ANDES, the high resolution spectrograph for the ELT: science case, baseline design and path to construction

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Event: SPIE Astronomical Telescopes + Instrumentation, 2022, Montréal, Québec, Canada

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Ground-based and Airborne Instrumentation for Astronomy IX, edited by Christopher J. Evans, Julia J. Bryant, Kentaro Motohara, Proc. of SPIE Vol. 12184, 1218424
© 2022 SPIE · 0277-786X · doi: 10.1117/12.2628689

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ABSTRACT

The first generation of ELT instruments includes an optical-infrared high resolution spectrograph, indicated as ELT-HIRES and recently christened ANDES (ArmazoNes high Dispersion Echelle Spectrograph). ANDES consists of three fibre-fed spectrographs (UBV, RIZ, YJH) providing a spectral resolution of ∼100,000 with a minimum simultaneous wavelength coverage of 0.4-1.8 μm with the goal of extending it to 0.35-2.4 μm with the addition of a K band spectrograph. It operates both in seeing- and diffraction-limited conditions and the fibre-feeding allows several, interchangeable observing modes including a single conjugated adaptive optics module and a small diffraction-limited integral field unit in the NIR. Its modularity will ensure that ANDES can be placed entirely on the ELT Nasmyth platform, if enough mass and volume is available, or partly in the Coudé room. ANDES has a wide range of groundbreaking science cases spanning nearly all areas of research in astrophysics and even fundamental physics. Among the top science cases there are the detection of biosignatures from exoplanet atmospheres, finding the fingerprints of the first generation of stars, tests on the stability of Nature's fundamental couplings, and the direct detection of the cosmic acceleration. The ANDES project is carried forward by a large international consortium, composed of 35 Institutes from 13 countries, forming a team of more than 200 scientists and engineers which represent the majority of the scientific and technical expertise in the field among ESO member states.

Keywords: ground-based instruments, high resolution spectrographs, infrared spectrographs, extremely large telescopes, exoplanets, stars and planets formation, physics and evolution of stars, physics and evolution of galaxies, cosmology, fundamental physics

1. INTRODUCTION

The European Extremely Large Telescope (ELT) will be the largest ground-based telescope at visible and infrared wavelengths. The flagship science cases supporting the successful ELT construction proposal were the detection of life signatures in Earth-like exo-planets and the direct detection of the cosmic expansion re-acceleration. It is no coincidence that both science cases require observations with a high-resolution spectrograph.

High-resolution spectroscopy is a truly interdisciplinary tool and, during the past decades, has enabled some of the most extraordinary discoveries spanning all fields of Astrophysics, from Planetary Sciences to Cosmology. Indeed, high-resolution spectrometers have allowed astronomers to go beyond the classical domain of astrophysics and to address some of the fundamental questions of Physics. ESO has a long and successful tradition in high resolution spectroscopy as demonstrated by the exquisite suite of medium-high resolution spectrographs offered to the community of Member States. UVES, FLAMES, CRIRES, XSHOOTER and HARPS have enabled European teams to lead in many areas of research. ESPRESSO has now joined this suite of very successful high-resolution spectrographs, fulfilling the promise of truly revolutionising some of these research areas. The scientific interest and high productivity of high-resolution spectroscopy is reflected by the fact that more than

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30% of ESO publications are based on its high-resolution spectrographs. However, it is becoming increasingly clear that, in most areas of research, high-resolution spectroscopy has reached the "photon-starved" regime with 8-10m class telescopes. Despite major progress on the instrumentation front, further advances in these fields desperately require a larger photon collecting area. Due to its inherently "photon-starved" nature, amongst the various astronomical observing techniques, high-resolution spectroscopy requires the collecting area of Extremely Large Telescopes.

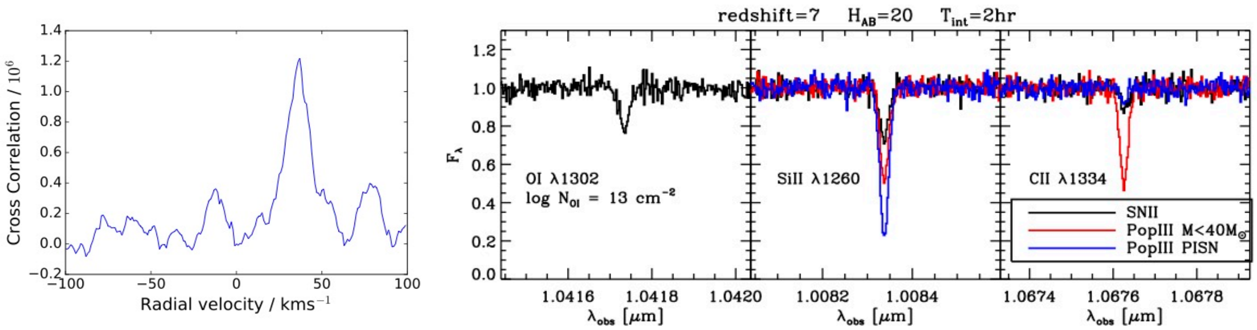

Figure 1. ANDES science highlights. Left: Cross Correlation Signal indicating the clear detection of O_2 in a Proxima-b like exoplanet in 70h of total integration (adapted from Fig. 4 of Hawker & Parry 2019, see that paper for details on the simulation). Right: Observations of a z=9 quasar with $H_{AB} = 22$ and a total integration time of 10h showing ANDES capability of distinguishing IGM enrichment by normal SNII supernovae or by low mass and pair instability Supernovae from Pop III Stars (simulations by the ANDES Science Team).

