Karlsruhe Institute of Technology

Recent Developments in Beam Diagnostics at ANKA

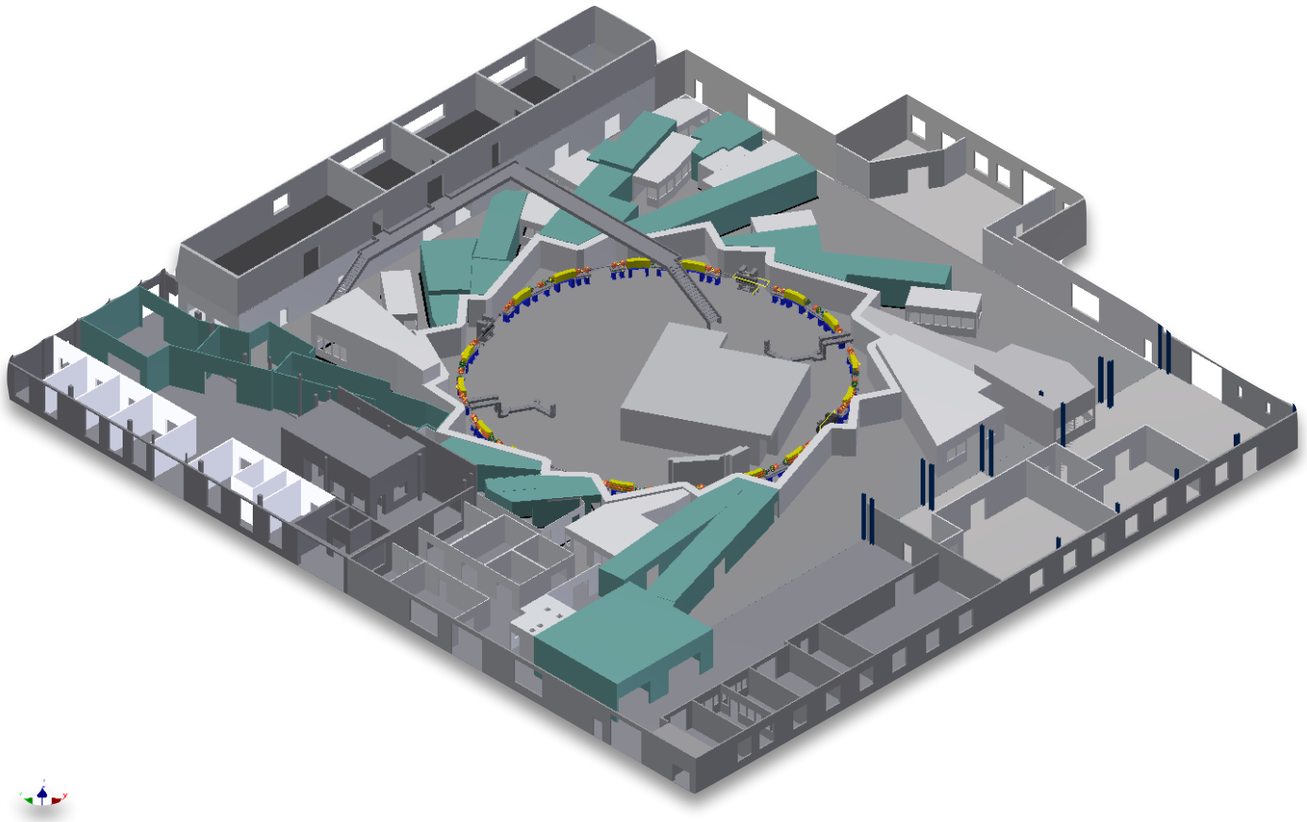
M. Schuh for the ANKA Team

XXII ESLS Workshop 2014, Grenoble

ANKA Synchrotron Light Source at **KIT**

Introduction: The ANKA Storage Ring

- Circumference 110.4 m
- RF frequency ≈ 500 MHz
- RF voltage up to 450 kV per cavity (4 total)
- Ramping machine (injection at 500 MeV)

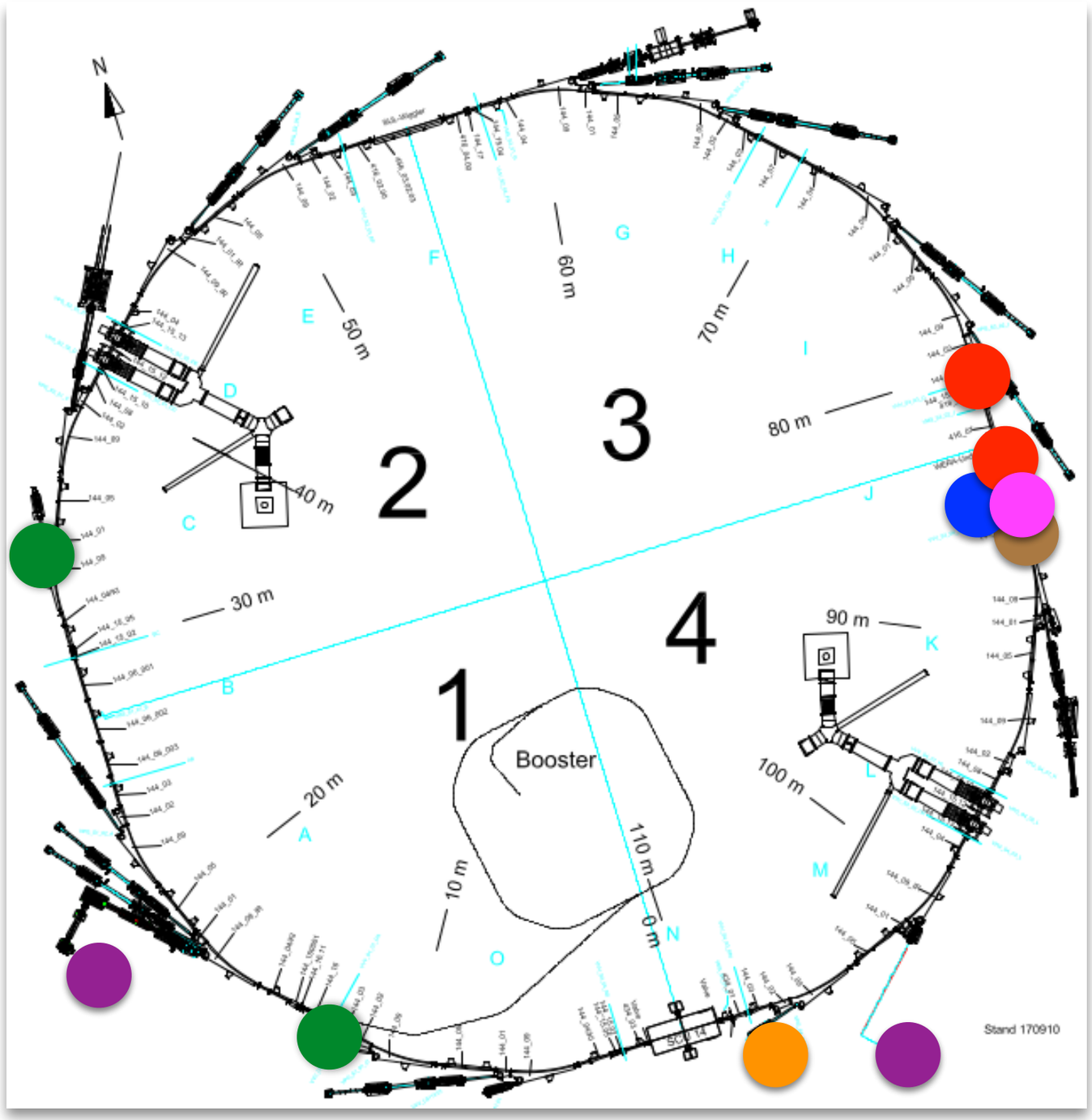


- **Normal operation:**
- Energy 2.5 GeV
- Current 120-200 mA
- Multi-bunch (4 trains with 30-33 bunches each)
- **Natural bunch length (RMS)**
  $\sigma_{z,0} \approx 13$ mm (45 ps)

- **Low Alpha mode:**
- Coherent THz radiation
- Energy 0.5 - 1.8 GeV (usually 1.3 GeV)
- Current ≈ 0.05 - 70 mA
- Single- or multi-bunch
- **Natural bunch length**
  $\sigma_{z,0} \approx 0.3$ - 4.5 mm (1-15 ps)

