CRIRES and VISIR, ESO's latest tools for infrared studies of PNe beyond the Milky Way

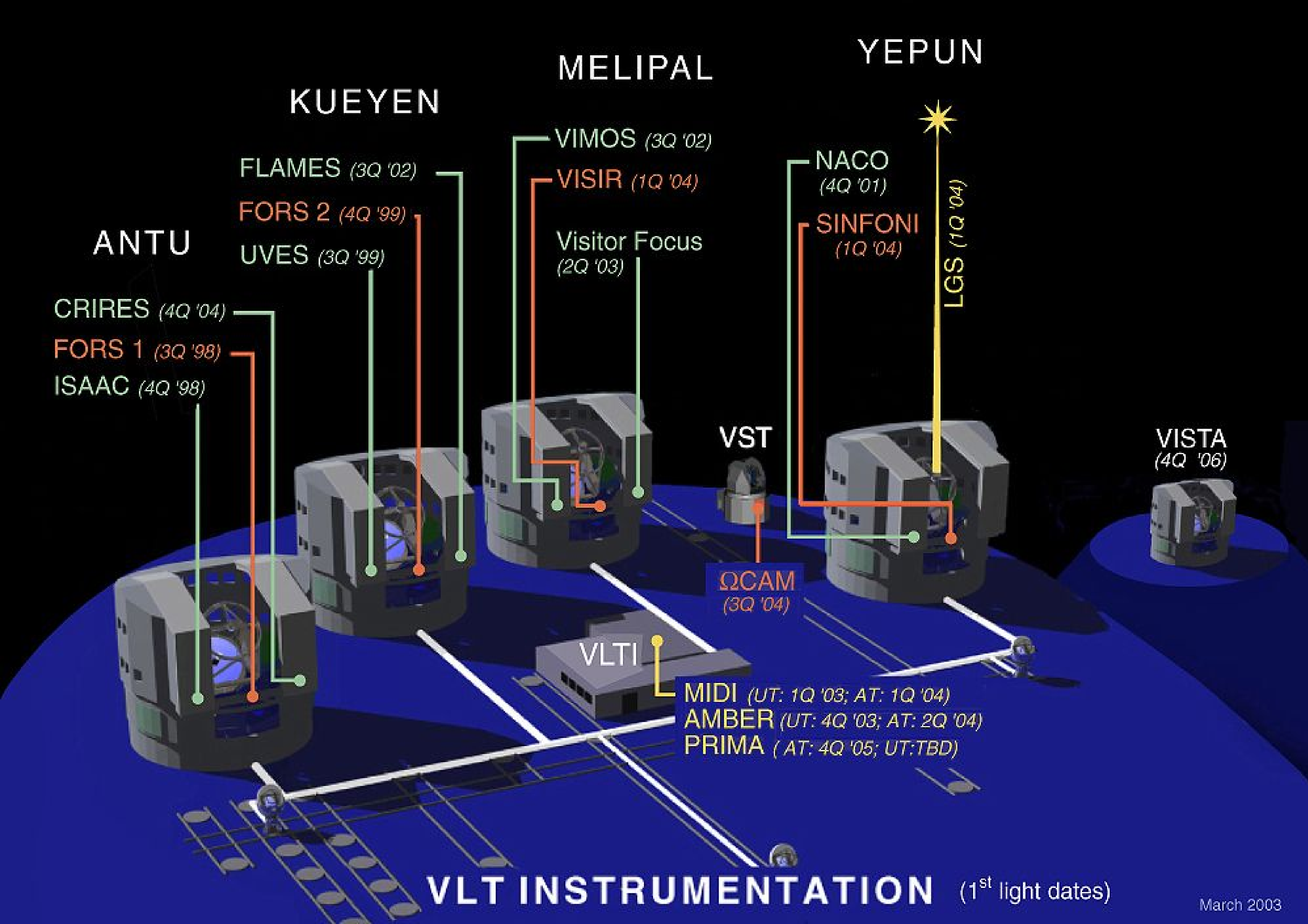
May 19, 2004 *Hans Ulrich Käufl, ESO*

Description of VISIR and CRIRES

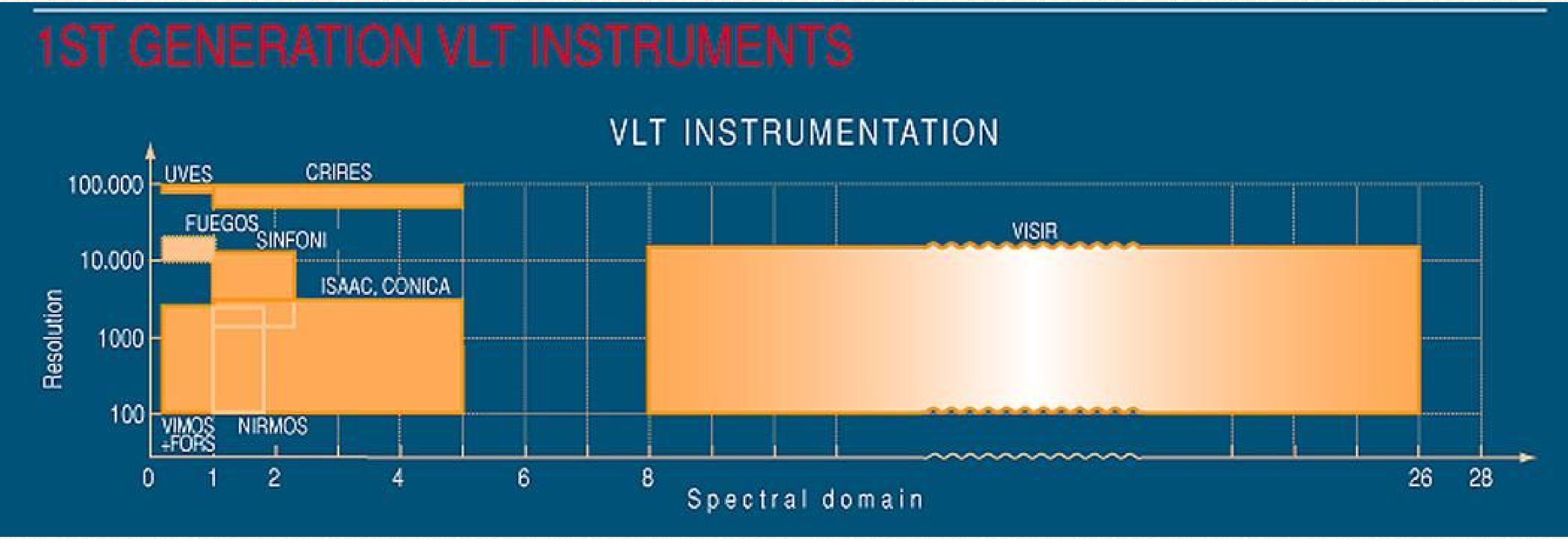
- VISIR: description and report from "first light"
- CRIRES: description and status

