Astrophysical Technology Group

INAF-OAT

A new arrival at the VLT: the commissioning of the X-shooter spectrograph

P. Di Marcantonio – *INAF-OATs (on behalf of the X-shooter consortium)*

X-shooter has been built by a Consortium of European Institutes comprising:

- ESO (*PI S. D'Odorico, PM H. Dekker*)
- Denmark (*PI/PM P. Kjærgaard-Rasmussen*)
- France (*PI F. Hammer, PM I. Guinouard*)
- The Netherlands (*PI L. Kaper, PM R. Navarro*)
- Italy (***PI R. Pallavicini**, PM F. Zerbi*)

ATG has been responsible for the design, development, integration and commissioning for the control software of the whole instrument.

People involved @ INAF:

Roberto Pallavicini (Co-PI),

F. M. Zerbi, V. de Caprio, A. de Ugarte Postigo, M. Riva, P. Spanò, M. Tintori (INAF-OABr)

P. Di Marcantonio, P. Santin, A. Zacchei, C. Zamberlan, M. Vidali (INAF-OATs)

R. Cosentino, P. Bruno (INAF-OACt)

X-shooter resources

	effort (FTE)	Cost (k€)	Contribution
Denmark	19	850	Control electronics, Backbone unit, FEA, system test of UVB spectrograph
ESO	15	1510	Overall ProjMan.& SysEng, detectors, final system integration and commissioning, logistics
France	12	140	IFU, DRS
Italy	**19**	**800**	**Optomechanical design and integration of UVB and VIS, system test of VIS spectrograph, Control Software**
Netherlands	1.8	2044	NIR spectrograph, contribution to DRS
Total	**66.8**	**5344**	

	Guaranteed Nights
Italy	**44.5**
Denmark	45.5
France	20.8
Holland	43.5
Total	**154.3**

INAF-OATs (only) GTO involvement:

- Abundances and Dust in high redshift (z>4.0) Damped Lyman α galaxies (PI: Molaro P., CoI: Vladilo G., D'Odorico V.)
- Optical-NIR spectra of quasars close to re-ionization (z~6) (PI: D'Odorico V., CoI: Molaro P., Cristiani S., Viel M., Vladilo G.)
- Extremely metal-poor stars in SDSS fields (PI: Bonifacio P., CoI: Molaro P.)
- Tomography of the Intergalactic Medium with multiple QSO lines of sight (PI: Stefano C., CoI: F. Calura, E. Vanzella, V. D'Odorico, M. Viel, P. Monaco, …)
- A 100 burst X-Shooter / Swift GRB afterglow legacy survey (CoI: Pian.E.)
- X-Shooting Supernovae (CoI: Pian E.)
- Study in situ of GRB progenitors and their host galaxies with X-Shooter : from z = 0.1 to 2.3 (CoI: Pian E.)

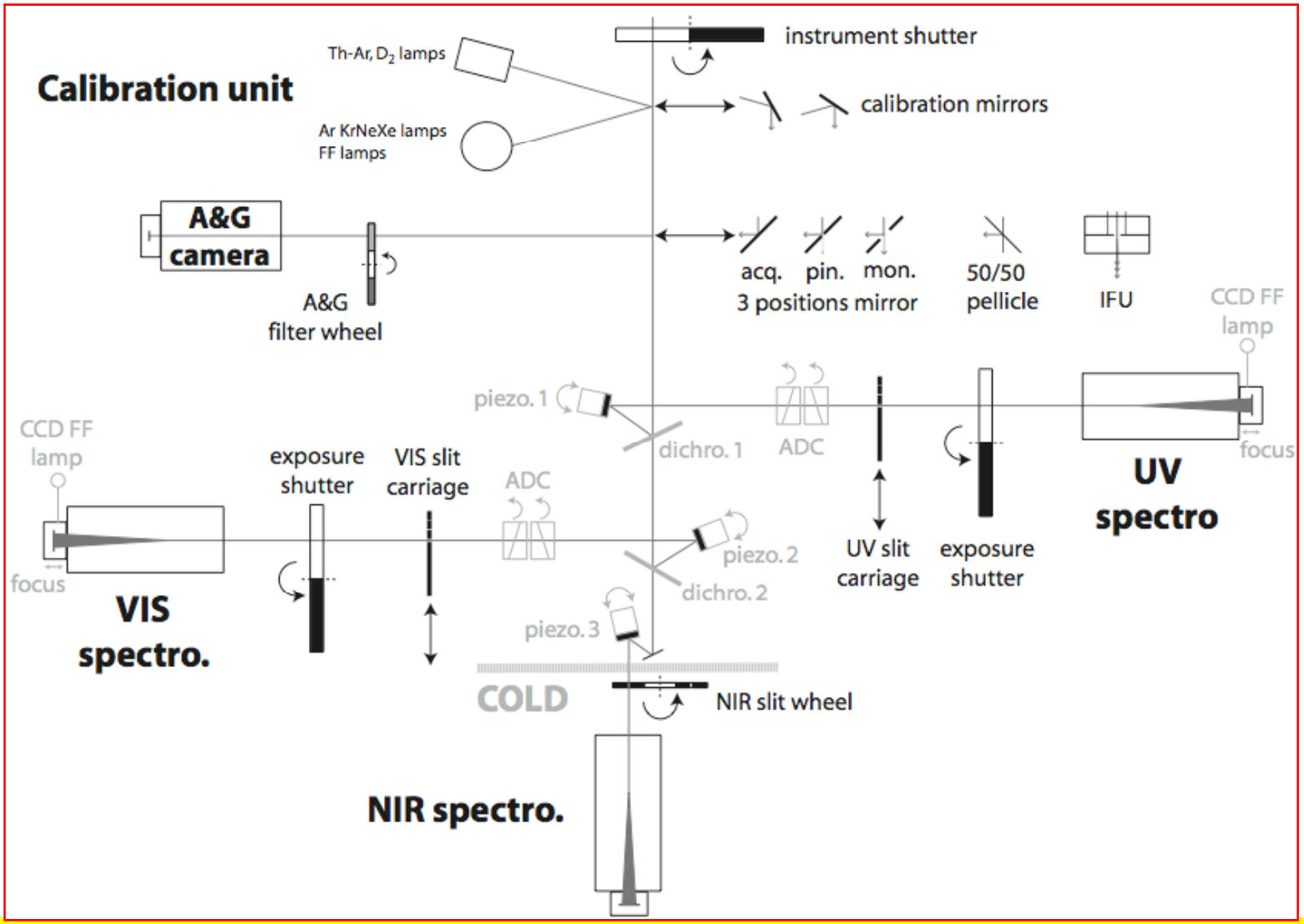
X-shooter time schedule

STC 56	Dec 2003
PDR	Dec 2004
FDR	Feb – Jul 2006
Integration@ESO	2008
PAE	Sept 2008
Comm #1	Nov 2008
Comm #2	Jan 2009
Comm #3	Mar 2009
Comm #4	May 2009
SV or GTO (several periods)	Jul – Sept 2009
Start of Operations	1.10.2009

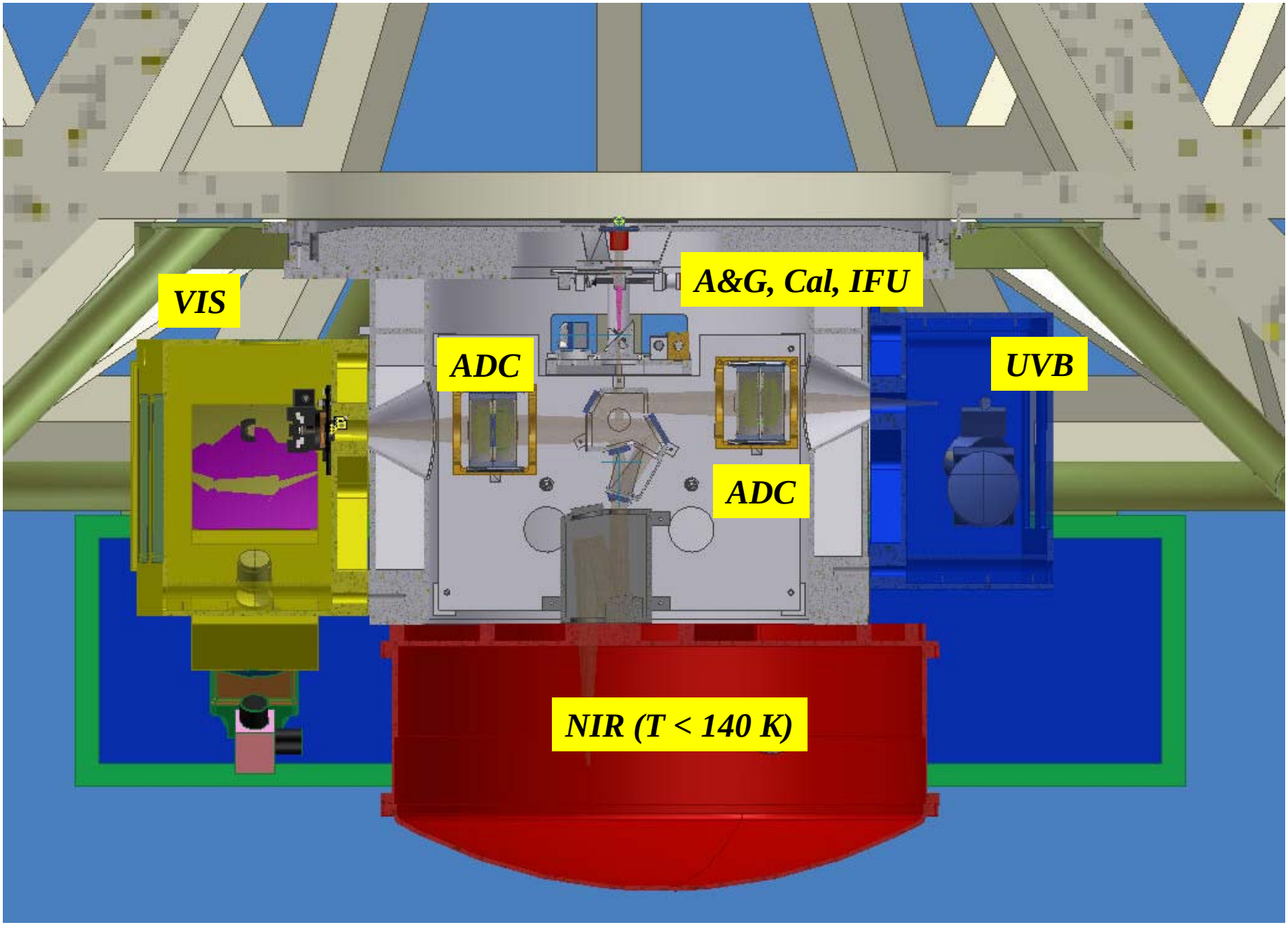
X-shooter commissioning team

- Wavelength range: three arms covering from 300 nm to 2500 nm
- Fixed prism cross-dispersed echelle format (slit length 11")
- Detectors:
  - 2K x 4K 15µ CCDs (UVB and VIS arms)
  - 2K x 1K segment of a 2K x 2K 18µ Hawaii 2RG MBE (NIR arm)
- IFU (1.8" x 4"), ADC for UVB and VIS arms, calibration unit and A&G unit
- Spectral resolution: ~7000 to 12000 for 0.6" slit or IFU
- High Detective Quantum Efficiency
- Pipeline delivering sky-subtracted, wav cal 2D spectra and 3D data cube for the IFU

