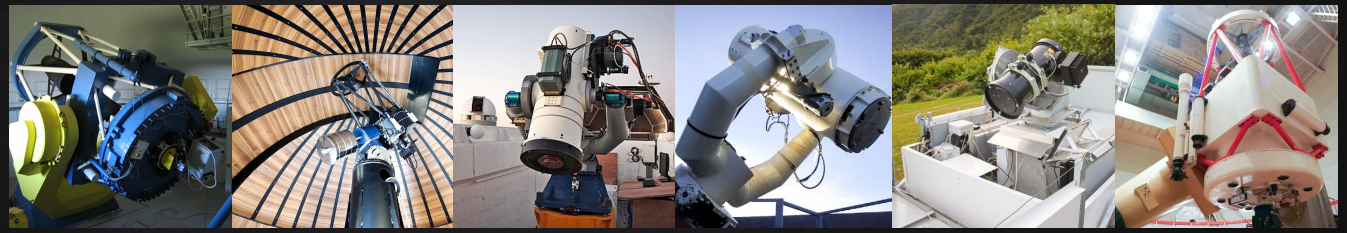
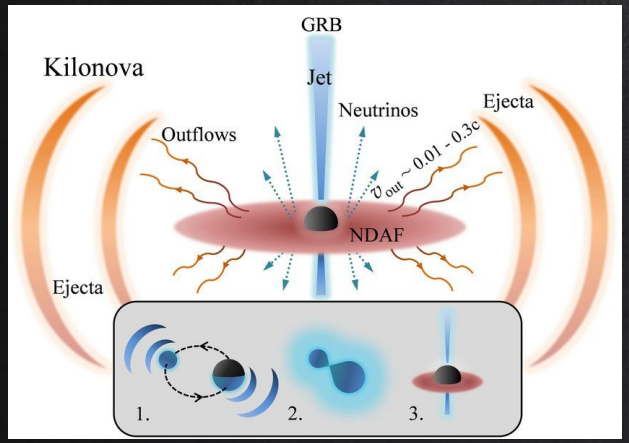
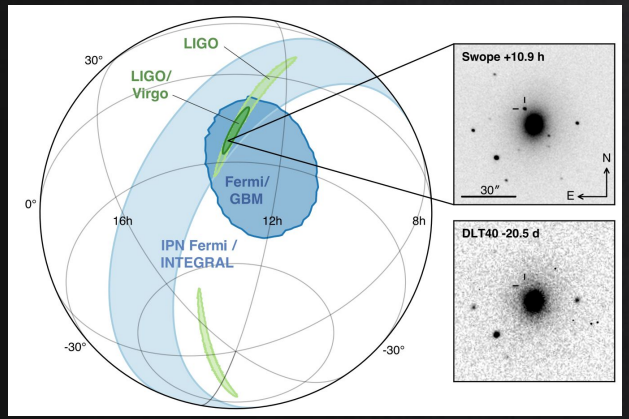
GRANDMA

Global Advanced rapid Network Devoted to multimessenger addicts



Multi-messenger astronomy





Why was GW170817 so bright and blue early?

