



4MOST – 4m Multi-Object Spectroscopic Telescope

The 4MOST Project at the start
of science operations

Roelof de Jong, PI (AIP)

9 Sept 2026

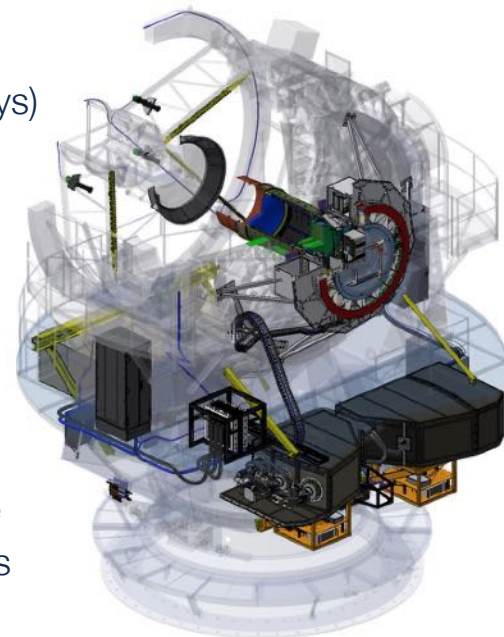
www.4MOST.eu



4MOST: Wide-field, high-multiplex optical spectroscopic survey facility for ESO

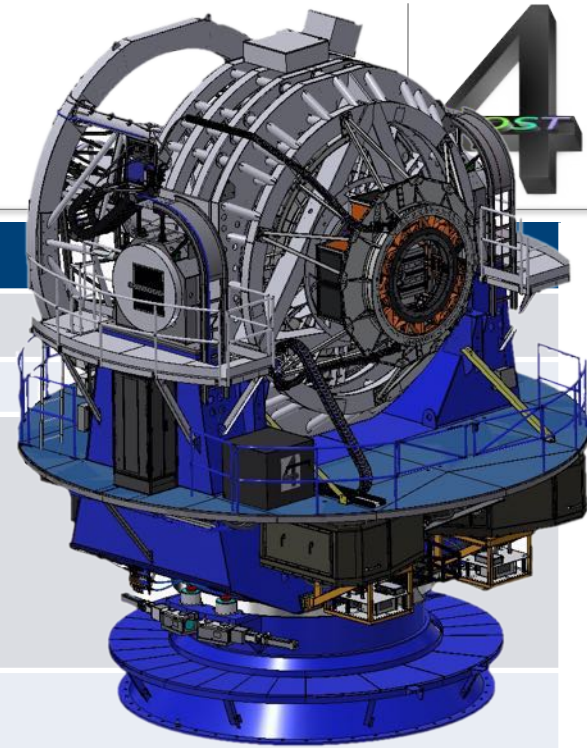


- Status:
 - 4MOST has had First Light and is currently in its final Verification Phase
 - Operations start on **VISTA** telescope Oct 2026 (first of several 5-year Surveys)
 - Q2 2027: First public Data Release (DR0)
- Science:
 - Cosmology, galaxy evolution, high-energy, transients and Galactic science
 - Complement large-area space missions: Gaia, eROSITA, Euclid, PLATO
 - Complement ground-based surveys: SKA, Rubin, VST, VISTA, DES, etc.
- Survey facility:
 - Consortium delivers instrument, science operations, data products, science
 - Run all-sky, 5-year long, public surveys in parallel, with ~yearly data releases
 - Key surveys organized by consortium in coordination with community
 - Add-on surveys from community and Chile through ESO peer-reviewed applications



Instrument Characteristics

Specification	Design value
Field-of-View (hexagon)	$\sim 4.2 \text{ degree}^2 (\varnothing > 2.6^\circ)$
Multiplex fiber positioner	2436
Medium Resolution Spectrographs (2x)	R $\sim 4000\text{--}7500$
# Fibres	812 fibres (2x)
Passband	370–950 nm
Velocity accuracy	$< 1 \text{ km/s}$
Spectral sampling (pixels/FWHM)	$> 2.8 \text{ pixels}$
High Resolution Spectrograph (1x)	R $\sim 20,000$
# Fibres	812 fibres
Passband	392.6–435.5 nm, 516–573 nm, 610–679 nm
Velocity accuracy	$< 1 \text{ km/s}$
Spectral sampling (pixels/FWHM)	$> 2.56 \text{ pixels}$
# of fibers in $\varnothing=2'$ circle	> 3
Fibre diameter	$\varnothing=1.42 \text{ arcsec}$

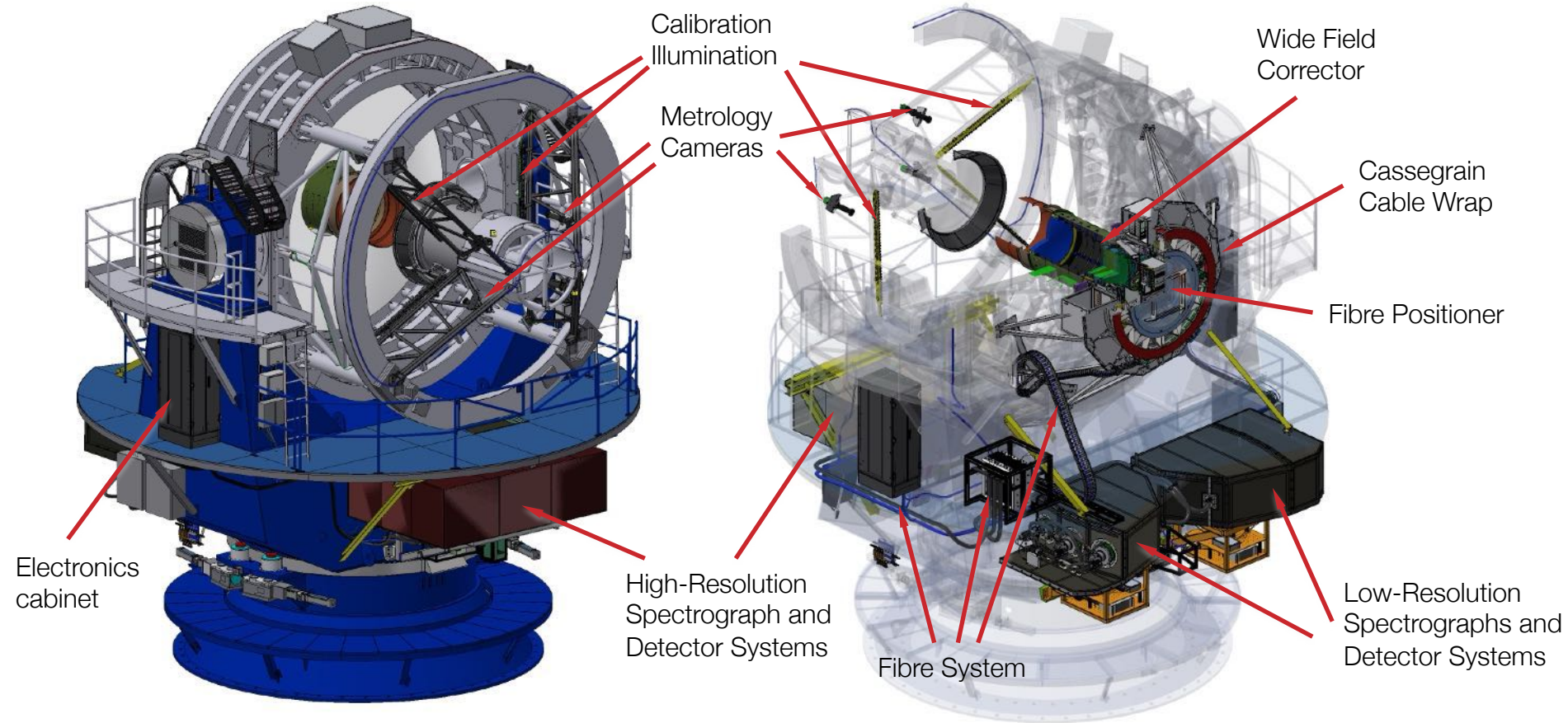


VISTA at Paranal Observatory, Chile

4
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4MOST on VISTA



Now all functioning on the telescope



Wide Field Corrector and Atmospheric Dispersion Compensator (WFC/ADC)



4 Lens Groups with 2
counter-rotating prisms

Field $\varnothing = 2.6$ degree

535 mm Focal Diameter

Largest lens ~950mm

ADC functions to $ZD=55^\circ$

L1 – Fused Silica

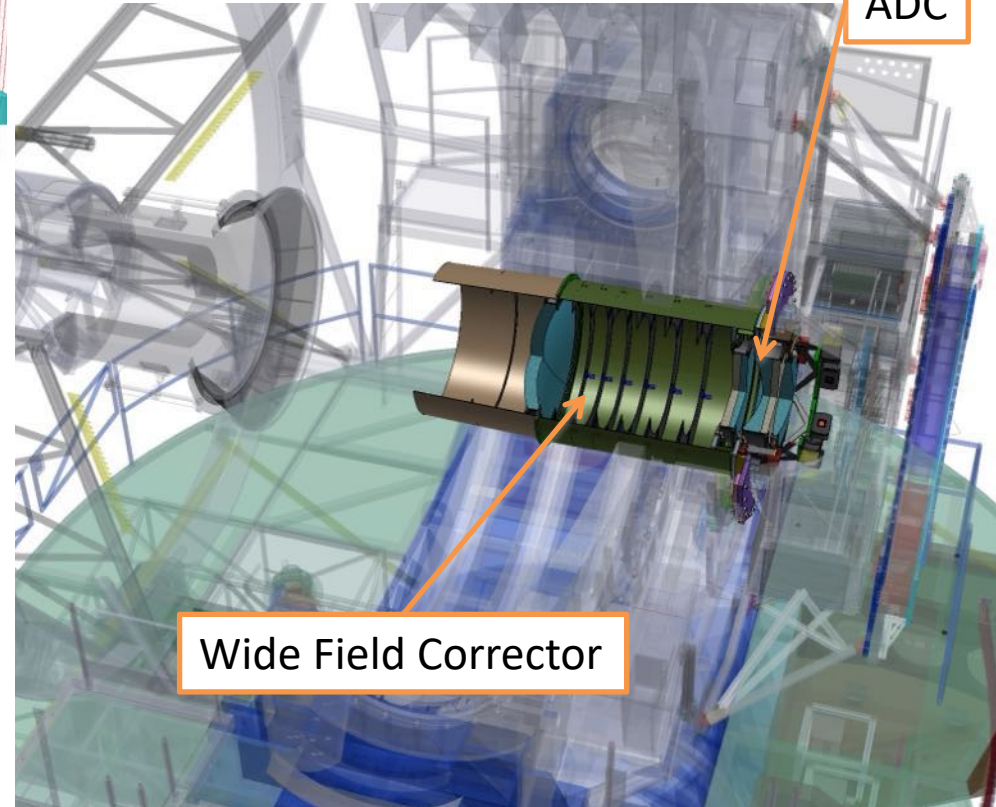
L2 – L2A – LLF1; L2B – NBK7

L3 – L3A – NBK7; L3B – LLF1

L4 – NBK7

Design and construction AIP

Assembly and alignment UCL



Wide Field Corrector and Atmospheric Dispersion Compensator (WFC/ADC)



