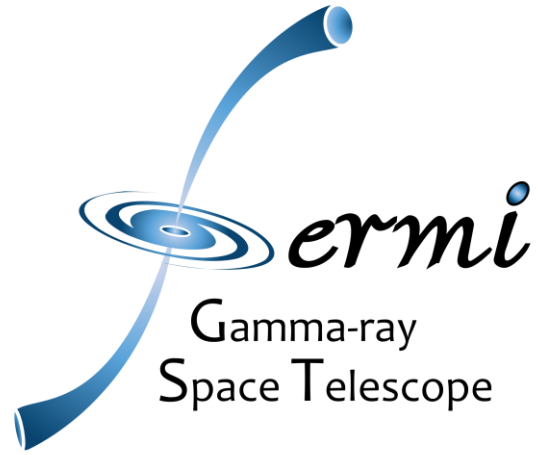




International Particle
Physics Outreach Group



Istituto Nazionale di Fisica Nucleare

Fermi-LAT Masterclasses

FABIO GARGANO – INFN BARI



The Fermi experiment

- ▶ Fermi is a powerful gamma ray space observatory that has opened a wide window on the universe. With a huge leap in all key capabilities, Fermi data is enabling scientists to answer persistent questions across a broad range of topics, including supermassive black-hole systems, pulsars, the origin of cosmic rays, and searches for signals of new physics
- ▶ The mission is an astrophysics and particle physics partnership, developed by NASA in collaboration with the U.S. Department of Energy, along with important contributions from academic institutions and partners in France, Germany, Italy, Japan, Sweden, and the United States.

The Fermi experiment

▶ On the satellite there are two different experiments:

