SOXS

Son Of X-Shooter at ESO/NTT

Sergio Campana

Osservatorio astronomico di Brera

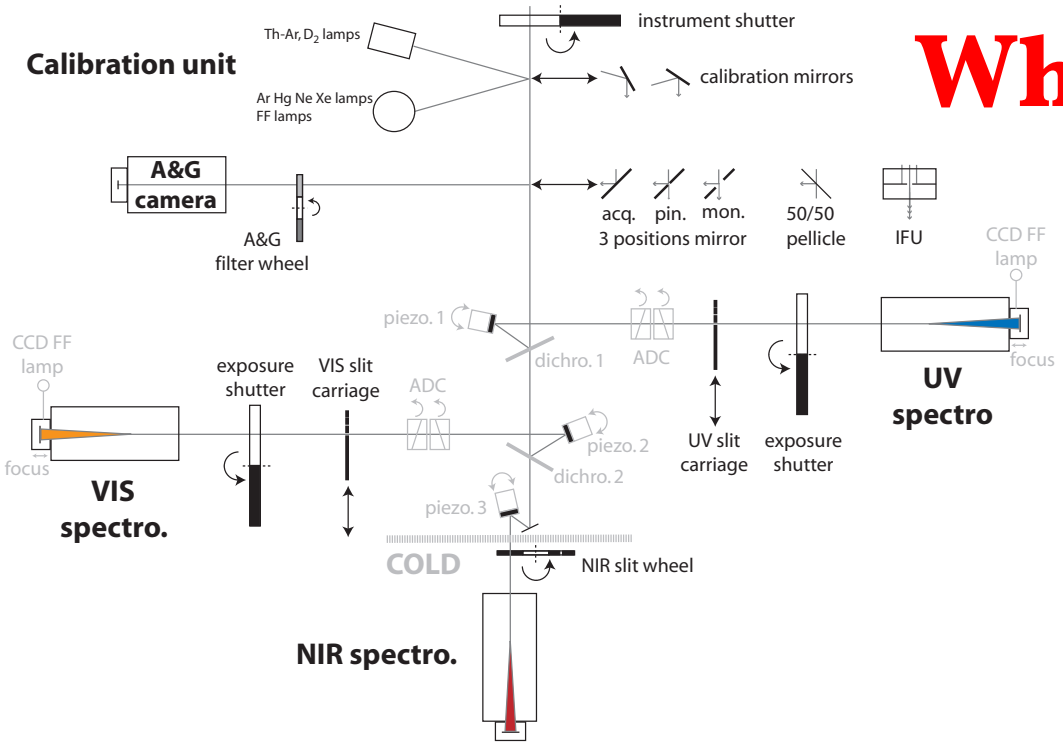
On behalf of a large collaboration

Monteporzio Catone – CNOC IX – 24 settembre 2015

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

What is X-shooter (the father)



UVB			VIS			NIR		
Slit width (″)	Resolution ($\lambda/\delta\lambda$)	Sampling (pix/FWHM)	Slit width (″)	Resolution ($\lambda/\delta\lambda$)	Sampling (pix/FWHM)	Slit width (″)	Resolution ($\lambda/\delta\lambda$)	Sampling (pix/FWHM)
0.5	9100	3.5	0.4	17400	3.0	0.4	11300	2.0
0.8	6300	5.2	0.7	11000	4.8	0.6	8100	2.8
1.0	5100	6.3	0.9	8800	6.0	0.9	5600	4.0
1.3	4000	8.1	1.2	6700	7.9	1.2	4300	5.3
1.6	3300	9.9	1.5	5400	9.7	1.5	3500	6.6
IFU	7900	4.1	IFU	12600	4.2	IFU	8100	2.8

Band	U	B	V	R	I	J	H	K’
mag	21.5	21.7	21.7	21.6	21.2	20.5	20.8	19.3

Continuum spectrum S/N=10 - 1 hr exposure

NOT Transient Explorer – A new work-horse for the Nordic Optical Telescope

A cross-dispersed spectrograph covering 350-1700 nm, resolution ~4000 (possibly with also a higher-res mode), single slit (with different choices for the slit width), including ADC and efficient enough to be sky-limited in 30 min integration.

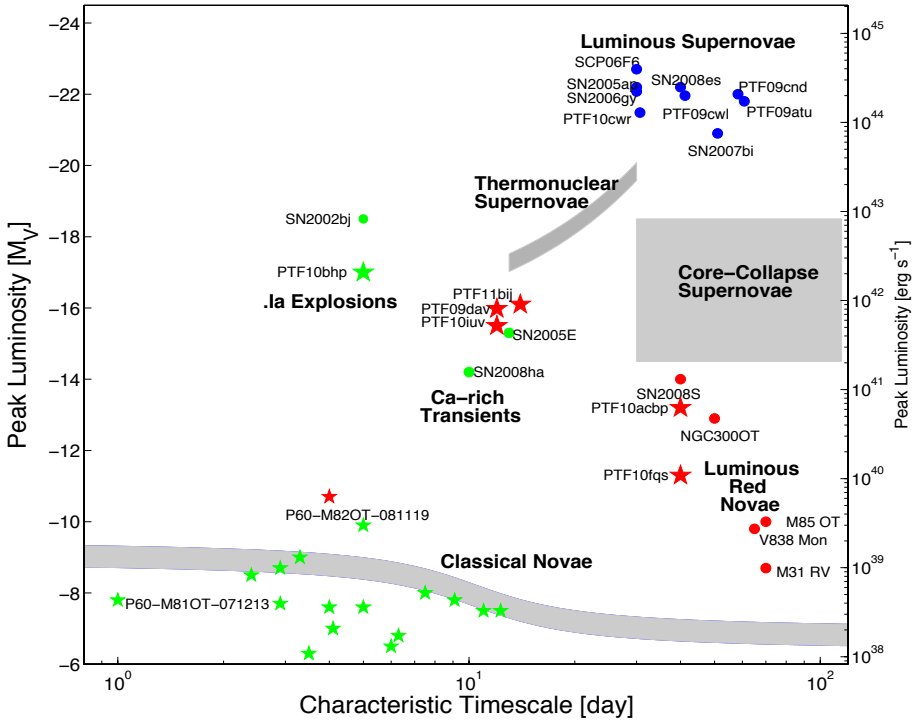
Visible imager with 5-6 arcmin FOV, 2k x 2k detector, sampling 0.15-0.18 arcsec per pixel.

