# SON OF X-SHOOTER )SOXS(

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ON BEHALF OF THE SOXS CONSORTIUM

# WHAT IS SOXS

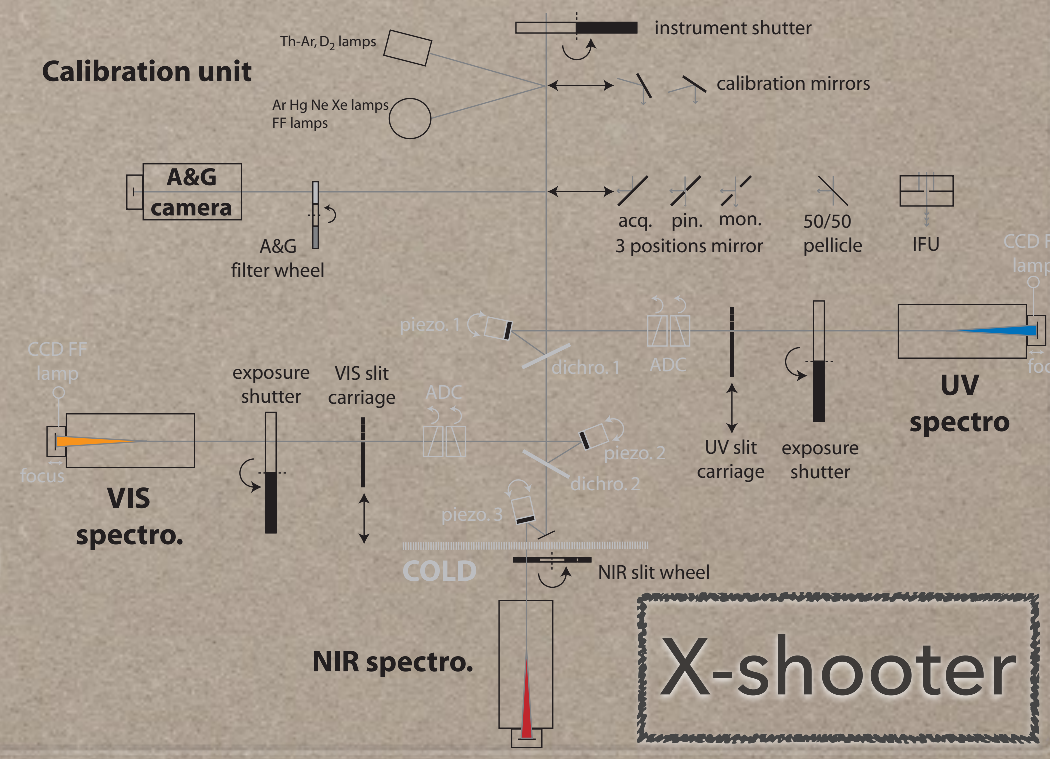
ESO call for new instruments at NTT (06/2014)

Proposal submission (02/2015)

