



Osservatorio Ottico di Coloti

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Indice



Obiettivi del progetto



Stato attuale dell'osservatorio di Coloti



Prossimo futuro



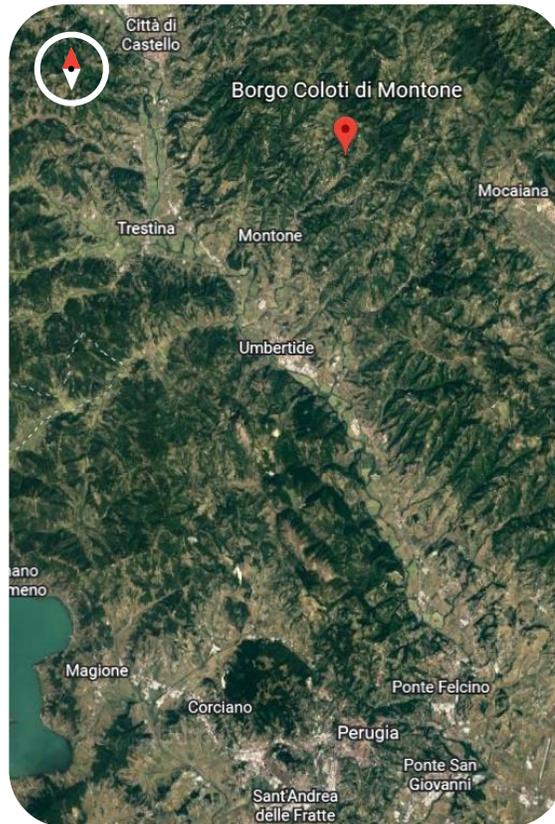
Lavoro in parallelo



Corsi, conferenze e workshop

Obiettivi del progetto

Messa in funzione e remotizzazione del telescopio ottico di Coloti per scopi **divulgativi** e **scientifici**



Obiettivi del progetto

Oltre **400** visitatori dalla riapertura dell'osservatorio di un anno fa



Eventi con il comune

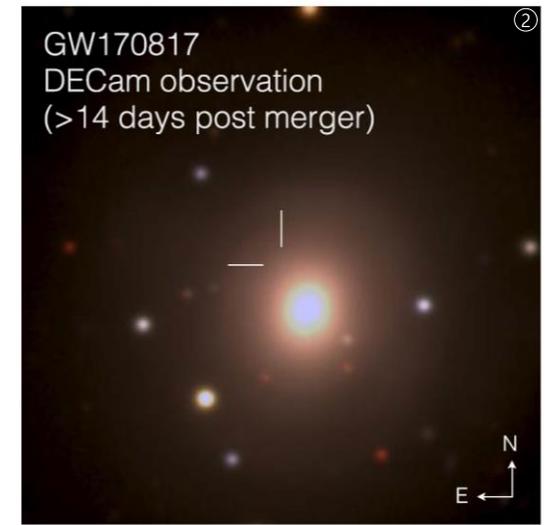
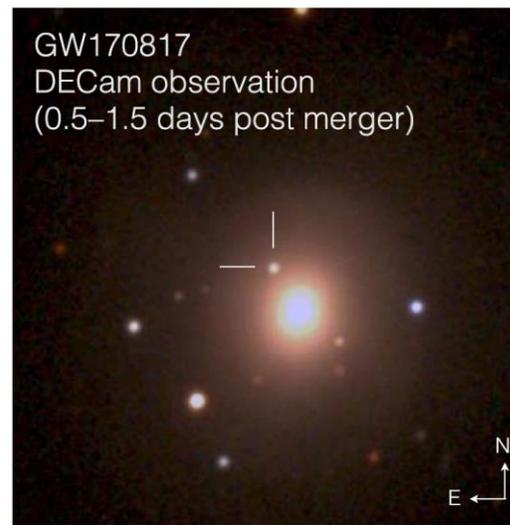
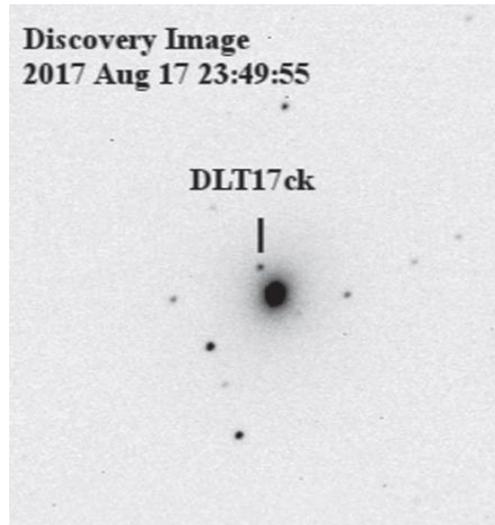
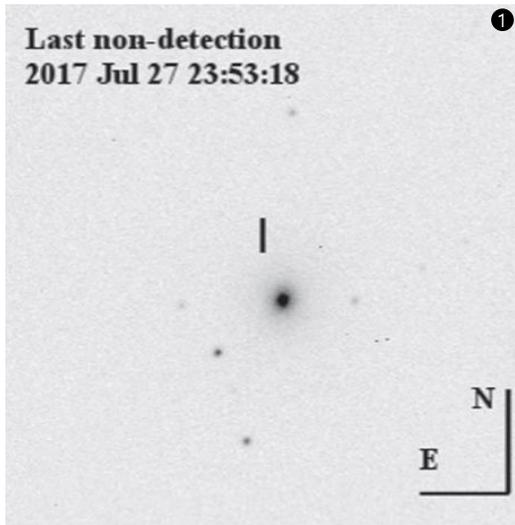


Ricercatori e studenti

Obiettivi del progetto

Follow-Up di eventi multimessenger

- **IC170922A**, neutrino ad alta energia (PeV) corrispondente a un flare di un Blazar
- **GW170817**, onde gravitazionali dalla coalescenza di due stelle di neutroni



