# Status Report DESY

## Tango Meeting 2023

- Status Petra III
- Planning Petra IV
  - Timing, synchronization
  - Replace VME with MicroTCA
  - Evaluate EC user interfaces, Bluesky

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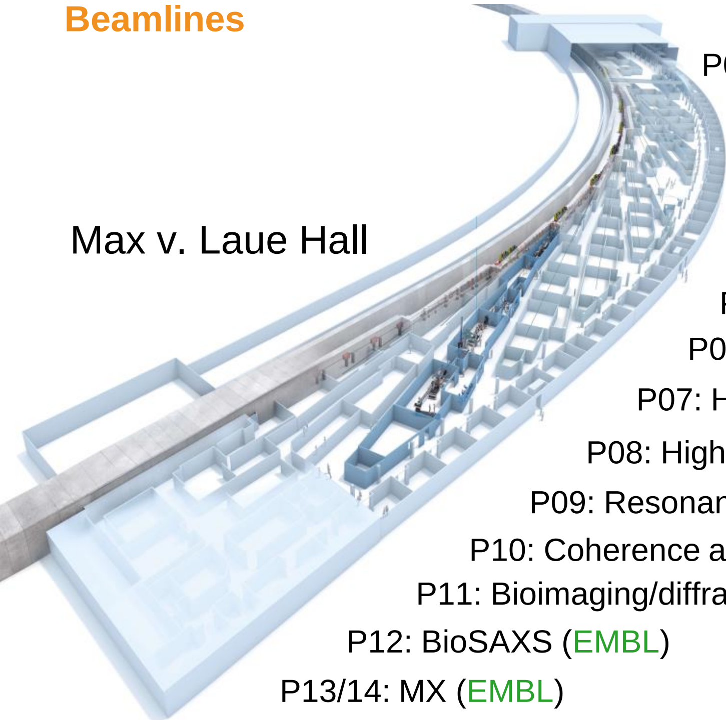
# PETRA III.

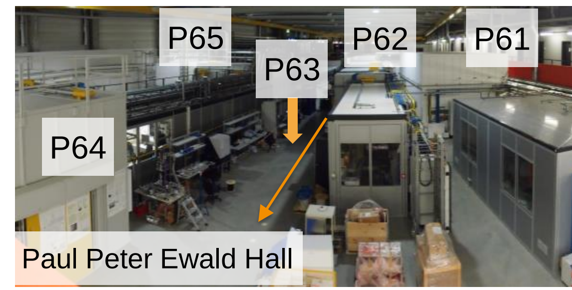
## Beamlines




P01: Dynamics beamline, IXS, NRS
P02.1: Powder diffraction & total scattering
P02.2: Extreme conditions
P03: Micro-, nano-SAXS, WAXS (DESY, Hereon)
P04: Variable polarisation XUV
P05: Micro-, nano-tomography (Hereon)
P06: Hard X-ray micro-, nanoprobe
P07: High-energy materials sci. (Hereon, DESY)
P08: High-resolution diffraction
P09: Resonant elastic scattering/diffraction
P10: Coherence applications
P11: Bioimaging/diffraction
P12: BioSAXS (EMBL)
P13/14: MX (EMBL)

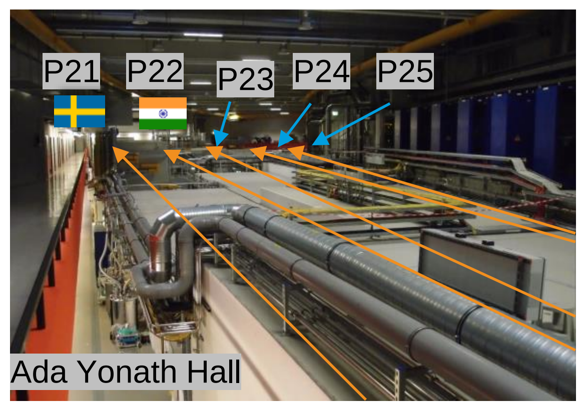
ErUM Pro, ErUM Data

Federal Ministry of Education and Research




P21: Swedish materials science beamline
- P21.1 High-energy broad band diffraction
- P21.2 High-energy diffraction and imaging

P22: Hard X-ray photoelectron spectroscopy
P23: In-situ and nano diffraction **/ HIKA** (DESY, KIT)
P24: Chemical crystallography
P25: Bio-med. imaging, Powder XRD, Innovation

