Update on Kinetic Inductance Detectors activities in France

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Outline

1 – NIKA2 status update

2 – After NIKA2: B-SIDE

3 – New materials for lower frequencies

4 – Cosmic rays interactions on KID arrays

NIKA2 overview

NIKA2: a dual-band photometer for IRAM 30m

- Correct FOV: ***6.5 arcmin***
- Total pixel count: ***≈ 3000***
- Arrays count: ***3 (2mm + 2 x 1.25mm)***

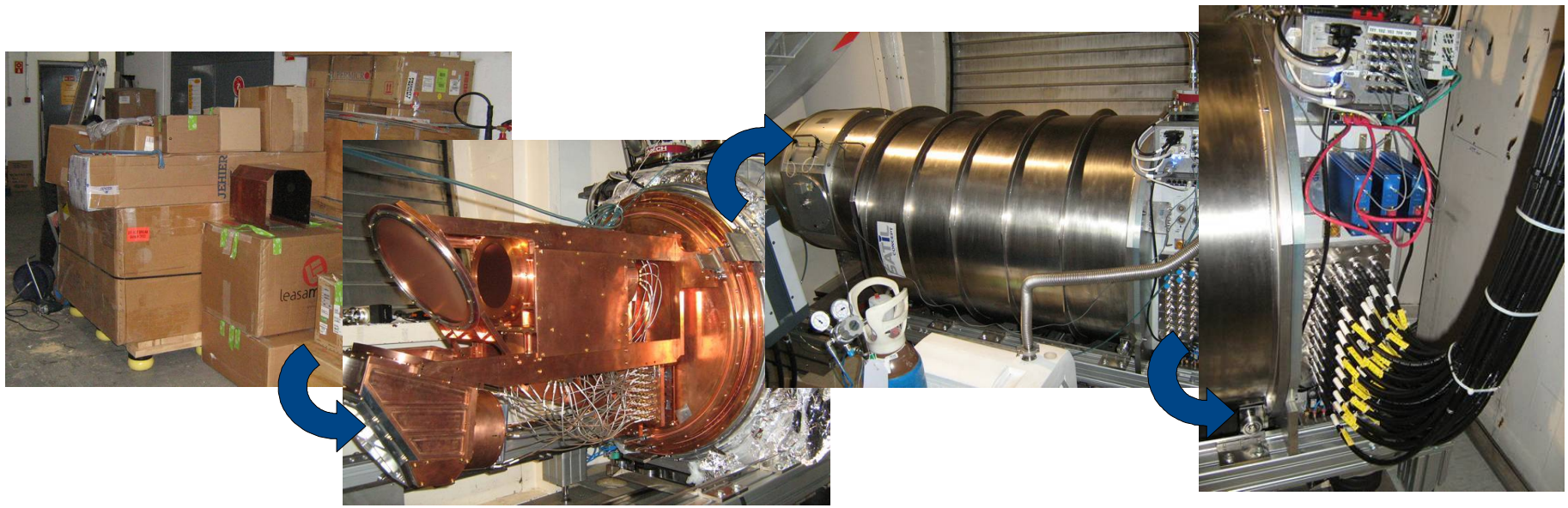
Wavelength (central) [mm]	2.0	1.2
Frequency (central) [GHz]	150	250
NEFD [mJy·s$^{1/2}$ /beam] goal on 90% of the pixels	10	15
NEFD [mJy·s$^{1/2}$ /beam] specification on 50% of the pixels	20	30
FWHM [arcsec] goal	16	10
FWHM [arcsec] specification	18	12
FOV diameter [arcmin] goal	6.5	
FOV diameter [arcmin] specification	5	
Pixel size in beam sampling unit [Fλ] goal	0.6	
Pixel size in beam sampling unit [Fλ] specification	0.9	

NIKA2 installation

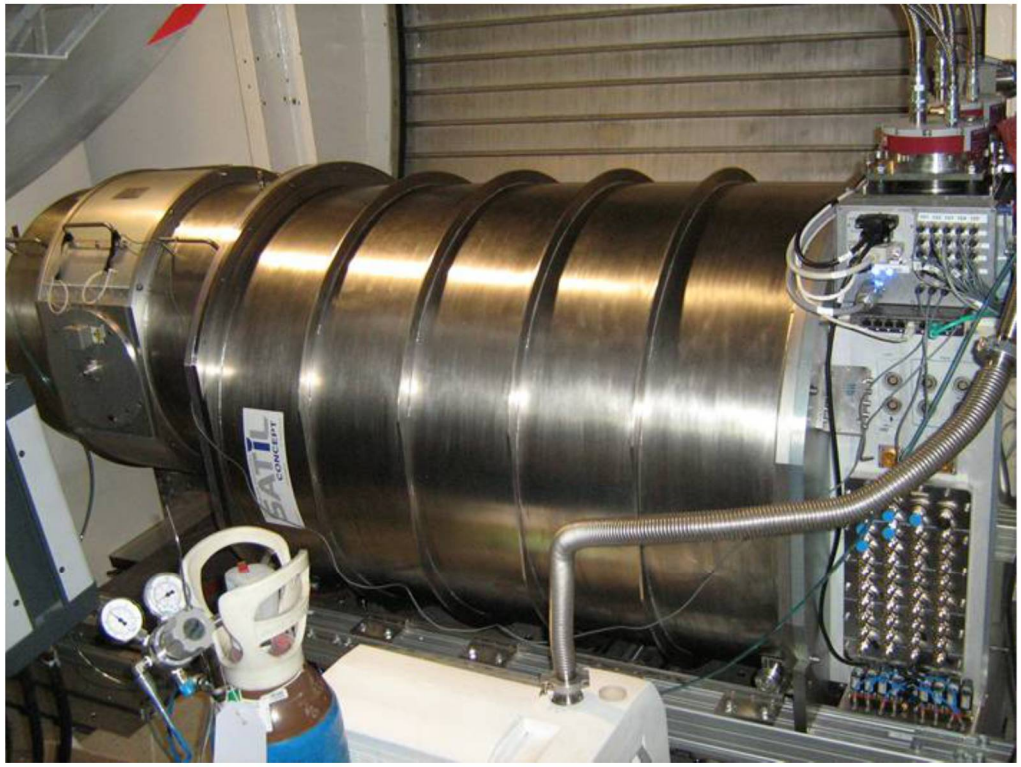
09/2012 Project financed, kick-off

Mid-2015 Expected installation at IRAM

Fall 2015 Installation at IRAM (in just 3 days!!)



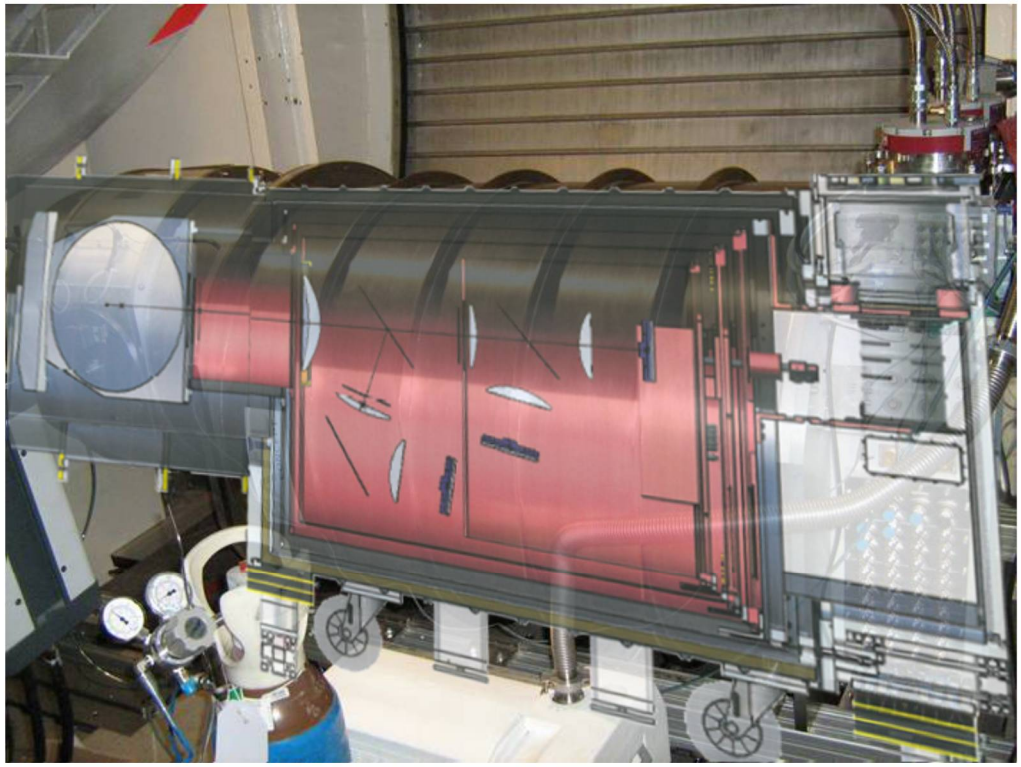
NIKA2 installation



The cryostat :

- **1.3 ton**
- 2.3m length
- Full remote operation
- Cryogen free
- Base T ≈ 150mK

NIKA2 installation



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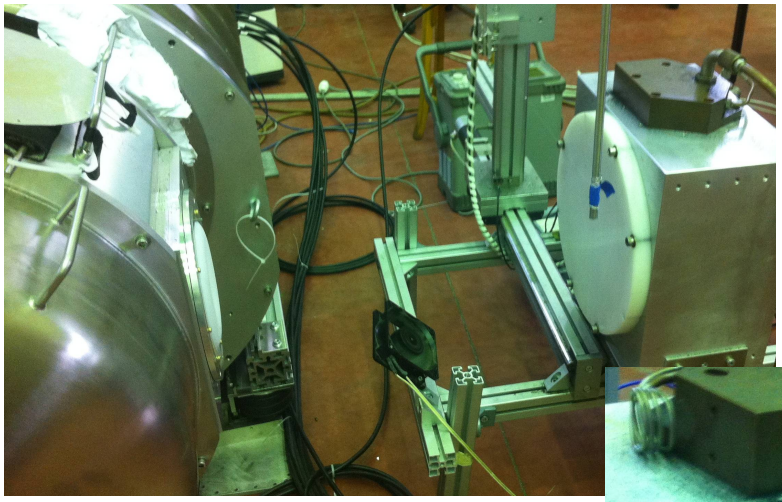
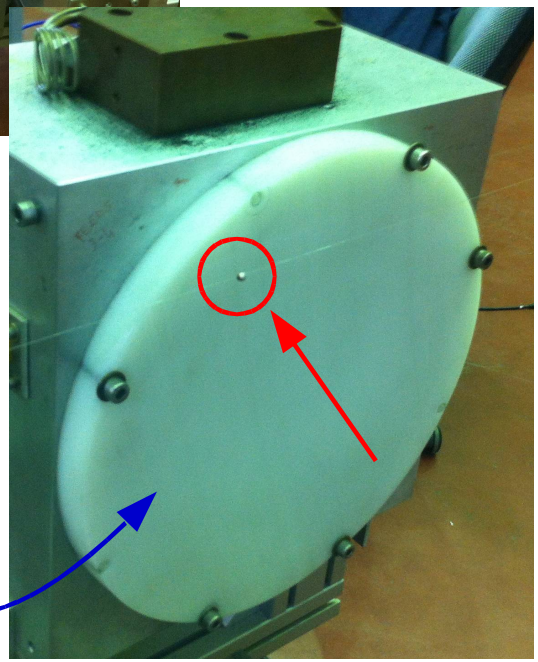
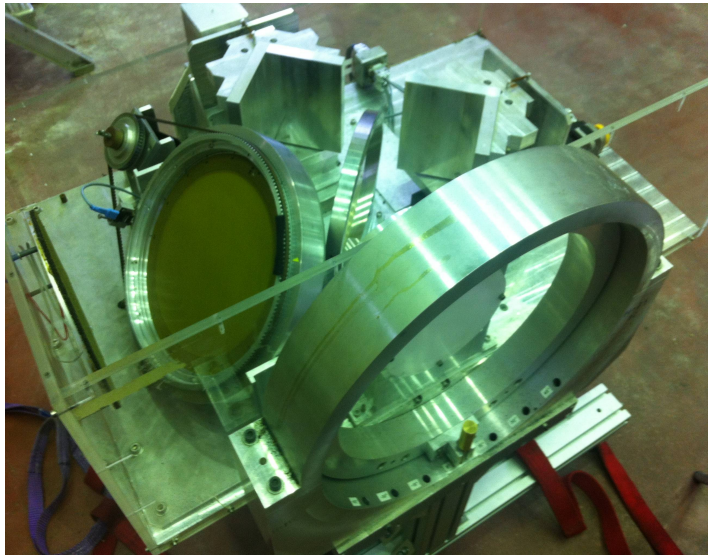
Test facilities