Un mese prima
17 luglio

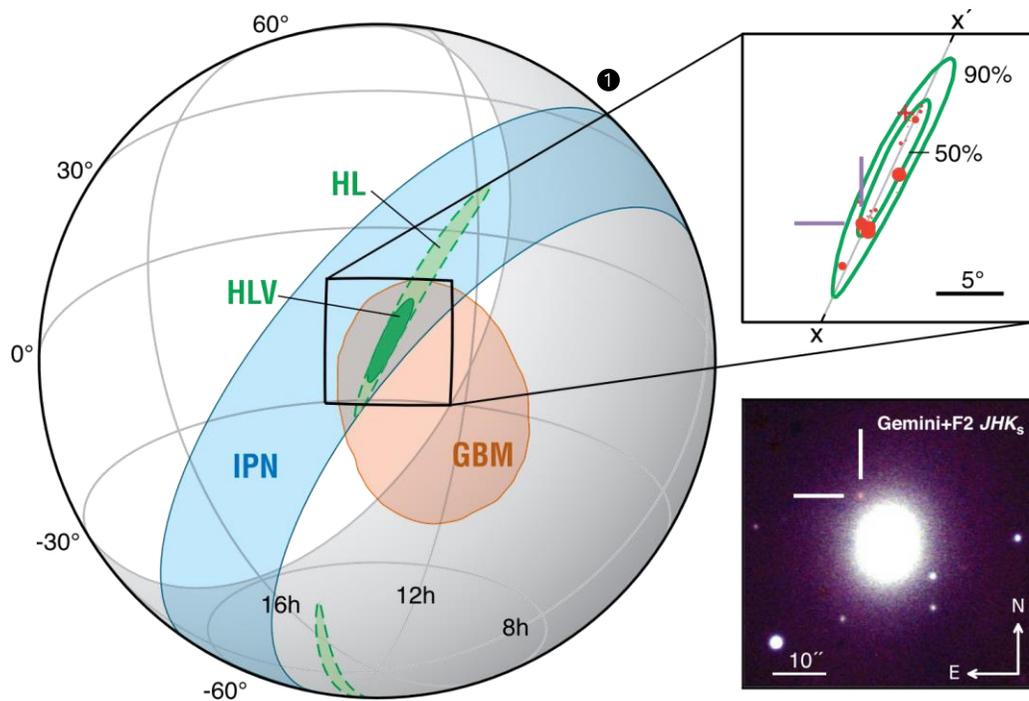
Merging e inizio emissione
17 agosto

Fine Emissione
1 settembre

¹ Valenti, S., et al., 2017, APJL 848(2), L24, ² Soares-Santos, M., et al., 2017, APJL, 848(2), L16

Obiettivi del progetto

Inserire l'osservatorio di Coloti nel network **GRAWITA** per follow-up multimessenger (radio, near-infrared, ottico, x-ray, gamma-ray).



GRAvitational **W**ave **I**naf **T**e**A**m

Osservazioni necessarie per individuare la sorgente con precisione.

Attualmente: 4 osservatori in Italia, 2 in Cile, 1 in USA.

¹ Kasliwal, M. M., et al., 2017, Science 358(6370), pp. 1559-1565.

