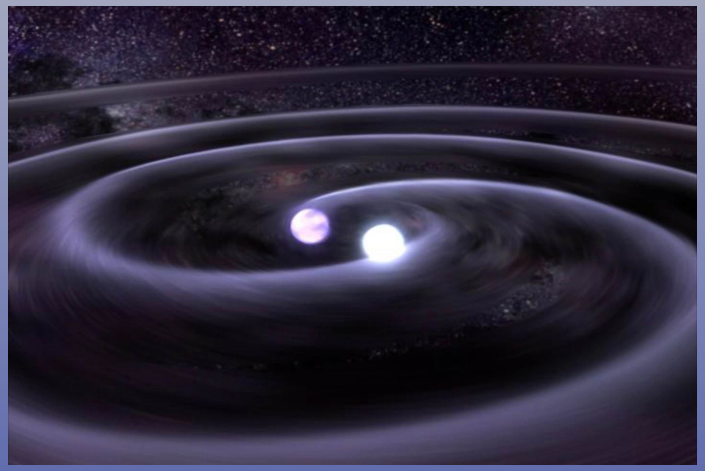
Exploiting the spatial and spectral capabilities of MAAT@GTC to shed light on the kilonova phenomenology

L. Izzo (DARK/NBI)

MAAT@GTC

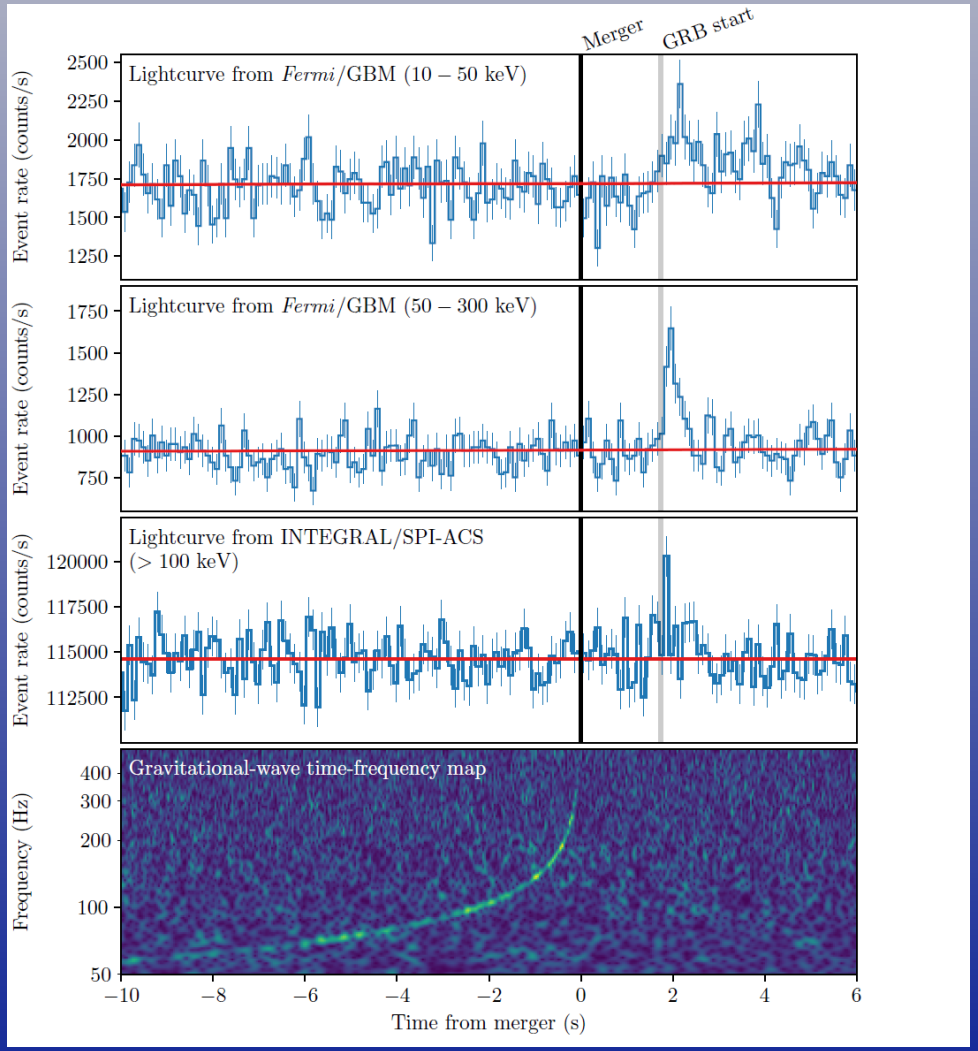
DARK

Introduction



GW emission in BNS merger

August 17, 2017

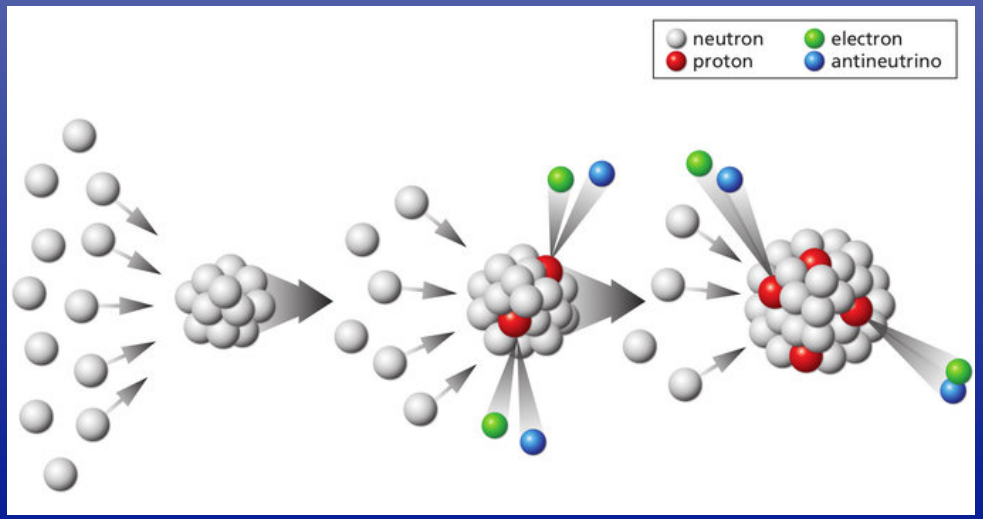


(LVC 2017)

