

CIRP ICME '23 Conference

17th CIRP International Conference on

INTELLIGENT **C**OMPUTATION IN **M**ANUFACTURING **E**NGINEERING

12 - 14 July 2023

 **Fraunhofer**
J_LEAPT UniNaples

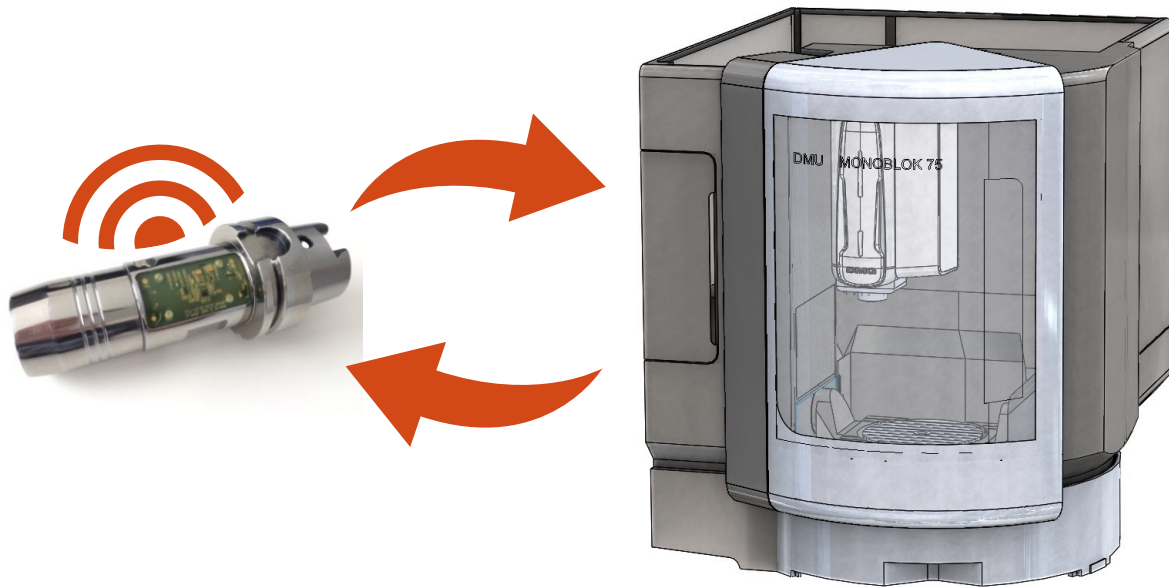
CNC Machine Tool Focused Edge Computing in Manufacturing

L. Tonejca (née Plessing), C. Mayer, T. Trautner, G. Mauthner, F. Bleicher

TU Wien, Institute of Production Engineering and Photonic Technologies,
Karlsplatz 13, 1040 Vienna, Austria



- **Retrofitting** CNC with sensors/actuators
- **Bi-directional** communication




- **Interaction** at the application level
- Continuous data **collection** from CNC and retrofitted device
- **Deployable** on standard industrial edge device
- **Integration** with standard protocols
- **Adaptability** of the application by the customer
- Convenient **usability**, manageability, and scalability

- Flexible w.r.t. **CNC** vendor and interface
 - Most popular **control vendors** in Austria: Heidenhain, Siemens, Fanuc
 - Standard control **interfaces**: Ethernet/IP
 - Standard M2M **protocols**: OPC-UA, Modbus, MQTT or proprietary API
- Flexible w.r.t. **edge** hardware and OS
 - Standard **operating system**: mostly Linux, else Windows

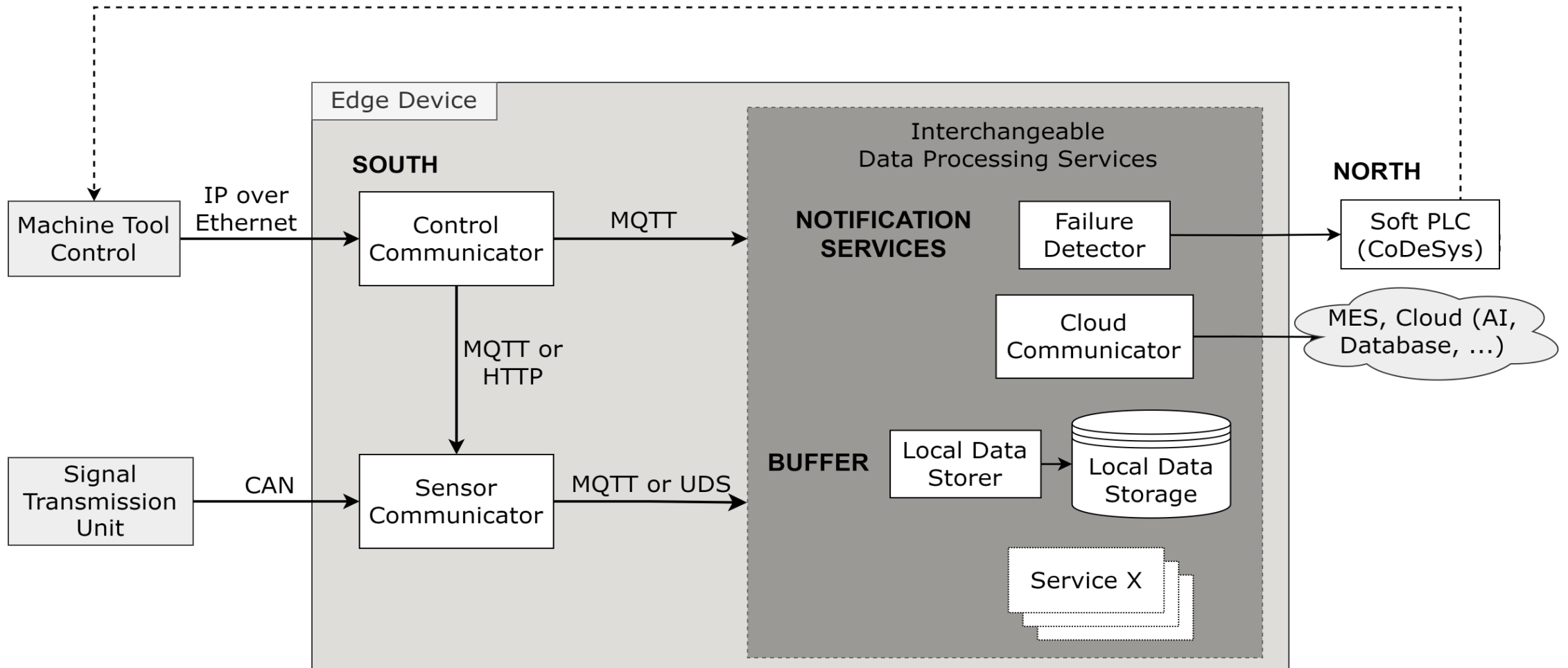
- **Maintainable** by the costumer
 - **Modular** structure and straightforward to **deploy**: Containerization
 - Most popular high-level **programming** language: Python

