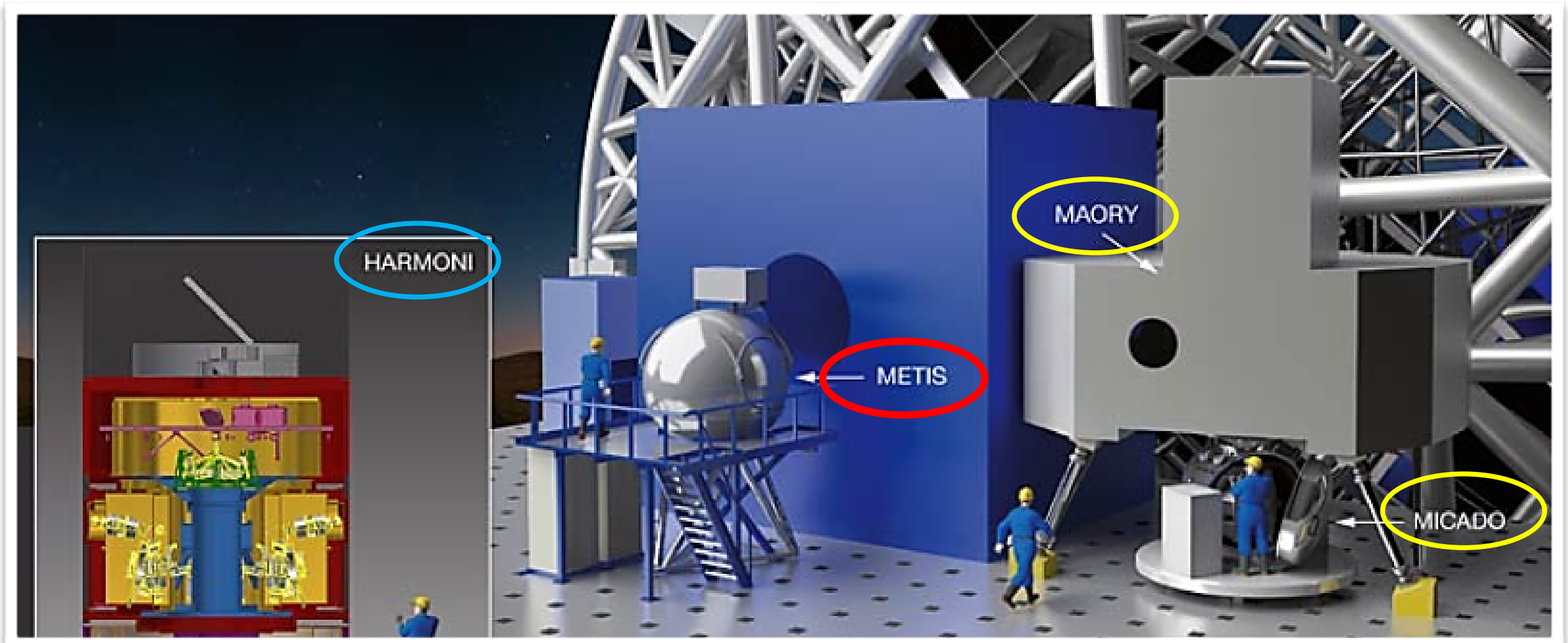
High-contrast imaging with E-ELT/METIS

Olivier Absil
Université de Liège

1st VORTEX international workshop — Caltech — August 2016

First E-ELT instruments approved

- Three « first light » instruments



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Project timeline

Total Project

No		Short description		Date
KM.1	KOM	ESO Kick-Off Meeting	T_0	**14-10-2015**
KM.2	PDR	Preliminary Design Review	T_0 + 24 months	**1-10-2017**
KM.3	FDR	Final Design Review	T_0 + 48 months	**1-10-2019**
KM.4	PAE	Preliminary Acceptance (Europe)	T_0 + 108 months	**1-10-2024**
KM.5	PAC	Provisional Acceptance	T_0 + 126 months	**1-04-2026**
KM.6	FA	Final Acceptance	T_0 + 150 months	**1-06-2027**

Phase B
Phase C
Phase D
Phase E

Phase-B

No		Short description		Date
	CM01	Ph-B Consortium kick-off		**28-09-2015**
KM.1	KOM	ESO Kick-Off Meeting		**14-10-2015**
	CM02	Consortium progress meeting	CM01 + 5 months	**Mar 2016**
	CM03	Ph-B consortium midterm meeting	CM01 + 12 months	**Oct 2016**
	CM04	Consortium progress meeting	PDR – 7 months	**Mar 2017**
		PDR documents delivery	PDR – 1.5 months	**Aug 2017**
KM.2		PDR	CM01 + 24 months	**Oct 2017**

now

Instrument baseline

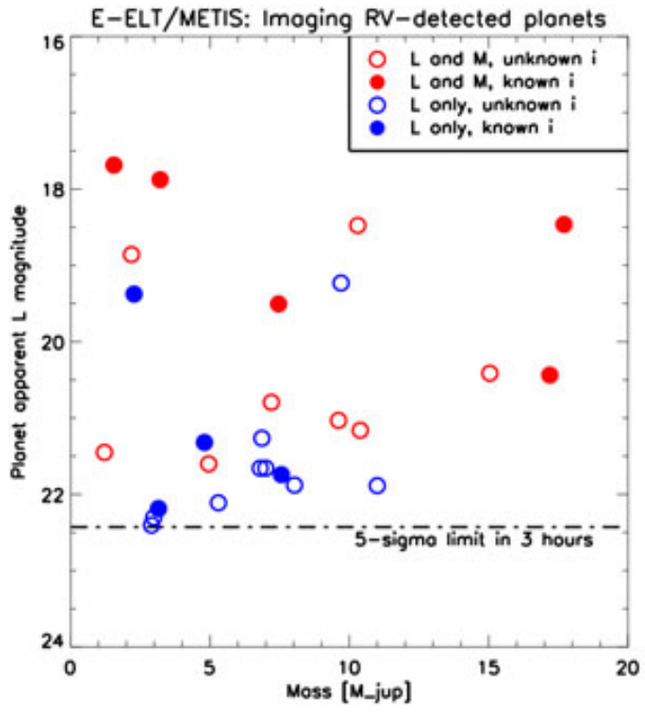
METIS will include the following observing capabilities:

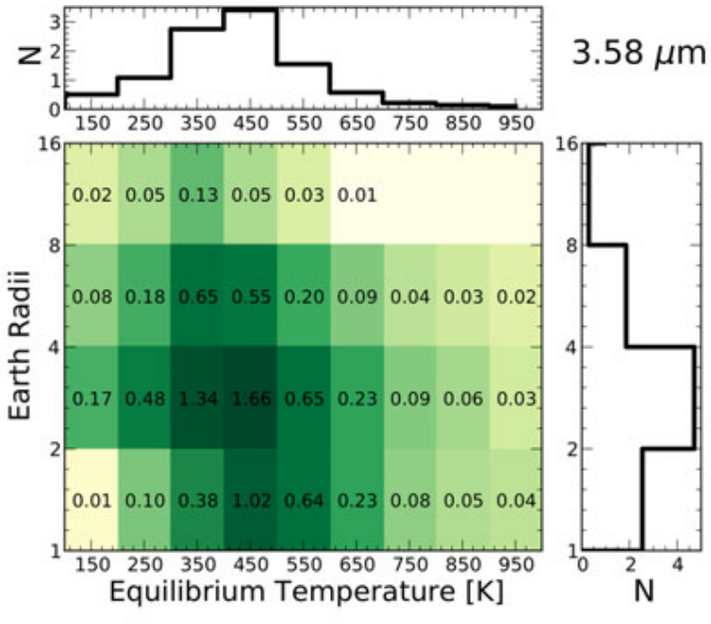
- **Imaging at 3 – 19 µm.** The imager includes low/medium resolution slit spectroscopy as well as coronagraphy for high contrast imaging.
- **High resolution (R ~ 100,000) IFU spectroscopy at 3 – 5 µm,** including a mode with extended instantaneous wavelength coverage.

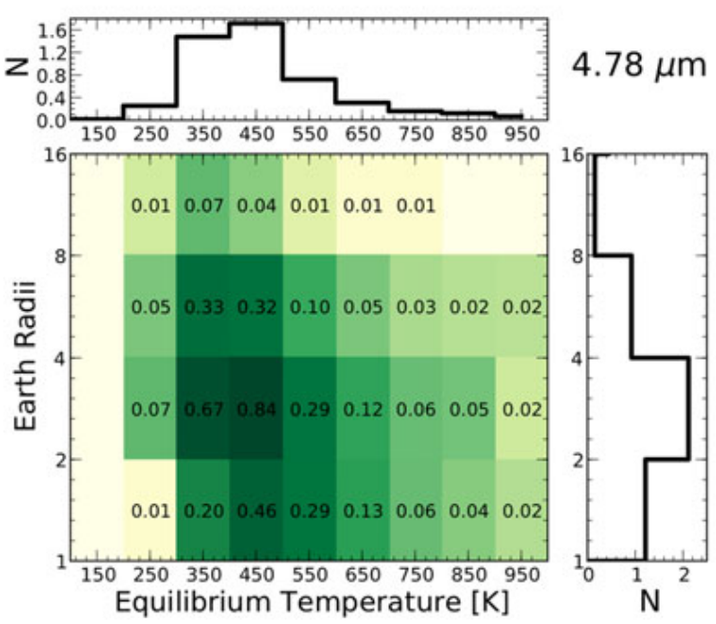
➢ All observing modes work at the **diffraction limit** with single conjugate (SC) and eventually assisted by a laser tomography adaptive optics (LTAO) system.

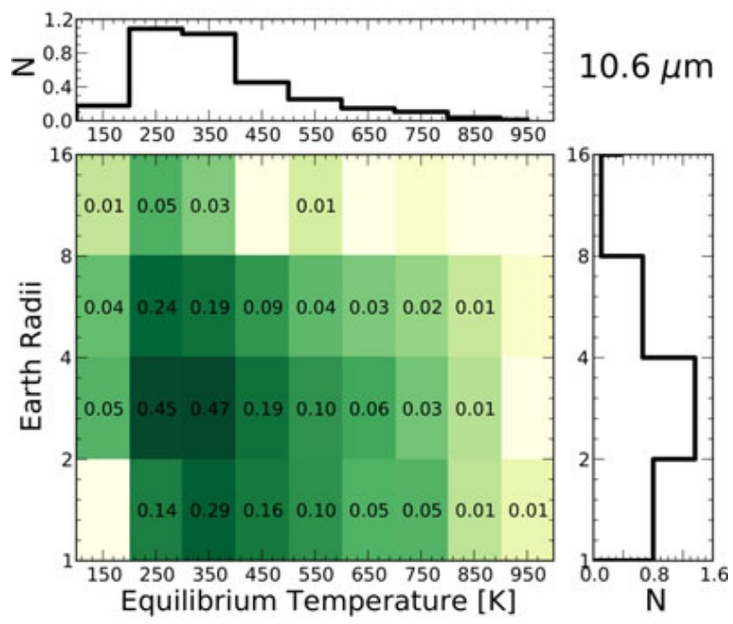
The sky's the limit … literally

- Thermal IR imaging & spectroscopy of RV giant planets
- Photometry of 1-4 $R_\oplus$ planets at room temperature









