Fermi Summer School 2015

Week 1

	Tues, May 26	Wed, May 27	Thurs, May 28	Fri, May 29	Sat, May 30
8:15	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**
9:00	The Fermi Mission - Julie McEnery	Particle Acceleration - Markos	Dark Matter Searches in the LAT - Andrea pdf	Gamma-ray Generation - Markos Markos' SSC Code SSC Model Parameter Notes	Gamma-ray Detective Work - Reshmi
10:00	Radiation Processes - Markos Georganopoulos	The Fermi Large Area Telescope - Andrea Albert pdf	History and Techniques of Imaging Atmospheric Cherenkov Telescopes - Jamie Holder pdf	The Fermi LAT Catalogs - Seth Digel	Astroparticle Physics at the South Pole - Detecting high-energy neutrinos with IceCube - Naoko Neilson
11:00	**Break**	**Break**	**Break**	**Break**	**Break**
11:30	Pulsars - Tyrel Johnson	Student Talks	Student Talks / 1 Slide Summaries	Blazars - the Observational Perspective - Reshmi Mukherjee	Student Talks / 1 Slide Summaries
12:30	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Lunch**
1:30	The Likelihood Method - Liz Hays Steve's sample code: - errors_poisson.py - lima.py - conf_lima_1d.py - ul_lima_1d.py - ul_bayes_lima_1d.py Instructions for installing the Fermi Virtual Machine Science Tools Intro and Data Exploration (includes VM shared folder setup) - Elizabeth Ferrara Students choose a source for analysis.	Likelihood in the LAT Likelihood Tutorial – Jeremy Perkins Poll students for use of scripted analysis.	Generating LAT XML Models - Elizabeth Ferrara instructions for using make3FGLxml.py script Testing for sources Advanced Likelihood (cover convergence, 3 basic scripting tools, minor update) Data: - Advanced_Likelihood.tgz PDG Statistics review pdf (deltaLL values in Table 38.2 on page 29) Binned Analysis Example	IRFs Tutorial (Tyrel) Useful scripts: *--customIRFplotter.py* *--plotIRFs.py* Line Analysis with the LAT - Andrea FermiSummerSchool_LineTutorial.pdf FT1_to_ROOT.py FitVela.py	1 Slide Summaries (cont) Advanced Topic: Summed likelihood tutorial, summed likelihood analysis files summedLikeFiles.tgz Pulsar analysis Updated pulsar ephemerides
				Crab Feast TBD	

Week 2

	Mon, June 1	Tues, June 2	Wed, June 3	Thurs, June 4	Fri, June 5
8:15	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**
9:00	Cosmic Background Radiation - Yoshi Inoue (Lecture notes)	Cosmic Gamma-ray Background - Yoshi	Cosmic Infrared/Optical background - Yoshi	Future MeV - Liz IACT telescope construction and reconstruction - Jamie	Final Wrap-up
10:00	Diffuse Emission - Seth	Data Analysis with IACTs - Jamie	Overview of HAWC Science - Ignacio Taboada	GRB Observations and Analysis - J. Michael	Project Results and Feedback
11:00	**Break**	**Break**	**Break**	**Break**	**Break**
11:30	Fundamental Physics from High Energy Observations - Julie	Trip to Wallops	GRB Theory- J. Michael Burgess	Data Analysis with HAWC - Ignacio	Workshop Close Out
12:30	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Lunch**

1:30	Student Talks 1 Slide Summaries Advanced Topics: Working groups	Trip to Wallops	Student Talks 1 Slide Summaries GRB tutorial - J. Michael • getGBMdata.py , getGBMdata_lib.py • Binning GBM Data Notebook • Post Analysis Notebook • GRBtutorial.tgz • GRBspectralTools.tgz FSSC web page on rmfit Advanced Topics	HAWC sensitivity tutorial - Ignacio Effective Area script: EffArea.C Advanced Topics: Useful tutorials LAT Extended source analysis notebook	
			Virden Hosted BBQ		

Student Talks and 1 Slide Schedule

Wed., May 27

- **>>** Studying the gamma--ray variability of the blazar 1ES 1215+303- Floriana Zefi

