



# NGAO Wavefront sensors: conceptual design report

## WBS 3.2.3.5

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Design Meeting (Team meeting #12)  
Dec. 13<sup>th</sup>, 2007

# Agenda

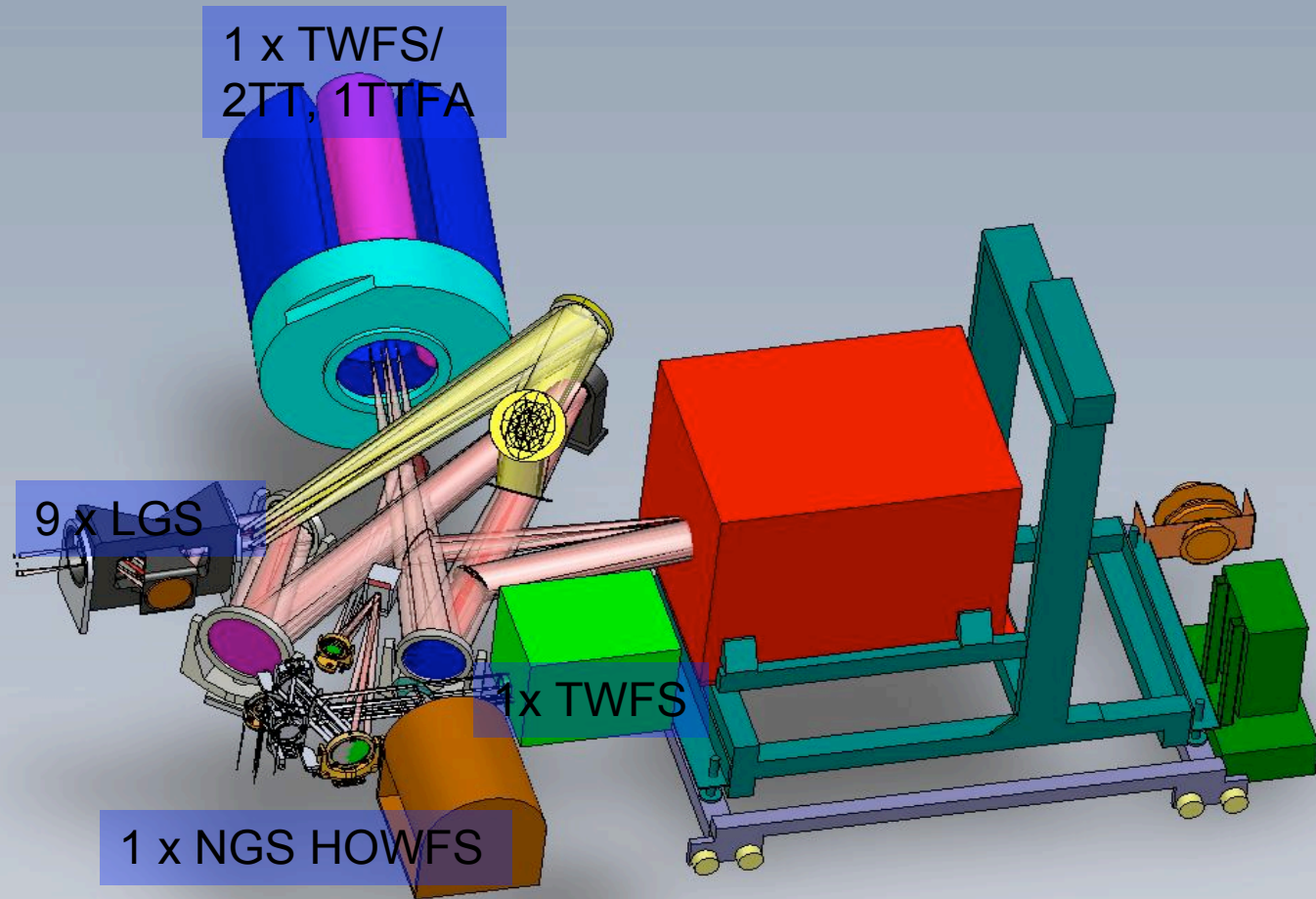
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- WFS location in I-tier and II-tier cases
- LGS WFS explained
  - Asterism configuration
  - Why doesn't it rotate?
  - Finer details.
- Design input parameter table (same as the one shown in meeting 11)
- Table showing sample output of 1st order design calculations.
- LGS WFS motion control table
- Technical Challenges - status
- Status of deliverables
- OSM concept
  - TT
  - LGS
  - An architect's view point.

