

OSIRIS:

(**O**ptical **S**ystem for **I**maging and low
Resolution **I**ntegrated **S**pectroscopy)

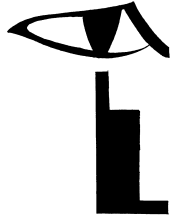
SURVEYING THE Ly α UNIVERSE

FROM Z = 7 TO 2

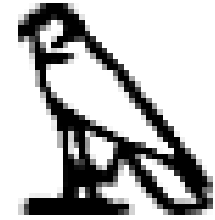
Jordi Cepa (OSIRIS PI)

Instituto de Astrofísica de Canarias/U. La Laguna

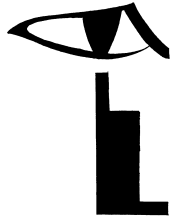
On behalf of OSIRIS, and OSIRIS survey teams



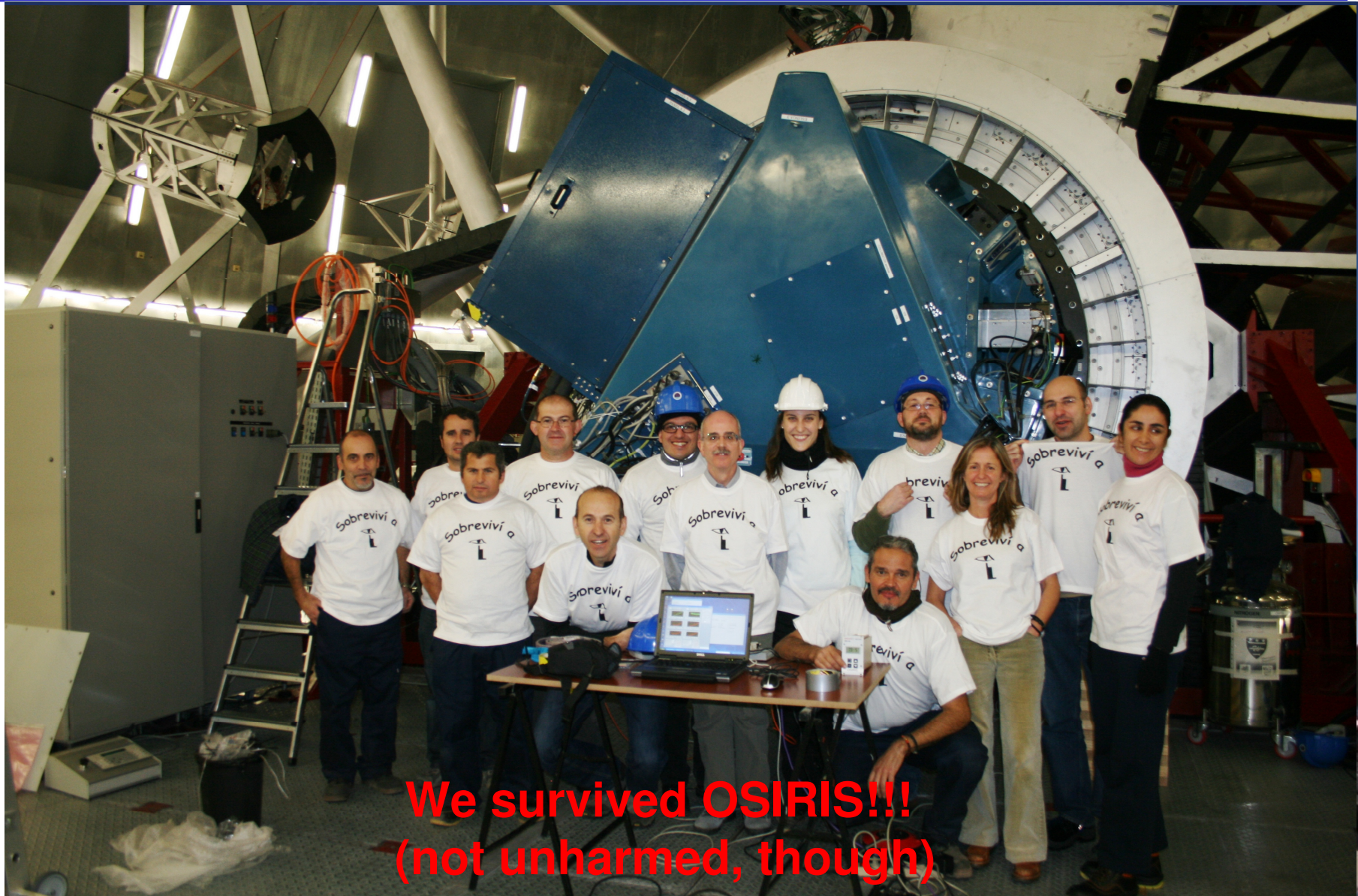
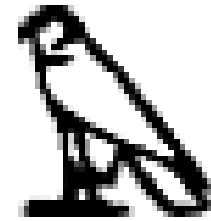
OSIRIS basics



