Instrumentation – the future

Work Package 3

OPTCION Proposal FP7.2A

Innovative Enabling Instrument Technologies

Objectives

- Innovative technologies aimed at optimising use of E-ELT and current facilities.
- Technologies:
  - Enable and/or revolution next generation instruments
  - Also address near term (within 5 years) needs
  - Develop proven test-beds or prototypes demonstrations

Work Packages

- Coordination and Networking
- High Efficiency Scalable Dispersive Elements
- Astrophotonics
- High Throughput Optics

Primary participants

- AIP, ATC, BRERA, Durham, LAM, NOVA
- WP Lead: UKATC

Coordination and Networking

Objectives

- Coordinate, network activities and represent.

Lead

- Hermine Schnetler (UKATC)

Co-Lead

- Roger Haynes (AIP)

Science Advisory Panel

- Representing instrument developers and users

Cost to EU: €0.2M

High Efficiency Scalable Dispersive Elements

Objectives

- Develop dispersion systems with improved efficiency and higher dispersion over a larger wavelength range (UV-VIS-NIR-MIR).

Lead

- Filippo Zerbi (BRERA)

Co-Lead

- David Lee (UKATC)

Participants

- Primary: BRERA, UKATC
- Possible Partners:
  - Institutes: Durham, LAM, IAC
  - Industry: Jobin-Yvon, QioptiQ, Fraunhofer, Jena, Zeiss, TNO …

Cost to EU: €1.0M

High efficiency scalable dispersive elements (2)

Description of work

- **Develop** and open and affordable **European access** to an **expert grating design facility** to enable researchers and designers to obtain efficiency optimisation modelling without having to be "experts".
- **Develop** innovative spectrometer layouts with the **grating including optical power**.
- Investigate **improved optical designs** that use dispersive elements in **more efficient configurations** – using what we have more efficiently.

High efficiency scalable dispersive elements (3)

- Investigate **synergies between grating production and photonics manufacturing**, e.g. using ultrafast laser inscription to **manufacture/modify grating structures.**
- Continued **exploration** of possible **alternative materials to dichromated gelatin** in order to develop improved transmission and access infrared wavelengths.
- **Explore volume phase grating production** possibilities **with European companies** such as Jobin-Yvon or QioptiQ.

Astrophotonics

Objectives

- Develop key photonic spectroscopy components
  - Low cost, compact and robust photonics filters for OH-suppression.
  - Develop miniature, robust, cost effective integrated photonic spectroscopic systems taking particular advantage of AO.

Lead

- Roger Haynes (AIP)

Co-Lead

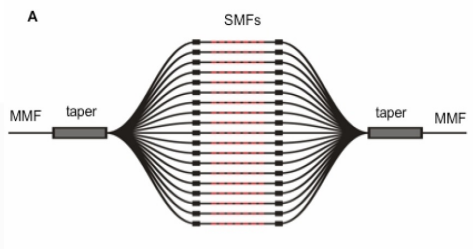
- Jeremy Allington-Smith (Durham)

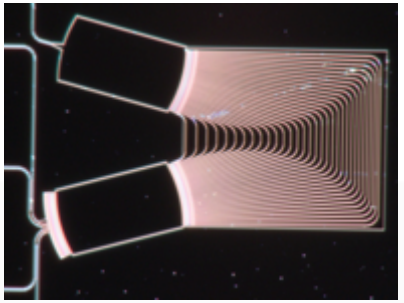
Participants

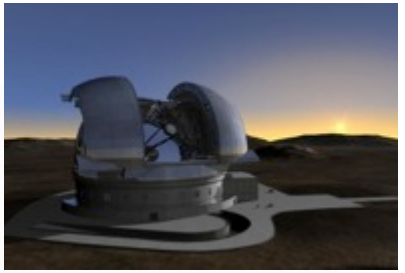
- Primary: AIP, Durham
- Possible Partners:
  - Institutes: AAO, Sydney, Bath, Heriot-Watt, Grenoble (IPAG), Jena, Köln
  - Industry: ROC, NKT-Photonics, Teraxion, CIP, Gemfire

