European Extremely Large Telescope
Astronomical instrumentation

21 September 2011

Wilfried Boland
NOVA introduction

- Netherlands Research School for Astronomy
  - Top research school, evaluated exemplary in 2010
  - Federation of university astronomy institutes
  - 290 fte scientific staff (20% is directly funded by NOVA)

- Mission
  - Facilitating top astronomical research in the Netherlands
    - Hire researchers
    - Build instruments
  - Train young astronomers at highest international level
ESO Very Large Telescope
Atacama Large Millimeter Array
ALMA
NOVA ESO projecten

MIDI

NEVEC

OmegaCAM voor VST → OmegaCEN

SINFONI: 2k camera voor SPIFFI: nabij-IR integral field spectrometer

Optical bench voor SPHERE Zimpol

MUSE-ASSIST: test set-up voor nieuwe VLT deformeerbare secundaire spiegel

X-Shooter nabij-IR spectroscopische arm
Nieuwe grote ESO project: ~40m optisch/IR telescoop
Fase B afgerond: klaar voor de bouw! (na goedkeuring Council)
**NOVA instrumentation program**

- Many discoveries are driven by new instrument capabilities
  - Involvement in instrument ⇒ decision about functionality
  - Involvement in instrument ⇒ understanding the instrument performance
  - Involvement in instrument ⇒ early access to data
  - Involvement in instrument ⇒ ideal position to make discoveries!

- **NOVA strategy:**
  - Design & construct instruments for international facilities
  - Focus on ESO
  - NOVA Optical-Infrared instrumentation group located at ASTRON in Dwingeloo
Instrument Project Characteristics

- Collaborations with international partners (for ESO projects ~4-6 partners)
- NOVA astronomer NL-leader and connection to the international consortium
- Common Project management procedures under ESO protocol (PDR, FDR, progress meetings etc.)
- Hardware design and manufacturing by NOVA Optical-IR instrumentation group
- Dutch astronomers in (inter)national science team to ensure interesting capabilities
Objective:
- Participate in design & construction of instrumentation for E-ELT
  - In one as a leading partner (40% share)
  - In another one as minor partner (20% share)

Funding:
- General NOVA budget
- ESFRI grant of 18.78 M€
  - 8.78M€ for design and development
  - 10M€ to build one instrument (requires PI role)
- Other grants
## E-ELT: 8 SCIENCE INSTRUMENTS +2 Post Focal AO MODULE STUDIES

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>MAIN OBSERVING MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPTIMOS</strong></td>
<td>Multi-slit and fiber MOS options are being studied</td>
</tr>
<tr>
<td><strong>CODEX</strong></td>
<td>High Resolution, High Stability Visual Spectrograph</td>
</tr>
<tr>
<td><strong>METIS</strong></td>
<td>Mid IR camera /spectrograph</td>
</tr>
<tr>
<td><strong>EAGLE</strong></td>
<td>WF, Multi IFU NIR Spectrograph. +AO</td>
</tr>
<tr>
<td><strong>HARMONI</strong></td>
<td>Single IFU, Wide Spectral Band Spectrograph</td>
</tr>
<tr>
<td><strong>SIMPLE</strong></td>
<td>High-Resolution IR spectrograph</td>
</tr>
<tr>
<td><strong>MICADO</strong></td>
<td>NIR Camera sampling to the DF</td>
</tr>
<tr>
<td><strong>EPICS + XAO</strong></td>
<td>Planet Imager and Spectrograph</td>
</tr>
<tr>
<td><strong>MAORY</strong></td>
<td>(MCAO) with 2 additional DM</td>
</tr>
<tr>
<td><strong>LTAO</strong></td>
<td>Module Provides DL images over a field &lt;30”</td>
</tr>
</tbody>
</table>
E-ELT Instrumentation in NL

- **Consortium:**
  - Universities: NOVA, TU Delft, UTwente
  - Technological institutes: ASTRON, SRON & TNO
  - Companies: Airborne Composite BV, Dutch Space, JPE

- **Applied for in 2008, awarded in 2009, end 2020+**

- **Phase I (8.78M€):**
  - Preliminary design (4 instruments)
  - Technology developments

- **Phase II (10M€):**
  - Construction of one instrument
Industrial participation

- Large research facilities means big business
- Industry can become project supplier to ESO and/or NOVA
  - Construction of the telescope
  - Delivery of subsystems to the telescope
  - Supplier of parts of instrumentation, or partner in (optical, mechanical or thermal) design; partner is R&D to demonstrate technical readiness
Industrial participation

- Large research facilities means big business
- Industry can become project supplier to ESO and/or NOVA
  - Construction of the telescope
  - Delivery of subsystems to the telescope
  - Supplier of parts of instrumentation, or partner in (optical, mechanical or thermal) design; partner is R&D to demonstrate technical readiness
Technology developments I

- Vibration-free and precise cryo-coolers
  - Present partners: UTwente, Dutch Space
  - Motivation: High precision instruments, no vibrations
  - Potential solution: sorption coolers
  - Remaining problems:
    - Cooling power too low (10mW $\Rightarrow$ 1W)
    - University product $\Rightarrow$ commercial product
Technology developments II

- **Movable cryogenic systems**
  - **Present partners:** NOVA Op-IR, JPE, SRON, TNO
  - **Motivation:** High precision positioning and stability of movable elements in a cryogenic environment (80K)
  - **Problems:**
    - Opto-mechanical engineering
    - Very accurate positioning (nm), metrology and control
Technology developments III

- New optical components and materials
  - Present partners: Airborne, NOVA Op-IR, SRON, TNO
  - Motivation: Standard techniques will make the instrument rather big and heavy, or do not provide the required stability
  - Potential solutions: composite materials, immersed gratings, integrated optics, smart optics, free form mirrors
  - Remaining problems:
    - Behavior of composite materials in a cryo-vacuum environment (stiffness, air tightness, out-gassing)
    - Immersed gratings have not yet been made with the required accuracy
    - Manufacture products with the required accuracy (required micro-roughness RMS for free-form 30cm large Al mirrors = 15nm)
Other areas where NOVA will look for partners:

- Polarimetric elements and engineering
- Precision engineering
  - Better performance prediction,
  - improved overall system engineering control,
  - modeling alignment tolerances,
- Advanced data flow system
- AO Control (hardware and software)
- Industrial production process

There are many opportunities for industrial participation and products!
One example: METIS

Mid-infrared E-ELT Imager and Spectrograph

- Operating from 3 to 14 micron
  - Imager (L, M, N-band)
  - Low resolution long slit spectrometer (L, M, N-band)
  - High resolution IFU spectrometer (L, M band)
  - Coronography (L, M, N band)
  - Polarimetry (N-band)

- NOVA has PI role
  - Overall project management
  - High resolution IFU spectrograph
  - Fore optics
  - Cold central structure
Conclusion and Contact

There are many opportunities for industrial participation and products!

- Wilfried Boland (boland@strw.leidenuniv.nl)
- Frank Molster (molster@strw.leidenuniv.nl)