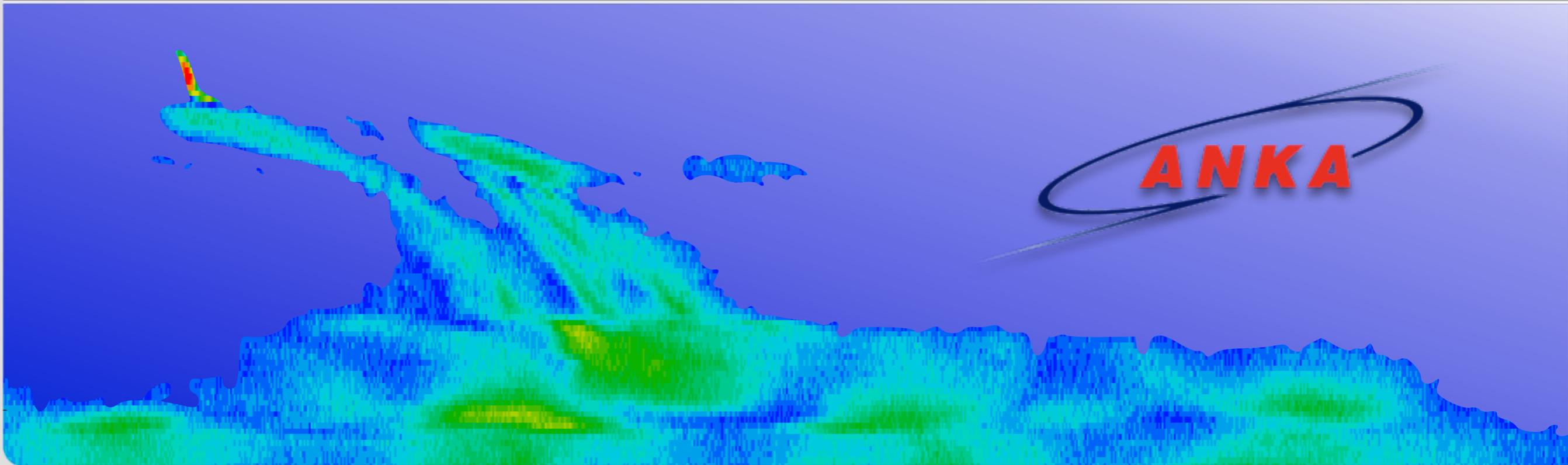


# Fast THz Detectors

Markus Schwarz for the ANKA-THz group

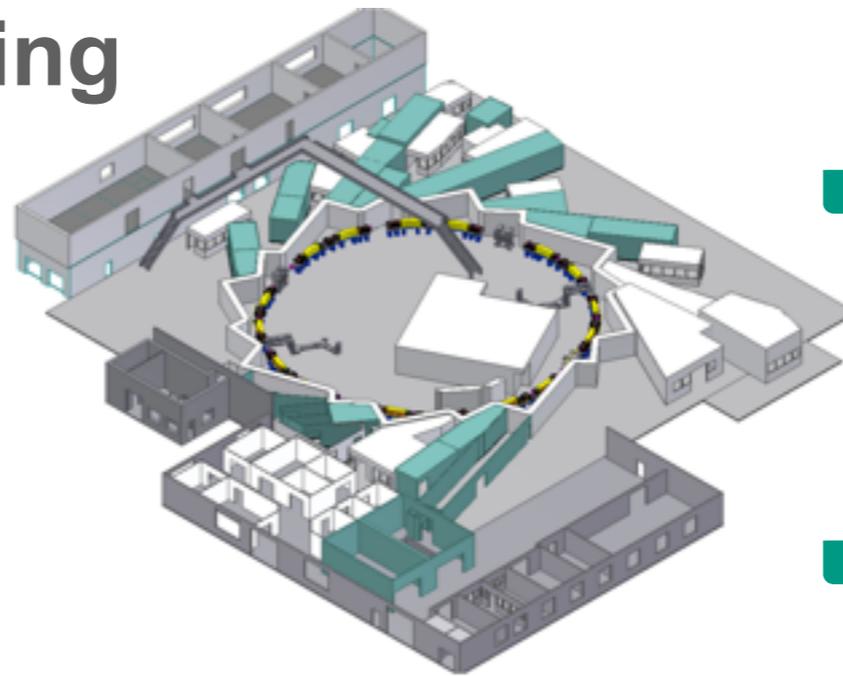
ANKA Synchrotron Light Source at KIT



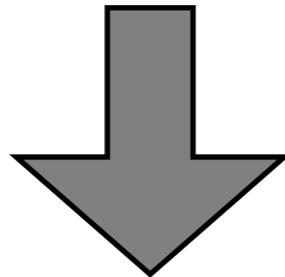
# The ANKA Storage Ring

## Key Parameters

- circumference: 110.4 m
- revolution time: 368 ns
- bunch spacing: 2 ns
- harmonic number: 184

