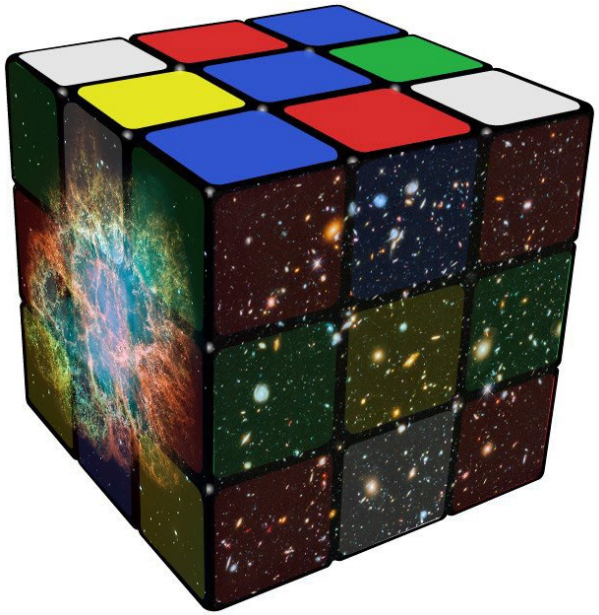


CUBES

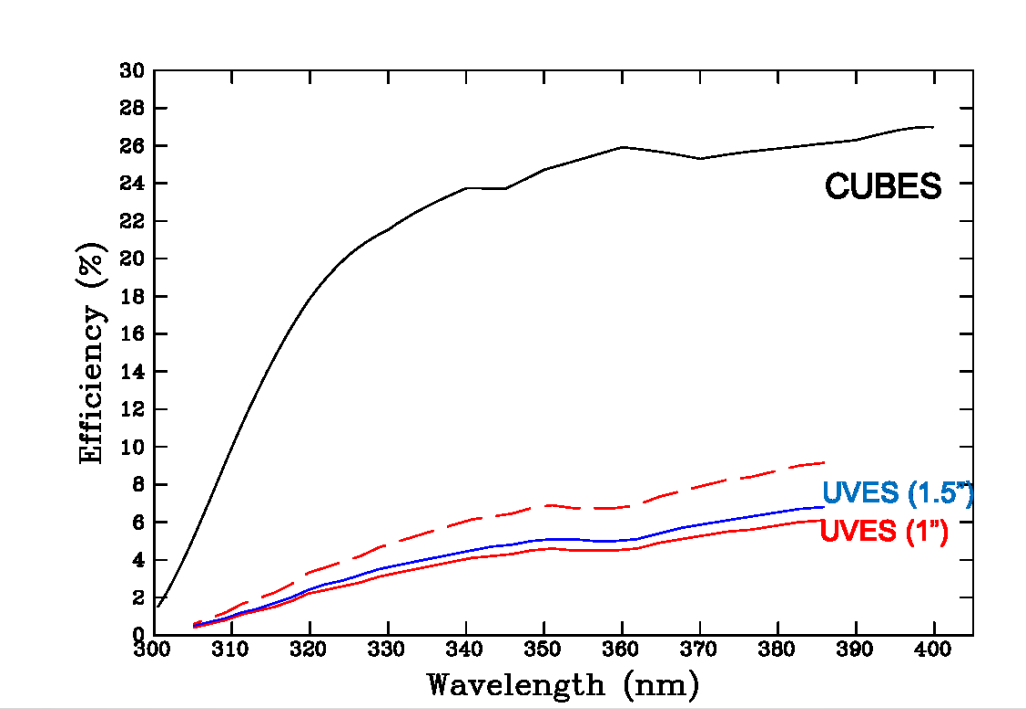
Cassegrain U-Band Efficient Spectrograph

Science

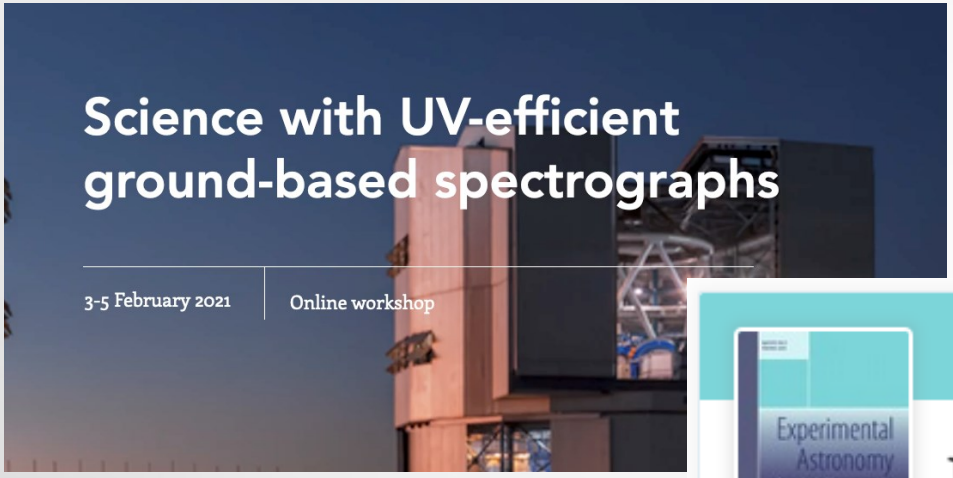
Chris Evans & Cyrielle Opitom

The ultimate UV instrument for Paranal

- Broad science case
- Unique discovery space (incl. cf. ELT!)
- 300-405 nm at $R \geq 22{,}000$ & $R \sim 7{,}000$
- Fibre-feed to UVES



The ultimate UV instrument for Paranal



Experimental Astronomy
Astrophysical Instrumentation and Methods

20+ papers subm./accepted for Special Issue

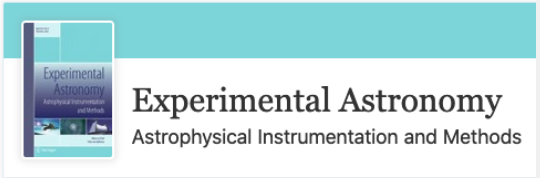
Incl. more technical papers on:

- System overview (Zanutta et al.)
- Simulation tools (Genoni et al.)
- Slicer design (Calcines et al.)
- Grating prototype (Zeitner et al.)

