Highlights of SPIE 2010
Part III
A personal view

Olaf Iwert

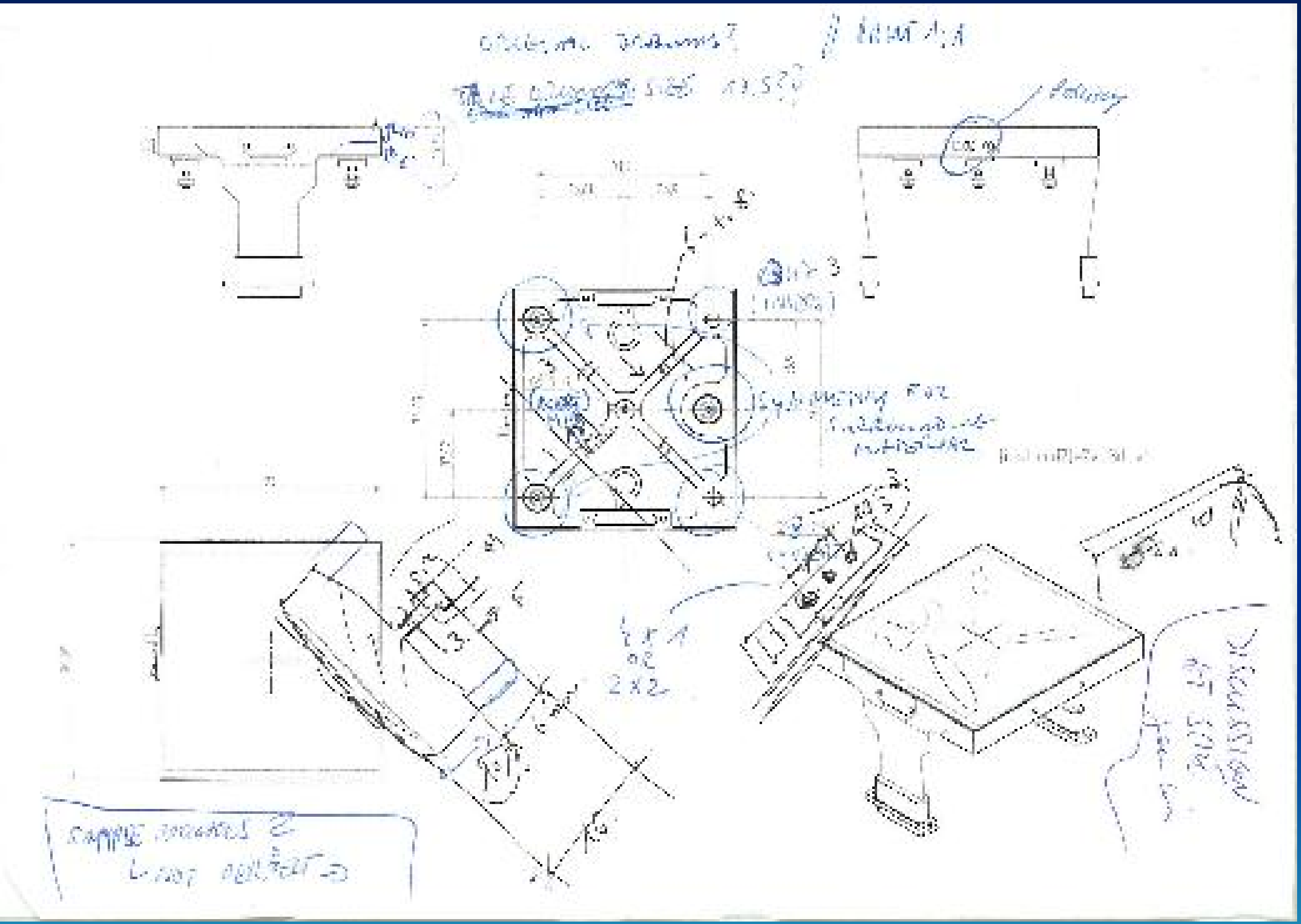
Challenges:

- During the conference
  - More than 1000 papers in one week
  - Parallelism
  - Shifts in schedule
  - Informal contacts
- After the conference:
  - Get the presentations
  - Can only trigger interest, details available….

Outline

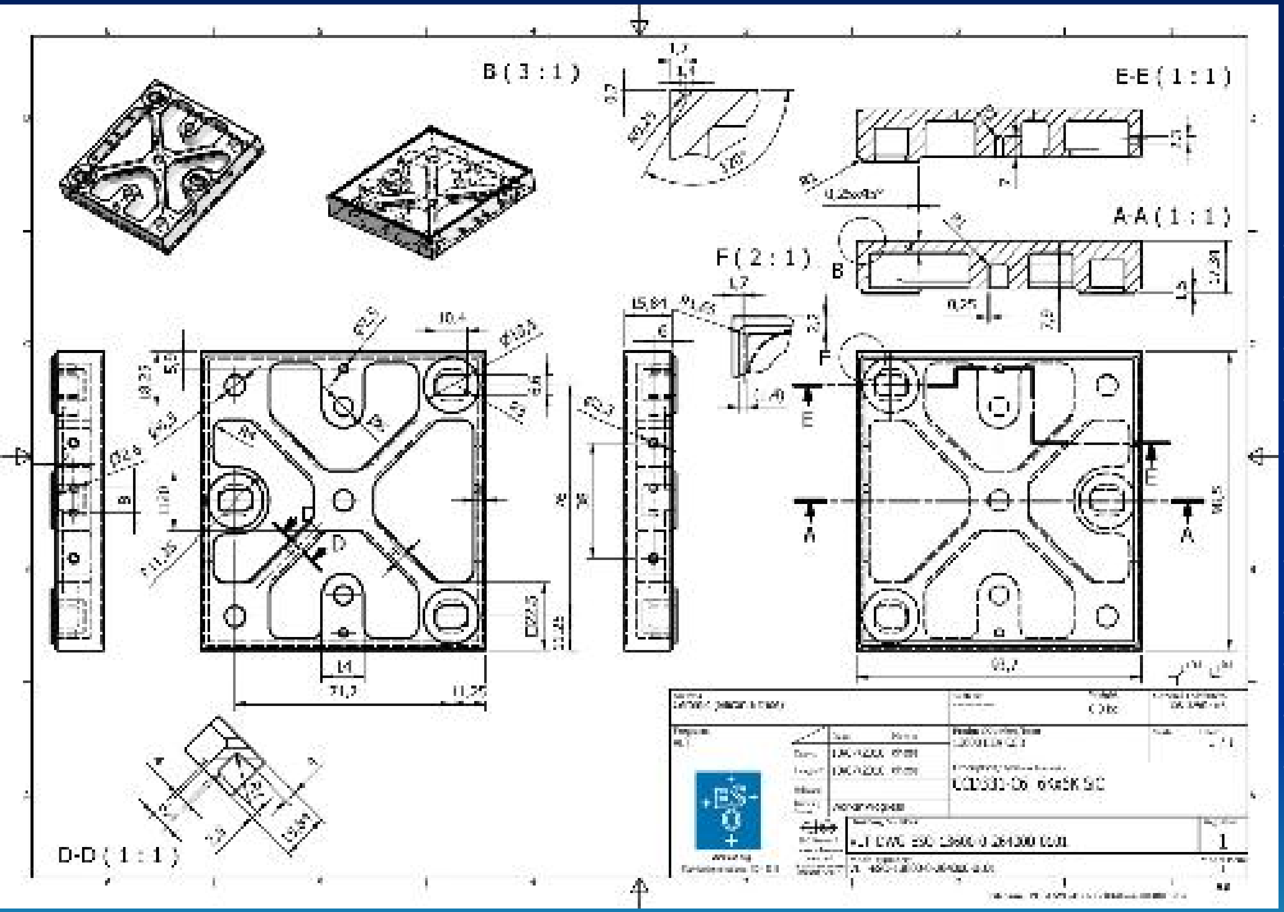
- Package design 6k x 6K, 15 um CCDs e2v
- 10.5 x 10.5 K, 9 um STA CCDs
- Curved detectors
- Hyper Suprime Cam
- Mosaic Groups
- Atacama 6.5 m telescope, University of Tokyo
- Pixel One (ELT imager concept)
- Project Management
- Satellite servicing
- (Interdisciplinary example technology)

SiC Package Design for 6kx6k, 15 um e2v (1)
From first idea to reality



- J. Lizon present (1st time)
- P. Jorden present
- G. Hess in Garching
- Email / personal

SiC Package Design for 6kx6k, 15 um e2v (1) Final ESO version

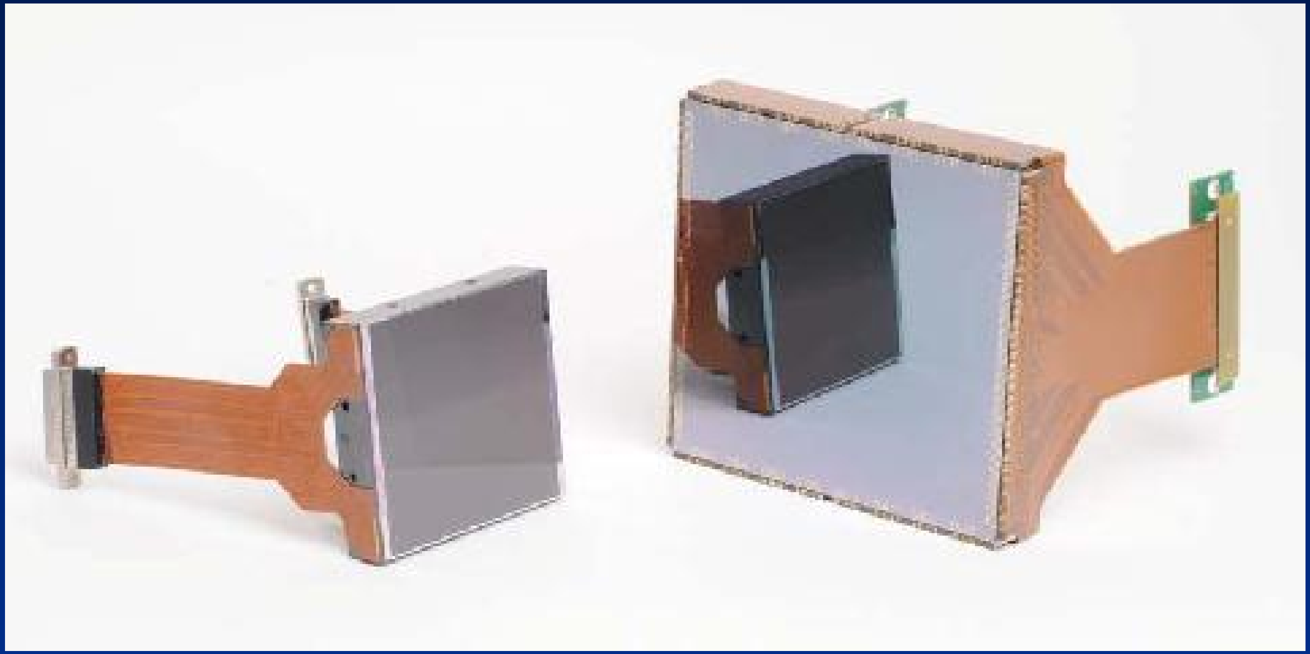


Final drawing e2v pending

- Main changes:
- Stiffness / Thickness
- Clamp system / heat transfer
- Cooling uniformity
- Provisions for pins

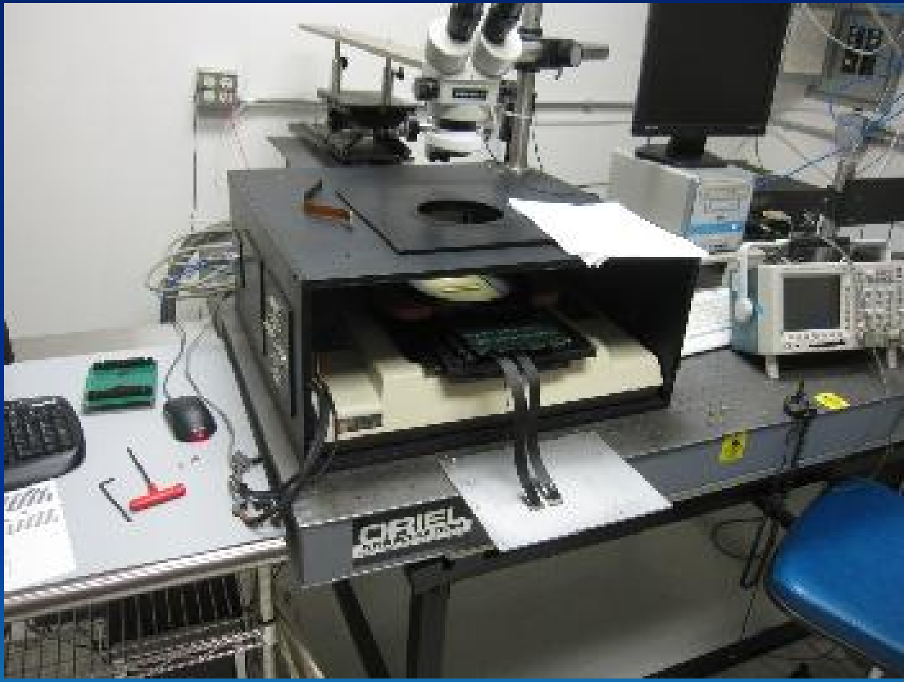
- Thermal analysis:
- e2v
- Gerd Jakob
- Comparison
- Do it for new arrangement ?

STA 10.5 K, 9um CCDs



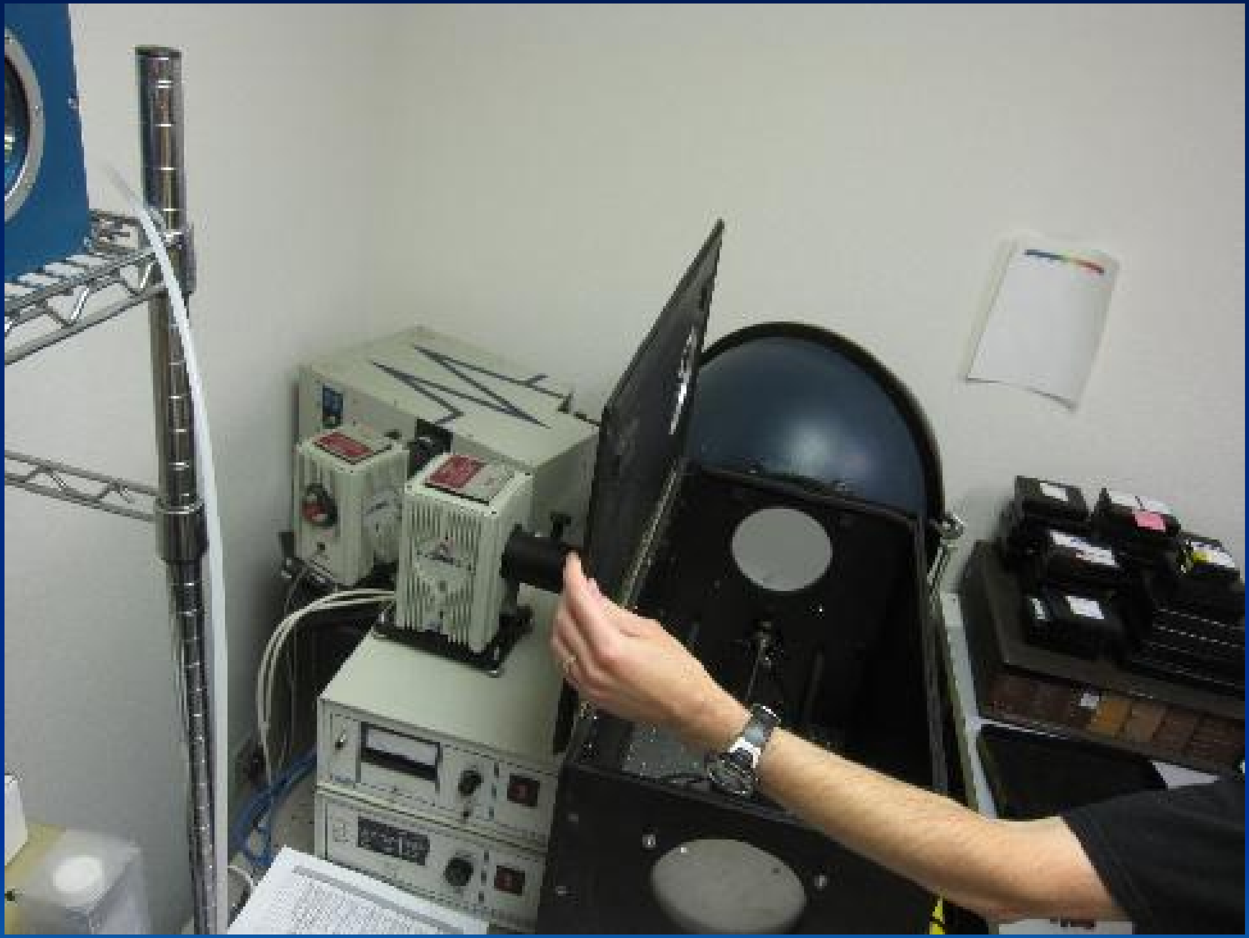
- Competitive ? / General company impression ?
- How many devices delivered ?
- Realistic readout noise figure / images in operation ?
- Thinned devices cosmetic quality ?
- Amplifier uniformity ?
- Package construction suitable ?
- Fixed technical specification accepted ?
- Adminstrative points: Bank guarantee, German sales representative (former e2v) ?

