The Relation Between the Radio and Gamma-Ray Emission in Blazars from 15 GHz Monitoring with The OVRO 40 m Telescope and *Fermi*-GST observations

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In collaboration with …

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Fermi meets Jansky – AGN in radio and gamma-rays

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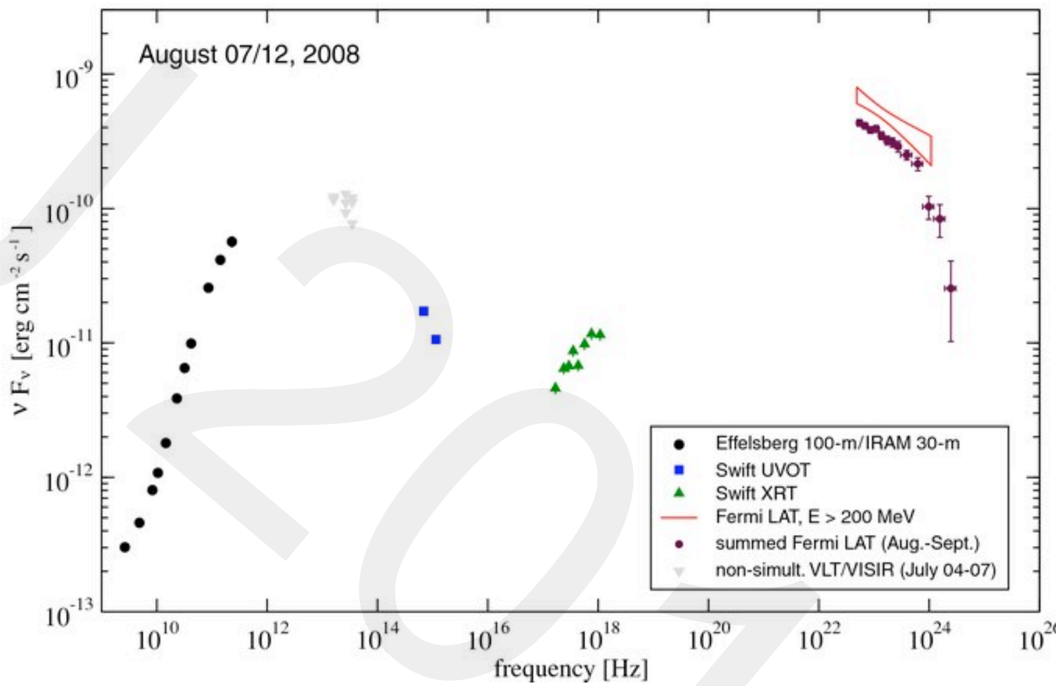
Overview

- Problem:
  - Where does the gamma-ray emission originate in blazars?
    - Various alternatives, e.g. Blandford and Levinson 1995, Marscher et al 2008
- Our strategy:
  - Study radio and gamma-ray light curves for a large number of sources
    - Monitoring 1500 sources
    - 454 detected by *Fermi*-GST on 1LAC "clean" sample