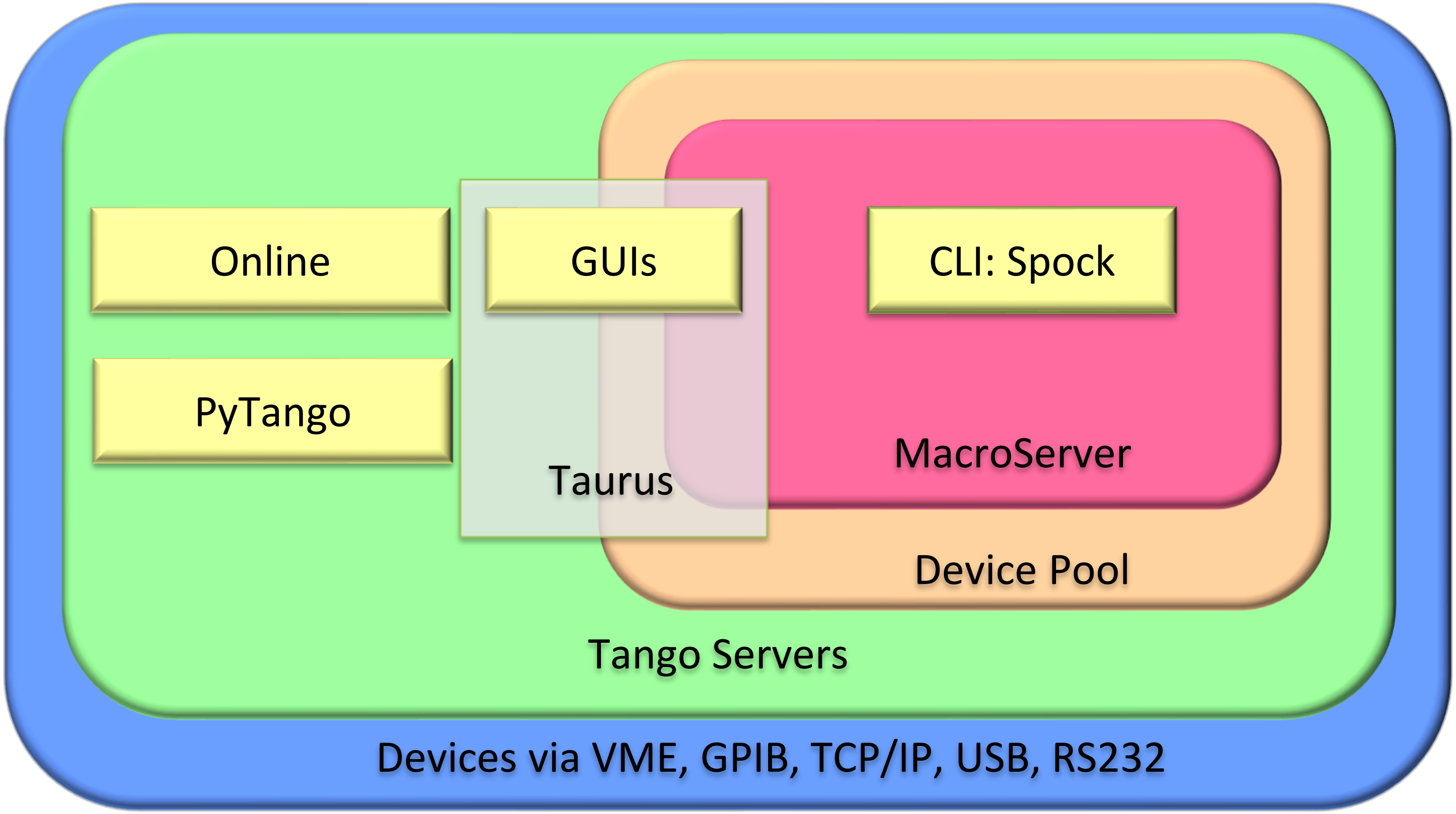



P61: High-energy wiggler beamline (Hereon, DESY)
P62: Small-angle X-ray scattering
P63: OperandoCat (MPG) (in planning)
P64: Advanced XAFS
P65: Applied XAFS
P66: Time-resolved luminescence spectroscopy



25 Beamlines, in total, about 50 experimental stations

# The Experiment Control System at PETRA III: Overview

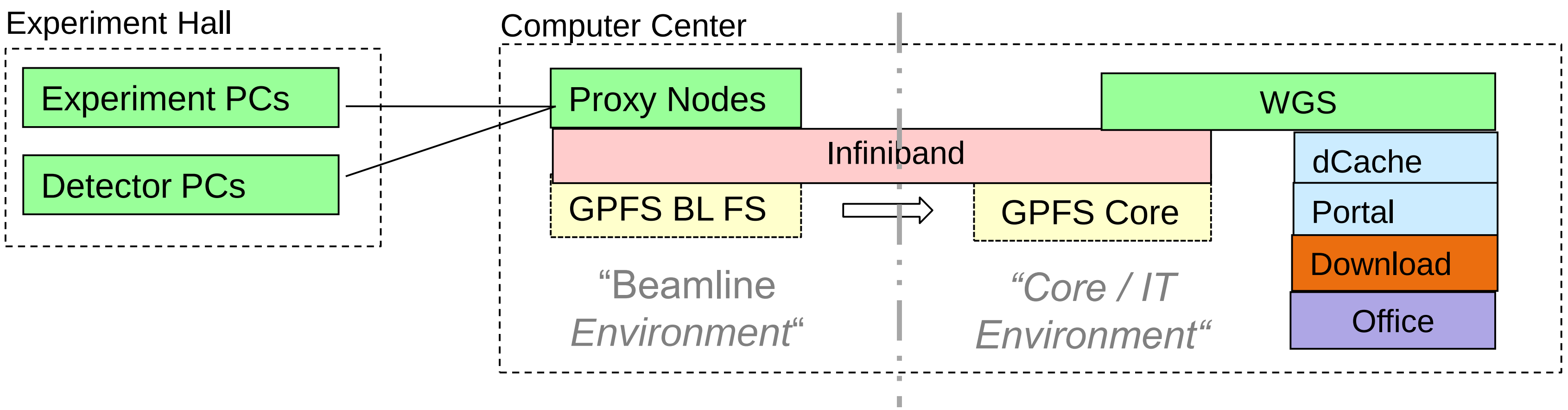



Taurus, Device Pool, MacroServer, Spock

Taurus: General purpose library

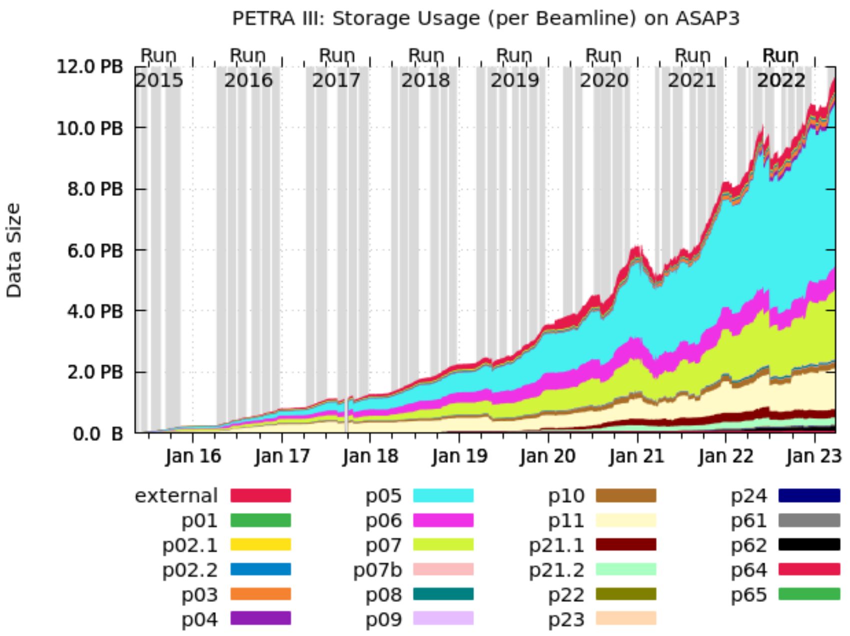
- Used by MacroServer, Device Pool
- Widget set for GUIs