- Sky simulator
  - beam maps/responsivity



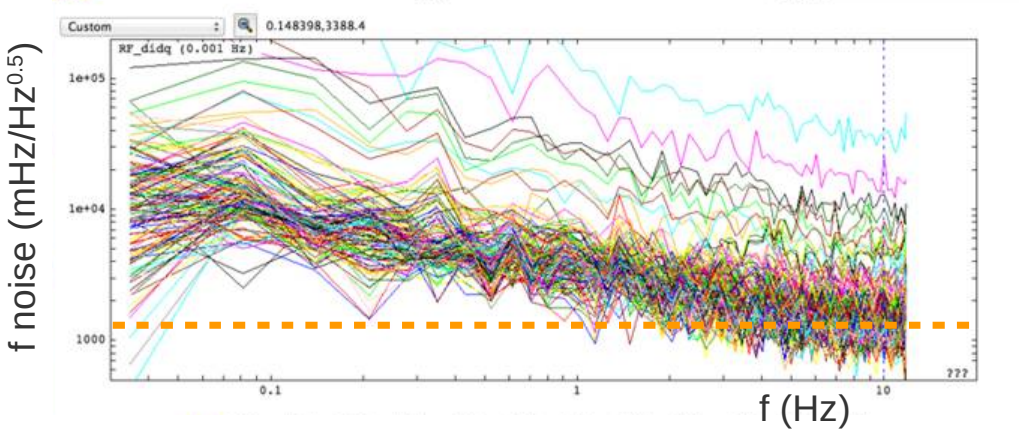


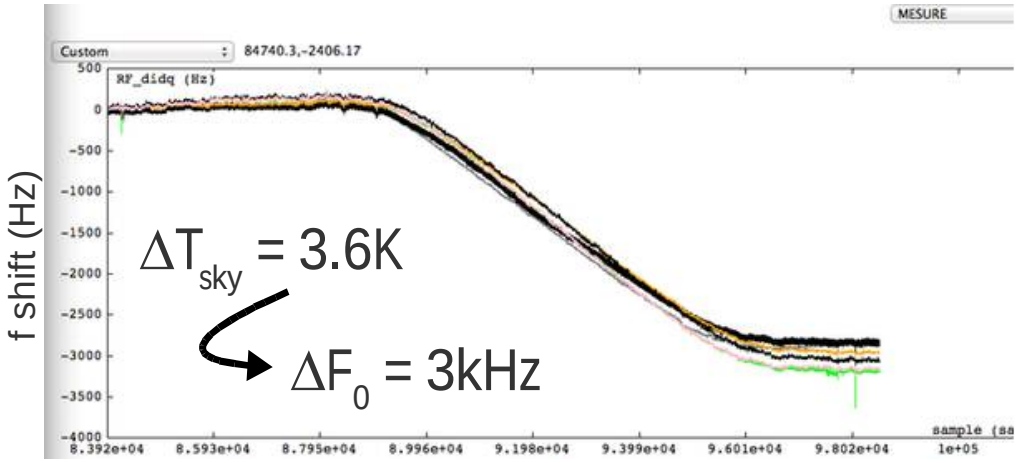
- Martin-Pupplet interferometer
  - absorption spectra



Test facilities

- Helps a lot in building confidence!





Noise level: 1÷2 Hz/Hz$^{0.5}$ @ 10Hz

Responsivity: 0.8 kHz/K

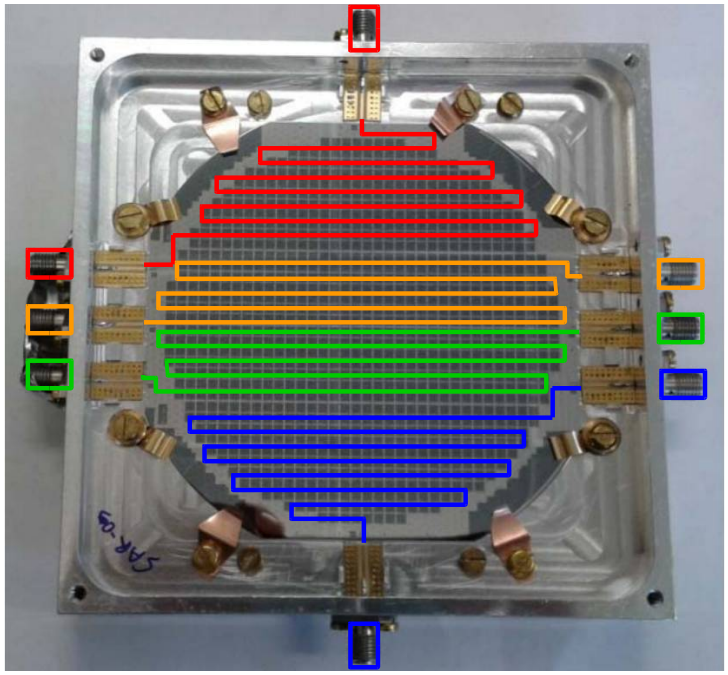
NET ≈ 1÷2 mK/Hz$^{0.5}$ per pixel

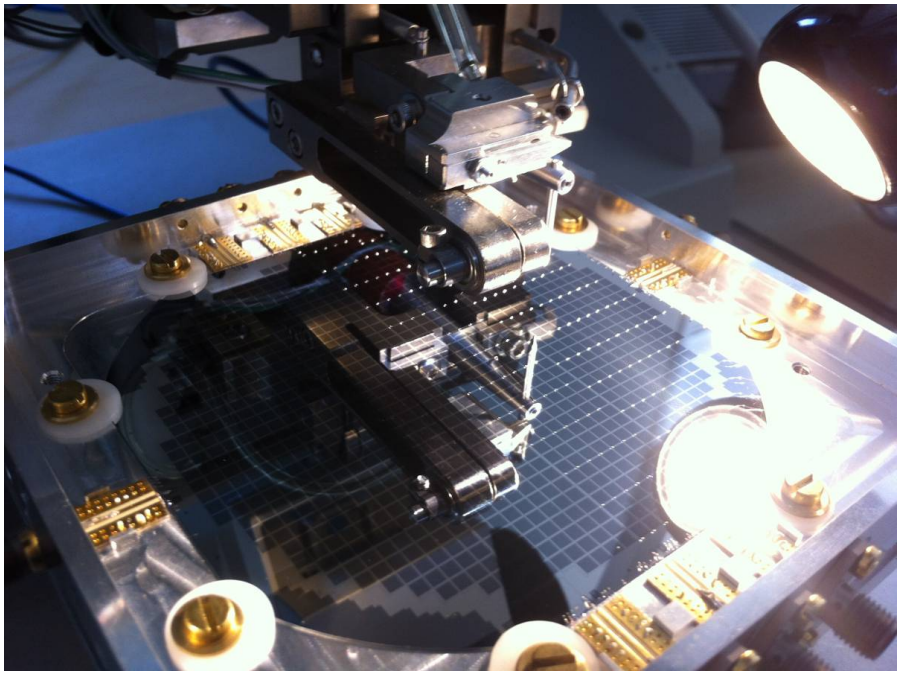
NEP ≈ 5 · 10^{-17}W/Hz$^{0.5}$

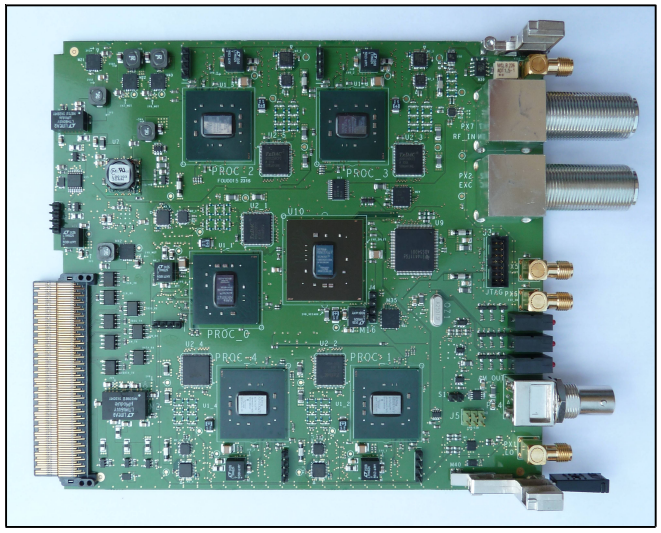
Near (at?) the photon noise limit!

NIKA2 : the arrays

1000 pixels 2mm array







O. Bourrion et al., 2012 JINST 7 P07014

- 2mm: 600÷1000 pixels → 4 feedlines
- 1.25mm: 1200÷2000 pixels → 8 feedlines

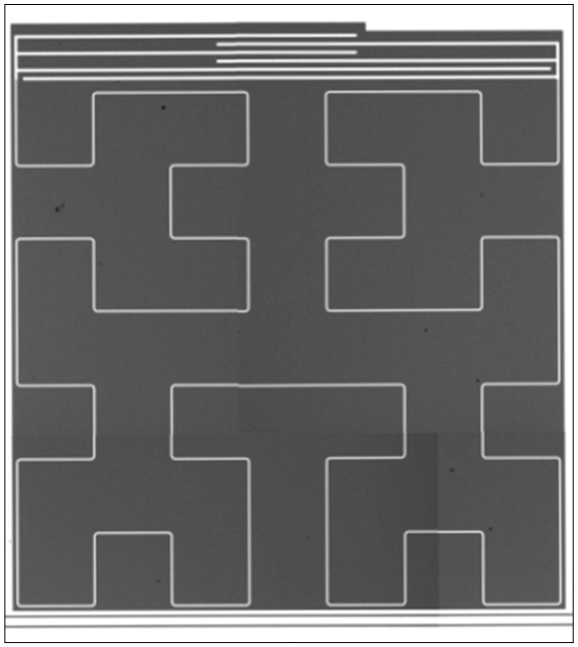
Single 4'' wafer fabrication

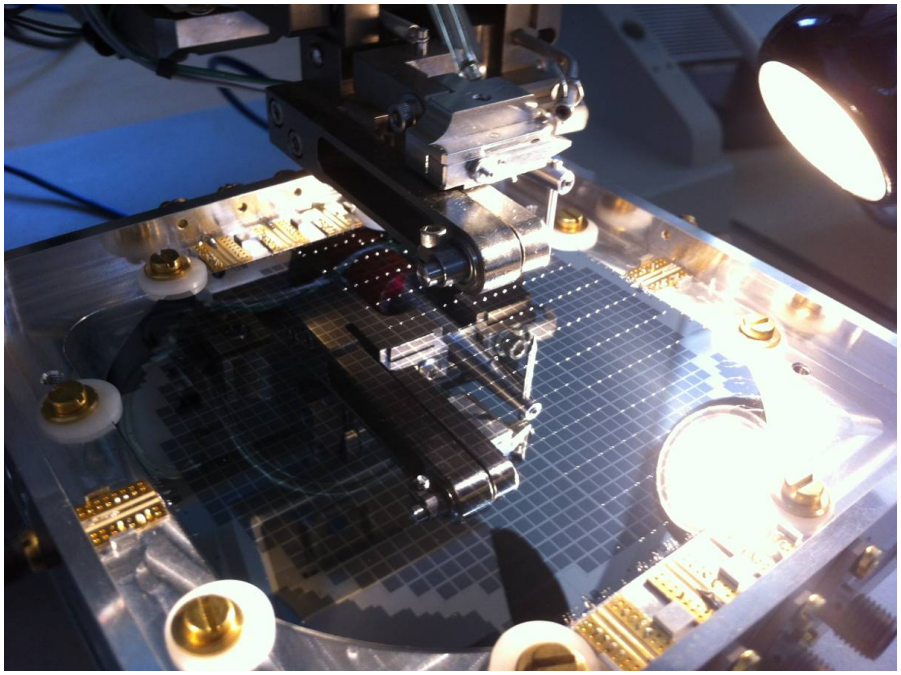
NIKELv1 boards: MUX factor 400 over 500MHz band

Current MUX factor: ***250*** (for safety + Q_i on ground!)

