

SALT and beyond

Possibilities for optical / NIR astronomy in Africa



Petri Väisänen

SALT status

Developments at SALT/SAAO

Future possibilities

LUVOIR lessons







SALT

The largest optical telescope in the Southern Hemisphere – 11m primary mirror

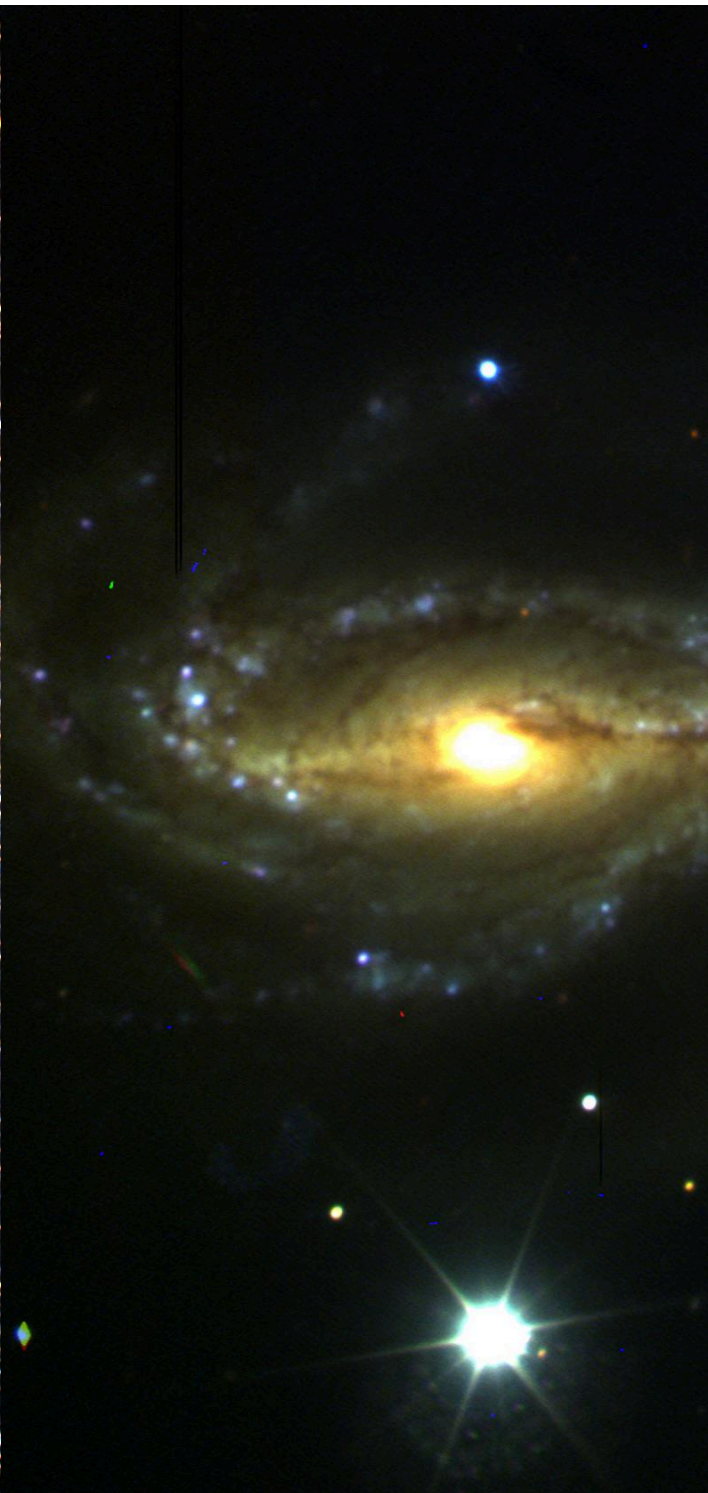
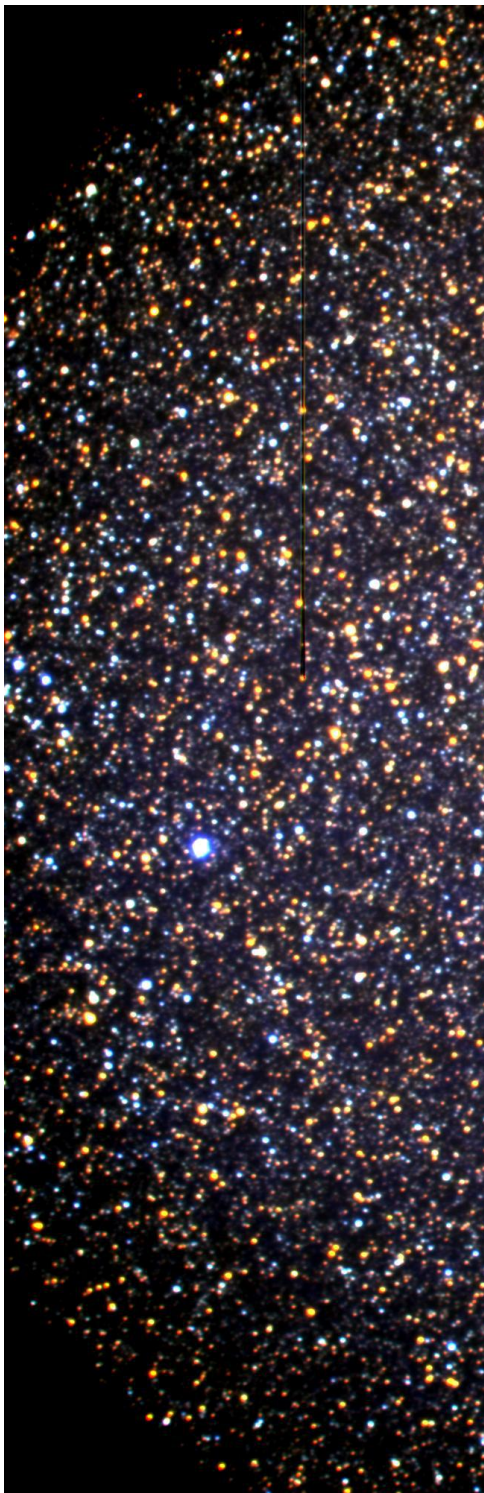


And – it is working very well right now!

