# Shaping E-ELT Science and Instrumentation Workshop

## Poster Abstracts

**Posters will be on display at the Bürgersaal from Monday 25th February to Thursday 28th February. Poster viewings will be during the coffee breaks.**

**P001**
**Lyu Abe (Observatoire de la Côte d'Azur)**
***High Dynamic Range Concepts for the E-ELT***
Although awaiting the first results of dedicated high contrast imaging instruments like VLT/SPHERE or Gemini Planet Imager, the high angular resolution and high constrast imaging communities are shaping the contours of the next possible instruments in that observational field. It is difficult to already plan what the next steps should be towards direct imaging of exoplanets (for example) without having actually obtain the first data. Indeed, the capabilities of these soon-to-come instruments rely on efforts on all levels that need to be validated on-sky: specific high contrast imaging optical components, data processing and analysis, observing strategies. Nevertheless, our understanding of current limitations to very high contrast imaging has kept on evolving theses past months and years. In order to overcome them, we follow two possible directions: to continue the R&D/R&T activities as a natural heritage to what has been done up to now in improving the manufacturing, operation, calibration and data analysis of existing high contrast concepts, which is mainly the case of E-ELT/EPICS. The other more prospective possibility is to develop original new concepts and to explore poorly studied fields. We present this twofold approach that we follow at Laboratoire J.-L. Lagrange: first the participation to the exploitation of VLT/SPHERE at the instrument and data analysis level, as well as laboratory studies of alternative coronagraphic concepts for the E-ELT/EPICS, altogether with partner institutes involved in these two projects. The other approach is lead by a strong interest in interferometric imaging concepts (e.g. a phased FIRST-like instrument) capable of very high contrast capabilities. The latter is also stongly motivated by the fundamental question of (temporal) stability concerns that we plan to include as part of these developments.

**P002**
**Olivier Absil (Université de Liège)**
***A mid-infrared vector vortex coronagraph for METIS: the AGPM project***
One of the main science cases of a diffraction-limited mid-infrared imager on the E-ELT will be the discovery and characterisation of extrasolar planets through direct imaging. The instrument will therefore need to provide high-dynamic range imaging at angular separations as small as possible from the target stars. Up to now, little attention has been paid to coronagraphic applications in the mid-infrared regime, because the dynamic range of 10-m class telescopes is generally limited more by background noise than by residual stellar light in direct images. This will not be the case any longer when using the collecting area of a 40-m class telescope, so that specific coronagraphs providing both a deep star light rejection on a wide band and a small inner working angle need to be designed and tested. Since 2005, we have been developing a new type of vector vortex coronagraph, called the Annular Groove Phase Mask (AGPM), based on concentric sub-wavelength gratings. Thi
s design inherently provides a small inner working angle and a 360° discovery space, while being adapted to broadband operation. Indeed, the grating parameters can be tuned to make the phase shift quasi-achromatic over a wide band. During the past few years, we have developped nano-lithography techniques on CVD diamond

substrates to produce subwavelength gratings for the mid-infrared domain, and a first generation of AGPMs has recently been manufactured for the L and N bands. In this talk, I will review the coronagraphic performance that we measured when testing these AGPMs in the lab and on the sky, including their recent first light on VLT/NACO and VLT/VISIR. These results will be discussed in the E-ELT context, and the perspectives for applications on METIS will be described.

**P003**
**Pedro Amado (Instituto de Astrofisica de Andalucia - CSIC)**
***Asteroseismology throughout the HR diagram with the E-ELT***
Oscillations in young and old stars and from the still-to-be-observationally-detected pulsating cool M dwarfs to the hot Be stars are an extremely useful observable to characterize the stellar interiors. Oscillations can be studied to infer the internal properties of stars through asteroseismology. This line of research will need the E-ELT for those faint and possibly very low amplitude objects like M dwarfs. For these objects, the detection and study of oscillations will open a new era which will allow the precise determination of the parameters of any planet they may host or the characterization of their internal structure and fundamental parameters.

**P004**
**Maria Bergemann (MPIA, Garching)**
***High-resolution spectroscopy of cool stars in the IR***
Near-IR spectroscopy of cool late-type stars is a relatively unexplored territory. Until recently, the progress was hampered by the absence of accurate atomic and molecular data and adequate model atmospheres which would correctly include various complex physical phenomena, such as convection, extension, non-local thermodynamic equilibrium. Today, this is not a stumbling block anymore. We show that the application of physically-realistic NLTE radiative transfer models to the analysis of high-resolution IR (Y,J,H,K) spectra of red giants and red supergiants allows us to determine their chemical composition with unprecedented accuracy. Abundances can be determined for a large number of chemical elements, including alpha-group and neutron-capture, which opens interesting perspectives for galactic and extra-galactic abundance studies.

