Simple

a high resolution NIR spectrograph for E-ELT

(selected by ESO for phase-A study)

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on behalf of the simple Consortium

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an *ideal* HR spectrometer

- resolving power *R* of at least 100,000
- all the wavelengths range in single frame
- high efficiency, stability and repeatability
- high radial velocity accuracy (< 1 m/s)

Table 1. List of all the HR-IR spectrometers in the world

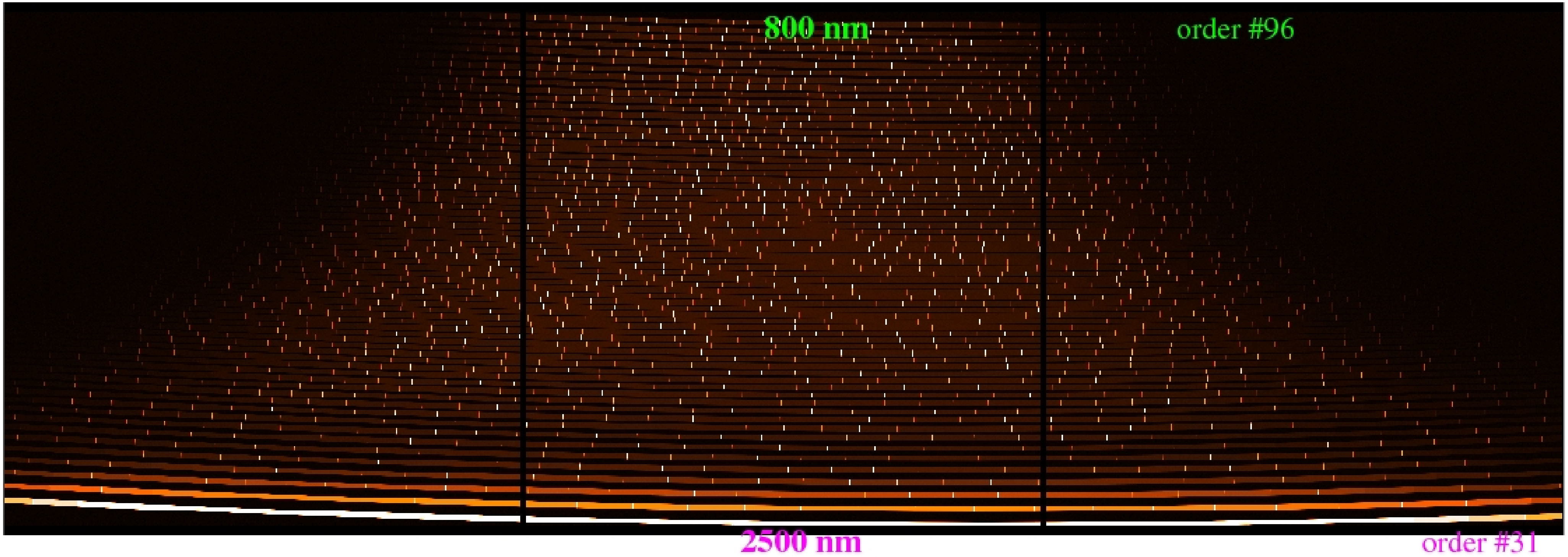
Instrument	Telescope	R_{max}	slit width for R_{max}	Spec. coverage in single frame
CRIRES	VLT (8m)+AO[a]	$1 \cdot 10^5$	0.2"	$\lambda/70$
PHOENIX	Gemini (8m)	$8 \cdot 10^4$	0.2"	$\lambda/200$
GIANO[b]	TNG (3.5m)	$5 \cdot 10^4$	0.5"	$\lambda/1.3$
NIRSPEC	Keck (10m)	$3 \cdot 10^4$	0.3"	$\lambda/10$
CSHELL	IRTF (3m)	$3 \cdot 10^4$	0.5"	$\lambda/240$

[a] coupled to a dedicated adaptive optics system
[b] in advanced stage of construction