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

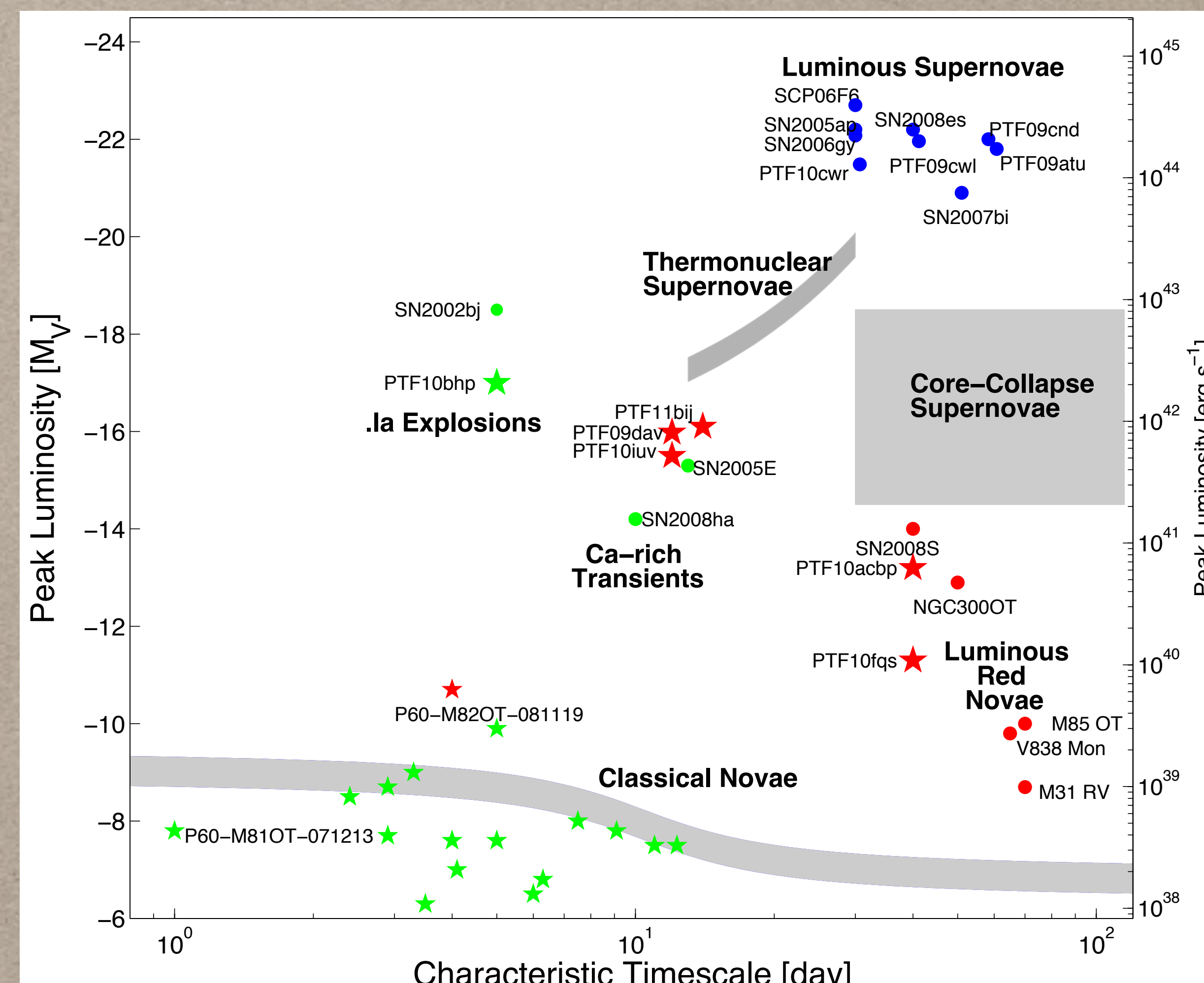
**Single-object spectrograph R~4,500 from U to H (350-17500 nm) @ ESO/NTT**
**1 hr - SNR~10 - R~20-20.5**

Similar to X-shooter
.. but also different, only two arms
with partial overlap around 870 nm
to cross-calibrate spectra



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

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



# WHY SOXS?

Spectroscopic machine for the transient sky.

