LUVOIR Telescope Design Overview:
Presented to the LUVOIR STDT

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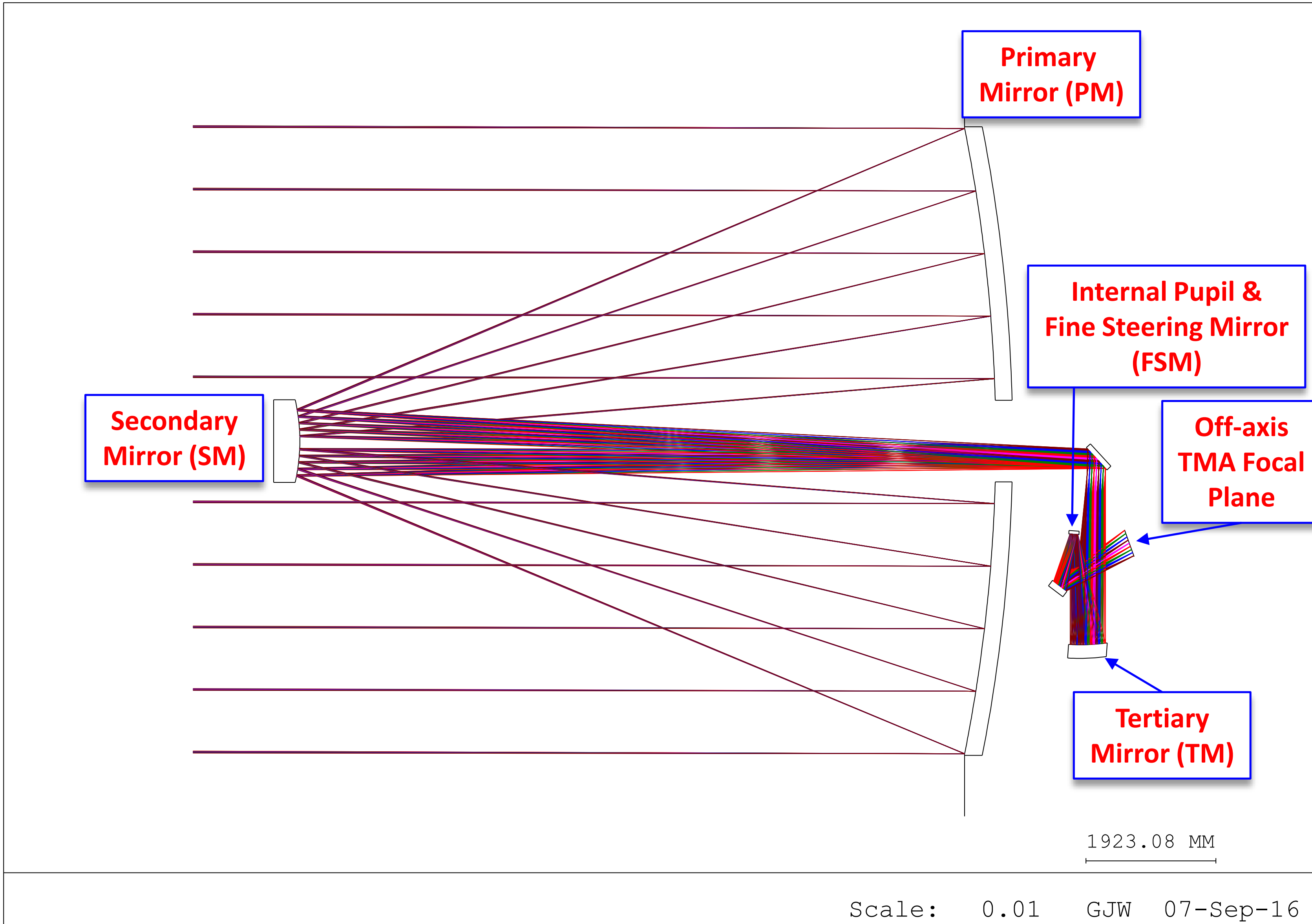
Objectives

