

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

Members of the Undulator Group past and present

Atoosa Meseck

Oliver Reichel

Jürgen Bakos

Stefan Gottschlich

Johannes Bahrtdt

Carsten Kuhn

Kiarash Karimi

Mario Strehlke

Guilherme Carraro Carella

Winfried Frentrup

Stefan Grimmer

Nasim Fallahi

Florian Laube

Sebastian Knaack

Christoph Rethfeldt

Overview

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



BESSY II



UE51 Details

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)



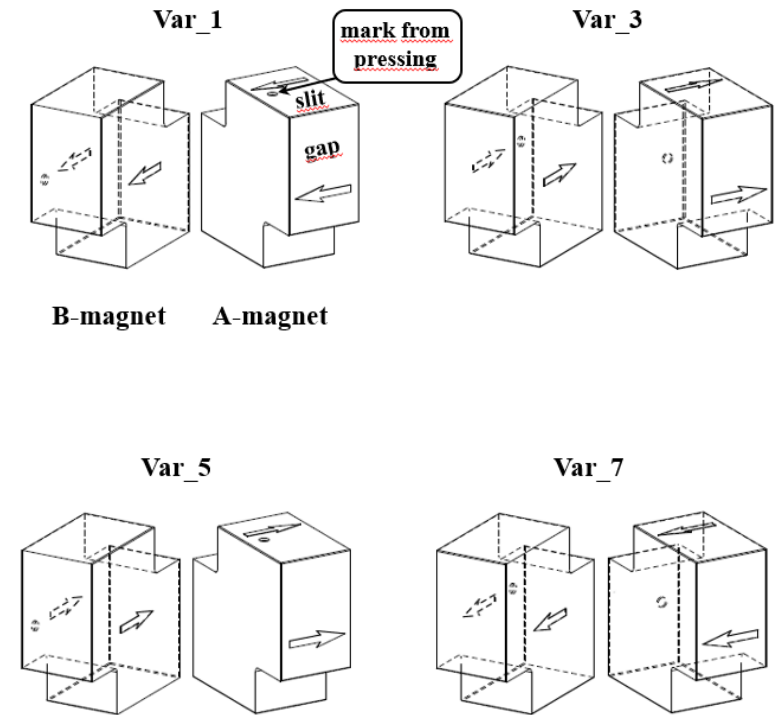
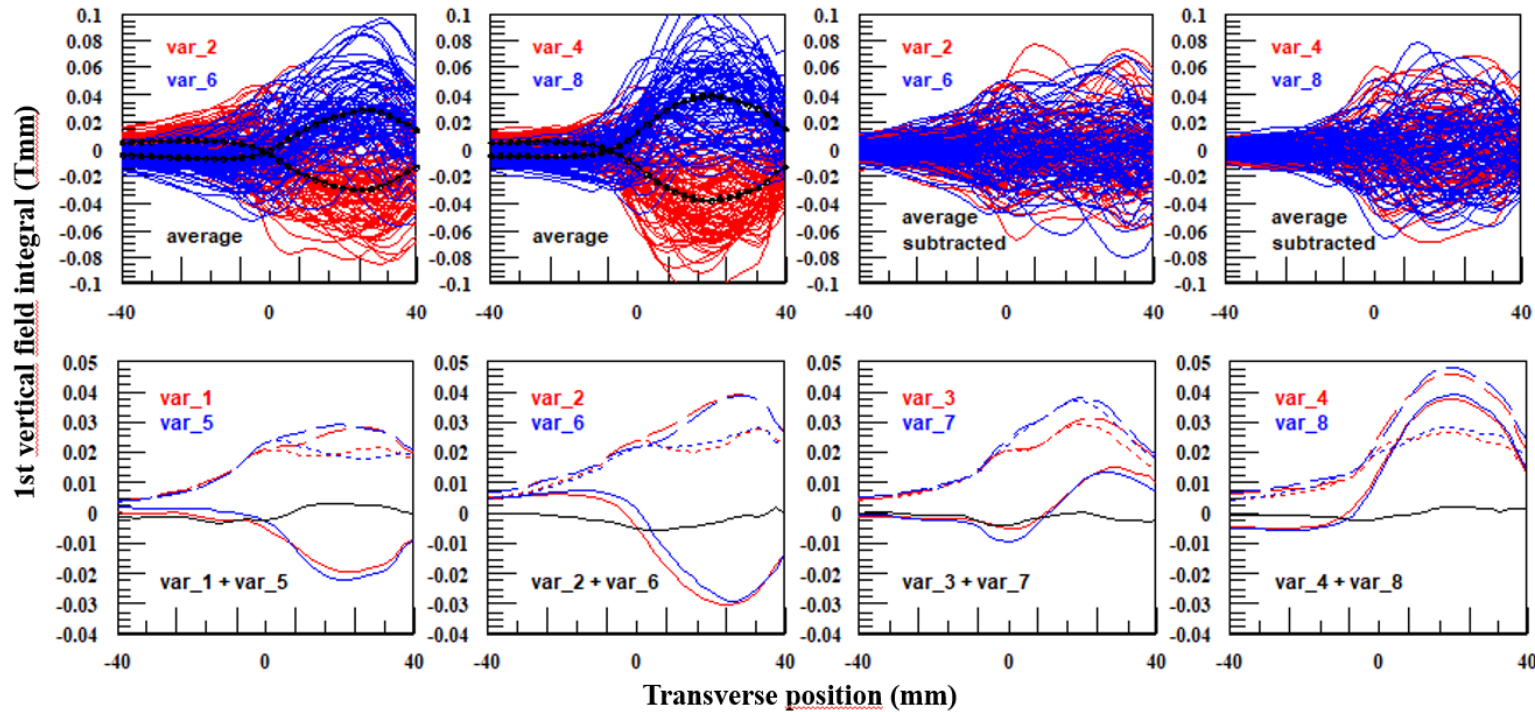
UE51 Magnet Characterisation

