SOLARIS CENTRE

Application of boosted decision trees in beam anomaly detection with high throughput data streaming system

5th ICFA Beam Dynamics Mini-Workshop on Machine Learning for Particle Accelerators
CERN 2025

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SOLARIS National Synchrotron Radiation Centre

Agenda

- Introduction - SOLARIS facility
- Beam anomaly detection Machine Learning solution
- Data streaming system

SOLARIS facility

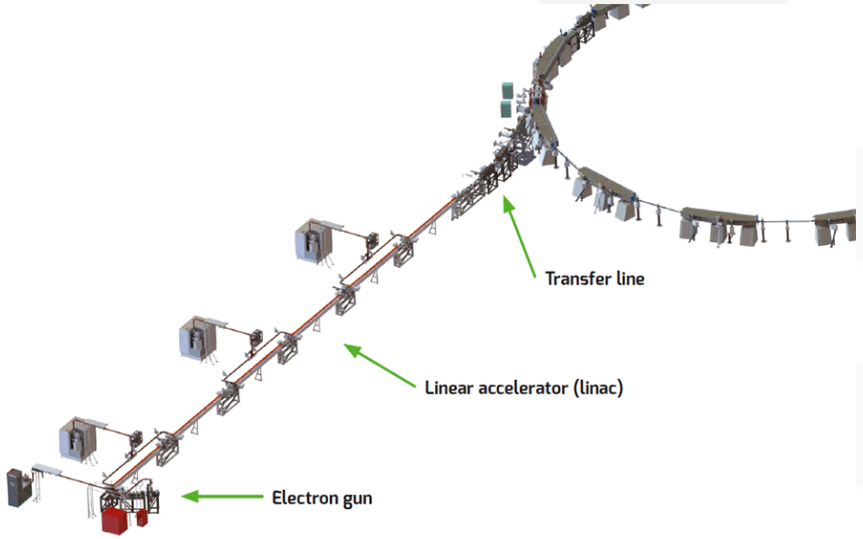
Synchrotron SOLARIS

- 3rd generation light source,
- 7 fully operational beamlines,
- Two more beamlines are under construction,
- The only synchrotron in Central Eastern Europe located in Poland.

SOLARIS facility

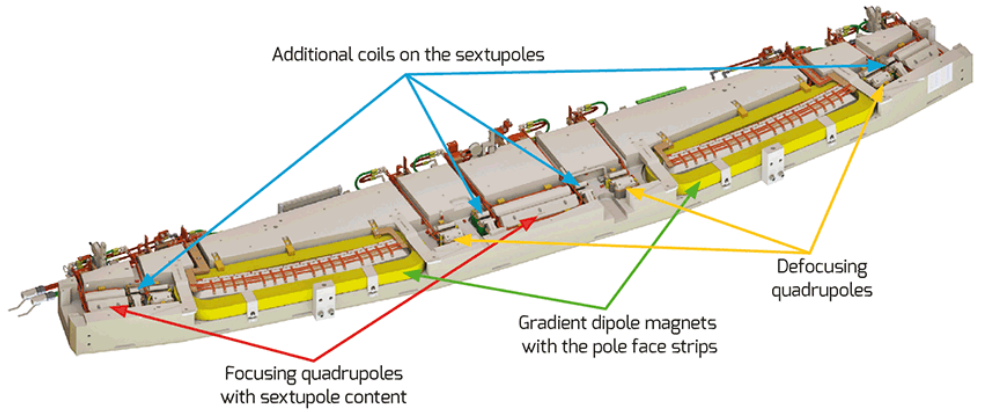
Linear accelerator

- 3 modulators,
- 6 accelerating structures,
- Delivered injection Energy - **550 MeV,**
- Max beam current – **26 mA.**



Storage ring

- Consist of **12 DBA cells**,
- Main RF frequency – **99,93 MHz,**
- Energy - **1,5 GeV,**
- Max beam current – **500 mA,**
- Circumference – **96 m.**

