



Minutes from the discussions of the technical meeting on the future bolometer instrument for the IRAM 30m telescope

<i>1st discussion</i>	Is it possible to suppress stray light efficiently with limited room ? Is a compromise of FOV against baffling and filtering necessary ?
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Short answer/summary: Yes it should be possible to suppress stray light without a huge cold optics system, and yes there is possibly a price to pay in terms of FOV.

Key points of the discussion:

- Participants should tell IRAM what are the limits in terms of instrument size versus FOV imposed by the restricted room available with current and future optics.
- The criteria of a pupil and cold stop well defined in the cryostat should suffice to define a low stray light device.
- Depending on their size and filling ratio, bare antennas are a solution in between filled arrays of “pure” absorbers ($0.5F\lambda$) and arrays of “efficient” feedhorns ($2F\lambda$).
- The reflective ellipsoids (Néel) should allow a good stray light rejection with low thermal load; volume $D=20\text{cm} \times h=40\text{cm}$ for 6' FOV.
- The Non-Sequential module of Zemax can simulate (at least crudely) stray light for a given system telescope + instrument.
- The maximum filter size currently available from Cardiff is $D\sim 30\text{cm}$.
- Cardiff filters can be 95-97% efficient in band, degrade as $\sim \cos$ with incident angle. What is the sensitivity to stray lights due to the 5% non-transmissible part ?
- Cryostat windows larger than 20cm are possible, the limiting factor is probably a compromise between diameter and thickness to handle the mechanical restricts due to the atmospheric pressure at the window interface.
- SL's Zemax files for the 10' FOV optics are available on the meeting web page.

<i>2nd discussion</i>	Does sky noise affect significantly measurements with feedhorns and filled arrays ?
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Short answer/summary: Sky noise is always mixed with other noise components in the data, but it can be largely removed. Horns can jiggle to remove anomalous refraction when it is slow enough, but filled arrays need only to integrate longer...

Key points of the discussion:

- MAMBO typical sensitivity $\sim 40\text{mJy}\cdot\text{s}^{1/2}$.
- RZ warned that data have source signal + sky noise + systematic errors. Systematic must be removed before trying to remove sky noise.
- Weather statistics¹ compare noise in data (not sky noise) to noise on absorber.
- RZ warned to use the values of anomalous refraction just in a statistical way¹. It affects all data in pointing periods (1-3 hours). Its rms values can be used to calculate the effective S/N, and for filled arrays (NOT horns) the effective observing time.
- When anomalous refraction is slow it is possible to get rid of this effect with feedhorns thanks to jiggling, but only if the source position is known or/and the source is strong. When it has fast periods¹, the power is partially lost between horns. With filled arrays the source may appear blurry but the all the power is collected.

¹ see document “Anomalous_refraction_30m”

- Sky noise in GISMO 2007 run shows up below 0.2 Hz (tau was excellent), but MAMBO statistics says 5 Hz. Quick analysis of GISMO 2008 run (after the meeting), seem to converge toward 5 Hz for cloudy periods...
- What is the dependence with the wavelength of the sky noise components ?
- Chopped or “wobbled” mode was invented for mono pixel instruments. For many pixels its use may not be advantageous (fast readout or DC coupling).

3rd discussion	What are technical options for a multiband instrument ?
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Short answer/summary: Use warm or cold dichroics allowing for several focal planes in several or one cryostat. LEKIDs are promising for a multicolor instrument.

Key points of the discussion:

- Warm dichroics efficiencies ~95%, for small incidence angles. Work ongoing to develop dichroics efficient at given a angle (e.g. 45 degree).
- The maximum size so far for Cardiff dichroics is 10 cm (*is it for cold dichroics only or warm dichroics also ?*), and they separate wavelengths of 1 and 2mm.
- There are big issues to solve for cold dichroics due to the mechanical effects of temperature changes: tension homogeneity, flatness, resistance to cracks, invariance of the patterns, and so on. But there’s good hope to address these issues.
- Dichroics tested on BLAST work well and stay flat.
- LEKIDs filters are the detectors (see Jonas paper), and they are tunable, so interesting for a multicolor instrument. Though tests at CSO are not conclusive so far.
- KIDs and BUGs technologies are each invariant in a big wavelengths range (good for fabrication processes). But using the same pixel for different wavelengths with TESs is paid with efficiency losses. This should not be too problematic for KIDs.
- Possible: 2 bands on a wafer + filter cutting atmosphere “spike” between them.
- Silicon lenses are interesting because of their high index of refraction, but their monoband antireflection coating totally forbids using them for a multiband beam.

