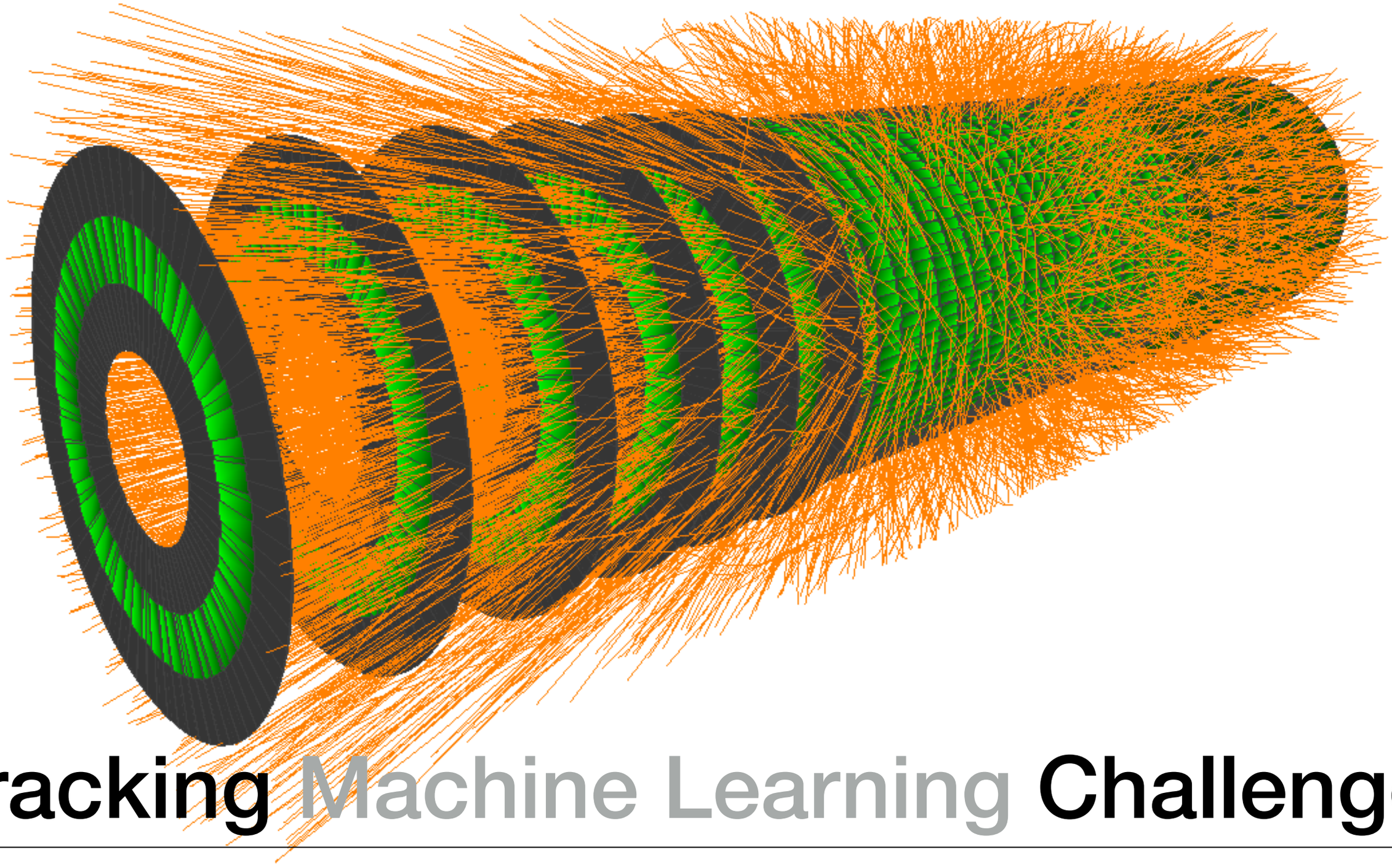


Tracking Machine Learning Challenge

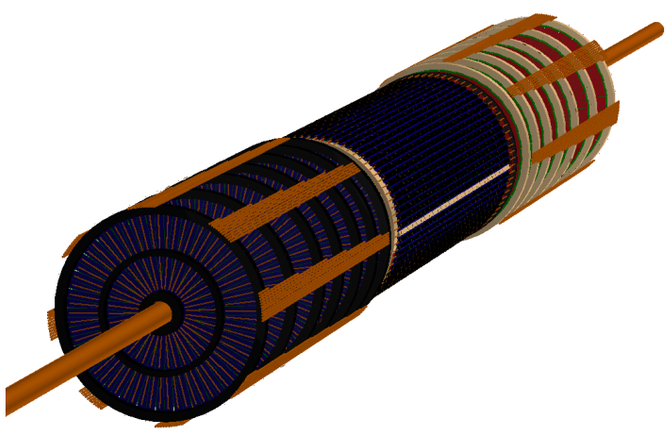
what's next ?

A. Salzburger (CERN) for the TrackML organisers
@SaltyBurger

Release timeline

Tentative release timeline for OpenData detector

Consolidation of detector & simulation

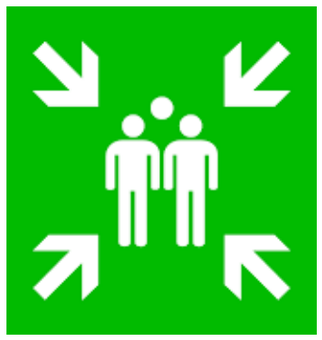


July/Aug 2019

Dataset production:
Geant4 simulation
(small statistics validation sample)

ACTS-Fatras simulation
(large statistics sample)