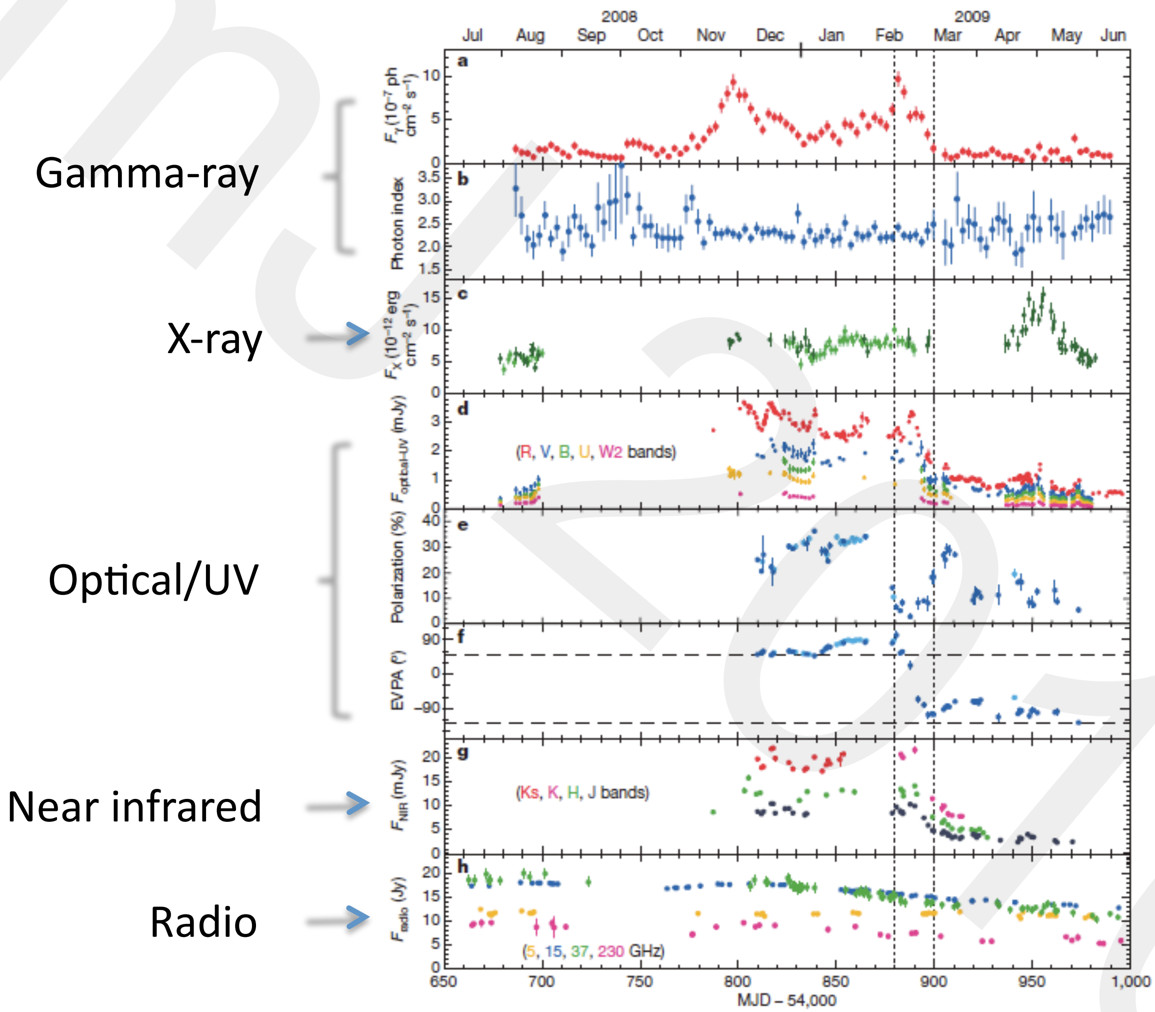
Introduction
Double peaked SEDs

Artist impression
http://imagine.gsfc.nasa.gov/



3C 454.3 from Abdo et al. 2009, ApJ 699, 817

Introduction
Variability and linear polarization

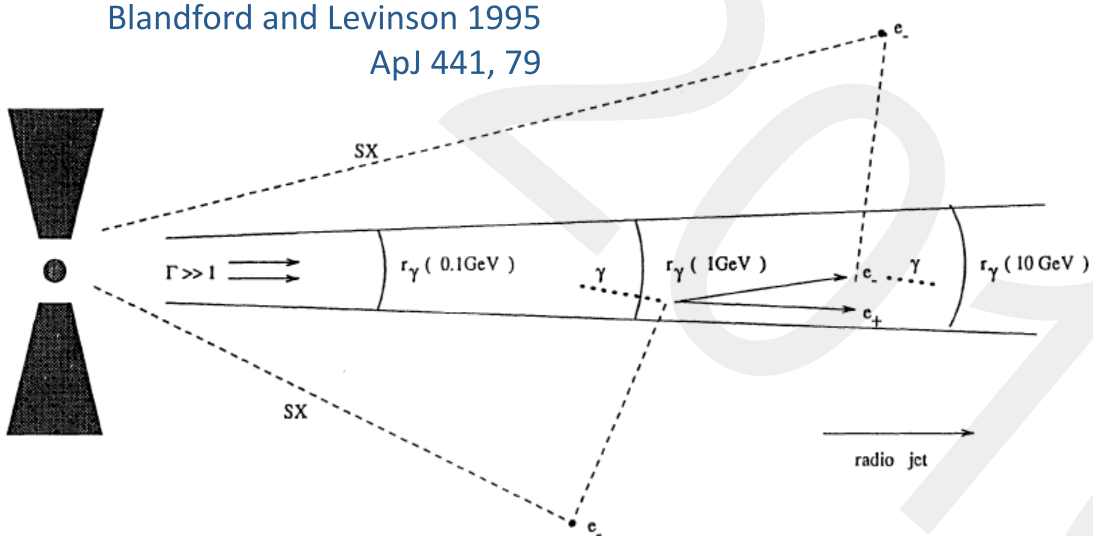


3C 279 multi-wavelength campaign, Abdo et al. 2010, Nature 463, 919

Introduction:
Gamma-ray emission zone

- Different classes of models
  - Composition of the jet
  - Origin the inverse Compton soft photons
  - Distance from the central engine

Blandford and Levinson 1995
ApJ 441, 79



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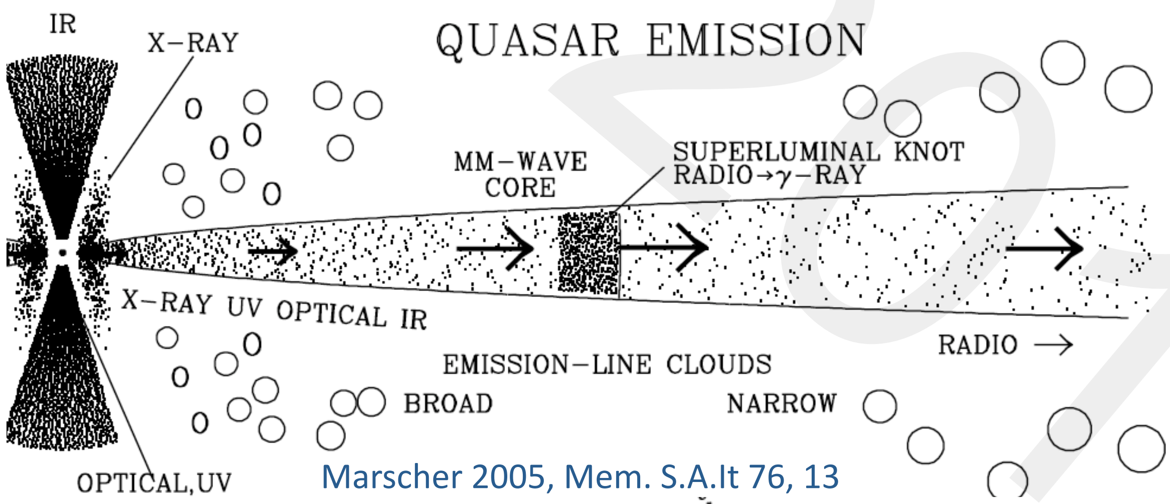
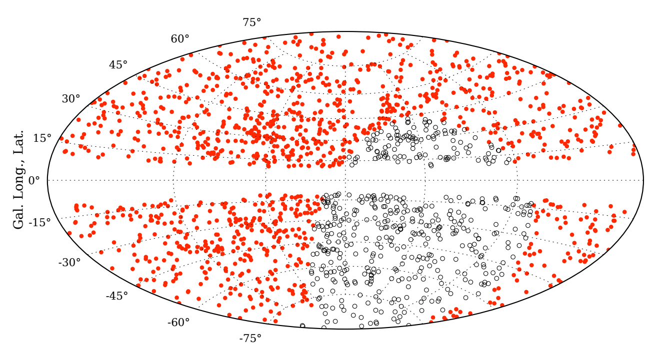


