HZB BESSY II Synchrotron

Measurement Reports and Lab Upgrades at HZB

E. Rial on Behalf of HZB Undulator Group

IMMW23 – Bad Zurzach, Switzerland– 10.10.2024

A RICH HISTORY OF MEASUREMENT

Acknowledgements

HZB BESSY II Synchrotron

Members of the Undulator Group past and present

Atoosa Meseck	Carsten Kuhn	Stefan Grimmer
Oliver Reichel	Kiarash Karimi	Nasim Fallahi
Jürgen Bakos	Mario Strehlke	Florian Laube
Stefan Gottschlich	Guilherme Carraro Carella	Sebastian Knaack
Johannes Bahrdt	Winfried Frentrup	Christoph Rethfeldt

Overview

HZB BESSY II Synchrotron

UE51

Background, shimming and installation.

Upgrade Plans

Pulsed wire, In-vacuum Hall Bench, Helmholtz Coil.

Upcoming Projects

UE56-3, IVUE32, Cryo-APPLE.

Facilities

Parameter	BESSY II	MLS
Ring Circ.	240m	48m
Energy	1.7 GeV	105 – 630 MeV
Straights	16	4
Undulators	APPLE II: 8 Hybrid Ex-Vac: 4 CPMU: 1	Hybrid Ex-Vac: 1

UE51 Details

HZB BESSY II Synchrotron

Parameter	Value
ID Type	APPLE II
Moving Axes	4 (full polarisation control)
Period Length	51.3mm
Number of Periods	84
Minimum Gap	15.6mm
Peak Field	0.812 T(Vertical Field) 0.645 T(Helical Field) 0.552 T(Horizontal Field)
Minimum Energy	64 eV (Horizontal) 95 eV (Circular) 122 eV (Vertical)