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. Bahrtdt, Magnet Pair Sorting Strategy for the HZB-in-Vacuum APLE II IVUE32- SRI2024 [JPCS]

Shimming Cycle

HZB: Magnetic Measurement Analysis

Select Data Folder For Analysis:

Select Processed Data File:

Enter Component Name:

Enter Ident Name:

Enter State of Component:

Enter Measurement Step (integer):

Choose the Measurement Equipment Used: **Granit Messbank** (dropdown)

Analyse Measurement

Waiting for Processing

Name	Class	Dims	Type	Data
UE51	Group			
Full_Undulator	Group			
Step_25	Group			
Step_34	Group			
G15	Group			
measurement	Group			
Step_37	Group			
Step_38	Group			
Step_41	Group			
Step_42	Group			
Analysed Data	Group			
Measurement Bench Settings	Group			
Metadata	Group			
Raw Data	Group			
State	Group			
Summary Results	Group			

Measure

- Single scan trajectories saved to individual files
- Metadata and Data saved separately
- Organised by Folder
- 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
- ASCII Data input (Metadata free)
- ASCII Output (Metadata free)

Apply

- Post-processing required to make outputs technician-readable

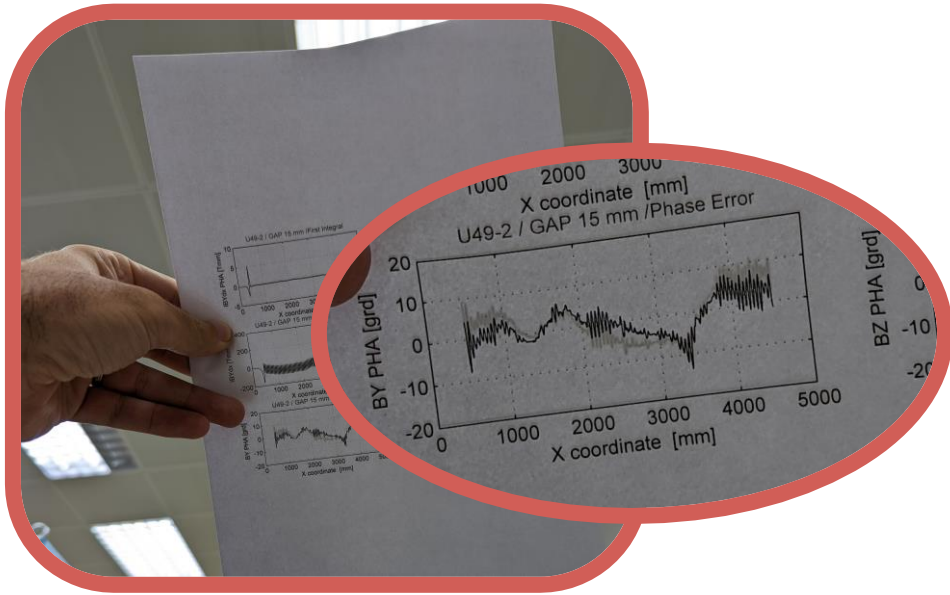
Process is SLOW!

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Shimming Cycle



Measure

- Single scan trajectories saved to individual files
- Metadata and Data saved separately
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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...