NIKA2 : the arrays

Hilbert LEKID design, *2-pol*
M. Roesch et al., Proc ISSTT 2011





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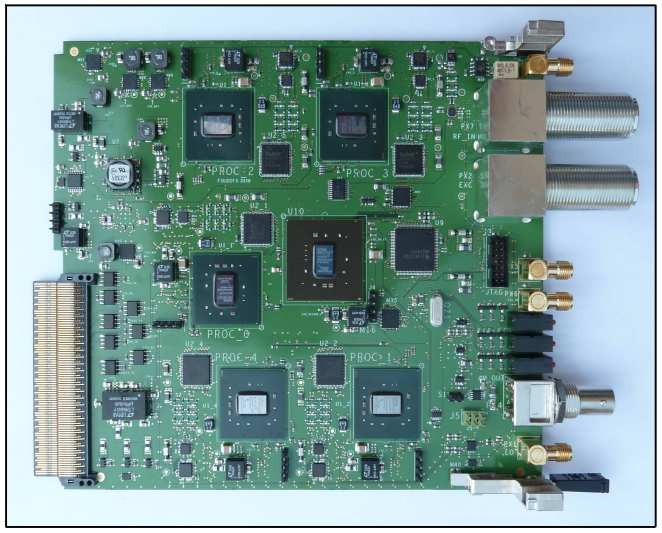

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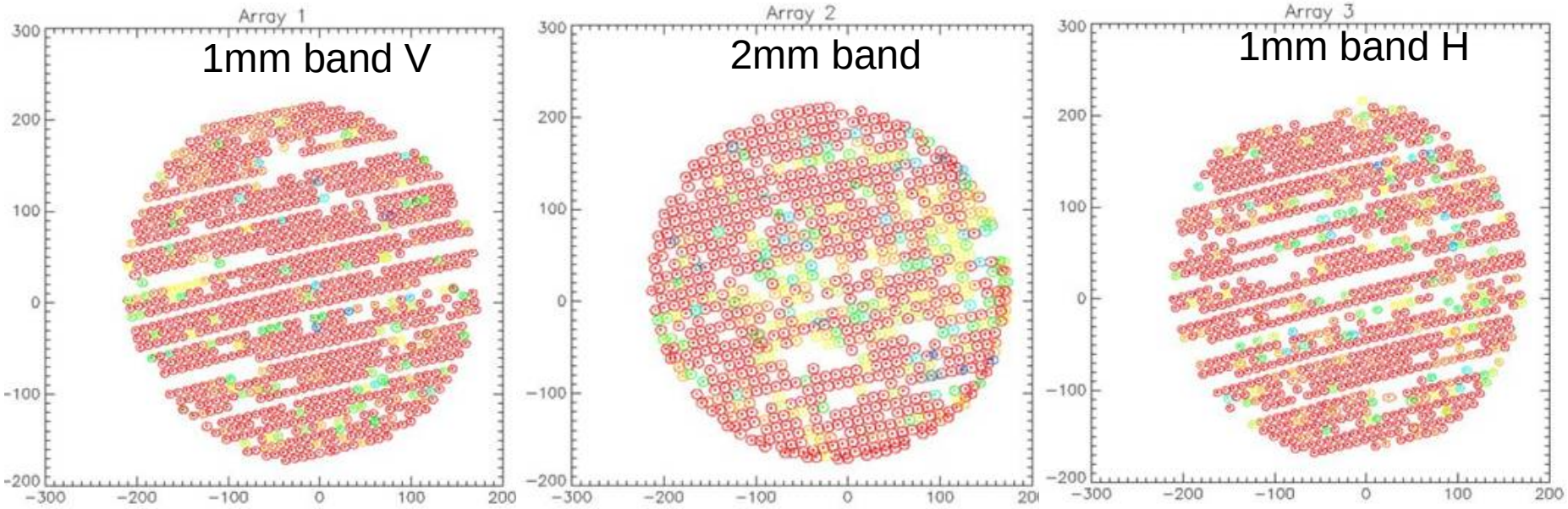
NIKA2 : arrays yield



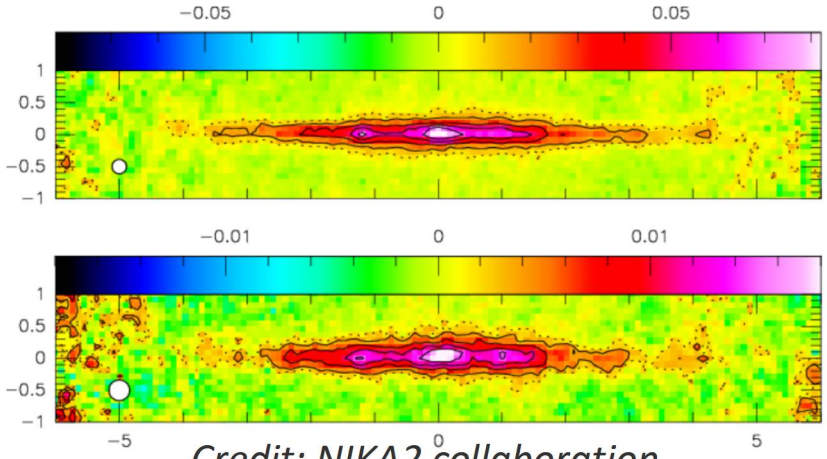
- Yield > 80%!

Preliminary NEFD:

- 15 ± 5 mJy.sqrt(s) @ 2mm
- 30 ± 5 mJy.sqrt(s) @ 1.2mm

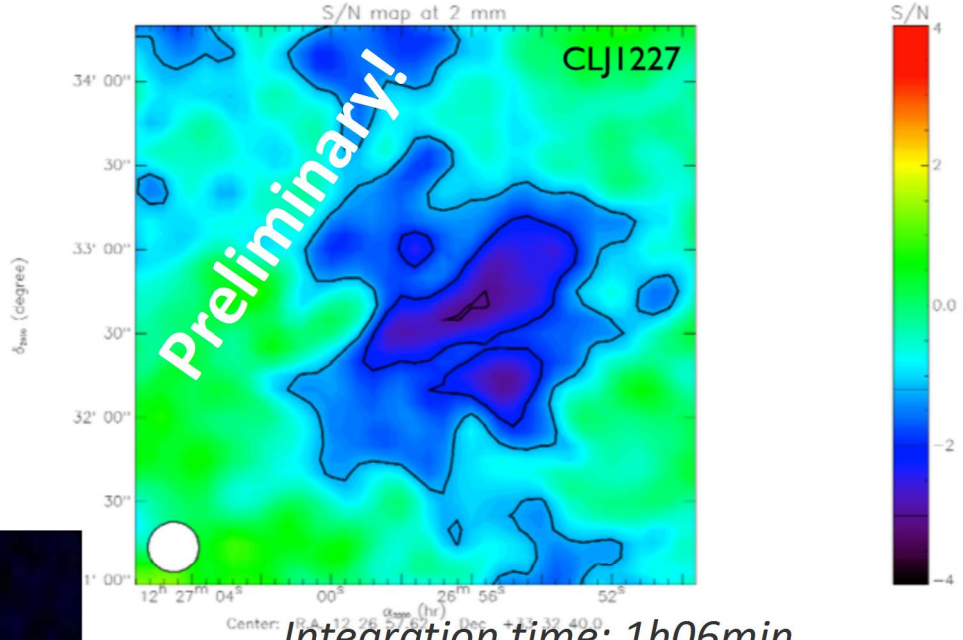
NIKA2 : preliminary picture gallery!

NGC891



Credit: NIKA2 collaboration

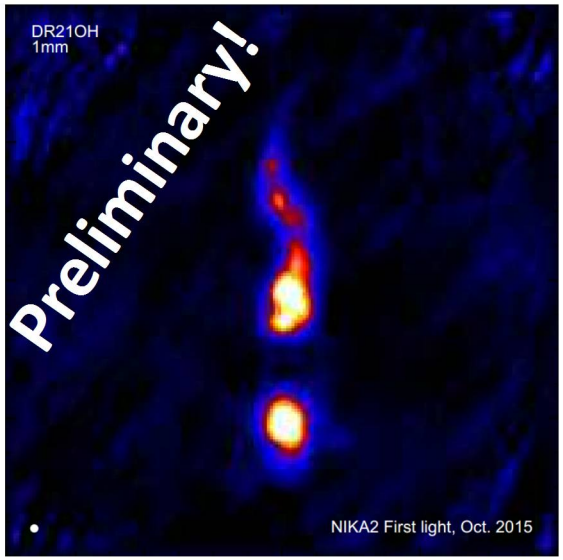
SZ effect in CLJ1227

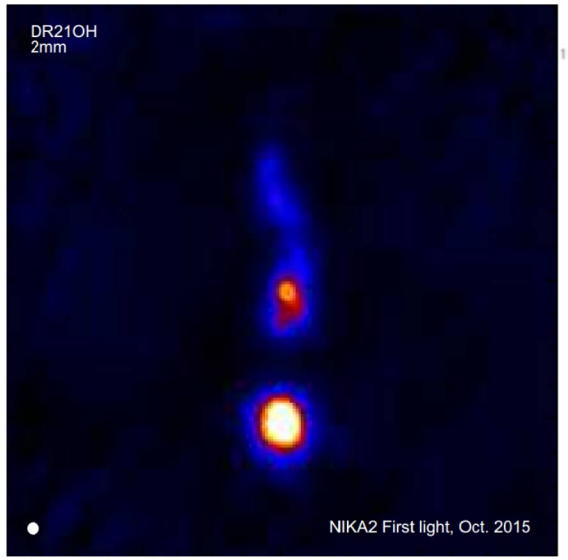


Integration time: 1h06min

Credit: F. Ruppin and NIKA2 collaboration

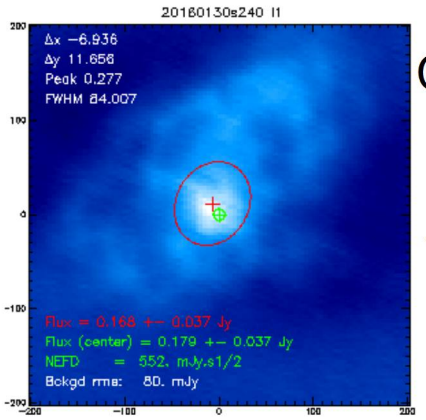
DR21OH





Integration time: 12 min

Credit: N. Ponthieu and NIKA2 collaboration



Crab nebula

IT: 15 min

Credit: NIKA2 collaboration

The B-SIDE project

B-SIDE: a balloon-borne experiments for the study of polarized foregrounds

- Funding: on the way! (hopefully..)
- Launch planned for 2018/2019

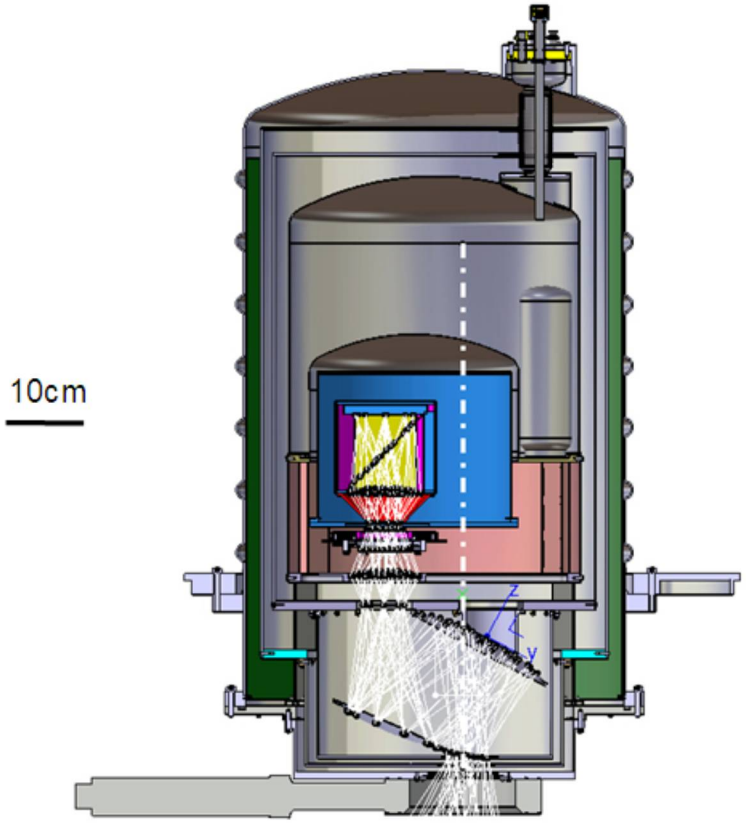
	Specifications	Goals
Primary mirror diameter (m)	0.8	
Instantaneous field-of-view (deg)	2	3
Angular resolution (arc-min)	7	5
Number of bands	1	2
Flight Duration (days)	1	3
Operating frequencies (GHz)	450-630	400-600 & 500-700
Number of pixels	980	1800
NEP ($W/Hz^{0.5}$)	$5 \cdot 10^{-16}$	$2 \cdot 10^{-16}$
Background per pixel	50-100 pW	

- Work has already begun!