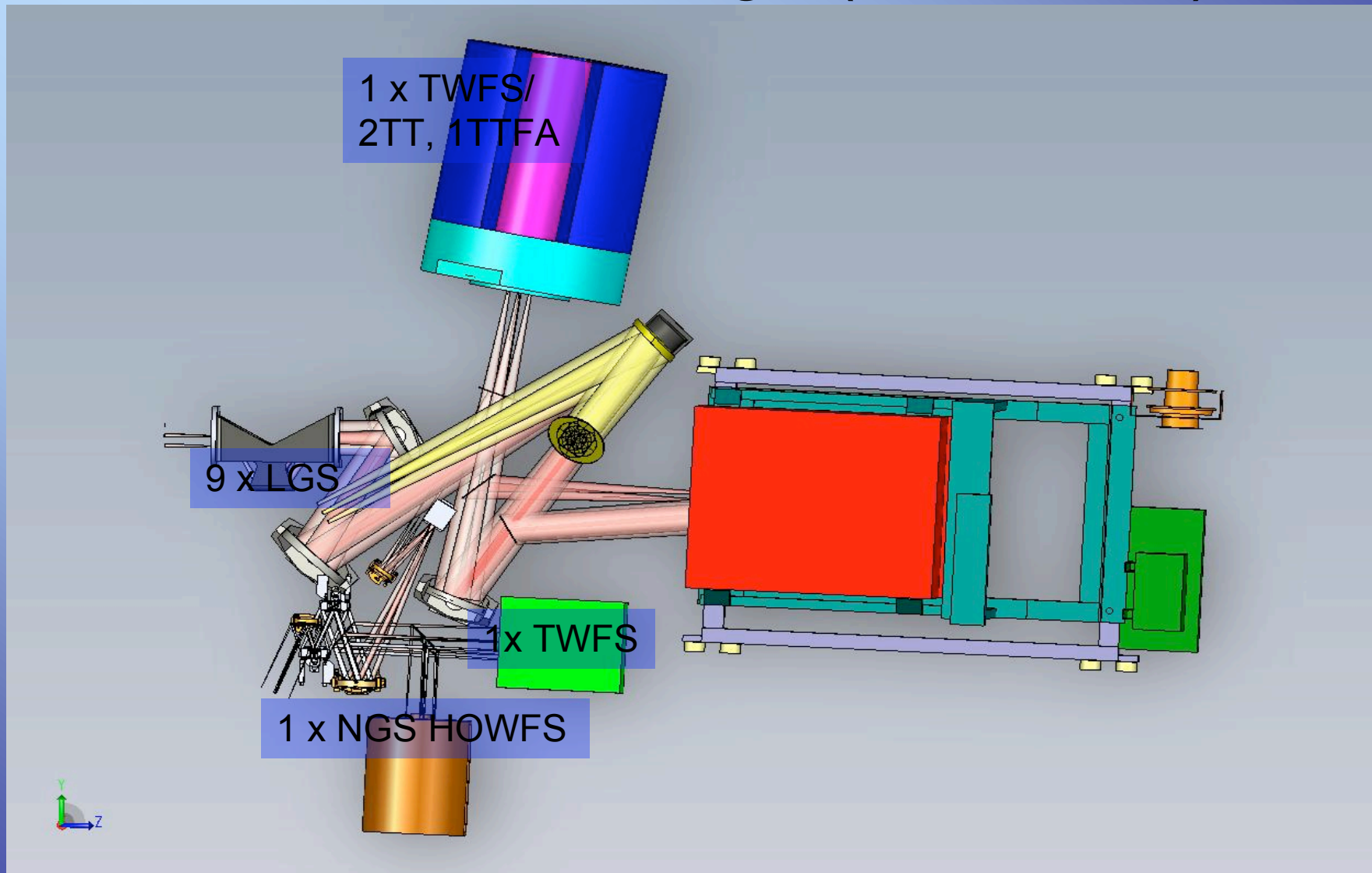
Note: Please refer to [WFS presentation made at Team Meeting 11](#) for programmatic details like Work scope, WBS definitions and input sources for this work.