▶ **FERMI-GBM**

▶ Scintillators detectors to measure photons in the range 8keV -40 MeV

▶ **FERMI-LAT**

▶ Pair conversion telescope to measure photons in the range 20MeV – 300 GeV



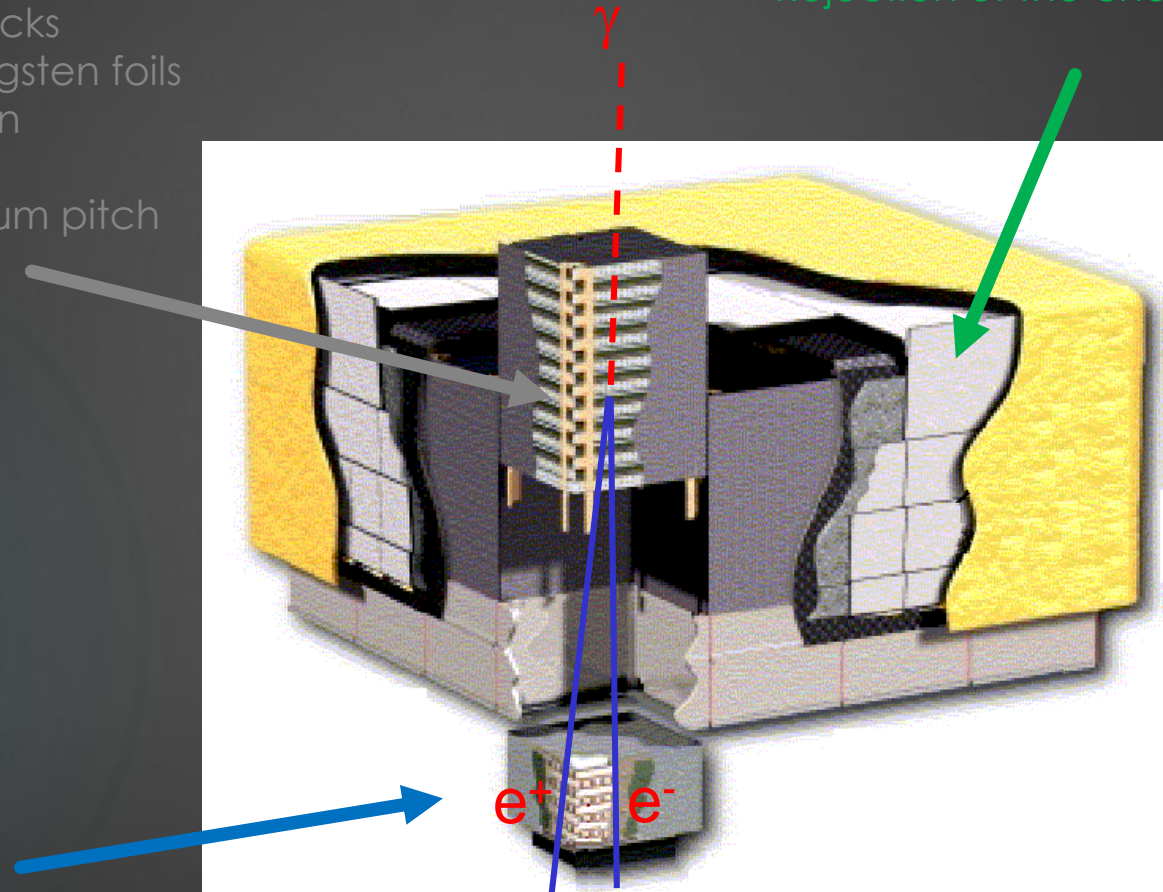
Fermi-LAT

Silicon tracker (TKR)

- Reconstruction of direction of incident gammas starting from e^+/e^- tracks
- 18 X-Y tracking planes with tungsten foils to enhance the pair production probability
- Silicon strip detectors with 228 μm pitch

Anti Coincidence Detector(ACD)

- 89 plastic scintillators
- Rejection of the charged background

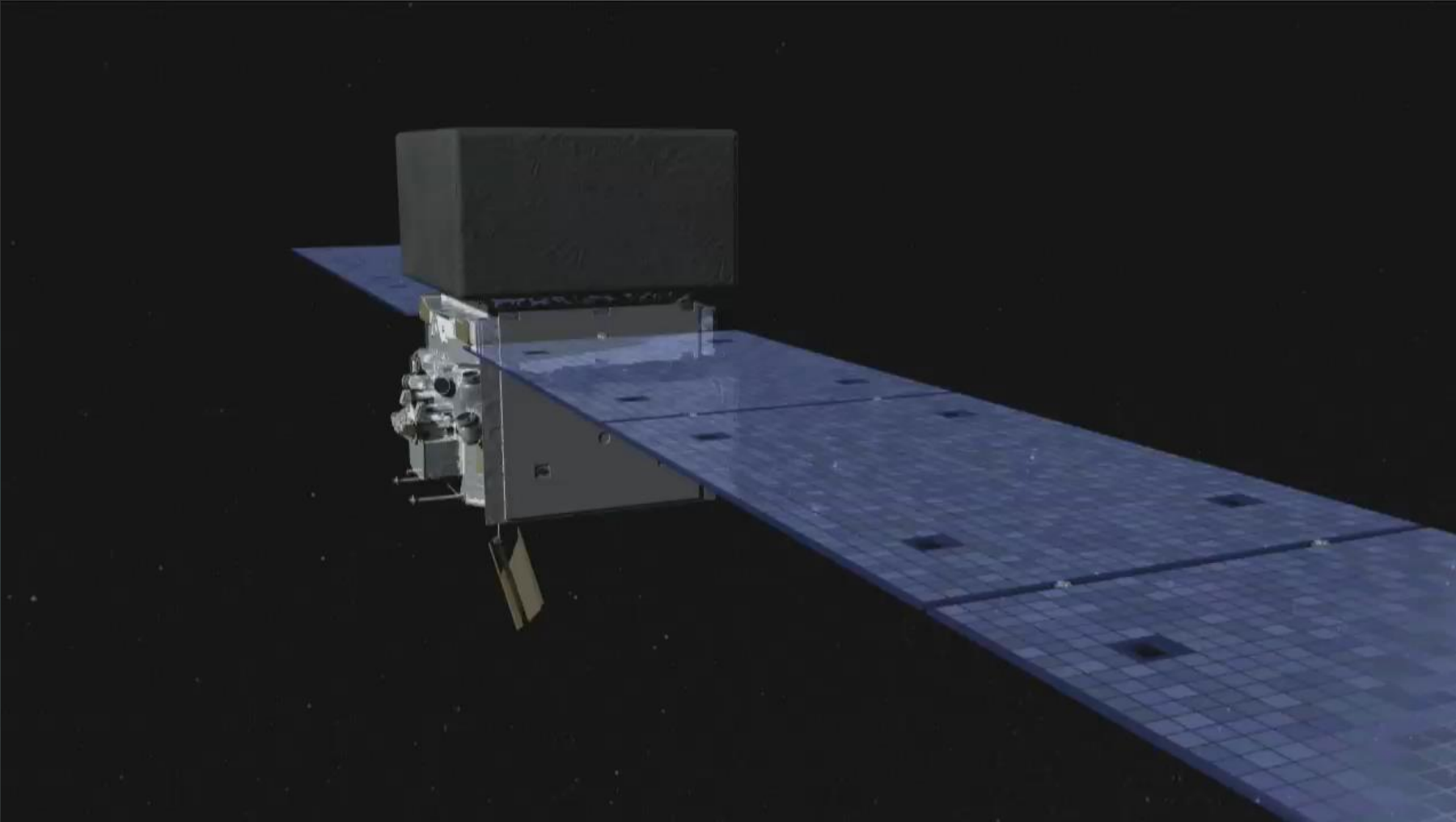


Calorimeter (CAL)