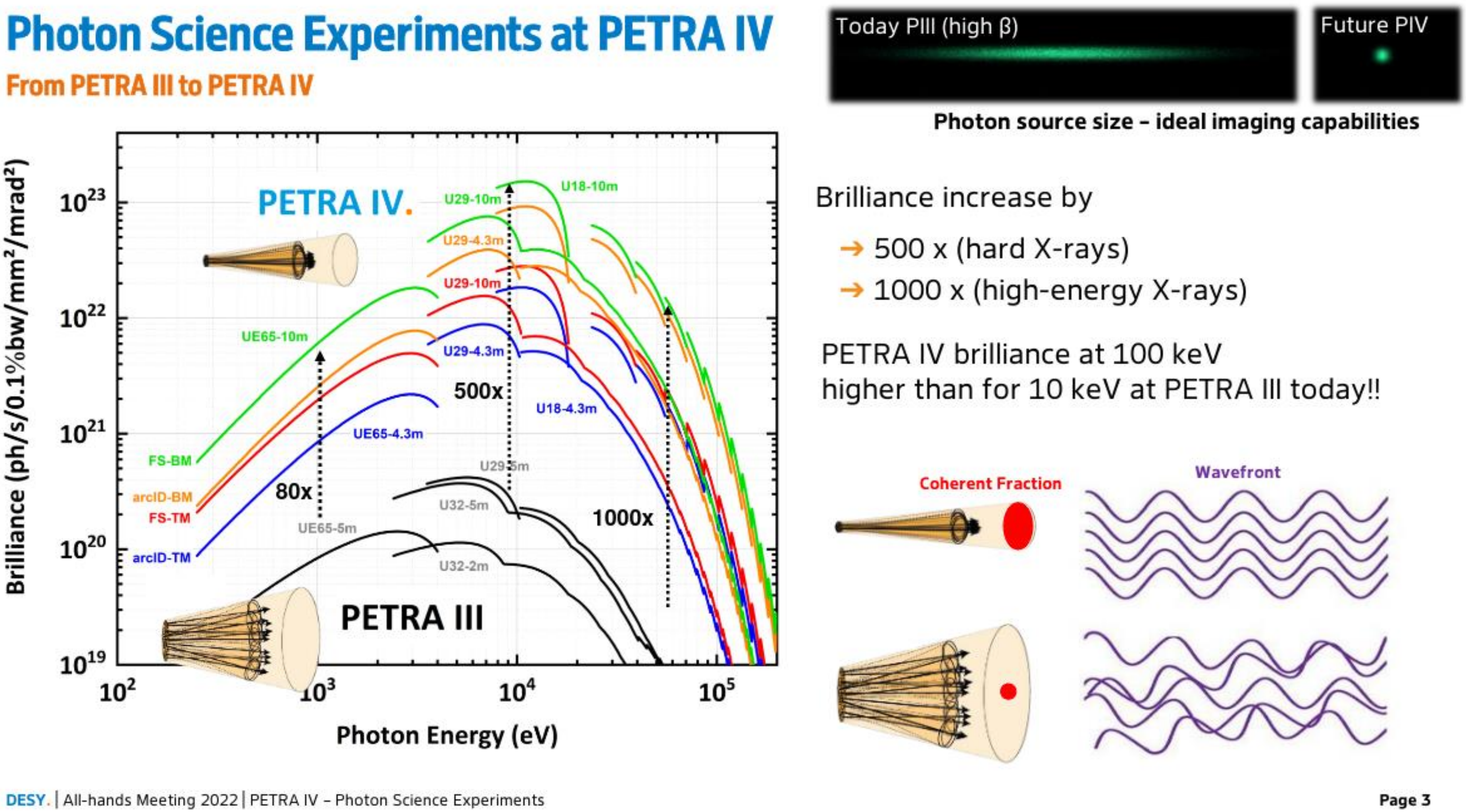
# DESY Photon Science Storage System




- Proxy nodes as entry points, scalable
- GPFS BL FS optimized for write-access
- GPFS core for data processing
- dCache: tape archive
- Gamma portal for download

- New policy, Feb. 2022:
  - Move data to dCache 180 days after BT
  - Dwell time can be adjusted
  - Staging possible, if fill level < 90%
- Data reduction increasingly important




