THESEUS AND THE GRB-COSMOLOGY

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THESEUS workshop - Naples 2017

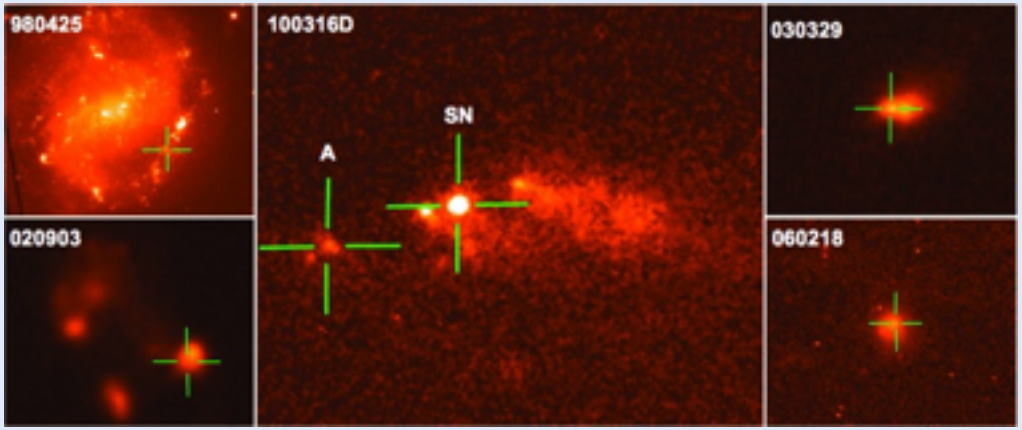
GRB-cosmology

"explore the physical conditions of the Early Universe (the cosmic dawn and re-ionization era) by unveiling the GRB population in the first billion years"

- SFR at high-redshift
- characterise physical properties of GRB hosts up to z~10 (metallicity, ionisation, stellar age…)
- first galaxies and cosmic re-ionisation
- distance indicators (?)

