Integrated Science Instrument Module

Presentation to the NGST Ad Hoc Science Working Group
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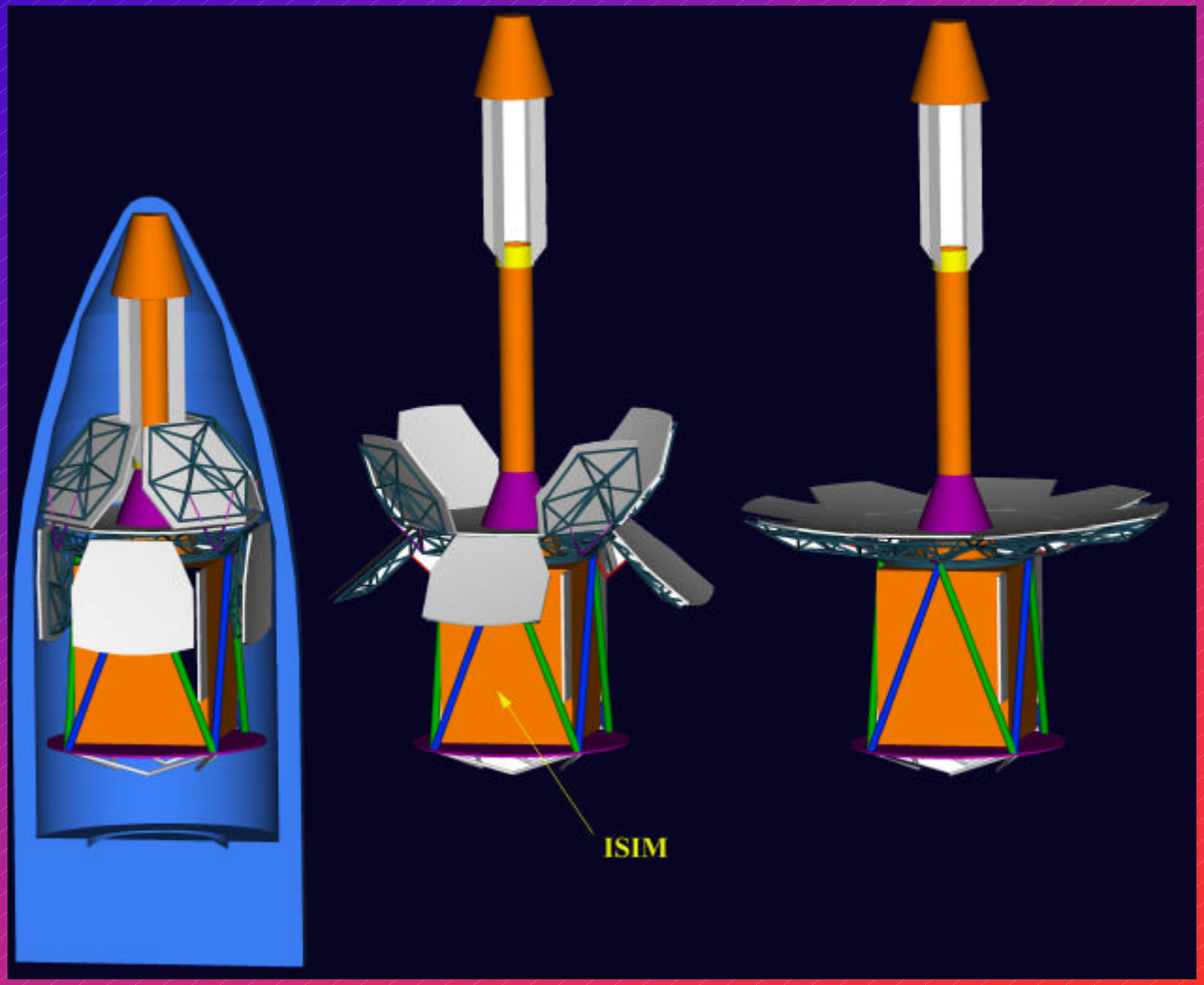
NGST baseline Integrated Science Instrument Module (ISIM) design study

- Study goals:
- Demonstrate mission science feasibility,
- Assess ISIM engineering and I&T feasibility,
- Assess ISIM cost feasibility,
- Identify ISIM technology challenge areas,
- Define ISIM interfaces ,
- Enable smart customer procurement of the ISIM.

- Architecture constraints:
- Integration with the “Yardstick” and other NGST 8 m architectures that are intended for packaging in an EELV or Ariane 5 meter class fairing.

- Ongoing progress can be monitored via ISIM IPT web site: http://www701.gsfc.nasa

NGST 8m: EELV Medium 5m Fairing

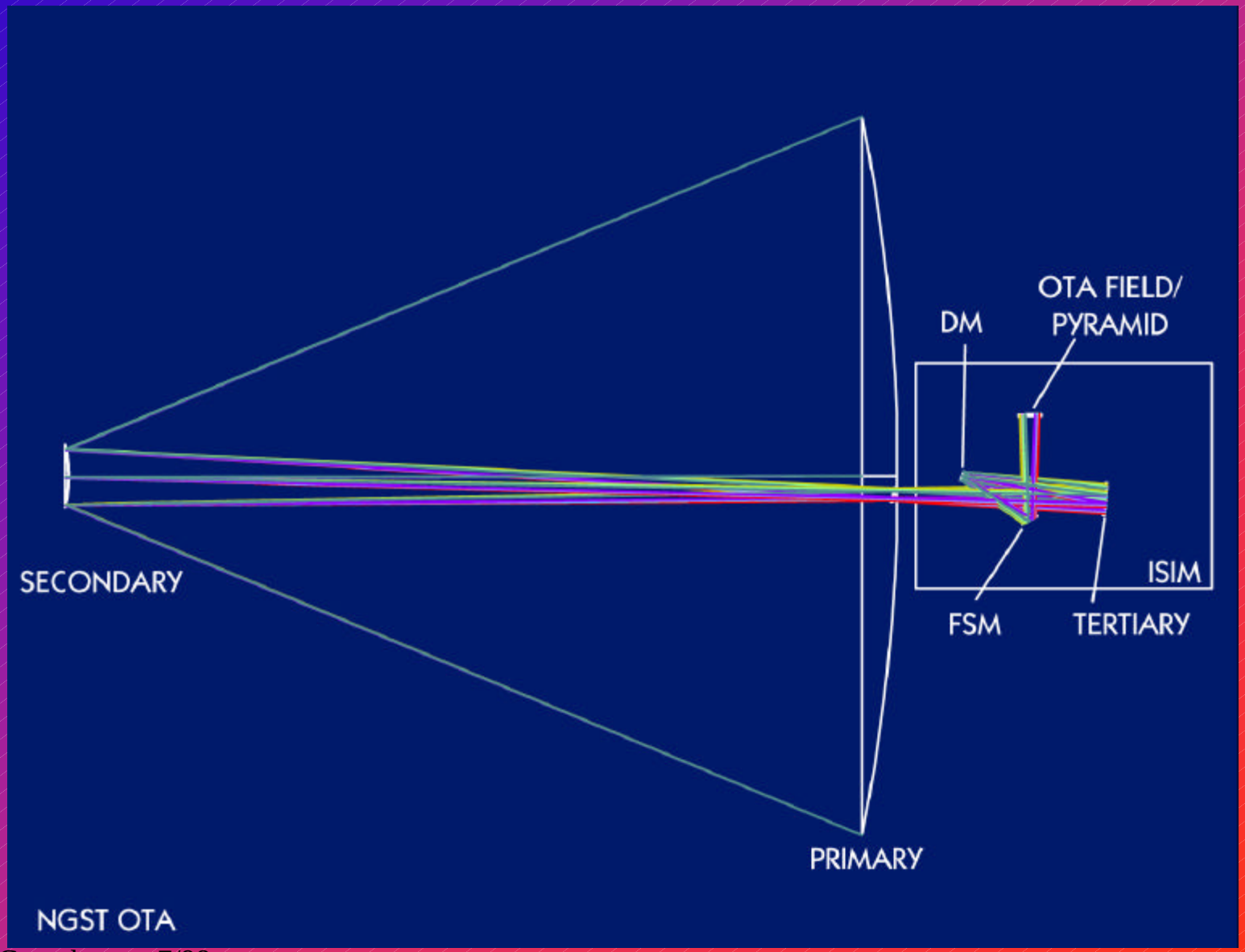


ISIM Baseline Science Instruments

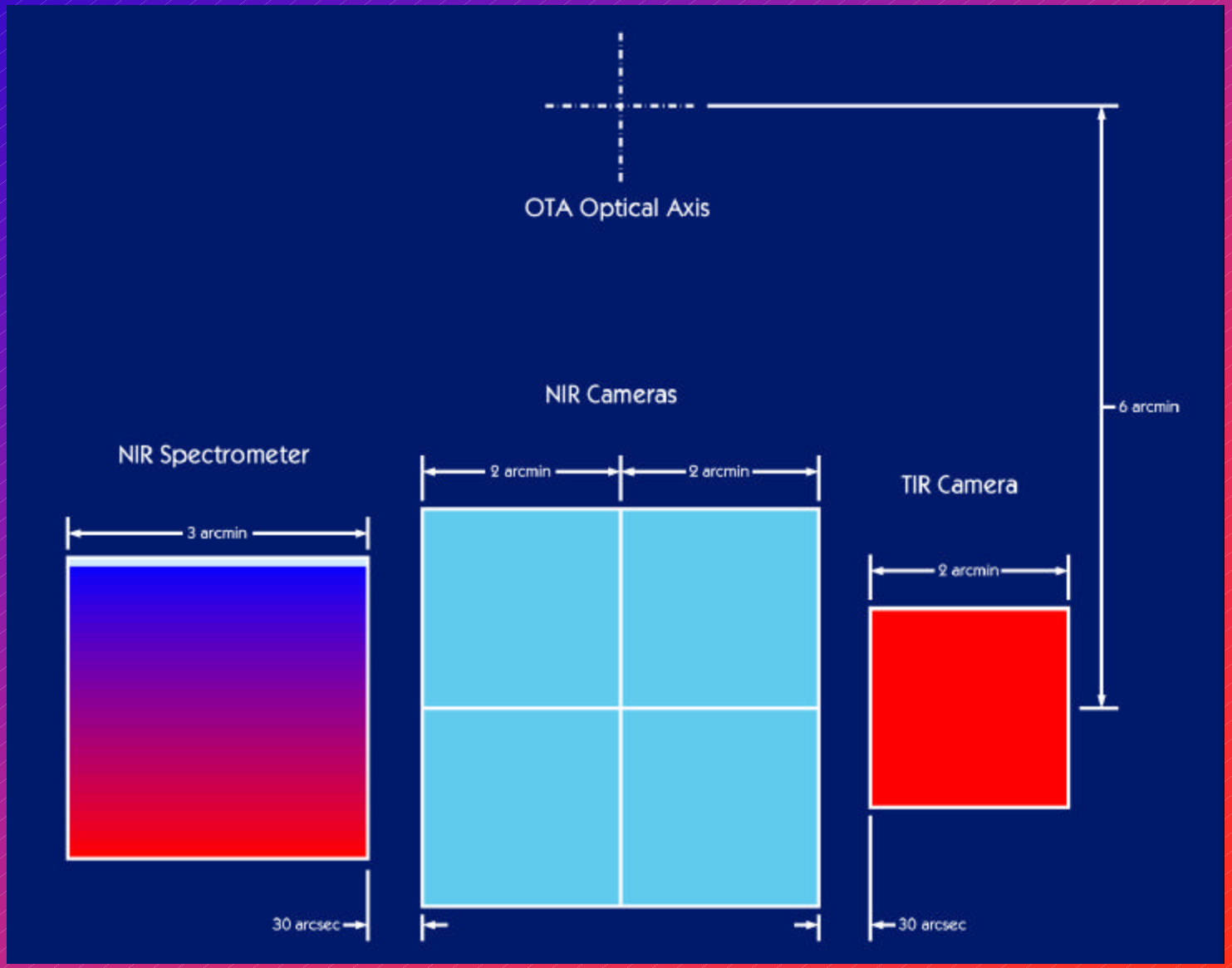
Instrument	Wavelength (μm)	Bandwidth	FPA	Pixel Pitch (μm)	Plate Scale (10^{-3}arc-sec)	Aperture Control (arc-min)
Near-IR Camera (1 of 4[1])	0.6 – 5.3	R = 2, 5 fixed filters, R = 50 - 200 tunable filters	4096 x 4096	27	29	quad-beam divider: four 2 x 2 fields chronograph mask[2]
Near-IR Spectrometer	0.6 – 5.3	R = 300, 3000 gratings	4096 x 4096	27	100	reflective slit mask: 2048 x 2048 micro-mirror array, 100μm pixels
Mid-IR Camera/Spec	5 – 28	broad-band filters, grisms, cross-disperser	1024 x 1024	27	230	slit selection + 2 x 2 camera

1. A quad-beam divider (pyramid mirror) apportions a 4 x 4 arc-min field of view over 4 identical cameras.
2. Holes in pyramid mirror facets used to form simple coronagraph.

