

WIR SCHAFFEN WISSEN – HEUTE FÜR MORGEN



PACMAN – HIPA studies



Outline

- Overview PACMAN
 - Research goals and status
- First months HIPA

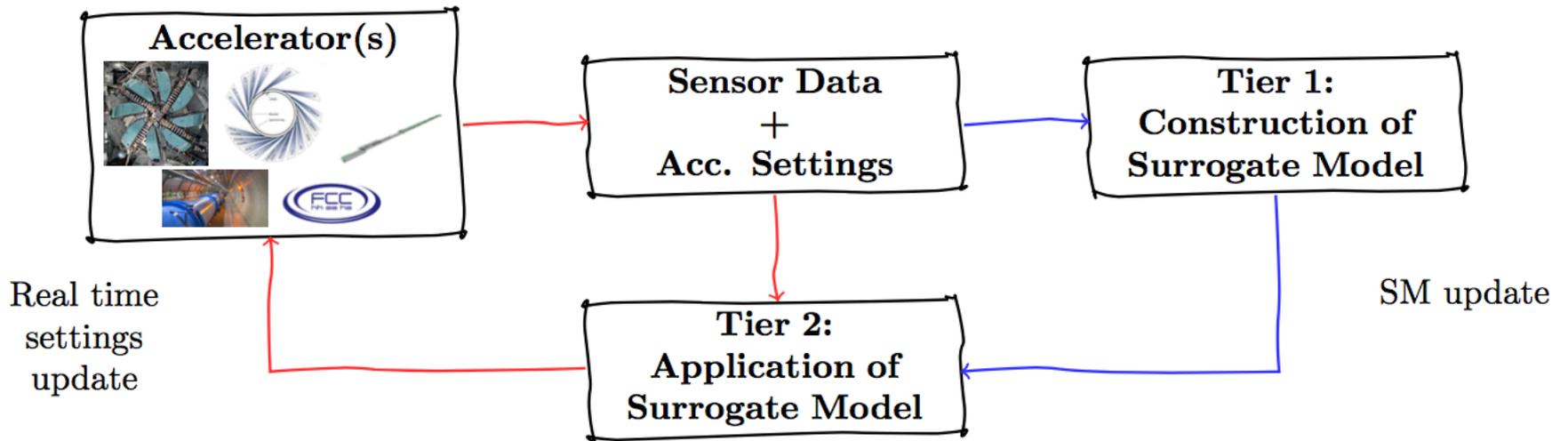


Figure 1: Sketch of the application of a Surrogate Model (SM) for particle accelerators. Red lines indicate real time data transfer.

- Research goals:

1. Minimise beam losses (HIPA and LHC)
2. Better control of accelerator parameters (HIPA and LHC)
3. Prevent unnecessary machine interruptions (HIPA)
4. Neural networks instead of particle tracking (LHC)

- Andreas Adelman PhD supervision Sichen Li working on surr. models (Tier 1)
- Sichen Li Research goal 3: Prevent Machine Interruption (Tier 1+2)
- Anastasia Pentina Surrogate model construction (Tier 1)
- Jochem Snuverink PI, data access, transfer surr. models to operation (Tier 2)
- Davide Reggiani Research goal 2: Parameter Control (Tier 2)
- Markus Janousch Connection operation (Tier 2), adaptation to future acc.
- Jaime Coello Transfer surrogate models to operation (Tier 2)
- Marco Schippers Postdoc supervision, general HIPA coordinator