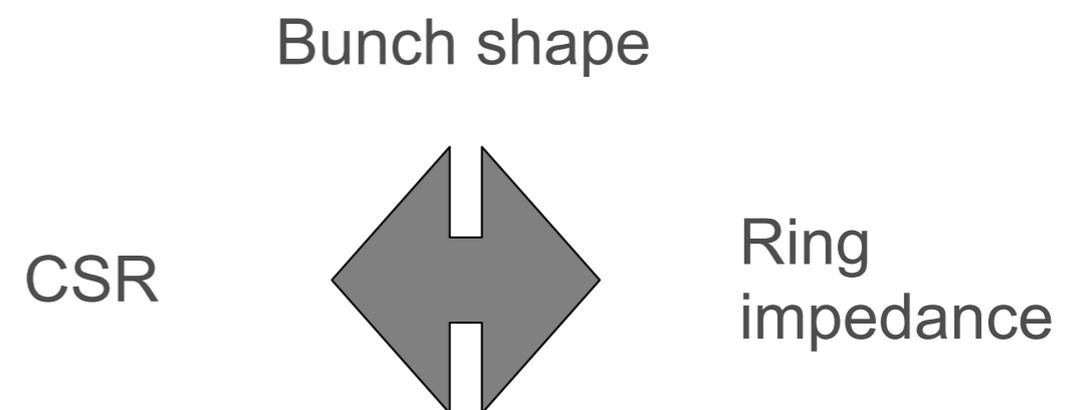


- Normal operation mode
  - beam energy: 2.5 GeV
  - multi bunch mode
  - bunch length: > 30 ps
- Low  $\alpha_c$  optics:
  - bunch length: ~ 1 ps
  - multi and single bunch



## Requirements for THz detectors:

- response time  $\ll 1$  ns
- high dynamic range



# THz Detectors at ANKA

## ■ Golay Cell

high sensitivity in THz range  
 response time: ~100 ms



picture: <http://www.tydex.com>

## ■ Schottky Diode Detector

spectral range: depends on antenna  
 response time: <130 ps



[www.acst.de](http://www.acst.de)

**room temperature**



## ■ Hot Electron Bolometer (HEB)

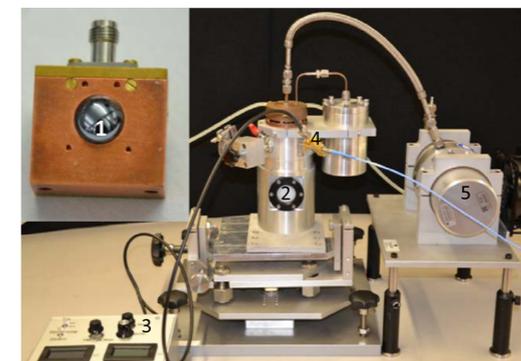


based on: SC niobium nitride  
 spectral range: depends on antenna  
 response time: <160 ps

A.D. Semenov et al.,  
 IRMMW-THz, 2009

## ■ YBCO Detector

based on:  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  (YBCO)  
 spectral range: depends on antenna  
 response time: down to 1 ps

