Conceptual design of SLR/LLR for South Africa

ILRS Workshop

GRASSE

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HartRAO Space Geodesy Programme

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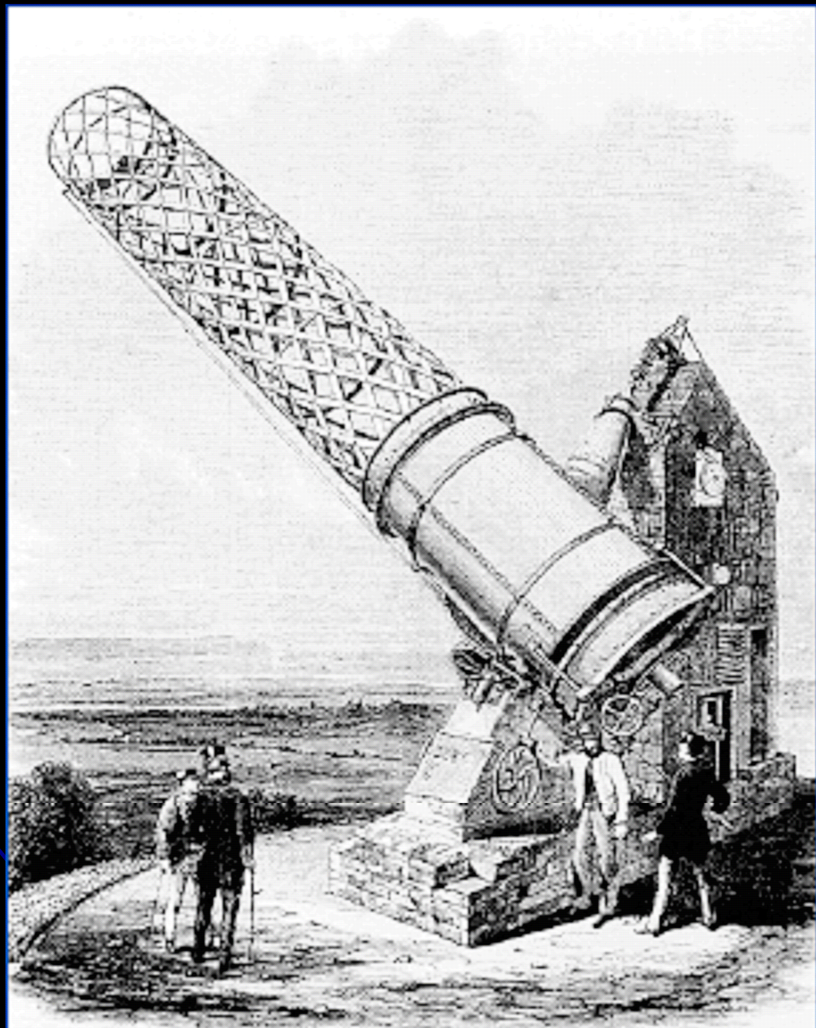
Small lie……but sounds acceptable..

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a photon on the moon and returning it safely to the earth."

Not a large target for ranging
but a large target for science
and a range of future
experiments