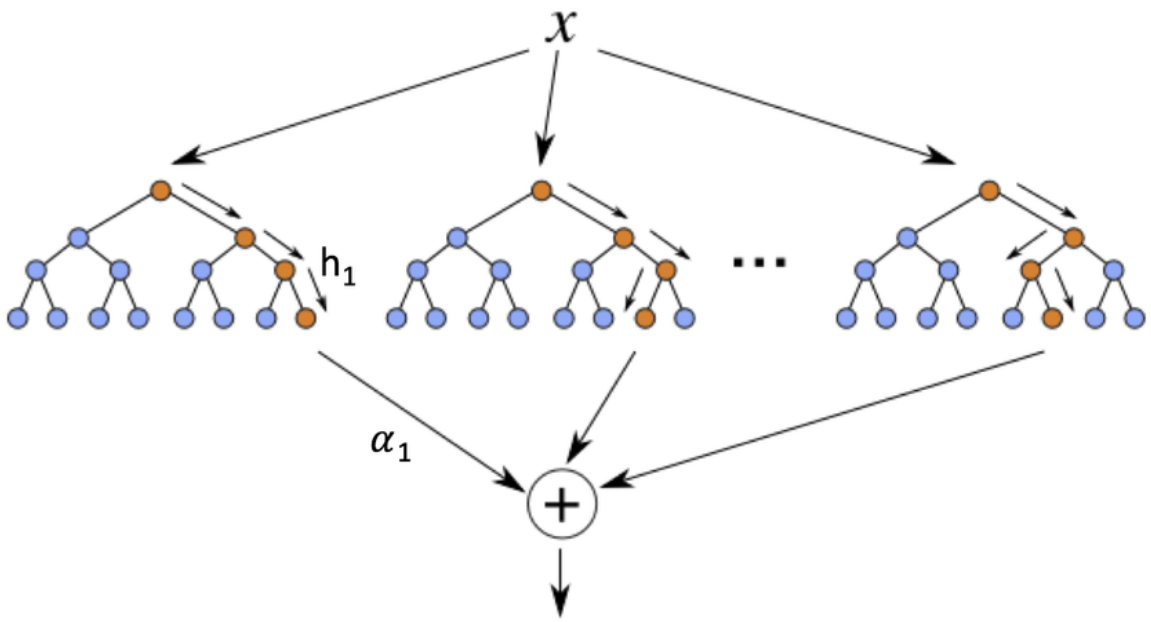


Machine learning in Synchrotron

Beam anomaly detection - **Boosted Decision Tree**

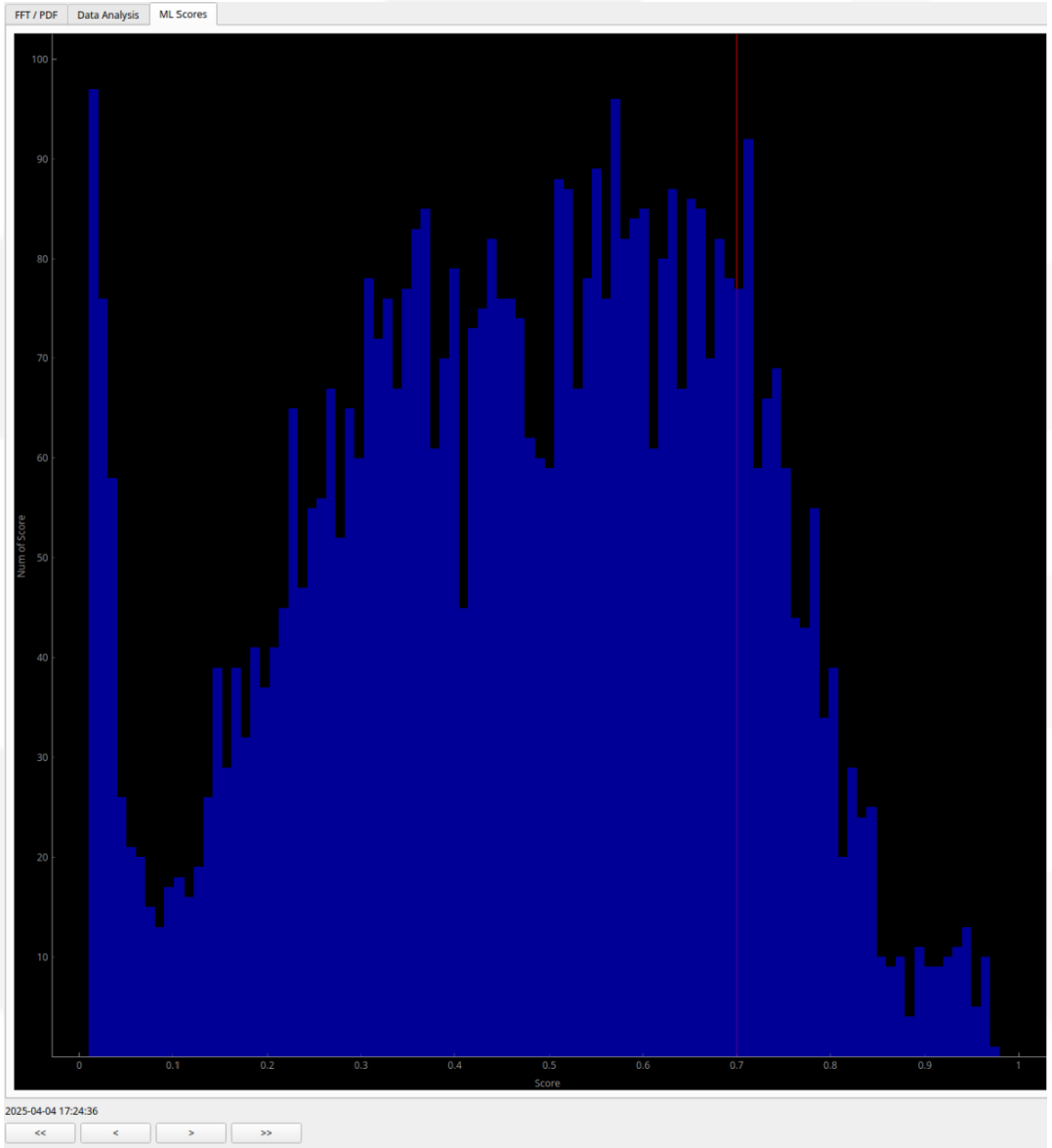
XGBoost tree configuration

- Estimators numer: **600**
- Learning rate: **0.01**
- Max depth: **10**
