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WSO-UV: THE NEXT SPACE TELESCOPE FOR ULTRAVIOLET ASTRONOMY

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I. Why an UV telescope?

- Richness of experimental data for the study of ***plasma with temperatures in between 3,000K and 300,000K***.
  - unmatched by any other domain

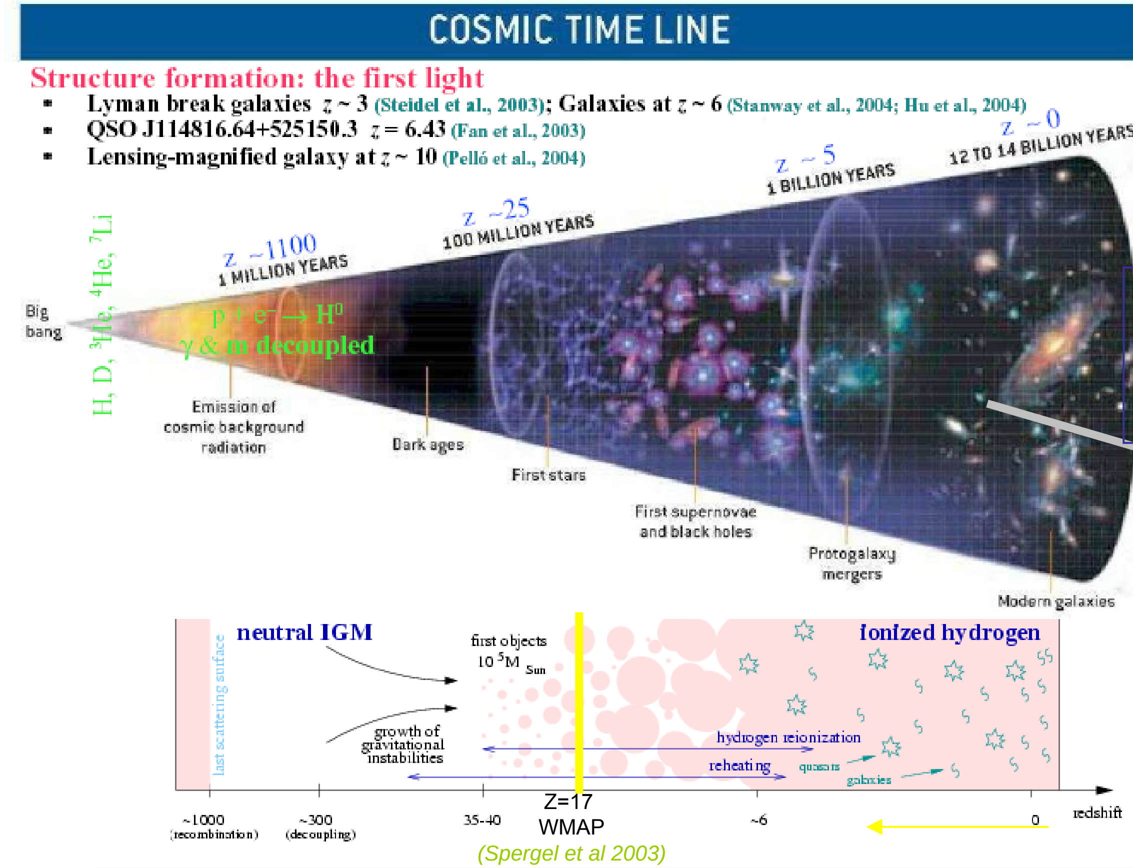
- ***Electronic transitions of the most abundant molecules***, observed in this range
  - E.g. H_2, OH, or CO: also the most sensitive to the presence of large molecules such as the PAHs.

- Most sensitive spectral tracers to ***diffuse baryonic matter***
  - HI Lyα in the nearby Universe and HeII Lyα at 2<z<9

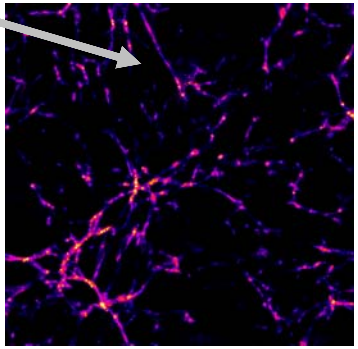
  - **Lyα 0<z<1.8 … about 80% of the Universe life**

WSO - UV

I. Why to trace ….
…the Universe Evolution?



***The Cosmic Web*: Chemical & Structural Evolution**



***Surveys:* SLOAN (10^5 QSOs z~2-4), GALEX(10^4 QSOs z~2)**

He II reionization phase ends at z=2.9 (Reimers, 1997)

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UV astronomy is Space astronomy

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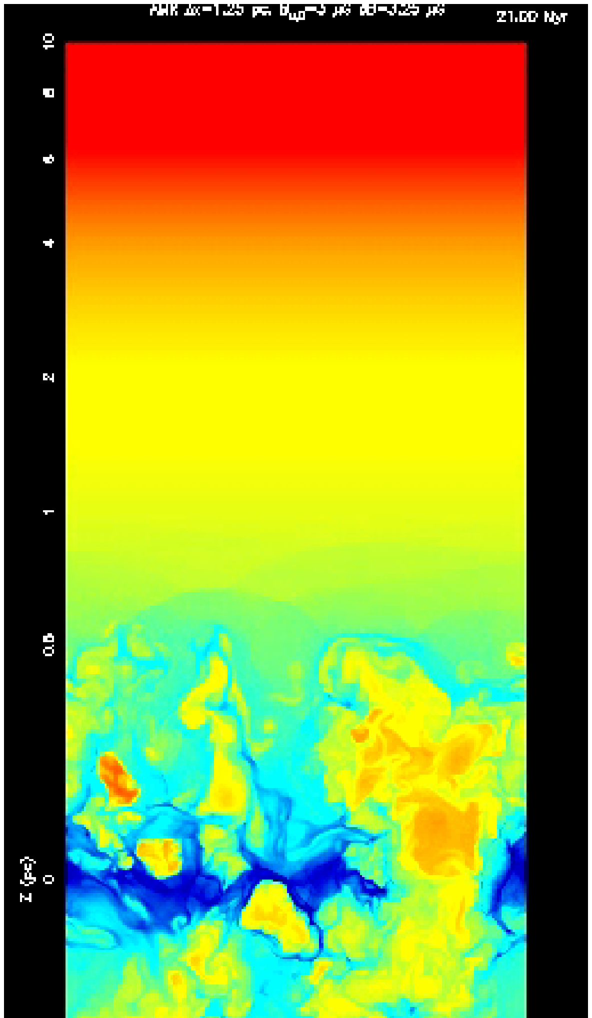


Z=0-1.5 Major epoch of galaxy assembly and metal production

Galactic winds enrich the IGM

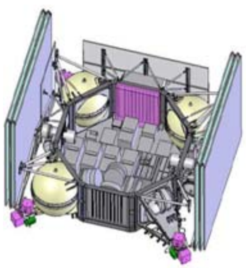
Numerical simulations show that IGM gas is distributed:

1. *Warm photoionized gas (10^4 K)*
2. *Warm/hot shocked gas (10^{5-7} K)*
3. *Collapsed halos, galaxies, and clusters (T > 10^7 K).*

UV lines are 500-1000 times more sensitive than their x-ray counterparts.

