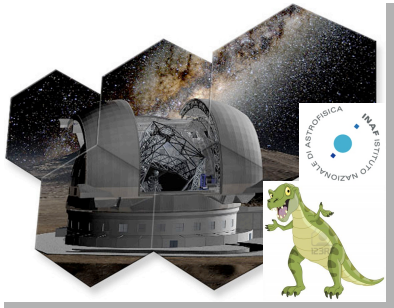


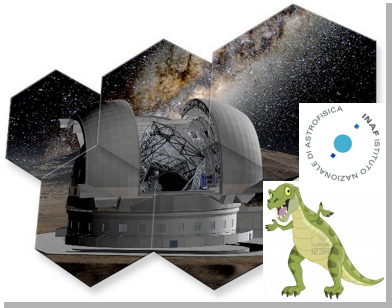
T-REX Unit
E-ELT HIRES

L. Origlia, E. Oliva, F. Zerbi, S. Cristiani

INAF, Italy

R. Maiolino

Cavendish Lab & Kavli, Cambridge, UK



T-REX Unit for the E-ELT HIRES

past milestones …

◆ oct 2011: given the new E-ELT/instrument roadmap & X-Shooter success the PIs, PMs & PSs of the CODEX (opt) & SIMPLE (IR) Phase-A studies met in Garching to start discussion (scientifically first and then technically) about the interest/opportunity for a high/medium res spectrograph with simultaneous wide spec coverage from opt to IR wavelengths

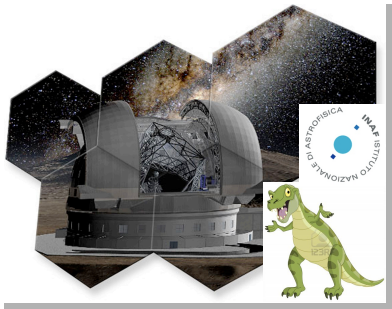
◆ nov 2011: letter to M. Casali to inform ESO about HIRES activities

◆ sept 2012: scientific workshop on E-ELT HIRES in Cambridge

✓ involvement of the whole European high res spectroscopic community

✓ explored all science cases from planet atmospheres to stars & stellar pop out to the high-z Universe and fundamental constants

✓ white paper with science cases and top level requirements (being written)



T-REX Unit for the E-ELT HIRES

Cambridge workshop: Towards the science case for E-ELT HIRES

Presentations

Haehnelt & Maiolino: Welcome and introduction

E-ELT PROJECT STATUS and OTHER FORTHCOMING HIGH RESOLUTION SPECTROGRAPHS

Liske: E-ELT project status

Szentgyorgyi: G-CLEF: A General Purpose Optical Echelle Spectrograph for the GMT

Da Costa: GMT instrument development

Pepe: ESPRESSO, a taste of high-resolution spectrographs on extremely large telescopes

Strassmeier: The PEPSI high-resolution spectrograph for the Large Binocular Telescope

E-ELT HIRES SCIENCE CASES: STELLAR SPECTROSCOPY and YOUNG STARS

E. Tolstoy: Chemistry and Kinematics of Stellar Populations

de Laverny: Stellar evolution and galactic archaeology with ELT/HIRES: some possible projects

Gustafsson & Korn: Raising the bar on stellar abundances: why and how?

Larsen: Detailed chemical abundance analysis of semi-resolved stellar populations

Testi: Disk-star interaction and evolution at the time of planet formation

Origlia: Summary of requirements and discussion

E-ELT HIRES SCIENCE CASES: HIGH REDSHIFT GALAXIES and COSMOLOGY

Petitjean: The interconnection between galaxies and the IGM

Fynbo: Spectroscopy of Gamma-ray Burst Afterglows

Tanvir: IGM and ISM in high-z galaxies through HIRES observations

Cimatti: Observing the different phases of the formation and evolution of massive galaxies

