



BARI-NOVA GORICA-PERUGIA-PISA-ROMA-STOCCOLMA-TORINO-TRIESTE

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THE FIRST FERMI MASTERCLASS ONLINE EDITION 2020



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The Fermi Masterclass

- The Fermi Masterclass is an **international program** offered to **high-school students** to study cosmic objects by performing basic analyses of Fermi-LAT data using professional software and direct guidance of scientists from the Fermi Collaboration
 - This project draws from the **Masterclass program** organized by the CERN International Particle Physics Outreach Group (**IPPOG**), involving thousands of students across the world
- The Fermi Masterclasses take advantage of the unique properties of the **Fermi-LAT data**
 - They are public, all-sky, promptly available and fairly simple to understand
 - Building on the **Fermi Science Tools** distributed by the Science Support Center, several groups in different countries have developed **software tools** and **examples** to allow simple inspection and analyses of Fermi data by non-experts

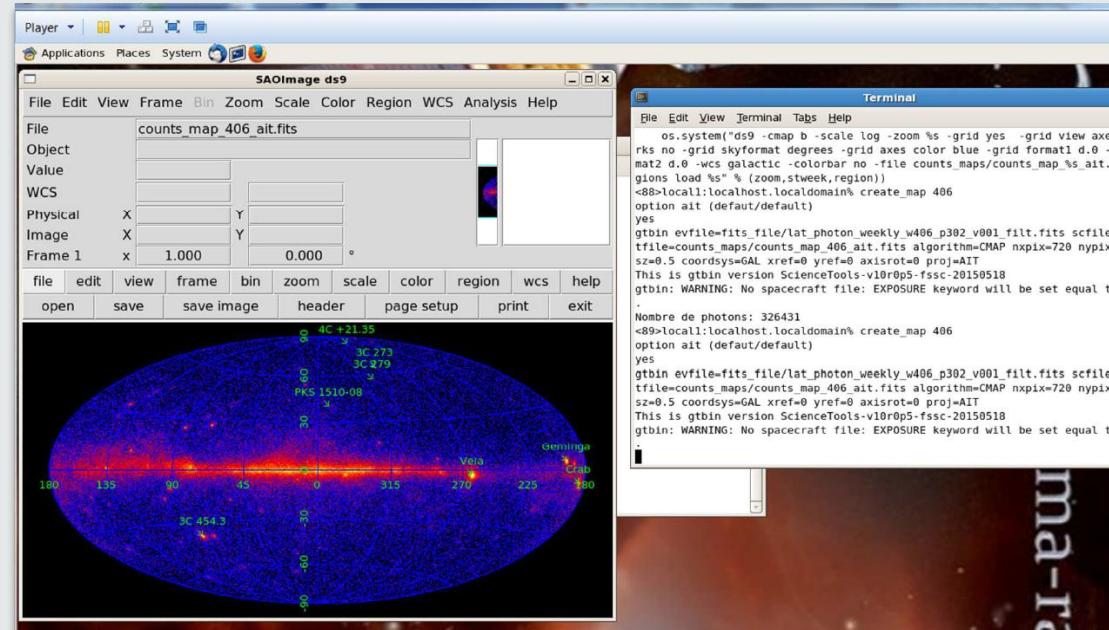
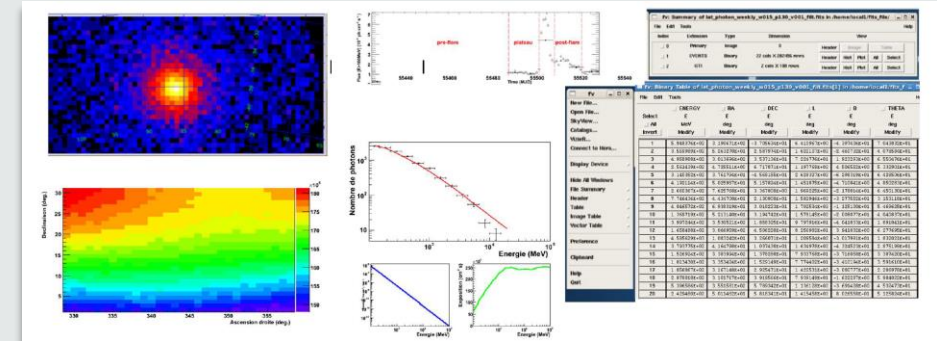


