Research project for LSST – TDA – 1

The astrophysical sources of gravitational waves and the variable X and Gamma-Ray sky

PIs:
E. Brocato (INAF–OAR)
M. Tavani (INAF–IAPS)
**M. Feroci** (INAF–IAPS)

The astrophysical sources of gravitational waves and the variable X and Gamma-Ray sky

Goal: Identification and study of EM counterparts of GW signals

LSST will match the multi-messenger era (sky localization ≈ a few tens of deg^2). Time to explore the EM/GW sources

e-LISA

LIGO/Virgo   KAGRA   LIGO India

2020   *2025*
SOXS   LSST   E-ELT

LSST enables to build large sample of sources of gravitational and electromagnetic radiation thus allowing deep insights on source nature, host galaxy properties, formation history, tests of GR, strong gravity labs, stellar evolution, etc.

Kilonova (BNS->BH)

Kilonova (BNS->NS)
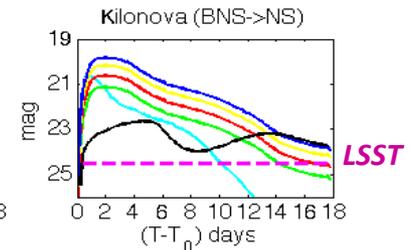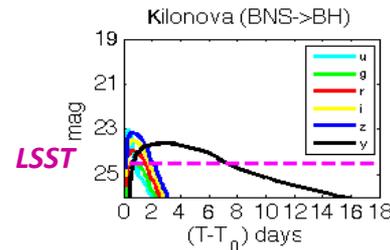
The dashed purple line is the 60 s exposure LSST 5-sigma sensitivity for point sources

off-axis GRB130603B
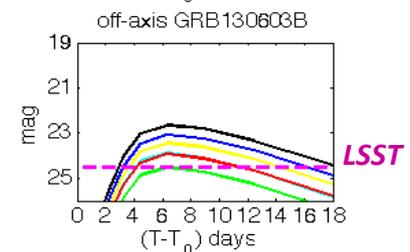
Examples of expected optical counterparts at 200 Mpc

Credits : G. Stratta

The astrophysical sources of gravitational waves and the variable X and Gamma-Ray sky

**LSST crucial for a variety of X and gamma-ray variable sources**

- **Galactic transients and binaries**

- **Optical flares and long-term monitoring of blazars**

- **GRBs**

- **GW source counterparts**

- **Exotic transients (e.g. tidal disruption events)**

Large sky coverage with multiple-cadence at different wavelengths is crucial for most of these sources

Blazar

Light curves:
Optical-gamma-ray correlation

Nova Cygni 2010 in Visible Light

60.Cyg

60.Cyg

·V407 Cyg

·V407 Cyg

1 degree

1 degree

March 7, 20:36 UT

March 10, 19:08 UT
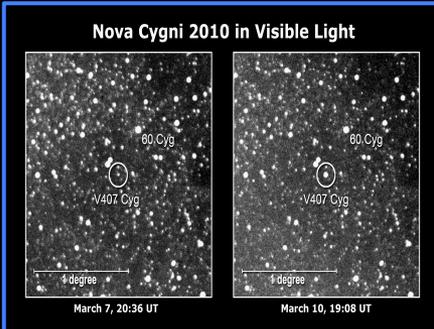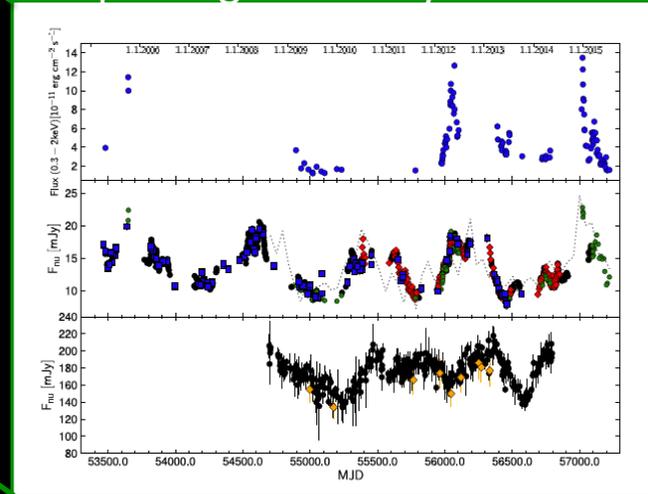
Optical and
gamma-rays:
Mutual triggers