The ultimate UV instrument for Paranal

- Science overview paper in prep.
- Summaries of other ExA articles
- Incl. other cases from SC doc

- First draft by end of Jan
- ‘Opt-on’ by Fri 18th Feb.
- Submission at end of Feb.



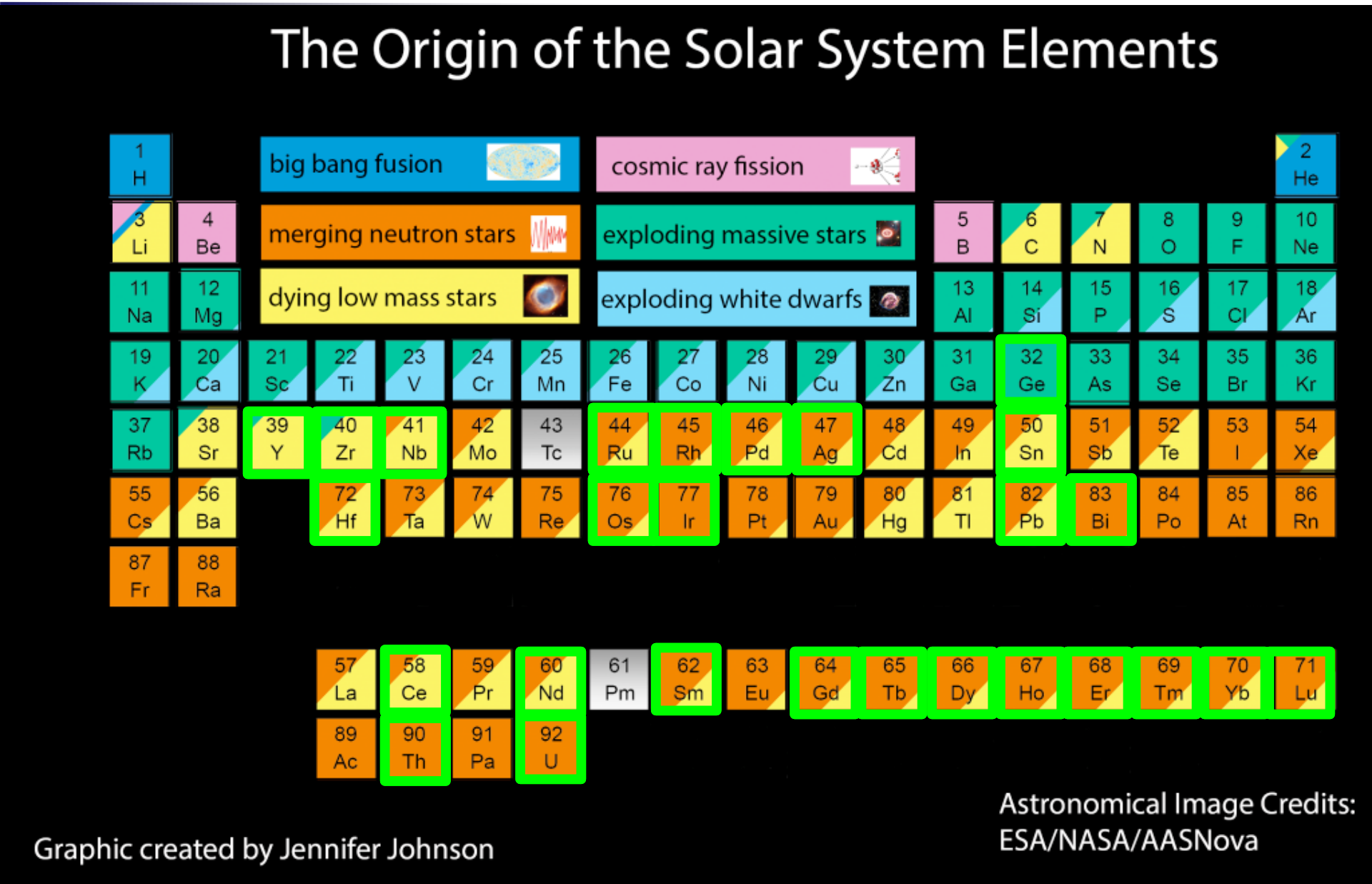
The CUBES Science Case

Chris Evans · Stefano Cristiani · Opitom · Gabriele Cescutti · Valentina D’Odorico · Juan Manuel Alcalá · Silvia Alencar · Sergei Balashev · Beatriz Barbuy · Nate Bastian · Roberta Carini · Brad Carter · Santi Cassisi · Bruno Castilho · Norbert Christlieb · Ryan Cooke · Stefano Covino · Katia Cunha · Valerio D’Elia · Annalisa De Cia · Gayandhi De Silva · Marcos Diaz · Paolo Di Marcantonio · Alessandro Ederoclite · Heitor Ernandes · Alan Fitzsimmons · Mariagrazia Franchini · Boris Gänsicke · Andrea Grazian · Camilla Hansen · Fiorangela La Forgia · Wagner Marcolino · Marcella Marconi · Alessandra Migliorni · Pasquier Noterdaeme · Bogumil Pilecki · Andreas Quirrenbach · Sofia Randich · Rodolfo Smiljanic · Colin Snodgrass · Julian Stürmer · Eros Vanzella · Paolo Ventura · Duncan Wright · Tayyaba Zafar

Received: date / Accepted: date

Abstract We introduce the scientific motivations for the development of the Cassegrain U-Band Efficient Spectrograph (CUBES) that is now in construction for the Very Large Telescope...