Sep 2019



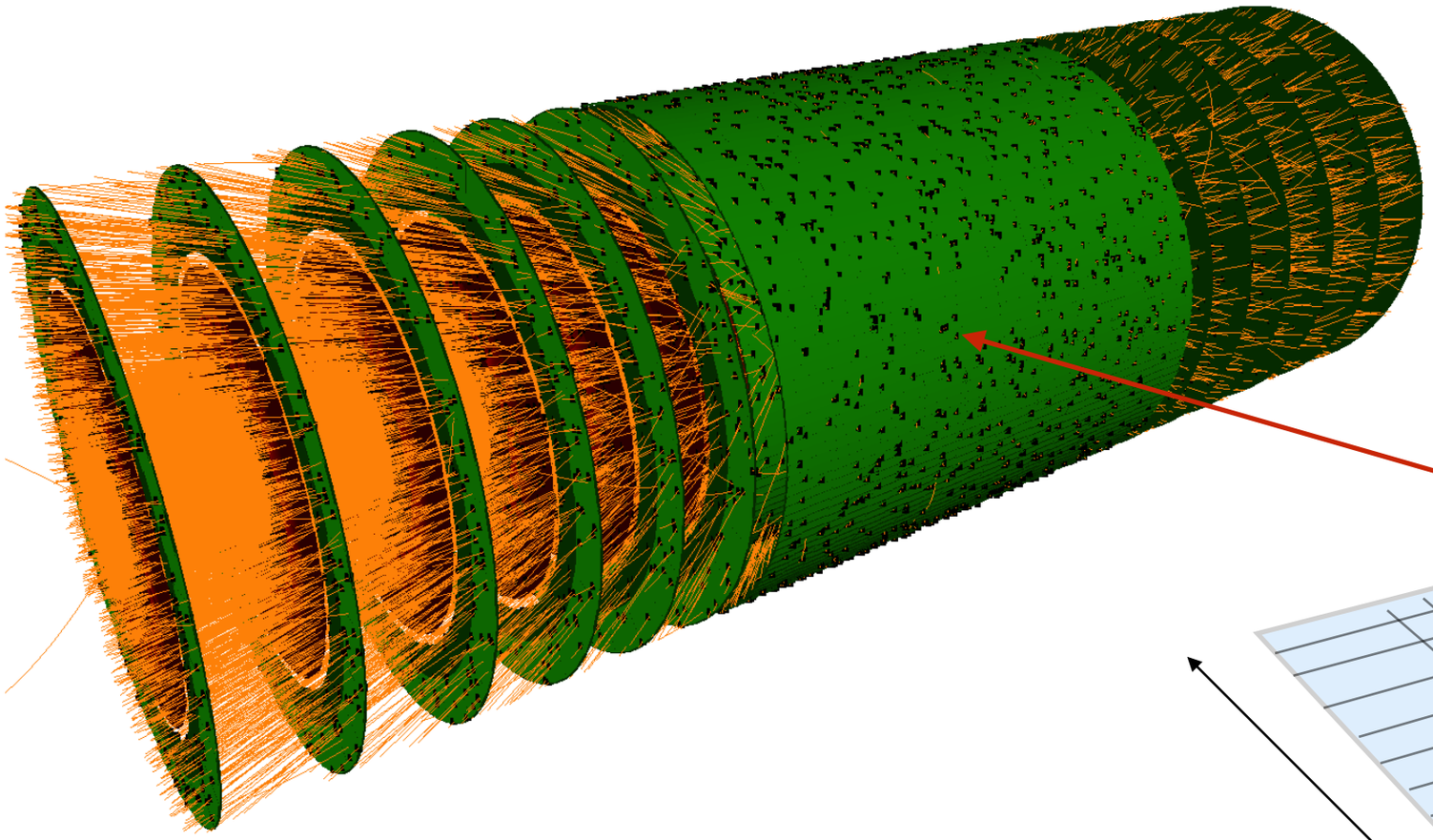
Let's assume we are here

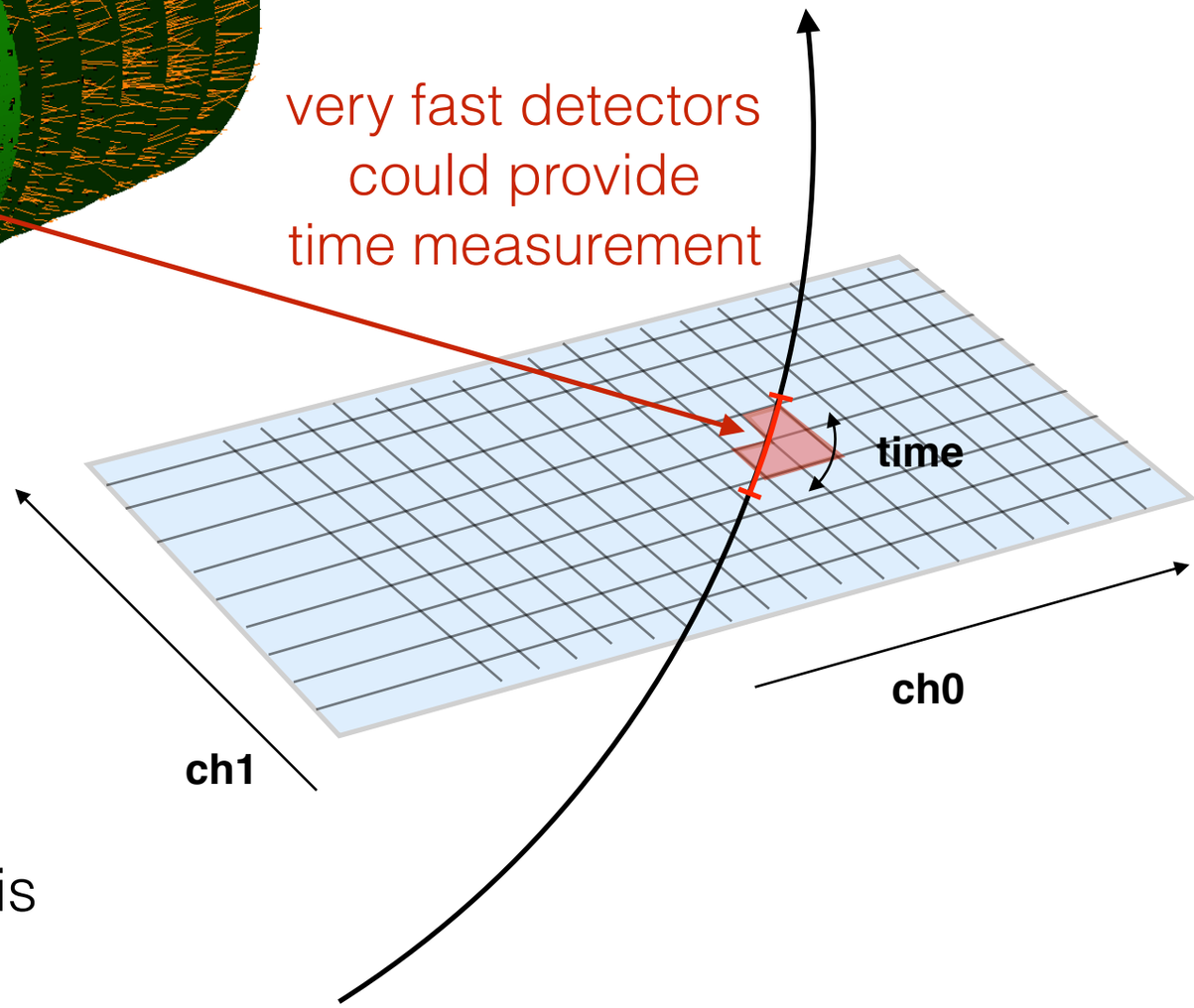
Part 1 Expanding the experimental scope

Evolving the Tracking detector

Future tracking detector technologies

- a full timing tracking detector to deal with higher pile-up





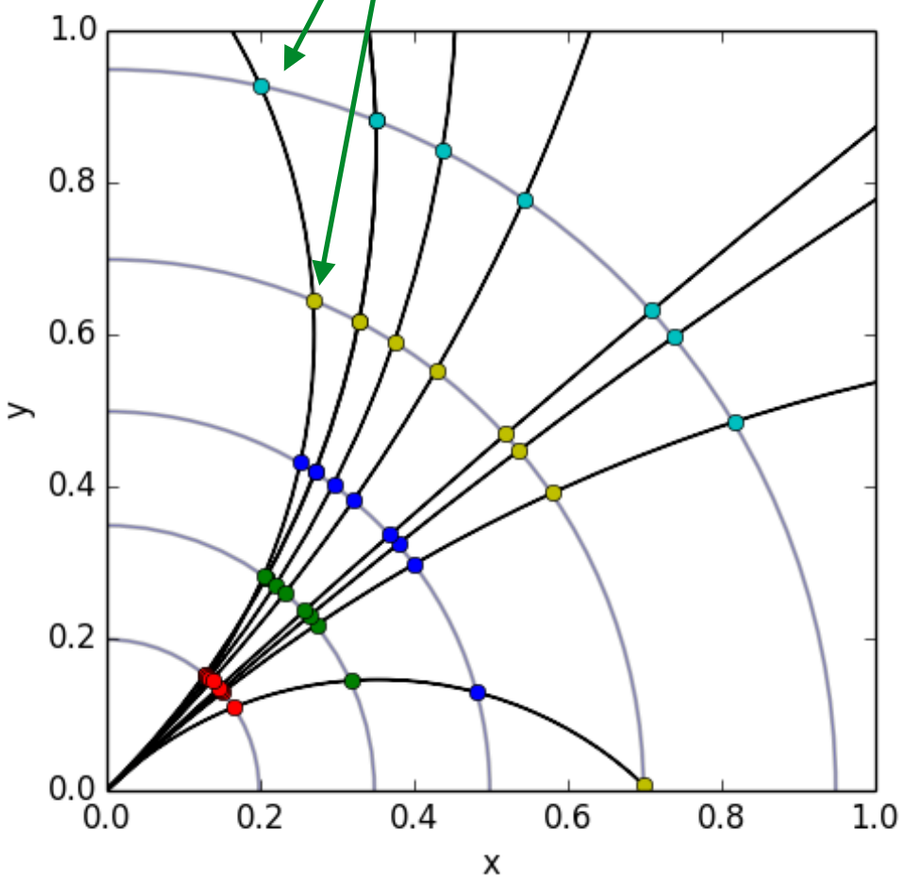
Geant4/ACTS simulation can provide this

Evolving the Tracking detector

Future tracking detector technologies