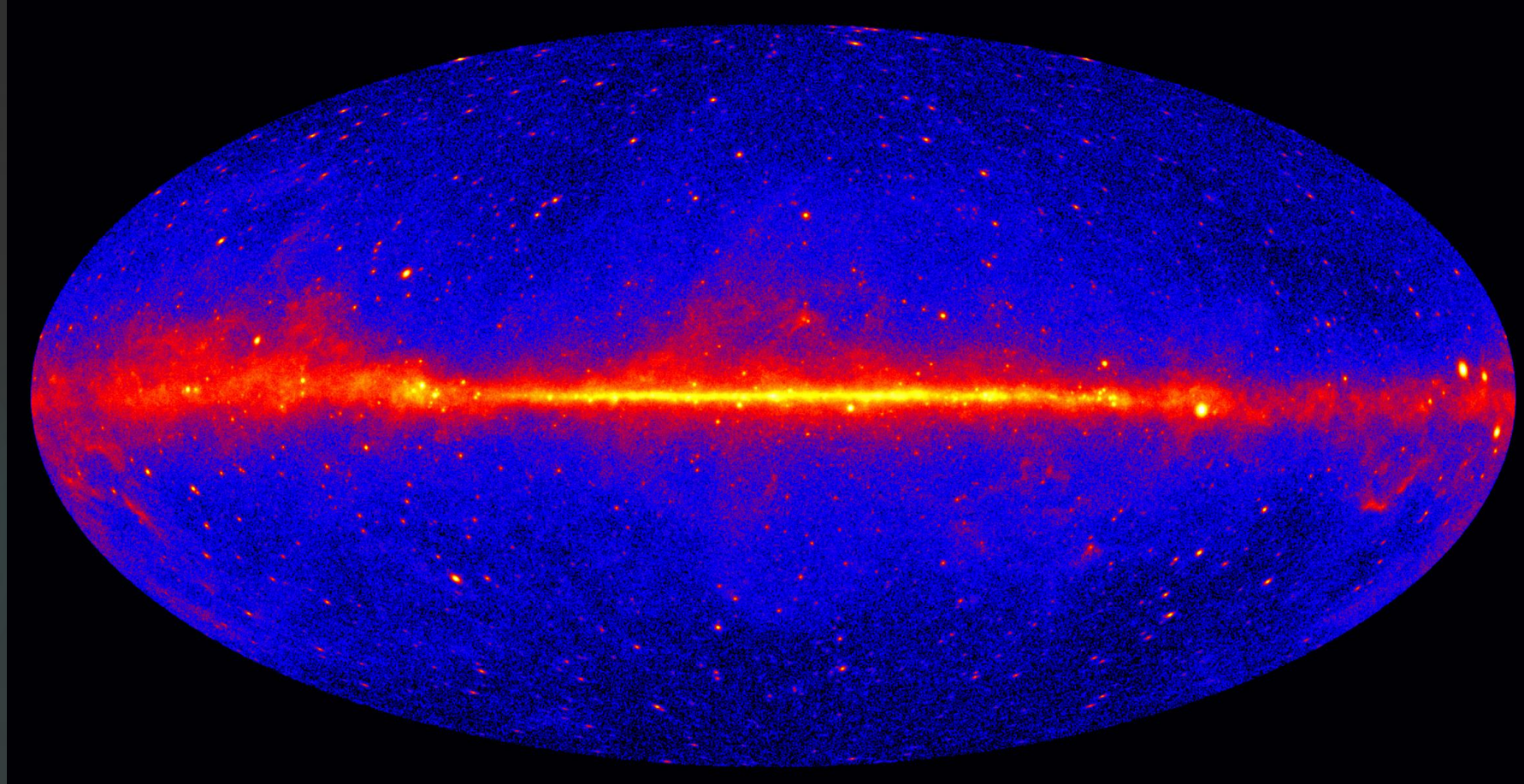
- 1536 CsI(Tl) crystals
- Measure of gamma-ray energy