Marscher 2005, Mem. S.A.It 76, 13

Observing program:
Radio monitoring

- OVRO 40-meter blazar monitoring
  - since July 2007
  - 1158 candidate gamma-ray blazars all CGRaBS objects with $\delta > -20^{o}$
    - CGRaBS, uniform and complete
  - Fermi detected sources are added, current sample ~1500 sources

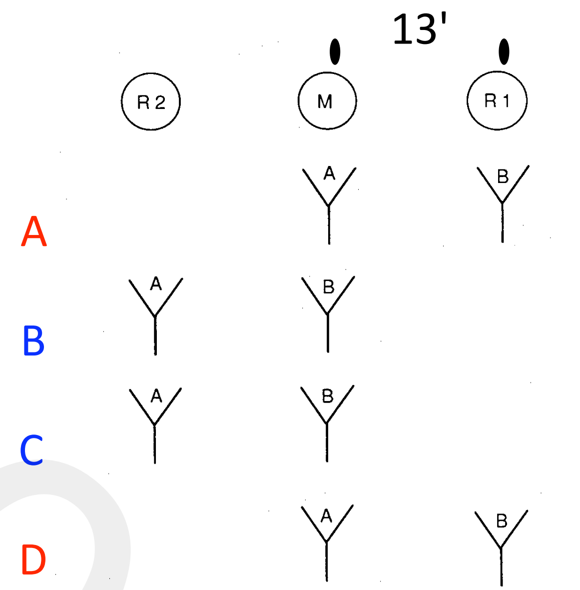


Distribution of CGRaBS sources in Galactic coordinates
Red circles represent monitored blazars

The OVRO 40 m Telescope at night
By Joey Richards

Observing program:
Radio monitoring

- System parameters
  - Dual-beam Dicke-switch system
    - FWHM 2′.5, Beam separation 13′
    - 15 GHz, 3 GHz bandwidth
    - Tsys ≈ 50 K, Trx ≈ 30 K
    - Lose a factor of 2 in sensitivity compared to ideal receiver
- Observations
  - ~ two fluxes per week
  - ~ 5 mJy thermal noise, ~2% flux proportional uncertainty
  - Periodic relative calibration with noise diode
  - Absolute calibration with 3C286



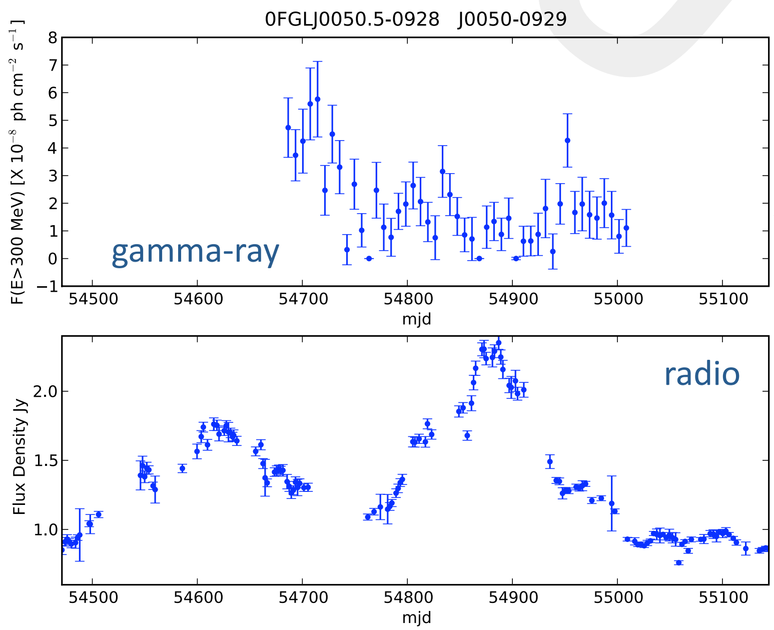
Adapted from Readhead et al 1989 ApJ 346, 566