Cost to EU: €1.2M

Astrophotonics: Spectroscopic System

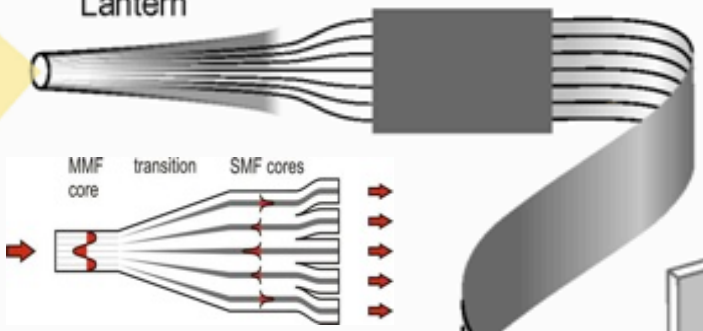


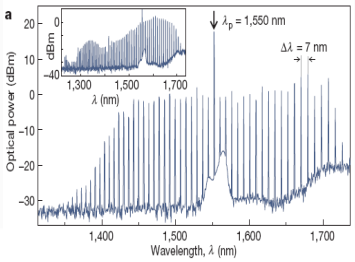




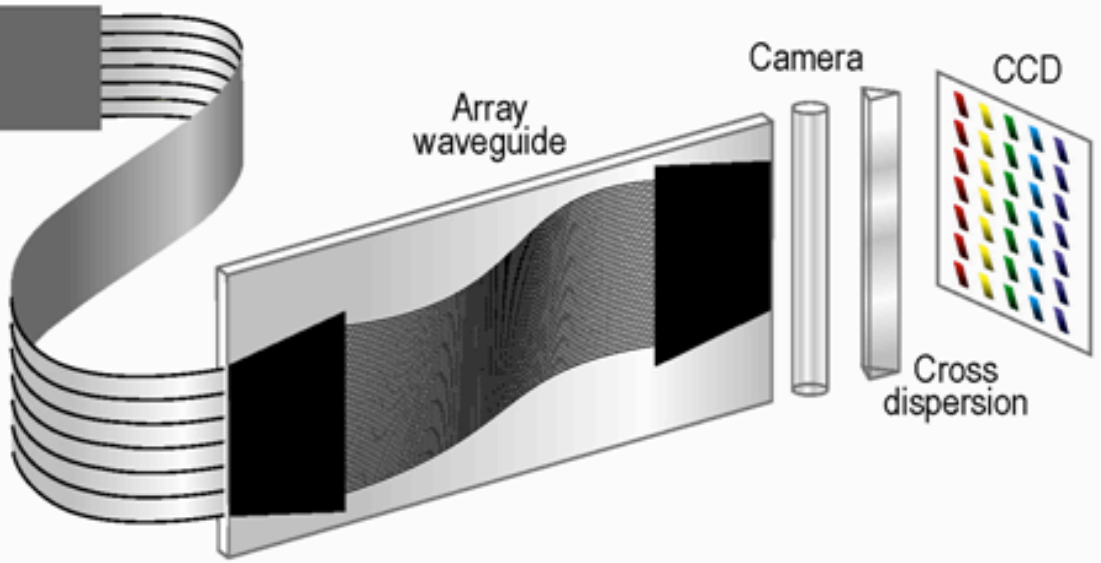
OH suppression

