Welcome

Matjiesfontein Technical Workshop

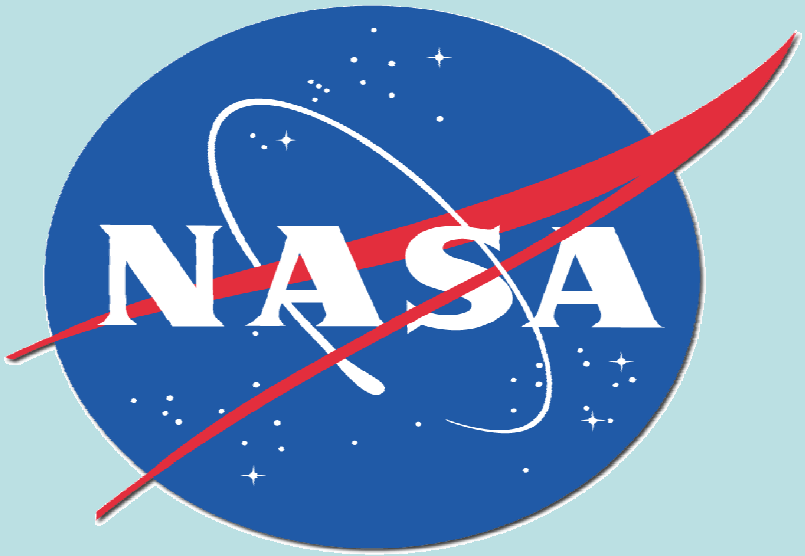
16-20 March 2009

Introduction to MOBLAS-6 Instrument

Johan Bernhardt

Overview

MOBLAS-6: NASA Satellite Laser Ranging System in operation at HartRAO since September 2000



MOBLAS-6 Instrument Sub-Systems

- Optical Receiving System
- Laser Transmitting System
- Time of Flight System
- Safety System
- Timing System
- Telescope Control System
- Metrological System
- Controller System
- Processing System

Optical Receive Sub-Systems

- Primary mirror
- Secondary mirror
- Sun Shutter
- Camera/Receiver Splitter
- Focal Lens
- Day Light Filter
- ND Wheel (Attenuation)
- FOV (Iris)
- PMT Receiver

Receiver Specifications

Cassagrain Telescope

- Aperture) 0.762 M
- Mount AZ-EL

Detector: Photek PMT – 318

- Multi Photon
- Primary Gain 532 nm
- Rise Time 350 ps
- Jitter: 100 ps

Laser Transmit Sub-Systems

- Cr4+NDYAG Oscillator (Saturable Absorber)
- Double Pass Amplifier (0 Deg. return)
- Harmonic Doubler
- Beam Expander
- Coude Path
- Beam Expander
- Laser Pulse Detector
- High Voltage Power Supply and controllers
- Cooling System
- Interlocking Systems

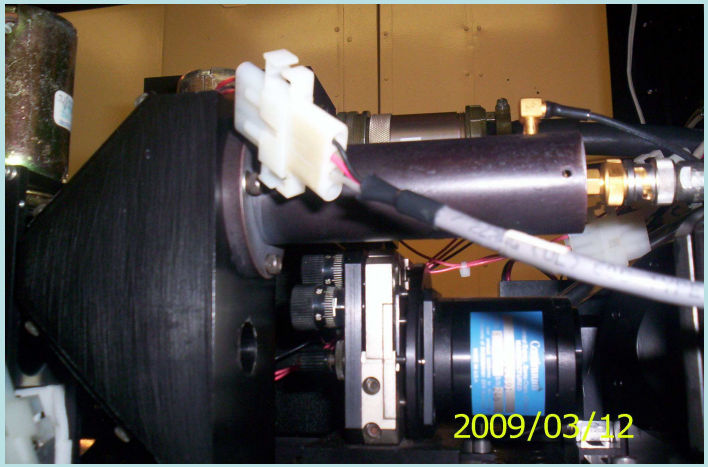
Laser Specifications

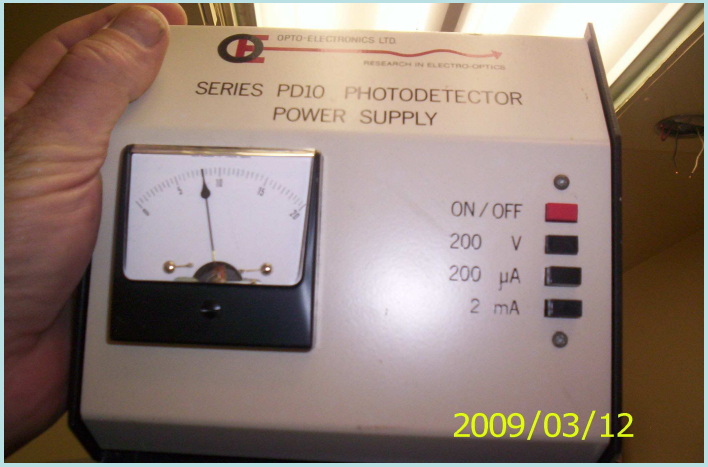
- Type: CR4+NDYAG
- Mode: Pulse 4/5 PPS
- Pulse With: Less than 200 ps
- Primary Wavelength: 1062 nm (IR)
- Energy: 230 mJ
- Amplification: Single Stage
- Secondary Wavelength: 532.1 nm (Green)
- Energy: 120 mJ
- Cooling: Liquid Cooling

