eXTraS unveils a supernova shock break-out candidate in XMM-Newton archival data

Andrea Tiengo

IUSS
Scuola Universitaria Superiore Pavia

Giovanni Novara, Andrea Belfiore, Martino Marelli, Gianni Lisini (IUSS Pavia), Giacomo Vianello (Stanford University), Ruben Salvaterra, Andrea De Luca, David Salvetti , Marco Scodeggio (IASF-Milano), Paolo D'Avanzo (OA Brera), et al.

EXTraS: *Exploring the X-ray TRAnsient and variable Sky*

FP7 Cooperation project funded by the European Union for 3 years (**2014-2016**).

Partners:

- **INAF**, Italy *(PI: Andrea De Luca)*
- **IUSS Pavia**, Italy
- **CNR – IMATI Genova**, Italy

- **University of Leicester** (UK)
- **MPG – MPE**, Germany
- **FAU – ECAP**, Germany

EXTraS aims at exploiting the **serendipitous** content of the **XMM-Newton** archive in the **time domain** and to make it **publicly available** to the community

http://www.extras-fp7.eu

See talk by A. De Luca tomorrow at 5 p.m.

The EXTraS search for new X-ray transients

For each EPIC observation, **source detection** is performed on images integrated on short time intervals

The time intervals are derived from **Bayesian Blocks** (BB) analysis *(Scargle 2013)*

The **transient candidates** are only the new point-like sources detected within the regions from which the specific time interval was derived.
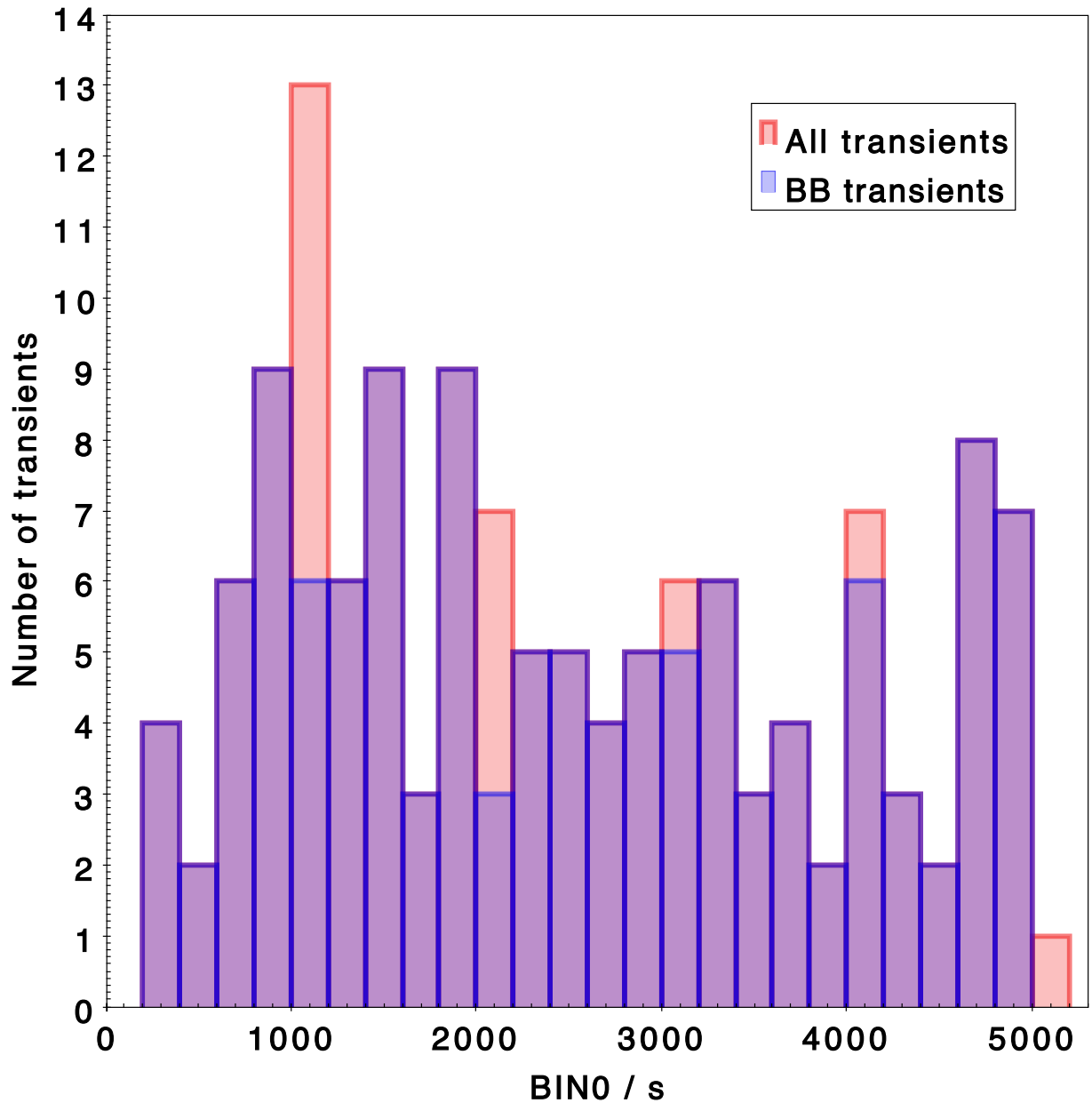
The transient candidates must be confirmed by manual **screening**
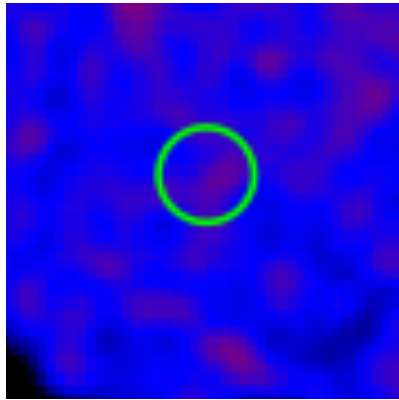
122 new transients

