



ESCAPE

European Science Cluster of Astronomy &
Particle physics ESFRI research Infrastructures

EOSC-Future Test Science Project : Extreme Universe

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Goals of the Extreme universe Test science project

- Exploit Astrophysical extreme phenomena through the gravitational waves, electromagnetic signals, or neutrino messengers.
- Understand extreme matter and particle processes in strongly curved space-time and compact objects
- Building convincing science cases proto-EOSC for MMA and Extreme Universe studies



Pilot projects

Main Research Area	Objects/sources	Messengers	ESF/RI involved	ESCAPE services EOSC-Future integrations	Data Analysis tools (AI,ML)	Pilot project(s)	Computing resources required	Partner PM involved
Compact objects	<i>Pulsars,..</i>	<i>radio, GW,..</i>	<i>LOFAR...</i>	<i>Multimessenger platform/Software catalogue,..</i>	<i>Machine Learning</i>	<i>1) Radio astronomy: FRB</i>		<i>42 PM Astron,..</i>
High energy Astrophysics	<i>GRBs, jets, AGN, BNS, CCSN</i>	<i>neutrinos, gamma-ray, radio,X-ray, GW,..</i>	<i>CTA, Virgo, KM3NET, SKA,LSST</i>	<i>Multimessenger platform/Software catalogue,..</i>	<i>Model comparison, Machine Learning</i>	<i>1)GRB/neutrino/GW analysis, 2) Blazar MWL/neutrino</i>	<i>GPU cluster Jupyter hub</i>	<i>12 PM UvA, 6 PM FAU. CNRS, 24 PM SNS</i>
Fundamental physics	<i>Dark matter, GR, Primordial Universe</i>	<i>GW,</i>	<i>Virgo, Einstein Telescope</i>	<i>Template banks, generation software,..</i>	<i>Machine learning approach</i>	<i>1) DM template bank and ML analysis pipeline 2) GW Stochastic background</i>	<i>GPU cluster Jupyter hub</i>	<i>10 PM INFN,12 PM UvA, 12 PM SNS, 2 PM FAU ...</i>



TSP-EU man power

- SNS: 24 PM (A. Iess) hired for MultiMessenger pilot project
- SNS: 12 PM (A. Parisi) hired for GW Exotic Waveform detection-->12PM UVA
- 12 PM UVA ??
- 10 (or 6) PM INFN (?) (the same PM hereafter?)
- 42 PM ASTRON (?)
- FAU: 9 PM (Mikhail Smirnov)
- INFN, CNRS-CPPM and NWO-Nikhef: 9PM (??)