  We report on correlated variability from the BL Lac source 1ES 1215+303 detected by the space-based Large Area Telescope, and VERITAS experiment. We studied the flux variability of the source in the energy range covered by Fermi-LAT (100 MeV < E < 100 GeV) from 56298- 56424 MJD (January-May 2014). During this time period a huge flare was detected from the source, correlated with the flare observed by VERITAS experiment at even higher energies (E>100 GeV). In the preliminary results the source shows a hard spectrum for this time period with a spectral index of 1.84 +/- 0.06. The averaged integral flux in the 0.1-100 GeV energy range is (8.19+/- 1.01)x10^-8 ph/cm^2/s. From the one-day time bin lig curve we estimated the variability time scale to be 4.41 h+/-0.09. We use these results and the opacity argument to set a limit on the Doppler factor.
- **>>** Fornax A - Jeff Magill

  Prior to the launch of Fermi in 2008, the radio
  galaxy Fornax A was identified as one of the few extragalactic objects that might be detected as spatially extended above 100 MeV. However, even though it was detected with high confidence in the first 2 years of the mission, it was not determined to be an extended source. Recently, the Fermi-LAT collaboration developed a new event-level analysis called Pass 8 which yields a larger acceptance, a better angular and energy resolution, as well as smaller systematic uncertainties. The improvements provided with Pass 8 combined with a longer exposure means that the spatial extension of Fornax A is significantly detected, making it only the second extragalactic gamma-ray source so far to show extent. Details of this measurement will be presented along with modeling of the emission above 100 MeV.
- **>>** The Speedster-EXD - A New Event-Triggered Hybrid CMOS X-ray Detector - Christopher Griffith

  We present the characterization of a new event driven x-ray hybrid CMOS detector developed by Penn State University in collaboration with Teledyne Imaging Sensors. Hybrid CMOS detectors currently have many advantages over CCDs including lower susceptibility to radiation damage, lower power consumption, and faster read-out time to avoid pile-up. The Speedster-EXD hybrid CMOS detector has many new features that improve upon the previous generation of detectors including two new in-pixel features that reduce noise from known noise sources: (1) a low-noise, high-gain CTIA amplifier to eliminate interpixel capacitance crosstalk and (2) in-pixel CDS subtraction to reduce kTC noise. The most exciting new feature of the Speedster-EXD is an in-pixel comparator that enables read out of only the pixels that contain signal from an x-ray event. The user can set the comparator threshold so that only pixels with signal above the set threshold are read out. This comparator feature can increase effective frame rate by orders of magnitude. We present the read noise, dark current, interpixel capacitance, energy resolution, and gain variation measurements of two Speedster-EXD detectors.
- **>>** Indirect dark matter search in dwarf spheroidal galaxies - Niki Klop

  Dwarf spheroidals are low luminosity satellite galaxies of the Milky Way which are highly dominated by dark matter. This makes them excellent candidates to search for signals from dark matter annihilation using gamma ray observations. I will discuss various aspects of my analysis of the Fermi-LAT data of several dwarf spheroidals and show my latest results.

Thurs., May 28

- **>>** The GCT's camera for the Cherenkov Telescope Array - Andrea De Franco

  The Gamma Cherenkov Telescope's (GCT) camera is a development project involving UK, US, Japanese, French, Australian and Dutch institutes for the dual-mirror Small-Sized Telescopes (SST-2M) of the Cherenkov Telescope Array (CTA). Two GCT camera prototypes are fully funded. The first will be based on multi-anode photomultipliers (MAPMs) and the second on silicon photomultipliers (SiPMs). The camera is designed to

record flashes of Cherenkov light lasting from a few to a hundred nanoseconds, with typical RMS image width and length of ~0.2° x 0.1° and has a 9° field of view. The physical camera geometry is dictated by the GCT telescope optics: a curved focal surface with radius of curvature 1 m and diameter 35 cm is required. The first prototype is now assembled and under extensive lab testing and meant to commissioned on field in the third quarter of this year. The SiPM based camera will follow shortly.

