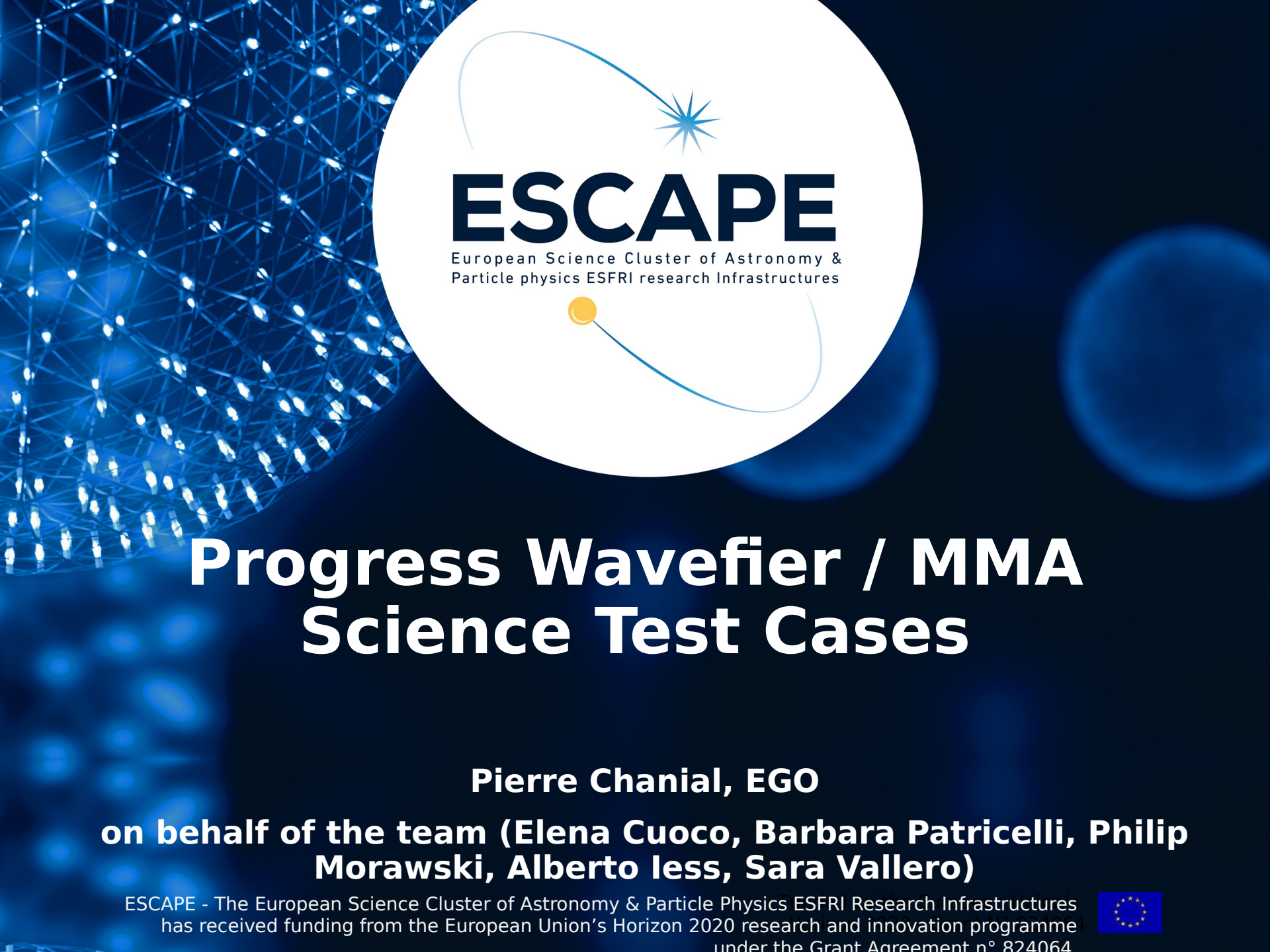


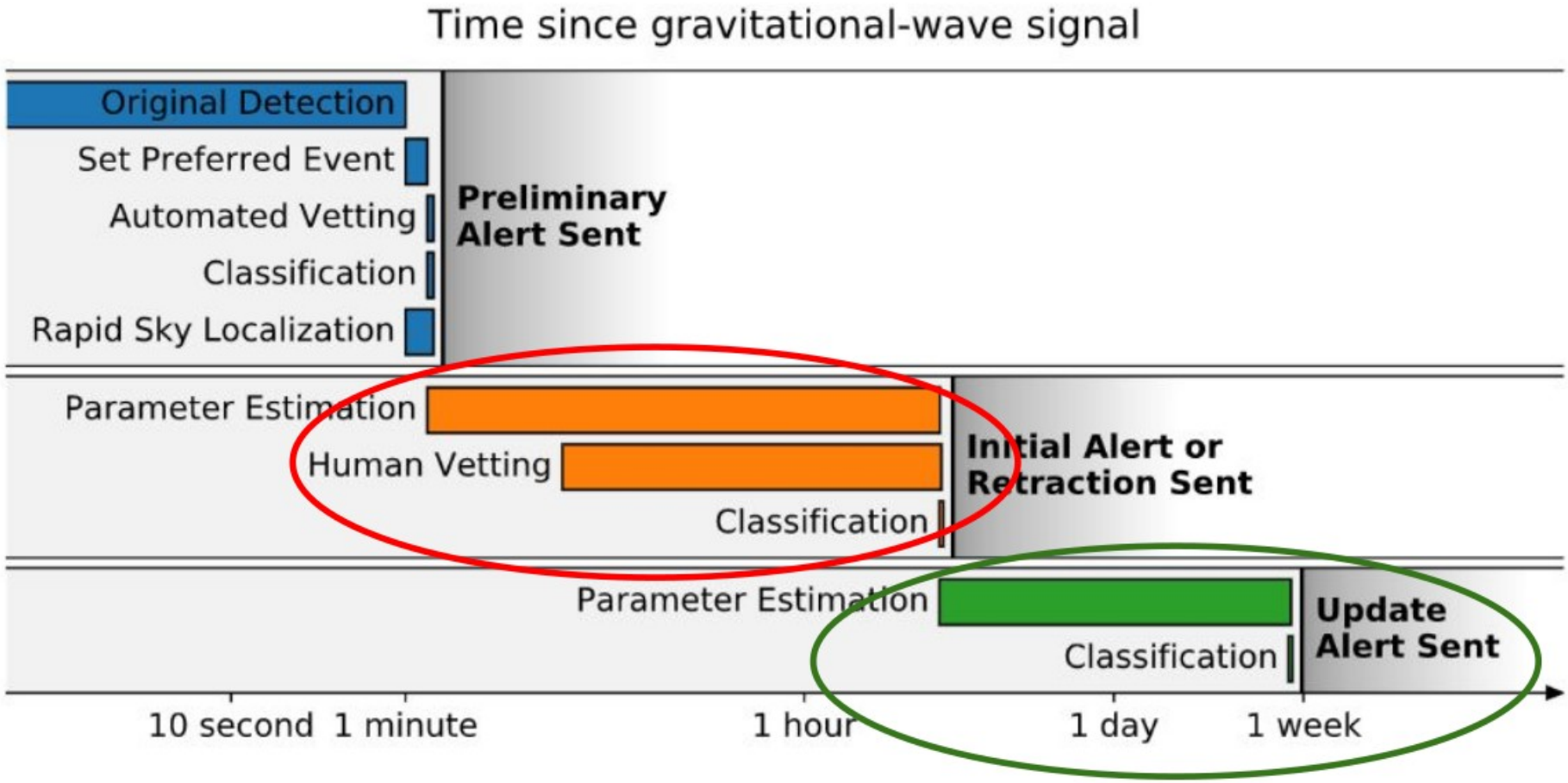
Progress Wavefier / MMA Science Test Cases

Pierre Chanial, EGO

on behalf of the team (Elena Cuoco, Barbara Patricelli, Philip Morawski, Alberto Iess, Sara Vallero)

