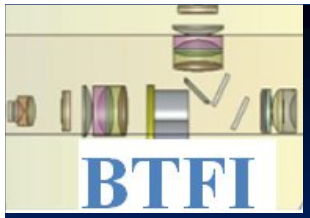


Instrument Overview

Keith Taylor (USP)

BTFI CoDR

24th September, 2007

Requirements & Performance (Pre-Sep'07)

Requirements:

- 370<λ<950nm (EMCCD)
- 4 science modes:
  - 2 * Spatial-Resolutions
    - SL or GLAO
  - 2 * λ-Resolution Ranges
    - FP or iBTF
- FP (single)
  - High-R ; Big ; Expensive
  - Supplier = SESO
    - Δℓ ~200μ (cf: QI ~4μ)
- iBTF (multiple)
  - Low-R ; Compact; Cheap
    - Tx; Scan-range Large
    - Rx; Scan-range Small
  - Complementary channel

Performance Summary:	**Seeing-limited**	**GLAO**
FoV	6*6 arcmin	3*3 arcmin
Sampling	0.23 arcsec	0.12 arcsec
FP (N~30) **Single FP**	Gap range, $\Delta\ell$ ~200μ ($\delta\lambda \sim \lambda^2/2\ell N$) Scan range, $\Delta\lambda \sim 30*\delta\lambda$ FP[1]+Filters 250<R<25,000	
iBTF		
DCG	Transmission: 5<R<15	
	Reflection: 10<R<50	
Doped-Glass	Transmission: 200<R<1,000	
	Reflection: 300<R<2,000	

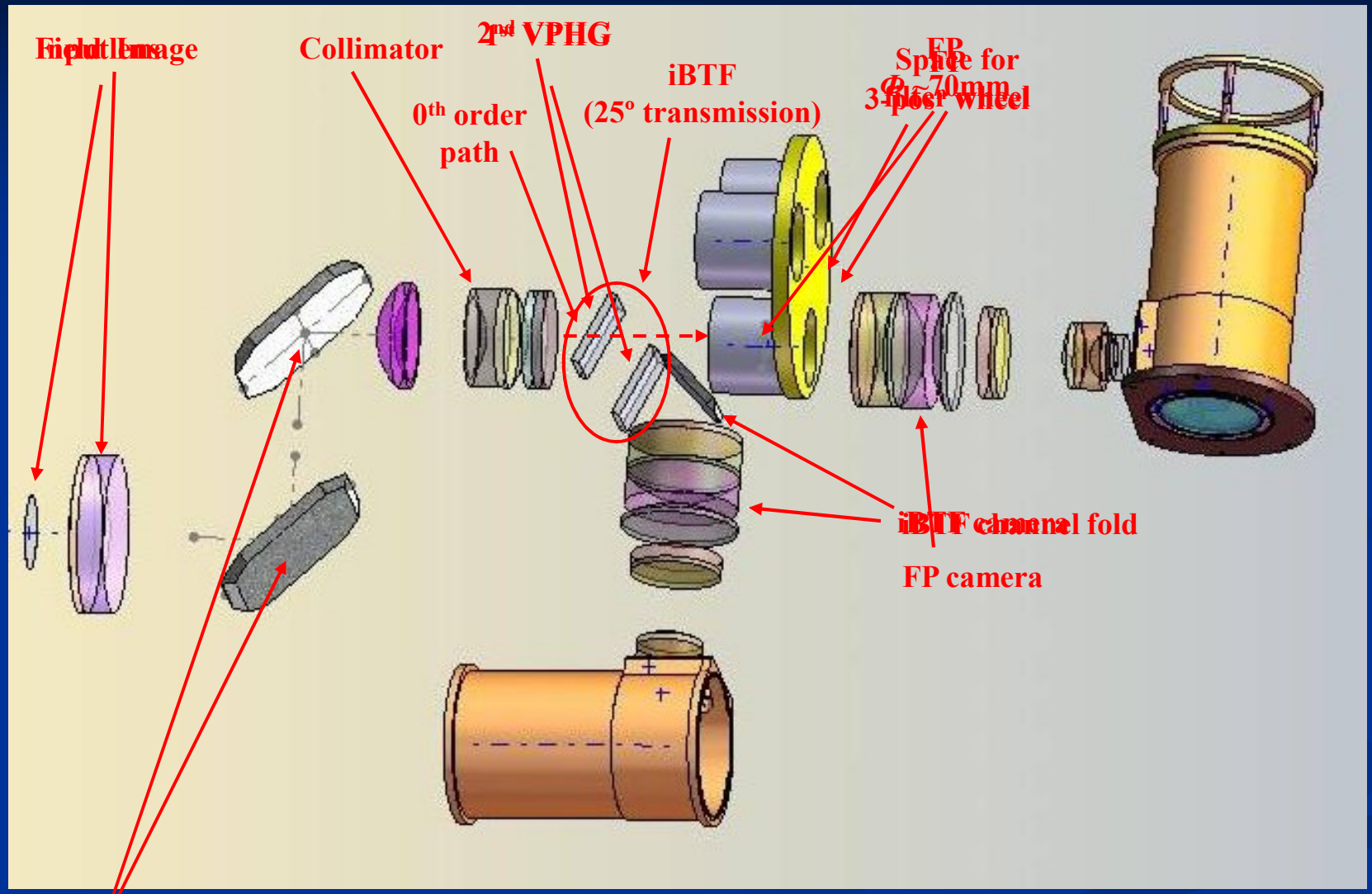
Performance Summary

- Field of View (assuming EMCCD – 1600^2 ; 16μm pixel)
  - GLAO-fed - FoV ~3' ; Spatial sampling ~0.12" (f/6.7 camera)
  - SL-fed - FoV ~6' ; Spatial sampling ~0.24" (f/3.3 camera)
  - IQ for both systems: 80%EE within 2 pixels
- Spectral Resolution:
  - iBTF: $5 < R < 5{,}500$
  - FP: $250 < R < 40{,}000$
- Peak [Average] efficiency > 18 [10]%
  - Telescope: ~61% [61%]
  - SAM: ~66% [59%]
  - BTFI: ~51% [40%]
  - CCD ~93% [61%]

Instrument Throughput

Wavelength	(nm)	350	450	550	650	750	850	950	Peak (%)	Average (%)
	Surface									
Telescope									61	61
	3 * Al reflections	0.61	0.61	0.61	0.61	0.61	0.61	0.61		
SAM									66	59
	4 * Hg reflections	0.65	0.71	0.81	0.90	0.92	0.94	0.96		
	1 * DM	0.84	0.84	0.84	0.84	0.84	0.84	0.84		
	1 * Dichroic	0.90	0.90	0.90	0.90	0.90	0.90	0.90		
	4 * A/R surfaces (MgF2)	0.89	0.93	0.95	0.95	0.93	0.92	0.91		
BTFI									51	40
	18 * A/R surfaces (MgF2)	0.59	0.72	0.79	0.79	0.72	0.69	0.65		
	2 * Hg reflections	0.81	0.84	0.90	0.95	0.96	0.97	0.98		
	Filter	0.85	0.85	0.85	0.85	0.85	0.85	0.85		
	FP (or BTFI)	0.60	0.70	0.80	0.80	0.80	0.70	0.60		
CCD		0.20	0.78	0.93	0.90	0.77	0.50	0.22	93	61
Totals	(%)	1	9	16	18	14	8	3	18	10

