UVES optical design

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(with valuable inputs from B. Delabre)

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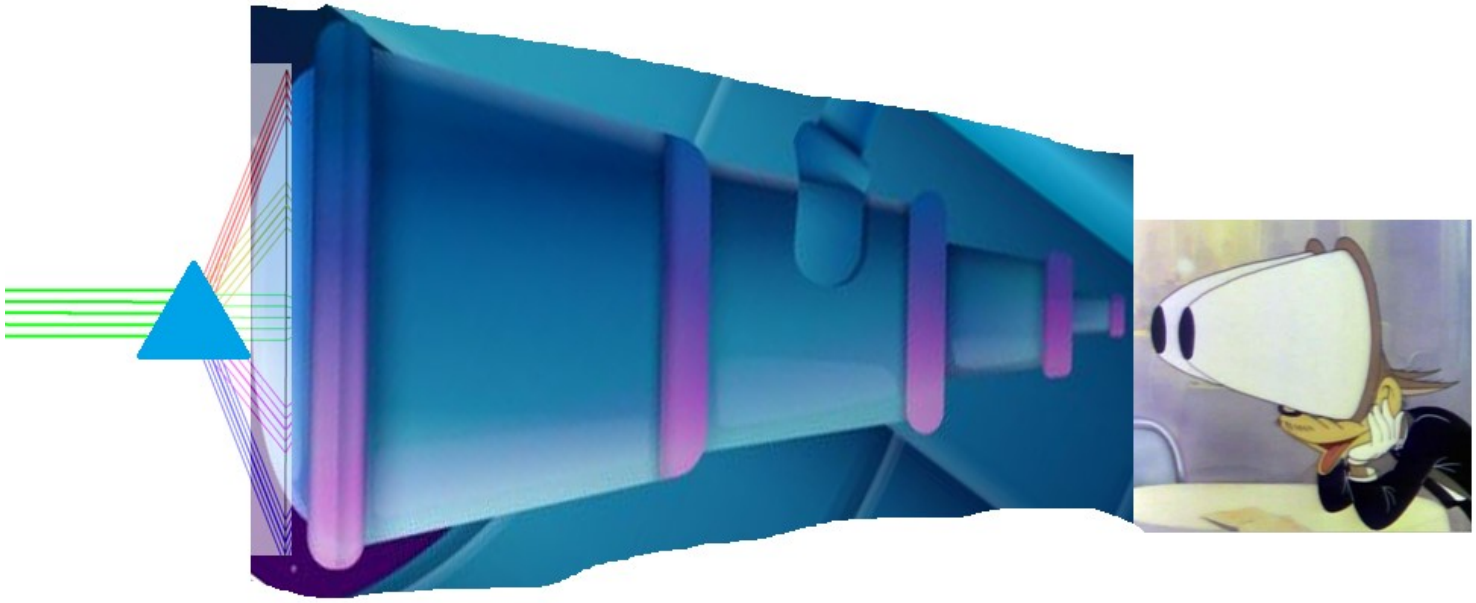
The White pupil Concept

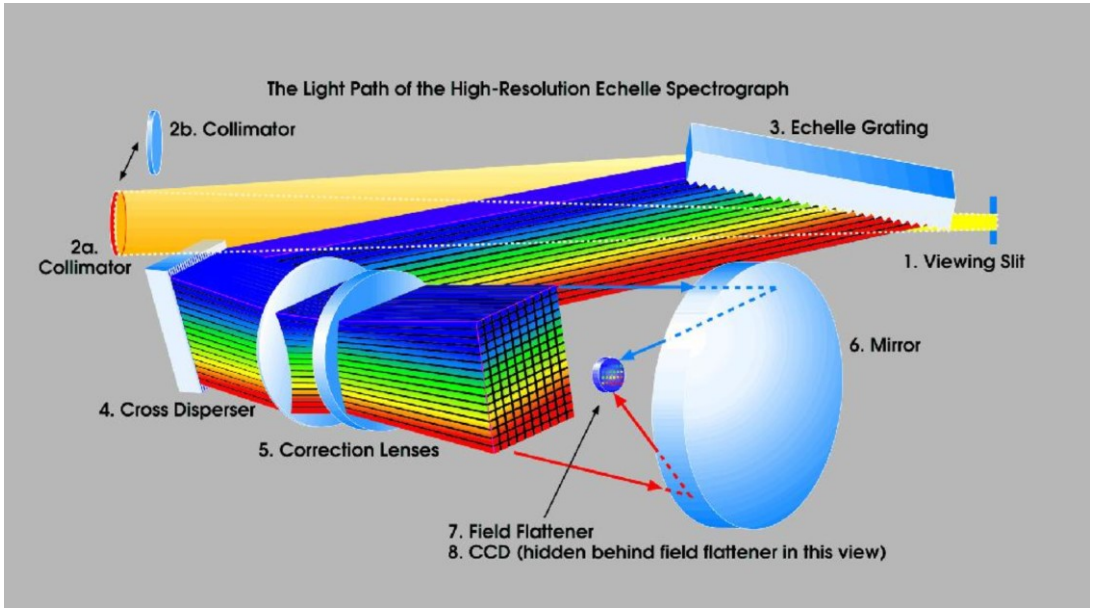
How to achieve very high spectral resolution without using large detectors, ultra large, ultra fast and impossible to design cameras ?



NB: This can be done also with many smaller telescope far from the pupil (strong vignetting!)

