Silicon Carbide based X-ray beam monitoring

Massimo Camarda [SenSiC GbmH (sensors, CH) & STLab srl (electronics, IT)]

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Outline

1. Mission of *SenSiC GmbH (& STLab srl)*
2. Locations of X-ray beam monitors
3. Whitebeam (polychromatic) monitoring
    I. Hole based sensors (orthogonal to the beam)
    II. Blade based sensors (parallel to the beam)
    III. Slit integrated sensors (orthogonal, but moveable)
4. Conclusions (+ presentation on controls + ***join EU project***)

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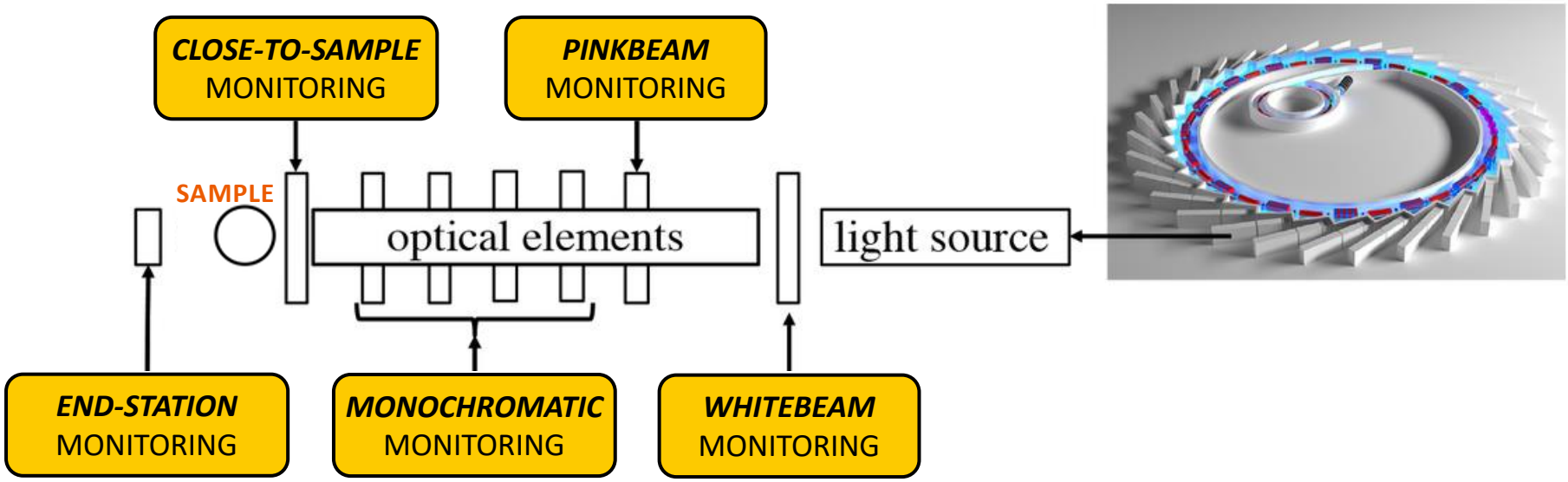
Generalities of Synchrotron X-ray beam monitoring



General requirements

- transparency (>98%)
- stability over time (whitebeam)
- good lateral resolution (<um)
- fast response (<ms, <us)
- large active areas (mm^2)

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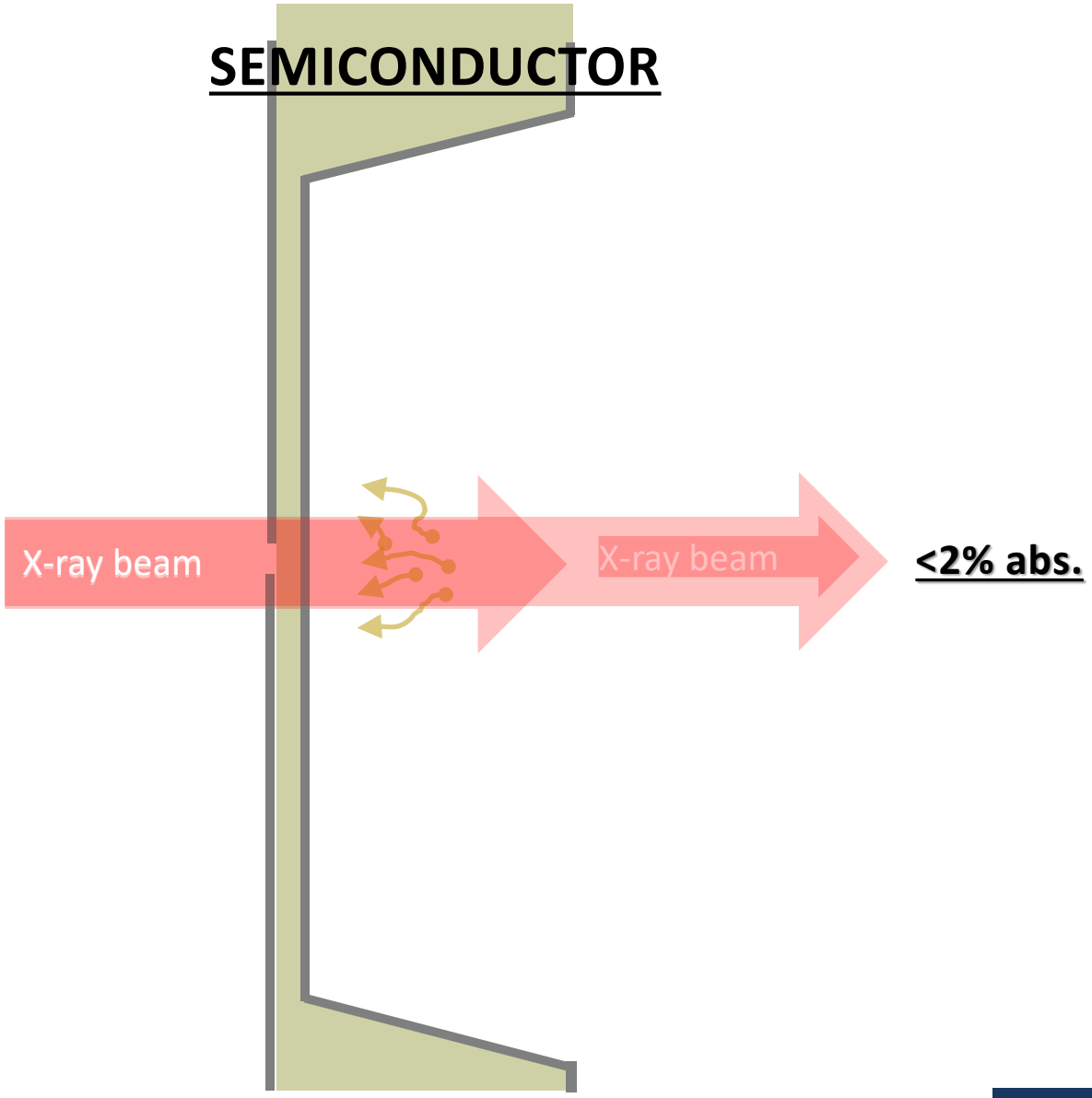
“Thin-membrane" solid state XBPM



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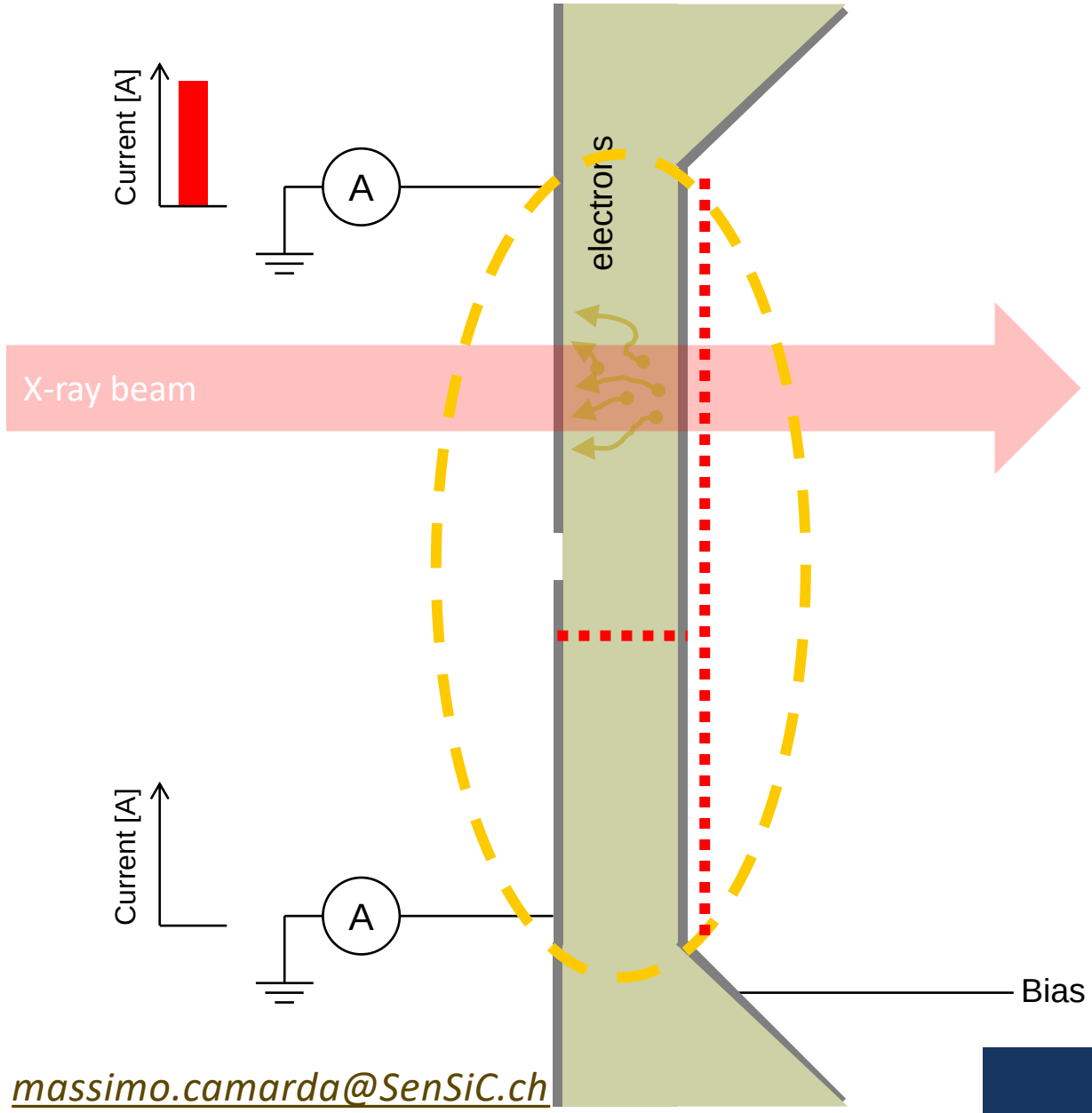
Standard "thin-membrane" XBPM