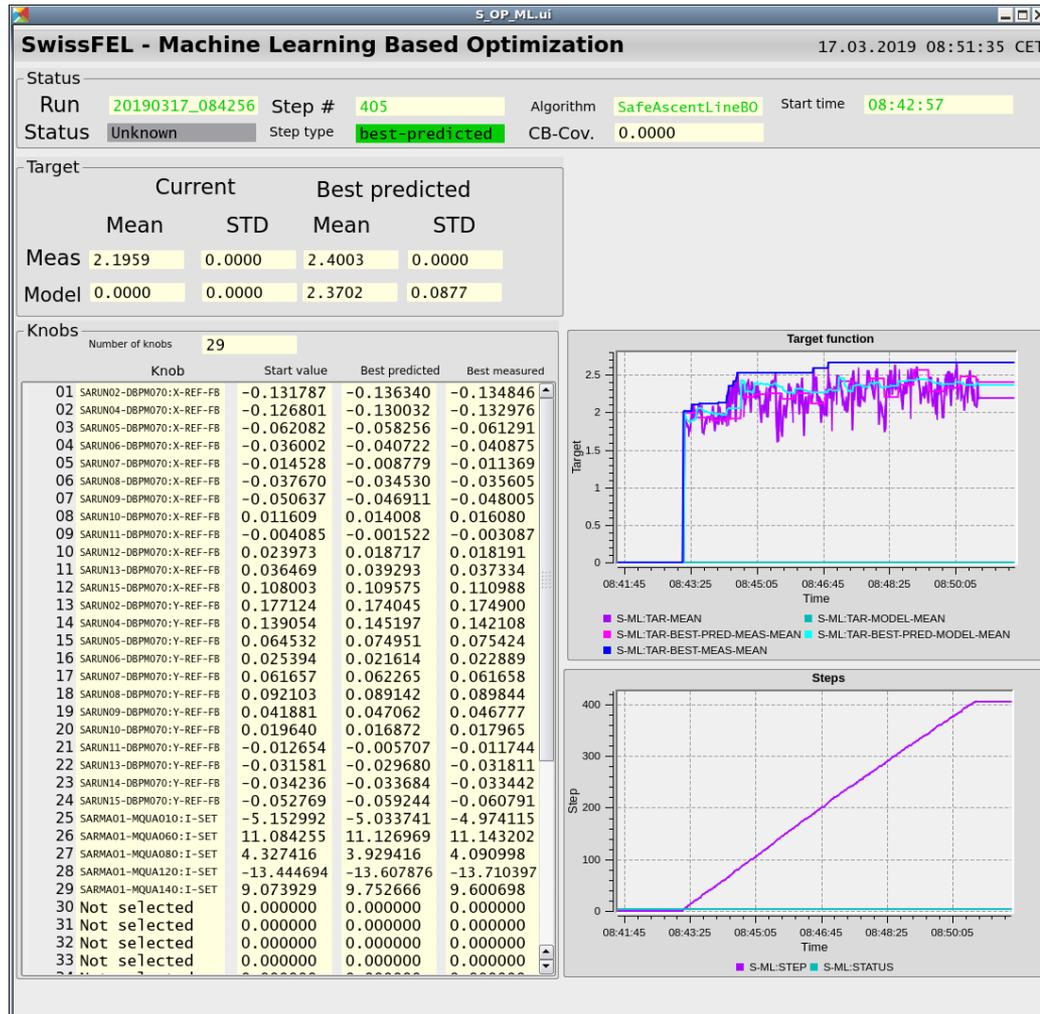
Tier /	WP	Partner (short name)				Year and Quarter							
		SDSC	PSI-Accel EPFL-Accel	PSI-LSM	PSI-Control	2019			2020				2021
						2	3	4	1	2	3	4	1
	1	L	P	P				M1.1		M1.2		M1.3	M1.4
	2	P	L		P	M2.1					M2.2		M2.3
	3	P	P	P	L		M3.1			M3.2		M3.3	

- Work packages and first milestones: see proposal
 - WP 1: Surrogate Model construction
 - WP 2: Accelerator Implementation
 - WP 3: Adaptation to Future Accelerators
 - M2.1: Data access and transfer procedure for WP 1
 - M3.1: Generalised data model defined
 - M1.1: Data models developed and data sets cleaned

