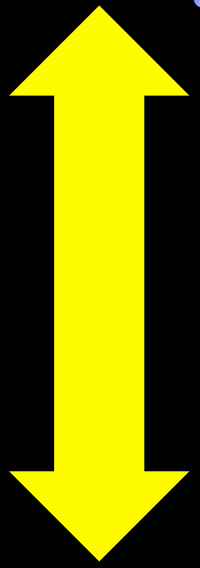
Gamma Ray Burst



Cosmology

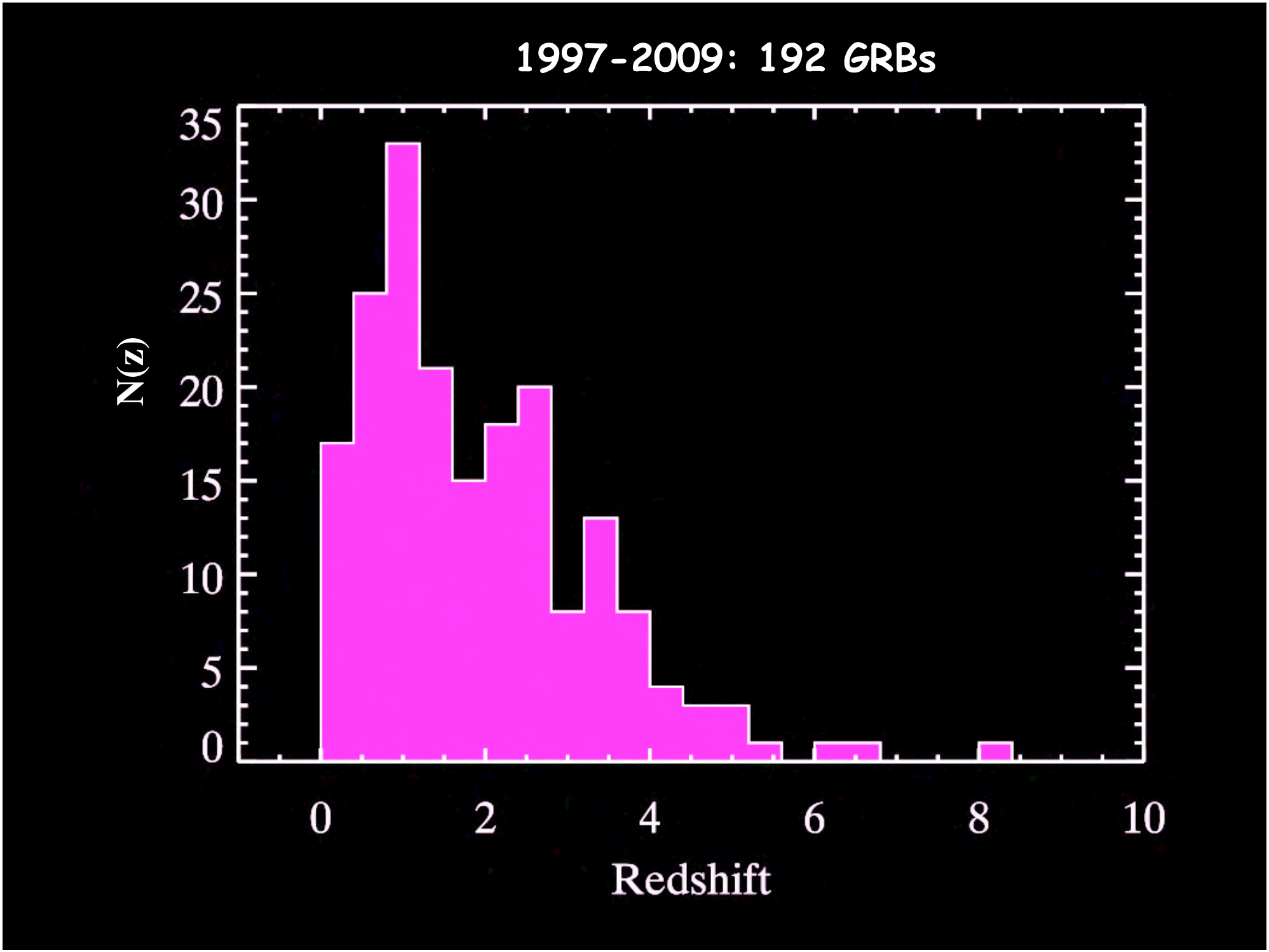
Giancarlo Ghirlanda

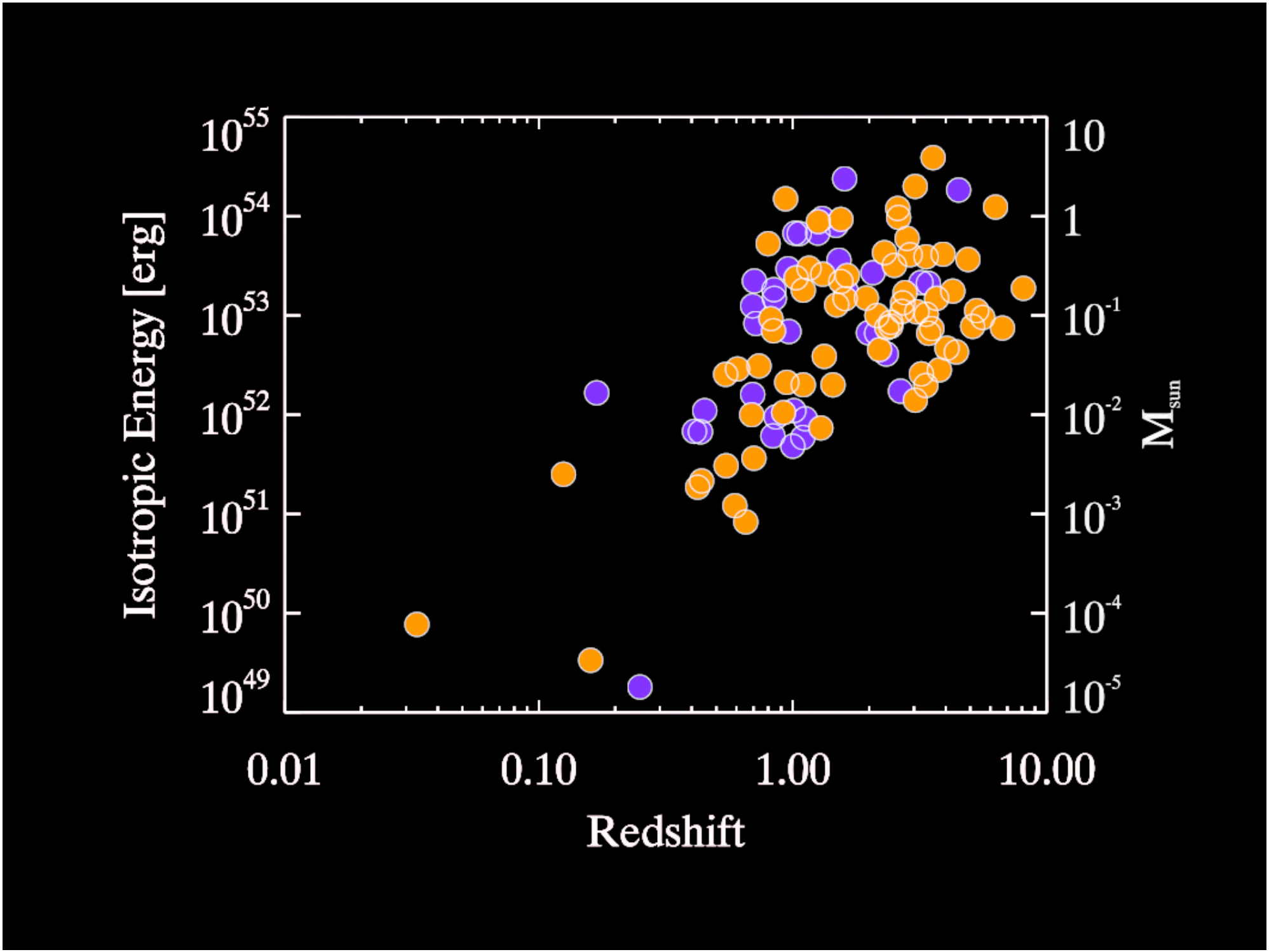
INAF-Oss. Astr. Brera

A. Celotti, D. Lazzati, C. Firmani, G. Ghisellini, M. Nardini,

L. Nava, F. Tavecchio

X-Ray Astronomy 2009 - Bologna


1997-2009: 192 GRBs
N(z)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
Redshift


