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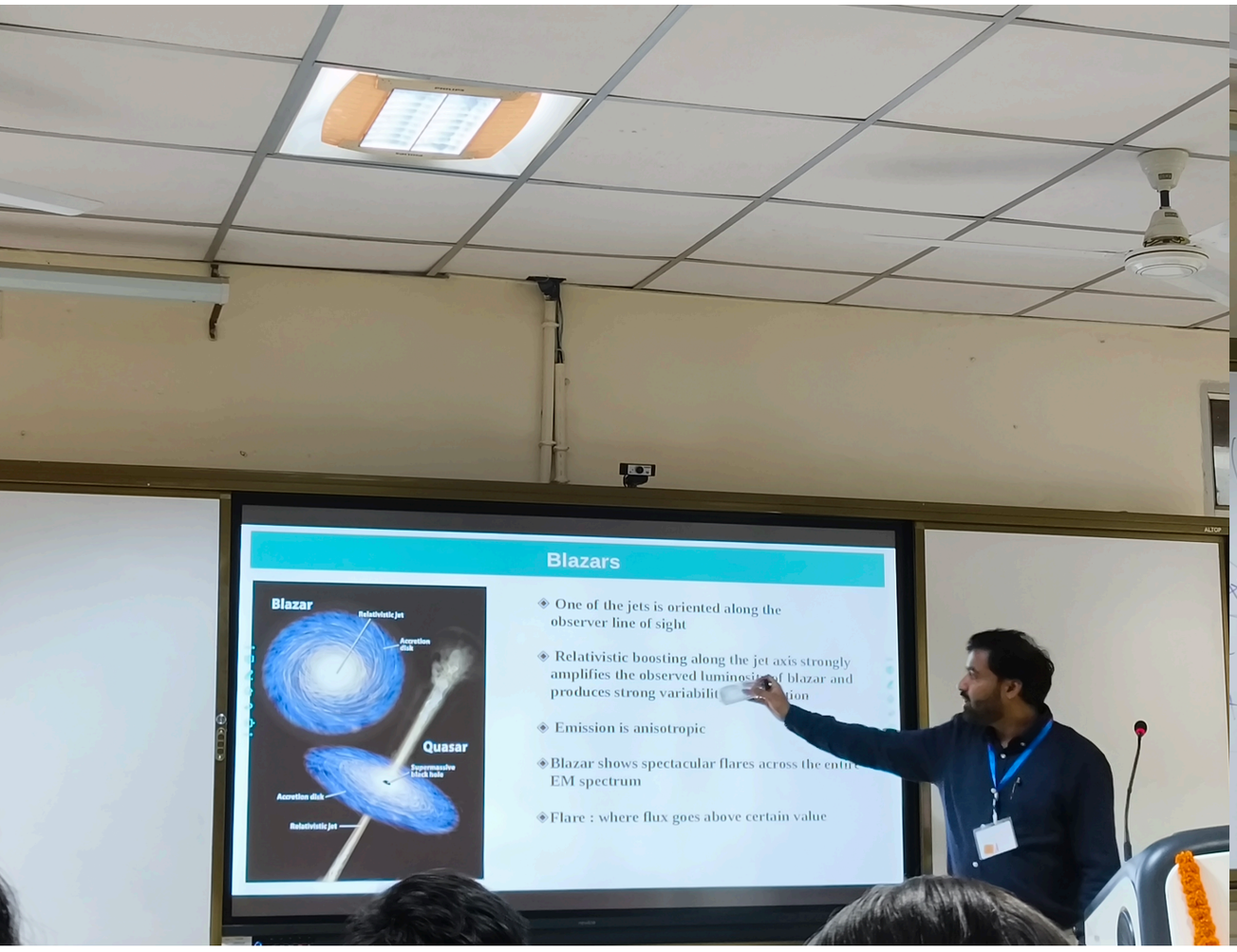
High Energy Astrophysics Workshop 2024

