A Model for the Polarization Angle Swing and Gamma-Ray Flare in 3C279

Haocheng Zhang

Collaborators: Xuhui Chen (DESY, Germany)

Markus Boettcher (NWU, South Africa)

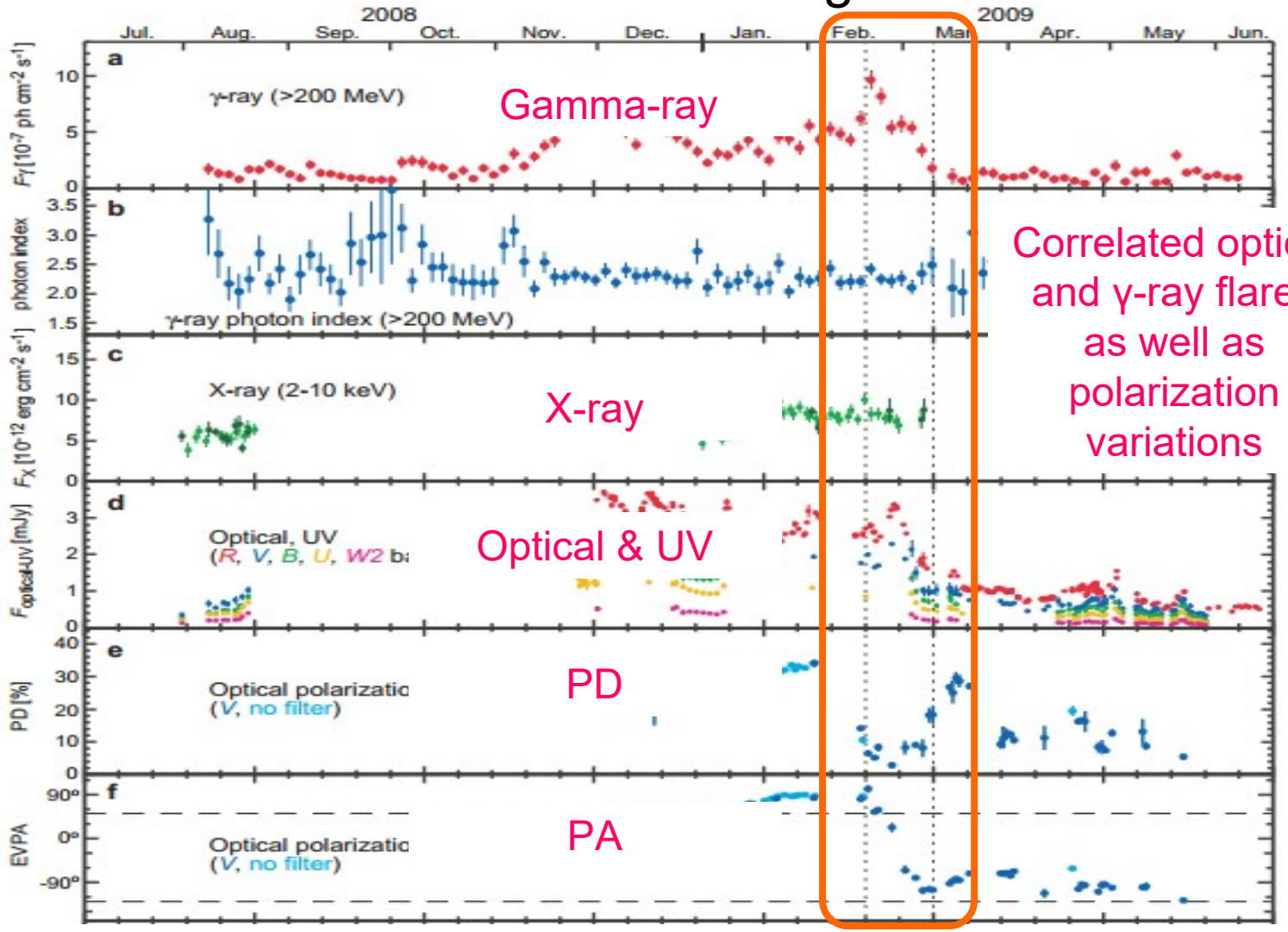
Fan Guo (LANL)

Hui Li (LANL)

