ETHzürich

Multi-wavelength observations on the gamma-ray periodic Blazar PG1553+113

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S. Ciprini, S. Cutini, R. Desiante, D. Gasparrini and F. Longo for the **Fermi-LAT** collaboration

Introduction

- Lots of work by lots of people:
  A. Stamerra, E. Prandini, J. Becerra, U. Barres, S. Covino, P. Da Vela,
  C. Ferrigno, E. Lindfors, M. Nievas, S. Paiano and A. Sandrinelli
  on behalf of the MAGIC
  S. Ciprini, S. Cutini, R. Desiante, D. Gasparrini and F. Longo
  for the Fermi-LAT collaborations

- PG 1553 has been studied for many years
  Therefore large set of MWL data available

- Inspired by Fermi LAT result

  - Lets take a first look at other wavelengths
    Detected in < 1 hrs @ TeV, Optical + others
    Fermi LAT requires > week

Past High Energy Measurements

- 1986 First observed in Ultra Violet

- 2005/6 Discovery at TeV energies by HESS

- 2006 MAGIC confirmation

- 2007 MAGIC upper limit on the red shift of <0.58

- 2009 MAGIC 1st MWL Campaign

- 2010 Hubble puts limits on red shift of >0.4 [0.43-0.58]

- 2010 HESS publishes 2 years of data

- 2011 VERITAS red shift upper limit <0.5

- 2011 MAGIC SED modelling including Fermi/LAT data

- 2014 VERITAS 3 years of data evidence for variability

- 2015 HESS using 2012 flare red shift limits 0.49$\pm$0.04

- →**Flux is variable - flares are observed, limits set on redshift and Lorentz Violation**

- 2015 Fermi/LAT Evidence for Quasi-Periodic Modulation

What's the plan?

- Source varies on weekly time scales
  Flares used to study LV and EBL also upper limit

- Observations in some of the wavelength has been sporadic
  Now we have fresh impetus to be more organised

- Blazar LCs are correlated
  Red noise therefore we need to monitor the source

- Measurement of correlation, time-lags, relative modulation strengths
 If we want to discriminate between the different scenarios we need all available data

Multi-wavelength Light Curve
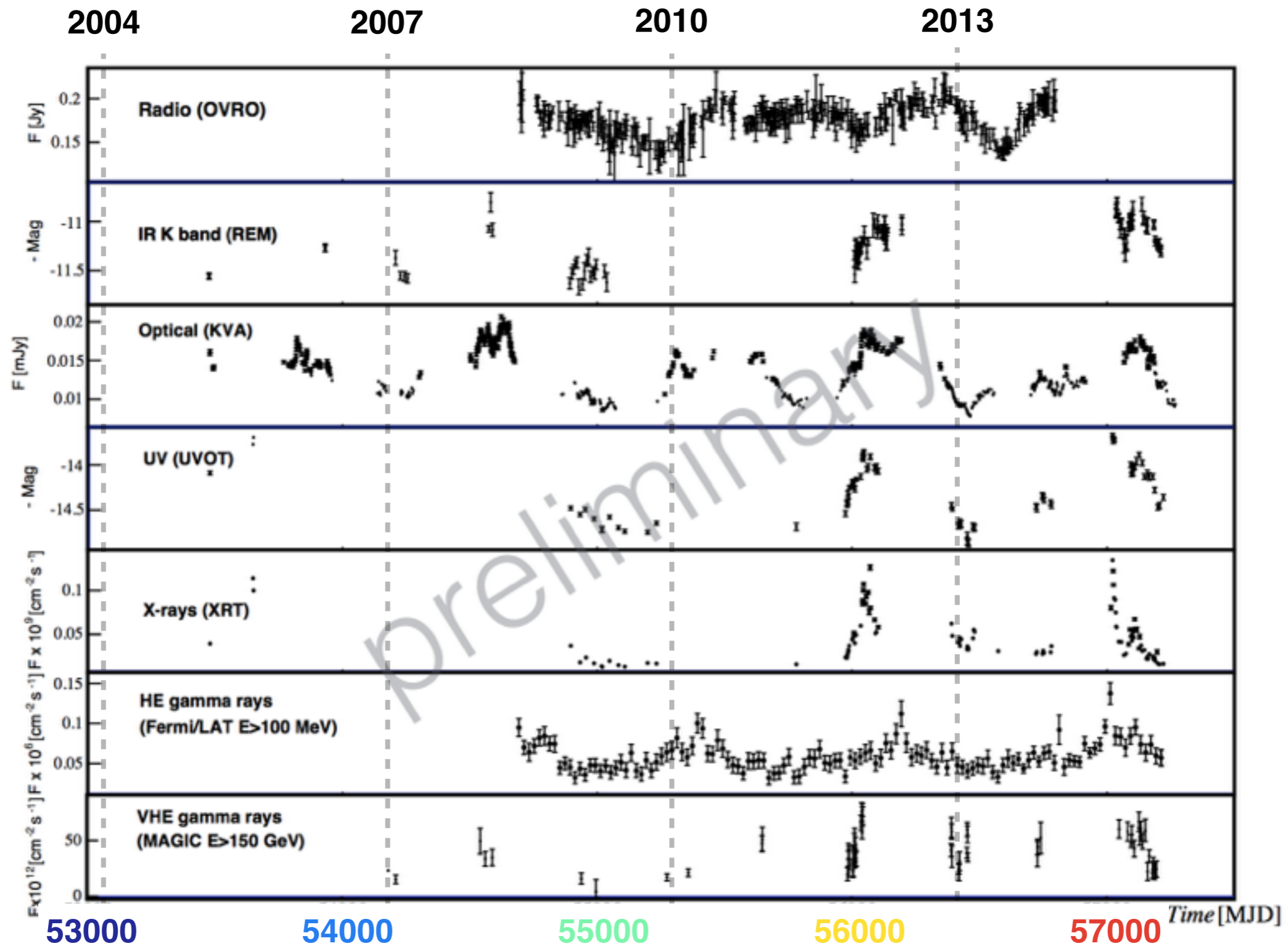
Correlation and Time Lags

- **Correlate** the nearest point in each light curve, with in 4 days

- For Fermi-LAT use the 20 day binning

- Discrete Correlation Function (**DCF**)
  *Edelson & Krolik ApJ **333** 646 (1988)*

- Often used to study the correlation between light curves as a function of time lag