The White pupil Concept

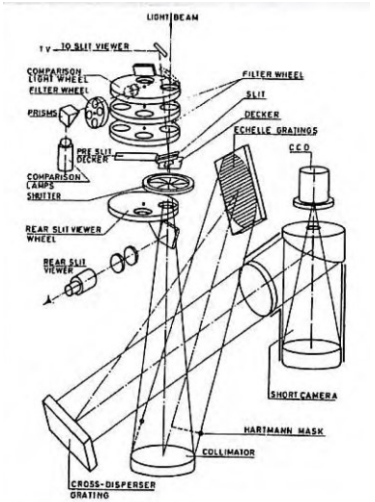
The Classical Approach for High resolution



KECK
High Resolution Spectrograph

- 1 Collimator followed by the Echelle+Cross disp.
- Large Schmidt camera 44inch
- Strong anamorphose and vignetting

CASPEC
@ ESO



The White pupil Concept

-Proposed by **A. Baranne** in early 70's

Use a Echelle Type of grating in Littrow with the collimator used in double path
A slit with overlapping diffraction orders is then created
Another transfert Collimator and Cross-disperser are needed

- Camera pupil size is almost a free parameter

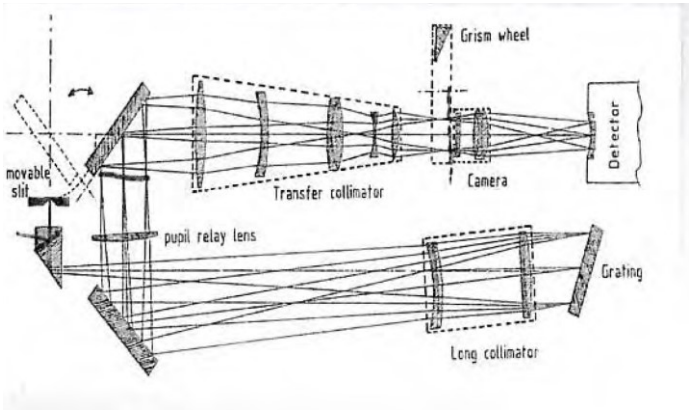
- But slit length is limited by the orders separation

The White pupil Concept

-A. Baranne applied his concept using a Schmidt Collimator in double path in CASSHAWEC

This was not a big success as the Schmidt corrector turned out to be a ghost images generator

EMMI was the first ESO instrument using that principle



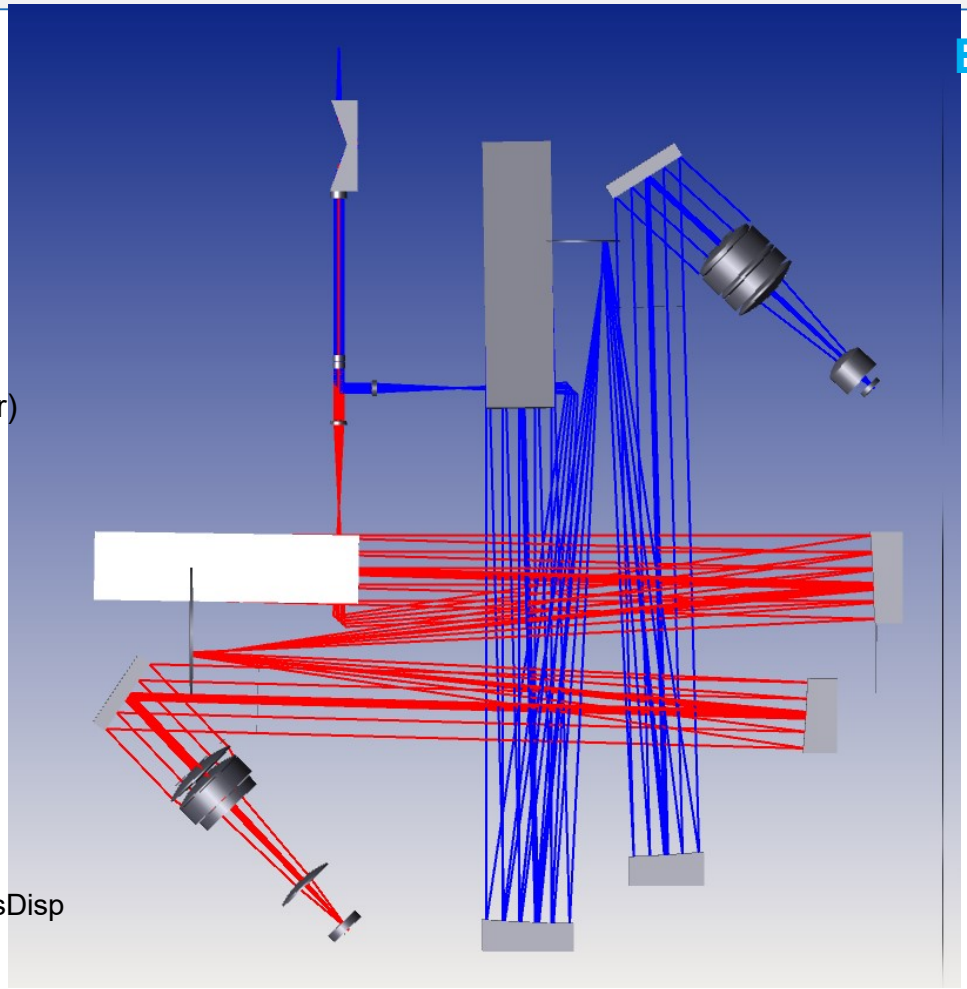
UVES in 1 Shot

Preoptics:

-1 Optical Derotator
-ADC+filters
-2 Achromatic at F/10
-Selection mirrors

Other features:

-Slit Viewers
-Adjustable Slits (Dekker)



Red ARM:

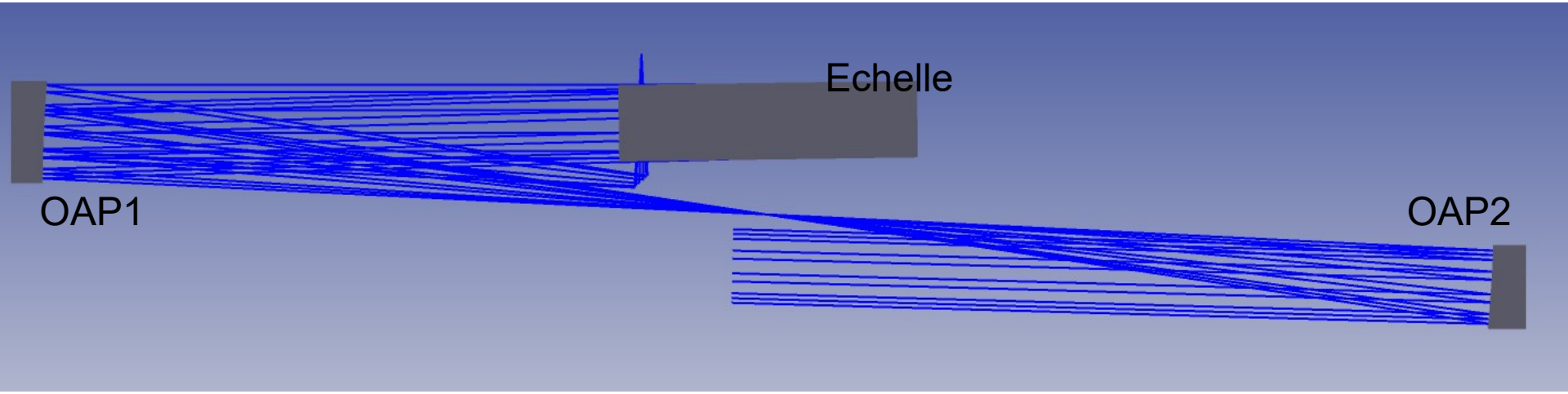
6 lenses (but 2 doublets)
EFL 500mm
200mm pupil
F/2.5 Achromatic Camera
R4 Echelle
0.42-1 micron
Covered using 2 Ex. CrossDisp
Usable FoV 12deg
(4kx4k)

BLUE ARM:

7 lenses
EFL 360mm
200mm pupil
F/1.8 Achromatic Camera
R4 Echelle
0.3-0.5 micron
Covered using 2 Ex. CrossDisp
Usable FoV 7.5deg
(2k*2k equ.)

UVES Secret 1

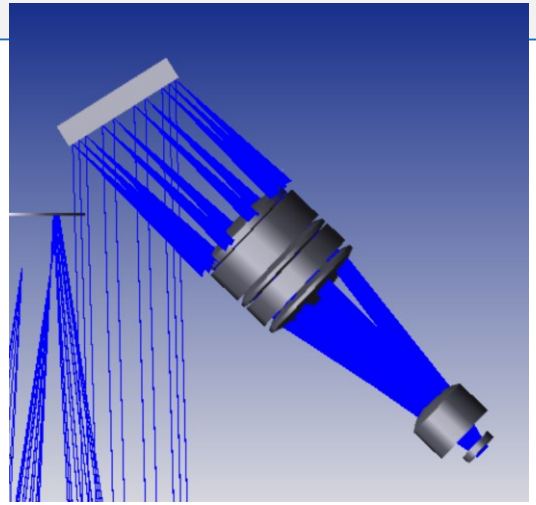
Main and Transfer Collimators combination!



1)Perfect compensation of vertical coma and Astig of OPA1 in double path by OPA2.
2)Perfect compensation of horizontal coma between OAP1 and OAP2

→Unbeatable Image Quality performances
→ No Ghost
→Only problem is Field Curvature (Cylindrical Cryostat window to correct this)

UVES Secret 2

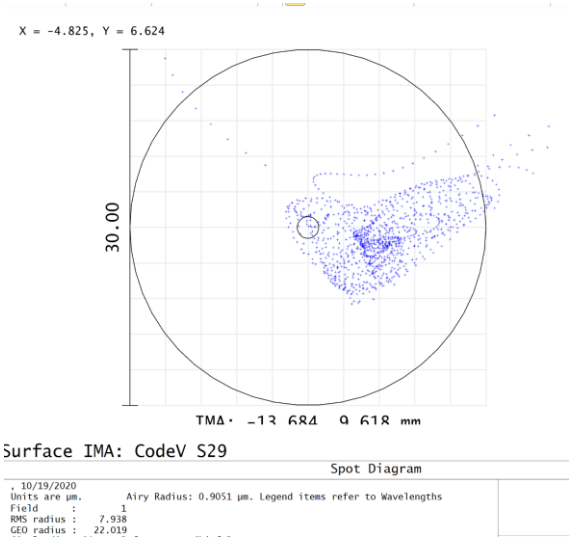


Vignetting of the Cameras:

- Camera far from the pupil
- Glass blanks larger than 200mm not existing

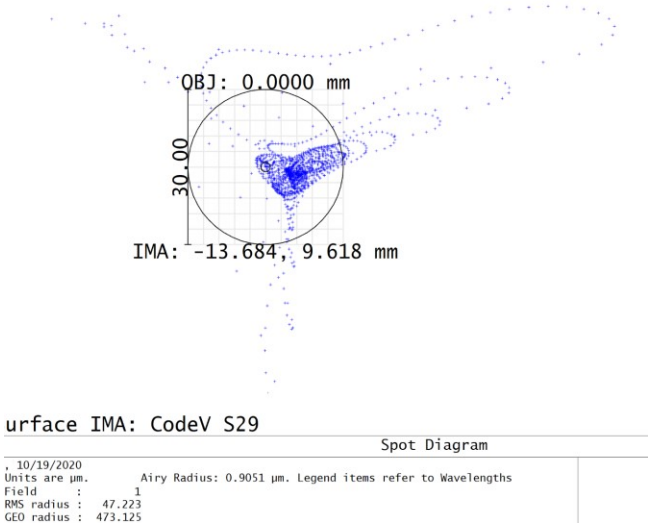
Up to 25% vignetting

Making a clever use of this vignetting allows very good images with only spherical and much thinner lenses



