Direct 100m WaveFront Sensing

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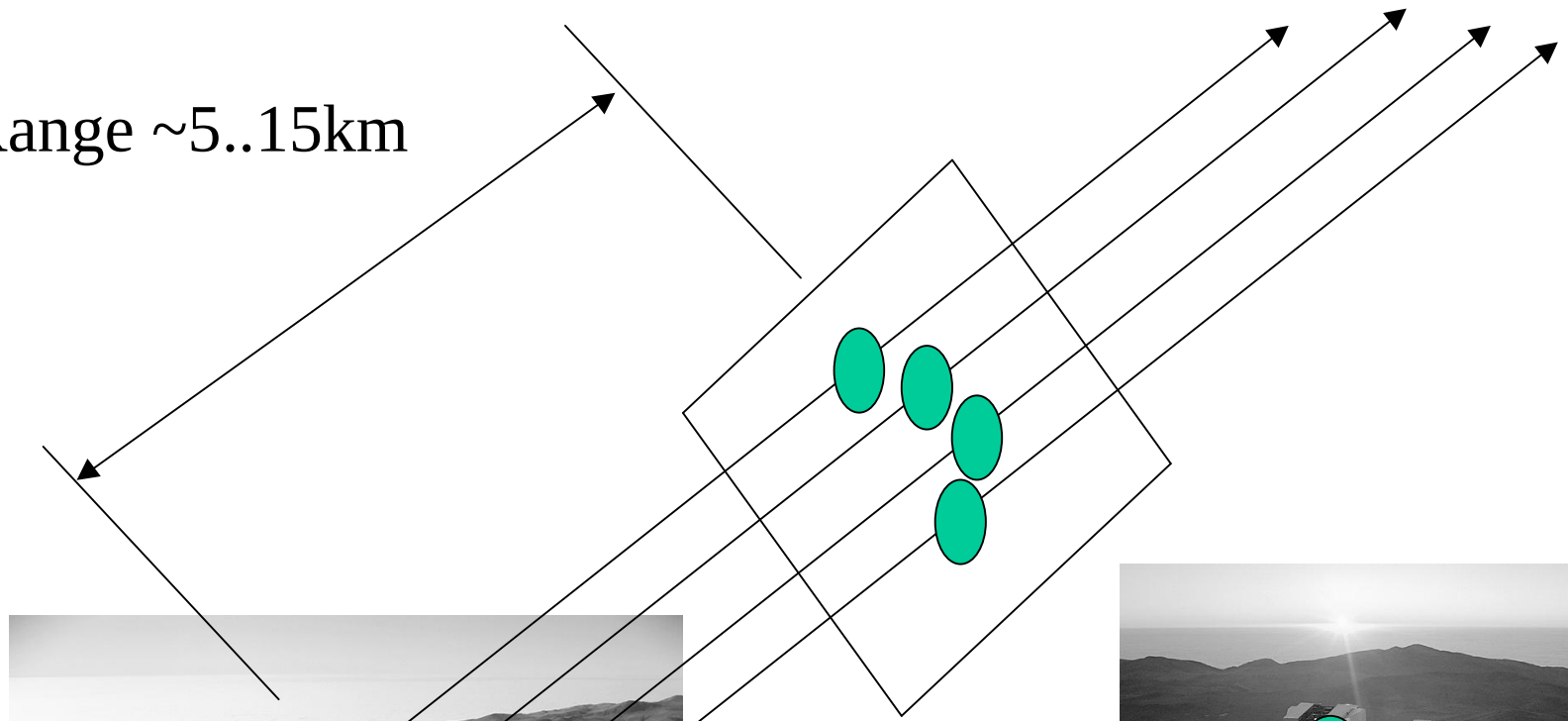
Range ~5..15km



VLT at Paranal

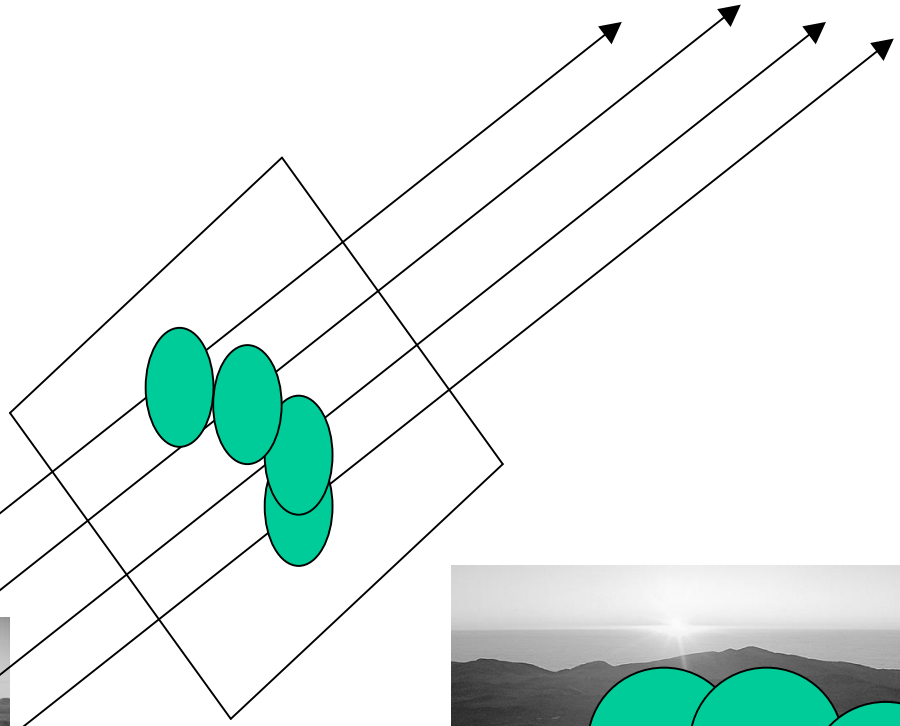
ESO PR Photo 43b/99 (8 December 1999)