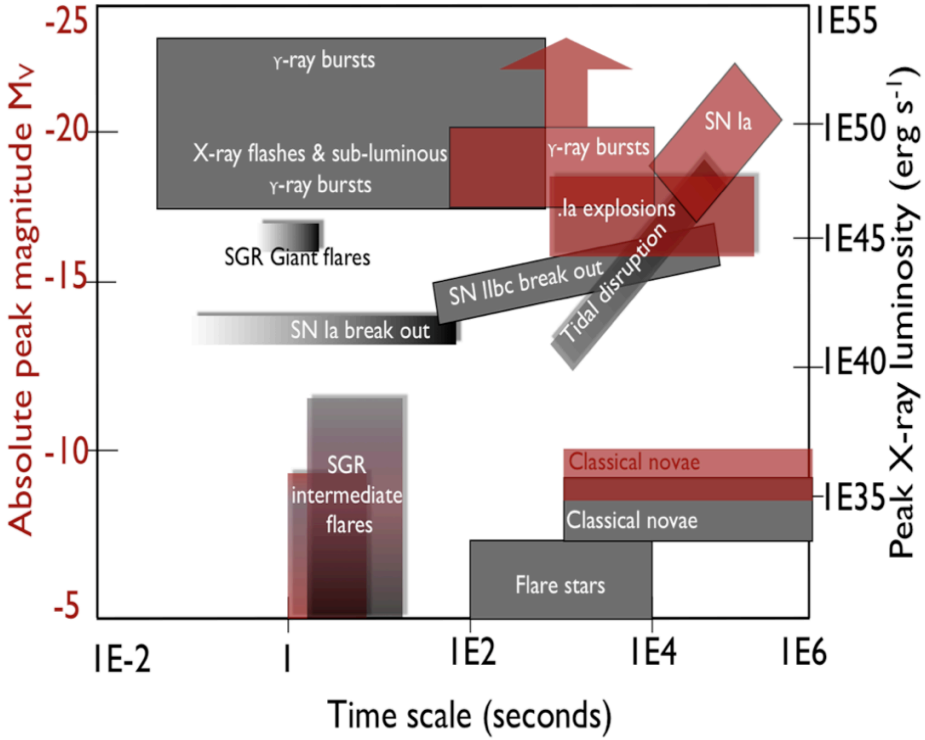
Near-IR imager using a 2k x 2k HAWAII-II detector with same FOV and sampling as in the visible.

De-scoped version: imaging reduced to a visible slit-viewing camera with FOV of 3 arcmin (similar to StanCam).