STA 10.5 K, 9um CCDs Company extended



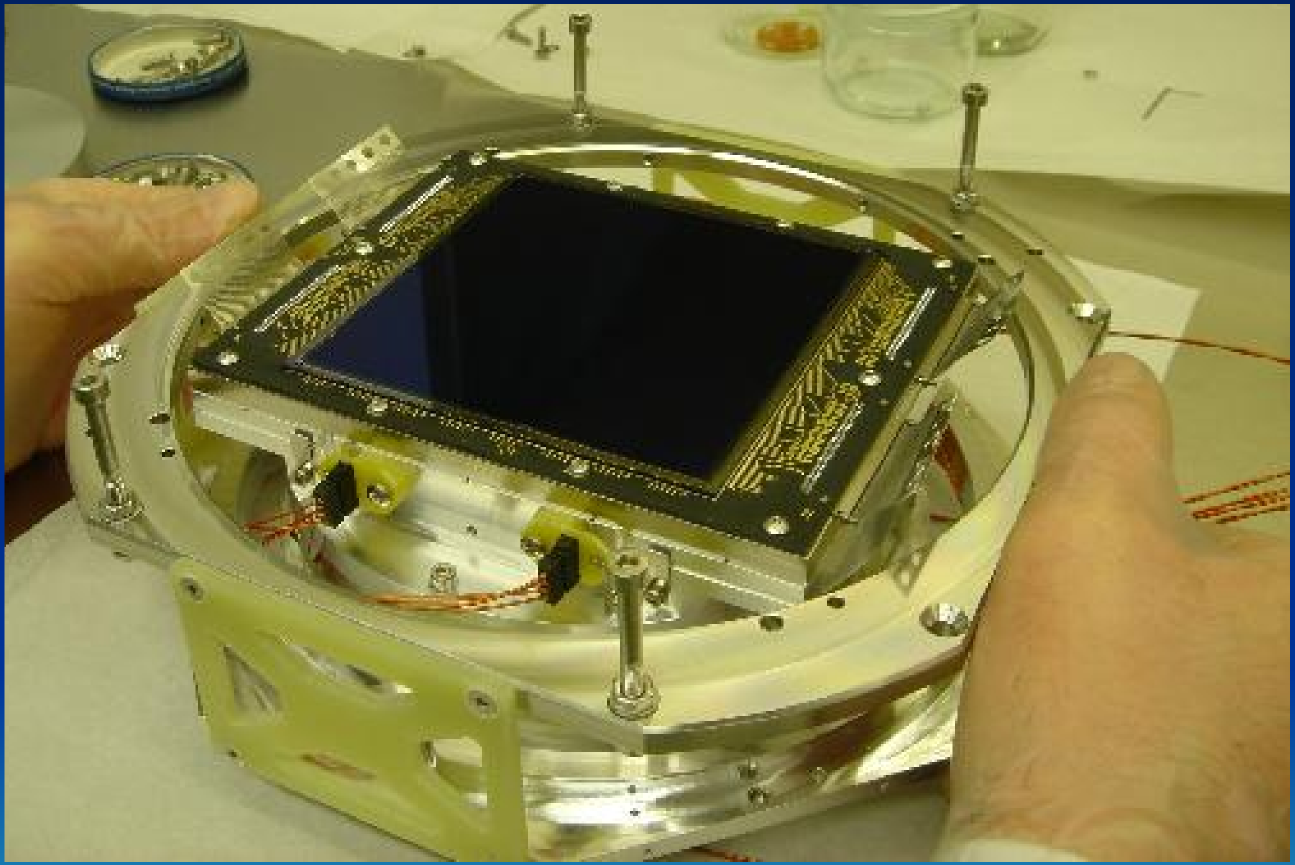
STA 10.5 K, 9um CCDs

STA 10.5 K, 9um CCDs

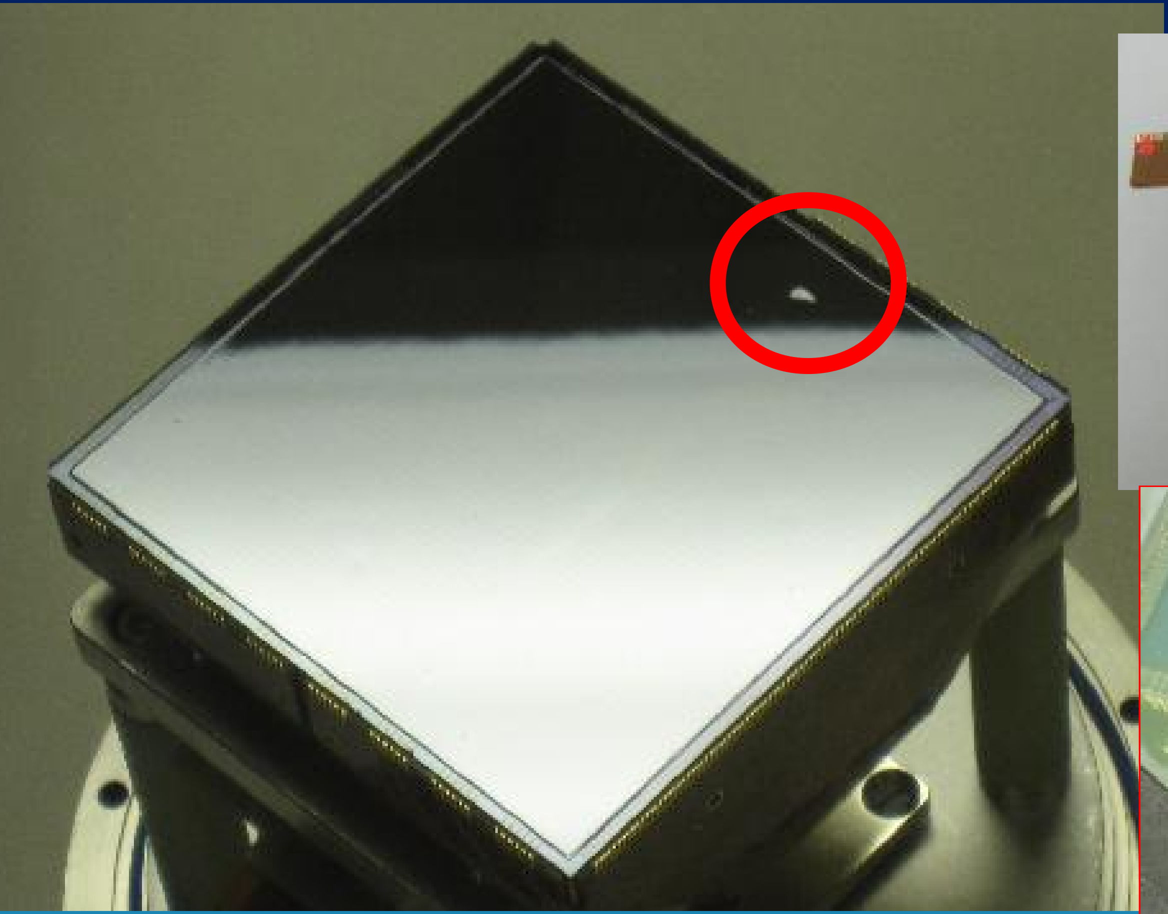


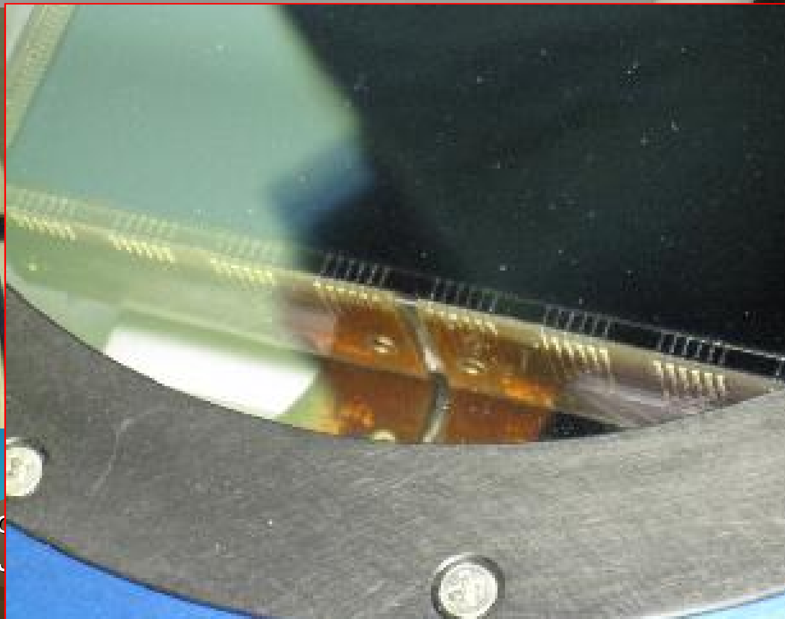
STA 10.5 K, 9um CCDs

- Conventional packaging Si / Si / Invar
- (e.g. PEPSI)