Duration of high confidence transients

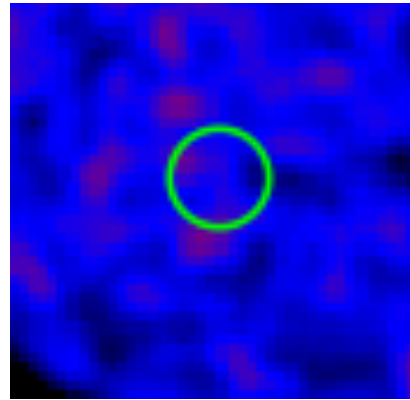**14 additional transients** from regions close to bright sources (**1 ks** time bins)

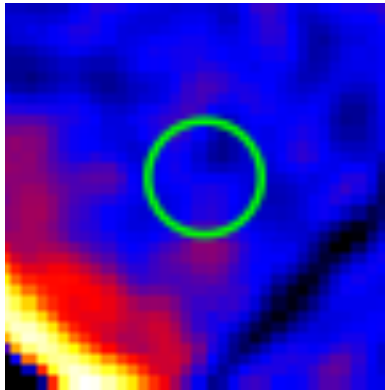The SN candidate is the **shortest transient** (315 s)
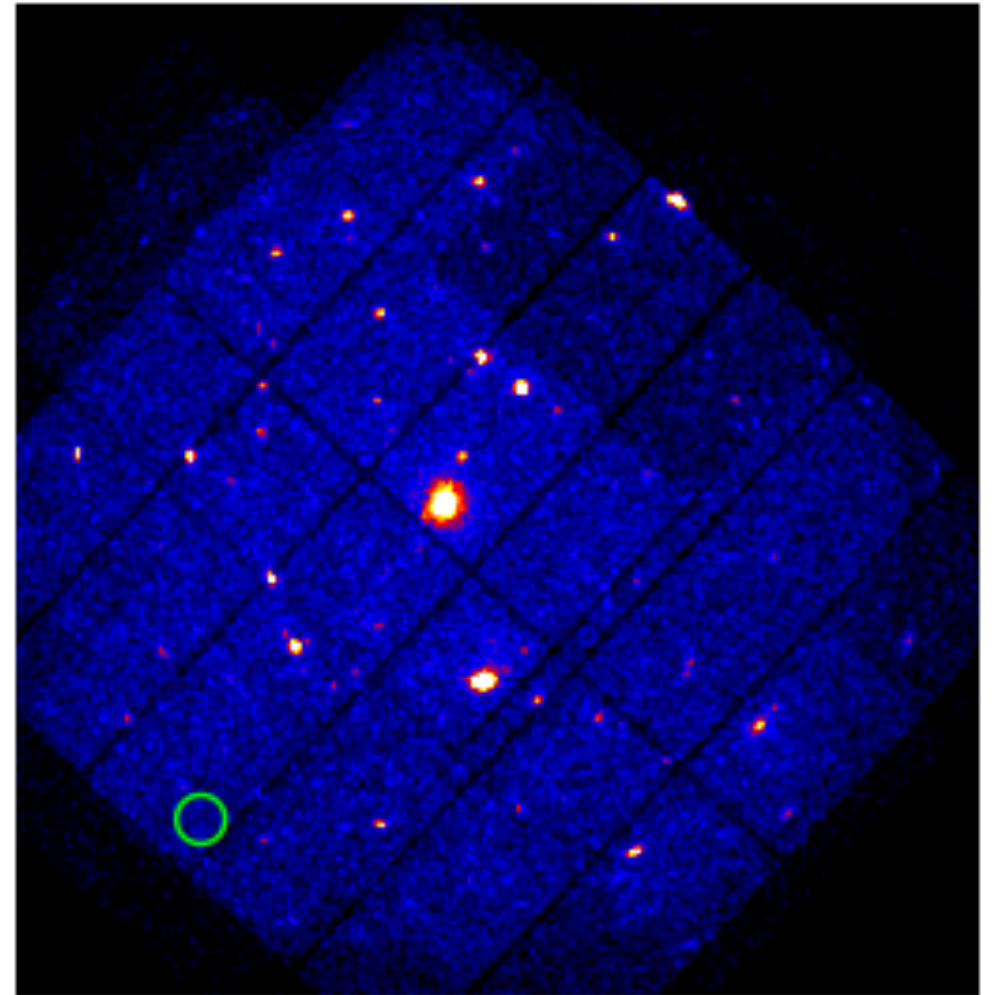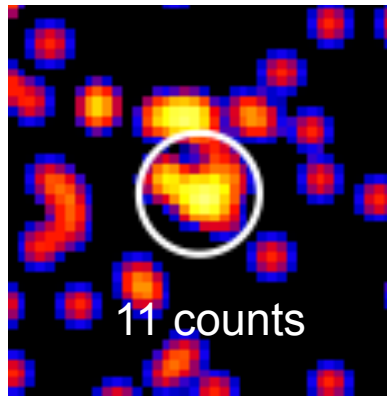
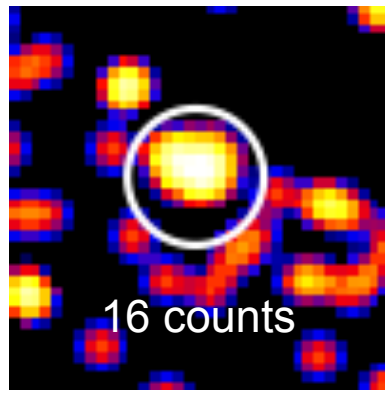# The SN candidate: X-ray data