- Review a few telescope designs
  - Three-mirror anastigmat (single focal plane) – TMA-SF
  - Three-mirror anastigmat (dual focal plane) – TMA-DF
  - Ritchey-Chretien - RC
- On-axis vs. off-axis designs
- Describe strengths and weaknesses of each
- Relate design considerations to LUVOIR priorities
  - Instrument accommodations
  - Packaging for launch vehicle
  - Polarization

Three-mirror Anastigmat - Single Focal Plane (TMA-SF)



TMA-SF Advantages

- Three mirrors simultaneously correct spherical, coma, and astigmatism aberrations
  - Enables diffraction-limited performance over very wide fields-of-view (> 8 x 8 arcmin)

- Access to an internal pupil allows for additional aberration correction:
  - Pointing control with a fine-steering mirror (FSM)
  - Fixed pupil plate corrector
  - Active control with a deformable mirror (DM)

- Heritage: JWST

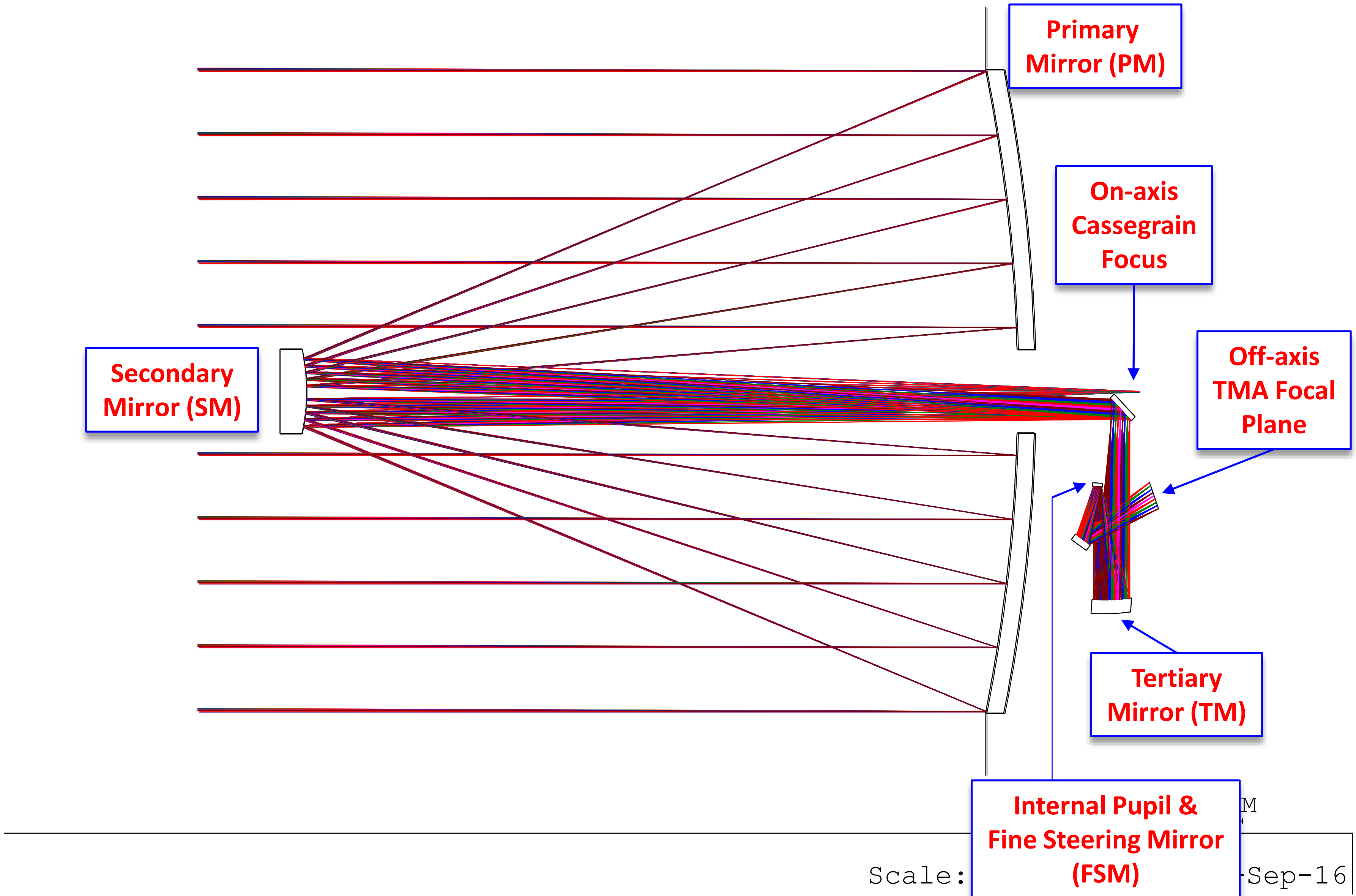
TMA-SF Disadvantages

- At least four reflections before entering instruments
  - More are likely in order to fold beam for packaging
  - Lower throughput for sensitive instruments in UV & coronagraph

- Complex aft-optical system (AOS)
  - Complicates system alignment
  - Could present difficulty for instrument packaging behind telescope

- JWST experience indicates stray-light can be difficult to baffle

Three-mirror Anastigmat - Dual Focal Plane (TMA-DF)



TMA-DF Advantages

- Narrow FOV on-axis Cassegrain focus
  - Aluminum coating
  - Only 2 reflections for high-throughput (UV & coronagraph) instruments

- Wide FOV off-axis TMA focus
  - Well-corrected wide-FOV instruments
  - Silver coating on TM, FSM, etc. for optimized Vis/NIR performance