- HR-NIR: an almost virgin field of research

simple: a high res NIR spectrograph for the E-ELT

- *R* ~100,000 (150,000)
- 0.8-2.5 microns spectrum in a single exposure



6K x 2K (or 12K x 4K) arrays mosaic

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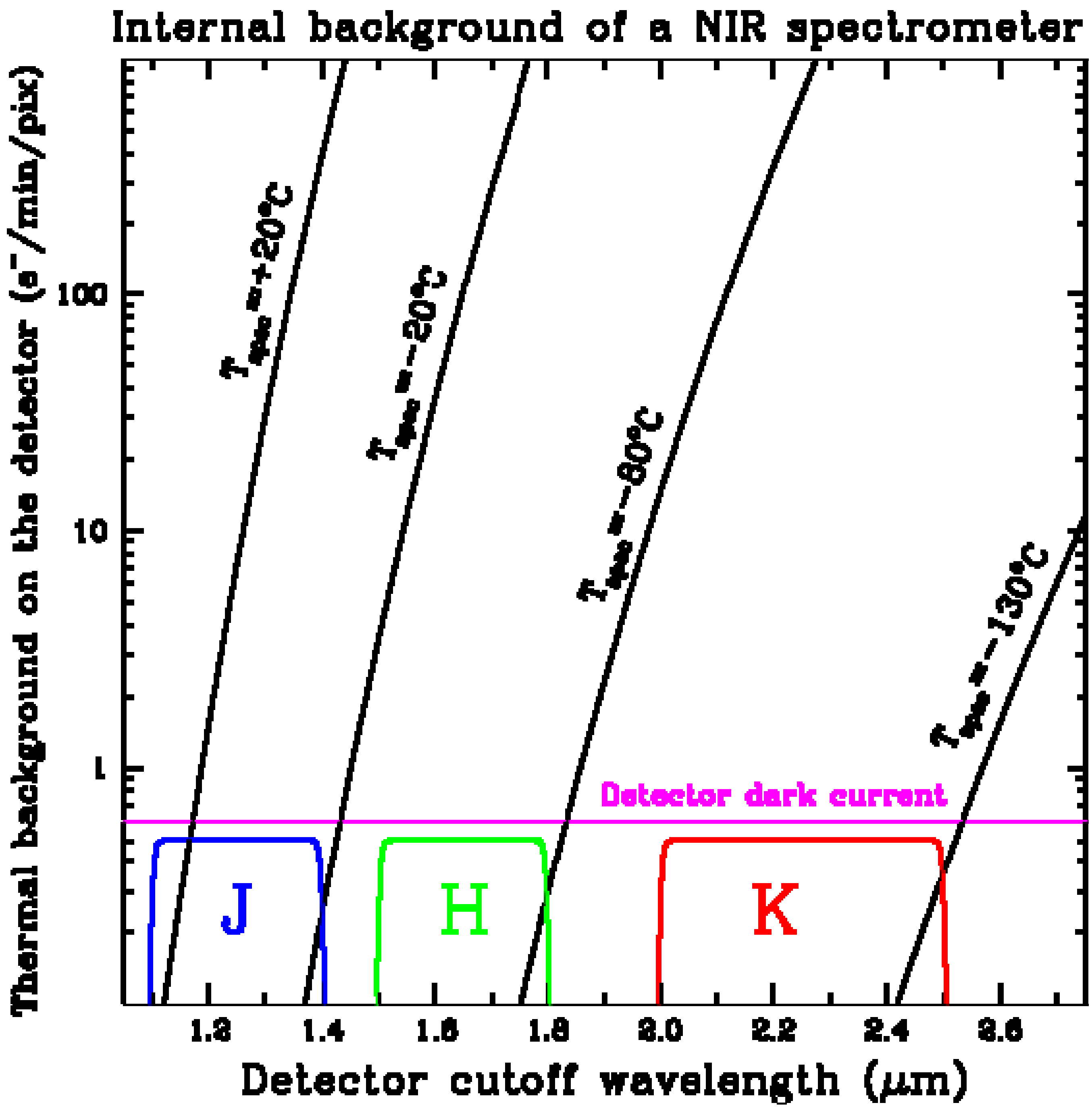
NIR: must cool instrument even if one cuts λ coverage to J band (1.4μm)



