

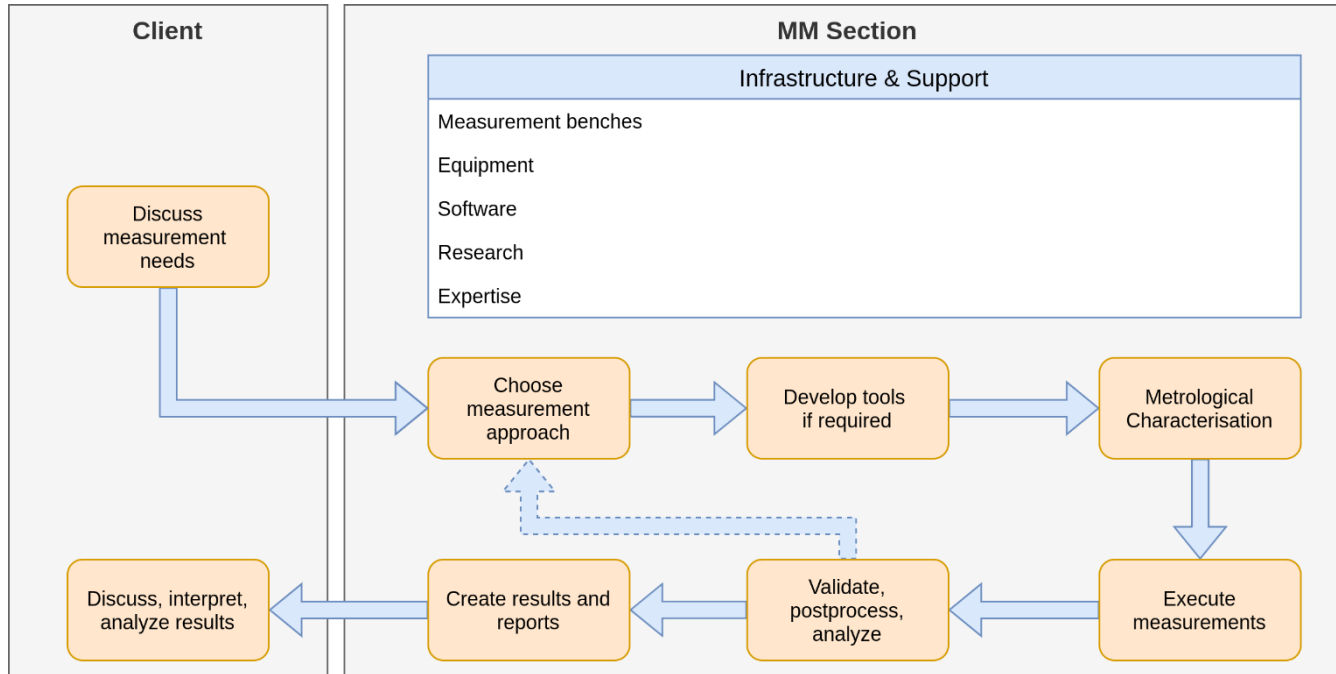
Magnetic Measurement Framework for Fully Traceable Measurements

Matthias Bonora, Marco Buzio, Lucio Fiscarelli, Carlo Petrone, Stephan Russenschuck

Outline

- MM needs systems
- Measurement flow
- Flexible Framework for Magnetic Measurements
- Processing
- Analysis / Results

MM Value Shop



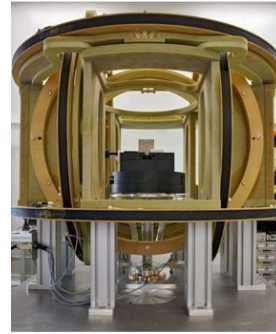
Magnetic Measurement Systems



Rotating coil systems



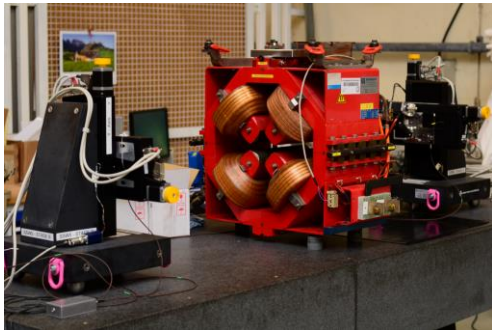
Ring-Sample
Permeameter



Helmholtz
coils



3D mapper

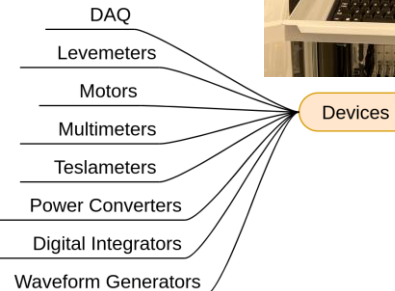
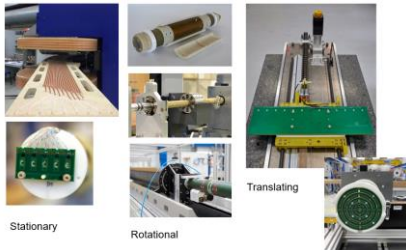


