The ESO Science Archive: towards the La Silla Paranal *Armazones* Observatory

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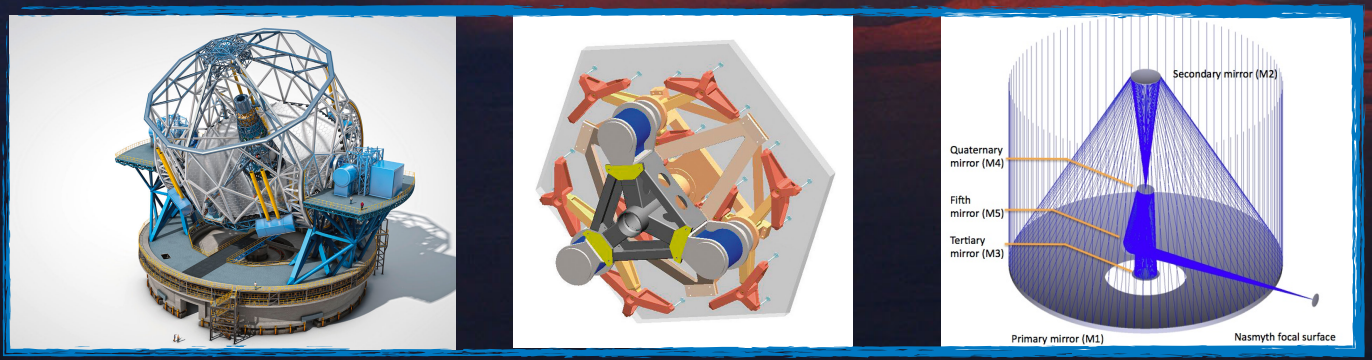
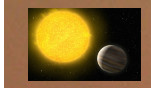
The Extremely Large Telescope (ELT)

- The E-ELT is the next (giant) step in optical-infrared astronomy: built and operated by ESO
- 39 meters in diameter, filled segmented aperture
  - 798 1.4-meter hexagonal segments
  - 5 mirror adaptive optics design: M4 with ~8000 actuators
  - Laser Guide Stars
  - Two Nasmyth platforms for the instruments
  - Possibility of a Coudé focus for ultra-stable instruments
- First light in October 2024

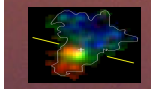


Top-level science cases

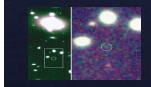


Extra-solar planets: discovery of Earth-like planets, direct imaging of larger planets and their atmospheres

Resolved stellar populations: resolve a representative sample of galaxies in the nearby Universe into stars to reconstruct directly their formation and evolution history



Physics of the high redshift universe: spatially resolved spectroscopy to the highest redshift galaxies to derive their stellar masses, ages, metallicities, star formation rates and dynamical states across cosmic time



Cosmology and fundamental physics: direct observation and measurement of the expanding Universe; variations the of fundamental physical constants over cosmic time