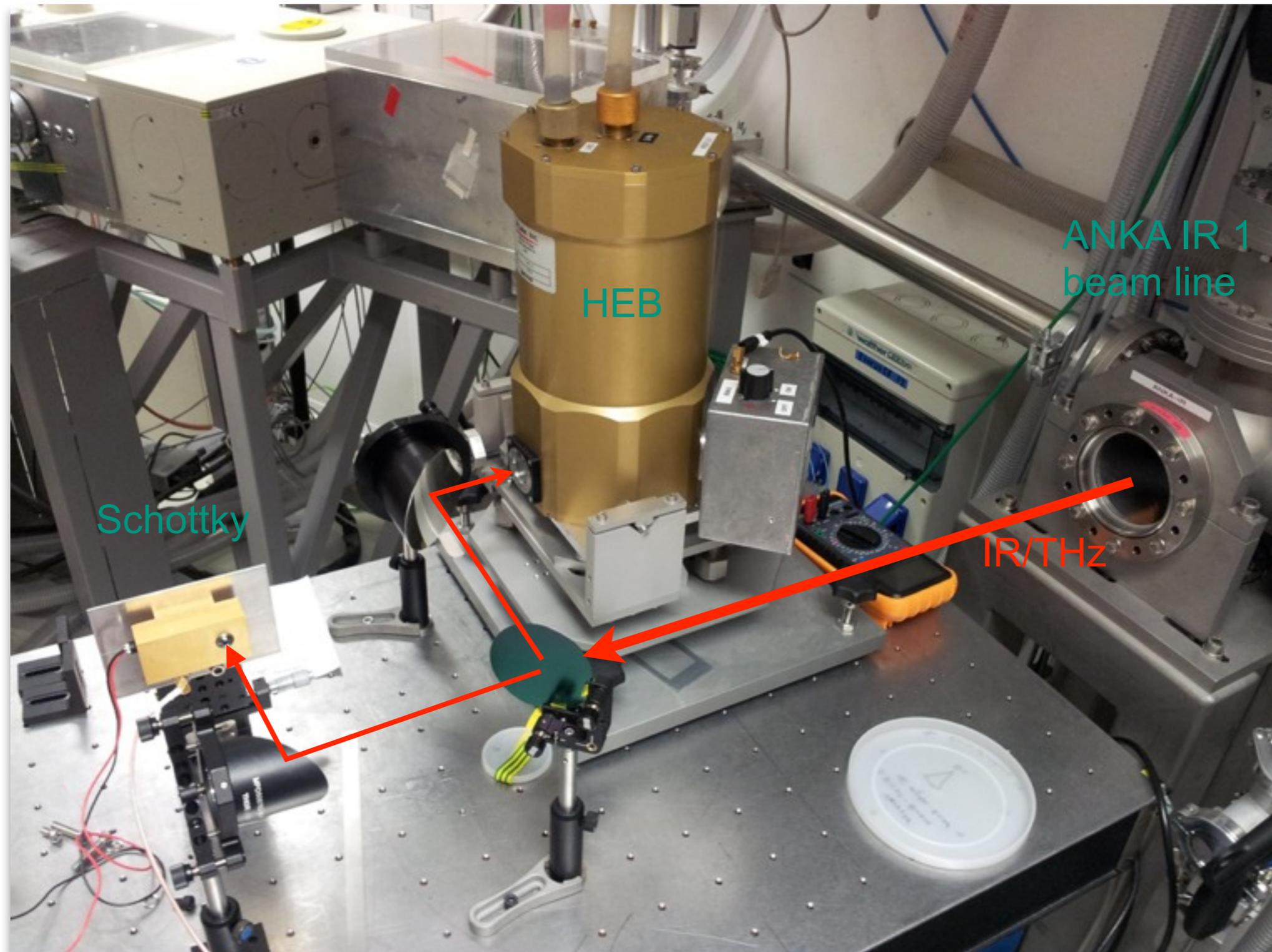


P. Thoma et al.,  
 Appl. Phys. Lett. 101,  
 2012

**cryo temperature**



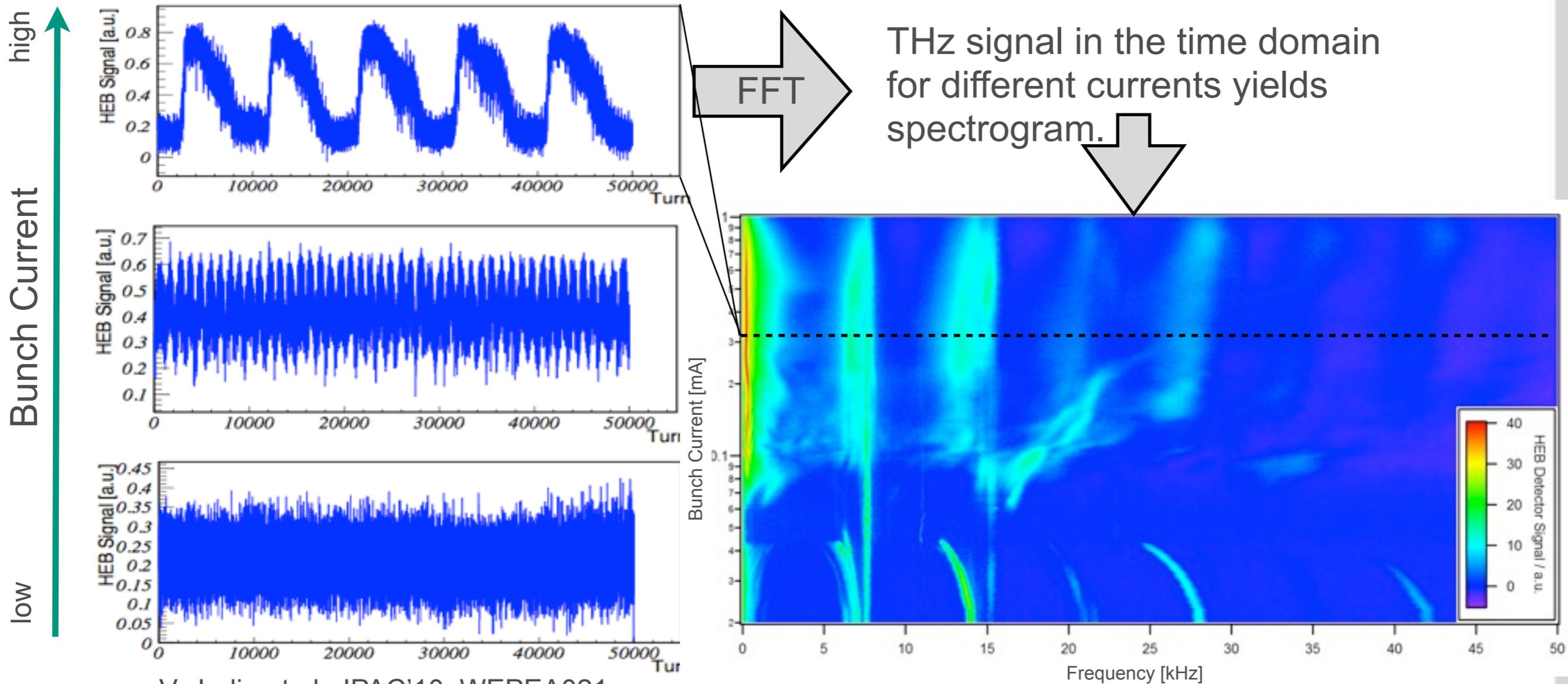
