

*Padova, March 3, 2017*

# **SON OF X-SHOOTER SOXS**

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ON BEHALF OF THE SOXS CONSORTIUM



# WHAT IS SOXS?

ESO call for new instruments at NTT (06/2014)

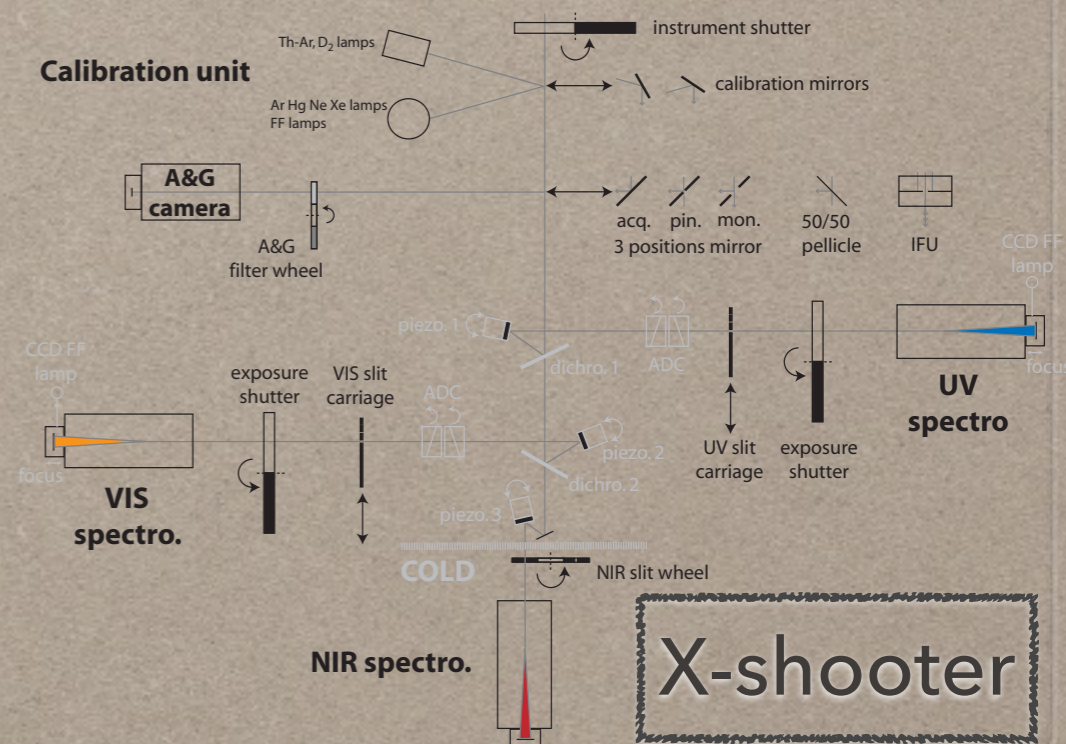
Proposal submission (02/2015)

SOXS selected by ESO (05/2015) out of 19

**Single-object spectrograph  $R \sim 4,500$  from U to H  
(350-1750 nm) @ ESO/NTT  
1 hr - SNR  $\sim 10$  -  $R \sim 20-20.5$**

Similar to X-shooter

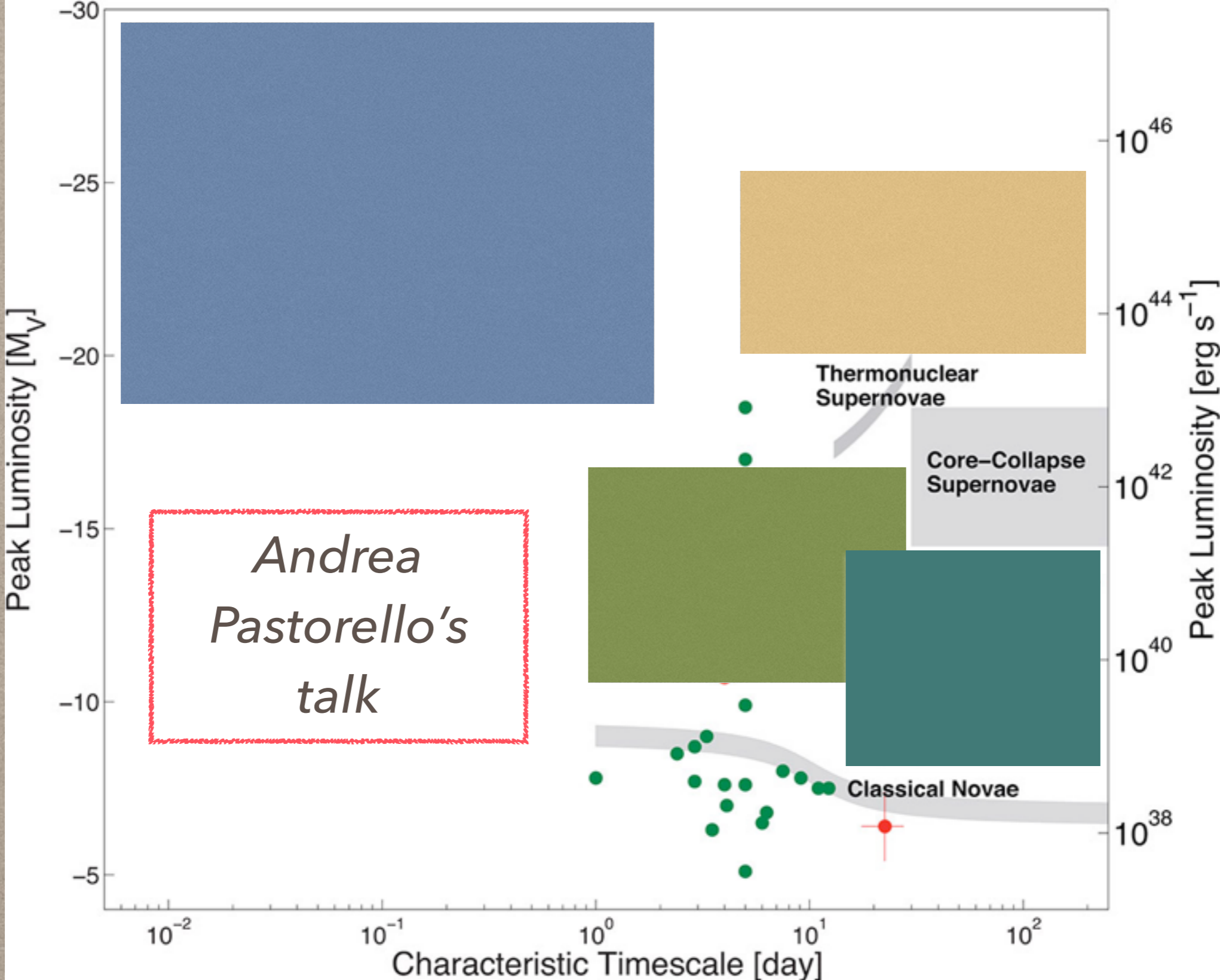
.. but also different, only two arms  
with partial overlap around 800 nm  
to cross-calibrate spectra