Nov 11, 2015

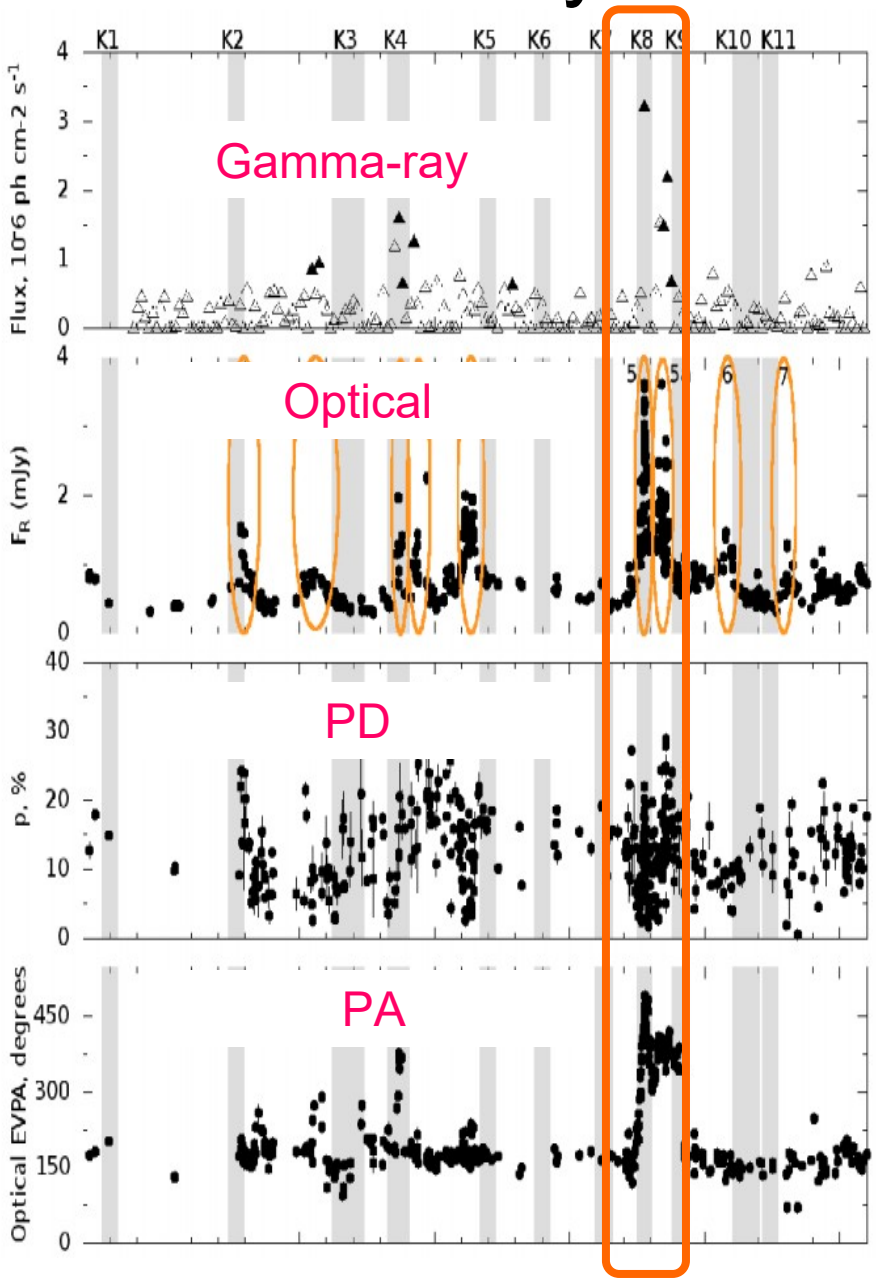
Blazar Variability and Polarization

1. Multiwavelength flares – particle acceleration?
2. Polarization variations – role of magnetic field?

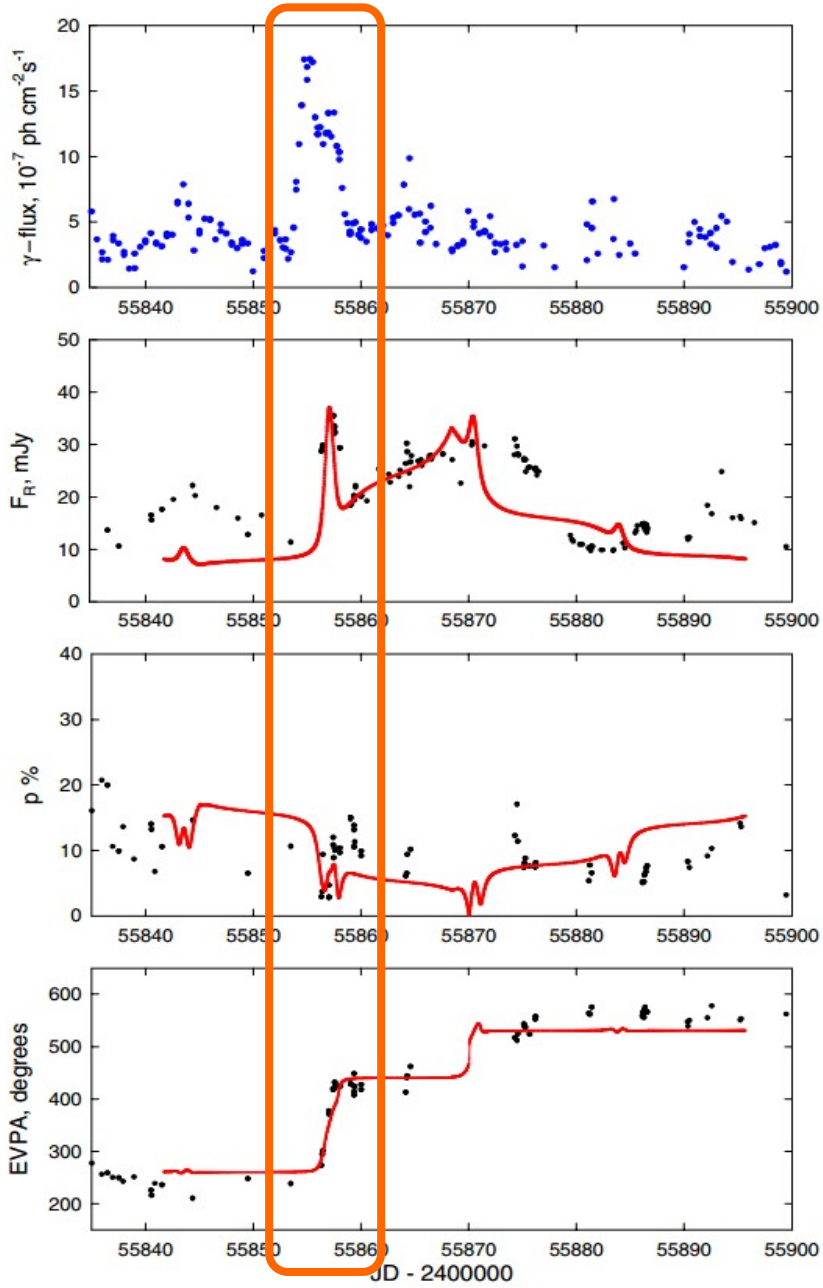


Abdo et al. 2010, Nature 463, 919

Blazar Variability and Polarization



Morozova et al. 2014, AJ 148, 42



Larionov et al. 2013, ApJ 768, 40

Issues in Theoretical Models

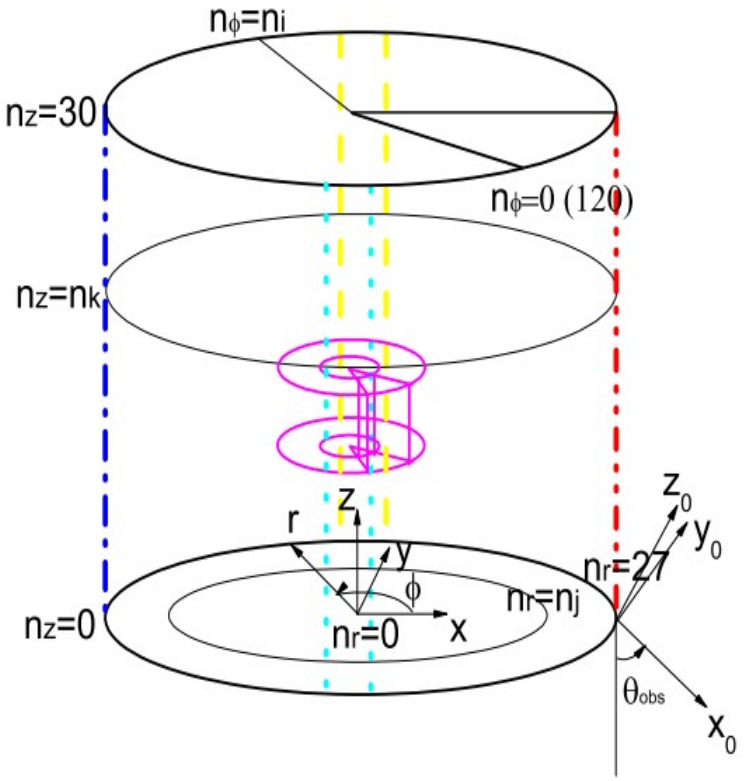
1. Models on polarization signatures usually ignore detailed radiation transfer and particle evolution, thus only qualitatively describe the polarization variations

2. Most detailed radiation models with particle evolution simply apply a chaotic magnetic field and do not consider any magnetic field evolution

3. We need a comprehensive tool to simulate the polarization-dependent radiation with time and frequency dependencies!

3DPol Code

The code takes magnetic field and particle population as inputs for each zone, then calculate Stokes parameters for all of them, finally add up incoherent Stokes parameters arrive to the observer at the same time



Advantage:

1. Easily couple with MHD, particle evolution

2. Full 3D polarization calculation

3. Detailed polarization-dependent radiation transfer

4. Include all light travel time effects

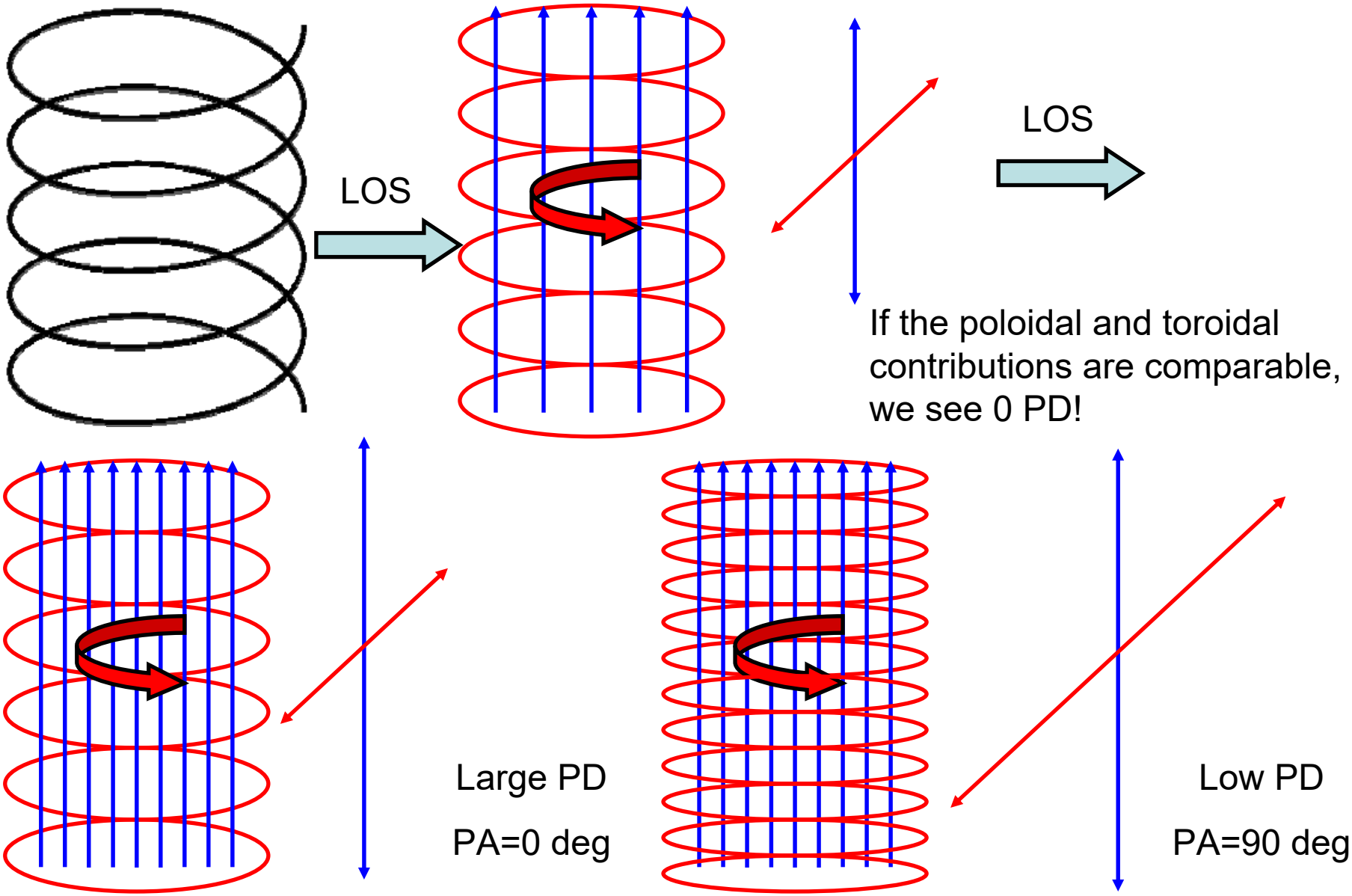
5. Time-, space- and frequency-dependencies