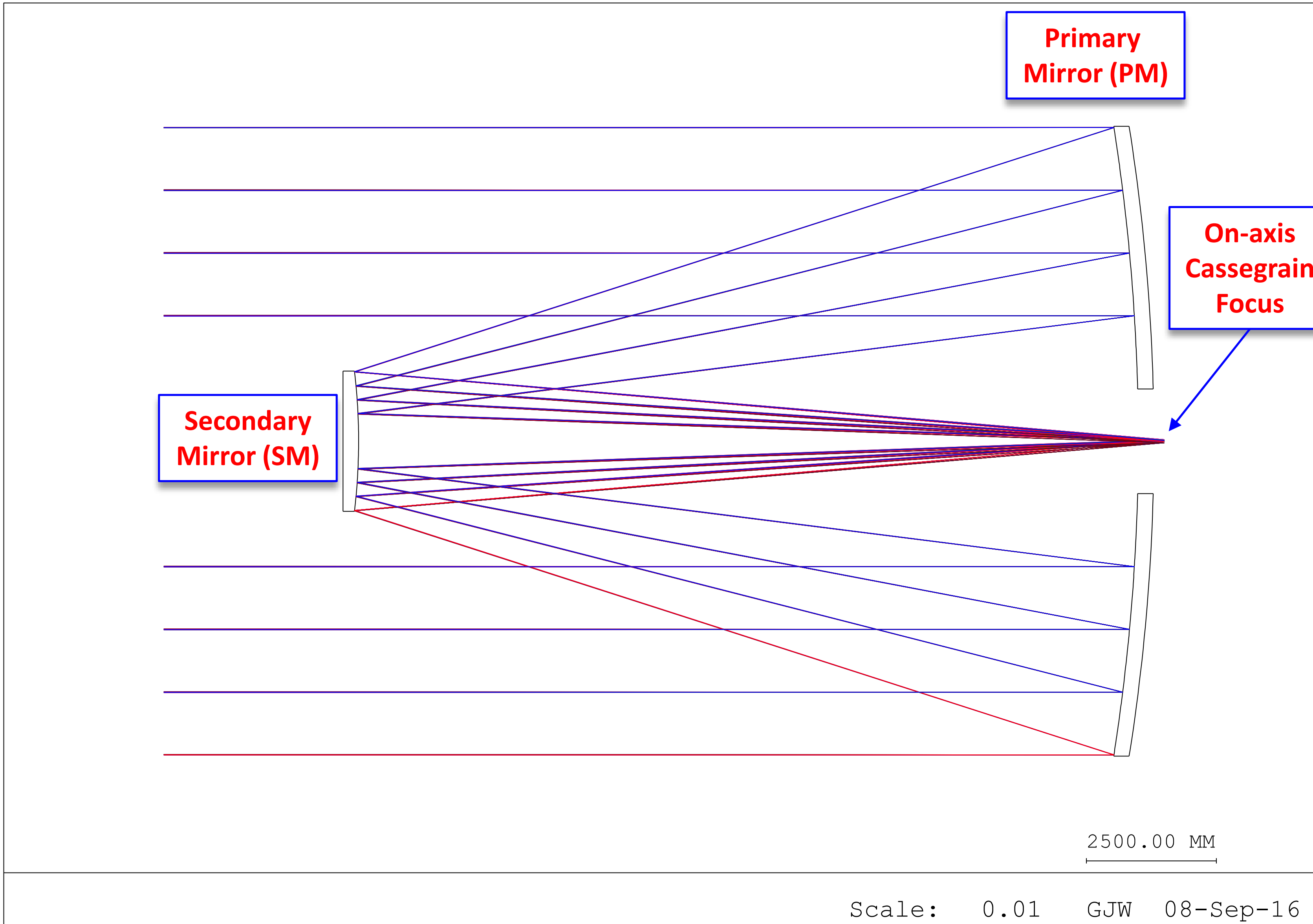
- Access to an internal pupil in TMA chain allows for additional aberration correction (but only in TMA focal plane):
  - Pointing control with a fine-steering mirror (FSM)
  - Fixed pupil plate corrector
  - Active control with a deformable mirror (DM)

- Heritage: WFIRST

TMA-DF Disadvantages

- Must balance aberrations between both focal planes
  - Requires a pupil corrector plate to recover image quality at TMA focus
- More difficult packaging configuration since both focal planes need to be accessible
  - May require more fold mirrors, reducing throughput in the TMA focus
- The Cassegrain focus is *very* narrow
  - Arcseconds instead of arcminutes

Ritchey-Chretien (RC)



RC Advantages

- Single, high-throughput focal plane
  - Possible for every instrument to only see two bounces (though some fold mirrors will likely be necessary)