Fermi Detects Gamma Rays from Nova Cygni 2010

Feb. 19 to March 9, 2010

March 10 to 29, 2010

Tidal disruption event
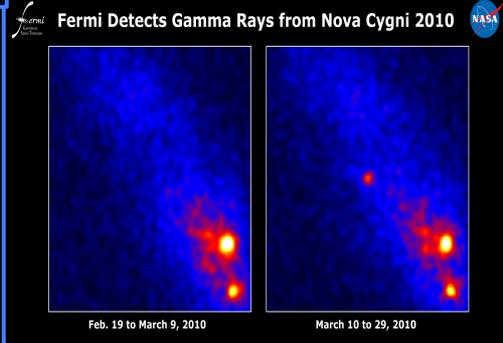
Trigger/
light curve/
Spectral Energy
Distribution
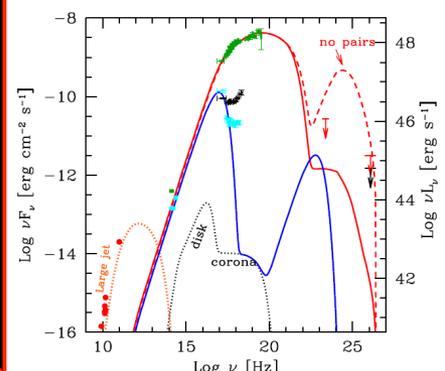
PARTICIPANTS
PIs: E.Brocato (INAF–OAR) / M. Tavani / M. Feroci (INAF–IAPS)
Junior Researchers: G. Stratta (INAF-IASF Bo), S. Piranomonte (INAF –OAR), I. Donnarumma (ASI, INAF affiliation in progress), G. Piano (INAF-IAPS)

SCIENTIFIC / TECHNICAL INTEREST
GW sources; gamma-ray transients and binaries; blazars; Tidal Disruption Events

LSST SCIENCE COLLABORATION(S) OF INTEREST
Transients/Variable Stars; Active Galactic Nuclei

The P.I.s will also lead a large number of INAF researchers

M. Tavani (INAF/IAPS, Univ. Roma Tor Vergata), M. Feroci (INAF/IAPS), I. Donnarumma (ASI, INAF), G. Piano (INAF/IAPS), A. Bulgarelli (INAF/IASF-Bo), F. Verrecchia (ASDC and INAF/OAR), P. Munar-Adrover (INAF/IAPS), G. Minervini (CIFS, INAF/IAPS), V. Fioretti, A. Zoli (INAF/IASF-Bo), C. Pittori, F.Lucarelli (ASDC and INAF/OAR), S. Vercellone (INAF/OA-Brera), E. Striani (CIFS and INAF/IAPS), M. Cardillo (INAF/OA-Arcetri and INAF/IAPS), F.Gianotti, M. Trifoglio (INAF/IASFBo), A. Giuliani, S. Mereghetti, P.Caraveo, (INAF/IASF-Mi), A. Chen (Wits University), A. Argan, E. Costa, E. Del Monte, Y. Evangelista, , L. Pacciani, P. Soffitta, , V. Vittorini (INAF/IAPS), G. Pucella, M. Rapisarda (ENEA-Frascati), G. Di Cocco, F. Fuschino, M. Galli, C. Labanti, M. (INAF/IASF-Bo), Marisaldi (University of Bergen), A. Pellizzoni, M. Pilia, A. Trois (INAF/OA-Cagliari), G. Barbiellini, (INFN Trieste), F. Longo (Univ. Trieste and INFN Trieste), A. Morselli, P. Picozza (INFN and Univ.Roma Tor Vergata), P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza), S.Colafrancesco (INAF/OAR and Wits University), N. Parmiggiani (University Modena and Reggio Emilia), A. Ferrari (Univ. Torino and CIFS), A. Antonelli (ASDC and INAF/OAR), A. Ursi (INAF/IAPS), P. Giommi (ASDC), A. Cavaliere (Univ. Roma Tor Vergata), B. Coppi (MIT), F.Capitanio (INAF/IAPS)