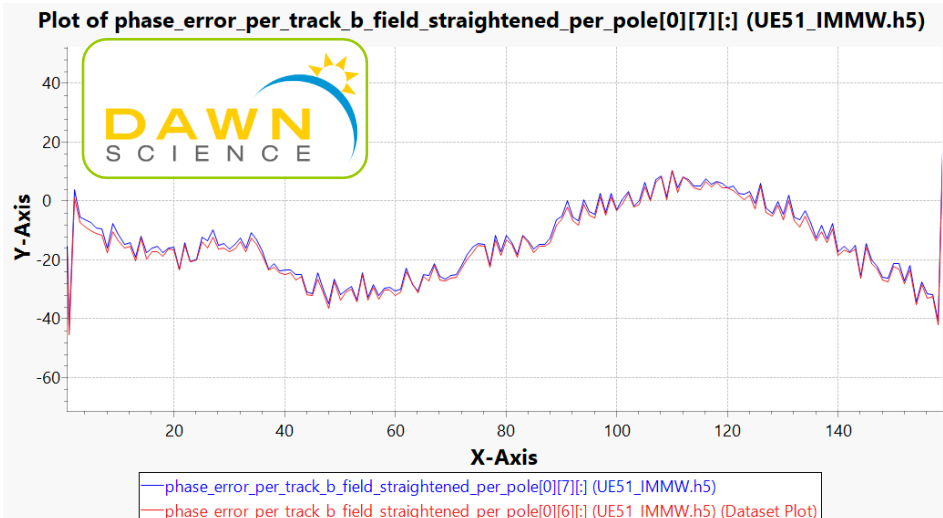
Predict

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

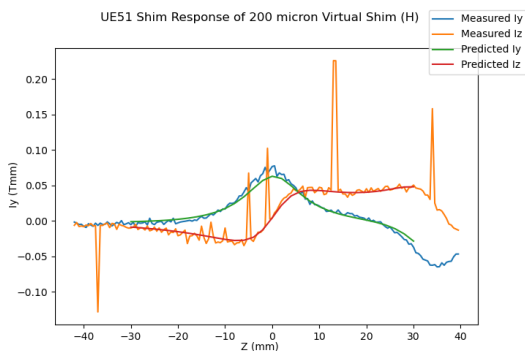
Apply

- 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



Measure

- Single scan trajectories saved to individual files
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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

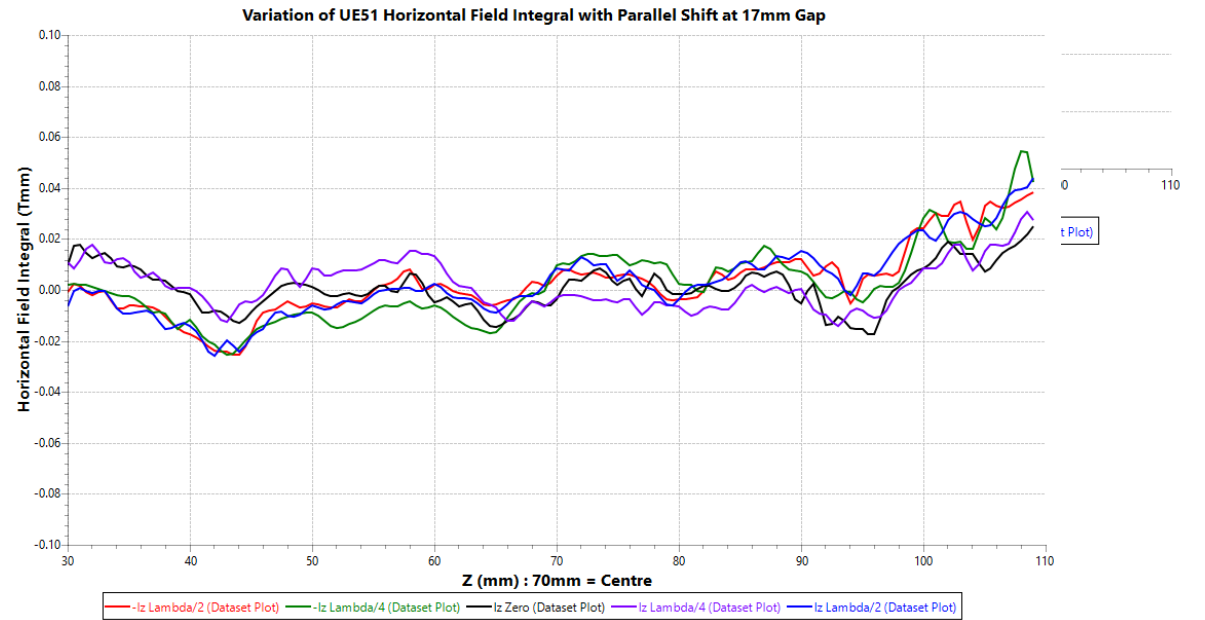
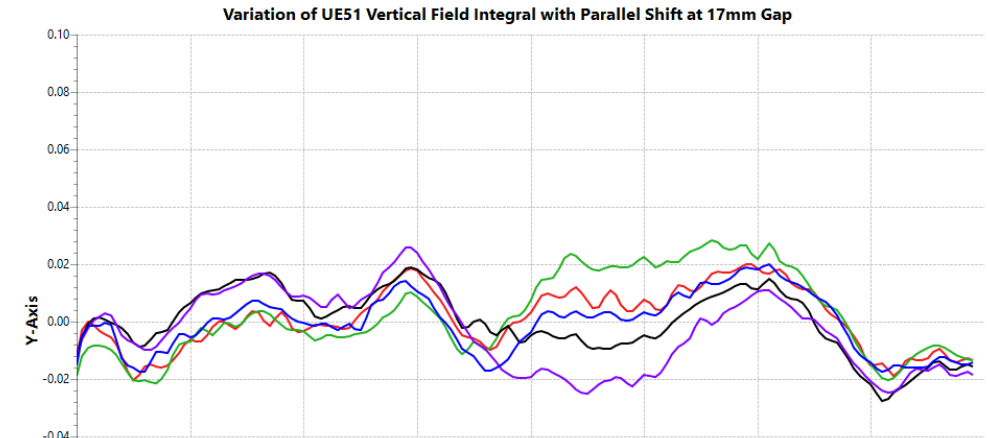
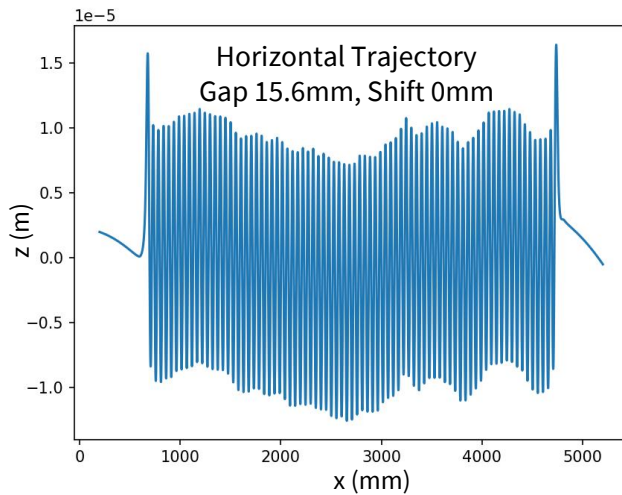
Apply