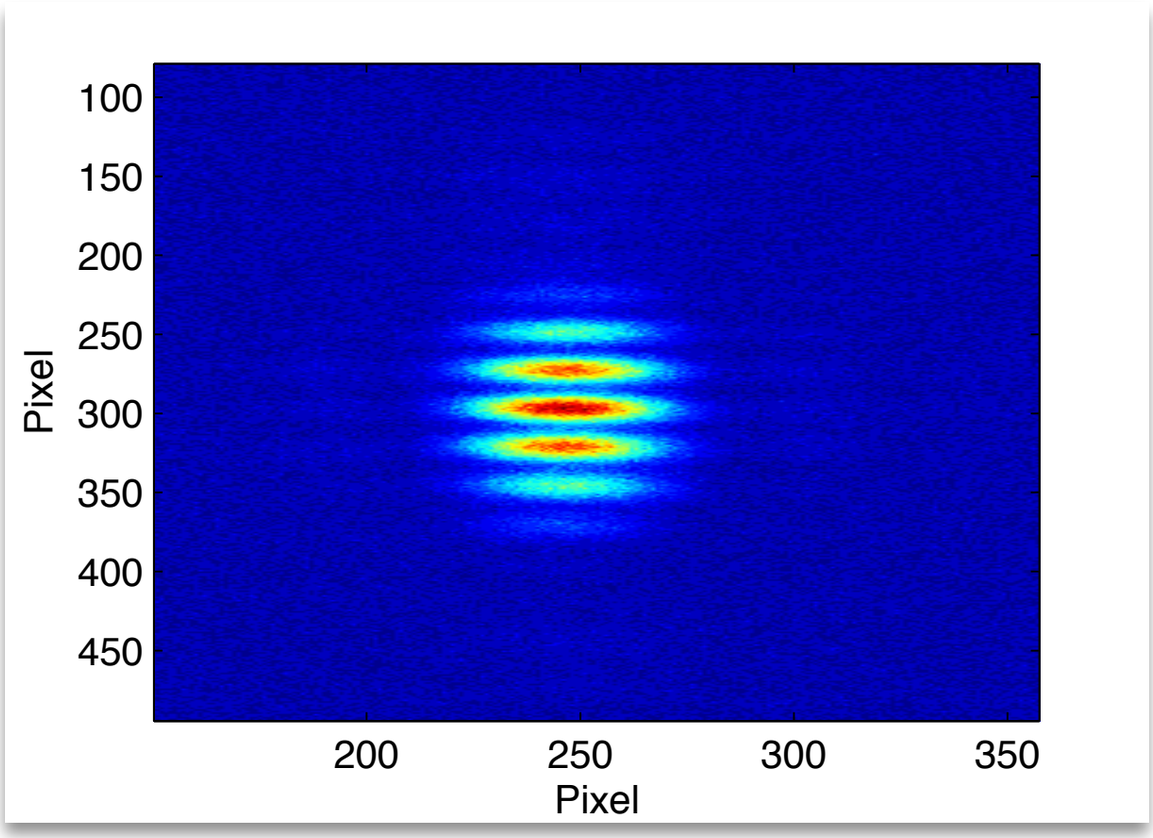
Diagnostics at ANKA

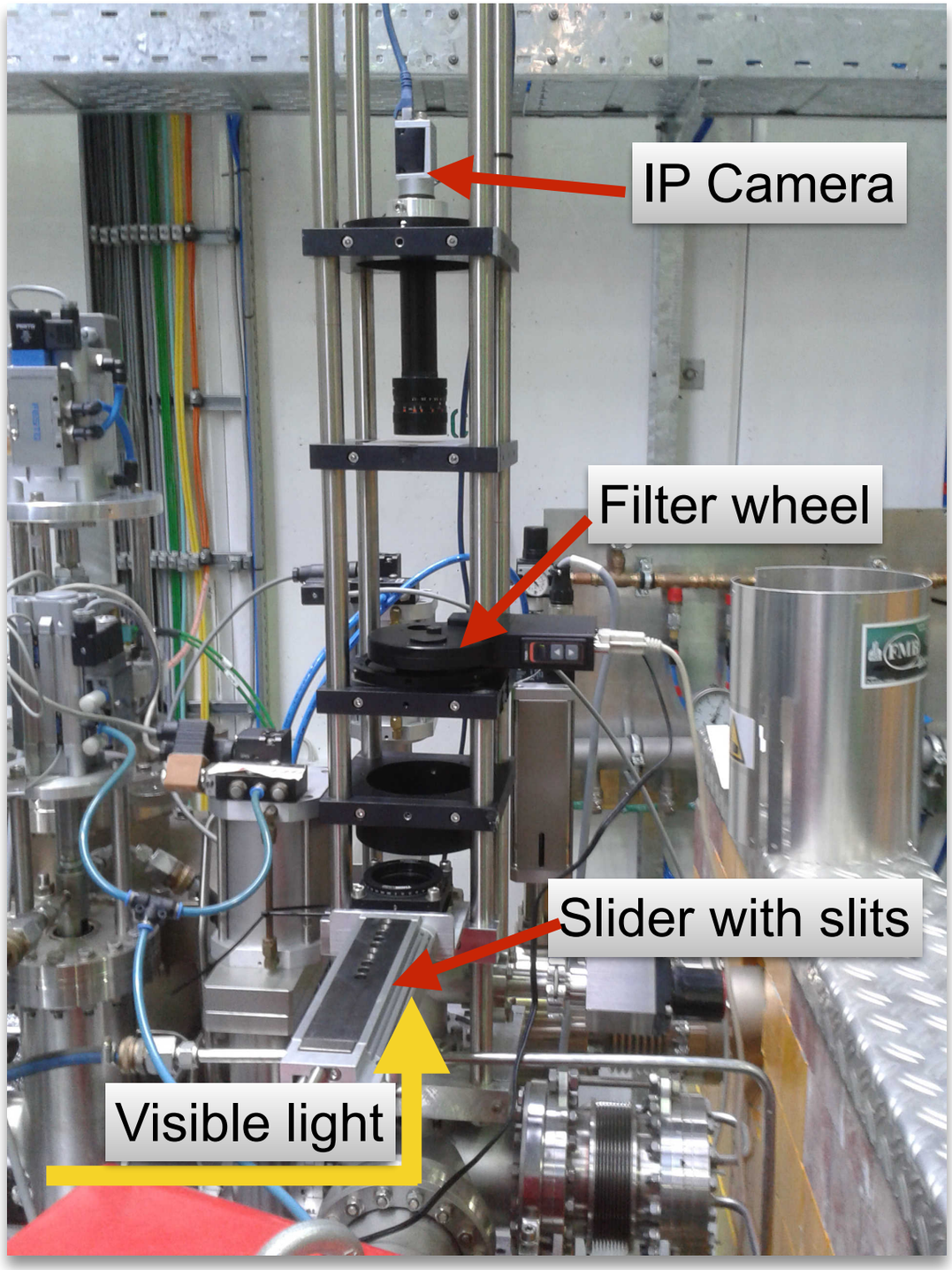
- Devices in operation
  - SR light monitor
  - EO-Nearfield setup
  - Streak camera
  - BBB feedback system
  - Ultra fast THz detectors
  - Lead glass detector
  - In-Air X-ray detector
  - BPMs
  - BLMs
- Devices under construction
  - Compton back scattering
  - Fast-gated camera



Synchrotron Light Monitor (SLM) Upgrade

- Digital camera to improve processing
- Filter wheel to increase dynamic range for single and multi-bunch operation
- Double slit interferometer to overcome diffraction limit in vertical plane