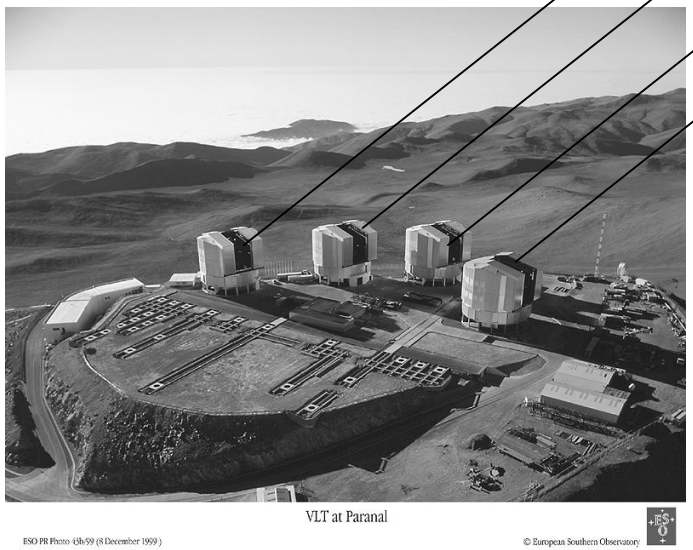
No FoV

VLT at Paranal

ESO PR Photo 43a/99 (8 December 1999)

Depending upon the position on the sky the coverage of a given layer will change but, in general, it will be of the order of magnitude of size of the pupil telescopes envelope (i.e. ~100x50m)





VLT at Paranal

ESO PR Photo 43b/99 (8 December 1999)

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FoV ~6’

VLT at Paranal

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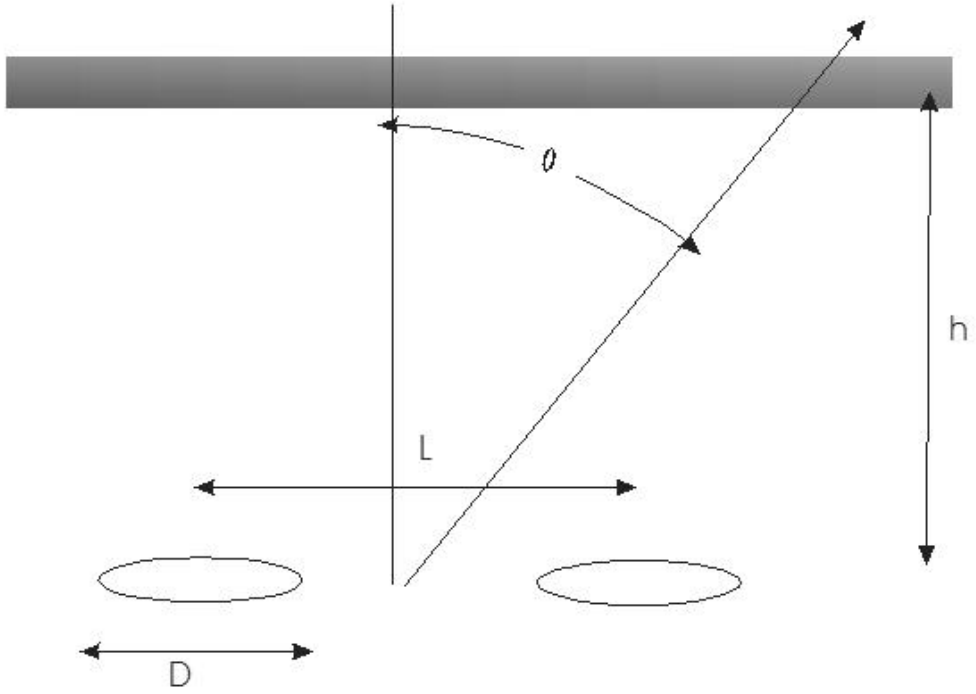
Basic geometry



Maximum distance
Between stars to have
Overlapping of pupils

$$\varphi = \frac{D}{h}\cos\theta$$

$$FoV = \frac{L-D}{h}\cos\theta$$

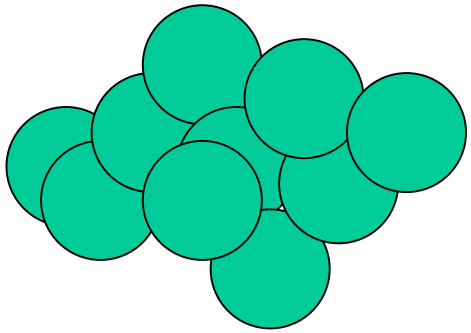
Field of View to make pupils
Smacking at the edge of the
Covered FoV