One Observatory: Armazones and Paranal

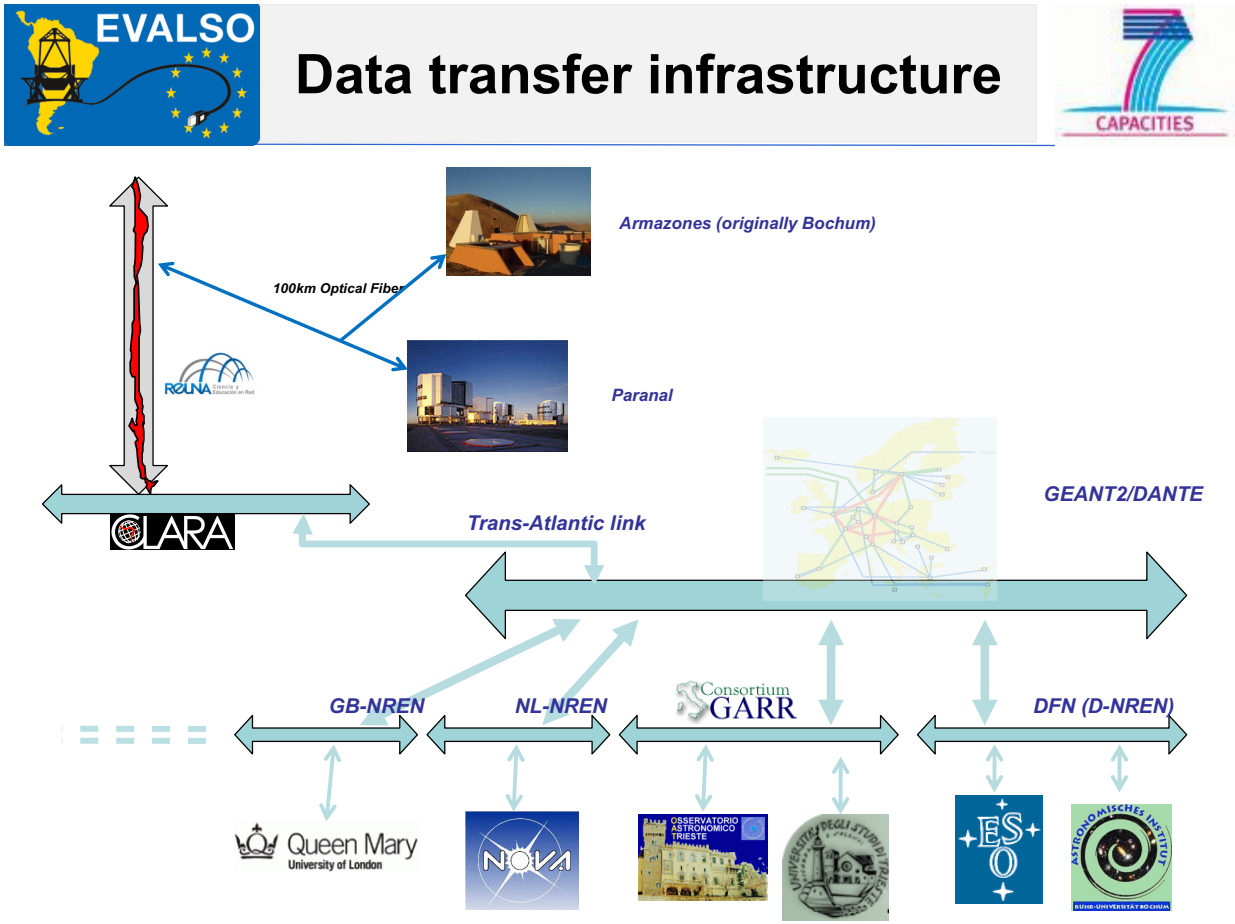
ELT science operations

- The E-ELT will be the fifth (EXTREMELY) big telescope of the La Silla Paranal Armazones Observatory
- Operational model derived from the VLT
  - Evolution, not revolution
  - Competitive access to observing time
  - Mix of different observing modes and programme types to optimize efficiency and science return
  - Science archive: raw data, data products
- La Silla Paranal Observatory as a fully functional, highly productive, cutting-edge “precursor”

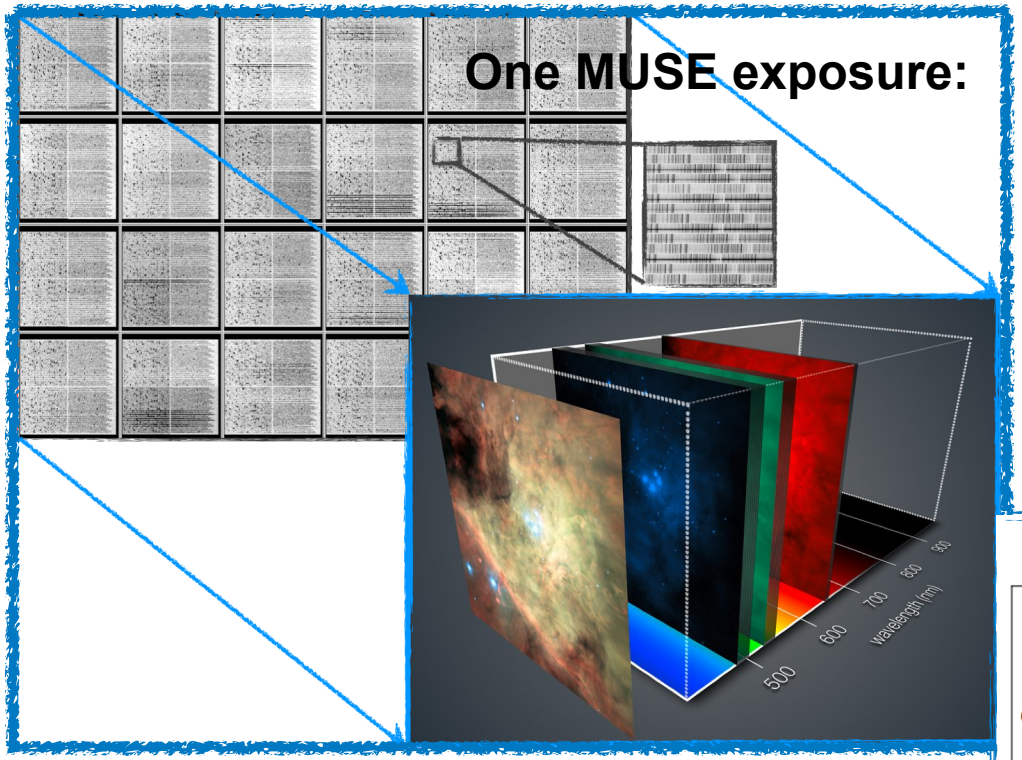
Not a challenge: data volume

- It took 20 years to reach 1 PB
  - Doubling timescale of a couple of years

- Compute resources not an issue
  - E.g. the infrastructure to generate science ready processed data for MUSE costs a fraction of the development cost of the data processing software



The challenge: data complexity



	Outerspace	Atmosphere	Telescope	AO	MICADO
Pixel data = observatory ⊛ science	Science object	Composition model (thermal / non-thermal)	M1	SCAO	Entrance window
	Galactic extinction	Kinematical model for ~32 layers (AO)	M2	MCAO	Derotator
	Cosmic rays		M3		Collimator
	Moon, planets, bright stars		M4		Filter
	Zodiacal light		M5		ADC
			M7		Imager optics, reimager
					Pedestal, pixelsensitivity, persistence, crosstalk, dark current, read-outl