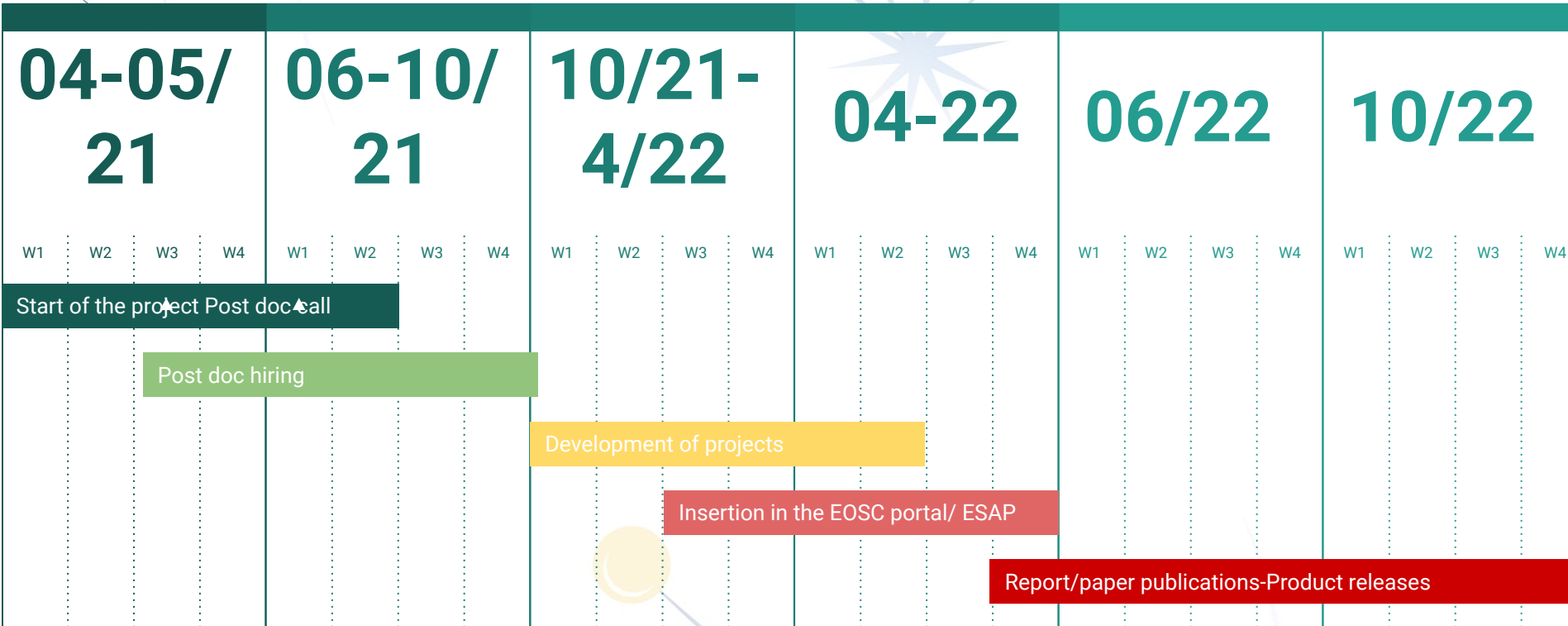
Plan of the work

We will continue with the project already started in ESCAPE, focusing on the realizations of **End to End workflow**

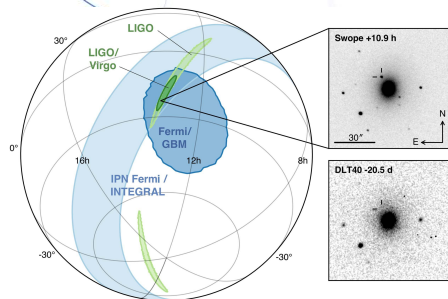
1. **Select the scientific goal: (<6 months)** ✓
 - a. **See table**
2. Evaluation of database, data, census of software already in place in the different participating ESFRI and assessment of interoperability (< 6months),
3. Organization of datasets for the Data analysis experiment (< 6months)
4. Development, implementation (18 months)
5. Publication, prototype release on EOSC portal (30 months)



TSP- EU timeline



Multi-probe real time analysis

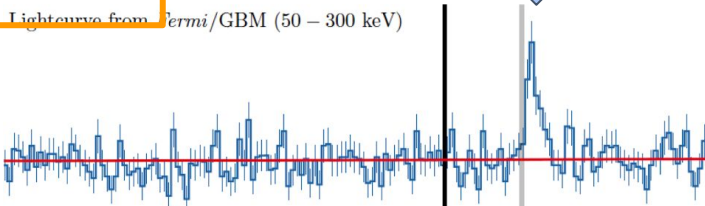


*Can we extract information
analyzing the heterogeneous
data?*

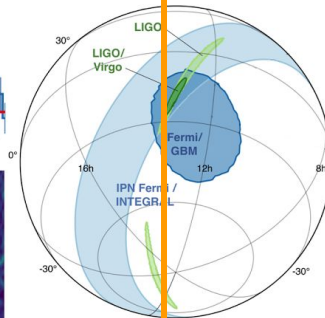
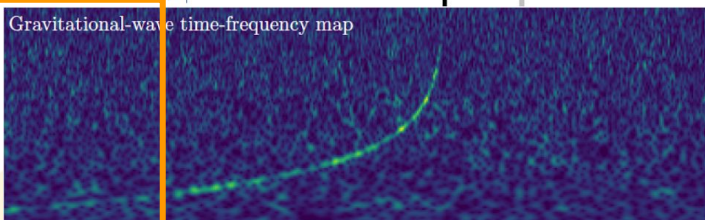
GW event