RMS spot size

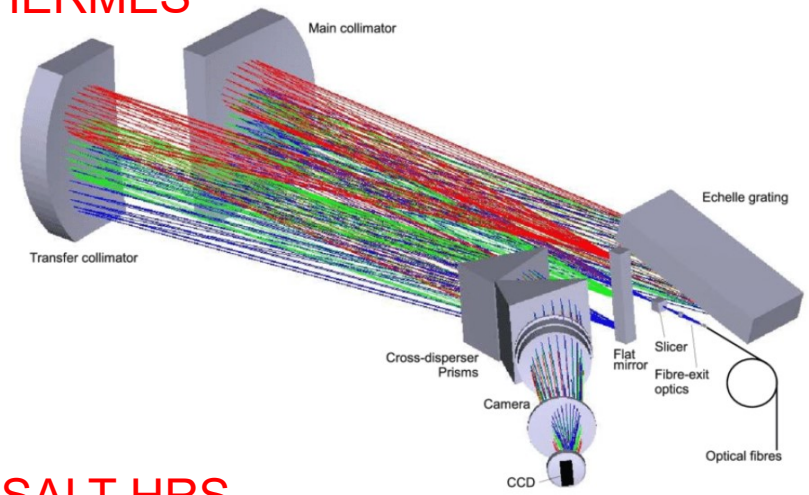
1 pix with Vignetting
vs **6pix** without !



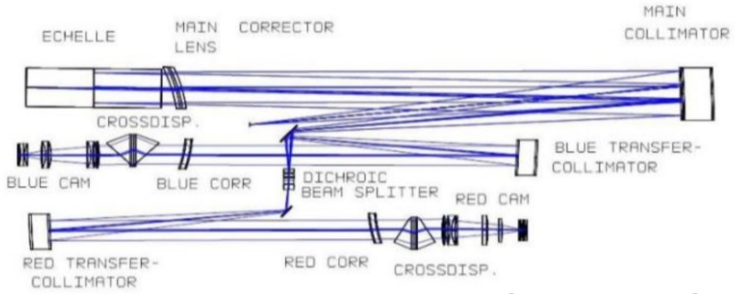
After UVES

COPIED Many times with variations of collimator:

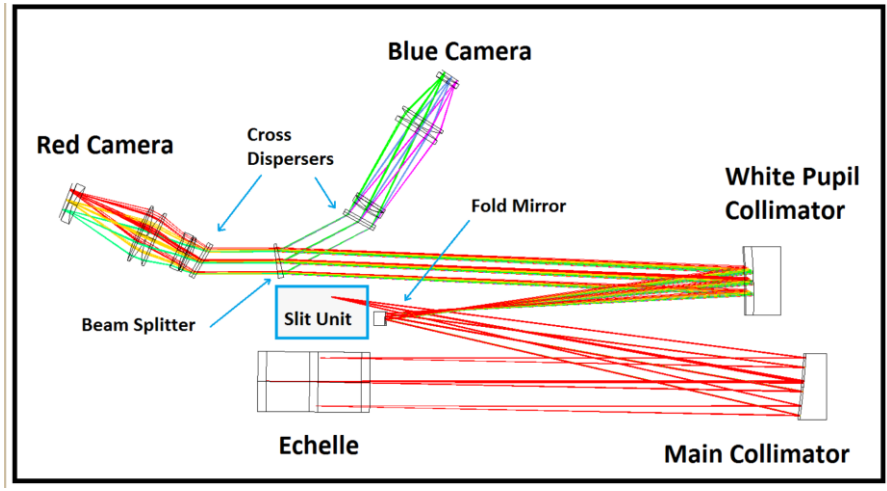
HERMES



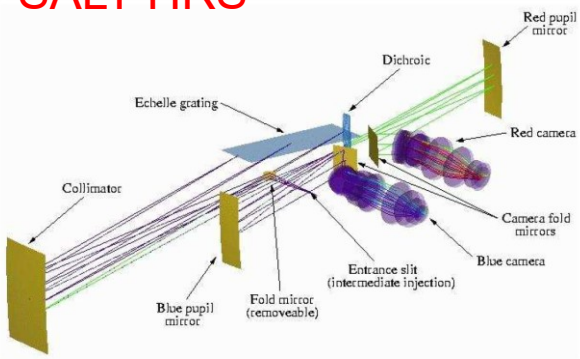
LBT PEPSI



GEMINI GHOST



SALT HRS

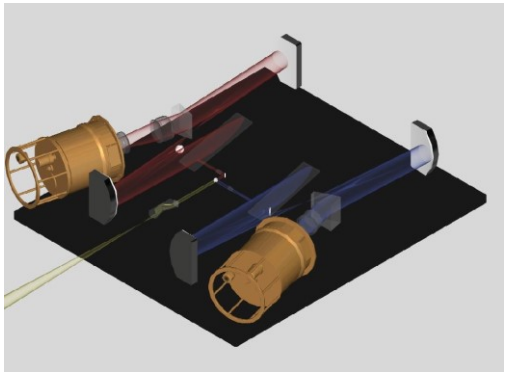


FEROS, HARPS, ESPADON, SPIROU, FOCES… the list is long

After UVES

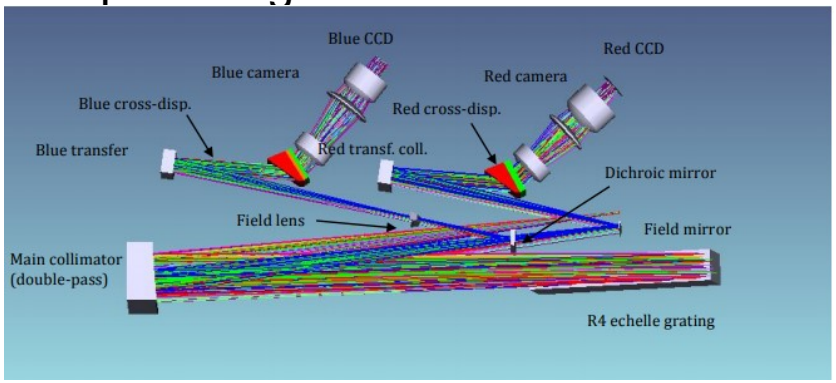
STELES

Spherical Transfert Collimator with Camera Compensation



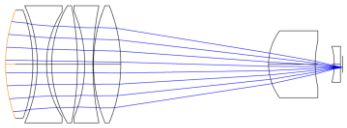
ESPRESSO

Spherical Trans Coll+ field flattener