MICADO

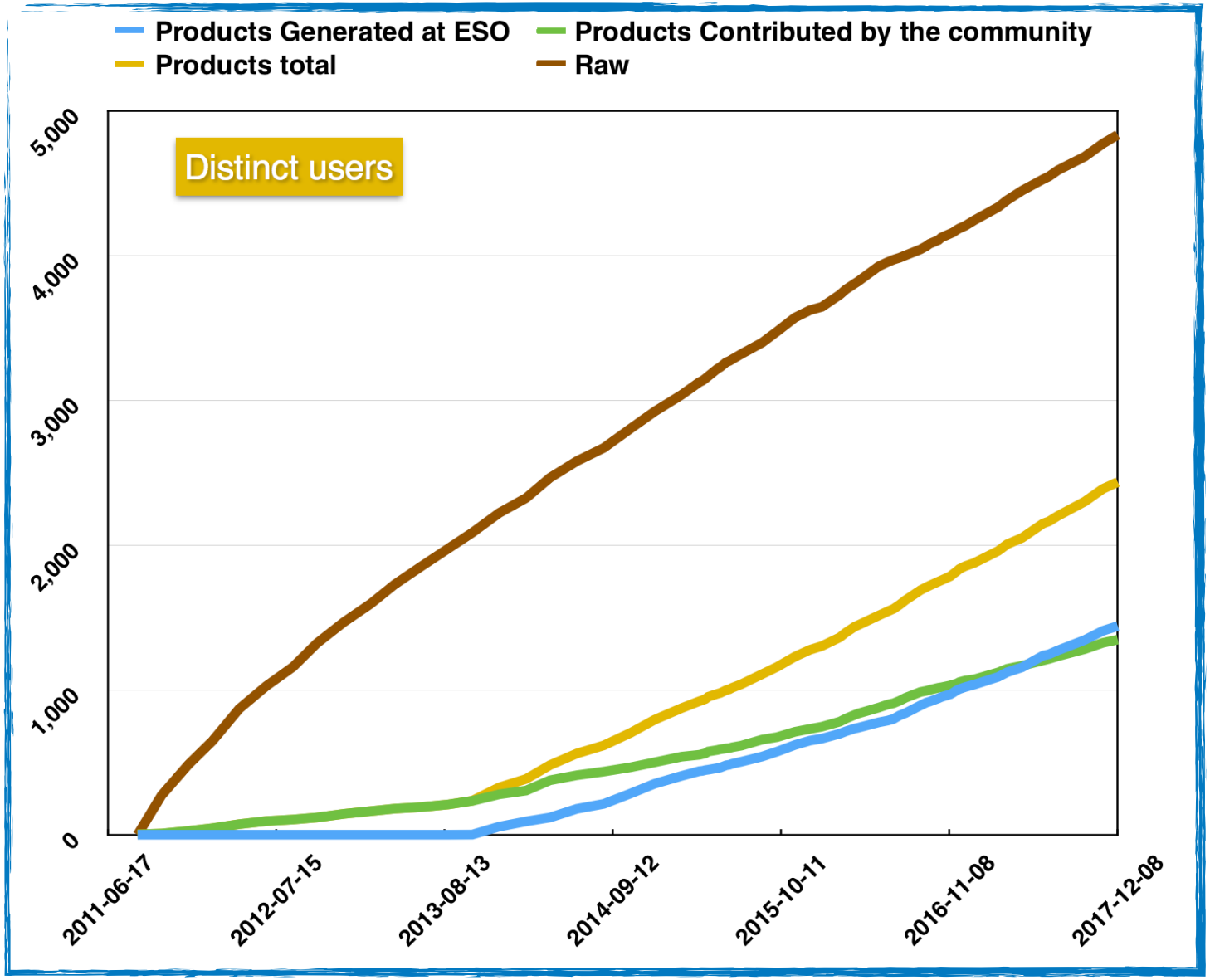
Observables	Astrophysical laws	On-site measurements (T, r, H, P, v..)	DM telemetry	WFS telemetry	Detector exposures