# Schottky - HEB Comparison



# Spectrograms

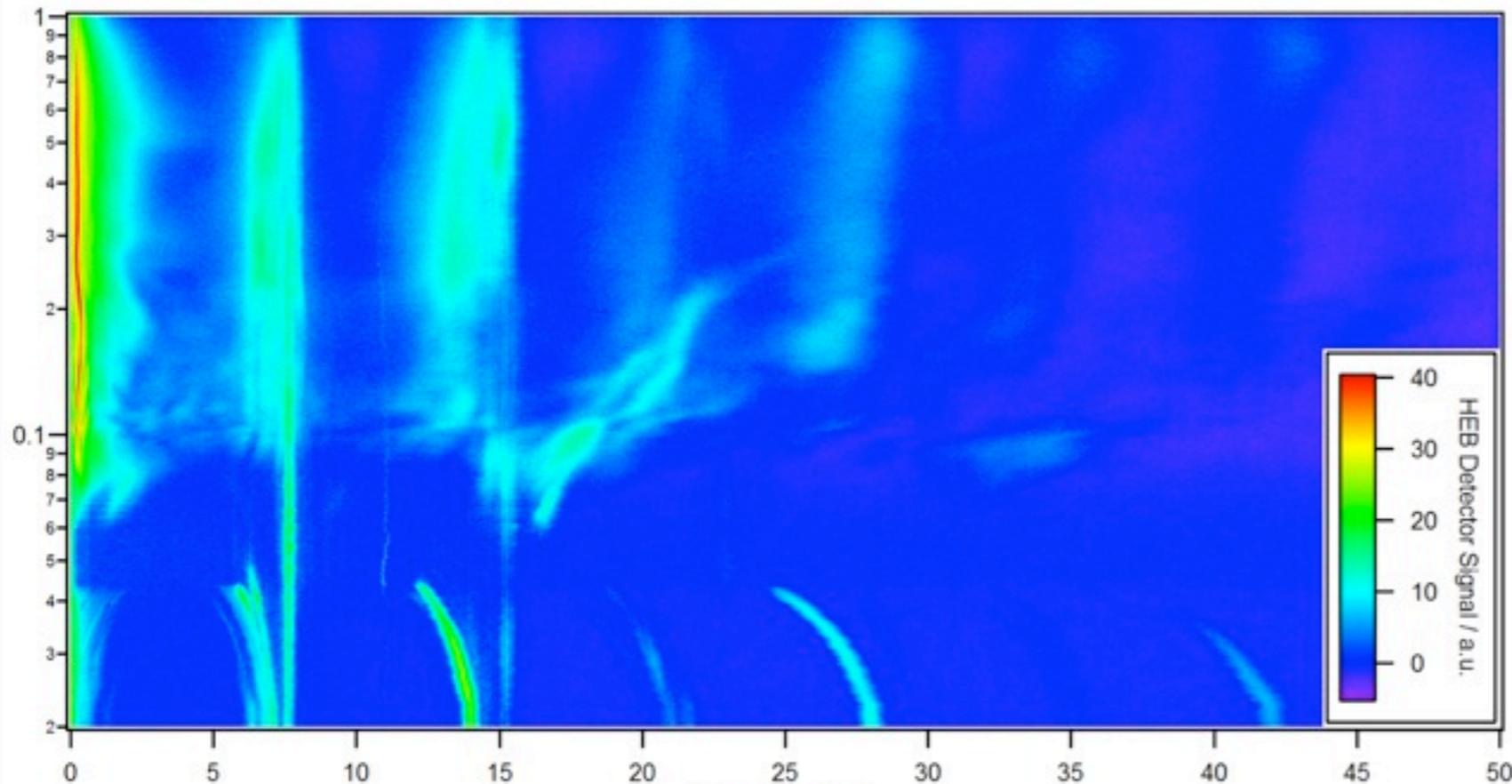
- Dynamics of sub-structures lead to bursts of CSR

