Bolometer matrix for X-ray detection in Astrophysics

New missions, requirements on instruments and present status of matrix development

C. Pigot

CEA Saclay / DAPNIA / Service D'Astrophysique

@ 1980 Einstein

Wolter 1 X-ray nested mirrors

Spectro-imager with coarse energy resolutio
using PSPC
Fine spectrometry
using Bragg crystals, gratings

@ 1993 ASCA,
@ 2000 AXAF-Chandra, XMM-Newton

Spectro-imager with medium energy resol.
using CCD's
Fine spectrometry in the low energy range
using gratings

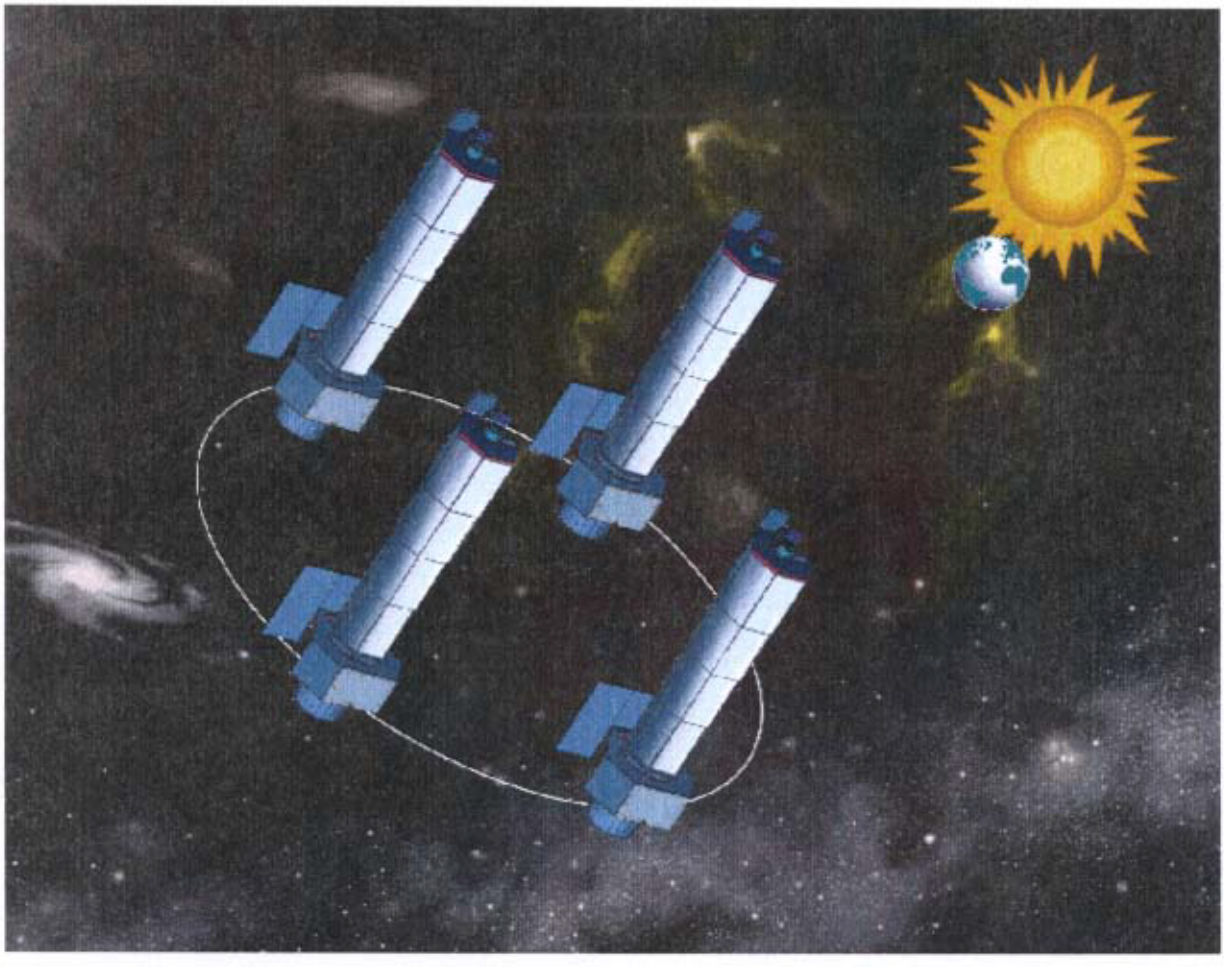
January 2000 ASTRO-E launch failure

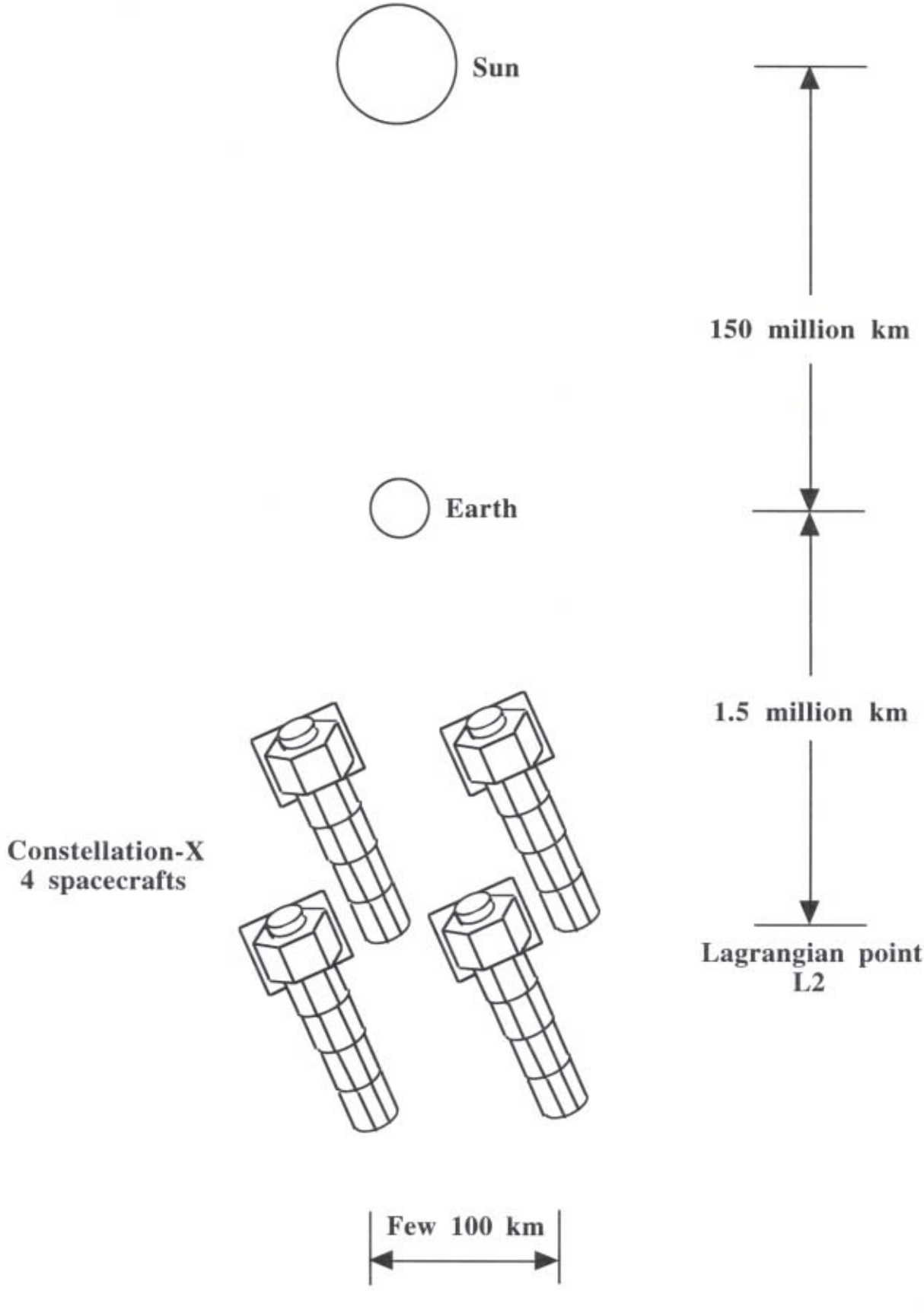
Would have demonstrated in space the first
microbolometers (linear array)

