WP3 Astrophotonics

OPTICON Board Meeting
Como, Oct. 16, 2012

Martin M. Roth
innoFSPEC Potsdam at AIP,
Universität Potsdam

Overview:

1. Why Astrophotonics ?
2. Roadmap 2013-2016
3. R&D Examples
4. Conclusions

1. Motivation

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European Commission

Blog of Neelie KROES

Vice-President of the European Commission

European Commission > The Commissioners (2010-2014) > Neelie Kroes > Blog

« Previous post | Blog | Next post »

Photonics – a great example of EU research in action

March 28th, 2012 | Number of views :6498

Maybe you haven't heard of Photonics? Or maybe you just think it's something they might use to kill the bad guys in Star Trek? In fact, it's not just real, it's an incredibly important field of technology.

RECENT POSTS

- Transforming our society through great innovations, "Made in Europe"
- A digital Europe needs digital investment
- Making Europe cloud active
- Better investment = better innovation: a radical shift for EU research in ICT
- Finding tomorrow's technology – European scientists hit the headlines

SEARCH

Search

In **manufacturing**, for example, lasers can create new processes that lead to extraordinary high quality: faster, more accurate **"zero fault" production**, and products that are lighter or easier to customise.

In healthcare, photonics sensors could allow very early and very accurate **detection of diseases like cancer**: sometimes even before there are any symptoms. And that could ultimately mean treatment that is both more effective and less invasive.

And photonics technology can also be used in **lighting for the home, office or street**: lighting that is easier to operate and control, more pleasant, and consuming less energy.

Indeed the benefits of so-called "solid state lighting" are so important that we've just consulted on the best way to stimulate this market in the EU. I am also looking at the offer to get better lighting into my office. And to show just what it can do, for example to policy makers passing through Brussels, we're looking to use solid state lighting **to light up the European Commission HQ in Brussels** as a demonstration.

What's more, this is an area where Europe is strong and leads in many key sectors: the **EU supplies about 21% of the global market worth around €300 billion**. And it's not just about big business either – there are around 5000 European small- and medium-sized companies active in photonics.

No wonder Photonics has been identified as one of the **"Key Enabling Technologies"** within our proposal for the future of EU research funding.

It was my great pleasure to **meet some of the representatives of the industry today** and outline again why their work is so important. Over the last year, they've been responding very actively and constructively to my call to have an ambitious public-private partnership in photonics that really delivers opportunities, growth and jobs for Europe. And now I hope that we will be able to launch this next year. They also told me about some of the great initiatives going on to bring photonics to Europe's schools – like the Photonics Explorer.

Continuing this investment in photonics technology – including launching this PPP – is just one of the things that would be possible once the European Parliament and Council **agree on our proposals for Horizon 2020**, the future of EU research funding. So I'll be continuing to work with them to ensure that we can indeed safeguard European research and innovation in this and other areas over the next funding period.

However, like many other sectors the potential of the photonics industry is currently limited by the so called "Valley of Death" in the innovation value chain. Giorgio Anania states that "photonic innovation in Europe tends to fall through in the stage between successful science and pilot scale industrial deployments, the latter being the stage at which jobs can start being created."

The founding of a Photonics PPP would address these concerns and brings to fruition the recommendation of the recently published KET High Level Group report which calls for forward-driven and long-term strategies involving all stakeholders – private and public – at European, national and regional levels. By building and strengthening bridges between scientific excellence and innovative production the PPP will result in the creation of an additional 70,000 – 100,000 jobs in the photonics industry leveraged to 350,000 to 600,000 new jobs for European industry overall. "What we expect from such a PPP", Anania said, "is to secure a long-term commitment from both the private and the public sector to investing in photonics research and innovation and thereby creating jobs and economic growth in Europe."

March 28, 2012

iPhone
9:41 AM
Messages
Calendar
Videos
Maps
Photos
Notes
Reminders
Weather
Camera
Newsstand
Clock
Passbook
Settings
iTunes
App Store
Stocks
Game Center
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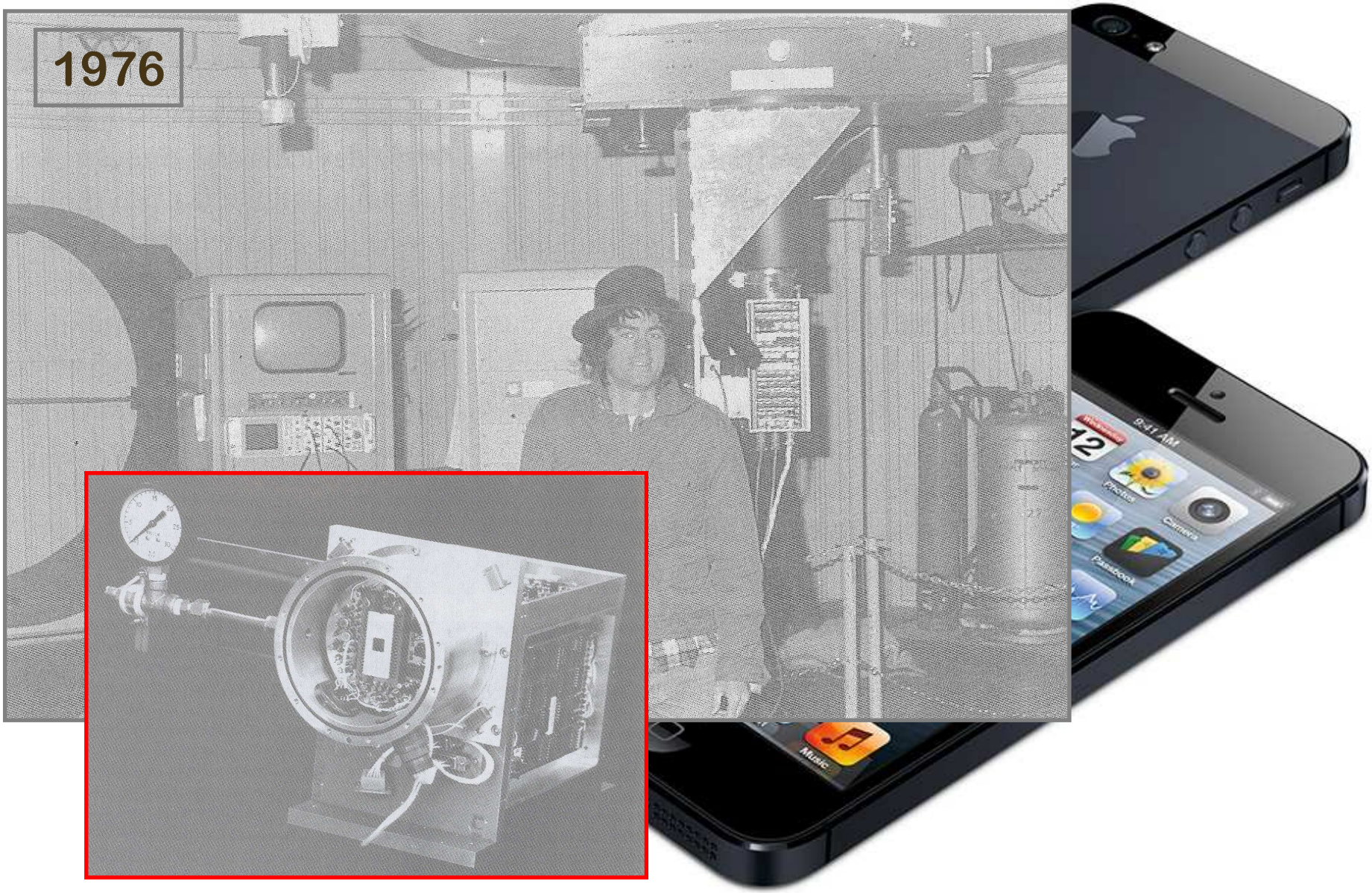
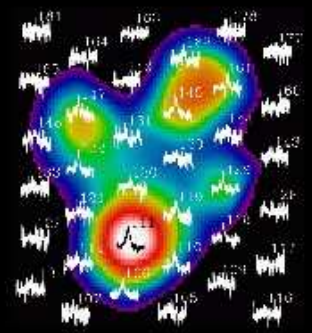
Mail
Safari
Music

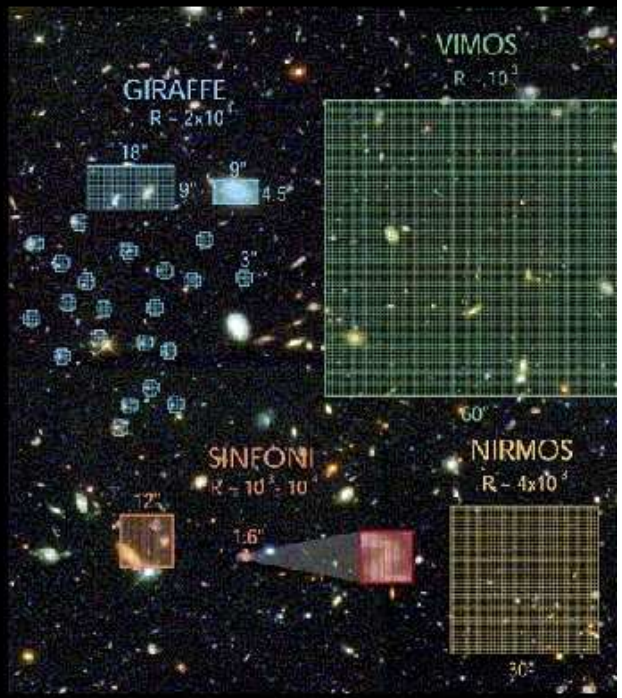

1976

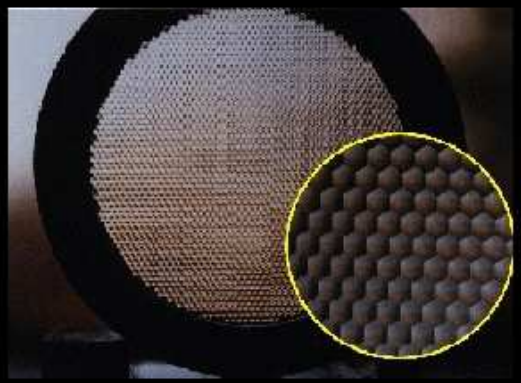
Euro3D

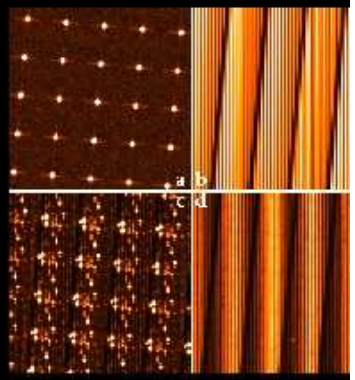
"Promoting 3D Spectroscopy in Europe"

A Research Training Network
funded by the European Commission









- *11 partner institutes with access to all major integral field spectrographs in Europe*
- *broad range of research programmes (projects covering 7 topics from stellar to extragalactic astronomy, and cosmology)*
- *State–of–the–art data analysis software development*
- *Winter School, workshops, secondments, and other training activities*
- *10 postdoc positions available, starting July 1, 2002*

Contact:

RTN Coordinator Dr. Martin M. Roth
Astrophysikalisches Institut Potsdam

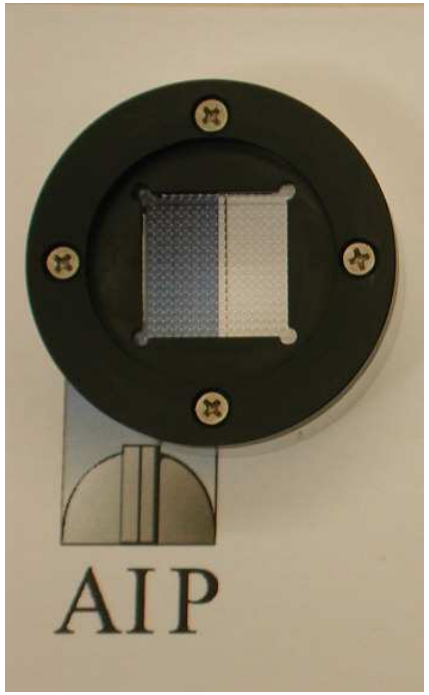
Tel.: +49–331–7499–313 *email: mmroth@aip.de*
http://www.aip.de/Euro3D

http://www.aip.de/Euro3D/

MUSE + KMOS,
2nd Generation VLT Instruments

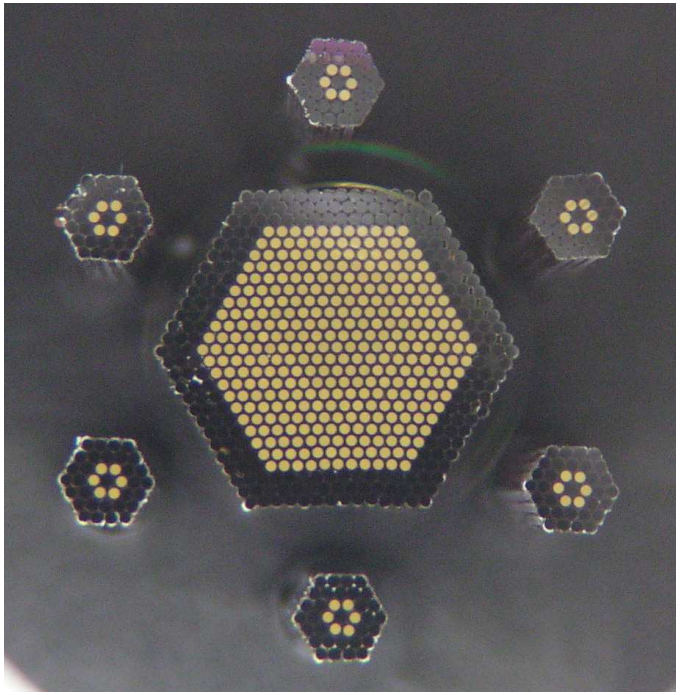
Integral Field Spectroscopy : the thorny road of innovation…