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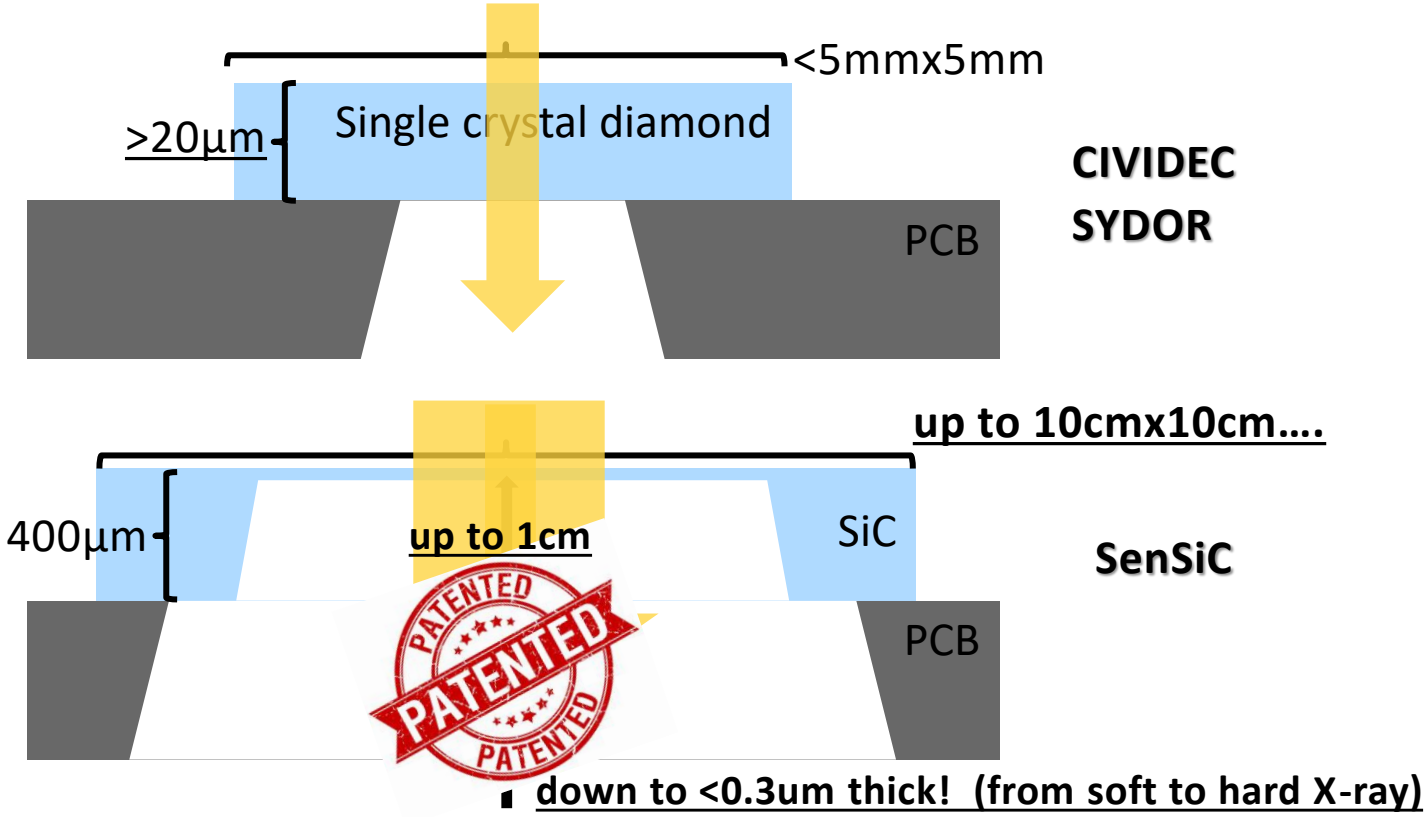
Comparison between Diamond and Silicon Carbide XBPM

"A comparison between <u>single crystal diamond</u> and SiC X-ray beam position monitors"

HOUGHTON, Diamond Light Source, SRI/JSR



<u>down to <0.3um thick! (from soft to hard X-ray)</u>

ultra-thin (framed) membrane!

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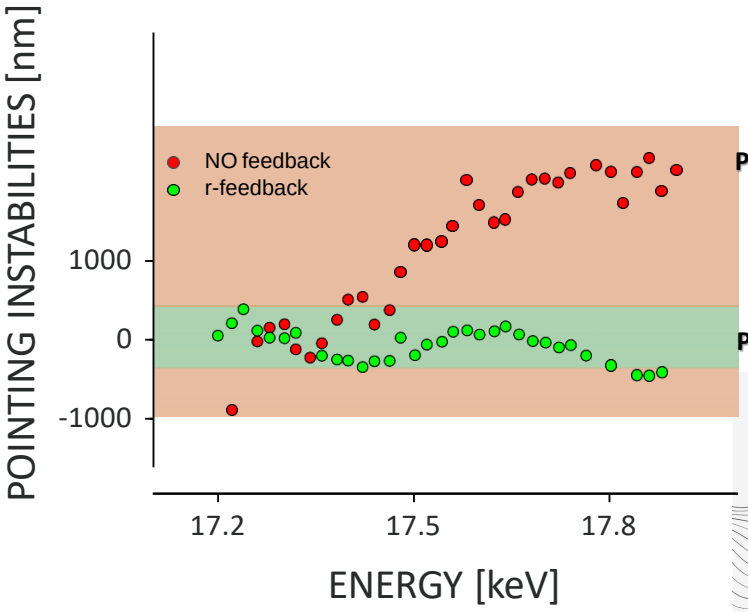
*up to instrumental limits

Monochromatic XBPM

successfull SiC XBPM feedback-loop schema



Pointing instability: 2.5µm

Pointing instability*: 0.4µm

x5 Improvement using feedback system using SiC XPBM

Control/feedback important in spectroscopy measurements to compensate for energy induced drifts!

*sigma: <400nm

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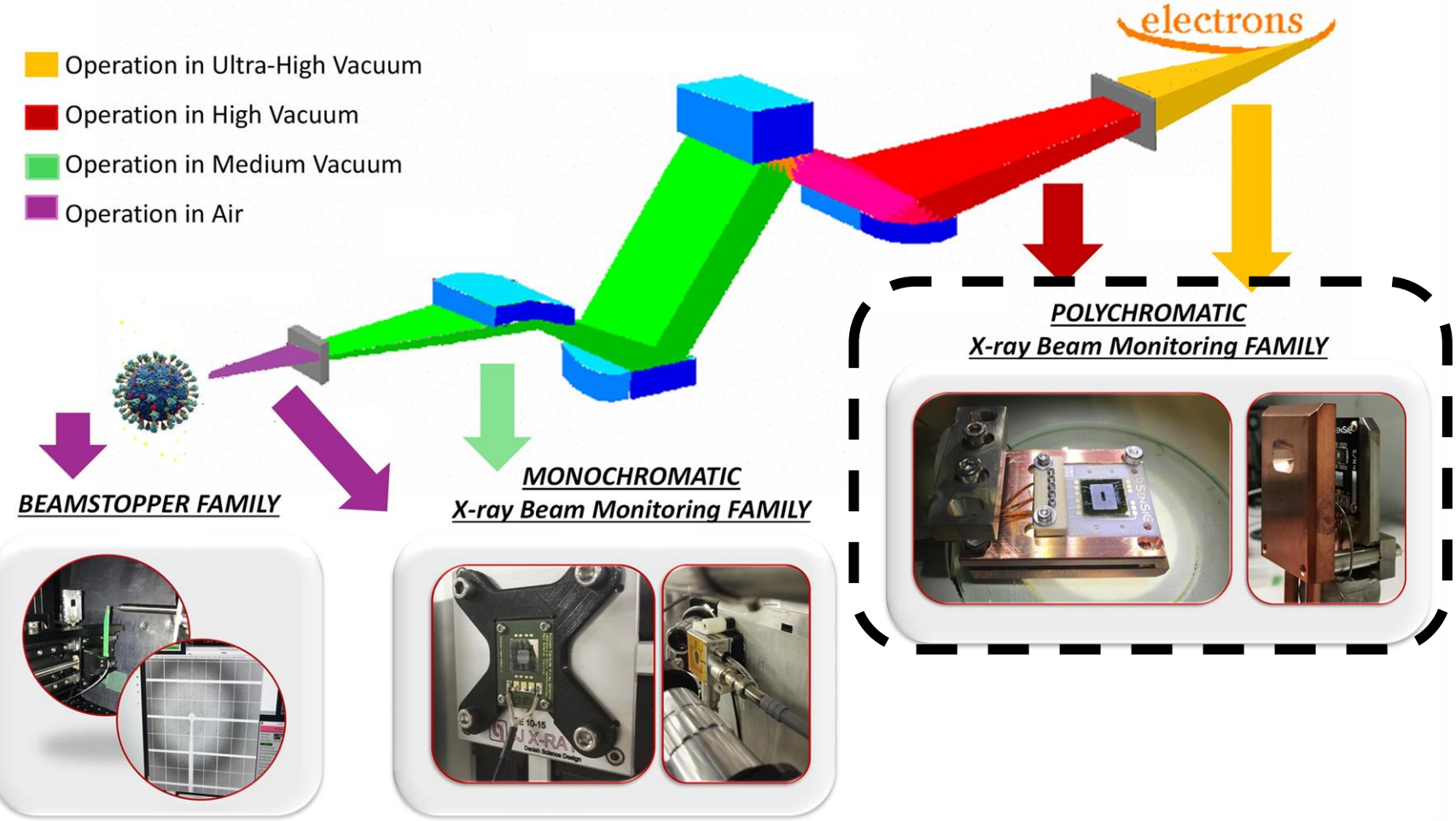
SenSiC (+STLab) mission
Fullfill –all- X-ray diagnostic needs (with turnkey solutions)

