



# Feasibility study of monitoring polychromatic X-ray beams at synchrotron radiation sources

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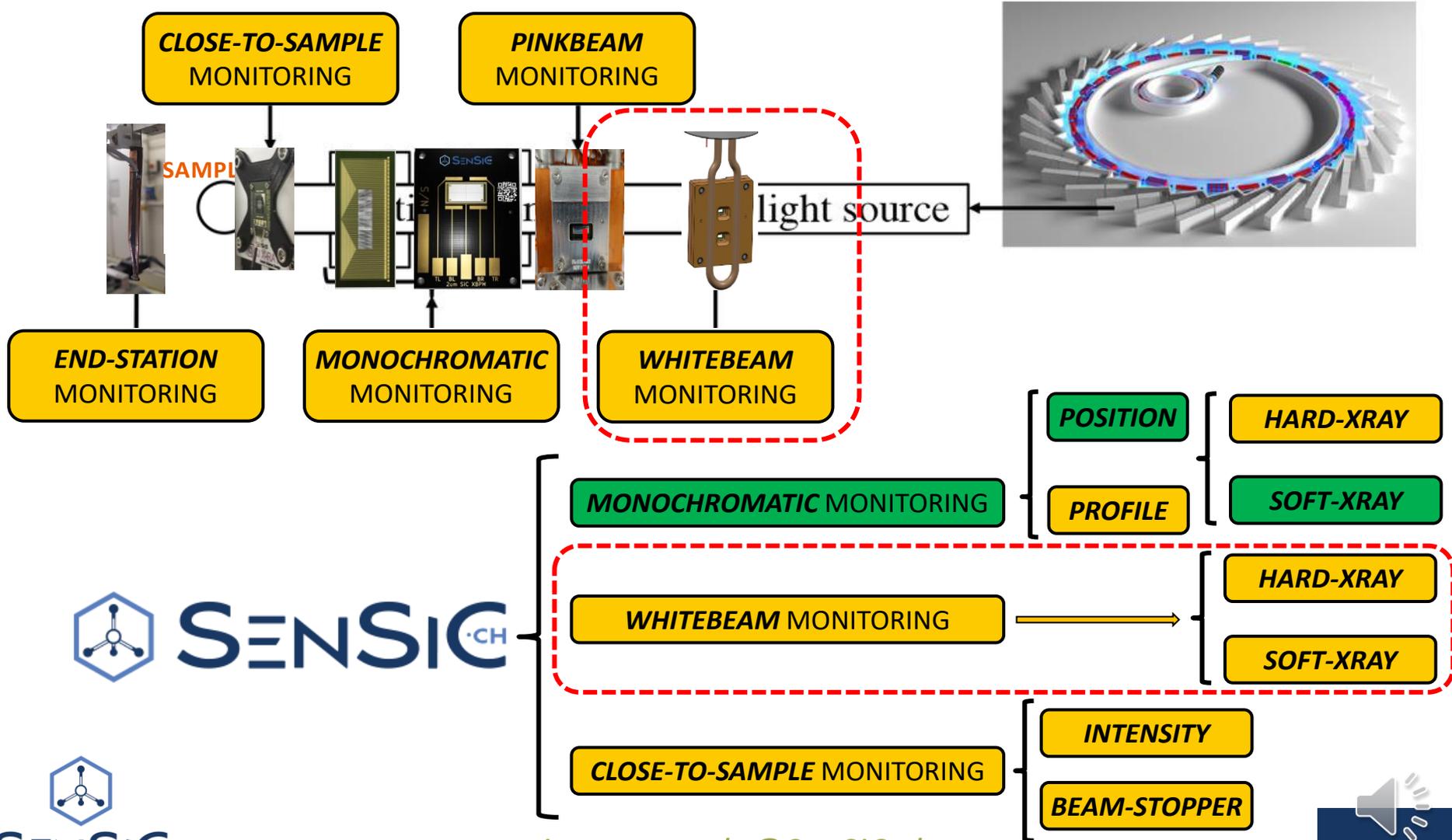
SRI2021



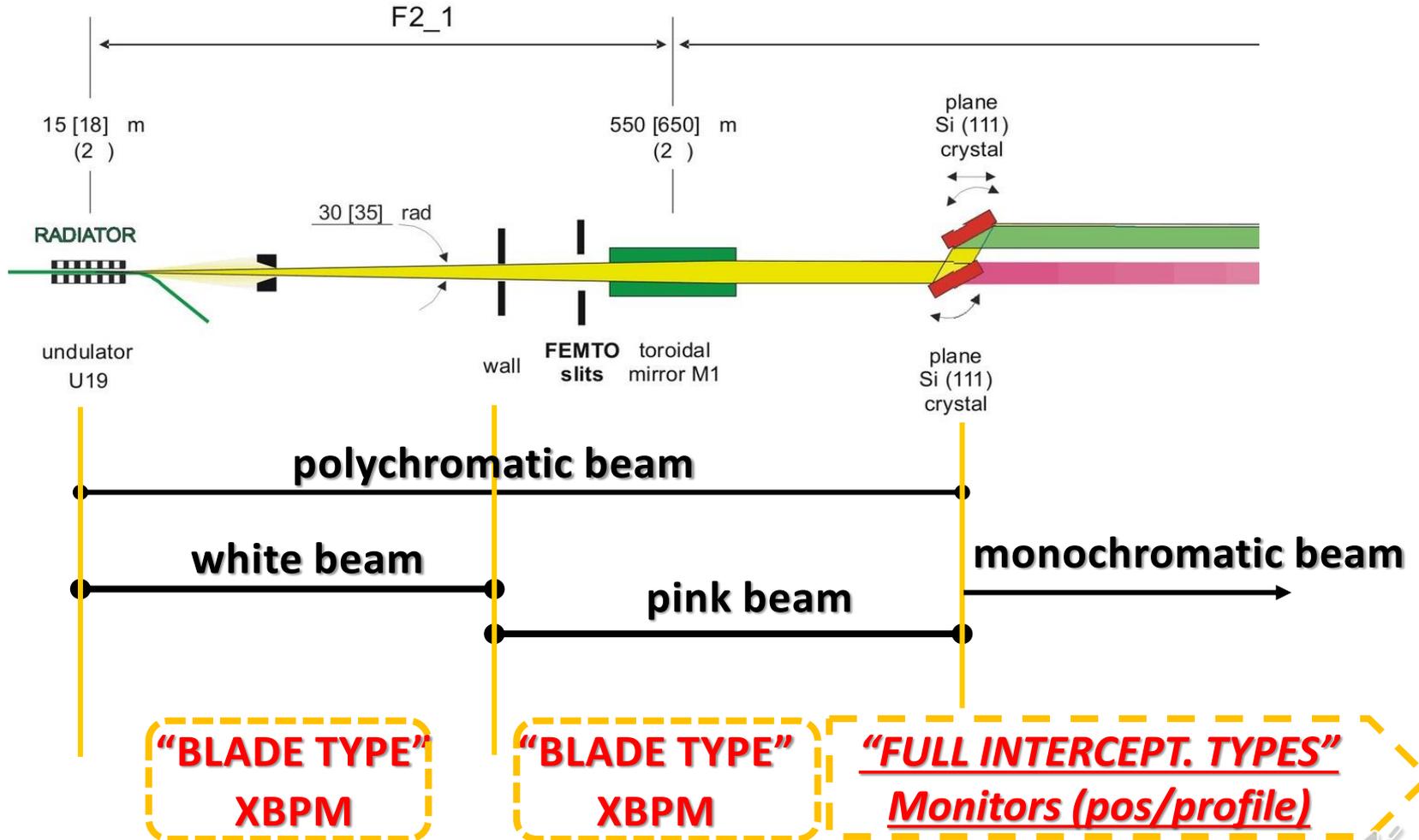
- Polychromatic monitoring
- Modelling to determine sensors characteristics
- Opportunities and difficulties
- Conclusions and outlook