Producing science papers, ~40 per year

Very cost-effectively



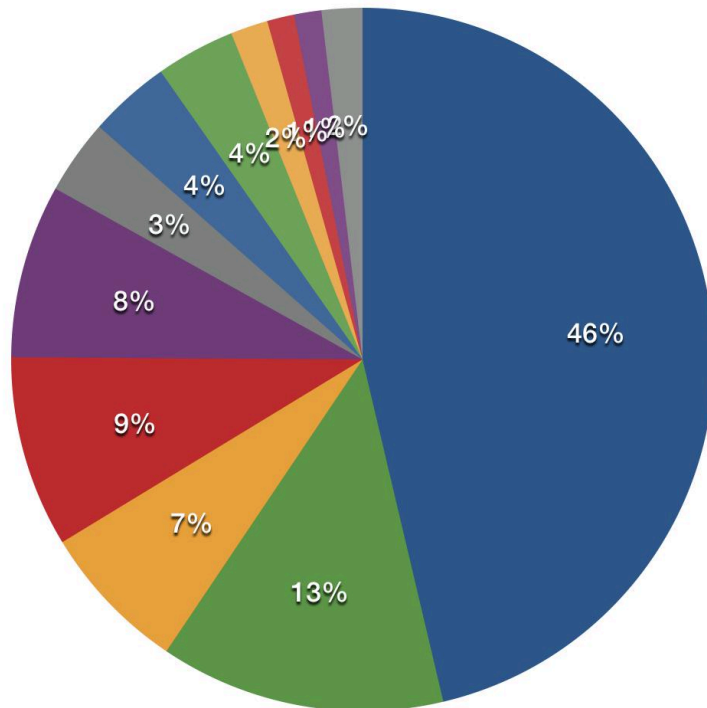


SALT Papers

N = 161 data papers to date

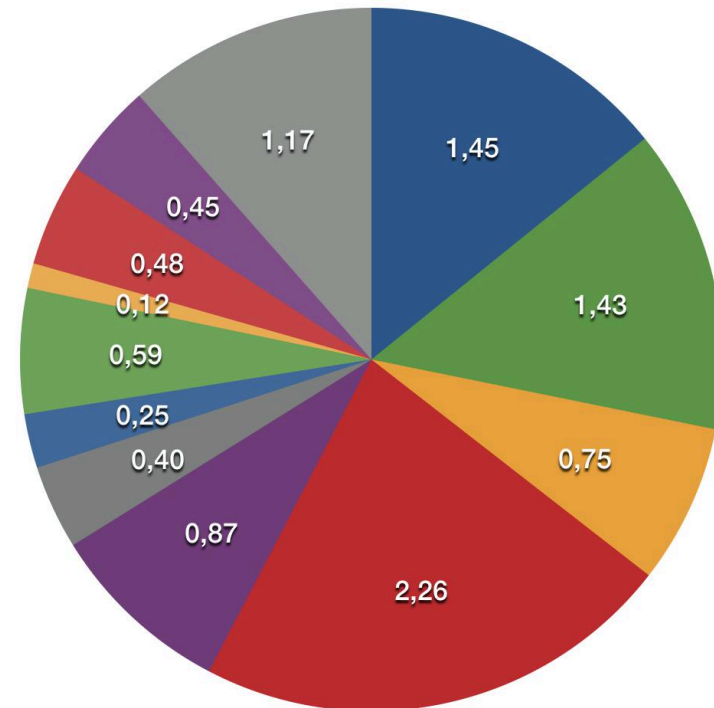
Percentage of time allocation

RSA POL DC UKSC RU HET GU IUCAA UW
 UNC UC AMNH

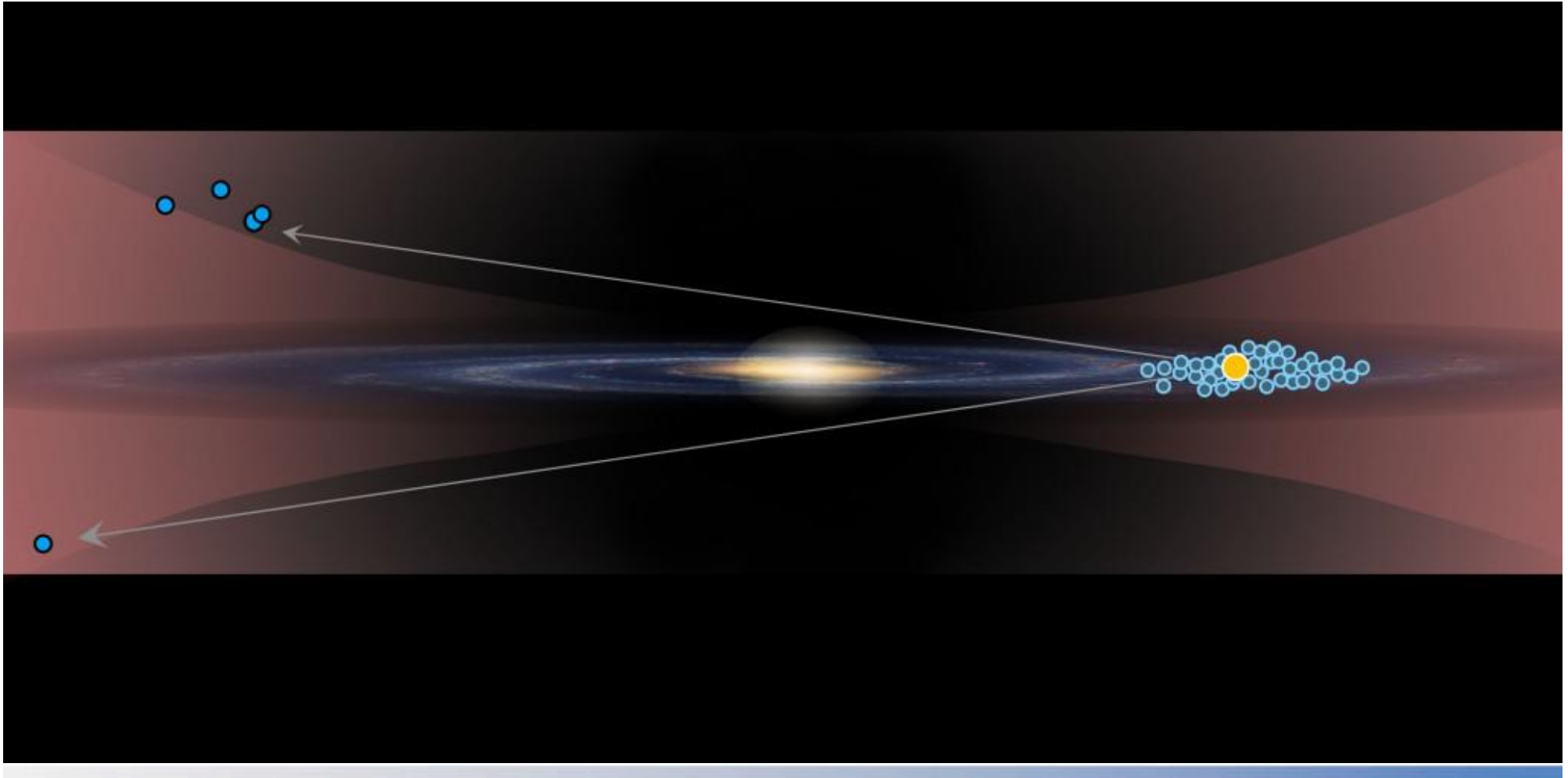


Scaled share of papers

RSA POL DC UKSC RU HET GU IUCAA UW
 UNC UC AMNH



Flared disk of the Milky Way



Feast, Menzies, Matsunaga & Whitelock
Nature, 14 May 2014

Feast Fest 2017 Astro Trends



(Note: the link on the library name is a public link to this library)

Most recent SALT papers:

Selected and retrieved 177 abstracts.