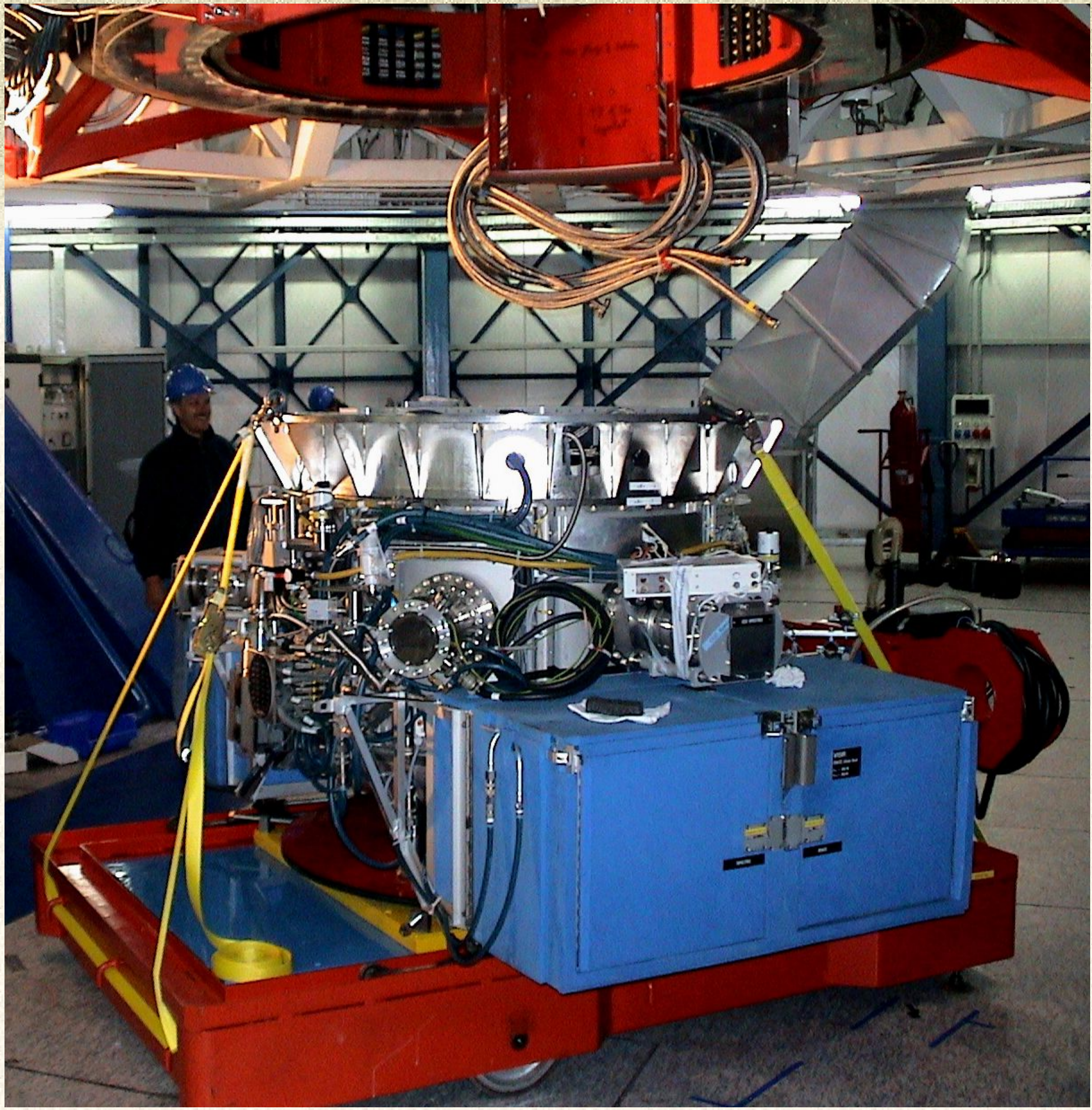
Potential of Infrared Imaging and Spectroscopy:

- surveying for PNe
- study of physical properties of PNe
- study of the PN - progenitors
- technicalities, constraints, pitfalls ...
- comparison to Spitzer


ANTU
KUEYEN
MELIPAL
YEPUN
CRIRES (4Q '04)
FORS 1 (3Q '98)
ISAAC (4Q '98)
FLAMES (3Q '02)
FORS 2 (4Q '99)
UVES (3Q '99)
VIMOS (3Q '02)
VISIR (1Q '04)
Visitor Focus (2Q '03)
NACO (4Q '01)
SINFONI (1Q '04)
LGS (1Q '04)
VST
ΩCAM (3Q '04)
VISTA (4Q '06)
VLTI
MIDI (UT: 1Q '03; AT: 1Q '04)
AMBER (UT: 4Q '03; AT: 2Q '04)
PRIMA (AT: 4Q '05; UT:TBD)
VLT INSTRUMENTATION (1st light dates)
March 2003