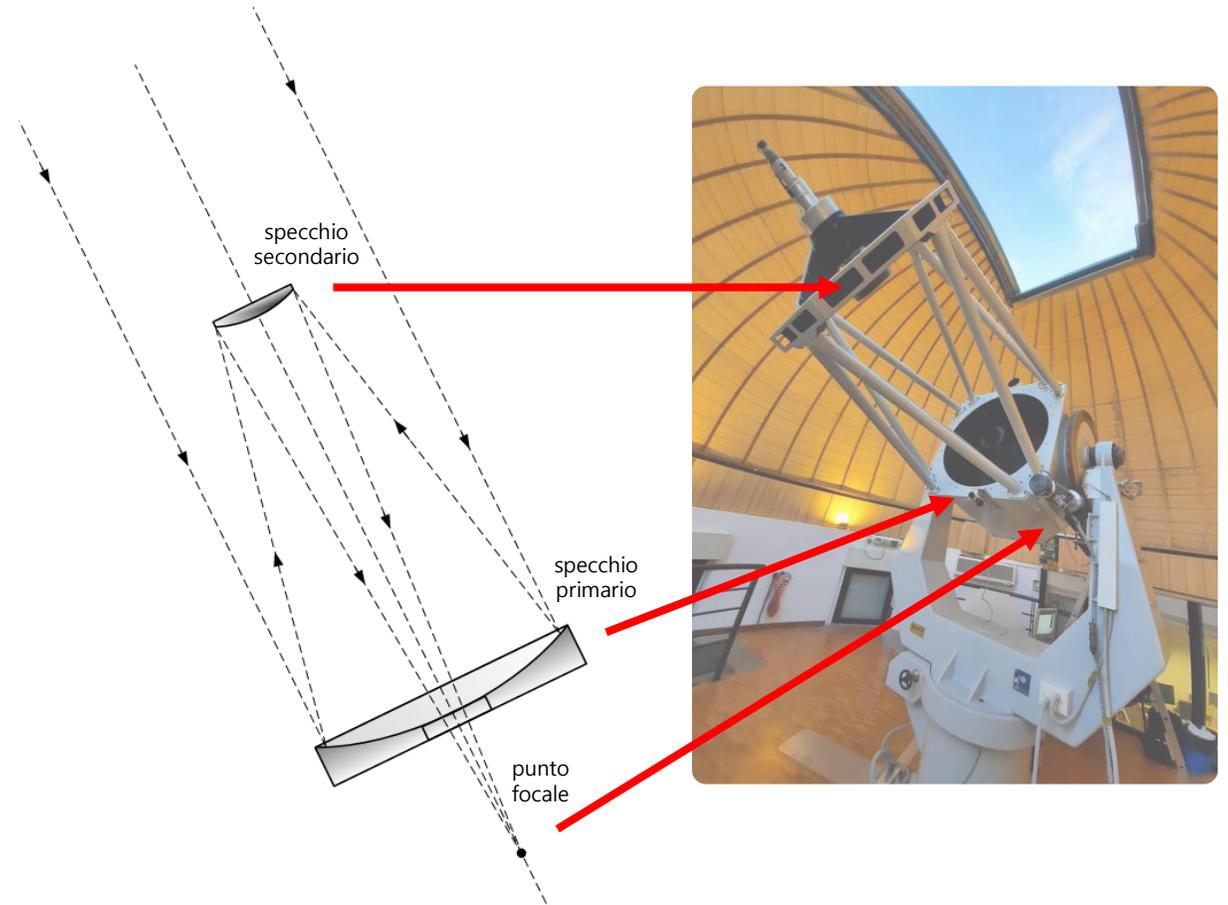
Stato attuale

Telescopio Cassegrain:

Specchio primario parabolico concavo da **80 cm**, e specchio secondario iperbolico convesso.

Il foceggiatore sposta lo specchio secondario, messa a fuoco non ideale.

Attualmente da gestire analogicamente.



Stato attuale

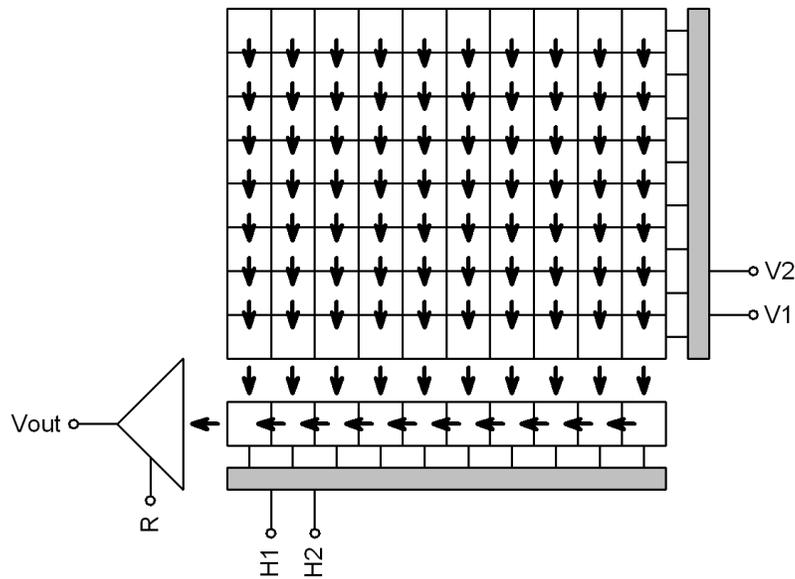
Camera CCD Charge-Coupled Device:

Moravian G2-1600 Mark II Full Frame

Pixel $9 \times 9 \mu\text{m}$ Risoluzione 1536×1024

Con il telescopio: $0.3'' \times 0.3''$ di cielo per pixel

Filtri Bessel: **U**, **B**, **V**, **R**, **I**



Stato attuale

Fotometria:

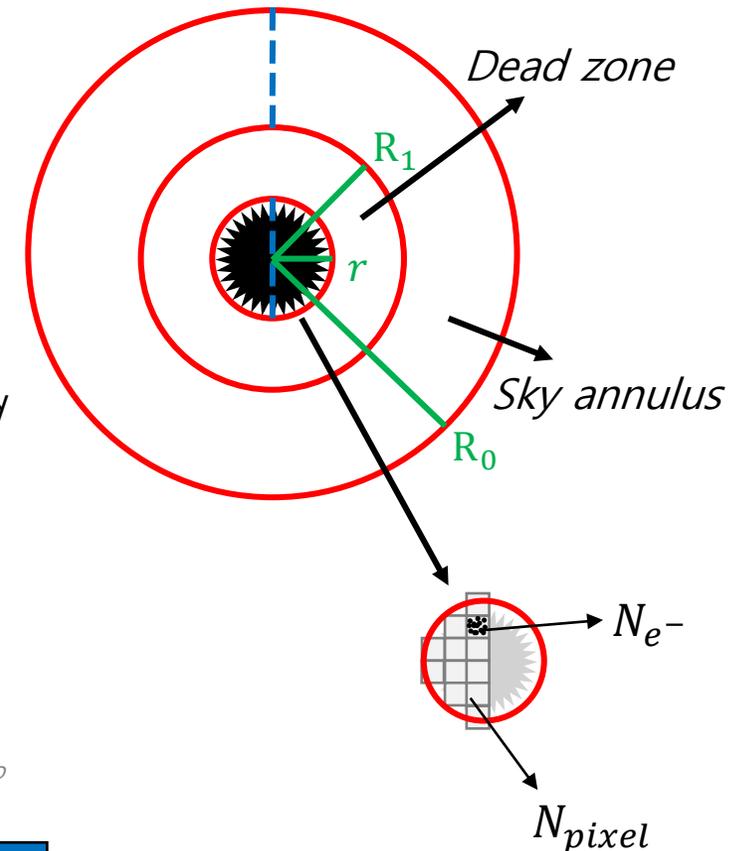
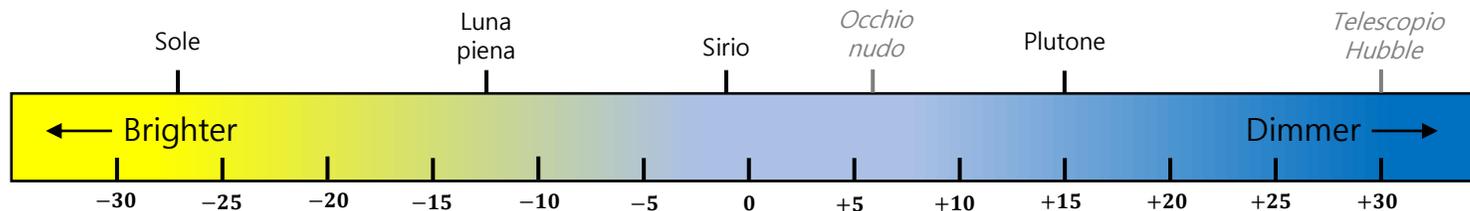
Al flusso totale bisogna sottrarre il fondo cielo calcolato nello *Sky annulus*.