Introduction

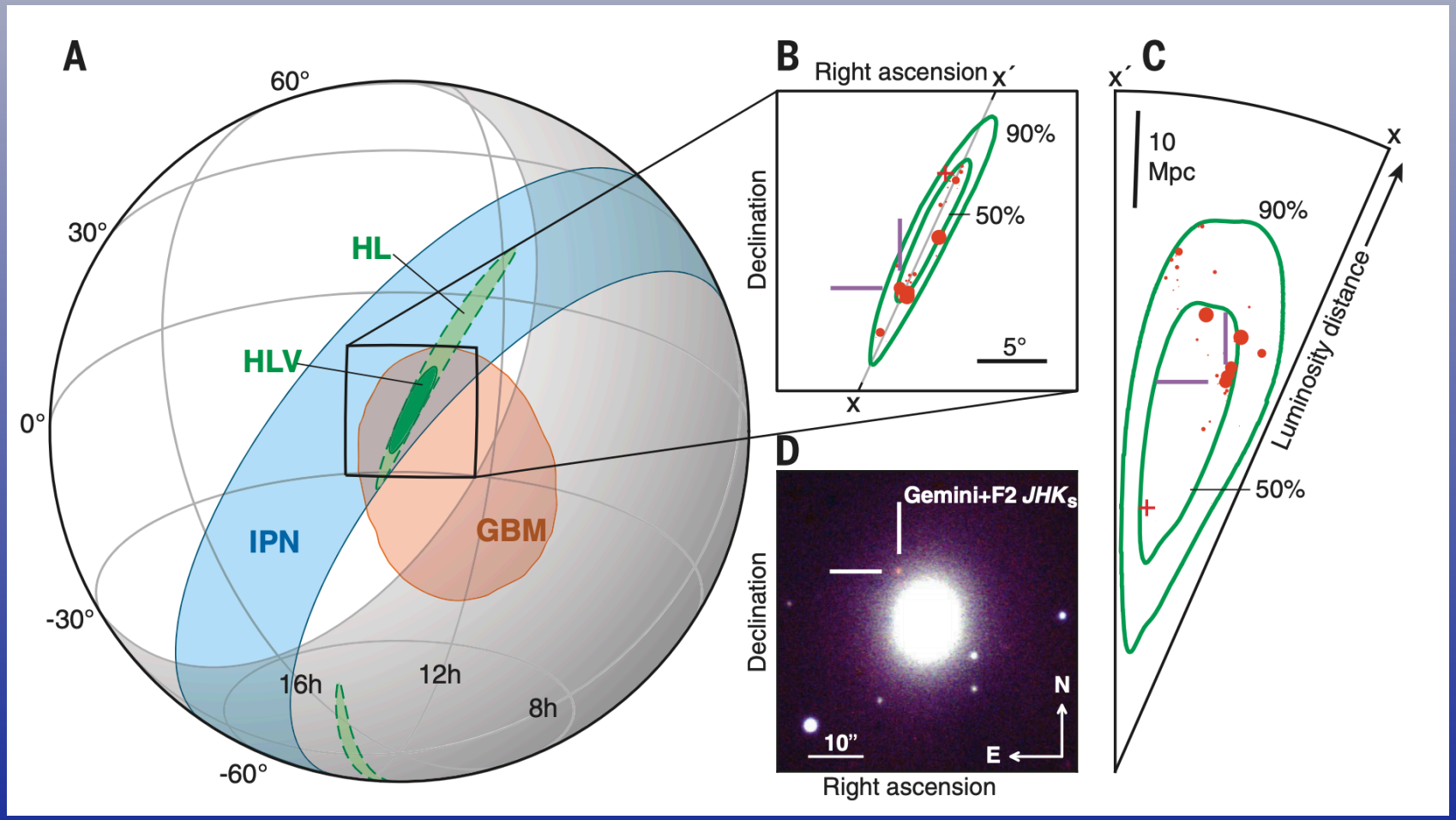
r-process

"Neutrons combine to form large compounds faster than the newly formed conglomerates break up again. In this way, heavy elements can grow from individual neutrons within less than a second."



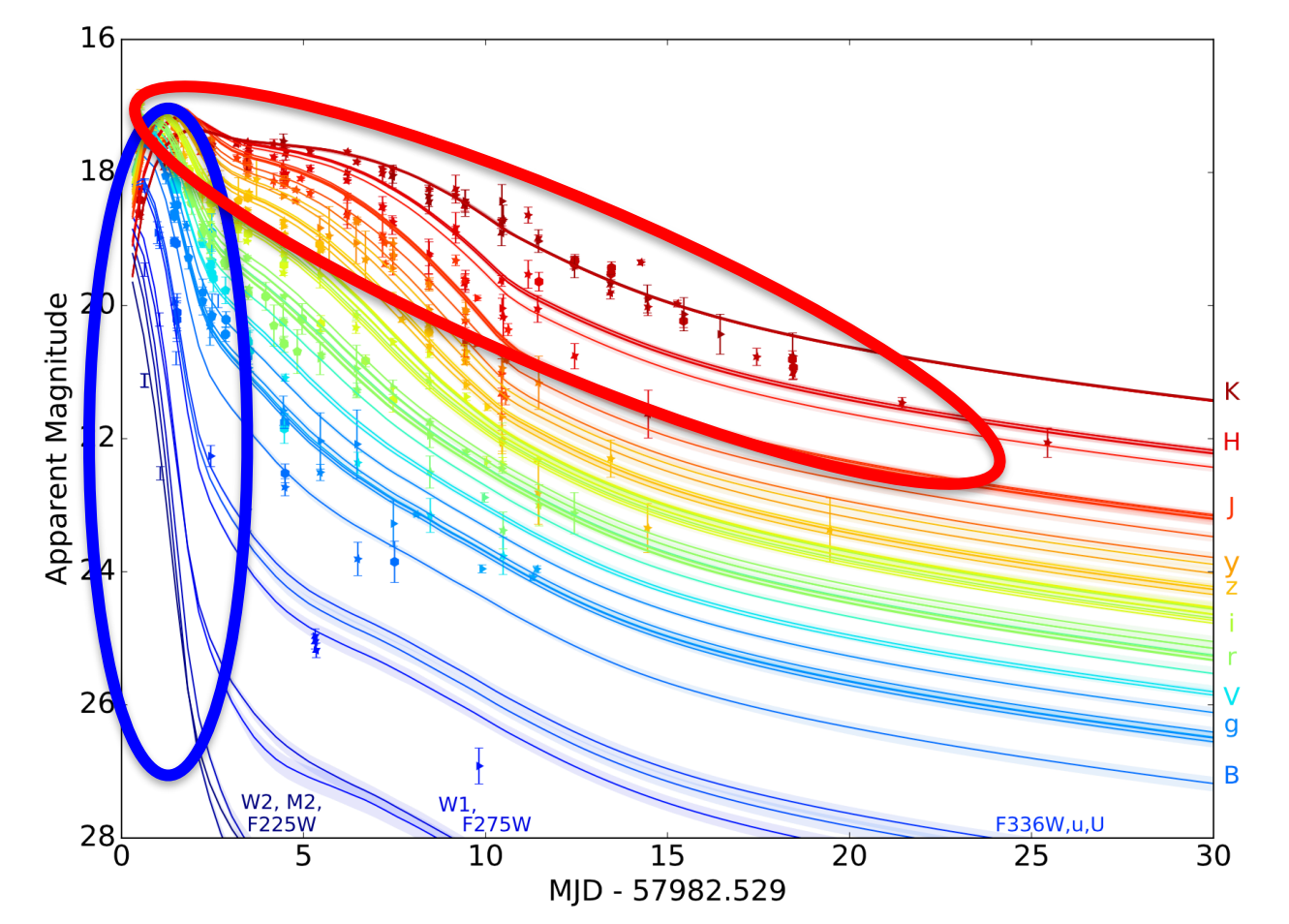
(Courtesy MPIA)

GW170817



(Kasliwal+ 2017)

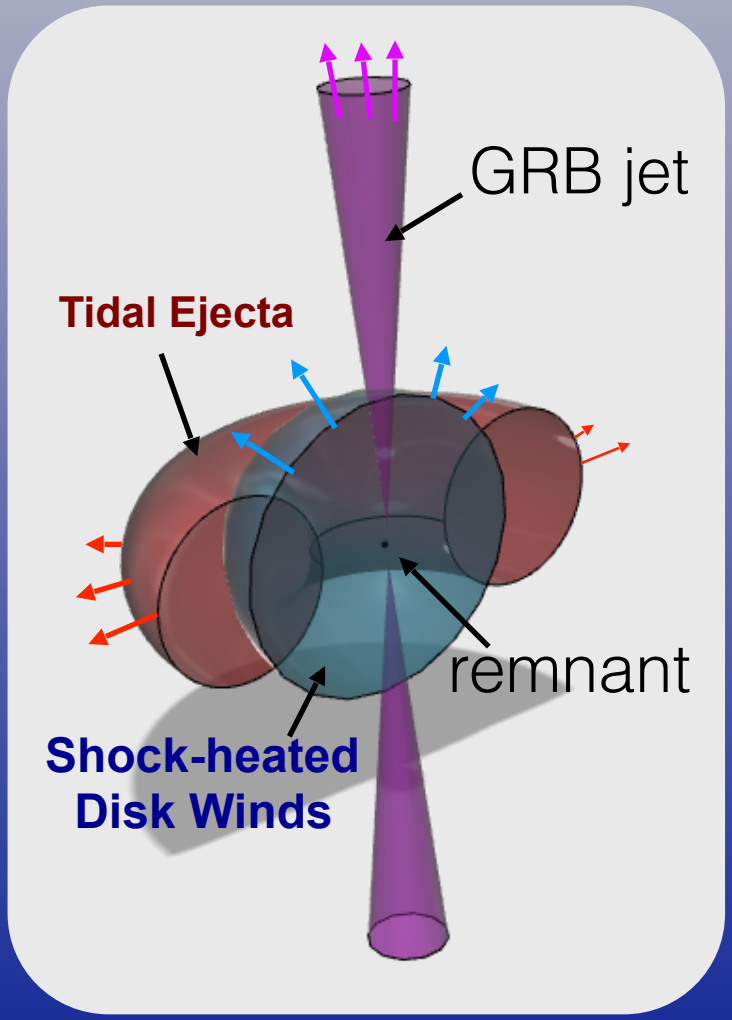
UV/Optical/NIR Light Curves



(Villar+ 2017)

thermal emission by radioactive decay of heavy elements synthesized in multicomponent (2-3) ejecta!