- Simplified optical train means less complicated alignment and testing

- Heritage: HST

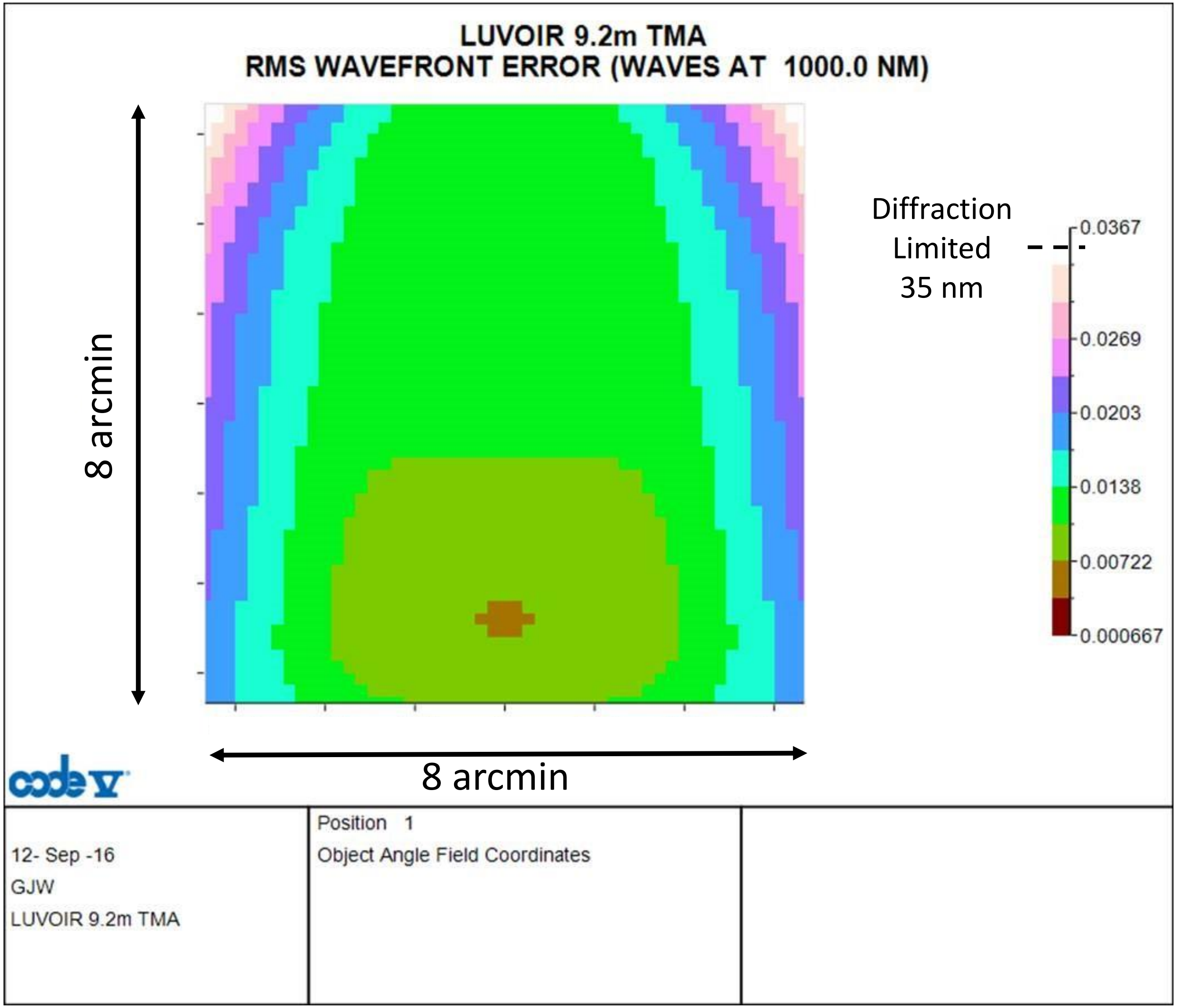
RC Disadvantages

- Narrower overall field-of-view than TMA designs
  - ~3 x 3 arcmin diffraction-limited
  - Instruments outside of this field will need internal corrective optics