ESCAPE - The European Science Cluster of Astronomy & Particle Physics ESFRI Research Infrastructures has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 824064

Gravitational Wave Alert System



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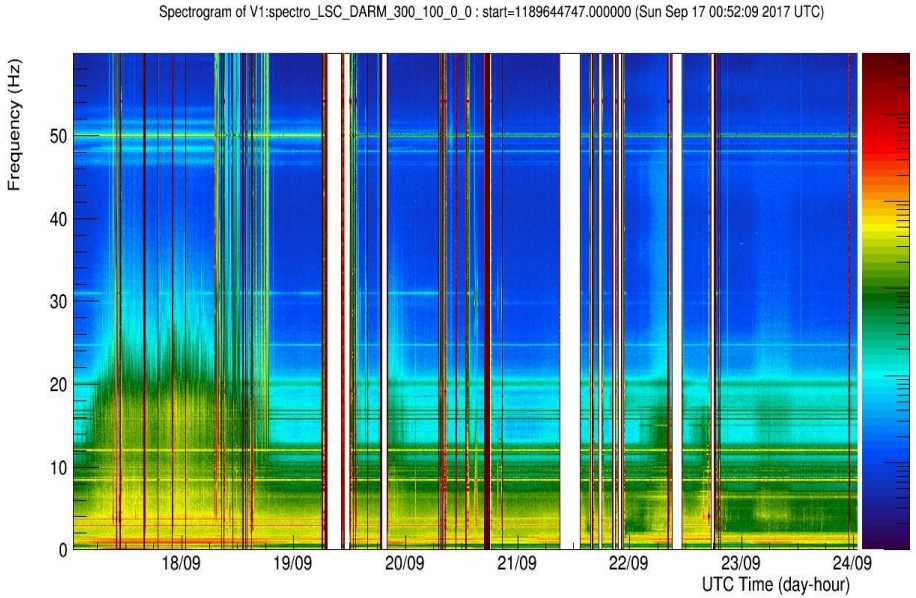
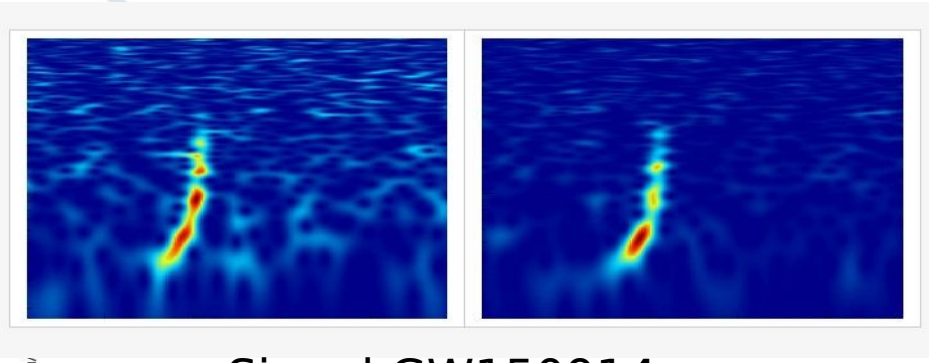
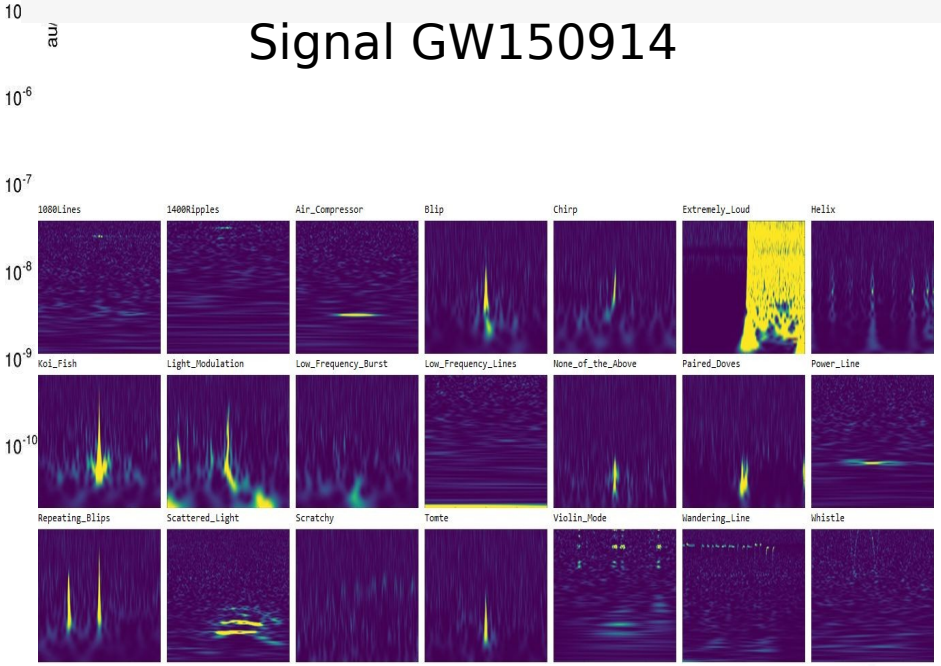
Detector Noise vs Signal