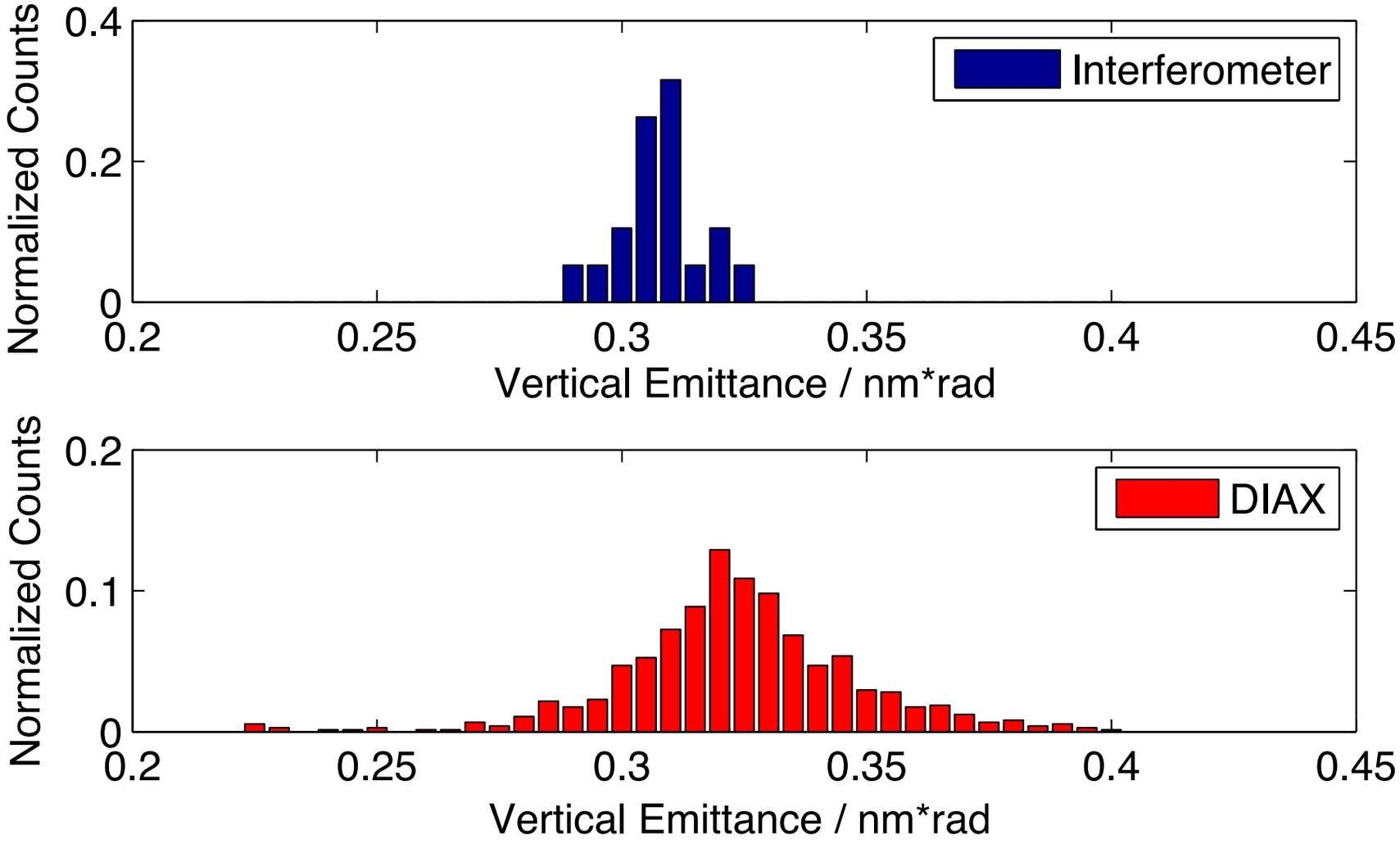




M. Holz, Y. Schön

Interferometric Beam Size Measurement

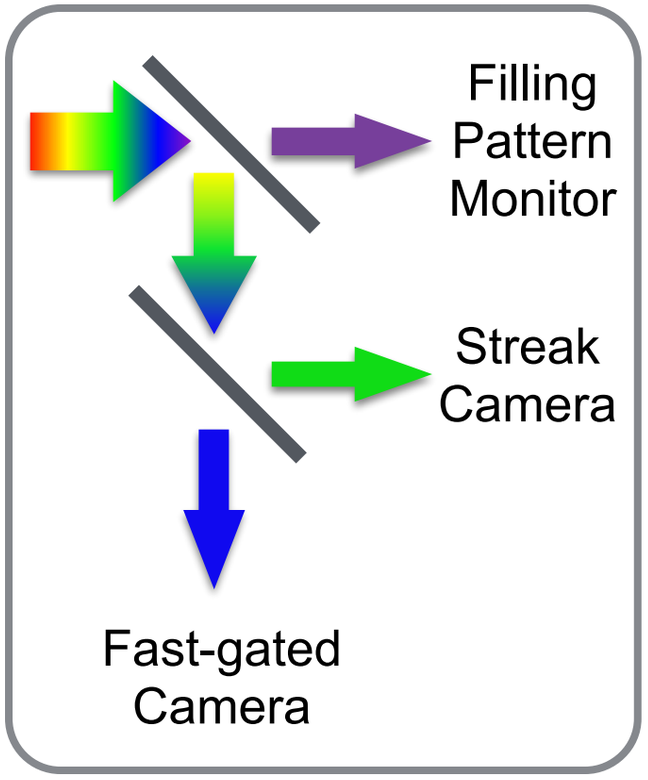
- Derive vertical beam size using interferometry
- In agreement with In-Air X-Ray Detector (DIAX)
- System not restricted to 2.5 GeV

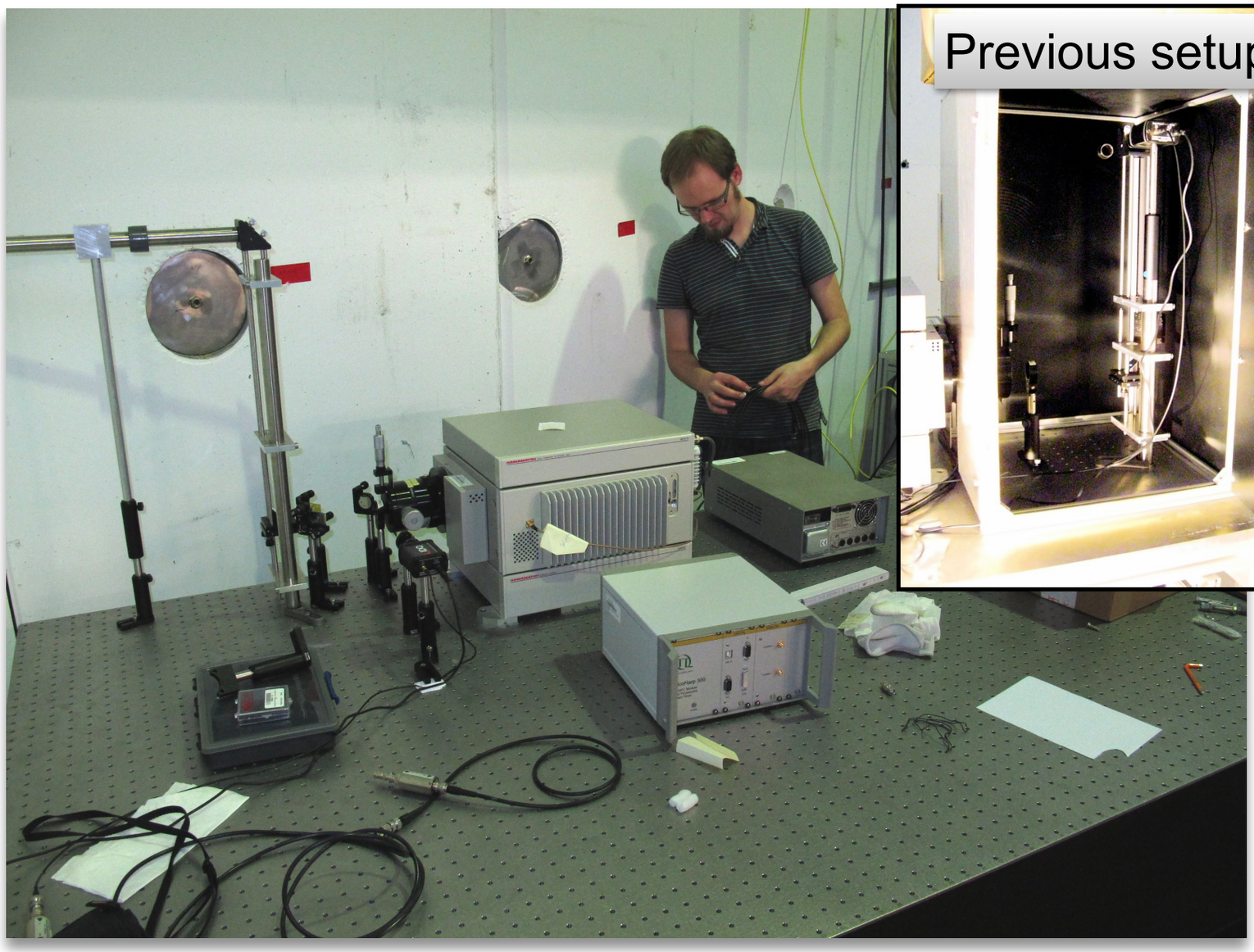


M. Holz

Visible Light Diagnostics Beam Line

- Beam line setup at existing 5°-port of a dipole magnet
- Dichroic mirrors and bandpass filters distribute the light to
  - Fill Pattern Monitor ✅
  - Streak Camera ✅
  - Fast-gated Camera