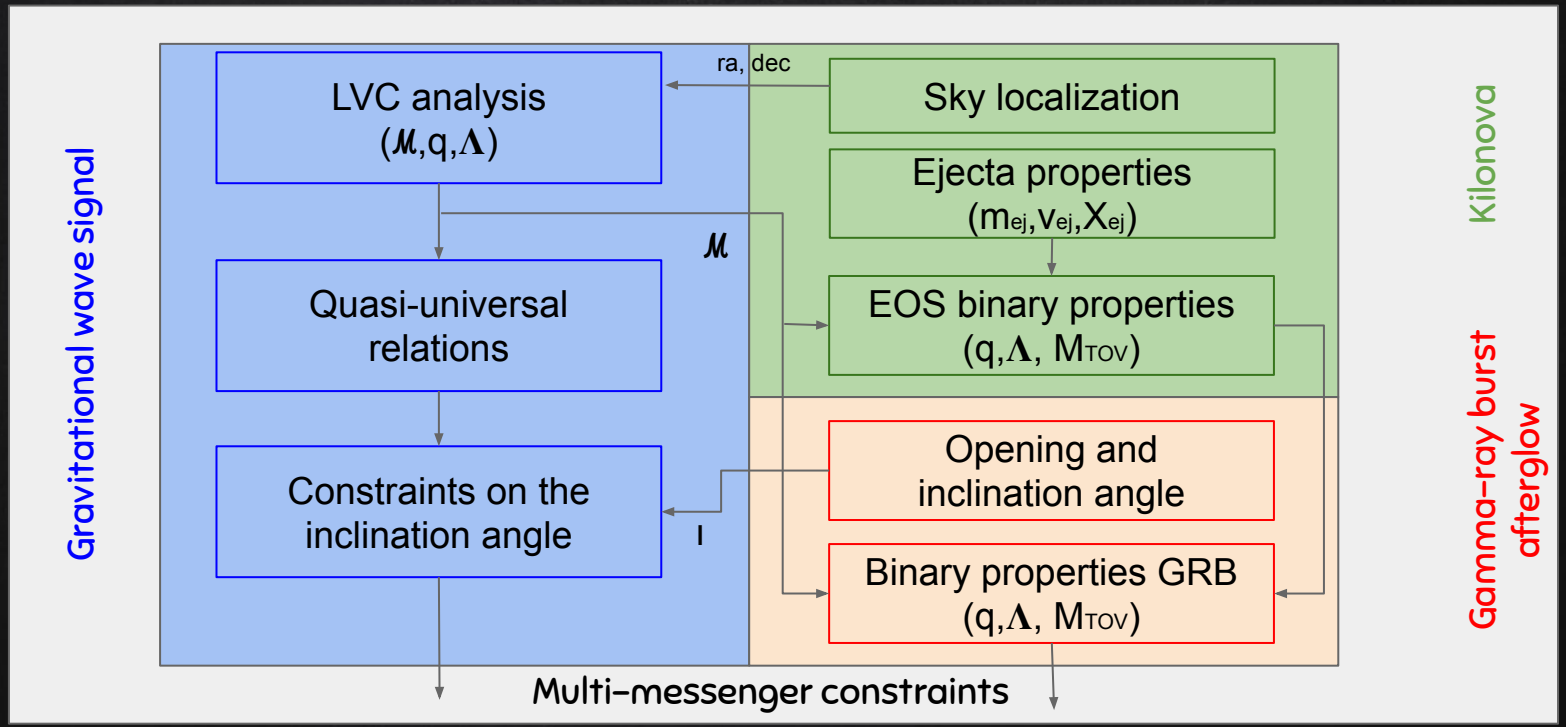
Do all neutron-star mergers generate relativistic ejecta?

How does the emission evolve in the first few hours post merger?

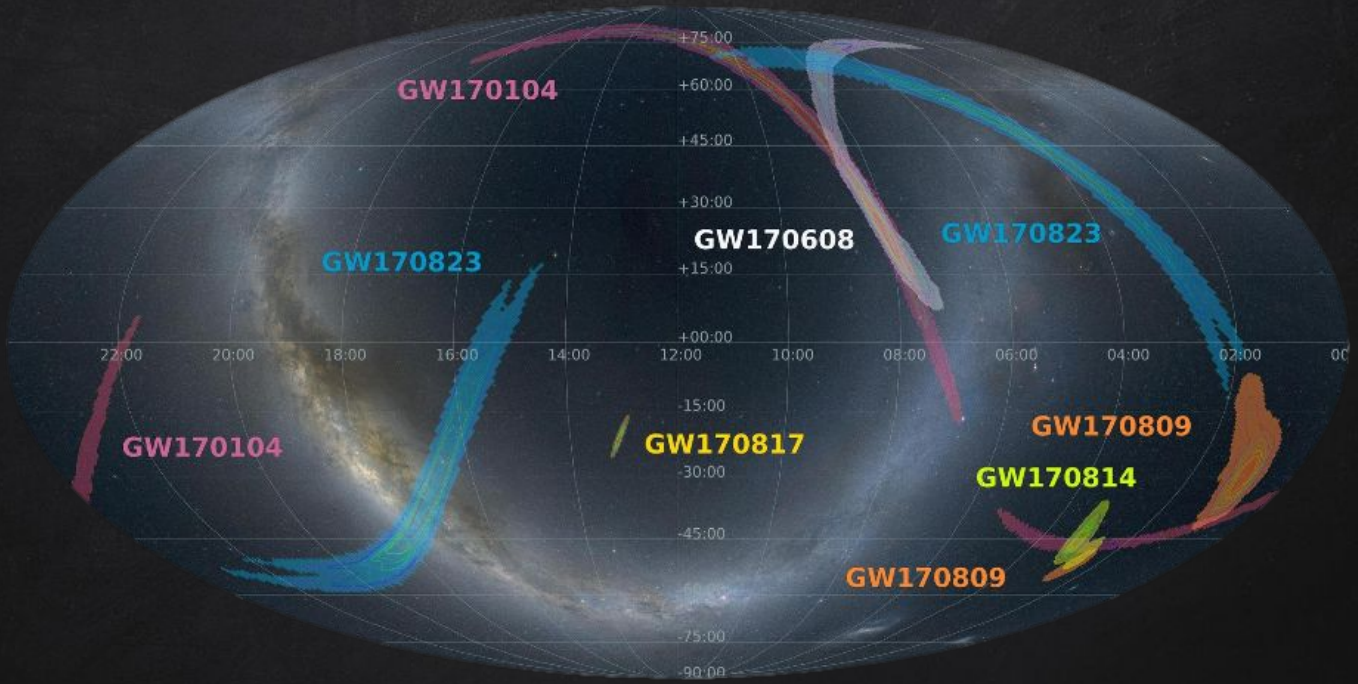
M. W. Coughlin, T. Dietrich, et al. Using kilonovae as standard candles to measure the Hubble Constant, submitted PRL, August 2019, 1908.00889