STA 10.5 K, 9um CCDs
Buttable packaging Si/Si/AlNi/mach. Si

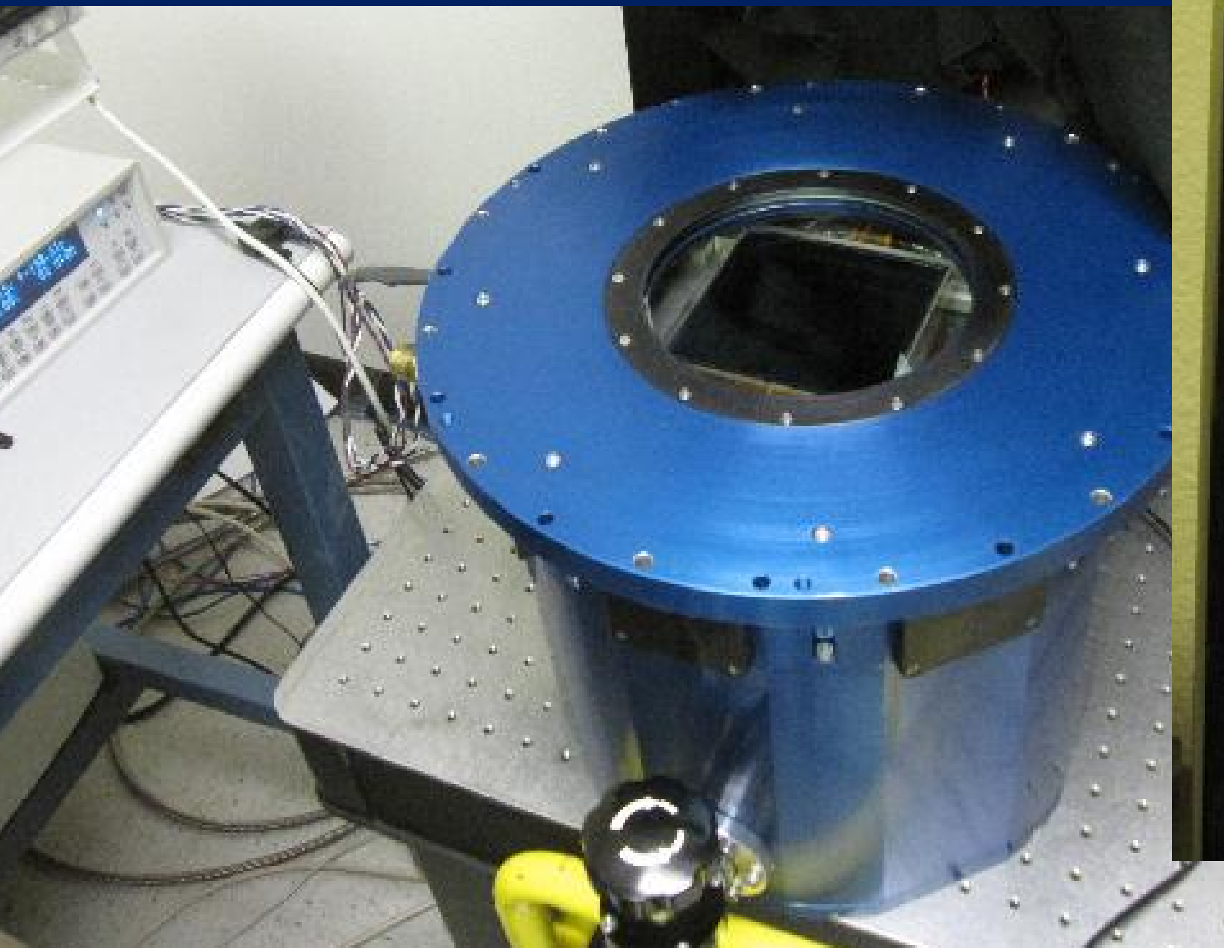


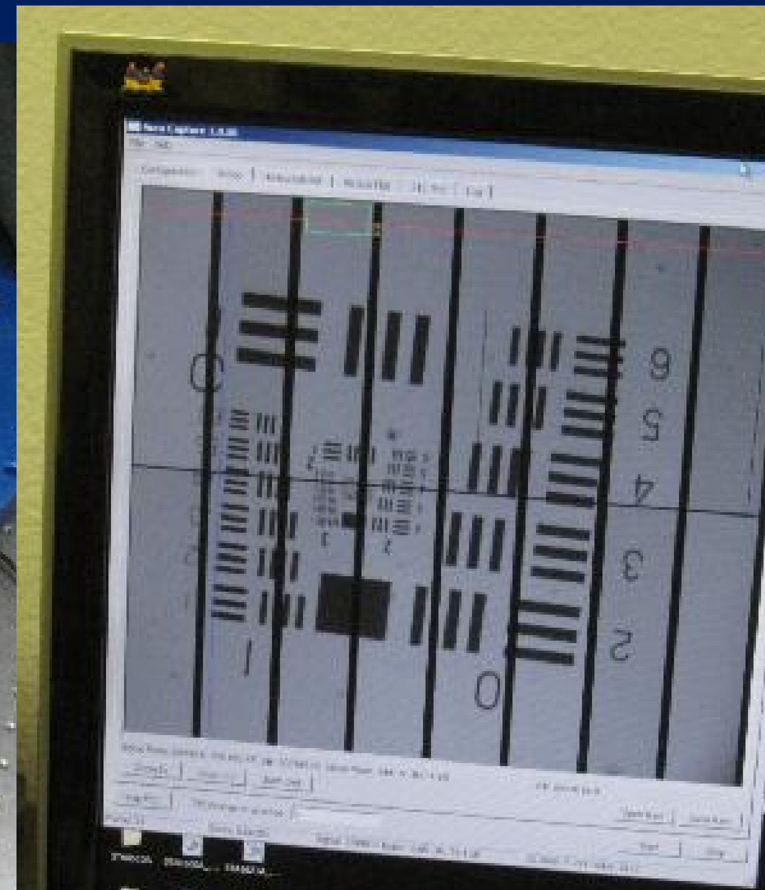


STA 10.5 K, 9um CCDs

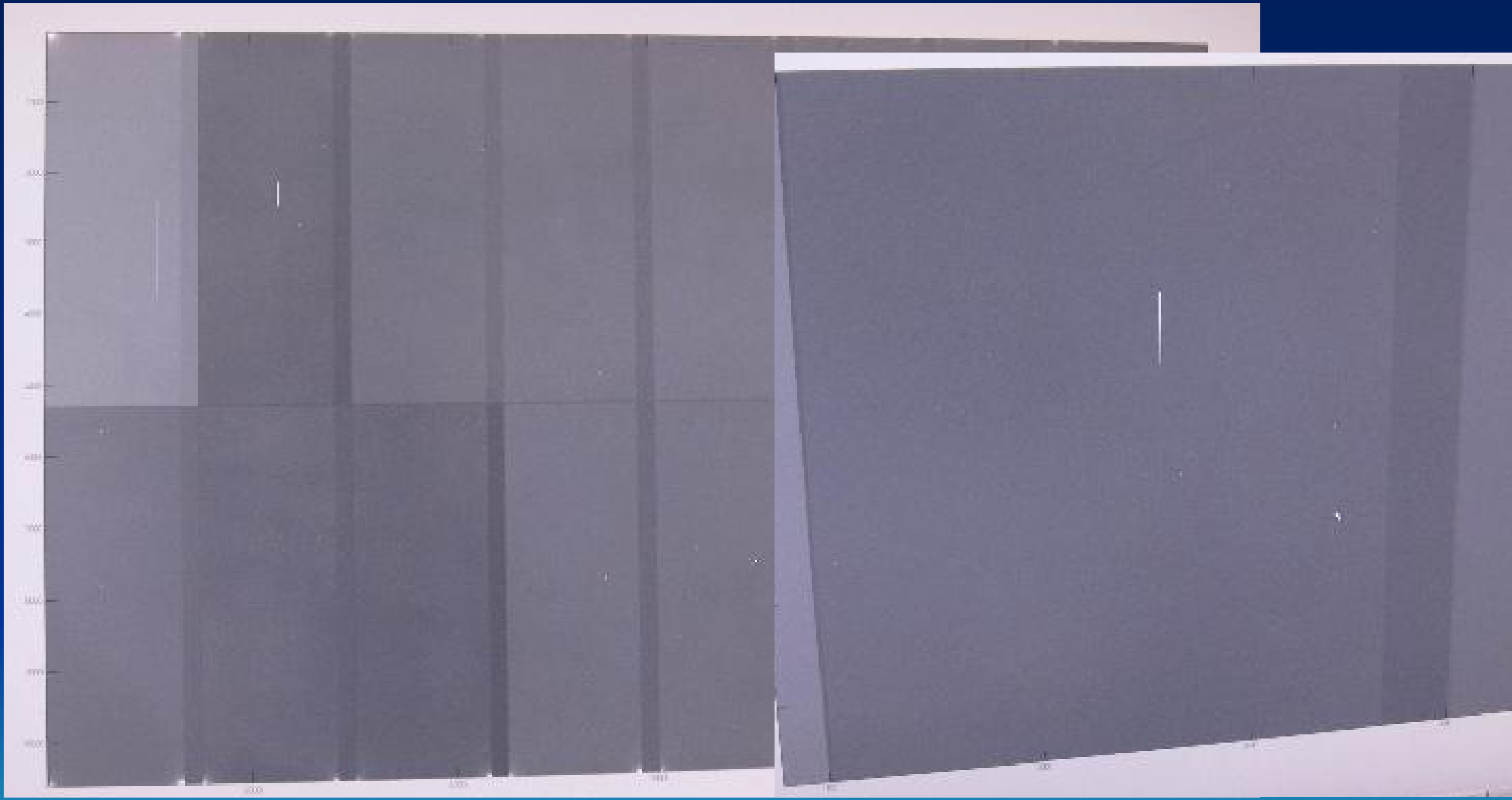
- STA1600
  - Standard device with dual stage high speed outputs
  - Full frame imager
- STA1600 MPP
  - Frontside illuminated low dark current
- STA1600 LN
  - 16 single stage low noise outputs.
- STA1600 FT
  - Frame transfer operation
- STA1600 DD
  - Deep depletion

STA 10.5 K, 9um CCDs





STA 10.5 K, 9um CCDs



STA 10.5 K, 9um CCDs
Main customer

USNO Robotic Astrometric Telescope
URAT

- 8 inch Refracting Telescope for Astrometry
- Upgrade initiated to a 2x2 array by Dr Norbert Zacharias for an all sky survey - URAT
- STA is providing complete system including
  - Dewar – Window – Bonn Shutter
  - Four BI STA1600 CCDs Three STA3000 Guiders
  - Five Aura cameras with software
  - Telescope robotic control software

STA 10.5 K, 9um CCDs

URAT 2x2 Focal Plane

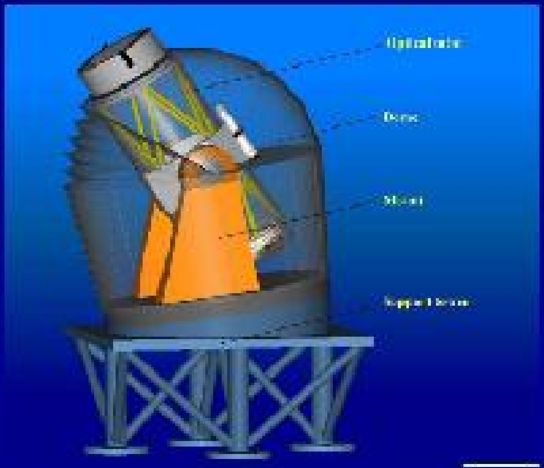
- Next generation astrometry focal plane
  1 Frame = 1 Gigabyte of data
- Incorporates buttable package version of STA1600
- GL Scientific Dewar

STA 10.5 K, 9um CCDs
Low Noise version

- Low noise version of STA1600
- 16 dual stage outputs are replaced with single stage low noise outputs
- Noise < 3 electrons
- Sensitivity 4-5 μV/e-
- Identical pinout
- Available Fall 2010

STA 10.5 K, 9um CCDs Application Antarctica

Antarctica Schmidt Telescopes (AST3)

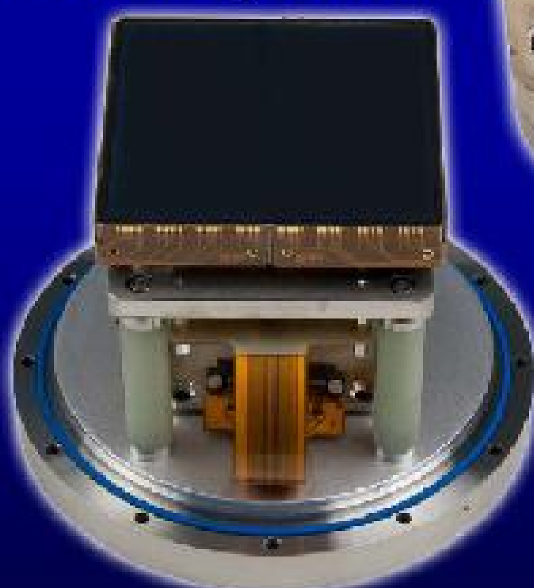


- Location Dome: A Antarctica
- Clear aperture: 50cm
- FOV: 4.2°
- Wave Band: 400nm-900nm (g, r, i filters for 3 telescopes)
- Scale:1 arcsec/pixel
- Image quality: 80% energy encircled in one pixel
- Type: STA1600FT
- Working mode: frame transfer

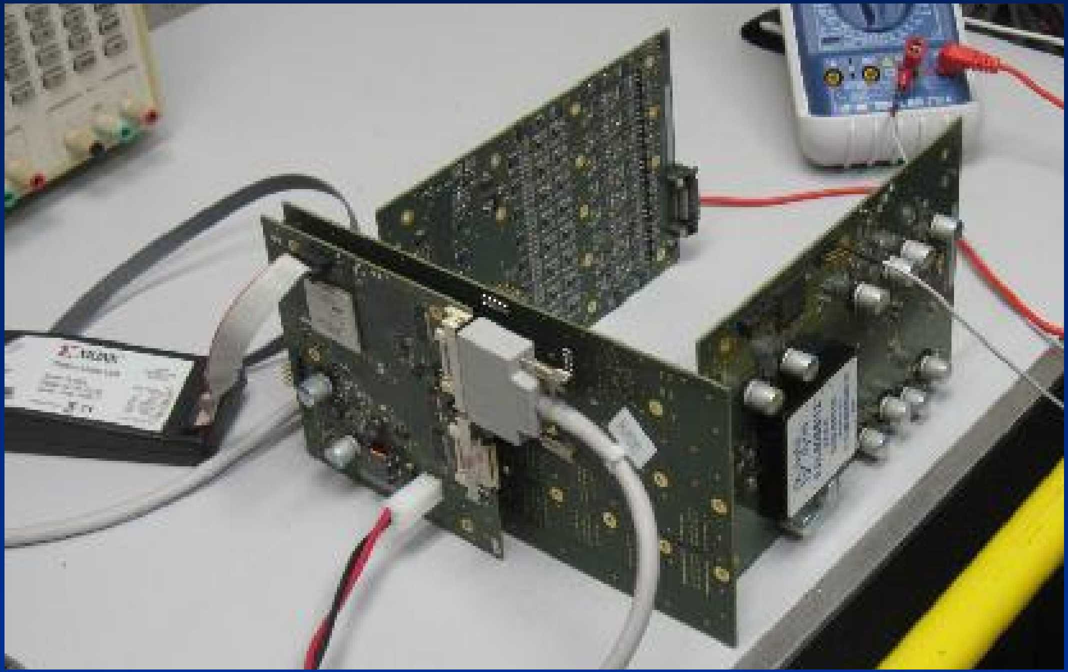
STA 10.5 K, 9um CCDs Application Antarctica

AST3 System STA1600FT

- Small 180 mm dewar system
- TE Cooling for operation at -80C
  - Average outdoor temperature -50C
- STA1600FT Split frame store operation



STA 10.5 K, 9um CCDs Controllers



- Custom built controllers per application so far
- More universal controller development now
- Very nice built in scope functionality to digitise video signal on the fly, while changing the timing; completely digital sampling
- Passive cooling by different means (heatsink layers / outside heat transfer material)
- 12 V supply and internal converters

STA 10.5 K, 9um CCDs Controllers

- Reflex Camera System
  - 11" x 9" x 5.5" (6-slot chassis)
- Flexible Modular Features
  - 8-ch 120 Mhz 16-bit A-D

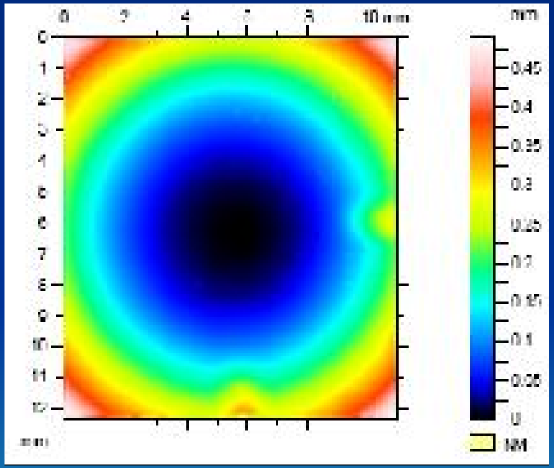
    12-ch 500 Mhz 16-bit clock driver
    - +/- 12V (Programmable slew)
  - 16-ch 16 bit DC bias
    - Voltage and current monitoring
    - Programmable current limit
  - Full cameralink interface
    - Swappable for custom, gigabit ethernet, firewire.

    Single 12 V DC power supply

Curved Detectors

- Good resonance with my poster

- Interesting paper from D. Dumas et al., CEA, Grenoble France
- “Curved infrared detectors: application to spectrometry and astronomy”, quoting our DfA paper



Results:

- Convex & concave functional microbolometer array with 10mm x 10mm area (supp.), 50 um thick,
- Curvature radius 67 mm
- Next trial : Curved cooled IR array

Subaru / JNTO

- Concept of instrument change-overs
- Fully automated
- Robot / very nice video
- Out of the instrumentation one ‘unusual’ example Hyper Suprime Cam Wide Field Camera:
- Design Report received
- Prime Focus
- Fully depleted Hamamtsu CCDs (now tested in the upgraded Suprime Cam)
- ..

Hyper Suprime Cam (Subaru / JNTO) Overview

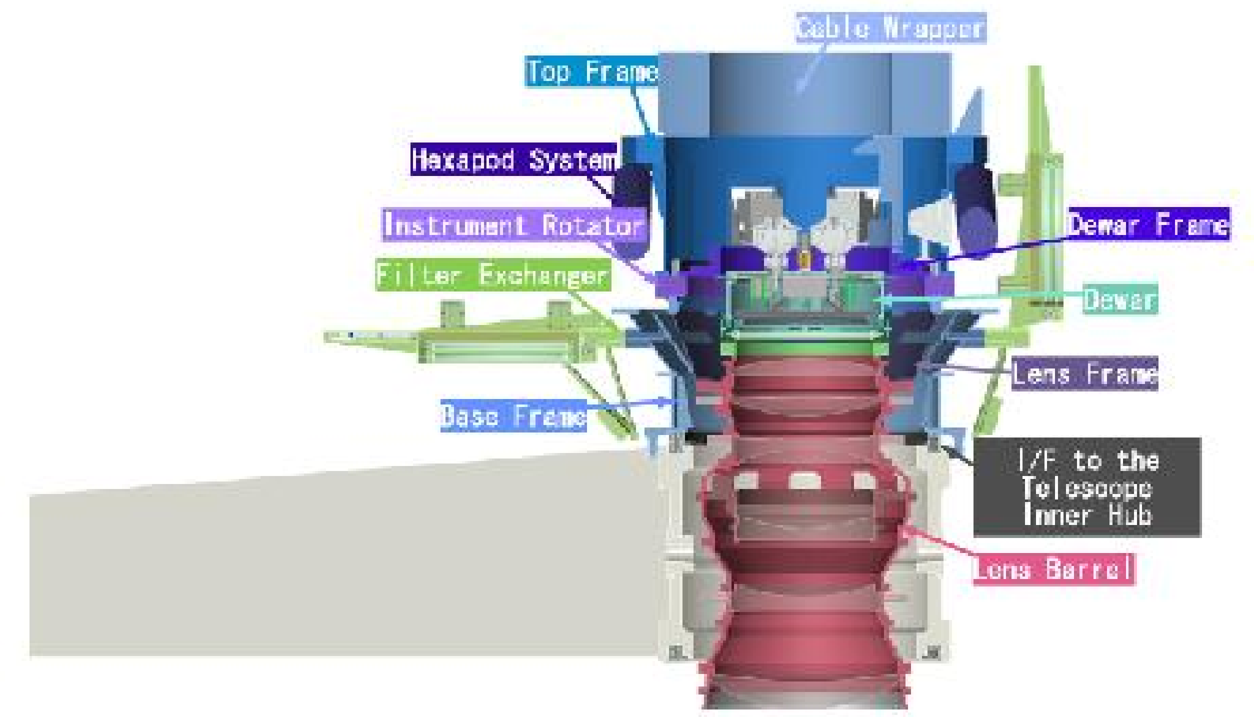


Figure 3.1: Schematic view of planned HSC structure.