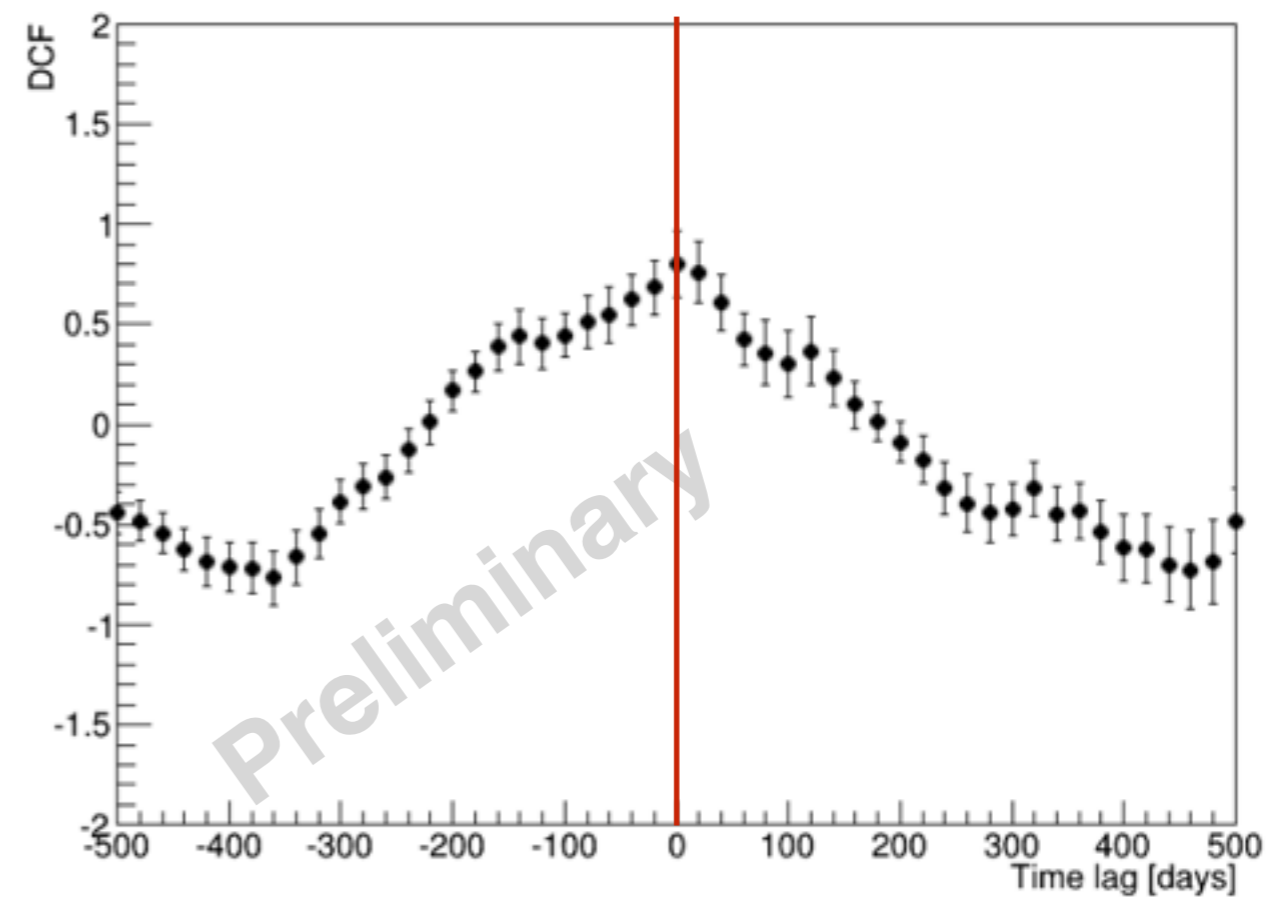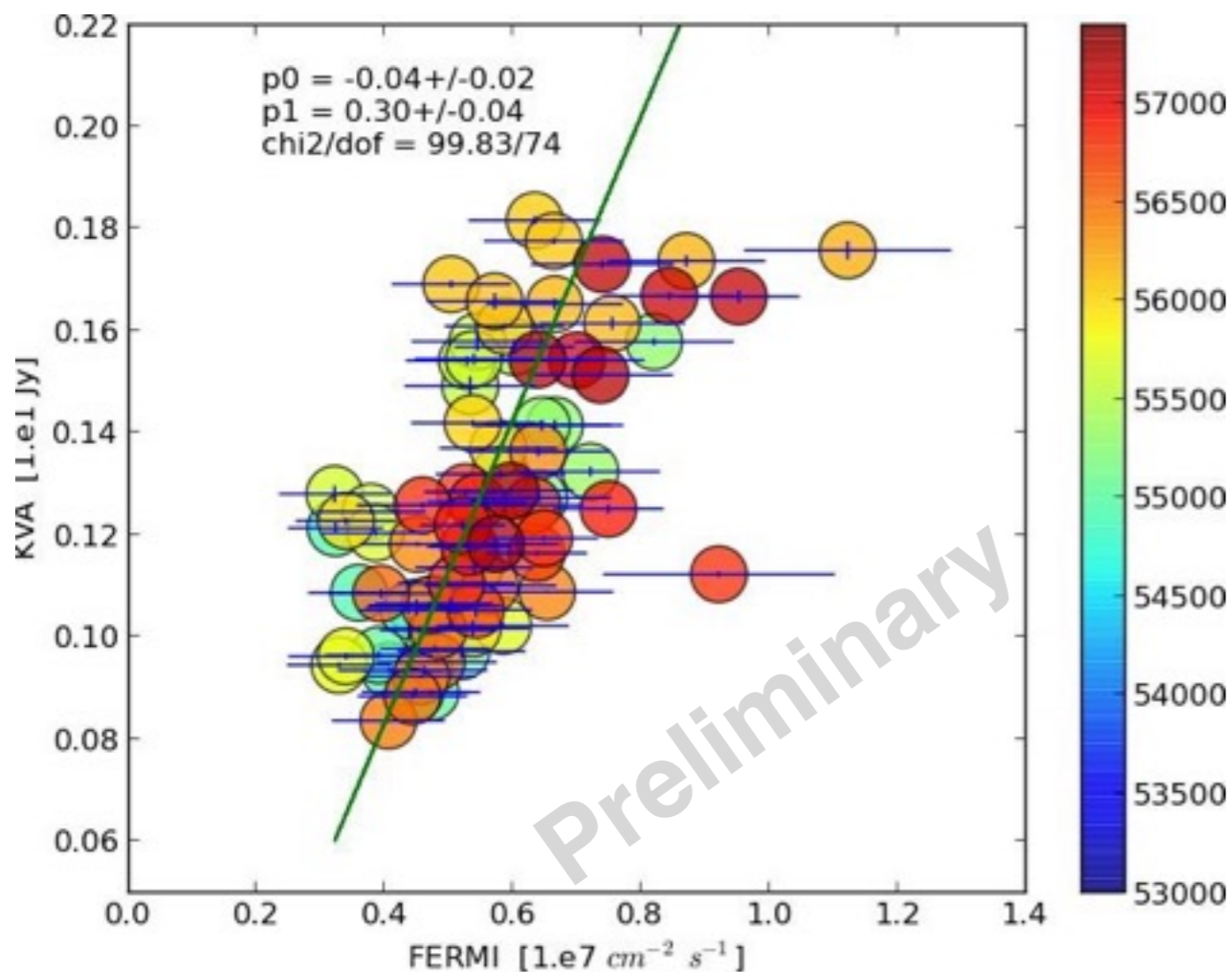- No interpolation required, but care is needed in binning