Tested Industry Standards:

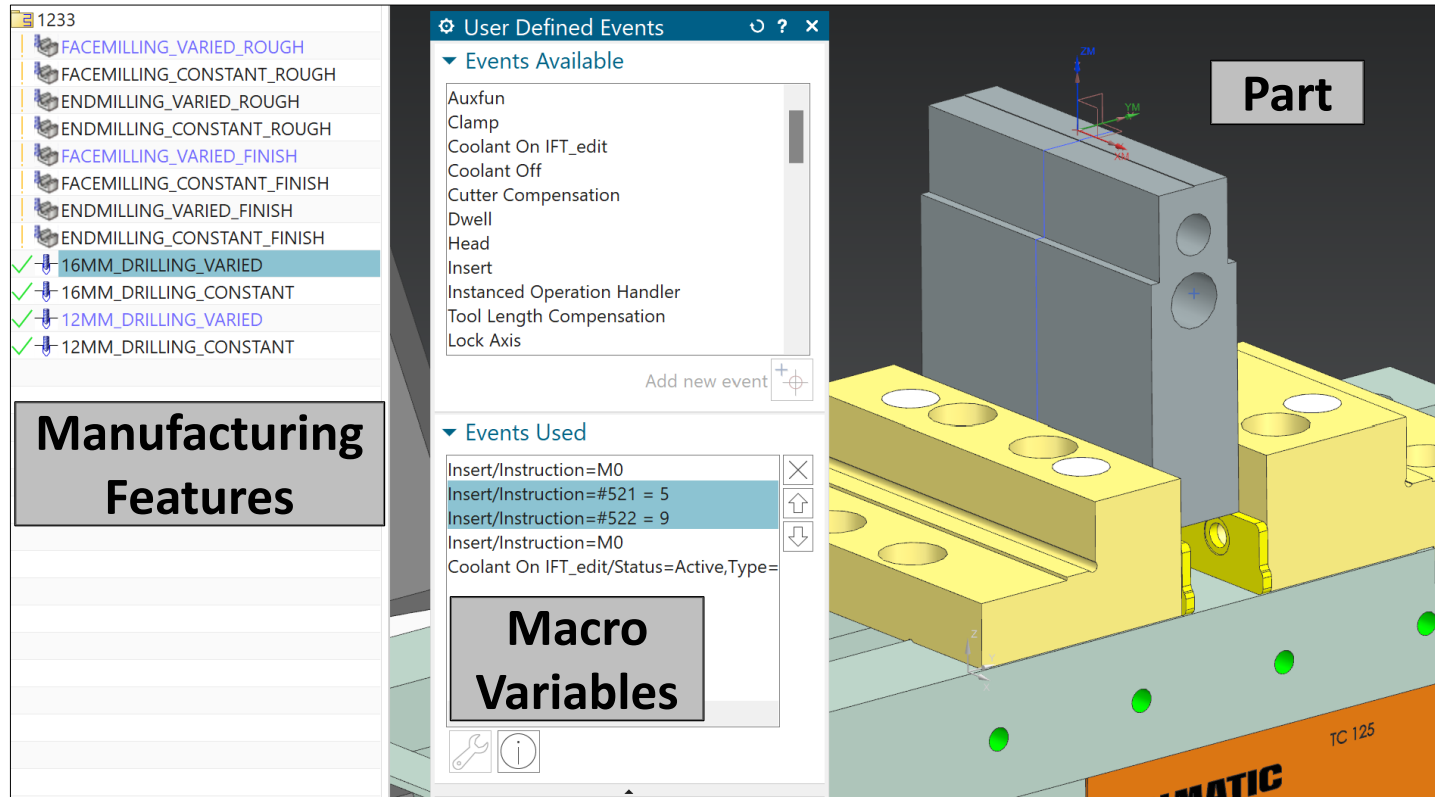


OPC UA
SIEMENS FANUC
debian ubuntu Windows 10

Architecture of Edge Application

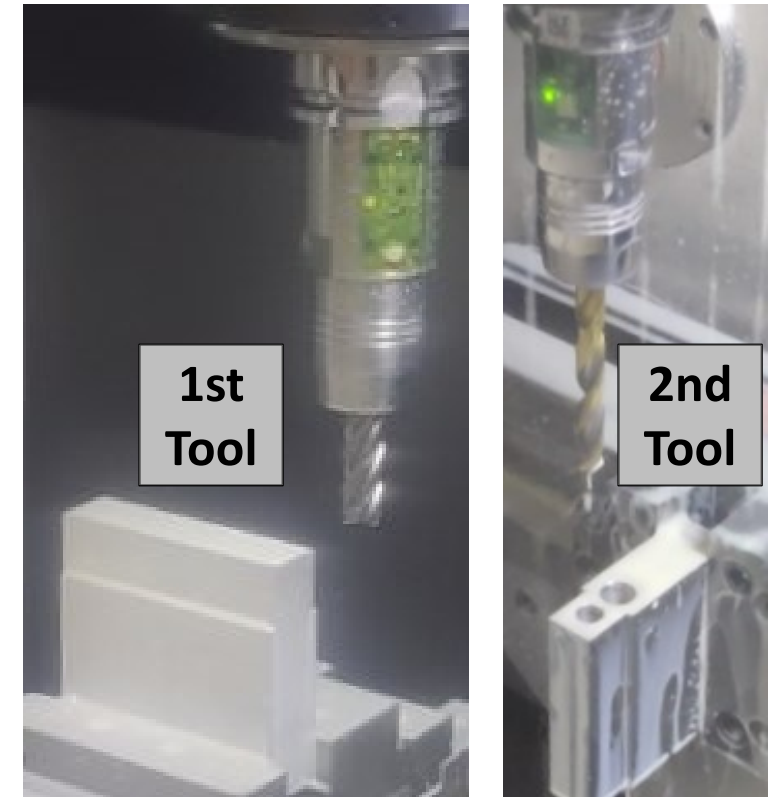


CAM-Setup (Input)



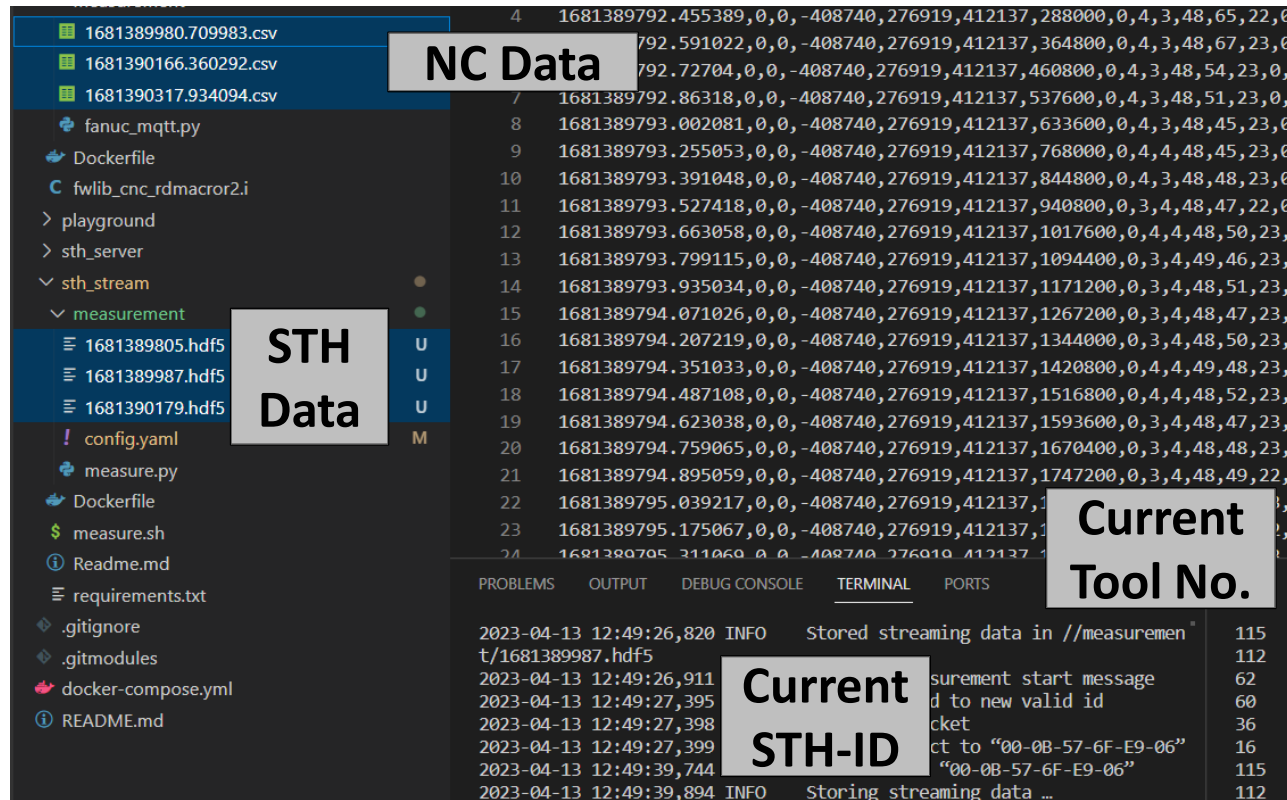
The screenshot displays the CAM software interface. On the left, a tree view under '1233' lists manufacturing features such as 'FACEMILLING_VARIED_ROUGH', 'ENDMILLING_VARIED_ROUGH', and '16MM_DRILLING_VARIED'. A 'Manufacturing Features' label is overlaid on this list. In the center, the 'User Defined Events' window is open, showing 'Events Available' (Auxfun, Clamp, Coolant On IFT_edit, etc.) and 'Events Used' (Insert/Instruction=M0, Coolant On IFT_edit, etc.). A 'Macro Variables' label is overlaid on the 'Events Used' list. On the right, a 3D model of a grey 'Part' is shown on a yellow workpiece, with a 'Part' label overlaid.

Live Process



Output

Fanuc (Output)