# SOXS@NTT IN A NUTSHELL

- *Broad band spectrograph 350-1750 nm*
- *R~4,500 (3,500-6,000)*
- *Two arms (VIS + NIR)*
- *S/N~10 spectrum - 1 hr exposure for R~20-20.5*
- *Acquisition camera to perform photometry ugriz (2'x2')*

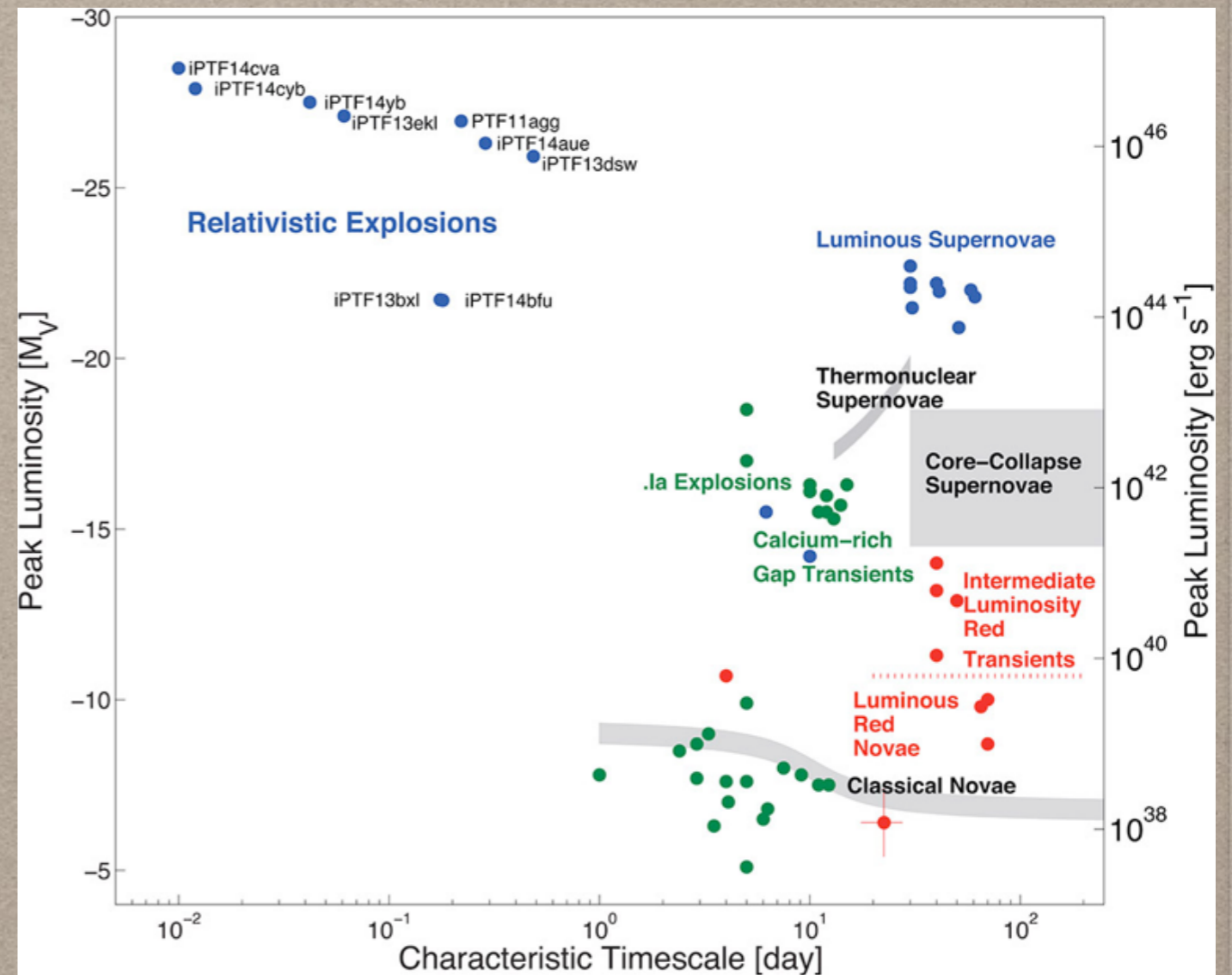
# EVOLUTION OF TRANSIENTS



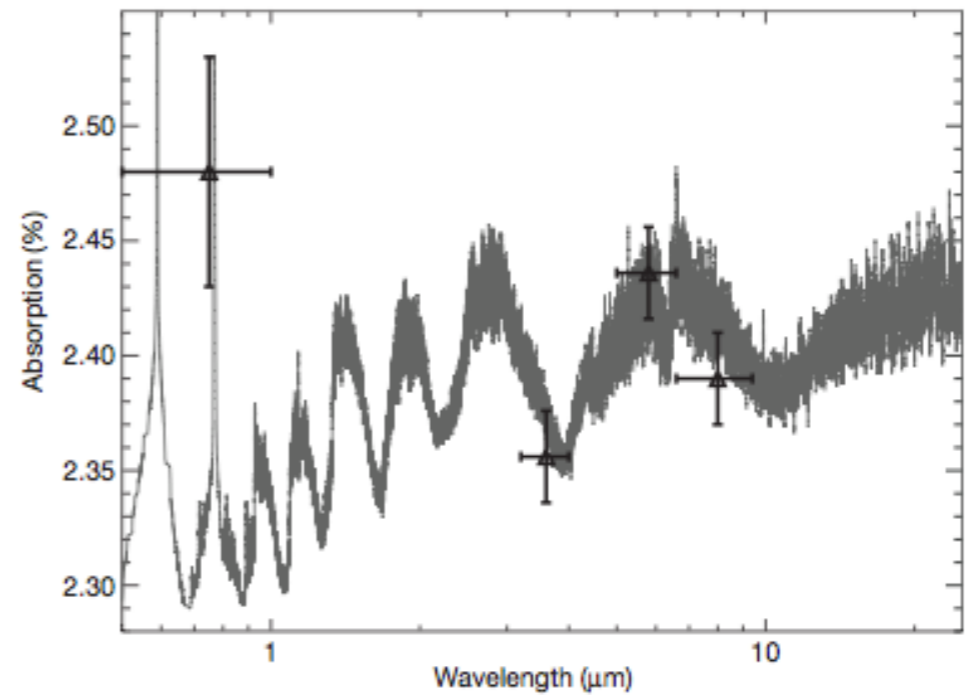
# SOXS IS FULLY DEDICATED TO THE SPECTROSCOPIC FOLLOW UP OF TRANSIENT

- Minor planets and asteroids
- Young stellar objects
- Planetary transits
- X-ray binary transients