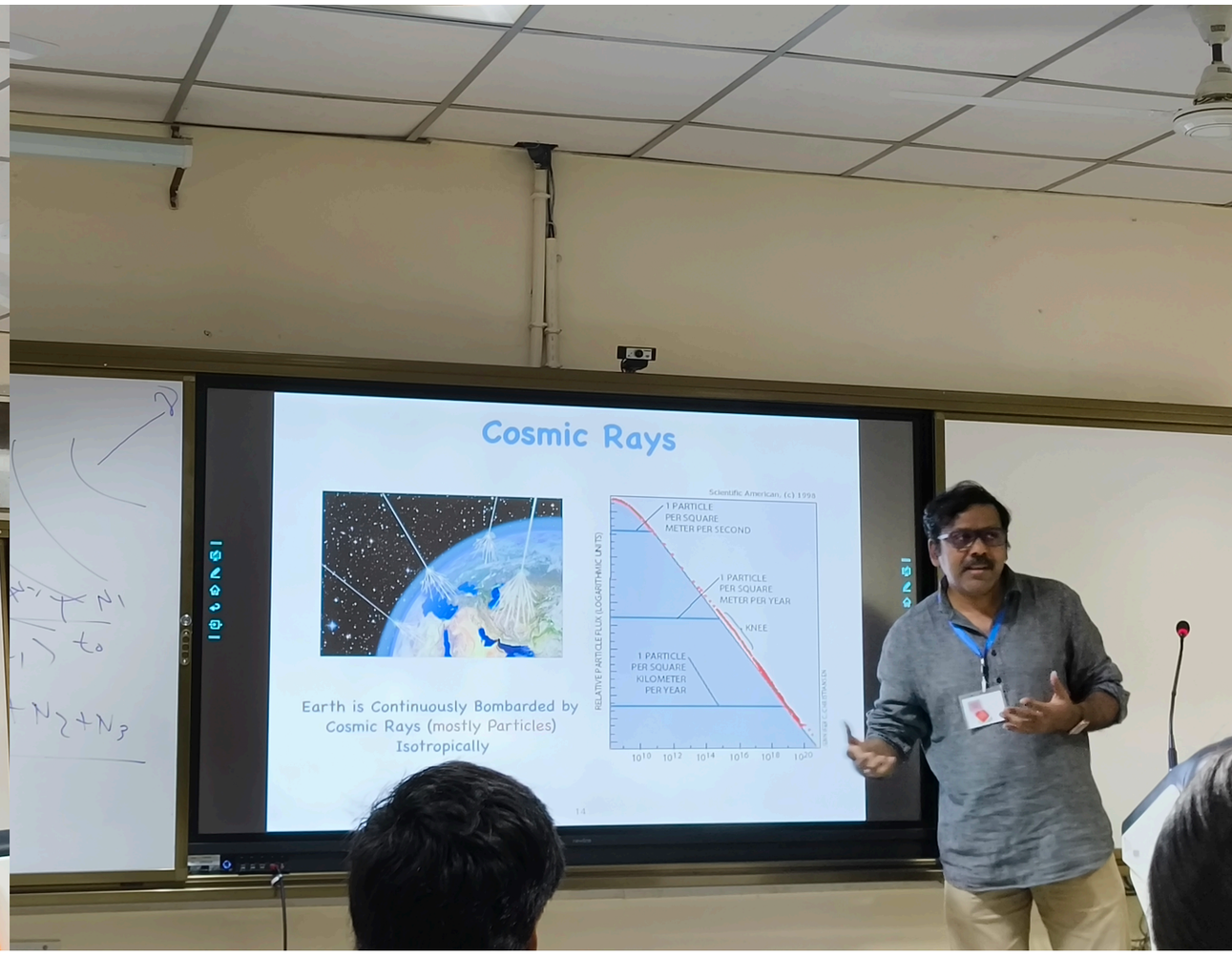
Hands-on session: Fermi-LAT gamma-rays

Ajay Sharma
S.N. Bose National Centre For Basic Sciences