- a full timing tracking detector to deal with higher pile-up

time information could help
essentially for pattern recognition



can be used to resolve
cense vertex populations

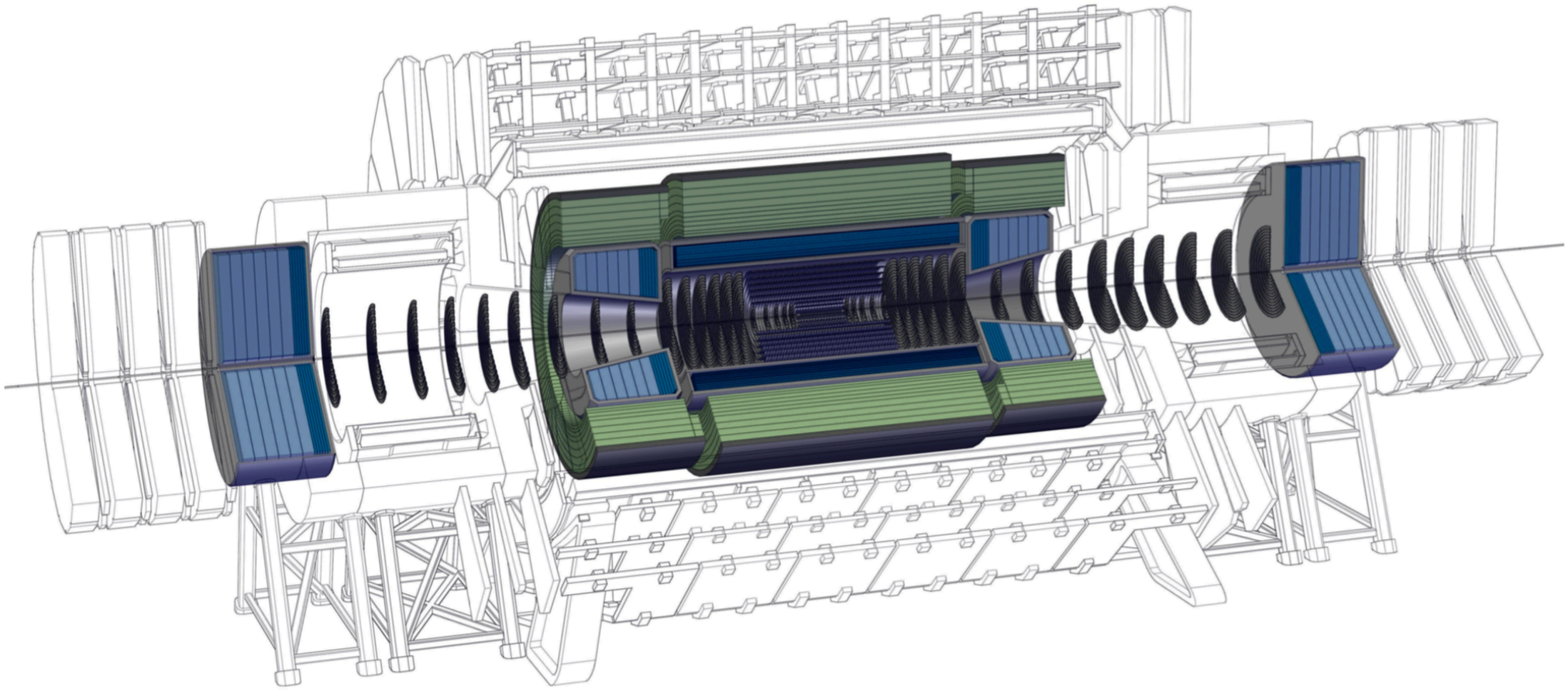
[source]

Evolving towards a full template HEP detector?

Several parties have expressed interest in a full detector

- Full event reconstruction will need a Calorimeter & Muon System

Calorimeter description of FCC-hh available in DD4hep, could adapt it to OpenData detector