The Fermi Masterclass – past editions

- Starting 2015, Fermi Masterclasses have been organized in **France** (Bordeaux and Montpellier)



- **Researchers moved to the schools** to meet the students and work with them on Fermi data
- The analysis software had to be installed on **school PCs (Virtual machines – COSMAX)**



The Fermi Masterclass – past editions

- Since **2017**, Fermi Masterclasses are being organized in **Italy** by the **Italian National Institute for Nuclear Physics (INFN)** in several cities (Bari, Perugia, Torino, Trieste), joined by Nova Gorica (**Slovenia**)
 - Over the years, more institutes joined (Rome [I], Jacksonville [USA], Stockholm [SE])
 - The program included
 1. **Introductory lectures** in the morning, where students learned about high-energy gamma-ray astrophysical phenomena, and about the Fermi experiment
 2. **Hands-on afternoon**, during which students could follow real-time tutorials in order to analyze Fermi-LAT data
 3. **Final videoconference** together with all other institutions, during which the results obtained could be presented and discussed

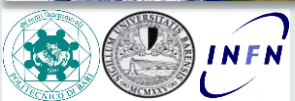


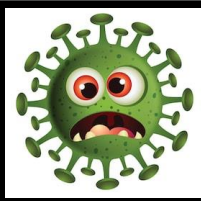
The Fermi Masterclass – past editions



- Focusing on different Fermi Sources and Scientific Highlights through the years!

| FERMI MASTERCLASS 2017 5 aprile 2017 Bari – Nova Gorica – Perugia – Torino – Trieste | FERMI MASTERCLASS 2018 Lampi di Raggi Gamma e Onde Gravitazionali 5 aprile 2018 Bari – Nova Gorica – Perugia – Torino – Trieste | FERMI MASTERCLASS 2019 Fotoni e Neutrini da Acceleratori Cosmici 5 aprile 2019 Bari – Jacksonville (USA) – Nova Gorica (SLO) – Perugia – Roma – Torino – | FERMI MASTERCLASS 2020 Pulsar nel Cielo Gamma 15 aprile 2020 Bari – Nova Gorica – Perugia – Roma – Stockholm – Torino – Trieste |
|---|---|--|--|
|  <p>Comitato organizzatore locale: Elisabetta Bissaldi Fabio Gargano Francesco Loparco Francesco de Palma</p> <p>Dipartimento Interateneo di Fisica «M. Merlin» Aula Multimediale Via E. Orabona 4 70125 Bari</p> <p>Per info e contatti: ✉ fermi.masterclass.bari@gmail.com ☎ 080 544 3169</p> |  <p>Credit: NASA</p> <p>Comitato organizzatore locale: Dott.ssa Elisabetta Bissaldi Dott. Leonardo Di Venere Dott. Piergiorgio Fusco Dott. Fabio Gargano Prof. Francesco Giordano Prof. Nico Giglietto Dott. Francesco Loparco Dott. Mario-Nicola Mazziotta Dott. Francesco de Palma Dott.ssa Silvia Rainò</p> <p>Dipartimento Interateneo di Fisica «M. Merlin» Aula Multimediale Via E. Orabona 4 70125 Bari</p> <p>Per info e contatti: ✉ fermi.masterclass.bari@gmail.com ☎ 080 544 3169</p> |  <p>Dipartimento Interateneo di Fisica «M. Merlin» Aula Multimediale Via E. Orabona 4 70125 Bari</p> <p>Comitato organizzatore locale: Elisabetta Bissaldi Pedro De La Torre Luque Francesco de Palma Leonardo Di Venere Piergiorgio Fusco Fabio Gargano Nicola Giglietto Francesco Giordano Francesco Loparco Nicola Mazziotta Silvia Rainò Davide Serini</p> <p>Per info e contatti: ✉ silvia.raino@ba.infn.it ☎ 080 544 3174</p> |  <p>Dipartimento Interateneo di Fisica «M. Merlin» Via E. Orabona 4, 70125 Bari Aula Multimediale – Ore 9</p> <p>Comitato organizzatore locale: Elisabetta Bissaldi Pedro De La Torre Luque Francesco de Palma Leonardo Di Venere Piergiorgio Fusco Fabio Gargano Nicola Giglietto Francesco Giordano Francesco Loparco Nicola Mazziotta Silvia Rainò Davide Serini</p> <p>Per info e contatti: ✉ silvia.raino@ba.infn.it ☎ 080 544 3174</p> |