Geometry and properties of the different ejecta components



Tidal Ejecta → **Red Macronova "equatorial"**

unbound by hydrodynamic interaction and gravitational torques

Peaks at days - 1 week after the merger

Secular – isotropic

accretion disk matter unbound by viscous and nuclear heating

Shock-heated → **Blue Macronova "Polar"**

squeezed mass at NS contact interface ejected by remnant pulsations

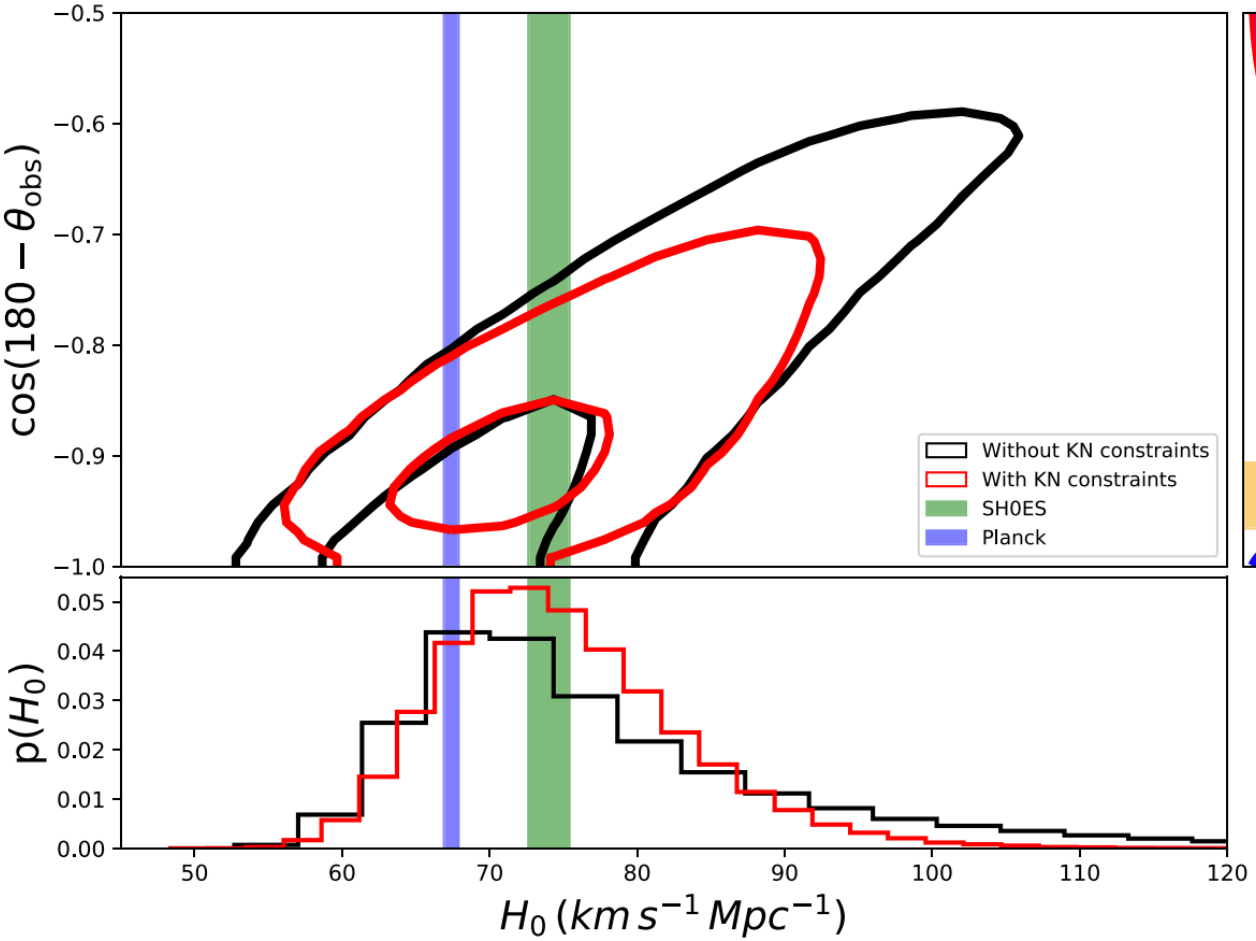
Peaks at 1-2 day after the merger

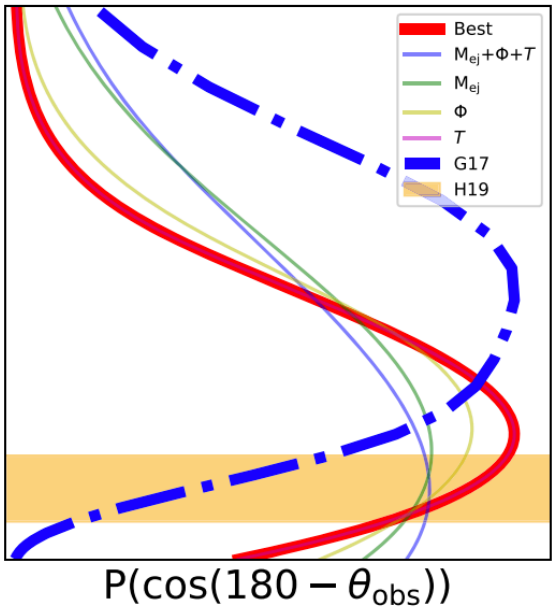
Disk Winds

neutrino absorption or magnetically launched winds

Courtesy S. Ascenzi & M. Branchesi

Constraints on H0

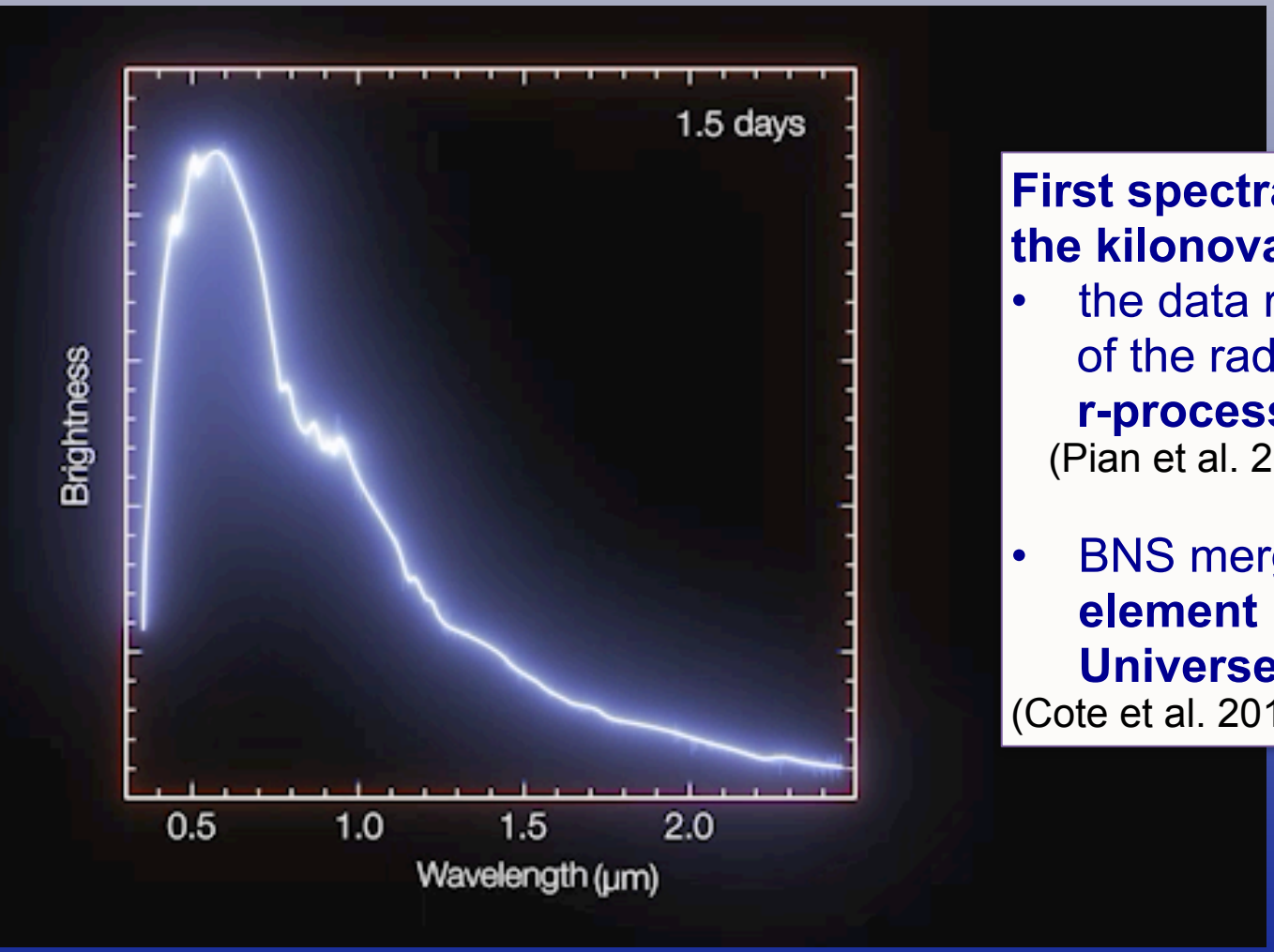




(Dhawan+ 2020)

Constraints on the inclination angle of the sGRB jet associated with GW170817 can improve H0 estimate

KN 170817 / AT 2017gfo



First spectral identification of the kilonova emission

- the data revealed signatures of the radioactive decay of **r-process nucleosynthesis**

