

6 October 2015



The poster for HEPRO V (High Energy Phenomena in Relativistic Outflows V) is a vertical layout. At the top left is the URL <http://hepro.via.unlp.edu.ar>. The main title 'HEPRO V' is in large blue letters, with a QR code to its right. Below it, the subtitle 'HIGH ENERGY PHENOMENA IN RELATIVISTIC OUTFLOWS V' is in orange. The location 'La Plata, Argentina' and dates 'October 5 - 8, 2015' are in blue. A section titled 'Topics to be covered include:' lists various scientific topics. Below that, 'Invited speakers:' lists names and affiliations. The 'SQC' section lists sponsors and their logos. At the bottom, there are logos for INAF, IASF Bologna, and Scuola Normale Superiore di Pisa, along with several astronomical images.

<http://hepro.via.unlp.edu.ar>

HEPRO V

HIGH ENERGY PHENOMENA IN RELATIVISTIC OUTFLOWS V

La Plata, Argentina
October 5 - 8, 2015

Topics to be covered include:

- Gamma-Ray Production in Relativistic Outflows
- Multiscale Properties
- Past Activity of the Galactic Center Black Hole
- Pulsar Winds, Microquasars, AGNs, GRBs
- Acceleration and Propagation of Relativistic jets
- Particle Acceleration and Transport

Invited speakers:

- F. Aharonian (IAAF, Bonn)
- Fabio de Góti (CONICET)
- Jonathan Arino (CNRS, Bordeaux)
- Shantanu Das (IIT Bombay)
- Martin Rees (IAGLR, Cambridge)
- Omry Khardjian (INAF, Pisa)
- Eugene Soffel (University of Bordeaux)
- Alex Lahaian (University of Wisconsin-Madison)

SQC:

- 1. Ministero dell'Università e della Ricerca (MIUR)
- 2. European Union (FP7)
- 3. National Science Foundation (NSF)
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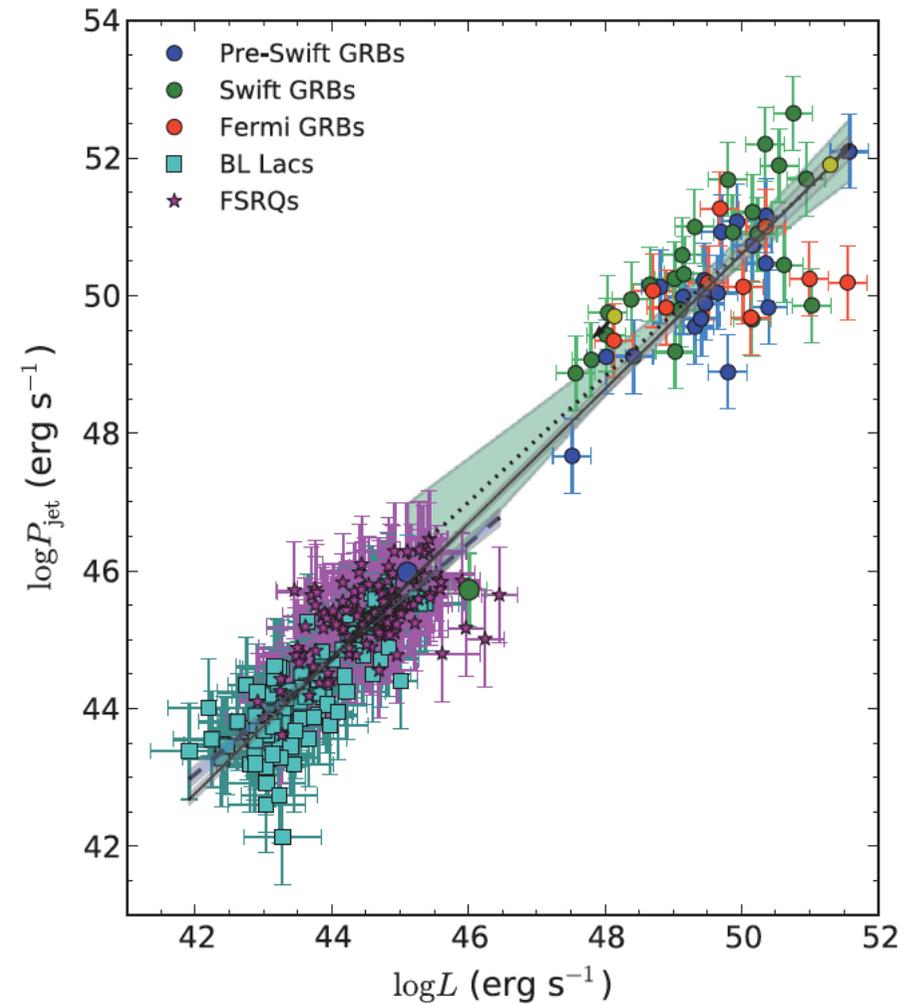
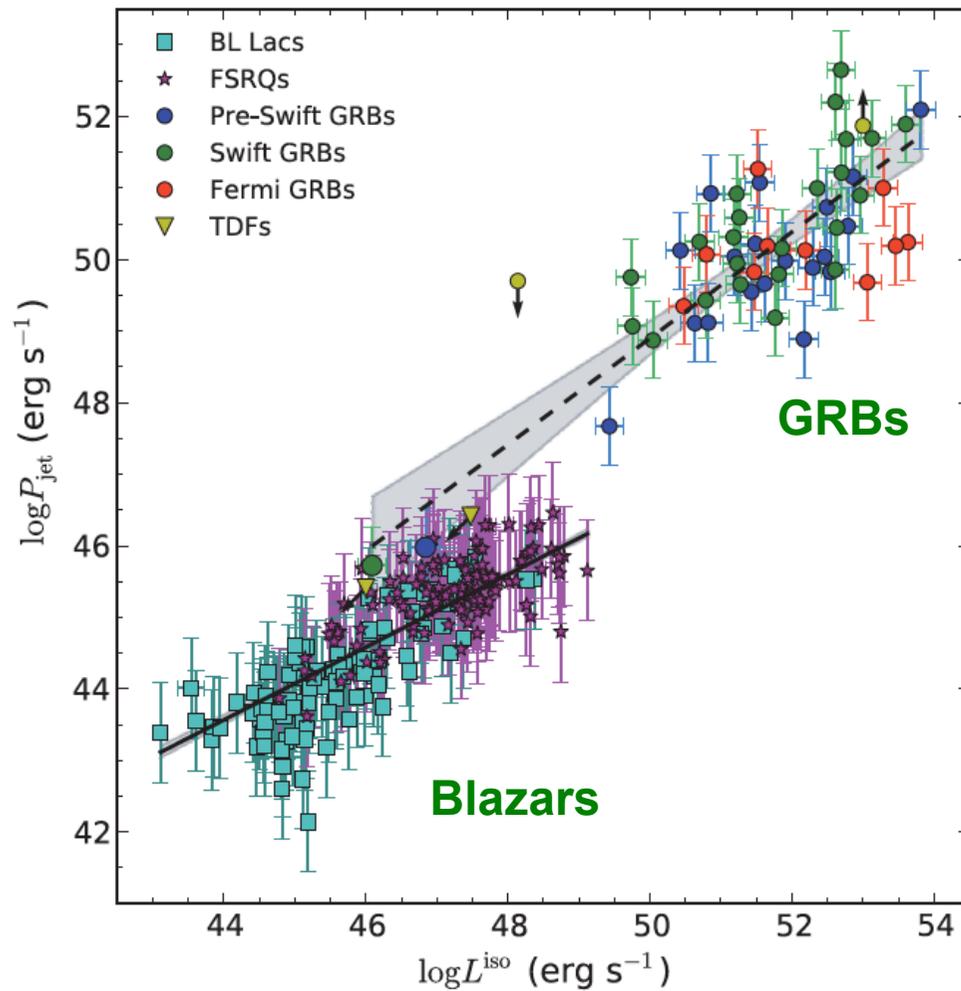
hepro.via.unlp.edu.ar



Relativistic Jets: an Overview of Recent Progress

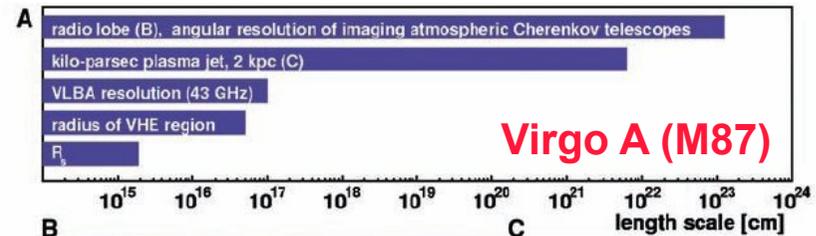
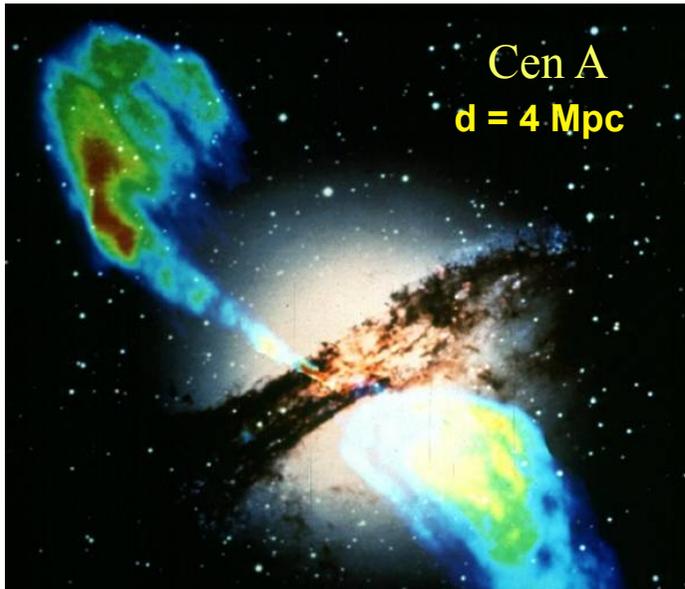
Elena Pian
INAF, IASF Bologna
& Scuola Normale Superiore di Pisa

A universal scaling for the energetics of relativistic jets From black hole systems

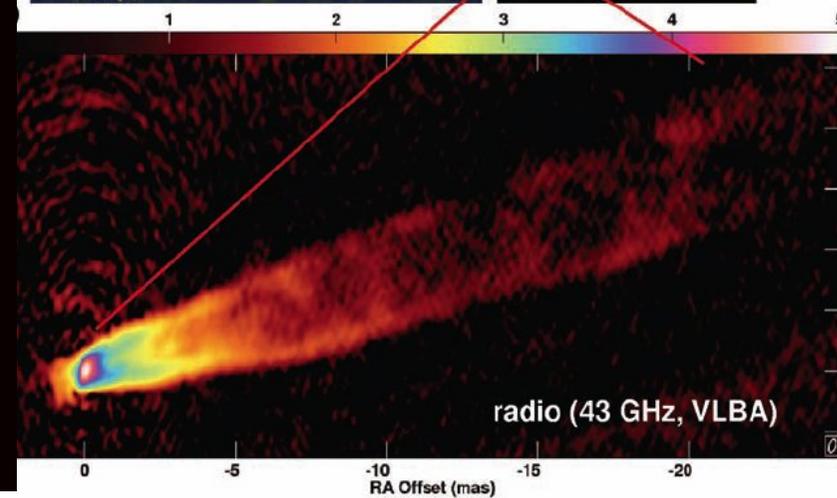
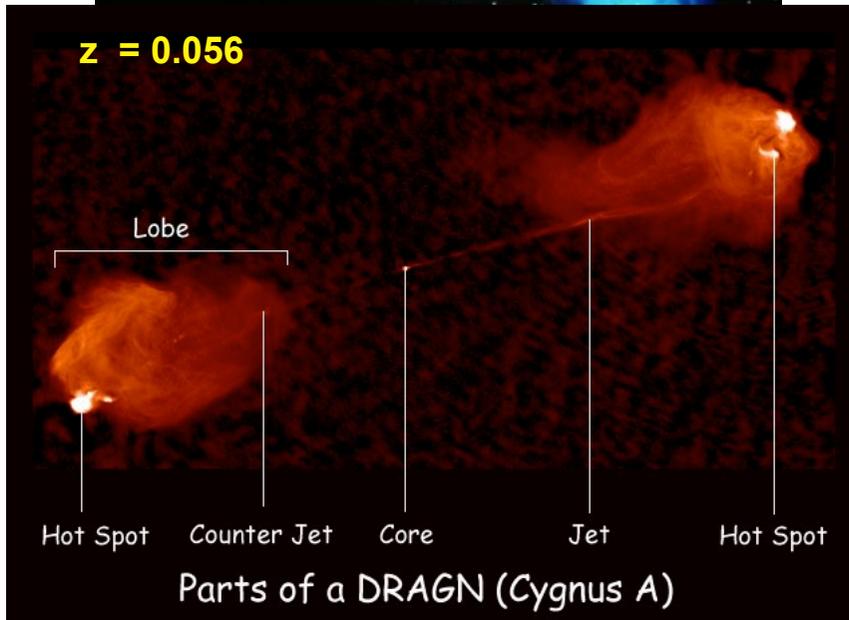
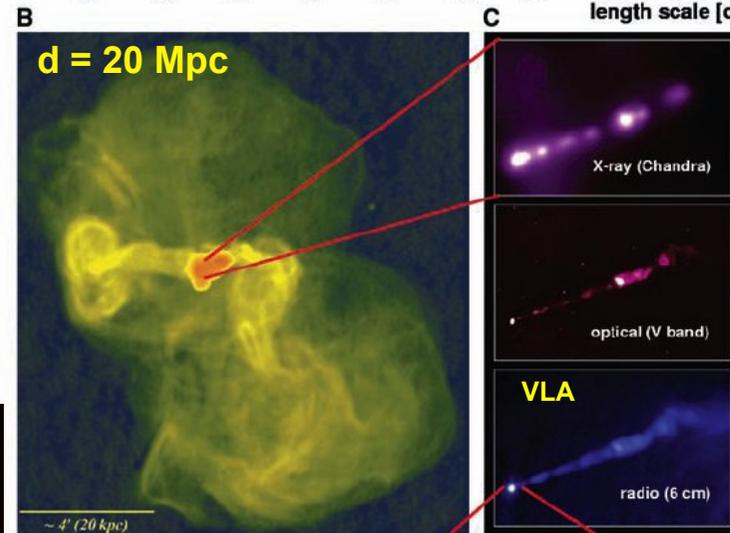


Extragalactic Jets: radiogalaxies and blazars

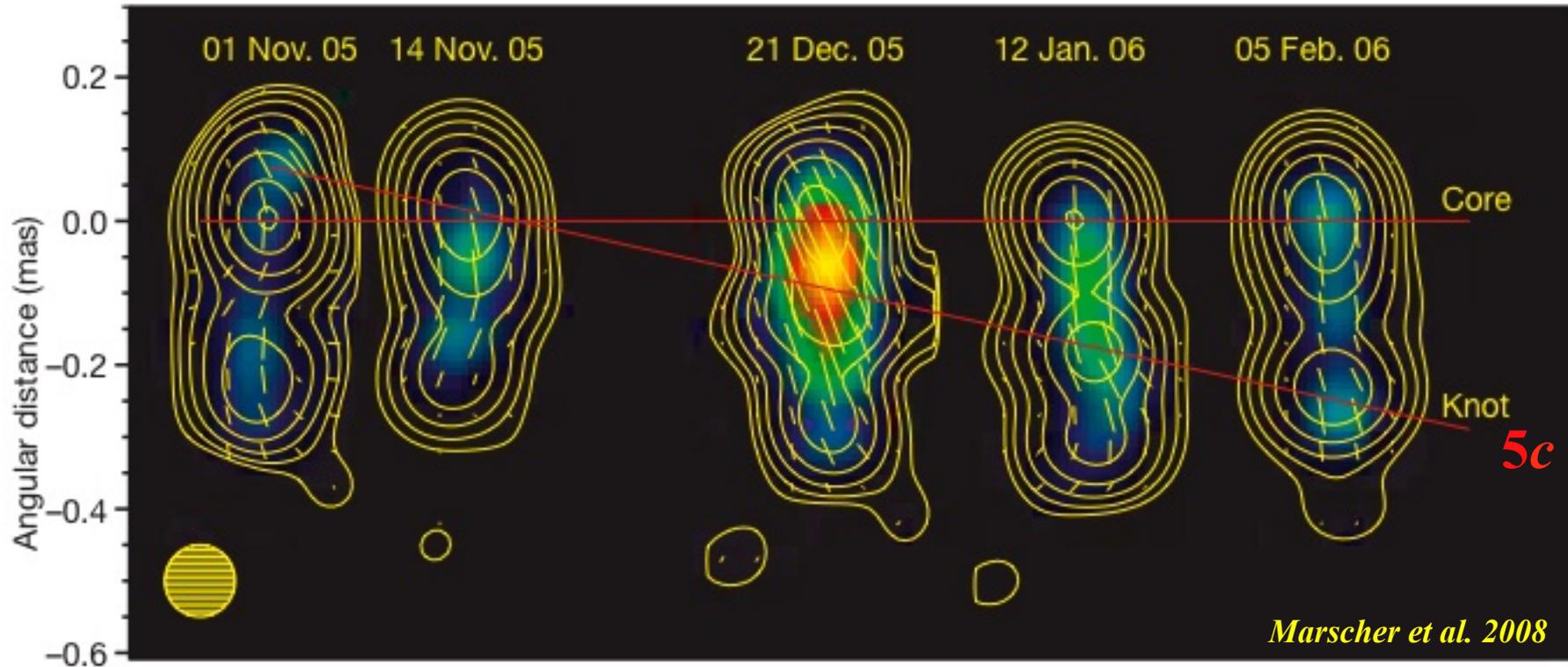
Lorentz factors $\Gamma \sim 10-20$



Virgo A (M87)