- Objective: **binary:logistic**



Machine learning in Synchrotron

Beam anomaly detection – **Online application**



Thanks to M. Wróbel for plot application

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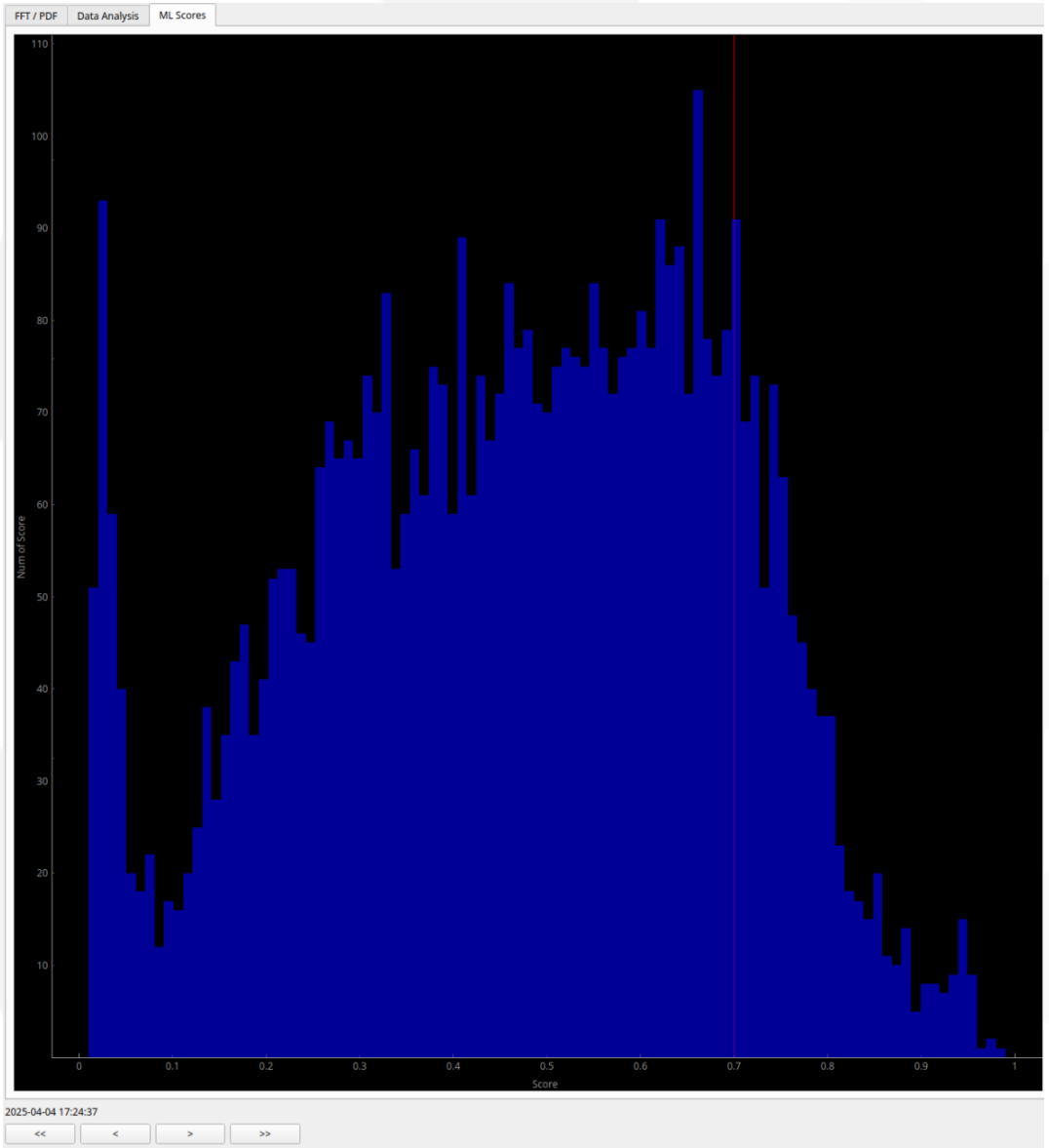
Beam anomaly detection – **Online application**