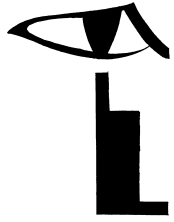
- Camera-Spectrograph for the GTC 10.4m telescope
- Wavelength range: 3650 to 10000 Å
- FOV 8.5' × 8.7'
- Imaging
 - ugriz
 - Medium band
 - **Tunable filters**
- Spectroscopy:
 - Long slit & MOS
 - R = 300 to **5000**
- **Fast modes** (photometry & spectroscopy)
- **Shuffle modes in tunable imaging & MOS**



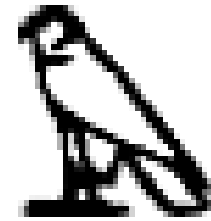
OSIRIS @GTC



**We survived OSIRIS!!!
(not unharmed, though)**



Tunable filters



- **OSIRIS tunable filters**

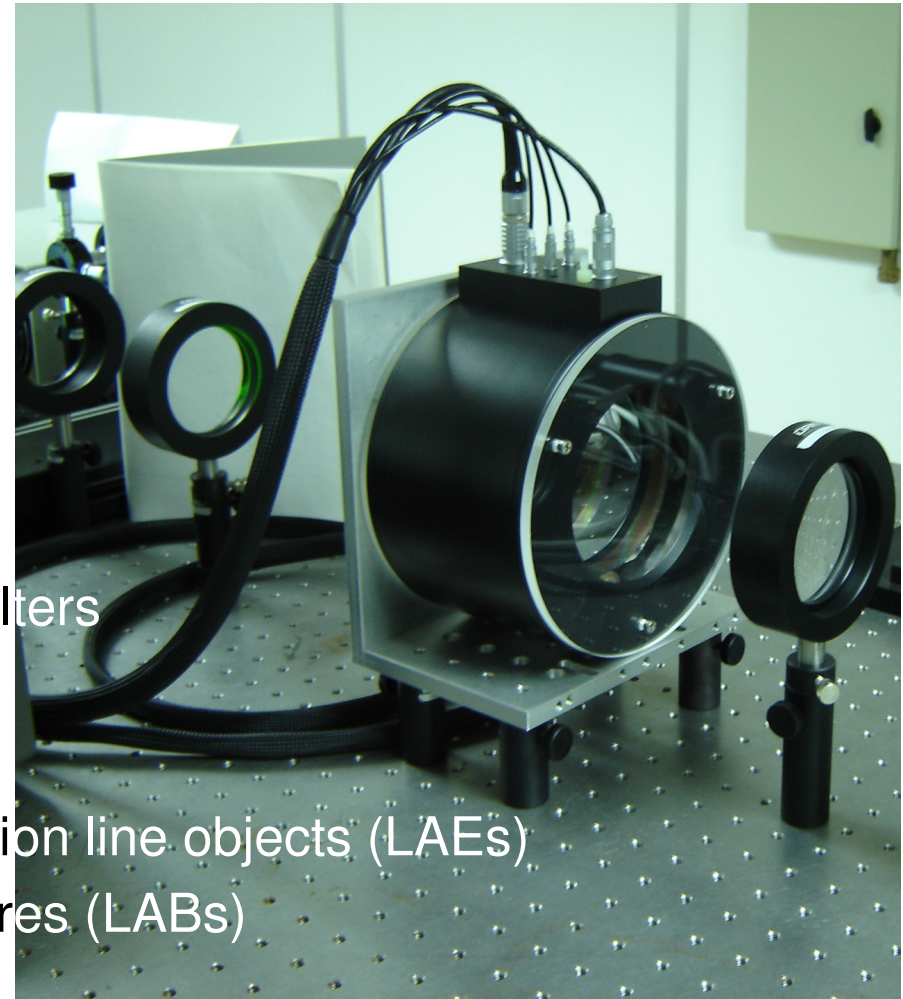
- Wavelength range 3650 to 10000 Å
- Tuning accuracy 1 Å
- Tuning time from 10 to 100 ms
- Minimum FWHM from 6 to 12 Å

- **Some advantages**

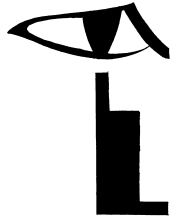
- Narrower than most available filters
- Higher efficiency than conventional filters