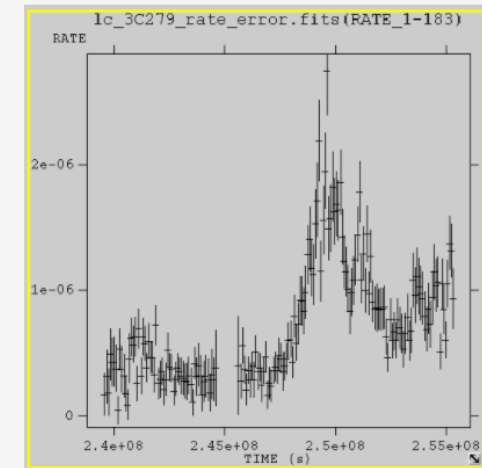


- Due to the Covid-19 pandemic, we decided to **cancel** the Fermi Masterclass Edition 2020 at the beginning of March 2020
- During the first Italian lockdown in April 2020, we created an **interactive path** on a dedicated **INFN outreach website** called [ScienzaXTutti](#) (“Science for all”) based on our experience with past Fermi Masterclasses, aimed to guide students to **autonomously discover** gamma-ray astronomy and the Fermi experiment, in particular:
 - Galactic sources
 - Extragalactic sources
 - Gamma ray bursts
- We developed also **interactive exercises** on the Google Colab platform based on Python and on public Fermi fits files



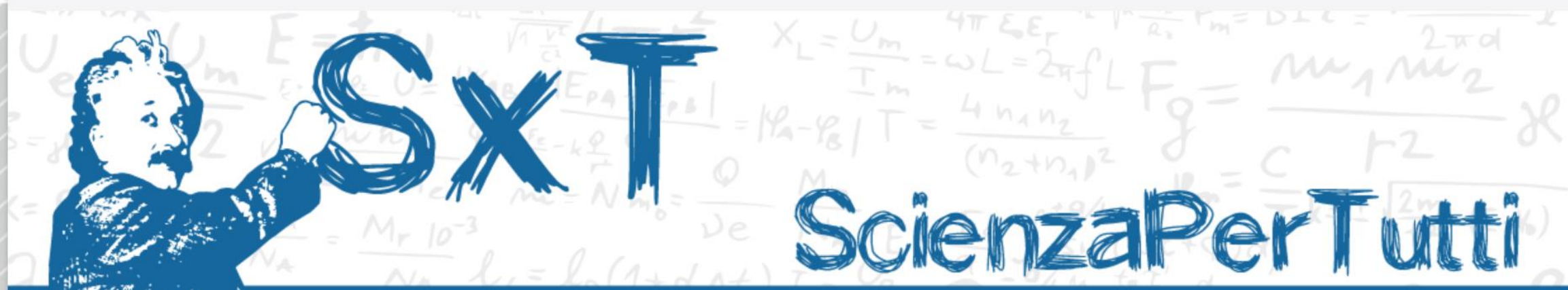
Esercizio interattivo

Nell'esercizio proposto a [questo link](#), potrete cimentarvi nell'analizzare i dati di LAT raccolti nei primi 6 mesi di osservazione, da agosto 2008 a marzo 2009. Tramite l'uso dei fogli di lavoro (notebook) di Google Colab potrete creare sia delle mappe di una porzione del cielo attorno a 3C 279, che le sue curve di luce. Per curva di luce si intende il numero di fotoni rivelati da uno strumento in funzione del tempo, in questo caso suddividendo l'osservazione in intervalli temporali di 1 giorno. Questa analisi viene fatta considerando prima una porzione di 10 gradi attorno alla sorgente, e in seguito solo di 1 grado, in modo da verificare la riduzione del segnale dovuto ad altre sorgenti non in esame. Nell'immagine sottostante si vede un esempio di quello che dovrete ottenere quando dai conteggi si passa a calcolare il flusso, tenendo quindi conto delle caratteristiche del tipo di osservazione e di quelle dello strumento stesso. Dal grafico appare immediatamente evidente la variabilità del flusso del quasar, che risulta molto brillante tra dicembre 2008 e gennaio 2009.



