MMA-ESCAPE activities: update

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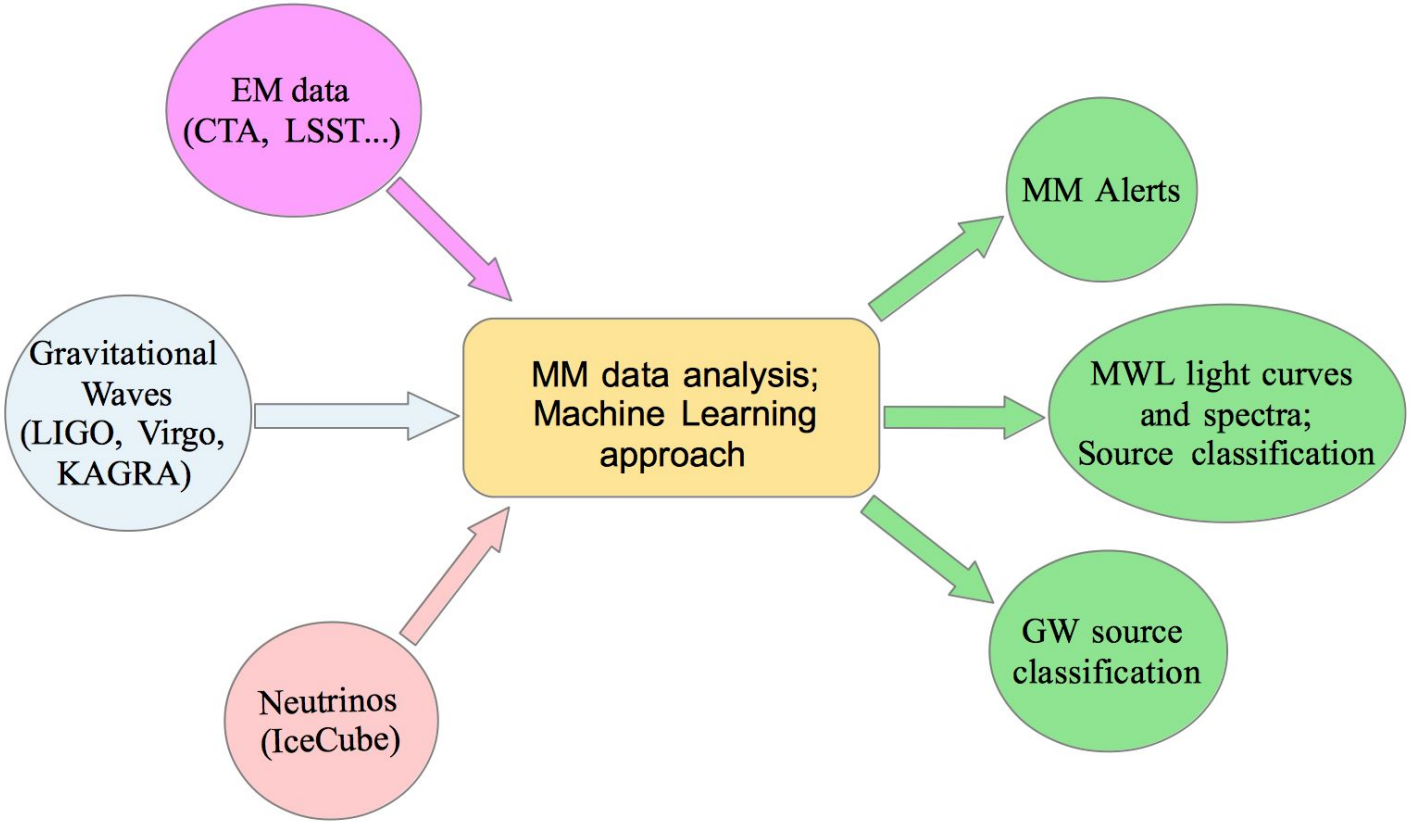
ESCAPE - FG3 telecon, February 12, 2021

Real time multi-messenger analysis



The project

For real time analysis of gravitational wave (GW) data we have **Wavefier**: a prototype for a real time pipeline for the detection of transient signals and their automatic classification (E. Cuoco et al., https://repository.asterics2020.eu/content/wavefier)