- **then,**

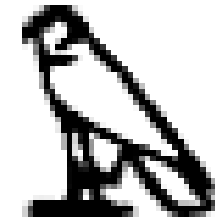
- Better matched for OH sky windows
- Very efficient detection of faint emission line objects (LAEs)
- Idib. for faint diffuse emission structures (LABs)



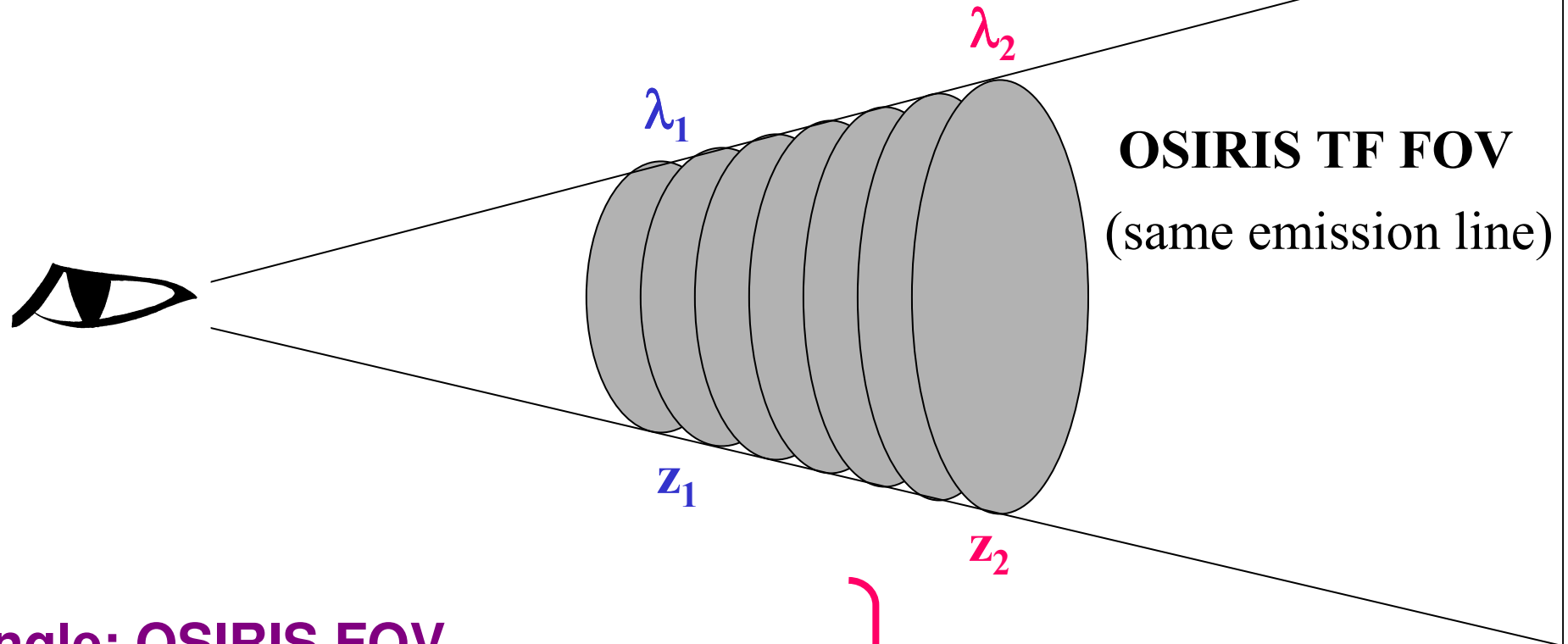
and in a 10m telescope!!!



Tunable Tomography



Allow Ultra-Deep Emission Line Surveys using TF

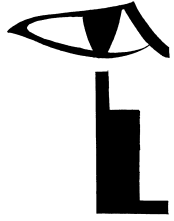


Angle: OSIRIS FOV

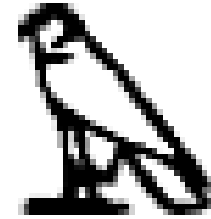
Height: $\Delta\lambda$ scanned = $\lambda_2 - \lambda_1$

Limiting magnitude: exposure time

Limited flux survey of a perfectly defined volume of Universe



OSIRIS Tunable Surveys: OTELO & HORUS

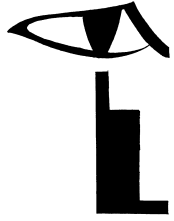


- **OTELO**

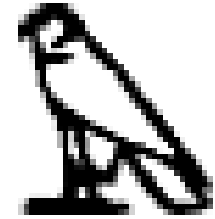
- OSIRIS Tunable Emission Line Object survey
- Scan the windows through OH sky lines at 815, 925 & 975 nm
- Ly α at $z = 5.6, 6.7$ and 7.0 (priority 6.7 & 7.0 at highest depth)