UE51 Magnet Characterisation

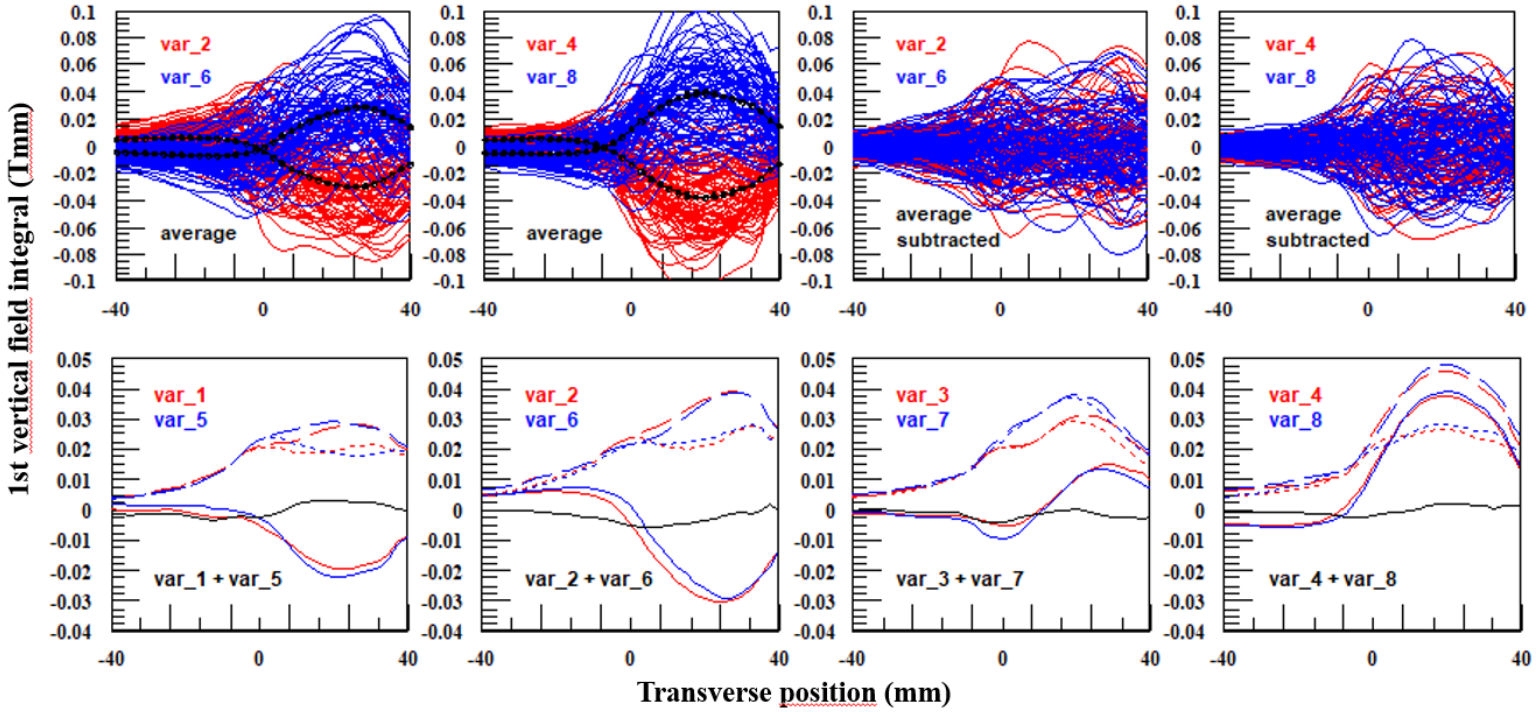
HZB BESSY II Synchrotron

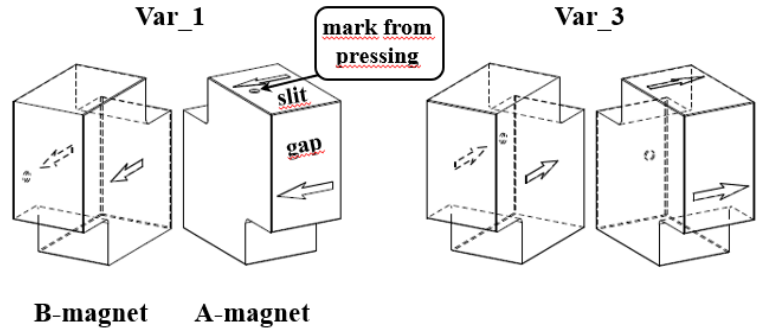
Systematic Errors

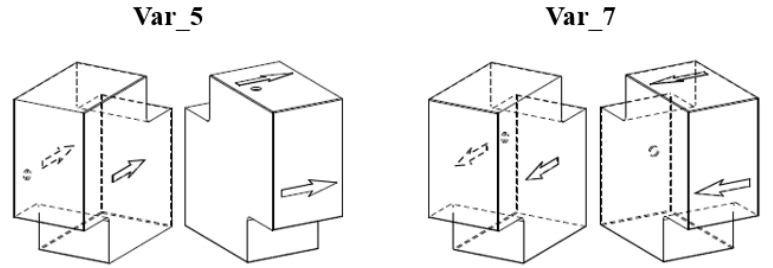
Errors arise systematically from the pressing and magnetisation of the magnets

Systematic pairing of differently pressed magnets correct these errors well

Improved sorting results







J. Bahrdt, Magnet Pair Sorting Strategy for the HZB-in-Vacuum APLLE II IVUE32– SRI2024 [JPCS]

Shimming Cycle

Measure

- Single scan trajectories saved to individual files
- Metadata and Data saved separately
- Organised by Folder
- Not possible to integrate undulator motion

Analyse

- Standalone analysis programme used
- 126 line input text file
- Multiple data input files
  - Expert users only!
  - Prone to user error…

Predict

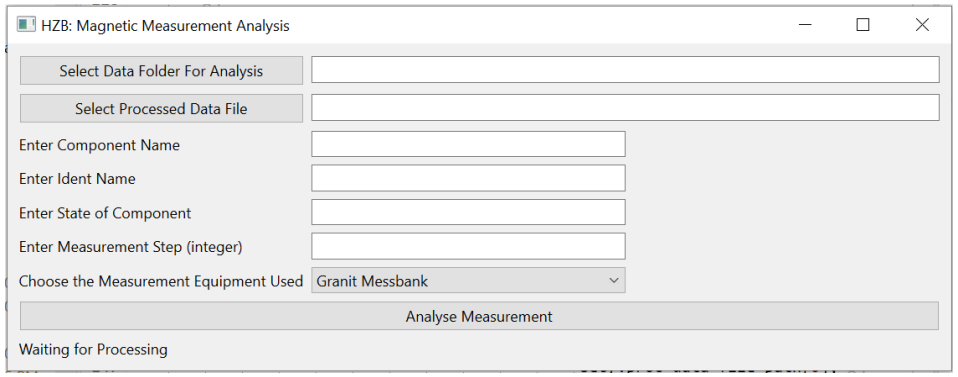
- Standalone shim programme
  - Virtual Shims, Iron-Shims, L-Shims, Magic Fingers
  - ASCII Data input (Metadata free)
  - ASCII Output (Metadata free)

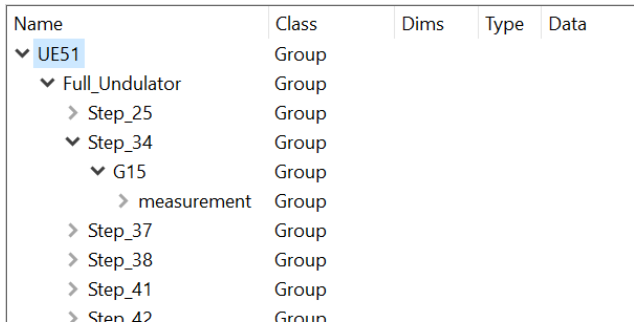
Apply

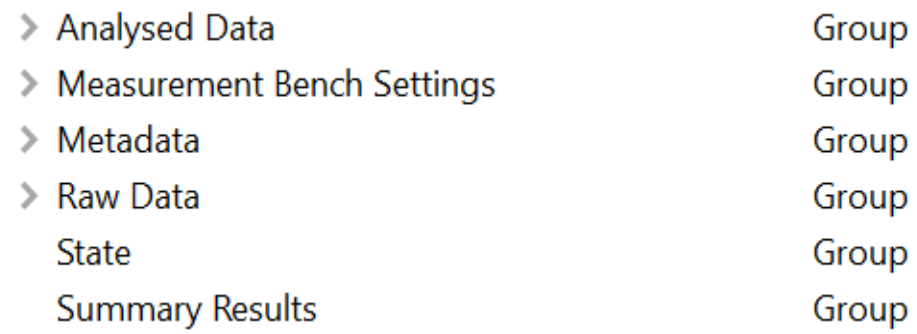
- Post-processing required to make outputs technician-readable

Process is SLOW!

