Detectors

COrE-PRISM meeting
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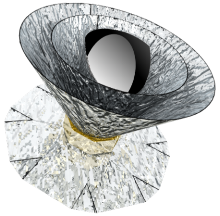
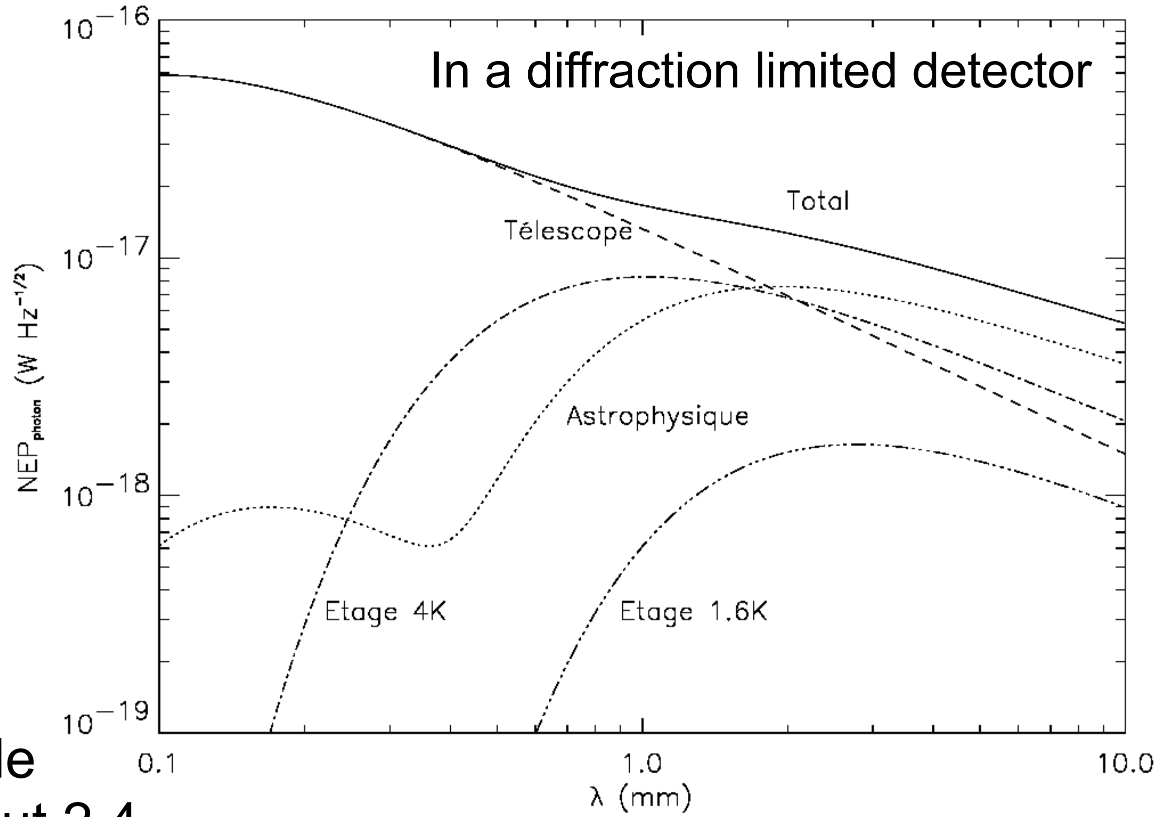
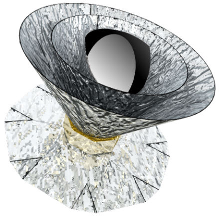
With inputs from Adnan Ghribi and Andrea Tartari



Detectors performances requirements



- NEP < Photon NEP
  - Planck assumptions:
    - ν/Δν=3, η=37%
    - Telescope: 50K, ε=1%
    - 1.6K stage: 1.85K, ε=15%
    - 4K stage: 5K, ε=20%
  - Filled array case: divide these numbers by about 2.4
- Time constant:
  - Highly Dependent on frequency channel and scanning strategy



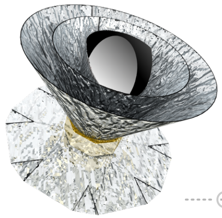
Detectors requirements

- PRISM:

Frequency range (GHz)	Req. NEP ($aW.Hz^{-0.5}$)	Req. time cst (ms)
30 - 75	3 – 6	3 – 1
90 - 320	4 – 7	1 – 0.4
395 - 660	1 – 3	0.4 – 0.1
800 - 6000	0.01 – 0.6	0.1 – 0.01

- COrE:

Frequency range (GHz)	Req. NEP ($aW.Hz^{-0.5}$)	Req. time cst (ms)
45 - 75	3	10 – 6
105 - 315	2 – 3	5 – 1
375 - 795	1 – 3	1 – 0.5