MOS1

MOS2

PN

Entire observation (net exposure >20 ks)

The new transient is NOT visible in the whole observation

The SN candidate: X-ray data
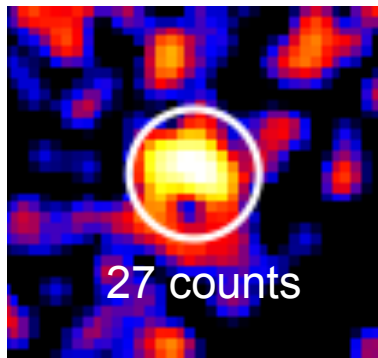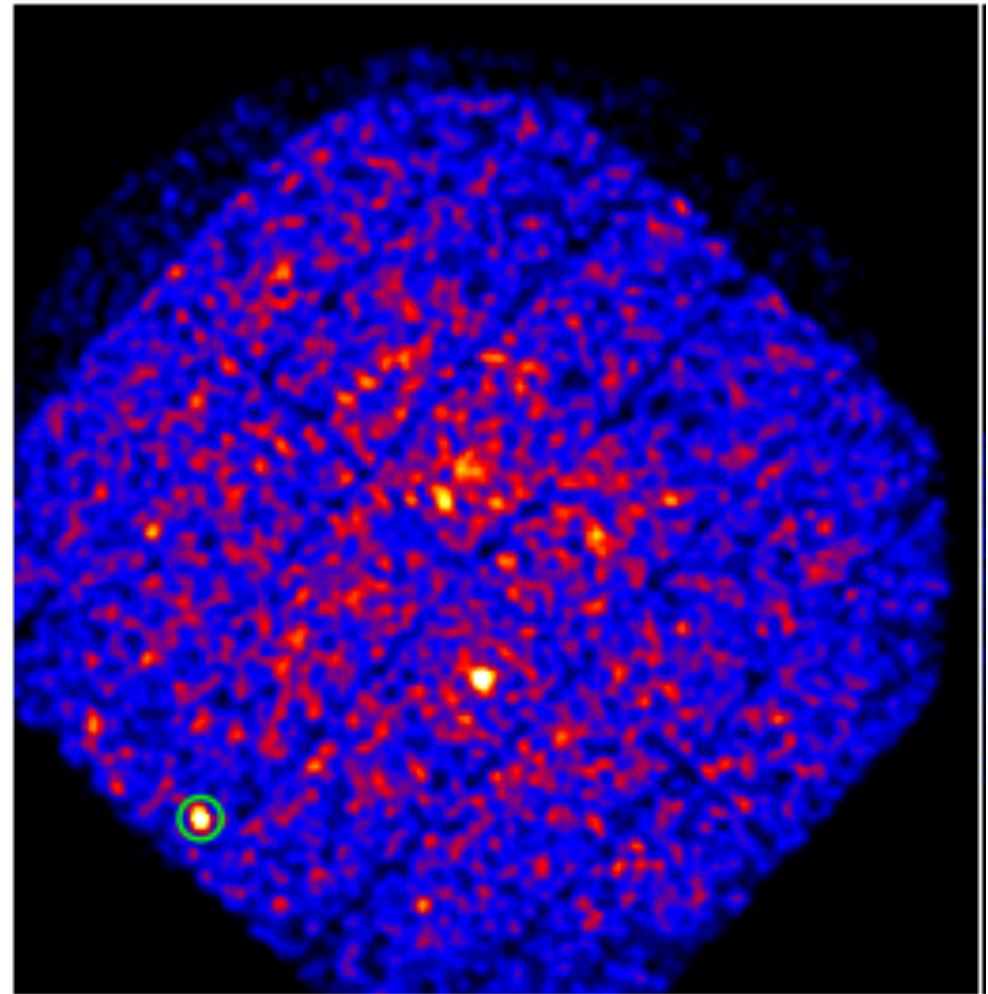

