Fermi Gamma-ray Telescope: Hands-on Activity

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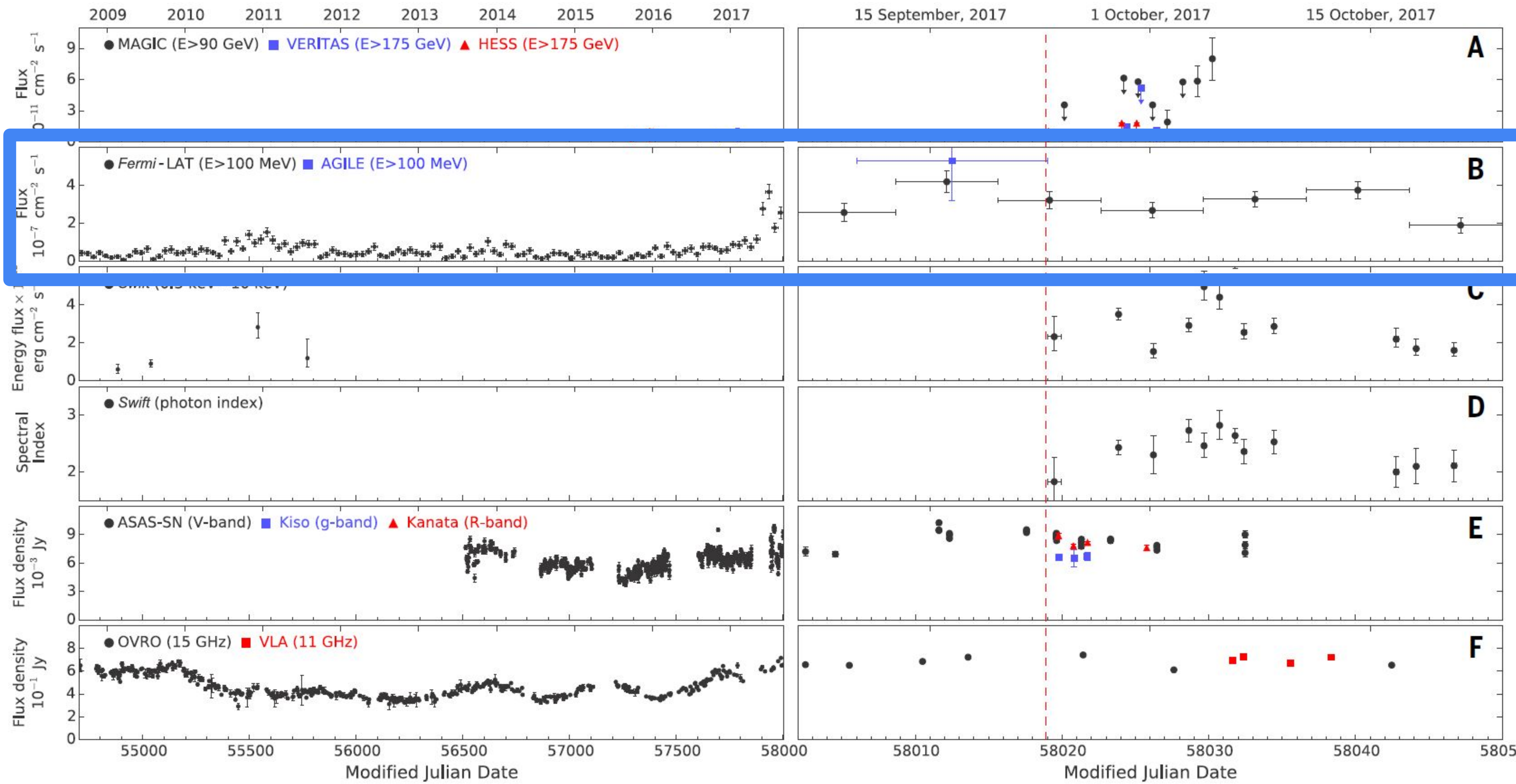
What will we do?

Analyze blazar TXS 0506+056 around the moment of neutrino IceCube-170922A detection using Fermi Space Telescope data.

We will:

- Model the region's gamma ray flux
- Obtain TXS 0506+056 gamma ray flux
- Construct an SED for this source
- Create a light curve

https://github.com/black-hole-group/fermipy-tutorial



The IceCube Collaboration et al 2018

The tools

- Fermitools: https://fermi.gsfc.nasa.gov/ssc/data/analysis/
- Fermipy: https://fermipy.readthedocs.io/

This kind of analysis usually take something between 6 to 8 hours!

We don’t have this amount of time!

Solution: most of the steps are already preprocessed. The outputs are available with the material you downloaded.

To start the tutorial

1. For Mac/Windows users only: look for the Docker icon in your computer and click on it to open the application.

2. `cd` to the `fermi` directory which contains the lesson files and where we plan to run our analysis

3. ```
   sudo docker run -it --rm -p 8888:8888 -v $PWD:/workdir -w /workdir fermipy/fermipy:11-05-02
   ```

4. Copy and paste the address displayed in your web browser, and replace the string between `http://` and `:8888` with `localhost`
   ```

To start the tutorial

5. Browse the folders until you find a file called `BlazarNeutrino.ipynb`. Double click it. This will open the Jupyter Notebook with the activity.

6. To run a cell with code, click on the cell and press:

Shift + Enter

I will also be running the tutorial on the screen and commenting on what is happening.

Other things to try

Generate TS map for a power-law point source with Index=2.0 and including the source in the model:

```
>>> model = {'Index' : 2.0, 'SpatialModel' : 'PointSource'}
>>> maps = gta.tsmap('TS_MAP_with',model=model,make_plots=True)
```

Generate TS map for a power-law point source with Index=2.0 without the source in the model:

```
>>> maps = gta.tsmap('TS_MAP_without',exclude='3FGL
J0509.4+0541_LP',model=model,make_plots=True)
```

Other things to try

Generate residual map for a Gaussian kernel with Index=2.0 and radius (R_68) of 0.3 degrees

```
>>> model = {'Index' : 2.0, 'SpatialModel' : 'Gaussian', 'SpatialWidth' : 0.3 }
>>> maps = gta.residmap('Res',model=model,make_plots=True)
```

Other things to try

Change the spectral model of the source do LogParabola:

```
# Remove the source
gta.delete_source('3FGL J0509.4+0541')

# Add 3FGL J0509.4+0541_LP to the model
gta.add_source('3FGL J0509.4+0541_LP', { 'glon' : 195.3985, 'glat' : -19.6308,
        'SpectrumType' : ‘LogParabola’, ‘norm’ : 1E-11, ‘Scale’ : 1000, ‘beta’ : 0.05,
        'SpatialModel' : 'PointSource' })
```

Then, fit the model again e make a new SED.

Other things to try

Light curve with 7 days bins
(close to the moment of the neutrino detection)

Other things to try

Localize the source:

```
>>> loc = gta.localize('3FGL J0509.4+0541', make_plots=True)
```

OBS: if you changed the spectrum type of the source, it is probably called '3FGL J0509.4+0541_LP' now.

Fermi Summer School

https://fermi.gsfc.nasa.gov/science/mtgs/summerschool/