Motivations for the UV: Heavy elements



Motivations for the UV: Heavy elements

Qs at VLT2030 mtg re: resolution

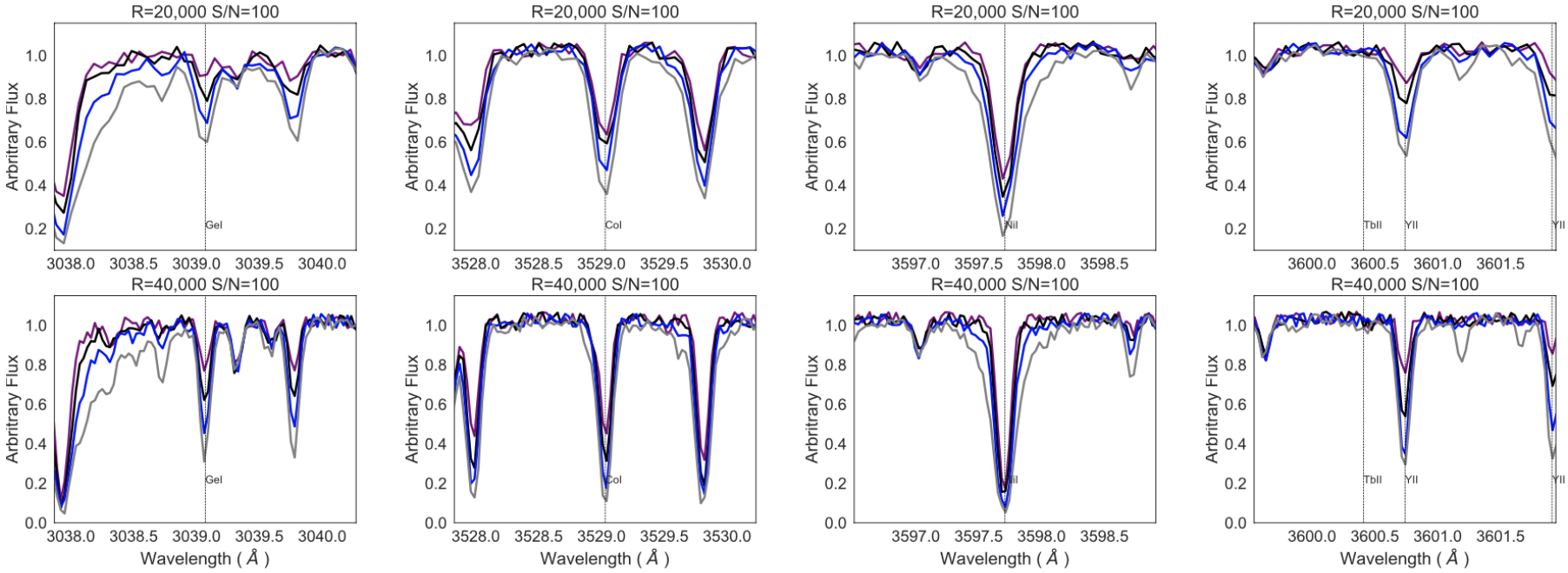
Addressed prior to Phase A

Written-up as SPIE paper in December

Stellar astrophysics in the near UV with VLT-CUBES

H. Ernandes[1,2,3], C. J. Evans[2], B. Barbuy[1], B. Castilho[4], G. Cescutti[5], N. Christlieb[6], S. Cristiani[5], G. Cupani[5], P. Di Marcantonio[5], M. Franchini[5],C. Hansen[7], A. Quirrenbach[6], R. Smiljanic[8]

[1]Universidade de São Paulo, IAG, Rua do Matão 1226, Cidade Universitária, São Paulo, 05508-900, Brazil
[2]UK Astronomy Technology Centre, Royal Observatory, Blackford Hill, Edinburgh, EH9 3HJ, UK
[3]IfA, University of Edinburgh, Royal Observatory, Blackford Hill, Edinburgh, EH9 3HJ, UK
[4]Laboratório Nacional de Astrofísica/MCTIC, Rua Estados Unidos, 154 - 37504-364, Itajubá, MG, Brazil
[5]INAF - Osservatorio Astronomico di Trieste, via G. B. Tiepolo 11, 34131 Trieste, Italy
[6]Landessternwarte, Zentrum für Astronomie der Universität Heidelberg, Königgstuhl 12, 69117, Heidelberg, Germany
[7]Max Planck Institute for Astronomy,Koenigstuhl 17, 69117 Heidelberg Germany
[8]Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00-716, Warsaw, Poland