Verdoes Kleiin (ESO-ESA workshop

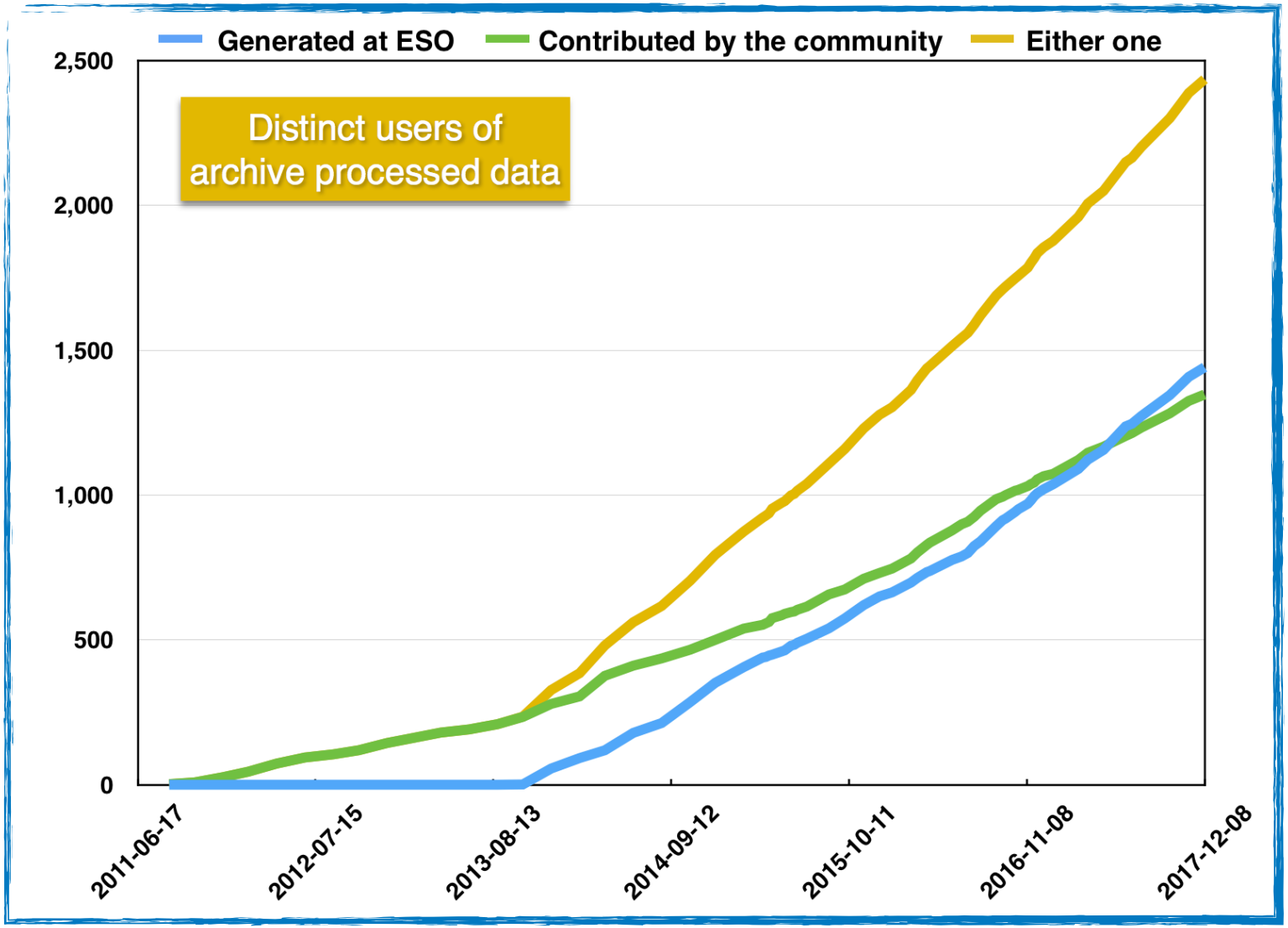
The ESO Science Archive Cheat Sheet

- Scientific and operational archive of the La Silla Paranal Amazones Observatory
  - VLT, VLTI, Survey Telescopes, NTT, 3.6 metre, national telescopes, hosted experiments … and the ELT …
- Content:
  - 44.8 Million files, 1.01 PB data
- Ingestion: ~130 TB /year
  - Raw: ~74 TB/year
  - Products (all flavours): ~48 TB/year
  - Miscellanea: ~9.5 TB/year
- Deliveries to external users: ~200TB/year
  - More data goes out than it comes in

