

## The First Fermi Masterclass Online Edition 2020

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**Rainó S.,<sup>a,f,\*</sup> Bissaldi, E.,<sup>a,f</sup> Bonino, R.,<sup>b,c</sup> Cutini, S.,<sup>d</sup> de Palma, F.,<sup>e,k</sup> Di Venere, L.,<sup>a,f</sup> Fusco, P.G.,<sup>a,f</sup> Gargano, F.,<sup>f</sup> Gasparrini, D.,<sup>g,j</sup> Latronico, L.,<sup>c</sup> Longo, F.,<sup>i</sup> Loparco, F.,<sup>a,f</sup> Lubrano, P.,<sup>d,i</sup> Mazziotta, M.N.,<sup>f</sup> Mereu, I.<sup>h</sup> and Serini, D.<sup>a,f</sup>**

<sup>a</sup>*Dipartimento Interateneo di Fisica "M. Merlin" dell'Università degli Studi di Bari e del Politecnico di Bari  
Via Amendola 173, I-70126 Bari, Italy*

<sup>b</sup>*Istituto Nazionale di Fisica Nucleare, Sezione di Torino, I-10125 Torino, Italy*

<sup>c</sup>*Dipartimento di Fisica, Università degli Studi di Torino, I-10125 Torino, Italy*

<sup>d</sup>*Istituto Nazionale di Fisica Nucleare, Sezione di Perugia, I-06123 Perugia, Italy*

<sup>e</sup>*Dipartimento di Matematica e Fisica "E. De Giorgi", Università del Salento, Lecce, Italy*

<sup>k</sup>*Istituto Nazionale di Fisica Nucleare, Sezione di Lecce, I-73100 Lecce, Italy*

<sup>f</sup>*Istituto Nazionale di Fisica Nucleare, Sezione di Bari, I-70126 Bari, Italy*

<sup>g</sup>*Istituto Nazionale di Fisica Nucleare, Sezione di Roma "Tor Vergata", I-00133 Roma, Italy*

<sup>h</sup>*Università degli Studi di Trieste and INFN - Trieste, Italy*

<sup>i</sup>*Università degli Studi di Perugia, Italy*

<sup>j</sup>*Space Science Data Center - Agenzia Spaziale Italiana, Via del Politecnico, snc, I-00133, Roma, Italy*

*E-mail: [silvia.raino@ba.infn.it](mailto:silvia.raino@ba.infn.it)*

The Fermi Masterclass is an international outreach event designed to give high-school students the unique opportunity to discover the world of High-Energy Astrophysics. Since 2017, following analogous experiences previously proposed mostly in France, various Italian universities and research institutes, guided by the National Institute for Nuclear Physics (INFN), organized a "full immersion" day of dedicated lectures and exercises in which students analysed real data collected by the LAT experiment aboard the Fermi satellite. Over the years, foreign institutes from Slovenia, Sweden and the U.S. also joined the effort, giving the students the unique opportunity to interact with each other as in real international collaborations. The 4<sup>th</sup> edition of the Fermi Masterclass was scheduled to take place in April 2020. However, due to the pandemic emergency, the Masterclass was initially postponed, and finally took place as an online edition on December 10th, 2020. Here we present the structure and organization of this first virtual event, including an interactive part of exercises accessible to the students through dedicated web platforms.

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\*Presenter

## 1. Introduction

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. Starting from 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.

## 2. 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 [1]).

Since 2017, Fermi Masterclasses have been 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 [Italy], Jacksonville [USA], Stockholm [Sweden]). The program included:

- Introductory lectures in the morning, where students learned about high-energy gamma-ray astrophysical phenomena, and about the Fermi experiment.
- Hands-on afternoon, during which students could follow real-time tutorials in order to analyze Fermi-LAT data.
- Final video-conference together with all other institutions, during which the results obtained could be presented and discussed.

Each Masterclass focused on different Fermi Sources and Scientific Highlights through the years [2]: active galactic nuclei (AGN), gamma-ray bursts and gravitational waves, gamma-rays and neutrinos from cosmic-ray sources, pulsars as shown in the posters in Figure 1. Unfortunately, due to the Covid-19 pandemic, the *Fermi* Masterclass 2020 foreseen in April 2020 had to be postponed.

## 3. *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 initially 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 [3], involving



Figure 1: Posters of the Fermi Masterclasses starting from 2017

students from various italian regions. As a platform we used Zoom in webinar mode, see Figure 2, that allowed us to manage a large number of participants very well without "interference" since Zoom events can be easily broadcasted on Facebook or YouTube [4]! We set no limit on the number of students per school/class and more than 600 students signed up. In the end we had 550 participants!



Figure 2: Screenshot of the Facebook event

The event lasted 3 hours and included 2 general talks («Gamma-Ray Astrophysics» – E. Bissaldi from Bari, «The Fermi Mission» – L. Latronico from Torino), 2 interactive exercises («Fermi in orbit & Skymap» – L. Di Venere from Bari, «AGN Flare Analysis» – F. de Palma from Lecce) and a final «competition» among students on the Kahoot platform [5]. The best 3 students were also awarded a Fermi plate (Figure 3).