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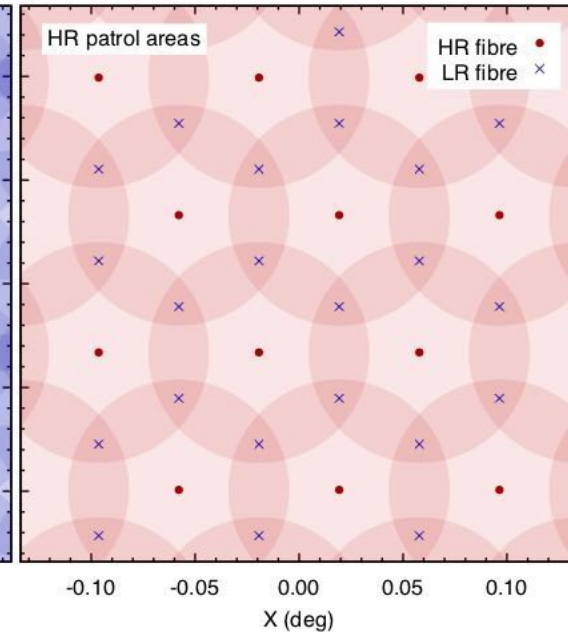
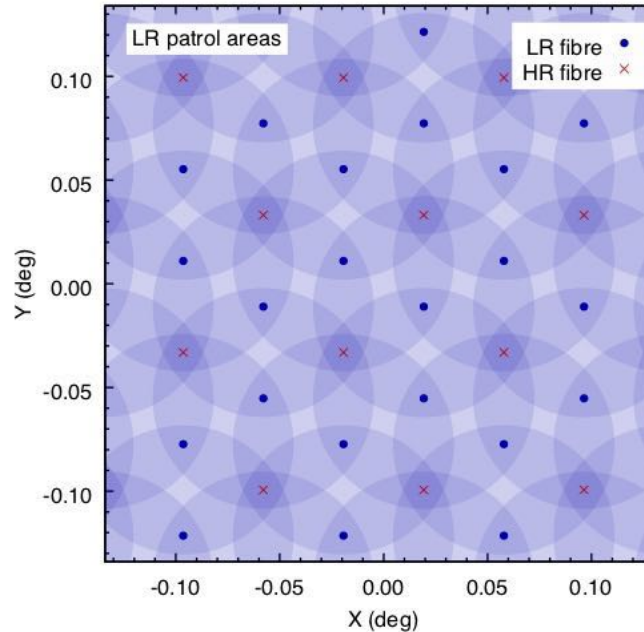
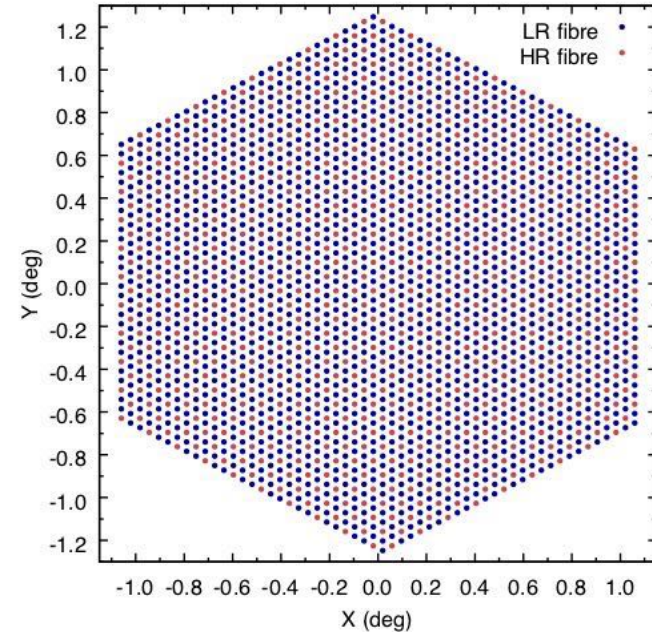
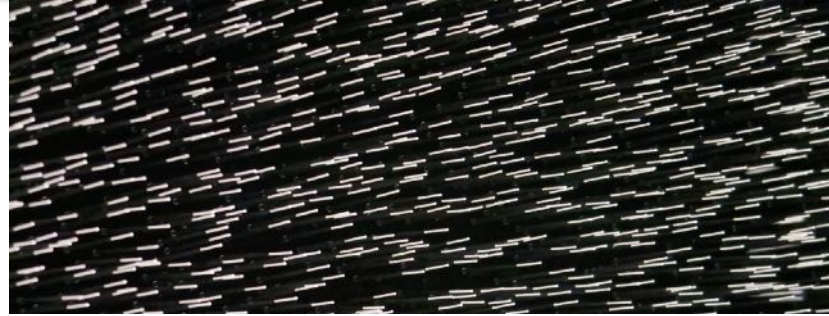


AESOP Fibre Positioner and Metrology System

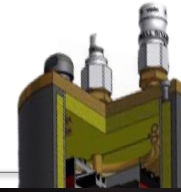


2436 Fiber Probes

- patrol diameter $2.4 \times$ pitch
= ~ 6 arcmin
- RMS accuracy $< 10\mu\text{m} / 0.17''$
- minimum separation $\sim 20''$
- reconfiguration time < 2 min



Metrology System



4
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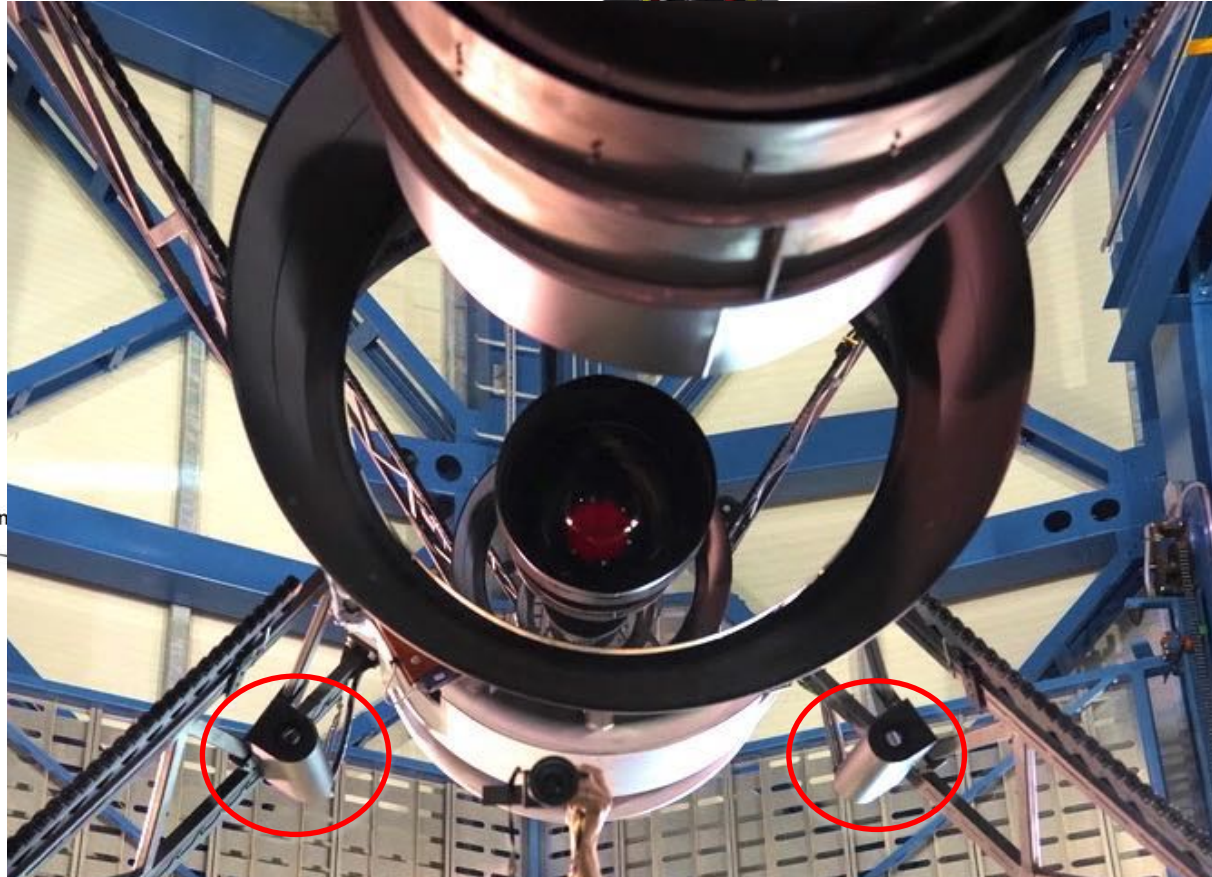
Four cameras viewing
AESOP Fibre Probes

Back Illumination System

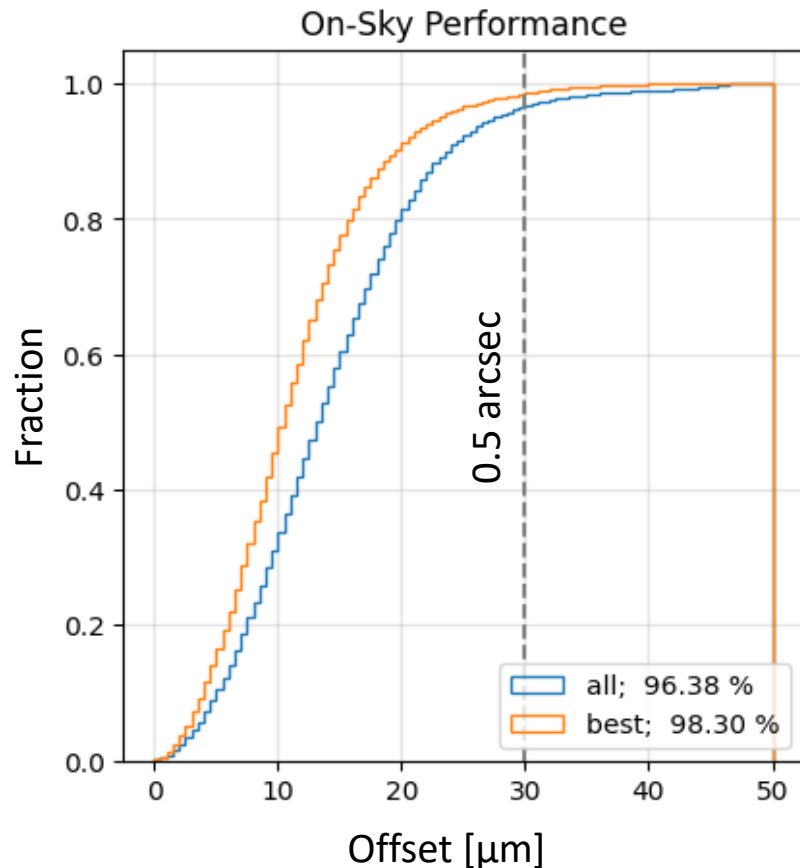
- Science Fibres
- Fiducial Fibres
- Guide Fibres

Need to measure fibre
positions to $\sim 5 \mu\text{m}$
precision out of $\sim 535 \text{ mm}$
(1 part in 100000)

M1 Prin



Positioning/metrology accuracy



- About 4% of fibres do not reach target
 - Problem now understood and easy correctable
 - Expectation is that >98% of fibres will position to <0.3"
- Positioning now limited by dome turbulence
 - Optimisations ongoing
- Clustered targets (2–5) in 3 arcmin
- Minimum separation ~20 arcsec
- Overheads (including slew) ~2m30s

4MOST Fibre Feed



2436 Science Fibres
85 micron core

24 Fiducial Fibres

12 Guide Fibre bundles

36 Simultaneous
Calibration Fibres

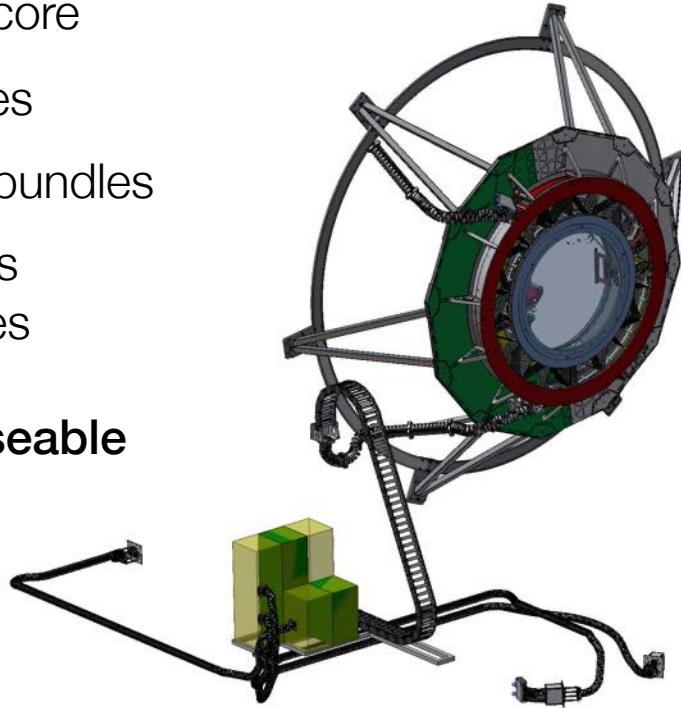
>98% fibres useable

Fibre lengths:

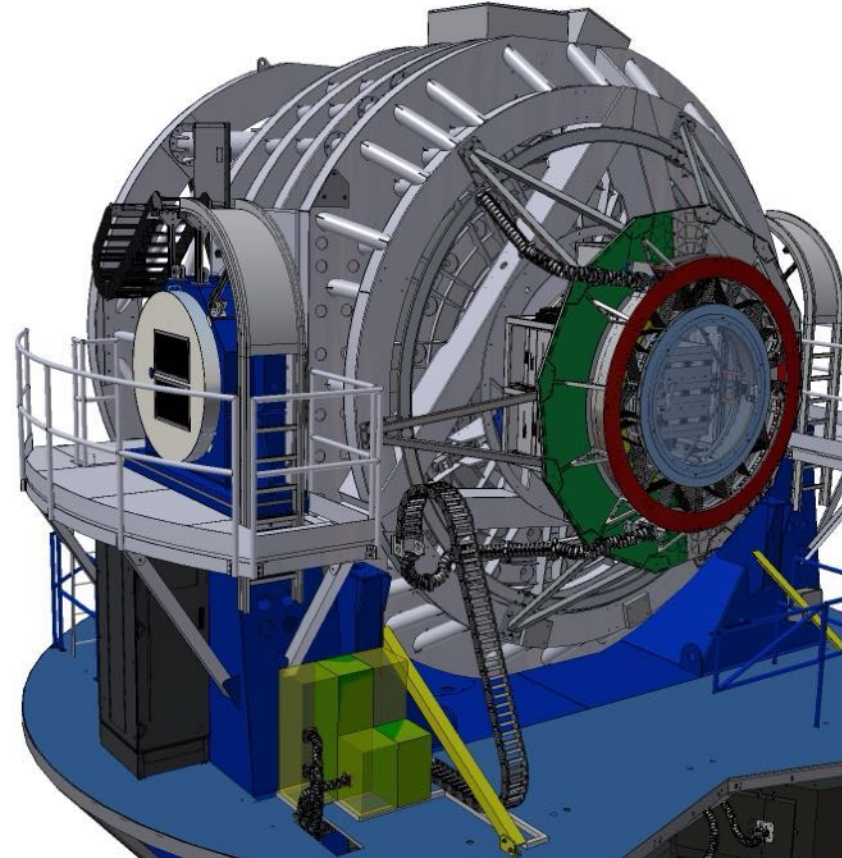
HRS: 25m

LRS-A: 22m

LRS-B: 23m



Design and build at AIP



4MOST Fibre Feed



2436 Science Fibres
85 micron core

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12 Guide Fibre bundles

36 Simultaneous
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HRS: 25m

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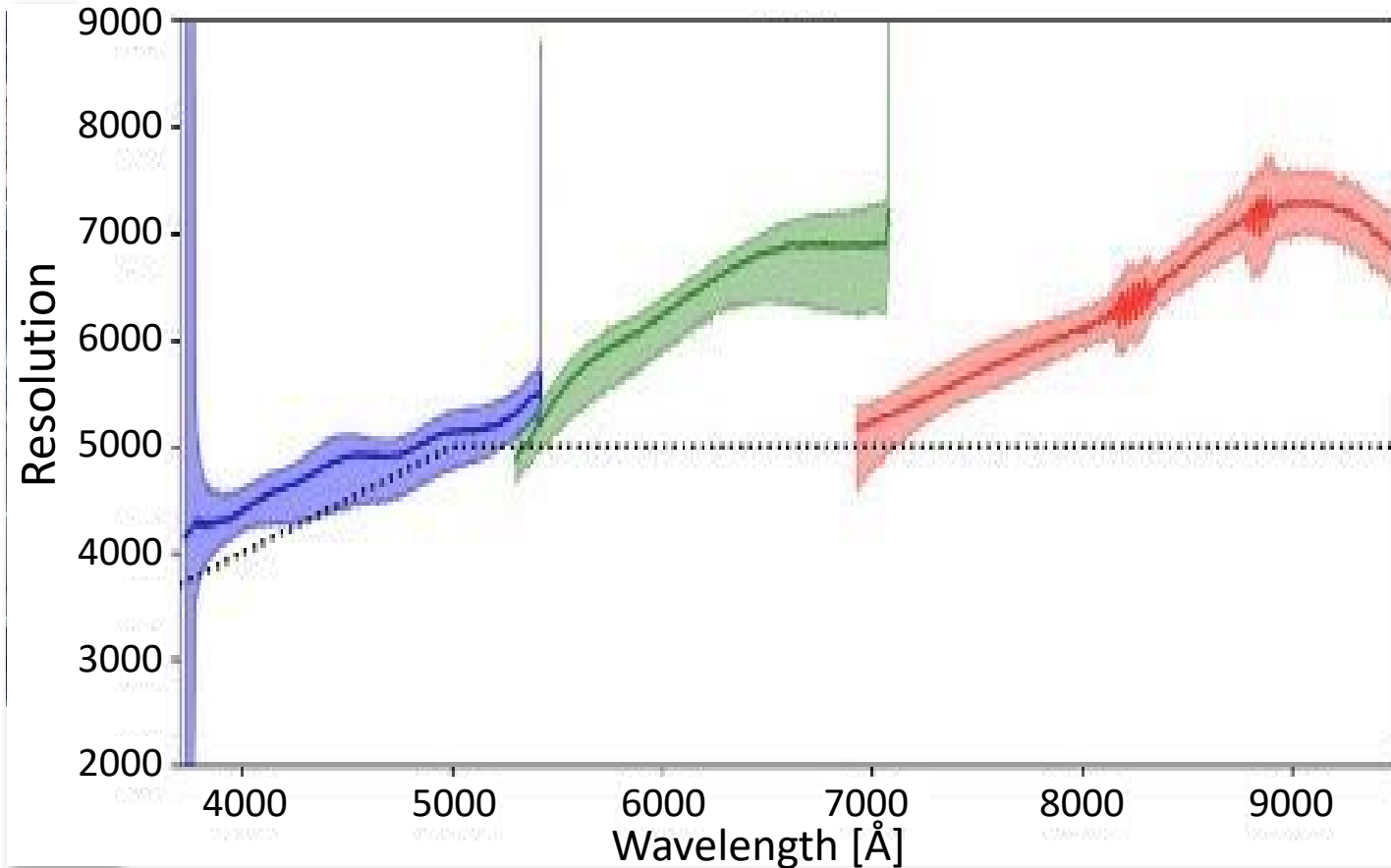


Design and build at AIP

Low Resolution Spectrograph (LRS)



3 arms
spectrograph
3 CCDs 6k x 6k
200 mm beam size
812 science fibres
per spectrograph
2 mirrored
spectrographs
Thermally stabilized
Design and build at
CRAL in Lyon

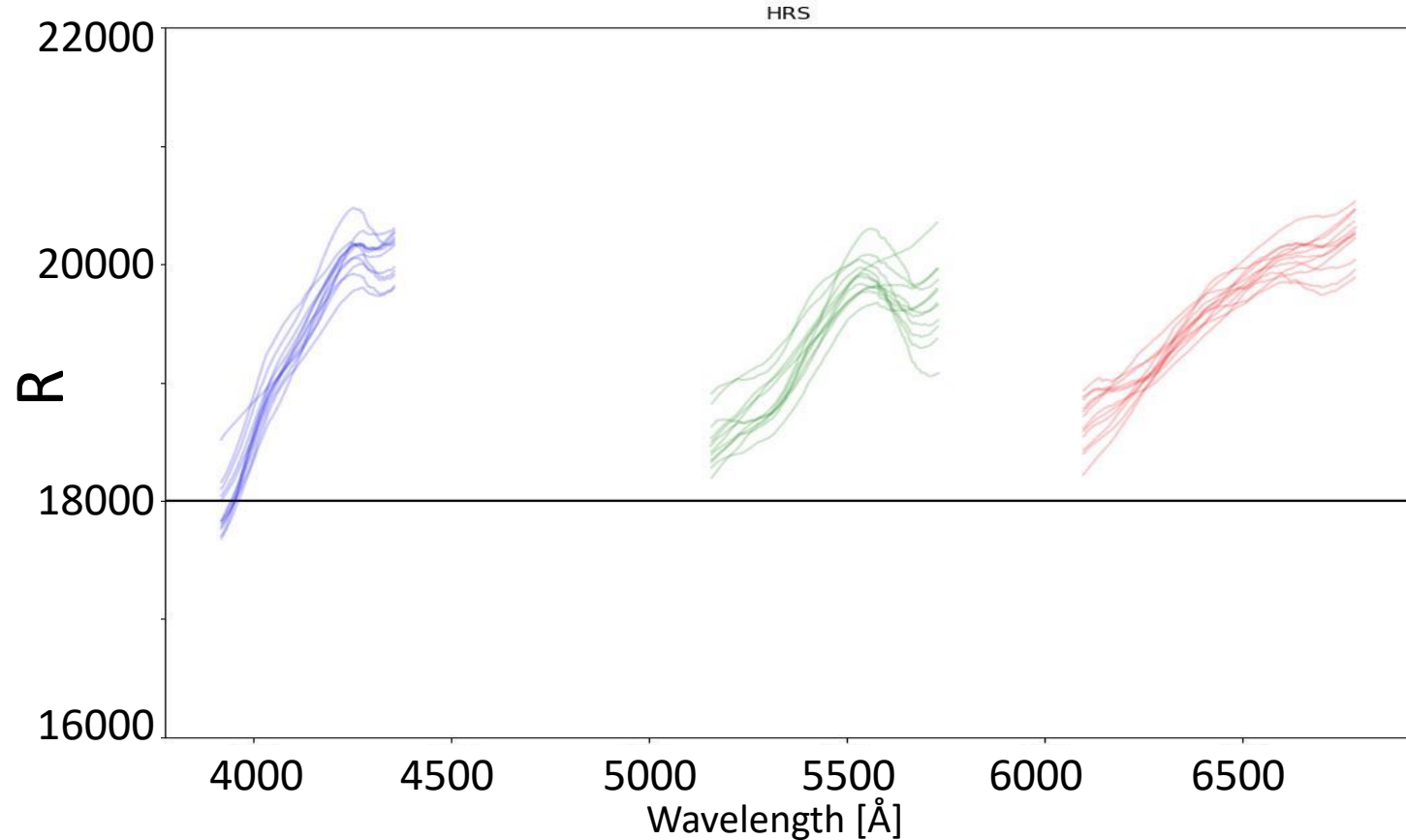


High Resolution Spectrograph (HRS)



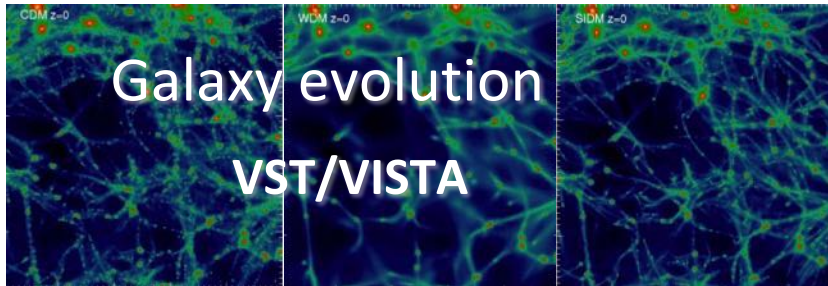
3 arms
spectrograph
3 CCDs 6k x 6k
250 mm beam size
812 science fibres
1 spectrograph

Design and build at
ZAH/LSW in
Heidelberg



Science Themes

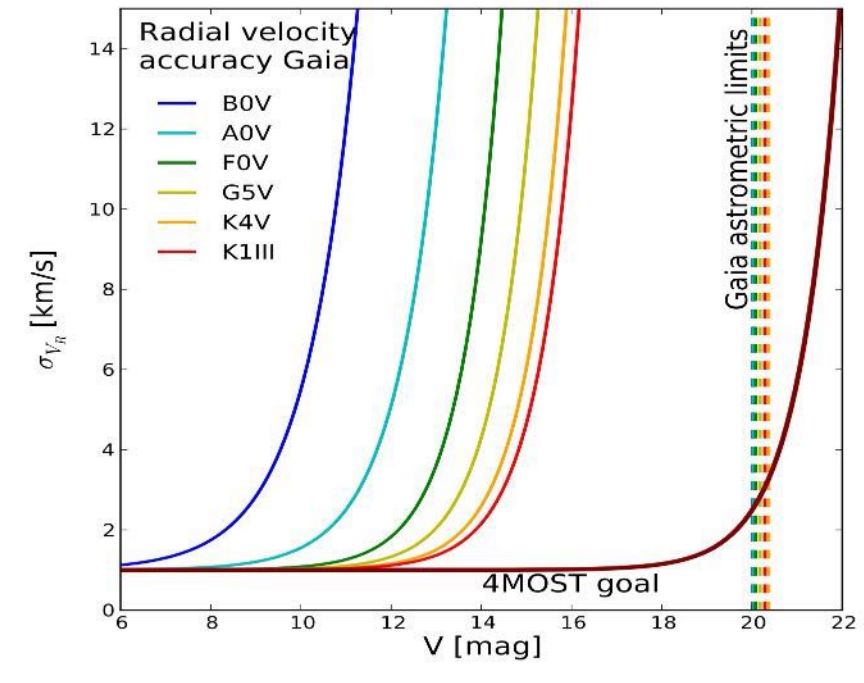
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Galactic Archeology: Gaia

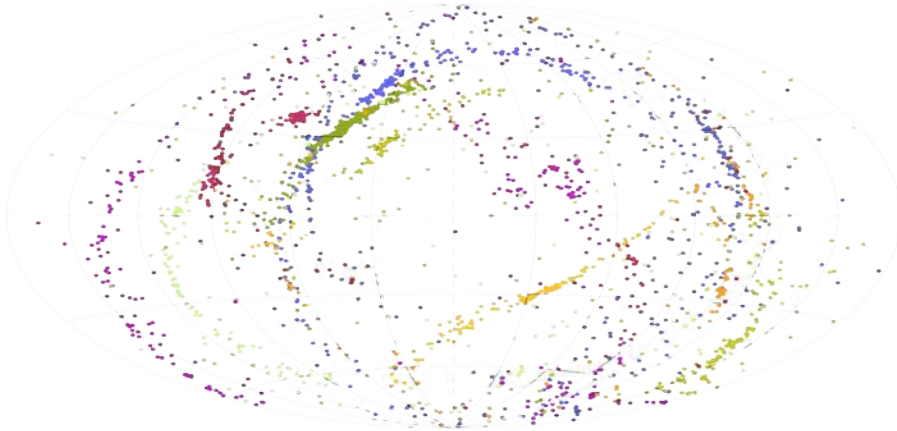
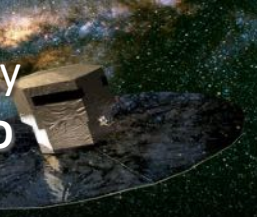