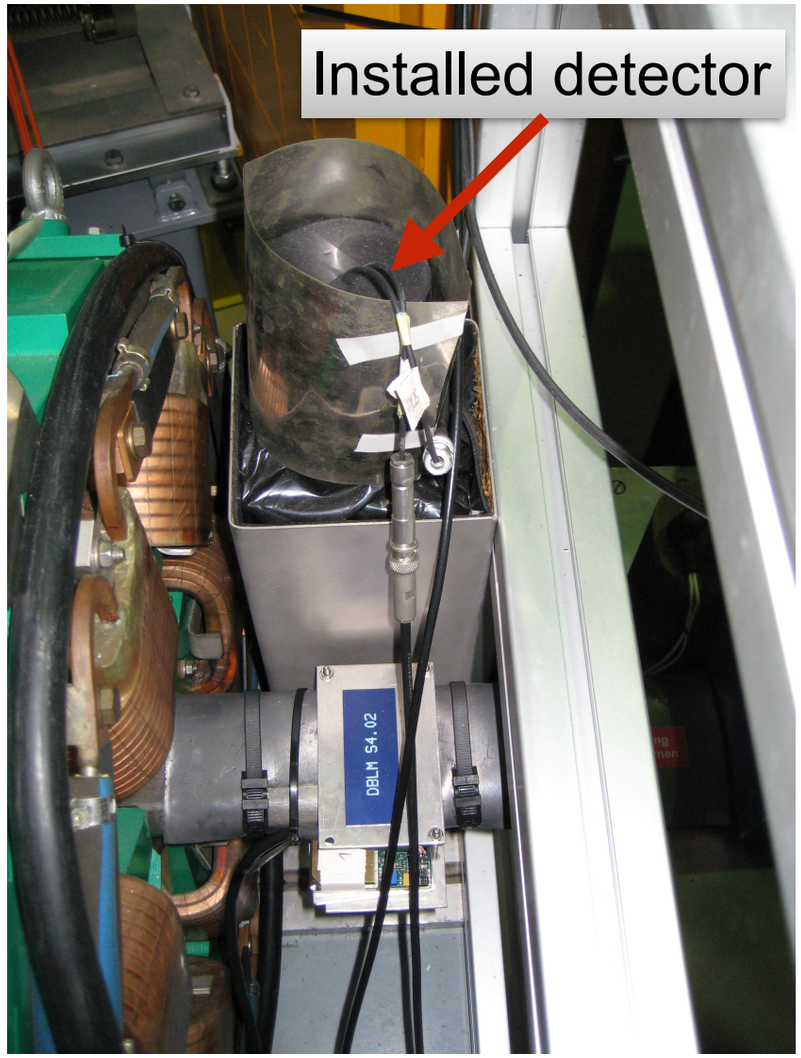
B. Kehrer, P. Schönfeldt, P. Schütze

Energy Measurement
Resonant Spin Depolarization Method

- Theory
  - Stored e-beam polarizes over time (~10 min @ 2.5 GeV, ~1.3 h @ 1.3 GeV)
  - Excite spin resonance
  - Touschek lifetime decreases
  - Measure excitation frequency & loss rate
- First time measured at ANKA in 2003
- Present setup at ANKA
  - Excite beam using BBB feedback system
  - Measure loss rate with a lead glass counter
  - Fully integrated in control system