Idea: extension of Wavefier to other messengers (e.g., photons)

First step (ongoing): create a "realistic" synthetic database of GW and electromagnetic (EM) coincident signals from transient astrophysical sources, to be used to test the pipeline

- Astrophysical sources: Compact Binary Coalescence (CBC) events
- GW signals: inspiral and merger phase
- EM signals: short Gamma-ray Bursts

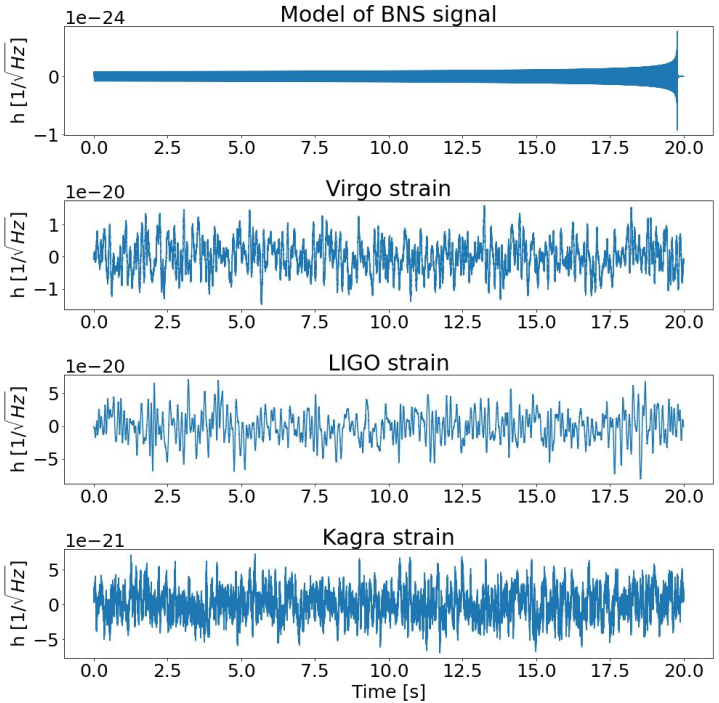
Astrophysical sources

We developed a pipeline that simulates a realistic population of CBC merging systems; the output is a csv table with all the relevant parameters of the systems

type	gps-end-time	mass1	mass2	spin1z	spin2z	inclination	polarization	ra	dec	distance
BNS	1357976201	2.07278405	1.904145064	0.02724415915	0.02118273997	73.03495512	157.5313961	141.0382803	-68.02167792	333.1889586
BNS	1365636659	1.79334238	1.852066842	0.04627983191	0.00355180291	145.6637301	7.278623079	119.7431444	-33.80123326	437.8237616
BNS	1371530526	2.198737846	1.692219043	0.03902645881	0.005913721293	73.74922245	51.60718347	160.0808101	-2.504430675	341.9969876
BNS	1349011844	2.161350534	1.684225498	0.02842169744	0.0009394900218	76.39240252	220.3544602	42.09623887	-62.56028203	403.6585891
BNS	1352006259	1.655547931	2.046446794	0.003011273581	0.03333833577	70.04538194	75.73772199	-133.5865328	21.66279197	327.373064
BNS	1358650543	1.65790227	2.482560757	0.005102240537	0.0104438378	132.6393198	235.1189972	-88.81502309	3.863428064	286.7519946
BNS	1345682083	1.165562712	1.984494384	0.006909147567	0.009829118084	105.2214038	295.5575627	-145.0435407	-42.52328762	210.0694765
BNS	1371462444	1.702976802	2.465141632	0.03024227599	0.03696317897	157.1647277	101.8105065	-136.729238	24.06166423	225.410909
BNS	1350696736	1.621394492	1.096221245	0.03462360597	0.02833007271	117.983743	188.3692992	-146.1814161	-8.736644129	447.550736
BNS	1350715208	2.00111557	1.197696794	0.03581636021	0.01447030465	129.3175057	211.1446565	-172.7612834	-41.13839371	76.79815204
BNS	1362044440	1.40501196	2.102791033	0.04810942726	0.01243765718	81.23891109	213.1350953	26.01068608	33.63062928	451.2844729
BNS	1354769364	2.269613009	2.049218913	0.01487184754	0.04068989099	101.9459298	317.197151	29.25823415	-49.77113204	405.7614201
BNS	1363540437	1.751986573	2.434125452	0.03219950996	0.02119275243	77.71430577	6.909551391	-71.433066	-18.6839158	303.5957053
BNS	1360158553	1.643153051	1.203211096	0.0149141163	0.02849824554	79.52855191	206.7570896	55.15229515	-17.71043383	346.5429931
BNS	1368942311	1.551342805	1.653797388	0.04459616775	0.04030969945	65.93472381	36.08167943	151.0137409	-25.37130055	458.4484898
BNS	1345381820	2.302189086	1.243739402	0.03077797821	0.006190999142	45.89172873	290.6348251	24.8762659	10.69806355	188.2596264