Correlations: Optical vs UV

- Z-axis (color) represents MJD

- Here we expect good agreement
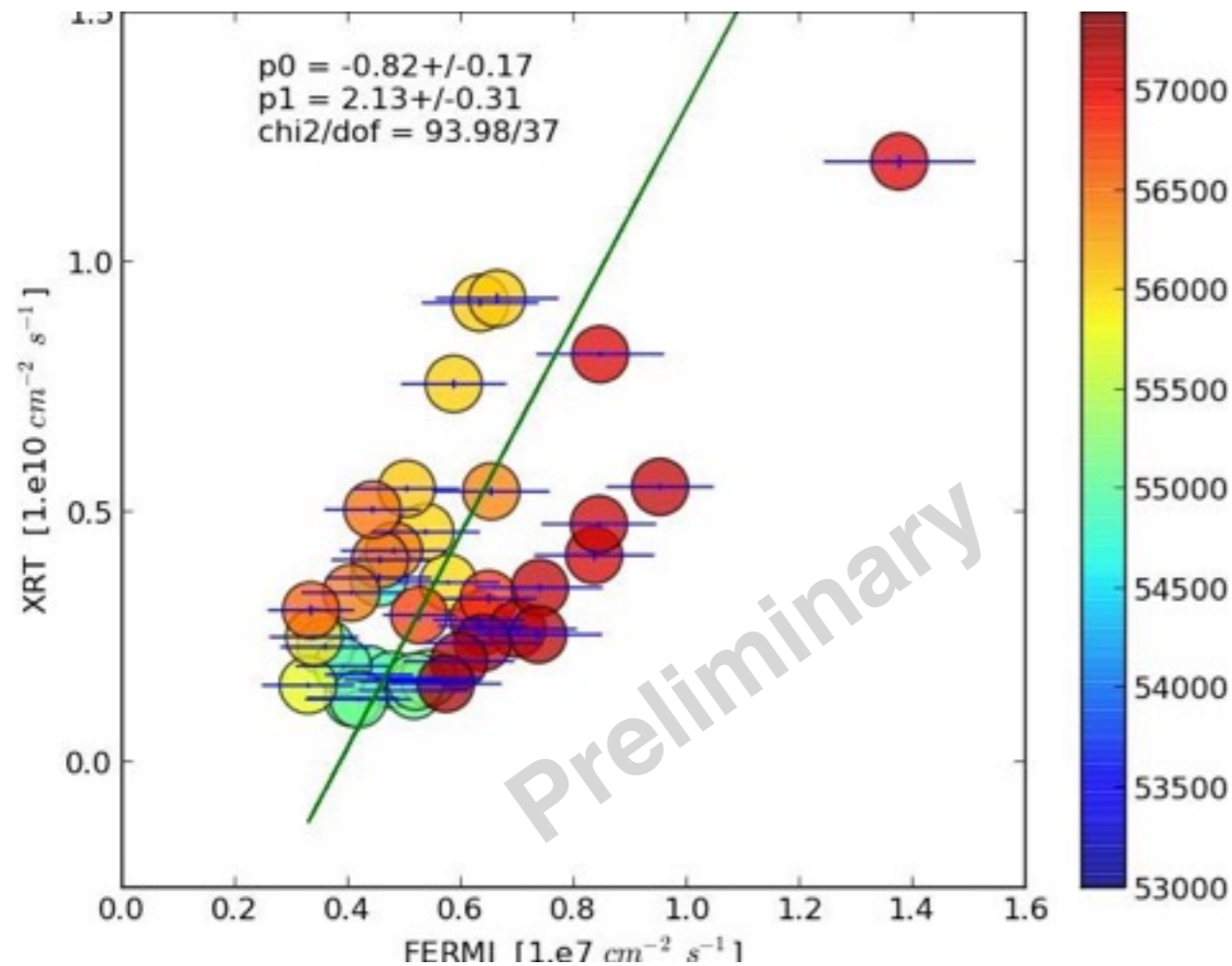 good cross-check