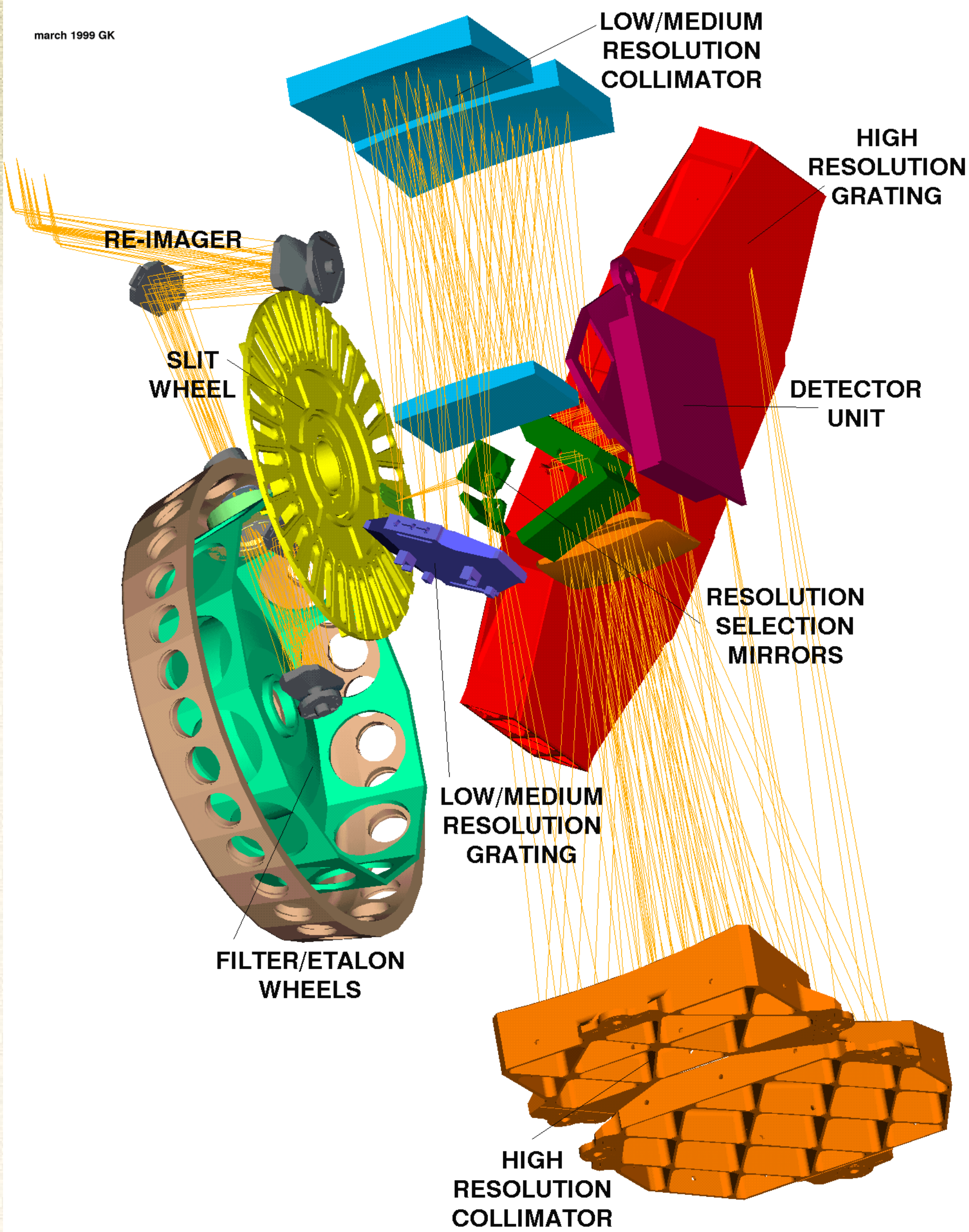
VLT- instrumentation in a (λ, λ/Δλ)-map





VISIR

- built by CEA/Astron
- 10/20 µm imager/ spectrometer (R ~ 500 – 30000)
- sensitivity (BLIP) ~ 2mJy 10µm imaging ~ 20-200mJy spectro
- diffraction limited (~ 0.3 ", sampling 0.075" / pix)
- as of May 2004 @ VLT-UT3

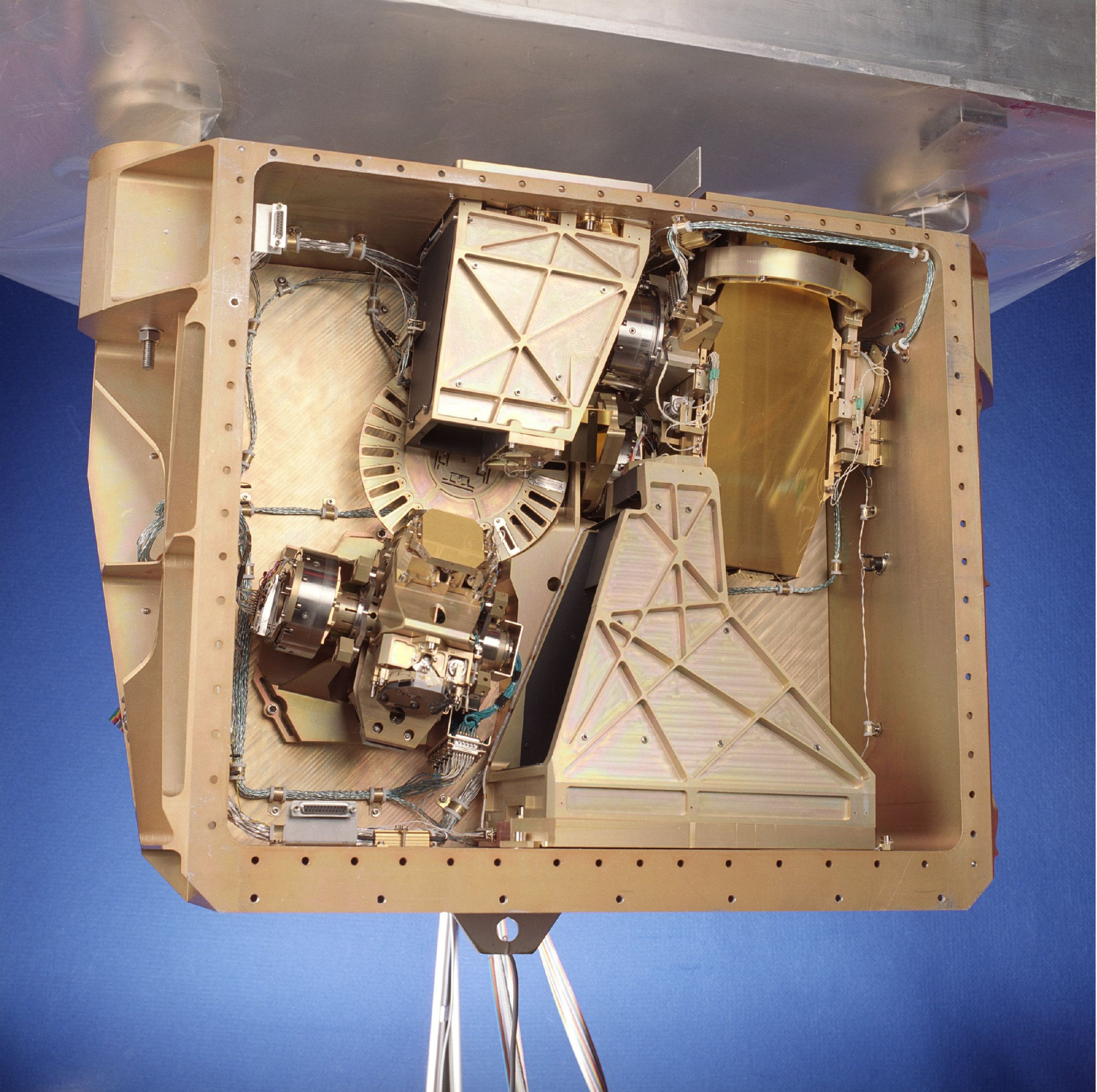


VISIR

- schematics of spectrometers (R ~ 500 - 30000)
- high-resolution grism x-dispersed (4" slit)