Lightcurve from Fermi/GBM (50 – 300 keV)

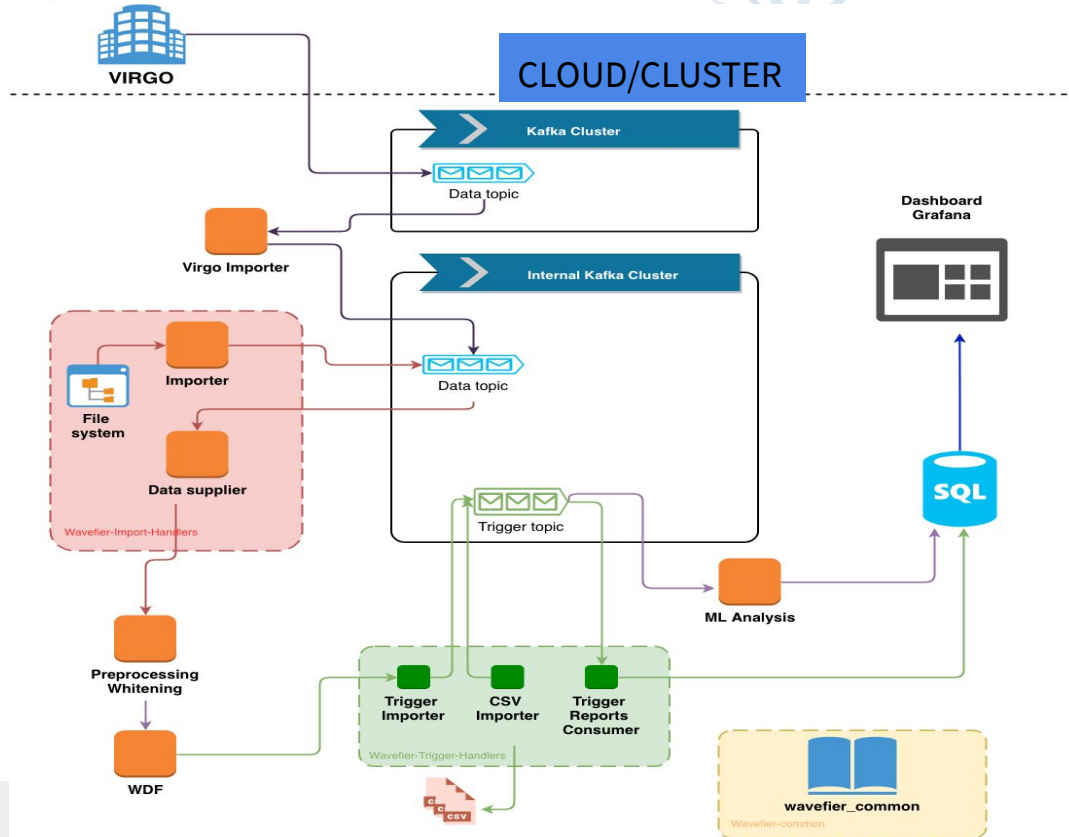
Short GRB event

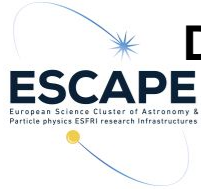


Gravitational-wave time-frequency map



Wavefier/online Architecture





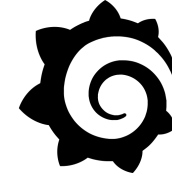
Data server



Kafka cluster



Dashboard



ESCAPE OSSR | Open-source Scientific Software and Service Repository
FAIR

ESCAPE DIOS | Data Infrastructure for Open Science

ESCAPE VO | Virtual Observatory

WDF + Machine Learning

SQL

Database

ESCAPE SAP | Science Analysis Platform

ESCAPE CS | Citizen Science



Which kind of ESCAPE service are we going to use?

