光球面放射の数値シミュレーションから明らかにする米徳関係の起源

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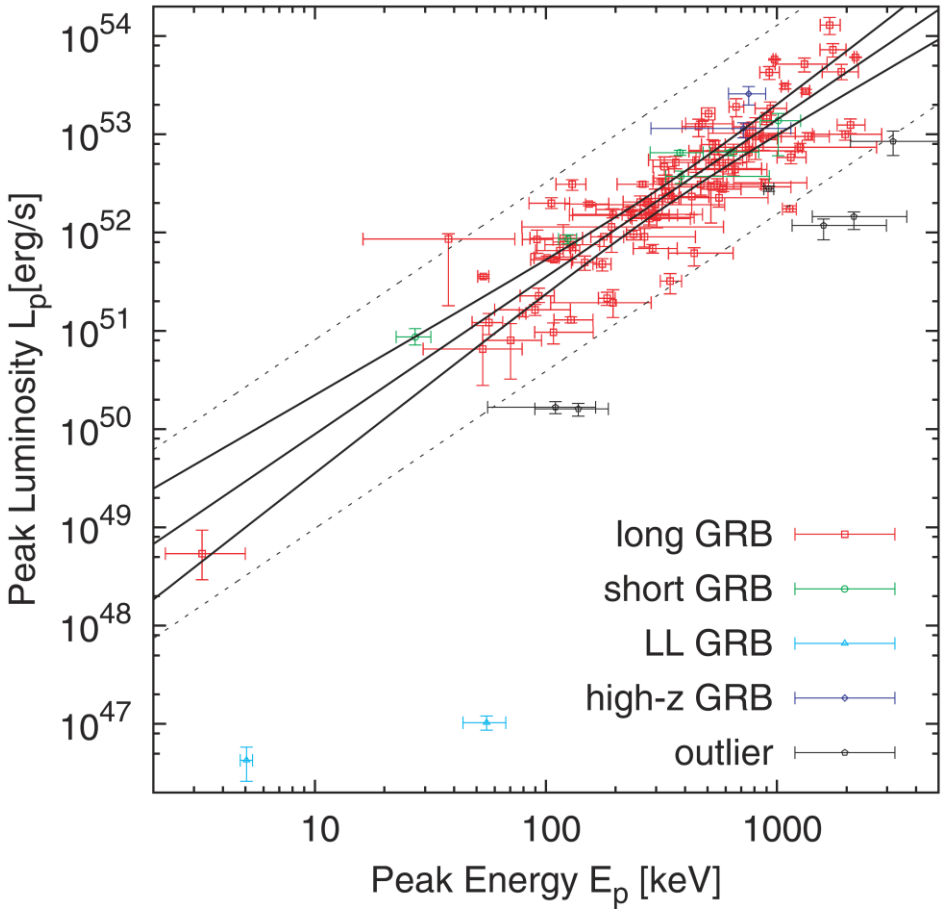
Yonetoku Relation

Tight correlation between E_p - L_p



$$L_{\rm p} = 10^{52.43\pm0.037} \times \left[\frac{E_{\rm p}(1+z)}{355\ {\rm keV}}\right]^{1.60\pm0.082}$$

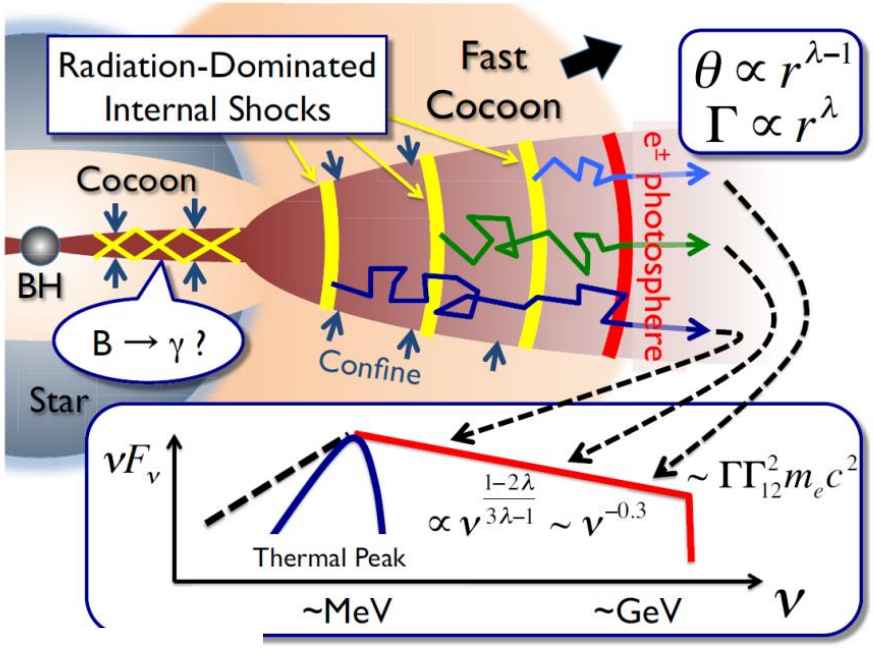
Yonetoku + 2004 ; 2010

Important for application to cosmology

Powerful diagnostic for emission mechanism

Photospheric Emission in GRB jet

Dynamics of Jet have significant effect on the radiation signature



Ioka+2011

Dynamics of Jet and Radiation transfer must be solved

Previous Studies

steady outflow or 1D model

Pe'er +2005,2006,2011; Giannios 2008; Beloborodov 2010,2011; Vurm+2011,2016; Lundman+2013,2014, Ito+2013,2014, Chhotray 2015