**P005**
**Xavier Bonfils (Observatoire de Grenoble)**
***Spectroscopic characterisation of exoplanets with a MOS/ELT***
When a transiting planet crosses the stellar disk, its opaque body blocks a fraction (~ Rp^2 / Rstar^2) of the stellar light and its atmosphere subtly filters an additional fraction. One can thus measure the wavelength dependence of the planetary radius Rp to detect atomic and molecular features present in the planetary atmosphere. From the ground, photometric light curves have been limited by systematics due to changing air mass, atmospheric conditions, telescope pointing or flat-field errors, that result in a correlated "red" noise. Multi-Object Spectrographs allows for simultaneous observations of comparison stars and thus provide an avenue to correct for the atmospheric variations and reach the precision required for exoplanet atmosphere characterization. I shall discuss the requirements for spectroscopic characterization of exoplanets with a MOS/E ELT and, in particular, how it can addresses the exciting science case of detecting biomarkers in the atmosphere of a distant habitable exoplanet.

**P006**

**François Bouchy (Geneva Observatory)**

***Radial velocity follow-up of terrestrial transiting planets***

The knowledge of the radius of an exoplanet by transit measurements combined with the determination of its mass through radial velocity measurements allows the determination of its bulk density. This quantity provides direct insights into the structure and composition of exoplanets. Although about 200 transiting planets with a constraint on their density are know, less than 10% of them are in the low-mass regime (m < 30 MEarth) including the so-called Neptune like and super-Earth like planets. Both Kepler survey and RV surveys have shown that small-size and low-mass planets are numerous but the determination of their true density is far to be trivial. For most of the known transiting low-mass planets, the uncertainties on their mass and radius unfortunately do not permit to properly constraint their internal structure nor composition. This situation mainly comes from the fact that high-precision photometric surveys like CoRoT and Kepler observe quite faint stars (mv=12-16) which are not appropriate for high-precision radial velocity follow-up. Next generation of transit surveys (NGTS, TESS, PLATO) will focus towards brighter stars (mv=10-13). One may estimate that several hundreds of validated low-mass exoplanets will be known in the next decade. The characterization of their mass and radius with an accuracy better then 10\% is crucial to study their internal structure and composition and to distinguish iron-rich planets, silicate planets, icy planets, and mini-Neptune. The detection of terrestrial planets (m < 10 MEarth) requires RV precision better than 1 m/s. The determination of their mass with 10% accuracy requires precision better than 30 cm/s. In the domain of magnitude of next generation transit surveys (mv=10-13), HIRES@ELT will permit to characterize the mass of transiting terrestrial planets down to 1 Earth mass.

**P007**

**Ian Crossfield (MPIA, Heidelberg)**

***Small, Cool, Nearby Exoplanets: Characterization with High-contrast/AO Instruments***

High-contrast E-ELT observations will permit atmospheric characterization of ~15 small (1-4 REarth), cool (200-400 K) planets in the Solar neighborhood. Planets around GJ 139, GJ 876, alpha Cen, and tau Cet may all be amenable to such observations, and high-precision RV surveys will discover additional targets. Near-infrared (J,H,K) observations will study these planets in reflected starlight, measuring optical albedos; mid-infrared (M,N) observations may directly measure thermal emission, providing temperatures and radiometric radii. These observations require extreme levels of AO performance: telescope and instrument requirements must be set so as to ensure that observations of nearby, temperate planets remain possible with E-ELT.

**P008**

**Marco Delbo (Observatoire de la Côte d'Azur)**

***High spatial resolution observations of solar system minor bodies with the ELT***

The technological advance in high spatial resolution astronomy offered by the ELT will provide unique opportunity to study the densities and internal structures of asteroids in unprecedented detail. In particular, the ELT can be used to measure the semimajor axis of the orbits of asteroid satellites and the shapes of these bodies. This method can provide very accurate masses since, by Kepler's third law, the orbital period and semi-major axis of the system uniquely determine the mass of the bodies. Going to smaller and fainter binary asteroids can revolutionize our understanding, because we will be sampling a new regime in physical properties.

**P038**
**Nicolas Epchtein (Université de Nice)**
***New Generation Near Infrared Surveys for the E-ELT era***

The Extremely Large Telescopes will require a new generation of large scale or even all-sky surveys much deeper than those presently available. The LSST will probably provide an appropriate answer for the optical range, but few projects have been proposed in the near infrared, so far. I"ll briefly review the existing projects in that respect with a special emphasis on a possible settlement of a survey facility on the Antarctic continent.