- **>>** TeV pulsed emission from the Crab detected by MAGIC - Daniel Galindo

  How and where pulsars accelerate particles have been long standing questions. The Crab pulsar, hosted inside its nebula, has been a test bench for any proposed pulsar emission scenario. The discovery of a power-law spectral component, above the cutoff measured by the LAT detector, on board of the Fermi satellite, and extending up to 400 GeV, has challenged the consensus view of the high-energy pulsars. The latest results obtained by the MAGIC collaboration, with more than 300 hours of observations, report the most energetic, ever detected, pulsed gamma rays coming from an astrophysical source, namely the Crab pulsar. The energy spectrum of the Crab pulsar extends up to ~2 TeV, connecting smoothly with the spectral points above 10 GeV measured by Fermi- LAT. Above 400 GeV the detected emission mainly comes from the interpulse, showing a pulse peak at a level of 6.5 sigma. The spectra of the two peaks follow two distinct power-law functions. These results imply that such energetic gamma rays are produced via Inverse Compton scattering in the vicinity of the light cylinder radius by an underlying particle population with Lorentz factors higher than 10^6. The exact site of gamma-ray production cannot be unequivocally assigned, given that none of the existing theories can reproduce all aspects of the observed measurements.
- **>>** X-ray and gamma-ray studies of the supernova remnant (SNR) CTB 37B hosting a young magnetar - Harsha Kumar

  The supernova remnant (SNR) CTB 37B, located in a complicated region of CTB 37, is associated with the 3.82 s magnetar CXOU J171405.7-381031. We present a high-resolution study of the remnant using all available Chandra and XMM-Newton observations in order to characterize the spatial and spectral properties of the diffuse emission, to address the debated age of the SNR, as well as to infer the supernova explosion properties. Observations of the CTB 37 complex performed with the H.E.S.S. telescope array revealed HESS J1713-381, the first TeV source coincident with a magnetar. The origin of the TeV emission has been attributed primarily to the SNR shell, although it has been also suggested that the magnetar may contribute to the HESS source. The source has not yet been detected in any previous studies with the Fermi Large Array Telescope (LAT) that has allowed for successful detections of several SNRs in the MeV- GeV energy range. A further investigation using additional Fermi data to date would help reveal any possible gamma ray emission from this region in the GeV regime, as well as shed light on the nature of its multi-wavelength emission.
- Matthew Meehan
- Andriy Petrashyk
- Mike Testa

Sat., May 30

- **>>** Searches for High-Energy Neutrinos from Gamma-Ray Bursts with the ANTARES Neutrino Telescope - Julia Schmid

  ANTARES is the largest high-energy neutrino telescope in the Northern Hemisphere. Its main scientific purpose is the search for astrophysical muon neutrinos that are detected via their charged-current interaction in Earth and the subsequent Cherenkov emission of the secondary muon in the water of the Mediterranean Sea. Gamma-ray bursts are among the most promising candidates for the experiment as they are thought to accelerate not only electrons - leading to the observed gamma rays - but also protons, which would yield the emission of EeV neutrinos. Compelling evidence of a high-energy cosmic neutrino signal correlated with any astrophysical source would, for the first time, prove the acceleration of hadrons beyond any doubt, a hypothesis that cannot unambiguously be put to the test by pure electromagnetic observation. However, to explain the origin of cosmic rays at ultra-high energies, it is absolutely crucial to identify those processes in the universe that are capable of accelerating baryons to such energies. The recent searches for muon neutrinos from gamma-ray bursts using data of the ANTARES telescope will be presented. Several techniques to single out a neutrino signal from GRBs in the ANTARES data were developed, both in the search for simultaneous as well as a possibly time-shifted neutrino emission with respect to the photon signal. Data from multiple spacecraft and Earth-bound telescopes within the Gamma-ray burst Coordinates Network such as the Swift and Fermi satellites were used to search for correlated neutrinos in the data from the ANTARES telescope. The search could not identify any significant neutrino excess associated with gamma-ray bursts, yet the non-observation is still compatible with the realistic second-generation numerical predictions of neutrino emission. However, I could demonstrate that the future telescope KM3NeT will be capable of putting these models to the test with unprecedented sensitivity, allowing for the first time the neutrino flux as predicted by the realistic models to be detected, or the parameter space upon which they are based to be severely constrained.
- Bryce Carpenter
- Pheneas Nkundabakura
- Mark Wells
- Maxwell Jingo
- Rachel Simoni