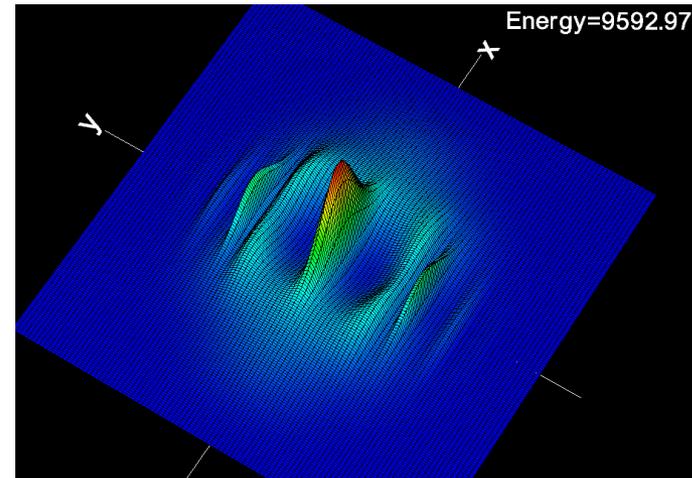
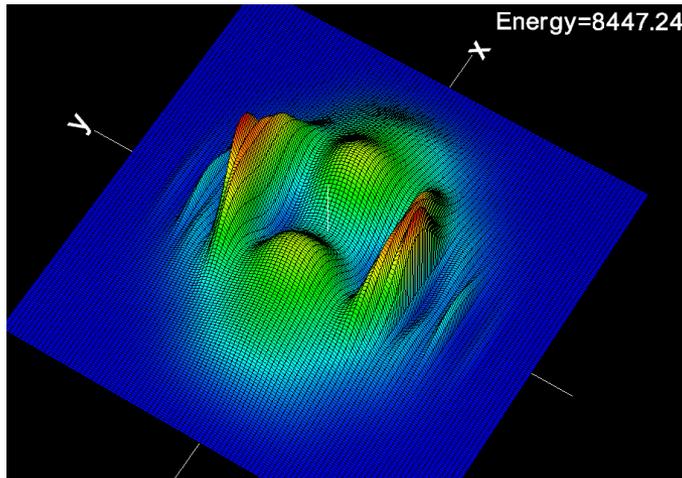
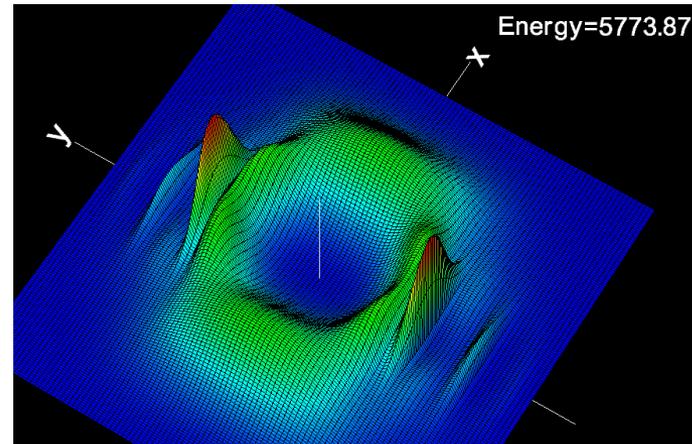
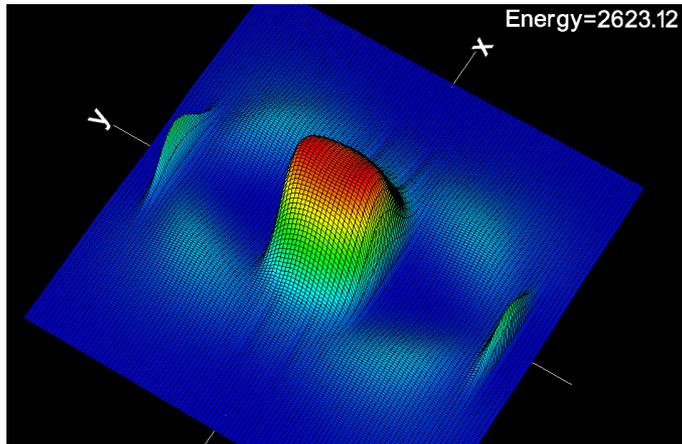
# Generalities of Synchrotron Beam monitoring



# Feasibility study of X-ray solid-state beam-monitoring for whitebeams



1. determine flux(E,x,y,z) generated by ID (Spectra)



plots using very wide acceptance window (24x24 nm<sup>2</sup>)

# ID whitebeam, spectra (microXAS)

## 1. determine flux(E,x,y,z) generated by ID (Spectra)

SPECTRA 10.2 - C:\Users\Massimo\Dropbox\191017 PSI\OTHER\DEVELOPMENTS\Console... - □ ×

File Select Calculation Run Utility Configuration Help

Accelerator Specification

Storage Ring

Bunch Profile: Gaussian Injection Condition: Default

Electron Energy (GeV)	2.411	Energy Spread	0.8784e-3		
Average Current (mA)	400	$\beta_x$ (m)	8.32	$\alpha_x$	-2.1
Circumference	300	$\beta_y$ (m)	0.52	$\alpha_y$	0.007
Bunches	400	$\eta_x$ (m)	0	$\eta_x'$	0
$\sigma_z$ (mm)	6	$\eta_y$ (m)	0	$\eta_y'$	0
Peak Current (A)	19.9471	$1/\gamma$ (mrad)	0.211945		
Natural Emittance (m.rad)	56.3e-10	$\sigma_x$ (mm)	0.2162	$\sigma_x'$ (mrad)	0.06045
Coupling Constant	0.00178	$\sigma_y$ (mm)	2.281e-03	$\sigma_y'$ (mrad)	4.386e-03
$\epsilon_x$ (m.rad)	5.62e-09	$\gamma\sigma_x'$	0.2852	$\gamma\sigma_y'$	0.02069
$\epsilon_y$ (m.rad)	1.000e-11				

Light Source Description

Linear Undulator

Link Gap & Field  Segmented Undulator  
 End Correction Magnets  Symmetric Profile

Gap Value	24	$\sigma_r$ (mm)	4.481e-03	$\sigma_r'$ (mrad)	0.01611
B(T)	0.845506	$\Sigma_x$ (mm)	0.2163	$\Sigma_x'$ (mrad)	0.06256
Periodic Length (cm)	1.9	$\Sigma_y$ (mm)	5.028e-03	$\Sigma_y'$ (mrad)	0.01669
Device Length (m)	1.8	$\lambda_{1st}$ (nm)	0.906835		
Regular Magnet Length (m)	1.748	$\epsilon_{1st}$ (peak:eV)	1363.12		
Number of Regular Periods	92	$\epsilon_{3rd}$ (peak:eV)	4096.47		
K Value	1.5	Flux <sub>1st</sub>	2.0206e+15		
$\epsilon_{1st}$ (eV)	1367.22	Brilliance <sub>1st</sub>	4.5073e+19		
		Peak Brilliance	2.24769e+21		
		Bose Degeneracy	0.698894		
		Total Power (kW)	1.83832		

Scan Configuration ×

Logarithmic Step?

Scan Fixed Energy (eV)

Initial Value

Final Value

Number of Points

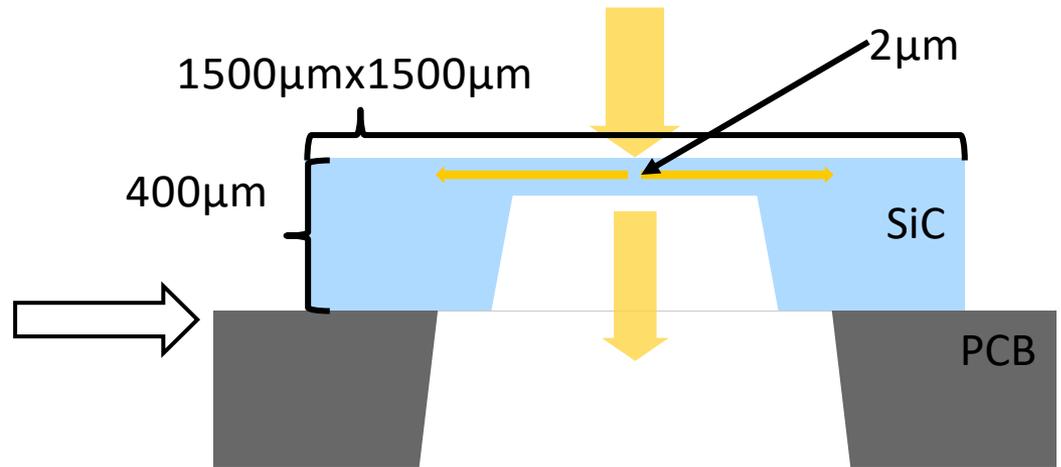
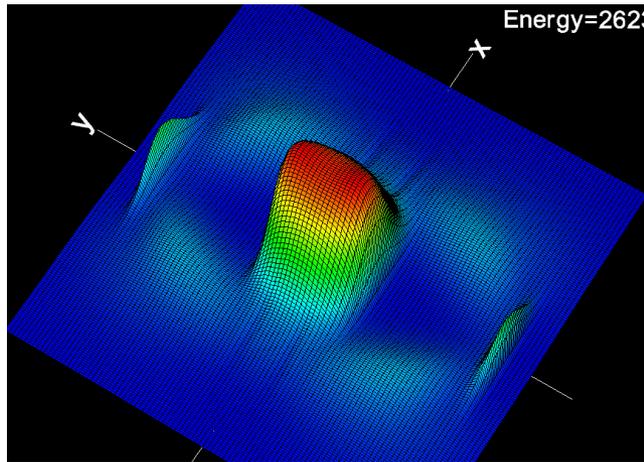
Interval or Gain/Step