LARR IFU



8 arcsec

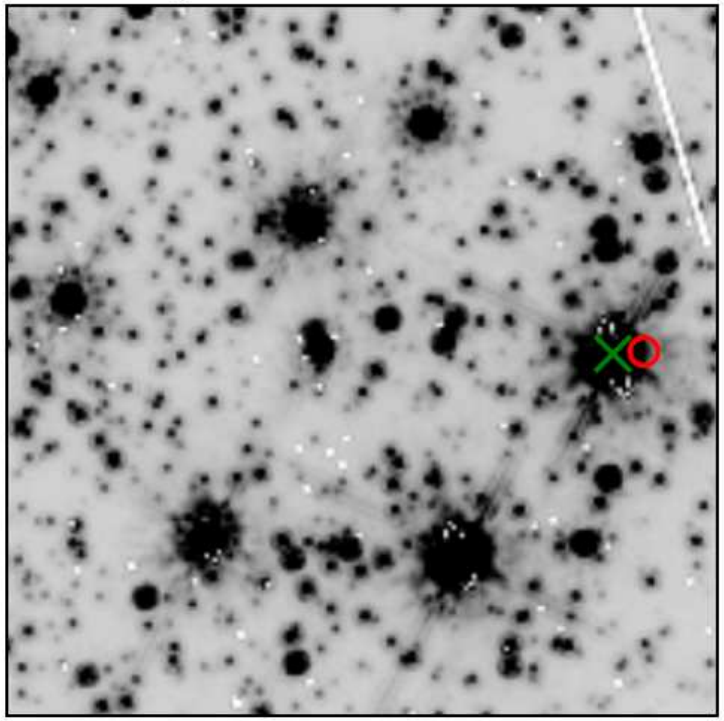
PPak IFU



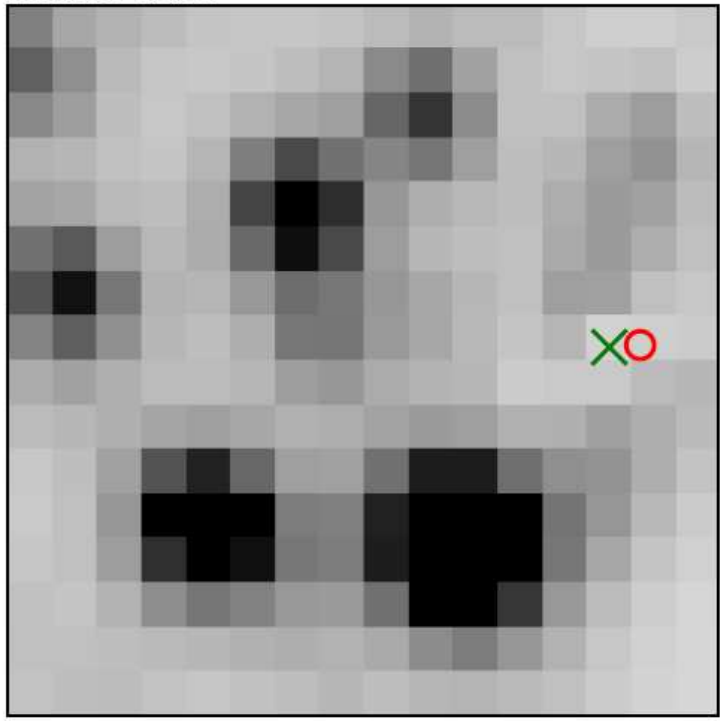
74 arcsec

PSF-fitting CCD photometry → Spectroscopy !

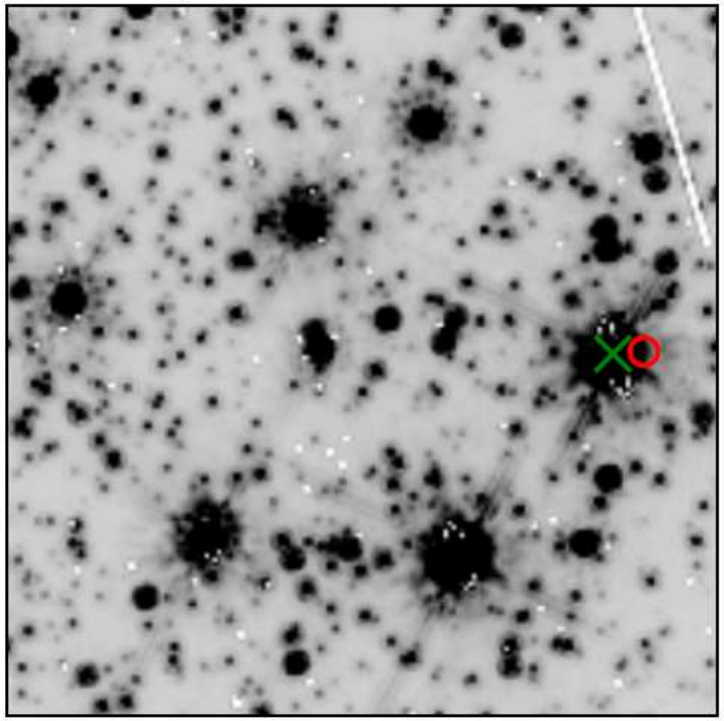
HST image

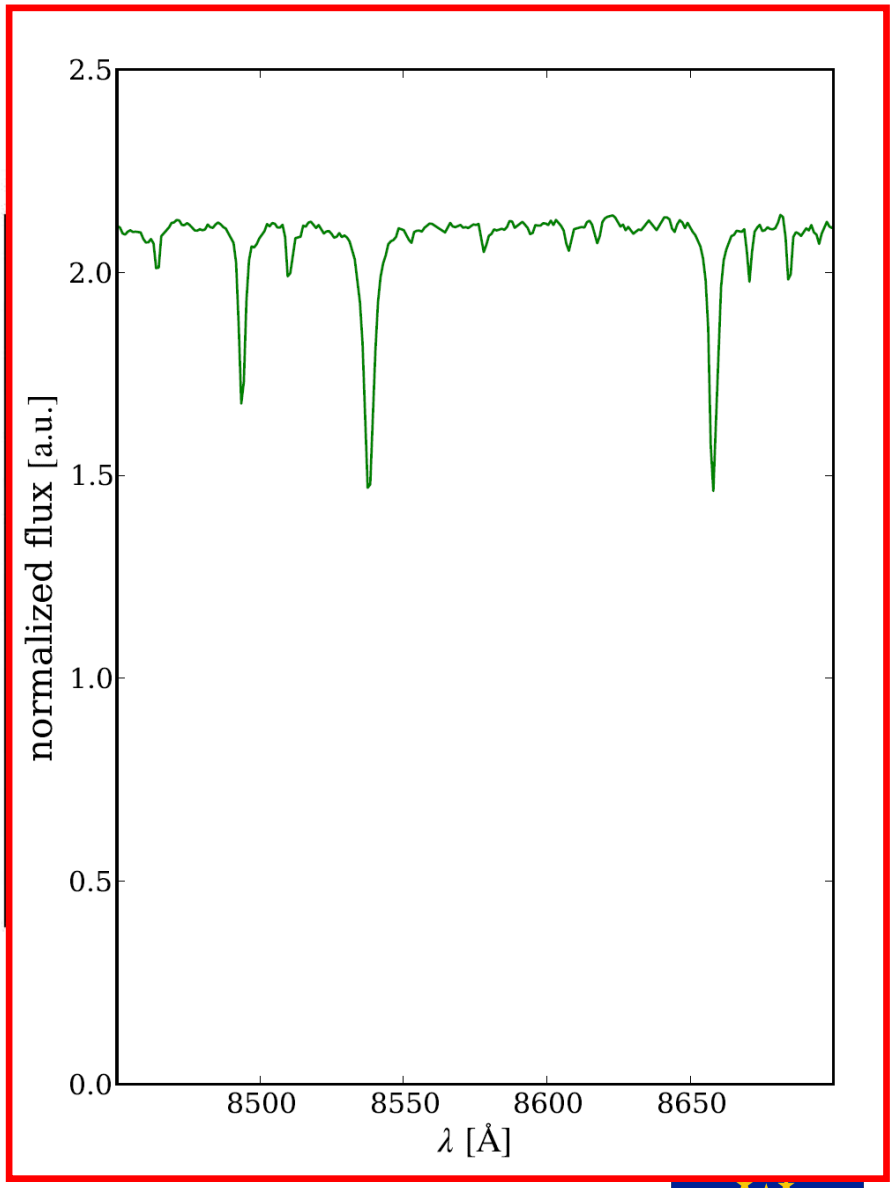


PMAS data



HST image





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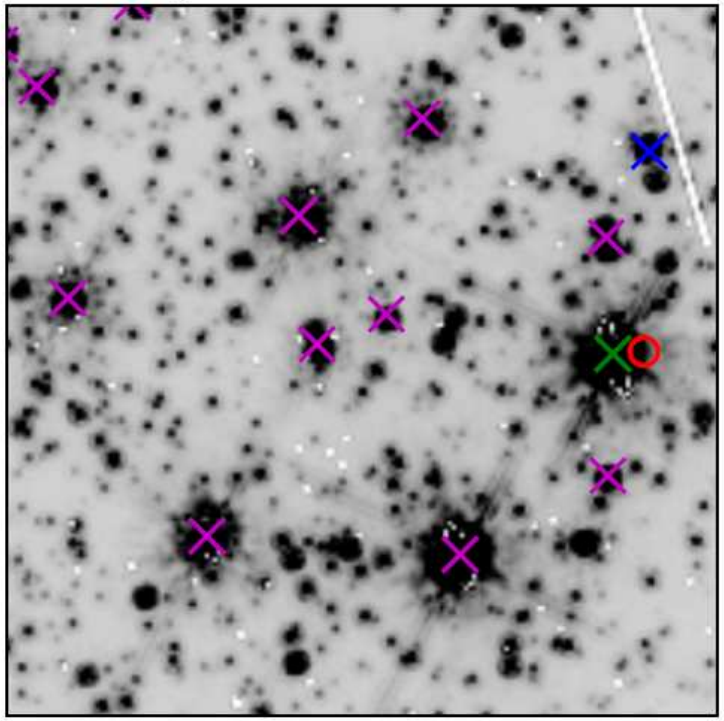
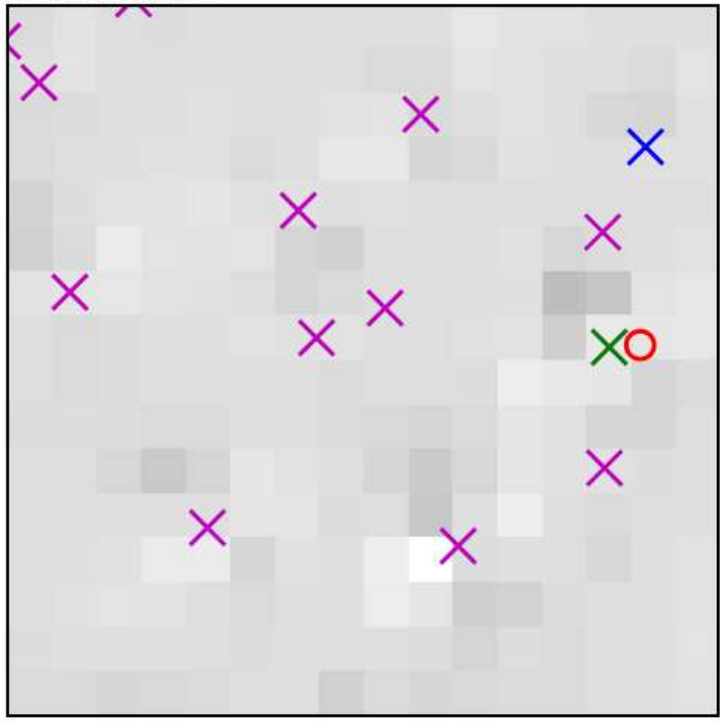