Introduction

GRBs are located in the brightest (H II) regions of their host galaxies

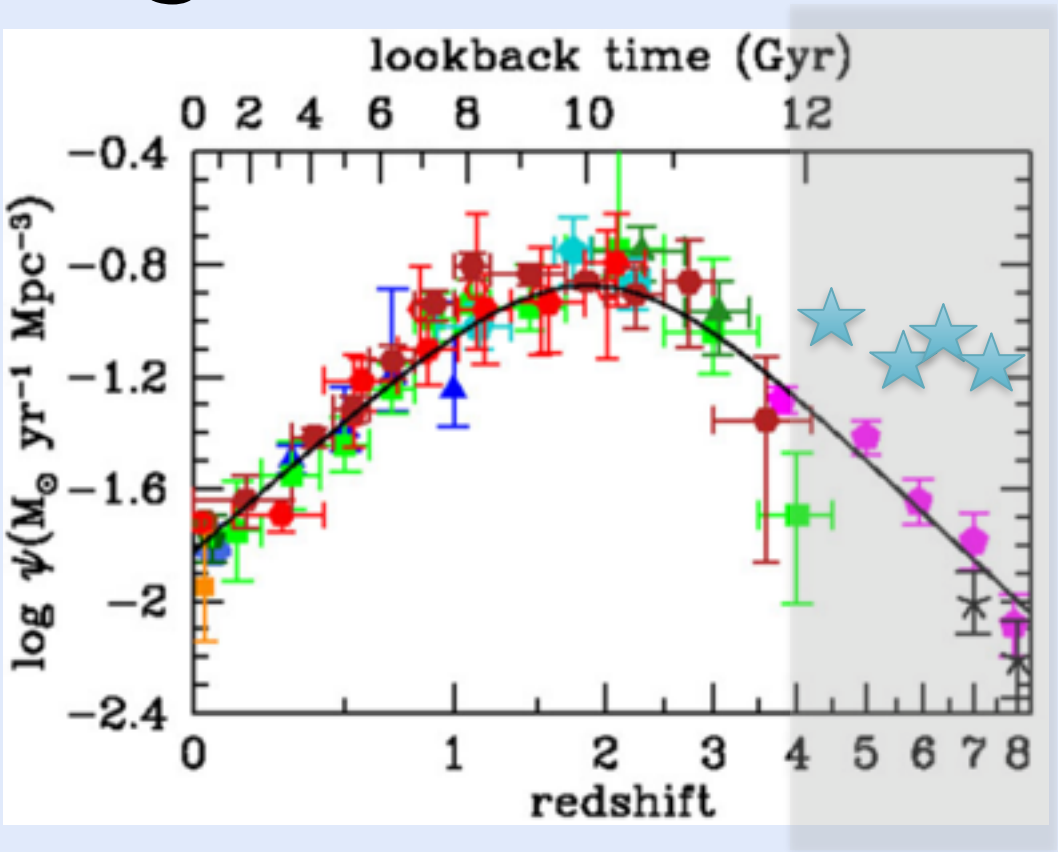


Bloom+2002
Fruchter+ 2006
Blanchard+ 2016

GRB host galaxies are generally faint star-forming systems

Large GRB luminosities -> occasion to detect and study the properties of galaxies that would remain undetected (while general galaxy surveys at high-z are biassed toward bright systems)

SFR at high-z



Kistler+ 2009
Trenti+ 2012
….

SFR through: a) Halpha emission line (z < 1.8)

b) UV light (z > 4)

Kennicutt 1989

Madau+ 2014

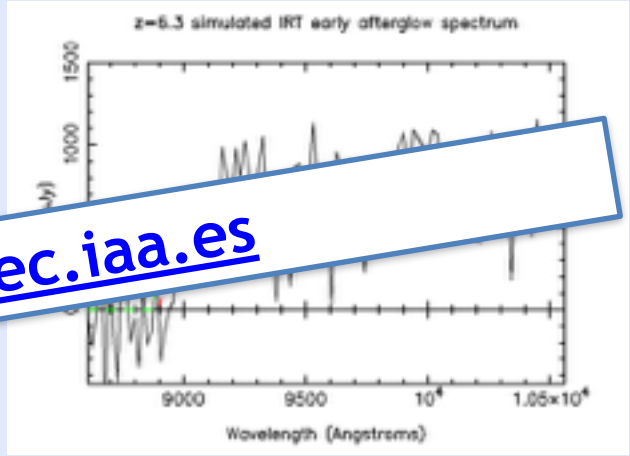
gas, dust & metals

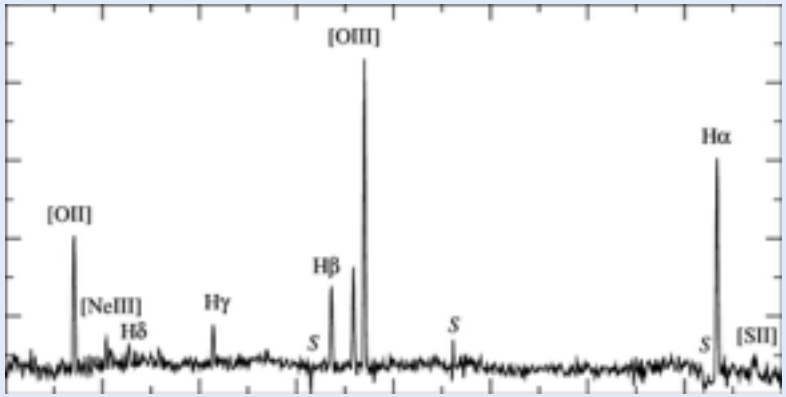
"long GRBs mainly form in sub-solar metallicity environments, but a notable fraction of GRB hosts shows near-solar metallicities"

absorption lines

first hours

http://grbspec.iaa.es





host emission lines

later times -> exact knowledge of the GRB location !!!