The B-SIDE project

B-SIDE: a balloon-borne experiments for the study of polarized foregrounds

- Design



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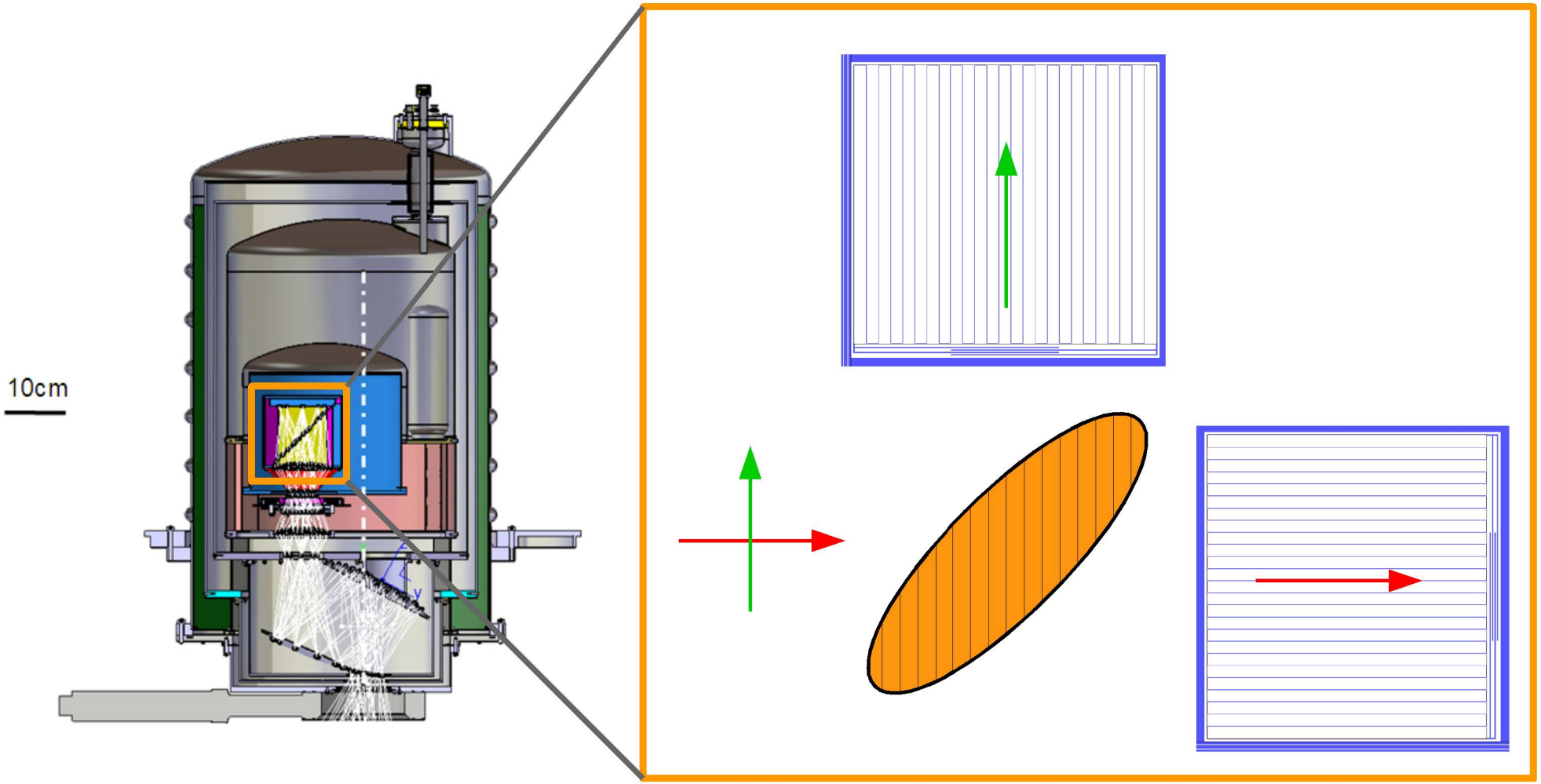

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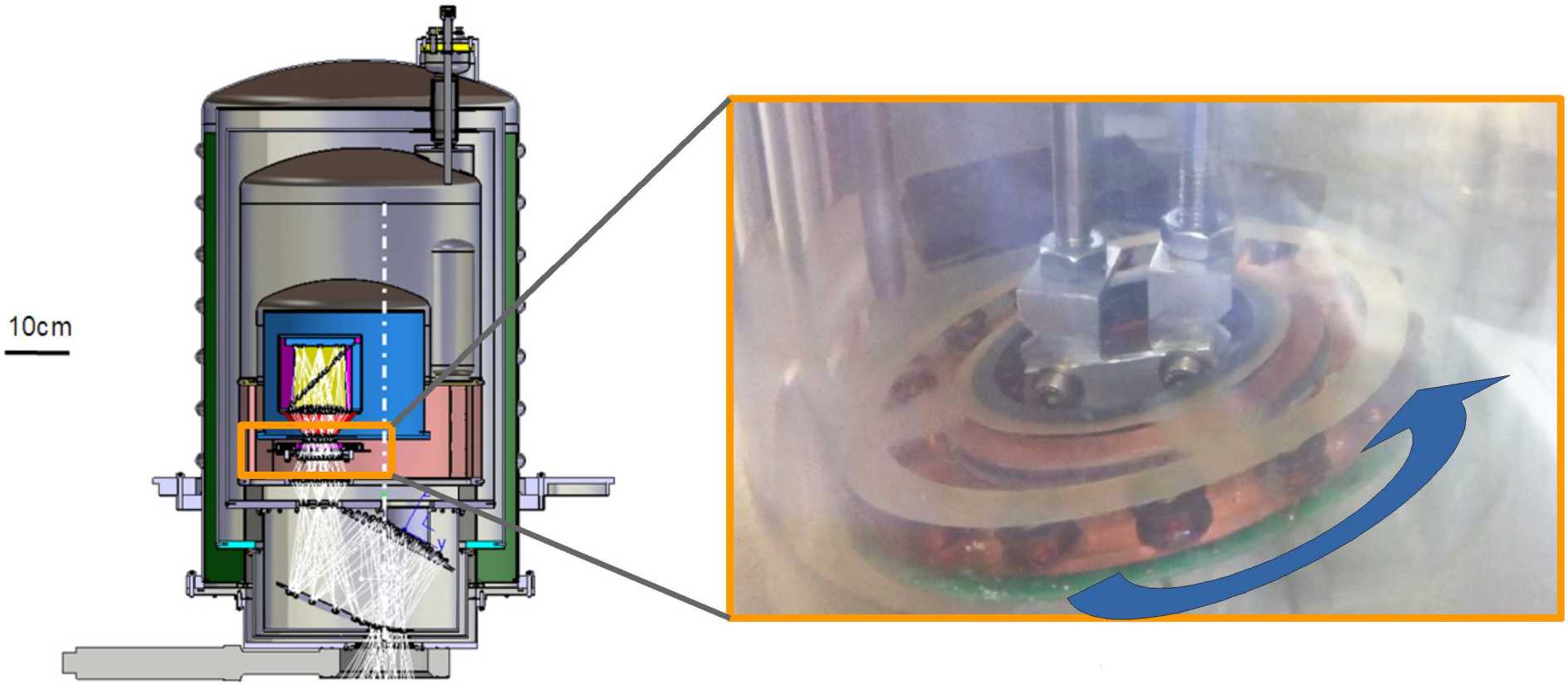
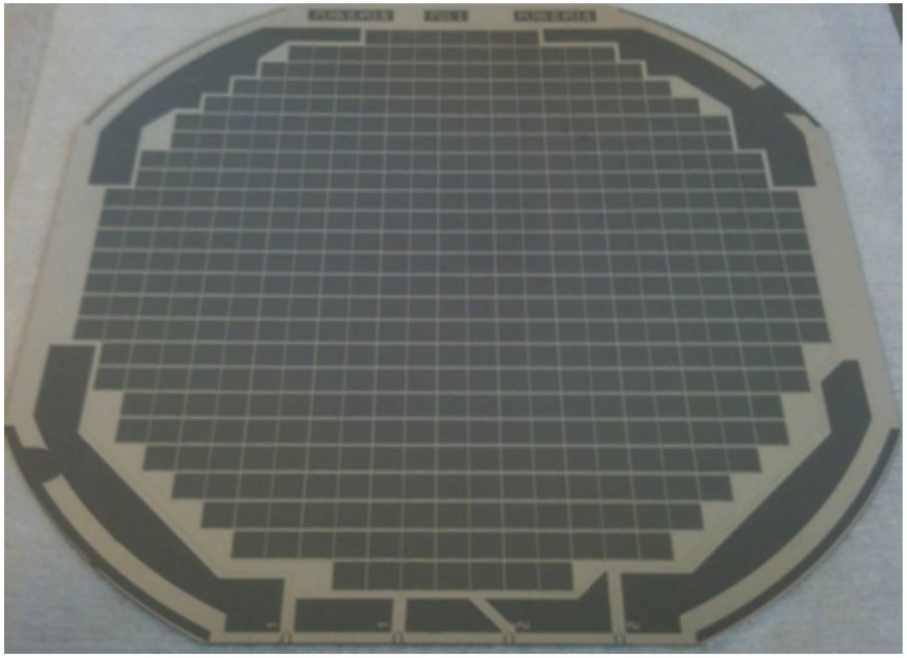


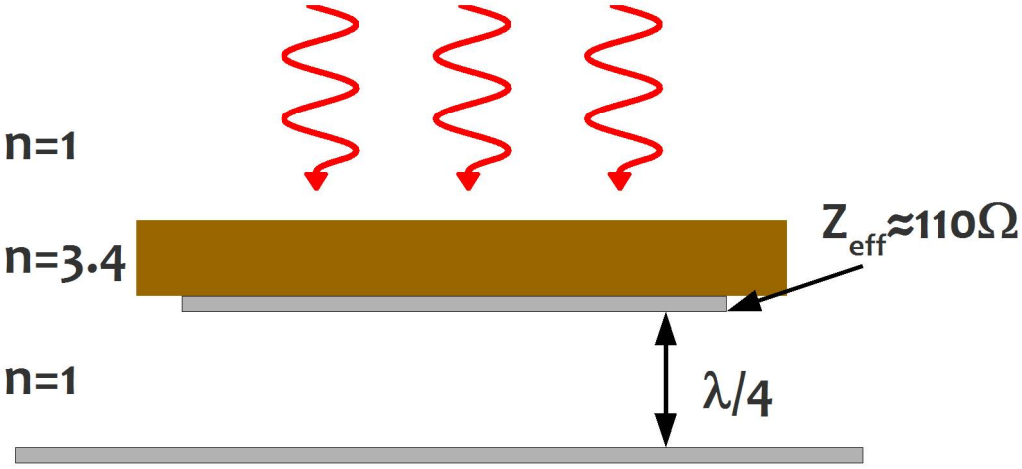
KID for BSIDE

'High' background application (~50 to 100 pW/pixel)

Aim mostly at rapid sky coverage

- *Frequency range: 450 to 700GHZ*





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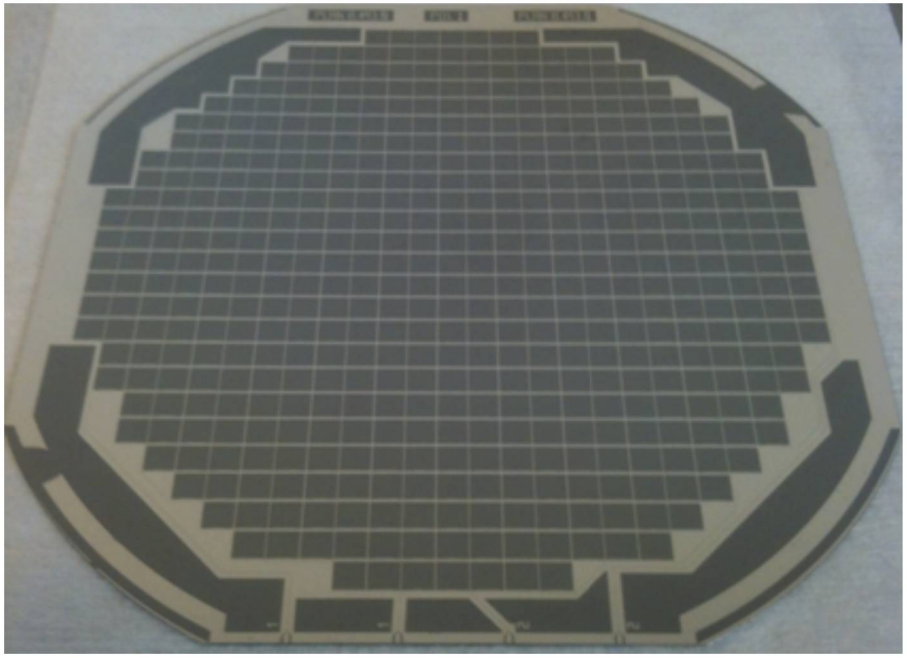