- GRB
- GW-&neutrino EM counterparts
- Radio sky transients & fast radio bursts

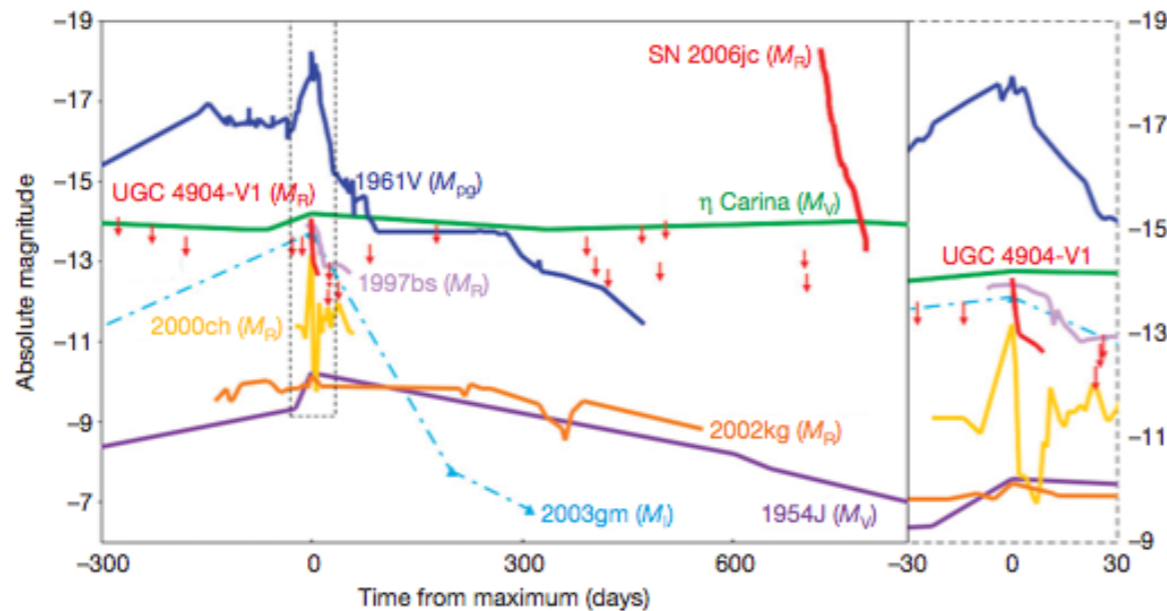


# Discovery space

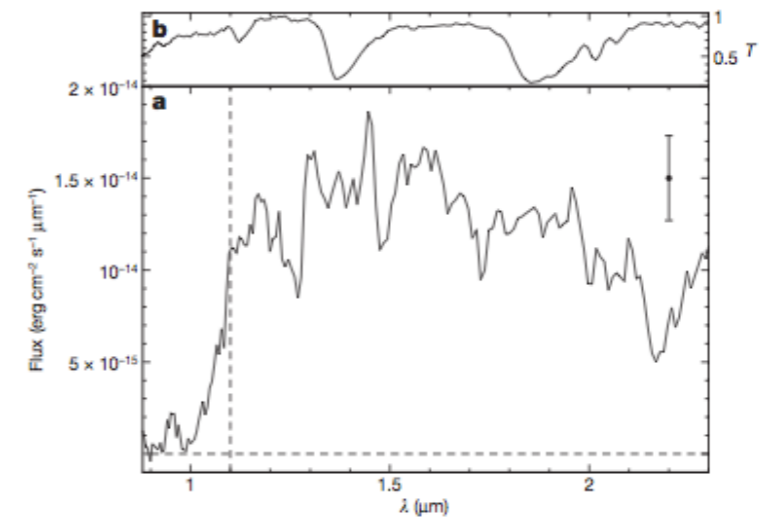


Water vapor in the atmosphere of a transiting planet

First SN shock break out



Major outburst 2 yr before the (probable) SN explosion



The most distant object in the Universe (at the time of discovery)

# A working example

During 2005-2013 Nature published ~180 astronomical papers with more than 50 citations.

Among them **36%** are on transients  
*and variable objects*

**PAST**

# PESSTO

- ~20% of selected candidates from SN searches enter into the observing queue
  - ~ 50% of the transients are eventually observed and classified
- 90% remain unclassified

## GAIA Transient Alerts

GAIA  
is  
coming

	<i>alerting object</i>	<i>5-yrs (Entire Mission)</i>	<i>main location</i>
interesting	Supernovae <19 mag	6000	out of plane
	Microlensing (bulge)	~1000	bulge/plane
	Microlensing (all sky)	~700	out of plane
	GRB optical counterparts	~hundreds (?)	out of plane
	R CrB-type stars	~hundreds (?)	gal. plane
	CN	150	gal. plane
contaminants(?)	FU Ori	14	gal. plane
	Eclipsing binaries	a million (?)	gal. plane
	AGNs	500,000 (?)	out of plane
	Asteroids	thousands (?)	out of plane
	Be stars	thousands (?)	gal. plane
	Long period variables/Miras	thousands (?)	gal. plane
	M-dwarf flares	2000	gal. plane
	DN (U Gem) (except rare big flares)	500 (?)	gal. plane



# EPESSTO

PRESENT

PESSTO evolved into **ePESSTO**

- Large program at ESO
- No longer fully public (even if there is still a service activity to classify transients)
- Approved for 4 semester for 90n/yr
- Not only SNe but **open** to other science cases
- Pathway to SOXS
- Italy involved (also thanks to SOXS)
- Two Italian scientists (out of 12) within the ePESSTO board

# WHY SOXS?

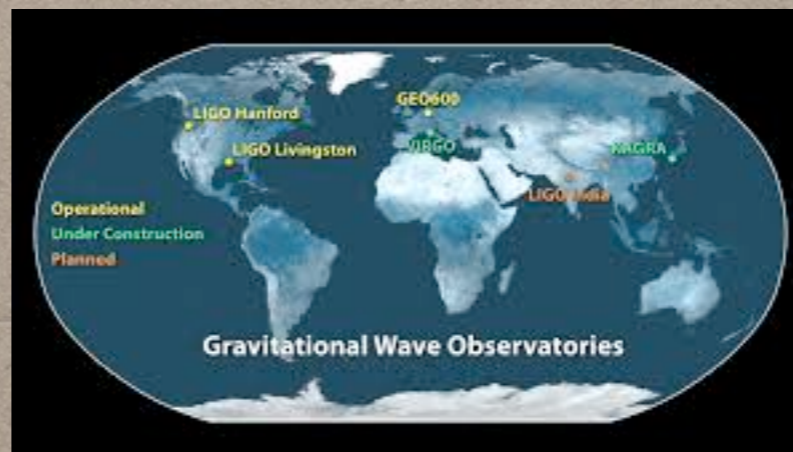
Spectroscopic machine for the transient sky.

Even now with PESSTO in place >70% of newly discovered transients remain without spectroscopic follow-up.