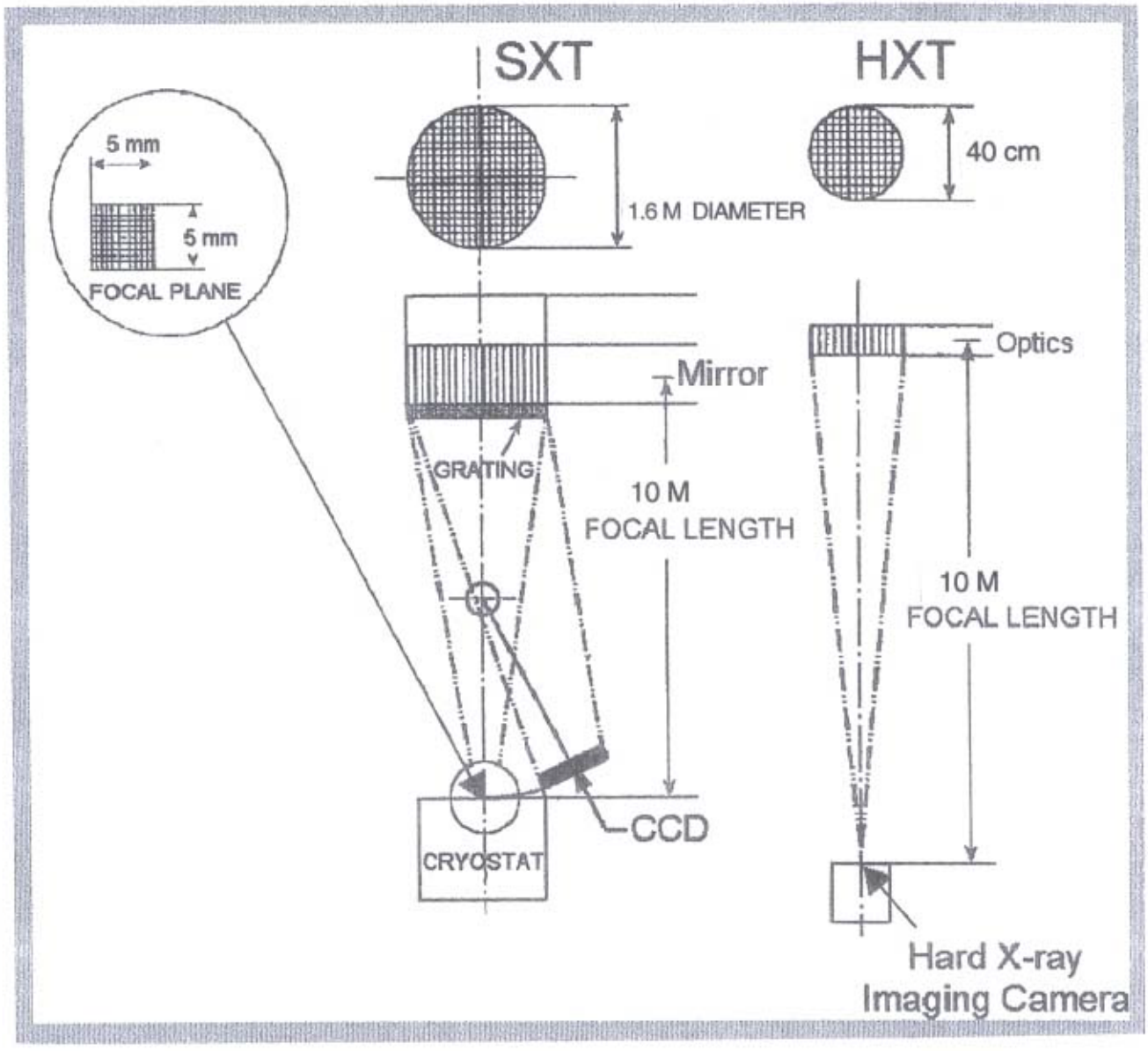
@ 2010 The Next X-ray mission generation