- Post-processing required to make outputs technician-readable

Process is SLOWER!

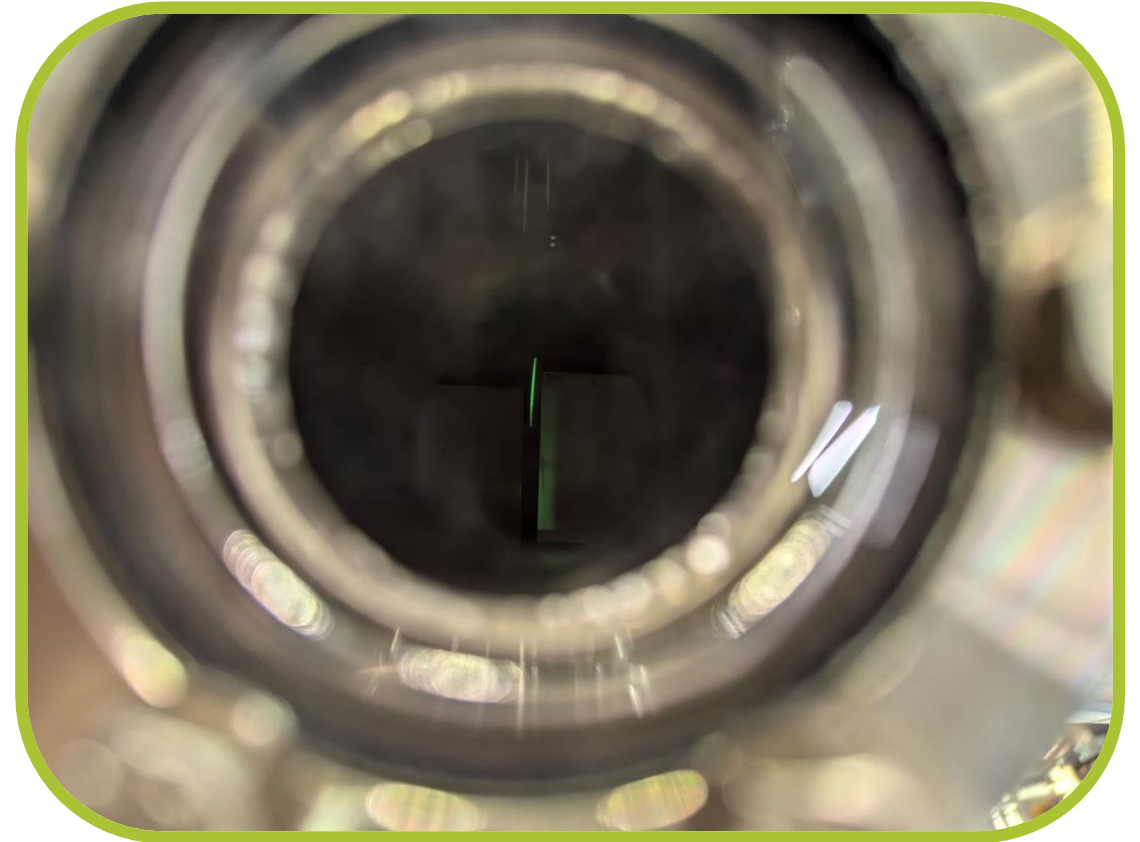
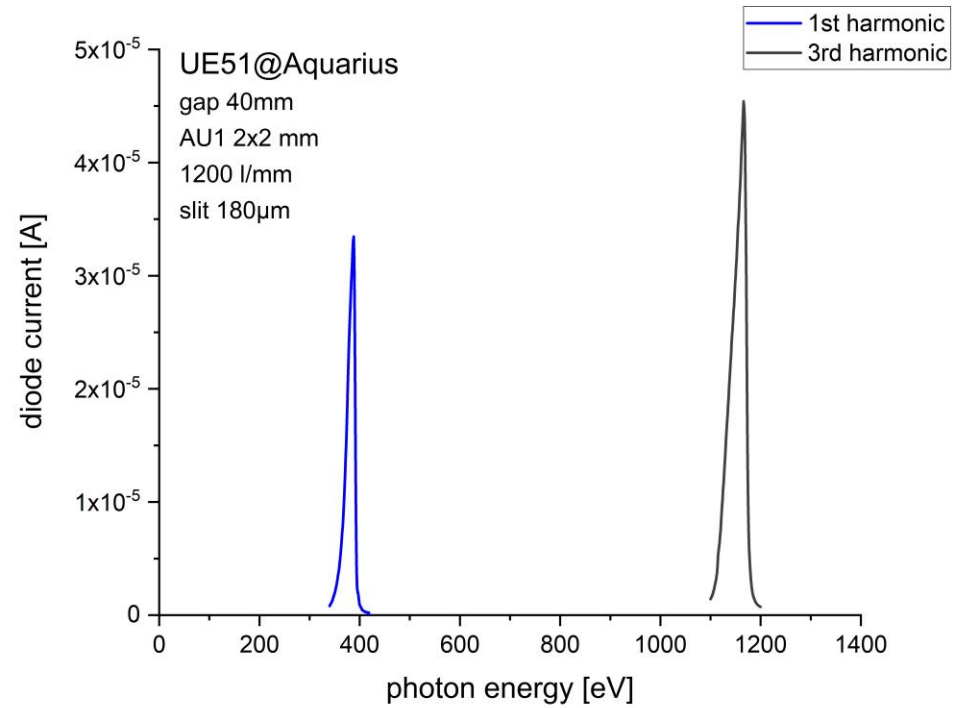
Final Measurements