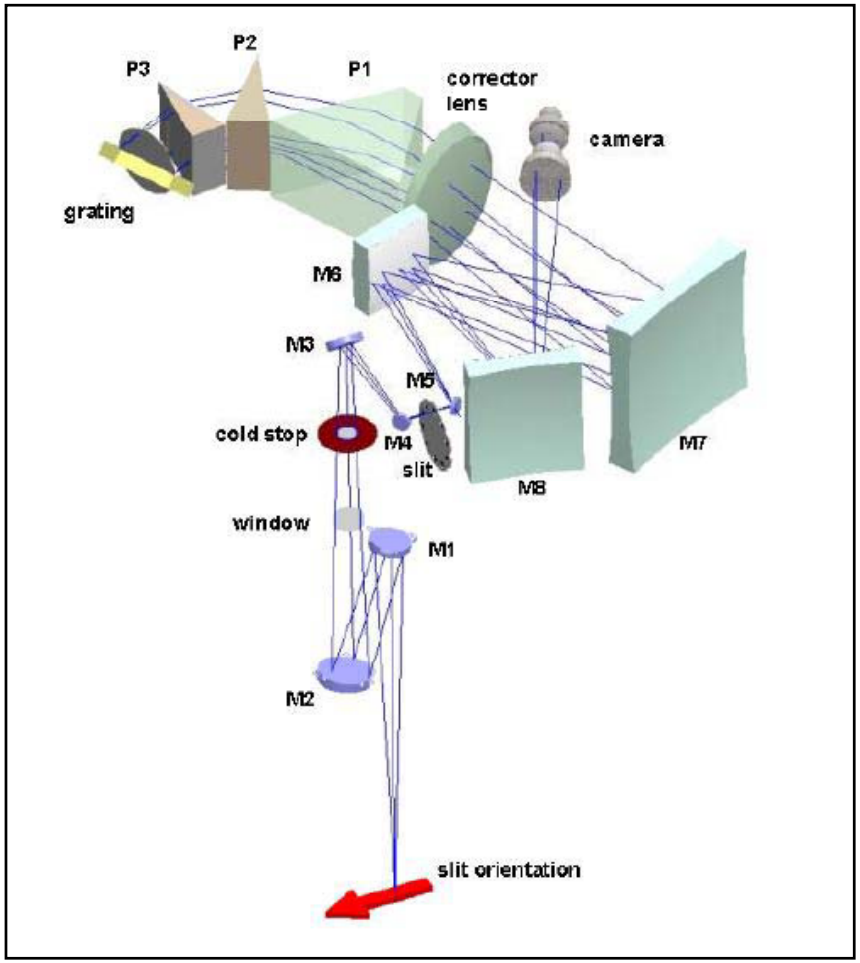
Instrument layout I

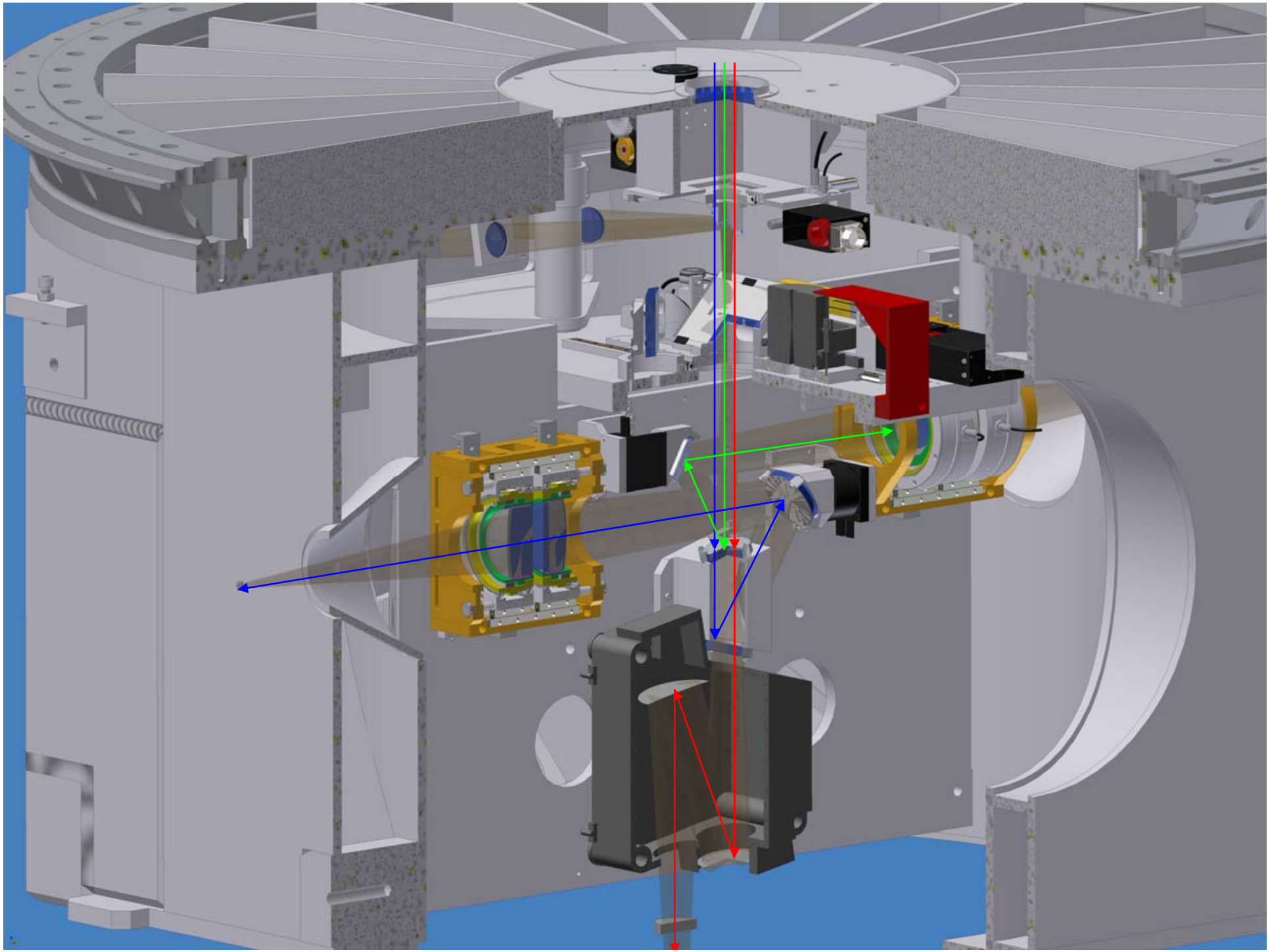


Instrument layout II

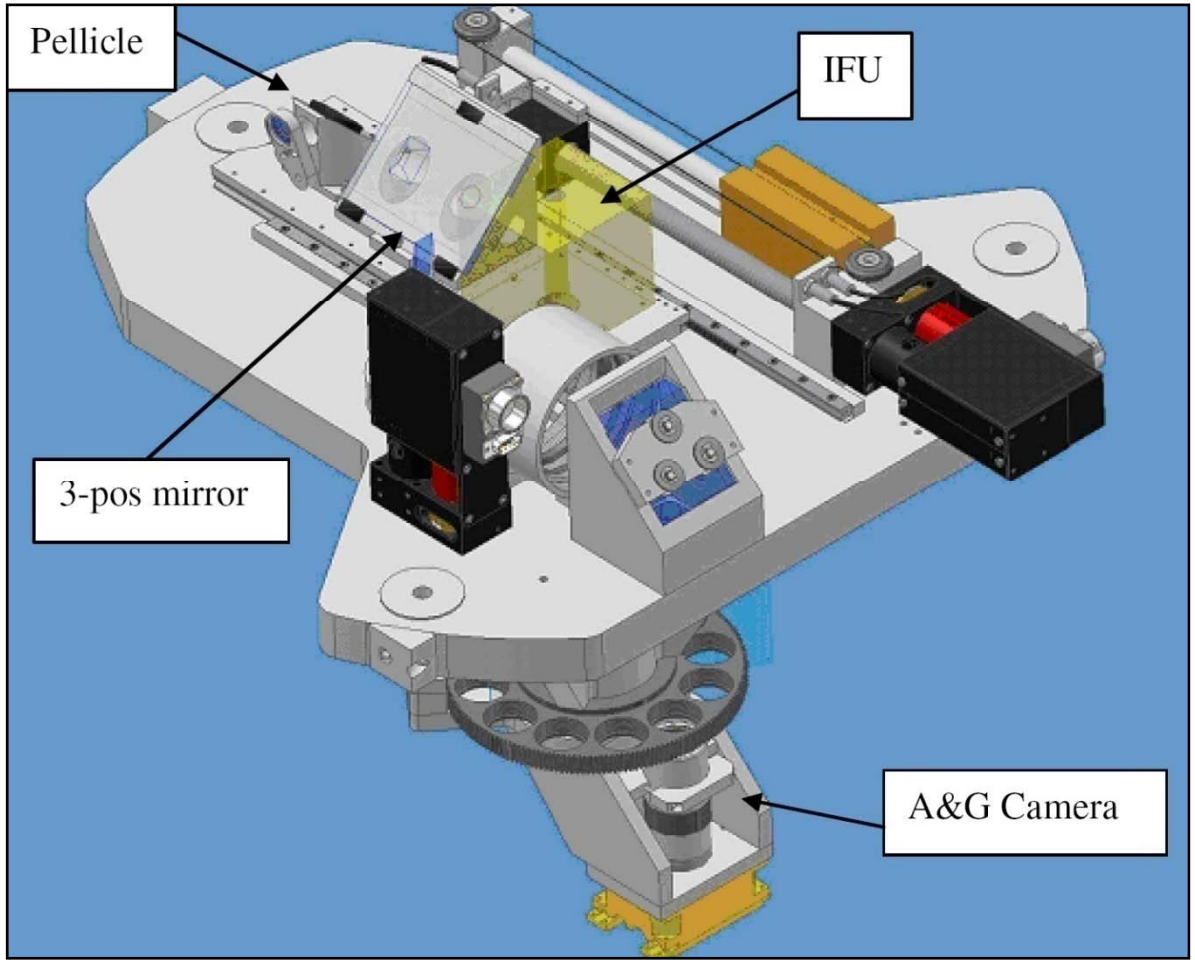


NIR optical layout

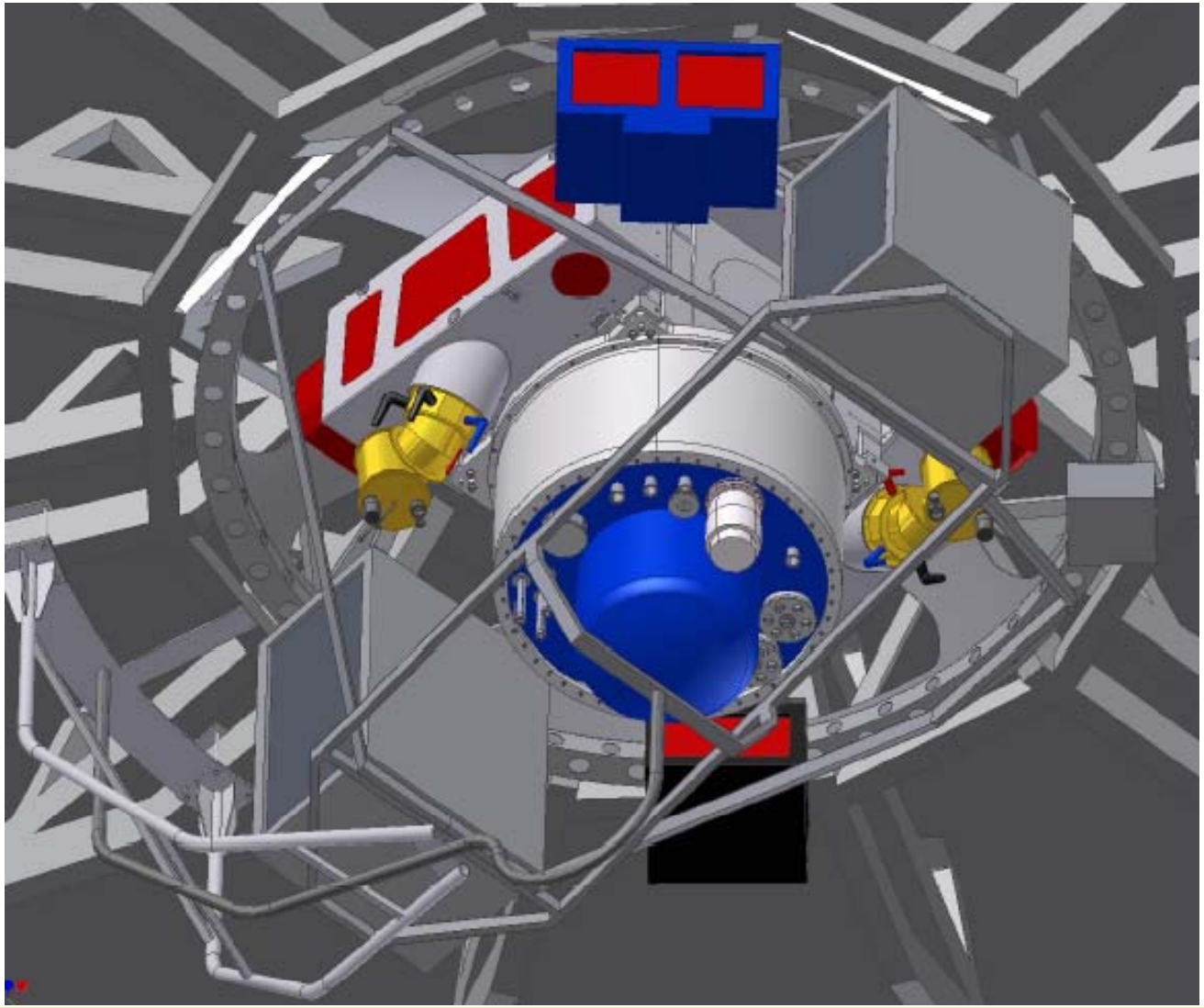




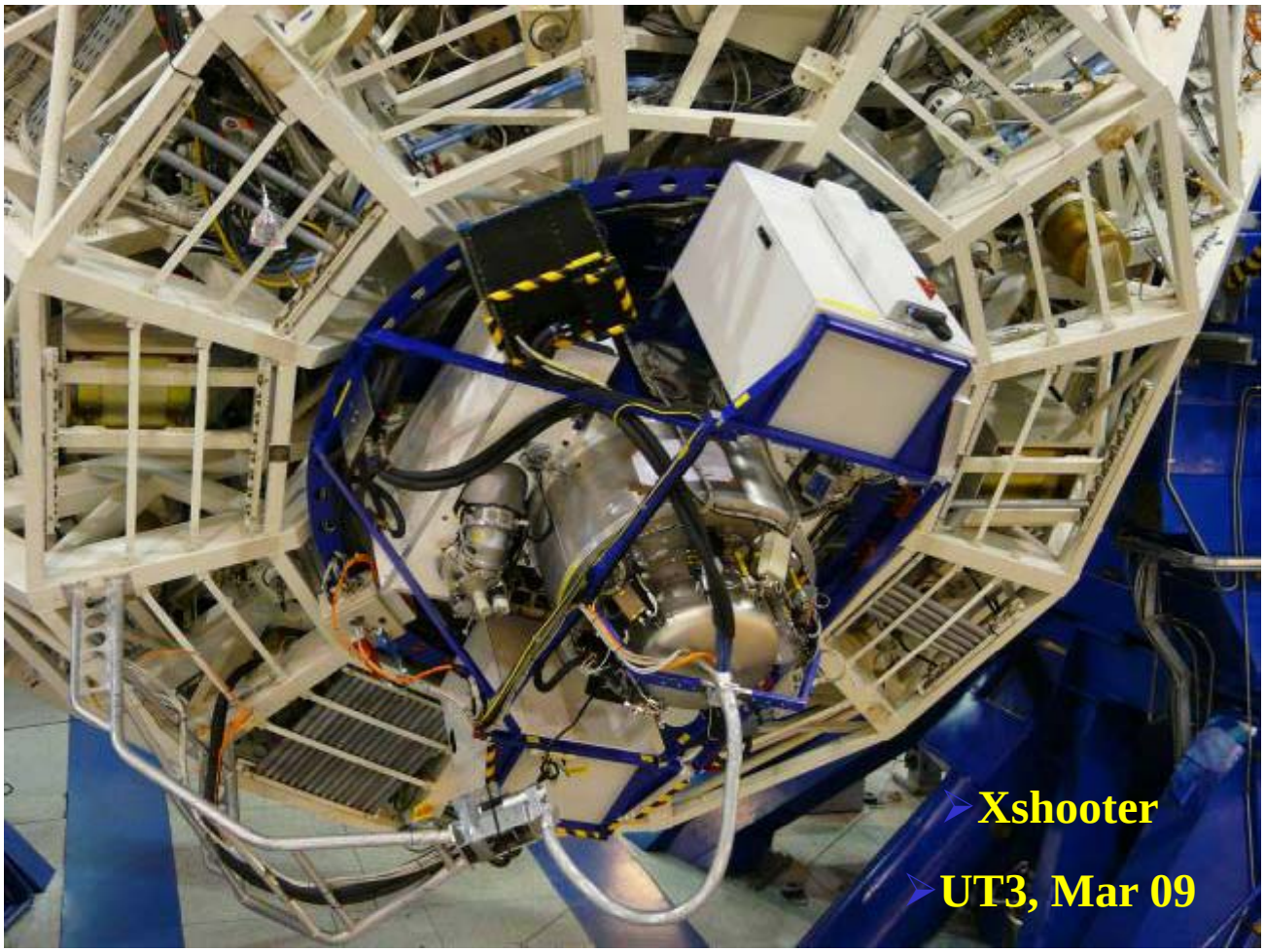
A&G unit



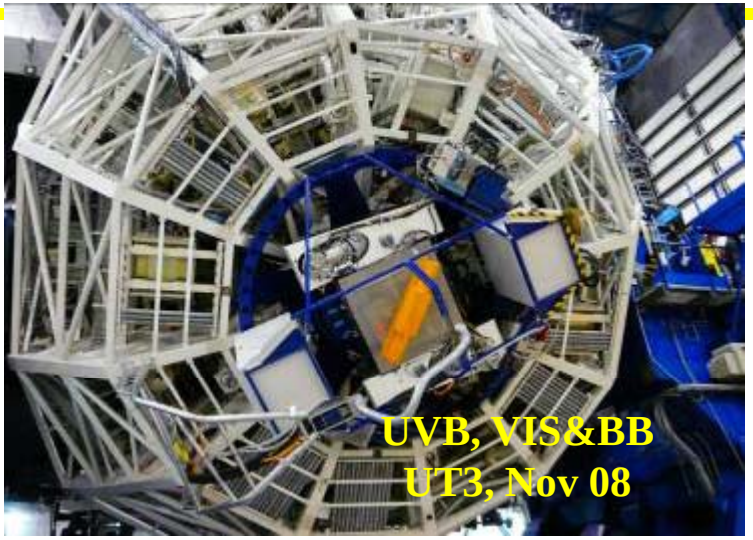
FDR CAD design