Isotropic Energy [erg]
10^{55}
10^{54}
10^{53}
10^{52}
10^{51}
10^{50}
10^{49}
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
M_{sun}
0.01
0.10
1.00
10.00
Redshift

GRBs

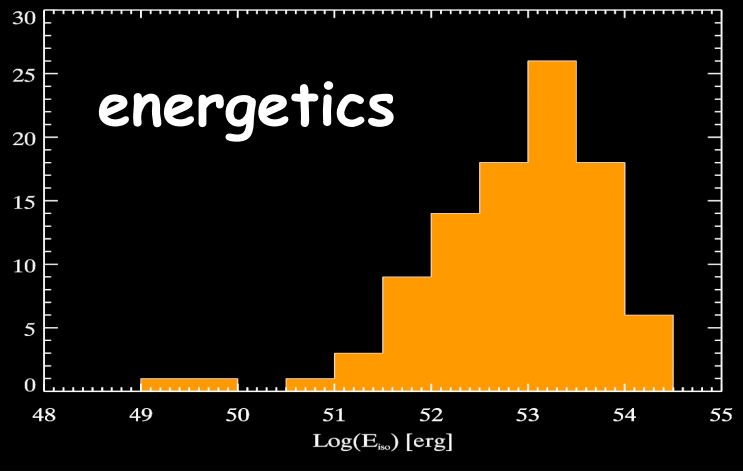
+ wide redshift distribution

+ powerful in gamma—rays

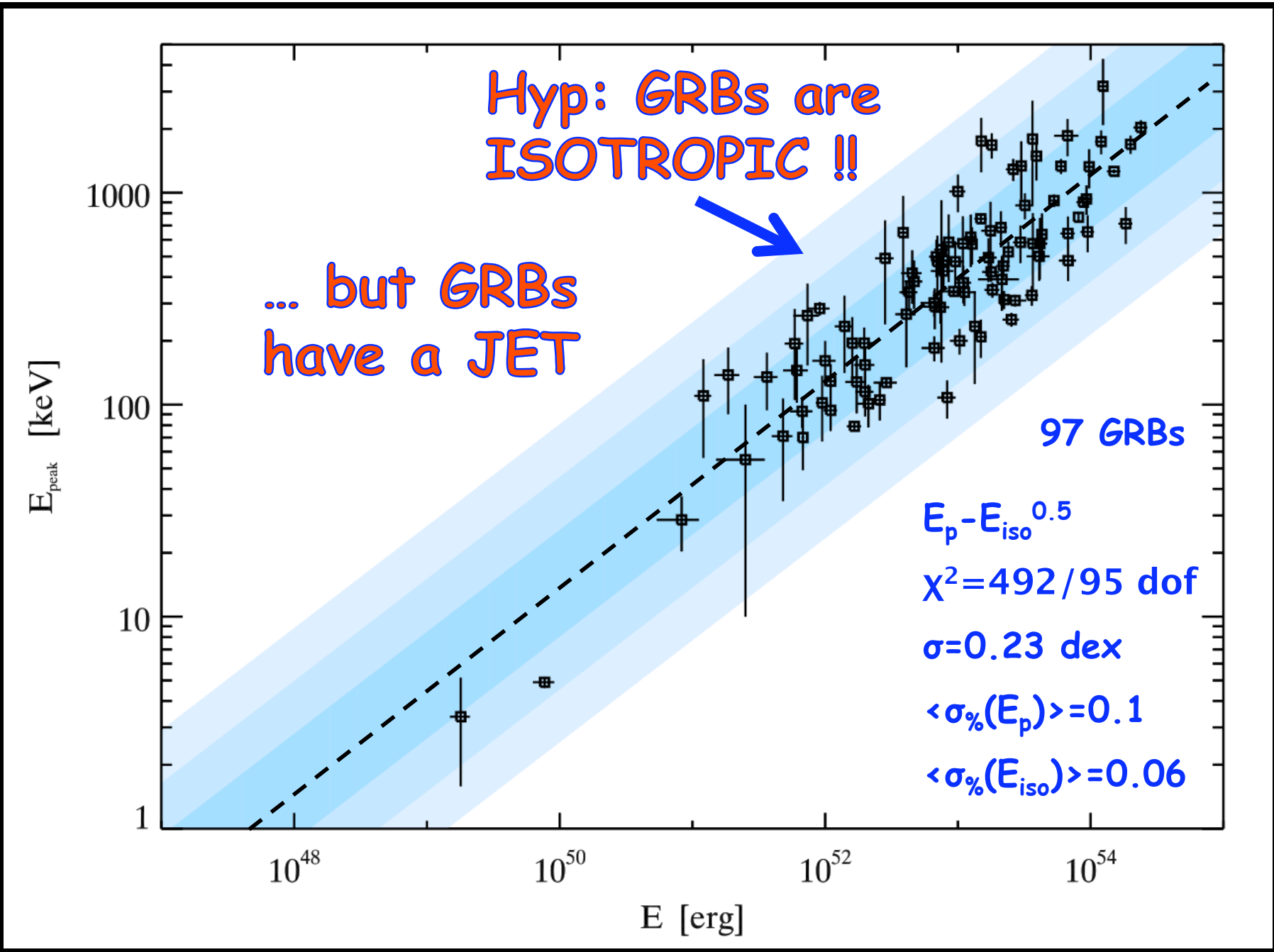
1) ISM in hosts, IGM, epoch of reionization, CSFR …