# NGAO I-tier design (Perspective View)

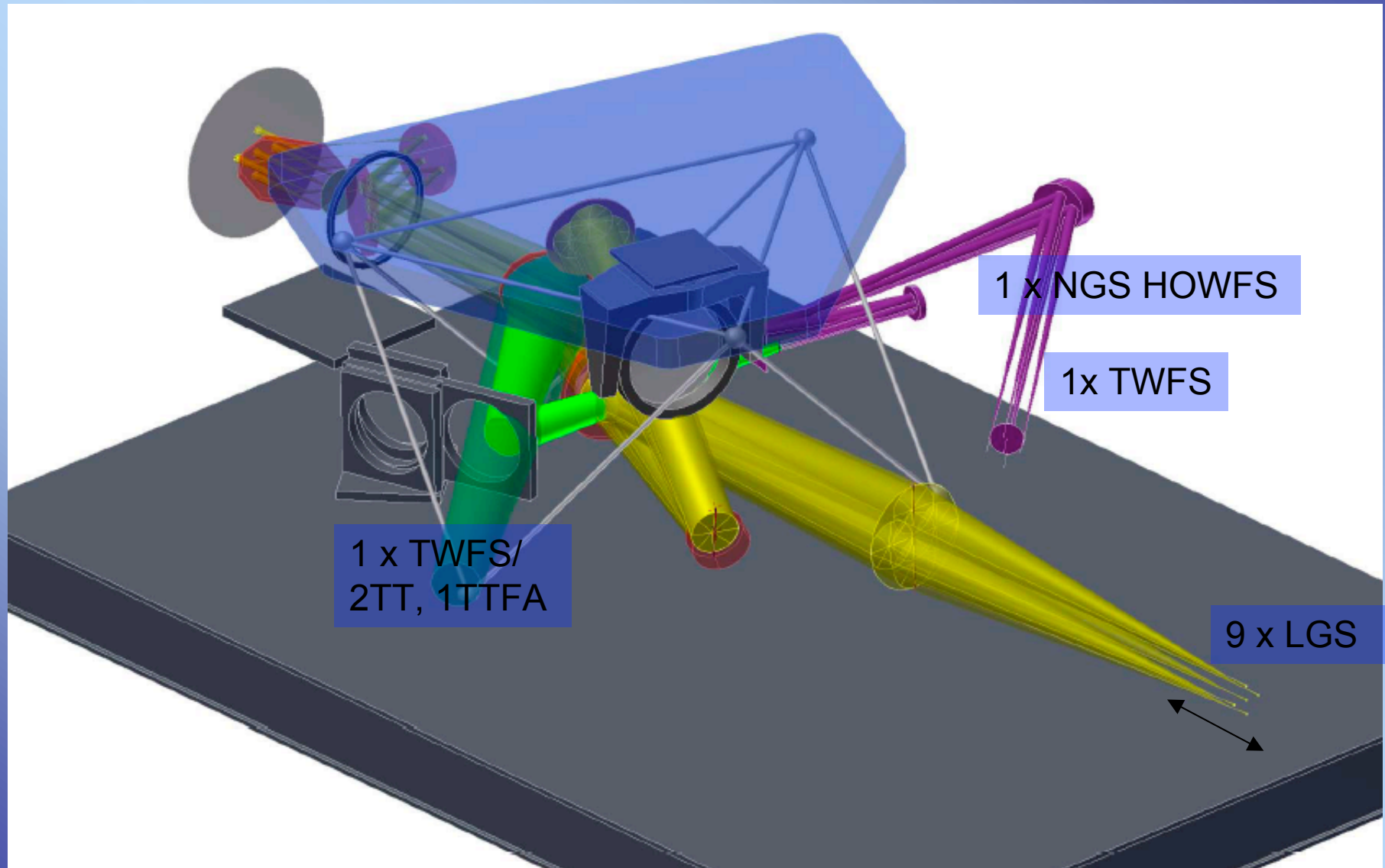


# NGAO I-tier design (Plan View)



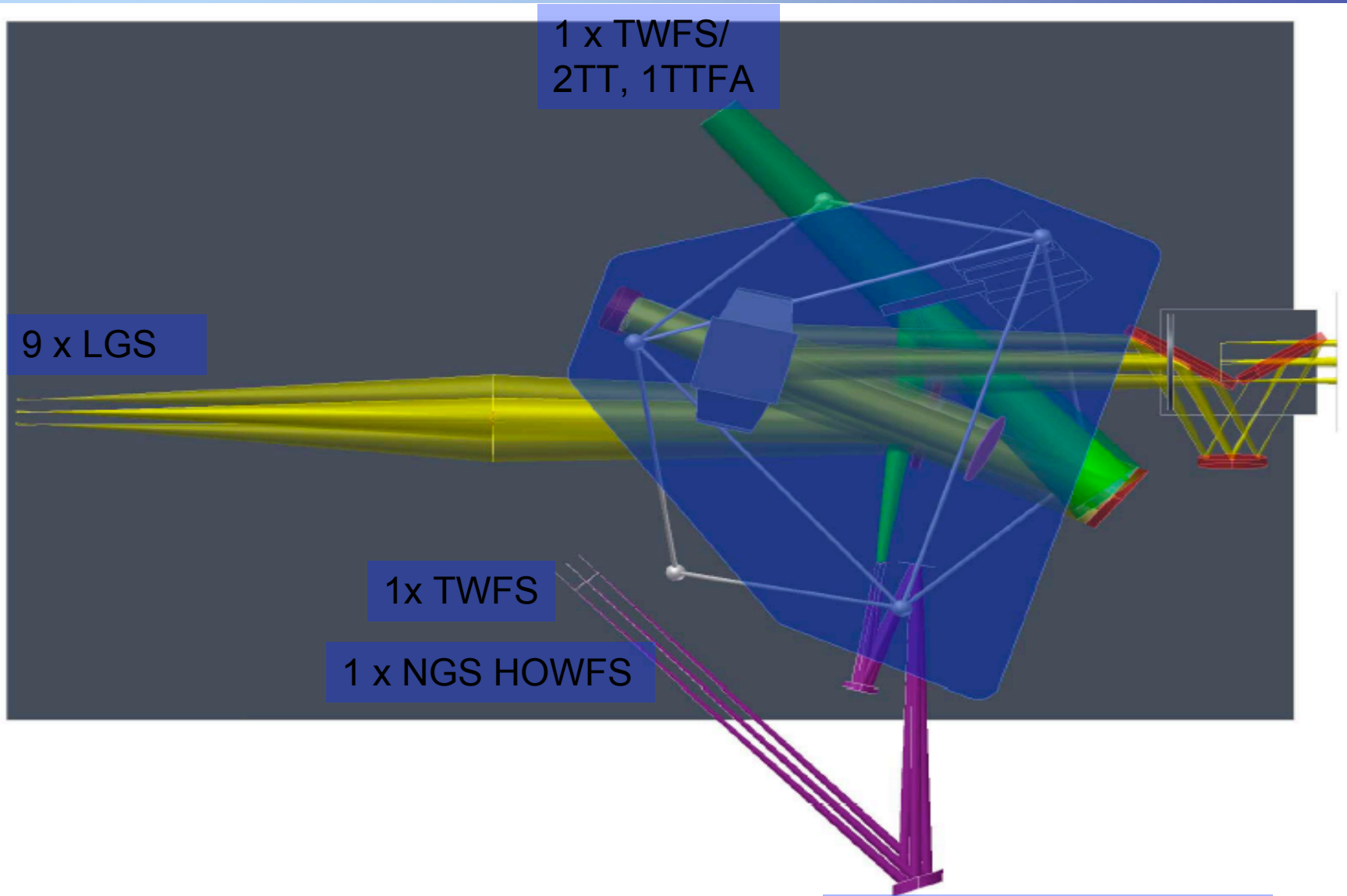


# NGAO II-tier design (Perspective View)



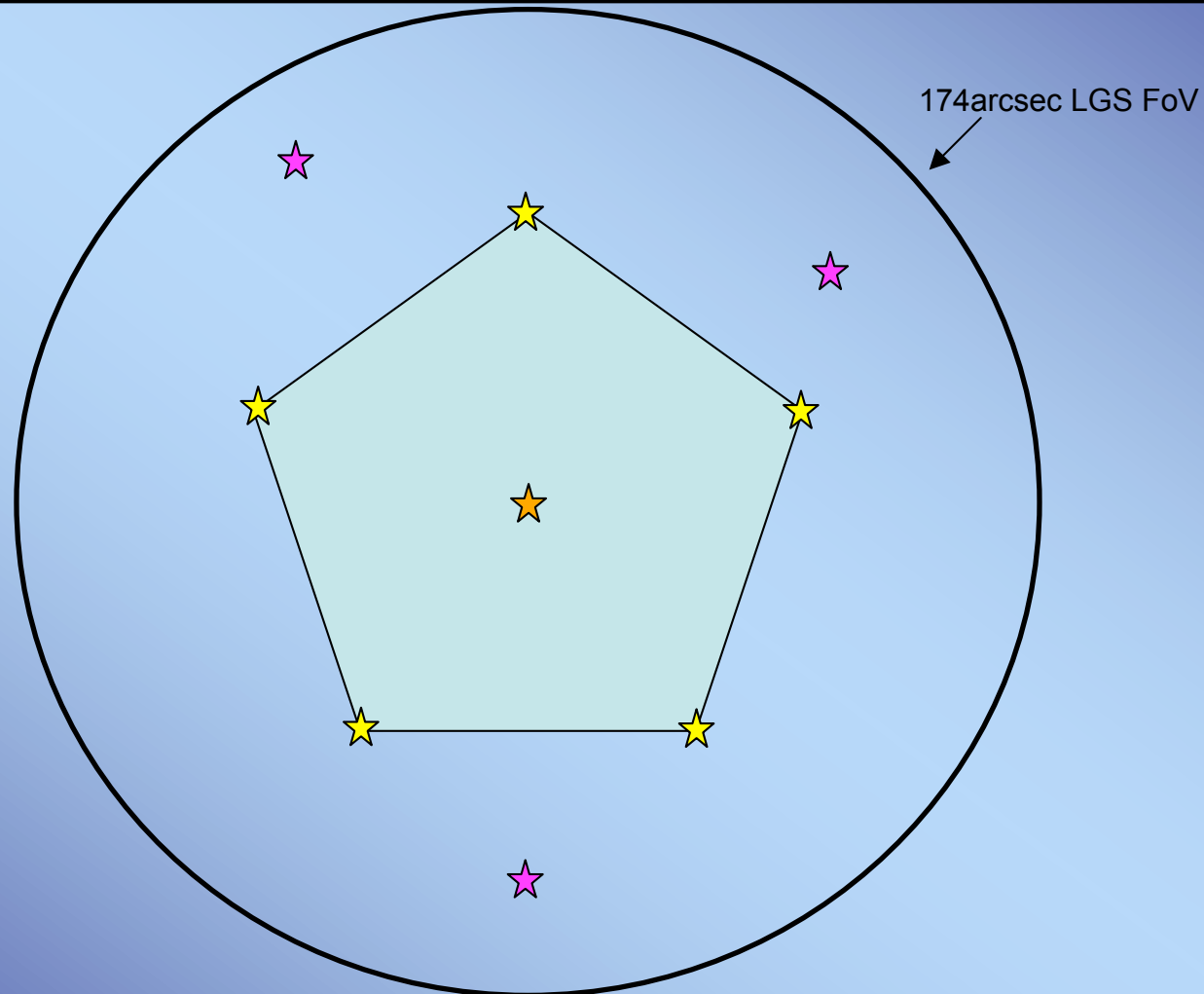
Courtesy: C. Lockwood

# NGAO II-tier design (Plan View)



# NGAO LGS WFS opto-mechanical design

## Basics and requirements



Fixed central LGS star

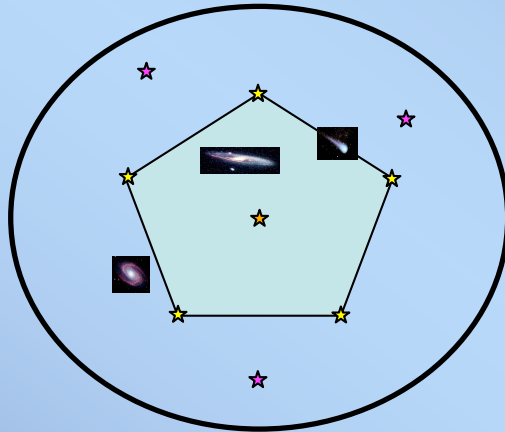
5 equi-angle LGS stars, variable radius,  $r_1=10''-150''$