Time of Flight Sub-Systems

- Transmit Detector (PD10-Start of Flight)
- Receive Detector (PMT318-End of Flight)
- Constant Fraction Discriminators
- Time Interval Counter (HP5370B)

Laser Transmit and Receive Detectors





Time Interval Counter

Safety Systems

- Eye Protection
- Aircraft Detect (Tracking Radar)
- Elevation Attenuation (On Site Safety)
- Mount Area Detectors
- Visual Monitoring
- Software Keyhole (Command VS Actual)
- Restricted Satellite Ranging

Video Monitoring

Timing Sub-System

- GPS Steered Rubidium Clock
- GPS (Time and Frequency Receiver)
- Distribution Amplifier (Synchronization)
- Time Code Generator (Station Time)

Rubidium Clock and GPS Receiver

Distribution Amplifier and Time Code Generator

Telescope Control Sub-Systems

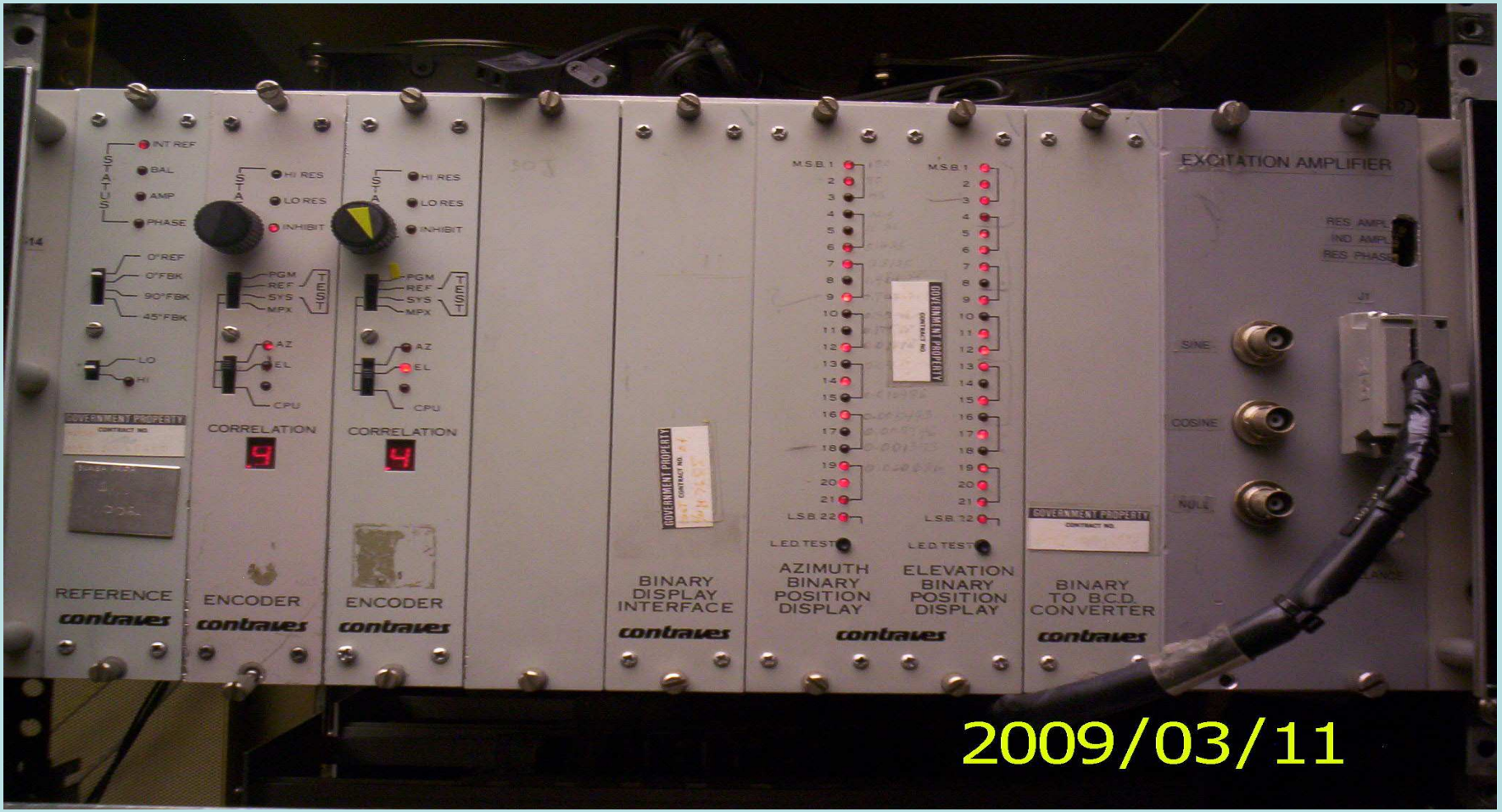
Telescope Drive

- Integral Torque Motors (AZ & EL)
- Dual Bridge Linear Amplifiers (Class A)