- The chemical composition and kinematics of stars are strongly coupled to birth environment
- Gaia measures distances and proper motions for ~ 1.5 billion stars
- 4MOST will complement Gaia with radial velocities and chemical composition for faint stars
- *Unique capability in the South (Milky Way bulge and MCs)*

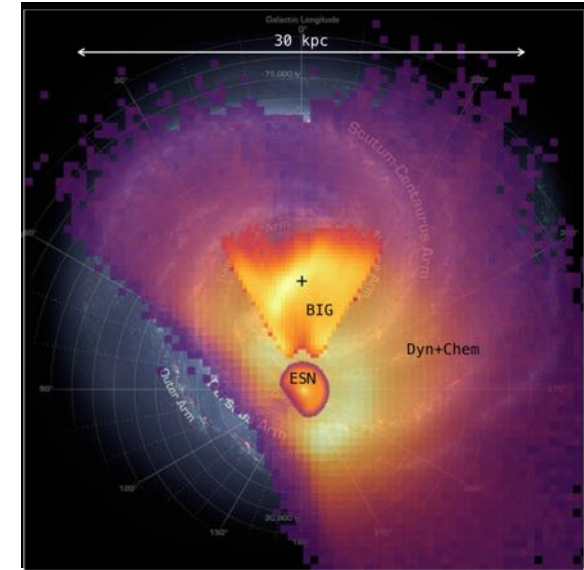


Galactic Archeology

Galactic Archeology
Gaia and PLATO



- Map the Dark Matter substructure distribution of the Milky Way and Magellanic Clouds
- Chemo-dynamical substructure of the MW & MCs halos: Accreted versus in situ formation
- Importance of population migration
- Formation and dynamical evolution of the Milky Way disk and bulge components
- Constraints on the very first populations of stars (Pop III, IMF, rotation)
- Properties of exoplanet host stars



Many dedicated stellar surveys

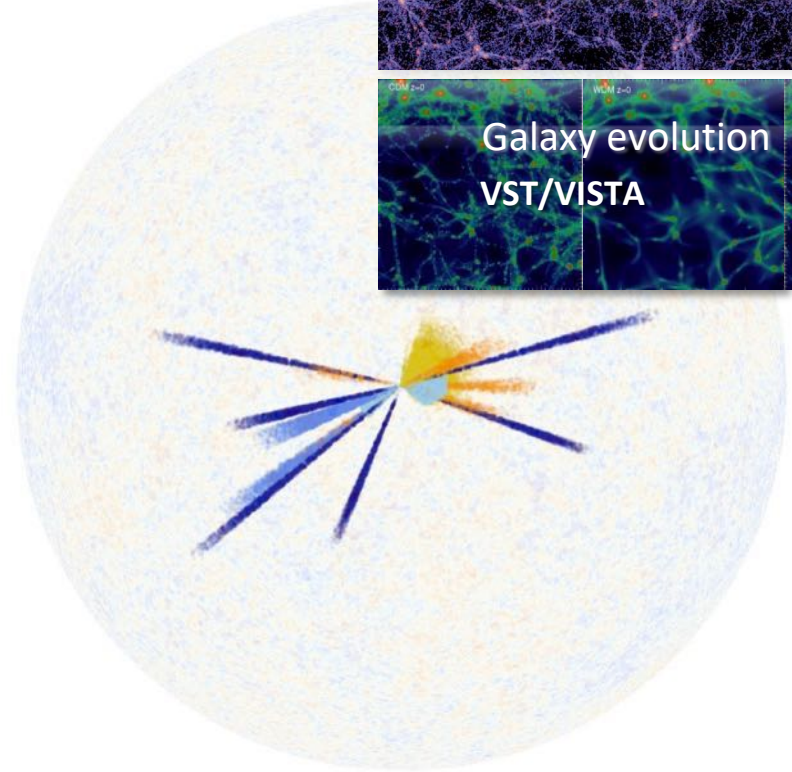
Galactic Archeology
Gaia and PLATO



- Magellanic Clouds, Dwarf Galaxies and their streams
- Very metal-poor stars (VMP)
 - All sky follow up of, e.g., SkyMapper, Pristine survey, APOGEE
 - Very metal-poor Pristine Inner Galactic survey (VMP PIGS)
- White Dwarfs (WD) and White Dwarf Binaries (WDB)
 - determine accurate masses and ages
- Compact X-ray Binaries (CWDB)
 - follow up of eROSITA point-sources
- Cepheids, RR Lyrae, and other variable populations
 - follow up of Gaia, OGLE, and VVX targets
- Asteroseismic giants in both LR and HR for bright targets (SeismoLR, SeismoHR)
 - complement CoRoT, K2, TESS and PLATO missions. Key targets for survey calibration
- Hot subdwarfs (HSD)
- Open and Globular Clusters (including diffusion & streams)
- Bulge Deep (BD)
- 100 pc survey (A100pc)
- Planetary Nebulae (PN)
- Young Stars

Extragalactic Surveys

- Cosmological models
 - Multiple tracers and methods
 - Peculiar velocities
- Galaxy evolution
 - Clusters and field
- Black hole – galaxy co-evolution
- Intergalactic baryons
- Time domain
 - Supernovae
 - AGN reverberation mapping
 - Tidal disruption events



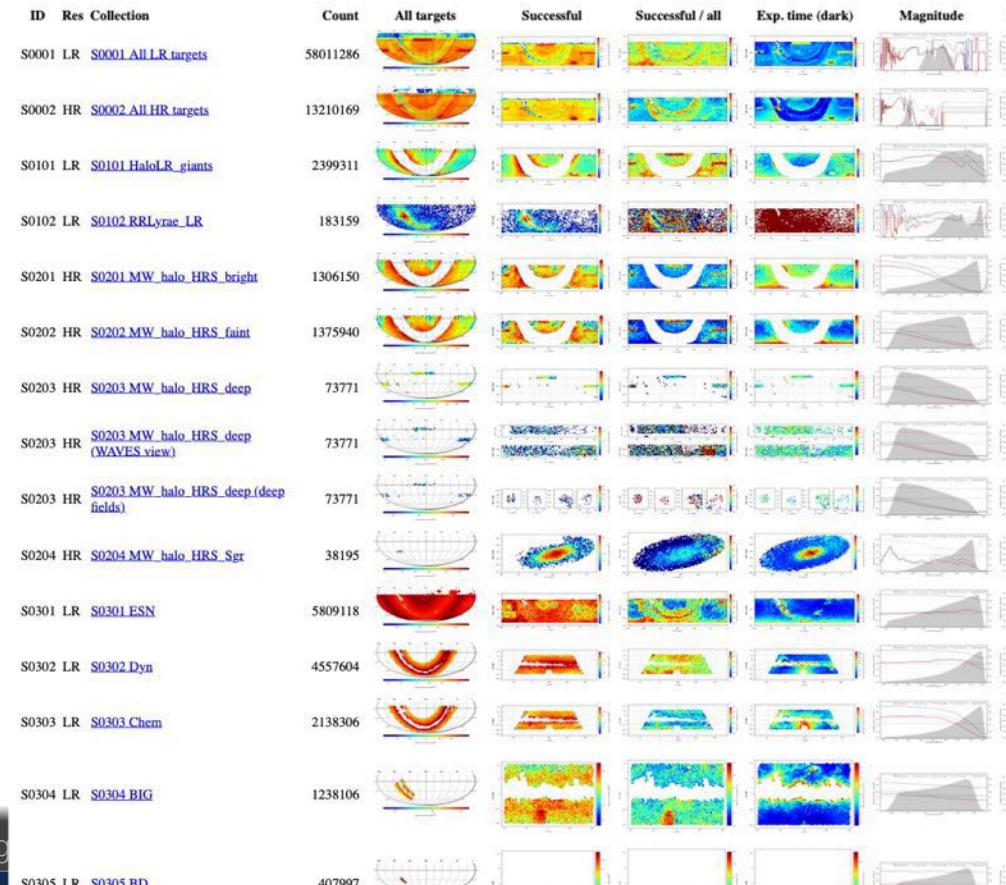
4MOST Science Programme



- 18 Surveys (30 PIs)
- 25 science programmes
- 140+ subsurveys main programmes
- +200 catalogues calibration, bad weather, supplementary (fillers)
- 100M+ potential targets in catalogues
- Very diverse requirements:
 - Large ($>10^7$) to small (<1000) number of targets
 - All sky to small areas
 - Sparse to densely sampled
 - High to low completeness
 - Bright to faint targets $\Rightarrow$ Bright/Grey/Dark time
 - Low and High Spectral Resolution
 - Time domain / transients
 - Cadence/repeats
 - Calibration

4MOST Simulation SELFIE ID = 129 (20230511) [iwg2_20230511_dog184HS2]

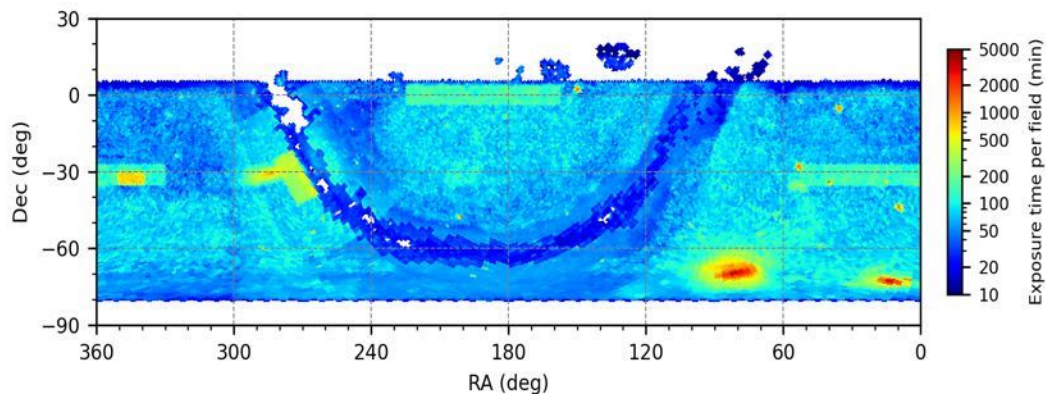
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4MOST Operations



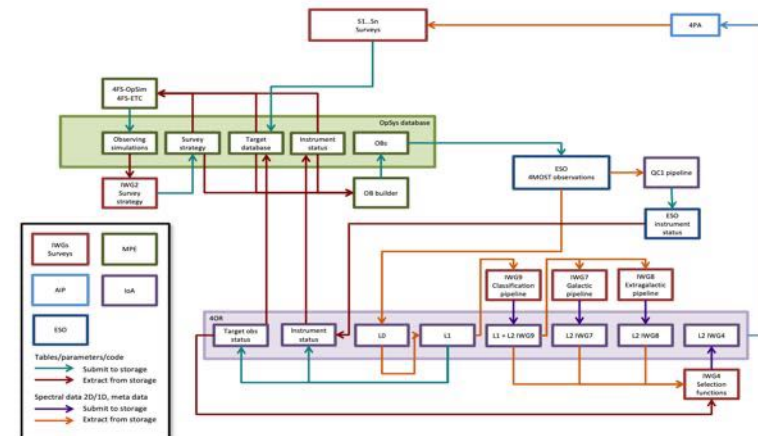
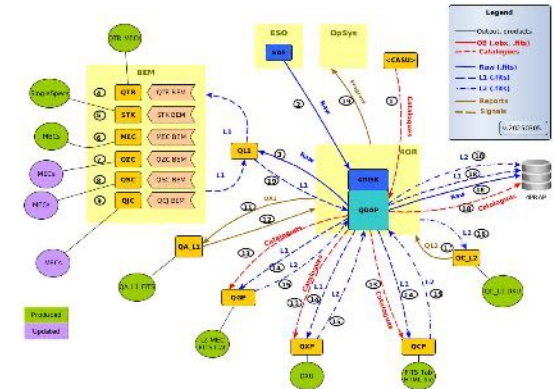
- Unique operations model for MOS instruments suitable *for most* science cases
- 4MOST program defined by *Public Surveys* of 5 years
- Surveys are defined by **Consortium** (70%) and **Community** (30%)
- All Surveys will run *in parallel*
 - Surveys share fibres per exposure for increased efficiency
- **Key Surveys** set observing strategy
 - Millions of targets all sky
 - Fill all fibres
- **Add-on Surveys** for smaller surveys
 - Small fraction fibres all sky or
 - dedicated areas
 - 10^3 to 10^6 targets
- Several passes of sky with exposures 2–30 mins
- Wedding-cake distribution for total time 1h to 20h