Nordic (Denmark, Sweden, etc.) + Italian collaboration

SOXS Science case: the transient sky



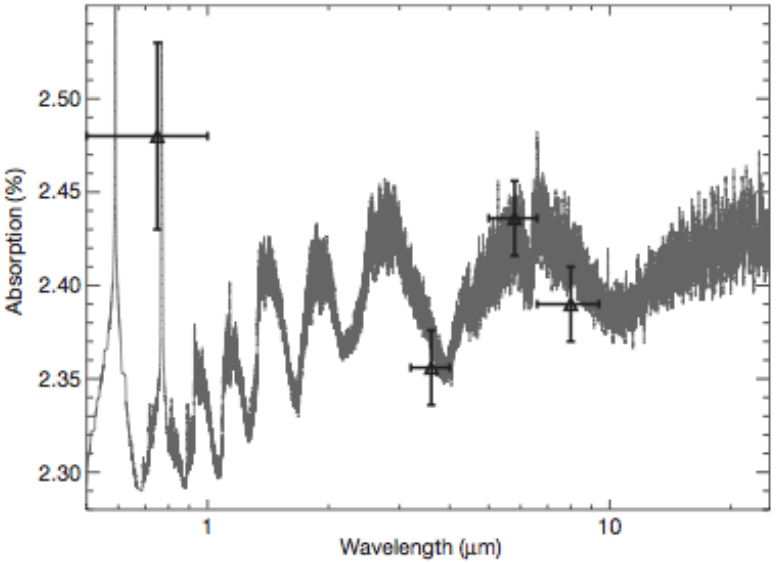


Just a few science cases

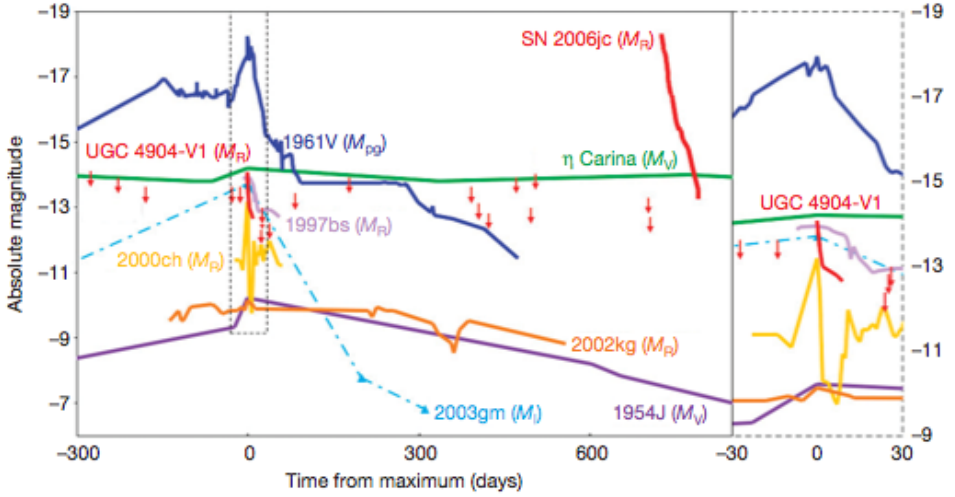
- Minor planets and asteroids
- Young stellar objects
- Planetary transits
- X-ray binary transients
- Novae
- Magnatars
- Supernovae (Ia, CC)
- GRB
- TeV transients
- GW & neutrino EM counterparts
- Radio sky transients & fast radio bursts

Discovery space

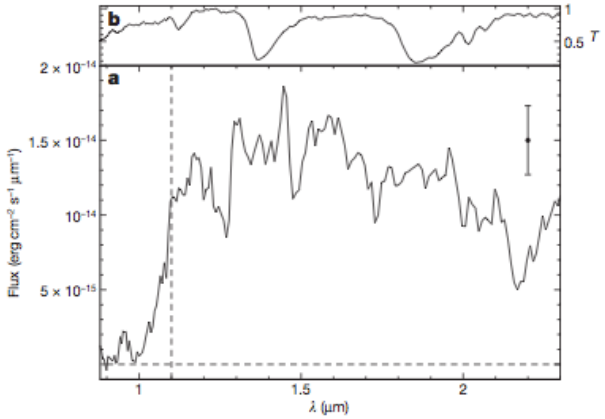
First SN shock break out



Water vapor in the atmosphere of a transiting planet



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 objects.

PESSTO

An already working example

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

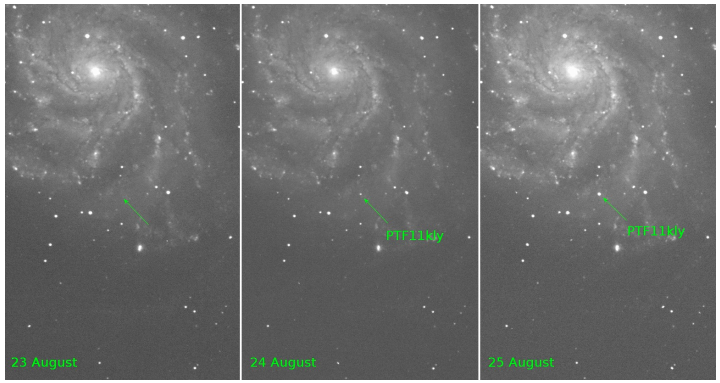
90% remain unclassified

GAIA is coming

GAIA Transient Alerts

	alerting object	5-yrs (Entire Mission)	main location
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
	FU Ori	14	gal. plane
contaminants(?)	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

What is SOXS



Spectroscopic machine for the transient sky.