Telescope Control

- Modular Precision Angular Control System (MPACS-22 Bit encoding System)
- Inductosyn / Resolver System (Sine Co-Sine Phase Relationship)

MPACS


STATUS
INT REF
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LED TEST
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POSITION
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POSITION
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BINARY
TO B.C.D.
CONVERTER
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EXCITATION AMPLIFIER
SINE
COSINE
NULL
2009/03/11

Meteorological System

Paroscientific MET3

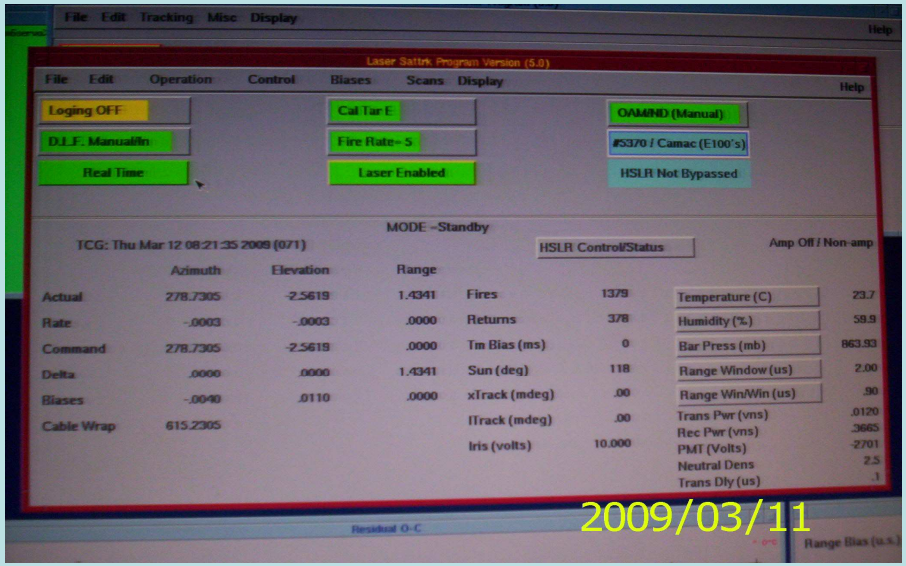
Temperature (C)

Humidity (%)

Barometric Pressure (mb)