approximated treatment for radiation

Lazzati+2009,2011,2013; Mizuta+2011;Nagakura+2011; Lopez-Camara+2014

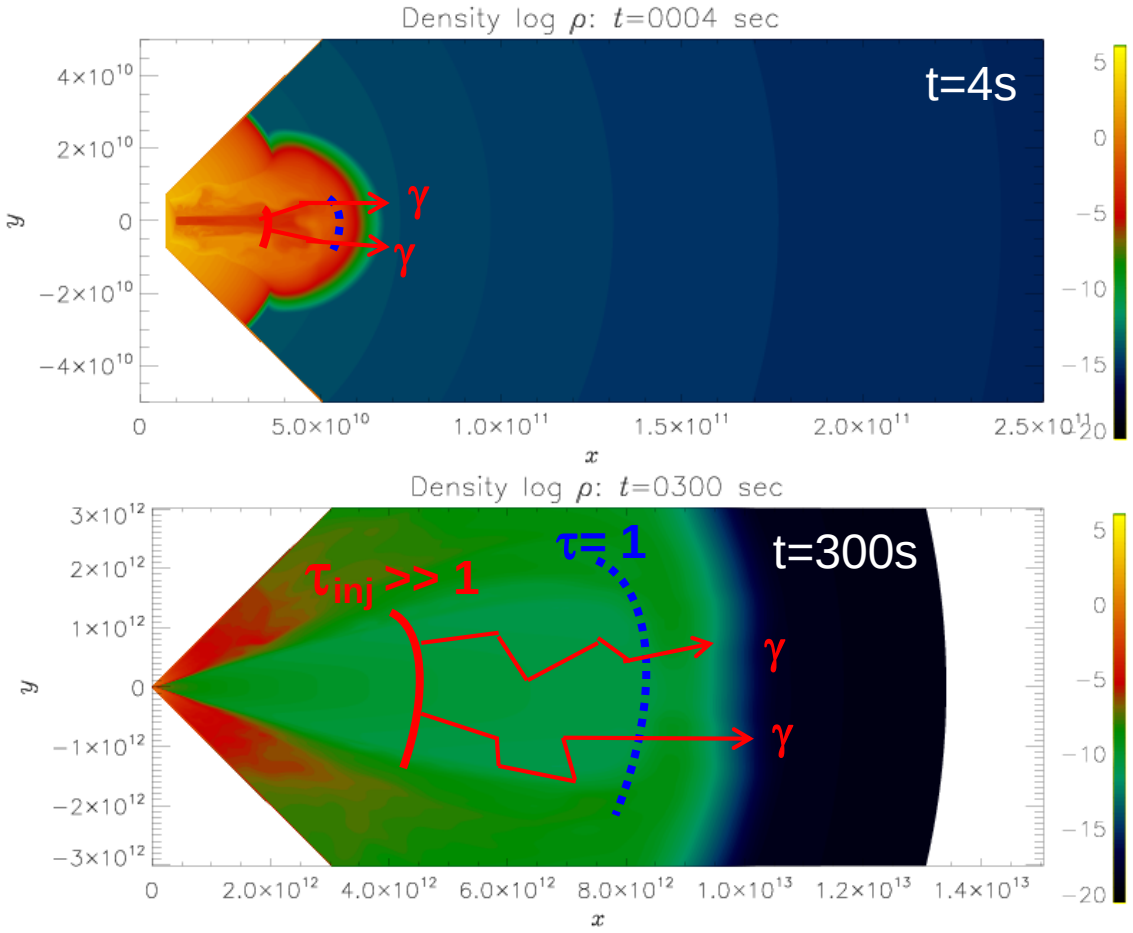
This Study

Radiation transfer calculation based on 3D hydrodynamical simulation

See also Lazzati 2016, Parsotan + 2017

3D relativisitic hydrodymaical simulation

Calculation of relativistic jet breaking out of massive progenitor star



Progenitor star

16TI（Woosley & Heger 2006）

M_* ~14Msun

R_* ~ 4×10^{10} cm

@presupernova phase

Jet parameter

$L_j = 10^{49}, 10^{50}, 10^{51}$ erg/s

$\theta_j = 5°$

$\Gamma_j = 5$

$\Gamma h = 500, 900$

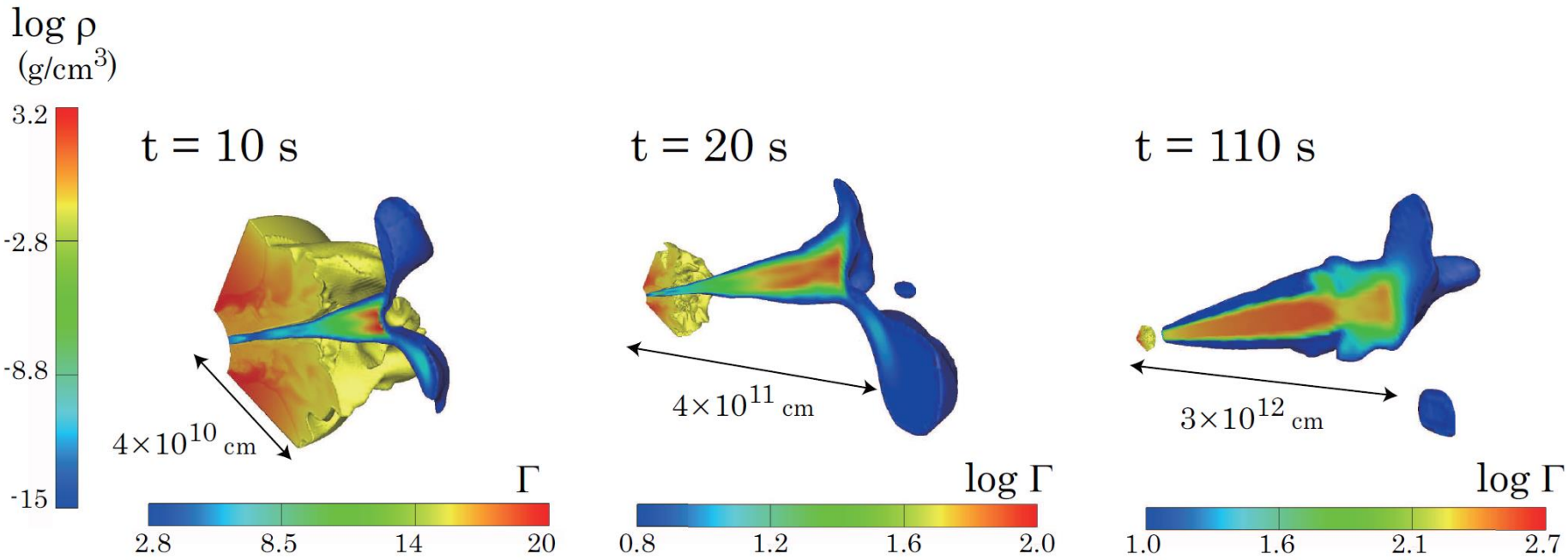
$R_{inj} = 10^{10}$ cm

3models with different power

Radiative transfer calculation

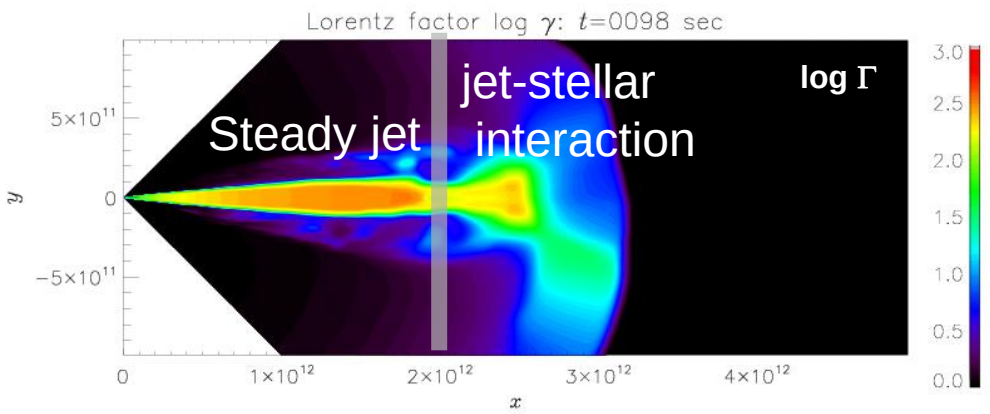
Propagation of photons are calculated until they reach optically thin region