(a) Ge I λ3039.07 (b) Co I λ3529.03 (c) Ni I λ3597.71 (d) Y II λ3600.74

Motivations for the UV: Heavy elements

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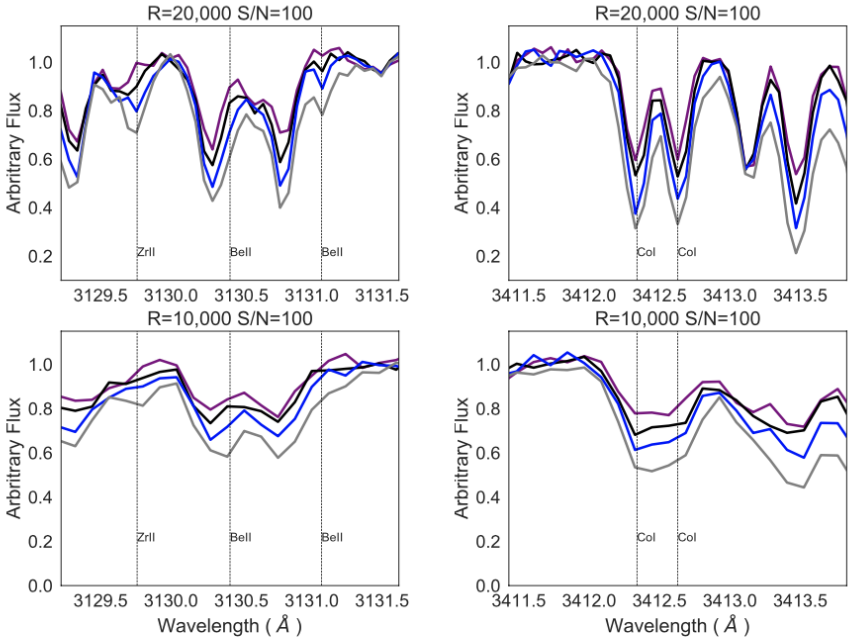
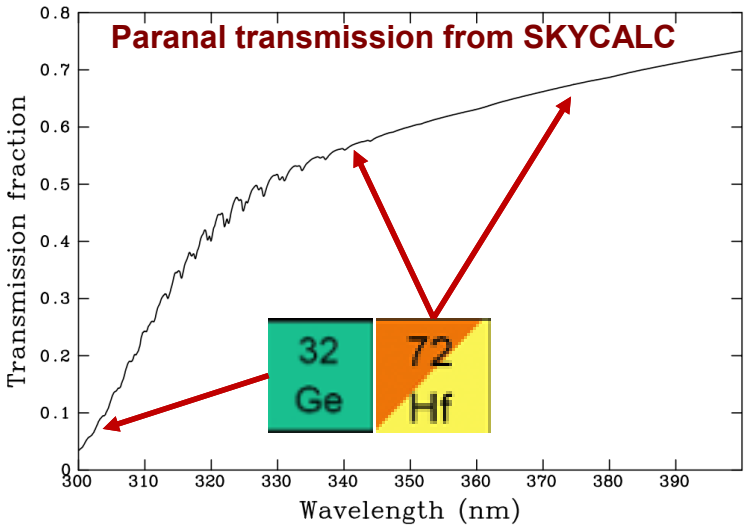


(a) Be II (b) Co I λ3412

Motivations for the UV: Heavy elements

Performance of CUBES Phase A design?

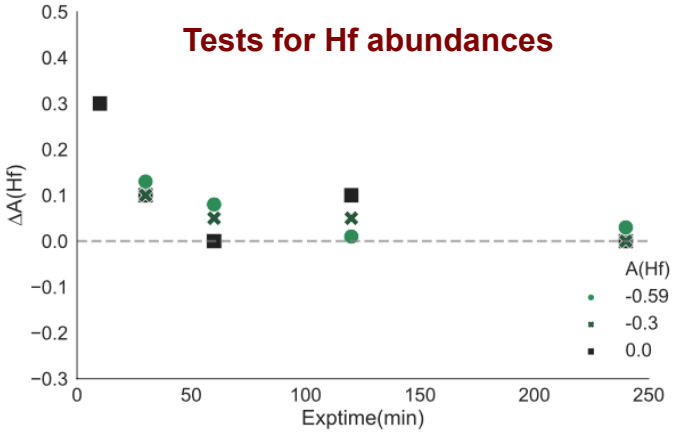


From Ernandes et al. (ExA Special Issue)

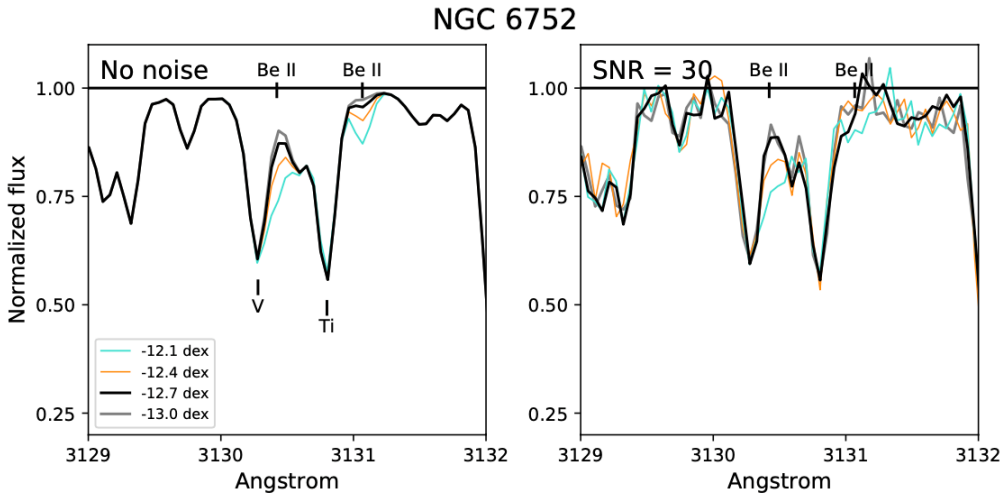
t_{exp} (min)	$S/N_{\lambda3050}$ ($U_{eff} \sim 14.25$)	$S/N_{\lambda3730}$ ($U_{E2E} = 16$)	$S/N_{\lambda3050}$ ($U_{eff} \sim 16.25$)	$S/N_{\lambda3730}$ ($U_{E2E} = 18$)
5	7	24	1	7
10	12	34	3	11
30	25	65	6	23
60	36	92	10	37
120	53	148	15	47
240	89	190	20	70