$$a\gamma = \nu = k + [\nu] = \frac{\Omega_D}{\Omega_c} = \frac{f_d}{f_{rev}}$$

$$a := \frac{g-2}{2} = (1159.6521811 \pm 0.0000007) \cdot 10^{-6}$$

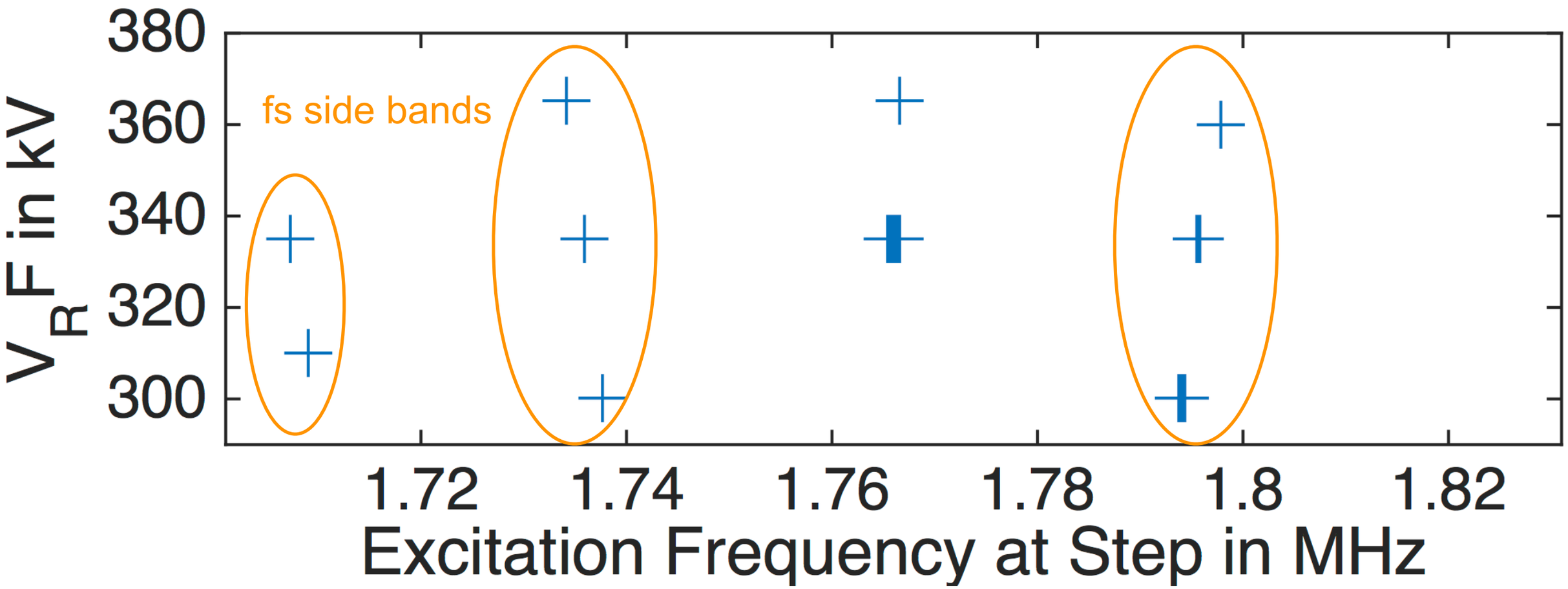


E. Hertle, N. Hiller

Resonant Spin Depolarization Measurement

- First results using the BBB feedback system
- Optimization ongoing

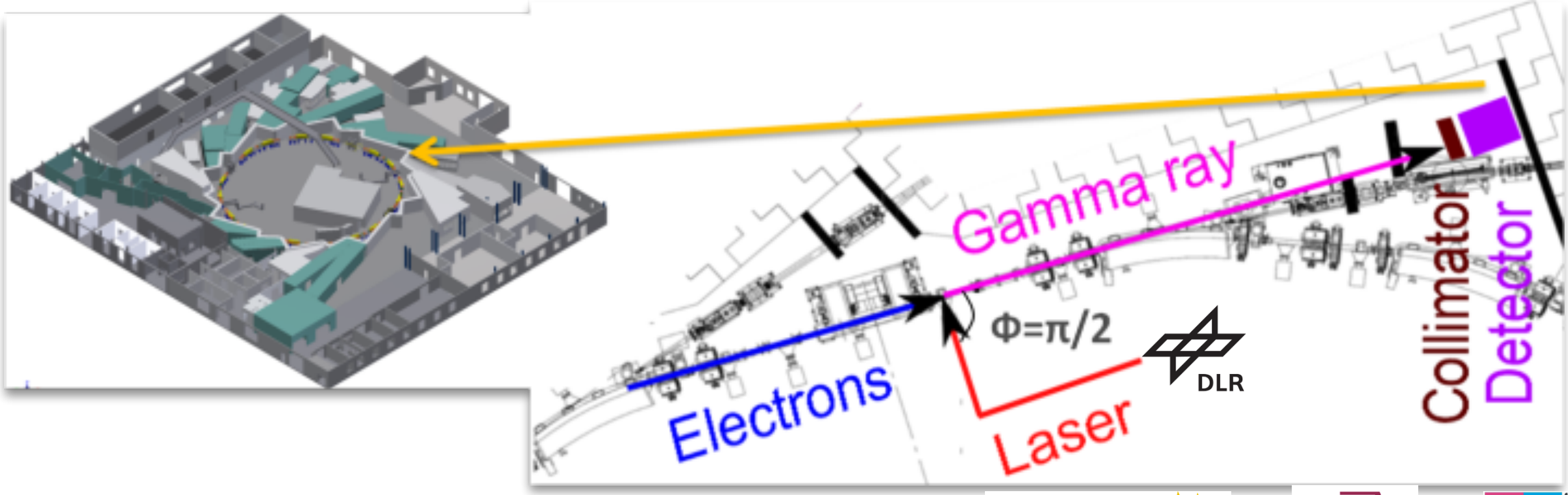
Preliminary



E. Hertle, N. Hiller

Energy Measurement
Compton Back Scattering (CBS) at ANKA

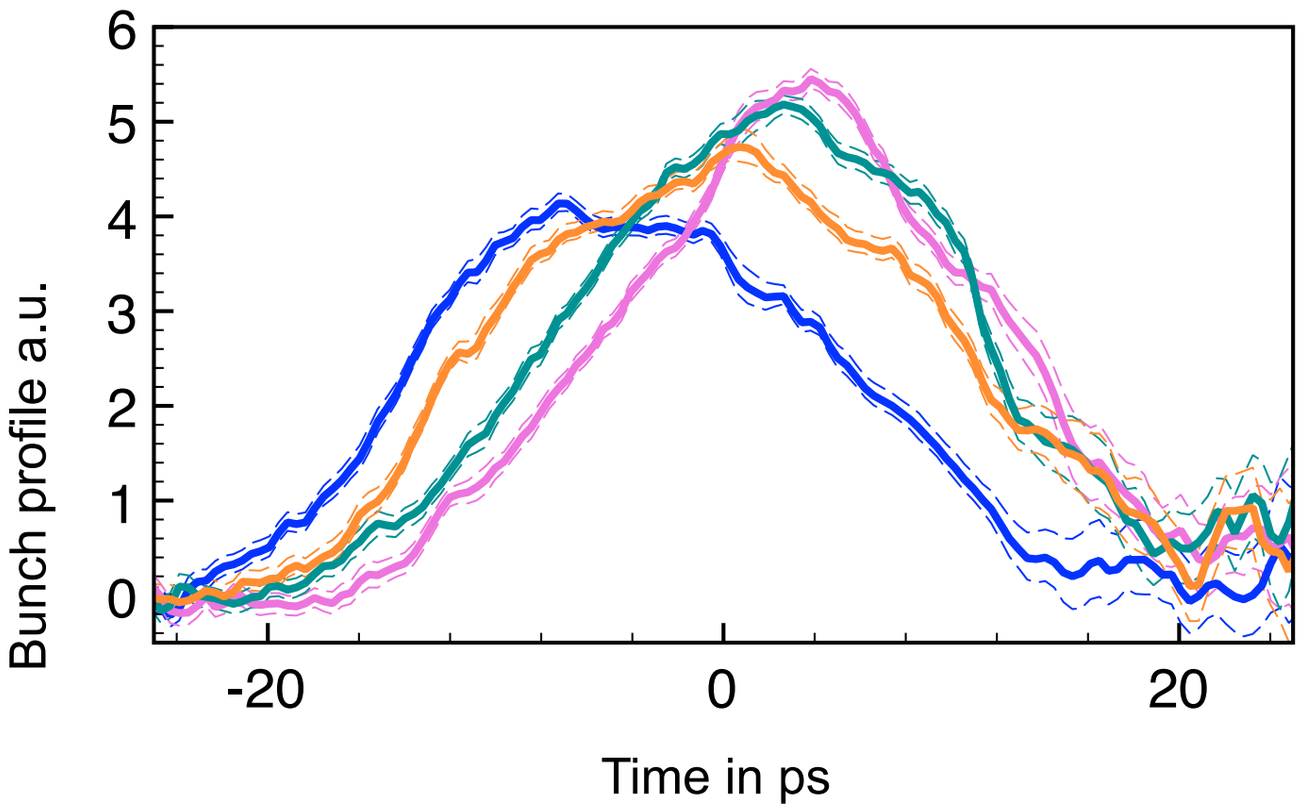
- Measuring the beam energy using CBS
  - Compton transverse configuration
  - High stability CW CO_2 laser (wavelength 10.3 µm) from DLR
  - High purity Ge (HPGe) spectrometer: high energy resolution (~10^{-3})
- Status: Under construction



C. Chang, M.J. Nasse, E. Bründermann

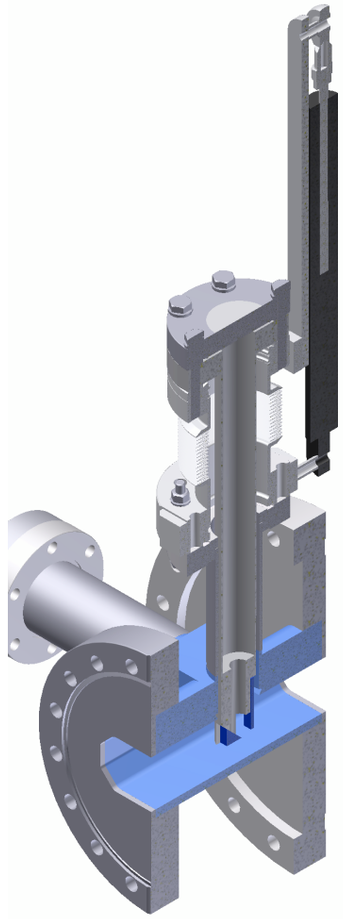
Bunch length measurements
Electro Optical Spectral decoding (EOSD)

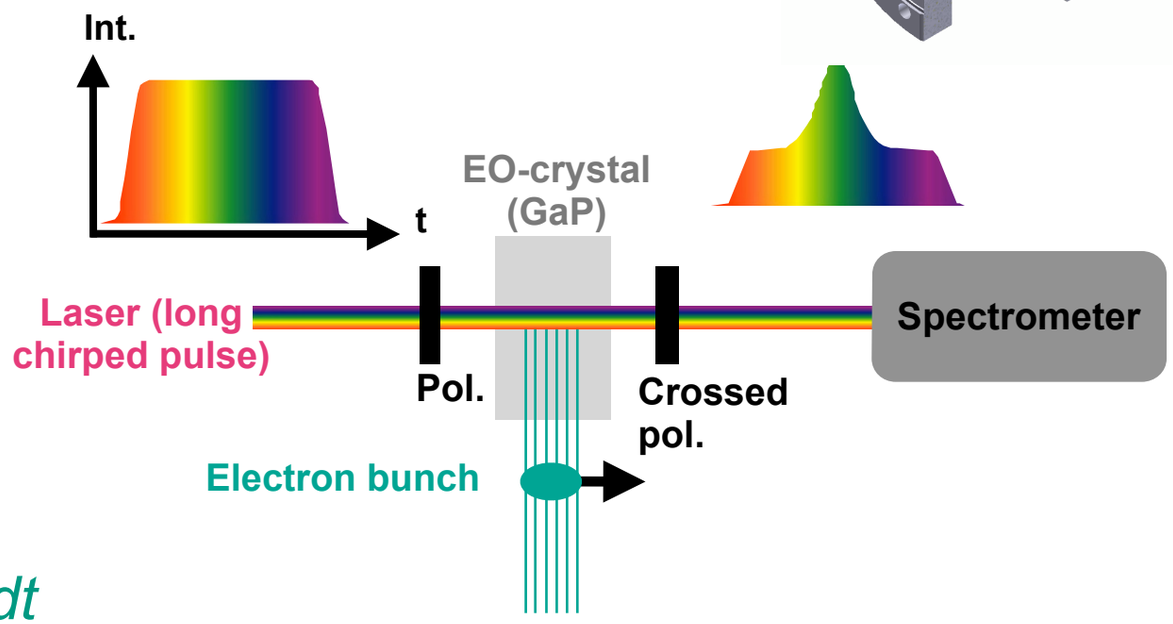
- **System permits observation of bunch substructure with sub-ps resolution**
- Readout of single-shot measurements is slow (<10 Hz)
- Wake-field cause heat-load issues during multi-bunch operation



