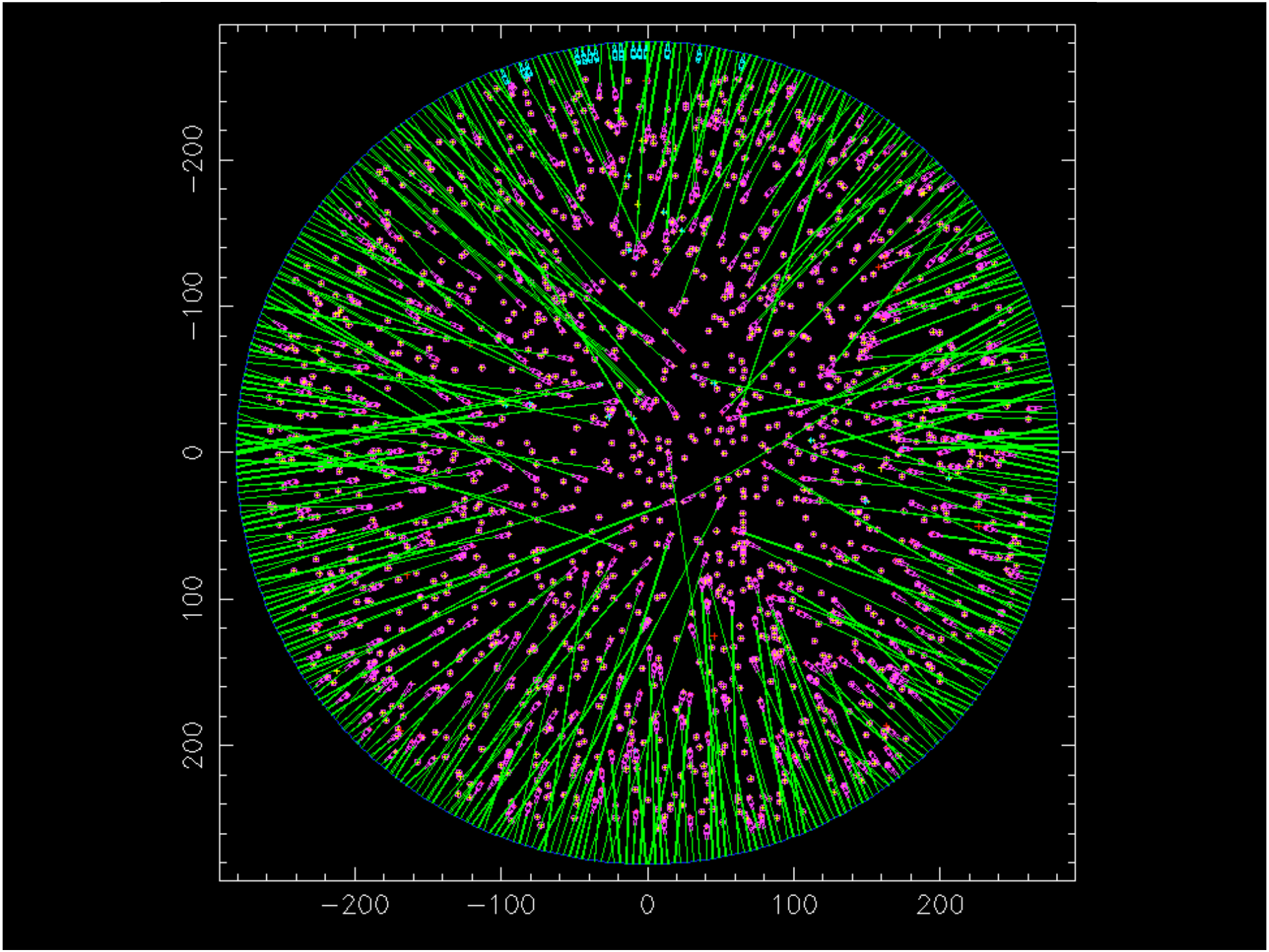
A Flexible High Performance Spectrograph for WHT MOS

Gavin Dalton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Background

- Build on experience from 2dF, FMOS, WFMOS, EVE
- OPTIMOS-EVE: E-ELT Phase A instrument design, Final review is next week.
  - 10’ FOV @ E-ELT, with multiple input fibre configurations to give combinations of multiplex and spectral resolution in the seeing/GLAO limit of the telescope.
- E-ELT is 3.25mm/”, WHT PF is 60μm”
- EVE-HR mode resamples to 67μm fibres to achieve R=30000
- How would the EVE spectrograph suit the WHT?