Photon Science Experiments at PETRA IV
From PETRA III to PETRA IV
Today PIII (high β)
Future PIV
Photon source size – ideal imaging capabilities
PETRA IV.
PETRA III
Brilliance (ph/s/0.1%bw/mm²/mrad²)
Photon Energy (eV)
U18-10m
U29-10m
U29-4.3m
U29-10m
U29-4.3m
U18-4.3m
UE65-10m
UE65-4.3m
FS-BM
arcID-BM
FS-TM
arcID-TM
U29-5m
U32-5m
U32-2m
UE65-5m
80x
500x
1000x
Brilliance increase by
→ 500 x (hard X-rays)
→ 1000 x (high-energy X-rays)
PETRA IV brilliance at 100 keV
higher than for 10 keV at PETRA III today!!
Coherent Fraction
Wavefront
DESY. | All-hands Meeting 2022 | PETRA IV – Photon Science Experiments
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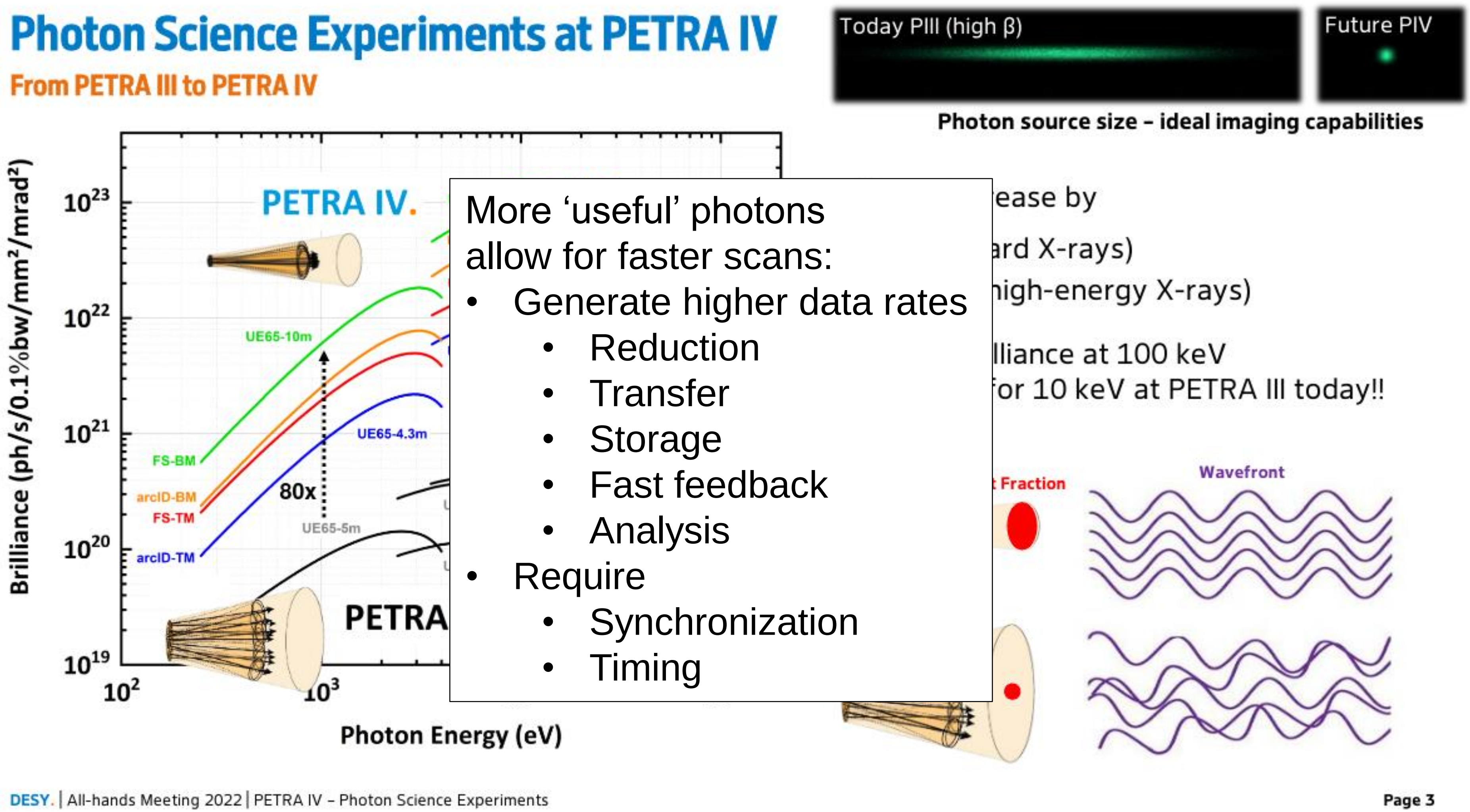



More 'useful' photons allow for faster scans:

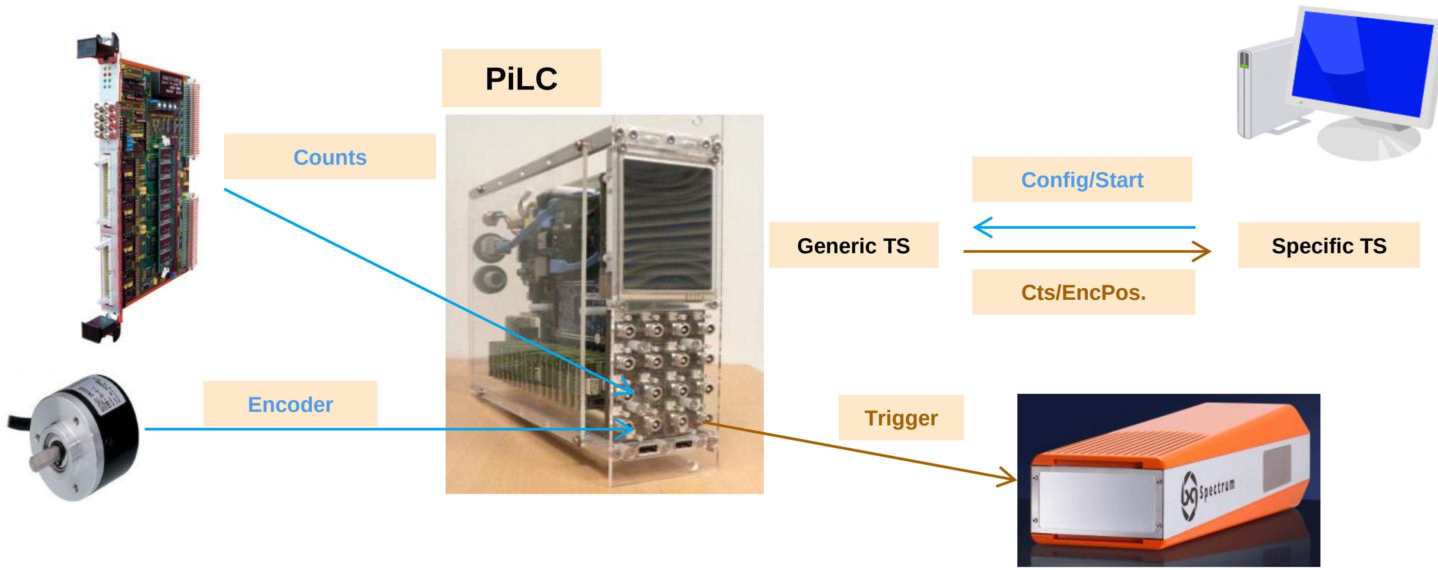
- Generate higher data rates
  - Reduction
  - Transfer
  - Storage
  - Fast feedback
  - Analysis
- Require
  - Synchronization
  - Timing

# Data Aquisition

- Paradigm: as little as possible IT infrastructure in the experimental hall
  - Limited space, 24x7, heat load
- 0D and 1D data are transferred through the control system
- Extreme user requirements
  - Single photon counting detector at 130 kHz, 2 bytes, 10 MP images size: 2.5 TB/s → 100 fibers (400 GE), 50% Ethernet saturation assumed
  - Measuring in 2 bit mode: 300 GB/s → 12 fibers
  - FPGA-based data reduction (reject bad images, azimuthal integration) : 30 GB/s
- To find the global optimum we have to consider FPGA-based data processing, server speed, network bandwidth, storage capacity, Maxwell nodes, considering fast feedback and analysis - Petra III will help us!