November 25th, 2024

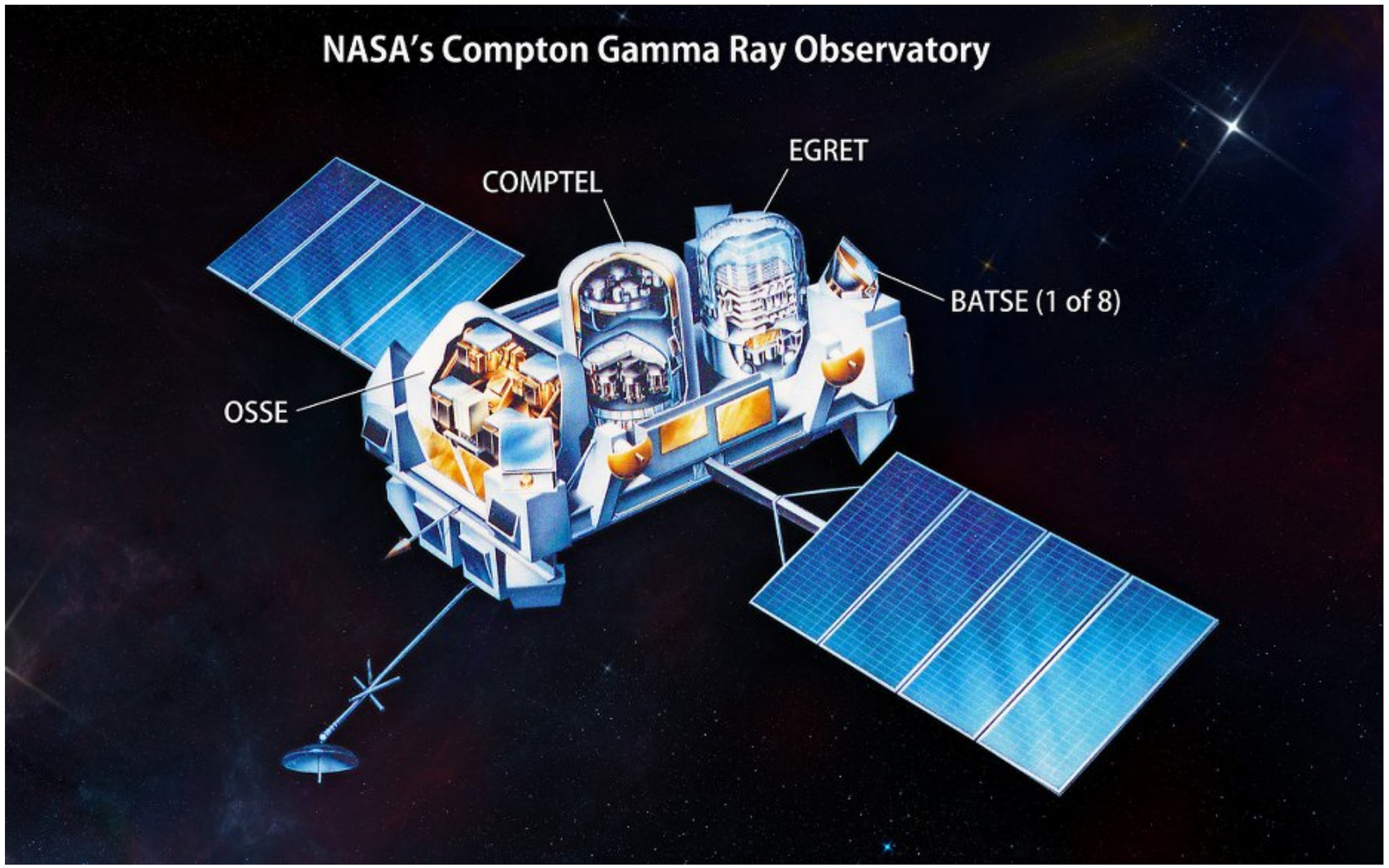
Morning session





History of gamma-ray detectors

Compton Gamma Ray Observatory (CGRO)

