VEGA: Status and Future Plans

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FIZEAU-Nice, LAOG-Grenoble, CRAL-Lyon
VEGA 2009: main points

• Huge effort on data processing

• Publication on principle and performance

• First science results
  – High spectral resolution: Deneb, Rigel.
  – Faint objects: AB Aur
  – New programs on fundamental parameters: 13 Cyg, ro Ap
  – “Classical” programs: Be stars, binaries
Nights 2009: not a great success

- 25 nights over 56: Gloom, fire, weather.
- Some troubles with the internal fringe tracker.
- Lot of programs but troubles with processing.

But:
- Good operations also in remote. Control system is now stable.
- Alignment is very stable.
- Good progress on the pupil shapes. Images…
Status of programs

2008: 29 nights with data    2009: 25 nights with data
Total=54 nights*~8h=432h

27 programs, 44 objects, 421 measures
1 measure = 1 hour for Cal-Tar-Cal + Spectral Calibration

![Graph showing 2008-2009 Programs and Measures]
Summary of the VEGA Science Programs

• First priorities
  – A/B Supergiants (Chesneau): see later
  – AB Aur (Perraut): see later

• Circumstellar environments (see Omar’s presentation)
  – Four Be stars
  – ups Sgr and bet Lyr

• Fundamental parameters (see Nicolas’s presentation)
  – 13 Cyg
  – bet Cep
  – ro Ap stars
  – sub giants

• Then: eps Aur, alp Cep, P Cyg, theta OriC…
## Status of the Science Programs

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Nights</th>
<th>Data</th>
<th>Processing</th>
<th>Quality</th>
<th>Analysis</th>
<th>Publication</th>
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<tbody>
<tr>
<td>V08</td>
<td>DenebRigel</td>
<td>12</td>
<td>20</td>
<td>100%</td>
<td>Good to excellent</td>
<td>Done</td>
<td>almost submitted</td>
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<tr>
<td>V12</td>
<td>HaeBe</td>
<td>13</td>
<td>15</td>
<td>50%</td>
<td>Medium</td>
<td>In progress</td>
<td>In preparation</td>
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<tr>
<td>Vxxx</td>
<td>del Sco, Chi Oph, Be</td>
<td>24</td>
<td>58</td>
<td>100%</td>
<td>Medium</td>
<td>Done</td>
<td>almost ready</td>
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<tr>
<td>V11</td>
<td>bet Lyr/Ups Sgr</td>
<td>14</td>
<td>30</td>
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<td>Good</td>
<td>In progress</td>
<td>In preparation</td>
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<tr>
<td>V27</td>
<td>eps Aur</td>
<td>2</td>
<td>9</td>
<td>100%</td>
<td>Good to excellent</td>
<td>Standby</td>
<td>In preparation</td>
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<tr>
<td>V01</td>
<td>13 Cyg</td>
<td>8</td>
<td>12</td>
<td>100%</td>
<td>Good</td>
<td>Done</td>
<td></td>
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<tr>
<td>V03</td>
<td>bet Cep</td>
<td>11</td>
<td>21</td>
<td>100%</td>
<td>Medium to excellent</td>
<td>More data</td>
<td></td>
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<tr>
<td>V06</td>
<td>HD49933</td>
<td>5</td>
<td>8</td>
<td>100%</td>
<td>Bad</td>
<td>New data</td>
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<tr>
<td>V23</td>
<td>del Cep</td>
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<td>7</td>
<td>100%</td>
<td>Bad</td>
<td></td>
<td></td>
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<tr>
<td>V02</td>
<td>Sirius</td>
<td>3</td>
<td>3</td>
<td>50%</td>
<td>Good</td>
<td>Standby</td>
<td></td>
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<tr>
<td>V16</td>
<td>ro Ap</td>
<td>7</td>
<td>9</td>
<td>50%</td>
<td>Good</td>
<td>In progress</td>
<td></td>
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<tr>
<td>V28</td>
<td>theta OriC</td>
<td>4</td>
<td>10</td>
<td>50%</td>
<td>good</td>
<td>Standby</td>
<td></td>
</tr>
<tr>
<td>V30</td>
<td>P Cyg</td>
<td>3</td>
<td>5</td>
<td>50%</td>
<td>Medium</td>
<td>Standby</td>
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</tr>
<tr>
<td>V31</td>
<td>Fast rotators</td>
<td>5</td>
<td>36</td>
<td>50%</td>
<td>Good</td>
<td>Standby</td>
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<tr>
<td>V22</td>
<td>sub Giant</td>
<td>16</td>
<td>33</td>
<td>30%</td>
<td>Good</td>
<td>Partly done</td>
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Status of VEGADRS