# Timing I: Continuous Scans with PiLC

Fast scans require a precise and flexible synchronization of motor positions, detector control and read-out.

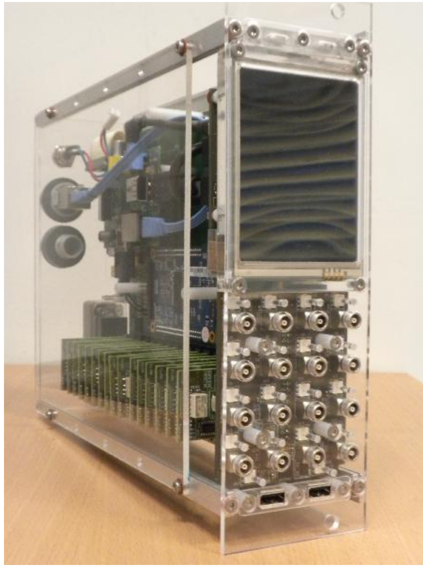



PiLC Controlled Scans

- A specific firmware is loaded into the PiLC
- A technique-specific TS configures the PiLC and starts it
- A generic TS serves as an interface
- The PiLC receives encoder and other signals
- The PiLC generates triggers, on time, on position, user-defined, etc. .

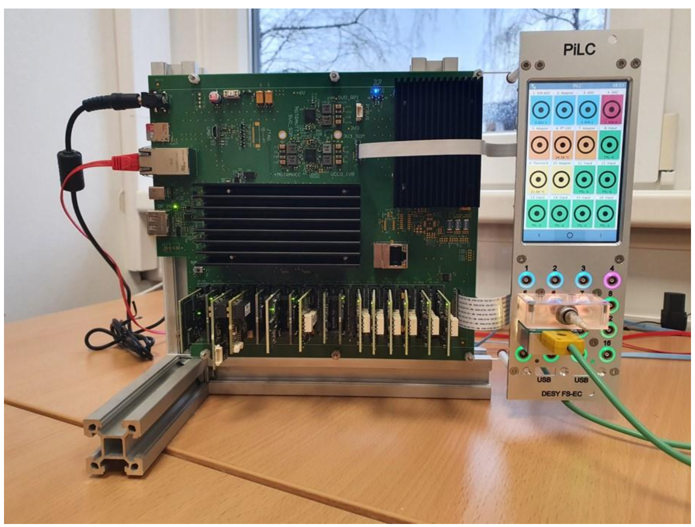
Tobias Spizbart, Joshua Supra, Teresa Nunez

# PiLC II



PiLC-I

PiLC-II




PiLC-II

Xilinx ZYNQ Ultra Scale+ (SoC)
- 4 ARM-Cortex A53 Cores @ 1.5 GHz
- 2 ARM-Cortex R5 Cores @ 600 MHz
- USB2-3, Gigabit Ethernet
- AXI Bus Gb/s: FPGA ↔ ARM Cores

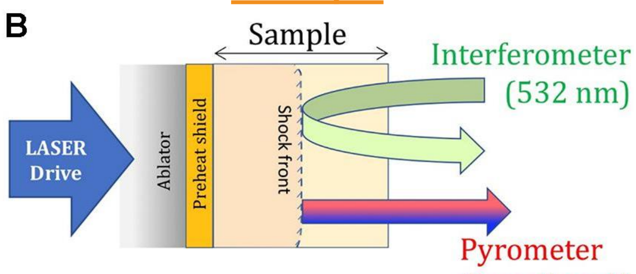
CPU
- Debian-10
- ZMQ Server
- Web interface

FPGA
- Specific application
- Configurable standard logic: AND, OR, XOR, delay
- Max trigger rate: 80 Mhz
- Recording 14 inputs: 10 kHz (sustained)

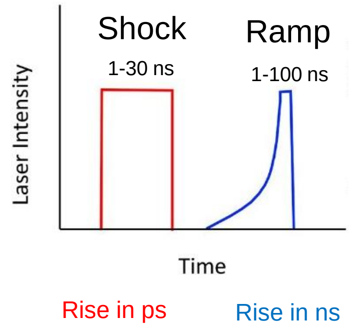
Tobias Spizbart, Joshua Supra

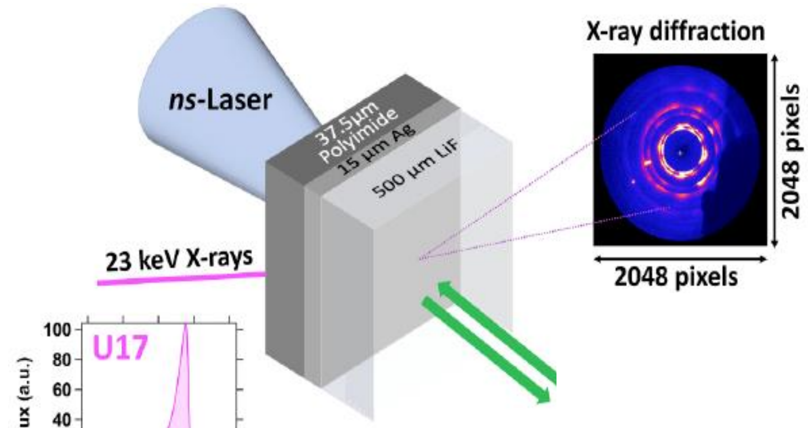
# Proposed Laser Shock/Ramp Compression at ExTReM (U41)

## Principle




Duffy & Smith (2019)

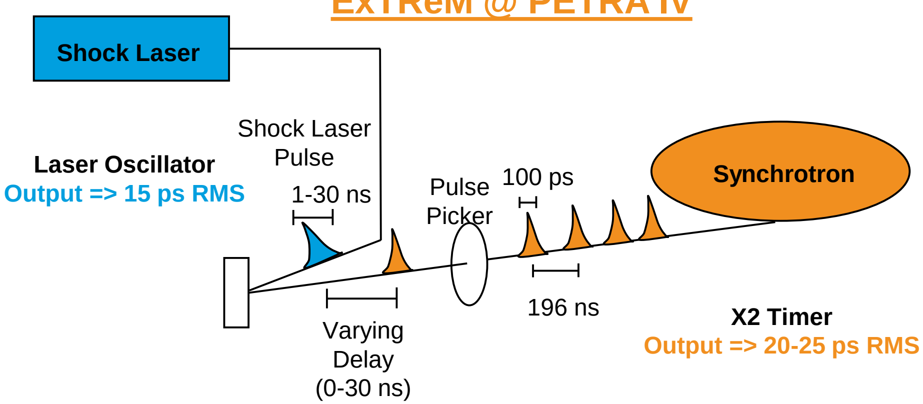



Colemann et al. 2022

## Example from the APS DCS

## ExTReM @ PETRA IV




- Laser generates shock front
- Duration 3 – 40 ns
- Laser: 15 ps rms
- Goal: Synchronize laser and Petra-4 < 15ps