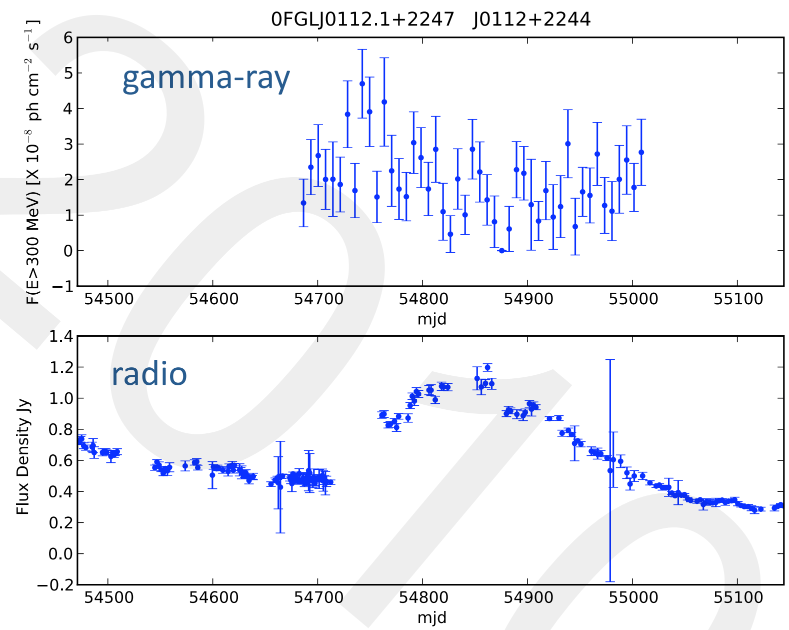
The 40 m Telescope in action

Three full days of observations with the OVRO 40m Telescope
video courtesy of Joey Richards

First results:
Almost 3 years of observations

- Examples of gamma-ray/radio light curves for 3 month Fermi detected sources, 52 objects in total





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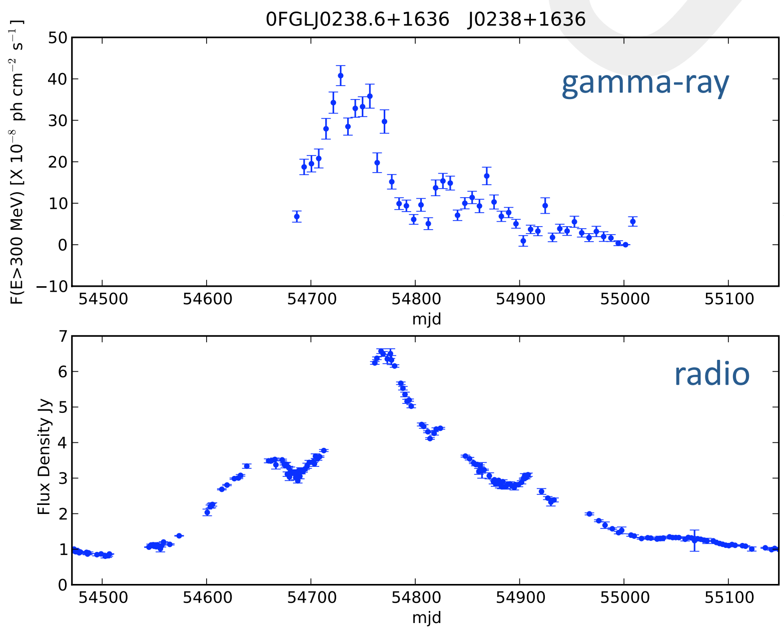
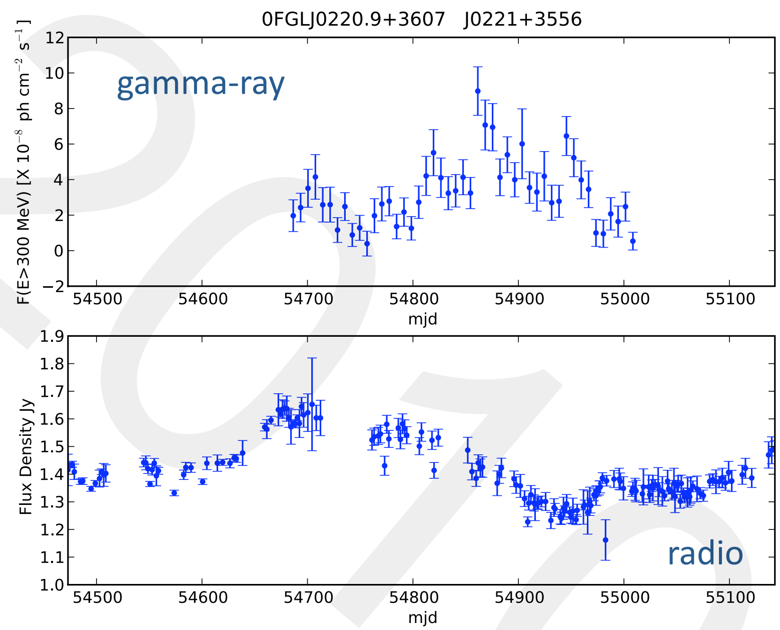
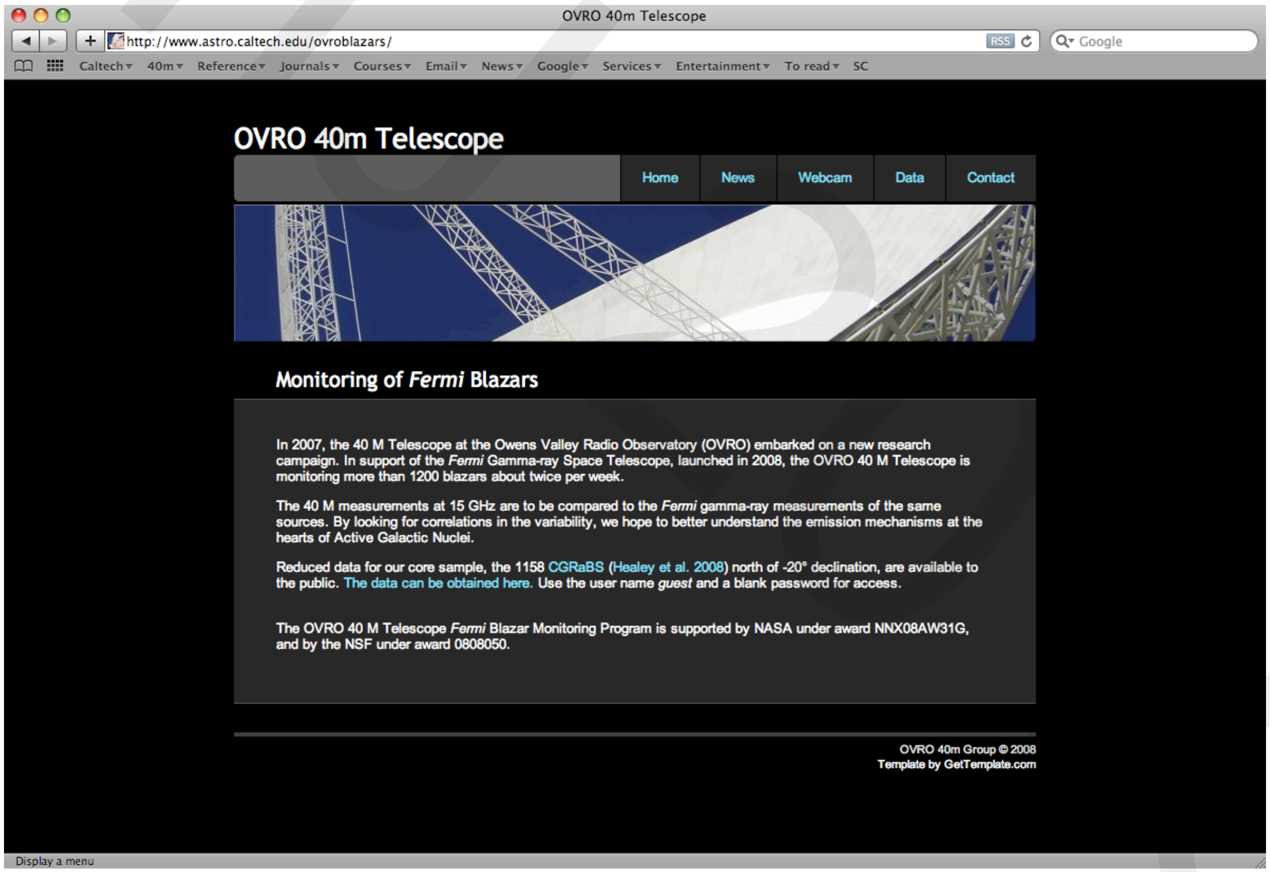