- 1.5 degree diameter
- 4 filter holders, exchange time < 10 minutes
- Back focal length 190 mm
- Focal plane diameter 495 mm (OmegaCAM 336)
- Focal plane flatness 30 um

Hyper Suprime Cam (Subaru / JNTO) Corrector

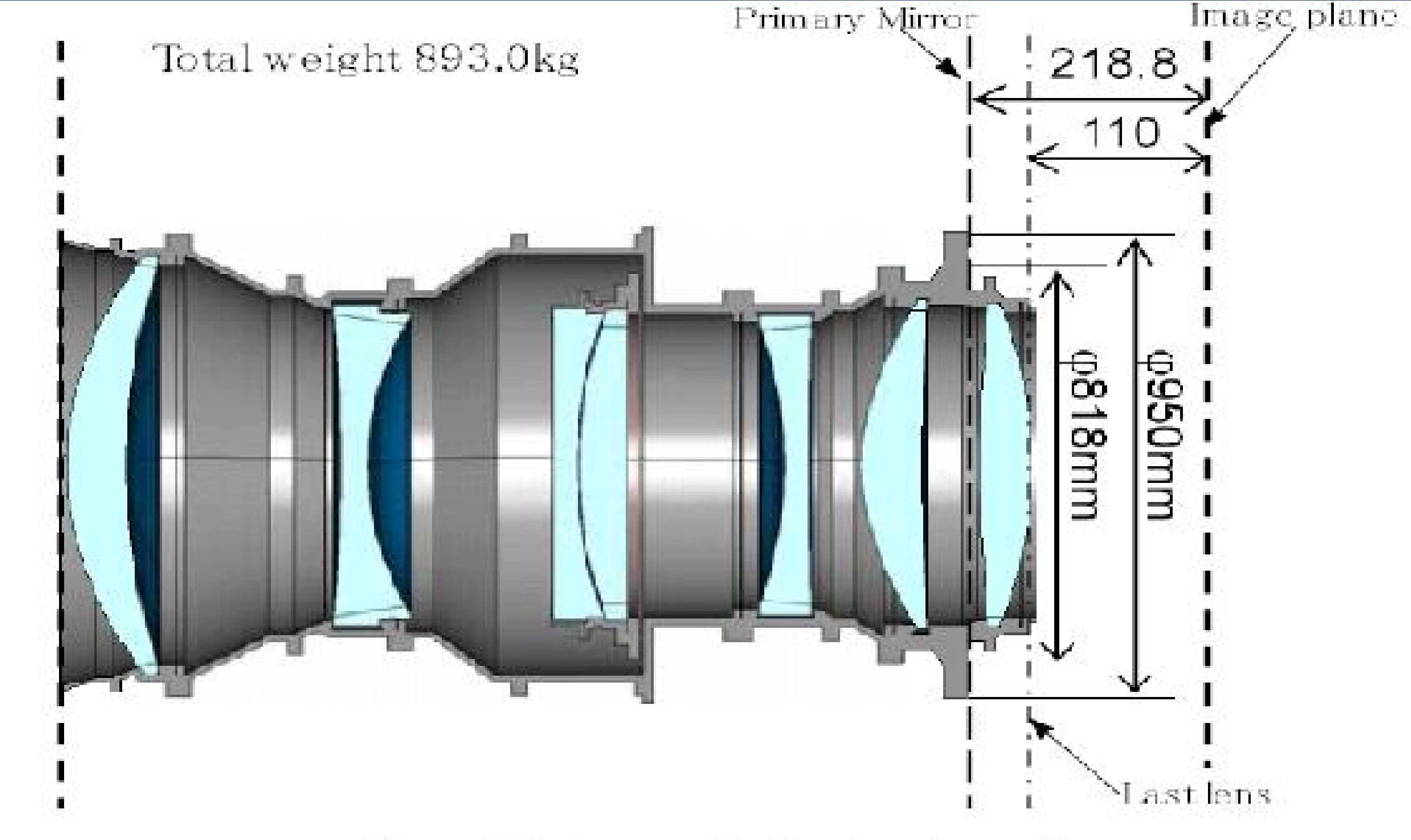


Figure 4.16: Layout of the lens barrel assembly

Hyper Suprime Cam (Subaru / JNTO) Dewar

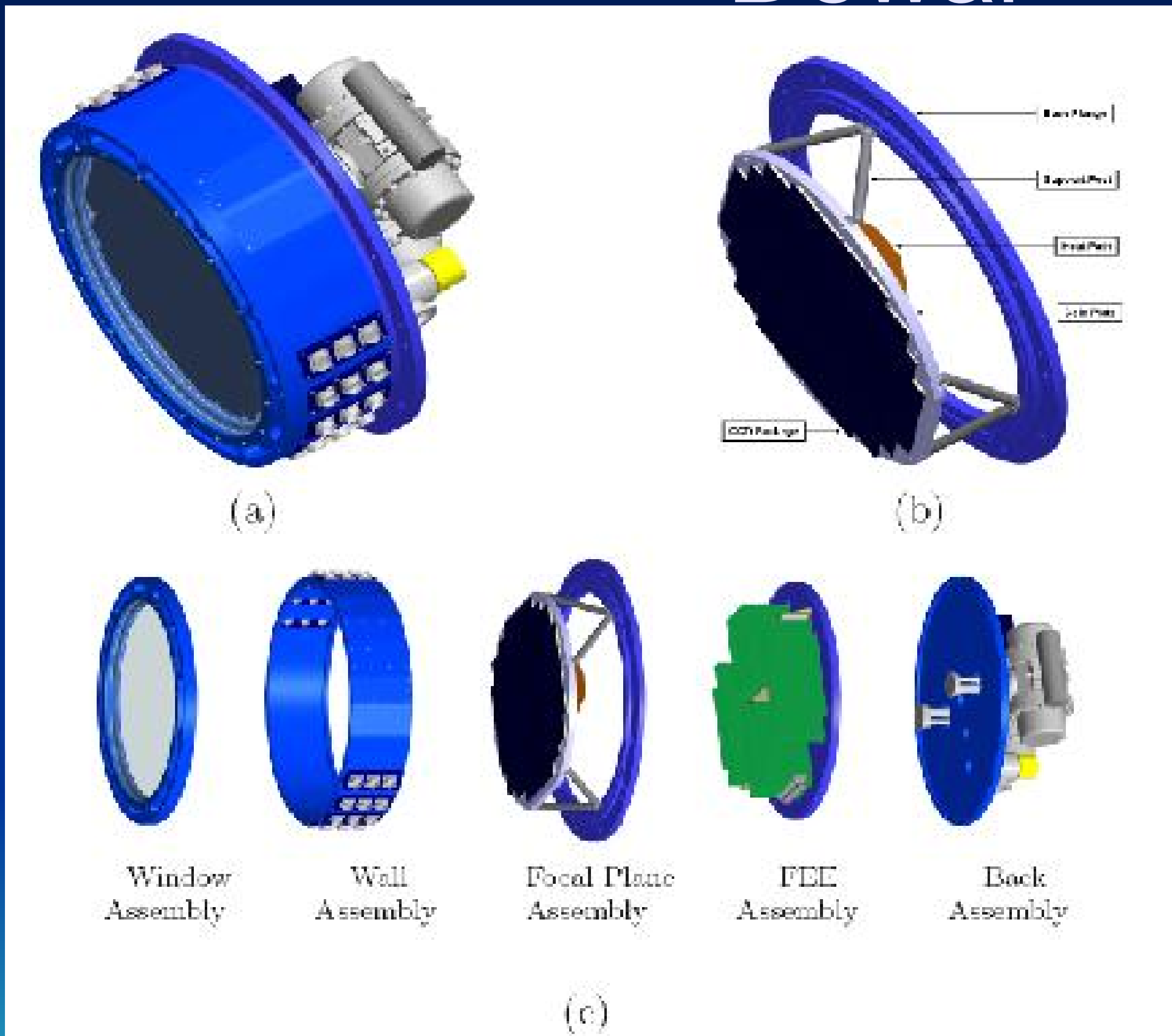


Figure 5.1: (a): Overview of the CCD dewar. The dimension of the CCD dewar is roughly 700 mm in diameter and 500 mm in height. (b): Detailed view of the focal plane assembly. (c): Exploded view of the CCD dewar. Main components of the CCD dewar are labeled.

- Dewar weight 200 kg
- 700 mm diameter
- 500 mm heigth
- SIC CCD baseplate, (Kyocera) 20 mm thick, 600 mm diameter
- CCD packages made of AIN
- Two large pulse tube Fuji Electric Coolers, dimensioned for 53 W cooling power including electronics at -100 C CCD operating temperature (??)

Hyper Suprime Cam (Subaru / JNTO) Completely integrated electronics

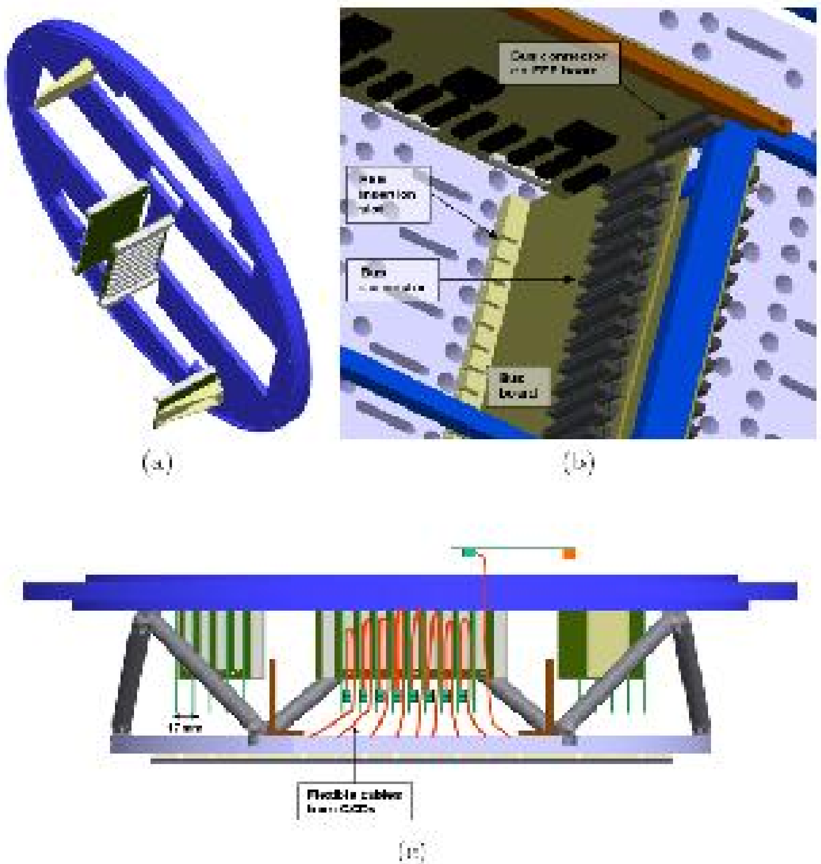
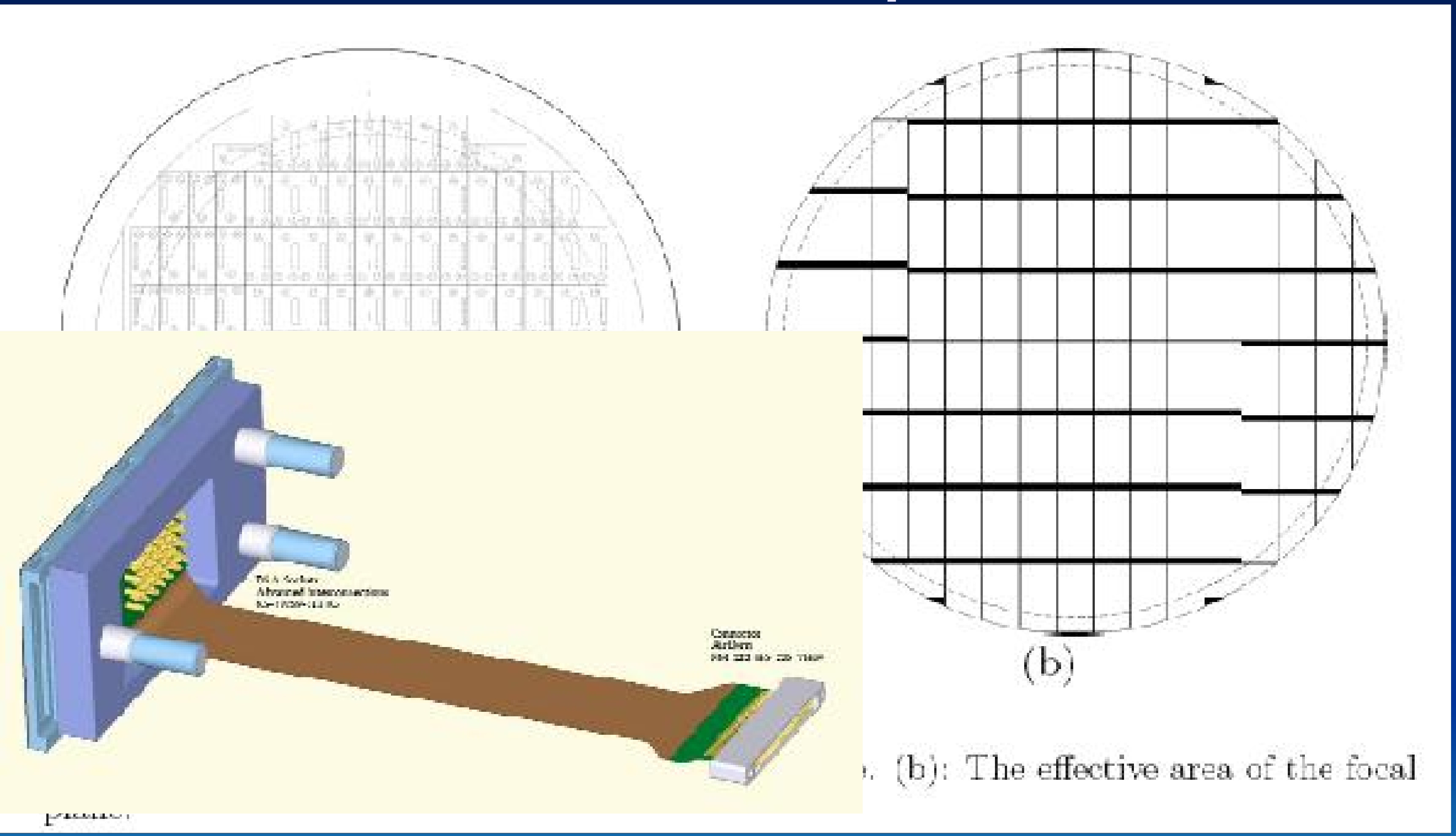


Figure 5.3: (a) Overview of the FEE assembly without FEE boards. (b) Detailed view around the bus board. (c) Schematic view which shows how FPC cables from CCDs are connected to FEE boards. Note that 9 FPC cables for the central FEE group are drawn in the figure.

- Internal electronics operated at +50 C
- Very low power consumption calculated

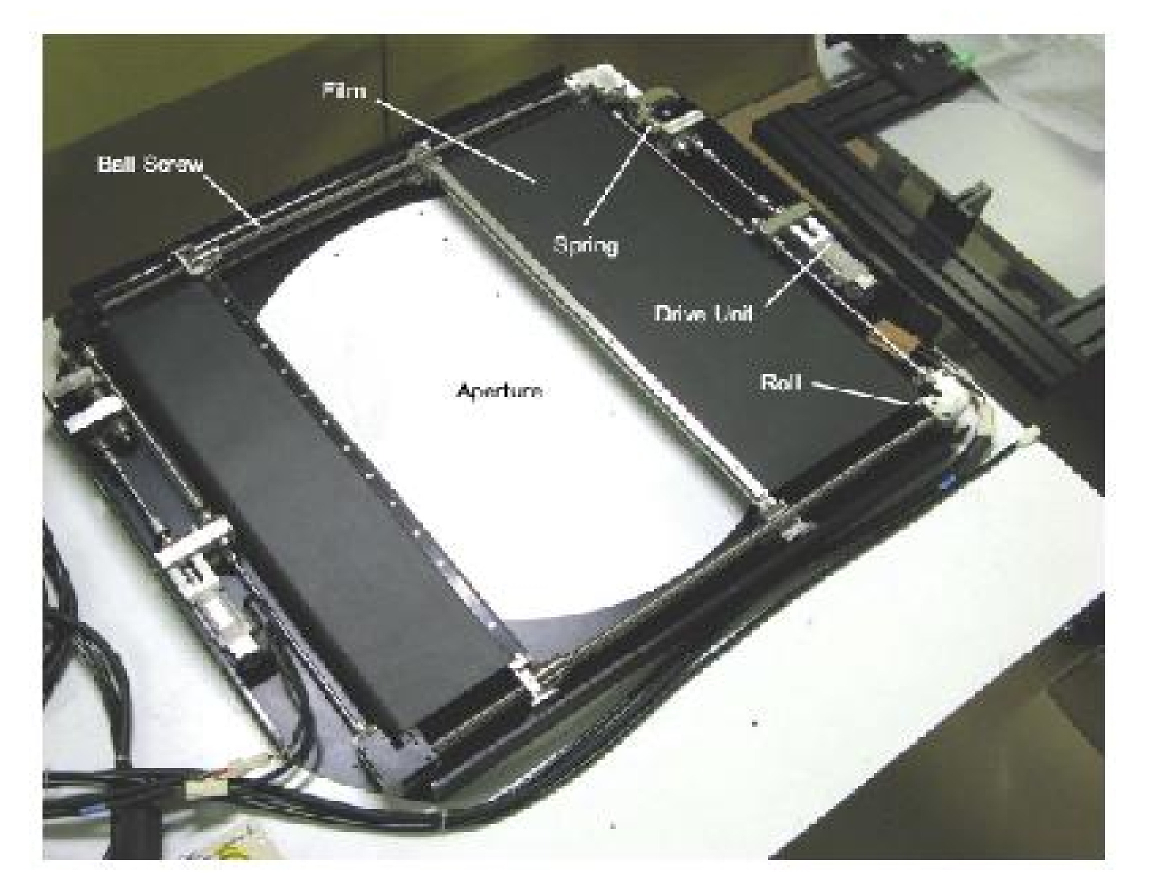
- Contamination ?