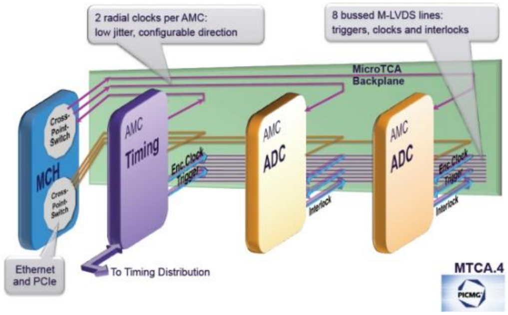
- Generates a 2 ns time base using the 500 MHz accelerator frequency
- Jitter: 10 ps
- RTM delays the signal, resolution 5 ps
- X3Timer: ‘Jitter cleaner’

# The X2Timer

## Well experienced Timing Hardware

- Developed together with DESY
- Can act as Transmitter and Receiver
- Provide continuous timing signals & trigger events
  - Internal on Backplane port 17-20 (MLVDS)
  - TCLK A/B
  - external on Front panel (LVDS)
  - TTL (LEMO) Trigger via RTM or converter box
- Provide bunch meta-information
- Dedicated fiber network with optional drift compensation
- Successful in operation at FLASH and European XFEL

https://techlab.desy.de/products/amc/x2timer/index_eng.html



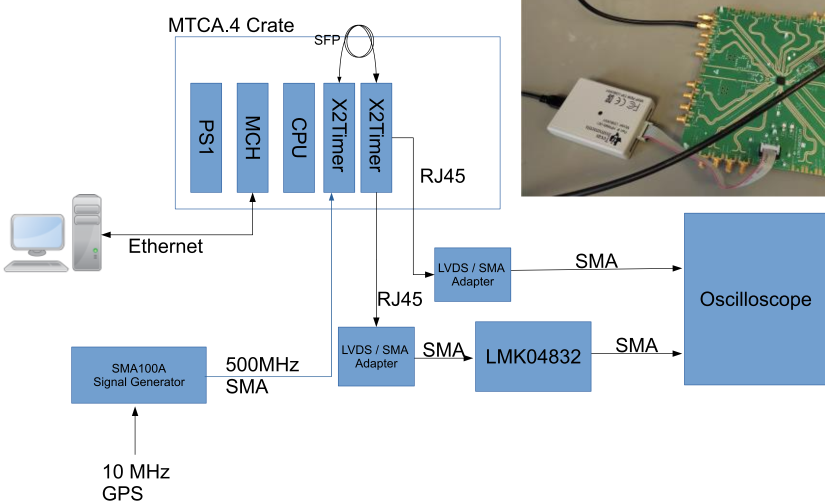

## Design changes needed for PETRA IV

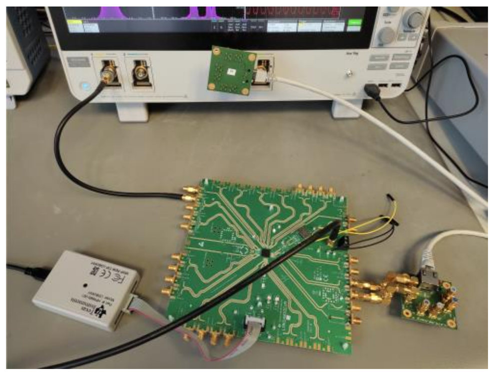
- Many components of the X2Timer are going end of life
- Output jitter can be improved
- CPU core for
  - real-time calculation of advance delays
  - Configuration and monitoring of peripherals
- Bunch-Metainformation differ from XFEL
- Front panel design
  - Save space
  - Additional interfaces (RF-Out / LEMO)
- RTM interface design by class recommendation

# Clock jitter cleanup

## Dual loop PLL Jitter cleaner

- Created noisy clock by sending through 2 X2timers
- Feed noisy Clock to the LMK04832 jitter cleaner board
- Jitter can differentiated between
  - Random Jitter RJ
  - Deterministic Jitter DJ
  - Periodic Jitter PJ



## First results (Mean)

- LVDS-Output of X2Timer
  - RJ = 12.25 ps
  - DJ = 39.3 ps
  - PJ = 38.9 ps
- Output of LMK04832 (LVDS Level)
  - RJ = 460.1  fs
  - DJ = 799.1 fs
  - PJ = 799.0 fs