First results:
Public data release

- Visit our website for more information



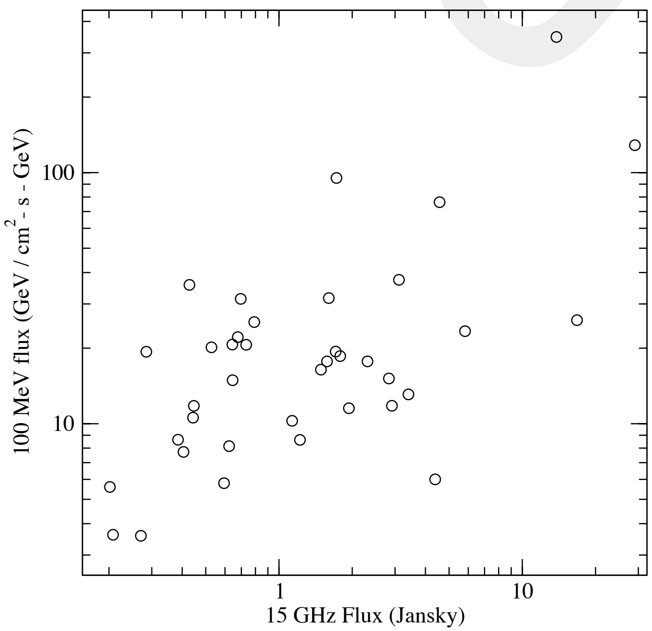
http://www.astro.caltech.edu/ovroblazars