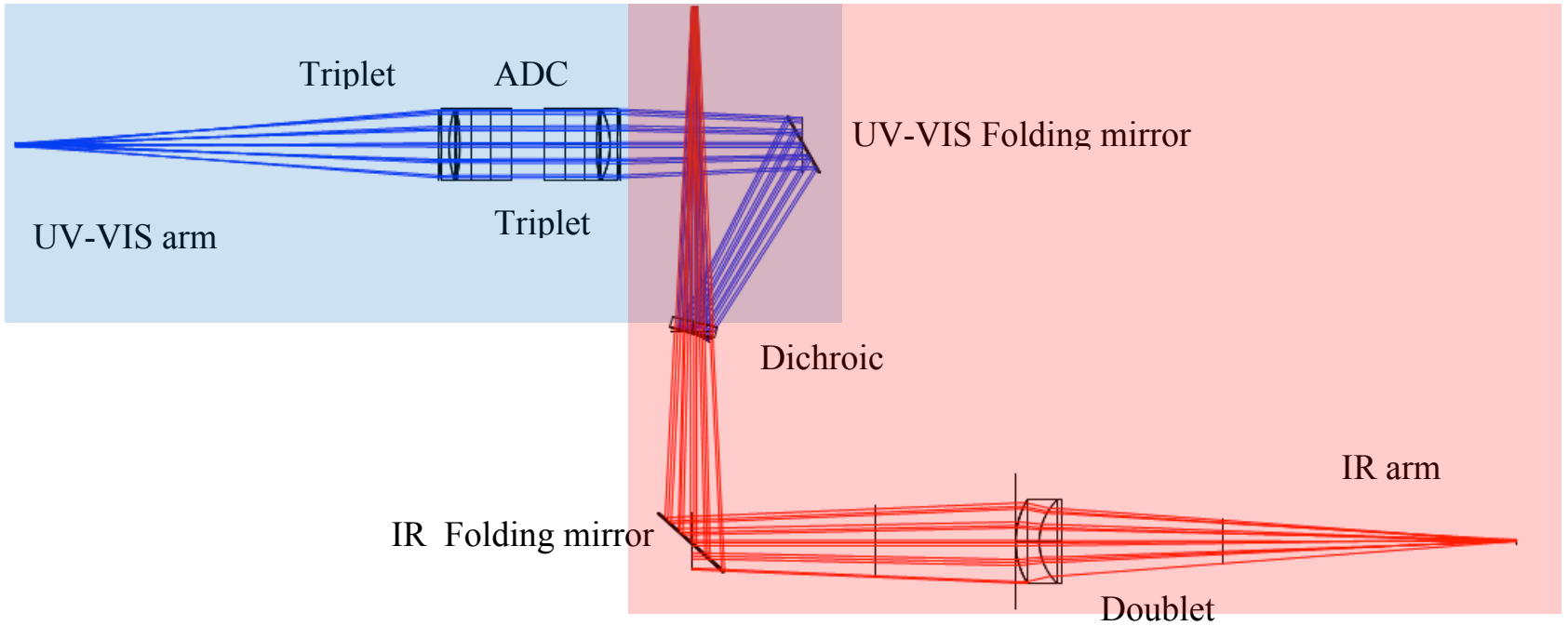
Even now with PESSTO in place >70% of newly discovered transients remain without spectroscopic follow-up.

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-alters GW-alters, TeV alerts, etc. but very limited spectroscopic follow-up

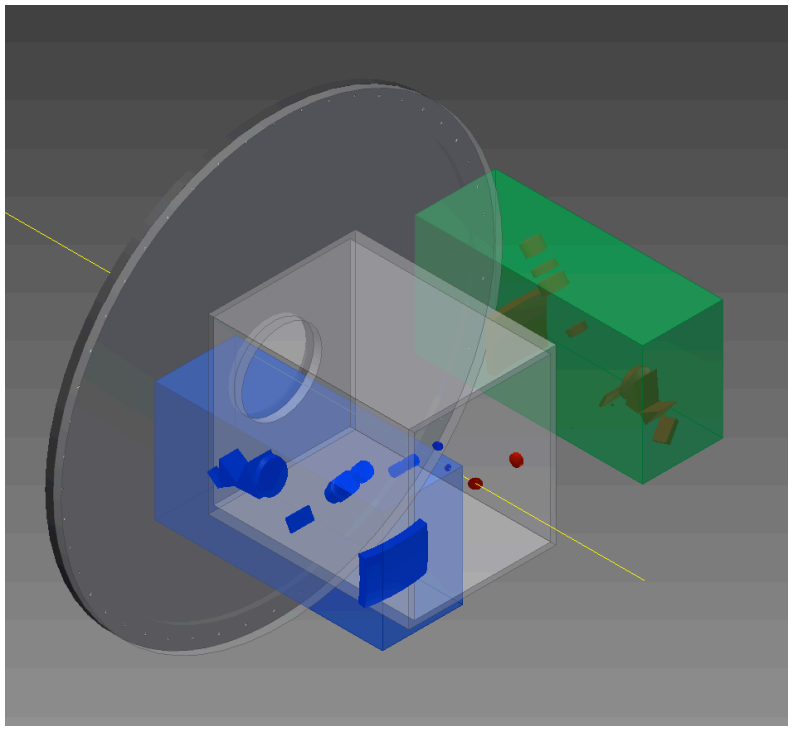
SOXS @ NTT

We propose to build and operate a spectroscopic facility, SOXS (Son of X-Shooter), with a wide spectral coverage (0.35-1.75 μm) and good spectral resolution (R~4,500) able to characterize and follow-up in depth any kind of transient source