Zhang et al. 2014, ApJ 789, 66

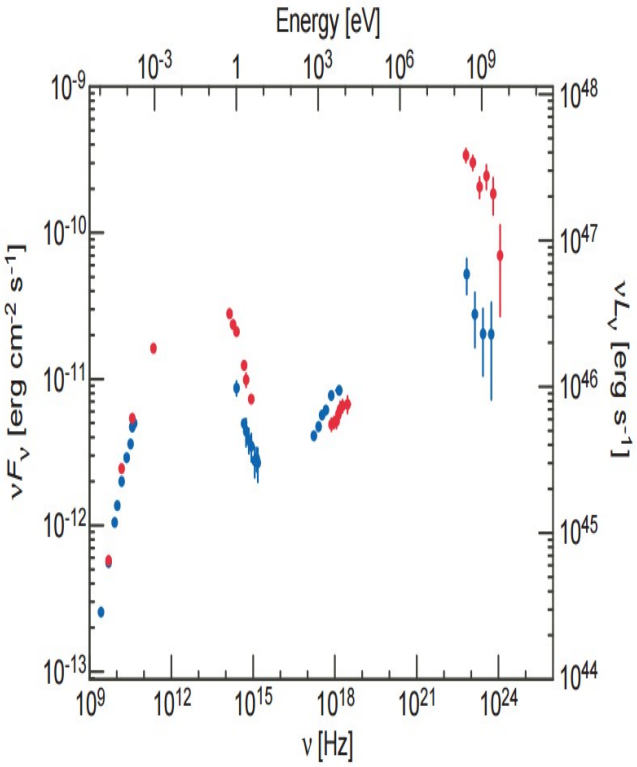
Polarization

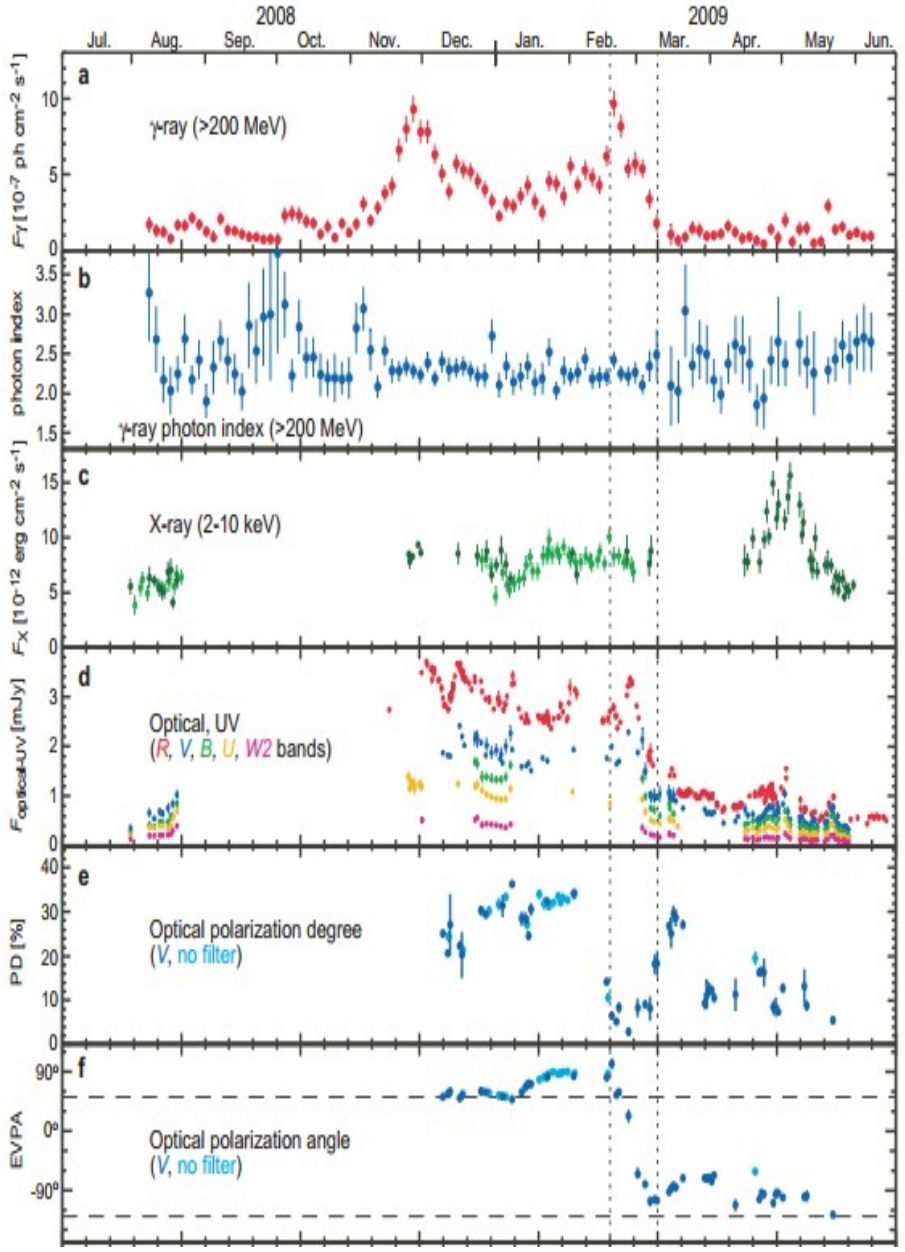
Common Sense: <10% PD means strong turbulence

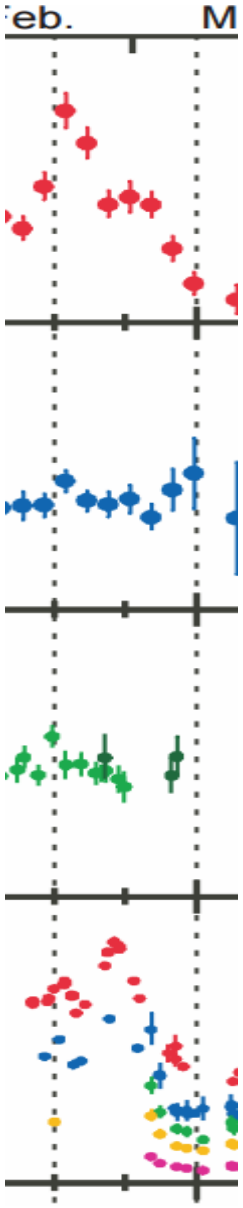
Not true!



