GO-IRS:

a new optical multi-object spectrograph proposed for the 10.4 m GTC

GO•IRS

David Montes • GO-IRS MW co-chair
Universidad Complutense de Madrid (Spain)

Science with GO-IRS:

from the Milky Way to the most distant quasars

Prepared by:
José A. Caballero • Project Scientist
Centro de Astrobiología (Madrid, Spain)

With major contributions from:
Jian Ge • Principal Investigator
University of Florida (USA)
Yipeng Jing, Jiaru Chu, Anthony González, Tinggui Wang, Mariano Moles, Emilio Alfaro, Lei Hao, Scott Powell, John Groot, Bo Zhao et al.

GTC

GO•IRS

Gran Telescopio Canarias - 10.4 m

Specifications

GO•IRS

Announcement of opportunity for the third generation instruments for the 10.4 m GTC:

- High-throughput spectrographs
- $R_1 \approx 10{,}000$, $R_2 \approx 20{,}000$
- Folded Cassegrain focus
- Multiplex
- $\Delta\lambda \approx 3700 - 9800$ Å (optical)
- $\Delta\lambda \approx 0.95 - 2.5$ µm (near-IR)

4+1 proposals

Optical:

- **GO-IRS** (PI: J. Ge, UF, USA)
- **MEGARA** (PI: A. Gil de Paz, UCM, Spain)

Near-IR:

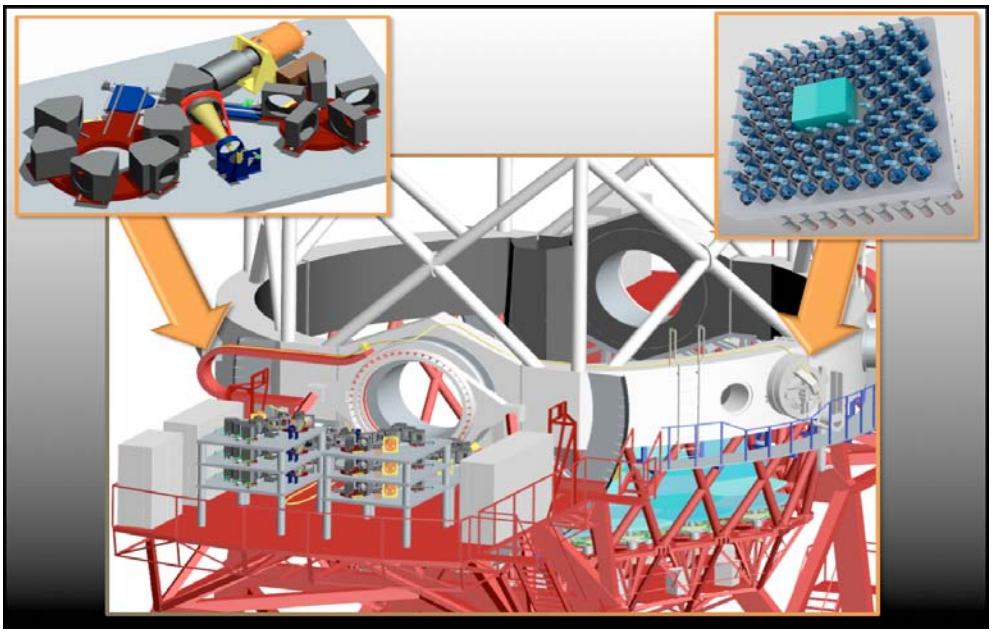
- **MIRADAS** (PI: S. Eikenberry, UF, USA)
- **NIRINTS** (NAHUAL)(PI: E. L. Martín, CAB, Spain)

Conceptual Design Review in June 2010

MEGARA

(Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía)

Central IFU of 12”x14”
+ 94 fibres in a FoV of 3.5’x3.5’
with R = 5600 - 17000



http://guaix.fis.ucm.es/megara

GO-IRS

GTC Optical - Intermediate Resolution Spectrograph

GO-IRS Science Team I

Co-PI: Jiaru Chu (USTC, China)

PI: Jian Ge (UF, USA)

Co-PI: Yipeng Jing (SHAO, China)

Senior advisors:
M. Moles (CEFCA)
J. Gunn (Princeton)
Y. Cui (NIAOT)

Co-PS: T. Wang (USTC, China)

PS: J.A. Caballero (CAB, Spain)

Co-PS: A. González (UF, USA)

Local Universe co-chairs:
L. Hao (SHAO)
A. Sarajedini (UF)
E. Peng (PKU)

Milky Way co-chairs:
D. Montes (UCM)
J. Johnson (OSU)
Y. Chen (NAOC)

Distant Universe co-chairs:
S. Yang (SHAO)
H. A. Kobulnicky (UWVO)
N. Benítez (IAA)

GO-IRS Science Team II

E. J. Alfaro, C. Allende Prieto, D. J. Benford, N. Benítez, S. Boudreault, J. A. Caballero, C. Cao, X. Cao, L. Chen, Ya. Chen, Yu. Chen, R. de Grijs, **N. M. De Lee**, V. P. Debattista, X. Dong, M. Esposito, **E. B. Ford**, Y. Gao, **J. Ge**, **A. H. González**, J. I. González Hernández, M. Gu, J. Gunn, **F. Hamman**, L. Hao, D. H. Hughes, G. Israelian, C. Jiang, **P. Jiang**, Y. Jing, J. A. Johnson, H. A. Kobulnicky, A. Klutsch, X. Kong, **E. Lada**, **B. L. Lee**, C. Li, D. Li, Y. Liang, W. Lin, X. Liu, A. R. López Sánchez, J. Ma, S. Mao, E. L. Martín, H. Mo, M. Moles, A. Monreal Ibero, D. Montes, H. J. Newberg, **D. C. Nguyen**, E. Peng, **A. Sarajedini**, **V. Sarajedini**, J. Shen, J. Shi, M. C. Smith, J. G. Staguhn, **J. C. Tan**, H. Wang, J. Wang, T. Wang, Z. Wang, H. Wu, H. Yan, X. Yang, H. Yuan, W. Yuan, M. R. Zapatero Osorio, H. Zhan, P. Zhang, D. Zhao, G. Zhao, W. Zheng, X. Zheng, H. Zhou

GO-IRS Science Team III

~80 science team members in >30 institutions (25% USA, 50% China, 25% Spain):