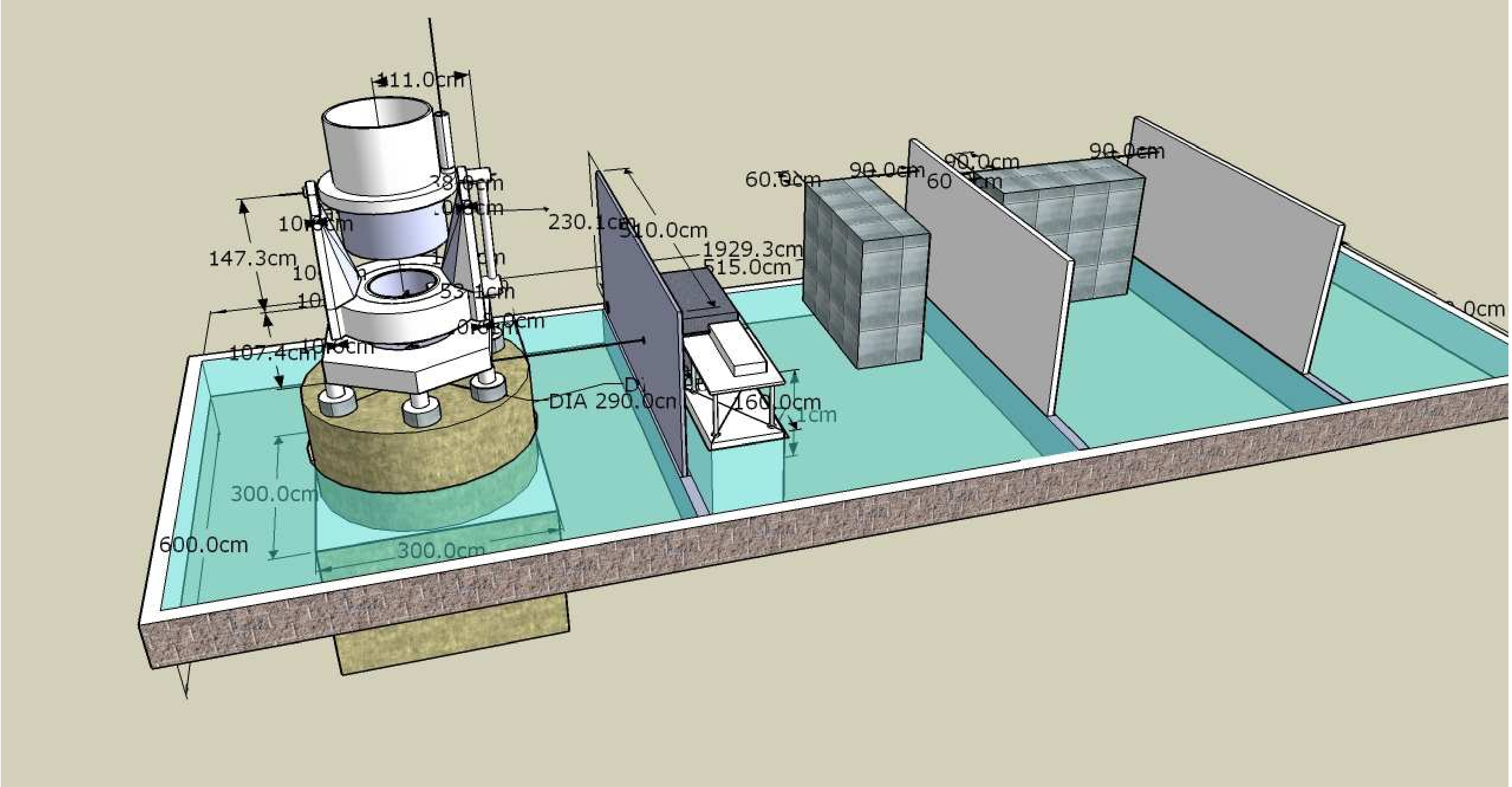
Not as expensive or difficult as sending a man to the Moon, but still expensive and very challenging

So what will we use… some old telescope….