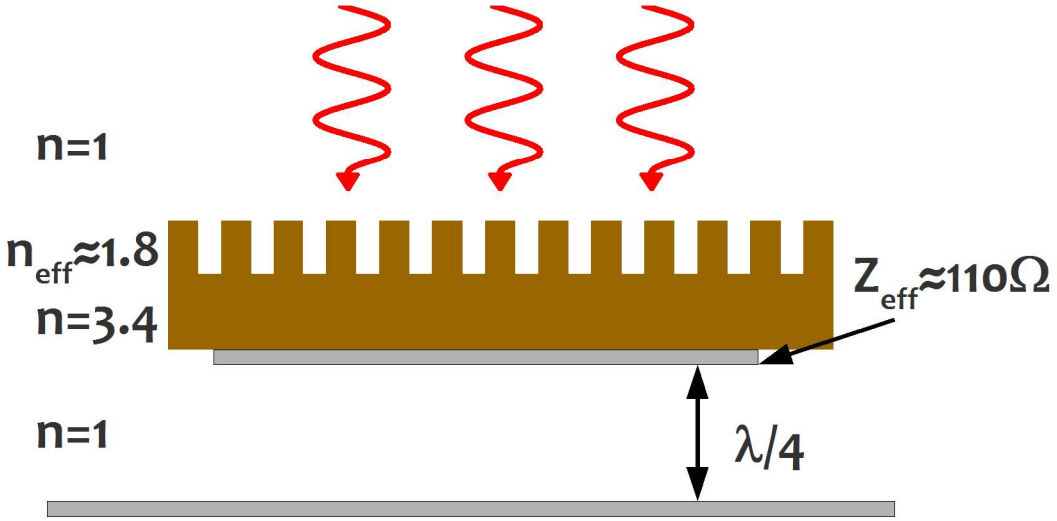

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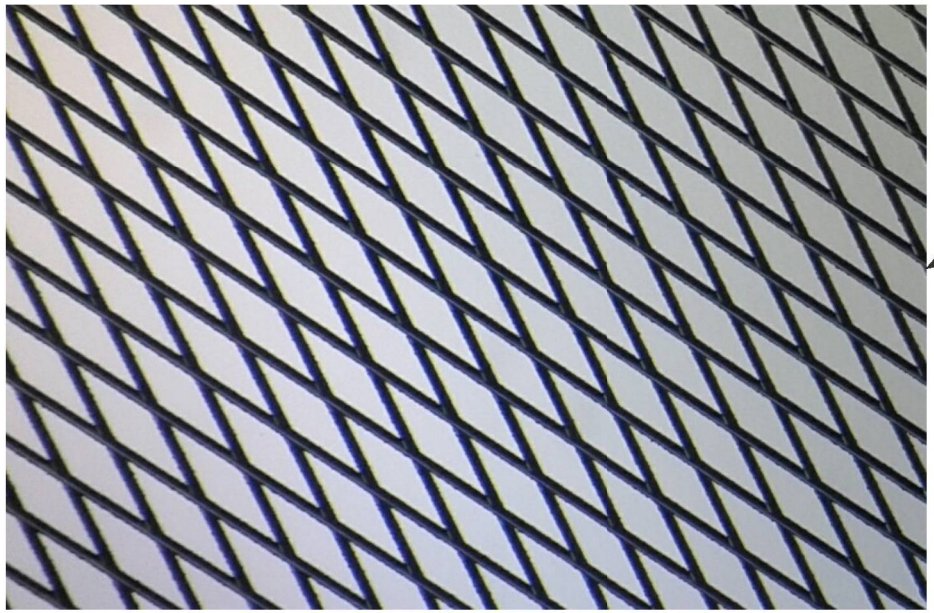

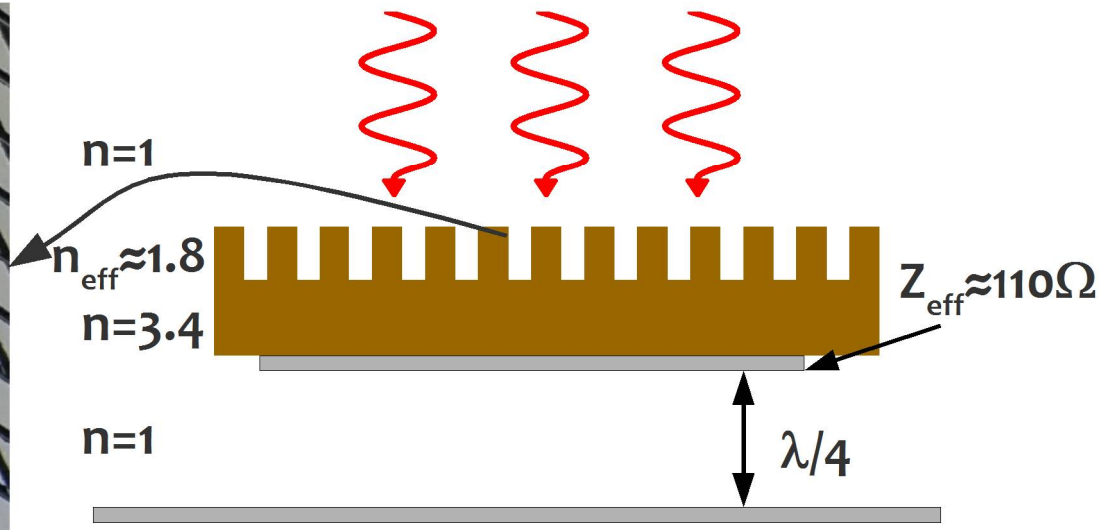

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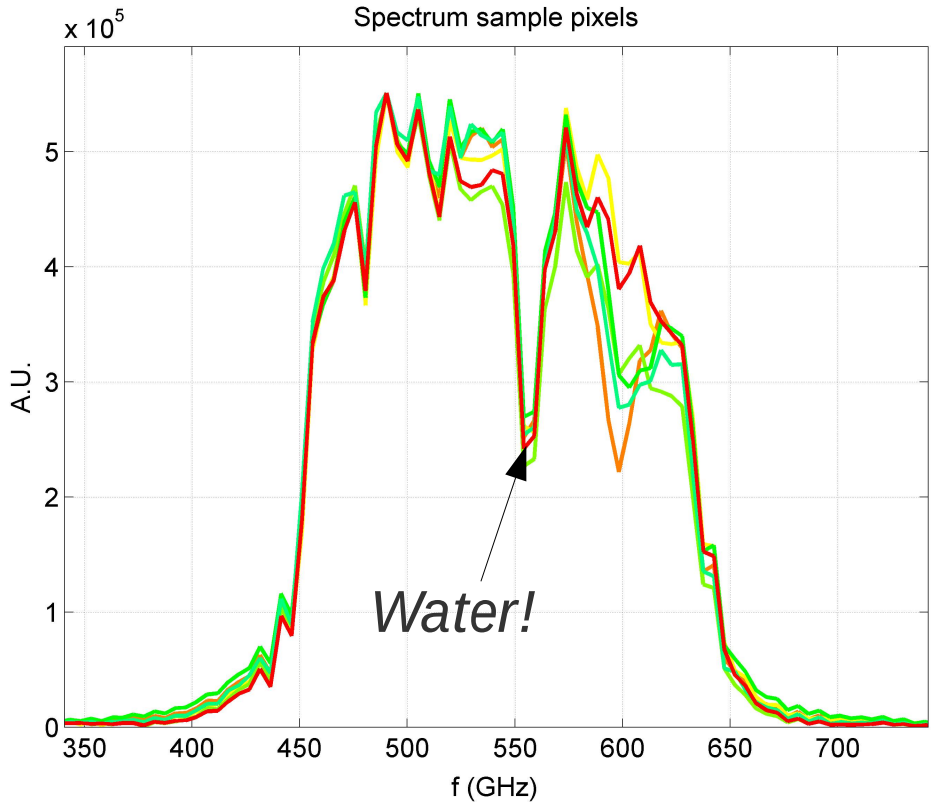
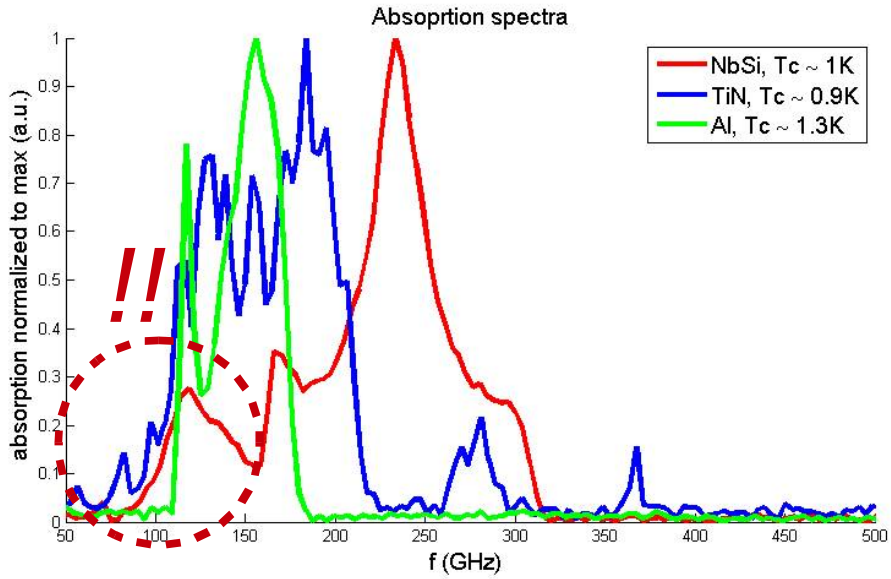


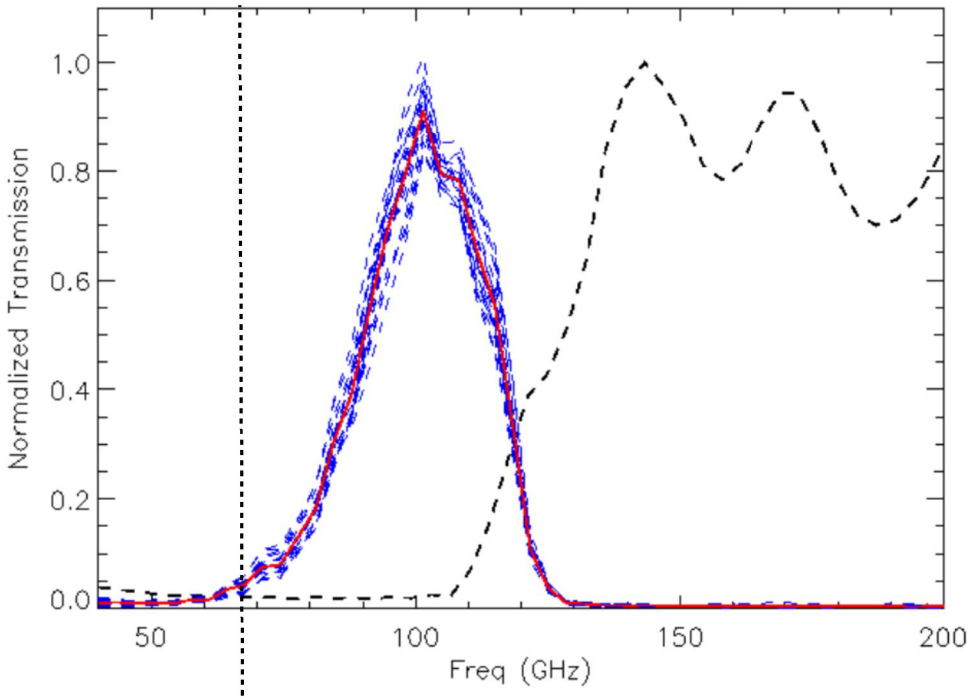
Lower frequencies : TiAl

- Thin Aluminum ok only above ≈100GHz!
- Plenty of other materials available, but beware of their properties!
- Example: Ti_xN_{1-x}, Nb_xSi_{1-x}...
- Ti_xN_{1-x}: NEP worse under lower background!
- Ti/TiN?