NC Data

STH Data

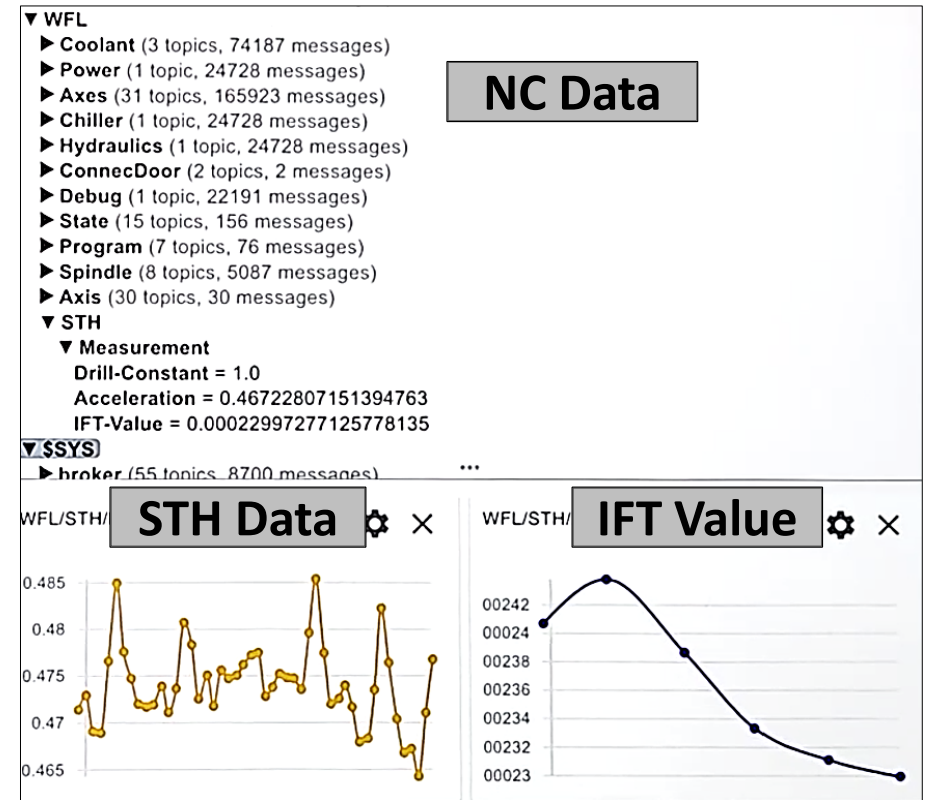
Current Tool No.

```

4 1681389792.455389,0,0,-408740,276919,412137,288000,0,4,3,48,65,22,0
792.591022,0,0,-408740,276919,412137,364800,0,4,3,48,67,23,0
792.72704,0,0,-408740,276919,412137,460800,0,4,3,48,54,23,0,
7 1681389792.86318,0,0,-408740,276919,412137,537600,0,4,3,48,51,23,0,
8 1681389793.002081,0,0,-408740,276919,412137,633600,0,4,3,48,45,23,0
9 1681389793.255053,0,0,-408740,276919,412137,768000,0,4,4,48,45,23,0
10 1681389793.391048,0,0,-408740,276919,412137,844800,0,4,3,48,48,23,0
11 1681389793.527418,0,0,-408740,276919,412137,940800,0,3,4,48,47,22,0
12 1681389793.663058,0,0,-408740,276919,412137,1017600,0,4,4,48,50,23,
13 1681389793.799115,0,0,-408740,276919,412137,1094400,0,3,4,49,46,23,
14 1681389793.935034,0,0,-408740,276919,412137,1171200,0,3,4,48,51,23,
15 1681389794.071026,0,0,-408740,276919,412137,1267200,0,3,4,48,47,23,
16 1681389794.207219,0,0,-408740,276919,412137,1344000,0,3,4,48,50,23,
17 1681389794.351033,0,0,-408740,276919,412137,1420800,0,4,4,49,48,23,
18 1681389794.487108,0,0,-408740,276919,412137,1516800,0,4,4,48,52,23,
19 1681389794.623038,0,0,-408740,276919,412137,1593600,0,3,4,48,47,23,
20 1681389794.759065,0,0,-408740,276919,412137,1670400,0,3,4,48,48,23,
21 1681389794.895059,0,0,-408740,276919,412137,1747200,0,3,4,48,49,22,
22 1681389795.039217,0,0,-408740,276919,412137,1824000,0,3,4,48,49,22,
23 1681389795.175067,0,0,-408740,276919,412137,1900800,0,3,4,48,49,22,
24 1681389795.311060,0,0,-408740,276919,412137,1977600,0,3,4,48,49,22,
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS
2023-04-13 12:49:26,820 INFO Stored streaming data in //measuremen 115
t/1681389987.hdf5 112
2023-04-13 12:49:26,911 INFO Measurement start message 62
2023-04-13 12:49:27,395 INFO d to new valid id 60
2023-04-13 12:49:27,398 INFO cket 36
2023-04-13 12:49:27,399 INFO ct to "00-0B-57-6F-E9-06" 16
2023-04-13 12:49:39,744 INFO "00-0B-57-6F-E9-06" 115
2023-04-13 12:49:39,894 INFO Storing streaming data ... 112

```

Siemens (Output)