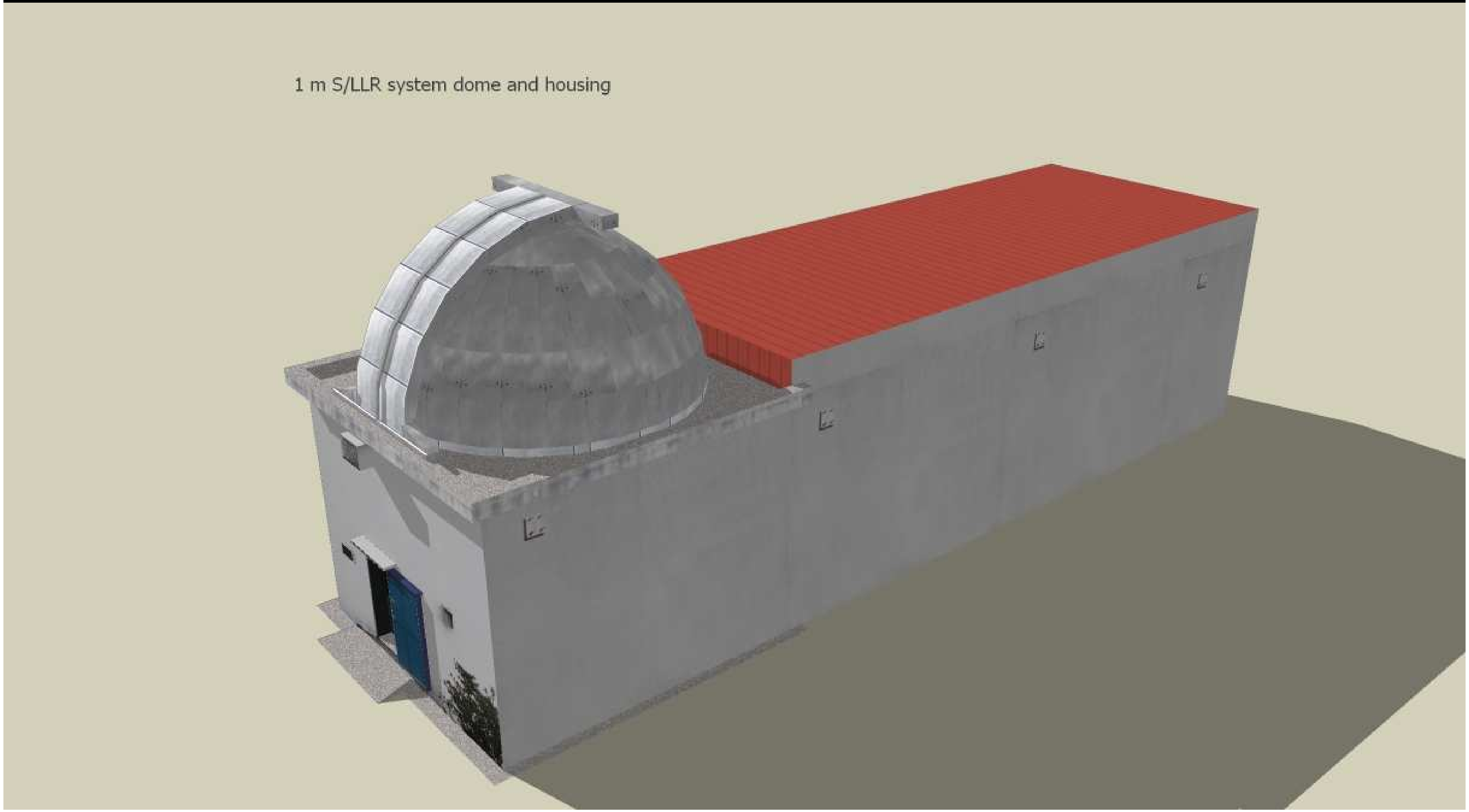


Or not quite so old (I am older)?…..

Started conceptual design of system, many alternatives, have to consider longevity and maintenance of complete system, not only the electronics, software and mechanics, but also some new innovative ideas will be sought



Building with MORE space than MOB6, maybe something like this



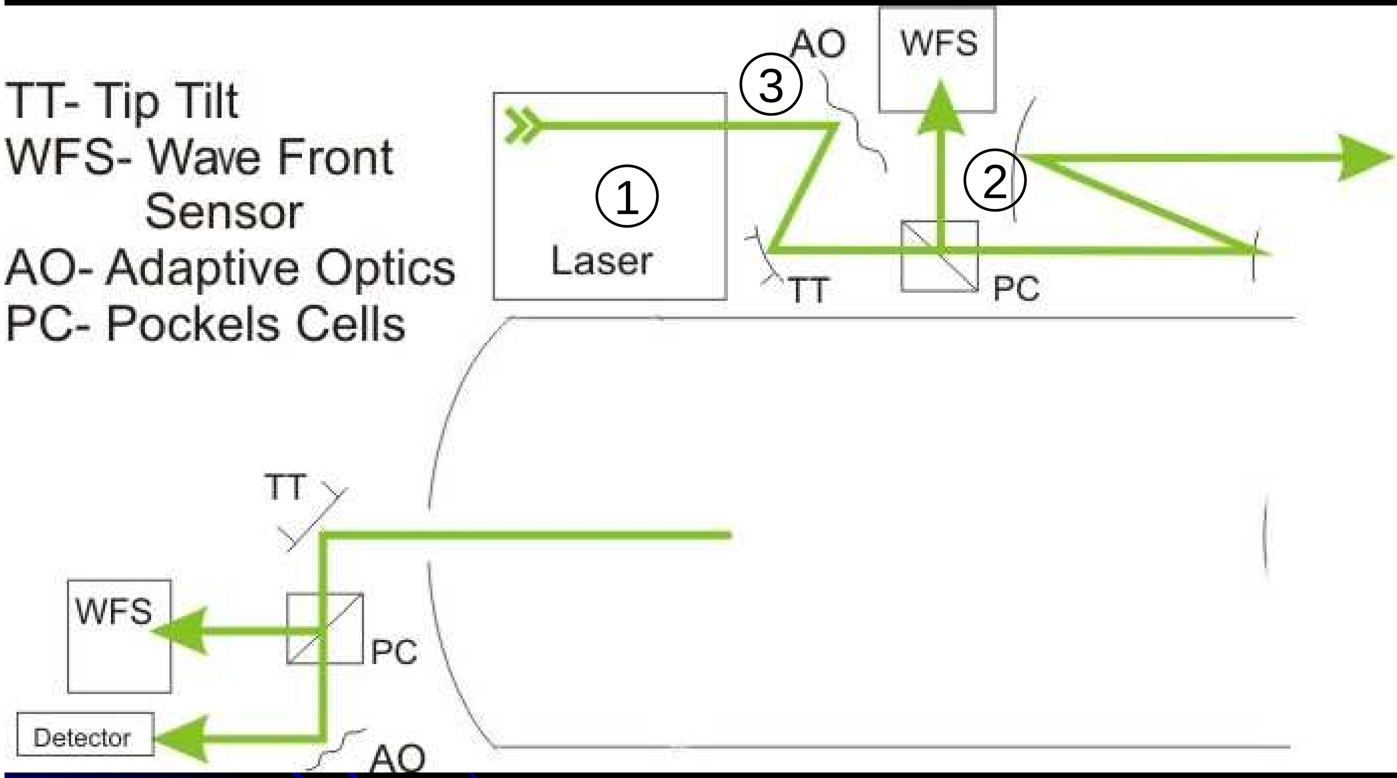
Proposal for new concept

- Compact, light-weight diode-pumped laser Nd-YIf mounted onto telescope
  - **Pump diodes separately with light delivered to laser through multi-mode fibres**
  - **Very good beam quality**
  - **Smaller telescope for outgoing beam (e.g. ~40 cm diameter)**
  - **High-rep-rate operation, e.g.**
    ~1 kHz, 20 to 50 mJ, 20 to 100 ps (if practical…cooling etc)