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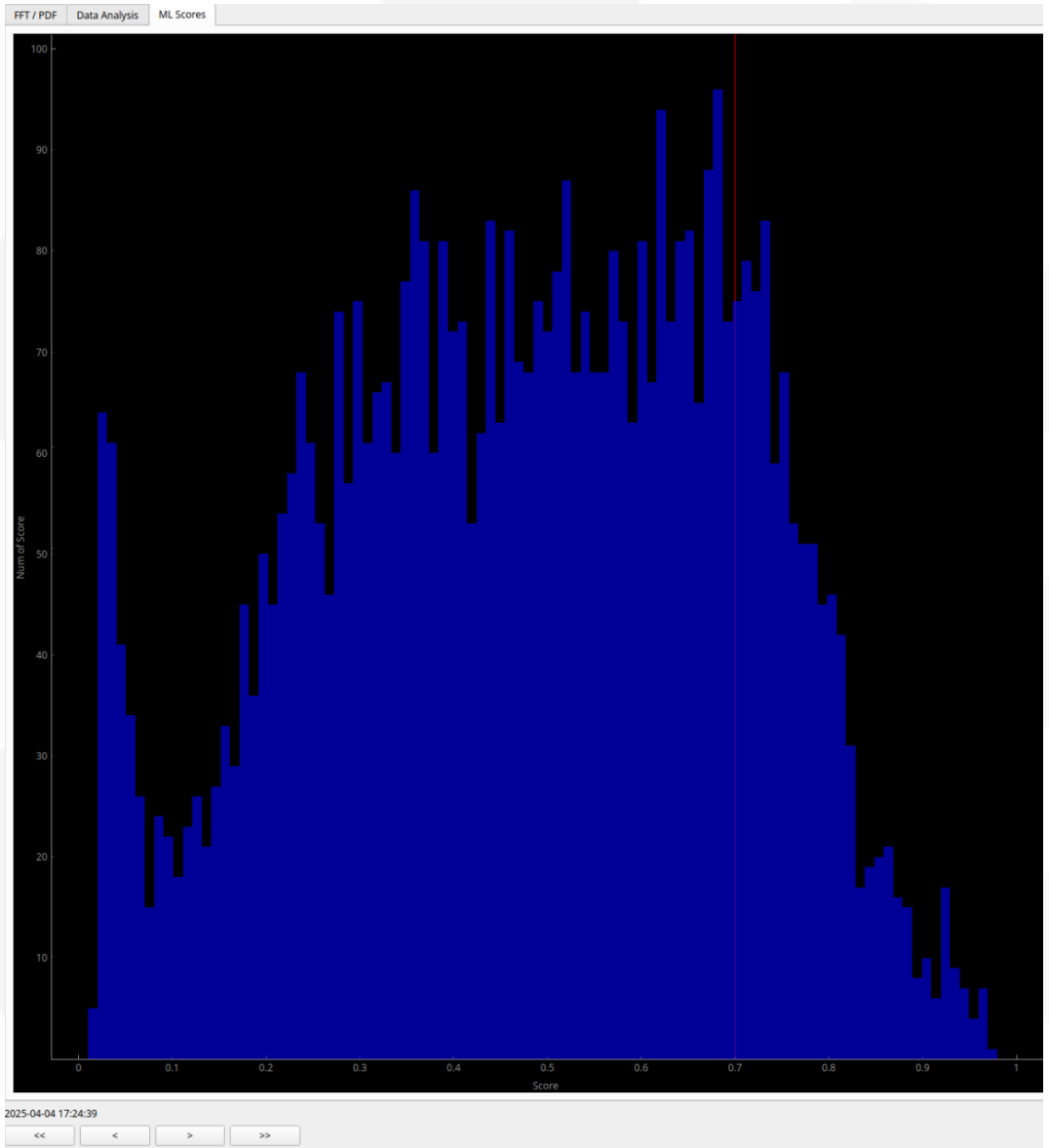
Beam anomaly detection – **Online application**