N. Hiller, B. Kehrer, A. Borysenko, P. Schönfeldt

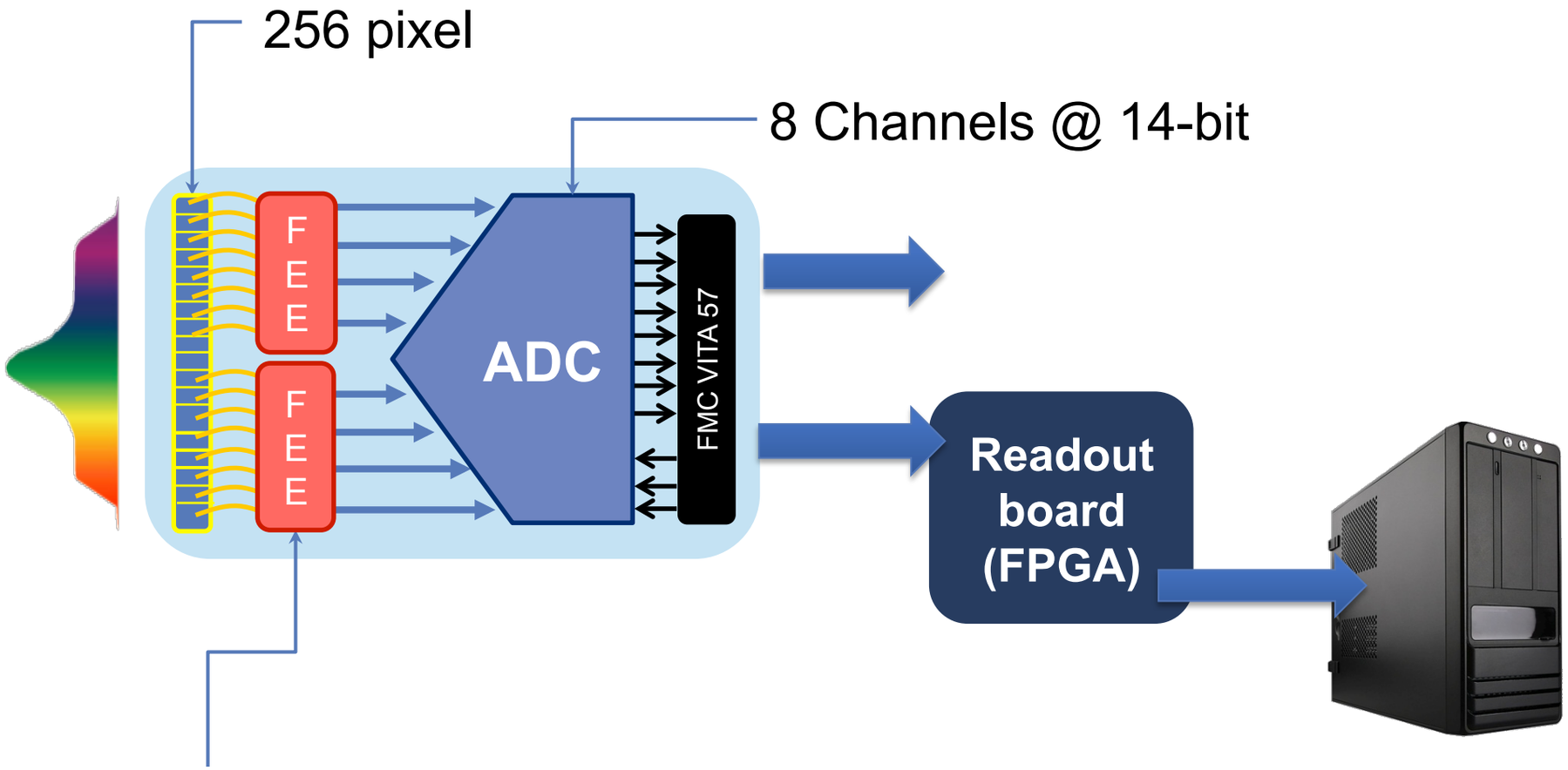
Principle: Modulate electric-near-field of electron bunch onto spectrum of laser pulse, then analyze laser to decode signal.





EOSD - Upgrades at ANKA

- Studies to reduce the effects of wake-fields by changing the chamber geometry
- Collaboration started to develop ultra-fast line array detector with MHz rep rate:



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DESY

PAUL SCHERRER INSTITUT PSI

Lodz University of Technology

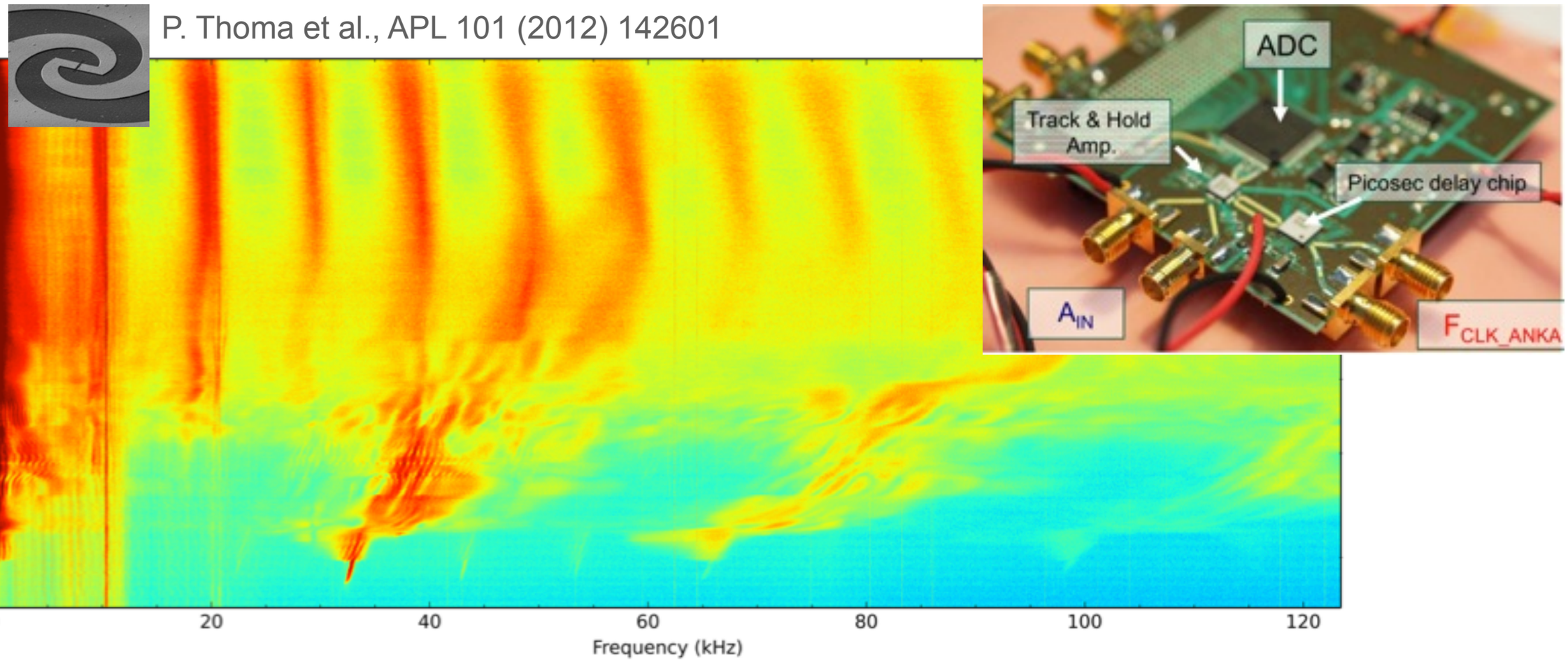
HZDR

GSI

Ultrafast THz Diagnostics

- Example project within KIT accelerator technology platform
- THz detector developments
- **Ka**rlsruhe **P**ulse **T**aking **U**ltra-fast **R**eadout **E**lectronics (KAPTURE)
- GUI for online analysis under development
- Status: Data taking and analysis