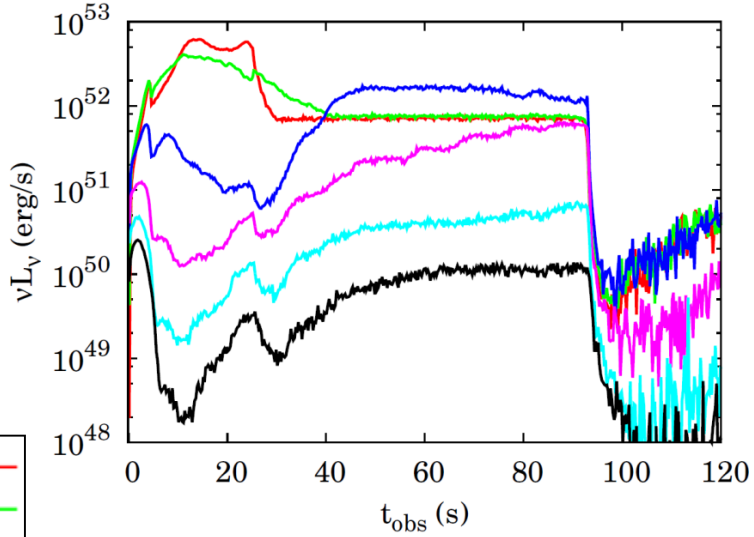
fiducial model $L_j = 10^{50}$ erg/s

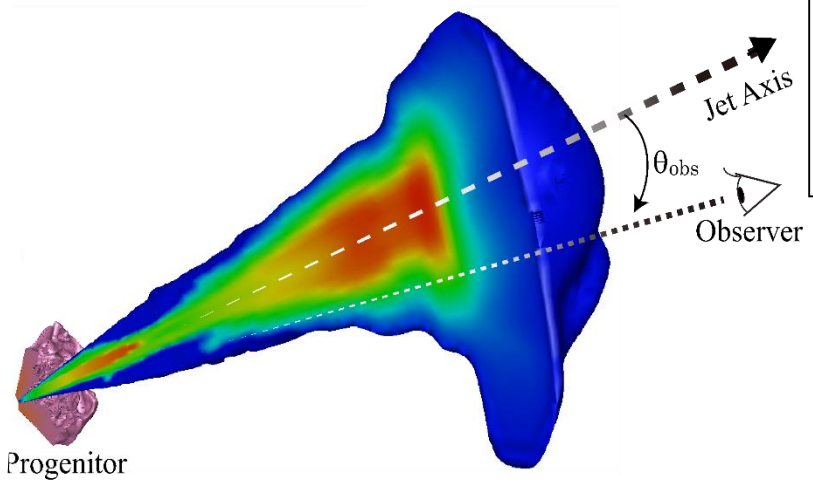


Ito + 2015

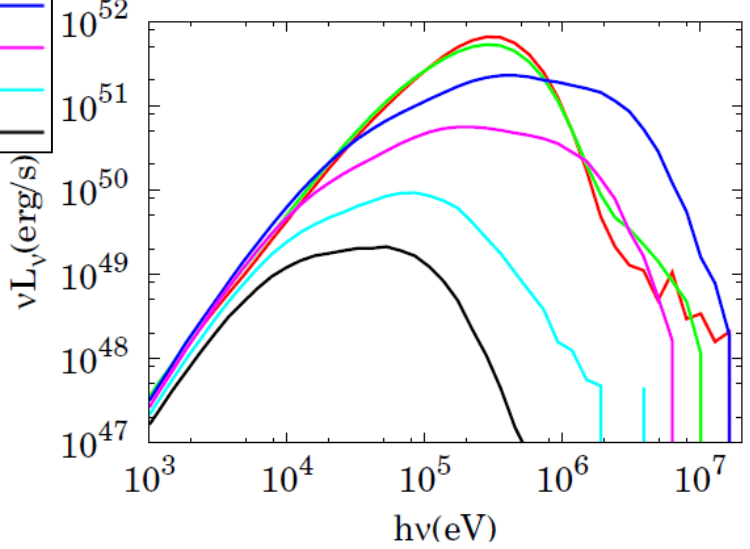
fiducial model $L_j = 10^{50}$ erg/s



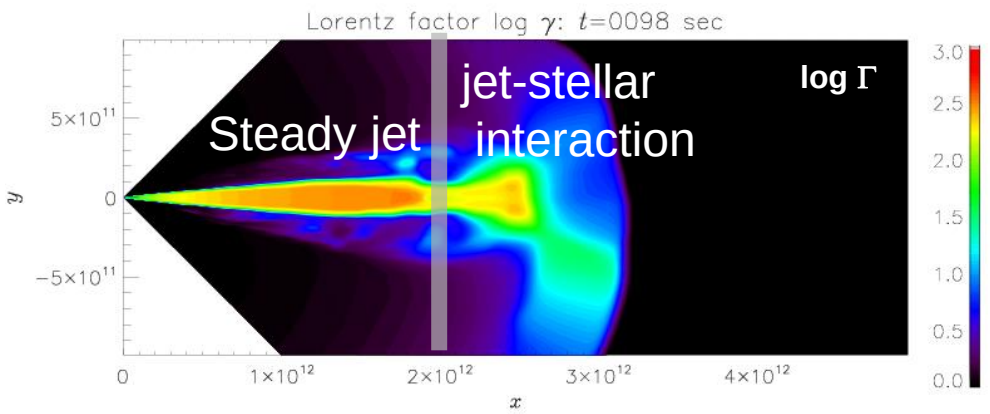


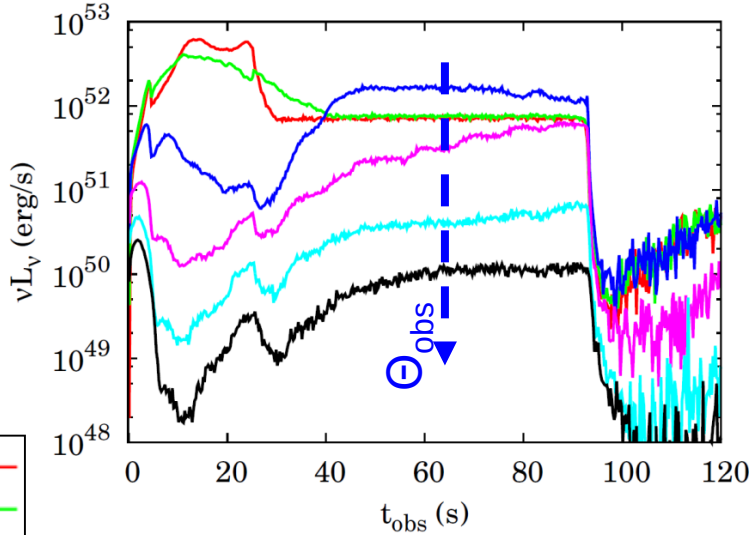


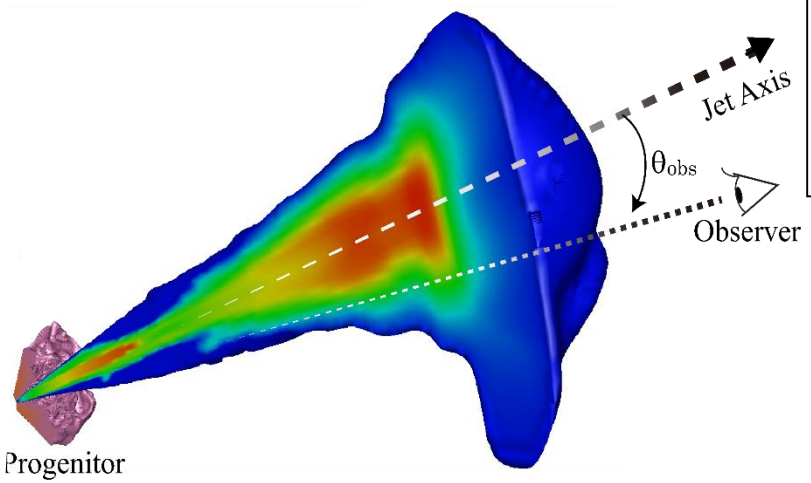
θobs=0°
θobs=2°
θobs=4°
θobs=6°
θobs=8°
θobs=10°