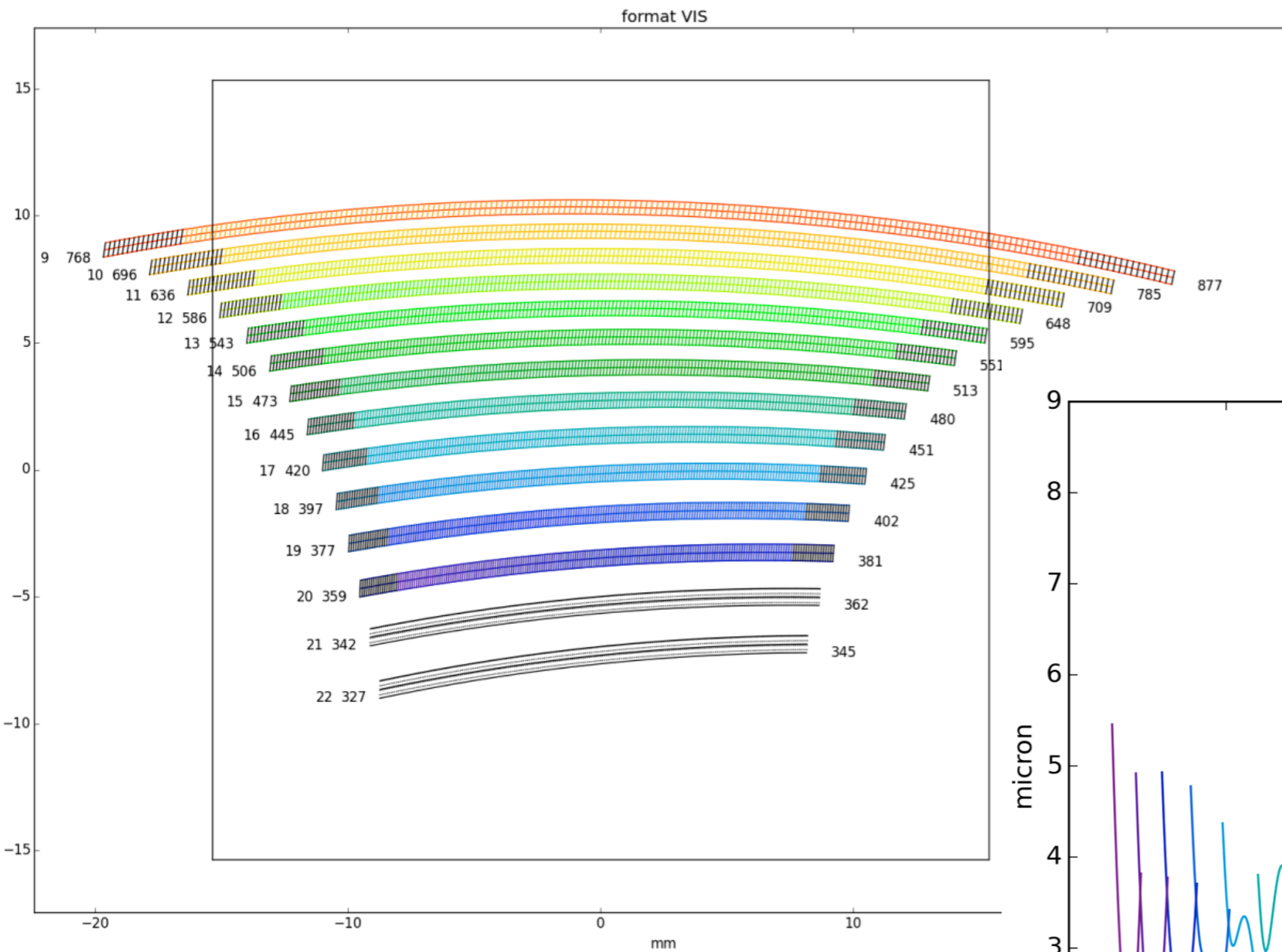
In the near future years there will be many imaging survey wide-field telescopes (iPTF, DES, Pan-STARRS, LSST) as well as high-energy transients (Swift, INTEGRAL, MAXI), GAIA-alerts GW-alerts, TeV alerts, etc. but very limited spectroscopic follow-up