Broadband noise



Signal GW150914



Glitches

Gravity Spy, Zevin et al (2017)
https://www.zooniverse.org/projects/zooniverse/gravity-spy

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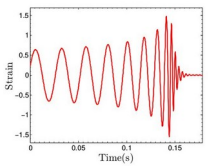
Wavefier Online / Offline Architecture



kafka MirrorMaker at CNAF

kafka

timelines

triggers

Grafana dashboard

WDF Detector

Wavefier Classifier

Kubernetes Cluster Prototype at GARR

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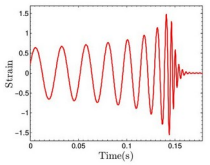
Wavefier Online / Offline Architecture



kafka MirrorMaker at CNAF

ESCAPE data-lake

Other potential real-time or offline pipelines

kafka

timelines

triggers

Grafana dashboard

WDF Detector

Wavefier Classifier

Kubernetes Cluster Prototype at CNAF

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Questions

- Integration with WP2
  - ➔ data locality (CNAF → datalake → CNAF)
  - ➔ RT : notification when new files are added to the datalake
- Integration with WP4
  - ➔ dealing with timelines
  - ➔ should GWOSC join IVOA ?
- How to integrate Kubernetes-managed jobs with WP5 ?
  - ➔ cluster deployment, management and monitoring
  - ➔ application deployment and scaling
  - ➔ at the JupyterHub level (development, model training)

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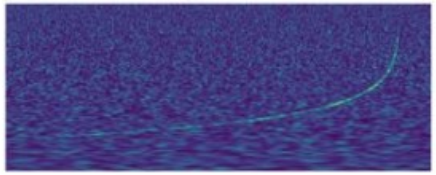
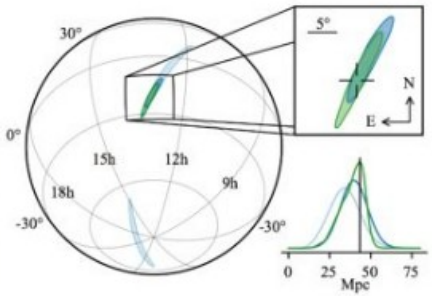
GW170817 detection and EM follow up

