Choosing a Setup for TS23

TS23 is the most commonly used coudé setup on the 2.7m telescope (also sometimes called by its original name, 2dcoude). The TS23 name translates as follows:

There are two spectrographs at coude, designated TS1 and TS2. TS2 means Tull Spectrograph 2 (Tull, MacQueen, Sneden and Lambert PASP 107, 251, 1995). TS2 is on the left side seen looking from the M5 mirror turret toward the spectrographs, and TS1 is on the right side. TS2 has two foci – F1 and F3. TS23 indicates the lower resolving power F3 focus, with R=60,000 when using a CCD with 24 micron pixels such as TK3.

For TS23 using grating E2 and detector TK3 (pixel size = 24 micron), the pixel scale at the detector is 0.56 arcsec/pixel. Thus, to properly Nyquist sample the spectrum (with no binning in the spectral direction) you should use a slit that is at least 1.12 arcsec wide. Anything narrower and you are undersampled. For TS2, the slit width and height are chosen by putting in one of the slit plugs that are available. The following are available:

	Slit Length (mm)	Width (μm)			L x W (arcsec)
		(Center)	(-End)	(+End)	
1	3.51	86	90	89	8.2 x 0.20
2	3.471	145	136	139	0.34
3	3.460	251	253	248	0.59
4	3.478	511	513	507	1.20
5	3.484	765	767	761	1.79
6	3.475	1,010	1,010	1,020	2.37
7	5.567	134	136	137	13.0 x 0.31
8	5.563	255	255	257	0.60
9	5.569	509	516	513	1.19
10	5.575	758	753	756	1.78
11	5.576	1,023	1,021	1,020	2.40
20	6.500	324	320	332	15.2 x 0.76
21	6.500	515	513	519	1.21
22	6.500	907	889	911	2.13
14	12.856	83	84	81	30 x 0.20
23	12.742	135	130	127	0.32
15	12.866	508	509	510	1.19
16	12.867	758	751	756	1.78
17	12.875	1,020	1,021	1,016	2.39
13	0.300	300			0.70 Dia.

Inspecting this table, you will see that slit 4 is of an appropriate width to sample the spectrum for an unbinned chip (it also is the proper height to separate the orders so you do not need a filter for that purpose). If you were to bin the chip in the dispersion direction by a factor of 2, then the width of a

pixel would be 48 microns or 1.12 arcsec. Now, slit 4 is no longer wide enough to properly Nyquist sample the spectrum. You would need to go to slit 6 to be Nyquist sampled.

Many times, people open the slit in order to let in more light. In the absence of binning, the slit will subtend more of the sky and therefore more light can hit the detector *in theory.* The problem with this approach is that it depends on poor seeing. If the seeing is decent (better than the slit width) then the resolution of the spectrum is actually set by the image size. Thus, if you use a 2.37 arcsec slit and the seeing is 1.2 arcsec, you are not really setting the resolution with the slit. What is more, the wavelength zeropoint of the spectrum is set by where the image of the star is within the slit. As the star moves within the slit, the zeropoint shifts, making for an unstable wavelength scale (both zeropoint and resolution).

You can also bin in the spatial direction. This is not as egregious as binning in the spectral direction. However, unless you are really starved for photons (cannot get over the read noise in your integration) this really does not help you much over binning after the fact. Indeed, with larger spatial pixels from binning, it is more difficult to accurately trace the orders as they diagonalize the chip, and it is more difficult to reject cosmic rays.

Bottom line: We recommend slit plug 4 for TS23 with binning 1x1. If you want to use a wider slit for sensitivity, slit 5 with 1x1 or 1x2 binning will work. But see the caveats above before you do this. If you can overcome the read noise in your normal integration, we recommend binning after the fact. If you do use slit 5 with 1x1 binning, noise can be reduced with an optimal filter as described in Brault and White, A&A 13, 169, 1971.