Kruhler+ 2015

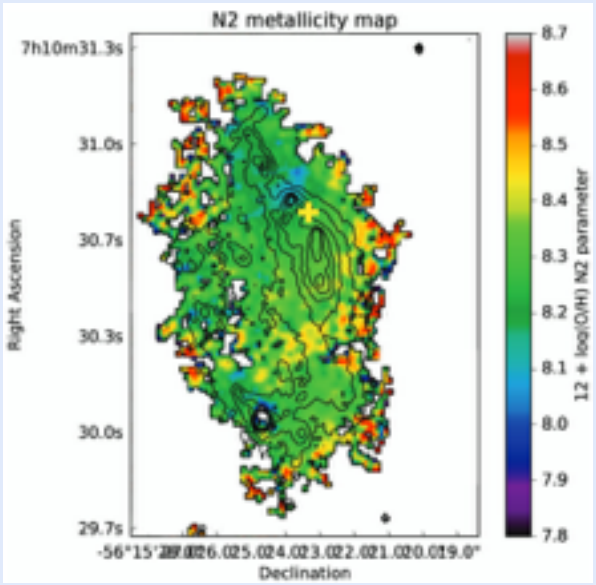
GRB immediate environs

"slit spectra measurements of GRB hosts are averaged across the entire host -> metallicities (SFR...) do not reflect the progenitor star abundances..."

