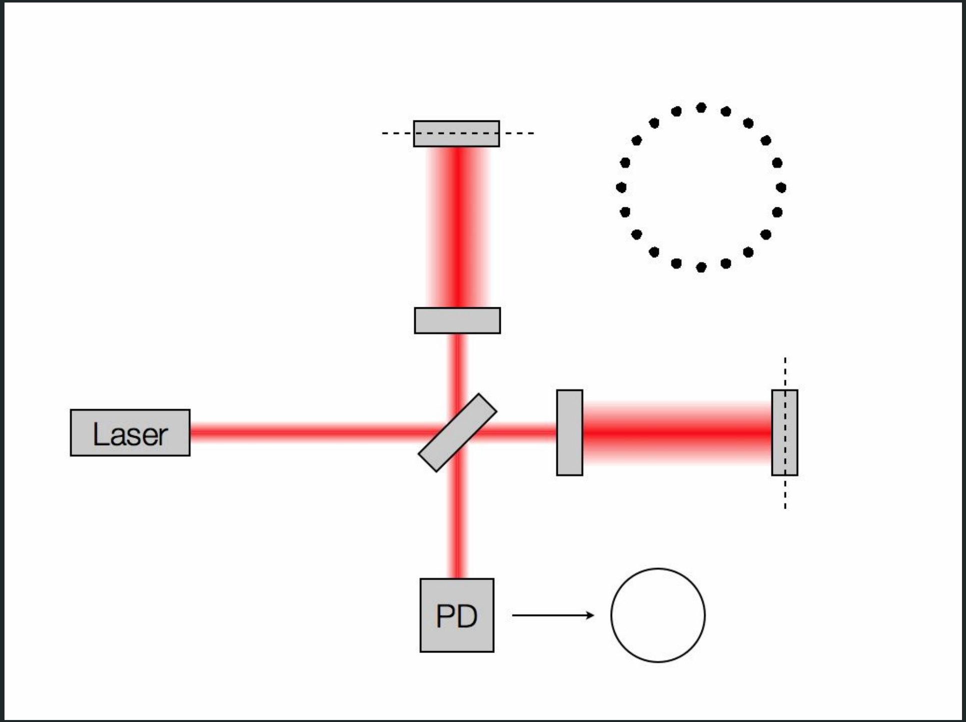


Gravitational Waves from Compact Binaries



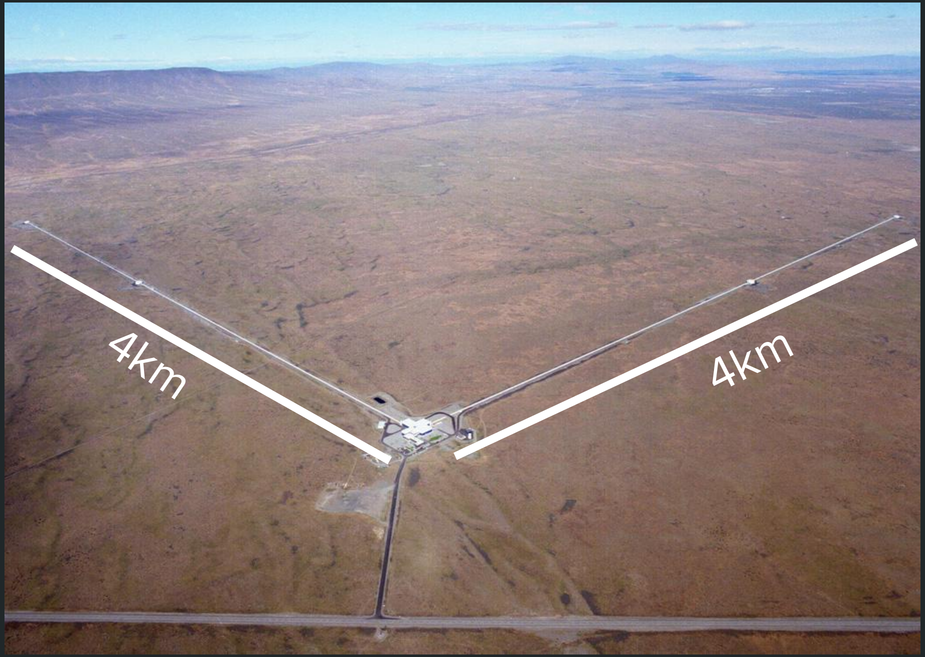
Leslie Wade, Kenyon College

Ground-based GW Interferometer Detectors

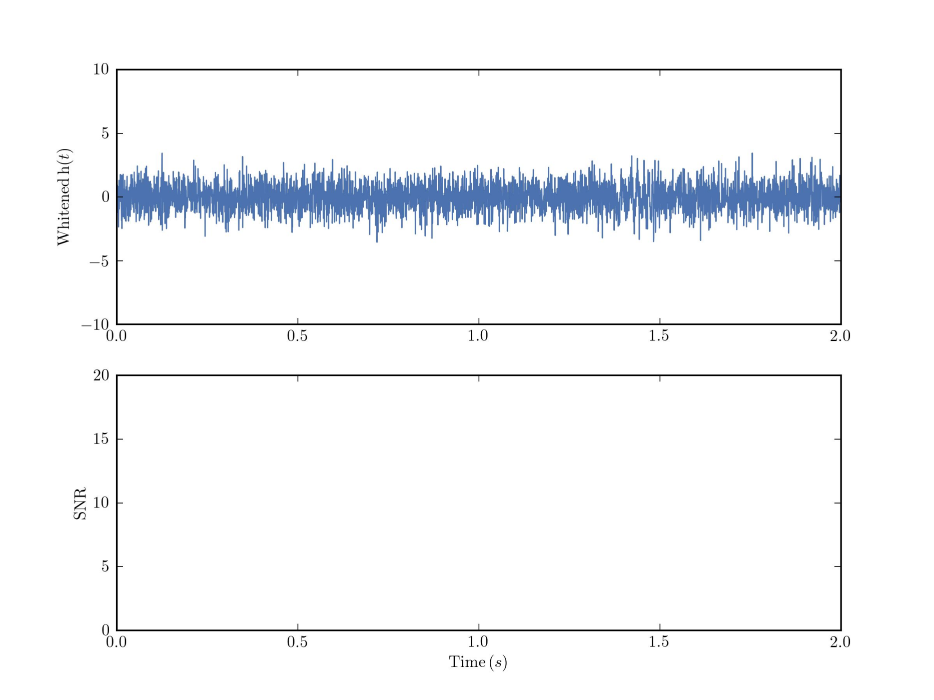


Ground-based GW Interferometer Detectors

- Two LIGO detectors currently in operation
  - Hanford, WA (pictured)
  - Livingston, LA
- Virgo detector in Cascina, Italy
- KAGRA detector in Hida, Japan