but

for selected lines longslit mode possible

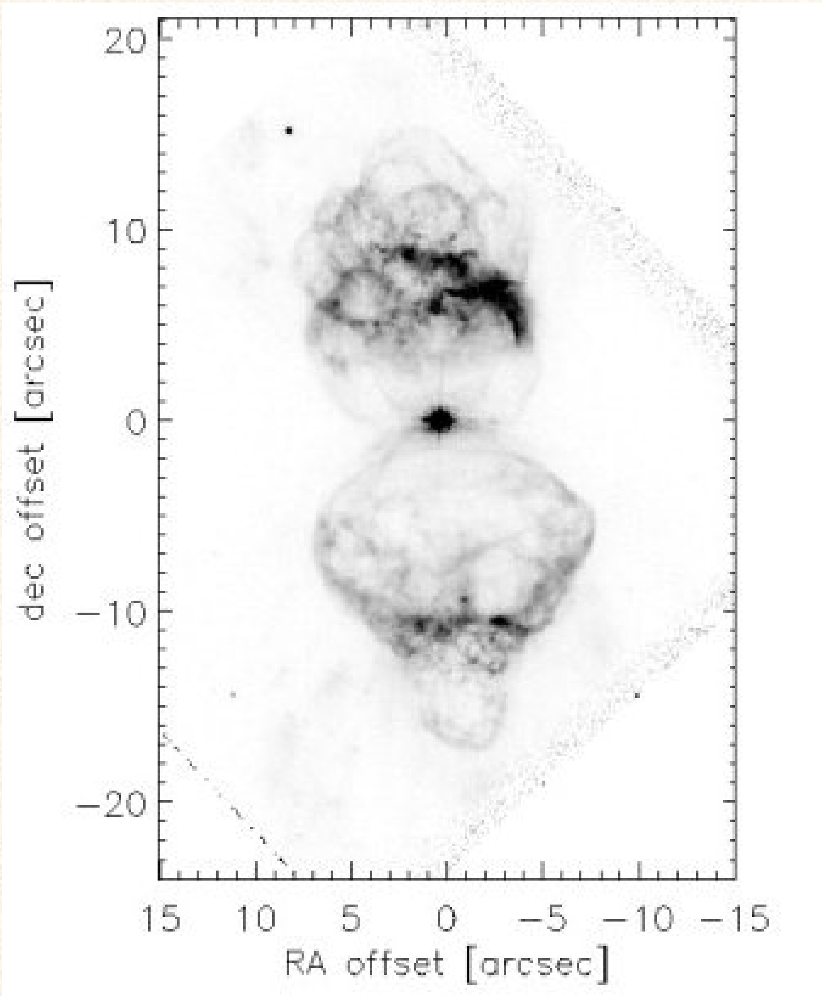


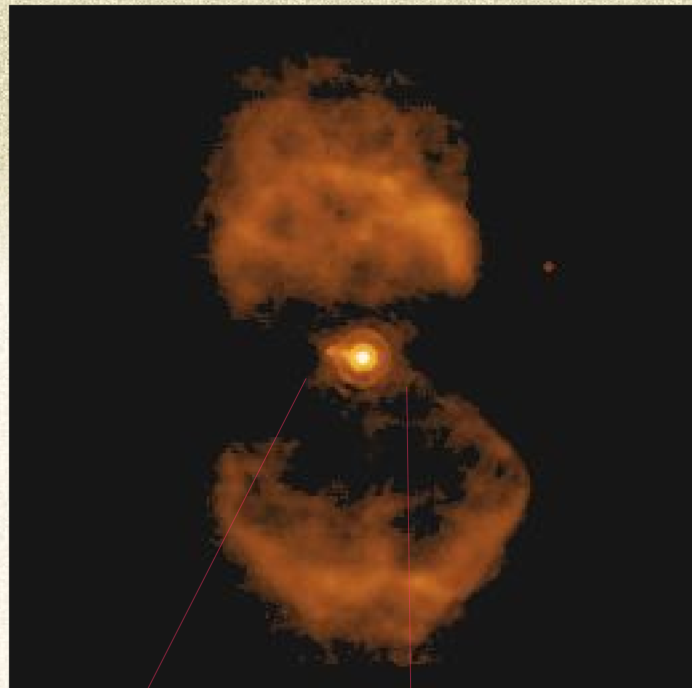
VISIR

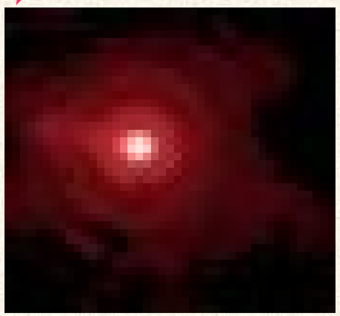
- close view of spectrometers
- detector mount on lid (removed)
- re-imager and order selection on back side

