Feedback on the use of heterodyne receivers and on the LP experience

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ESO Users Committee – “APEX Operations”

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1. ALLSMOG: the APEX low-redshift legacy survey for molecular gas
A simple cartoon to visualize a complex process. What we know from observations:

- Most star-forming galaxies follow a tight correlation between SFR and $M_*$, the “main sequence” (at least up to z~2)  
  [Brinchmann+04, Noeske+07, Peng+10, Lilly+13, Renzini+Peng15, Schreiber+15]

- Only a few % outliers lie above the main sequence, the “starbursts”  
  [Sanders+88, Rodighiero+11, Schreiber+15]

- Passive galaxies observed up to z~2.5: their star formation halted early and rapidly ([alpha/Fe] enhancement, old stellar populations)  
  [Franx+03, Cimatti+04, Onodera+12, Thomas+10, Matteucci 94, Fontanot+09]
A simple cartoon to visualize a complex process. What we know from observations:

- Most star-forming galaxies follow a tight correlation between SFR and $M_*$, the “main sequence” (at least up to $z \sim 2$)
- Only a few % of outliers lie above the main sequence, the “starbursts”
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What is the link with $H_2$ gas?
We need large + unbiased $H_2$ surveys: COLDGASS, HRS, ALLSMOG ...

cartoon by S. Lilly

References:
[Brinchmann+04, Noeske+07, Peng+10, Lilly+13, Renzini+Peng15, Schreiber+15]
[Sanders+88, Rodighiero+11, Schreiber+15]
[Franx+03, Cimatti+04, Onodera+12, Thomas+10, Matteucci 94, Fontanot+09]
The ALLSMOG Survey

CO(2-1) APEX survey of nearby low-mass star forming galaxies

- Large (2.5 yrs, ESO P92-P96) “poor” PWV SHeFI-1 project. Completed ~3 months ago (31 Dec 2015).
- >340h of observations, 89 sources in total
- Observing strategy: aim to S/N > 5 (on the CO line) or rms= 0.8 mK@dv=50 km/s
- Data immediately public (ESO archive). Reduced spectra and tables available at www.mrao.cam.ac.uk/ALLSMOG
- Ancillary data available for the full sample (optical, HI, allow to estimate galaxy properties)
Data reduction and analysis
Detection rate and distributions

16%  78%

$M_*$

$\log M_\star \,[M_\odot]$ 

$\log$ SFR $\,[M_\odot \, yr^{-1}]$

46/89 (52%) detections, comparable to high-$M_\star$ surveys (54%, COLDGASS)

Cicone+, in prep
H$_2$ consumption timescale, $\tau_{H2}$ vs sSFR

$\tau_{H2} \approx 10$ Gyr

Higher sSFR (i.e. above MS values) are associated with lower $\tau_{H2}$

A unique relation fits all galaxy types

Dynamical processes (e.g. mergers) induce starburst episodes that drive the sSFR up and at the same time lower $\tau_{H2}$ and/or enhance SFE (by compressing gas)

Hunt+15, Bothwell+14, Saintonge+11
Galaxy growth intrinsically linked to cold H$_2$ gas

But works differently for different galaxies. CO/H$_2$ surveys so far have evidenced:

- **Main Sequence** (~ constant sSFR): Growth driven by amount of H$_2$ (quiescent, linear mode of star formation, S-K law). But high-M$_*$ galaxies have longer $\tau_{\text{H}_2}$.
- **Starbursts** (high sSFR): High concentrations of *dense* H$_2$ (due to dynamical processes e.g. mergers). Higher SFE and lower $\tau_{\text{H}_2}$.
- **Passive galaxies** (low sSFR): Almost void of H$_2$ gas

... stay tuned for new results from ALLSMOG
II. What worked (very) well
Phase I

- 300h (4 semesters) Large Programme accepted after second submission attempt in P92

- The OPC comments from first submission (P91) were useful, the OPC strongly encouraged a resubmission

- The LP got an extension of one additional semester (P96), allowing us to complete the 300h of observations initially requested (and eventually even exceed them!)
### Phase I

**Additional ESO heterodyne projects I am involved in:**

<table>
<thead>
<tr>
<th>Period/ID</th>
<th>Time request</th>
<th>instrument</th>
<th>PI</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>198.A-0708</td>
<td>150h (LP)</td>
<td>SHFI-1</td>
<td>Koss</td>
<td>Second (re-)submission. Pretty good OPC report after 1(^{st}) submission.</td>
</tr>
<tr>
<td>098.A-0774</td>
<td>28h</td>
<td>SHFI-1/PI230</td>
<td>Cicone</td>
<td>Quick response and great support from ESO and MPIfR about possibility to access PI230 Rx.</td>
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</table>
Phase II and observations

• We had the chance to update and refine regularly the target list and the observing strategy. Lot of flexibility from APEX staff on this side, crucial for scientific return (especially for an LP)!

• We even got extra >40h of observations with respect to the original time request of 300h

• Most of the data were taken with much better PWV than expected (typically PWV~2mm)

• Observing experience was amazing and very instructive (I supported >350h of observations during ESO time). The project greatly benefited from direct observational experience

• Enthusiastic support from APEX staff (astronomers, operators, and other observers) who were always willing to help
Data products and science

• First check and reduction done by observers and operators 
  very useful to keep track of the potential issues (baseline 
  ripples, quick PWV variations and noisy scans, etc.)

• Good and quick science return (~3 years since the 
  beginning of the survey):
  – 2 publications by the team (Bothwell+14,+16), +1 paper 
    submitted and 2 manuscripts in prep.
  – 7 publications from outside the team using our data
III  Ways to improve? A few ideas...
Phase I

- Adjust the ESO proposal template for APEX (the current one requires information such as seeing overhead, lunar phase, etc..)

8. Justification of requested observing time and observing conditions

Lunar Phase Justification: As a sub-millimetre/millimetre-wavelength telescope, APEX observations are not affected by the phase of the moon.

- Provide updated statistics about oversubscription of LST ranges, instruments, frequency bands. This information could be made available to both users and ESO OPC members (could it be used in the technical evaluation process, e.g. to “promote” projects asking for undersubscribed conditions?)
Phase I

• Introduce an **helpdesk + public knowledgebase** for APEX users (similar to ALMA)

• Ensure to have at least **one millimeter/radio expert in each ESO OPC panels evaluating APEX proposals** (to avoid situations in which potential technical issues (mis)identified by non-experts implicitly condition the science evaluation outcome)?
Phase II and observations

- Evaluate alternatives to the Twiki system (esp. for LPs)?

Twiki pages of LPs can get quite messy and confusing because they get updated by many different people and over a long period of time.
Data reduction and analysis

- Introduce a quantitative data quality assessment (e.g. “quality tag” the bad scans)?
Conclusions

• I am not sure there is much room for improvement.. the “APEX user experience” is already great!

• I hope my feedback was still useful

• Thanks!