GW data

We developed a pipeline that simulates the GW strain associated with CBC mergers, based on the sensitivity of 2nd generation interferometers (LIGO, Virgo, KAGRA); the output is a HDF5 file.

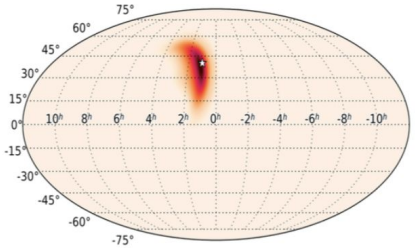


EM data

We are considering two different scenarios:

1. **EM follow-up of GWs:**

GW alert → Sky localization → EM follow-up

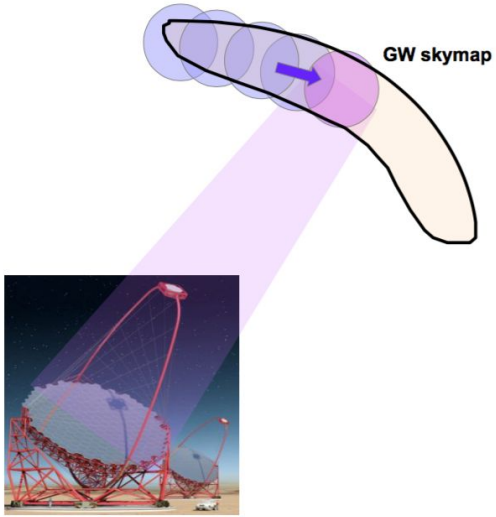


2. **Independent EM observations**

   (see, e.g., *Fermi*-GBM observation of GRB 170817A)

EM data - scenario 1

We developed a pipeline to model the gamma ray emission associated with CBC mergers and simulate the high-level EM data collected by the **Cherenkov Telescope Array** (CTA); the outputs are fits file containing the list of events for each CTA observation.



Example:

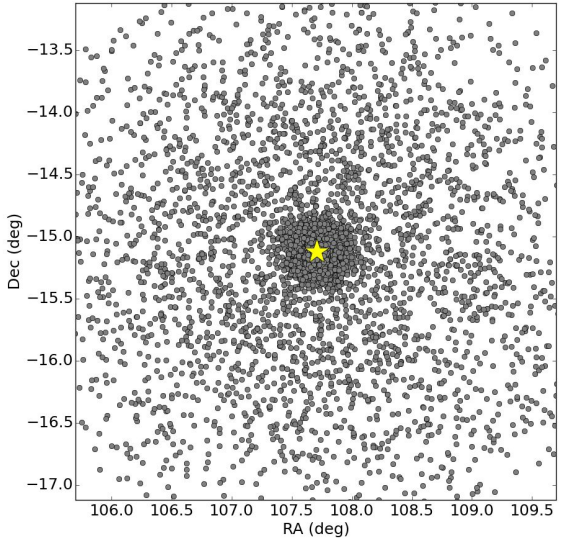
RA=107.71°, Dec=-15.12°

d_L=438 Mpc

CTA South

Time delay: 160 s

Observing time: 60 s



EM data - scenario 2

We are currently extending the simulations to the ***Fermi*** satellite, in collaboration with *Massimiliano Razzano* and *Nunziato Sorrentino* (University of Pisa).

- large Field of View (*Fermi*-GBM: 9 sr)
- high duty cycle (*Fermi*-GBM: 50 %)

  ⇒ Continuous monitoring of the entire sky (unocculted by the Earth)

- Simulation of continuous sets of data, to be analysed jointly with GW data