Superluminal motions in extragalactic VLBA jets

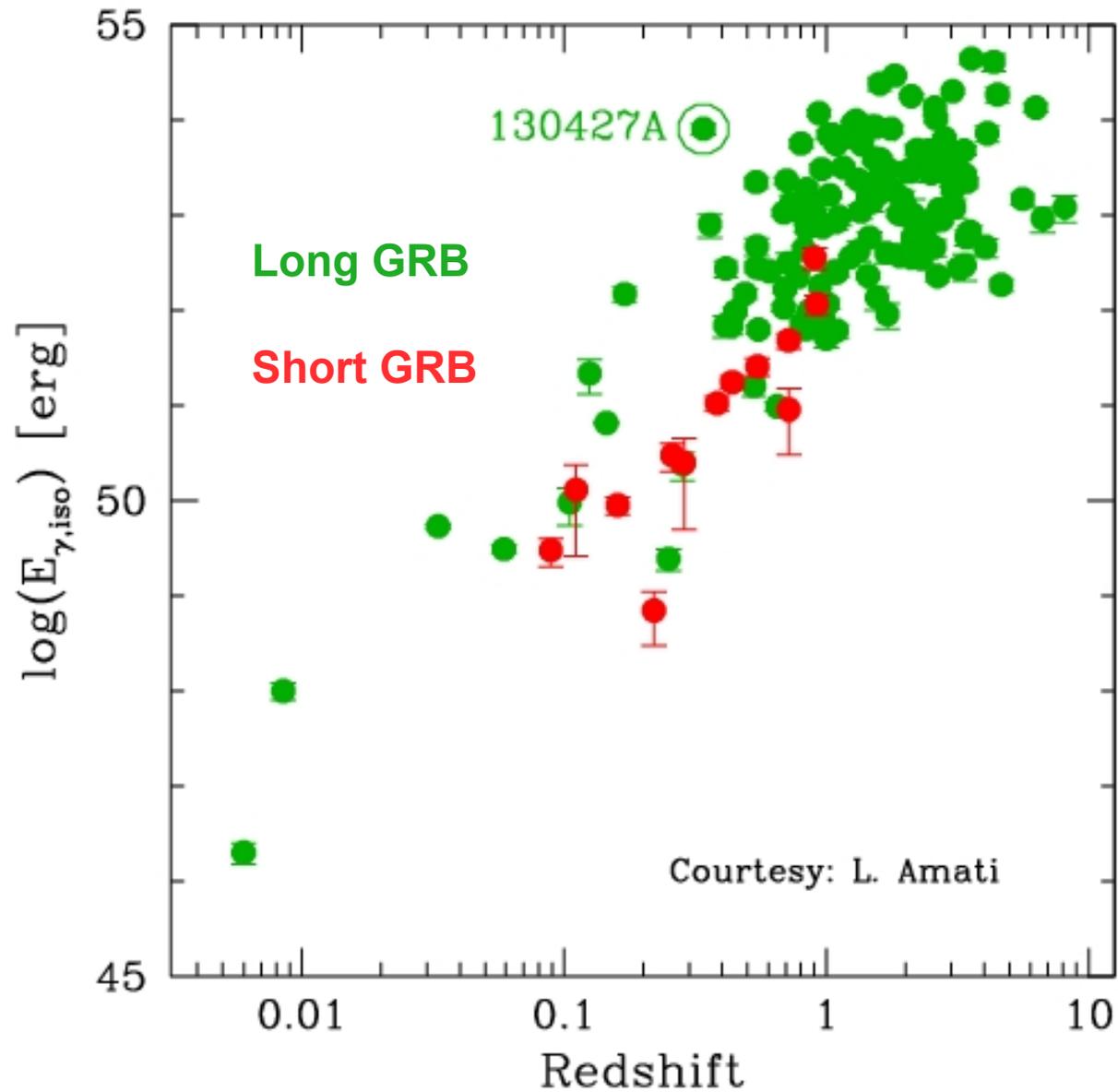


Lorentz factor: $\Gamma = \frac{1}{\sqrt{1 - \beta^2}}$

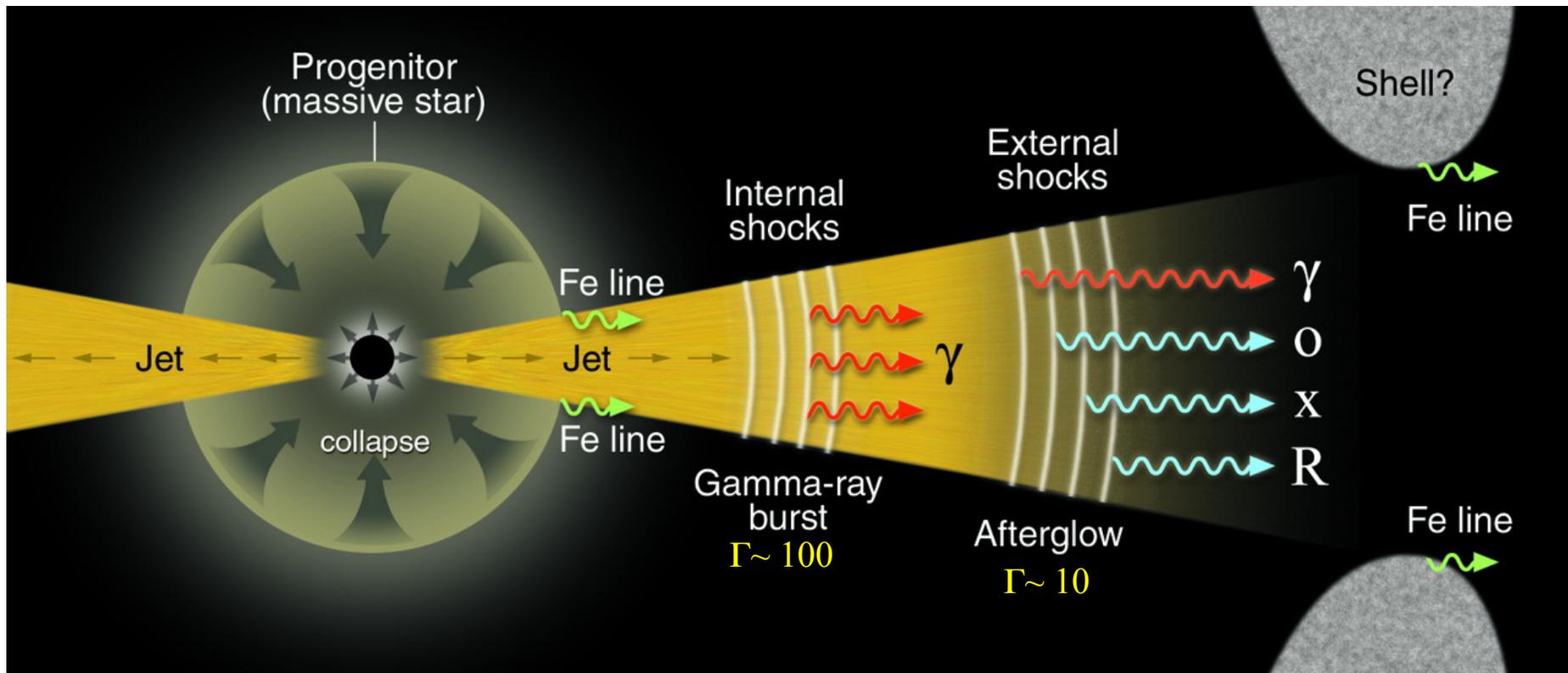
Doppler factor: $\delta = \frac{1}{\Gamma(1 - \beta \cos \theta)}$

If we assume that $\theta = 5$ deg: $\beta_{\text{app}} = 5 \rightarrow \beta = 0.9866 \rightarrow \Gamma = 6 \rightarrow \delta = 9.5$
 $\beta_{\text{app}} = 20 \rightarrow \beta = 0.9994 \rightarrow \Gamma = 30 \rightarrow \delta = 7.6$

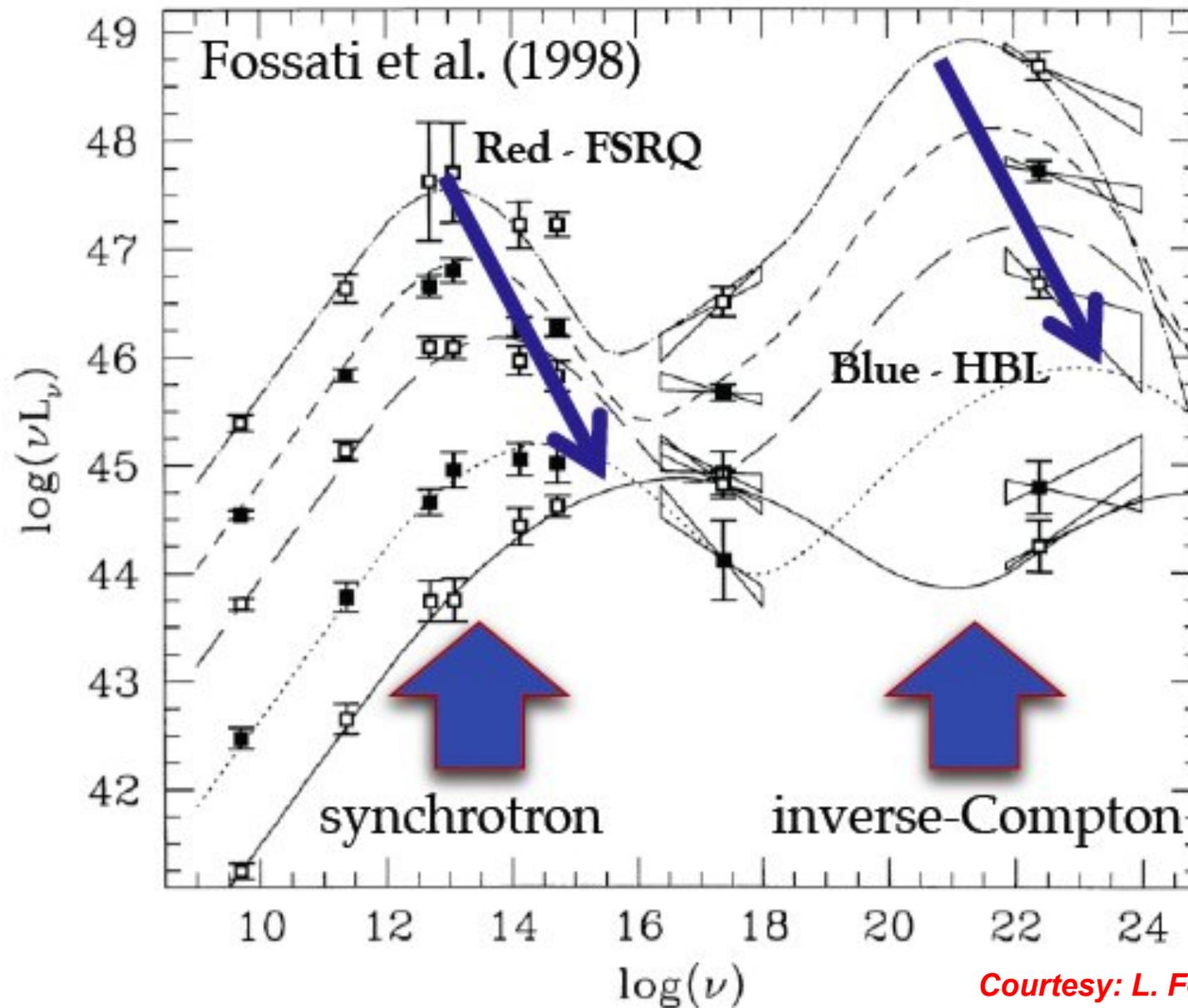
Isotropic irradiated γ -ray energy vs redshift (~ 400 GRB redshifts known)



GRB jet “artist concept”

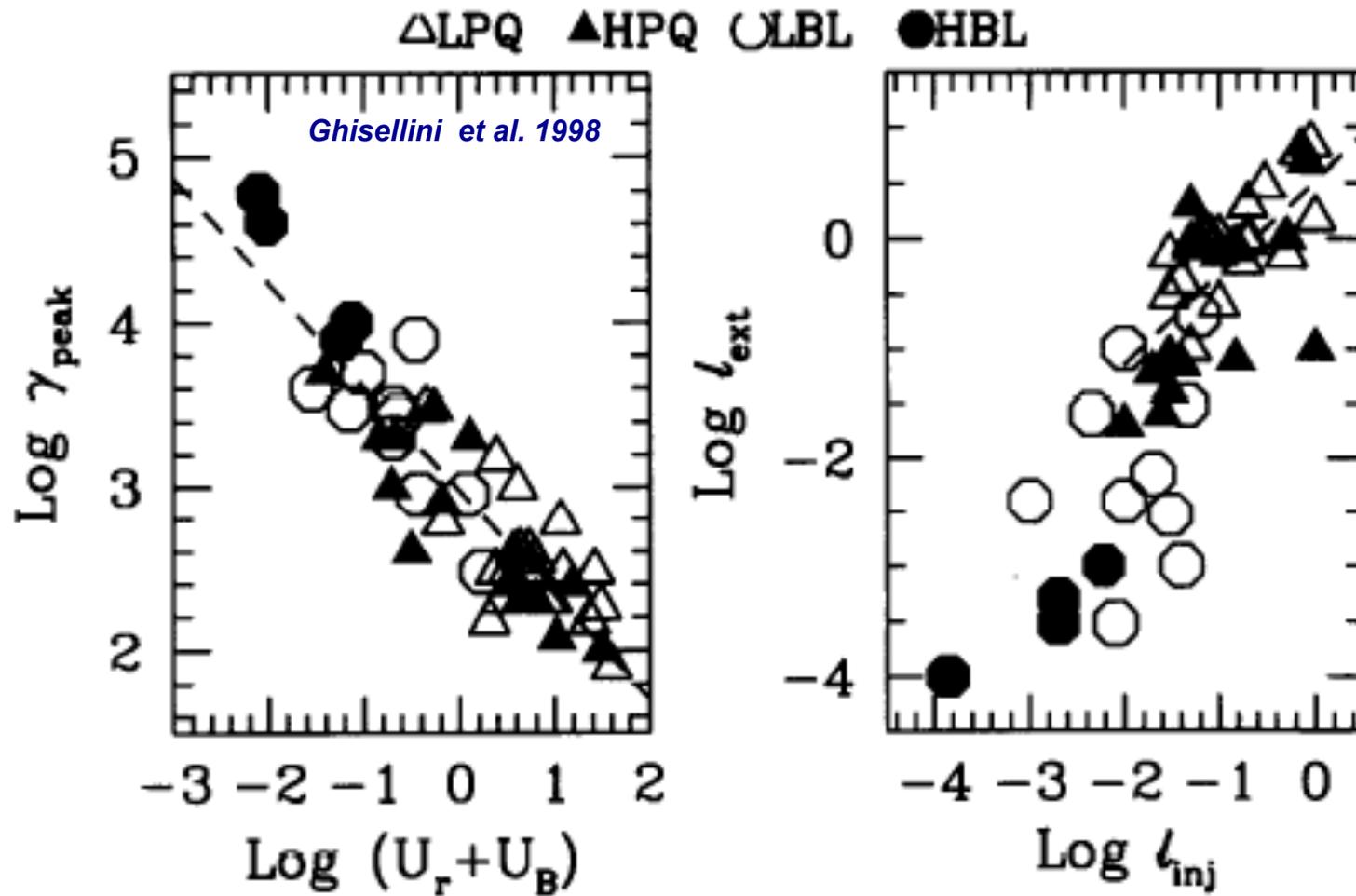


Blazars “spectral sequence”



Courtesy: L. Foschini

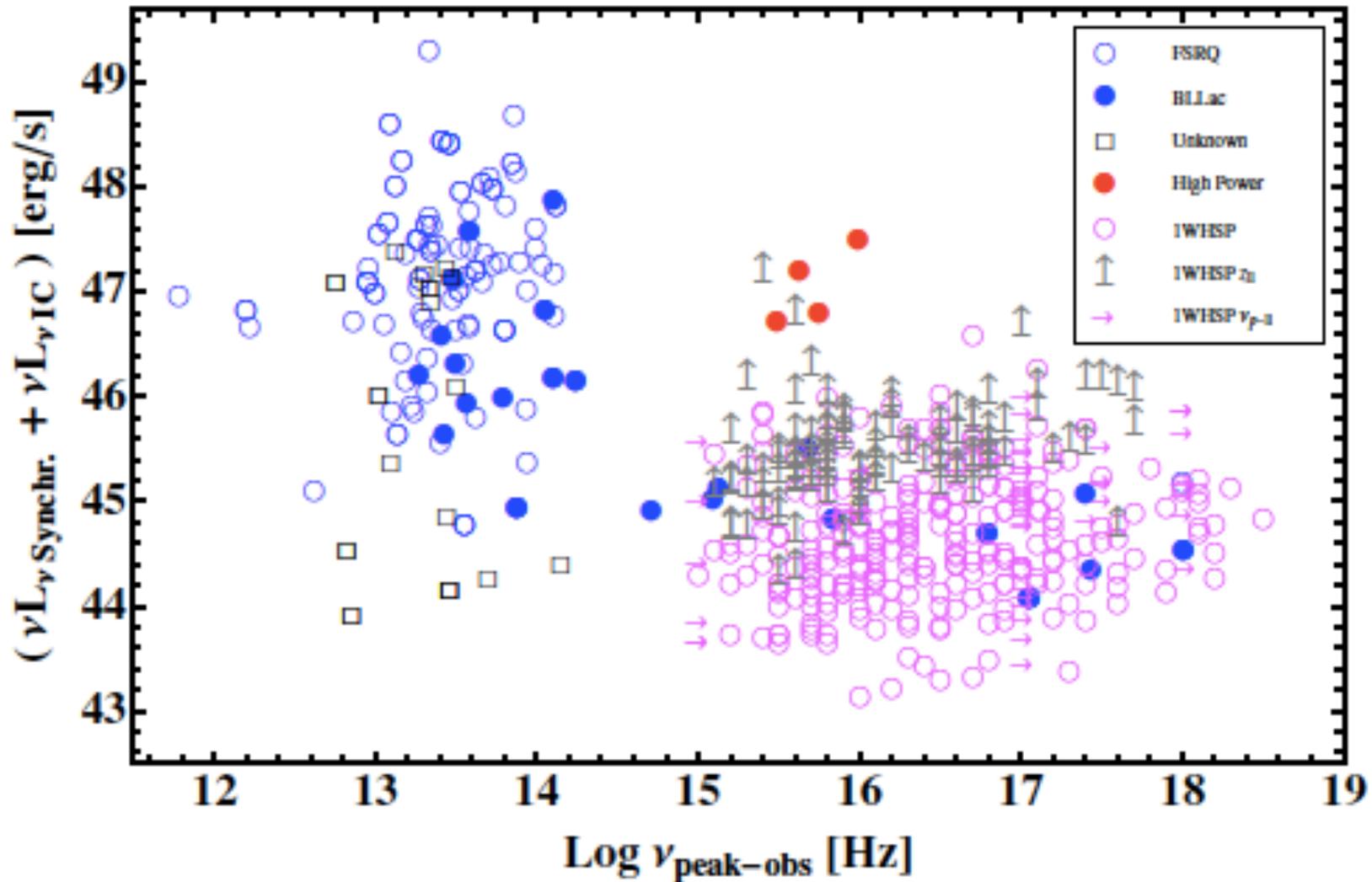
Blazars sequence: internal vs external photon fields