B. P. Abbott, et al. Estimating the Contribution of Dynamical Ejecta in the Kilonova Associated with GW170817., 850:L39, December 2017

Multi-messenger astronomy
A bridge between Physics and Astrophysics



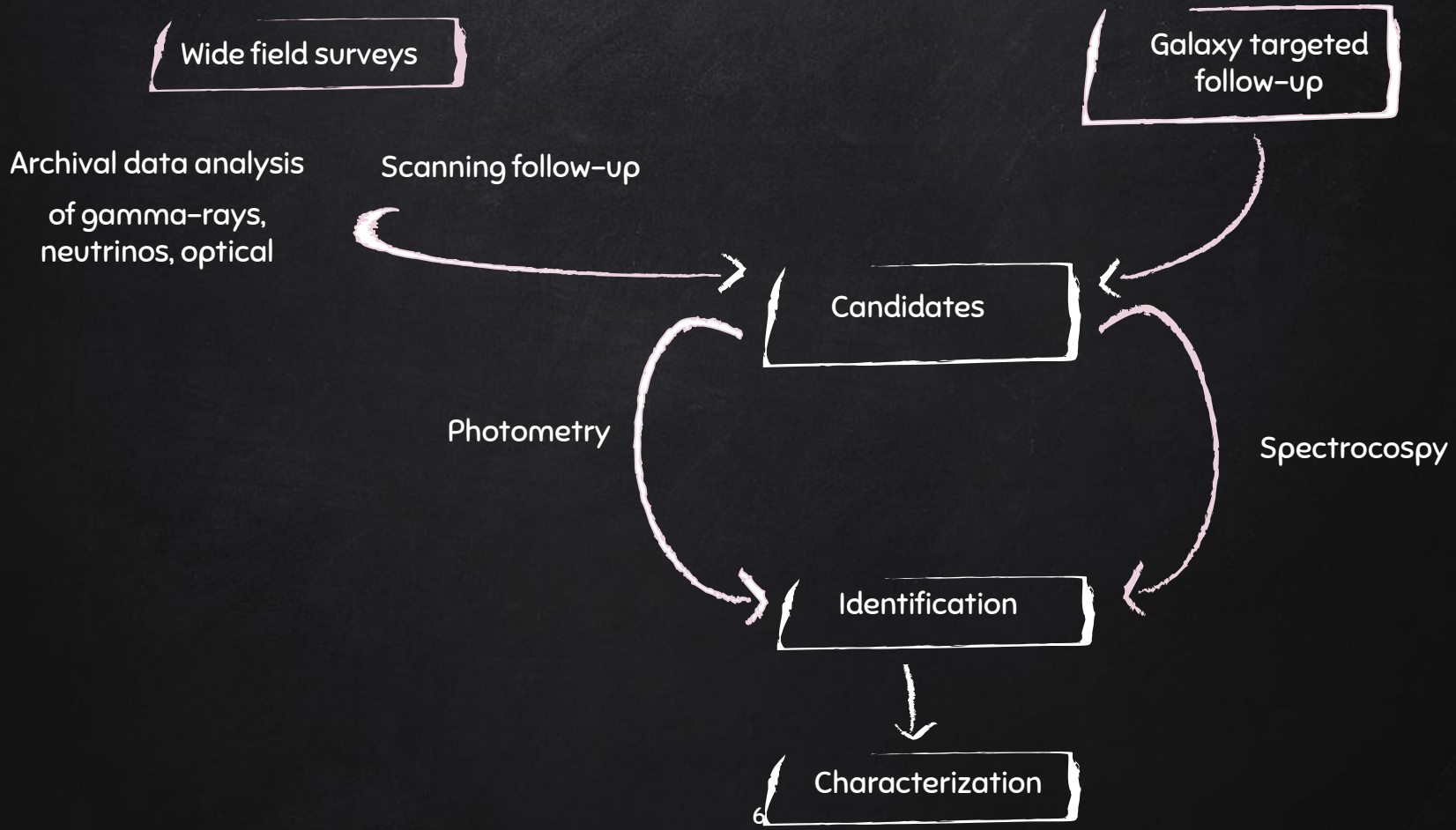
LIGO-Virgo O2 campaign



Low latency gravitational wave alerts for multi-messenger astronomy during the second advances LIGO and Virgo observing runs APJ, 2019 - S.Antier and M.Cho for the LVC collaboration

Where is Charlie ?

Follow-up strategy



Requirements

- Large coverage of the sky
- Rapid Follow-up
- Multi wavelength
- Central system

Concept

1.

2.

3.

