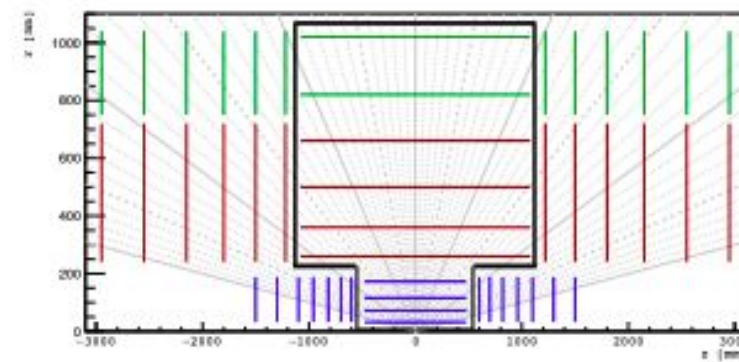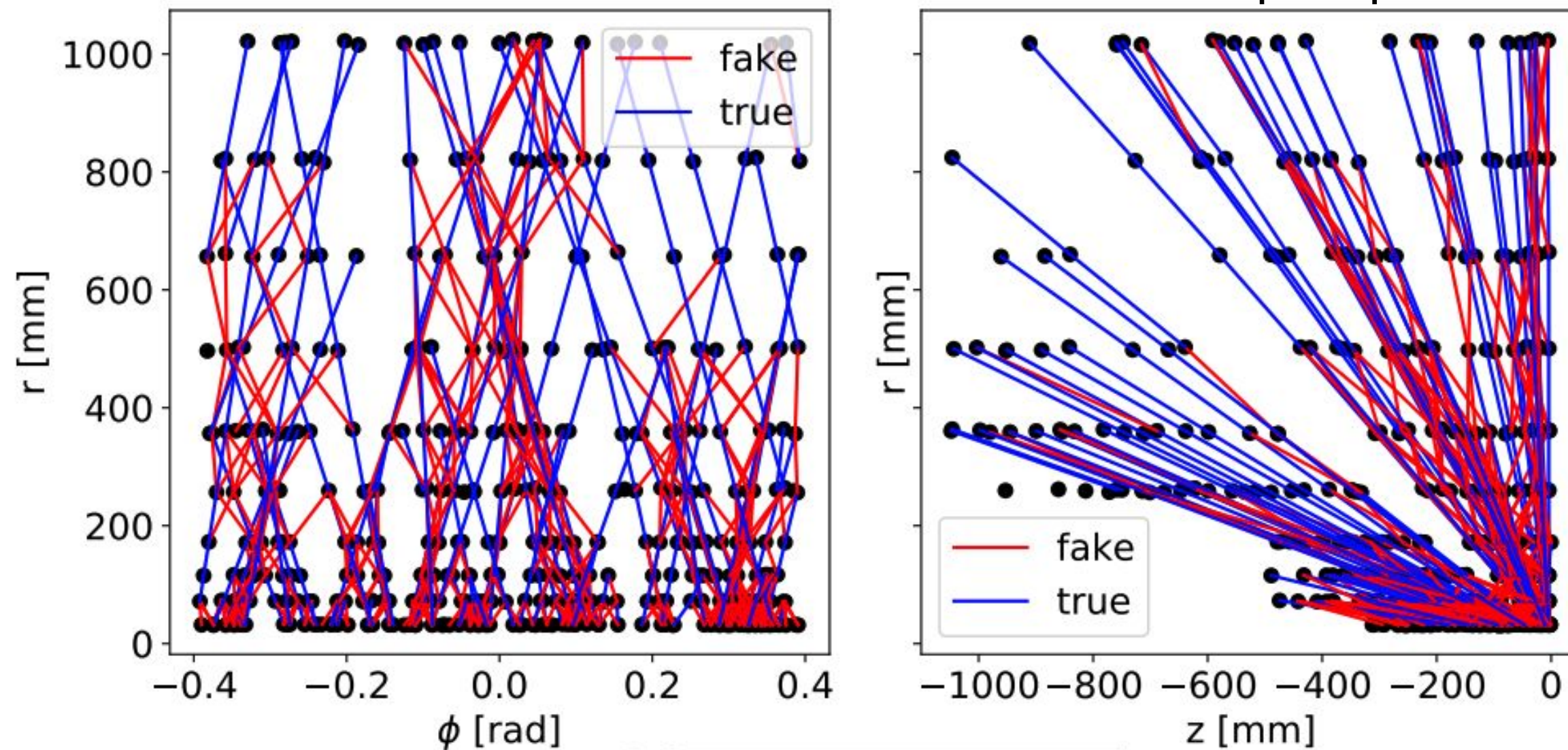# Particle ID with timing using quantum algorithms