When defining the ELT instrumentation, ESO commissioned two phase-A studies for high resolution spectrographs, namely CODEX[1] (covering the 370 nm – 710 nm wavelengths range) and SIMPLE[2] (covering the 840 nm – 2400 nm wavelengths range). The studies, completed in 2010, demonstrated the importance of optical and near-IR high-resolution spectroscopy at the ELT. ESO thus decided to include a High-REsolution Spectrograph (HIRES) in the ELT instrumentation roadmap. At the same time, the CODEX and SIMPLE consortia realized the great scientific importance of covering the optical and near-infrared spectral ranges simultaneously: this marked the birth of the HIRES Initiative that started developing the concept of an XSHOOTER-like spectrograph, but with higher resolution, capable of providing R ∼100.000 over the full optical and near-infrared wavelengths range. Following a community workshop in September 2012 the HIRES Initiative has prepared a White Paper summarizing a wide range of science cases proposed by the community (Maiolino et al.[3]) and also prepared a Blue Book with a preliminary technical instrument concept. With the start of construction of the ELT, the HIRES Initiative became a Consortium, recruiting additional institutes which expressed their interest in HIRES and responding to the ESO call for the phase-A study of HIRES. The Phase A study started in March 2016 and was successfully concluded in April 2018. Since new Institutes from USA and Canada joined the HIRES consortium, and many activities in preparation of the start of construction were performed. Finally, in December 2021, the ESO Council approved the signature of the Construction Agreement for HIRES which was then renamed ANDES (ArmazoNes high Dispersion Echelle Spectrograph).

This paper provides a general description of the ANDES project, science and consortium. In section 1 we describe the ANDES science goals and priorities, in section 3 the instrument concept and and in section 4 the consortium and its organization.

2. SCIENCE GOALS

2.1 Exoplanets and protoplanetary disks

The study of exoplanet atmospheres for a wide range of planetary objects, from gas giants to rocky planets, and from hot to temperate planets, is a primary objective in the field for the next decade. In particular, the detection of components such as molecular oxygen, water and methane in Earth- or super-Earth sized planets is considered to be truly transformational, as they may be regarded as signature of habitability or even signatures of life. Simulations of ANDES observations have been performed by Snellen et al.[4,5] and Hawker & Parry.[6]

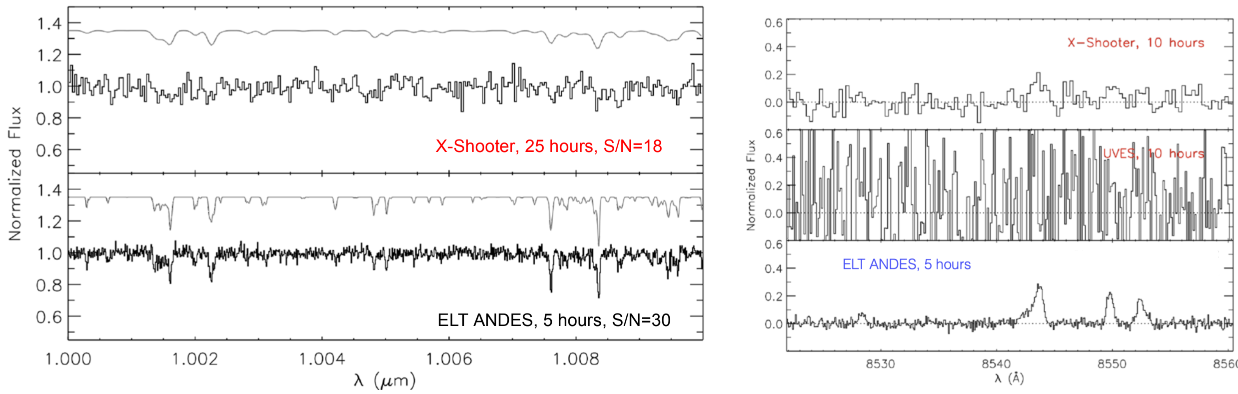

Figure 2. Left: simulated observations using VLT+XSHOOTER (top) and ANDES (bottom) of a z=7 source $J_{AB} = 20.2$. Signal-to-noise ratios per spectral channel have been calculated assuming a 25 (5) hour integration with XSHOOTER (ANDES). The top spectra in both figures are the adopted models convolved with the instrument spectral resolution. Right: simulated observations using VLT+XSHOOTER (top), VLT+UVES (middle) and ANDES (bottom) of the region below Lyman-α for a $z \approx 6$ quasars at $m_{AB} \leq 21$ mag.

ANDES will be able to probe the atmospheres in transmission during the transit of an exoplanet in front of its host star. As an example, it will be possible to detect CO_2 absorption in Trappist-1 b with a S/N of 6 in 4 transits of the planet, while O_2 absorption at 0.75 μm can be detected in only 25 transits of the planet, i.e. less than 30 hours of observations. ANDES will also be able to directly probe exoplanets, by spatially resolving them from their host star, focussing on their reflected star light and taking advantage of the angular resolution of the ELT with AO-assisted observations. For example, it will be possible to detect the Proxima-Cen b planet in 4 nights of integration with a S/N of 8 with a relatively simple system of single conjugate adaptive optics (SCAO), similar to that used by other ELT first-light instruments. Figure 1, left, shows that ANDES will be able to detect O_2 from a Proxima-b like exoplanet in 70 h of integration.