PMAS data



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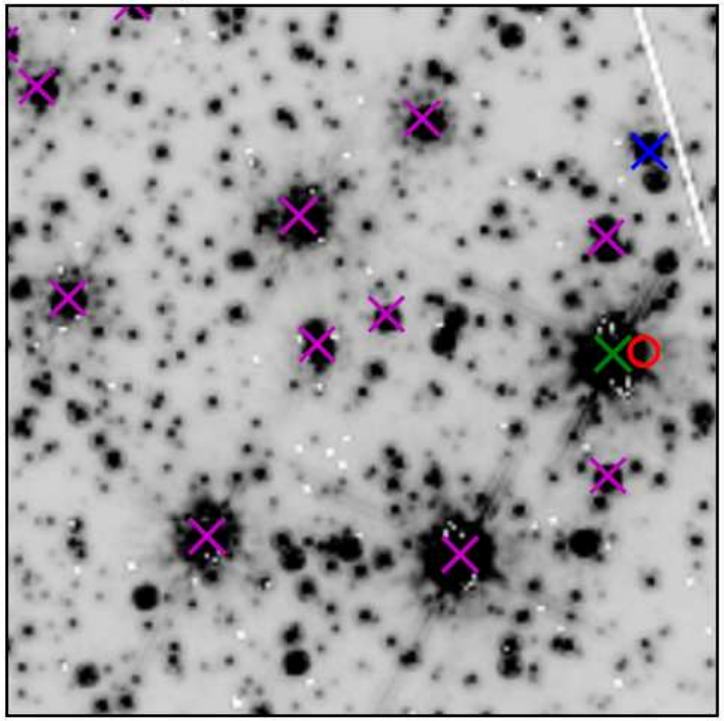
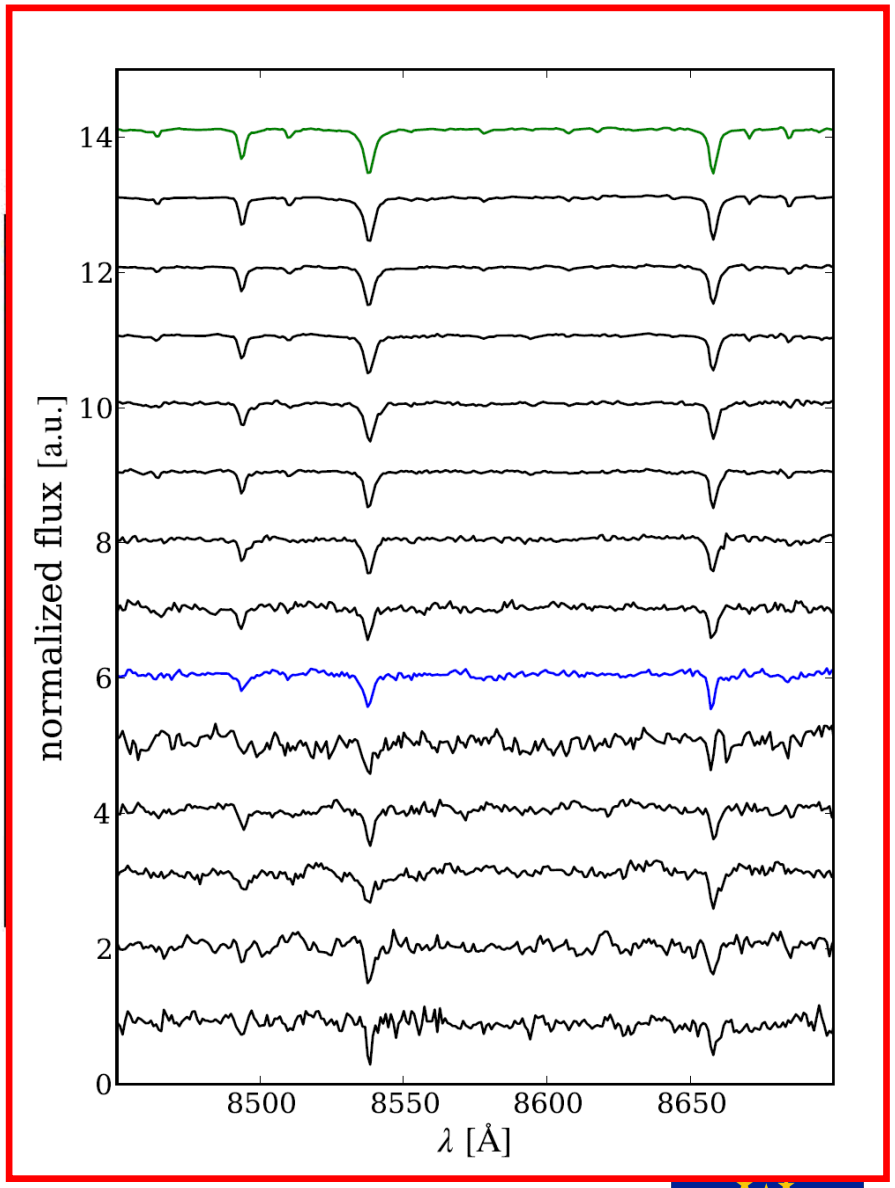
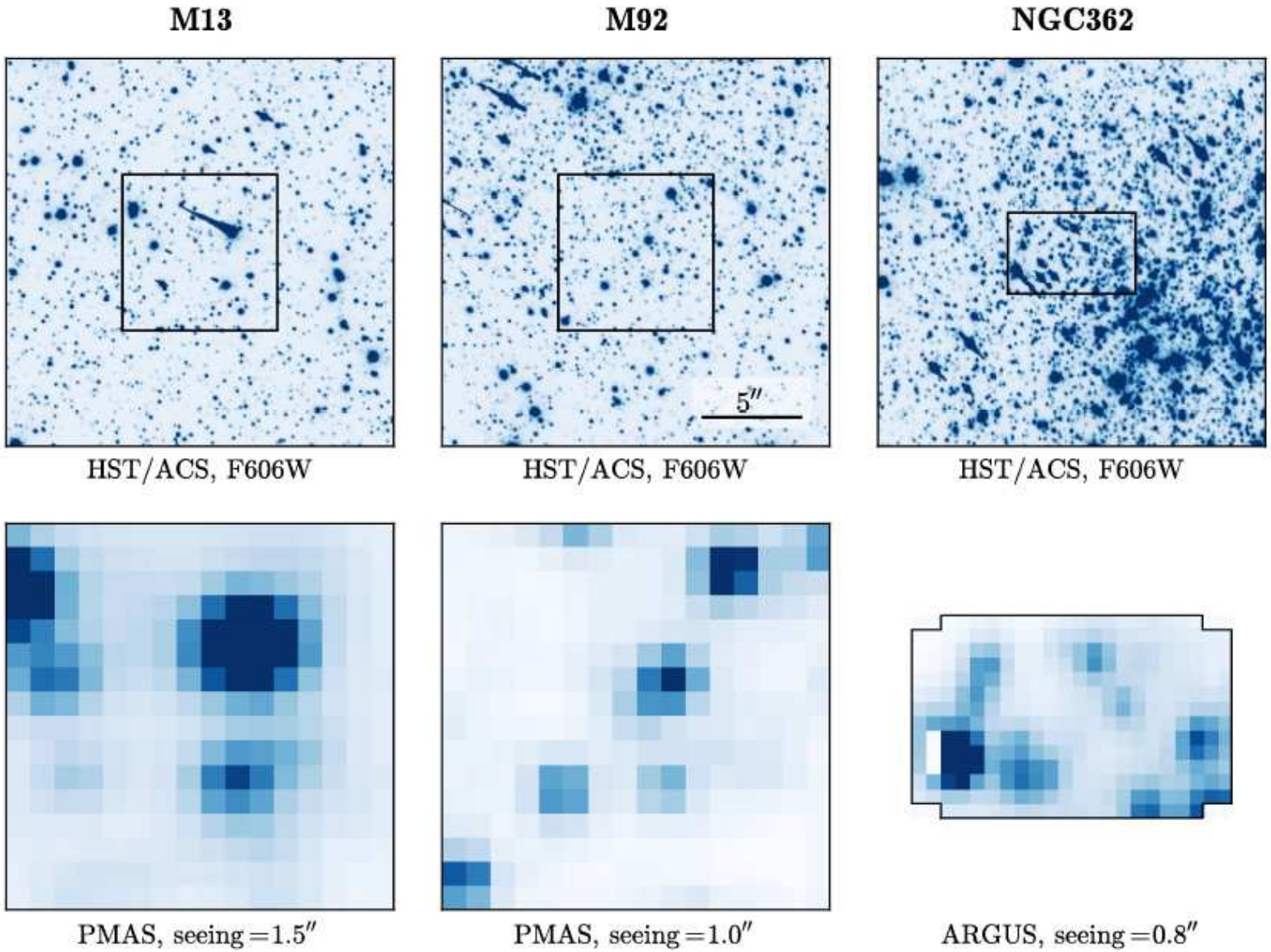


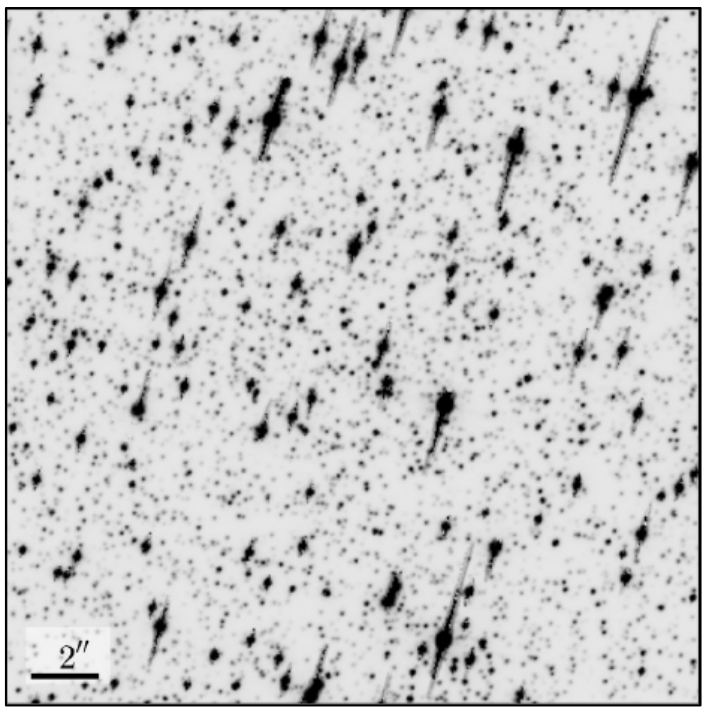


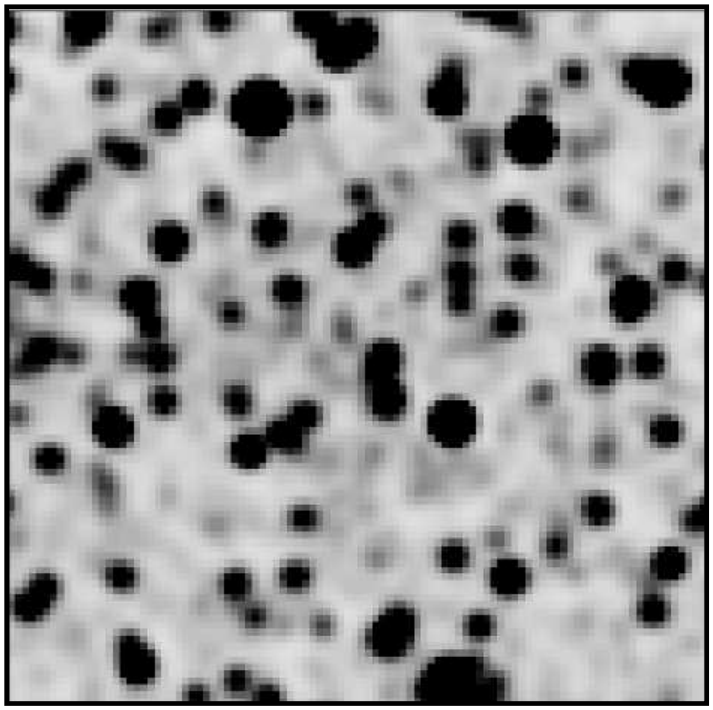


Kamann et al. A&A, submitted

Crowded-field PSF-fitting 3D spectroscopy of globular clusters with MUSE

MUSE „Dry Run“ (Kamann et al. A&A, submitted)