**Figure 3:** The Fermi plate won as a reward by one of the best students participating to the masterclass.

### 3.1 Interactive exercises

During the first Italian lockdown in April 2020, we had created an interactive path on a dedicated INFN outreach website called *ScienzaXTutti* (“Science for all”) [6] based on the experience with past Fermi Masterclasses and aimed to guide students to autonomously discover gamma-ray astronomy and the Fermi experiment, in particular:

- Galactic sources
- Extragalactic sources
- Gamma ray bursts

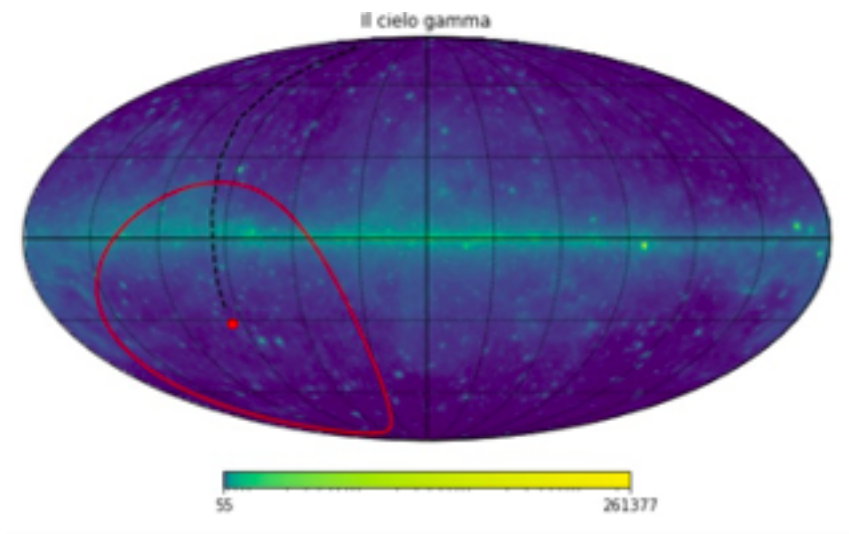
We had developed also interactive exercises on the Google Colab platform based on Python and on public Fermi fits files [7].

Both exercises proposed to students during the online Masterclass 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 have been too slow to install the Science Tools on Colab, we used only already available standard python modules. Some files were pre-calculated and stored on Google Drive (ft1, ft2, exposure,...).

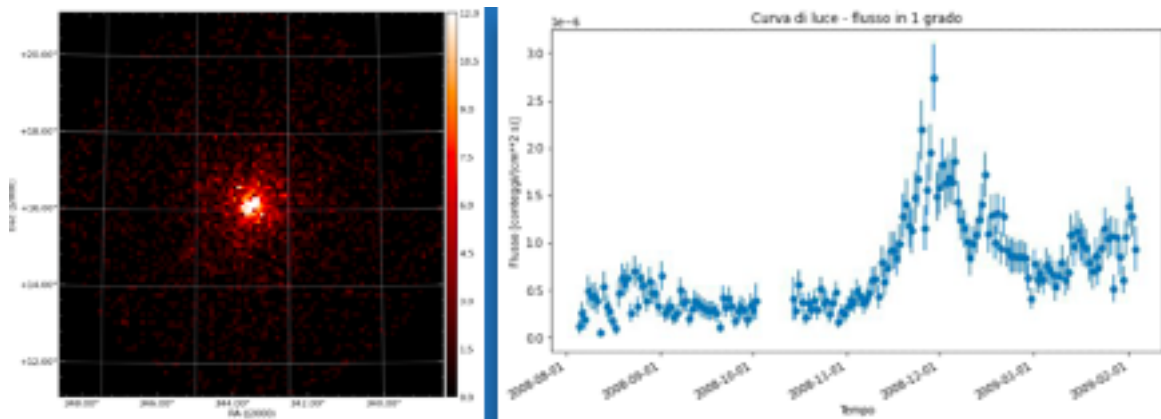
With the first interactive exercise [8], the students were able to:

- Retrieve the data and create tables
- Explore ft2 spacecraft files
- Convert time formats
- Explore satellite altitude and position
- Plot a Skymap showing the satellite pointing direction as time passes (Figure 4)

With the second interactive exercise [9], students learned how to create maps and lightcurves. They analyzed a portion of the sky around the blazar 3C 279 during a bright flaring phase between December 2008 and January 2009. They were able to:



**Figure 4:** Skymap showing the satellite position as determined by students in the first interactive exercise.



**Figure 5:** Left: count map, Right: light curve of the blazar 3C279 during its flaring phase between December 2008 and January 2009, as determined by students in the second interactive exercise

- Retrieve the data
- Explore the ft1 files
- Select the correct interval and RoI
- Create maps and lightcurves (Figure 5)
- Create a gif with a succession of maps highlighting the source variability

#### 4. Conclusions

Our experience with the Online Fermi Masterclass 2020 proved to be very successful. We received very positive feedback from students and teachers. Our outlook for 2021 is to plan a Fall

2021 edition to take place possibly in November/December: we are still not able to understand if it will be virtual or not, a lot will depend on the pandemic evolution. In the meantime, following our example, a lot of groups in Italy and abroad are developing more «Scienza x Tutti» online initiatives and are developing similar interactive paths for e.g. cosmic rays (ex. Auger and CTA).

## References

- [1] [<https://www.cenbg.in2p3.fr/COSMAX-Installer-les-outils>]
- [2] [<https://agenda.infn.it/event/17899/>]
- [3] [<https://agenda.infn.it/event/21447/>]
- [4] [<https://www.youtube.com/watch?v=MNteKhY8T7klist=PL33m23KgFTLvqgeFz8o-2zqimw4zyUEFu>]
- [5] [<https://kahoot.com>]
- [6] [<https://scienzapertutti.infn.it/raggi-gamma>]
- [7] [<https://fermi.gsfc.nasa.gov/ssc/data/access/>]
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