Hyper Suprime Cam (Subaru / JNTO) Focal plane



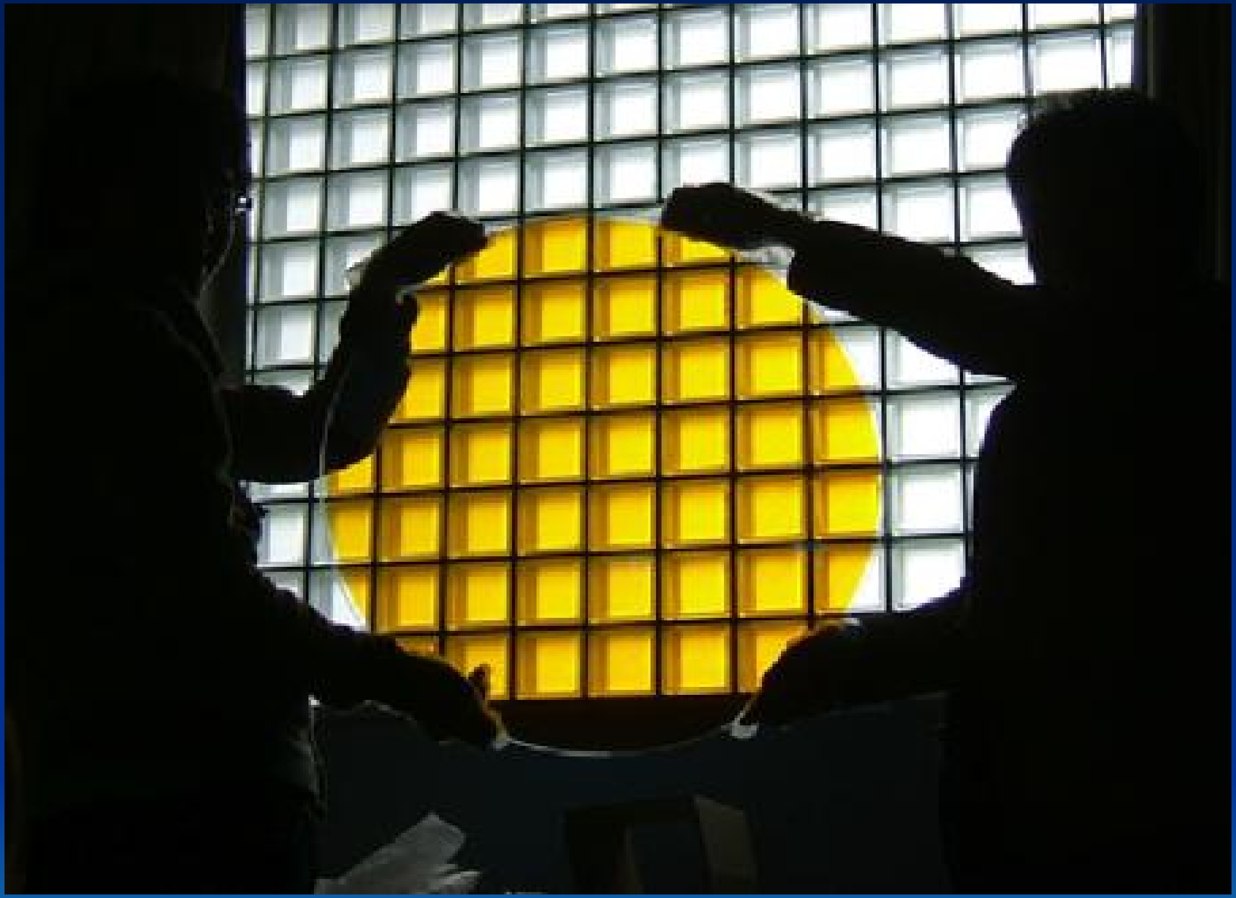
- 119 CCDs, 2k x 4K, 15 um, fully depleted Hamamtsu
- 8 CCDs for Autofocus, mounting the CCDs at different heigth and reading fast

Hyper Suprime Cam (Subaru / JNTO) Shutter



- 600 mm aperture diameter
- One of the very few exceptions to BONN shutters

Hyper Suprime Cam (Subaru / JNTO) Filter



- Prototype BARR filter, 600 mm diameter, 15 mm thick

Dark Energy Survey (DES) Fermilab / CTIO

- Worried about transport to Chile: Double number of CCDs (spares)
- No safety system in dewar (emergency pump etc.)
- No fine temperature control system (also PANSTARRS) in focal plane

PANSTARRS

•PANSTARRS is working on a 'software' temperature regulations system in the focal plane, where the fine temperatyrue control is achieved through turning on & off CCD outputs

Keck red upgrade, LBNL CCDs

•Mentioned 'glowing' of AlNi packages, particular batch ?

Tokyo Atacama Observatory

Project Overview

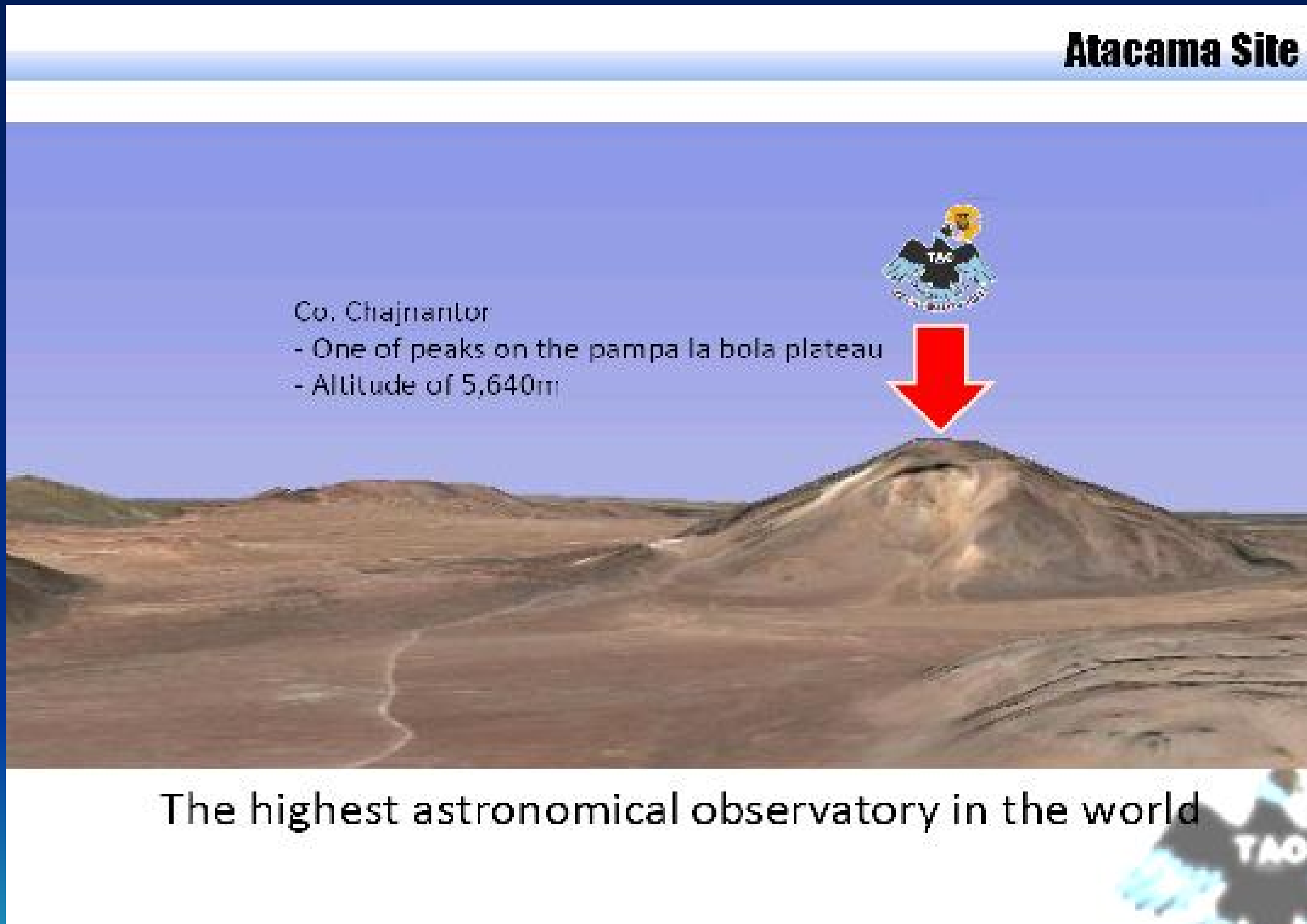
TAO

The university of Tokyo Atacama Observatory

- a 6.5m infrared/optical telescope
- the highest site in the world (5,640m)
- led by Institute of Astronomy, the University of Tokyo

supported by >70 Japanese universities/institutes

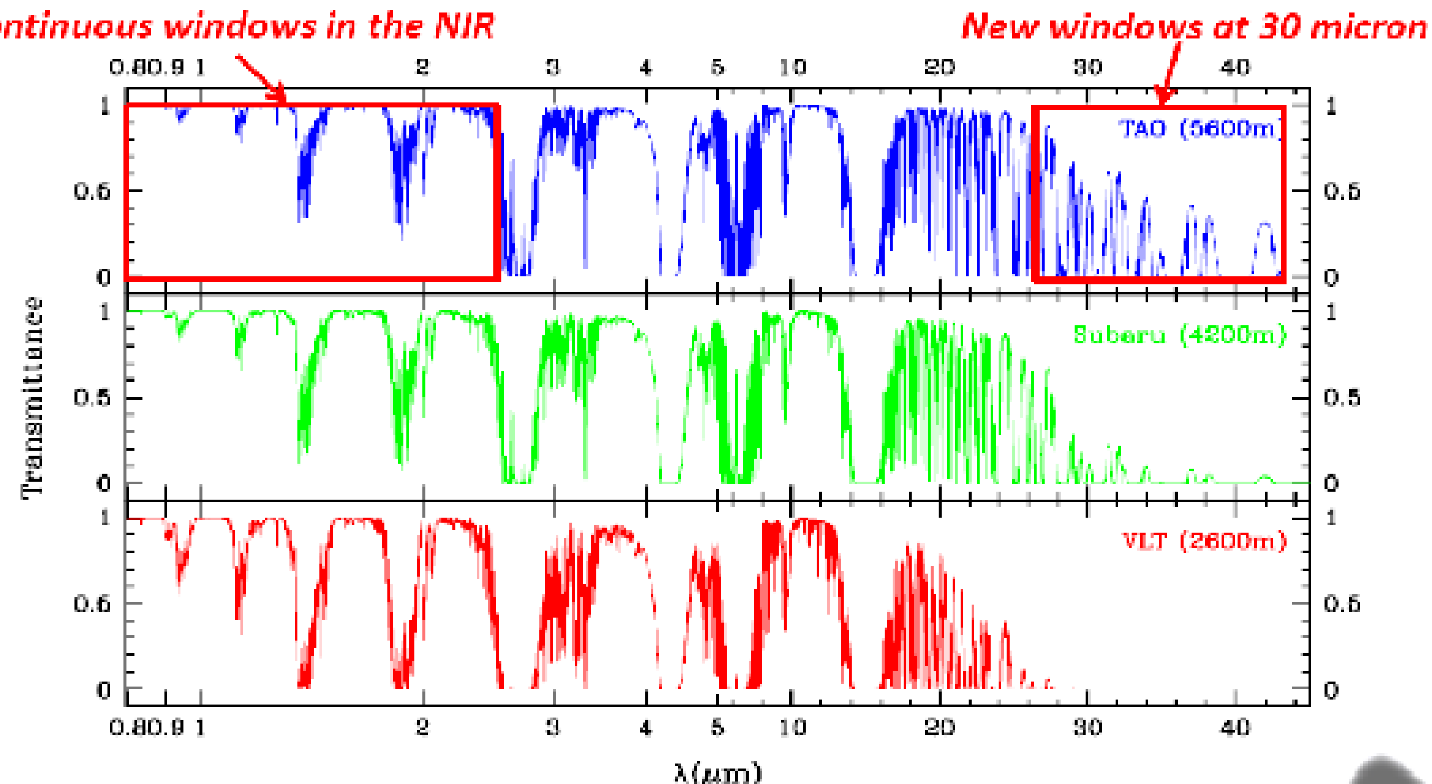
Tokyo Atacama Observatory



Tokyo Atacama Observatory

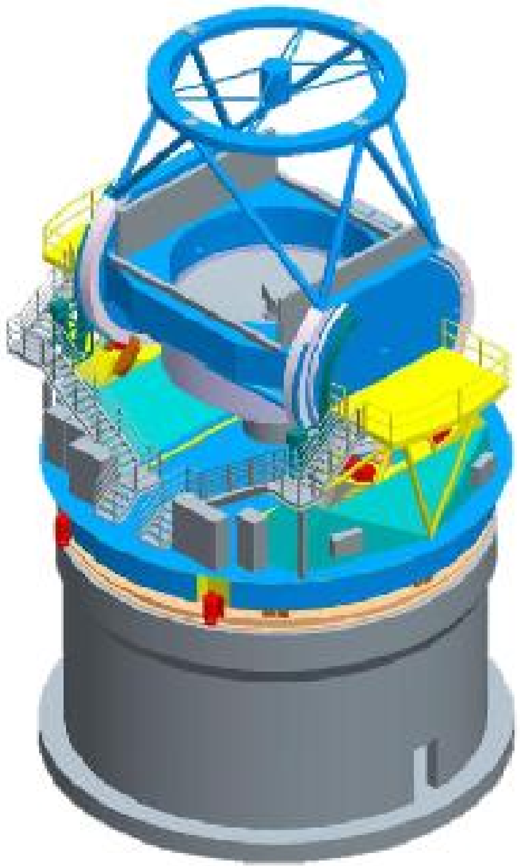
Atacama Site

high altitude + dry weather condition
→ atmosphere at the infrared wavelengths is transparent