Principle of operation

5



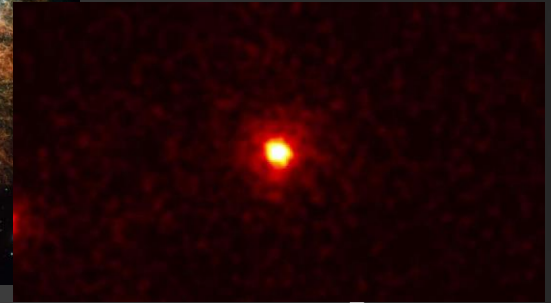
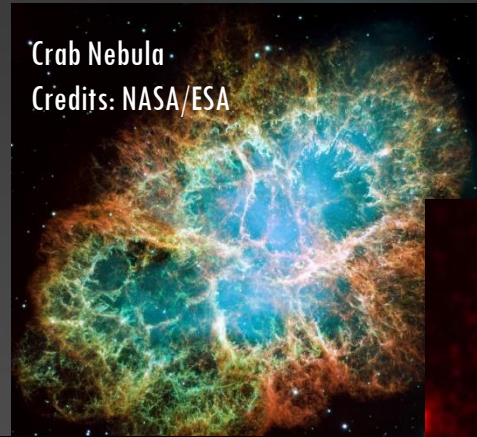
Gamma-ray sky



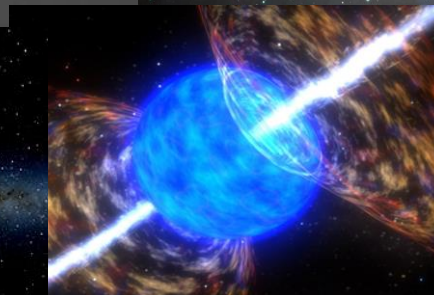
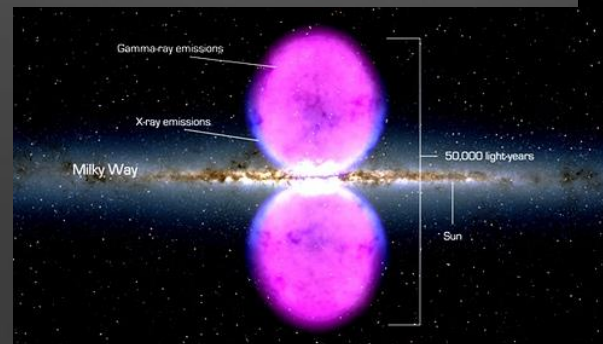
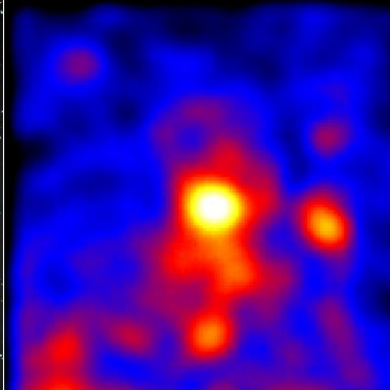
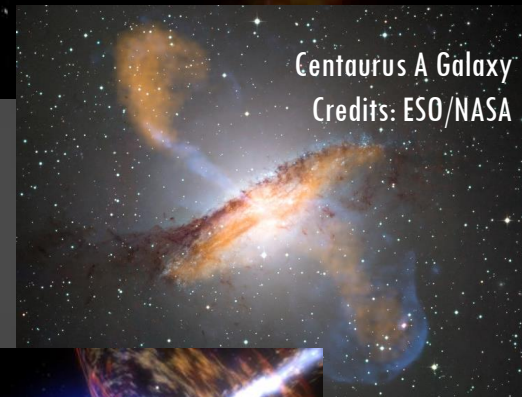
- ▶ Gamma-ray sky obtained with 5 years of Fermi-LAT data with $E > 1 \text{ GeV}$

some of the FERMI Highlights

- Super Nova Remnants
 - After gigantic stellar explosions
- Pulsars
 - Rotating neutron stars
- Active Galactic Nuclei
 - Super Massive black holes
- Gamma ray burst
 - Massive stellar explosions or coalescence of two stars
- Fermi Bubbles
 - Black hole relic at the center of our galaxy



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Masterclasses in France

- ▶ Starting from 2015 Benoit Lott (CNRS-IN2P3) has organized Fermi masterclasses in France (Paris and Bordeaux) with a “non standard” format
- ▶ The scientists move in the schools to meet the students and work with them on Fermi data
- ▶ The software is installed on school PC (Virtual machines)
- ▶ The masterclass involve 11th and 12th degree students
- ▶ The project has been presented by Benoit at the IPPOG meeting in Paris in April 2015