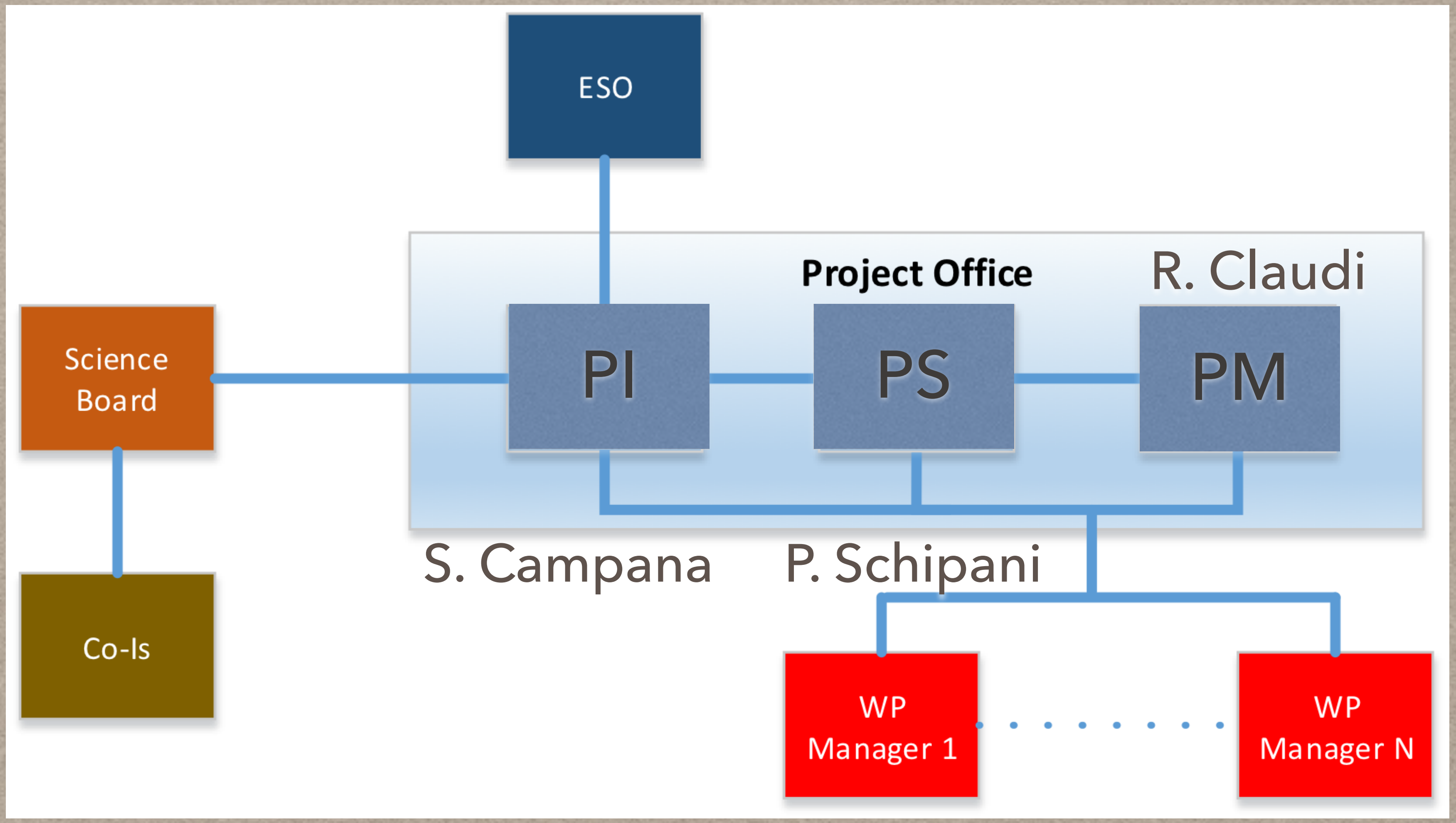
Even now with PESSTO in place >70% of newly discovered transients remain without spectroscopic follow-up.