Tokyo Atacama Observatory

TAO 6.5-m telescope



TAO 6.5-m telescope

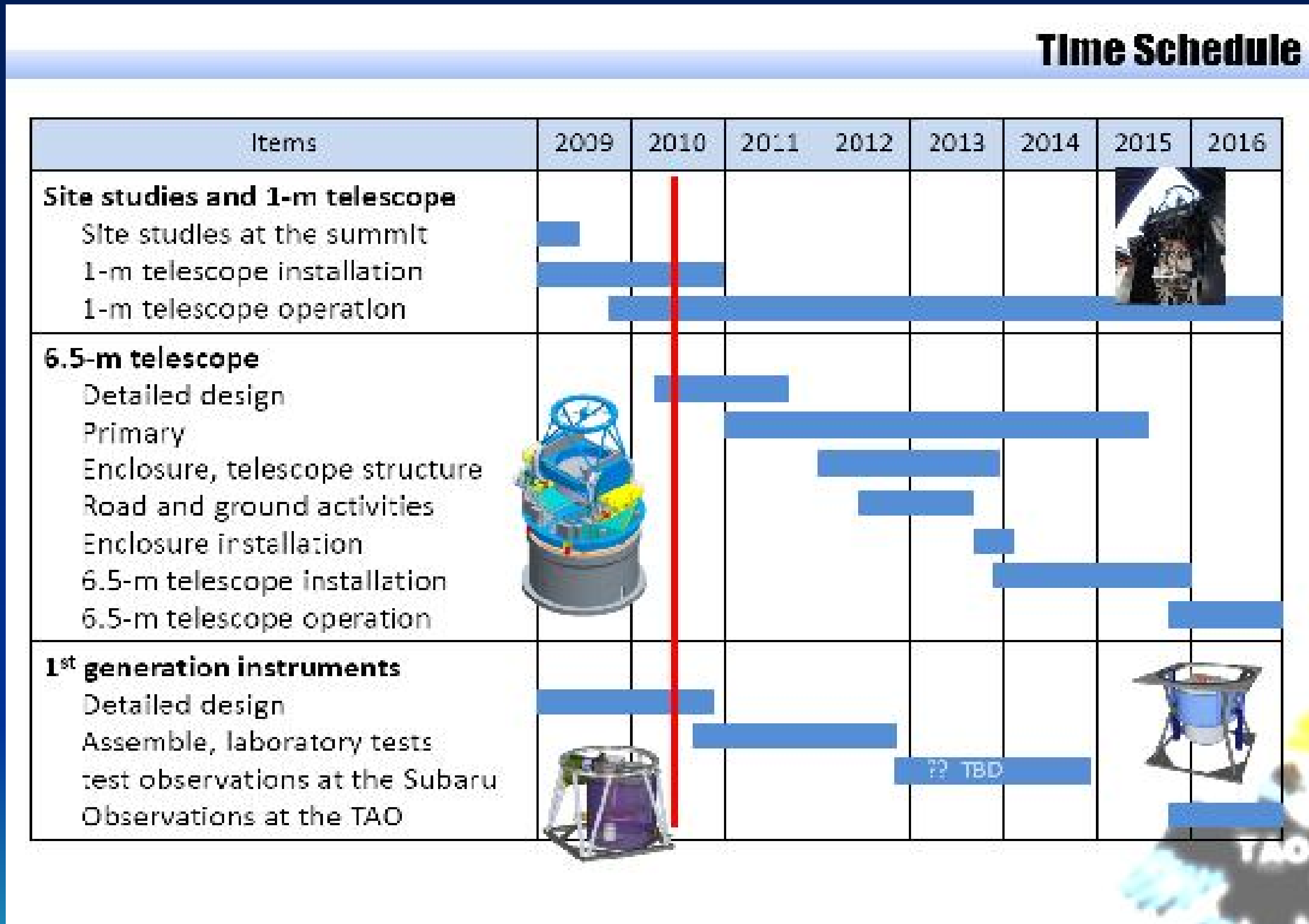
The best infrared telescope on the earth

Telescope type	: Cassegrain / Ritchey-Chretien
Primary diameter	: 6,500 mm
Final focal ratio	: 12.2
Foci	: Cassegrain + 2 Nasmyth
Field of view	: ϕ25 arcmin

The final F-ratio and the cassegrain interface is the same as the Subaru telescope

Instruments can be **shared** between the TAO and the Subaru

Tokyo Atacama Observatory



Pixel_One

...a possible technology to exploit direct seeing limited imaging using the whole field of ELTs…

INAF OAR

F. Pedichini, A. Di Paola and V.

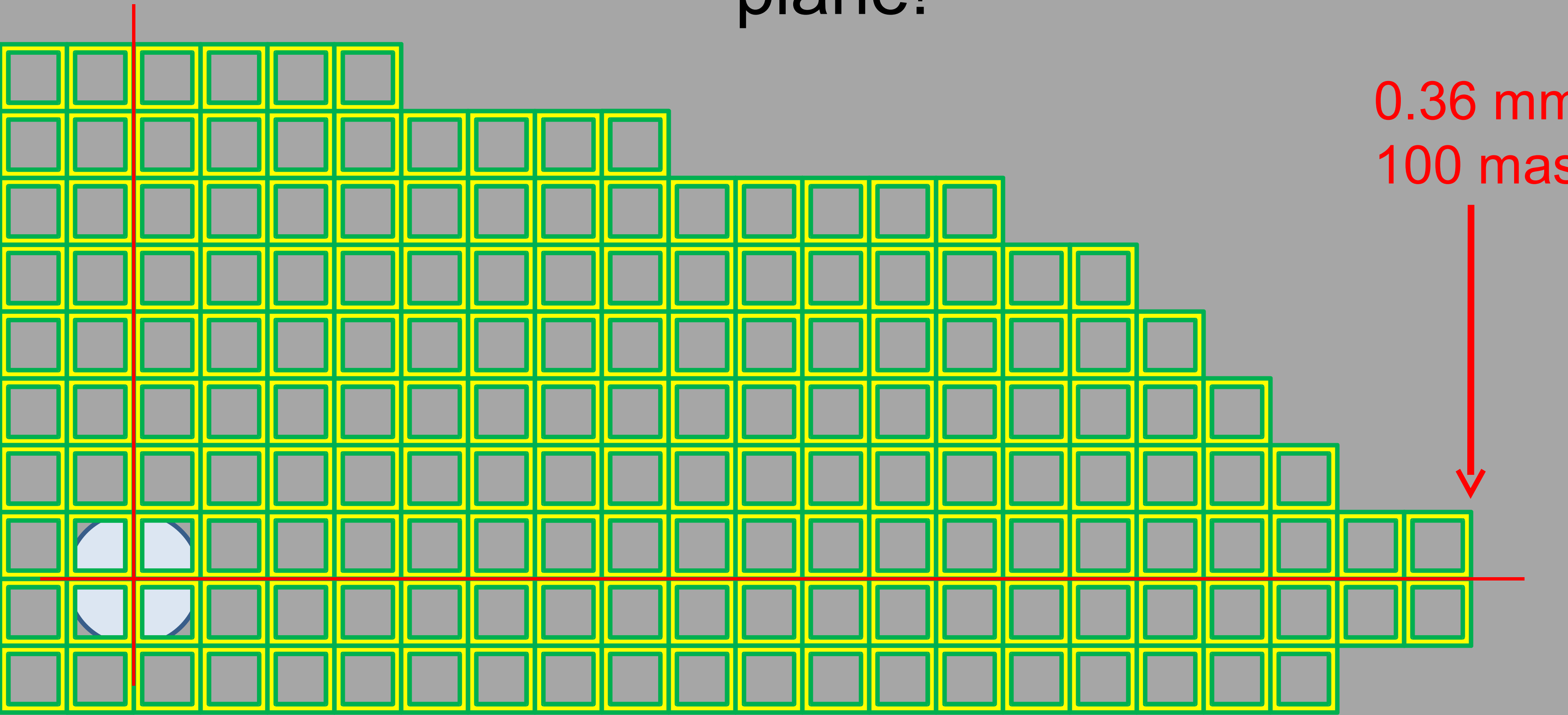
Overview of …
ELT@seeing.limited.it

Main optical parameters:

- *Aperture 42 m*
- *Mirror surface 1276 m2*
- *F number 17.7 #*
- *Focal lenght 743 m*
- *Field of view 5 x 5 arcmin2*
- *Scale 0.27 arcsec/mm*
- *Focal plane side 1071 mm (@ 5 arcmin)*
- *Seeing 0.6-0.8 arcsec FWHM*

Diffraction limited PSF vs. *seeing*

The Airy disk diameter at λ=0.5μm is about 4 mas (18 μm) just two CCD pixels at ELT focal plane!

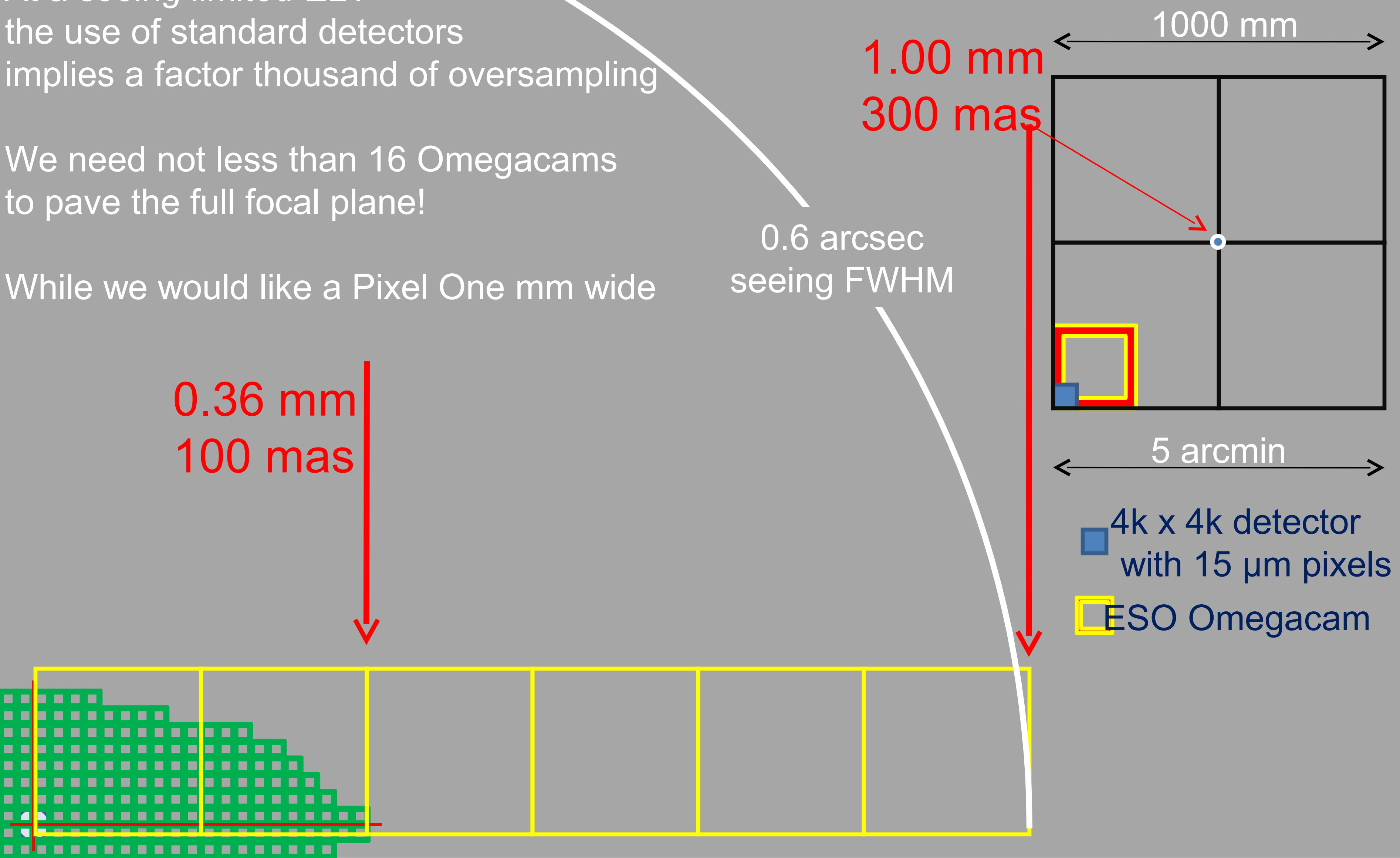


…a different view…. at the *seeing* scale

At a *seeing limited* ELT
the use of standard detectors
implies a factor thousand of oversampling

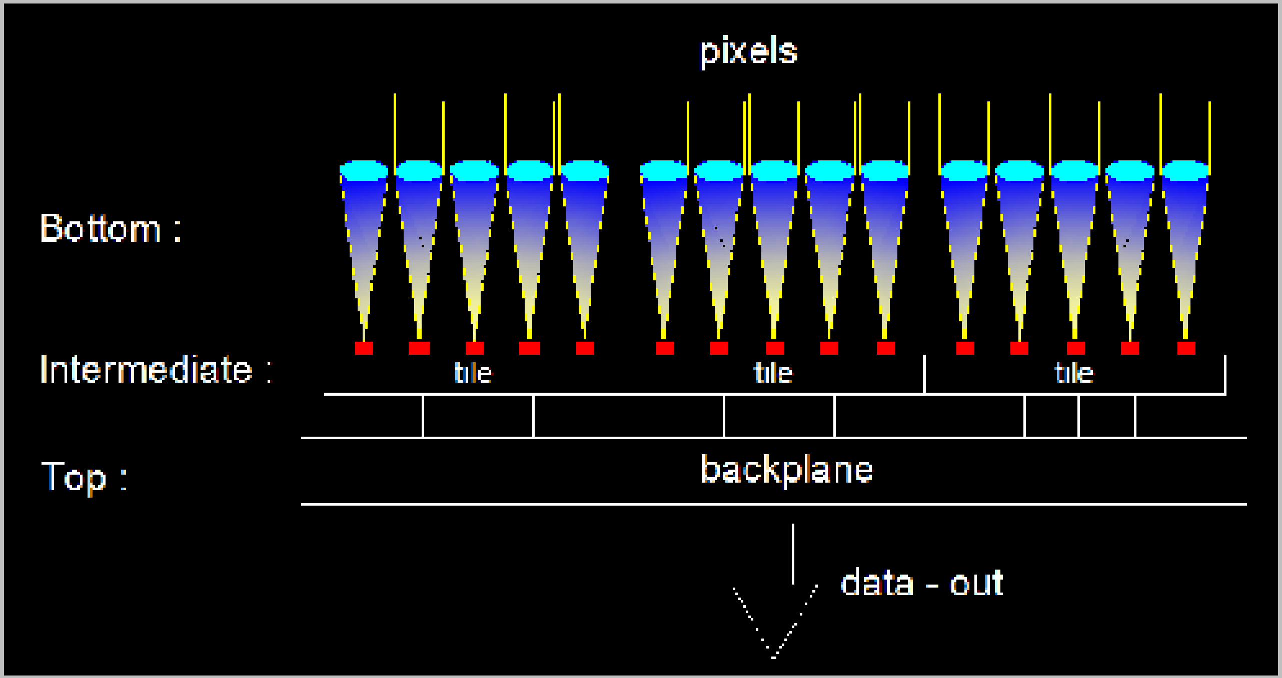
We need not less than 16 Omegacams
to pave the full focal plane!

While we would like a Pixel One mm wide



Pixel_One for "Dummies"

The philosophy of Pixel-One is to realize an array of elementary **1 pixel cameras** well matched to the ELT seeing-limited PSF and to interconnect them through a

