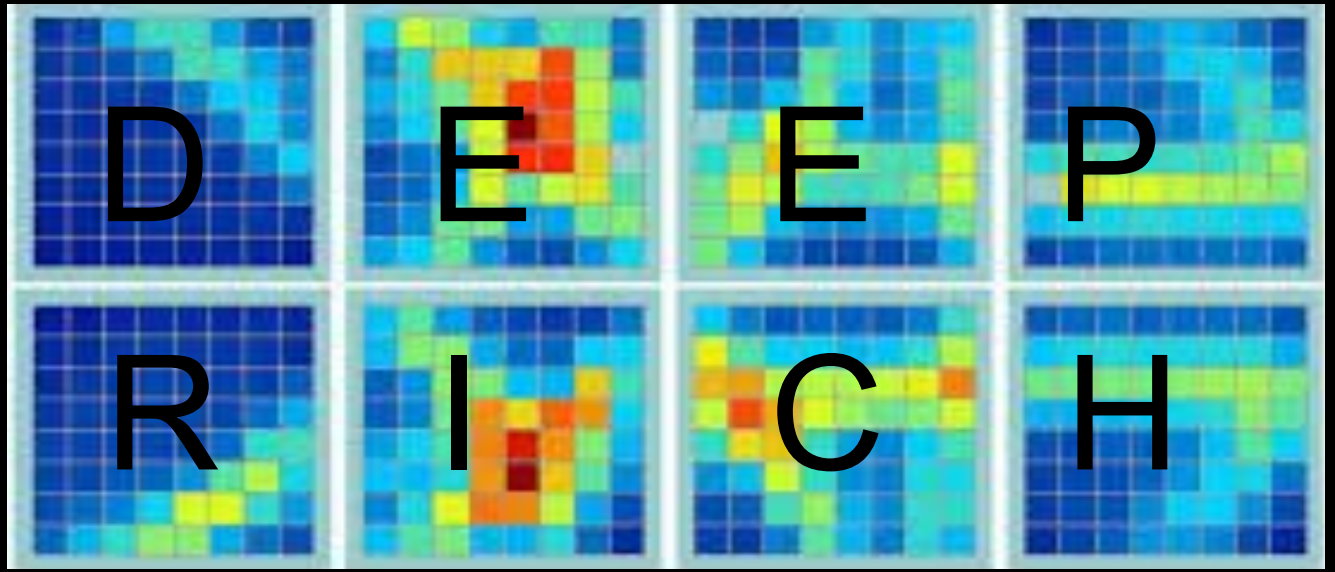

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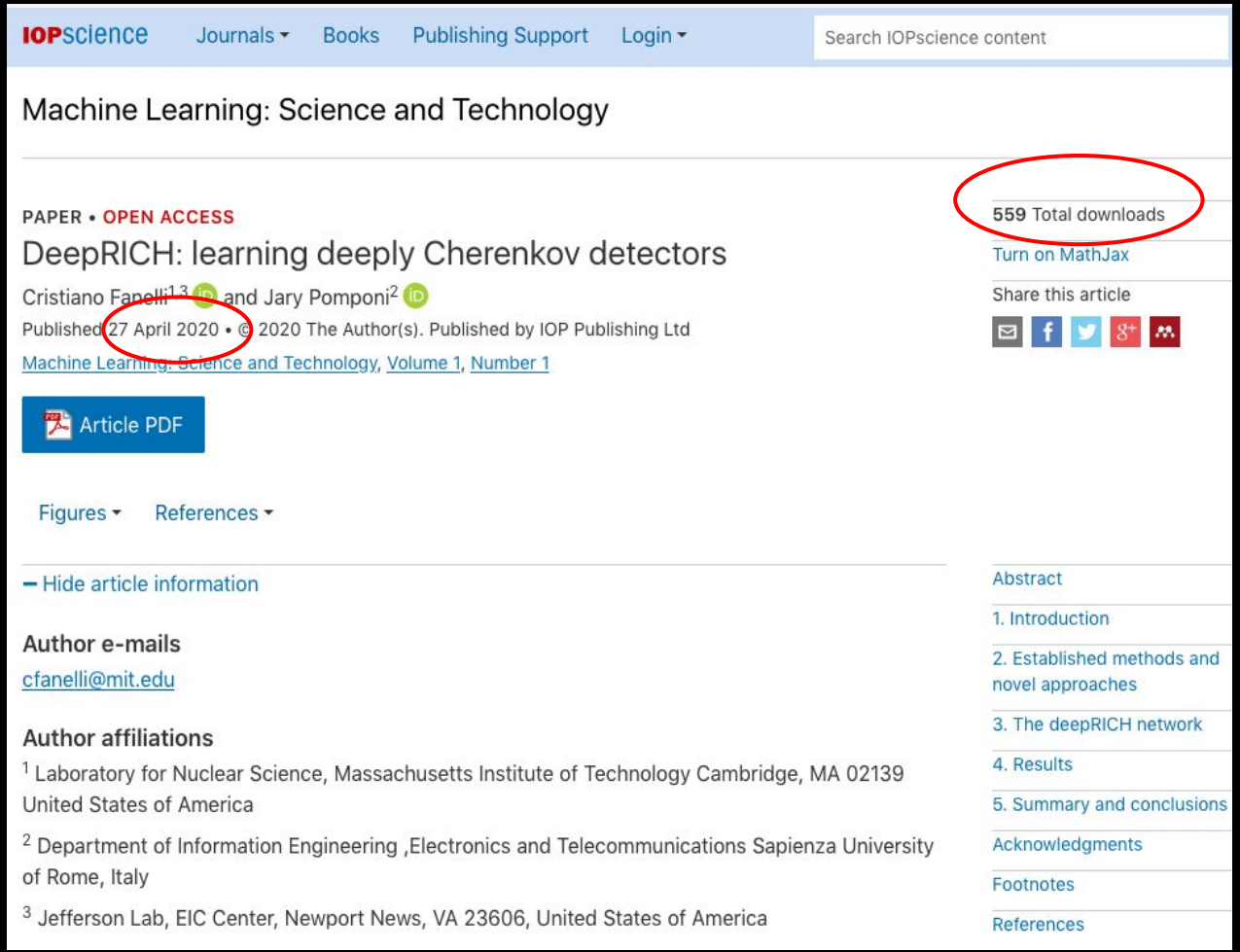
What follows is mostly taken from the paper:

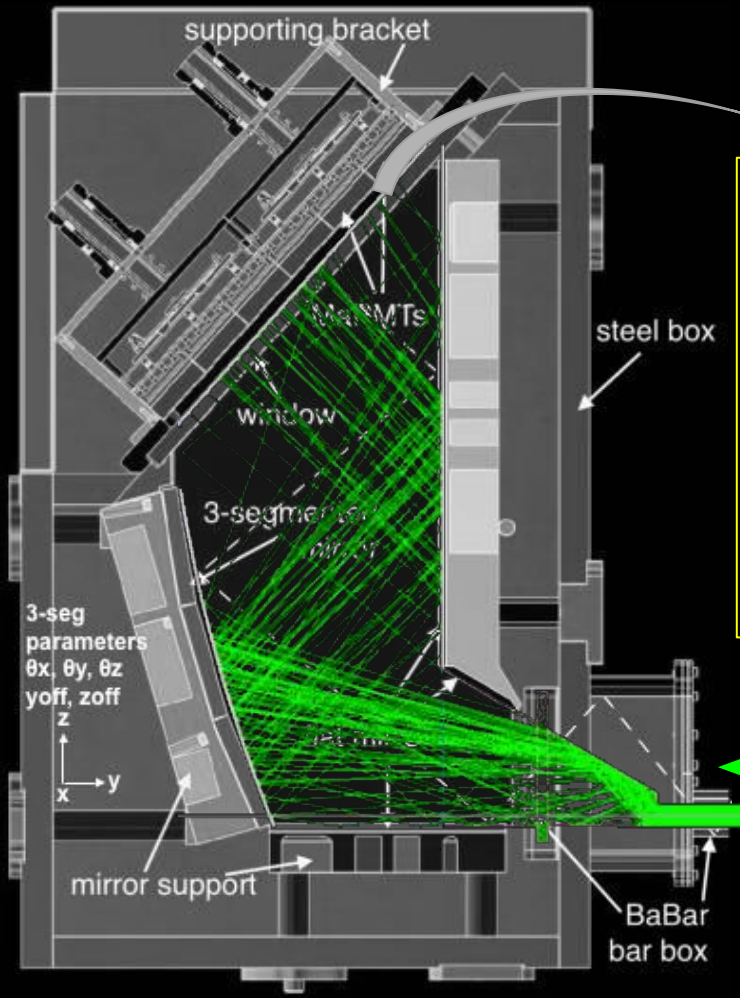
"DeepRICH: learning deeply Cherenkov detectors." IOP *Machine Learning: Science and Technology* 1.1 (2020): 015010.