2.5-3 mags deeper than UVES for metal-poor stars

Takes us from handful of objects to 100s, to constrain nucleosynthesis models

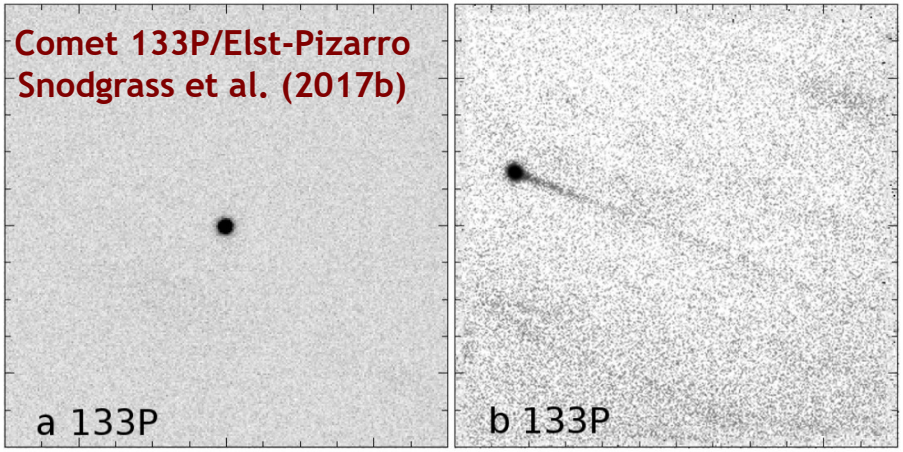


& light elements too…

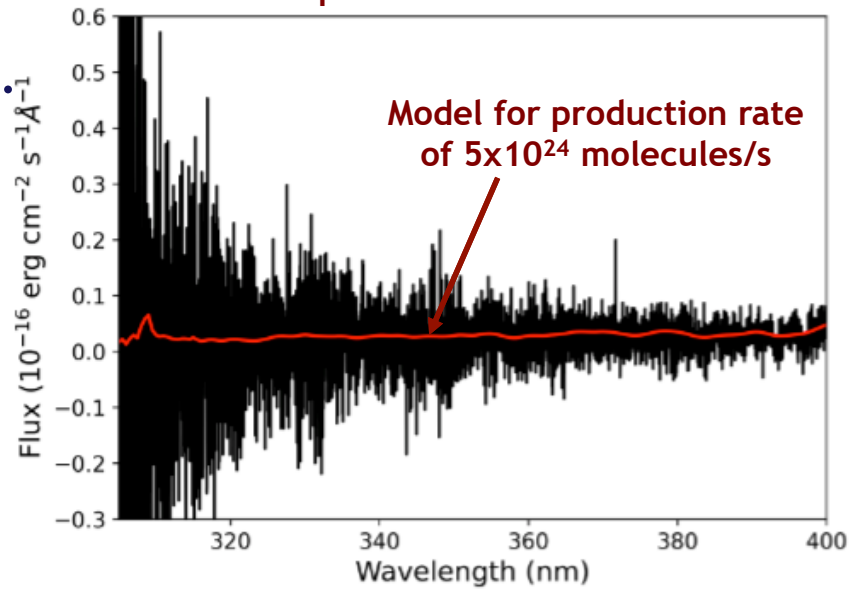


Cometary Science

Searching for water in the asteroid belt…

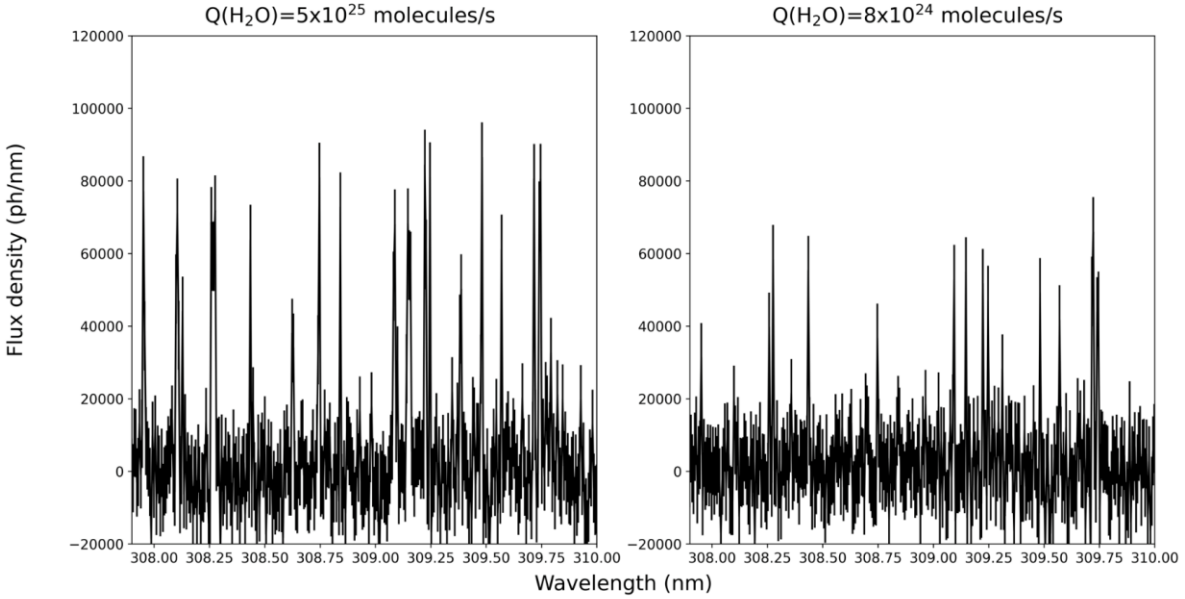


X-Shooter spectrum of Comet P/2012 T1



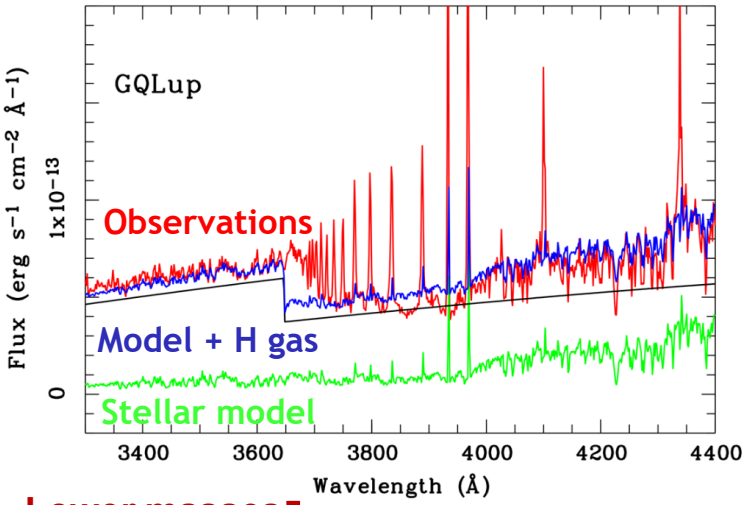
Simulations from Opitom et al. (ExA Special Issue)

OH detections 10 times lower (~5x10^{24} molecules/s) in 2hrs