Silicon Carbide (SiC) In-line X-ray Detectors



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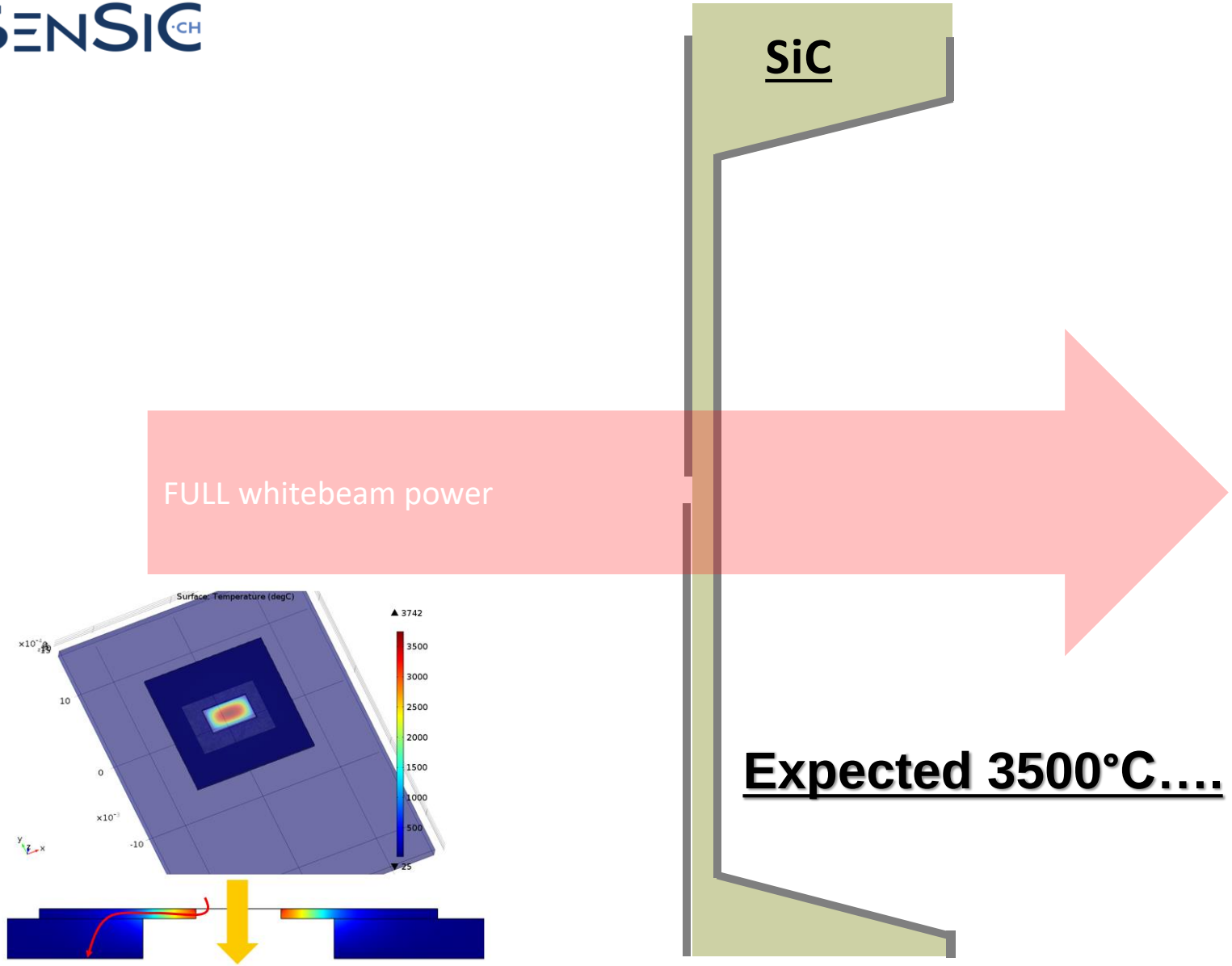
“Thin-membrane" solid state XBPM



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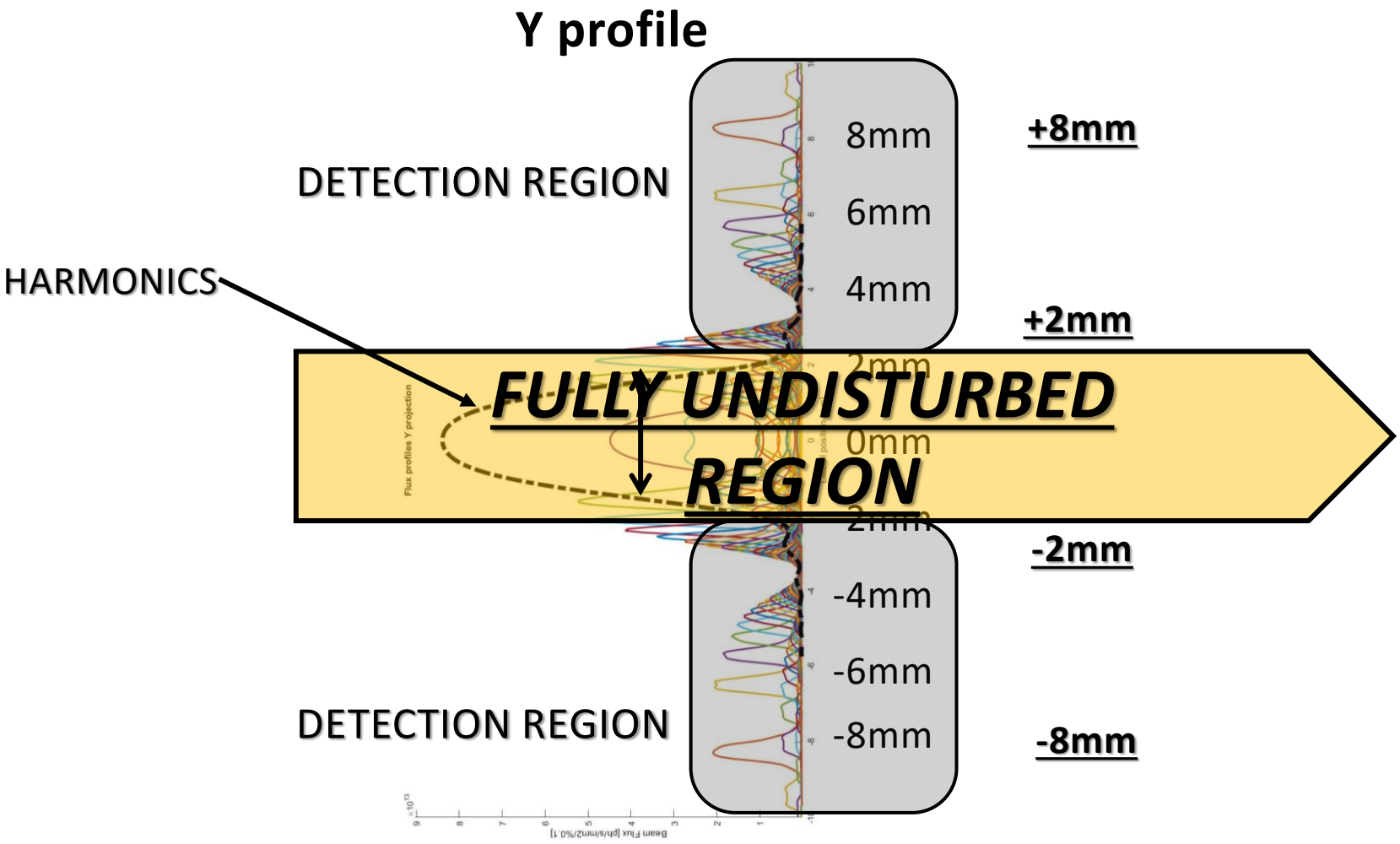
Generalities of whitebeam monitoring



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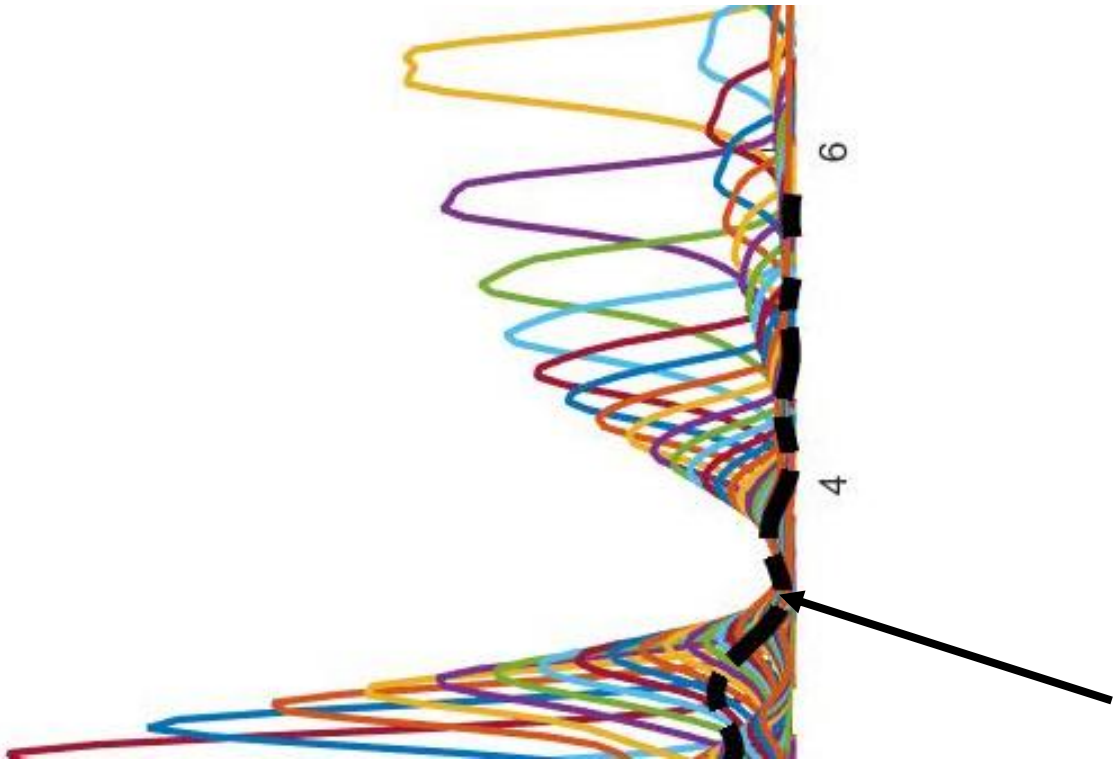
Generalities of whitebeam monitoring



WE ARE NOT MEASURING THE «TAILS» OF THE BEAM

WE ARE REALLY MEASURING THE «OFF HARMONIC» COMPONENTS!