simple: a high res NIR spectrograph for the E-ELT

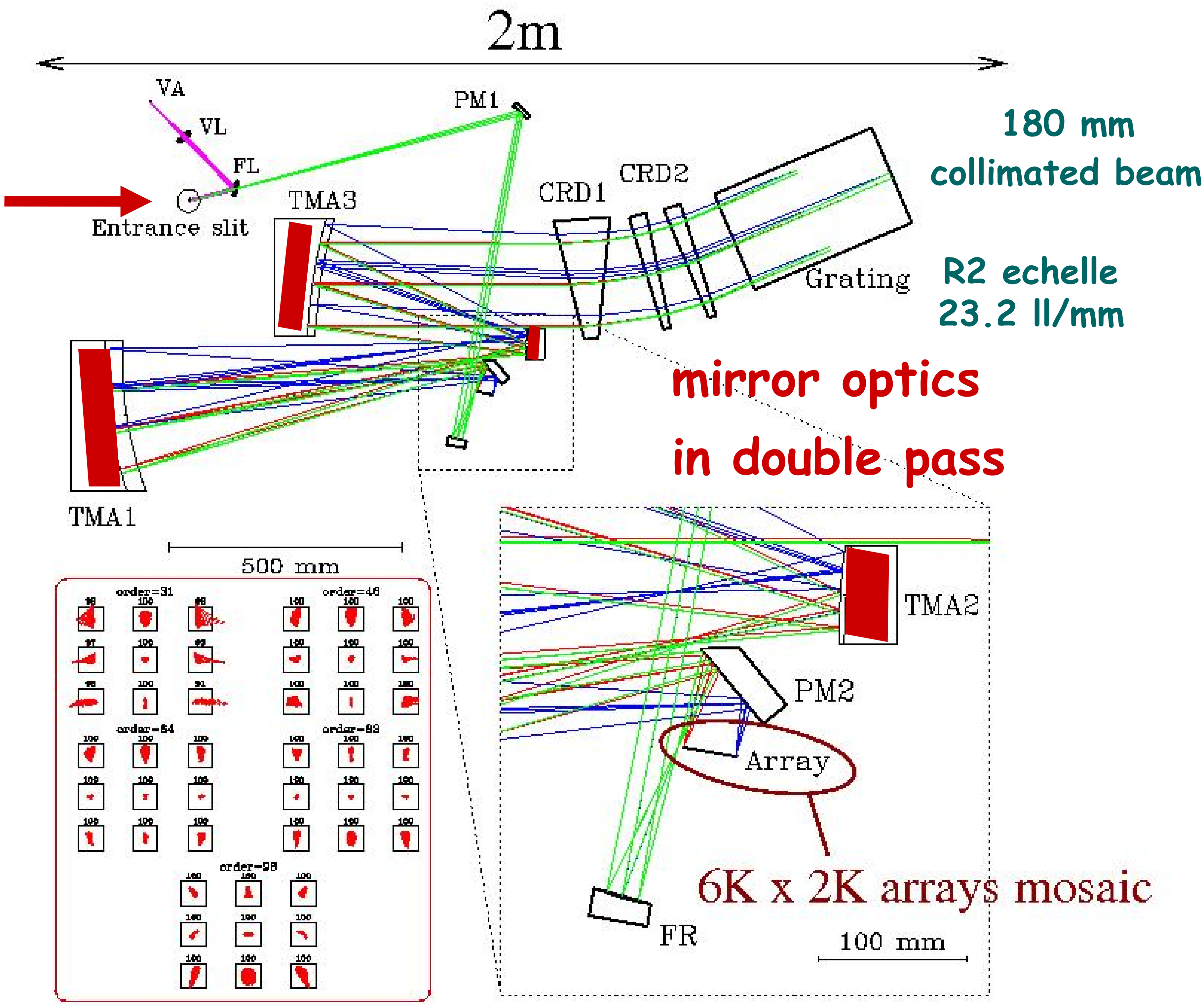
cryogenically cooled

optics in vacuum ➔ spectral stability

~simple technology

simple: a high res NIR spectrograph for the E-ELT

cross-disperser prisms ➔ optimize λ-coverage & efficiency


2m
VA
VL
FL
PM1
Entrance slit
TMA3
CRD1
CRD2
Grating
180 mm
collimated beam
R2 echelle
23.2 ll/mm
mirror optics
in double pass
TMA1
500 mm
order=31
order=46
order=64
order=89
order=98
TMA2
PM2
Array
6K x 2K arrays mosaic
FR
100 mm

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Performances: main scaling laws

- Limiting flux for a given s/n ratio scales with telescope area

$$m_{lim} = \text{constant} + 5.0 \cdot \log_{10}(D_{tel})$$

- Limiting flux for a given s/n ratio linearly scales with the fraction of light falling inside the slit ("slit efficiency" *SLE*)