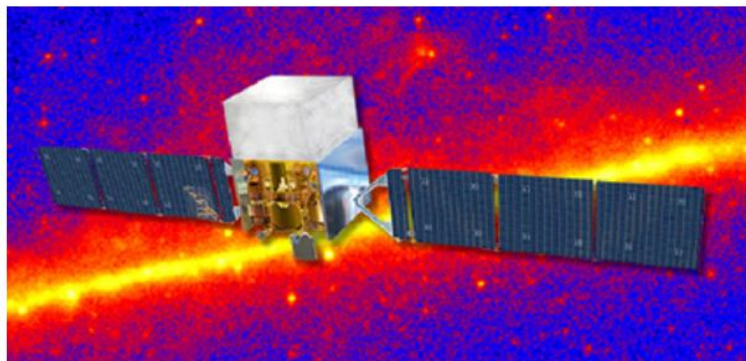
Ref. https://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/aperture_photometry.html

I dettagli dell'analisi sono indicati passo passo nel Google Colab.



<https://scienzapertutti.infn.it/raggi-gamma>

1. I raggi gamma



Il percorso "Raggi gamma" presenta una breve **introduzione all'astrofisica gamma**, la radiazione elettromagnetica più energetica che ci raggiunge dalle profondità dell'Universo. Lo studio di questa radiazione, svolto con potenti telescopi in orbita **come il rivelatore Fermi**, ci aiutano a capire la natura ed i meccanismi di funzionamento di oggetti lontanissimi da noi, sia nella nostra che in altre galassie. I raggi gamma nello spazio furono osservati per la prima volta negli anni '60 dalla costellazione di satelliti militari americani VELA, progettati per monitorare possibili test nucleari non autorizzati nell'atmosfera terrestre. Grazie a questi satelliti "non scientifici" si è però scoperto che i raggi gamma provengono da oggetti astrofisici molto lontani dalla Terra, sia nella nostra Galassia (come pulsar, resti di Supernova, etc.) che al di fuori (come nuclei galattici attivi, gamma ray burst, etc.).

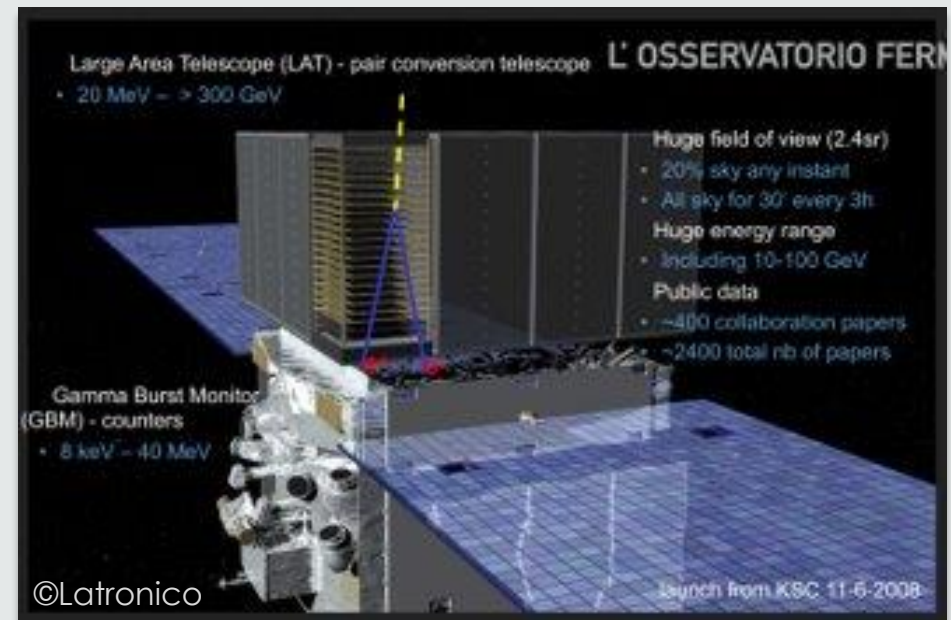
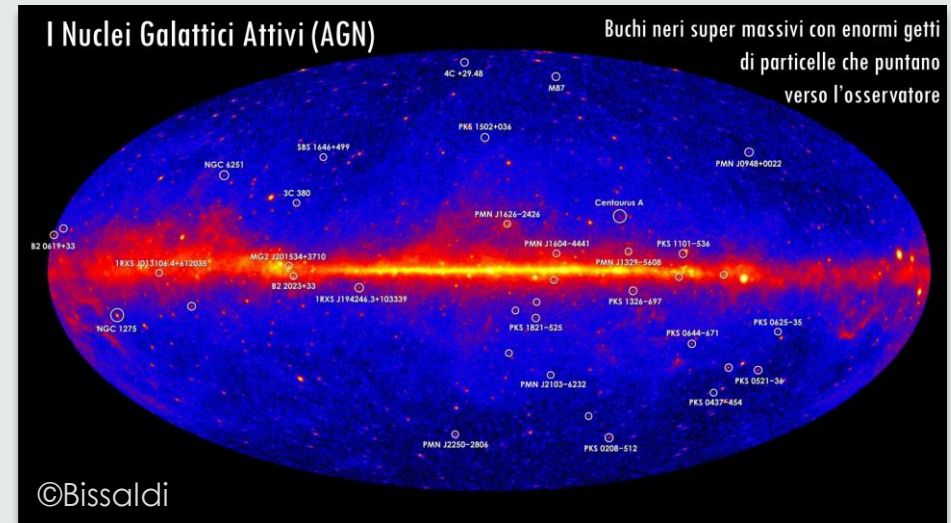
The first Fermi Masterclass Online Edition