Shimming Cycle







Measure

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- Not possible to integrate undulator motion

Analyse

- Simplified Analysis Process
- Incorporates Measurement (Meta)Data
- Analysis (Meta)Data combined
- HDF5 Format
  - Expert users only…

Predict

- Standalone shim programme
  - Virtual Shims, Iron-Shims, L-Shims, Magic Fingers
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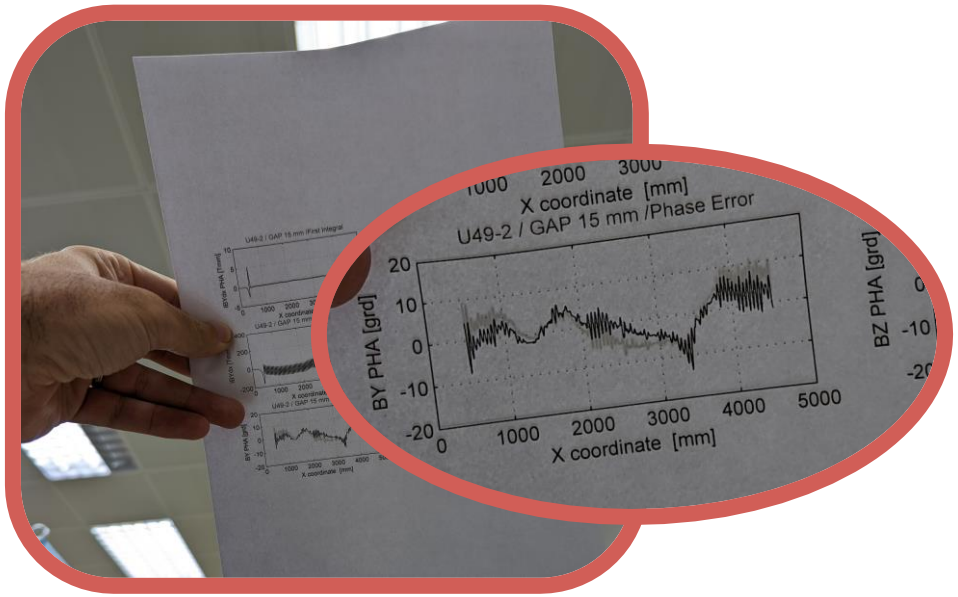
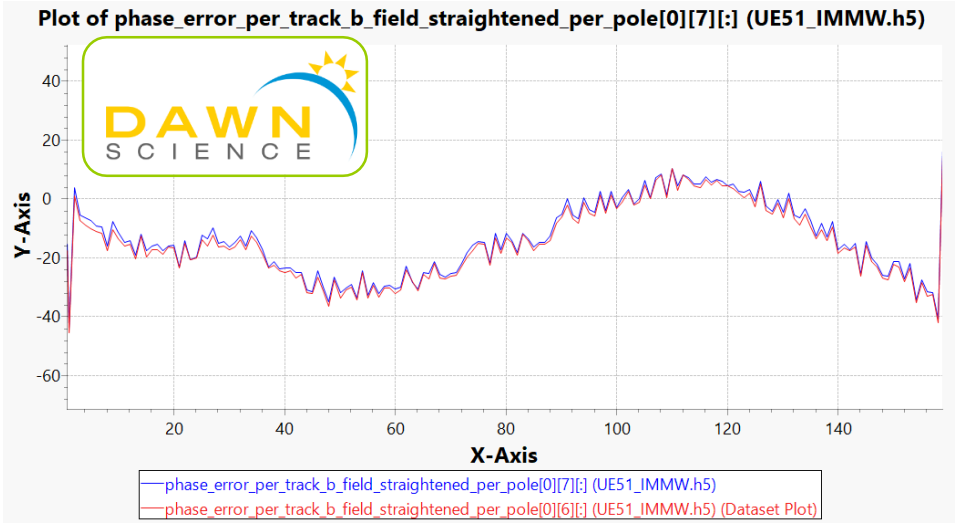
Shimming Cycle





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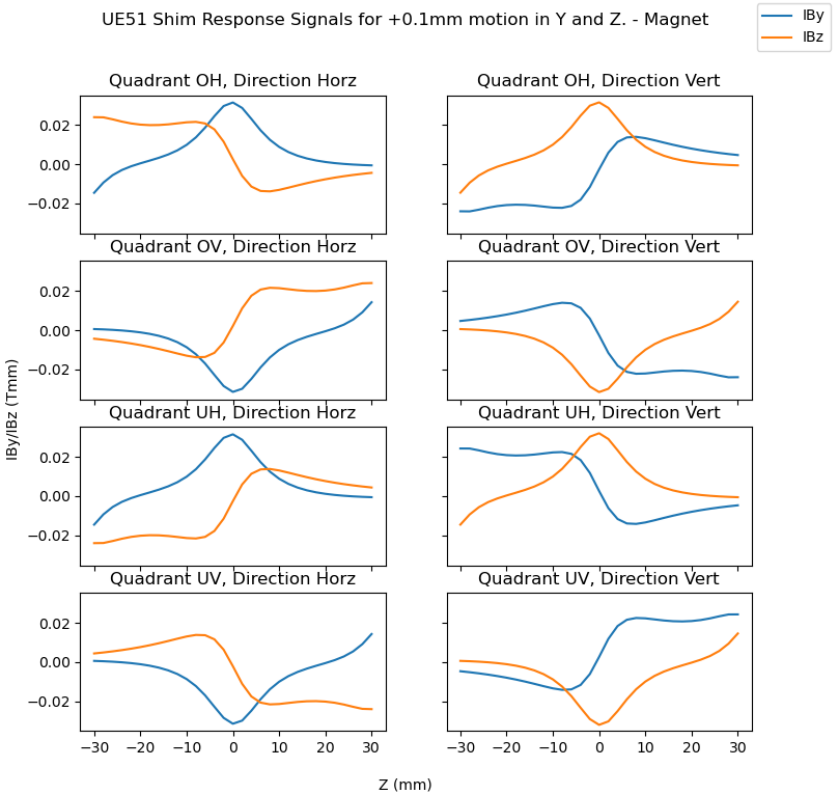
Apply

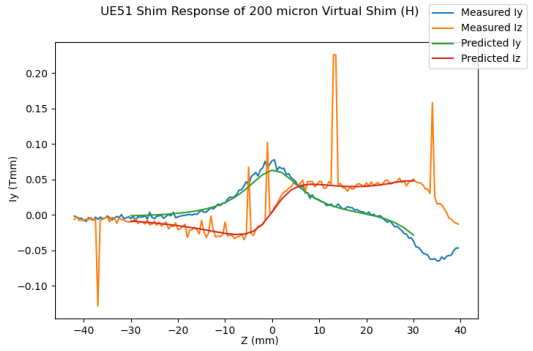
- Post-processing required to make outputs technician-readable

Process is SLOW!