Bunker: High resolution at high redshift - galaxy evolution with HIRES/ELT

Murphy: Fundamental physics and cosmology with E-ELT quasar spectroscopy

Cristiani: Summary of requirements and discussion

E-ELT HIRES SCIENCE CASES: EXOPLANETS

Gillon: Transiting planets atmospheric studies

Lovis: Science requirements for the characterization of exoplanet atmospheres

Snellen: Exoplanet atmosphere characterization at high spectral resolution

Santos: Prospects for the detection of reflected light from other worlds

Udry: Radial Velocity Follow-up of terrestrial transiting planets

Queloz: Summary of requirements and discussion

E-ELT HIRES: SUMMARY and DISCUSSION

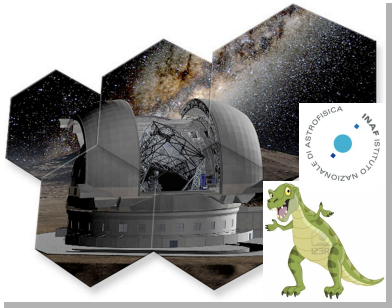
Pasquini: summary of science requirements

Oliva & Delabre: Technical issues

Maiolino & Haehnelt: Brief summary and next steps (white paper)

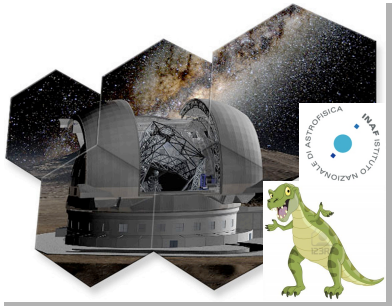
- 90 participants even without advertising the workshop on the CADC server

- nice agreement among the different communities on the top level requirements and on the basic instrument concept



T-REX Unit for the E-ELT HIRES
science top level requirements

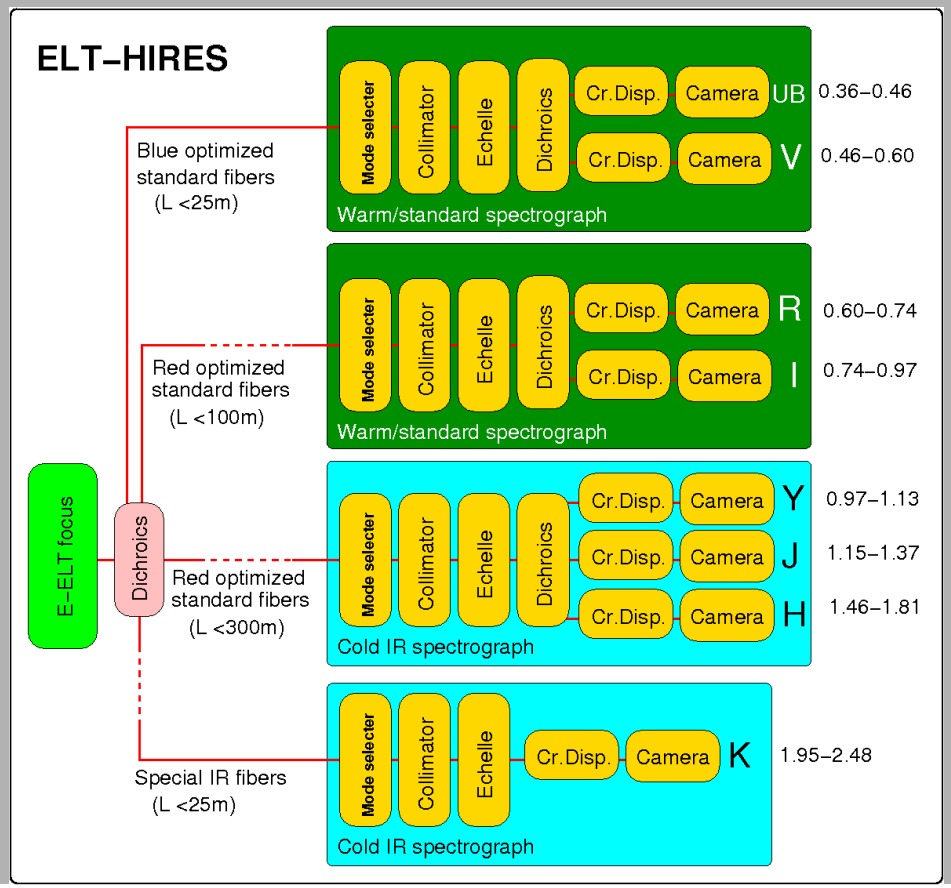
- **target sizes & spatial resolution**:
  - mostly point sources (stars, exo-planets, QSOs) or moderately extended (~1" galaxies) ➔ seeing/GLAO PSF
  - sub-structures at ~10mas scale (CS disks): DL in K
  - point sources in very crowded fields: ~ tens mas
- **spectral range & coverage in one exposure**:
  - as wide as possible
  - simultaneous 0.37-2.45 micron highly desirable for complete line diagnostics & redshift coverage
- **spectral resolution(s) & multiplexing**:
  - R>=100k + single obj ➔ exo-planets & chemical evol (stars, IGM)
  - R~10k +10 obj ➔ stellar pop, galaxy evolution, IGM tomography
  - R~100k + IFU/MOS at ~DL → CS disks, dense stellar fields



