Machine Learning for Velo Upgrade Pattern Recognition

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LIV.

LHCb

Science & Technology Facilities Council

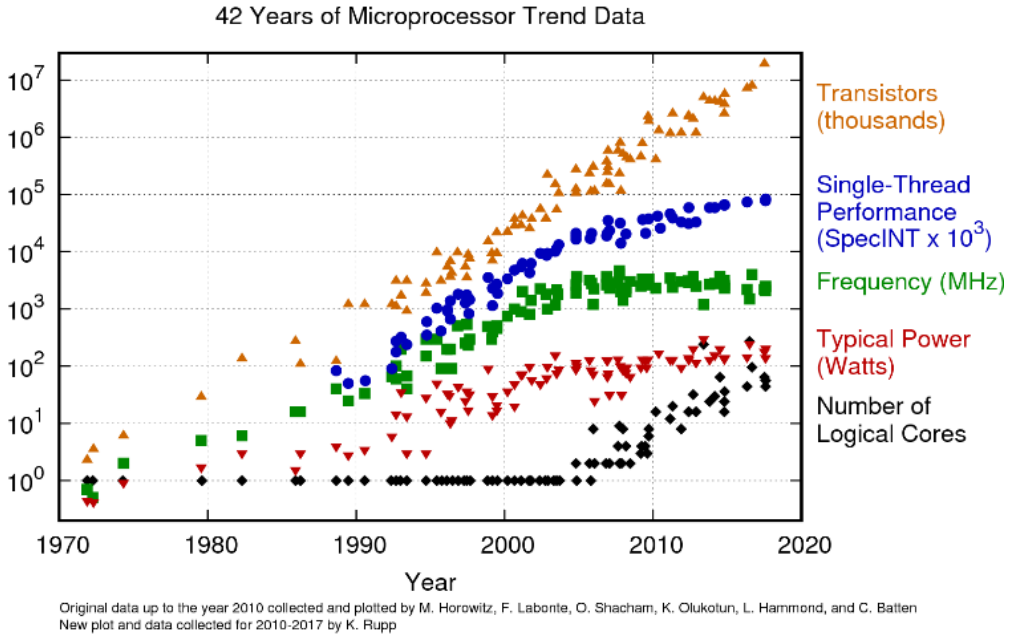
FONDAZIONE BRUNO KESSLER

Contents

1. LHCb upgrade.
2. Hybrid Approach to tracking.
3. Front-end hybrid inspection.
4. Plans for the future.

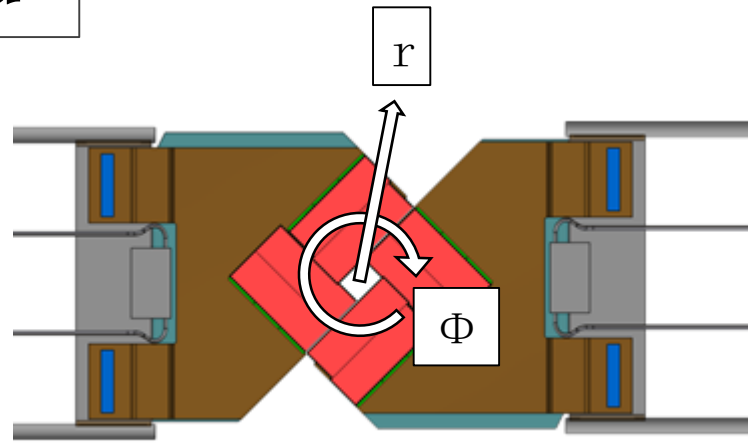
LHCb Upgrade

- Brand new Velo detector, readout at 40MHz.
- Provide tracks for first stage of trigger.
- Large speed up required for real-time tracking.
- Computer performance trend is towards parallelism.