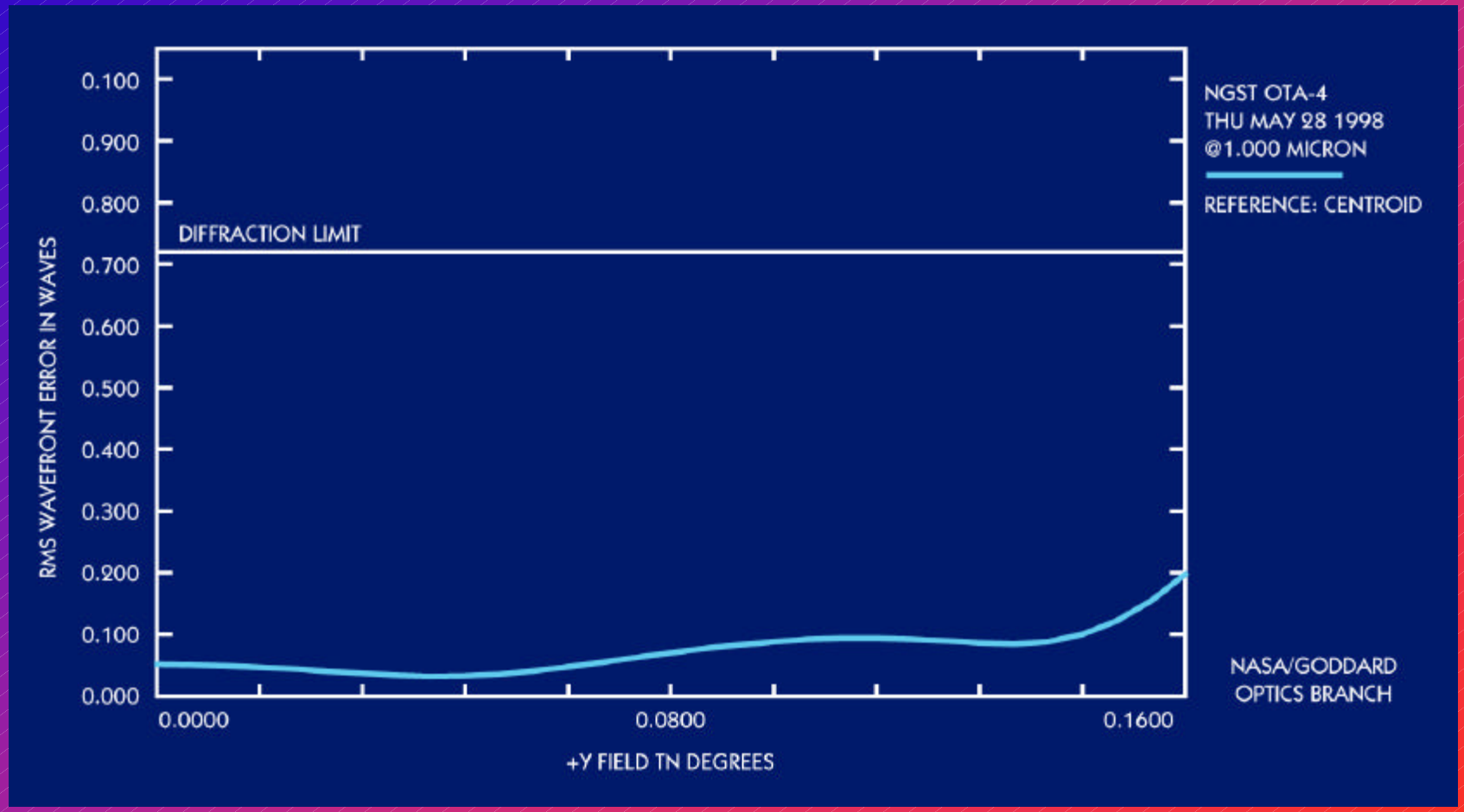
OTA and ISIM System Optical Schematic



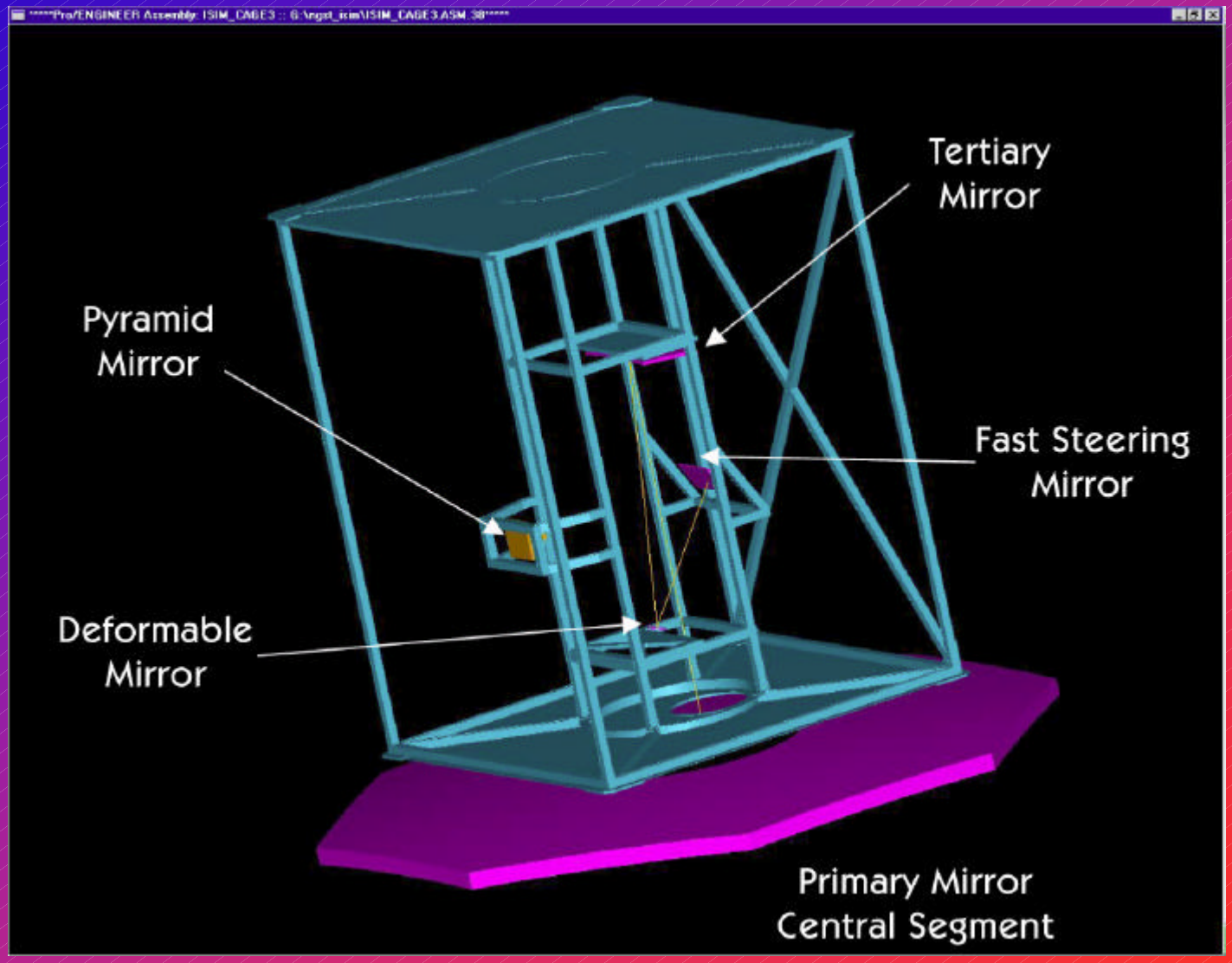
NGST ISIM Fields of View



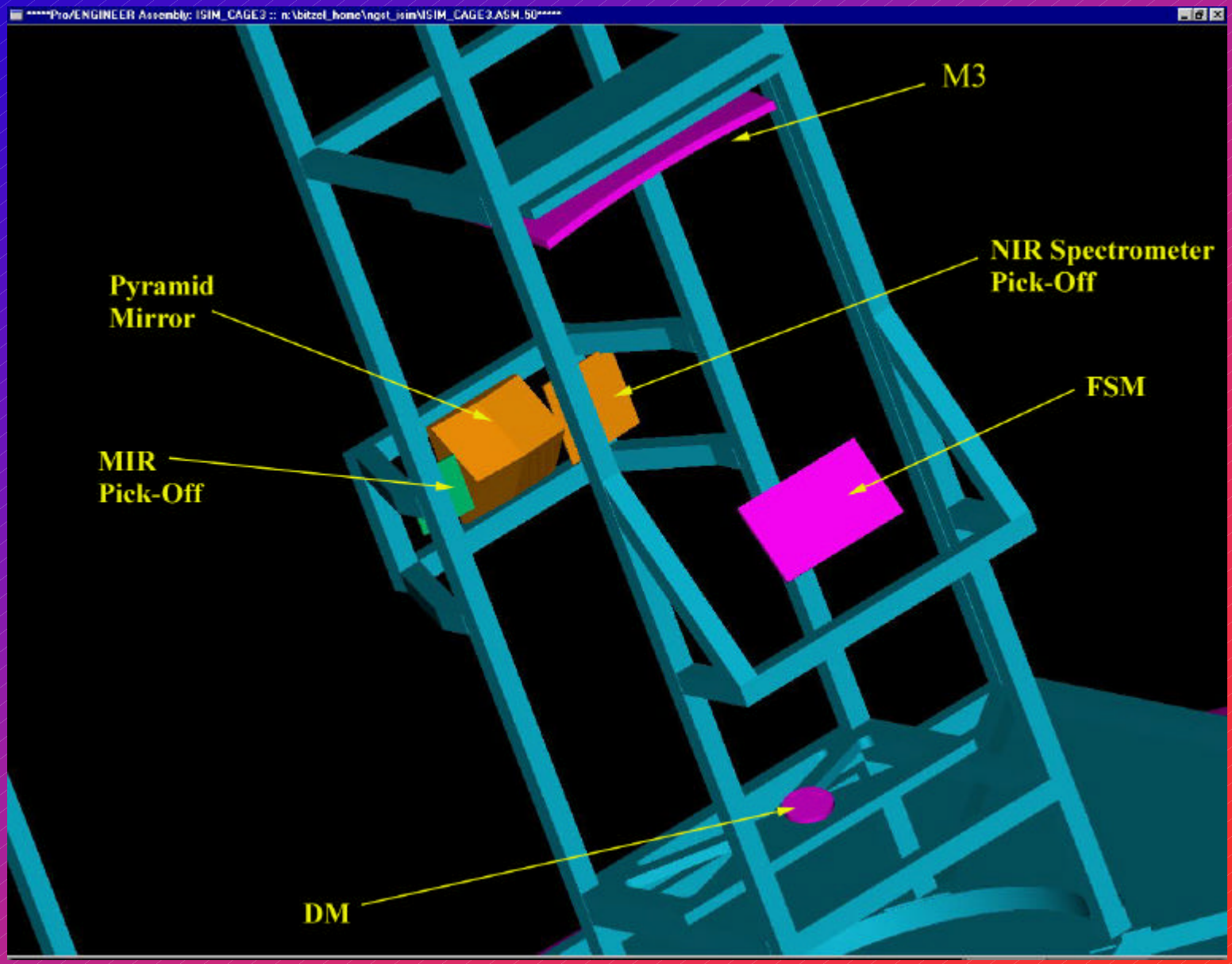
RMS Wavefront Error Vs Field Position



The ISIM instruments are located in an off-axis position.
This configuration yields excellent image quality.



The OTA tertiary mirror, deformable and fast steering mirror assemblies, and pyramid mirror integrate into the ISIM in a modular fashion.



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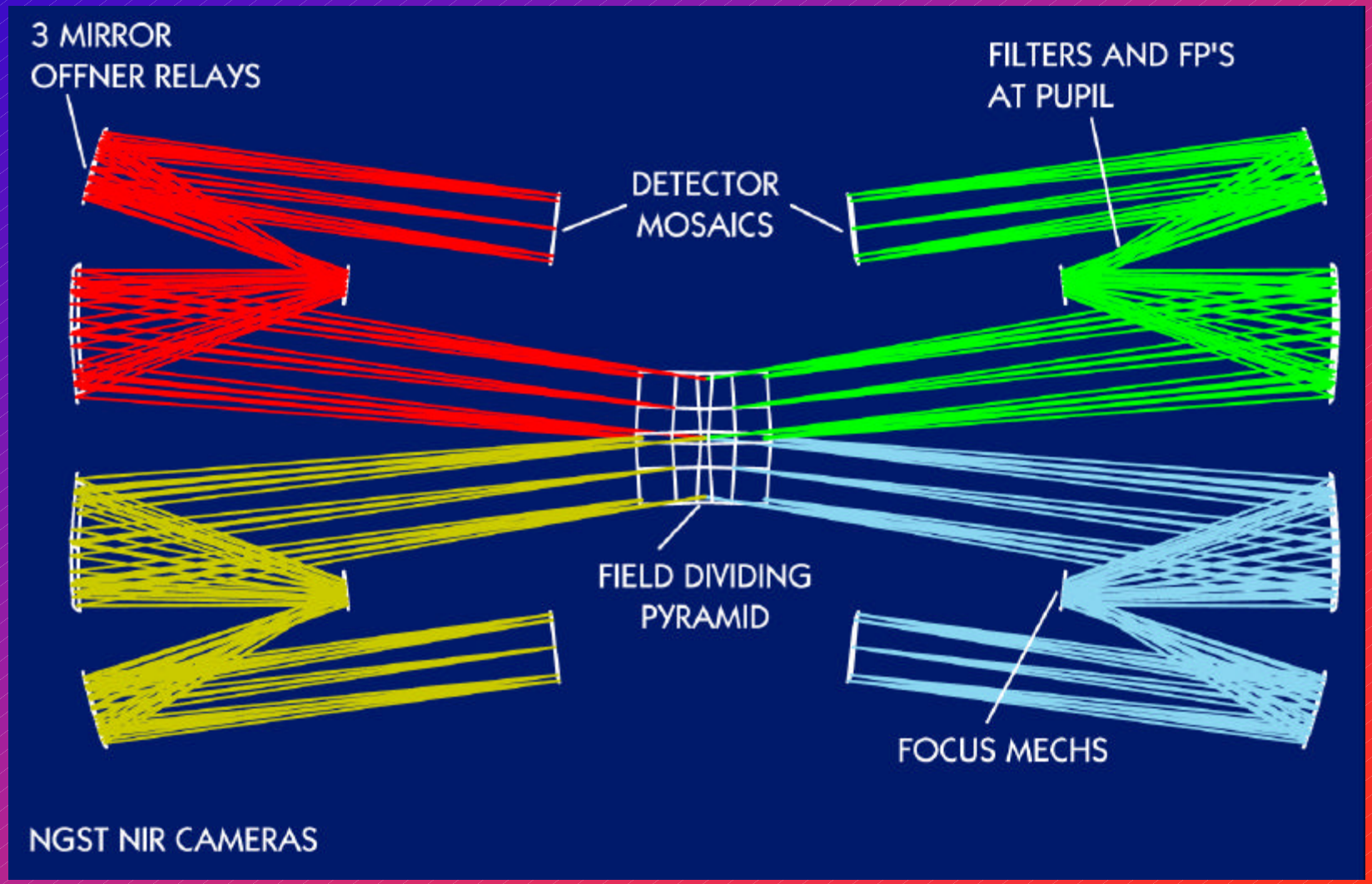
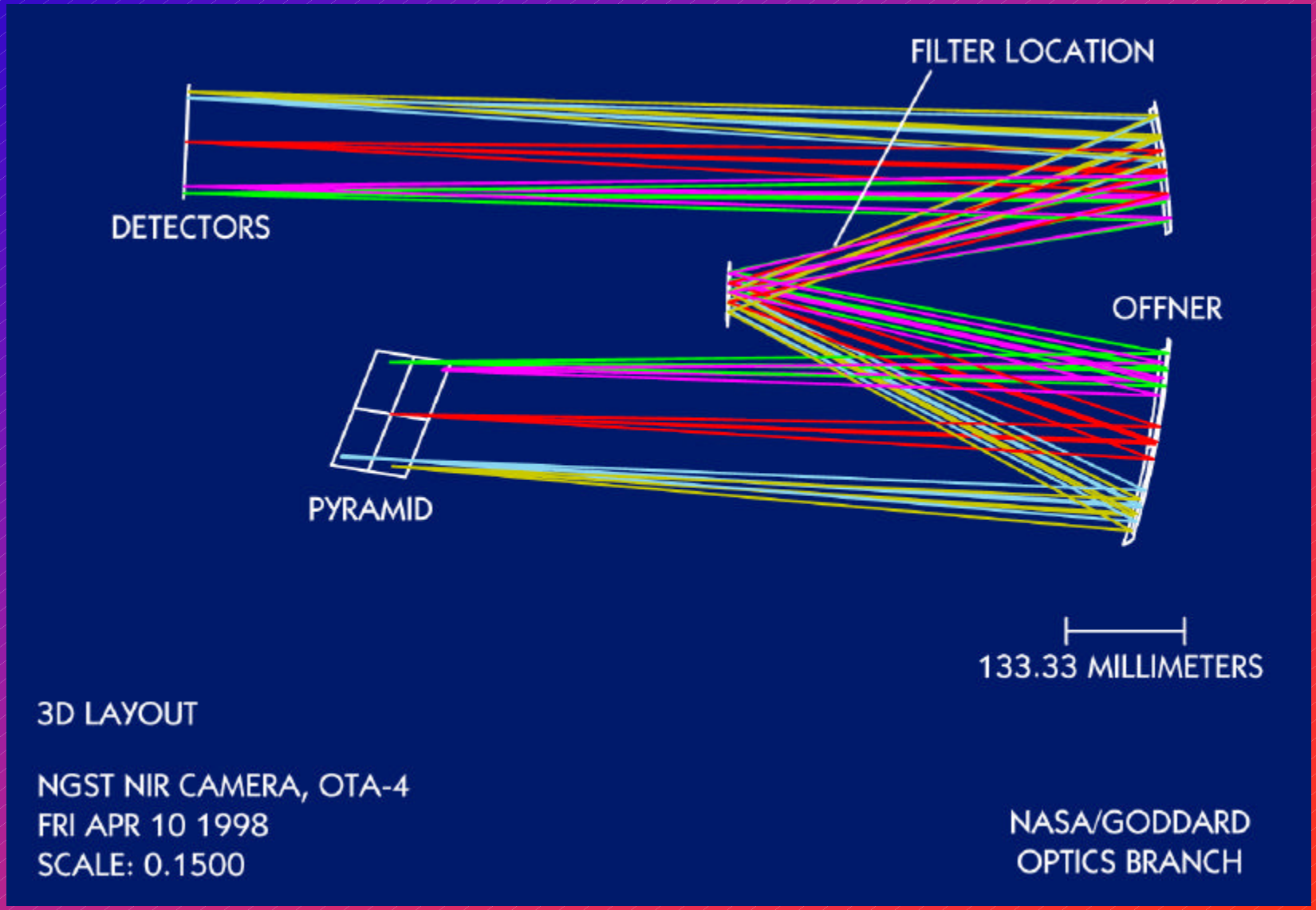
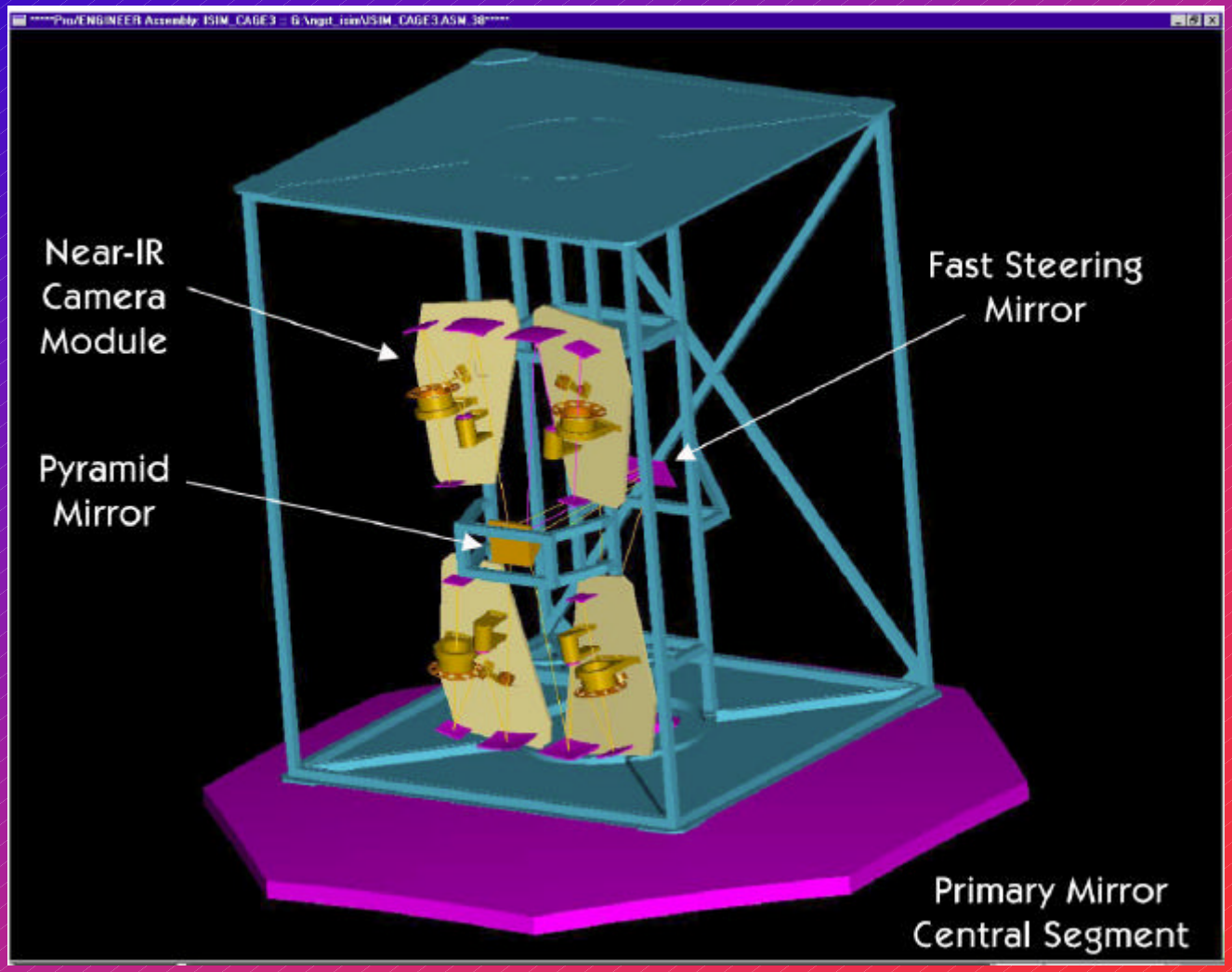
Near-Infrared Wide Field Camera Optical Schematic