Protoplanetary disks are a natural outcome of angular momentum conservation in star formation and are ubiquitous around young, forming stars. ANDES will be able to determine the properties of the gas in the inner star-disk region, where different competing mechanisms of disk gas dispersal are at play. This will constrain on one side the mechanisms through which the forming star acquires mass and removes the angular momentum, and on the other side the initial condition for planets formation.

2.2 Stars and Stellar Populations

The vast light-collecting power of the ELT will enable detailed high-resolution spectroscopy of individual stars, and in particular very faint red dwarfs and distant red giants in nearby galaxies, for which ANDES will be able to provide tight constraints on the atmospheric parameters. These constraints will be extremely important to characterize the stellar hosts of exoplanets. ANDES will also expand our horizon by measuring the heavy-elements abundances of the most primitive and ancient stars (low mass, low metallicity) in our Galaxy and its satellites helping us to understand what is the lowest metallicity for which gas can collapse to form low-mass stars, and what are the nature and yields of the very first generation of stars (the so called Pop III stars) and their supernovae. Last, but not least, the combination of very high spectral resolving power and diffraction-limited angular resolution makes the ELT a unique resource for deepening our understanding of the physics of stellar atmospheres and nucleosynthesis processes, e.g., by allowing to spectroscopically resolve the effects of surface convection and to measure isotopic abundances of atomic species.

2.3 Galaxy Formation and evolution and the intergalactic medium

The detection of Pop III stars and the observational characterization of their properties is one of the main objectives of extragalactic astrophysics. Proto-galaxies hosting Pop III stars are expected to be too faint for direct detection. However, the signature of Pop III stars can be detected through their nucleosynthetic yields which can be potentially observed in the abundance patterns of very metal-poor absorption systems in the high-resolution, wide-range spectra of bright high-redshift sources, for example, GRB afterglows or superluminous supernovae, provided by ANDES in the NIR (Figure 1, right). The direct detection and characterization of the beginning of the reionization epoch is another very important goal in the study of galaxy formation. This process is believed to have been dominated by ultraviolet photons from the first generations of galaxies, most of which might be too faint to be observed directly even with JWST. By targeting bright quasars and GRB afterglows at high redshift as background continuum sources, ANDES will be able to study both transmission features in the Lyman-α forest and metal absorption lines associated with these reionization-epoch sources, constraining the patchiness of the reionization process, the properties of the ultraviolet background radiation and the chemical enrichment of the IGM in this epoch.

2.4 Cosmology and Fundamental Physics

The observational evidence for the acceleration of the expansion of the universe and the tensions that have been highlighted by different cosmological probes have shown that our canonical theories of cosmology and of fundamental physics may be incomplete (and possibly incorrect), and that there might be unknown physics yet to be discovered. ANDES will allow to search for, identify and ultimately characterize any new physics through several different but fundamentally inter-related observations which will enable a unique set of tests of the current cosmological paradigm. ANDES will be able to constrain the variation of fundamental physical constants like the fine-structure constant α and proton-electron mass ratio μ with the advantage, compared to laboratory measurements, of exploring variations over 12 Gyr timescales and 15 Gpc spatial scales. A detection of varying fundamental constants would be revolutionary: it would automatically prove that the Einstein Equivalence Principle is violated (i.e. gravity is not purely geometry), and that there is a fifth force. ANDES will enable a test of the CMB temperature-redshift relation, $T(z) = T_0(1 + z)$, which is a robust prediction of standard cosmology but that must be directly verified by measurements. A departure from this relation can in turn reveal a violation of the hypothesis of local position invariance (and thus of the equivalence principle) or that the number of photons is not conserved. ANDES measurement will greatly improve on the existing constraints on T(z) compared to existing data. The redshifts of cosmologically distant objects drift slowly with time (the so-called Sandage effect). A redshift drift measurement is fundamentally different from all other cosmological observations and can provide a direct detection of cosmic re-acceleration, thus undoubtedly confirming cosmic acceleration, the existence of dark energy and potentially provide evidence for new physics. ANDES will be capable of detecting the redshift drift in the Lyα forests of the brightest currently known QSOs ($\sim$ 6 cm/s/decade at z = 4 for a Planck-like standard cosmology). The ELT may thus become the first facility ever to watch the Universe change in "real time".

2.5 Science Priorities

These are just a few of the many science cases that can be addressed, a collection of many of these can be found in the community white paper.[3] However, in order to define the instrument baseline design a prioritization of the science cases was performed by the ANDES Science Team following criteria of scientific impact (transformational versus incremental), feasibility and competitiveness. Then, if the TLR's of the top priority science cases were enabling other science cases, the latter were not considered any further in the subsequent prioritization, as considered accomplished together with the top priority science cases. The top science priorities and associated requirements are listed below. We remark that these are not absolute science priorities, but science priorities identified with the aim of driving the instrument design.