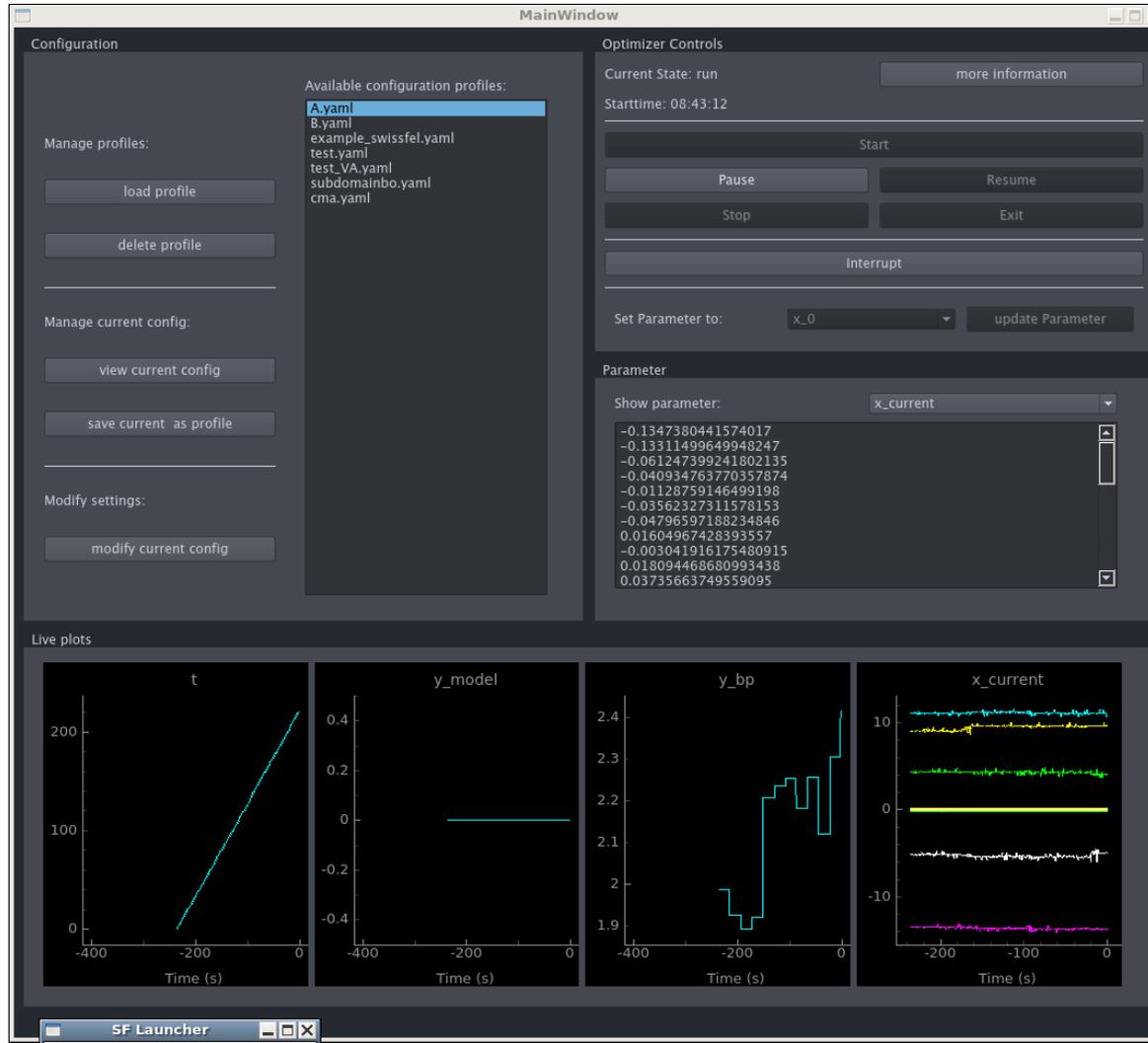
Research goal 1: Minimise beam losses

- HIPA beam intensity limited (to some extent) to the beam losses
 - Reduce damage and activation
- Optimisation is now mostly done empirically
- Large potential for automated optimisation and surrogate model construction
 - No accurate and fast physics model available
 - Needs to be *safe*
- HIPA status: preliminary tests done on HIPA with safe Bayesian optimisation with Johannes Kirschner (ETH PhD Student of Andreas Krause) and Nicole Hiller developed originally for SwissFEL
 - Tests and data taking will restart after startup
- We profit a lot from the work at SwissFEL
 - Optimisation studies will continue
 - New project on how to reuse old model / data
 - GUI development by SwissFEL operator
- Open question: implementation in OCELOT?
 - an optimisation framework with several algorithms used mainly at other FELs