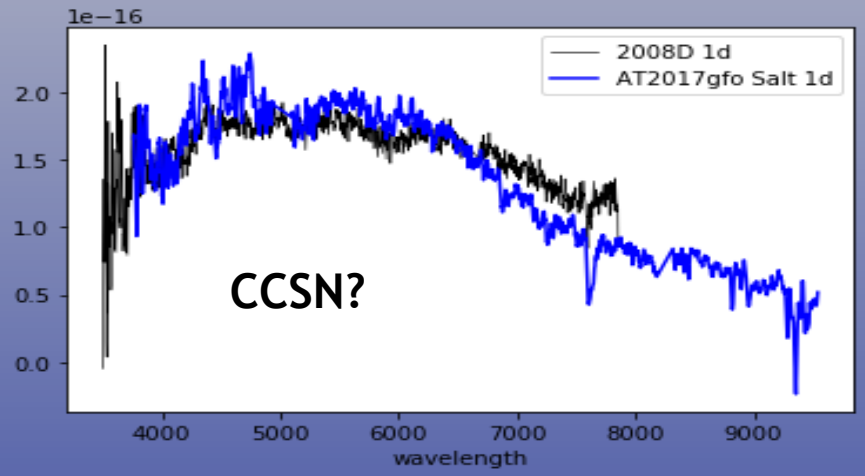
(Pian et al. 2017, Smartt et al. 2017)

- BNS merger **site for heavy element production in the Universe!**

(Cote et al. 2018, Rosswog et al. 2017)

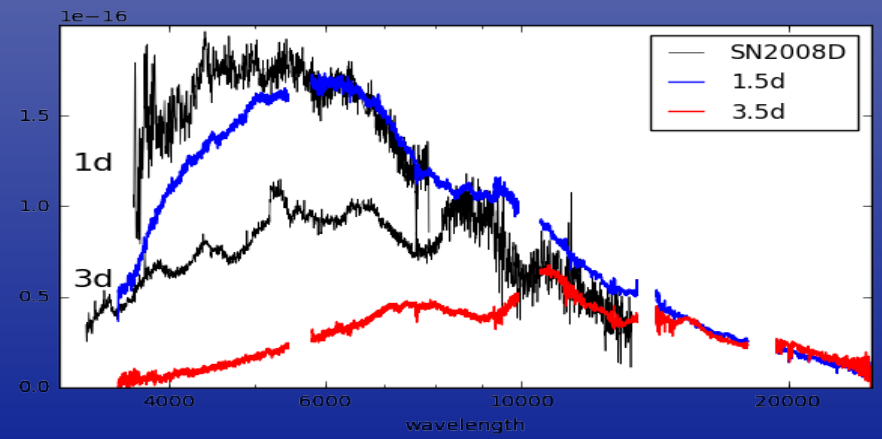
Credit: ESO/E. Pian et al./S. Smartt & ePESSTO/L. Calçada
Courtesy M. Branchesi

KN 170817 / AT 2017gfo



The low S/N optical spectrum at 1d matches very well that of SN2008D/ XRF080109 at similar phase

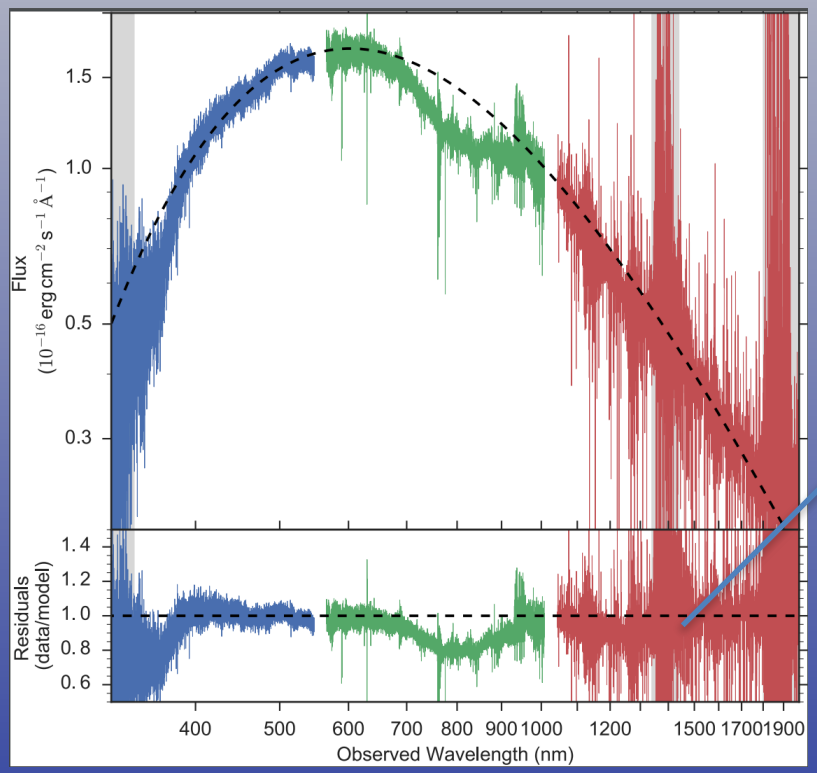
There is **no evidence** for a kilonova



In a couple of days the peak of the spectral energy distribution shifts to the near infrared. Broad spectral features appear that are completely different from that of all know SN types