Local team

Scientists – Infrastructure

Connecting existing facilities that are not supposed to be connected within a year

Created in April, 2018

by LAL – Obs Nice

More than 65 scientists

PI. S.Antier

22 institutes / groups

CNRS/LAL – APC – IAP – Obs Nice – IRAP – LAM

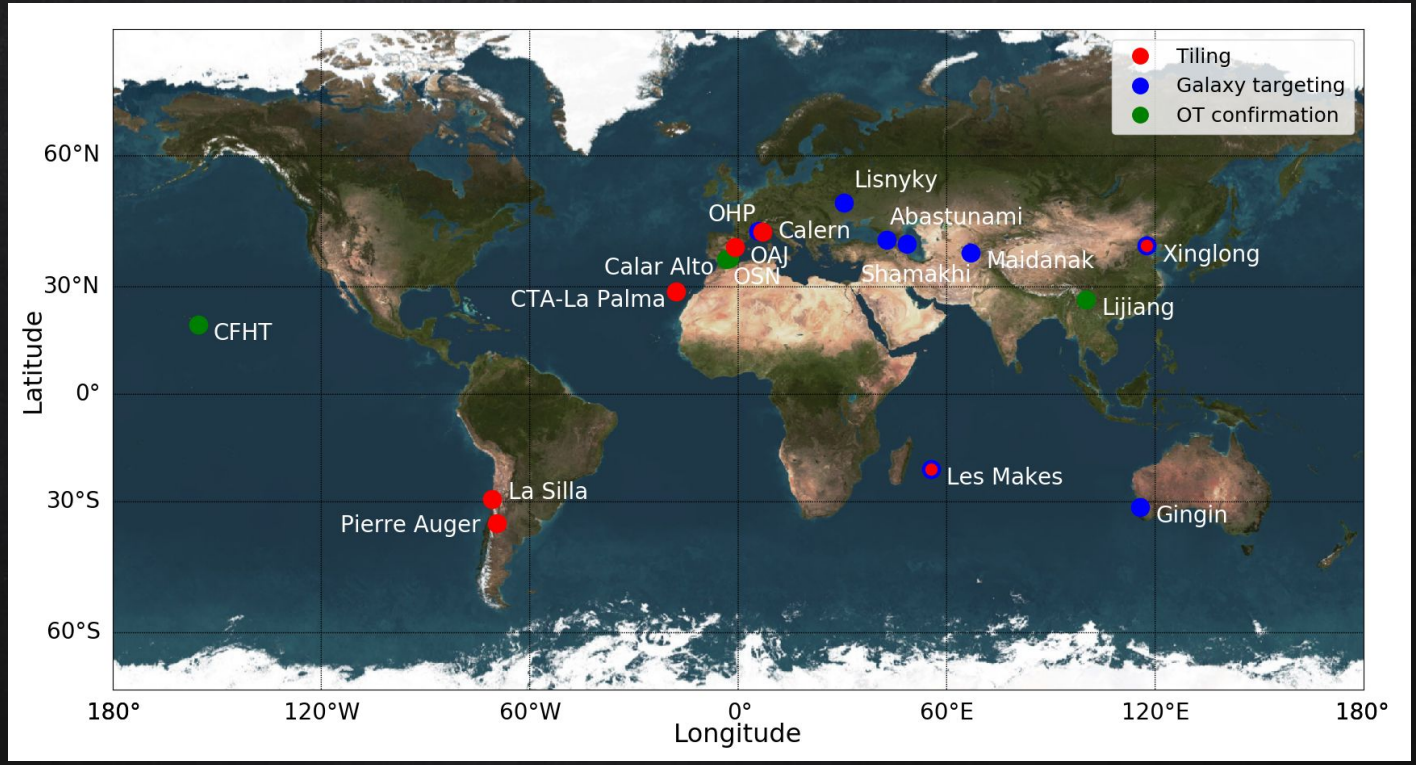
Present in

11 countries

17 observatories

GRANDMA: Global Rapid Advanced Network Devoted to the Multi-messenger Addicts, Accepted MNRAS, GRANDMA collab. July 2019

An empire where the sun never rises



ToO Proposal 2020A CFHT (PI. Coleiro) – NOEMA (PI. Kann) – TNT/TRT (PI. Noysena)

GRANDMA collaboration

Consortium

- More than 65 scientists from astronomy and GW fields
- Joining GRANDMA required LOI for science/contribution and shifts

Science management plan

- Core team + observers
- Alphabetic order with 1–2 names in front in major contribution
- Data are not public

Alert survey

4 x 6h reported in the different groups during one week

Follow-up advocate needs:

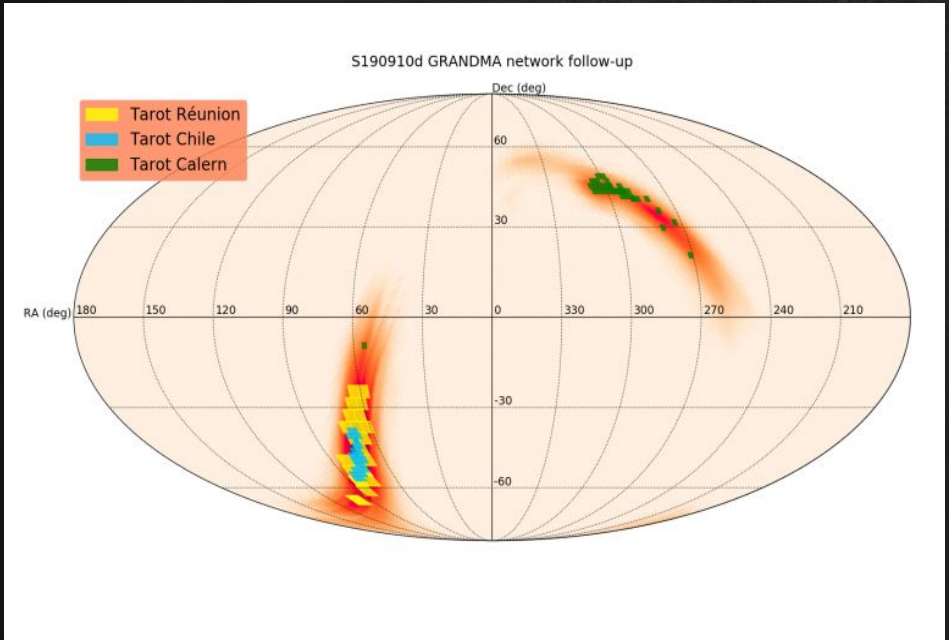
- Monitoring the network
- Report OT and observations to GCN

Development different works packages

- Collaboration
- Data Base
- Detection pipeline
- Alert manager and plan sender
- Network optimization
- Photometric and spectroscopic follow-up
- Infrastructure coordination
- Citizen science
- Review

Joint Scheduler

Resp. Coughlin, Leroy



✘ Spatial coverage

Distribution of the tiles over the network

✘ Temporal resolution

Best portion of the credible region observed several times with 1h delay minimum

✘ Galaxies specific selection

Compatible with GW distance and with galaxies properties. See Jean-Grégoire Ducoin talk

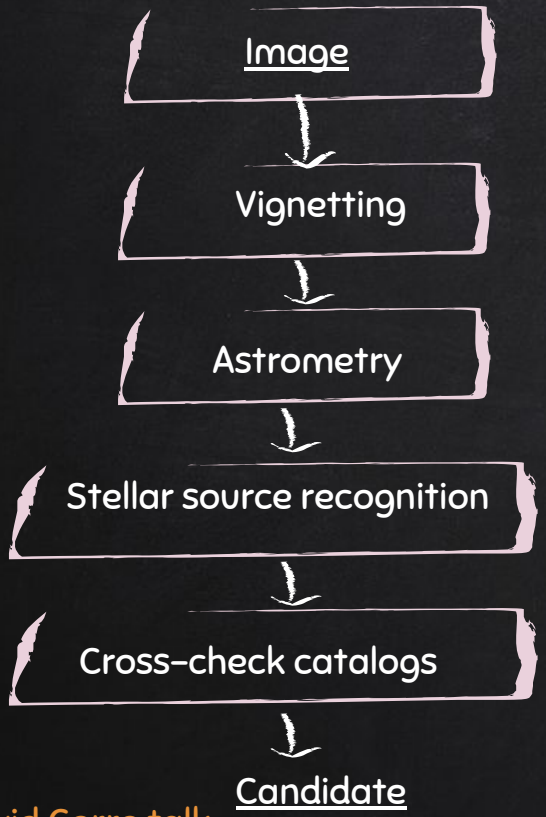
✘ Designed for each telescope

Taking account location of the telescope, maximum tiles, strategy, ...

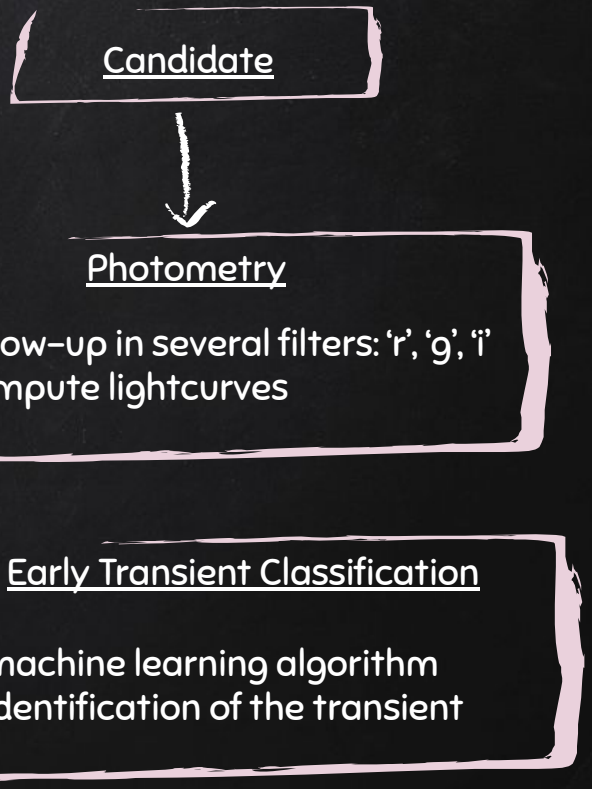
Optimizing Multi-Telescope Observations of Gravitational-Wave Counterparts, MNRAS, Coughlin, Antier, Corre et al, Sept 2019
https://arxiv.org/abs/1909.01244

