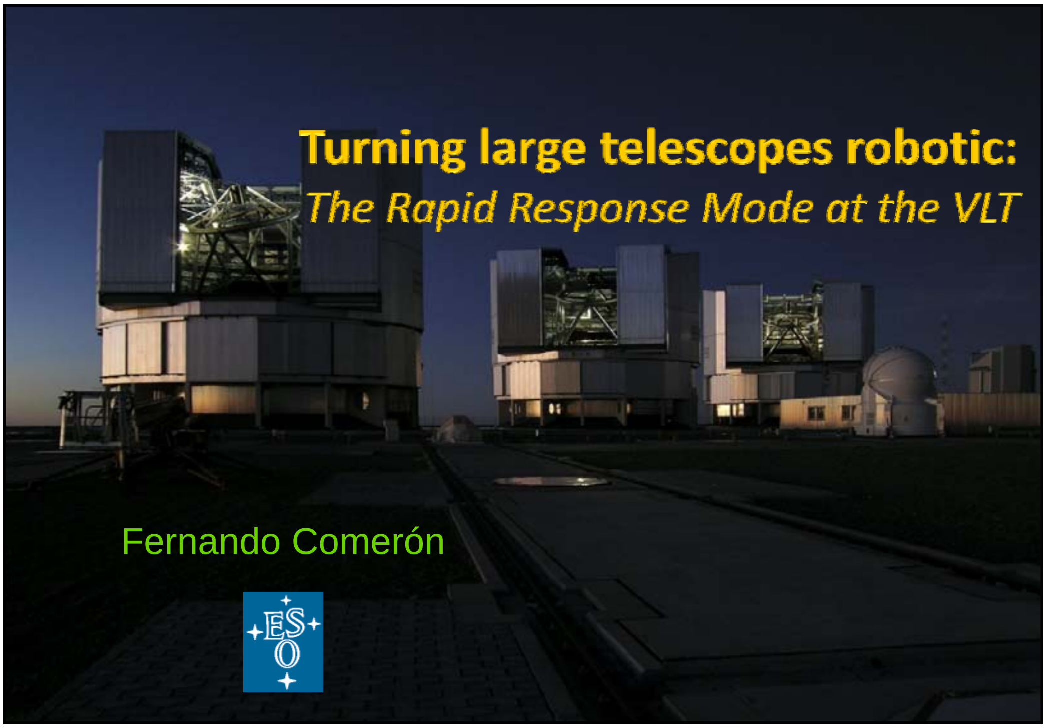

Turning large telescopes robotic:

The Rapid Response Mode at the VLT

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The ESO Very Large Telescope: basic facts

- 4 Unit Telescopes, each 8.2m diameter, on Cerro Paranal (Chile), at 2635m over sea level)
- The telescopes can be connected to form a near-infrared interferometer, with baselines of 120m, also using 3 1.8m Auxiliary Telescopes
- In operations since 1999
- Currently 11 instruments, plus 2 interferometric instruments, covering a broad range of wavelengths, resolutions, and techniques

Why a Rapid Response Mode at the VLT?

- Great light collecting power: high S/N snapshots of quickly varying phenomena make it possible to study fast, faint transients in great detail
- Wide range of instrumentation available: imaging, long-slit and integral field spectroscopy, polarimetry, adaptive optics, high time resolution… both in the visible and near-infrared
- Rapid Response Mode offered since 2003. Currently available at 4 instruments (FORS2, ISAAC, UVES, SINFONI); soon to be available in X-Shooter

