A Summary of Multimessenger Science with Neutron Star Mergers

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on behalf of

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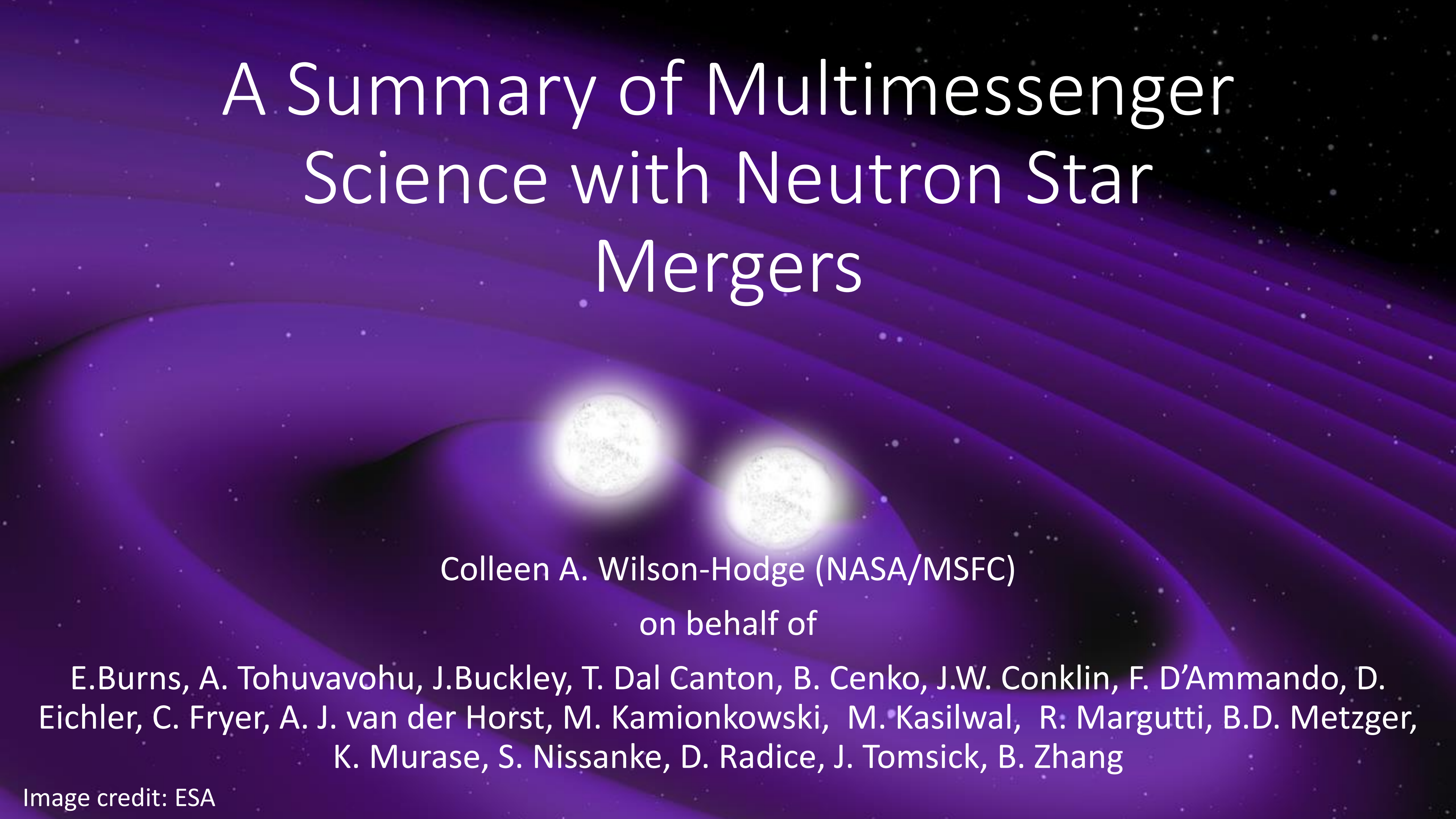
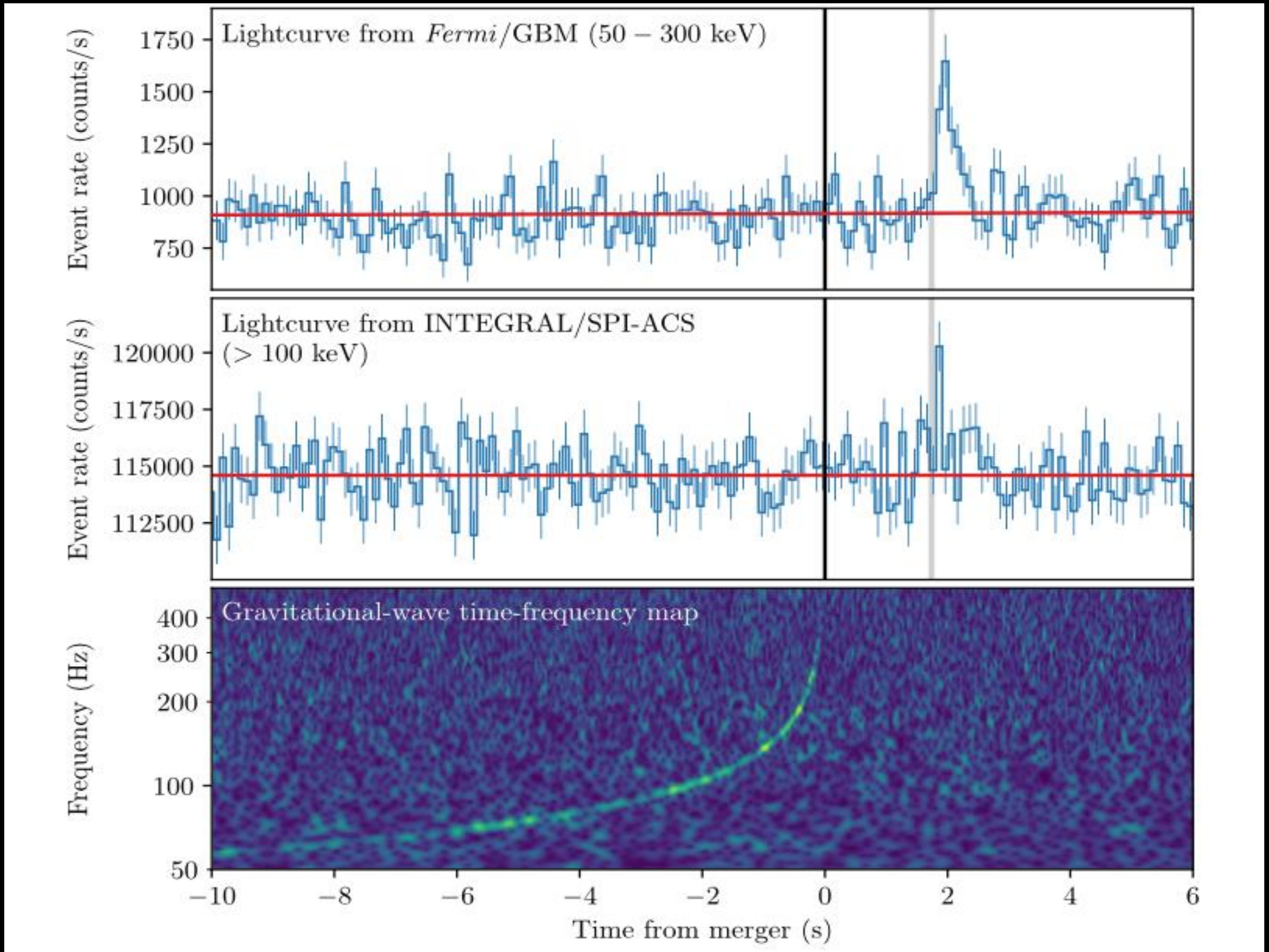
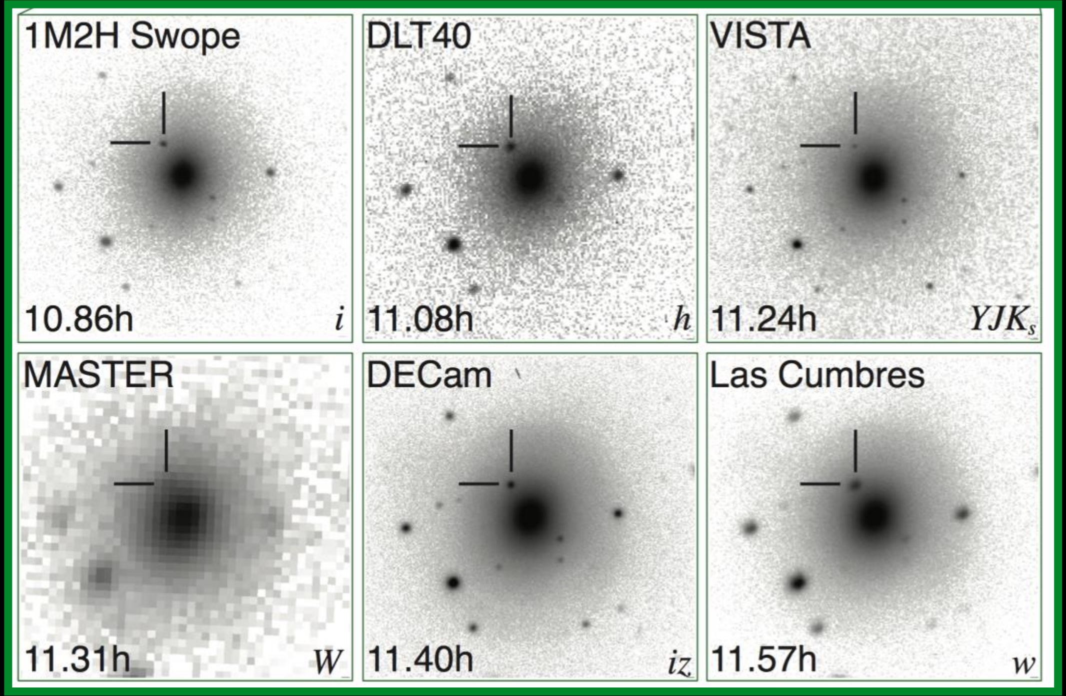