GRANDMA Data analysis

Resp. Corre, Coleiro

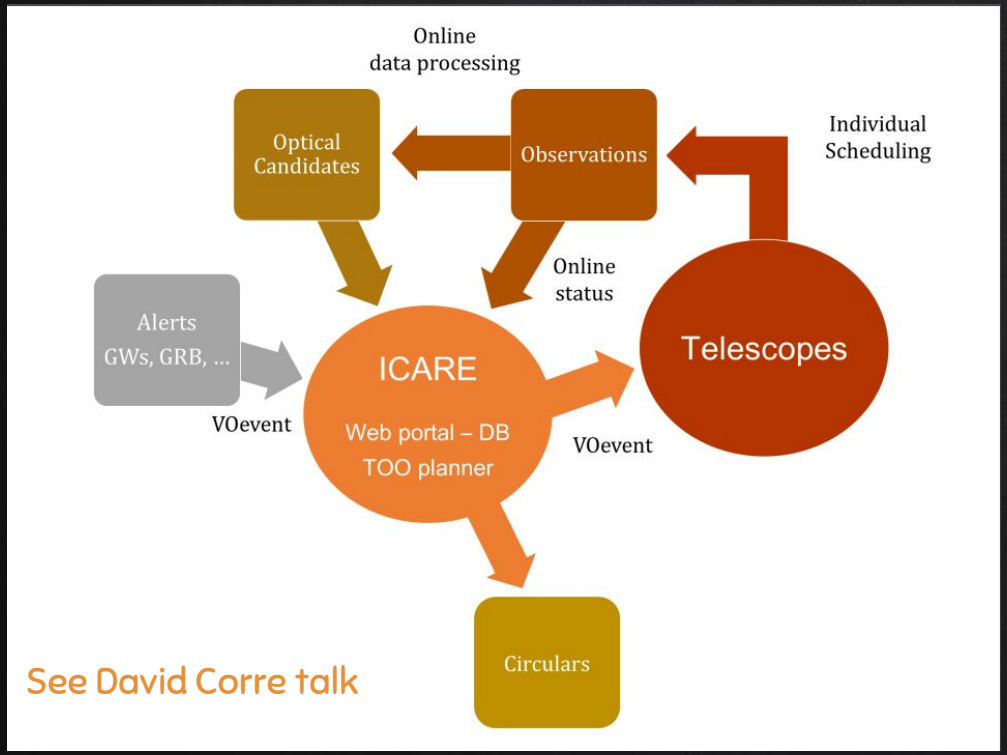


See David Corre talk



See Cosmin Stachie talk

GRANDMA E-Infrastructure: ICARE
Resp. Gendre



See David Corre talk

✘ Communication with telescopes

Standardized specific Voevents

✘ Central Manager

Reception of any type of alert and sender

✘ Time domain Web portal

Monitor of GW/GRB observations and candidates
Candidates from online pipelines
External candidates
Automatic report

✘ Central data base

Interface and Communication for Addicts of the Rapid follow-up in multi-messenger Era, In prep, Antier, Corre, Gendre et al