Stretched wire systems

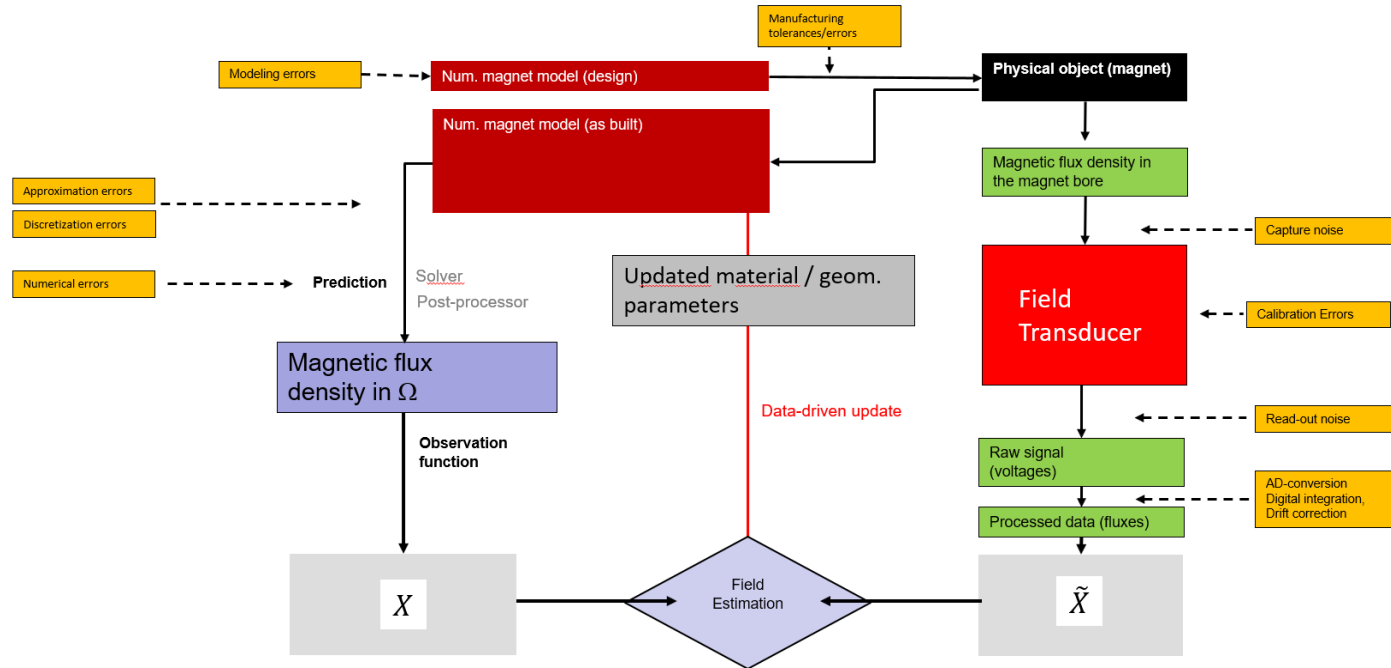
Translating Fluxmeter



Magnetic Measurement Systems

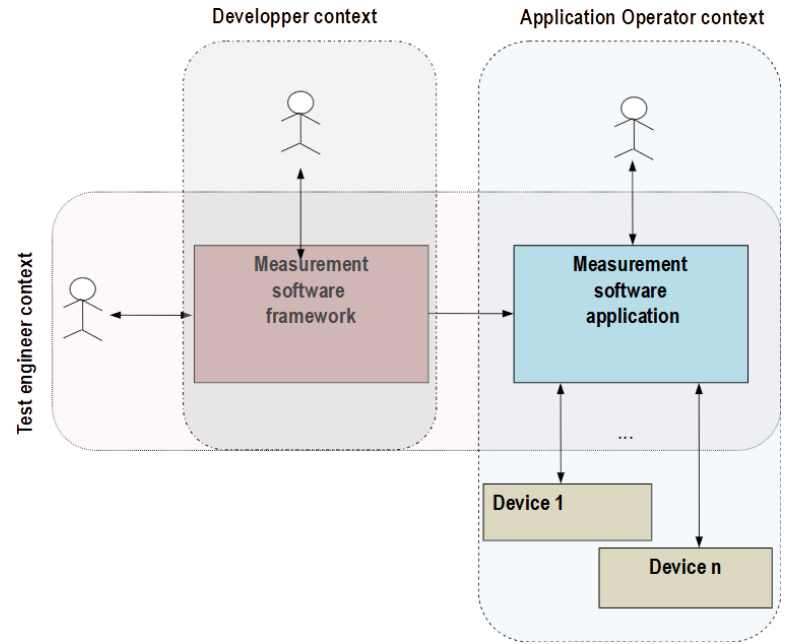


Merge Measurements and Simulations



Magnetic Measurement Roles

- Different roles
 - Development
 - Script development
 - Operation



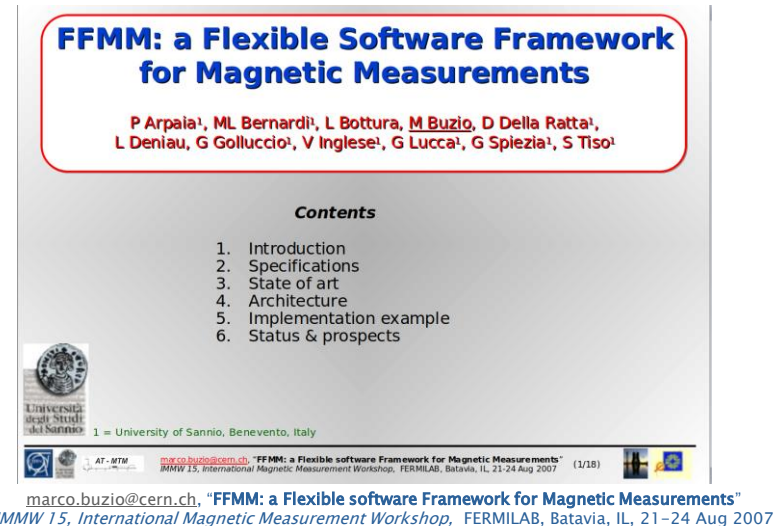
MM Software Requirements

- Different measurement benches and types
- Similar, yet different acquisition systems
- Different sensors and actuators
- Different actors of usage
- Measurement data storage and retrieval
- Postprocessing and analysis

- → Need for an efficient software platform as base of operations

A Flexible Framework for Magnetic Measurements

- Idea for a software framework for magnetic measurements
- Reusable
 - Easy to implement small independent blocks
 - Blocks are reusable when needed
- Flexible
 - Easy to write measurement applications
 - Still full control and extendibility






FFMM: a Flexible Software Framework for Magnetic Measurements

P Arpaia¹, M.L. Bernardi¹, L. Bottura, M. Buzio, D. Della Ratta¹, L. Deniau, G. Golluccio², V. Inglese¹, G. Lucca¹, G. Spiezia¹, S. Tiso¹

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1. Introduction
2. Specifications
3. State of art
4. Architecture
5. Implementation example
6. Status & prospects