- No Time Lag

- Feature at ±200 days ?
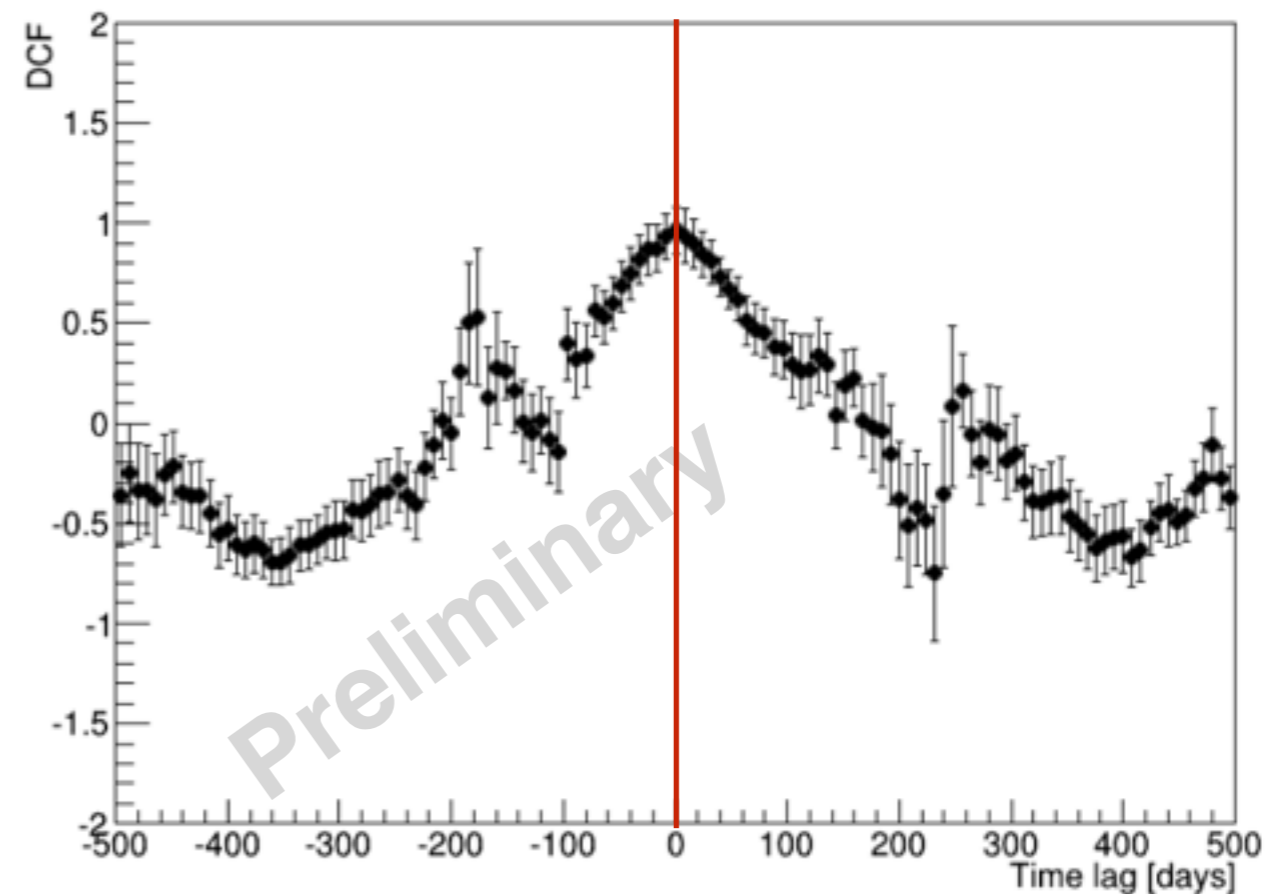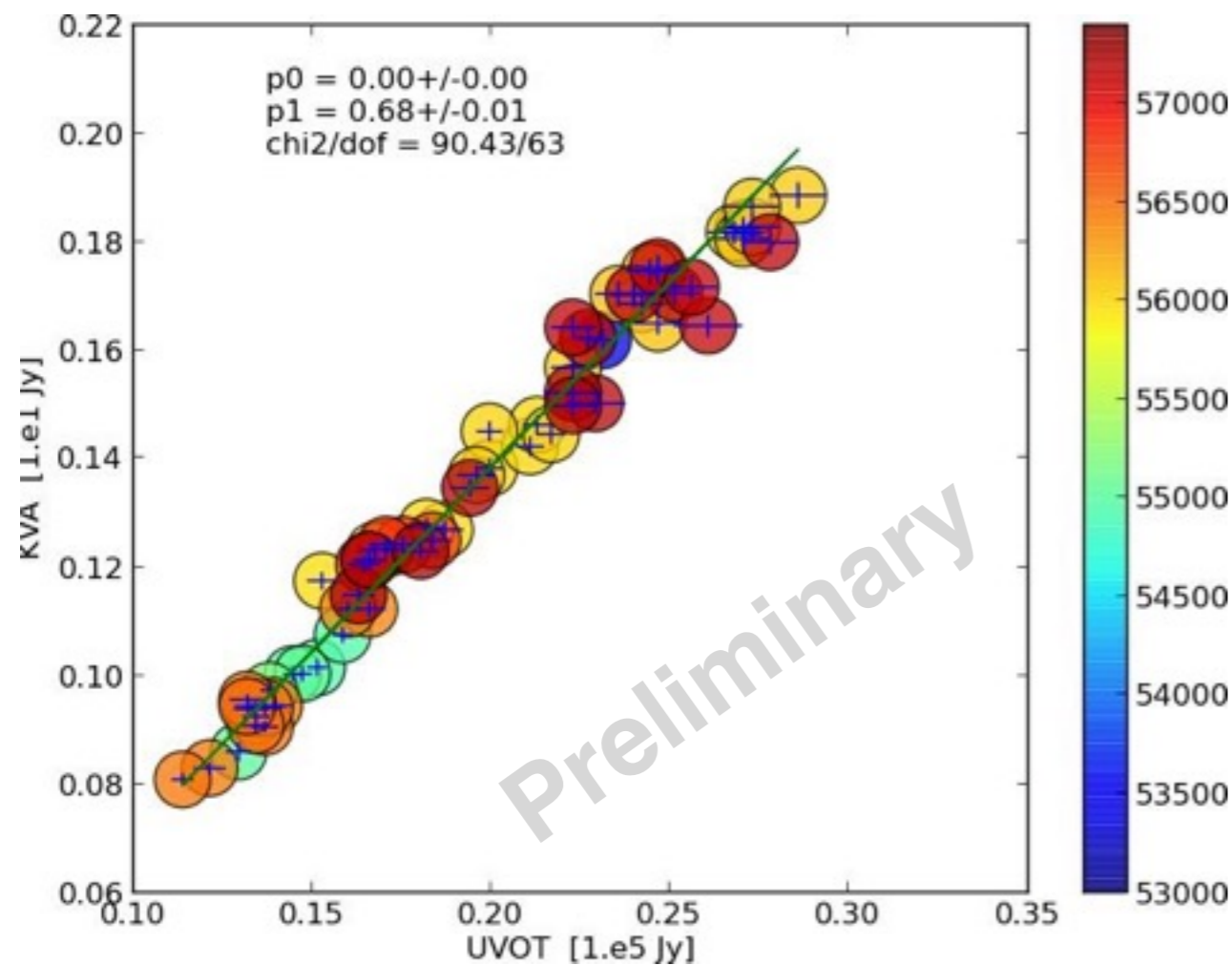
Correlations: Optical vs HE

- Hint of correlation (Pearson Correlation > 6 sigma)