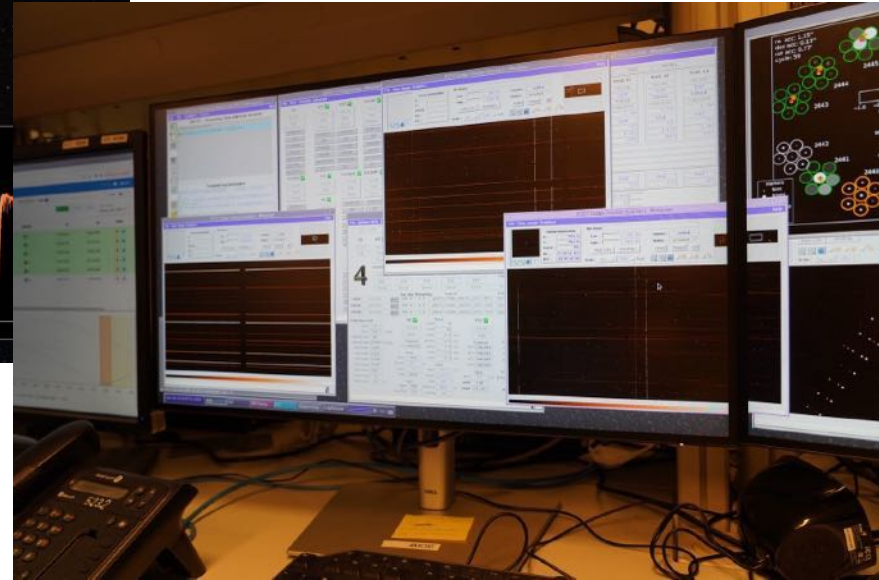
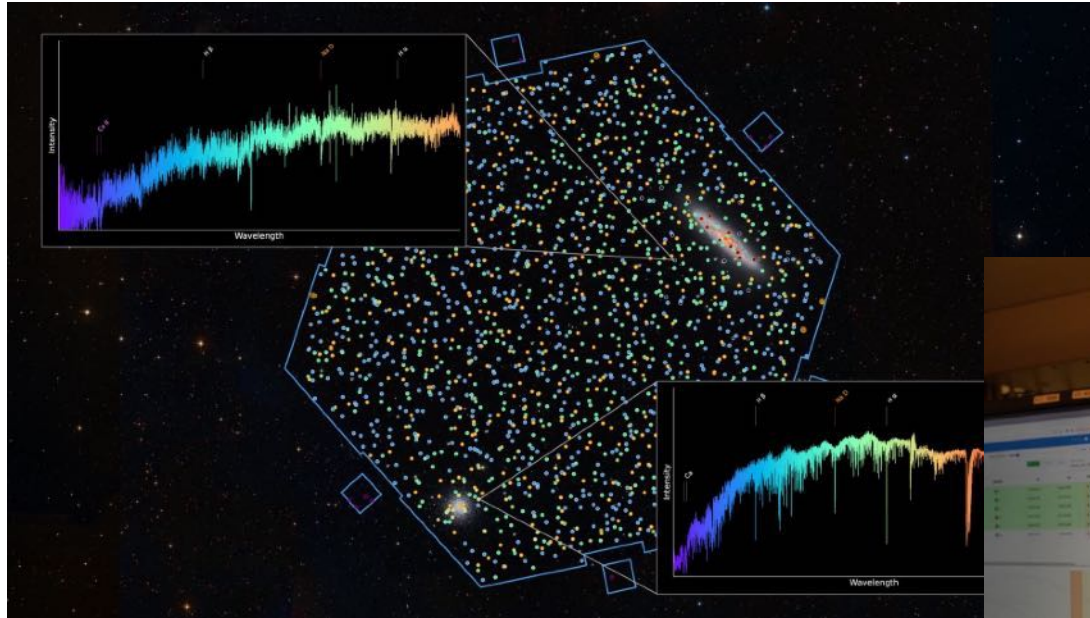
Operations and Data Flow



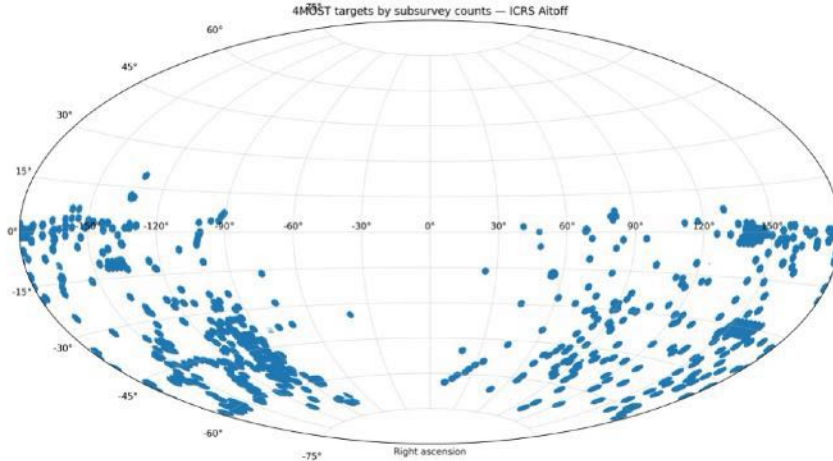
- Surveys define target catalogue and observing success
- Observations planning (4MOST OpSys group)
 - Create observing visit locations and schedule
 - Create Observation Blocks (OBs) with targets assigned to fibres
 - Control OBs on telescope through Designated Visitor Mode
 - (similar to robotic operations for clean selection function)
- Execute observations at VISTA (ESO)
 - Night and daytime operations
 - Maintenance
- Data reduction and analysis (4MOST DMS group)
 - L1 pipeline: instrument calibrations, 1D spectra extraction
 - L2 pipelines: classifications, Galactic, extragalactic, selection functions
 - Dedicated Working Group for data quality control
 - Archiving and Publishing
 - ESO and dedicated 4MOST Public Archive (4PA)



18 October 2025: First Light!



Ten weeks of Survey Program Validation



Single targets observed:

499,822

- Number of single spectra*:
11, 204, 931

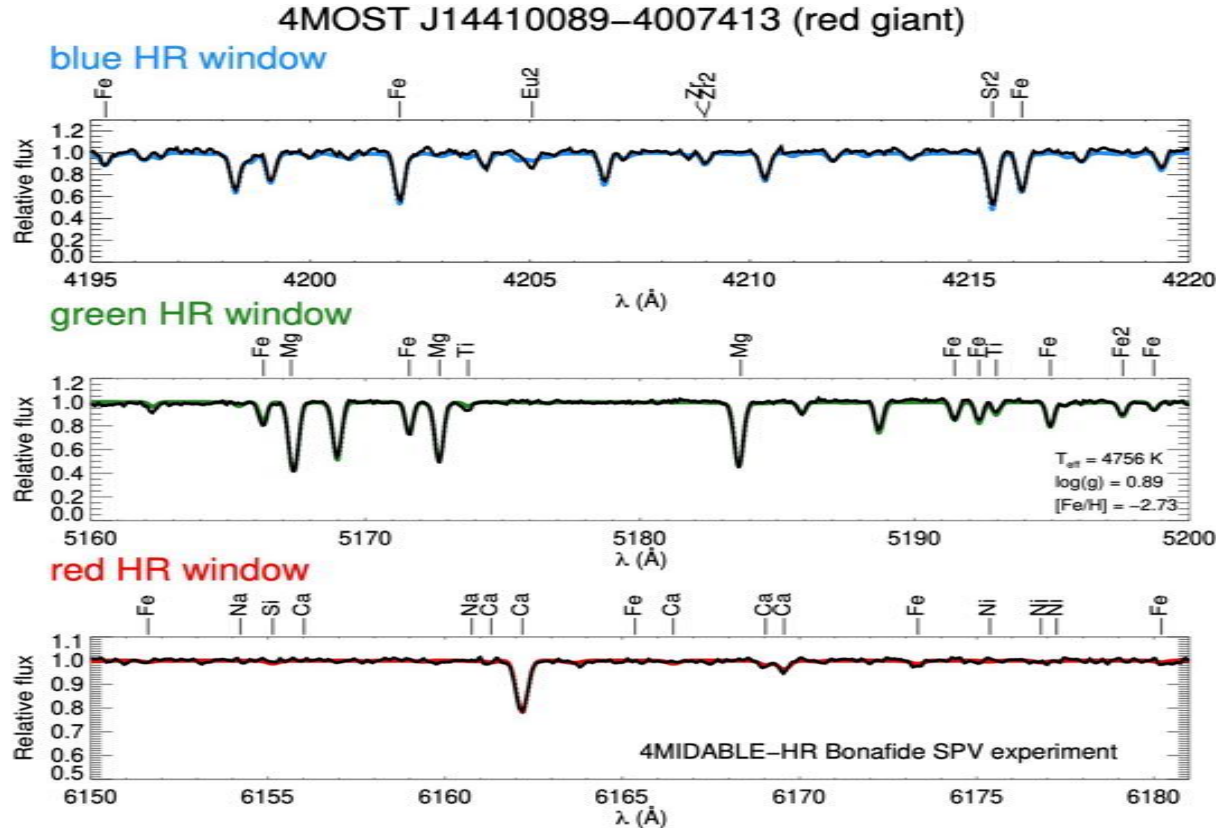
- Stacked*:
LR=1,163,780
HR=453,525

- S-Stacked* :
LR=1,476,164
HR=527,460

Marica Valentini
Amata Mercurio
Patricia Shady

*: 3 arms per resolution + joined LR

Initial result: HRS spectra



- $T_{\text{eff}} = 4756 \text{ K}$
- $\log(g) = 0.89$
- $[\text{Fe}/\text{H}] = -2.73$

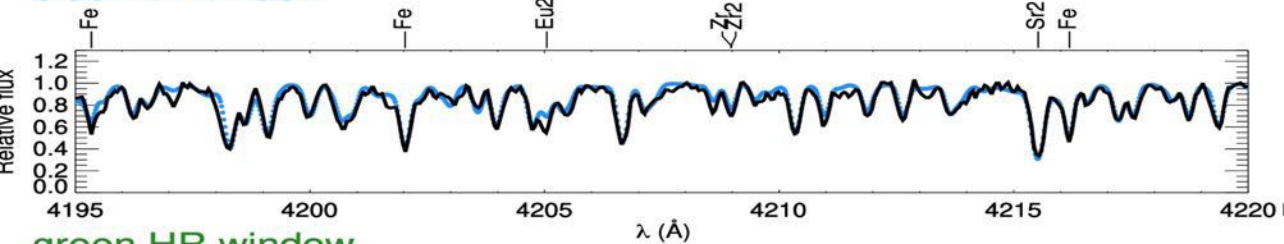
SAPP pipeline
Nicholas Storm
Maria Bergemann
IWG3 + IWG7

Initial result: HRS spectra

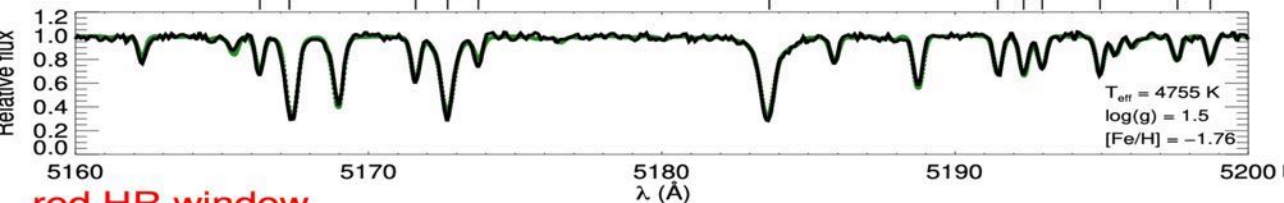


4MOST J07015000–5658507 (red giant)