P. Thoma et al., APL 101 (2012) 142601



M. Caselle et al., IPAC 2014

Summary and Outlook

- Active R&D Programm
  - Synchrotron light monitor upgraded, continue refurbishment
  - Extended visible light diagnostics beam line
  - Finish Compton back scattering setup early 2015
  - In progress: fast-gated intensified CCD
  - New / better diagnostics features available with longitudinal kicker cavity (ANKA Status Talk)
  - New EO-Vacuum chamber for multi bunch operation and fast readout
- Perspective: combine different methods and tools into one common framework (synchronized, triggered, automated data analysis, common user interface, …)

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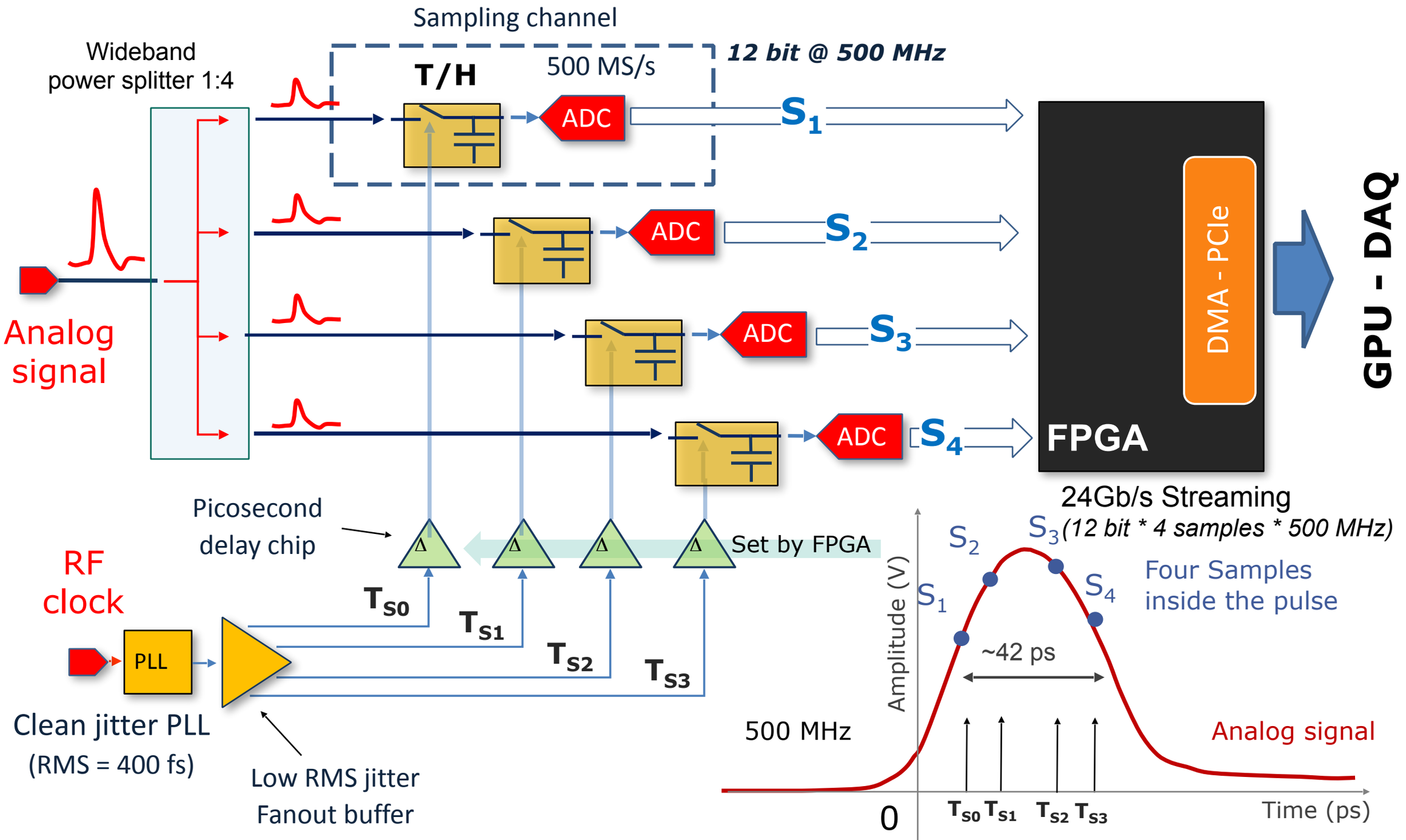
Thank You for Your Attention!

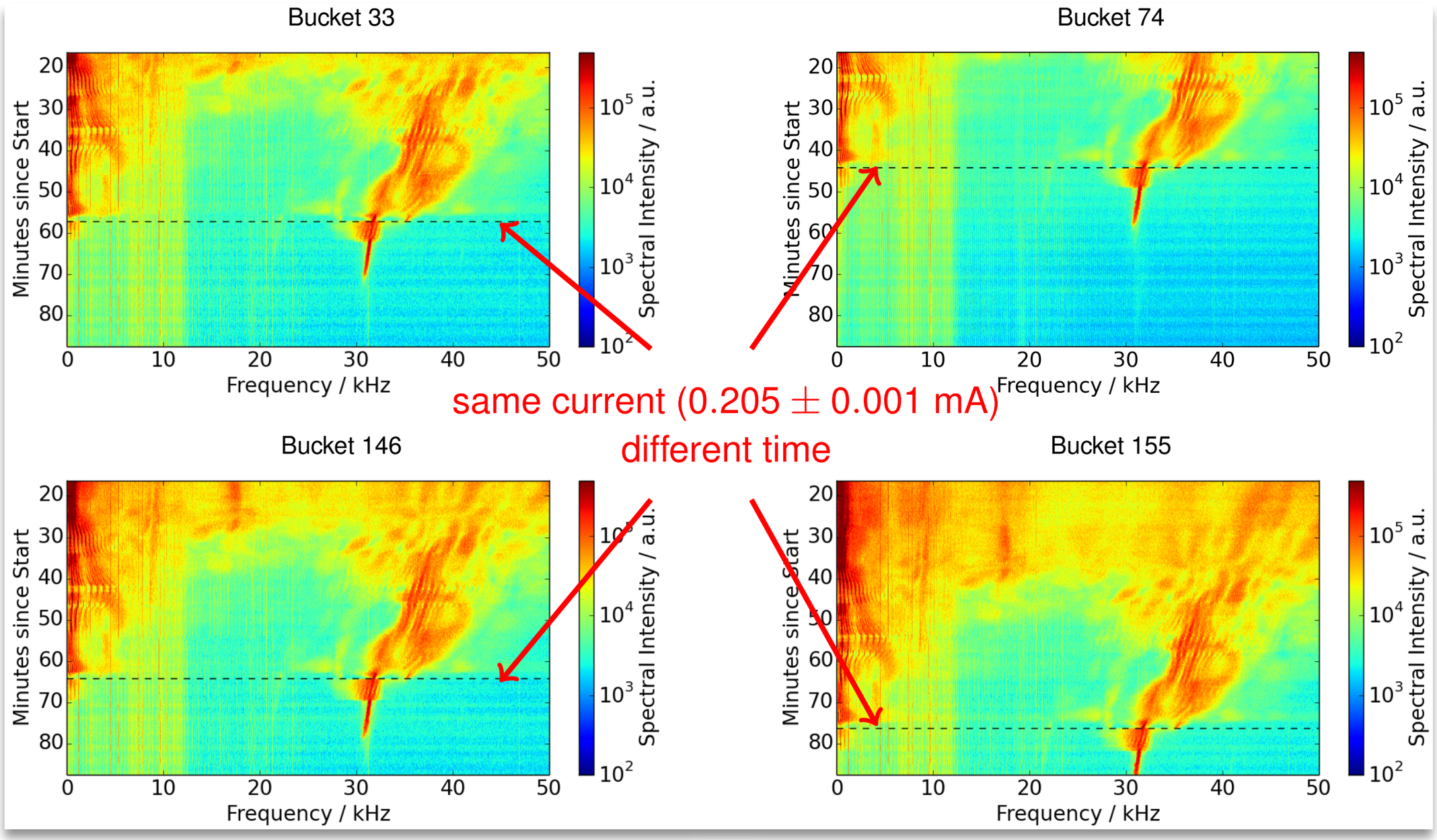
KAPTURE - Concept



M. Caselle et al. *"An Ultra-Fast Data Acquisition System for Coherent Synchrotron Radiation with Terahertz Detectors"*, Proceeding of Topical Workshop on Electronic for Particle Physics, Perugia 23-27 September 2013. JINST_124P_1113