THz signal in the time domain  
measured with HEB for different currents

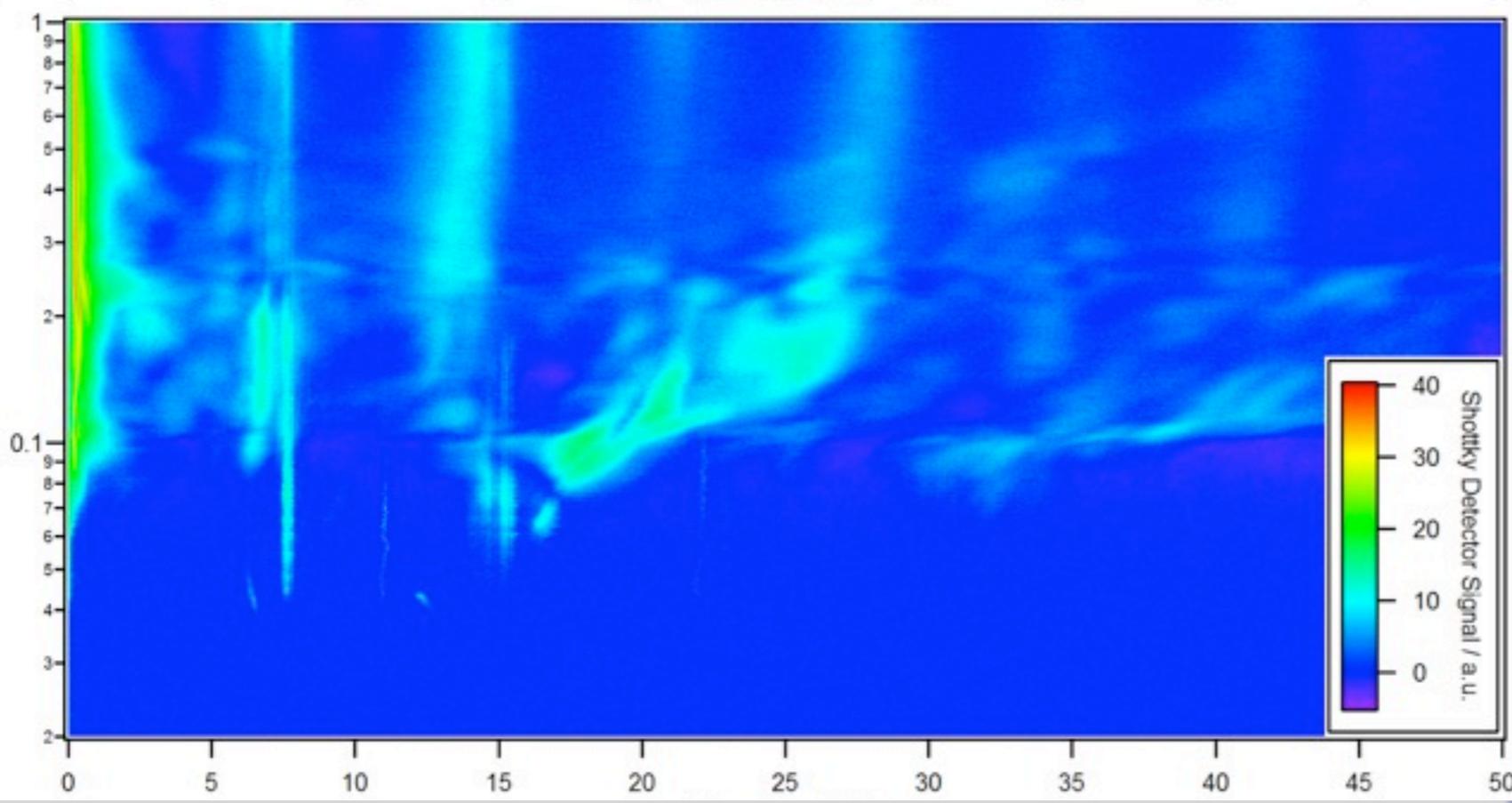
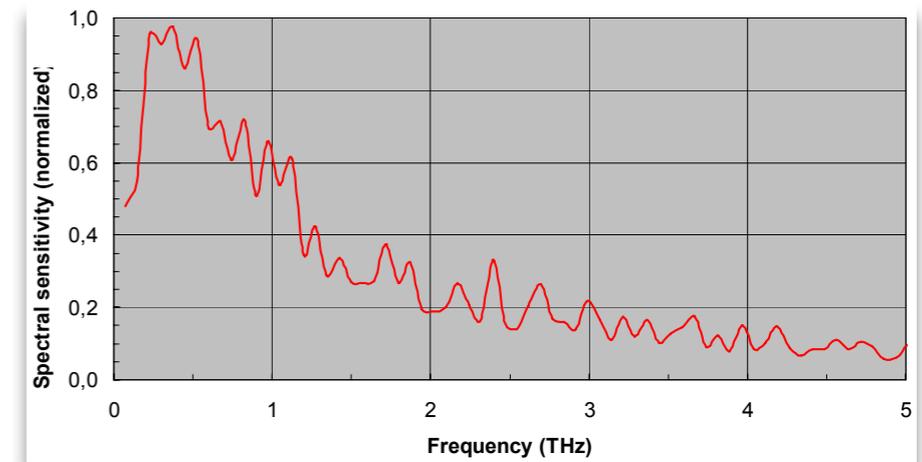


V. Judin et al., IPAC'10, WEPEA021

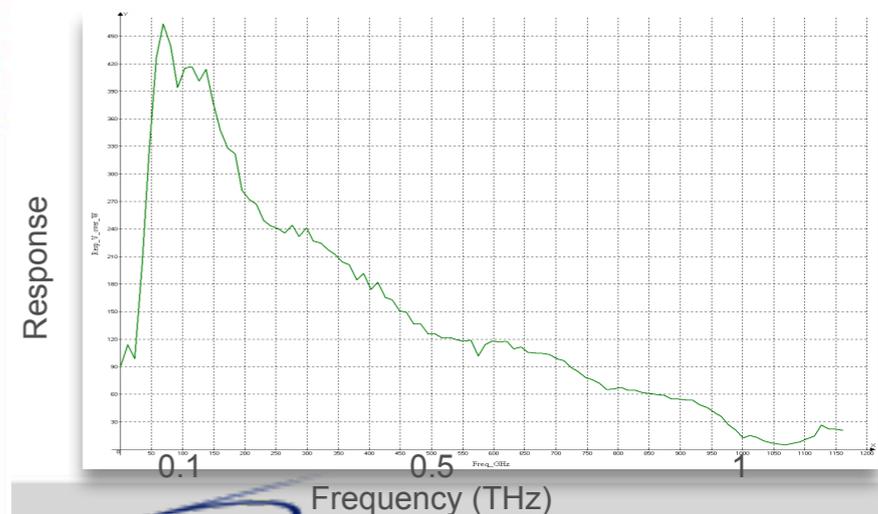
# Schottky - HEB Comparison



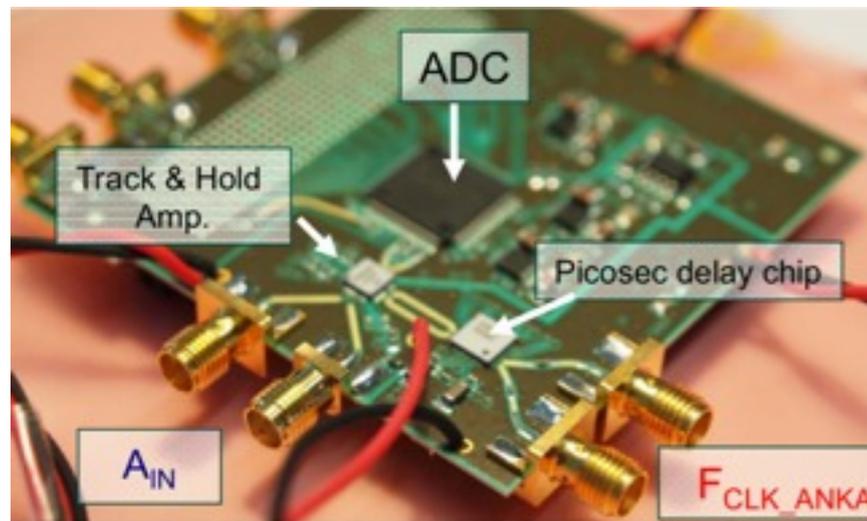
- HEB
- saturated for high currents
- more sensitive at low currents