#	Bibcode Authors	Score Title	Date	List of Links Access Control Help
1	<input type="checkbox"/> 2017MNRAS.469..193P Pahari, Mayukh; Gandhi, Poshak; Charles, Philip A.; Kotze, Marissa M.; Altamirano, Diego; Misra, Ranjeev	1.000 Simultaneous optical/X-ray study of GS 1354-64 (=BW Cir) during hard outburst: evidence for optical cyclo-synchrotron emission	07/2017	A E X R U
2	<input type="checkbox"/> 2017A&A..603A..24M Malacaria, C.; Kollatschny, W.; Whelan, E.; Santangelo, A.; Klochkov, D.; McBride, V.; Ducci, L.	1.000 Optical spectroscopy of the Be/X-ray binary V850 Centauri/GX 304-1 during faint X-ray periodical activity	07/2017	A E F X R U
3	<input type="checkbox"/> 2017MNRAS.468..564M Mata Sánchez, D.; Charles, P. A.; Armas Padilla, M.; Buckley, D. A. H.; Israel, G. L.; Linares, M.; Muñoz-Darias, T.	1.000 Swift and SALT observations of the multiple outbursts of MAXI J1957+032	06/2017	A E X R U
4	<input type="checkbox"/> 2017MNRAS.467.4101G Groenewald, Daniël N.; Skelton, Rosalind E.; Gilbank, David G.; Loubser, S. Ilani	1.000 The close pair fraction of BCGs since $z = 0.5$: major mergers dominate recent BCG stellar mass growth	06/2017	A E F X R U
5	<input type="checkbox"/> 2017MNRAS.467.3239R Ratsimbazafy, A. L.; Loubser, S. I.; Crawford, S. M.; Cress, C. M.; Bassett, B. A.; Nichol, R. C.; Väisänen, P.	1.000 Age-dating luminous red galaxies observed with the Southern African Large Telescope	05/2017	A E F X R C N U
6	<input type="checkbox"/> 2017MNRAS.467.3105M Munoz, Melissa; Moffat, Anthony F. J.; Hill, Grant M.; Shenar, Tomer; Richardson, Noel D.; Pablo, Herbert; St-Louis, Nicole; Ramiaramanantsoa, Tahina	1.000 WR 148: identifying the companion of an extreme runaway massive binary*	05/2017	A E F X R U

Couple of near-term SALT developments

RSS Near-Infrared IFU - in 2019

217 fibers in a hexagon (28" on-sky) or elongated hexagon (16" x 38")

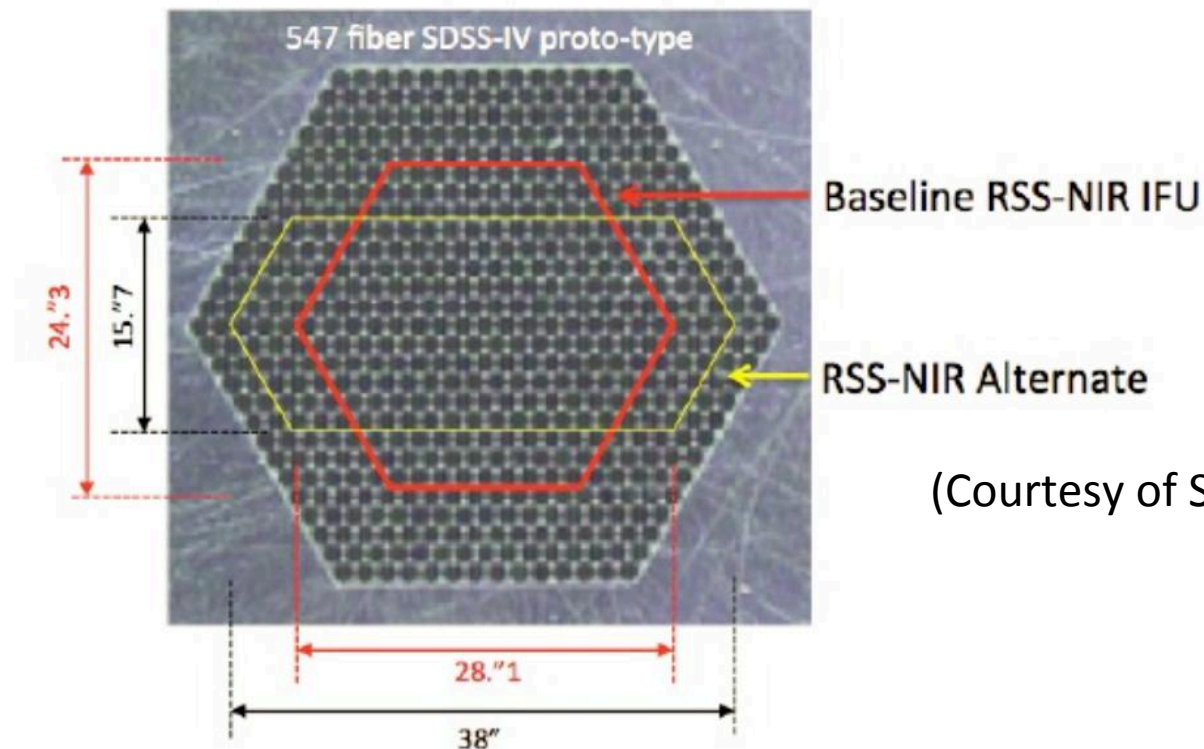
2 sets of 15 sky fibers

1.33" core fibers spaced at 1.65"

Achieves $R \sim 2000 - 6000$ over $\lambda = 900-1700$ nm

Slit V-groove blocks (25 fibers each) tilted for telecentricity

Final fiber size selection will interplay with the collimator design



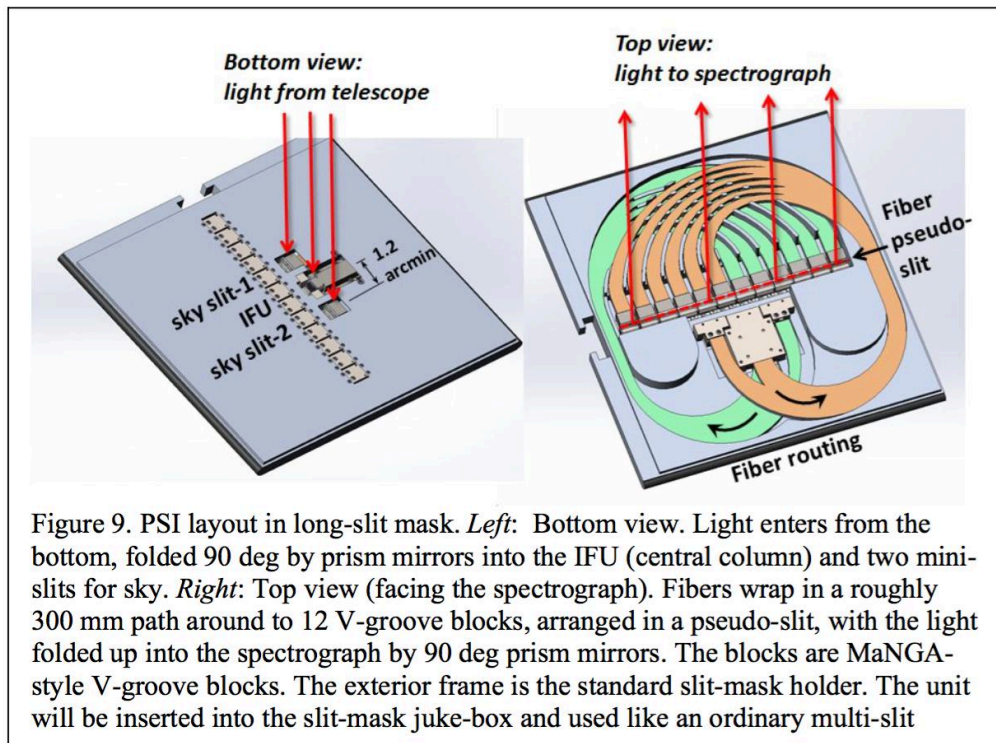
(Courtesy of S. Crawford)

RSS Upgrade

- Collimator upgrade
 - RSS Guider
 - 600 line/mm grating
 - CCD upgrade
 - RSS efficiency
 - Pipelines for all the modes
- 70% of the telescope usage is RSS longslit
 - >20% improvements in RSS performance
 - Improved MOS performance
- (Courtesy of S. Crawford)



Slit IFU



- design by UW
- 14x24" FOV
- ~\$18k hardware costs
- New capabilities and better performance (better sky subtraction)



(Courtesy of S. Crawford)

Feast Fest 2017 Astro Trends



And the longer term ??