1. Exoplanet atmospheres in transmission, requiring a spectral resolution of at least 100,000, a wavelength coverage of at least 0.50-1.80 µm and a wavelength calibration accuracy of 1 m/s. The implementation of the above TLRs would automatically enable the following science cases:

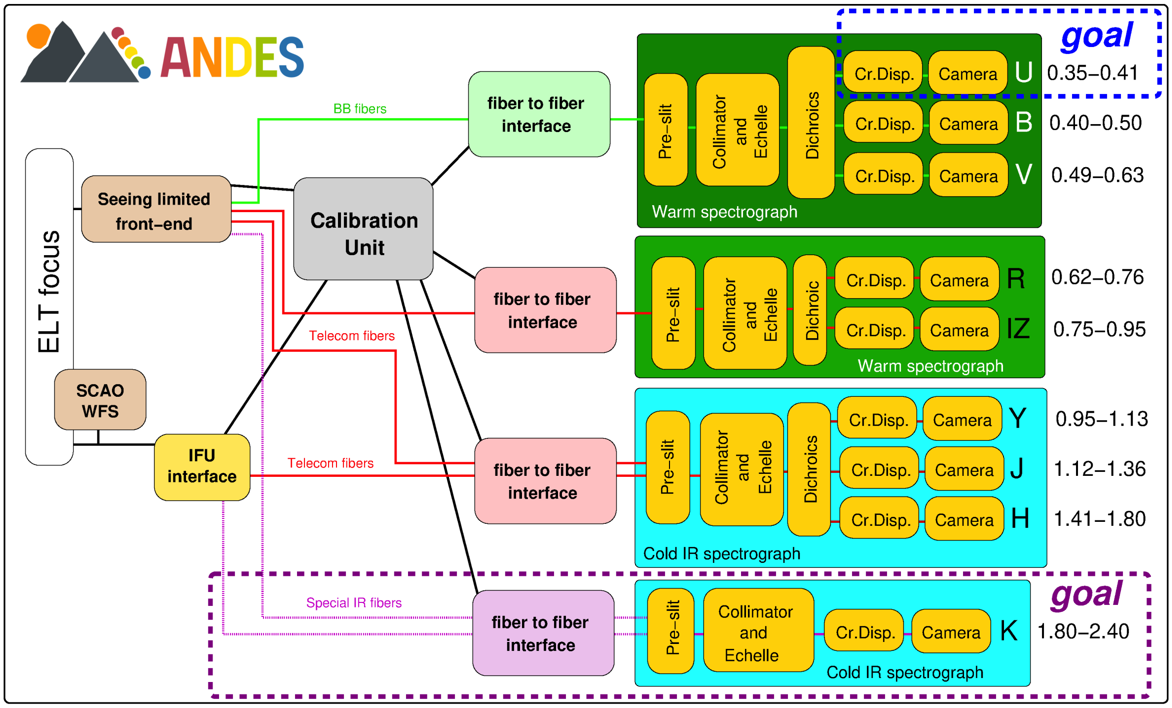

Figure 3. ANDES architectural design, outlining the instrument subsystems: Front End (seeing-limited and AO assisted with SCAO unit), Fibre Link, Calibration Unit, VIS-Blue, VIS-Red, NIR and NIR-K (cold spectrographs). Andes Logo by Alexis Lavail (Uppsala).

- reionization of the universe,
- the characterization of cool stars,
- the detection and investigation of near pristine gas,
- the study of Extragalactic transients.

2. Variation of the Fundamental Constants of Physics, requiring an extension to 0.37 µm in addition to the TLRs of priority 1. These extension towards the blue would also automatically enable to investigate:

   - the cosmic variation of the CMB temperature,
   - the determination of the deuterium abundance,
   - the investigation and characterization of primitive stars.

   At $\lambda < 0.40 \mu m$ the throughput of the ELT is expected to be low as a consequence of the planned coating. However, even in the range 0.37-0.40 µm the system is expected to outperform ESPRESSO at the VLT, and new coating is under study by ESO and may be available a few years after first light.

3. Detection of exoplanet atmospheres in reflection, requiring, on top of the TLRs of priority 1, the addition of an Adaptive Optics (SCAO) system and an Integral Field Unit. Reflected-light spectra allow tracing atmospheric emission from lower altitudes on the dayside of the exoplanet. These additional TLRs would automatically enable also the following cases:

   - Planet formation in protoplanetary disks,
   - Characterization of stellar atmospheres,
   - Search of low mass Black Holes.

4. Sandage test. Its additional TLRs, are a wavelength range of 0.40-0.67 µm and a stability of 2 cm/s, enabling also:
   - radial velocity searches and mass determinations of Earth-like exoplanets