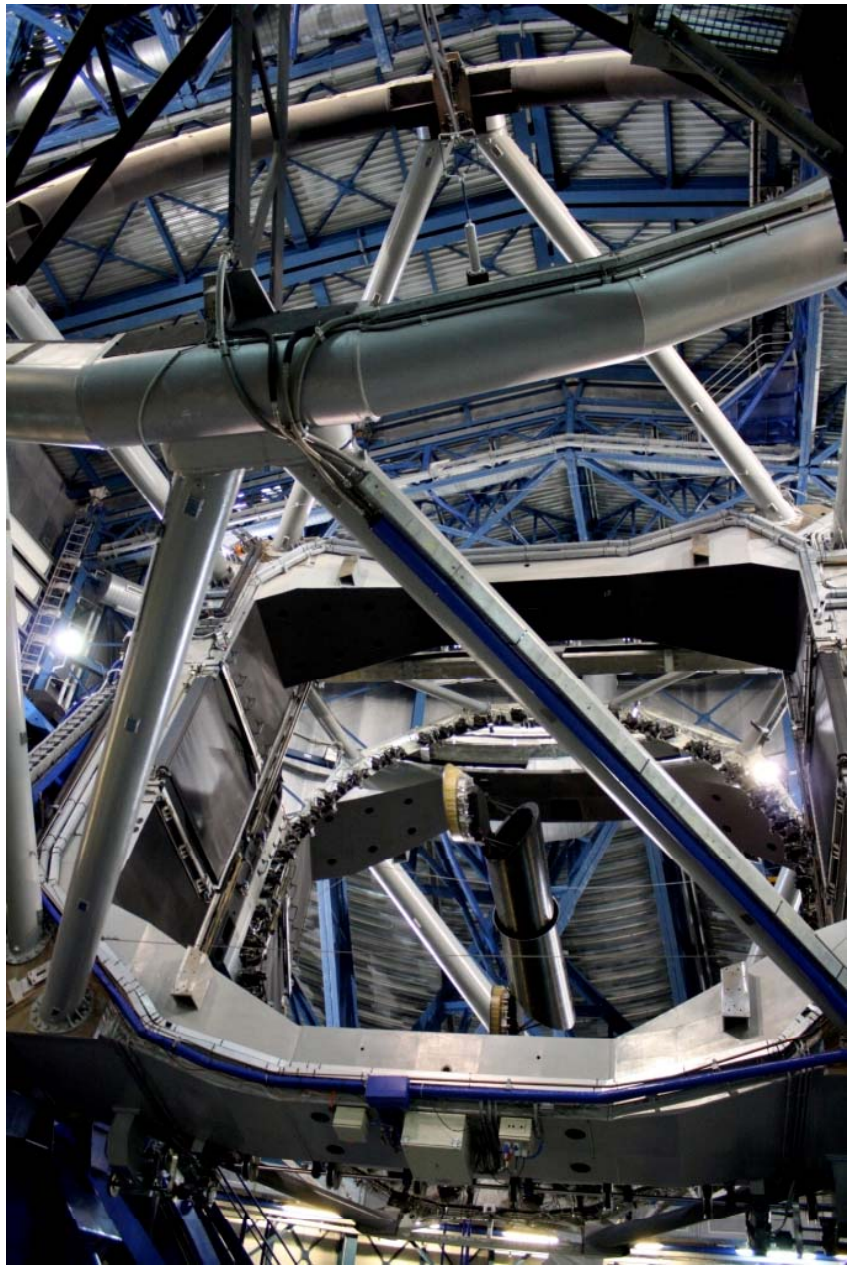


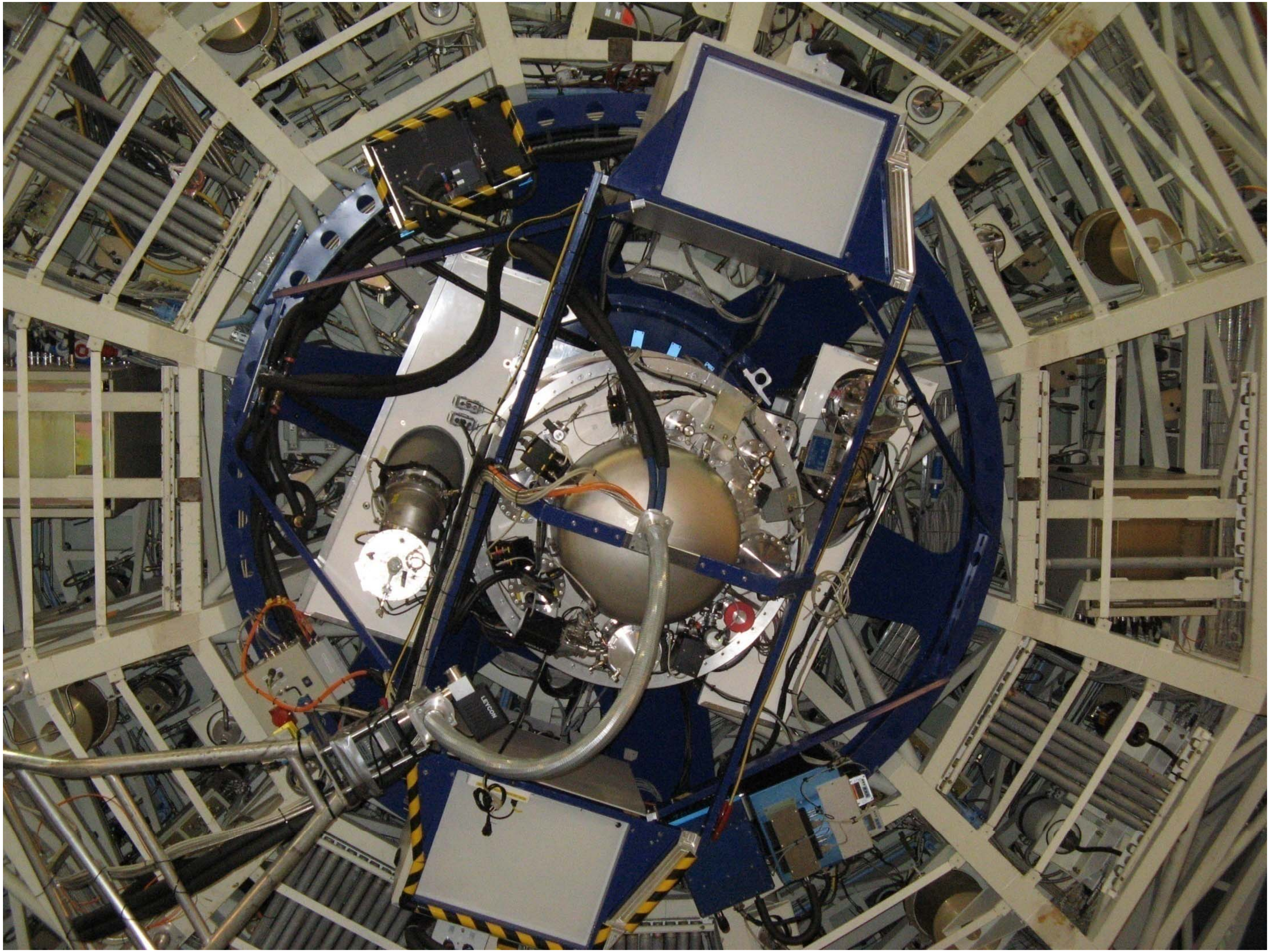
Eventually …

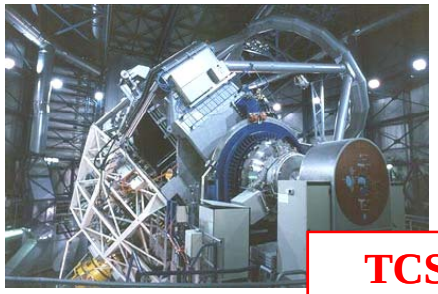


UT3 integration

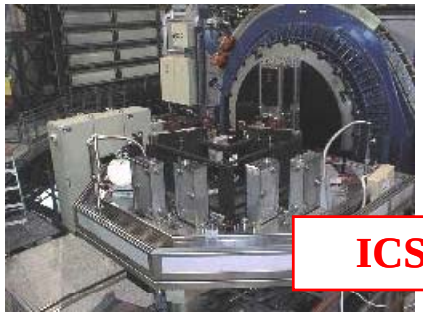








TCS



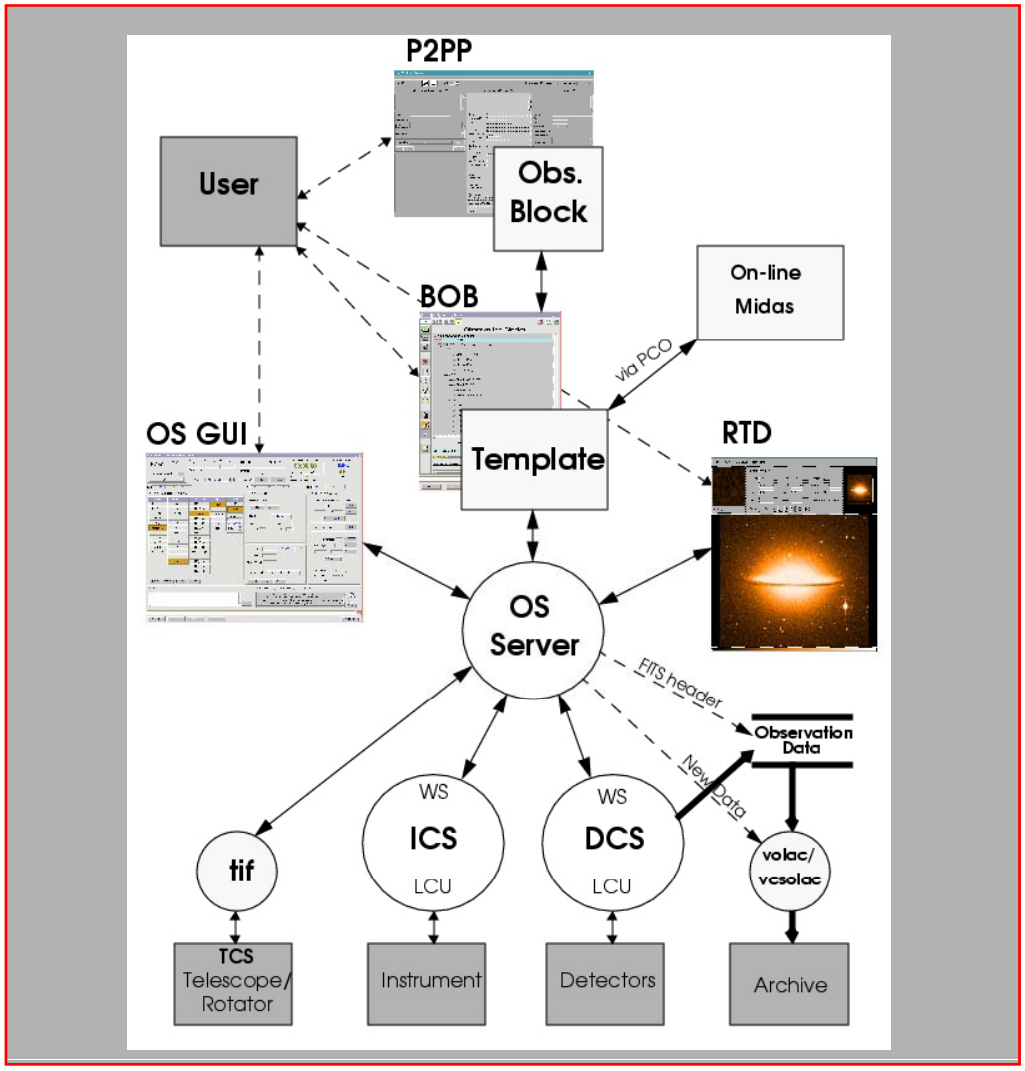
ICS

Observation Software (OS)

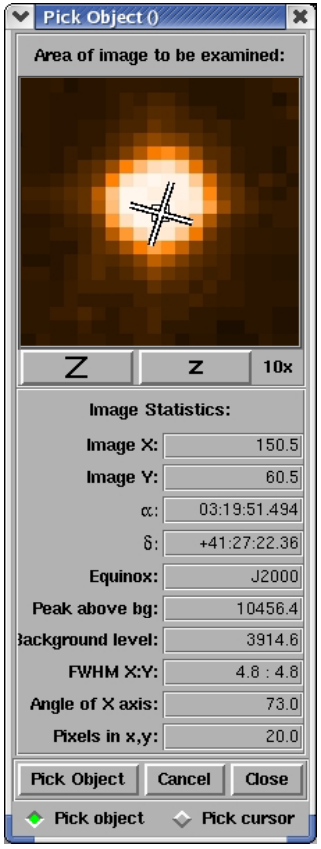
DCS (TCCD/FIERA/IRACE)