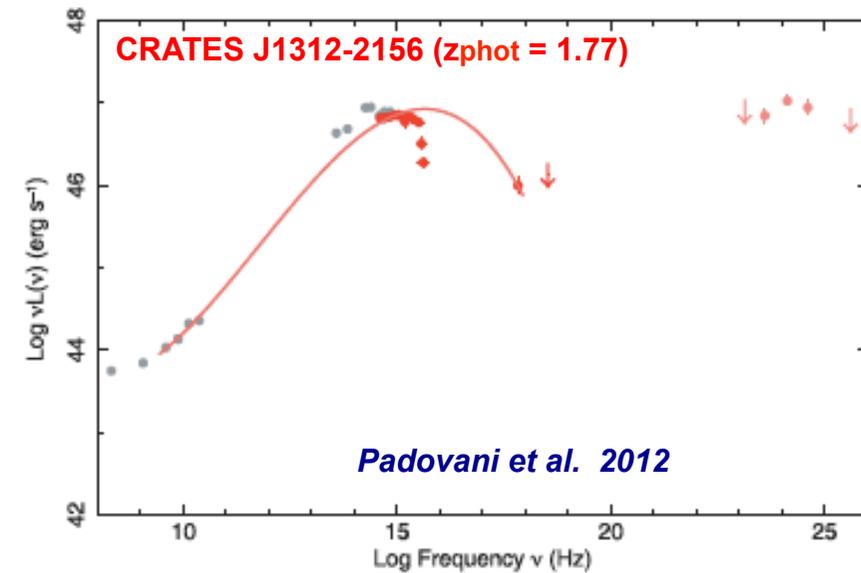
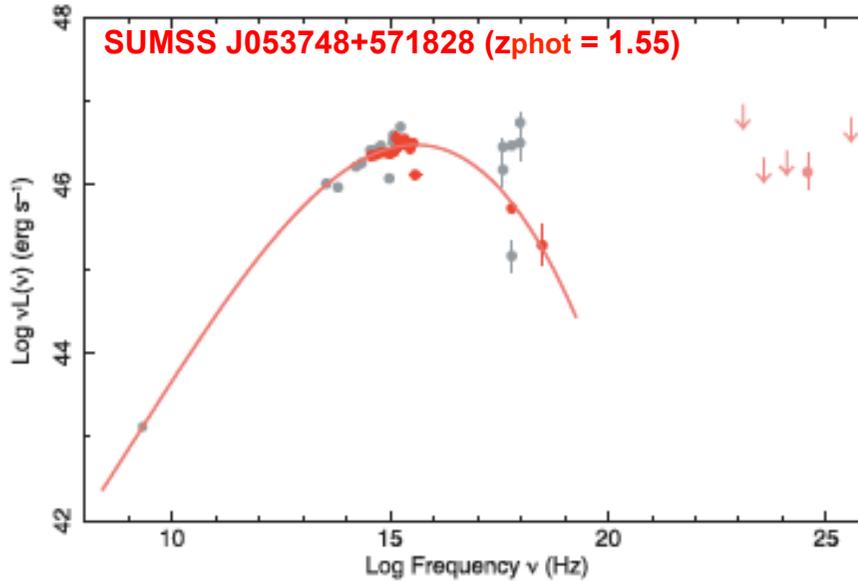
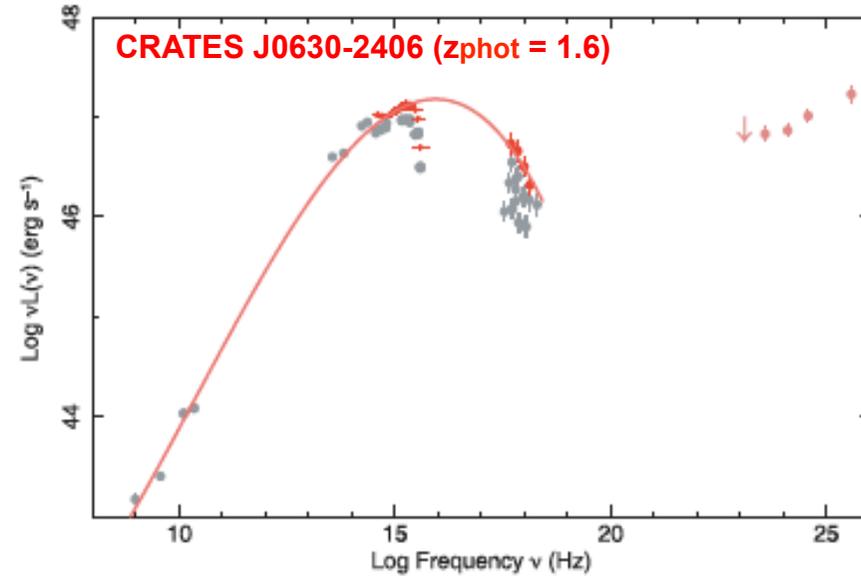
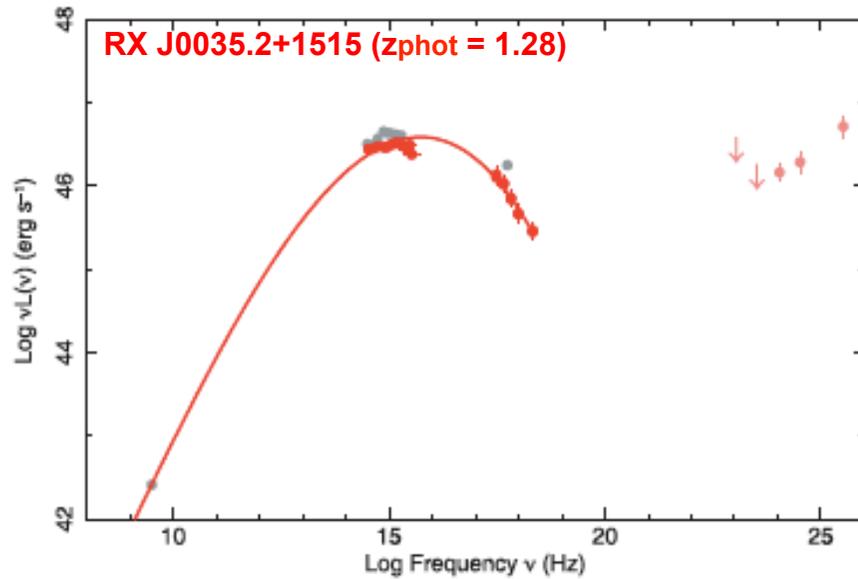
Peak random Lorentz factor anticorrelates with total jet power (see exceptions in Padovani et al. 2012, Arsioli et al. 2015)

External photon compactness correlates with injected power, see also Sbarrato et al. 2012

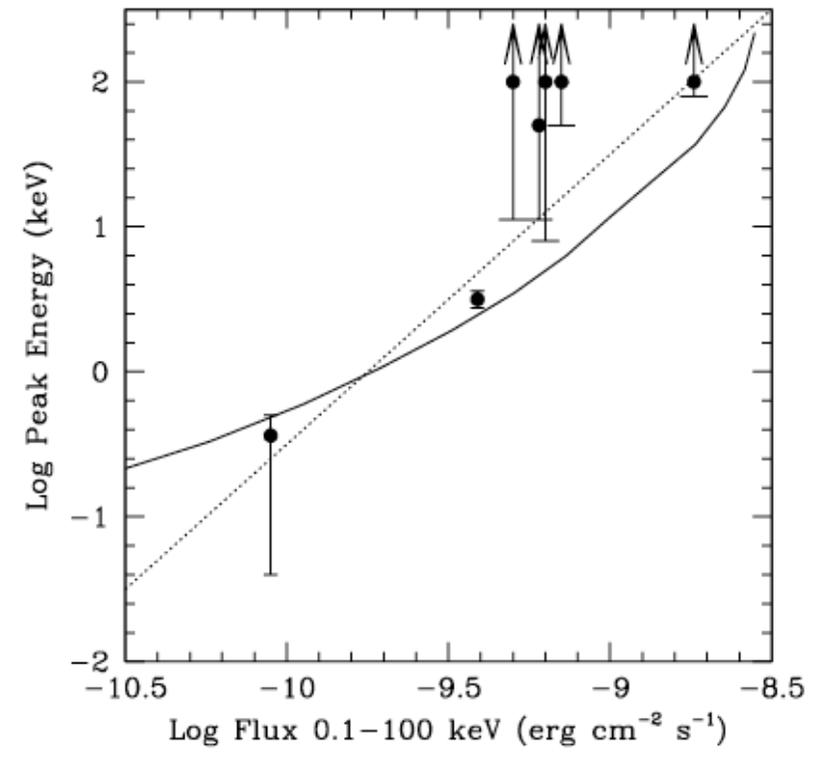
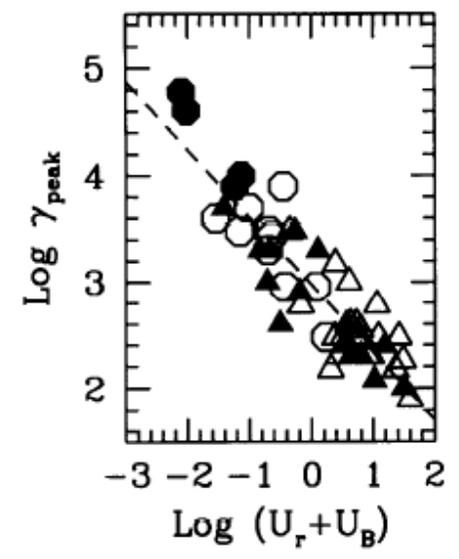
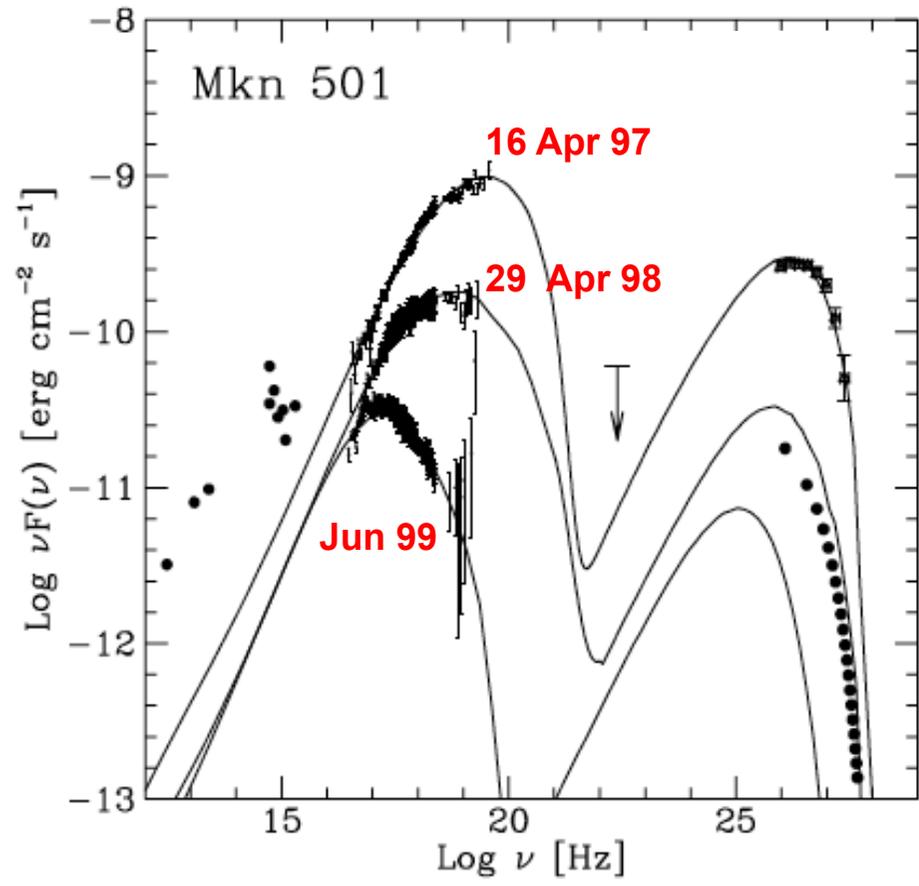
A counterexample: High power, high synchrotron peak blazars



High power, high synchrotron peak blazars

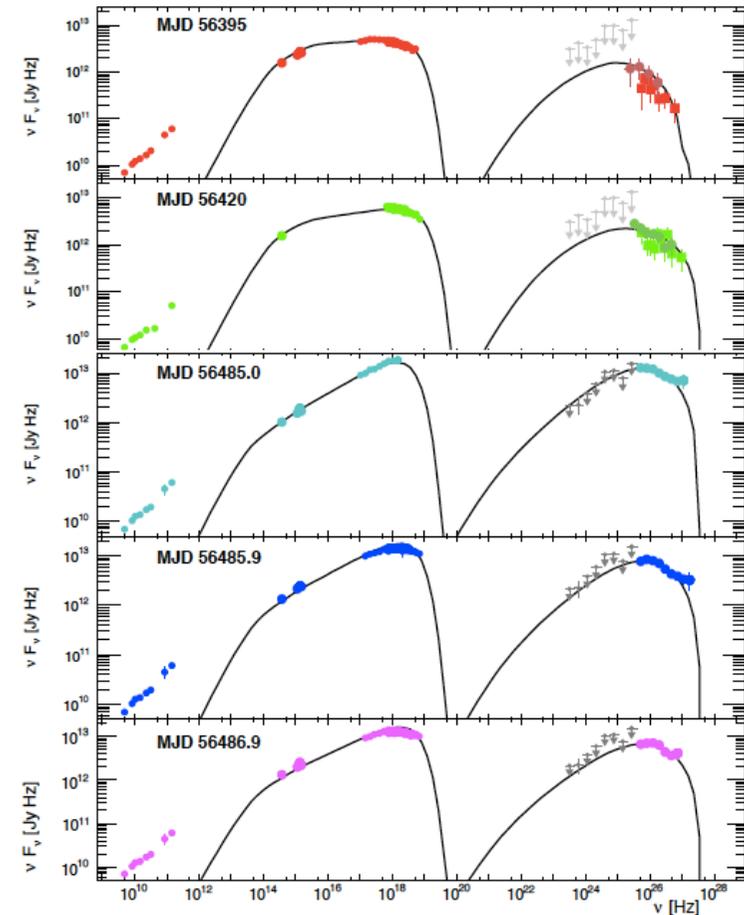
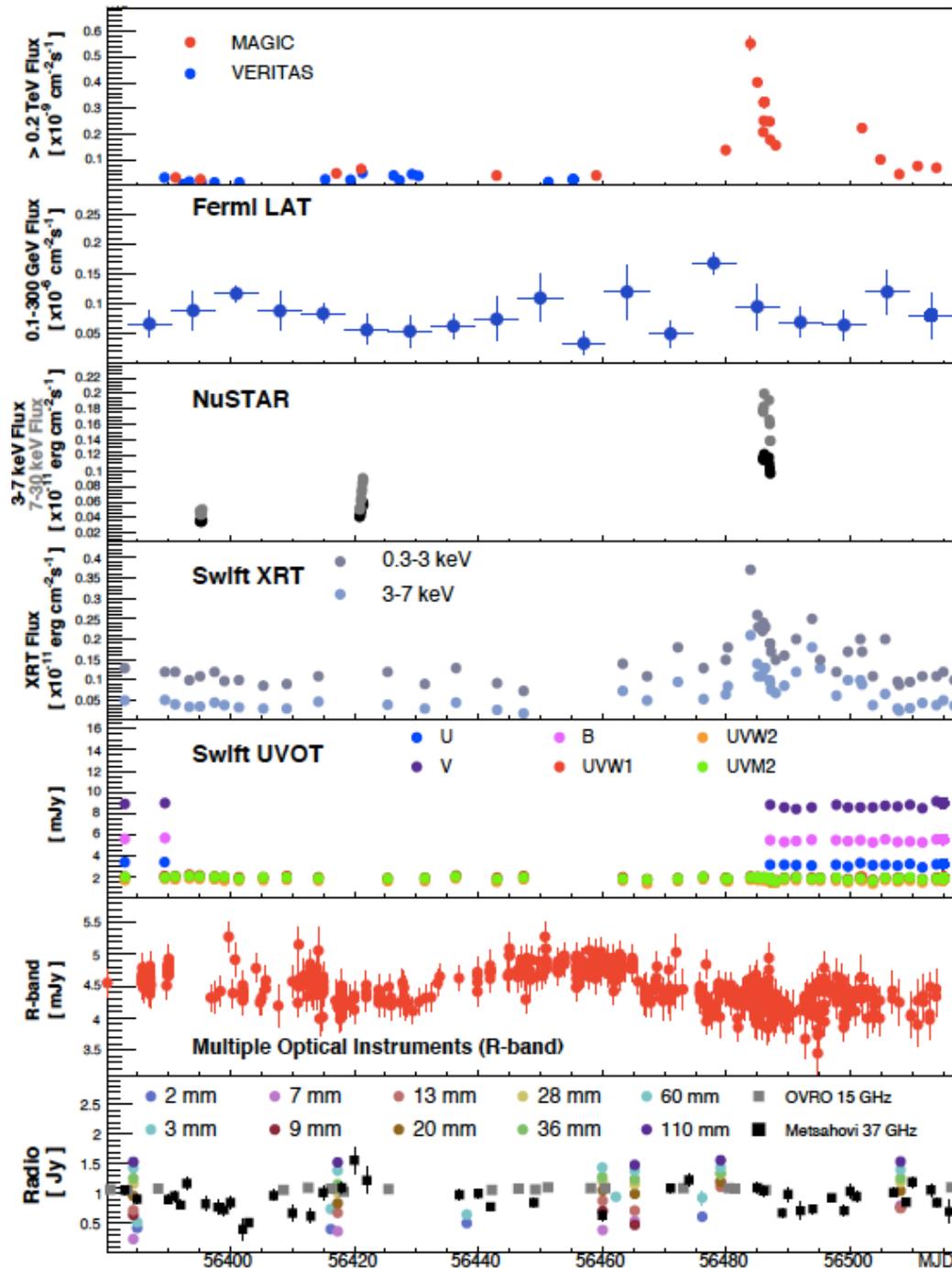


