LUVOIR/POLLUX
Instrument configuration baseline
Overview

Workshop, Marseille

09/10/2017

Introduction

- Aims of this talk
  - Give an overview of the current status of POLLUX
  - Define the POLLUX instrument baseline
  - List all critical and/or open points
  - Identify/validate next steps
  - Share concerns/possible solutions

Driving Requirements (currently)

- REQ 01: Spectral Resolution: 120 000 (200 000)
- REQ 02: Waveband:
  - REQ 02a: 98-390 nm (90-visible)
  - REQ02b: Minimum order length: 5 nm
  - REQ 02c: Full wavelength range avaialble in one shot
  - REQ 02d: 1-2nm overlap between wavelength range
- REQ 03: SNR
  - SNR=10 for flux 1e-17 erg/s/cm2 in the NV line (124 nm) in a brown dwarf within 40 pc and dispersion 100,000 in 10,000 seconds
  - + S/N per resolution element of 100 integrating for 1 hour a flux of 10^-14 erg cm^-2 s^-1 A^-1
- REQ 04: Polarization
  - REQ 04a: Circular + linear
  - REQ 04b: Sensitivity: 10^-4 – 10^-5
- REQ 05: Aperture size: 0.03''
- REQ 06: Observing mode: with and without polarimetry

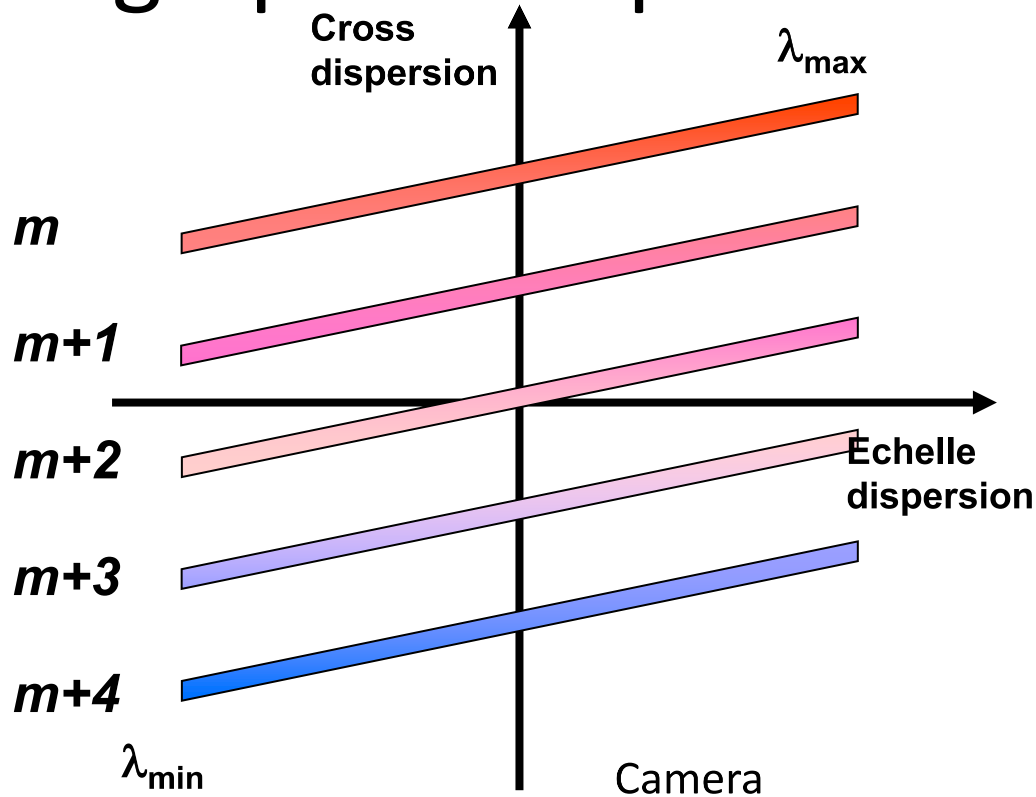
Echelle Spectrograph Principle

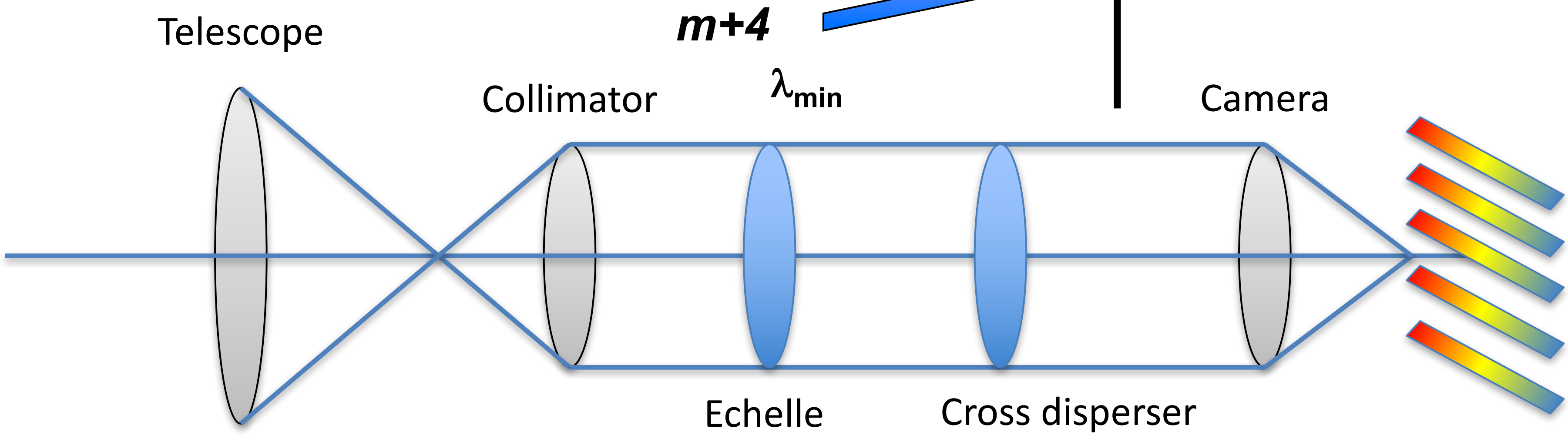
Spectral Resolution

120 000 (200 000)