**P009**
**Michele Fabrizio (Università di Roma Tor Vergata)**
***The impact of a MOS@E-ELT to constrain kinematics and chemical evolution of nearby dwarf galaxies.***
Multi-object spectrographs (MOS) available at the 10m class telescopes disclosed a new scenario concerning the structure and the evolution of nearby dwarf galaxies. They typically display a broad metallicity distribution, suggesting that the environment plays a key role in the chemical evolution of these fluffy stellar systems. Moreover, there is evidence that dwarf galaxies show a complex kinematic structure probably reminiscent either of a disk or of a bulge.
We present accurate iron abundances for a sizable sample of red giants in the Carina dSph based on spectra collected with UVES at ESO/VLT. We discuss preliminary evidence concerning NLTE effects between FeI and FeII. Moreover, we will also present preliminary results concerning the Carina kinematic structure. We are using a very large data set of homogeneous radial velocity measurements covering the entire body of the galaxy. We found evidence of two different kinematic components that seem to be correlated with different Carina sub-populations.
The opportunity to collect data with a MOS@E-ELT for a sizable sample of stars with deep magnitudes (22-25) will allow us for the first time to investigate the chemical composition of unevolved (main sequence) and minimally (subgiant) evolved stars in several nearby galaxies. We present simulations concerning selected dSph and dIrr.

**P010**
**Renato Falomo (INAF – Osservatorio Astronomico di Padova)**
***The E-ELT view of high z active and inactive galaxies***
We investigate the expected capabilities of quasi diffraction limited imaging observations in the ELT era to study both normal (inactive) and active galaxies in the high z Universe. The novel capabilities will be able to investigate key issues concerning the formation and evolution of galaxies, supermassive black holes and their role for powering luminous quasars. Detailed simulations of the expected observations are presented using the design performances of MICADO at E-ELT and compared with those obtained by JWST instrumentations.

**P011**
**Boris Gaensicke (University of Warwick)**
***The chemical composition of extra-terrestrial planetary debris***
The strong surface gravity of white dwarfs implies that metals will sink out of the photosphere on time-scales that are orders of magnitude shorter than their cooling ages, and therefore white dwarfs are expected to have either pure hydrogen or helium atmospheres. Yet, the existence of metal-polluted white dwarfs has been a conundrum for nearly a century.

We know now that these white dwarfs are polluted by accretion of rocky debris, remnants of a former planetary system. With hindsight, this is may not come as too

much of a surprise, as our Sun will eventually evolve in a white dwarf orbited by Mars, the outer planets, and hosts of asteroids - and a similar fate awaits many of the known exo-planetary systems!

State-of-the art model atmosphere analyses of high-resolution spectra of white dwarfs demonstrate that the bulk composition of the circumstellar debris is overall similar to that of the terrestrial planets in the Solar system, yet there is evidence for a variety of thermal processing and possibly differentiation in the parent bodies. Perhaps most astonishing are the lower limits on the mass of the parent bodies that were accreted, ranging up to 1e24g, i.e. well above the most massive asteroids in the Solar system. These chemical abundance analyses are currently, and for some time to come, by far the most precise studies of extra-solar planetary material, and are now being used by theorists to constrain the formation of terrestrial planets.

A key limitation in this exciting new field of exo-planetary research is the faintness of white dwarfs: to date, only about a dozen "bright" (V~15) metal-polluted white dwarfs have been studied in sufficient detail, at the expense of substantial amounts of Keck Hires and VLT UVES/X-Shooter time. With the vast aperture of the E-ELT, and an efficient high-resolution spectrograph, it will be possible to carry out elaborate abundances studies for large numbers of white dwarfs, effectively determining the parameter space that allows the formation of terrestrial planets. Establishing the necessary target samples will be accomplished by a combination of the VST and VISTA public surveys and low-resolution follow-up with 4MOST.

I will provide a brief overview of the current state of the field, and outline the requirements for future high-resolution instrumentation.

**P012**

**Laura Greggio (INAF – Osservatorio Astronomico di Padova)**

***Studying the Stellar Metallicity Gradient in Virgo Ellipticals with E-ELT Photometry***

The imaging capabilities currently foreseen for the E-ELT will offer the unique opportunity to perform accurate stellar photometry in crowded fields. In particular we will be able to construct Color-Magnitude Diagrams (CMDs) for distant galaxies in high surface brightness regions. Among the many interesting applications, we consider the estimate of the metallicity distribution of stellar populations from the color distribution of their Red Giant Branch stars. We focus on the analysis of the CMDs obtained at different radii in a typical giant Elliptical galaxy, member of the Virgo Cluster.
The different crowding conditions imply a systematic trend of the accuracy of the derived metallicity distribution. We characterize this effect quantitatively with end-to-end simulations based on the MICADO @ E-ELT specifications, under various assumptions for the Point Spread Function.

