LUVOIR/POLLUX
First sizing and preliminary thoughts

Workshop, IAP

3/4/17

Introduction

- Aims of this talk
  - To give an overview of the current status of POLLUX
    - Defining the top-level opto-mechanical architecture of POLLUX
  - To share concerns/possible solutions
  - To identify priorities in the requirements (if any)

- All points addressed here are proposals and/or examples… nothing frozen yet !

Top-level Scientific Requirements

- REQ 01: Spectral Resolution: 120 000 (200 000)
- REQ 02: Waveband:
  - REQ 02a: 98-390 nm (90-visible)
  - REQ02b: Minimum order length: 6 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
- + SNR=10^5 below 156 nm integrating for 15 hours over 0.1 nm a total flux of 5x10^-17 erg cm^-2 s^-1
- REQ 04: Polarization
  - REQ 04a: Circular + linear
  - REQ 04b: Sensitivity: 10^-6 – 10^-11
- REQ 05: Aperture size: 0.03''
- REQ 06: Observing mode: with and without polarimetry

Top-level Scientific Requirements

- REQ 01: Spectral Resolution: 120 000 (200 000)
- REQ 02: Waveband:
  - REQ 02a: 98-390 nm (90 visible)

Not considered yet:

Magnitude faintest target: V=26

Radial velocity stability: 1/10th of pixel

Flux stability: 0.001% over 30h

Time resolution: 1sec in FUV and 30sec in NUV

Max exposure time : 30h

brown

r 0.1

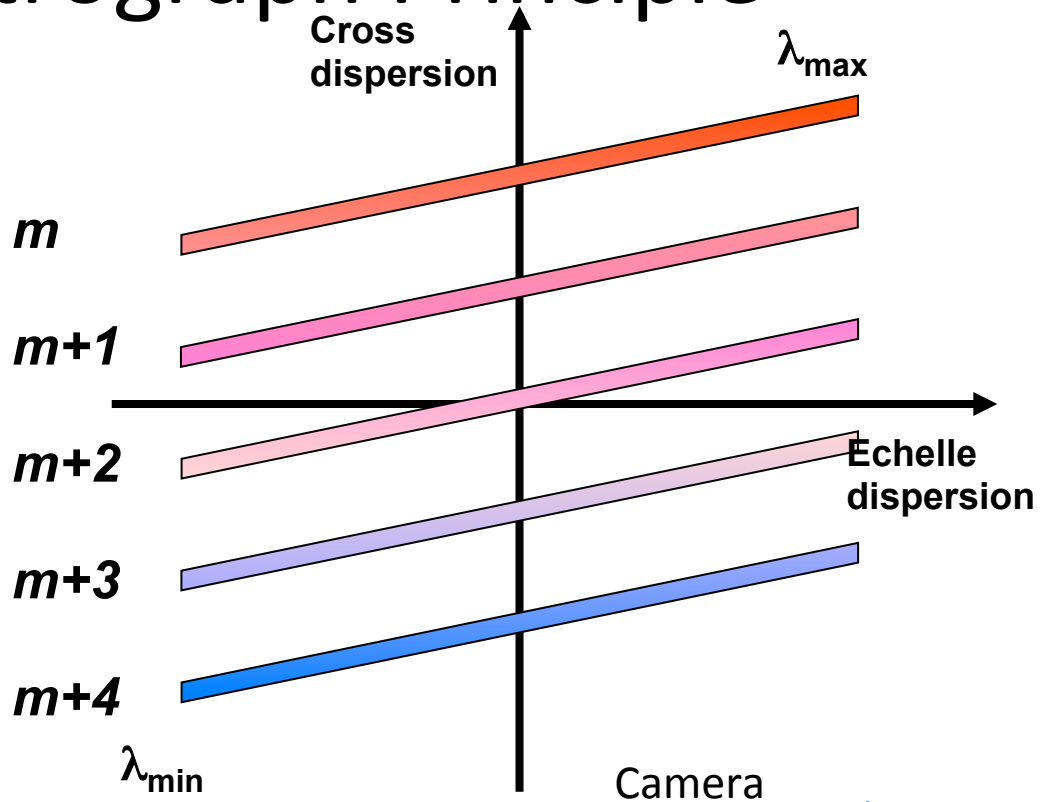
- REQ 04: Polarization
  - REQ 04a: Circular + linear
  - REQ 04b: Sensitivity: 10^-6 – 10^-11
- REQ 05: Aperture size: 0.03''
- REQ 06: Observing mode: with and without polarimetry