$$F = \Sigma(N_{e^-}) - N_{pixel} \cdot \left(\frac{e^-}{pixel}\right)$$

Average sky background

La magnitudine (Δm) per misurare la luminosità di un oggetto (anche per flussi a differenti lunghezze d'onda: *b-v*):

$$\Delta m = -2.5 \log(F_1/F_2)$$

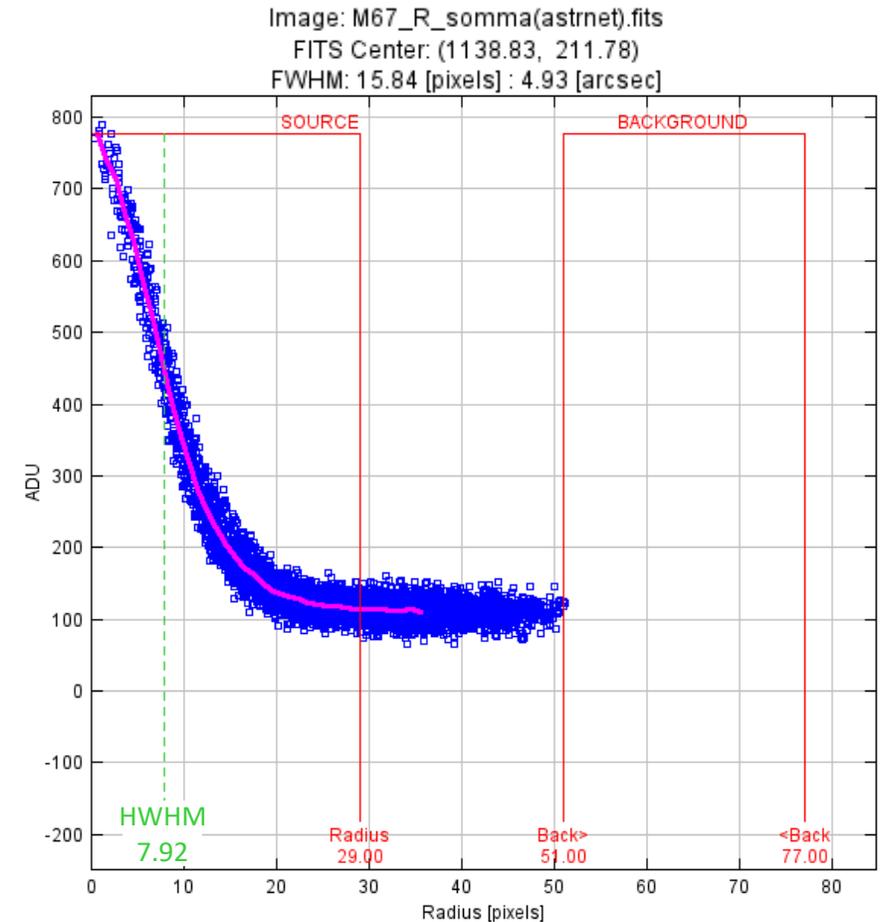
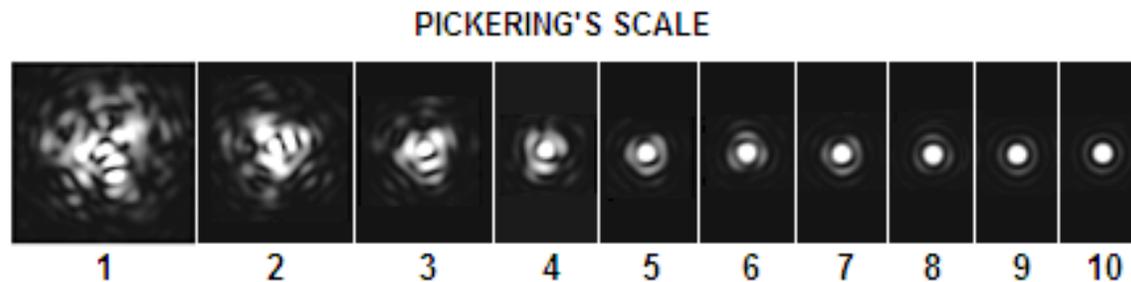


Stato attuale

Seeing:

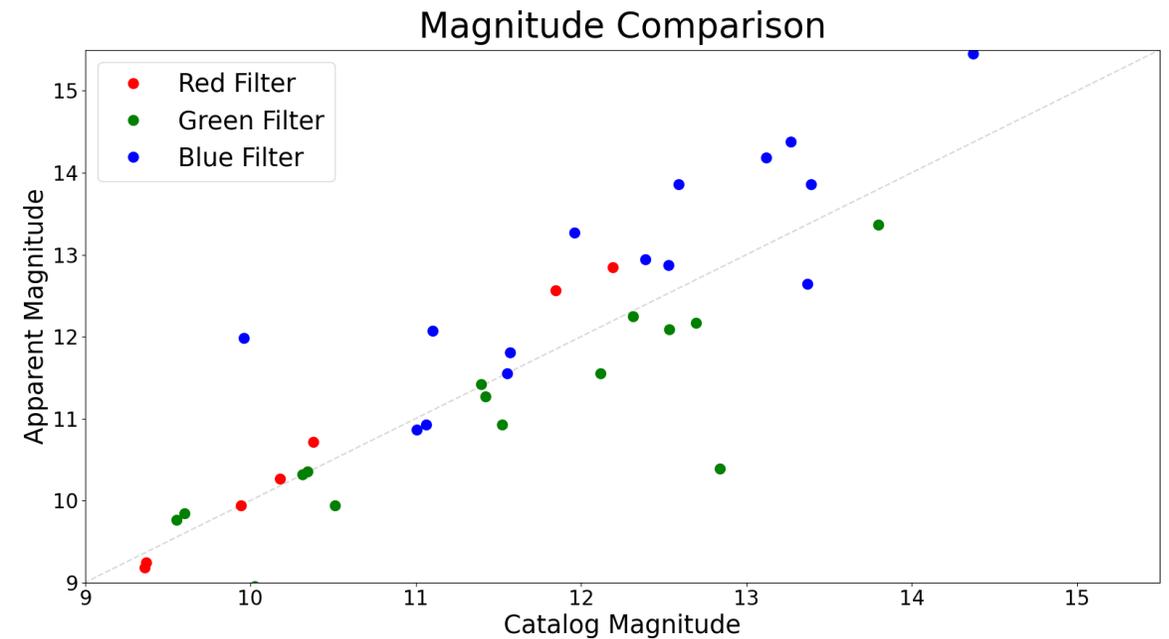
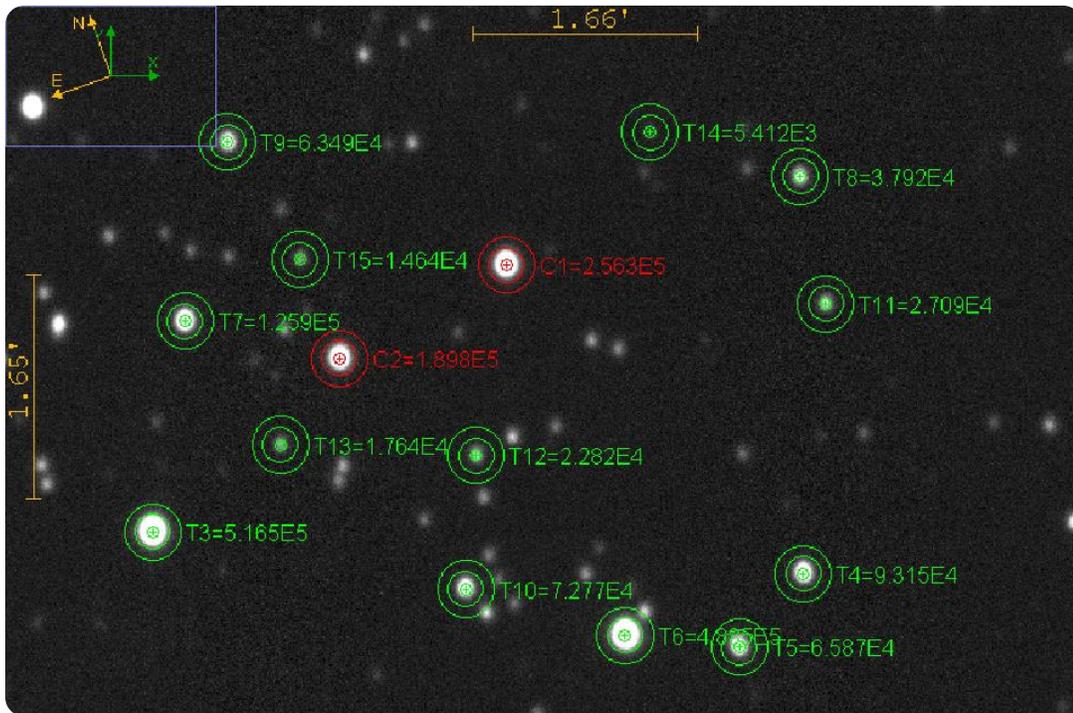
Turbolenza atmosferica, espressa in arcosecondi (tra 0.5'' e 2'') o come *Full Width at Half-Maximum*.

Migliorare la messa a fuoco per poter misurare il seeing da Coloti.



Stato attuale

Esempio di fotometria d'apertura: si possono usare delle **comparison star** da cui calcolare la magnitudine dei **target**.



Intermezzo



Luna, distanza ≈ 380 km



Stella doppia Albireo, distanza ≈ 410 ly

Intermezzo



Nebulosa di Orione, distanza ≈ 1500 ly

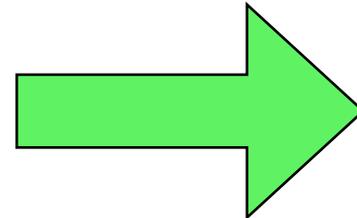


Galassia Sombrero, distanza $\approx 30 \cdot 10^6$ ly

Prossimo futuro

Cambiamenti in atto:

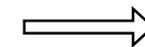
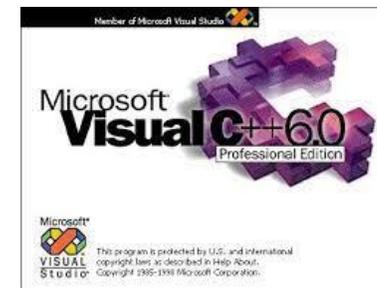
- Modernizzazione di **computer** e **software**
- Miglioramento della messa a **fuoco**
- Sostituzione della stazione **meteo**
- Sistema di controllo della **camera**



Remotizzazione

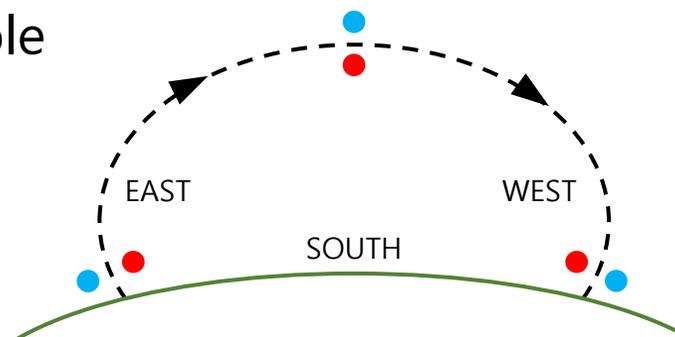
Prossimo futuro

- Una nuova **workstation** per il controllo generale e l'archiviazione dei dati.
- Due **computer industriali** per il controllo di telescopio e camera.
- Da Visual C++ 6.0 a **JAVA**: comunicazione con porte seriali da riscrivere.