Synchrotron peak frequency vs power anticorrelation does not hold in individual sources



Ghisellini 1999; Tavecchio et al. 2001

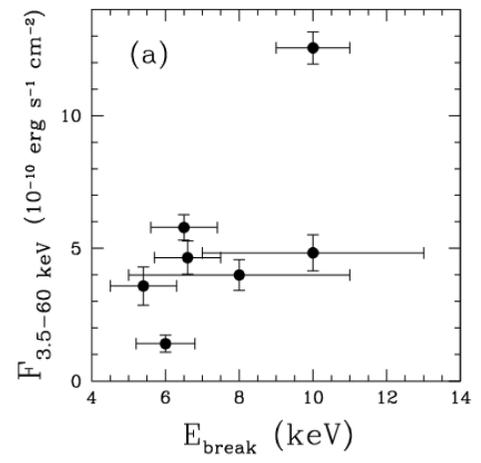
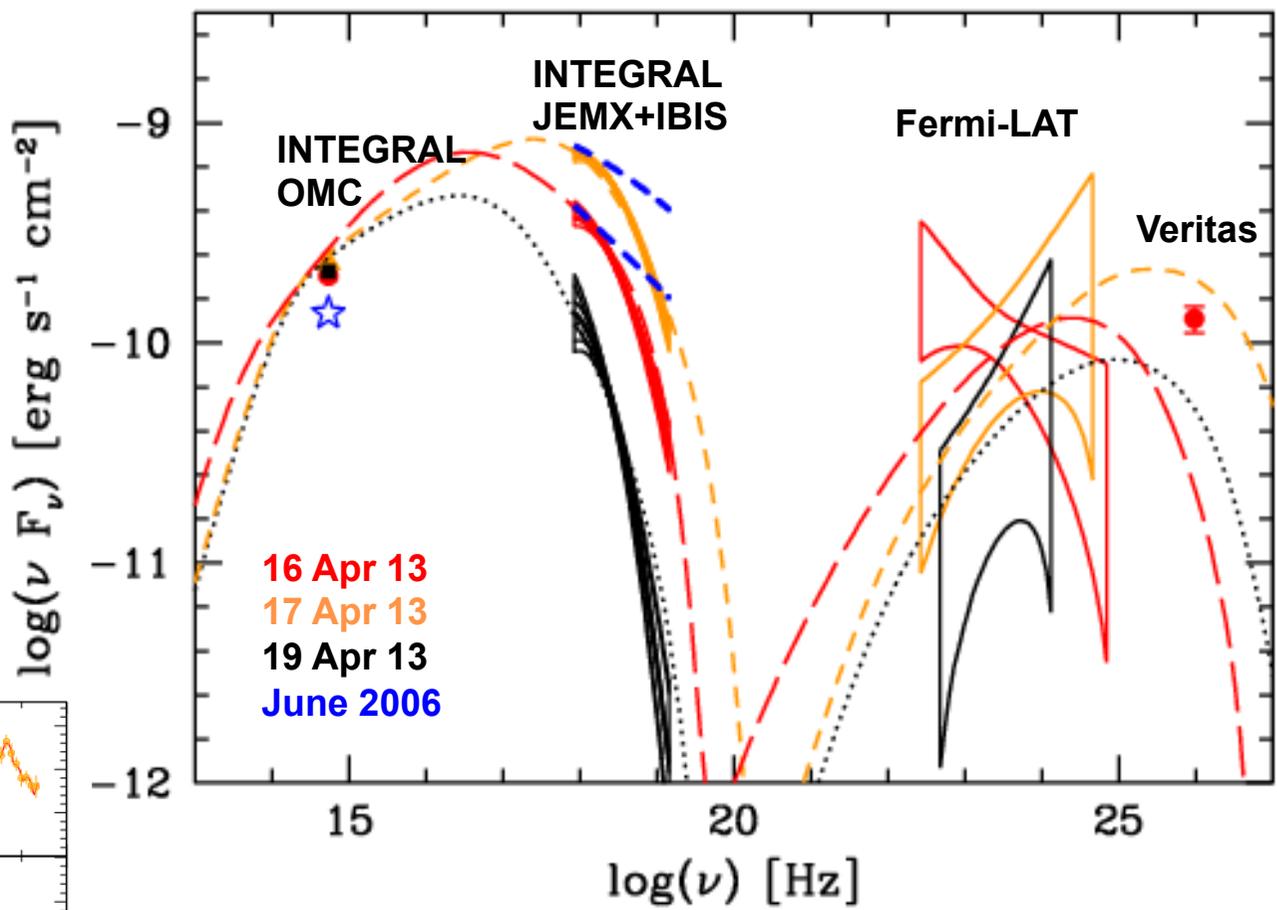
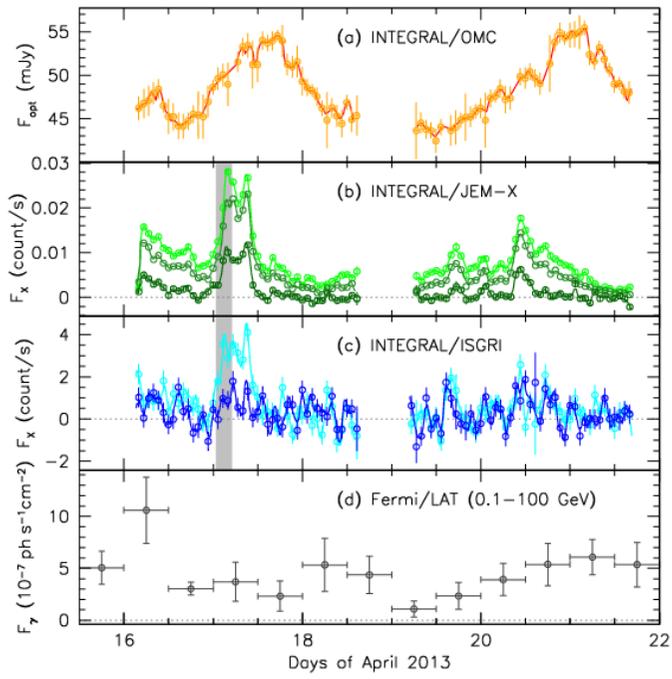
Nustar observations of Mkn501 in August 2013



Furniss et al. 2015

High synchrotron peak BL Lac Mkn421 ($z = 0.031$)

April 2013



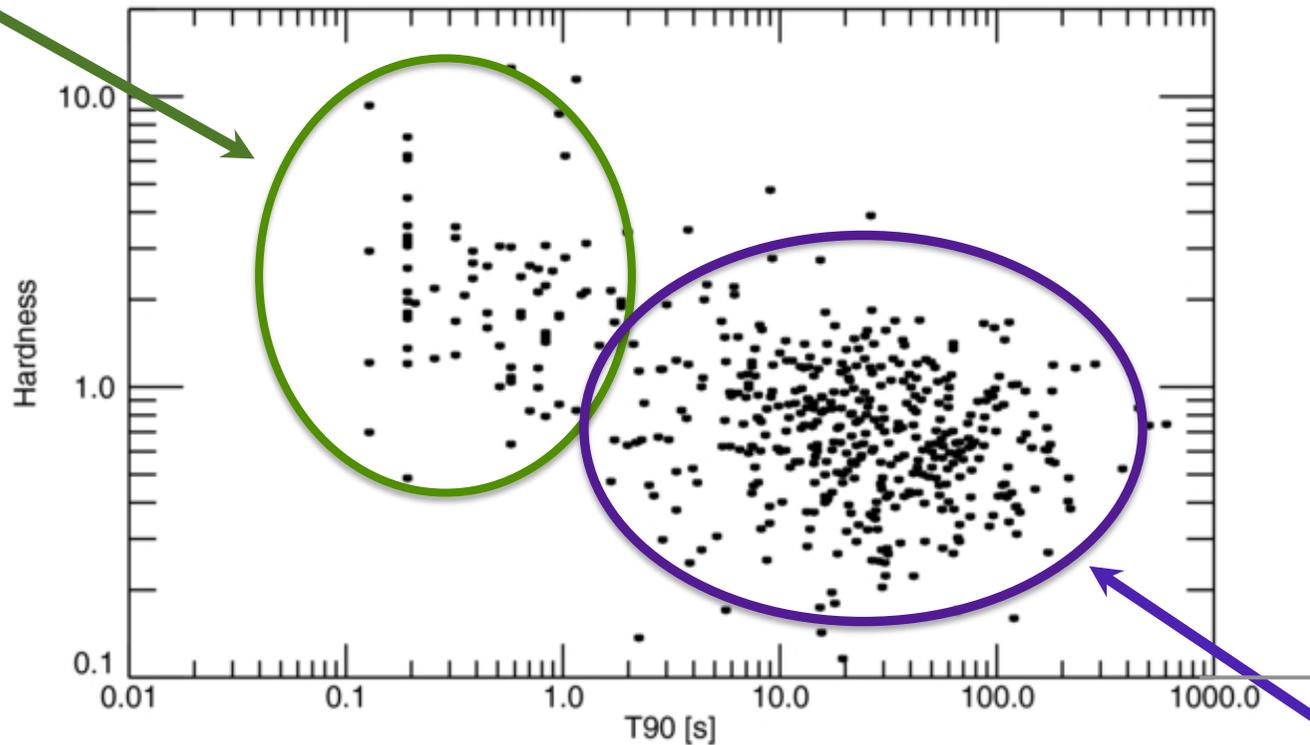
The peak energy
correlates with the flux
but has an upper limit
of ~10 keV

