VI SCSLSA Sremski Karlovci, Serbia, June 11-15, 2007

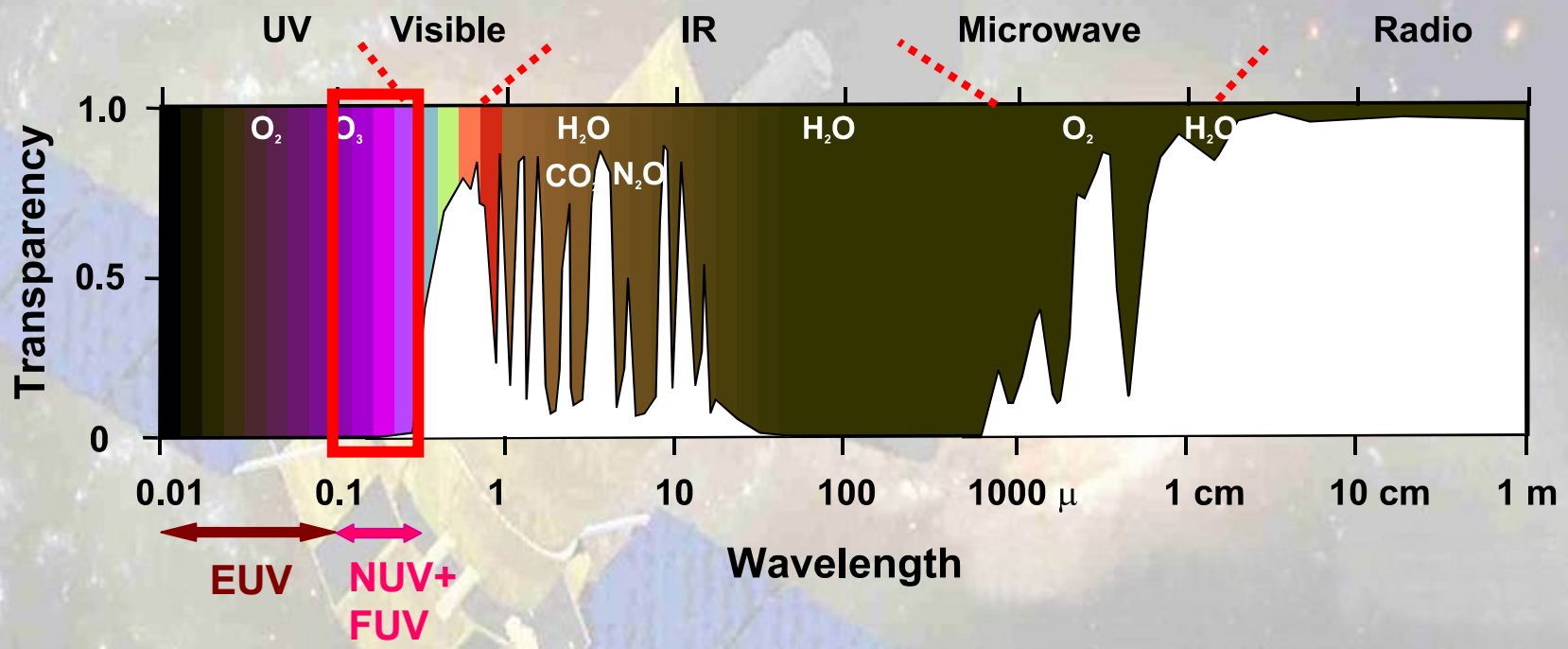
World Space Observatory-UltraViolet

WSO-UV: international space mission for the nearest future

Mikhail Sachkov

on behalf of the WSO-UV team

Transparency of the Earth atmosphere



THE NEED FOR UV SPECTROSCOPY

Most resonance transitions of ions, atoms and molecules of astrophysical importance fall in the UV.

Many objects are being discovered with Galex, high energy missions (XMM-Newton, Swift, Integral) and ground-based surveys requiring UV photometric & spectroscopic follow-ups.

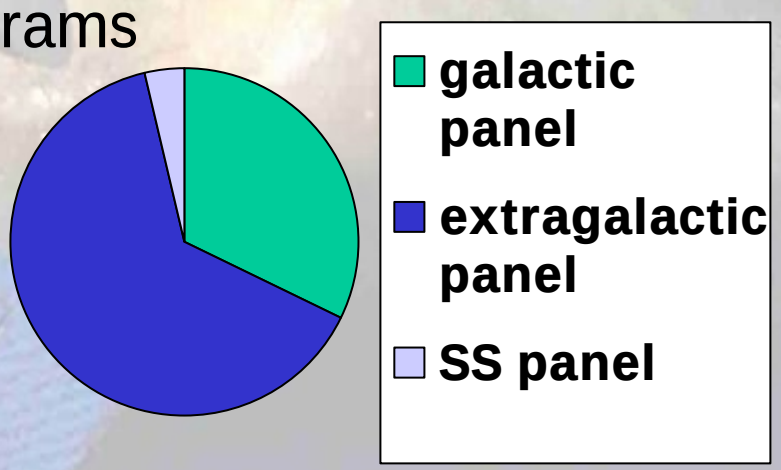
Access to UV spectroscopy limited in time,wavelength and resolution (FUSE (2010), Galex (2007),HST(SM4-2013))

A dedicated UV spectroscopic facility would have enormous impact on new discoveries

Does the Scientific Community request an UV/optical Space Telescope?

- **Cycle 16 HST**: 821 proposals
  - 581 GO, 13501 requested orbits (2000 available)
    OVERSUBSCRIPTION: 7 to 1!!!!
  - 33 LP + 4 Tre., 5272 requested orbits (1000 available)
    OVERSUBSCRIPTION: 5 to 1!!!!