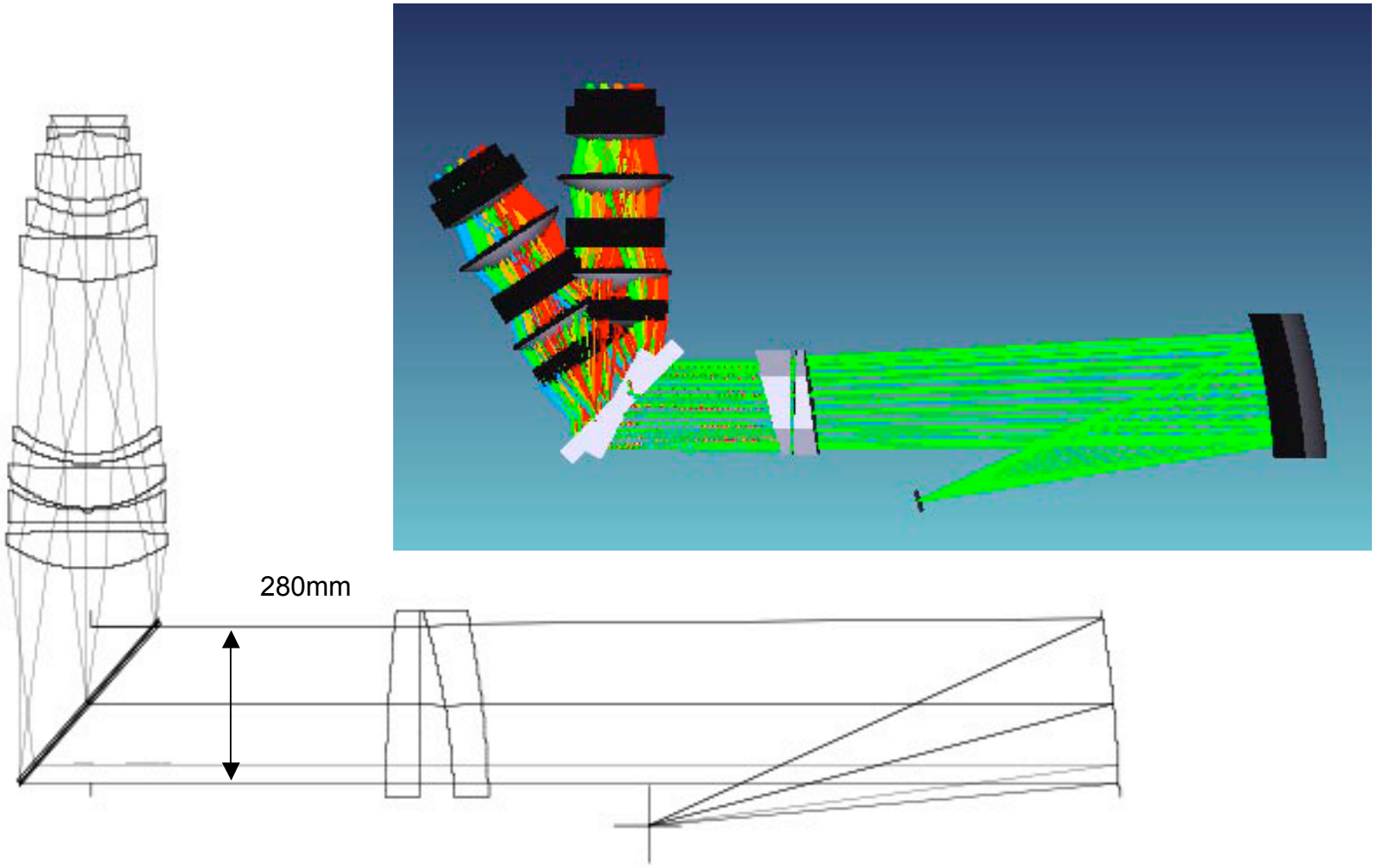
Spectrograph Design

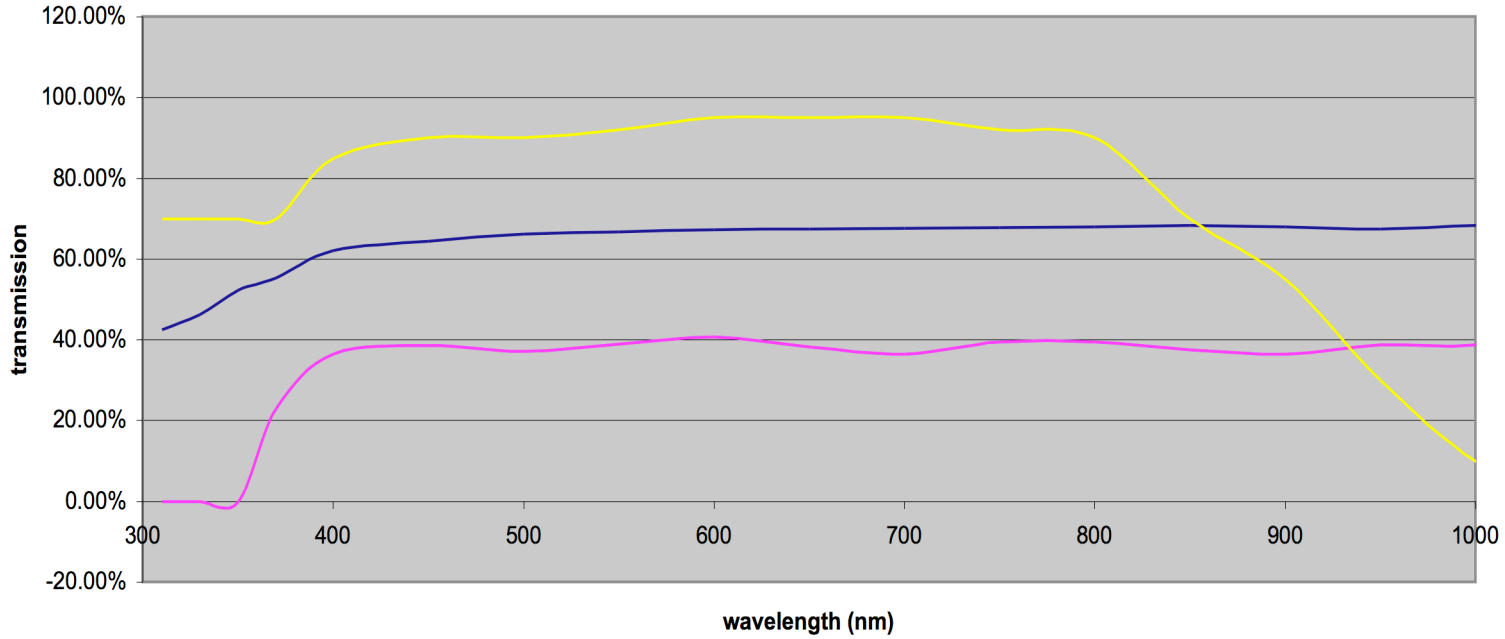
- 330mm slit length
- F/3.5 input, 280mm beam diameter.
- F/1.9 camera
- 12kx12k CCD mosaic (4 chips)
- Use 67 micron cores (~1.2” at WHT prime), 2.3 pixels/fibre core (example only).
- 7 fibre subslit is 0.67mm (7 fibres plus cladding plus 1 calibration fibre, allows for seeing and S-P)
- 420 science targets can be accomodated, allowing for some inter-object gaps
- 1st order VPH gratings -> $\lambda/6$ simultaneous coverage at R=25000 (3 gratings).

Lower resolution mode

- Same spectrograph, 600l/mm grating at 10 degree incidence angle gives R=5000 with 600nm simultaneous coverage.
- Peak throughput ~30%.
- Might need to add a fold for accomodation purposes.