Initial Serial #

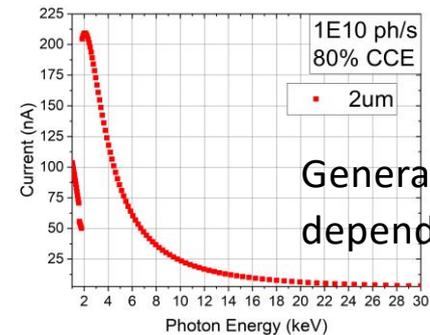
OK CANCEL

## 2. determine current on XBPM

Flux after optical elements



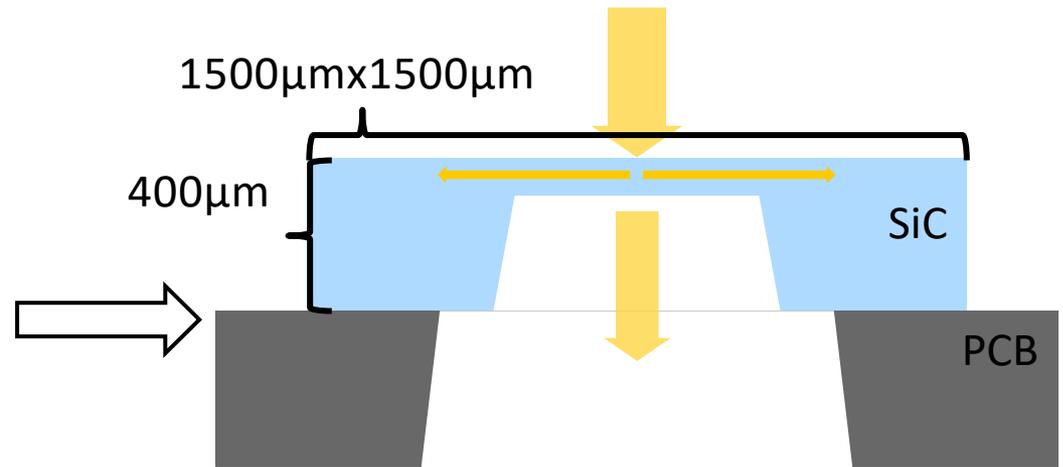
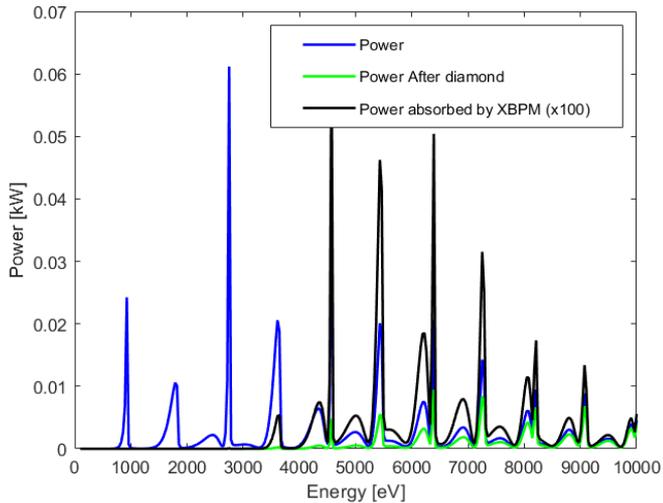
**(X,Y,E) CURRENT MAPS** ←