Controller System

- System PC Controlled via CAMAC
- Override by Safety Interlock System



Processing System

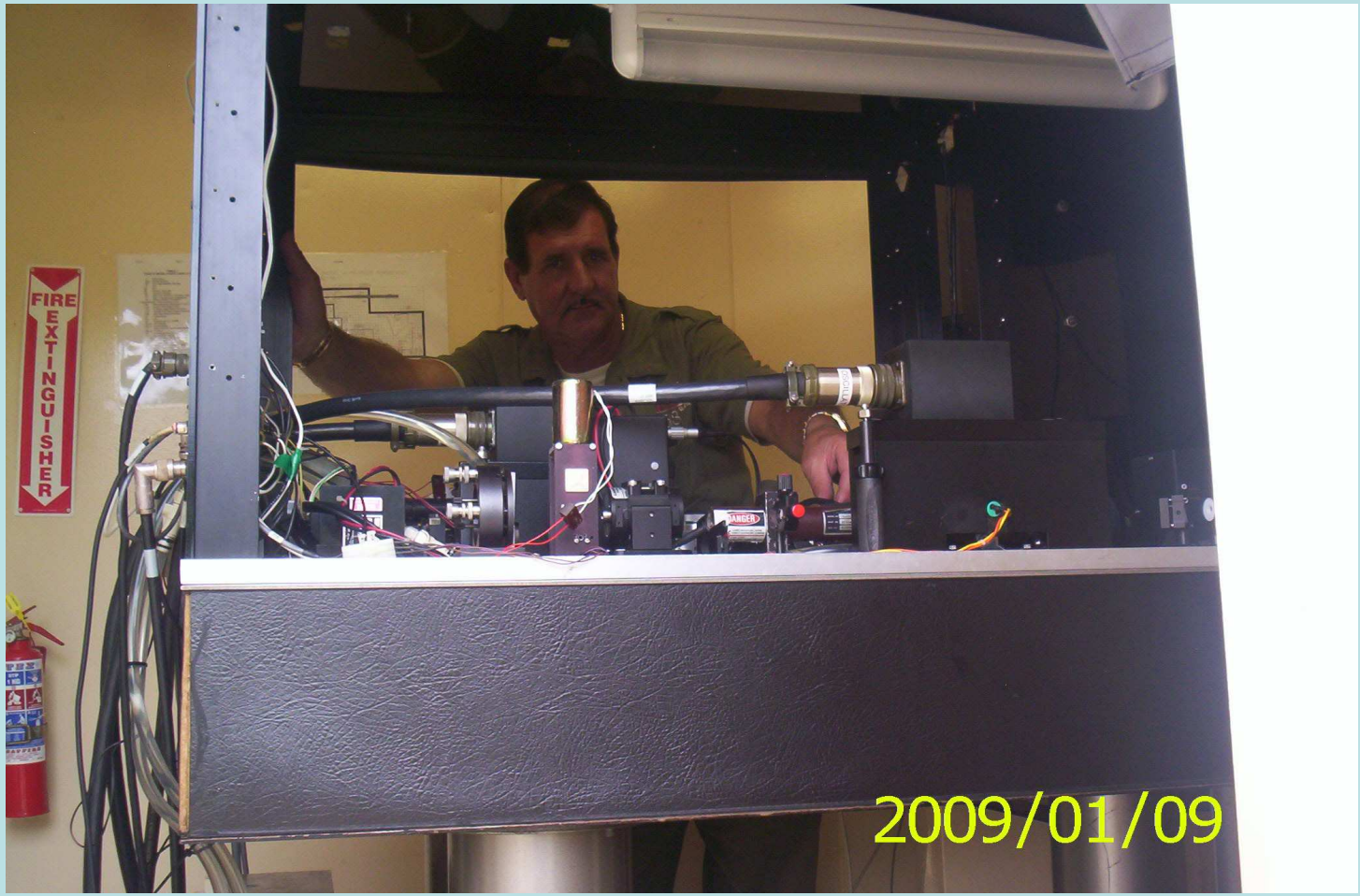
- PC Controlled
- FTP (CPF’s & Data Files via Internet)
- Back-up (HartRAO Geodesy Server)

Repairs

Damaged roof-top wheel

Worm-drive maintenance

Laser Maintenance



Satellite Ranging

Operational Hours

- Week Days: 24 HRS
- Weekend and Public Holidays: 8 HRS/Day

Operational Staff

- Johan Bernhardt (SLR Manager)
- Willy Moralo (Operations Supervisor)
- Samual Stefhu (Operator)
- Cristina (Operator and MSC Student)

THANK YOU!

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SLR Earth Sensing Missions

The earth sensing satellites carry experiments designed to sense the earth to acquire data on worldwide environmental changes such as the green house effect, ozone layer depletion, tropical rain forest deforestation, and abnormal climatic conditions, in order to contribute to international global environmental monitoring.

SLR Radio Navigation Missions

The radio navigation satellite constellations (Global Positioning Systems) are now commonly used throughout the World

SLR Experimental Missions

The experimental satellites carry diverse experiments that do not fit into one of the other mission classifications (i.e. geodetic, earth sensing, positioning). These satellites are irregularly shaped objects in relatively low altitude orbits.

Lunar Reconnaissance Orbiter (LRO)

- **LRO** is the first in a series of missions to the moon , planned for launch early this Year
- **LRO** mission will not only enable future human exploration but also provide excellent opportunities for future science missions.
- **LRO** will spend at least one year in low orbit around the Moon, collecting detailed information about the Lunar environment.

LRO Mission

- Supply information on the Lunar radiation environment
- Evaluating the biological impacts and allowing development of protective technologies
- Provide highly accurate 3D Lunar maps
- Map mineralogy across the Moon
- Search for polar volatiles
- Provide sub-meter resolution imaging
- Provide an assessment of features for landing sites