But the VLT was not designed to be a robotic telescope…

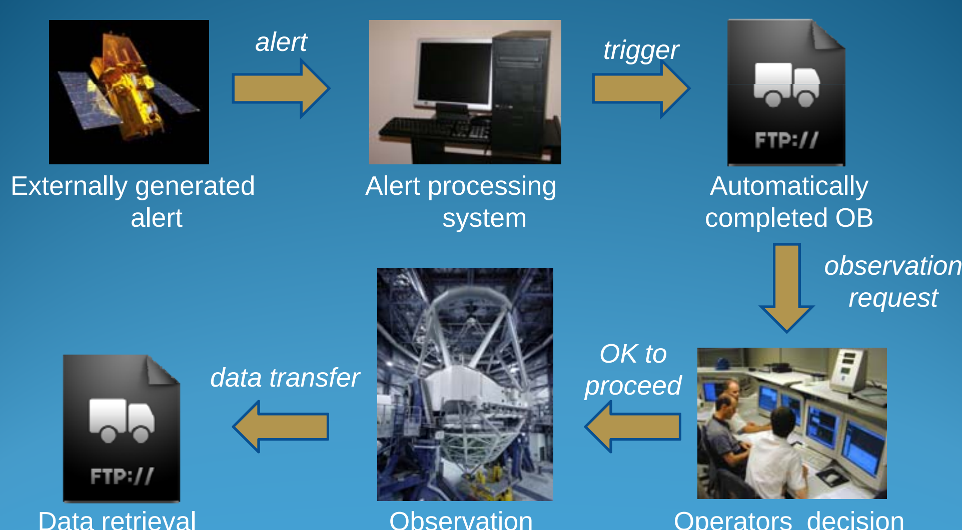
The VLT operations model

- Strongly based on *flexible scheduling*: most of the time (~70%) devoted to Service Mode observations, with user-specified constraints
- Short-term scheduling based on prevailing conditions, user-specified constraints, relative priorities among programmes, degree of completion, time criticality, instrument in use, optimization of the share of calibrations…
- Minor fraction (~30%) devoted to Visitor Mode, when real-time decisions based on science criteria are expected
- Target-of-Opportuntiy observations can be easily accommodated, non-disruptively, in the Service Mode schedule
- Rapid Response observations a bit more challenging, but also feasible…

How it works

- A generic proposal is submitted, selected on scientific grounds
- Phase 2: generic Observation Blocks (logical units describing an observation) are submitted to ESO, to be completed when a trigger is received
- Data immediately made available to Principal Investigator via FTP
- The telescope can be observing the event *within 6 minutes* of the trigger arrival

How it works



Some highlights

- 15 programmes have made use of Rapid Response Mode thus far
- Nearly 20 papers including reference to observations made in this mode

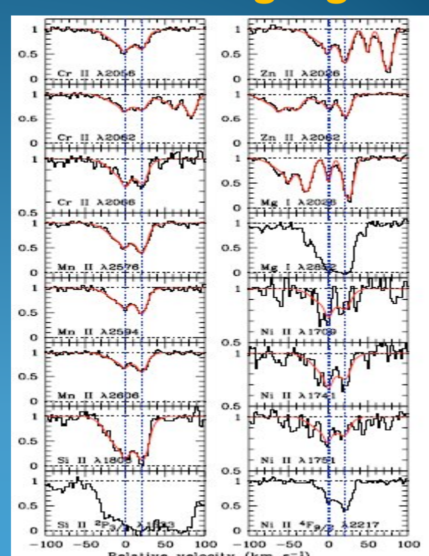
Fruchter et al. 2001; Draine & Hao 2002; Perna & Lazzati 2002; Perna et al. 2003). Detection of these time-dependent processes, with timescales ranging from seconds to days in the observer's frame, would not only provide direct information on the physical conditions of the interstellar medium (ISM) surrounding the GRB, but would also constrain the properties of the emitted GRB flux before it is attenuated by foreground absorbers in the host galaxy and in intervening gas clouds. In the X-ray, evidence has been found for a time-variable H I column density (Starling et al. 2005; Campana et al. 2007), presumably due to the ionization of the nearby neutral gas. In the optical, none of these processes have been observed until recently, when Dessauges-Zavadsky et al. (2006) reported a $\sim 3\sigma$ variability detection of Fe II $^6D_{7/2}$ $\lambda 2396$[1], observed at two epochs roughly 16 h apart. Such observations are technically very challenging because high-resolution spectroscopy combined with the rapidly decaying afterglow flux requires immediate follow-up with 8–10 m class telescopes.

providing a $3'$ error circle localization. Observations with the *Swift* X-Ray Telescope (XRT) resulted in a $5''$ position about one minute later (Falcone et al. 2006b), which triggered our desktop computer to activate a VLT-RRM request for observations with the Ultra-violet and Visual Echelle Spectrograph (UVES). This was received by the VLT's unit telescope Kueyen at Cerro Paranal at 3:08:12 UT. The on-going service mode exposure was ended immediately, and the telescope was pointed to the XRT location, all automatically. Several minutes later, the night astronomers Stefano Bagnulo and Stan Stefl identified the GRB afterglow, aligned the UVES slit on top of it, and started the requested observations at 3:16 UT (i.e. 10 min after the *Swift* γ-ray detection). This represents the fastest spectral follow-up of any GRB by an optical facility (until the RRM VLT/UVES observations of GRB 060607, also triggered by our team, which were started at a mere 7.5 min after the GRB; Ledoux et al. 2006). A series of exposures with increasing integration times (3, 5, 10, 20, and 40 min, respectively) was performed with a slit width