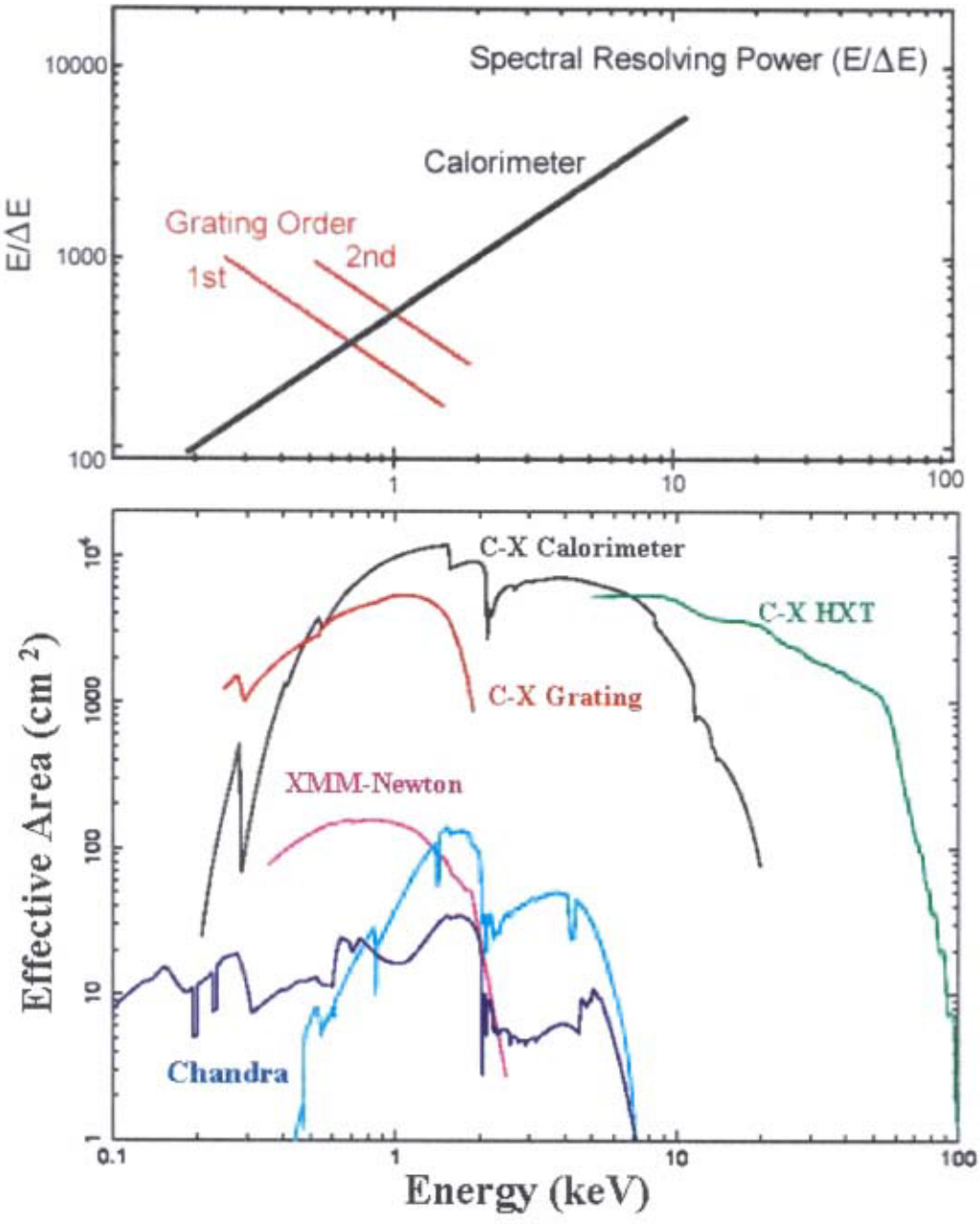
Constellation-X	NASA
XEUS	ESA

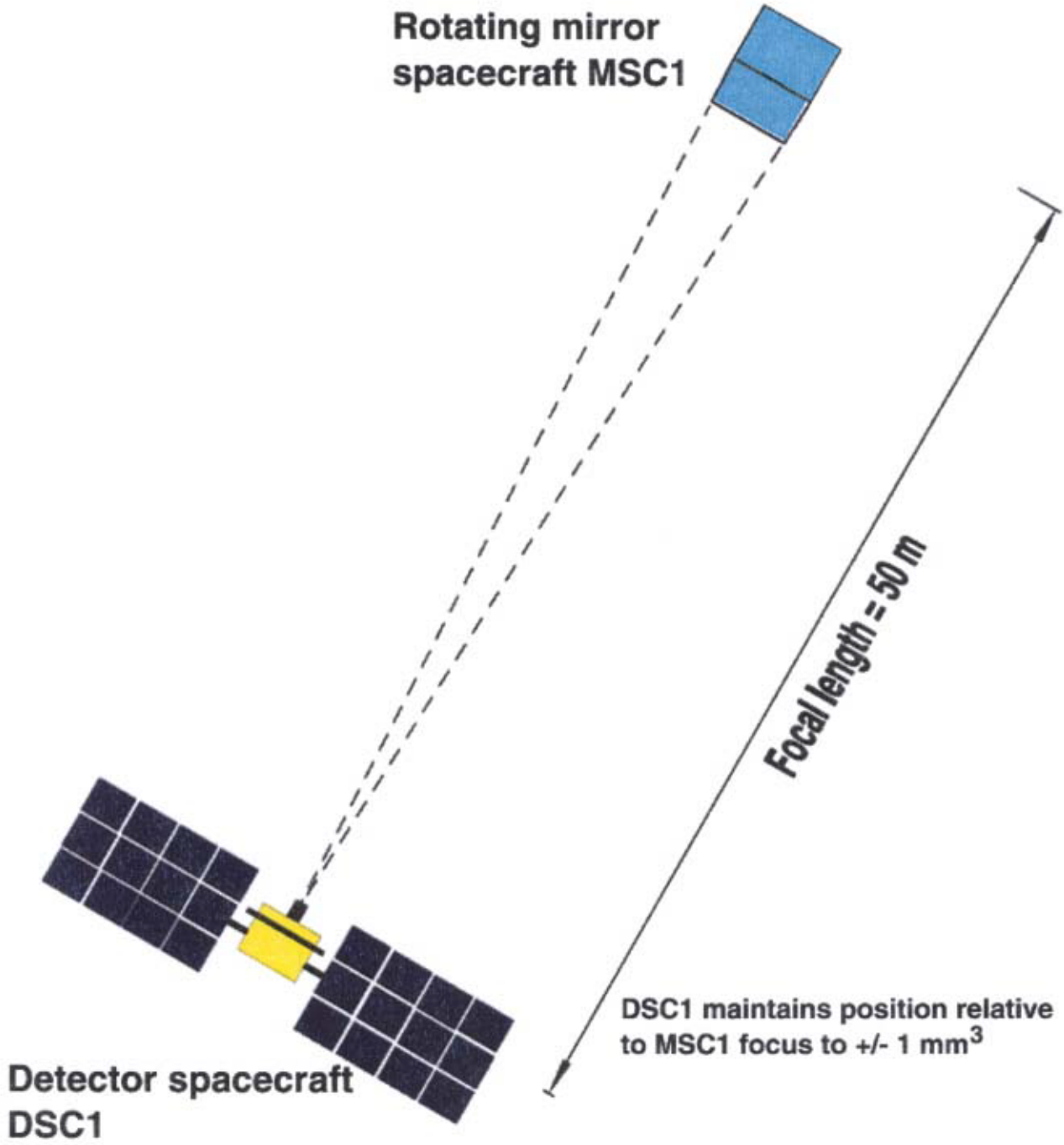
Spectro-imager with high energy resolution
using 2-dimensional microcalorimeter array