BTFI – current, 2-channel, configuration

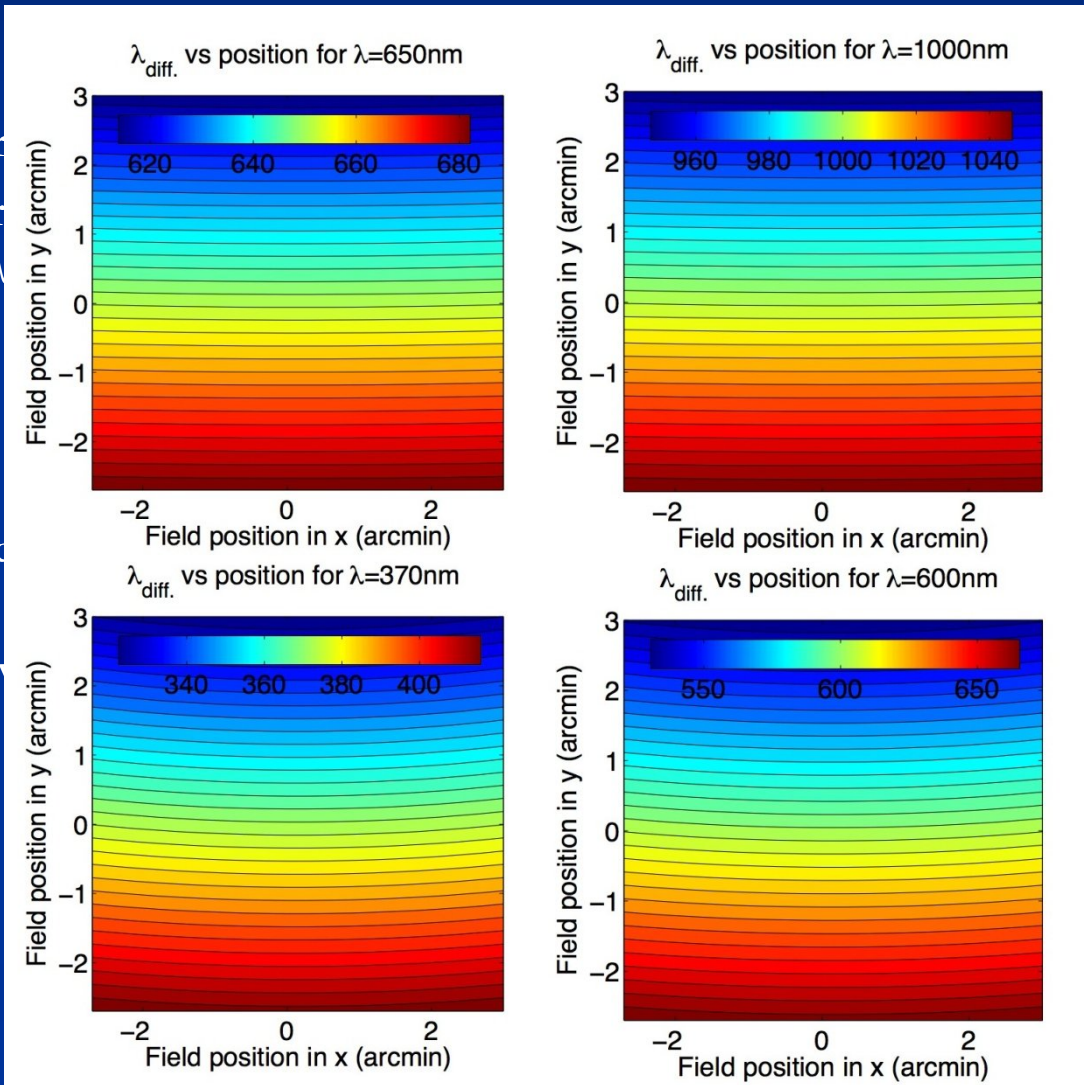


Concept Evolution

- Oct'06: iBTF concept introduced as an alternative to Claudia's FP concept
  - Problems:
    - Maximum R? – R<5,000 (est.)
    - 20<R<200 – dead zone? ***– Tertiary concern***
    - Severe λ gradient in dispersion dir^{n}. ***– Secondary concern***
    - Could iBTF support wide field angles (<6°)? ***– Primary concern***
- Dec'06: PhotonEtc's 1st report on iBTF
  - ***Confirms Tertiary concern***
- Feb'07: PhotonEtc's 2nd report on iBTF
  - ***Quantifies Secondary concern***

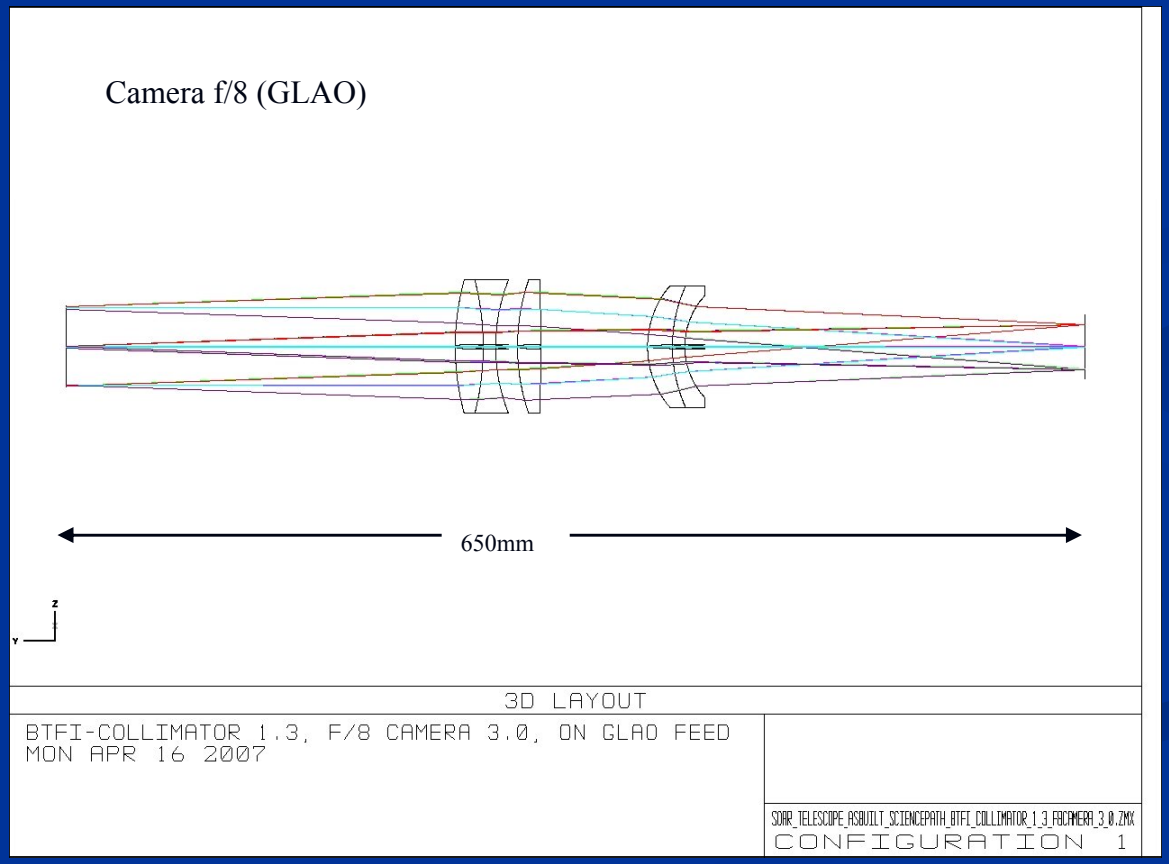
Transmission gratings λ-gradient

- 2 different gratings needed
  - cover 370-625nm and 625-1000nm r
  - angles ranging from [23,9°;46,3°] for the « red » grating for low and high λ
- Effect (Δλ) reduced by:
  - Larger tilt angles
    - Smaller (<25°) tilt angle cause 0th orc
  - SL ⇨ GLAO – by factor of 2
    - Argument against seeing-limited, Fo
  - λ-scan >> Δλ
    - Compatible with iBTF survey mode