Basic geometry

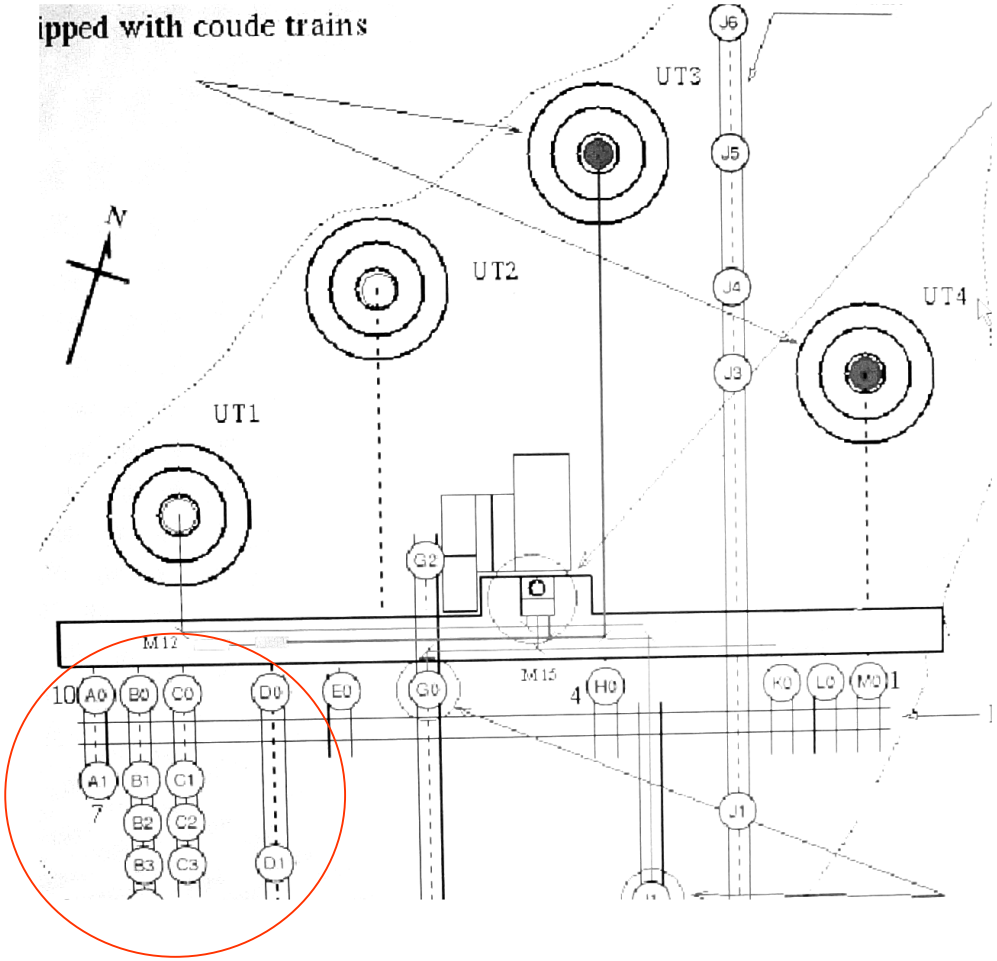
- For the two closest VLTs this gives 7..9arcmin, that is 250mm class optics for F/15
- Use of Auxiliary Telescopes can be crucial and make more effective such a measurement

Basic geometry

- Maximum distance between stars is 100arcsec
- This makes the required of stars to be in range 20..60 to have a 4x stitching between the WFs
- Stitching error can be low as the number of independent measurement to stitch two extremes of the patch can be done through several different routes