SOXS@NTT will have 180 n/yr (for >5 yr)  
~3,000 - 4,000 spectra/yr

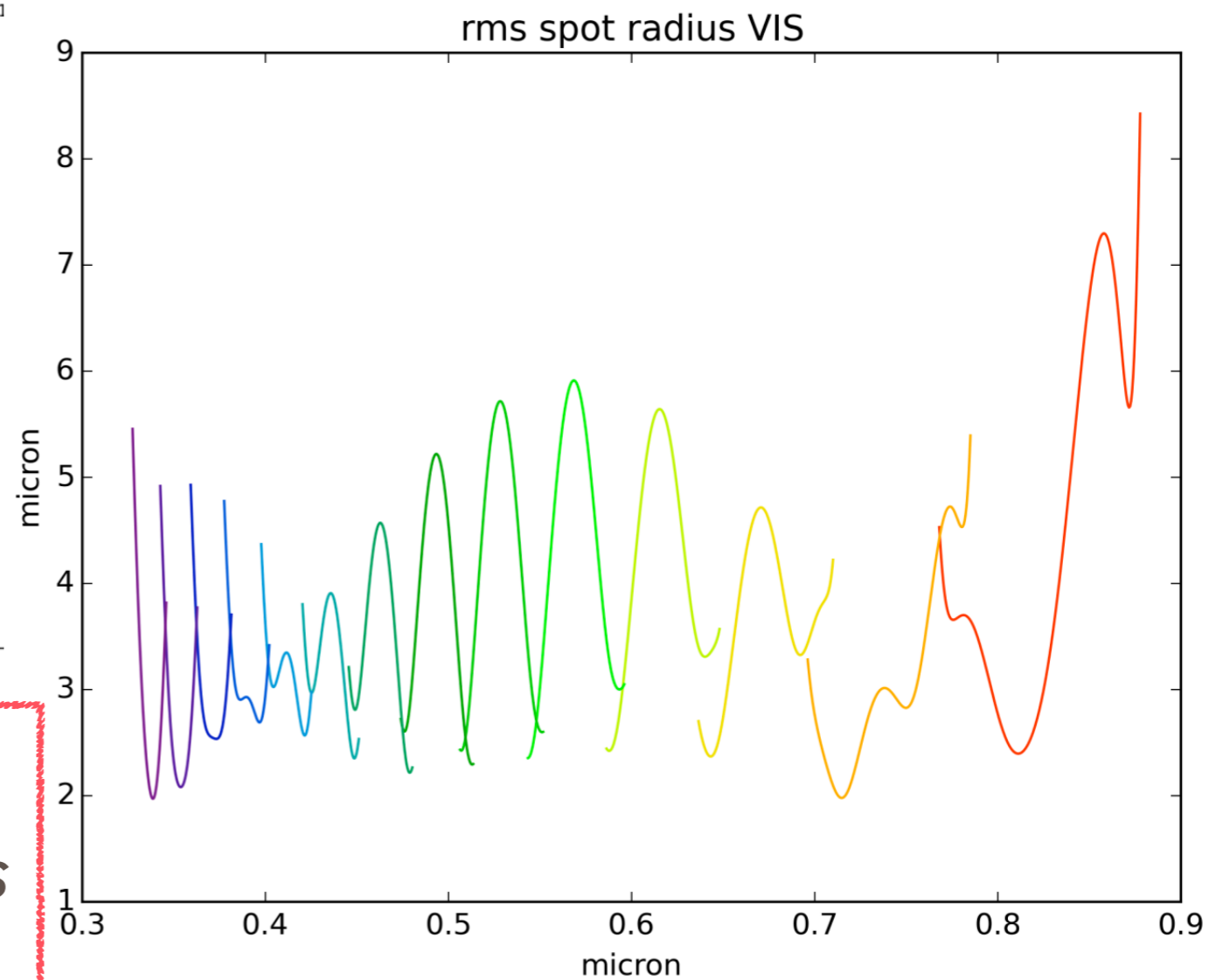
FUTURE



# VIS/**BLUE** spectrograph *BASELINE*

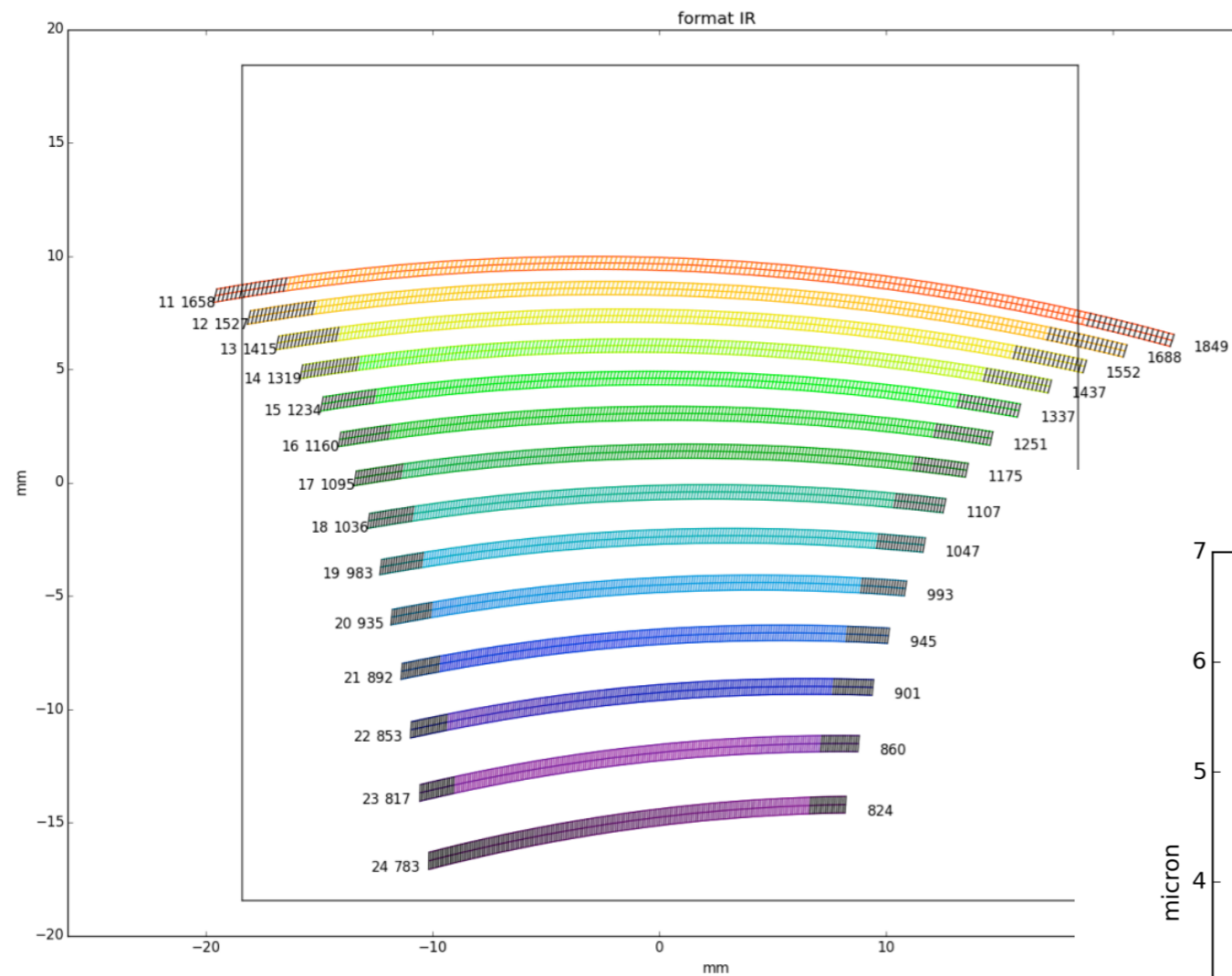


Pixel size 15 micron  
2048x2048

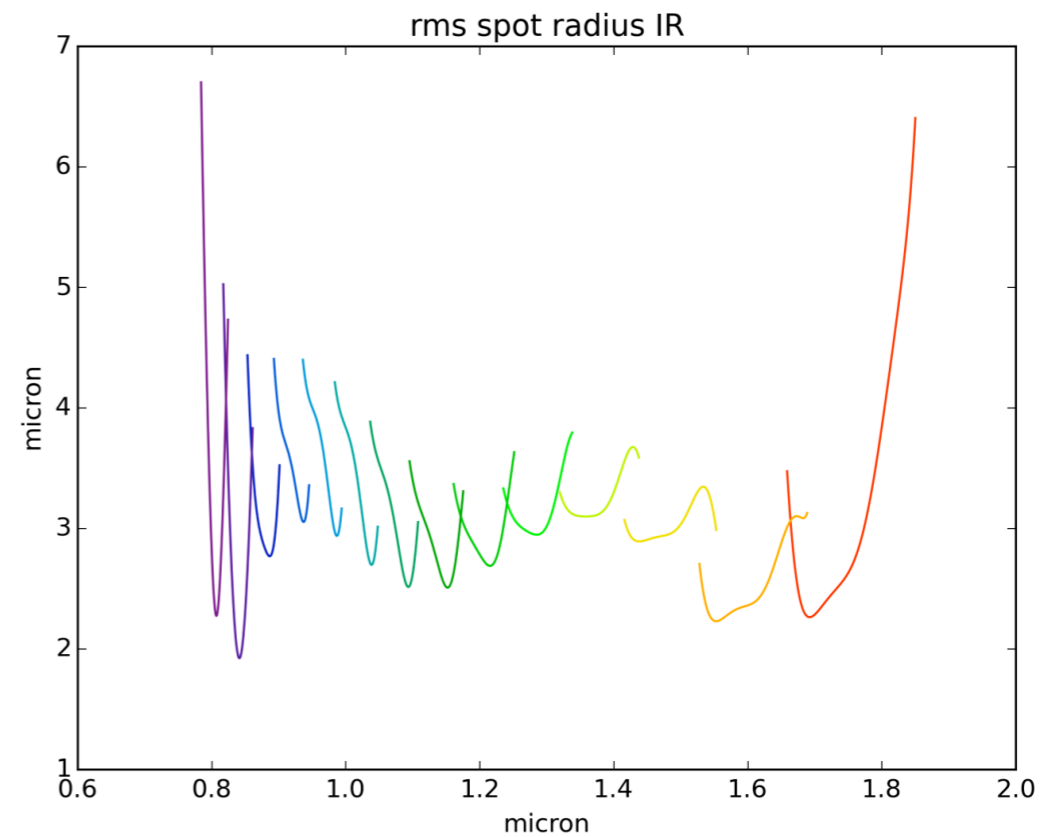


*Innovative design with VPHs  
and 4 different optical cameras  
(Israel)*

# NIR/RED spectrograph



Pixel size 18 micron  
2048x2048



# TIMELINE (TIGHT!)

Date to be operational on sky: end 2020

PDR	July 2017
FDR	July 2018
End of Procurement	April 2019
AIT & Test in Europe	June 2020
Instrument in Chile	August 2020
End of Commissioning	December 2020