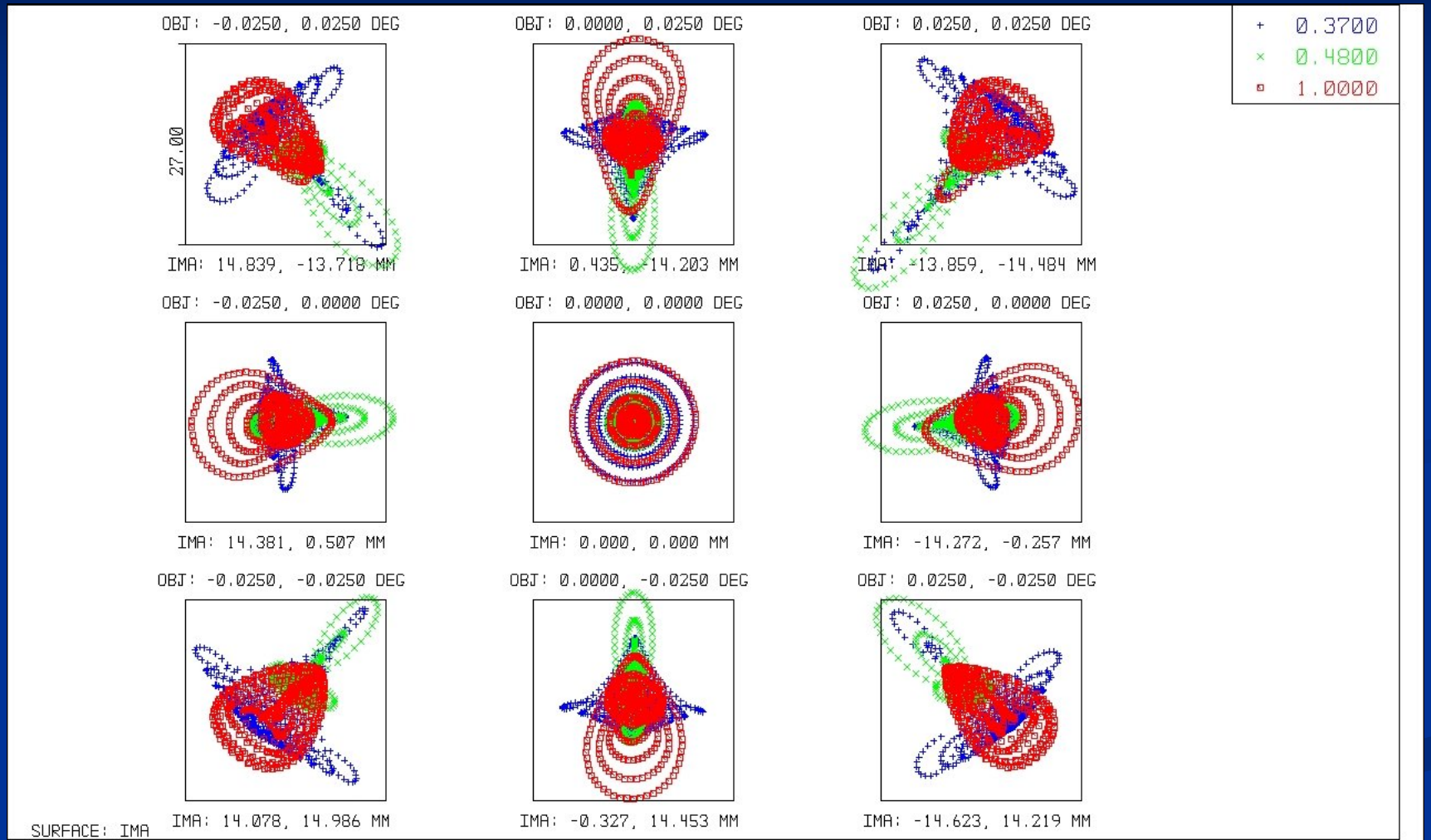


Concept Evolution, cont.

- Mar'07: Collimator/camera designs (Damien Jones)
  - Designs successful and *still current*