2009/03/09


2009/01/12


MRU3
MRU4
2009/01/09

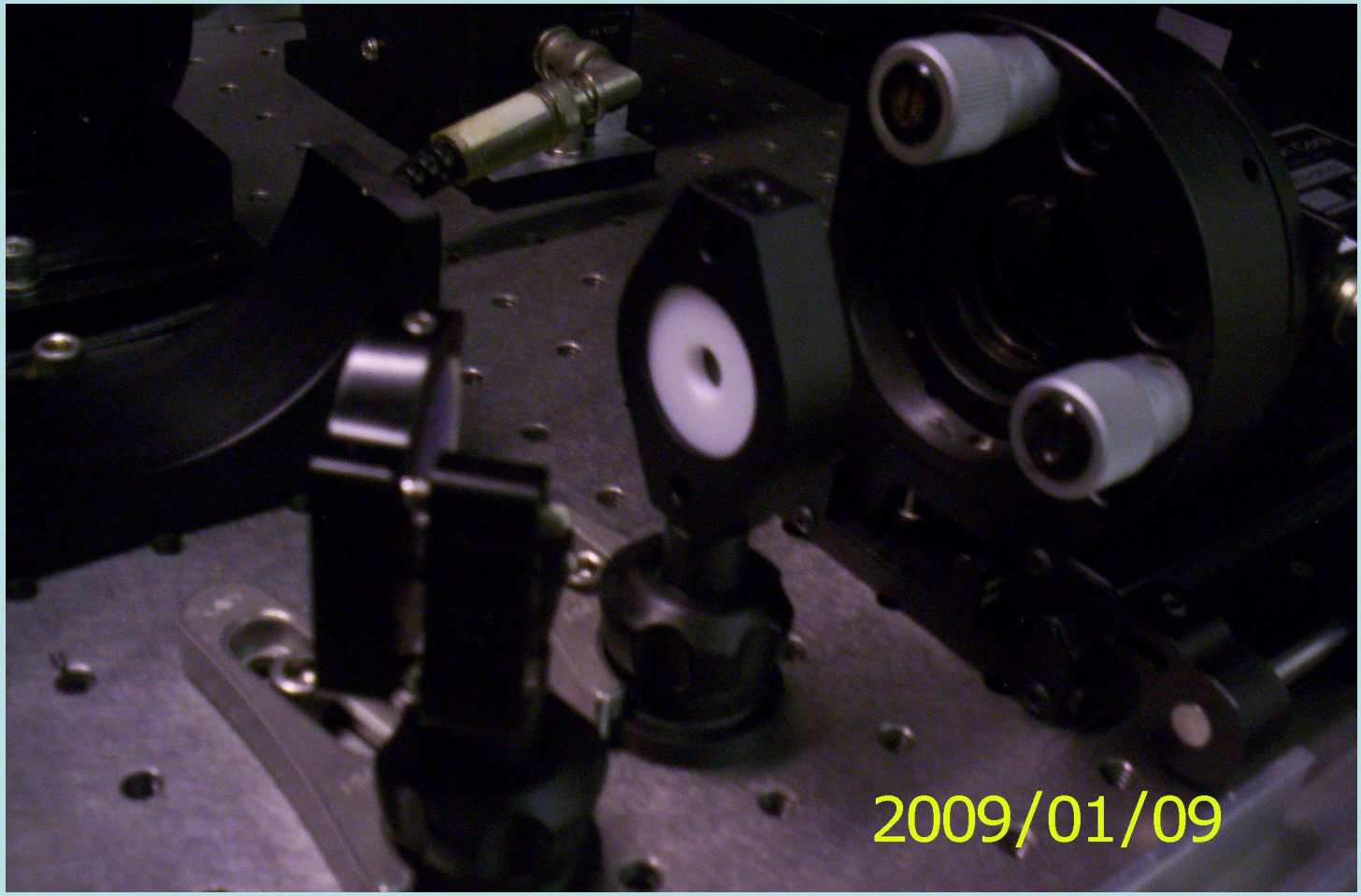
MOBLAS-6 October 2008 Laser Upgrade

The Team from left to right standing: Sammy Tshefu (operator), Luzuko Futwa(operator), Andre van der Merwe (Machine Shop), Johan Bernhardt (SLR manager), Christina (Student and operator) and Willy Moralo (SLR supervisor and operator). In the front: Thomas Oldham from the USA (laser expert contracted by NASA)

CR4+NDYAG Upgrade

- The main objective with this upgrade was to replace the old problematic dye configuration (Q-switched dye in chlorobenzene solution pumped through a dye cell in the laser oscillator cavity) with a CR4 Saturable Absorber (a special doped crystal manufactured for Nd:Yag 1032 nm Q-switched mode locking)

Picture showing the CR4 Saturable Absorber



Reason for upgrade

- The problem with the old configuration was that the dye concentrate weakens over time and the laser oscillator then became unstable and weak in output power or even fails to laze, this required frequent maintenance and a need to adjust the dye concentrate on a weakly basis to maintain operation