CROSS-CHROMATIC MONITORING

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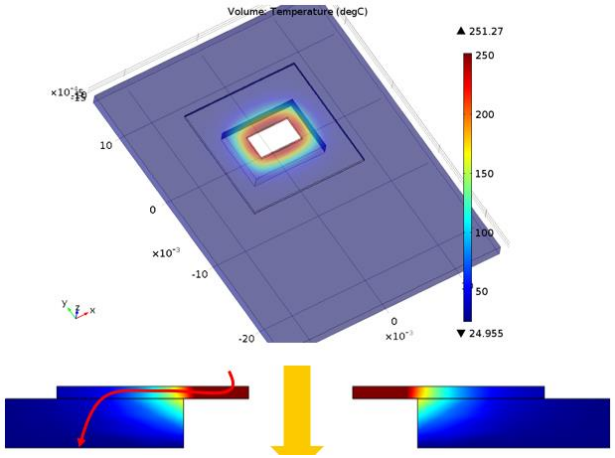
“Thin-membrane" solid state XBPM

SiC

FULL whitebeam power



Expected 250°C (1/10th)

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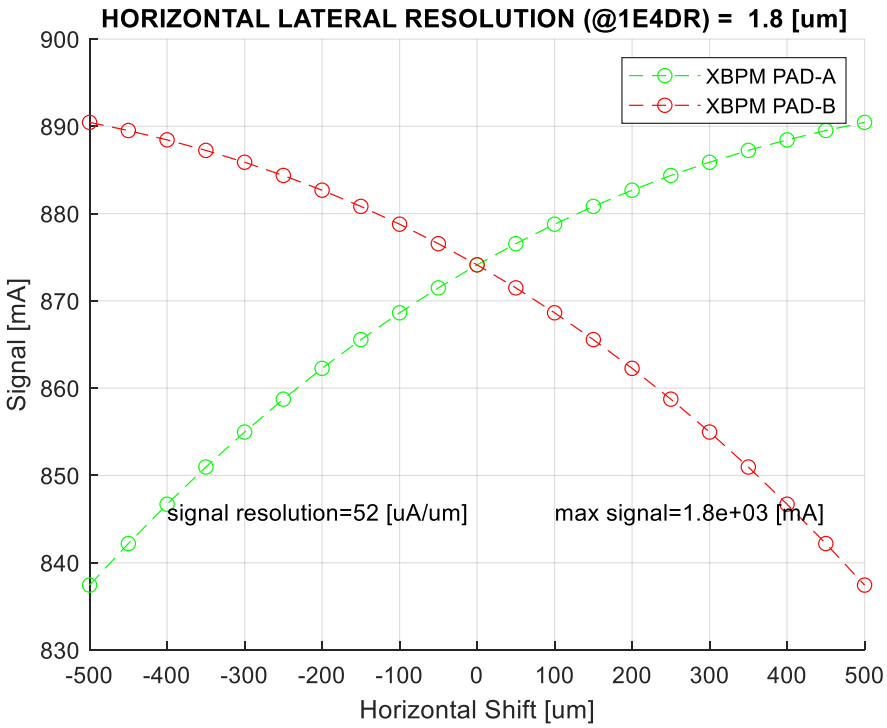
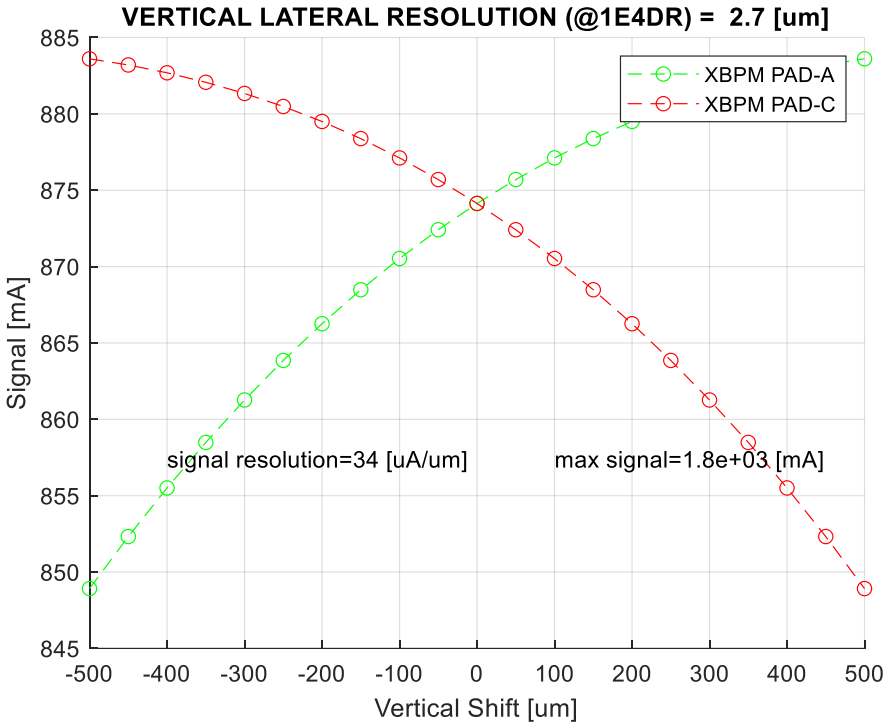
Knife-edge scan at center "*HOLE-type*" 2um SiC XBPM, microXAS





Lateral resolution of [1.8um,2.7um]

(≈x2 improvement!!)

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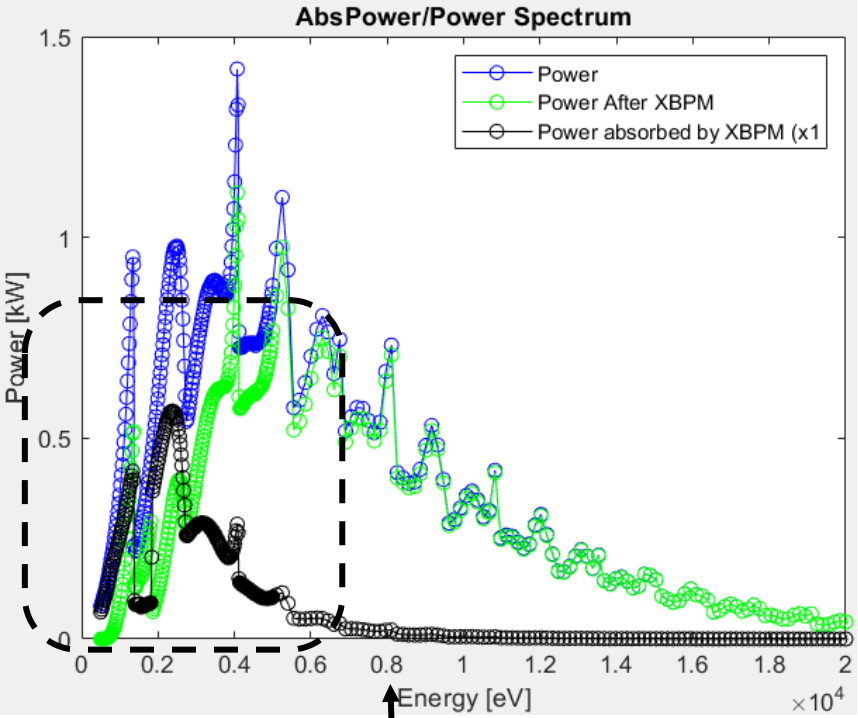
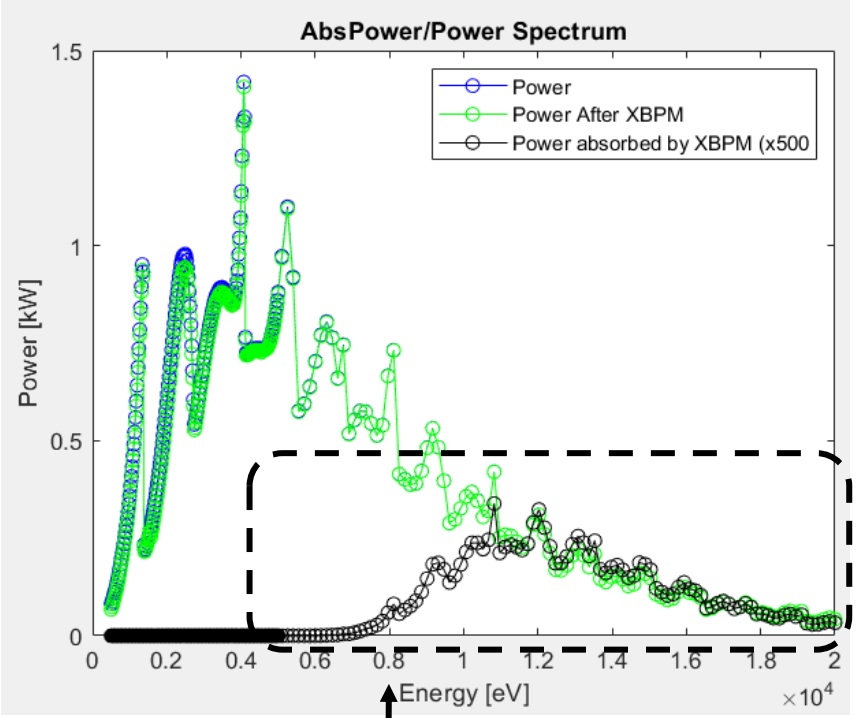
HOLE-type whitebeam sensors: FILTERING METHOD