Spectrograph design

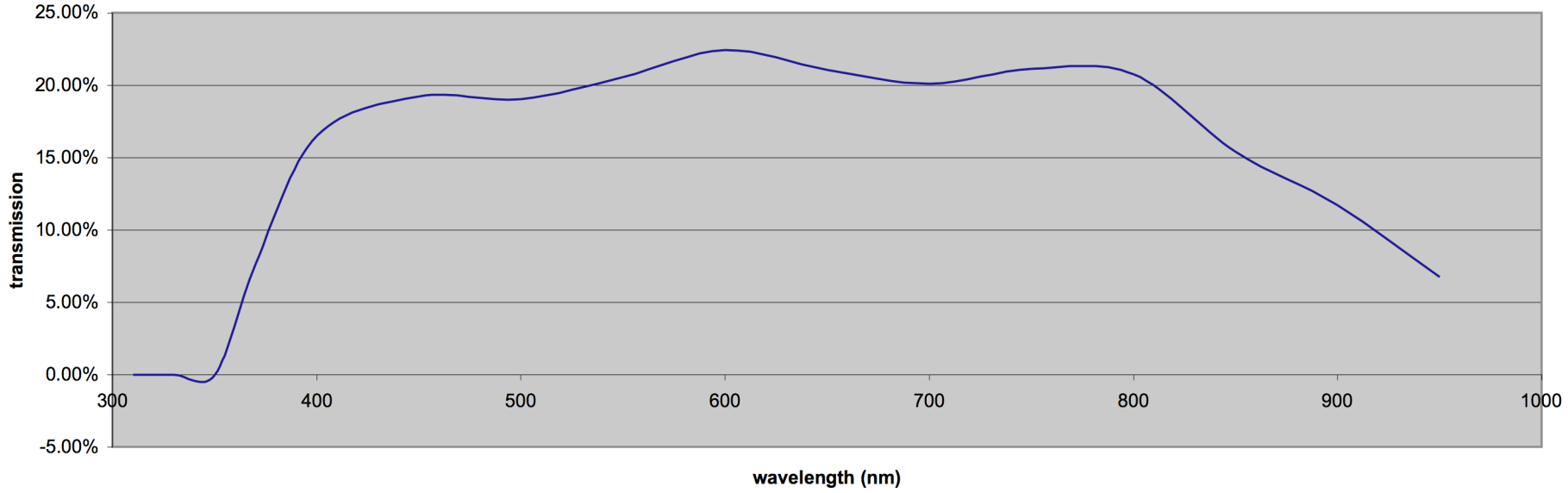


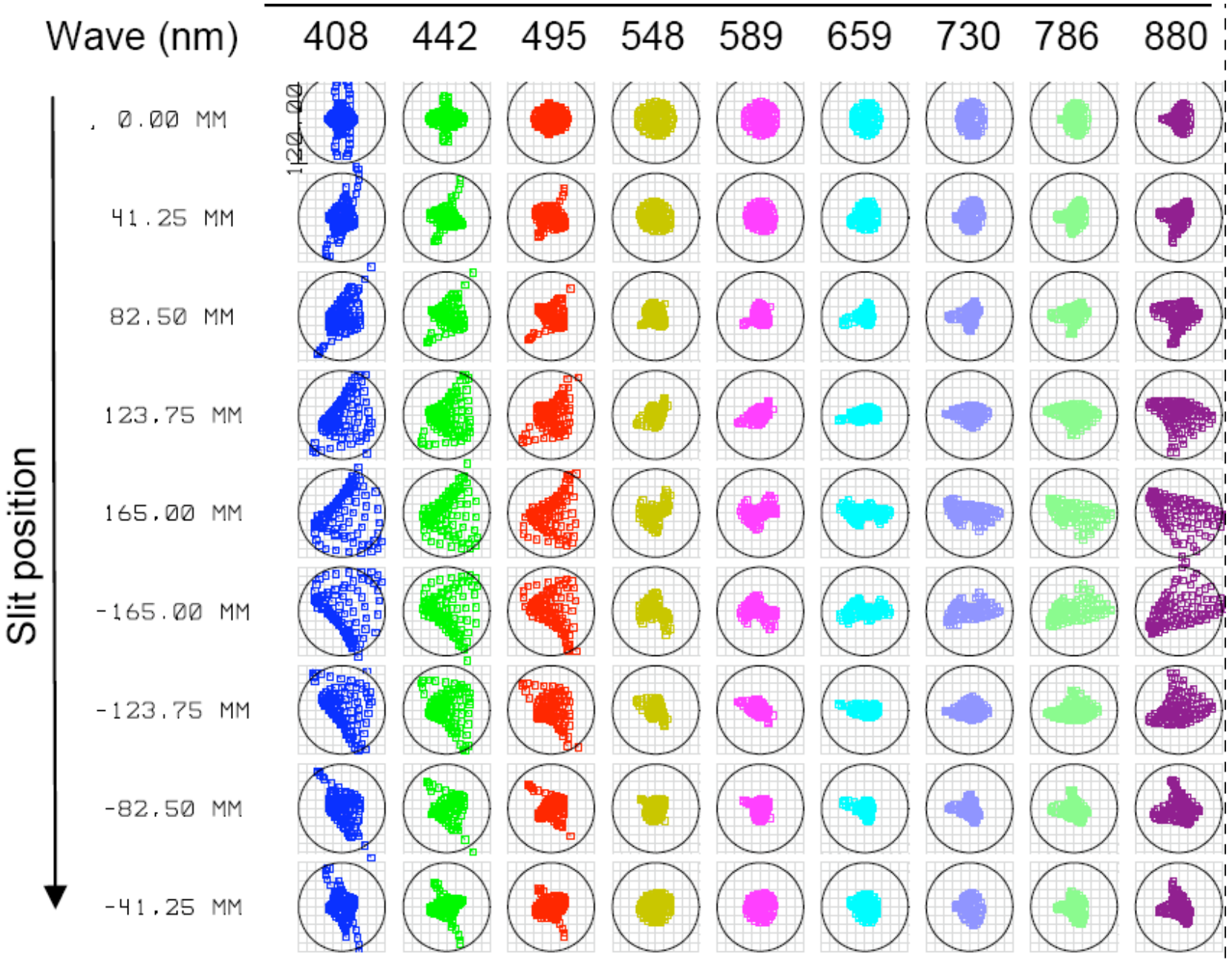


c.f.
FLAMES/
UVES ~ 4%

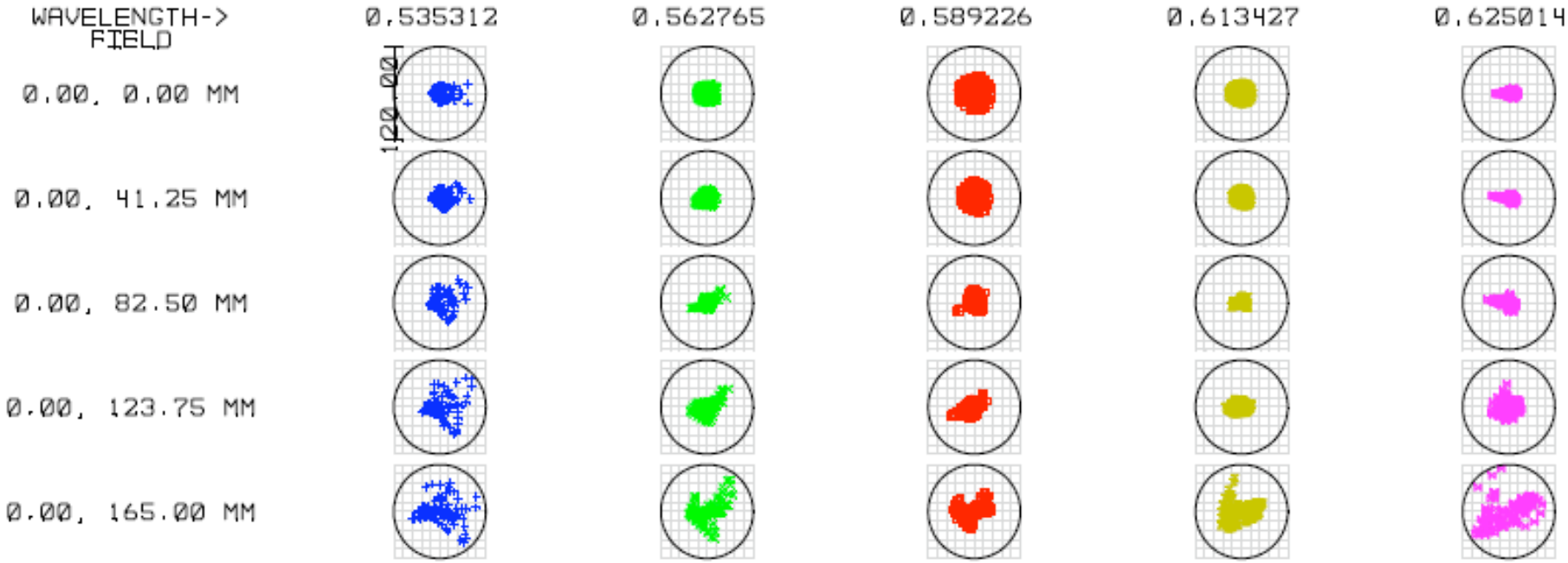
HERMES
~6%

overall transmission of WHT-EVE HR modes, including telescope

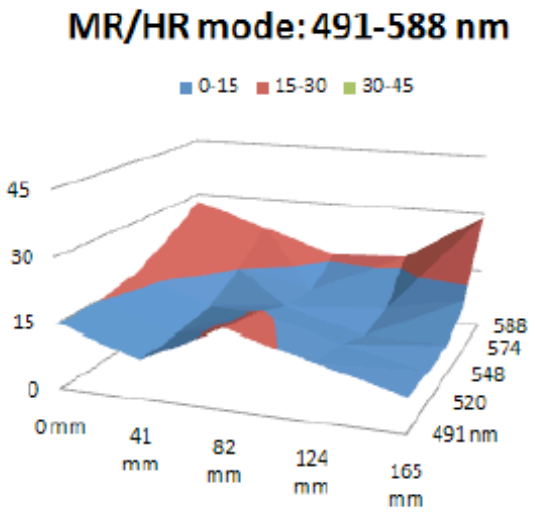


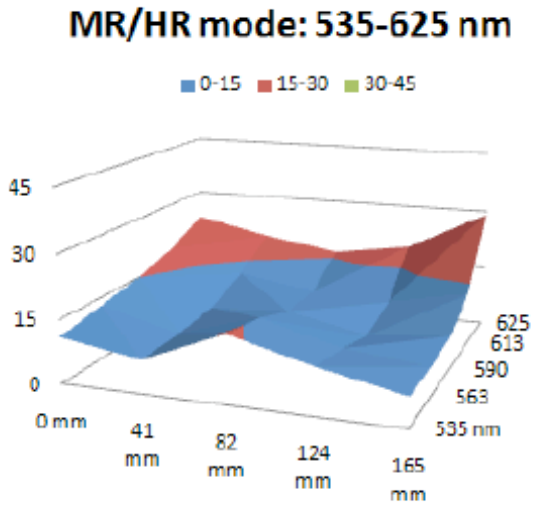