VISIR

- 1st light results
  Menzel 3 [Ne II]
- comparison HST Hα



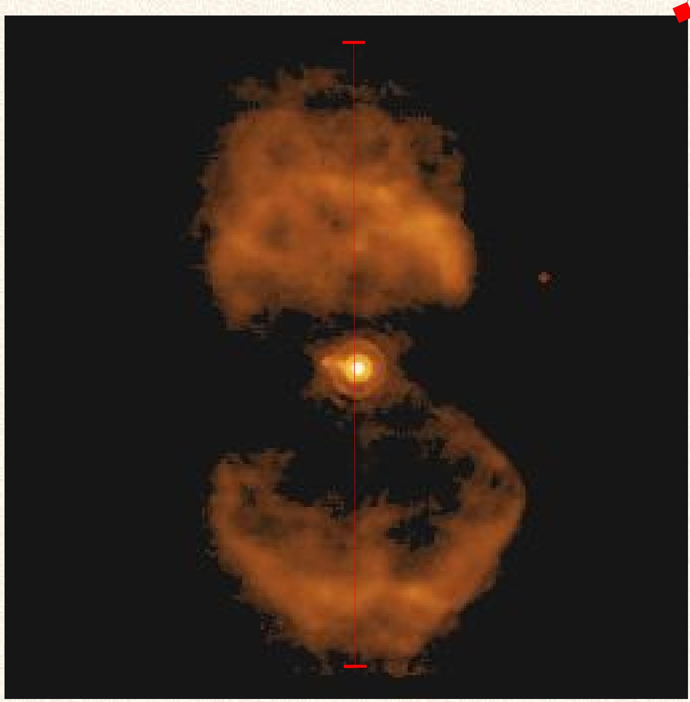


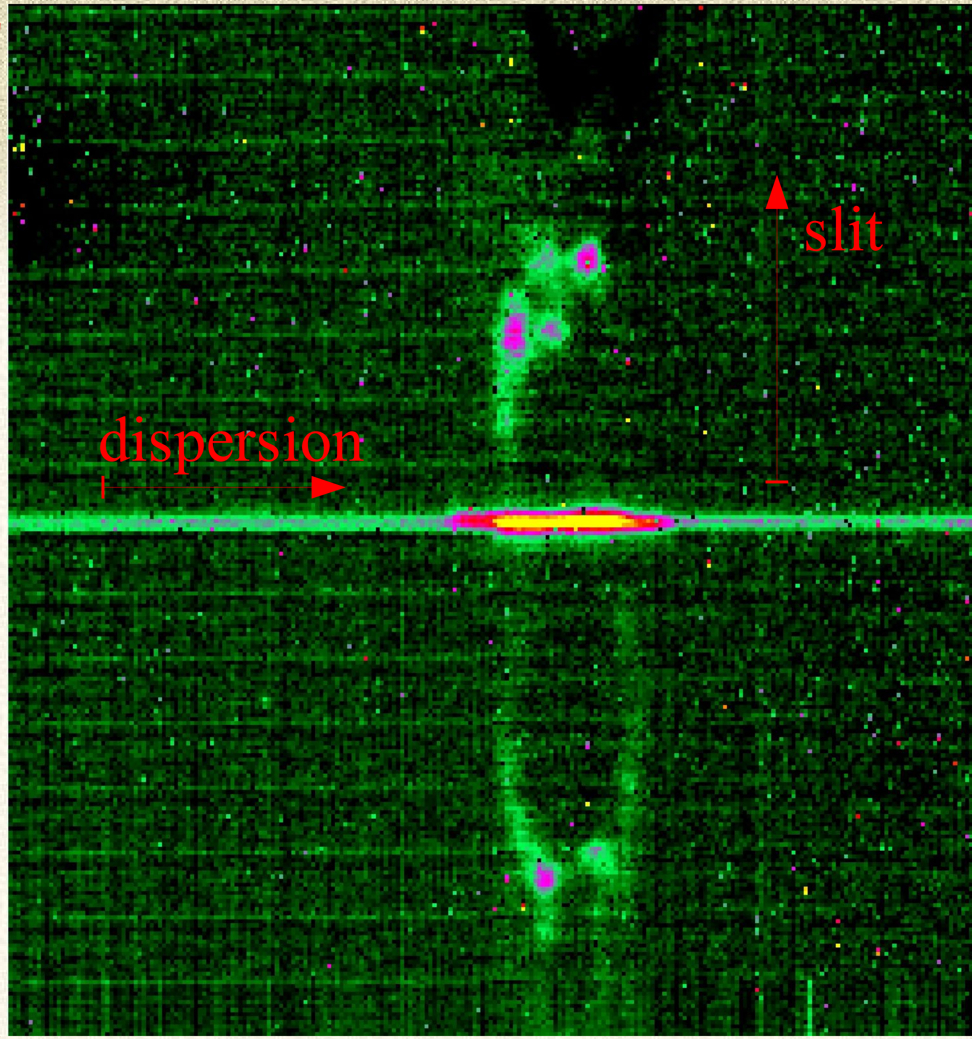


- blow-up of central star region with Airy rings

VISIR

- more 1st light results
  Menzel 3 [Ne II]
- long-slit spectroscopy
  R ~ 30000 (i.e. 10 km/s)

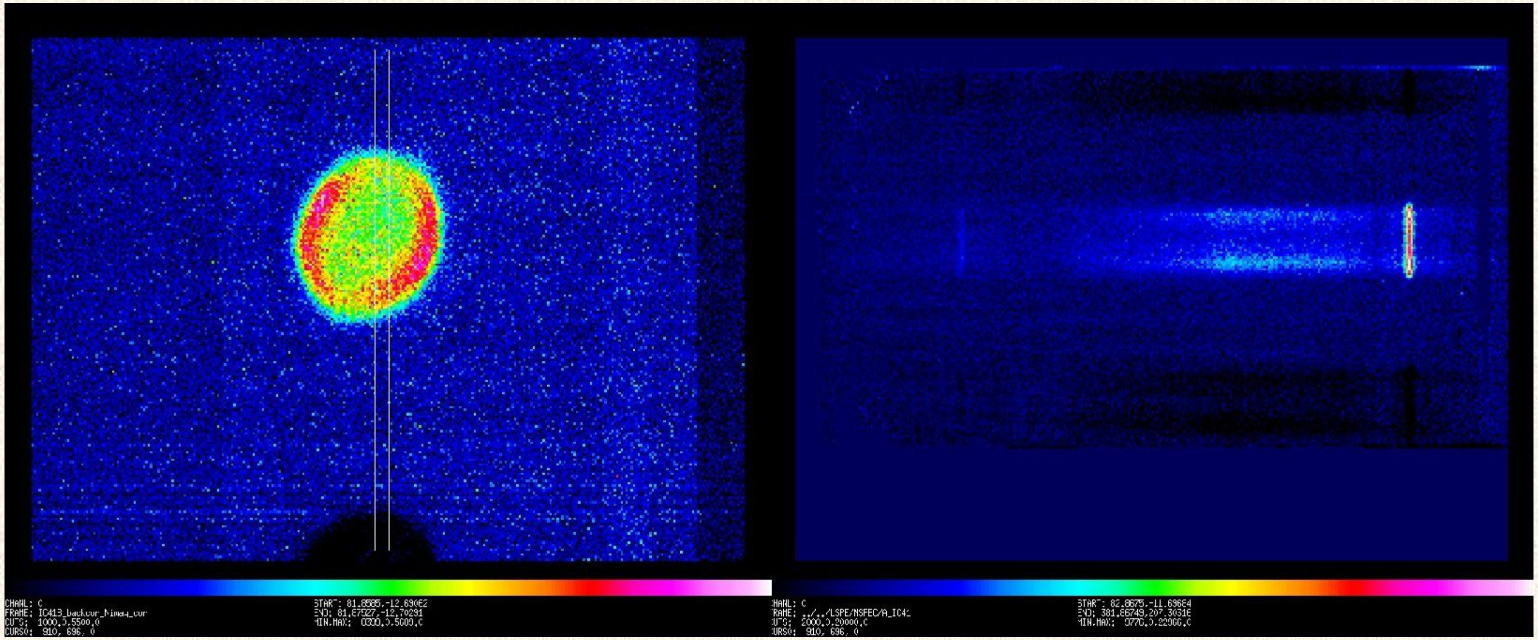




- note: in BLIP (back-ground noise limited performance)
  S/N α √R

VISIR outlook

- more 1st light results under VISIR home page
- next commissioning June 30 – July 6 2004
- detection in [Ne II] or [S IV] is only a question of surface brightness within 0.3″
  => e.g. Menzel 3 easily detectable up to > 100 kpc
- below, a preview using TIMMI2 on IC418