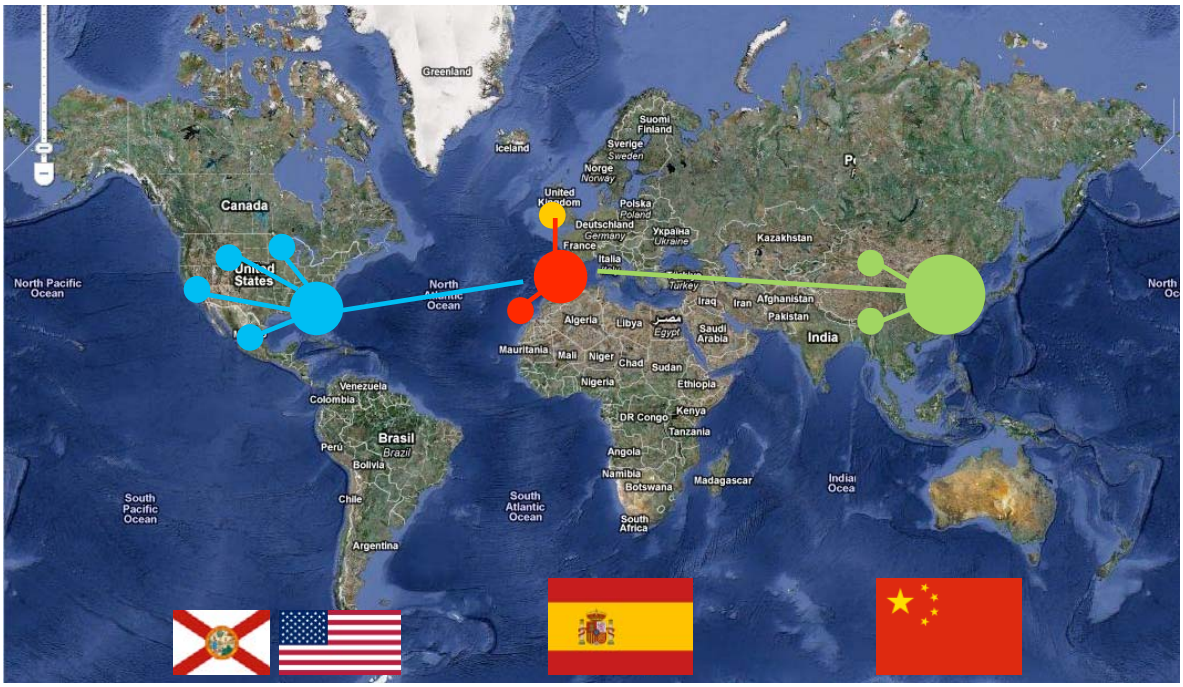
- **UF** (12), OSU, WUVO, UMass, JPL, RPI, JHU, Princeton + NASA Goddard, UTexas

- SHAO (13), NAOC (7), USTC (6), PKU (5), PMU, SDU, YNAO, NJU

- IAC (4+?), CAB (3), UCM, IAA, CEFCA, abroad, [UK] + UAL?, UB?... + INAOE?

Science Team IV

Coordinated worldwide science team!



Our feedback

GTC requirements + Science Vision:

- Maximum field of view available at the focal station
- Maximum multiplex factor
- Maximum wavelength coverage and throughput (fiber size)
- At least one additional low-resolution mode

MOS @ 8-10 m

Telescope	Instrument	MOS FoV (arcmin)	Δλ (μm)	MOS R_{max} (λ/Δλ)	N of MOS fibres	N of IFU fibres	Status
GTC	**GO-IRS**	**15.1**	**0.37-1.00**	**20,000**	**1,000 (500)**	**1,600 (800)**	**Proposed**
Keck	Deimos	16.7 x 15.0	0.41-1.10	5,000	<130 (mask)	0	On sky
VLT	FLAMES (GIRAFFE)	25	0.37-0.95	24,000	130	300 +300	On sky
VLT	VIMOS	14 x 16	0.36-1.00	2,500	<650 (mask)	6,400	On sky
HET	VIRUS	20	0.36-1.00	850	132	32,600	Being built

Design Reference Cases

One DRC for each Science Working Group:

1. "Near-field cosmology" in the Milky Way, ***2E5*** **(MW)**

2. Nearby galaxies and Local Group **(LU)**

1. GTC GO-IRS Galaxy Deep Survey, ***3GDS*** **(DU)**

Design Reference Cases

SWG	DRC	Acronym	MOS R ($\lambda/\Delta\lambda$)	N of targets	N of nights
MW	DRC1	2E5	20,000 (MOS)	200,000 stars	30
LU	DRC2a	Local Group	10,000 (MOS +IFU)	10,000 targets	20
"	DRC2b	z=0	5,000-10,000 (IFU+MOS)	75 galaxies	56
DU	DRC3	3GDS	2,000-5,000 (MOS)	35,000 +215,000 galaxies	30+60

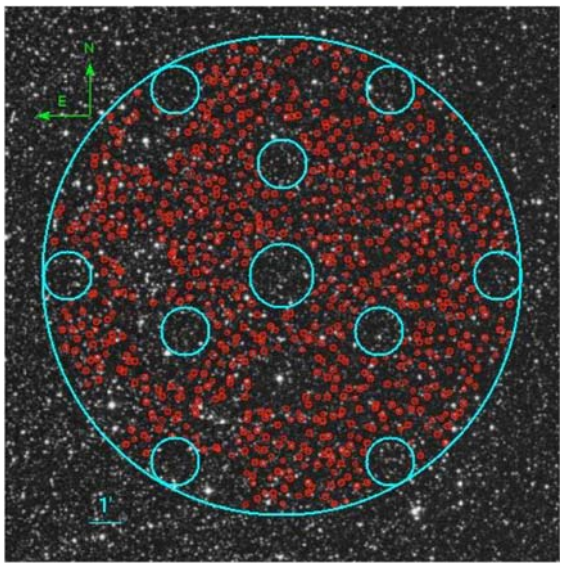
Our Science Vision

GO-IRS worldwide (and ASTRONET European) astronomical Science Vision for the next ~5 years:

1. Do we understand the extremes of the Universe? **DU**
2. How do galaxies form and evolve? **MW, LU, DU**
3. How do stars and planets form? **MW**

Science with GO-IRS:

Milky Way



DRC1: 2E5

- 200,000-star survey in the Milky Way

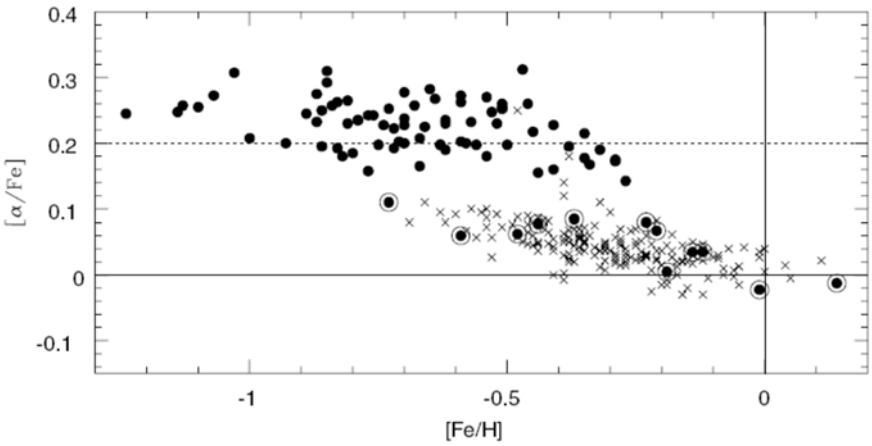
- Kinematical and chemical properties of different stellar populations

- Direct determination of radial velocities (±0.5 km/s), metallic abundances (±0.1 dex)

- Complement to ***Gaia***: parallaxes and proper motions for stars with G > 17 mag

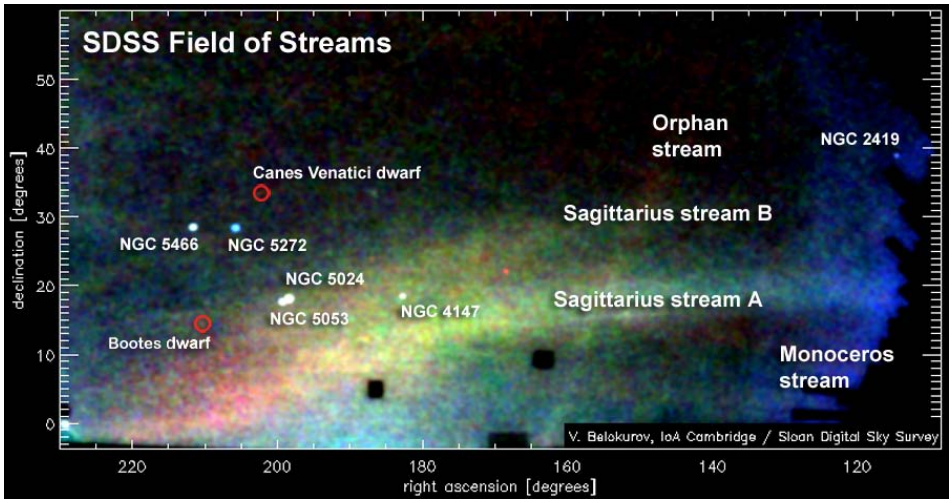
DRC1: 2E5

- S/N > 50 (V < 19 mag) in 1 h
- $\Delta\lambda$ = 5250-5720, 6000-6780 Å
- 300 pointings
- 800 fibers on targets (rest: sky + auxiliary)



DRC1: 2E5

The most complete multi-dimensional analysis of stellar populations:
space (3D), velocity (6D), Fe, C, N, O, Al… Li, Hα, *vsini…*



Other MW science

- Massive spectral characterization of young open clusters (Gould Belt): R = 20,000 (+IFU)

- Lithium and accretion in young brown dwarfs (Orion): R = 10,000

- Spectral types of planetary-mass objects: R = 5,000

- Differential spectroscopy of transiting giant exoplanets (all Northern hemisphere)

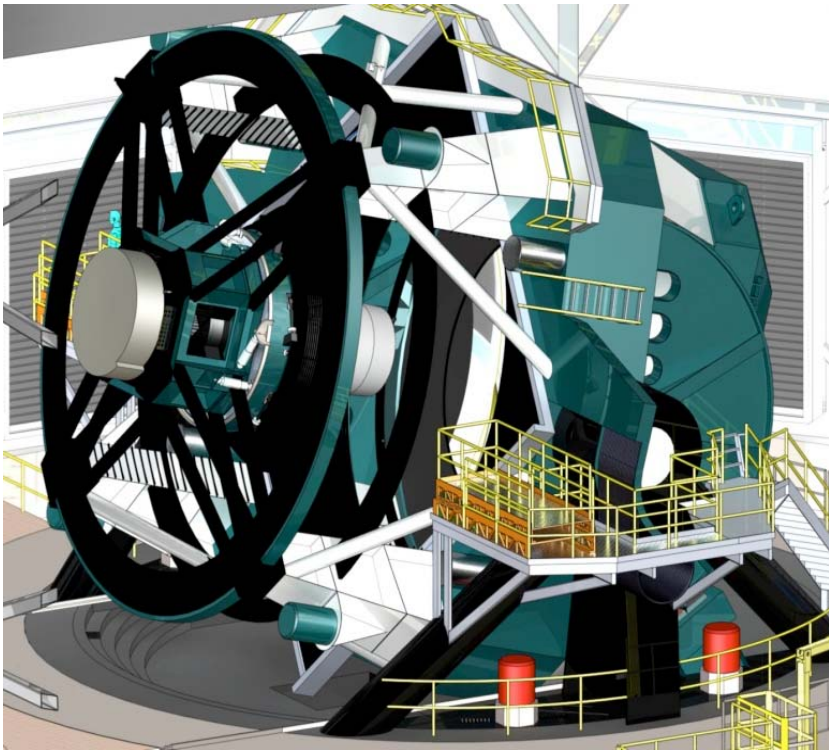
Science with GO-IRS:

Synergies

Synergies: LSST

- Large Synoptic Survey Telescope: 8.4 m, 3.2 Gpix

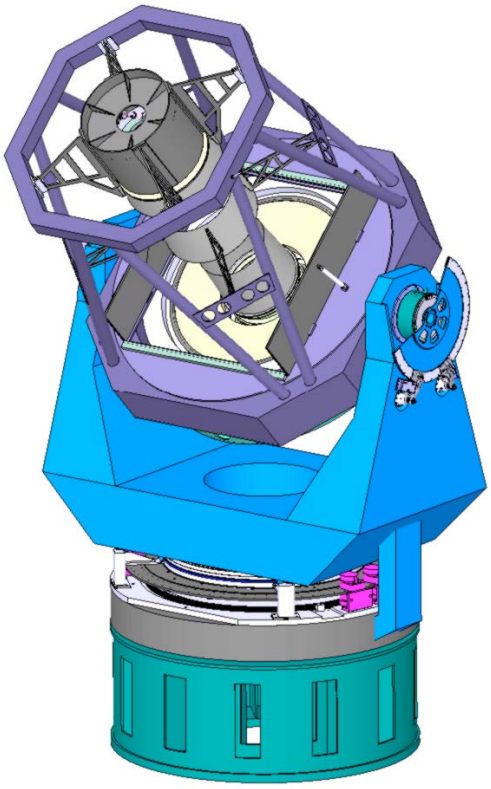
- Full sky coverage every three nights



Synergies: J-PAS

- **Javalambre**-PAU Astrophysics Survey
- 2.5 m, 1.4 Gpix
- Spanish project

(M. Moles)



Synergies: VISTA & VST

- Data will be (eventually) public
- Already being exploited
- Also: UKIDSS…

Synergies: *Gaia*

- ESA space mission, launch late 2012

- Full complementariness with MW 2E5 DRC

- Spanish REG: ***"Red para la explotación científica de Gaia"***

Opto-mechanical design:

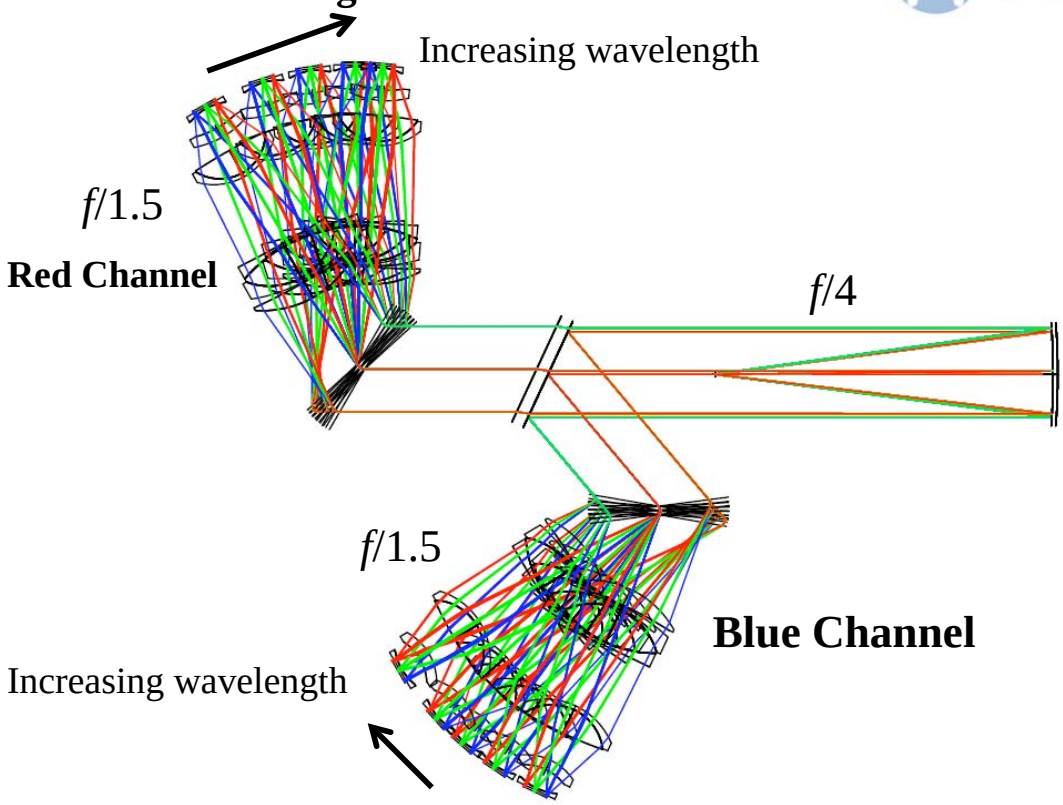
Conceptual Design Review

Bo Zhao, John Groot & Jian Ge
University of Florida (USA)

Instrument concept

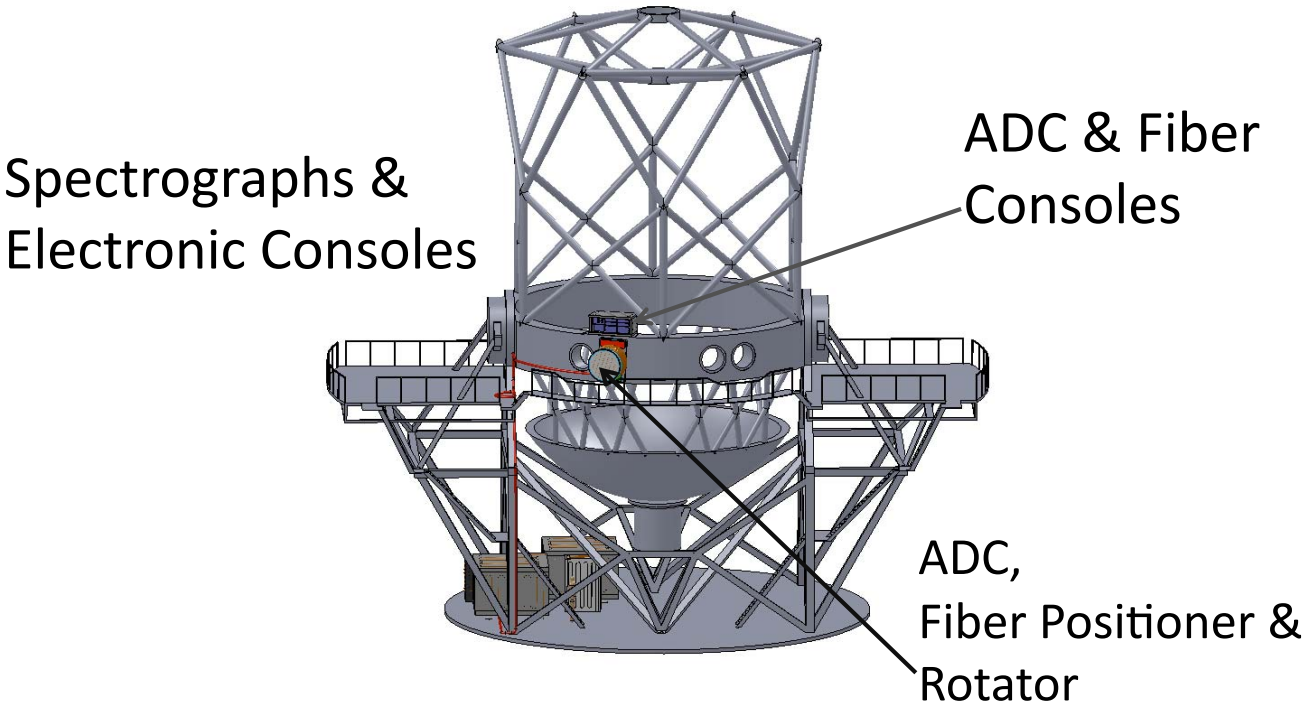
- Fiber fed: 1000 MOS + 4 x 200 IFU
- Two channels: red (0.37-0.60 μm) and blue (0.60-1.00 μm)
- R = 20k, 10k, 5k (red), 2k (blue) and intermediate resolutions
- **Two twin units**: 2 x (500 MOS + 400 IFU)
- Tune resolution and wavelength intervals with two sets of fibers (0.70 and 0.45 arcsec; TBC) and rotating cameras
- VPH gratings in rotating wheels