Numerical simulations of the galactic fountain D’Avillez et al 2008

II. The WSO-UV telescope



Telescope: T-170M, Russia
1.7 m diameter, primary λ range 110 - 340 nm,

Instruments:
HIRDES: UVES, VUVES, R $\approx$ 5-6 x 10^4; Germany
LSS, R $\approx$ 2500, China and cooperation (UK,G,Uk,Ru)
ISSIS, 2 imagers Spain

Platform: “Navigator”, Russia

Orbit: geosynchronous one, i=51.8^o

Launcher, launch: “ZENIT SB”, Russia

Ground Segment: Russia, Spain – shared mission and science operations (50%-50%)

II. The WSO-UV telescope

T-170 assembly room

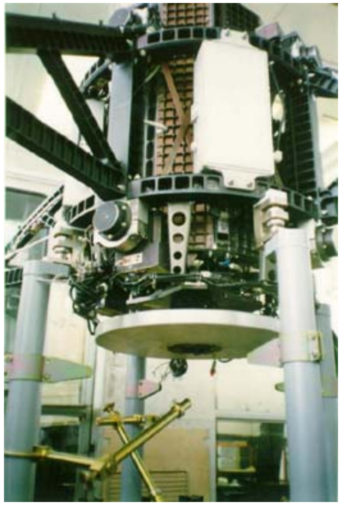
Primary mirror mock-up

Telescope T-170M is being designed/manufactured in the Lavochkin Association (Russia)

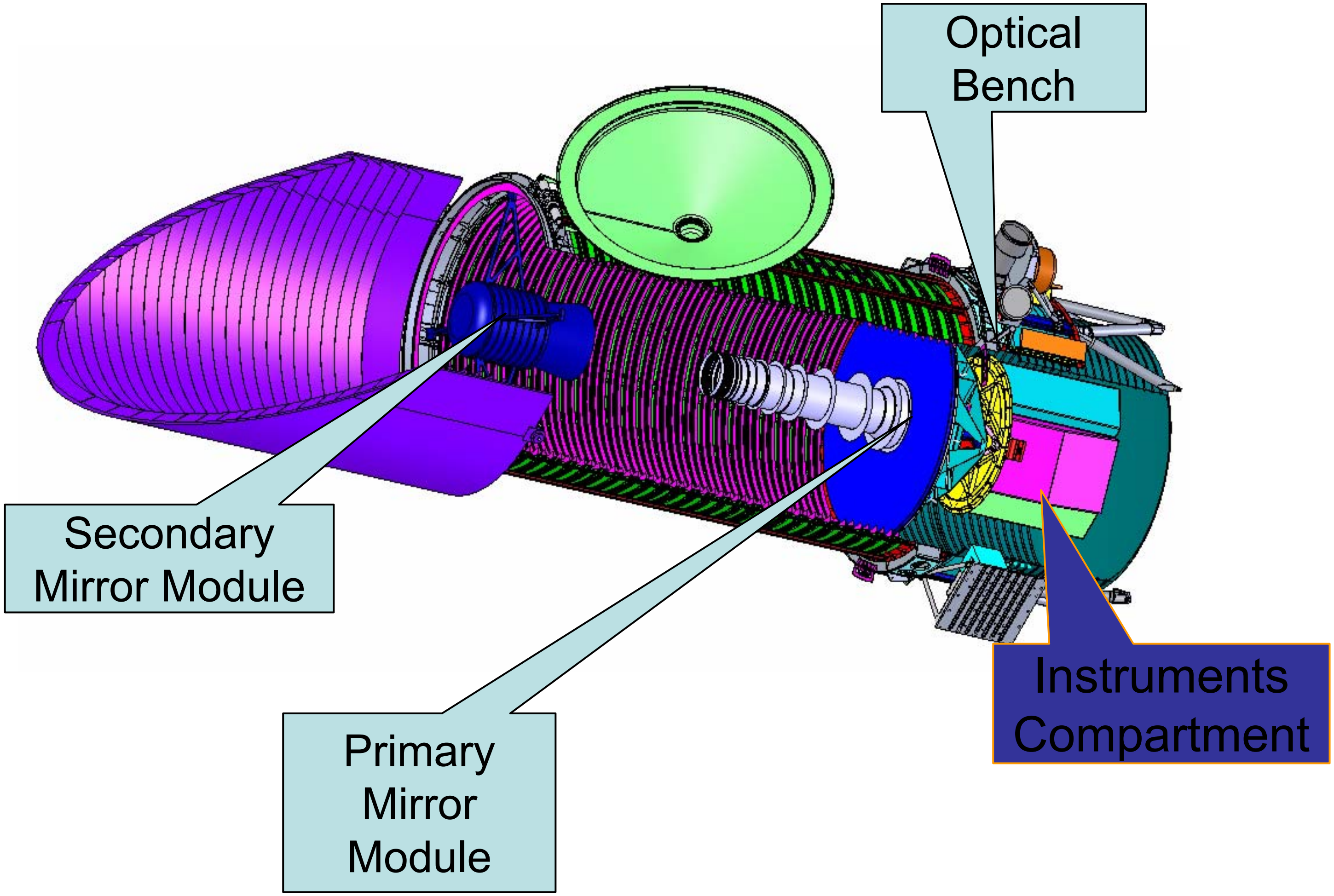
Ritchey-Chretien F/10 with corrected field of view 0.5^{o}

Coating optimized for the primary wavelength range: 100-350 nm

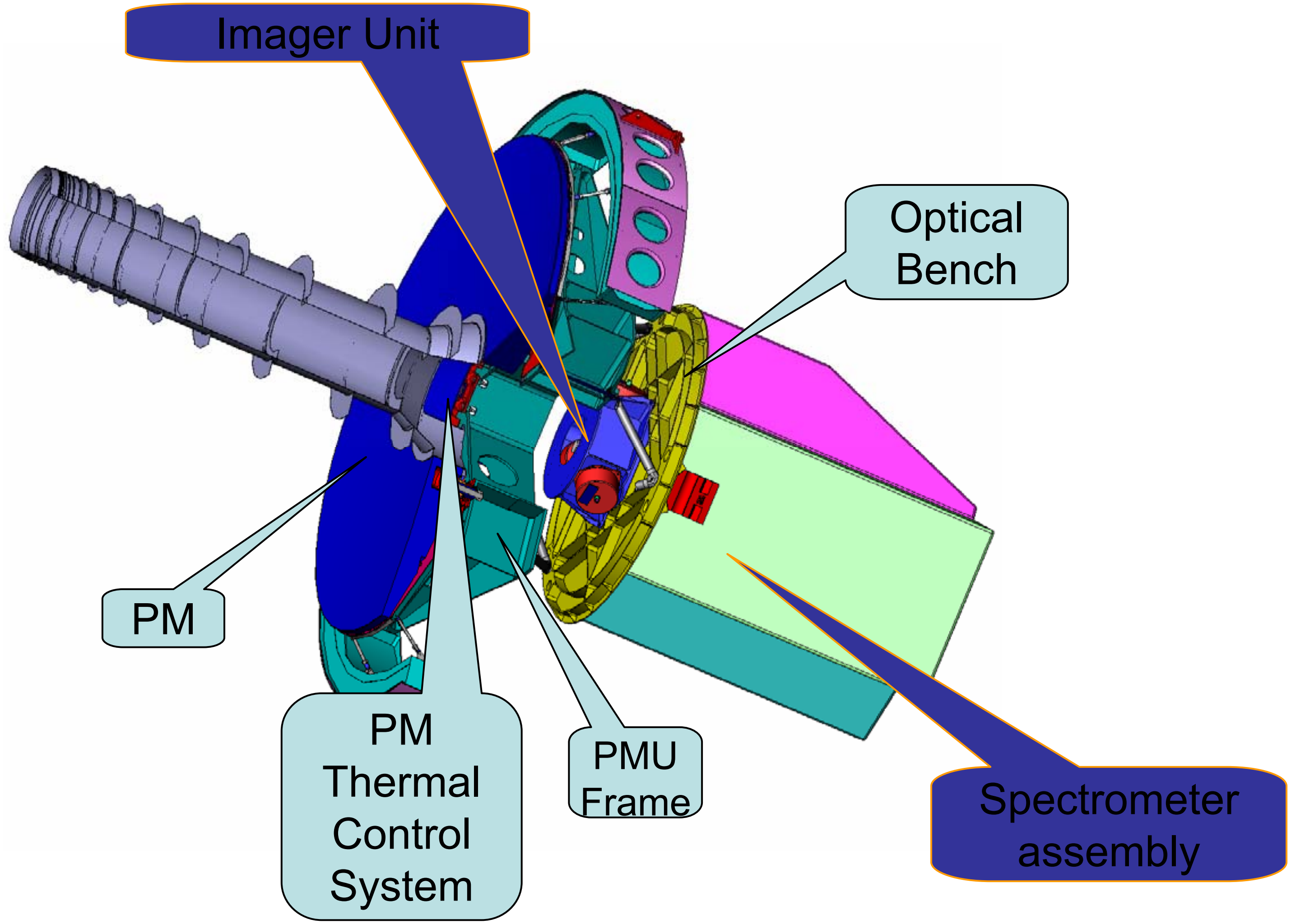
Assembly of the engineering mock-up of the Secondary Mirror Unit (SMU) of the T-170 Telescope in the «Voskhod» Science and Technology Center(Izhevsk, Russia)