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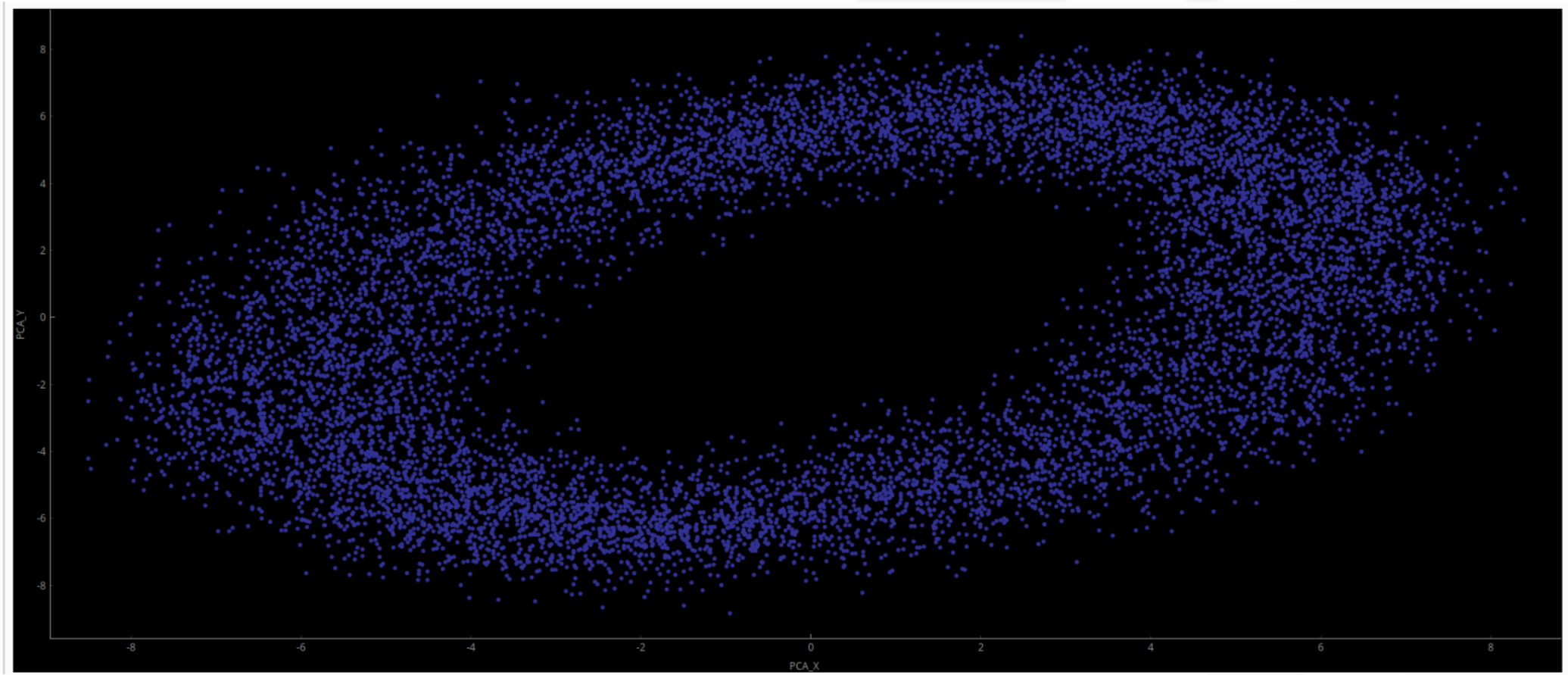
Beam anomaly detection – **Principal Component Analysis (good case)**