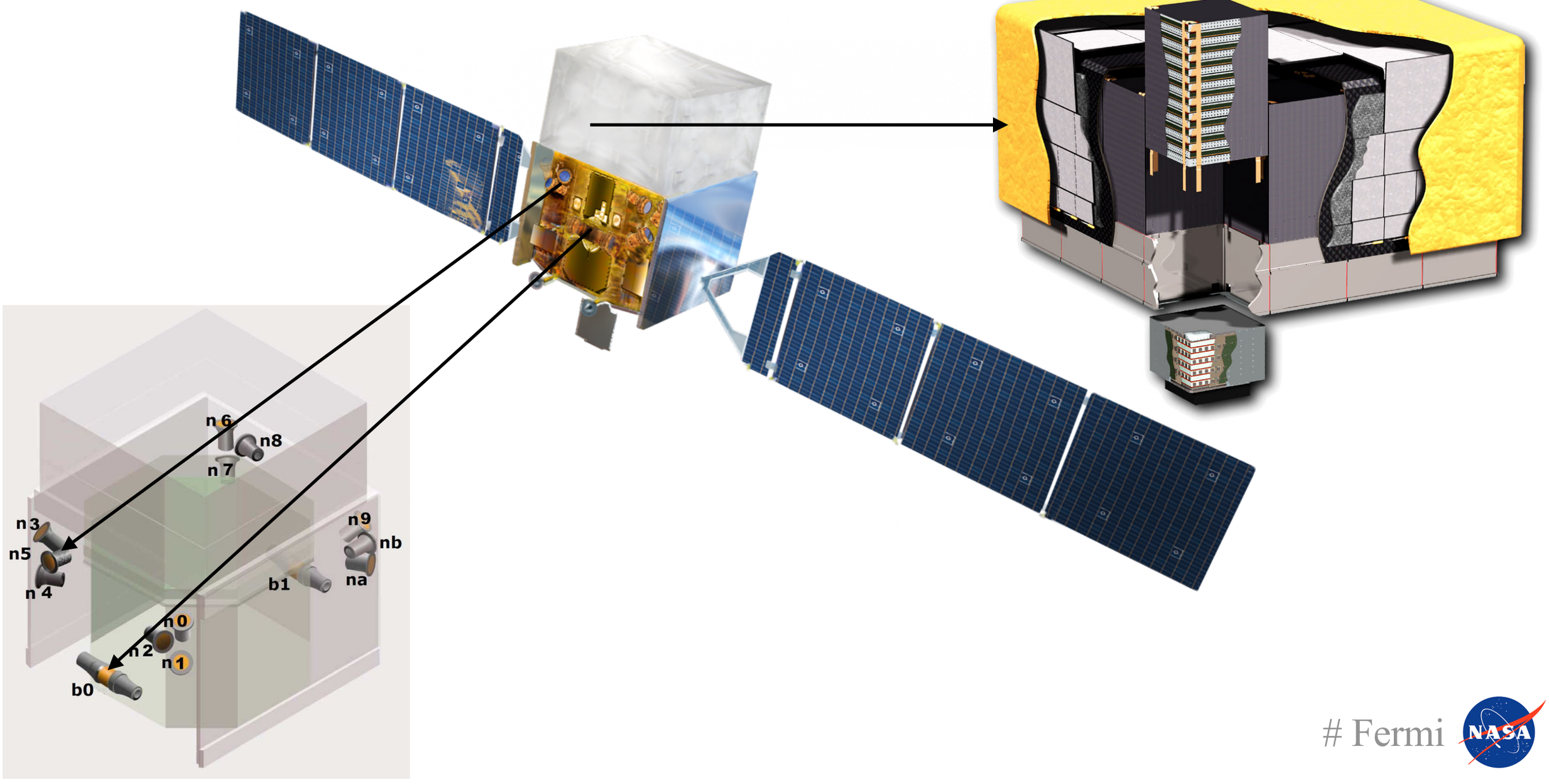


Source of information

Fermi Gamma-ray space based telescope

* Launched by NASA in 2008
* Energy coverage : from few keV upto 300GeV
* Scanning whole the sky in every 3 hours

- FoV: 2.5 sr
- Energy range: below 20MeV upto 300GeV



Fermi

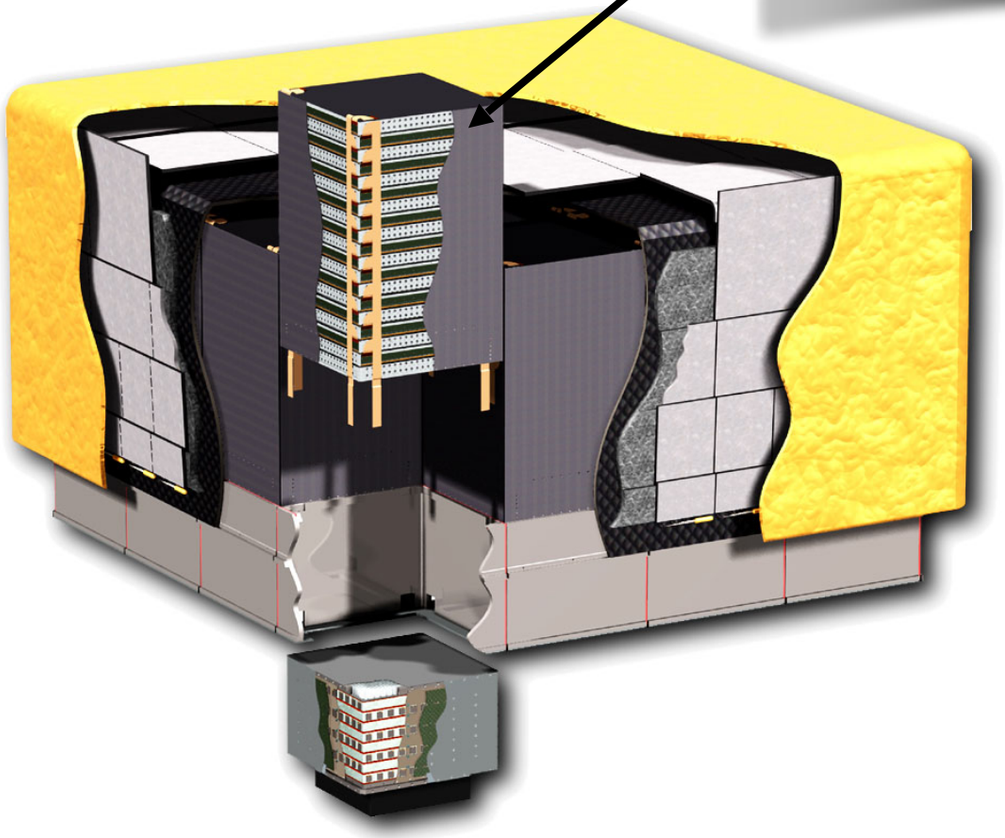
Large Area Telescope

Fermi Gamma-ray Space Telescope

Tracker (4×4 array of towers)

Si-strip tracker (TKR)