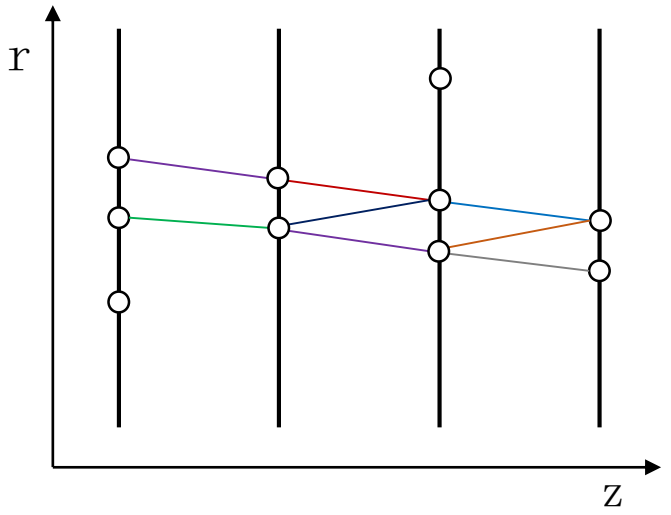


Hybrid ML Tracking: Method

1. Neural network creates doublets.
2. Remove incompatible doublets.
3. Join doublets into tracks.
4. Clone killing.



- Different NN for each pair of modules.
- Inputs are (r, Φ) of each hit.
- Output is probability that each target hit is connected to seed hit.
- Each hit can be processed in parallel.



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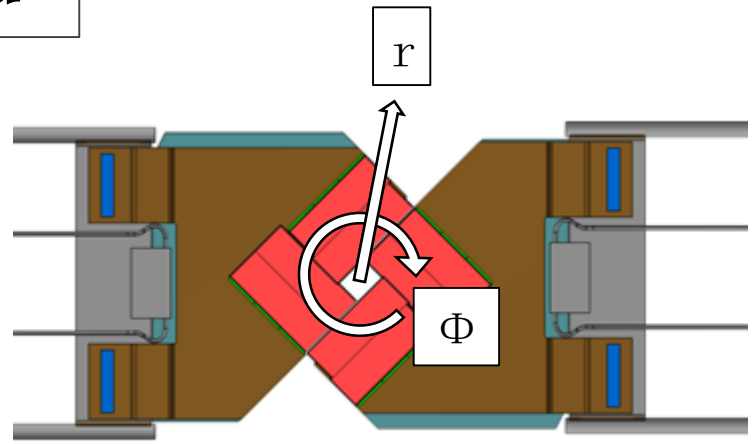
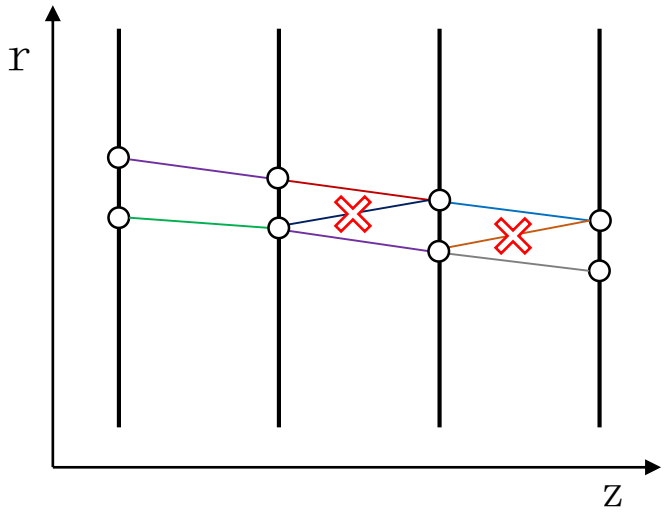


- NN allows more than one doublet from a seed hit.
- Doublets with most similar r-gradient kept, or minimum Φ gradient for end of track hits.
- Removes branching of tracks.



Hybrid ML Tracking: Method

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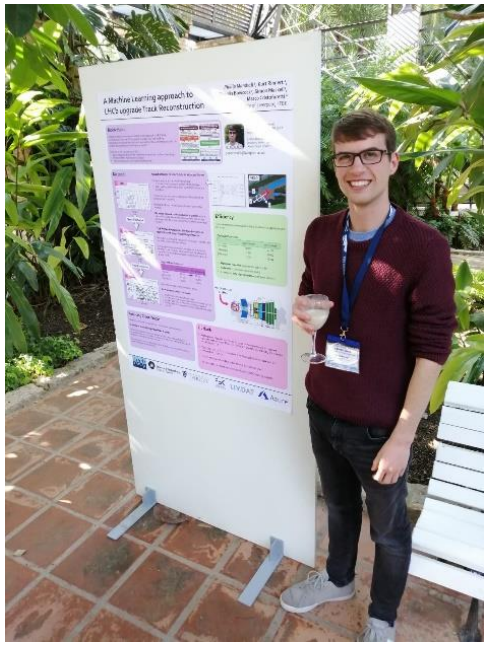
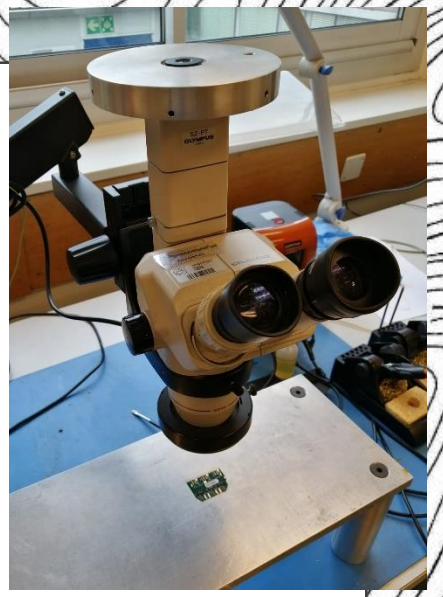