Pian et al. 2014

Hardness-Duration Classification of GRBs

$$H = \frac{50 - 300 \text{ keV flux}}{10 - 50 \text{ keV flux}}$$

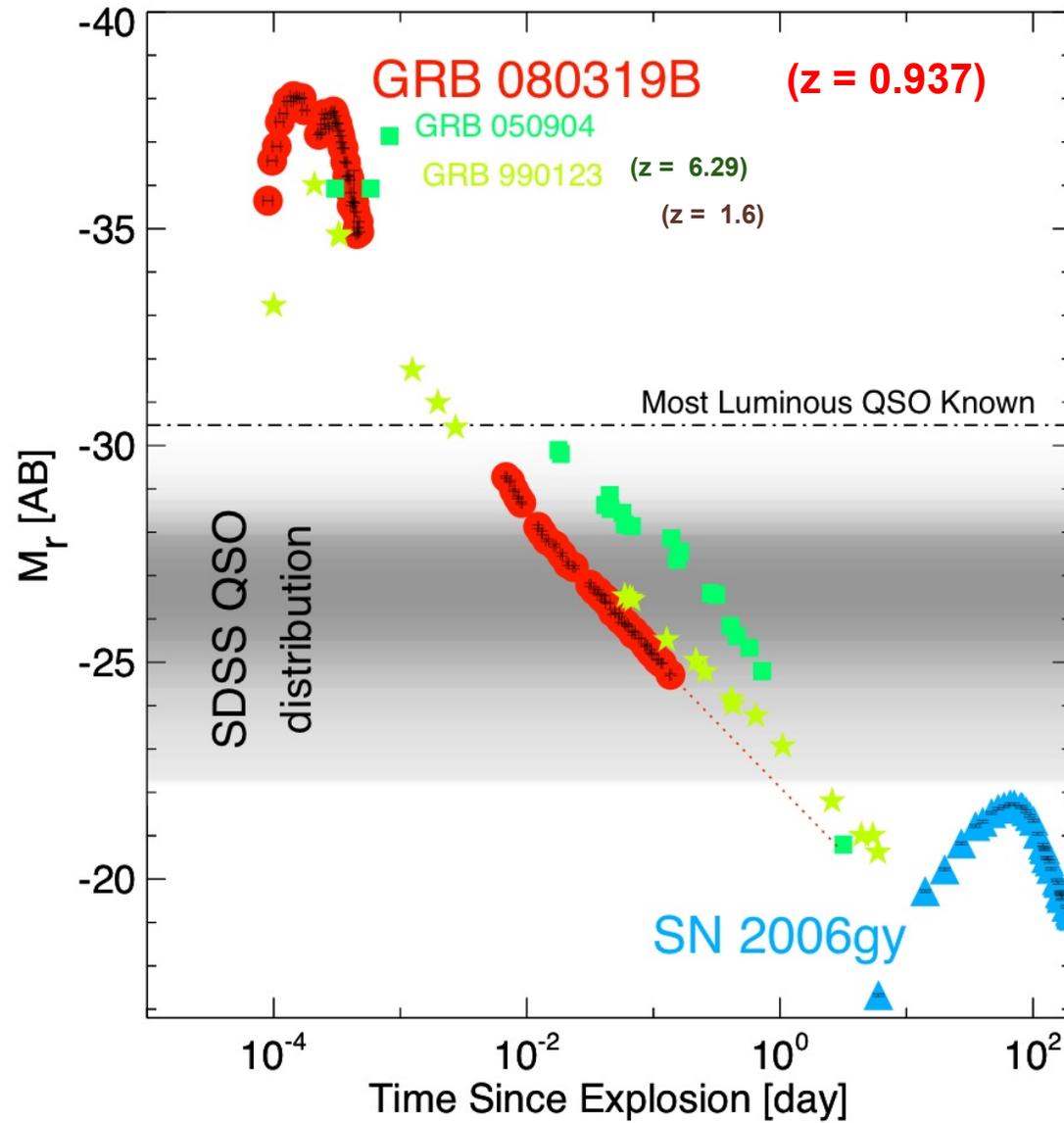
Short/Hard



Long/Soft

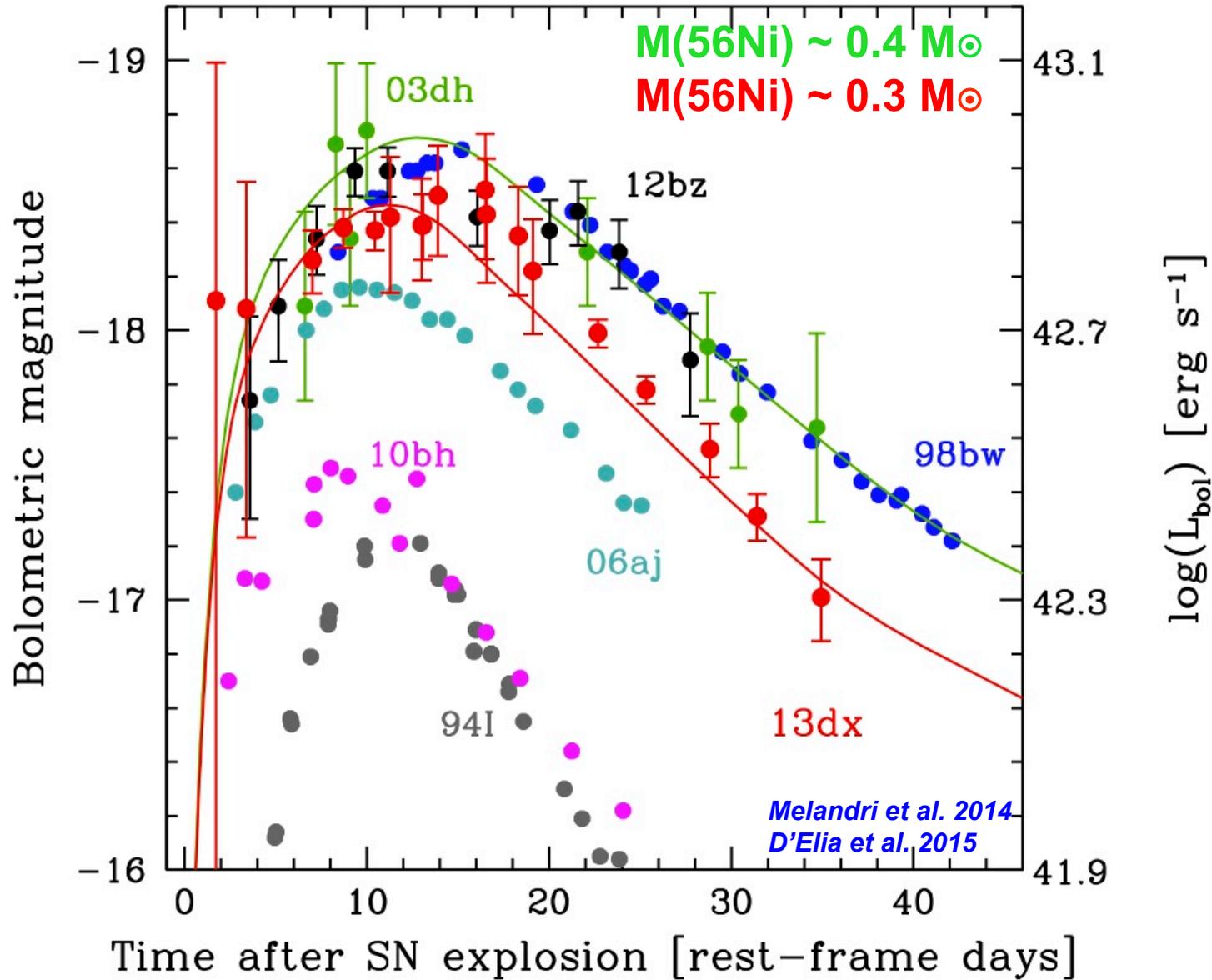
Kouveliotou+1993; von Kienlin+2014

Early Multiwavelength GRB Counterparts

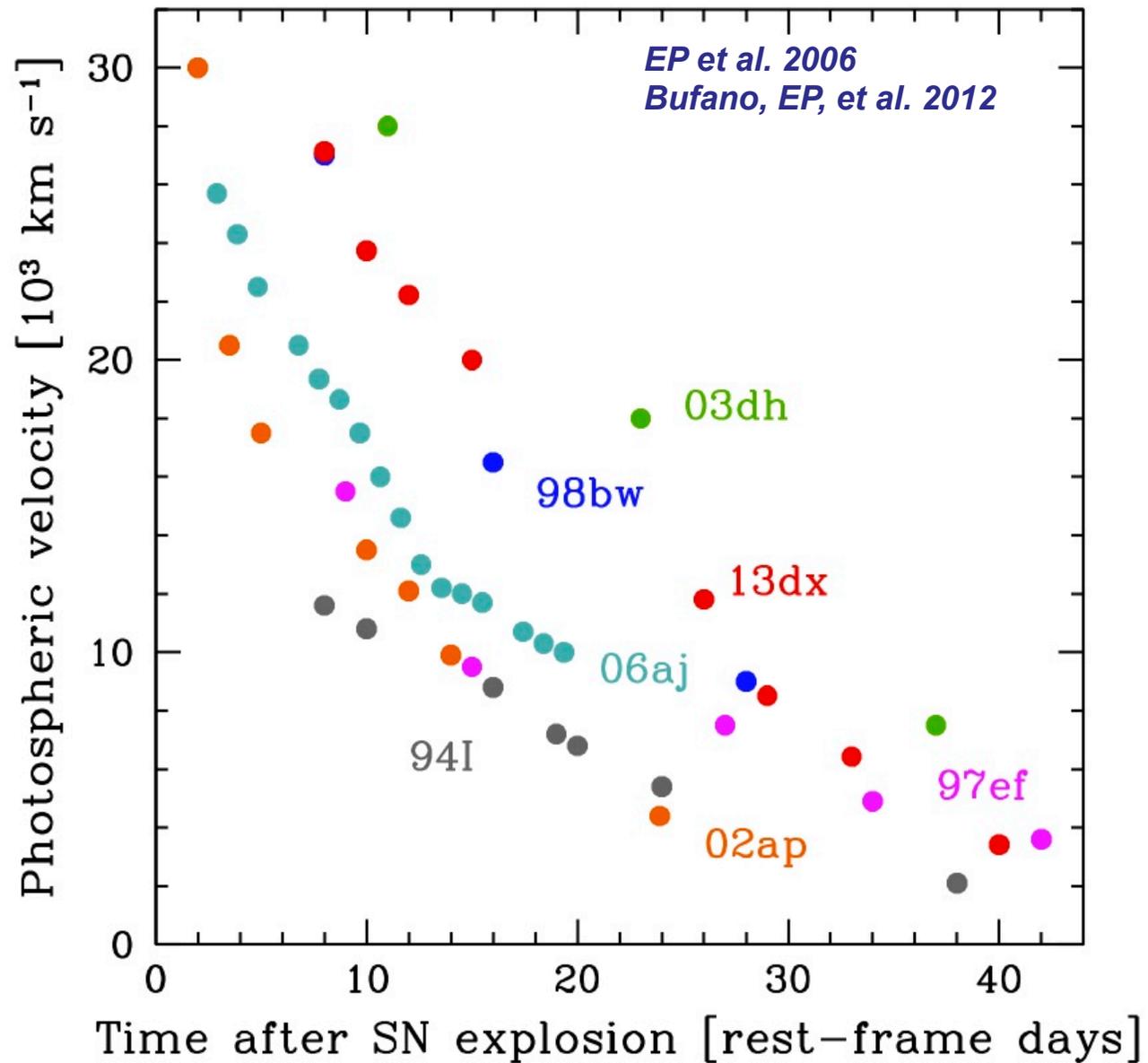


Bloom et al. 2008

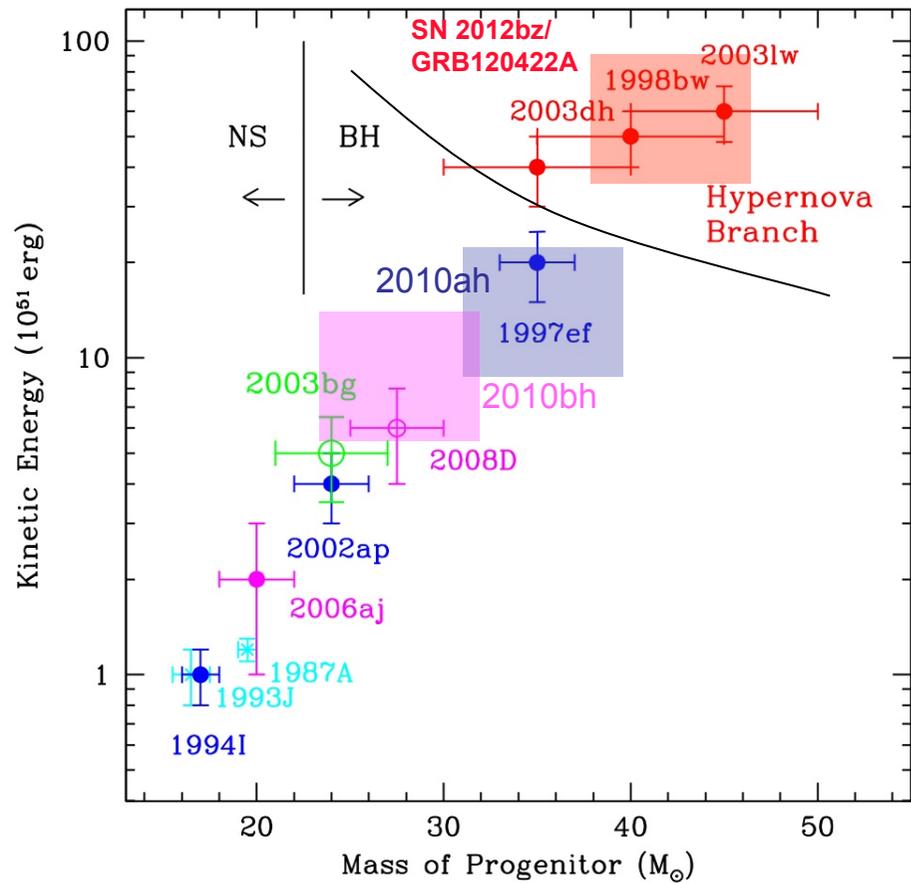
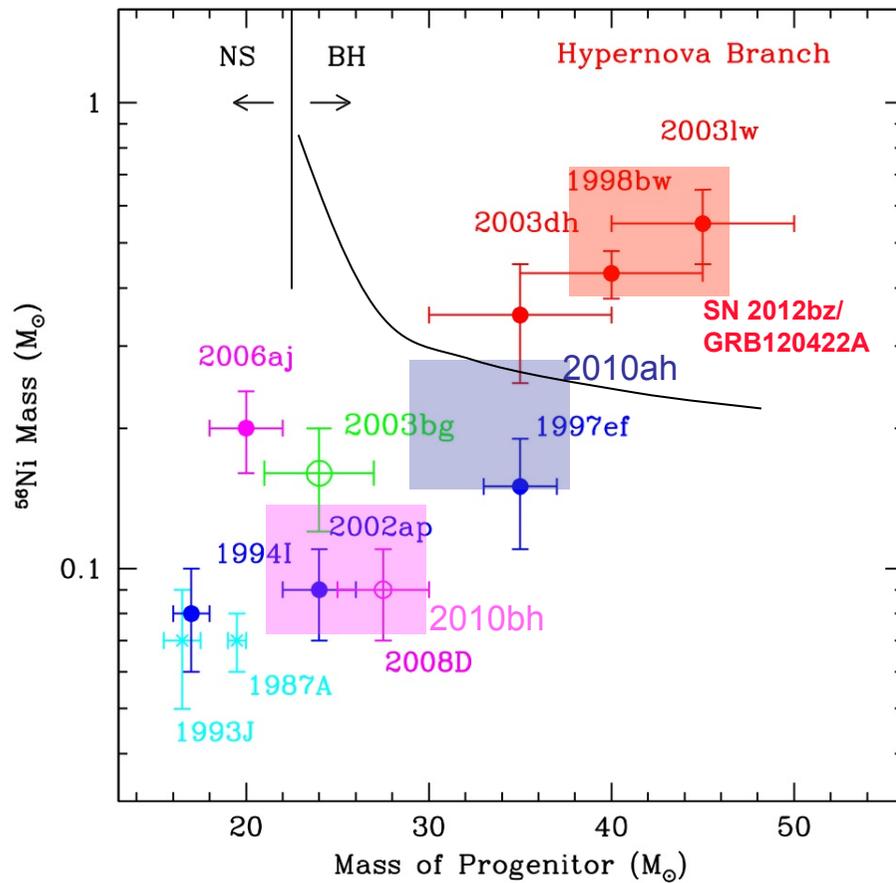
Light Curves of GRB Supernovae at $z < 0.3$



Photospheric velocities of Type Ic SNe: high kinetic energy

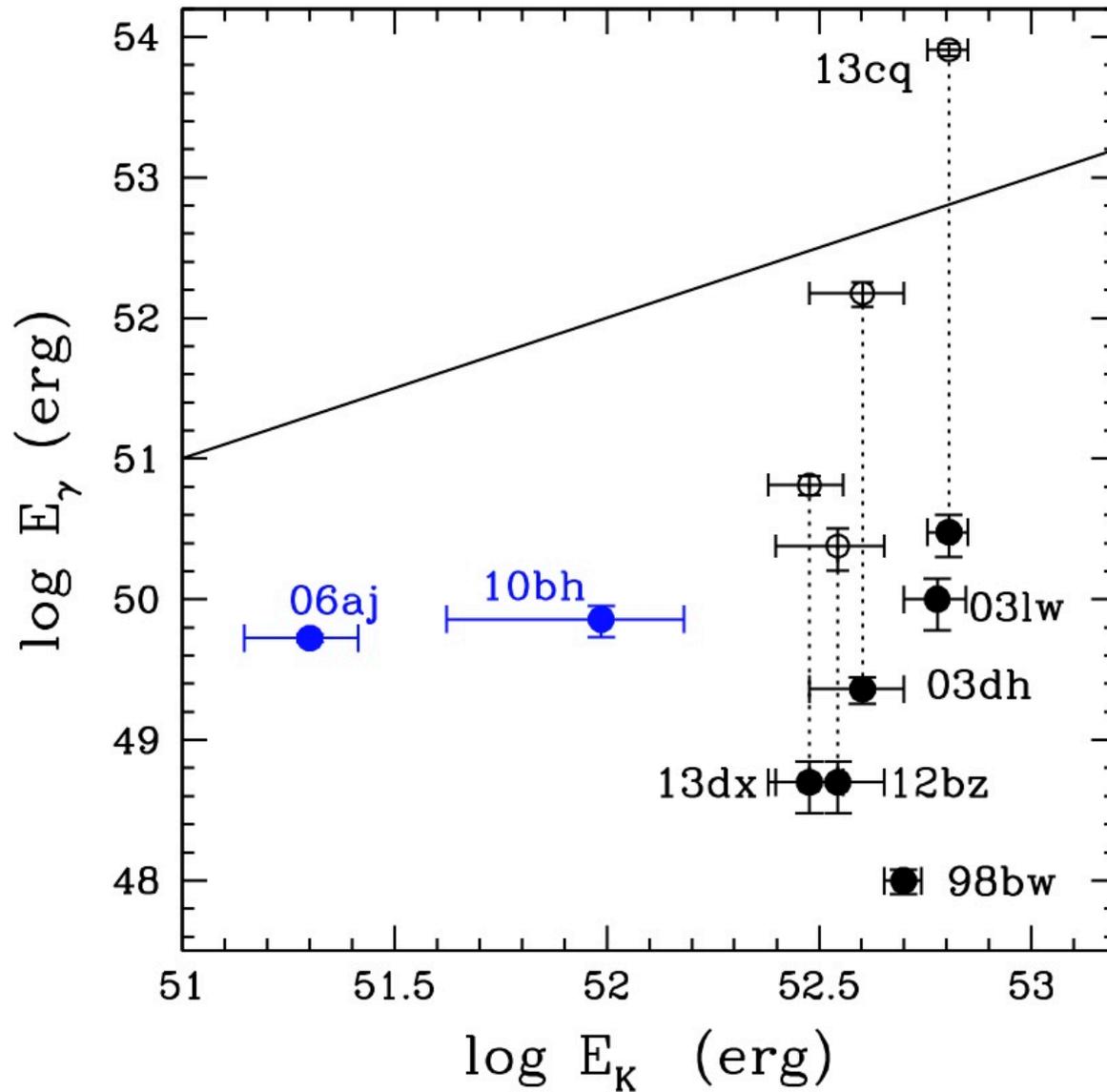


Properties of CC-Sne as $f(M_{\text{prog}})$



A minimum mass and energy seem to be required for GRBs:
(Mazzali et al. 2013)

GRB energy output versus SN kinetic energy



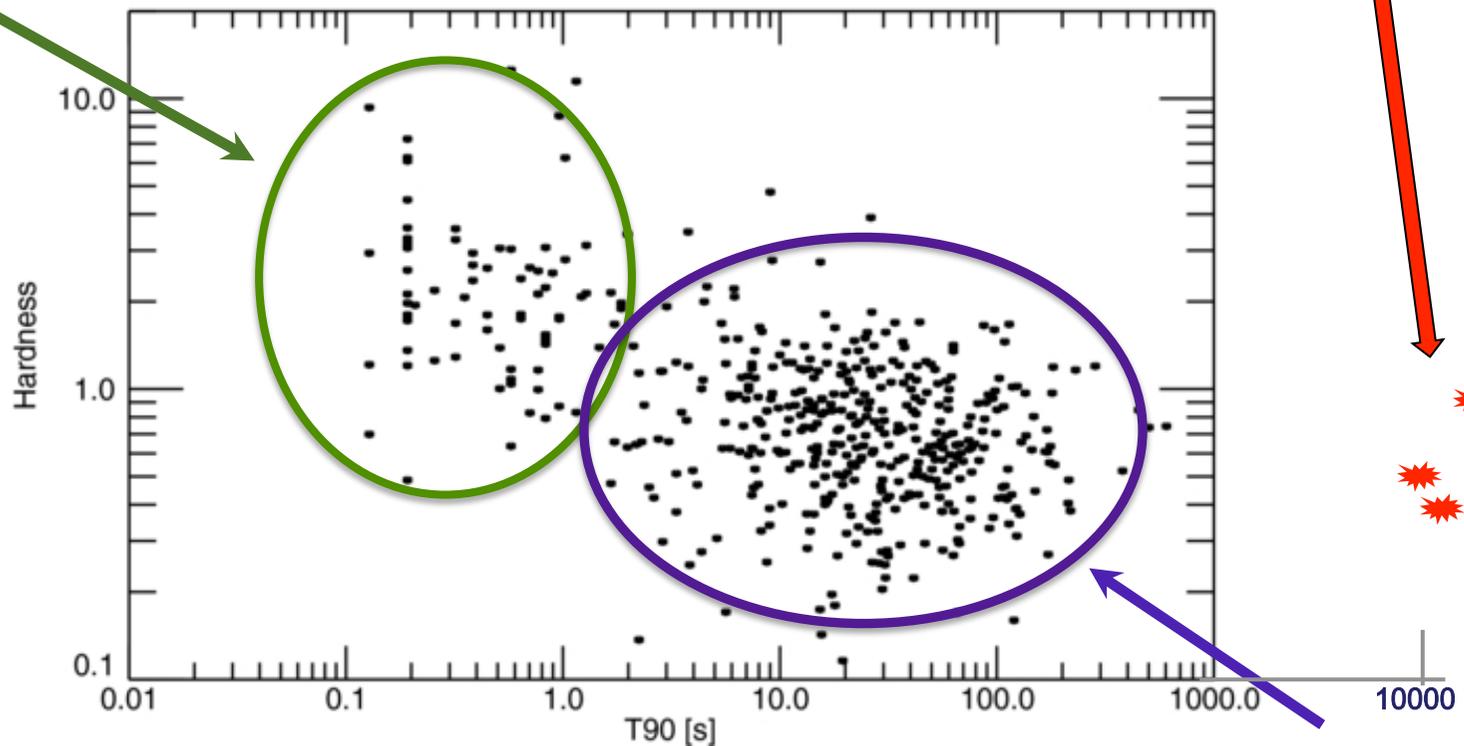
Supernova kinetic energy is very close to Rotational energy of millisecond NS