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

SOXS@NTT will have 150 n/yr  (for 5-6 yr)
~3,000 - 4,000 spectra/yr

# STRUCTURE

Italian lead




Large Italian involvement

13 INAF institutes

11 for science & 7 for hardware

# SOXS SCIENCE BOARD

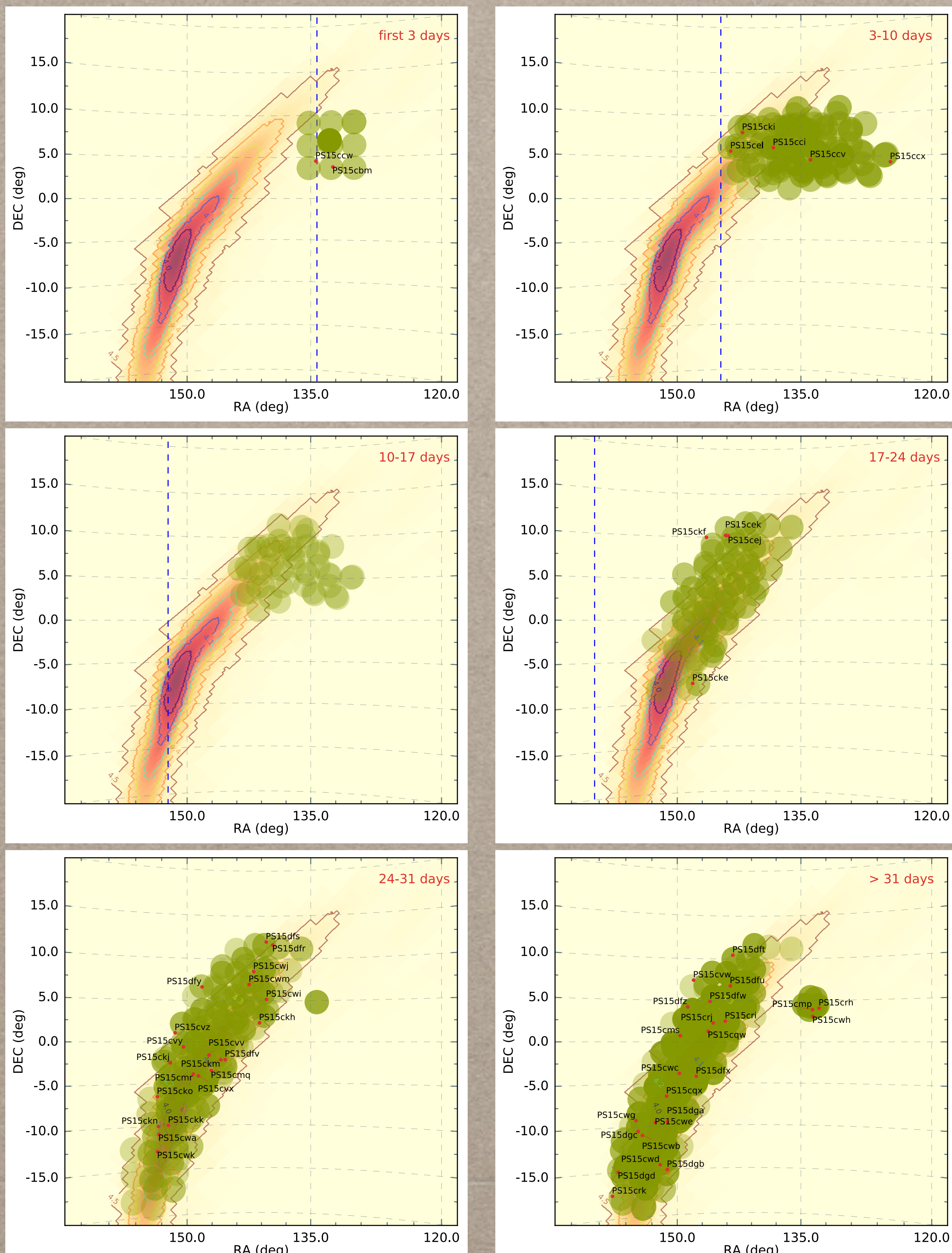
S. Campana (INAF-OABrera) - Italy
E. Cappellaro (INAF-OAPadova) - Italy
M. Della Valle (INAF-OANapoli) - Italy
A. De Ugarte Postigo (IAA-CSIS) - Spain
J. Fynbo (Dark-NBI) - Denmark
M. Hamuy (Millenium Inst.) - Chile
G. Pignata (Millenium Inst.) - Chile
S. Smartt (Univ. Belfast) – UK
S. Basa (LAM) – France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

# (ORIGINAL) TIMELINE

| 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 **GW experiments** (4 detectors) - LSST - CTA - SKA*

# WHAT CAN DO SOXS FOR GW




## PanSTARSS and PESSTO

*Smartt et al. 2016*

442 deg$^2$ -4.2% probability

57 transients

**Table 2.** Transient candidates in the field of GW150914 (56 in total). Discovery dates refer to the date of the first detection by Pan-STARRS. For reference, GW150914 was discovered at 20150914.41 (MJD 57279.41).

