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the experiment

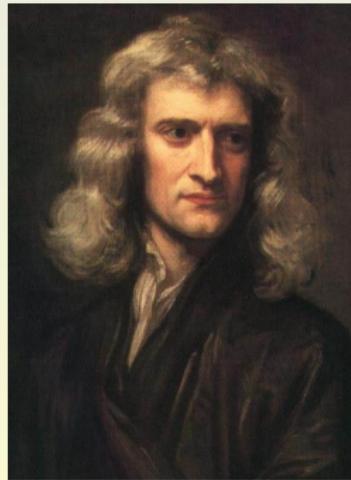
data analysis

GW150914



MAX-PLANCK-GESELLSCHAFT

Gravitation

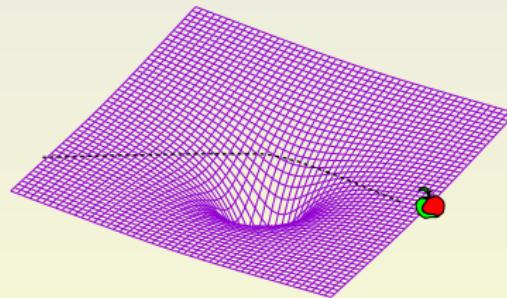


http://en.wikipedia.org/wiki/Isaac_Newton



MAX-PLANCK-GESELLSCHAFT

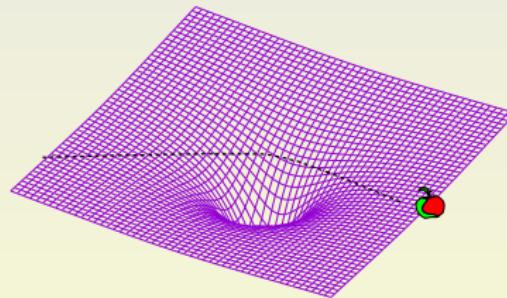
Gravitation



$$g_{\mu\nu}(x)$$



Gravitation

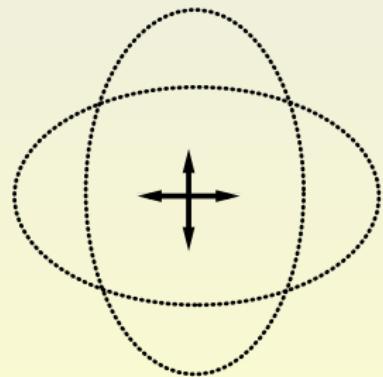


$$g_{\mu\nu}(x) = \eta_{\mu\nu} + h_{\mu\nu}(x) + \mathcal{O}_{\mu\nu}^3(x)$$

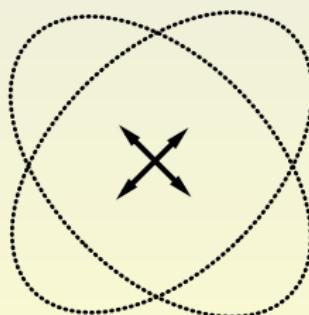


Einstein field equation → gravitational waves

+ mode

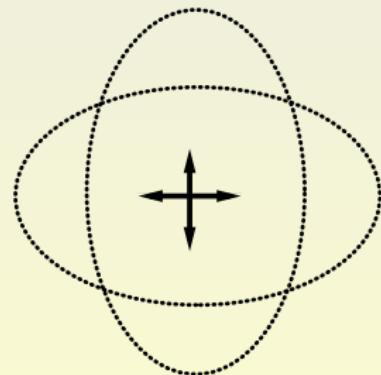


x mode

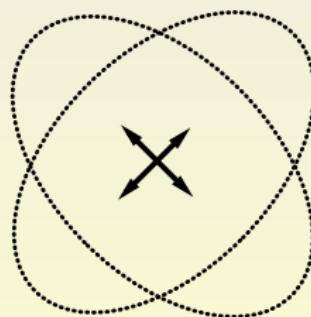


Einstein field equation → gravitational waves

+ mode



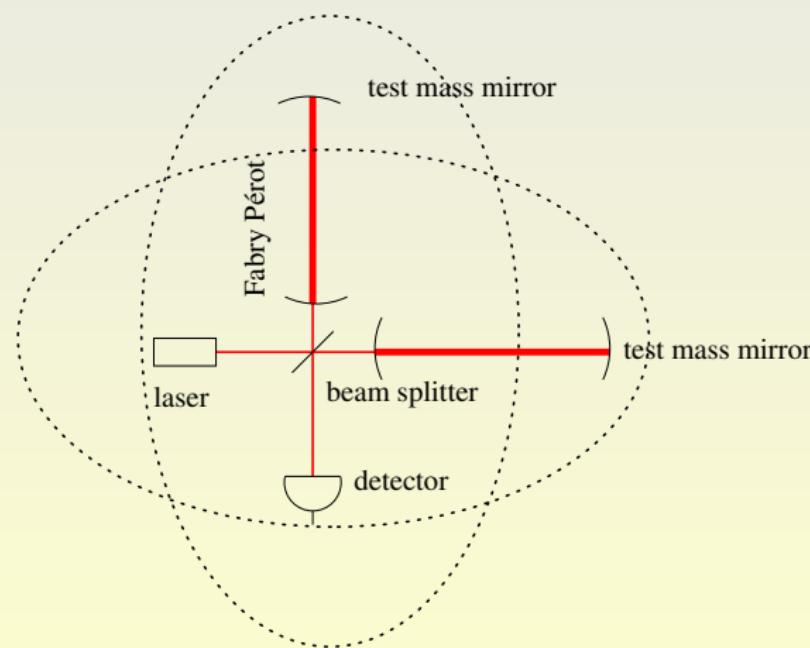
x mode



oscillating run times for photons in different directions



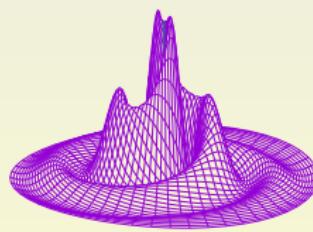
Michelson Interferometer



MAX-PLANCK-GESELLSCHAFT

possible sources

- ▶ bursts
- ▶ inspiral waveform
- ▶ continuous waveform
- ▶ stochastic background