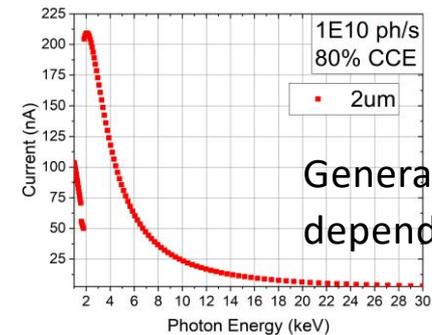
Generated current depends on  $E_{ph}$

## 2. determine current on XBPM

Flux after optical elements

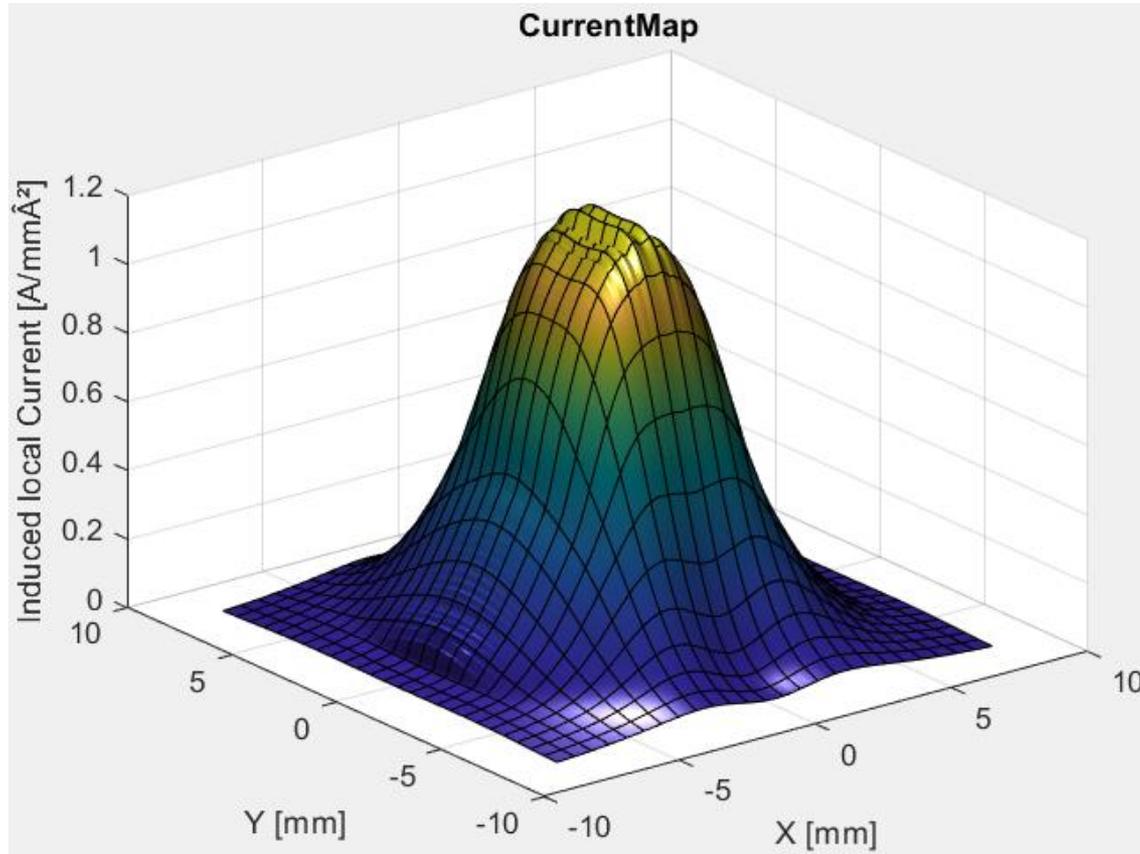


Energy integrated (X,Y) MAP ←

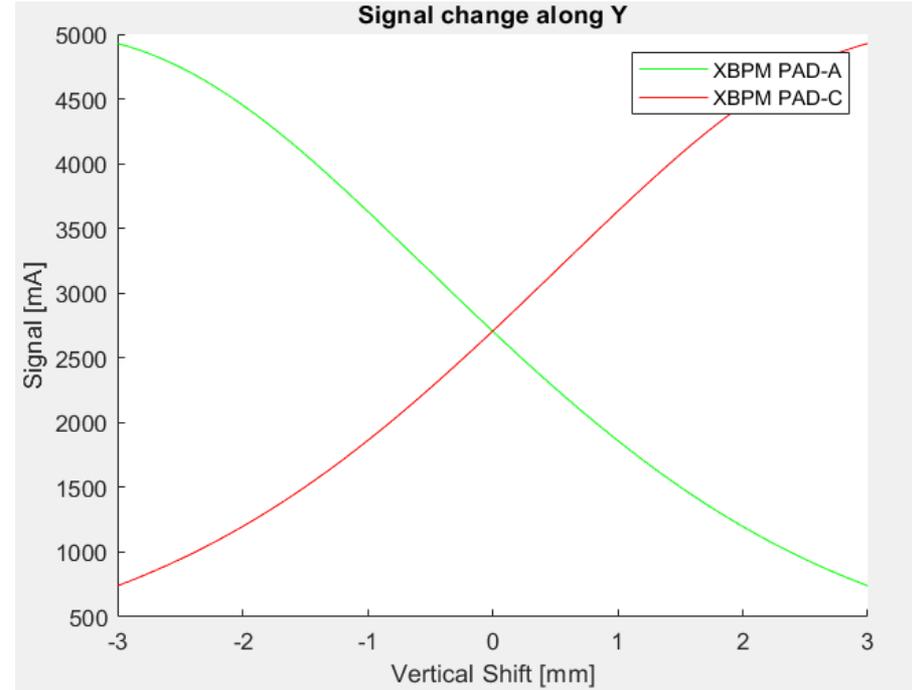
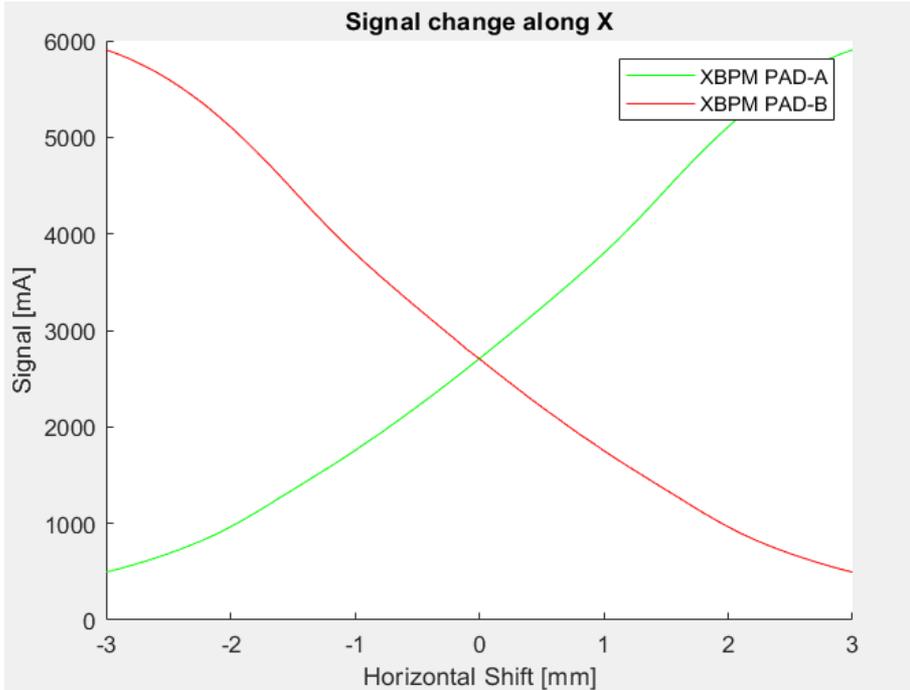


Generated current depends on  $E_{ph}$

# Beam to Current conversion “Standard 2um SiC XBPM”

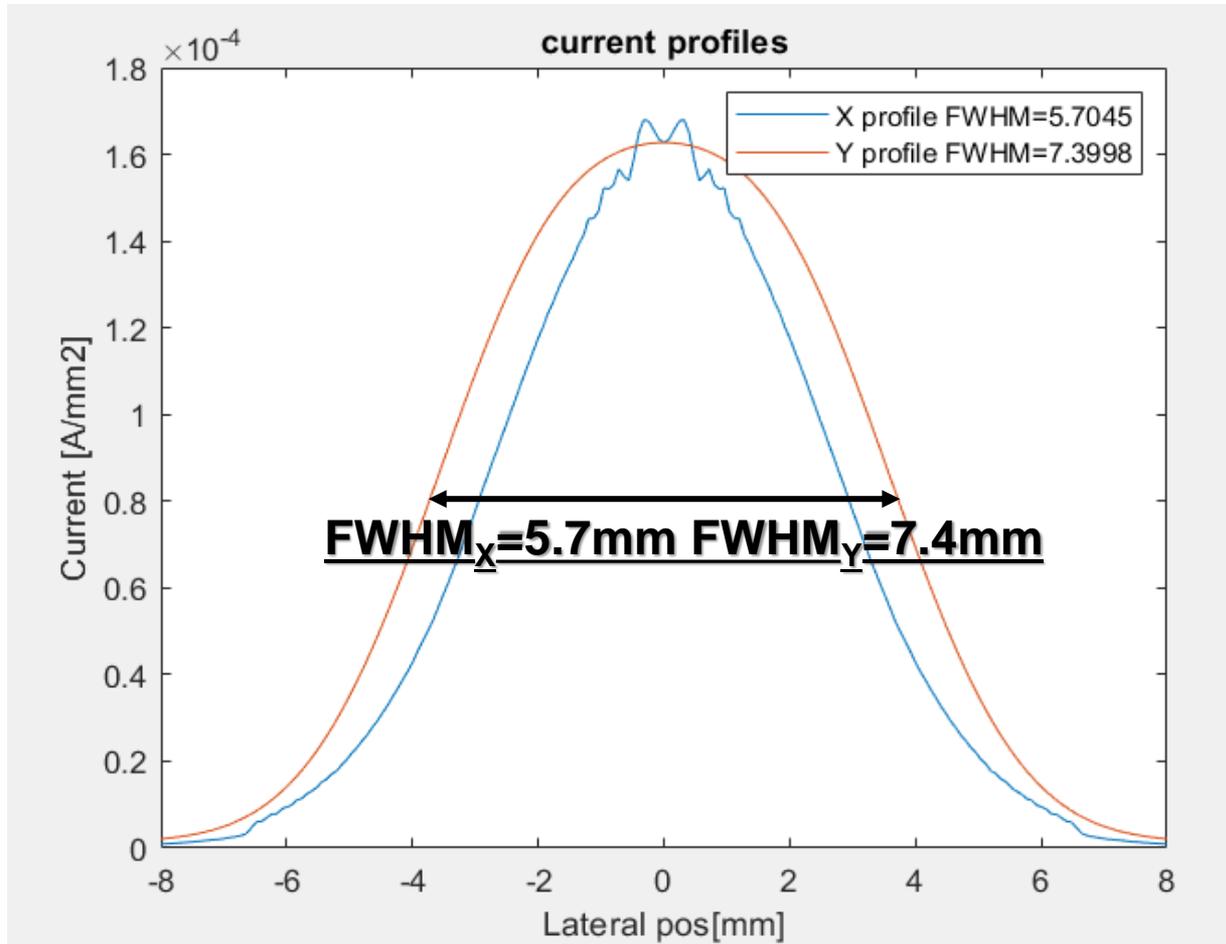


# Knife-edge scan at center “Standard 2um SiC XBPM”



**Max current signal 21.0634[A]!**

**Max current temperature 4000°C!**



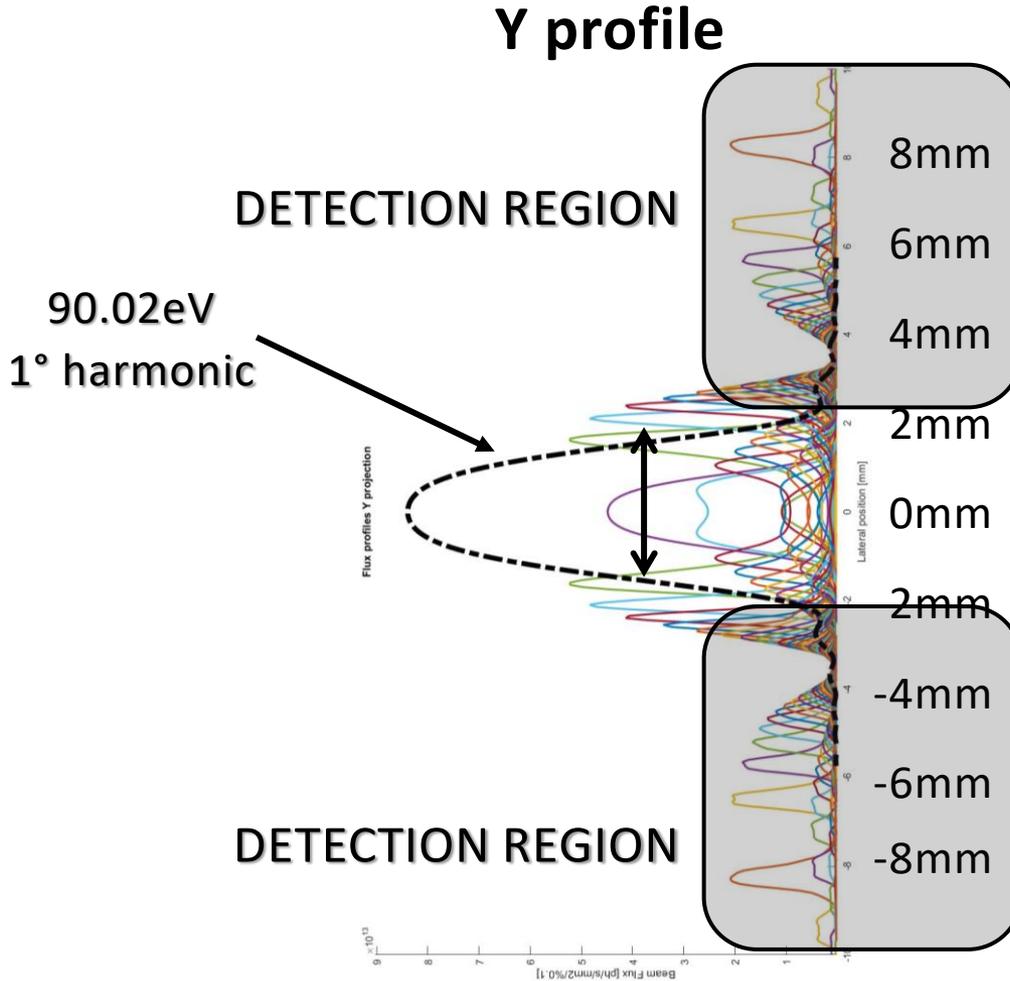
# Pink beam monitoring: cross-chromatic monitoring