- 18 XY tracking planes with tungsten foil converters
- **Measure the photon direction**



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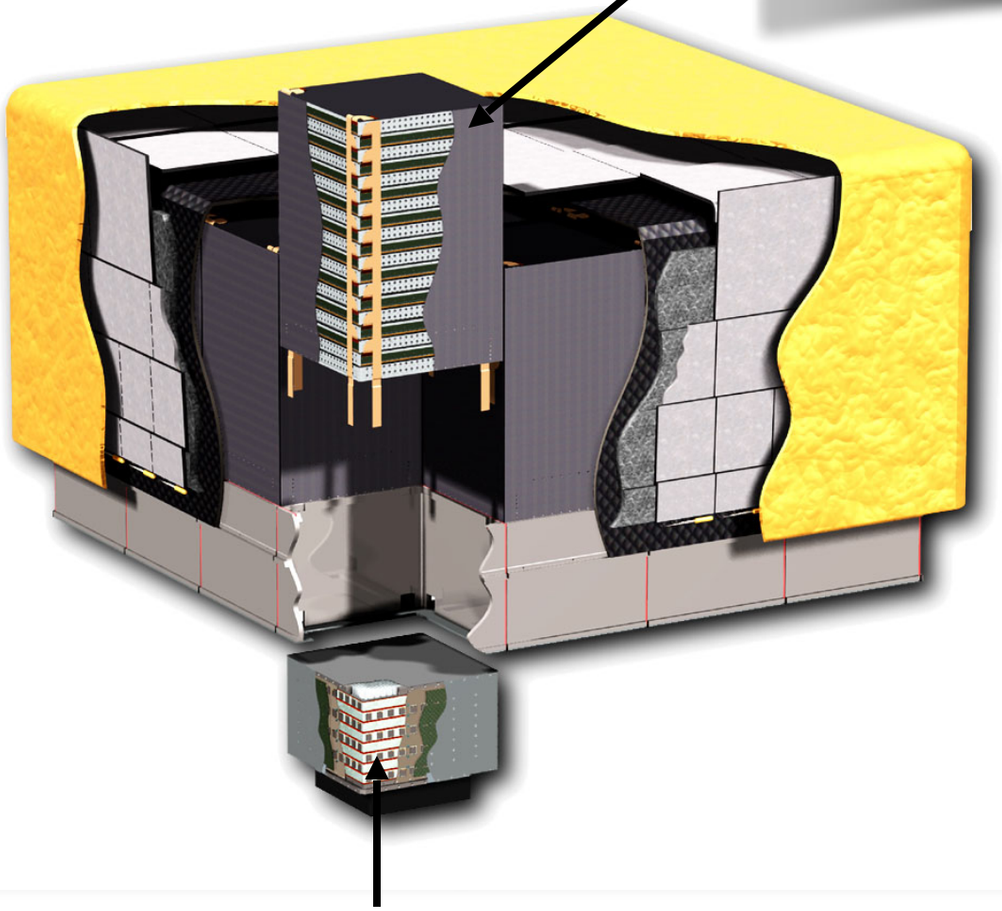


Calorimeter

- Hodoscopic CsI calorimeter (CAL): Array of 1536 CsI crystals in 8 layers
- **Measure the photon energy**