Hardness-Duration Classification of GRBs

$$H = \frac{50 - 300 \text{ keV flux}}{10 - 50 \text{ keV flux}}$$

Four GRBs with duration $>10^4$ s

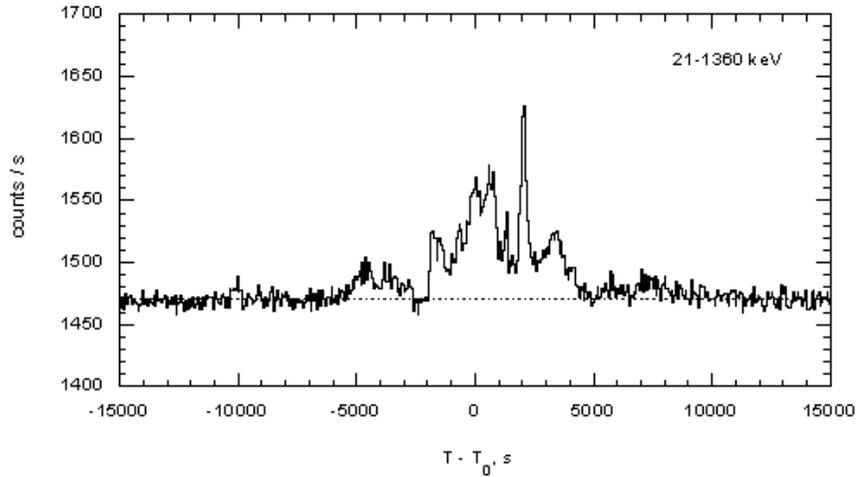
Short/Hard



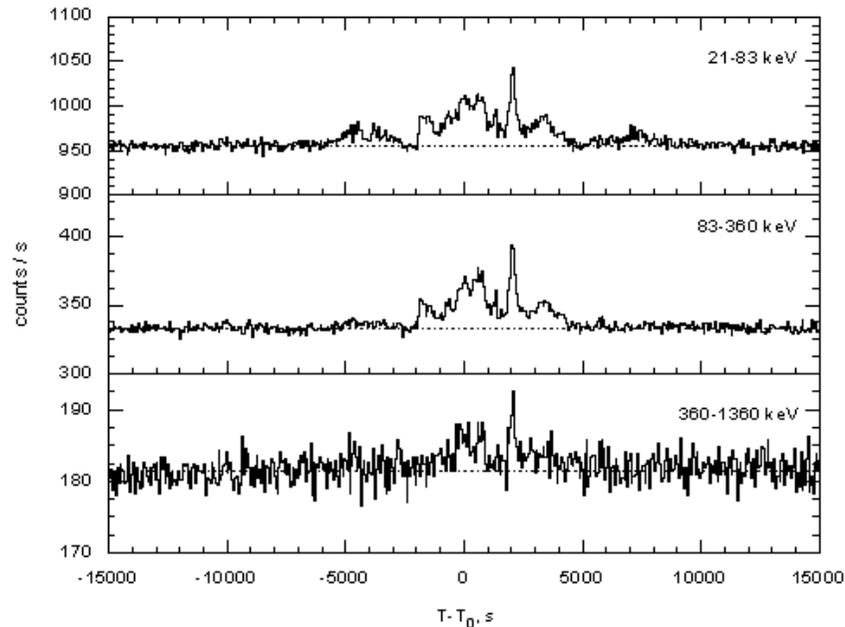
Long/Soft

Kouveliotou+1993; von Kienlin+2014

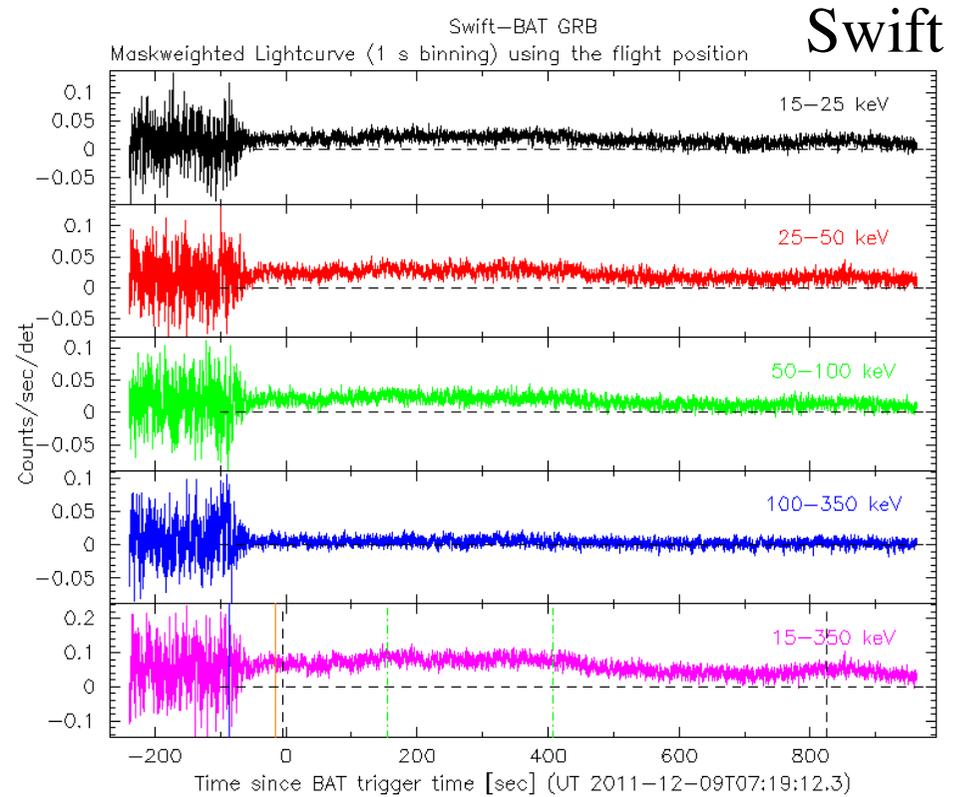
KONUS-WIND GRB 111209
 $T_0 = T_0(\text{BAT}) = 25928 \text{ s UT (07:12:08)}$
 S1



Konus-Wind

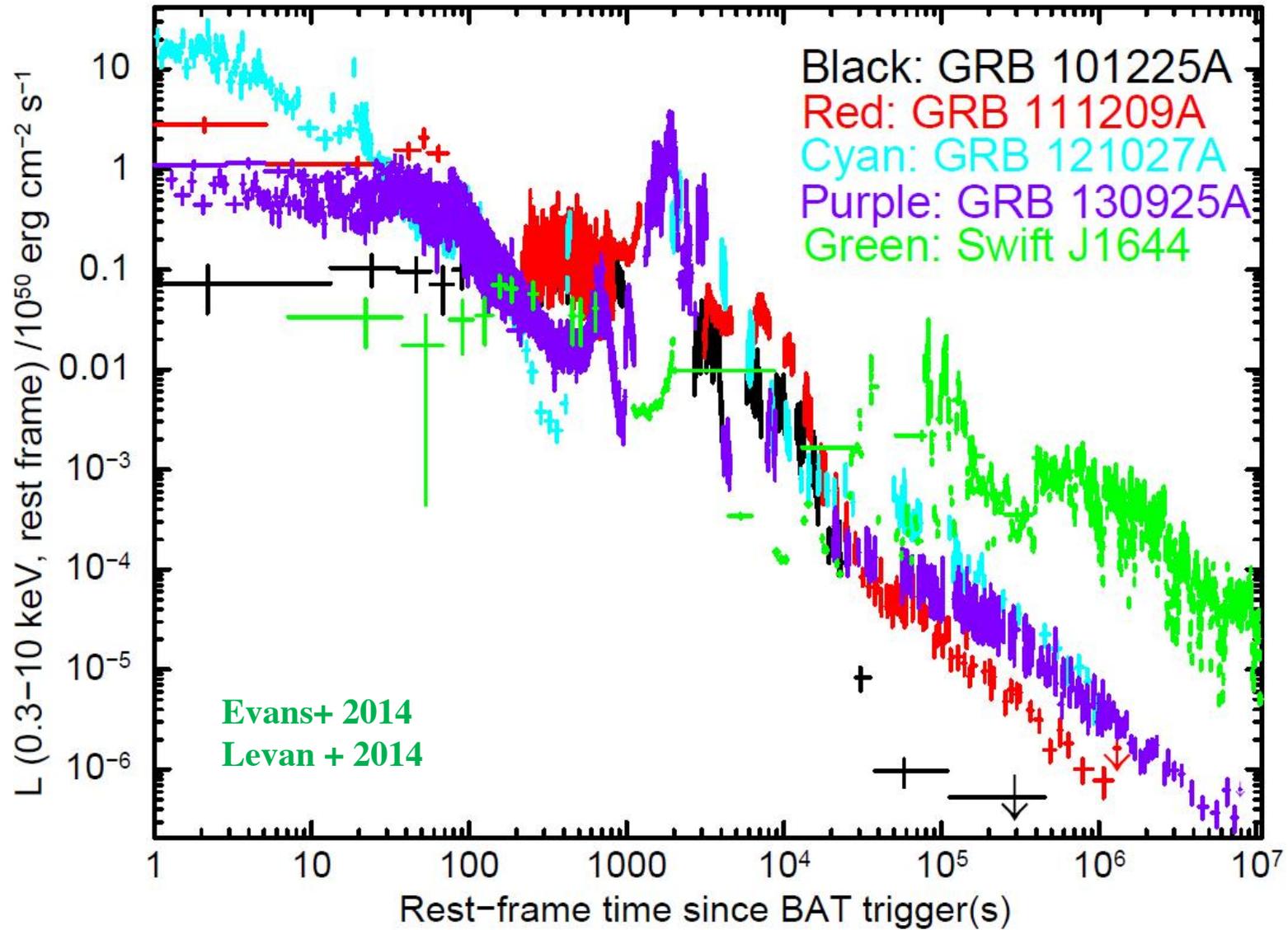


GRB 111209A ($z = 0.677$) prompt light curve



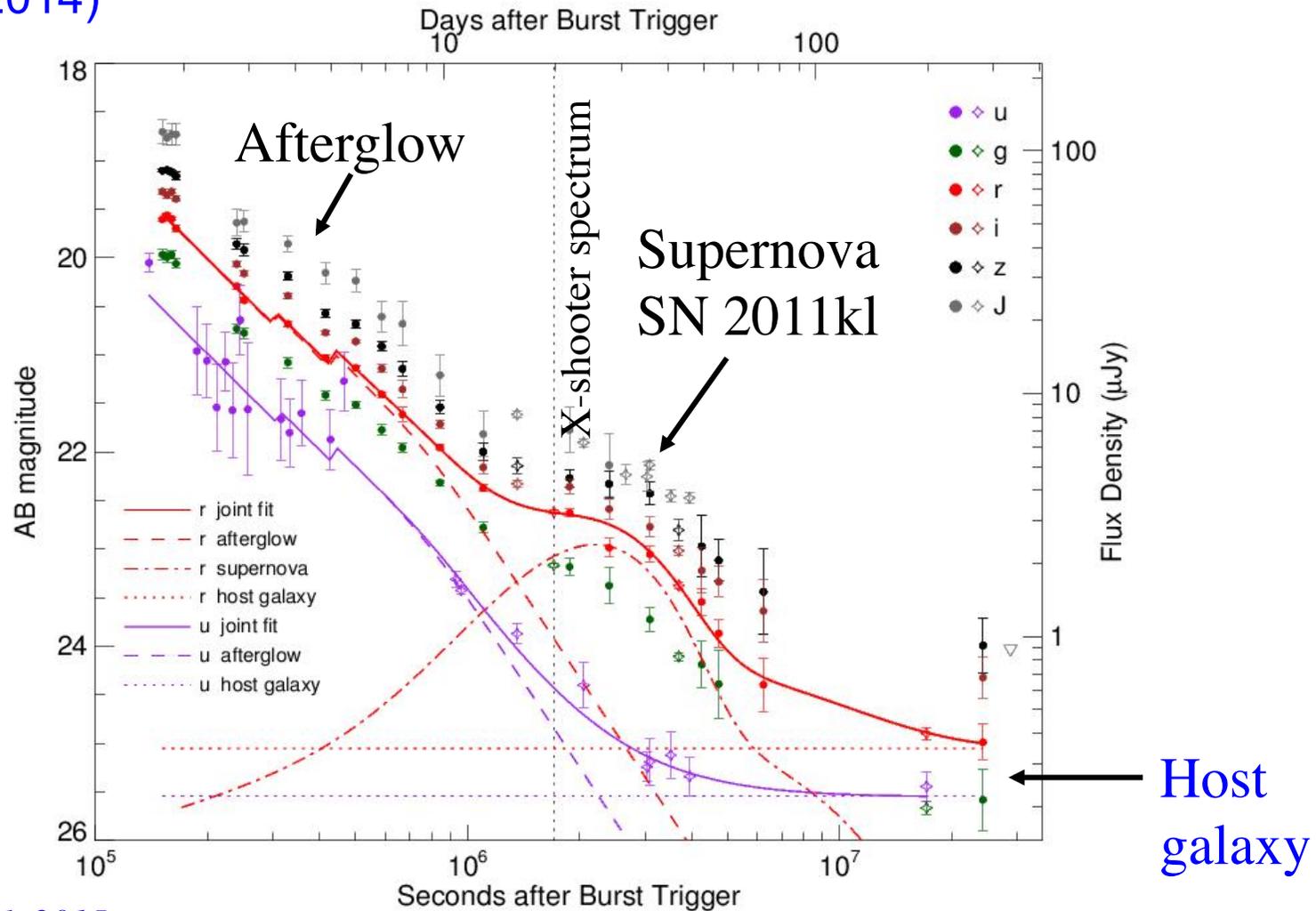
Ultra-long duration can be properly recognized only by interplanetary satellites

Ultra-long GRBs

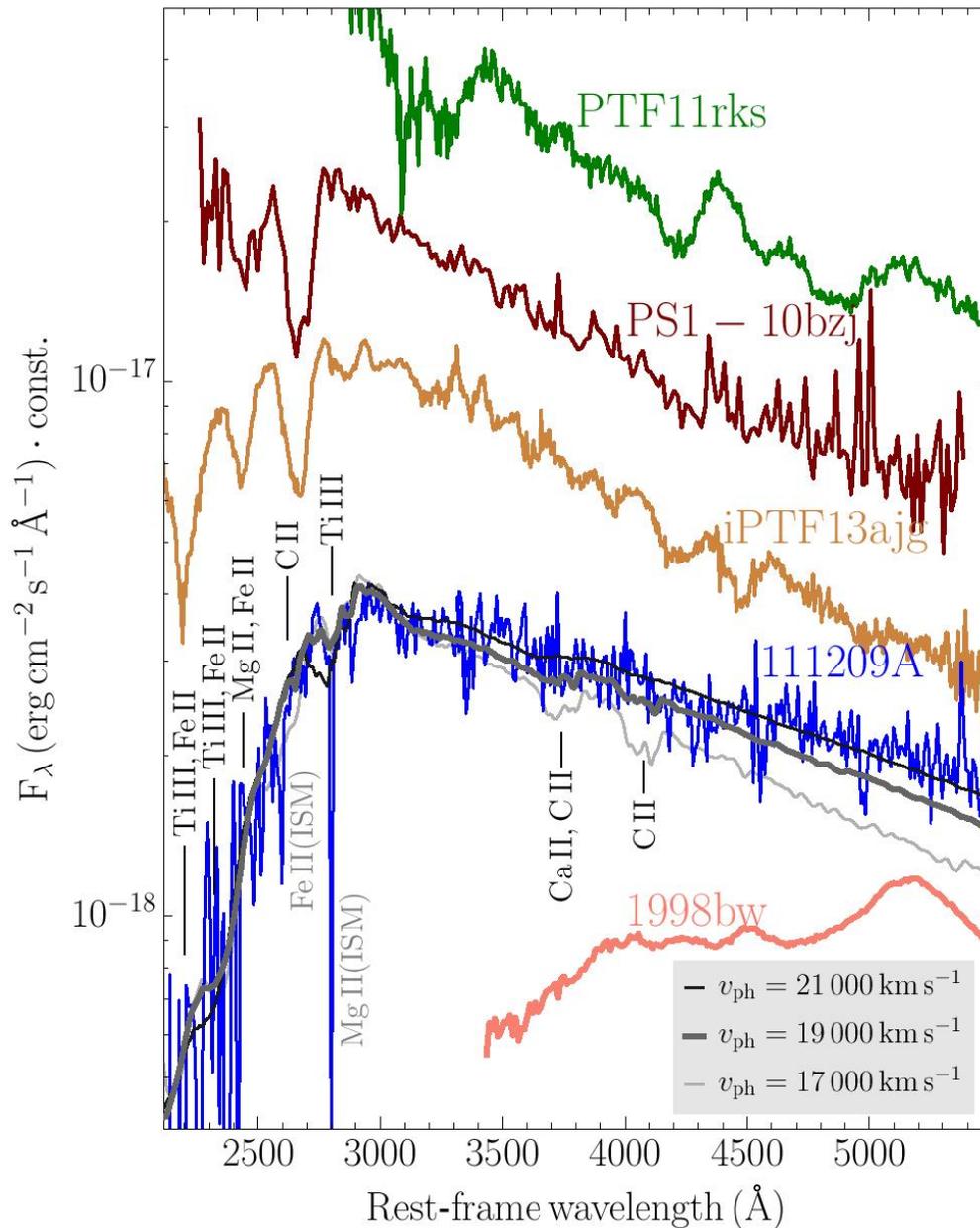


Ultra-long GRB 111209A ($z = 0.677$) & its SN

7-channel GROND@2.2m observations over 70 days
Added Swift/UVOT + publ. HST data (from Levan et al. 2014)

