AHEAD 2020

EU Review Meeting – WP12

Funded by the Horizon 2020
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Grant Agreement No. 871158

JRA/WP12- Multimessenger Astronomy Exploitation and Tools

G S
S I

Marica Branchesi

Gran Sasso Science Institute

F2F meeting May 4

Multimessenger Astronomy

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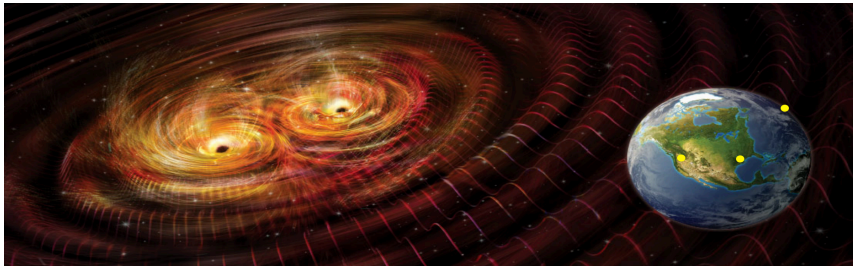

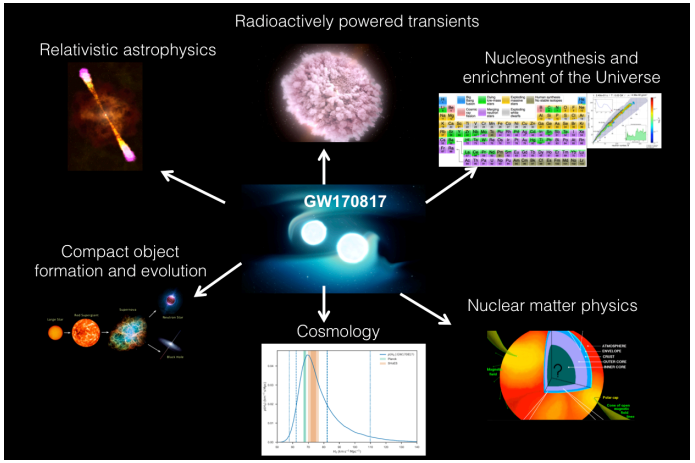

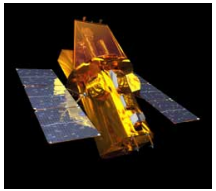

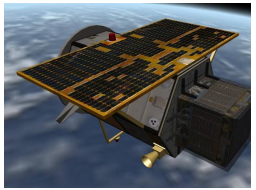

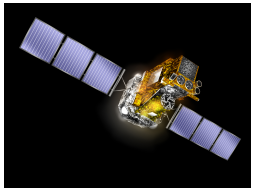

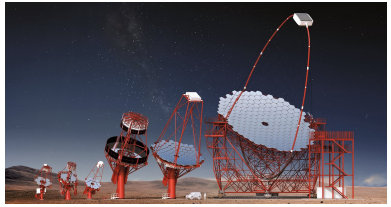

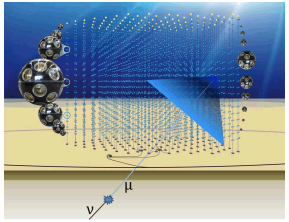

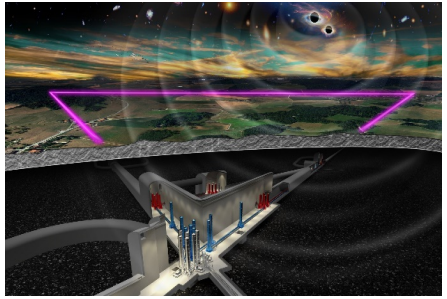

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WP12 objectives:

1) develop tools and procedures to optimize observative programmes to rapidly detect and send alerts, and to improve the counterpart searches;

2) build multi-messenger database and tools to access and analyse multi-messenger data;

3) develop models and make them accessible to enable the multi-messenger and multi-wavelength interpretation of large data sets;

4) develop pilot science studies able to drive the design of new facilities and operation for the new generation of multi-messenger observatories.