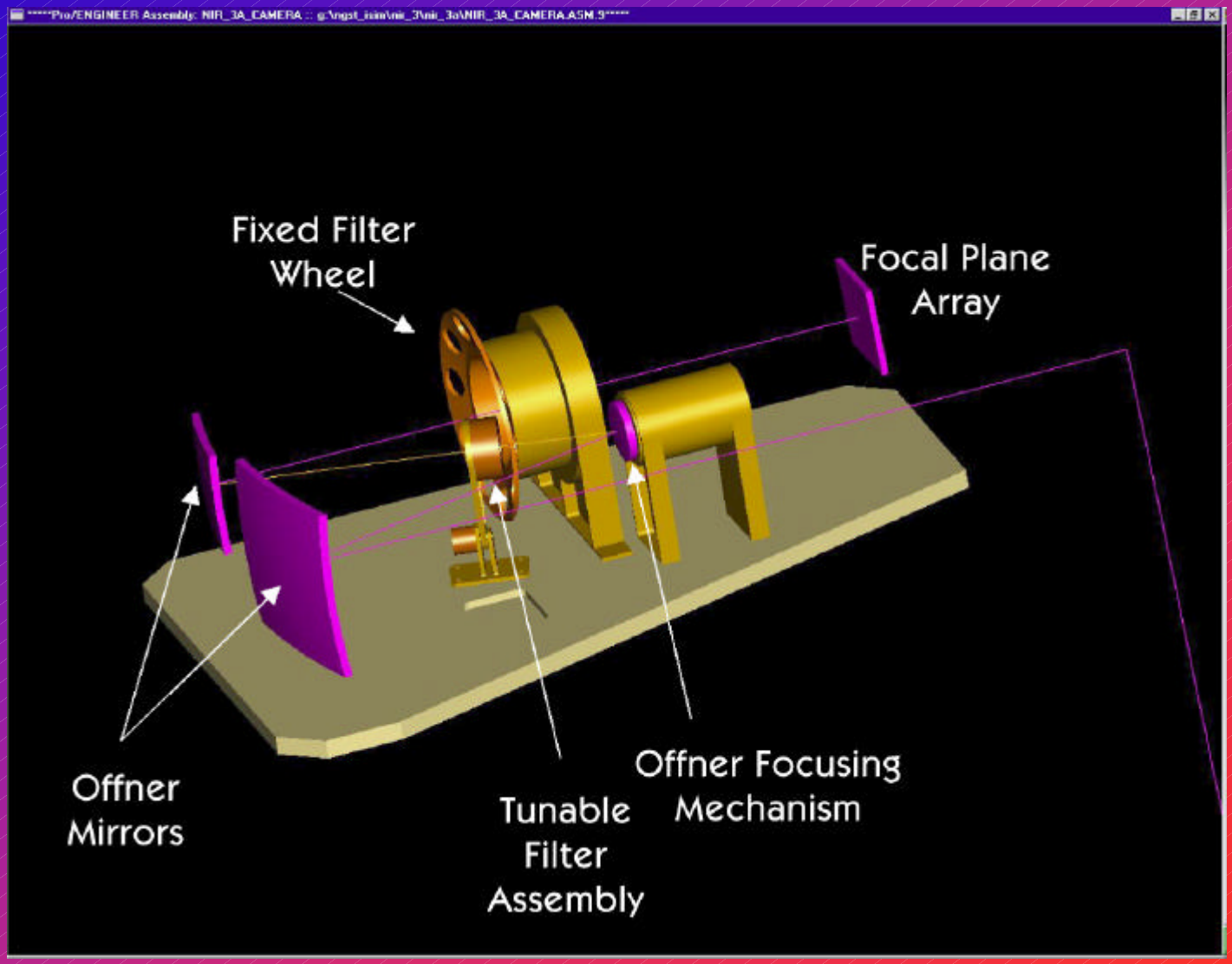


Near-Infrared Wide Field Camera Optical Schematic

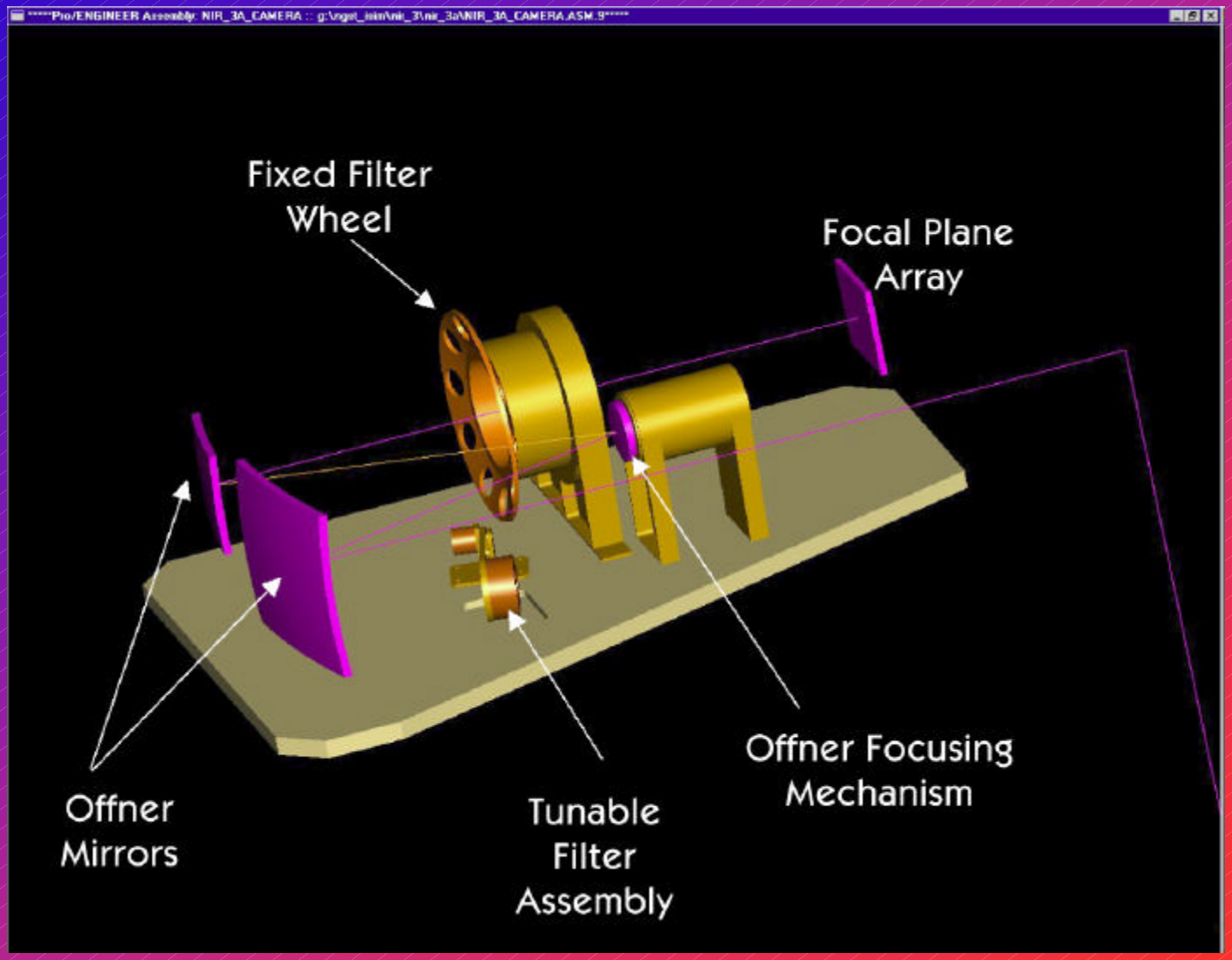




The ISIM near-infrared wide field camera employs a pyramid beam divider to apportion a 16 square arc-min field of view over four identical camera modules. Each module utilizes a 4096 x 4096 focal plane array covering 4 square arc-min.



Each camera channel includes a focusing Offner relay, filter wheel, and retractable tunable filter.



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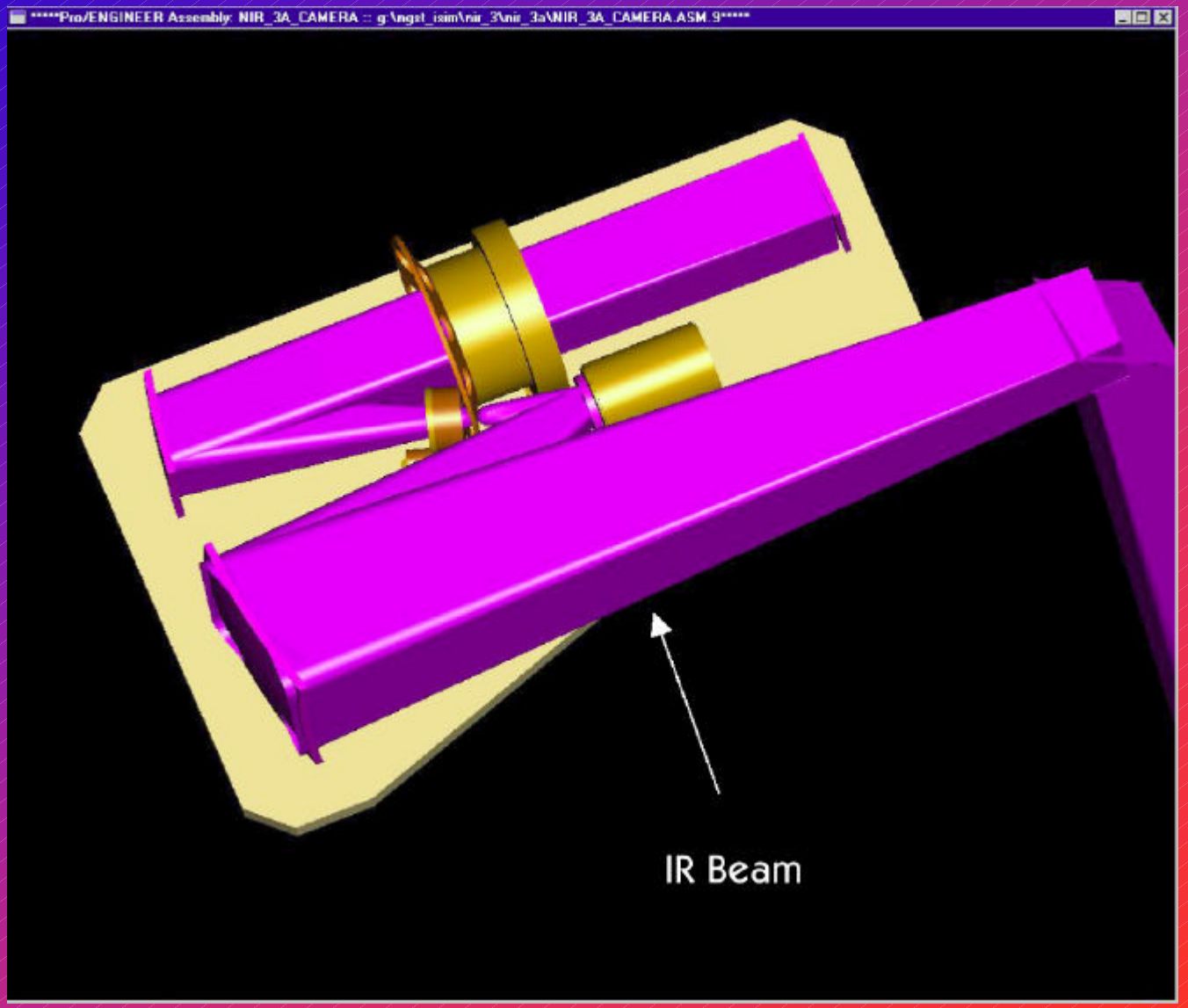
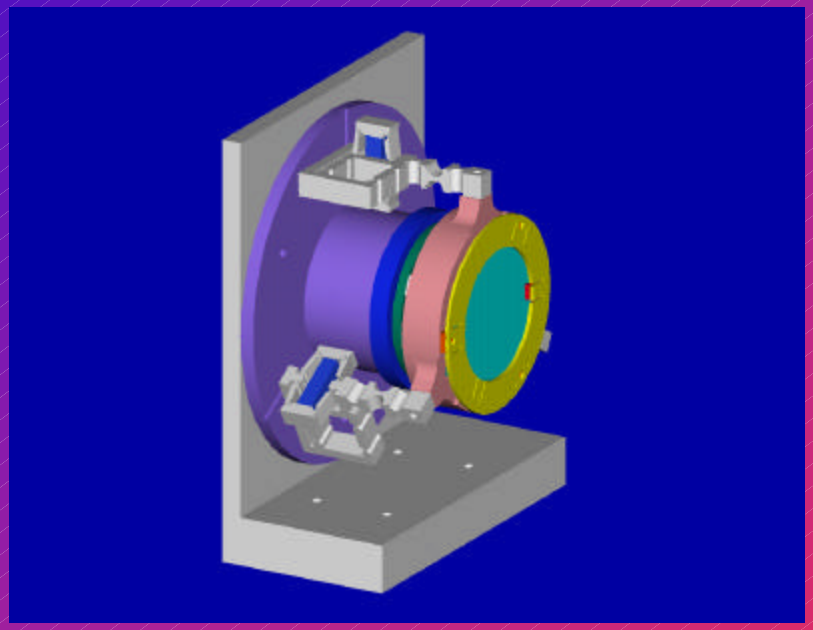
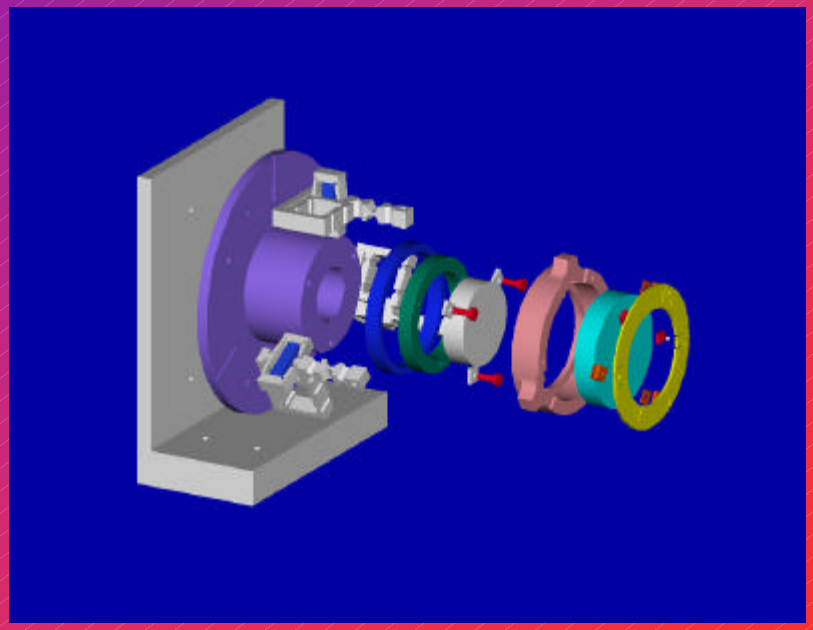


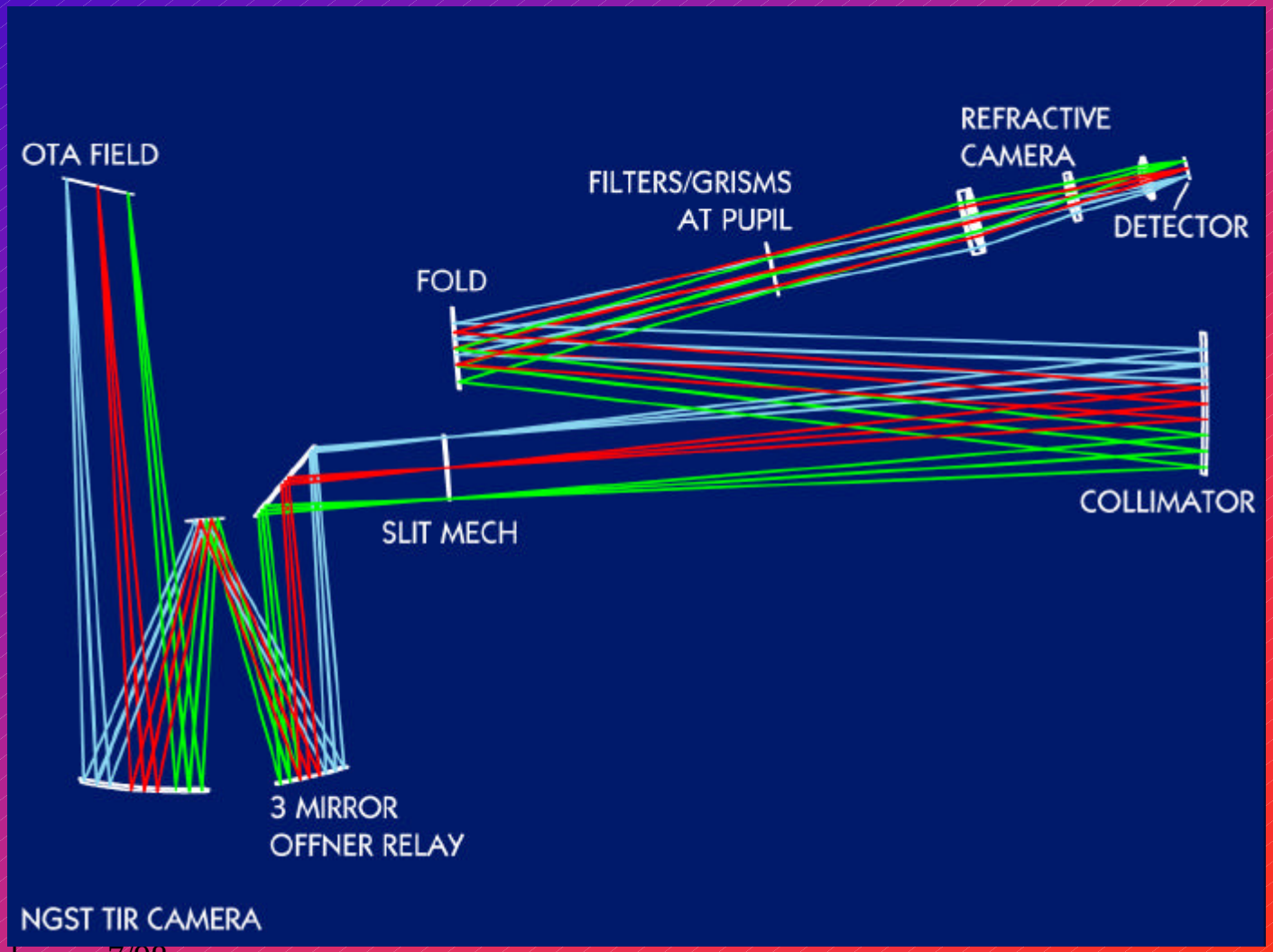
Near-infrared camera module with solid model beams.