location of the detectors



MAX-PLANCK-GESELLSCHAFT

sky position

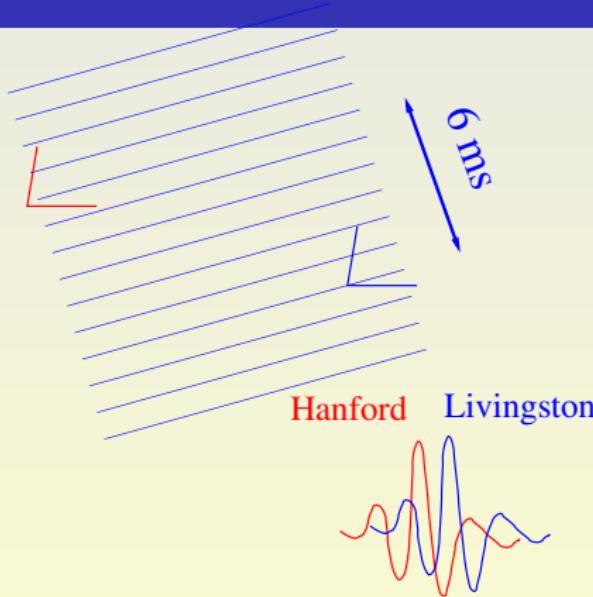


Hanford Livingston



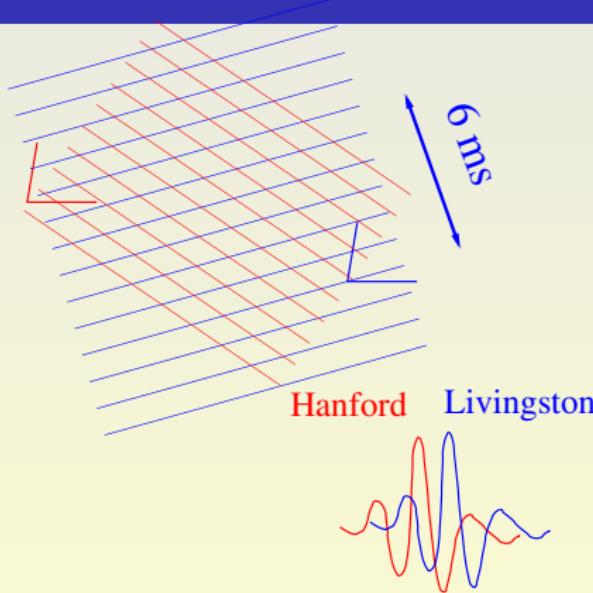
MAX-PLANCK-GESELLSCHAFT

sky position



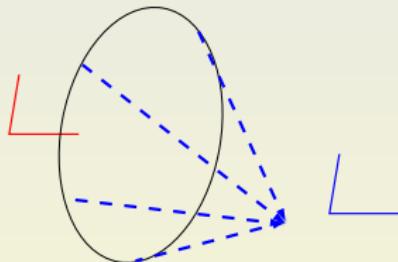
MAX-PLANCK-GESELLSCHAFT

sky position

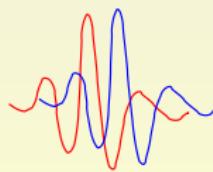


MAX-PLANCK-GESELLSCHAFT

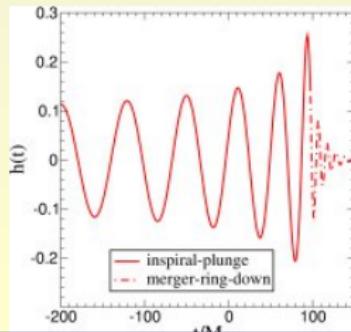