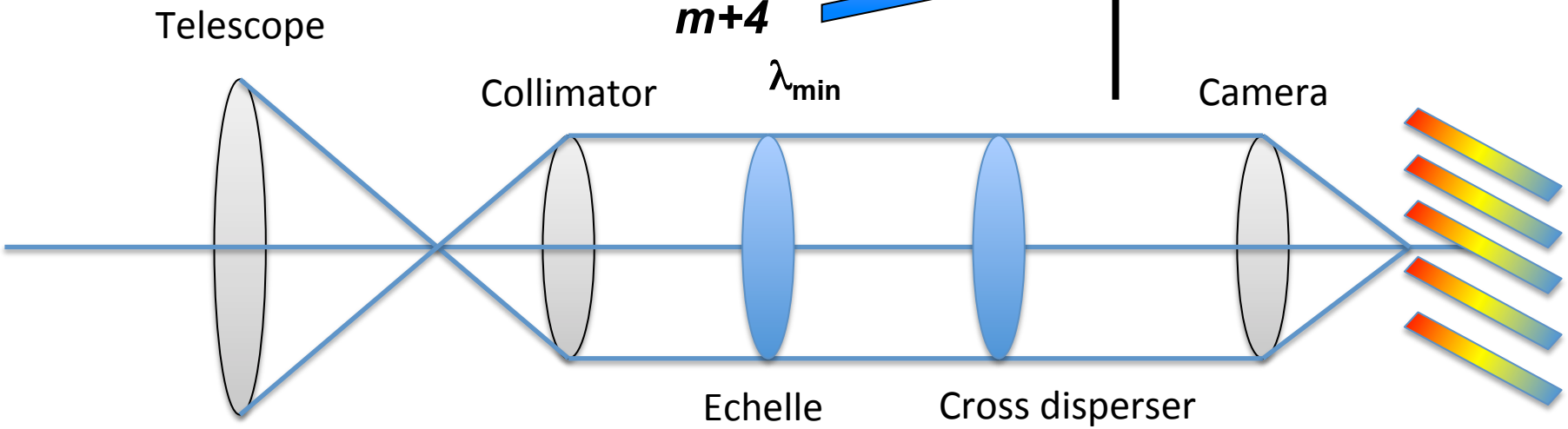
Echelle Spectrograph Principle

Spectral Resolution

120 000 (200 000)