4th discussion	What are the environmental requirements for various detectors ?
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Short answer/summary: Measurements of electromagnetic interferences and vibrations are under way at the 30m, this should help the instrumental design.

Key points of the discussion:

- Different detector technologies in 1 cryostat are not compatible.
- The 30m cabin is equipped with an optical table minimizing vibrations (succeeded to reduce MAMBO excess noise).
- An accelerometer will be used to measure vibrations at several locations of the receiver cabin and for various conditions of the telescope operations. Measurements with a magnetic sensor will also be conducted.
- Very efficient magnetic fields are difficult to do but mandatory for SQUIDs because of their big pick up. It is also necessary for KIDs but less demanding.
- Pulse tubes are attractive for cryogenic operations, but must be installed with caution regarding vibrations, mainly caused by the change of size of their tube, and by their motor. These effects should not be problematic when locking their frequencies.
- Optical noise created when the telescope starts and stops moving is also something that has a non-negligible effect.

<i>5th discussion</i>	What are the constraints and compromises to build the best efficient and versatile instrument ?
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Short answer/summary: Budget and organizational issues came up in the discussion. For a better technical answer participants should send propositions compatible with IRAM's constraints. IRAM specifically encourages a test of KIDs in the NEEL cryostat at the telescope next summer.

Key points of the discussion:

- IRAM budget for the future instrument is ~6 Meuros maximum (mostly dedicated time, cash part ~1 Meuros max). Wish to have the instrument at the 30m in ~5 years.
- IRAM will send an extended list of constraints to participants, who will propose instrument designs few times latter, possibly in collaboration with others.
- Most participants agreed to be part of a possible consortium.
- Concerning the realization of the various instrument components, IRAM can participate to electronics, optics, data processing and software.
- SRON goal: a KIDs demonstrator including readout, ready for summer 2009.
- Néel is willing to collaborate with SRON to make this demonstrator (cryostat, optics, ...). An official letter will be sent to IRAM before the end of the year.
- It will be easier to define and budget the large instrument when all the technologies will have been tested (i.e. GISMO 2nd run and a KID prototype on the 30m, and TES on Apex).
- When the constraints and technologies are better defined and characterized, IRAM will issue a new call for precise proposals.

<i>6th discussion</i>	What are the next steps ?
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Short answer/summary: A web page related to the meeting will be created, where all the files and documents useful to the development of the future instrument will be available. Instrument proposals from participants should be issued by next year.

Key points of the discussion:

- SL will put on a web page: presentations of the meeting, Zemax files of the 10' FOV optical design proposition, RZ slides concerning seeing and sky noise (see the document "Anomalous_refraction_30m"), the receiver cabin measurements (Magnetic and vibrations), the receiver cabin dimensions (plan, STEP files).
- Cardiff will address the questions concerning the maximal size possible for cold and warm dichroics, and the behavior of the filters transmissions with angle.
- KIDs prototype coordinated by Néel possibly at the 30m by summer 2009.
- Horns vs filled arrays: baffling is a key question that will be further investigated.
- List of things to do for the future:
 - IRAM has been asked to define better the compensation for partners developing the instrument, in particular for "foreigners" and "insiders" of its organization.
 - IRAM can support up to ~50 keuros for preparatory work, preferably in form of travels and other logistical elements.
 - IRAM is also ready to consider support in terms of personnel.
 - PM will send the measures of Cardiff optical elements to SL, who will post them on the meeting web page.
 - The outcome of this meeting and related results of ongoing discussions will be presented to the IRAM SAC & council 2009.