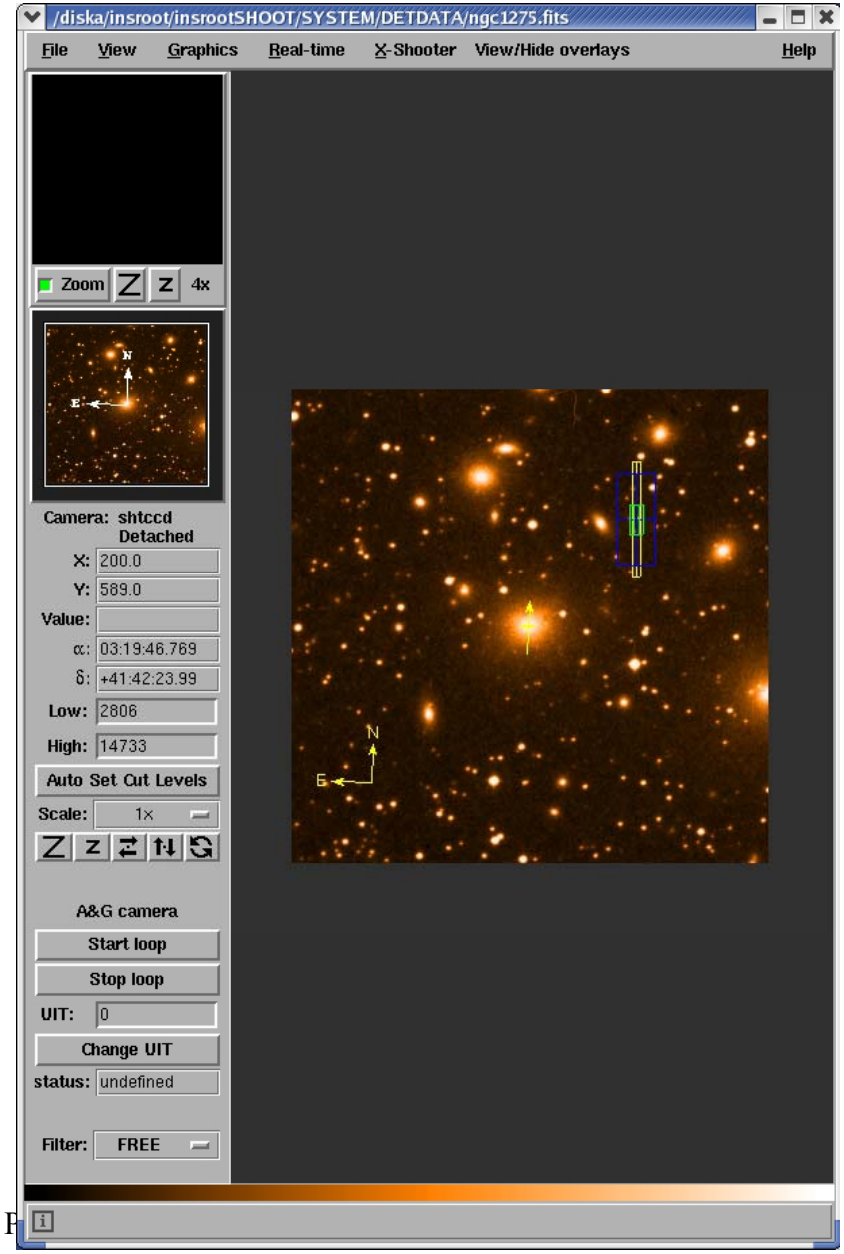
ARCHIVE

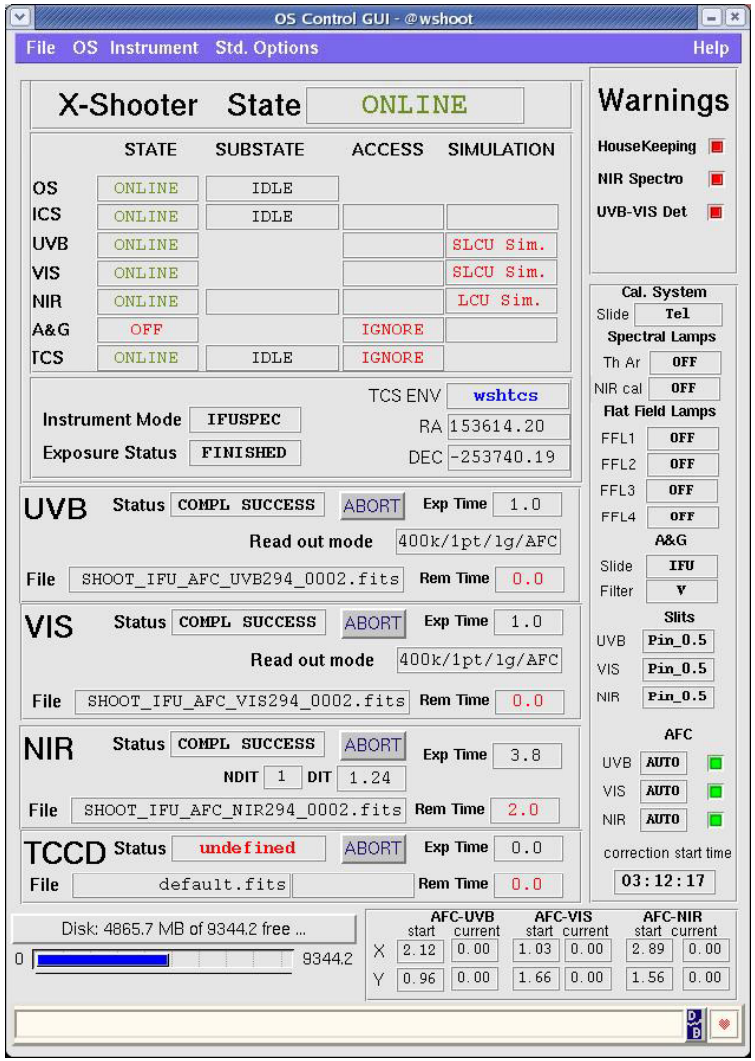
ESO control software - full path

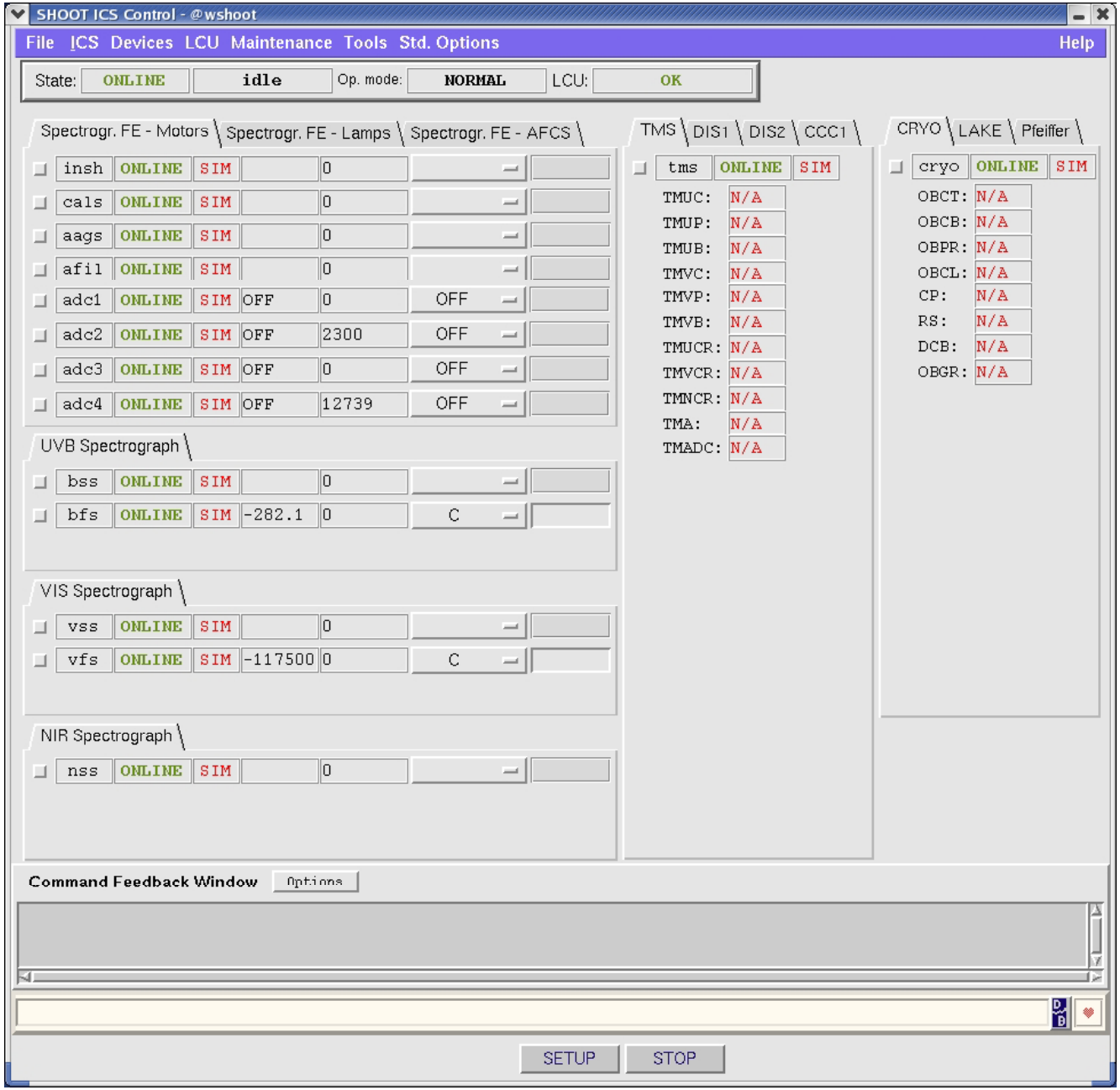


Object Acquisition

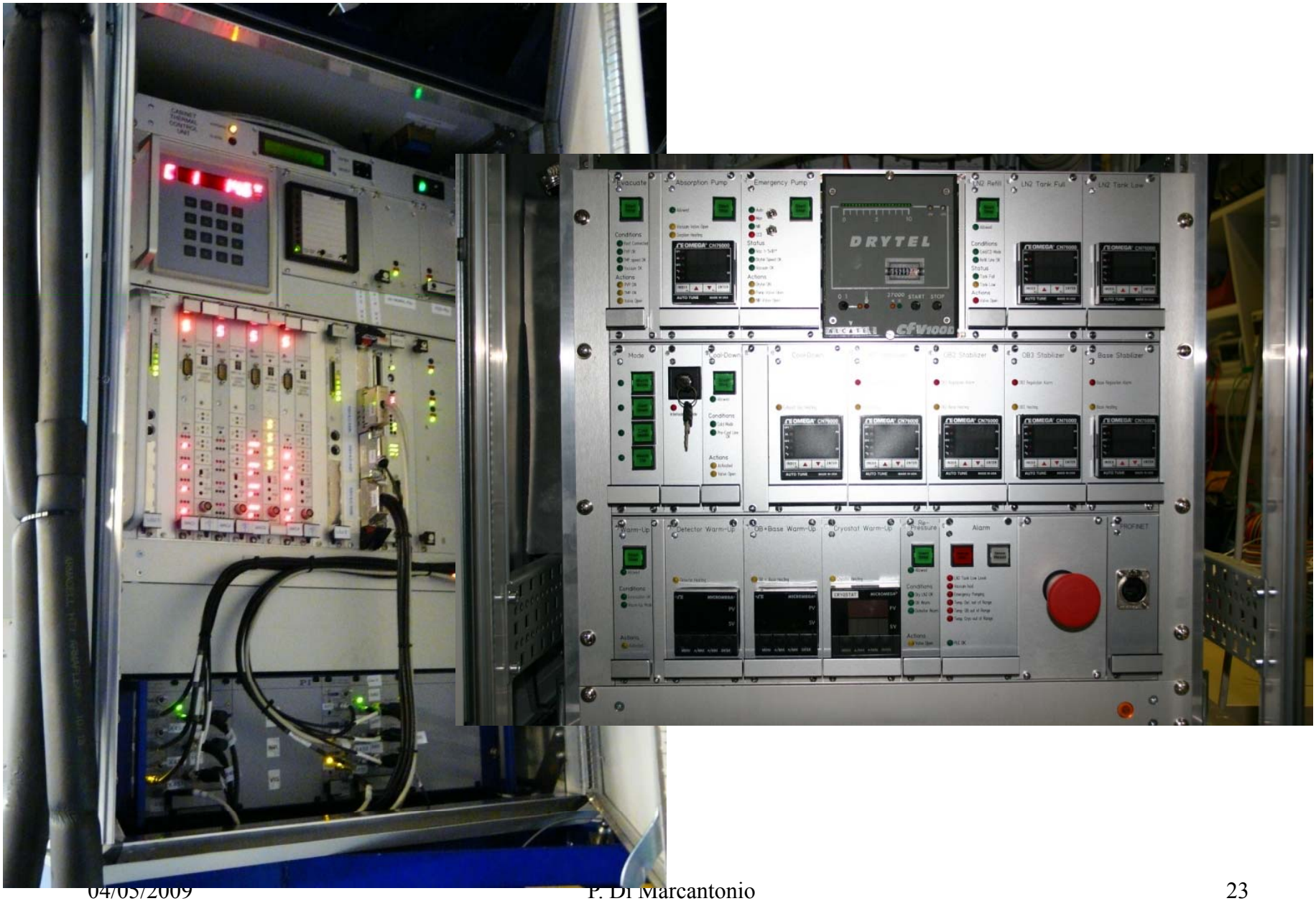





OS Control GUI - @wshoot
File OS Instrument Std. Options Help
X-Shooter State ONLINE
STATE SUBSTATE ACCESS SIMULATION
OS ONLINE IDLE
ICS ONLINE IDLE
UVB ONLINE SLCU Sim.
VIS ONLINE SLCU Sim.
NIR ONLINE LCU Sim.
A&G OFF IGNORE
TCS ONLINE IDLE IGNORE
TCS ENV wshtcs
Instrument Mode IFUSPEC
Exposure Status FINISHED
RA 153614.20
DEC -253740.19
UVB Status COMPL SUCCESS ABORT Exp Time 1.0
Read out mode 400k/1pt/lg/AFC
File SHOOT_IFU_AFC_UVB294_0002.fits Rem Time 0.0
VIS Status COMPL SUCCESS ABORT Exp Time 1.0
Read out mode 400k/1pt/lg/AFC
File SHOOT_IFU_AFC_VIS294_0002.fits Rem Time 0.0
NIR Status COMPL SUCCESS ABORT Exp Time 3.8
NDIT 1 DIT 1.24
File SHOOT_IFU_AFC_NIR294_0002.fits Rem Time 2.0
TCCD Status undefined ABORT Exp Time 0.0
File default.fits Rem Time 0.0
Disk: 4865.7 MB of 9344.2 free ...
0 9344.2
Warnings
HouseKeeping
NIR Spectro
UVB-VIS Det
Cal. System
Slide Tel
Spectral Lamps
Th Ar OFF
NIR cal OFF
Flat Field Lamps
FFL1 OFF
FFL2 OFF
FFL3 OFF
FFL4 OFF
A&G
Slide IFU
Filter V
Slits
UVB Pin_0.5
VIS Pin_0.5
NIR Pin_0.5
AFC
UVB AUTO
VIS AUTO
NIR AUTO
correction start time
03:12:17
AFC-UVB start current AFC-VIS start current AFC-NIR start current
X 2.12 0.00 1.03 0.00 2.89 0.00
Y 0.96 0.00 1.66 0.00 1.56 0.00

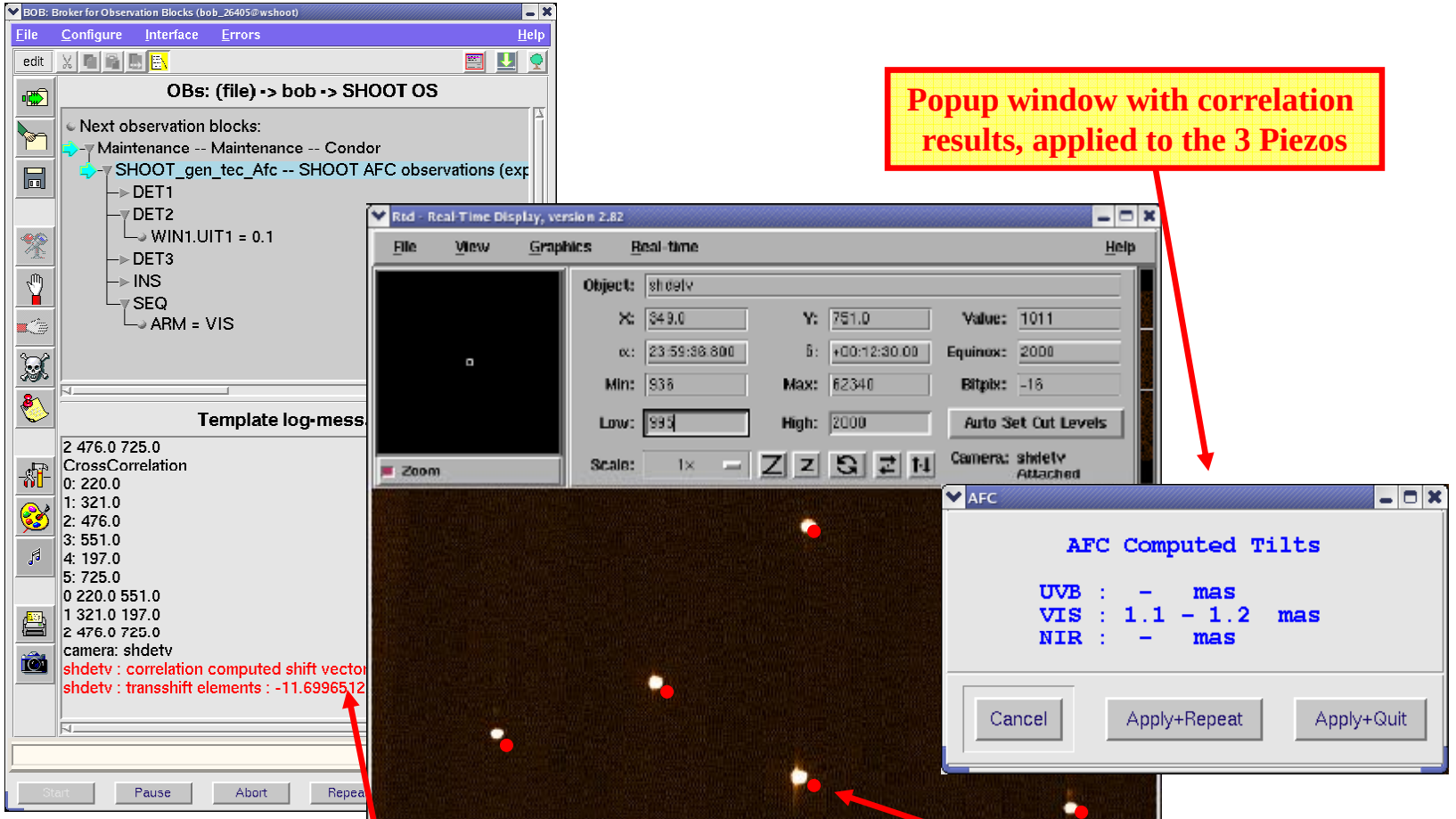