  + 2005 orbits for survey programs
  + 3505 targets for snapshot programs



On the WSO-UV science case

I. The Cosmic Web (history of reionization, search for baryons, SNI as a “standard candle”)

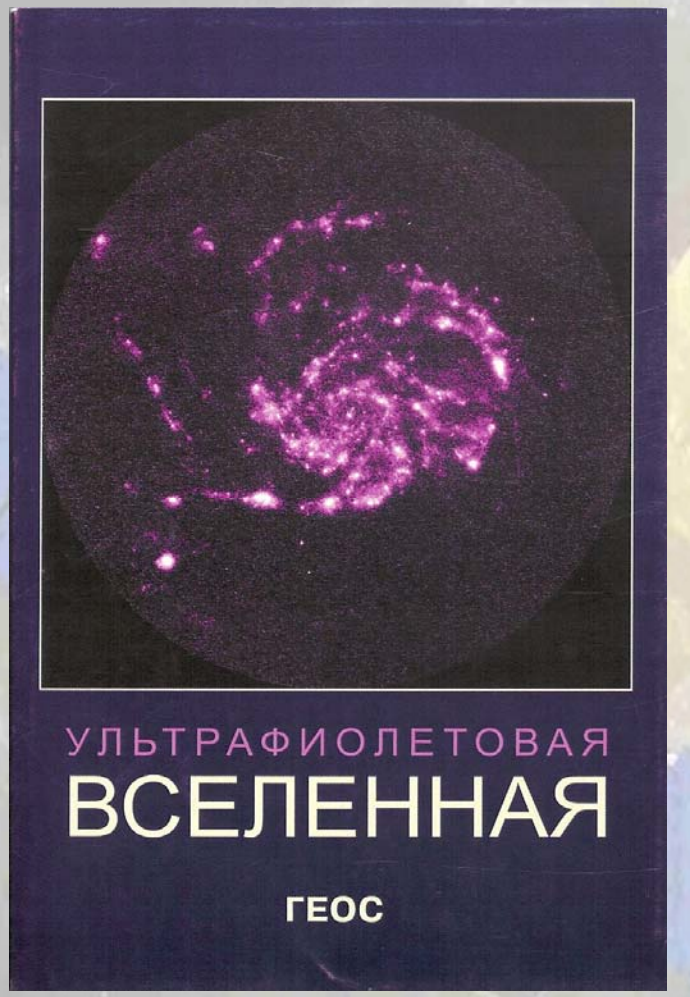
II. Star formation and evolution of galaxies

III. Activity on stars (obs. support of mass transfer theory in CB, physics of WD etc.)

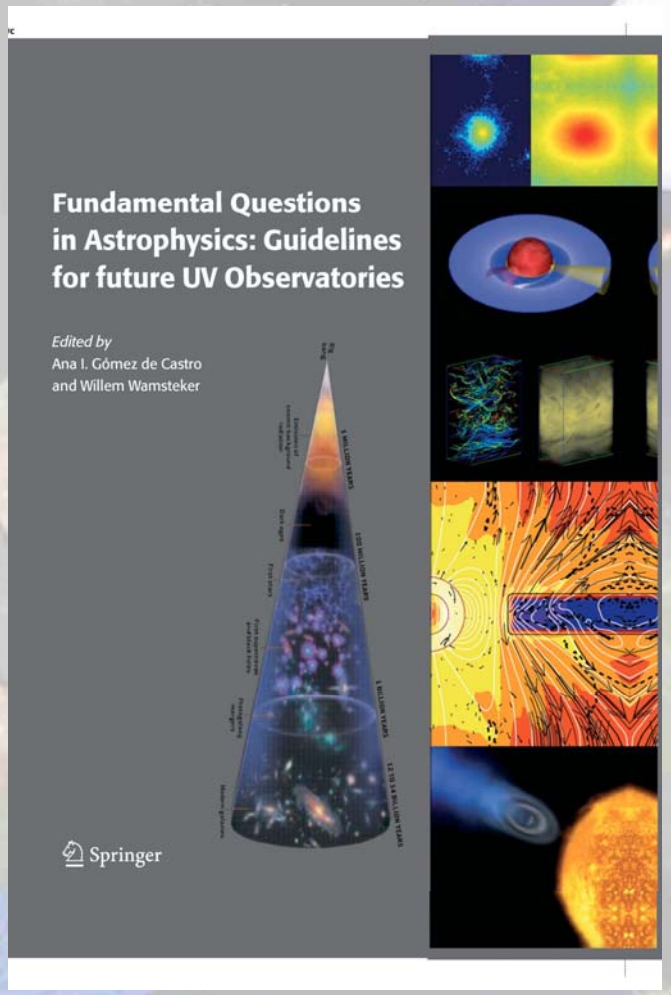
IV. The early evolution of the Sun and its interaction with the young planetary disk

V. Atmospheres of exoplanets

Science with WSO/UV



Ultraviolet Universe, 2001



May, 2006

year

1970

1980

1990

2000

2012

COPERNICUS
IUE
ASTRON

HST

FUSE
GALEX

WSO-UV

The WSO-UV Implementation Committee (WIC)

Argentina	J. Sahade
Baltic-Nordic Countries	P. Hakala
China*	F.-Z. Cheng
Italy *	I. Pagano
France	M. Dennefeld
Germany*	K.Werner, N. Kappelmann
India	J. Murthy
Israel	N. Brosch
The Netherlands	K. A. van der Hucht
Russia*	B.Shustov chair
South Africa	P. Martinez
Spain*	A.I. Gomez de Castro
UK	M. Barstow
Ukraine *	N. Steshenko
UN	H. Haubold

* - official participants

The World Space Observatory in UV (WSO-UV) is the solution to the problem of future access to UV spectroscopy!

WSO-UV is ideally placed, and essential, to provide follow-up studies of the large number of UV sources expected from the GALEX sky survey!

WSO/UV mission model

Telescope: T-170M, *Russia.*

1.7 m diameter, primary λ range 110 - 340 nm,

Spectrographs:

UVES, VUVES, R $\approx$ 5-6 x 10^4; *Germany,*

LSS, R $\approx$ 2500, *China and cooperation (UK, Germany, Ukraine, Russia..).*

Imaging: FCU, *Italy*

to be specified. What is expected:

primary λ range 110 - 340 nm, 2 UV Imagers: one for max. spatial resolution (~ 0.1 arcsec); one for max. sensitivity; and one Imager for visual domain