Spot Plots

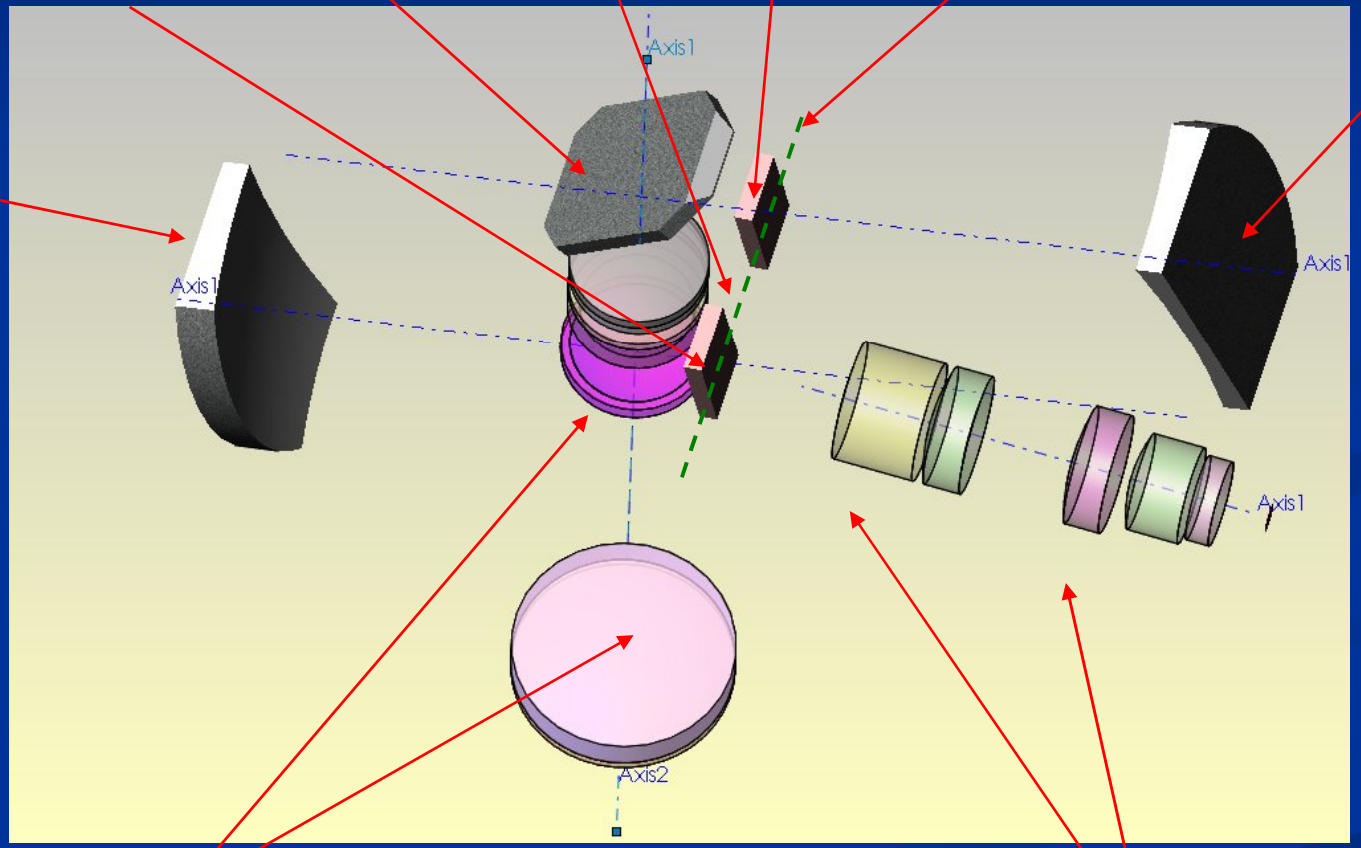

OBJ: -0.0250, 0.0250 DEG
OBJ: 0.0000, 0.0250 DEG
OBJ: 0.0250, 0.0250 DEG
0.3700
0.4800
1.0000
27.00
IMA: 14.839, -13.718 MM
IMA: 0.435, -14.203 MM
IMA: -13.859, -14.484 MM
OBJ: -0.0250, 0.0000 DEG
OBJ: 0.0000, 0.0000 DEG
OBJ: 0.0250, 0.0000 DEG
IMA: 14.381, 0.507 MM
IMA: 0.000, 0.000 MM
IMA: -14.272, -0.257 MM
OBJ: -0.0250, -0.0250 DEG
OBJ: 0.0000, -0.0250 DEG
OBJ: 0.0250, -0.0250 DEG
IMA: 14.078, 14.986 MM
IMA: -0.327, 14.453 MM
IMA: -14.623, 14.219 MM
SURFACE: IMA
SPOT DIAGRAM
BTFI-COLLIMATOR 1.3, F/8 CAMERA 3.0, ON GLAO FEED

Concept Evolution, cont.

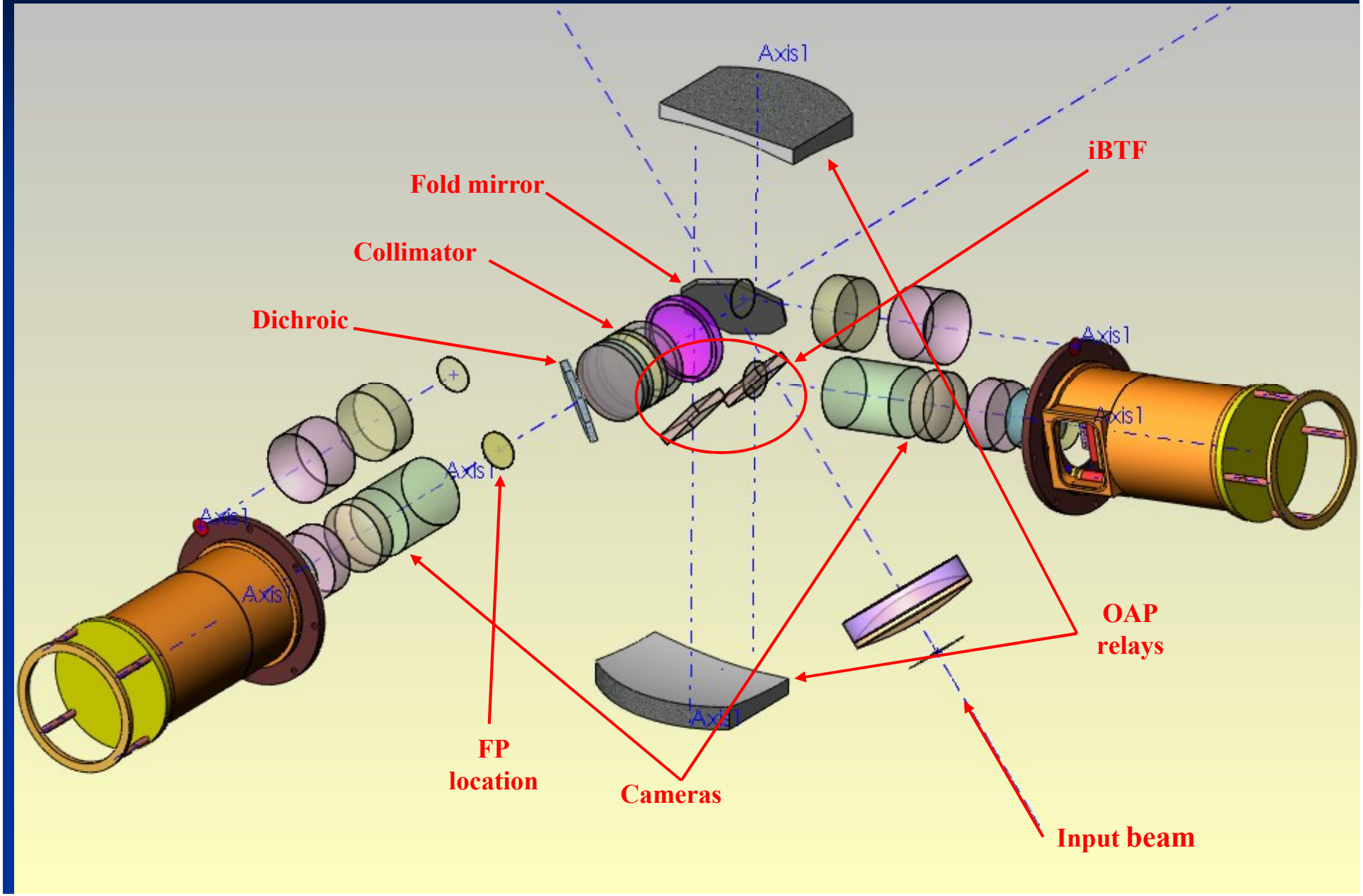
- May'07: KT & Rene visit SOAR to explore space envelope issues

- Jun'07: KT & Rene layout optics based on:
  - Single [VPHG + Retro-Reflector + Tilt mechanism]
    - ⇨ Large VPHGs (<200mm) and comparably large retro-mirrors
  - Solution: Pupil-Relay (eg: Offner) from 1st to 2nd VPHG
    - ⇨ Dual VPHGs (~50mm) + Single Tilt mechanism
    - ⇨ Pupil-Relay is large but will fit in space envelope

Pupil-Relay Configuration (Jun'07)