2) Cosmological parameters

… but

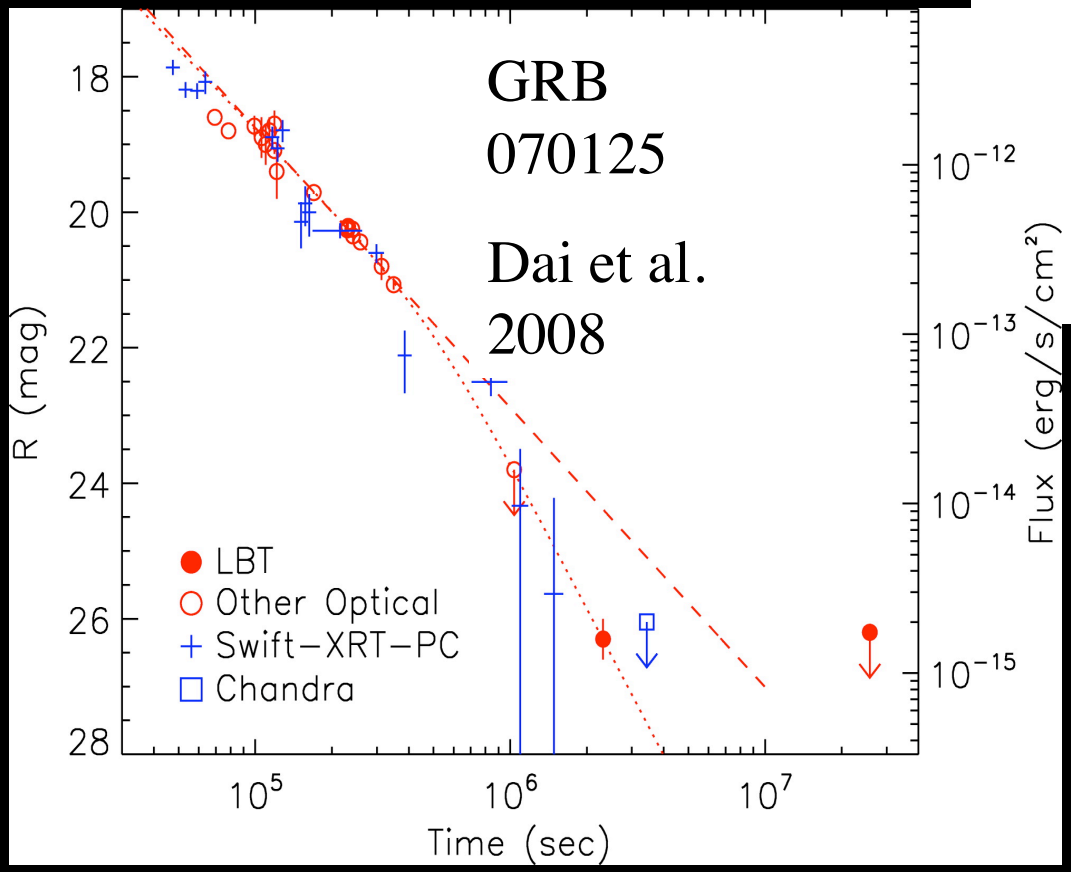


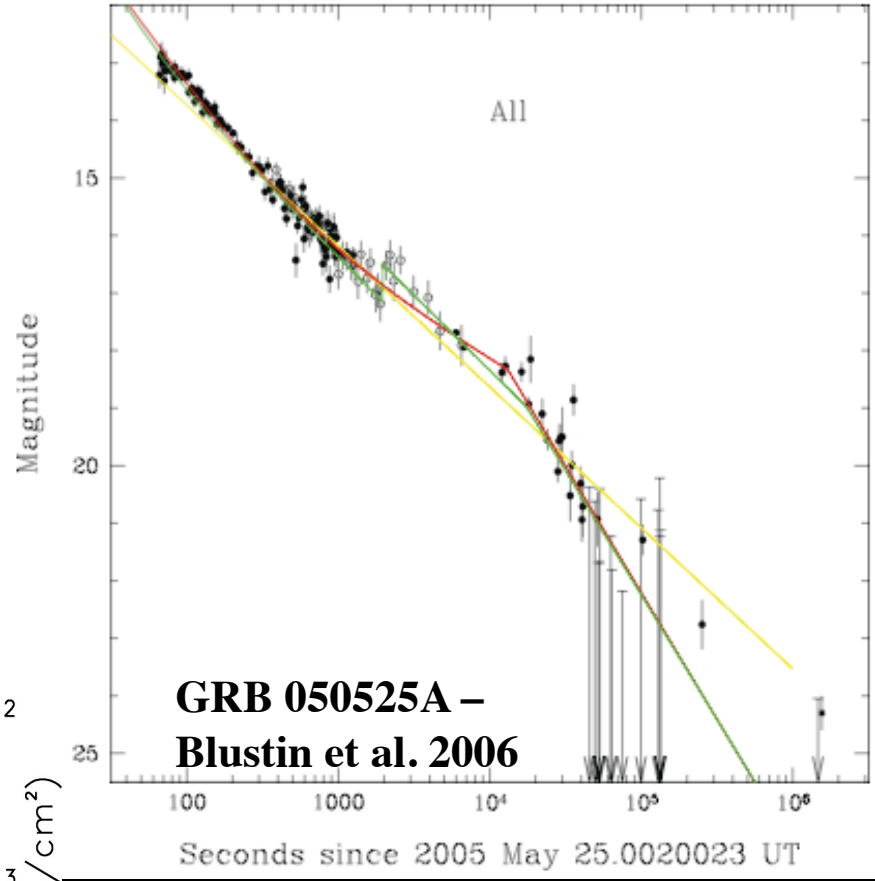
need method to standardize GRB energetics