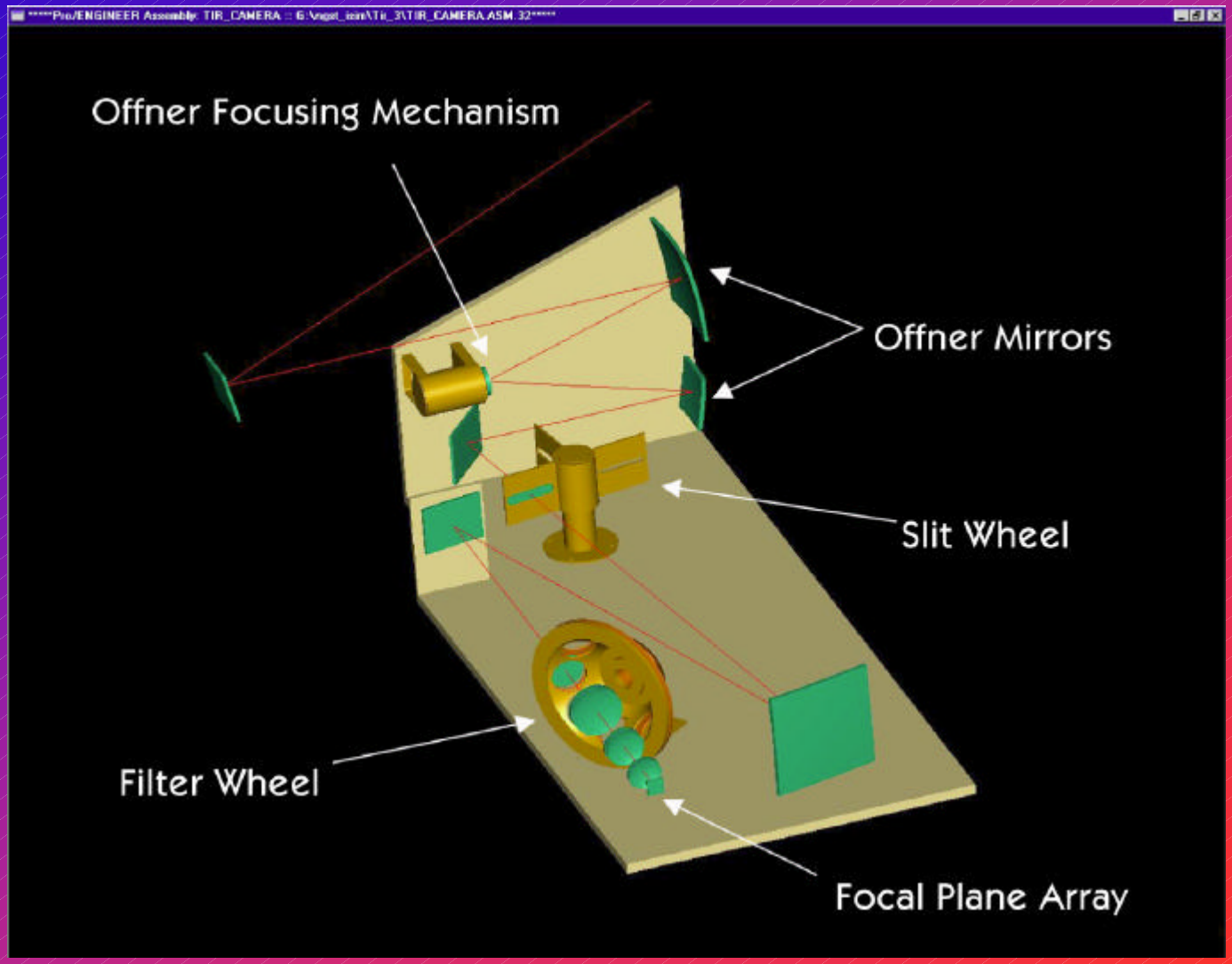
Prototype Cryogenic Tunable Filters Under Development for NGST By GSFC & Northrop Grumman Corp.



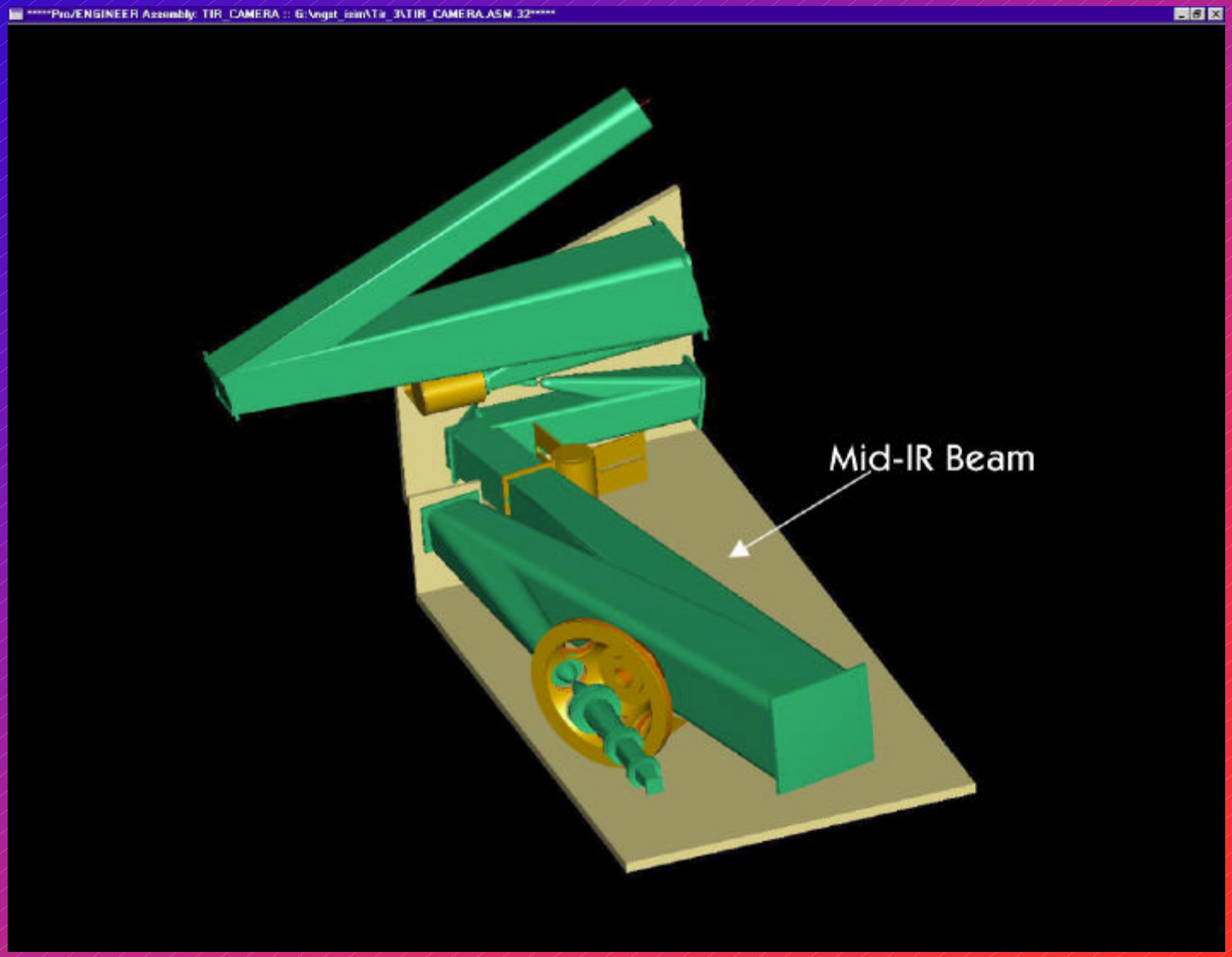


Mid-Infrared Camera/Spectrometer Optical Schematic

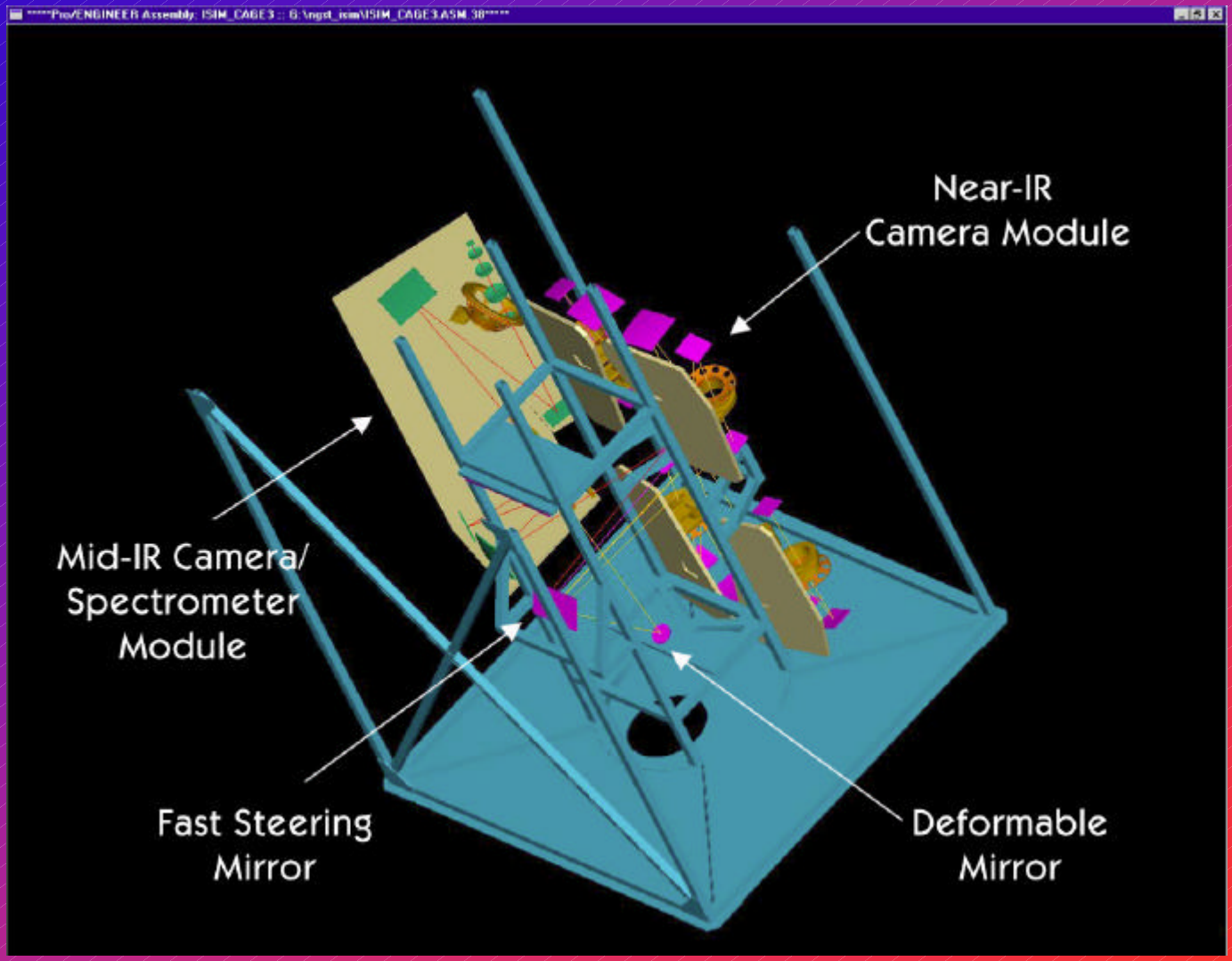




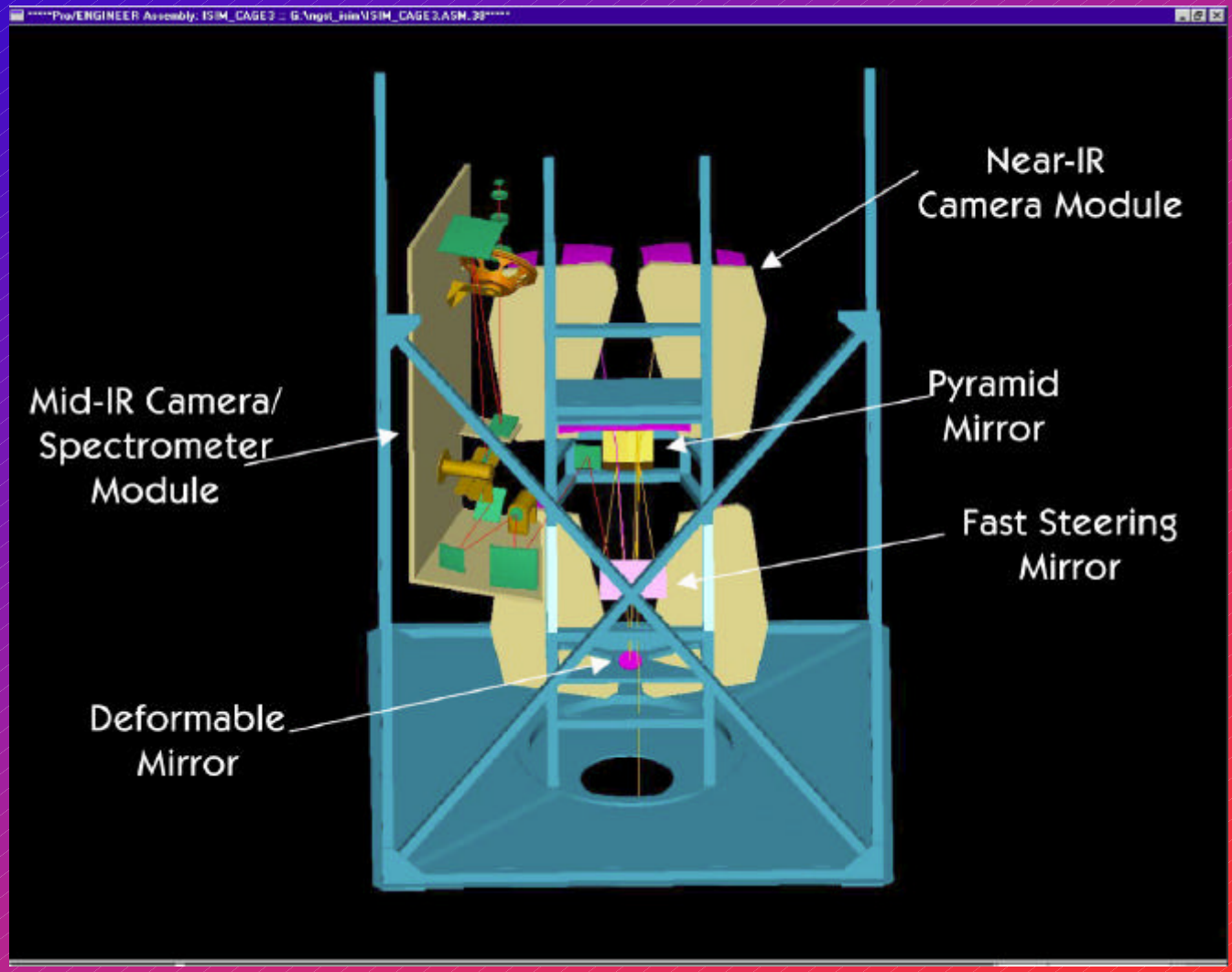
The mid-infrared camera/spectrometer module utilizes a 1024 x 1024 focal plane array and contains selectable slits, filters, and cross-dispersed grisms.



Mid-infrared camera/spectrometer module with solid model beams.



The near-ir camera and mid-ir camera modules integrate into the ISIM in a modular fashion. Near-ir spectrometer not shown.