Pupil-Relay with FP/“complementary” (but not 0th order) channel



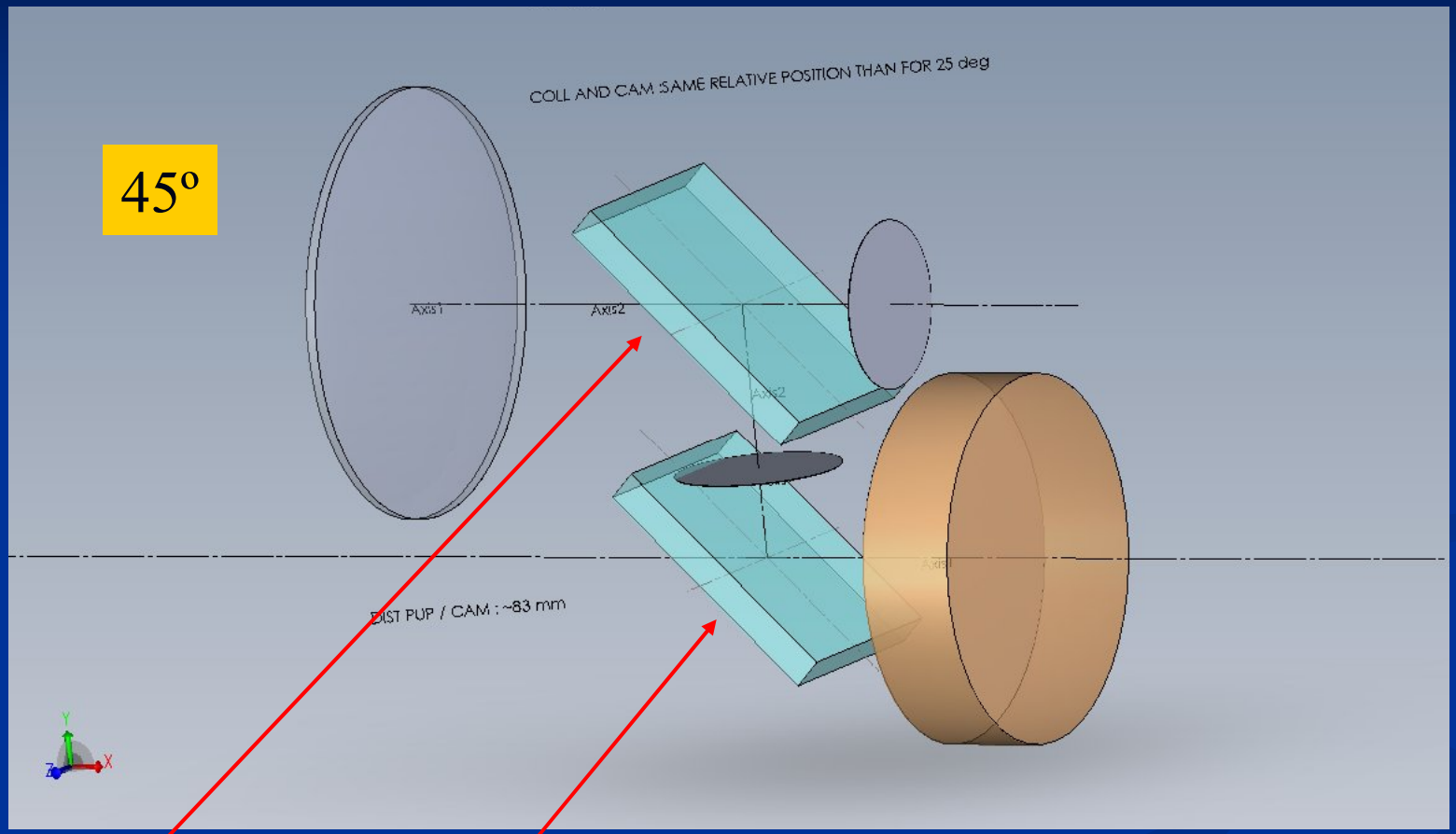
Concept Evolution, cont.

- Jun'07: DJ – Pupil-Relay has fundamental problems
  - Chromatic aberrations not controlled
  - Refractive alternative *may* be practical, but …
    - DJ "Large complex/costly optics"
- Jul'07: PMG – independent tilt control no problem
  - ⇨ Freedom to articulate VPHGs and retro-reflectors independently
  - ⇨ Abandon Pupil-Relay, for now
  - ⇨ Look again at minimizing size of VPHGs

Concept Evolution, cont.

- Aug'07: KT & SBO brainstorm layout issues (2 possibilities):
  - SBO delivers preliminary findings (31st Aug)
  - Final report due (19th Sep)
- Aug'07: KT & Rene trial layout of SBO's provisional concepts
  - VPHG size reduced to ~100mm (still large)
  - 1st grating – simple rotation ; 2nd grating – rotation/translation

Original iBTF configuration: non-Pupil-Relay (Reflection)



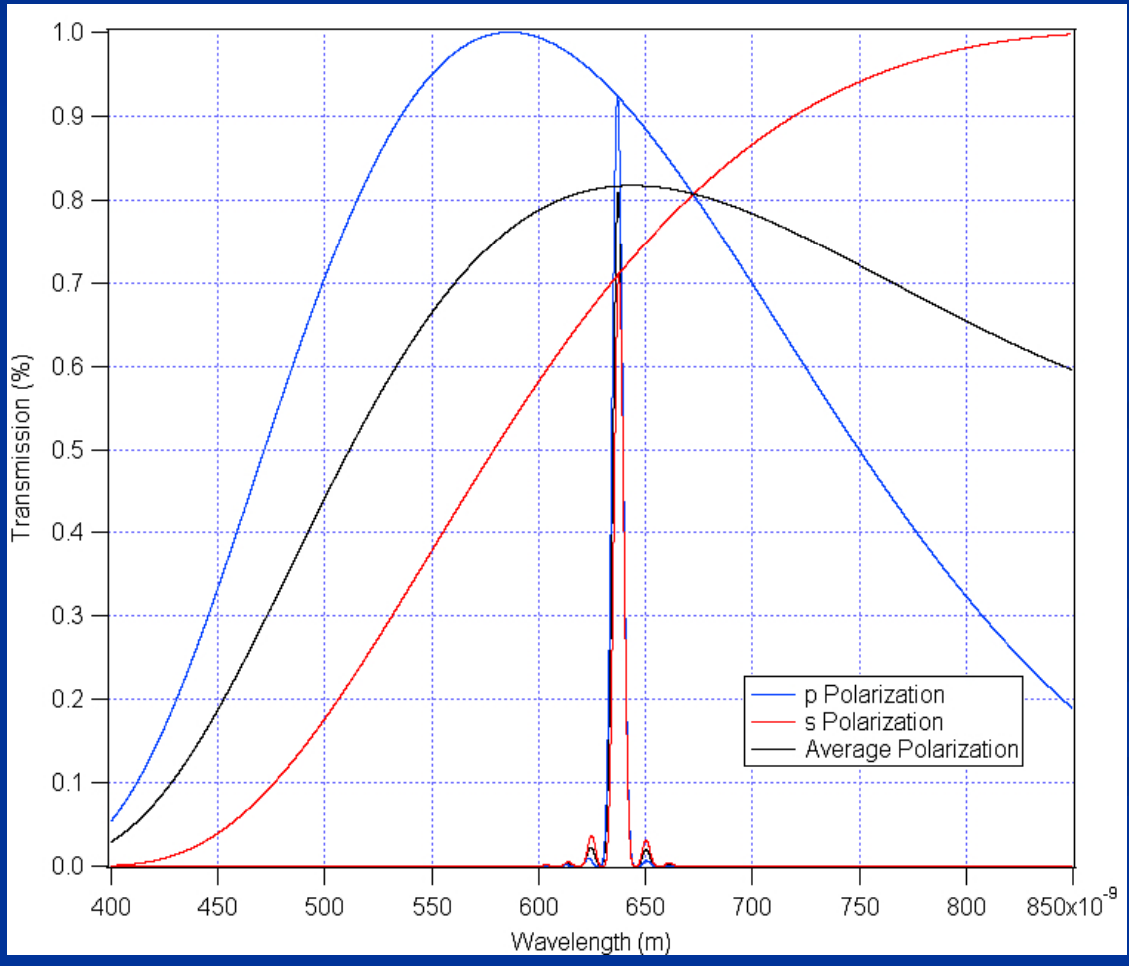
1st VPHG
simple rotation

2nd VPHG
Rotation + translation

iBTF Transmission (DCG)