**P013**

**John Lee Grenfell (Technische Universität Berlin)**

**Potential biosignatures on Earth-like planets orbiting in the Habitable zone of cool M-dwarfs and the effect of incoming (E)UV - friend or foe?**

We present theoretical spectra of biosignature species for Earth-like planets orbiting in the Habitable Zone of cool (M7) M-dwarfs. We vary incoming (E)UV within its uncertainty limits. Results suggest that the effect upon bio-species ozone , nitrous oxide and methane is significant. Increased (E)UV can stimulate ozone production by enhancing molecular oxygen photolysis. We present theoretical spectra and discuss implications for future strategies.

**P014**

**Stephanie Heikamp (Leiden Observatory)**
***Calibration Techniques for the Thermal Background on ELTs***
Observing in the thermal infrared is challenging due to the high thermal background. This background emission from the sky, telescope and instrument can be several orders of magnitude greater than the science signal. There are techniques to remove the background emission such as chopping/nodding the telescope but for ELTs this technique is not feasible because the mirrors are large and difficult to move on typical chopping and nodding time scales. New methods must be developed to accurately remove the background for ELTs.

Internal pupil chopping within the instrument is an option but the beam through the telescope changes drastically when moving the internal chopping mirror. Therefore, new chopping schemes need to be devised to counteract the noise created by the different beam footprints. Additionally the detector performance should be taken into account. The gain stability and linearity of the detector is important because it affects the residual noise levels. A method to characterize the stability is by using a Dicke switch, this device switches between the telescope beam and an internal cold reference source to detect detector drifts.

The results are of importance to the METIS instrument, the science cases are driven by deep observations, high spatial and spectral resolution and low magnitude observing which calls for great background calibration and subtraction methods.

**P015**
**Frank Helmich (SRON Netherlands Institute for Space Research)**
***Synergies between SPICA/SAFARI and ELT***
When the far-IR satellite SPICA flies around 2023 it will scan large parts of the sky measuring faint spectral lines of high-redshift galaxies, as well as deep integrations on proto-planetary disks, TNO''s/KBO''s and possibly exoplanet atmospheres. These science topics align very well with plans for METIS and EPICS on the E-ELT. In this poster/talk I will present the possibilities that SPICA/SAFARI offers and how it connects to the E-ELT

**P016**
**Matthew Horrobin (Universität zu Köln)**
***Serendipitous surveys with the E-ELT***
The huge leap in light collecting power provided by the E-ELT presents a new possibility for scientific use, serendipitous surveys. We discuss the capabilities of such surveys and the main science cases that they will contribute to.

**P017**
**Valentin Ivanov (ESO)**
***The High-Cadence, High-Time-Resolution Observations at ESO - Headstart for the E-ELT Instrumentation***
I review the high-impact science results yielded from many ESO instruments with high-cadence and high-time resolution modes: from lunar and TNO occultations to timing of X-ray sources, pulsar observations, extrasollar planet transits, and lucky imaging. I shortly describe the potential new science applications that the new generation of 30-40-metre class telescopes will open for high-time-resolution science.

**P018**
**Pascal Jagourel (Observatoire de la Côte d'Azur)**
***A combined high definition and high multiplex Multi Object Spectrograph at E-ELT***

Several approaches towards a MOS at E-ELT have been conducted at phase A level. It is now time to come out with a single instrument that covers both the optical and the near Infrared, that exhibits a multiplex capability (100 or larger) allowing both optimizing telescope exploitation and obtaining unique scientific results on this tremendous diameter telescope, and, last but not least, that will benefit from AO to reach an optimized spatial resolution with respect to high definition science requirements for a limited number of IFUs.

A conceptual design meeting those general goals will be presented. Main technical specifications will be listed and a possible progressive implementation scheme will be discussed with the aim to reduce both the needed cash-flow to reach 1st light and, also, to take into account components with present low TRL (risk mitigation).

**P019**

**Hans Ulrich Kaeufl (ESO)**

***The OH-airglow as a Tool to Characterize Extra-Solar Planets***

At present various projects to find planets or entire planetary systems around main sequence stars in the solar neighborhood are under way. A multitude of next generation programs for planet searches are ongoing. In the era of ELTs, that is when ELTs will be operational, there will be literally 1000s of confirmed planetary systems. There may even exist spectro-photometric detections of such planets. At this point it becomes inevitable to consider the next logical step: the spectroscopic detection and analysis of the atmospheres of these planets. High-resolution spectroscopy, i.e. resolving *v* sin(i) of these planets, in the wavelength regime of 950-1750nm is presented as a powerful and promising tool. In view of the obvious contrast problems in detecting such planets non-LTE features are specifically targeted. Sensitivity estimates for the detection of the non-thermal OH glow in oxygen-bearing atmospheres are given. With 8m-class telescopes such as the VLT such a search is impossible, but an NIR echelle spectrograph at the projected ESO 40m telescope could detect Earth-like planets at a distance of ~10 parsec. The technical requirements for the best detectability will be sketched. Preparatory work with CRIRES, ESO''s Cryogenic will be described.