↓

Echelle Spectrograph (3 or 4 elements)





Spectral channels

- Baseline
  - 2+1 channels compatible with optical limits and detector characteristics

FUV	MUV	NUV
• ≈90nm • ≈123nm	• ≈119nm • ≈220nm	• ≈210nm • ≈390nm

- Rationales/drivers:
  - Limit the amount of channels (huge photon loss when splitting)
  - Minimum: 90nm discussed next slide
  - Maximum (400nm): related to the nb of octave
  - Intermediate (220nm): arbitrary (but detector limitations)
  - Overlap: depends on the technology (see architecture)

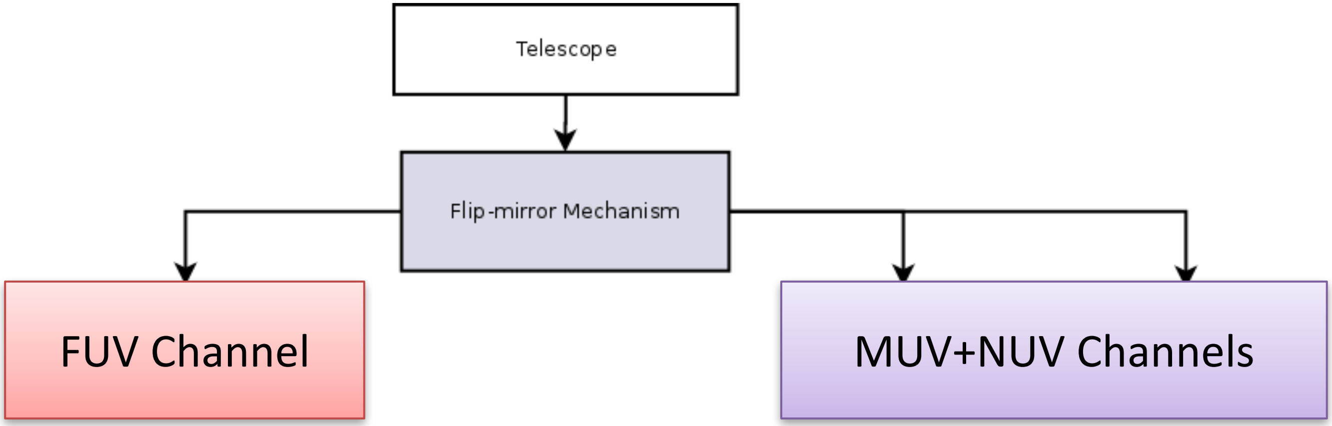
Spectral channels

- Baseline
  - 2+1 channels compatible with optical limits and detector characteristics

FUV	MUV	NUV
• ≈90nm • ≈123nm	• ≈119nm • ≈220nm	• ≈210nm • ≈390nm

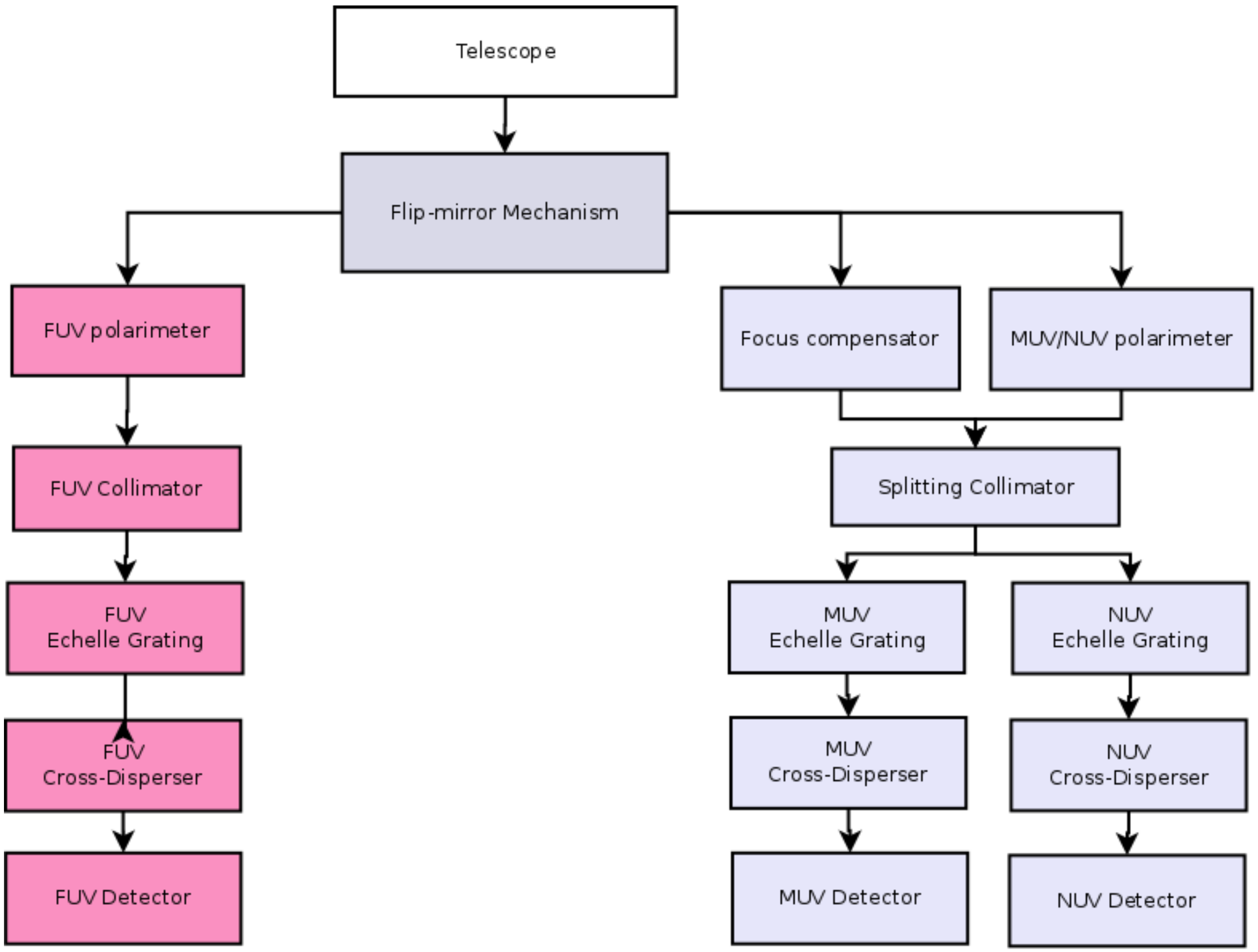
- Spectral Separation
  - A flip-mirror mechanism at the entrance to feed
    - either the FUV channel or the MUV+NUV channels
  - A spatial splitter to separate the MUV and NUV
    - The collimator will act as spatial splitter (conservative approach)