## Y profile

- Energy=30eV
- Energy=201eV
- Energy=372eV
- Energy=544eV
- Energy=715eV
- Energy=886eV
- Energy=1058eV
- Energy=1229eV
- Energy=1401eV
- Energy=1572eV
- Energy=1743eV
- Energy=1915eV
- Energy=2086eV
- Energy=2257eV
- Energy=2429eV
- Energy=2600eV
- Energy=2772eV
- Energy=2943eV
- Energy=3114eV
- Energy=3286eV
- Energy=3457eV
- Energy=3628eV
- Energy=3800eV
- Energy=3971eV
- Energy=4143eV
- Energy=4314eV
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- Energy=4657eV
- Energy=4828eV
- Energy=5000eV

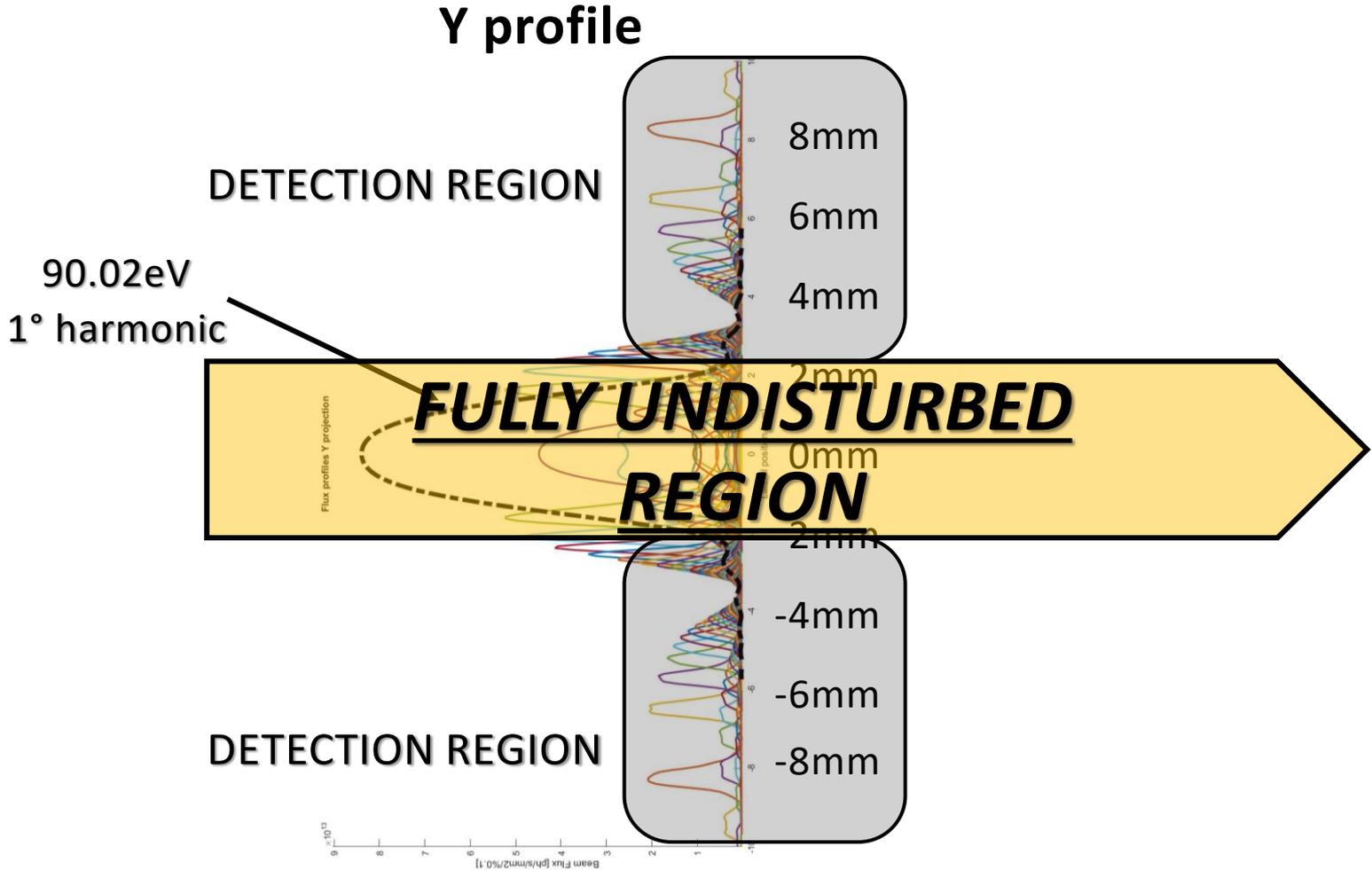
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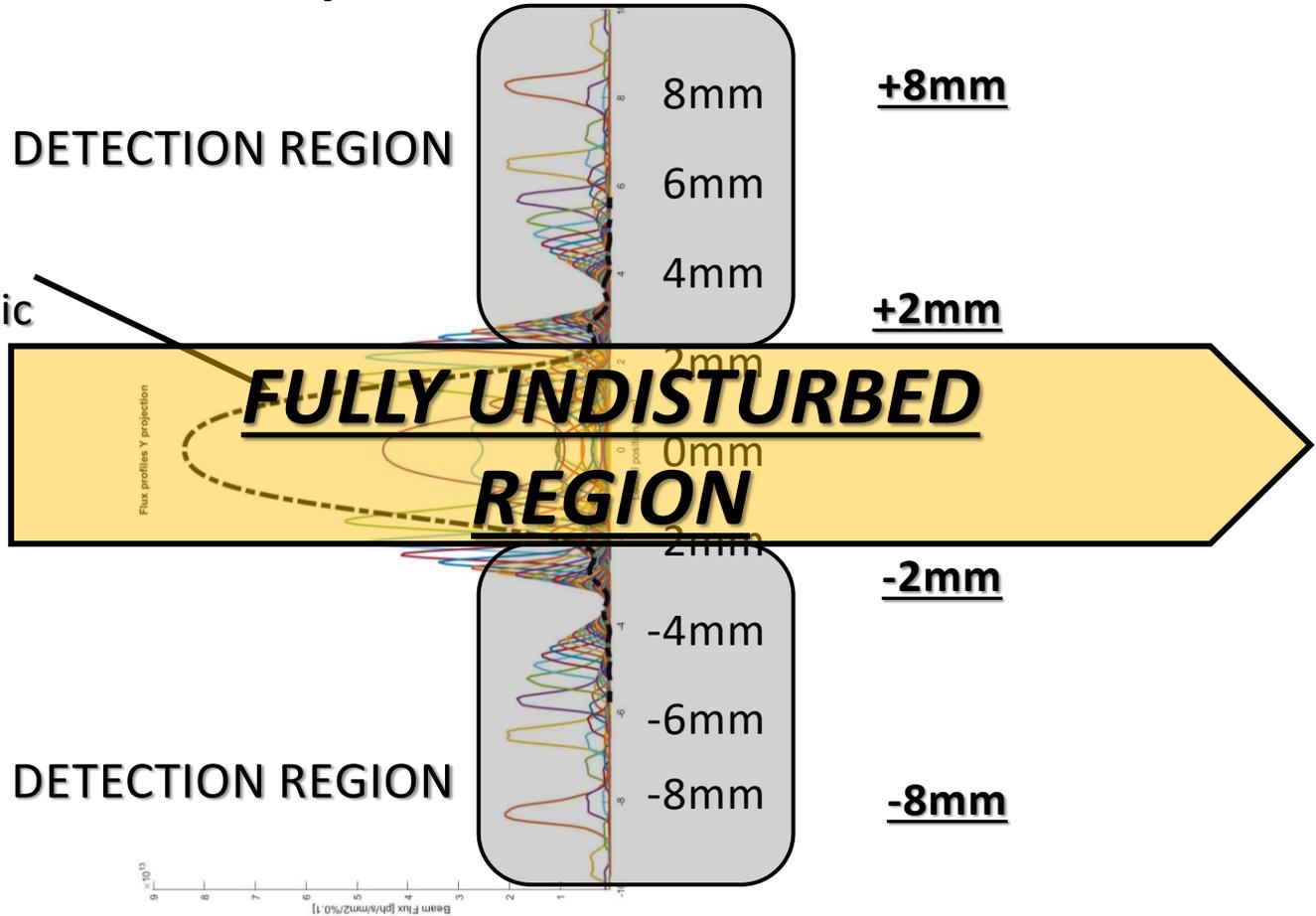