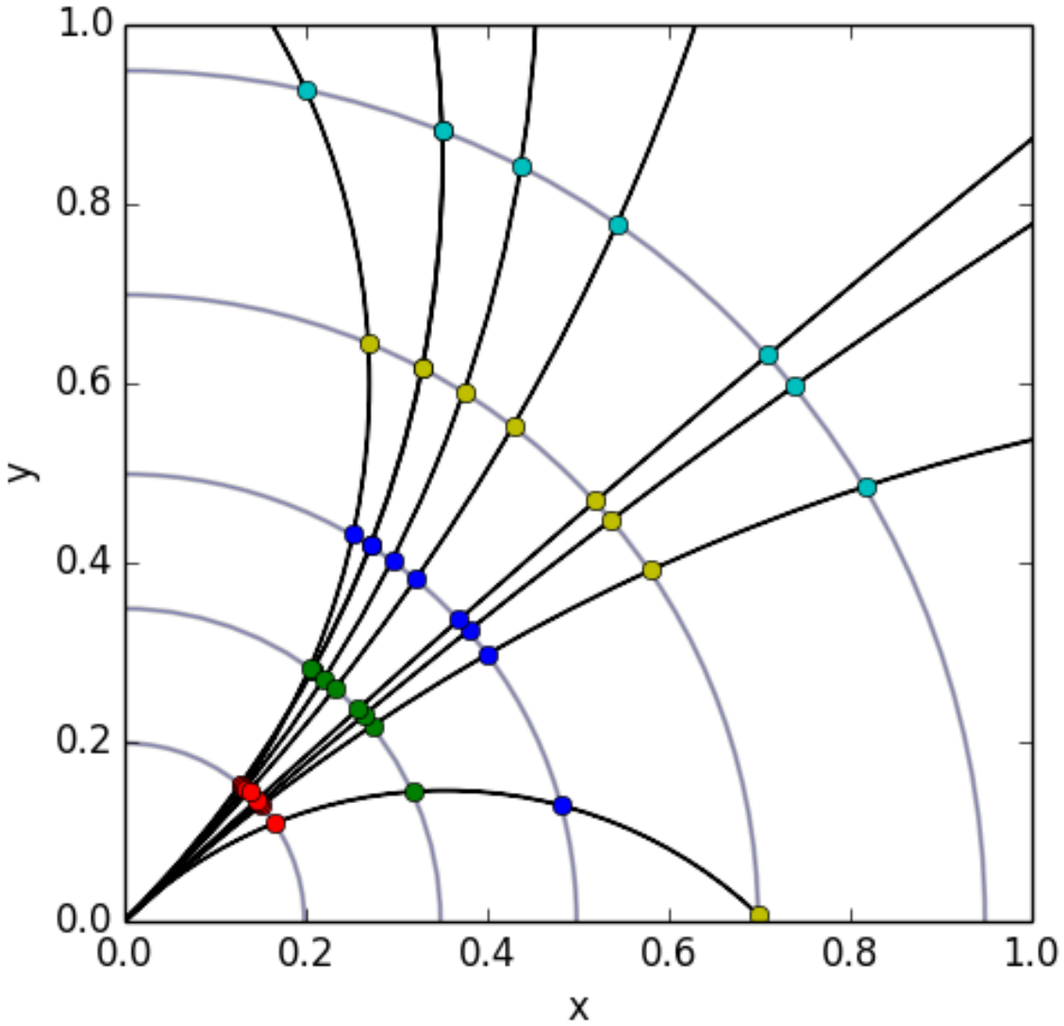


→ No ad-hoc fast simulation exists

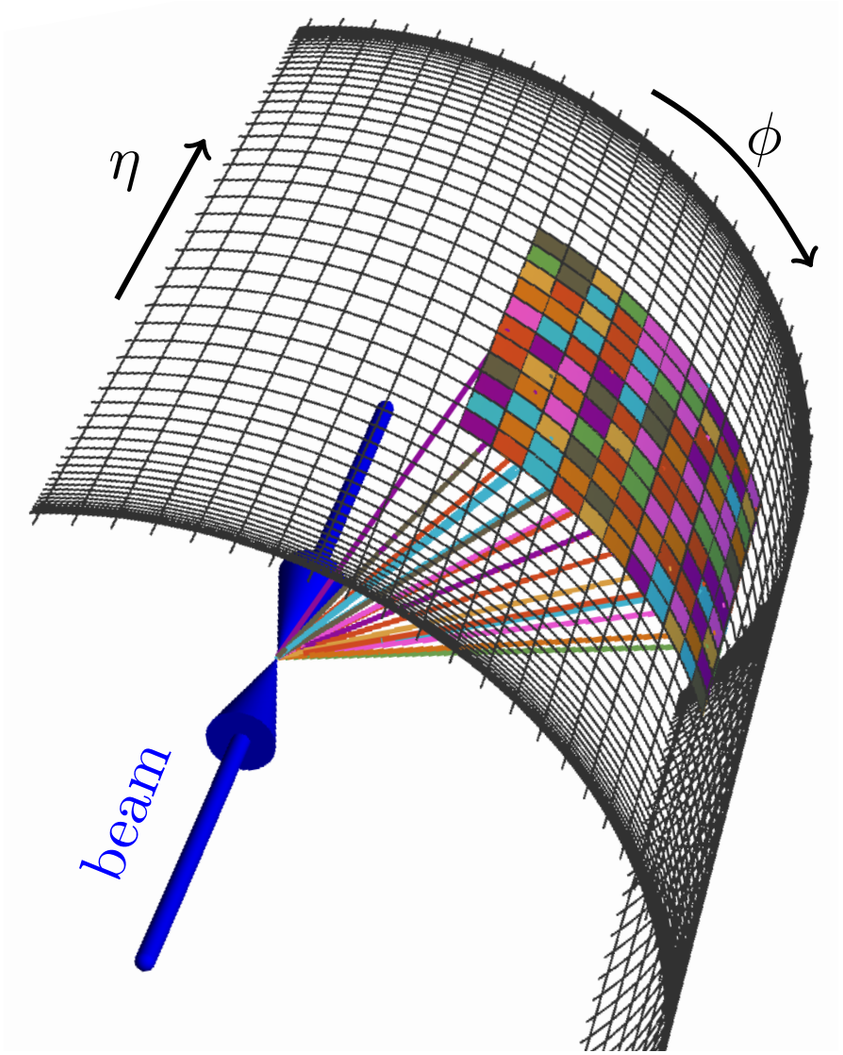
Join forces with GAN/VAE calorimeter fast simulation developments?

Calorimeter Reconstruction

Charged and natural particles deposit energies in calorimeter cells



Tracking view



Calorimeter view

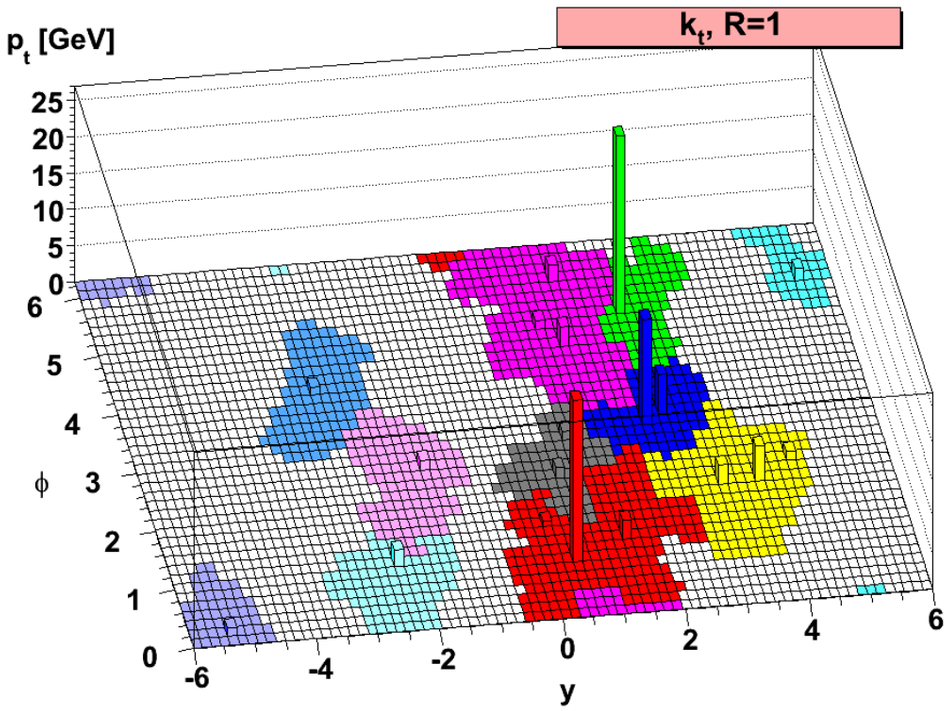
Calorimeter Reconstruction

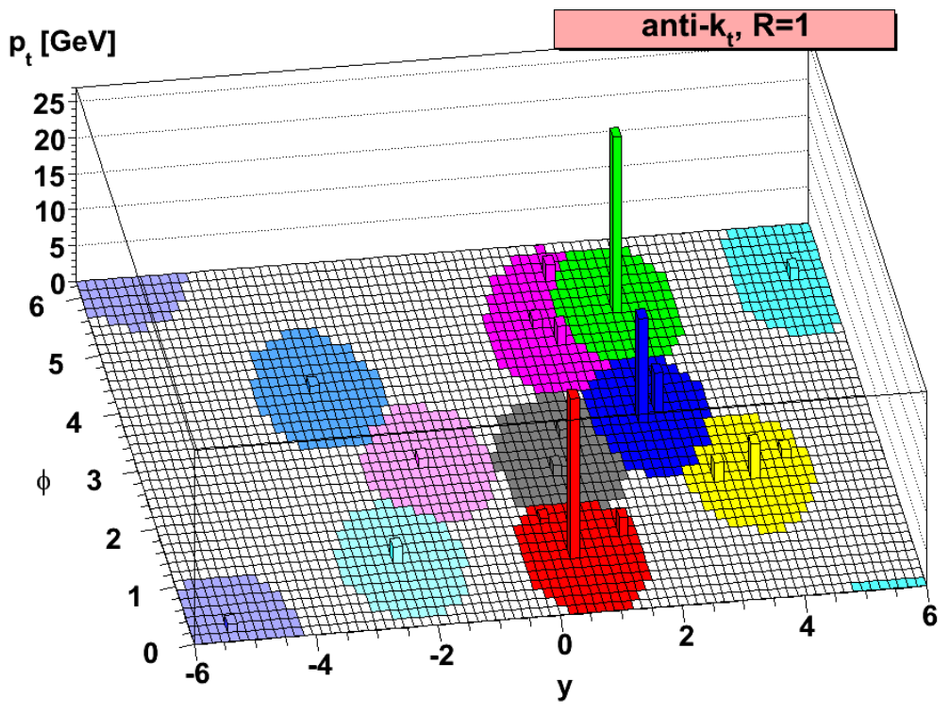
First build “clusters of cells” representing one particle

- quite a lot of calibration, noise reduction, pile-up suppression
- in general though a connected component analysis with constraints

Run an interactive algorithm to cluster “particles” together into jets

- this is done in 2D space (rapidity **y**, azimuthal angle **ϕ**)