Basham, M et al. (2015). J. Synchrotron Rad. 22, doi:10.1107/S1600577515002283 – dawnsci.org

Shimming Cycle





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- Not possible to integrate undulator motion

Analyse

- Simplified Analysis Process
- Incorporates Measurement (Meta)Data
- Analysis (Meta)Data combined
- HDF5 Format
  - Expert users only…

Predict

- Callable python functions
  - Virtual Shims, Magic Fingers
- HDF5 stores input and output

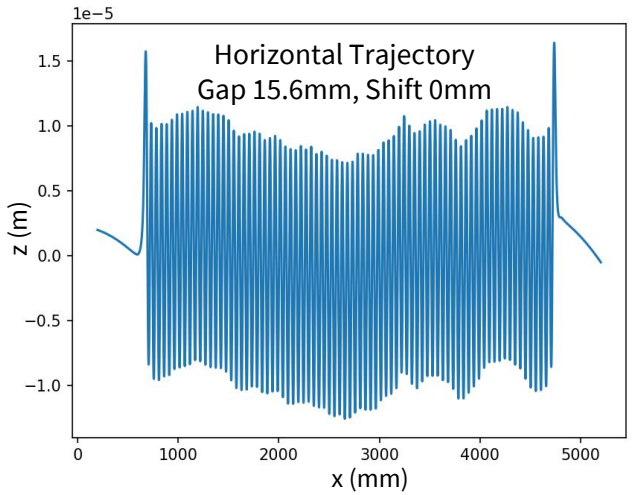
Apply

- Post-processing required to make outputs technician-readable

Process is SLOWER!

Final Measurements

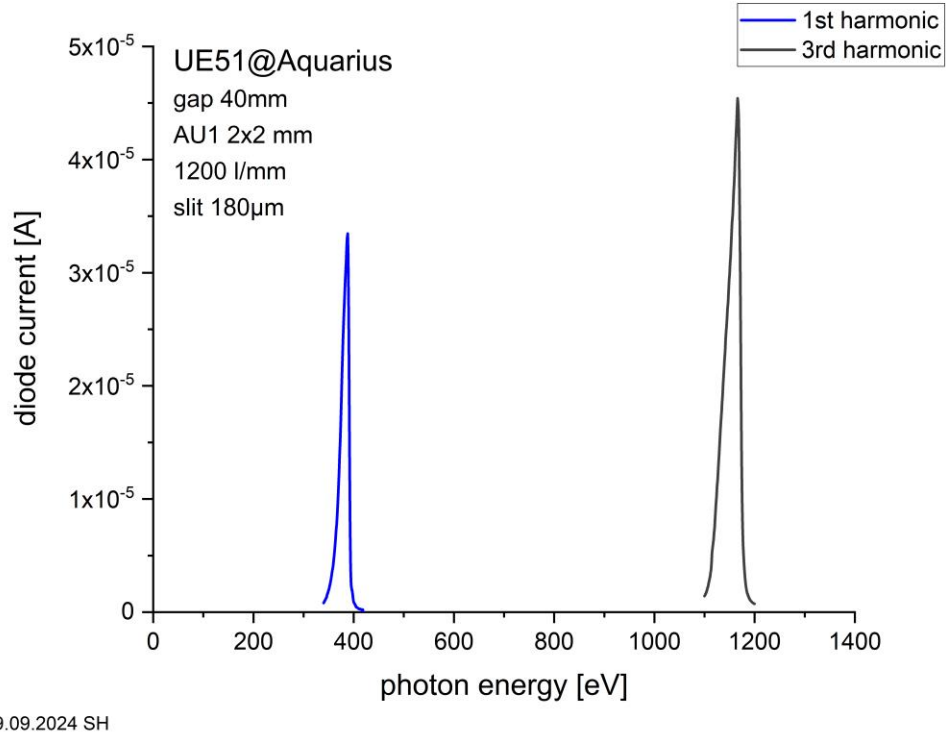
Property	Value
Minimum Gap	15.6mm
Peak Field	0.825 T (V), 0.542 (H)
Field Integral (and shift variation)	+/- 0.02 Tmm
Straightness	+/- 2 micron