# Pink beam monitoring: cross-chromatic monitoring

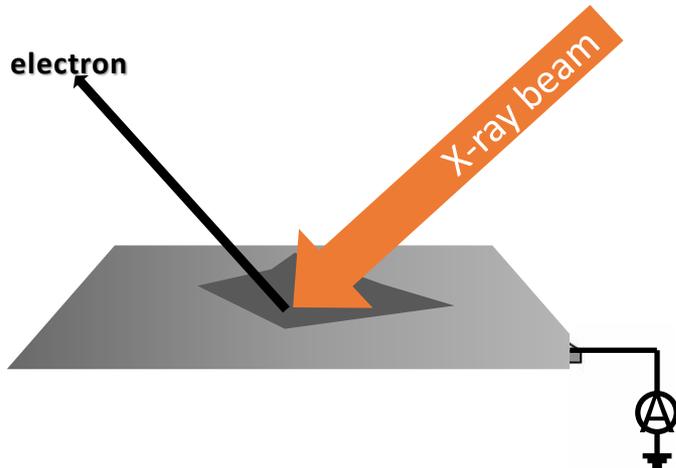
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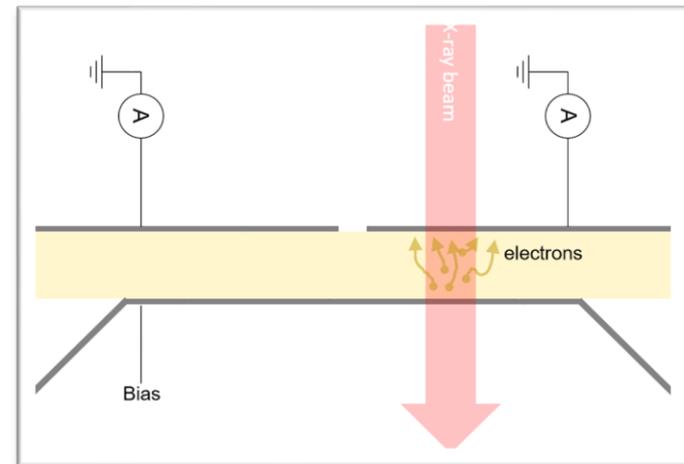
90.02eV  
1° harmonic



metal based  
*external* photoemission



semiconductor based  
*internal* photoemission

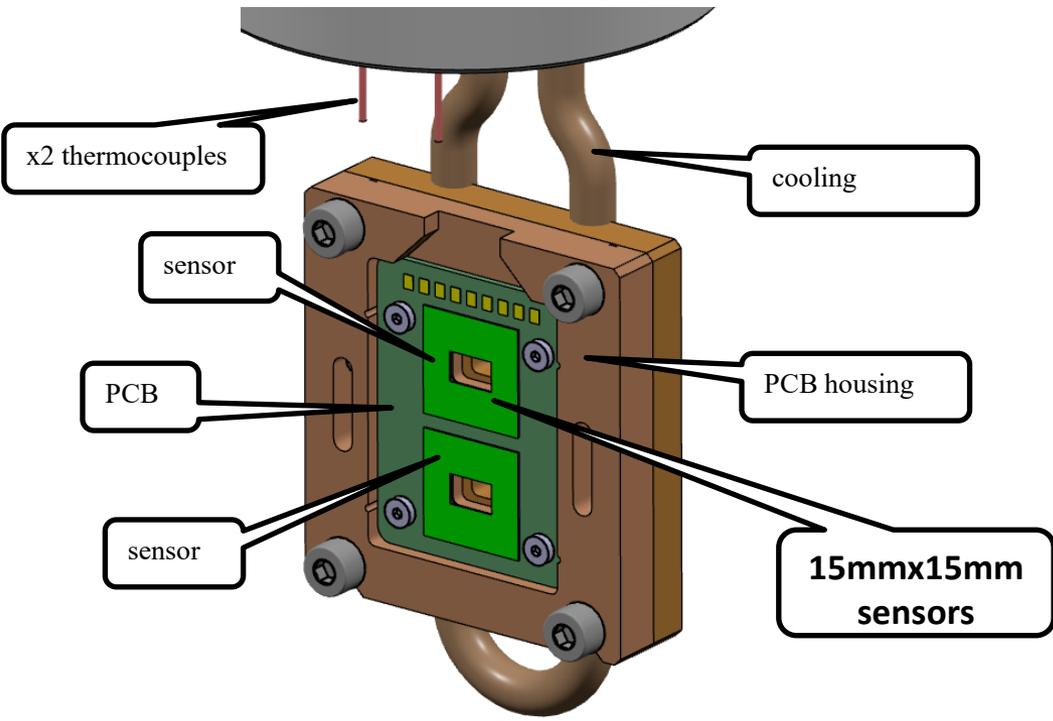


😊 MUCH HIGHER YIELDS (X1000)

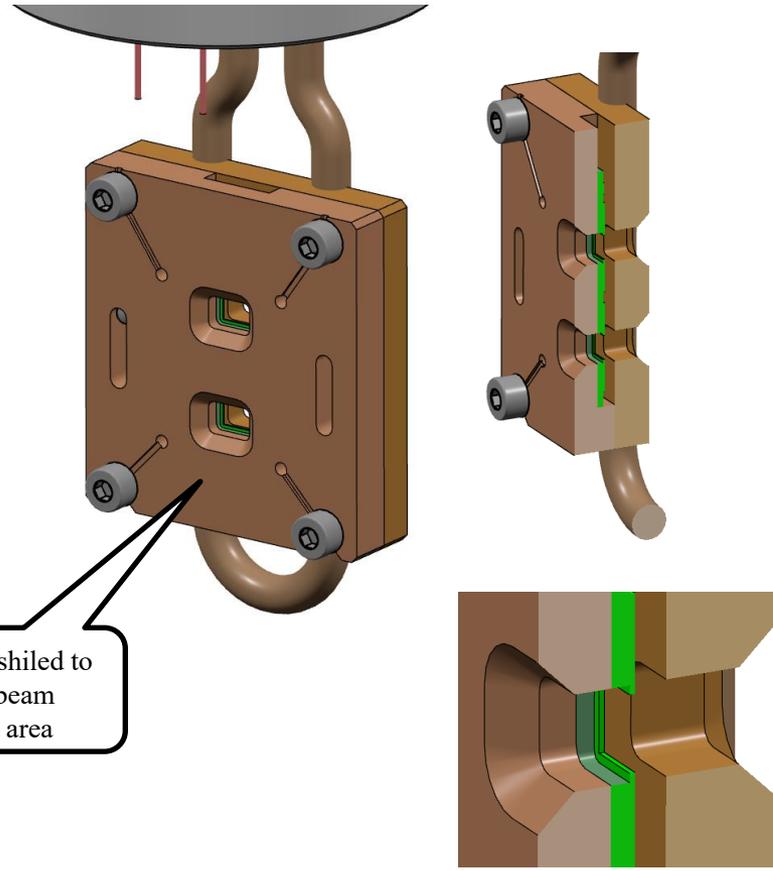
😊 NOT PRONE TO SURFACE CONTAMINATION EFFECTS

😞 BUT STABILITY OVER TIME?