Pupil slicing

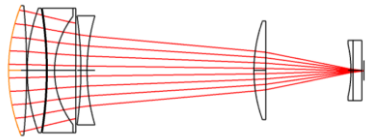


Huge benefit of fixed format detector for the camera designs

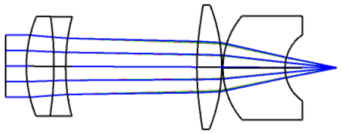
UVES Blue



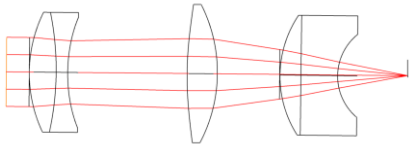
UVES Red



VS



ESP Blue



ESP Red

Blue Arm upgrade Ideas

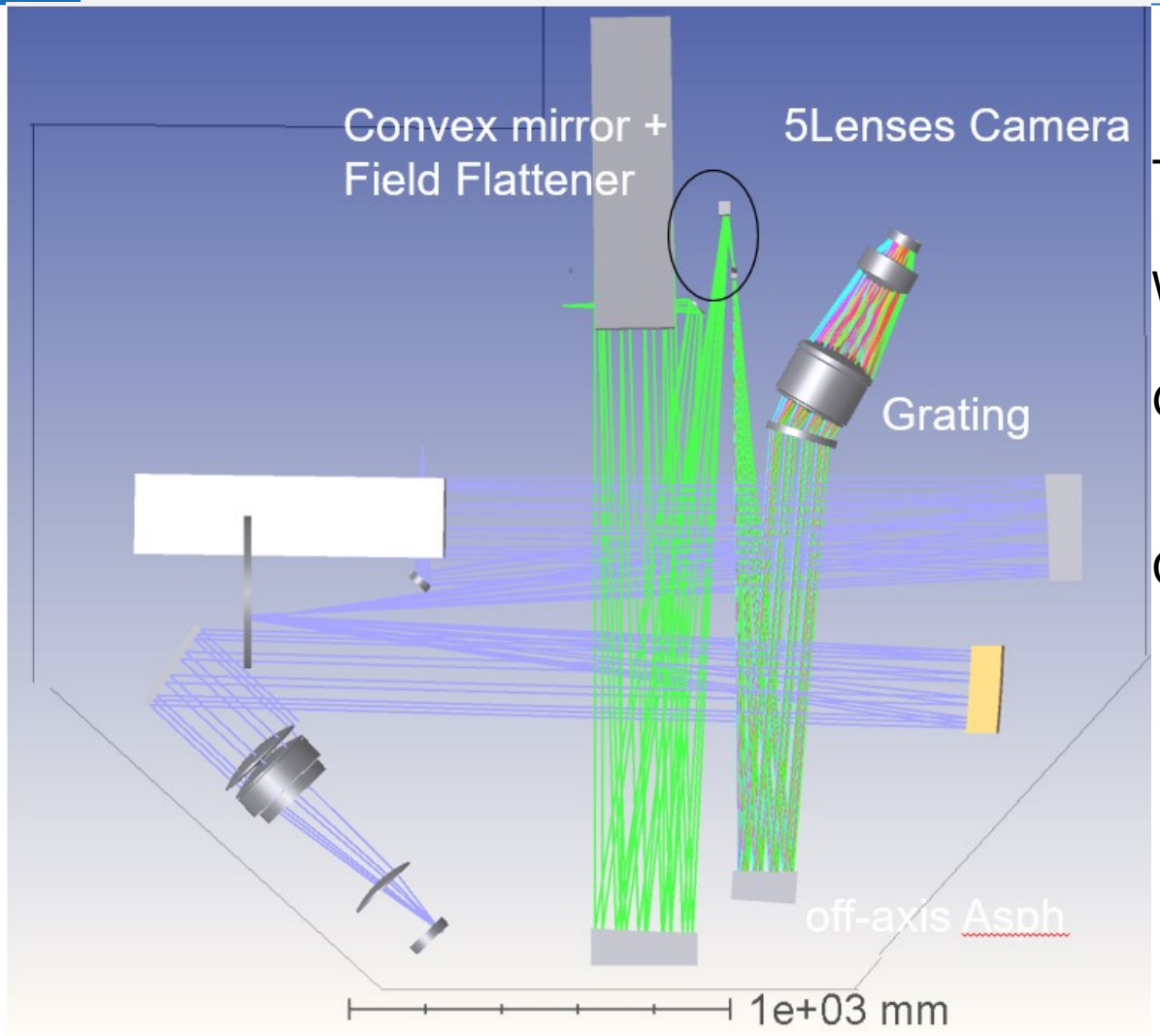
- To double the camera FoV to cover the full wavelength range in one shot (4k by 4k)