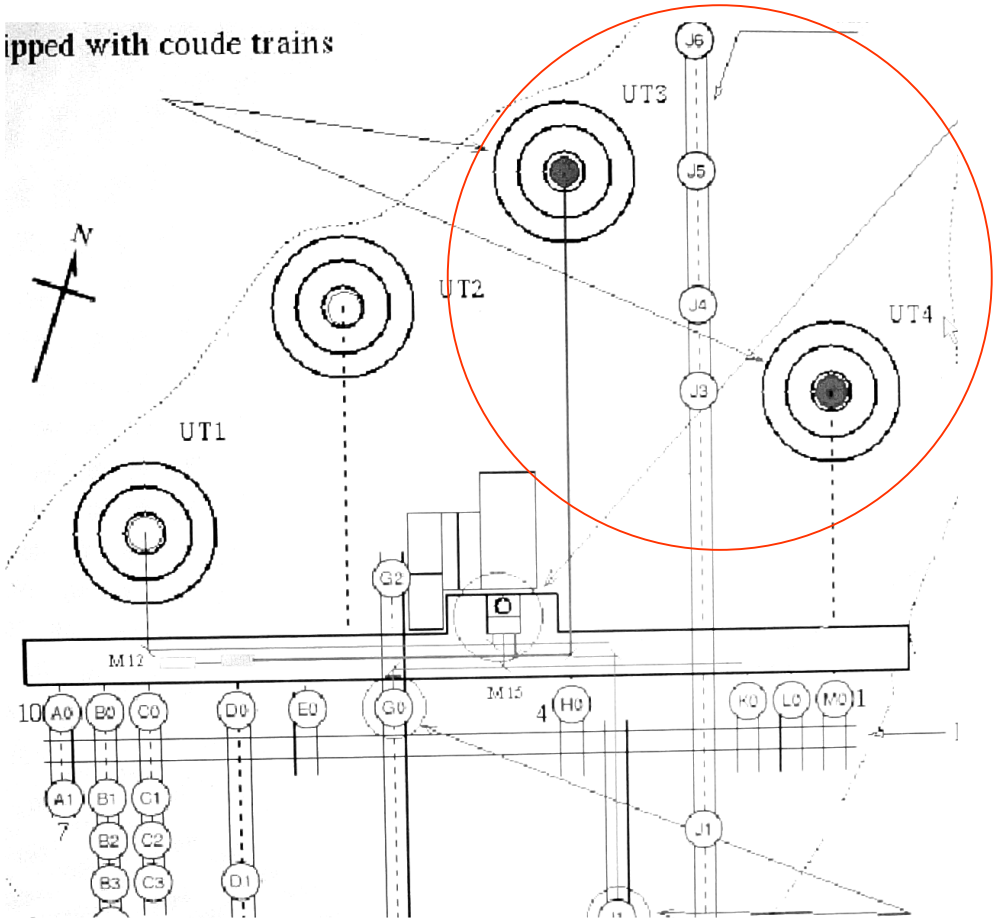


Which UTs and ATs?



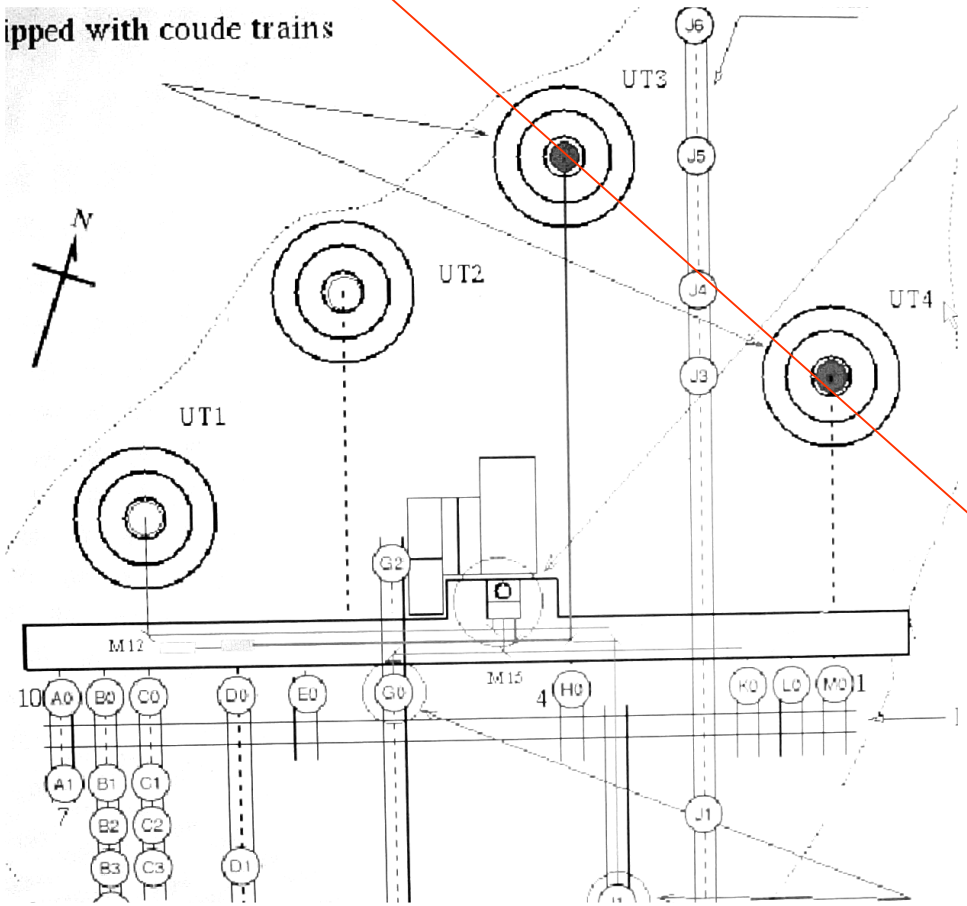
Cluster of ATs
To setup/commission and/or testing purposes and to get 30m class WFsensing

Which UTs and ATs?



Two UTs and 2..3 ATs to get 60m class WFsensing

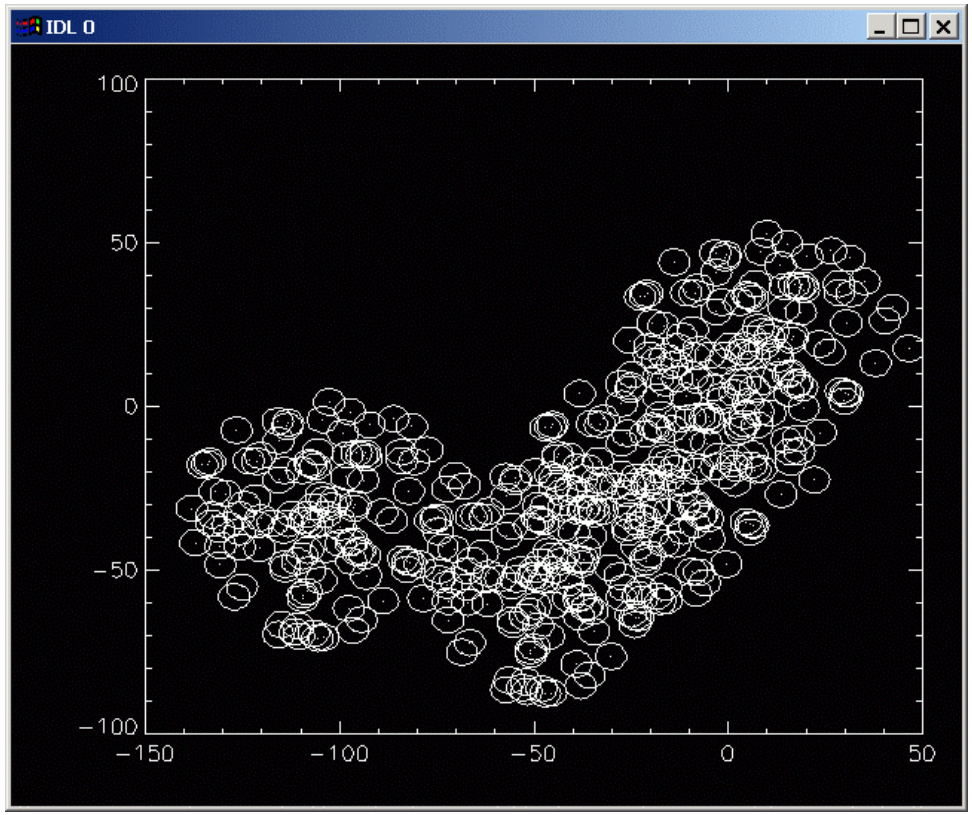
Which target?