- Pipeline is now defined with a small number of modes
  - $V^2(t)$, $V^2$, $Ve^{i\phi}$

- Still some parameters to adjust depending on SNR
  - Number of frames
  - Spectral width of science channel

- Main limitations in the processing
  - Photon centroiding hole in $V^2$ mode. Low $V^2$.
  - Accurate spectral calibration in High Spectral Resolution.
  - OIFITS output in $Ve^{i\phi}$ mode.
  - Post-processing tools for handling large amount of individual data.

- Main limitations in the data
  - Phase noise residual
  - Group delay tracking
  - Saturation of detector in photon counting regime
Summary of performances *(A&A 508 2009)*

**Spectrograph Characteristics**

<table>
<thead>
<tr>
<th>Resolution</th>
<th>$R$</th>
<th>Typical lim. magnitude</th>
<th>Best perf.</th>
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<td>Low</td>
<td>1700</td>
<td>6.8</td>
<td>7.5</td>
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<tr>
<td>Medium</td>
<td>6000</td>
<td>6.5</td>
<td>7.5</td>
</tr>
<tr>
<td>High</td>
<td>30 000</td>
<td>4.2</td>
<td>5.5</td>
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</table>

**Limiting magnitude**

<table>
<thead>
<tr>
<th>$\delta$</th>
<th>HA(h)</th>
<th>$\lambda$(nm)</th>
<th>$V^2_{\text{Nat}}$</th>
<th>$V^2_{\text{High}}$</th>
<th>$V^2_{\text{Low}}$</th>
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<tbody>
<tr>
<td>29°</td>
<td>[0;+5]</td>
<td>640</td>
<td>0.36 ± 0.02</td>
<td>0.34 ± 0.02</td>
<td>0.36 ± 0.03</td>
</tr>
<tr>
<td>29°</td>
<td>[0;+5]</td>
<td>650</td>
<td>0.34 ± 0.03</td>
<td>0.36 ± 0.02</td>
<td>0.38 ± 0.04</td>
</tr>
<tr>
<td>52°</td>
<td>[-1:+4]</td>
<td>640</td>
<td>0.40 ± 0.04</td>
<td>0.34 ± 0.03</td>
<td>0.38 ± 0.02</td>
</tr>
<tr>
<td>52°</td>
<td>[-1:+4]</td>
<td>650</td>
<td>0.38 ± 0.03</td>
<td>0.38 ± 0.03</td>
<td>0.44 ± 0.01</td>
</tr>
<tr>
<td>63°</td>
<td>[-1:+4]</td>
<td>640</td>
<td>0.26 ± 0.01</td>
<td>0.24 ± 0.01</td>
<td>0.24 ± 0.02</td>
</tr>
<tr>
<td>63°</td>
<td>[-1:+4]</td>
<td>650</td>
<td>0.28 ± 0.01</td>
<td>0.28 ± 0.02</td>
<td>0.28 ± 0.02</td>
</tr>
</tbody>
</table>

**Differential phase**

**Polarisation behaviour**
Interests in the visible of A/B supergiants (e.g. Deneb A2Ia, and Rigel B8Ia):
- Very bright and used as stellar candles,
- large diameters (60-100 solar radii), Deneb and Rigel are 2-3mas sources
- Variability in Hα line (R>10000), sensitive to mass-loss and its perturbations, time scale weeks to months.

