Science case:
Search of electromagnetic counterparts of Gravitational Waves

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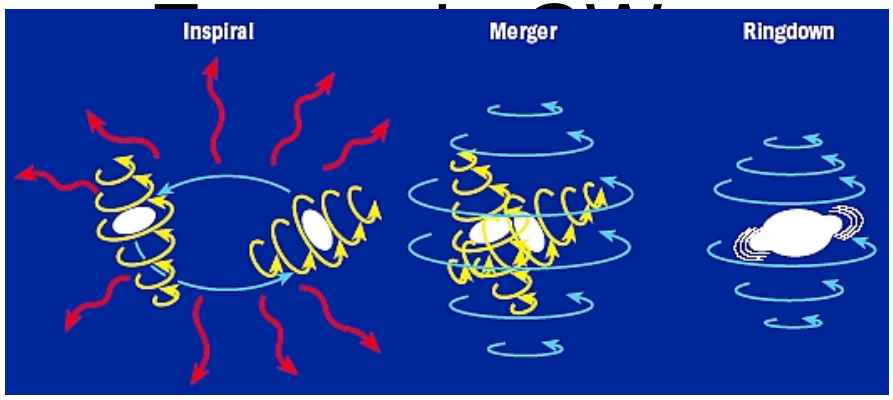
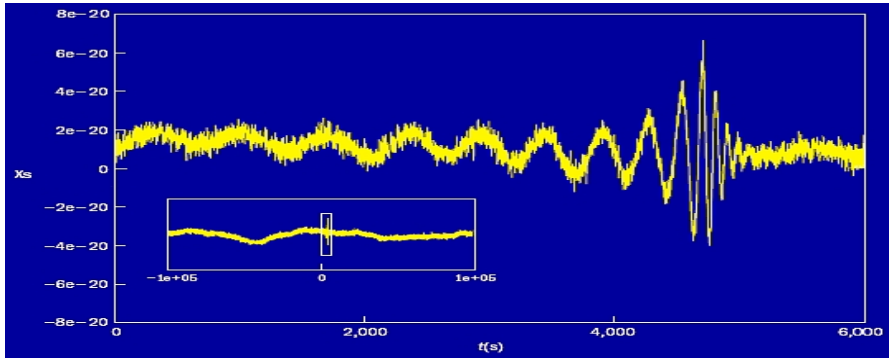
on behalf of the INAF GW Collaboration

Gravitational waves: sources

Coalescence of compact objects (CBC)