STANDARD HOLE SiC XBPM



main signal contribution coming from <8keV photons

<u>FILTERING</u> HOLE SiC XBPM



main signal contribution coming from <8keV photons

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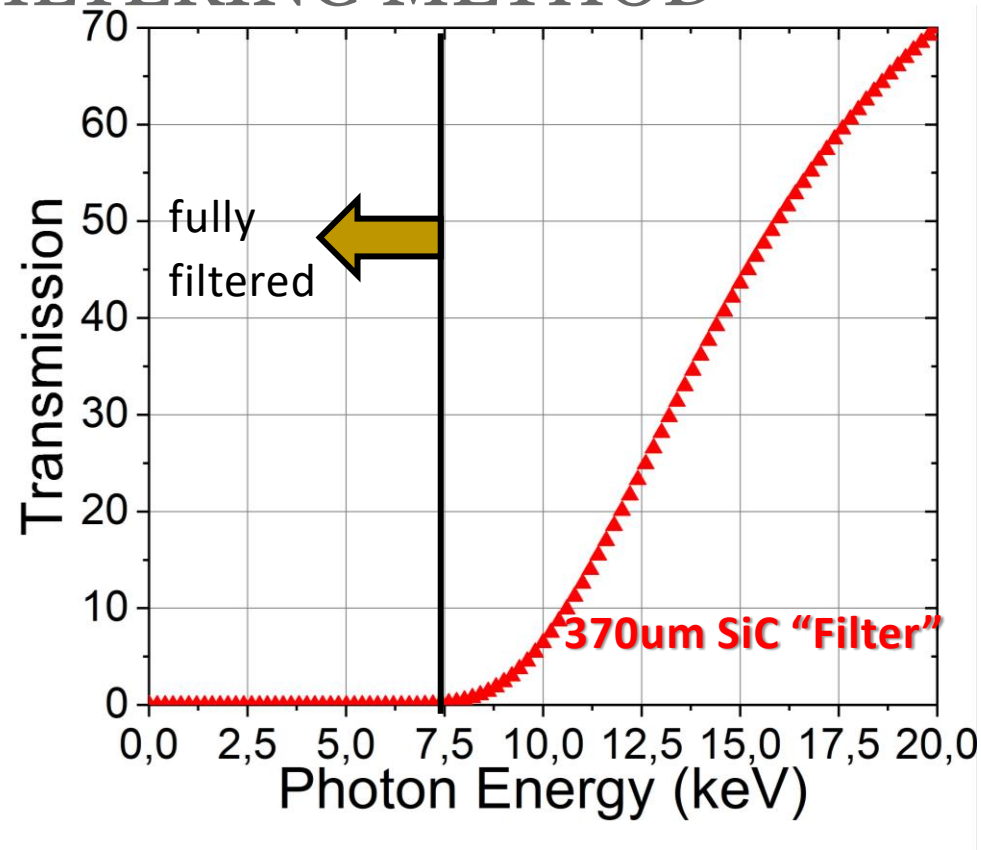
HOLE-type whitebeam sensors: FILTERING METHOD



filtering everything below 7.5keV → *cross-chromatic* monitoring

filtering everything below 7.5keV → bendig magnet radiation

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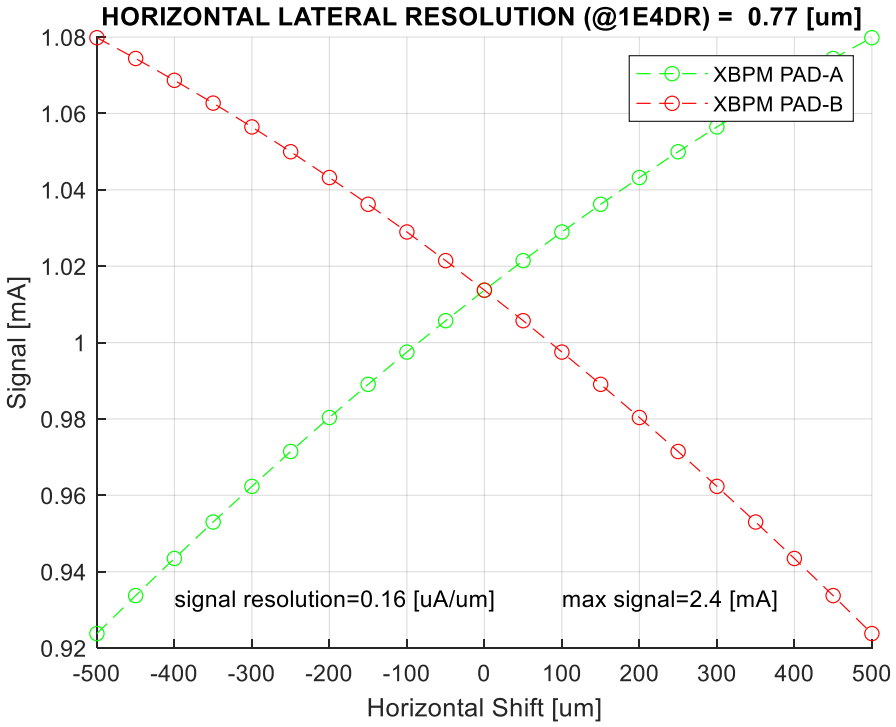
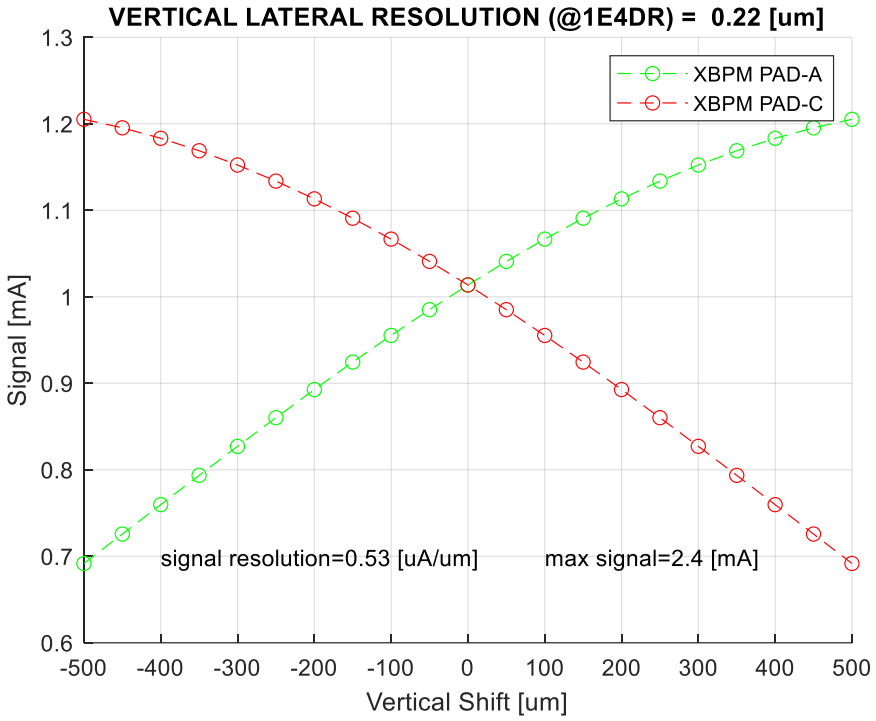
Whitebeam monitoring “FILTERED Blade-type” 2um SiC XBPM, microXAS





Max current on device (diaphram) 2 [mA] (>x1000 reduction)

Lateral resolution of [0.7um,0.22um] (>x3-10 improvement*)

2um mem= [2.7um,3.7um]
blade=[1.8um,2.7um]

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Knife-edge scan at center for microXAS

"Standard" 2um SiC XBPM

- Lateral resolution of [2.7um– 3.7um]
- Max current on device 3[A]
- Max temperature 3600°C

"BLADE" SiC XBPM

- Lateral resolution of [1.8um– 2.7um]
- Max current on device 1.7[A]
- Max temperature 250°C

"FILTERED BLADE" SiC XBPM

- Lateral resolution of [0.7um(!)– 0.22um]
- Max current on device 1[mA]
- Max temperature 250°C

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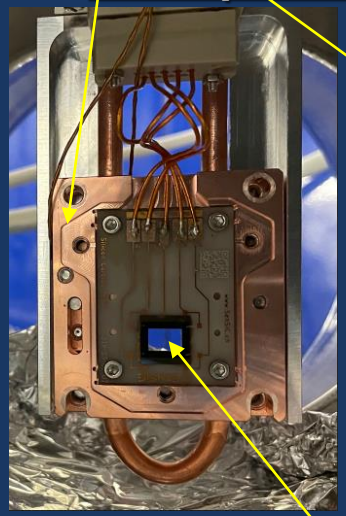
Pinkbeam sensors: hole-type sensors

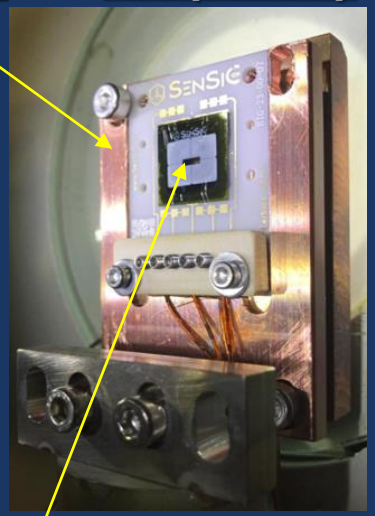
COPPER/COOLING

SLS

SIMS (softX)

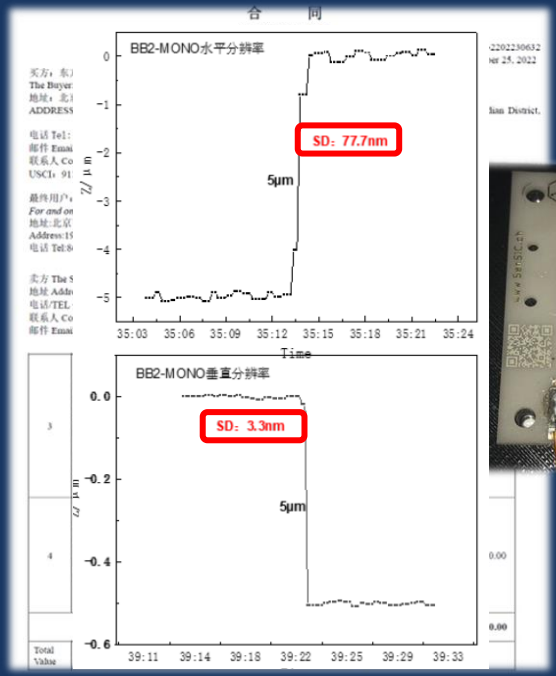


MS (hardX)



HOLES

HEPS



(very small) HOLE

submicron resolution achieved!