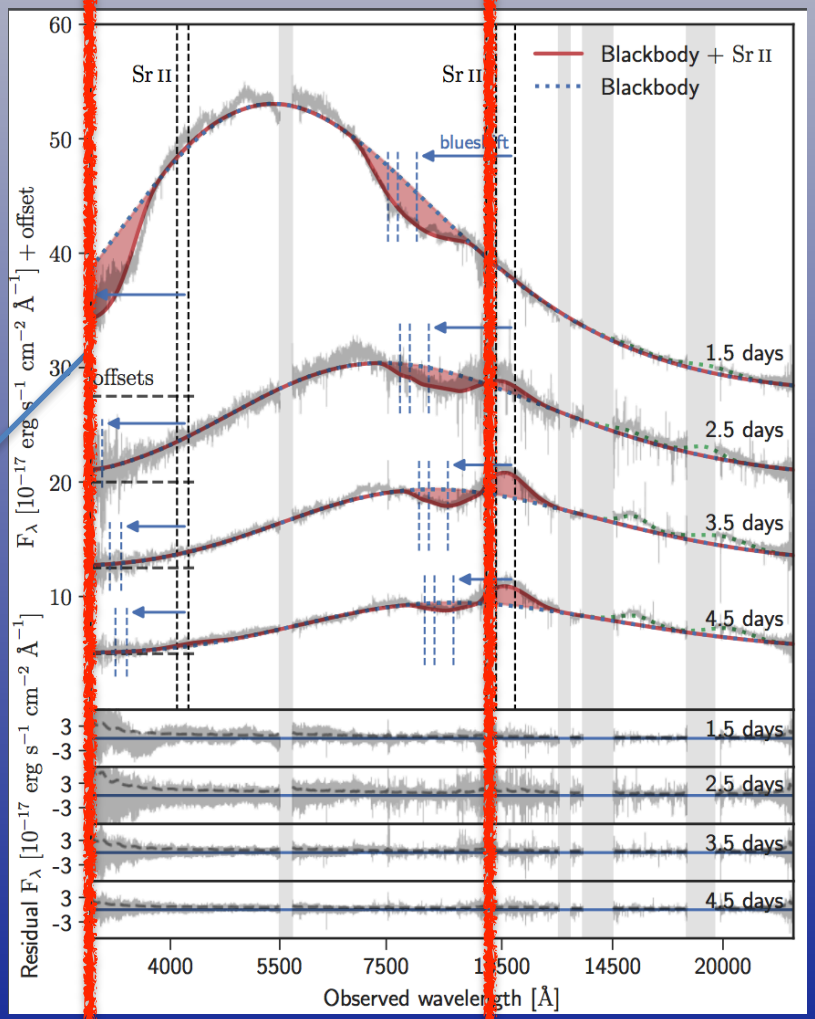
(Buckley+ 2017, McCully+ 2018

MAAT & kilonovae



identification of the
neutron-capture element transition

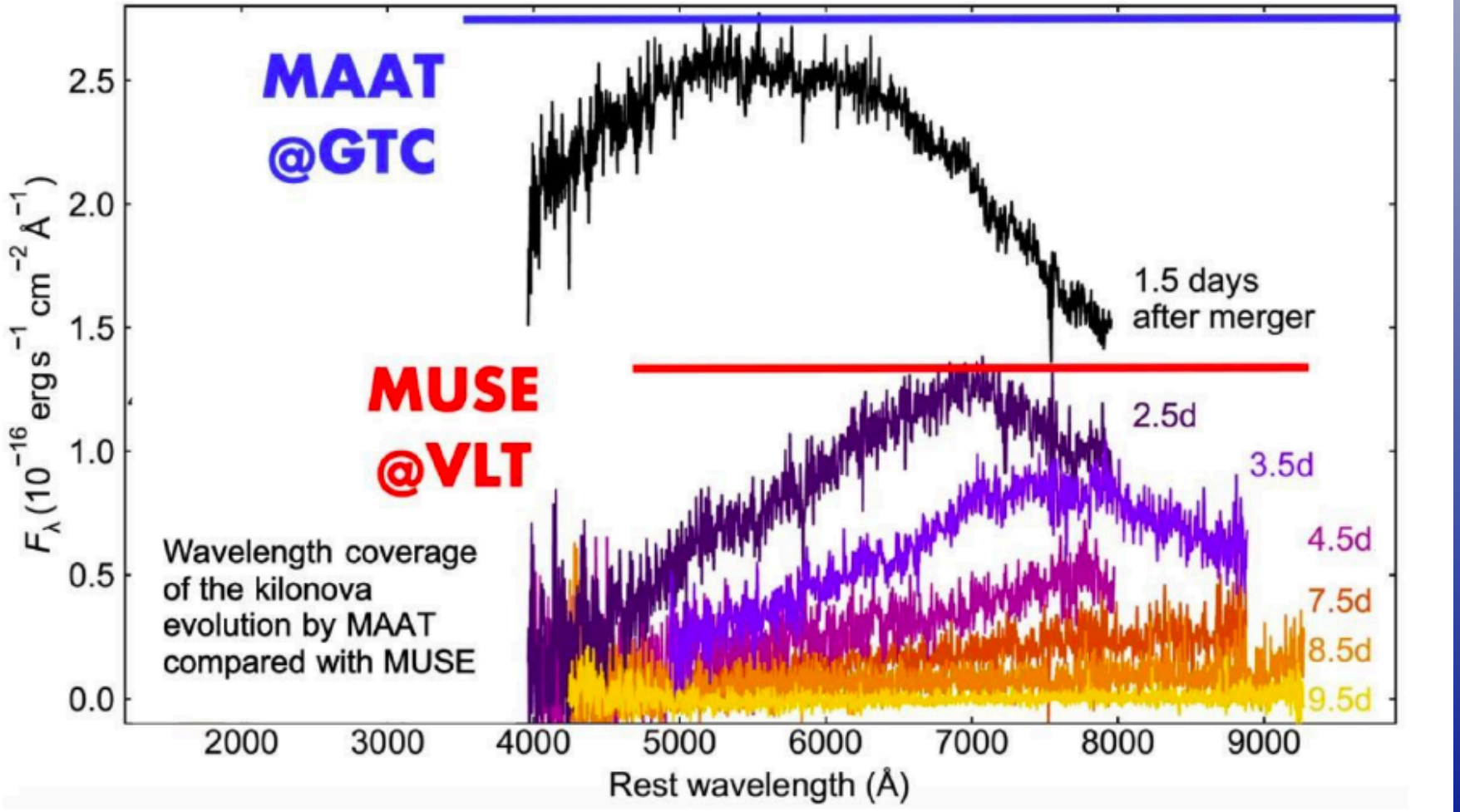
Sr II 869 nm
(triplet)



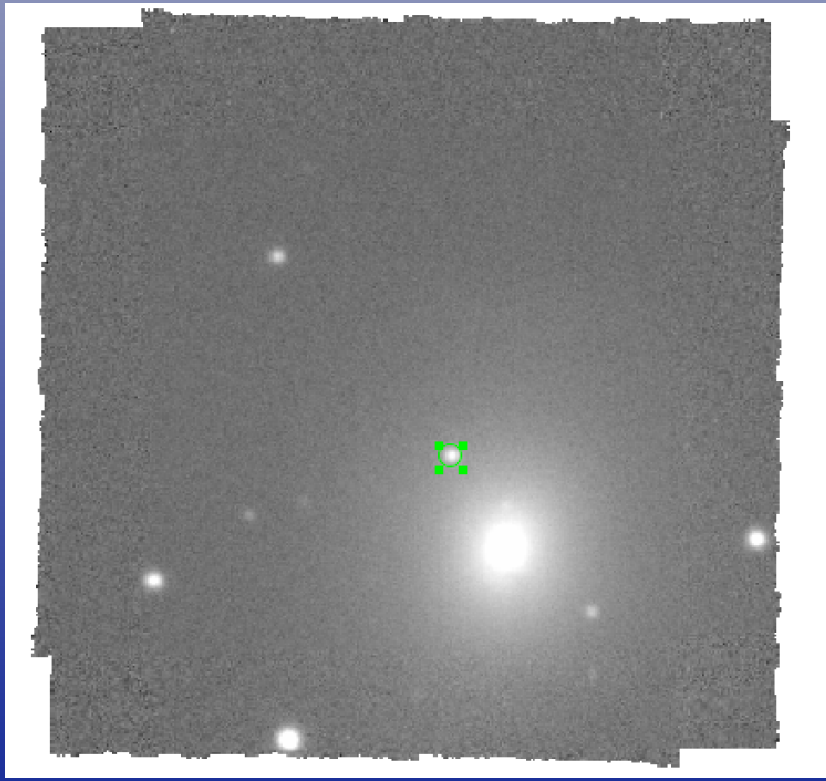
(Watson+ 2019)