An Example of Optical Layout with Different Grating Settings at R=10k

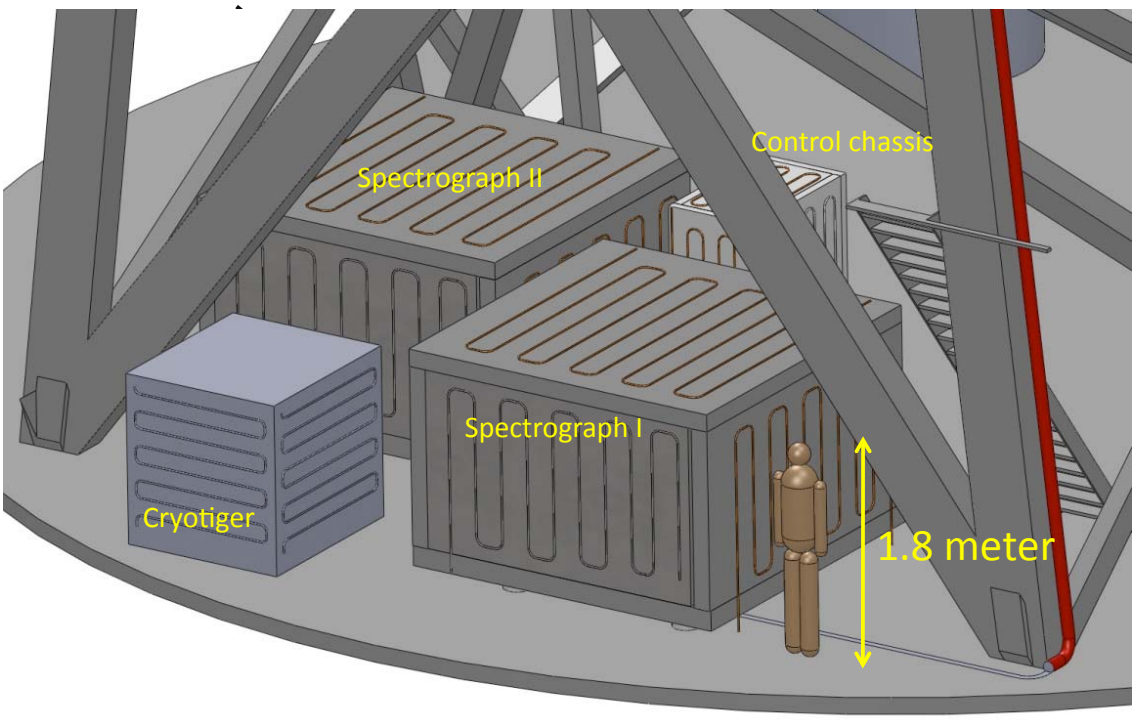


- **Entire wavelengths can be covered by rotating gratings and camera system**

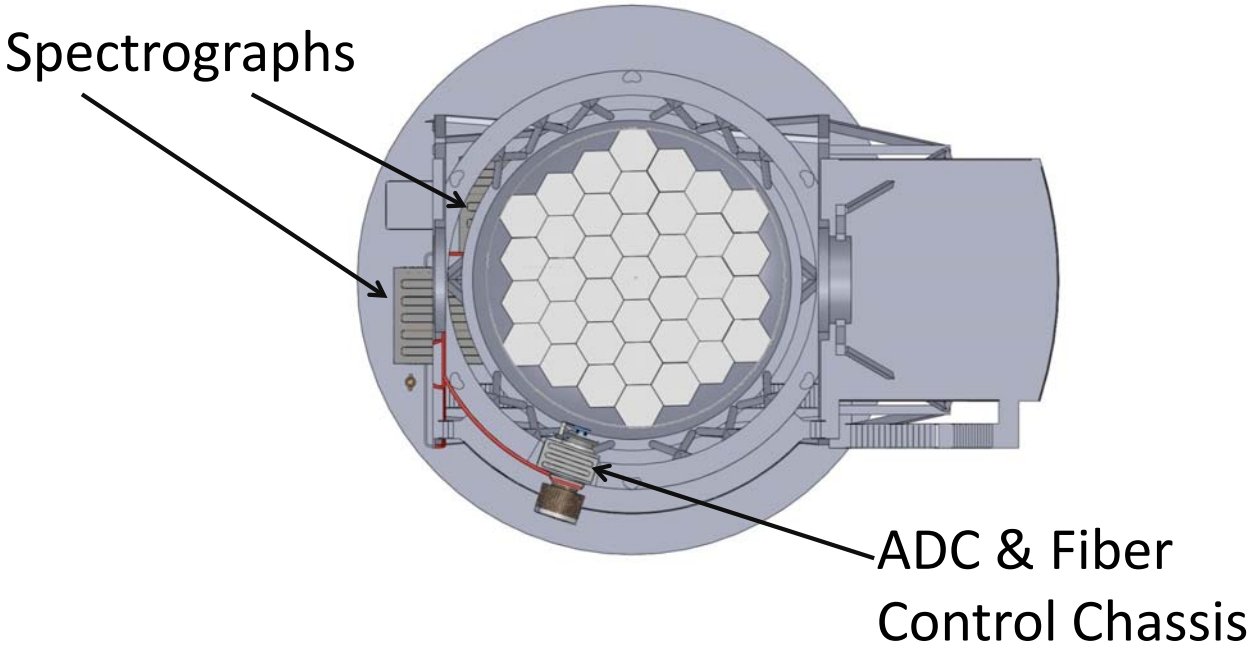
Instrument overview



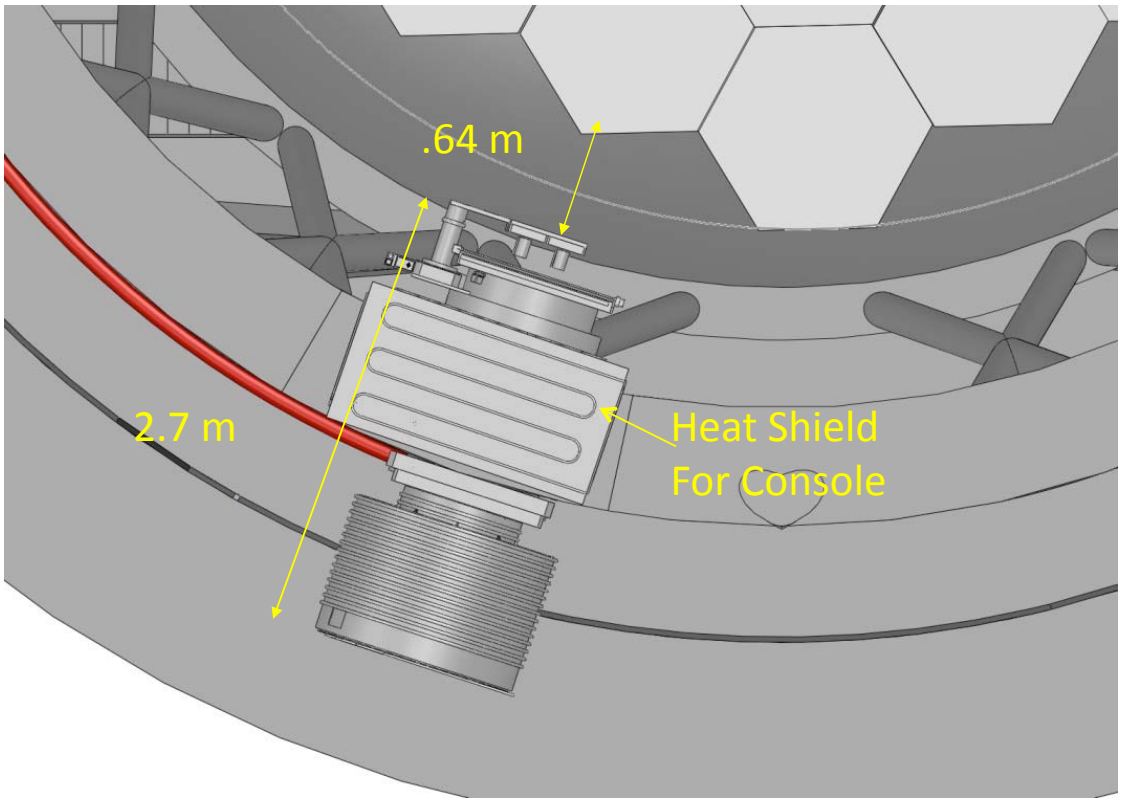
Instrument overview



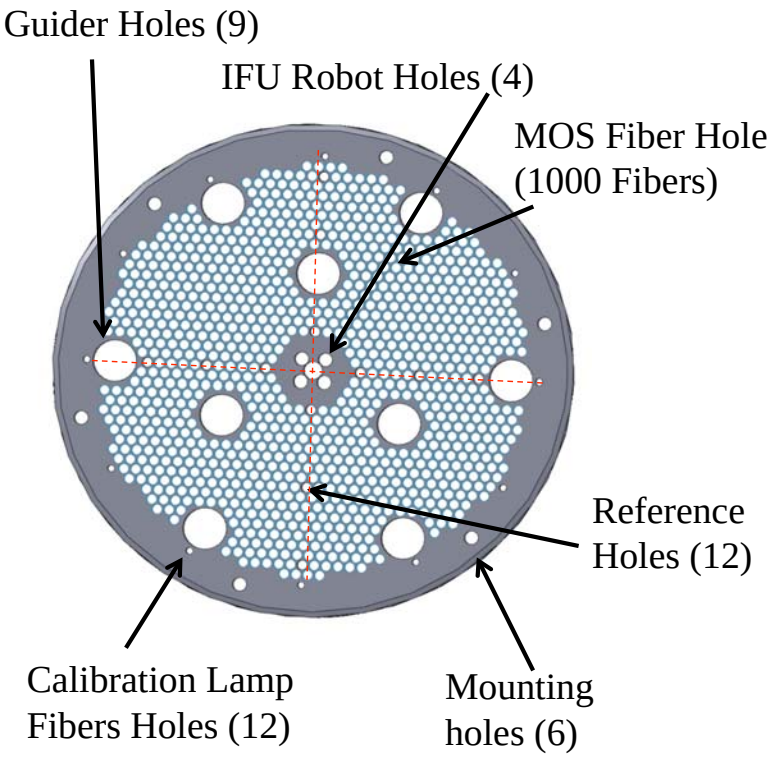