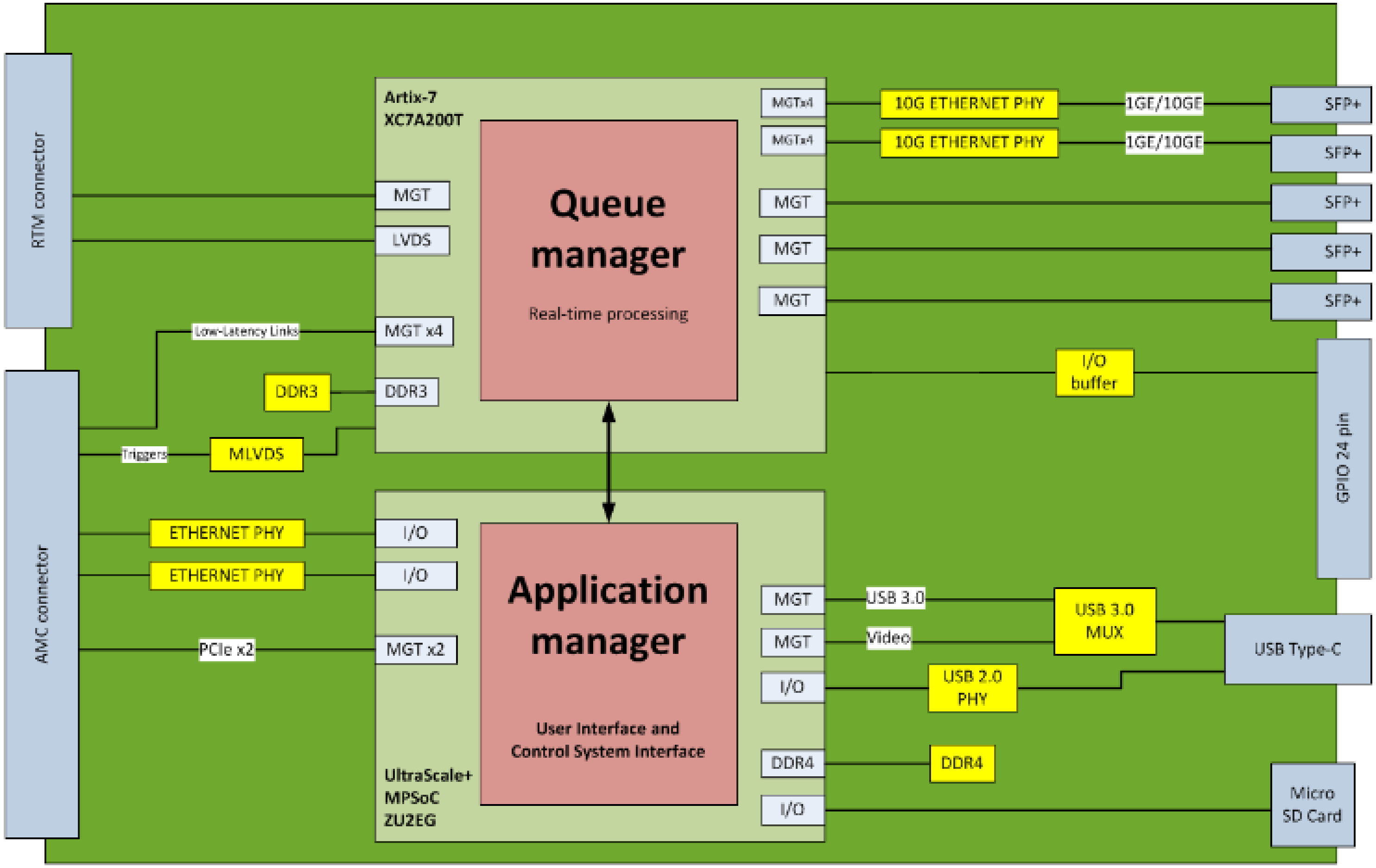
## Next steps

- Compare Jitter of different RF frequencies
- Tests with longer optical cable
- Parallel test on phase noise analyzer

Timing, experiment – accelerator, promising

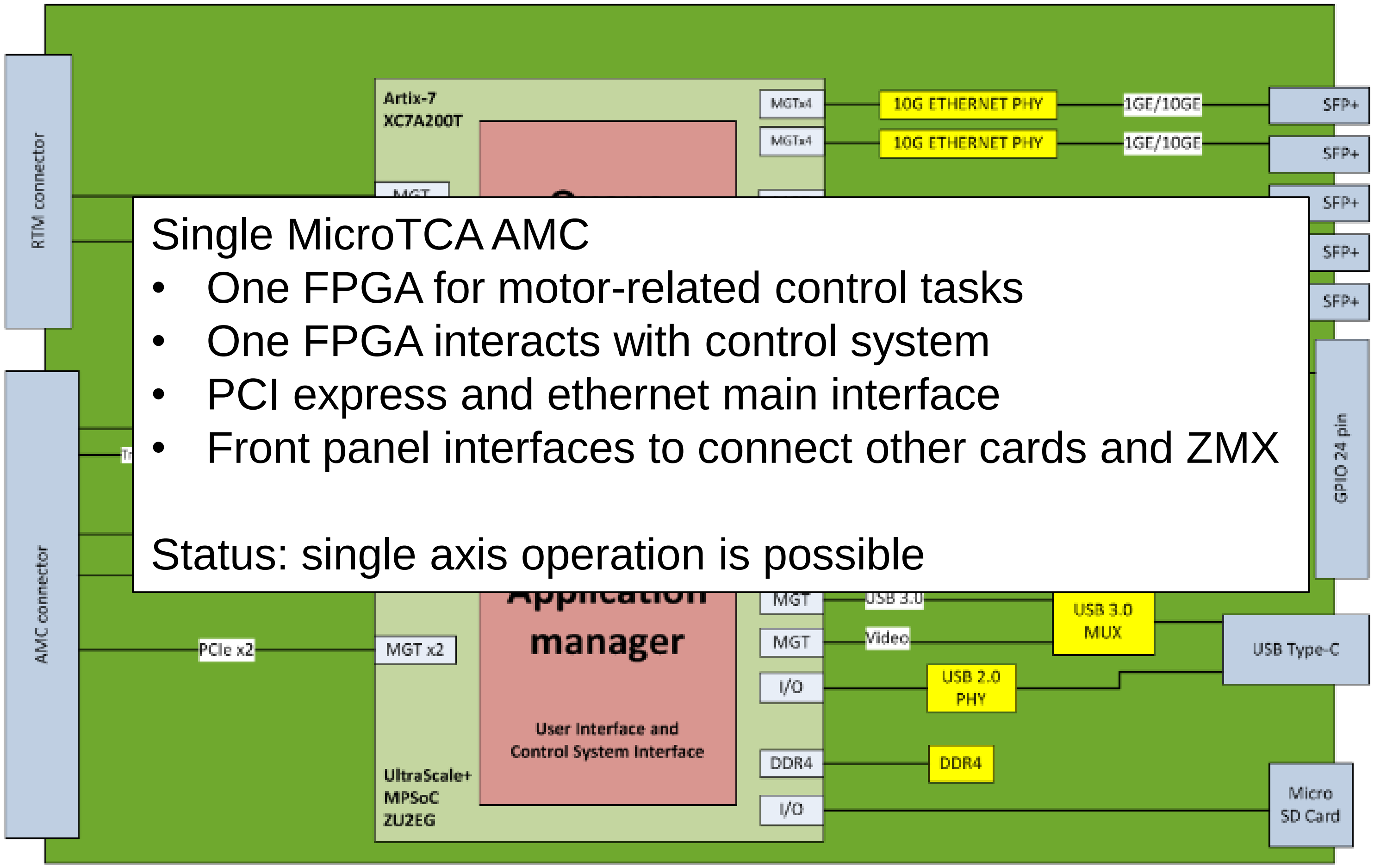
# Timing III: MicroTCA Motion Controller