“ Phil, what the heck just happened ... ? ”



(Michael Feast at MEARIM 2008 in Cairo)

“ Right, we need to be thinking about our strategy going forward ! ”



" Everybody, together now !
PUSH. PUSH !! "

SA
Astro
Strategy



What lies beyond the hill ... ??



What lies beyond the hill ... ??



Feast Fest 2017 Astro Trends



What lies beyond the hill ... ??



We just don't
know for sure

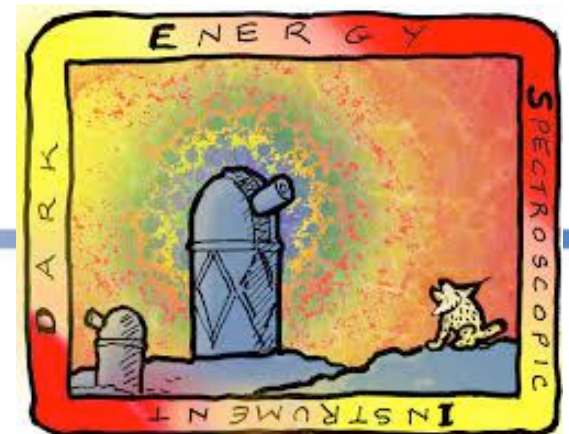
Can't afford
to cruise

But we can
plan



Massively Multiplex spectroscopy

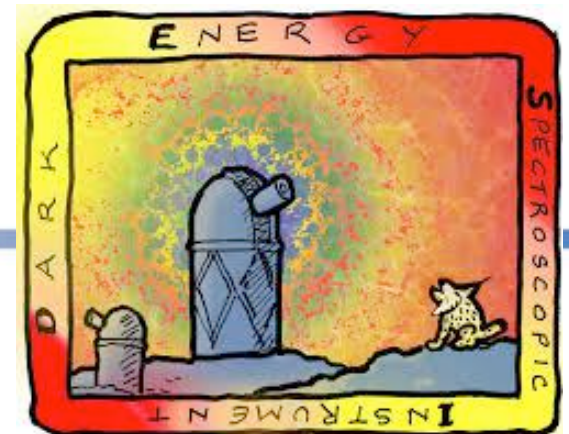
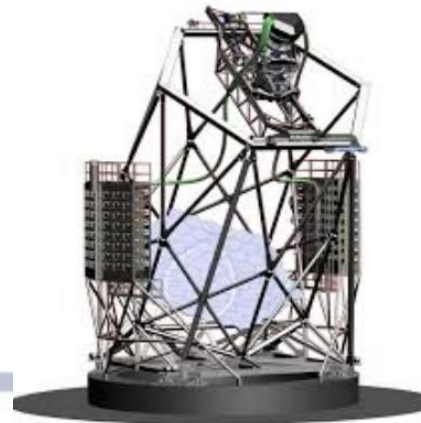
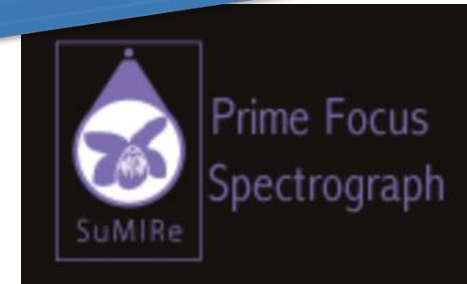
- Huge surveys. Especially cosmological (but other science drivers too)
- Ultimately mapping out the “whole universe”
- **4MOST, DESI, EUCLID, PFS, HETDEX, MOONS, MSE, etc.**



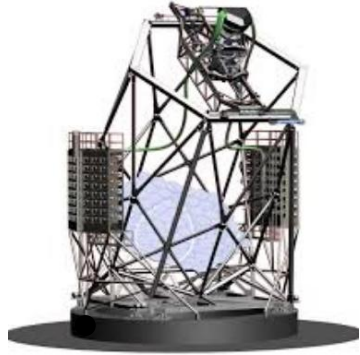
Massively Multiplex spectroscopy

- Huge surveys. Especially cosmological (but other science drivers too)
- Ultimately
- 4MOON, MOON, etc.