3 roaming LGS stars, variable radius,  $r_2$  where  $(r_2-r_1 > 10\text{arcsec})$

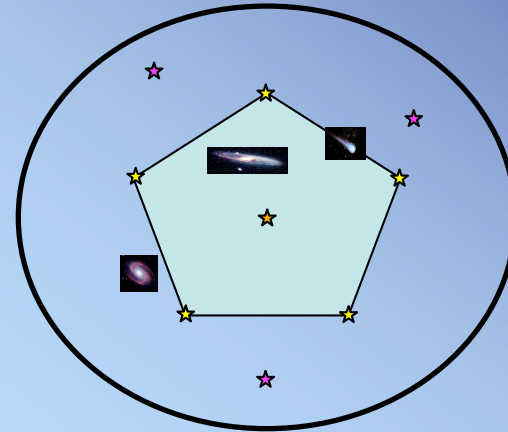


# Why LGS (now) don't need to rotate - the WF scenario

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On sky



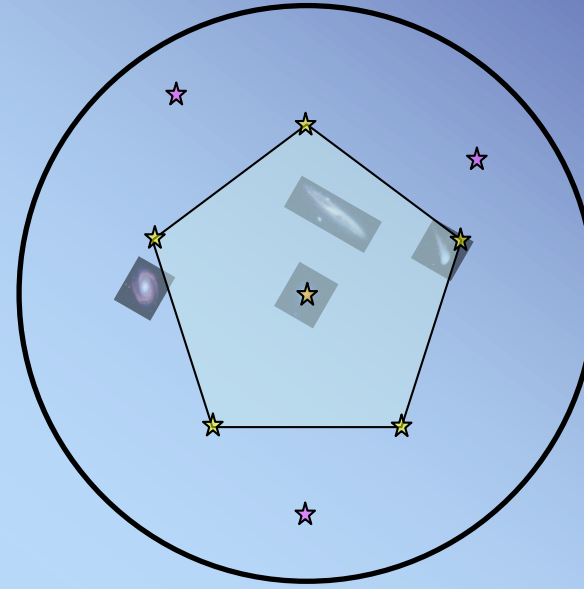
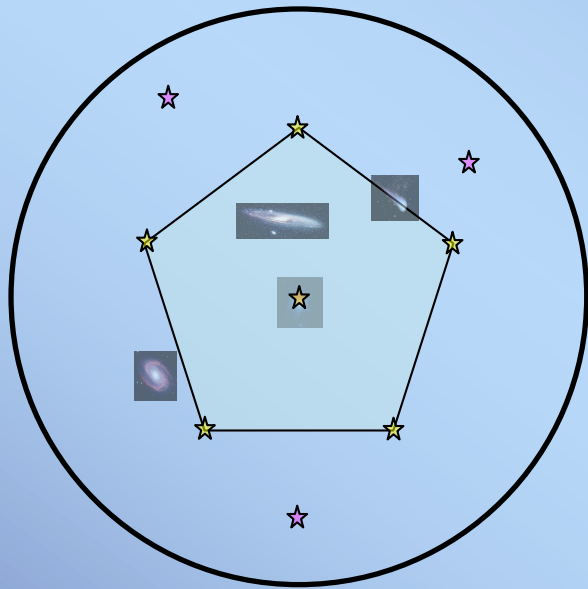
At the AO focal plane after some time.

- The LGSF team has come up with a novel scheme to keep the LGS asterism fixed WRT the sky while telescope tracks.
- The K-mirror keeps the sky (and hence the LGSs) fixed on the detector in this configuration.