$$m_{lim} = \text{constant} + 2.5 \cdot \log_{10}(SLE)$$

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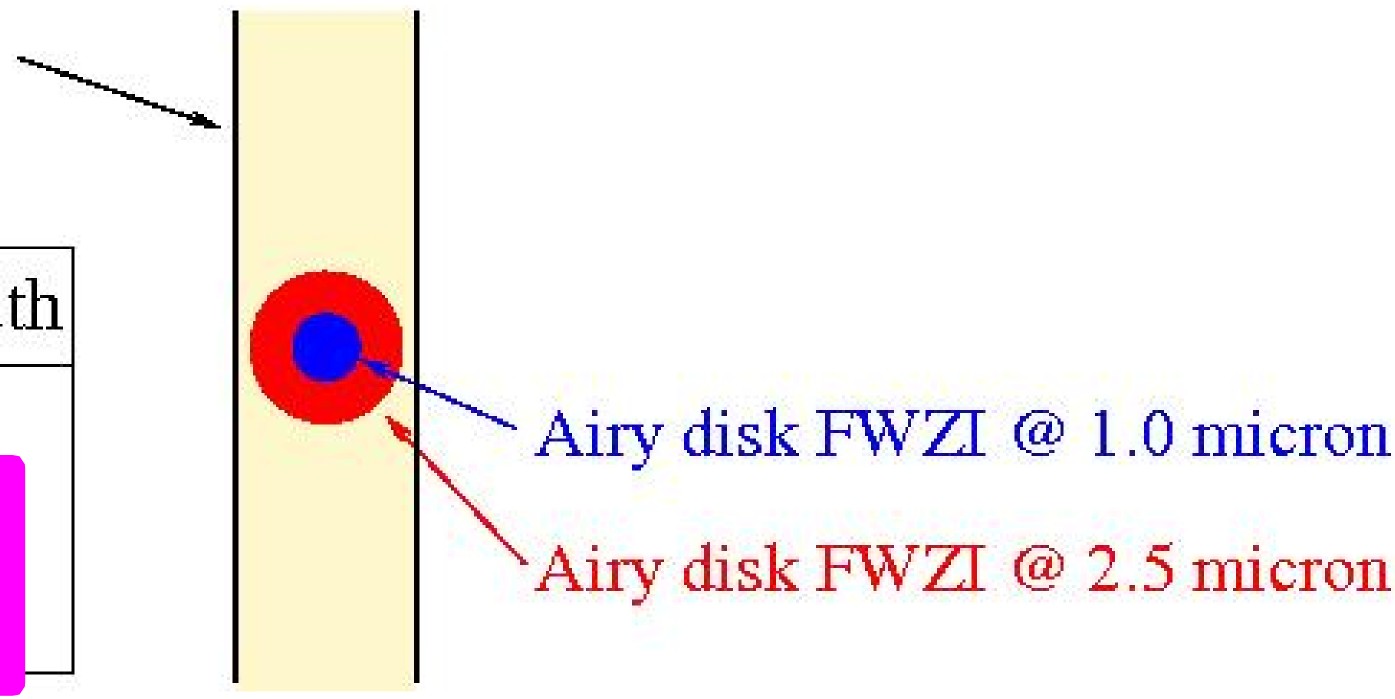
$$m_{lim} = \text{constant} + 2.5 \cdot \log_{10}(SLE)$$



D–Tel	slit–width
3.5m	0.43"
8.2m	0.19"
42m	0.036"

AdOpt !

(slit width using the same spectrometer on different telescopes)

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expected performances on the 42m E-ELT

(conservative estimates)

Table 3.2: Limiting magnitudes in the I,J,H,K bands for different s/n.

S/N	*Limiting magnitudes (Vega) for 2hr integration*
10	I=18.9 , Y=19.3 , J=19.6 , H=19.6 , K=19.3
30	I=17.4 , Y=17.8 , J=18.1 , H=18.1 , K=17.8
100	I=15.5 , Y=15.9 , J=16.1 , H=16.2 , K=15.9

