Tecniche di Apprendimento Automatico e Autoencoding negli Esperimenti di Irraggiamento in Fisica delle Alte Energie

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CERN

IRRAD
Proton Facility

MINES PARIS | PSL

Machine Learning and Autoencoding Techniques in High-Energy Physics Irradiation Experimets

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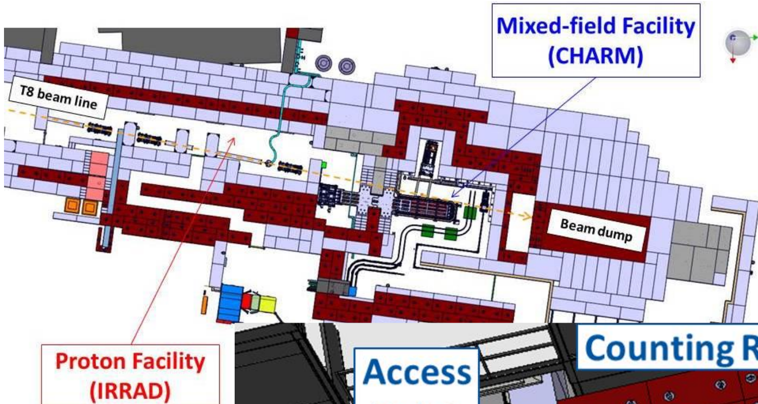
1. Introduction to IRRAD facility



IRRAD Proton Facility

- Located on T8 beamline – a 24 GeV/c proton beam extracted from PS ring.