**P020**

**Zeinab Khorrami (Observatoire de la Côte d'Azur)**

**High spatial resolution of the compact starburst cluster R136 at 50 to 10 mass**

The young, 1-2 My, R136 massive star cluster in the LMC, harbors the most massive stars ever weighted.Yet, the core of the cluster has never been spatially resolved with enough details to constrain the kinematics and the fraction of binary components as well as the different stellar populations of R136.
HST data collected for more than 15 years in UV and the visible compared now to UVES spectroscopy of R136 with the VLT have brought new insights to the nature of the brightest individual components of the cluster. We think however that a real breakthrough to understanding R136 and its precise IMF will come from imagery of its core using MCAO and/or extreme adaptive optics imagery following initial high spatial resolution data from NAOS and MAD past observations.
We prepare observation of R136, with SPHERE, the VLT extreme AO resolution to progress over observations of the same kind and to pave the route for future imagery of R136 with the E-ELT at 10 mas resolutions in the mean IR wavelenghts.
This contribution describes our preliminary simulations of multi-epoch imagery of R136 using the CAOS tool for A.O. on SPHERE/VLT in realistic observing conditions from which E-ELT future 10 mas resolution imaging of the cluster can be driven by EPICS and MICADO instrumentsstF

**P021**

**Sylvestre Lacour (Observatoire de Paris)**
***FLAKE, a fast camera for the ELT***
During this talk, we will make an argument for an early instrument solely based on post-processing. On the E-ELT, the use of a fast camera combined with the appropriate deconvolution algorithms would allow diffraction limited imaging in the 0.9-2.5µm range for a whole range of science cases including high contrast with a resolution down to ~5 mas (i.e circumstellar environments) and precision astrometry (i.e galactic center) on a ~1'' FoV. That would apply even with any defective -or missing - segments (or segment clusters) on the 39-m primary mirror. This instrument would permit early science at high angular resolution, within the scientific topics of YSO, late type stars, and AGNs. We propose to build the "Fast and Light Aperture masking and specKle imager for the E-ELT" (FLAKE) instrument. We will present a design which consists of a low order AO, a pupil wheel, and two avalanche gain HgCdTe detectors: one in the pupil plane and one in the focal plane. The idea is to realize the simplest possible instrument based on the most advanced deconvolution algorithm: Holographic imaging (Schoedel et al., 2012), Kernel-phase deconvolution (Martinache, 2010) and Aperture masking (Lacour et al., 2011).

**P022**
**Søren Larsen (Radboud University Nijmegen)**
***Detailed chemical abundance analysis of semi-resolved stellar populations***
Detailed information about the chemical evolution of stellar populations is currently only available for the Milky Way and a few of its closest neighbours. Even in the ELT era, high-dispersion spectroscopy of all but the brightest individual stars will be well beyond reach if we wish to study galaxies in a representative sample of the Universe (i.e. at least out to the nearest large galaxy clusters, Virgo and Fornax). Fortunately, stellar clusters will be observable at high spectral resolution out to these distances and, furthermore, will be resolvable into their individual constituent stars with AO-assisted ELT imaging. This combination will be very powerful for carrying out detailed chemical abundance analysis of clusters spanning the entire age range from young "super-star clusters" to ancient globular clusters, and thereby gain insight into the chemical evolutionary histories of the parent galaxies. As a feasibility demonstration, I will show results from our recent pilot project in which we obtained integrated-light abundances of the globular clusters in the Fornax dwarf spheroidal galaxy with UVES. I will also discuss on-going efforts to extend this type of analysis to younger star clusters in actively star-foming galaxies.

**P023**
**Michael Meyer (ETH Zürich)**
***Star and Planet Formation with the E-ELT: Overcoming Confusion with 2022 Vision***
Many of the most critical open questions in star and planet formation research can only be addressed through observations at the highest possible angular resolution. For some problems (exoplanet imaging and resolving young stellar populations in nearby galaxies), the source of noise is the confusion limit at the limit of adaptive optics assisted performance. Here the time to complete an observation goes as the diameter of the telescope to the sixth power. I will describe projects that can be undertaken with the E-ELT that address: 1) how common are stars like the Sun in the Milky Way and other galaxies? and 2) how common are planetary systems like our own? These projects take advantage of the unique attributes of E-ELT that are complementary to other facilities (e.g. JWST and ALMA).