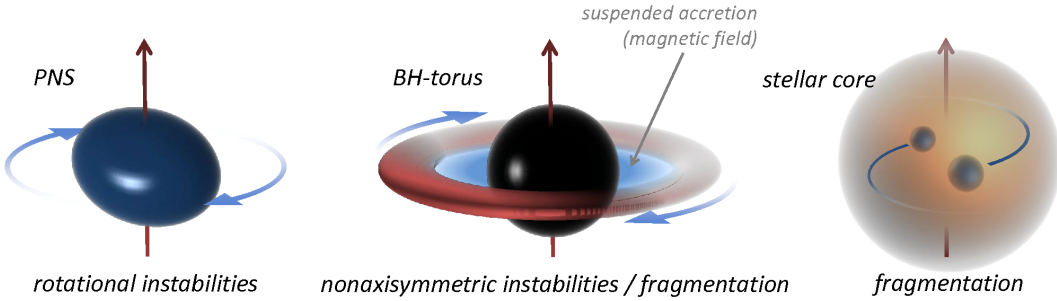
- Known waveform



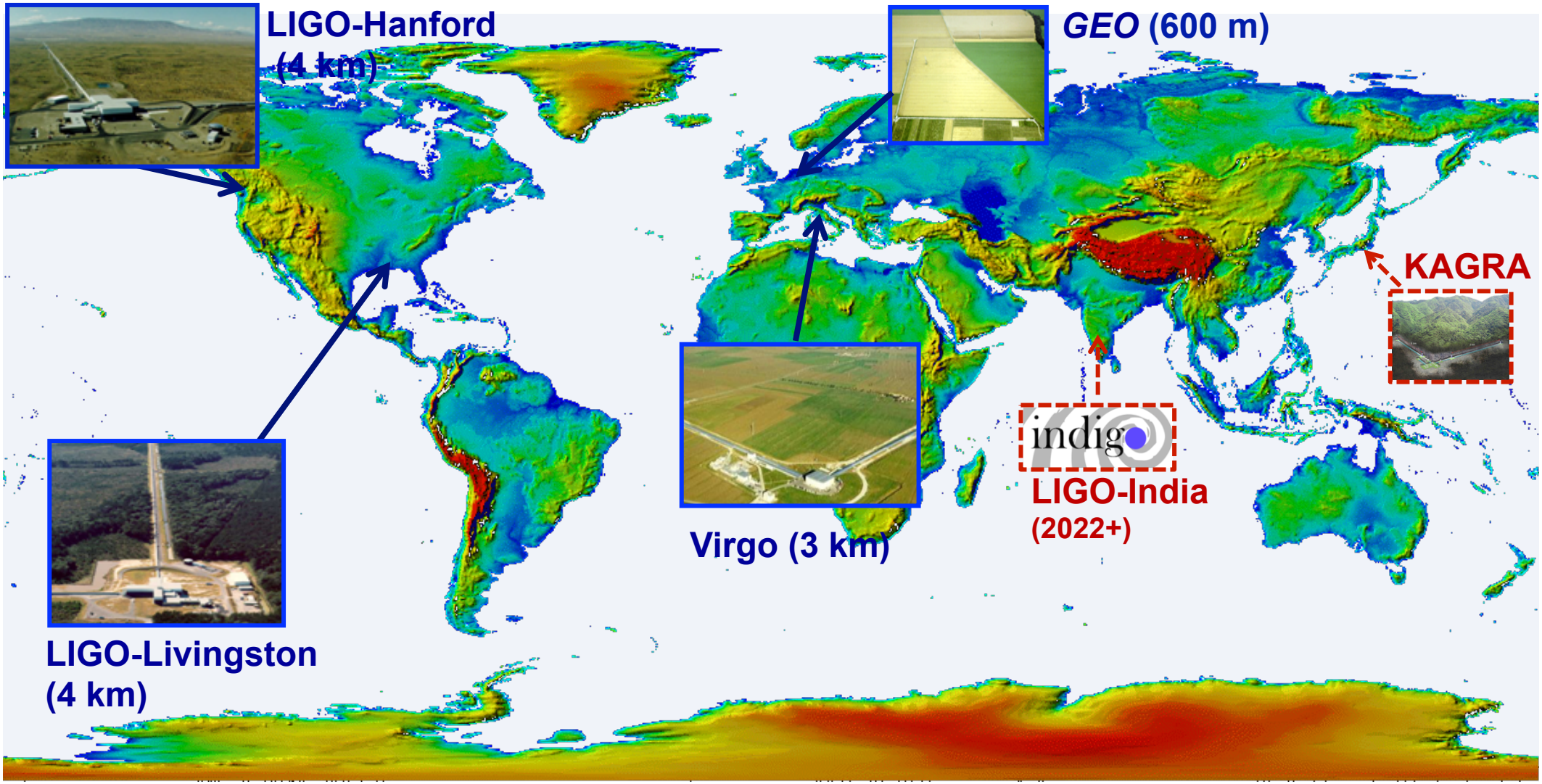


Core-collapse of massive stars

- Waveform and energy emitted in GW uncertain:
  - Likely $10^{-8} M_o c^2$
  - Optimistic $10^{-4} M_o c^2$