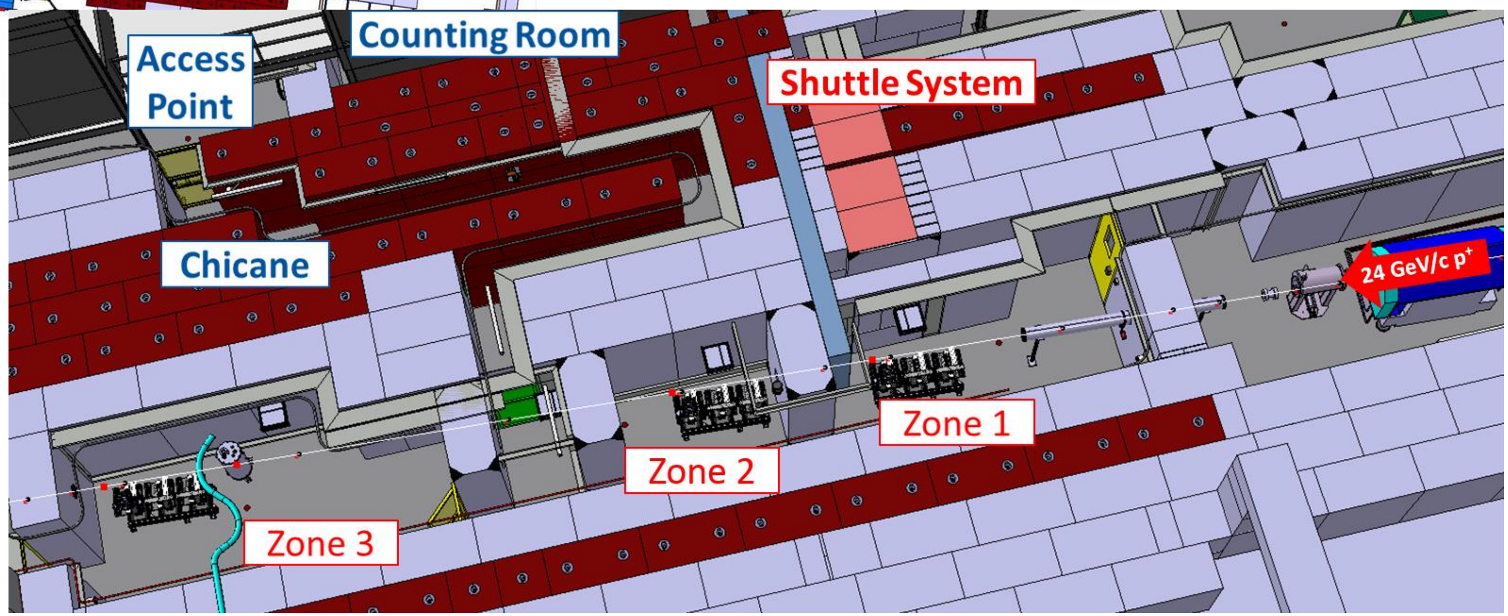


Fig. 1. The location and layout of the IRRAD facility. Divided into three zones and equipped with a shuttle system, it is a place for electronic qualification and radiation hardness assessment.

2. Automatic Assessment of Experimental Proposals

Goal

- Support to facility users – to prepare better experiments
- Support to User Selection Panels – to prepare better reviews

Simple goal – yet lots of challenges

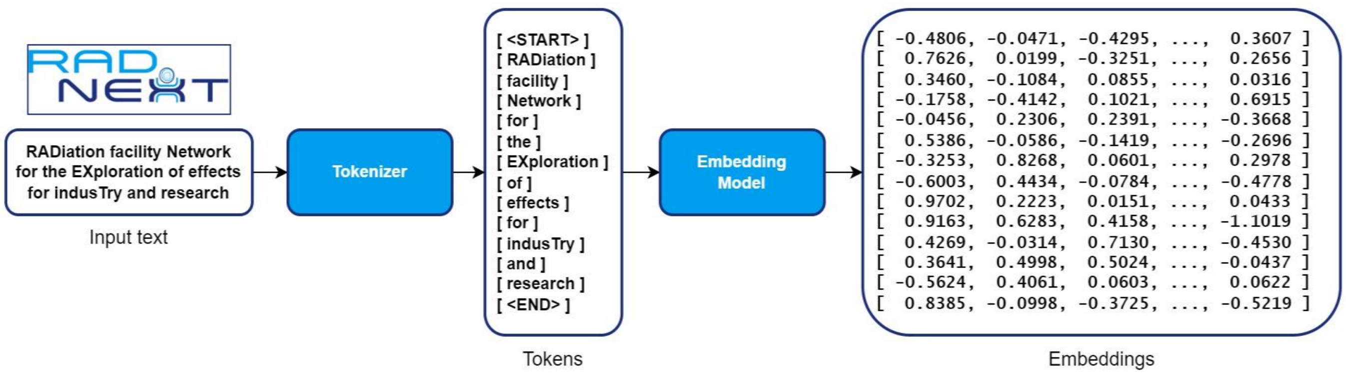


Fig. 2. An illustration of embeddings creation of a short text. The result is a real vector obtained with the transformer architecture.