Baseline block diagram

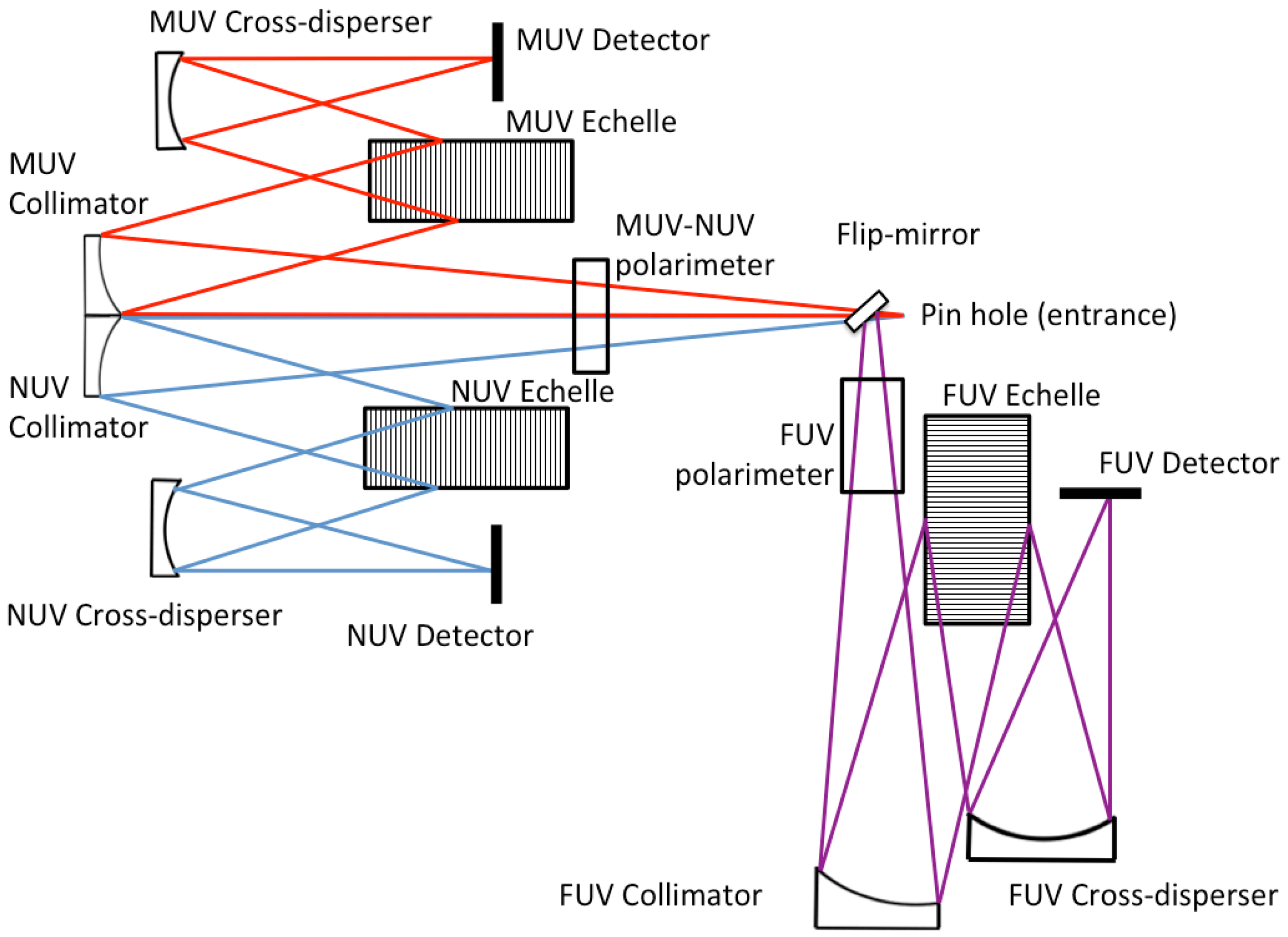


- This architecture allows for:
  - Dedicated polarimeters (FUV and MUV/NUV)
  - Large overlap between wavebands
  - Injecting calibration light sources
  - Parallel developments
  - …