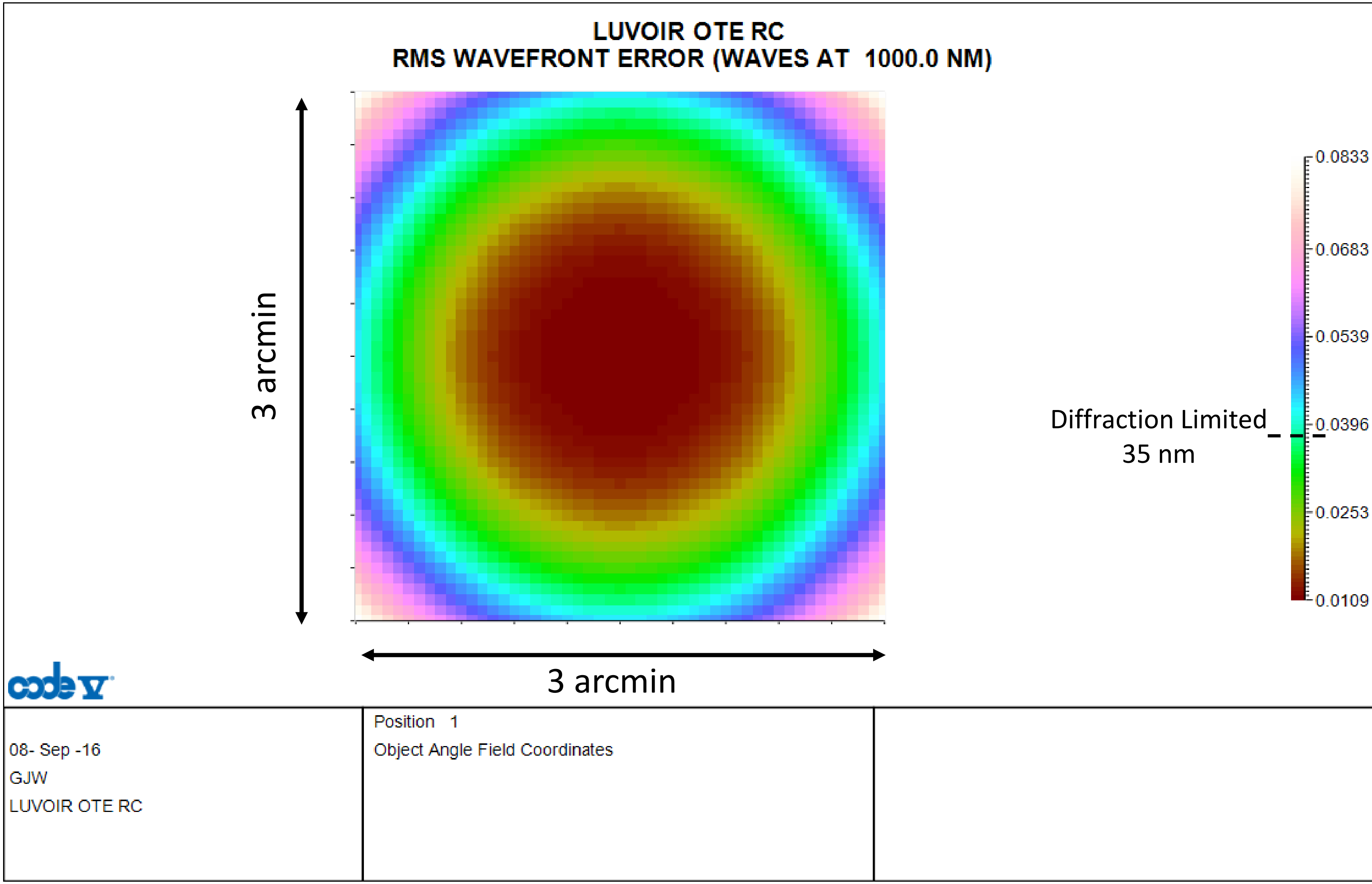
- A curved focal plane can help improve the image quality
  - May require some creativity in instrument packaging and design

- No access to internal pupil for a fine-steering mirror
  - Puts all pointing requirements on the spacecraft / disturbance isolation system

Field-of-View Map: 9.2 m TMA



Field-of-View Map: 12 m RC



On-axis vs. Off-axis

- All of these designs were presented as nominally on-axis
- Any of them could be made to be off-axis
- Off-axis advantages:
  - No-obscuration improves overall throughput and possibly coronagraph ease of design / performance
- Off-axis disadvantages:
  - Higher angles-of-incidence at PM & SM → Larger polarization effects
  - Generally increases aberration → Smaller well-corrected FOV
  - PM-to-SM distance increases → Impacts stability & packaging
  - Unclear how an off-axis segmented design could be packaged to fit inside of a fairing