First results:
Radio/gamma-ray correlation

- The apparent correlation is confirmed using simulations

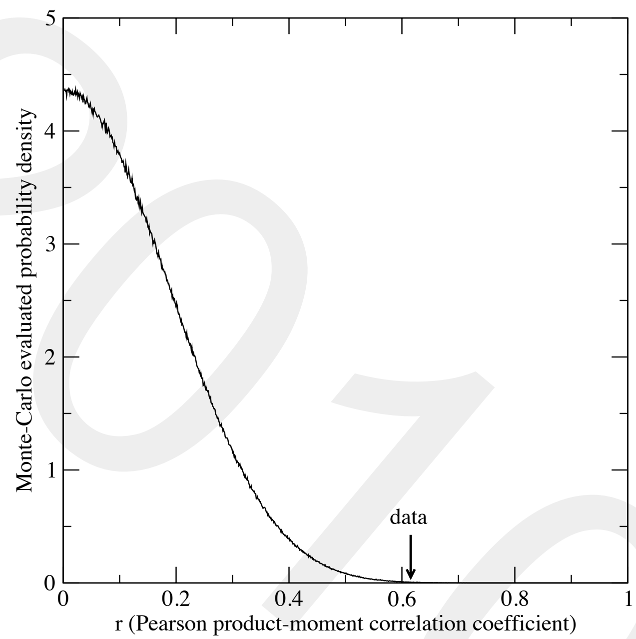
Flux density correlation

Gamma-ray flux density



Radio flux density

Correlation significance

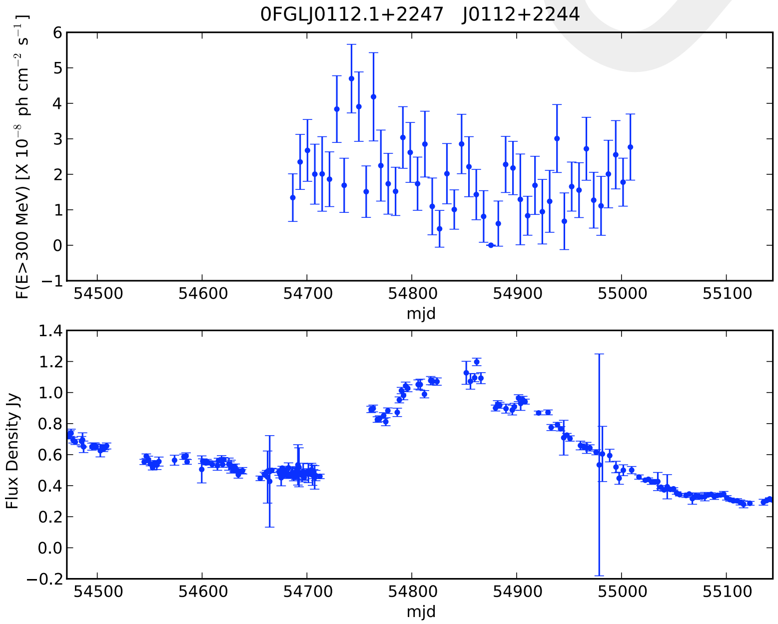


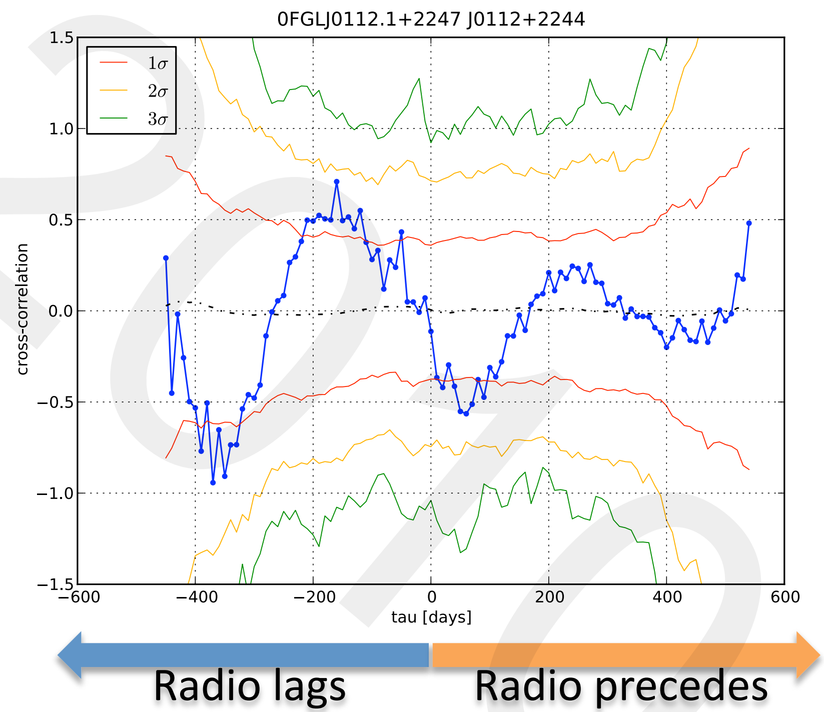
r = 0.61

P(chance) = 2 x 10^{-4}

First results:
Radio/gamma-ray time lags

- Examples cross-correlations. 3 month Fermi detections, using 11-months of Fermi data and 2 years of radio monitoring
- Significance evaluated using simulated data with a power-law PSD ~ 1/f^β { β_radio = 2.5, β_gamma = 2.0





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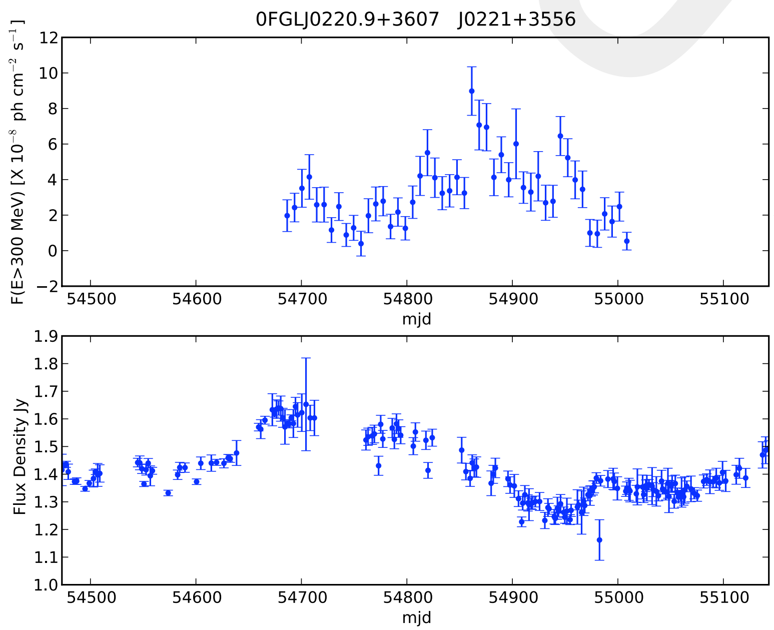