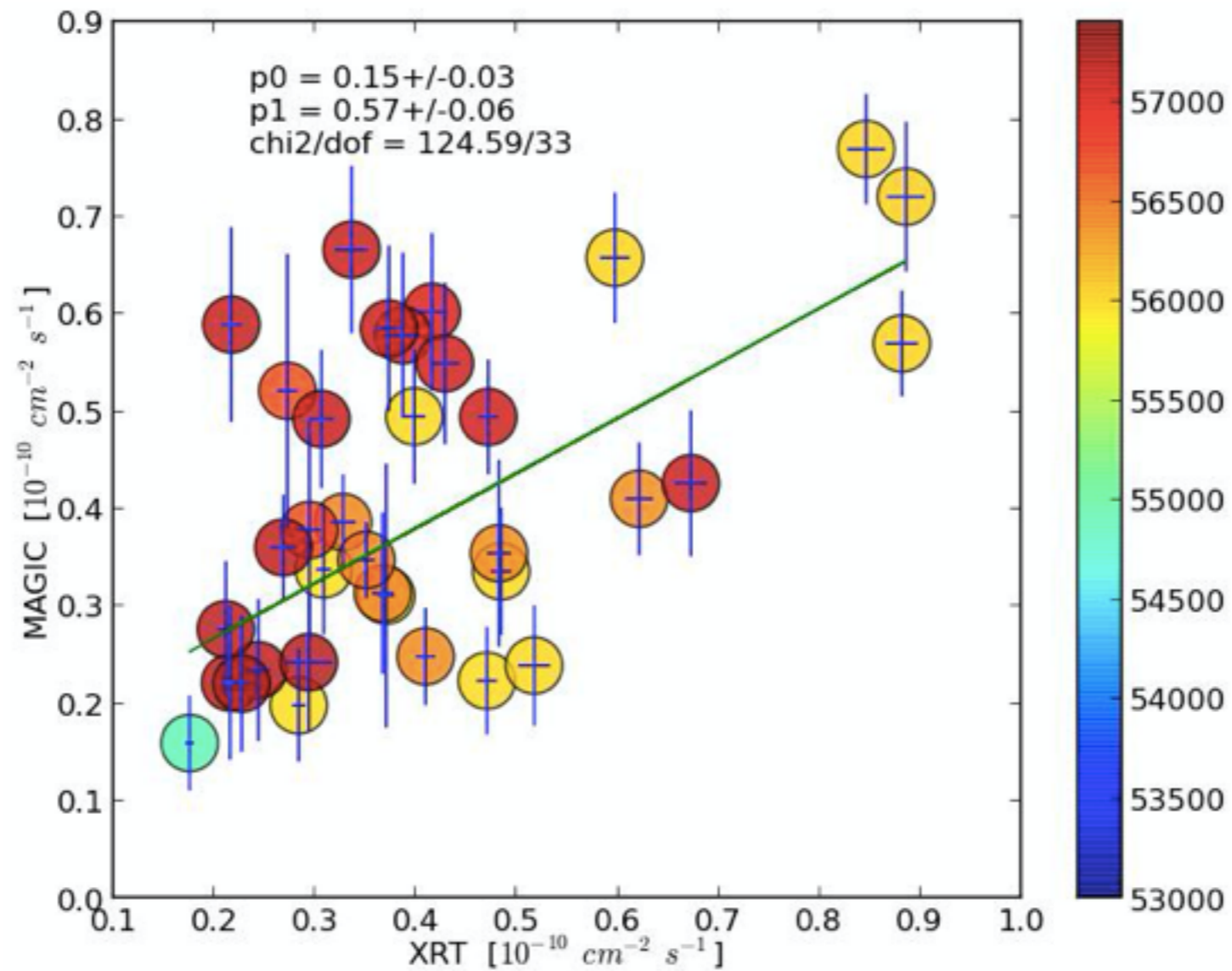- No time lag but DCF is broad

Correlations: X-ray vs HE

- Hint of correlation (Pearson > 4 sigma)
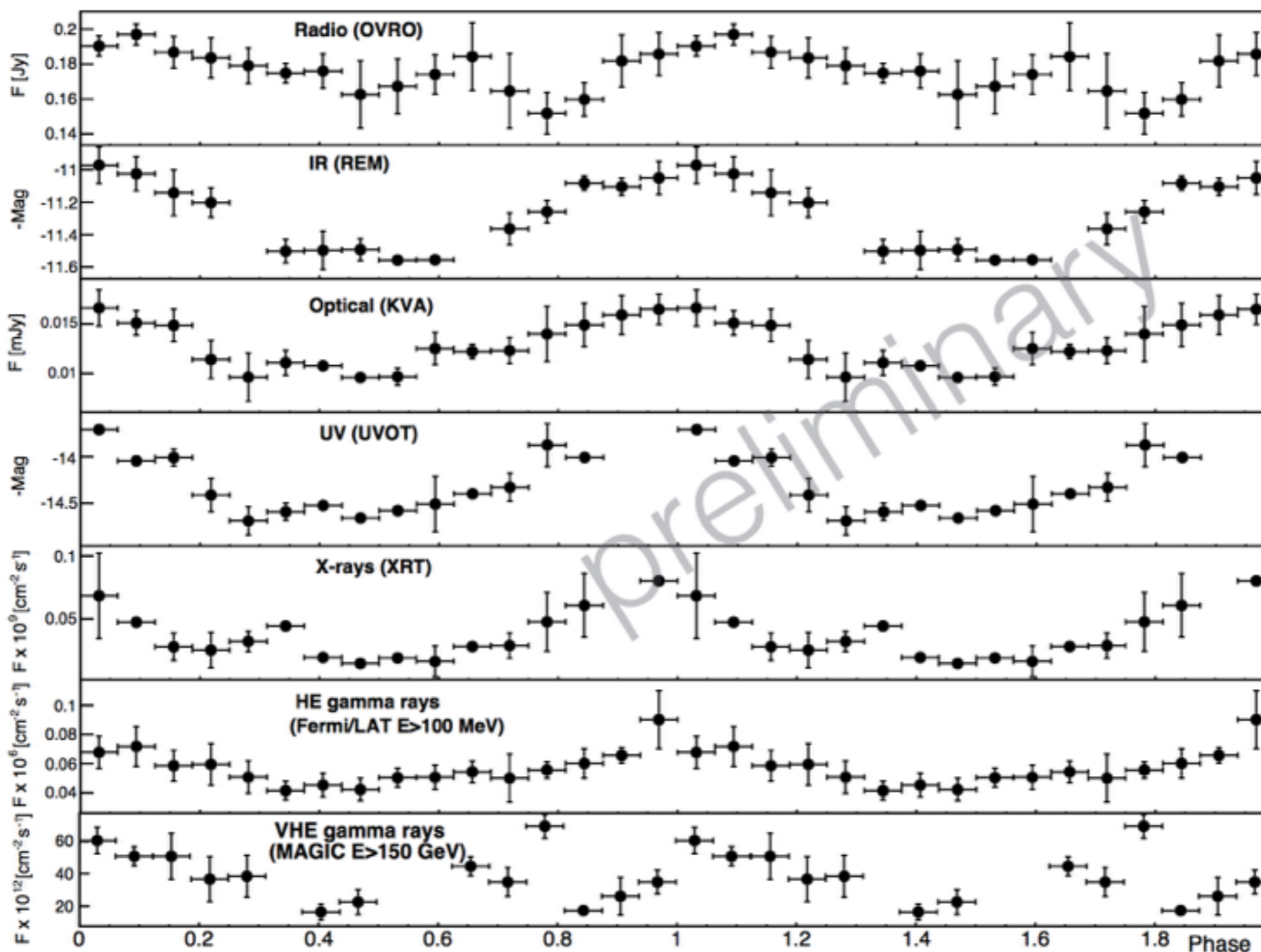 Possibly on short time scales

- Broad peak in the DCF
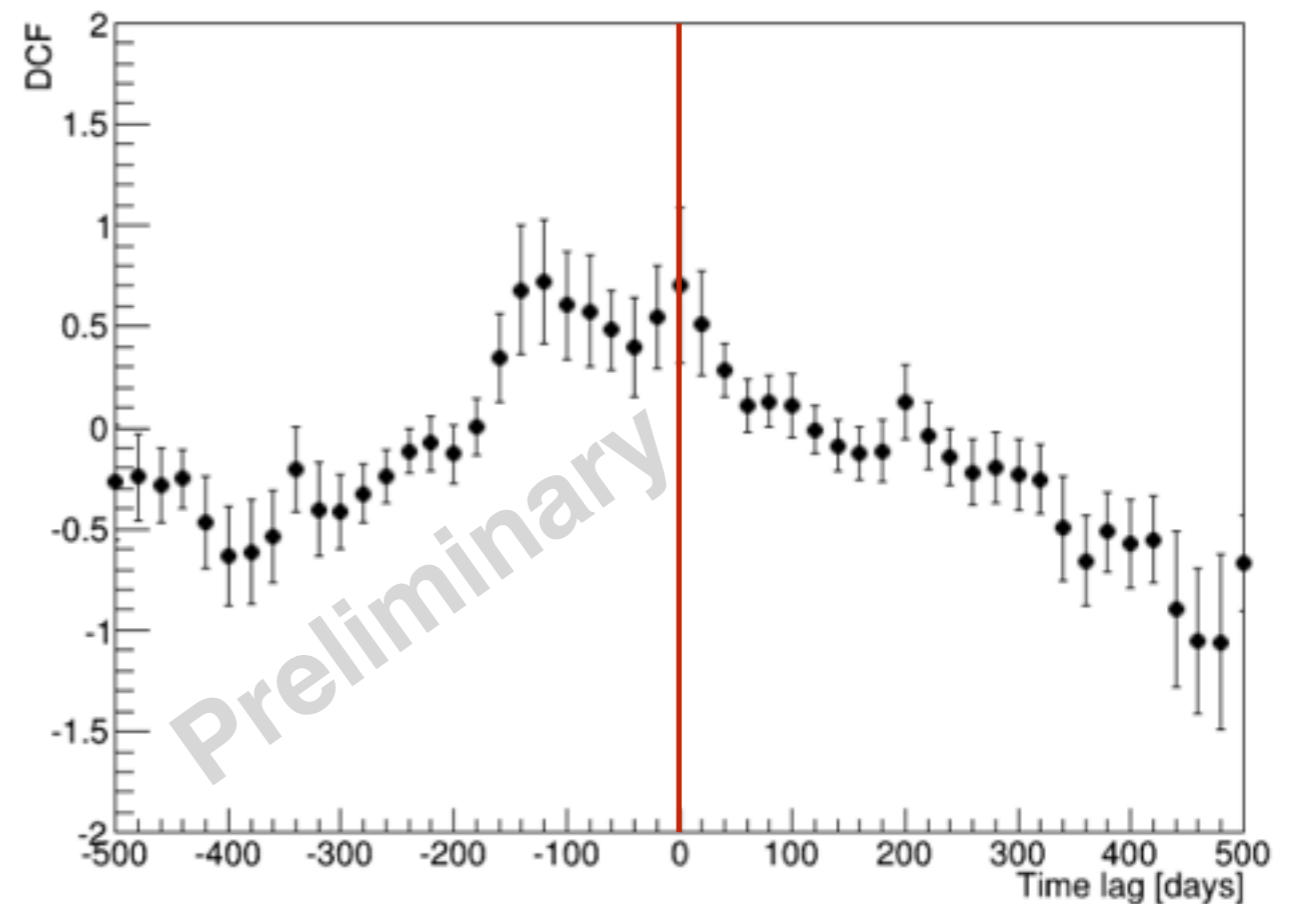
Correlations: MAGIC vs XRT