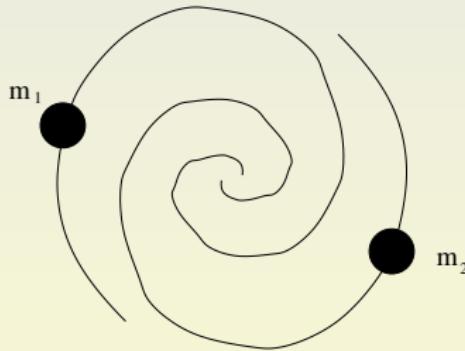
sky position



Hanford Livingston



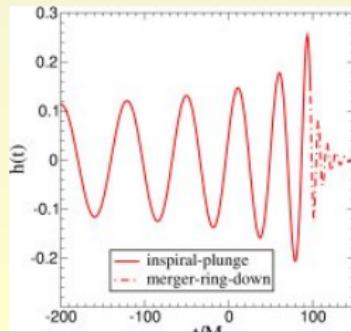
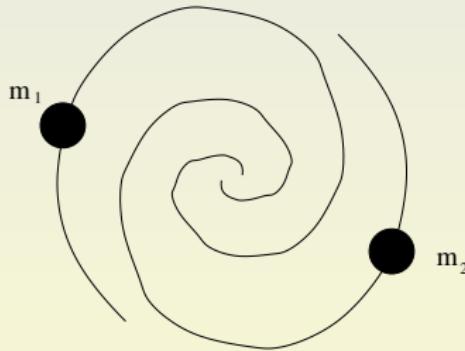
extracting the signals



MAX-PLANCK-GESELLSCHAFT

extracting the signals

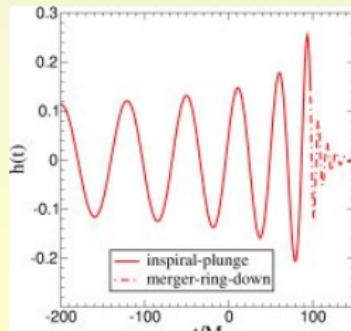
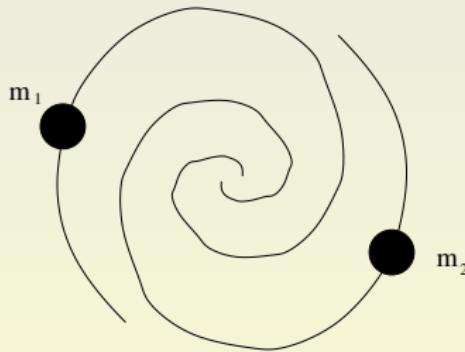
$$\rho = 4 \int df \frac{\tilde{s}(f) \tilde{h}^*(f)}{S(f)}$$



