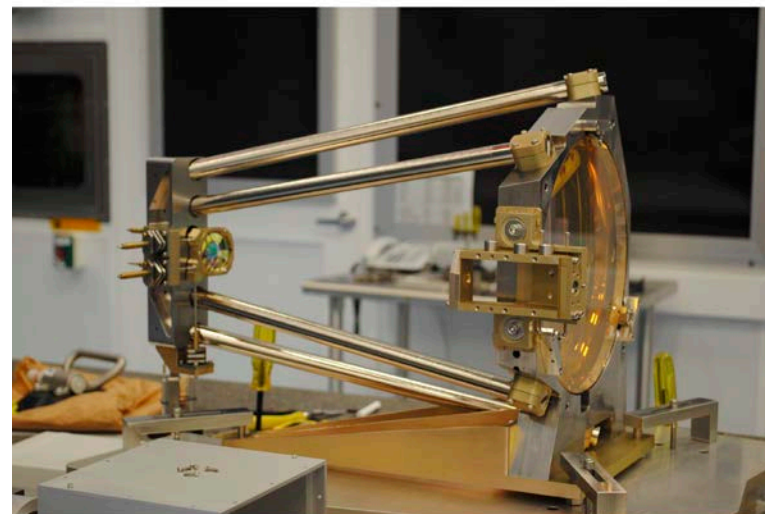
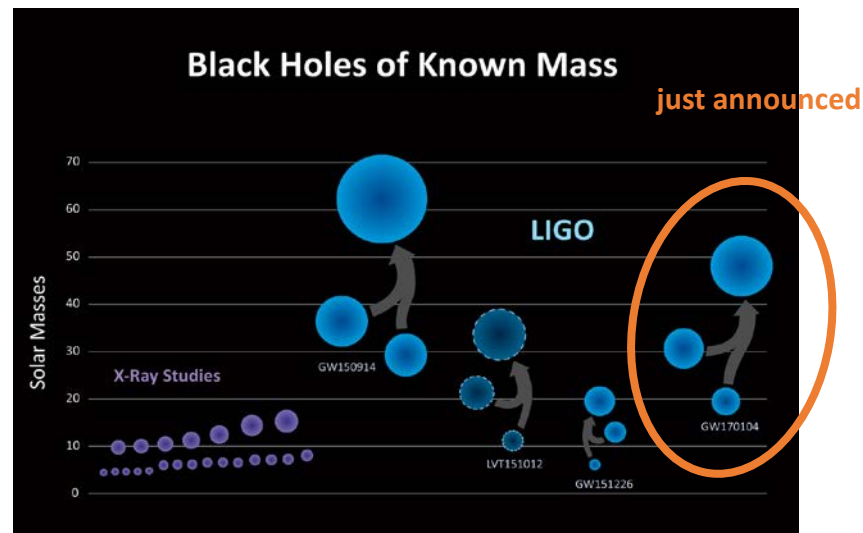


3rd confirmed detection of gravitational waves from merging black holes

- **What are the science questions?**
 - How are black holes formed?
 - Was Einstein right about gravity?
- **What were the findings?**
 - Black hole mergers occur at rate of ~ 1 per month
 - LIGO's black holes heavier than those previously known
 - More power radiated in gravitational waves than light from all stars in the universe combined
- **New Science: Origin of these systems is a puzzle**
 - Chance encounters of two black holes?
 - Evolved from a pair of massive stars
- **What is GSFC's involvement?**
 - LIGO data analysis & theory
 - Follow-up LIGO triggers with NASA assets – Fermi, Swift, WFIRST
- **New opportunity for GSFC and NASA**
 - NASA is partnering with ESA to develop space-based LISA gravitational wave observatory.
 - LISA is like JWST for gravitational waves – detects sources you can't see from the ground, observes objects at much larger distances
 - The NASA part of LISA is being led from Goddard
 - Key technologies: **telescope, lasers**, micro-thrusters, phasemeter, charge management
 - Technology development underway now!



Abbott, et al. "GW170104: Observation of a 50-Solar-Mass Binary Black Hole Coalescence at Redshift 0.2", *Phys. Rev. Lett.* **118** 221101. GSFC Authors: Barthelmy (661), Camp (663), Cannizzo (661), Dal Canton (663), De Rosa (663), Fulda (663), Gehrels (661), Singer (661)