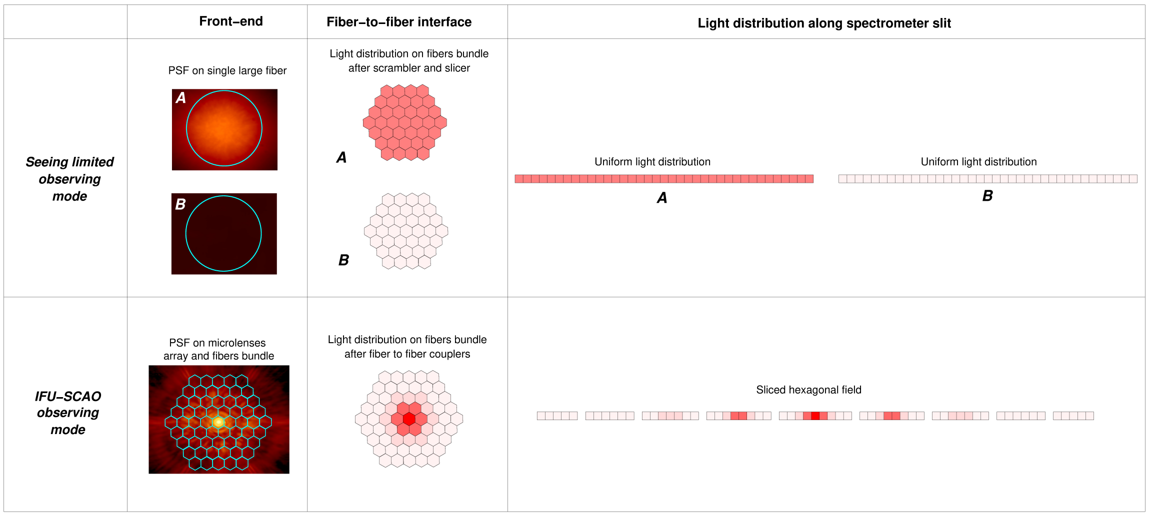

Figure 4. Schematic view of the illumination and of the organization of the fibers for the two baseline observing modes of ANDES

3. INSTRUMENT CONCEPT

Following phase A and further studies before the start of construction, the ANDES baseline design is that of a modular instrument consisting of three fibre-fed cross dispersed echelle spectrographs VIS-BLUE (UBV), VIS-RED (RIZ) and NIR (YJH), providing a simultaneous spectral range of 0.4-1.8 µm at a resolution of 100,000. The goal is to extend the wavelength range to 0.35-2.4 µm, with the addition of a NIR-K spectrograph. The fibre feeding allows several, interchangeable, observing modes ensuring maximization of either accuracy, throughput or spatially resolved information. Together with the SCAO module, the proposed baseline design is capable of fullfilling the requirements of the 4 top science cases.

The baseline design is summarized below but several alternatives have been evaluated during and after the Phase A study. Also, several add-ons made possible by the modular nature of the instrument have been considered. The overall concept is summarized in Figure 3: in the Front End the light from the telescope is split, via dichroics, into 4 wavelength channels: all wavelength channels are fed from the seeing-limited front end, but the infrared wavelenght channels can alternatively receive adaptive optics corrected light through the integral field unit (IFU) interface.

Each wavelength channel interfaces with several fibre bundles that feed the corresponding spectrograph module. Each fibre-bundle corresponds to an observing mode and all together they constitute the Fibre Link.[?] All spectrographs, VIS-BLUE, VIS-RED, NIR and NIR-K have a fixed configuration, i.e. no moving parts, allowing to fulfil the requirements on stability. They include a series of parallel entrance slits consisting of linear micro-lens arrays each optically coupled to the fibre bundles. The split in wavelengths between the spectrographs is influenced, among other parameters by the optical throughput of the different types of fibres available on the market; therefore, the different modules can be positioned at different distances from the focal plane of the telescope (see Figure 4 for more details).

The whole instrument should be placed on the Nasmyth platform, if enough volume and mass is available. If necessary, the fibre feeding allows the VIS-RED and NIR modules to be placed in the Coudé Room, which can also host the Calibration Unit.

The total cost of the instrument has been estimated to be around 35 millions of Euros (45 including NIR-K), with over 650 FTEs required for the duration of the project.