Prossimo futuro

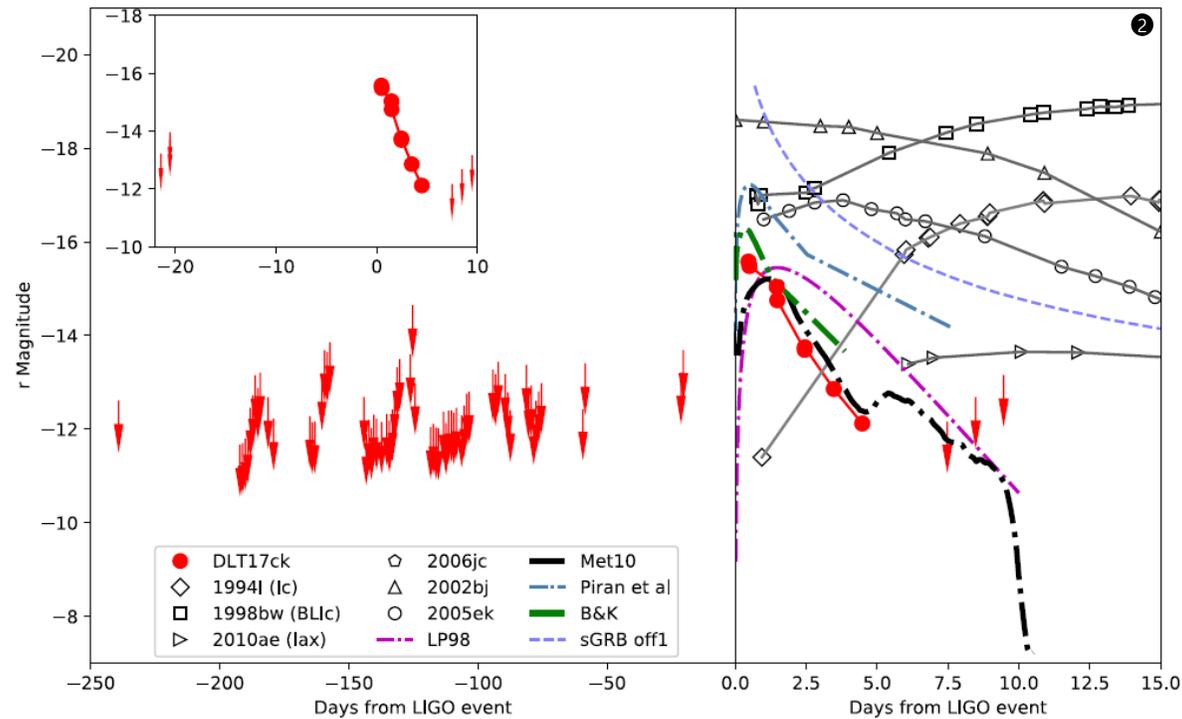
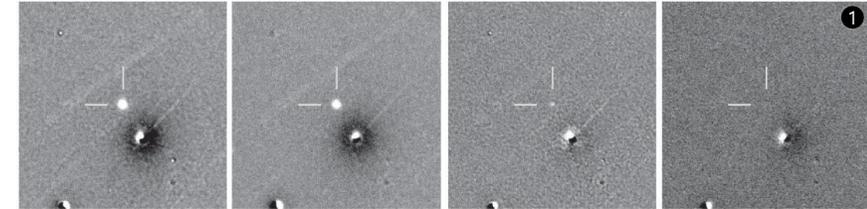
- Nuova **stazione meteo**, dati da integrare anche per la correzione delle immagini.
- Gestione digitale del **foccheggiatore**.
- Un **derotatore di campo** per avere singole prese dati più lunghe.