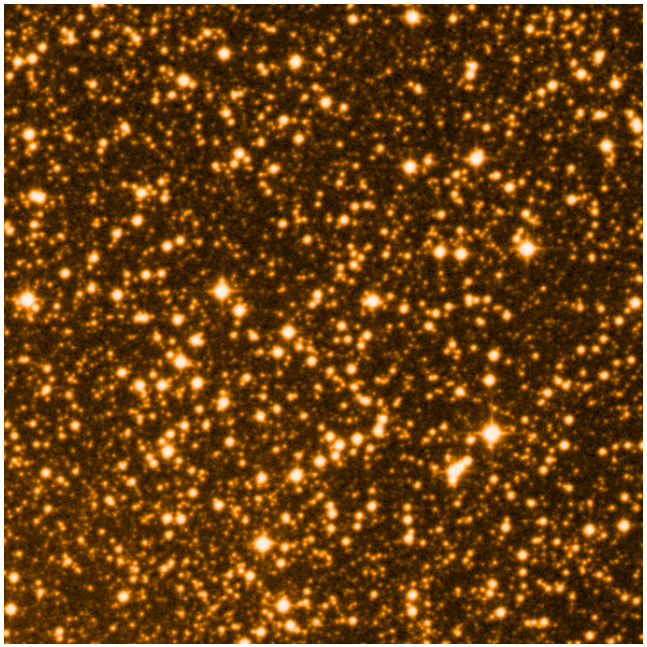


UT3 and UT4 forms a line thet, at an elevation fo 45deg intersect Milky Way on four occasions (two declination angles defined)

Example of a simulation

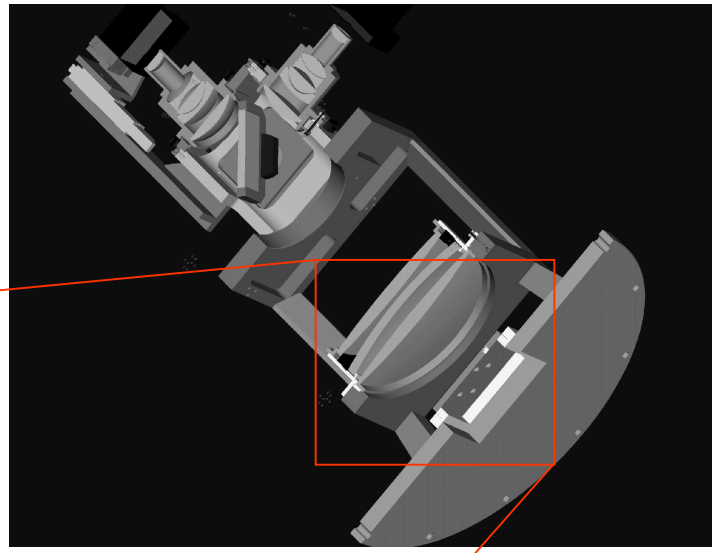
The layer coverage at 10km
With all the four VLTs