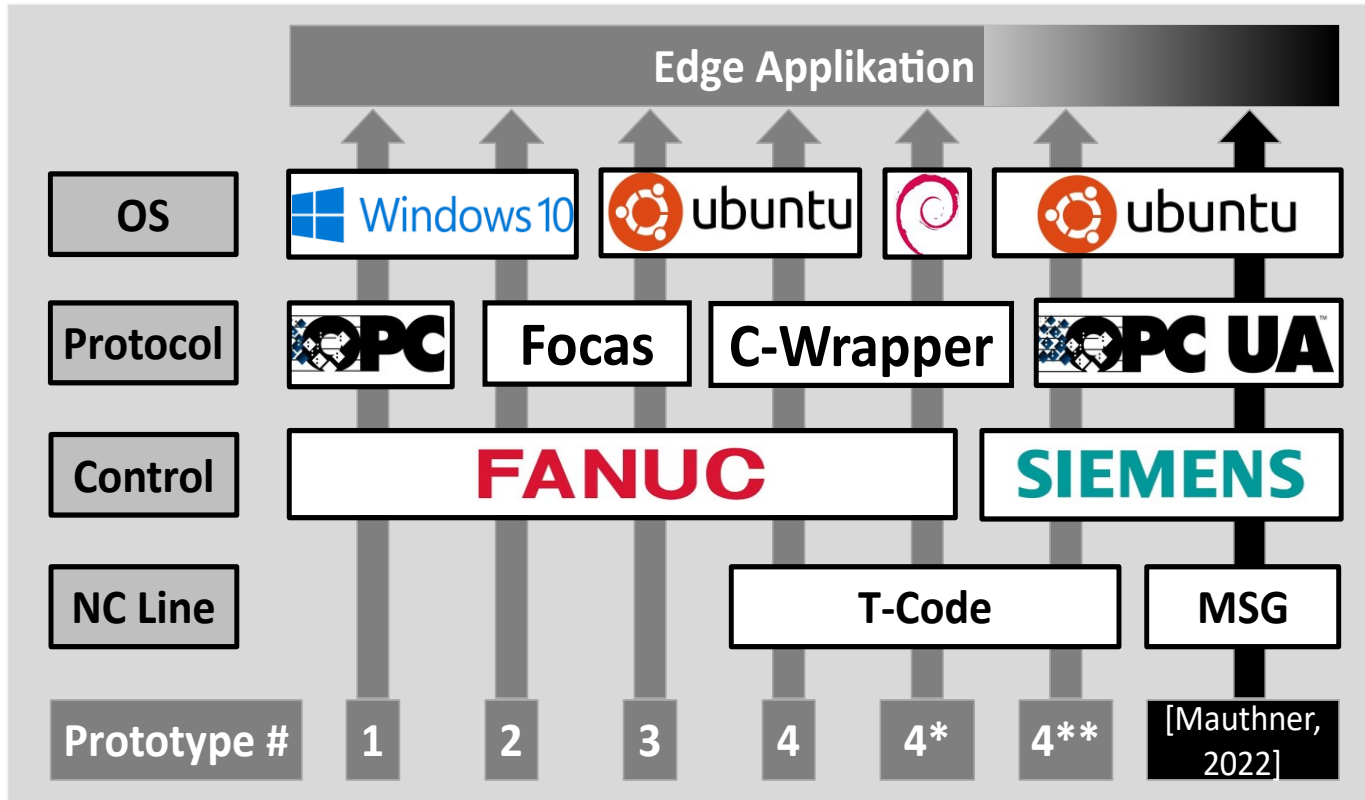
NC Data

- ▼ WFL
 - ▶ Coolant (3 topics, 74187 messages)
 - ▶ Power (1 topic, 24728 messages)
 - ▶ Axes (31 topics, 165923 messages)
 - ▶ Chiller (1 topic, 24728 messages)
 - ▶ Hydraulics (1 topic, 24728 messages)
 - ▶ ConnecDoor (2 topics, 2 messages)
 - ▶ Debug (1 topic, 22191 messages)
 - ▶ State (15 topics, 156 messages)
 - ▶ Program (7 topics, 76 messages)
 - ▶ Spindle (8 topics, 5087 messages)
 - ▶ Axis (30 topics, 30 messages)
- ▼ STH
 - ▼ Measurement
 - Drill-Constant = 1.0
 - Acceleration = 0.46722807151394763
 - IFT-Value = 0.00022997277125778135
- ▼ \$SYS
 - ▶ broker (55 topics, 8700 messages)