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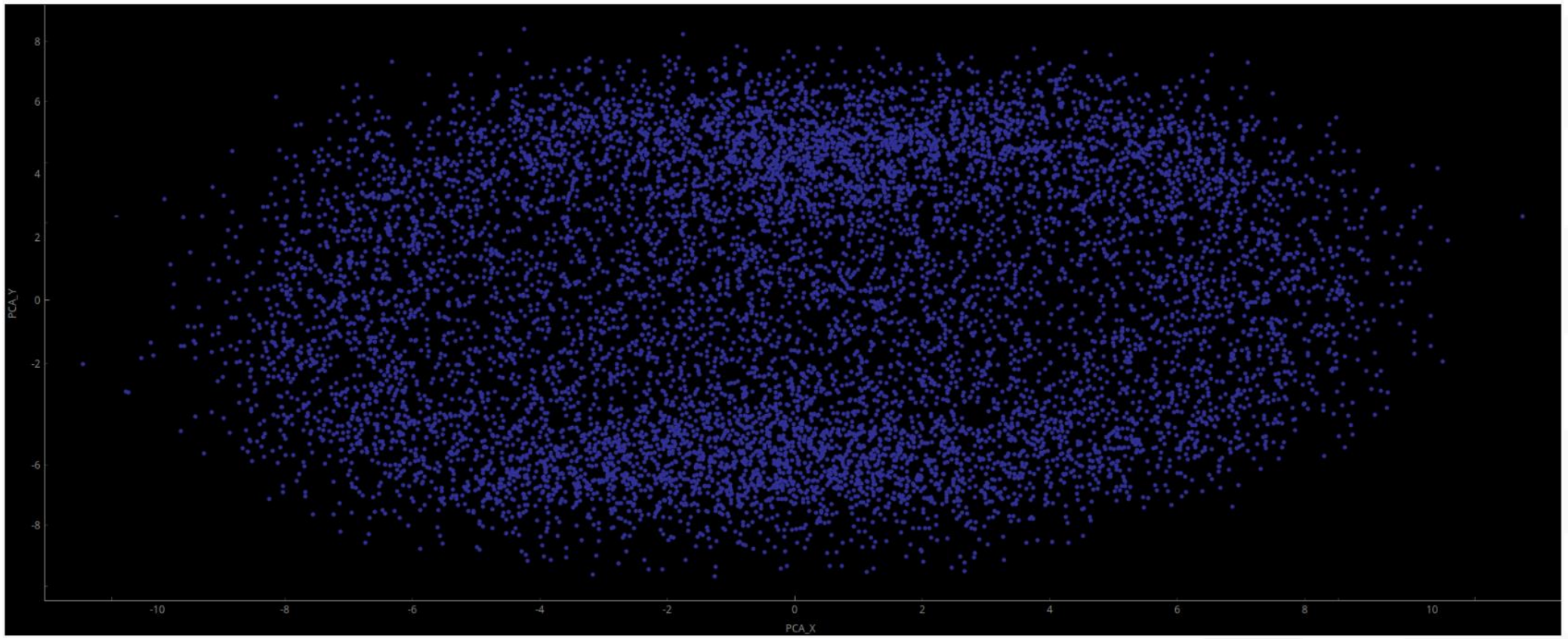
Beam anomaly detection – **Principal Component Analysis (bad case)**



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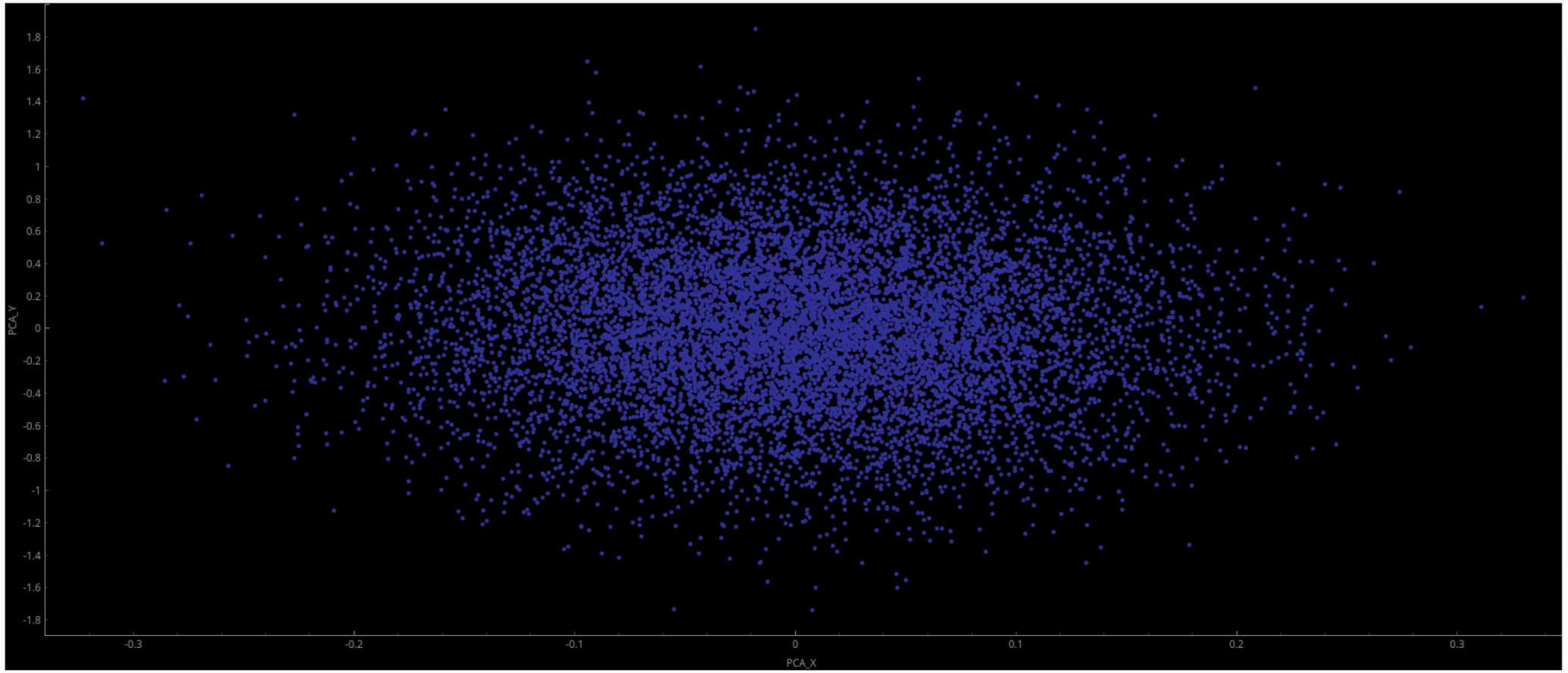
Beam anomaly detection – **Principal Component Analysis (section 6)**