Lantern



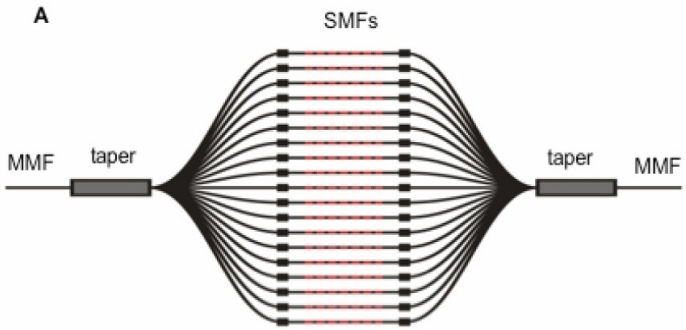


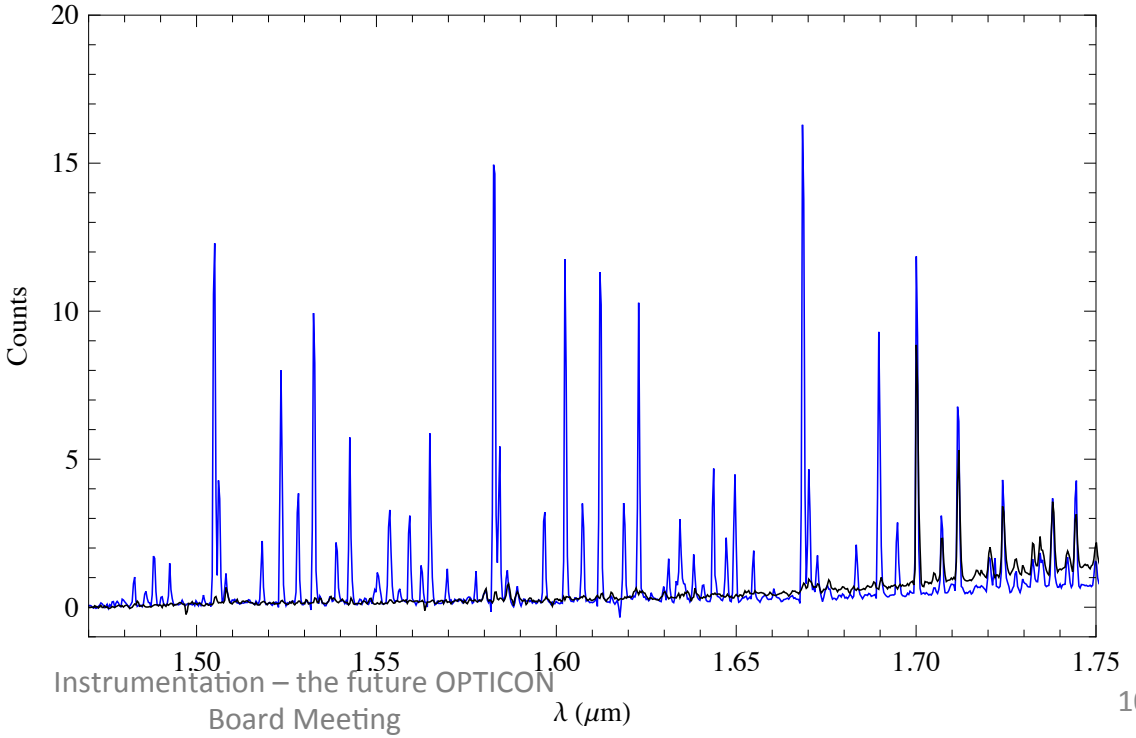
Ribbon cabling



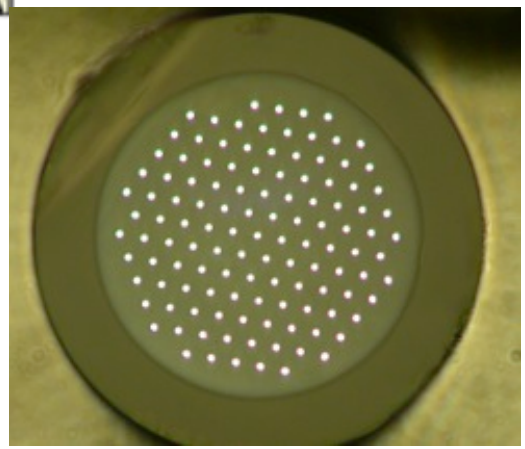
Astrophotonics: OH-suppression current status