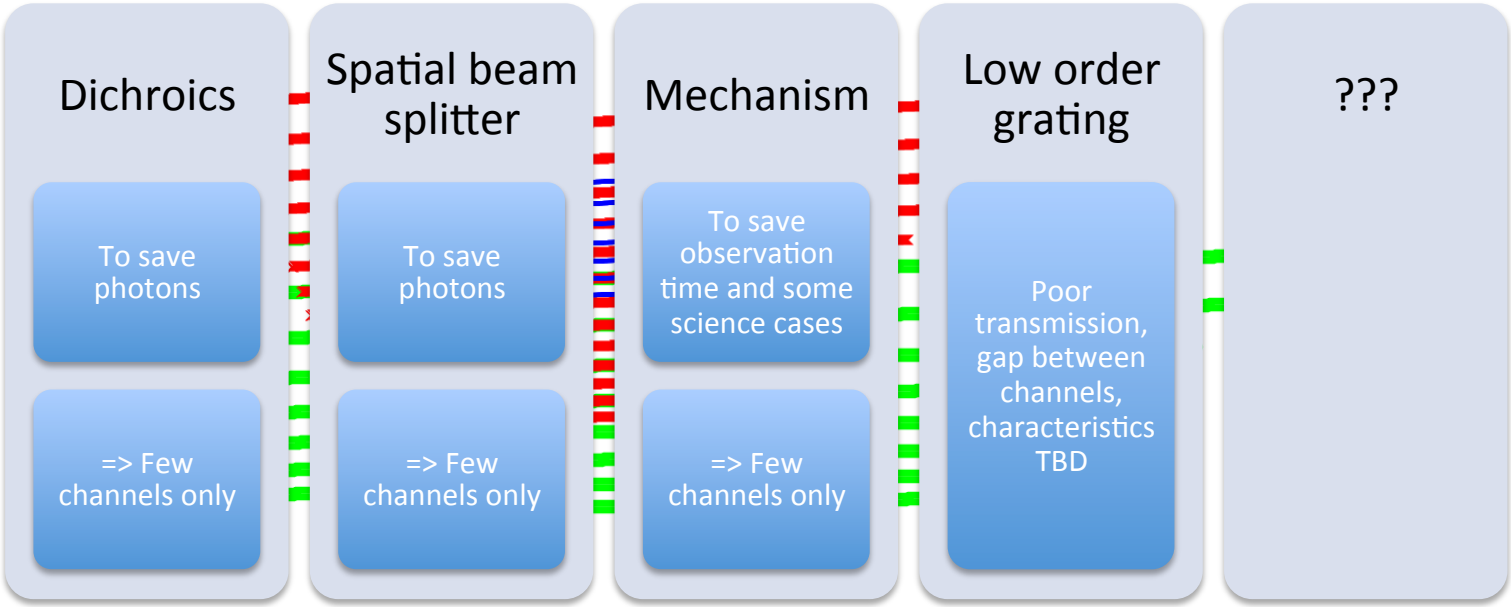
Echelle Spectrograph





Waveband: 98-390nm

- Need for a spectral separation
  - At least 2 channels are needed (2 octaves)
- Possible (identified) solutions:



- => Limit the amount of channels

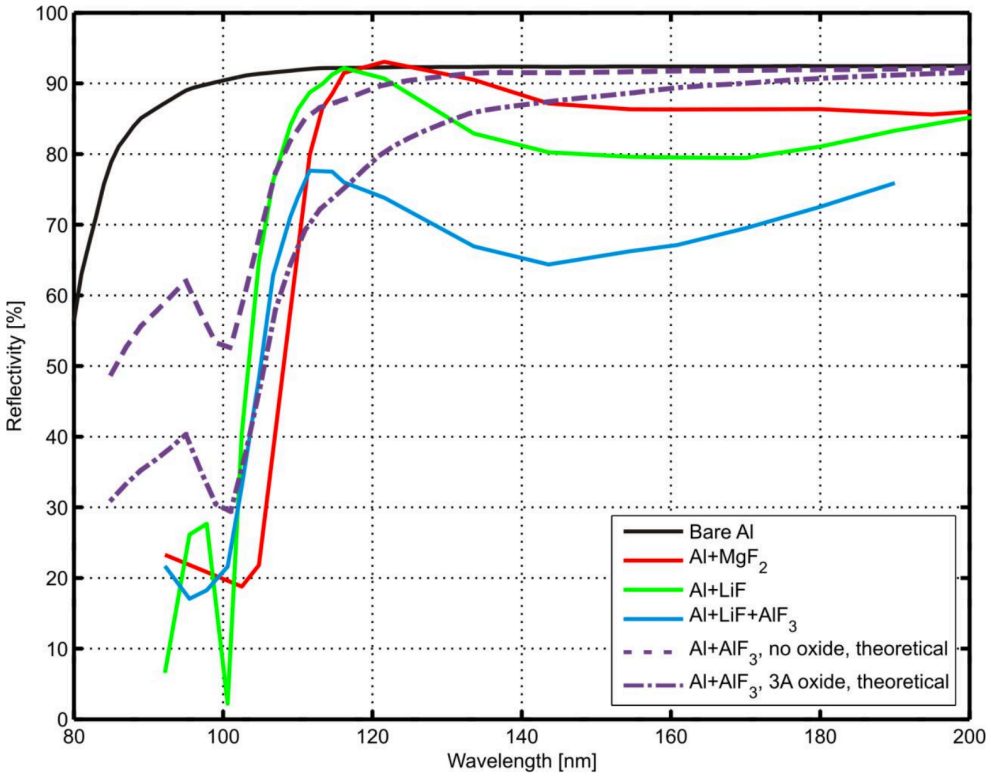
Channels

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

FUV	MUV	NUV
• ≈90nm • ≈125nm	• ≈120nm • ≈220nm	• ≈220nm • ≈400nm

- Rationales/drivers:
  - Minimum: 90nm discussed next slide
  - Maximum (400nm): related to the nb of octave
  - Intermediate (220nm): arbitrary (but detector limitations)
  - Overalap: depends on the technology (see architecture)