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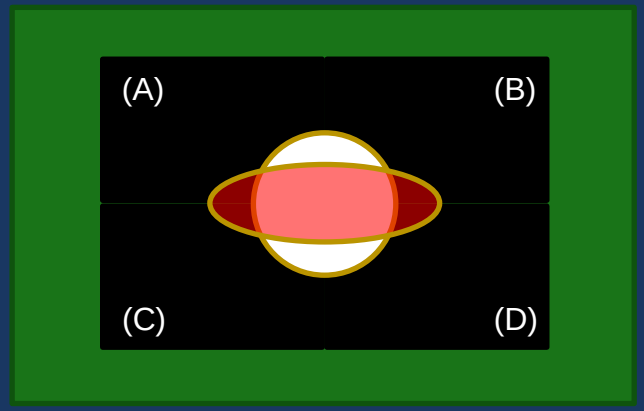
Limits of hole-type sensors



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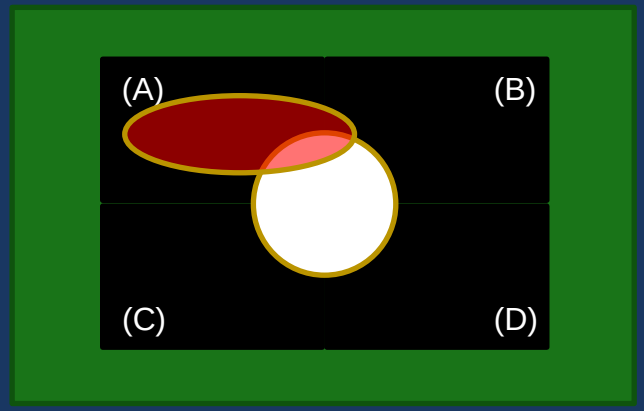
Limits of hole-type sensors



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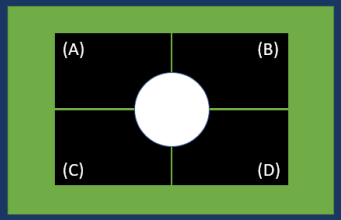
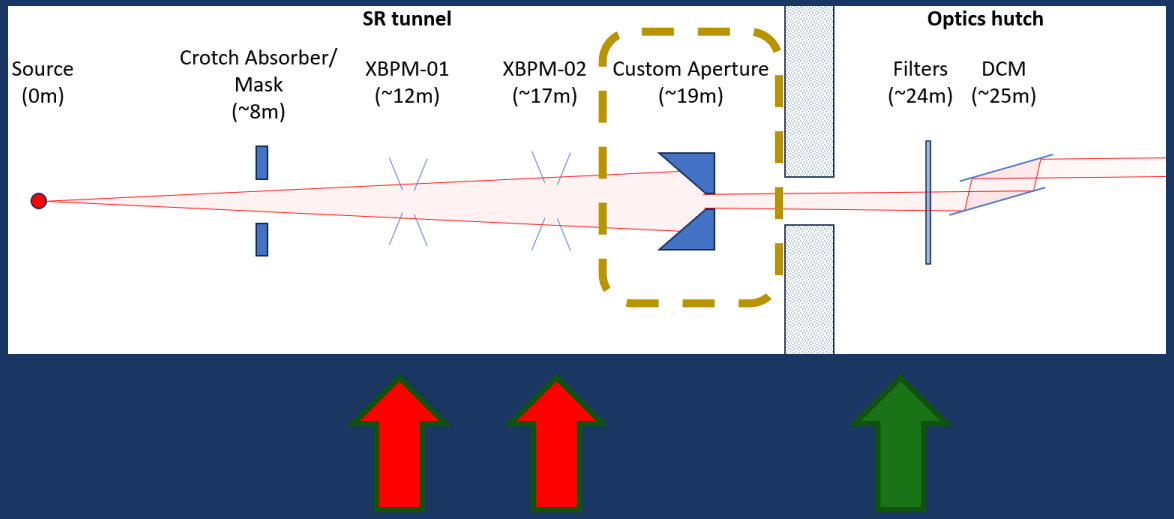
Limits of hole-type sensors





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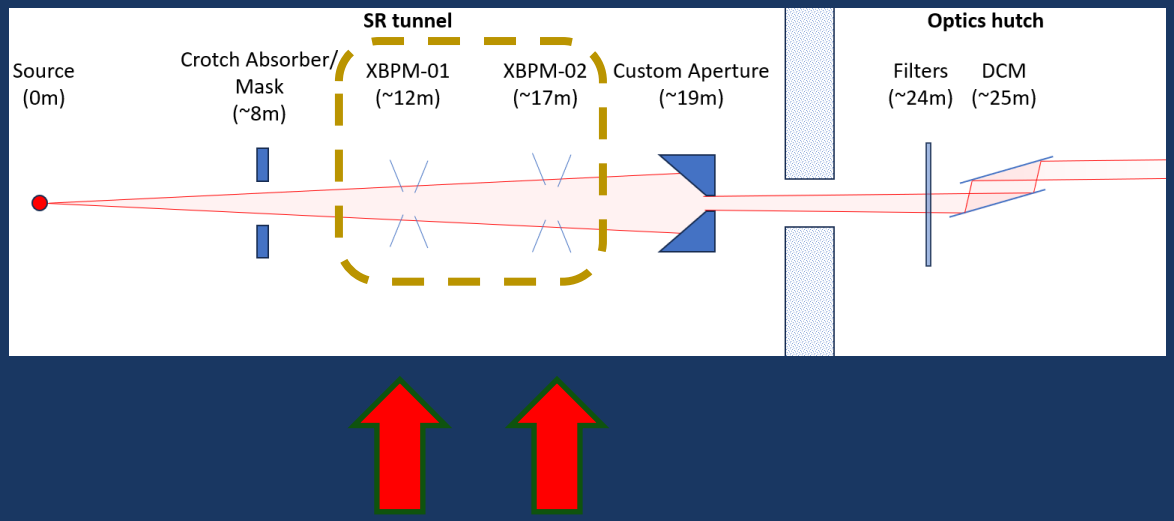
Metal (Tungsten) blade monitors



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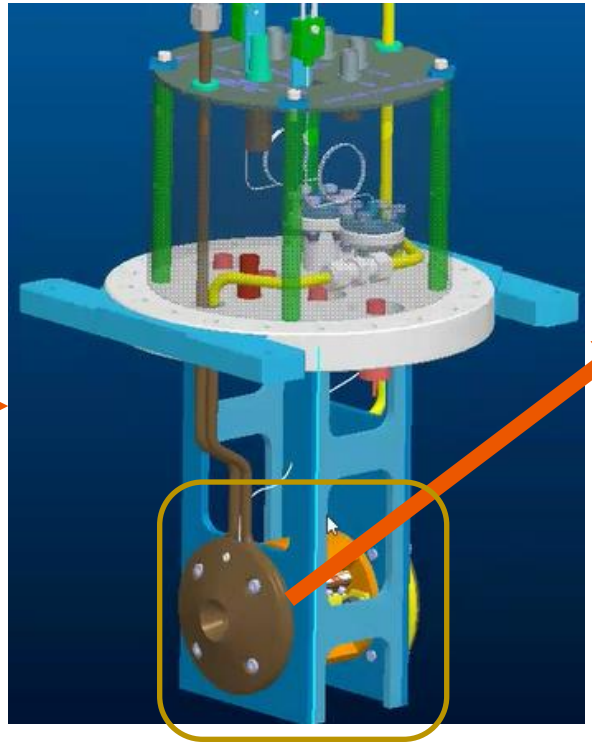
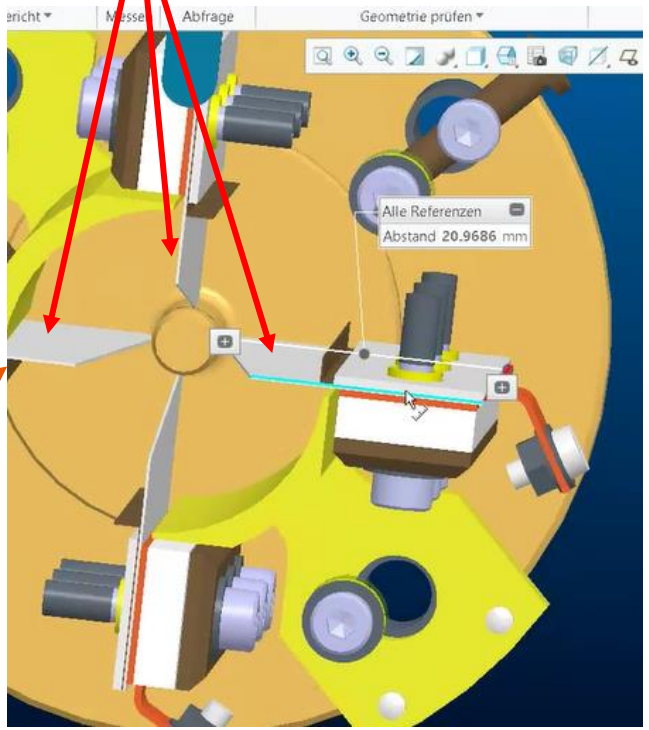
Currently avaiable whitebeam monitors
METAL BLADES SENSORS