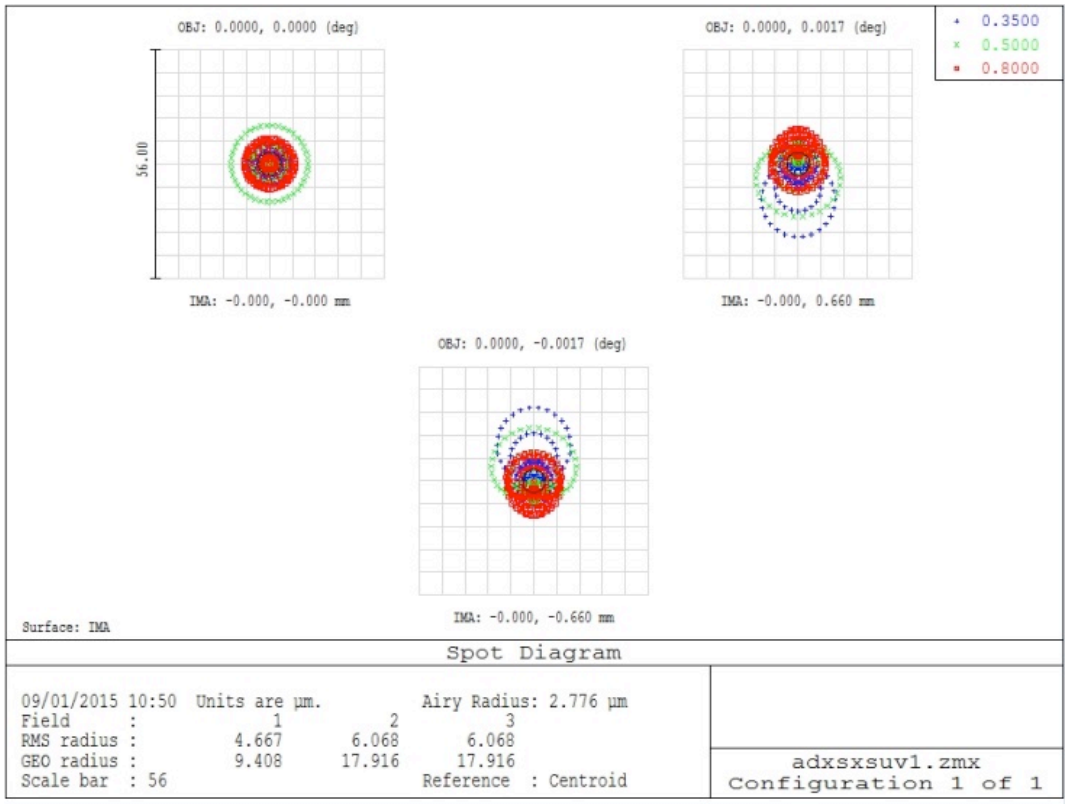
A possible optical layout of the Common Path