- To maintain a reasonable size for the camera, this requires to reduce the size of the white pupil.
  -Use a transmission grating (ion-etched) to have the camera closer to the pupil
  -By modifying the transfert collimator, change the pupil size and position
- Combining all this will also have an improvement on the overall throughput (grating efficiency, less vignetting)

How?
Convert UVES transfer collimator into a ESPRESSO type transfert collimator

UVESPRESSO?

Preliminary design



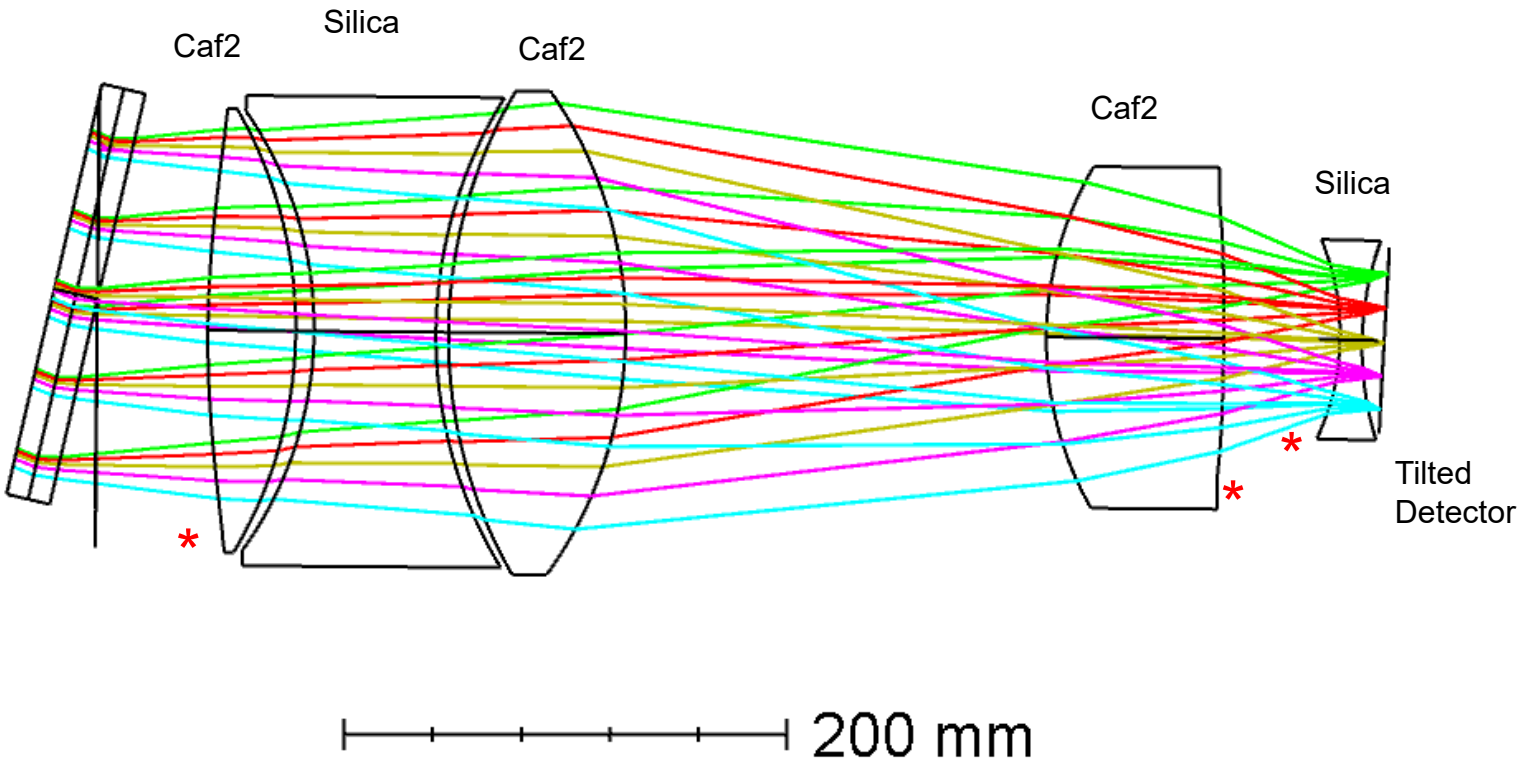
Trans Coll Focal: 1500mm

White Pupil: 150mm*200mm

Grating: 200mm x 200mm
1080 lines per mm

Camera Focal : 270mm

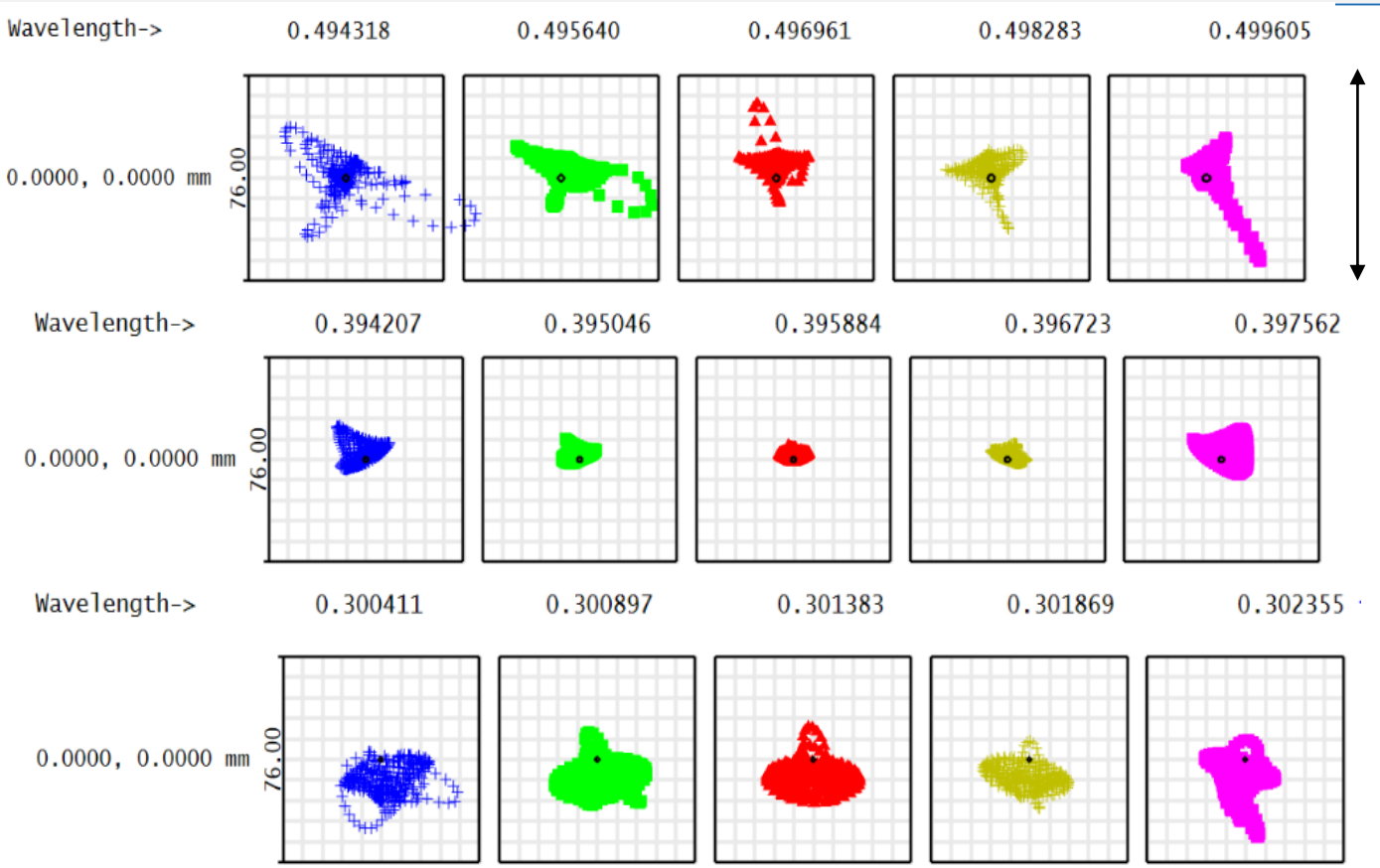
Camera



Focal Length 280mm, 5Lenses 3asph.
F/#=1.8
No correction of axial color
Angular FoV 7.8 deg by 12.4deg