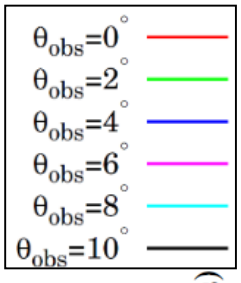


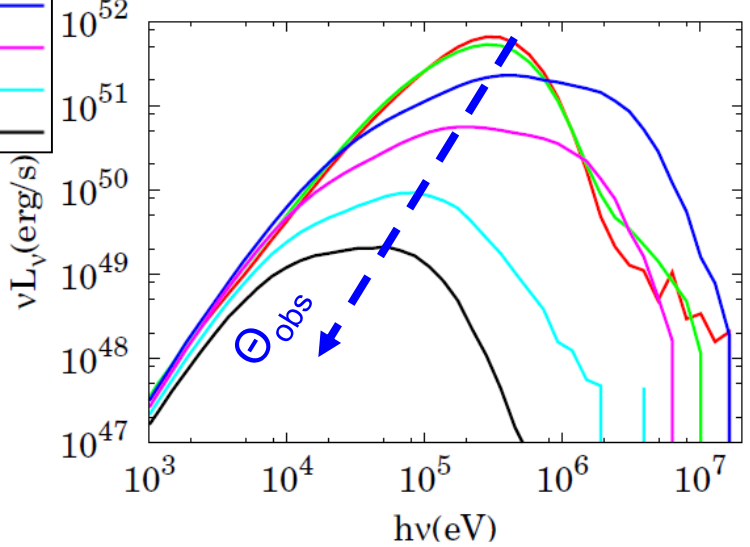
fiducial model $L_j = 10^{50}$ erg/s





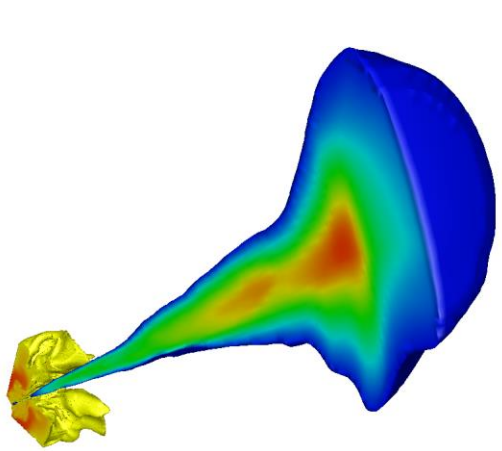


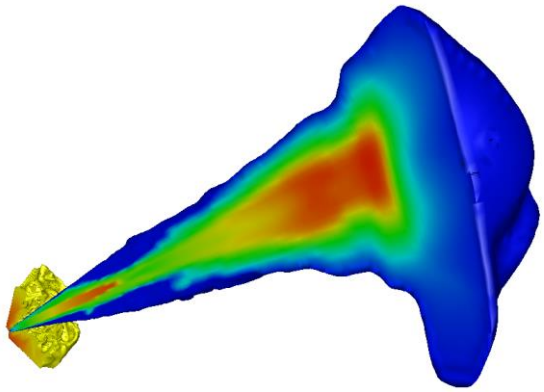


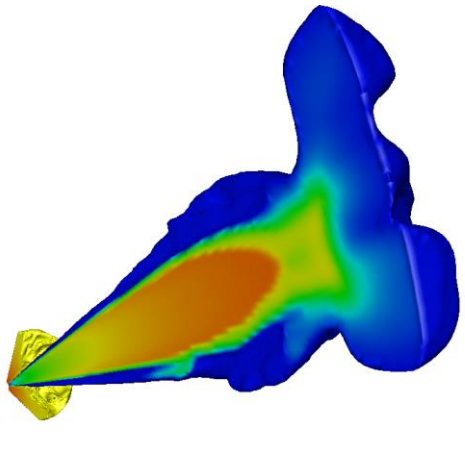


E_p & L_p decline as Θ_{obs} increases

Dependence on jet power







$L_j = 10^{49}$ erg/s

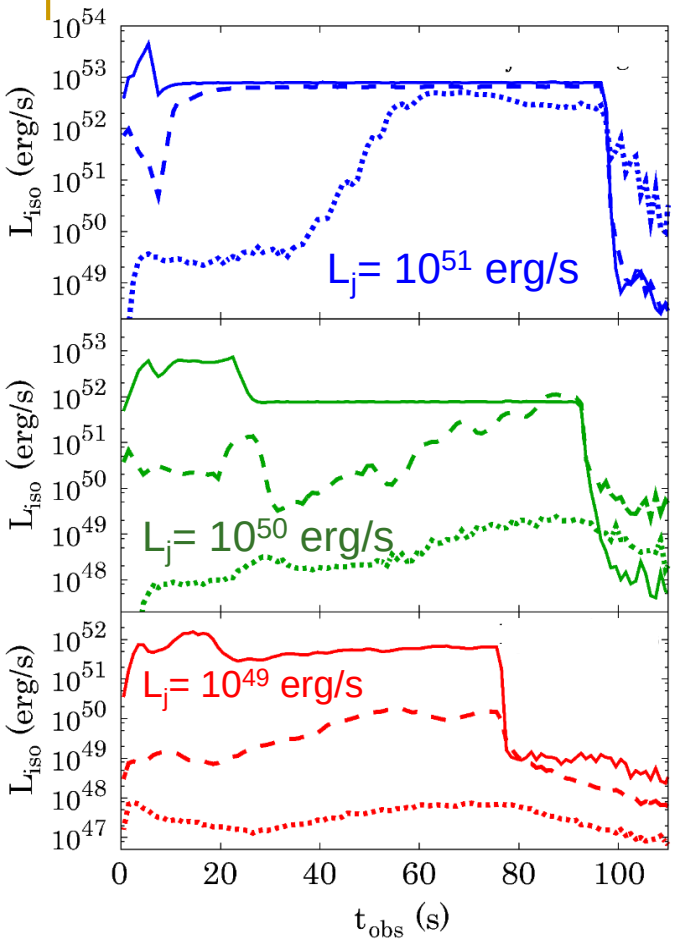
$L_j = 10^{50}$ erg/s

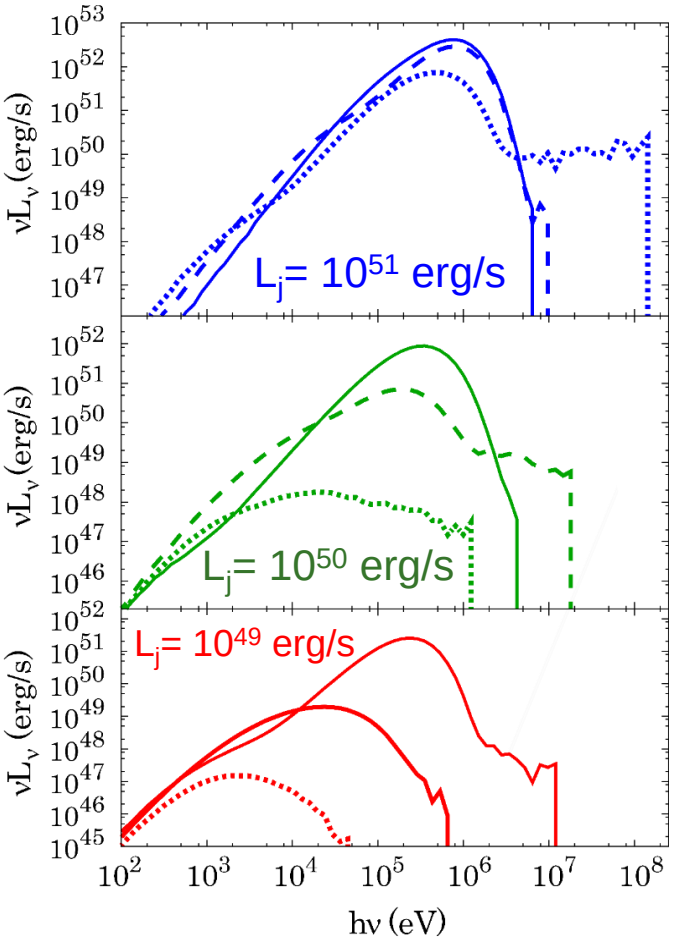
t=40s

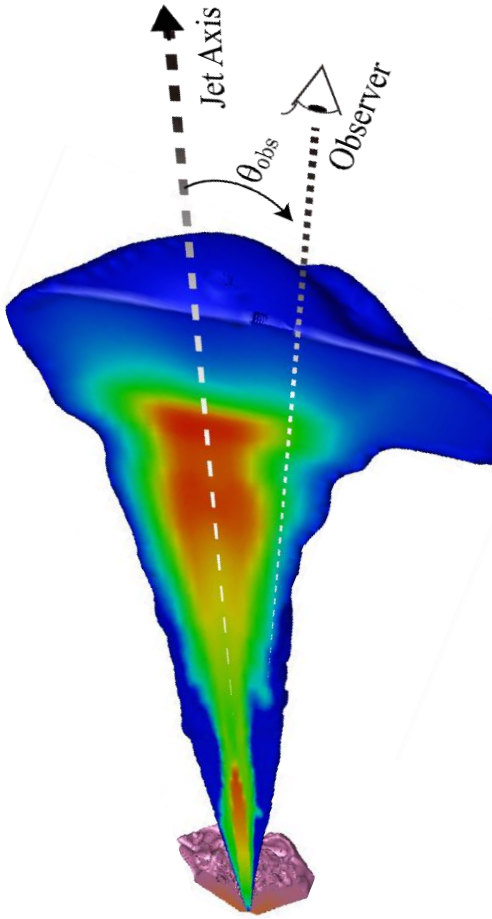