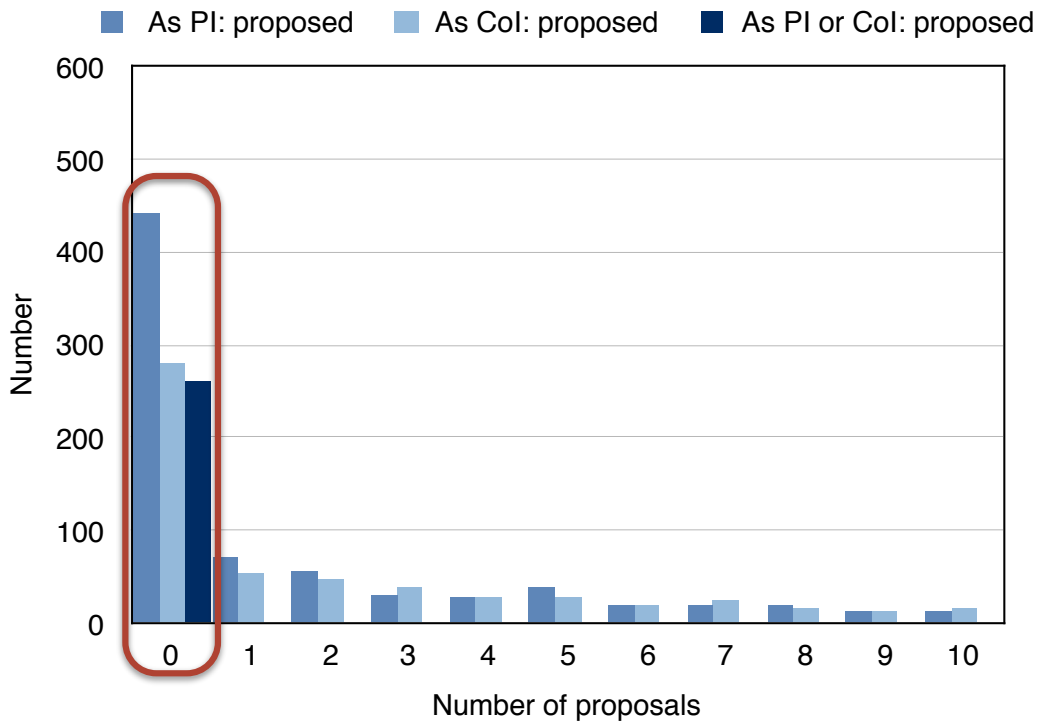
The science user community

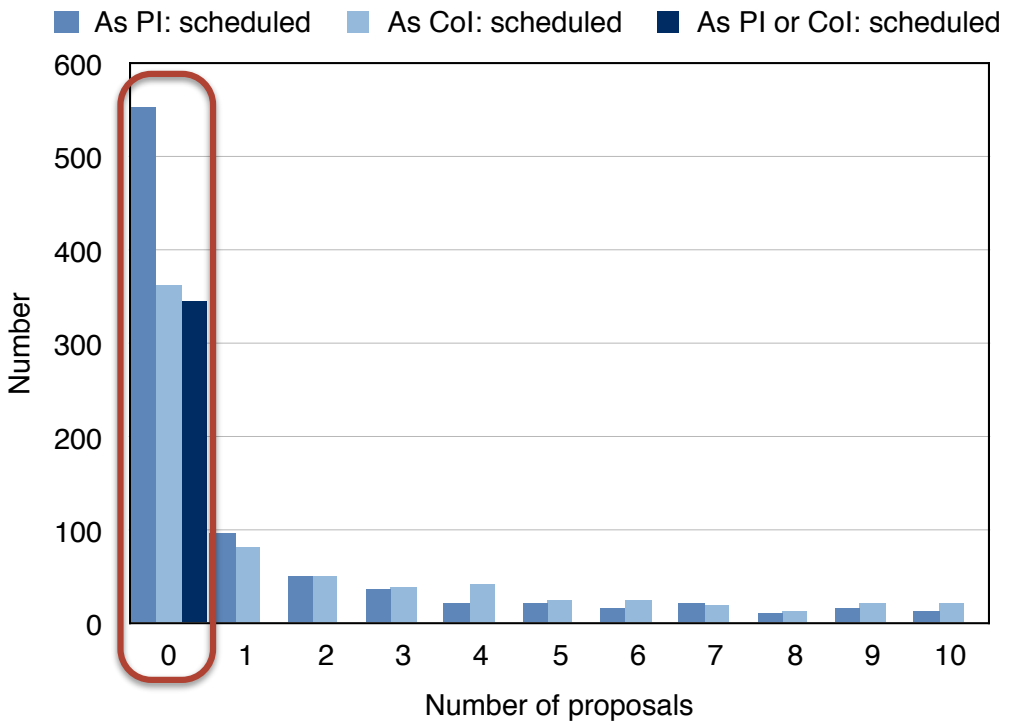


The science user community: processed data



Observing vs archive

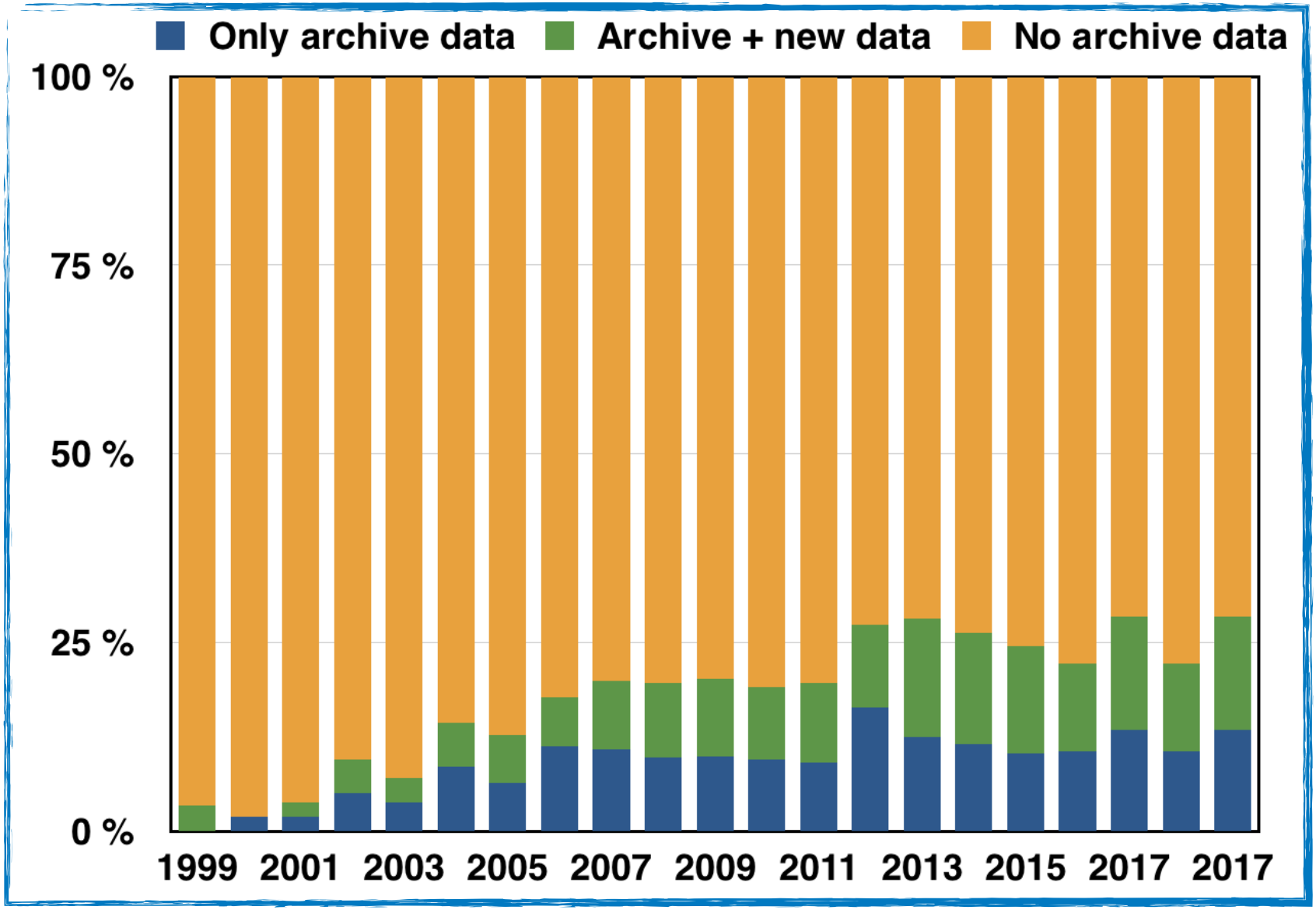




- Users of archive data: 30% have never applied for time, neither as PIs nor co-Is; 37% have never gotten time, neither as PIs nor co-Is
  - For comparison, 1/3 of the Phase 1 PIs have never got time