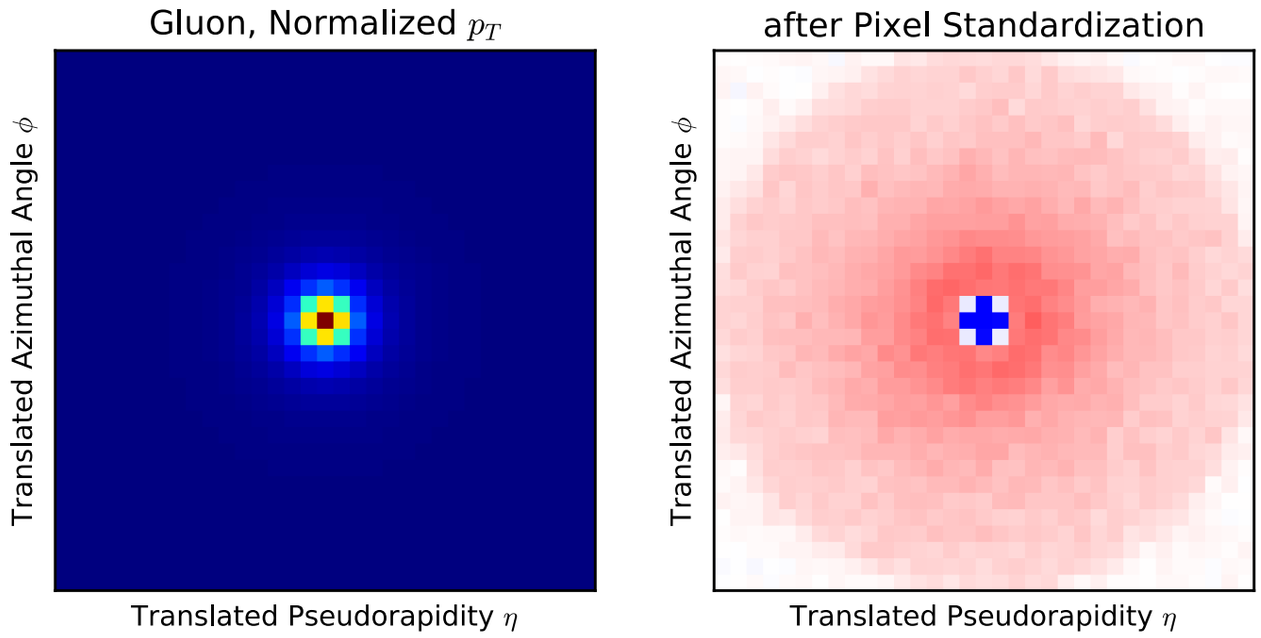




Jet Identification quark/gluon jet tagging with CNNs

Jets from quarks and gluons have different morphologies

- identification helps to clear the macroscopic from the microscopic view

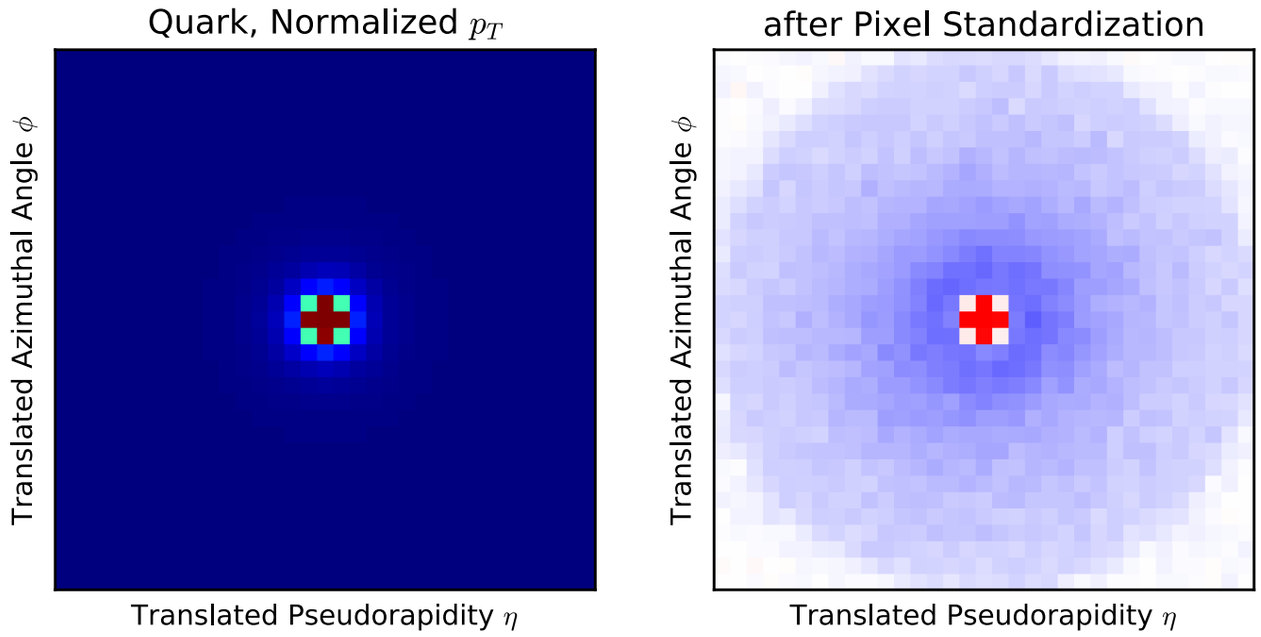


Supplement this adding color to the images:

`red` = transverse momenta of charged particles

`green` = the transverse momenta of neutral particles

`blue` = charged particle multiplicity



Source:
arxiv.org:612.01551

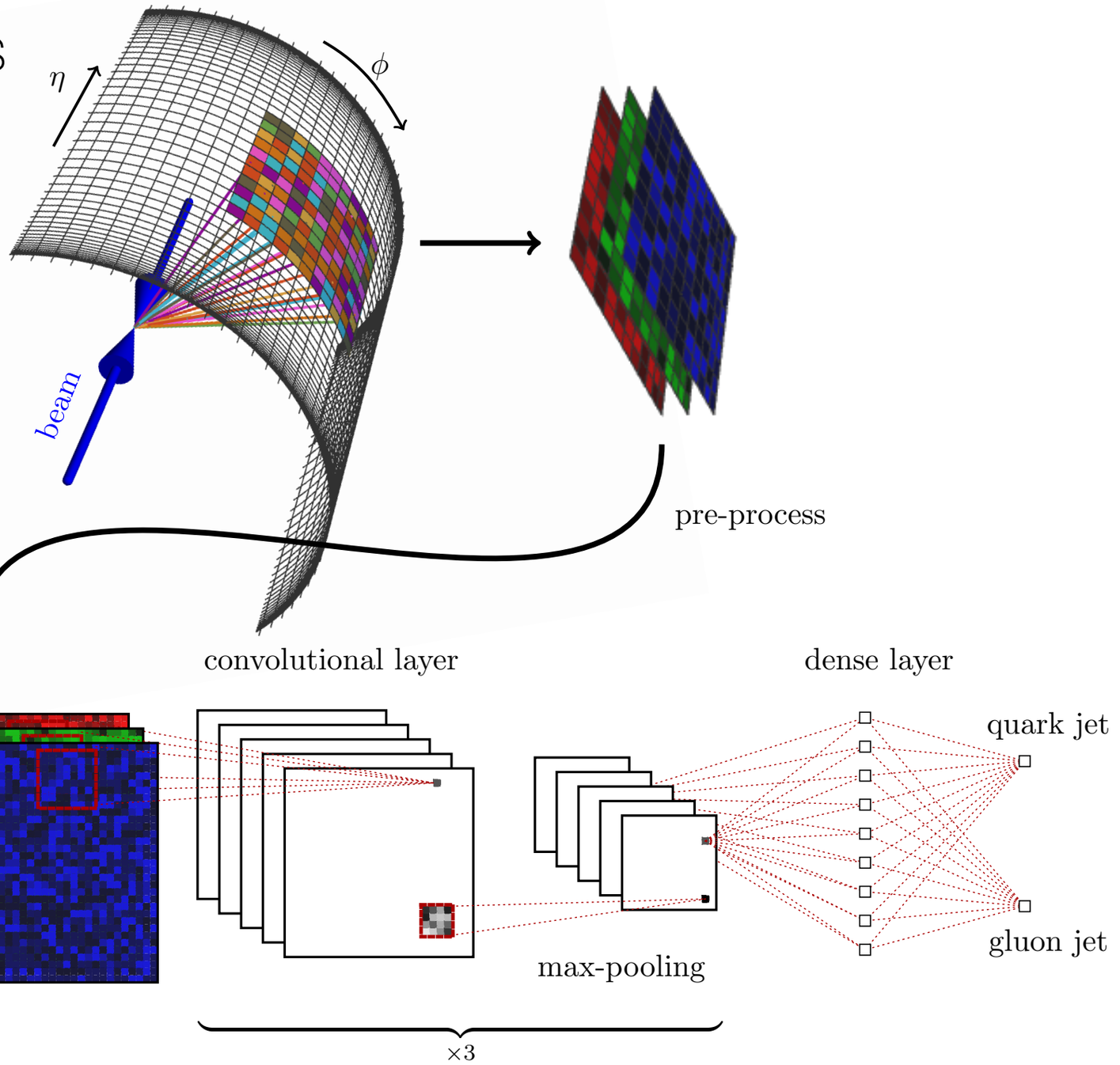
Jet Identification quark/gluon jet tagging with CNNs