- Monitor display



- Optimisation settings



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JSON Raw Data Headers

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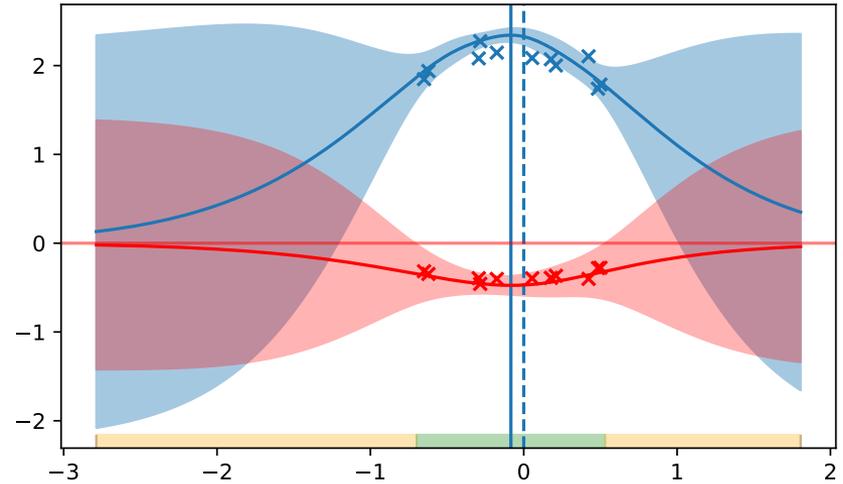
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      model:
        beta: 2
      models_gp:
        noise_var: 0.1
        kernels:
          0:
            0: "GPy.kern.Matern52"
            1:
              variance: 0.5
              lengthscale: 1
              ARD: true
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        beta: 2
      models_gp:

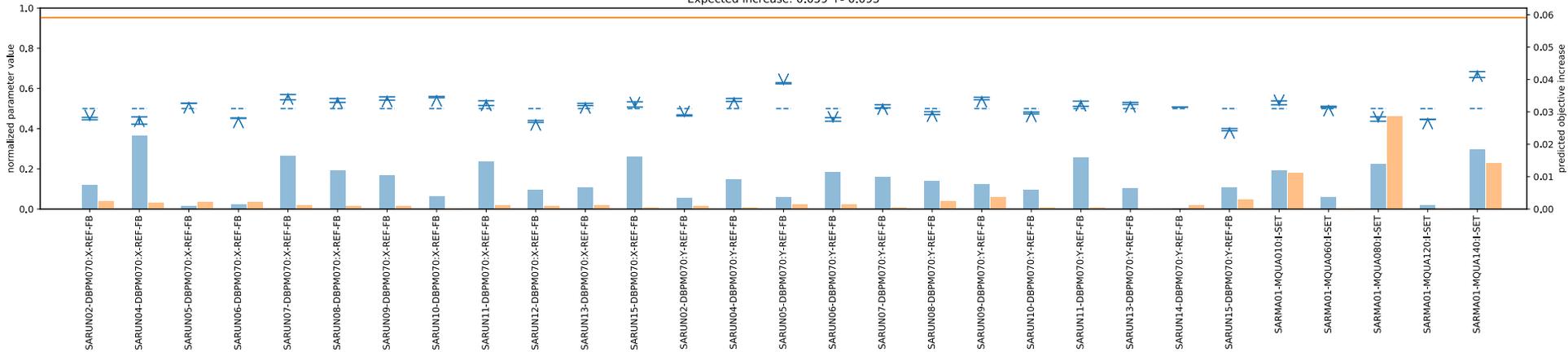
```

- Advanced diagnostics plots immediately available

Iteration: 8
 beta= 2, variance= 5.0,
 noise variance= 0.1

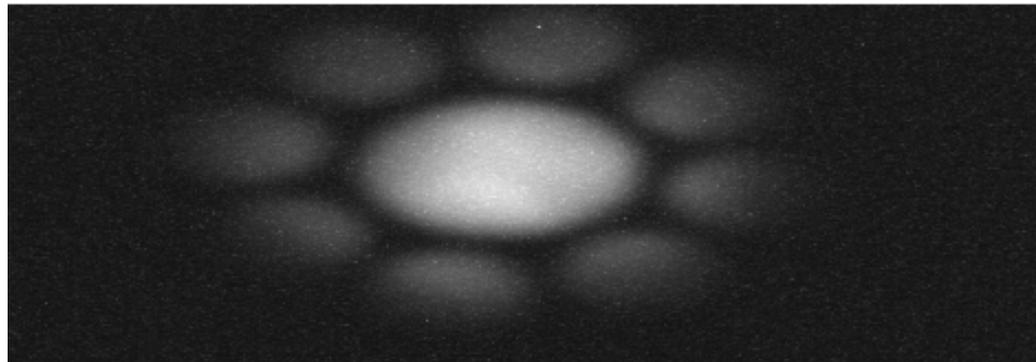


Expected increase: 0.059 +- 0.093



Research goal 2: Parameter Control

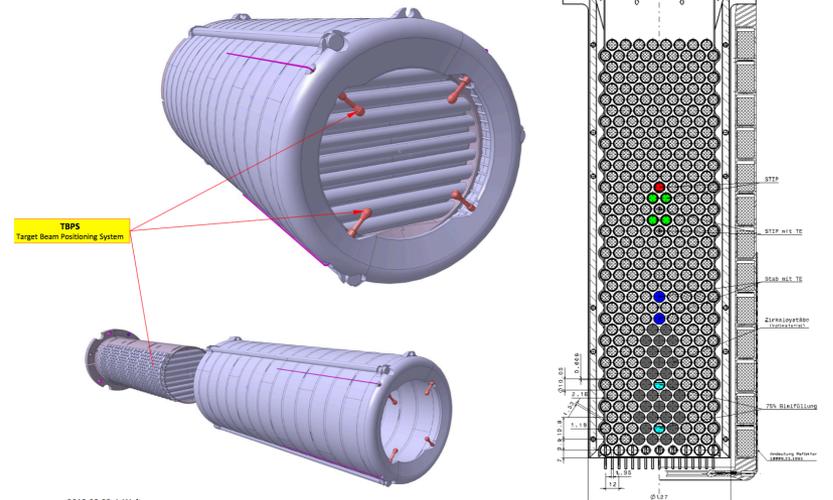
- Stable and safe operation very important
 - Beam parameters and beam collisions need to be controlled to a high level
- 1. Construct surrogate models of beam parameters from diagnostics data
- 2. Some safety systems can be slower than other diagnostics data
 - Use surrogate models for prediction to enhance safety systems
- HIPA use case and status: target spot size control
 - Direct measurement (VIMOS camera) rel. slow (~ 30 ms) and in precarious state
 - VIMOS data now stored in consistent way
 - **Challenges**
 - Critical area
 - Few data with bad measurements; no good image at small currents