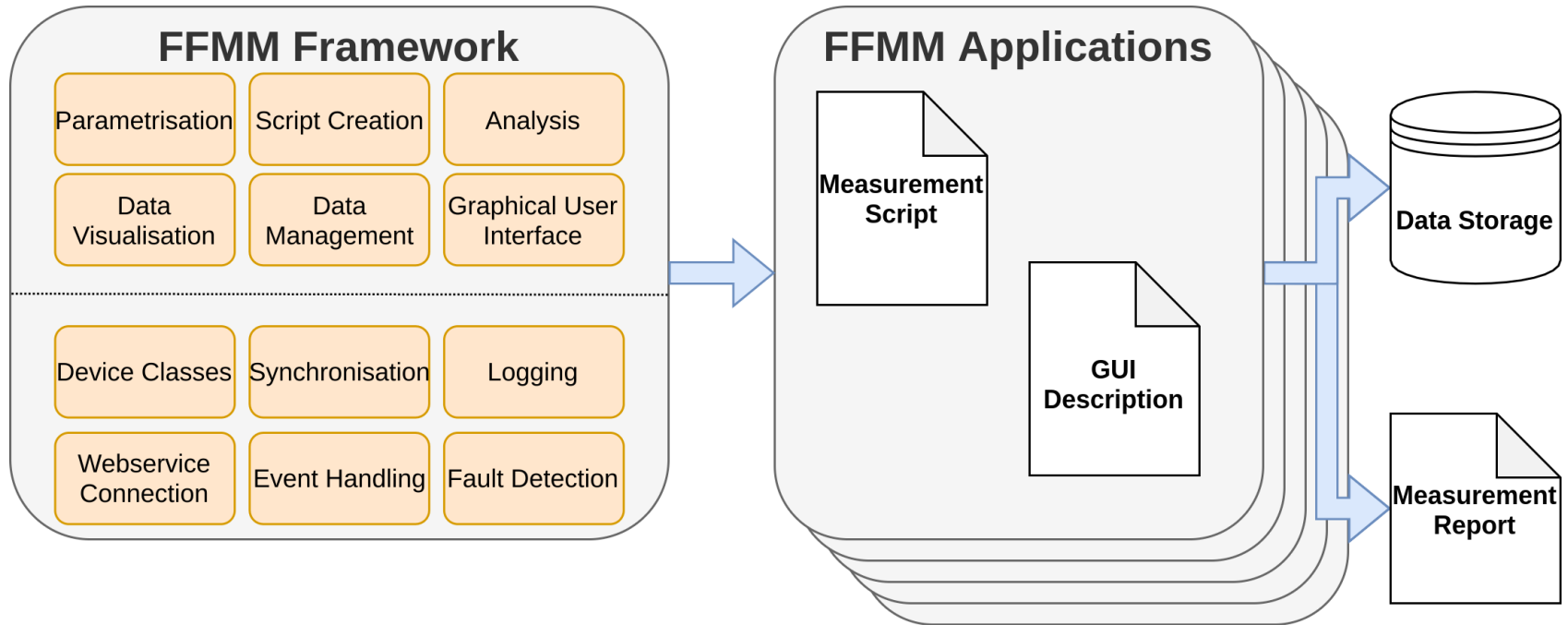
 UNIVERSITÀ degli STUDI del SANNIO
1 = University of Sannio, Benevento, Italy

 AT-NTM  marco.buzio@cern.ch "FFMM: a Flexible software Framework for Magnetic Measurements" (1/18)
IMMW 15, International Magnetic Measurement Workshop, FERMI LAB, Batavia, IL, 21-24 Aug 2007

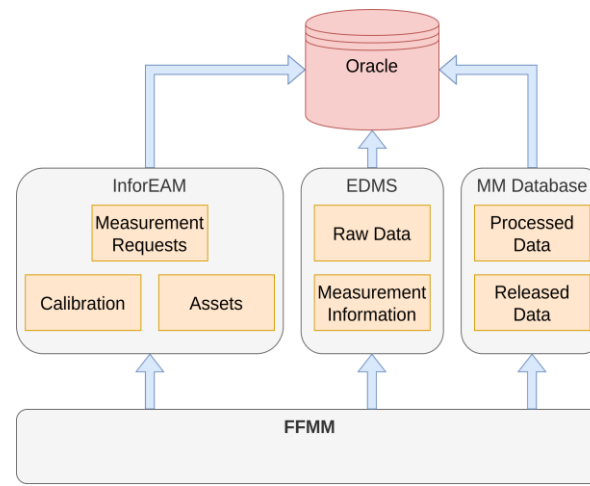
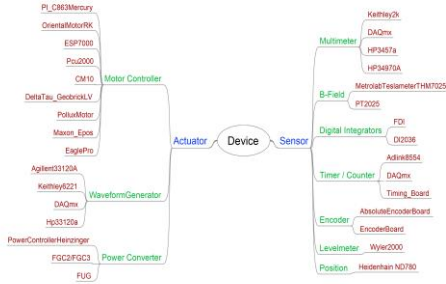
marco.buzio@cern.ch, "FFMM: a Flexible software Framework for Magnetic Measurements"
IMMW 15, International Magnetic Measurement Workshop, FERMI LAB, Batavia, IL, 21-24 Aug 2007

A software framework, in computer programming, is an abstraction in which common code, providing generic functionality, can be selectively overridden or specialized by user code for providing specific functionalities.