Jets from quarks and gluons have different morphologies

- identification helps to clear the macroscopic from the microscopic view

Preprocessed images fed into a CNN

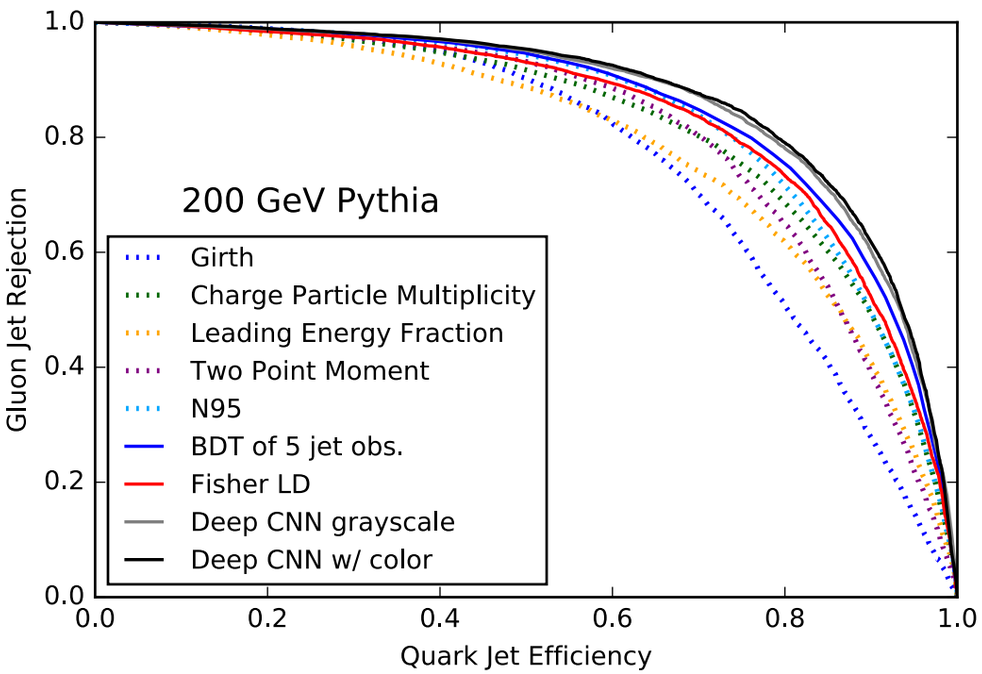
- max-pooling
- dense layer
- finally 2 output nodes for quark/ gluon classification