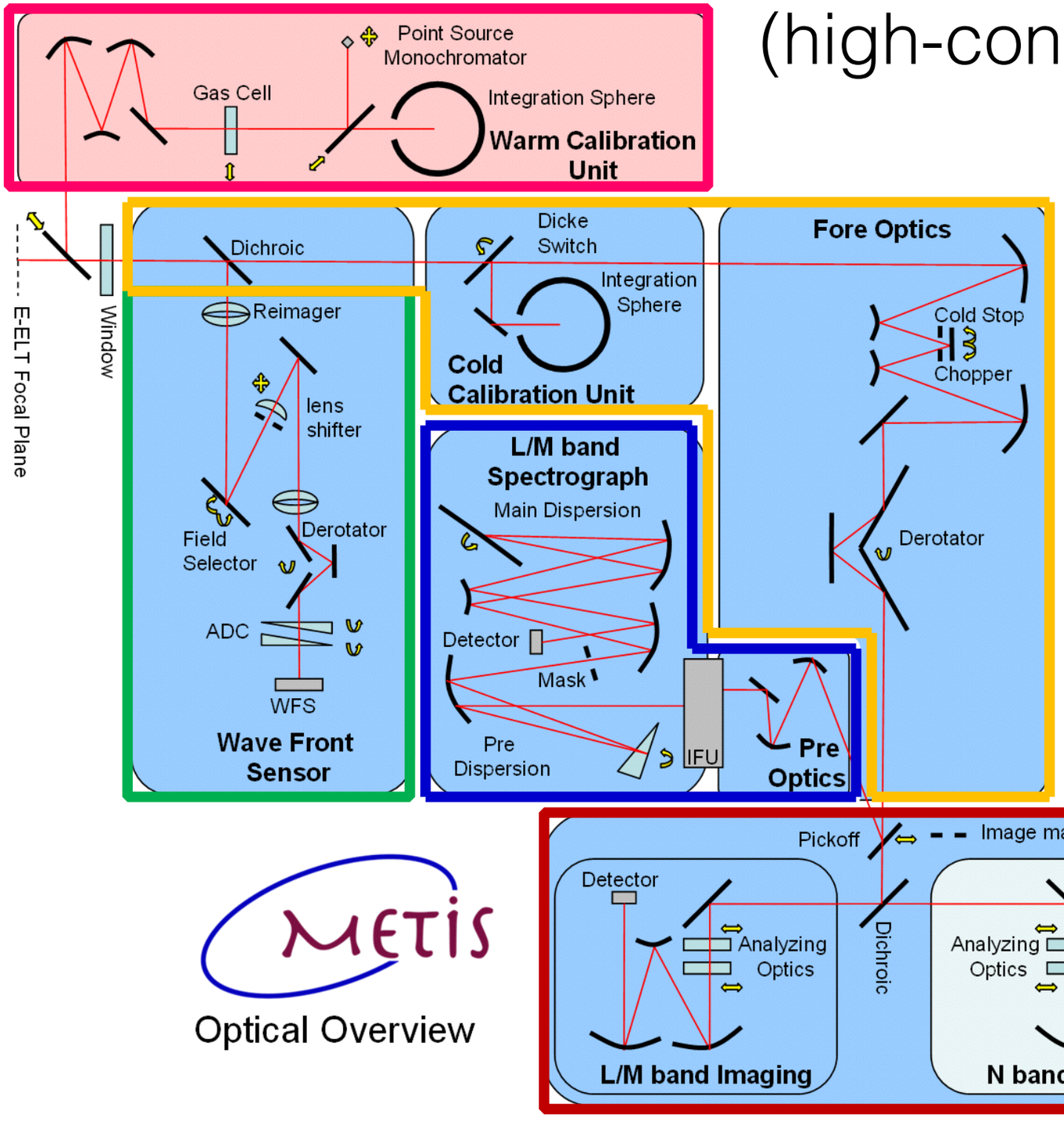
How to get there?

- Need to achieve background-limited performance as close as possible (baseline: 5 λ/D, goal: 2 λ/D)

- Two baseline high-contrast imaging modes:
  - AGPM vortex coronagraphy
  - (vector) Apodizing Phase Plate

From Phase-A design

(high-contrast barely considered)