MAX-PLANCK-GESELLSCHAFT

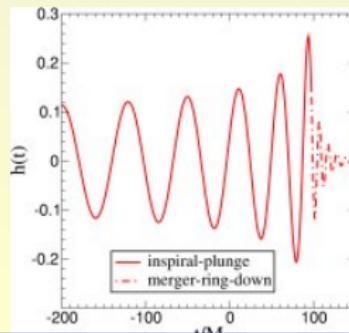
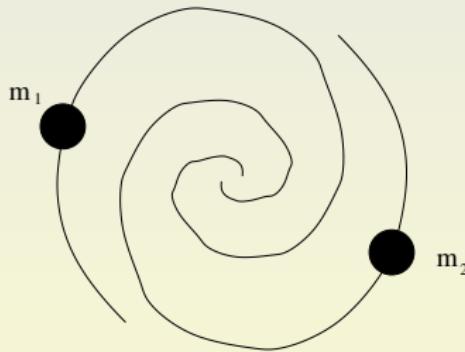
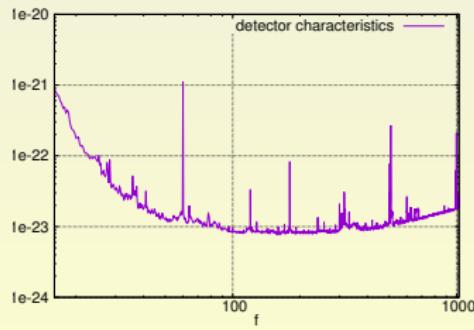
extracting the signals

$$\rho = 4 \int df \frac{\tilde{s}(f) \tilde{h}^*(f)}{S(f)} e^{2\pi i f t_0}$$



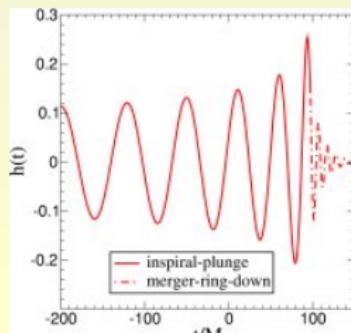
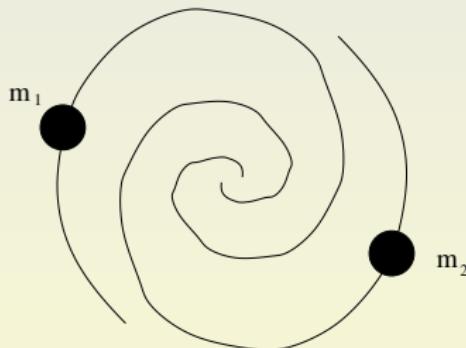
MAX-PLANCK-GESELLSCHAFT

extracting the signals



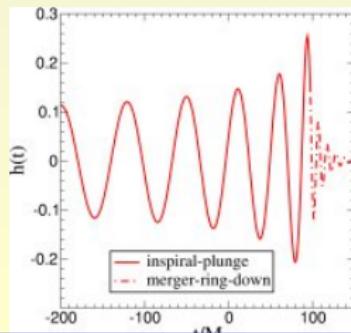
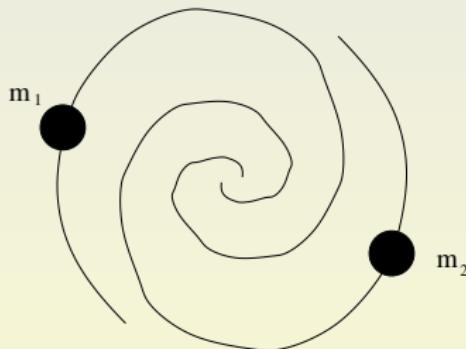
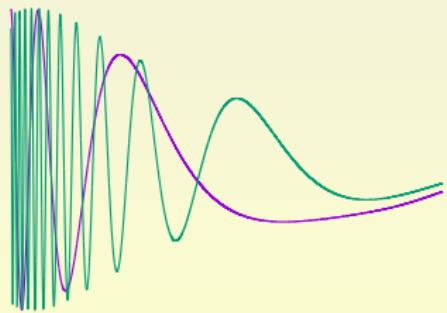
MAX-PLANCK-GESELLSCHAFT