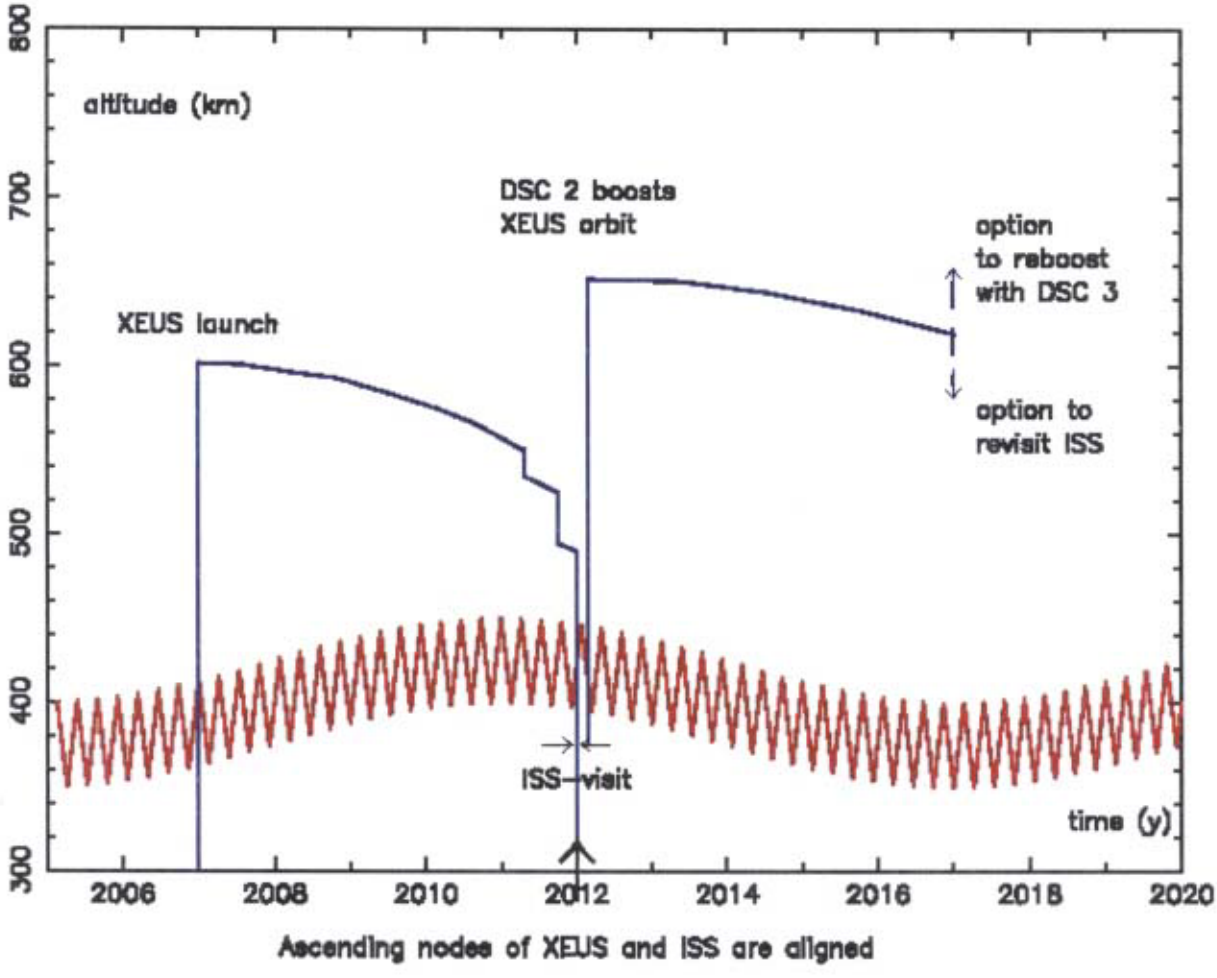



Sun
150 million km
Earth
1.5 million km
Constellation-X
4 spacecrafts
Lagrangian point
L2
Few 100 km


SXT
HXT
5 mm
5 mm
FOCAL PLANE
1.6 M DIAMETER
40 cm
Mirror
Optics
GRATING
10 M
FOCAL LENGTH
10 M
FOCAL LENGTH
CCD
CRYOSTAT
Hard X-ray
Imaging Camera


Spectral Resolving Power (E/ΔE)
E/ΔE
10000
1000
100
Calorimeter
Grating Order
2nd
1st
1
10
100
C-X Calorimeter
C-X HXT
C-X Grating
XMM-Newton
Chandra
Effective Area (cm 2)
10000
1000
100
10
1
0.1
1
10
100
Energy (keV)


Rotating mirror
spacecraft MSC1
Focal length = 50 m
DSC1 maintains position relative
to MSC1 focus to +/- 1 mm3
Detector spacecraft
DSC1


altitude (km)
DSC 2 boosts
XEUS orbit
option
to reboost
with DSC 3
XEUS launch
option to
revisit ISS
ISS–visit
time (y)
800
700
600
500
400
300
2006
2008
2010
2012
2014
2016
2018
2020
Ascending nodes of XEUS and ISS are aligned