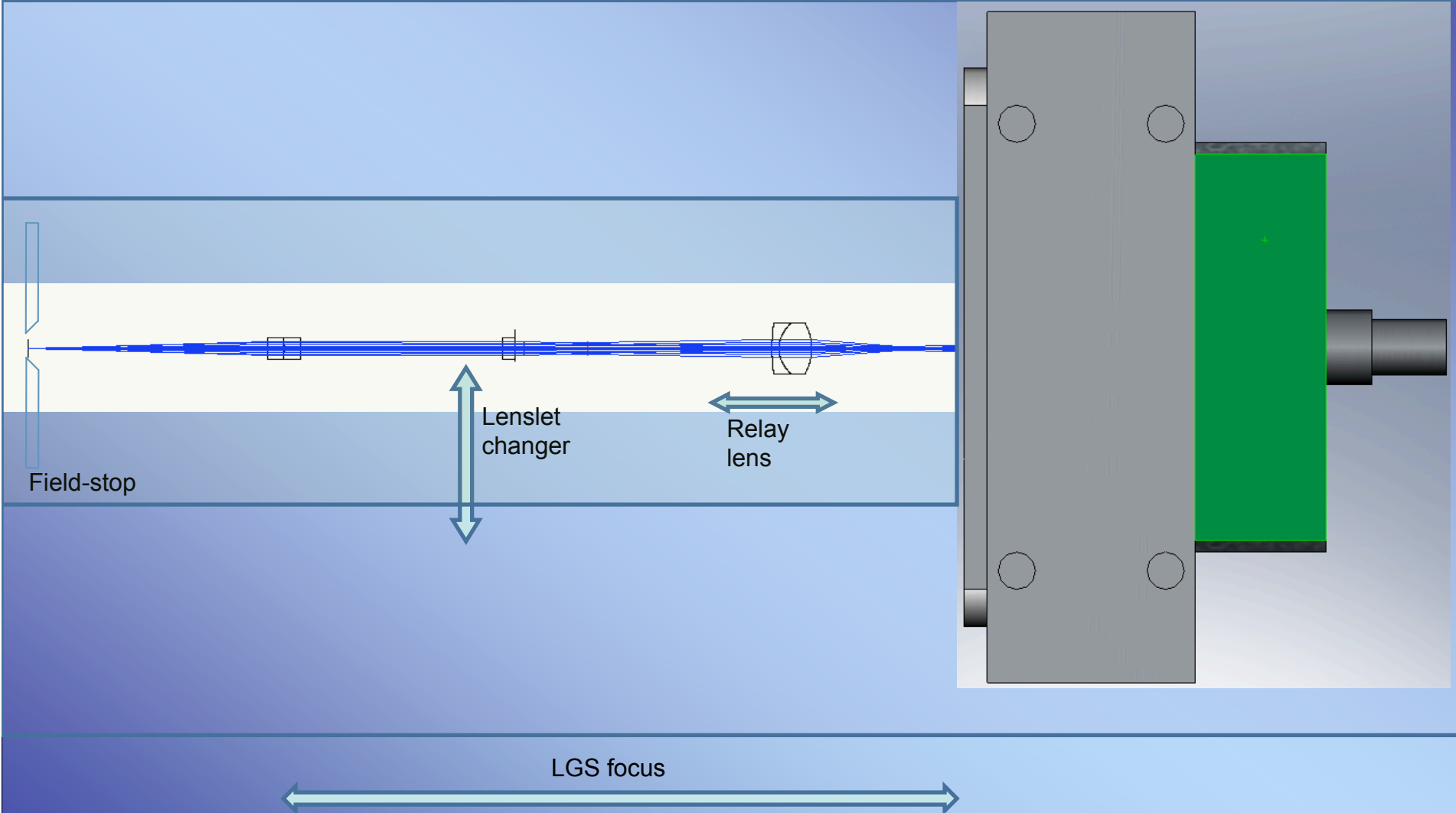
# Why the LGS (now) don't need to rotate- NF on-axis star



- This observing mode is mostly for high contrast observation
- K mirror keeps pupil fixed
- The uplink mechanism is conceptualized so that it can be either used to keep the LGSs fixed WRT to the sky or keep them fixed with respect the WFS.
- In this case the LGS's rotate WRT to sky, this doesn't affect the on-axis observation, and yet the LGS WFSs can be stationary.



# LGS WFS details



# WFS design input parameters

WFS type	Location	Sensing wavelength (nm)	Input PS (um/")	# of sub-apertures	Detector PS("/pixel)	Filters	Comments
NGS HOWFS	near NF sci. inst.	400-900	2254	32x32, 64x64	1.5	no filter	Steering mirrors for OSM
LGS HOWFS	after WF relay	589 nm	727	16x16, 32x32, 64x64	1.45	no filter	Has to track Na layer, tilted focal plane, field dependent aberrations. Steering mirrors for OSM
TT	inside d-NIRI	1.16 - 1.33	727	1x1	0.030	J, H and J & H	will use d-NIRI OSM
TTFA	inside d-NIRI	1.16 - 1.33	727	2x2	0.030	J, H and J & H	will use d-NIRI OSM
Truth sensor	near NF sci. inst.	400-900	2254	5x5	1.6	no filter	do we need two (one at d-NIRI ?) OSM can be steering mirrors for the NF one, and d-NIRI default OSM for truth sensor at the d-NIRI channel

## Assumptions:

1	TT(FA) shall use extra pixels when guiding on extended objects.
2	32x32 NGS case: Planetary sources between 7-10 mag.
3	16x16 and 32x32 for LGS is for a de-scope option
4	Truth sensor works on a 21st mag. Star with 21 maSec (1D) jitter with 0.6" spot at 1 Hz (EBS analysis)

The TTFA #s are TBC



# Typical output from developed code

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Config/ Parameter	F_coll	demag.	f_lenslet	u	v	f_relay	r_lenslet	f_num	beam size_r	lenslet pitch
64x64 LGS	48.00	2.11	0.25	36.47	17.28	11.72	0.13	4.57	7.97	0.05
32x32 LGS	48.00	2.11	0.50	36.30	17.20	11.67	0.26	4.57	7.94	0.11
16x16 LGS	48.00	2.11	1.00	35.96	17.04	11.56	0.52	4.57	7.86	0.22

- F\_coll - Collimator focal length
- Demag - Lenslet spot separation (spot separation at the detector)
- F\_relay - Focal length of relay lens.
- F\_lenslet - Lenslet focal length
- Pitch - Lenslet pitch
- (u+v) - Distance between lenslet focal spots to detector.