Fermi

Large Area Telescope

Fermi Gamma-ray Space Telescope

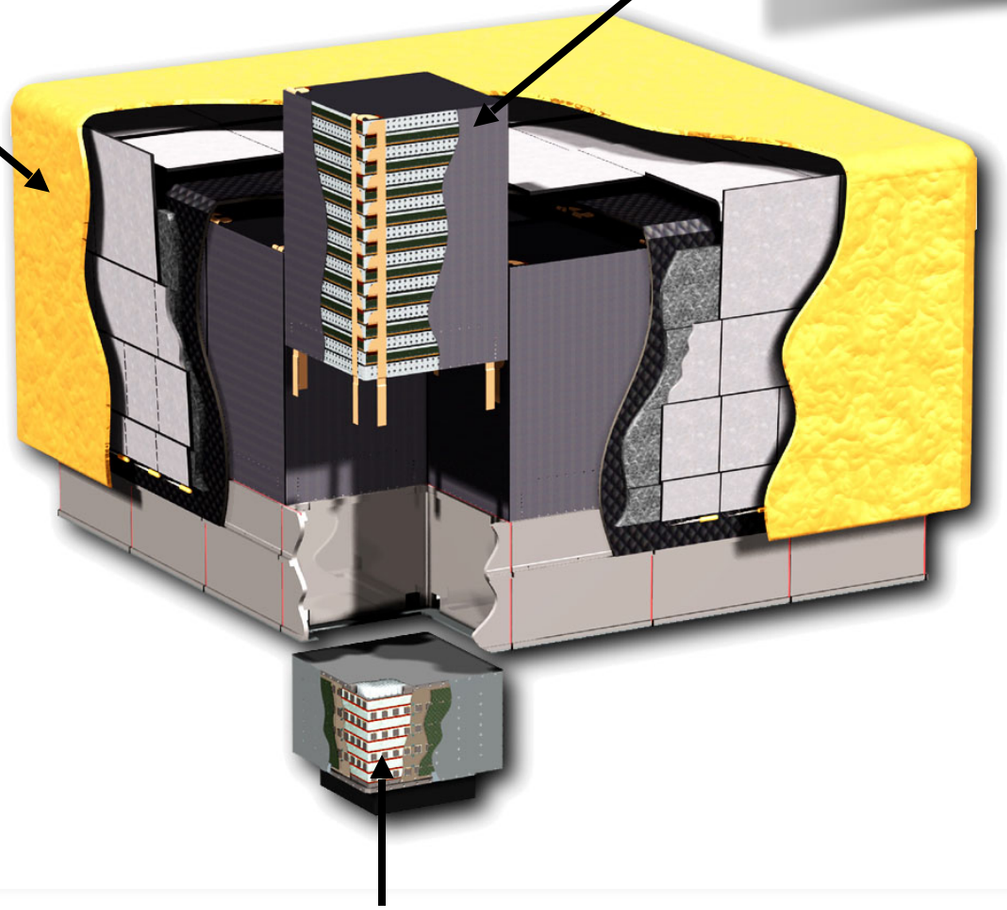
Anti-coincidence detector (ACD)

- 89 plastic scintillators tiles
- **Reject the background of charged cosmic rays.**

Tracker (4×4 array of towers)

Si-strip tracker (TKR)

- 18 XY tracking planes with tungsten foil converters
- **Measure the photon direction**



Calorimeter

- Hodoscopic CsI calorimeter (CAL): Array of 1536 CsI crystals in 8 layers
- **Measure the photon energy**

Fermi

Key Science by Fermi-LAT

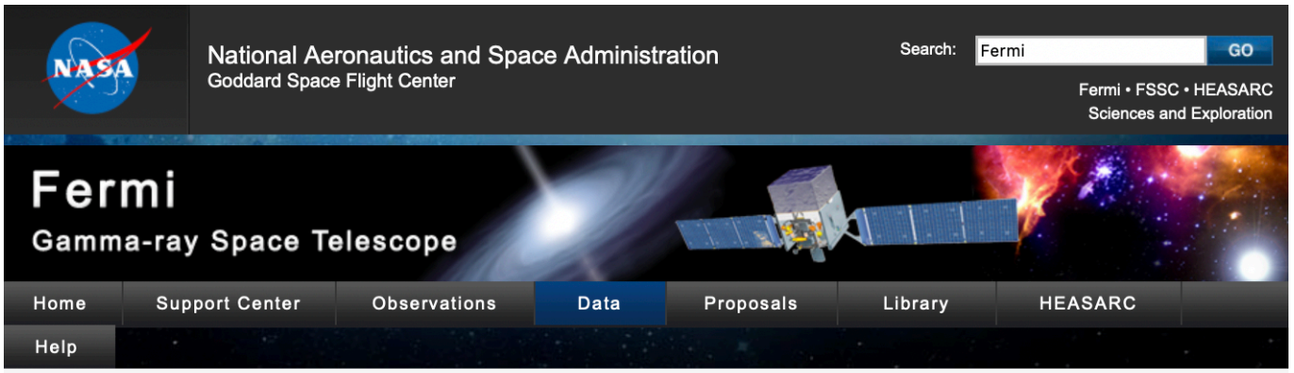
Task for today

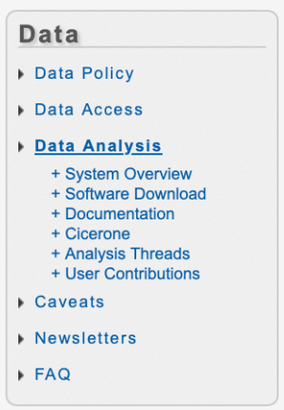
We are going to analyse the Fermi-LAT data of blazar PG 1553+113

- Download the raw data of this source
- Setup the tool for the analysis
- Create a config file containing all the basic information of procedure and data files
- Start the analysis:
  - ➡ Model the source
  - ➡ Obtain the source gamma-ray flux
  - ➡ Produce an spectral energy distribution (SED) and a light curve

Installation of tools

- Fermitools: https://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/
- Fermipy: https://fermipy.readthedocs.io/en/latest/index.html





Installing the Fermitools

The FSSC now uses the Conda package manager to install the Fermitools, and the source code is now hosted on GitHub.