SHOOT ICS Control - @wshoot
File ICS Devices LCU Maintenance Tools Std. Options Help
State: ONLINE idle Op. mode: NORMAL LCU: OK
Spectrogr. FE - Motors
Spectrogr. FE - Lamps
Spectrogr. FE - AFCS
insh ONLINE SIM 0
cals ONLINE SIM 0
aags ONLINE SIM 0
afil ONLINE SIM 0
adc1 ONLINE SIM OFF 0 OFF
adc2 ONLINE SIM OFF 2300 OFF
adc3 ONLINE SIM OFF 0 OFF
adc4 ONLINE SIM OFF 12739 OFF
UVB Spectrograph
bss ONLINE SIM 0
bfs ONLINE SIM -282.1 0 C
VIS Spectrograph
vss ONLINE SIM 0
vfs ONLINE SIM -117500 0 C
NIR Spectrograph
nss ONLINE SIM 0
TMS
DIS1
DIS2
CCC1
tms ONLINE SIM
TMUC: N/A
TMUP: N/A
TMUB: N/A
TMVC: N/A
TMVP: N/A
TMVB: N/A
TMUCR: N/A
TMVCR: N/A
TMNCR: N/A
TMA: N/A
TMADC: N/A
CRYO
LAKE
Pfeiffer
cryo ONLINE SIM
OBCT: N/A
OBCB: N/A
OBPR: N/A
OBCL: N/A
CP: N/A
RS: N/A
DCB: N/A
OBGR: N/A
Command Feedback Window
Options
SETUP
STOP

Local Control Unit (LCU)




Xenon
Argon
Krypton
Neon
ThAr
Deuterium
Cryostat Overview
NIR Cryostat
Heaters
CCD Sensors
UVB
VIS
LN2 Tank
Operation Mode
Warm Mode
Cool Down
Cold Mode
Warm Up
Functions
Evacuate
Absor.Pump
Emerg.Pump
MAIN
NIR
LN2 Refill
Pre-Cool
Warm Up
Repressure
Emergency Pumping not in AUTO Mode
Main Menu
Alarm Display
Operation Mode
Cryostat Overview
Interlocks Conditions

Active Flexure Compensation



Popup window with correlation results, applied to the 3 Piezos

AFC executed during object acquisition, in parallel with telescope Active Optics, (but generally faster)

Correlation of two arc spectra taken with a pinhole in spectrograph and one in Cass focal plane