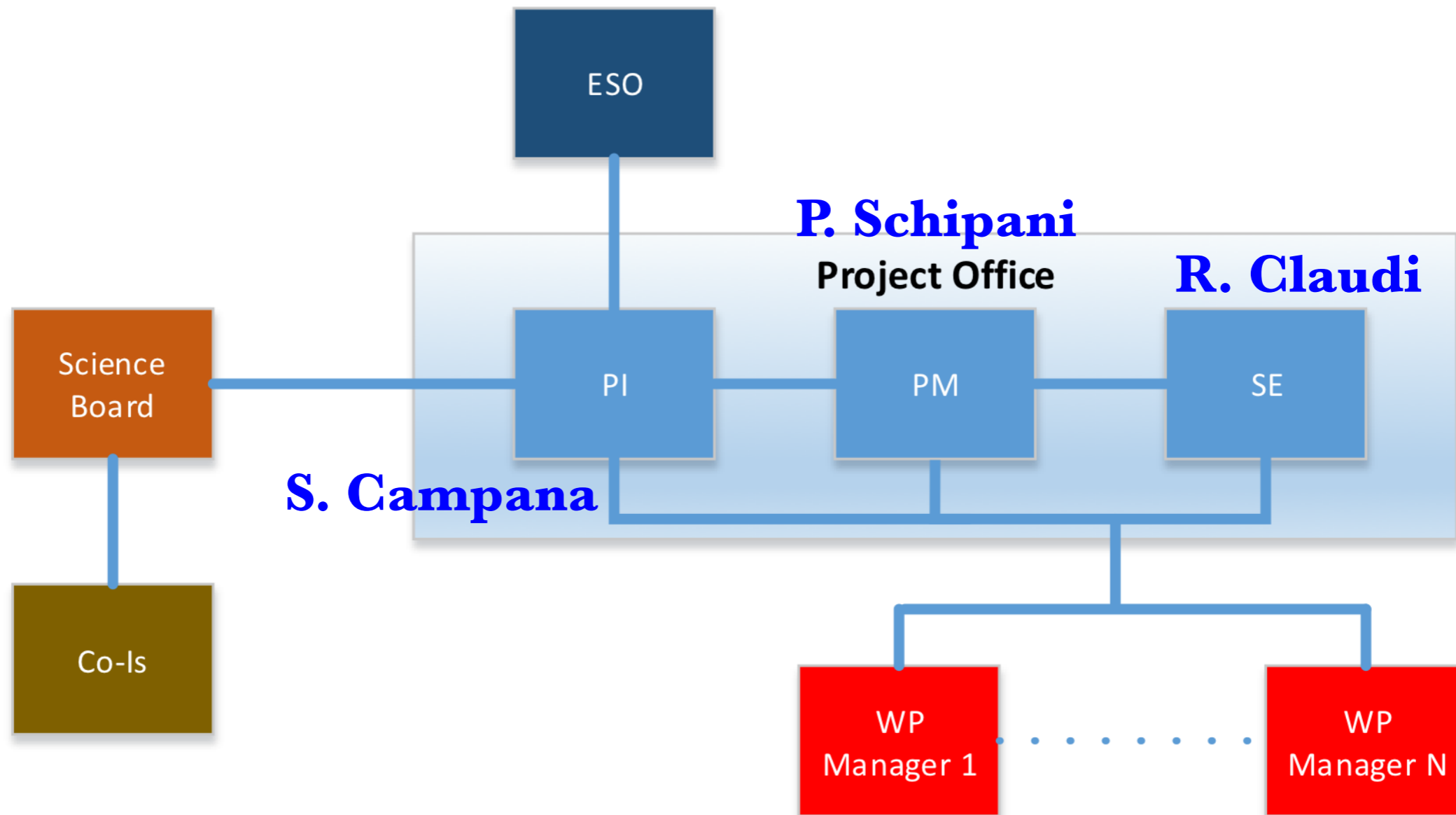
*LSST - CTA - SKA*

*good timing with GW experiments (4 detectors) -*

# FUNDS SITUATION

- SOXS fully funded up to PDR
- SOXS has been selected by INAF to participate to the 'best practice'-project competition (to cover ~40% of the total Italian involvement)
- MoU up to PDR signed with ESO

# Consortium structure



# Science Board

E. Cappellaro (INAF-OAPadova) - Italy

M. Della Valle (INAF-OANapoli) - Italy

G. Pignata (Millenium Inst.) - Chile

S. Smartt (Univ. Belfast) - UK

A. Gal-Yam (Weizmann) - Israel

I. Arcavi (Tel Aviv University) - Israel

S. Mattila (FINCA) - Finland

S. Campana (INAF-OABrera) - Italy

still contacts with NL, DK, F, USA, UK



# OBSERVING TIME/MONEY SHARE

- Still evolving...

Italy ~50%

Israel ~25% (VIS-ARM optics and mechanics)

Chile ~10% (Acquisition camera)

UK ~10% (VIS-CCD, reduction pipeline)

Finland ~5% (Calibration Unit?)

# OPERATIONS

ESO will reward the SOXS consortium with NTT observing time.

now ePESSTO 90n/yr  
future SOXS 180n/yr

Observers on-site and instantaneous response to fast alerts. Possibility to trigger fast ToO out of consortium time.

<5% of the consortium time open to the community as fast ToO (Swift-like) observations (public data)

Relevant information (redshift, peculiar sources, etc.) announced in real time through GCN, ATEL, IAUC, etc.

Consortium data public after a short (6-12 months TBD) proprietary period.

Source class	Obs. Time	Key project & Aim
All	500 <u>hr</u>	Fast characterization of transients from other surveys