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Task 12.1: Management
(GSSI – *task coordinator* M. Branchesi)

Task 12.2: Prompt High Energy emission
(INAF, MPG, NASA/MSFC – *task coordinator* A. Bazzano)

Task 12.3: Broadband electromagnetic follow up of gravitational-wave events
(NASA/GSFC, INAF, UBATH, ULEIC - *task coordinator* E. Troja)

Task 12.4: Very High energy and neutrinos
(CEA/IRFU, DESY, INFN – *task coordinator* F. Schussler)

Task 12.5: Rapid detection of gravitational-wave signals and alerts to the astronomical community (SRON/NIKHEF, EGO, INFN – *task coordinator* S. Caudill)

Task 12.6: GW data and multi-messenger data analysis
(GSSI, CNRS/APC, INFN - *task coordinator* M.Branchesi)

Task 12.7 Multi-messenger science for the new generation of gravitational-wave detectors (INFN, *task coordinator* M. Punturo)

AHEAD 2020

Major progress and achievements

Observational and data analysis tools

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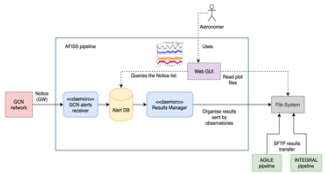
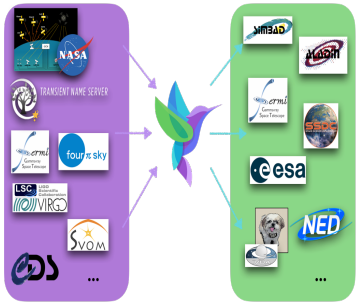


AFIS prototype: platform performing joint analysis of the prompt data detected by AGILE, FERMI, INTEGRAL and SWIFT

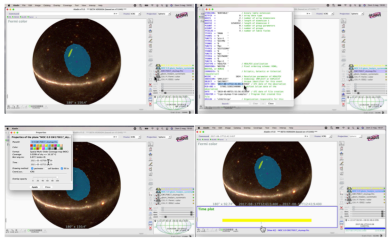
Astro-COLIBRI: a novel tool for real-time multi-messenger astrophysics

To evaluates alerts in real time, filter them by user-specified criteria, and provide an assessment of observing conditions of several observatories



Multi Order Coverage (MOC) maps

to plan multi-messenger observations, managing complex regions of the sky, such as GW sky-maps



- developed within the Virtual Observatory standards
- applied to GW and high-energy data
- under developing for ET

SPACE-TIME MOC (ST-MOC) to encode space and time simultaneously

Version 1.0 released in August 2021

- for both professional and amateur astronomers
- already regularly employed by burst advocates in several observatories (e.g. H.E.S.S., CTA/LST-1, SVOM, etc.)
- integration into the KM3NeT work in progress

P. Reichherzer et al 2021 ApJS 256 5

SOFTWARE entirely developed to meet the F.A.I.R. principles

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Major progress and achievements

Data access, theory modelling and tools

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Gravitational Wave Open Science Center

Provides **open access GW data** from gravitational-wave observatories, along with access to tutorials and software tools

Main work:

- prepare data to be released and tools to access the data, documentation
- organize tutorial
- reviewed the GWOSC data accessibility in Europe

Modeling of relativistic jets and their afterglows

Development of **SCALEFIT**, a routine for fast afterglow modeling based on 2D relativistic hydrodynamic simulations

afterglow library

LSC LIGO Scientific Collaboration
VIRGO
Public Alerts User Guide

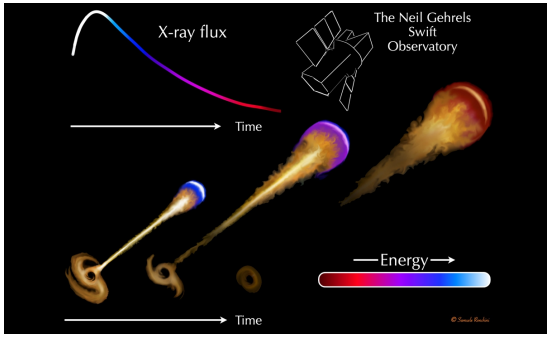
Primer on public alerts for astronomers from the LIGO and Virgo gravitational-wave

Notice Types

For each event, there are up to five kinds of GCN Notices:

An **Early Warning GCN Notice** may be issued for CBC events up to tens of seconds *before* merger. The candidate must have passed some automated data quality checks, but it may later be retracted after human vetting. There is no accompanying GCN Circular at this stage. Early Warning alerts are an experimental feature in O3. Early Warning alerts are only possible for exceptionally loud and nearby CBC events, and are expected to be rare.