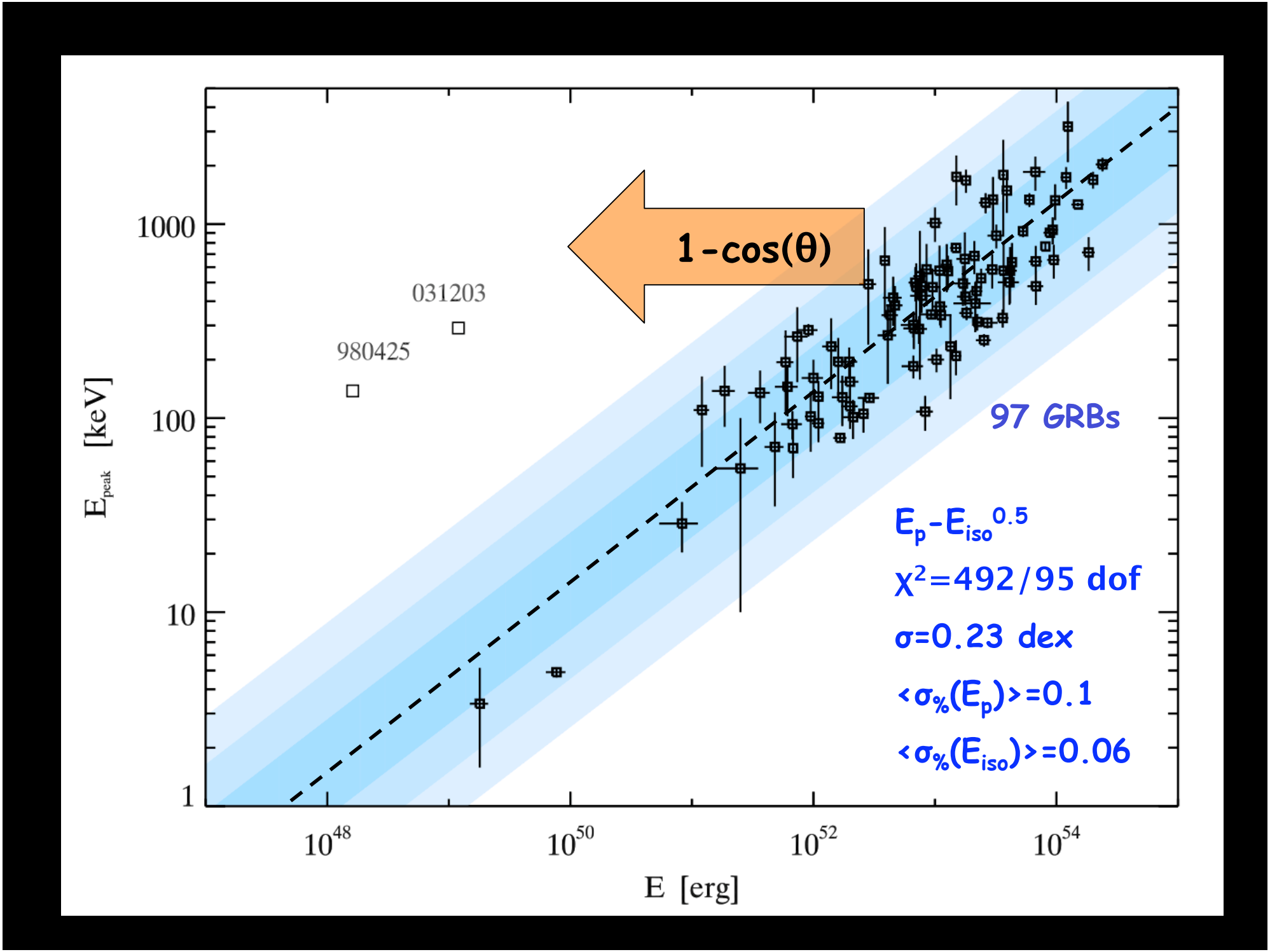


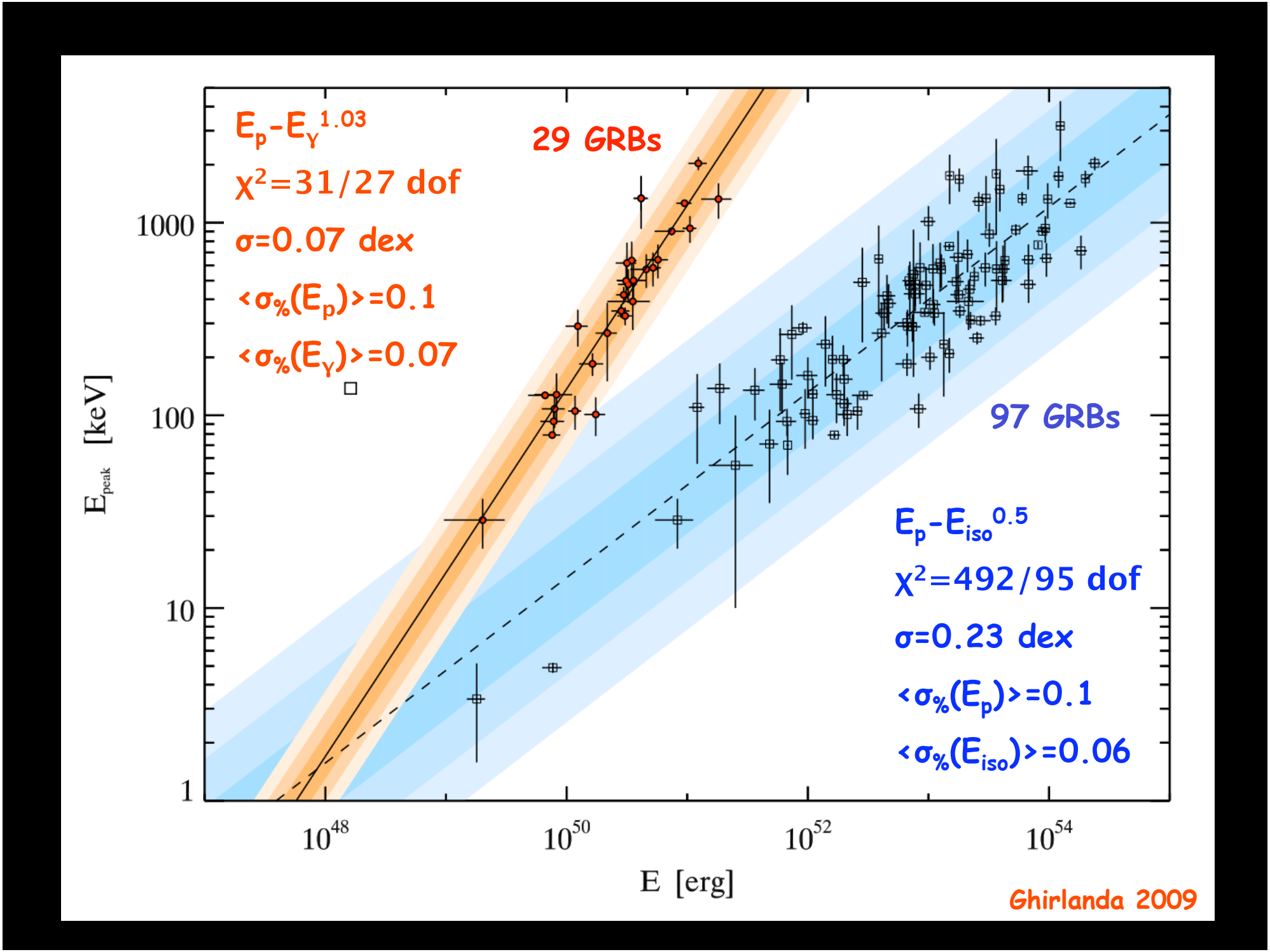
Amati et al. 2002; Lamb et al. 2003; Yonetoku et al. 2004; Ghirlanda et al. 2004,2005; Amati et al. 2008; Nava et al. 2008; Ghirlanda et al. 2009

Obs. evidences of JETs

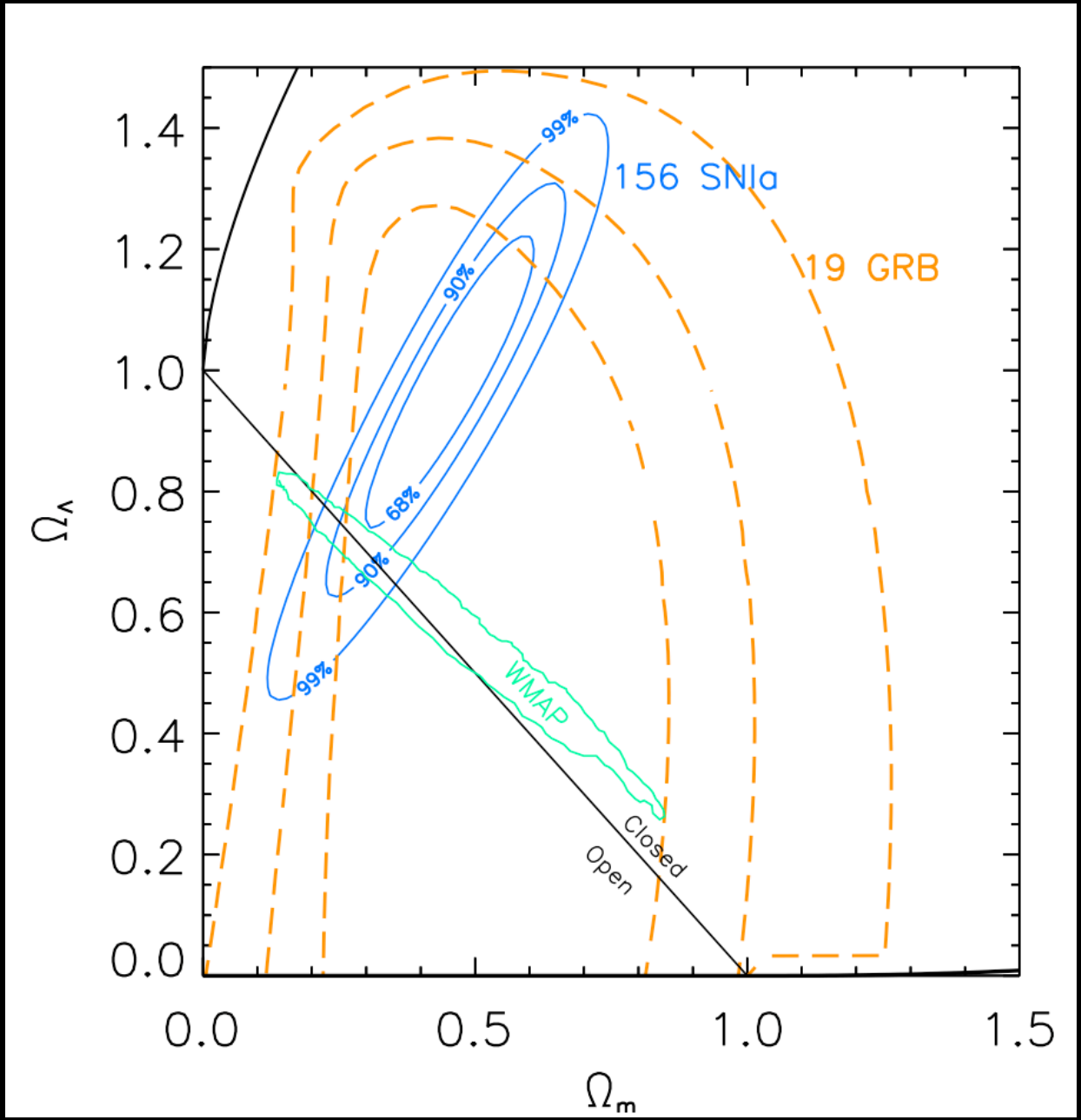





1-cos(θ)
031203
980425
97 GRBs
E_p-$E_{iso}^{0.5}$
χ^2=492/95 dof
σ=0.23 dex
<σ%(E_p)>=0.1
<σ%(E_{iso})>=0.06
E_{peak} [keV]
E [erg]
1000
100
10
1
10^{48}
10^{50}
10^{52}
10^{54}