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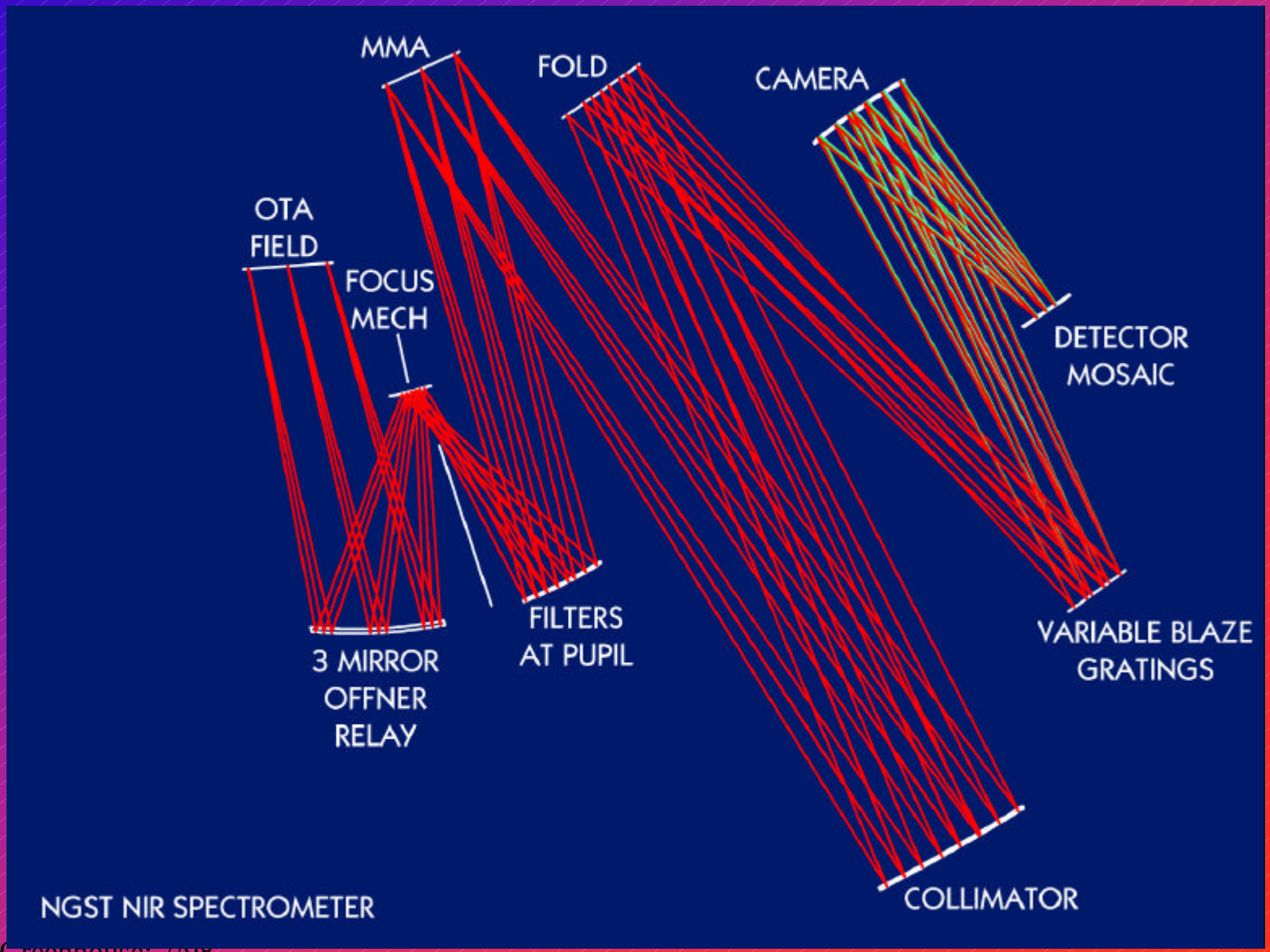
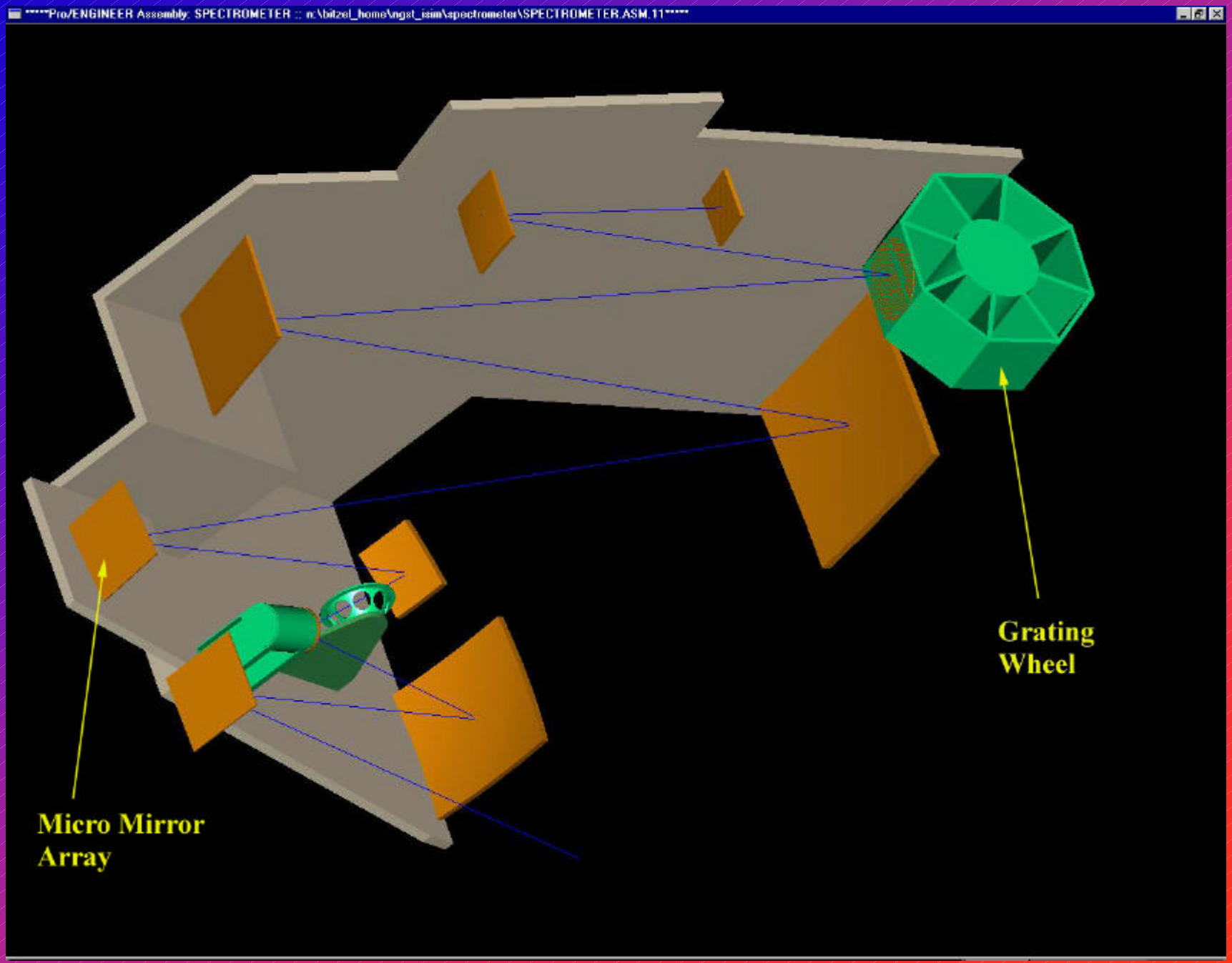
Near-Infrared Micro-Mirror Array Spectrometer Optical Schematic





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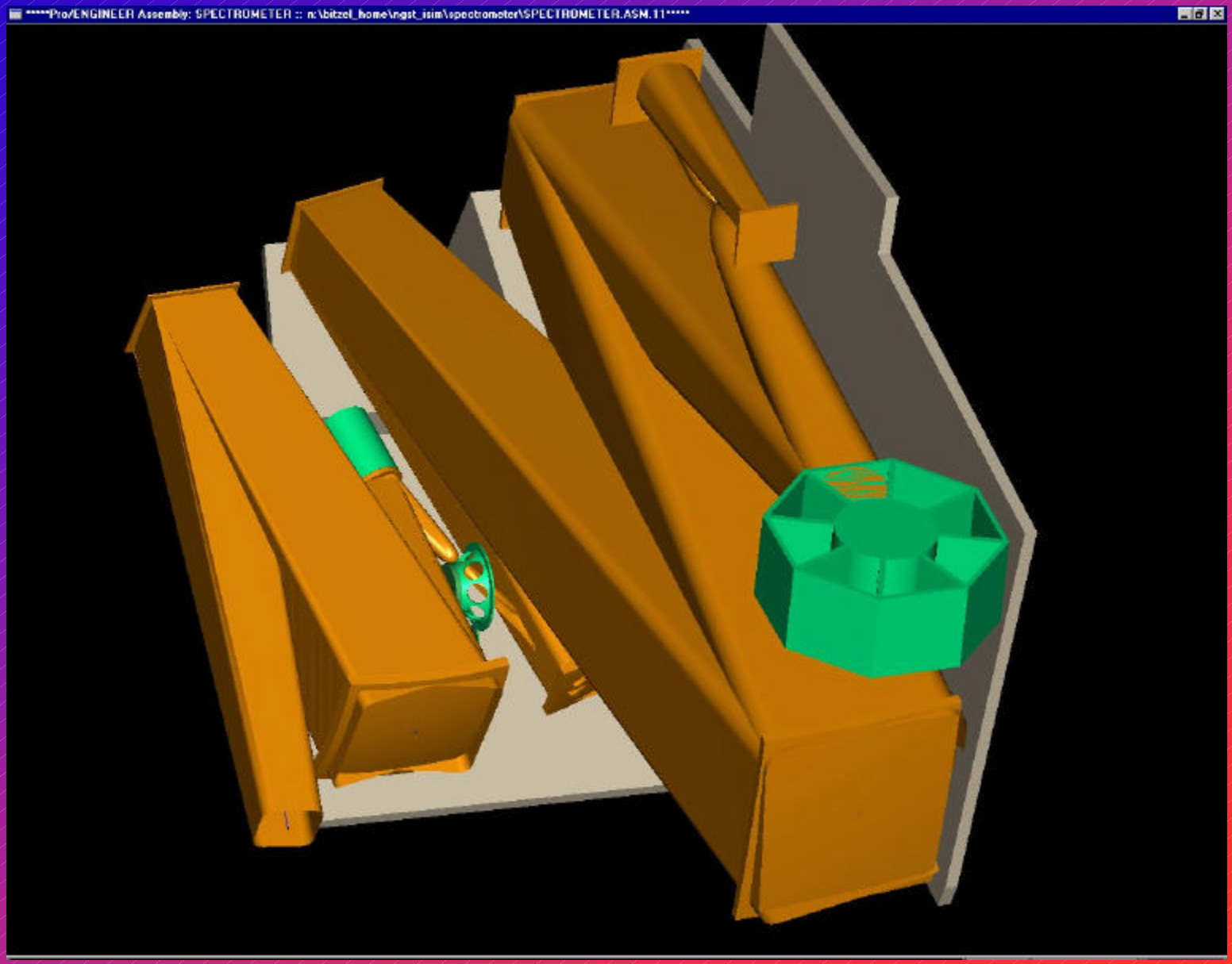

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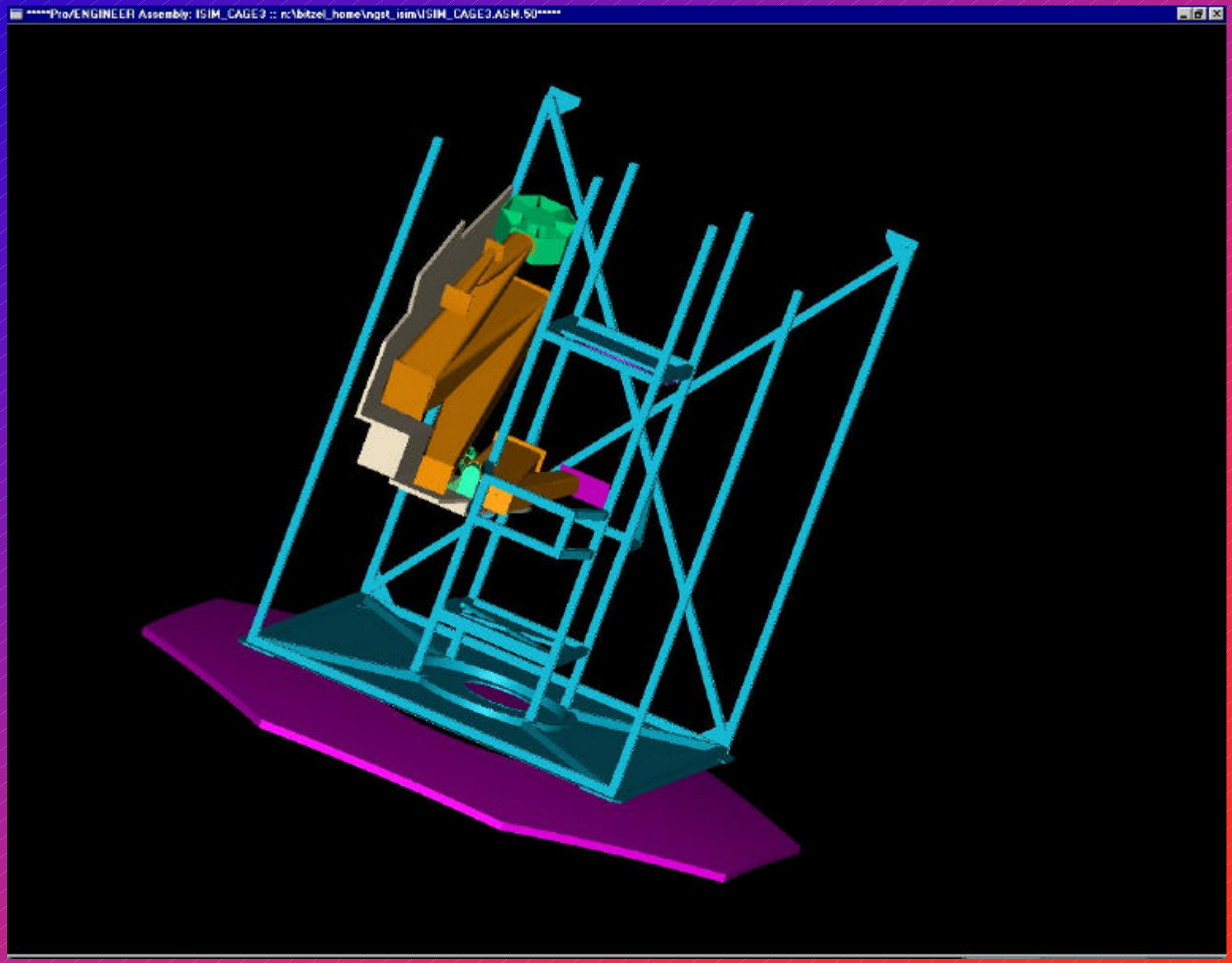

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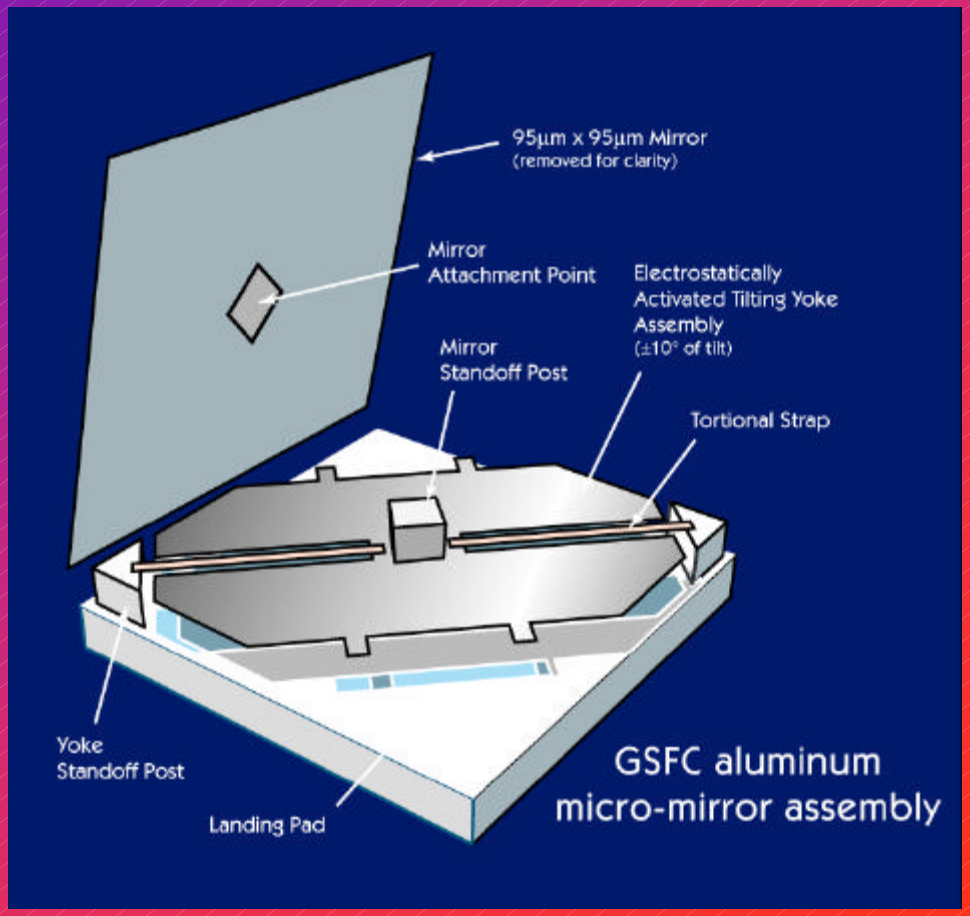
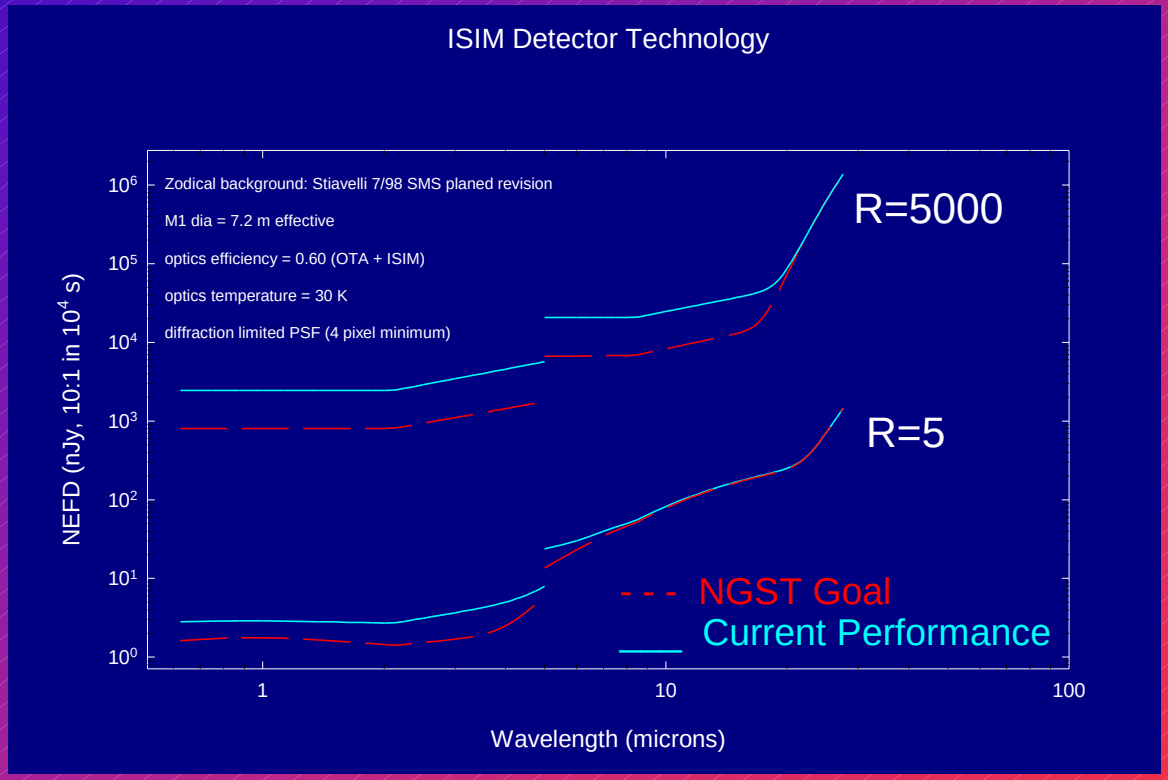
MEMS Sensor Optics

GSFC Cryogenic Micro-Mirror Arrays for Multi-Object Spectroscopy

- 30 K operating temperature
- 100 micron pixel pitch
- aluminum surface micro-machining
- low voltage electrostatic actuation
- scalability goal: 2048 x 2048
- first 3 x 3 pixel unit cell demonstrator during Dec 98



Performance Exhibited By Current Detectors Is Near NGST Goals



	QE	Read Noise (e) multiple read	Dark Current (e/s)
Alladin InSb	0.8	15	0.1
Near-IR goal	0.8	3	0.02
Current Si:As	0.5	8	10
Mid-IR goal	0.5	3	1