GW alerts: *developing data analysis able to produce early-warning triggers for O4*



How GRB jets cool

First evidence of adiabatic cooling of particles in the relativistic outflows of GRBs during the steep decay

Ronchini et al. 2021, Nature Communication

Press-release July 6 2021

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Major progress and achievements

Upcoming/future detector studies

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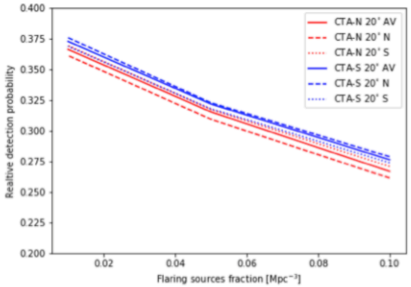
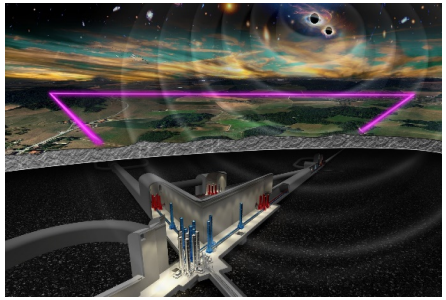
Gamma-ray instruments' strategies to follow-up multi-messenger alerts

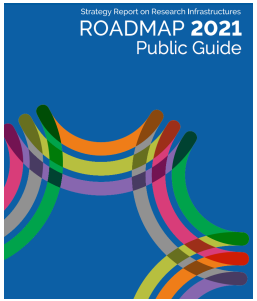
Simulation to study **CTA** response to neutrino alerts from generic and steady sources



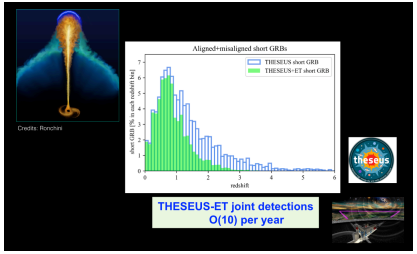
Detection probability for 30 min observation



ET in the ESFRI



Studies of ET/THESEUS



Ciolfi et al. 2021, Experimental Astronomy
Rosati et al. 2021, Experimental Astronomy

Gravitational-wave International Committee roadmap including multi-messenger perspectives

Bailes et al. 2021, Nature Physics Review, 3, 5, 344

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Summary

- very productive activities for each tasks (observational strategy, data analysis and theory tools,theory modelling, studies/ roadmap for upcoming/future detectors);
- many young researchers and students involved in the tasks' development

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TODAY:

- What are the progresses of the different activities?
- Are deliverables and milestones well on track?
- How can we strength collaboration among the team working on different tasks?

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DELIVERABLES/ MILESTONES

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12.1	Meeting to discuss plan, WP task status, on-going activities and deliverables	12	30	Meeting report
12.2	Verification and approval of the AFIS Platform prototype	12	36	Report
12.3	Approval of FINAL AFIS Platform and documentations	12	48	Report
12.4	Verification and approval of the PROTOTYPE of the public repository of multi-band EM data products and the public library of afterglow models	12	36	Report
12.5	Approval of the FINAL multiband EM data products and public library of afterglow models and documentations	12	48	Report
12.6	Verification and approval of the PROTOTYPE for transient activity overview and KM3NET alert system	12	36	Report

MILESTONES

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12.8	Approval of the document about VHE and neutrino observation and analysis strategy, and future instrument requirements	12	48	Report
12.9	Verification and approval of prototype of low-latency early warning GW alert production	12	36	Report
12.10	Approval of FINAL low-latency early-warning GW alert production and documentations	12	48	Report
12.11	Verification and approval of the prototype for tools for the (re-)analysis of public GW data and joint high-energy and GW analysis	12	36	Report
12.12	Approval of final tools for the (re-)analysis of public GW data and joint high-energy and GW	12	48	Report