Detection chain options

- Beam forming
  - Horn antennas
    - Single moded
      - Single band — Highest TRL
      - Multichroïc
    - Multi moded
      - Single band
      - Multichroïc
  - Planar antennas
    - Single moded
      - Single band
      - Multichroïc
      - ν < 700GHz (Nb)
    - Multi moded
- Polarisation separation
  - Quasi-optics
    - Polariser
  - Waveguide
    - OMT with polariser
    - OMT
    - ν < 300GHz
  - Planar
    - OMT
    - Antennas
    - ν < 700GHz (Nb)
  - Polarisation sensitive absorber
    - PSB — Highest TRL
- Spectral filtering
  - Quasi-optics — Highest TRL
  - Waveguide
  - Planar — ν < 700GHz (Nb)
- Detection
  - TESs — Highest TRL
  - KIDs — ν > 100GHz (Al)
  - CEBs
  - Coherent

[ITT Next Generation Sub-millimetre Wave Focal Plane Array Coupling Concepts]

Single technology?

- Technologies limitations:
  - Waveguide technology: difficult above ~ 300GHz
  - Planar technology: low losses below 700GHz (Nb)
  - KIDs: work above 100GHz (Al)
- **Large frequency coverage => no single technology for the focal plane today**
  - PRISM proposal:

ν_c range	Req. NEP	Req. τ	Focal plane technology			
			Detector technology		Optical coupling	
[GHz]	$\left[10^{-18}\,\mathrm{W}/\sqrt{\mathrm{Hz}}\right]$	$[ms]$	Baseline	Backup	Baseline	Backup
30 - 75	3.3 – 5.7	2.96 – 1.18	TES	HEMT	MPA/CSA	HA
90 - 320	4.6 – 7	1.18 – 0.4	TES	KIDS	HA+POMT	MPA
395 - 660	0.94 – 3.1	0.4 – 0.13	TES	KIDS	MPA/CSA	LHA
800 - 6000	0.011 – 0.63	0.13 – 0.01	KIDS	HEB/CEB	MPA/CSA	LHA

- HA: Horn Array
- MPA: Multichroic Planar Antenna
- LHA: Lithographed Horn Array
- CSA: Crossed Slot Antenna
- POMT: Planar Ortho-Mode Transducer

Estimated TRL

- From PRISM proposal:

Frequency (GHz)	Technology	TRL	Used for
30 - 90	HEMT	9	WMAP, Planck-LFI
	Bolometers	2-3	(CLASS)
90 - 400	Feedhorn coupled TES	7	Ground/balloon projects, SPICA
	Antenna coupled TES	5	PolarBear, SPIDER
	KIDs	5	NIKA, MUSE
	CEBs	4	Research
400 - 2000	Antenna coupled TES	5	PolarBear, SPIDER
	Planar Resistive Bolometers	9	Herschel-PACS
2000 - 6000	Planar Resistive Bolometers	9	Herschel-PACS
	HEB, SIS	9	Herschel-HIFI

Detectors pros and cons

	TESs	KIDs	CEBs
Sensitivity			On paper
Time constant	τ ~ 1ms	τ ~ 0.1ms	τ ~ 0.1ms
Dynamic range	Medium	High	Medium
CR sensitivity	High	High	Low
Space qualif. readout		P. dissipation	No mux
Fabrication	Complex	Simple but…	
Sensitivity to T fluctuations	Sensitive	Low	
EMC			
TRL	7	5	4

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Sensitivity to Cosmic Rays of Cold Electron Bolometers for Space Applications

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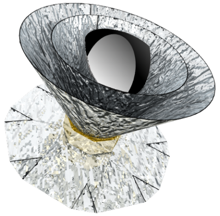
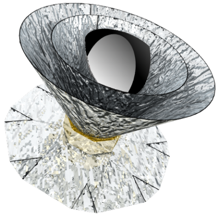
Abstract An important phenomenon limiting the sensitivity of bolometric detectors for future space missions is the interaction with cosmic rays. We tested the sensitivity of Cold Electron Bolometers (CEBs) to ionizing radiation using gamma-rays from a radioactive source and X-rays from an X-ray tube. We describe the test setup and the results. As expected, due to the effective thermal insulation of the sensing element and its negligible volume, we find that CEBs are largely immune to this problem.



European developments

- **TESs:**
  - SRON: TESs + readout for SPICA
  - Cambridge: TESs for SPICA
  - France
    - CEA-LETI: use of Herschel-PACS developments?
    - CNRS: TESs + readout for CMB (QUBIC)
  - Italy: Genova (X-rays transfer to mm)
  - Germany?
- **KIDs:**
  - France: NIKA
  - Italy: Sapienza + CNR (100GHz)
  - SpaceKIDs (FP7, 2013-2015): KIDs space qualification
- **CEBs:**
  - Chalmers
- ITT « Next Generation Sub-millimetre Wave Focal Plane Array Coupling Concepts »



Production issues

- Several 100s of detectors needed per frequency bands
- Total of several 1000s of detectors
- **Mass production is needed!**
  - **Reproducibility**
  - **Redundancy in the process**
  - **Reliability**
  - **Flexibility**
- Is this feasible in academic environment?
  - Action started in France with Renatech (microfabrication facility network)
  - Coordination in Europe needed?