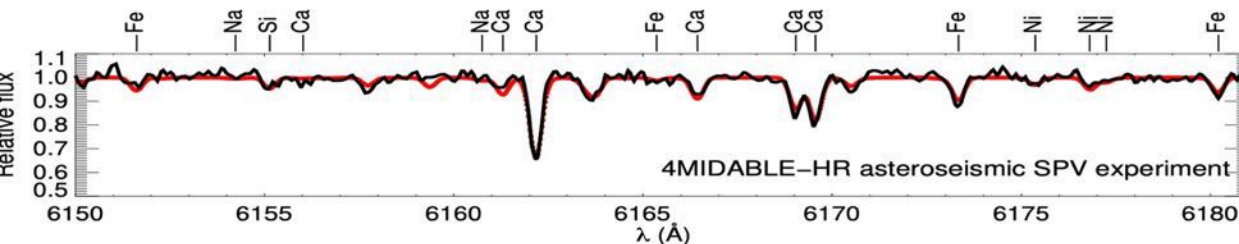
blue HR window



green HR window



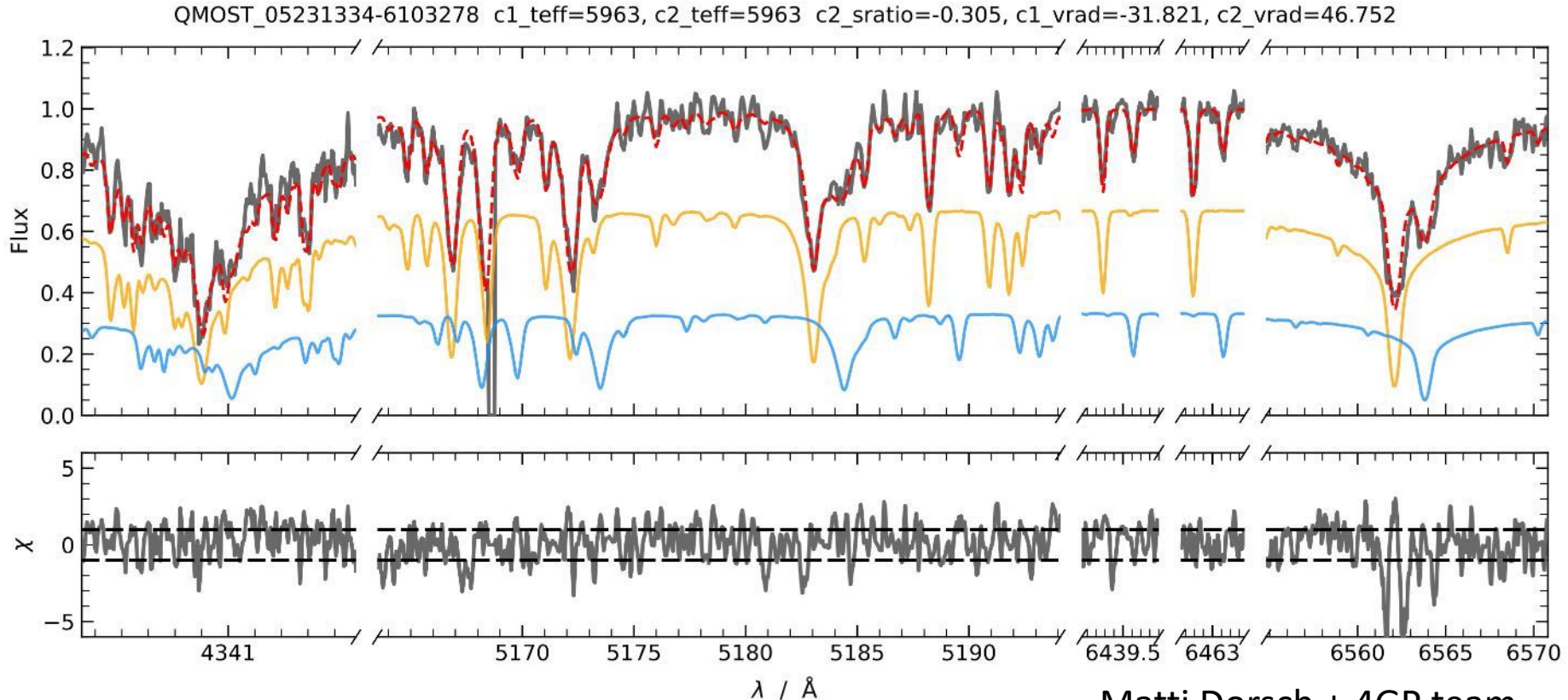
red HR window



- $T_{\text{eff}} = 4755 \text{ K}$
- $\log(g) = 1.5$
- $[\text{Fe}/\text{H}] = -1.76$

SAPP pipeline
Nicholas Storm
Maria Bergemann
IWG3 + IWG7

Initial result: Binary Stars

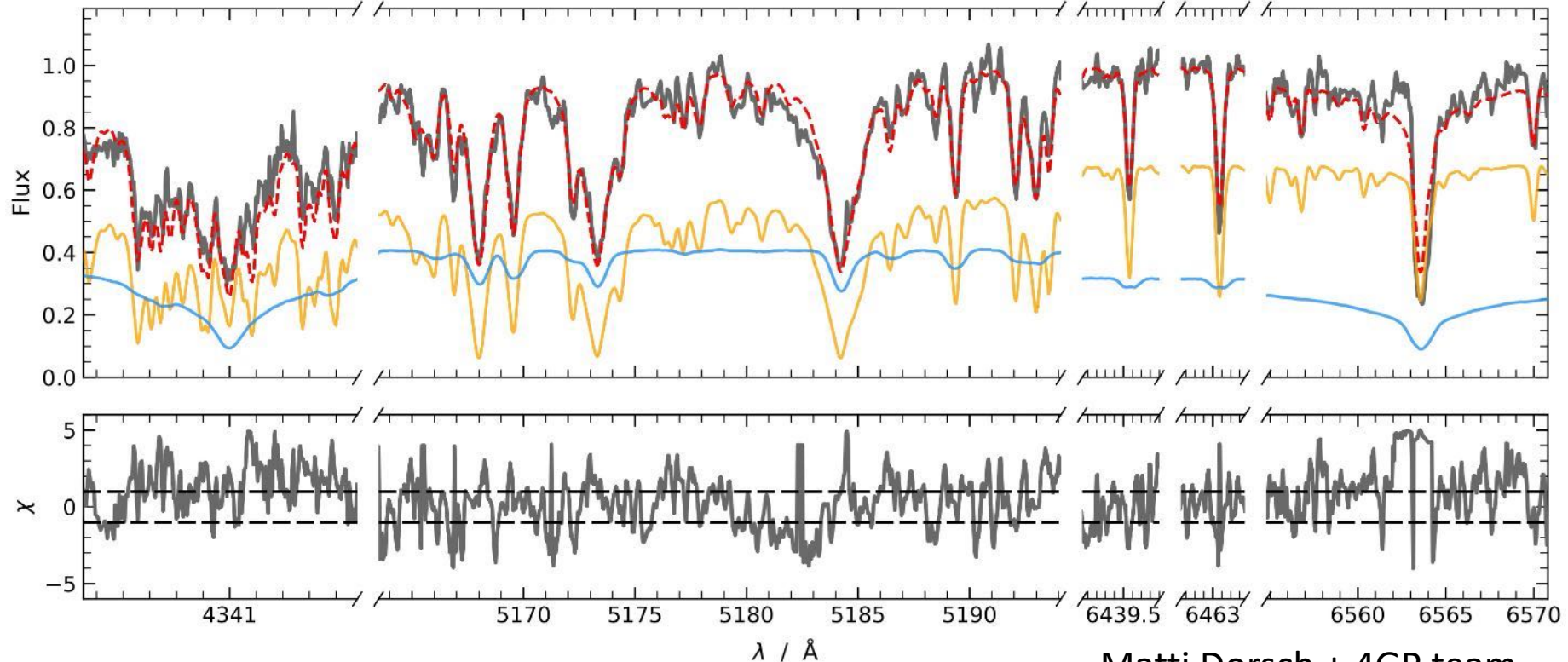


Matti Dorsch + 4GP team

Initial result: Binary Stars

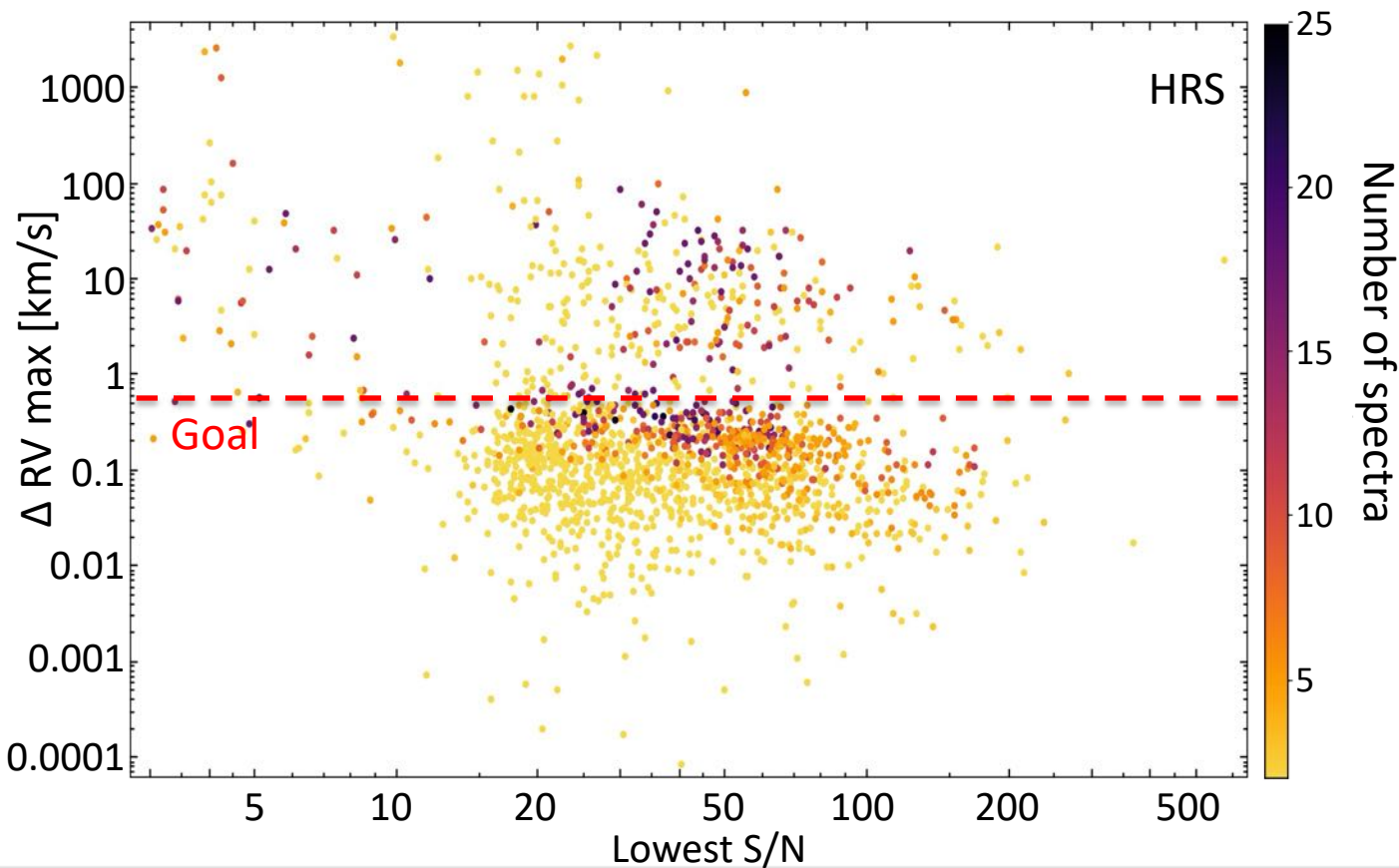


QMOST_12474010-5940444 c1_teff=4561, c2_teff=7230 c2_sratio=-1.101, c1_vrad=35.379, c2_vrad=36.784