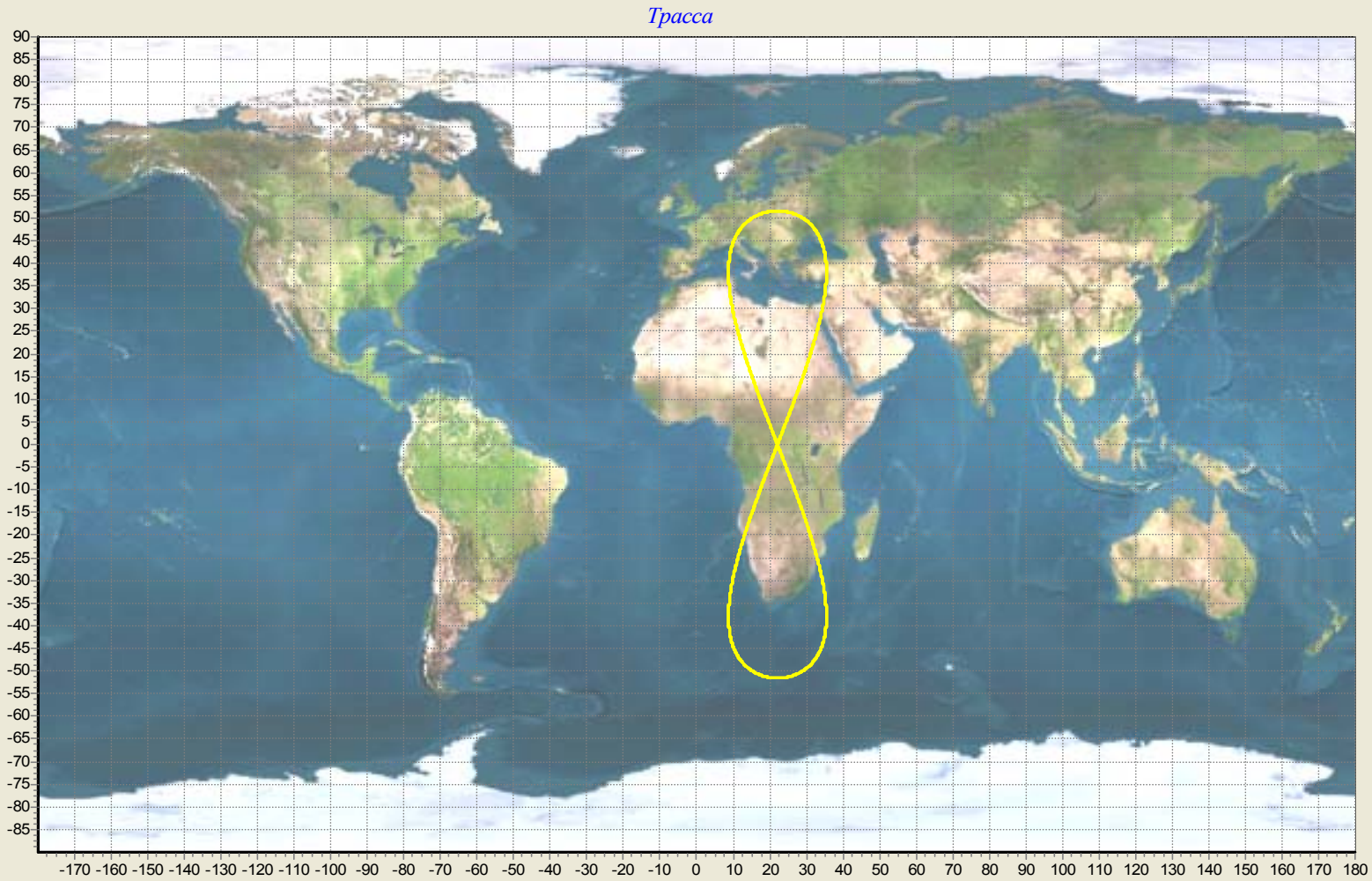
Platform: "Navigator", *Russia*

Orbit: geosynchronous one, i=51.8^o

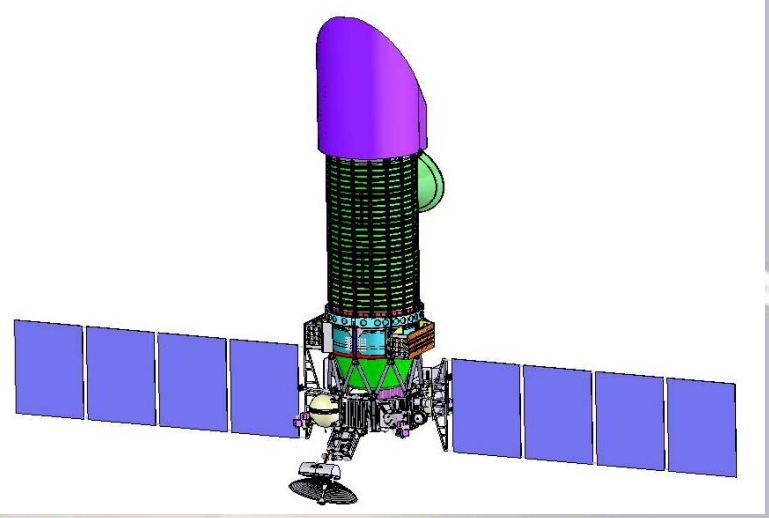
Launcher, launch: "ZENIT SB", Russia

Ground Segment: *Russia, Spain (contributions from Italy, China, Ukraine,South Africa … are being considered)*

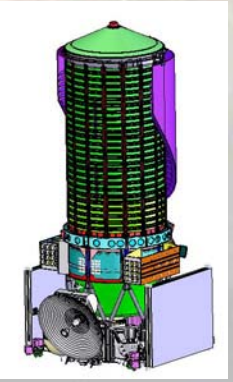
WSO-UV orbit (a variant of geosynchronous orbit, *i*=51.8°)



"WSO/UV" Spacecraft



•Life time	≥ 5 years
•Spacecraft mass with propellant, kg	2900
•Payload mass, kg	1600
•The SIC power consumption, W	750
•Data transmission rate, megabit/sec	≥2
• Stabilization and pointing accuracy using the FGS data	0,1″



WSO-UV in the world (participants supported by national agencies)

- ***China***
  CNSA and CAS decided to participate in LSS (as responsible partner for the LSS) and consider participation in GS. Phase A/B1 of the LSS is planned to be finished in October 2007.

- ***Germany***
  DLR is waiting for progress with other instruments. HIRDES Phase B1 is successfully completed in 2006 (Instrument Interface Control Document - by Kayser-Threde Co.).

- ***Italy***
  Decision of ASI to participate in the Project is made September 2006. Phase A/B1 of the FCU is planned to be finished in November 2007.

- ***Spain***
  CDTI has compromised to co-fund (with ROSCOSMOS) the development of the whole Ground Segment/MOC/SOC. Phase A of the GS is planned to be finished in 2007.

WSO-UV in Russia

- WSO-UV (also local name Spectrum-UV is used) Project is considered by Roscosmos and by the RAS as one of the key projects in space science program.
- The project is included in the Federal Space Program of Russia for 2006-2015 with launch date 2010.
- Funding is realistic.