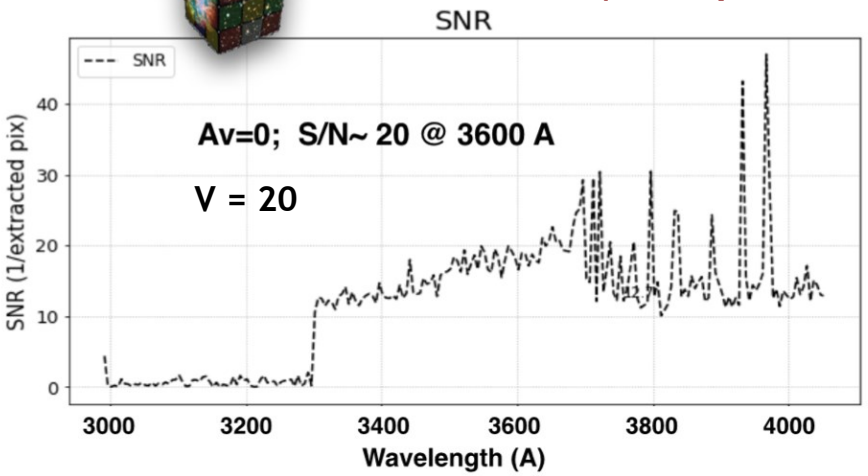
Accretion/outflows in young stars

Near-UV is powerful for studies of YSOs (accretion, jets, winds etc)

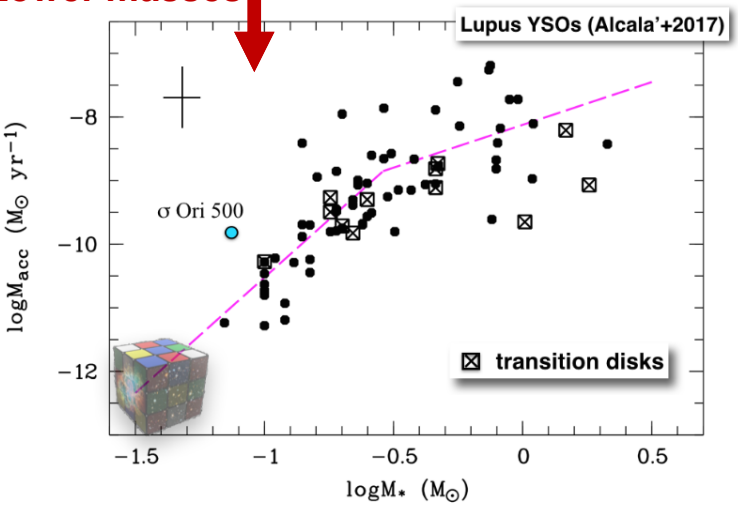


Further

From Alcalá et al. (ExA Special Issue)



Lower masses



Now kpc distances rather than just nearby star-forming regions

Low-res mode: sensitivity for faintest sources, so larger distances/extinction

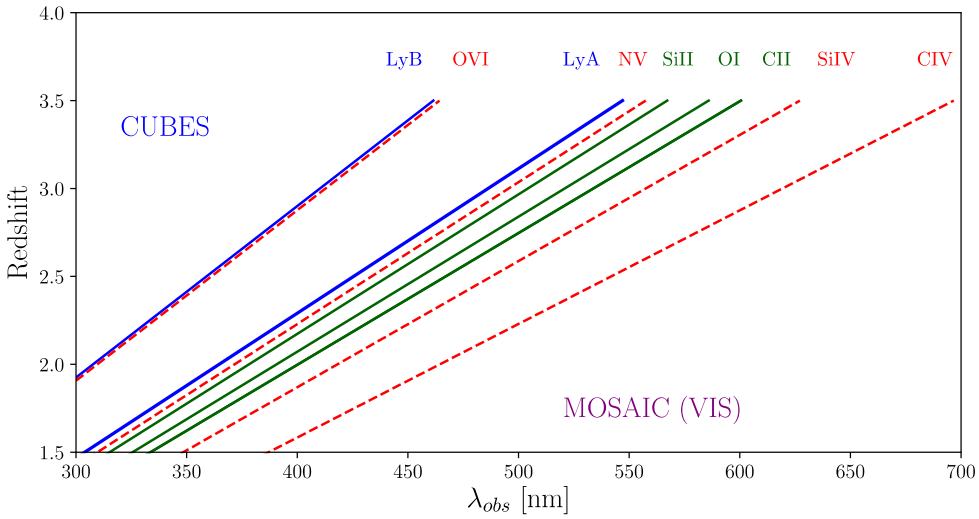
Longer wavelength observations needed but objects also highly variable