Matti Dorsch + 4GP team

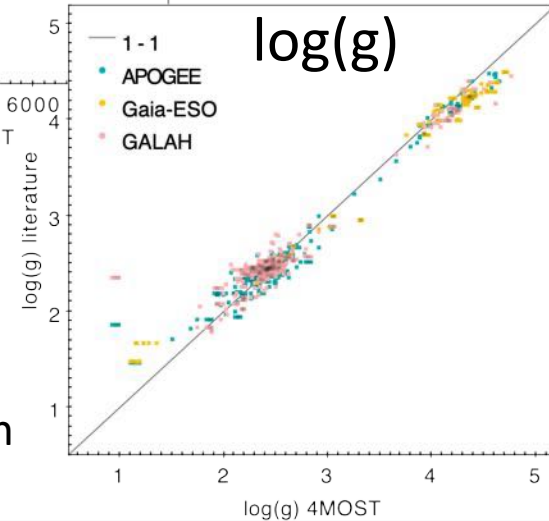
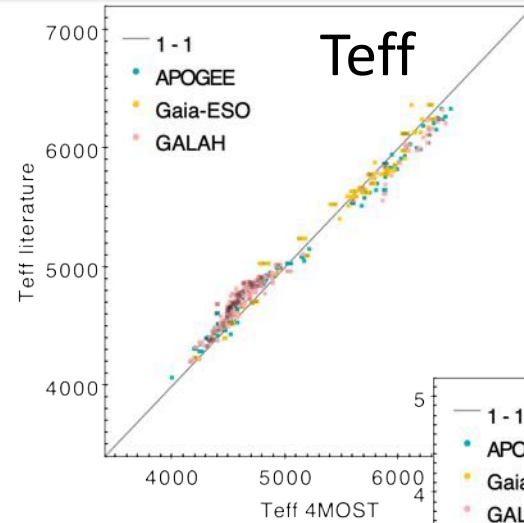
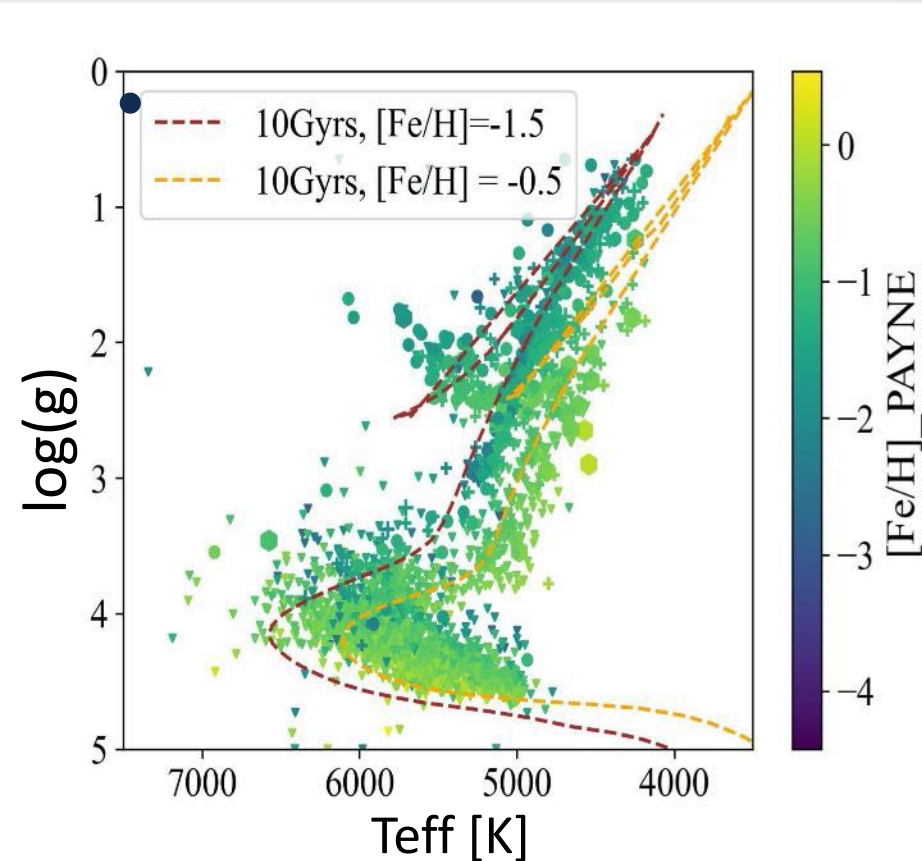
Initial result: Radial Velocity Repeats



- Repeats show that precision easily meets goal of <0.5 km/s at $S/N > 30/\text{\AA}$

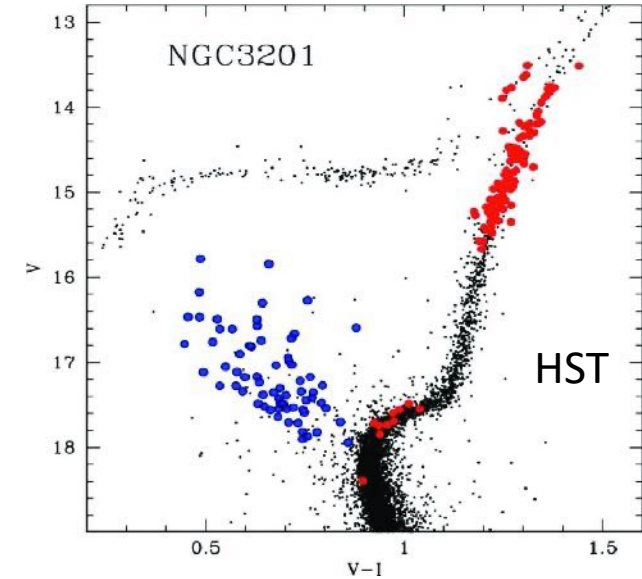
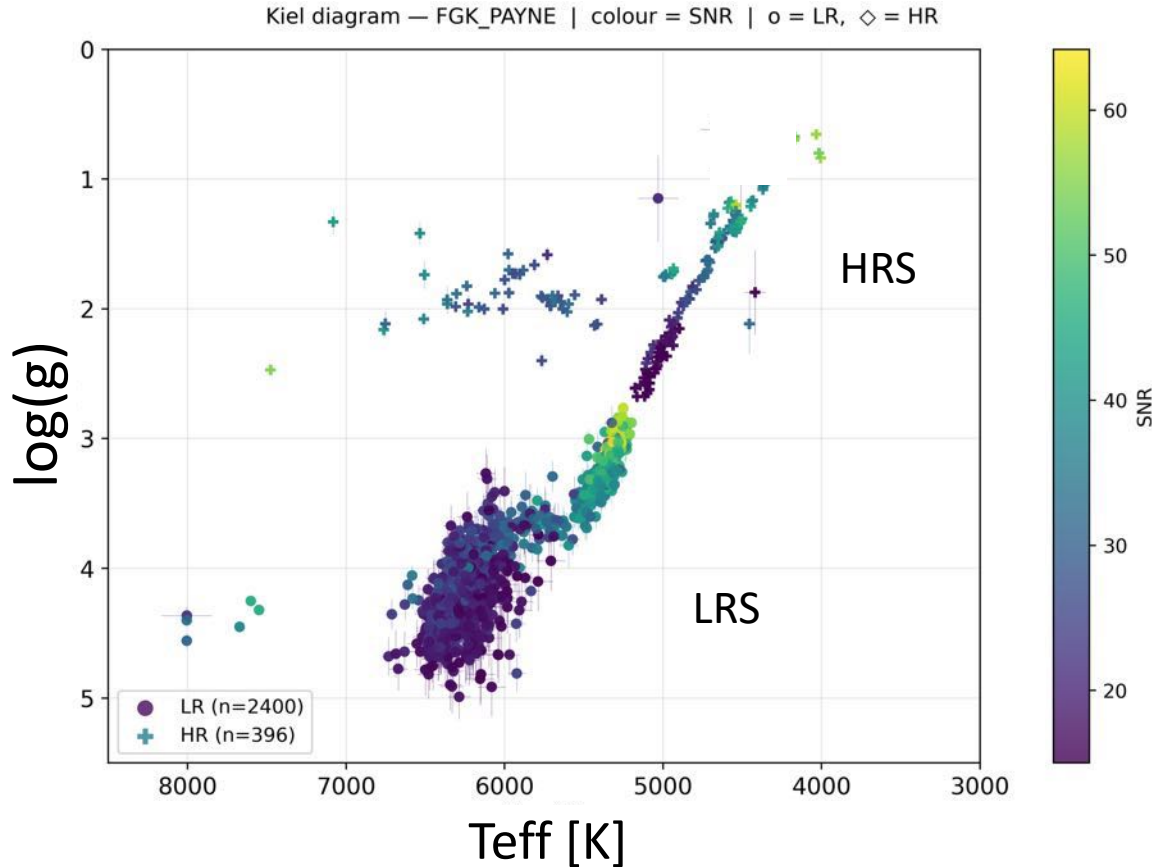
Ross Church + 4GP team

Initial result: Kiel diagram



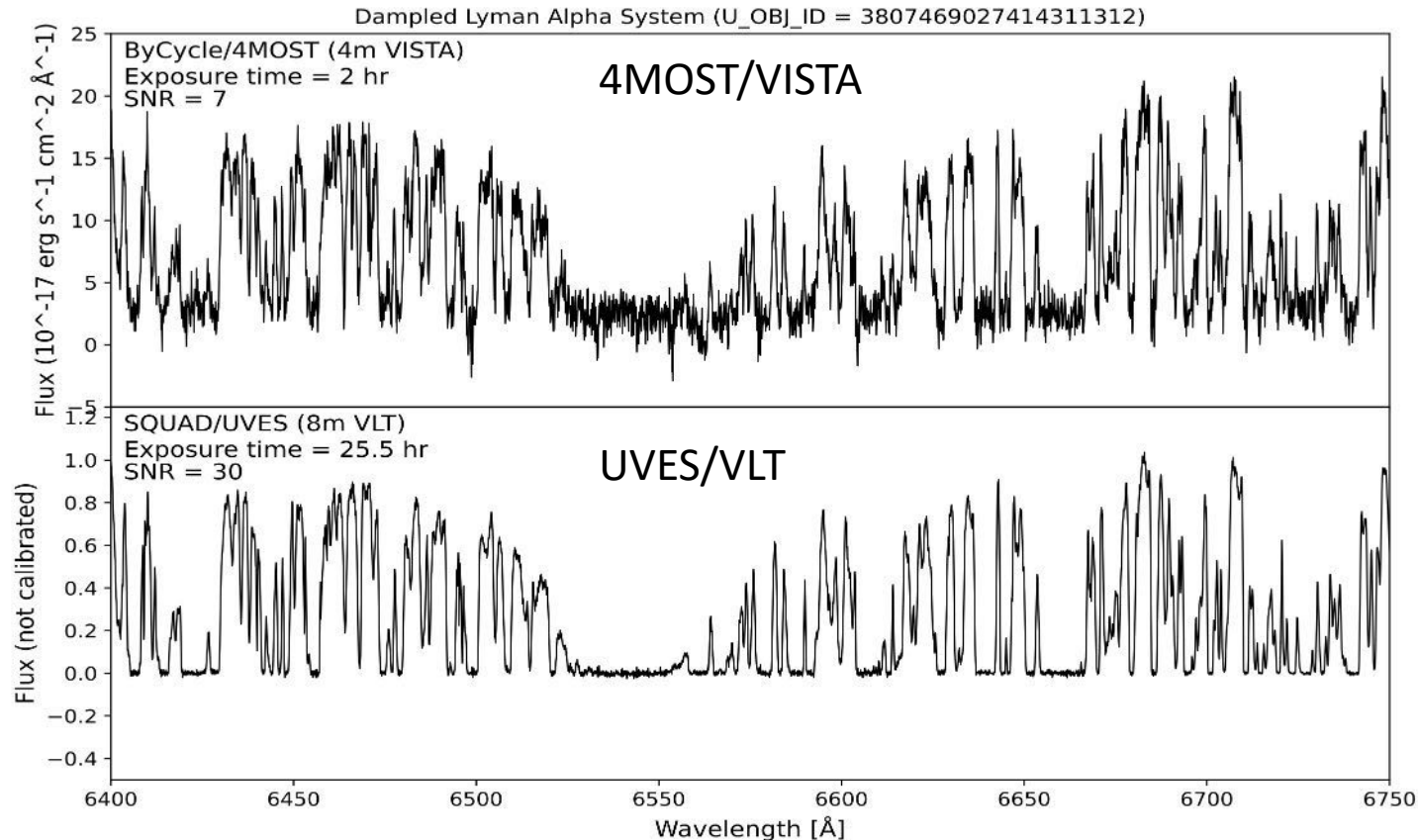
SAPP pipeline
Nicholas Storm
Maria Bergemann
IWG3 + IWG7