Gravitational-wave Data Analysis

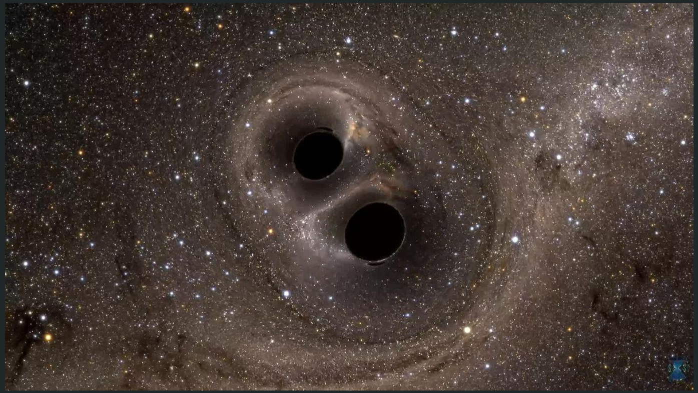


x 10^6

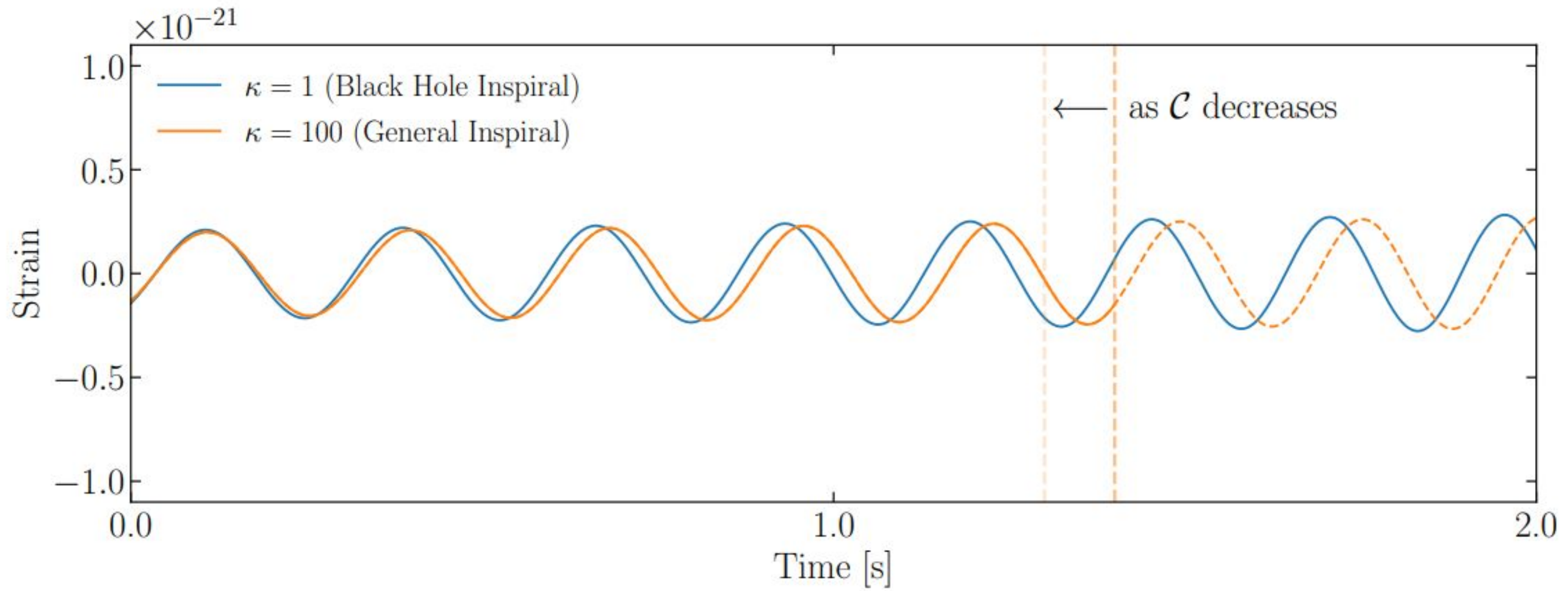
Ryan Magee, LIGO Caltech

Searching for New Gravitational-Wave Sources

- Black holes and neutron stars close to perfect spheres
- Can parameterize ability of object to distort when spinning (kappa)
- Kappas away from unity quickly become undetectable in standard LIGO searches



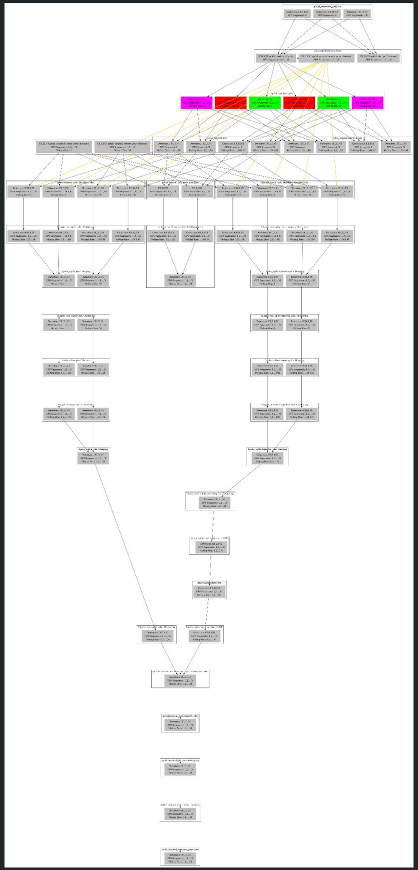
Searching for New Gravitational-Wave Sources



High level view of Analysis Workflow

- Inputs
  - LIGO Hanford detector data, 16 kHz, order 100 days
  - LIGO Livingston detector data, 16 kHz, order 100 days
  - 500,000 waveforms, 512 Hz, order 1-100 seconds
- Workflow in 5 day chunks
  - Measure frequency spectrum of noise
  - Decompose waveforms
  - Filter data
  - Aggregate statistics
  - Assign Significance / Data Reduction
- Data Products
  - Decomposed waveforms (50 GB / 5 days)
  - Reduced filter output (10 GB / 5 days)
  - Final results (100 MB / 5 days)

DAG



IGWN OSG

- GW searches naturally fit high-throughput computing workflows
- LIGO-specific resources available but limited
- Challenge moving forward: analyzing data using more abundant high performance resources
  - OSG perfect resource for GW searches, already solved problem of mapping HTCondor workflows onto HPC clusters
  - IGWN OSG adds abundant HPC resources resources to LIGO Data Grid resources, simplifies use of proprietary data

Collaborator List

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Backup slides

Template Bank

- Matched-filtering assumes you know the signal *a priori*
- Look for discrete signals contained within continuous signal parameter space
- Discretize parameter space such that any signal in continuous space will have 97% overlap with at least one point