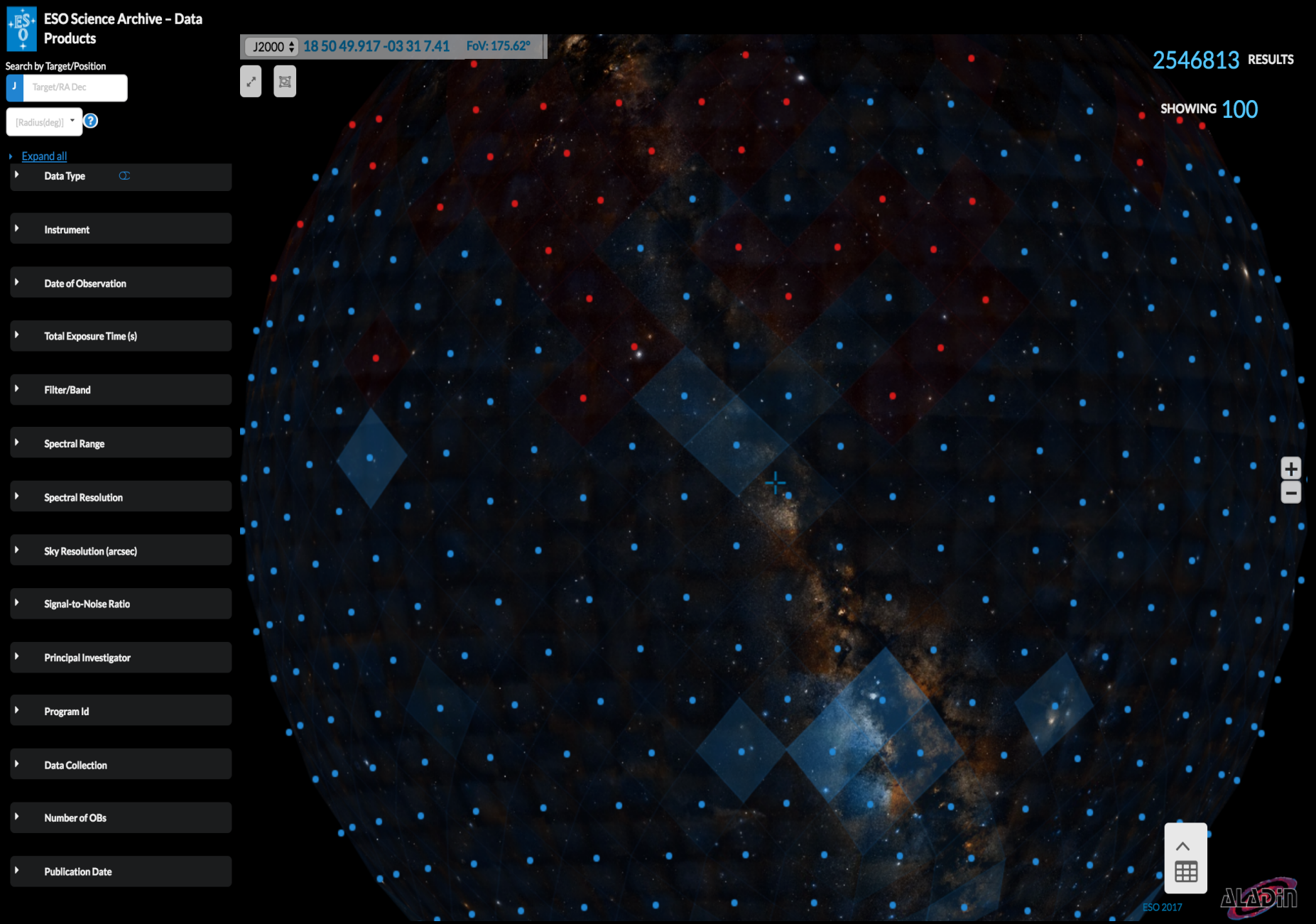
Archive publications

telbib.eso.org



The evolution of the ESO Science Archive

- High-level goals
  - Foster the discovery and use of ESO data (LPO and ALMA)
  - Place them in the wider context of other data
- Rich interactive interface to ESO data
  - Full exploitation of curated metadata
  - Query on physical properties (position, energy, resolution, depth, signal-to-noise, …)
  - Graphical previews and interaction to aid discovery
- Share data within the Virtual Observatory
  - ESO data discoverable beyond the dedicated interface, without re-developing existing tools
  - Support for complex, multi-archive queries
  - Restricted to common metadata


ESO Science Archive – Data Products
Search by Target/Position
Target/RA Dec
[Radius(deg)]
Expand all
Data Type
Instrument
Date of Observation
Total Exposure Time (s)
Filter/Band
Spectral Range
Spectral Resolution
Sky Resolution (arcsec)
Signal-to-Noise Ratio
Principal Investigator
Program Id
Data Collection
Number of OBs
Publication Date
J2000
18 50 49.917 -03 31 7.41
FoV: 175.62°
2546813 RESULTS
SHOWING 100
ESO 2017
ALADIN

ESO Science Archive – Data Products

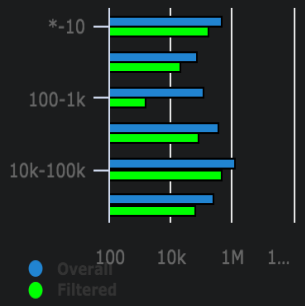
Search by Target/Position

Target/RA Dec

[Radius(deg)]