VISIR <--> Spitzer (ex SIRTF)

- sensitivity: Spitzer wins by up to ~ 10^3 (imaging)
  <u>but</u>
- spatial resolution VISIR/VLT wins at least a factor of 10 (CRIRES wins a factor of ~ 20-30)

- spectral coverage: Spitzer wins (e.g. a comparison [S III] to [S IV] not really feasible from the ground
  <u>but</u>
- spectral resolution: VLT/VISIR/CRIRES wins by a factor of up to 100
  <u>and</u>
- sensitivity disadvantage of BLIP partially compensated

Historical: TIMMI@3.6 <--> ISO (Waters et al.)

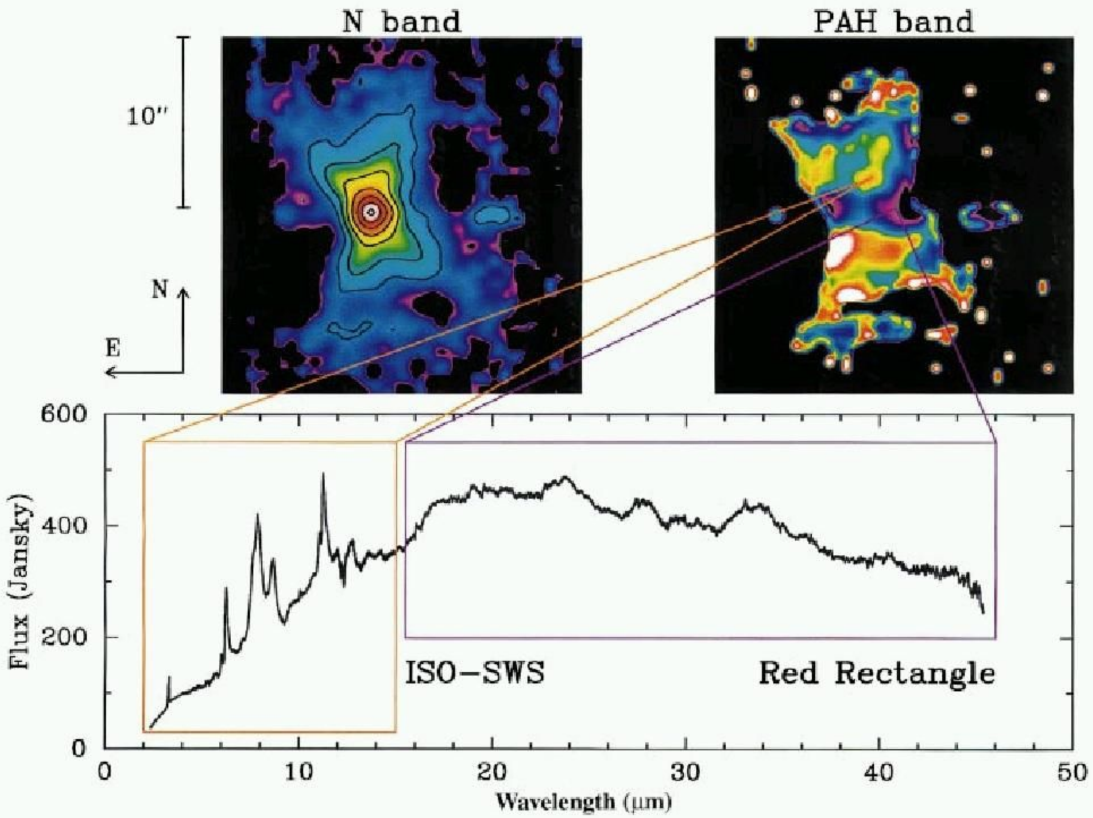


Figure 3 Spatial distribution of the oxygen and carbon rich components of the Red Rectangle. Top, False-colour images of the broad-band 10 μm emission (left) and continuum subtracted narrow-band 11.3 μm emission (right) in the Red Rectangle nebula. The images were taken on 24 February, 1994 with the 10 μm camera TIMMI attached to the 3.6 μm telescope of the European Southern Observatory (ESO), La Silla, Chile. The pixel size is 0.33 arcsec. The broad-band 10 μm image shows that the bulk of the emission at that wavelength originates from the circumbinary disk, and the brightness distribution of the narrow-band 11.3 μm image shows that the carbon-rich carriers of the UIR bands are located in the extended nebula[5,6]. Bottom, ISO-SWS spectrum of the Red Rectangle. The boxes relate the carbon-rich components to the extended nebula, and the oxygen-rich component to the circumbinary disk in the centre of the nebula, respectively.