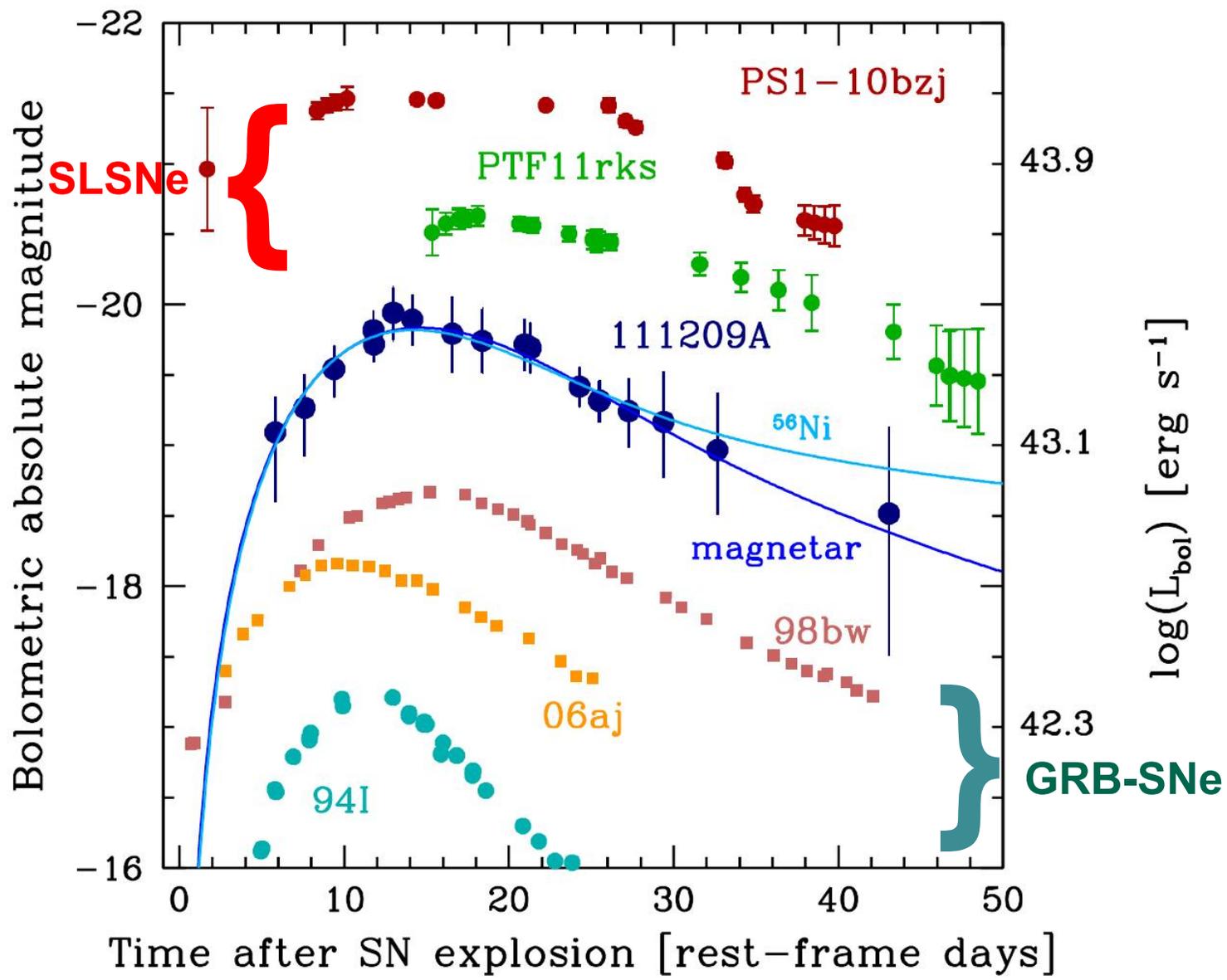


SN 2011kl spectrum ($z = 0.677$)



- SN 2011kl X-shooter spectrum reminiscent of SLSN
- Spectrum very blue and (nearly) no absorption lines:
 - ➔ little ejecta
 - ➔ high velocity
- Spectrum reproduced with radiation transport code (Mazzali+00) and a density profile $\rho \sim r^{-7}$
- featureless spectrum due to line blending ($v_{\text{ph}} \sim 20,000 \text{ km/s}$)
- no evidence of freshly synthesized material mixed-in, unlike in GRB-SNe

SN 2011kl light curve

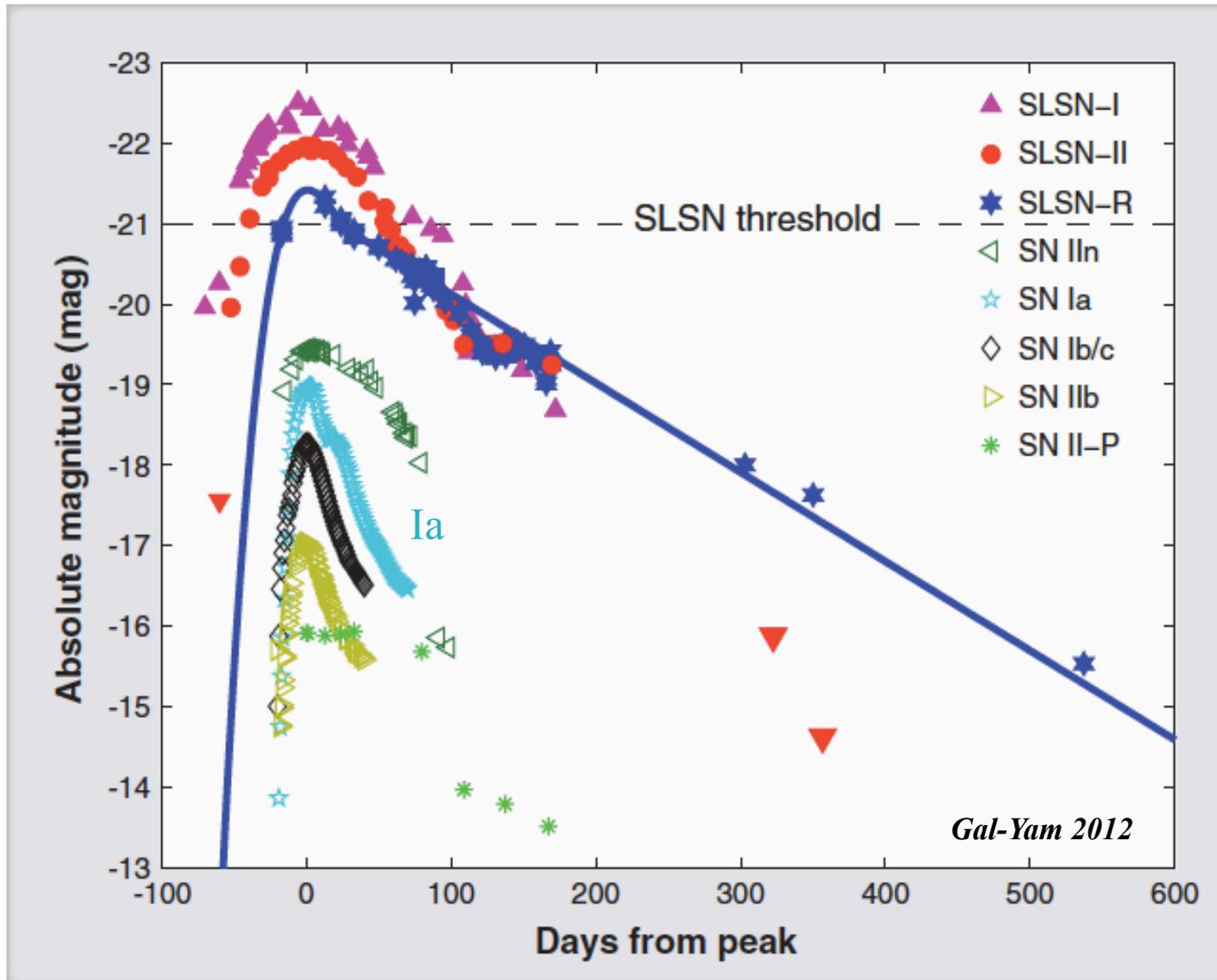


The missing link between GRBs
And SLSNe:

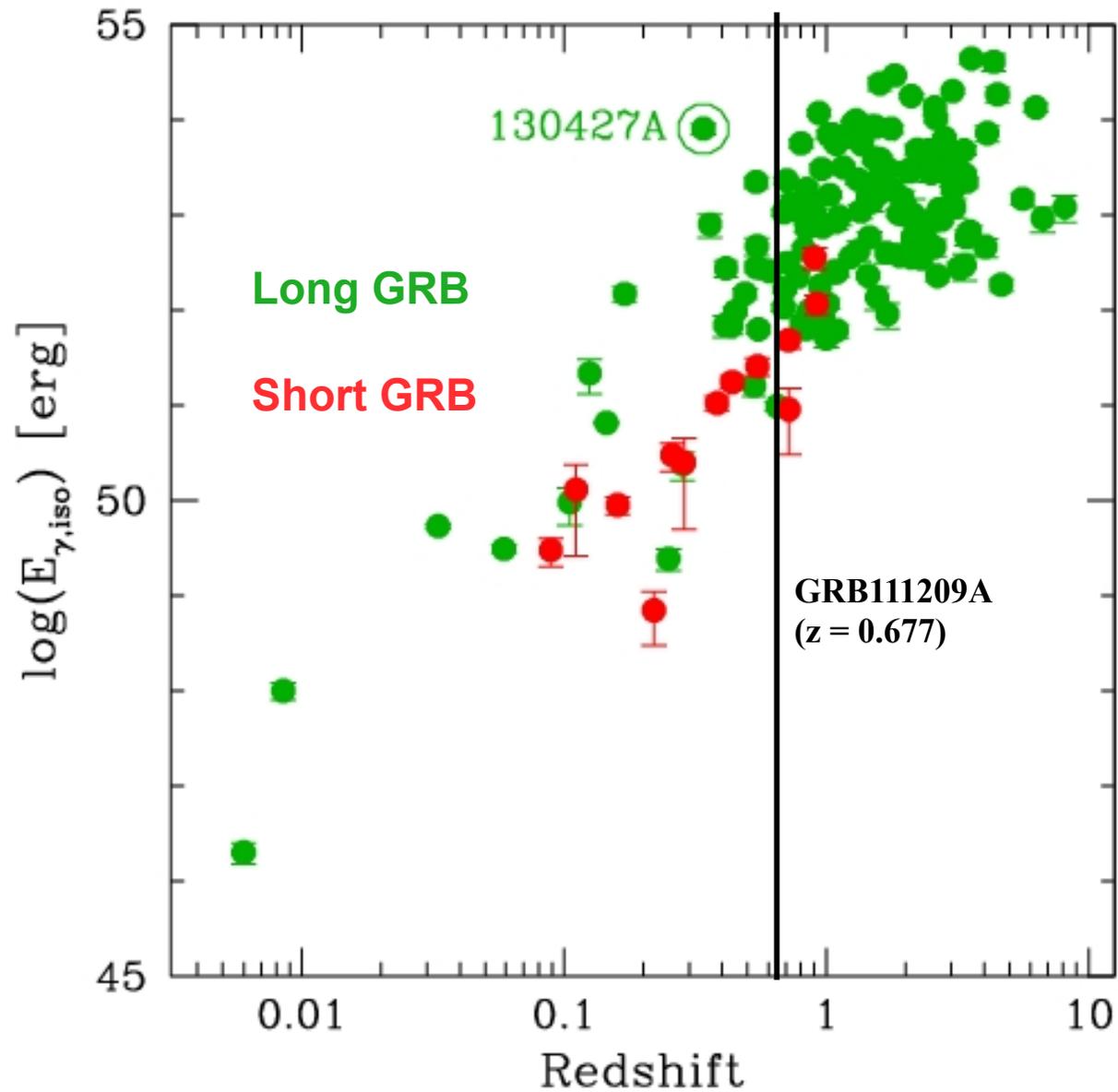
GRB111209A/SN2011kl: a very
luminous supernova associated with
an ultra-long GRB

A “compelling” case for magnetar?

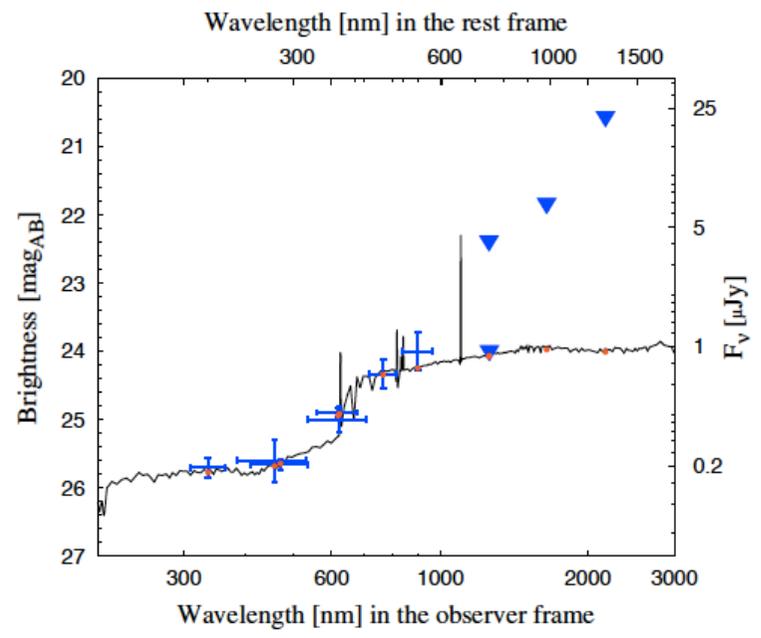
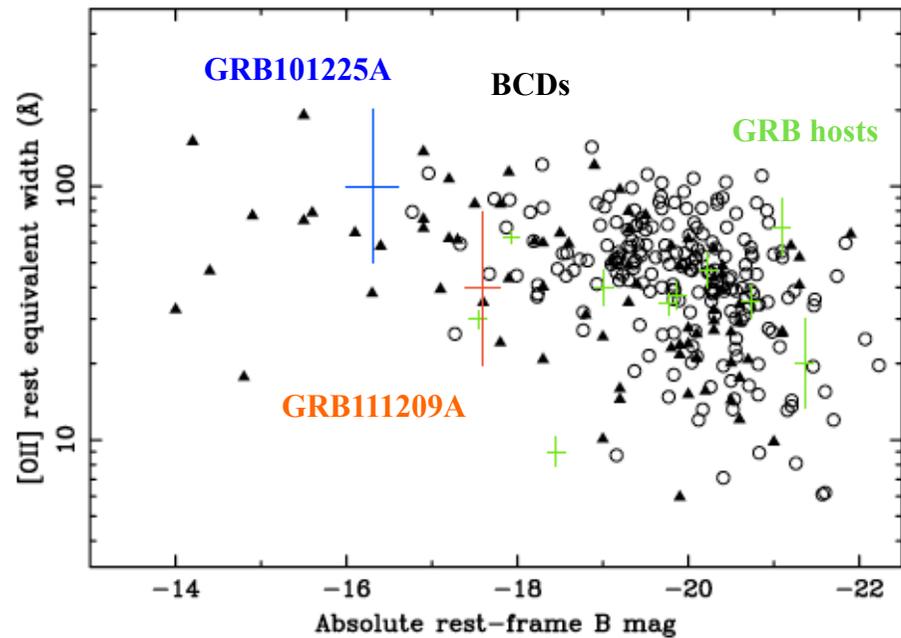
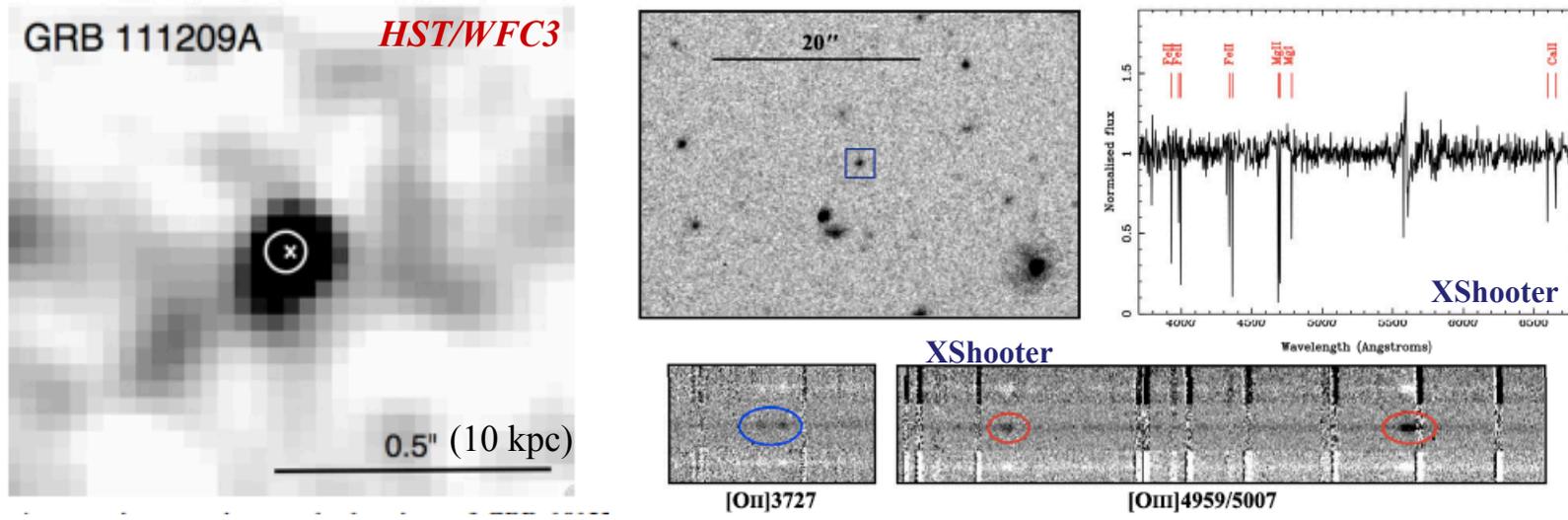
Supernova light curves