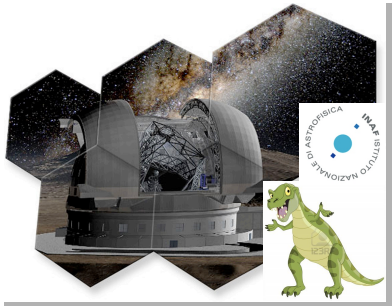
T-REX Unit for the E-ELT HIRES

a possible instrument concept (Oliva & Delabre)

- Fundamental approach: highly modular concept within reasonable technological limits.
- Modules and observing modes may be added or removed following a trade-off study between scientific priorities & tech/cost constraints.

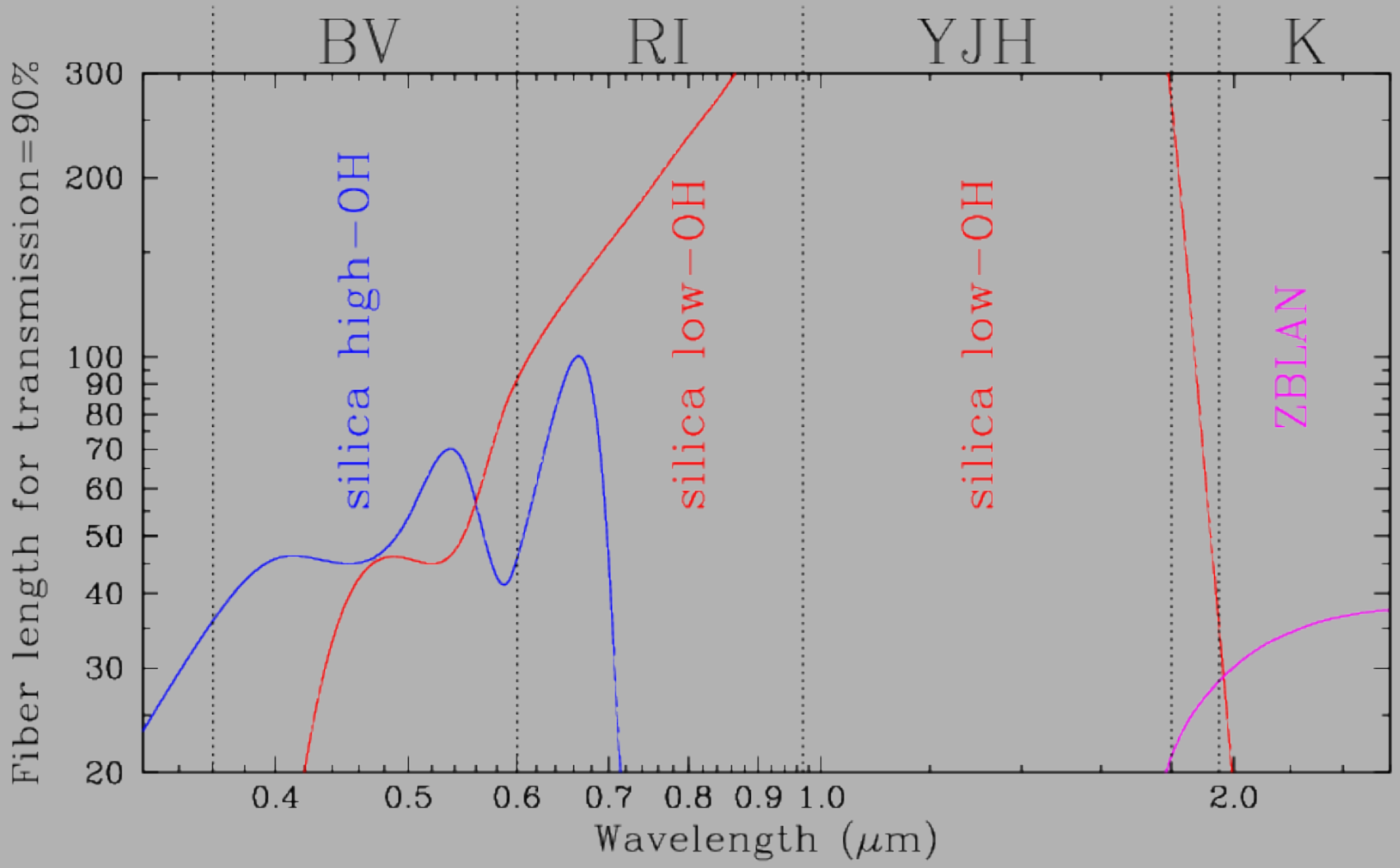


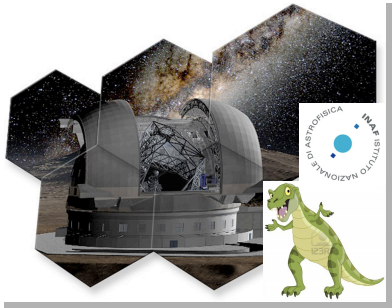
- 4 independent fiber-fed modules (i.e. spectrometers) optimized over 4 spectral ranges (UBV, RI, YJH, K).
- Different observing modes are obtained using different and independent groups of fibers feeding each spectrometer.
- Observing mode is selected in the pre-slit section (fore-optics) of each module. No change inside the spectrometers.