extracting the signals



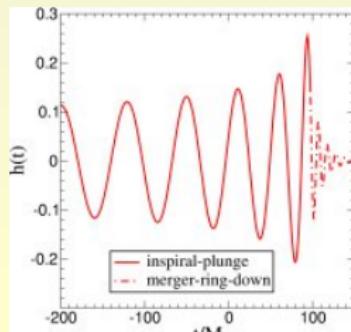
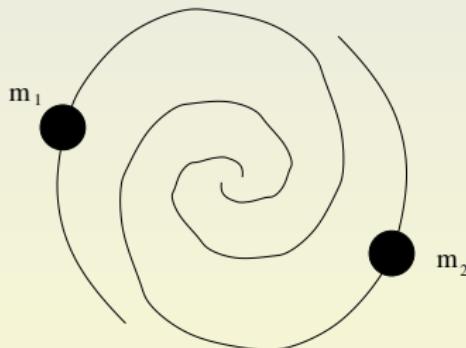
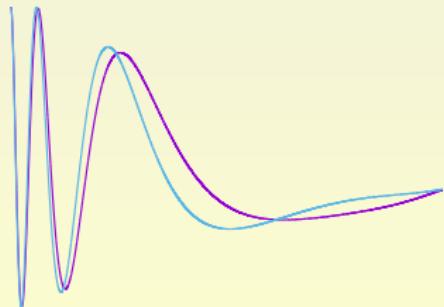
MAX-PLANCK-GESELLSCHAFT

extracting the signals



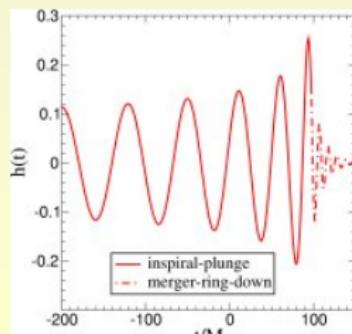
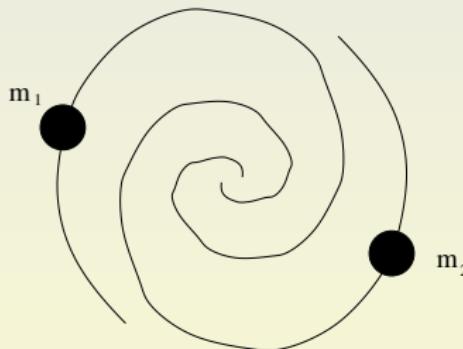
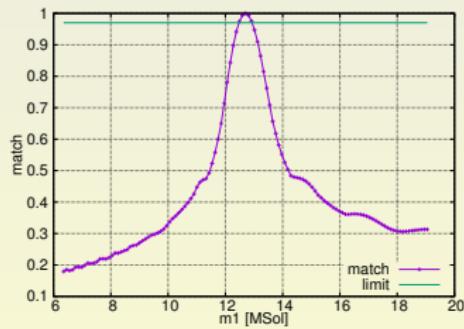
MAX-PLANCK-GESSELLSCHAFT