Lavoro in parallelo

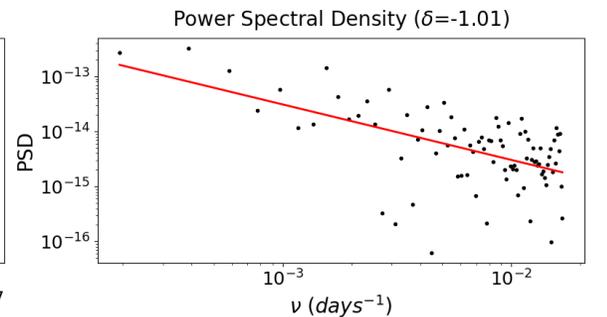
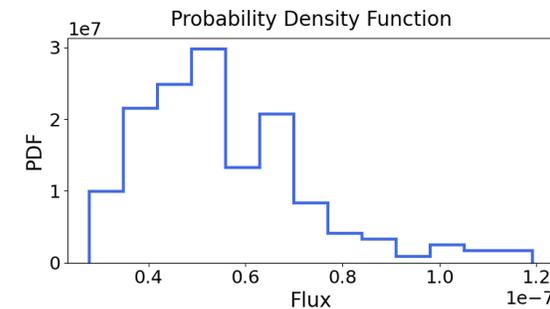
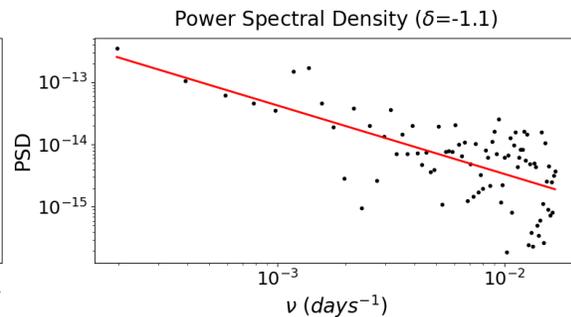
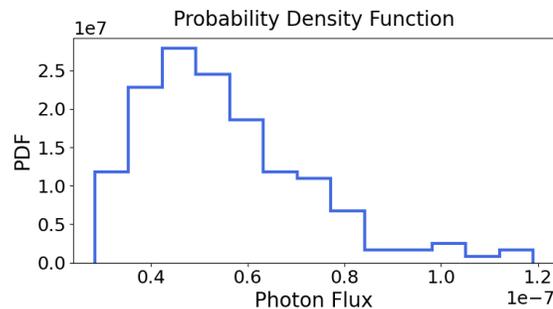
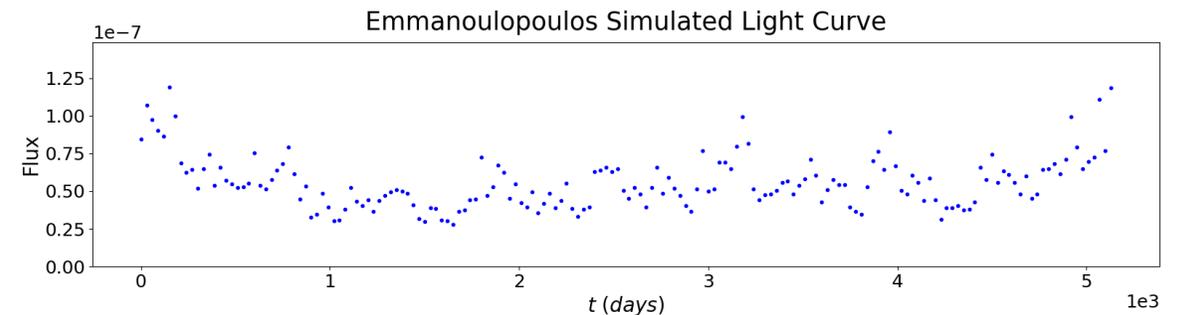
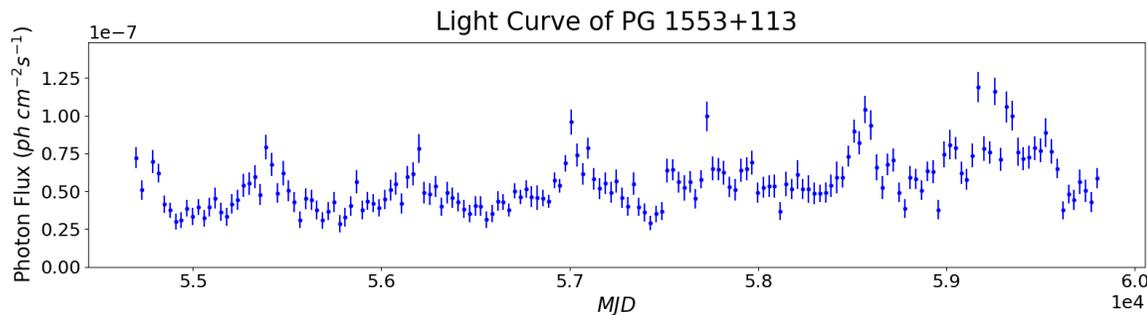
Studio della variabilità di oggetti transienti extragalattici.

La sorgente di **GW170817** mostra variabilità prima dell'evento e un'evoluzione peculiare dopo l'evento.



Lavoro in parallelo

Simulazioni tramite l'**algoritmo** di **Emmanoulopoulos**¹ per poter studiare curve di luce con caratteristiche simili (**P**robability **D**ensity **F**unction e **P**ower **S**pectral **D**ensity).



Corsi

- **Uncertainty and Probability**
- **Multimessenger:**
 - **Gamma-ray**
 - Neutrini
 - Onde Gravitazionali
- Effective Field Theory:
 - Teorica
 - Spintronics
- Physics at Colliders
- **Introduction to Space Physics**
- Nanosystems:
 - Nanomagnetismi molecolari per quantum computing
 - Spettroscopia Raman
 - Spettroscopia di materiali nanostrutturati
- Flavour Physics
- **Teaching and Learning Physics**

Conference workshop

Barcelona

7th Heidelberg International Symposium

Sexten

Hands On The Extreme Universe With High Energy Gamma Rays

7th Heidelberg International Symposium on High Energy Gamma-Ray Astronomy

2022 BARCELONA

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Study of periodicity in Blazar light curves observed by Fermi LAT

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Abstract

Long term periodicity in gamma-ray Blazar light curves could be linked to the innermost zone of the complex structure of AGN, like possible presence of binary system of supermassive black holes [1] or it could shed light on the origin of gamma-rays emission.

The work analyzes 1523 sources, whose 14 years light curves come from the Fermi LAT 'Repository' (LCR), making use of Lomb-Scargle Periodogram (LSP) [2][3] and wavelet weighted Z transform (WWZ) [4].

All the available possibilities for the light curves in the LCR, such as different temporal samplings and the use of photon flux and energy flux, are taken into account in order to ensure more reliable results.

We found out high significance periodicity in less than 1% of the sources considered, and in few other sources hints of possible periodicity.

Our results are compliant with the findings of recent literature [5][6] focused on searches of periodic modulation in AGN.