Karolos Potamianos :: Daniel Dobos :: Bilge Demirköz :: **Kristiane Novotny**

TIME SAVING · KNOWLEDGE OVERVIEW · UNEXPECTED INSIGHTS

Make Complexity Irrelevant

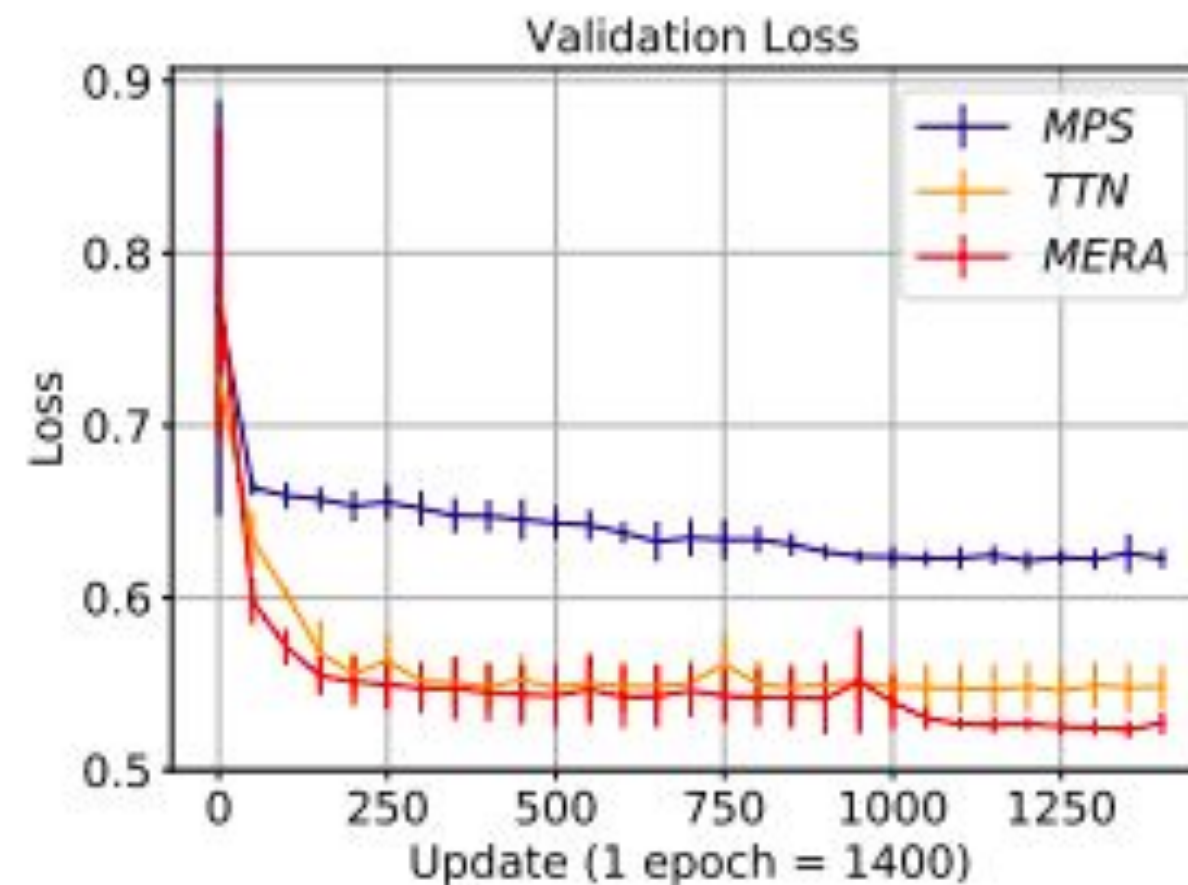# Performance of Particle Tracking Using a Quantum Graph Neural Network
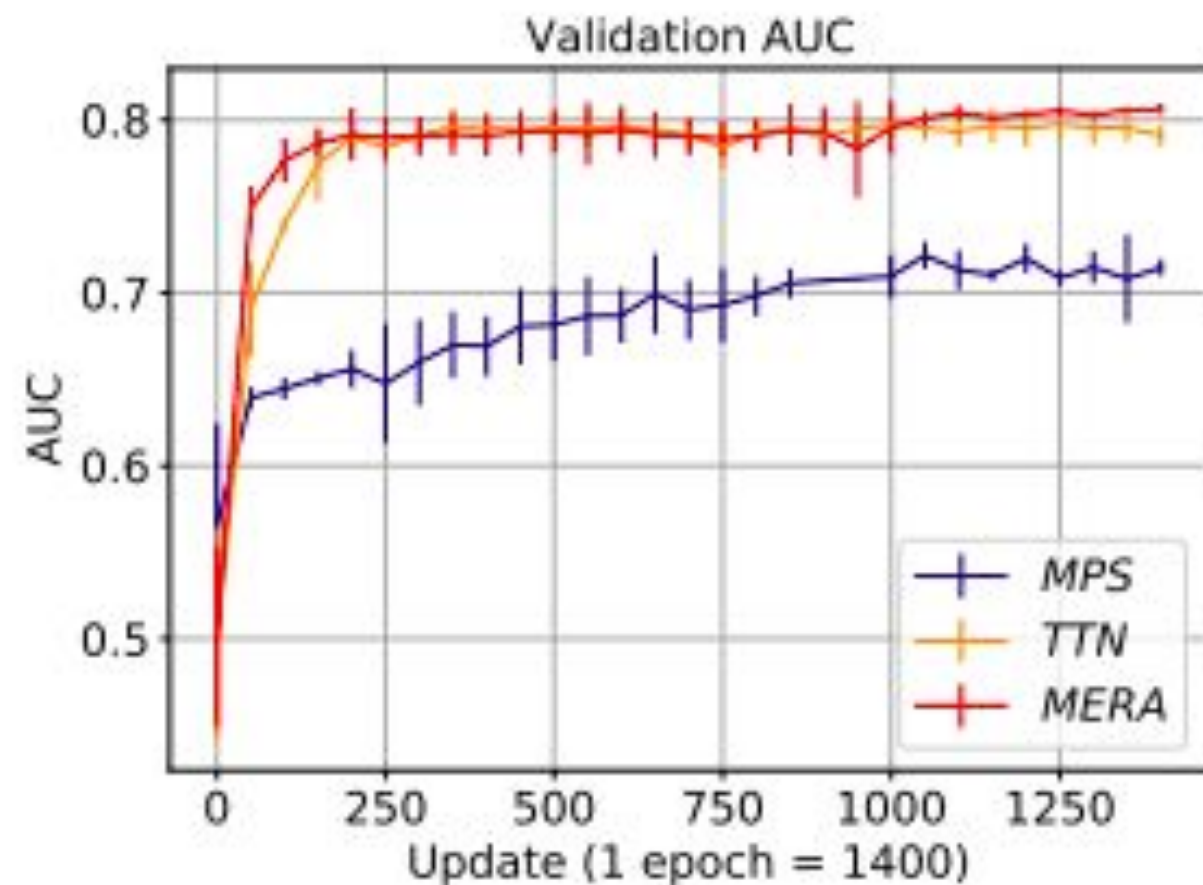
https://quantum.cern/quantum-graph-neural-networks