extracting the signals

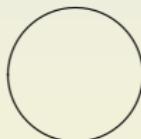


MAX-PLANCK-GESELLSCHAFT

extracting the signals

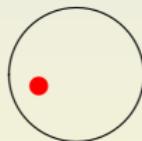


template banks

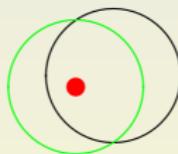


MAX-PLANCK-GESELLSCHAFT

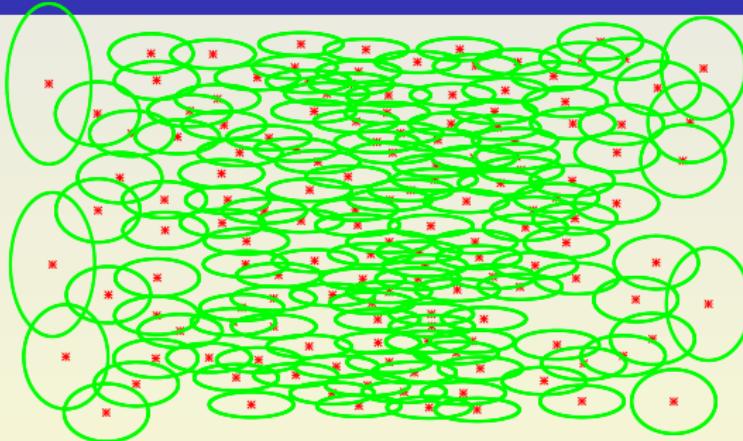
template banks



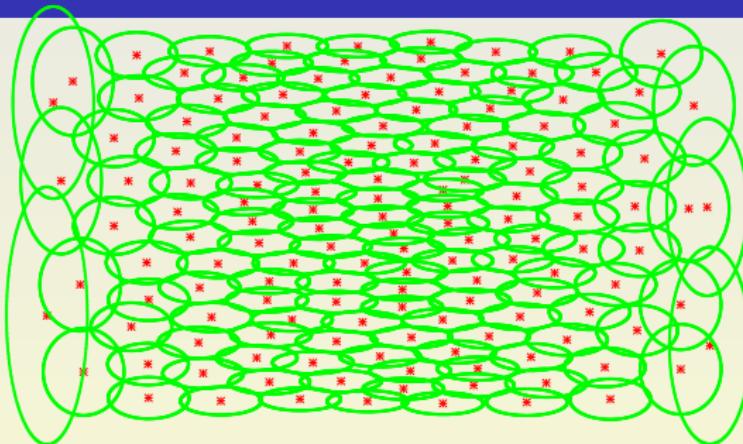
template banks



template banks



template banks



MAX-PLANCK-GESELLSCHAFT

template banks

- ▶ 250,000 templates
- ▶ 200,000 data sets
- ▶ 100,000 condor jobs
- ▶ 20% of Atlas resources



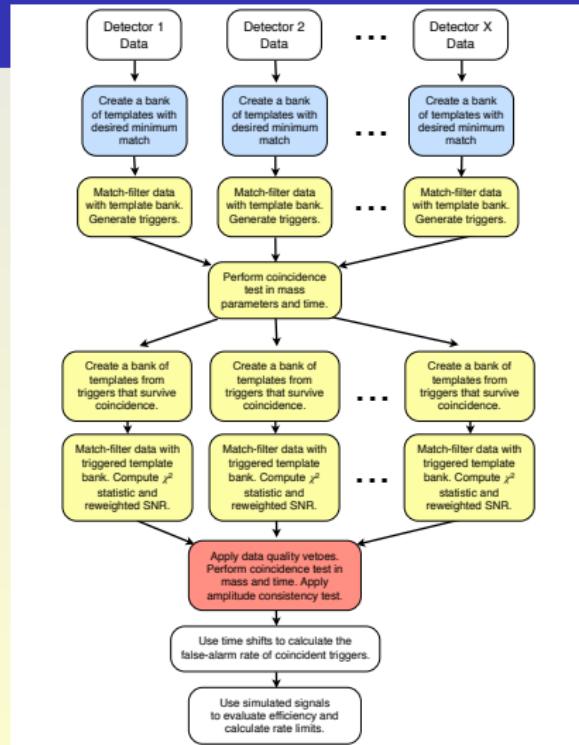
MAX-PLANCK-GESSELLSCHAFT

template banks

- ▶ 250,000 templates
- ▶ 200,000 data sets
- ▶ 100,000 condor jobs
- ▶ 20% of Atlas resources
- ▶ ⇒ 100M triggers/detector