GNOSIS instrument commissioning underway



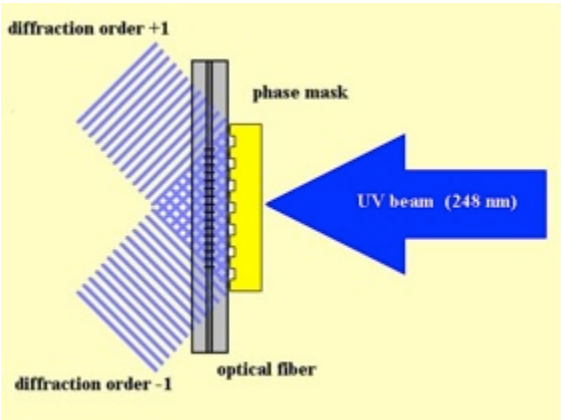


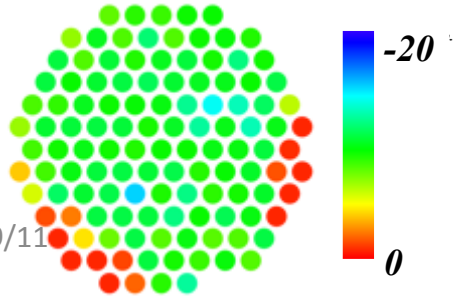
Astrophotonics: Multicore OH-suppression



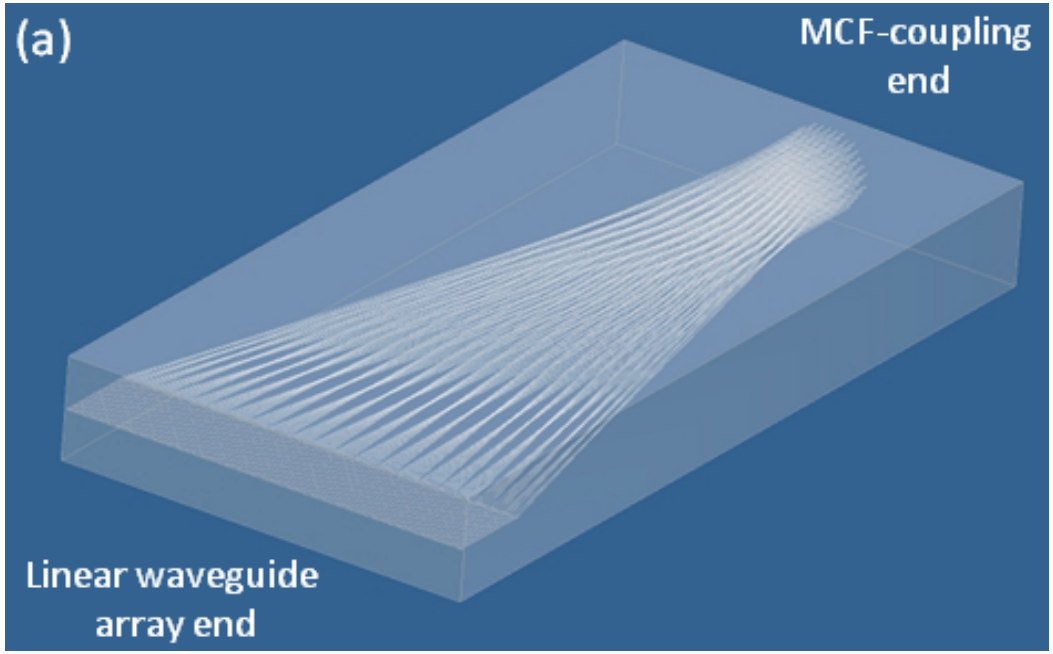
Massively **reduce size, cost and complexity** of current generation of OH-suppression devices

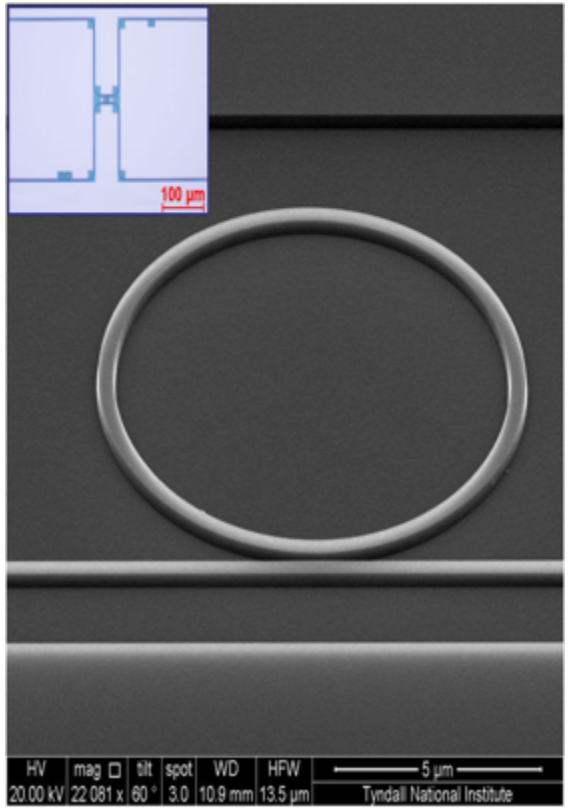
- Develop **multicore lantern** optimised for FBG's
- Develop **FBG writing** techniques
- Develop environmentally **robust packaging**
- **Mass production** compatible techniques
- **Added value**
  - FBGs for Time Domain Astronomy
  - Mode noise free fibres