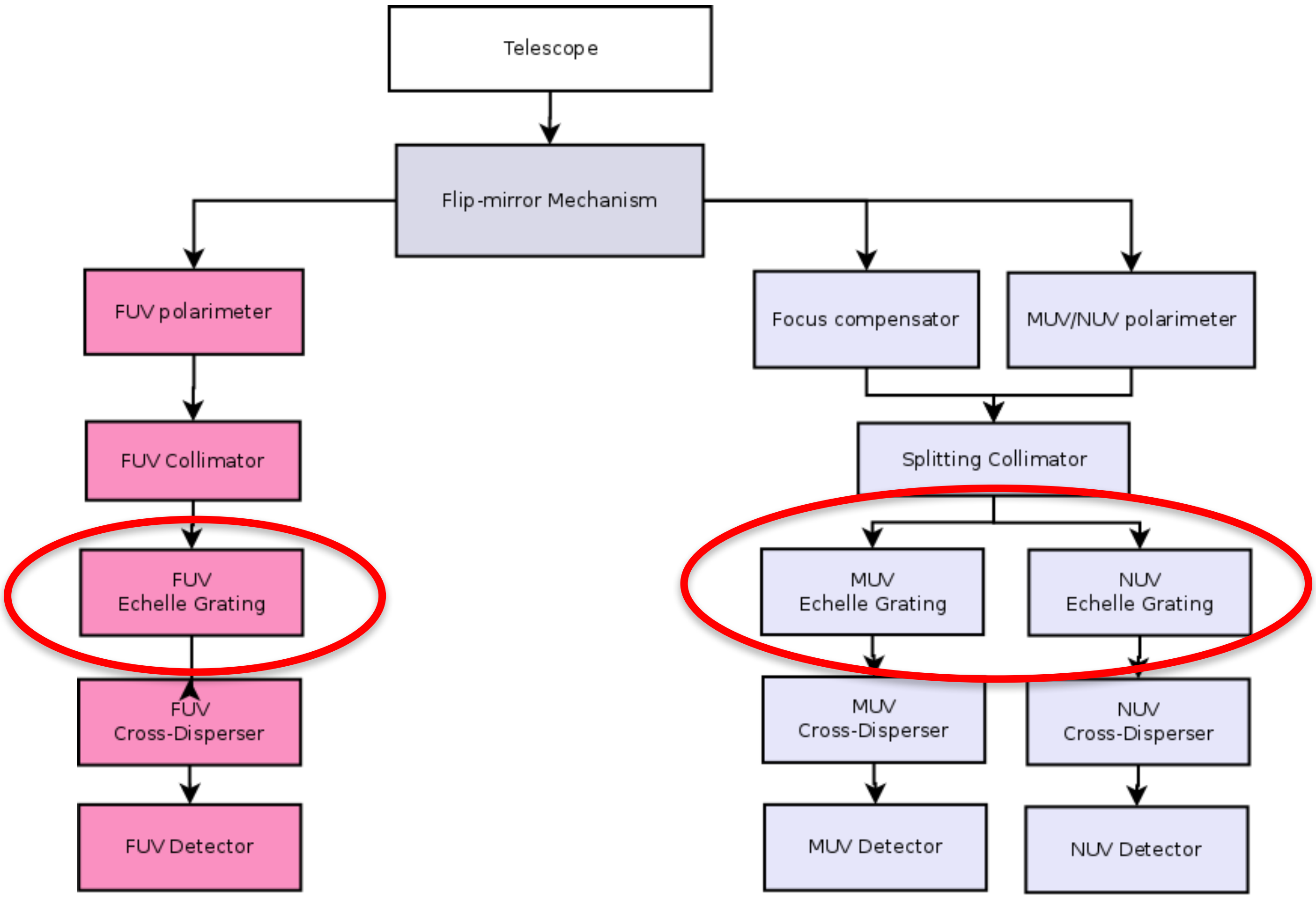
Baseline block diagram



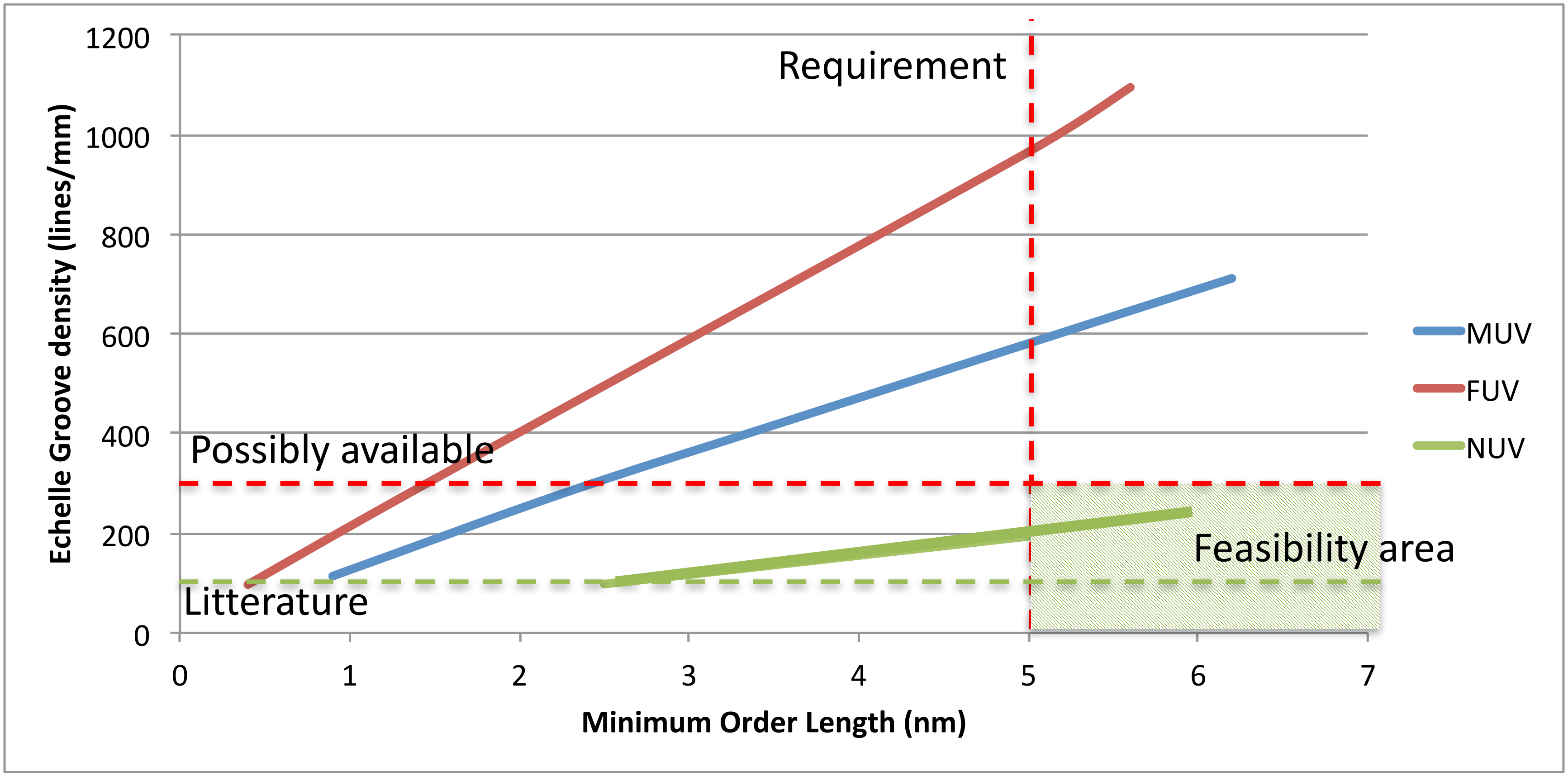
Schematic view



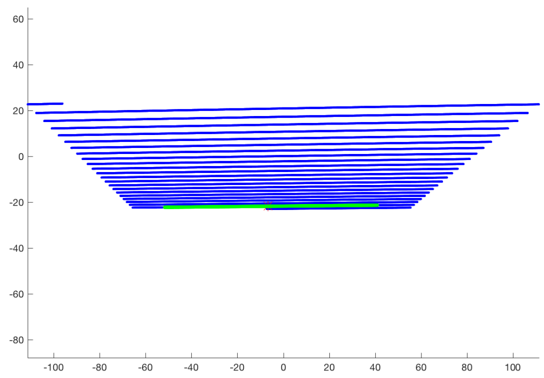
Baseline block diagram



Echelle grating feasibility



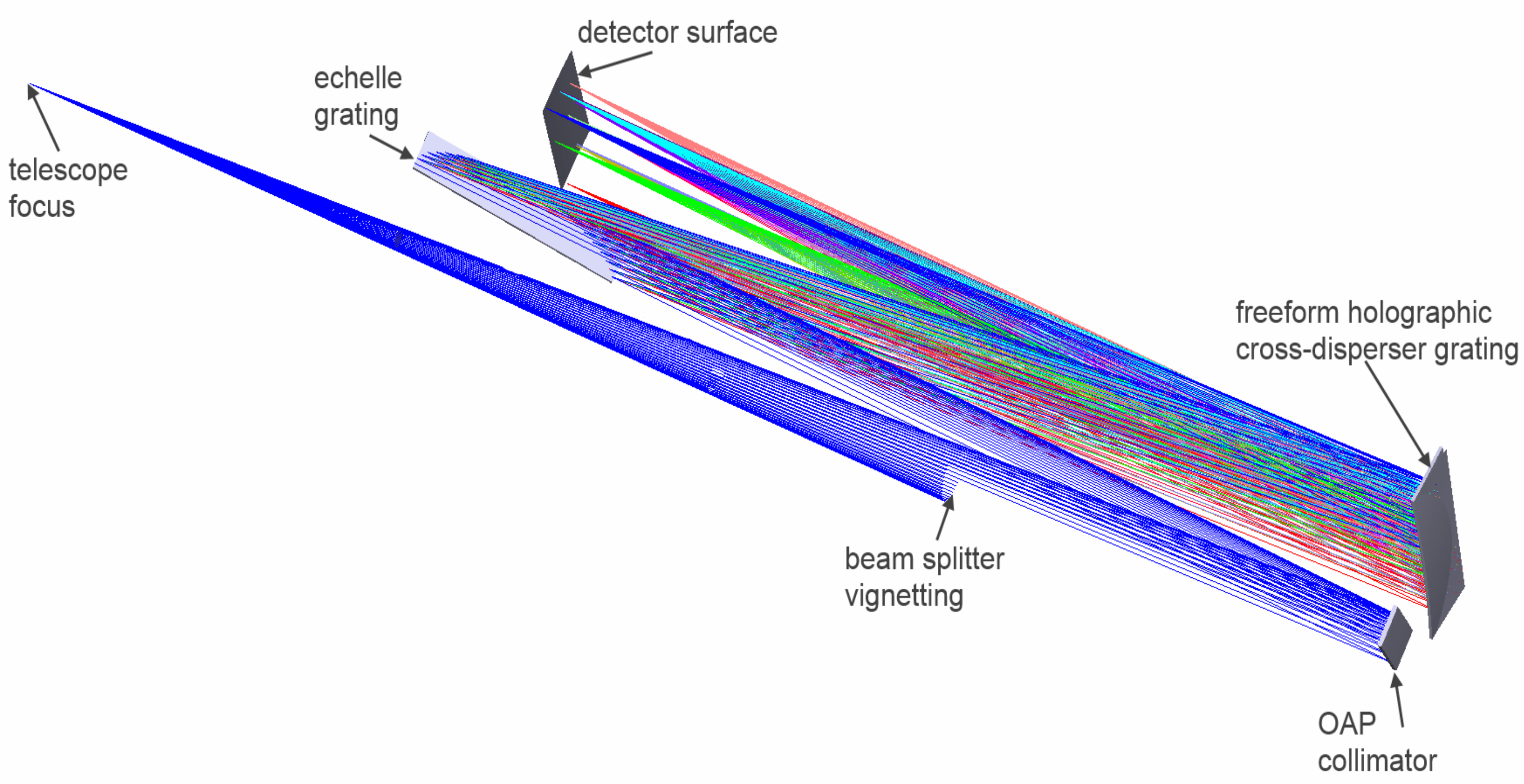
Spectral order length



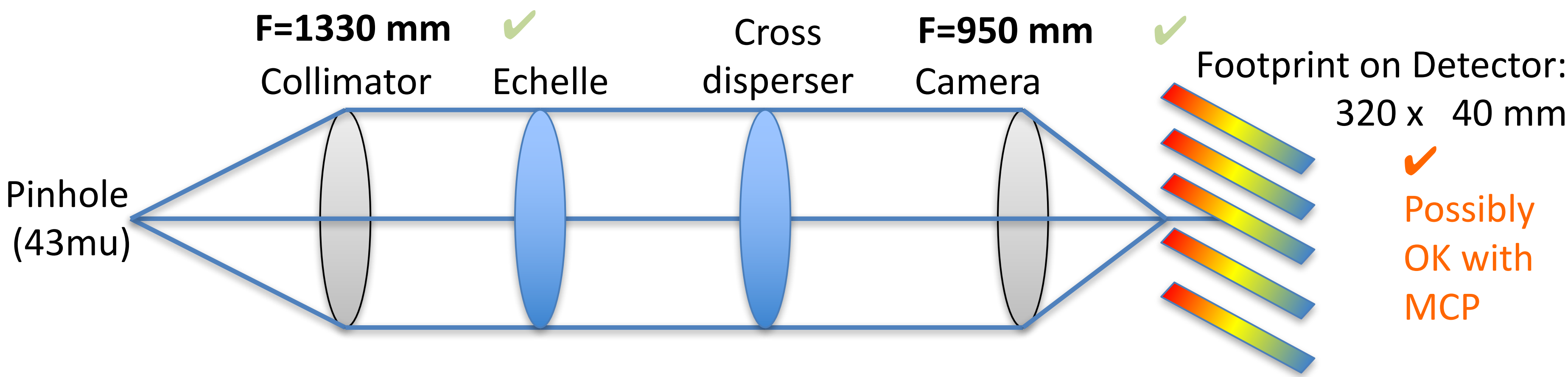
FUV	MUV	NUV
2.3 – 3.9 nm	1.9 – 6.1 nm	1.9 – 6.3 nm

- Echelle grating from Richardson grating company
  - Blaze angle: 63.00 deg
  - Groove density: about 316.00 lines/mm
  - Grating clear aperture: 66.70 mm by 146.91 mm
- This grating is on catalog but:
  - Is facet shape compatible with UV?