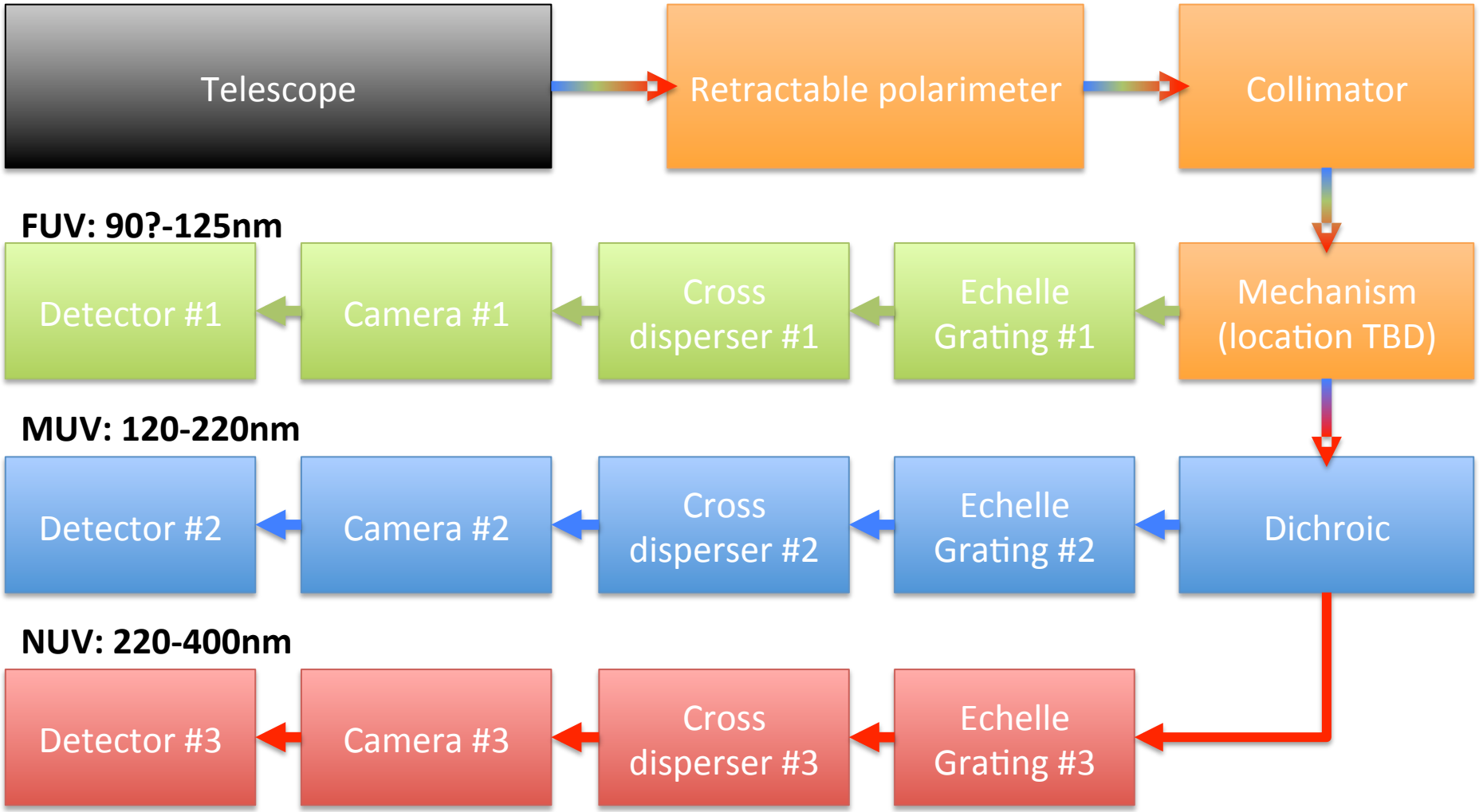
Minimal WB: 90 nm (goal)