Star view of telescope

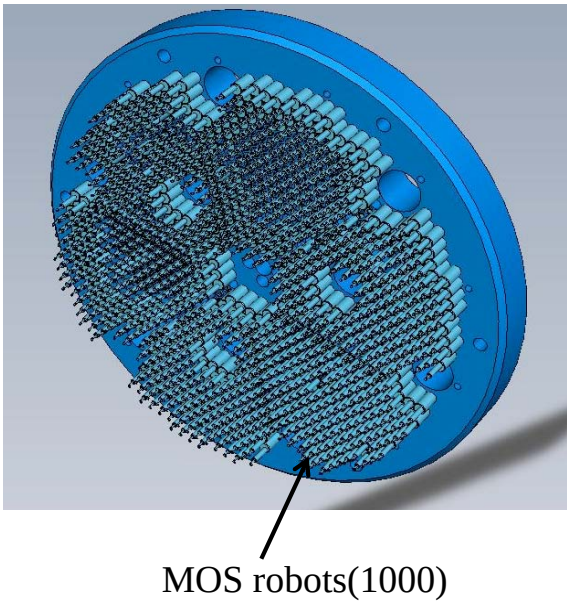


Star view of telescope

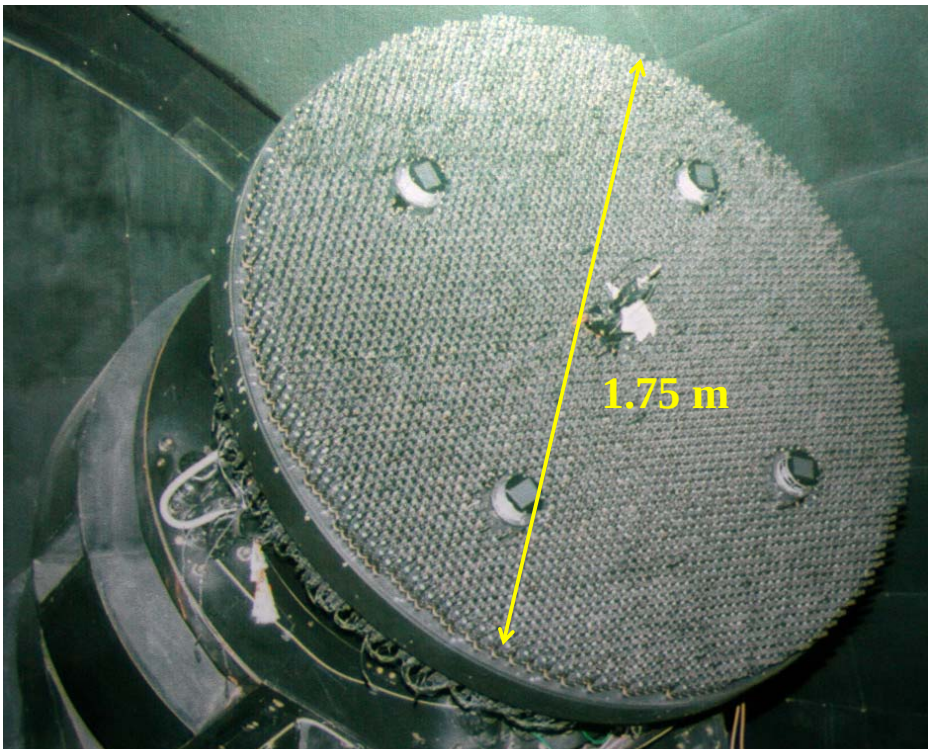


Focal plane plate

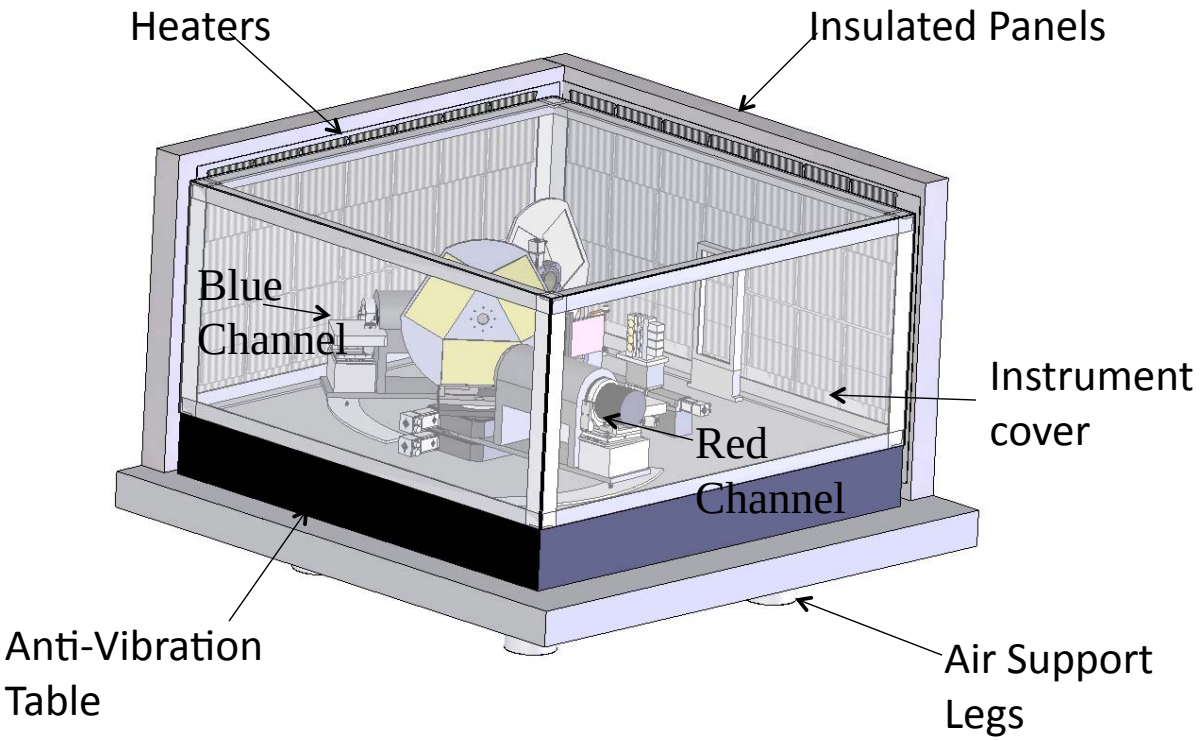




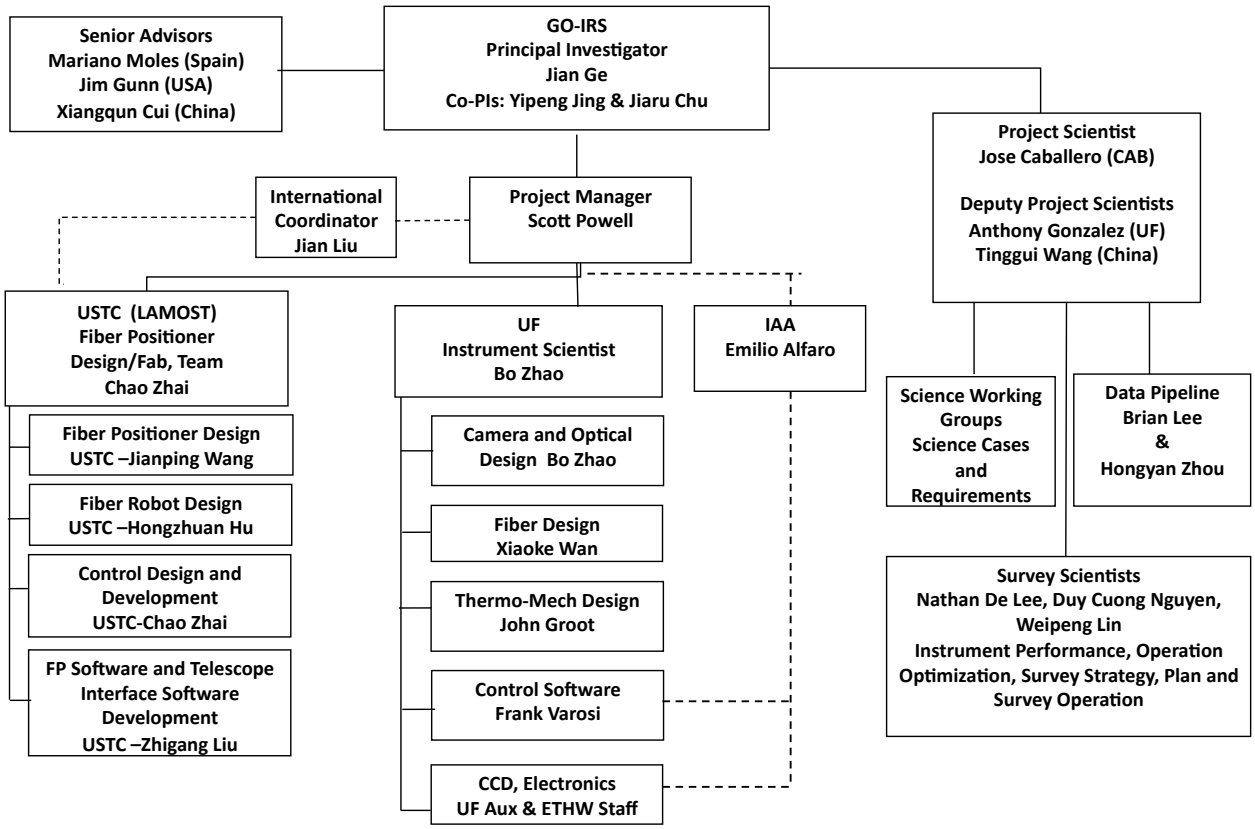
LAMOST fiber positioner



Spectrograph system



Organization



Key facts