METIS

Optical Overview

Common Fore-Optics

AO Wavefront Sensor

Imager

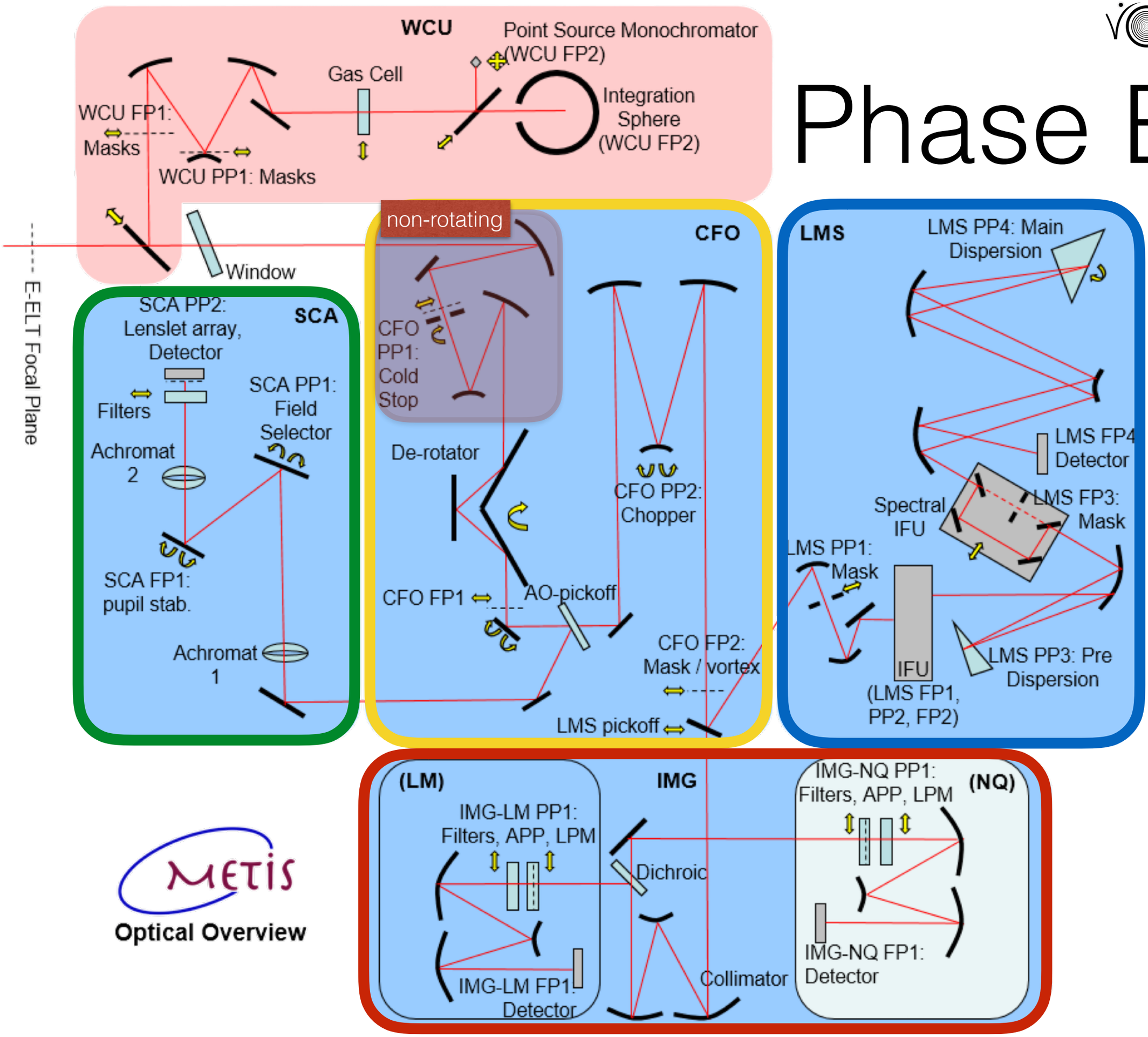
IFU Spectrograph

Warm Calibration Unit

to …

VORTEX

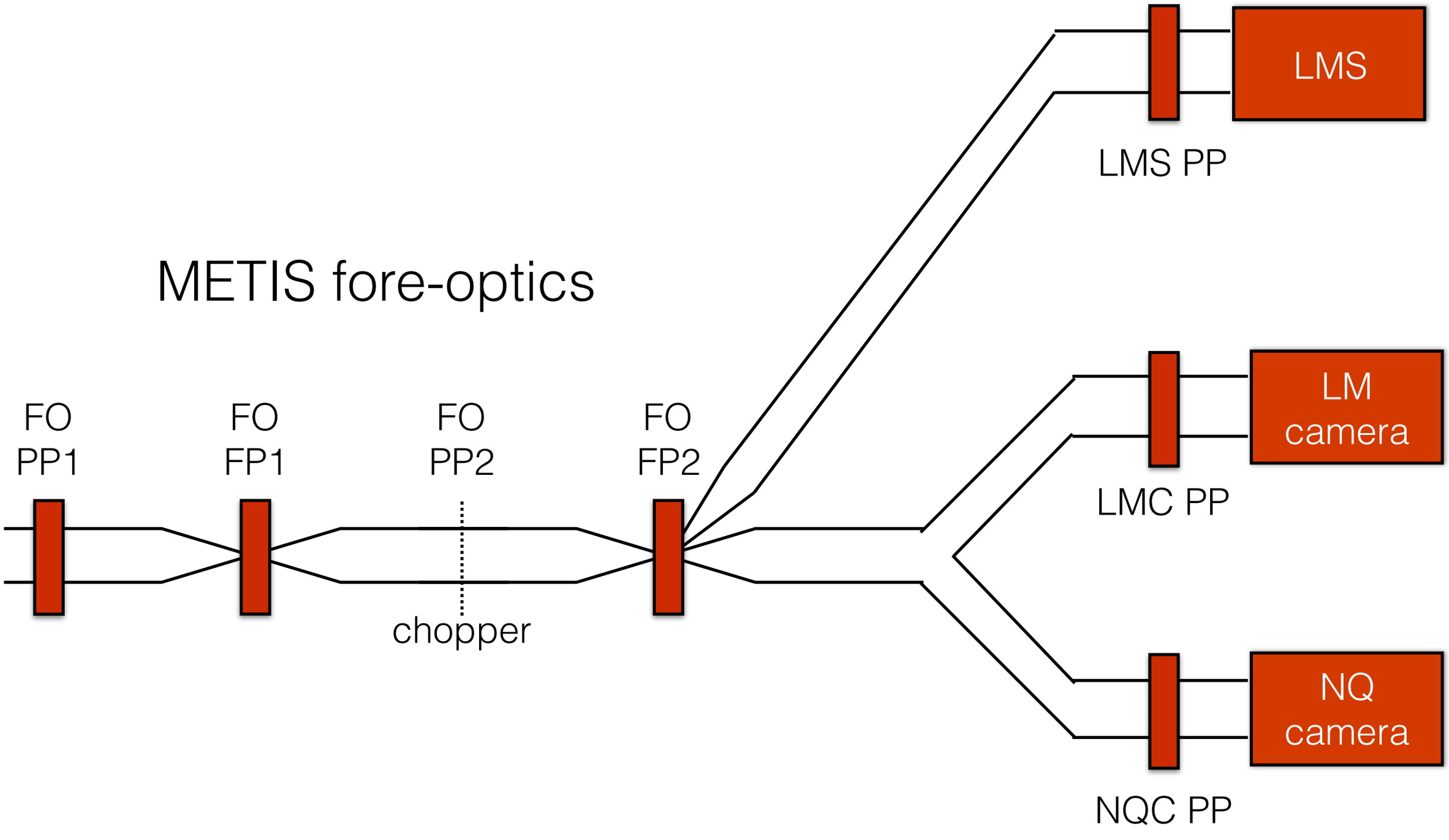