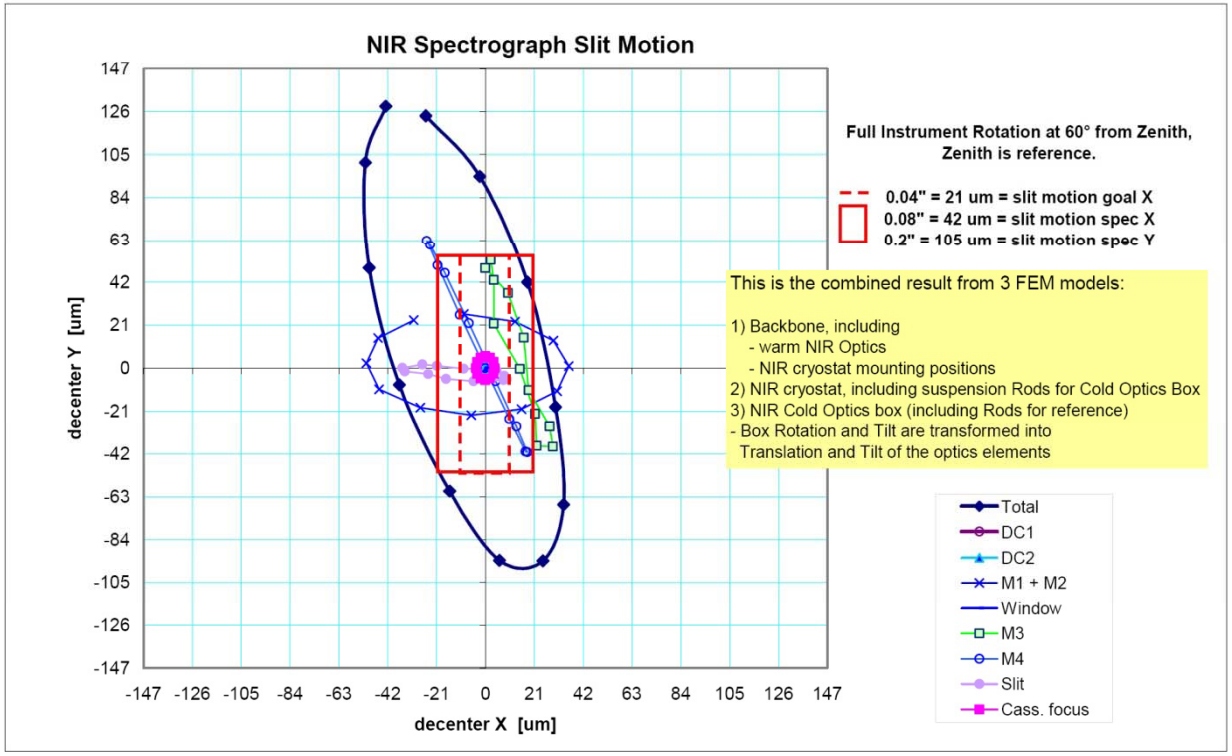
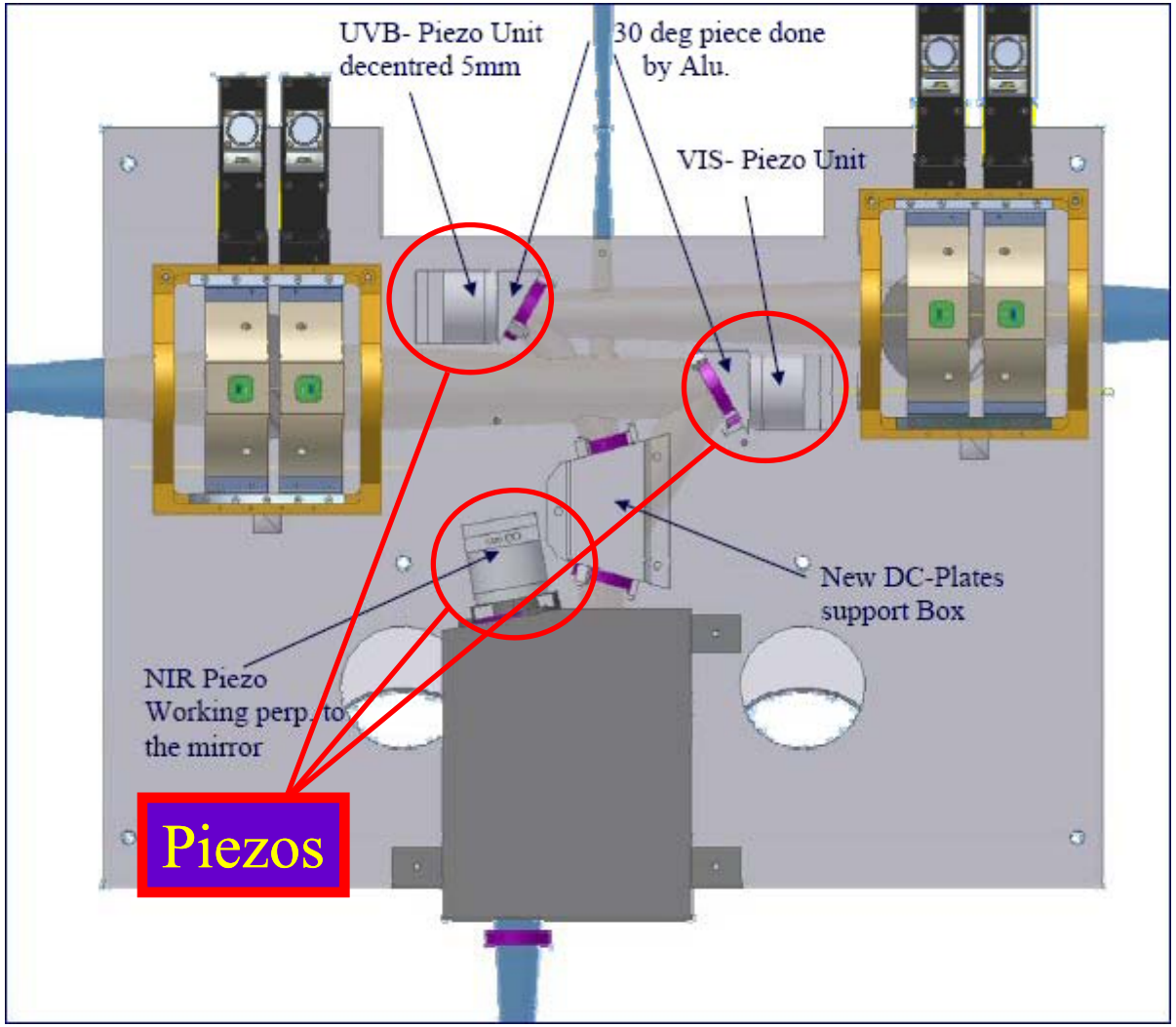
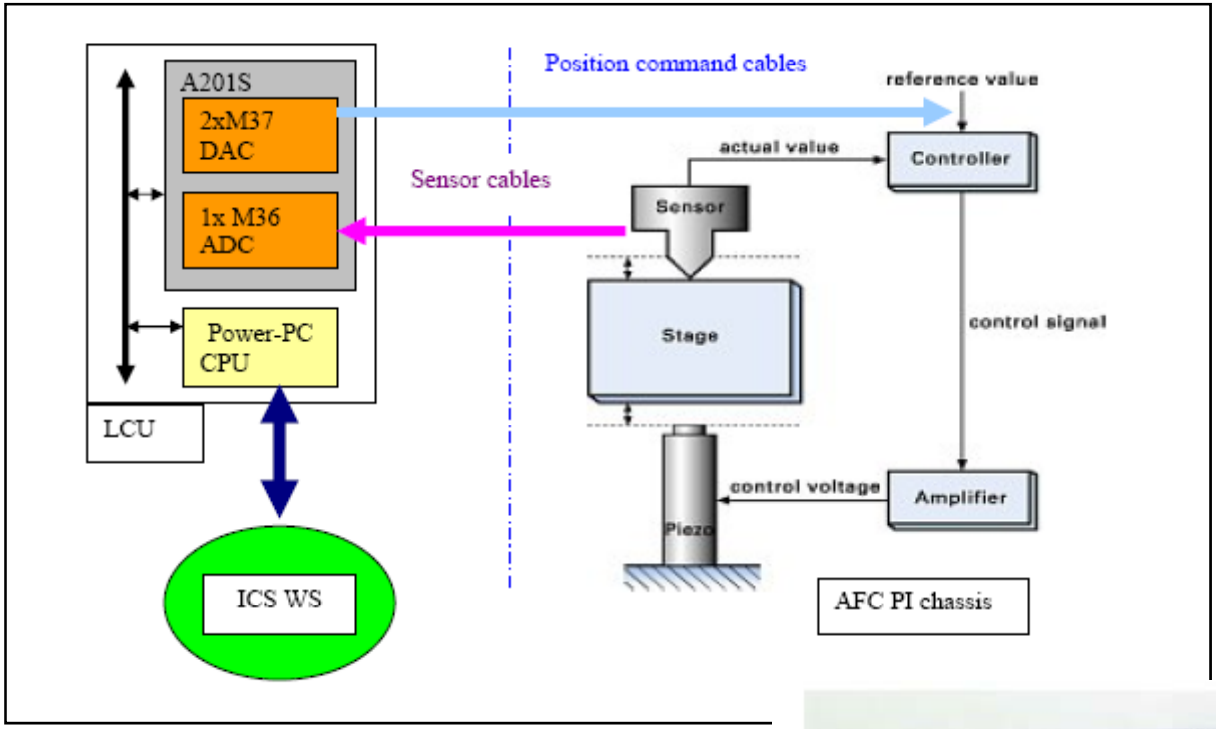


Figure 58 NIR Spectrograph Slit Motion in the NIR slit plane. Combined Result from the 3 FEM analyses. From Zenith as zero position the maximum NIR slit motion is --52 µm in X direction and +131 µm in Y direction. This is just out of specification.

AFC mechanics



AFC electronics



Some results from the three commissioning periods:

- nov 2008 and jan 2008- integration/installation of the UVB and VIS spectrograph with a dummy NIR;

Cited from a report sent to STC:

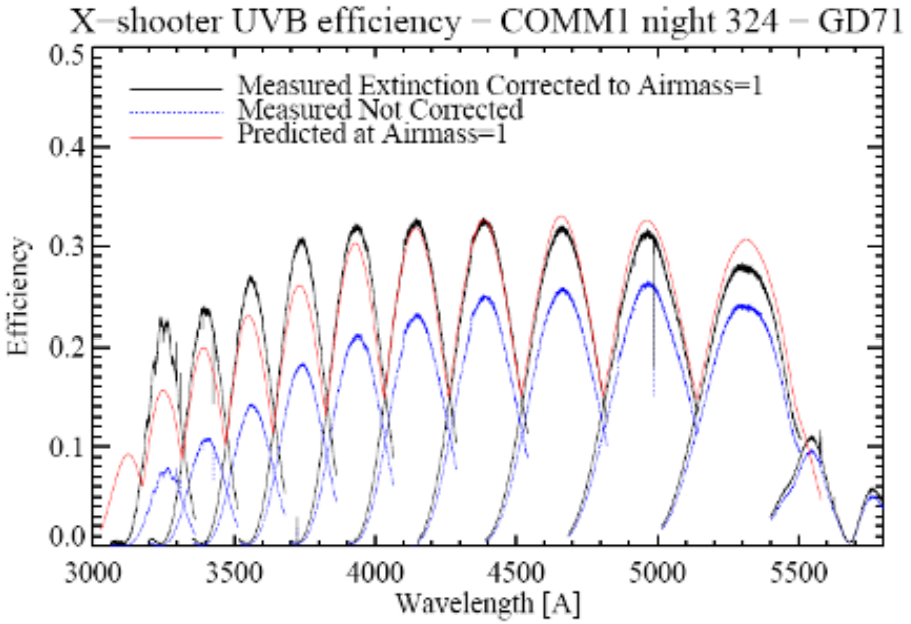
*"… a total of **17 nights**, **no losses due to technical problems or weather**. The overall efficiency and mechanical flexure are in spec. The hardware, software and operational interfaces with the telescope environment (A&G procedures, OBs, flexure compensation system, ADCs, IFU…) all work as expected in line with the desired **"point and shoot"** objectives for this instrument."*

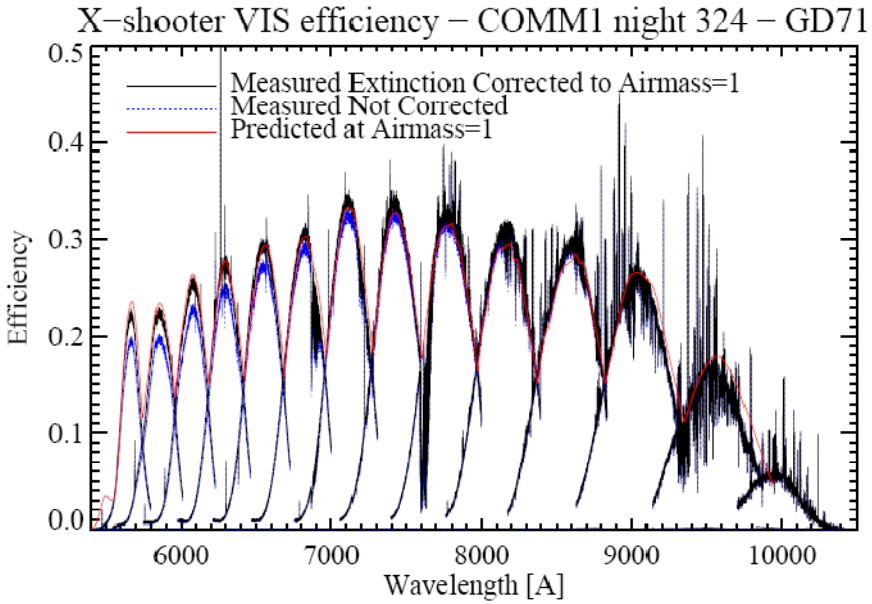
- march 2009 – first light with the full instrument:

Excerpt from a report sent to STC: ***March 14***

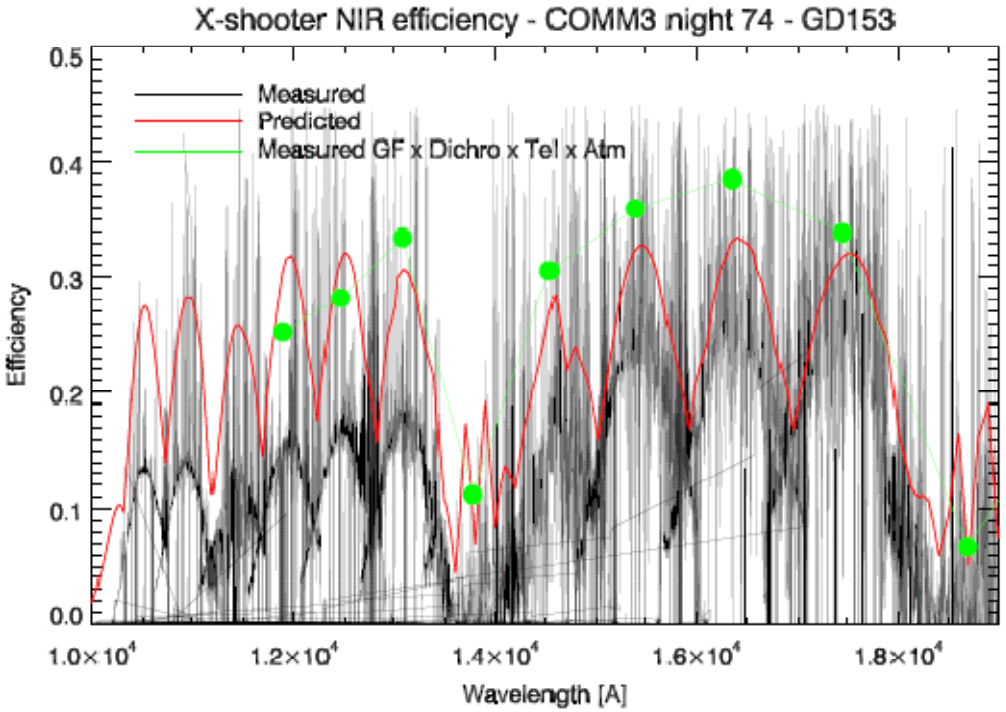
*"… first light was achieved quite smoothly on. Commissioning continued until the morning of March 20 (**6 nights**, of which 0.75 lost due to VLT SW problems not directly related to the instrument and 1.75 due to weather). There were no significant losses due to problems with specific instrument hard- or software. NIR spectral resolution as a function of slit width was verified and found in agreement with predictions. Nodding and sky offset modes mostly used for the on sky observations. On faint targets, integration times of up to 25 minutes were used, also in the NIR. Classical A – B nodding was tested and works very well in the UVB and VIS arms."*

Measured Efficiency UVB/VIS



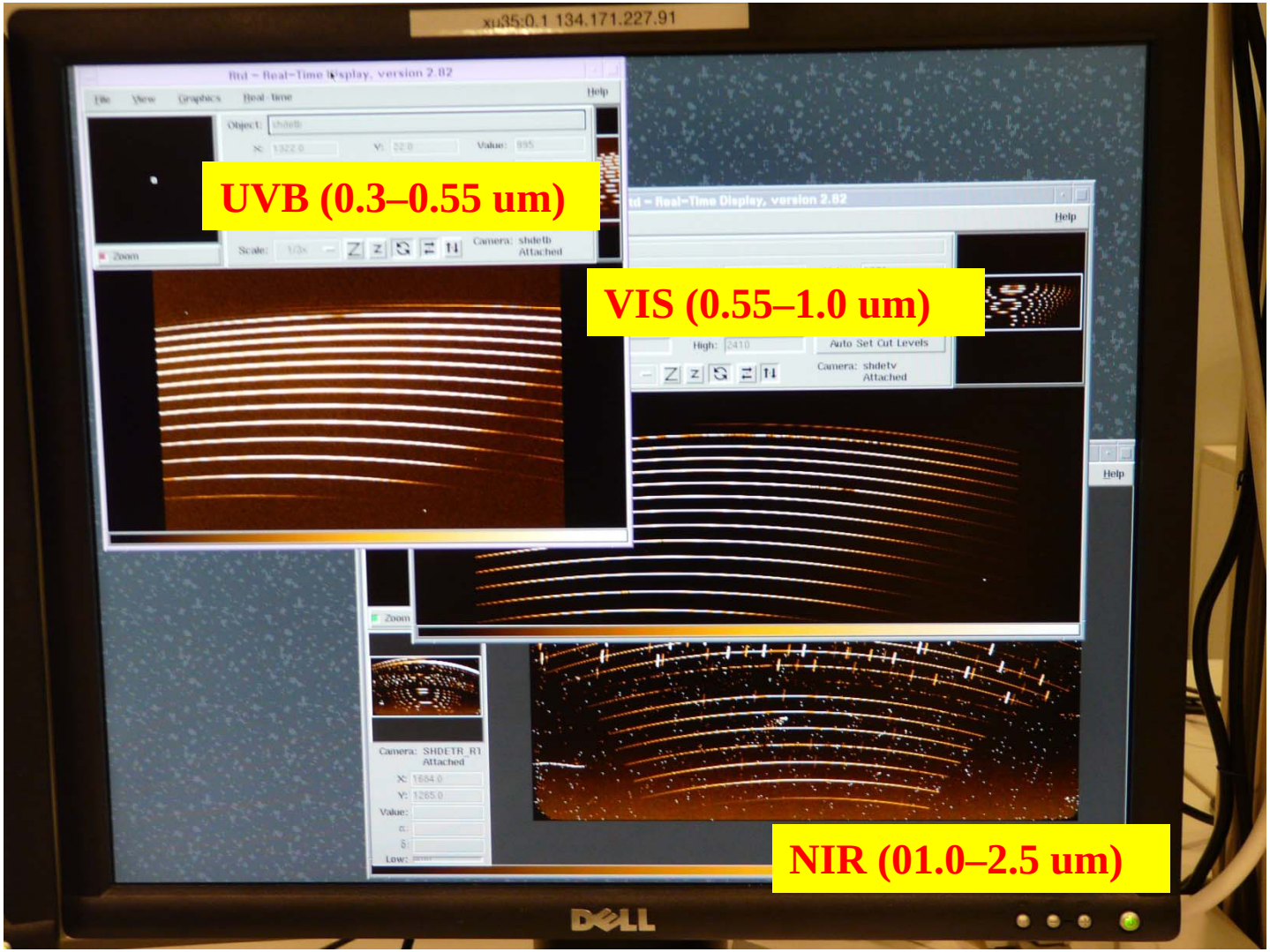


Measured Efficiency NIR

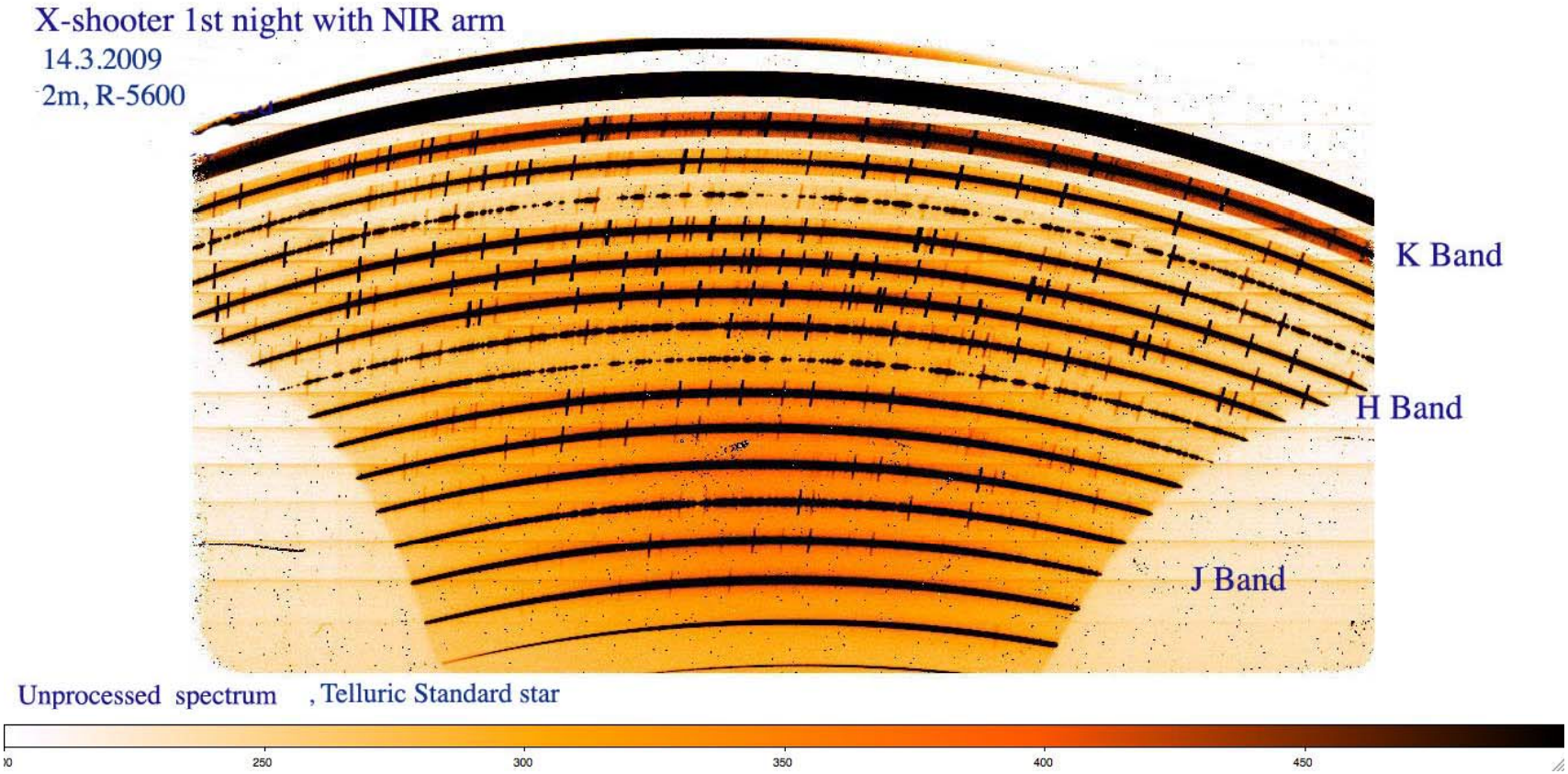


Reduction of the observations of standard stars shows a peak blaze efficiency in U – H band which exceeds or is equal to predictions, except in J band. K band is still being analyzed.

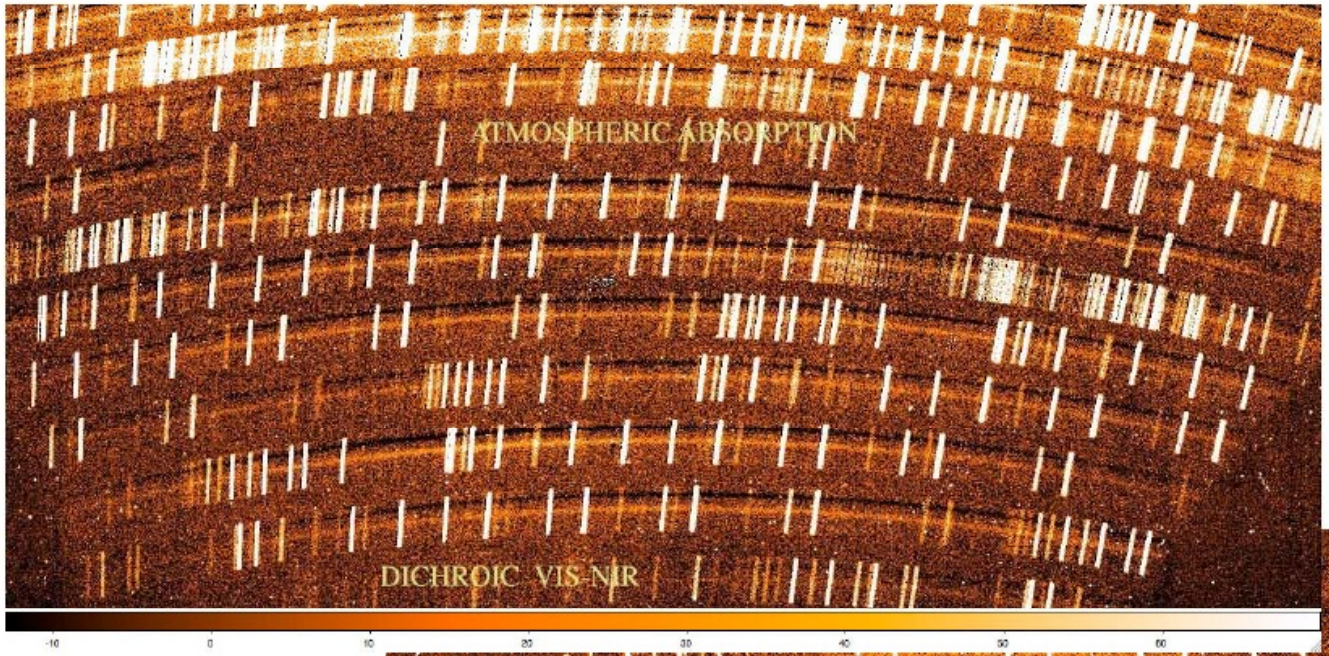
First light 14/03/09 23:22 standard star, 10s