II. The WSO-UV telescope

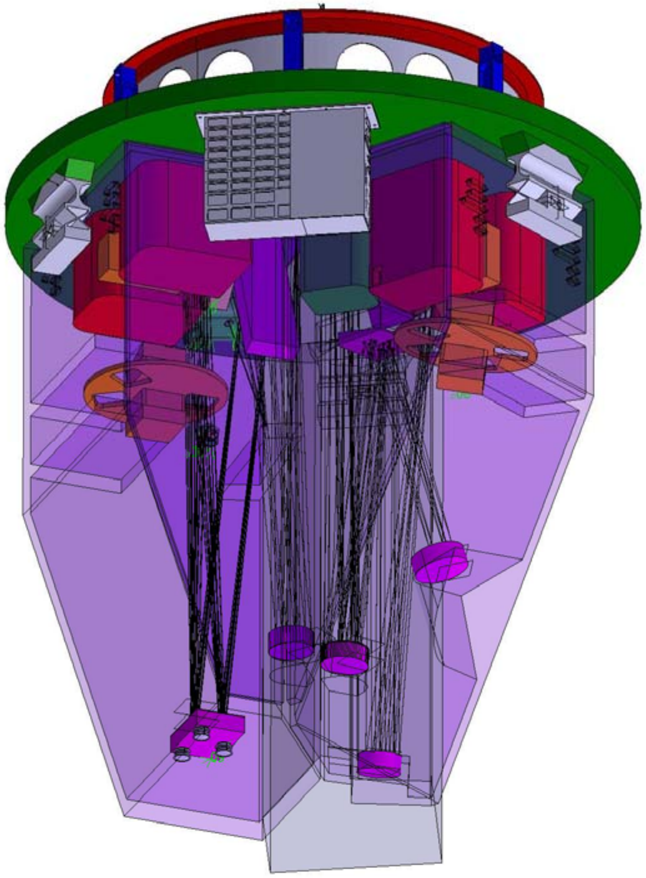


II. The WSO-UV telescope



II. The WSO-UV telescope

Eberhard Karls Universität Tübingen
Institut für Astronomie und Astrophysik
ISAS Institute for Analytical Sciences Dortmund and Berlin
KAYSER-THREDE

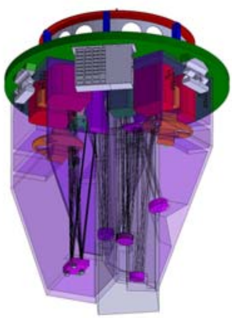


HIgh Resolution Double Echelle Spectrograph (HIRDES)

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

WSO - UV

II. The WSO-UV telescope



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

II. The WSO-UV telescope

Long Slit Spectrograph (LSS)

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

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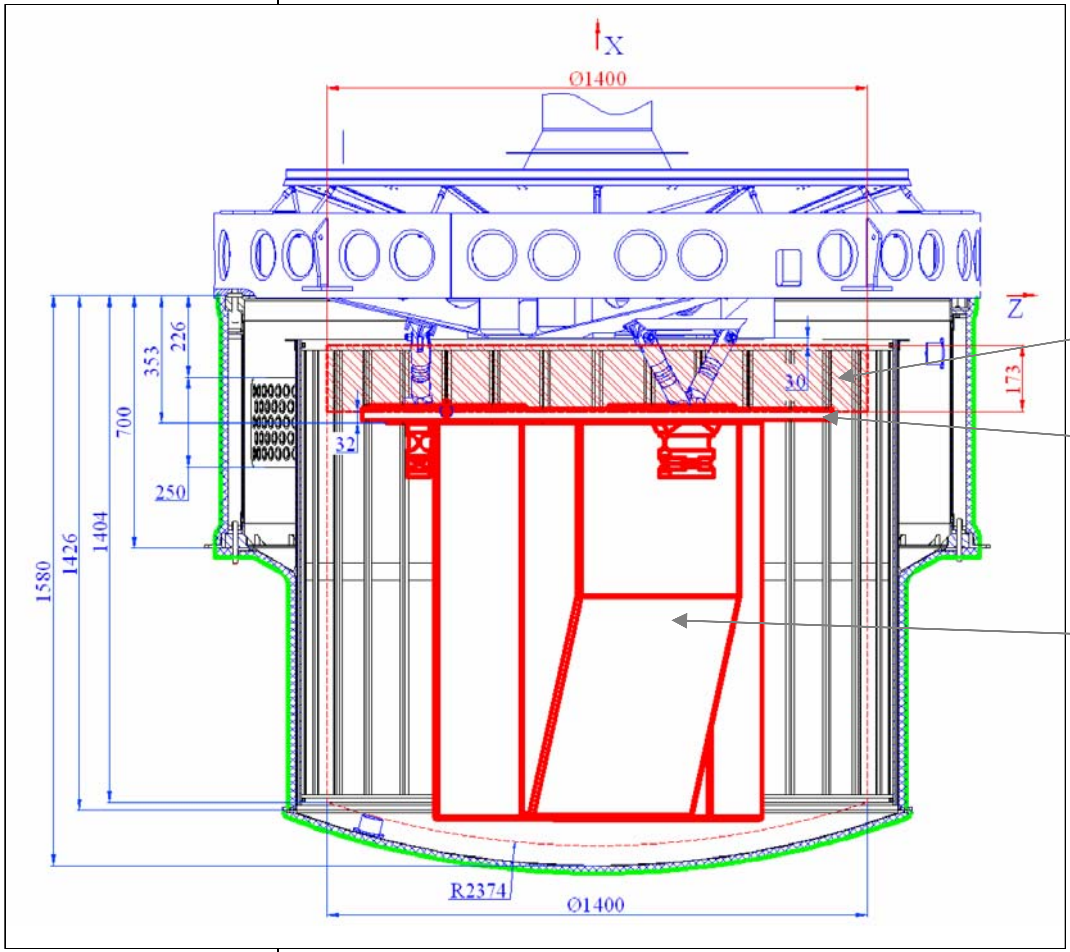
II. The WSO-UV telescope