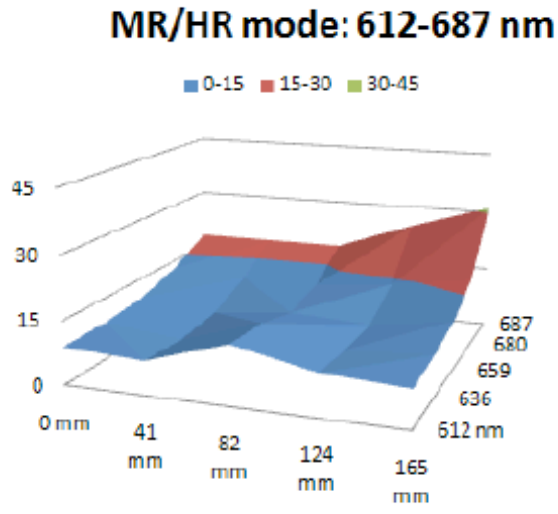
Circle corresponds to a 223μm core



Detector focus/tilt optimised over a particular setting



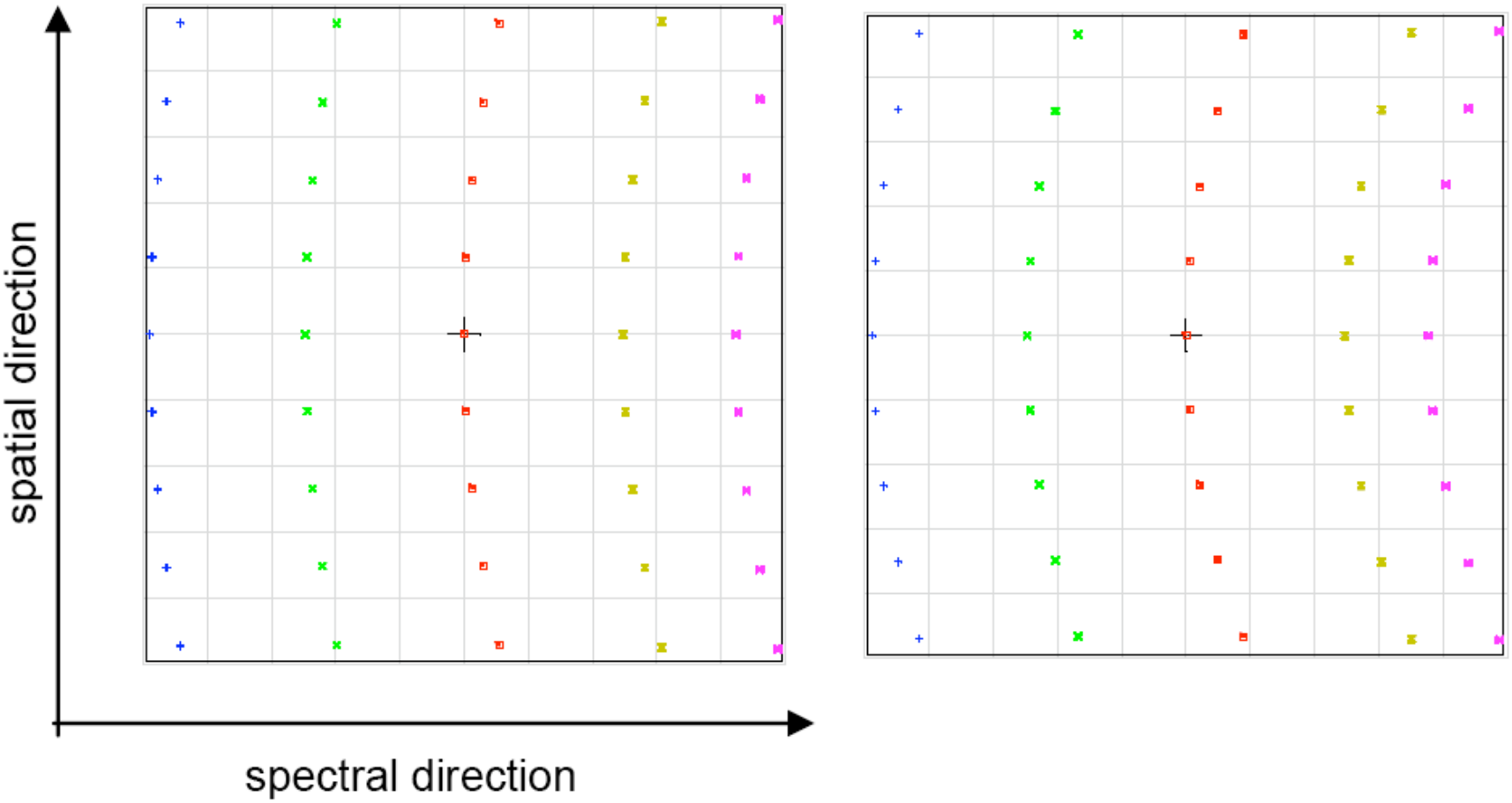




Spot radius in microns vs field position.

Observing mode	Grating	Blaze wavel. (nm)	Simultaneous Coverage (nm)	Angle of incidence (deg)	Resolution
MR/HR	GR-1-VIS-45-440	440	365-440 (λ/5.4) 400-470 (λ/6.2) 460-516 (λ/8.7)	40.8 45.0 52.4	14000-17000 / 23000-28000 16500-19500 / 27000-32000 21500-24500 / 36000-41000
	GR-1-VIS-45-590	590	490-590 535-625 610-690	40.8 45.0 52.4	
	GR-1-VIS-45-780	780	655-785 710-830 820-920	40.8 45.0 52.4	