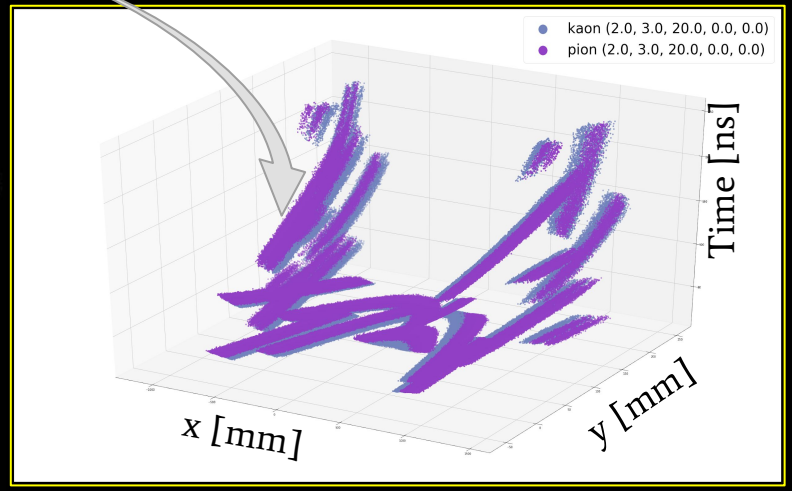
CF and Jary Pomponi

(open access)



DIRC Detector Schematics





3D (x,y,t) readout allows to separate spatial overlaps.

Patterns take up significant fractions of the PMT in x,y and are read out over 50-100 ns due to propagation time in bars.

H12700 PMTs have a time resolution of O(200 ps) and read-out electronics giving time information in 1 ns buckets.

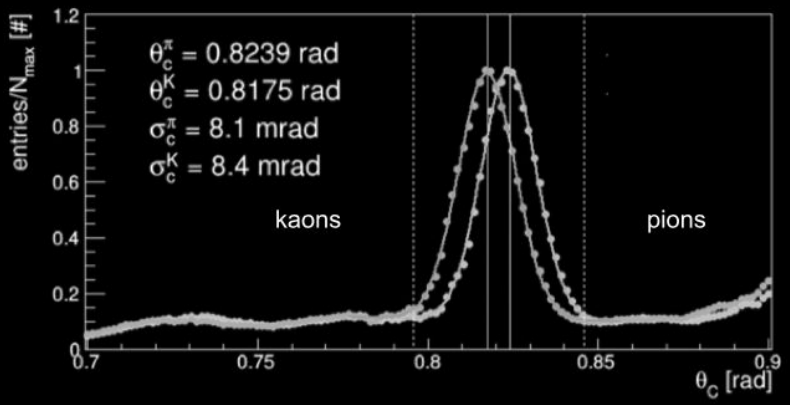
Reconstruction Algorithms: Established Methods