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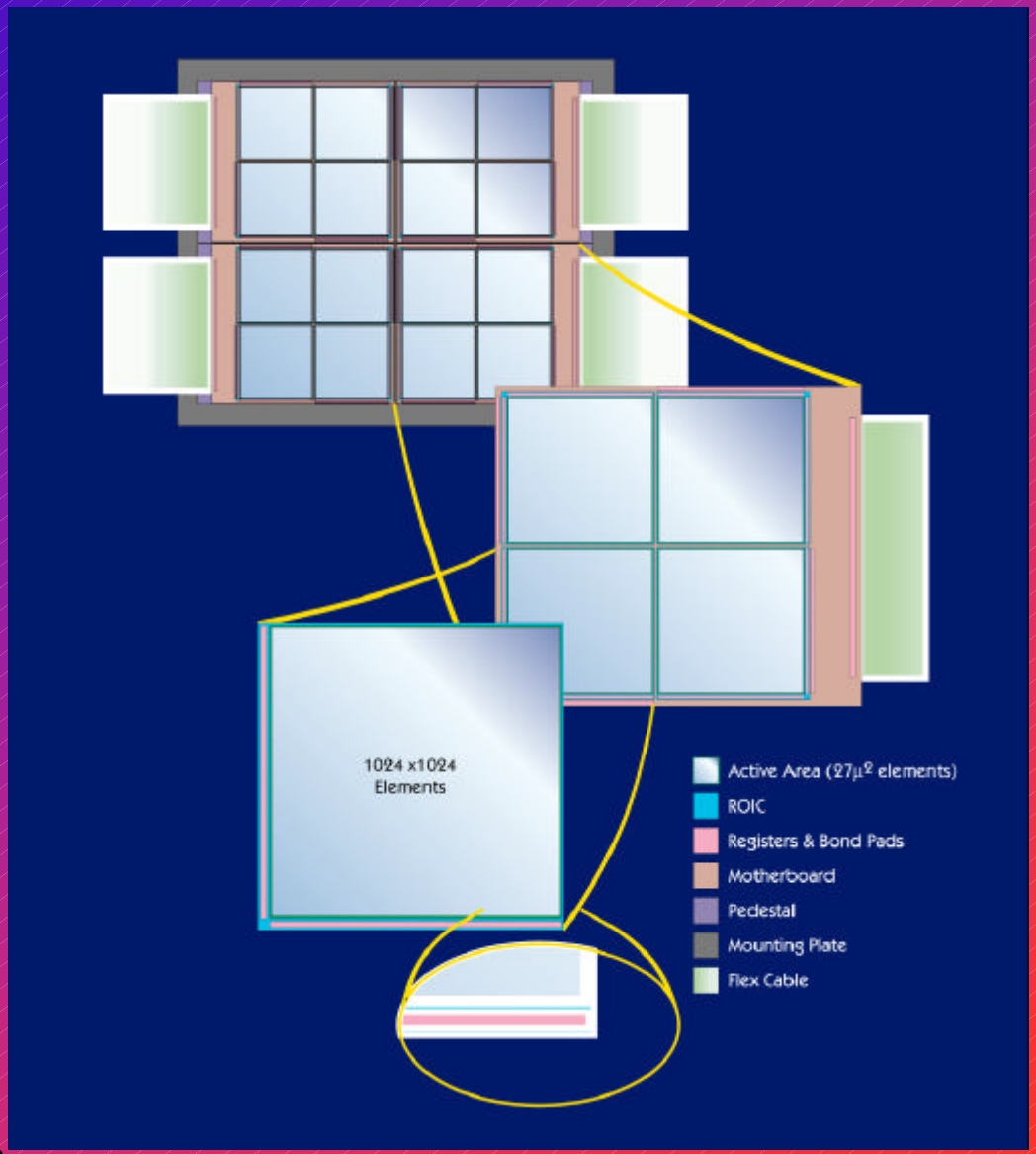
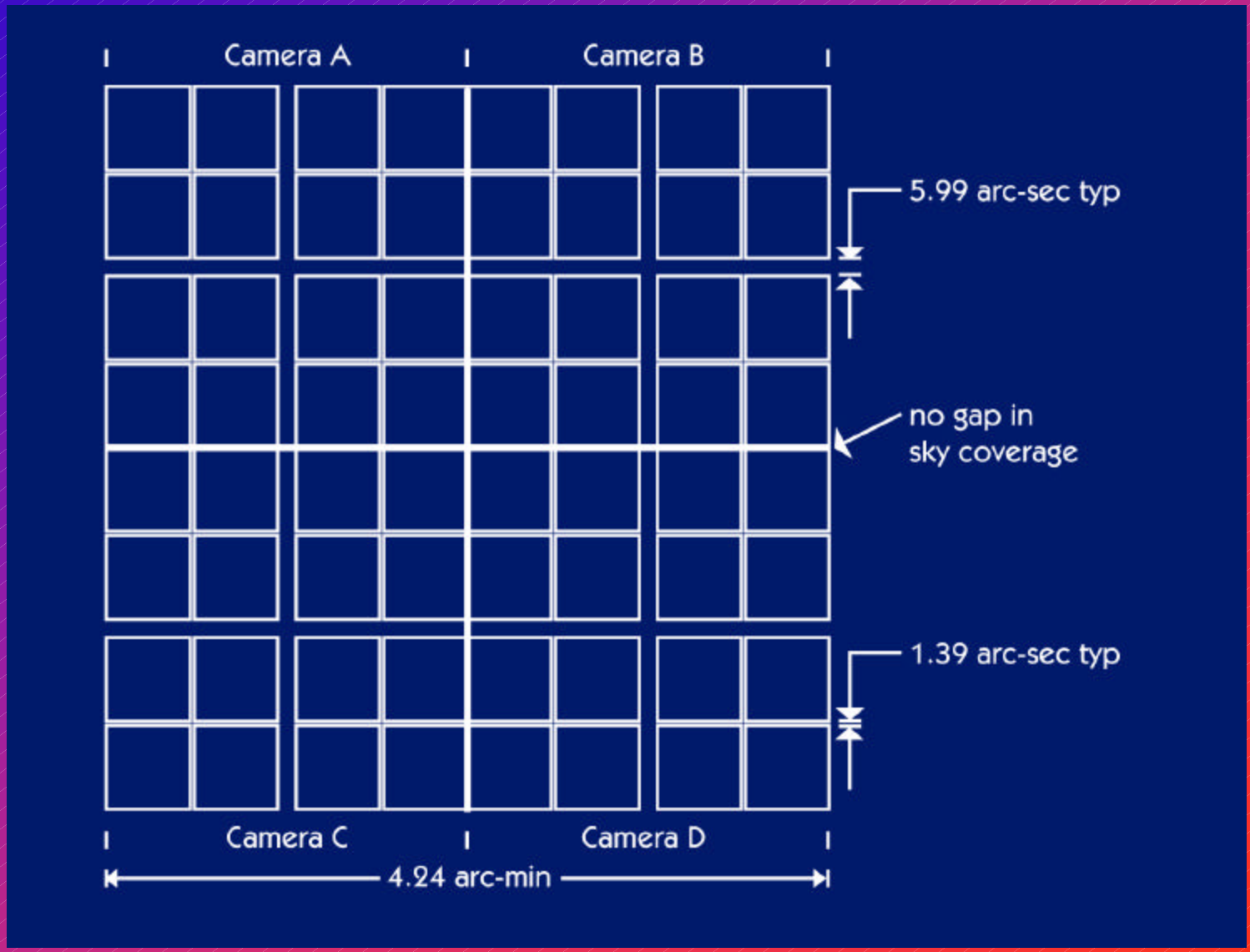
4096 x 4096 Near-Ir FPA Mother Board Assemblies



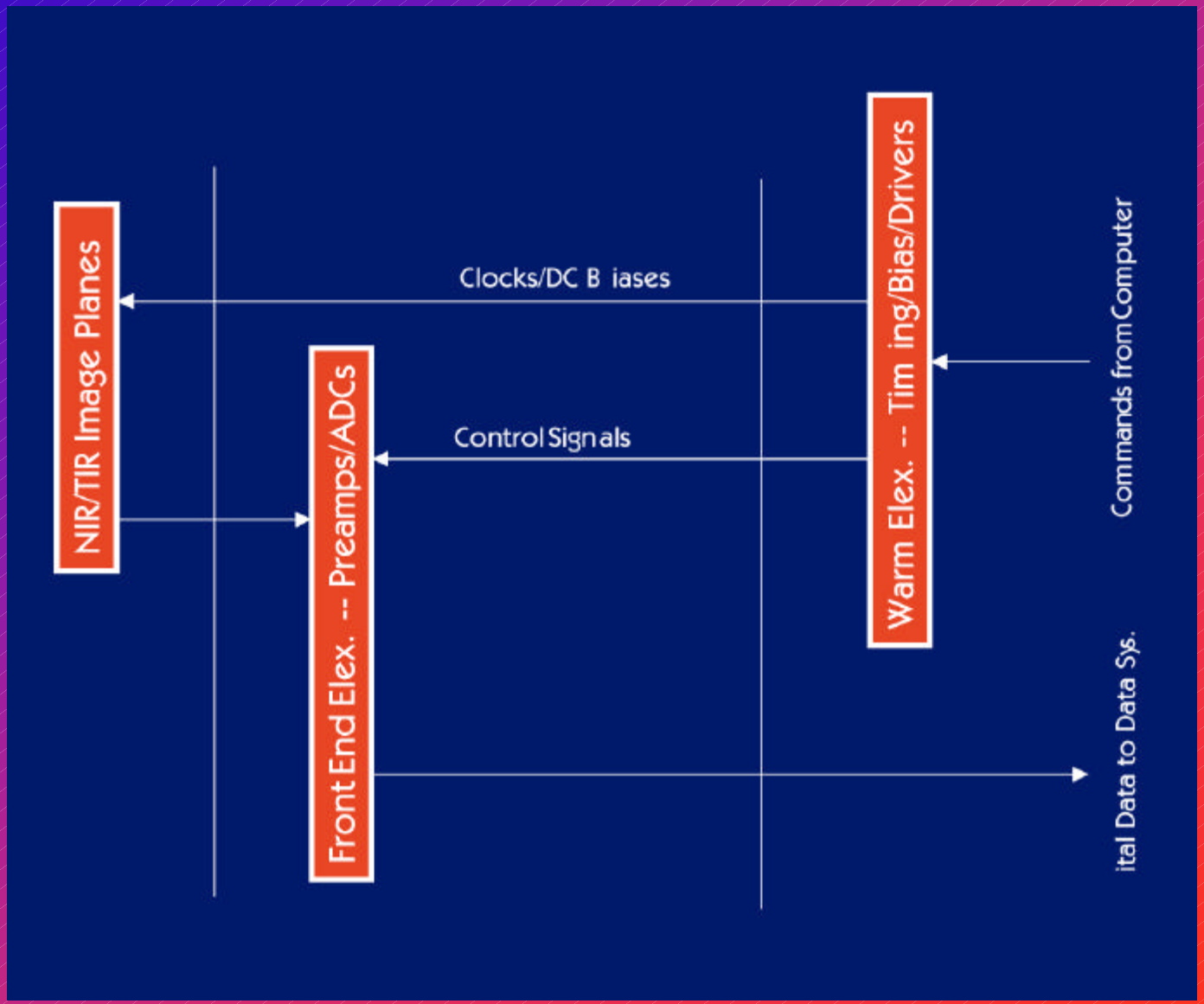
Near-Ir Quad-Camera FOV



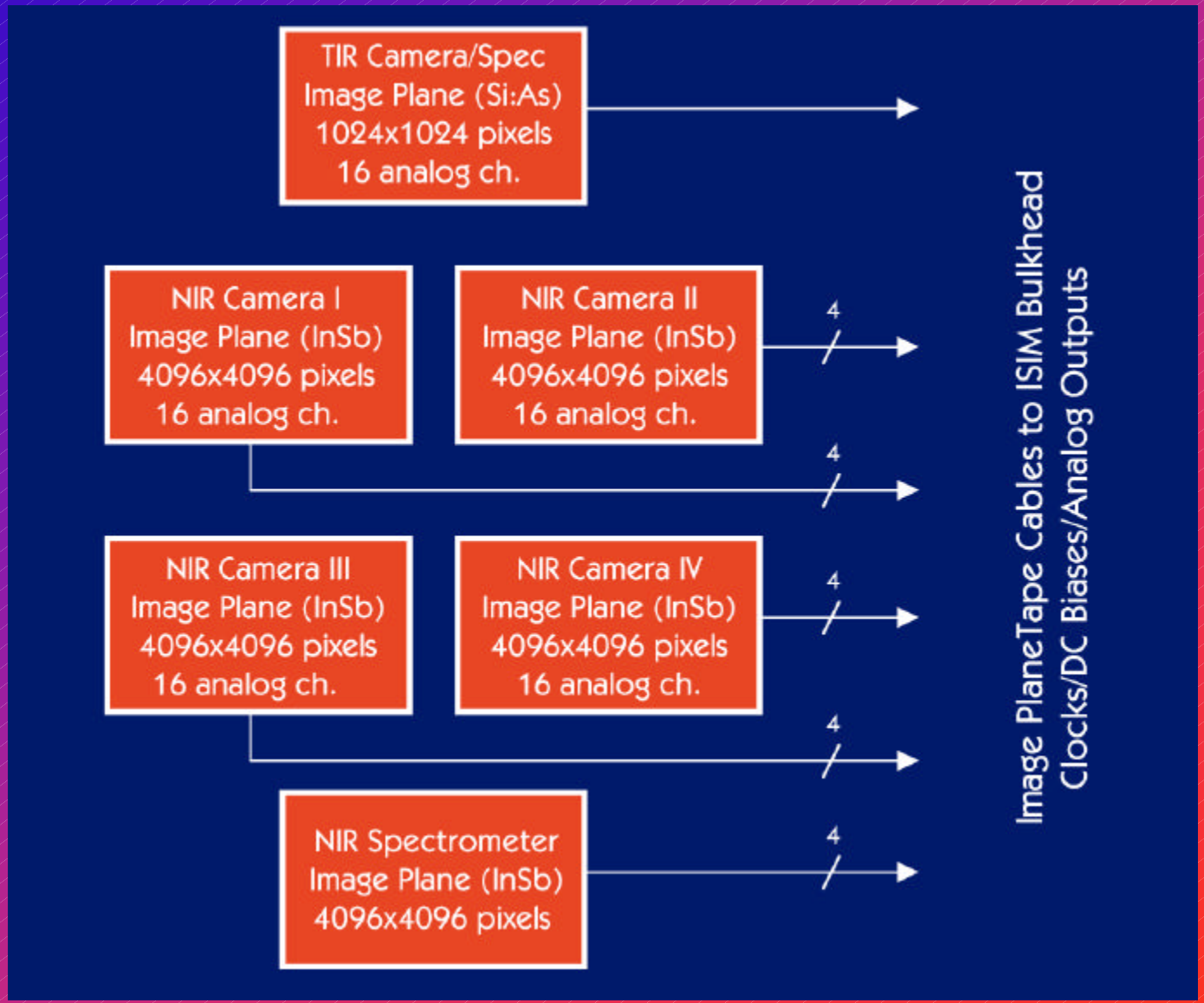
Detector Electronics Functional Blocks

- Focal Plane Arrays
  - near-ir, mid-ir hybridized detectors/ROICs
  - driven by warm electronics
  - analog outputs to front end electronics
- Front End Electronics
  - preamplifiers, analog-to-digital converters, digital multiplexers
  - driven by FPAs and warm electronics
  - digital outputs to ISIM data system
- Warm Electronics
  - command interface, timing generators, DC bias sources and drivers
  - driven by ISIM computer via command interface
  - control outputs to FPA and front end electronics