3C 279 data



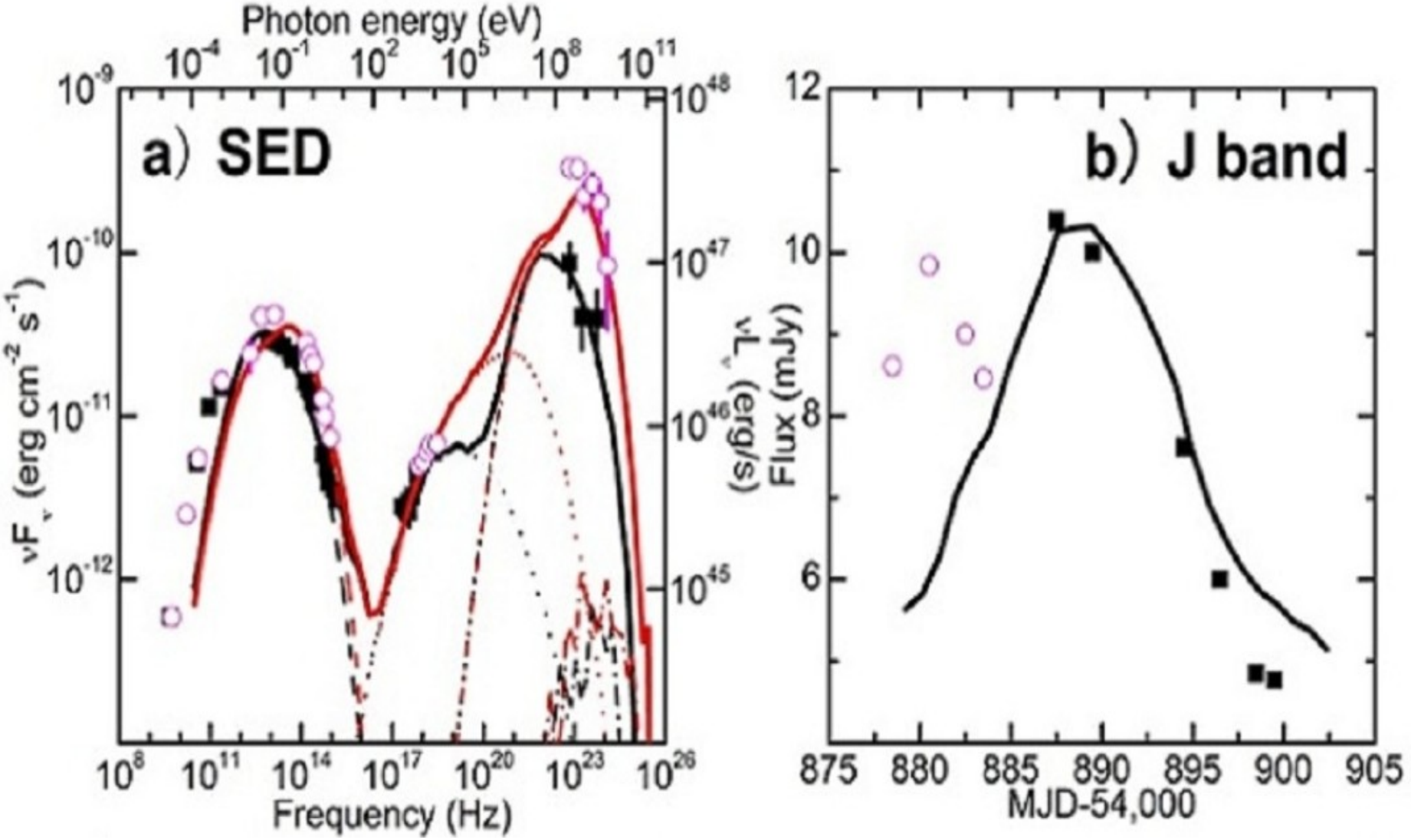




Abdo et al. 2010, Nature 463, 919

3C 279 Fittings

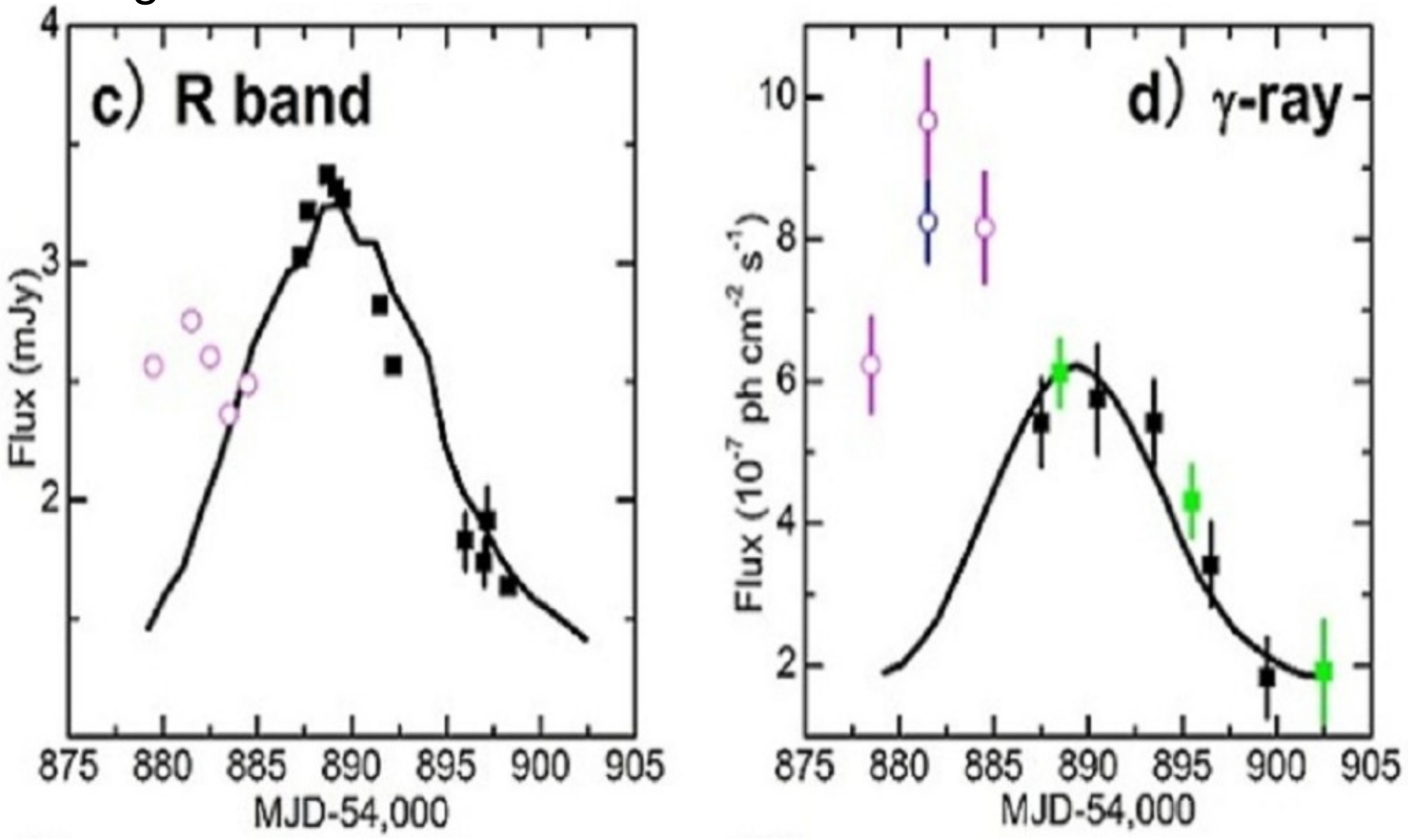
1. Gamma-ray due to EC – excess in nonthermal particles