| Name | RA (J2000) | Dec (J2000) | RA (J2000) | Dec (J2000) | Discovery Date | Discovery MJD | Disc mag. | Disc. filt. |
|---|---|---|---|---|---|---|---|---|
| PS15cbm | 08 49 19.85 | +03 48 17.8 | 132.33271 | +3.80494 | 20150917.62 | 57282.62 | 18.55 | $i_{P1}$ |
| PS15ccw | 08 57 30.60 | +04 31 56.1 | 134.37750 | +4.53225 | 20150917.63 | 57282.63 | 19.31 | $i_{P1}$ |
| PS15cci | 09 13 22.76 | +06 10 47.3 | 138.34483 | +6.17981 | 20150919.63 | 57284.63 | 18.32 | $i_{P1}$ |
| PS15ccx | 08 18 03.91 | +04 18 04.2 | 124.51629 | +4.30117 | 20150919.63 | 57284.63 | 19.42 | $z_{P1}$ |
| PS15ccv | 08 55 23.05 | +04 41 19.0 | 133.84604 | +4.68861 | 20150922.62 | 57287.62 | 20.03 | $i_{P1}$ |
| PS15cel | 09 34 11.58 | +05 46 45.2 | 143.54825 | +5.77922 | 20150923.63 | 57288.63 | 19.53 | $i_{P1}$ |
| PS15cki | 09 28 27.24 | +08 00 51.5 | 142.11350 | +8.01431 | 20150923.64 | 57288.64 | 19.17 | $z_{P1}$ |
| PS15cej | 09 35 19.41 | +10 11 50.7 | 143.83087 | +10.19742 | 20151002.62 | 57297.62 | 18.13 | $i_{P1}$ |
| PS15cek | 09 36 41.04 | +10 14 16.2 | 144.17100 | +10.23783 | 20151002.63 | 57297.63 | 17.24 | $z_{P1}$ |
| PS15cke | 09 52 35.14 | -07 36 32.0 | 148.14642 | -7.60889 | 20151002.64 | 57297.64 | 16.72 | $z_{P1}$ |
| PS15ckf | 09 45 57.71 | +09 58 31.4 | 146.49046 | +9.97539 | 20151003.65 | 57298.65 | 17.57 | $y_{P1}$ |
| PS15cwj | 09 27 44.89 | +08 31 32.1 | 141.93704 | +8.52558 | 20151013.60 | 57308.60 | 20.02 | $i_{P1}$ |
| PS15cwi | 09 21 31.27 | +05 10 26.8 | 140.38029 | +5.17411 | 20151013.61 | 57308.61 | 20.43 | $i_{P1}$ |
| PS15ckm | 09 43 47.15 | -02 10 13.3 | 145.94646 | -2.17036 | 20151013.61 | 57308.61 | 19.57 | $i_{P1}$ |
| PS15ckj | 10 07 58.59 | -02 29 47.9 | 151.99412 | -2.49664 | 20151013.61 | 57308.61 | 18.31 | $i_{P1}$ |
| PS15cko | 10 14 01.69 | -06 30 46.9 | 153.50704 | -6.51303 | 20151013.62 | 57308.62 | 19.51 | $i_{P1}$ |
| PS15ckh | 09 24 55.83 | +02 19 25.1 | 141.23263 | +2.32364 | 20151013.62 | 57308.62 | 19.40 | $i_{P1}$ |
| PS15cvz | 10 05 41.49 | +01 05 33.2 | 151.42288 | +1.09256 | 20151013.62 | 57308.62 | 19.55 | $i_{P1}$ |
| PS15cvy | 10 01 45.13 | -00 36 06.8 | 150.43804 | -0.60189 | 20151013.63 | 57308.63 | 19.76 | $i_{P1}$ |
| PS15ckn | 10 13 29.31 | -10 00 06.1 | 153.37213 | -10.00169 | 20151014.62 | 57309.62 | 19.44 | $i_{P1}$ |
| PS15ckk | 10 08 48.60 | -09 54 50.7 | 152.20250 | -9.91408 | 20151014.62 | 57309.62 | 16.43 | $i_{P1}$ |
| PS15dfs | 09 21 37.60 | +12 01 38.0 | 140.40667 | +12.02722 | 20151015.60 | 57310.60 | 20.94 | $i_{P1}$ |
| PS15dfr | 09 18 29.04 | +11 40 10.4 | 139.62100 | +11.66956 | 20151015.60 | 57310.60 | 21.31 | $i_{P1}$ |
| PS15cwm | 09 30 01.03 | +06 58 12.6 | 142.50429 | +6.97017 | 20151015.61 | 57310.61 | 20.90 | $i_{P1}$ |
| PS15dfy | 09 52 48.76 | +06 38 04.5 | 148.20317 | +6.63458 | 20151015.61 | 57310.61 | 19.82 | $i_{P1}$ |
| PS15cvv | 09 49 30.25 | -01 36 37.5 | 147.37604 | -1.61042 | 20151015.62 | 57310.62 | 20.14 | $i_{P1}$ |
| PS15cmr | 09 57 03.59 | -03 53 24.3 | 149.26496 | -3.89008 | 20151015.62 | 57310.62 | 19.35 | $i_{P1}$ |