Open	500 <u>hr</u>	Open time for spectroscopic <u>ToO</u> observations
Asteroids & TNO	200 <u>hr</u>	Characterization of populations of minor bodies, input to models of <u>solar system formation</u> and mitigation of impact hazard
Comets and new comets	100 <u>hr</u>	
Planetary transits	200 <u>hr</u>	Monitor of >5 bright stars for primary and secondary eclipses
Young stellar objects	100 <u>hr</u>	
Stars	100 <u>hr</u>	
X-ray binary transients	200 <u>hr</u>	Derive the mass function of >10 <u>XRB</u> transients in outburst
<u>Magnetars</u>	50 <u>hr</u>	Fast follow up of >10 <u>magnetar's flares</u>
Novae	100 <u>hr</u>	
ILOT	300 <u>hr</u>	
<u>SN Ia</u>	500 <u>hr</u>	Statistical sample of >150 <u>SNe Ia</u> in the low- $z$ Universe to study the <u>local properties and dust extinction</u>
CC-SN	500 <u>hr</u>	
Super-luminous supernovae	500 <u>hr</u>	Build a statistical spectroscopic sample of <u>SLSN</u>
Prompt GRB	100 <u>hr</u>	Fast spectroscopy of >50 GRBs to probe the galaxy host medium
High- $z$ ( $z > 5$ ) GRB	50 <u>hr</u>	Transmission spectra of >5 high-redshift GRBs
<u>GRB-SNe</u>	100 <u>hr</u>	Follow the evolution of >5 SN associated to nearby ( $z < 0.3$ ) GRBs
Active galactic nuclei and <u>blazars</u>	200 <u>hr</u>	
Tidal disruption events	100 <u>hr</u>	Study the spectral evolution of >10 TDEs
Gravitational Wave triggers	200 <u>hr</u>	Spectroscopic follow up of candidate GW counterparts. This includes <u>kilonovae</u> from short GRBs.
Neutrino triggers	100 <u>hr</u>	Spectroscopic follow up of candidate neutrino counterparts
Unknown	300 hr	



working...

thank you