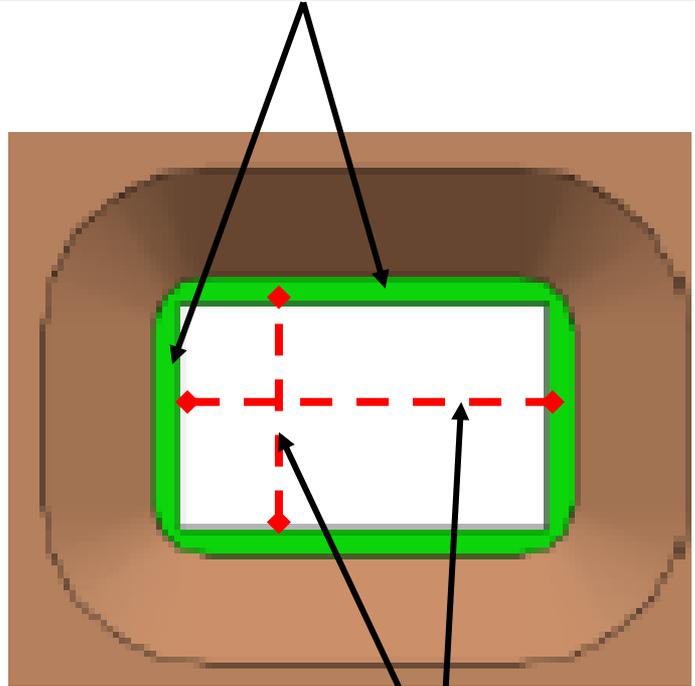
# Chamber design



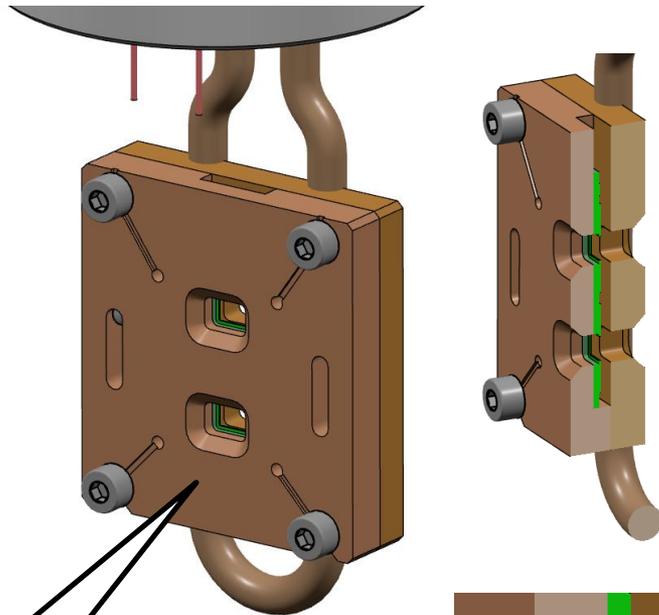
## 0.5-2mm Silicon Carbide sensor



Copper shiled to control beam exposed area

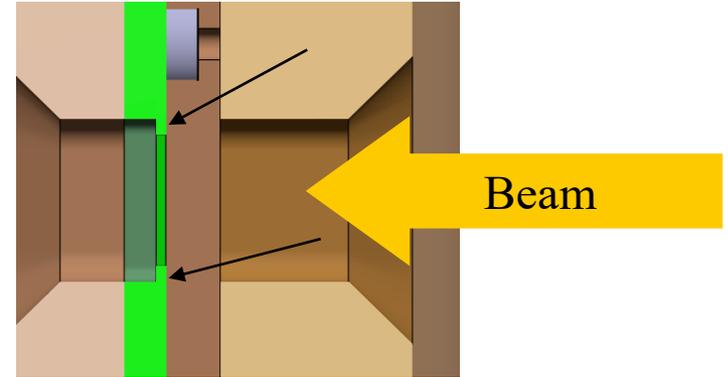


**7.6x5.2 central opening**

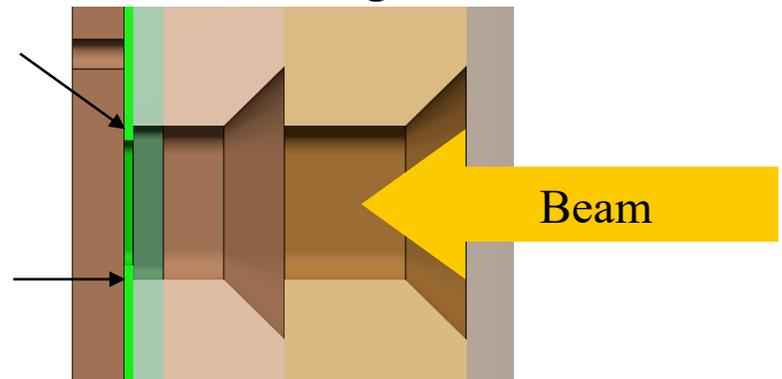


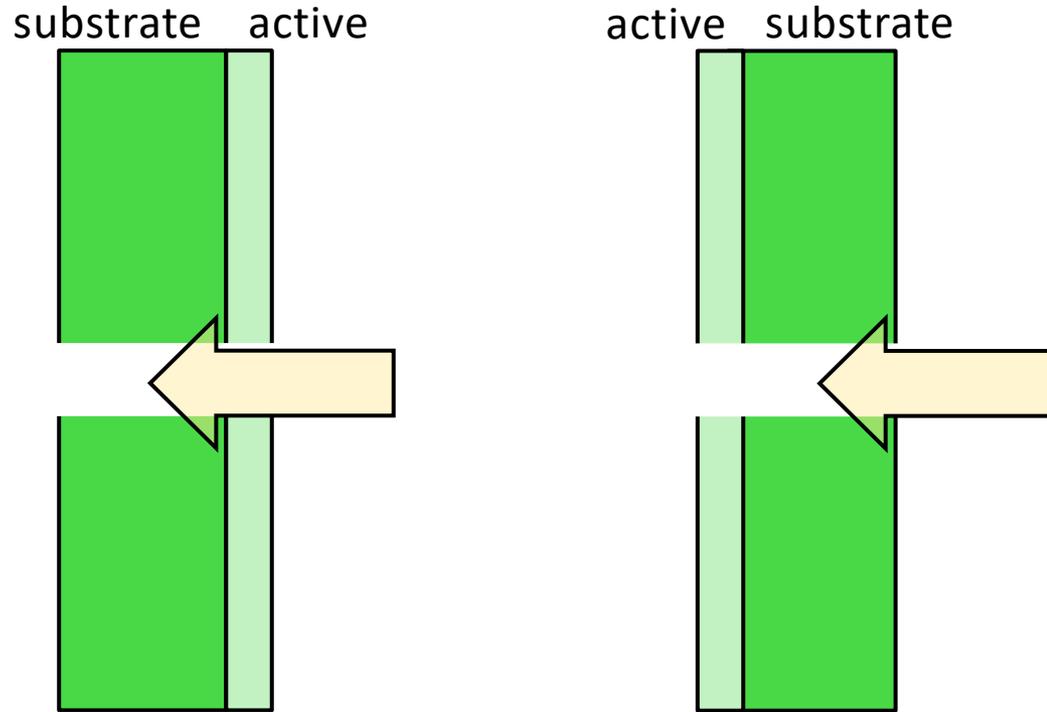
Copper shiled to control beam exposed area