 - Data not well synchronised



- First look at data by Jaime
 - Temperature sensors in the target
 - VIMOS camera data
- Goal: try to predict temperature and VIMOS from accelerator data
 - Current
 - Loss monitors
 - Position monitors
 - etc.

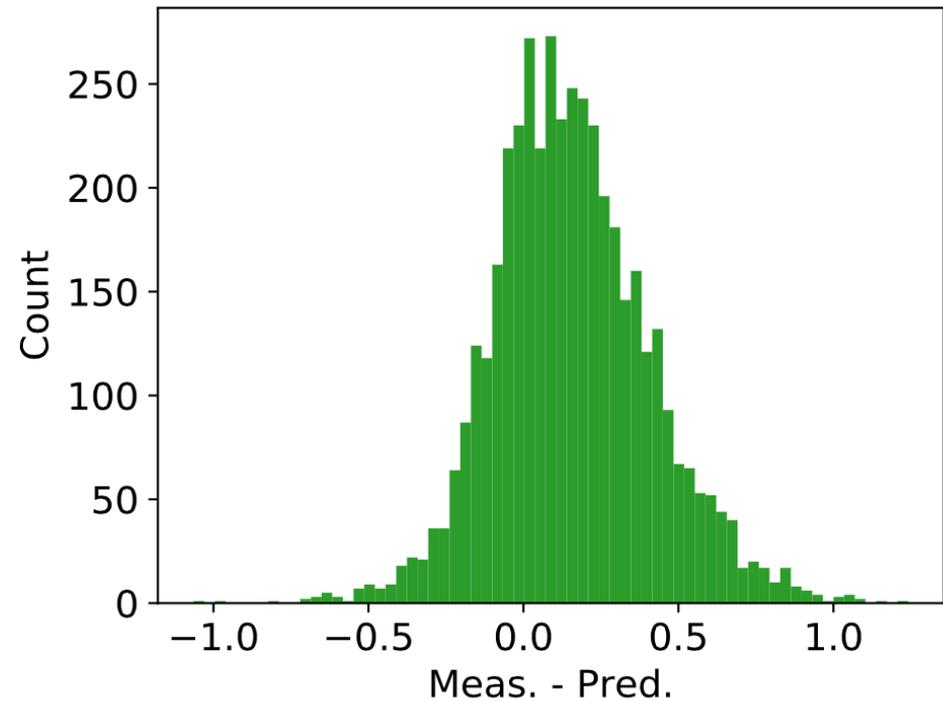
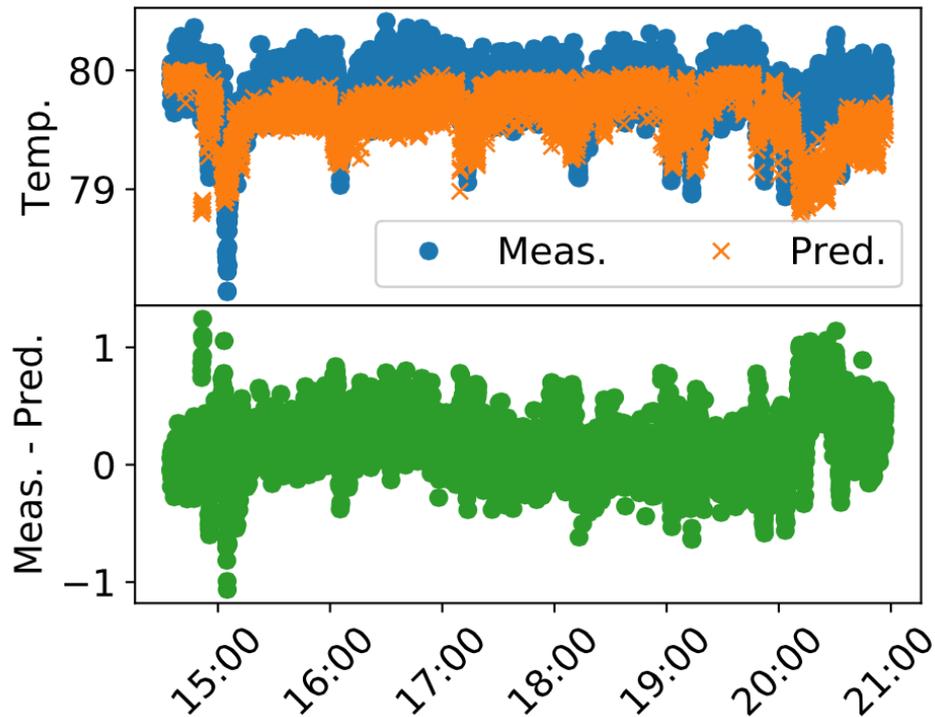


Längsdraht (Kettfaden) 0.3mm
 Querdraht (Schussfaden) 0.1mm



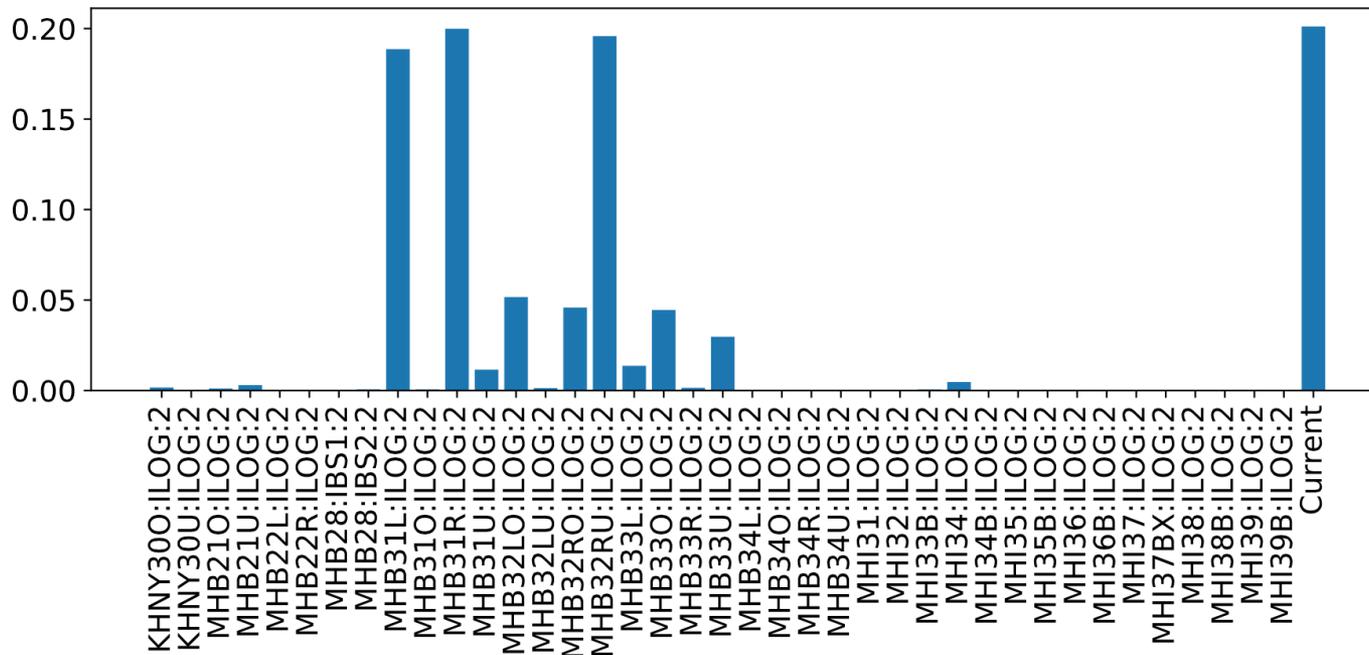
Temperature prediction

- First look with MLP (single layer NN) and Random Forest
 - Loss monitors and current to predict average temperature at a future day



Feature importance from Random Forest

- As expected current important
- Other loss monitors more important than others
 - need to verify with beamline expert (Davide)





Research goal 3: Prevent machine interruption

- See presentation by Asya
- Python API for archive extraction extended

- email list: pacman@lists.psi.ch
- homepage: <https://gitlab.psi.ch/PACMAN>



PACMAN

PACMAN (Particle Accelerators & Machine Learning) project. PACMAN is a joint project between the Swiss Data Science Center (SDSC), the École polytechnique fédérale de Lausanne (EPFL) and PSI

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 **PACMAN**
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Backup



- Online viewer
 - <https://hipa-data-ui.psi.ch/>
- Python API
 - https://github.com/paulscherrerinstitute/data_api_python
 - The library accesses the data via the DataAPI REST service and (by default) loads it into a Pandas data frame.

Example:

```
import data_api as api
import datetime
now = datetime.datetime.now()
end = now-datetime.timedelta(minutes=10)
data = api.get_data(channels=['ABK1:IST:2'], start='2018-12-10
                        00:00:00.000', end=now, base_url='https://data-api.psi.ch/hipa')
```