Very crowded market

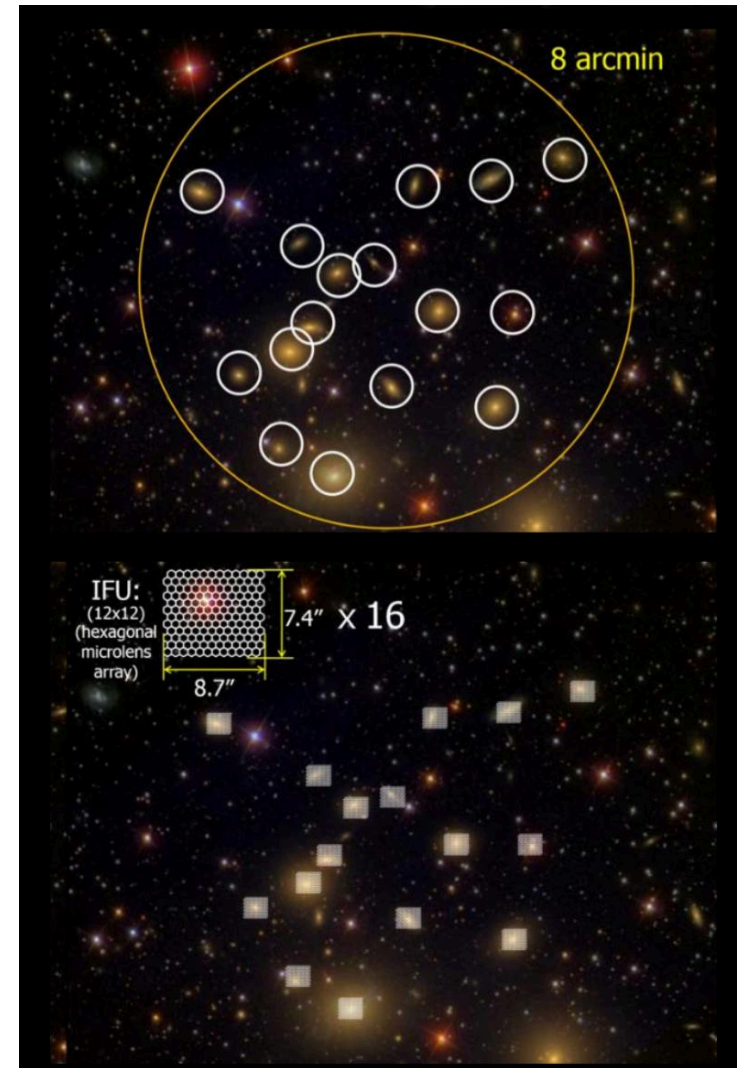


Integral Field Units

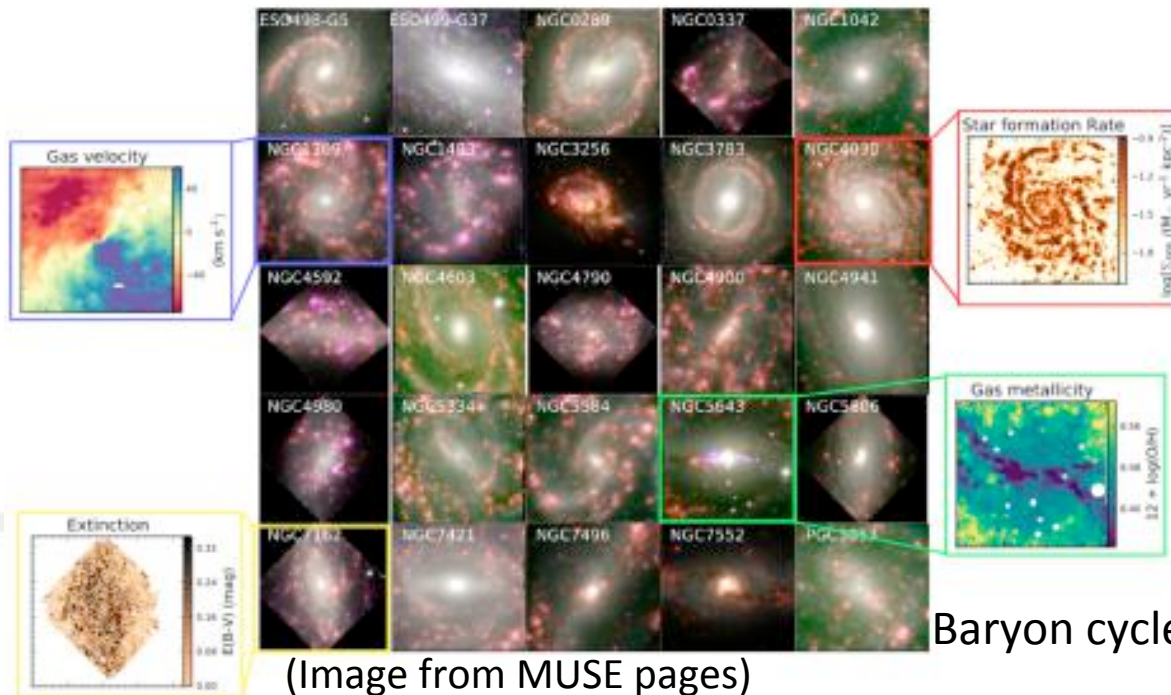


Efficient and multi-purpose

- **MUSE, KMOS, VIRUS, MANGA, SAMI, DOTIFS, MEGARA, etc.**



DOTIFS: Chung, Ramaprakash, et al.



Baryon cycle.

Integral Field Units



Efficient and multi-purpose

- MUSE, KMOS

We should discuss these



DOTIFS: Chung, Ramaprakash, et al.



Baryon cycle.

(Image from MUSE pages)

Exo-planets

“Cosmology has driven the construction of big telescopes for the past 100 years. The search for life will drive the construction of big telescopes for the next 100 years” - Chas Beichmann

Proxima Centauri

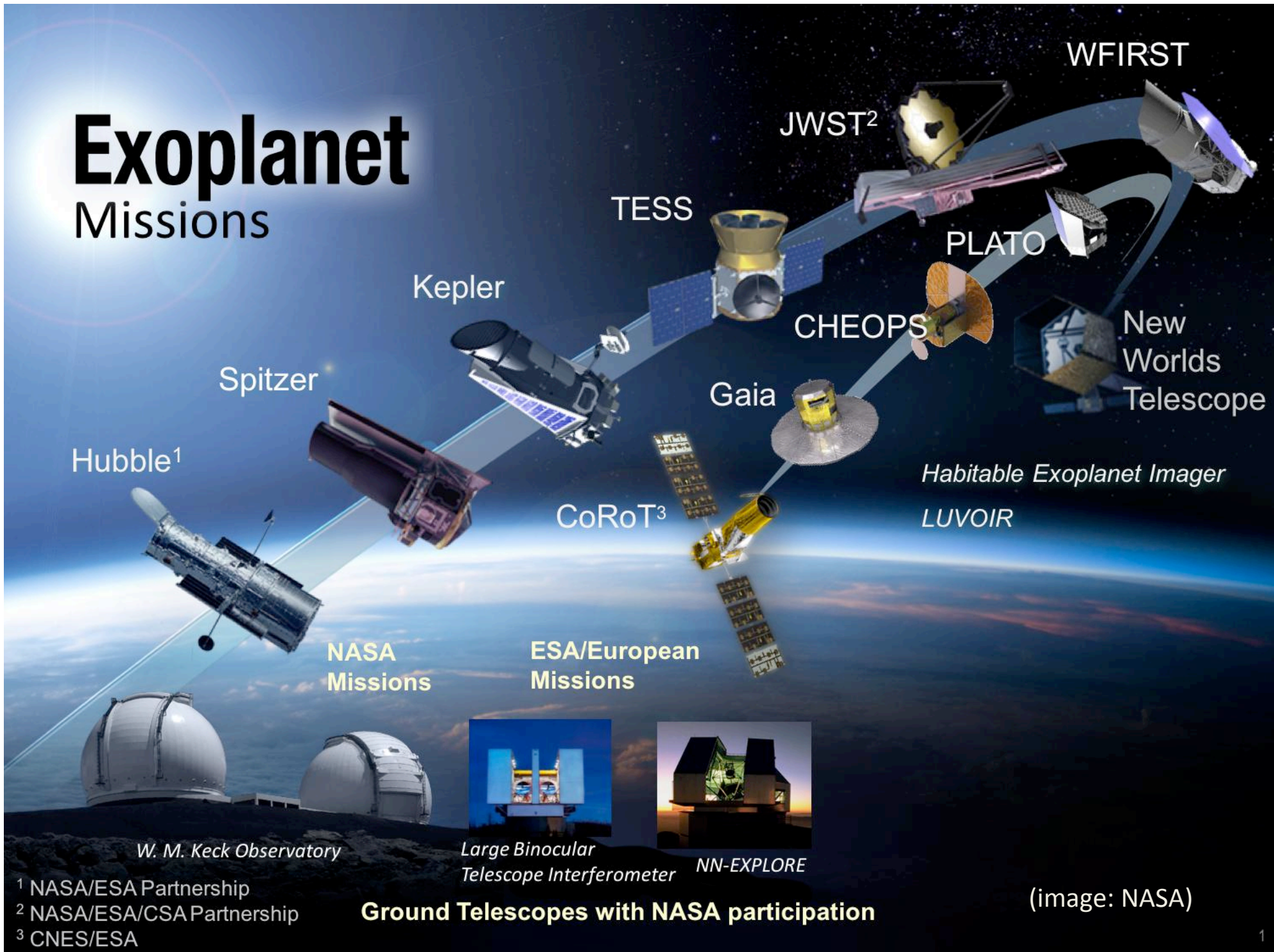
Alpha Centauri AB

- **Kepler, HARPS, WASP, Corot, OGLE, PLANET, Trappist, etc.**
- **Next: TESS, CHEOPS, PLATO, ...**