WSO-UV in Russia

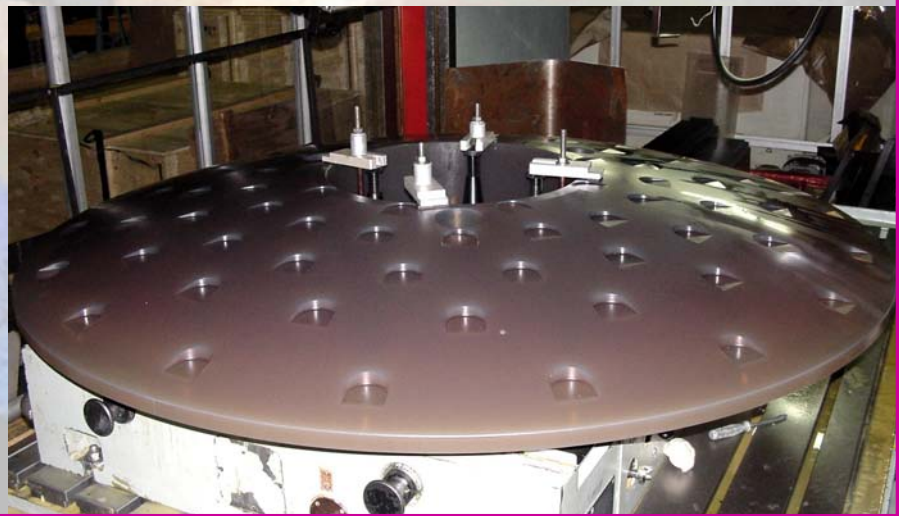
(ctd.)

- Telescope T-170M is being designed/manufactured.
- Platform “Navigator” is designed and mock-up are under tests. The first launch: 2007 («Spectrum-R» and «Electro» Projects).
- GS (Russian centers) are under design.

In Lavochkin Association, Russia

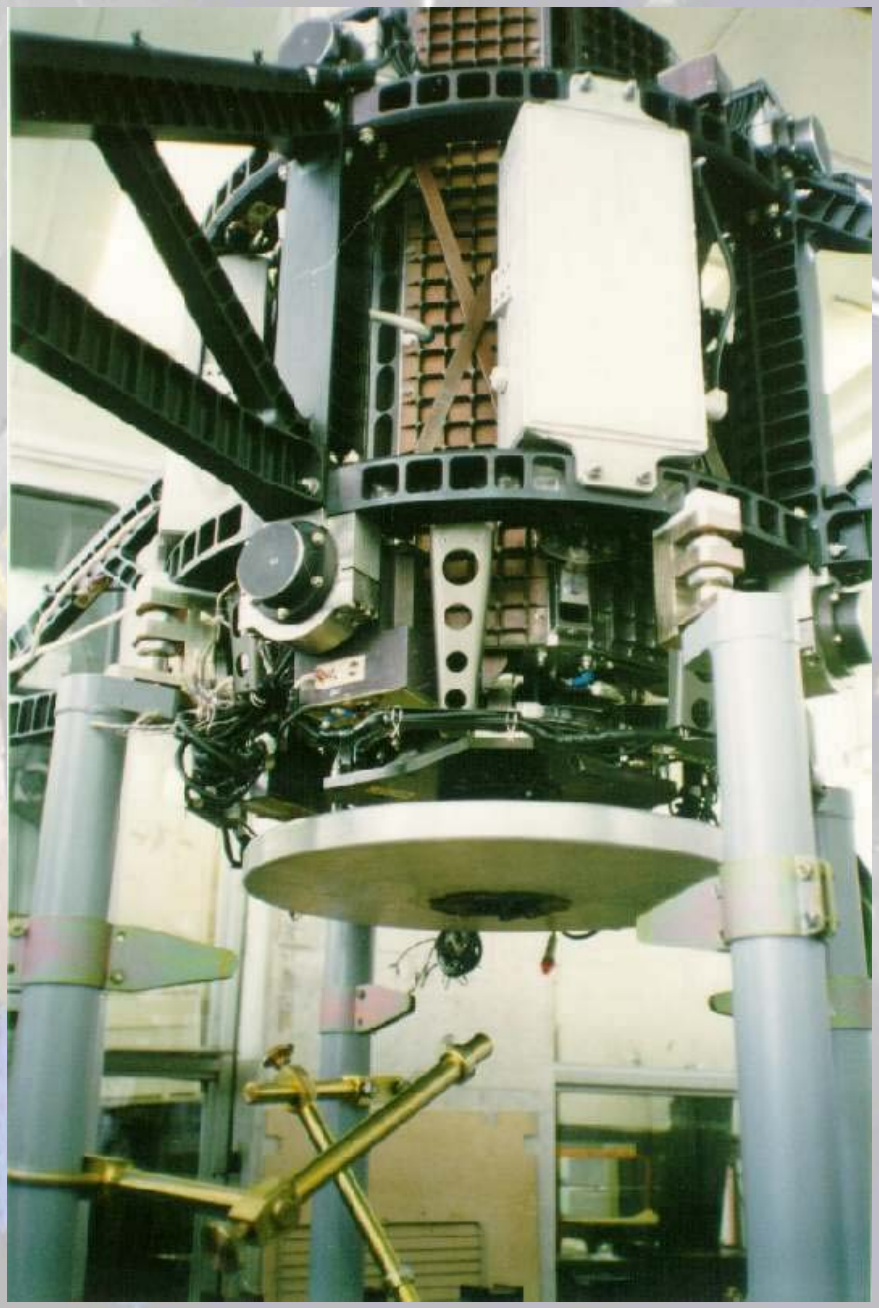
T-170 Telescope in assembly room of the Lavochkin Association (Moscow)

Primary mirror mock-up



WSO - UV

Assembly of the engineering mock-up of the Secondary Mirror Unit (SMU) of the T-170 Telescope in the «Voskhod» Science and Technology Center (Izhevsk, Russia)