T-REX Unit for the E-ELT HIRES

fibers ➔ independent location of each spectrograph on the platform/other rooms

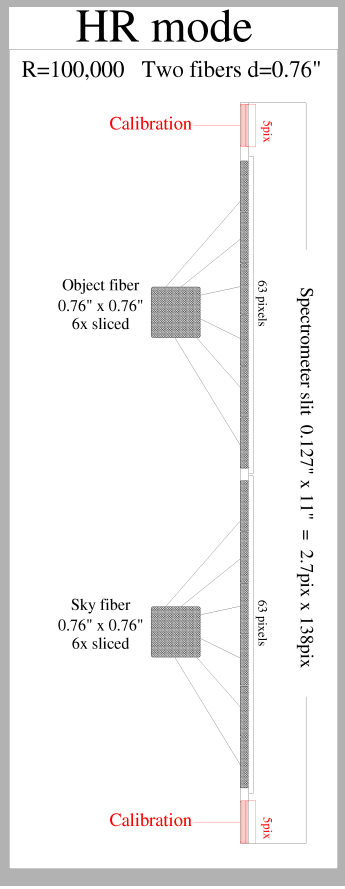


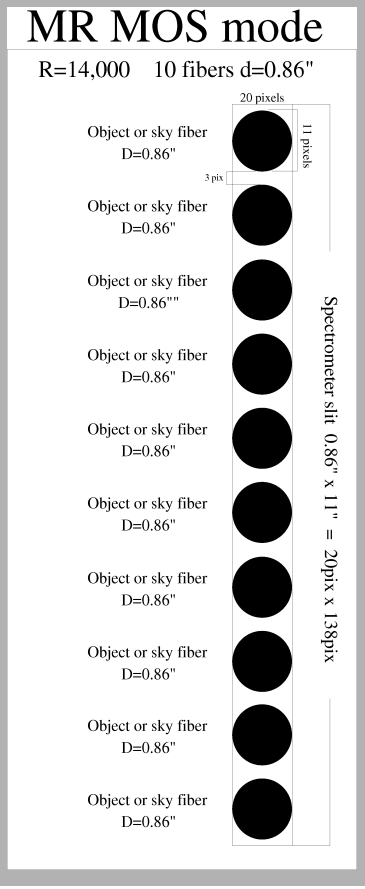


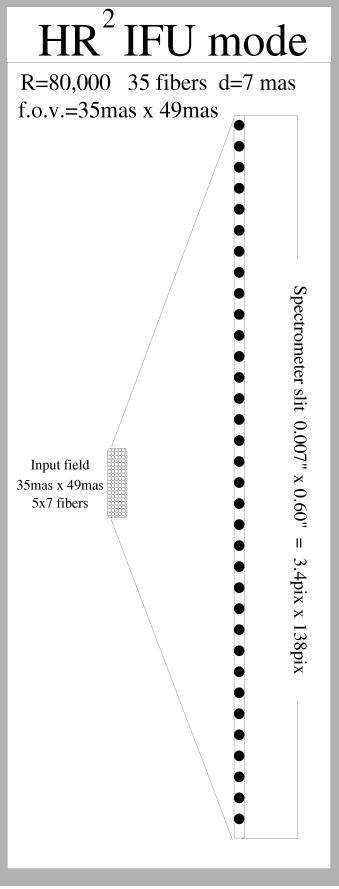
T-REX Unit for the E-ELT HIRES

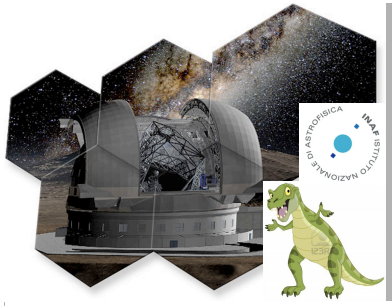
possible observing modes …

- pseudo-slit of 11” (138 pix) along the spatial direction Y
- Y-pixels can be used for slicing (HR) or MOS/IFU
- spectral format (cross-dispersed) is fixed, the same for all observing modes
- different slit-widths (0.13” at R =100,000) are used to achieve different spec res