$L_j = 10^{51}$ erg/s

Ito + 2017, submitted

Dependence on jet power



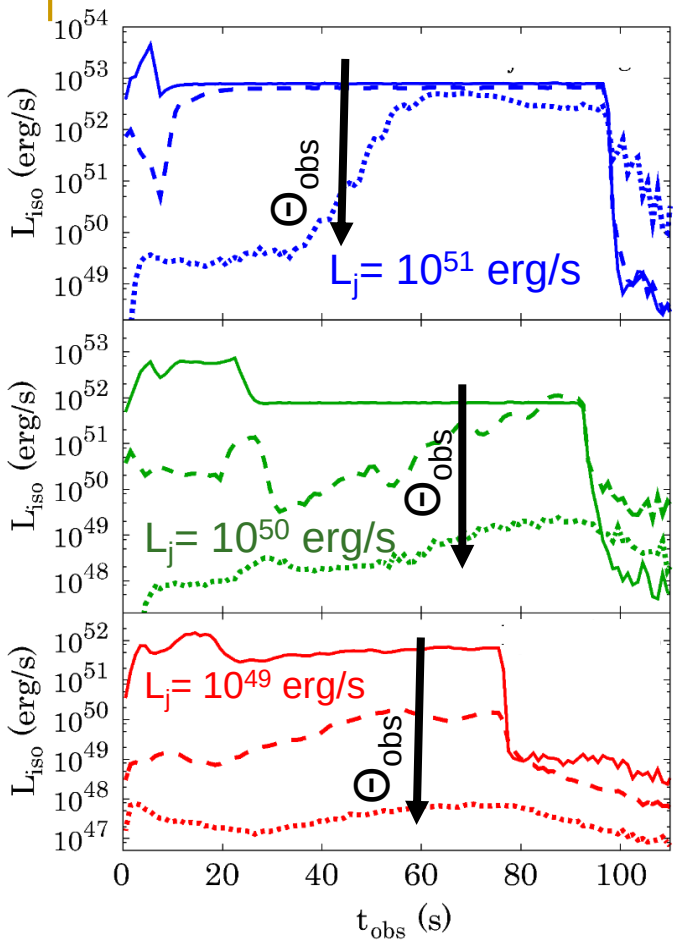


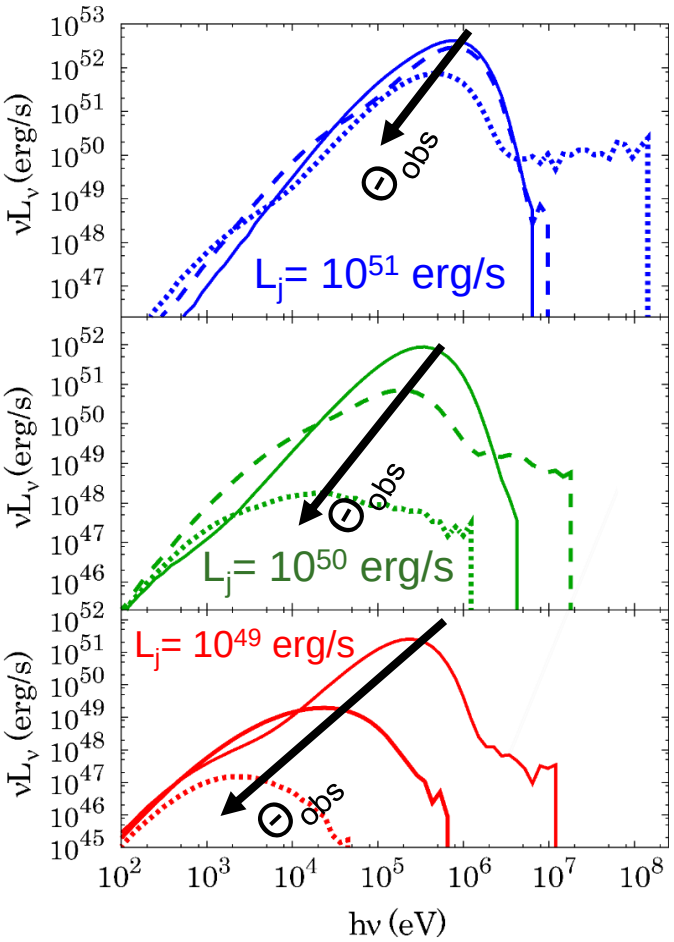


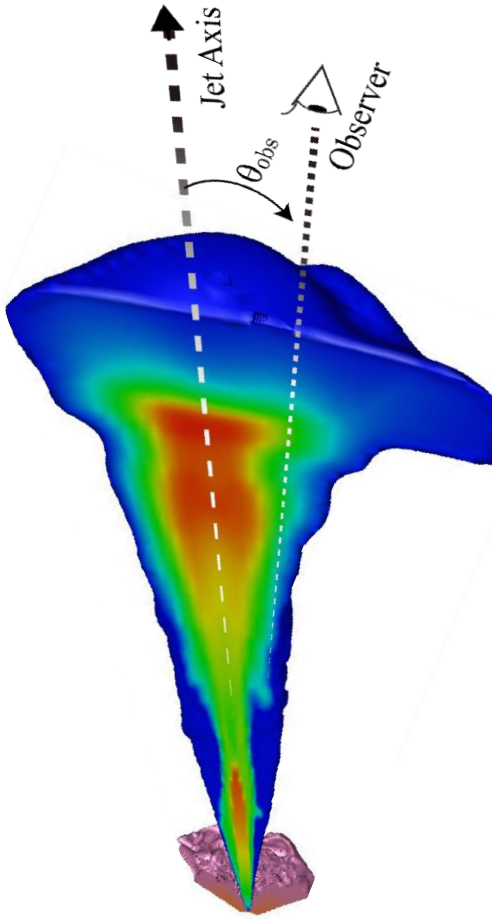
Θ_{obs} = 0° Θ_{obs} = 5° Θ_{obs} = 10°

L_p & E_p are systematically higher for higher L_j

Dependence on jet power





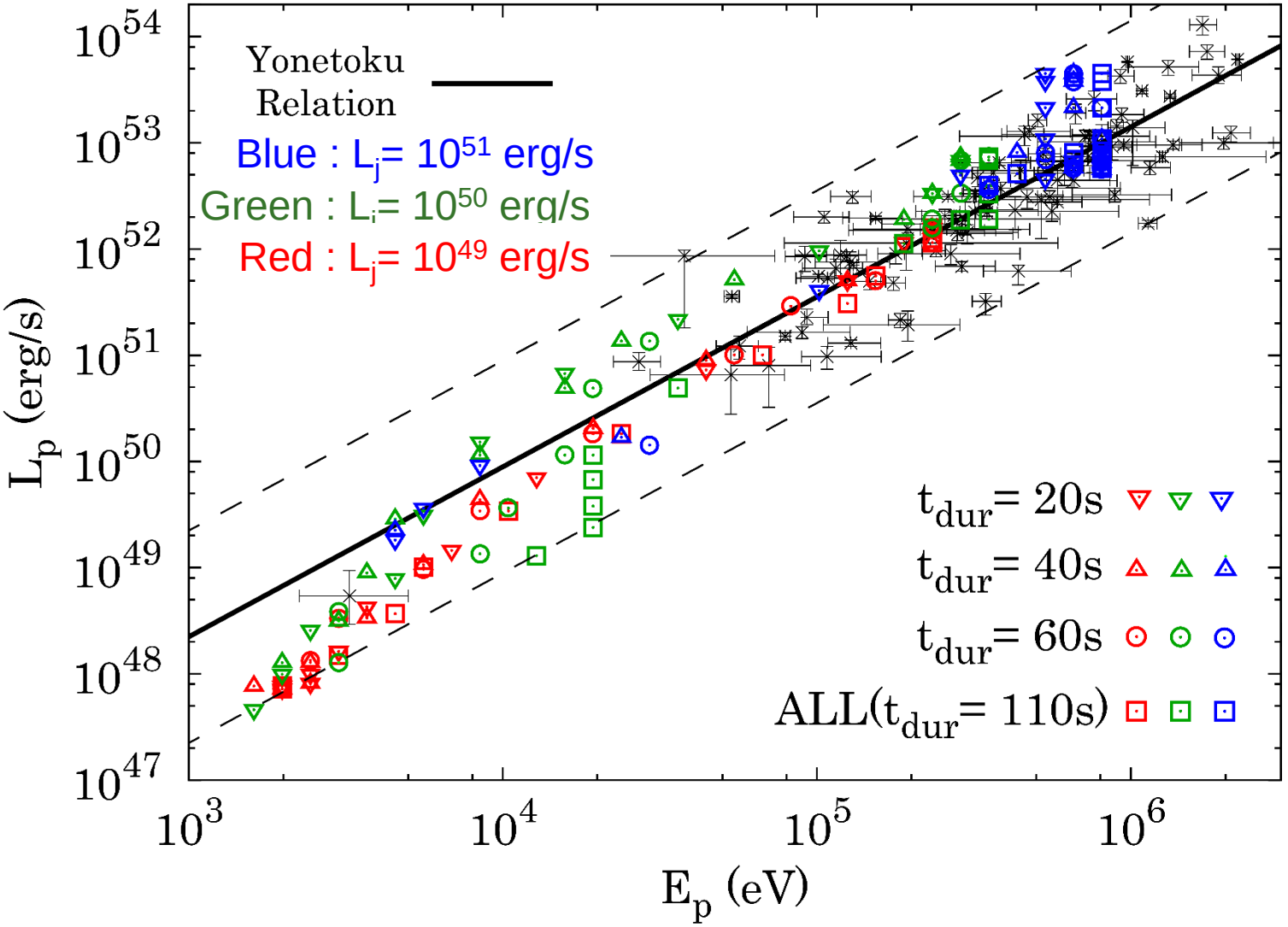


Θ_{obs} = 0° Θ_{obs} = 5° Θ_{obs} = 10°

E_p & L_p decline as Θ_{obs} increases

lateral structure of jet induces the viewing angle dependence