- Schottky
- more sensitive at high currents
- blind at low currents

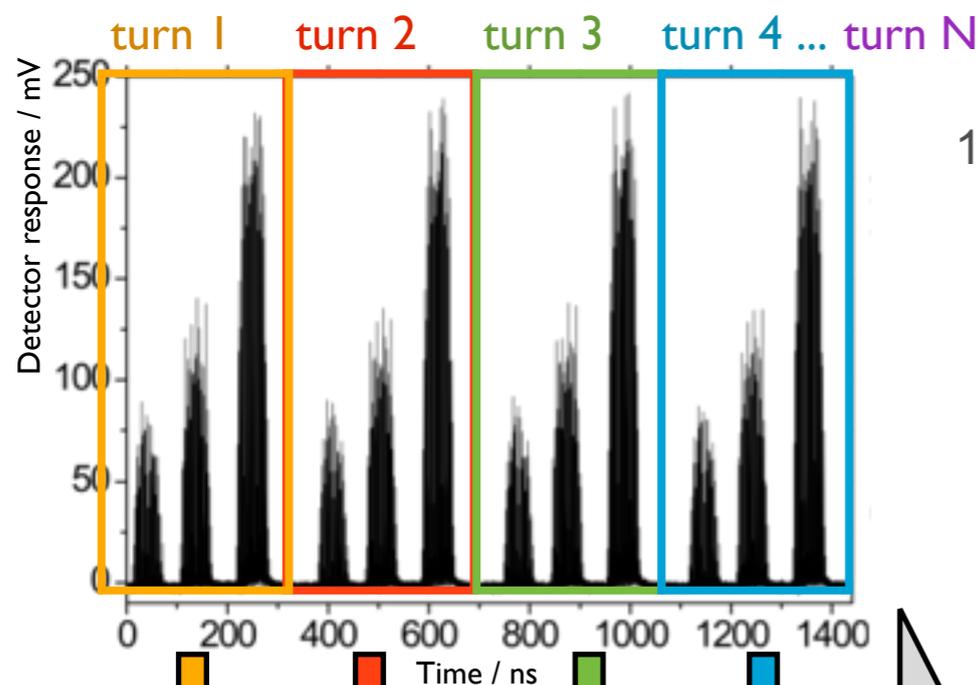


# Fast FPGA Digitizer Board for ANKA

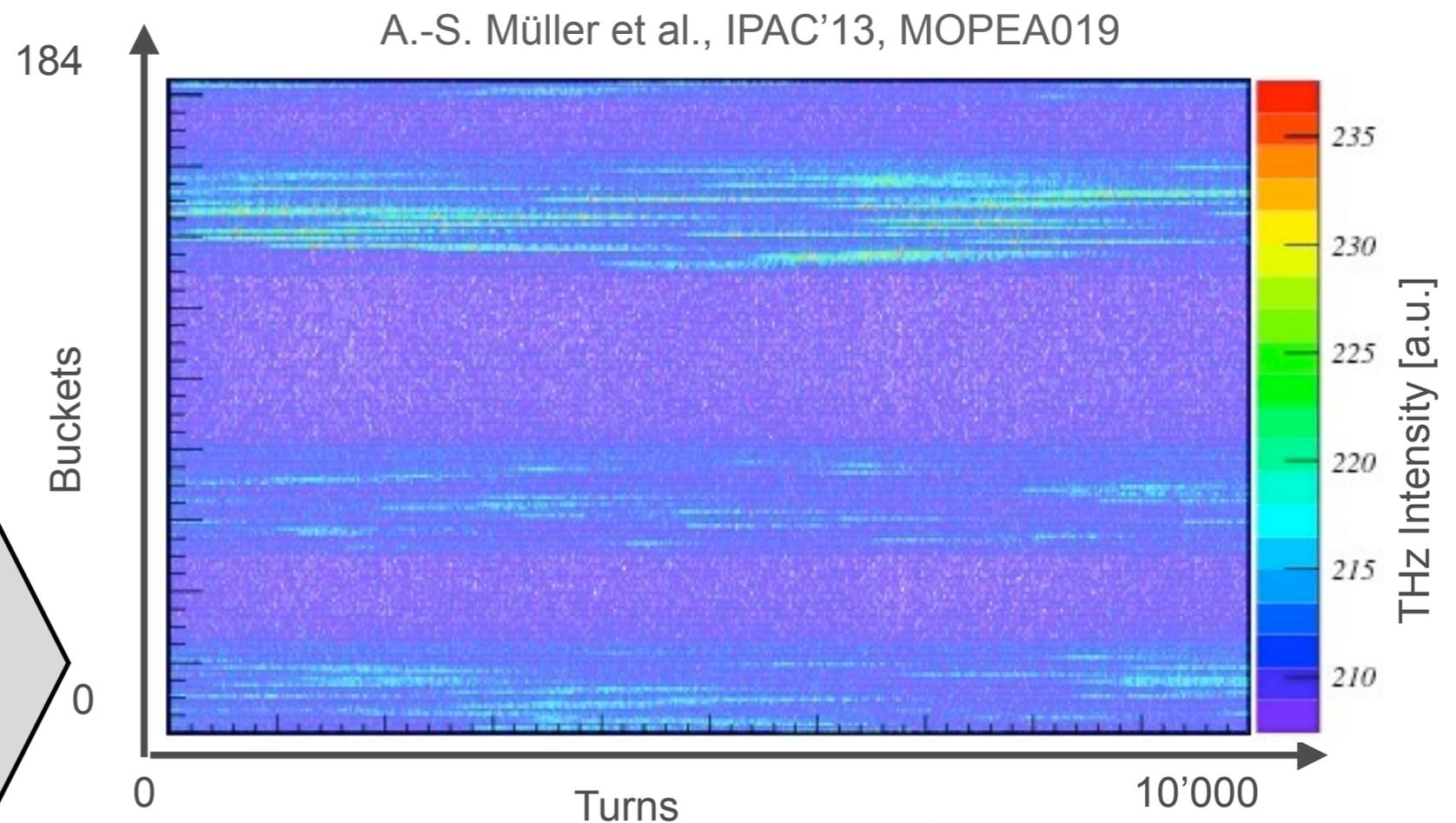


- simultaneous monitoring of all 184 buckets
- turn-by-turn acquisition
- continuous acquisition up to 100k turns
- data rate: 4GB/s ~ 12TB/h  
⇒ HDD write speed limited