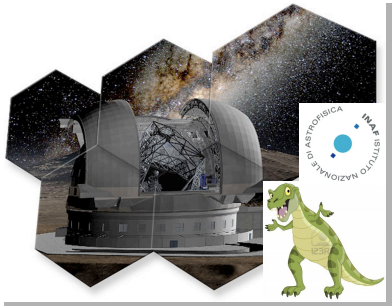


T-REX Unit for the E-ELT HIRES

possible observing modes …

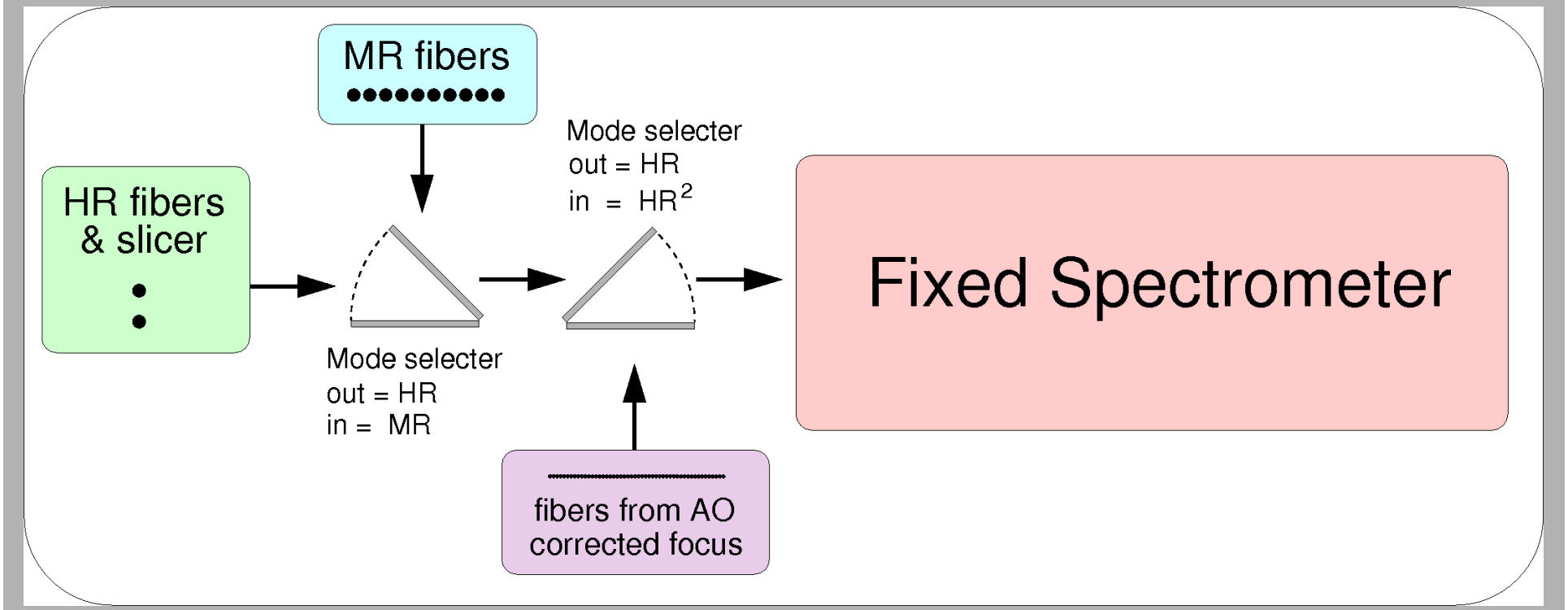
Mode	R	D-fib	N.obj	Size of Res. Element		Comment
				sky	pixels	
HR	100,000	0.76"	$2 + \lambda_{cal}$	0.127" x 5.0"	2.8 x 63	1x6 slicing
MR MOS	14,500	0.86"	10	0.86" x 0.86"	20 x 11	MOS on ELT 10' fov
HR^2 IFU	80,000	7mas	35	7mas x 7mas	3.5 x 2	SCAO fov 35x49 mas
Other options						
HR^2 MOS	80,000	0.030"	35	.030" x .030"	3.5 x 2	MOS on MCAO 2' fov
LR MOS	7,000	0.89"	16	1.79" x 0.45"	40 x 6	2x1 slicing

