New narrow-band filters for SITELLE
Recommendations to prepare observing proposals

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Three new filters (SN4, SN5, SN6) are offered for regular proposals for SITELLE since 24B. Their transmission curves can be found here and the scientific and technical justification for the SN4 filter is also available here. The analysis of the commissioning data taken in 24A (during February and March runs) for the new filters has made good progress, especially for the SN4 filter. The ETC still does not include those filters, however we provide here the main recommendations and tips to prepare observing proposals.

It appears that the SN4 filter actually has a bandwidth of 13 nm, three times narrower than the SN3 filter one, and that the SN5 filter actually has a bandwidth of 9 nm, four times narrower than the SN2 filter one. The SN6 filter mostly overlaps the wavelength range of the C3 filter (but also of the SN2 filter) and has a bandwidth of 24 nm roughly twice as narrow as the C3 filter.

We were able to check that the gains of observing with the SN4 filter rather than with the SN3 filter are as expected from theory when the observations remains in the background-noise limited regime. For relatively faint targets (emission line surface brightness SB $\leq$ SB$_0$ = 10^{-15} erg s^{-1} cm^{-2} arcsec^{-2}), we have shown that this regime is reached with the SN4 filter as long the individual exposures are of at least 16s per step under dark conditions. We recommend using at least 16s per step and ideally 40s per step (and up to ~90s to avoid other problems such as tracking issues). These recommendations can be reduced in case observations have to be carried out under grey and bright time, up to a factor 2. The choice of the exposure time has to be chosen as a compromise between the needed signal-to-noise ratio (S/N) and spectral resolution (R) as a large spectral resolution requires more steps (N$_{\rm steps}$), so a larger total exposure time for a given exposure time per step. With the SN4 filter, for sources with emission lines brighter than SB > SB$_0$, the noise is no longer limited by the sky background and is dominated by the source itself. Within this regime, the minimum exposure time per step can be reduced by a factor SB/SB$_0$. We recommend not using exposures lower than 3-4s to avoid a too large fraction of overheads. Nonetheless, within this regime, the main interest of the new filter is to reduce significantly the overheads to reach an elevated spectral resolution (above R = 5000). Similar recommendations should be adapted for the SN5 filter, whereas exposure times per step twice shorter should be good for the SN6 filter with a surface brightness limit SB$_0$ = 2×10^{-15} erg s^{-1} cm^{-2} arcsec^{-2}.

The commissioning observations clearly demonstrated that the instrument modulation efficiency decreases at the edge for large optical path differences, limiting the spectral resolution achievable by SITELLE with the SN4 filter to less than R = 12500. However, in the central region, a spectral resolution larger than R = 15000 (and up to about R ~ 20000) remains reachable (see resolution map, Figure 1) on about half the area covered by SITELLE field-of-view. Due to the large number of steps needed to reach a very high spectral resolution and the limited spatial coverage for such a resolution, it is not recommended to request a spectral resolution larger than about R ~ 12500.

In summary, the new narrow-band filters must be preferred to larger-band filters in the following cases:

1. Faint object not within the reach of the larger band filters in reasonable exposure times (typically lines with SB < 10^{-16} erg s^{-1} cm^{-2} arcsec^{-2} without any binning). Compared to the SN3 filter, observations with the SN4 filter reach the same depth for total on-source exposure three times lower, or need the same total on-source exposure time to reach a S/N 1.7 times larger.

2. Only a few lines are needed for the scientific analysis (e.g. only Hα and [N II]$\lambda\lambda$6548,6583 for SN4, or only [O III]λ5007 for SN5).

3. A high spectral resolution (typicall R > 5000) is needed for e.g. kinematics purposes for relatively bright sources.

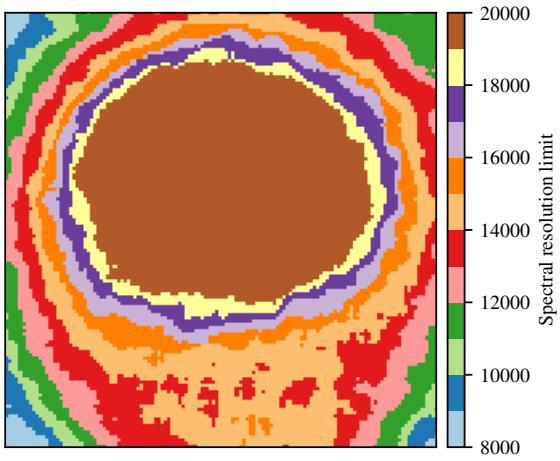

Figure 1: Map of the limiting spectral resolution over the field-of-view of SITELLE. It corresponds to $R_{lim} = \lambda/FWHM_\lambda = c/FWHM_v$, where c is the speed of light and FWHM is the line full width at half maximum expressed either in wavelength of velocity, estimated from unresolved night sky emission lines in observations with the SN4 filter at a spectral resolution R = 15000.

The number of steps scales linearly with the spectral resolution ($N_{steps} = dN_{steps}/dR \times R$). We have $N_{steps,SN4} = 0.094 \times R$ for the SN4 filter (half required with the SN3 filter), $N_{steps,SN5} = 0.108 \times R$ for the SN5 filter (half required with the SN2 filter) and $N_{steps,SN6} = 0.173 \times R$ for the SN6 filter.

In order to prepare observing proposals, the S/N or the total exposure time can be scaled as follows. For the SN4 filter, the ETC with the SN3 filter should be used, and the following scaling should be applied:

- the S/N for a given total on-source by a factor $\sqrt{3} = 1.7$,
- or, the total exposure for a given S/N by a factor 1/3.

For the SN5 filter, the ETC with the SN2 filter should be used, and the following scaling should be applied:

- the S/N for a given total on-source by a factor $\sqrt{4} = 2$,
- or, the total exposure for a given S/N by a factor 1/4.

For the SN6 filter, the ETC with the C3 filter should be used, and the following scaling should be applied:

- the S/N for a given total on-source by a factor $\sqrt{2} = 1.4$,
- or, the total exposure for a given S/N by a factor 1/2.

Note that when a line starts to get resolved, the S/N do no longer improve when increasing the total exposure time (with a constant exposure time per step, i.e. increasing the spectral resolution), but this is also true with the other filters. The time needed per steps can be inferred by dividing the total on-source exposure by the number of steps. The overheads are then estimated by counting 4.1s per step.

We recall that the SN5 and SN6 filters are the property of Zhenya Zheng. Teams interested in using these filters contact him (`zhengzy@shao.ac.cn`) to initiate a discussion before writing a proposal to avoid duplication of science goals. The SITELLE instrument scientist (`epinat@cfht.hawaii.edu`) should be contacted for any help and more advices regarding proposal preparation with these filters.