A Flexible Framework for Magnetic Measurements



FFMM: Components



#Script = Techdemo 2

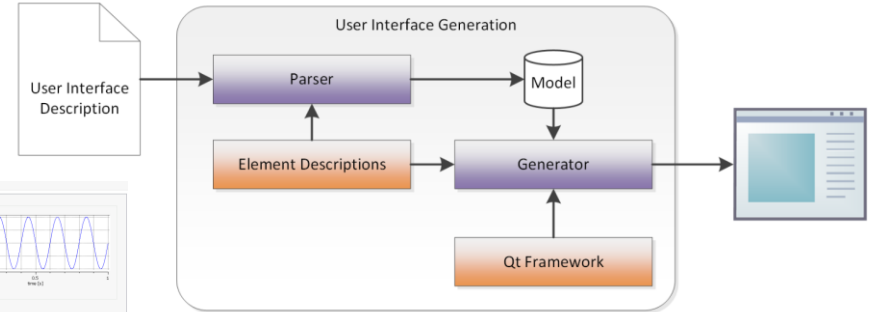
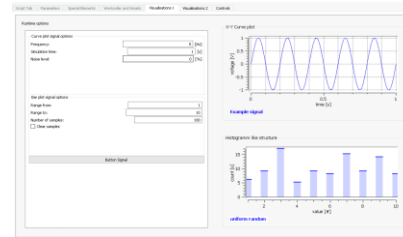
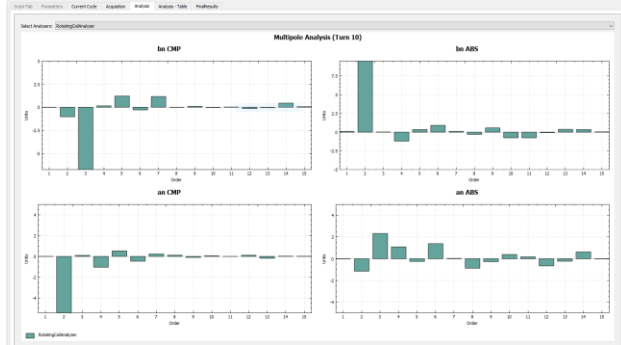
grouping = Group Groups
grouping.description = Text "Used to group a list of Par

grouping.check = Group "Checkable Groups" checkable
grouping.check.description = Text "Checkable groups have

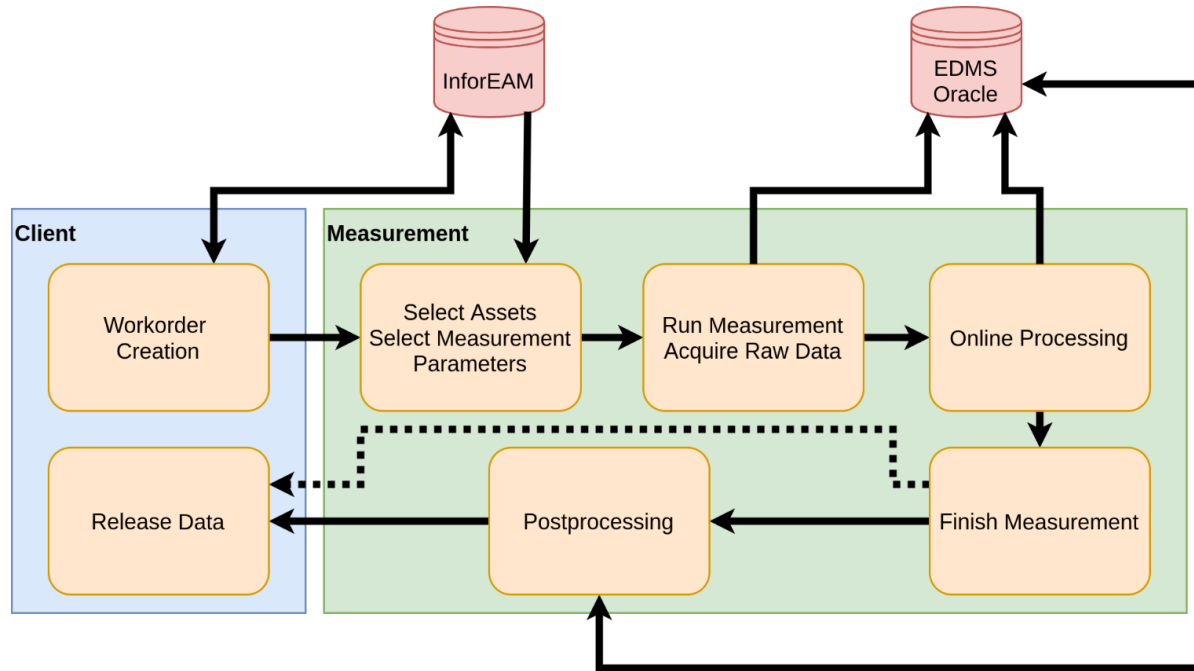
grouping.flat = FlatGroup "A flat group"
grouping.flat.name = Text Flatgroup
grouping.flat.description = Text "A FlatGroup has no vi

grouping.select = ComboGroup "Combo group" checkable
grouping.select.sub1 = FlatGroup "Subgroup 1"
grouping.select.sub1.description = Text "Combo groups s"
grouping.select.sub2 = Group "Subgroup 2" checkable
grouping.select.sub2.description = Text "Any group can t