- AAI authentication service
- Data lake
- Data analysis platform (ESAP)
- Software catalogue
- Virtual Observatory
- Citizen science links
- ...



Detailed project: *Compact objects, pilot1*

Team/Lab/ESFRI involved: Vedantham, Hessels, Swinbank, van Haarlem, Meyer / ASTRON / LOFAR (42 PM)

- Classify sources in LoTSS.
- Radio as probe of particle acceleration.



Detailed project: *High Energy Astrophysics, pilot1*

Team/Lab/ESFRI involved: *INFN 10 PM , SNS 24 PM, FAU 6PM, LAPP 6PM ?? (please confirm)*

- GW, Neutrino, GRB multimessenger analysis
- Real time ML platform



Detailed project: *High Energy Astrophysics, pilot2*

Team/Lab/ESFRI involved: **UVA 12PM, FAU 6PM, LAPP 6PM?**

- Developing capabilities for joint modeling of MWL observations from radio through X-rays with very-high-energy (VHE) gamma-rays from CTA and VHE neutrinos from KM3NET.



Detailed project: *Fundamental Physics, pilot1*

Team/Lab/ESFRI involved: UVA 12PM, SNS 12PM,...

- Exotic GW waveform template and ML application
 - Waveform template generation and database inclusion
 - ML application for the detection



Detailed project: *Fundamental Physics, pilot2*

Team/Lab/ESFRI involved: 10 PM INFN

Modeling, detection and parameter estimation for non-Gaussian stochastic backgrounds of gravitational waves.

The two key ingredients are:

- *A Markov chain Monte Carlo procedure which generate segments of data for a network of detectors with the correct statistics,*
- *A fast superposed waveform generator, which will be optimized by using machine learning techniques.*



Additional requests

- MoU for data sharing. Easy access and templates for the teams
- Policy for publications?
- In kind/ external participation. Do we need to formalize?





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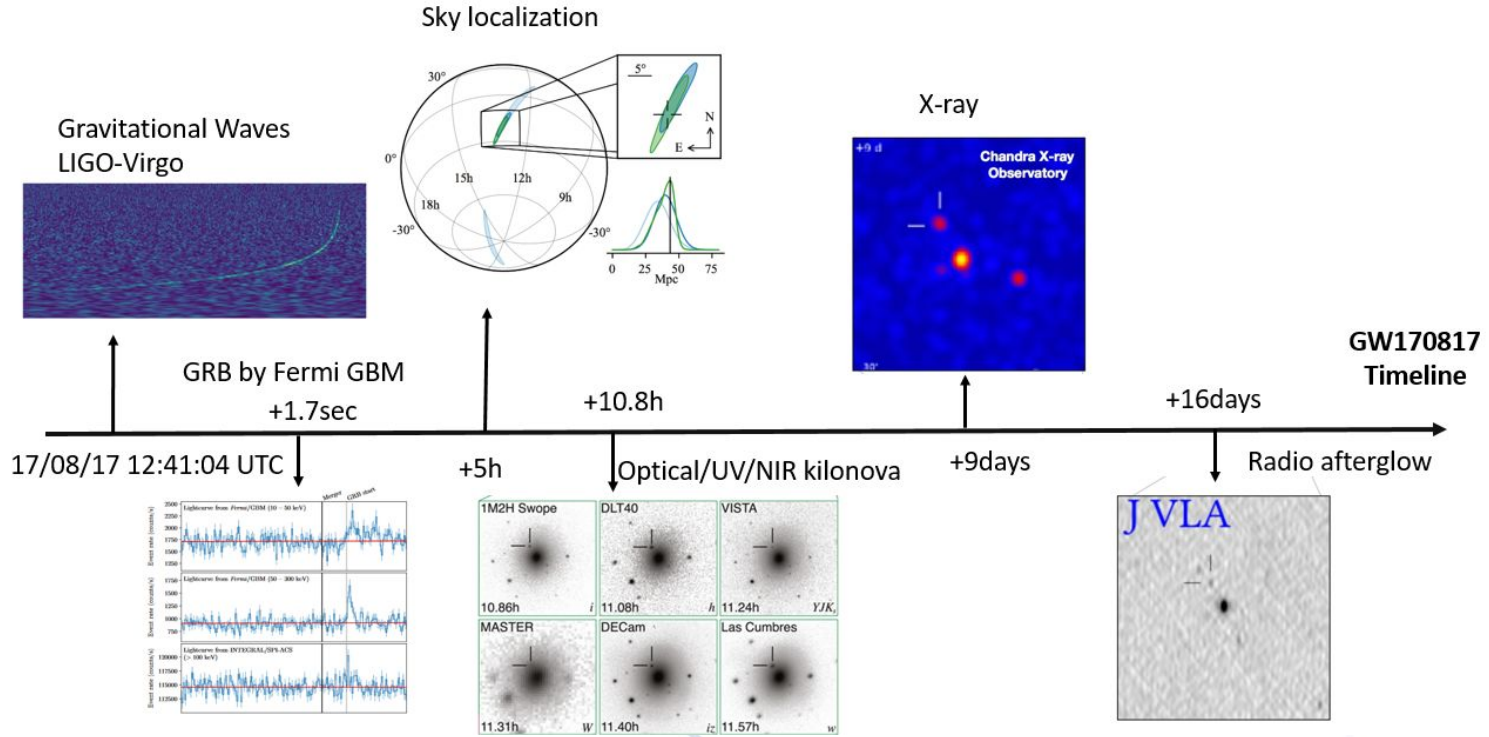
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extra