# Motion control description for LGS WFS

Location	Type	Range of Travel	Min. step size
LGS Channel (ind. Unit focus)	delta z	~10 mm	10 um
LGS Channel (lenslet exchanger)	delta X, delta Y	delta X ~20 mm, delta Y=1 mm	2 um
LGS Channel (ind. Focus)	delta z	few mm	5 um
Pick-off (theta mech)	delta theta	360 deg.	0.2"(UP)/115" (LA)
Pick-off (Phi-mech.)	delta phi	360 deg.	0.2"(UP)/300" (LA)
LGS WFS unit overall focus	delta z	130 mm	1 mm





# Technical Challenges - status

- OSM details have to be figured out for each WFS - should we prototype?
- It is a hard problem to package 9 LGS WFSs with:
  - 5 beacons that lie on a circle with variable radius (focal spots radius varying from 7 mm-146mm) & 3 roving beacons that go anywhere - concept developed
  - Individual translation stages to account for LGS focal plane with variable tilt - concept developed
  - *Combination of doublet and one focusing lens to keep the pupil at the lenslet for a Na-layer object distance that varies from 90Km-180Km? (Probably not required)*
  - The WFS has to move to account for the Na-layer distance varying with zenith angle (~10 um accuracy) - concept developed
  - Motion control: 1 lens 1D(T), each LGS WFS 1D(T), whole LGSWFS package 1D(T), radial in-out for each (but central) WFS 1D (T). OSM (field steering mirrors? 2x2D (tilt)), mechanism to pick off roving beacons! [(T)- translation] - LGS table made
  - *Shearing spherical plates to create correct coma (do these just need to shear or rotate and shear?) - Done away with!*
  - *LGS WFSs will have a 1/2" pupil mirror in the design that can be replaced by a MEMS DM at a later stage - done away with Switching lenslets/ relay optics to allow for multiple pupil sampling scales (~2 um of motion accuracy).*
- IR sensors:
  - Will guide on extended objects - some work has been done.
  - OSM, optical design, ME design and packaging strongly dependent on d-NIRI progress - Jim and Chris are doing a stupendous job!



# Deliverables (as per revised scope)

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1. Conceptual optical design(s):
    - a. *WFS concepts have been presented multiple times and the concept presented at [team meeting 11](#) was accepted as baseline by the project. These parameters were chosen after seeking science team (LMcG, DLM) input.*
    - b. *A rough volume envelope and a conceptual design submitted to the opto-mechanical group in mid-Nov.*
    - c. *A matlab routine has been written that readily calculates the different WFS parameters given inputs from the table in [this presentation](#) and some other mechanical constraints.*
  2. Feed into relevant sections of FRD version 2.0 (in particular update TT sensor requirements and performance based on the type of source):
    - a. *Lots of work has gone into liaising with Chris and feeding into the FRD.*
    - b. *Have worked with Erik to convey mechanisms to the non-RTC/ supervisory control group.*
  3. LGS pick off mechanism concepts.
    - a. *Will defer to Anna for comment*
  4. Conceptual designs and first order optical design for the LGS WFSs, TT(FA) sensors.
    - a. *Still waiting on opto-mech. design constraints and selection mechanism to finalize 1st order design.*
  5. First order Mechanical packaging:
    - a. *I hope that Mechanical volume envelopes are being made by Jim/ Chris based on my initial estimates. We can alter these easily as they may just be cubical volumes for now.*
  6. Preliminary mechanical design and 3D model (at least a cartoon showing the envelopes occupied by the WFSs).
  7. Acceptance and completeness of concepts and conceptual design with information on what needs to be done during the preliminary design phase.
    - a. *No team meeting held as opto-mech. design isn't confirmed.*
  8. Update the terms in the error budget spreadsheet based on conceptual design.
    - a. *Have worked with Rich on looking at error budget terms and getting spot sizes at the detector considering various effects. But without confirming optical performance, its hard to feed back in to the EBS.*
- Documentation for all the above.
- a. *Will be completed in first week of Jan*



# Volume table feed into opto-mech. design

WFS/ dimensions [mm]	Length (Z)	Breath (X)	Width (Y)	# of sensors	Pick off mechanisms	Comments
LGS WFS	150	100 <sup>⊘</sup>	100 <sup>⊘</sup>	9	defer to AMM	3 pupil sampling scals
NGS WFS	375	100 <sup>⊘</sup>	100 <sup>⊘</sup>	1	defer to AMM	2 pupil sampling scales, near the NF sci. instrument
TT*	650	150	150	2	defer to AMM	
TTFA*	650	150 <sup>⊘</sup>	150 <sup>⊘</sup>	1	defer to AMM	
TWFS <sup>⊗</sup> [VIS/ IR]	200 (200)	100 <sup>⊘</sup> (150 <sup>⊘</sup> )	100 <sup>⊘</sup> (150 <sup>⊘</sup> )	1(+1)	defer to AMM	near the NF sci. instrument

⊗ - Both in NF (visible) and WF (IR)