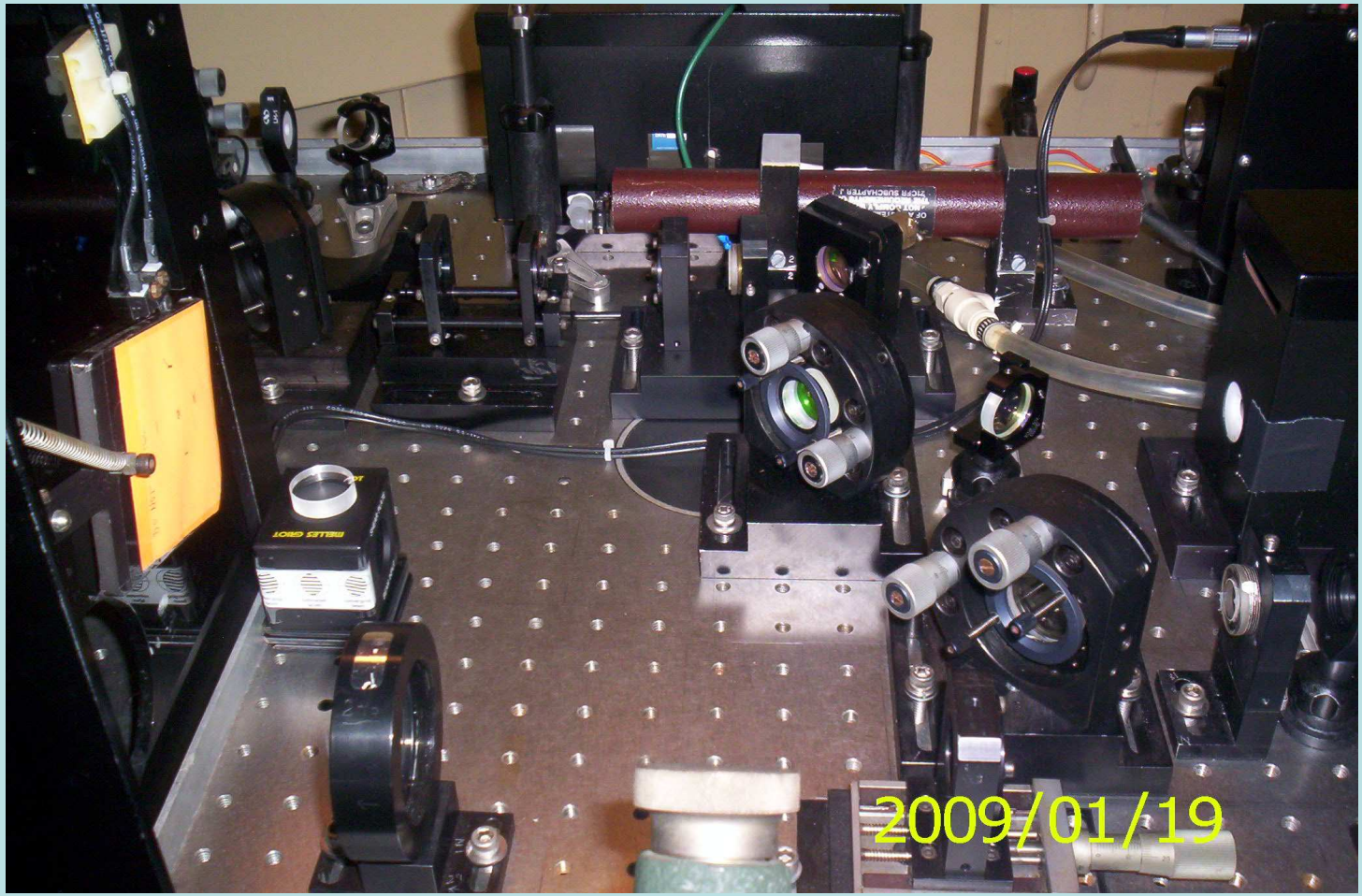
Picture of old laser table layout showing the Dye Cell, Dye Reservoir and Dye Pump (the 3 stainless steel components

Extend of upgrade

- The upgrade was also used as an opportunity to do detail inspection repair and service on all optical components used in the laser system to the extend that we had to remove all the optics from the laser table. The laser table layout was also affected by this upgrade and in short we basically had to rebuild the laser from scratch again.

Post upgrade tests revealed that MOBLAS-6 laser system is performing much better in terms of laser beam quality, stability and require less maintenance.