Phase B



METIS

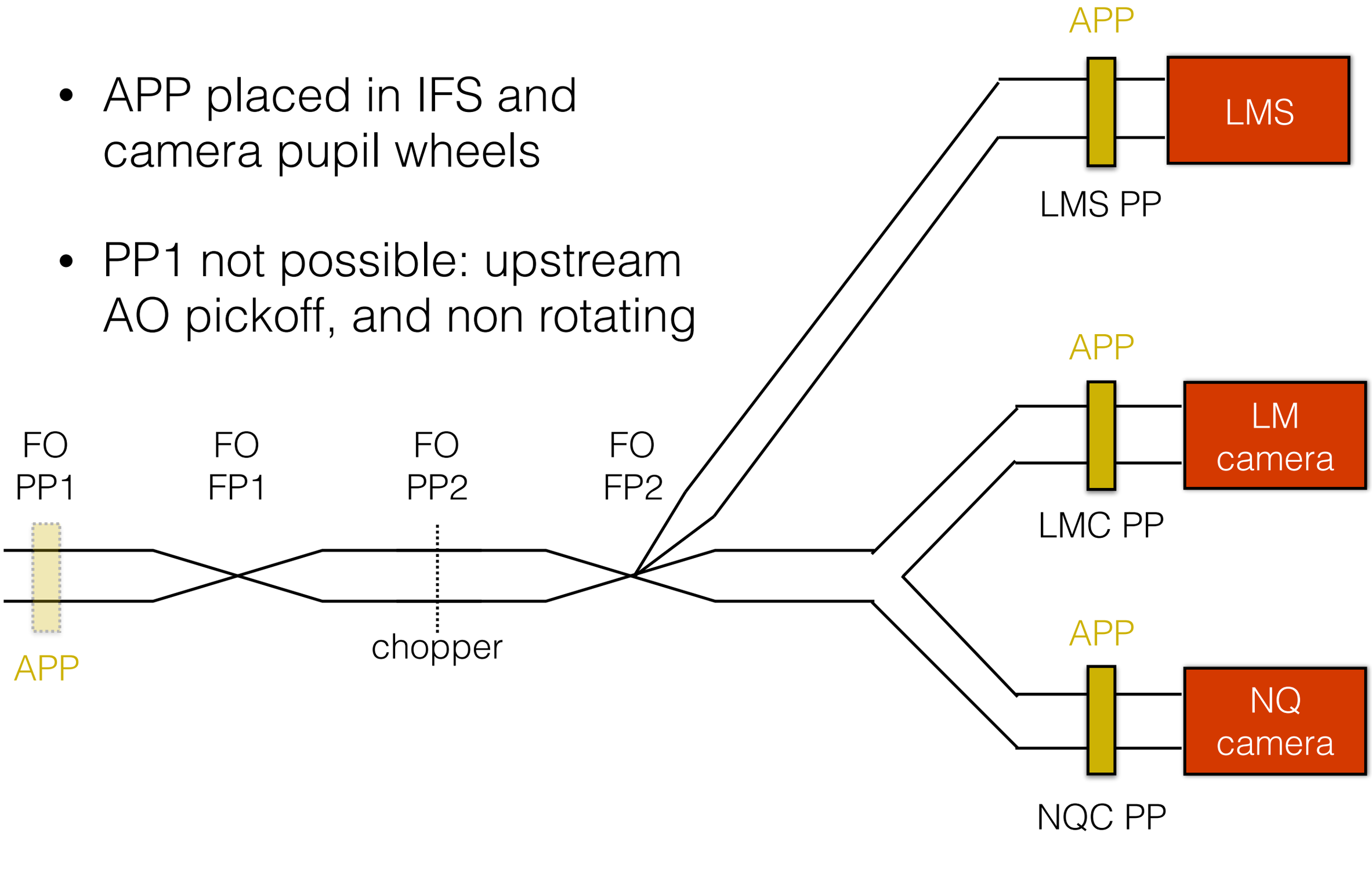
Optical Overview

Coronagraphic layouts



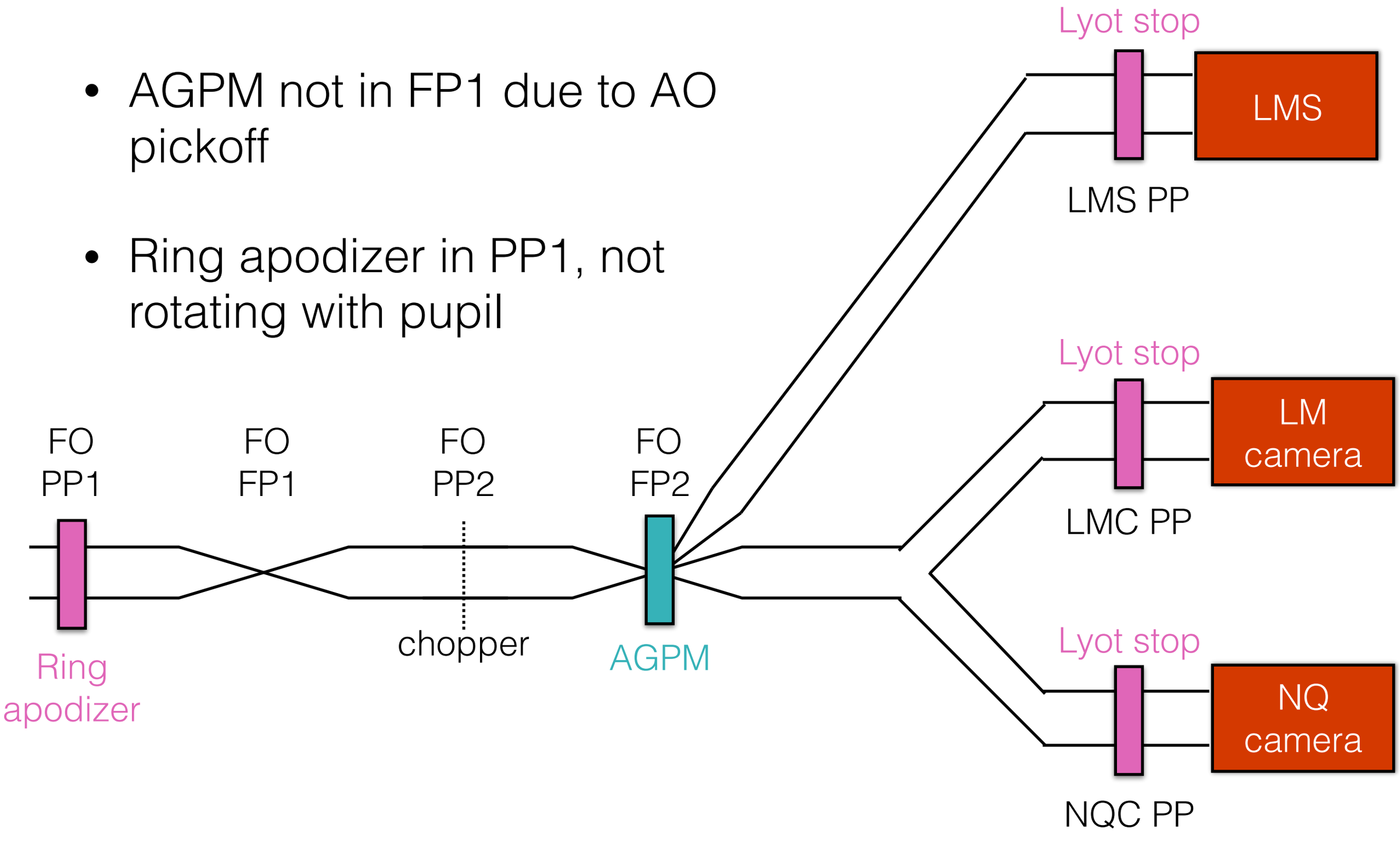
APP layout

- APP placed in IFS and camera pupil wheels