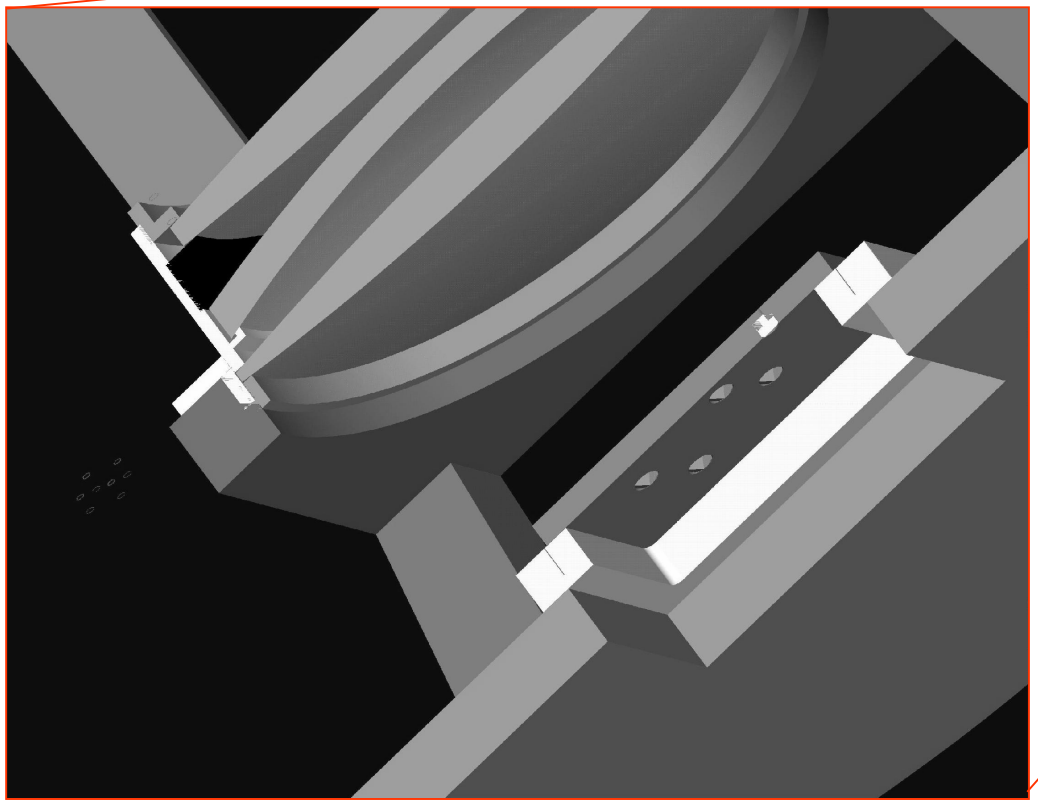




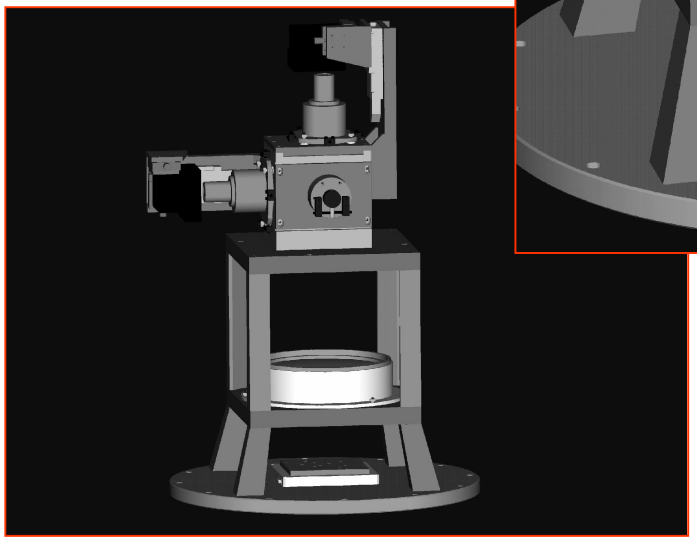
The starfield
(NGC4052)

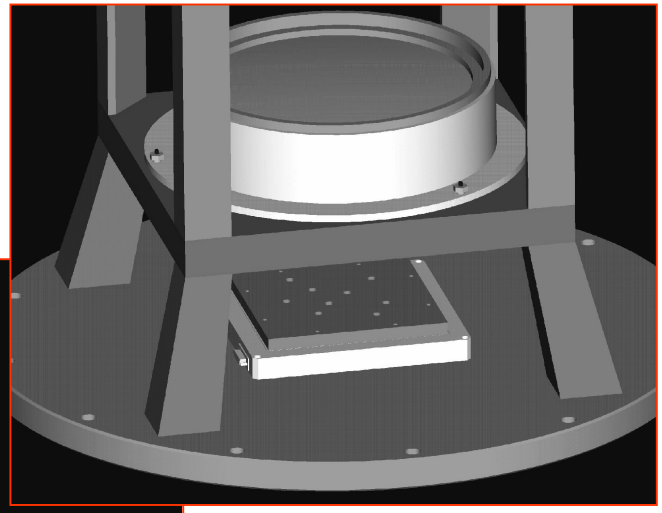
Multi-pyramids vibrated by piezo-actuated device (PI) feeding two large format CCDs operating at ~10Hz with a common synchronization