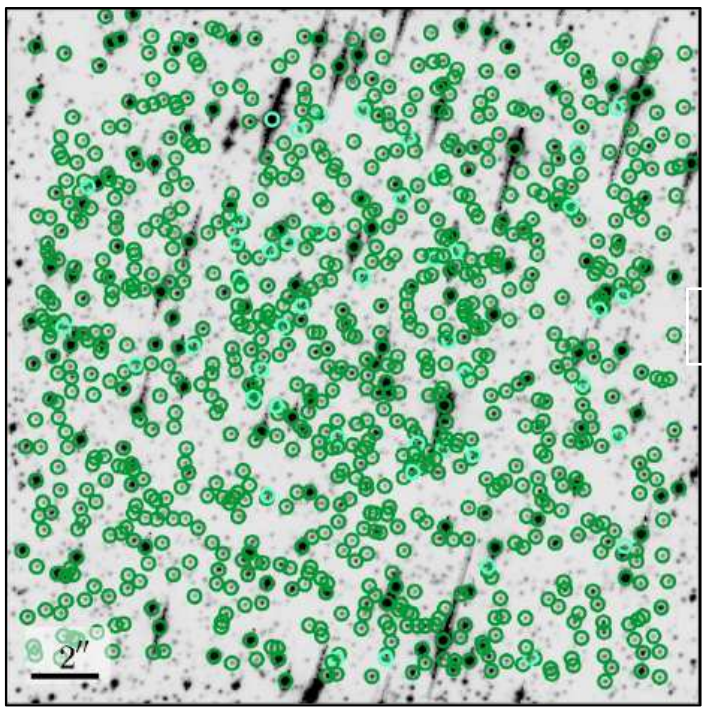


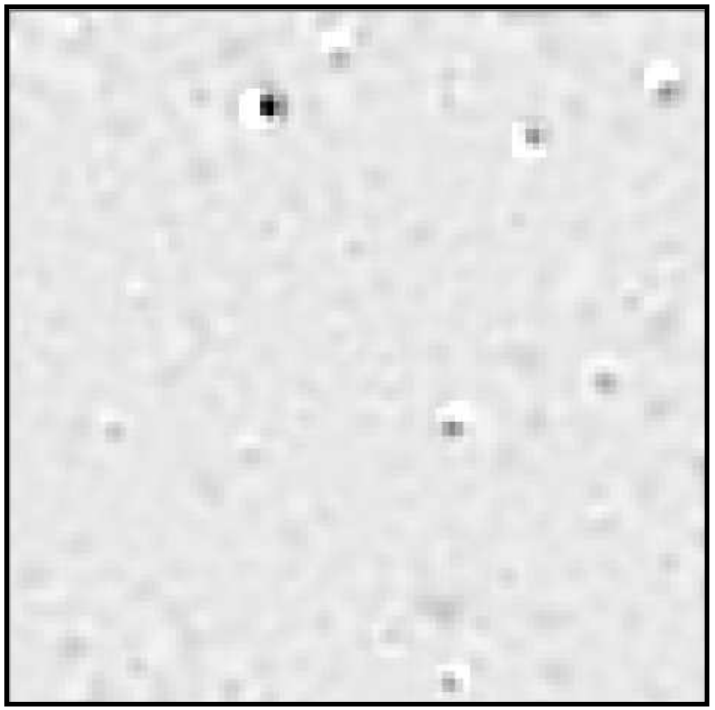


47 Tuc, 36.000 stars from HST

Crowded-field PSF-fitting 3D spectroscopy of globular clusters with MUSE

MUSE „Dry Run“ (Kamann et al. A&A, submitted)





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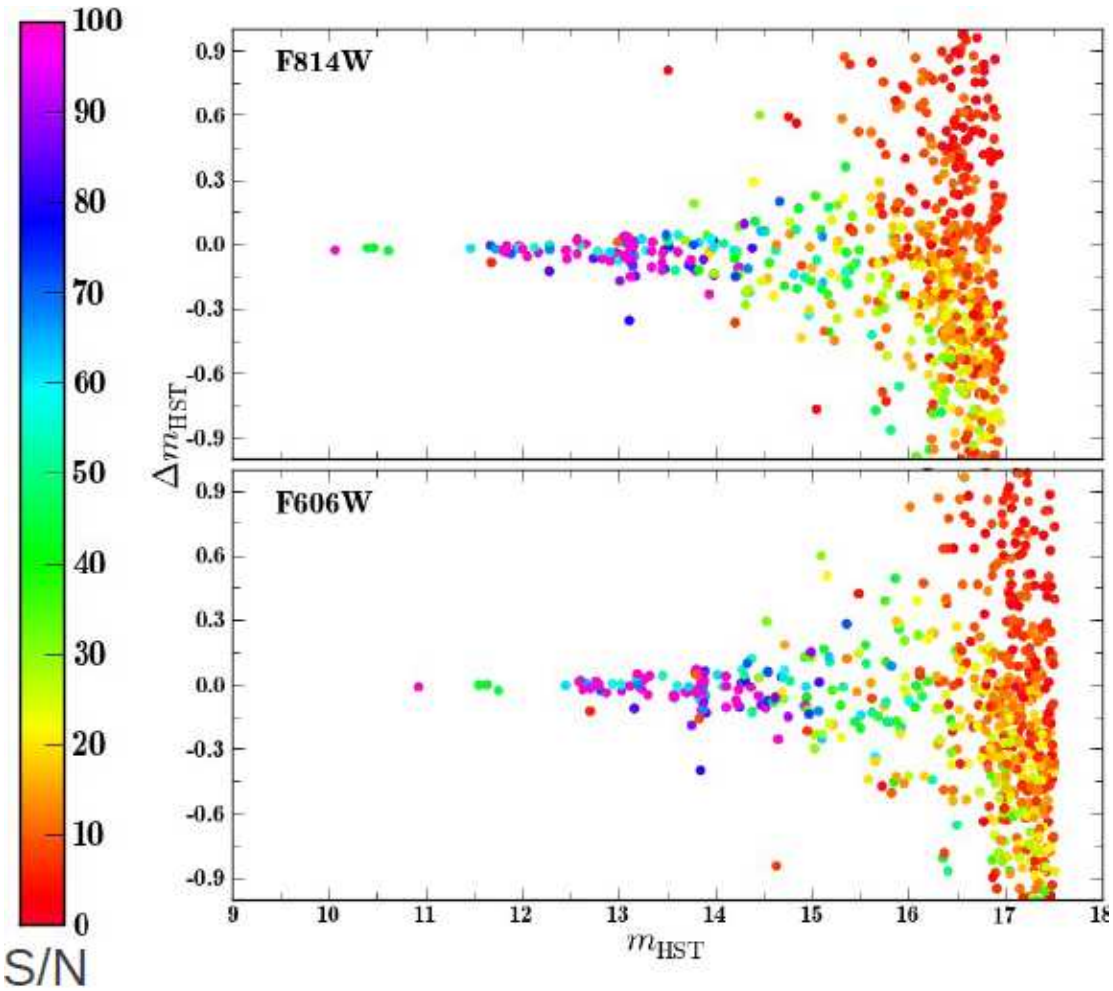


⇒ derive:

- T_{eff}
- log g
- Fe/H
- v_{rad}

http://www.caha.es/CALIFA/

CALIFA SURVEY

Calar Altó Legacy Integral Field spectroscopy Area survey

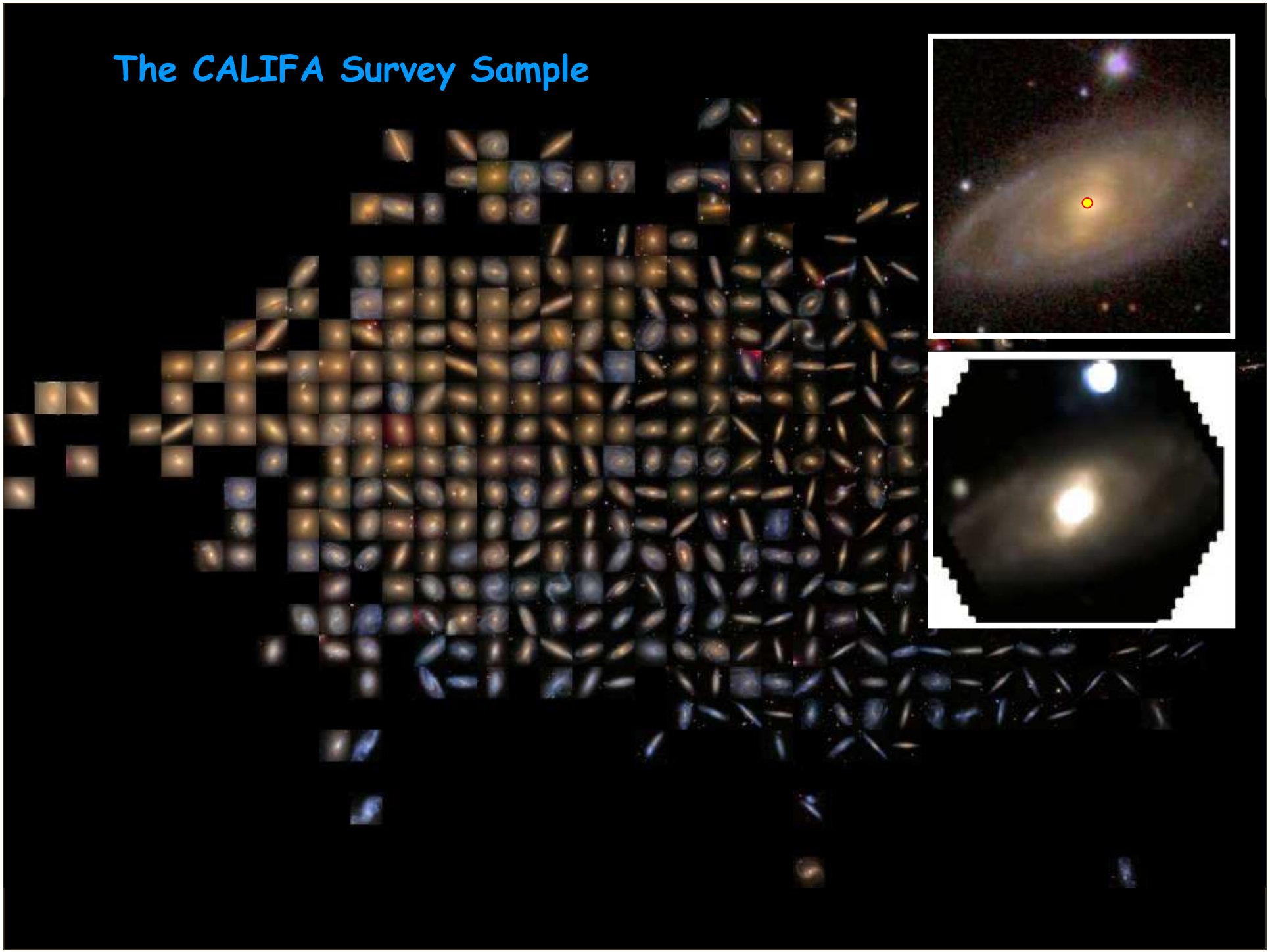
Home | Observed Objects | News | Publications | Contact | Next Events

- CALIFA Summary
- CALIFA Red Book
- CALIFA Collaboration
  - Members
  - Structure
  - Publications
- News
  - News
  - Next Events
- CALIFA Sample
  - Observed Objects Up-to-Date
  - SDSS Poststamps: Obs. Sample
  - SDSS poststamps: Full sample

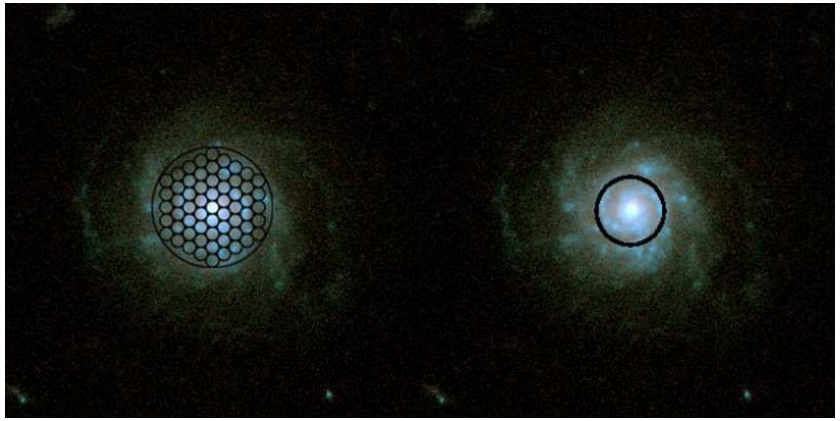
SUMMARY OF THE PROJECT

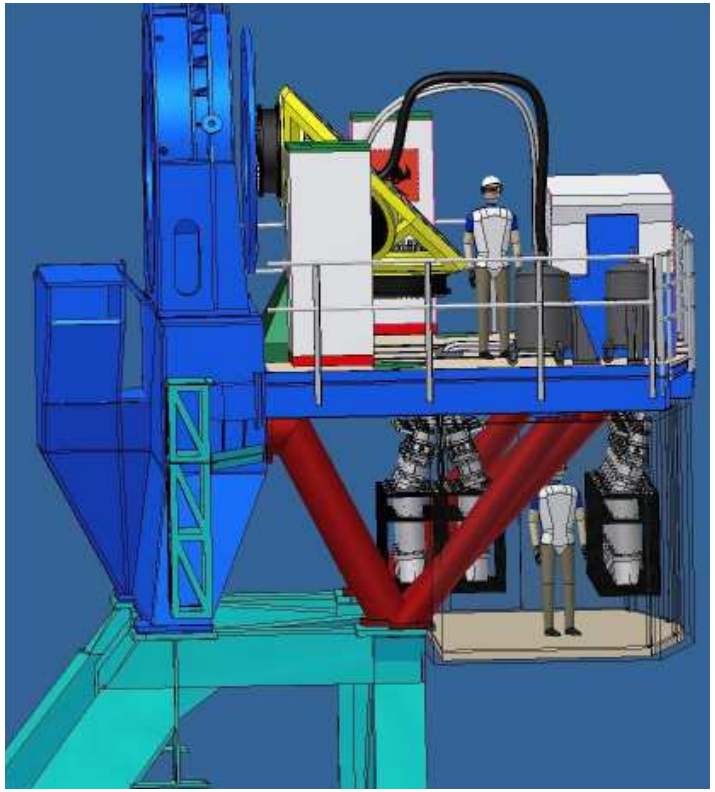
The Calar Alto Legacy Integral Field Area Survey (CALIFA) is observing a statistically well-de
galaxies in the local universe using 250 observing nights with the PMAS/PPAK integral field spect
on the Calar Alto 3.5 m telescope. CALIFA will make its reduced data public as soon as their qual
data reduction pipeline has been verified.
Our survey will provide the largest and most comprehensive wide-field IFU survey of galaxie
addressing fundamental issues in galaxy evolution. The two-dimensional spectral maps obt
well-defined sample will allow for example to 1) extend the kinematic classification of galaxies
sequence using a homogeneous dataset, 2) study the ISM over entire galaxies and a large samp
insights on the importance of AGN, star formation, shocks and old stars as ionization sources, 3) s
in the outskirts of disk galaxies to assess the importance of star formation vs. radial migratio
aperture corrections for the much large single-fiber surveys, such as SDSS, 5) derive stellar pop
and metallicity to constrain the formation mechanisms of early- and late-type galaxies alike. As th
we expect more exciting science we have not thought about to emerge. CALIFA can also be viewe