2. Automatic Assessment of Experimental Proposals

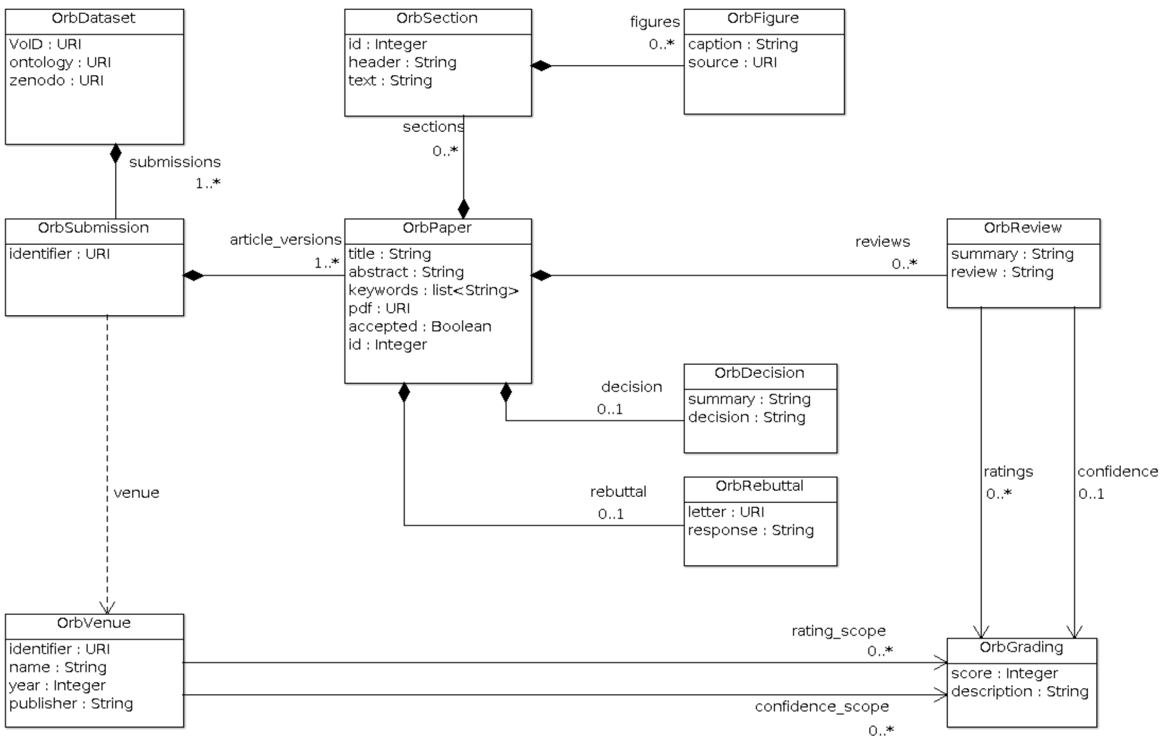


Fig. 3. The UML diagram presents the architecture of the ORB dataset. It is the third iteration involving resources like OpenReview, Sci-Post and PeerJ.

3. Transverse Beam Profile Monitoring

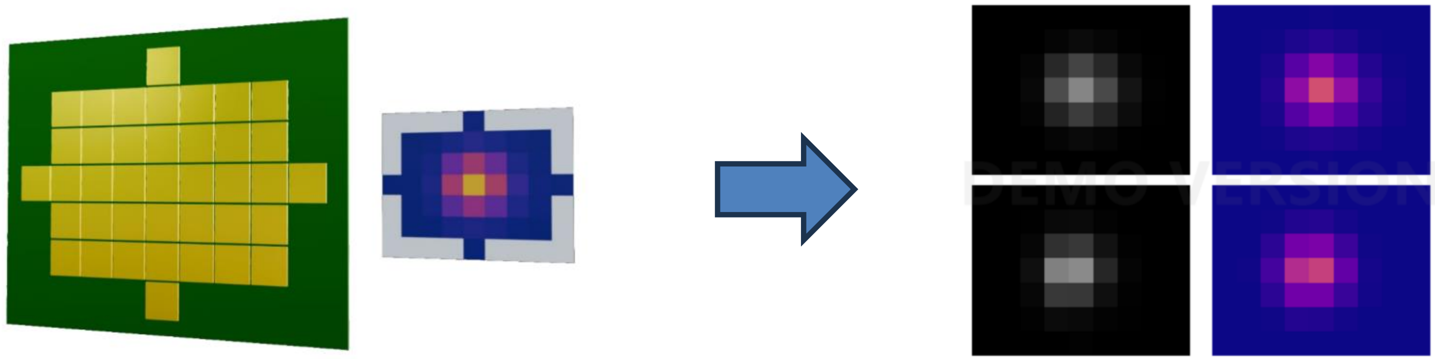
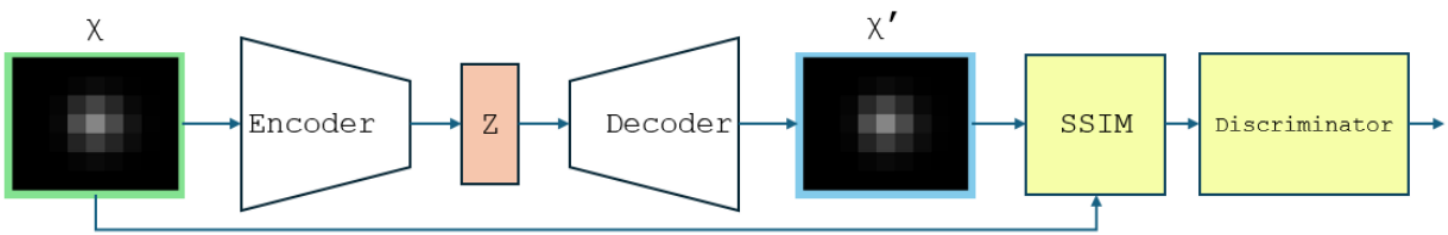