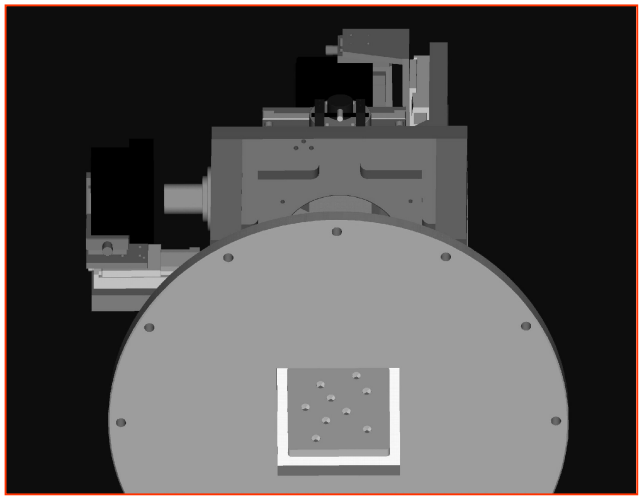


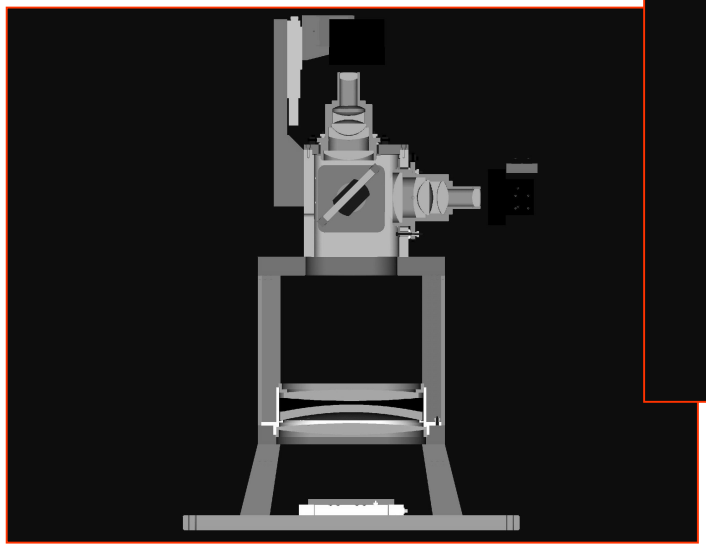


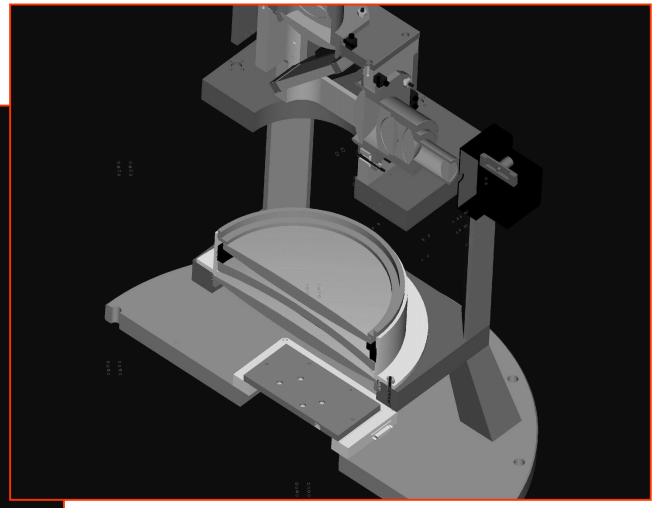
GND layer is accurately measured and numerically removed. The large FoV ensure a small depth of focus (~100m)











Simply other views…

Numerical/MUSE approach?

- It could be interesting to evaluate the experiment with a large number of small WFSensors
- To reduce cost detector should be cheaper
- Remember we do not need 100Hz coverage but just a few mSec. Integration time, with a duty cycle of 10Hz or so
- Multiple layers could be done simultaneously

Ground layer issue

- Removal of copies of GND layers can be easily done by removing the correlated part with the (known) disposition of stars.
- The approach should measures well layers in the range 3+..15km
- Ground layer are left…

Outcome of the experiment

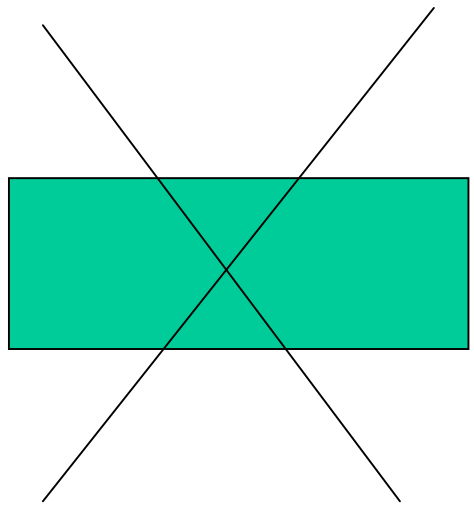
- 100m scale WFsensing technological demonstration
- Snapshots of layers with unprecedent coverage
- Maximum stroke, outer scale $L_o(h)$, Taylor hypothesis & predictability, evolution of turbulence, *each of these per layer* range, checked in a fully unambiguous way