Some highlights

- Gamma-Ray Burst (GRB) afterglow photometric follow-up
- Investigation of the intervening intergalactic medium (dust content, metallicity, reionization epoch) along the line of sight to distant GRBs
- Investigation of the interstellar medium surrounding the GRB (ionization, dynamics)
- GRB/Supernova connection

  Potential goes beyond GRBs



The future

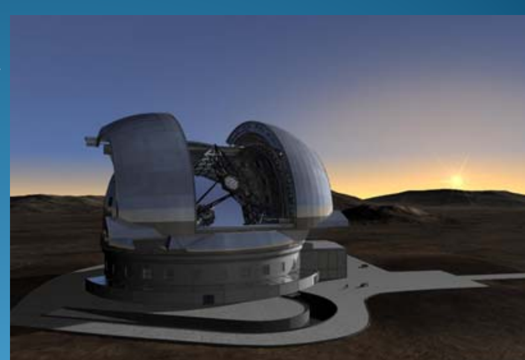
- A fast connection between Paranal and Europe will allow near-real time interaction, both ways, between an observer locate anywhere and the observatory
- EVALSO is a pilot project, funded by the European Commission, to build a fiber link between Paranal and Cerro Armazones and the Chilean backbone near Antofagasta
- EVALSO is expected to provide Gbps capacity between the observatories and Europe

EVALSO

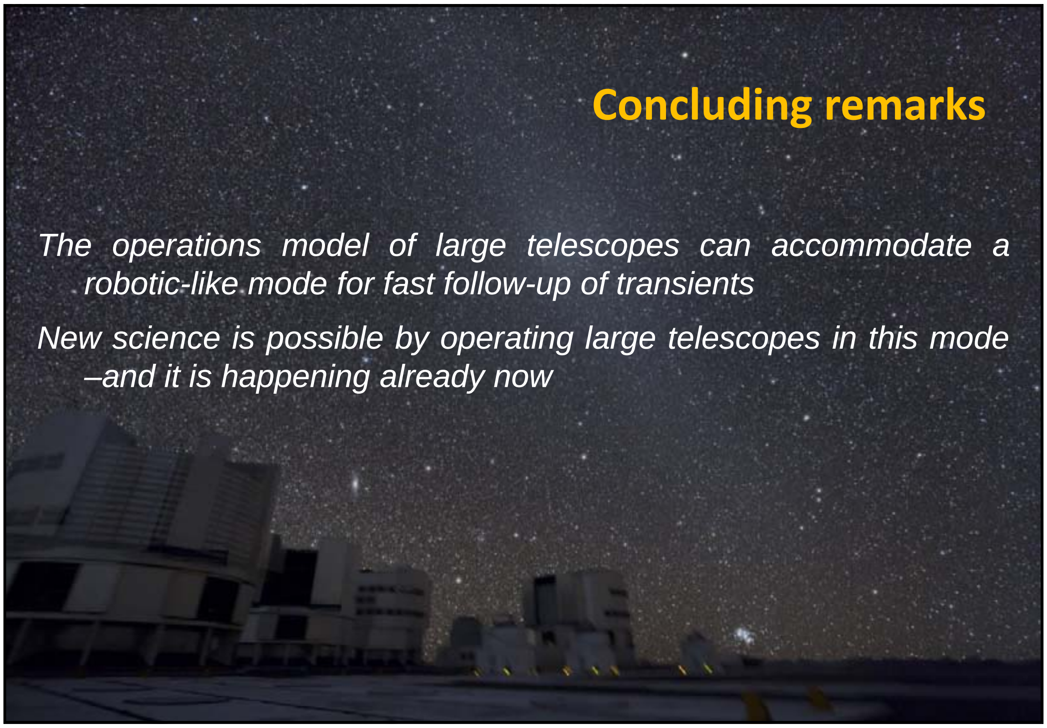
CAPACITIES

The future

- The 42m European Extremely Large Telescope (E-ELT) will be a fully adaptive telescope, equipped to address a wide range of astrophysical and cosmological problems
- Rapid Response Mode can also be implemented at the E-ELT: diffraction-limited imaging and spectroscopy with a 42m telescope



- Nothing in the E-ELT design precludes its implementation: fast response time (<20 min after trigger is received) is expected o be possible
- Operations expected to begin around 2018


Concluding remarks
The operations model of large telescopes can accommodate a robotic-like mode for fast follow-up of transients
New science is possible by operating large telescopes in this mode –and it is happening already now