GRAWITA: GRAvitational Wave Inaf TeAm

E. Brocato, L. Amati (INAF-IASF Bo), L. A. Antonelli, S. Ascenzi (INAF-OAR), M.T. Botticella (INAF-OAC), M. Branchesi (Urbino University/INFN Firenze), M. Burgay (INAF-OACa), S. Campana (INAF-OABr), E. Cappellaro (INAF OAPd), P. Casella (INAF-OAR), S. Covino, P. D'Avanzo (INAF-OABr), V. D'Elia (INAF-ASDC), F. Getman, A. Grado (INAF-OAC), G. Greco (Urbino University, INFN Firenze), G. Israel (INAF-OAR), L. Limatola (INAF-OAC), A. Melandri (INAF-OABr), L. Nicastro, E. Palazzi, E. Pian (INAF-IASF Bo), S. Piranomonte (INAF-OAR), A. Possenti (INAF-OACa), L. Pulone (INAF-OAR), A. Rossi (INAF-IASF Bo), G. Stratta (Urbino University/INFN Firenze), G. Tagliaferri (INAF-OABr), V. Testa (INAF-OAR), L. Tomasella, L. Stella, G. Iannicola, M. Lisi (INAF OA-Roma), L. Masetti, D. Vergani, A. Bulgarelli, G. De Cesare, A. Rossi (INAF IASF-Bologna), A. Stamerra, F. Longo, M. Razzano, G. Pivato, B. Patricelli, G. Cella (SNS-Pisa), G. Ghisellini, G. Ghirlanda, R. Salvaterra (INAF OA-Milano)

Connessioni con osservazioni di altre *facilities*

	radio	X-ray	Gamma-rays	VHE γ-rays
Blazar/μquasar	SKA	Swift; ASTROSAT; eRosita; IXPE; eXTP; Theseus; ATHENA	AGILE, Fermi; e-ASTROGAM, AMEGO	CTA
GRBs	SKA	Swift; ASTROSAT; eRosita; Theseus; eXTP; ATHENA	AGILE, Fermi; e-ASTROGAM, AMEGO	CTA
TDEs	SKA	Swift; ASTROSAT; eRosita; IXPE, Theseus; eXTP; ATHENA	AGILE, Fermi; e-ASTROGAM, AMEGO	CTA?

	GW	Radio	Opt + NiR	X-ray and Gamma-rays	VHE γ-rays
GW sources	LIGO/Virgo Interfero-meters, KAGRA, LIGO India, E-LISA	SRT, ATCA, SKA	VST, VLT, LBT, TNG, NOT, Asiago, C.I., REM, SOXS@NTT, NTE@NOT, SVOM JWST, E-ELT	Swift, AGILE, INTEGRAL, Fermi Theseus, SVOM ATHENA	Magic CTA

Tipo di analisi dati prevista/necessaria, inclusa di sviluppo e cadenza temporale

- ✓ **Data availability in "minutes"**
  Fast reaction to ToO after external triggers and fast data release (critical for GW, GRBs, less for TDEs)
    - **Preliminary (rough) identification of LSST transients needed to activate ToO (e.g., *optical spectroscopy*, IXPE, CTA)**
      critical point: Expected time delay
      observations -> broker -> early classification -> data
- ✓ **ToO.** What is the status of the discussion?
- ✓ **Fast access ("a day") to Optical light curve for flaring /rapid known sources (e.g., blazars)**
- ✓ **Access to long-term light curves** (hour/daily/weekly time bin)
  Problem: The frequency of sampling could affect the light curves for transients.

    - **Full band data (u, g, r, i, z, y)**
    - **similar methodology in quick look analysis for transient sources (e.g. synergy with SKA)**

An handful of open issues:

❖ **Working groups**

❖ **Data sharing policy for science cases transversal to different projects (e.g. overlaps with projects led by Raiteri and Ghirlanda)**

❖ **Financial support**

❖ **Strategy vs 'LSST Science Collaborations'**