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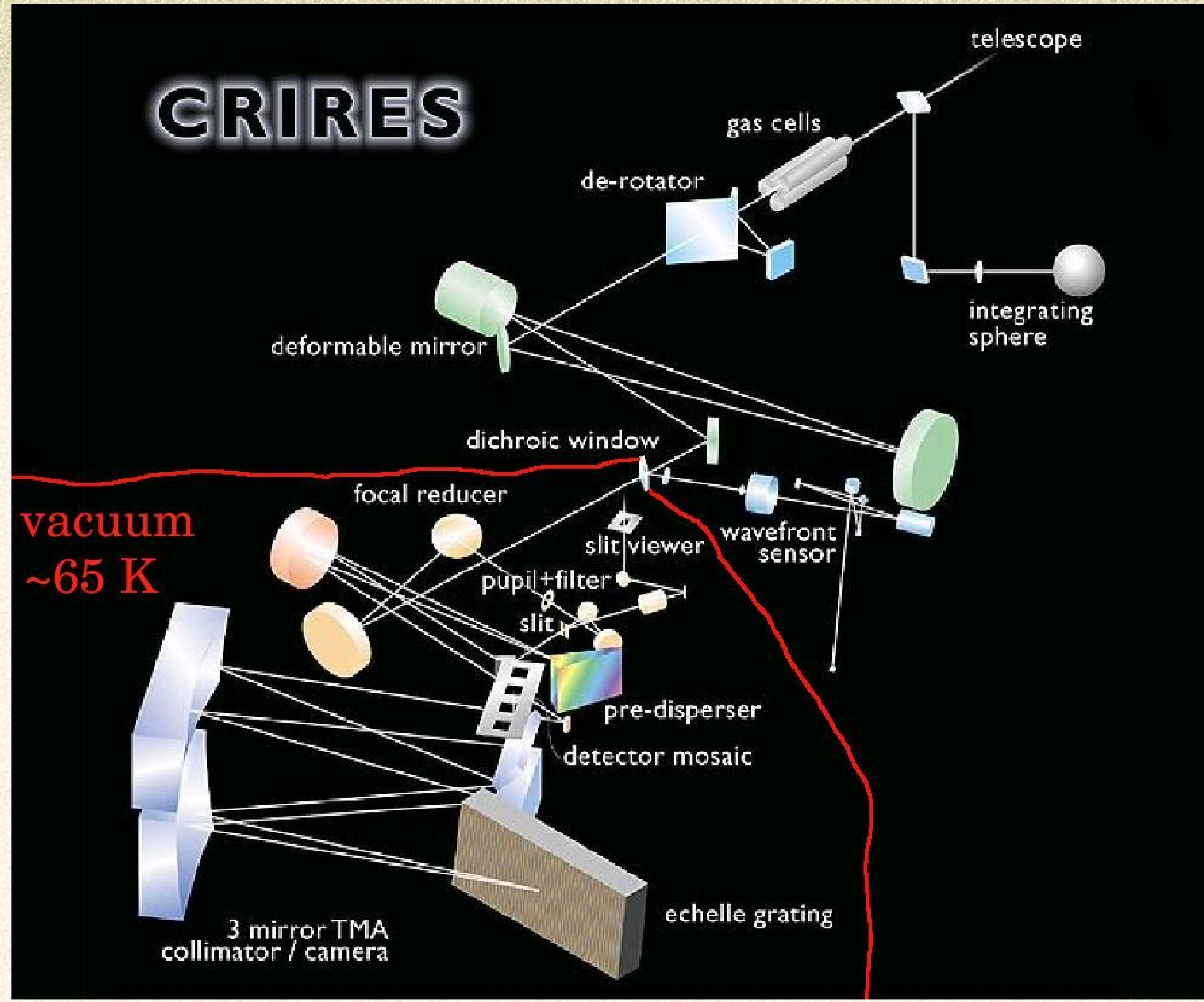
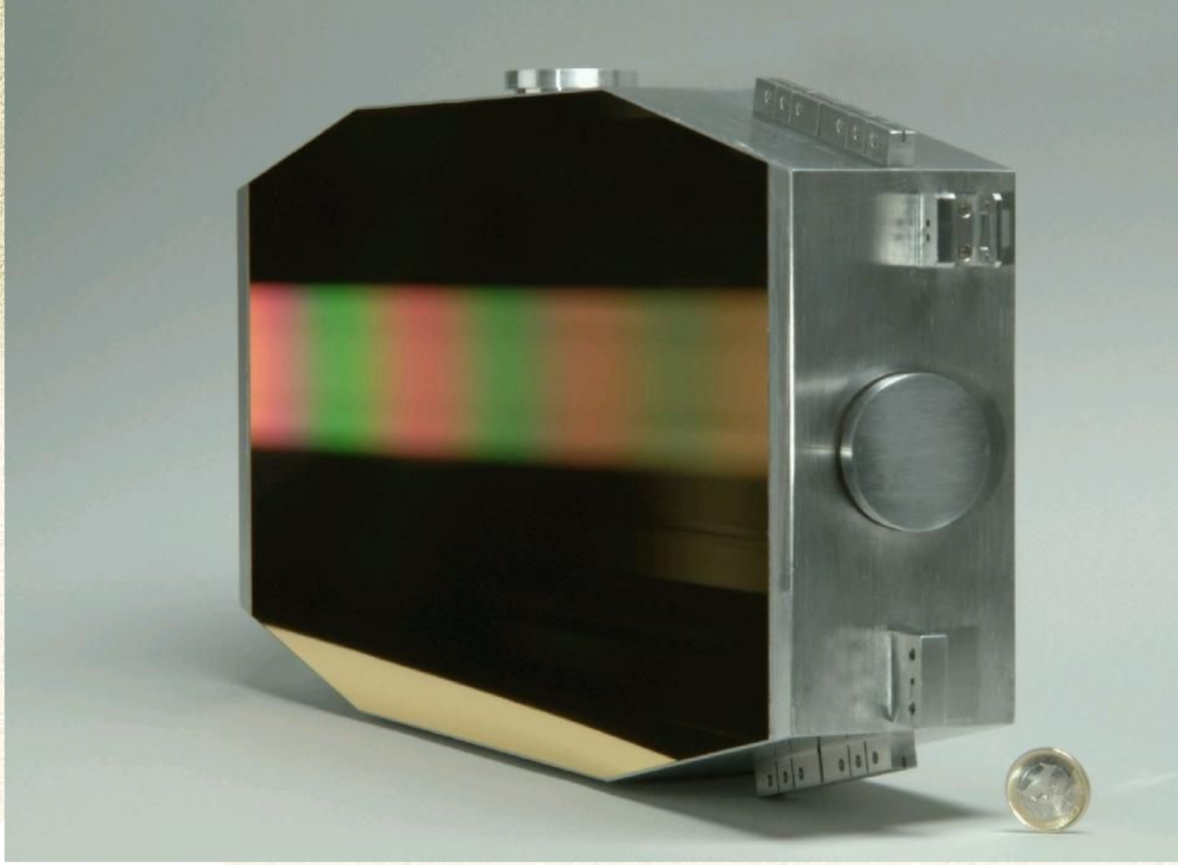
good example that ISO-IR spectroscopy was difficult to understand without the spatial information only available at groundbased telescopes