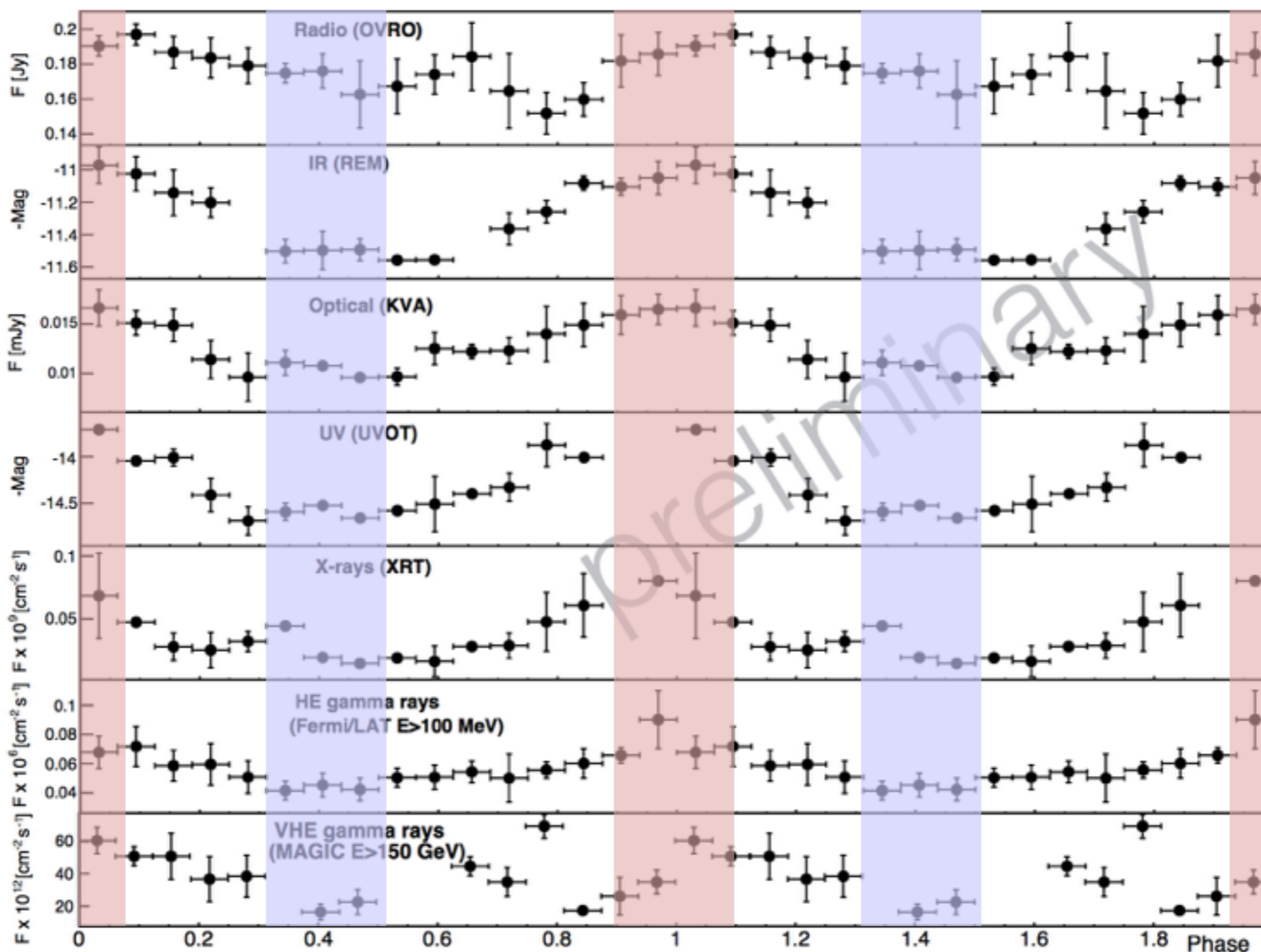- DCF is not useful as LC are not well sampled