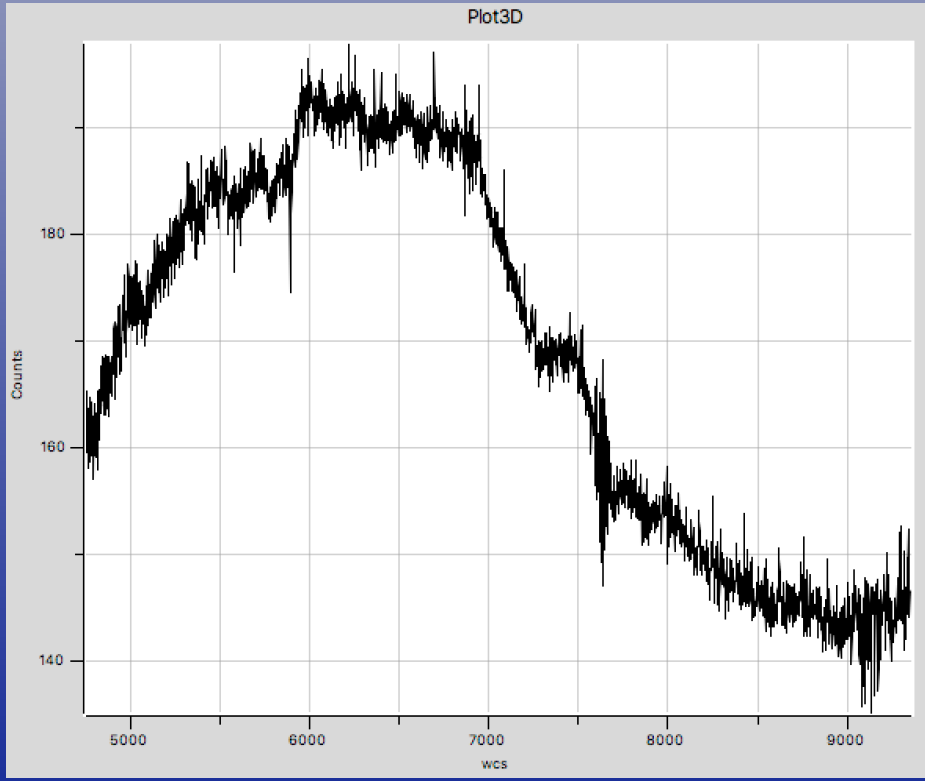
MAAT & kilonovae

Follow-up of newly-discovered KNe

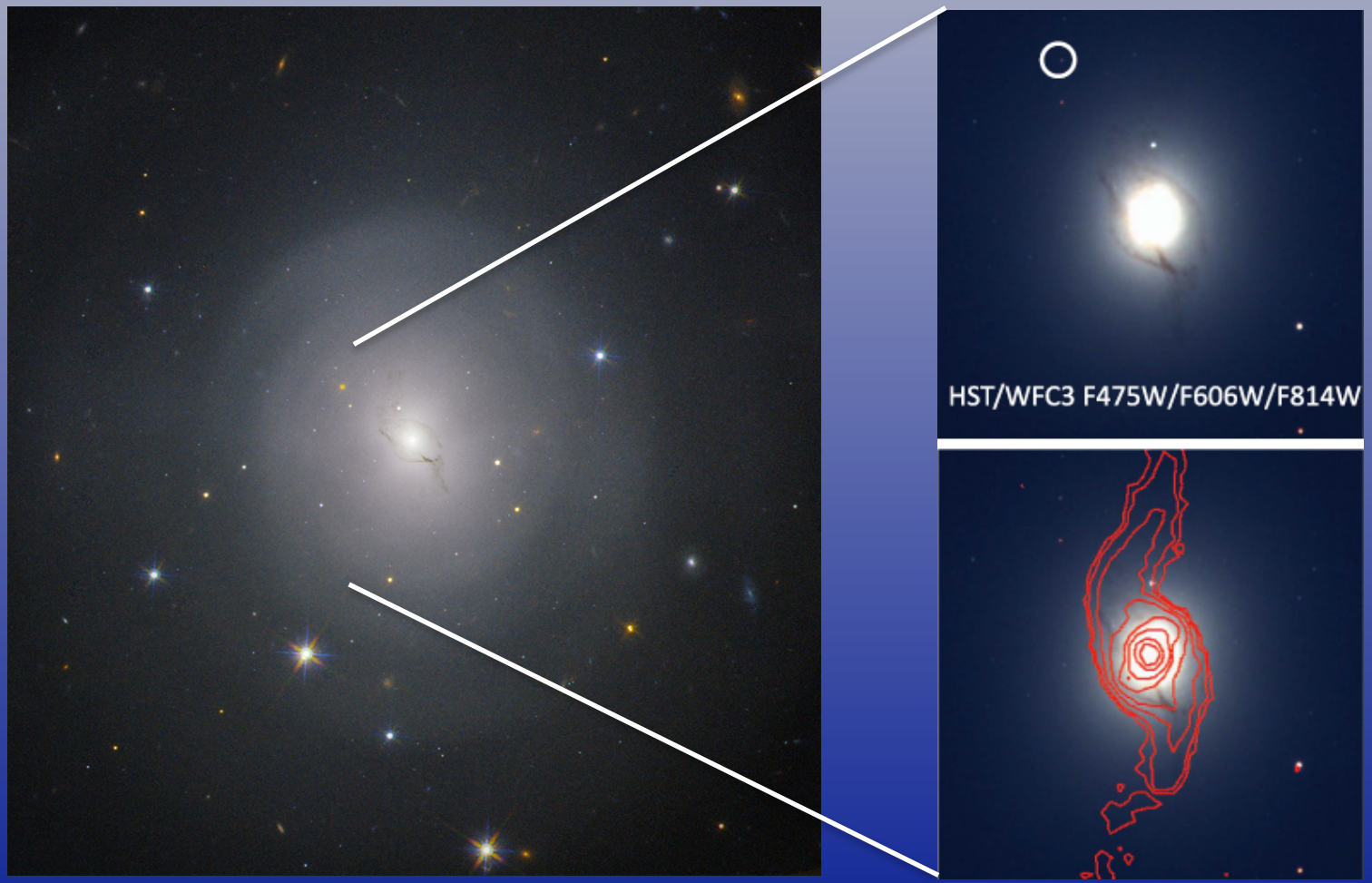


AT 2017gfo as observed by MUSE





NGC 4993



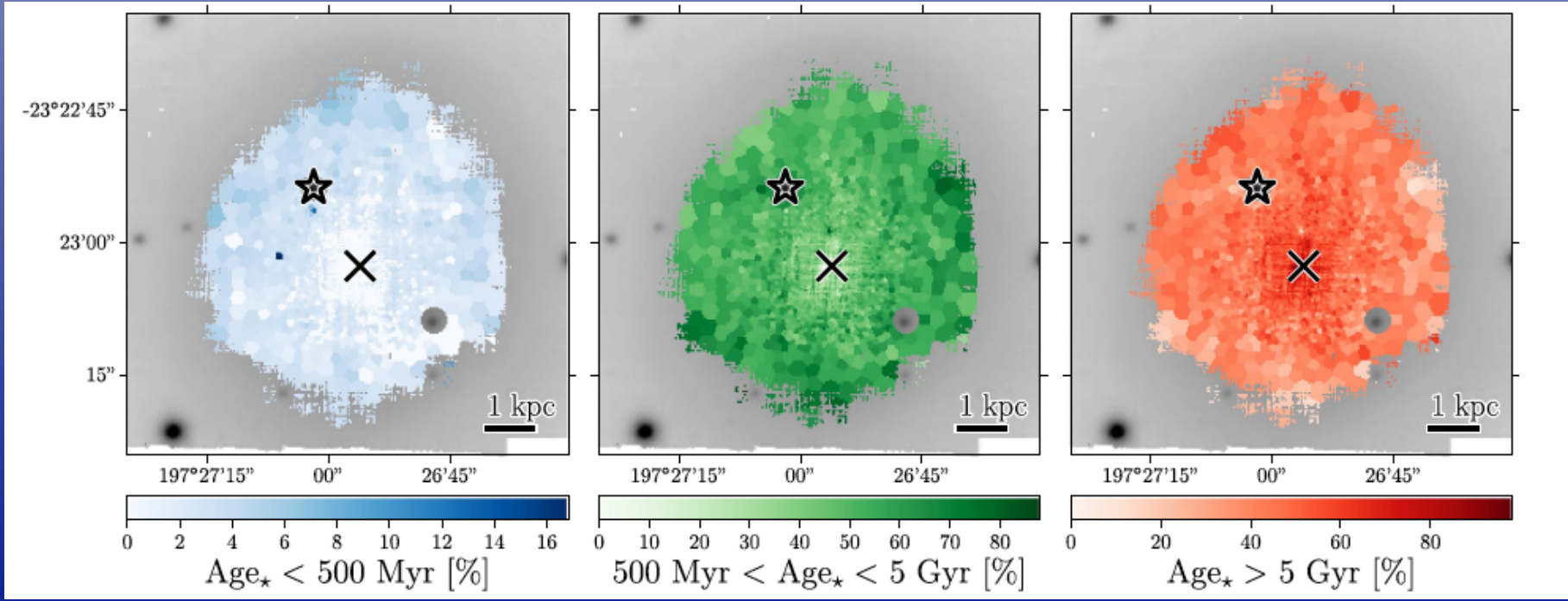
(Levan+ 2017)

NGC 4993

Stellar mass = 1.4 x 10^{11} MSun

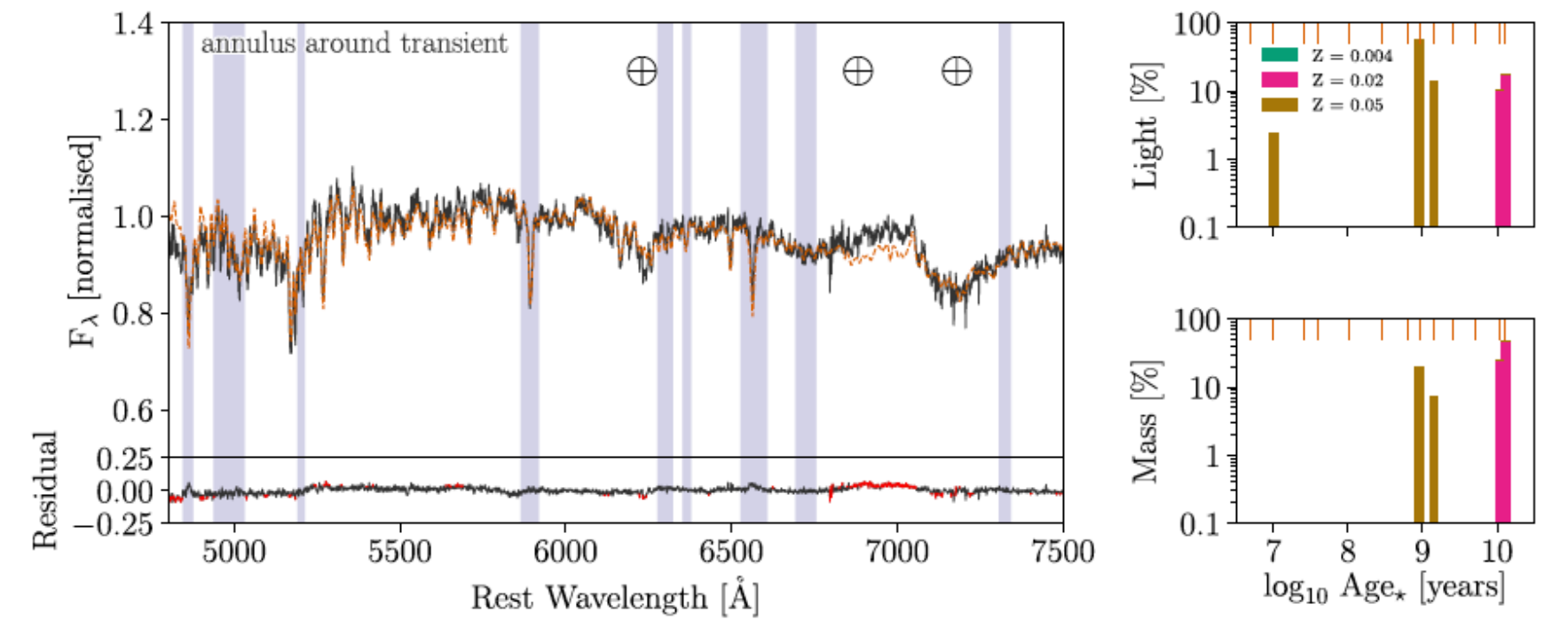
almost no ongoing SFR

small offset wrt the centroid of the galaxy



(Levan+ 2017)