ISSIS:

Imaging and Slitless Spectroscopy Instrument

	HSC	CfS
Spectral Range	1200-2000Å	1200-6000Å
Spatial Resolution	0,1”, TBC (T-170M limited)	0,1”, TBC (T-170M limited)
Spatial Sampling	0,05 arcsec	0,05 arcsec
Field of View	>2,1 arcmin	>3,4 arcmin
Temporal Resolution	40ms	60s
Detector Type	CsI MCP	Full-frame CCD
Detector Format	>2048x2048 px (TBC)	4096x4096 px
Spectral Filters	10 (TBC)	10 (TBC)
Slitless Spectroscopy	Yes, R~300	Yes, R~300
Coronagraphy	No (TBC)	Yes (TBC)

II. The WSO-UV telescope



ISSIS dimensions:

- $\varnothing_{max}$ = 1400 mm
- H_{max} = 173 mm

Space for ISSIS

Telescope OB

Spectrographs assembly

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II. The WSO-UV telescope

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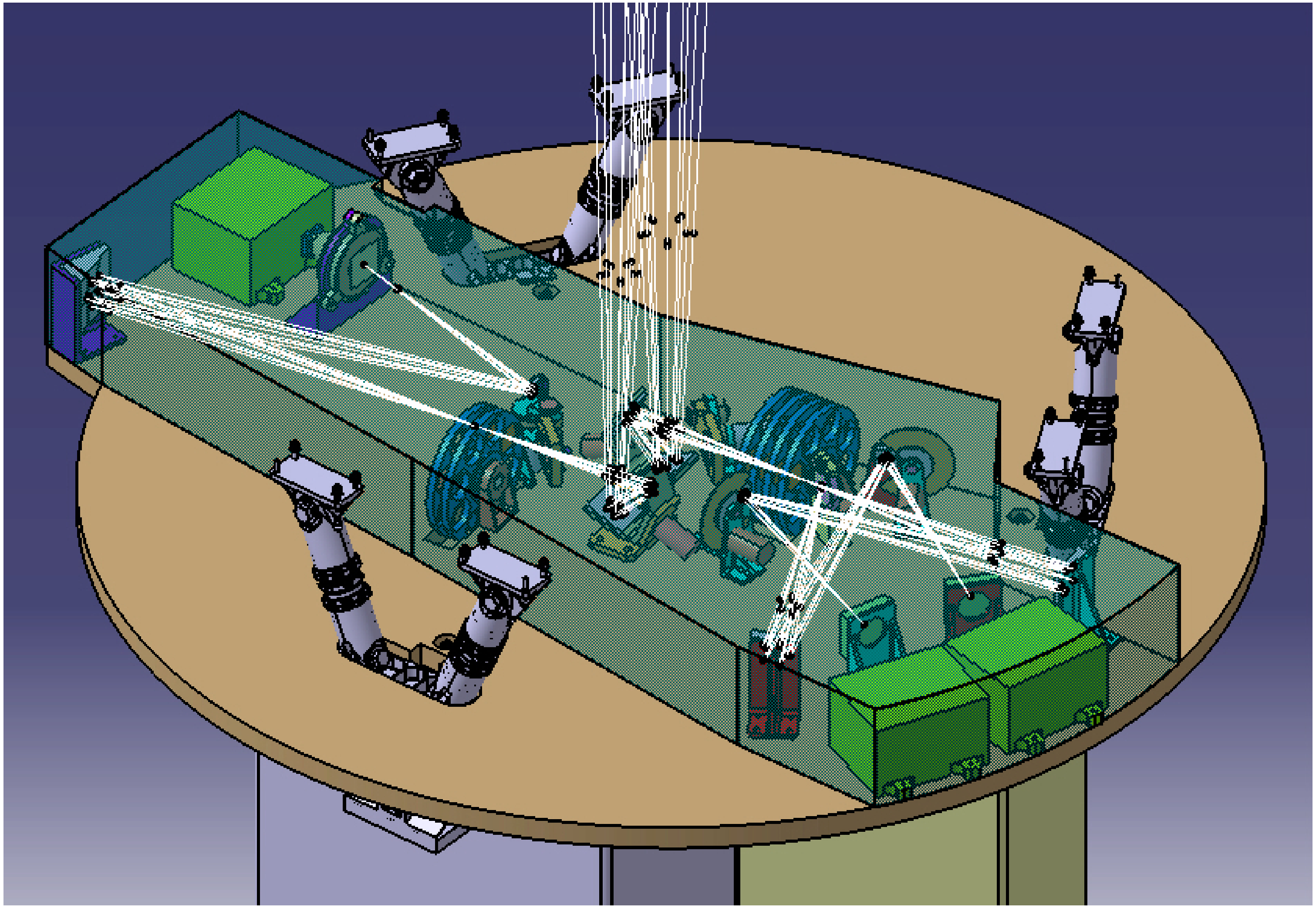
ISSIS Basic Configuration (4/4)

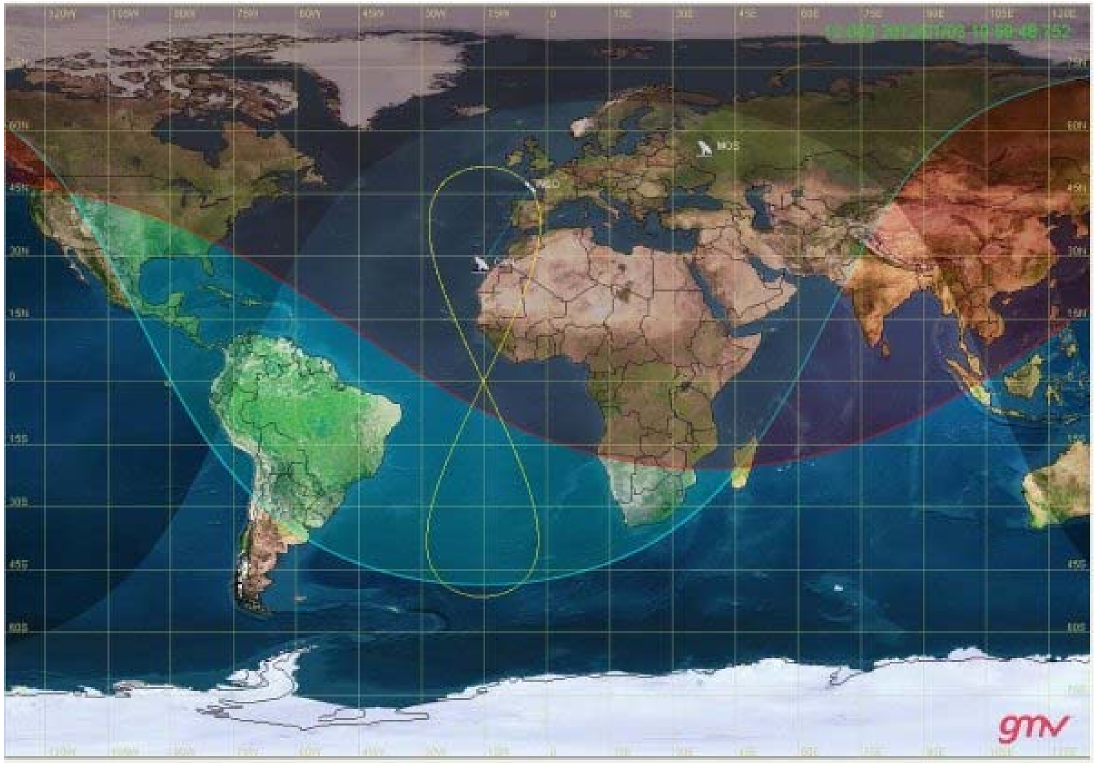


II. The WSO-UV telescope

WSO/UV orbit

circular with radius 35800 km, i=51.8º
a variant of geosynchronous orbit

lower UV background than HST



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II. The WSO-UV telescope

GROUND SEGMENT:

•Ground Station Control Center (GSCC) and Ground Communications Subnet (uplink/downlink): Russia & Spain. **22-24 hours coverage.**

•Mission Operations Center (MOC), real-time spacecraft monitoring and control function (also includes flight dynamics). Prompt response to TTOs

•Science Operations Center (SOC), scheduling and supervision of the WSO scientific operations. Also includes calibration, processing and verification of scientific data.