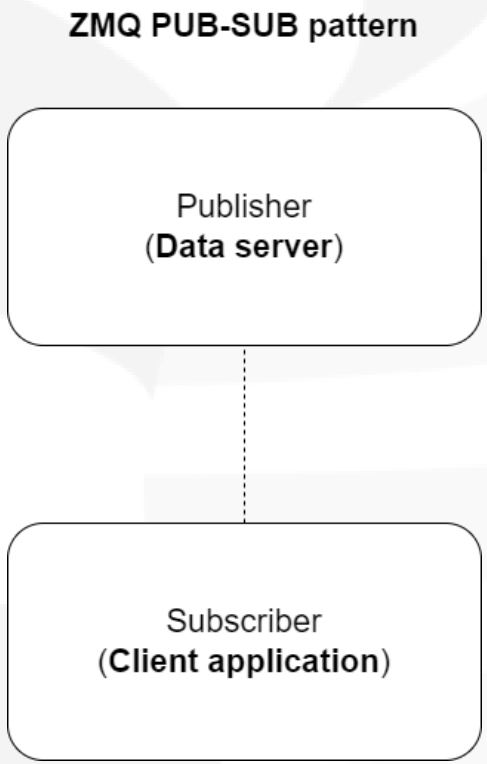
Streaming System

Technology:

- Written in Python 3.9,
- ZMQ framework,
- Build based on **Publisher-Subscriber** pattern.

Abilieties:

- Operating on 10 kHz signal,
- 3 MB/s online transmission,
- Scallable.