3-3.5 mag deeper than 8-10m class telescopes

$$m_{lim} = \text{constant} + 5.0 \cdot \log_{10}(D_{tel})$$

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science in the next decades

- fully complementar to JWST (only low R)
- an almost virgin field of research

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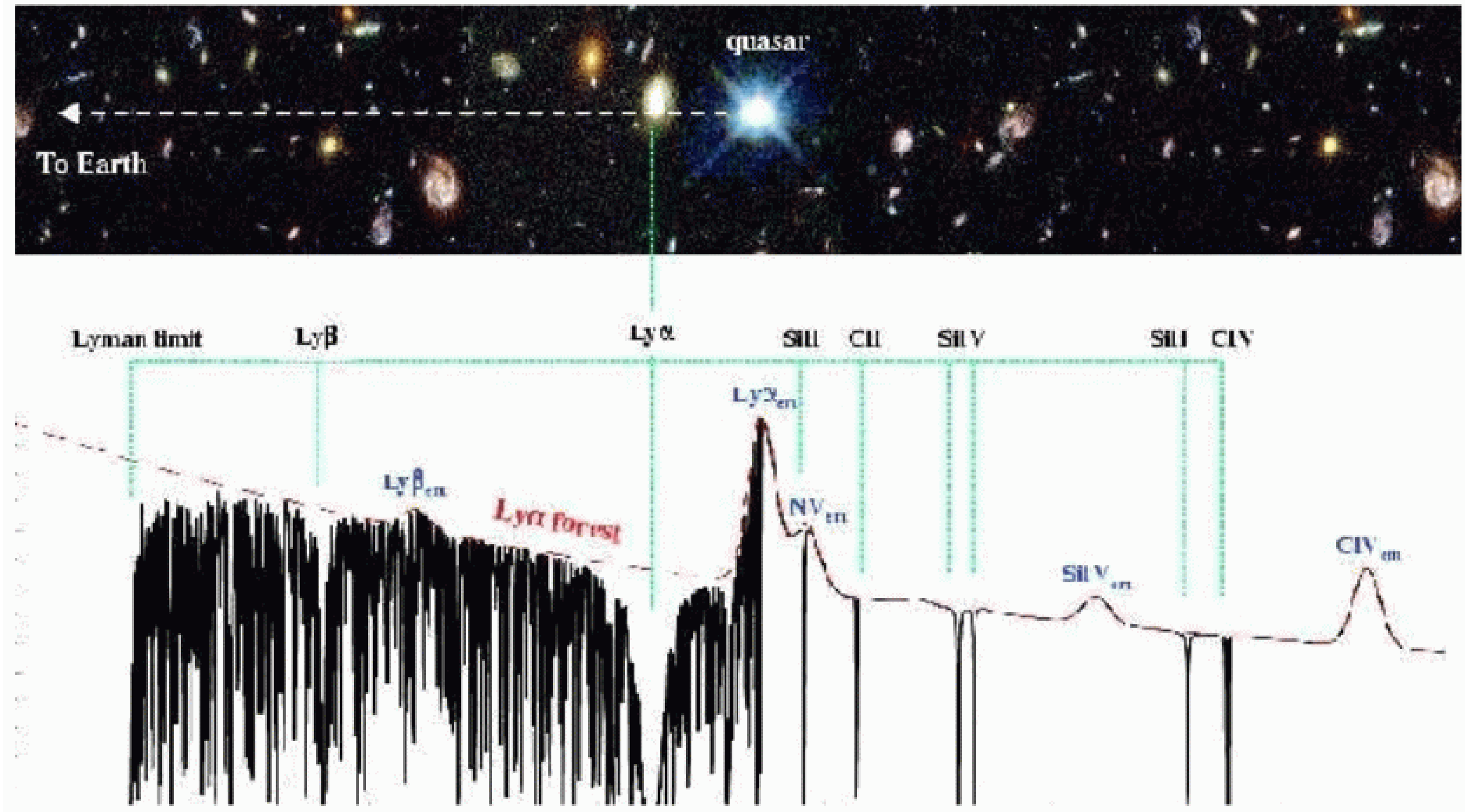
Unique science (needs IR, high-R & ELT)