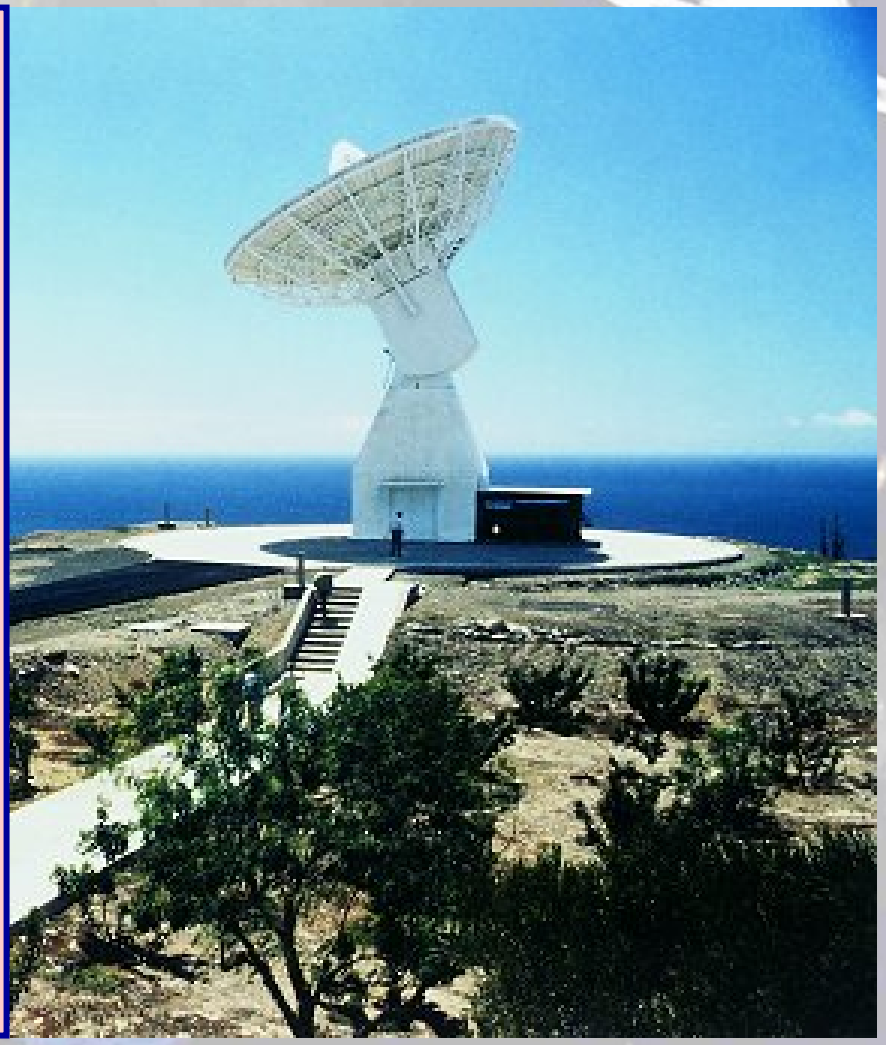


On the cooperation in the field of Ground Segment for WSO/UV

- Ground Stations from Spain, Russia (and South Africa) have to be involved.

15m antenna at Maspalomas

- Reception:
  - L (1.65 - 1.75) swap feed
  - S (2.2 - 2.3), G/T = 19dB/k
  - X (8.0 - 8.4), G/T = 30dB/k
- Uplink
  - S band (2.0 – 2.4GHz), EIRP of 66dBW
- Three axis: 10deg/s,
- Program and Autotrack
- Usage: EOS reception, TT&C



10m antenna at SAC

- Reception:
  - L (1.65 - 1.75) swap feed
  - S (2.2 - 2.3), G/T = 19dB/k
  - X (8.0 - 8.4), G/T = 30dB/k
- Uplink
  - S band (2.0 – 2.4GHz), EIRP of 66dBW
- Three axis: 10deg/s,
- Program and Autotrack
- Usage: EOS reception, TT&C

MLD-1 Station

- 10 m antenna
  - L, S, X – receive
  - S band - transmit
  - Tracking channels (in the three bands).
  - Receiving systems.
  - Uplink System in S Band (Telecommand and Ranging)
  - Transmitting System.
  - Data processing Systems.
  - Recording systems.
  - Frequency and Timing System.
  - Monitor and Control System.