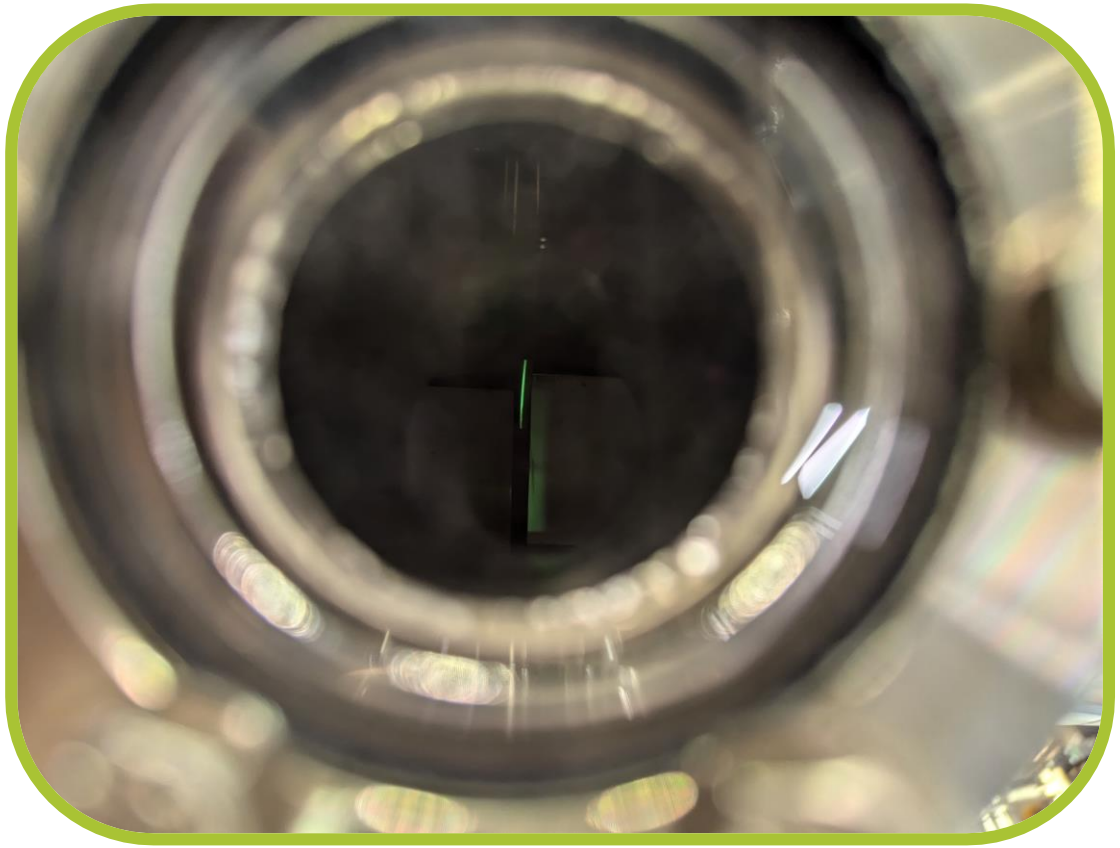


First Light

HZB BESSY II Synchrotron

Installed May 2024
First Light September 2024





First Light

HZB BESSY II Synchrotron

Installed May 2024

First Light September 2024

Assessment of goals

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Strategise

- Explore solution space
  - Software
  - Controls
  - Data Storage
  - Fail Fast Mentality

Execute

- Assess programme against milestones.
- Continue to provide measurements during development.
- Report progress at IMMW23