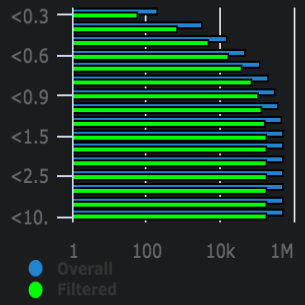
Collapse all

Spectral Resolution

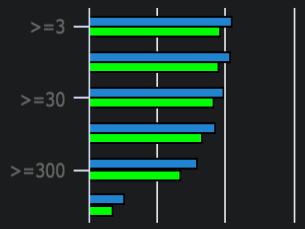


from - to

Sky Resolution (arcsec)



Signal-to-Noise Ratio



J2000 17 56 35.324 -21 19 25.61 FoV: 89.33°

Reset the FoV

824666 RESULTS

SHOWING 100

Number of OBs: 8847
Filters:

Filter	Tot.exp.time	Abmaglim max
Ks: 1927	91576	18.69
r_SDSS: 173	3800	22.02
NB_659: 141	14400	21.23
g_SDSS: 107	3000	23.01
Y: 101	10560	20.20
Z: 101	10560	21.09
i_SDSS: 101	2000	21.10
u_SDSS: 93	10800	22.16
H: 87	3552	18.75
J: 87	10656	19.75
870u: 2	0	

ESO 2017

ALADIN

ESO Science Archive – Data Products

Search by Target/Position

J | Target/RA Dec

[Radius(deg)]

Collapse all

Object

- ATLAS survey 44944
- HD128621 19439
- Str05 13484
- Str04 13176
- Str06 12748

Show 45 more out of 426415

Search...

Data Type

- SPECTRUM 1989013
- CATALOG 279739
- IMAGE 271072
- CUBE 5814
- VISIBILITY 1154

Instrument

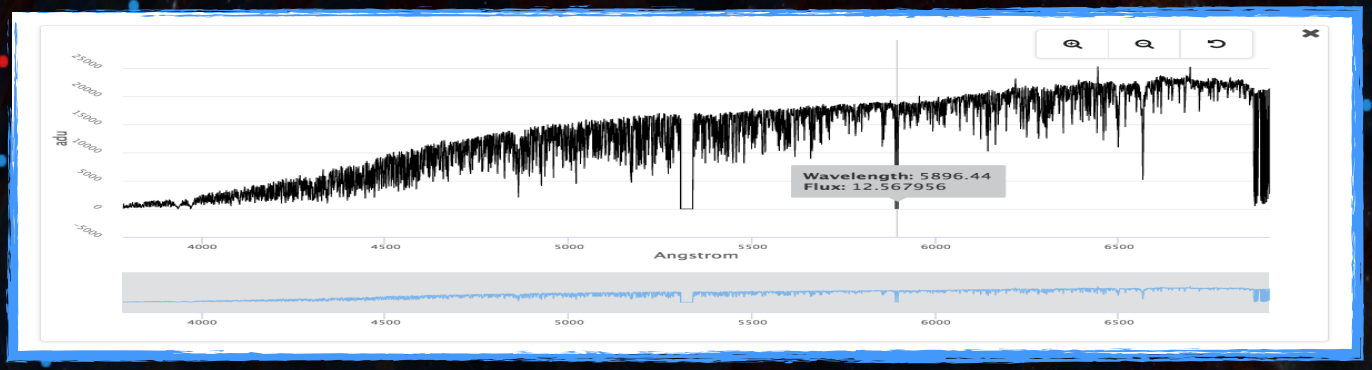
- GIRAFFE 1369713
- VIRCAM 448871
- HARPS 255586
- UVES 126680
- VIMOS 118264