Picture of the upgraded laser layout



Oscillogram: Laser output pulse response time

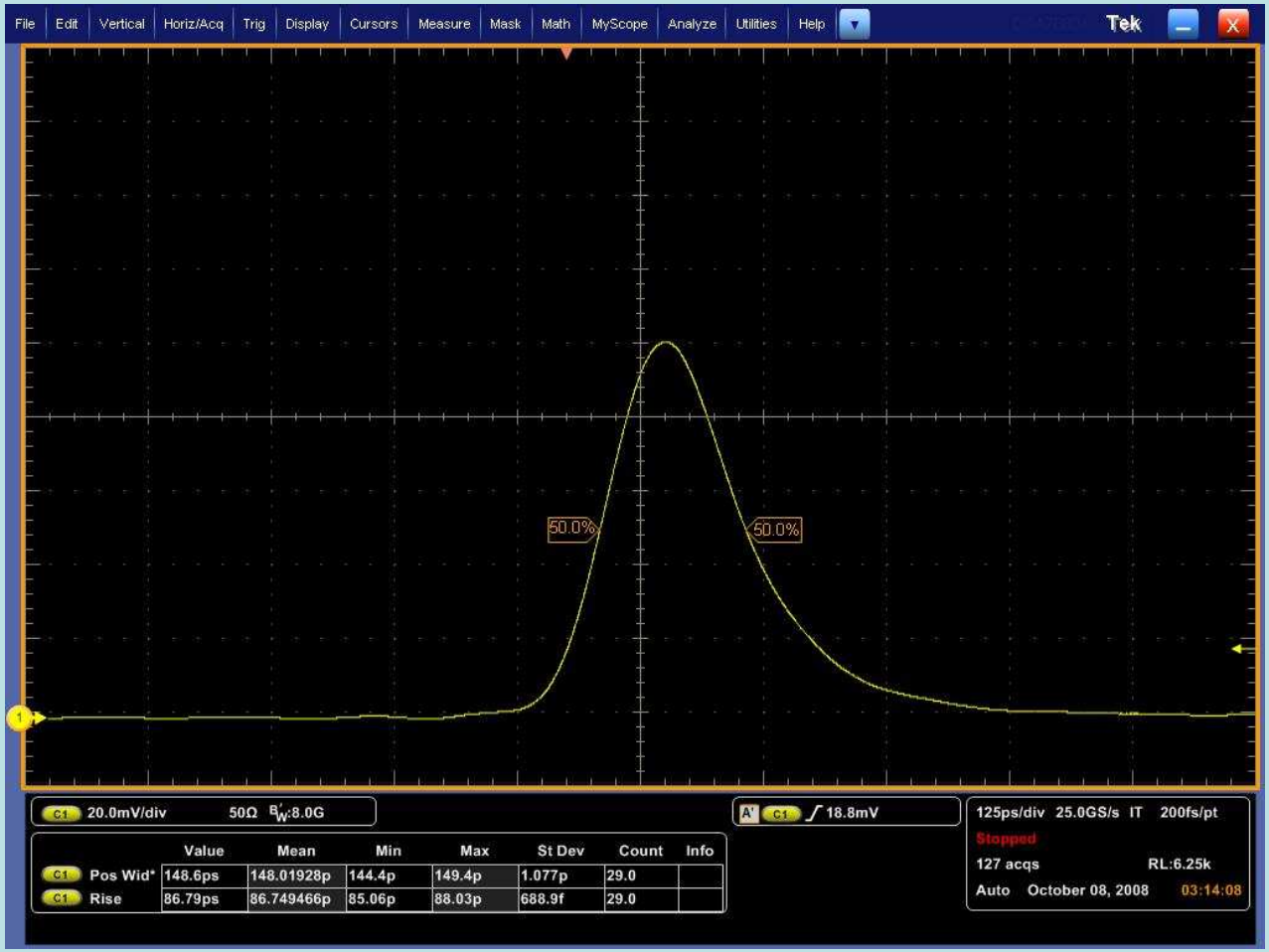
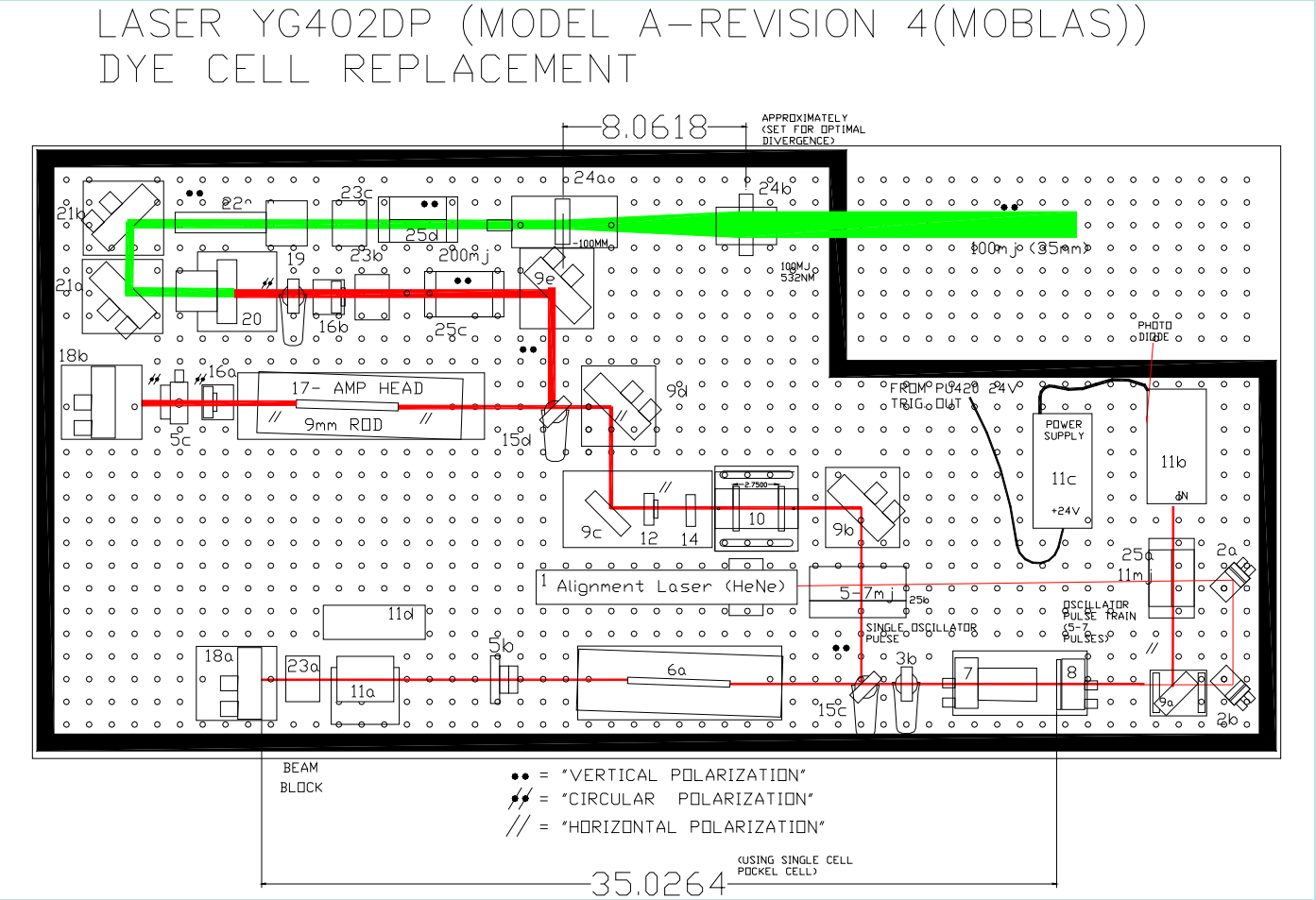