R ~100

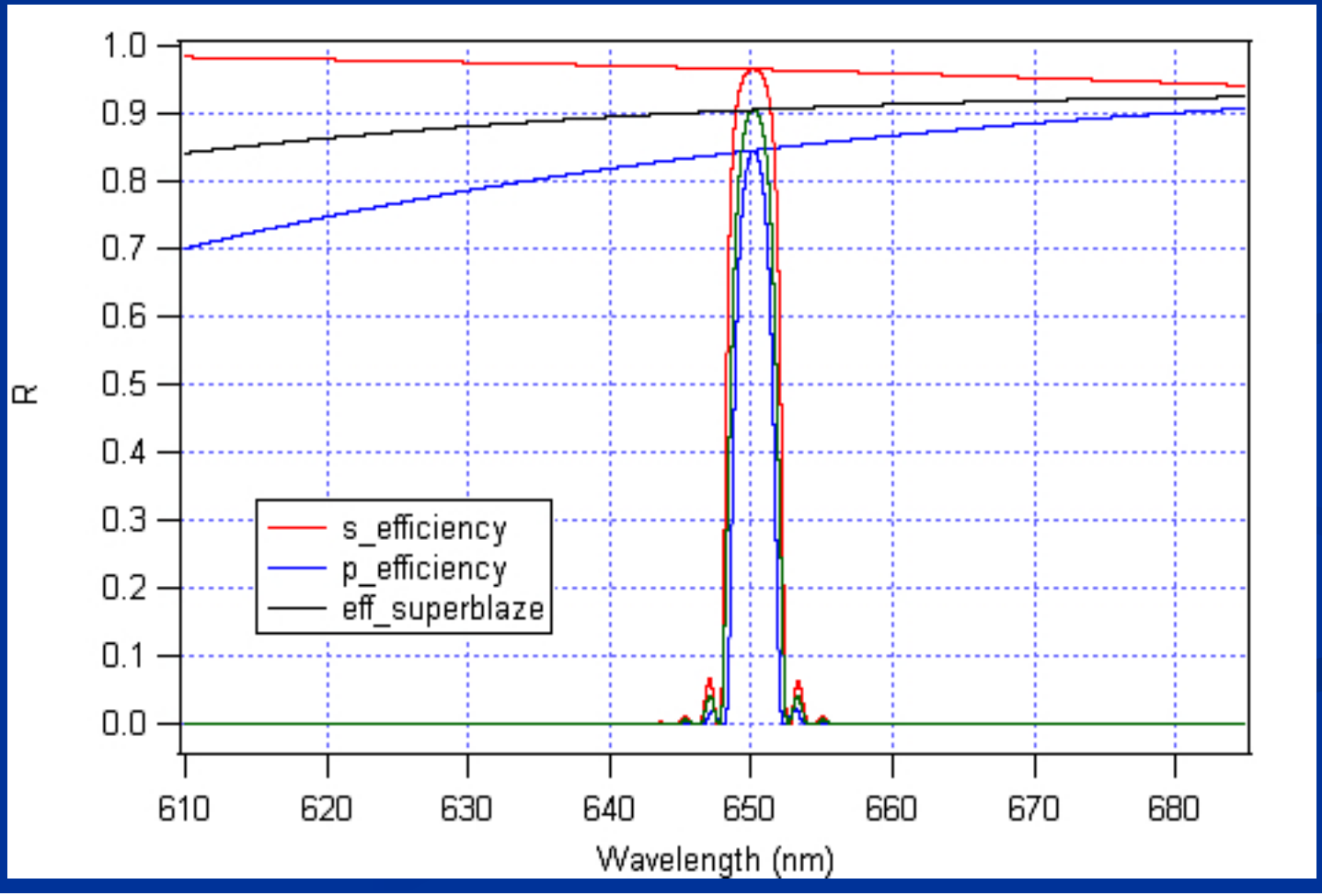
Tuning$_{25^o\text{-}45^o}$ from λ ~460 to 700nm



iBTF Reflection (DCG)

R ~200

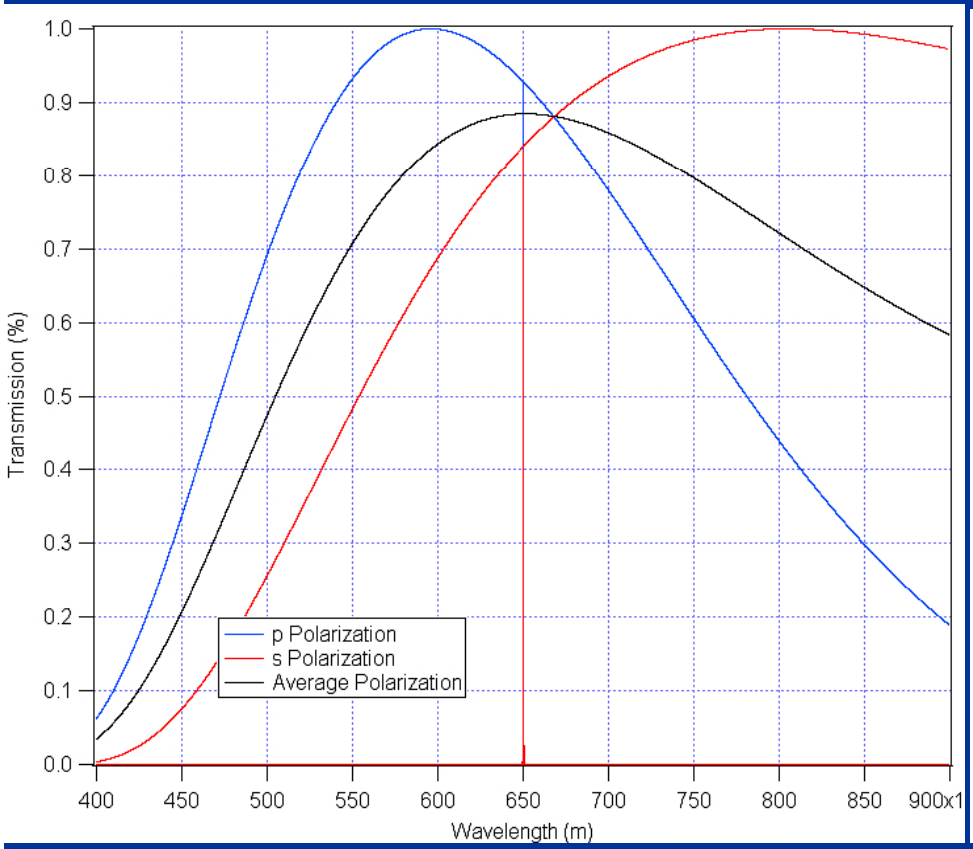
Tuning$_{25^o\text{-}45^o}$ from λ ~620 to 675nm