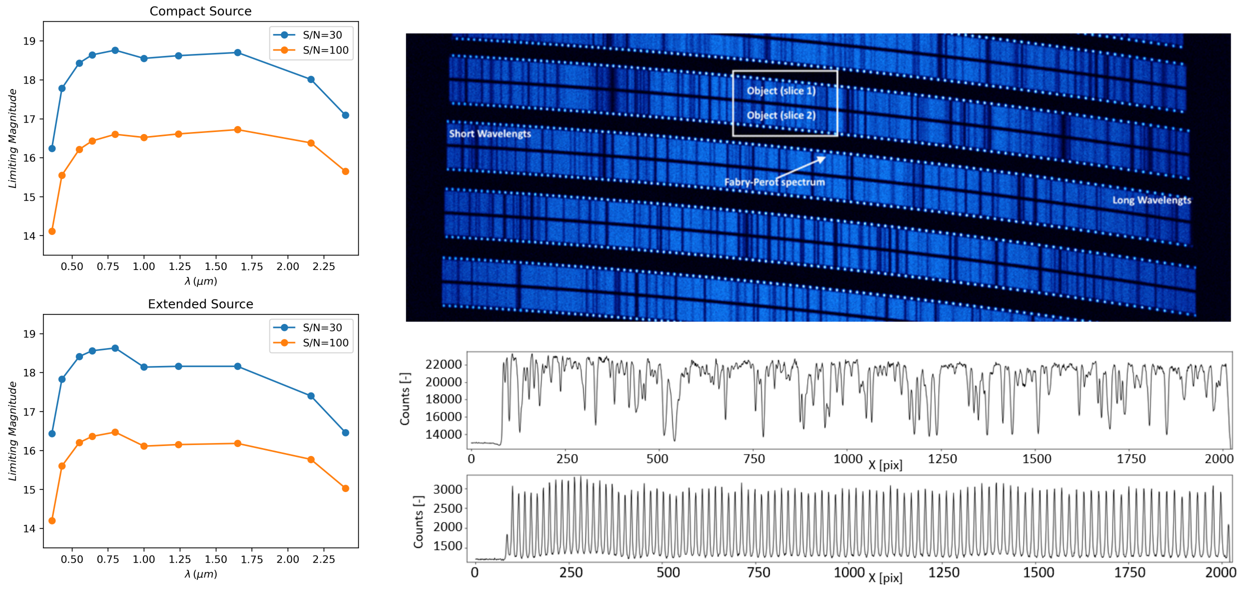

Figure 5. Left: ANDES limiting magnitudes obtained from the ETC for different S/N ratios (30 – top and 100 – bottom), compact and extended sources (left and right). Observations are in seeing-limited mode with R = 100,000 a total exposure time of 1800s. Right: ANDES E2E simulated frame. Top panel: raw data showing the spectra of a G2V star and the simultaneous calibration light from the Fabry-Perot. In the lower panel, the extracted spectra of the calibration source and the scientific target are shown.

Full end-to-end simulations are performed to evaluate the effect of technical choices on the science goals: an example is shown in figure 5, which shows a simulated ANDES raw data frame, together with the extracted spectra of the science source and of the associated Fabry-Perot for wavelength calibration. Such simulations are performed using a flexible and scalable Cloud-Based architecture, described by Genoni et al.[7] with the adoption of in-hardware accelerated computing using the NVIDIA Cuda development system. The Exposure Time Calculator, regularly updated to take into account modifications in the design, is maintained by INAF-Arcetri and can be run at the http://hires.inaf.it/etc.html web link. This ETC can compute the limiting magnitude achievable at a given wavelength, in a given exposure time and at a given signal to noise ratio or it can compute the signal to noise ratio achievable at a given wavelength, in a given exposure time and at a given magnitude. ANDES expected performances computed with the ETC are summarized in Figure 5. Figure 2 uses simulations performed by the Science Team for the extragalactic science case to show the improvement of the combination of ELT and ANDES with respect to existing, lower resolution instruments, like XSHOOTER and UVES. Although ANDES has a higher resolution and smaller spectral channels, it is able to reach much higher S/N in a much shorter time.

4. THE ANDES CONSORTIUM ORGANIZATION AND PATH TO CONSTRUCTION

The ANDES Consortium is composed of institutes from Brazil, Canada, Denmark, France, Germany, Italy, Poland, Portugal, Spain, Sweden, Switzerland, United Kingdom and USA. The full list of institutes is presented in table 1. Overall, the consortium includes 35 Institutes from 13 Countries. Consortium members are listed as authors of this paper.

The consortium is currently organized as shown in Figure 6. The Consortium is led by the PI, who is the point of contact with ESO.

The Steering Committee (SC), composed by one representative per Partner, is the ultimate decision-making body of the Consortium providing a general oversight for the Project with particular attention on Project costs and on the use of financial and human resources within the Project. The SC allows a proper connection with the funding agencies ensuring that adequate level of funding, manpower resources and infrastructures necessary to the ANDES Project are obtained.

The Executive Board (EB), composed by one representative per Country, provides regular advice to the PI and the SC on all technical and scientific matters, in order to ensure the fulfilment of the scientific objectives of the Project. The EB and the PI are responsible for preparing all the documents which require approval of the SC.