E_p-$E_\gamma^{1.03}$
χ^2=31/27 dof
σ=0.07 dex
<σ%(E_p)>=0.1
<σ%(E_γ)>=0.07
29 GRBs
97 GRBs
E_p-$E_{iso}^{0.5}$
χ^2=492/95 dof
σ=0.23 dex
<σ%(E_p)>=0.1
<σ%(E_{iso})>=0.06
E_{peak} [keV]
E [erg]
1000
100
10
1
10^{48}
10^{50}
10^{52}
10^{54}
Ghirlanda 2009

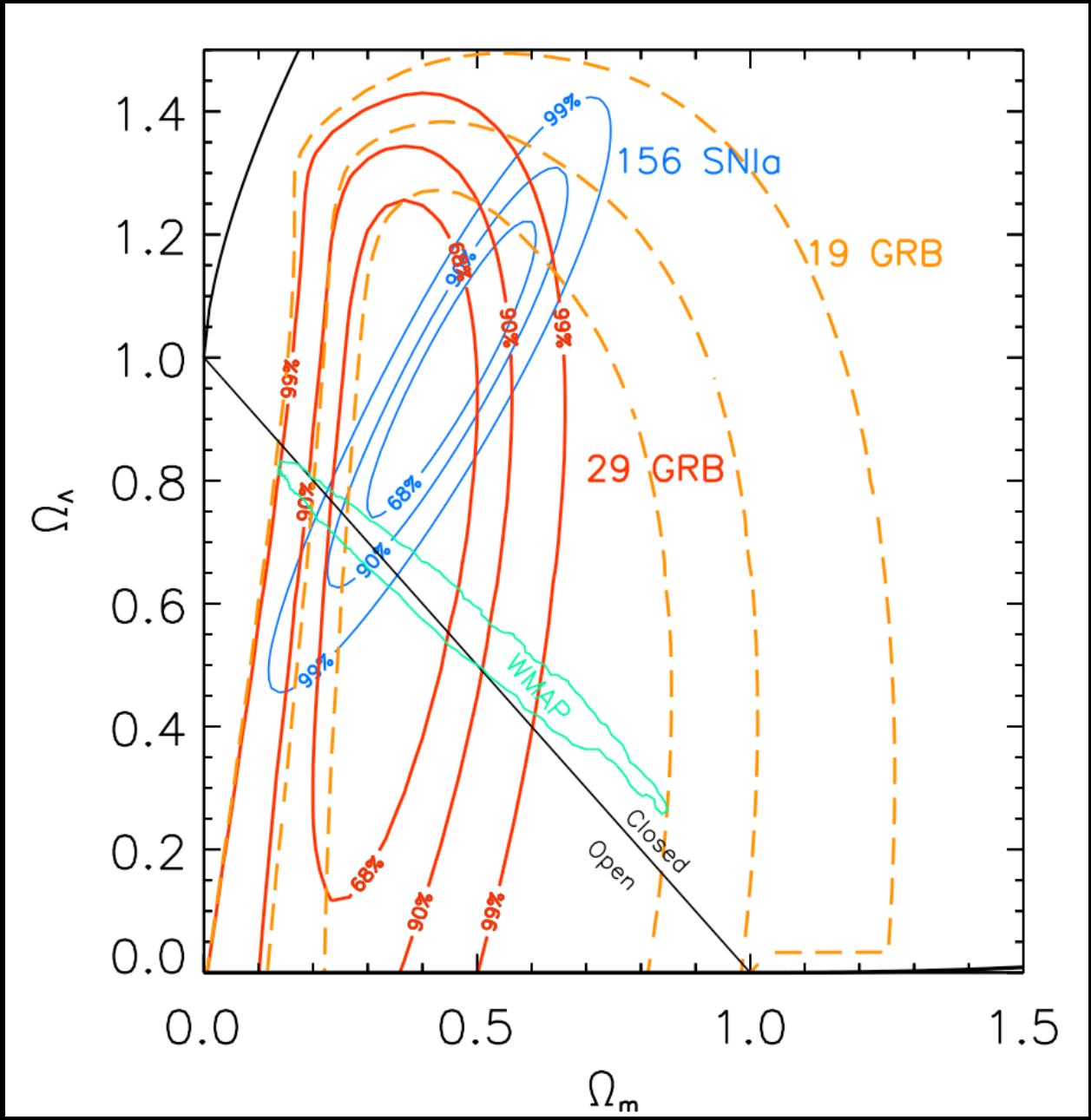
Constraints on $\Omega_M - \Omega_\Lambda$ with the Ep-Eγ correlation