SOXS @ NTT



Initial performances

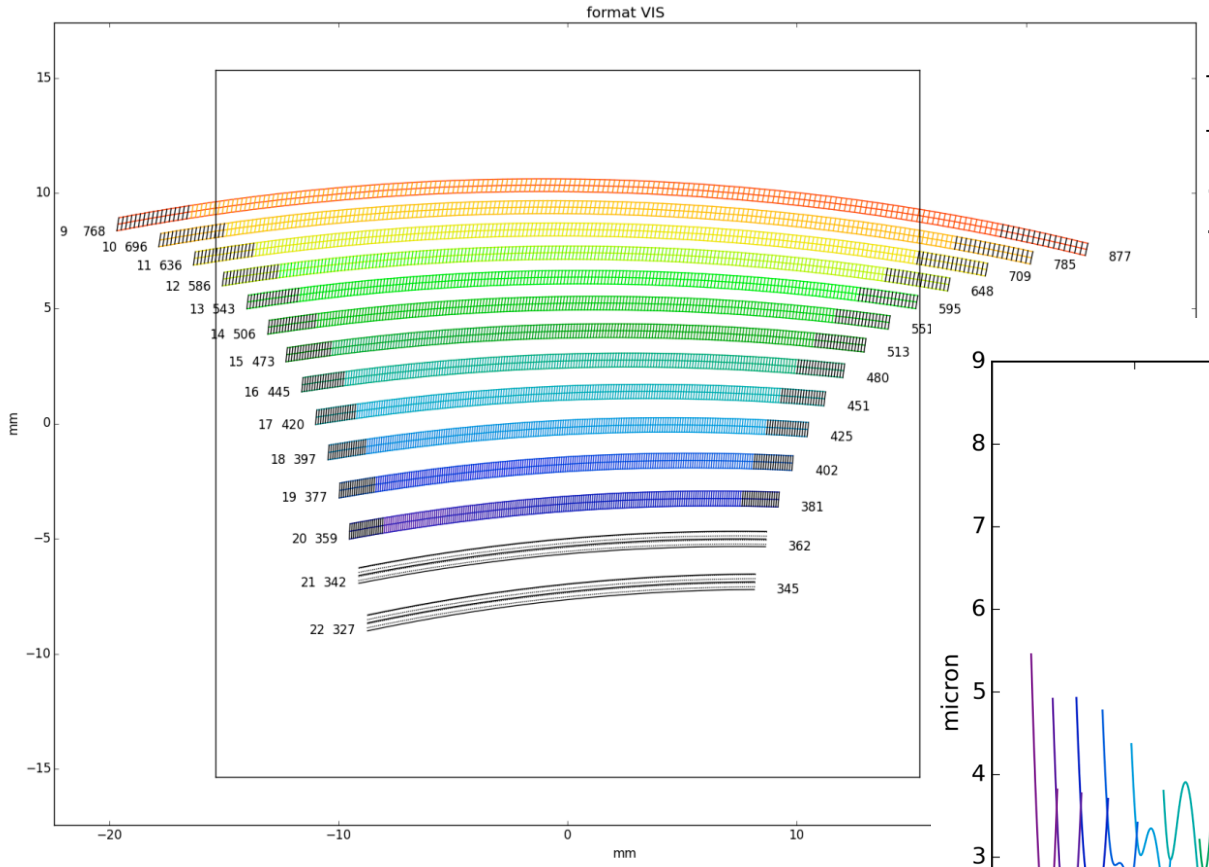


BLUE arm

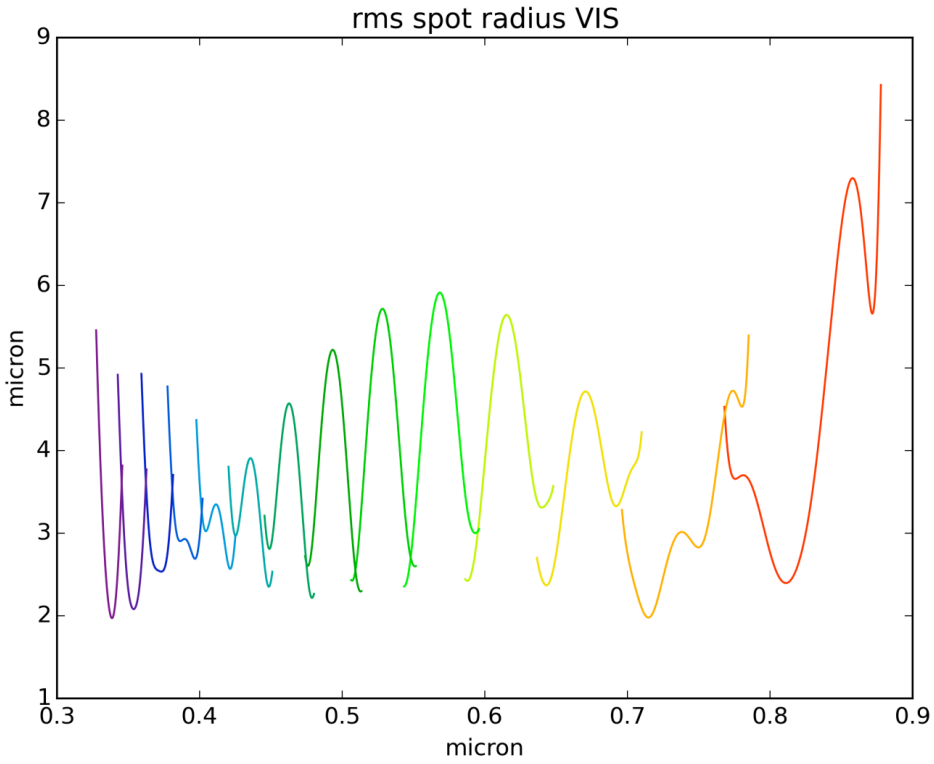
0.5 arcsec box

0 and ±12arcsec positions

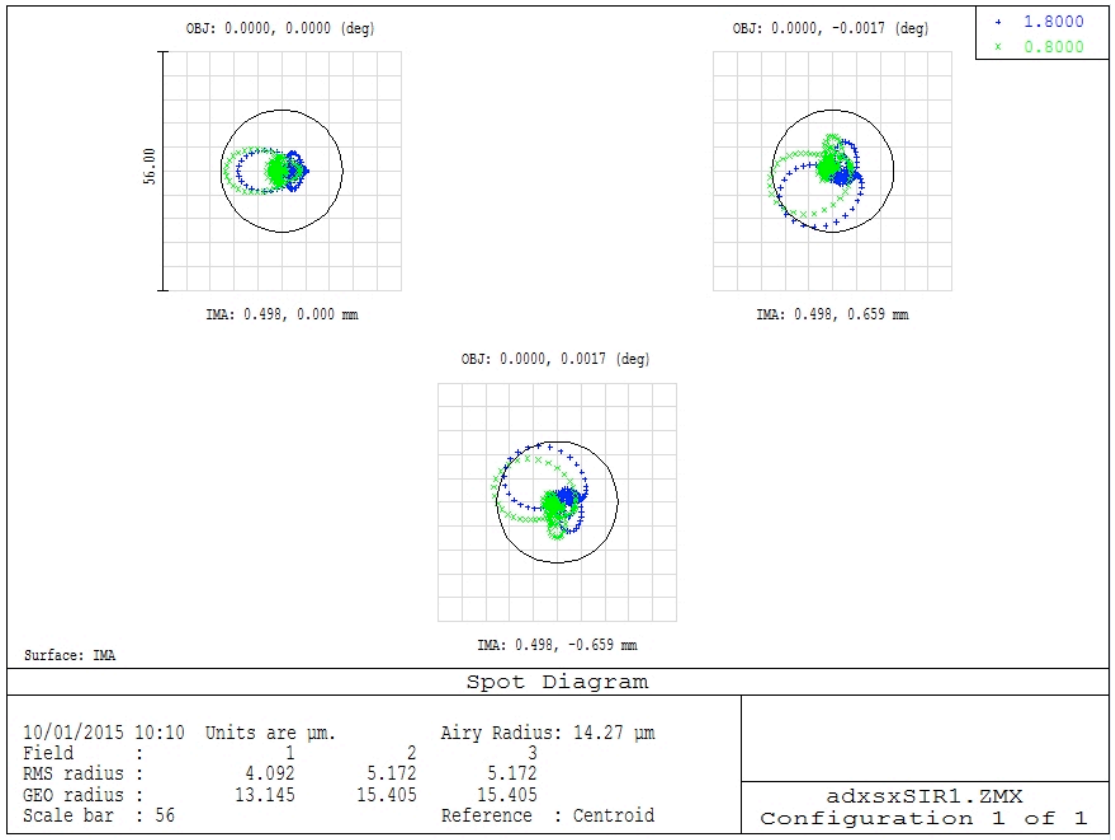
BLUE spectrograph



Pixel size 15 micron