X-ray Evolving Universe Spectroscopy and Constellation X technical characteristics

	XEUS	CONS.-X (SX
Energy range	0.05 - 30 keV	0.25 - 10 k
Focal length	50 m	10 m
Effect. area	6 m^2 @ 1 keV 3 m^2 @ 8 keV	1.5 m^2 @ 1 k 0.6 m^2 @ 6 k
Ang. resol.	5 to 2 arcsec	15 arcsec
Field of view		
NFI	1 arcmin	2.5 arcmin
WFI	5 arcmin	
Spectral resol.		
NFI (CIS)	2 eV @ 1 keV 5eV @ 8 keV	5 eV

Common requirements

- Spectral resolution 5 eV (2 eV)
- Good Quantum Efficiency @ 100% up to 10 ke
- Oversampling the PSF
by a reasonable factor (2 to 3)

XEUS	2" (50 m)	->	480 μm
CONST.-X	15" (10 m)	->	730 μm

pixel size of @ 250 μm

- Coverage of the FOV with a 1000 pixels array

  use of a mosaic (2x2) for XEUS

  1 array for CONST.-X

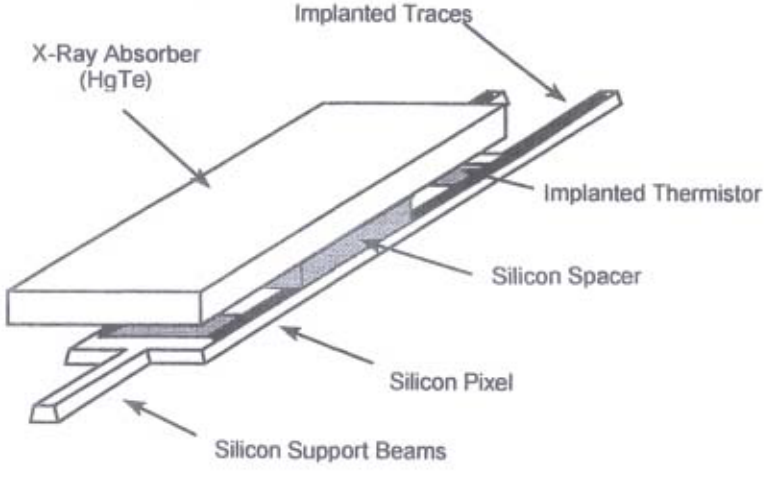
- Counting rate

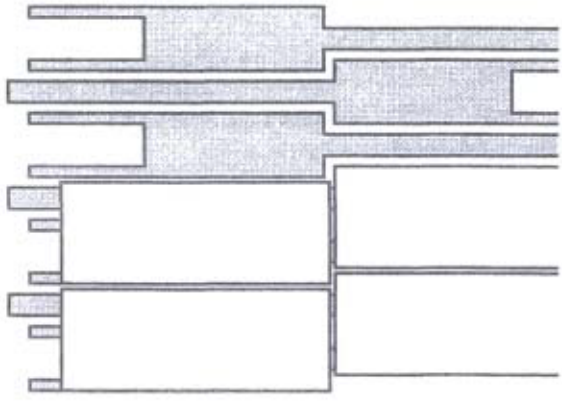
  read-out speed
  number of read-out chains
  pile-up reconstruction