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



Installed May 2024

First Light September 2024



19.09.2024 SH

First Light

Installed May 2024

First Light September 2024



Assessment of goals



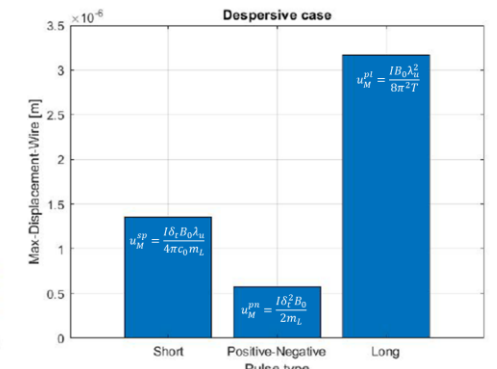
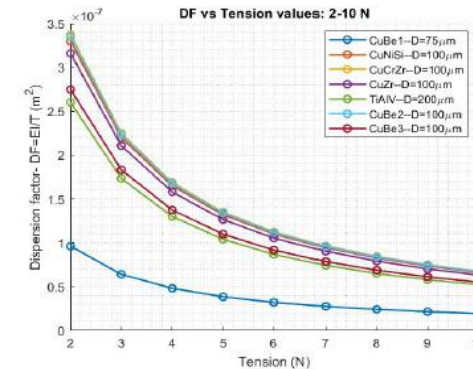
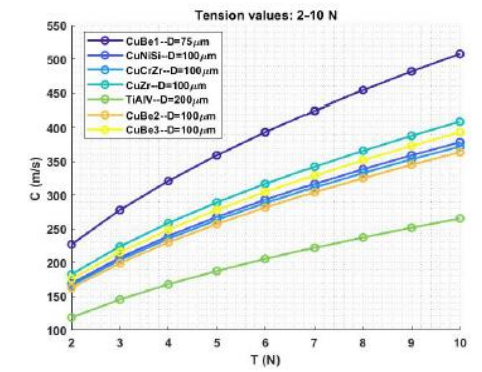