  - Tunable or as it is ?
  - To be space qualified (with a compatible coating)
  - Single provider identified so far !
  - Availability in 15-20 years from now?

Optical design (see Eduard's talk)



Example of "fully" compliant config.



WAVELENGHT RANGE:

- From 120 to 220 nm (MUV)
- Order size (max): 14.8 nm ✔
- Order size (min): 6.2 nm ✔

AVERAGE RESOLUTION: 125 000 ✔

- Minimum Resolution: 91 000 ✗
- Maximum Resolution: 208 000 ✔

ECHELLE GRATING CHARACTERISTICS:

- Grating Blaze angle: 63.00 deg ✔
- Groove density: 713 lines/mm ✗ Not Usual
- Grating diameter: 70 mm by 150 mm ✔?
- Grating orders from 12 to by 21 ✗ Not Usual

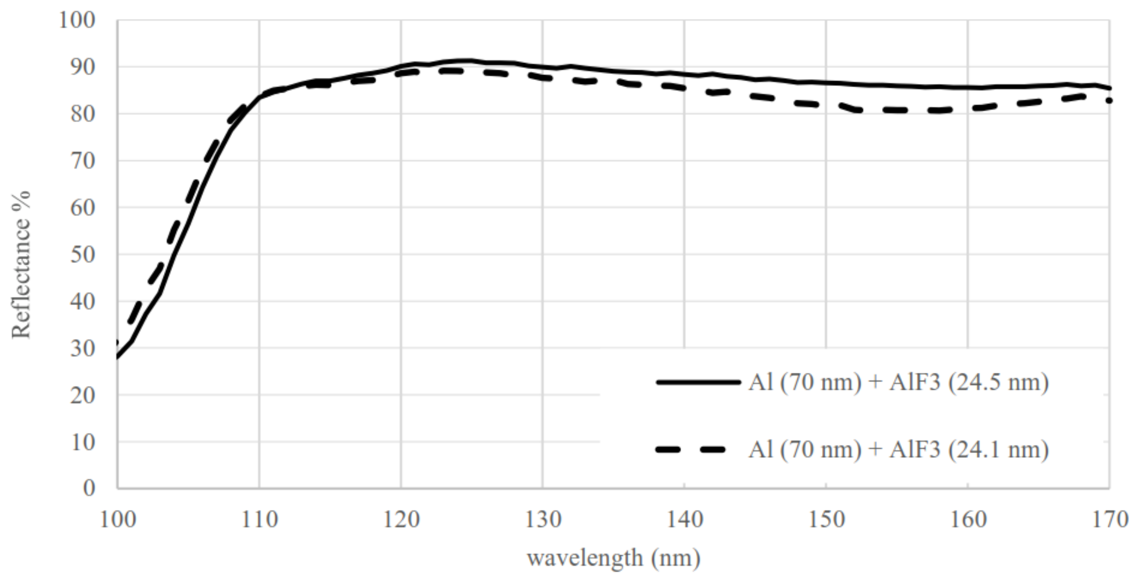
CROSS DISPERSER CHARACTERISTICS:

- Groove density: 450 lines/mm ✔

Cross-disperser (see Eduard's talk)

- Cross-disperser acting as camera mirror
  - minimizes the amount of optical elements
- This configuration adds complexity on this element.
  - Grating on an aspherical surface with non-linear lines
  - The feasibility to be assessed
- Back-up option
  - Consider a plane cross-disperser + a camera mirror
  - This option is close to what exists today.
  - Note that the total efficiency of this could be higher than the baseline.