- Adaptive optics to reduce laser divergence and field of view independent of seeing conditions.
  - **Laser itself creates guide star through time gating to returns from higher atmosphere**
  - **With a 30 cm outgoing beam, a divergence of ~0.5 arcsec could be achieved.**
  - **This gives a factor 4 improvement compared to 1 arcsec, much more compared to most current systems.**
  - **The reduced field of view will reduce noise by a similar factor**

- Automatic pointing system ensures optimum overlap of laser and telescope field of view.

Proposed system: outgoing laser

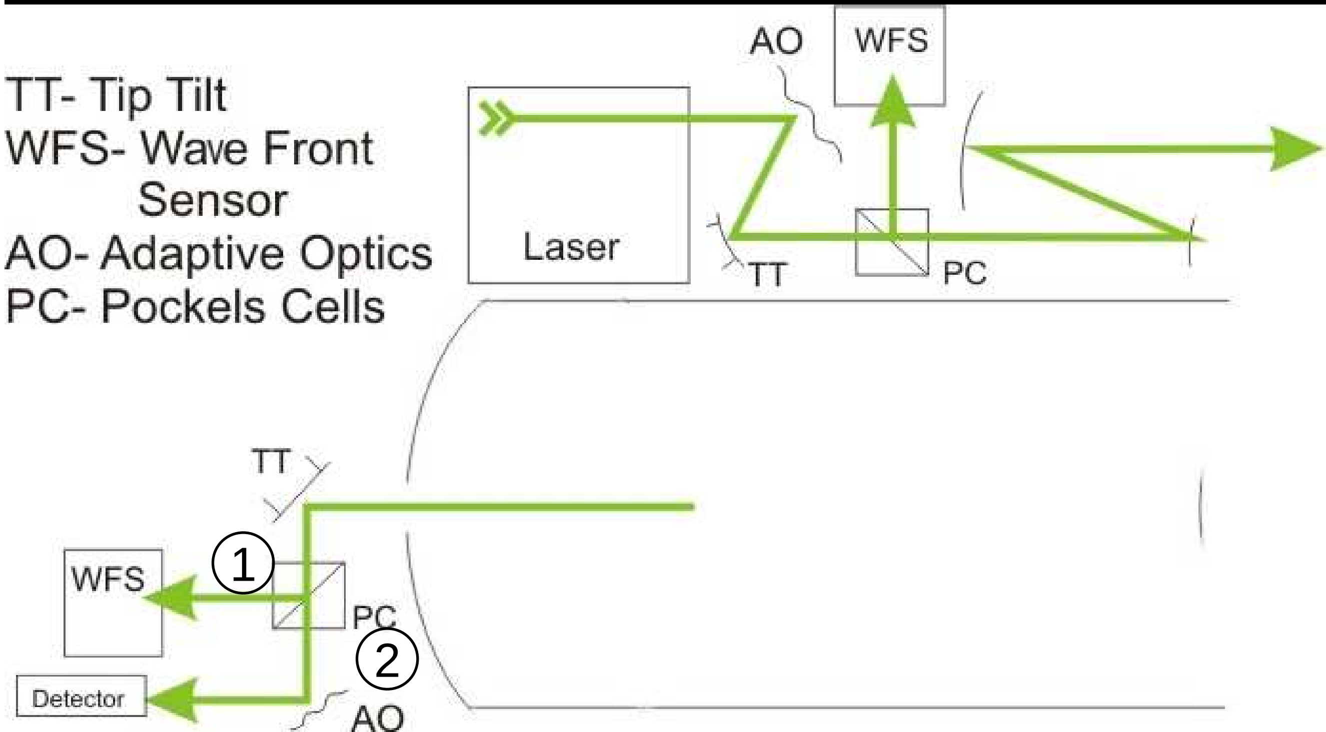


1. Laser with good beam quality

2.Time-gated detection of wave front through laser telescope

3**. Adaptive optics to correct laser divergence ⇒ Very low laser divergence ⇒ Factor 3 to 10 improvement of intensity on moon**