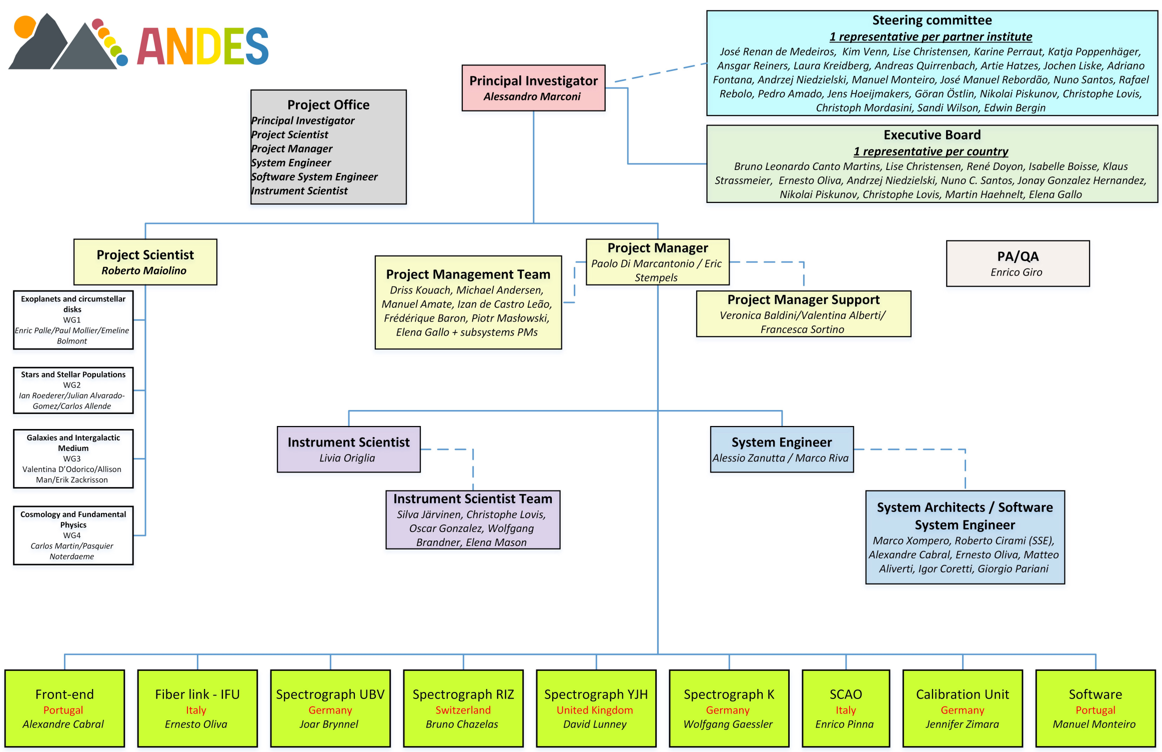

Figure 6. ANDES Consortium organization breakdown structure. ANDES logo by Alexis Lavail (Uppsala)

With a loose analogy we could associate the PI to the Prime Minister, the EB to the Government, and the SC to the Parliament.

The Project Office is composed of Project Scientist, Project Manager, Instrument Scientist, System Engineer and Software System Engineer.

The Project Scientist leads the Science team which is composed of a science team at large and of a core science team. The science team at large is composed of 4 working groups, each with a chair and two co-chairs: Exoplanets and Circumstellar Disks, Stars and Stellar Populations, Formation and Evolution of Galaxies and Intergalactic Medium, Cosmology and Fundamental Physics. The PS, as chair, the coordinators and deputies of each working group constitute the core science team. Overall, the science teams is composed of about 100 scientists.

The Project Manager leads the Project Management team and is responsible for managing the project.

The System Engineer leads the System Team which includes the managers of each of the major sub-systems and the system architects.

Finally, figure 6 also shows the countries which are leading the effort for each of thee major subsystems, as well as the major contributors for each work package.

A list of the key people in the ANDES consortium is indicated in table 2.

In December 2021, the ESO Council has approved the construction of ANDES and the signature of the Construction Agreement between ESO and INAF (the leading technical institute). The Consortium has started phase B activities with internal Welcome (remotely on January 12-13, 2022) and Kick-off (Florence, April 27-29, 2022) Meetings and is awaiting the official kick off of Phase B with ESO. Considering a completion of Phase B in 2024, the instrument should start commissioning at the telescope in 2030/2031.

5. CONCLUSIONS

The ANDES baseline design is that of three ultra-stable and modular fibre-fed cross dispersed echelle spectrographs providing a simultaneous spectral coverage of 0.4-1.8 µm (goal 0.35-2.4 µm) at a resolution of 100,000 with several, interchangeable, observing modes ensuring maximization of either accuracy, throughput or spatially resolved information. Overall, the studies conducted so far have shown that the ANDES baseline design can address the 4 top priority science cases, being able to provide ground-breaking science results with no obvious technical showstoppers.

The construction of ANDES includes the majority of the institutes in ESO member states with expertise in high resolution spectroscopy and will require an estimated 45 MEUR in hardware (including the K band and excluding contingencies) and about 650 FTEs. Contingencies are expected to be low (5-10%) because the proposed baseline design is based on proven technical solutions and can benefit on heritage from HARPS and ESPRESSO and other previous high-resolution spectrographs, e.g. PEPSI at the 11.8m LBT, SPIRou and CARMENES. The construction will last about 8-10 years. Therefore, with Phase B concluding in 2024, ANDES could be at the telescope as early as 2031.

Overall, ANDES is an instrument capable of addressing ground-breaking science cases while being almost (telescope) pupil independent, as it can operate both in seeing and diffraction limited modes; the modularity ensures flexibility during construction and the possibility to quickly adapt to new development in the technical as well as science landscape.

ACKNOWLEDGMENTS

The Italian effort for ANDES is supported by the Italian National Institute for Astrophysics (INAF).
The Portuguese participation is supported by FCT - Fundação para a Ciência e a Tecnologia through national funds and by FEDER through COMPETE2020 - Programa Operacional Competitividade e Internacionalização by these grants: UID/FIS/04434/2019, UIDB/04434/2020 & UIDP/04434/2020; POCI-01-0145-FEDER-032113 & PTDC/FIS-AST/32113/2017. Swedish participation in the ANDES project is made possible through the national Swedish ELT Instrumentation Consortium (SELTIC), suppored by the Swedish Research Council (VR). CJM acknowledges FCT and POCH/FSE (EC) support through Investigador FCT Contract 2021.01214.CEECIND/CP1658/CT0001. JLB acknowledges funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program under grant agreement No 805445. MTM acknowledges the support of the Australian Research Council through Future Fellowship grant FT180100194 SS acknowledges funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program under grant agreement No 804240. TMS acknowledgment the support from the SNF synergia grant CRSII5-193689 (BLUVES)

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Table 1. Consortium Partners and Institutes