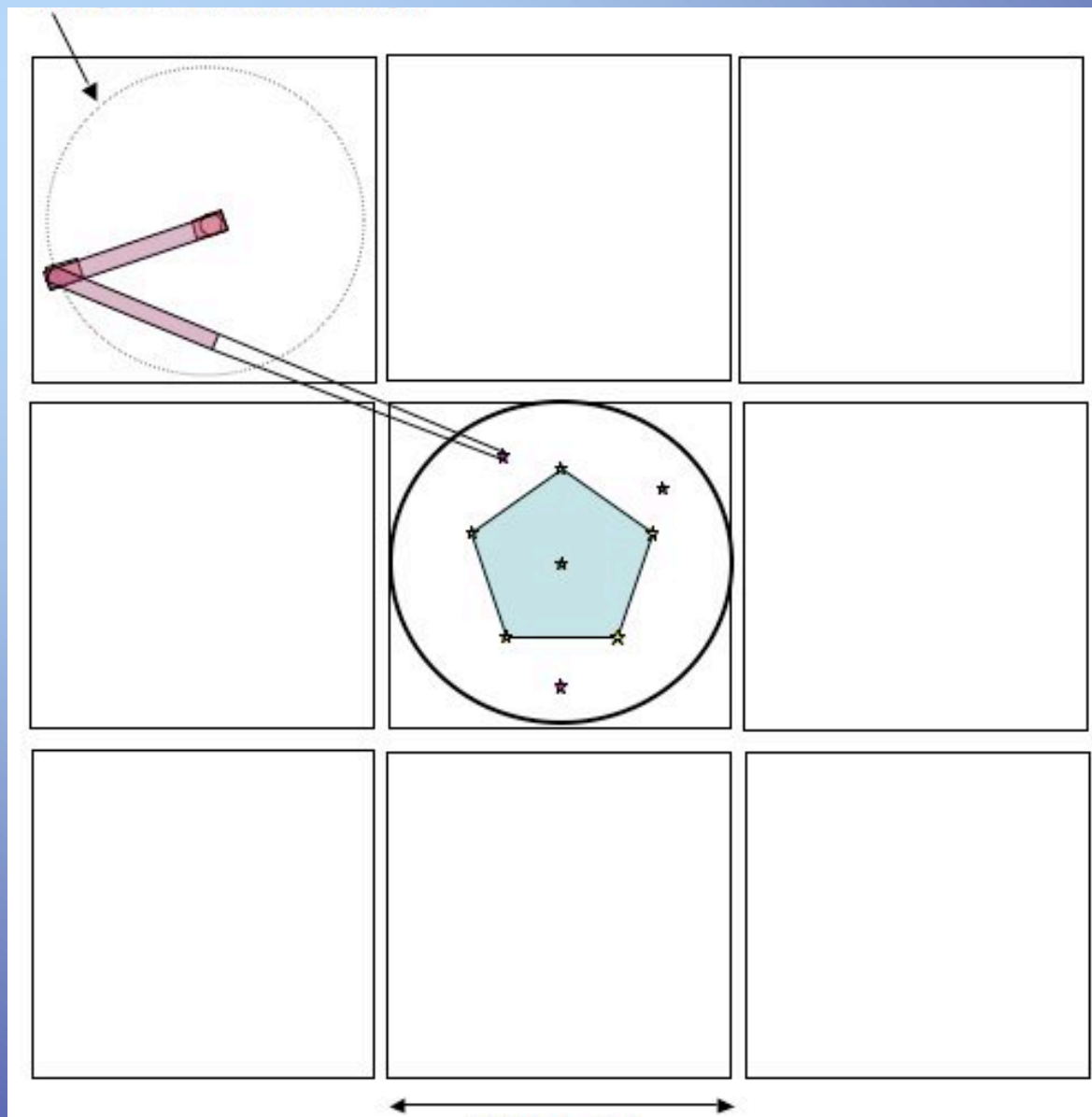
\* - cryogenic

⊘ - Assumes e2v package size

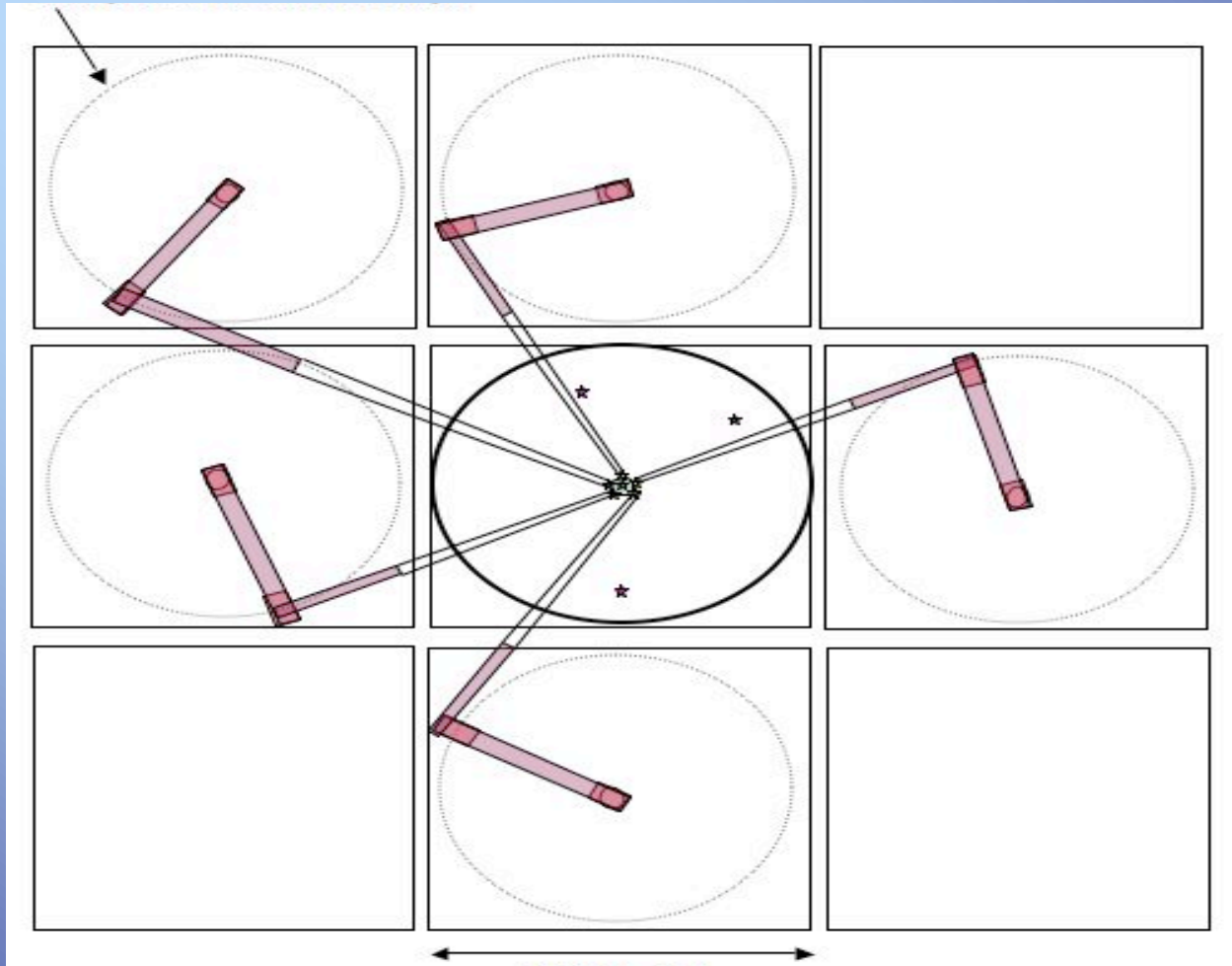
<sup>⊘</sup> - Estimate



# TT(FA) pick off: theta-phi mechanism

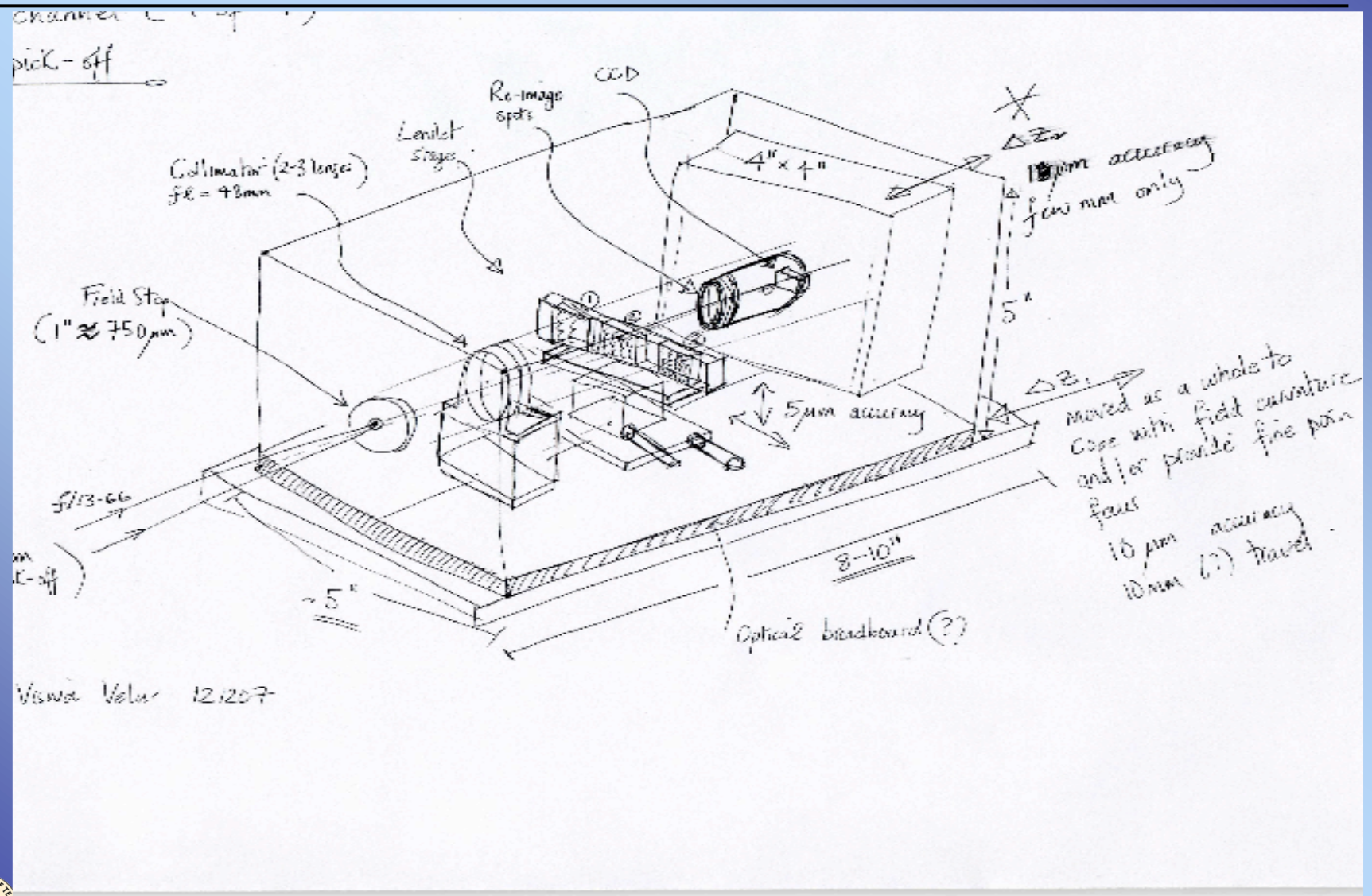