Proposed system: receiving

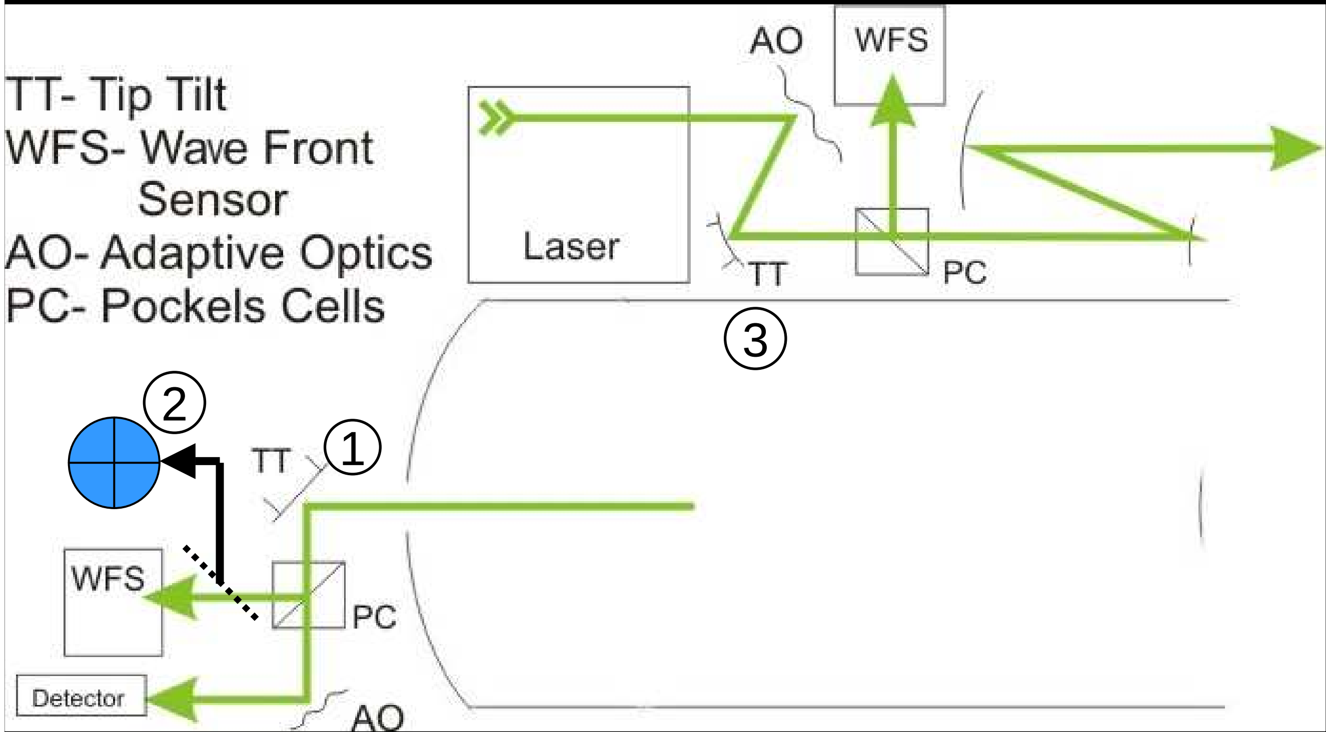


1. Time-gated detection of wave front through main telescope
2. Adaptive optics to improve receiving resolution

→ Can significantly reduce field of fiew

→ Factor 3 to 10 reduction of noise

Proposed system: pointing



1. Tip-tilt mirror to actively fine-adjust pointing to retro-reflector
2. Time-gated detection of laser direction from atmospheric far-field scattering
3. Tip-tilt mirror to adjust laser pointing to main telescope

→ Always perfect alignment of laser beam to main telescope

Many choices and decisions to be made during design phase

E.g. encoders, event timers, software platform, source code etc.

- BEI – ALMA 26 Bit. Resolution (Res) ; 0.3 arc-sec RMS Accuracy (Acc) Absolute type > $85,000 ea.
- Heidenhain Tapes 27-31 Bits Res; 0.1-0.6 arc-sec RMS Acc. Semi-absolute

Cost $32K - $145k, not including mounting and other expensive issues.

- Farrand Inductosyn 27 Bits Res; 0.1 arc-sec RMS Accuracy (theory)
- Multiturn Optical 24-25 Bits Res; ~ 1 arc-sec? Acc Absolute

Cost: Each encoder is inexpensive at ~$3400. Mechanical mounting drives costs and determines accuracy.