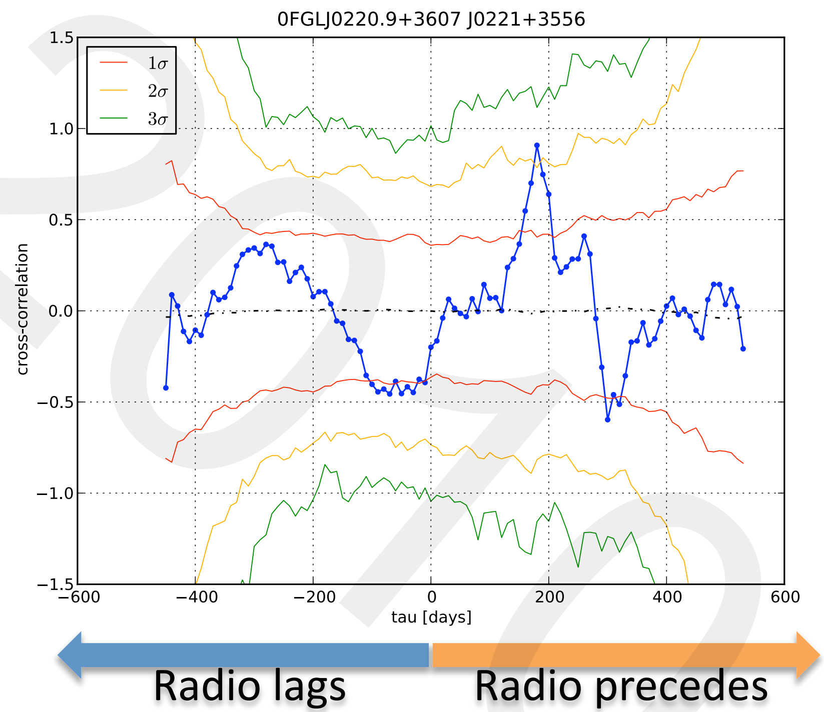

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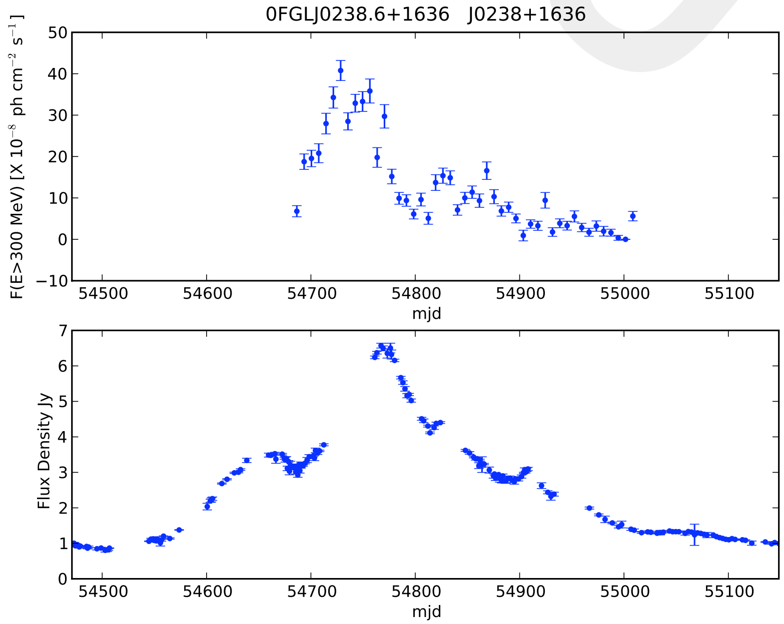