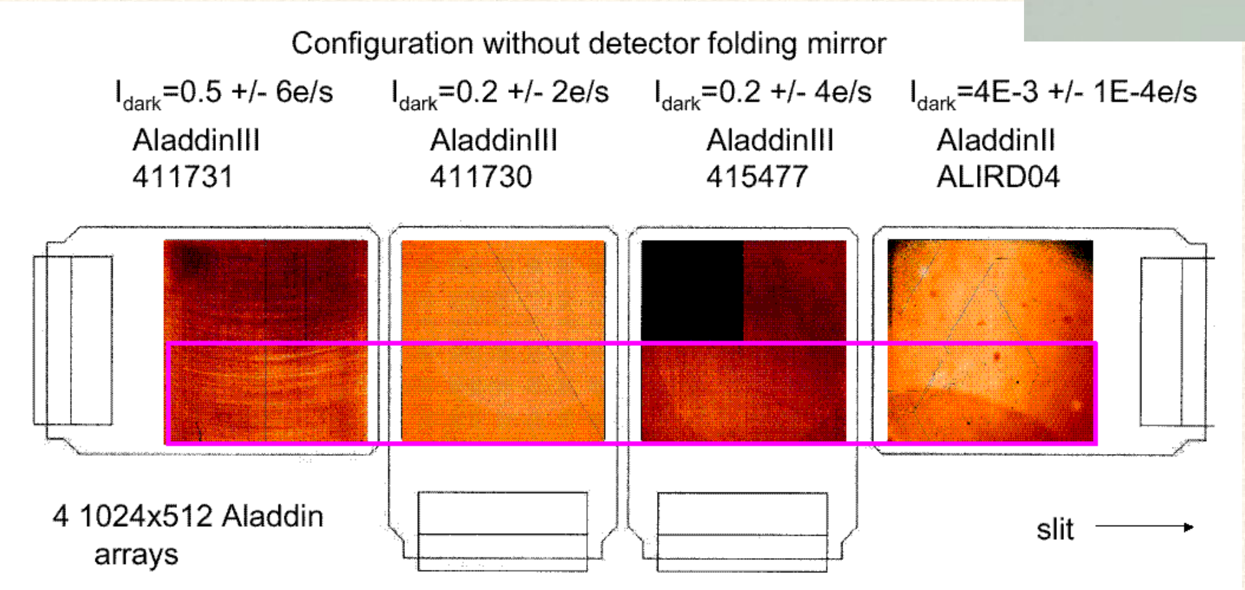


- λ: 1.0-5.4μm
- $\Delta\lambda \approx$ 3 km/s
- 4 • 1 k x 0.5 k InSb detectors
- ☞ instantaneous λ-coverage $\approx$2%
- precision for calibration and stability ~ 75m/s
- curvature sensing Adaptive Optics ☞ 0.2” spatial res. for 40” slit
- stability!!!!

CRIRES

- being built by ESO in house
- status: in integration
- first laboratory spectra expected in summer 2004
- **right:** 40cm R4-Echelle
- **bottom:** detector mosaic



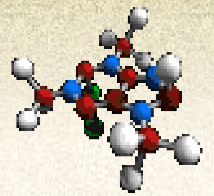


if interested a tour through the lab could be organized

CRIRES: spectral features of interest:

- atomic lines:
  - various Hydrogen recombination lines (e.g. Pa_β, Br_γ, Br_α, Pf_β)
  - various Helium lines
  - forbidden lines: e.g.
    in J-band: [Fe II]
    in K-band: [KrIII]
    in L-band: [Zn IV]
    c.f. Mike Barlow, proceedings of ESO-workshop "High Resolution Infrared Spectroscopy in Astronomy"
- molecular lines
  - H_2 lines from hot shocked molecular gas (quadrupole trans.)
  - "normal" dipol rotational-vibrational transitions

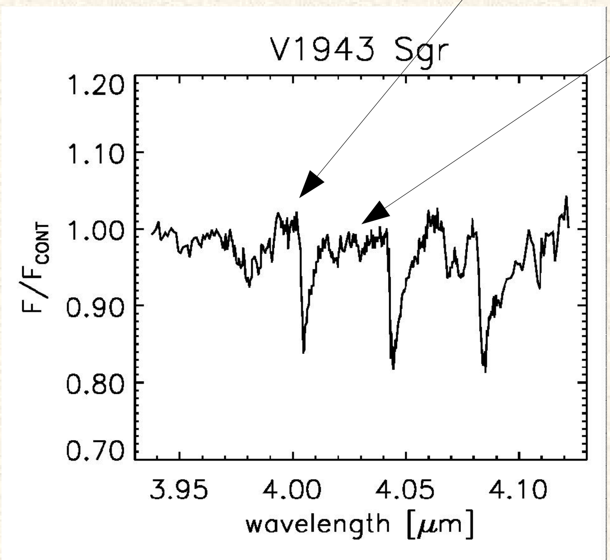
AGB & post AGB: Rotational-Vibrational Molecular Spectra

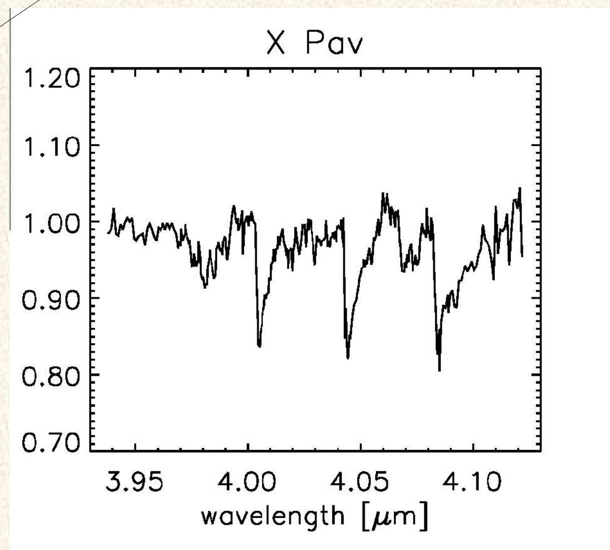


- <u>To remember</u>: for one molecular species several hundred infrared transitions can be expected which all have a different optical depth and which therefore sample different altitudes in stellar atmospheres

- isotopic shifts scale with the reduced mass: $$M_{red} = \frac{m_1 \cdot m_2}{m_1 + m_2}$$

e.g. for $^{28}Si^{16}O$ vs $^{29}Si^{16}O$: $\Delta M_{red} \approx 1.0\ \%$





left: examples low resolution spectra of the bandheads of overtone transitions of SiO (from Aringer et al. 1999 A&A 342); all structure is statistically significant; ~ 100 lines each 2-3km/s wide merge into one bandhead CRIRES allows to observe "single" lines

CRIRES and VISIR are not just built for PNe and post-AGB-star research but they seem to be a perfect match:

- sufficient atomic lines available for detailed studies of excitation conditions and kinematics
- rot.-vib. molecular spectra are an extremely efficient tool
  - to study atmospheres and their physics
  - to study physics of mass loss and dust formation
- IR-studies are least affected by extinction
- easy access to abundances and isotopic ratios
  - constraints on thermo-nuclear models (s-process isotopes)
- the sensitivities allow to do research on star samples selected by other criteria than apparent magnitude.