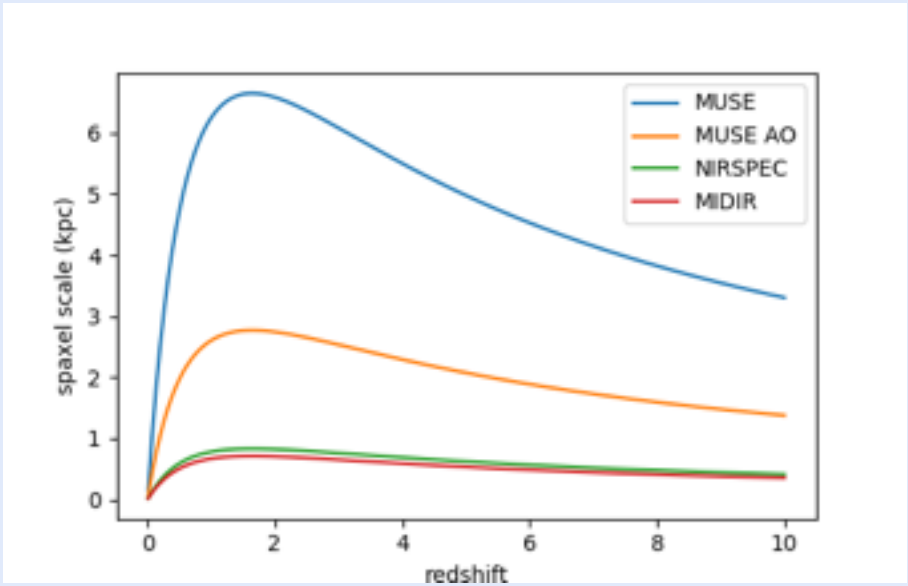
spatially-resolved spectroscopy

- **resolution ~ 0.5-1kpc**
- **Z variations ~0.3dex**

Sanchez+ 2014; Kruhler+ 2017



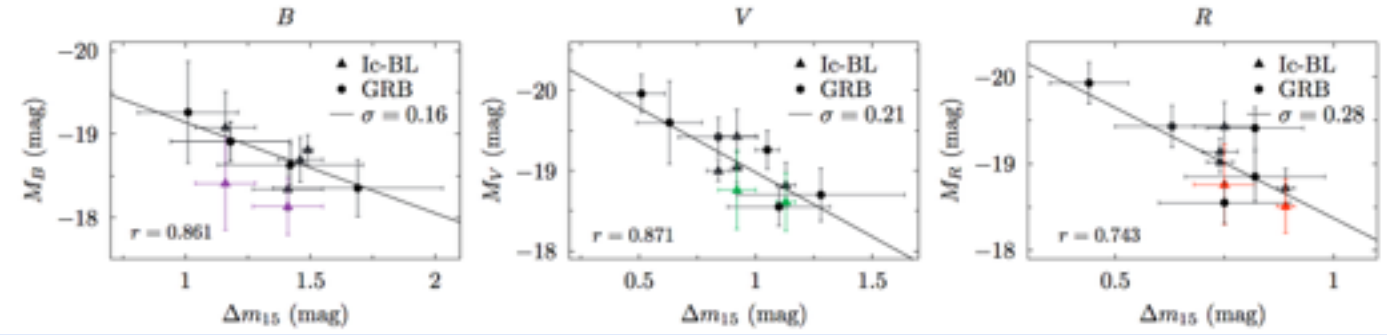
Izzo+ 2017



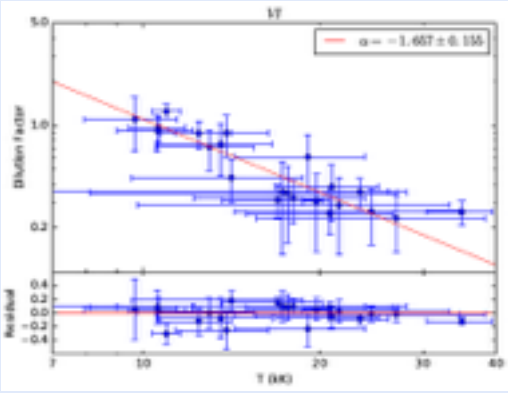
low-z distance indicators

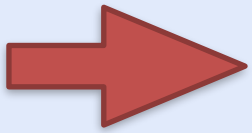
Expanding Photosphere applied to GRB-SNe

1) BVR luminosity - decline relationship

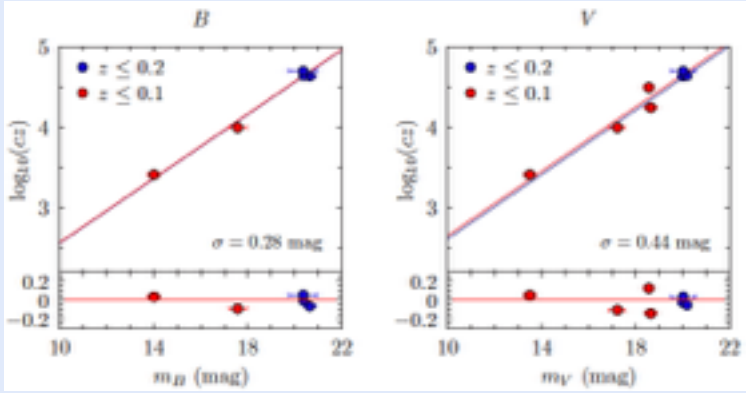


2) correction for the dilution factor





Cano+ in prep.

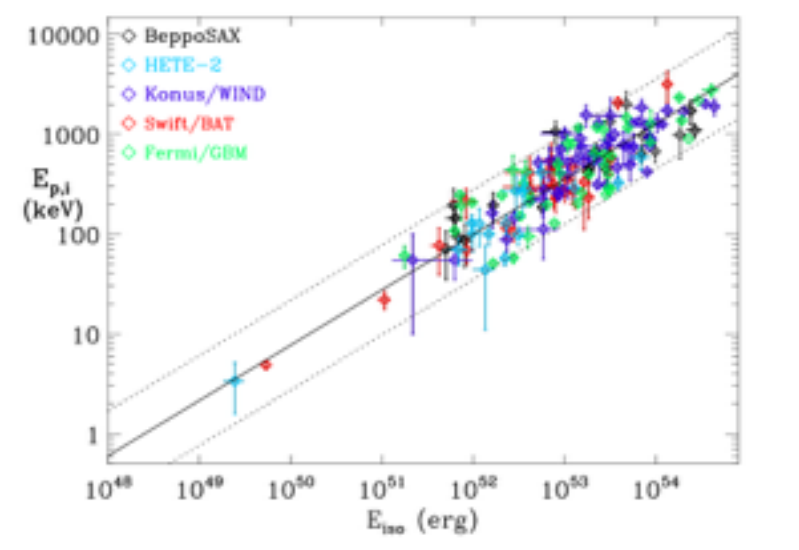


high-z distance indicators

"in recent years, the existence of correlations between GRB observables with total energy/luminosity emitted has been confirmed"