InputFields = Group "Text input elements"
InputFields.description = Text "For default value input"
InputFields.reals = Input "<Real> (decimal) values:" Real
InputFields.ints = Input "<Integer> values:" Integer
InputFields.txt = Input "<Text> values (anything):"
InputFields.desUnit = Text "An optional Unit info can be
InputFields.unit = Input Length: Real mm
InputFields.cps = Input "Counts per second:" Integer cps

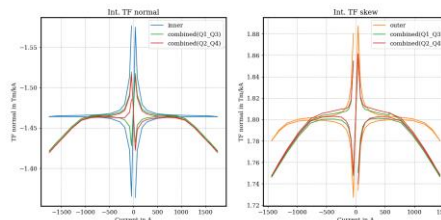


FFMM Measurement Workflow and Data Storage



FFMM Postprocessing

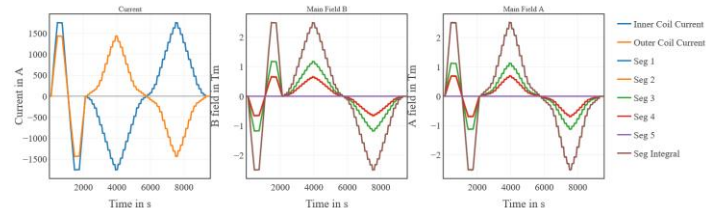
- Postprocessing with Python/Jupyter scripts
 - Retrieve data by measurement request
 - Perform data cleanup and checks on measurements
 - Generate plots, tables, release data into database
- Reusable
 - Generic template with parameters
 - Customized template for specific magnets
 - Common core classes for processing, plotting and database access
- Traceable
 - Common code in version control
 - Applied transformations stored in script on EDMS
 - released data linked to EDMS document



Current: 1755 A

	Unit	Value
I	A	1754.9999
TF	Tm/A	1.4593
Integrated Strength	Tm	2.5610

n	bn	an
1	10000.000	-0.039
2	-0.344	-1.483
3	-11.075	0.841
4	-0.074	1.032
5	-6.702	0.656
6	0.021	0.459
7	-3.475	0.456
8	-0.207	0.043
9	-0.147	-0.087
10	-0.142	0.123
11	1.757	-0.340
12	0.162	-0.097
13	-1.523	0.423
14	-0.026	-0.001
15	0.147	-0.030



Postprocessing Rotating Coil Measurements

Postprocessing step to check, clean and Release Rotating Coil Measurements

Parameters

Selection of Run

There are multiple ways of selecting a Measurement

- parentWO: Measurement Request Workorder
- woNumbers: Run Workorder numbers (Rotating Coil measurement runs)
- magnetName: Magnet asset names
- edmsIdList: Directly via a list of Run Analysis edms ids

```
In [4]: removeOutput *
1 displayMarkdown("""### Version information
2 In analysis_tools package version: (0)
3 """, format_analysis_tools__version__)
```