The CALIFA Survey Sample



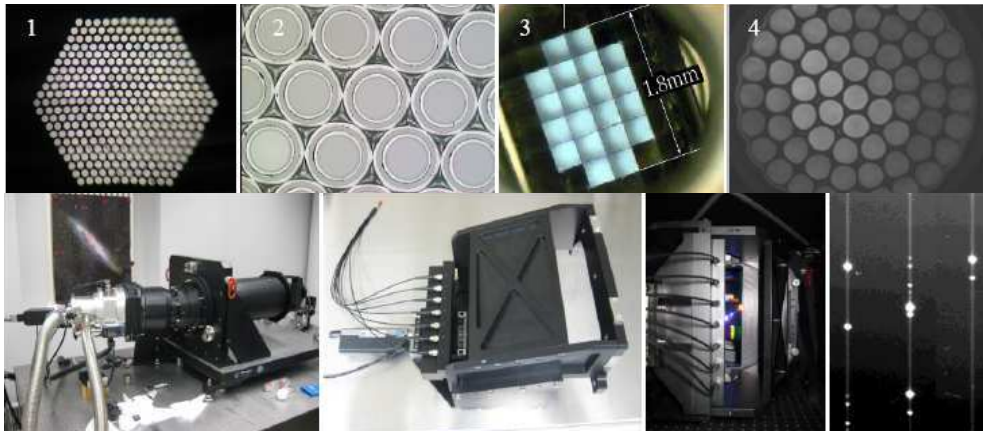
FIREBALL Proposal





FIREBALL Baseline Parameters

- FLAMES OzPoz patrol field with 26’ diameter FoV
- 90 hexabundle IFUs, each with ~5” diameter FoV
- Hexabundles: 61 fibres, 0.6” projected fibre core diameter
- 6 spectrographs, adapted for fibre-feed, R~1200-2100
- free spectral range: 430-850nm (goal: blue extension)
- total throughput goal: 30%
- sensitivity: R ~19.8 survey limit, resulting in 100-160 galaxies per FLAMES field at median z ~ 0.2; typical half-light sizes for disk galaxies 2”-6” diameter
- detector head, NGC CCD controller, vacuum/cooling system adapted from MUSE
- individual spectrograph shutters
- no moving parts other than shutters + fibre positioner
- retain full existing facility and utilise as much FLAMES infrastructure as practical

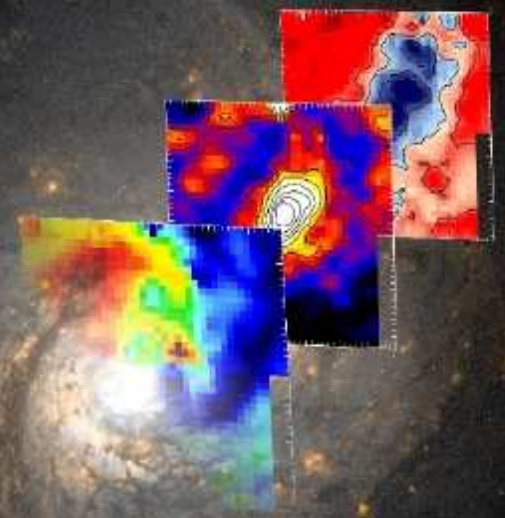


9th Potsdam Thinkshop

Leibniz Institute for Astrophysics Potsdam

innoFSPEC

Innovative faseroptische Spektroskopie und Sensorik



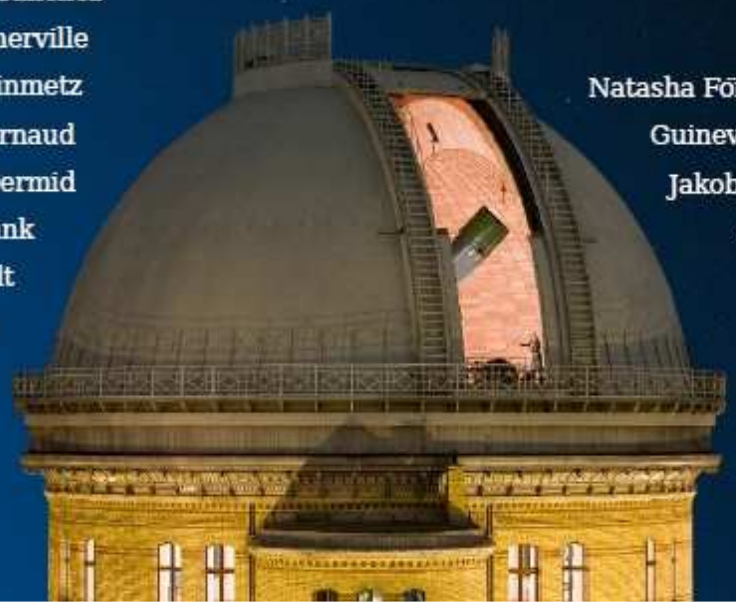
Galaxy surveys using Integral Field Spectroscopy:

Achievements and Opportunities

September 10-13, 2012
http://www.aip.de/thinkshop9

Invited Speakers:

Joss Bland-Hawthorn
Sebastian F. Sánchez
Rachel Sommerville
Matthias Steinmetz
Frederic Bournaud
Richard McDermid
Mark Swinbank
Karl Gebhardt
Göran Östlin
Julia Bryant
Sean Moran
David Law
Rob Crain



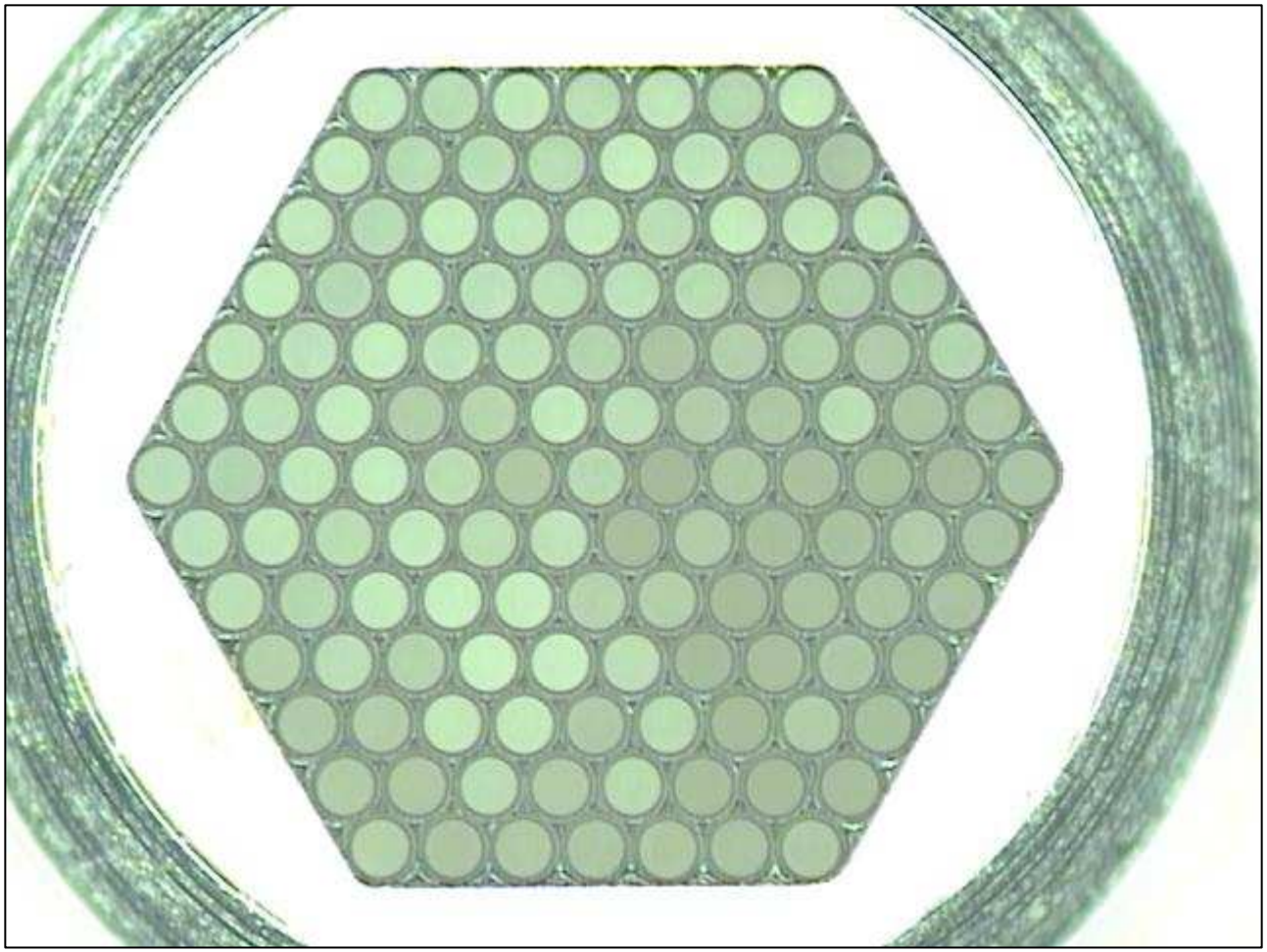
SOC:

Natasha Förster-Schreiber
Guinevere Kauffmann
Jakob Walcher (chair)
Alexei Moiseev
Eric Emsellem
Kevin Bundy
Scott Croom
Martin Roth
Bob Nichol
Gary Hill

Topics covered:

The early growth of galaxies
Galaxy spins and implications for cosmology
Formation and evolution of galaxy disks
The making of dynamically hot components
AGN triggering and feedback
Nearby galaxies at high spatial resolution
Dwarf galaxies
Simulations of galaxy formation
Projects and concepts for large IFS surveys