STH Data

IFT Value

Prototype Evaluation



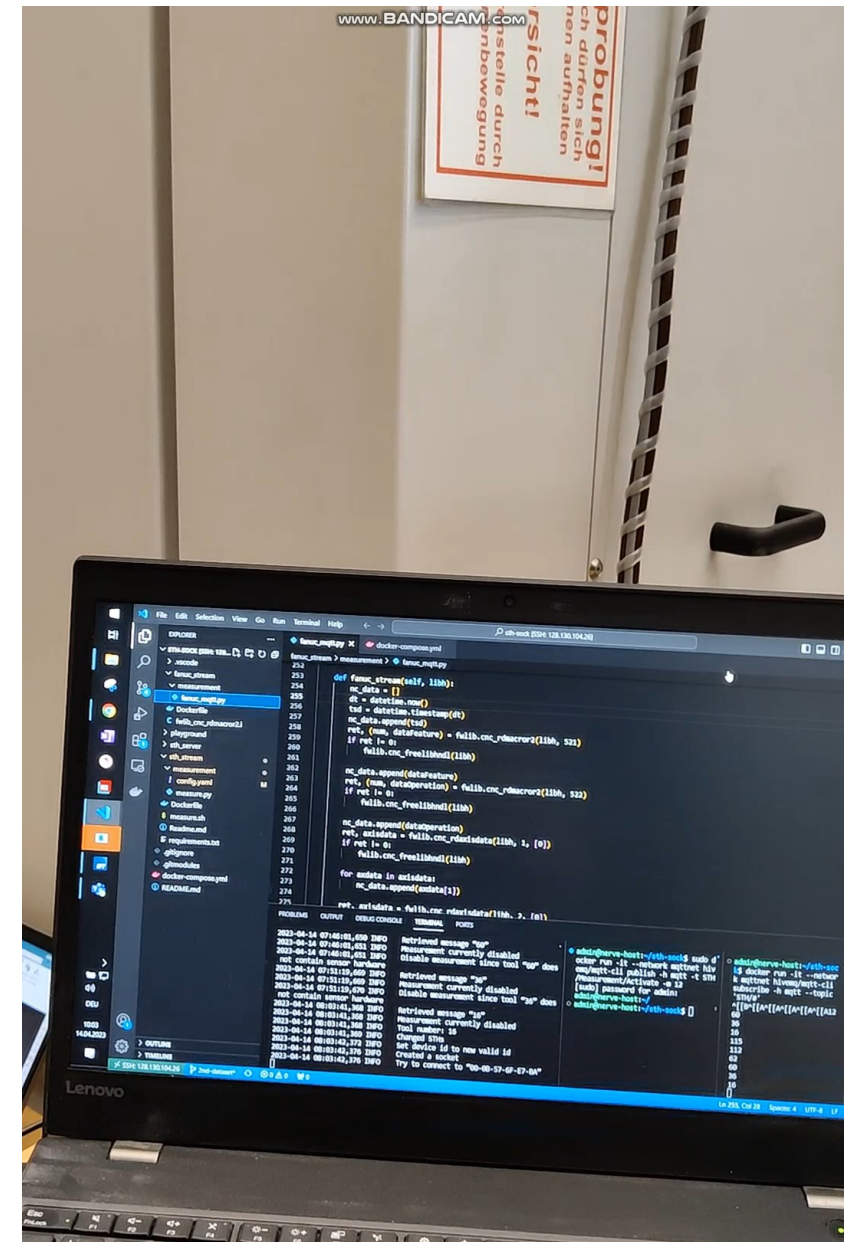
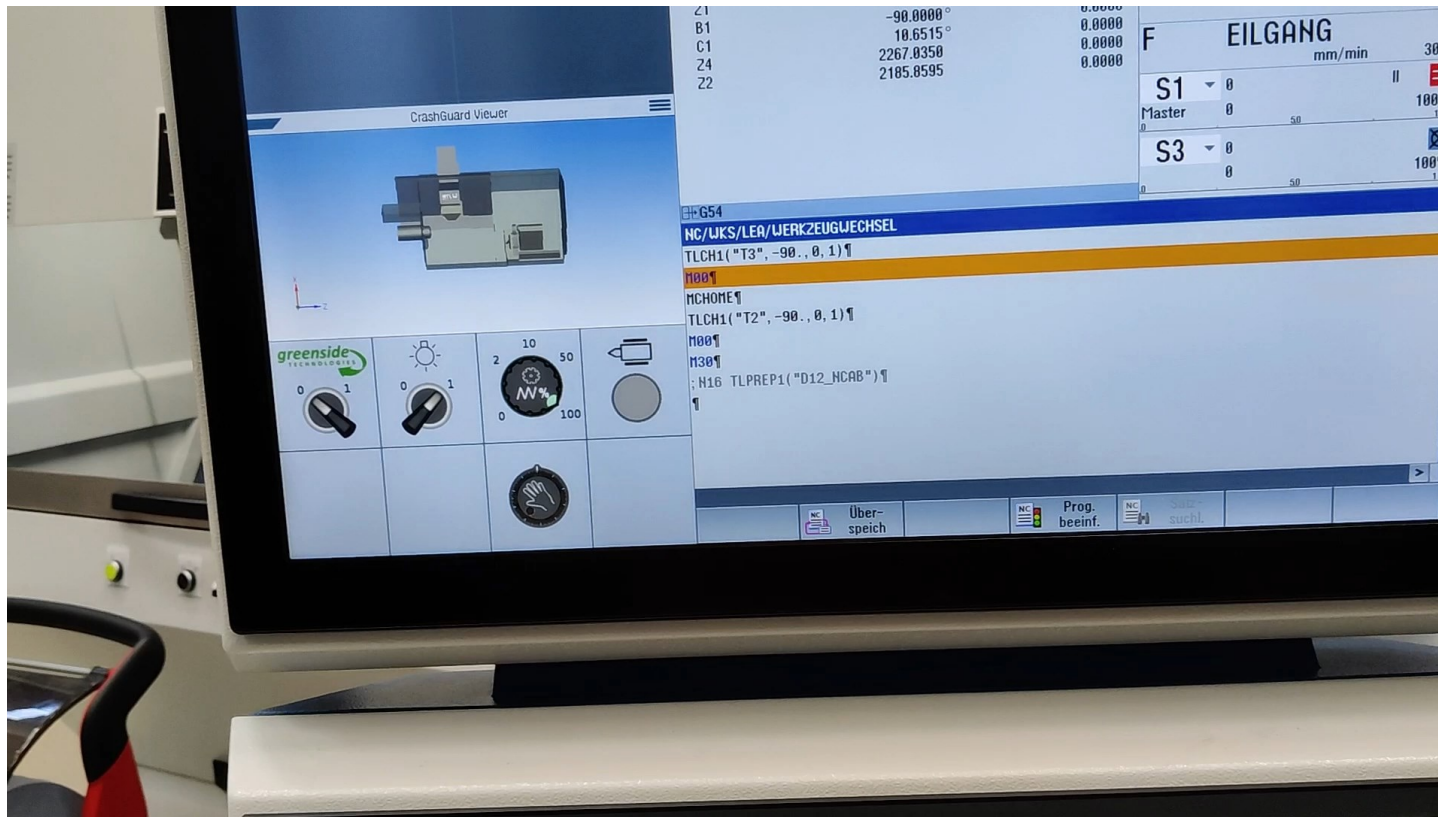
[Mauthner, 2022]: doi:
10.1016/J.PROCIR.2022.04.053

Prototype #	1	2	3	4
Evaluation question				
Effectiveness	~	~	~	~ +
Feasibility (time)	~	~	~	+
Viability (cost)	-	~	+	+
Scalability	-	+	+	+
Stakeholder support	~	-	~	+