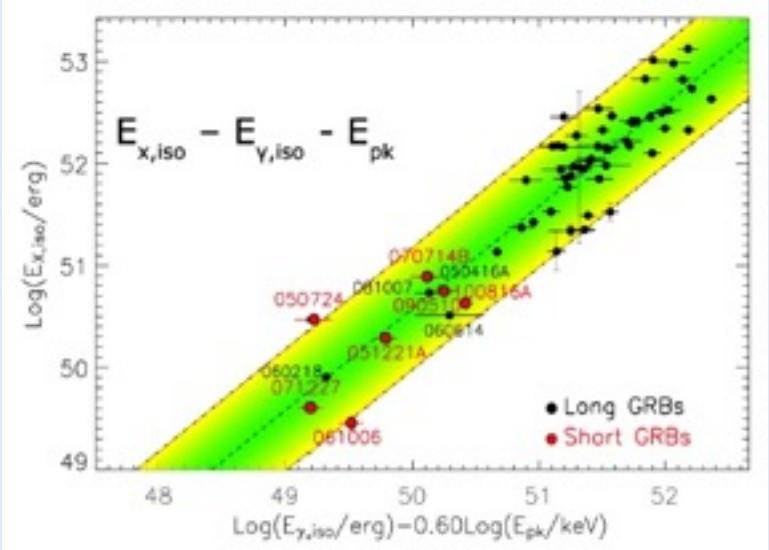
Amati+ 2009

E_p - E_{iso}



Amati+ 2002

E_p - $E_{X,iso}$ - $E_{\gamma,iso}$



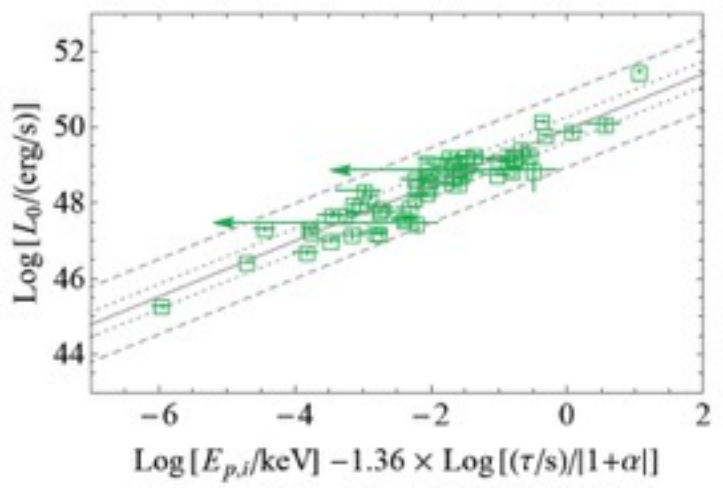
Bernardini+ 2012

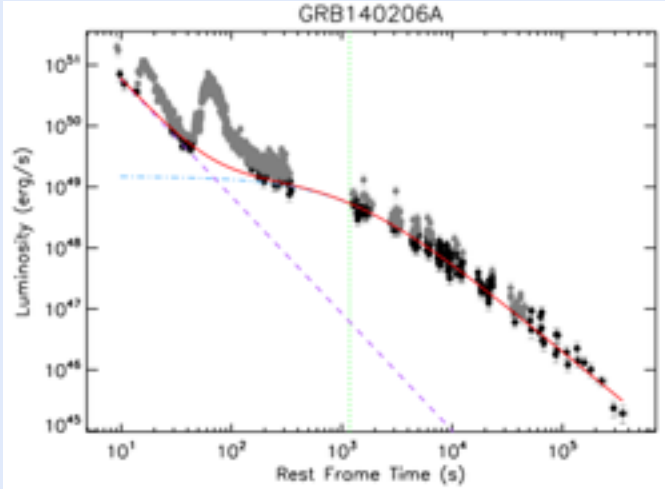
+ others (next talks...)

high-z distance indicators

Combo relation

$$\log\left(\frac{L_0}{\mathrm{erg/s}}\right) = \log\left(\frac{A}{\mathrm{erg/s}}\right) + \gamma\left[\log\left(\frac{E_{p,i}}{\mathrm{keV}}\right) - \frac{1}{\gamma}\log\left(\frac{\tau/\mathrm{s}}{|1+\alpha_X|}\right)\right]$$