NIR arm J, H, K

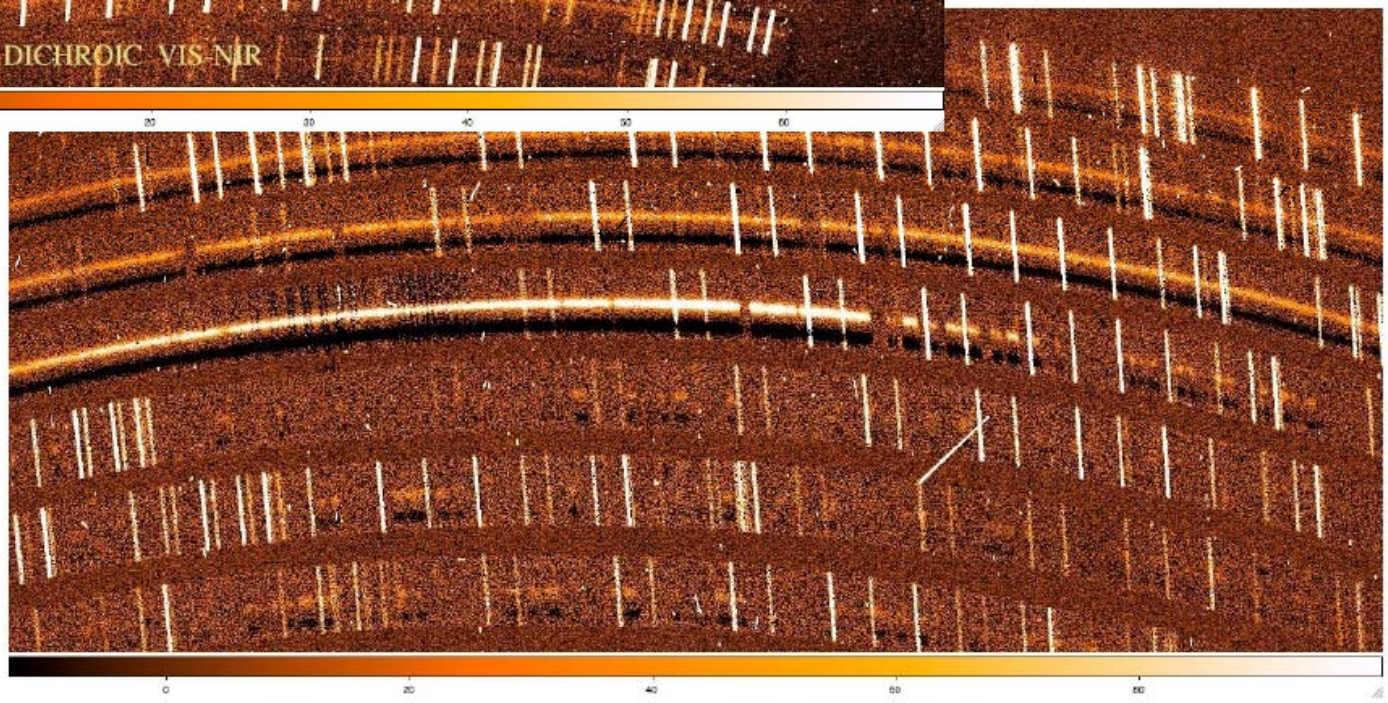

X-shooter 1st night with NIR arm
14.3.2009
2m, R-5600
K Band
H Band
J Band
Unprocessed spectrum , Telluric Standard star
250
300
350
400
450

Observations of faint targets: a QSO at z=6 (2x30m, subtracted one from the other)



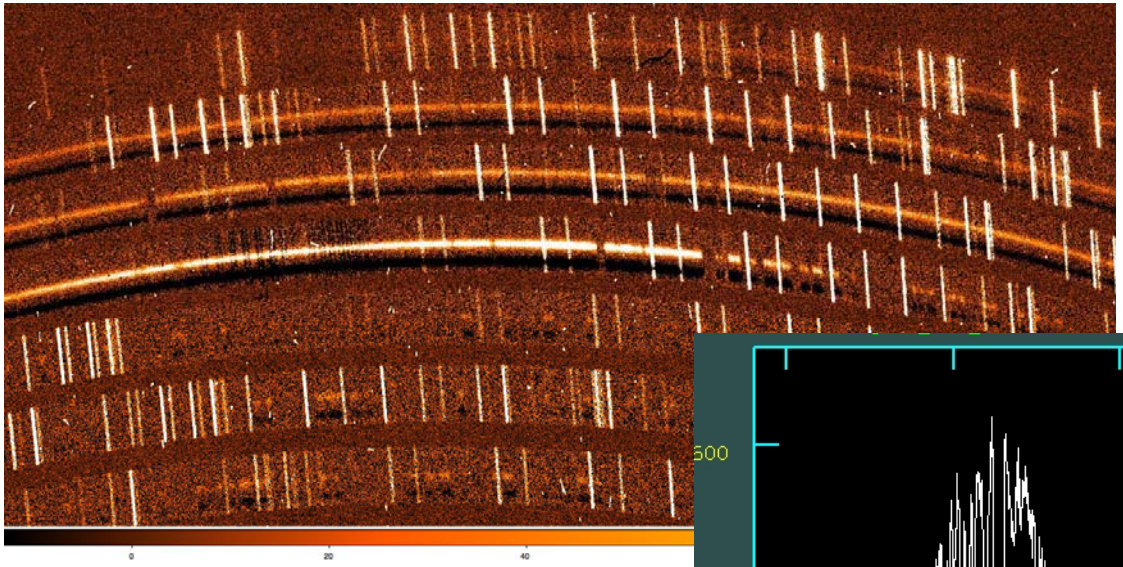
H and J Bands,
R= 5900

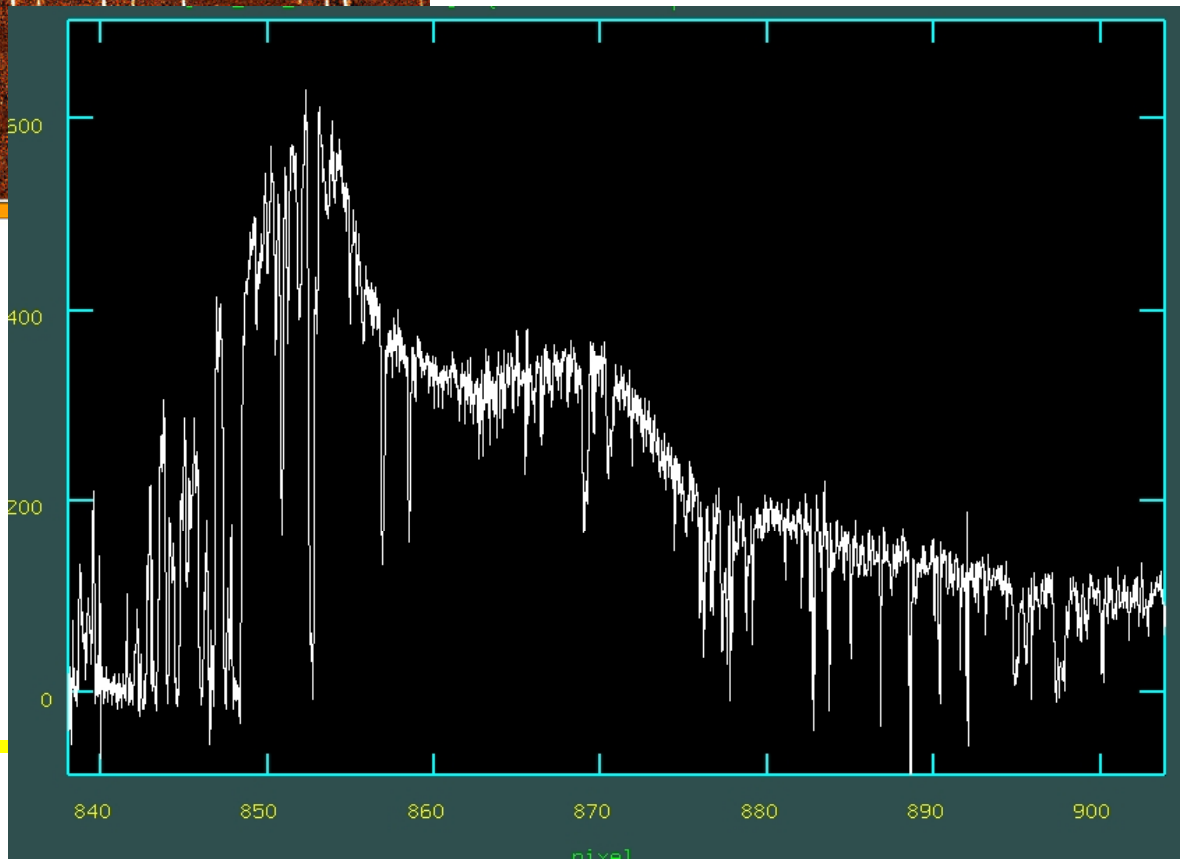
N.B. Residual sky due to intensity variations in the night



VIS-RED above 700nm,
R= 8800

QSO at z=6.016

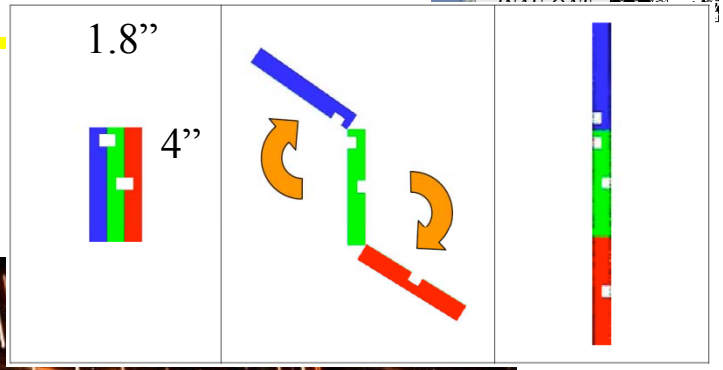


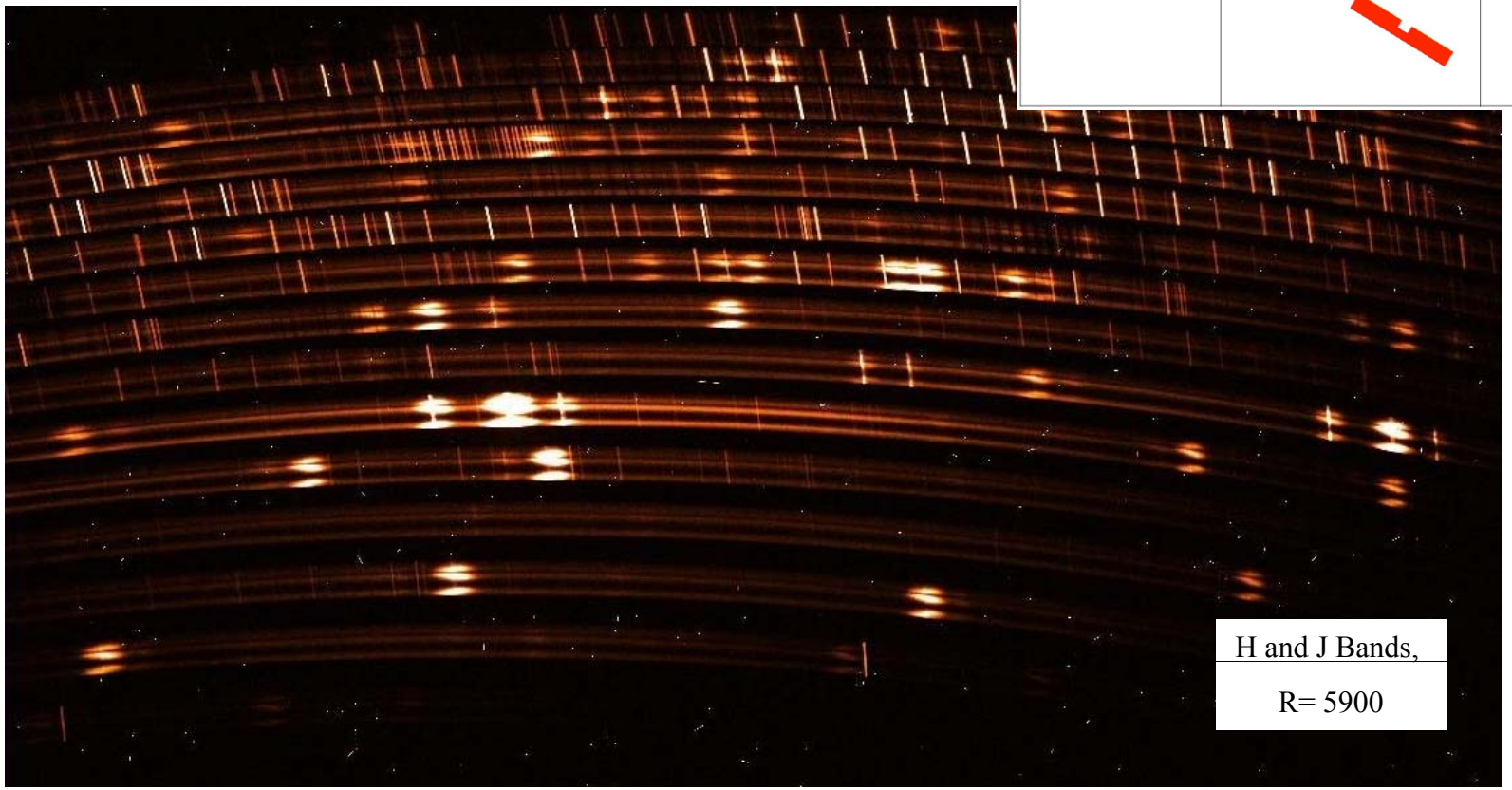


VIS-R above 700nm,

R= 8800

IFU Vis-R spectrum of SN 1987A in the LMC





20min integration, Spectral Range 550-1025 nm, R=12600