2048x2048



Initial performances

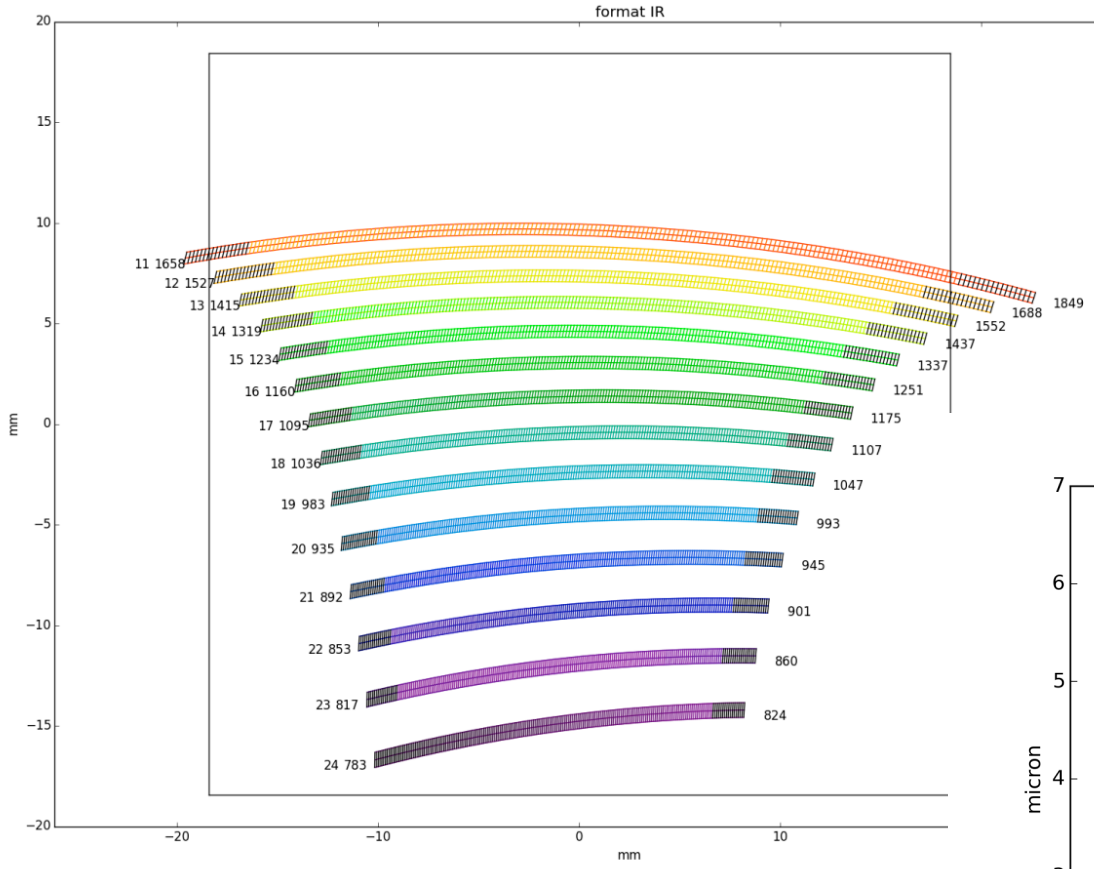


RED arm

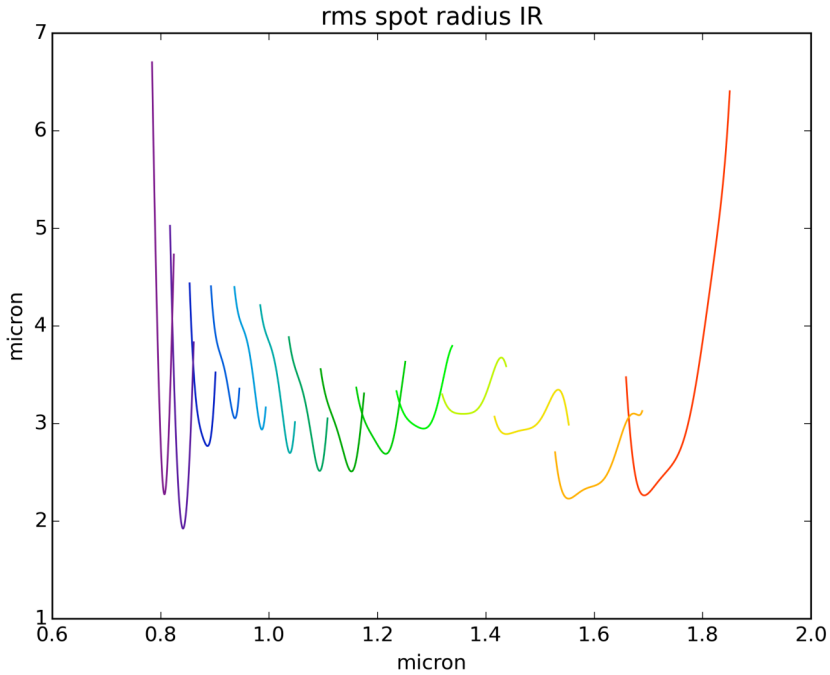
0.5 arcsec box

0 and ±12arcsec positions

RED spectrograph



Pixel size 18 micron
2048x2048



SOXS performances

- Goal:

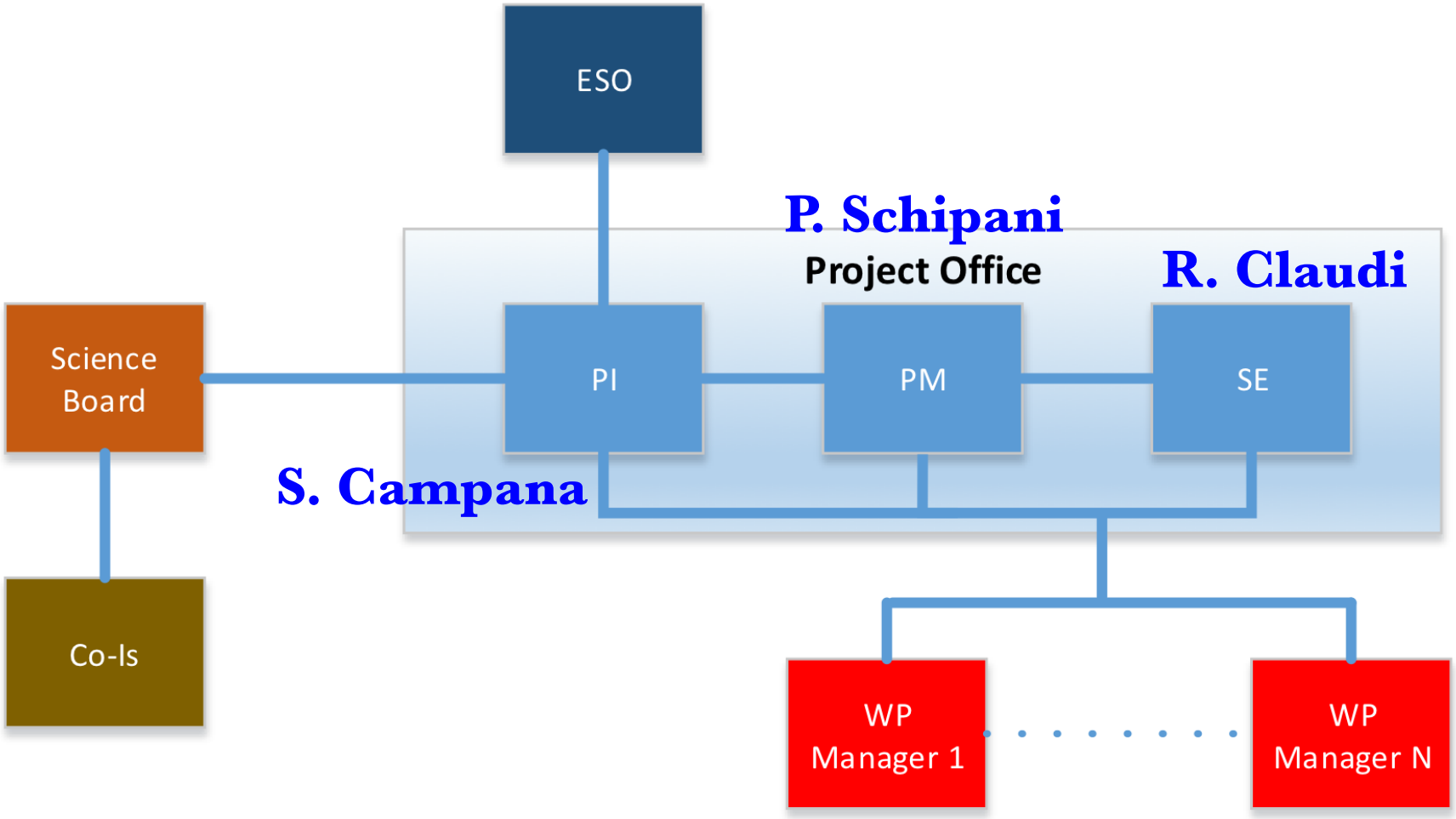
continuum spectrum R~20-20.5 S/N=10 in 1 hr

This nicely match limiting magnitude of current (e.g. iPTF) synoptic surveys

“Extended” guiding camera to use as imaging (optical) instrument >3 arcmin FOV.

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

Consortium structure



Science Board

S. Campana (INAF-OABrera) - Italy
E. Cappellaro (INAF-OAPadova) - Italy
M. Della Valle (INAF-OANapoli) - Italy
A. De Ugarte Postigo (IAA-CSIS) - Spain
J. Fynbo (Dark-NBI) - Denmark
M. Hamuy (Millenium Inst.) - Chile
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S. Smartt (Univ. Belfast) – UK
S. Basa (LAM) – France
L. Le Guillou (LNPHE) – France
B. Schmidt (ANU) – Australia
M. Colless (ANU) – Australia
A. Gal-Yam (Weizmann) – Israel
S. Mattila (FINCA) – Finland

Funds

>84% secure funds (as most of the projects)

Remaining funds have been/are going to be asked for at different national agencies

Timeline 2016-2020

Project phase	Aprrox. start	Approx end	Duration
Phase A	12/2015	04/2016	5 months
Phase B	05/2016	10/2016	5 months
Phase C	11/2016	08/2017	10 months
Phase D	09/2017	12/2019	28 months
Phase E	12/2019	>2023	

Good timing with CTA (and SKA)

Operations

ESO will reward the consortium with NTT observing time.

We will start from ~2018 with existing instruments (EFOSC2+SOFI) and when SOXS will be ready (mid-2019) we will continue with SOXS.

We will likely have ~150 n/yr.

Observers on-site and instantaneous response to fast alerts.

Data policy

<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 (1-3 months TBD) proprietary period.

Thanks