- *small data scatter σ=0.28*
- *60 GRBs - no outliers !!!*

- *LC fitting procedure (SN-like)*
- *accurate calibration*

Izzo+ 2015

high-z distance indicators

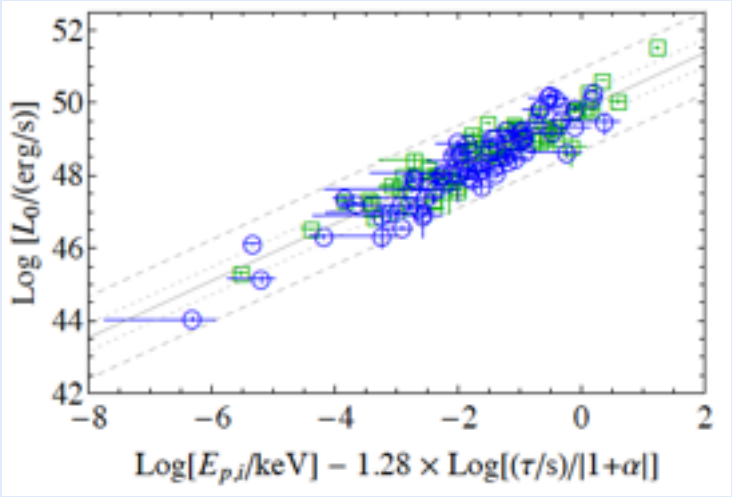
Recent compilation

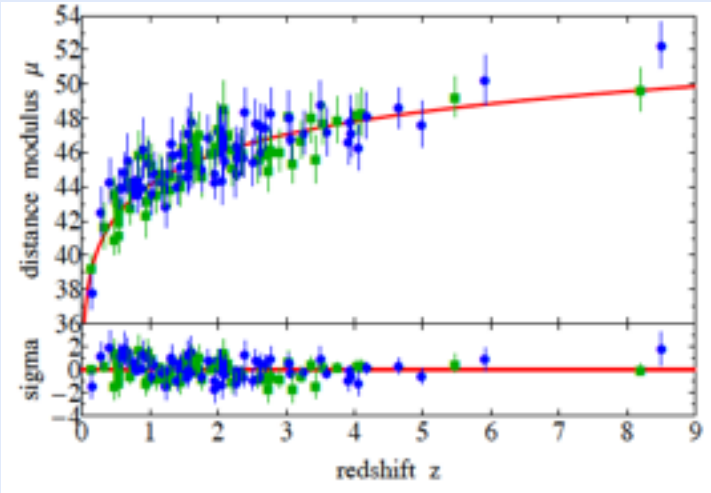
132 GRBs up to Dec 2016

(still no outliers)