19 GRBs

Ghirlanda, Ghisellini, Firmani, Lazzati 2004,2005

Constraints on Ω_M–Ω_Λ with the Ep-Eγ correlation

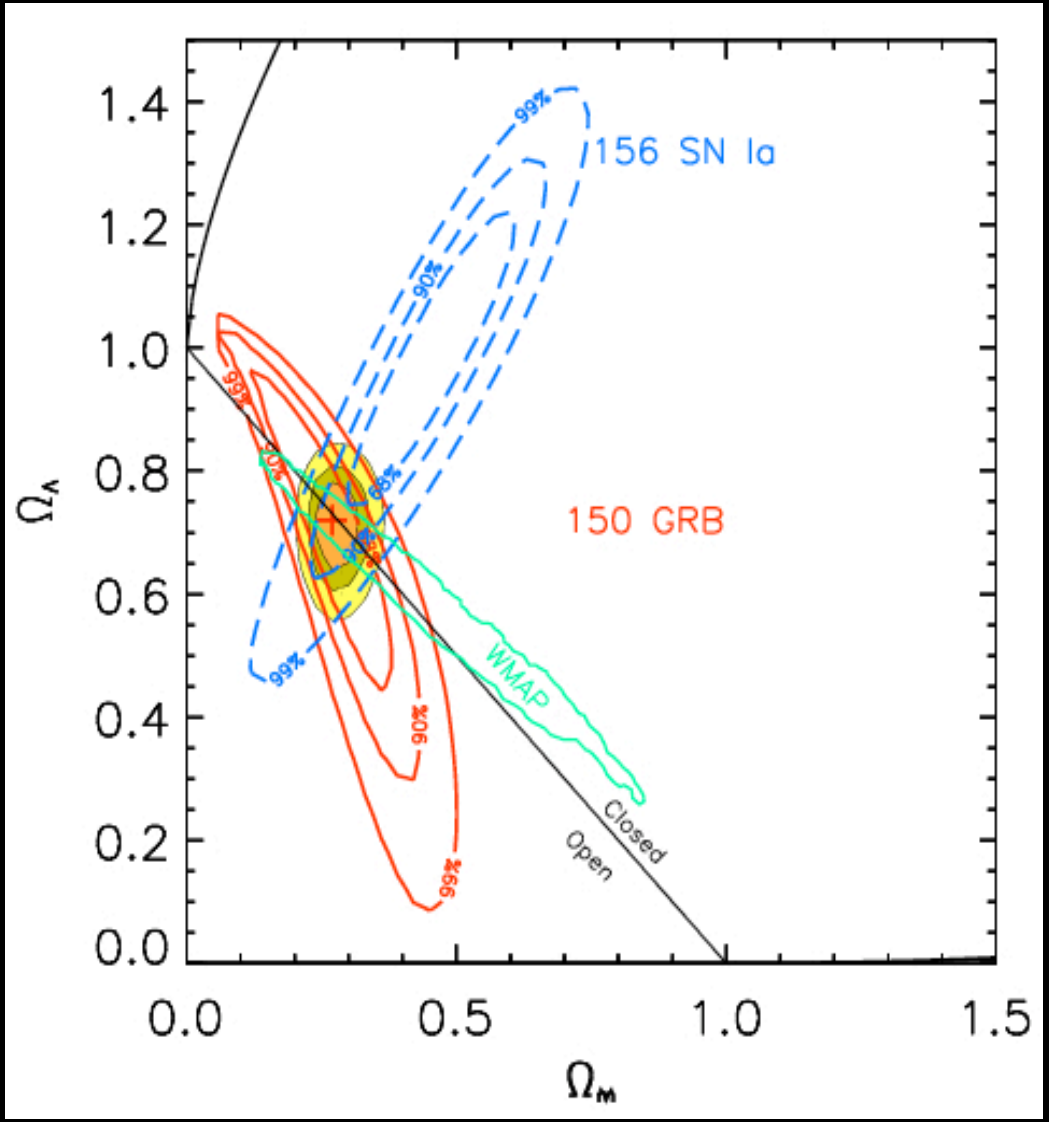


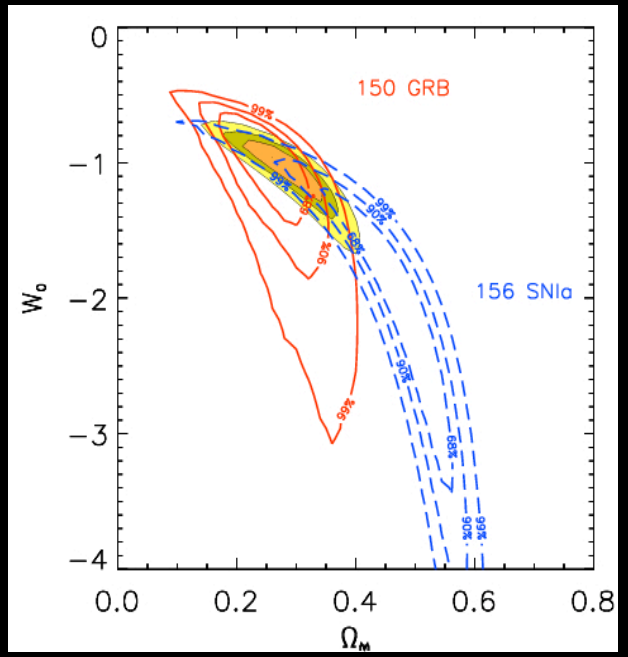
29 GRBs

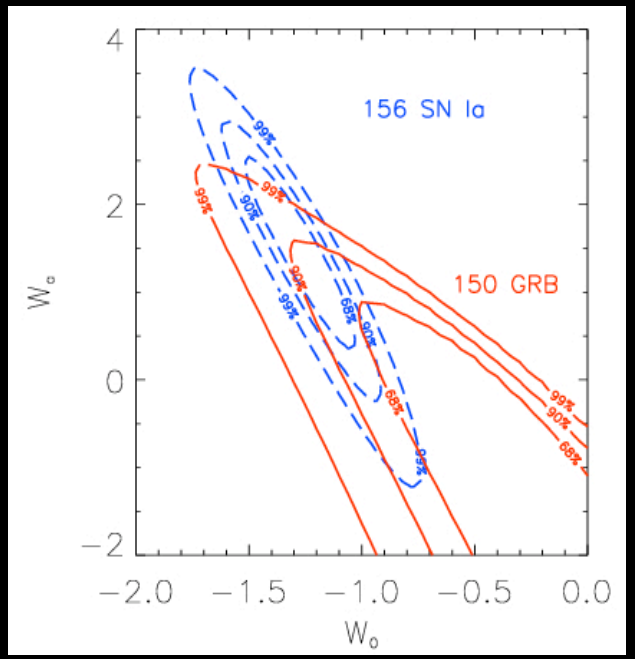
Ghirlanda, Ghisellini, Firmani, Lazzati 2004,2006