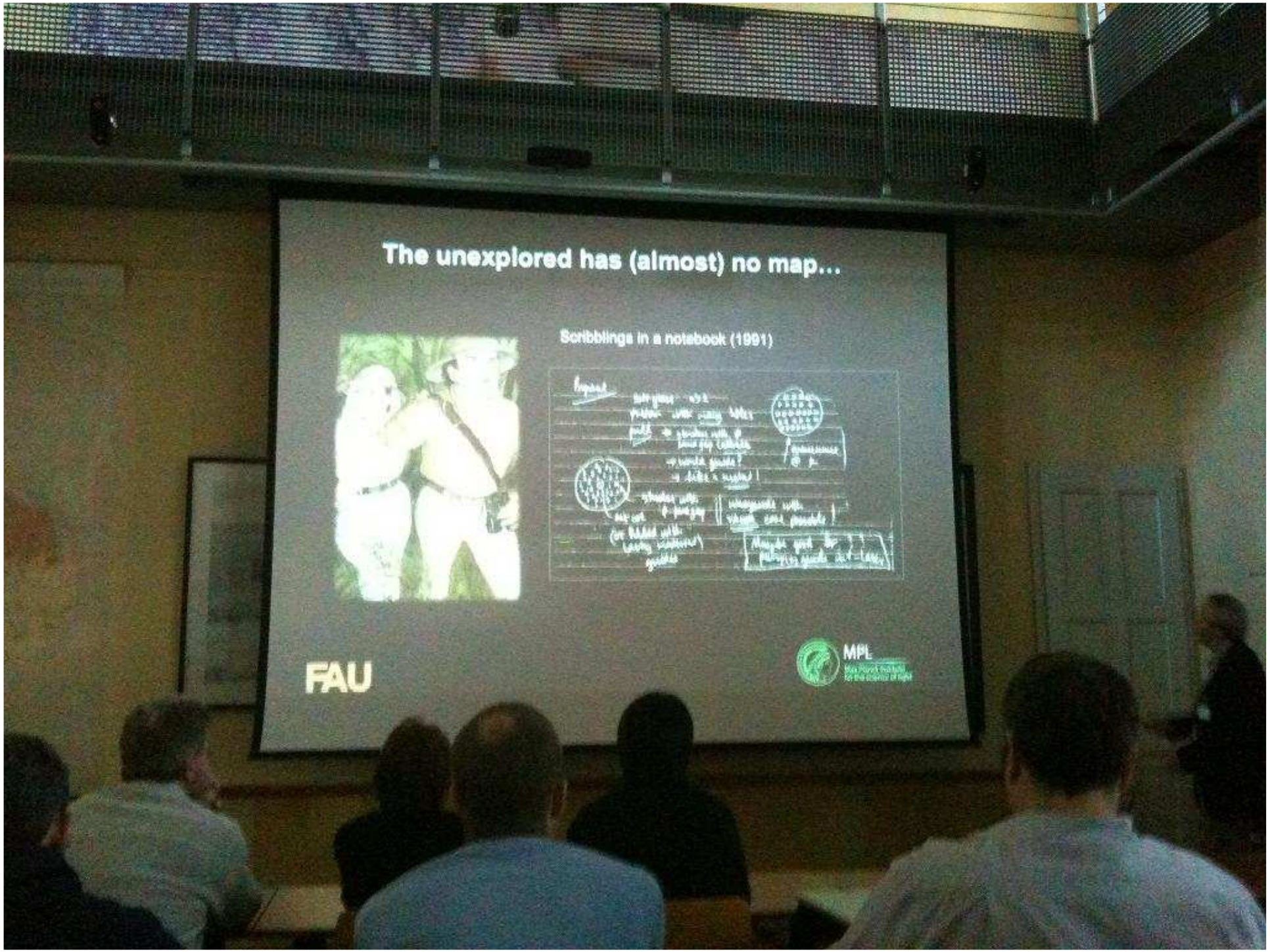
SDSS „AS3“



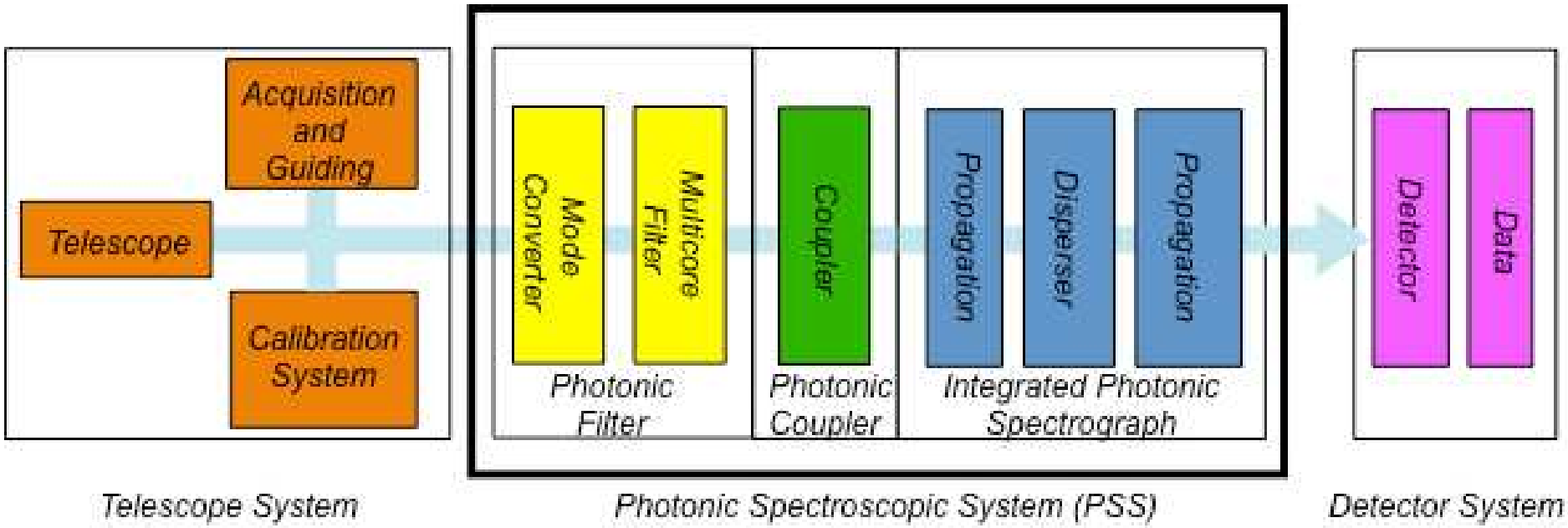
MaNGA Prototype Ferrule (August 2012)

→ Europe may loose the lead !

2. Roadmap 2013-2016

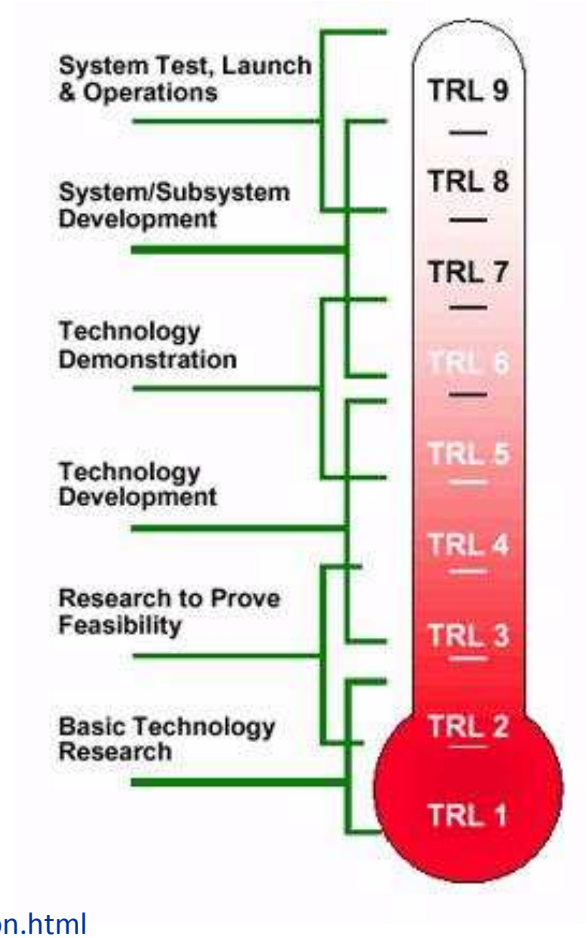

The unexplored has (almost) no map...
Scribblings in a notebook (1991)
FAU
MPL

Work package number	WP 3	Start date or starting event		2013-01-01		
Work package title	Astrophotonics					
Activity type	RTD					
Participant number	19	17	11	23	24	
Participant short name	AIP	UDUR	AAO	HWU	UBATH	
Person-months	24	18	24	12	8	


Acquisition and Guiding
Telescope
Calibration System
Mode Converter
Multicore Filter
Photonic Filter
Coupler
Photonic Coupler
Propagation
Disperser
Propagation
Integrated Photonic Spectrograph
Detector
Data
Telescope System
Photonic Spectroscopic System (PSS)
Detector System

Technology Readiness Level System

Major applications	
Photonic Filters	
Integrated Spectrographs	
Photonic Calibration	
Photonics in Interferometry	
Photonic Reformating (Pupil/Image)	
Photonic Switching	
Photonic technologies	
Structured Fibres	
3D Waveguide Structures	
Plane Lightwave Circuits	
Technology for the mid-infrared	



http://web.archive.org/web/20051206035043/http://as.nasa.gov/aboutus/trl-introduction.html

3. R&D Examples

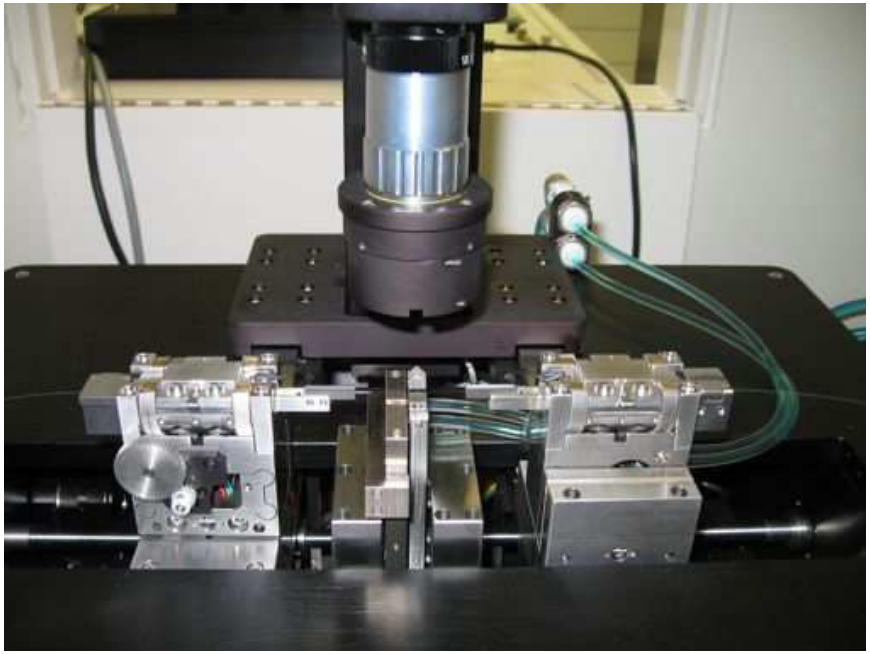
Fibre Tapers

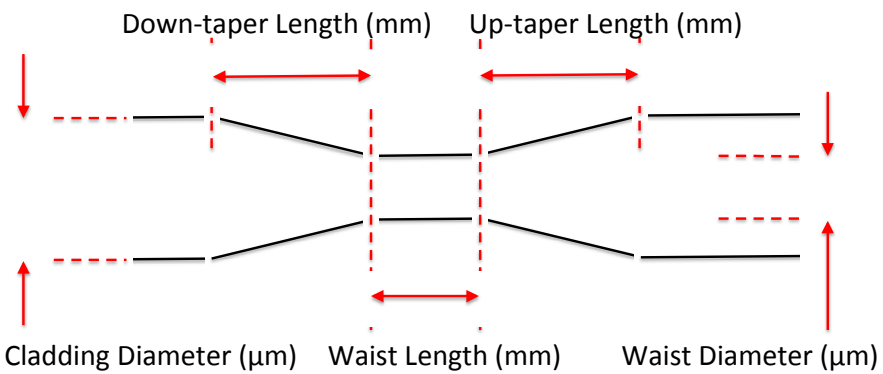
Efficient coupling telescope to photonics

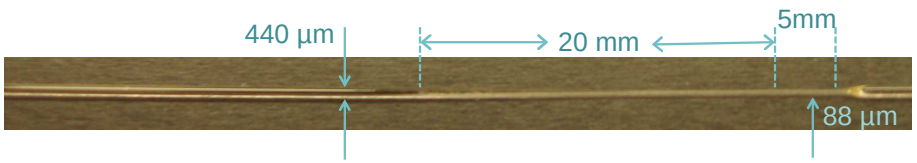
- Photonic Lanterns (PL) [later slide]
- Replace conventional bulk optics
- Multimode Taper Transitions (MTT)
- SM tapers
- Hexabundles [later slide]
- Planar waveguide coupling
- Astro-combs

Collaborations and industry links

- AAO: MANIFEST Study for GMT
- Polymicro Technology (MOLEX)
- Ceram Optec
- Leoni FiberTech
- University of Aston (FBG's and Sensing)







Photonic Lanterns & Multicore Fibres

Multimode to Single Mode

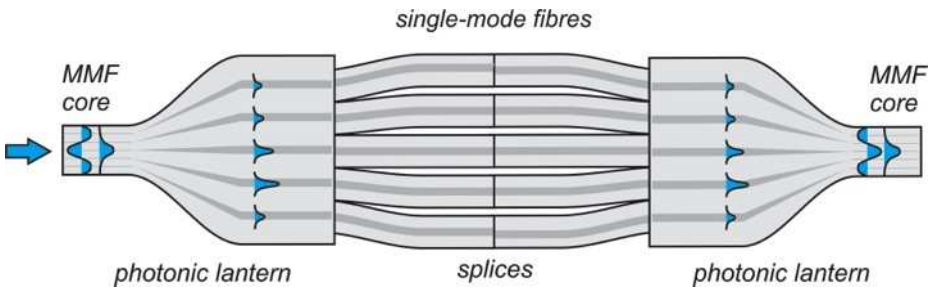
- Photonic Lantern (PL)
- Conventional (1x61)
- Multicore (1x121)
- Fibre Bragg Gratings
- GNOSIS bulky filter
- Next Gen. Multicore