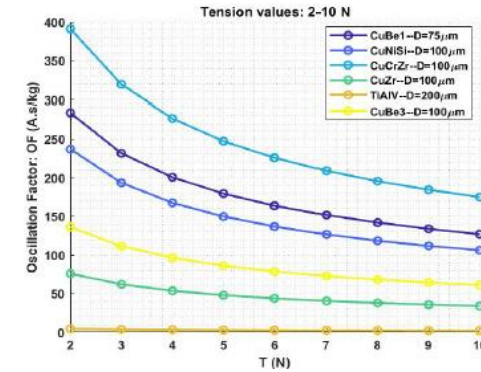
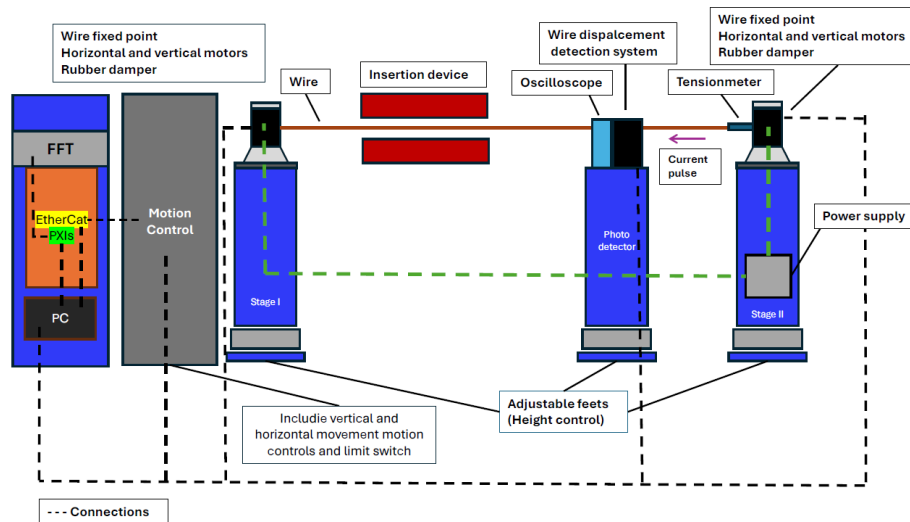
Pulsed Wire

Small Aperture In-Vacuum Devices

Investigations into wire properties

Hardware ready

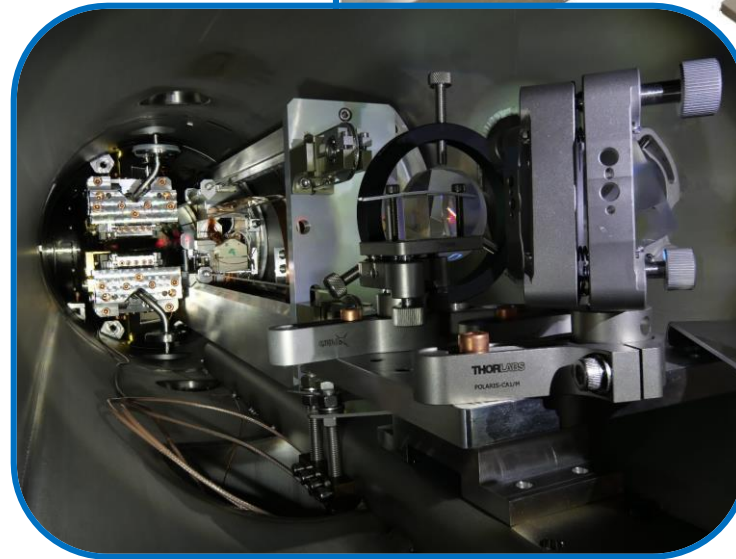
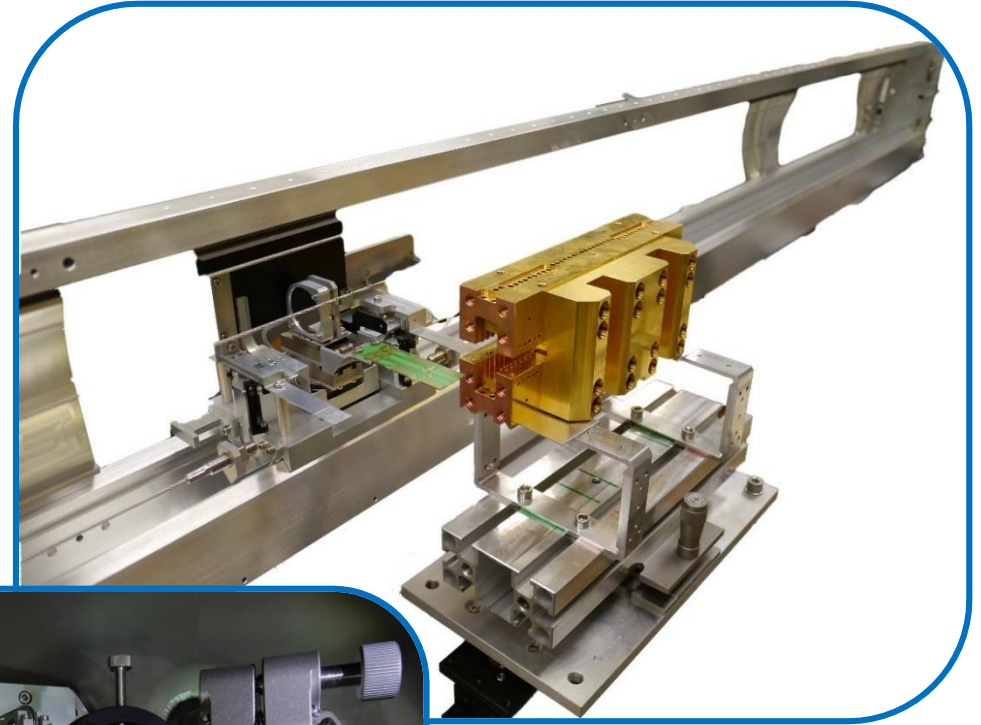
Control and measurement still to be developed.