Instrument Accommodations

- Each of the LUVOIR instruments may have a preference for one or more of these designs
- The following slides address each instrument separately and discuss the trades associated with each of the telescope designs
- Once all of the instrument performance specifications are in hand, the engineering team will design the telescope to optimize performance over all of the instruments

Vis/ NIR Coronagraph

- Only requires a small FOV (~arcsecs)
  - Could go in any focal plane of any design

- Cassegrain focus of the TMA-DF, and RC design are attractive for:
  - High throughput due to reduced number of reflections
  - Better wavefront stability with fewer optics in the path

- TMA focus is attractive for:
  - Access to a fine-steering mirror for better pointing control

UV Imager & Spectrograph

- TMA-SF design is least desirable
  - Lots of reflections reduce throughput, BUT
  - Allows for wide FOV, with stable pointing behind a FSM

- TMA-DF Cassegrain focus
  - Improves throughput with only two reflections, BUT
  - Extremely limited FOV, pointing must be provided by spacecraft

- Ritchey-Chretien is best overall
  - High throughput with only two bounces
  - Achievable ~2x2 arcmin FOV

- Need to understand pointing stability requirements to determine if there is a need for a FSM

Vis / NIR Wide-field Imager

- Obviously wants to be at either of the TMA focal planes for wide field-of-view
- Would need internal corrective optics to work with the limited field-of-view of the Ritchey-Chretien
  - Needs additional study to determine what's achievable
- Need to understand pointing requirements of astrometry mode to determine if an FSM is necessary

Vis / NIR Multi-resolution Spectrograph

- Very narrow field-of-view
  - Could go in any focal plane of any design

- Need to understand requirements for radial velocity measurements to understand requirements on telescope

Summary Stoplight Chart

	TMA-SF	TMA-DF	RC
High-Throughput Channel			
Wide Field-of-View Channel			
Cassegrain Focus FOV			
Alignment Complexity			
Instrument Packaging Complexity			
Availability of Fine-Steering Mirror			
Angle-of-Incidence Impact on Polarization			

LUVOIR Launch Vehicle Fairing Telescope & Instrument Accommodation

Norman Rioux

LUVOIR Telescope Accommodation

Telescope Aperture Diameter (m):		**6**	**9.2**	**12**	**16**	**20**
Launch Vehicle						
SLS Block 2B						
50 k kg to L2 orbit — Mass Margin	**M**	Feasible	Feasible	Feasible	Feasible	Feasible
10 m fairing — Fairing Volume Margin	**V**	Feasible	Feasible	Feasible	Feasible	Feasible
SLS Block 1B						
38 k kg to L2 orbit	**M**	Feasible	Feasible	Feasible	Feasible	Feasible
8.4 m fairing	**V**	Feasible	Feasible	Feasible	Feasible	Feasible
Delta IV Heavy						
10 k kg to L2 orbit	**M**	Feasible	Feasible	Needs Validation	Not Feasible	Not Feasible
5 m fairing	**V**	Feasible	Feasible	Needs Validation	Not Feasible	Not Feasible

Feasible · Not Feasible · Needs Validation

LUVOIR Observatory Instrument Accommodations

- LUVOIR should initially assume the observatory will accommodate four or more instruments
  - HST was launched with five instruments, JWST has four instruments
  - LUVOIR is consistent with this flagship-mission heritage
  - Study resources may limit number of instruments assessed in detail to three

- Concepts that assume an SLS launch vehicle with 8.4 m or 10 m dia. fairing can accommodate more than four instruments
  - SLS 8.4 m or 10 m concepts will be constrained by cost before mass to orbit or fairing volume constrains the number of instruments.

- Concepts that assume a launch vehicle with a 5 m dia. fairing (like Delta IV Heavy) might find accommodating four instruments challenging.
  - Current information is in such a formative state that there is no justification for not developing four-instrument concepts for these vehicles at this time.
  - Instrument accommodation studies can probe for instrument accommodations risks
  - Accommodation studies can also provide basis for mitigating and overcoming risks