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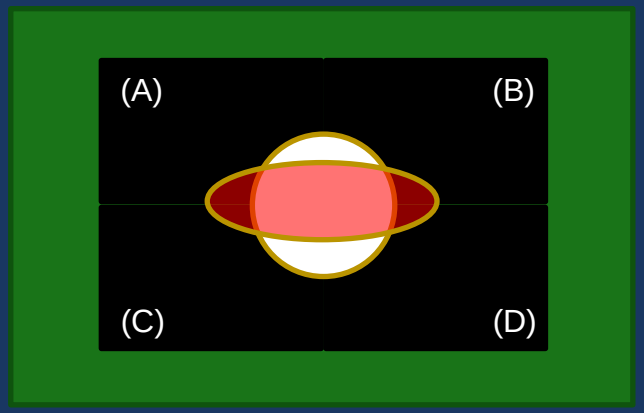
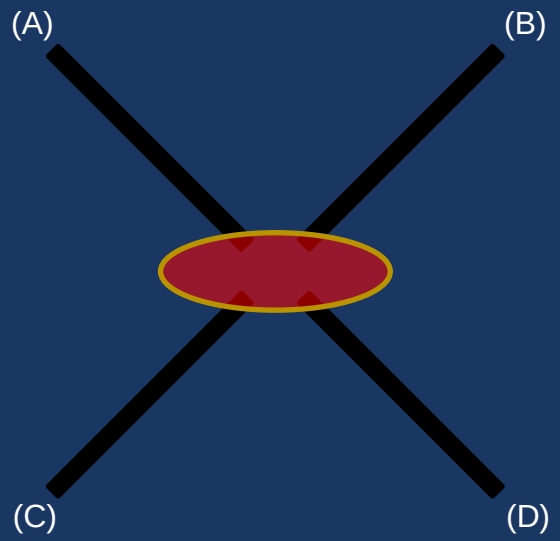
Sensors comparison





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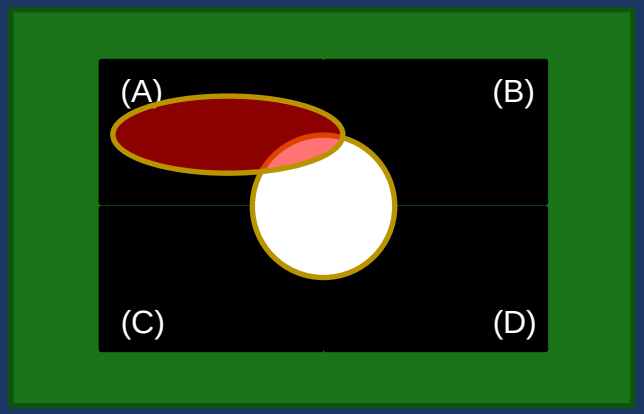
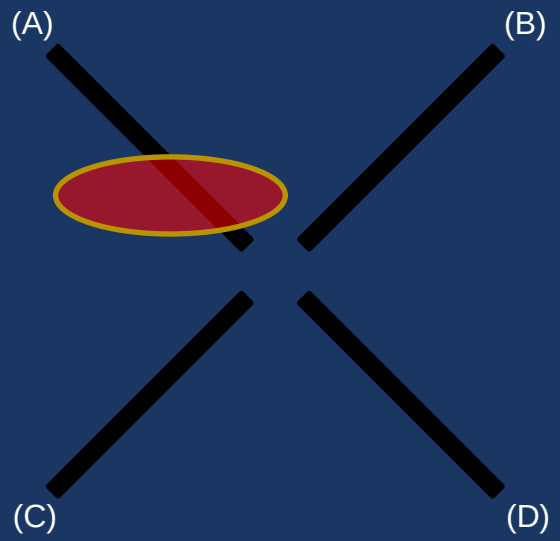
Sensors comparison





CRITICAL HEATLOAD

NON-CRITICAL HEATLOAD

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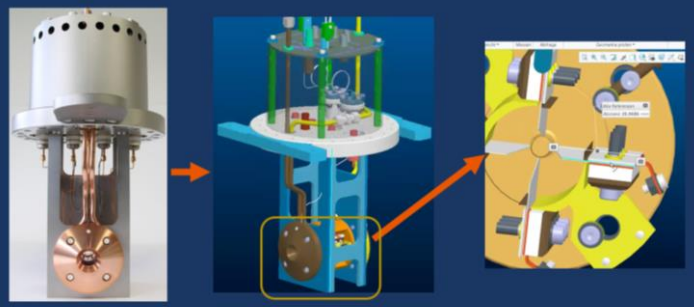
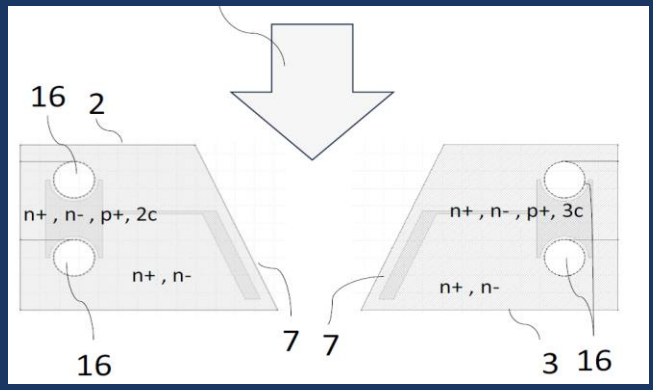
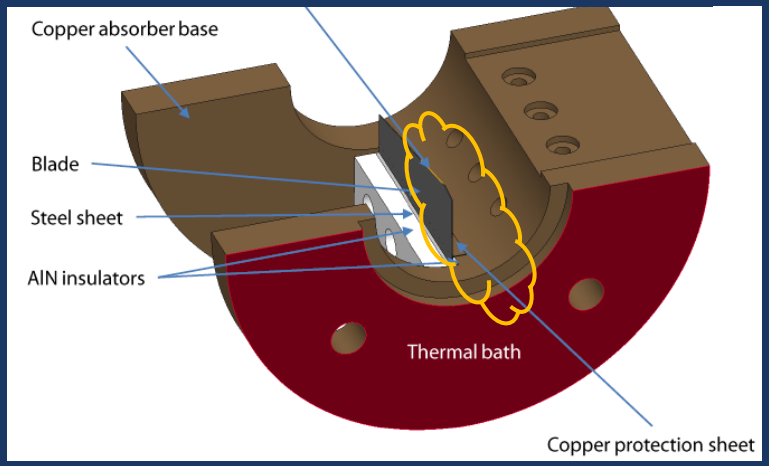
New Semiconductor-based SiC Blades







PATENTED
PATENTED
PATENTED

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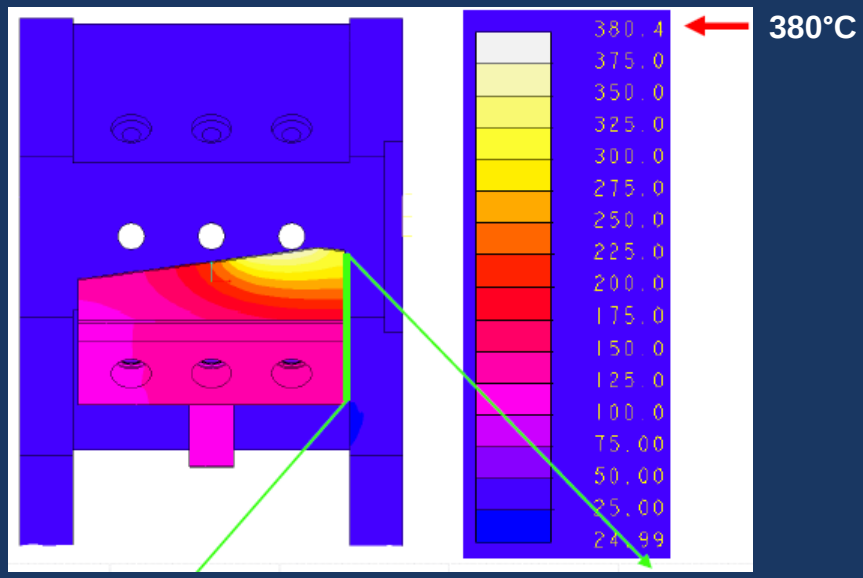
New Semiconductor-based SiC Blades

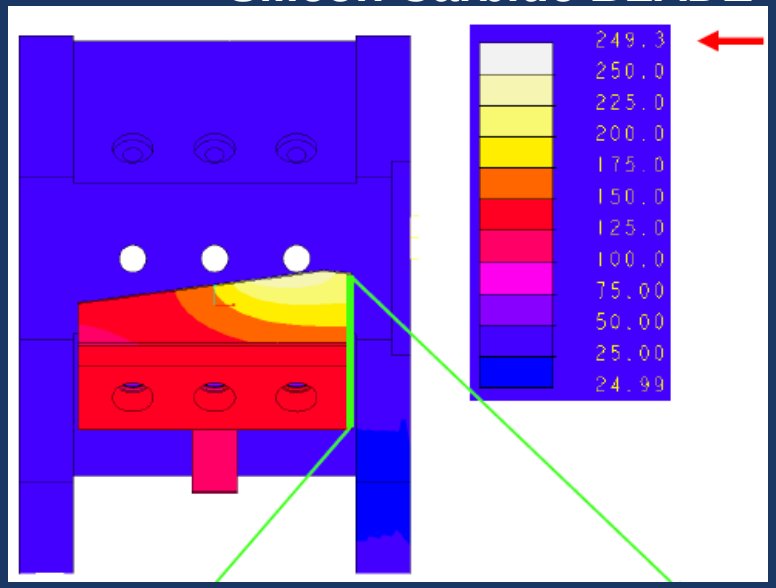
34% temperature reduction

TUNGSTEN BLADE



380°C

Silicon Carbide BLADE



250°C

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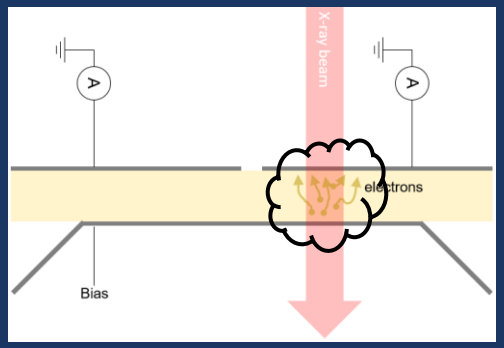
New Semiconductor-based SiC Blades