Diagram: Laser Layout



- **YG402 DP (MODEL D-REV3) LASER LAYOUT KEY**
- 1) HeNe laser
- 2a/b) Aluminum Mirror
- 3b) Cr4+Yag Saturable Absorber
- 4) N.A.
- 5a) N.A.
- 5b) Pinhole, l.6mm dia.
- 5c) Pinhole, 7 mm dia.
- 6) SF811-07 7mm//2□-2□ Oscillator Head
- 7) AML-1 (Acousto-optic modelocker)
- 8) Output coupler (1mm etalon)
- 9,9a,b/c/d/e) 45□ 1064nm turning mirror
- 10) Beam expanding telescope X1.5 (L1:F=-92mm,L2:F=155mm)
- 11a) Pockel Cell & 2-axis mount
- 11b) PF Delay Adjust Board Enclosure
- 11c) 150/300 Volt Power Supply Enclosure
- 11d) Marx Bank Board Enclosure
- 12) ½ Waveplate
- 13) N.A.
- 14) Diverging lens (f= -0.28M)
- 15c, d) 45°Polarizer
- 16a, b) 1/4 Waveplate
- 17) SF811-09 2□/2□ double pass amplifier head
- 18a, b) 0□ mirror
- 19) Converging lens(F=+1.5M)
- 20) Second harmonic generator (SHG)
- 21a, b) Dichroic mirror (Rmax=532nm@45°, Tmax=1064nm)
- 22) Start Diode Assembly
- 23a) Oscillator Beam Block
- 23b) ND Attenuation (Eyesafe 4.5ND)
- 23c) Output Beam Block
- 24a) Negative Lens of Beam Expander #3
- 24b) Positive Lens of Beam Expander #3
- 25a) Power Meter Base Plate (Oscillator Pulse Train- 11-14mj)
- 25b) Power Meter Base Plate (Oscillator Single Pulse- 5-7mj)
- 25c) Power Meter Base Plate (Amplifier Single Pulse- 200mj)
- 25d) Power Meter Base Plate (Green Single Pulse- 100mj)

MOBLAS-6 Repairs

- Failure Analysis and Prevention
- Special to Type Jigs (Laser Rod)

Data Transmission

Data Archive

MOBLAS-6 Upgrades

- Telescope Cable Boom
- Translator
- Calibration Targets
- Return rate Monitoring

Telescope Cable Boom

Monorized

Translator

Calibration Targets

- Nelson Pier De misters

MOBLAS-6 Calibration

- Laser Alignment and Pulse Slicing
- Laser Q
- Coedaypath and Bore sight Alignment
- Star Calibration
- Monument Seasonal Drift (Sinusoidal)

MOBLAS-6 Laser Safety

- Minimum Elevation Tracking
- Laser Alignment and access
- On Site Target Ranging (10ND)
- Telescope Access
- Aircraft Safety
- Telescope Incorrect Pointing Angle

Special to type jigs

MOBLAS-6 Upgrades

- Air-conditioning
- Cable Boom Automation
- Translator Automation
- Calibration Pier De-misters

Air-conditioning

Cable Boom Automation

Translator Automation

Calibration Pier De-misters

- Picture