- PP1 not possible: upstream AO pickoff, and non rotating



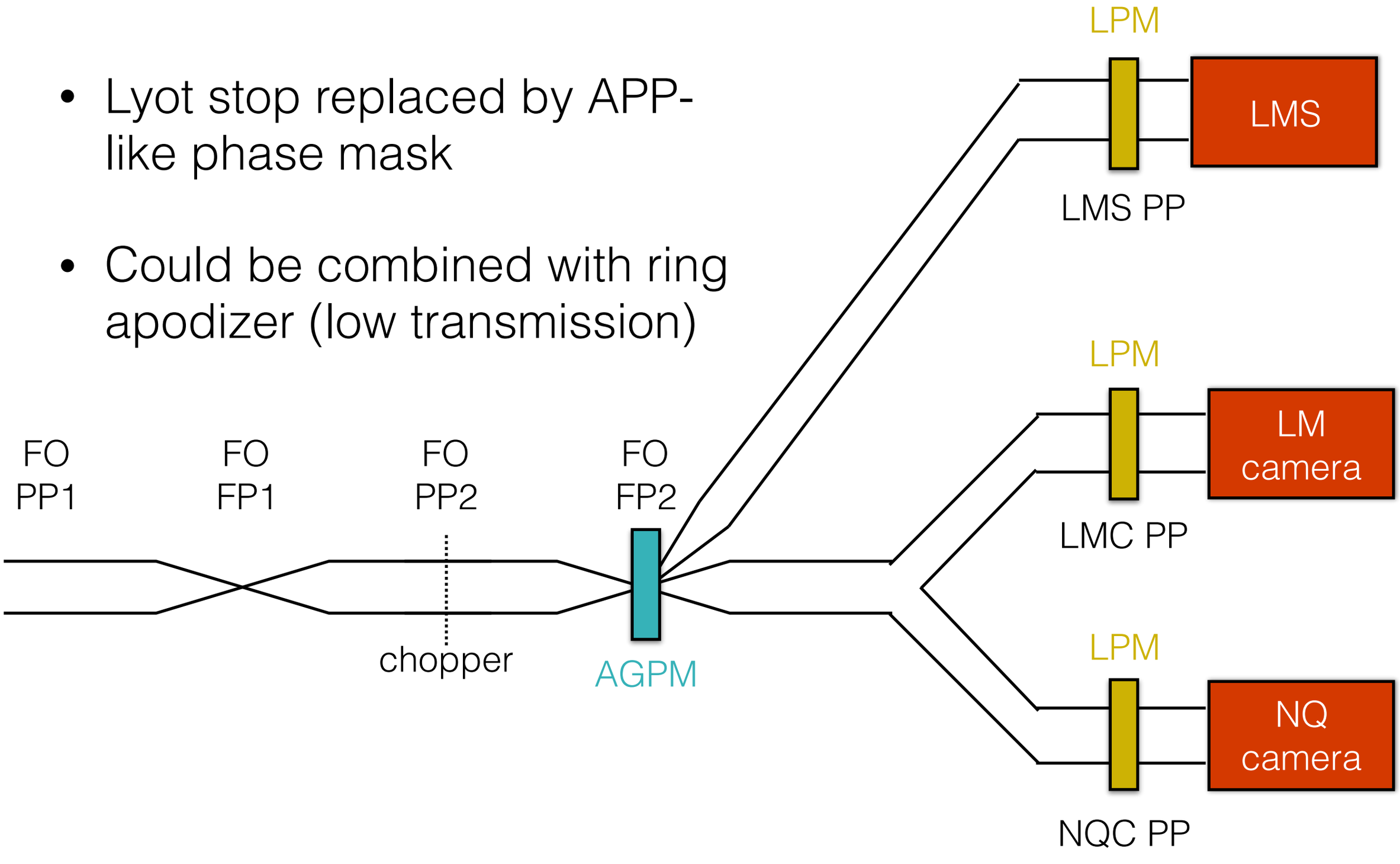
Ring-apodized VC layout

- AGPM not in FP1 due to AO pickoff
- Ring apodizer in PP1, not rotating with pupil