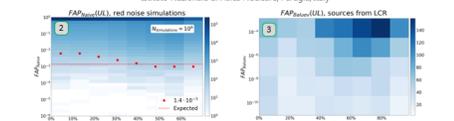
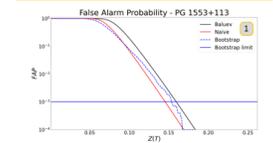
<https://arxiv.org/abs/2205.02439v1>

Analysis

The first method used is the LSP in addition to the changes introduced by Scargle [2] for the classical periodogram, we included some practical consideration of 'Significance' [3] related to significance and uncertainty. The second method used is a wavelet transform for discrete and uneven spaced time series [4], this allows the study of temporal evolution of periodicity. These methods were validated through periodic light curve simulations.

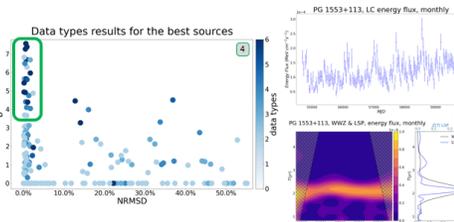
Neither method allows finding uncertainty, because 'it is proportional to period' or 'direct significance of the periodicity found'. For this reason, we use the False Alarm Probability (FAP), the probability that data consisting in pure noise will lead to a peak of a similar magnitude.

The most reliable method for the FAP is Bootstrap, based on randomization of the time series, but it has a high computational cost. The naive method underestimates the FAP in the analysis of the entire catalog, we chose 'Global method', in that overestimates the FAP as it is shown in Figure 1, and it is faster.



Results

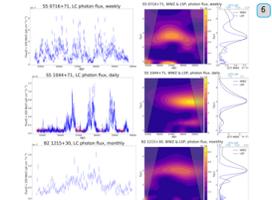
For a simpler representation of the significance we associate Figure 4 is the summary graph of the analysis of the entire catalog, with significance above 3.5σ. Normalized Root-Mean-Square Deviation (NRMSED) < 3% and periodicity found with more than 2 data types. When the UpperLimit (UL) percentage exceeds the 40%, the significance increases above the expected value in the case of red noise. Figure 2, for LCR sources we can see the same effect, Figure 3.



Conclusions

The analysis methods: LSP and WWZ, were validated through periodic light curve simulations, while with red noise simulations we verified the goodness of FAP as a significance estimation method.

Among the 1523 sources in the LCR, a significant periodicity was found in 25 blazars: 15 Flat Spectrum Radio Quasars (FSRQ) and 10 BL Lac objects (BLO). We identified a golden sample of 8 sources with very high significance, shown in the table: three of these sources with light curves, local and global spectrum and periodogram are shown in Figure 6.



Source Name	RA J2000	Dec J2000	Type	Best T (yr)	FAP
PG 0450-180	07:113	-27:241	FSRQ	1.5	1.4e-10
PG 0454-234	74.261	-23.414	FSRQ	1.5	1.4e-10
PG 0716+71	119.448	71.361	FSRQ	1.6	1.4e-10
S5 1044+71	162.307	71.730	FSRQ	3.0	1.4e-10
B2 1215+30	184.476	30.118	BLO	3.0	1.4e-10
PG 1553+113	239.923	113.261	BLO	2.2	1.4e-10

Bibliography

[1] S. Komossa, "Observational evidence for binary black holes and active double nuclei", *Astronomy and Astrophysics*, vol. 377, p. 743, 2006.

[2] J. H. Scargle, "Studies in astronomical time series analysis. I. Statistical aspects of spectral analysis of unevenly spaced data", *Astrophysical Journal*, vol. 218, pp. 813-818, Dec. 1982.

[3] J. H. Scargle, "Unravelling the Lomb-Scargle Periodogram", *Astrophysical Journal*, vol. 276, p. 16, May 1987.

[4] M. Torricelli, "Wavelets for period analysis of unevenly sampled time series", *A&A*, vol. 112, pp. 1081-1078, Oct. 1996.

[5] M. Alcázar, et al., "Multiwavelength evidence for quasi-periodic modulation in the gamma-ray blazar PG 1553+113", *The Astrophysical Journal*, vol. 812, no. 2, p. 147, 2015.

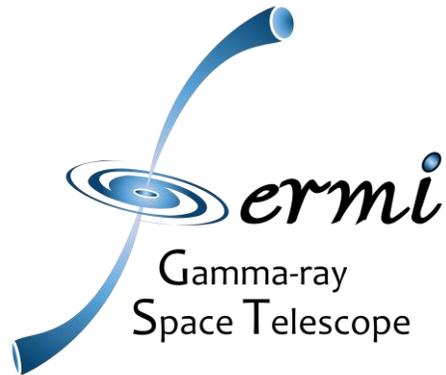
[6] P. F. et al., "Systematic Search for γ-Ray Periodicity in Active Galactic Nuclei Detected by the Fermi Large Area Telescope", *ApJ*, vol. 886, p. 75, June 2019.

SEXTEN CENTER FOR ASTROPHYSICS RICCARDO GIACCONI

Conferenze e workshop

Pisa

Fermi-LAT Collaboration
Meeting

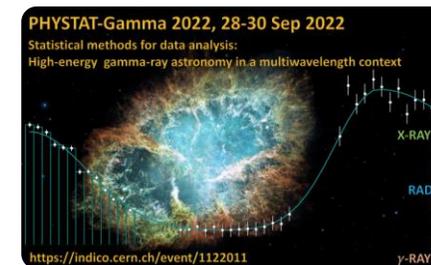


Phystat-Gamma 2022

*Statistical Methods for Data Analysis:
High-energy gamma-ray astronomy
in a multiwavelength context*

Volterra

3rd Gravi-Gamma Workshop:
The multimessenger view of
the black hole life cycle



Conclusioni

Prossimi step:

1. **Organizzazione** hardware: una workstation, due computer industriali, stazione meteo
2. Inizio messa a punto **remotizzazione**
3. Presa dati consistente per **calibrazioni** e **rodaggio**
4. **Follow-up** multimessenger e pipeline di analisi