WSO - UV

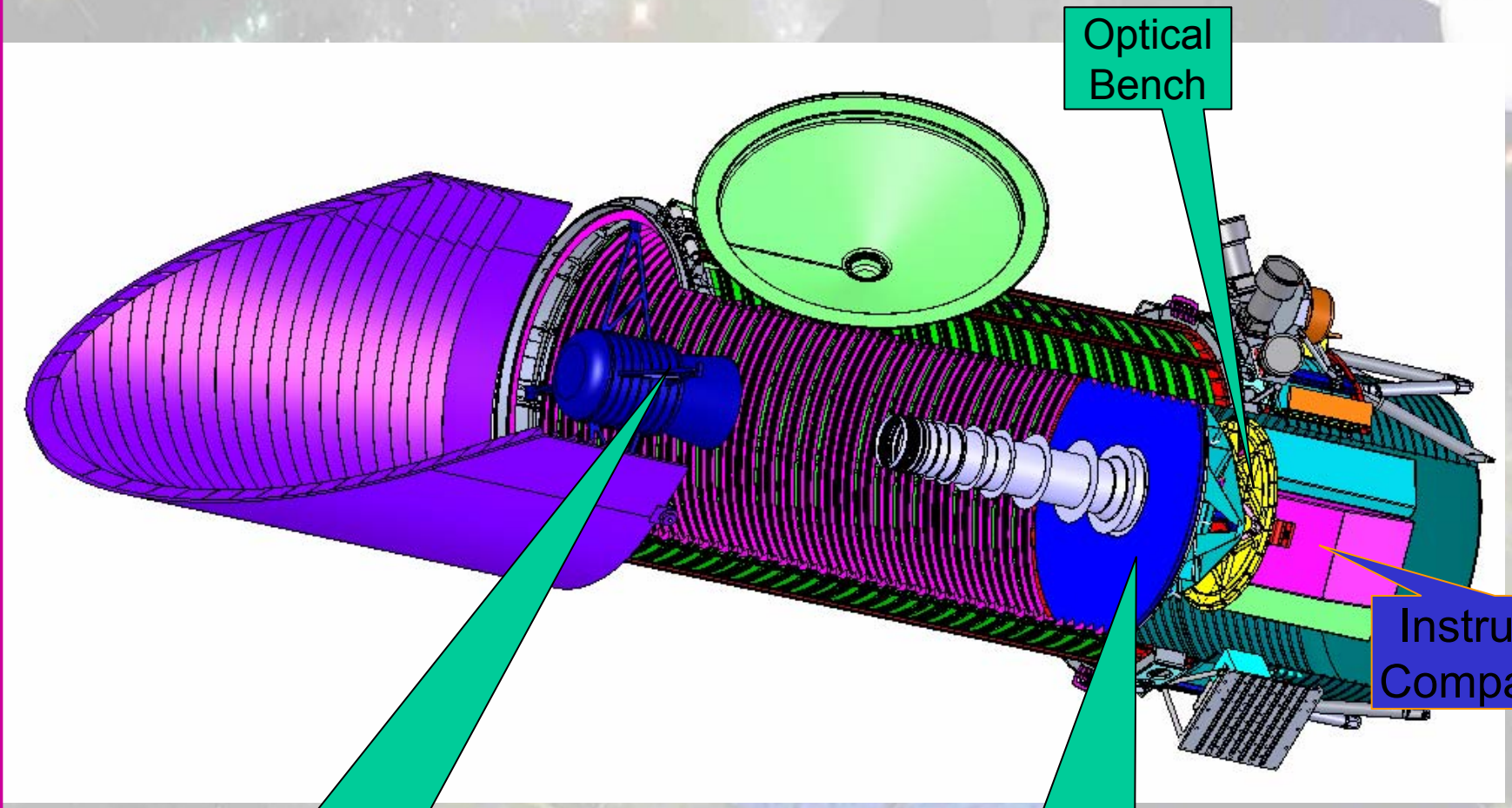
Комплекс П-2500 в Евпатории

Комплекс П-2500 в Уссурийске

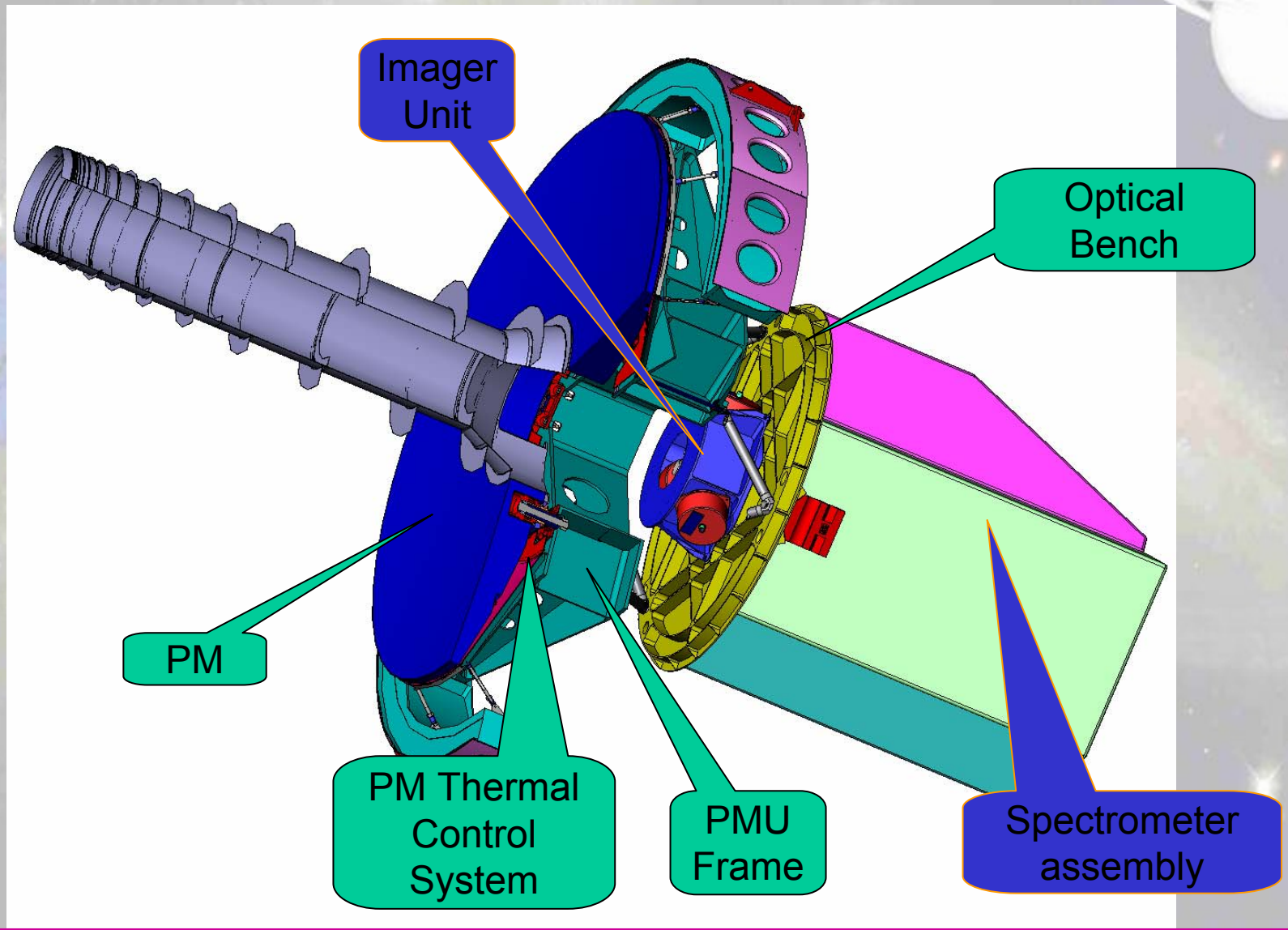
Cooperation on WSO/UV GS: State of art

- Ground Segment Working Group was set up at the WIC meeting in Moscow (June 2006).
- Mission Operation Center(s) is(are) considered to be created jointly by Russia and Spain as it stays in the agreement Roscomos-CDTI, that was signed in February 2007.

T-170M Telescope



Zooming ….
The Instruments Compartment



The focal-plane instruments on board WSO-UV

WSO-UV Payload

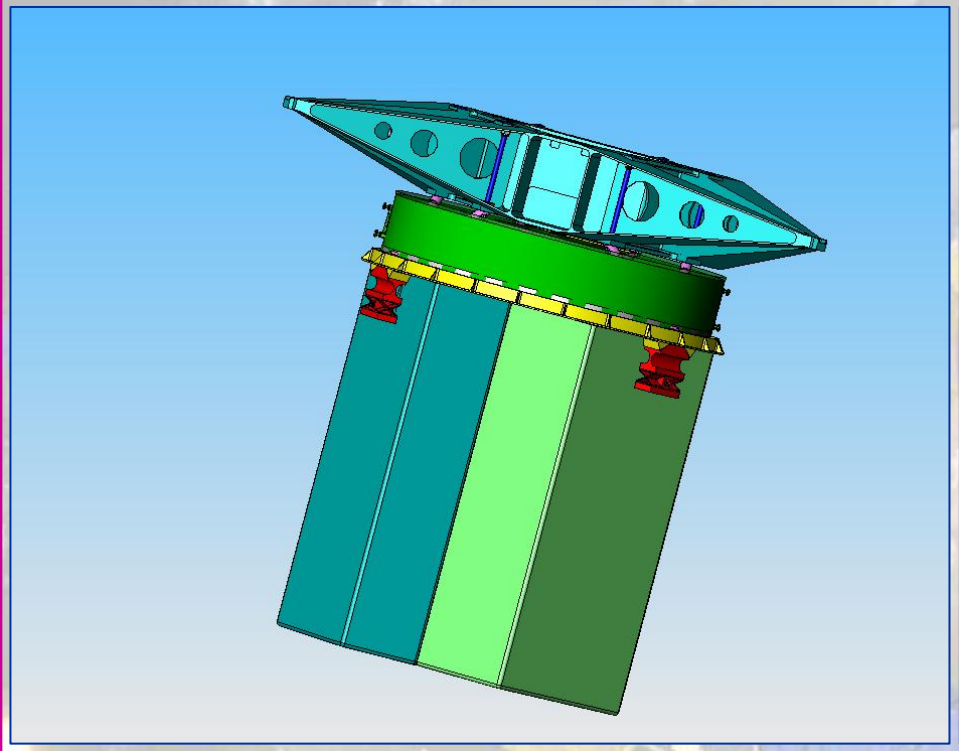
- **HIRDES**: **R~50,000** echelle spectrographs:
  - **UVES** (178-320nm)
  - **VUVES** (102-180nm)