LUT-based geometrical

R. Dzhygadlo et al. Nucl. Instr. And Meth. A, 766:263 (2014)

1. Creation of the LUT: store directions at the end of the radiator for each hit pixel

2. Direction from the LUT for the hit pixels are combined with the track directions (from tracking)

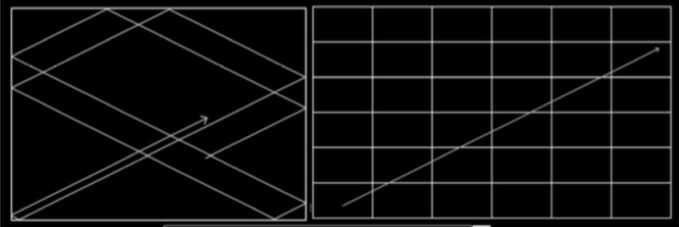


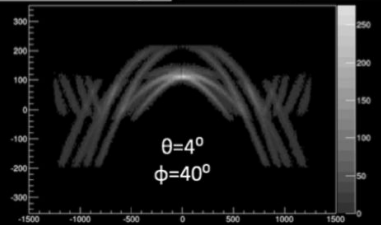
KDE-based

J. Hardin and M. Williams, JINST 11.10 (2016)

Fast tracing mapping straight lines through a tiled plane

1. Generation - 2. Traces through bars - 3. Traces through expansion volume





$$P(x) \approx \sum_{i}^{n} K(x - s_i)$$

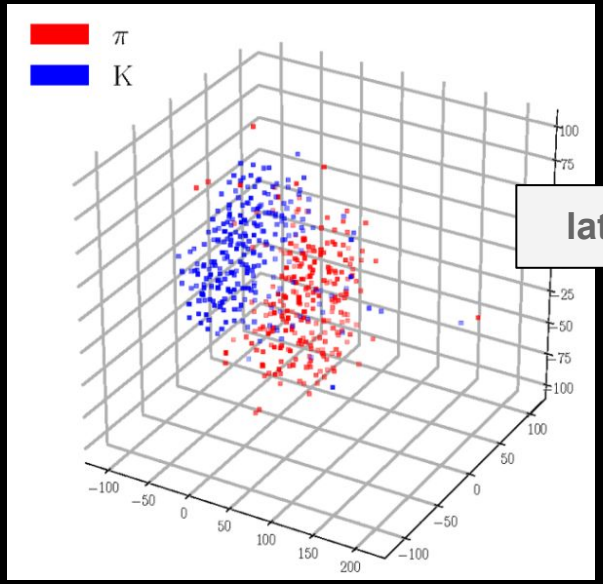
https://github.com/jmhardin/FasDIRC

basically a trade-off memory/CPU usage

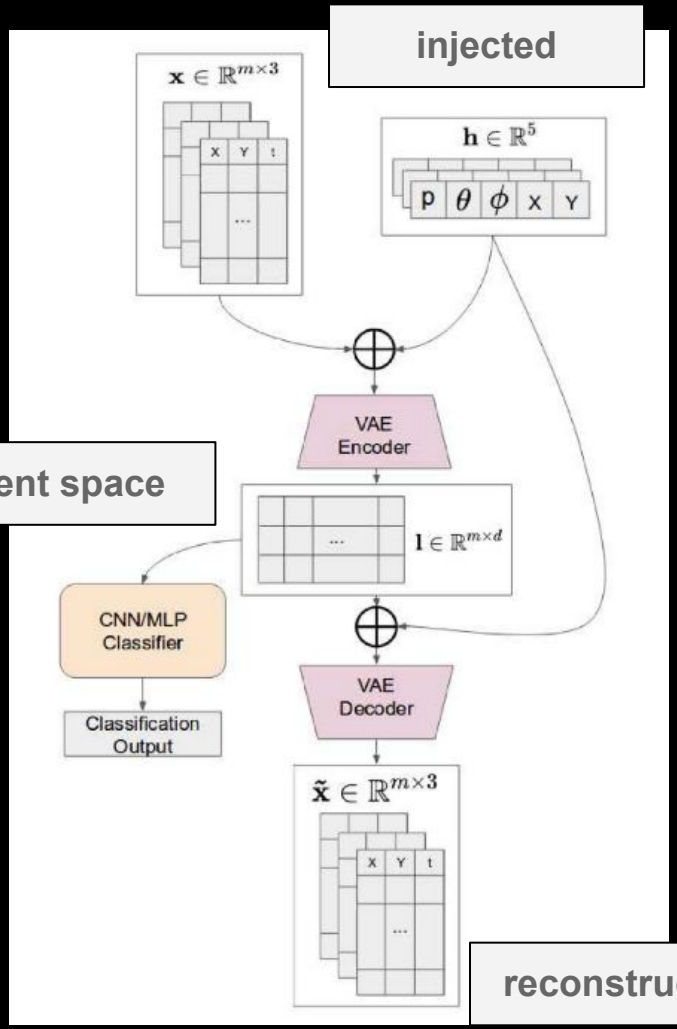
faster reconstruction/hit pattern

better resolution in regions with high overlap

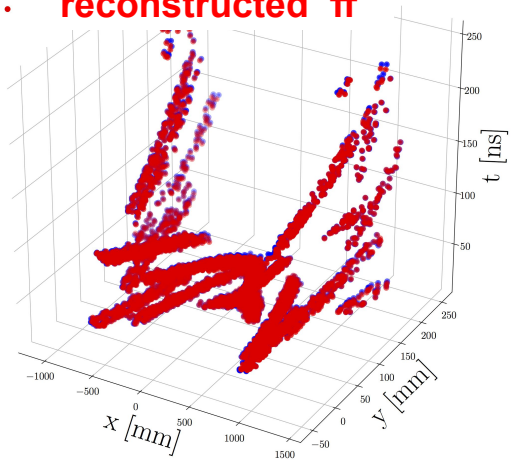
DeepRICH Architecture



t-SNE used for 3D visualization



- injected π
- reconstructed π



DeepRICH Performance

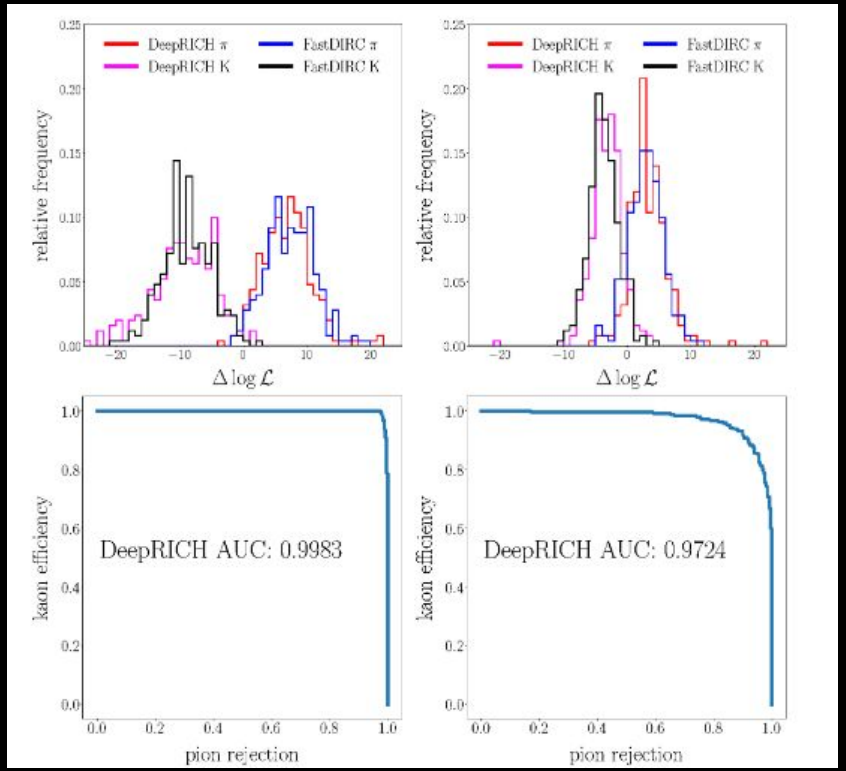


Table 3. The area under curve (%), the signal efficiency to detect pions ε_S and the background rejection of kaons ε_B corresponding to the point of the ROC that maximizes the product $\varepsilon_S{}^*\varepsilon_B$. The corresponding momenta at which these values have been calculated are also reported. This table is obtained by integrating over all the other kinematic parameters (i.e. a total of ∼6k points with different θ, ϕ, X, Y for each momentum).