Masterclasses in Italy

- ▶ Following the very established example of the International Masterclasses (hands on particle physics) we have organized a one-day event dedicated to Fermi-LAT experiment.
- ▶ The Fermi-LAT masterclasses have been organized by INFN in Italy and different research units have been involved both in Italy (Bari, Perugia, Torino, Trieste) and in Slovenia (Nova Gorica)

Masterclasses

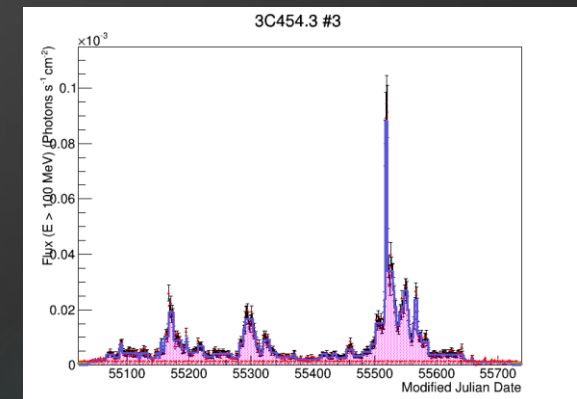
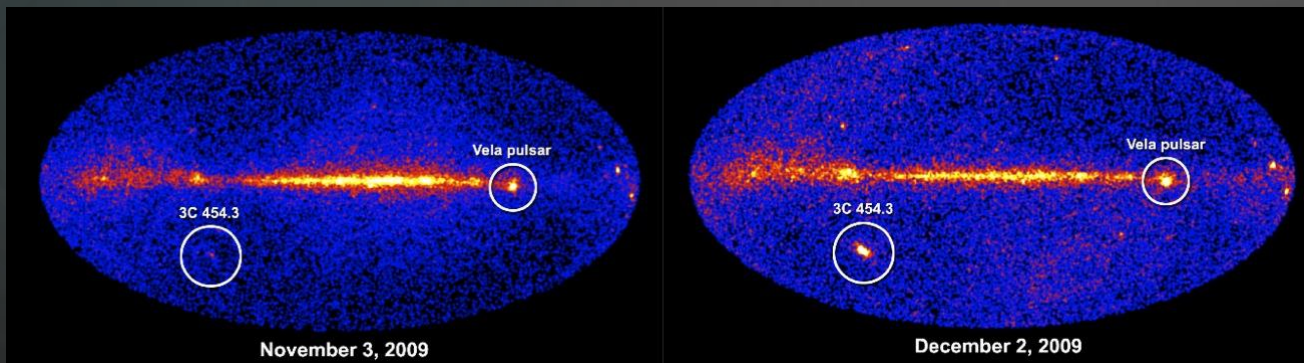
- ▶ The Fermi Masterclass is designed to give secondary school students the unique opportunity to personally discover the world of astroparticle physics. The universities and research units participating in the initiative organize "full immersion" days of lectures and exercises in which the students will deal with real data, produced by the Fermi experiment in orbit since 2008.
- ▶ The program includes a "theoretical morning", characterized by introductory seminars on "frontier" Physics and an "experimental afternoon", during which students will analyze data from the Fermi experiment with the same analysis software tools used in the collaboration. The day ends with a videoconference among all the involved institutions, during which the results obtained will be presented and discussed.