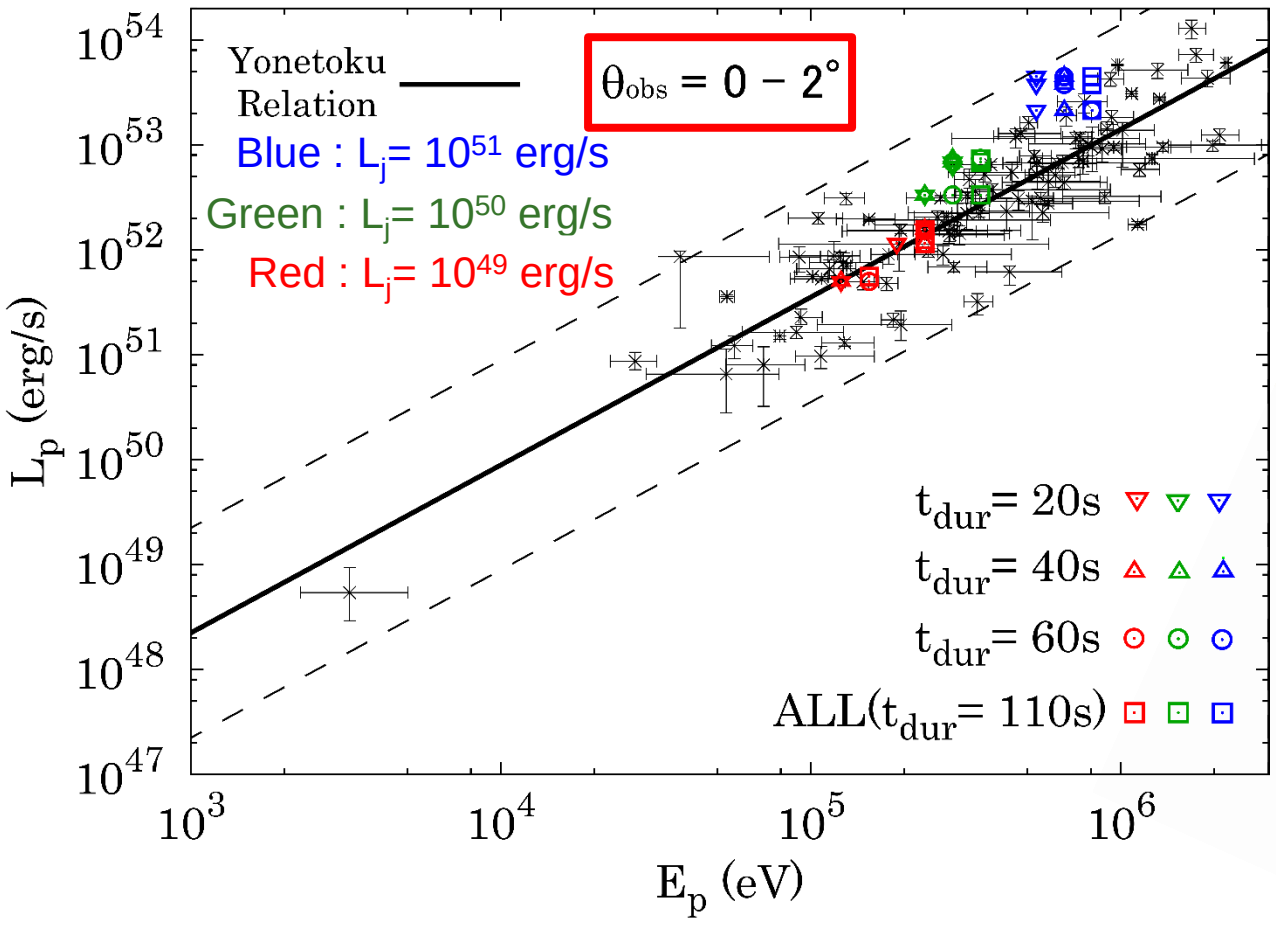
Yonetoku relation

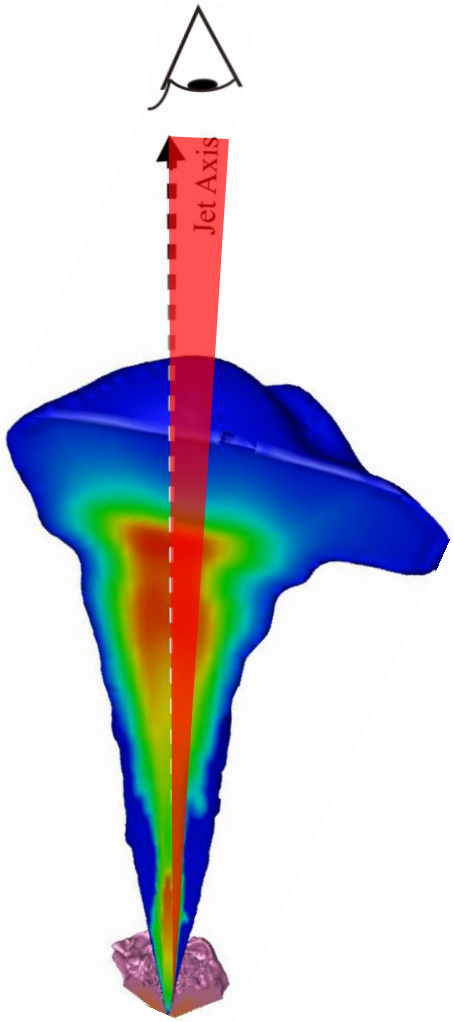


Remarkable match with observations

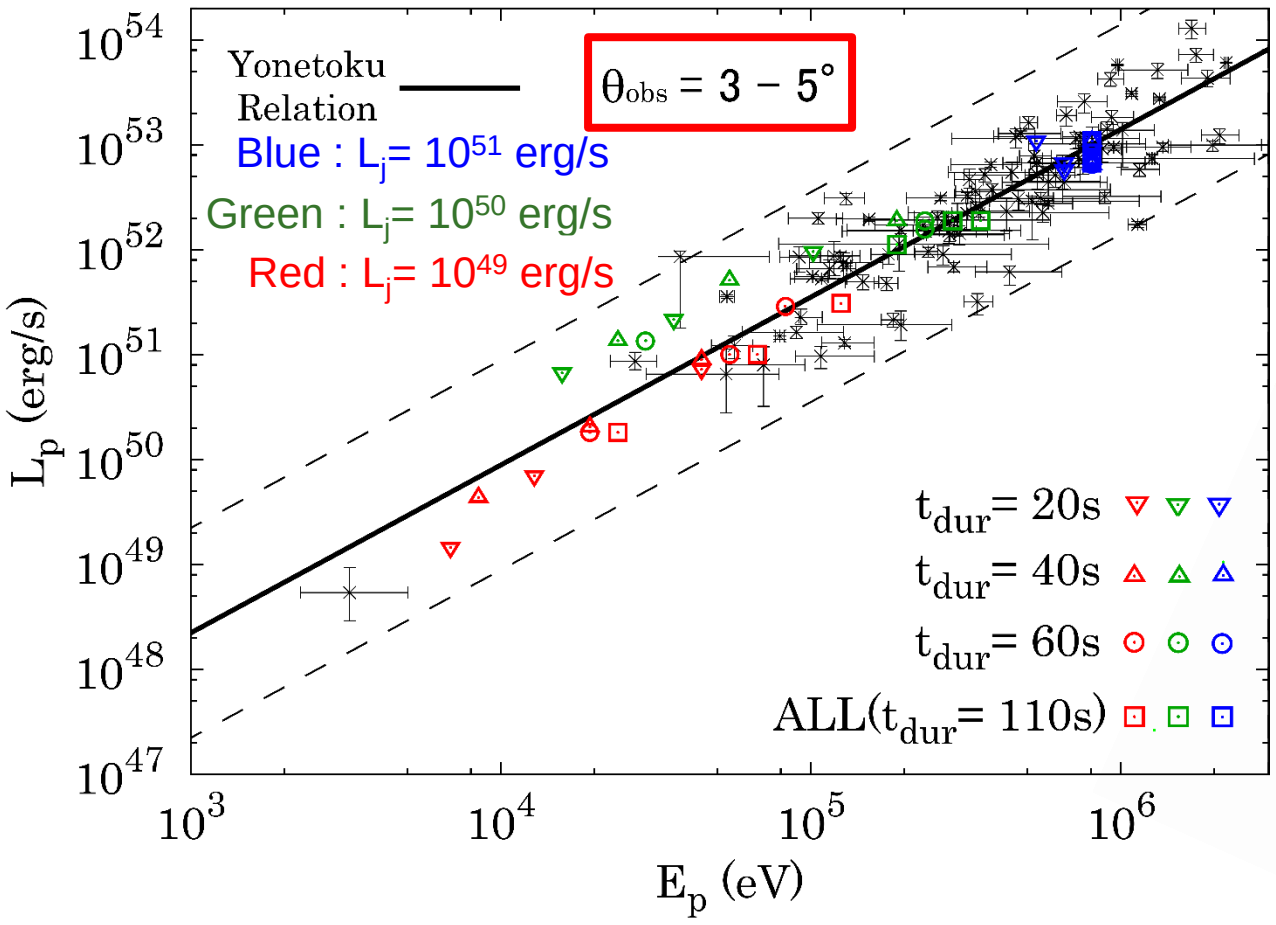
Evidence of photospheric emission as dominant radiation process

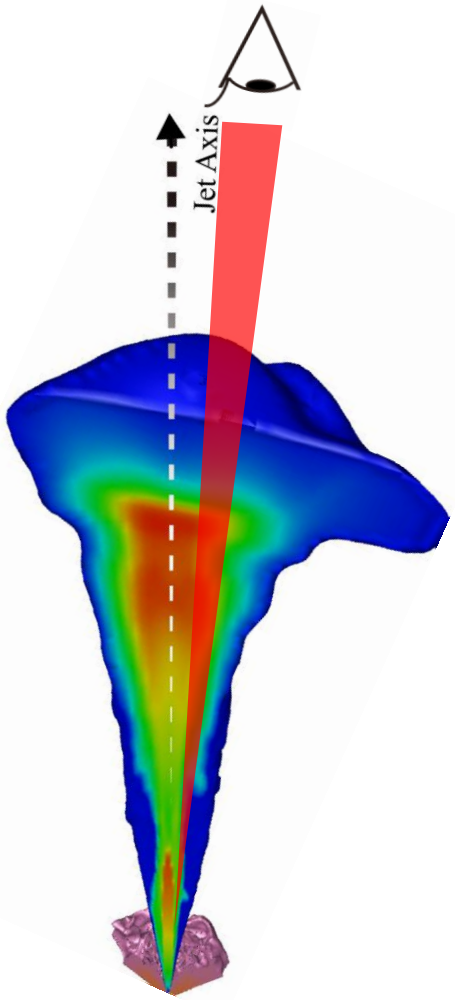
Yonetoku relation: viewing angle dependence



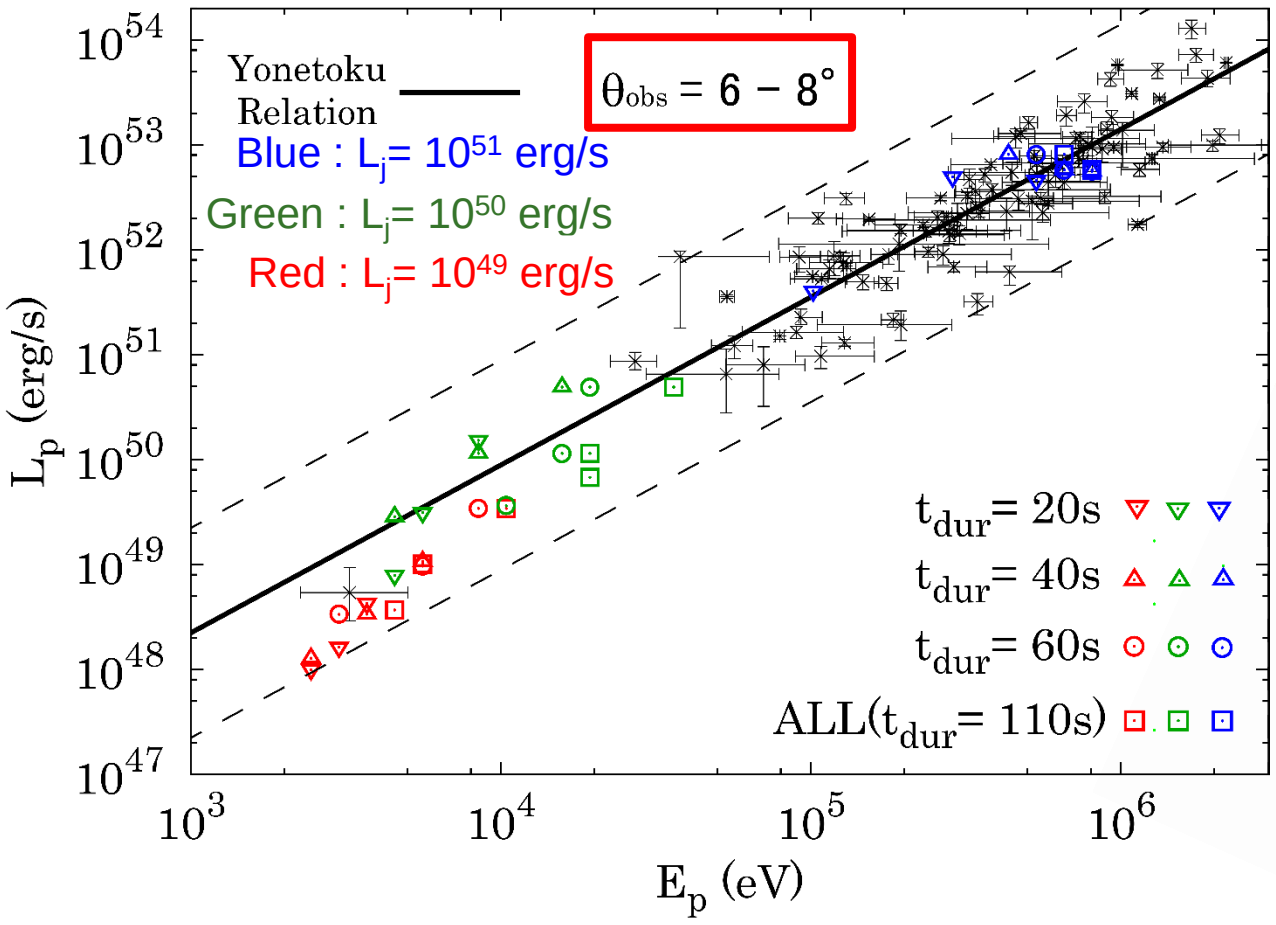


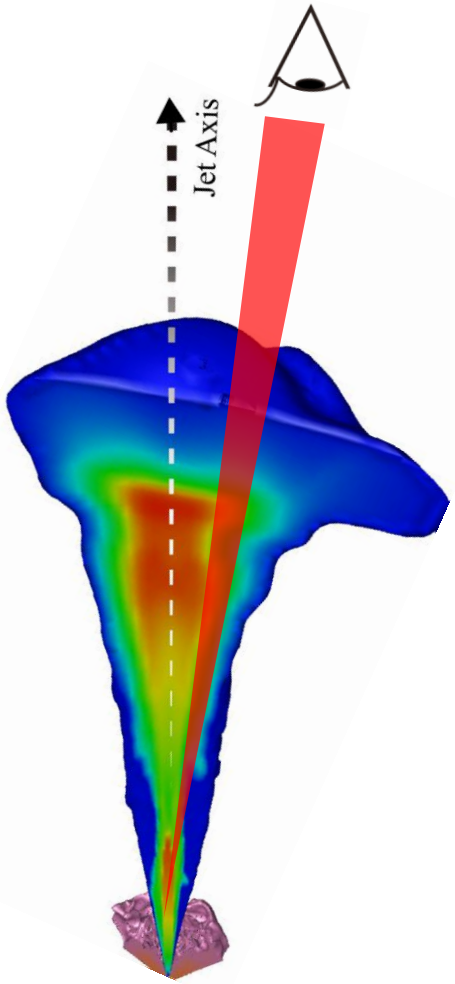
Yonetoku relation: viewing angle dependence