| PS15cmq | 09 48 22.97 | -03 27 41.4 | 147.09571 | -3.46150 | 20151015.62 | 57310.62 | 20.19 | $i_{P1}$ |
| PS15cvx | 09 54 35.48 | -04 07 22.3 | 148.64783 | -4.12286 | 20151015.62 | 57310.62 | 20.32 | $i_{P1}$ |
| PS15dfv | 09 41 38.31 | -02 10 21.8 | 145.40963 | -2.17272 | 20151015.62 | 57310.62 | 20.83 | $i_{P1}$ |
| PS15cwa | 10 13 18.75 | -10 54 43.9 | 153.32812 | -10.91219 | 20151015.63 | 57310.63 | 20.27 | $i_{P1}$ |
| PS15cwk | 10 13 55.42 | -12 52 49.2 | 153.48092 | -12.88033 | 20151015.63 | 57310.63 | 20.11 | $i_{P1}$ |
| PS15cms | 09 58 35.10 | +00 44 34.7 | 149.64625 | +0.74297 | 20151017.62 | 57312.62 | 19.93 | $i_{P1}$ |
| PS15cvw | 09 52 09.25 | +07 26 48.3 | 148.03854 | +7.44675 | 20151018.61 | 57313.61 | 19.86 | $i_{P1}$ |
| PS15cmp | 08 54 24.40 | +03 54 00.5 | 133.60167 | +3.90014 | 20151019.58 | 57314.58 | 21.82 | $r_{P1}$ |
| PS15crh | 08 51 16.19 | +04 03 57.9 | 132.81746 | +4.06608 | 20151019.58 | 57314.58 | 21.39 | $r_{P1}$ |
| PS15cwh | 08 54 15.18 | +03 04 59.0 | 133.56325 | +3.08306 | 20151019.58 | 57314.58 | 22.09 | $r_{P1}$ |
| PS15cri | 09 36 50.66 | +02 31 20.0 | 144.21108 | +2.52222 | 20151021.60 | 57316.60 | 20.67 | $i_{P1}$ |
| PS15cwb | 10 16 21.58 | -11 00 10.5 | 154.08992 | -11.00292 | 20151021.61 | 57316.61 | 20.25 | $i_{P1}$ |
| PS15dgc | 10 18 20.86 | -10 31 28.3 | 154.58692 | -10.52453 | 20151021.61 | 57316.61 | 20.42 | $i_{P1}$ |
| PS15cwe | 10 10 24.74 | -09 33 10.0 | 152.60308 | -9.55278 | 20151021.63 | 57316.63 | 20.47 | $i_{P1}$ |
| PS15crk | 10 30 03.48 | -17 31 38.7 | 157.51450 | -17.52742 | 20151021.63 | 57316.63 | 19.97 | $i_{P1}$ |
| PS15dgb | 10 04 43.54 | -15 00 03.8 | 151.18142 | -15.00106 | 20151021.63 | 57316.63 | 20.71 | $i_{P1}$ |
| PS15dga | 10 04 42.37 | -09 31 14.8 | 151.17654 | -9.52078 | 20151021.63 | 57316.63 | 20.34 | $i_{P1}$ |
| PS15dfx | 09 50 52.07 | -04 09 46.3 | 147.71696 | -4.16286 | 20151023.60 | 57318.60 | 20.80 | $i_{P1}$ |
| PS15cwg | 10 19 19.55 | -09 16 01.2 | 154.83146 | -9.26700 | 20151023.61 | 57318.61 | 20.39 | $i_{P1}$ |
| PS15crj | 09 42 42.16 | +02 18 09.8 | 145.67567 | +2.30272 | 20151023.62 | 57318.62 | 20.88 | $i_{P1}$ |
| PS15dfz | 09 54 59.64 | +04 14 08.1 | 148.74850 | +4.23558 | 20151023.62 | 57318.62 | 20.68 | $i_{P1}$ |
| PS15dfu | 09 34 24.28 | +06 48 01.0 | 143.60117 | +6.80028 | 20151023.62 | 57318.62 | 21.19 | $i_{P1}$ |
| PS15dft | 09 33 09.38 | +10 28 02.2 | 143.28908 | +10.46728 | 20151023.62 | 57318.62 | 19.41 | $i_{P1}$ |
| PS15dfw | 09 44 11.65 | +04 54 52.1 | 146.04854 | +4.91447 | 20151024.60 | 57319.60 | 21.00 | $i_{P1}$ |
| PS15cwc | 09 59 01.22 | -03 48 04.3 | 149.75508 | -3.80119 | 20151024.61 | 57319.61 | 21.11 | $i_{P1}$ |
| PS15cqx | 10 05 03.70 | -06 29 44.7 | 151.26542 | -6.49575 | 20151024.61 | 57319.61 | 20.32 | $i_{P1}$ |
| PS15dgd | 10 27 26.07 | -14 58 20.1 | 156.85862 | -14.97225 | 20151024.61 | 57319.61 | 20.55 | $i_{P1}$ |
| PS15cqw | 09 45 06.43 | +01 17 02.0 | 146.27679 | +1.28389 | 20151025.60 | 57320.60 | 20.99 | $i_{P1}$ |
| PS15cwd | 10 08 06.70 | -14 25 08.5 | 152.02792 | -14.41903 | 20151025.62 | 57320.62 | 20.93 | $i_{P1}$ |