- MR-MOS for all modules/wavelengths with <u>full spec coverage</u>
- HR^2 MOS/IFU only in IR where AO works
- patrol field of MOS depends on where the fibers positioner is located
- possible parallel modes, e.g. MR-MOS in optical while HR in IR on a single object

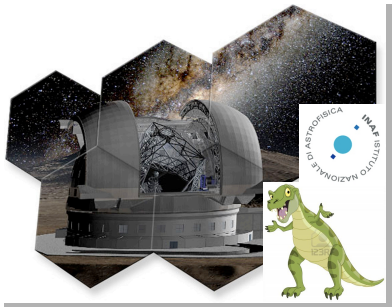


T-REX Unit for the E-ELT HIRES

scheme of a spectral module

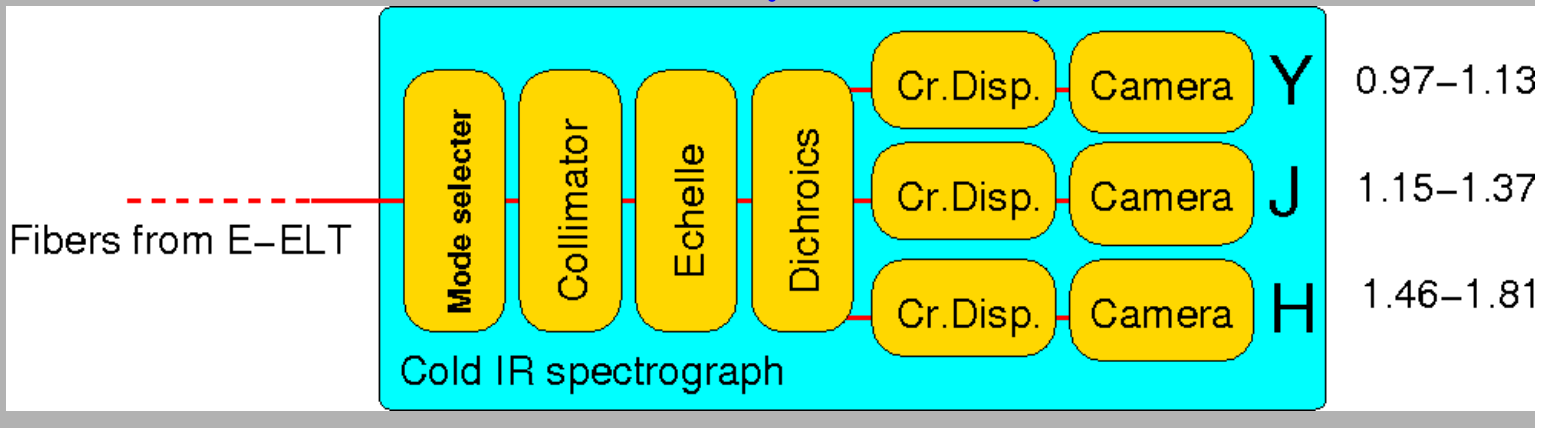


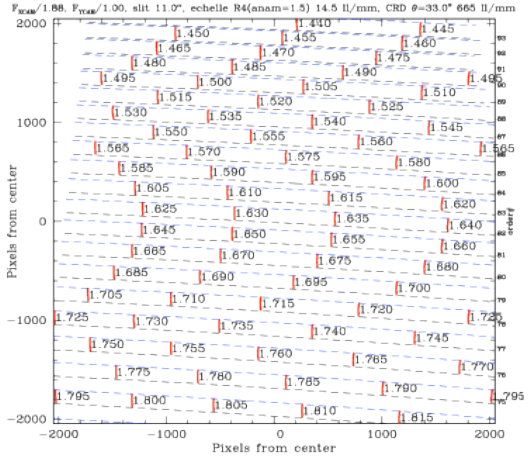
HR mode has fixed optics → stability OK

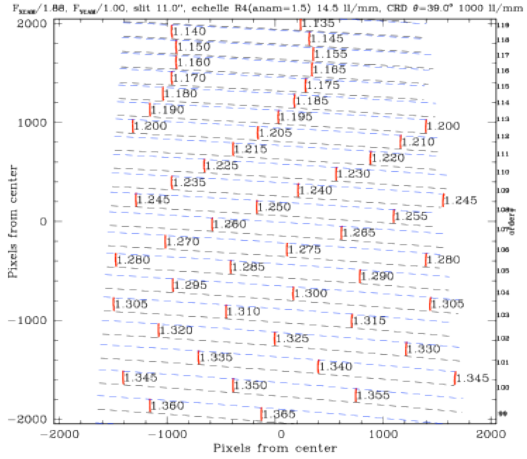


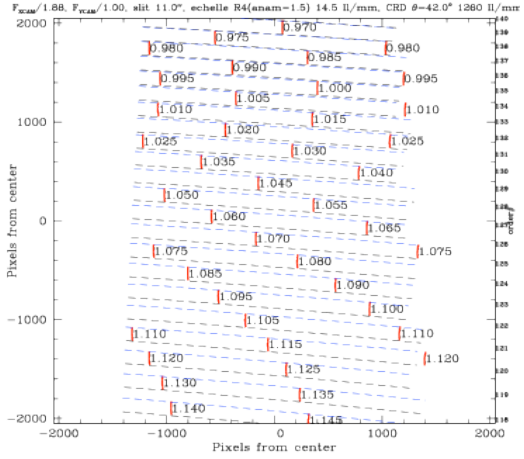
T-REX Unit for the E-ELT HIRES

YJH module: cross dispersed spectral format