flow chart CBC



MAX-PLANCK-GESELLSCHAFT

parameter estimation

- ▶ Nested Search
- ▶ Multi Nest
- ▶ Markov Chain Monte Carlo

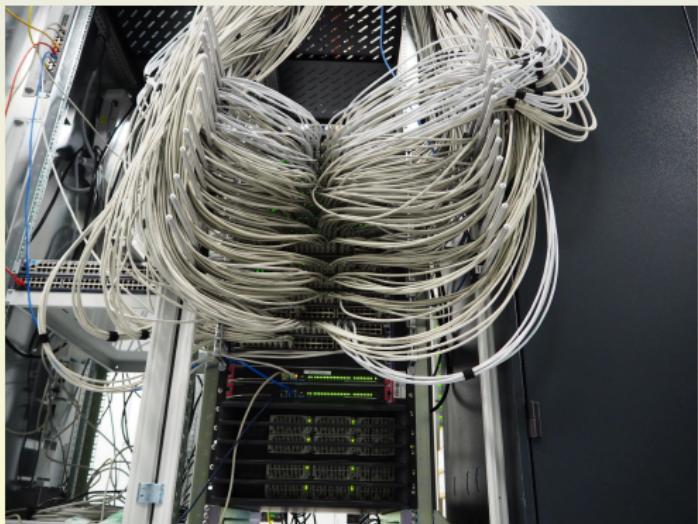


Atlas compute farm

- ▶ 102 water cooled racks with 42 HU
- ▶ 3200 compute nodes
 - ▶ mostly E3-1220 v3 3.1GHz 4 cores
 - ▶ 16GB RAM
 - ▶ 1TB HDD
 - ▶ 60 GB SSD
 - ▶ GTX750 GPU
- ▶ 37 LDR Server with 50TB each
- ▶ HSM with 1.2PB disk storage and 4PB tape storage (2x)
- ▶ HP 12900 core switch with 720 10GB ports
- ▶ 102 TOR switch with 40GB uplink and 48 1GB links



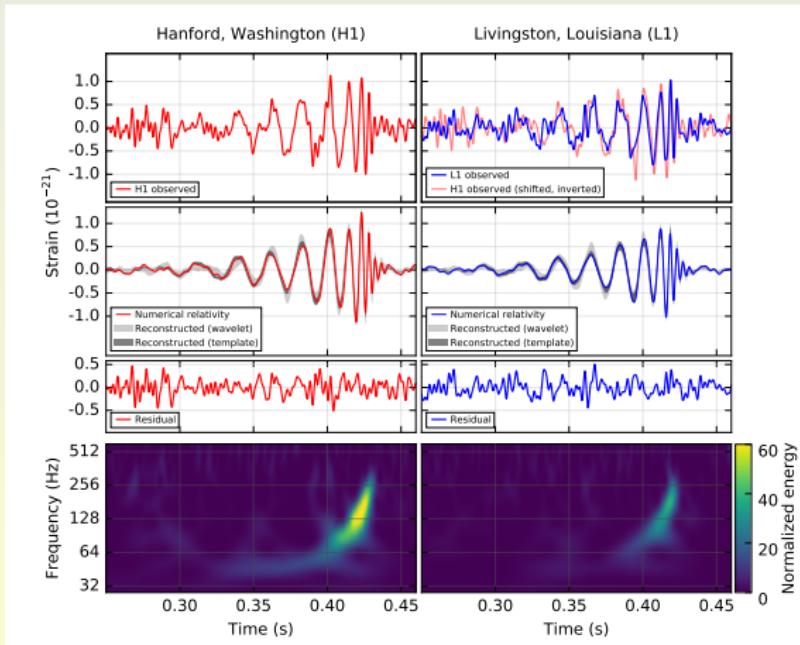
Atlas compute farm



Atlas compute farm

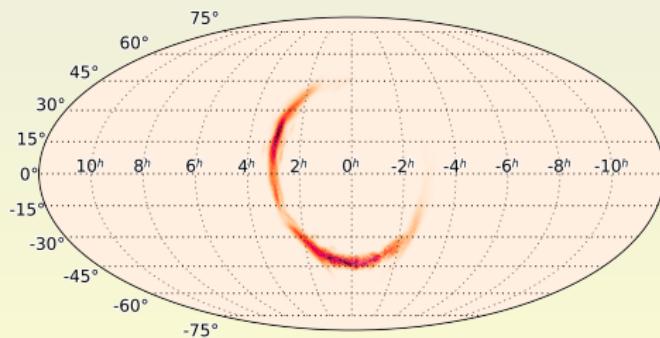


results



PRL 116 061102 (2016)

sky position



MAX-PLANCK-GESSELLSCHAFT

scientific achievement

- ▶ GW can be measured
- ▶ existence of black holes
- ▶ existence of black hole binary systems
- ▶ merger of black holes
- ▶ Einstein field equations are working well in the strong field regime



MAX-PLANCK-GESELLSCHAFT