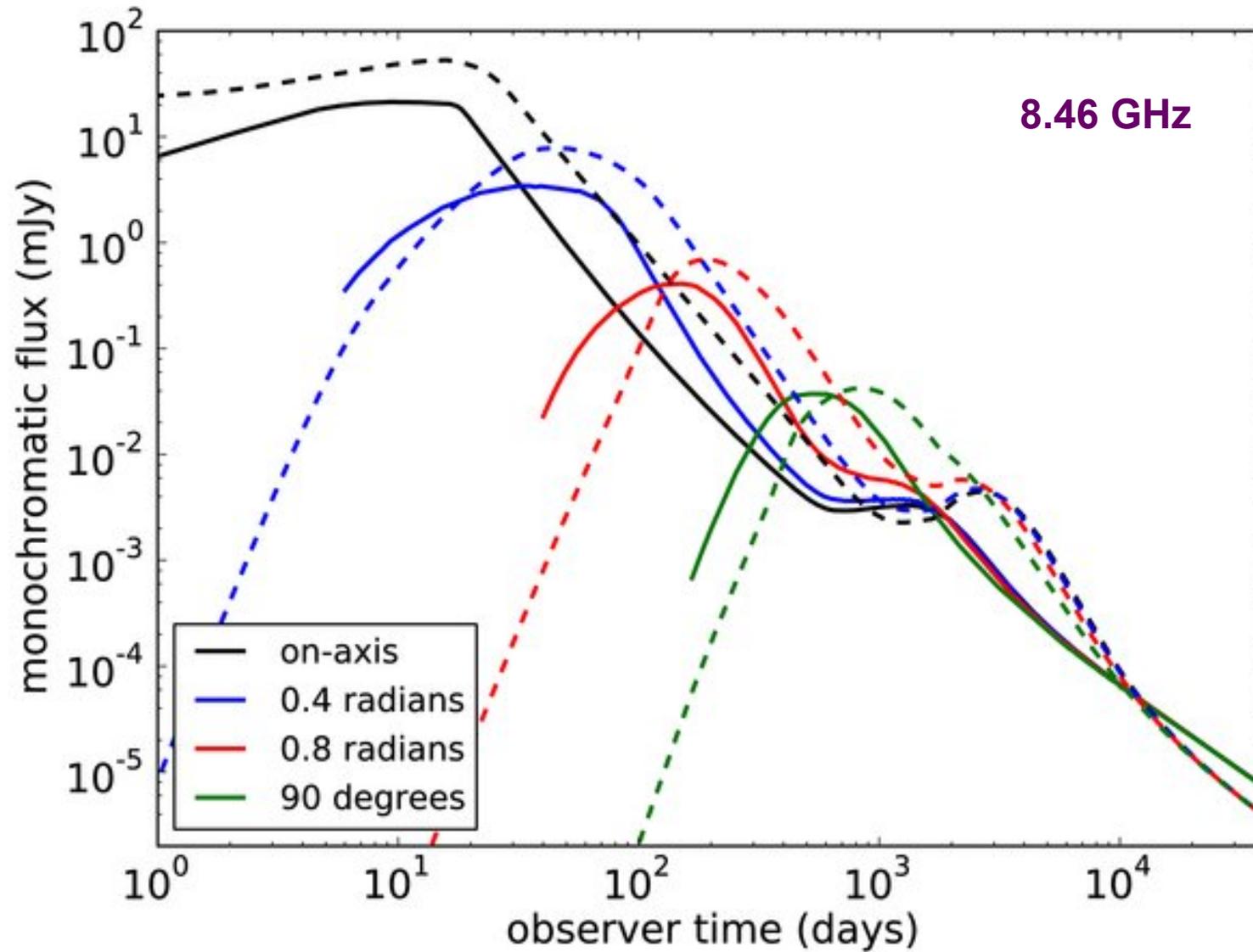
Isotropic irradiated γ -ray energy vs redshift



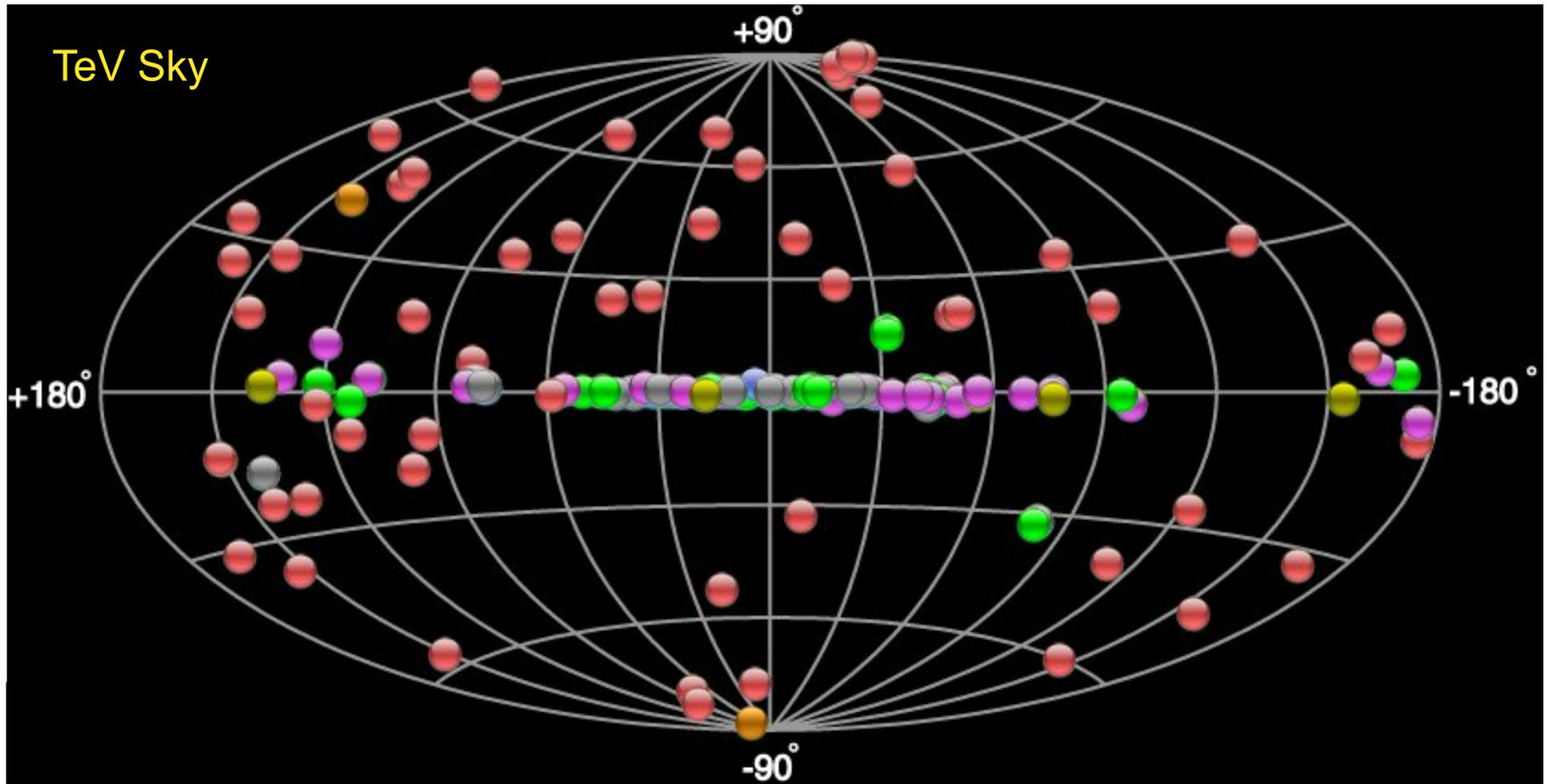
GRB111209A host: Low-extinction, highly star-forming, low Z



Simulated and analytical radio emission of GRBs



TeV Sky



~150 sources

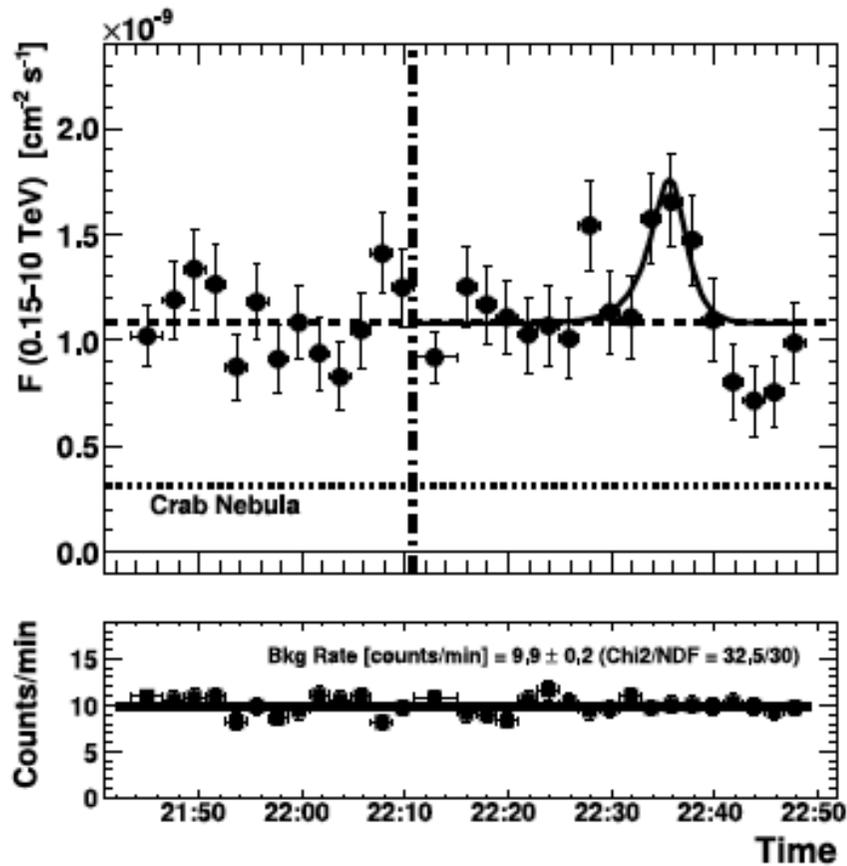
- PWN
- Starburst (M82, NGC253)
- HBL, IBL, FRI, Blazar, FSRQ, LBL, AGN (unknown type)
- Globular Cluster, Star Forming Region, uQuasar, Cat. Var., Massive Star Cluster, BIN, BL Lac (class unclear), WR

- Shell, SNR/Molec. Cloud, Composite SNR, Superbubble
- DARK, UNID, Other
- Binary, XRB, PSR, Gamma BIN

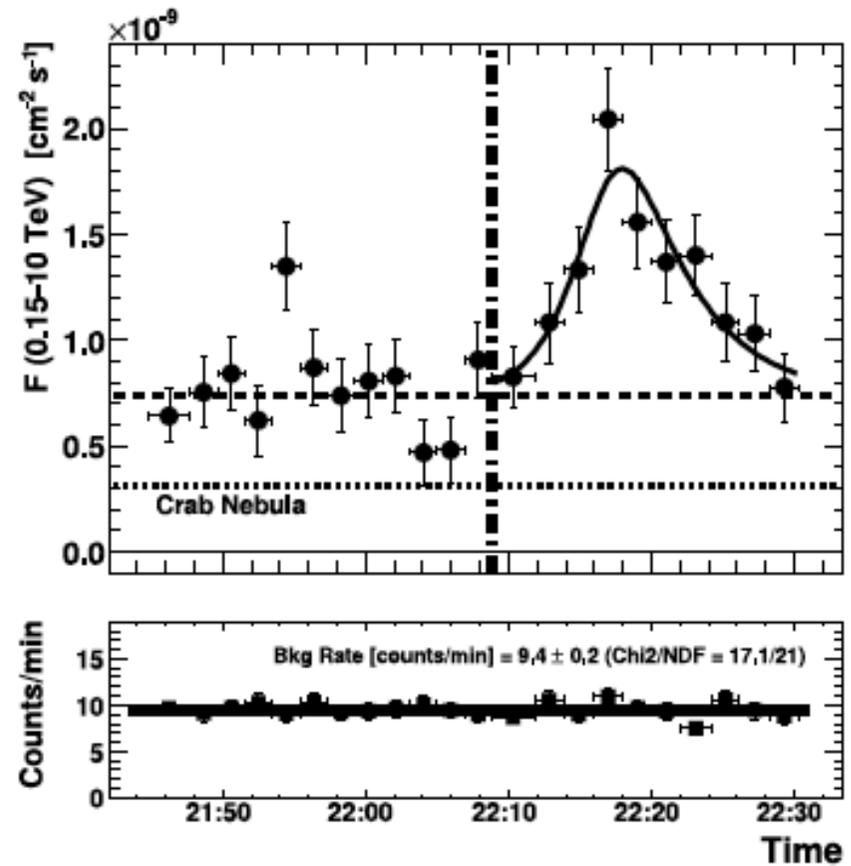
<http://tevcatalog.uchicago.edu>

TeV minute time-scale variability of Mkn501 (MAGIC)

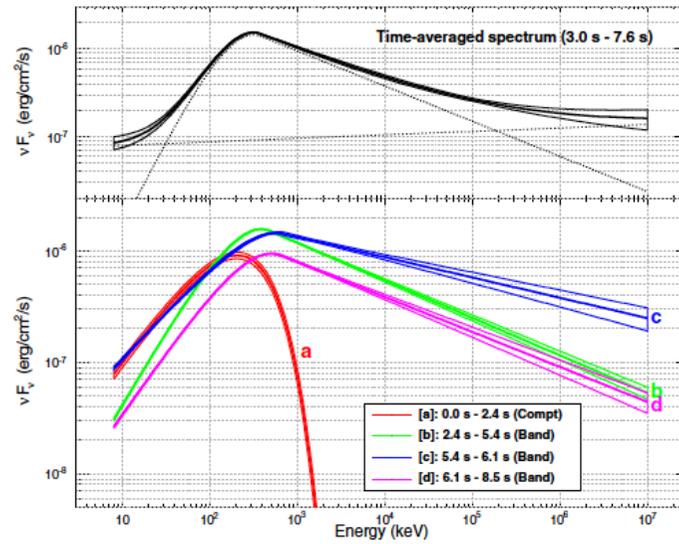
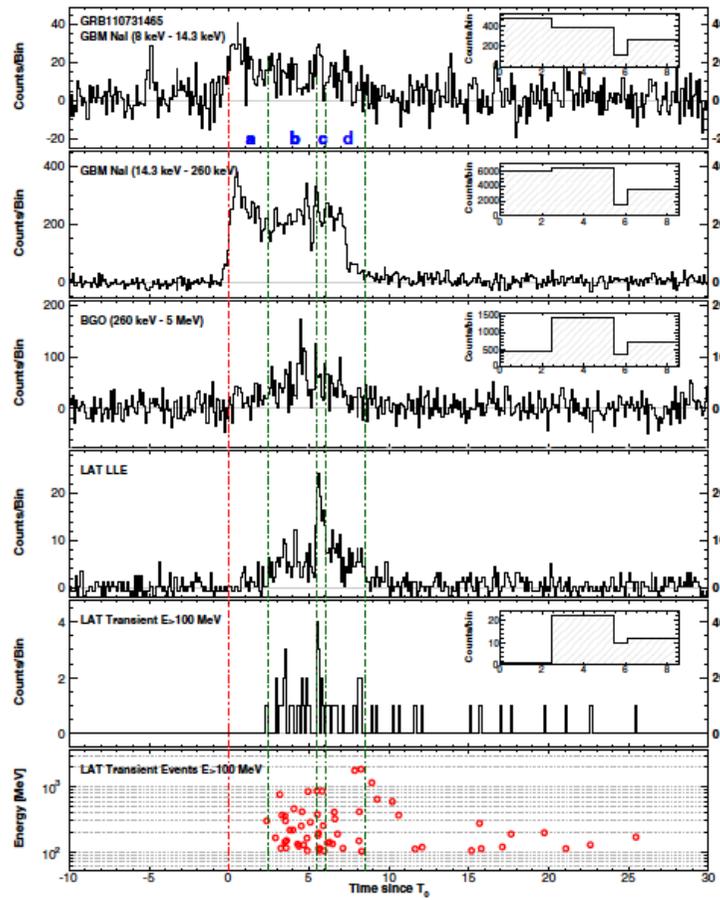
30 June 2005



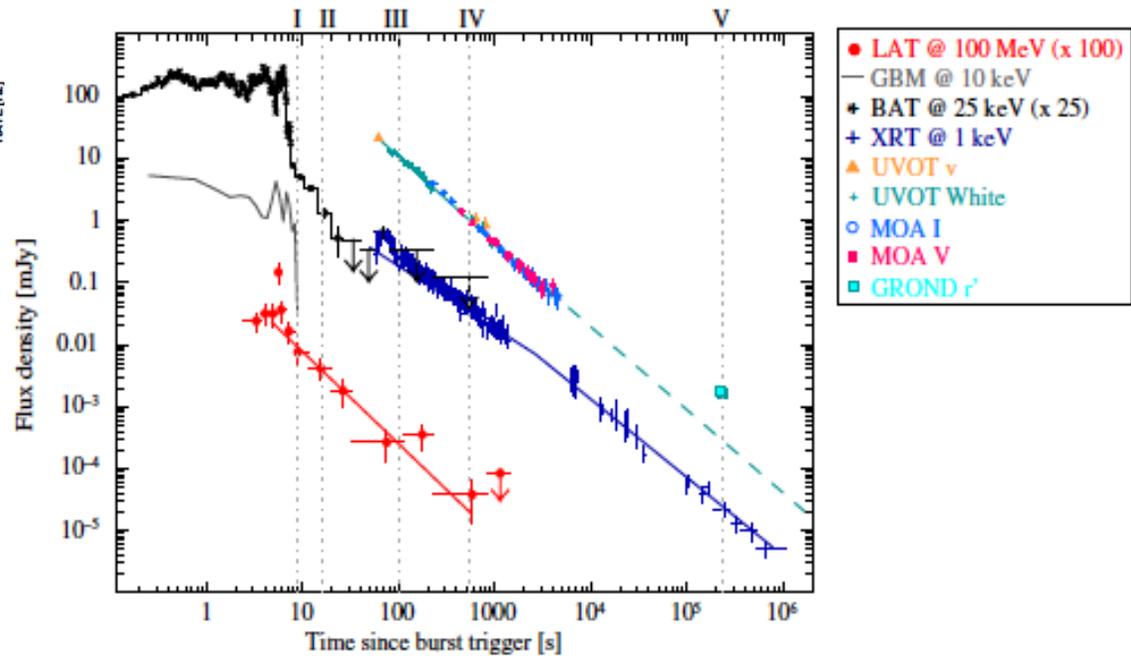
9 July 2005



GRB110731A ($z = 2.83$) as a template to estimate TeV emission



Ackermann
et al. 2013



scaling to $z \sim 0.3$ and
extrapolating to 1 TeV, flux
at 1000s is ~ 5 Crab

Conclusions and open problems

Analogies in relativistic jets on many scales, despite difference in origin

High synchrotron blazars may have intrinsic differences that allow only a subset of them to become really extreme. Correlated X-ray and TeV variability may be revealing in this sense

Are all GRB jets related to accretion on a promptly formed BH or is magnetar a viable scenario?

As it was done with AGNs, can we unify GRBs and supernovae based on their jet viewing angle?