Distortion



Can put a curve into the slit to tidy this up…

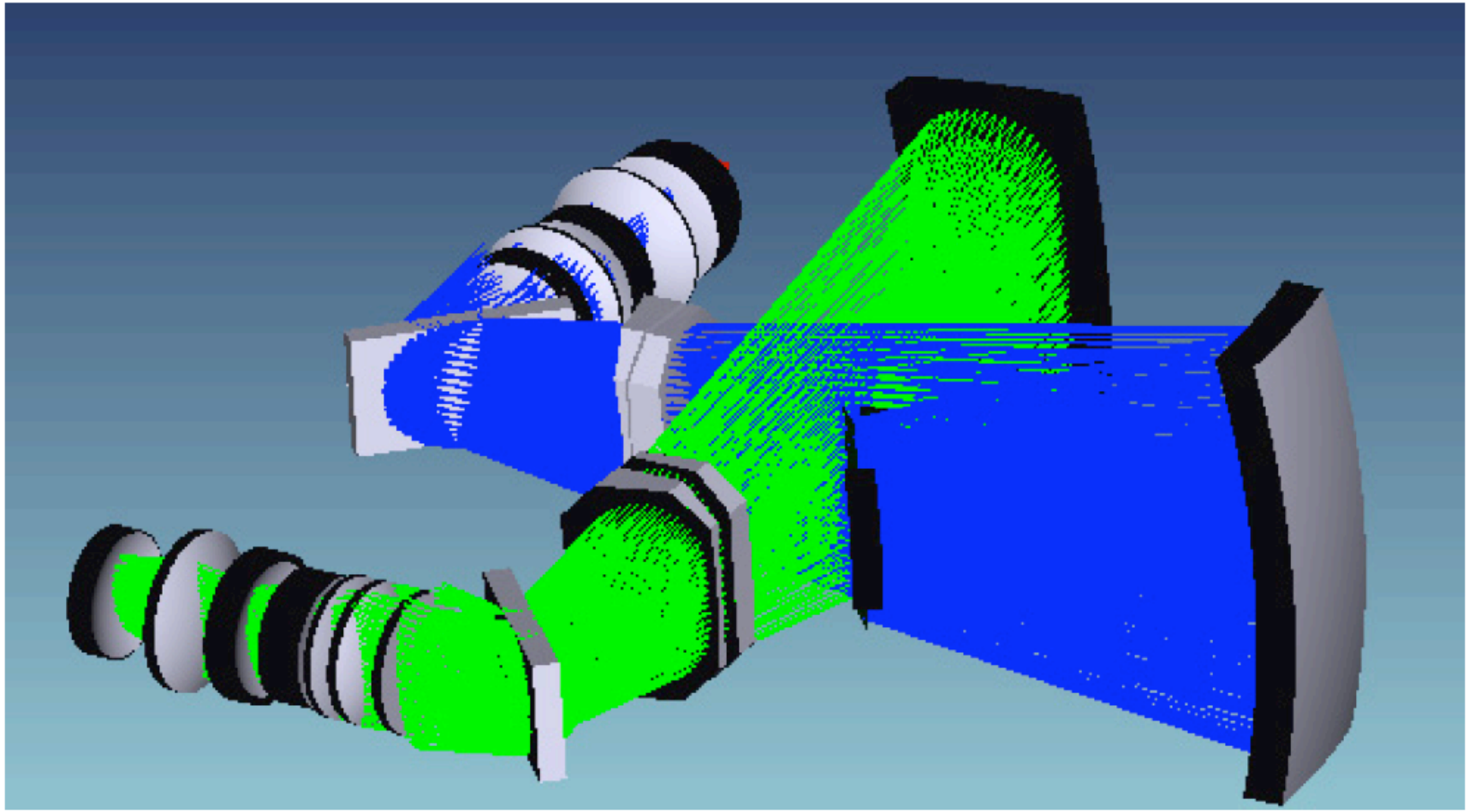
Cost estimate

- Based on EVE, looks to be around 2.5M€ hardware, including detectors for one spectrograph. Plus something like 15-20FTEs.
- Mechanical design for EVE done by ASTRON, so already a strong UK/NL connection
- Add to this 700k€ for fibres/buttons/slit (3-5FTEs), 1M€ each for a positioner, corrector, and telescope mods -> 6M€ hardware plus ~40FTEs buys an interesting instrument.

Other Considerations

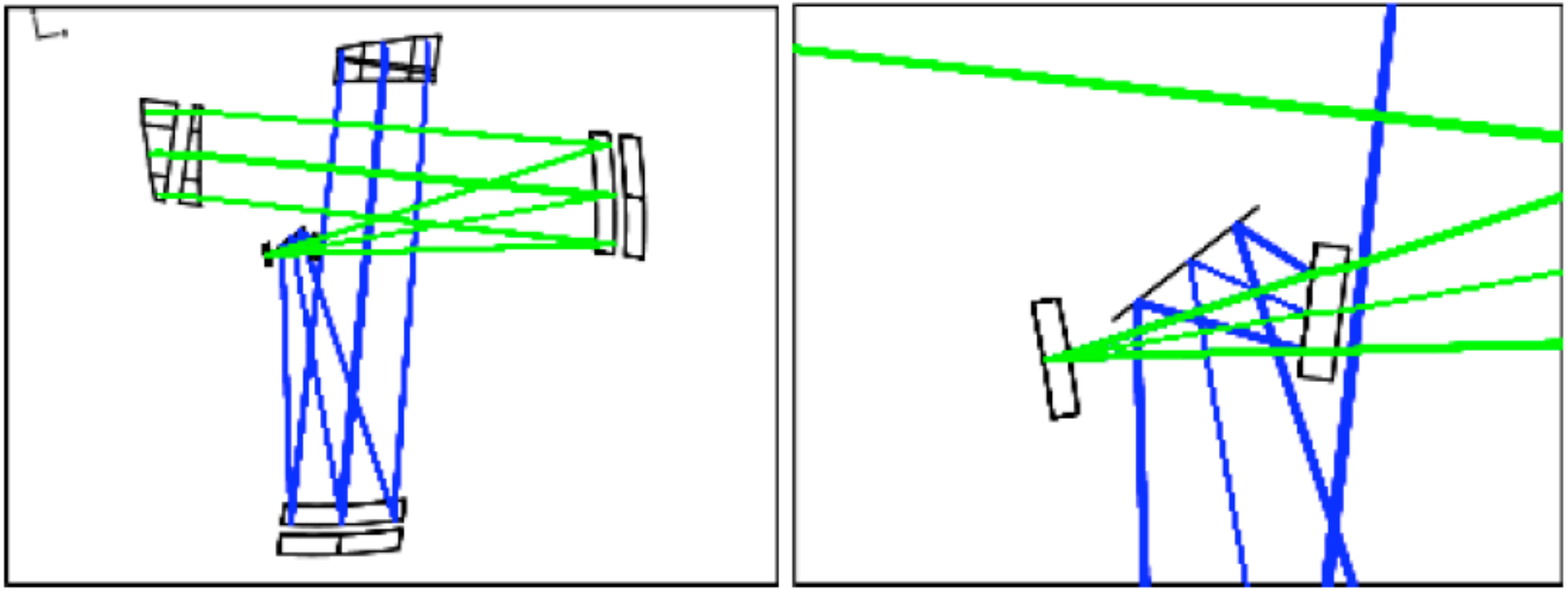
- If no requirement for R~25000
  - Smaller beam size, cheaper spectrograph
  - But no going back
- Could go to a dual beam (dichroic after the slit), but probably constrained by costs
- Can easily increase the multiplex within this design (single 1” fibres), but can we fit 3500 fibres within the focal plane
  - ECHIDNA-type positioner
    - Some drawbacks, high cost
  - COBRA-type positioner
    - High cost?

Dual Beam?



Blue limit is 370nm (VPHG materials) but could push to 1 micron in the red (high-rho chips)… but this is an expensive option (two collimators and two cameras).