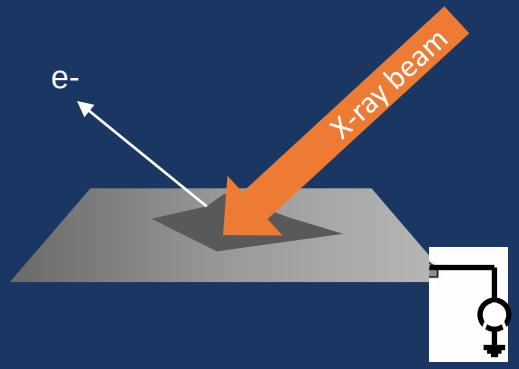
semiconductor based

***internal* photoemission**



metal based

***external* photoemission**



1. **34% temperature reduction**
2. **MUCH HIGHER (>X100) SIGNALS (internal charge multiplication)**
3. **NO SIGNAL CHANGES DUE TO SURFACE CONTAMINATIONS**
4. **POSSIBILITY OF FILTERING BACKGROUND SIGNAL**

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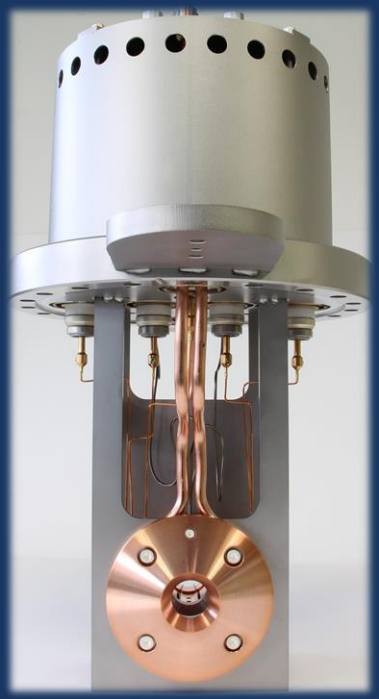
Substitution of metal blades to SiC ones / agreements



- **POSSIBILITY OF *RETROFITTING ALL-INSTALLATIONS***
- **AGREEMENT WITH FMB-BERLIN TO TEST NEW SYSTEM**
- **AGREEMENT WITH DLS (UK) TO INSTALL NEW SYSTEM**
- **AGREEMENT WITH PSI TO INSTALL NEW SYSTEM (after DLS/DT)**

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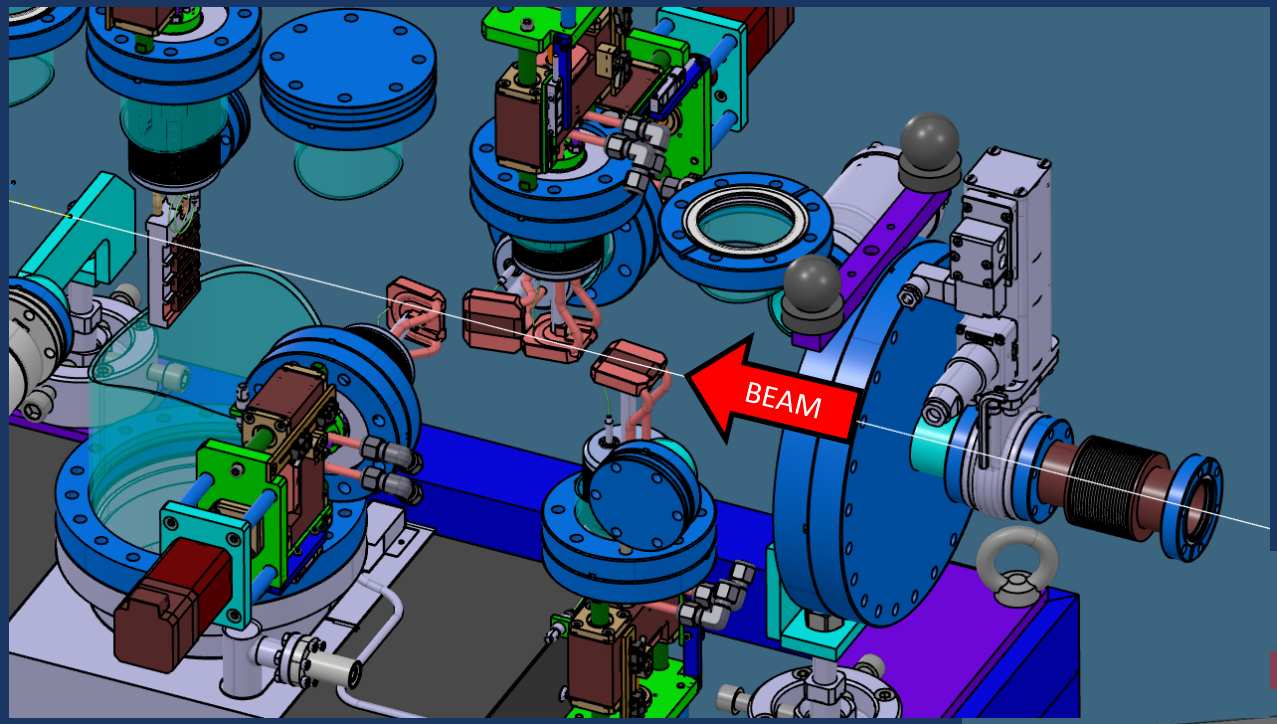
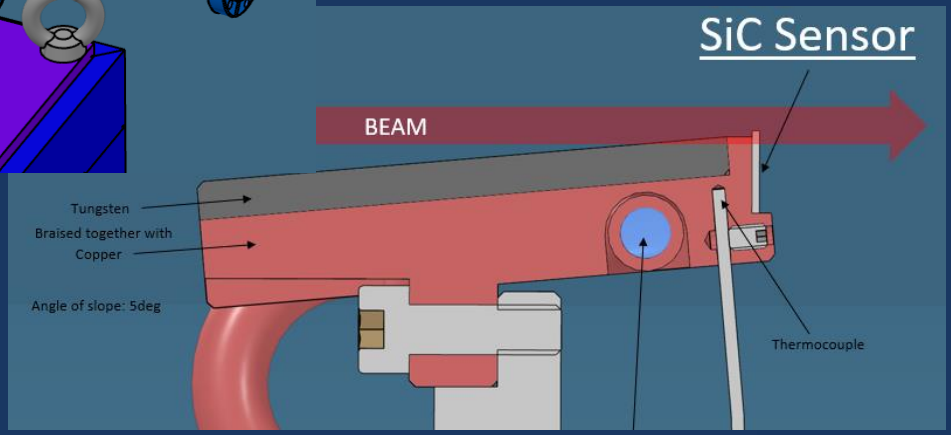
Whitebeam sensors integrated in movevable slits (PXI-SLS)





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conclusions

- SenSiC (sensors) and STLab (readout&controls*) are pursuing (with all difficulties…) development of diagnostic elements at all X-ray stages

*Dr. N. La Rosa Wednesday 17:25

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conclusions

- SenSiC (sensors) and STLab (readout&controls*) are pursuing (with all difficulties…) development of diagnostic elements at all X-ray stages
- Whitebeam represents a hot development, aiming to fullfill an technology gap, to support beam stabilization(s) [X-ray, downstream, electrons, up stream]

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conclusions

- SenSiC (sensors) and STLab (readout&controls*) are pursuing (with all difficulties…) development of diagnostic elements at all X-ray stages)
- Whitebeam represents a hot development, aiming to fullfill an technology gap, to support beam stabilization(s) [X-ray, downstream, electrons, up stream]
- We are developing three different sensors types:

(1) HOLE TYPE

Validated at PSI & IHEP
submicron resolution

(2) BLADE TYPE

retrofit of FMB-chambers

(3) SLITS INTEGRATED

- ***We are also developing readout & control electronics**

- **We are looking for *interested institutions for EU project proposal***

**Dr. N. La Rosa Wednesday 17:25*

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Dr. N. La Rosa Wednesday 17:25

"*Development of control systems for the stabilization of synchrotron X-ray beams*"

UNIVERSITÀ degli STUDI di CATANIA

DEPARTMENT OF ELECTRICAL, ELECTRONIC, AND COMPUTER ENGINEERING

STLAB SENSIC·CH

DEVELOPMENT OF A CONTROL SYSTEM FOR THE STABILIZATION OF SYNCHROTRON X-RAY BEAMS

NICCOLÒ LA ROSA

PROF. MAIDE BUCOLO
DR. MASSIMO CAMARDA

ENG. SAMUELE MOSCATO

PhD in Energy, Computer and Telecommunications Systems Engineering

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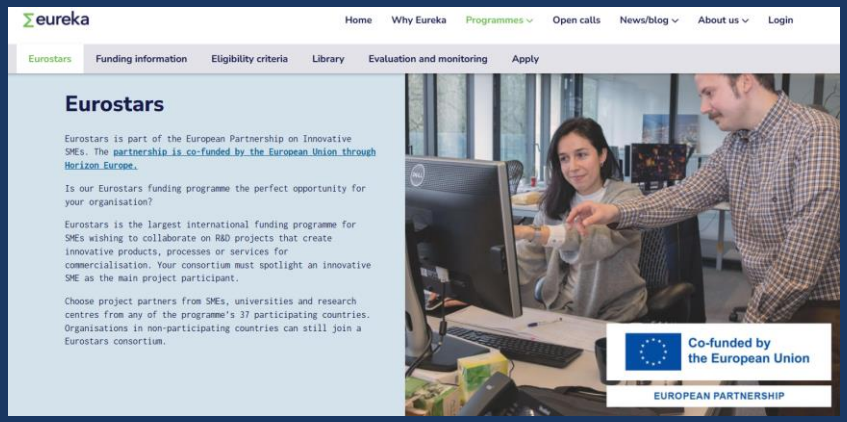
EUREKAT-EUROSTAR EU PROJECT

“Precision Active Control of X-ray Beamlines” (PAC-X)



- 500k€-1000k€ /2-3years project
- Grants covering up to [40% (FR) / 70% (SE) / 100% (DE)] of project costs
- Deadline 12th September
- Beamtimes from facilities will allow testing/development of sensors+readout+control (turn-key) solutions
- Developed systems will be owned by facilities/beamlines at the end of the project(!)
- SOLEIL, ELETTRA, PTB/BETTY-II already IN (as single beamlines)

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