## Active sensor area facing beam



## 180° FLIPPED configuration

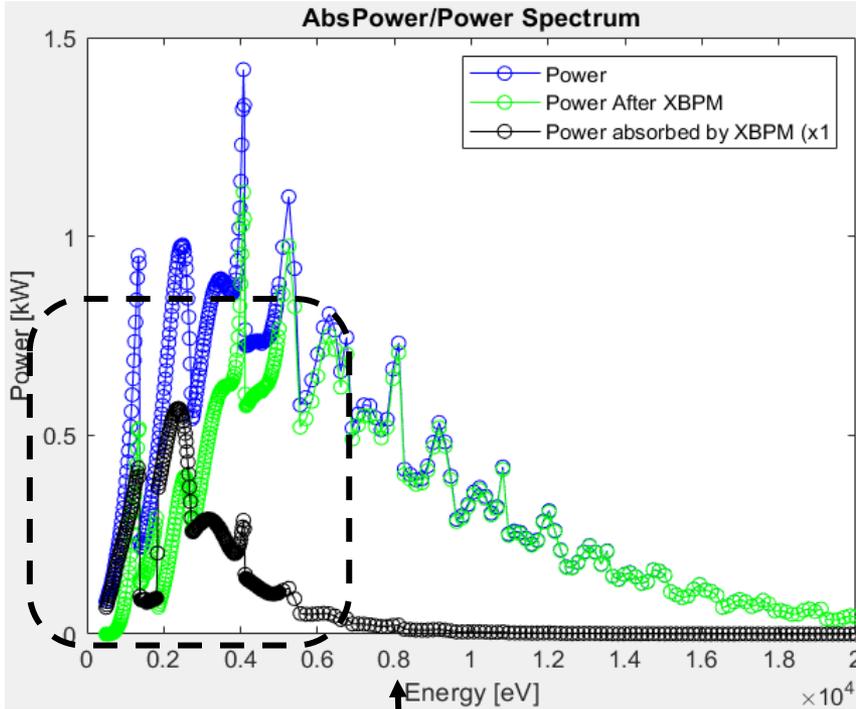




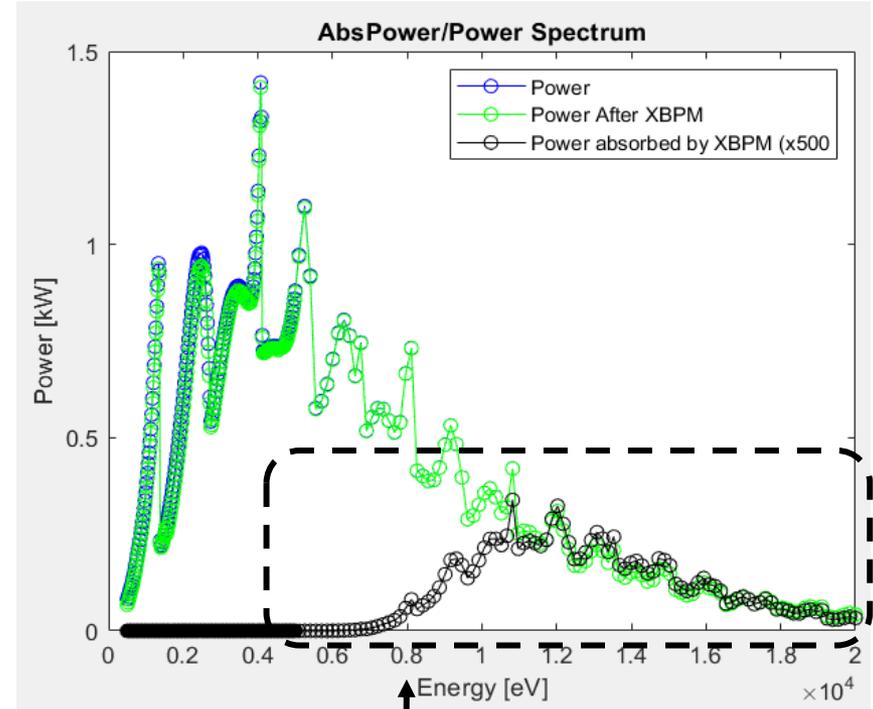
- we are using an ***“integrated/monolithic/local filter”***
- quite strong filter (*equivalent to 3.6mm diamond window*)
- a filter present only on the tails, not at beam center
  - applicable for all Xray beamlines (soft-hard)

## STANDARD SiC XBPM

## FLIPPED SiC XBPM

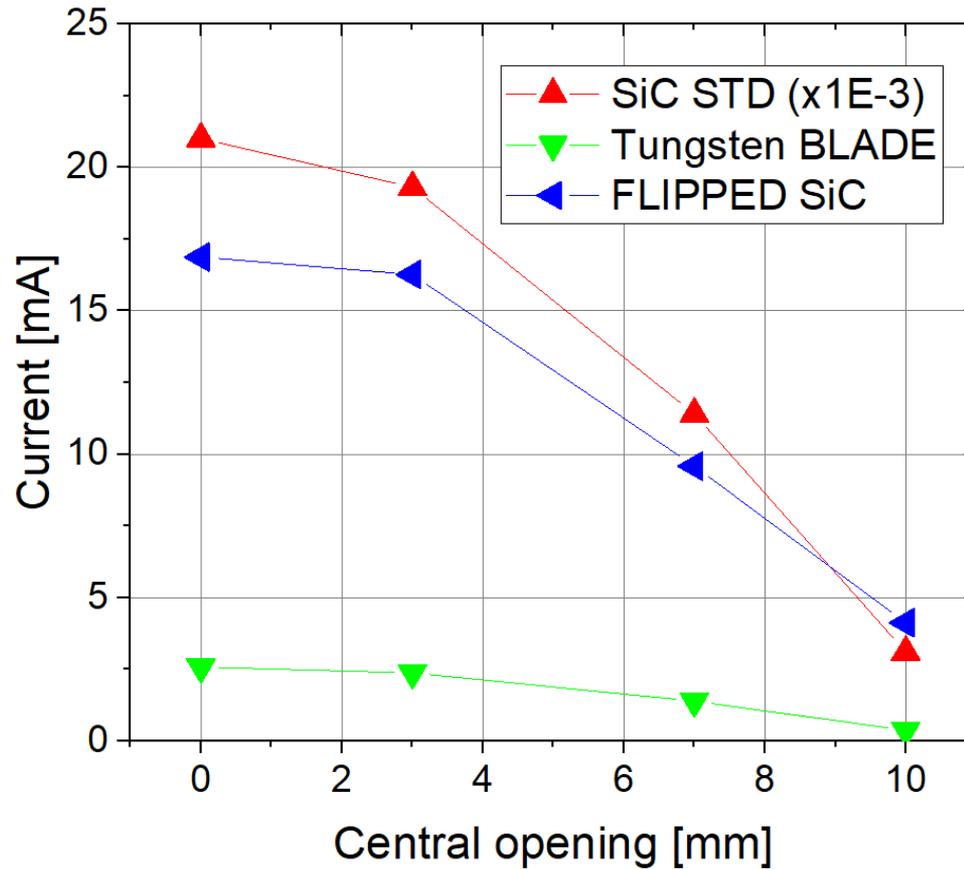


main signal contribution coming from <8keV photons



main signal contribution coming from <8keV photons

# “flipped” SiCBlade: benefits

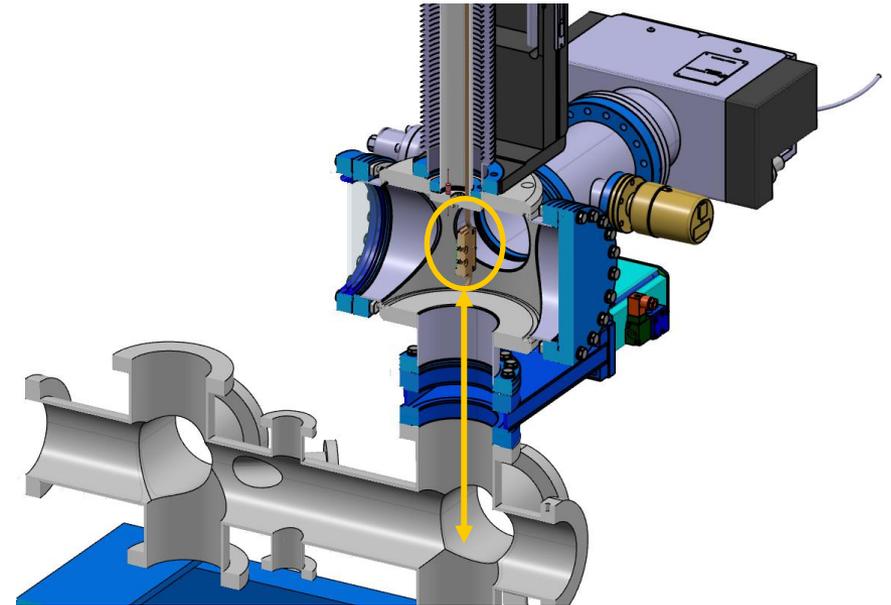
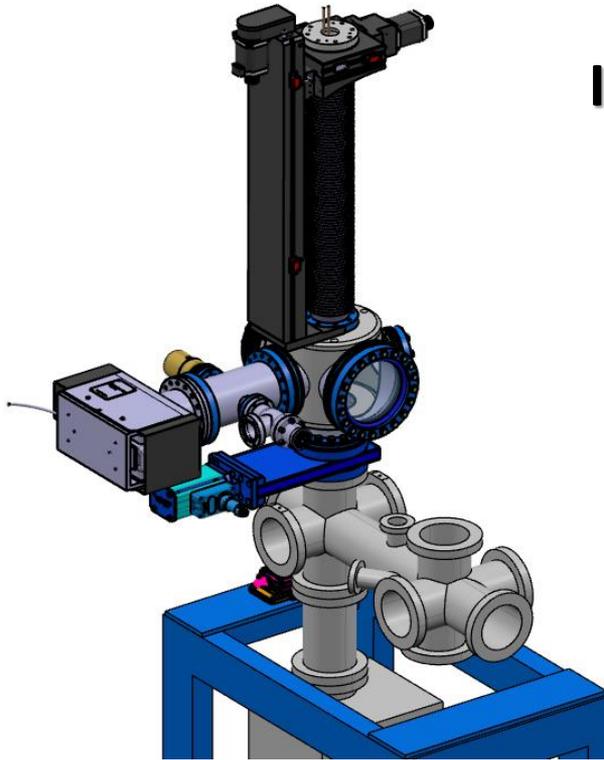


**Max current signal 10mA**

**Max device temperature 200°C**

**even higher lateral resolutions\***

## Installation during summer shutdown



- A theoretical framework model to predict whitebeam sensors:
  - for different ID and locations (Spectra)
  - current signals, heat load and temperature (Matlab and COMSOL)
- “Standard” SiC XBPM cannot work at frontend locations  
**(non-full intercepting)**
- “SiCBlades” ideal alternative solution for such locations, many benefits:
  - 😊 Central region of the beam completely un-disturbed
  - 😊 The very large sensor size needed (**up to 2cm**) achievable by SiC XBPM
  - 😊 Similar to metal-blade front-end monitoring, **but with much superior signals/stability**
- “flipped Blade type” SiC sensor can further improve characteristics:
  - 😊 further reduction of current signal
  - 😊 Increase of resolution → lower effective FWHM
  - 😊 Elimination of bending magnet noise → selection of hard-Xray components



THANKS A LOT FOR YOUR ATTENTION

Thanks to PSI

&

HAPPY TO PERFORM THESE ANALYSIS FOR YOUR WHITEBEAM LOCATIONS

Q&A

Acknowledgments

*partially funded by the Aargau Forschungsfonds*