Lower frequencies : TiAl

- Bi-layers have been widely used (for example for TES!)
- Proximity effect gived T_c intermediate between 2 materials
- Example : **Ti/Al**!
- Different tests made, best results for **Ti_{10nm}/Al_{25nm}**

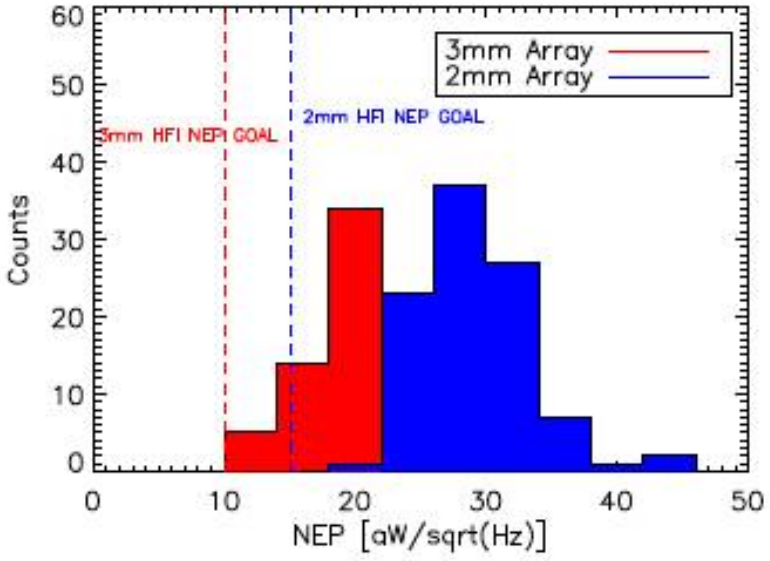


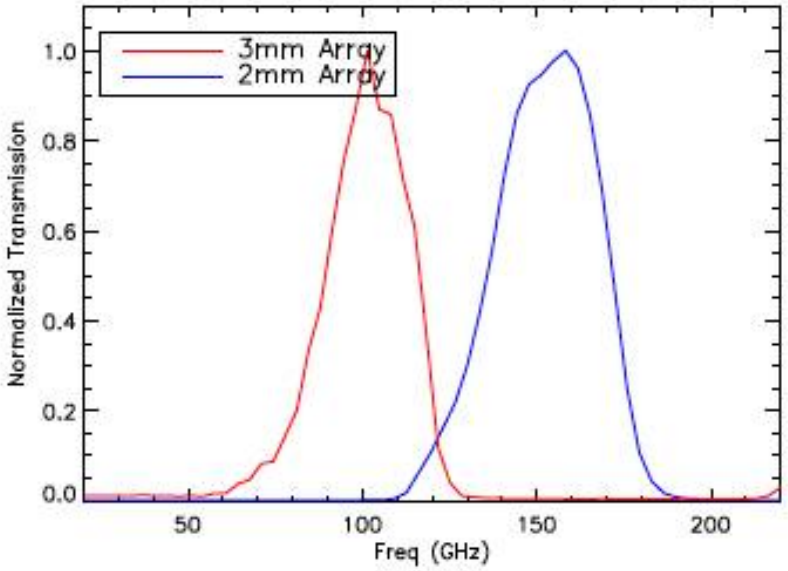
A. Catalano et al., ***A&A***, 580 (2015) A15

$\nu_{cutoff} \approx 65GHz \longrightarrow T_c \approx 0.9K$

Lower frequencies : TiAl

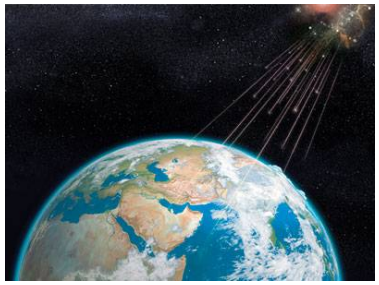
	3mm array	2mm array
Valid Pixels [#]	132	132
Pixel size [mm]	2.3	2.3
Film	Titanium-Aluminium bi-layer	Aluminium
Film Thickness [nm]	10-25	18
Silicon Wafer Thickness [μm]	525	300
Transition Critical Temp [K]	0.9	1.3
Frequency Cut-off [GHz]	65	110
Polarised Sensitive Detectors	non	non
Optical Background [pW]	0.3	0.5
Angular Size [Fλ]	0.75	0.75
Overall Optical Efficiency [%]	30	30





Catalano et al, JLTP 2016

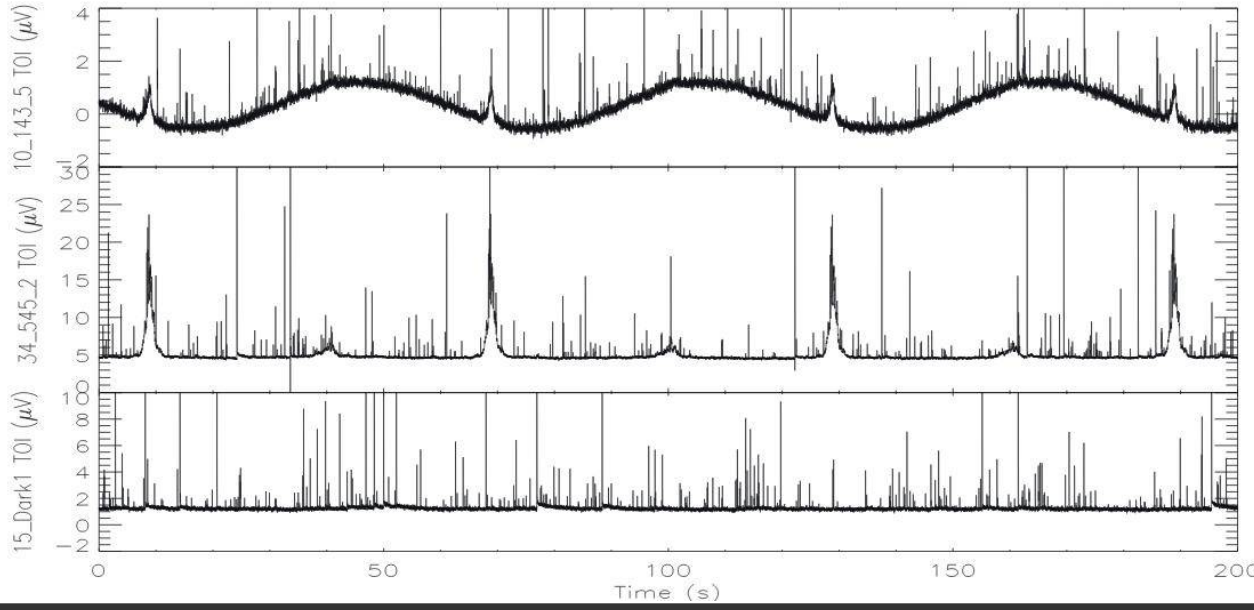
CR impacts on KID arrays



• Space-based missions are exposed to an intense flux of high-energy particles, known as Cosmic Rays(CR)

CR can reach focal plane giving an unwanted glitch masking the scientific signal

Planck: order of 15% of data loss!



Planck HFI Core team
A&A 536, A6 (2011)

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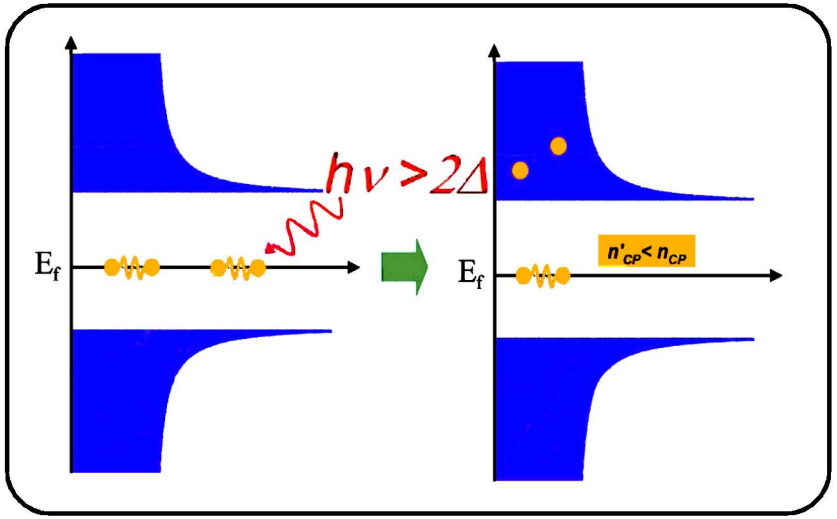
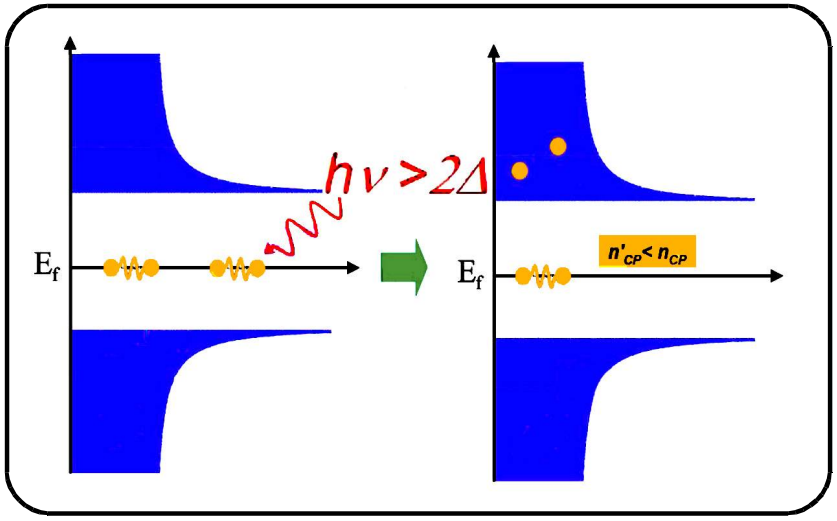


- KID are pair-breaking detectors
- This makes them less affected by CR hits
- (...and the bath T is less critical)

- But we have to verify (and quantify) this!

The high-range instrument..
(for a satellite!)

CR impacts on KID arrays



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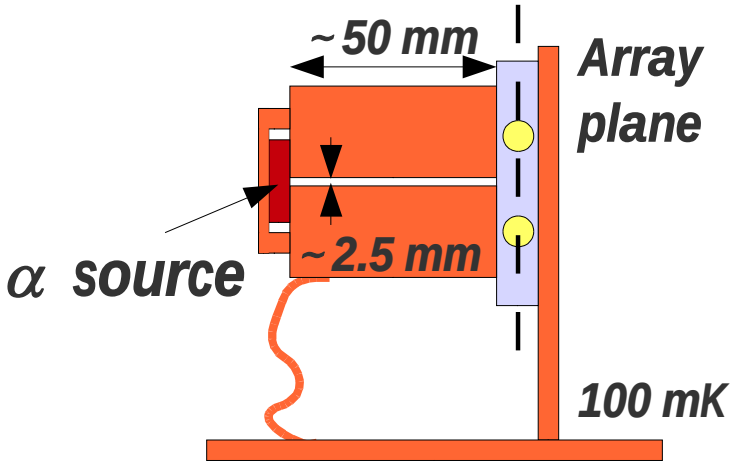
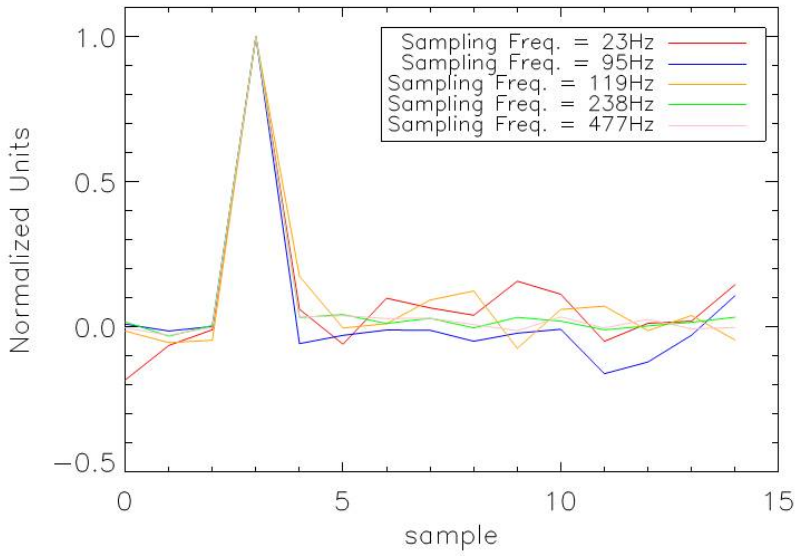
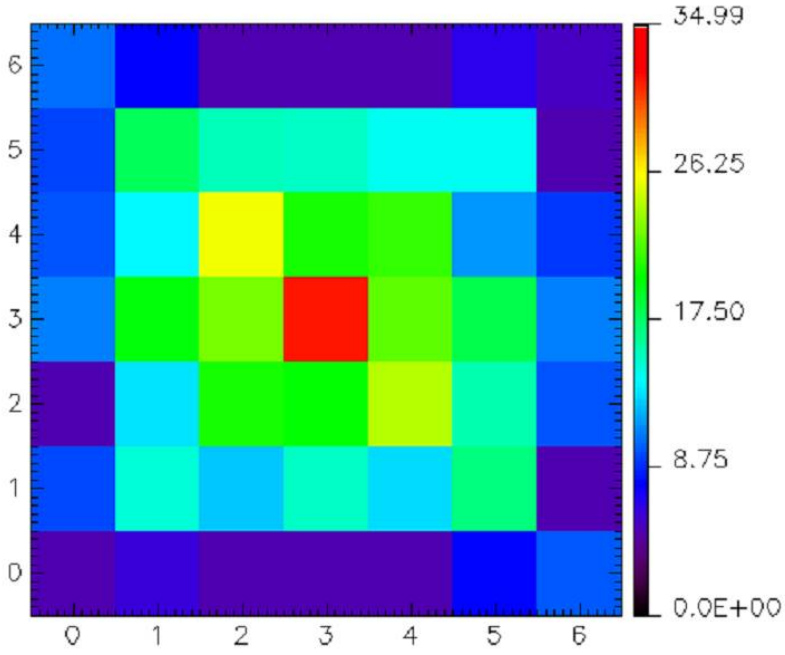


The quick and dirty solution (and yet very effective!)

