				Level or risk or influence							Damage -- Answering high risks only (What could go wrong?)						
Subsystem	**Component**	**Primary function What must it do?**	**Affecting enviroment**	**vacuum (1e-6)**	**high temp (500C)**	**low temp (100C)**	**vibrations**	**magnetic field**	**mechanical torque**	**neutrons**	**vacuum**	**high temp (500C)**	**low temp (100C)**	**vibrations**	**magnetic field**	**mechanical torque**	**neutrons**
Optical entry & steering	1st mirror (top, azimuthal)	Reflect IR light from divertor tiles downwards; pre-shot steering (manual adjustment).	vacuum (1e-6), high temp (500C), vibrations, neutrons	low	high	none	high	none	none	low		Reflective coatings may evaporate or degrade under thermal exposure, causing image blurring or full signal loss.		Image stability is influenced by mechanical vibration. Also alignment drift over time.			
Optical entry & steering	2nd mirror (central, elevation)	Redirect light horizontally into telescope axis.	vacuum (1e-6), high temp (500C), vibrations, neutrons	low	high	none	high	none	none	low		Reflective coatings may evaporate or degrade under thermal exposure, causing image blurring or full signal loss.		Image stability is influenced by mechanical vibration. Also alignment drift over time.			
Optical entry & steering	rotatable flange + bearings	Enable rotation of mirrors before chamber closure.	vacuum (1e-6), high temp (500C), vibrations, neutrons	to assess	to assess	none	low	none	none	low	Welding or fusing of surfaces possible.	Grease or lubricants may outgas or break down. Solid-state friction interfaces may bake.					
Shutter	shutter	Cover the elements of the diagnostics (input window) that degrade due to sputtering.	vacuum (1e-6), high temp (500C)	low	low	none	none	none	none	none							
Vacuum interface	tokamak internal flange and vacuum window	Mechanical connection & vacuum barrier between chamber and telescope.	vacuum (1e-6), high temp (500C), vibrations	low	low	none	low	none	none	none							
Vacuum interface	vacuum cryo tube	Structural support, maintains alignment and cooling interface, provides thermal insulation or cooling.	vibrations, low temp (100C), mechanical torque	none	none	low	high	none	high	none				Coupled vibrations from external flanges may amplify internal misalignment.		Tube deformation under torque may displace internal telescope and lens mounts. leading to focus loss. At worst, the lens are misaligned permanently	
Vacuum interface	external flange / mounting plate	Mechanical connection & vacuum barrier between cryostat and telescope.	vibrations, low temp (100C)	none	none	low	low	none	none	none							
Optical train	lens system (~10 lenses)	Focus and transmit IR image from mirror to camera. MWIR, maintain ~0.5 mm/pixel at 1.5 m.	neutrons, low temp (100C)	none	none	to assess	none	none	none	low			The optical train is misaligned, extended or torqued.				
Optical train	lens mounts	Hold and align lenses inside the telescope tube.	vibrations, neutrons, low temp (100C), mechanical torque	none	none	to assess	high	none	high	low			The individual lenses are misaligned due to thermal expansion.	The lens are loose and off-axis due to vibrations		Tube deformation under torque may displace internal telescope and lens mounts. leading to focus loss. At worst, the lens are misaligned permanently	
Telescope tube	outer support tube	Supports lens train and camera housing. Allows removal for bakeout or high-temp experiments.	vibrations, magnetic field	none	none	none	low	to assess	high	none					Tube deformation under torque may displace internal telescope and lens mounts. leading to focus loss. At worst, the lens are misaligned permanently	Tube deformation under torque may displace internal telescope and lens mounts. leading to focus loss. At worst, the lens are misaligned permanently	
Telescope tube	concentric movable inner tube (some lens?)	Supports camera housing. Maintains optical axis alingment of lenses and camera.	vibrations	none	none	none	low	none	none	none							
IR detection	IR camera (TELOPS FAST-IR 2K)	Capture MWIR image. Positioned outside vacuum; fixed focal plane.	magnetic field, neutrons	none	none	none	none	to assess	none	high					The electronics of the camera is damaged in the magnetic field.		The electronics of the camera is damaged by the neutrons.