Zhang et al. 2015, ApJ 804, 58

3C 279 Fittings

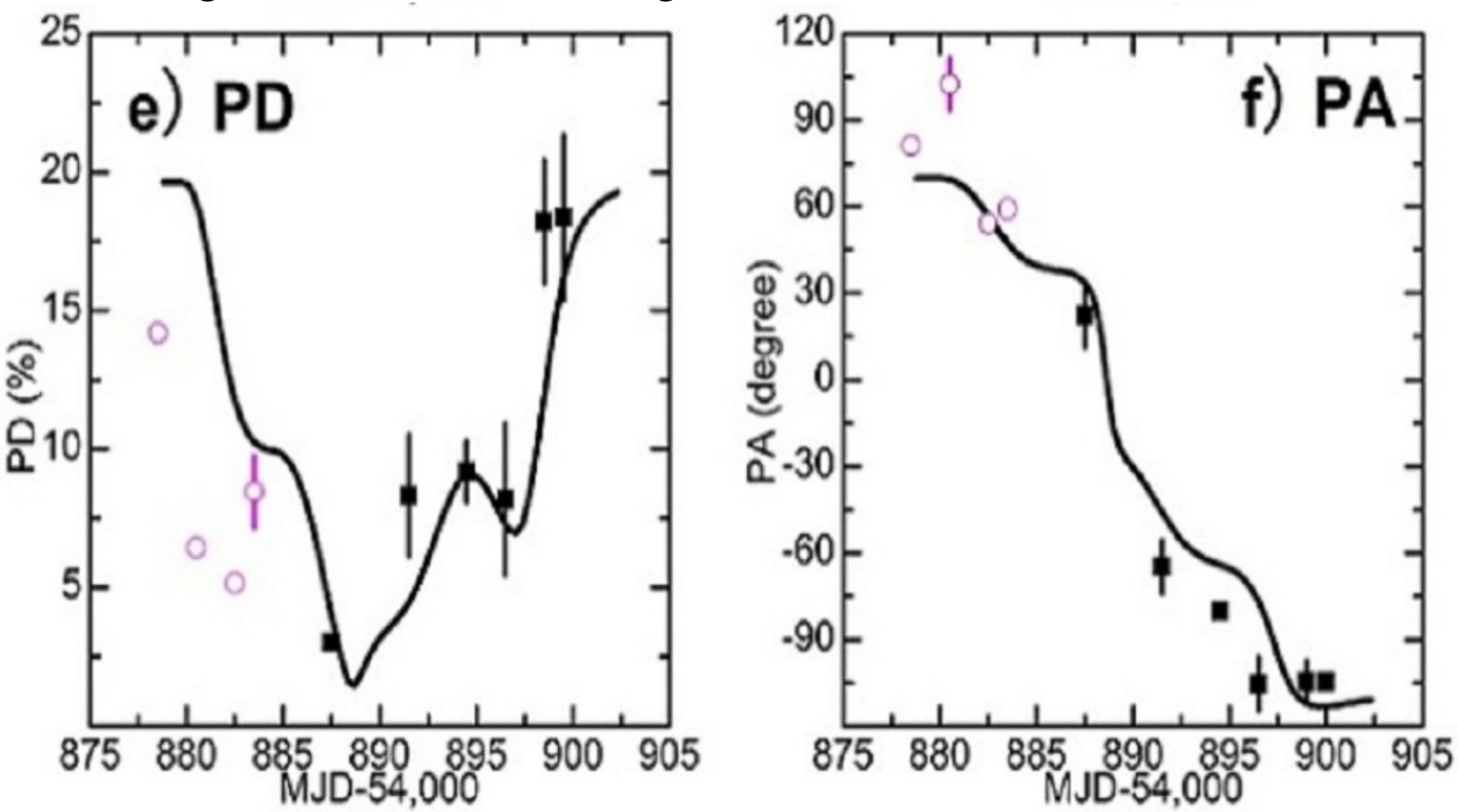
2. Higher gamma-ray flare level than optical – decrease in magnetic field