**P024**
**Roberto Mignani (University College London)**
***High Time Resolution Astrophysics with the E-ELT***
Astrophysics in the high time resolution domain studies a variety phenomana on milli- and microsecond scales, such as pulsations from rotating neutron stars, giant pulses and radio/X-ray bursts in pulsars and magnetars, and black hole variability. These are the fastest phenomena yet observed in astrophysical objects. many of them can be detected also in the optical and studied with adequate instrumentation. The unprecedented light-collecting area of the E-ELT will produce very large photon fluxes that will enable novel studies of very rapid source variability. In this talk, I will present the scientific drivers for high time resolution facilities at the E-ELT and introduce novel instrument concepts based on quantum detector technology.

**P025**
**Florentin Millour (Observatoire de la Côte d'Azur)**
***From MATISSE to METIS: possible synergies***
The Very Large Telescope Interferometer will host, starting from 2015, a pioneering mid-infrared instrument: MATISSE, whose prominent science cases are the formation of planetary systems and the characterization of the innermost regions of the Active Galactic Nuclei. With this talk, we will underline some of the key astrophysical questions we foresee to solve with MATISSE: with an angular resolution ranging from 4 to 10mas (130m baselines), MATISSE will study stellar sources exhibiting dust and gaz signatures in their vicinity. As an example, MATISSE will provide a sharp view of massive interacting binaries or mass-losing stars at high angular resolution.
The E-ELT will provide a slightly lower angular resolution at the same wavelength as MATISSE, and similar resolution in the near-infrared. The E-ELT instruments, especially in the mid-infrared (e.g. METIS) will provide two complementary views to the MATISSE sources:
- a study of the circumstellar media at higher contrast than VLTI
- a fine kinematical study at high resolution (R~100000).
Used together, MATISSE and the mid-IR ELT instrument can provide an unprecedented insight on the propagation of deep-seated disks or wind perturbations into an extended, mainly dusty, circumstellar medium. This potential synergy will be presented through some chosen examples.

**P026**
**Kieran O'Brien (University of Oxford)**
***Volume-phase holographic gratings for E-ELT instruments***
HARMONI will be the first light Integral Field Spectrograph for the E-ELT. It will feature a number of VPH gratings operated at cryogenic temperatures. These gratings cover a wide spectral range (both in the near-IR and optical) and have a number of different dispersions. This poster will summarize the prototyping work being carried out by the HARMONI team ahead of the start of Phase-B and is intended to act as a discussion point for other teams considering incorporating similar elements in their designs for future E-ELT instrumentation.

**P027**
**Ernesto Oliva (INAF - Arcetri)**
***HIRES design: an optimized HR spectrograph and a super X-shooter***
The primary goal of the HIRES project is to provide the astronomical community with a high resolution spectrograph optimized in terms of wide spectral coverage, high throughput, stability, spectral resolution and capability to achieve extremely high S/N ratios. We show how a classical instrument design, which is the natural evolution of current HR spectrometers for 4-10m class telescopes, must necessarily contain

features which can be easily employed to perform multi-objects medium resolution spectroscopy with full spectral coverage. The extra observing modes do not affect the performances of the HR spectrograph, and only require minor additions to the fore-optics of the spectrometer

**P028**
**Laura Pentericci (INAF - Roma)**
***Exploring the reionization epoch with the E-ELT***
The epoch of re-ionization is a fascinating time in the history of the Universe that is still largely unexplored. Lyman alpha emitting galaxies at high redshift offer a powerful probe of both reionization and of the early phases of galaxy formation. In particular the Lyman alpha emission is an efficient tool for identifying the very first galaxies and provide a robust test of the reionization epoch.
I will review the most recent observational results on high redshift galaxies and the current constrains that we can place on the reionization epoch using the first statistical samples of spectroscopically confirmed z=7 Lyman break galaxies. I will then discuss how future spectroscopic surveys with the E-ELT of very high redshift LBGs and Lya emitters will allow us to explore and characterize the reionization epoch in great detail.