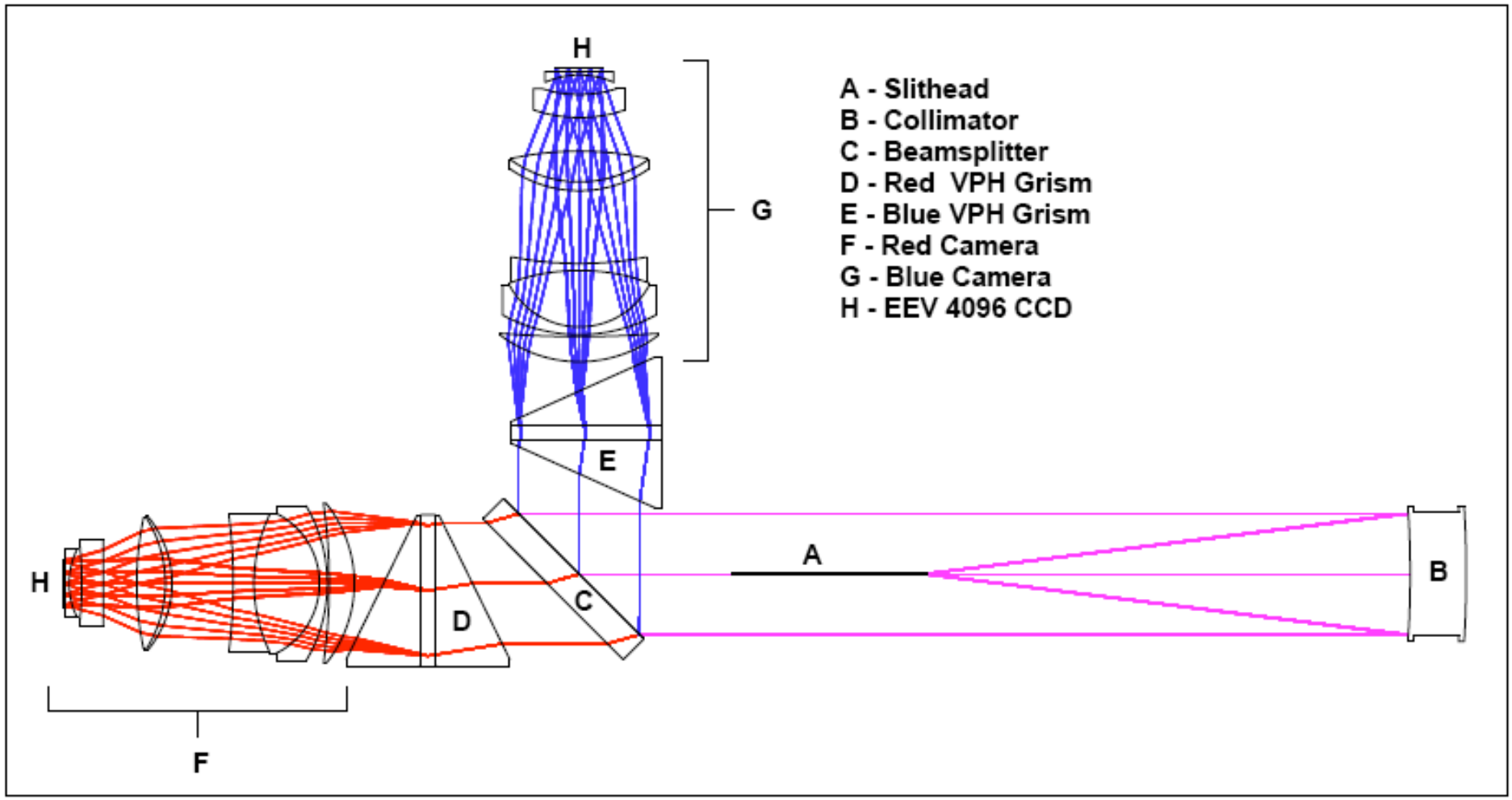
Dual Beam?



Works OK, but the area close to the slit is now very nasty.

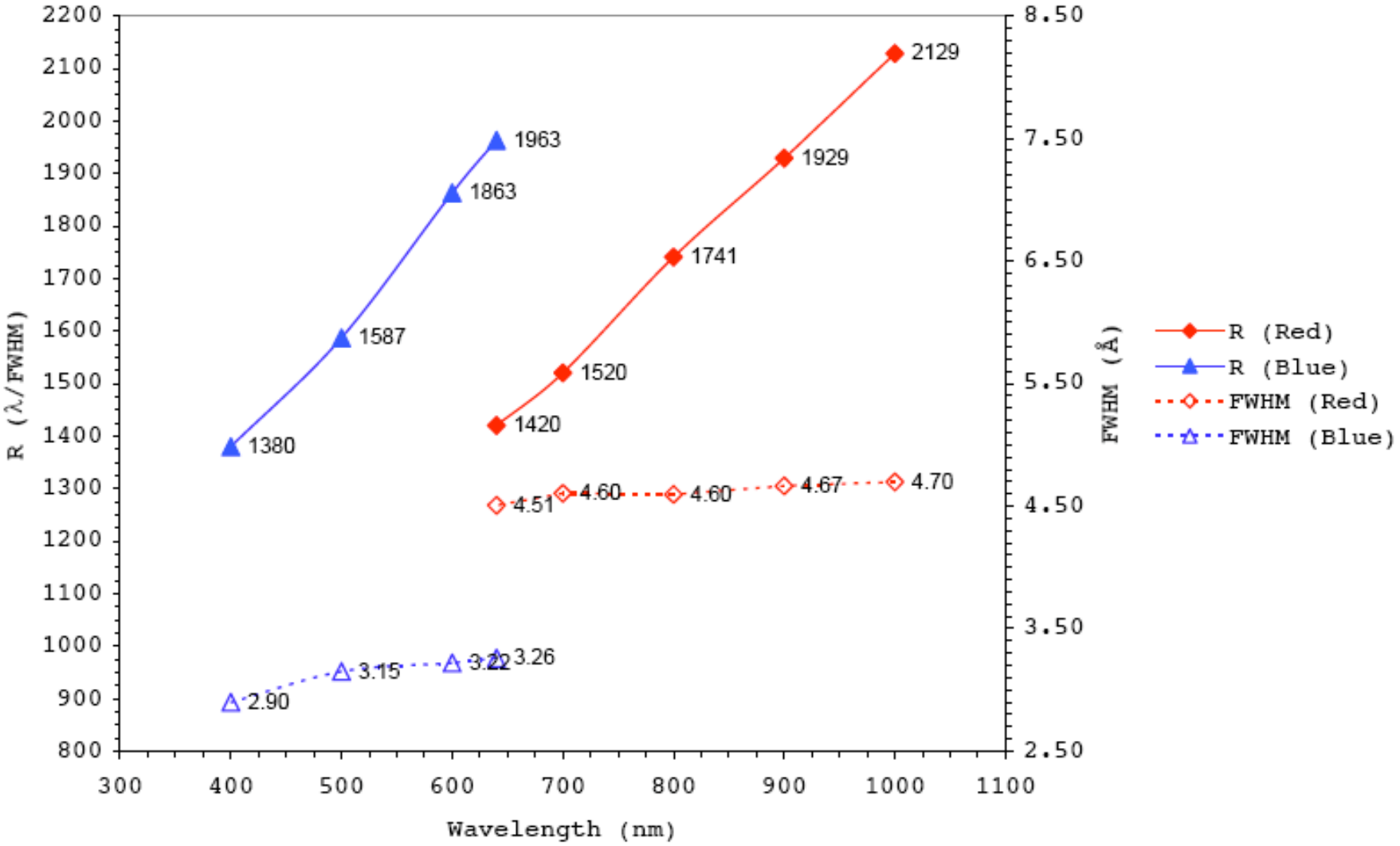
And now we can no longer curve the slit easily.