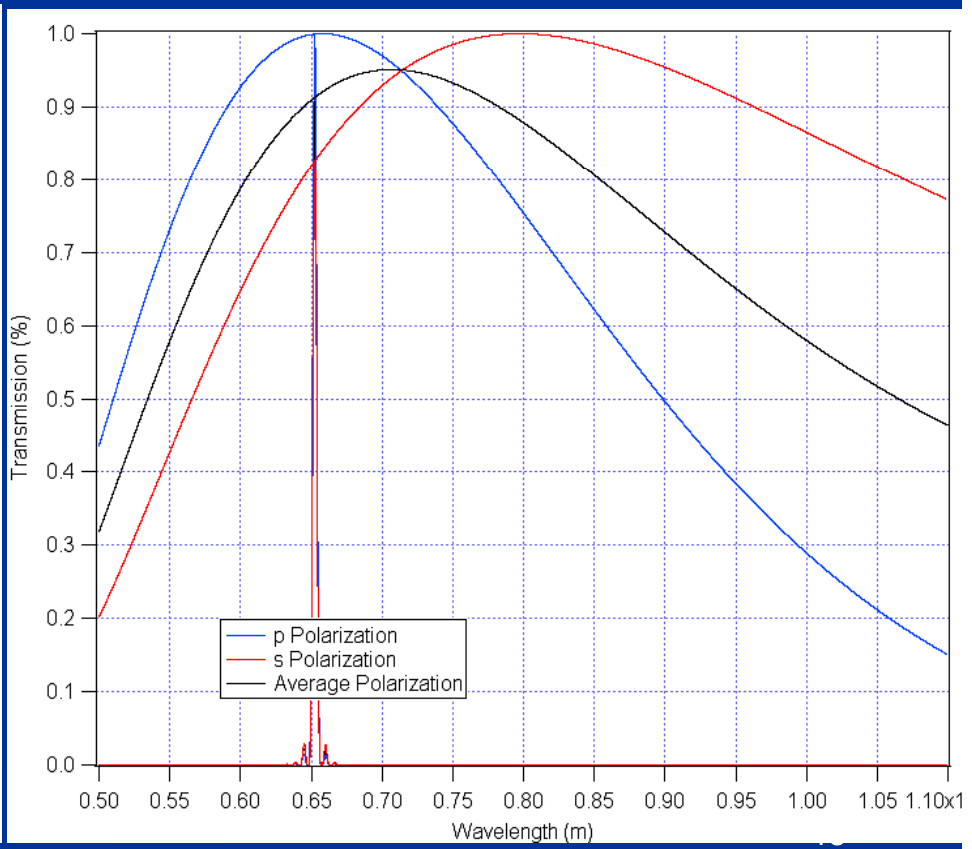


iBTF Transmission (Doped-Glass)

R ~3,420
Tuning$_{25^o\text{-}45^o}$ from λ ~500 to 850nm

R ~200
Tuning$_{25^o\text{-}45^o}$ from λ ~650 to 1,100nm

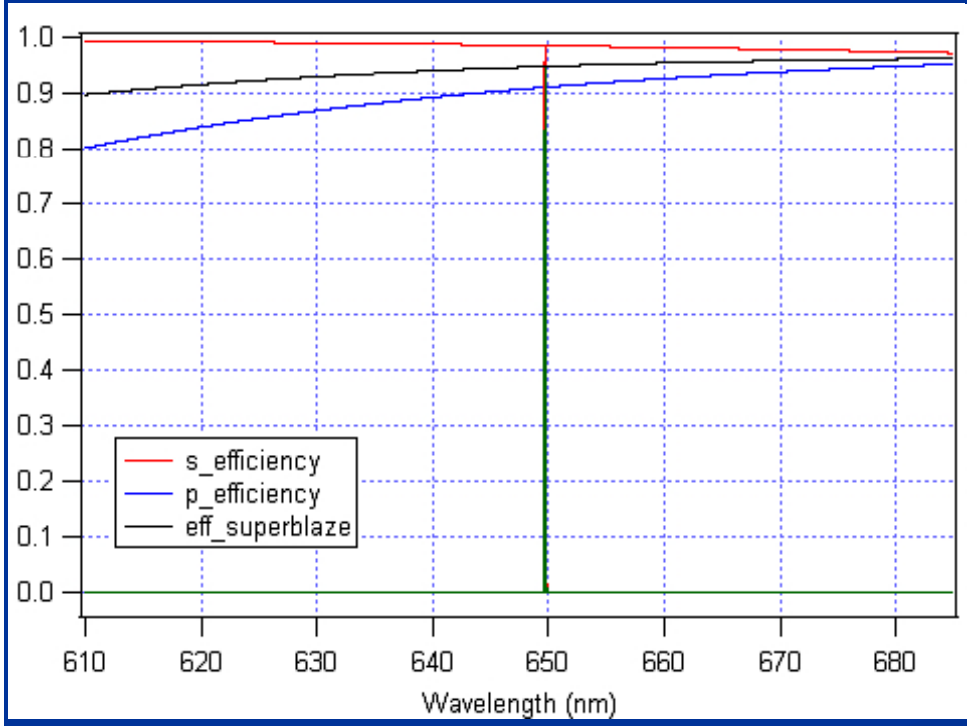


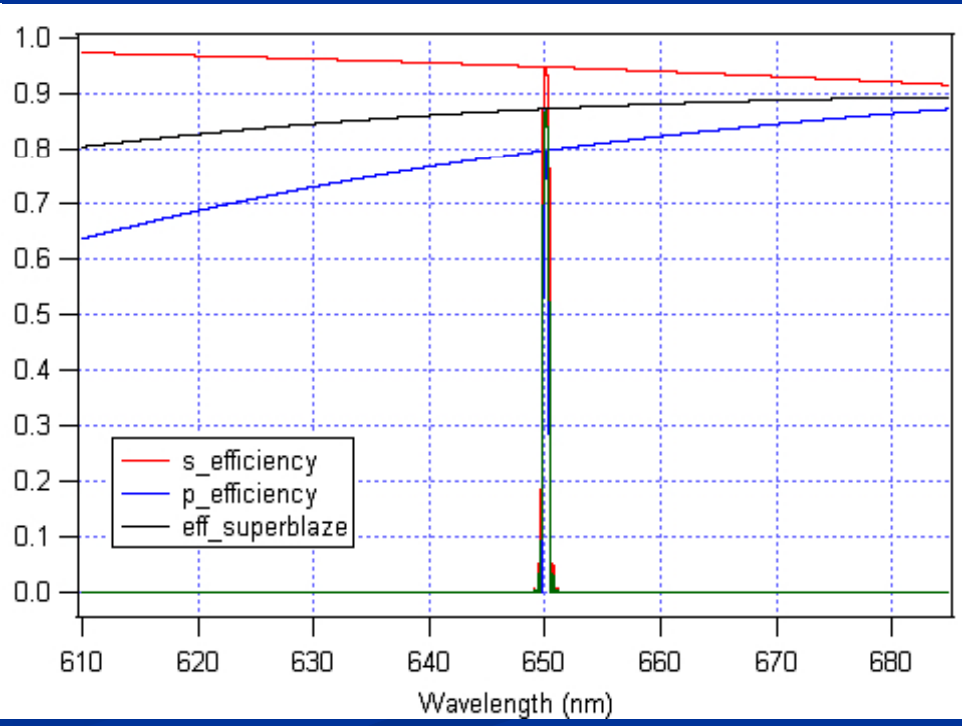


iBTF Reflection (Doped-Glass)

