Minutes of NIKA-2/MOKA Detector Work Group meeting, September 25 2012

S. Leclercq

Participants:

Néel:	Alessandro Monfardini, Martino Calvo
LPSC:	Andrea Catalano
AIG Cardiff:	Simon Doyle, Sam Row, Edgard Scordillis
SRON:	Stephen Yates
IRAM Grenoble:	Karl Schuster, Samuel Leclercq

Agenda

- Summarize main sources of problems of KIDs and make a plan for improving the performances
- Assess each lab capacities in terms of fabrication means, test beds, and simulation
- Discuss how to share each lab capacities for the collaboration

Minutes

Bold characters below = main items and key words for fast reading.

- Plan to improve the detector

1st of all: make a **list of factors limiting the sensitivity** with numbers (estimations) allowing quantifying the respective weight of each component:

- **Optics**: throughput (losses on mirrors, lenses, …), stray light, …
- **Detectors**
- **Amplifiers**: e.g. show VNA measures on resonances, …

AIG Cardiff (Simon Doyle et al) **can characterize** these elements if Néel/IRAM provide them, **and write reports**.
→ Need to write a **document with hypothesis**, measures to do, actions to improve the detectors quality up to the goals. This document should be **ready by the end of the year** / begin of 2013, along with the MoU.

At the telescope: characterise the best pixel on sky with the whole chain.
In parallel in the lab: do measurement with individual element to identify what is working, understand how/why it's working or not, and reproduce the experiments.

SD: the biggest problem is probably not the detector noise anymore, but rather the **responsivity;** there's 3-4 parameters not very well known that we can play with.

For the **next run at the telescope**: make a plan to **characterise the best pixel →** characterize with all the pixels, then with only 1 tone, and do that for the best pixel and for an average or bad pixel.
Note: currently the best pixel reaches roughly the requirement with roughly 12 $mJy \cdot s^{1/2}$, and with a better amplifier we could even go below that number.

Question of homogeneity: why some pixels are better than others?
The material is uniform, so it must be **cross-coupling**. → OK, but what causes it? Is it fabrication errors or a pure physical effect ? The simulations on small arrays produce some jitter of the resonances similar to what we observe, but nothing allows us to predict what will be the resonance jitter of real arrays; the effect seems variable depending on the material used (Al / TiN…), the thickness (45 nm is ~OK, but thinner films shows worse resonances dispersions), etc. → So is it due to microfabrication defaults or is it a real physical effect (e.g. weak links)?
➔ We **need to understand** better the effects of weak links; so we need models and measures (need a plan about how to measure the effect).

- Cross-coupling

<u>**Possible sources:**</u>

- **Standing waves**
- **Asymmetric modes on feed line**
- **Geometrical capacitive coupling**
- **Patching, stretching (frequencies)**
- **Fabrication process**
- **Physics of thin films**
- **Box modes (box hosting the KID wafer)**

➔ These hypotheses **can be tested individually in a dark cryostat**, so no need to go to the telescope. Some random processes may play a role (including in the microfabrication): repeat the experiments at least twice.
Scaling problem: the last 25 pixels array (NIKA prototype run 1) was pretty nice (nice VNA curves, etc.), in fact most of the problems appeared and strengthened with >100 pixels arrays. ➔ We have to do the tests on big arrays. ➔ Fabricate a batch of several identical arrays that can be used for tests.
<u>- Prioritisation:</u>
1) Test the simpler things: standing waves, box modes, fabrication processes, physics of thin films.
2) Then the more complicated: asymmetric modes (long because need to test various microfabrication designs…), patching (need simulations)…
<u>- Simplest experiments that could be done quickly:</u>
1) Effect of phase (change the phase of 1 tone only; it will probably have no effect, but let's check)
2) Box mode is probably the easiest: just need to change the box lid of the sample holder (it is used as backshort) in order to change the EM environment.
==> We **need a clear road map** for the detectors improvement.
==> We **need a plan of tests to do at the telescope for the November 2012 run**.
==> We need to define the **work distribution** for this effort of cross-coupling mitigation (who does what, when, and so on)

Thin films; where can we make them?

- PTA: possible to work on 4' wafers, but since this is a self service facility it is not reliable in terms of quality and reproducibility.
- IEF in Paris: high quality, but availability uncertain.

- **IRAM**: available and high quality, but only 2' wafers for now (upgrade to 4' foreseen)

For the tests it is maybe better to use IRAM's microfabrication; it's the same as for the wafers used at the telescope, and the arrays we would characterize would be made in known reproducible conditions. Only problem: the capacity to make air bridges for KIDs is not proven yet, but Catherine is working on it.

Masks management: Until now they were designed and ordered by Alessandro or Marcus, but we miss a **tracking document**: idea – simulation – goals – design – fabrication – tests – results. → It looks like we miss a **coordinator** managing an identified detector group and reporting actions. Actually this somewhat exist: there's a readme for each mask with explanations on the design, and a wiki keeping track of the arrays characteristics, the tests conducted, and the main results:
https://camera30m.ias.u-psud.fr/doku.php/proposals_and_array_testing
→ We just need to organize this better and spread the word (i.e. not only to everybody in the work-group, but also inform the IRAM boards that this exists)

For the **cross-coupling tests,** we need **10 wafers** at least to start properly the investigations:

- 4 with 20nm depositions
- 2 with 40nm depositions
- 2 with 80nm depositions
- 2 with 20nm depositions + air bonds

==> Test asymmetric modes, fabrication processes hazards, box modes.
Tasks assignations:

- Néel: organise the masks designs, fabrication, etc. (from 2011); organize KIDs fabrication at IRAM.
- IRAM: Fabrication on the 10 wafers foreseen
- Cardiff: Packaging & testings
- Néel: verify testing on same chip

Other test to do (oissibly in parallel:
Physics of thin films: fabricate 2 films 12nm, 2 films 15 nm, 2 films 18 nm → Néel & IRAM take care of this.