Please see the Fermitools Wiki for the Quickstart Guide, detailed Installation Instructions, and other documentation about the Tools.

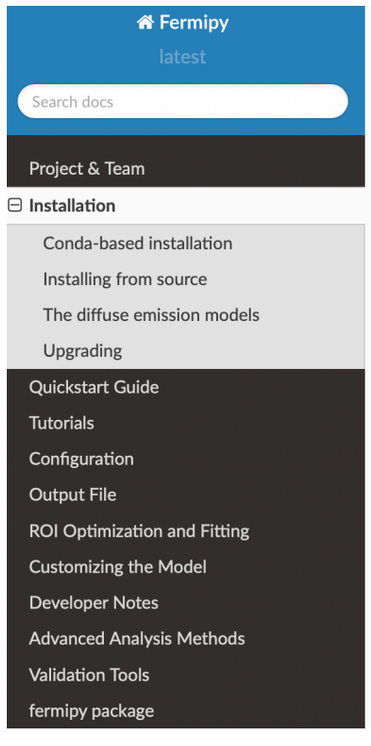
If you encounter problems, please see the Troubleshooting and Error Reporting guides.

For more information about why the change to Conda was made, please read The Fermitools and Conda.

The release of new versions of the Fermitools will be announced on the fermi-soft mailing list. Please see the Fermi newsletter page if you would like to be added to the list.

The FSSC has also created a Docker container pre-loaded with many of the necessary tools required to do Fermi Analysis. It includes the Fermitools, Fermipy, the GBM Data Tools, and the HEASARC's FTOOLS along with a host of other programs. This container will run on Windows, MacOS, and Linux. You can find it (with instructions) on Github or Docker Hub.

The last pre-Conda version of the analysis tools, Science Tools v11r5p3, was released Feb 15, 2018 is still available for download.



Installation

Note

From version 1.1.xx, fermipy is only compatible with fermitools version 2.2 or later, and with python version 3.9 or higher. If you are using an earlier version, you will need to download and install the latest version from the FSSC.

Please report any issues on github.

These instructions will install fermipy as well as its dependecies.

Conda-based installation

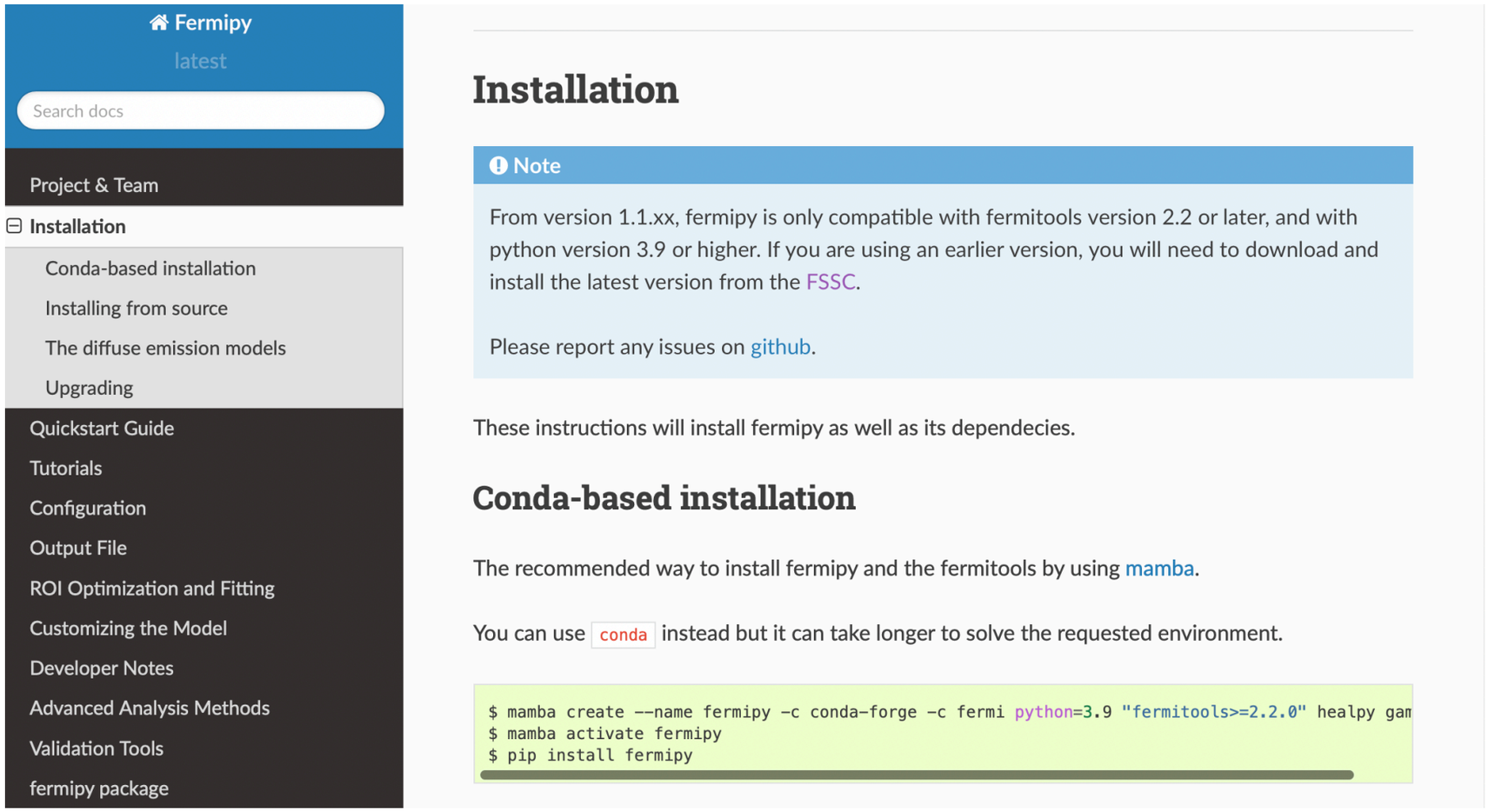
The recommended way to install fermipy and the fermitools by using mamba.