Plan

- Desired Outcomes
- Timescales
- Costs
- Staff

Resource

- Scientist/Engineer
- Motion Control Expert
- Structured Student Support

Pulsed Wire

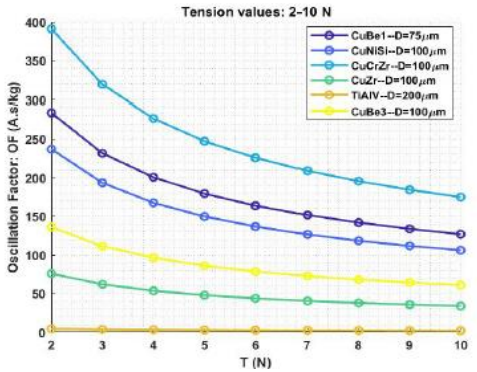
HZB BESSY II Synchrotron

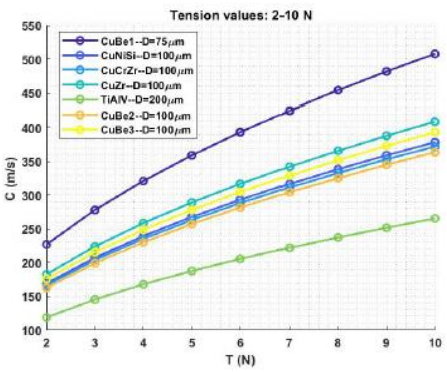
Small Aperture In-Vacuum Devices

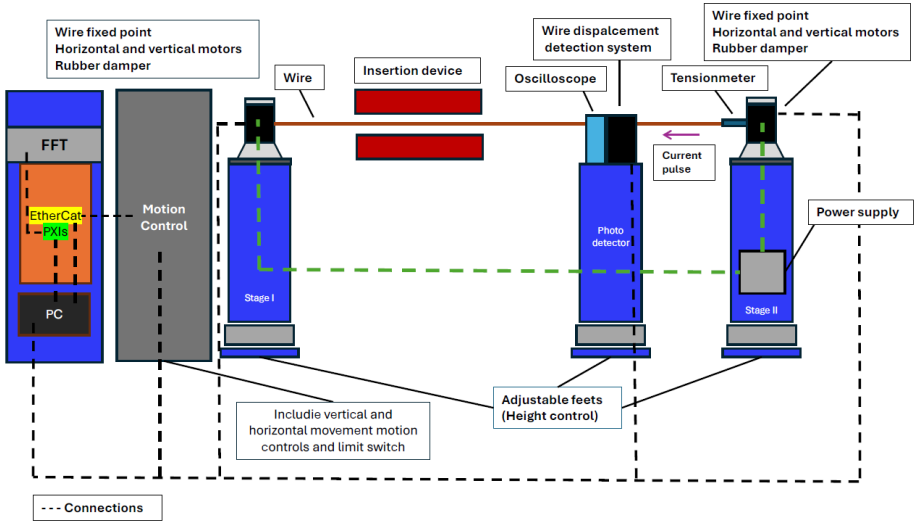
Investigations into wire properties

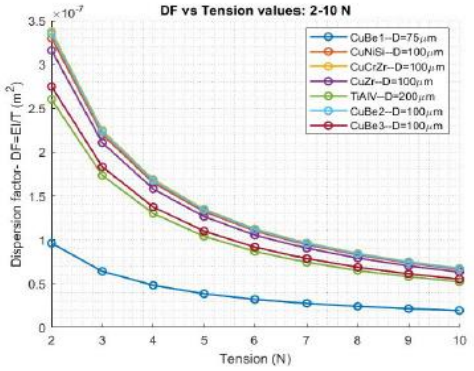
Hardware ready

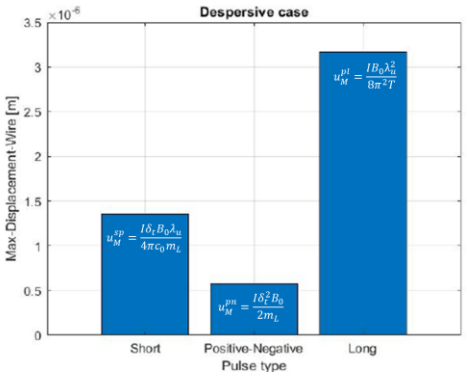
Control and measurement still to be developed.











N. Fallahi, Status of pulsed wire magnetic field measurement set-up at HZB/BESSY – SRI2024 [JPCS]

In Vacuum Bench Hall Probe

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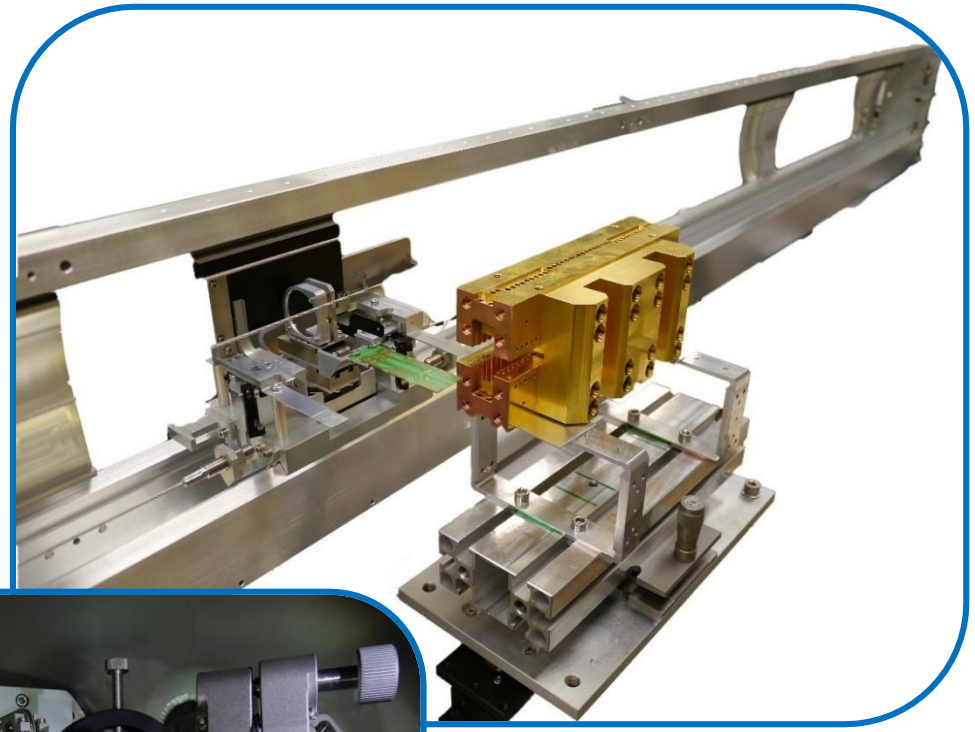
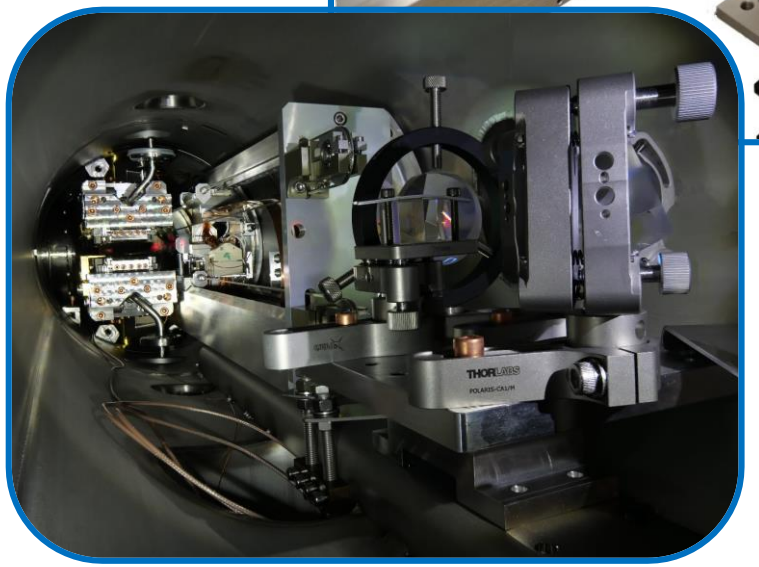
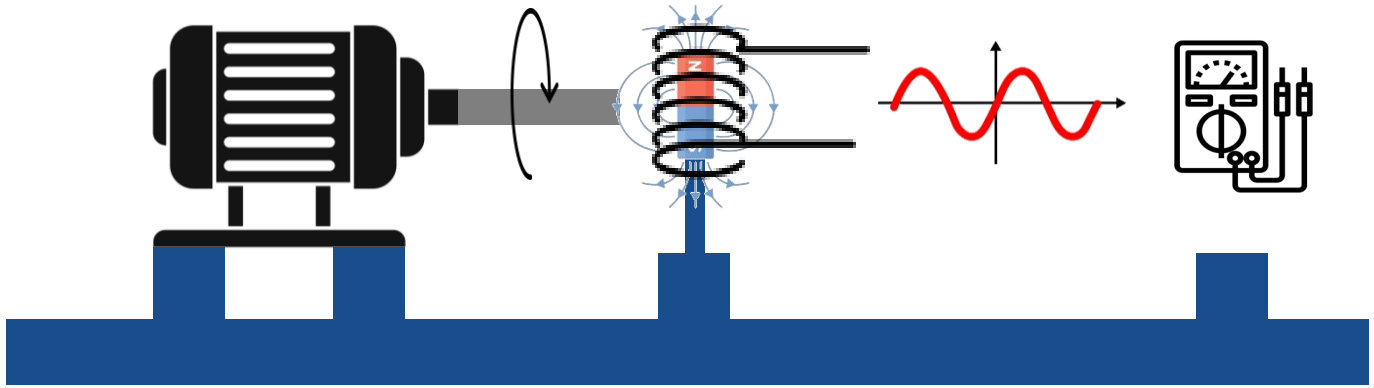
Goals 2024