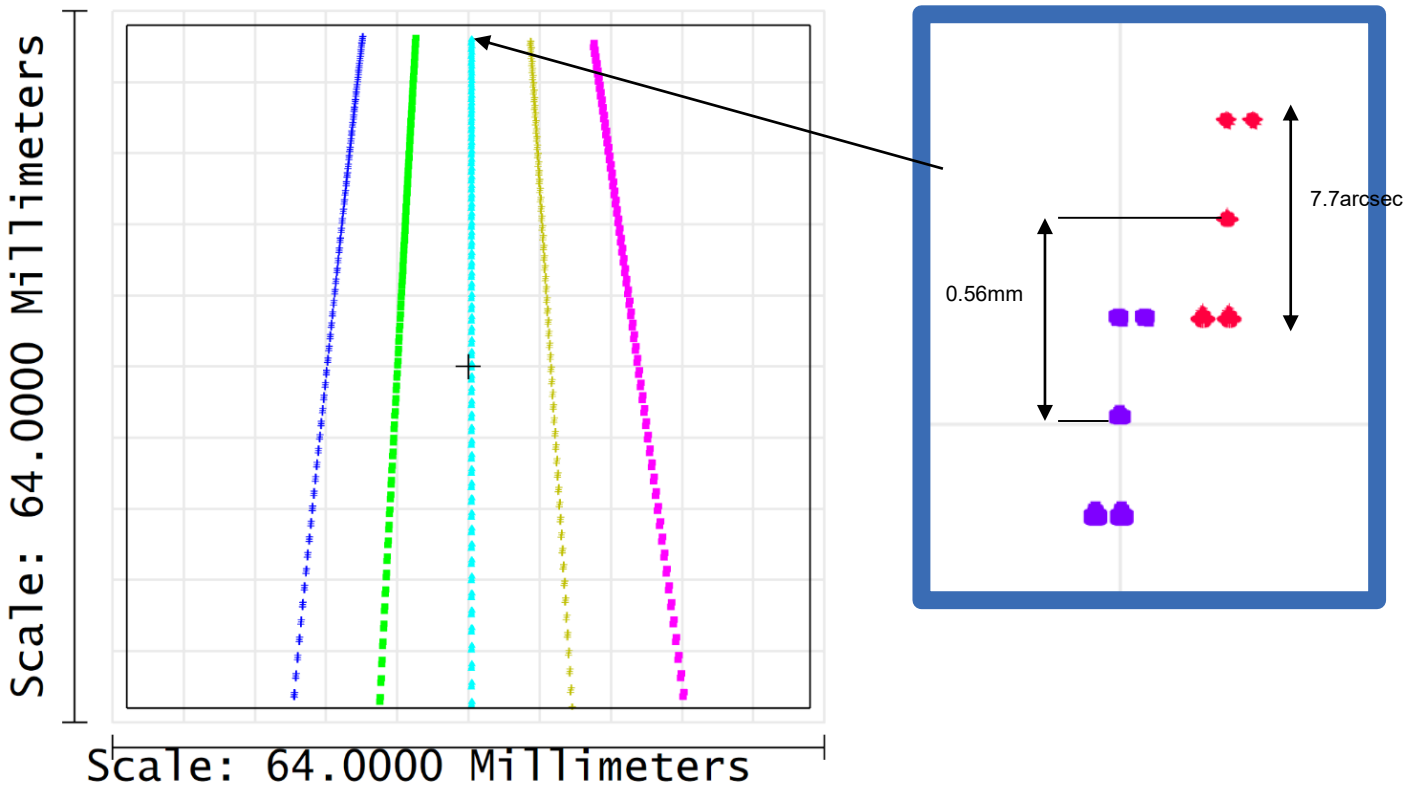
* aspheric

Rms Spot diagram



Similar Spot Size as the current Blue Camera

Spectral Format



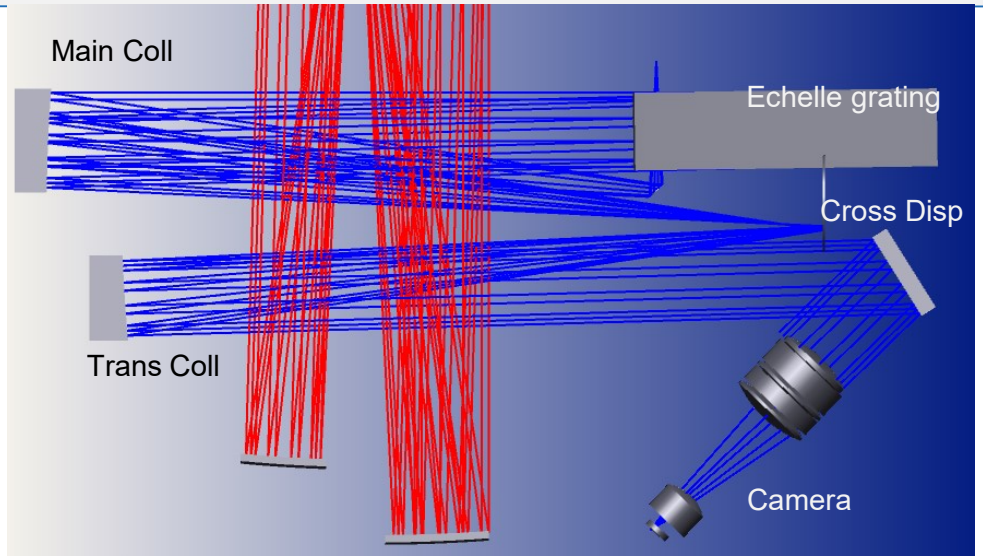
Echellogram from diffraction order 94 to 155. (300 to 500nm)
Minimal order separation (155-154) = 560micron center to center
Max slit length about 7.7 arcsec (no gap)

Throughput improvement

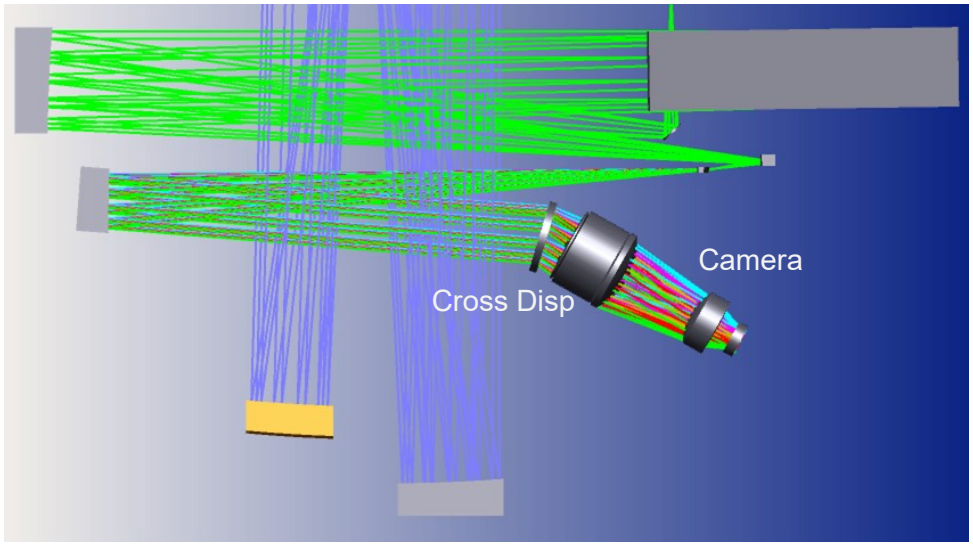
- 10 to 15% more efficient grating
- 1 Lens Less : 2%
- No Vignetting: up to 25% affecting extreme blue and red
- New Blue Detector ???

→ 50% relative increase (Not everywhere)

Thanks for your attention!



UVES Blue Arm



UVES upgrade