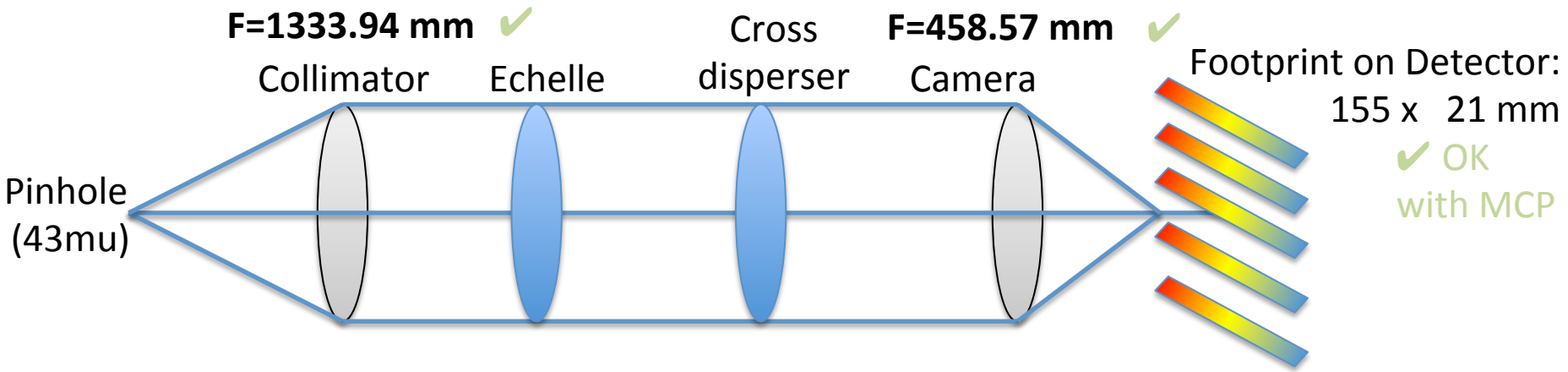
Extracted from tech. note LUVOIR; M. Bolcar

- Telescope Transmission
  - 30%^4 = 8%
- Instrument transmission
  - 50%^3 = 12.5%
- Optical efficiency: 1%
- Without polarization, without QE
- Impact on the transmission in the rest of the band

Example of Possible Architecture



Configuration #1: “fully” compliant



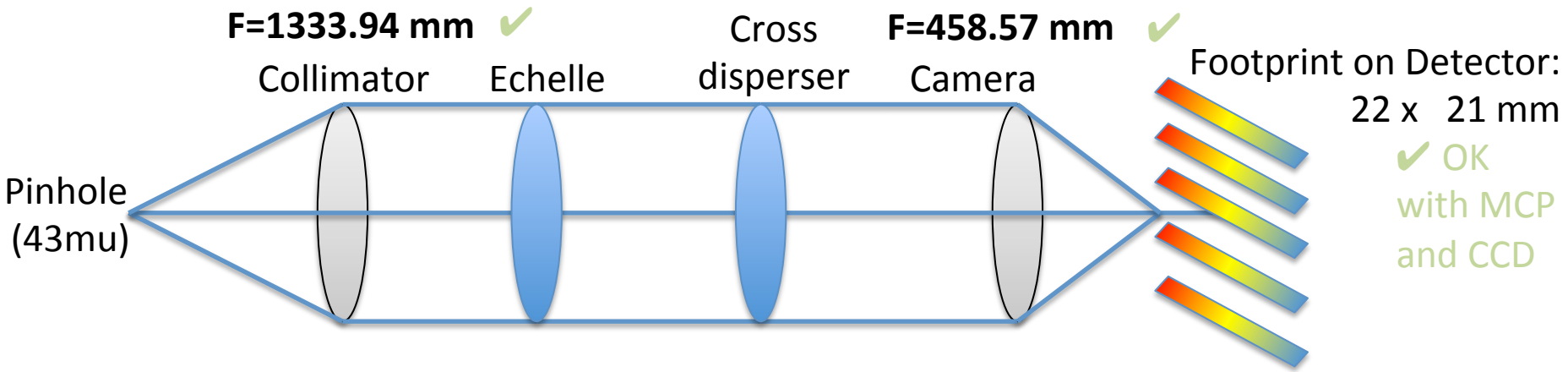
WAVELENGHT RANGE:
- From 120 to 220 nm
- Order size (max): 15.644 nm ✔
- Order size (min): 5.989 nm ✔

AVERAGE RESOLUTION: 124585 ✔
- Minimum Resolution: 91311 ✗
- Maximum Resolution: 208236 ✔

ECHELLE GRATING CHARACTERISTICS:
- Grating Blaze angle: 63.00 deg ✔
- Groove density: 675.00 lines/mm ✗ Not Usual
- Grating diameter: 66.70 mm by 146.91 mm ✔
- Grating orders from 12 to by 22 ✗ Not Usual