- Improved position feedback
- Length Extension
- Improved Vacuum Compatibility



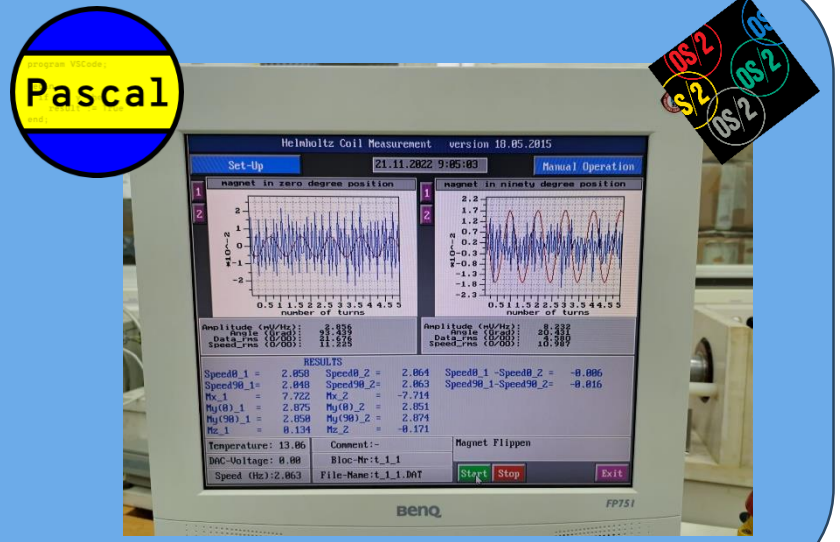


Helmholtz Coil Test Bench



Old System

- Obsolete Programming Language.
- OS/2 almost 24 years old.
- No technical support.
- Unfriendly outputs for analysis.



Helmholtz Coil Overview

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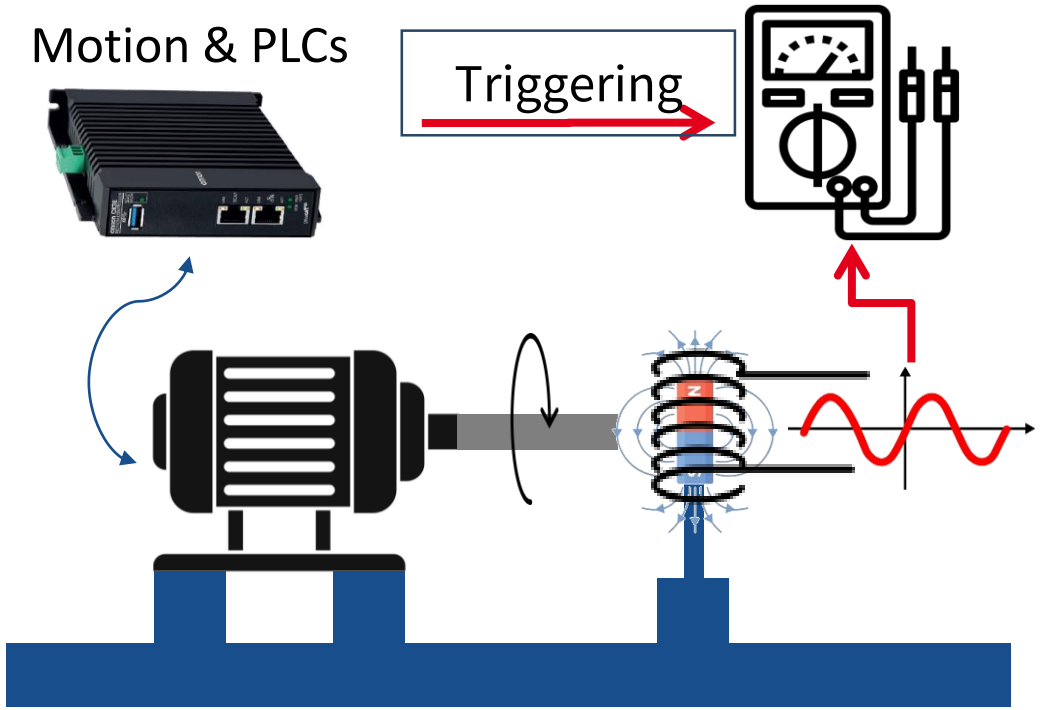
Hardware