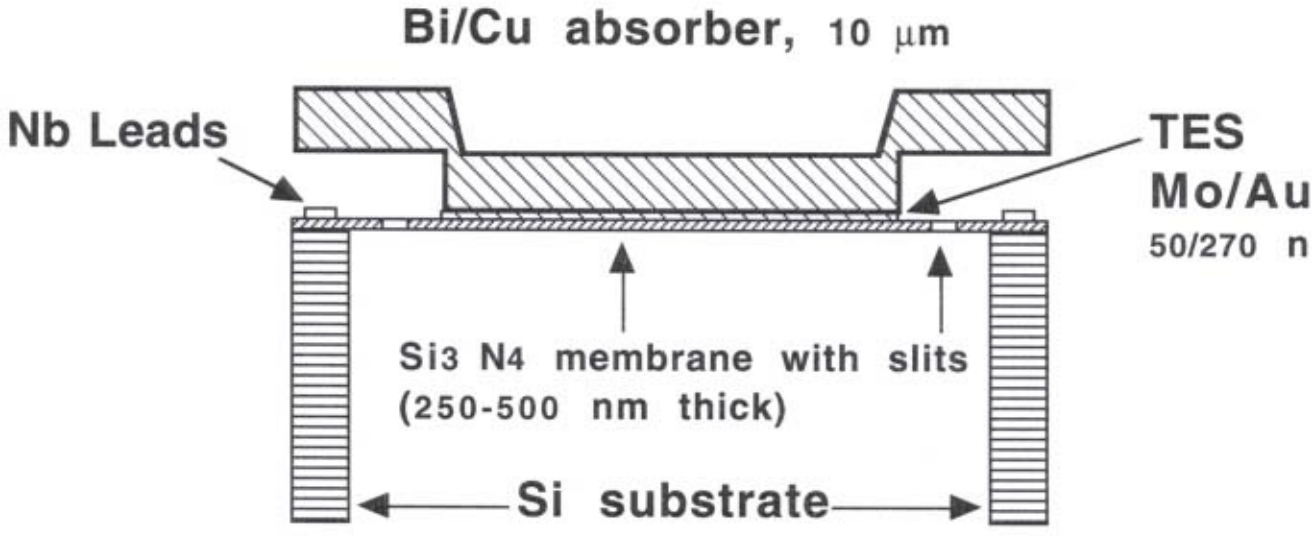
The XRS instrument on ASTRO-E

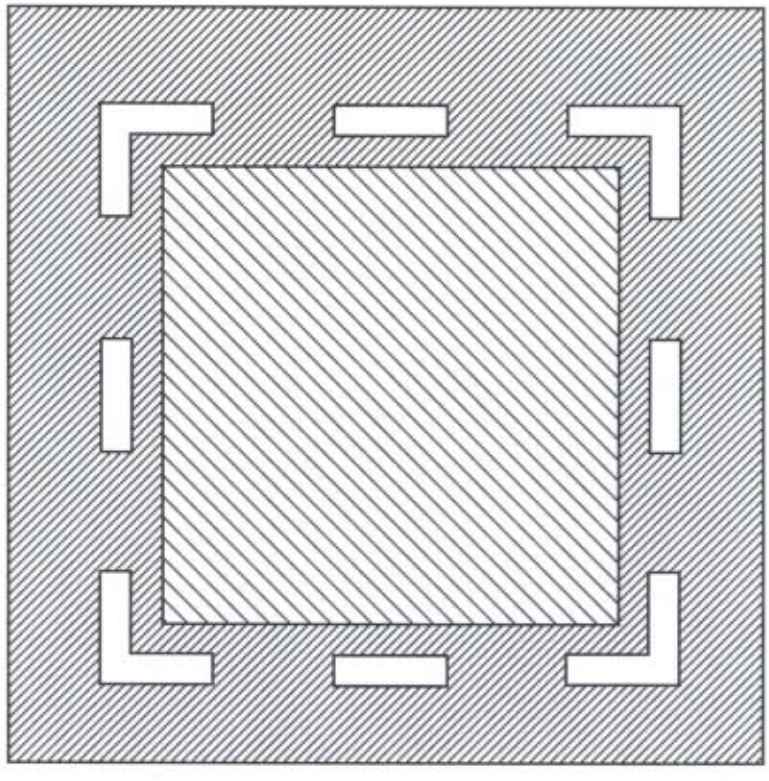
launch failure in January 2000

- A bilinear array of 32 pixels
- 1230x320 μm2 pixel size
  8 μm thick HgTe absorber
- Ion implanted silicon sensor
- One read-out channel per pixel
- 95 % filling factor
- 12 eV @ 6 keV