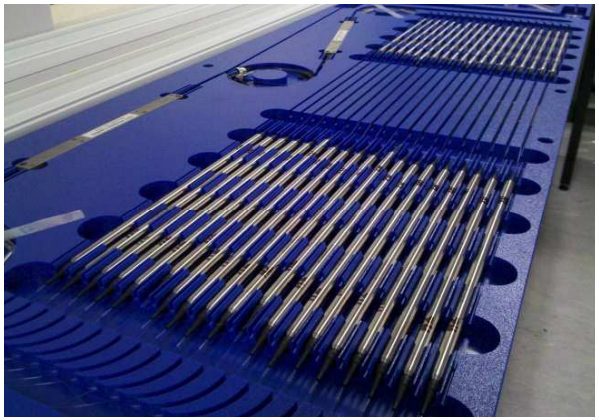
Characterisation of PLs

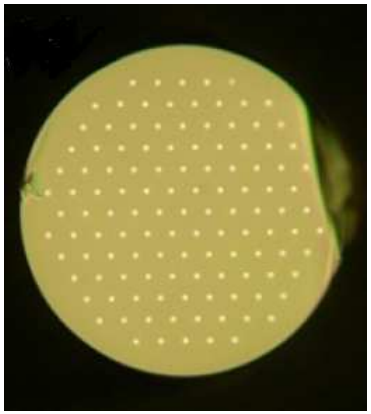
- Modal Noise
- Chromatic effects

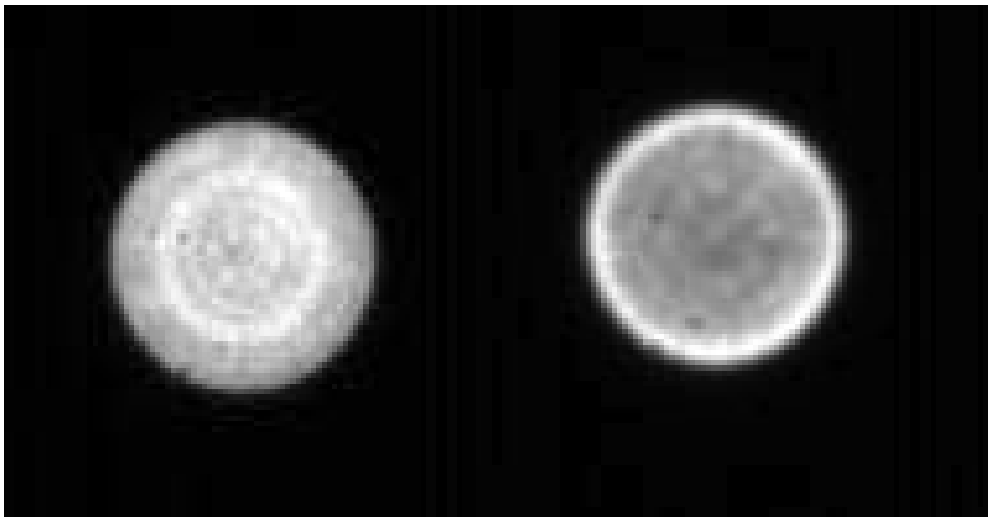
Collaborations

- University of Bath
- ASPIC (AAO and USyd)
- Heriot Watt University









Fibre Bragg Gratings and Photonics Filters

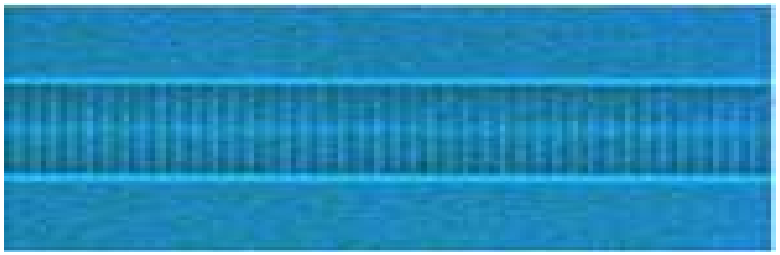
OH Suppression

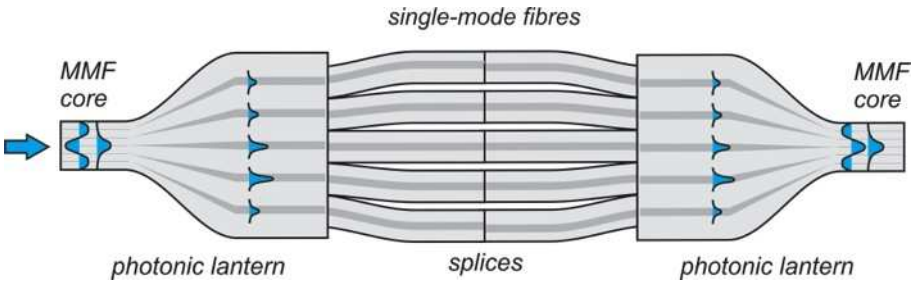
- Sensitivity increase of up to 30
- Photonic Lantern (PL)
- Fibre Bragg Gratings (FBGs)
- FBG Facility at innoFSPEC in 2013 (400 K€)
- on-sky demonstrator: GNOSIS@AAT
- PRAXIS new OH suppression in 2013

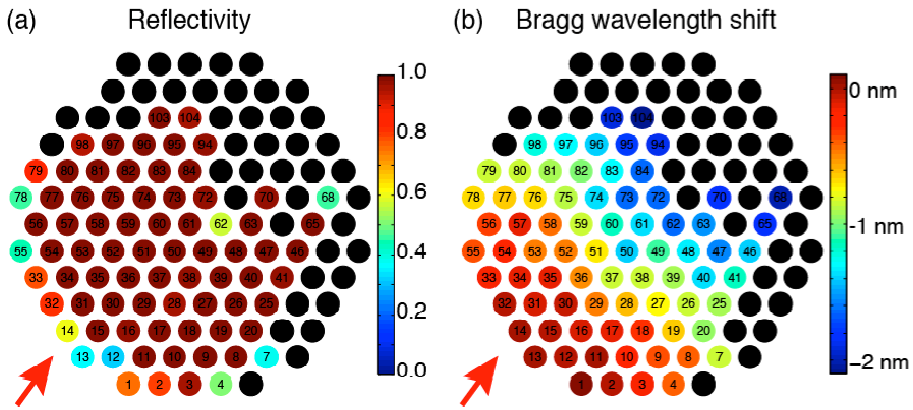
- Next generation filters in multicore fibre
  $\longrightarrow$ compact, Robust, Lower cost

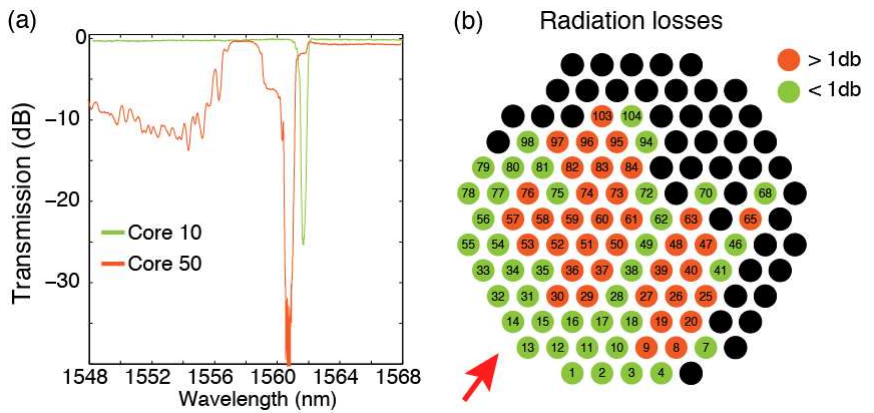
Collaborations

- University of Bath
- University of Aston
- Friedrich-Schiller-Universität Jena
- University of Valencia
- ASPIC (AAO and USyd)
- Heriot Watt University









Photonic Calibration Techniques

Laser Frequency Combs

- Nonlinear optical fibres
- Micro-resonators

(1) Nonlinear fibre approach

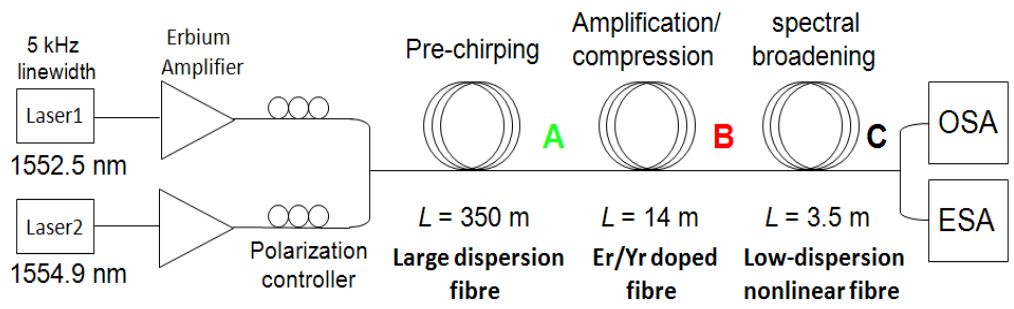
- Two lasers with tuneable comb spacing
- Dispersion, nonlinear coefficients, length

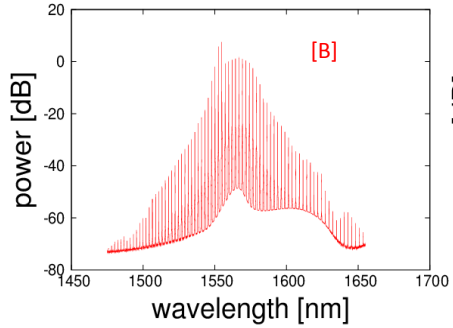
(2) Micro-resonators

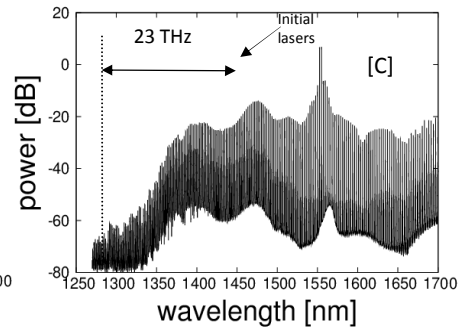
- Phase matched and equal spaced resonances
- Dispersion optimised Si_3N_4/SiO_2 waveguides
- Tailor waveguide material and structure

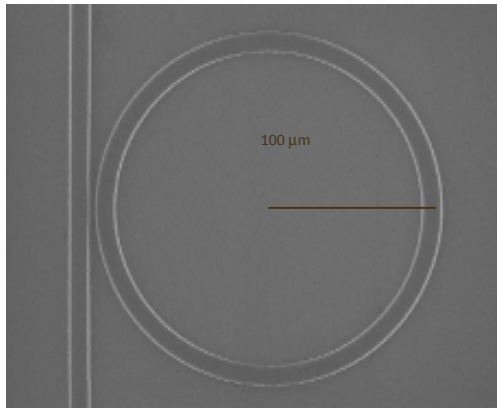
Collaborations:

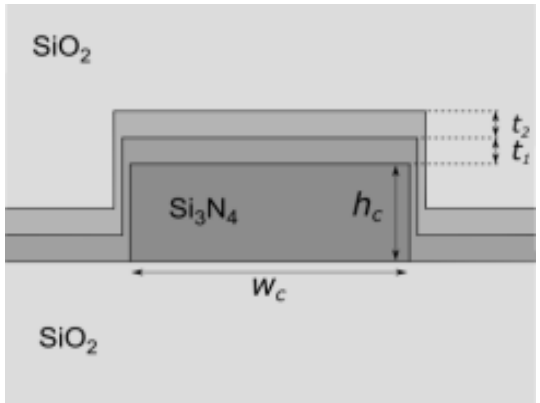
- LZH and Andres Rieznik: Fibre approach
- IHP (Si_3N_4): Micro-resonator approach
- InFaSe: Waveguide characterisation

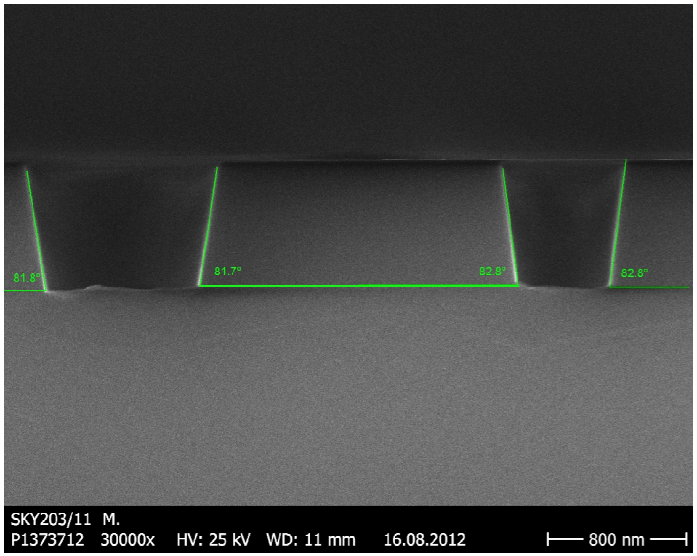












Integrated Photonic Spectrographs (IPS)

IPS based on arrayed waveguide gratings (AWG)