Metals & kinematics in Ly-alpha absorbers at z>4

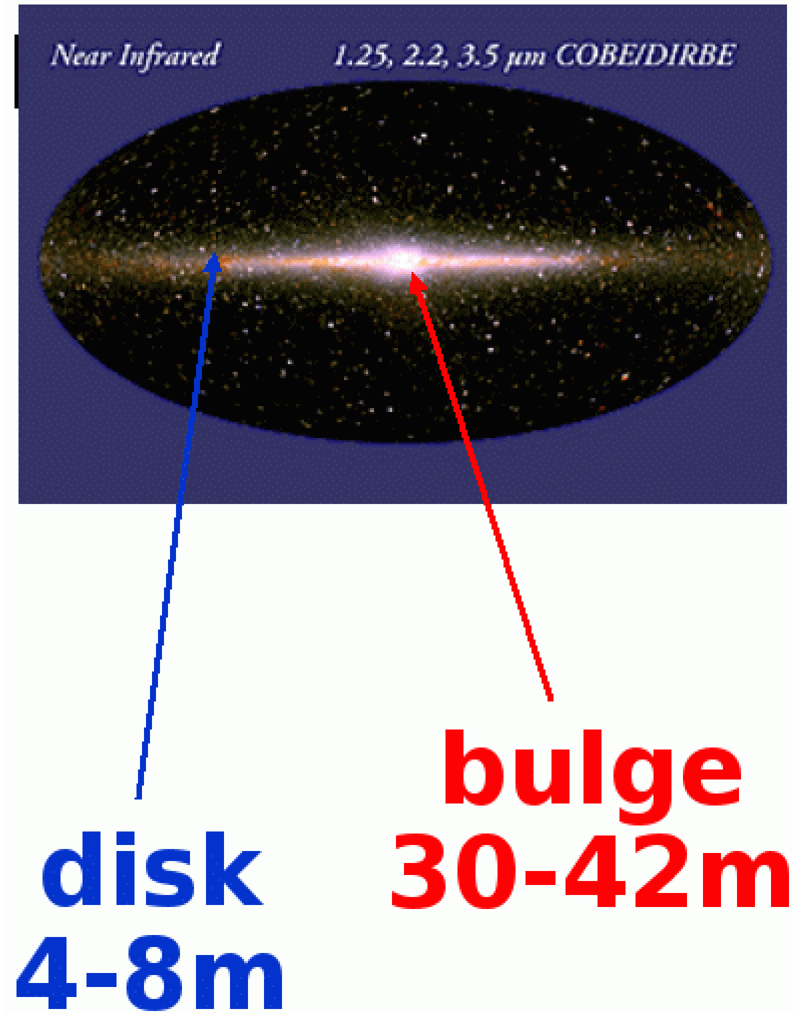


R~100,000 spectra of J,H,K~19 QSOs/GRBs at s/n~20

simple: a high res NIR spectrograph for the E-ELT

Unique science (needs IR, high-R & ELT)

Early nucleo-synthesis and chemical enrichment in the inner Galaxy, from accurate measurements of metallicities in main sequence stars



R~100,000 spectra of J,H,K~17 mag stars at s/n>50

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Unique science (needs IR, high-R & ELT)

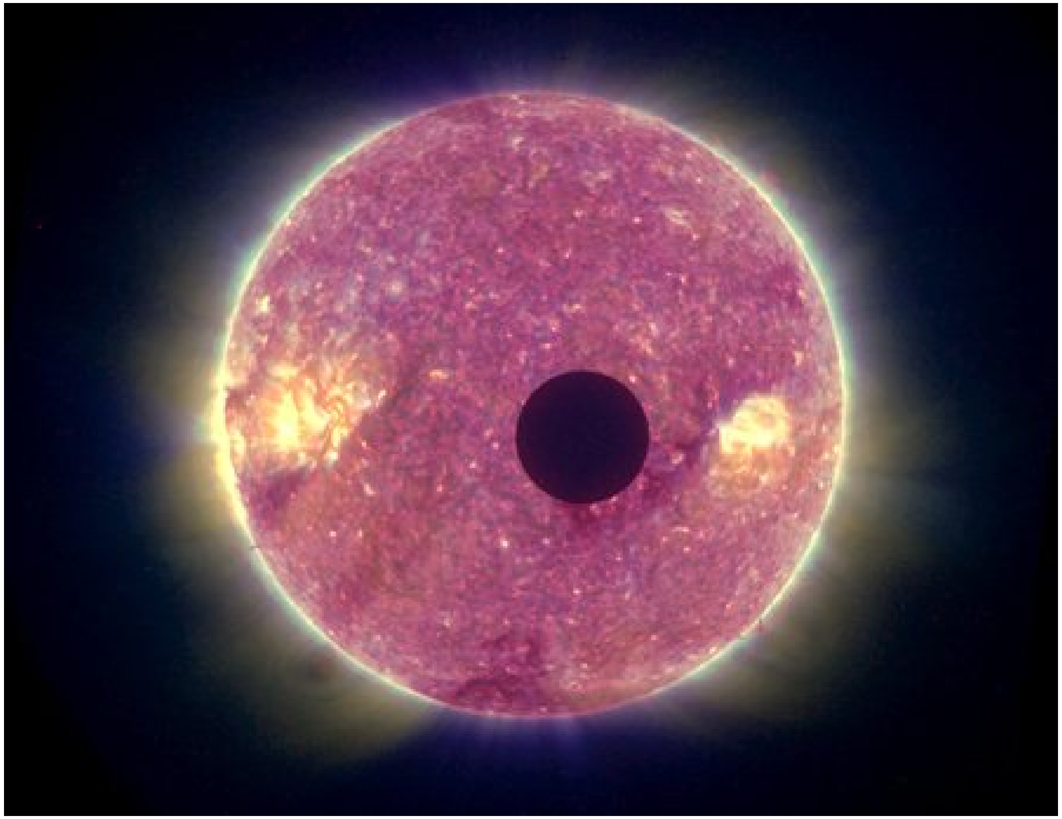
Spectro-astrometry of very dense, hot regions of stellar disks within ~1 AU from the star

R>100,000 with ~10 mas spatial resolution along slit

simple: a high res NIR spectrograph for the E-ELT

Unique science (needs IR, high-R & ELT)