Image credit: ESA

GW170817/GRB 170817A/AT2017gfo



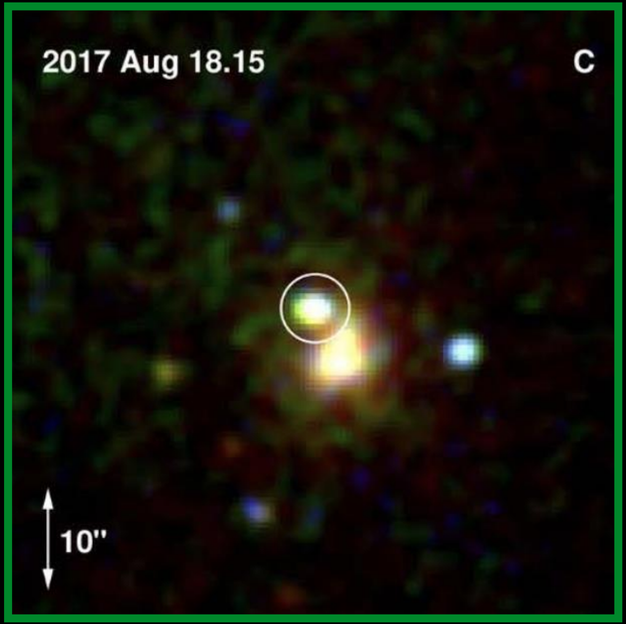
Abbott et al. 2017



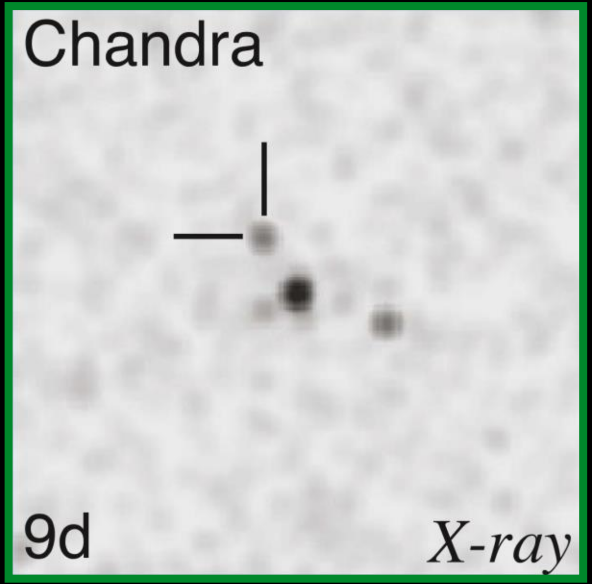
Abbott et al. 2017

+12 hours detection of blue kilonova

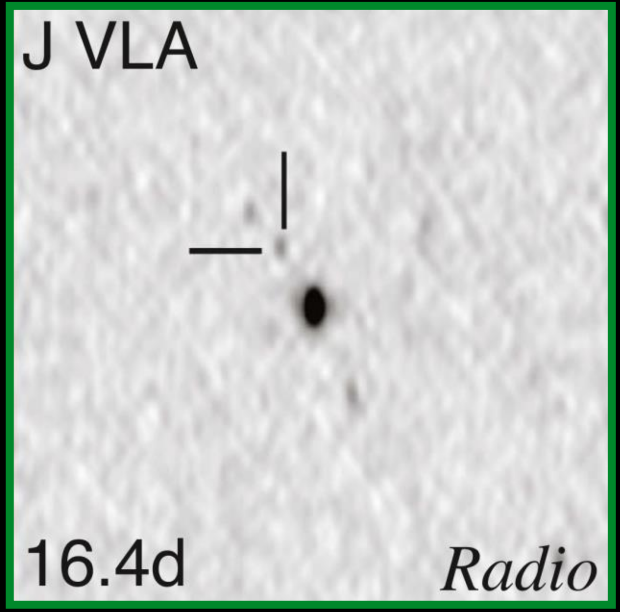
GW170817/GRB 170817A/AT2017gfo



+13 hours bright, but fading UV source (Evans et al 2017)