tight constraints on

cosmological parameters



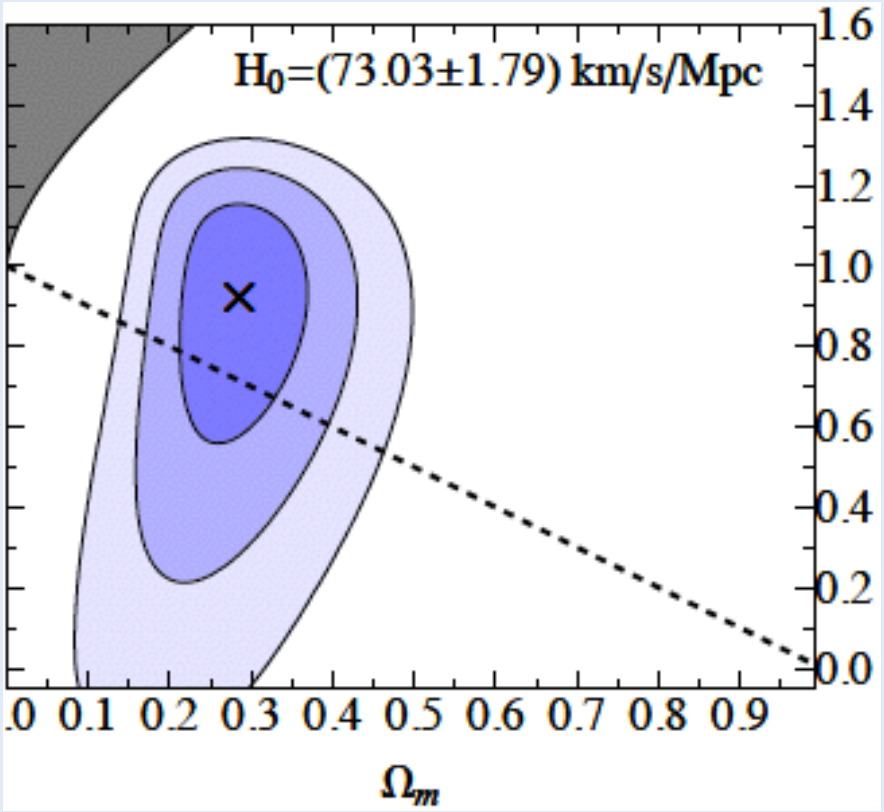


$$\mu_{GRB} = -97.45 + \frac{5}{2}\left[\mathcal{A} - \psi(\gamma, E_{p,i}, \tau, \alpha_X, F_0)\right]$$

Muccino+ 2017

high-z distance indicators

Results

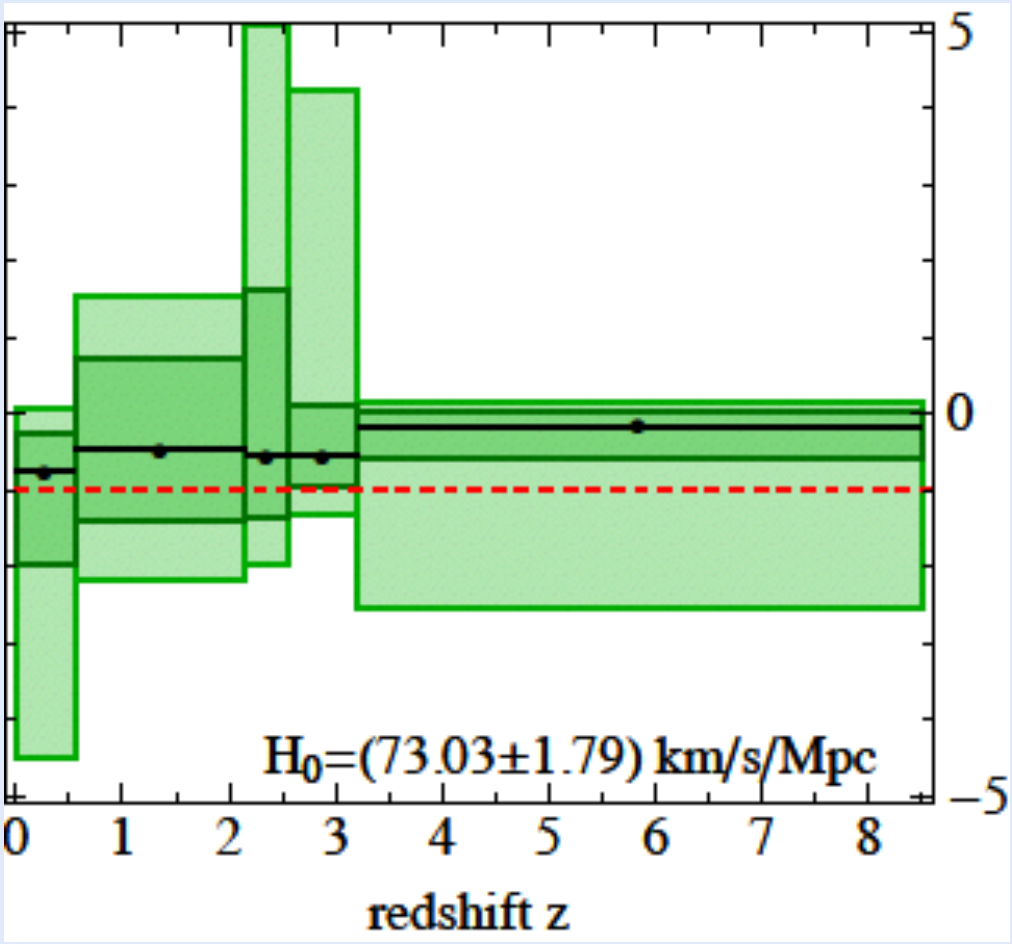


Ωm = 0.28 (+0.09,-0.07)

