Instrumentation for the follow-up and characterisation of transients

Antonio de Ugarte Postigo
IAA-CSIC
DARK/NBI

Granada, 14 October 2016
Astronomy in the Era of the Giants

• In the 2020s new giant telescopes and surveys will be available
  – JWST, ELTs, SKA, ...
  – LSST, ZTF, J-PAS, ...

• 100s of objects will be discovered each night

• New instrumentation
Science cases

- Supernovae
- X-ray binaries
- Gamma-ray bursts
- Tidal disruption events
- Extrasolar planets
- Transneptunian objects
- Astereoseismology
- Active galactic nuclei
Wish list

• Fast and efficient
• Imaging
• Spectroscopy
• Broad wavelength coverage
• Time resolution
• Additional capabilities:
  – IFS
  – Polarimetry
X-shooter

• Echelle spectrograph at VLT

• Characteristics:
  – $R \sim 1000$
  – 3000-24800Å
  – 3 x echelle
  – Good efficiency: $\sim 30\%$

• Limitations:
  – Single channel VIS acquisition
  – Slow acquisition
NTE at the 2.5m NOT

- Double echelle spectrograph
- Single slit and single grating
- 3500-17500 Å
- VIS+NIR acquisition
- $R \sim 5000$
- Full range ADC
- 2018
SOXS at the 3.5m NTT

- Experience of X-shooter on a 3m telescope
- 2 x echelles, 2 slits
- 3500-17500 Å
- R~4500
- VIS acquisition
- ADC in the VIS
- ~2020
The OCTOCAM concept

- Multi-channel (8!)
- Wide wavelength range (3700-23500 Å)
- Multiband imaging
- Broad band spectroscopy
- High time resolution
- GROND + X-shooter + ULTRACAM + MORE! = OCTOCAM
OCTOCAM for the 8.1m Gemini

- Two 8.1m telescopes: Chile and Hawaii

- Managed by AURA (Association of Universities for Research in Astronomy)

- USA, Canada, Brazil, Argentina, Australia, South Korea, Chile

  - 2014: Open call for Feasibility Studies (GIFS, 4 projects selected)

  - 2016 (29th Aug): Call for instrument design
The OCTOCAM team

Science Team

Álvaro Álvarez-Candal, Brazil
Rodolfo Angeloni, Chile
Stefano Bagnulo, UK
Franz Bauer, Chile
Amanda Bayless, USA
Melina Bersten, Argentina
Marcelo Borges Fernandes, Brazil
Tom Broadhurst, Spain
Nat Butler, USA
Brad Cenko, USA
Lydia Cidale, Argentina
Jesus Corral-Santana, Chile
Peter Curran, Australia
Vik Dhillon, UK
René Duffard, Spain
Robert Fesen, USA
Gastón Foltalé, Argentina
Jonathan Fortney, USA
Ori Fox, USA
Anna Frebel, USA
Lluís Galbany, Chile
Rafael Garrido Haba, Spain
Daryl Haggard, USA

Eric Hintz, USA
David Kaplan, USA
Oleg Kargaltsev, USA
Chryssa Kouveliotou, USA
Adam Kraus, USA
Michaela Kraus, Czech Republic
Ho-Gyu Lee, South Korea
Chris Lidman, Australia
Teo Muñoz-Darias, Spain
Jerome Orosz, USA
Thomas Pannuti, USA
Jennifer Patience, USA
Daniel Perley, USA
Noemí Pinilla-Alonso, USA
Brian Schmidt, Australia
Steve Schulze, Chile
Denise Stephens, USA
Juan Carlos Suárez, Spain
Nial Tanvir, UK
Ezequiel Treister, Chile
Daniel Vanden Berk, USA
Sjoert van Velzen, USA
Stefanie Wachter, Germany
Instrument scheme