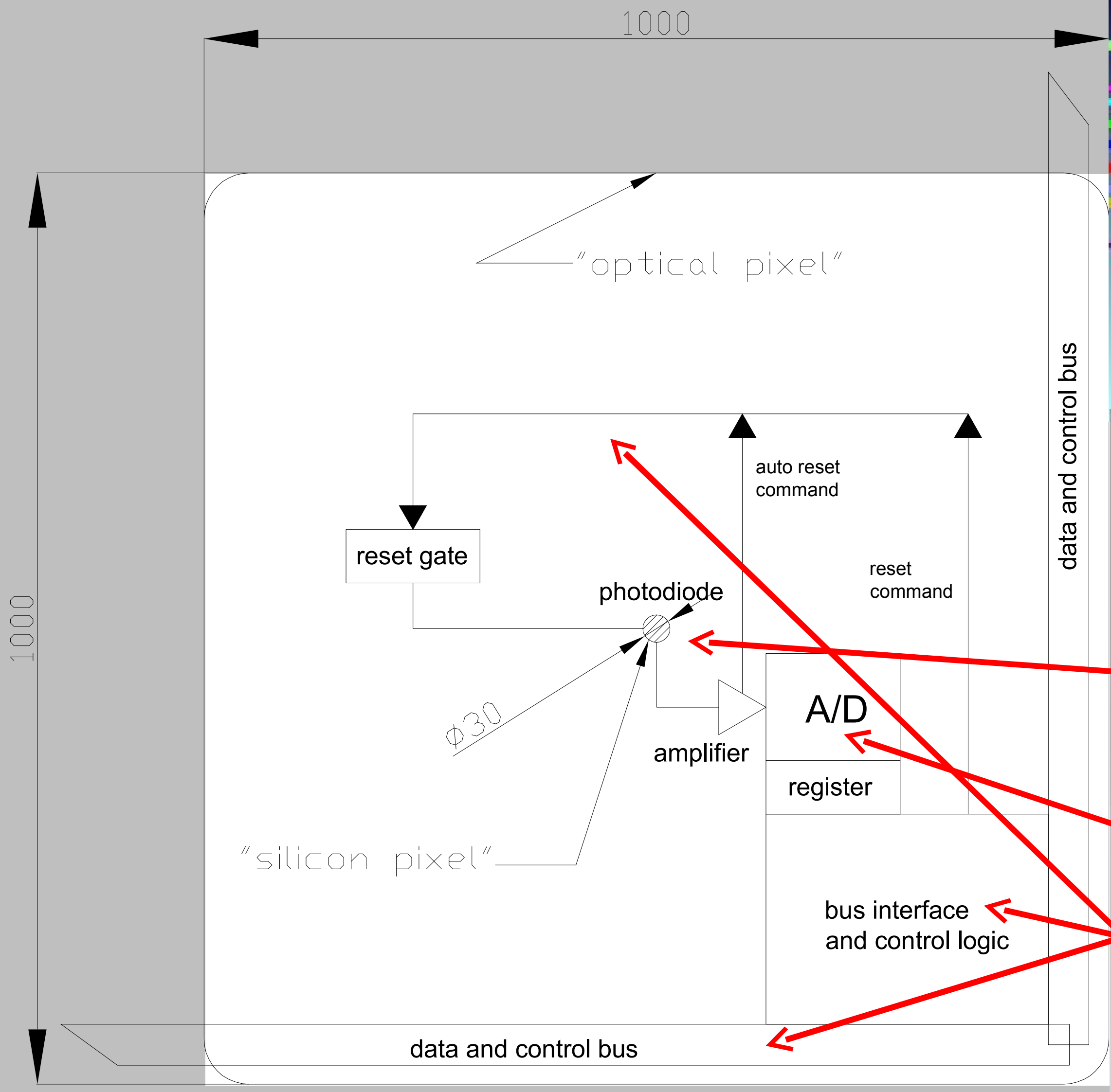


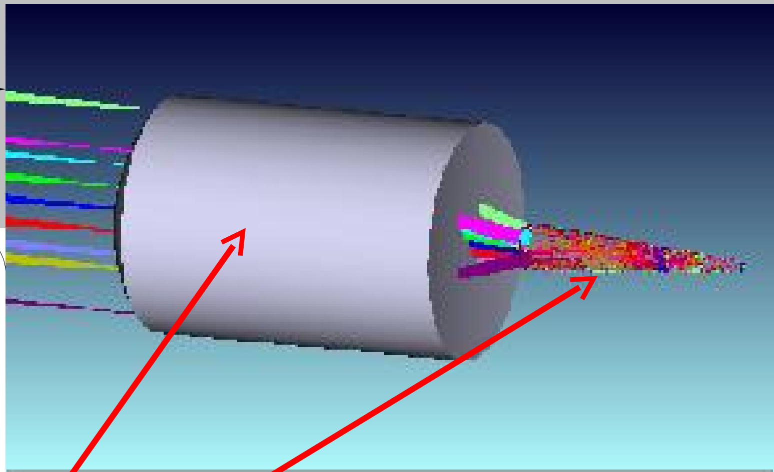
Bottom level – a smart CMOS pixel fed through a dedicated micro-lens or light-pipe with its digitizer and local data memory.

Intermediate level – a tile of a thousand smart CMOS pixels bonded to a data bus multiplexer.

Top level – the backplane that holds the tiles in position at the focal plane, provides the service power and interfaces the tiles' data links to some "standard" communication channels.

Bottom level for “Nerds”: The Pixel





1. A micro lens about 1 mm wide sample the focal plane.
2. A light pipe sqeezes the beam to a few micron spot.
3. A **“small”** cmos-pixel integrates and converts photons to electrons.
4. A local ASIC digitizes at 16 bit and adds/stores the result.
5. The ASIC manages the self-reset, the control signals, the data transfer on the local busses and the integration time.

Pixel features:

1. The local A/D can sample at 16 bits, 1e-/adu the light flux at kHz rates and integrate the result in a digital register allowing a photometric impressive dinamic > 32 bits not related to the pixel “fullwell”
2. The pixel ASIC manage all the read-out and integration processes avoiding to saturate the “photodiode” by an automated control of the reset gate….

Backplane:

Pixel_One Backplane is a real parallel array of “smart” imagers and each “*pixel*” of them can be programmed to accomplish different exposure times *(something like “HAWAII on chip guiding”).* This approach reduces the data rate and leave the fast sampling only where or when is really needed. *(pre-imaging required)*

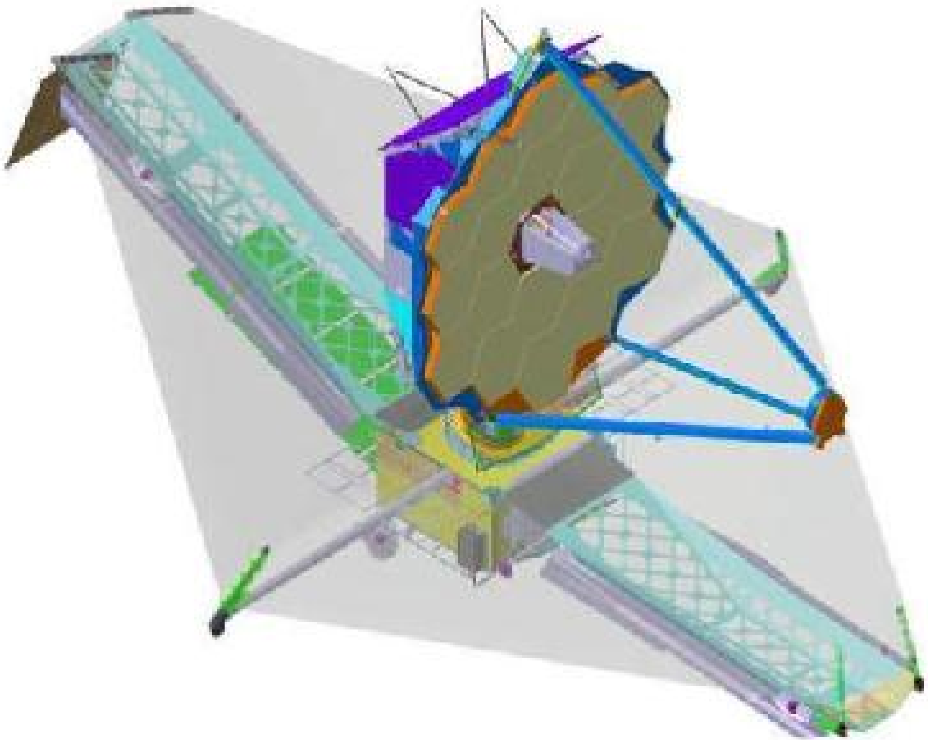
Final remarks on Pixel_One

- Pixel-One technology is modular easy to replicate and free from cryogenic.
- It is optimized to the next generation of E.L.T.s in seeing limited conditions. Performances are close to an ideal imager on the full focal plane.
- It performs time resolved photometry at millisecond scale.
- It has an impressive photometric dynamic range with no “bright source smearing”
- Side-products ?: ELT First Light Camera and WFS

ONE Showstopper: the microlens

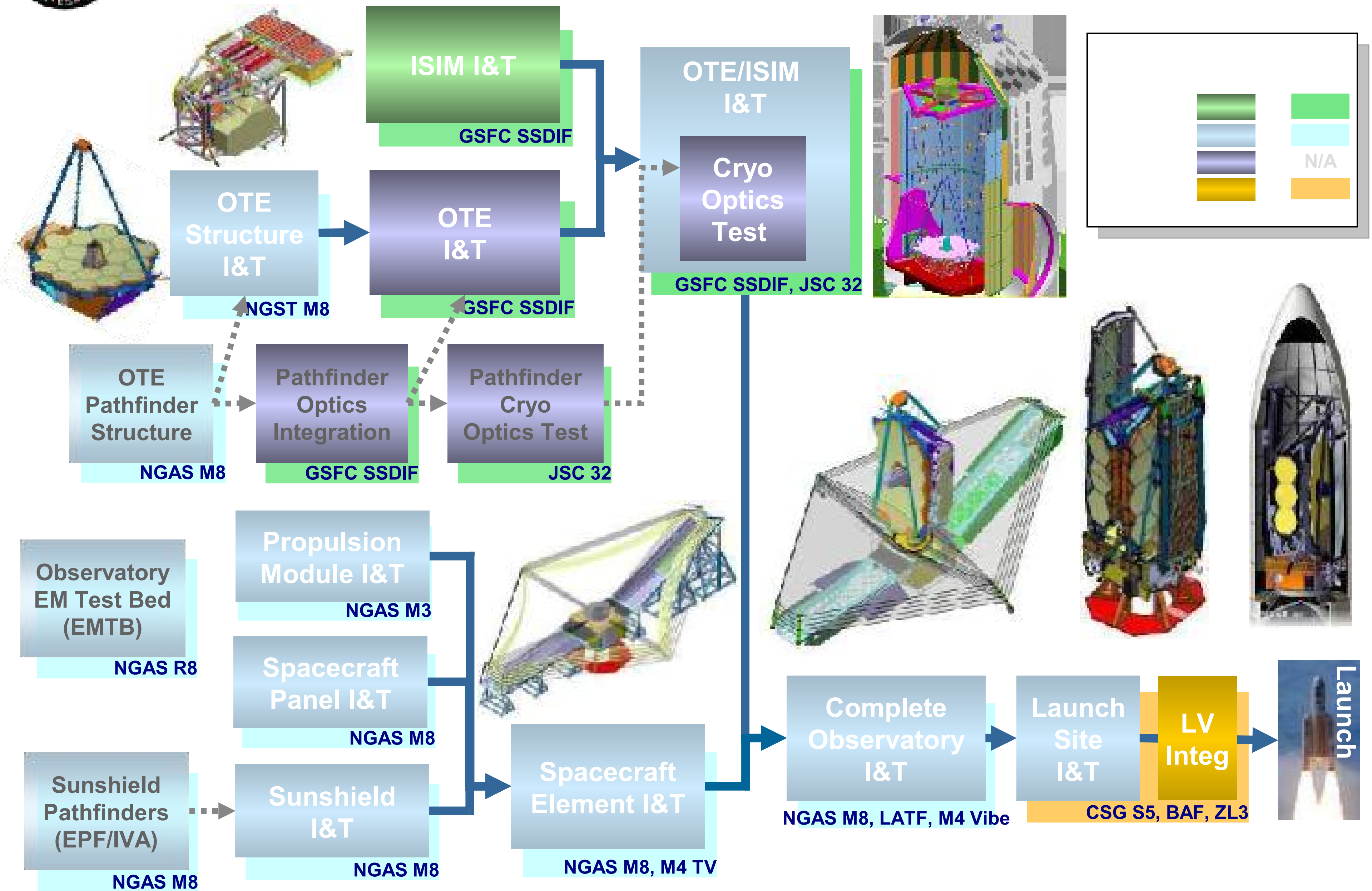
Cost: to be investigated

Managing Complex Space Missions like the James Webb Space Telescope



JWST Full Scale Model at the GSFC

Integration &Test Flow Overview



What hasn't worked out so good

- Achieving TRL-6 is necessary but not always sufficient for building the flight hardware. The technology development activity on JWST was absolutely necessary but we also realized, in some cases, the engineering proved to be harder than we thought as well
  - Detectors: I believe that the definition of TRLs fails to address a key issue for this technology which is accounting for production yield of the device. In addition to demonstrating the detector technology, the TRL 6 definition should mandate that the predicted yield of producing the device be demonstrated so that the flight project can properly plan
  - ASICs: A similar argument as for the detectors can be made for the ASICs
  - TRL scope: I think the TRL activity works for discrete components – ensures the component as a stand alone item is ready for integration to a flight program – but misses the integrated effect of that technology in the overall system. The interaction between systems is never fully appreciated and the cross system

What hasn't worked out so good (Cntd)

- Timely cost phased reserves are absolutely required but rarely available. This has huge leverage on the run out cost of the program. Without them there is a realistic chance, when problems arise, the project will be forced to defer some work to later years which has a compounding effect of at least doubling the cost of the deferred work and reducing the available reserves in the out years
- Maturing the JWST technologies into flight hardware took longer and costed more that planned. We probably needed 35-40% reserves in those years

What does work no matter the project

- Communicate communicate communicate. Can’t over communicate

- A test is worth a thousand analyses.
- Get operating time on the hardware and software.
- Test as you fly. Don’t forget to test with the ground system. Can’t completely test JWST as you fly. It’s too big

Project Management (2)

Management and systems engineering of the Kepler mission

SPIE 7738-24

James Fanson, Leslie Livesay, Margaret Frerking, Brian Cooke

Jet Propulsion Laboratory

California Institute of Technology

SPIE Astronomical Instrumentation

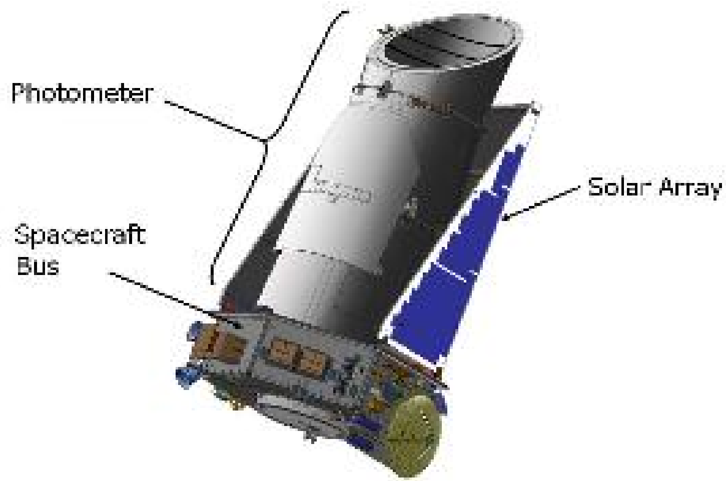
San Diego, California

28 June 2010

Project Management (2)

Kepler: NASA's first mission capable of detecting Earth-size planets

- Seeks to determine whether Earth-like planets are common or rare in the galaxy
- Measures the dimming of stars when planets transit across their disks
- Simultaneously measures brightnesses of 100,000 stars at part-per-million precision
- Winning proposal submitted in 2001 by ARC with Ball as system contractor



- Three months after selection NASA established new policy requiring all robotic missions to be managed by JPL or GSFC
  - Paradigm shifting from "faster-better-cheaper" to "mission success first"
  - Kepler directed to add either JPL or GSFC to lead dev phase management
  - JPL selected and added to team in 2002

Project Management (2)

Theme 3: Don't underestimate complexity or the difficulty of scaling existing technology

- Kepler flight vehicle contained no new technology, but…
- Focal Plane Array Assembly (FPAA) featured focal plane of unprecedent-ed scale (95 megapixels)
- Comprises more than 20,000 parts
- Degree of engineering required significantly and chronically underestimated
- Challenging requirements drove decisions with unintended consequences
  – Amplifiers power cycled to save heat dissipation, resulting in unintended noise sources
  – Cost-cutting measures like testing readout electronics with two instead of all ten boards cause late discovery of crosstalk noise

Satellite Servicing Assessment Humans / Robots

Early results from NASA's assessment of satellite servicing

Author(s): Harley A. Thronson, Jr., Mansoor Ahmed, Jacqueline A. Townsend, Arthur O. Whipple, William R. Oegerle, Benjamin B. Reed, NASA Goddard Space Flight Ctr. (United States)
NASA/GSFC