•Science Data Processing Center (SDPC) – or pipeline - provides end users both mission products and associated data required for their Utilization.

•Science Archive – VO compliant

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International Partnership

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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.

Contribution: Launcher & Launch, Spacecraft, Telescope, Ground Segment

PI: Boris Shustov /INASAN - Contractor: Lavochkin

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.).

Contribution: HIRDES

PI: Klaus Werner/IAAT – Contractor: Kayser-Threde

International Partnership

SPAIN

Agreement signed between CDTI and ROSCOSMOS (March 19th, 2007). CDTI has compromised to co-fund the development of the whole Ground Segment/MOC/SOC. Phase B of the GS is planned to be finished in 2009.

July 2009, Agreement Spain-Russia for ISSIS instrument close to completion.

Contribution: Ground Segment (MOC&SOC)+ISSIS

P.I.: Ana I. Gómez de Castro/UCM

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.

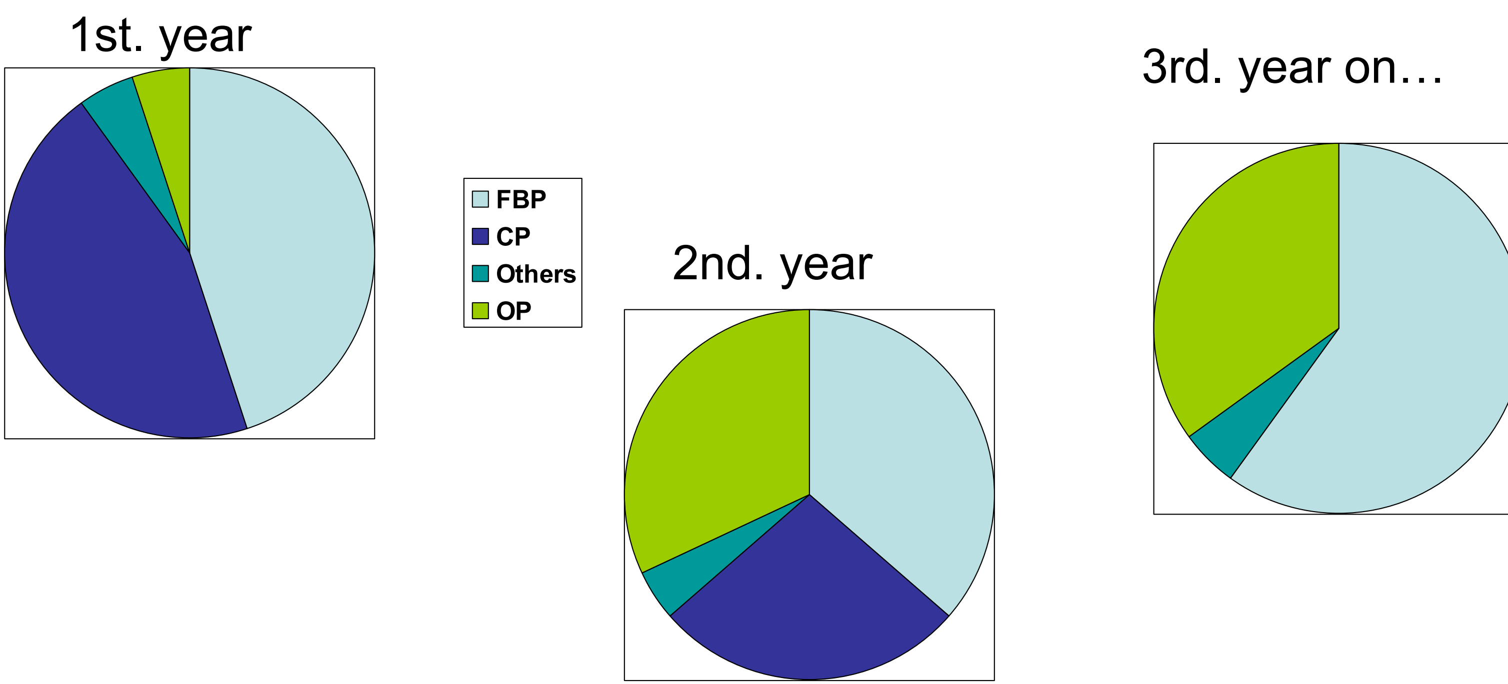
Contribution: LSS
P.I.: Gang Zhao

Time sharing policy

Core Program (CP): Fundamental science to be carried by the project team

Funding Bodies Program (FBP): Guaranteed Time to the countries funding the project

Open Program (OP): Open program to the world wide scientific community



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The core program - I

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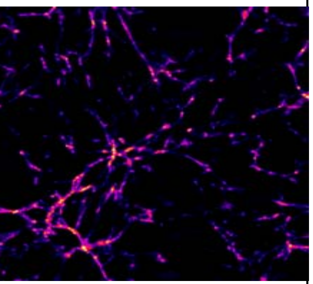
-CORE PROGRAM-

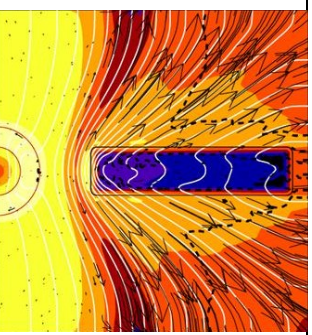
Discovery or long heritage projects focused on the unique capabilities of WSO/UV:

- R=50,000 with very high sensitivity
- HiRES UV imaging
- High Sensitivity Far UV imaging

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

The core program - II





Key issues for the core program:

1. Galaxy formation: determination of the distribution of diffuse baryonic matter in the Universe (up to z=2-3), its physical properties and its chemical composition.