- **1000 MOS** fibers in a large field of view (**15'**) and intermediate resolution (**R=2,000-20,000**) with **IFU** capability at a 10-m class telescope
- Possibility to investigate **virtually all objects** in the Universe: from exoplanets to distant quasars
- Big team of enthusiastic, experienced astronomers and engineers in **USA**, **China** and **Spain** working shoulder to shoulder
- Apply **telescope-proof technology** (LAMOST, MARVELS…)

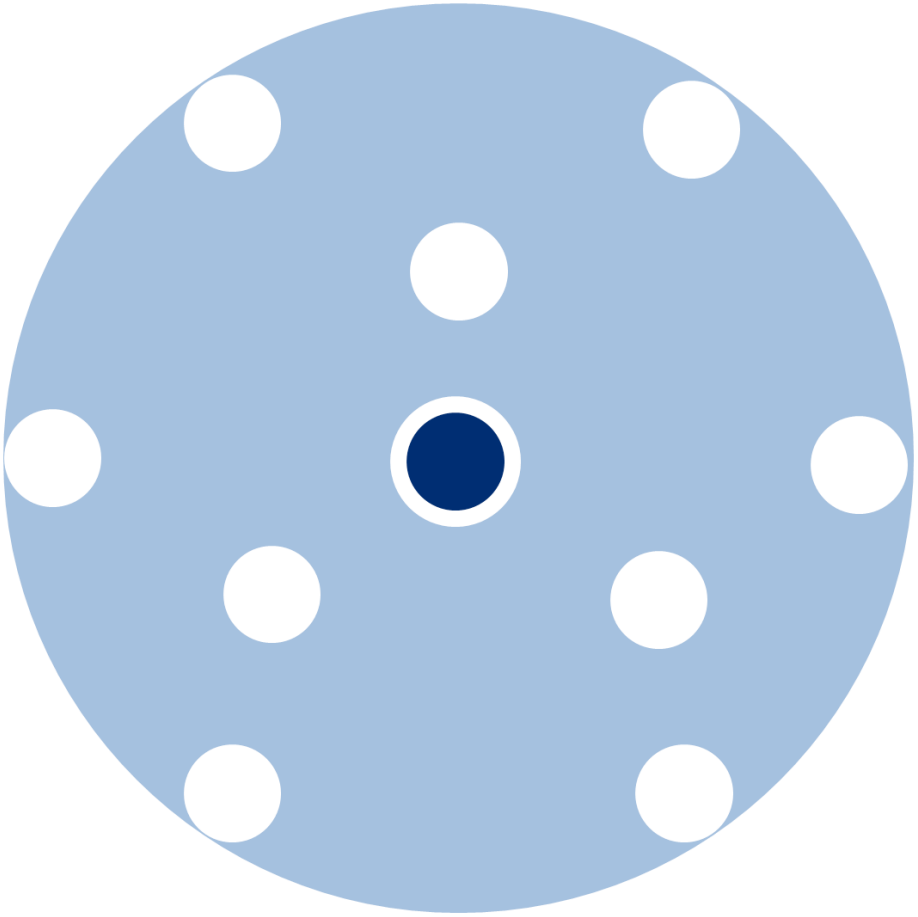
GTC announcement

In late September, GTC announced that the third-generation instruments will be:

- MEGARA (optical)
- MIRADAS (near-IR)

But…

GTC has started negotiations with China for building a GO-IRS-like instrument.



http://marvels.astro.ufl.edu/GO-IRS/