Ghirlanda et al. 2009

… The future …

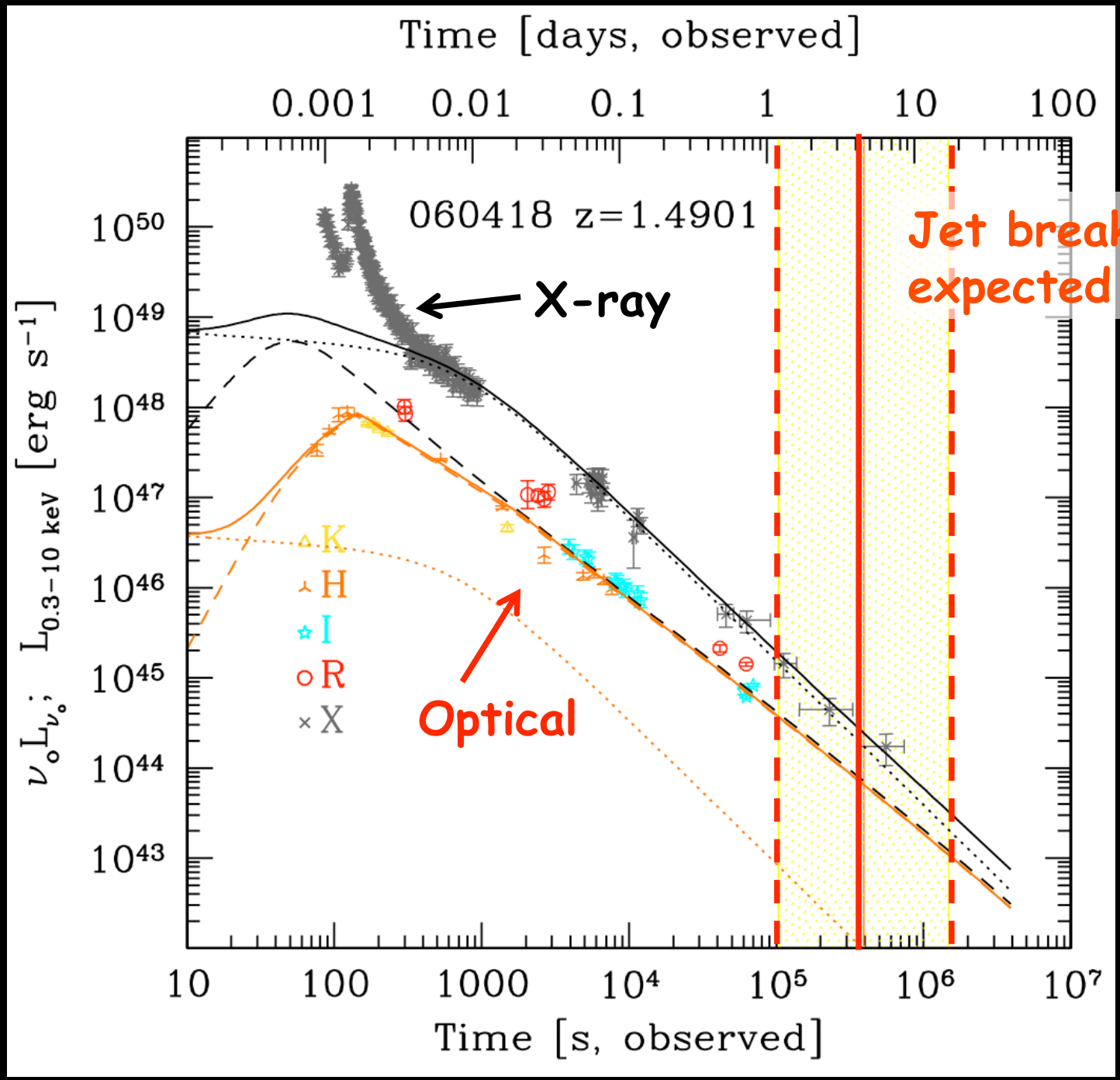

156 SN Ia
150 GRB
WMAP
Closed
Open
99%
90%
68%
Ω_Λ
Ω_M
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.5
1.5


150 GRB
156 SNIa
99%
90%
68%
w_0
Ω_M
0
−1
−2
−3
−4
0.0
0.2
0.4
0.6
0.8


156 SN Ia
150 GRB
99%
90%
68%
w_a
w_0
4
2
0
−2
−2.0
−1.5
−1.0
−0.5
0.0

1) 15 GRBs in 2005 → 29 GRBs in 2009 with jet break time measured

2) The spectral-energy correlations are due to instrumental selection effects

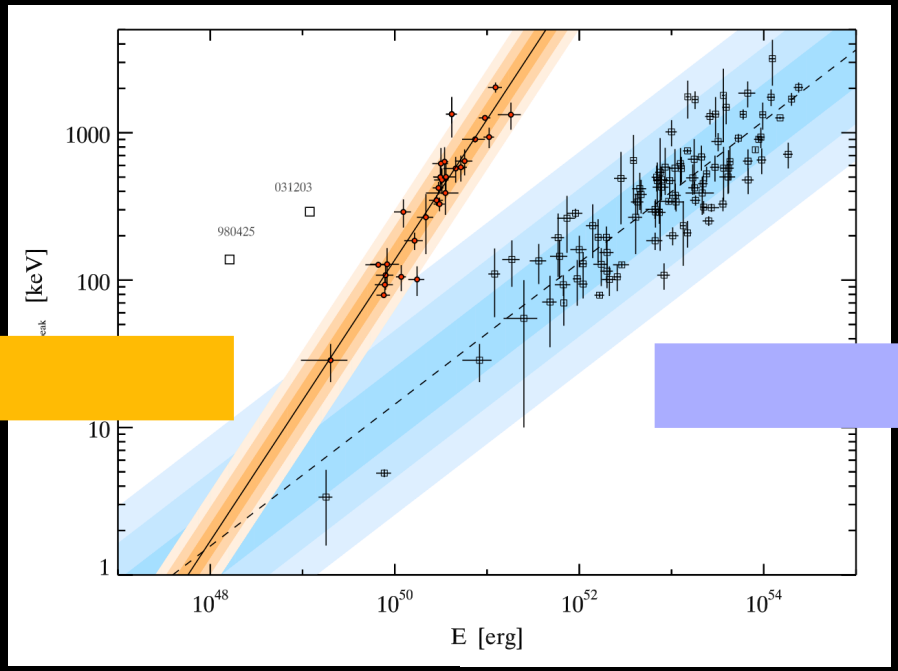


Ghisellini et al. 2007; Nardini et al. 2008

Alternatives?

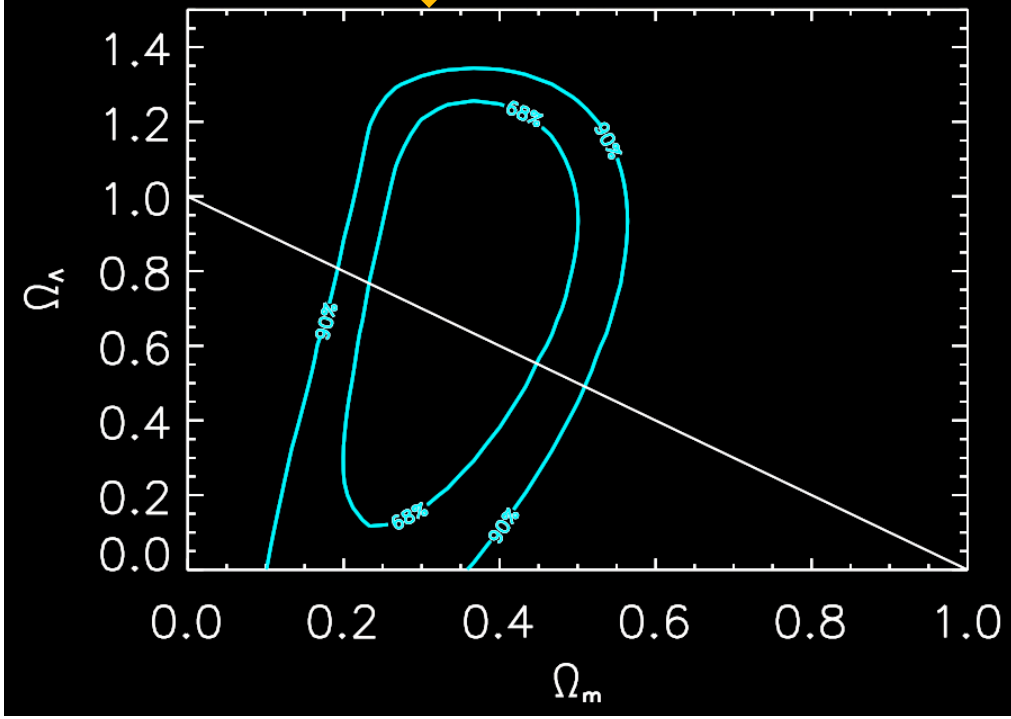
Kodama et al. 2008
Amati et al. 2008

introduce an extra scatter term on Ep (gaussian and = for all bursts)