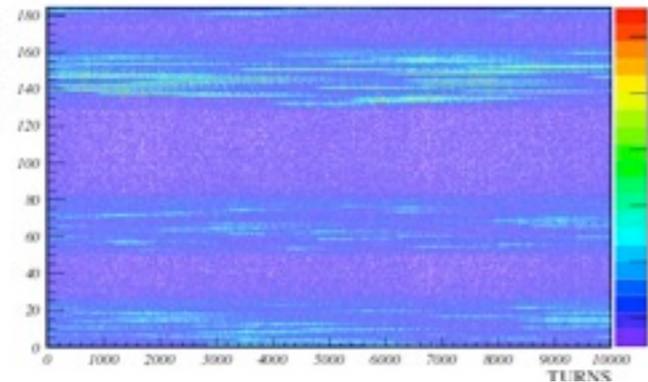
M. Caselle et al., IPAC'13, WOBB202



184 peak values recorded per turn

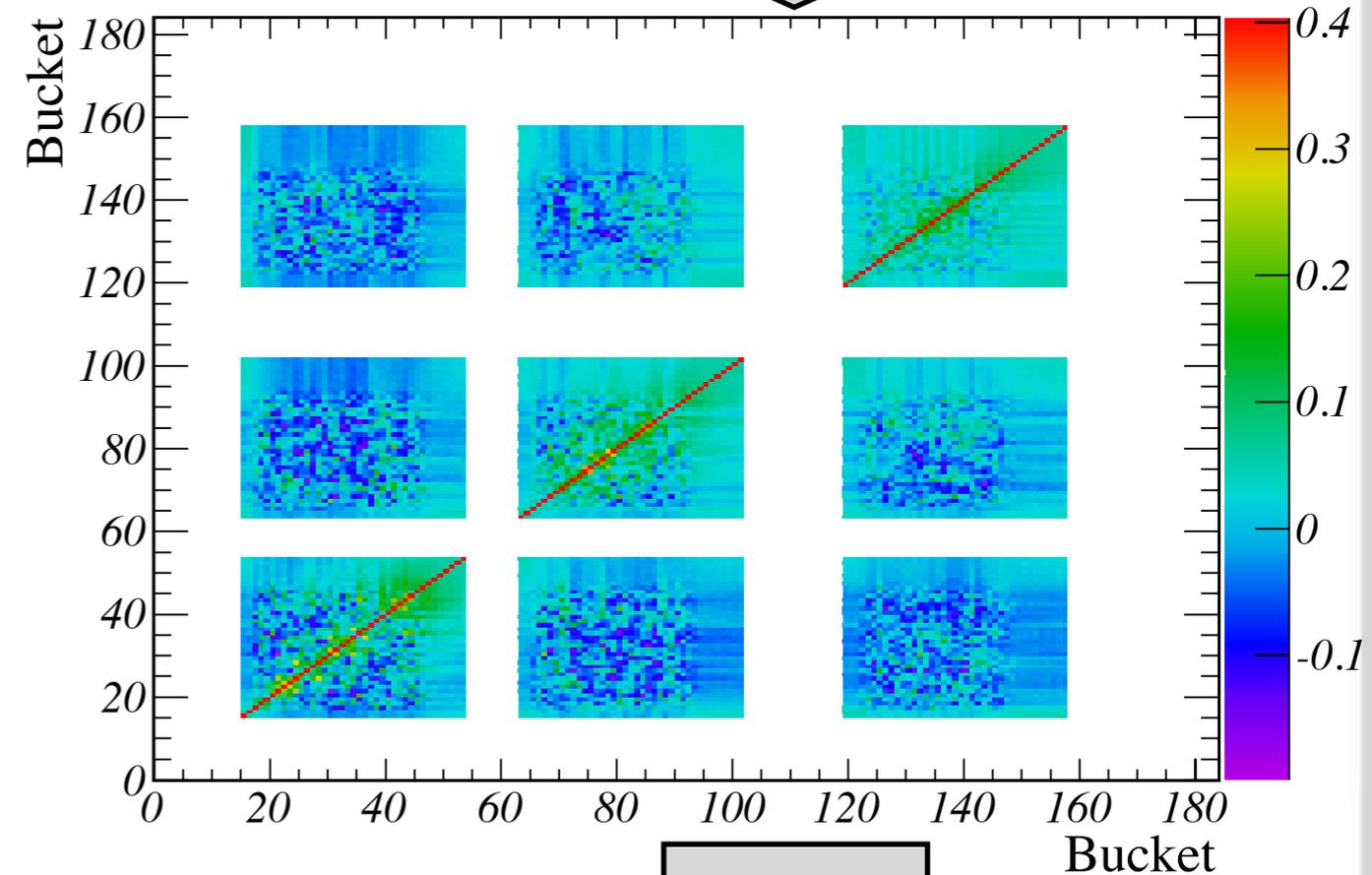
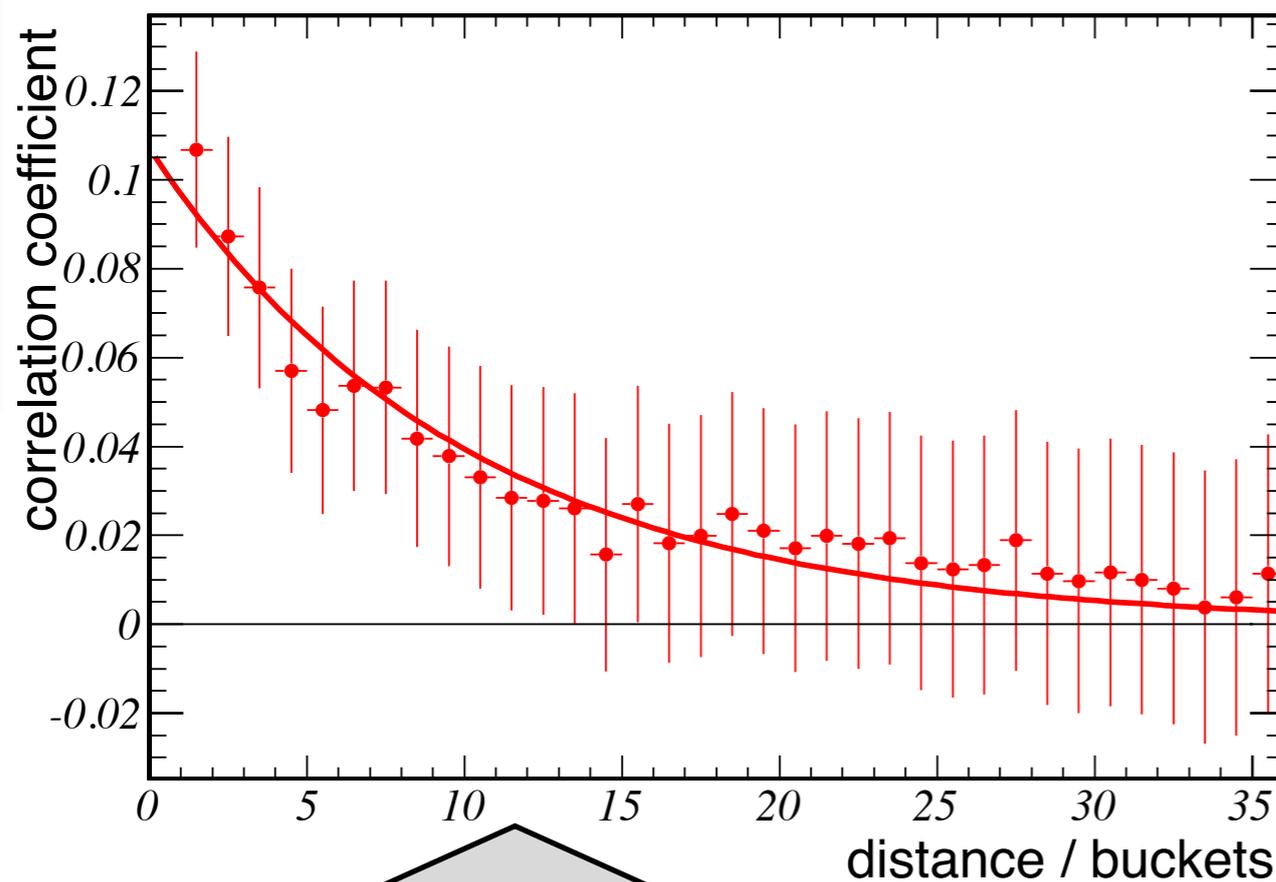


# Long Range Bunch-Bunch Correlations



Correlation coefficient of THz signal between buckets x and y for all 184 buckets

A.-S. Müller et al., IPAC'13, MOPEA019



Average correlation coefficient as function of bucket distance

# Summary

## ■ Fast THz detectors

- Cryo and room temperature detectors
- Response times of 160 ps or below
- HEB and Schottky diode detectors yield similar results
- Allow to study bursting pattern

## ■ Fast FPGA digitizer board

- Enables continuous monitoring of all 184 buckets on a turn-by-turn basis
- Established correlation of THz emission over distances of about 10 buckets

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**Thank you for your attention!**