- In November 2020 Italy experienced a **second lockdown** and we had to definitively put aside the idea of a “standard” Fermi Masterclass at our institutes
- We were very doubtful of proposing yet another online event for high school students who could be “saturated” with this form of involvement
 - However, based on having already conceived and developed interactive exercises that could be easily carried out remotely, we decided to go for a **national online edition**, involving students from various regions
- As a platform we used **Zoom in webinar mode**, allowing us to manage a large number of participants very well without “interference”
 - Zoom events can be easily broadcasted on **Facebook** or **YouTube!**
 - We set **no limit** on the number of students per school/class
 - More than 600 students signed up, and in the end we had **~550 participants!**



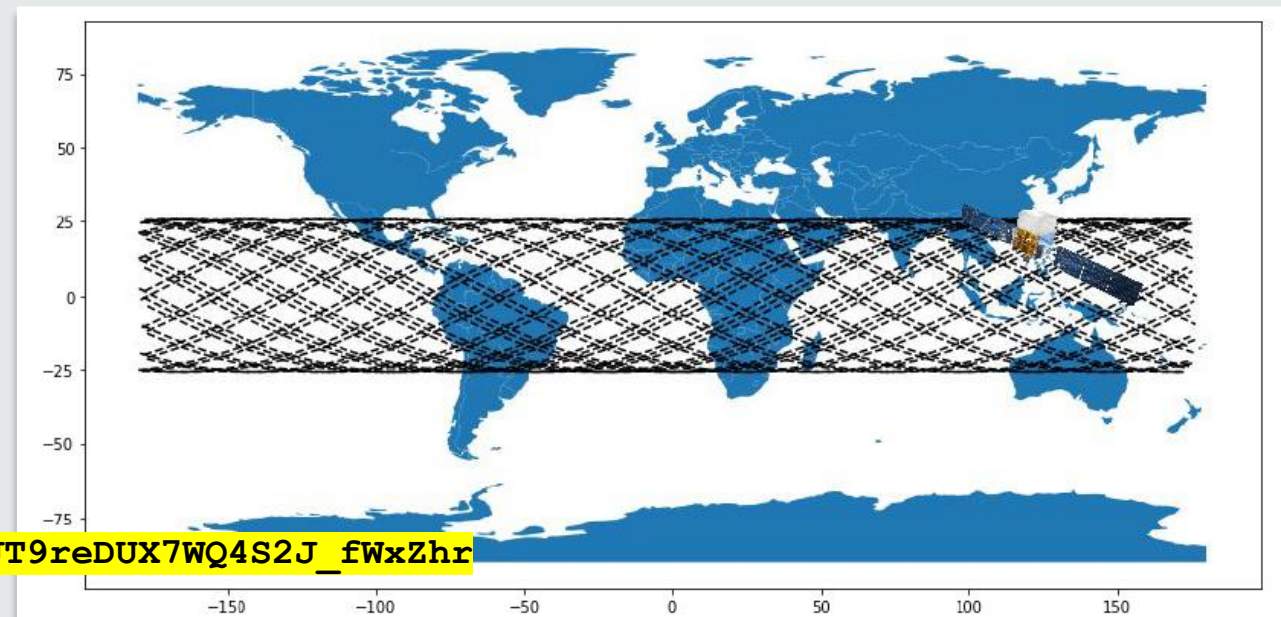
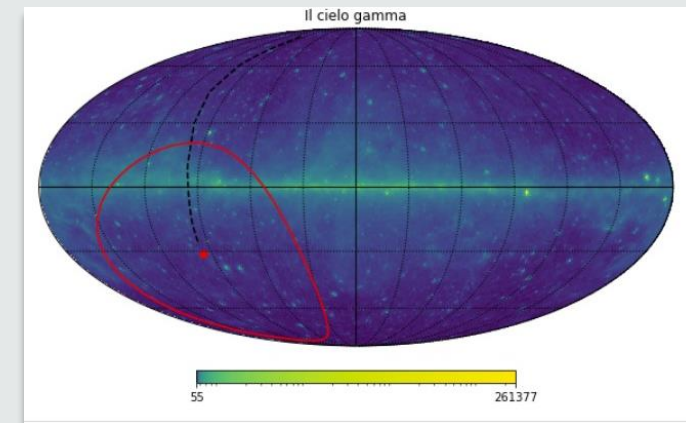
The first Fermi Masterclass Online Edition

- The event lasted ~**3 hours** and included 2 general talks, 2 exercises and a final «competition» among students
 1. «Gamma-Ray Astrophysics» – E. Bissaldi (Bari)
 2. «The Fermi Mission» – L. Latronico (Torino)
 3. «Fermi in orbit & Skymap» – L. Di Venere (Bari)
 4. «AGN Flare Analysis» – F. de Palma (Lecce)
 5. «Playing with Kahoot!» – S. Cutini (Perugia)
 - The best 3 students got a **Fermi plate** as a reward