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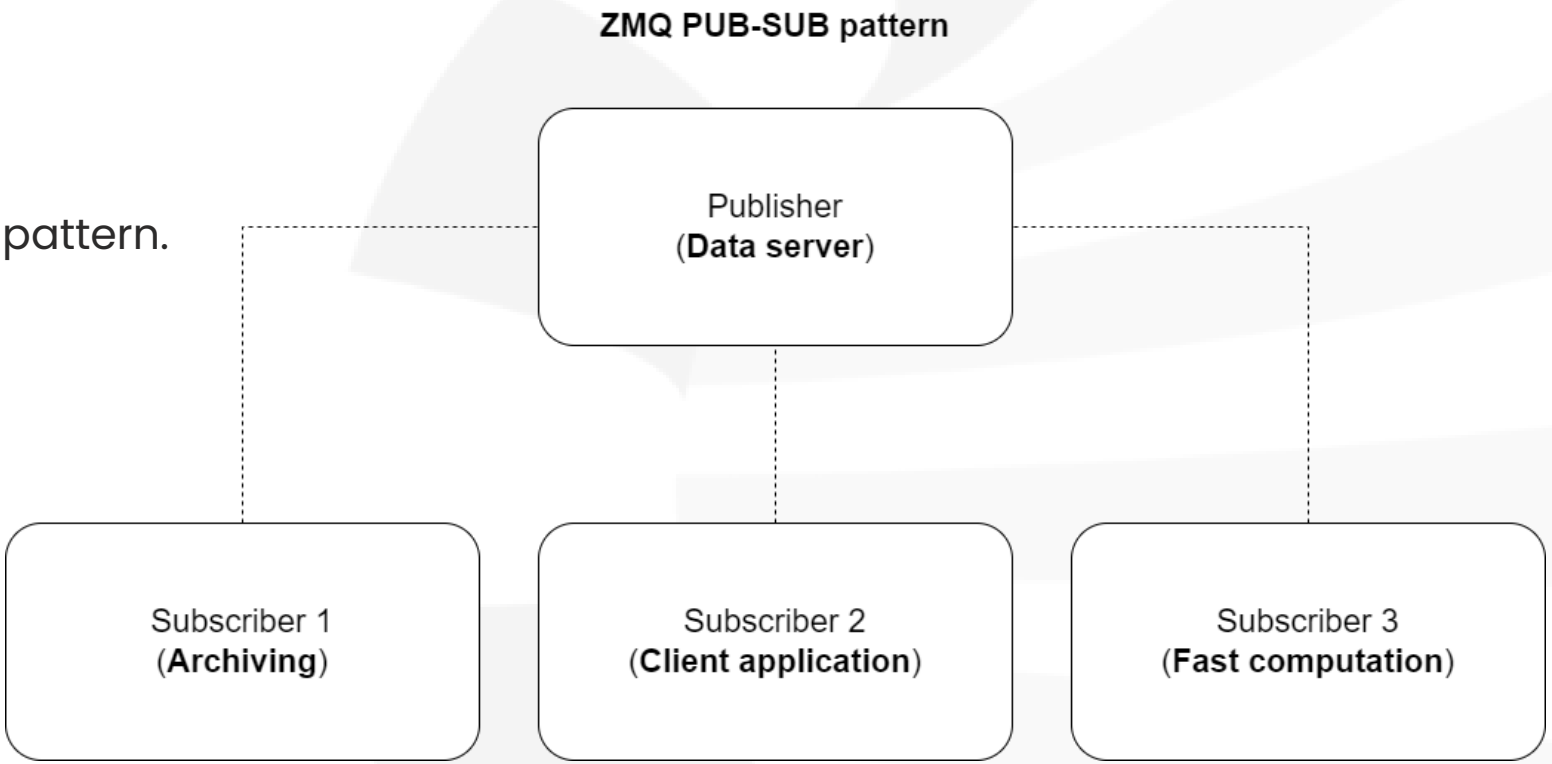
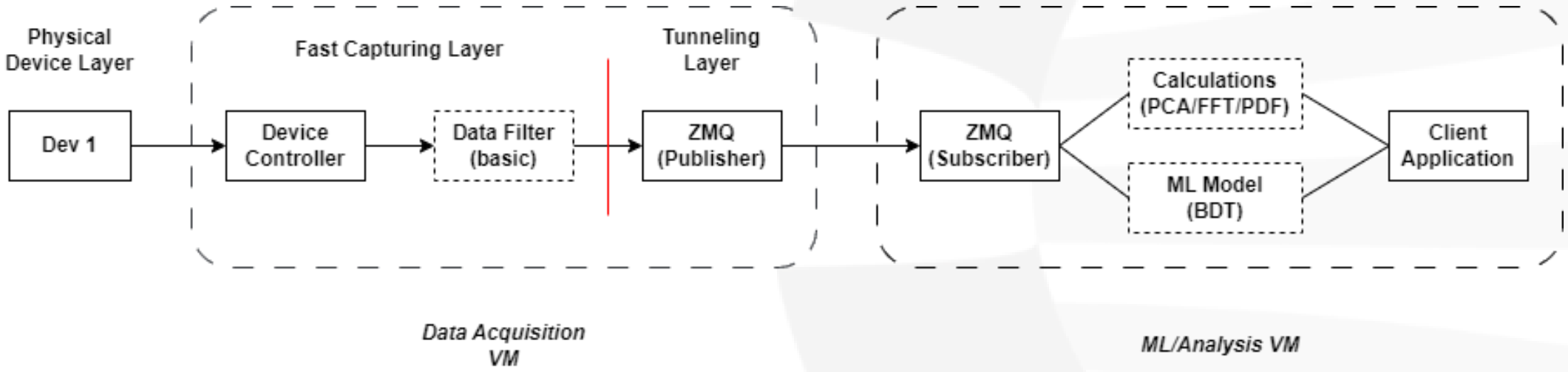


Streaming System

Architecture



Streaming System

Future plans

- Integration streaming management with Controls System,
- Implementation of **Parallel Pipeline** ZMQ patter (task distribution).

Thank you

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