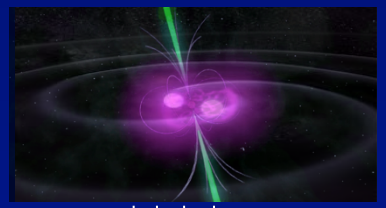


Gravitational Waves: Detection

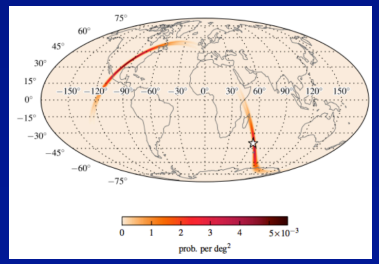


LIGO and Virgo currently under upgrade
They will observe the sky (10-1000 Hz) as a single network
aiming at the first direct detection of GWs

Search of electromagnetic counterparts of Gravitational Waves

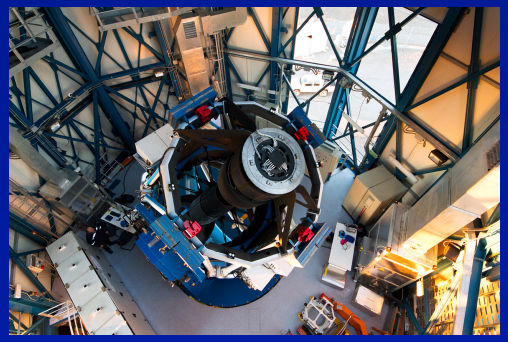


LIGO/Virgo Interferometers ➔ error boxes on sky: ≥ 200 degree^2

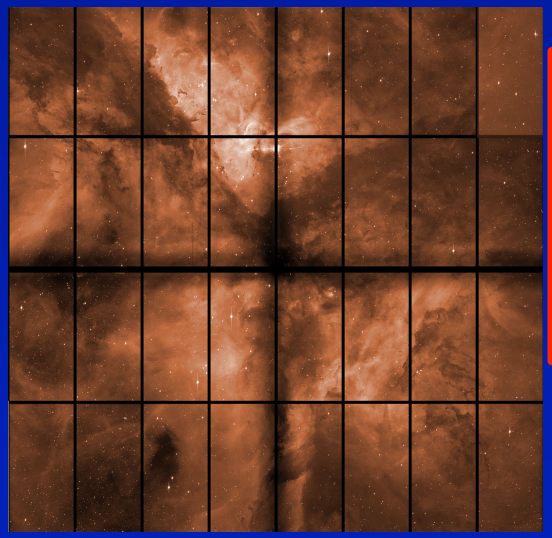


Problem:
➔ Hundreds of astronomical images have to be analyzed to search transient objects

INAF-Alert center



VST – OMEGA-CAM
Field of View 1 deg^2
Resolution 0.21 arcsec/pixel
1 single image ~ 1.3 Gb



Computing challenge:
Calibrate and analyzes hundreds of wide field astronomical images and
search for transients objects in few hours (constraints due to the fading time of the astronomical targets)

Of course, further observational steps (spectroscopy & follow-up) are needed to characterize the discovered transients and then to validate the final identification of the counterpart of GW signals

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A real example:
After LIGO/Virgo alert, VST images are obtained by INAF GW collaboration

- **Number of images : ≥ 200 images (~18000x18000 pixels each to map 1 deg^2)**
- **Image size : ~ 1.3 GB / image**
- **Calibration time: ~ 6.5 hours for a set of ~ 200 astronomical images**

(VST center : computer spec. : 256 cpu cores / ~ 900 GB RAM / ~ 300 TB storage)


VST-Data Center

Bottleneck :

- **each single images has to be analyzed with specific software to identify transients**
- **human intervention is still required**
- **small workstations are presently used for this step**

Case A (*reference images not available*)
Analysis time of one VST image**: ~ 2 hours / image 1800000 detected objects**
(computer spec.: 12 cpu cores / 128 GB RAM / ~ 12 TB storage)
+ time needed to identify transients by using available catalogs in the observed field

Case B (*reference images available*)
Image subtraction (well established technique to search transients when reference images are available)
~ 20 min / image (computer spec.: 32 cores AMD 6328 / 128 GB RAM)

We are currently working to improve software performances and to obtain faster (and large RAM) computing facilities