Country	Consortium Partners
Brazil	Board of Stellar Observational Astronomy, Federal University of Rio Grande do Norte, Natal
Canada	Observatoire du Mont-Mégantic and the Institute for Research on Exoplanets, Université de Montréal – COPL (Centre for Optics, Photonic and Laser), University Laval – Department of Physics & Astronomy, University of Victoria – Dunlap Institute + Dept. Astronomy & Astrophysics, University of Toronto – Quebec Artificial Intelligence Institute (Mila)
Denmark	Instrument Centre for Danish Astrophysics representing: – Niels Bohr Institute, København – Aarhus University – Danmarks Tekniske Universitet (DTU), Lyngby
France	Centre National de la Recherche Scientifique (CNRS) representing: – LAGRANGE, Observatoire de la Côte d'Azur, Nice – LAM (Laboratoire d'Astrophysique de Marseille), Marseille – IRAP (Institut de Recherche en Astrophysique et Planetologie), Un. Toulouse – IPAG (Institut de Planétologie et d'Astrophysique), Un. Grenoble Alpes – LUPM (Laboratoire Univers et Particules), Université de Montpellier – IAP (Institut d'Astrophysique de Paris) – LMD (Laboratoire de Météorologie Dynamique), Ecole Polytechnique
Germany	Leibniz-Institut für Astrophysik Potsdam (AIP) Institut für Astrophysik und Geophysik, Universität Göttingen (IAG) Max-Planck-Institut für Astronomie, Heidelberg Zentrum für Astronomie (ZAH), Universität Heidelberg Thüringer Landesternwarte Tautenburg (TLS) Department of Physics, Hamburg Observatory, Universität Hamburg (UHH)
Italy	Istituto Nazionale di Astrofisica (INAF), 'Leading Technical Institute'
Poland	Nicolaus Copernicus University in Toruń
Portugal	Instituto de Astrofísica e Ciências do Espaço, Porto Centro de Investigação em Astronomia/Astrofísica da Universidade do Porto Associação para a Investigação e Desenvolvimento de Ciências, Universidade de Lisboa
Spain	Instituto de Astrofísica de Canarias Consejo Superior de Investigaciones Científicas (CSIC, Spain) representing: – Instituto de Astrofísica de Andalucía (IAA) – Centro de Astrobiología de Madrid (CSIC-INTA)
Sweden	Lund University Stockholm University Uppsala University
Switzerland	Département d'Astronomie, Université de Genève Physikalisches Institut, Universität Bern
United Kingdom	Science and Technology Facilities Council representing: – UK Astronomy Technology Centre – Cavendish Laboratory & Institute of Astronomy, University of Cambridge – Institute of Photonics and Quantum Sciences, Heriot-Watt University
USA	Department of Astronomy, University of Michigan

Table 2. Key persons in the ANDES Consortium

Principal Investigator	Alessandro Marconi
Steering Committee	José Renan de Medeiros, Kim Venn, Lise Christensen (chair), Karine Perraut, Andreas Quirrenbach, Ansgar Reiners, Artie Hatzes, Jochen Liske, Katja Poppenhaeger, Laura Kreidberg, Adriano Fontana, Alessandro Marconi (PI), Andrzej Niedzielski, José Manuel Rebordao, Manuel Monteiro, Nuno Santos, Pedro Amado, Rafael Rebolo, Nikolai Piskunov, Goran Ostlin, Jens Hoeijmakers, Christoph Mordasini, Christophe Lovis, Sandi Wilson, Edwin Bergin
Executive Board	Bruno Canto, René Doyon, Lise Christensen, Isabelle Boisse, Klaus Strassmeier, Alessandro Marconi, Ernesto Oliva (chair), Andrzej Niedzielski, Nuno Santos, Jonay González Hernández, Nikolai Piskunov, Christophe Lovis, Martin Haehnelt, Elena Gallo
Project Office	
Project Scientist	Roberto Maiolino
Project Manager / Dep.	Paolo Di Marcantonio / Eric Stempels
System Engineer / Dep.	Alessio Zanutta / Marco Riva
Software System Engineer	Roberto Cirami
Instrument Scientist	Livia Origlia
PA/QA	Enrico Giro
Science Team	
Chairs & Co-Chairs	Enric Pallé, Emeline Bolmont, Paul Molliere (WG1: Exoplanets & Circumstellar Disks) – Ian Roederer, Carlos Allende Prieto, Julián Alvarado-Gómez (WG2: Stars & Stellar Populations) – Valentina D'Odorico, Allison Man, Erik Zackrisson (WG3: Galaxies & Intergalactic Medium) – Carlos Martins, Pasquier Noterdaeme, Michael Murphy (WG4: Cosmology & Fundamental Physics)
System Team	Driss Kouach, Michael Andersen, Manuel Amate, Izan de Castro Leao, Frederique Baron, Piotr Maslowski, Elena Gallo, Veronica Baldini, Valentina Alberti, Francesca Sortino (Project Management Team & Support) – Silva Jarvinen, Christophe Lovis, Oscar Gonzalez, Wolfgang Brandner, Elena Mason (Instrument Scientists Team) – Marco Xompero, Roberto Cirami, Alexandre Cabral, Ernesto Oliva, Matteo Aliverti, Igor Coretti, Giorgio Pariani (System Architects)
Subsystem Managers	Alexandre Cabral (Front End), Ernesto Oliva (Fibre Link), Joar Brynnel (UBV Spectrograph), Bruno Chazelas (RIZ Spectrograph), David Lunney (YJH Spectrograph), Wolfgang Gaessler (K Spectrograph), Enrico Pinna (SCAO), Jennifer Zimara (Calibration Unit), Manuel Monteiro (Software)