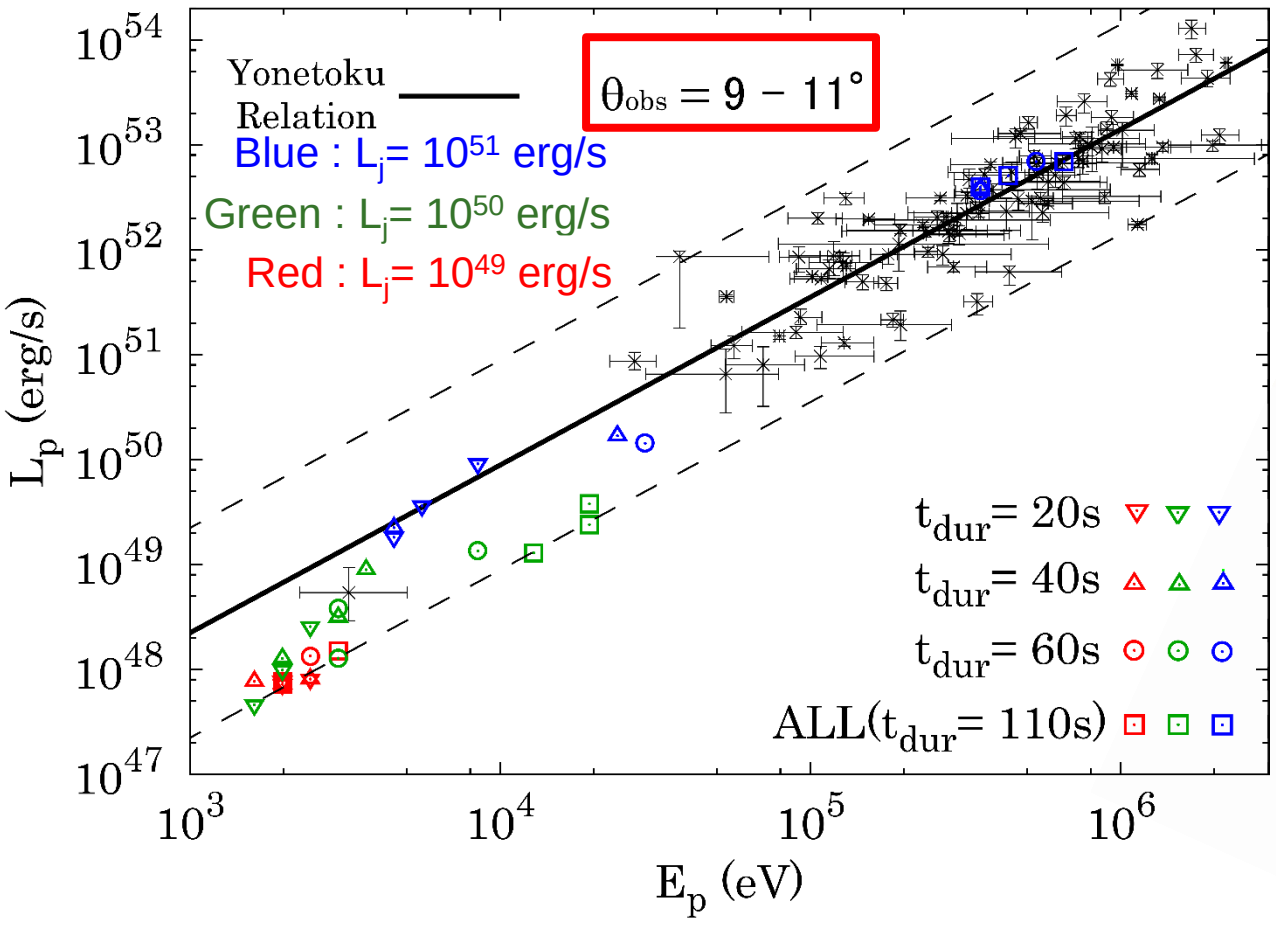


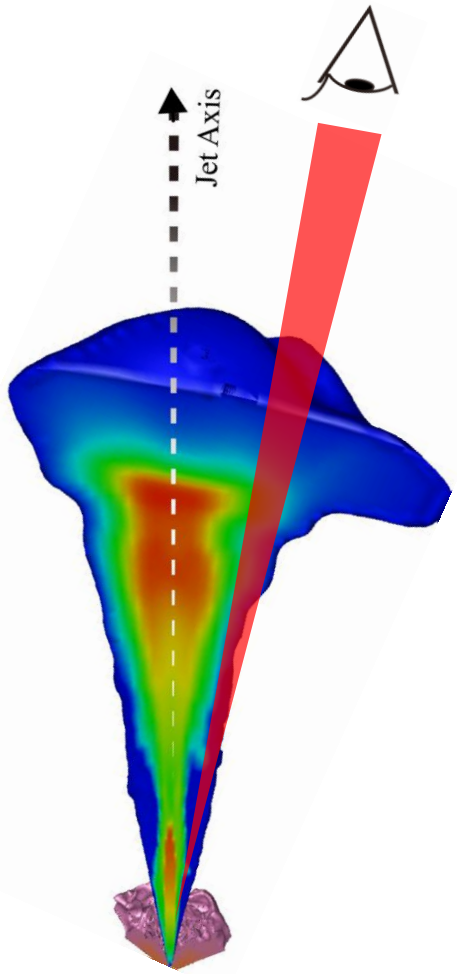
Yonetoku relation: viewing angle dependence





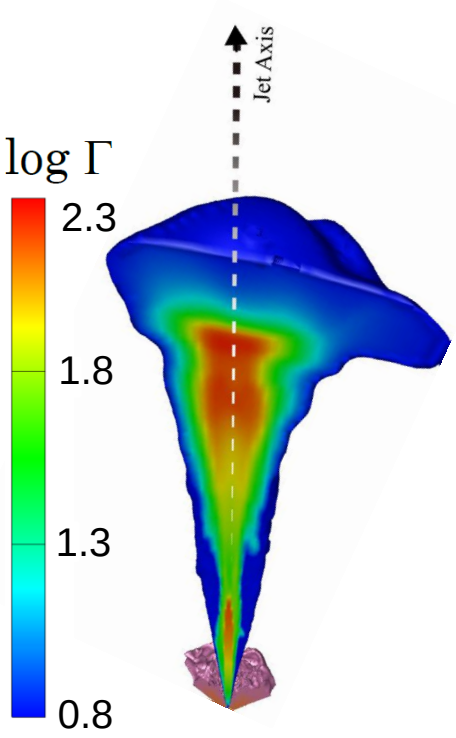
Yonetoku relation: viewing angle dependence