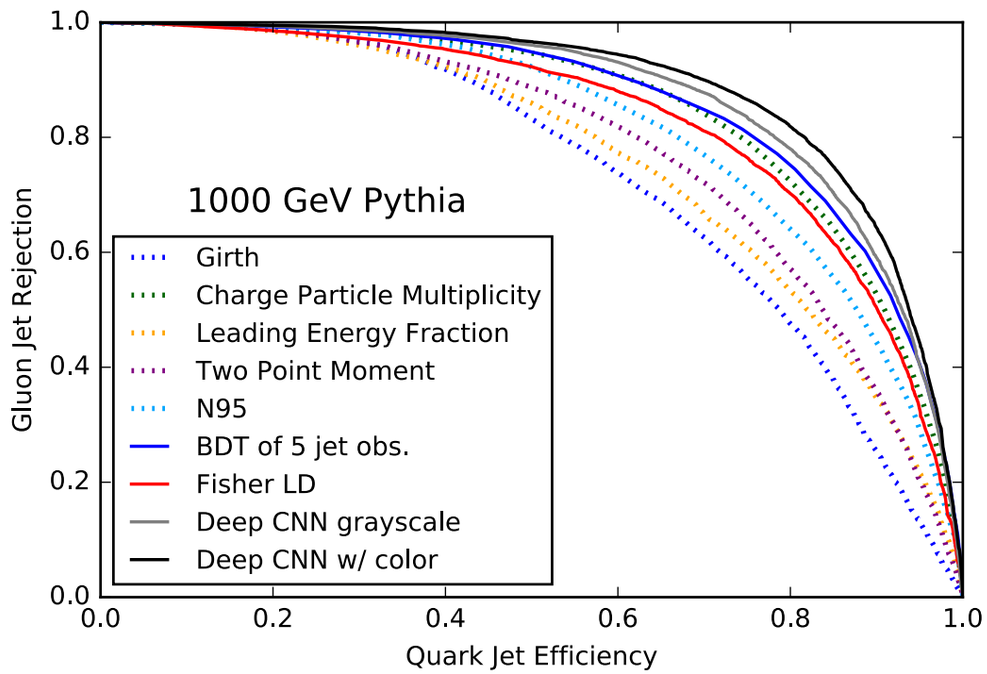


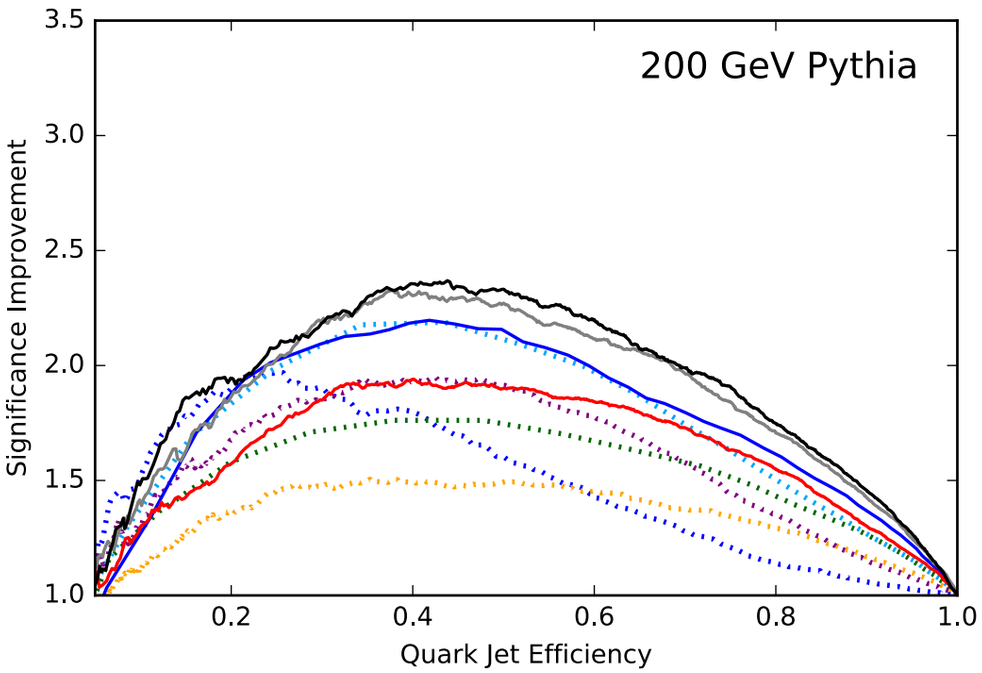
Source:
arxiv.org:612.01551

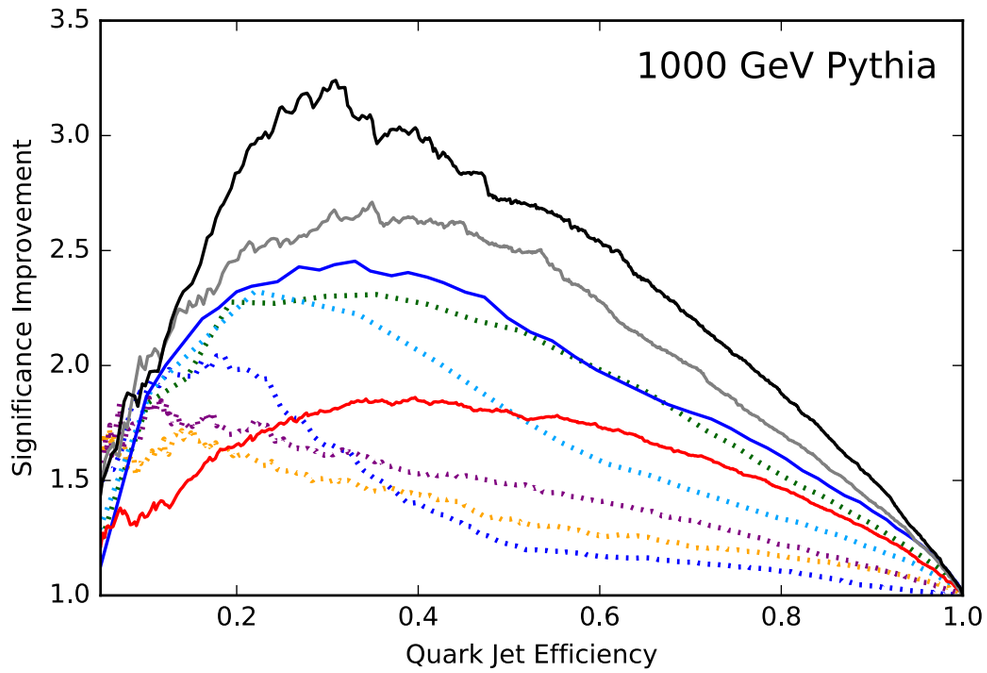
Jet Identification quark/gluon jet tagging with CNNs

Some performance checks:









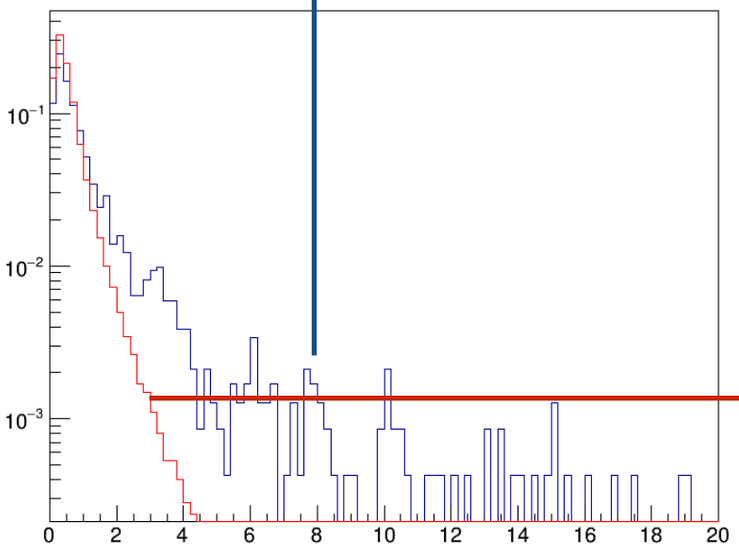
Source:
arxiv.org:612.01551

Provide simulator instead of dataset ?