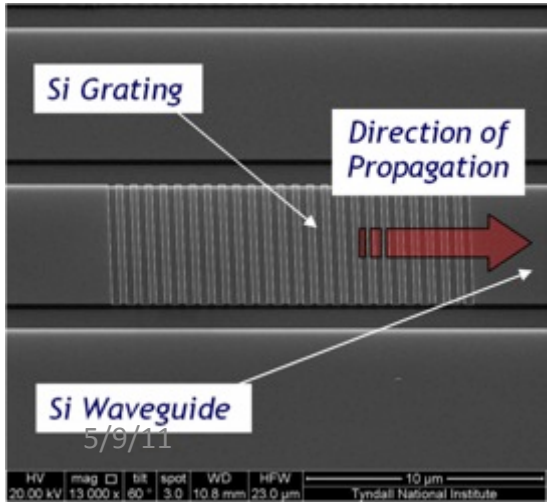


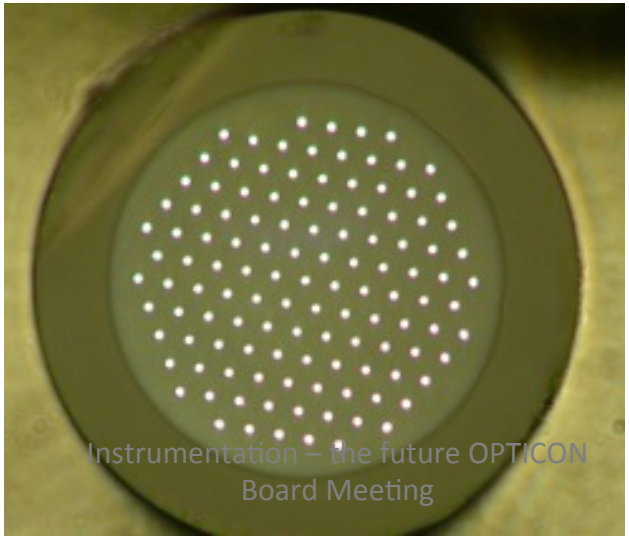


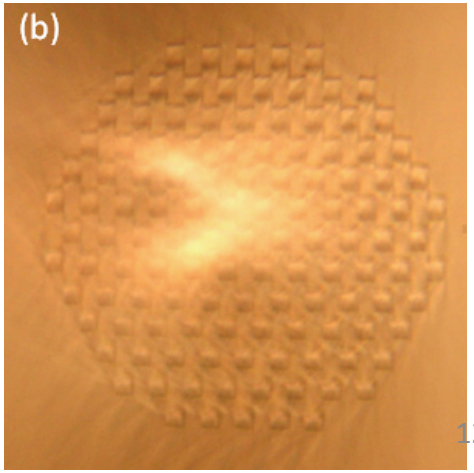
Astrophotonics: Future Photonic Filter Technologies