Folded MWL Light Curve

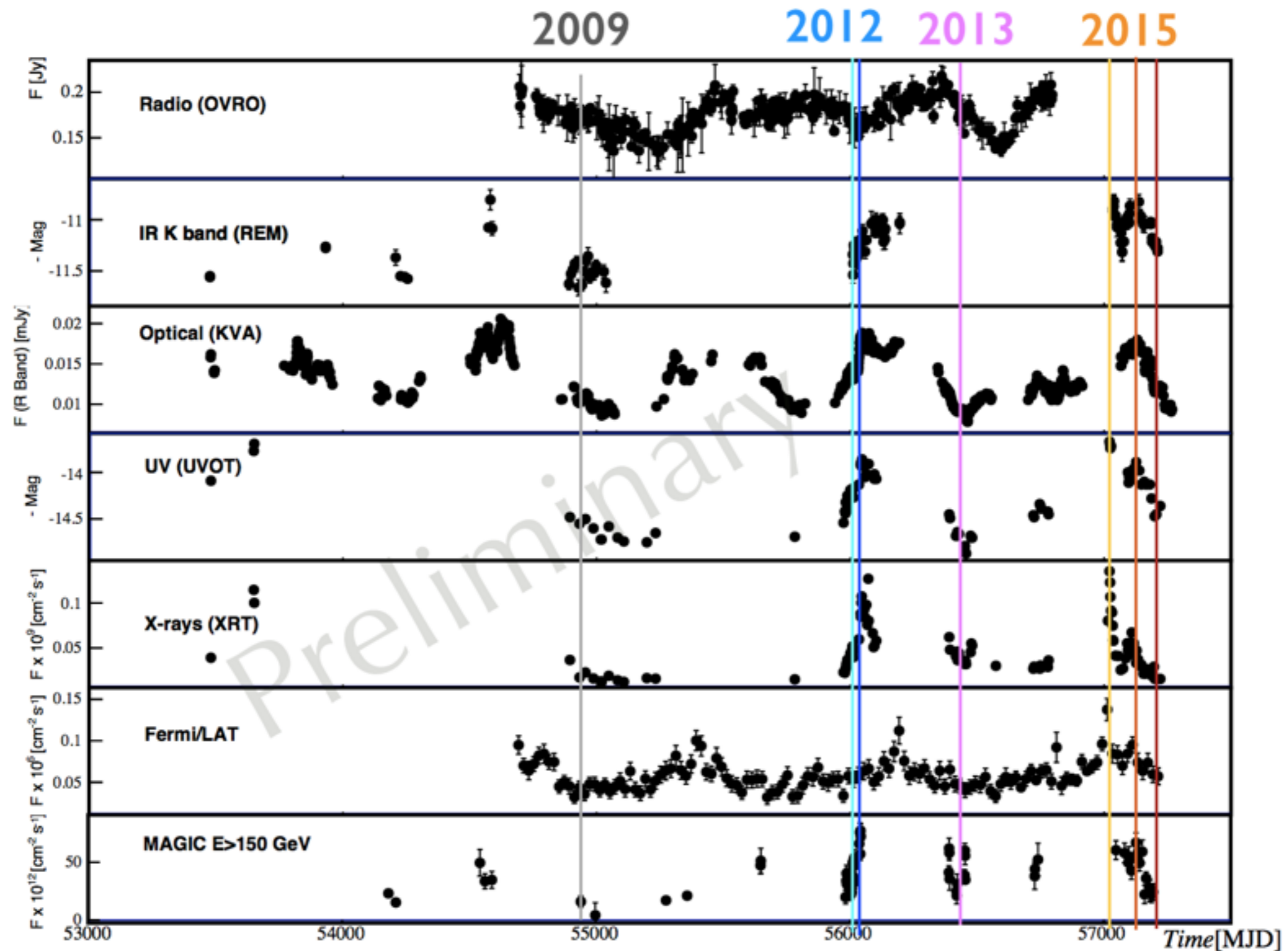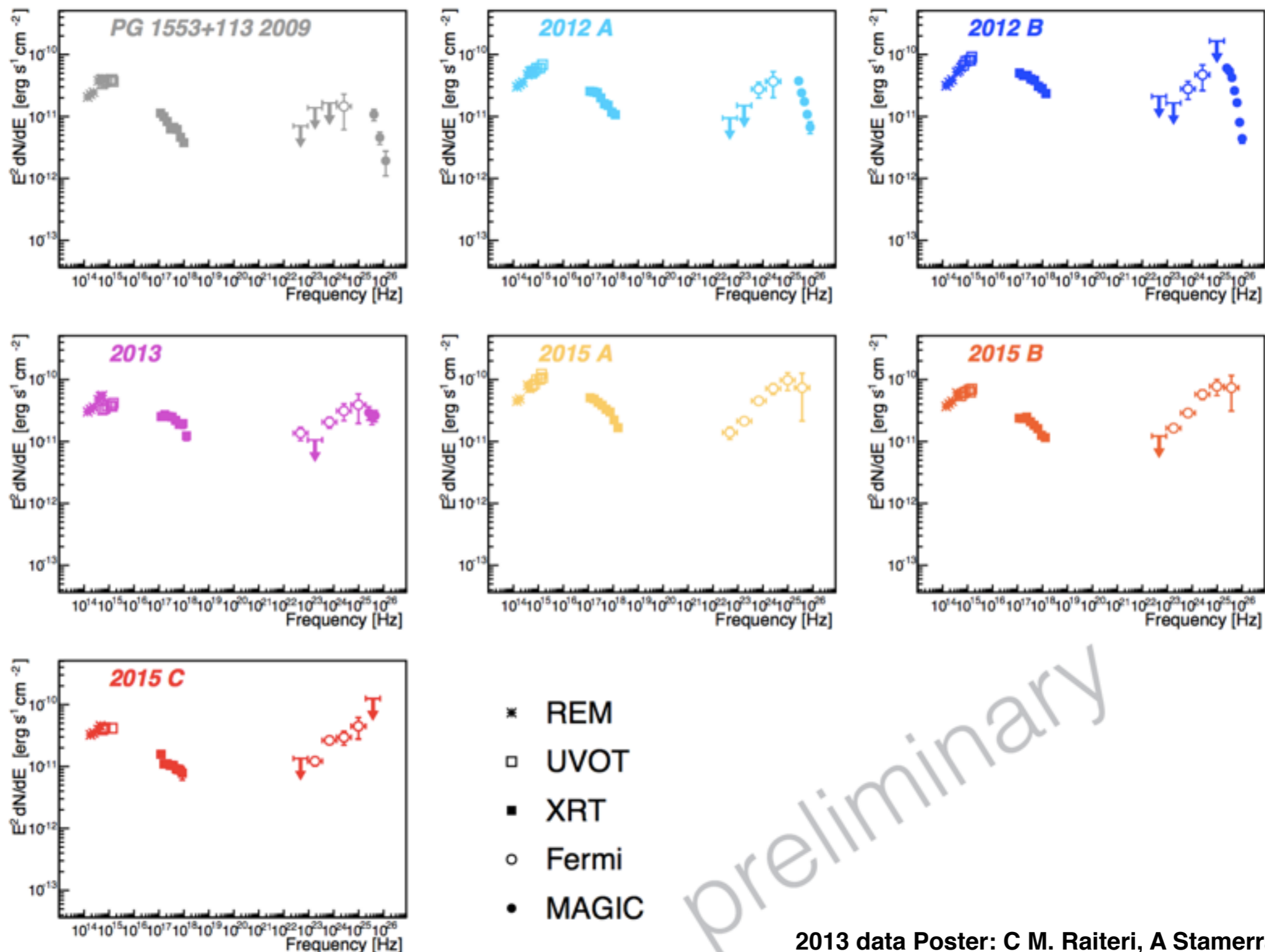- Fold the light curves using the Fermi/LAT period: 798 days