11 counts

MOS1

16 counts

MOS2

27 counts

PN

1σ **position error**: 1.9"

Time interval: 315 s

The position is consistent with a blue galaxy
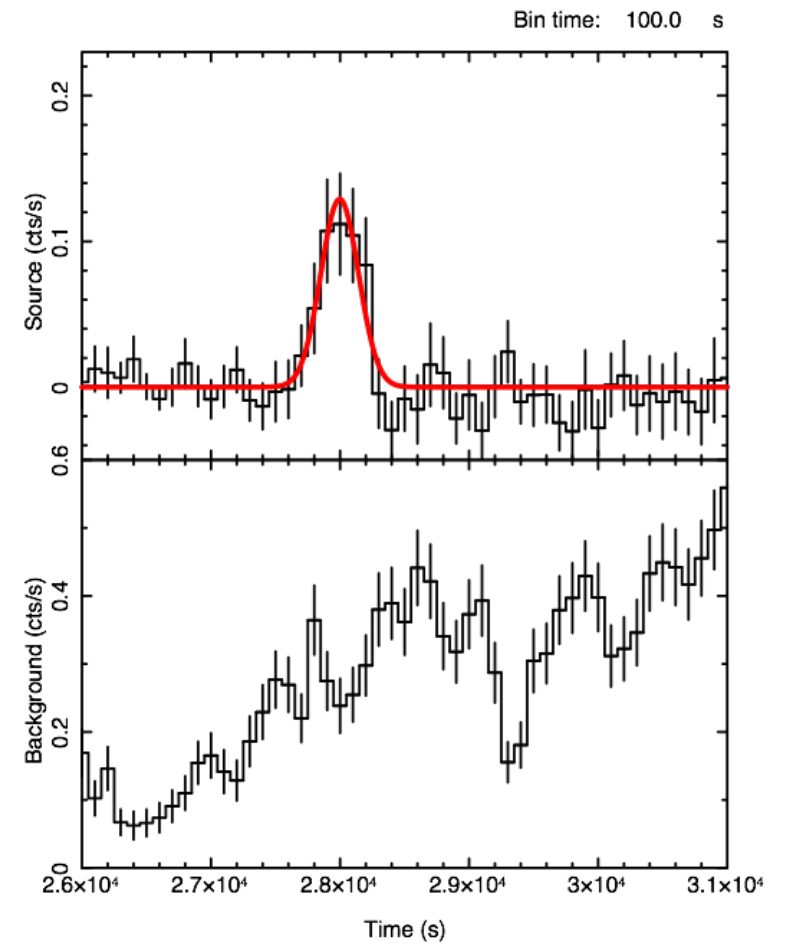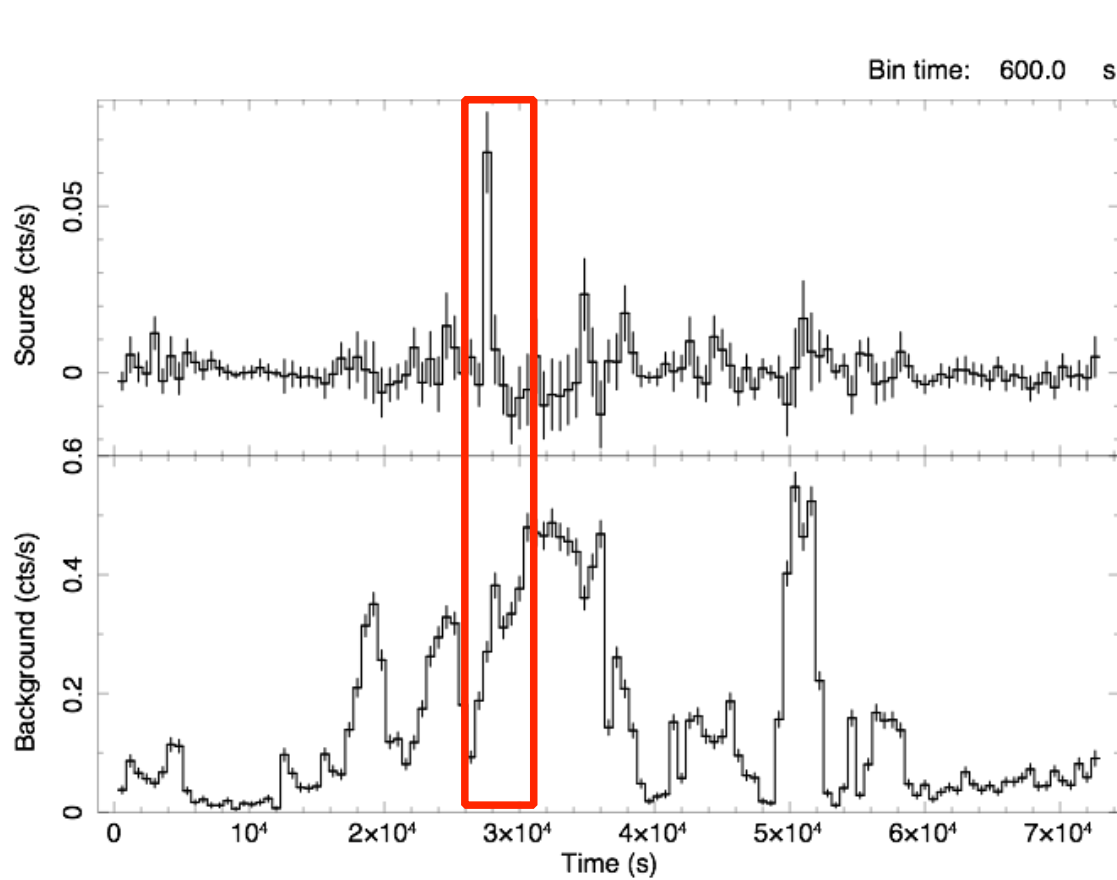with no redshift reported in literature