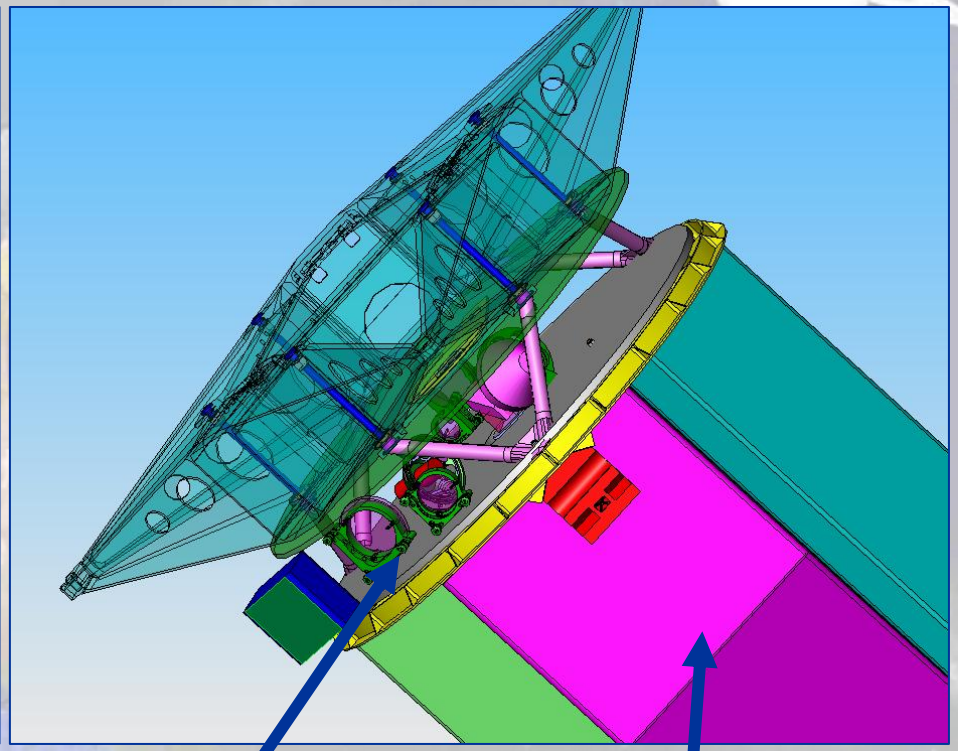
- **LSS**: 102- 320 nm, **R~1500–2500** long slit (1x75 arcsec) spectrograph

- **FCU**: 3 imaging cameras:
  - **FUV** : scale=0.20 "/px; FoV= 6.6x6.6 arcmin^2
  - **NUV** : scale=0.03 "/px; FoV= 1.0x1.0 arcmin^2
  - **UVO** : scale=0.07 "/px; FoV= 4.6x4.6 arcmin^2

- ***FGS***: Fine Guidance System (3 sensors 1kx1k)

The Instruments Compartment …. other views





WSO-UV Hi-Res Spectrographs

- **HIRDES**
  High Resolution Double Echelle Spectrograph

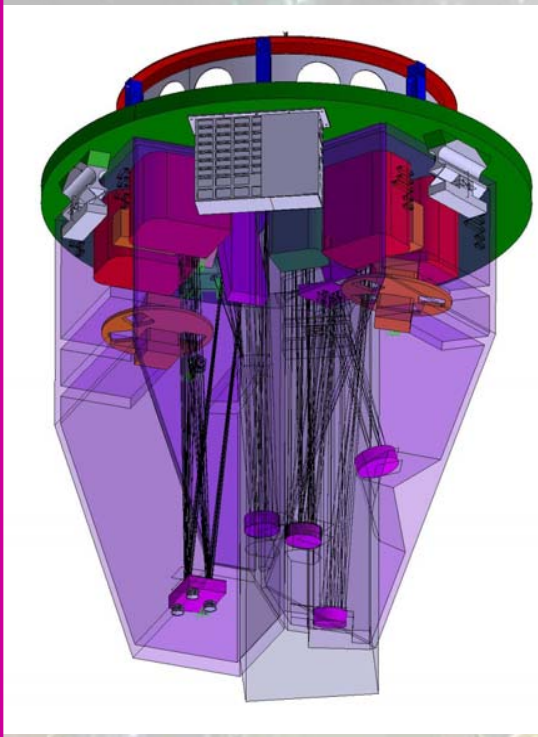
Funding Agency: DLR
Science Contractor: Universität Tübingen, Institut für Astronomie und Astrophysik
Industry Contractor: Kayser Threde
Principal Investigator: Prof. Dr. Klaus Werner
Instrument Scientist: Dr. Norbert Kappelmann

Heritage:

ORFEUS flown on the Space Shuttle on two space shuttle flights in 1993 and 1996 (Barnstedt et al. 1999, Richter et al. 1999).