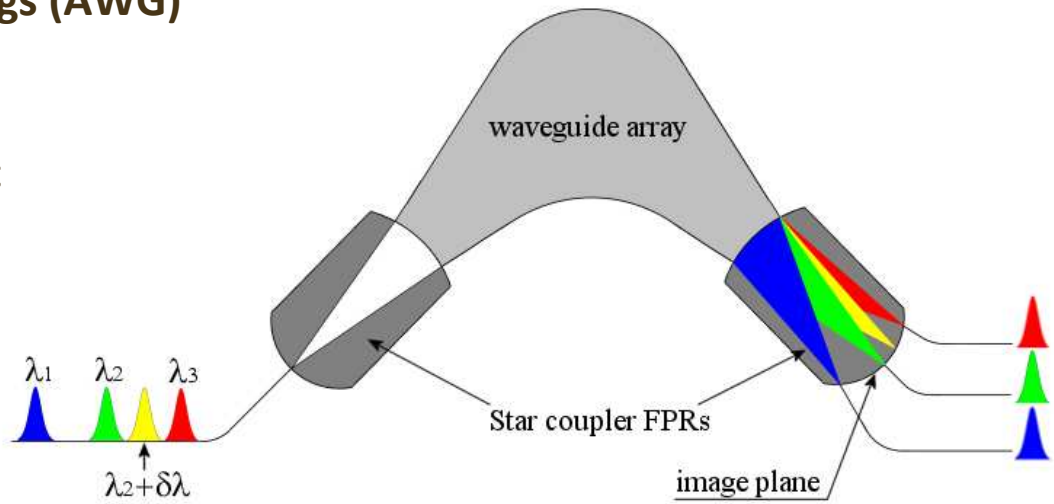
- Replicable, modular and robust
- Small and costs effective
- Astronomy, remote sensing, etc

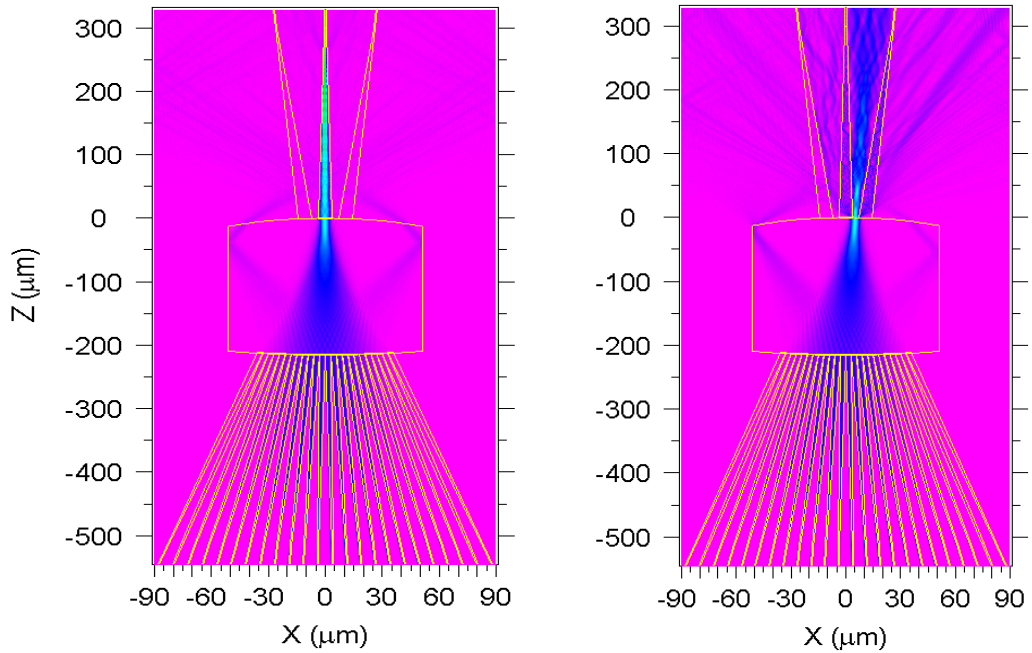
Si_3N_4 and silica-on-silicon

- Two substrate platforms
- 48 channels, 0.4nm spacing
- R ~ 7600

Collaborations

- OCR Soton, Gemfire (SoS)
- IHP (Si_3N_4)
- MQ-Photonics and AAO





On-sky Demonstrators: GNOSIS & PRAXIS

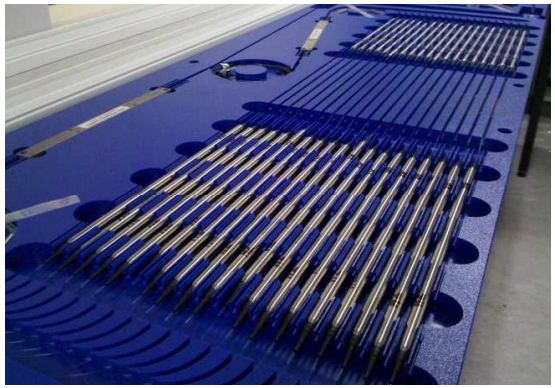
GNOSIS

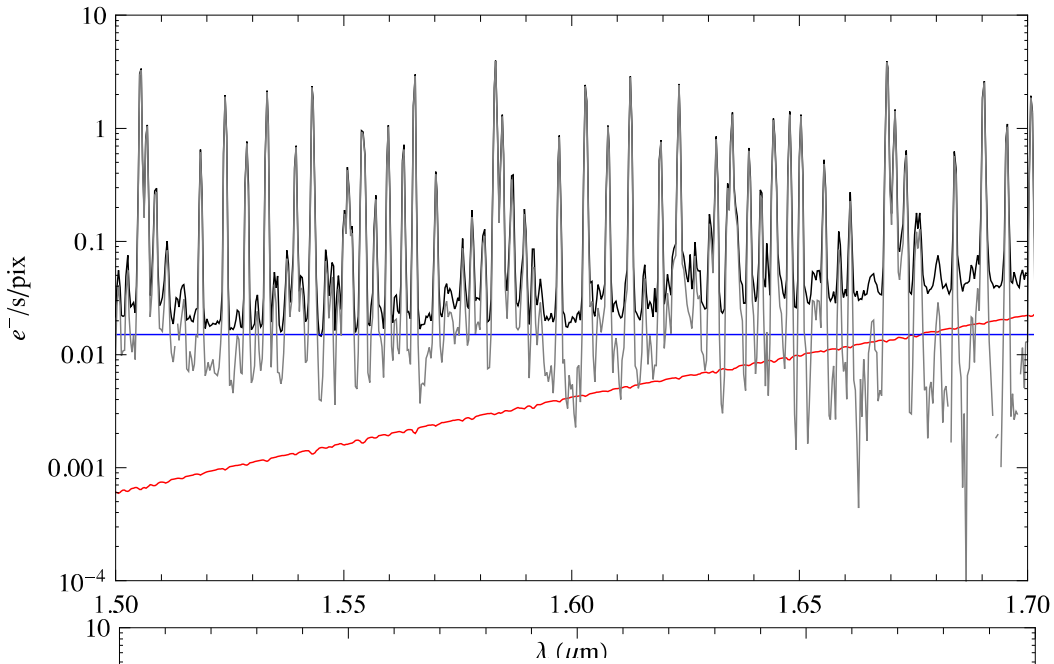
- Commissioned in 2011
- Excellent OH Suppression
- Low efficiency
- Limited S/N gains
- High thermal background
- Detector noise limited
- Photonic Lanterns co-funding[1)] 200 K€

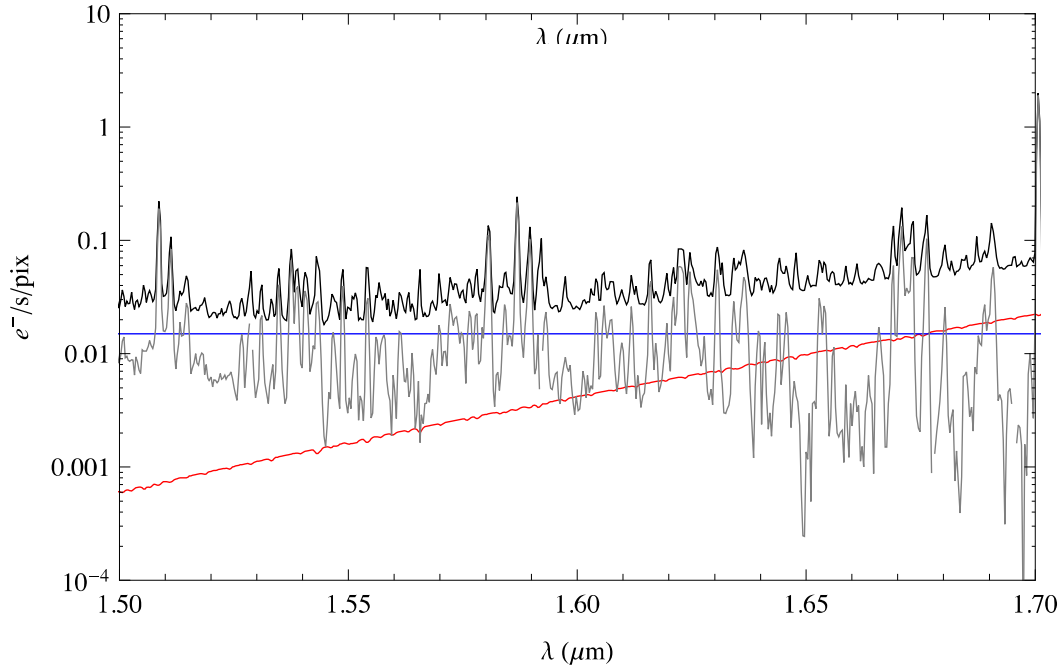
PRAXIS

- Development 2012 – 2013
- ASPIC (AIP, UP, AAO, USyd)
- New high efficiency design
- Cold fibre slit
- low noise detector co-funding[1)] 350K€

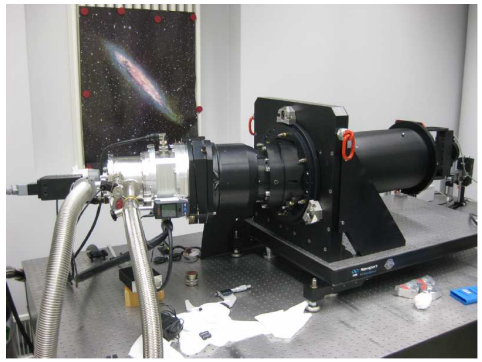
[1)] innoFSPEC Potsdam

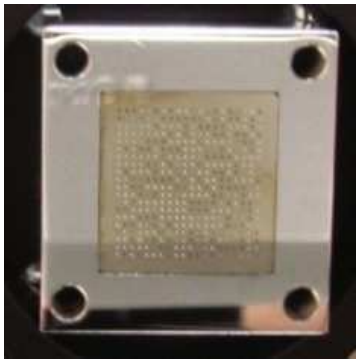






High multiplex / imaging spectroscopy – technology transfer





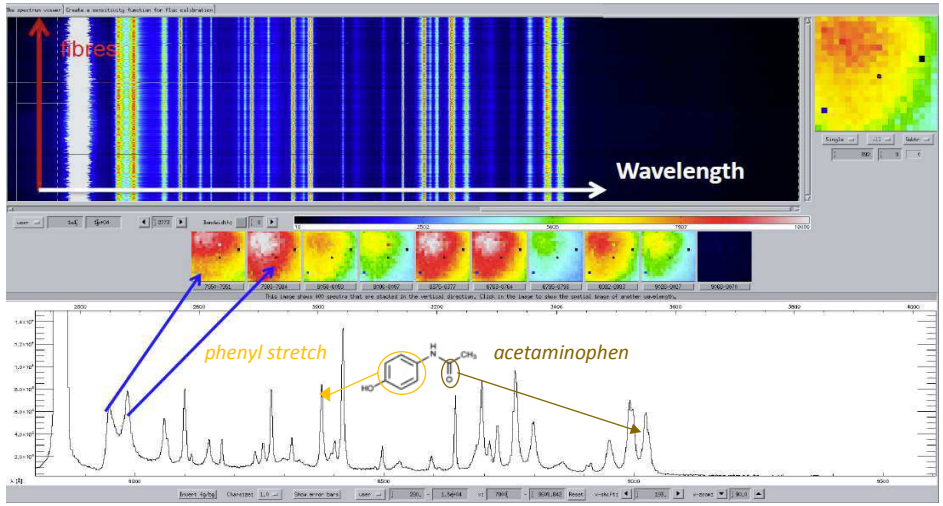
ERA2:

Lab Demonstrator from WtW Program 2010

Multichannel spectroscopy for:

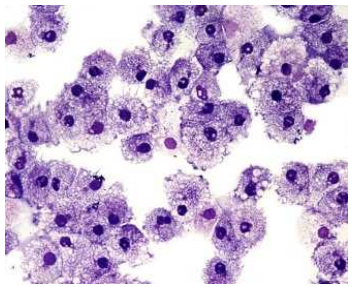
- label-free imaging Raman spectroscopy
- Multiple marker fluorescence spectroscopy
- Hyperspectral autofluorescence imaging

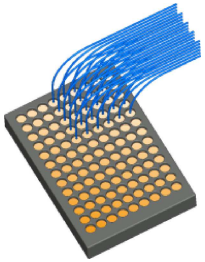
Wavelength range: 460-930nm
$\Delta \lambda < 0.3$nm and 400 spectra



Collaborations and industry links

- LMTB GmbH in Berlin
- Charite University Hospital Berlin
- IPHT Jena





innoFSPEC

Innovative faseroptische Spektroskopie und Sensorik

Innovation Center for fiber-optical Spectroscopy and Sensing

Headquarter at AIP Campus in Potsdam Babelsberg

4. Conclusions

- Astrophotonics = key enabling technology ?
- broad range of applications
- currently at an early stage
- European joint activities leading world-wide
- OPTICON WP3 promising focus for numerous activities with funding from elsewhere