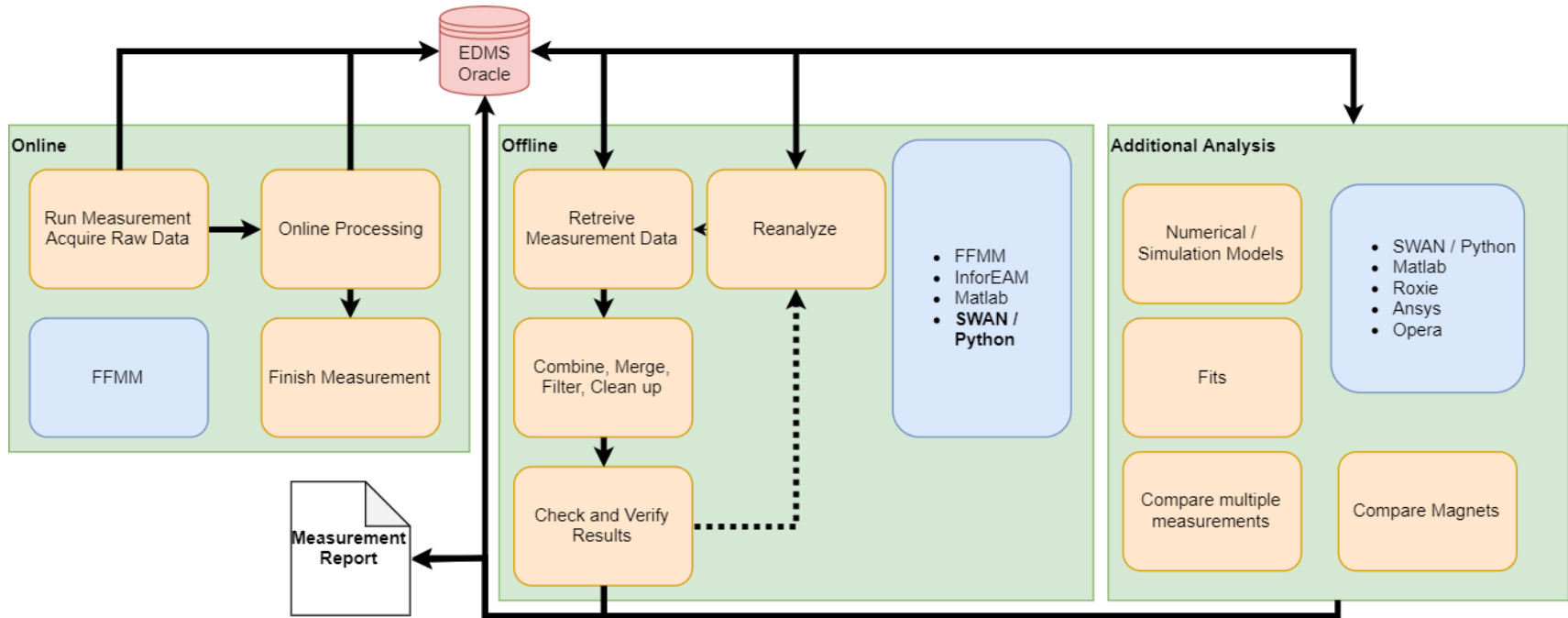
Version information

analysis_tools package version: 2021.8.14.dev19+g6c6d009

```
In [5]: parameters *
1 parentWO = 2049814
2 woNumbers = None
3 magnetName = None
4 # Enter EDMS number
5 # woNumber = None
6 run_name = ()
7 EDMSid = 1.0000
8 skipSet = 1.0000
9 # List of relevant segments, or None if all segments should be kept
10 relevant_segments = None
11
12 interested_golies = range(2,14)
13
14
15 segment_length_override = None
16 segment_pos_override = None
17
18 #z = 253.89*2e-3+0.9975
19 #z = (250-252.89*2e-3)*1e-3+0.9975
20 segment_length_override = '{0}'.format(z) for z in range(1,6) for b in ['A','B']
21 segment_pos_override = '{0}'.format(z) for z in range(1,6) for b in ['A','B']
22 #segment_pos_override['A'] = -1000
```