# COMBINED FOLLOW-UP: PHOTOMETRY + SPECTROSCOPY

| Instrument | Band[a] | Depth[b] | Time[c] | Area (deg$^2$) | Contained probability (%) cWB | LIB | BSTR. | LALInf. | GCN |
|---|---|---|---|---|---|---|---|---|---|
| Optical | | | | | | | | | |
| DECam | $i, z$ | $i < 22.5$, $z < 21.5$ | 3.9, 5, 22 | 100 | 38 | 14 | 14 | 11 | 18344, 18350 |
| iPTF | $R$ | $R < 20.4$ | 3.1, 3, 1 | 140 | 3.1 | 2.9 | 0.0 | 0.2 | 18337 |
| KWFC | $i$ | $i < 18.8$ | 3.4, 1, 1 | 24 | 0.0 | 1.2 | 0.0 | 0.1 | 18361 |
| MASTER | C | $< 19.9$ | -1.1, 7, 7 | 590 | 56 | 35 | 55 | 49 | 18333, 18390, 18903, 19021 |
| Pan-STARRS1 | $i$ | $i < 19.2 - 20.8$ | 3.2, 21, 42 | 430 | 28 | 29 | 2.0 | 4.2 | 18335, 18343, 18362, 18394 |
| La Silla–QUEST | $g, r$ | $r < 21$ | 3.8, 5, 0.1 | 80 | 23 | 16 | 6.2 | 5.7 | 18347 |
| SkyMapper | $i, v$ | $i < 19.1$, $v < 17.1$ | 2.4, 2, 3 | 30 | 9.1 | 7.9 | 1.5 | 1.9 | 18349 |
| *Swift* UVOT | $u$ | $u < 19.8$ (gal.) | 2.3, 1, 1 | 3 | 0.7 | 1.0 | 0.1 | 0.1 | 18331 |
| | $u$ | $u < 18.8$ (LMC) | 3.4, 1, 1 | | | | | | 18346 |
| TAROT | C | $R < 18$ | 2.8, 5, 14 | 30 | 15 | 3.5 | 1.6 | 1.9 | 18332, 18348 |
| TOROS | C | $r < 21$ | 2.5, 7, 90 | 0.6 | 0.03 | 0.0 | 0.0 | 0.0 | 18338 |
| VST | $r$ | $r < 22.4$ | 2.9, 6, 50 | 90 | 29 | 10 | 14 | 10 | 18336, 18397 |

SOXS@NTT

150 n/yr for 5-6 yr

~3,000 - 4,000 spectra/yr