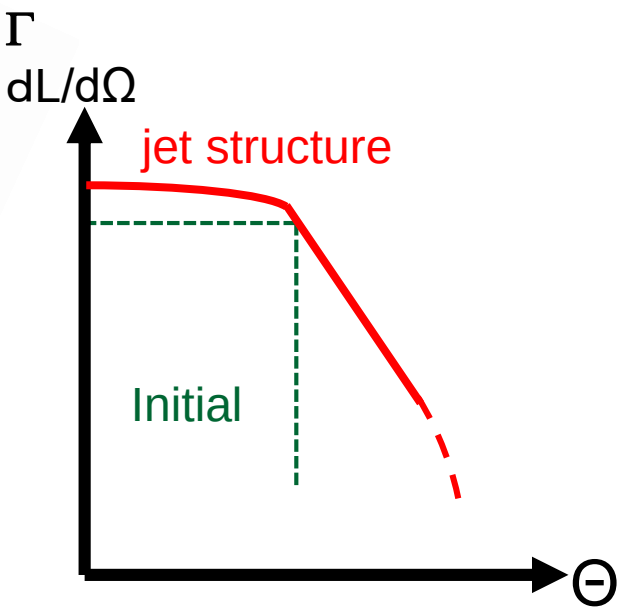


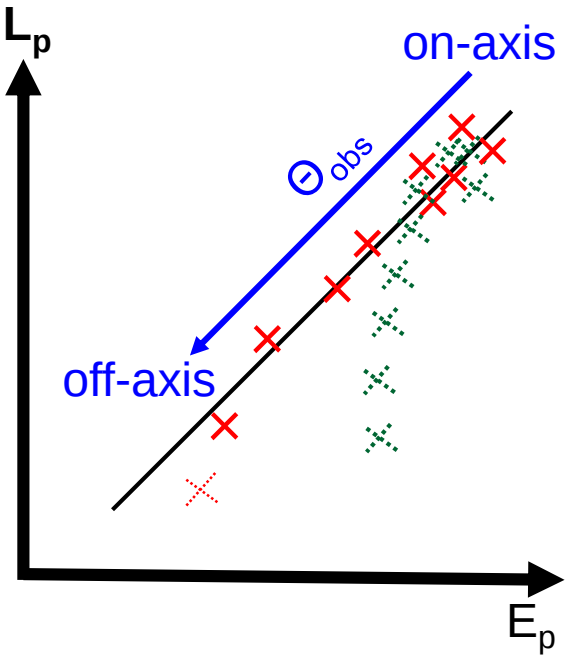


Origin of viewing angle dependence

Lateral structure developed during propagation

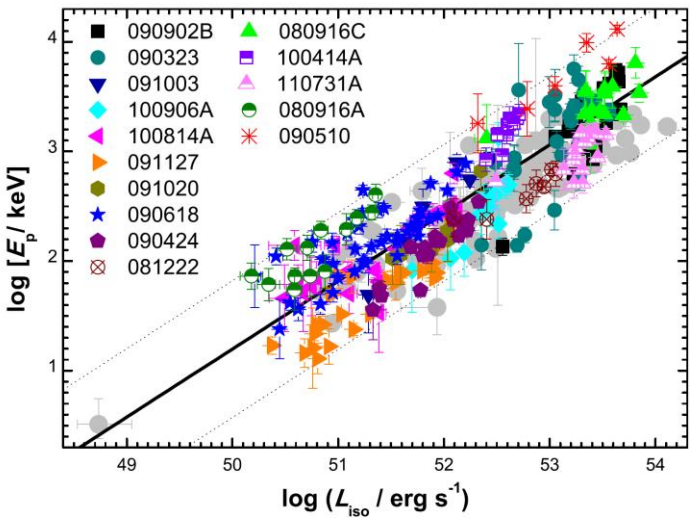






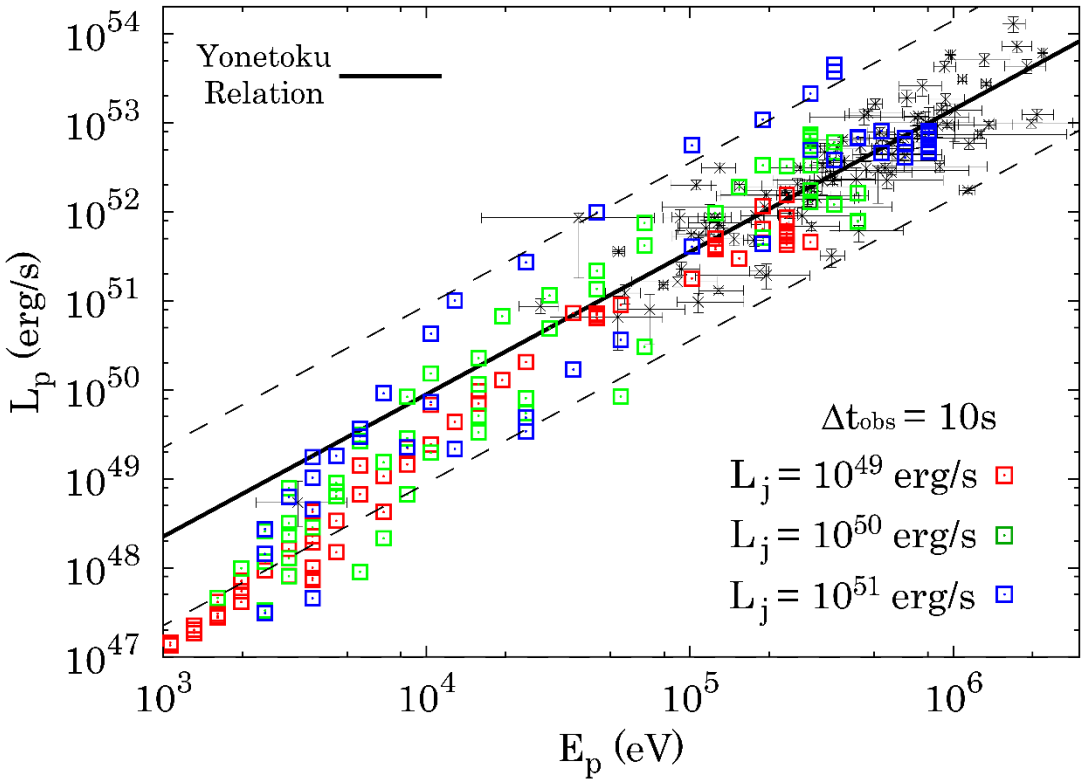
Fast Powerful core
surrounded by decaying wing

Time resolved Yonetoku relation



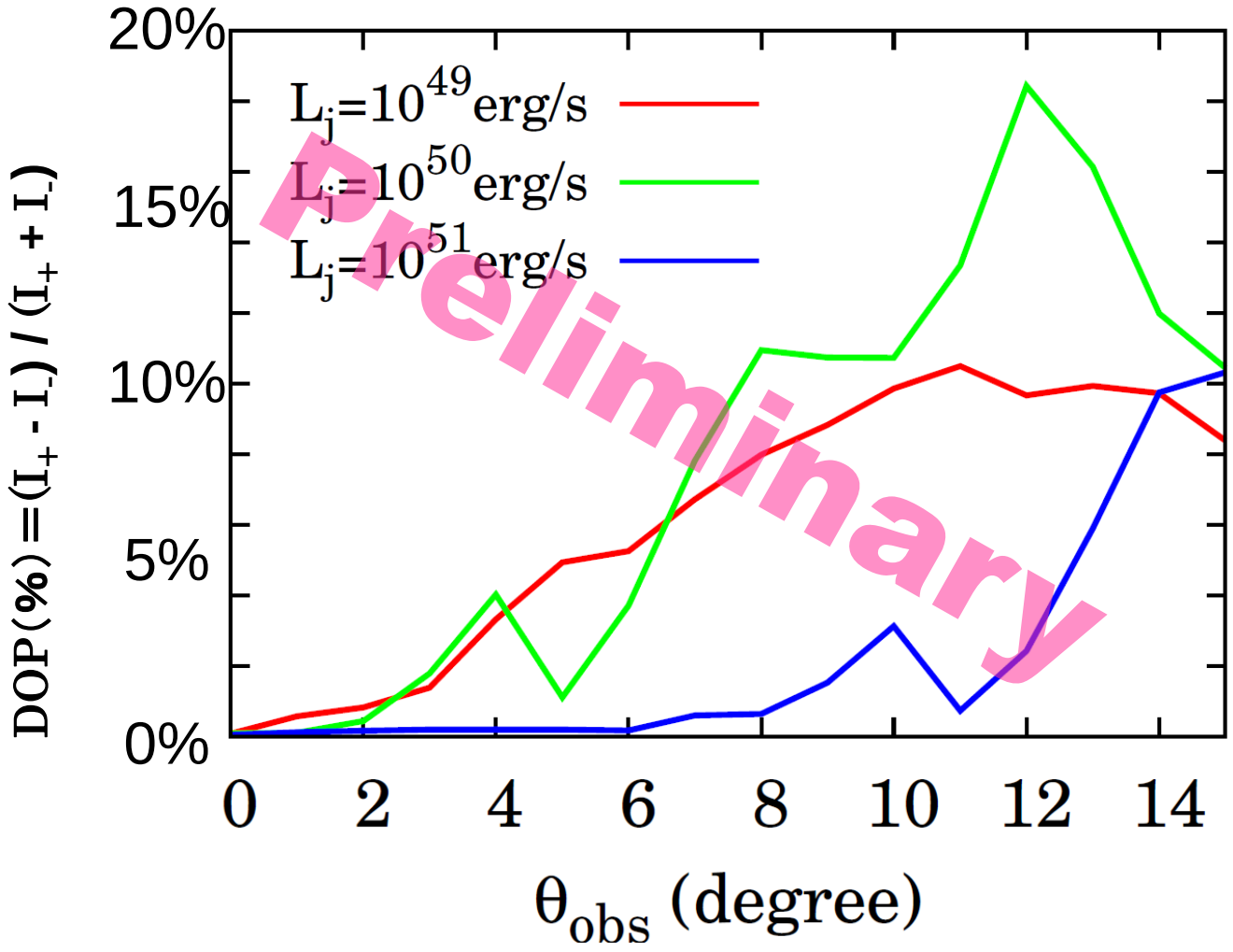
Lu + 2012

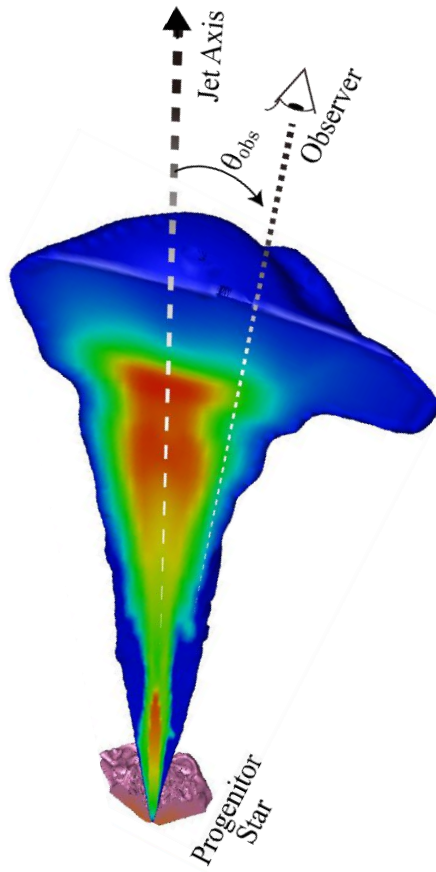
15 GRBs with time resolved Ep and redshift



Yonetoku Relation holds *regardless* of the time interval

polarization





High polarization (>10%) at large Θ_{obs}

Ito + 2017 in prep.

Summary

- Jet structure developed during propagation causes notable time variability
- Central engine activity can be directly observed in the light curve
  engine activity is not smeared out during the propagation
- Structure of jet broadens the thermal spectrum
  multi-color effect, bulk Comptonization at shock
  possible origin of Band spectrum
- Yonetoku relation is an inherent feature of phosphoric emission
  This relation holds regardless of the jet power
  evidence of photosphric emission as a dominant radiation mechanism
- Prediction of high polarization at large viewing angle