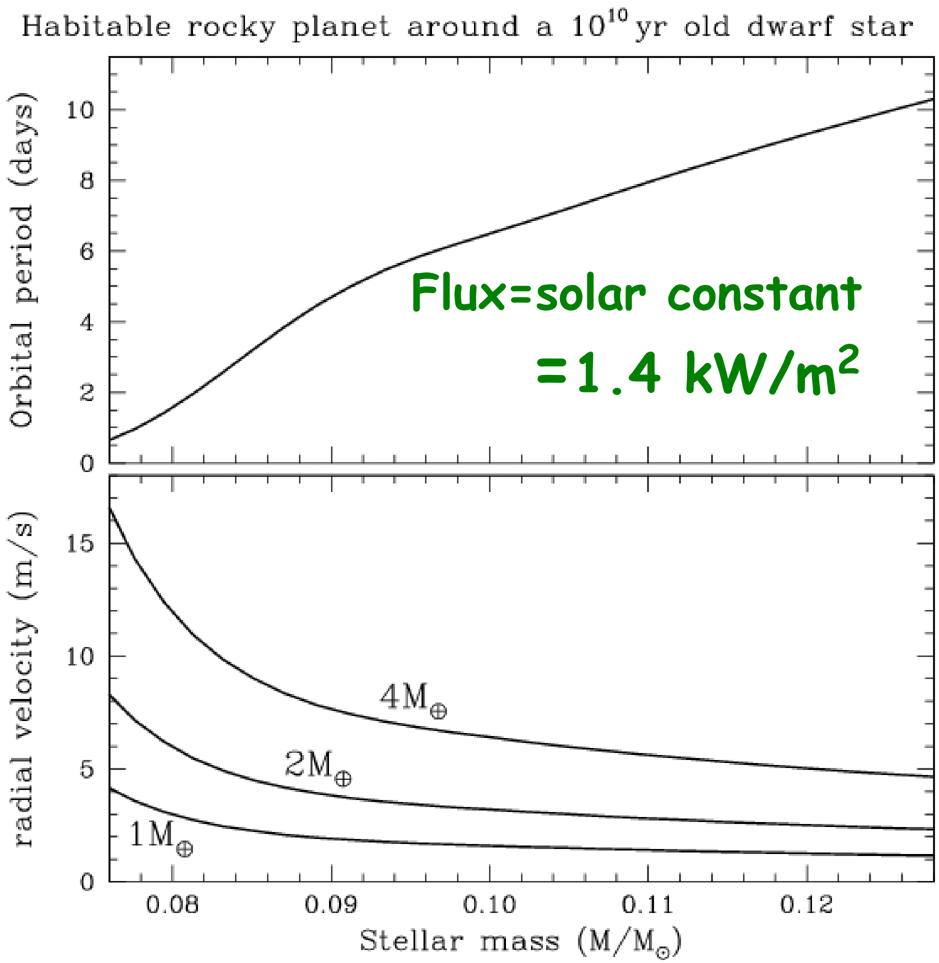
Study atmospheric absorption features during transits of earth-like planets on habitable orbits around low mass stars



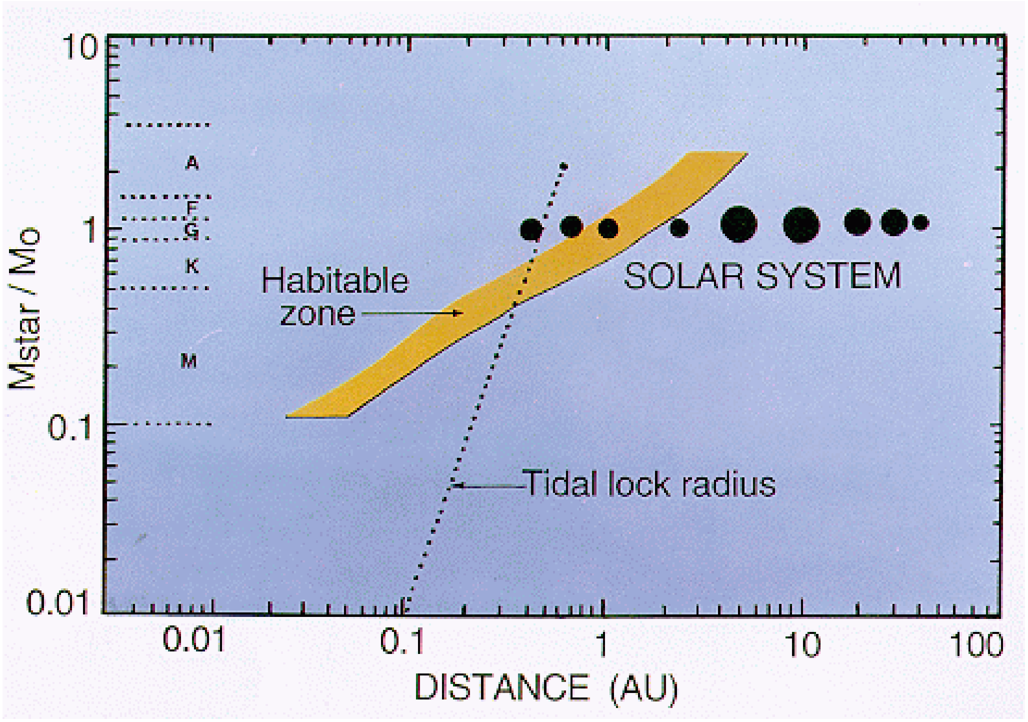
Lines depth ~0.001% of continuum in J,H,K~13 objects