Data and Tools

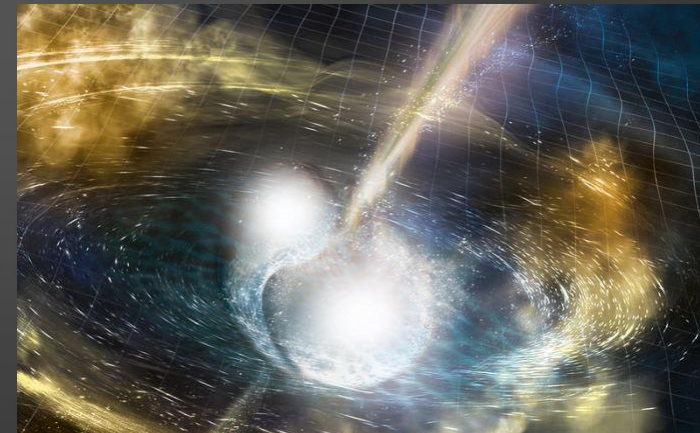
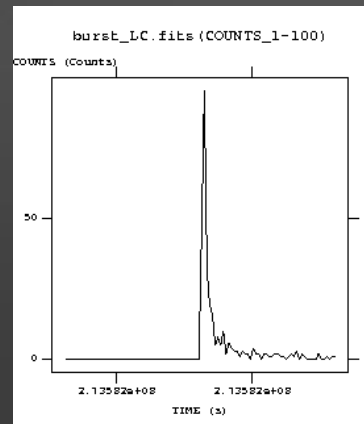
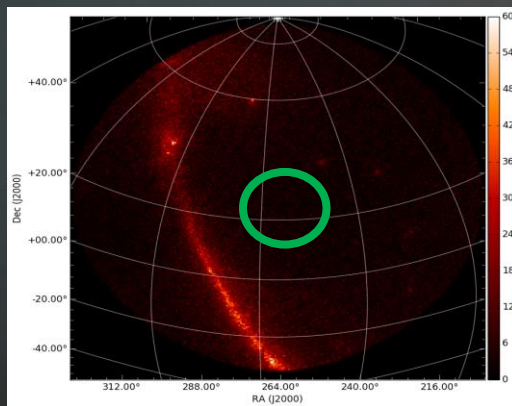
- ▶ The Fermi LAT data policy is to have public data for photons
- ▶ Also the analysis tools are available with detailed user manuals. They are maintained and updated by the collaboration
- ▶ <https://fermi.gsfc.nasa.gov/ssc/data/>
- ▶ This is very important since we can use all the data we need for the masterclasses without any special agreement

2017

- ▶ In the 2017 edition we have chosen to study the light curve of an AGN, namely the blazar 3C454.3
- ▶ We have split a two-year dataset among the different institutions participating to the masterclass; each group of students has built their own light curve
- ▶ During the videoconference at the end of the day we have summed up all the contributions and shown a two year light curve
- ▶ This was useful to explain that, while the sky at visible wavelengths is almost steady, the gamma-ray sky is very variable; the study of variability allows scientists to understand the features of very far objects(7.7 Gly)