Rigel, Kaufer et al. 1997, PhD thesis
Deneb, Przybilla et al. 2008
VEGA/CHARA observations of Deneb: the Hα line

Time variability

![Graphs showing time variability of Hα line at different wavelengths and phases.](image-url)
Full 1D modeling of the wind of Deneb

Parameters from the model of Schiller et al. 2008

**Conclusions:**

- The Hα line is complex, subtle opacity effects.
- The visibility curve is a better indicator of mass-loss rate. The observed visibilities are very close to the model.
- The continuum diameter in the near-IR is predicted to be 2-3% larger than in the visible.
- The near-IR visibility curve is much less dependant on any mass-loss rate variations than in the visible. The CHARA/FLUOR observations were probably not very sensitive to circumstellar material.
AB Aur is a **prototype of Herbig Ae/Be stars** and, as such, it has been fully observed in spectroscopy, in infrared interferometry (PTI, IOTA, …)

- Spectral type : A0
- Magnitudes : V = 7.1 / K = 4.4
- Distance : 144 pc
- Luminosity : 47 L\(_\odot\)
- Large infrared excess
- No jets, no CO flow
- Variability of the H\(\alpha\) emission at a scale of a few hours

⇒ Stellar activity, link wind and disc, …
VEGA observations

- **2008. S1S2**: Clear spatial resolution of AB Aur in H\(\alpha\)
- **2008. W1W2**: Fringes but SNR too poor
- **2009. S1S2**: Tracking problem

Wind modelling

PCygni profile
A wind only does not allow us to reproduce the spectrum AND the visibility curve, even if this wind is very extended. Another component has to be considered. We assume a brightness asymmetry in agreement with:

- the spiral arms detected at few hundreds of AU
- the non-null closure phase measured by Millan-Gabet et al. (2006)
- the binarity signals recorded by spectro-astrometry by Baines et al. (2006)

Perspectives:

- Observe AB Aur in 2010 with larger baselines to resolve its photosphere
- Take benefit of IR fringe tracking
Future plans

• Publications
• Improved processing
• Tracking
• Stability and optimization of the instrumental visibility
• Better ergonomics of VEGA in general
Recent works: temporal processing

This statistical analysis improves the data analysis: bias removal, better estimation even in case of poor tracking.
Recent work: photon centroiding hole

Saturation effect in the emission lines

Improved algorithm will be necessary: need to record more and larger sub-images and develop an optimized post-processing.

We plan some tests of EMCCD detectors that could be used in the future in the bright flux regime.
Work on tracking

- Bad behaviour of the internal group delay tracking. Need some improvements.

- Tests of VEGA+FLUOR and VEGA+CLIMB are foreseen at the beginning of the season.

- Accuracy needed on group delay tracking:
  - Low spectral resolution: 4 µm
  - Medium spectral resolution: 5 µm
  - High spectral resolution: 35 µm

1 grad = 10µm
Instrumental visibility

Calibrator of eps Aur, on 2009 November 17th

The idea is to take time to test that in different conditions:
- integration time of the tip/tilt (fast piston noise?)
- effects of OPLE position?
- effects of external perturbations?
Ergonomics of VEGA

• Preparation is fine, for 2T.
  – New plans for 3T with improved performances (via JMMC and new ASPRO software).

• Night scheduling is horrible:
  – different strategies, important number of observing blocks, experience of observers.
  – Needs are identified but nobody for doing that!
  – Two levels: during the preparation and at the time of observations.
  – Similar needs on other instruments?

• Automatic fast processing at the end of the night.
  – Should be operational by the summer.
  – The idea is an automatic quality check with results stored in the database.

• We are starting a kind of VO tool aiming at managing all information and software related to VEGA observations.
  – Prototype by the end of 2010 if funded.
Conclusions

Continuous efforts on data processing.

Better focus on specific and unique science programs.

Better ergonomics of VEGA for a wider use inside the CHARA group.

Develop the VEGA and CHARA communications for a better operation.

Thanks to CHARA team

Hal, Theo, Judit, Laszlo, Nils, Chris, PJ, Gail, Steve and Larry