Follow-up optical observations

From CTIO* optical high resolution spectrum we derive a redshift of z = 0.092 ± 0.003, corresponding to a distance of 424 Mpc

GROND

1.9" radius
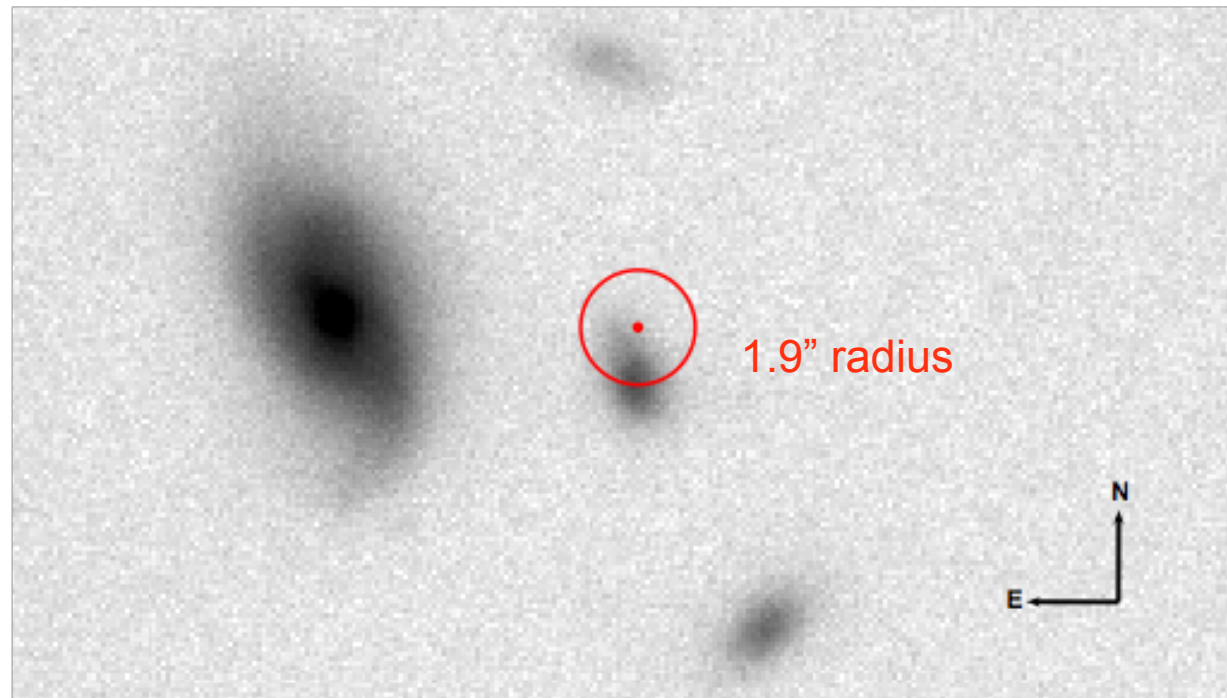
* (COSMOS spectrograph at the Blanco Telescope of the Cerro Totolo Inter-American observatory)