→ UVES fibrelink

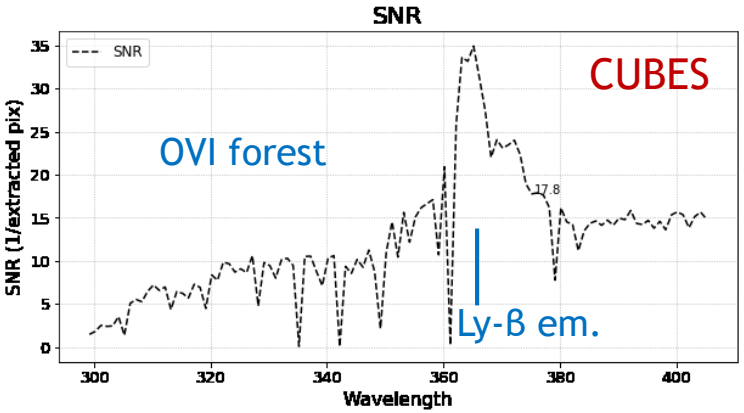
Sufficient S/N with UVES within CUBES t_{exp}

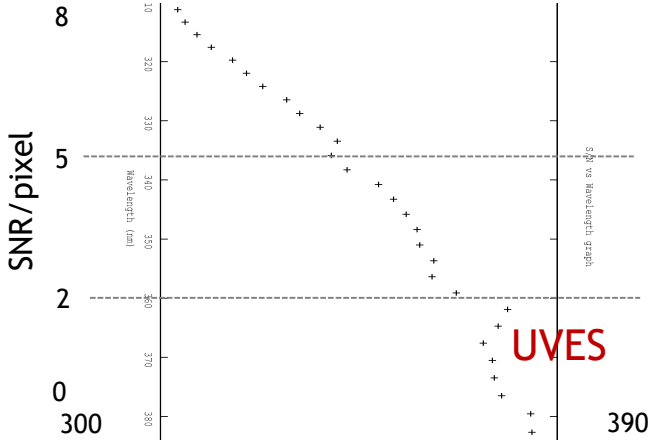
Chasing baryons at cosmic noon

CUBES will enable the study and characterization of baryons in the inter-CGM at z~1.5-3.0 with different tracers (mainly HI and OVI).



D'Odorico (ExA Special Issue)





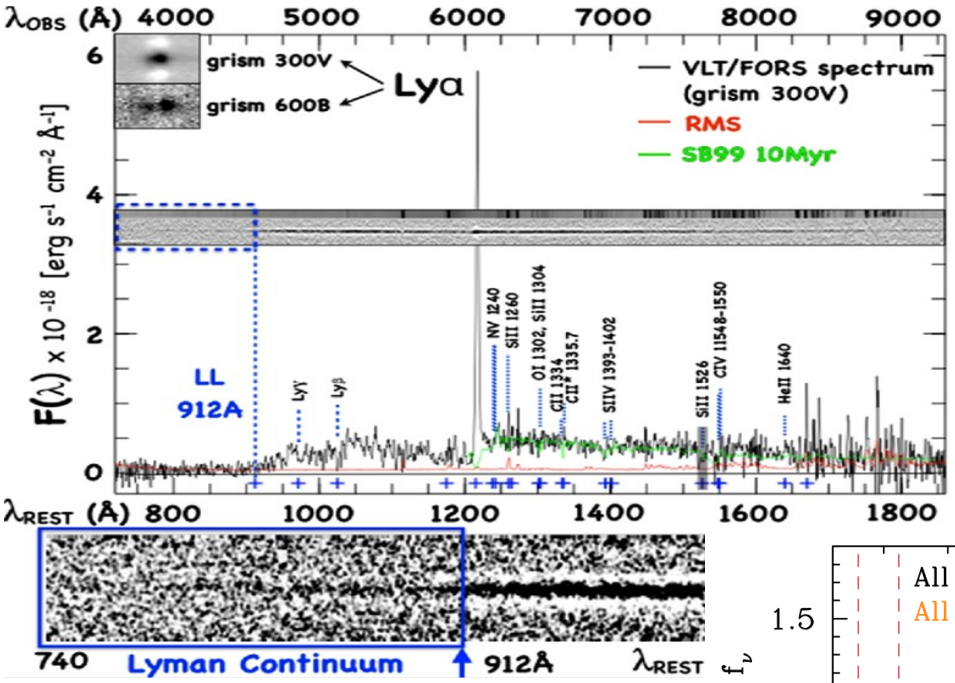
QSO at z=2.5 observed for 2x600s

- Critical complementarity with ELT HIRES & MOSAIC
- Significant improvement of SNR/pix compared to UVES

Escape fraction from high-z galaxies

To quantify f_{esc} from galaxies (cf. QSOs) in context of cosmic UV background

LR-mode ensure we are background limited for faint high-z sources

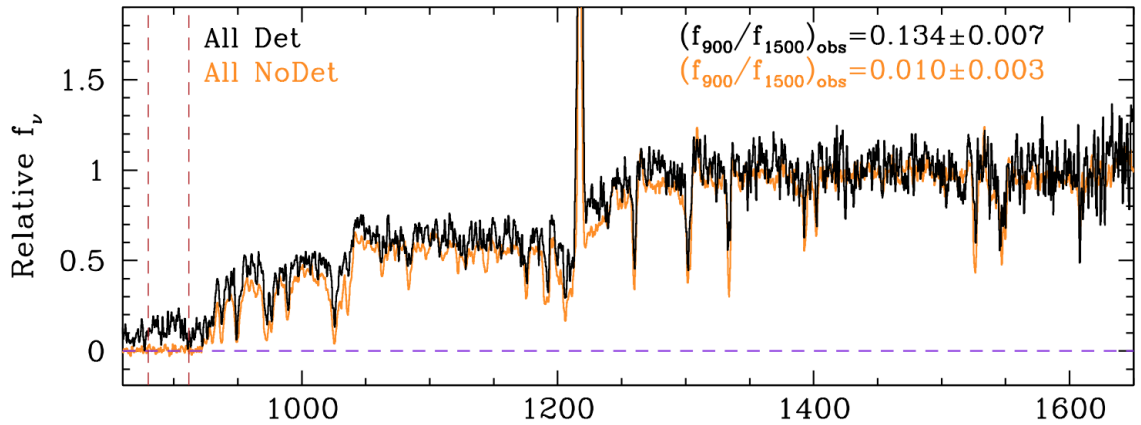


z = 3.999 (Vanzella et al. 2018)