- Precision Gears ~ 30 Bits Res; ~1 arc-sec Acc Absolute

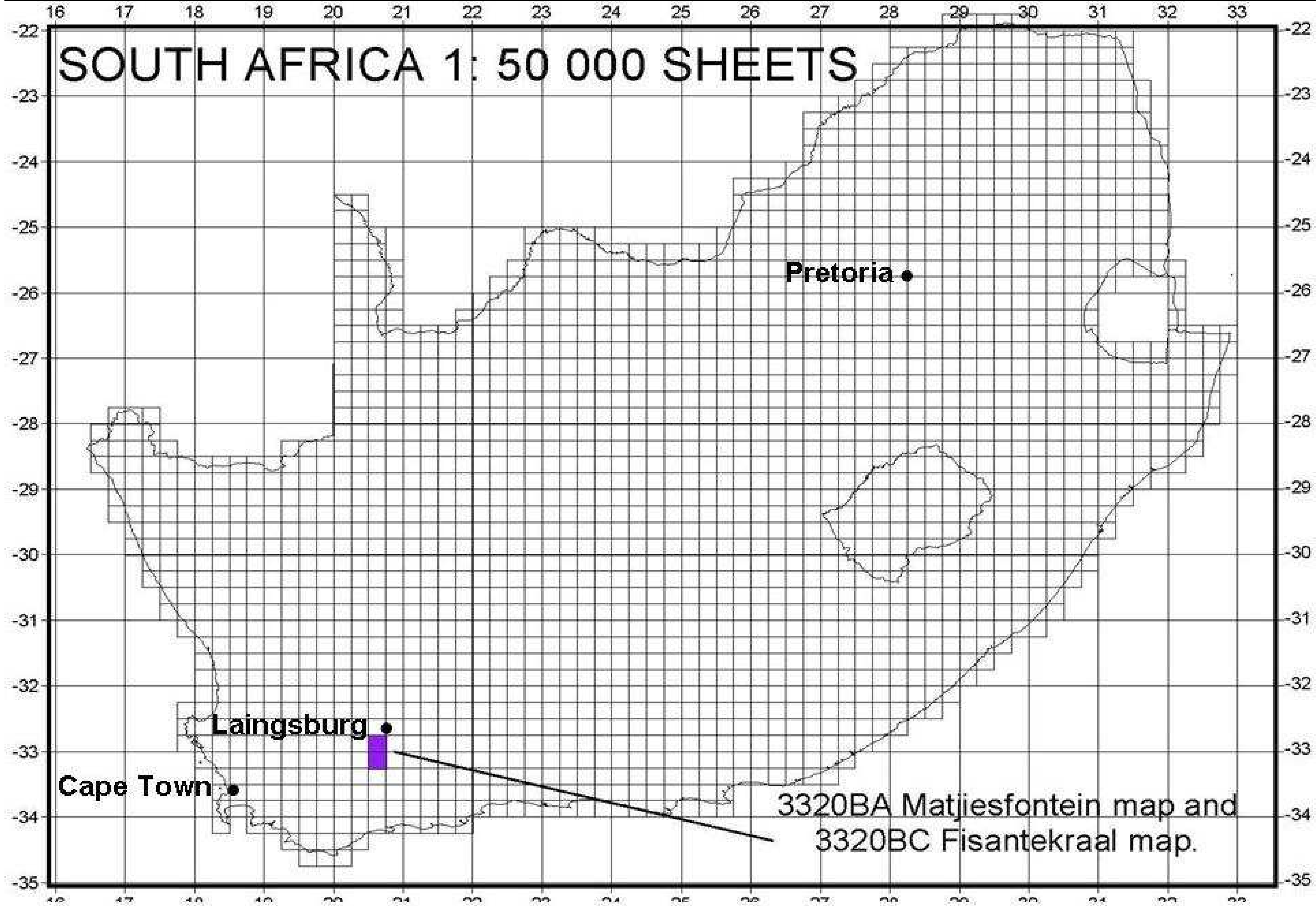
HET used precision ground gears with resolvers.

- IMU 21 Bits Res or better Absolute

Inertial units are expensive (~ 170K to $1.5M), but have extremely well known drift characteristics.

Pointing requirements of 1 arcsec can be met by all (but not the budget)

Location relative to current HartRAO site, 1000 km to south-west



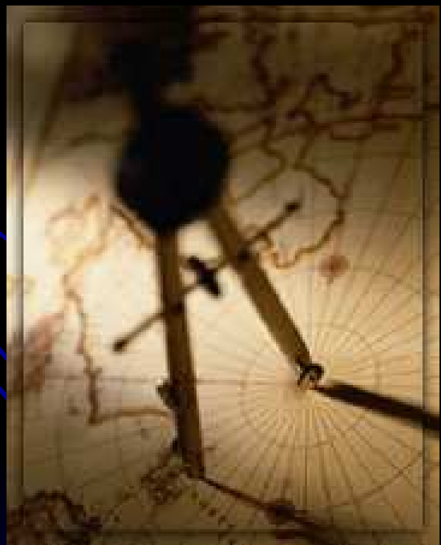
Why not at HartRAO?

Situated some distance from cities (35km), but suffering from very bad atmospheric conditions due to pollution, high orbiters (e.g. GPS) very difficult, LLR impossible, need better site out in desert-like environment

In any event…..

New direction for attainment of scientific and service goals is required

The concept of the Global Geodetic Observing System (GGOS) has been created by the geodetic community to meet high accuracy challenges and improved network geometries (project within GEOSS)



How and why

play a new game?