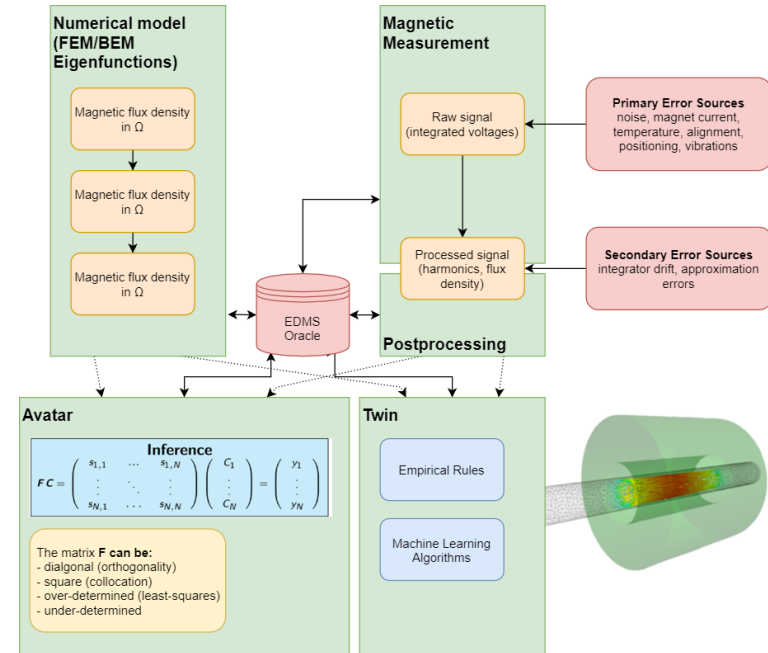


FFMM Postprocessing Workflow



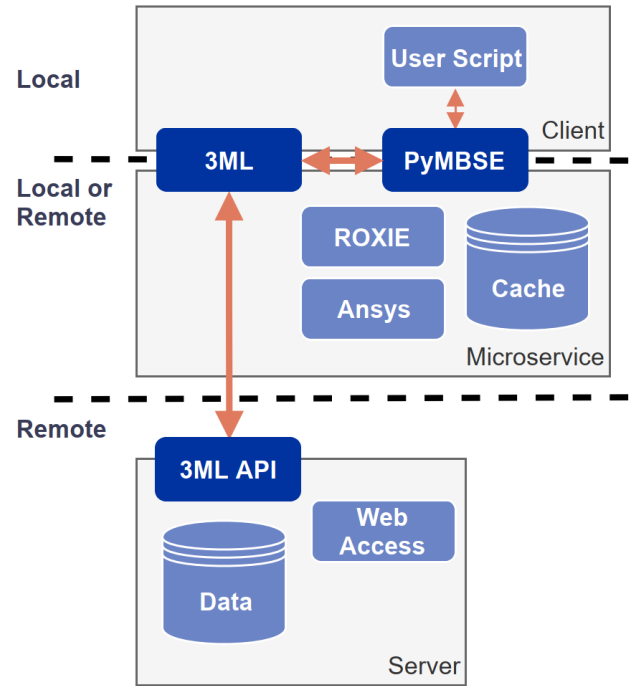
Further Postprocessing

- Combine Models and Measurements
 - Avatar: measurement, simulation, inference based on Kirchhoff's theorem
 - Twin: Fusion of measurements, models, empirical rules, machine learning
- Track Avatars, Twins and applied algorithms in database
- Improve models with measurement data
- Better understanding of the magnet
- Feedback for new transducers or measurements

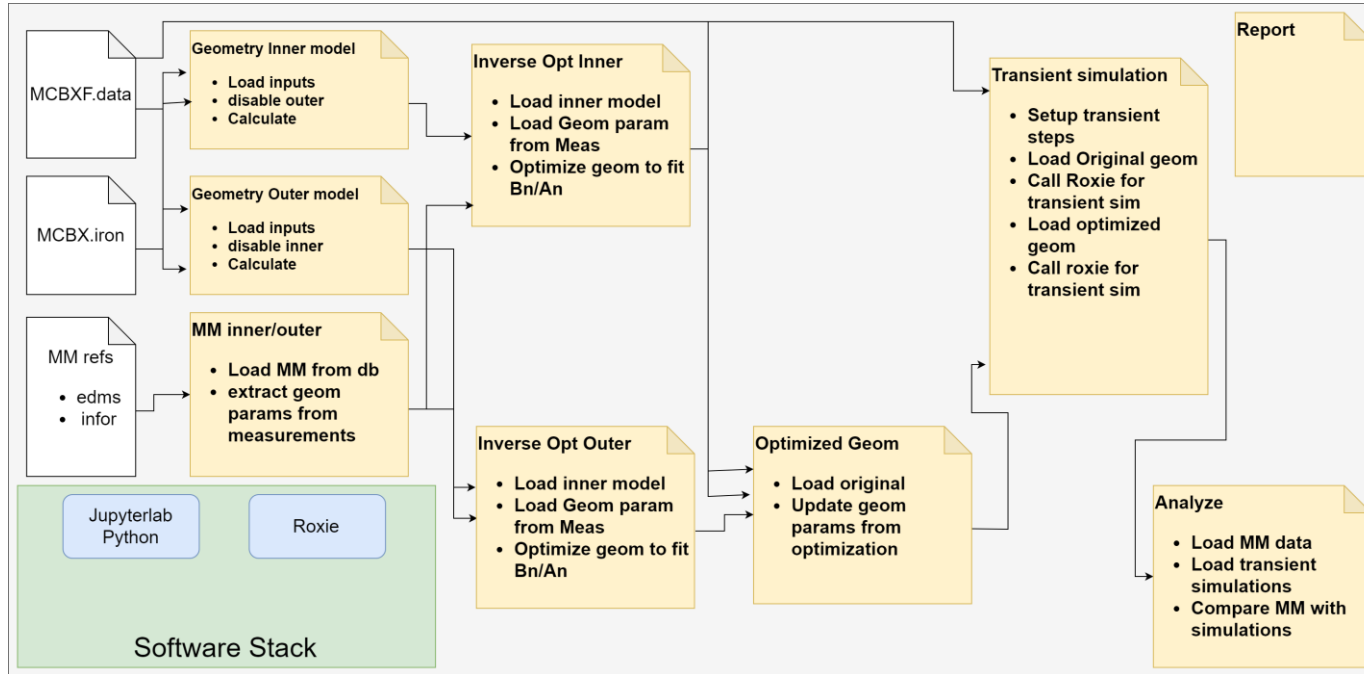


3ML – Magnetic Model Management Layer

- MBSE
 - Measurement models
 - Simulation models
 - Dependencies
 - Automated workflow
 - Result queries



3ML – Measurement Based Geometry Update



Conclusion

- Framework to build measurement applications
 - Built-in traceability and data storage
 - Measurement, postprocessing, analysis
- Integration in CERN IT infrastructure
- Link with simulations and models