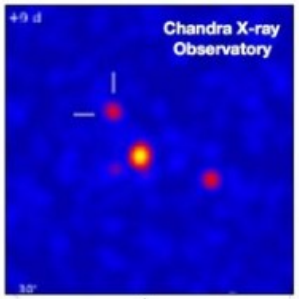
Gravitational Waves
LIGO-Virgo



Sky localization



X-ray



GW170817
Timeline

GRB by Fermi GBM
+1.7sec

+10.8h

+16days

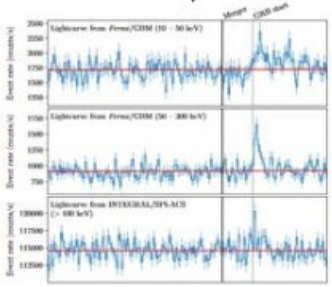
17/08/17 12:41:04 UTC

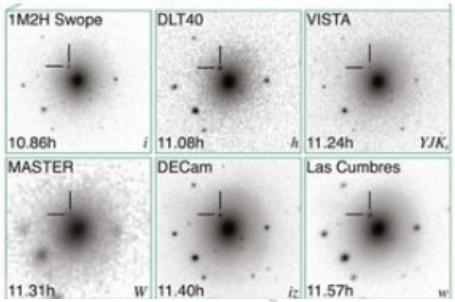
+5h

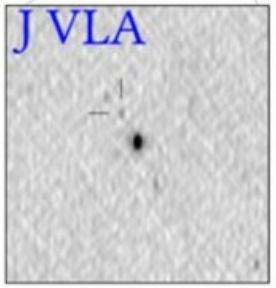
Optical/UV/NIR kilonova

+9days

Radio afterglow







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Gravitational Waves & Multimessenger astronomy

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

- **Short GRB**
  Fermi GBM, INTEGRAL, Astrosat, IPN, Insight-HXMT, Swift, AGILE, CALET, H.E.S.S., HAWC, Konus-Wind
- **Gravitational waves (well-modeled)**
  Ligo/Virgo

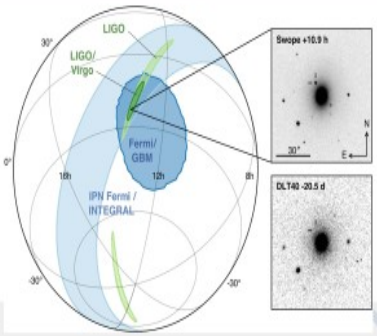
EARLY TRIGGERS (*sec to mins*)

- **X-Ray**
  Swift, MAXI/GSC, NuSTAR, Chandra, Integral
- **UV**
  Swift, HST
- **RADIO**
  ATCA, VLA, ASKAP, VLBA, GMRT, MWA, LOFAR, LWA, ALMA, OVRO, EVN, e-MERLIN, MeerKAT, Parkes, SRT, Effelsberg
- **IR**
  REM-ROS2, VISTA, Gemini-South, 2MASS, SPITZER, NTT, GROND, SOAR, NOT, ESO-VLT, Kanata Telescope, HST
- **Optical**
  Swope, DECam, DLT40, MASTER, VISTA, ESO-VLT + other

BROADBAND FOLLOW-UP (*hrs to days*)

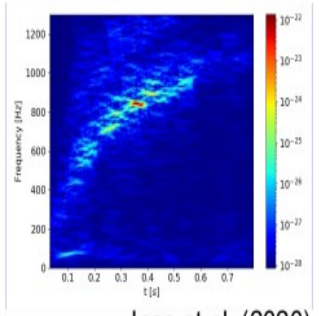
Binary Neutron Star Merger

- *Fast alert and sky Localization for follow-up study*
- *Better understanding of physical processes (e.g. heavy-element nucleosynthesis)*



Abbott et al. (2017)

- **Neutrinos**
  (prompt emission of ~ 90% of total CCSNe energy)
  IceCube, ANTARES, Pierre Auger Observatory
- **Gravitational waves**
  (prompt emission, unknown waveform, carry little energy)
  Ligo/Virgo



Iess et al. (2020)

- **E.M. emission** (delayed emission)

Core-Collapse Supernovae

- *Shed Light on explosion mechanism (neutrino-driven, MHD, acoustic)*
- *Information on physical characteristics of progenitor star (mass, rotation)*
- *Information on proto-neutron star*

Elena Cuoco

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MMA progresses

- Extend Wavefier to optical, for the detection of transient phenomena using ML. Still in the investigation phase
  - ➔ which data can we include
  - ➔ production of large multi-messenger simulated datasets
  - ➔ how to handle two streams of data in wavefier

- Multi-messenger analysis
  - ➔ inclusion of Fermi public data ?
  - ➔ discussions with CTA
  - ➔ contacting ZTF, IceCube, km3net

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