Cenk Tüysüz, Jean-Roch Vlimant, Bilge Demirkoz, Karolos Potamianos, Daniel Dobos, Kristiane Novotny, Carla Rieger, Sofia Vallecorsa

Performance of Particle Tracking Using a Quantum Graph Neural Network
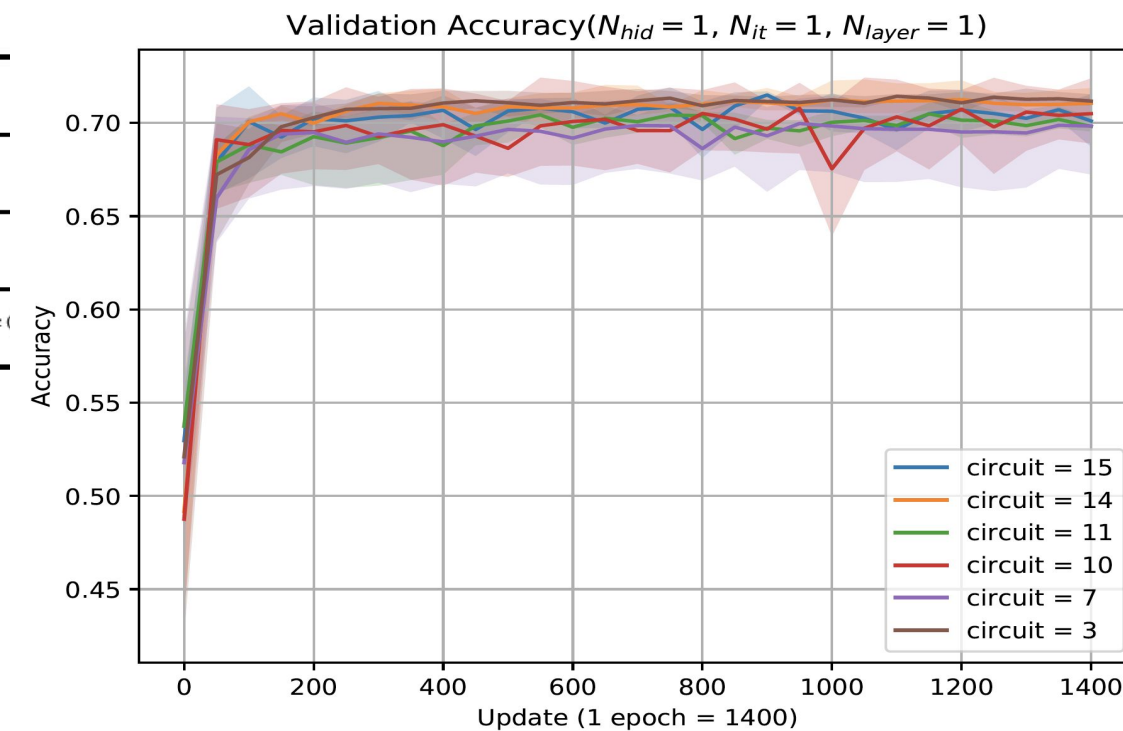
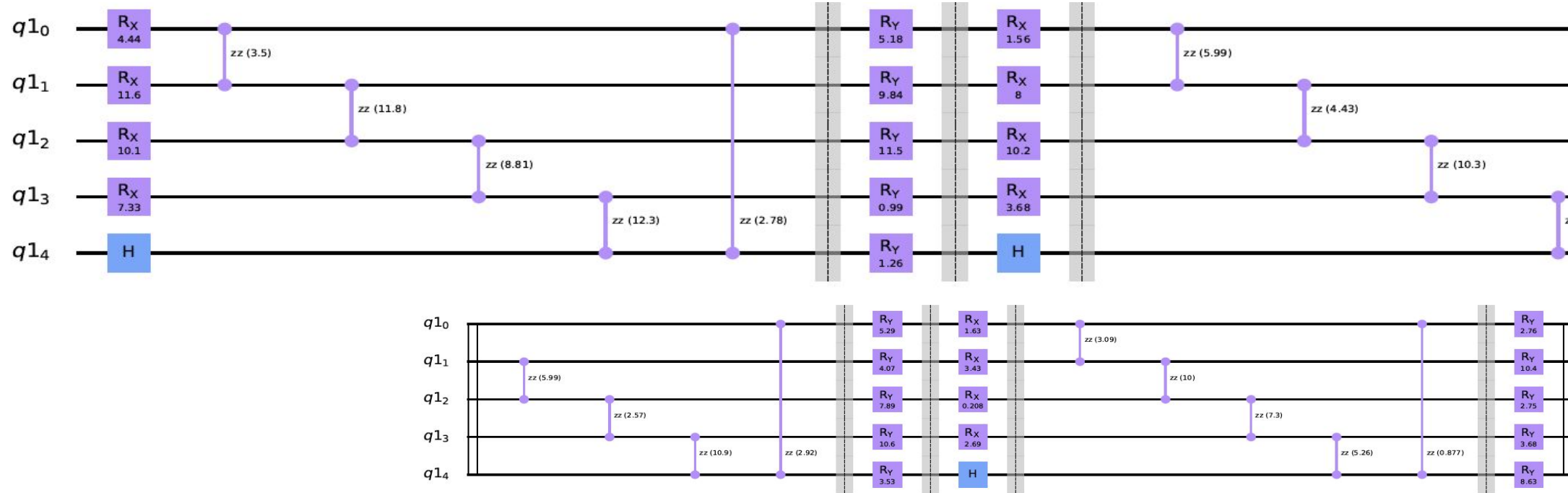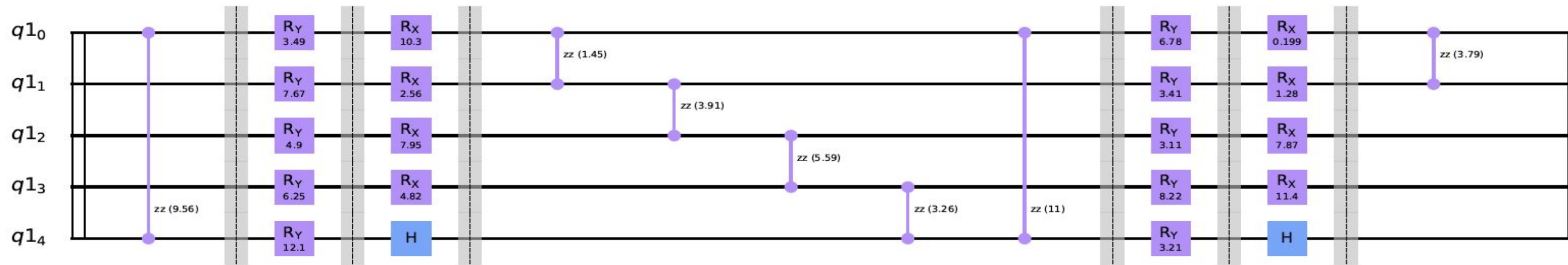https://quantum.cern/quantum-graph-neural-networks

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Performance of Particle Tracking Using a Quantum Graph Neural Network

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Current status

- Higher intensity with upcoming HL-LHC era
  - Many more combinations possible when reconstructing particle tracks
  - Wrong assignment of particle tracks to vertices
  - Computationally expensive
- Additional timing information to spatial information helpful
- Timing layer is supposed to
  - reduce background
  - improve reconstruction of particle ID