CROSS DISPERSER CHARACTERISTICS:
- Groove density: 450 lines/mm ✔

Configuration #2: “feasable” (today)



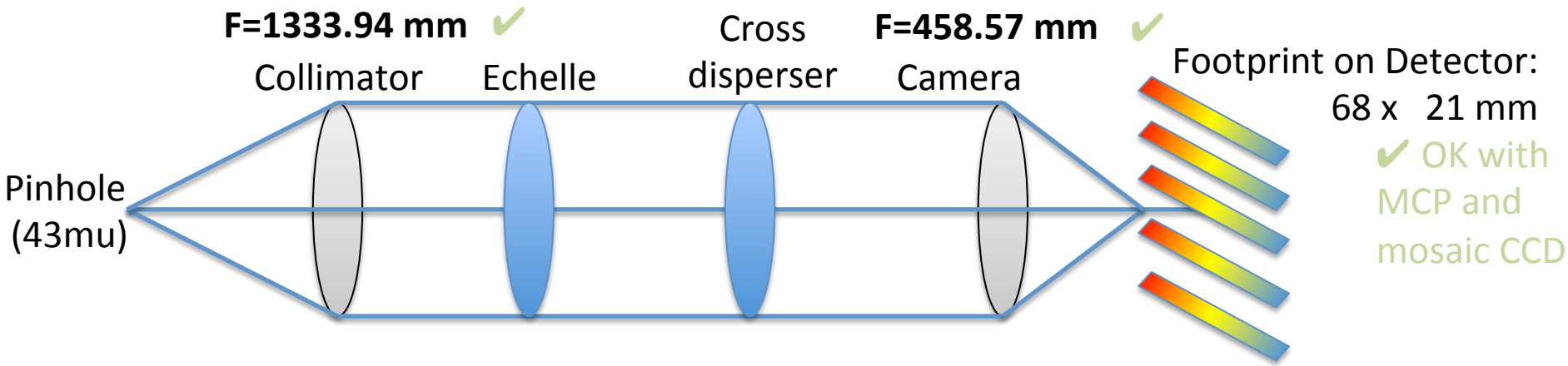
WAVELENGHT RANGE:
- From 120 to 220 nm
- Order size (max): 2.688 nm ✗
- Order size (min): 0.827 nm ✗

AVERAGE RESOLUTION: 119875 ✔
- Minimum Resolution: 113773 ✔
- Maximum Resolution: 126756 ✔

ECHELLE GRATING CHARACTERISTICS:
- Grating Blaze angle: 63.00 deg ✔
- **Groove density: 101.00 lines/mm** ✔
- Grating diameter: 66.70 mm by 146.91 mm ✔
- Grating orders from 80 to by 147 ✔

CROSS DISPERSER CHARACTERISTICS:
- Groove density: 450 lines/mm ✔

Configuration #3: “realistic” (tomorrow)



WAVELENGHT RANGE:
- From 120 to 220 nm
- Order size (max): 7.502 nm ✔
- Order size (min): 2.551 nm ✗

AVERAGE RESOLUTION: 124396 ✔
- Minimum Resolution: 106571 ✔
- Maximum Resolution: 150361 ✔

ECHELLE GRATING CHARACTERISTICS:
- Grating Blaze angle: 63.00 deg ✔
- **Groove density: 304.00 lines/mm** ✔
- Grating diameter: 66.70 mm by 146.91 mm ✔
- Grating orders from 27 to by 49 ✔

CROSS DISPERSER CHARACTERISTICS:
- Groove density: 450 lines/mm ✔

Open points impacting the architecture

- Most critical requirements
  - REQ02b: 6 nm/order leading to >600lines/mm
  - REQ02c: all the spectrum in oneshot
- Major identified trade-off:
  - Spectral separation
    - dichroics, mechanism, or any combination of them
  - Polarimeter retractability
    - If confirmed: mechanism + focus compensator to be studied
  - Detector technology and Pixel size:
    - impact of the detector cut-off, characteristics, pixel size, …
- Feasability studies
  - Echelle Grating with groove density higher than 100lines/mm
  - Coating performance expected
    - impact on the FUV and the need to retract the polarimeter
  - Cross disperser performance (e.g. improved with ion etching)
  - Large focal plane?

Not discussed here (yet)

- Polarimeter
  - Design based on mirrors to meet the shortest wavelength
- Detectors
  - Constraints to be taken into account
- Mass/volume

- And many more …