CR impacts: 'astro' sampling rate

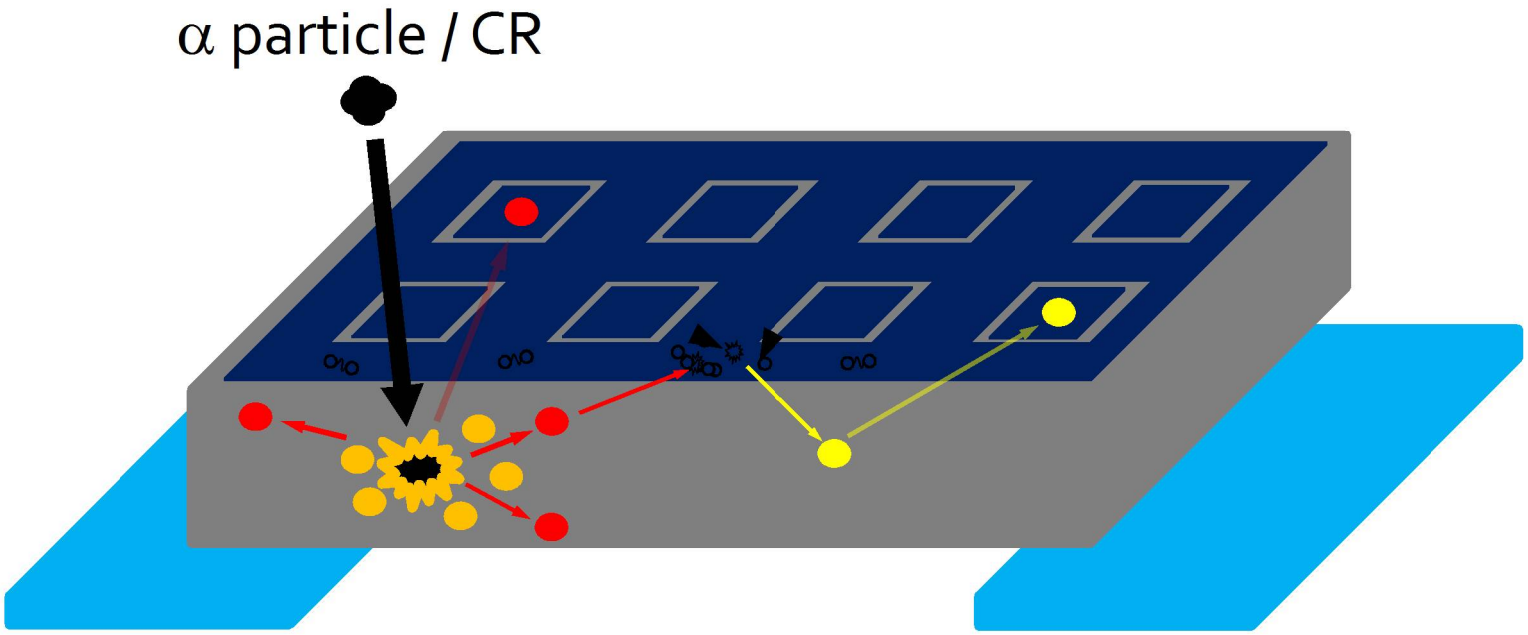
- First tests already done
- Particle energy adjusted to mimic CR in space
- Results in good agreement with expectations ($\tau \approx 100$us)





CR impacts: phonon absorbing layers

- Already like this, data loss estimated is at less than 10%
- And we can do much better...



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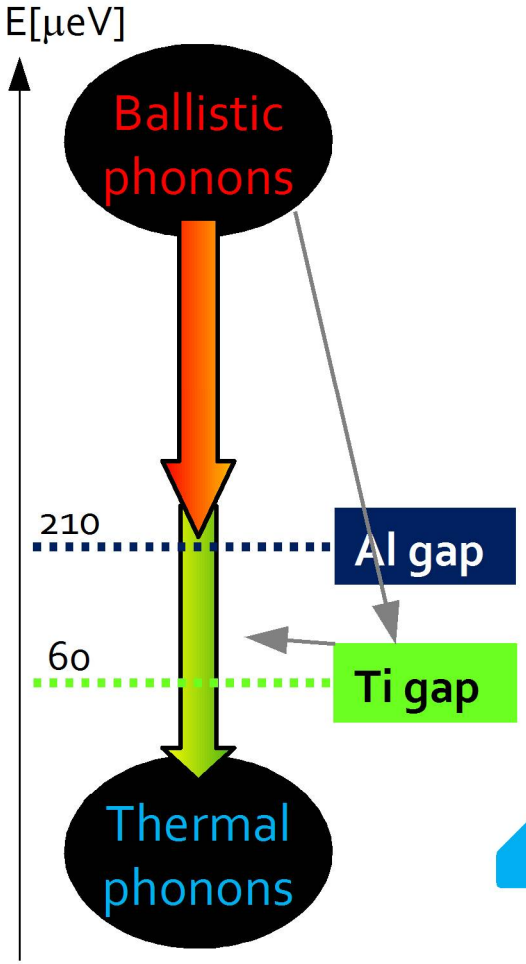
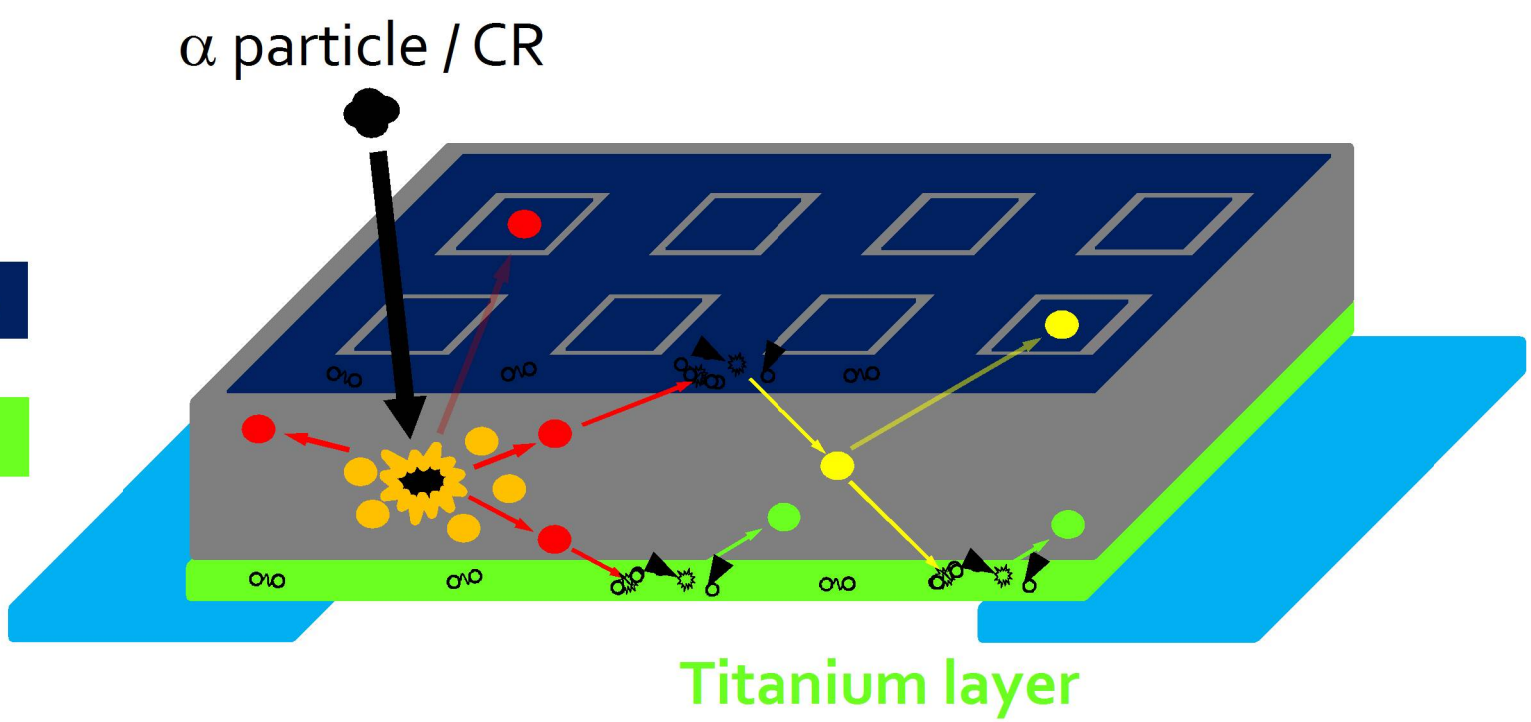
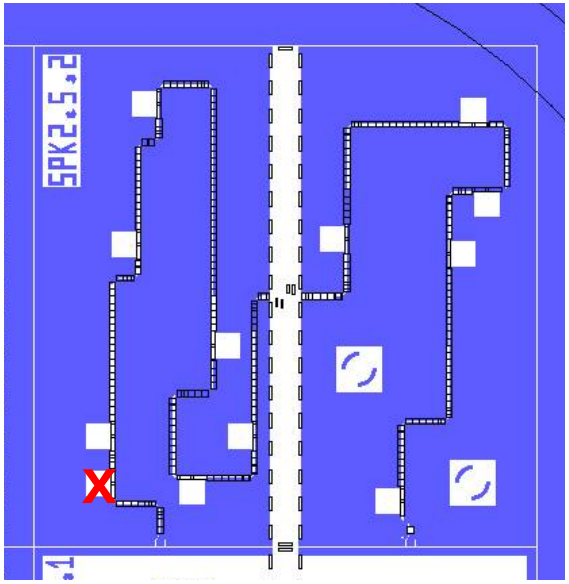




CR impacts: 'fast' sampling rate

- We can give a deeper look at what's going on
- Fast electronics, small pixels count
- Use in this case 'full power' alphas



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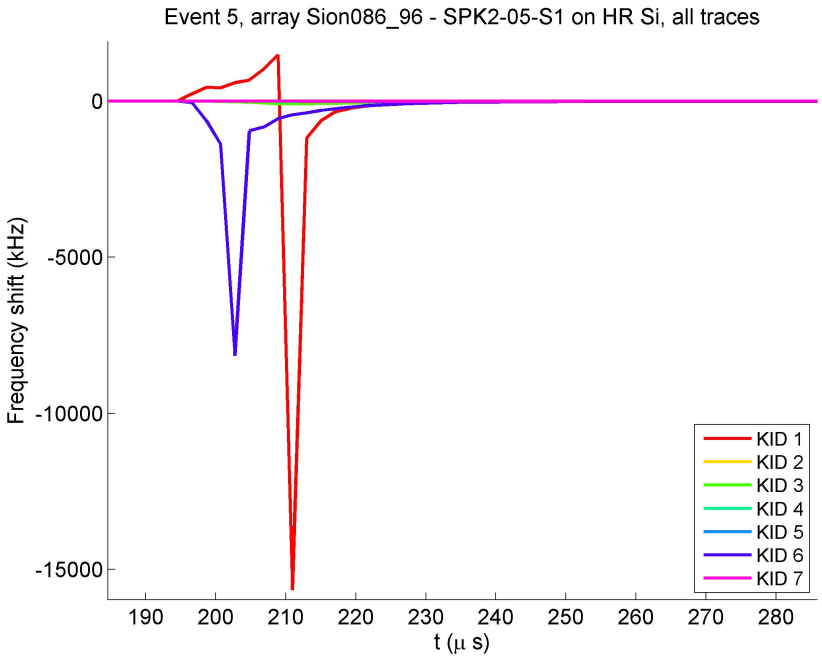
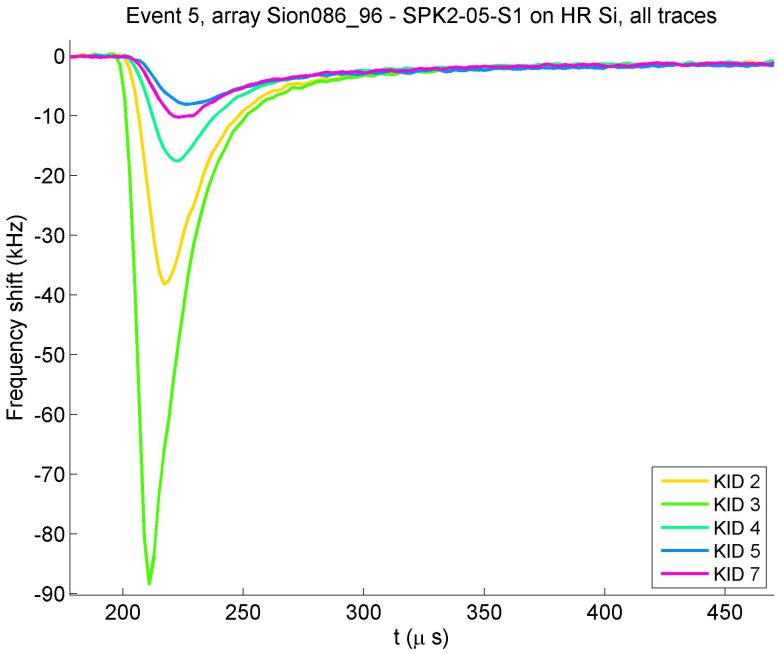
- Use in this case 'full power' alphas