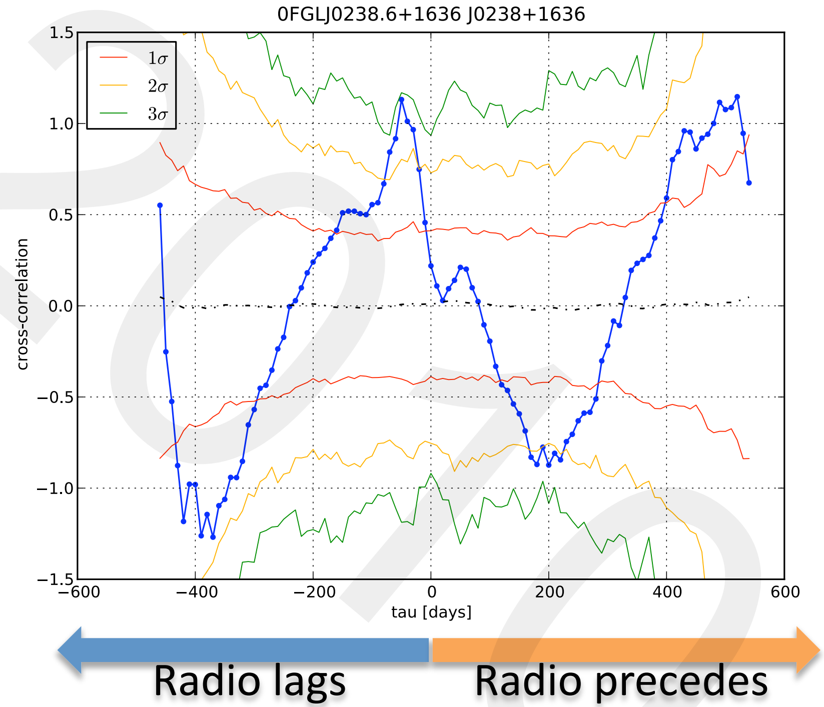

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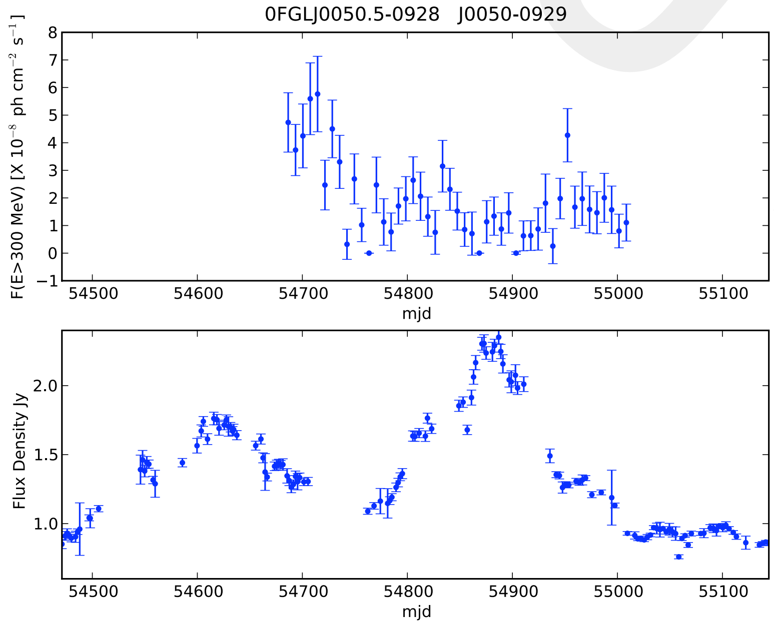
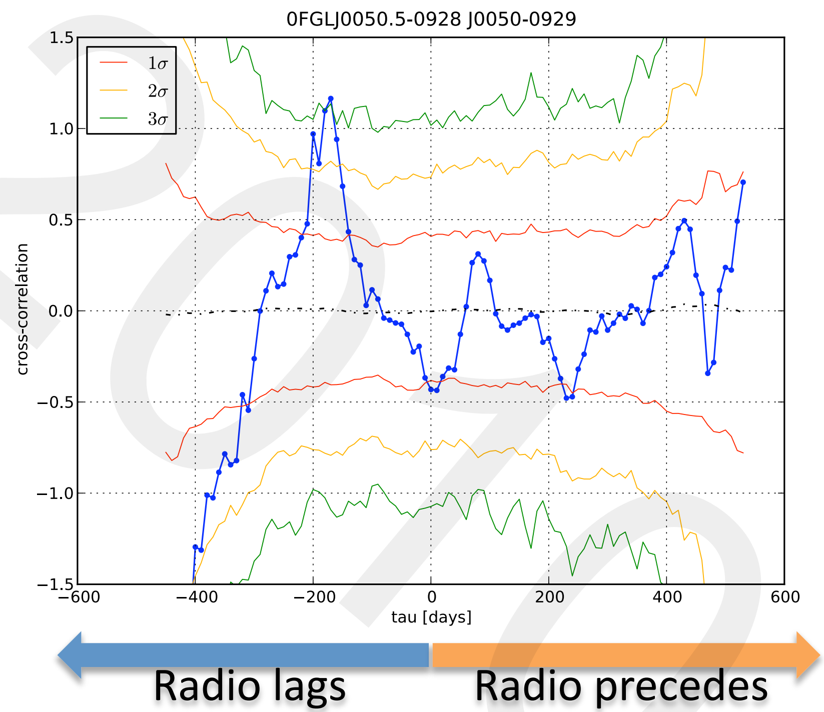


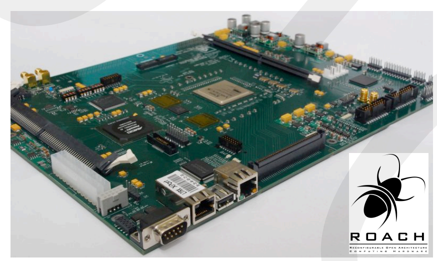


New receiver:
Polarization and better sensitivity

- New receiver will measure polarization
  - Polarization variability related to magnetic field structure on emission region
- Increases sensitivity
  - Both polarizations
  - Wider bandwidth
- Under construction
  - Radio frequency components design and acquisition
  - Digital backend

- Commissioning expected by end of the year

Polarization receiver schematics



Digital backend using hardware from CASPER

Summary

- **First results:**
  - **Radio/gamma-ray flux density correlation is significant**
  - **Radio/gamma-ray time lags require longer duration light curves**
- *Fermi*-GST provides a large sample of gamma-ray blazars with improved sensitivity and cadence. These are being observed by the OVRO 40-m Telescope plus all CGRaBS
- The correlated variability at these two bands will be used to constrain the location of the gamma-ray emission zone
- A new receiver which measures polarization is under development and commissioning is planned for the end of the year