Coating (see Luca's talk)



- As baseline Al+AlF3 could be considered
- Investigations on the coating thicknesses could help improving the efficiency

Polarimeters (see Arturo's talk)

- MUV/NUV channels:
  - Modulator composed of 3 rotating mirrors
  - Analyser is a Wollaston made of MgF_2
- FUV channel:
  - More critical because of the low reflectivity of coating and the absence of transparent material
  - Modulator composed of 3 rotating mirrors coated with SiC
    - At high incidence angle SiC reflects >80% (to be confirmed)
  - Analyser using Brewster angle
    - but only the P polarisation can be used i.e. <50% transmission

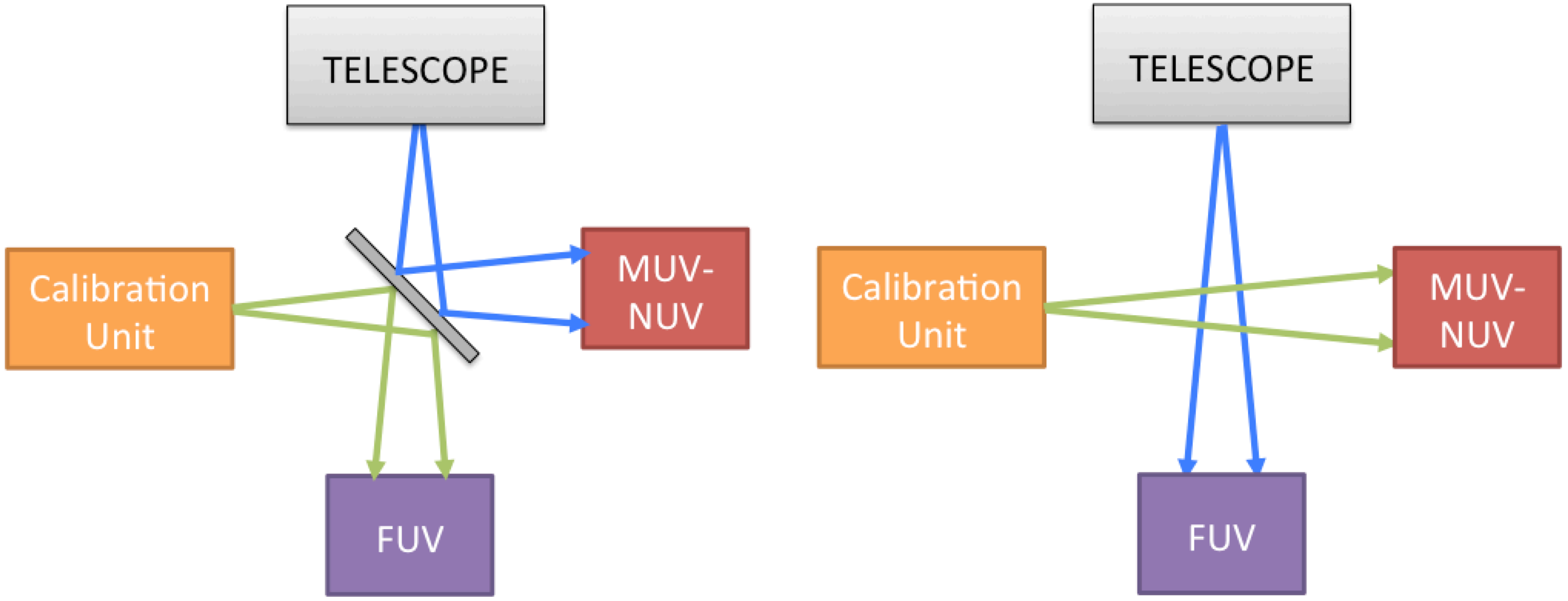
- Retractability:
  - When retracted the optical path shall be compensated
  - A focus compensator is required in the MNUV:
    - Translate the detector is not sufficient
    - Translate the collimator requires to 2-axis mechanism (off-axis mirror)
    - Pick another field up but requires 2 mirrors to feed the channel in any case

Detector baseline (see Jon's talk)

- FUV and MUV channels
  - MCP detectors
    - 200x200mm with 20mu spatial resolution element
  - "Heritage" from LUMOS

- NUV channel
  - CCD detectors
    - 4k x 4k with 13 microns pixel size

Calibration unit possible injection



WITH FOLDING MIRROR **WITHOUT FOLDING MIRROR**

~~See Pierre's talk for the calibration unit~~

(Preliminary) Maturity matrix (to be discussed)

Component	Maturity	Back-up	Comment
Flip-mirror	High	Not needed	Equivalent mechanism already flying
FUV polarimeter	Low	Not identified	
MNUV polarimeter	Medium	Arago's proposal	No critical except for the coatings
Collimators	High	Not needed	Classical OAP
Echelle grating	Very low	Not identified	Single provider, UV compatibility to be assessed, space qualification required, availability in 15y, …
Cross-dispersers	Medium	TBD	Under study with Horiba Equivalent grating have flown.
EUV coating	Medium	LUMOS coating	
MNUV coating	Medium	LUMOS coating	developments are expected
FUV detector	Medium	CPA under dev.	Based on LUMOS
MUV detector	Medium	CPA under dev.	Based on LUMOS
NUV detector	High	Not needed	Equivalent already flying