First interactive exercise

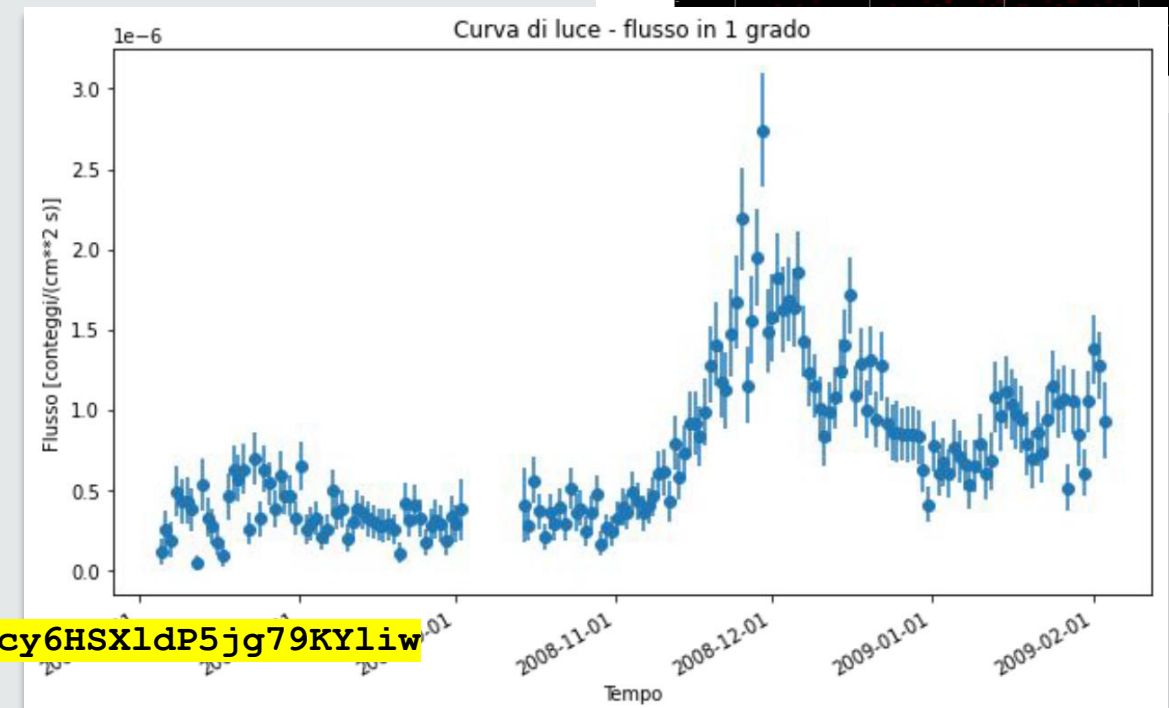
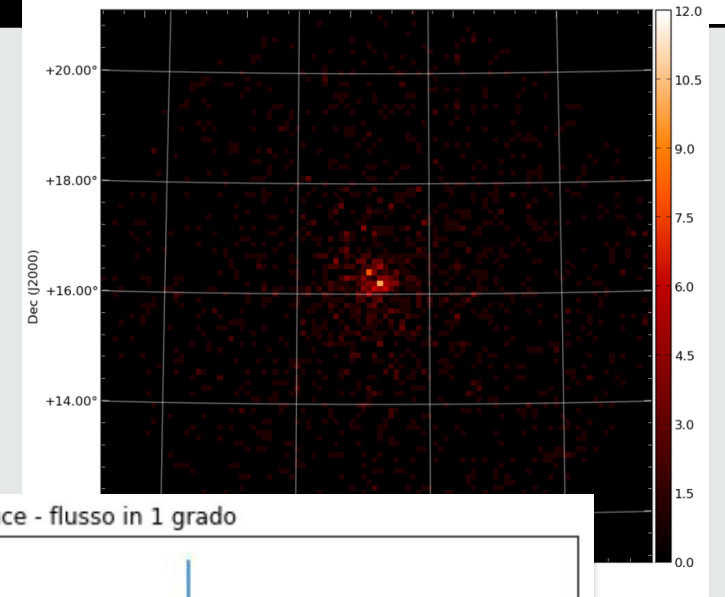
- Both exercises are based on **Google Colab**
 - Hosted **Jupyter notebook** service that requires no setup to use, while providing free access to google computing resources
 - Since it would be slow to install the Science Tools on Colab, we used only already available **standard python modules**
 - Some files have been **precalculated** and stored on gdrive (ft1, ft2, exposure,...)
- The students were able to
 - Retrieve the data and create tables
 - Explore ft2 files
 - Convert time formats
 - Explore **satellite altitude and position**
 - Plot a **Skymap showing the satellite pointing direction** as time passes



https://colab.research.google.com/drive/1-hyY4SoEoQJT9reDUX7WQ4S2J_fwXZhr

Second interactive exercise

- Here, students can **create maps and lightcurves** of a portion of the sky around the **blazar 3C 279** during a bright flaring phase between December **2008** and January **2009**
- The students were able to
 - Retrieve the data
 - Explore the ft1 files
 - Select the correct interval and RoI
 - Create maps and lightcurves
 - **Create a gif** with a succession of maps highlighting the source variability



<https://colab.research.google.com/drive/1g-GgHHG1jbjQFcy6HSXldP5jg79KYliw>

Conclusions and outlook

- Our experience with the Online Fermi Masterclass 2020 proved to be **very successful**
 - We received **very positive feedback** from students and teachers
- Outlook for 2021:
 - Italy is still going through severe lockdown phases, vaccination proceeding slowly
 - Planning a **Fall 2021 edition** to take place possibly in **November/December (virtual?)**
- More «**Scienza x Tutti**» online initiatives followed our example in Italy and abroad, and are developing similar interactive paths for e.g. cosmic rays (ex. Auger and CTA)