NGC 4993



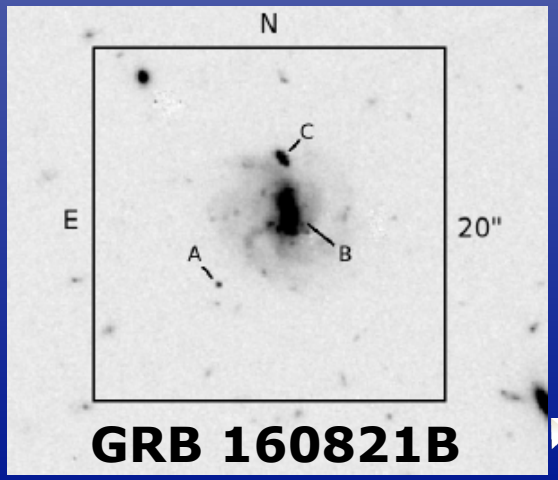
old stellar population -> old progenitor for the BNS (>~ 10^9 yrs)

(Levan+ 2017)

a first sGRB-KN sample

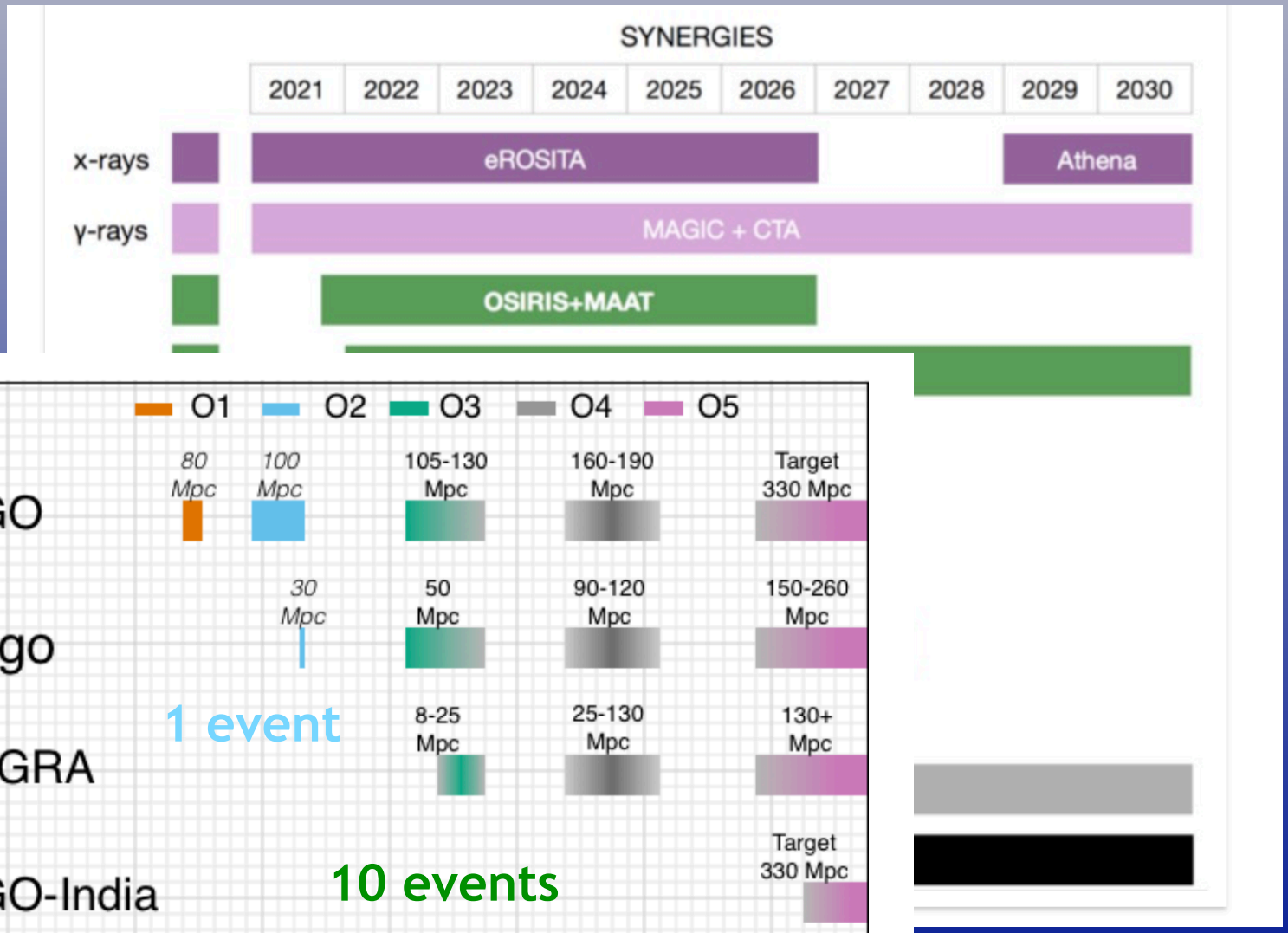
late-time rest-frame I-band excess in sGRB afterglow lightcurves

GRB 150101B	0.13	early
GRB 160821B	0.162	late
GRB 050709	0.16	late*
GRB 060614	0.125	late*
GRB 070809	0.22	hostless
GRB 130603B	0.36	late
GRB 170817A	0.008	early



late-to-early type ratio **2:1**

MAAT in the context of LVC runs



Conclusions

- Important contribution of MAAT to KN science
- ToO observations of very faint sources - possible only with 8-10m class telescopes
- Ejecta composition at early (bright) KN phases
- Possibility to study the environment of new KNe
- Prominent role in the following O4 (2022-2023) and O5 (2025?) LVC runs

Thank you !!!

building a KN sample

late-time rest-frame I-band excess in sGRB afterglow lightcurves

GRB 150101B	0.13	early
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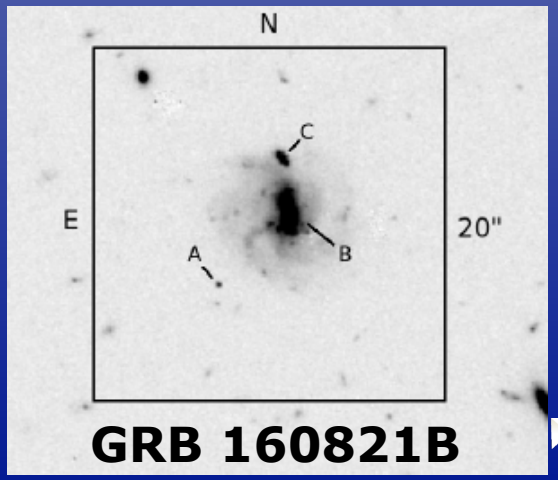
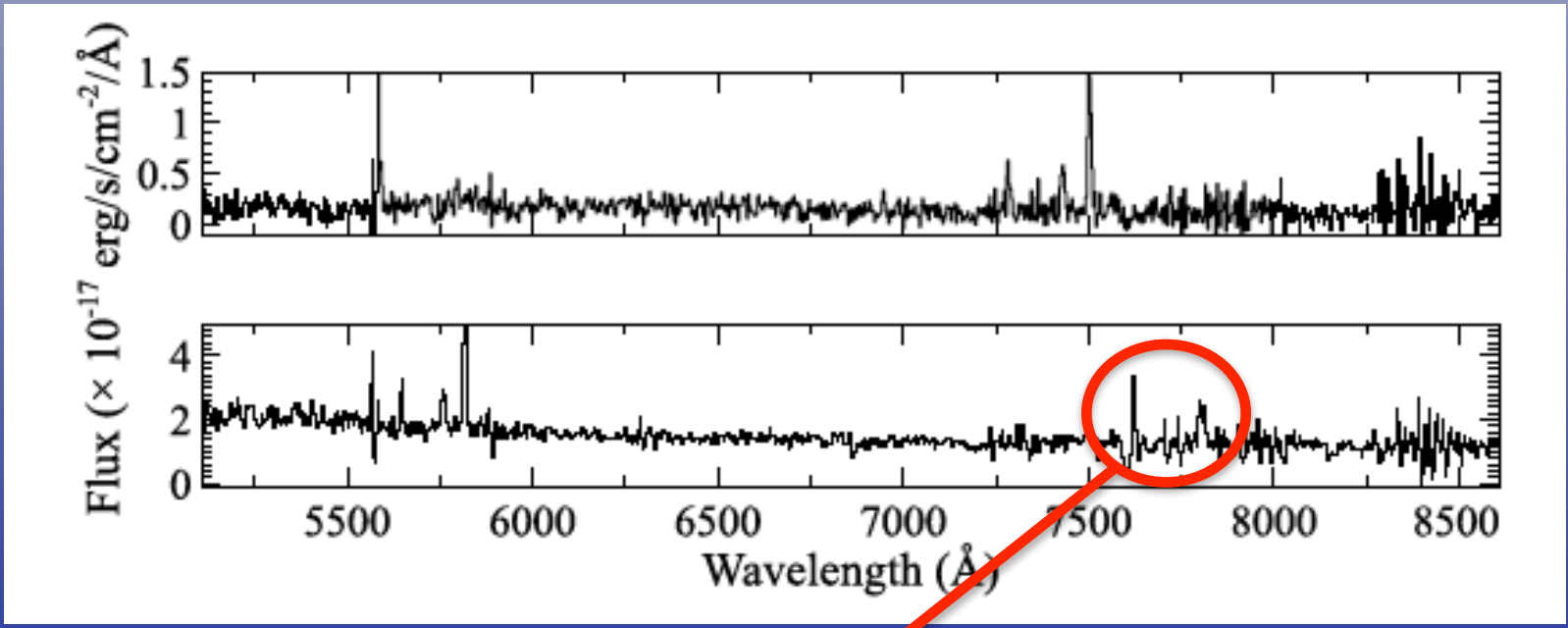