2. The Milky Way formation and evolution

3. Evolution of astrophysical disks to understand the role of the “disk-source of gravity” interaction in driving the observed outflows and to understand the evolution of disks when they become passive (specially in protoplanetary systems)

4. Atmospheres of extrasolar planets and astrochemistry in strong UV fields

The core program - II

MANAGEMENT OF THE CORE PROGRAM

1. A kick-off conference in May-June 2010 in St. Petersbourg.

2. Set-up of international consortia for the CP among the project members

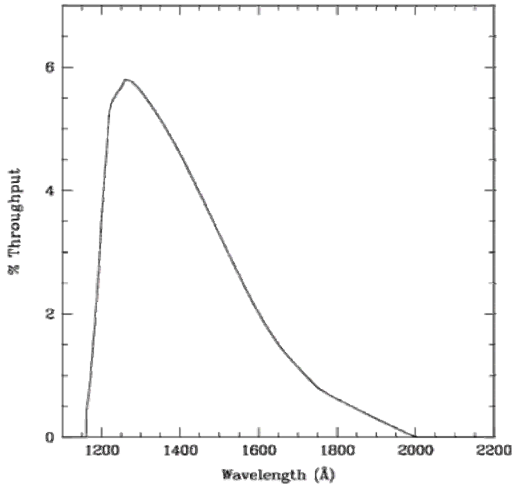
3. Preparation of proposals for the core program – deadline Sept-Oct 2011

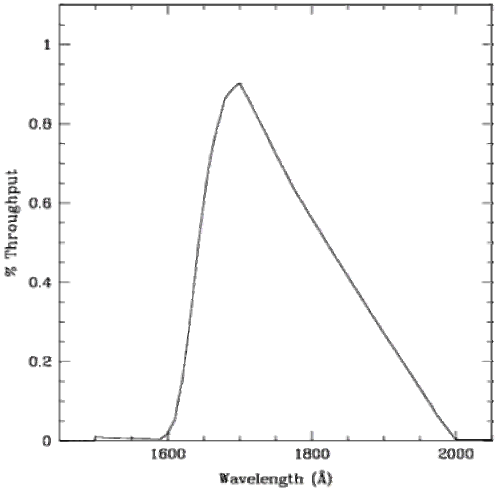
4. Selection of the best proposals – beginning 2012

III. WSO-UV versus HST

ISSIS/HSC vs. HST/ACS/SBC

Similar sensitivity
Similar filters set-up
Field of view: 16 times larger
Spatial resolution: 0.05 arcsec
Dispersors: Grating/Prism/Grism under evaluation





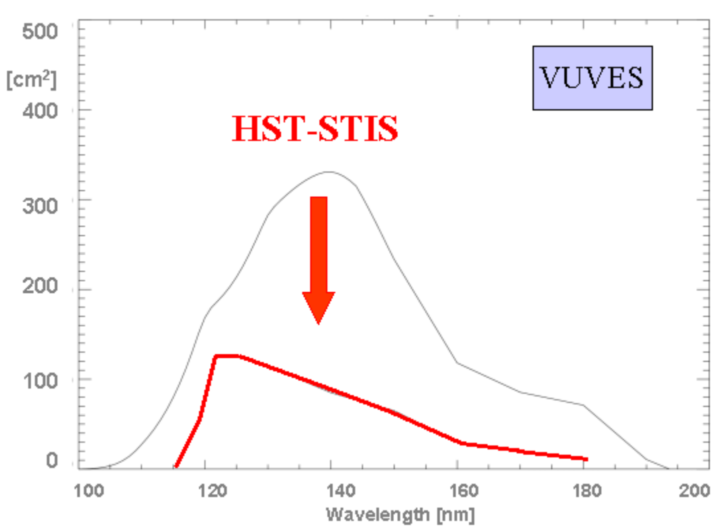
III. WSO-UV versus HST

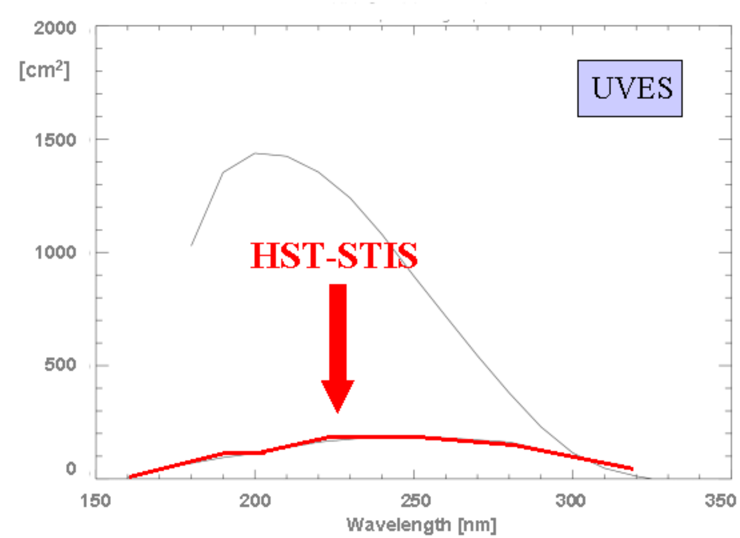
HIRDES-UVES Res.:50,000– Range:175-310nm
HIRDES-VUVES Res.:55,000– Range:103-176nm

Comparison Aeff HIRDES – HST/STIS

$\lambda/\Delta\lambda$ = 50,000 HIRDES

$\lambda/\Delta\lambda$ = 37,000 STIS





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IV. WSO-UV & the Lyα Universe

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HIRDES: Absorbers (including LAA)

the highest sensitivity in 1900-2300A range

LSS: Populations of extragalactic HII regions (R~2000)