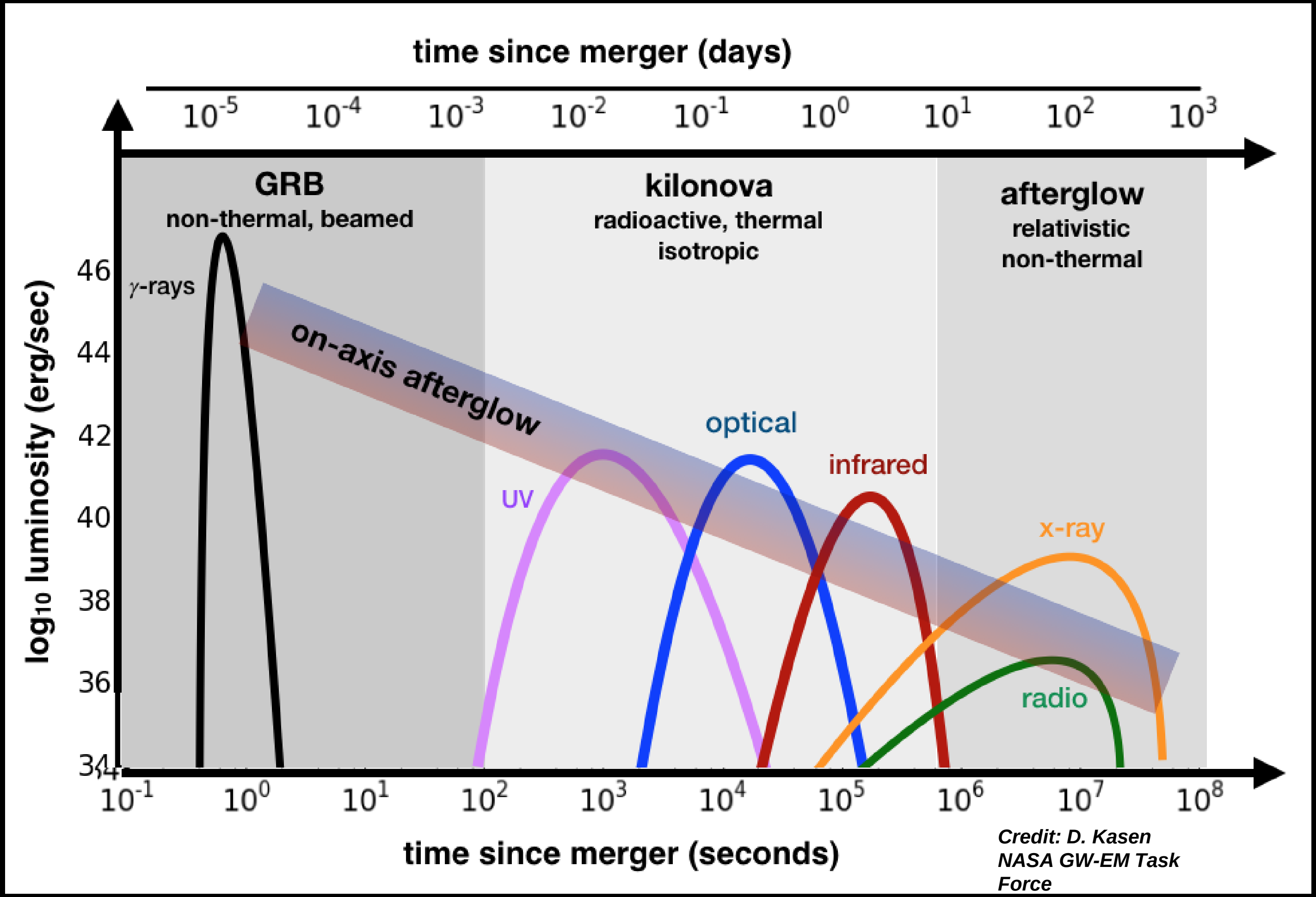


+9 d First evidence of delayed X-ray emission (Troja et al. 2017)



+16 d Radio counterpart (Mooley et al. 2017)

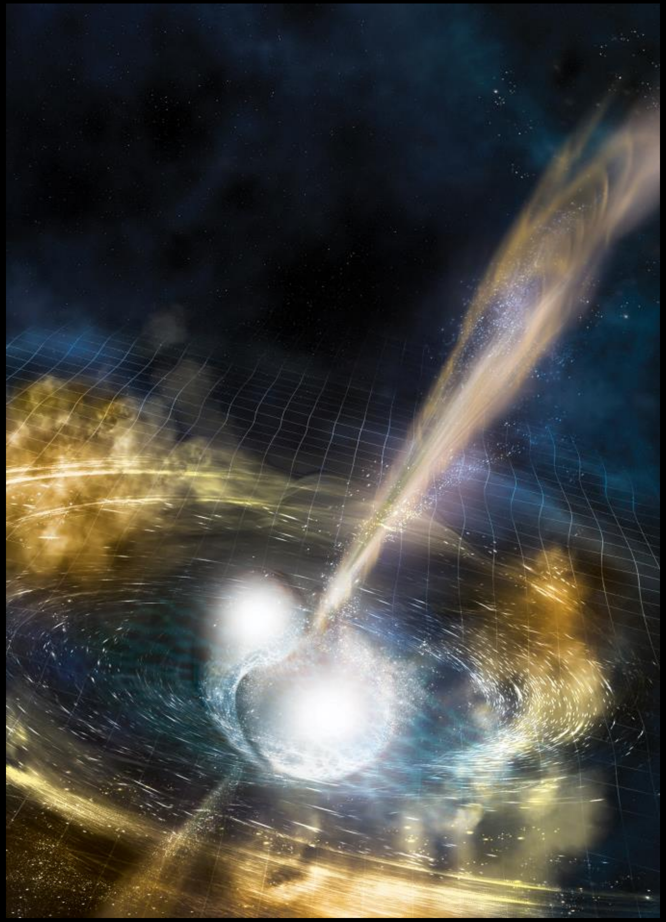
Electromagnetic Counterparts to NS Mergers



- Counterparts across the EM spectrum
  - Prompt Short Gamma-ray Burst (SGRB) relativistic jet: viewed on (or slightly off)-axis
  - Kilonova: Radioactive glow from heavy elements, isotropic
  - Afterglow: relativistic jet as it interacts with the surrounding medium. Onset varies with viewing angle.