Fig. 4. New BPM DAQ (Data Acquisition) electronics is used to monitor the beam profile. The existing data was used to create custom dataset for anomaly detection.



+offline with 16x speed-up

Fig. 5. A Convolutional Autoencoder with SSIM (Structural Similarity Index Measure) metric provides the foundation for real-time anomaly detection - an off-centred beam.
One problem is that a „good" profile is sometimes mistaken for an off-centred.

4. IBPM x MWPC - crossanalysis

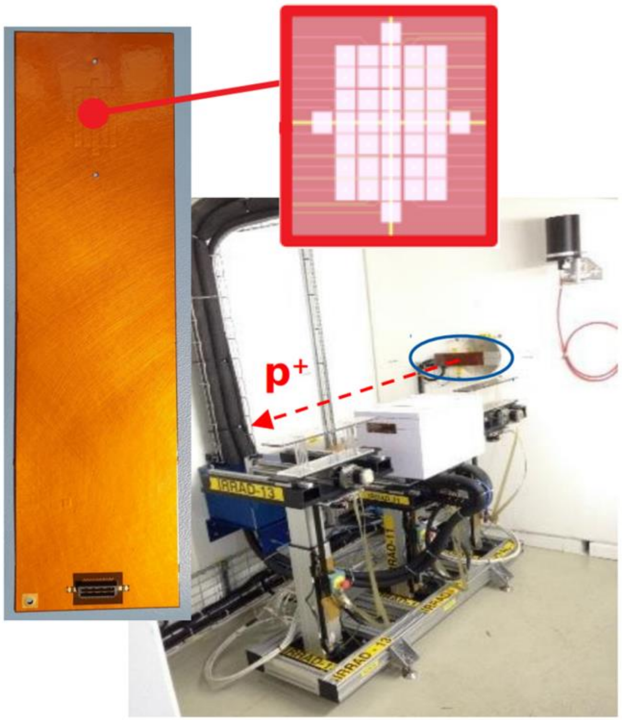


Fig. 6. Crossanalysis between two devices allows to identify their respective strengths and weakpoints. That knowledge results in „super-resolution" model – a software enhancement applied for chosen BPM detector.

Links and available resources

1. ORB – CERN Gitlab repository
   https://gitlab.cern.ch/irrad/orb-dataset

2. „The Open Review Based dataset" - arXiv preprint
   https://arxiv.org/abs/2312.04576

3. „ML-Based Classification and Evaluation of the Bean Profile Patterns" – Euro-Labs report
   https://web.infn.it/EURO-LABS/wp-content/uploads/2024/08/EURO-LABS_MS29_final.pdf

4. „Machine learning for the anomaly detection and characterization of the 24 GeV/c proton beam at CERN IRRAD Facility" – IPAC 2025 Proceedings Paper
   https://meow.elettra.eu/81/doi/jacow-ipac25-thpm110/index.html

5. „Characterization of an IRRAD beam profile monitor at the CERN T8 beamline and improvements via cross-analysis with multiwire proportional chamber" – IPAC 2025 Proceedings Paper
   https://meow.elettra.eu/81/doi/jacow-ipac25-thpm111/index.html

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www.radnext.web.cern.ch

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www.web.infn.it/EURO-LABS

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