You can use `conda` instead but it can take longer to solve the requested environment.

```
$ mamba create --name fermipy -c conda-forge -c fermi python=3.9 "fermitools>=2.2.0" healpy gam
$ mamba activate fermipy
$ pip install fermipy
```

Installation of tools

- Fermipy: https://fermipy.readthedocs.io/en/latest/index.html




```
$ conda create --name fermipy -c conda-forge -c fermi python=3.9 "fermitools>=2.2.0" healpy gammapy notebook
$ conda activate fermipy
$ pip install fermipy
```

Download the raw data

National Aeronautics and Space Administration
Goddard Space Flight Center

Search: Fermi GO

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Data

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- **Data Access**
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  - + LAT Weekly Files
  - + LAT Light Curve Repository
  - + GBM Data
- Data Analysis
- Caveats
- Newsletters
- FAQ

LAT Photon, Event, and Spacecraft Data Query

Object name or coordinates:	PG 1553+113
Coordinate system:	J2000
Search radius (degrees):	15
Observation dates:	2024-01-01 00:00:00,2024
Time system:	Gregorian
Energy range (MeV):	100,300000
LAT data type:	Photon
Spacecraft data:	☑

Start Search | Reset

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Query L241120025552FD19599806 submitted.

Please see LAT Data Caveats for important information about Fermi LAT data.

Your search criteria were:

Equatorial coordinates (degrees)	(238.929,11.1901)
Time range (MET)	(725760005,752112005)
Time range (Gregorian)	(2024-01-01 00:00:00,2024-11-01 00:00:00)
Energy range (MeV)	(100,300000)
Search radius (degrees)	15

The estimated time for your query to complete is 17 seconds. The results of your query may be found at https://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/QueryResults.cgi?id=L241120025552FD19599806.

Server	Position in Queue	e Remaining (sec)
Photon Server	Query complete	N/A
Spacecraft Server	Query complete	N/A

The filenames of the result files consist of the query ID string with an identifier appended to indicate which database the file came from. The identifiers are of the form: _DDNN where DD indicates the database and NN is the file number. The file number will generally be '00' unless the query resulted in a large data volume. In that case the data is broken up into multiple files. The values of the database field are:

- PH - Photon Database
- SC - Spacecraft Pointing, Livetime, and History Database
- EV - Extended Database

In the event that you do not see any files with the data type you requested listed below, you should try resubmitting your query as there may have been a problem.

Filename	Number of Entries	Size (MB)	Status
L241120025552FD19599806_PH00.fits	88449	8.32	Available
L241120025552FD19599806_PH01.fits	74885	7.05	Available
L241120025552FD19599806_PH02.fits	59023	5.56	Available
L241120025552FD19599806_SC00.fits	751688	117.58	Available

If you would like to download the files via wget, simply copy the following commands and paste them into a terminal window. The files will be downloaded to the current directory in the terminal window.

```
wget https://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L241120025552FD19599806_PH00.fits
wget https://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L241120025552FD19599806_PH01.fits
wget https://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L241120025552FD19599806_PH02.fits
wget https://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L241120025552FD19599806_SC00.fits
```

Setup the tool for analysis

Activate your fermipy environment

https://github.com/ajaykhoj/HEAW-2024-Hands-on-activity

https://github.com/ajaykhoj/HEAW-2024-Hands-on-activity

Download all the raw data, preprocessed files, and Jupyter notebook from the GitHub page.

Let’s start data analysis of Fermi-LAT