Initial result: Globular Cluster NGC 3201



Nagaraj Vernakar + 4GP team

Initial result: (Damped) Ly- α system



2h – 4m
800 HRS spectra

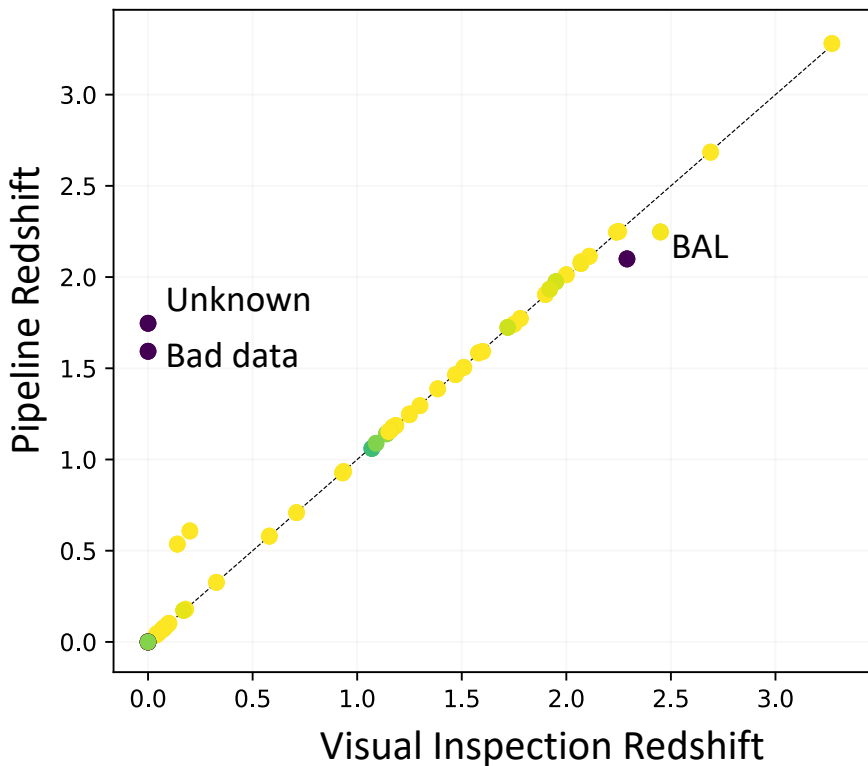
25.5 h – 8m
1 spectrum

Tamsyn O'Beirne,
Rajesh Potlia

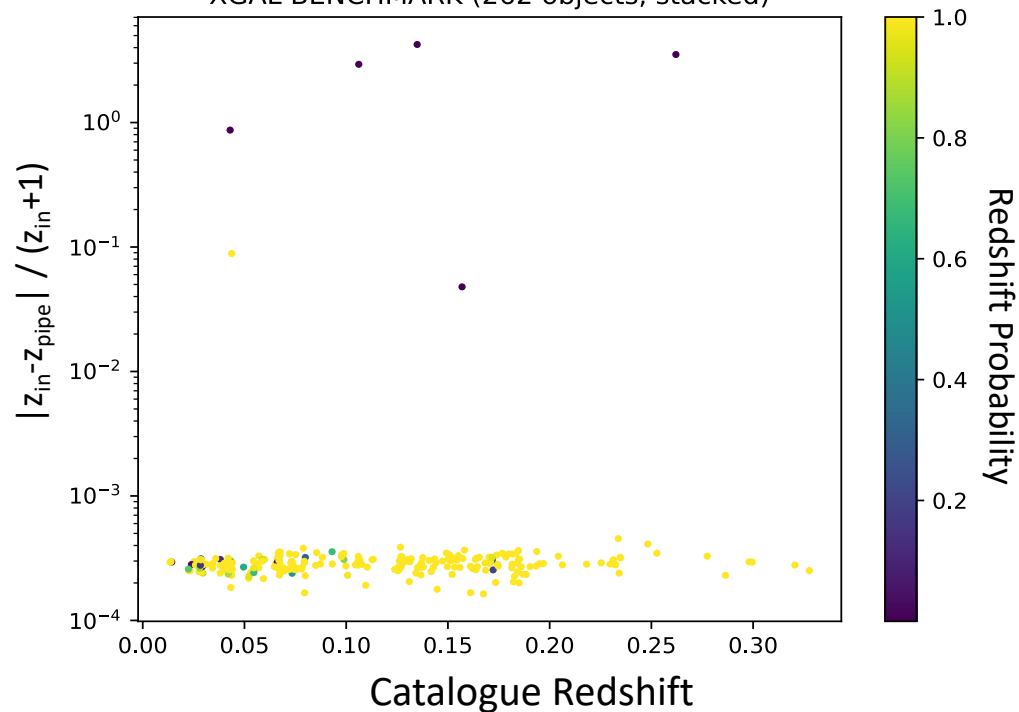
Initial results: redshift success



First PAQS observations (SYS-COM) Nov 2025

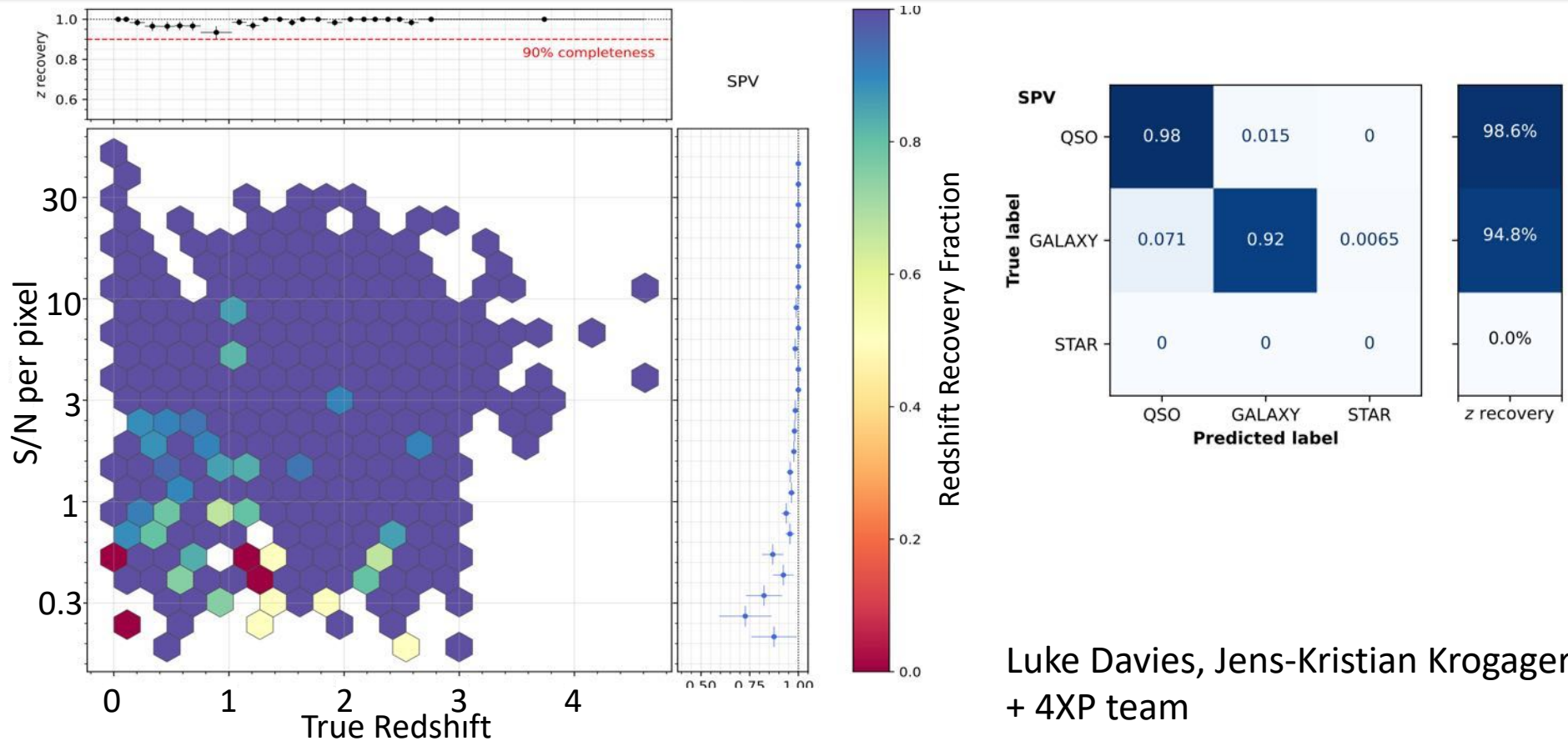


XGAL BENCHMARK (262 objects, stacked)



Jens-Kristian Krogager + 4XP team

Initial results: redshift success



Luke Davies, Jens-Kristian Krogager
+ 4XP team

Initial results: transients work-flow



TiDES-SN26ahb

Send to Slack

Name TiDES-SN26ahb
Tides ID 183
RA 120.55252
Dec -4.23901
Constellation Monoceros
Lasair-ZTF
Lasair-LSST

Tags

No tags

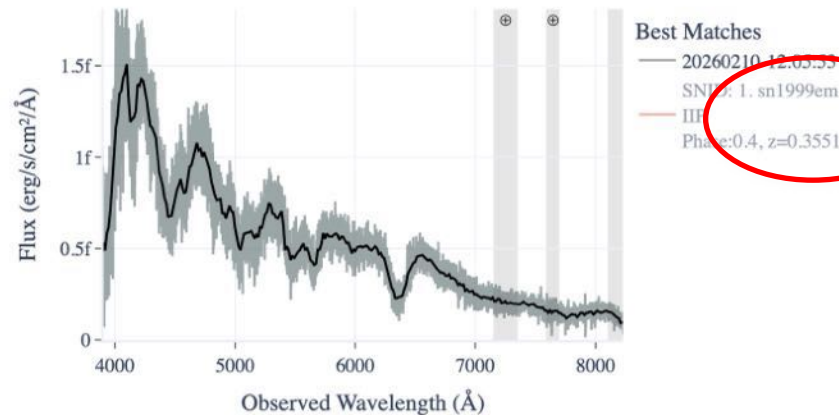
auto classification ok galactic
high-redshift
human classification ok
human classification unsure
noise released

Classifications

Auto Classification

Class: SN Ia
Probability: 0.995

Spectroscopy



Best Matches

— 20260210_12.05.55
SNID: 1. sn1999em
— IIF
Phase: 0.4, z=0.3551

☒ Binned (Å): 15

Download spectrum (ASCII)

Common Lines

☐ H ☐ He I ☐ He II ☐ C II ☐ C III ☐ C IV ☐ N II ☐ N III ☐ N IV ☐ NV ☐ O I ☐ [O I]

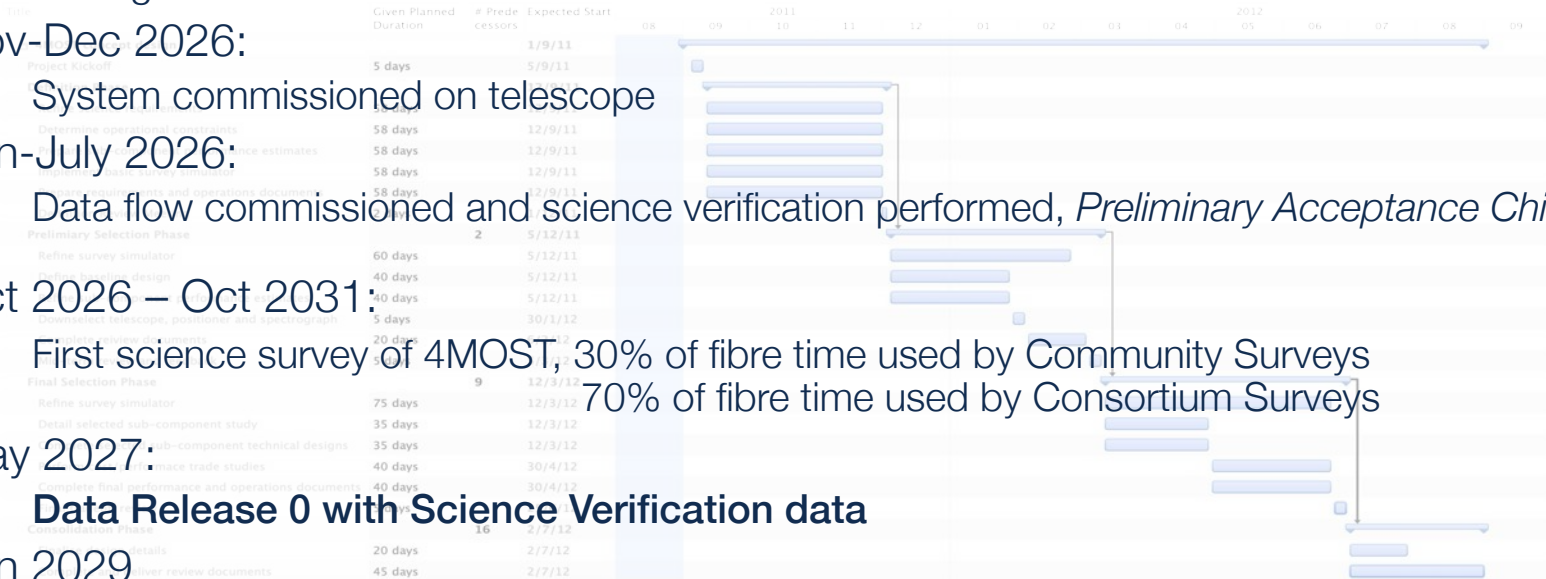
- Transient work-flow:
 - Use brokers to get candidates
 - Daily ingest of candidates in 4MOST DB
 - Observe when candidates are in FoV
 - Next morning processed in dedicated pipeline
 - Daily human check for special alerts

Phil Wiseman + TiDES team

Schedule and Milestones



- 18 Oct 2025:
 - First light
- Nov-Dec 2026:
 - System commissioned on telescope
- Jan-July 2026:
 - Data flow commissioned and science verification performed, *Preliminary Acceptance Chile*
- Oct 2026 – Oct 2031:
 - First science survey of 4MOST, 30% of fibre time used by Community Surveys
70% of fibre time used by Consortium Surveys
- May 2027:
 - **Data Release 0 with Science Verification data**
- Jan 2029
 - Data Release 1 with year-1 data of survey
 - Call for Proposals for second 5-year survey



Thank you!

- Contributions from 1200+ engineers, programmers, managers, and scientists
- Continuous installation, verification, commissioning activities from May to Dec 2025
- Ten weeks of observations for Science Verification in March–May 2026
- Seven weeks of (remote) Operation Rehearsals
- Typical shifts of 1 week with typically 4-8 people on the mountain
 - 40+ shifts with almost 200 missions + many ESO support efforts
- Not a single day slip from original plan!

4

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ESO Messenger 175