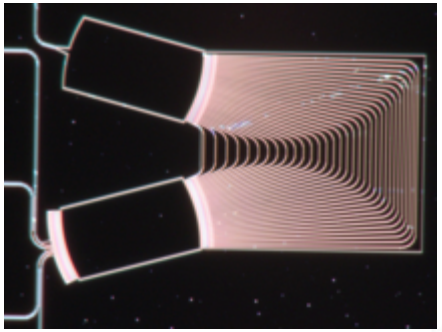


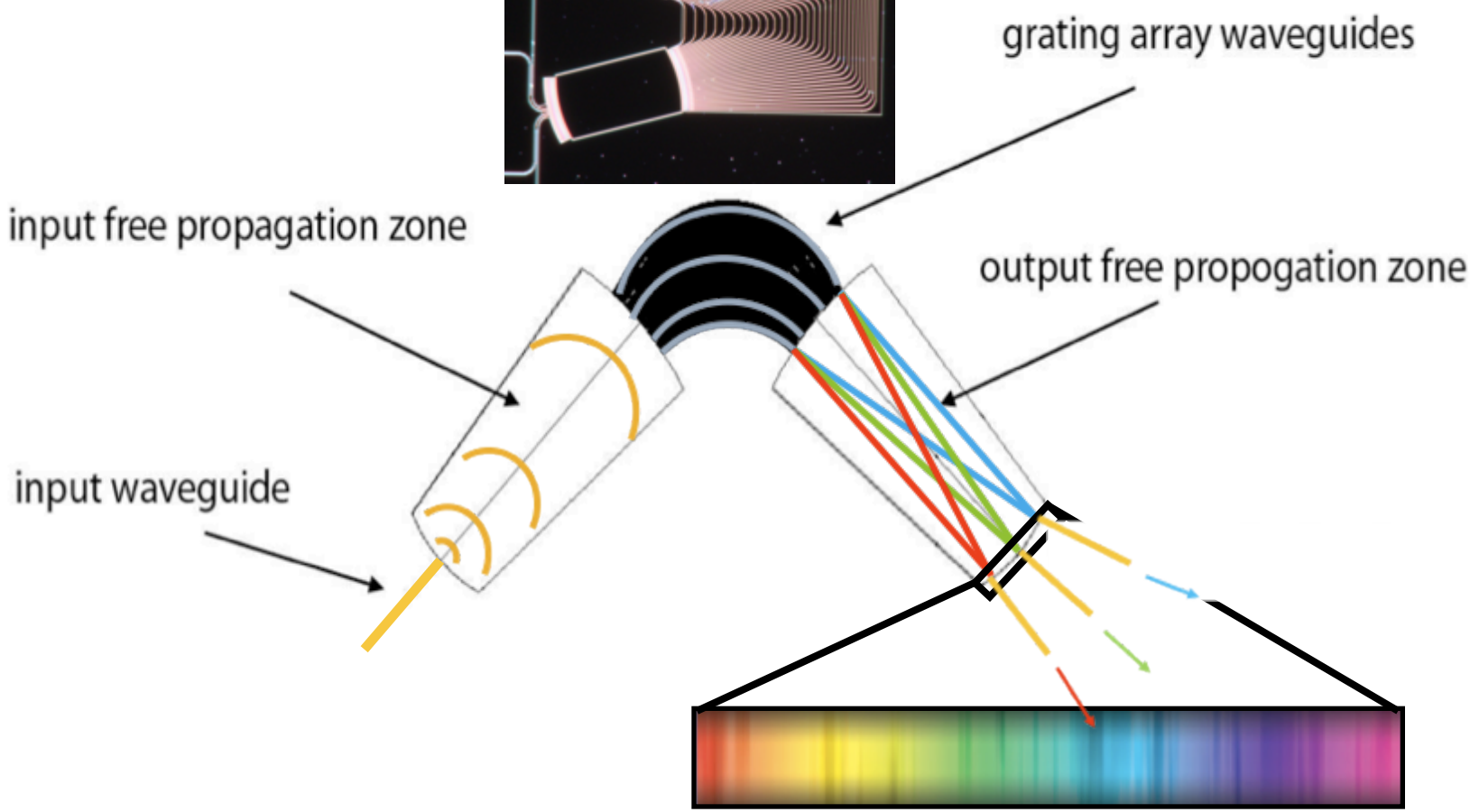
Astrophotonics: OH-suppression

- Extend wavelength to cover 0.7-2.2μm
- Develop Multicore fibres
- Develop FBG writing techniques/facilities
- Develop integrated waveguide devices
  - Lanterns & Couplers
  - Integrated Bragg gratings filters
  - Micro-resonator filters

Astrophotonics: Integrated photonic spectrograph

Arrayed Waveguide Grating





Astrophotonics: Integrated Photonic Spectrograph

Develop a spectrograph on a chip system components, massively reduce size, cost, risk of spectroscopic facilities