IR detection	camera mount & support block	Fine-tune focus and align optical image with sensor plane.	vibrations, neutrons	none	none	none	low	none	none	low							
IR detection	magnetic shielding	Protect camera electronics in high-field environment.	magnetic field	none	none	none	none	low	none	none							
Thermal management	cooling spirals / jackets	Maintain optical and mechanical stability during heat exposure. Prevent overheating of lenses near hot plasma-facing regions.	high temp (500C), vibrations, magnetic field, neutrons	none	high	none	low	low	none	to assess		The cooling coils are damaged by heat cycles.					Some cooling can enhance the neutron damage.
		Consulted:								Vladimir Weinzettl							Vladimir Weinzettl

component	damage / risk	expertise area	TOPTEC possible input	Silly questions, check wording	
"2nd mirror (central, azimuthal)", "1st mirror (top, elevation)"	Reflective coatings may evaporate or degrade under thermal exposure, causing image blurring or full signal loss.	thermal, material sci, optics	☑	Which coatings can survive long-term exposure to 500C?	
"2nd mirror (central, azimuthal)", "1st mirror (top, elevation)"	Image stability is influenced by mechanical vibration. Also alignment drift over time.	mechanical, optics	☑	How can vibration damping be integrated at the mirror mount?	What level of angular displacement can be tolerated before image degradation?
rotatable flange + bearings	Welding or fusing of surfaces possible.	thermal, vacuum	☐	Are materials and surface finishes vacuum-bake compatible?	Can dry lubrication or coatings prevent surface evaporation in vacuum?
rotatable flange + bearings	Grease or lubricants may outgas or break down. Solid-state friction interfaces may bake.	thermal, mechanical, vacuum	☐	What lubricant alternatives are suitable for UHV and 500C?	Can solid-state bearing designs withstand bakeout cycles?
vacuum cryo tube	Coupled vibrations from external flanges may amplify internal misalignment.	optics, stress sci, structural design	☑	What reinforcement strategies can reduce vibration coupling across the cryo tube?	Can internal lens supports be mechanically isolated from external flanges?
vacuum cryo tube, outer support tube, lens mounts	Tube deformation under torque may displace internal telescope and lens mounts. leading to focus loss. At worst, the lens are misaligned permanently	optics, structural design, integration	☑	What is the maximum torque the structure can tolerate without significant focus shift?	What is the maximum torque the structure can tolerate without significant focus shift?
lens system (~10 lenses)	The optical train is misaligned, extended or torqued.	optics, stress sci, thermal, structural design	☑	What is the maximum torque the structure can tolerate without significant focus shift?	
lens system (~10 lenses), lens mounts	The individual lenses are misaligned due to thermal expansion.	optics, thermal, stress sci	☑	What lens mount tolerances are required to maintain optical alignment?	Can lens seats allow for thermal expansion without drift?
lens mounts	The lens are loose and off-axis due to vibrations	optics, stress sci	☑	Can vibration isolators or damping foam be applied at lens mounts?	
IR camera (TELOPS FAST-IR 2K)	The electronics of the camera is damaged in the magnetic field.	integration	☐	Is magnetic shielding required around the camera electronics?	
IR camera (TELOPS FAST-IR 2K)	The electronics of the camera is damaged by the neutrons.	material sci, integration	☐	Are radiation-hard components needed for neutron exposure?	
cooling spirals / jackets	The cooling coils are damaged by heat cycles.	thermal, vacuum, material sci	☐	Can expansion loops or flexible tubing improve thermal resilience?	
cooling spirals / jackets	Some cooling can enhance the neutron damage.	thermal, material sci	☐	Can rerouting or shielding reduce unwanted neutron effects?	