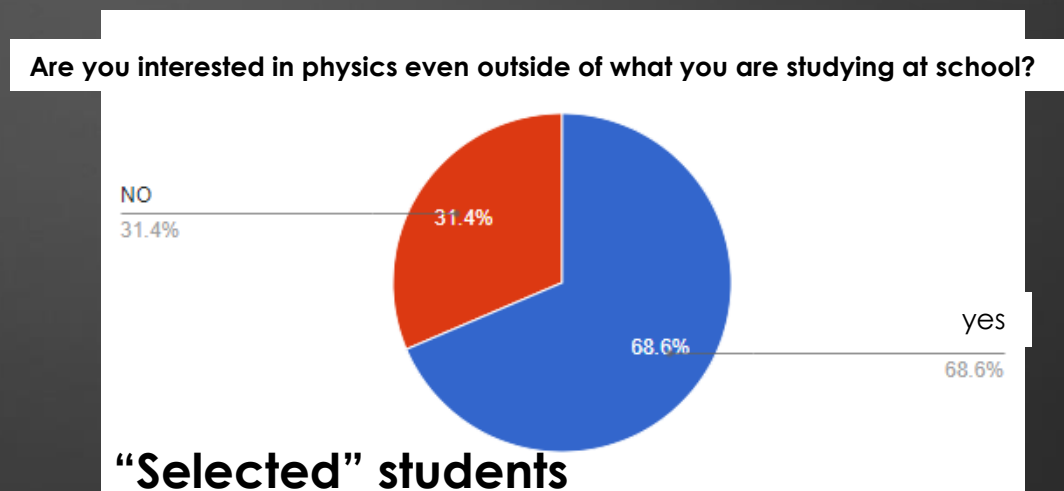
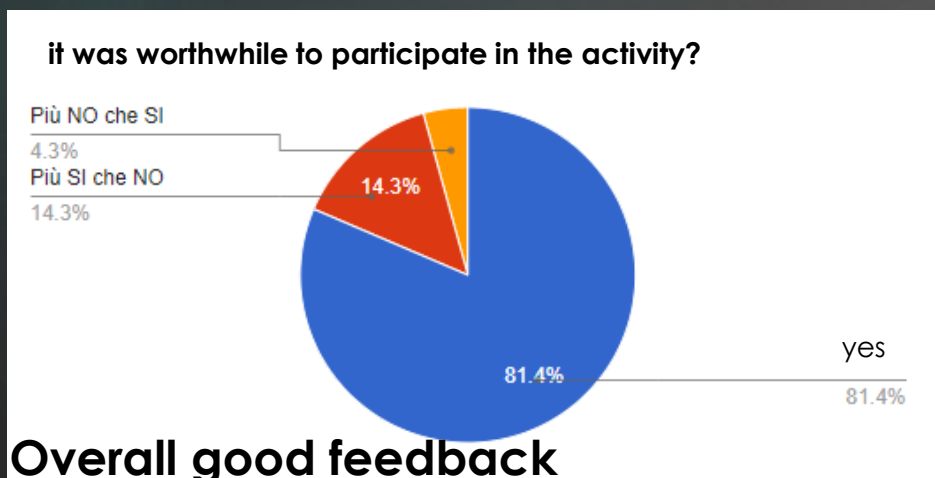
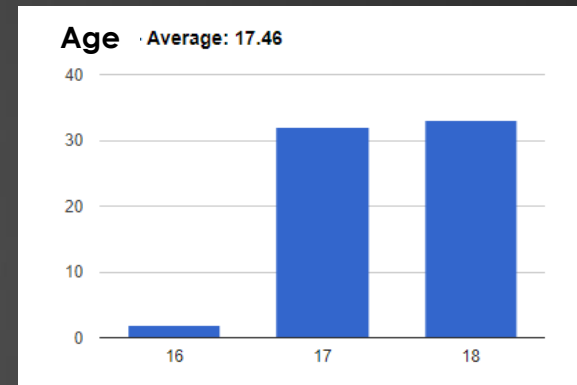
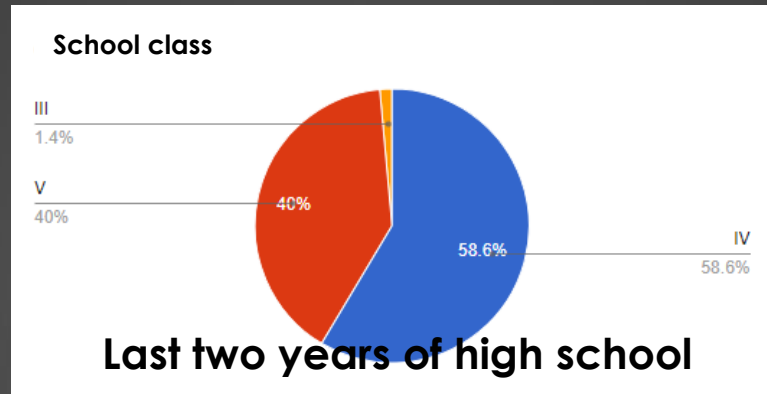
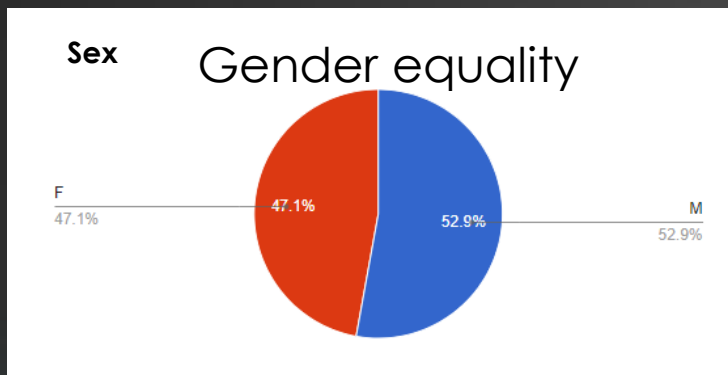
- ▶ In the 2018 edition we have chosen to study Gamma Ray Bursts
- ▶ We have selected a few of them and each site has studied in detail just one. In particular in each site we have divided the data related to a single gamma ray burst among different students and we have asked them to identify the position in space and the time of the burst
- ▶ For each burst we have asked them to build a light curve and during the videoconference at the end we have compared the different kind of burst observed
- ▶ In this way we have also introduced the difference between long and short burst and the connection to gravitational waves
- ▶ We have also had the opportunity to have a videoconference with a NASA scientist and this has been very appreciated from the students



- ▶ In both editions almost 200 students participated and we had a very good feedback

