NOEMA
An astronomical infrastructure in the French Alps

K.-F. Schuster

- Structure and Organization of IRAM
- NOEMA
- Things to come
- Conclusions
IRAM Organization

- Founded 1978 as non-profit organization
- CNRS (France)
  MPG (Germany),
  IGN (Spain) joins 1989
- HQ Grenoble (~75 Pers.)
  Science Operation and Technical Dev.
  Softw. & Data Center Admin.
- Observatories:
  Pico Veleta (Spain)
  Plateau de B. (France)
  (~50 Pers.)
- Annual Budget
  14 Mio. EU (consolidated)
IRAM Mission

- Operate two world class mm/submm observatories
  - IRAM 30m telescope Pico Veleta Spain
  - NOEMA Northern Extended Millimeter Array

- Develop advanced technology for millimeter Astronomy and act as an center of excellence in this field.

- Develop the related science community and training of forthcoming generations of scientists.
Interferometer NOEMA (8/12), France

30 m Telescope, Spain

Headquarter Grenoble, France
IRAM users

- 15% open time, 85% IRAM partner
- Countries: 43
Millimeter Wave Astronomy fundamentally changed during the last 15 years:

• Became important pillar of multi-wavelength Astronomy.

• Transition from single object projects to multi object surveys.

• Arrival of ALMA, a 1.3 billion Eu world wide project in the southern hemisphere.
NOEMA
Northern Extended Millimeter Array

The Concept

• Double the number of 15 m antennas at PdB from 6 to 12
• Increase of IF bandwidth from 8 GHz to 32 GHz
• New Correlator: Full low resolution coverage + 128 flexible high resolution windows
• Extension of the Baselines from 0.8 to 1.6 km
• Organize ~50 MEu for this!
NOEMA Motivations

- Investigate Galaxy and Star Formation throughout the history of the universe.
- Understand interstellar and circumstellar chemistry and its influence on star and planet formation. Detection of complex and potentially prebiotic molecules.
- Allow large, statistically significant surveys.
- Provide easy accessible discovery space.
- Generate full sky coverage in the millimeter range.
- Enhance IRAM partners use of ALMA.
(a) ~0.3" maps of the 158-μm continuum in HFLS3, (b) velocity integrated [CII] line emission, (c) isovelocity field and (d) velocity dispersion map obtained with the IRAM interferometer in A-configuration, overlaid on a Keck/NIRC2 2.2-μm adaptive optics image (rest-frame UV/optical light). Work by Riechers et al. 2013, Nature, 496, 239
PdBI Map of CO(1-0) in M51

Schinnerer (PI), Dumas, Garcia-Burillo, Kramer, Leroy, Meidt, Pety, Rix, Schuster, Thompson
Bright CO resulting from the interaction of a runaway O star with the diffuse ISM: 1. 30m only


AE Aurigae (a.k.a HD 34078)
- O9.5V runaway star (ejected from the Orion Trapezium region).
- Distance: 530 pc.
- Velocity: 120 km s\(^{-1}\) ⇒ 1.2° on-sky every 10\(^{5}\) yr.

The diffuse IC 405 nebula
- No CO detected in neither Dame et al. (9") nor Planck (15") at ~1 K km s\(^{-1}\) sensitivity.
- 10 K clumps detected with the 30m in \(^{12}\)CO (J=1–0) (23") mainly (but not only) at the edge of the diffuse gas (200 square arcminutes mapped at 0.2 K sensitivity in 0.5 km s\(^{-1}\) channels in 30hrs).
- 30 K sub-structures when mapped at 4" resolution at PdBI (150-fields mosaic).
- \(\text{H}_\alpha\) extinction ⇒ Translucent gas (\(A_v \sim 2 – 3\)) but the standard \(X_{CO}\) factor applies.

⇒ Response of a diffuse cloud to the sudden excitation by an O star
⇒ A template for high mass stellar feedback.
Bright CO resulting from the interaction of a runaway O star with the diffuse ISM: 2. 30m + PdBI


AE Aurigae (a.k.a HD 34078)
- O9.5V runaway star (ejected from the Orion Trapezium region).
- Distance: 530 pc.
- Velocity: 120 km s\(^{-1}\) ⇒ 1.2\(^{\circ}\) on-sky every 10\(^5\) yr.

The diffuse IC 405 nebula
- No CO detected in neither Dame et al. (9') nor Planck (15') at \(\sim 1\) K km s\(^{-1}\) sensitivity.
- 10 K clumps detected with the 30m in \(^{12}\)CO (J=1–0) (23'') mainly (but not only) at the edge of the diffuse gas (200 square arcminutes mapped at 0.2 K sensitivity in 0.5 km s\(^{-1}\) channels in 30hrs).
- 30 K sub-structures when mapped at 4'' resolution at PdBI (150-fields mosaic).
- H\(\alpha\) extinction ⇒ Translucent gas (A\(_{\nu}\) \(\sim\) 2 – 3) but the standard \(X_{\text{CO}}\) factor applies.

⇒ Response of a diffuse cloud to the sudden excitation by an O star
⇒ A template for high mass stellar feedback.
The PdB Site

PWV

Phase Fluctuations (100GHz)
Baseline Extensions
The NOEMA Receivers

<table>
<thead>
<tr>
<th>Band</th>
<th>NOEMA-1</th>
<th>NOEMA-2</th>
<th>NOEMA-3</th>
<th>NOEMA-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Frequency (GHz)</td>
<td>72-116</td>
<td>127-179</td>
<td>200-276</td>
<td>275-373</td>
</tr>
</tbody>
</table>
NOEMA Correlator Technology
Fast Sampling for 4 GHz Sub-bands
(Gentaz et al.)
NOEMA Project Schedule

2017: Phase I: 10 Ants + Rx + 1\textsuperscript{st} Correlator for 12 Ants

2018: Baseline Extension to 1.6 km

2019: Phase II: 12 Antennas + Rx

2020: Rx Dual Band Upgrade + 2\textsuperscript{nd} Correlator

TOTAL NOEMA Costs: 55 MEu

Total Investments on PdB: >130 MEu
Antenna 7 inauguration  22 Sept. 2014
Ant 9
first roll out
The Next Big Thing: Creating a world wide interferometer (mm-VLBI) to image the BLACK HOLE in the center of our galaxy!
Other Activities at NOEMA Side

- ASTEP – radiation hardness of microelectronics
- Solar panel Testing CEA - LITEN – DTS
- GPS RéNaG (Réseau National GPS) - dismounted
NOEMA
(Northern Extended Millimeter Array)

Thank You for Your Attention