VC+LPM layout

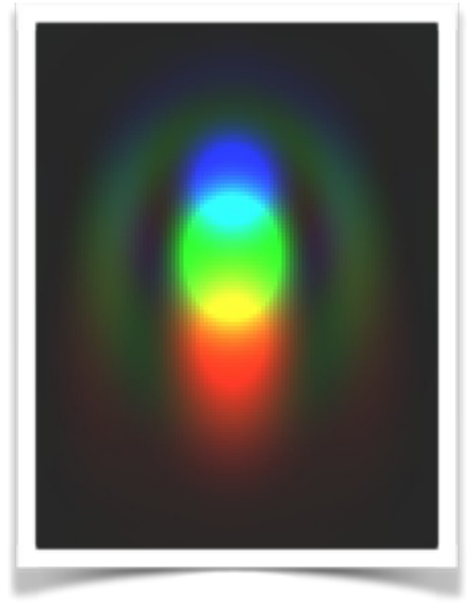
- Lyot stop replaced by APP-like phase mask
- Could be combined with ring apodizer (low transmission)



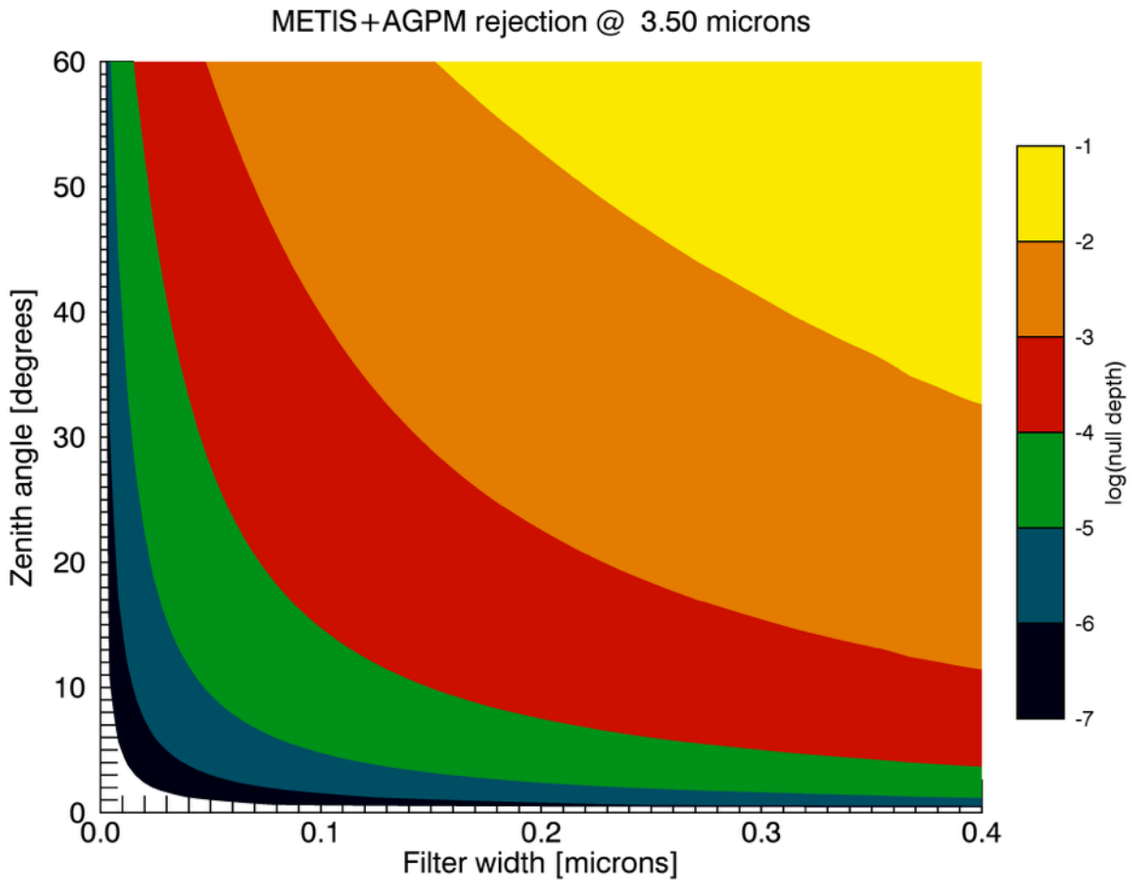
Main limitations / constraints of vortex observing modes

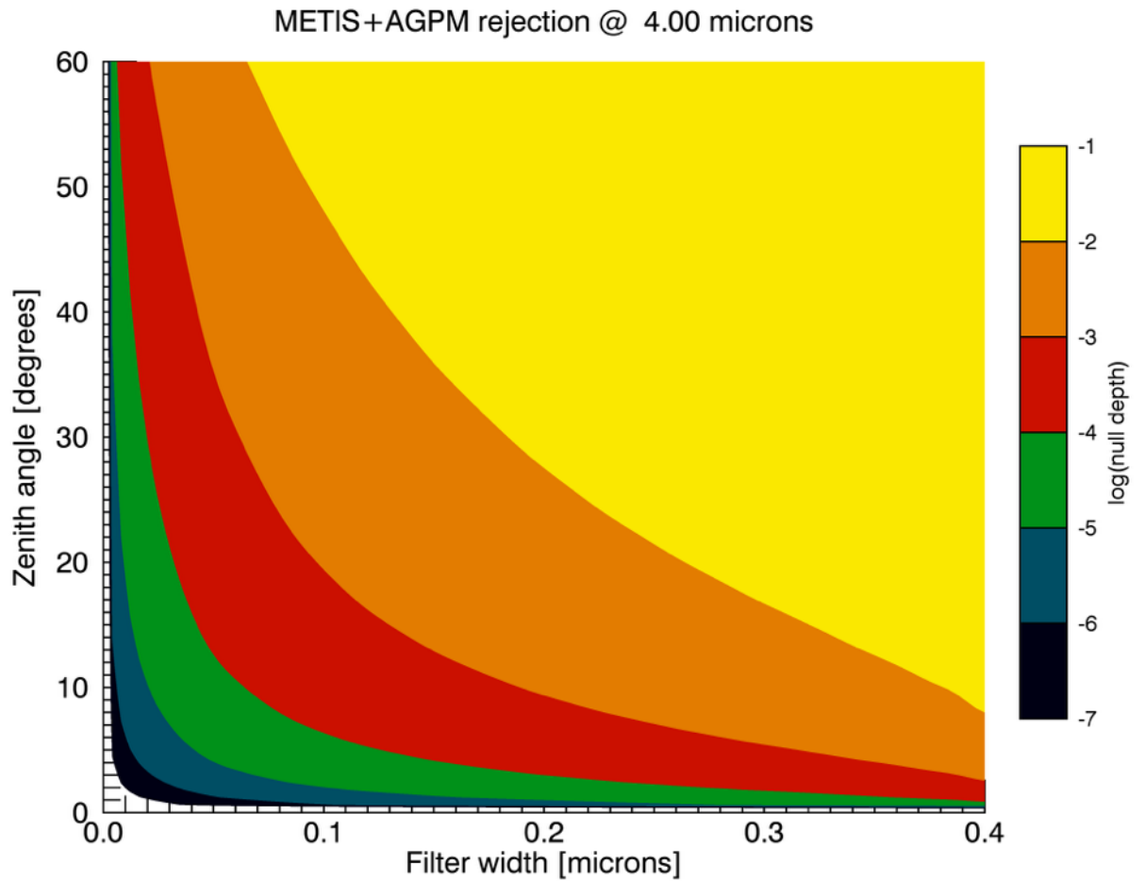
- Vortex downstream chopper —> no chopping, unless:
  - AGPM can be made « K-band invariant » —> in FP1
  - Two AGPMs side-by-side in FP2, and chopper very accurate
- Vortex+IFS combination not possible with AGPM in FP2:
  - AGPM and IFS pick-off both fixed wrt METIS FoV
  - IFS image slicer needs dithering for proper sampling
- Ring apodizer cannot be optimized for spiders
- No atmospheric dispersion compensator