Zhang et al. 2015, ApJ 804, 58

3C 279 Fittings

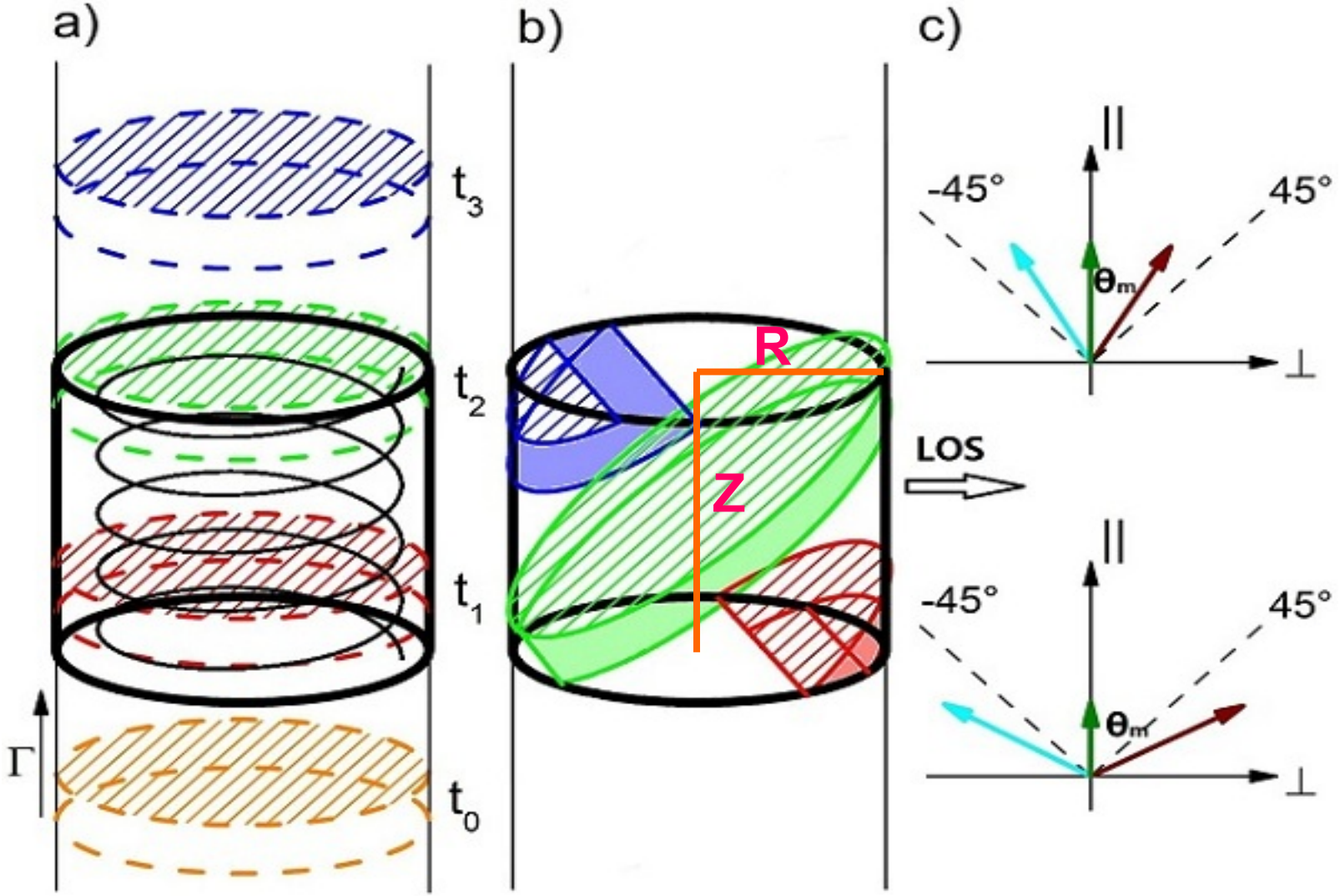
3. Smooth PA rotation and PD drops from 20% to 0 at peak – comparable poloidal and toroidal contributions and stronger turbulence during flare



Zhang et al. 2015, ApJ 804, 58

Light Travel Time Effects

No asymmetric structure is necessary to produce the 180 deg PA rotation!



Zhang et al. 2015, ApJ 804, 58

Summary

1. We build a 3DPol code featuring polarization-dependent emission with time-, space-, and frequency-dependence

2. 180 deg PA rotation can be produced from an axisymmetric straight jet without the assumption of any asymmetric structures

3. Multiwavelength spectra, light curves and polarizations signatures together can provide stringent constraints on the inner-jet information

4. Based on the fittings of 3C 279, magnetic energy dissipation can play an important role in the blazar flaring activities. Shock-initiated magnetic reconnection process is likely the driver of this event. Polarization signatures can help to distinguish the shock-driven and the magnetic-driven flares