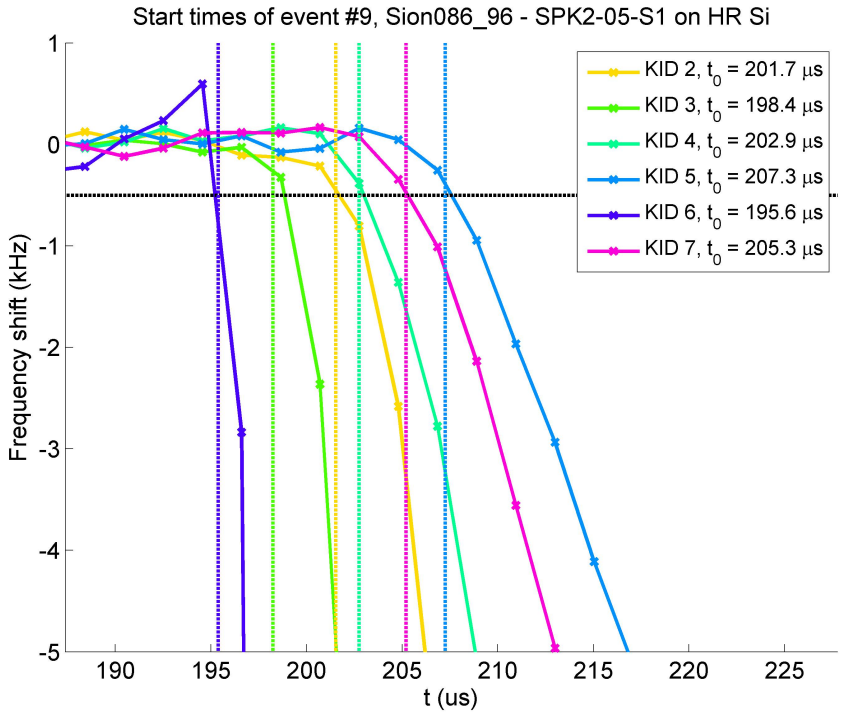


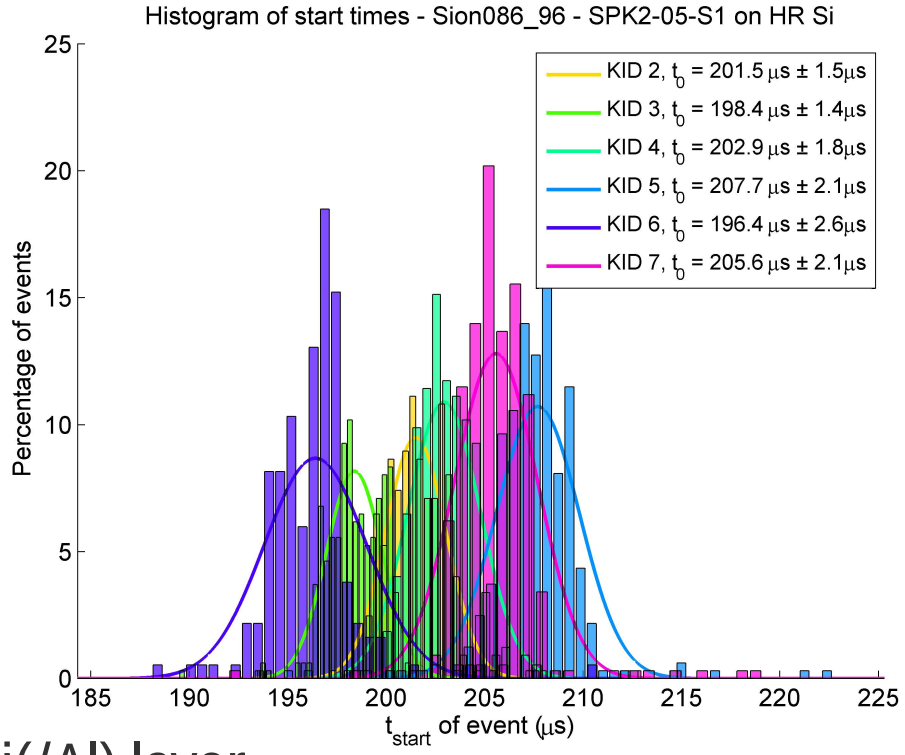


Without Ti(/Al) layer

CR impacts: 'fast' sampling rate

- We can give a deeper look at what's going on
- Fast electronics, small pixels count
- Use in this case 'full power' alphas

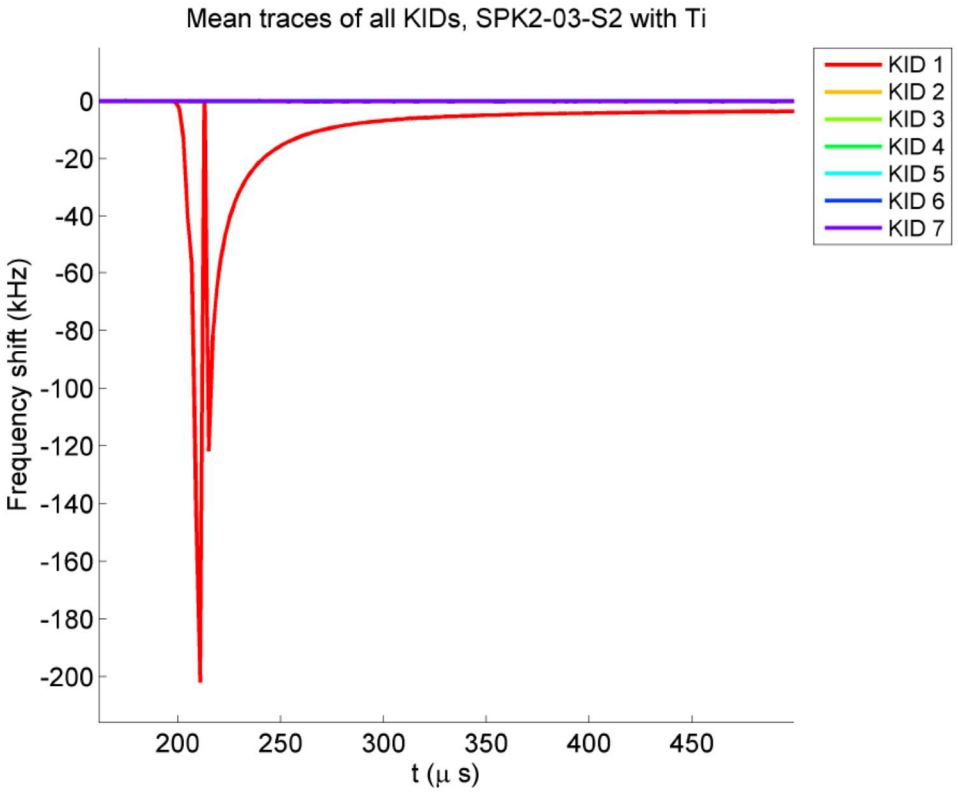




Without Ti(/Al) layer

CR impacts: 'fast' sampling rate

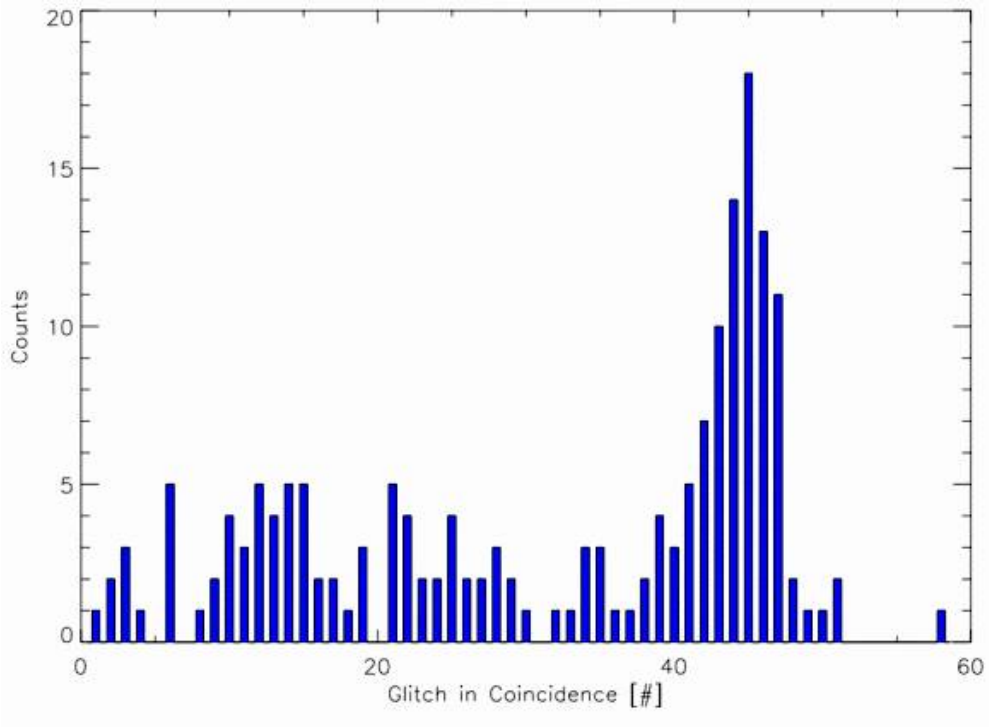
- We can give a deeper look at what's going on
- Fast electronics, small pixels count
- Use in this case 'full power' alphas



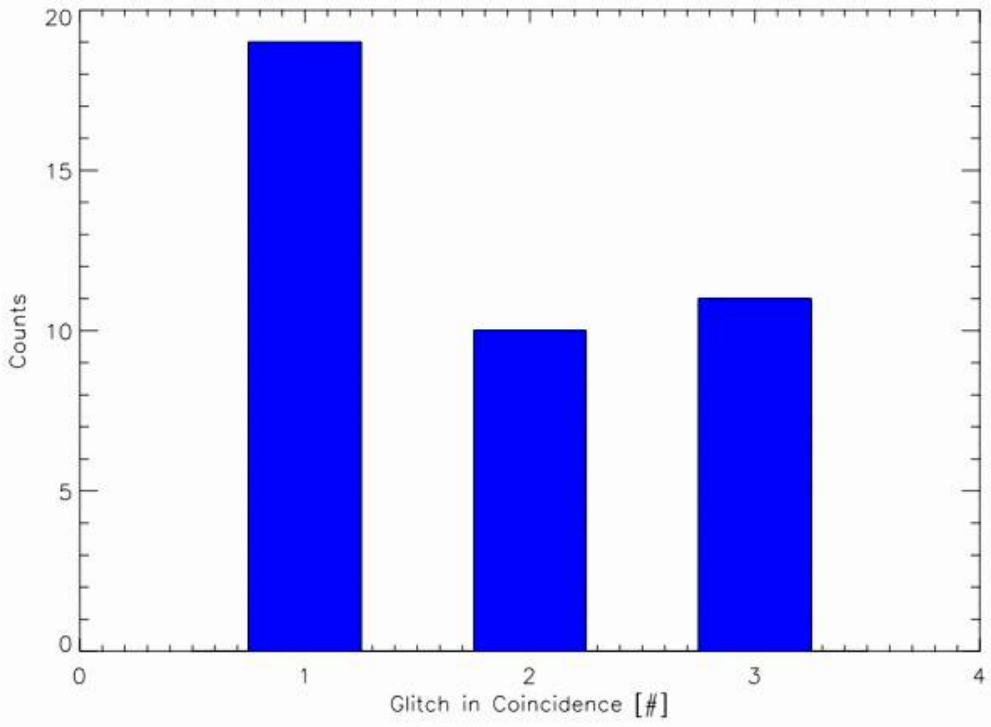
With Ti(/Al) layer

CR impacts: 'astro' sampling rate

- Note: preliminary results… (SPIE for more!)
- But very promising!



Without Ti(/Al) layer



With Ti(/Al) layer

Thank you!