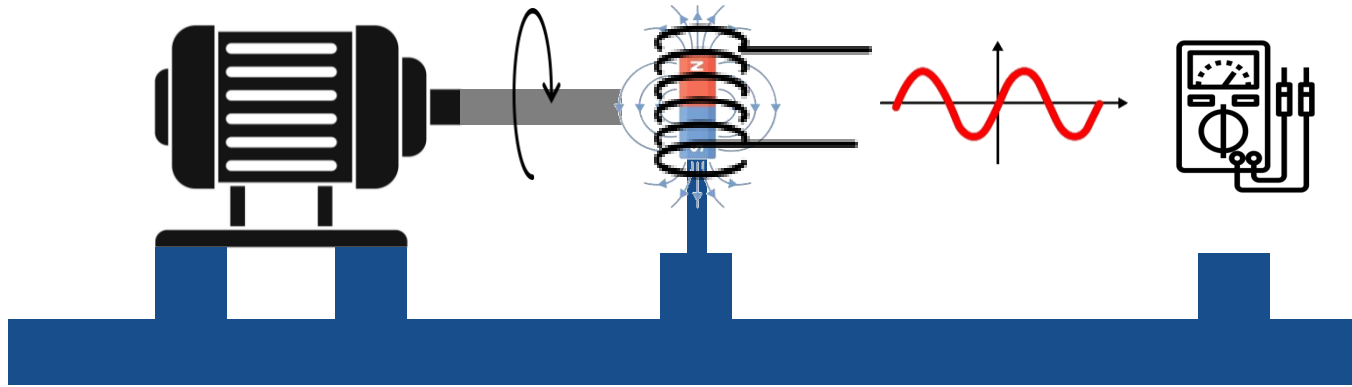


N. Fallahi, Status of pulsed wire magnetic field measurement set-up at HZB/BESSY – SRI2024 [JPCS]

Goals 2024

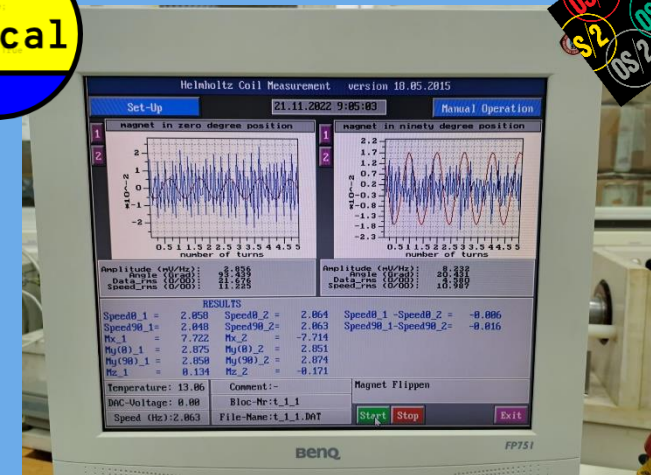
- Improved position feedback
- Length Extension
- Improved Vacuum Compatibility