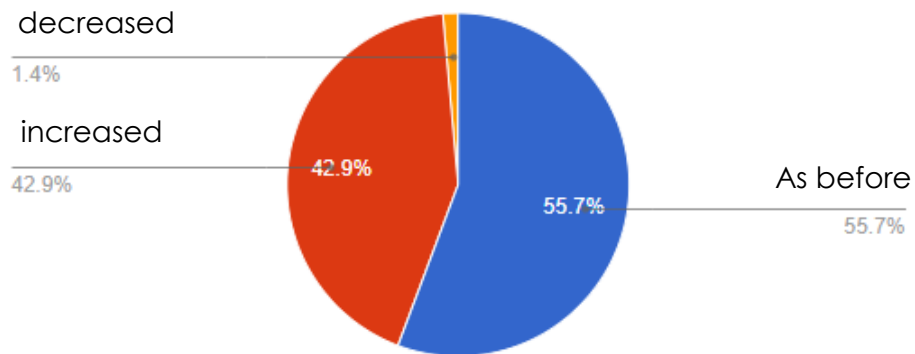


Survey 2018

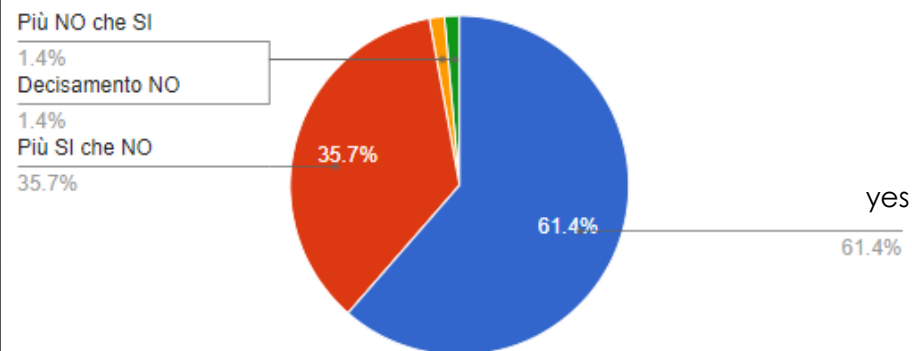


Survey 2018

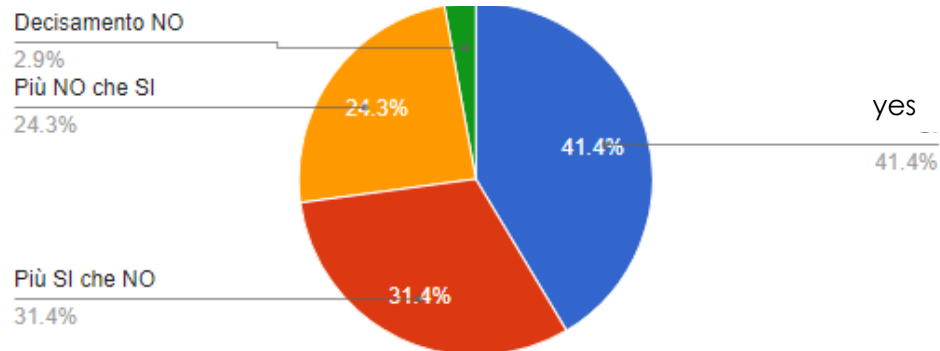
Having attended the masterclass, your interest in physics is ..



Have the activities been useful to better understand physics?



will the activities carried out be useful in choosing your future studies?



What next

17

- ▶ INFN has been supportive of the initiative and encouraged to expand it, and is also supportive in terms of resources
- ▶ We are working to increase the number of sites across Europe
- ▶ Since our data and software are public also institutions and scientist that are not in the Fermi-LAT collaboration can join the Fermi Masterclasses
- ▶ The IPPOG support can strongly help us to grow in numbers
- ▶ Moreover this activity could be, in a near future, inside a “Multimessenger Masterclass” project (gamma-ray x-ray, cosmic-ray, gravitational waves)

Fermi masterclasses - Summary

18

16th IPPOG meeting - 4 to 6 October - CERN -
F. Gargano - Fermi Masterclasses

- ▶ The Fermi Masterclass is designed to give secondary school students the unique opportunity to personally discover the world of astro-particle physics. Inspired by IPPOG masterclasses
- ▶ Two editions
 - ▶ Organized by INFN (mainly Italian sites)
 - ▶ 2017 on AGN and variable gamma-ray sky
 - ▶ 2018 on Gamma-ray Burst and connection with Gravitational Waves
 - ▶ >200 students in each edition with very good feedback
- ▶ We got already the INFN support for 2019 edition and we are trying to increase the number of institution involved. IPPOG help is very welcome.