NIR

ADC

Polarimeter
slit
mini-IFU
cryostat

Light from
telescope

collimator
grism/filter
camera
detector

VIS

J
H
K

Y

g
z
r
OCTOCAM for Gemini

- Partners: SwRI, IAA-CSIC, GWU, AAU, FRACTAL, Leiden Obs.
- Feasibility study funded by AURA in 2015
- Construction proposal submitted in August 2016
- Final decision at the end of 2016
Imaging

- Simultaneous VIS/NIR observations in $g, r, i, z, Y, J, H, K_S$
- Frame transfer detectors + HAWAII-2RG
- Negligible overheads
  - No filter change time loss
  - No readout time loss
- 3'x3' field of view or 4.2' diameter
- 3'x3'x8 = 72 sqr. arcmin
- 8x14 = 112 sqr. arcmin

GMOS 5.5'x5.5'
30.25 sqr. arcmin

FLAMINGOS-2 6.1’Ø
29.22 sqr. arcmin
Spectroscopy

- From 3 700 Å to 23 500 Å
  - [OII] 3727/3729 Å at $z = 0$
  - H-alpha at $z = 2.5$
  - Extinguished sources
- High efficiency VPH gratings
- Resolution ~4000
  - Look through the NIR sky lines
  - Continuum of faint sources
  - Velocity field in galaxies
- Long slit 3 arcmin
Integral field units

- Image slicer 9.7”x6.8”
- 0.4” resolution elements
- Wavelength coverage UV+IR!
- Full spectral resolution at any seeing

- GRB & SN host galaxies
- Massive star environment
- TNO & comets

- Extra: Adaptive Optics IFU 2.5”x3.6”
- 0.08” resolution elements
- 9500-23500Å
• Based on the design of Snik et al. (2012) for X-shooter
  ✓ Structure and magnetism in SNe
  ✓ Stellar physics
  ✓ Characterization of transients
**Time resolution**

- Optical: Frame transfer detectors
- NIR: H2RG+Sidecar
- No compromise for classical observations
- Negligible readout overheads
- ~10 Hz full frame
- ~100 Hz windowed

<table>
<thead>
<tr>
<th>Channel</th>
<th>Exposure times</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10ms</td>
</tr>
<tr>
<td>g</td>
<td>Windowing</td>
</tr>
<tr>
<td>r</td>
<td>Windowing</td>
</tr>
<tr>
<td>i</td>
<td>Windowing</td>
</tr>
<tr>
<td>z</td>
<td>Windowing</td>
</tr>
<tr>
<td>Y</td>
<td>65 - 75 e^- (12 bit)</td>
</tr>
<tr>
<td>J</td>
<td>65 - 75 e^- (12 bit)</td>
</tr>
<tr>
<td>H</td>
<td>65 - 75 e^- (12 bit)</td>
</tr>
<tr>
<td>Ks</td>
<td>65 - 75 e^- (12 bit)</td>
</tr>
</tbody>
</table>

- XRBs
- Magnetars
- GRBs
- Ocultations
- Transits
## OCTOCAM specifications

| **Simultaneous spectral range** | 4000-23500 Å (*grizYJHK*) in imaging  
3700-23500 Å in spectroscopy |
|-------------------------------|----------------------------------------------------------------------------------|
| **Field of view**             | Imaging: 3’x3’, or circular FoV of 4.2’ diameter  
Spectroscopy: 3’ Long slit  
9.7”x6.8” IFU (0.4” slitlets)  
2.5”x3.6” AO-IFU (0.08” slitlets) |
| **Plate scale**               | 0.18”/pixel                                                                      |
| **Spectral resolution**       | VIS: 4700, NIR: 4200                                                             |
| **Average efficiency**        | Imaging: 41%  
Spectroscopy: 33%                                                              |
| **Maximum full-frame rate**   | 10 Hz full frame                                                                 |
| **Observing modes**           | Multiband imaging  
Wide band spectroscopy (long slit, IFU, AO-IFU)  
High time-resolution Spectropolarimetry |
An OCTOCAM for CAHA?

- 7’ FoV
- 3500-16000 Å
- Single slit
- R\sim1000-4000
- VIS/NIR Multiband imaging
  - IFU
  - Polarimeter
Thank you!