**P029**
**Romain Petrov (Observatoire de la Côte d'Azur)**
***Chromatic Differential Astrometry with the E-ELT***
Chromatic Differential Astrometry (CDA) measures the displacement ε(λ) of the photocenter of non-resolved sources as a function of wavelength. The parts of the source with different spectral signatures, which are spatially merged in the spectrum s(λ), contribute to ε(λ) with a weight directly related to their relative angular positions. Thus, ε(λ) gives the source position angle and angular size together with new constraints on its structure and kinematics. It solves many "confusion" effects between different parts of a source with different spectral signatures. Applications include planets and other faint companions of stars, galaxies with different redshifts, AGN BLRs and NLRs, protoplanetary disks, debris disks and circumstellar gas envelopes. The technique is now commonly used in optical interferometry and the feasibility on single apertures has been demonstrated.
The angular resolution of CDA, i.e. the accuracy on ε(λ), improves like B.D, where B is the telescope baseline and D the diameter of its collecting surface. This makes it particularly interesting for the E-ELT where B=D≈40m, yielding the same resolution than the VLTI with D=8m and B=200m but at much higher magnitudes. CDA does not need dedicated instruments and can be applied to many spectrographs and spectro-imaging instruments. As an operation mode of existing slit spectrographs it has achieved measurements with 0.01 pixel accuracy that corresponds to a resolution gain of up to 50. In realistic laboratory benches, with a specific observing mode and data reduction approach, we achieve 0.001 pixel accuracy. Additional calibration devices could allow gaining an additional order of magnitude and the E-ELT would then yield angular information with a (few) micro-arc-second resolution. This presentation illustrates the principle, achievements and potential of CDA, some examples of science applications and discusses the possibility to use it in several of the E-ELT instruments.

**P030**
**Giovanna Pugliese (Radboud Universiteit Nijmegen)**
**High Dispersion Spectroscopy of GCs with a metallicity spread in M31**
Until now, most spectroscopic analyses of extragalactic stellar populations have been based on relatively low resolution spectroscopy, combined with pre-computed simple stellar population models. In this work we are studying globular clusters in

M31, using high dispersion spectroscopy both in the optical and the near-infrared. We combine the integrated-light spectroscopic observations with resolved photometry of individual stars in the clusters. Using stellar parameters derived from the observed colour-magnitude diagrams, we compute integrated-light spectra specifically for our target clusters. This allows us to determine chemical abundances by adjusting the abundance patterns in the model spectra until the best match to the observed spectra is obtained. With the E-ELT, this approach will be applicable to galaxies at distances of tens of Mpc, and will thus allow detailed chemical abundance analysis for globular clusters in the nearest large galaxy clusters, Virgo and Fornax.

**P031**
**Mathieu Puech (GEPI – Observatoire de Paris)**
**Web-based scientific simulation tools for E-ELT instruments**
In the frame of the E-ELT phase A studies, we have developed scientific end-to-end simulators which were used to constrain the instruments high level specifications. These simulators were coupled to a web interface called websim, which provides a user-friendly access and allows to run specific simulations with different scientific objectives. We will give a short description of these simulators, illustrate how they were used in practice to derive instrument top level requirements, and present the on-going and planned improvements.ov@

**P032**
**Laura Schreiber (INAF - Osservatorio Astronomico di Padova)**
***PSF estimation in Adaptive Optics images of crowded stellar fields***
The growing number of available Adaptive Optics (AO) imaging facilities raised the need of significant improvement in the AO Point Spread Function (PSF) modeling. In fact, AO images are characterized by structured PSF with sharp core and extended halo and by a variation across the field of view, mostly evident in single-reference systems. A more uniform correction may be achieved by Multi Conjugate Adaptive Optics (MCAO), a technique based on the use of two or more deformable mirrors and several Guide Stars, demonstrated on sky by MAD on the Very Large Telescope and planned for the future E-ELT. In this context, we explore the problems related to PSF extraction across the Field of View in MCAO images of crowded point-like source fields being applicable to many scientific objects like globular clusters, star forming regions and incipiently resolved galaxies. This study is based on simulated images generated with synthetic PSFs available from the Phase-A study of the E-ELT MCAO system (MAORY) and different crowding conditions. The data have been analyzed with the StarFinder photometry package employing a numerical PSF extracted directly from the simulated science field. Two different PSFs have been used: an estimation from the images of the brightest stars and the PSF reconstructed by a blind deconvolution of the science field. A comparison of the two PSF estimation methods as a function of crowding is shown.

**P033**
**Eva Schmalzl (Leiden Observatory)**
***An end-to-end instrument model for the mid-IR E-ELT instrument METIS***
The optimal performance of an instrument relies critically on accurate performance estimates during its design phase. These need to be modeled to give the science and engineering teams a preview of the performance of the instrument, to guide the design process, to prove the capabilities of the instrument and to prepare science ready software tools before the instrument is operational. METIS, the Mid-infrared E-ELT Imager, is the only instrument concept for the E-ELT that covers the thermal infrared wavelengths from 2.9-14 micron (L, M and N band). It contains a diffraction limited imager and an integral field high resolution spectrograph. METIS was identified in the instrument roadmap as the third instrument for the E-ELT. To

demonstrate the capabilities of METIS, we are developing an end-to-end instrument model, which will be able to simulate the full capacity of METIS. We explain the structure and data format of the simulator and show first results of science simu lations with the imager and IFU.