habitable earths: detection from Doppler shift

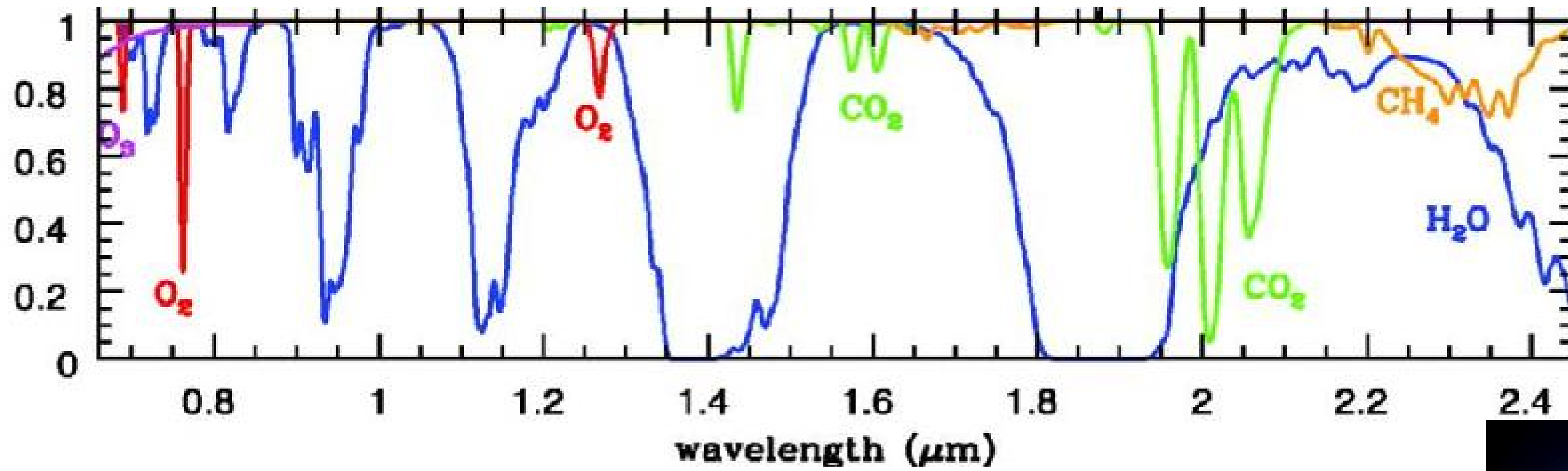
$$v_{rad} \simeq 0.09 \left(\frac{M_*}{M_\odot}\right)^{-5/4} \left(\frac{M_{planet}}{M_{Earth}}\right) \quad \text{m/s}$$

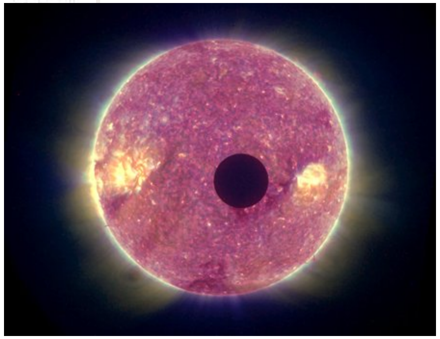


Easier on lowest mass stars



habitable earths: transmission spectra





planet atmosphere seen during transit

Line depth diluted by geometric cross-section

$\Sigma_{atm}/\Sigma_{star} = 2\pi R_p H_{atm}/\pi R_*^2 \sim$ few x 10^{-5} for a 0.1 M_{sun} star

ELT-simple may reach J,H,K~12-13 and have a good probability of finding a suitable system. Unfeasible with JWST and 10m class telescopes.