Ground layer measurements

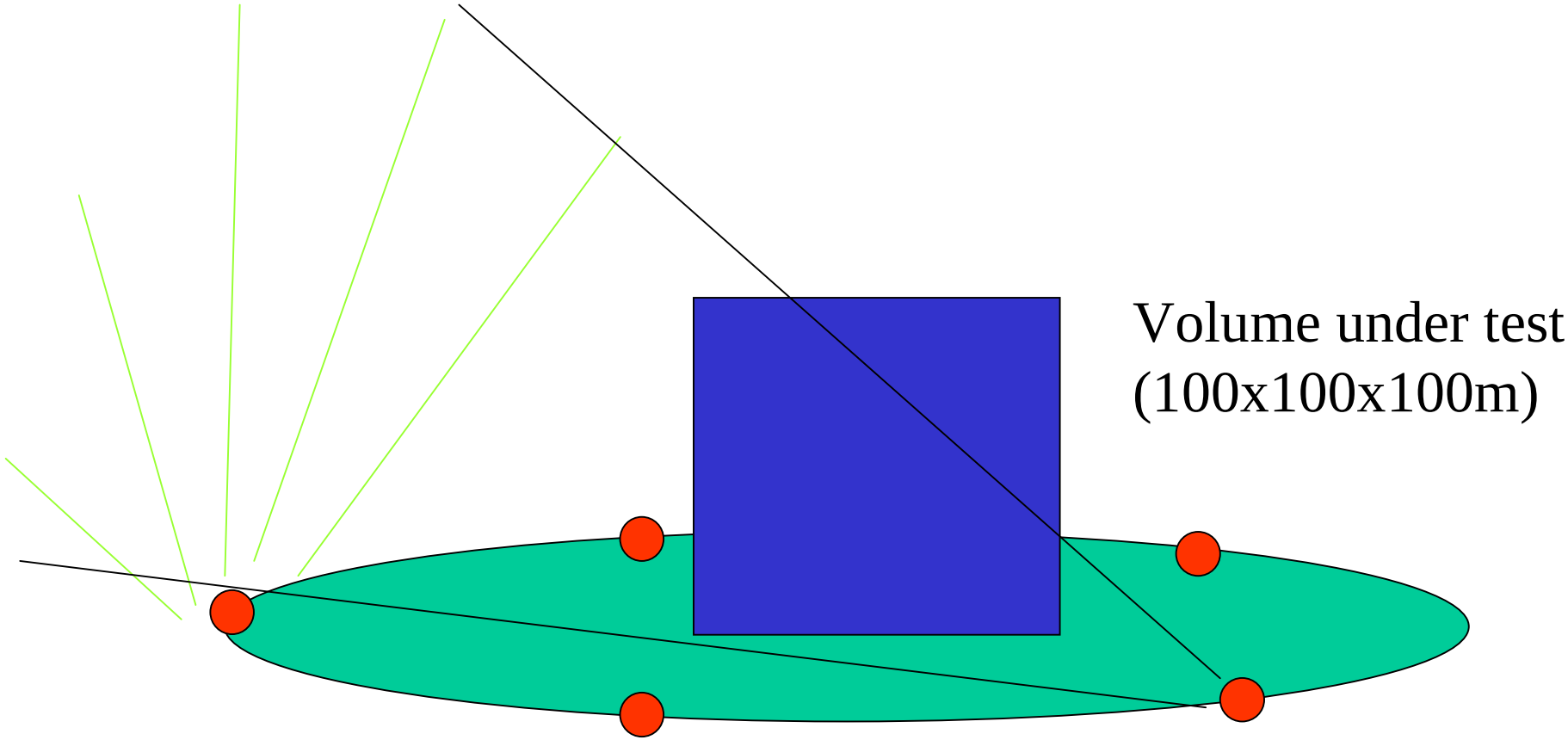
- It is in general difficult to have good measurement of GND layer if obtained by difference of two measurements with a small difference (1-0.7=0.3…)
- As soon as the angle of arrival of NGSs and LGSs is large there is huge sensitivity on thickness of GND layer

FoV vs. thickness

- 100arcsec means 0.5m at 1Km
- 20arcmin (PF corrector) means 0.5m at 80m
- 20arcmin means 6m at 1Km
- LGSs at ELTs will means several arcmins in any case



Is there a way to direct measure the GND layer on 100m scales?

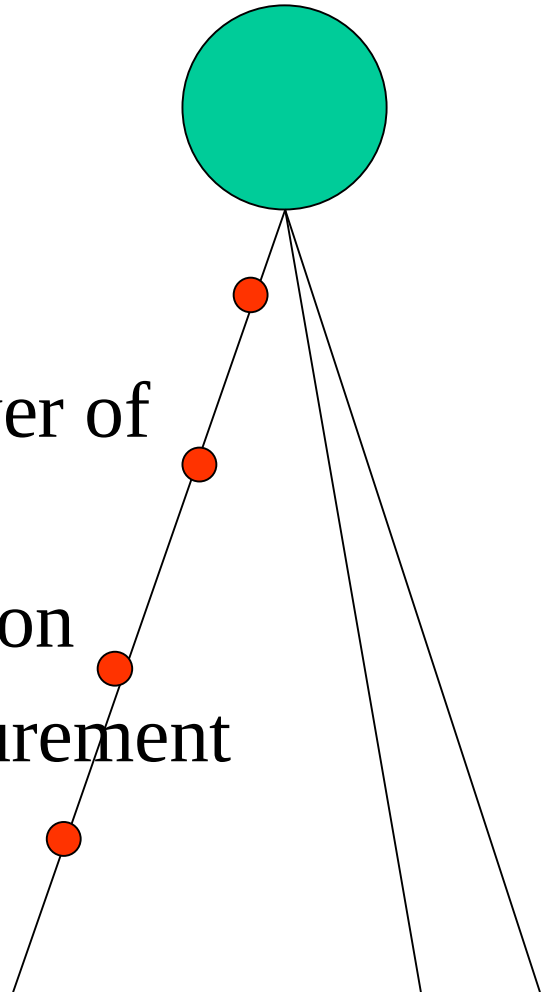


Tomography of a 100m cube

- Very low power laser as the Rayleigh return is expected from less than 300m
- Wide Field objectives
- Local scintillation
- There are literature on horizontal propagation and we can get ides from a lot of existing apparatus

Tomography of 100m cube

- Laberyie-like approach
- Balloon with 100m wire
- Retroreflectors attached on the strings
- Radar equations scales with fourth power of Laplacian of turbulence!
- The key point here is accurate subtraction
- And/or calibration or *dirty* direct measurement (why dirty?)



Conclusions

- Direct approach for layers 3+..km can be done.
- Simultaneous measuring of all the other parameters is needed and Ok (I agree with the Conans…)
- Ground layer characterization needs tailored concepts to provide 10m resolution in Cn2 over the telescope volume.