Proxima b

(image: ESO/M.Kornmesser)

Exoplanet Missions



Hubble¹

Spitzer

Kepler

TESS

JWST²

WFIRST

PLATO

CHEOPS

Gaia

New Worlds Telescope

CoRoT³

Habitable Exoplanet Imager
LUVOIR

NASA Missions

ESA/European Missions

W. M. Keck Observatory

Large Binocular Telescope Interferometer

NN-EXPLORE

¹ NASA/ESA Partnership
² NASA/ESA/CSA Partnership
³ CNES/ESA

Ground Telescopes with NASA participation

(image: NASA)

Exo-planets

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Proxima Centauri

Alpha Centauri AB

- **Kepler, HARPS, WASP, Corot, OGLE, PLANET, Trappist, etc.**
- **Next: TESS, CHEOPS, PLATO, ...**

- Need for Radial velocities in 1 – 10 m/s range

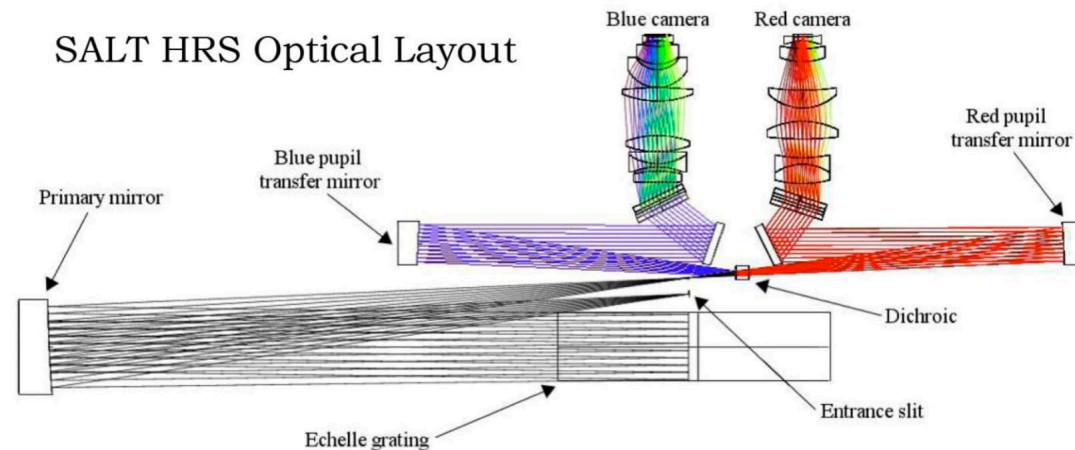
ESPRESSO, Carmeneres, Spirou, NIRPS, HRS, etc. ...

Proxima b

(image: ESO/M.Kornmesser)

HRS: High Resolution Spectrograph

- Low Resolution (LR)
 - $R \sim 14000$
- Medium Resolution (MR)
 - $R \sim 40000$
- High Resolution (HR)
 - $R \sim 65000$



- High Stability Mode – same as HR, but with highest wavelength accuracy, *in principle* down to few m/s [[exoplanet science - Laser Frequency Comb](#)]

Pipeline now available! Wavelength calibrated extracted spectra.
Out-of-the box velocity accuracy <200 m/s for all modes.



Exo-planets

“Cosmology has driven the construction of big telescopes for the past 100 years. The search for life will drive the construction of big telescopes for the next 100 years” - Chas Beichmann

Already have this - just need to
make it work for us!

- Keck, TESS, HARPNET, Trappist, etc.
- New Horizons, PLATO, ...
- Need for Radial velocities in 1 – 10 m/s range
ESPRESSO, Carmeneres, Spirou, NIRPS, HRS, etc. ...

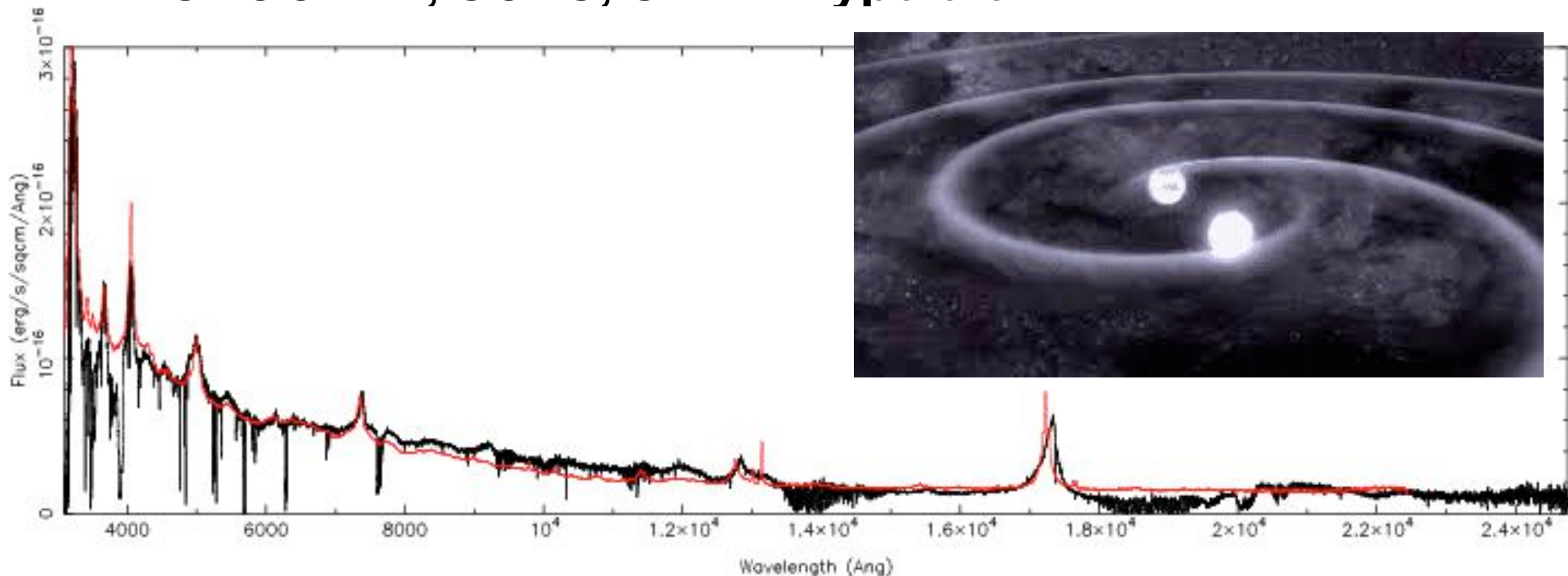
Proxima b

(image: ESO/M.Kornmesser)