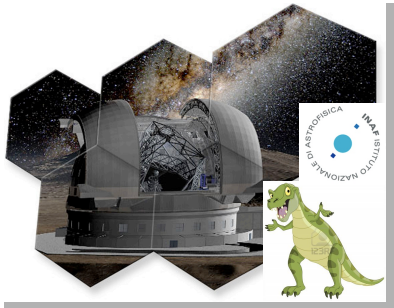




H 1.45-1.81 μm
orders 74-93

J 1.16-1.38 μm
orders 99-119

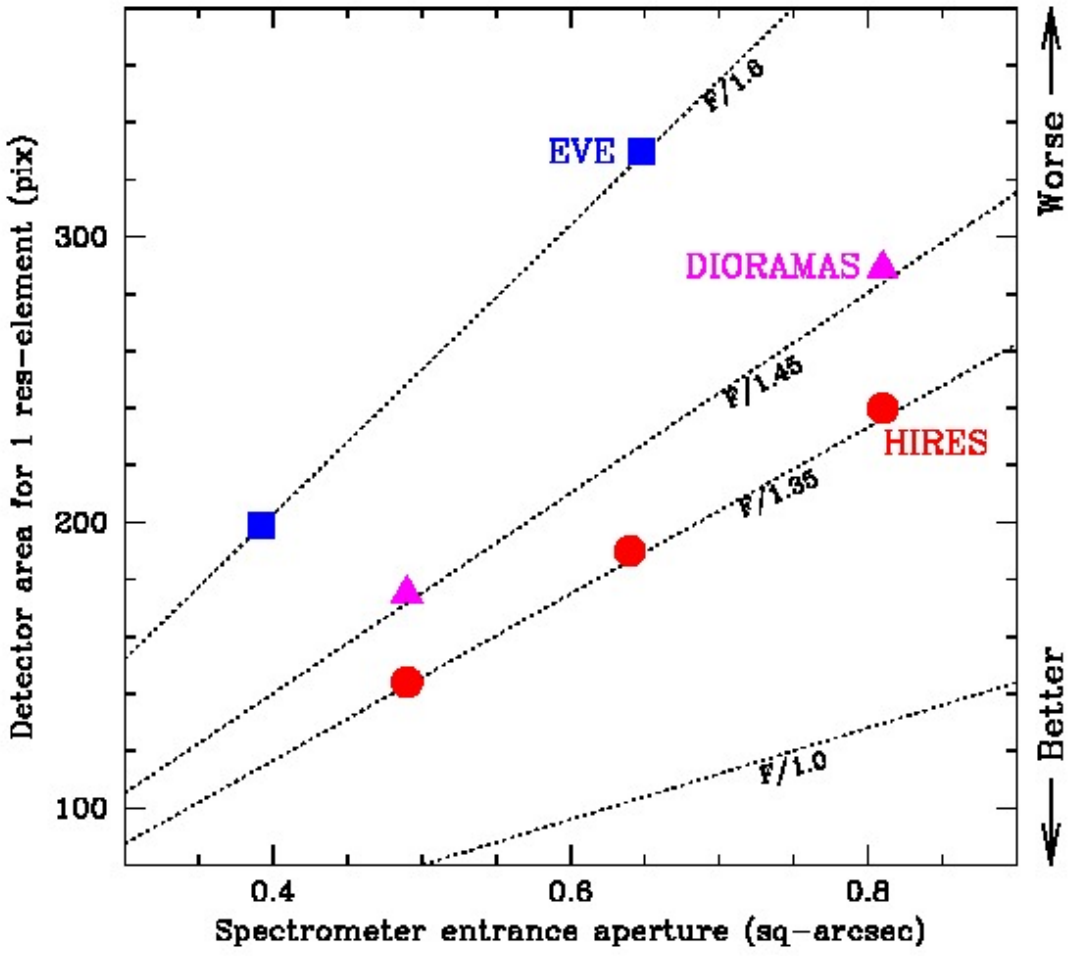
Y 0.97-1.14 μm
orders 118-140



T-REX Unit for the E-ELT HIRES

HIRES *vs* other MOS

$A\Omega$=constant $\rightarrow$ $N_{pix} = 160\ (\theta'')^2\ F^2$

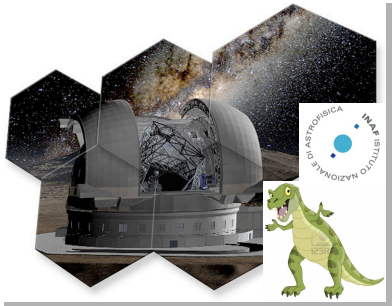


the large E-ELT aperture
&
the small pix size (15 μm)

necessarily imply

seeing/GLAO aperture
spreads over many pixels

HIRES
fastest camera ➔
lowest # of pix



T-REX Unit for the E-ELT HIRES

funding …

- 4 FTEs (new contracts) & some travel support for 2013
- request for additional financial support in the next years

forthcoming activities … next 2 months…

- jan23-24,2013 ➔ HIRES Italian workshop in Trieste

much scientific & technical interest/expertise in medium-high res spectroscopy

Sarg, Harps-N & Giano @ TNG
XShooter, Espresso, Crires & Moons @ VLT

- ✓ design, integration, tests, R&D of cryo-opto-mech systems
- ✓ design & development of low/high level software & control electronics
- ✓ R&D of fibers and related fore optics
- ✓ design, integration, tests of SCAO interfaces

- feb19,2013 ➔ HIRES kickoff meeting in Cambridge

- feb25-mar01,2013 ➔ Shaping E-ELT Science and Instrumentation at ESO