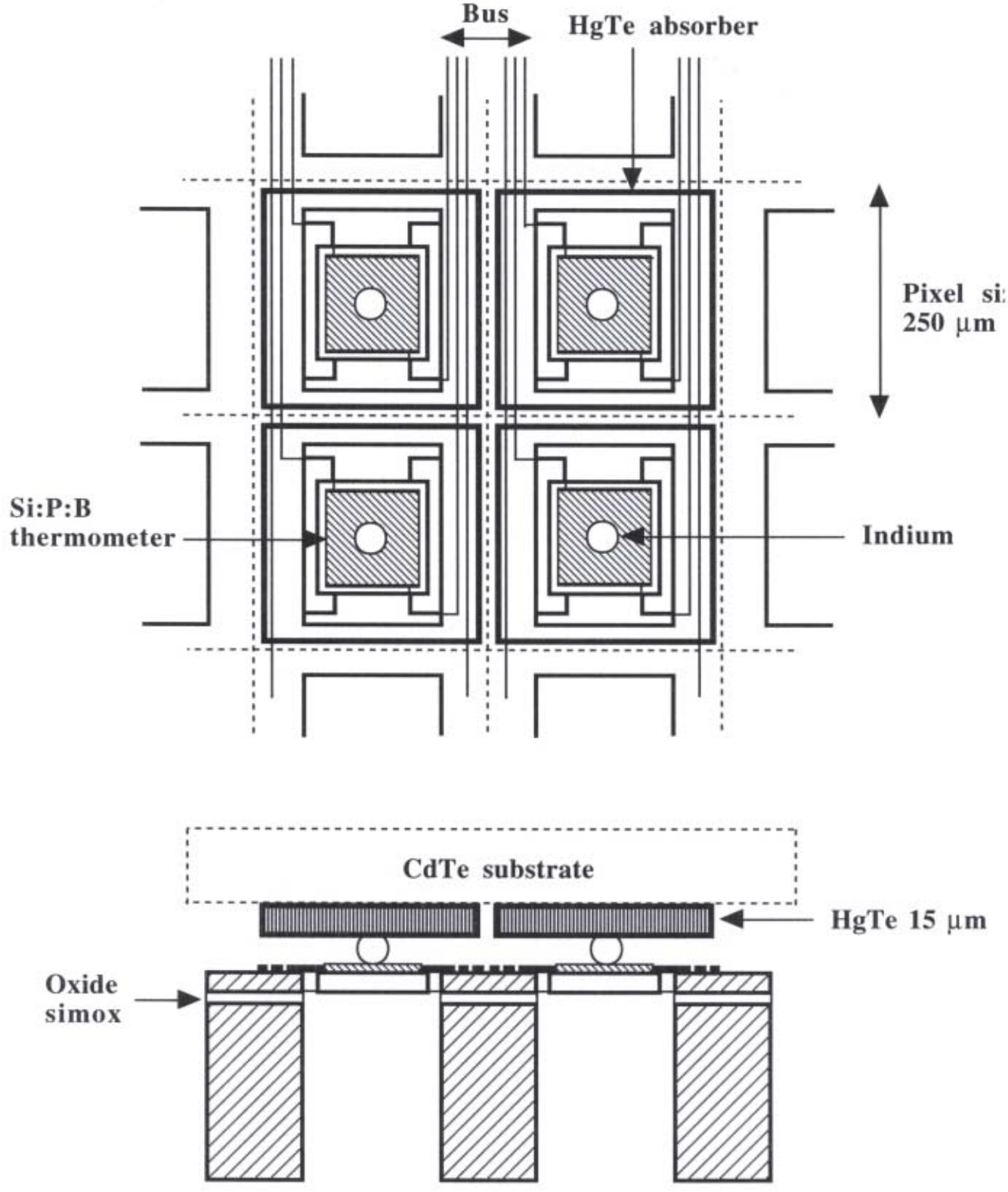








Goal: 30X30 pixels array (250X250 μm2 pixel size)
Mushroom structure
96 % packing fraction


Bus
HgTe absorber
Pixel si
250 µm
Si:P:B
thermometer
Indium
CdTe substrate
HgTe 15 µm
Oxide
simox