ATLAS computing model projections for Phase-2
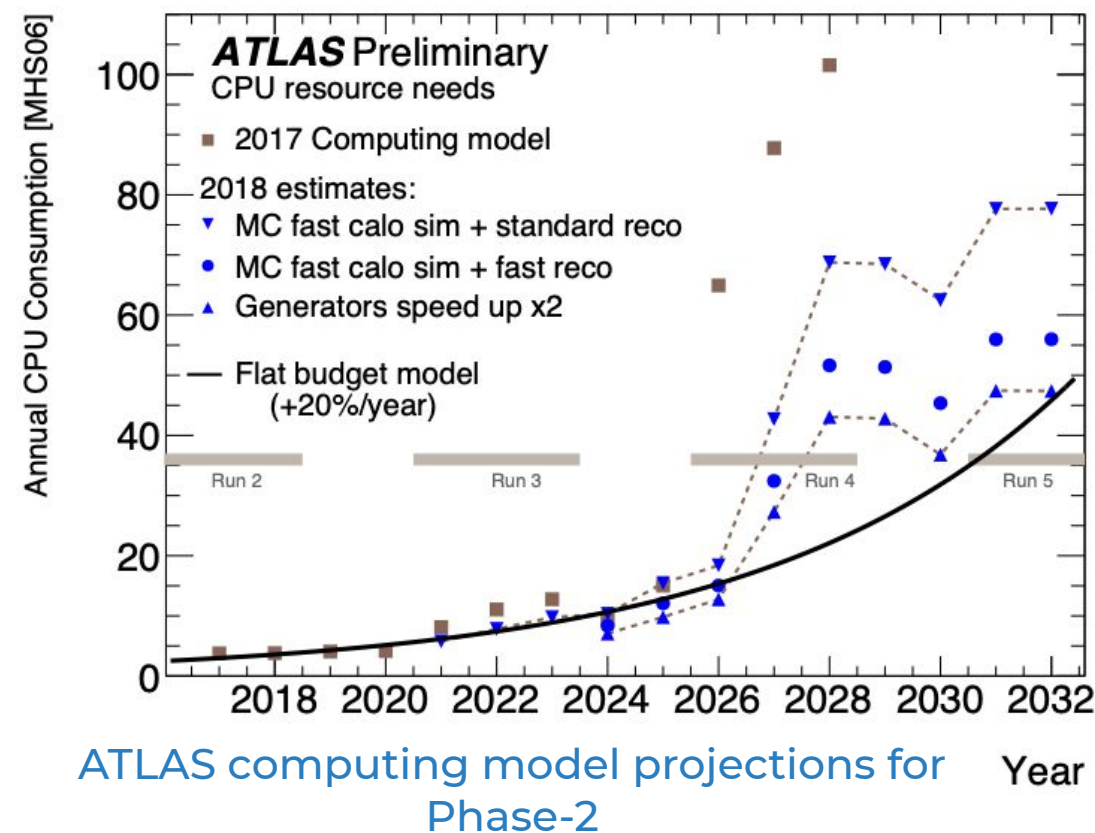
Number of tracks is expected to increase by 12-15 times

|	Run 1	Run 2	Run 3
μ	21	40	150-200?
Tracks	~280	~600	~7-10k

μ: Average number of interactions per bunch crossing

H. Gray, Track reconstruction in the ATLAS experiment, 2016.

5

Proposal

- Possible speed up of computation using QML
  - data encoded into quantum states
- Adding higher granularity to calorimeter due to 4D structure
- Reduction of possibilities due to small timing window
  - unambiguous identification of particle track
- Applicable to both high-energy (e.g. ATLAS, CMS) and precision frontiers (e.g. NA62, KLEVER)
- **Comparison to existing work**, e.g. Vallecorsa et al. 2020
- **Combining and extending prior work:** classification algorithms (e.g. QSVM, QGAN, BDT...) and track reconstruction algorithms (QGNN)