- **Science case and parameters** for IPS V4 demonstrator
- **Fabricate new chip** (IPS-V4) to our specification and test in the lab
- **Development of a science capable instrument**.
- New chip (IPS-V4) for on **telescope science demonstrator**
- Modifications and mass-fabrication of **new chips (IPS-V5)**
- **Integration** of new chips (IPS-V5) **with system components** (lanterns, detectors, cross-dispersers, etc.)
- **Science demonstrator on telescope** with IPS-V5 instrument

Each component has potential **application in conventional systems**

Applications outside astronomy: Biophotonics, Remote sensing, process monitoring, etc.

High Throughput Optics

Objectives

- Develop small and compact instruments with fewer optical surfaces than currently typical

Lead

- Emmanuel Hugot (LAM)

Co-Lead

- Lars Venema (ASTRON)

Participants

- Primary institutes
  - LAM, ASTRON, UKATC
- Possible Industry Partners
  - SESO, CEDRAT, CSEM…

Cost to EU: €0.6M

High throughput optics

- **Objectives**
  - Define **small and compact instruments**, with less optical surfaces than usual.
  - Prototype and characterise a fully integrated "**active extreme aspheric mirror**" made of a complex mirror, a smart actuation structure and a cryo-actuators grid optimised for the required functions.

- **Scientific impact**
  - **Less optics**: Increase of the instrument throughput, easier access to UV bands, reduction of system complexity, reduction of mass and cost, improvement of instrument reliability.
  - **Extreme aspheric mirror**: Increase of image quality by use of complex optics, wider field of view, wider bandwidth (reflective optics).
  - **Active surface**: Increase instrument observation time by decreasing integration, alignment and calibration time.

ASTRON active structure developed in phase 1 for flat surfaces

- Partners: LAM, ASTRON, UK ATC
- Possible Industrial Partners: SESO, CEDRAT, CSEM...

High throughput optics

- **Description of work, deliverables, schedule, budget**

  Use of tools developed in phase 1: Novel aspheric surfaces description, Zemax plug in, innovative manufacturing method for highly aspherics, smart active cryo-systems prototypes

  – **System studies** **T0 -> T0+18**
    1. ***Optimisation of E-ELT instruments sub systems optical designs*** by use of less optics, only reflective.
    2. Evaluation of the ***impact on the global system***

    Deliverables: *analysis and design report / performances of new optical concepts (flux, FoV, weight, size, ...)*

  – **Definition of active extreme aspheric mirror** **T0+6->T0+18**
    1. Define a ***smart optical concept*** made of extreme aspherics and specifications in terms of Optics shape, alignment tolerances, form errors, local errors, etc...
    2. Define specifications for an ***active structure*** able to deform the mirror for **compensation of form and alignment errors**,
    3. Design of the ***smart active structure*** *by use of topological optimisations*
    4. Design of ***smart actuation devices*** **(cryogenic-actuators)**

    Deliverable: *Specifications for the manufacturing of an highly aspheric mirror and its warping structure / design report on smart structure and cryognic actuators*

  – **Manufacturing active extreme aspheric mirror** **1.0Y**
    1. Manufacturing of an ***high quality extreme aspheric mirrors*** following specs
    2. Manufacturing of a ***smart actuation structure*** to be coupled to the mirror
    3. Manufacturing of ***cryogenic actuators***

    Deliverable: *Manufacturing and test report of aspheric mirror, Manufacturing and test report of smart actuation structure and cryo actuators*

  – **AIT phase** **1.0Y**
    1. ***Integration*** of aspheric mirrors and smart structures
    2. Characterisation of system at rest
    3. ***Full characterisation of the system functionalities and performances in cryogenic environment***

    Deliverable: *AIT report, active extreme aspheric demonstrator*

Summary of Instrumentation (WP3)

Technology developments

- High Efficiency Scalable Dispersive Elements
- Astrophotonics
  - OH-suppression
  - Integrated Photonic Spectrographs
- High Throughput Optics

Primary participants

- AIP, ATC, BRERA, Durham, LAM, ASTRON
- WP Lead: UKATC

Cost to EU: €3.0M