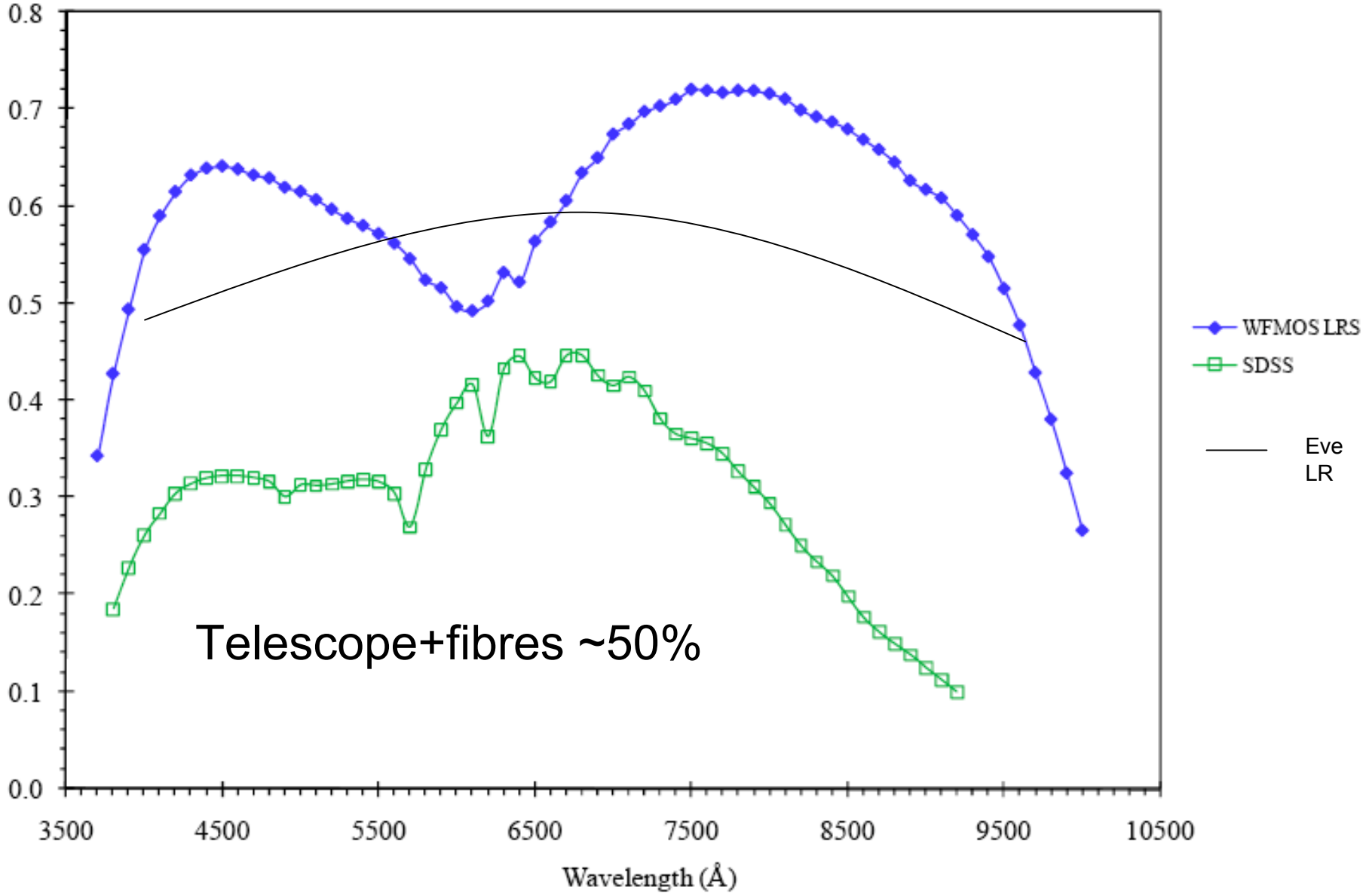
BOSS->WFMOS design, Low Res Only (fromJHU)



Slit length is 157mm, 200 micron fibre input at f/4, 4kx4kCCD.

Not much scope here for grating changes. Design would need some modification for WHT.


R (λ/FWHM)
FWHM (Å)
Wavelength (nm)
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
8.50
7.50
6.50
5.50
4.50
3.50
2.50
300
400
500
600
700
800
900
1000
1100
1380
1587
1863
1963
1420
1520
1741
1929
2129
4.51
4.60
4.60
4.67
4.70
2.90
3.15
3.22
3.26
R (Red)
R (Blue)
FWHM (Red)
FWHM (Blue)


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3500
4500
5500
6500
7500
8500
9500
10500
Wavelength (Å)
Telescope+fibres ~50%
WFMOS LRS
SDSS
Eve
LR

Summary

- There is a design that will provide excellent spectral coverage, high throughput and flexible spectral resolution within a single spectrograph.
- Enough slit length for IFU modes if desired.
- Not the only solution, but sufficiently well understood for the basis of a concept study for WHT-MOS.