schematic drawing of 4D reconstruction
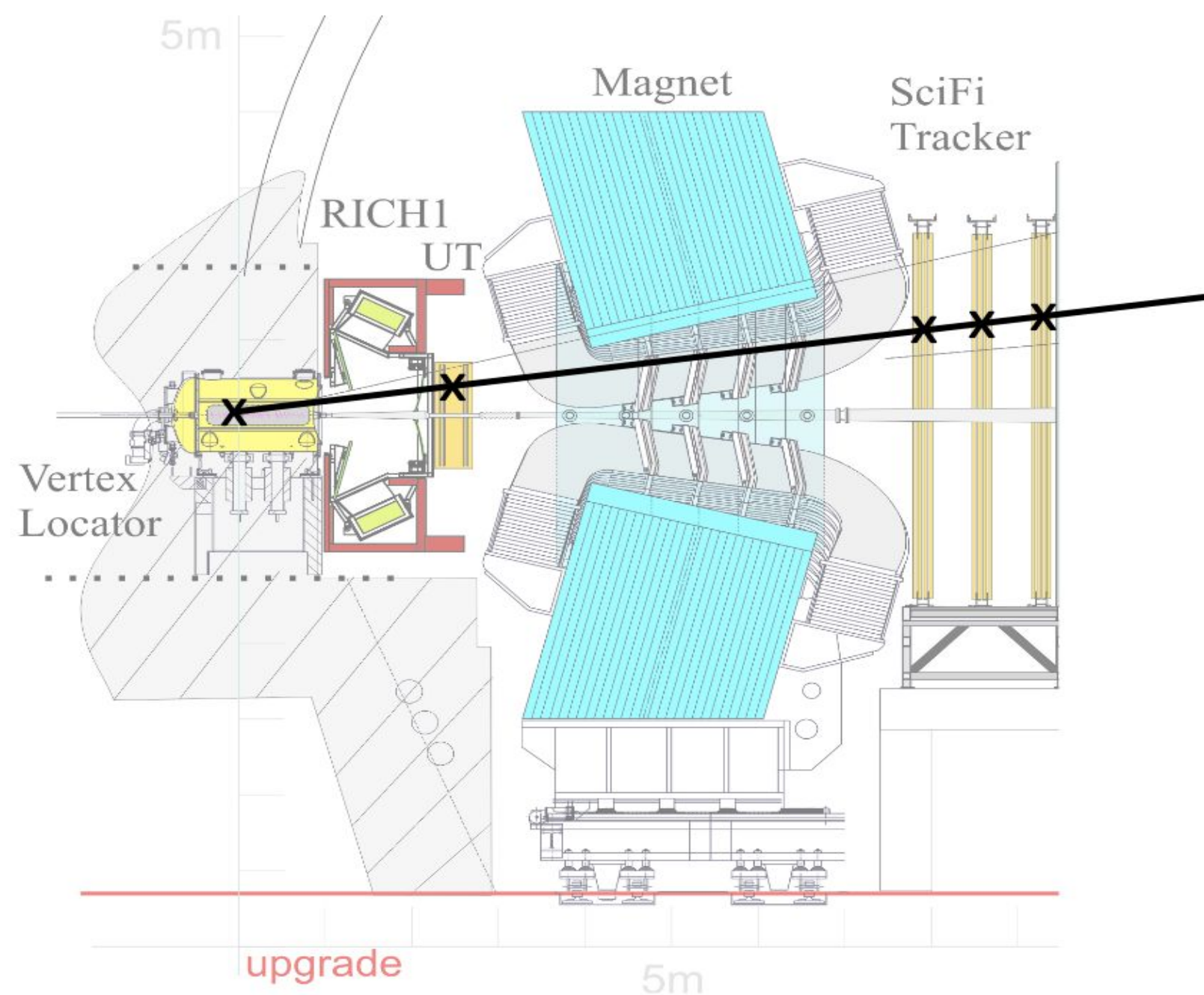
source: M. Williams, ECHEP Workshop 2020, slide 10

Thank you!

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