Comparison of Spectrograms

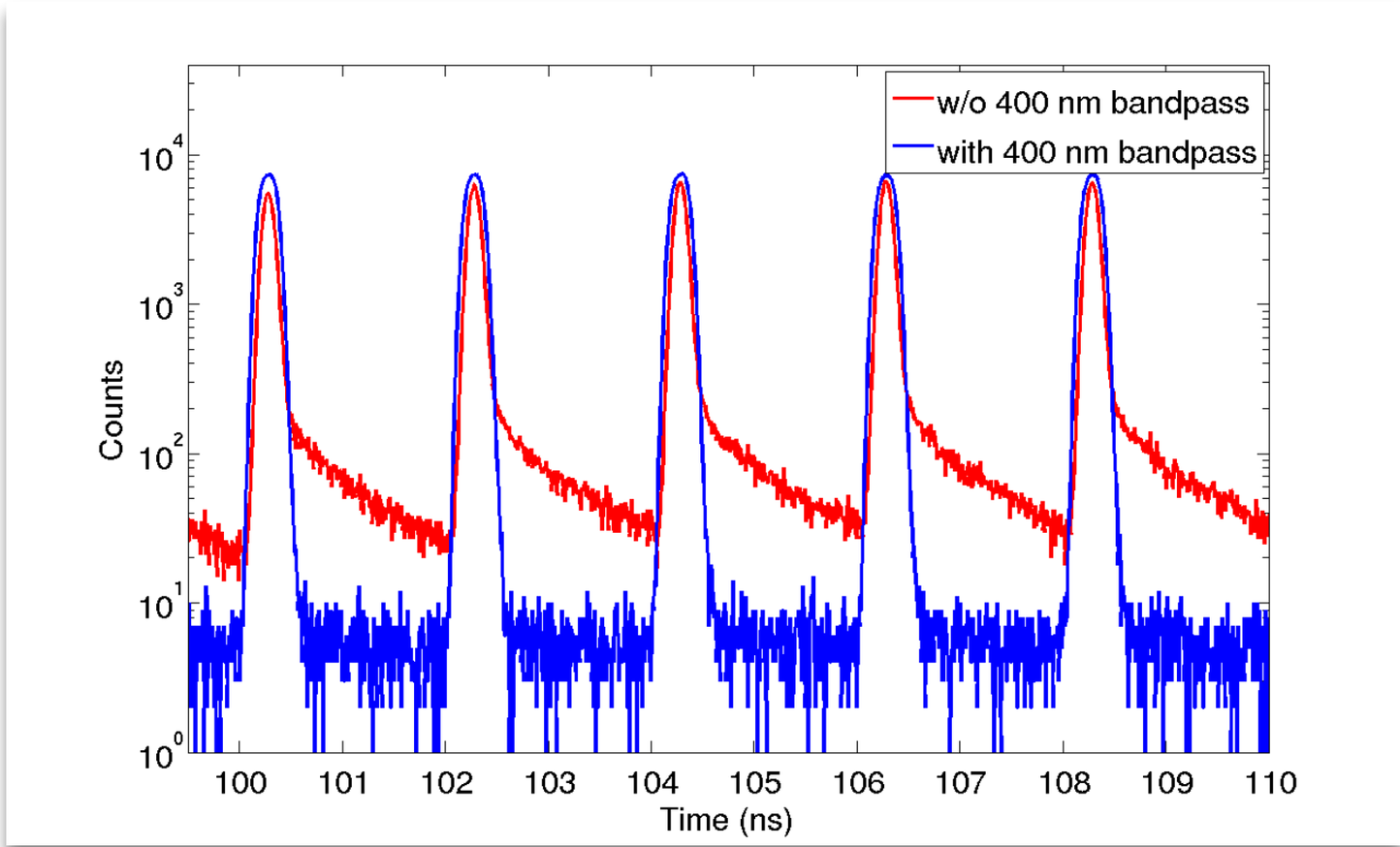
- THz Signal of different bunches during one decay



M. Brosi, J. Steinmann

Fill Pattern Monitor

- Based on time-correlated single photon counting using an Avalanche Photo Diode (APD)
- Bandpass filter (λ = 400 nm) for getting rid of diffusion tail[1,2]
- Dynamic range increased

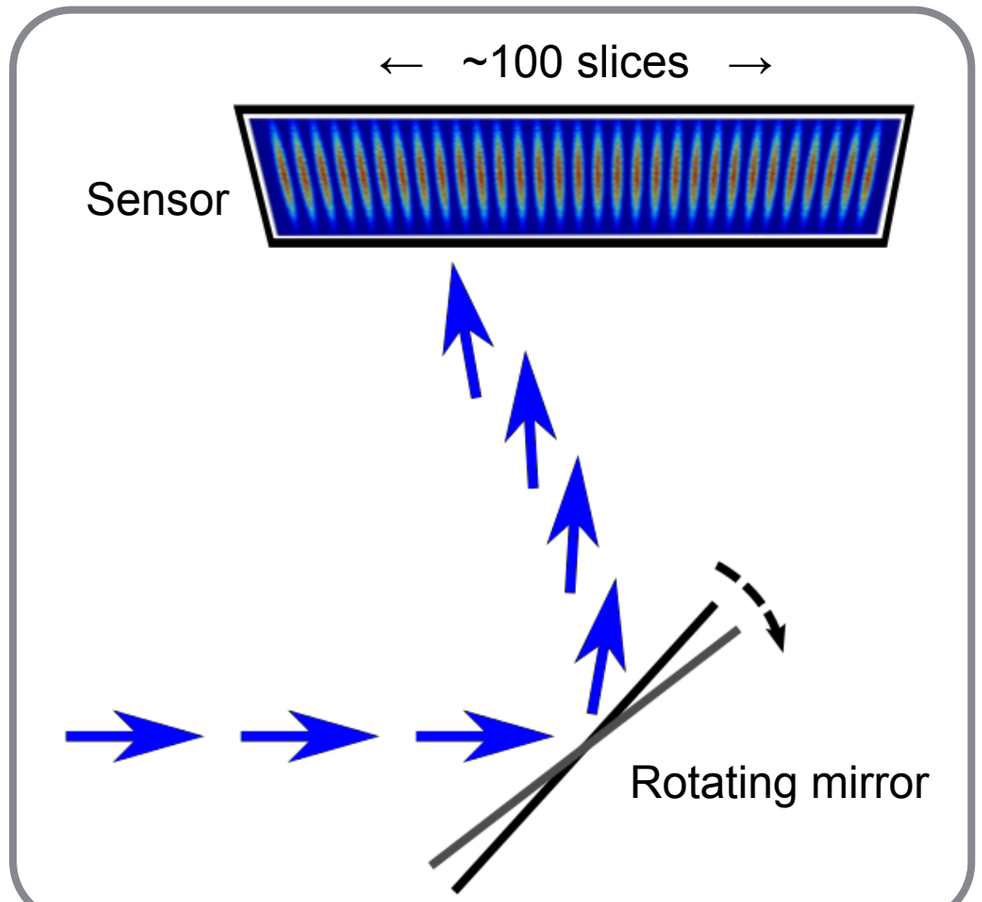


B. Kehrer

[1] G. Rehm et al., DEELS WS 2014
[2] S. Cova et al, 'Towards picosecond resolution with single-photon avalanche diodes', Rev. of Sci. Instr. 52.3 (1981): 408-412.

Fast-gated Intensified Camera

- **Task: Monitor size and position of a single bunch over consecutive revolutions in a multi-bunch environment**
- Follow the suggestion of J. Corbett
- Fast-gated intensified camera iStar 340T by Andor:
  - Optical gate width < 2 ns
  - Maximum gate repetition rate of 500 kHz: Imaging of every 6th turn
- A rotating mirror deflects consecutive pulses to different positions on the sensor
- Acquire ~100 slices
- Focusing optics optimized for horizontal plane
- Status: Under construction



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