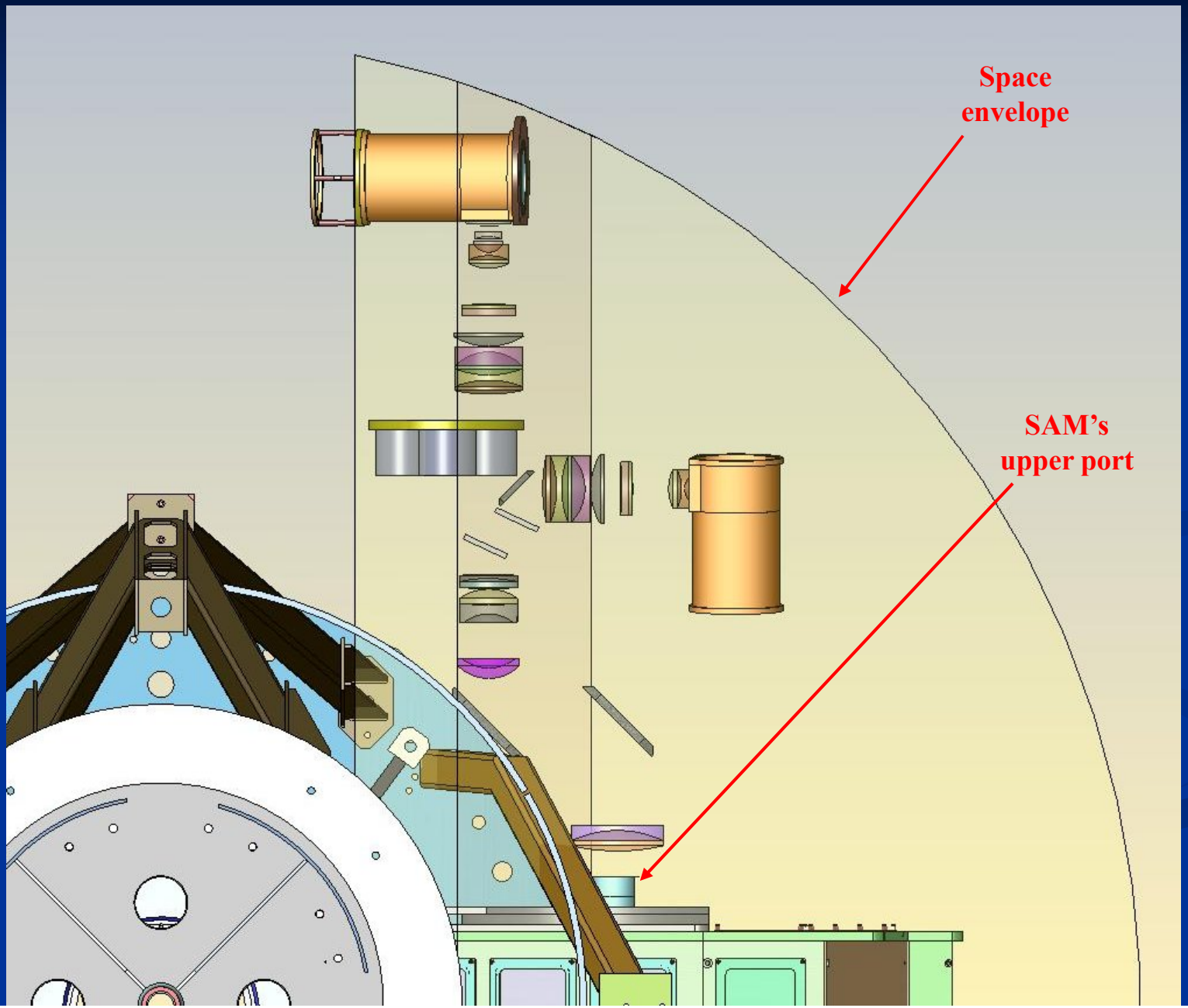
R ~5,400
Tuning$_{25^o\text{-}45^o}$ from λ ~620 to 675nm

R ~1,000
Tuning$_{25^o\text{-}45^o}$ from λ ~620 to 675nm





BTFI on SOAR/SAM visitor port



The *Current* Perspective

- Sep'07: Claudia + KT:

  (The "Requirements Epiphany" lunch)

  - Abandon wide-field:
    - FoV ~3' is acceptable even if GLAO fails
    - Dual FP configuration can now be supported
    - Smaller VPHGs: now ~70mm
    - Coll/Cam optics much simpler/smaller/fewer/cheaper
    - No need for large camera exchange mechanisms

NB: *All figures/drawings based on large-field design*

Requirements & Performance (Pre-Sep'07)

Requirements:

- 390<λ<950nm (EMCCD)
- 4 science modes:
  - 2 * Spatial-Resolutions
    - SL or GLAO
  - 2 * λ-Resolution Ranges
    - FP or iBTF
- FP (single)
  - High-R ; Big ; Expensive
  - Supplier = SESO
    - Δℓ ~200μ (cf: QI ~4μ)
- iBTF (multiple)
  - Low-R ; Compact; Cheap
    - Tx; Scan-range Large
    - Rx; Scan-range Small
  - Complementary channel

Performance Summary:	**Seeing-limited**	**GLAO**
FoV	6*6 arcmin	3*3 arcmin
Sampling	0.23 arcsec	0.12 arcsec
FP (N~30) **Single FP**	Gap range, $\Delta\ell$ ~200μ ($\delta\lambda$ ~$\lambda^2/2\ell N$) Scan range, $\Delta\lambda$ ~ 30*$\delta\lambda$ FP[1]+Filters 250<R<25,000	
iBTF		
DCG	Transmission: 5<R<15 Reflection: 10<R<50	
Doped-Glass	Transmission: 200<R<1,000 Reflection: 300<R<2,000	

Requirements & Performance (Post-Sep'07)

Requirements:

- 390<λ<950nm (EMCCD)
- 4 science modes:
  - 1 * Spatial-Resolution
    - GLAO (SL as back-up)
  - 2 * λ-Resolution Ranges
    - FP or iBTF
- FP (dual)
  - High-R ; Big ; Expensive
  - Supplier = SESO
    - $\Delta\ell$ ~200μ (cf: QI ~4μ)
- iBTF (multiple)
  - Low-R ; Compact; Cheap
    - Tx; Scan-range Large
    - Rx; Scan-range Small
  - Complementary channel

Performance Summary:	**Seeing-limited (back-up)**	**GLAO**
FoV	3*3 arcmin	3*3 arcmin
Sampling	0.12 arcsec	0.12 arcsec
FP (N~30)	Gap range, $\Delta\ell$ ~200μ ($\delta\lambda$ ~$\lambda^2/2\ell N$)	
Dual FP	Scan range, $\Delta\lambda$ ~ 30*$\delta\lambda$	
Option 1 [baseline]	FP^1+Filters	250<R<25,000
Option 2 [upgrade]	FP^1+FP^2+Filters	16,000<R<40,000
iBTF		
DCG	Transmission:	5<R<100
	Reflection:	?<R<200
Doped-Glass	Transmission:	200<R<3,000
	Reflection:	1,000<R<5,500

Which do we base-line?

- **Pre-Sept'07 advantages:**
  - Large seeing-limited FoV (~6*6 arcmin)
  - Single FP (Φ ~70mm) – cost issue?
  - Simultaneous iBTF mode always available

- **Post-Sept'07 advantages:**
  - 2 cameras (2*f/6.7) instead of 4 (2*f/3.3 & 2*f/6.7):
    - No f/3.3 cameras required - complex/expensive
    - No need for camera exchange mechanism
  - Smaller iBTF gratings:
    - Smaller λ-gradient – by factor of 2
    - ~70mm instead of ~100mm
  - Dual FP operation:
    - FP^1 in pupil (Φ ~70mm) + FP^2 in image plane (Φ ~100mm)
      - Higher Rs (>25,000) available
      - Better continuum/sky/star suppression
      - Significantly fewer IFs required for high-R work – cost savings
      - FP^2 can be regarded as an upgrade path (or borrowed from 3DNTT?)
  - Use of IR-direct port for SL work is a back-up when GLAO is non-operational