THE O3 CAMPAIGN

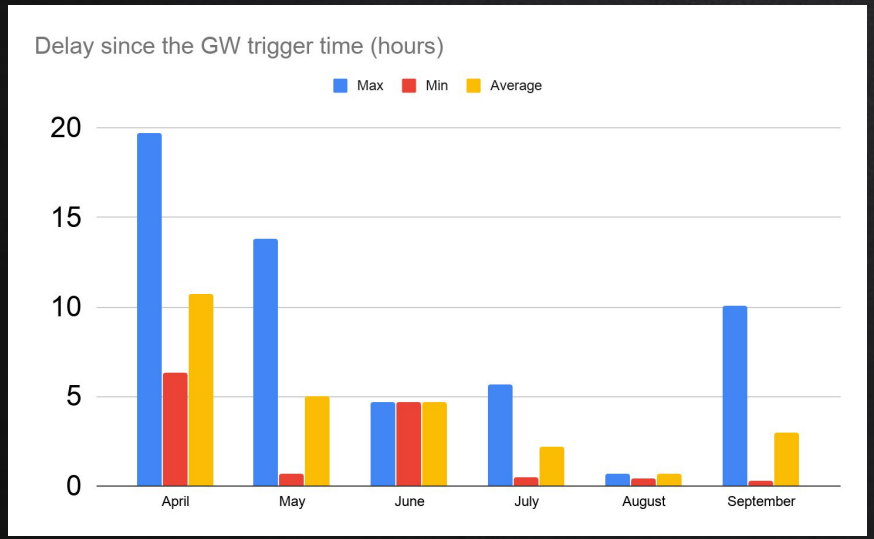
25/31 FOLLOW-UP OF GW ALERTS

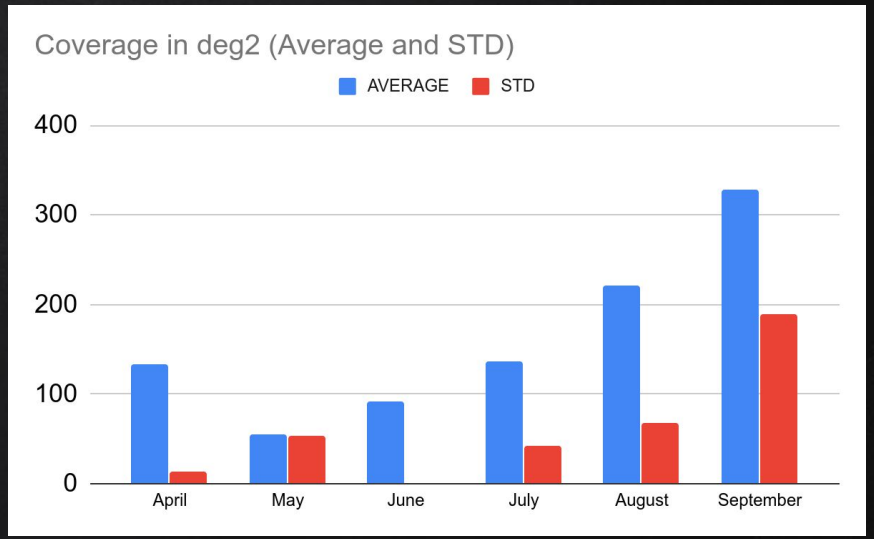
6 BNS

3 NS-BH

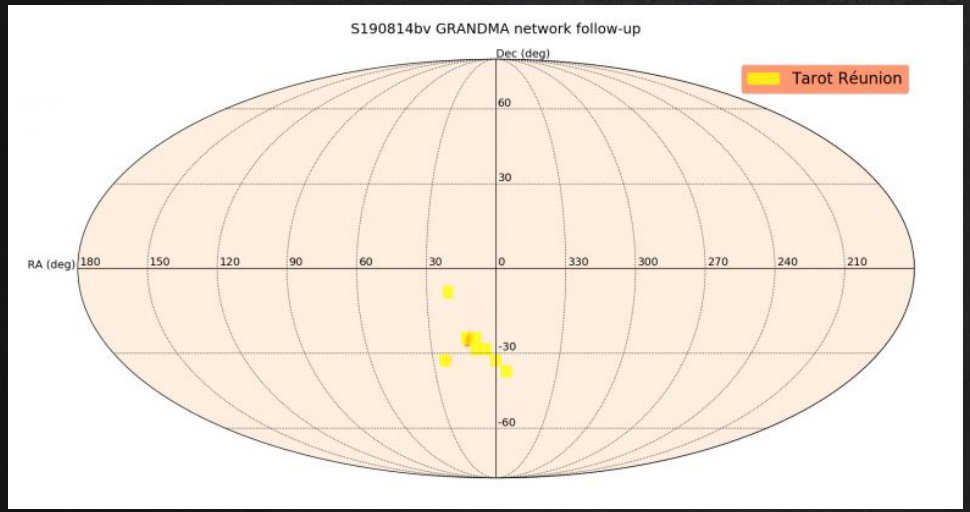
16 BBH

MERGERS





GW190814bv



On Sept 1, 21:10:39 UTC
NSBH (99%)
LAL Inference Dist Lum. 267 ± 52 Mpc
23 deg2 for the 90% credible reg.