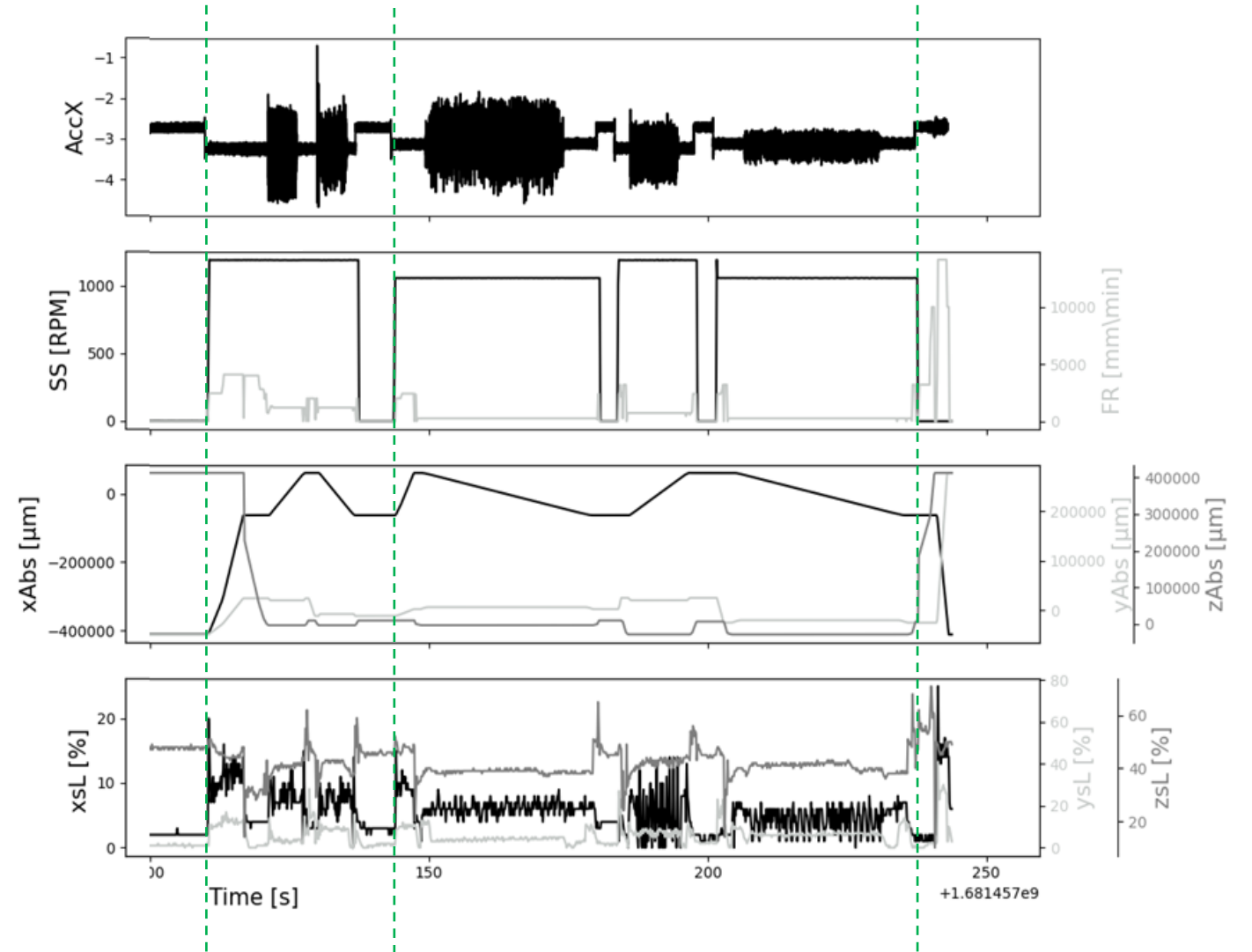
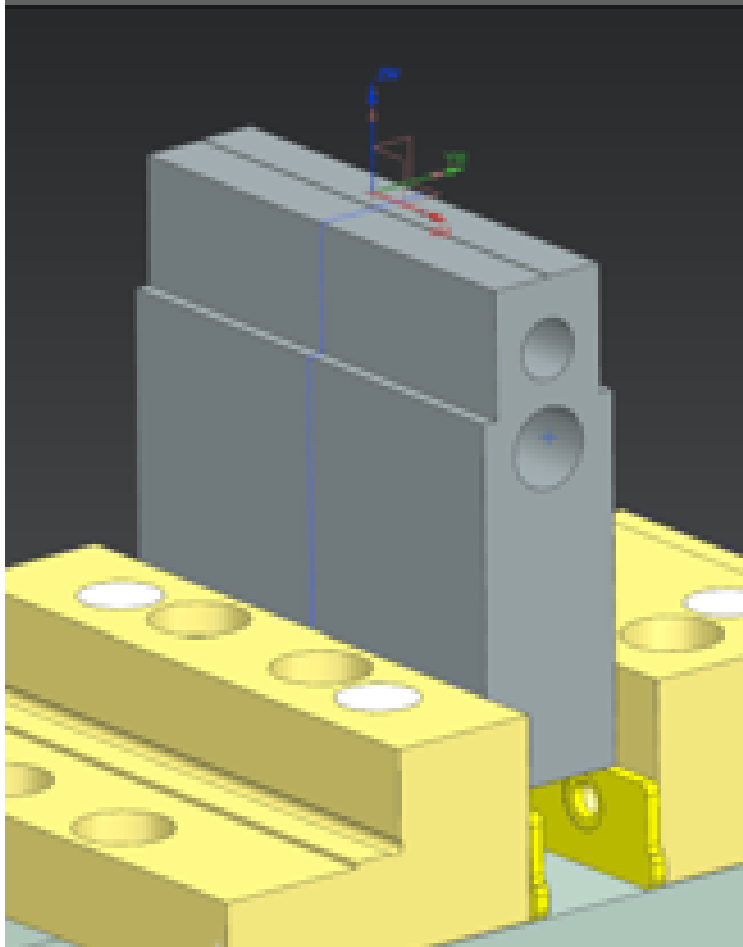
WFL M30 Millturn, DMU 75 Monoblock