Old System

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

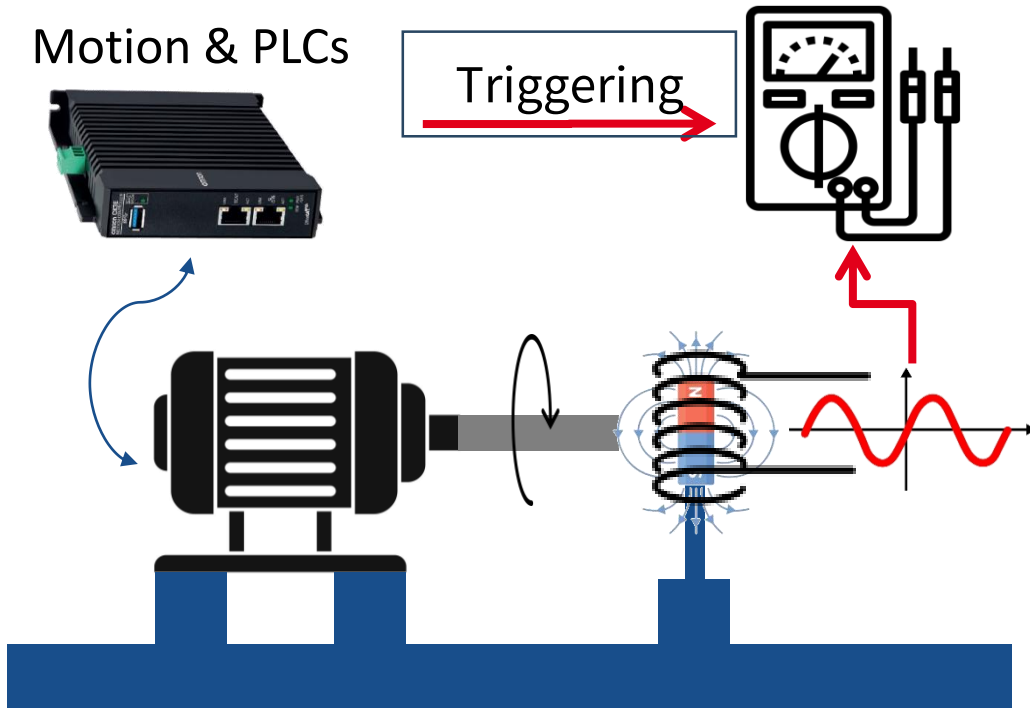


Helmholtz Coil Overview

Hardware

Motion & PLCs

Triggering

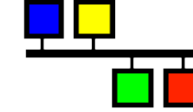


Control System

PMAC IOC

DMM IOC

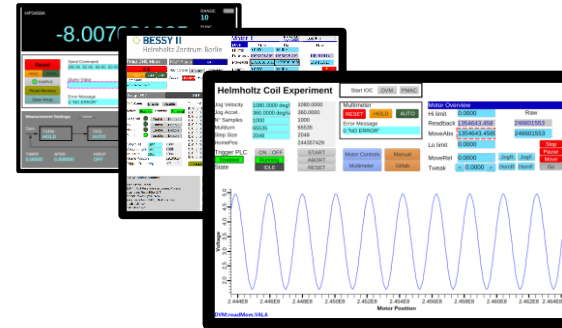
EPICS



Infrastructure



User Interfaces



Support



Courtesy of G. Carraro Carella

Status Equipment 2019

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

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

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

UE56-3

Refurbish module of UE56-2

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



IVUE32¹

In-Vacuum APPLE-II Device

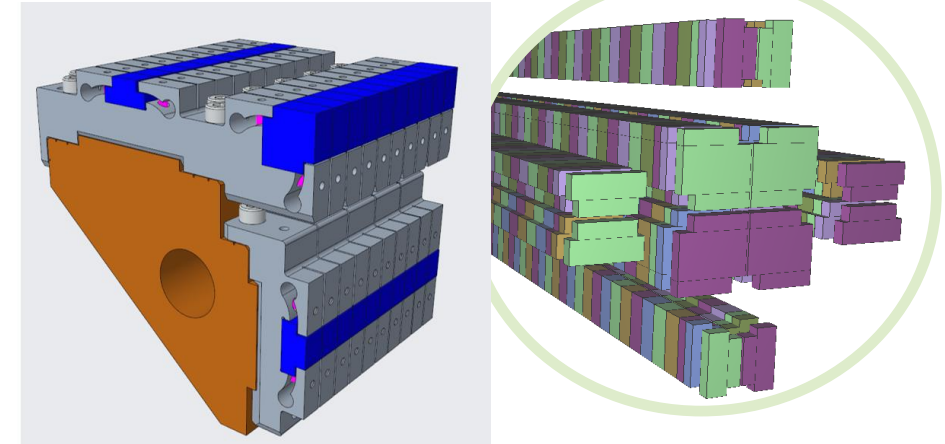
- 6mm minimum gap
- Clean assembly and measurement processes



Cryo-APPLE²

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

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

June 2023 Cyberattack

All IT infrastructure offline.

All official accounts disabled.

Does *anything* still work?



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]