Preliminary radiometric estimate

	EUV				MUV			NUV			
Wavelength (nm)	**90**	**98**	**115**	**120**	**120**	**150**	**200**	**250**	**300**	**350**	**400**
POLLUX+Telescope (w/o pol)	0,01%	0,01 %	1,73 %	3,00 %	1,35 %	1,60 %	2,39 %	2,39 %	2,39 %	2,39 %	2,39 %
POLLUX (max)+Telescope (w/o pol)	0,06%	0,04 %	5,10 %	8,81 %	3,97 %	4,71 %	7,03 %	7,03 %	7,03 %	7,03 %	7,03 %
POLLUX+Telescope (with pol)	0,00%	0,00 %	1,07 %	2,19 %	0,67 %	0,80 %	0,00 %	0,60 %	0,96 %	1,20 %	1,20 %
POLLUX (max)+Telescope (with pol)	0,01%	0,01 %	3,13 %	6,43 %	1,98 %	2,36 %	0,00 %	1,76 %	2,81 %	3,52 %	3,52 %

- Assumming (to be consolidated a lot!):
  - 4 mirrors for the telescope (Al+AlF3+3A oxyde)
  - polarimeters from Arturo inputs
  - Coatings from Udo's inputs (i.e. Al+AlF3)
  - Gratings (echelle and cross-disperser): 50% (based on internal discussions)
  - Detectors 40% (based on internal discussions)
  - One folding mirror
  - Spatial splitter

Driving Requirements (currently)

- REQ 01: Spectral Resolution: 120 000 (200 000) ✔
- REQ 02: Waveband:
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  - REQ02b: Minimum order length: 5 nm ✗
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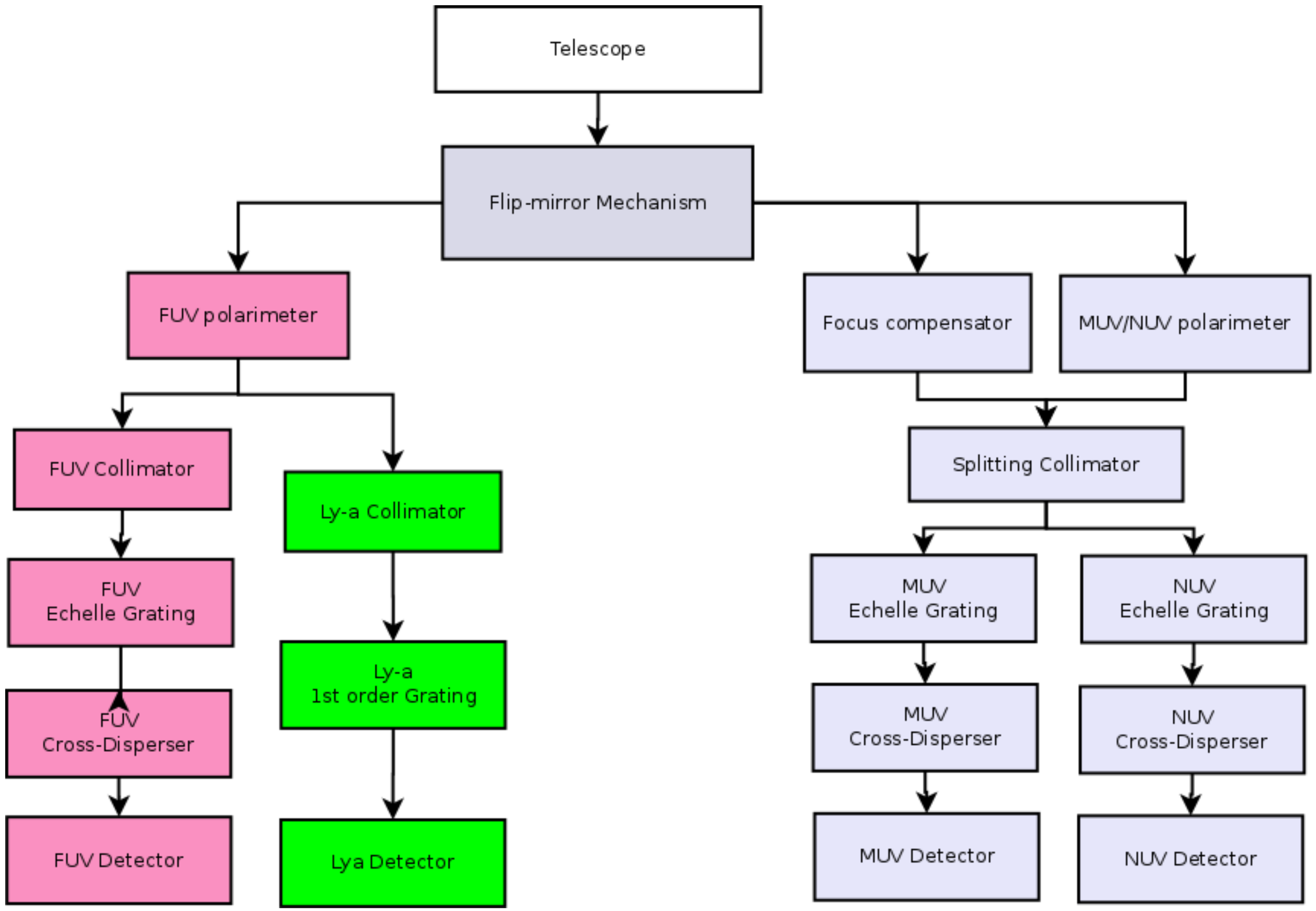
(possible) Alternative Architecture



Open points

- Urgent
  - Define target and goal requirements (priorities)
- Critical point
  - Echelle grating based on the capability of a single company ! No back-up option with the same performance identified for the moment
  - Focusing compensator for the MUV and NUV channels
- Open points:
  - Aternative dedicated Ly-alpha channel
  - Cross disperser performance (e.g. improved with ion etching)
- Next steps:
  - Tune the numbers to have a coherent design and a consolidated baseline !
  - Optical analysis (preliminary tolerances)
  - Mechanical architecture and preliminary design (volume and mass estimates)
  - Electrical architecture and preliminary design (power consumption estimate)