- **HORUS**

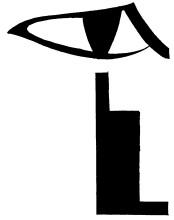
- Hydrogen and Oxygen Recombination lines Unified Survey
- Scan wavelengths around 389, 426, 499 & 584 nm
- Ly α at $z = 2.2, 2.5, 3.1$ & 3.8 (priority 2.2 at highest depth)



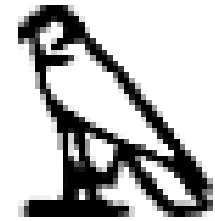
OSIRIS Tunable Surveys: Characteristics



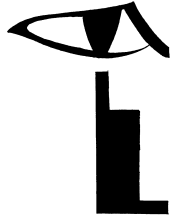
- In general, Ly α luminosity limit $\sim 10^{41}$ erg/s at every z
- But at selected pointings, $\sim 10^{-18}$ erg cm $^{-2}$ s $^{-1}$ (5σ) for every z
- Minimum detectable EW $\sim 2-3$ at the deepest flux limit
(EWs useful for our cherished outliers!)
- Goal: 0.1 sq. degrees
- Pointing at:
 - SXDS, COSMOS, GOODS-N, EGS (ancillary data)
 - Some QSO fields at z_{QSO}
- First phase: 25 nights (guaranteed time) starts October 2009
- OSIRIS follow-up spectroscopy at R=5000 for kinematics
- NIR GTC follow-up looking for optical lines at $z = 2-4$



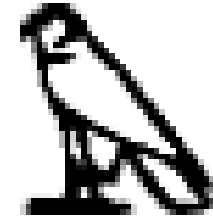
Why another survey?



- **Going deeper** ($\sim 10^{-18}$ erg cm $^{-2}$ s $^{-1}$ at 5σ with $EW \geq 2-3$)
- **Detecting fainter surface brightness**
- **Coherent dataset at every z** (same observational technique)
- **Accurate continuum subtraction**
 - well known filter spectral response
 - sampling nearby the emission line
 - not including the line within continuum
- **Accurate flux calibration**
- **Accurate redshift determination** ($\Delta z/(1+z) \sim 10^{-3}$, same data)
- **Possible detection emission outflows using the same data**
- **In summary: pushing to the limit a 10m telescope with TF**



Team

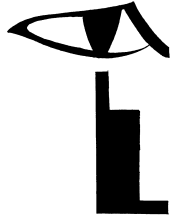


OTELO & HORUS

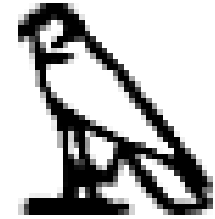
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Héctor Castañeda (IPN)
Jesús Gallego (UCM, HORUS Co-PI)
Ignacio González-Serrano (IFCA-UNICAN)
Ana Pérez-García (IAC)
José Miguel Rodríguez-Espinosa (IAC)
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Jean-Gabriel Cuby (LAM)
Johan Fynbo (KU, Sweden)
Rafael Guzmán (U. FI.-UCM)
Kim Nilsson (MPIA)
Ian Parry (IOA)
Roser Pelló (Toulouse)



Products: Ly α & outliers



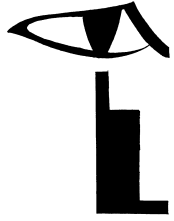
But... *Quicquid nitet notandum* (William Herschel moto)

Morphological Type	Maximum redshift	Expected number
E/S0	0.84	$3 \cdot 10^4$
Sa-b-c-d-Im	1.50	
Sy	1.50	$7 \cdot 10^3$
BCD	0.84	10^3
Ly α	7.00	10^3

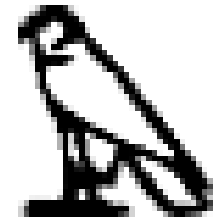
Plus LABs (beautifully suited for TF imaging)

But...field to field variation is an issue!!!

Raw estimates for no evolution and concordance cosmology



Summary



-
- **OSIRIS instrument at the 10m GTC already gathering data**
 - **OSIRIS TFs @10m GTC optimally suited for detecting Ly- α**
 - at very faint levels ($\sim 10^{41}$ erg/s)
 - low EWs ($\sim 2-3$)
 - with low surface brightness
 - **Tunable tomography surveys OTELO & HORUS starting**
 - **Yielding Ly- α plus other emitters from $z = 0.2$ to 7.0**
 - **Hope to show results the next meeting!**
 - **Expected follow-ups:**
 - R=5000 for kinematics
 - NIR spectroscopy of optical lines