HOW ?
Vision for new GGOS station

- Enter IISGEO…..International Institute for Space Geodesy and Earth Observation
- New site, selected for SLR/LLR/VLBI suitability (Matjiesfontein?, dry, clear skies, accessibile etc.)
- Develop/acquire new instrumentation
- Structure it to accommodate a multi-disciplinary approach to science, i.e. make provision to participate in the sciences that space geodesy supports
- Involve the SADC region to facilitate *capacity building*
- HartRAO space geodesy component to continue in parallel, collocation to be kept
- Some components could be phased out gradually when deemed feasible

First and 2nd phase of IISGEO

- 1. Complete high level GPS station (Met+Cesium+1sec streaming+bedrock monumentation, independent power system) ➡ **Already funded via Inkaba ye Africa**
- 2. Lunar/SLR LASER Ranger, based on 1 metre OCA telescope (some funding received… but need more!)

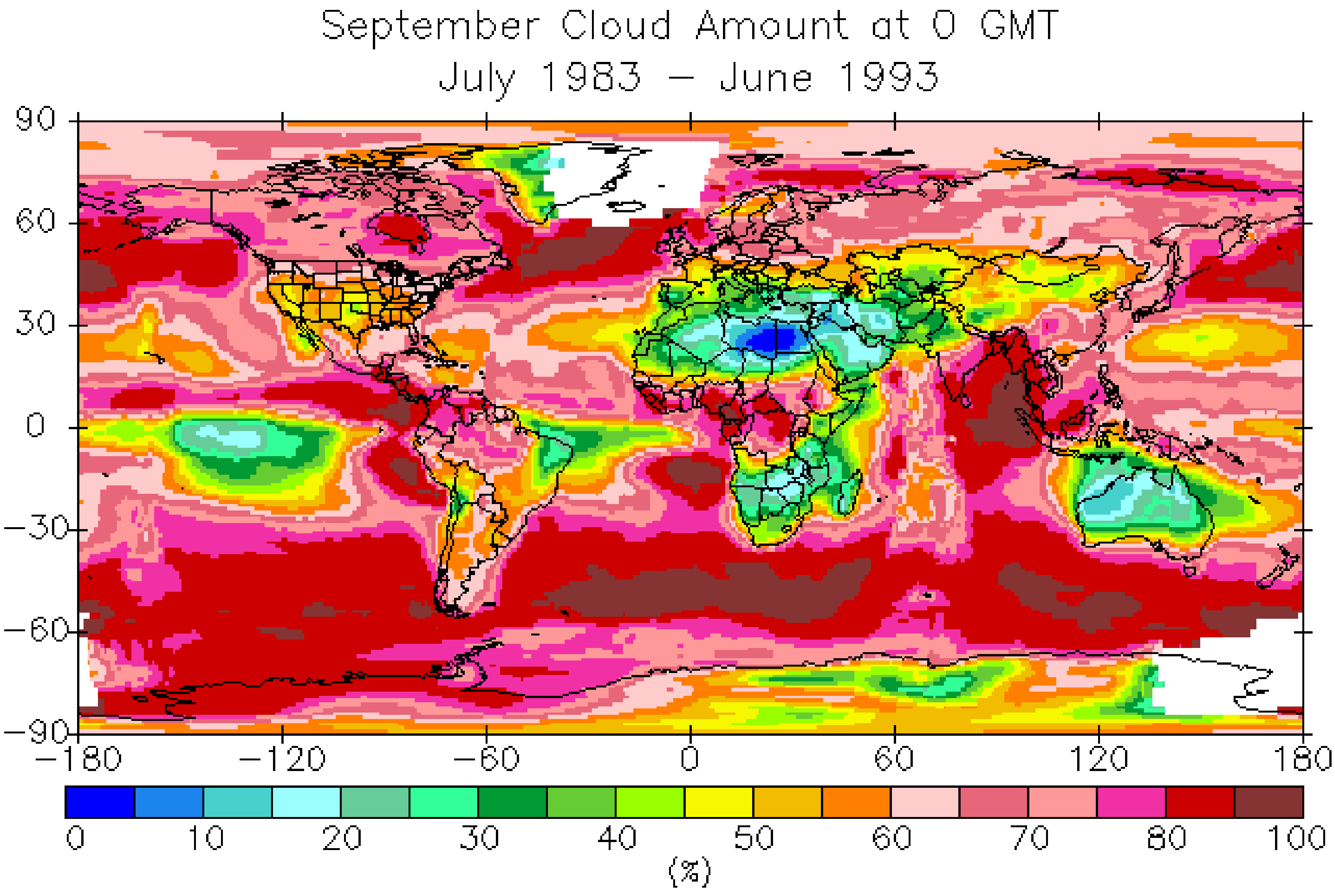
- Later phase to include VLBI2010 radio telescopes (2-4, 12 m dishes, DSNA? KAT?)
- Adequate infrastructure as required
- On-site workshops, accommodation for shift operators and students
- Training facilities, public outreach etc.

Why Matjiesfontein?