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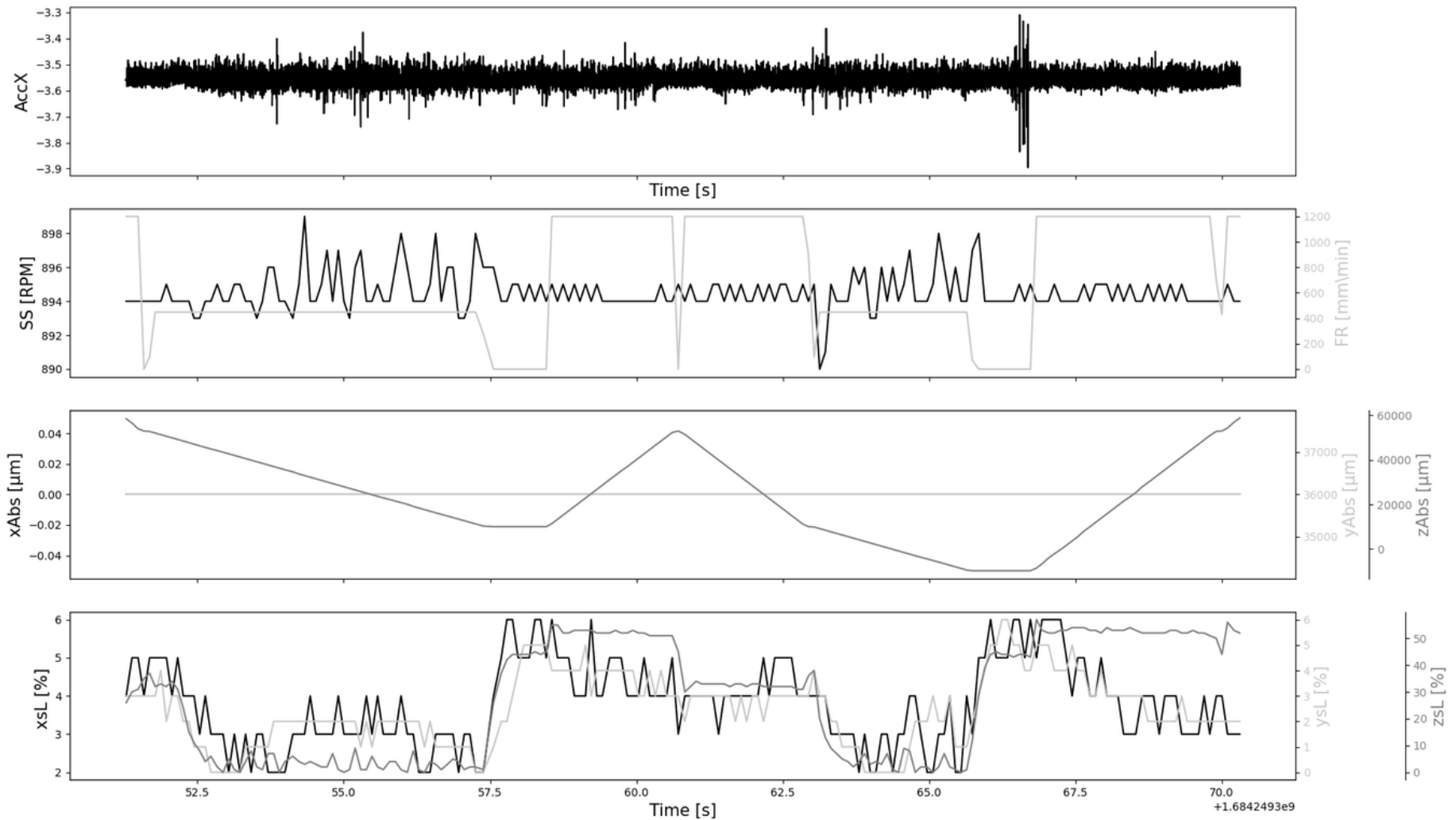


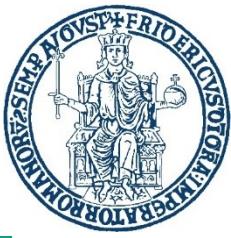


Validation



Validation – Drilling 16mm only





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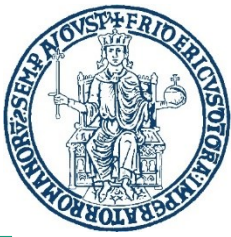
THANK YOU!

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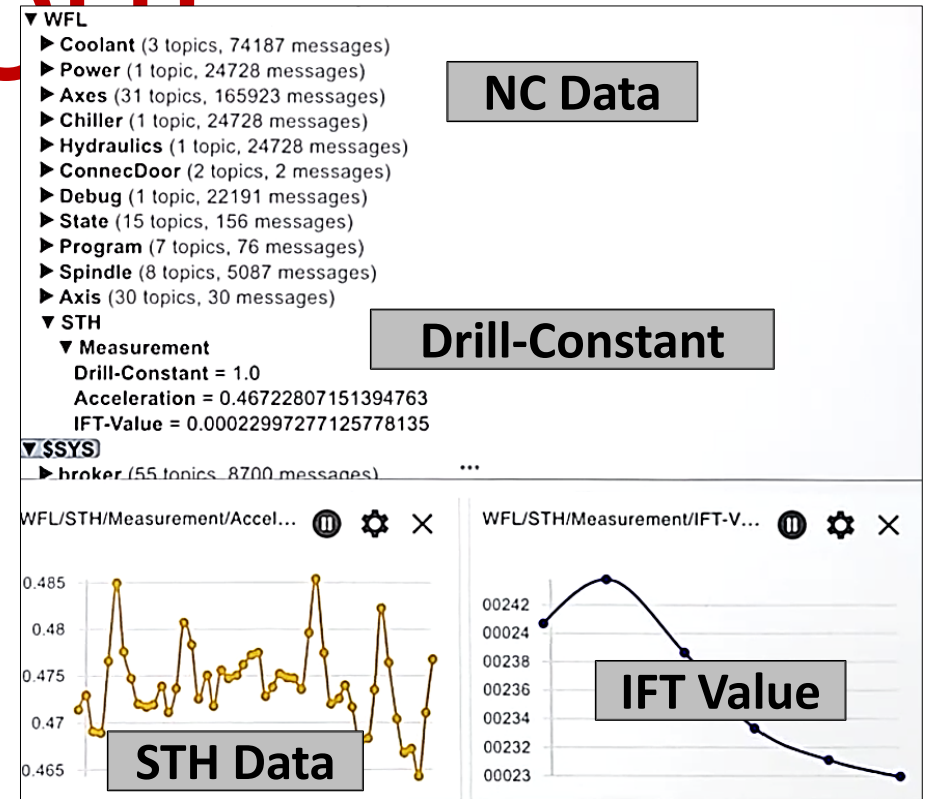
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THANK YOU!!!



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▼ \$\$SYS

- ▶ broker (55 topics, 8700 messages)

WFL/STH/Measurement/Accel... [Pause] [Settings] [Close]

WFL/STH/Measurement/IFT-V... [Pause] [Settings] [Close]

NC Data

Drill-Constant

STH Data

IFT Value