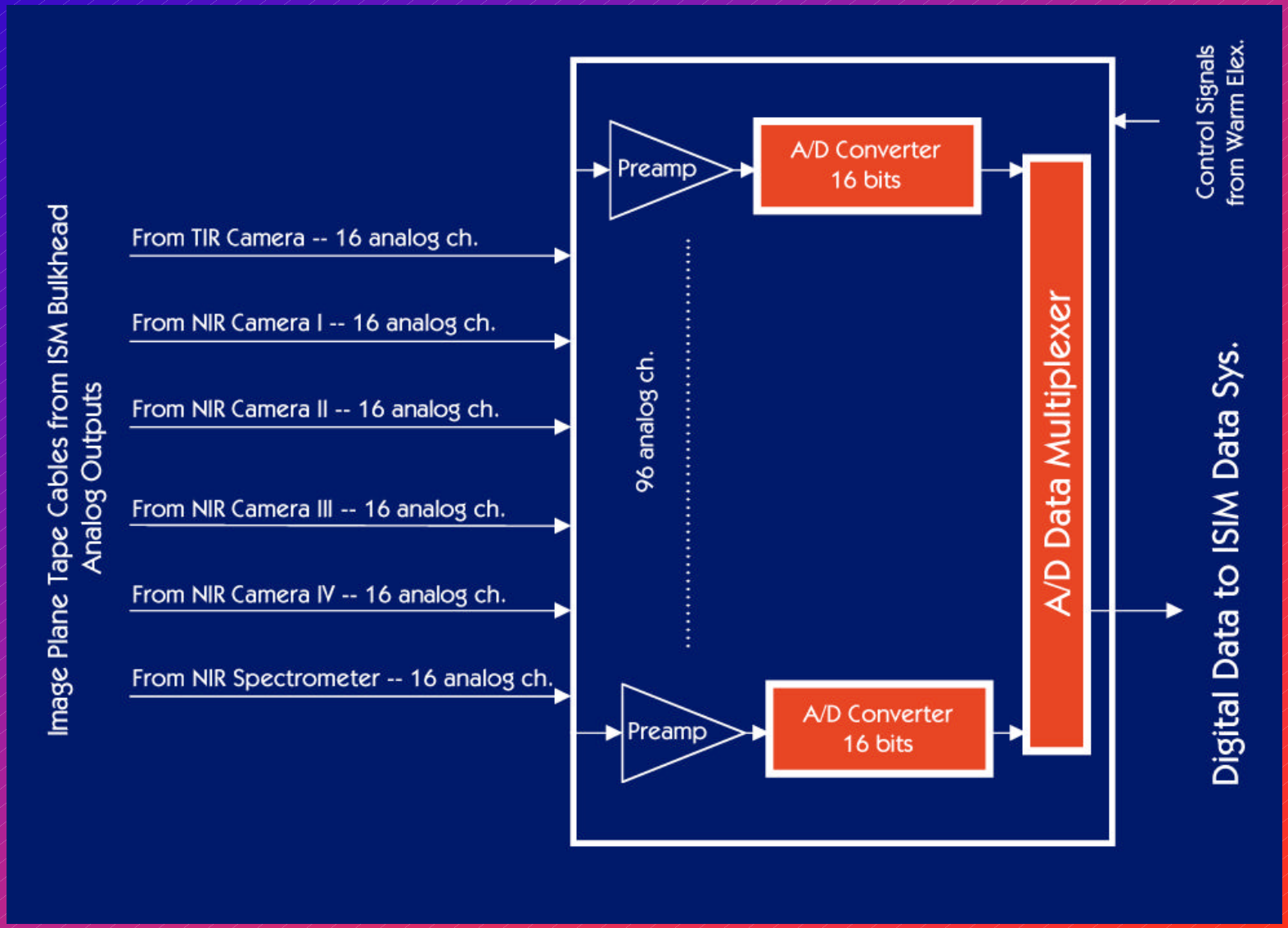
ISIM Detector Electronics Overview



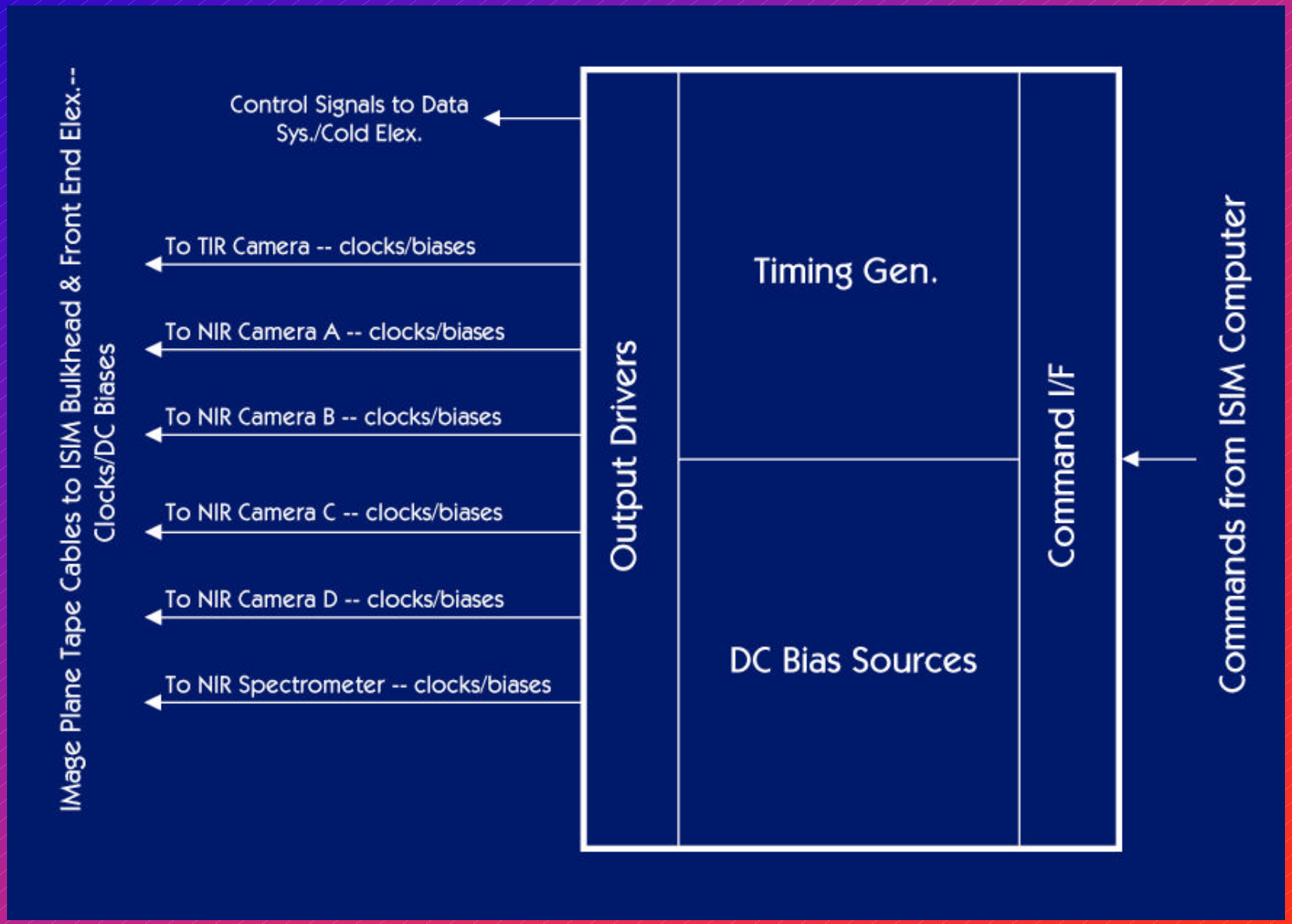
ISIM Focal Plane Arrays



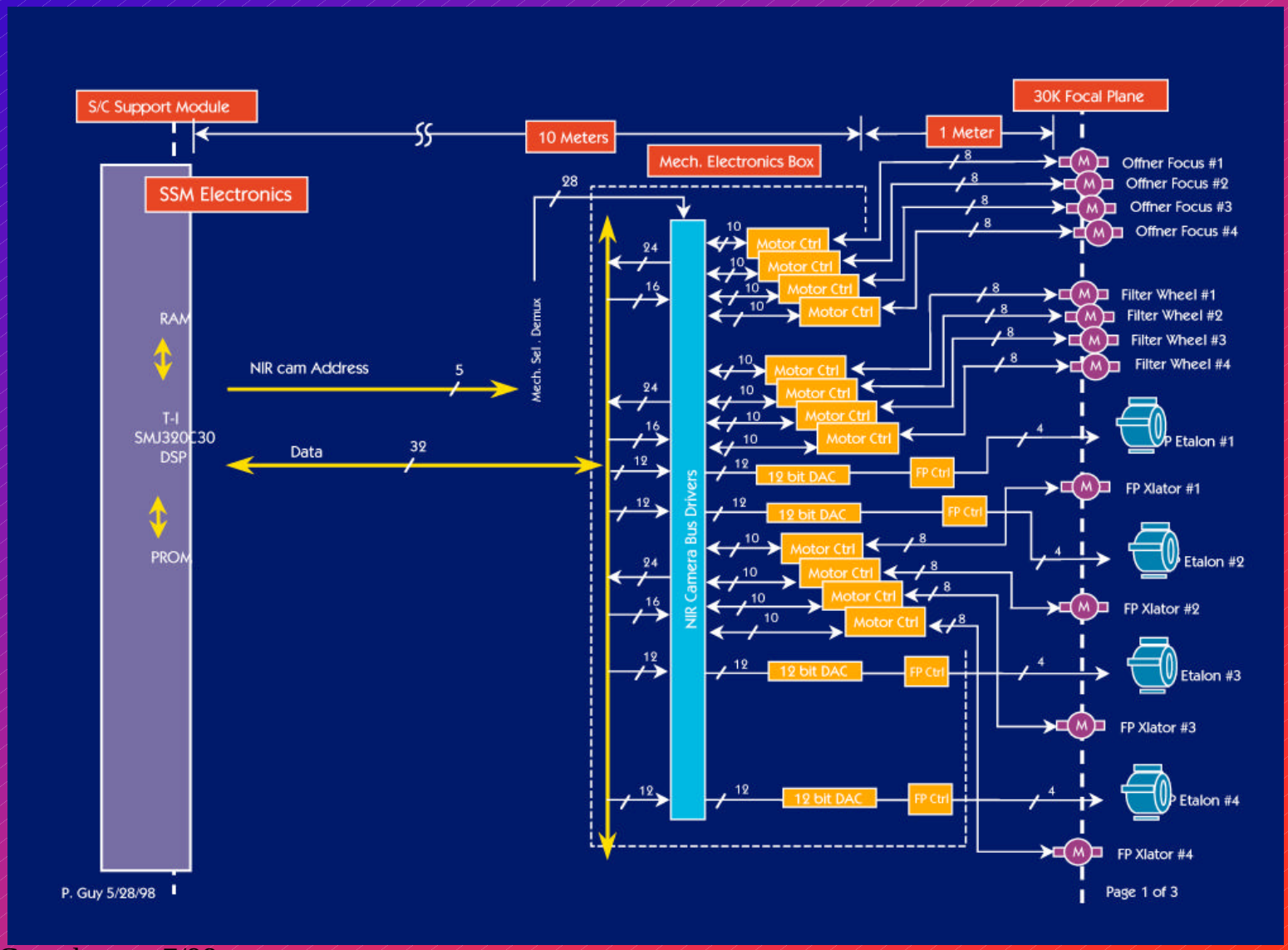
ISIM Front End Electronics



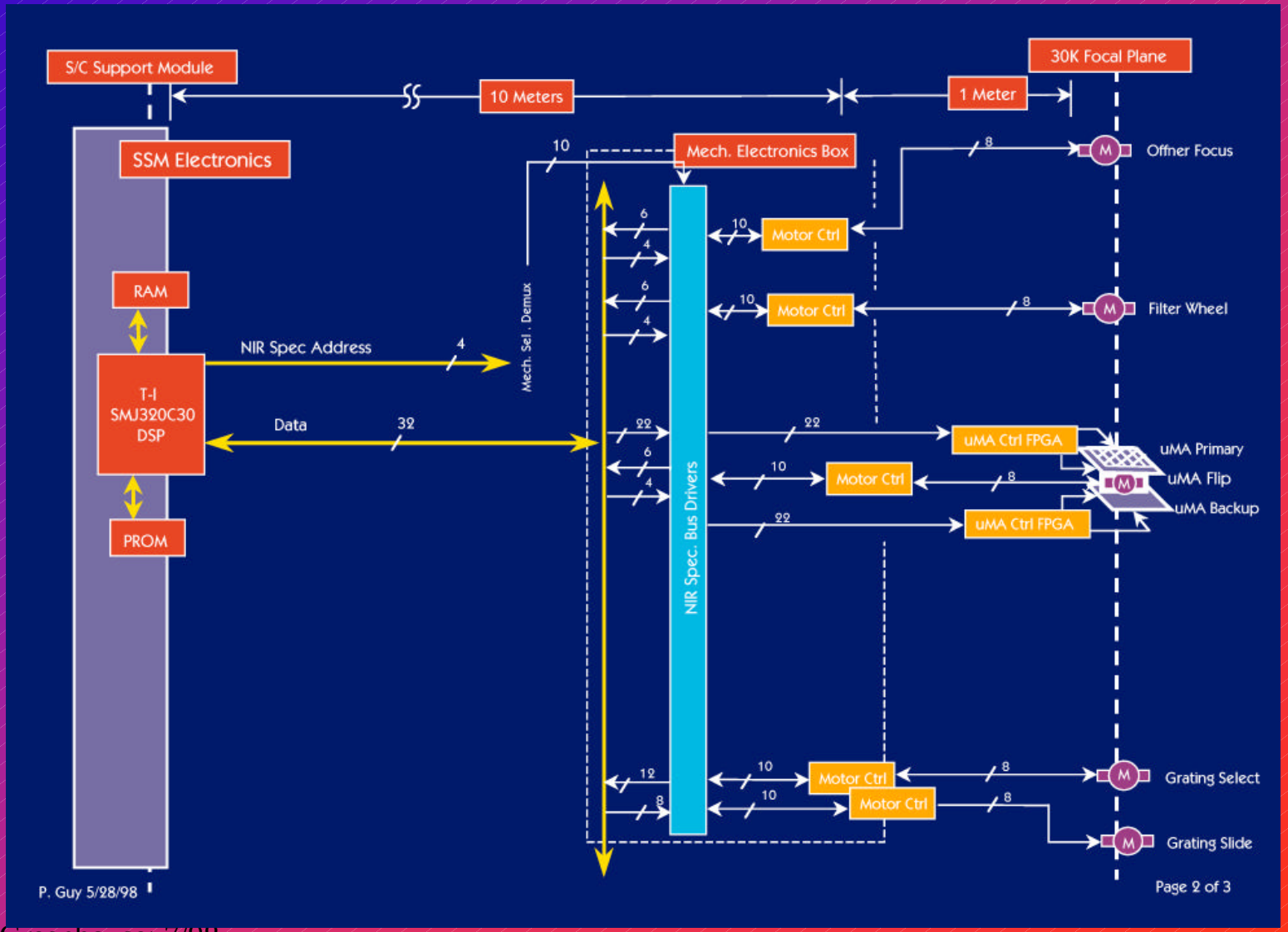
ISIM Warm Detector Electronics



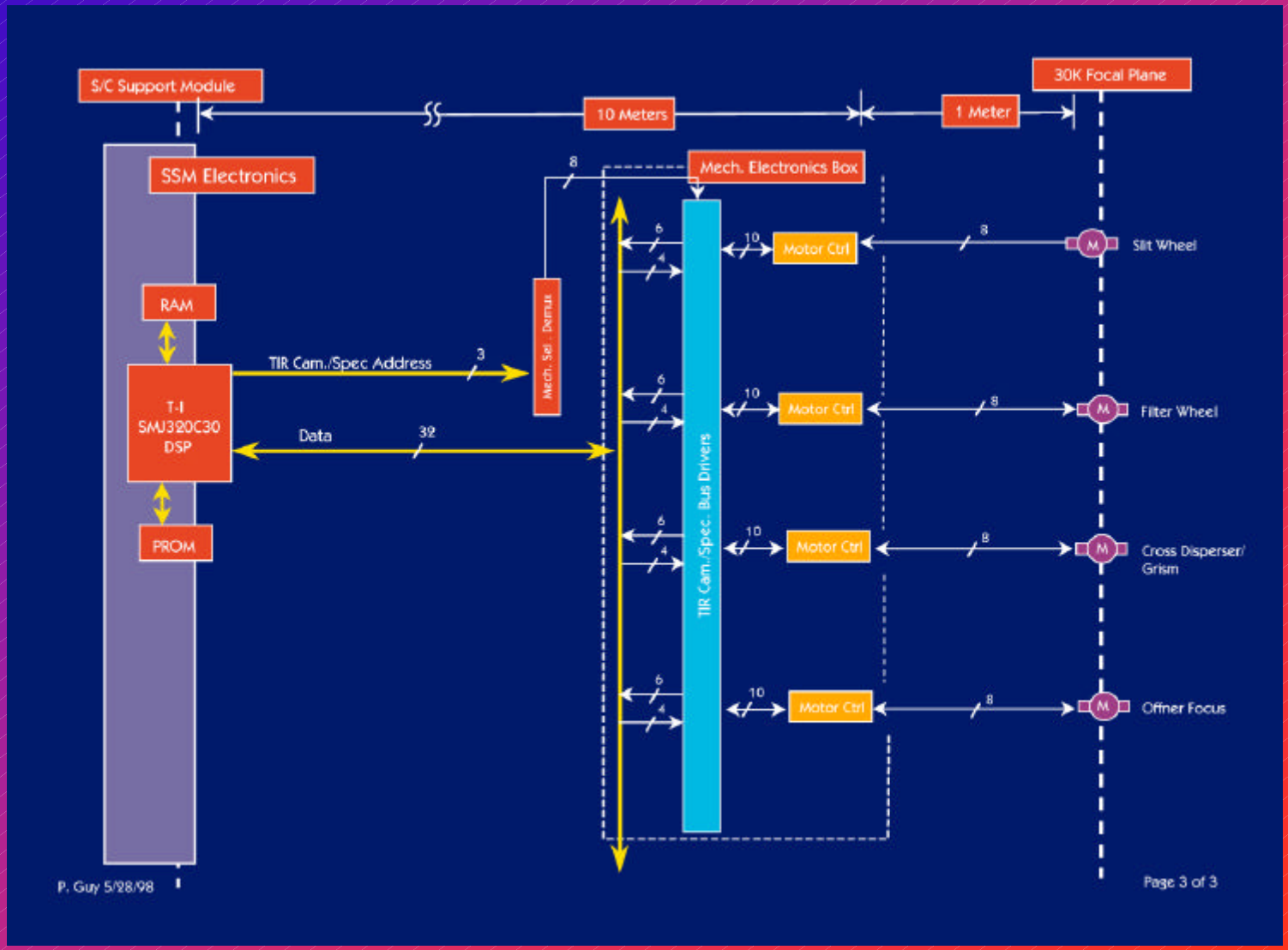
NIR Camera Mechanisms Block Diagram



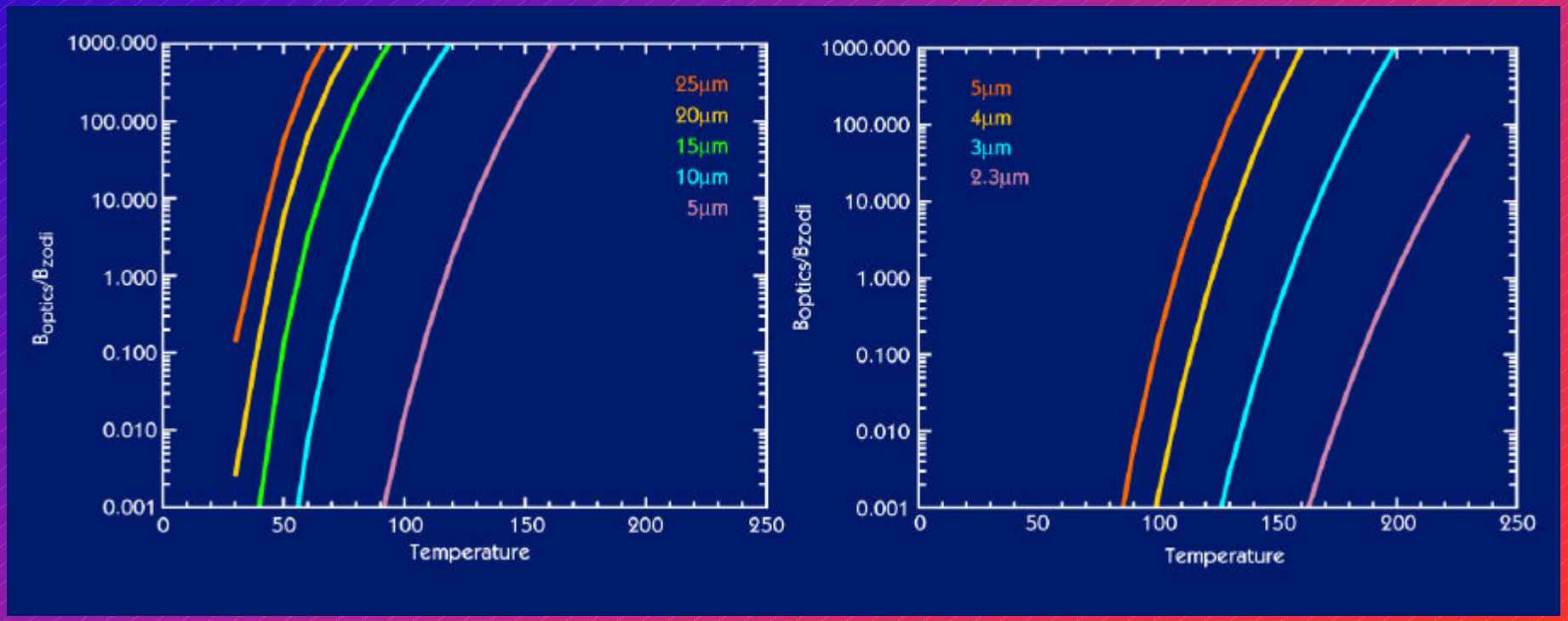
NIR Spectrometer Mechanisms Block Diagram