DGP/ITT: H. Schlarp, M. Tolkiehn, M. Fenner, S. Chystiakov)



# MicroTCA Motion Controller

DGP/ITT: H. Schlarp, M. Tolkiehn, M. Fenner, S. Chystiakov)




Single MicroTCA AMC

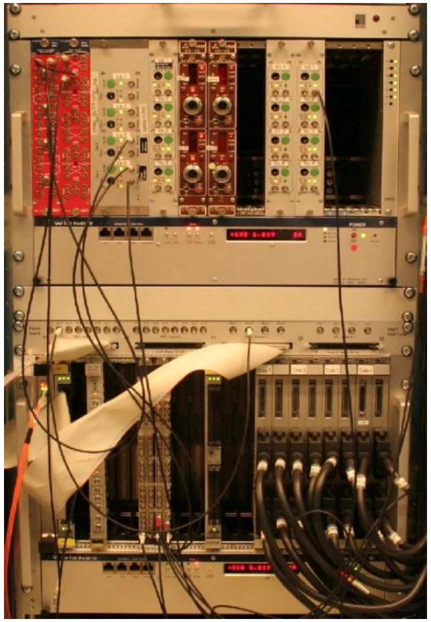
- One FPGA for motor-related control tasks
- One FPGA interacts with control system
- PCI express and ethernet main interface
- Front panel interfaces to connect other cards and ZMX

Status: single axis operation is possible

# VME vs. MicroTCA

Time to consider a replacement of VME by MicroTCA

- VME has come to a certain age
- MTCA is a modern standard, heavily used by DESY-M, EU-XFEL
- Petra IV timing will be based on MTCA



MicroTCA

- Highly configurable, very flexible, complex
- High speed busses: PCIe, 10 GE Ethernet, Serial Rapid IO, Serial Attached SCSI
- Several CPUs per crate possible
- Platform to integrate new electronics, AMCs, RTMs
- MicroTCA comes at a cost! Firmware and PCB developments.

To do:

- Build-up more expertise
- Verify that all VME modules can be replaced by MTCA parts (make a list of supported standard modules)
- Create a MTCA infrastructure

# Peta IV Experiment Control User Interface

Planning Petra IV: now is the right time to evaluate alternatives.

- Sardana
  - Well established at Petra III, used at many beamlines
  - Many user-written macros
  - Taurus applications
  - Issues: Ctrl-C, Measurement group ended acquisition in Fault state, community

- Bluesky
  - Used at many US labs but also elsewhere
  - Will be used in ROCK-IT, project involving automation, robotics, remote access, AI, fast feed back.
  - EPICS

- BLISS

# Bluesky Tests

See, if Bluesky can deliver the Sardana functionality (very prliminarey)

https://hasyweb.desy.de/services/computing/blueskyDocu/blueskyDocu.html

What has been done so far

- Integrated Tango through Ophyd devices.
- Magic commands for spec syntax
- Integrated pyspMonitor for 0D, 1D graphics

The help of Will Smith (HZB) and colleagues from BNL is acknowledged.

Workshop at Soleil on Bluesky, Yves-Marie Abiven, August 2-3

# Sardana vs. Bluesky

CLI:
  Sardana: ipython, spec syntax
  BS: ipython, no spec syntax (can be implemented by magic commands)

Scripting engine
  Sardana: MacroServer/Macros, extra process
  BS: Plans/RunEngine/QueueServer
    The RunEngine executes messages yielded from plans
    There are standard plans and user-written plans

Device access
  Sardana: Pool
  BS: Ophyd, signals are class variables

Environment
  Sardana: MacroServer environment (ScanFile, ScanDir, MG, …)
  BS: (for the tests an environment, including MG, ScanDir, ScanFile, etc. has been created as a memorized attribute of a Bluesky Tango server)

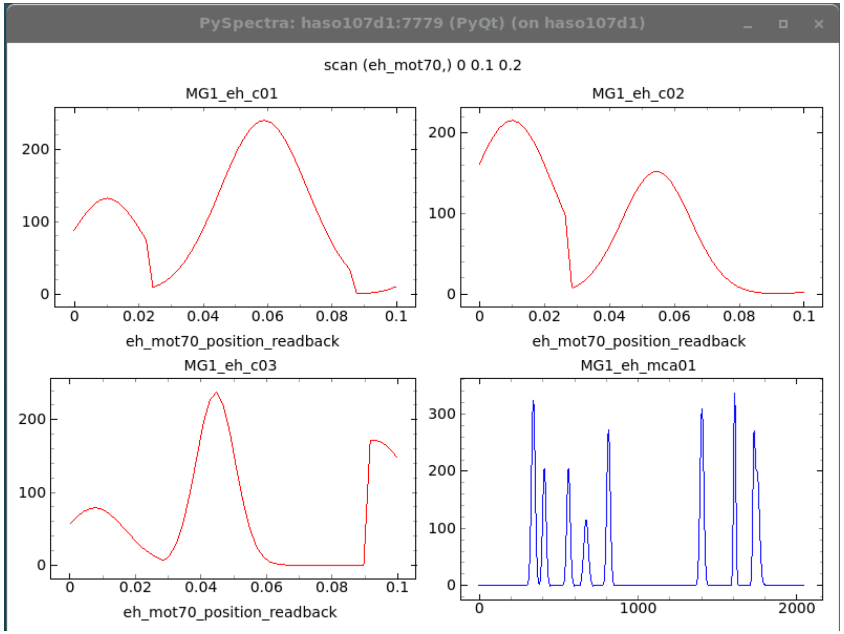
# Sardana vs. Bluesky

GUI
  Sardana: Taurus
  BS: (no problem)

Visualization
  Sardana: Door (magic)
  BS: DocHandler (callback handler)

Graphics:
  Sardana: Taurus, facility-specific apps.
  BS: matplotlib, 0D, (interface to pyspMonitor has been created)

Code injection:
  Sardana: hooks
  BS: per_step feature



Thanks for your attention