# LGS Object Selection - phi-theta mechanism





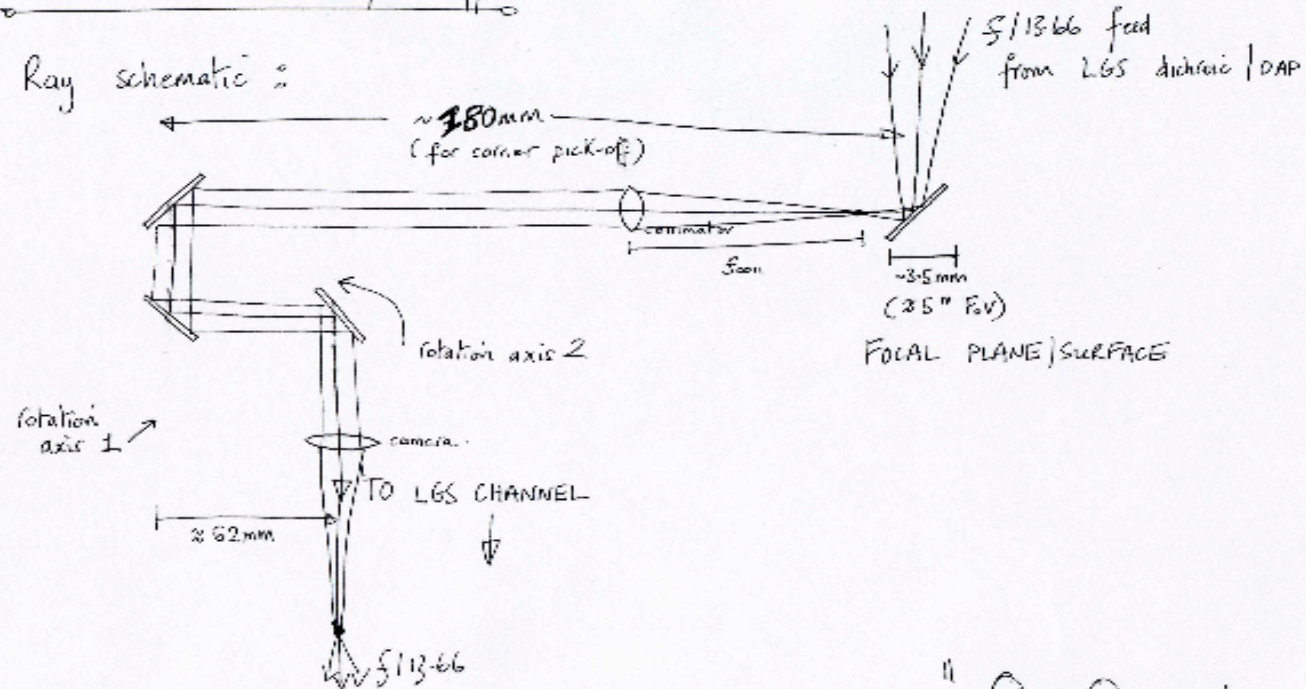
# The "Jørn Utzon" view



# More "Jørn Utzon" views

LGS - WFS unit pick-off

Ray schematic :



"  $\Theta - \Theta$  mechanism "

Anna Moore & Vivian Vaker 12/20/7-





# The theta-phi mechanism unraveled