Need greater near-UV sensitivity to probe f_{esc} at peak SF epochs

Detailed simulations presented by Vanzella et al. (ExA Special Issue)

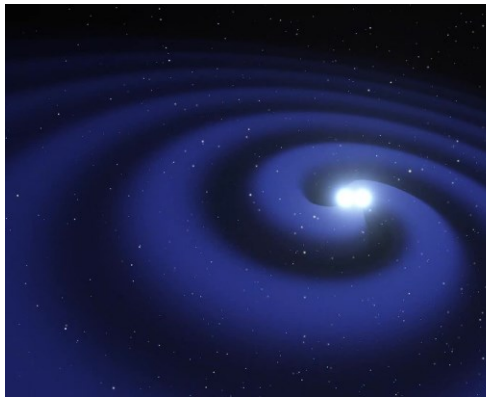
KLCS sample @ z~3 (Steidel et al. 2018)

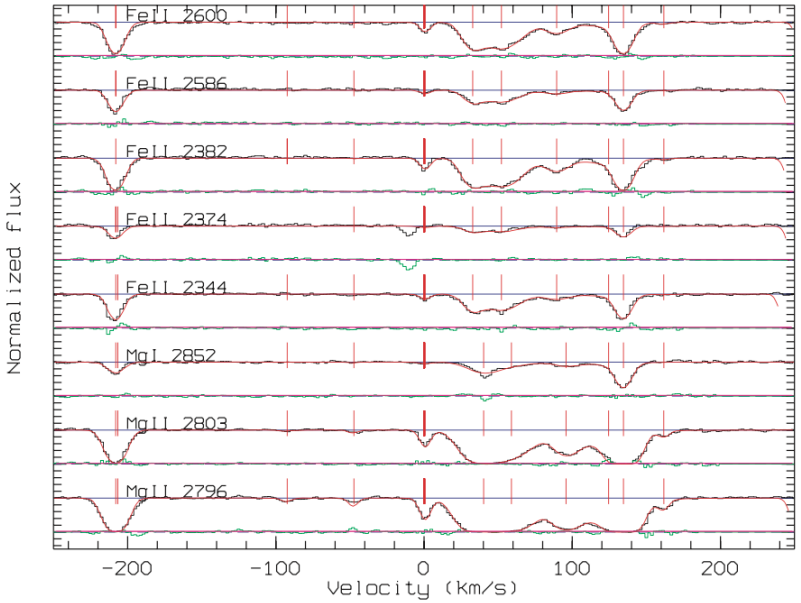


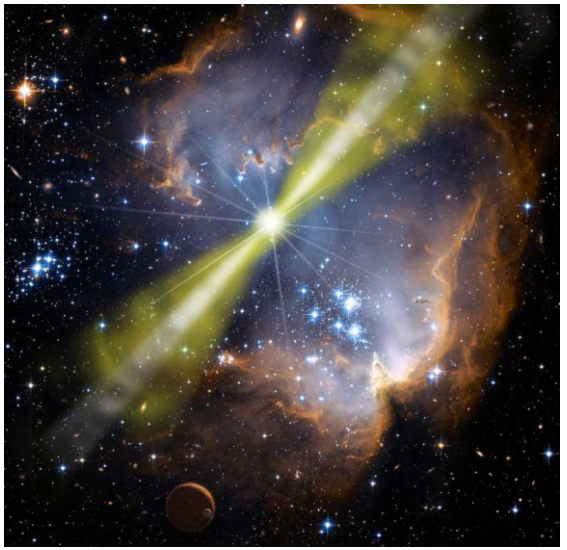
Transients

Transients (incl. kilonovae) a key motivation for fibre-link to UVES

Potentially excellent synergies with e.g. VRO/LSST







Absorption components in ISM to z=0.94 GRB (D'Elia et al. 2010)

Simultaneous CUBES+UVES observations critical for, e.g.:

- How GRB environment is influenced by the explosion
- Key diagnostic: FeII at λ_{rest}~ 240 nm, so redshift range currently limited
- Helps separate interstellar features

Plans for Phase B

- Any new compelling case that needs to be added to the science case?

- Track the compliance of instrument expected performance for a selected subset of science cases

  - 5-6 key cases (presented earlier) with strong requirements
  - Ensure that essential requirements are met in case of trade-off or design changes
  - Any other critical case that needs to be tracked?

Plans for Phase B

- Science workshop:

  Discuss GTO, sketch out strategy, identify broad themes, and tools needed

  - Ideally in person
  - When? June/early July?
  - Where? Suggestions are open

Plans for Phase B

- Finalize Operation and Calibration Plan

Impact of O_3 absorption on observations:

- Significant extinction at 300 nm
- Impact of seasonal variations? What data are available for Paranal?
- Can it be corrected using regular observations of flux standards?

Plans for Phase B

- Finalize Operation and Calibration Plan

  - A&G filters: single free/u-band filter or filter wheel with LSST filters? Consequences in terms of operation and calibration (flatfield)?

  - Others (2x2 binning for LR)

- Produce a draft structure of the commissioning plan

Plans for Phase B

Is there anything else needed from the science team?

Durham University

ZENTRUM FÜR ASTRONOMIE

Universidade de São Paulo
Instituto de Astronomia, Geofísica e Ciências Atmosféricas

CAMK PAN

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