TIR Camera, Spectrometer Mechanisms Block Diagram

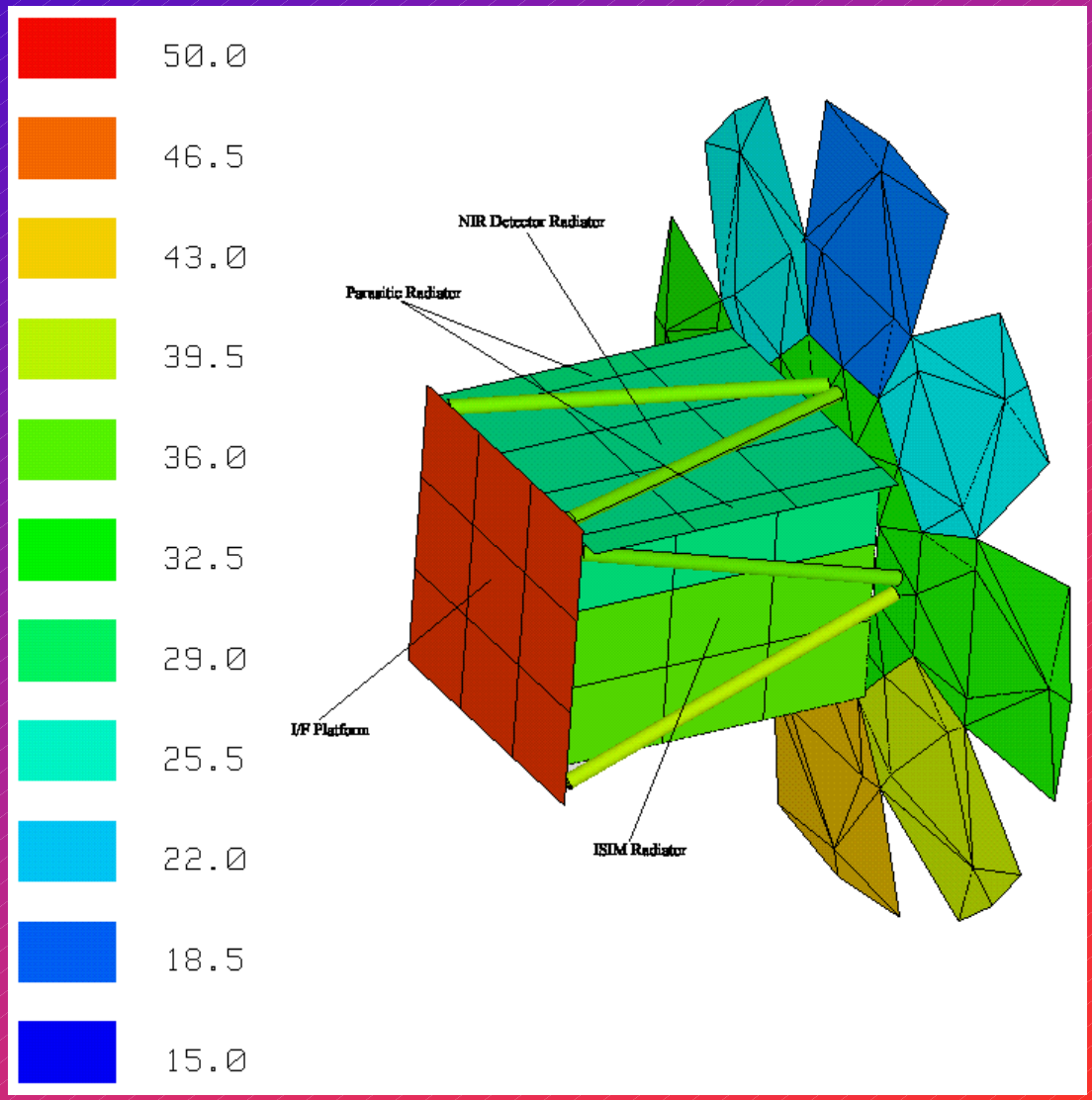


ISIM Cooling Requirements

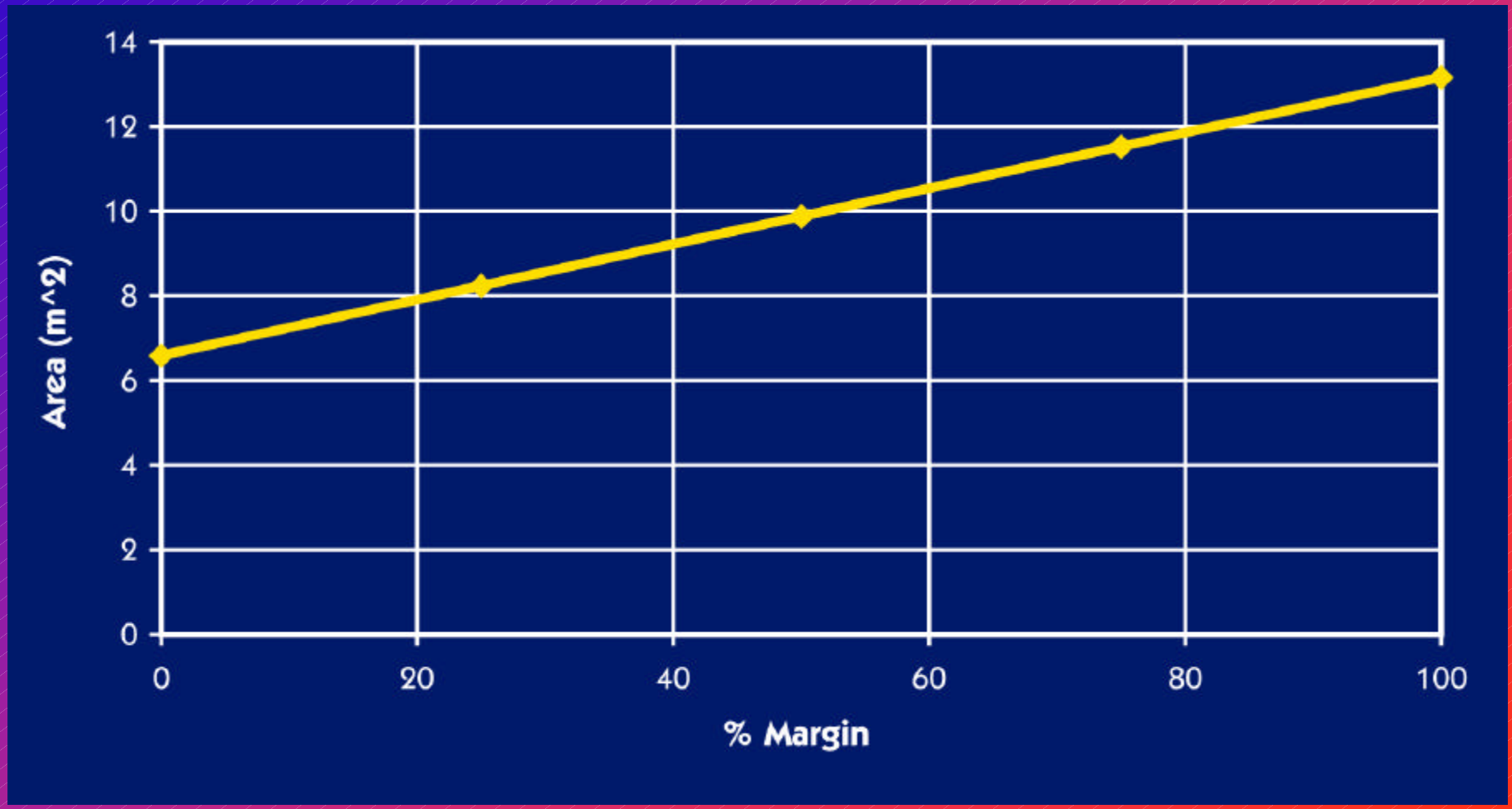


ISIM optical bench temperature as a function of thermal background power relative to the Zodical light at various wavelengths.

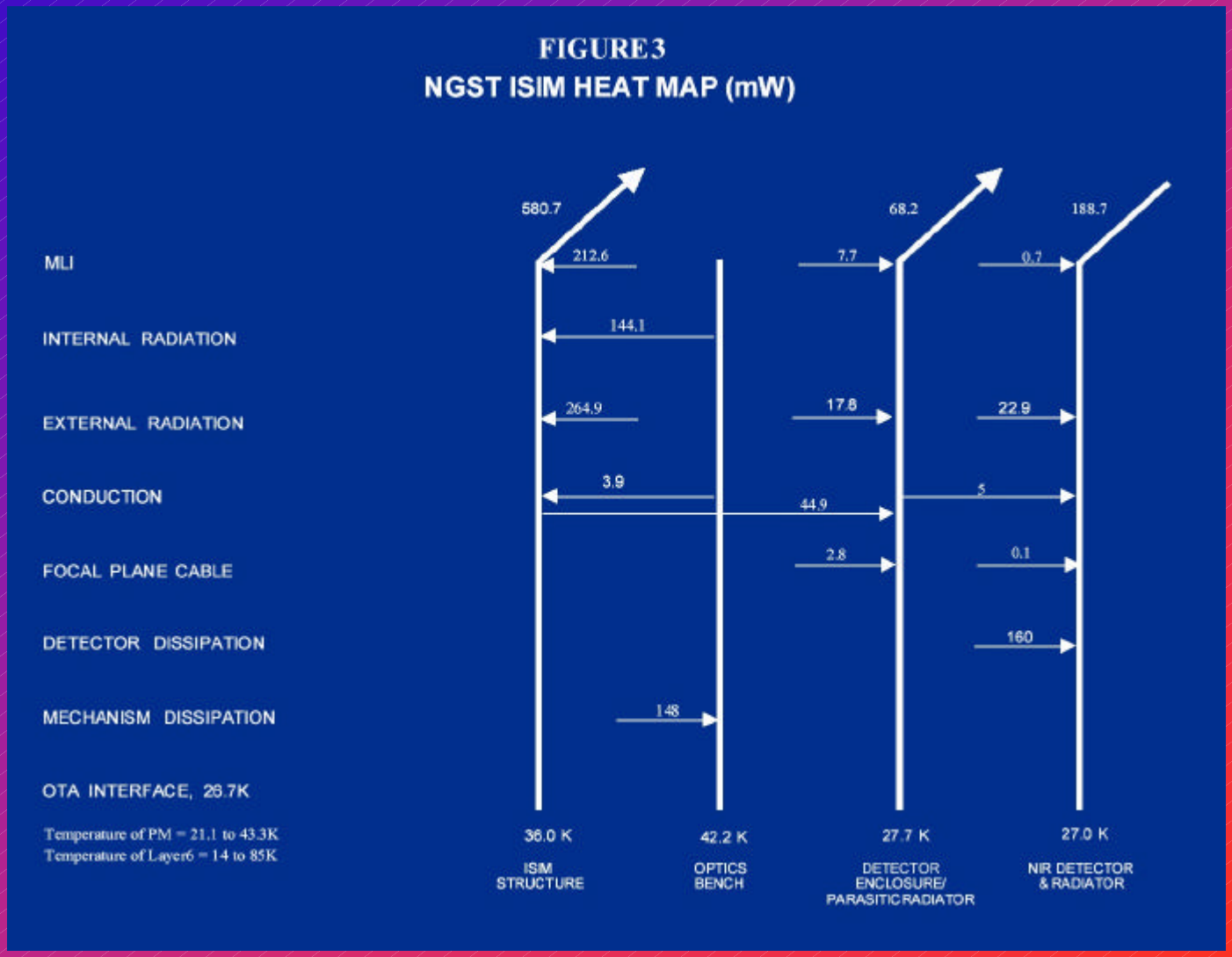
Thermal Radiator Configuration



Detector Radiator Area



NGST ISIM Top Level Heat Map



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C1388.041

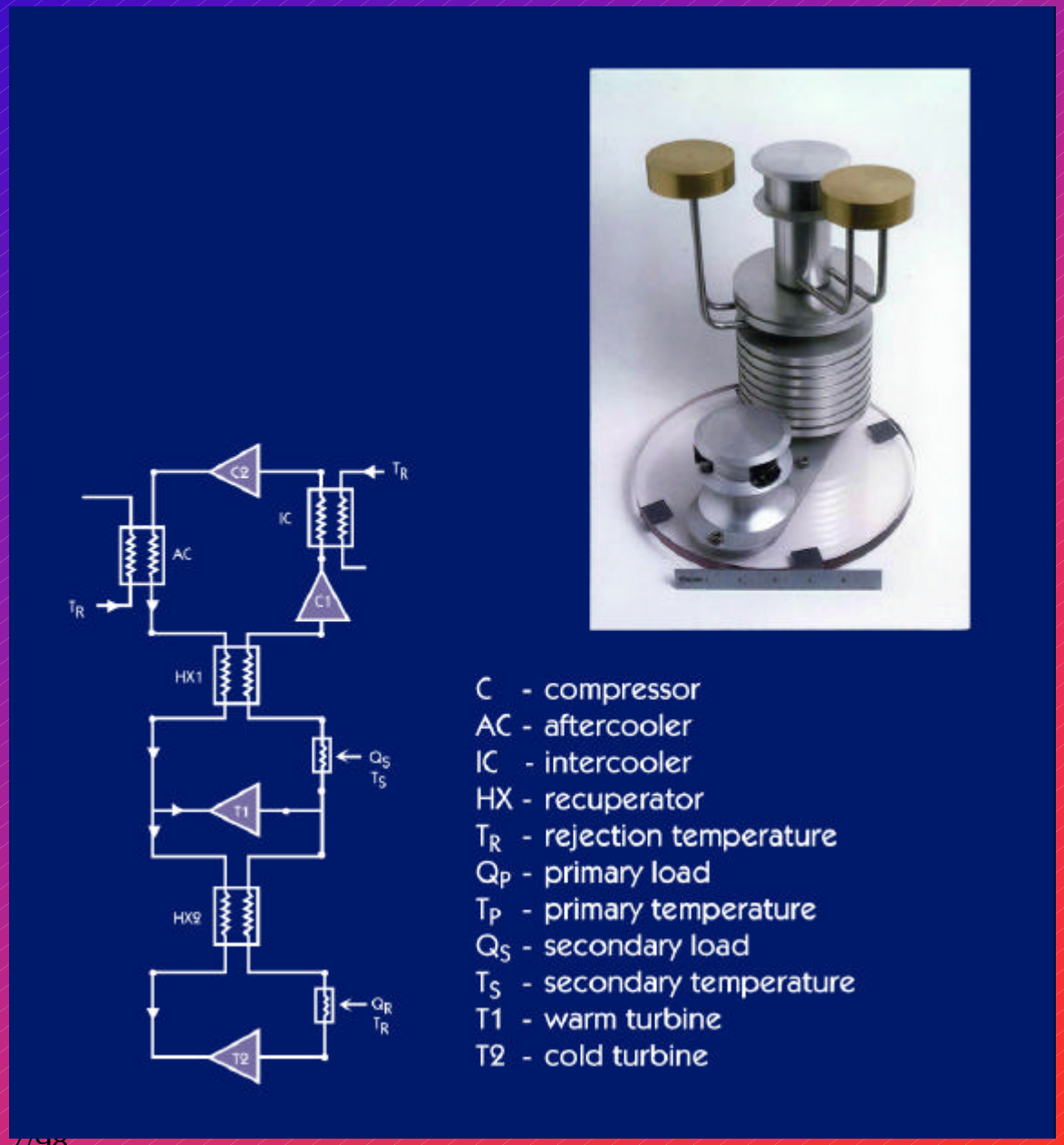
Creare Miniature Turbo-Brayton Cooler

Key Features

- Vibration Free
- Robust gas bearings ensure long life
- Low mass, highly efficient, easy to integrate
- Ideal for use with radiatively cooled heat sink

Status

- 5 watt, 65 Kelvin engineering model on life test
  - 215 watt input power too large for most NASA applications
- 35 K/60 K two stage cooler under development (USAF)
  - 125 watt input power with 300 K heat sink
- 30 K/ 6 K two stage cooler under development
  - Less than 60 watt input power with 220 K heat sink
  - 10 mW cooling power at 6 K
  - on life test during FY00


C2
TR
IC
AC
TR
C1
HX1
QS
TS
T1
HX2
QR
TR
T2
C - compressor
AC - aftercooler
IC - intercooler
HX - recuperator
TR - rejection temperature
QP - primary load
TP - primary temperature
QS - secondary load
TS - secondary temperature
T1 - warm turbine
T2 - cold turbine

Preliminary Findings Of Interest To ASWG

- maximum package volume approximately 20 cubic meters for EELV medium-plus fairing
- discrete instrument module layout feasible -- potential for no assembly sequence
- three major instrument modules feasible, potential for 4th, more than 4 unlikely
- passive cooling feasible for two near-ir instruments (five 4096K InSb FPAs) iff OTA ~32 K
- active cooling enabling for any additional instruments or warmer OTA (baseline FPA assumptions)
- fully redundant 30 K and/or 6 K active cooler can be accommodated within package and power constraints