Science from NS mergers – SGRB + GW

- Origin and implications of non thermal emission
- Relation to central engine
- Structure and interactions of SGRB jets
- Relationship between jets and progenitor
- Fraction of SGRBs from BNS and NSBH
- Presence of and lifetime of a heavy magnetar
- Merger time from GWs
  - Bulk Lorentz factor of jet
  - Size of gamma-ray emitting region
  - Origin of the prompt emission
  - Speed of gravity
- Neutron star equation of state

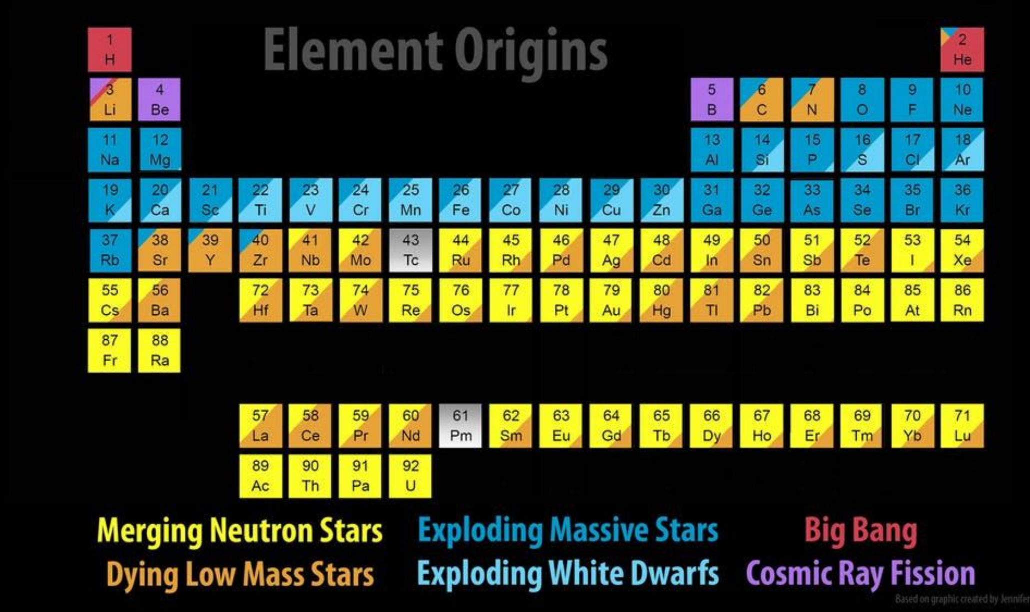


Credit: NSF/LIGO/Sonoma State University/A. Simonnet

Science from NS mergers – Kilonova+GW

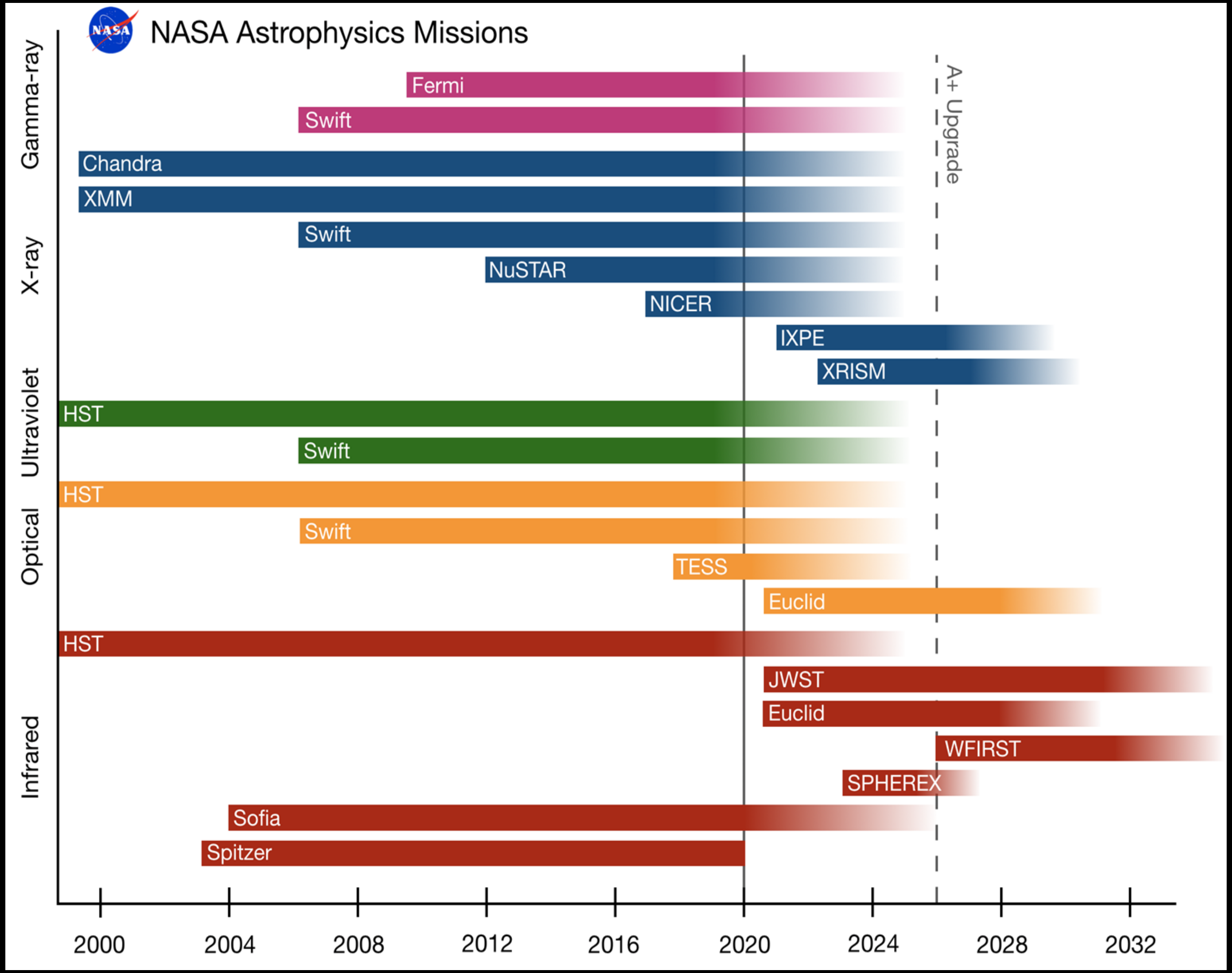
- Relationship between kilonova color and luminosity to properties of the progenitor
  - Merger type
  - Mass and spin of progenitors
  - NS EOS
- Origin of heavy elements
  - Fraction from NS mergers
  - Total and relative heavy element abudances
- Fundamental physics
  - Hubble constant
  - Neutron star equation of state

Credit: NASA/GSFC



Credit: Jennifer Johnson/SSDS

Outlook for NASA Missions for Multimessenger Observations



- Crucial capabilities for follow-up are aging
  - Gamma-ray – Fermi/Swift
  - X-ray -Swift
  - UV -Swift
- No currently planned replacements for these missions
- Cubesats/smallsats are complementary but do not replace the capability of Explorer-class or larger missions

Recommendations (Next 10 years)

- Vigorous funding for upgraded GW interferometers
- Allocation of observing time and ToOs for pointed telescopes and LSST follow-up of NS mergers
- Support for the full IceCube Gen-2
- Continued extension of the Fermi and Swift missions (UV, X-ray, and gamma-ray)
- Development of Wide-field UV (space-based) and NIR (ground-based) facilities
- Improvements to real-time communication for space-based missions
- Greater NASA-NSF cooperation
    - Funding of beam studies to understand nuclear processes
    - Robust funding of multimessenger simulation and theory programs
    - Resolving grand problems through NASA-NSF partnership
- Technical improvements
    - Real time reporting
    - Automated multimission and multimessenger searches
    - Prompt reporting of initial parameter estimation

Future Large-scale Missions

- Must be designed for the 2020s, not the current era
- Broadband sensitivity improvements for future GW interferometers
- Large scale gamma-ray observatory
  - Detection of far more SGRBs through improved ~keV-MeV sensitivity and broad sky coverage
  - Localization of SGRBs to sufficient accuracy for sensitive follow-up observations
- Sensitive, fast-response, high-spatial resolution X-ray telescope
- Sensitive UVOIR and radio telescopes