Muccino+ 2017

high-z distance indicators

Results



w = -1 OK up to z~3.5

from z > 4 some deviation is observed

(low number of GRBs ~10)

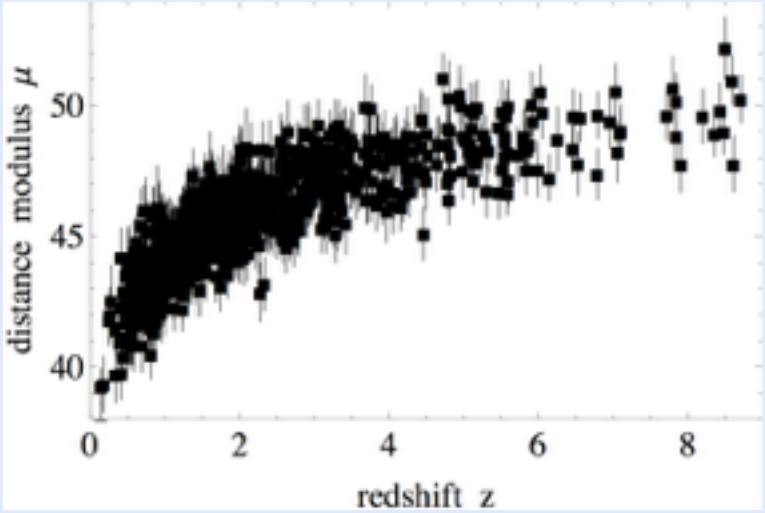
Muccino+ 2017

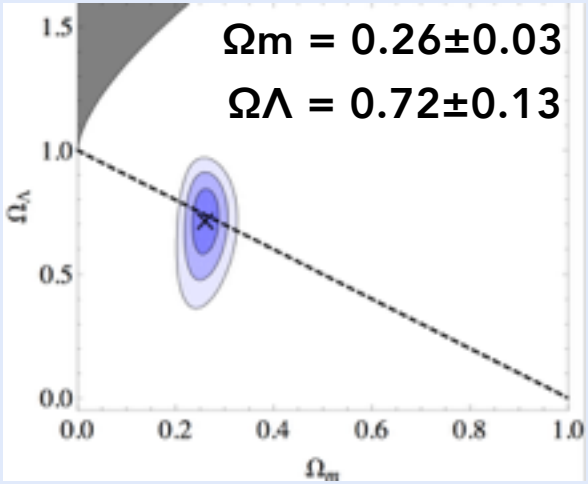
high-z distance indicators

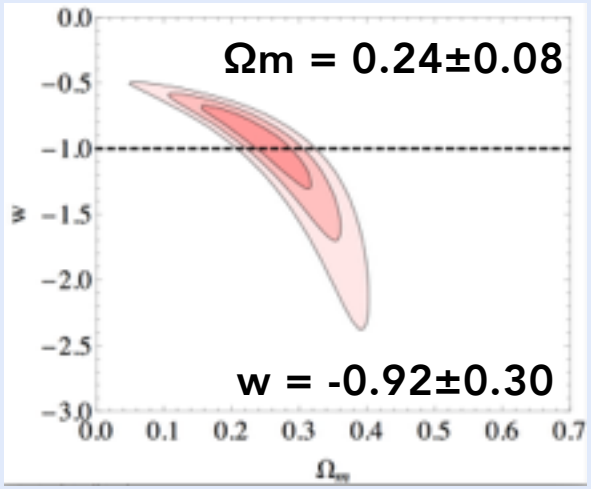
Simulating THESEUS GRBs

800 GRBs

(photo-z expectations)







Muccino+ in prep.

Conclusions

"…understand the evolution history of the Universe at very large redshifts, where no astrophysical probe has gone before…"

THESEUS will improve our knowledge of the Universe at ALL redshifts

- **low-z : localise nearby GRBs and their hosts, measure H0, determine the $z_{tr,}$ more GRB-SNe…**

- **high-z : SFR evolution, metallicities at high-z, test of LCDM model and possible evolution of w**

Thanks for the attention