Motion & PLCs

Triggering



Control System

PMAC IOC

DMM IOC

EPICS

Infrastructure

CI/CD

docker

User Interfaces

Support

SPHINX

HDF5

Courtesy of G. Carraro Carella

Status Equipment 2019

HZB BESSY II Synchrotron

Equipment	Hardware	Software
Hall Probe Measurement Bench	ANORAD Motion Control Agilent Voltmeter	PASCAL OS/2
Stretched Wire Bench	ANORAD Motion Control Agilent Voltmeter	PASCAL OS/2
Fixed Wire Bench	Berger Lahr (since 1996) Keithley Nanovoltmeter	PASCAL OS/2
Helmholtz Coils	SSB Antriebstechnik (<1996?) Agilent Voltmeter	PASCAL OS/2
In-Vacuum Hall Probe	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
In-Vacuum Stretched Wire	Controls Techniques Digitax Agilent Voltmeter	Labview Windows

Obsolescence and Technical Debt

Status Equipment 2022

HZB BESSY II Synchrotron

Equipment	Hardware	Software
Hall Probe Measurement Bench	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
Stretched Wire Bench	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
Fixed Wire Bench	Berger Lahr (since 1996) Keithley Nanovoltmeter	PASCAL OS/2
Helmholtz Coils	SSB Antriebstechnik (<1996?) Agilent Voltmeter	PASCAL OS/2
In-Vacuum Hall Probe	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
In-Vacuum Stretched Wire	Controls Techniques Digitax Agilent Voltmeter	Labview Windows

Obsolescence and Technical Debt

Status Equipment 2024

HZB BESSY II Synchrotron

Equipment	Hardware	Software
Hall Probe Measurement Bench	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
Stretched Wire Bench	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
Fixed Wire Bench	Berger Lahr (since 1996) Keithley Nanovoltmeter	PASCAL OS/2
Helmholtz Coils	Omron Power PMAC Agilent Voltmeter	EPICS/CSS Linux
In-Vacuum Hall Probe	Controls Techniques Digitax Agilent Voltmeter	Labview Windows
In-Vacuum Stretched Wire (+ Pulsed Wire Capability)	Controls Techniques Digitax Agilent Voltmeter	Labview Windows

Obsolescence and Technical Debt

Upcoming Projects

HZB BESSY II Synchrotron

UE56-3

Refurbish module of UE56-2

- Ex-Vacuum APPLE-II
- Repeat of SESAME work

IVUE32[1]

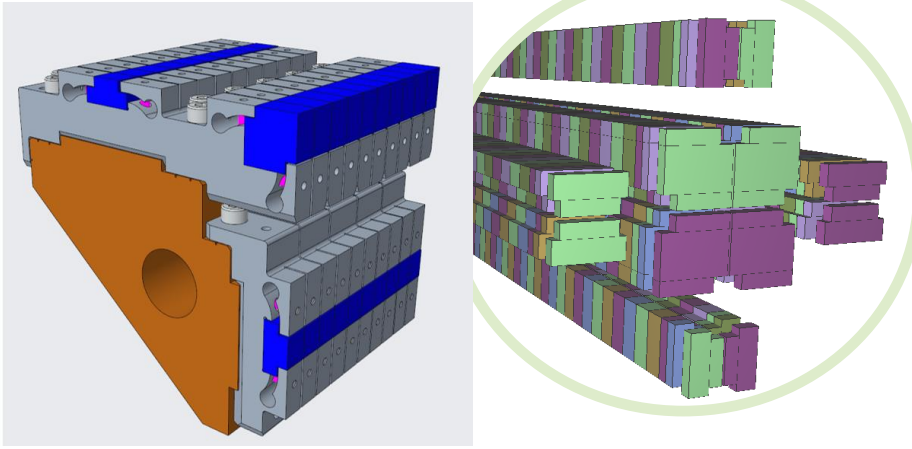
In-Vacuum APPLE-II Device

- 6mm minimum gap
- Clean assembly and measurement processes

Cryo-APPLE[2]

Cryogenic In-Vacuum APPLE Device

- 6 mm minimum gap
- ~1m length



Main Measurement Lab

- Continue Data Workflow Improvements
- Replace remaining obsolete equipment

In-Vacuum Hall Bench

- Improved position feedback
- Length Extension
- Improved Vacuum Compatibility

In-Vacuum Stretched Wire

- Integration of Pulsed Wire Measurement System

Summary

HZB BESSY II Synchrotron

Successes

UE51

- Built & Shimmed
- Installed & Integrated

Helmholtz Coil Control System

- Updated
- Ready for further roll out

Data analysis workflow

- Started…

Challenges

Measurement Facilities

- Clean measurement and assembly area

Measurement Equipment

- Upgrade of Fixed Wire Bench
- Revival of Pulsed Wire measurement system.
- Extension of In-Vacuum Hall Bench

Measurements

- Measurement of IVUE32 test structure.
- Initial measurements of IVUE32 components

Data Analysis Workflow

- Be able to report ‘Faster’

Postscript - Cybersecurity

HZB BESSY II Synchrotron

June 2023 Cyberattack

All IT infrastructure offline.

All official accounts disabled.

Does *anything* still work?

Postscript - Cybersecurity

HZB BESSY II Synchrotron

June 2023 Cyberattack

All IT infrastructure offline.
All official accounts disabled.

Recovery

BESSY II (storage ring) back within a couple of weeks
Beamlines restored after 13 months
Relatively rapid return to measurement possibilities due to Disk Images of measurement machines
Software/Modelling relatively quick to recover due to 'non official' backups – personal GitHub repos/non HZB repos.

Ongoing difficulties

Re-arrangement of internal IT network infrastructures has eliminated useful tools such as remote desktop.

- Some tools slowly coming back – NX, GOAT (Access via browser)

Data transfer is more difficult.
Official in-house repositories unavailable to external networks

Recommendations

Take cybersecurity seriously!
Wargame… what would happen in your group if all access to company systems was removed?

J. Viefhaus, Cybersecurity efforts undertaken at BESSY II– SRI2024 [JPCS]