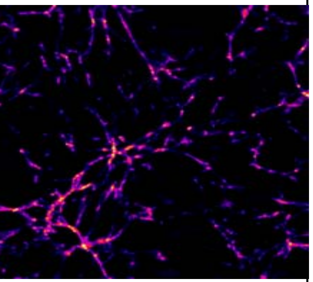
ISSIS: Lyman α Emitters (LAEs) – R~300

ACS/SBC sensitivity with a 16 times larger field

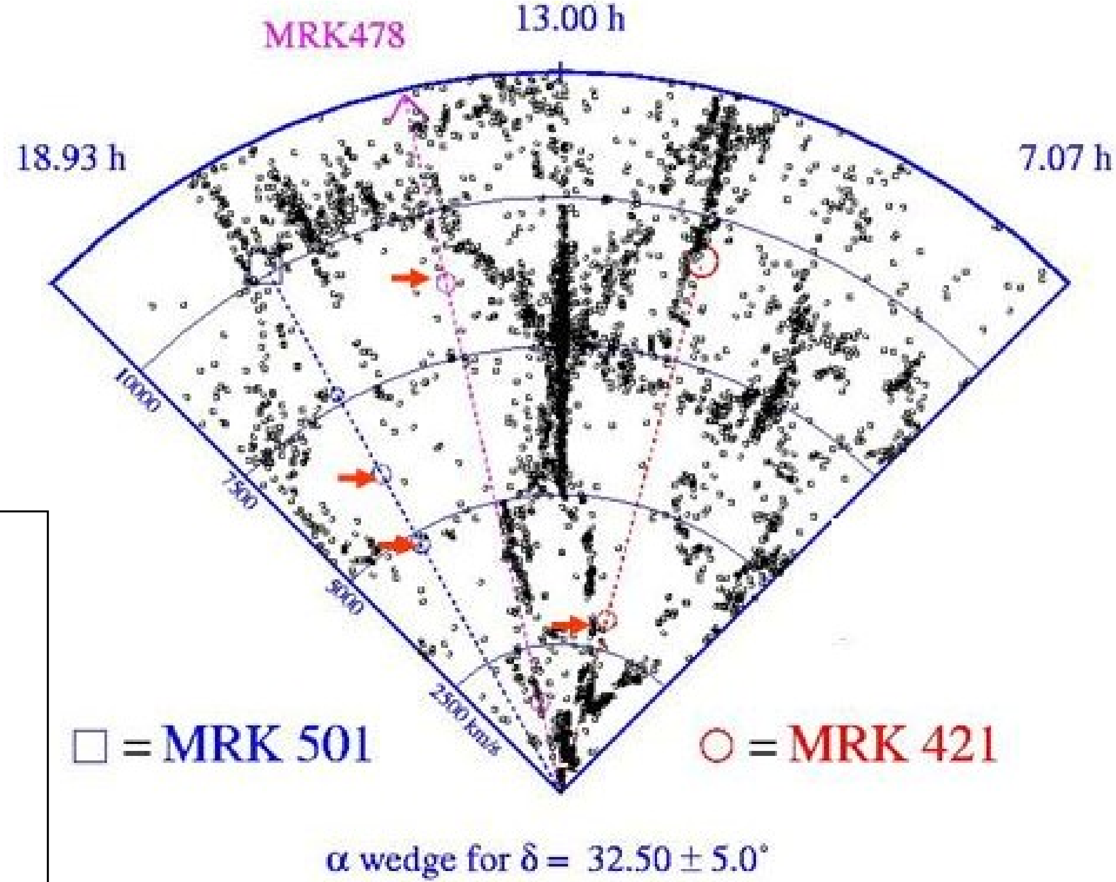
WSO - UV

IV. WSO-UV & Lyα Universe: **Absorbers**

Q-1



ARE LARGE GAS DEPOSITS ASSOCIATED WITH THE GREAT WALL? WITH BUBBLES?



Critical factor -> background targets (at V = 19-21)

@ V = 21 QSO populations spatial density (1 QSO/ 5 arcmin)

INTEGRAL FIELD SPECTROSCOPY

from Shull et al 2008

IV. WSO-UV & Lyα Universe: **Emitters**

A survey for LAEs to study:

- Intermediate-redshift analogs to Lyman-Break Galaxies
- The evolution of the SFR density in the critical range: z=1-0
- The evolution of the Lyα emitters from redshift z=1-0
- To improve the photometric-redshift determination

Lyα imaging of nearby galaxies to undertand Lyα photons propagation in the hosting galaxies and the circungalactic medium

IV. WSO-UV & Lyα Universe: Emitters

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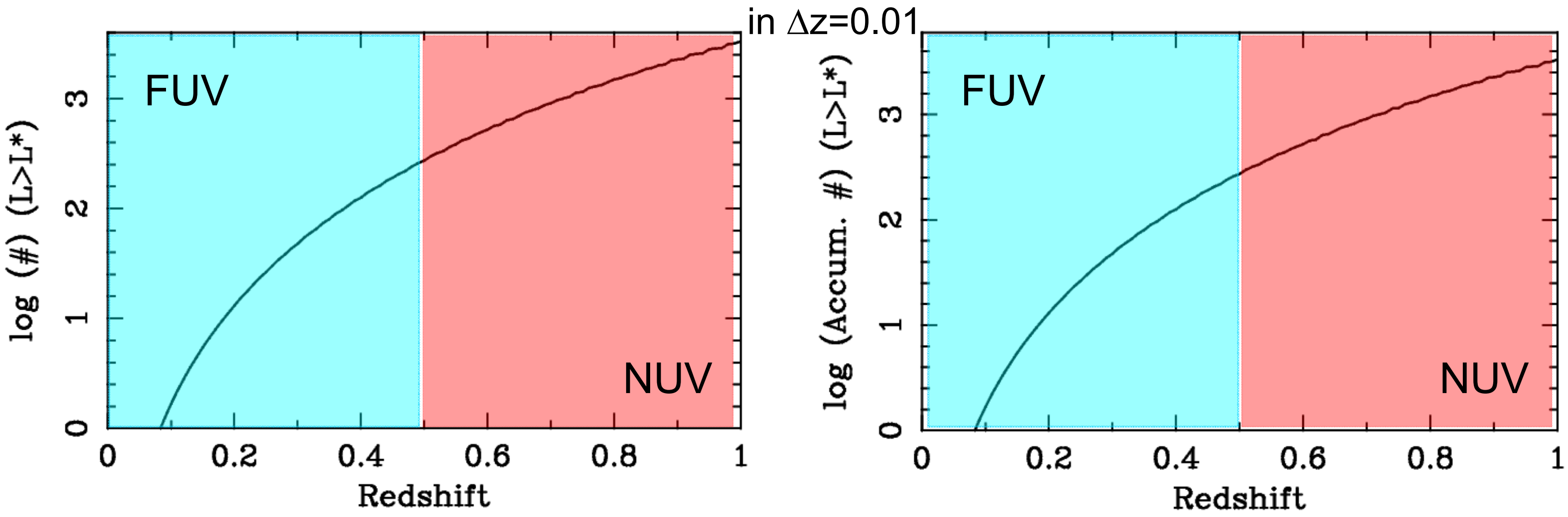
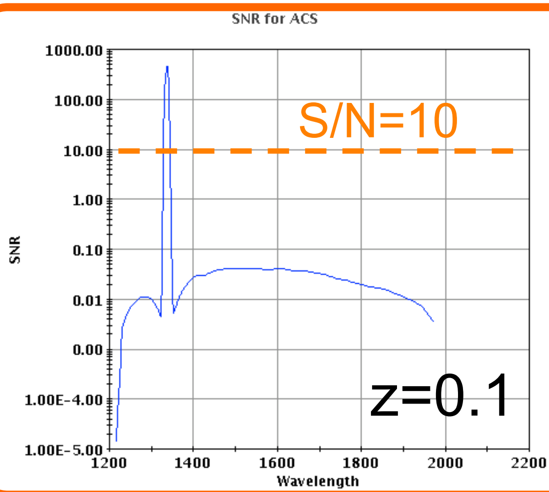
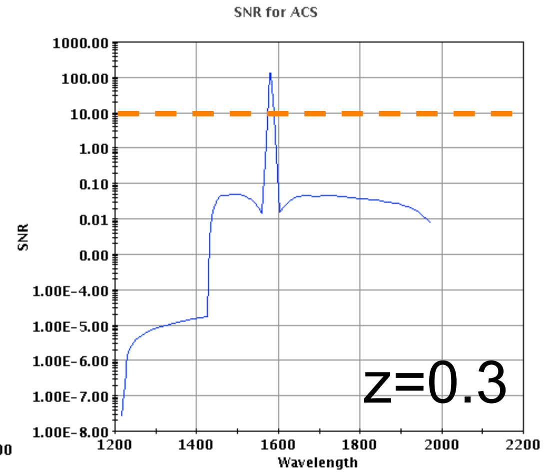
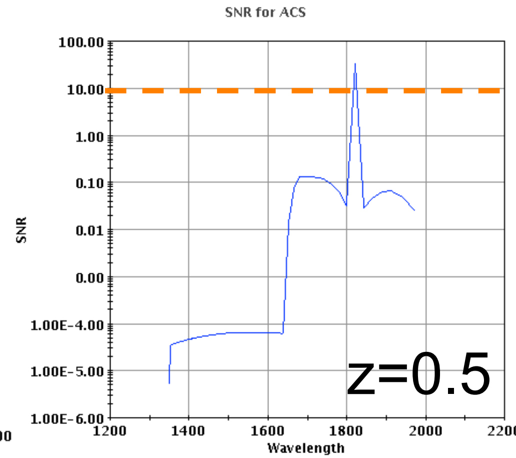
Number densities: Assuming a non-evolving LF from z=3 to z=1 (see Ouchi et al. 2008 for the range z=3-5) and a factor of 1/10 evolution in the number density (L>L*) from z=1 to z=0:



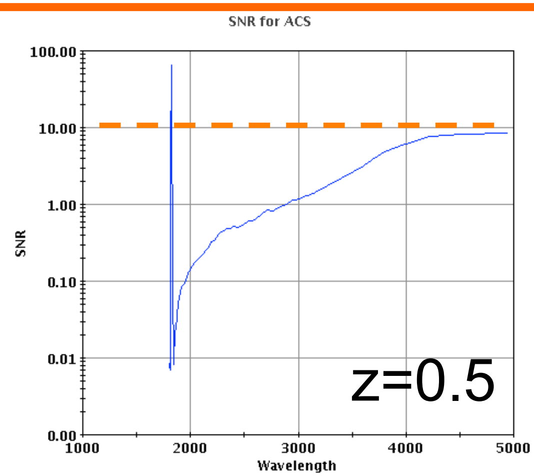
IV. WSO-UV & Lya Universe: **Emitters**

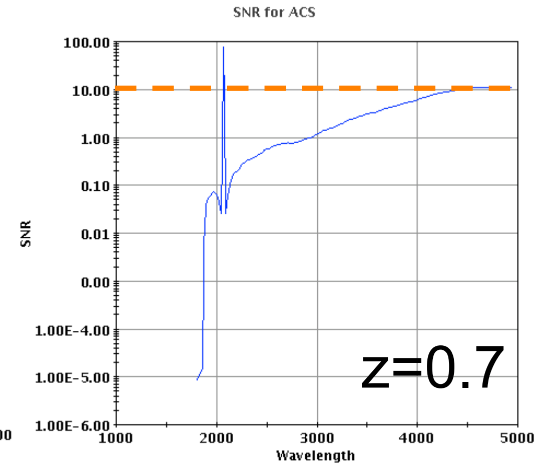


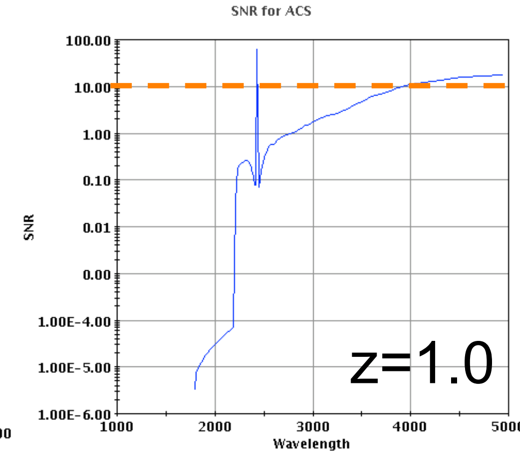




FUV







NUV

IV. WSO-UV & Lyα Universe: Emitters

Limiting magnitudes in imaging mode:

Spiral @ z=0.1 -> I=26.1 (3σ in F150LP*@HSC) in 1h
Spiral @ z=0.3 -> I=25.5 (3σ in F150LP*@HSC) in 1h
Spiral @ z=0.5 -> I=24.2 (3σ in F150LP*@HSC) in 1h

Spiral @ z=0.5 -> I=25.3 (3σ in F250W*@CfS) in 1h
Spiral @ z=0.7 -> I=25.8 (3σ in F250W*@CfS) in 1h
Spiral @ z=1.0 -> I=26.2 (3σ in F250W*@CfS) in 1h

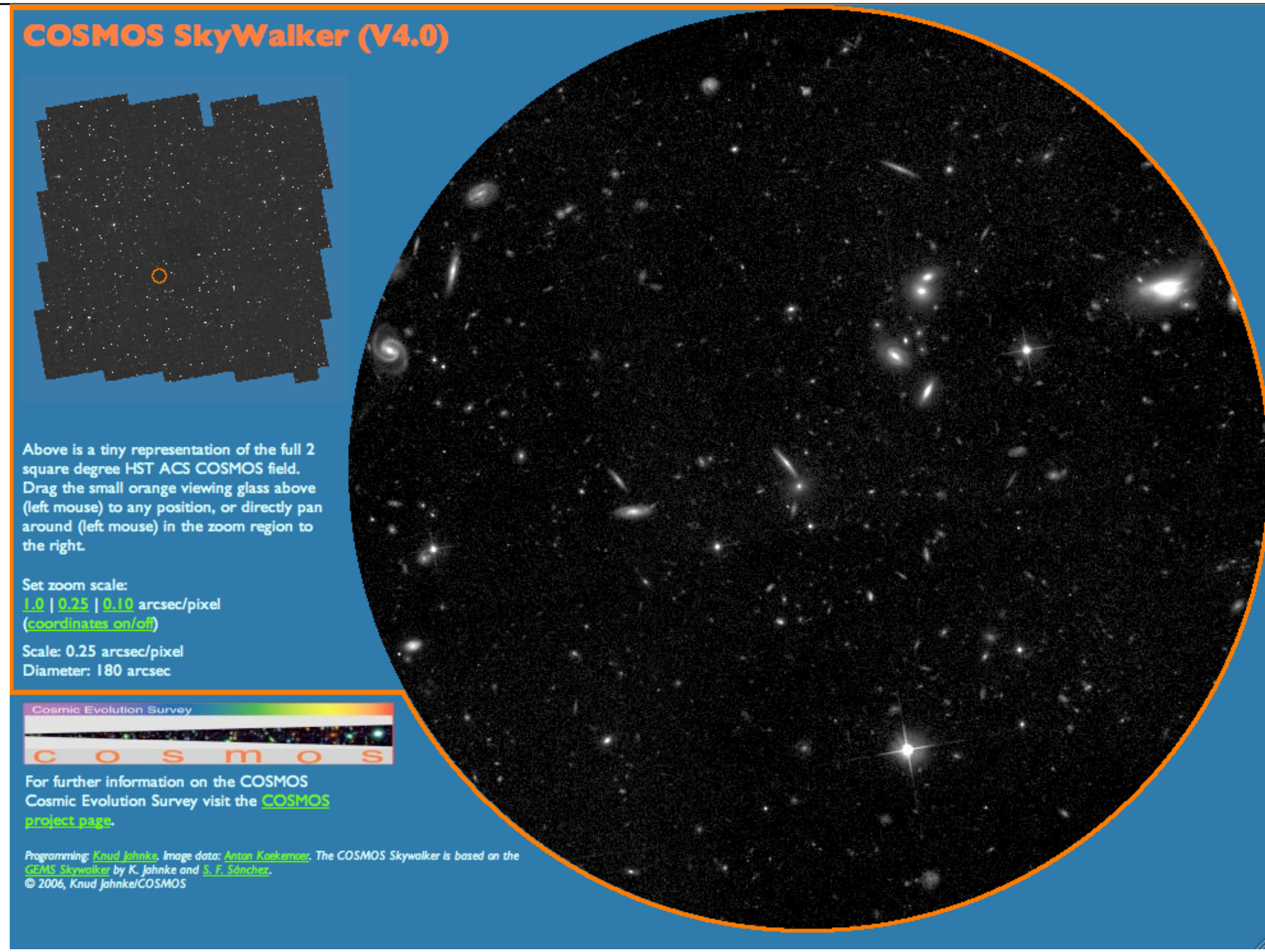
* The filters used for the simulation are analogous to those of the instrument ACS on board HST.

IV. WSO-UV & Lya Universe: Emitters

To cover the COSMOS survey with ISSIS:

Imaging: 8.4 days
(200 pointings)

Spectroscopy: 17 days
(200 pointings)



Keep updated through: www.wso-uv.net

(also wso.inasan.ru, www.wso-uv.es)

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