Transient science needs



- panSTARRS, ePESTO, ZTF, **LSST**, MeerKAT/LICHT, SKA, GAIA, **LIGO**, etc. Huge astrophysical range, incl **Grav. Waves**
- need: Fast, simple, high-throughput, large wavelength range, modest resolution, single or multi-object.
- **XSHOOTER, SOXS, SPRAT-type etc.**



Transient science needs

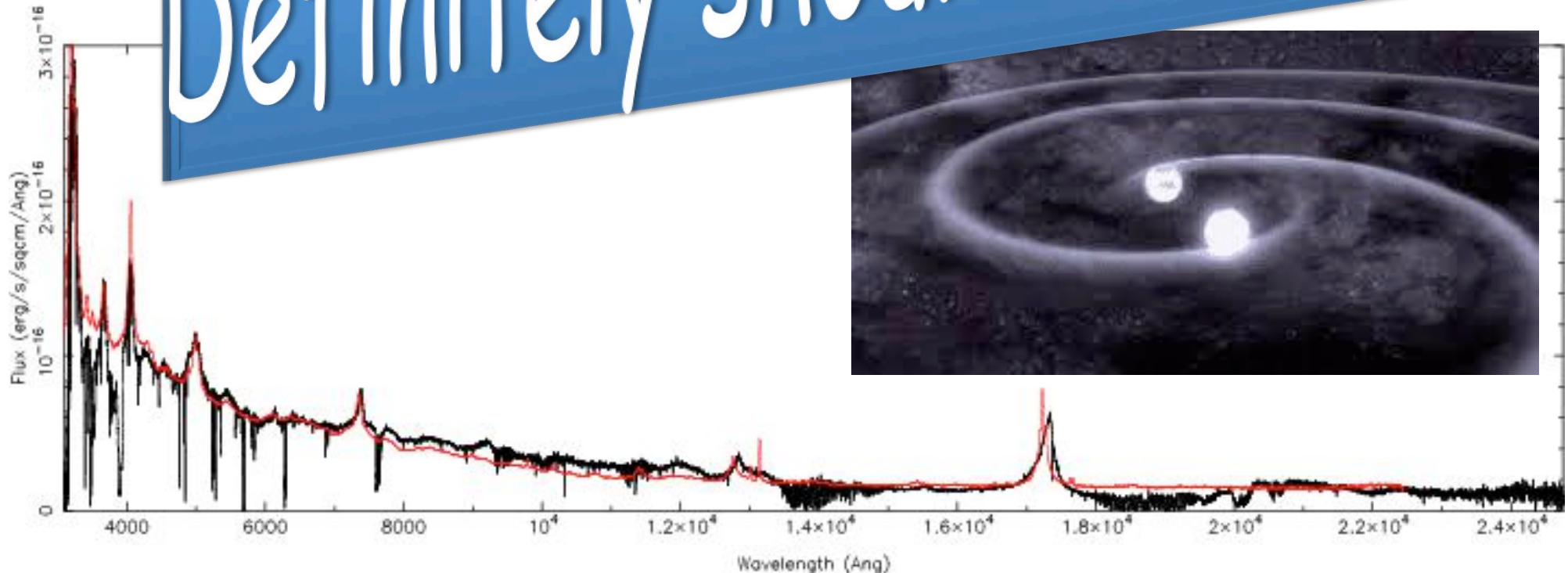


- panSTARRS, ePESTO, ZTF, **LSST**, MeerKAT/LICHT, SKA, GAIA, **LIGO**, etc. Huge astrophysical range, including **GRBs**

- need: Fast, simple, high-throughput, wide-field, medium-resolution spectroscopy

- X

Definitely should discuss





This is our remarkable asset !!



Sutherland Telescopes

(our own or guest, many with SA access)

SALT ; 1.9 m ; 1.0 m ; Lesedi

imaging, med/high-R spect., high speed modes, MOS, FP, im/spec polarimetry, wide field imaging

IRSF

Bison

SuperWasp

MONET

KELT

Las Cumbres

SOLARIS

KMTNet

MASTER

SANSA

Japanese 1.4 m IR imaging / polarimetry

UK solar telescope

UK exoplanet search

German 1.2m planet search & teaching

USA exoplanet search

USA 3x 1m optical robotic

Poland 2x 0.5 m exoplanet search

Korean 1.6 m 2° field exoplanet search

Russian 2x 0.45 m transient search

South Africa space debris, atmosphere

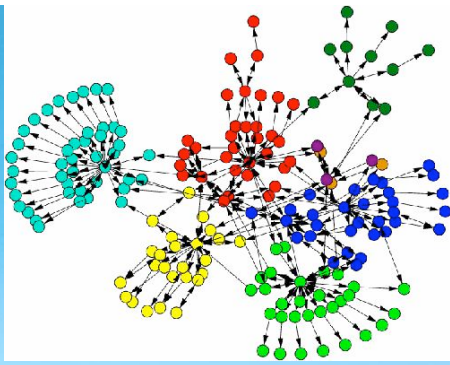
PRIME

MeerLICHT

1.8m Japanese, very wide field NIR, spect (?)