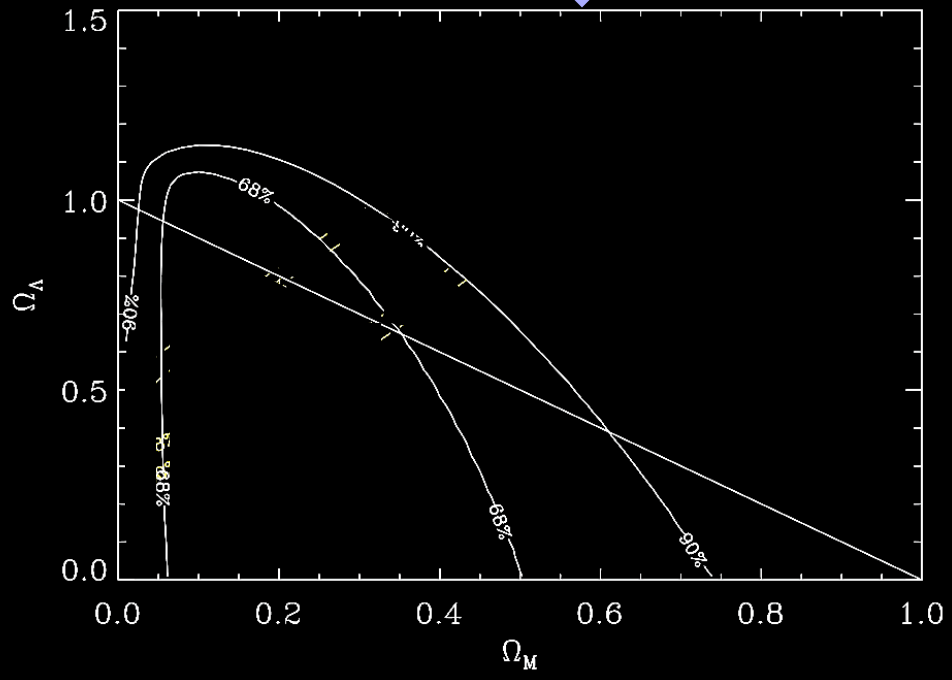
Ep-Eg

29 GRBs



Ep-Eiso

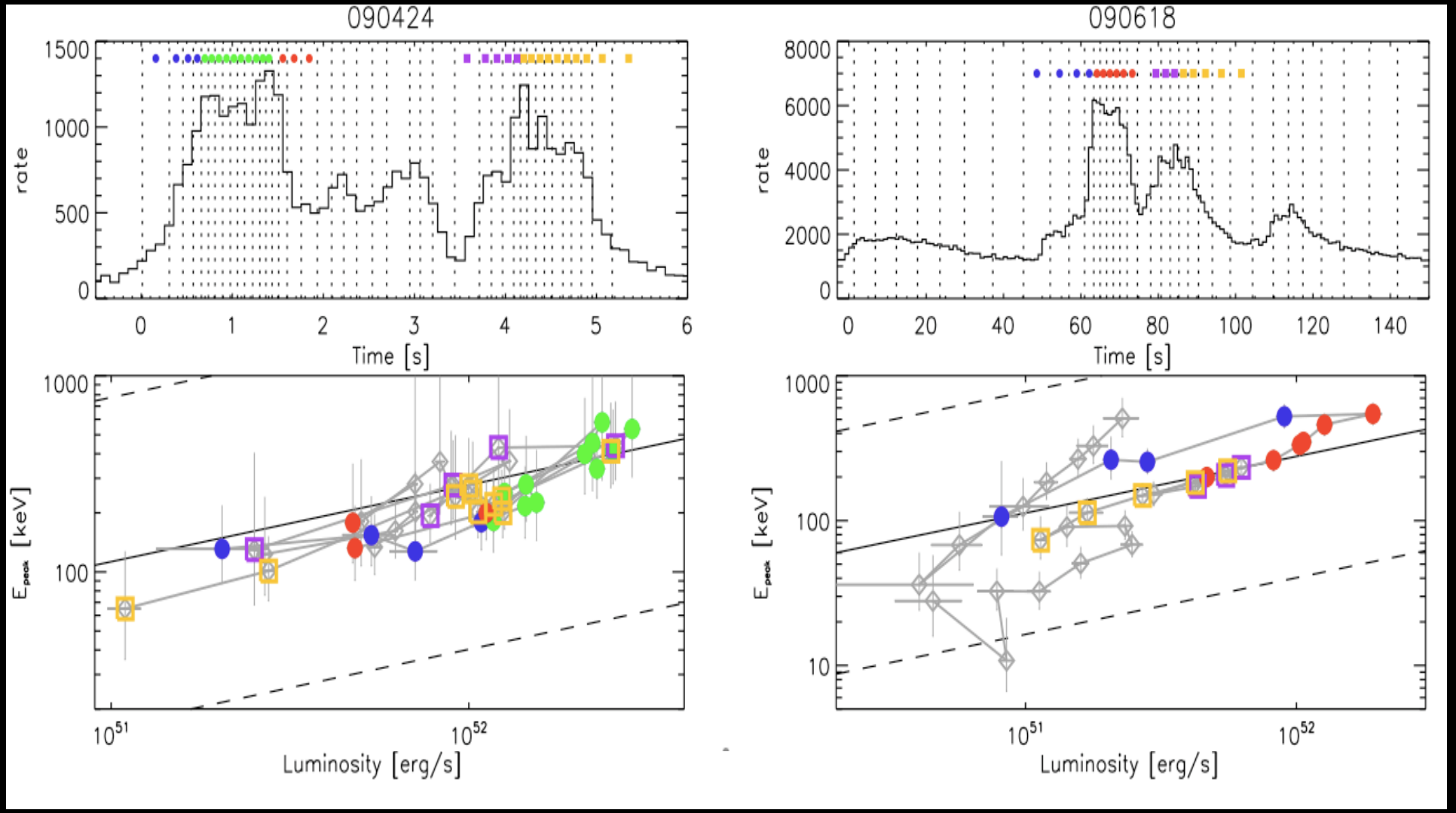
70 GRBs



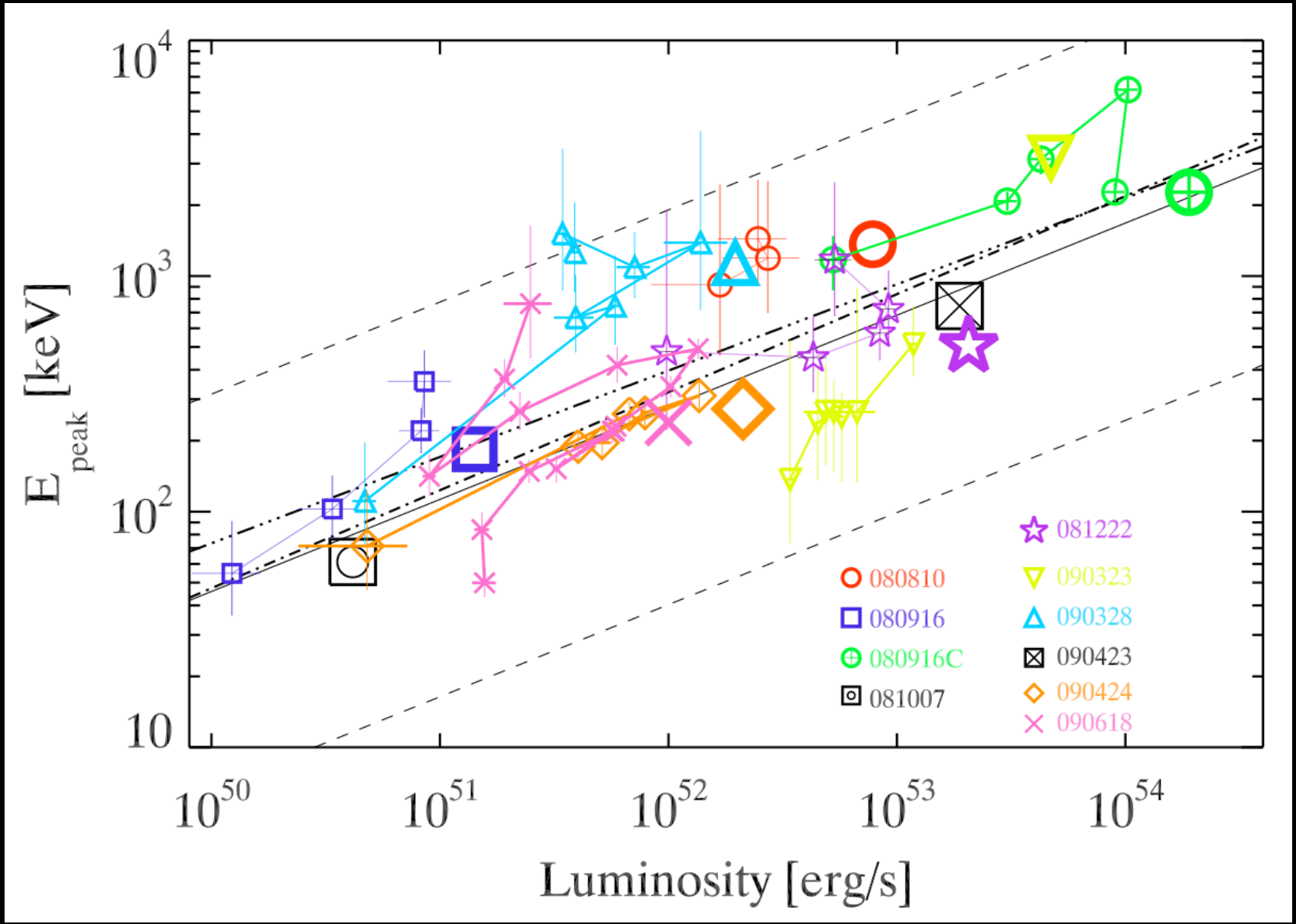
Instrumental selection effects ?

(Nakar & Piran 2005; Band & Preece 2006; Butler et al. 2008)

[Ghirlanda et al. 2006; Ghirlanda et al. 2008; Firmani et al. 2009; Nava et al. 2008]



Selection effects ?



Ghirlanda, Nava & Ghisellini 2009

GRBs as cosmological tools:

GRBs are

- extremely luminous
- detected up to z>6 …
- … in the gamma ray band

Appealing cosmological tools for:

1) Studying the high-z Universe
2) Constraining the cosmological parameters

GRBs energetics can be standardized

Through the less scattered correlation

e.g. Ep-Eγ correlation

Selection effects are not determining the correlations

… with some efforts to measure jet breaks in the optical