Folded MWL Light Curve

- Fold the light curves using the Fermi/LAT period: 798 days
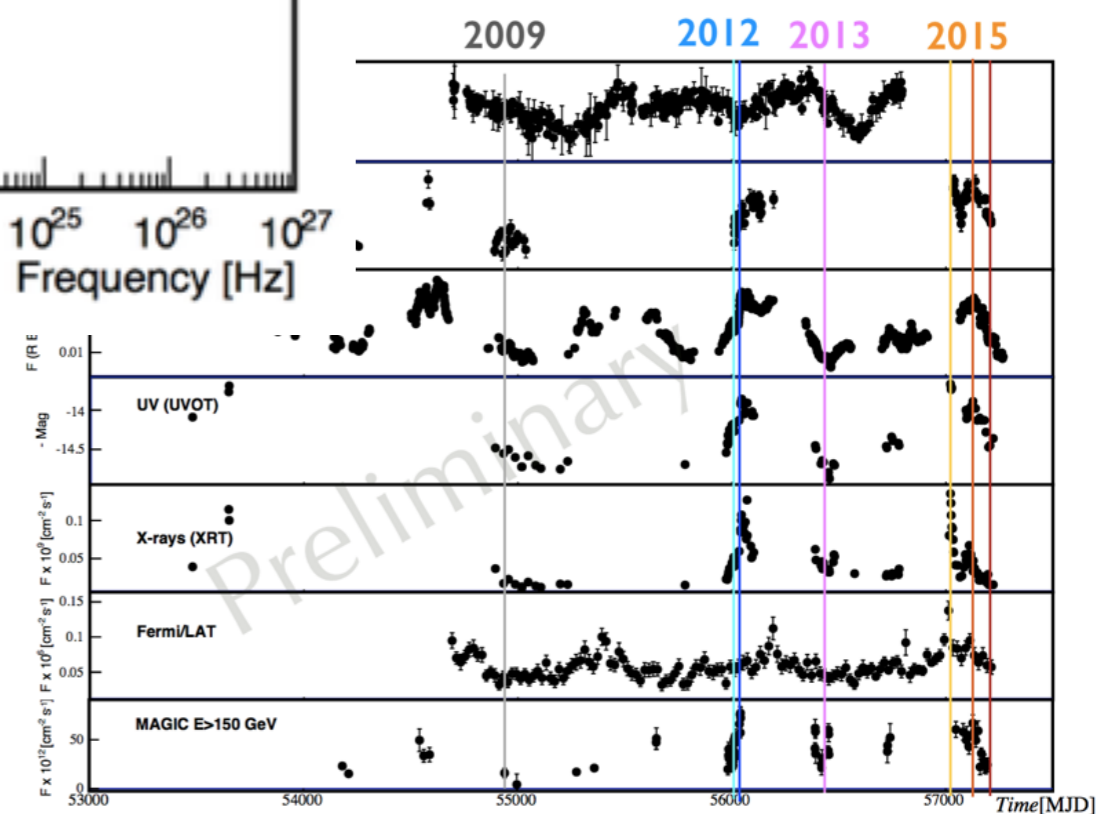
Selected Dates for SED

Spectral Energy Distribution

REM
UVOT
XRT
Fermi
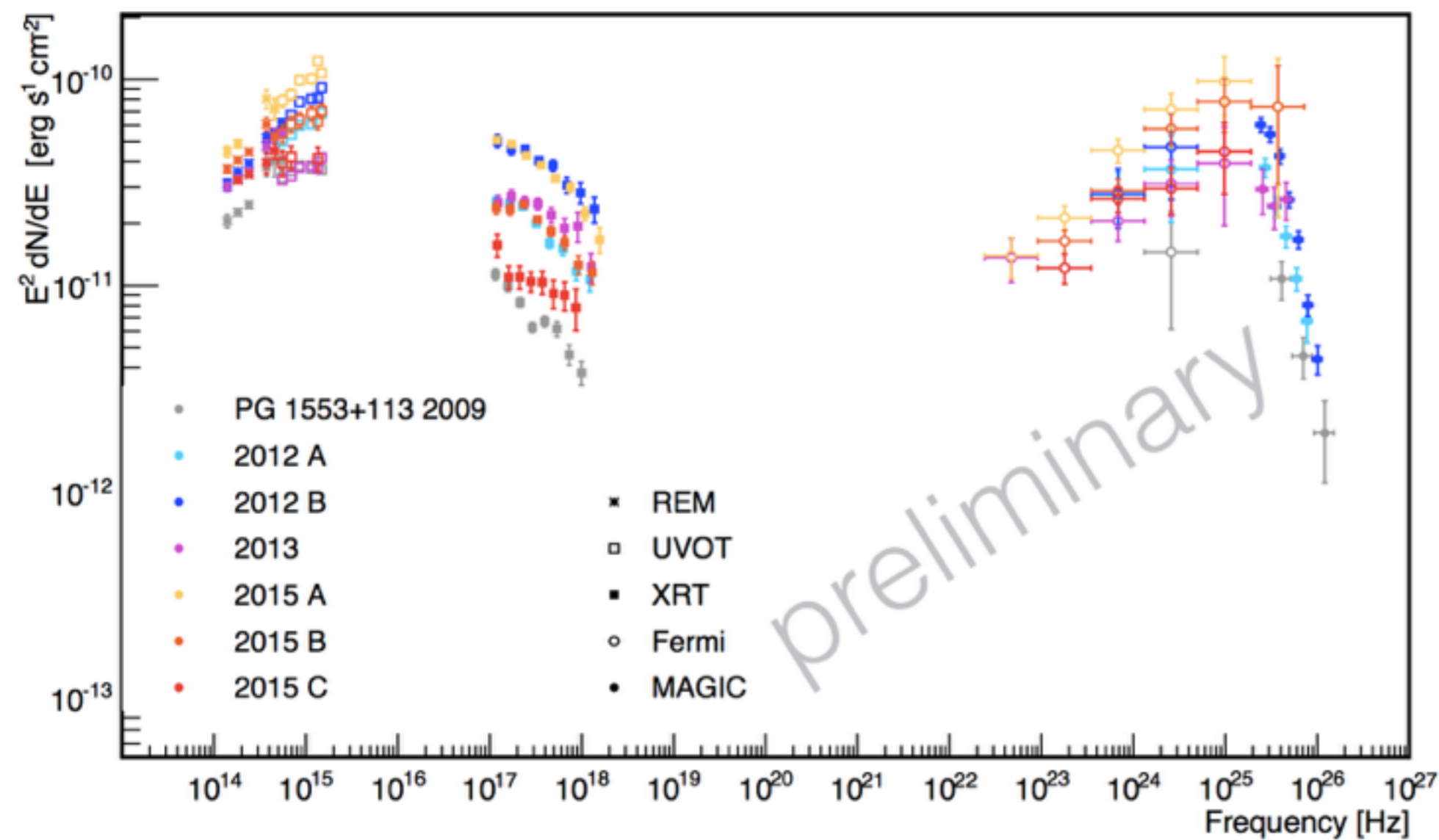MAGIC

2013 data Poster: C M. Raiteri, A Stamerra, M Villata

Spectral Energy Distribution

Conclusion and Outlook

- Long period and uneven sampling makes searching for the signal difficult

- Hints of correlation between
  IR-UV and Optical/X-ray - Gamma rays

- No evidence of time lags, part from radio

- Dedicated campaign involving more instruments, including VERITAS and HESS

- Polarisation data has also been collected analysis in progress

- This is a first step, more data and lots work required.