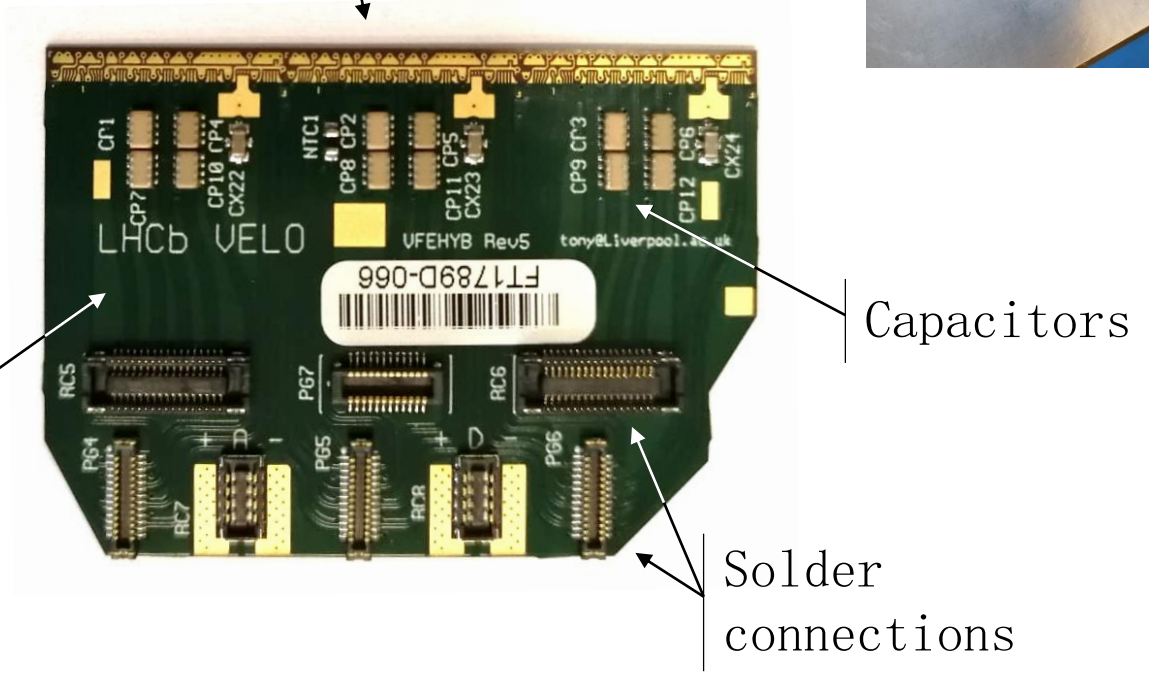
- Remaining doublets can be simply connected together.
- Track variables for clone reduction:
  - $\frac{dr}{dz}$, $\overline{\phi}$, $z-intercept$
- KDTree used to join tracks with small 3D distance between parameters.

Method	Efficiency	Ghost rate	Clone rate
Hybrid	97.3%	0.11%	1.04%
Conventional	98.9%	2.5%	1.0%

Front-end Hybrid Inspection

- Whilst at CERN I have been involved in Velo module production.
- By visually inspecting front-end hybrids.
- All initial problems solved.





Future Work

LIV.DAT placement

- OnTrac in Newcastle
- Provide software for the railway engineering industry.
- Working to analyse their data.

Complete ML tracking

- The step beyond the hybrid approach is to use a NN to go straight from hits to tracks.
- Difficulty is finding a way to map inputs to outputs, it is an unusual NN application.

FPGA Implementation

- Can these tracking algorithms be implemented of FPGAs?

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Thank you

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