TAROT network + Les Makes

31 min after GW T0

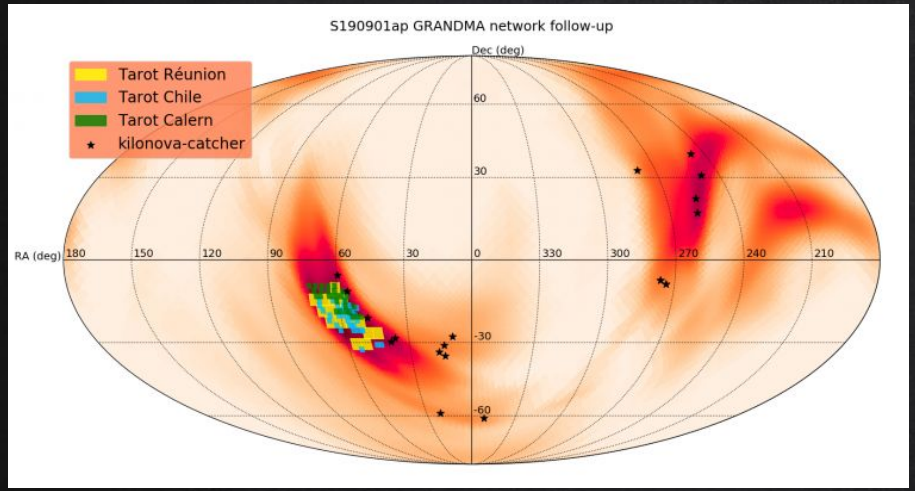
91 % of the LAL Inference coverage

162 deg2 for the GRANDMA network

18h for Total observation with multiple revisits

No counterpart found at 19 mag
https://gcn.gsfc.nasa.gov/gcn3/25338.gcn3
https://gcn.gsfc.nasa.gov/gcn3/25599.gcn3

GW190901ap



On Sept 1, 23:31:01 UTC
BNS (86%)
LAL Inference Dist Lum. 241 ± 79 Mpc
14 753 deg2 for the 90% credible reg.

TAROT network + kilonova-catcher

24 min after GW T0

9.1 % of the LAL Inference coverage

354 deg2 for the GRANDMA network

50h for total observation
with multiple revisits

No counterpart found at 18 mag

https://gcn.gsfc.nasa.gov/gcn3/25688.gcn3
https://gcn.gsfc.nasa.gov/gcn3/25666.gcn3

Optical network but not only .... Gamma-ray Bursts Searches Resp. Antier

GLAST/GBM, INTEGRAL/SPI-ACS daily data

Offline detection of GBM and SPI-ACS gamma-ray transients with wild binary segmentation

Confirmation of GBM (SPI) triggers

- Estimation of their significance
- independant duration of the GRB
- Search for precursors

New triggers

- Short, Long
- X-ray rich, Hard
- Cross match with catalogs

Detection of gamma-ray transients with wild binary segmentation, submitted MNRAS, Antier, Barynova et al, Sept 2019, https://arxiv.org/abs/1909.10002

GRANDMA Citizen science: Kilonova-catcher

Resp. Turpin, Cailleau

More than 40 participants
Telescopes from 15 cm – 30 cm

Observations made for NS-BH and BNS candidates
S190814bv – S190901ap

GW alert
Dist < 300 Mpc

List of potential galaxies
Ducoin et al.

Observations done by Amateurs

Analysis done by GRANDMA
Corre et al.

```
TITLE:   GCN CIRCULAR
NUMBER:  25688
SUBJECT: LIGO/Virgo S190901ap : No significant candidates found in GRANDMA citizen science observations
DATE:    19/09/09 13:53:09 GMT
FROM:    Jean-Gregoire Ducoin at LAL  <ducoin@lal.in2p3.fr>
```

https://grandma-kilonovacatcher.lal.in2p3.fr/

Global effort : No discovery yet

	GW alert rate	Telescopes involved	Time available	Delay	Nom. sensitivity GW Follow-up	Nom. sensitivity counterpart Follow-up	Spectroscopy	Other-wavelength
GRANDMA	25	23 in 17 sites	unlimited	~30 min	17 – 21 (c,r)	~23	~ 19 mag	gamma, smm (?)
GROWTH	8	~60 in 19 sites	few hours per alerts	~ hours	20.5 (g, r) ~22 (r, z)	~23	~ 22 mag	gamma radio
MASTER	30	14 in 7 sites	unlimited	~ minutes	~ 19 (c)	~20	no	–
GRAWITA	~8	~10 in 3 sites	few hours per alert Asiago unlimited	~ hours	16 – 22 (r)	~23	~ 22 mag collab. ENGRAVE	radio
GOTO	~5	2 in 2 sites	few hours per alerts	~ dozen of minutes	~20 (l)	~21	–	–
SVOM	11	7 in 3 sites	unlimited	~ hours	16 – 18 (c,r)	~21	~ 19 mag	Future
PS1 – Atlas	~7	2 in 1 site	few hours per alerts	~ hours	~19.5 (o) ~ 21 mag (i)	~22	collab. ENGRAVE	–

Future

- ✘ Generic low latency detection pipeline
- ✘ Advanced OT characterization and follow-up
- ✘ GRB program : follow-up and ICARE support

80% of GW alerts followed

Kilonova-Cactcher
Citizen science program

Multi-wavelength project
Including Physicist and astronomers

76% of first NS-BH loca.
covered in 1h at 17 mag

Multimessenger
Plateform ICARE

Une success story a la française

16 min between GW TO and
TAROT-TCA for 190915ak

Geographic diversity
23 telescopes in 17
observatories