SPIE Telescopes and Instrumentation
San Diego, CA
June 27, 2010

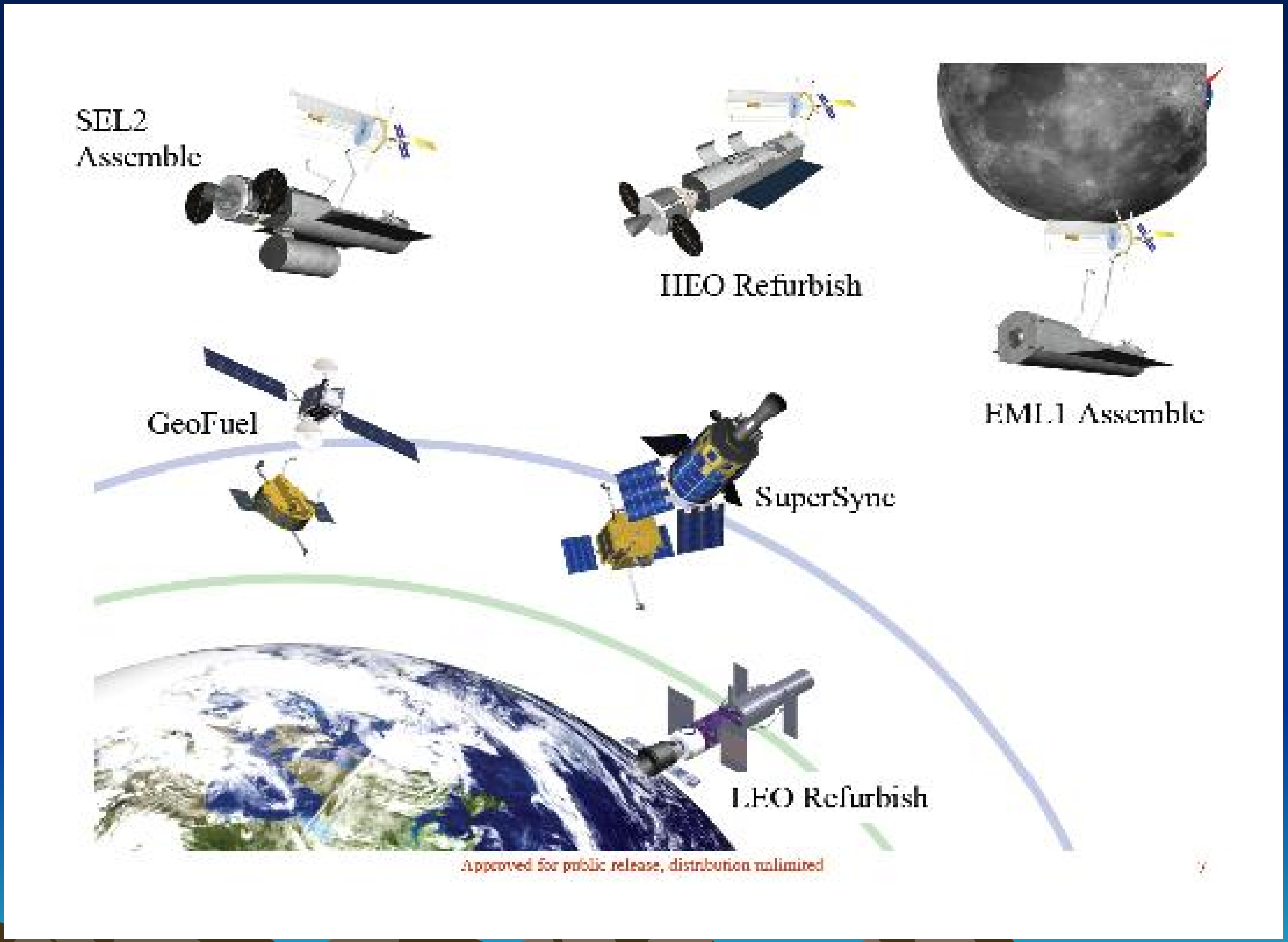
Satellite Servicing Assessment

Background

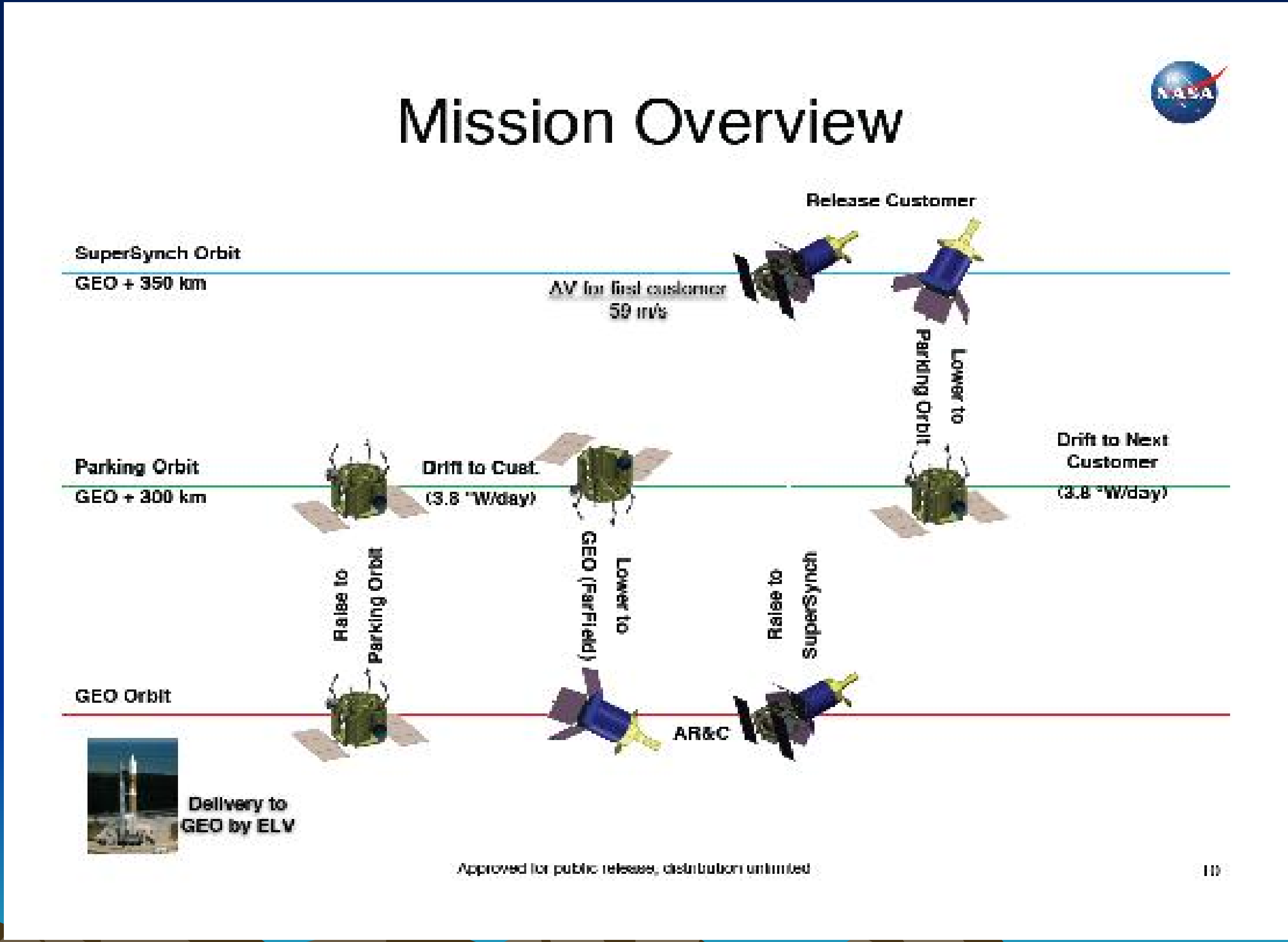
- Space Servicing Capabilities Project, Astrophysics Projects Division at Goddard Space Flight Center is responding to a Congressional directive to study the assess the feasibility, practicality and cost of servicing satellites using elements of currently planned and future NASA human spaceflight systems and/or robotic technologies.

- This work is in support of recommendations by the National Research Council, NASA's Authorization Act of 2008 (Public Law 110-422) and the FY2009 Omnibus Appropriations Act.

Satellite Servicing Assessment

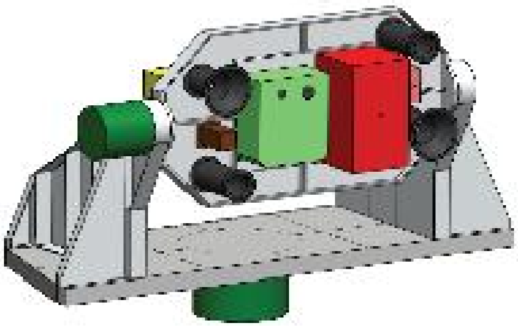


Geosynchronous Satellite Disposal



Satellite Servicer Elements

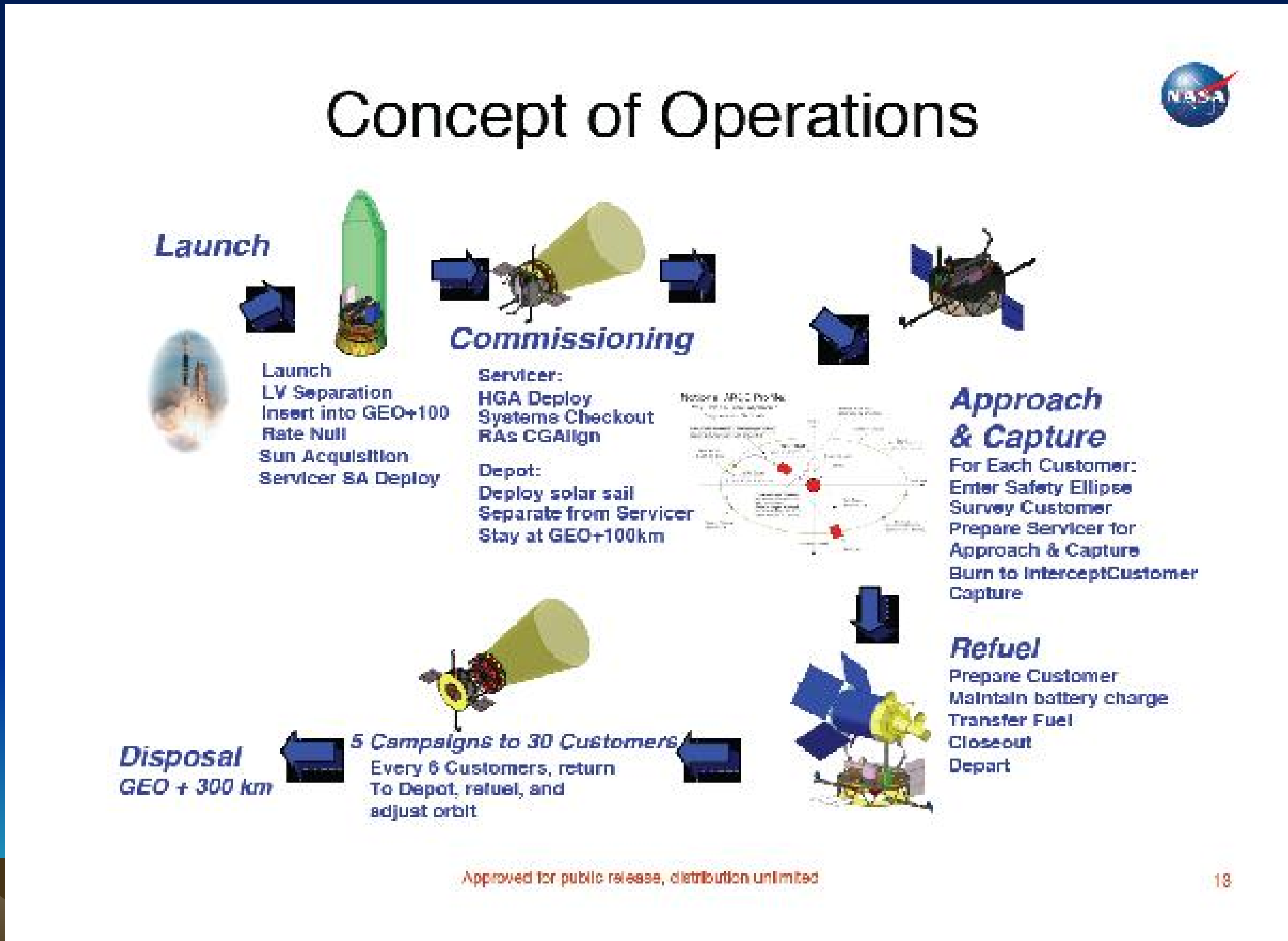
Specialized Servicer Elements (Payload)



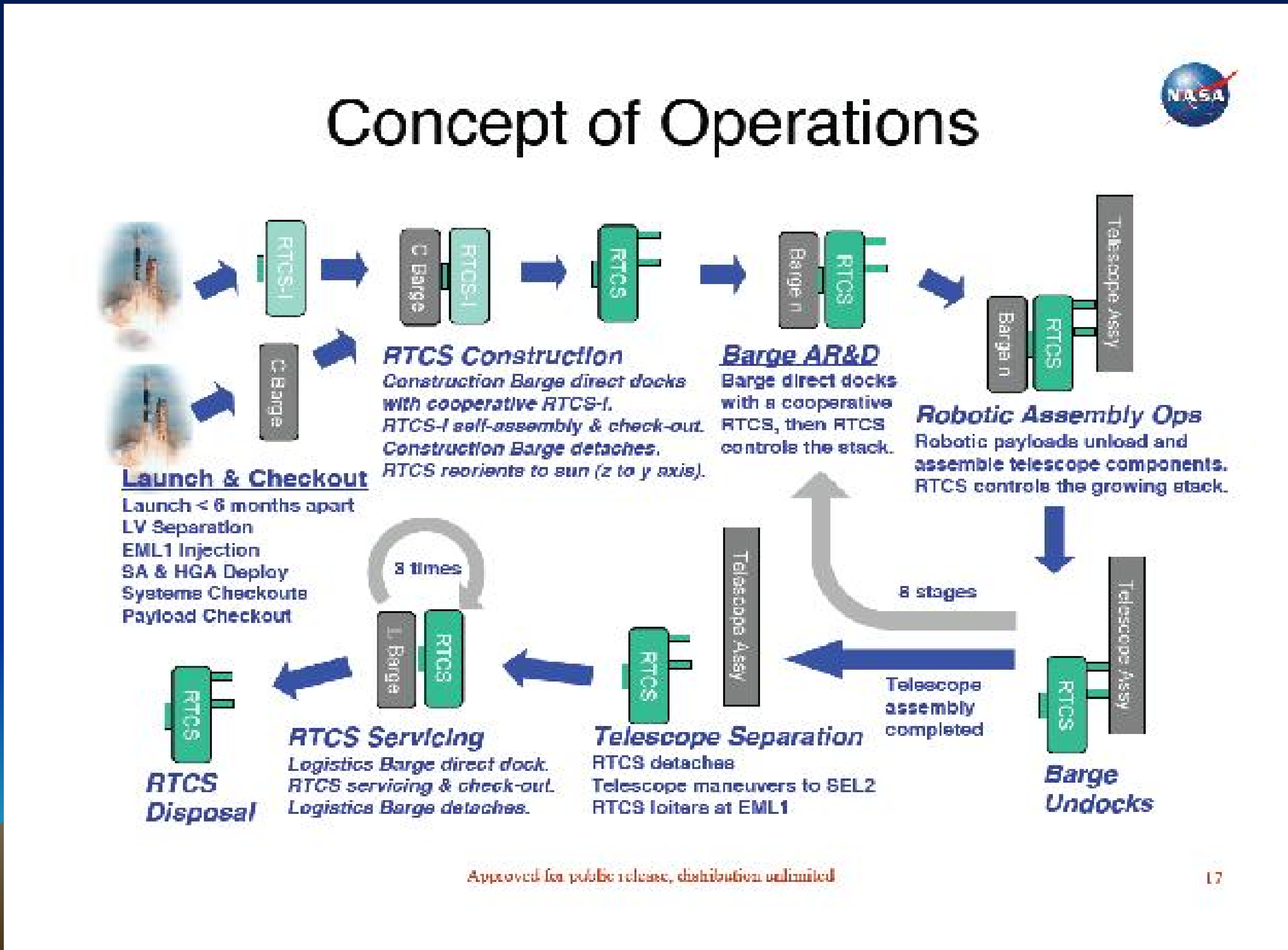
Autonomous Rendezvous and Capture Package
- Cameras
- LIDAR
- Laser Rangefinders
- 141 kg

Robot Arms (2 - 4 total)
- 7 DOF
- Cameras and LIDAR in End Effector
- 615 kg for 4 arms

Geosynchronous Satellite Refueling



Large Telescope Assembly in Space



Many other topics TBD:

- M. Dimmler (ESO) ALMA Transporter damping system

- U. Hopp et al. (USM):

Wendelstein Observatory equipping new 2m telescope with advanced instrumentation (e.g., Hawaii 2RG and mosaic of four 4k x 4k e2v CCDs (Spectral Instruments)

L. Strueder et al., Talk – **First X-ray Imaging Measurements @ the Linac Coherent Light Source (LCLS)**

e.g., imaging a virus with pn CCDs & free electron lasers

new interdisciplinary center for free electron lasers (350 people, UHH, DESY, MPG)