Mon., June 1

- Etienne Bourbeau
- Wenlei Chen
- Alisha Chromey
- Jason Watson
- Amanpreet Kaur
- Eman Moneer

Wed., June 3

- **>>** The High Altitude Water Cherenkov Observatory - Kelly Malone

  The High Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory, located at an altitude of 4100 m on the Sierra Negra plateau in Mexico, is a second-generation experiment designed to observe TeV gamma rays and cosmic rays from air showers. It consists of a large array of water Cherenkov detectors, each of which is equipped with 4 PMTs. HAWC's large field of view (~2 sr) and high duty cycle (>90%) make it well suited to constrain the cutoff and shape of high-energy GRB spectra. It also extends the spectral measurements with made with the Fermi-LAT up to 100 GeV to higher energies. I will discuss the status of HAWC's GRB searches.
- **>>** Muon Production Depth Studies - Hershal Pandya

The IceCube neutrino observatory also serves as a laboratory to study nuclear and electromagnetic cosmic particles. Primaries are observed as air showers in IceTop – the surface component of IceCube. By correlating arrival time of muons with distance from the shower core, the longitudinal history of the muon production may be resolved. We explore the usefulness of muon production depth distribution in resolving the mass of primary, and the dependence of this distribution on factors such as zenith, primary energy and sampling radial distance from shower core. We use the EHISTORY option in air shower simulation code CORSIKA to obtain true muon production depth distribution and use it as a benchmark to determine the corrections necessary in observed muon arrival time.

- **>>** Photospheric Emission from GRBs - Zeynep Acuner

  Abstract
- Rosa Becerra Godínez
- Clio Sleator
- Carolyn Kierans

Supporting Material

Really useful usage notes page for likelihood tools! [Likelihood Usage Notes]

Liz's favorite page on livetime and exposure: [http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone_Likelihood/Exposure.html]

Glossary of Fermi and related jargon

Example ipython notebook from Eric Charles' lecture for statistics in astronomy grad course: Guest Lecture of Applications in Astro Statistics id 17506

Things to do and Eat

These are places we've gone in the past for food:

- These are close by (walking, bike ride)
  - Rose & Crown (http://roseandcrownlewes.com)
  - Striper Bites (http://www.striperbites.com)
  - The Buttery (https://butteryrestaurant.com)
  - Notting Hill Coffee (http://www.nottinghillcoffee.com)
  - Half Full (http://www.halffulllewes.com)
  - Kindle (http://www.kindlerestaurant.com)
  - Jerry's Seafood (http://www.jerrys-seafood.com)
  - Gilligan's (http://gilliganswaterfront.com/home.html)
  - King's Ice Cream (http://www.kings-icecream.com/)
- These within driving distance
  - Dogfish Head (worth at least one trip if you like beer: http://www.dogfish.com/restaurant/index.htm)
  - JD's Filling Station (http://www.jdsfillingstation.com)
  - There are lots of restaurants along Coastal Highway (Route 1) but need a car.
  - If you're looking for a trip for dinner, head to Rehoboth.

Some useful shops:

- Grocery store?

- Rite Aid Pharmacy (444 Savannah Road, probably need a car)
- Ocean Suds II Laundromat (18675 Coastal Highway)
- R&L Liquors (207 Second Street)

Things to do. Ask for details.

- Fishing Trip (on a boat!)
- Take the Ferry to Cape May
- Rent Kayaks (http://www.eastofmaui.com/)
- Cape Henlopen
- Check out Rehoboth
- Dogfish Head Brewery Tour (not the restaurant) (http://www.dogfish.com/community/tours/index.htm)
- Rent Bikes