No ADC: consequences on vortex observations

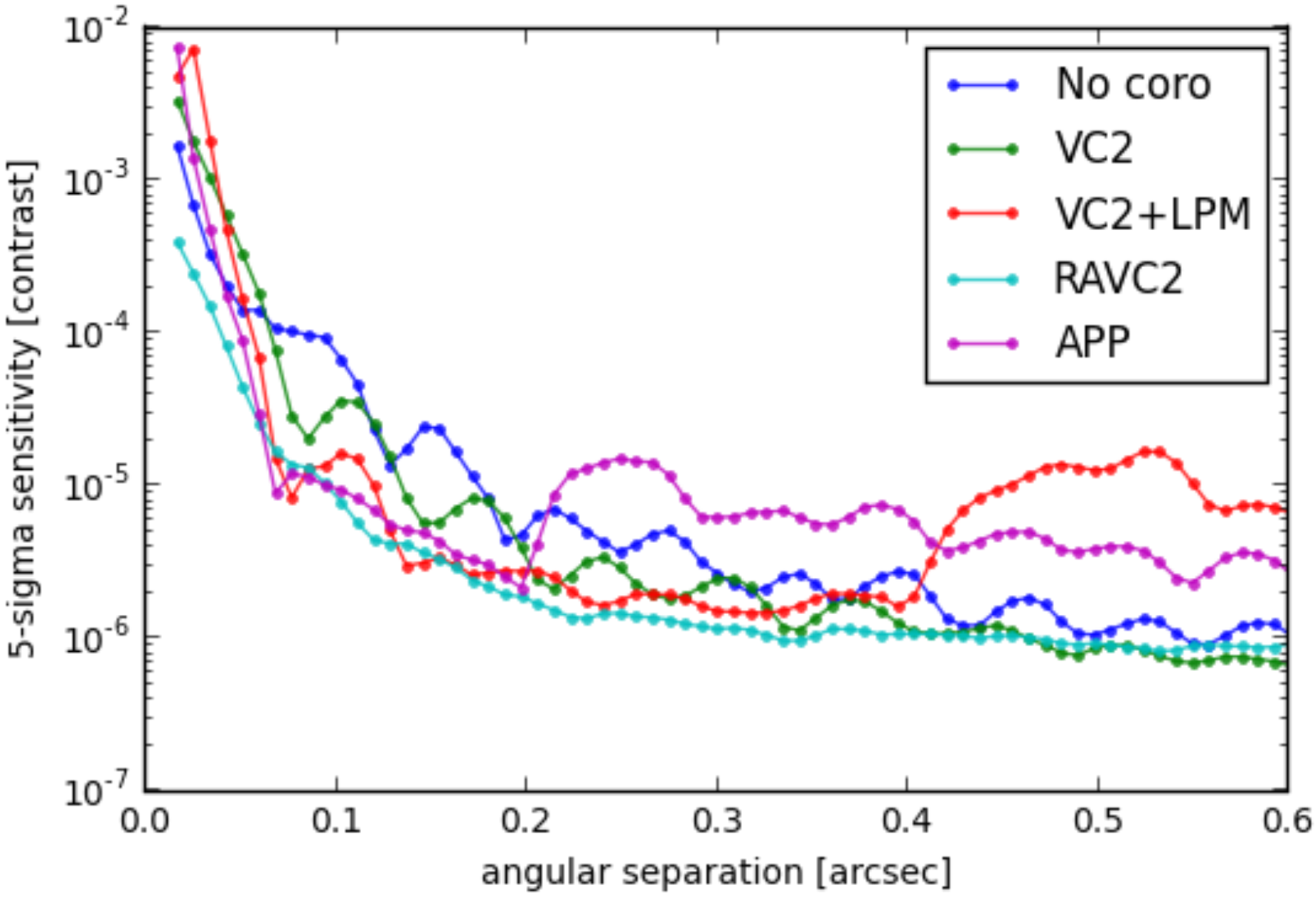


- AGPM can only be used close to zenith and/or in narrow-band filters
- Charge-4 vortex would greatly help





Expected ADI performance (see Brunella's talk this afternoon)



New apodizer solutions could significantly improve sensitivity

Main pending issues

- Finalize narrow & broad band filters —> will affect final AGPM parameters
- NCPA measurement technique?
- Charge-4 vortex design, manufacturing & testing
- Ring apodizer design, manufacturing & testing
- LPM design, manufacturing & testing