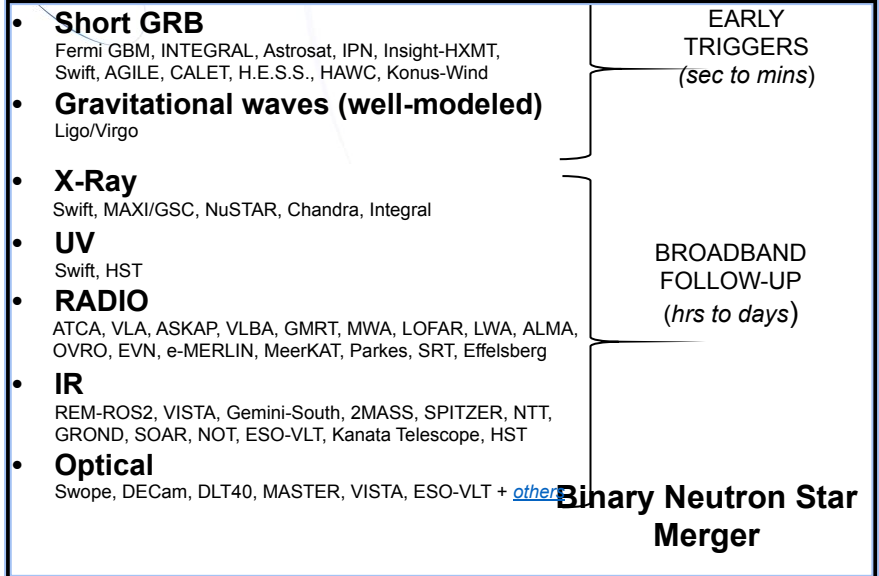
EXTRA slides



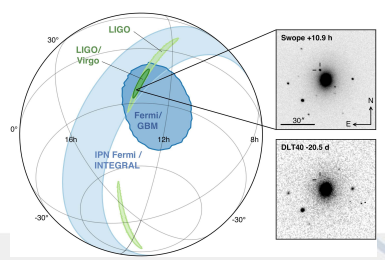
GW170817 detection and EM follow up



Gravitational Waves & Multimessenger astronomy



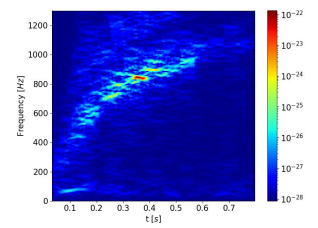
- Fast alert and sky Localization for follow-up study
- Better understanding of physical processes (e.g. heavy-element nucleosynthesis)



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



less et al. (2020)

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