X-ray light curve

47 net counts by integrating the Gaussian profile

Comparison with SN2008D

The flare energy and duration are very similar to those of the X-ray transient associated to **SN2008D***, interpreted as the emission from the **shock break-out** of a core-collapse supernova

	SN 2008D	Transient source
d	27 Mpc (z=0.006494)	424 Mpc (z=0.092)
Fluence	2.3×10^{-7} erg cm^{-2}	8×10^{-10} erg cm^{-2}
Total energy	2×10^{46} erg	1.7×10^{46} erg
Peak luminosity	6.1×10^{43} erg s^{-1}	4.3×10^{43} erg s^{-1}

X-ray **spectrum** possibly steeper than that of SN2008D*; >3σ evidence for absorption > $N_{H,Gal}=3 \times 10^{20}$ cm^{-2}

* (Soderberg et al.,2008)

Supernova association

Being discovered in archival data, no follow-up optical observations to **search for a supernova**; no sufficiently deep archival optical observations; outside OM FoV during *XMM-Newton* observation

SN2008 was discovered during the observation of a SN-rich galaxy, whereas our discovery is serendipitous

http://www.nasa.gov/centers/goddard/news/topstory/2008/swift_supernova.html
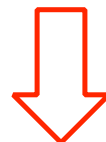
Event Rate

- **Serendipitous** discovery

- Sky coverage of the EXTraS survey corresponds to the **full sky** observed by the PN **for ~8 minutes**

- From *preliminary* estimate of sensitivity (fluence ~ 5×10^{-10} erg cm^{-2}), the **horizon** of the EXTraS survey is **~550 Mpc (z~0.12)**

From this single detection, the *(preliminary)* event rate is **1.3×10^5 yr^{-1} Gpc^{-3}**, consistent with Sorderberg et al. (2008) and a factor ~2 larger than core-collapse SN rate (~6×10^4 yr^{-1} Gpc^{-3}).

Optical SN searches might have missed a significant fraction of core-collapse SNe

Work in progress

- More **simulations** to evaluate **sensitivity** and constrain **event rate**
- Further analysis of **optical data** to better characterize **galaxy properties**
- **Optical follow-up** of a few other possible **SN candidates**
- Search for **additional SN candidates** among fainter transients, 3XMM sources with <100 counts and more recent data

Conclusions

- The **EXTraS** algorithm for the detection of faint and short X-ray transients could detect an analogue of the **SN 2008D X-ray flare** at a **>15 times larger distance** (~300 times smaller fluence)

- After careful evaluation of the algorithm **sensitivity** and the systematic screening of the **full XMM-Newton archive**, a robust estimate of the **event rate** can be derived and compared with the **core-collapse supernova rate**