late-to-early type ratio **2:1**

building a KN sample

GRB 160821B



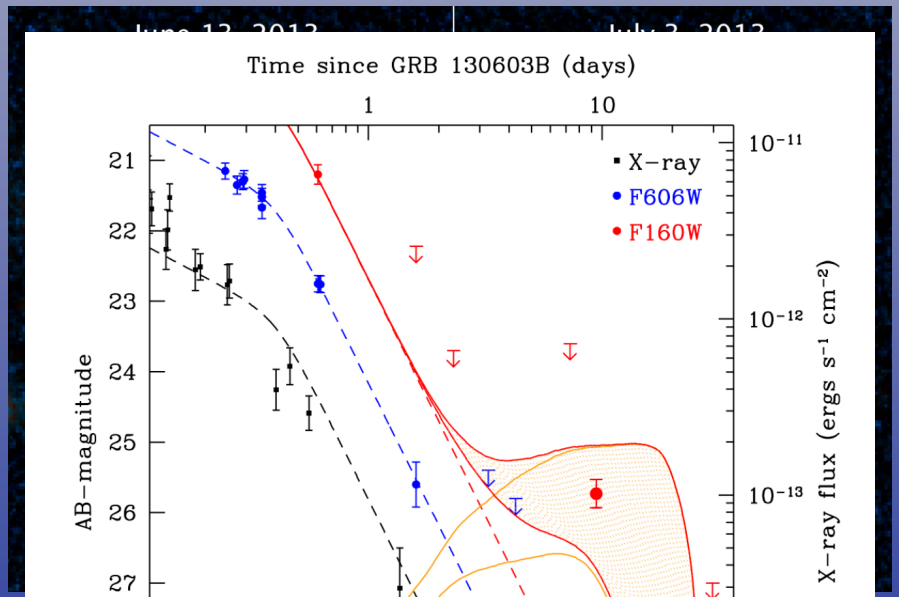
moderate metallicity

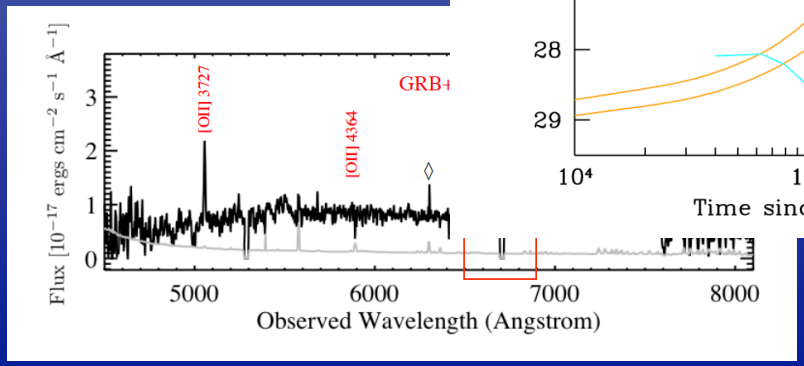
presence of shocks (?)

(Lamb+ 2019)

building a KN sample

GRB 130603B



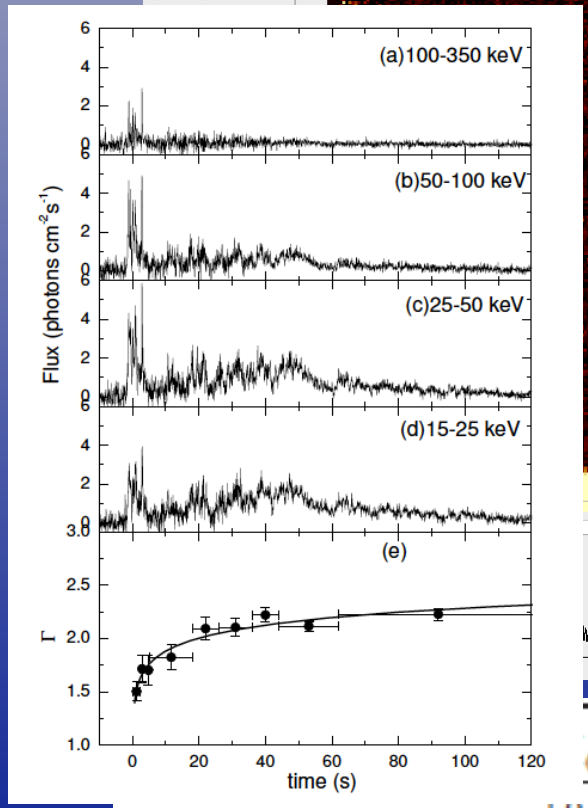


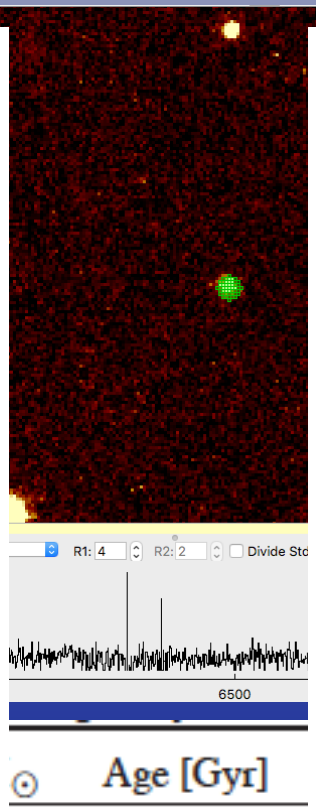
	$-20.96\ (\pm 0.07)^e$
	$1.84\,M_\odot\ yr^{-1}$
/H)	8.7 ± 0.2
	$5 \times 10^9\ M_\odot$
A_V	1.3 mag

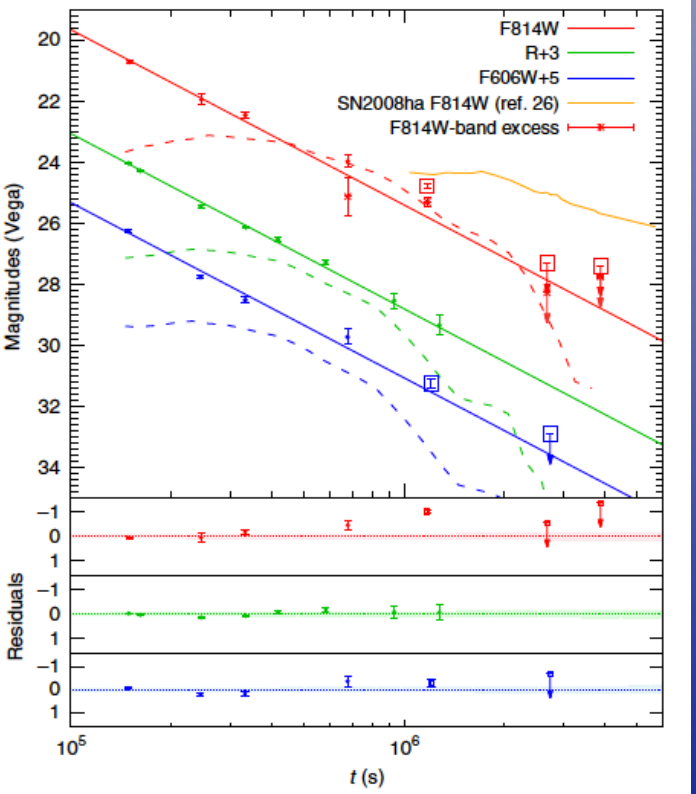
(Tanvir+ 2013, Cucchiara+ 2014)

building a KN sample

GRB 060614







060614	$8.2^{+0.5}_{-0.2}$	$7.8^{+2.4}_{-0.3}$	$0.6^{+0.1}_{-0.6}$	0.005

(Zhang+ 2006, Yang+ 2015, Izzo+ in prep)