**P034**
**Ray Sharples (Durham University)**
***Near-infrared multi-object spectroscopy: lessons learned from KMOS***
I will present the latest results from the KMOS commissioning runs on the ESO VLT and plans for scientific exploitation of KMOS via the GTO programme. Implications for the desired capabilities of a multi-object near-infrared spectroscopic instrument on the E-ELT will be drawn.

**P035**
**Ralf Siebenmorgen (ESO)**
***E-ELT observations of shadows, gaps, and ring-like structures in proto-planetary disks.***
The E-ELT will resolve inner structures in passively-heated disks around T Tauri and Herbig Ae stars. We simulate how an E-ELT mid-infrared instrument will detect dust emission from such disks and a near-infrared instrument the scattered light characteristics. The simulations apply a novel vectorised Monte Carlo dust radiative transfer model (ApJ 751, 2012). Thanks to the vectorisation the run time is drastically reduced so that new disk-structure physics can be treated (AA 539, 2012). Proto-planetary disk dust is composed of either fluffy carbon and silicate grains of various sizes or dust of the diffuse ISM. Under the assumption of hydrostatic equilibrium we find that the disk in the inner rim puffs up, followed by a shadowed region. The shadow reduces the temperature of the midplane and decreases the height of the extinction layer at the disk surface. It can be seen as a gap in the disk unless the surface is again exposed to direct stellar radiation. There the disk puffs up a second time, a third time and so forth. Therefore several gaps and ring-like structures are present in the disk surface and appear in emission images. They result from shadows in the disks and are present without the need to postulate the existence of any companion or planet. We show that to resolve such structures the resolution of the ELT is required. Compared to Herbig Ae stars, such gaps and ring-like structures are more pronounced in regions of terrestrial planets around T Tauri stars. We also show that with the high contrast and high Strehl-ratio of EPICS it will be possible to resolve these structures in near-infrared scattering, where a ripple-like pattern is observed, while current generation instruments (e.g. SPHERE) lack the required contrast. We present an accurate treatment of PAH molecules in the MC code. Particular attention is given to the photo-dissociation of the molecules by energetic photons. Besides PAH destruction, we also consider the survival of the molecules by vertical mixing within the disk. By applying typical X-ray luminosities the model accounts for the low PAH detection probability observed in T Tauri and the high PAH detection statistics found in Herbig Ae disks (A&A 543, 2012). We show that the destruction and survival of the molecules requires METIS in low-resolution spectroscopy. Mid IR images of disks with spherical halos are presented and we show that disks are easier to resolve when PAH emission dominates.

**P036**
**Yiannis Tsamis (Open University)**
***Studies of photoevaporating protoplanetary discs from the VLT to the E-ELT era***
Photoevaporating protoplanetary discs (proplyds) in the vicinity of hot massive stars, such as those found in Orion, are important objects of study for the fields of star

formation, early disc evolution, planetary formation, and H II region astrophysics. I will present results from our ongoing integral field spectroscopy of proplyds in the Orion nebula and other HII regions. Using VLT FLAMES, X-shooter, and Calar Alto PMAS we have taken deep, spatially-resolved spectra of the photoevaporated wind and jets arising from these landmark sources, and measured key properties including their metallicities (Tsamis et al. 2011; Tsamis & Walsh 2011; Mesa-Delgado et al 2012; Tsamis et al. 2012 and in preparation). These studies provide a foretaste, as well as a few constraints, of what could be attainable in this field with the envisaged E-ELT instrumentation suite.

**P037**

**Yanbin Yang (GEPI – Observatoire de Paris)**

***Sky subtraction for fiber-fed instruments***

Multi-Object Spectrographs, in particular fiber-based concepts, are potentially important for studying faint sources on the E-ELT. The detection and study of such faint sources will require sky continuum (i.e., between OH lines) subtraction with <=1% accuracy. Using FORS2 narrow-band imaging and FORS2 long-slit data, we characterized the spatial and temporal variations of the sky continuum at ~9000A. We found that it can be decomposed into several Gaussian random fields with scales ranging from 2 to ~200 arcsec and total amplitude < 0.5%. This can be considered as an upper limit on the sky continuum variations over a field-of-view of a few arcmin. Furthermore, using technical observations with VLT/FLAMES in I band, we tested several sky subtraction methods and found that the cross beam-switching and dual stare are the most accurate techniques which allow us to reach an accuracy <=1%. We will present a simple operational concept to warrant such an accuracy together with first estimates of sky subtraction performances with an IFU.