	DeepRICH			FastDIRC		
Kinematics	AUC	ε_S	ε_B	AUC	ε_S	ε_B
4 GeV/c	99.74	98.18	98.16	99.88	98.98	98.85
4.5 GeV/c	98.78	95.21	95.21	99.22	96.33	96.32
5 GeV/c	96.64	91.13	91.23	97.41	92.40	92.47

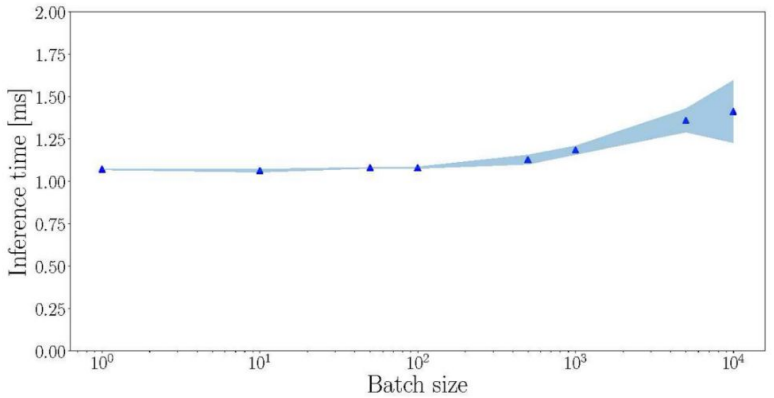


Figure 9. After training, the inference time is almost constant as a function of the batch size, meaning that the effective inference time—*i.e.*, the reconstruction time per particle—can be lower than a μs, the architecture being able to handle 10^4 particles in about 1.4 *ms* in the inference phase. Notice that the corresponding memory size in the inference phase is approximately equal to the value reported in table 4.

Perspectives

- The DeepRICH architecture can learn different topologies of hit patterns and can be used for different types of imaging Cherenkov Detectors (DIRC, RICH… hence the name)
- Planning to deploy DeepRICH on both DIRC and RICH detector too.
- Not only fast PID:
  - Training possible on real data with high purity. Allows to “deeply” learn the Cherenkov detector response (info useful for alignment)
- Recently started analysing simulated and real data from the GlueX DIRC.