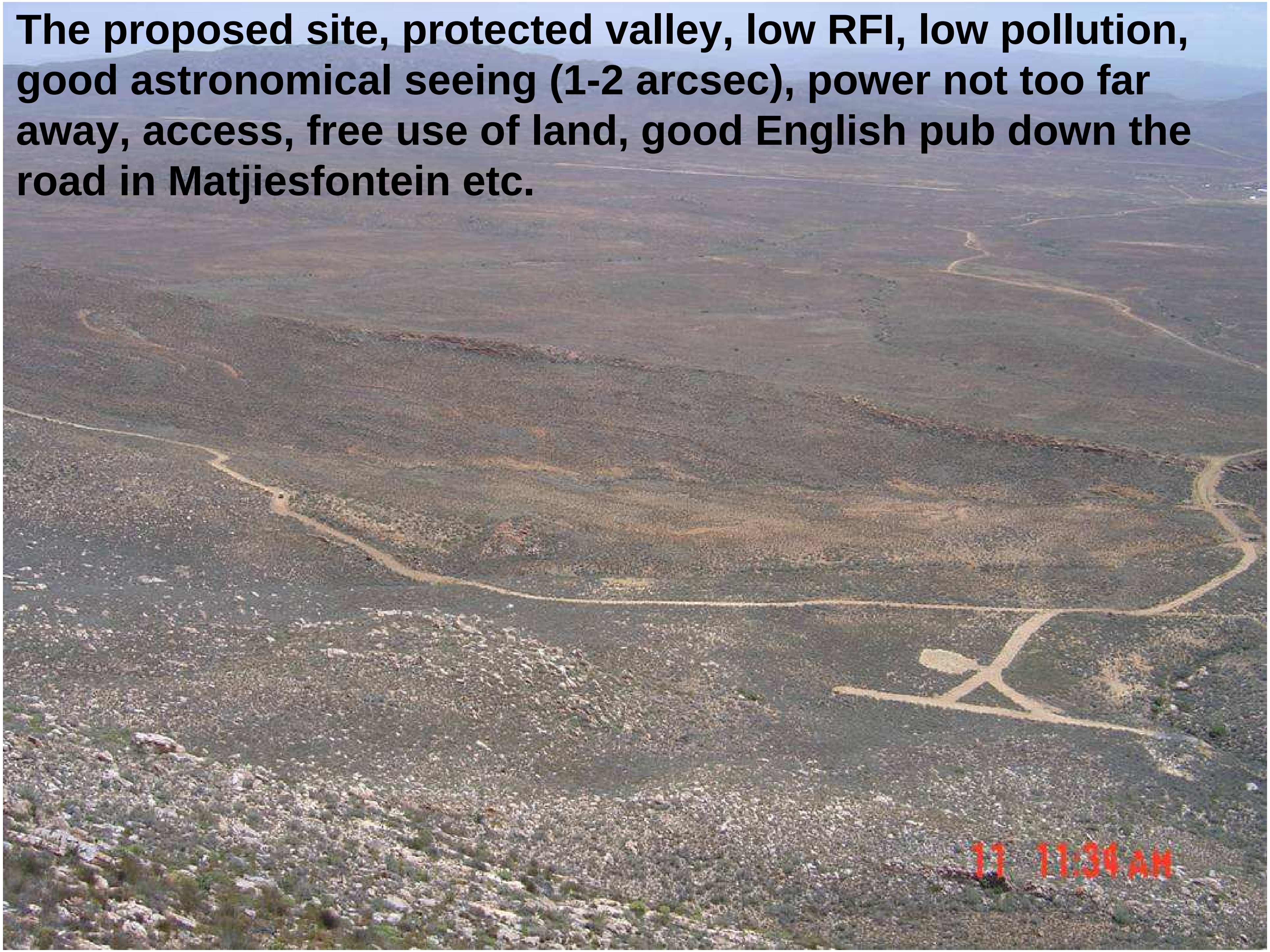
- Low cloud cover
- Low water vapour content
- On summer/winter rainfall region border
- Good astronomical seeing conditions (preliminary tests show 1-2 arcsec)
- Infrastructure (close to N1, water, electricity, railway, small protected valley)
- Accessibility
- Synergy with SAAO/SKA

Aerial photo of proposed site, could locate LLR at height of 900 or 1850 m

Site needs to be evaluated



The proposed site, protected valley, low RFI, low pollution, good astronomical seeing (1-2 arcsec), power not too far away, access, free use of land, good English pub down the road in Matjiesfontein etc.



Start-up Budget implications

Project	2007/8	2008/9	2009/2010	2010/2011	2011/2012	2012/2013
IISGEO infrastructure	3	6	6	6	6	6
S/LLR	3	8	8	8	8	8
VLBI	-	-	15	15	15	15
Running	1	1	4	4	5	8
Total (M)	**7**	**15**	**33**	**33**	**34**	**37**

6 Year budget towards IISGEO Capital = R 136 M
6 Year running funds R 23 M

Finish