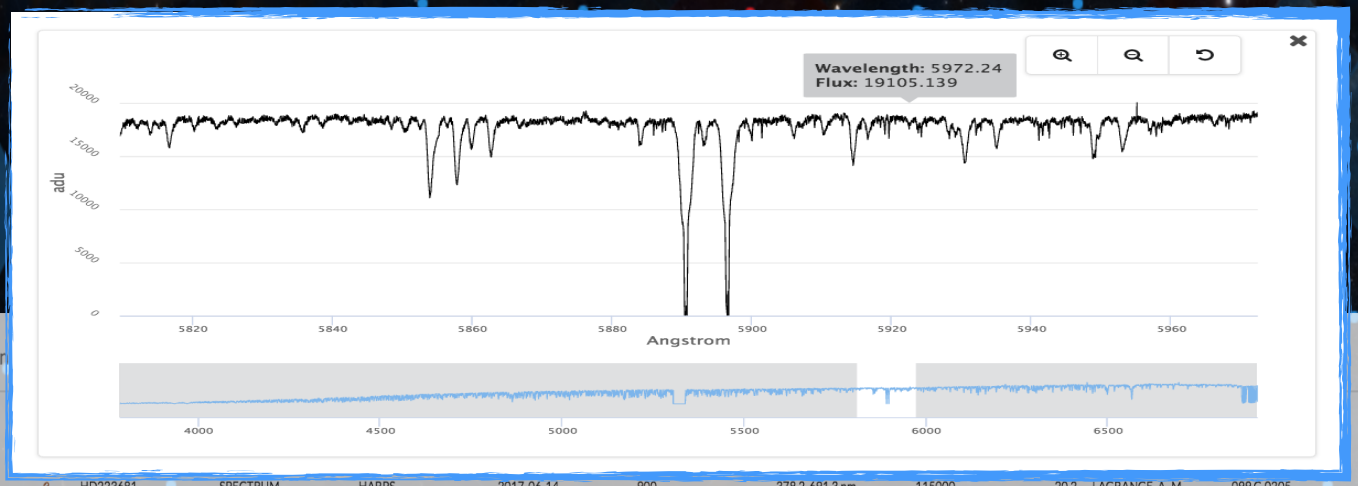
Show 15 more out of 20

J2000 22 08 31.045 +07 58 36.82 FoV: 175.97°

2546813 RESULTS

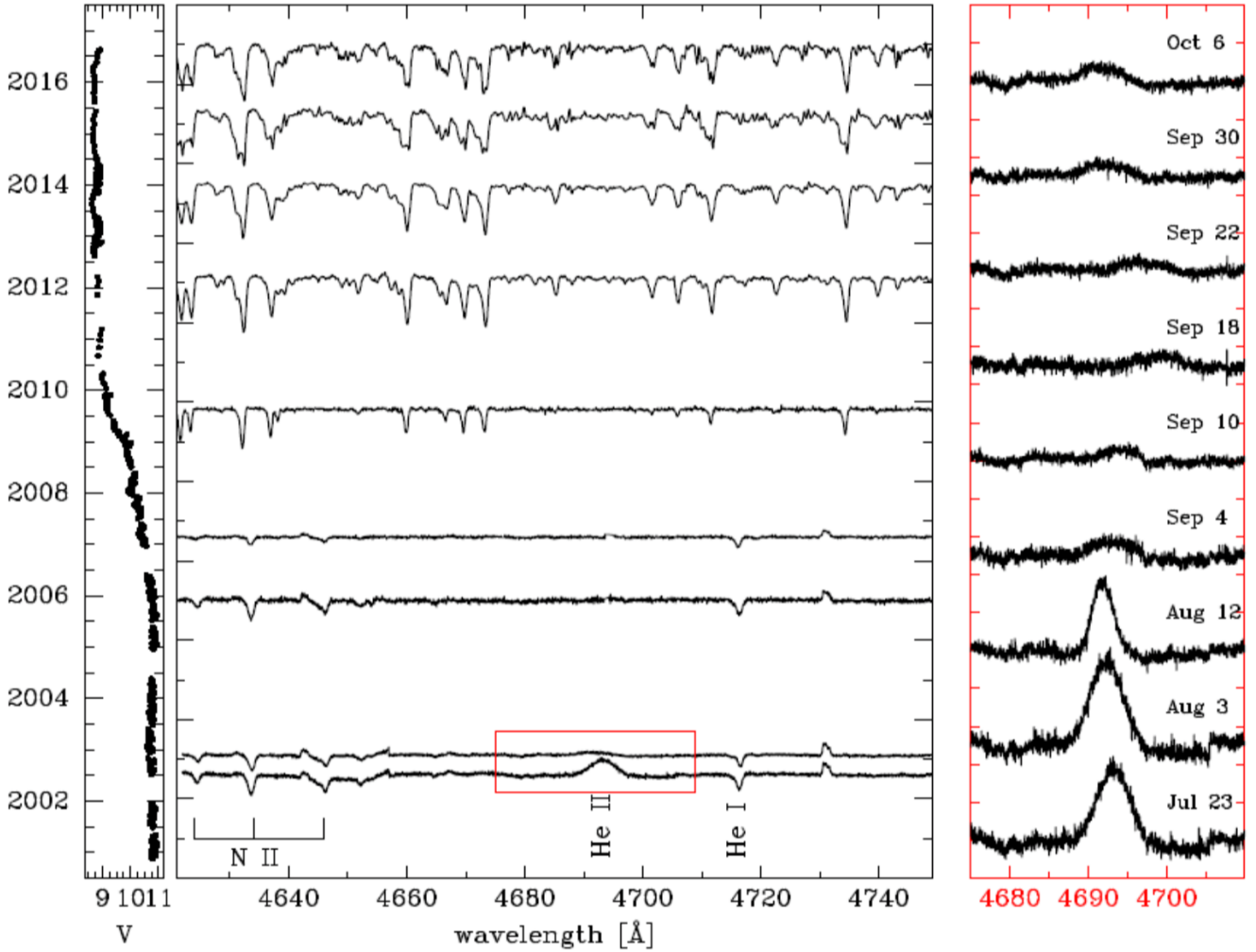
SHOWING 100





Action											Collection	#Ol	Pub.Da
	HD223681	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	20.2	LAGRANGE, A.-M.	099.C-0205	HARPS	single	2017-06-15
	HD218860	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	46.4	LAGRANGE, A.-M.	099.C-0205	HARPS	single	2017-06-15
	HD218860	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	42.8	LAGRANGE, A.-M.	099.C-0205	HARPS	single	2017-06-15
	HD000013	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	10	LANNIER, JUSTINE	097.C-0864	HARPS	single	2017-06-15
	HD000013	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	9.8	LANNIER, JUSTINE	097.C-0864	HARPS	single	2017-06-15
	HD202917	SPECTRUM	HARPS	2017-06-14	900	378.2-691.3 nm	115000	48.9	LAGRANGE, A.-M.	099.C-0205	HARPS	single	2017-06-15

With great accessibility comes great responsibility…



"*…a perverse flaw in the 2002 UVES data, which was not corrected by the applicable ESO pipeline*"

Some conclusion…

- The ESO Science Archive has quite a bit of VO inside and outside
  - Standards, tools, protocols, …
- There is no point in reinventing a wheel that is working
  - Still, the wheel needs to evolve to cater for specific needs
  - From a project point of view, it is important to have a timeline for when changes will be implemented
- Time domain will keep growing in importance
  - Main drivers: exoplanet searches and transient follow-up
- Data quality and curation are and will be key for success
- EOSC seems like a very promising way forward
  - “Data stewardship”