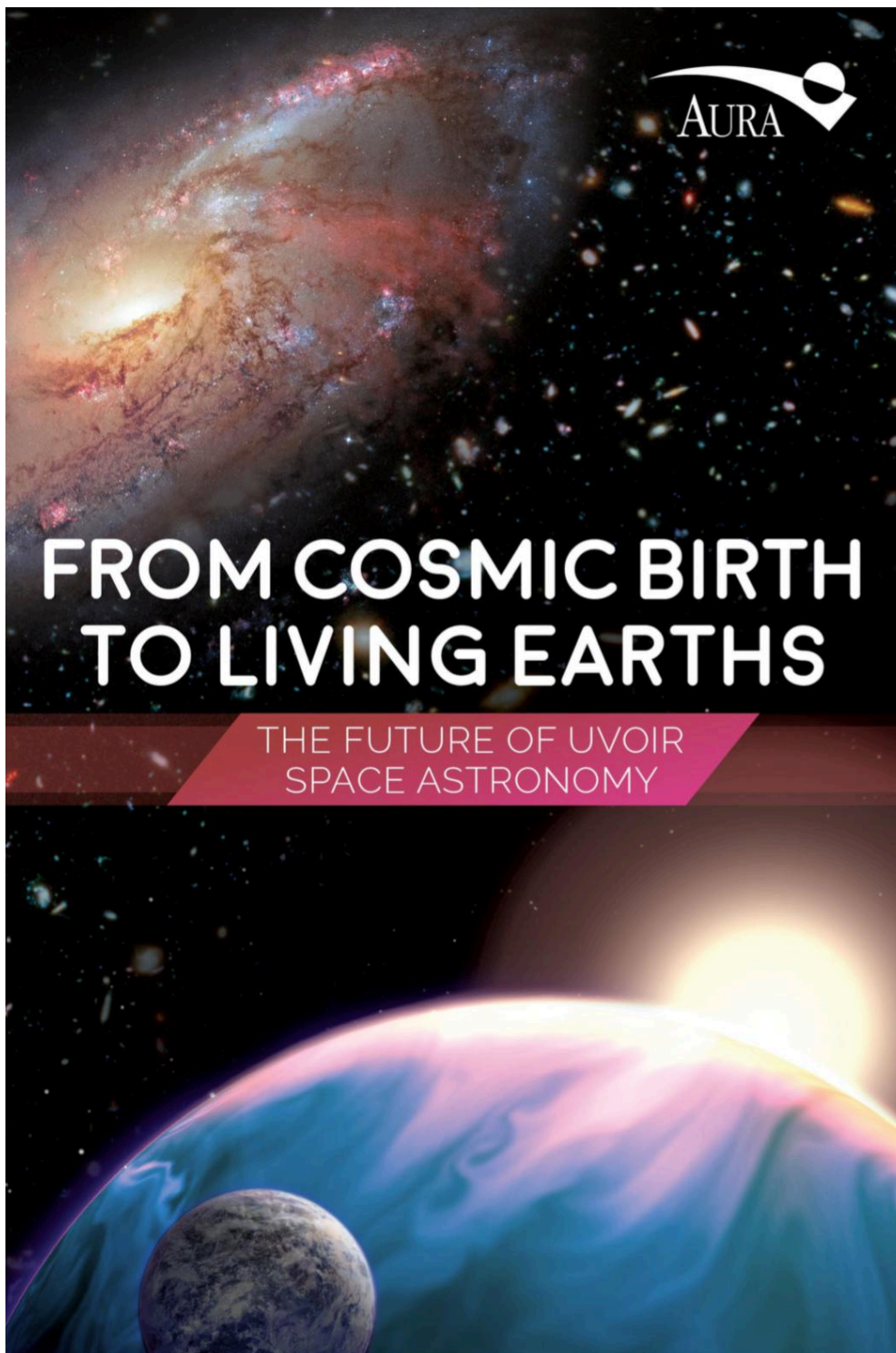
0.65m slaved to MeerKAT





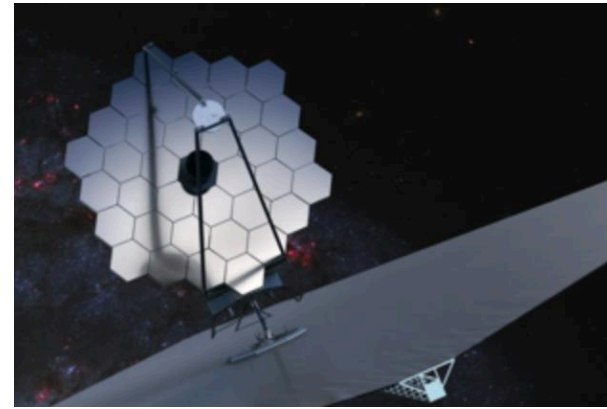
Make the whole mountain top a
Giant Transient (follow-up) AI machine !!



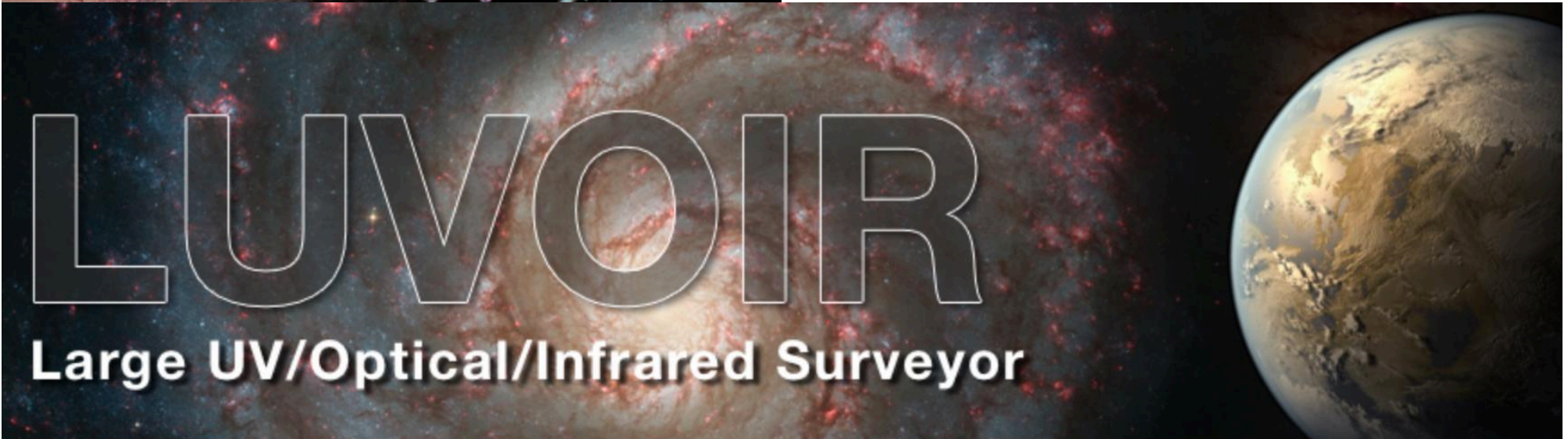


[A space interlude ...]

Dalcanton et al. arXiv:1507.04779



**12–16-m
space tele-
scope (!)**

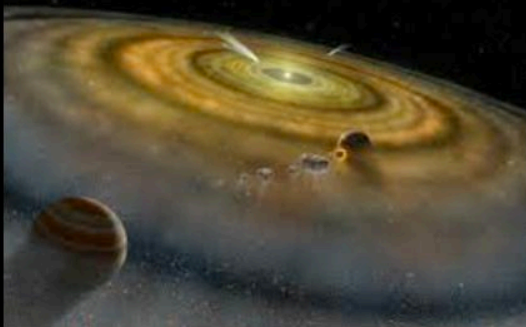


<https://asd.gsfc.nasa.gov/luvoir/>

Dalcanton et al. arXiv:1507.04779

Why are we better together?

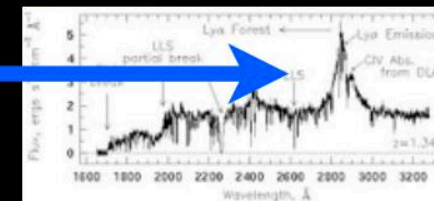
Exoplanets



Highly compelling
top-line science
message

Large, diverse
community
guaranteeing on-
going science
innovation

Astrophysics



(slide courtesy:
J. Dalcanton)

Possible LUVOIR Lessons

- The “killer app” concept.
“*Sutherland, the ultra-fast peak of intelligence*” ??
- Any other science directions we should consider ?



Other final comments

- Make our science output world-class and forward-looking.
We will fail unless we do relevant and top notch science ourselves (but note we can choose the way we do it)
- Students and post-docs. Exposure to major developments.
More exchange and trips.



Other final comments



Other final comments

- Make our science output world-class and forward-looking.
We will fail unless we do relevant and top notch science ourselves (but note we can choose the way we do it)
- Students and post-docs. Exposure to major developments. More exchange and trips.
- Take instrumentation seriously – effort and investment. Skills. If *WE* build a science-driven instrument, *WE* will get the cream from the top, the most exciting results.
- Think of ways to be more relevant in the SA society.



Conclusions

SALT is working well. Spread the news. Just Use It.

SALT is the most cost-effective large telescope science producer in the world

In the process of thinking future strategy, aligning both SALT and SAAO goals and purposes to be competitive in the 2020s

Transients ?

IFU science ?

Instrumentation ?

Exoplanets ?

Time to still come up with ideas !



plus lots of collaborations and great science !