HIRDES

STATUS: *end of Phase B1 study*



Parameter	Baseline Requirements
Wavelength coverage • UV Spectrograph • VUV Spectrograph	 174-310 nm 102-176 nm
Spectral Resolution	> 48000
Simultaneous coverage	As far as possible
Minimum sensitivity • SNR= 10 in 10 h • SNR= 100 in 10 h	 16 mag (VUVES); 18 (UVES) 11 mag (VUVES); 13 (UVES)
Detectors	MCPs
Limit loads in all axes w/o SF	15 g (tbc)
Stiffness (first fundamental eigenfrequency)	> 40 Hz (tbc)
Operational temperature	20 °C +/- 1°C (tbc)
Transmission	> 60 % (300 nm) -tbc > 30 % (100 nm) -tbc
Envelope	1080 x 920 x 670 mm^3
Mass	155 kg - tbd
Power	150 W – tbd
Data Rate (raw data/downlink)	Tbd / 1.6 Mbit/sec

WSO-UV Low-Res Spectrograph

- **LSS**
  Long Slit Spectrograph

Funding Agency: CNAS
Science Contractor: National Astronomical Observatories of China Academy of Science (NAOC)
Industry Contractor: to be selected
Principal Investigator: Prof. Gang Zhao

STATUS: ***Phase A/B1 in progress***

LSS Spectrograph

Parameter	Requirements
Wavelength coverage – FUV channel – NUV channel	 102~190 nm (1 or 2 subchannels) 190~320 nm
Width of slit	1″ ≈ 82 μm
Length of slit	75″ ≈ 6.2 mm
Spectral resolution	1500~2500
Spatial resolution	0.5”~1”
Detectors	MCPs

WSO-UV Imagers

- **FCU**
  Field Camera Unit *(new name coming soon!!!)*

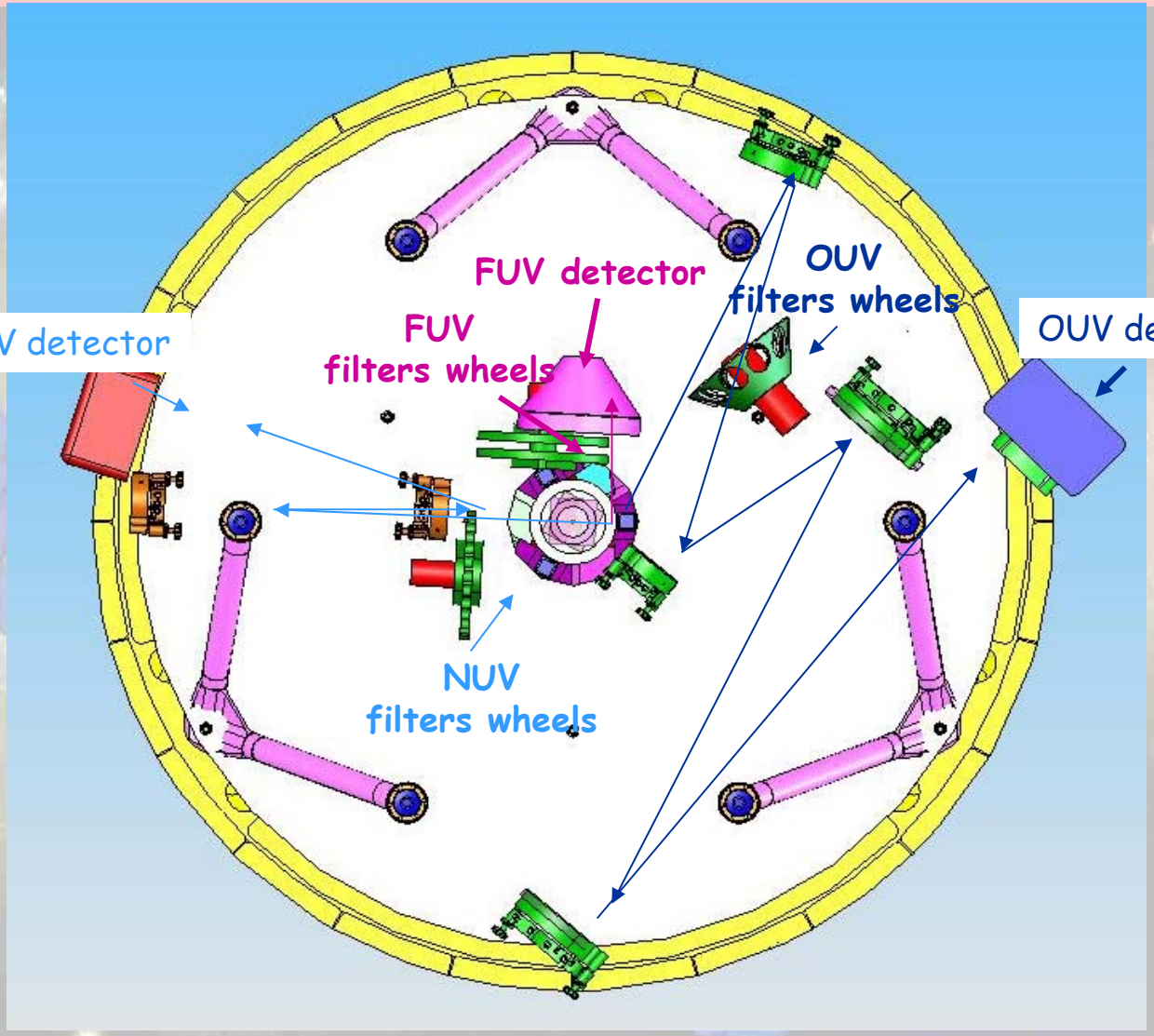
Funding Agency: ASI
Science Contractor: Istituto Nazionale di Astrofisica (INAF)
Industry Contractor: to be selected
Principal Investigator: Dr. Isabella Pagano

STATUS: ***Phase A/B1 in progress***

WSO-UV Imagers

- Criteria:
- Large wavelength coverage (115-700nm)
- Large field of view
- High spatial resolution; this is mandatory to:
  - Morphological studies (e.g. planets, planetary nebulae, star formation regions, external galaxies)
  - High accuracy stellar photometry
  - High accuracy stellar astrometry
  - Resolve stars in crowded fields (e.g. in star clusters, external galaxies, star formation in AGNs)

Opto-Mechanical layout



Science with the WSO-UV

- CORE PROGRAM
- FUNDING BODIES PROGRAMS
- OPEN TIME for the International Community

-CORE PROGRAM-

Discovery or long heritage projects focused on the unique capabilities of WSO/UV:

- R=50,000 with very high sensitivity
- HiRES FUV imaging

To be carried out during the first 2 years of the project.

SCIENCE APPLICATIONS with UV SPECTROSCOPY

Cool Stars & Stellar Magnetic Activity

Accretion & Outflow Processes

Stellar Populations

Galaxies and AGNs

SNe as Tracers of Universe Structure and Chemical Evolution

http://wso.inasan.ru and links therein