Input for TrackML simulation

detector → CERN OPEN DATA PORTAL → <xml> → .json

physics



HepMC → ats

on the fly → ats

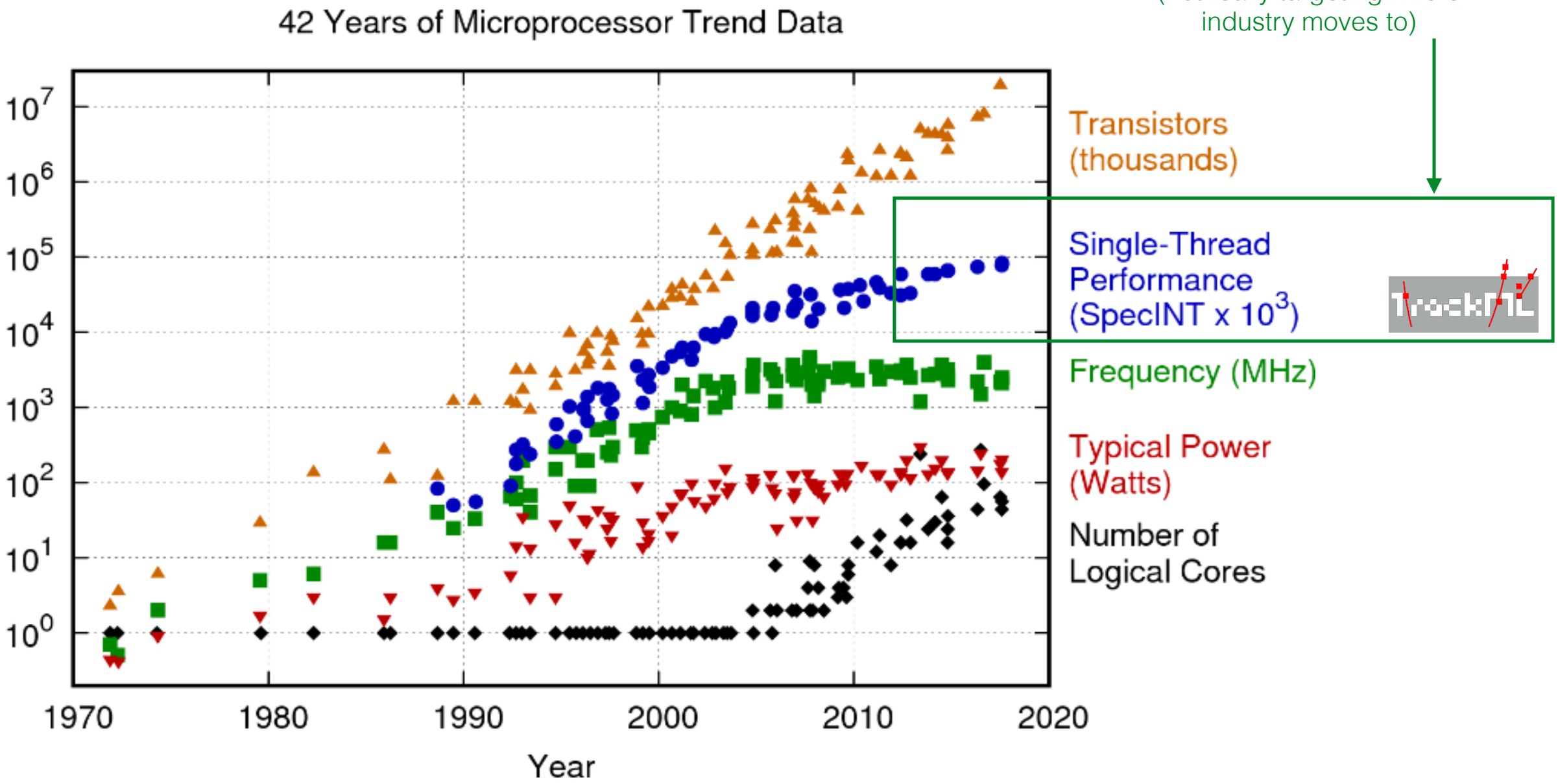
ats → .csv / .obj → TrackML

Part 2 Expanding the technological scope

Trends in Computing

End of Moore's law …

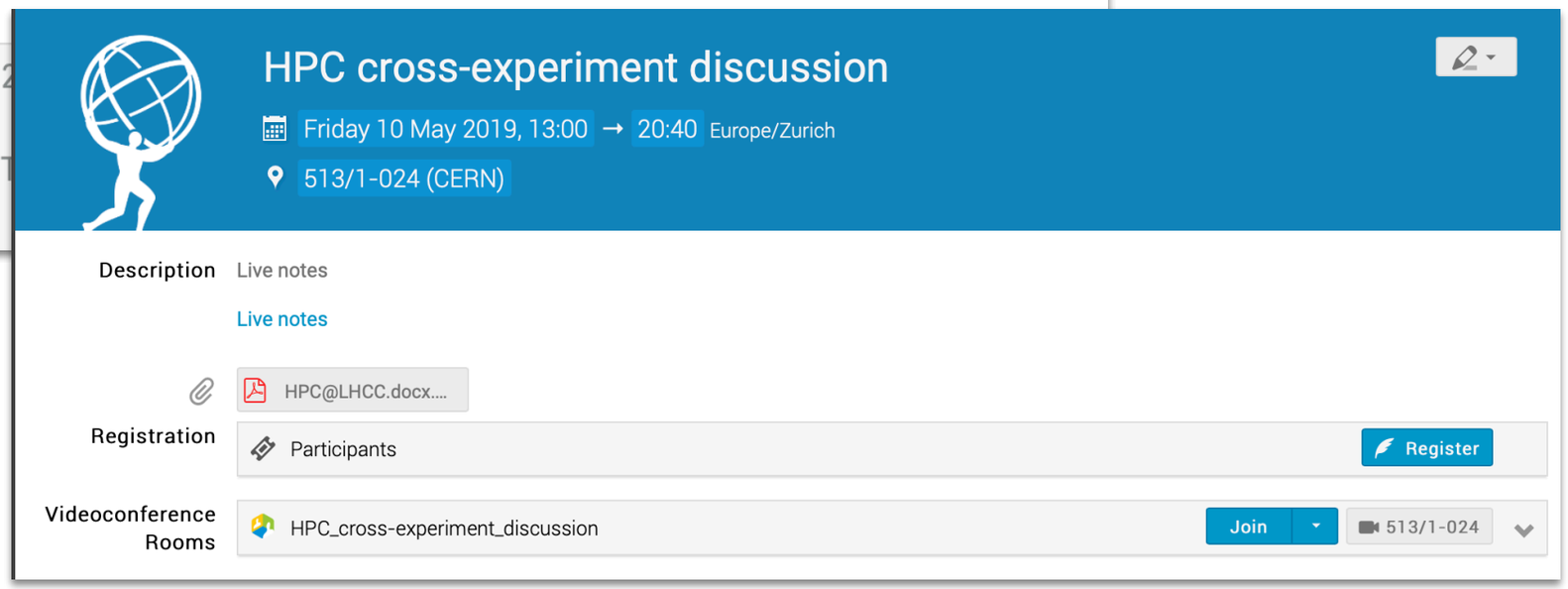
Phase-2 of TrackML offered VMs with 2 cores
(not really targeting where industry moves to)



Trends in Computing HPCs

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/SC/Oak Ridge National Laboratory United States	2,414,592	148,600.0	200,794.9	10,096
2	**Sierra** - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94,640.0	125,712.0	7,438
3	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
4	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	**Frontera** - Dell C6420, Xeon Platinum 8280 2 InfiniBand HDR , Dell EMC Texas Advanced Computing Center/Univ. of T United States				

Trends towards HPCs
requires action for HEP



[source]

TrackML on GPUs?

many ML packages have GPU support!

Running a GPU based TrackML challenge natural next step

HEPiX

GPUs - Programmability

- NVIDIA CUDA:
  - C++ based (supports C++14), de-facto standard
  - New hardware features available with no delay in the API
- OpenCL:
  - Can execute on CPUs, AMD GPUs and recently Intel FPGAs
  - Overpromised in the past, with scarce popularity
- Compiler directives: OpenMP/OpenACC
  - Latest GCC and LLVM include support for CUDA backend
- AMD HIP:
  - Interfaces to both CUDA and AMD MIOpen, still supports only a subset of the CUDA features
- GPU-enabled frameworks to hide complexity (Tensorflow)
- Issue is performance portability and code duplication

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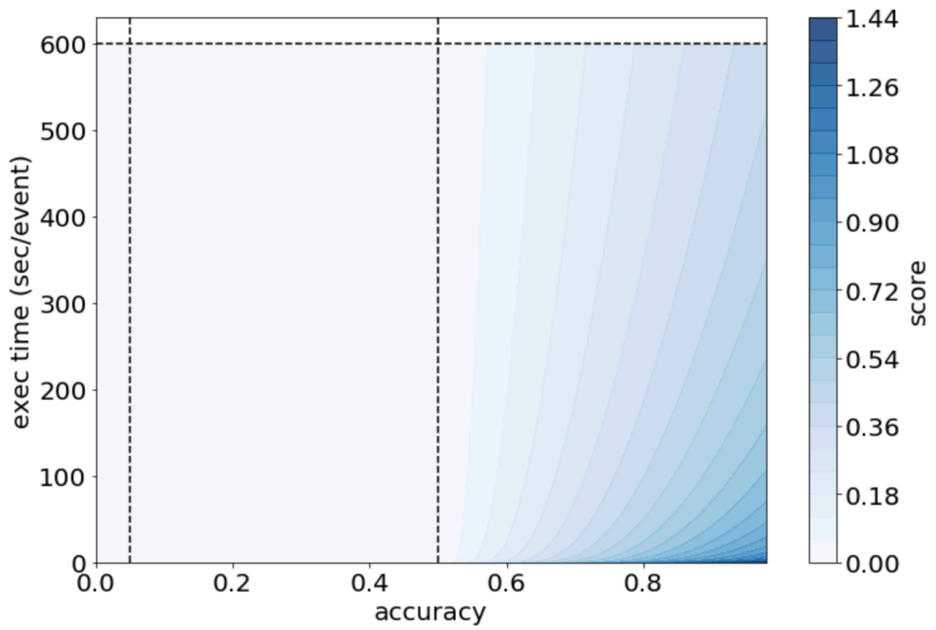
[source]

on GPUs?

Running a GPU based TrackML challenge natural next step

If we want to run a combined accuracy/speed score

- need a similar environment as Phase-2 with GPU backend
- need hardware resources



Phase 2 Control of timing environment

CodaLab

	hit_id	x	y	z	volume_id	layer_id	module_id
0	1	-64.409897	-7.163700	-1502.5	7	2	1
1	2	-55.336102	0.635342	-1502.5	7	2	1
2	3	-83.830498	-1.143010	-1502.5	7	2	1
3	4	-96.109100	-8.241030	-1502.5	7	2	1

event(s) are loaded in memory

start — API to call (C++ CPP, PY)

User executable

stop

solution

VM2 cores, 4 Gb memory

Final comments

I hope you had fun in the challenges, and you stick around !

Background knowledge

- Very good slides for beginners
- Lecture of particles tracking
- Full helix equations for ATLAS - All equations you need!
- Diplom thesis of Andreas Salzburger (Wow, he started in this field as a CERN student already in 2001 :p)
- Doctor thesis of Andreas Salzburger
- CERN tracking software Acts - Sadly, we didn't have time to explore it :)

Andreas Salzburger **Competition Host** · just now · Options · Edit · Reply 0

Oh - you made me feel old now ... :-)

Thanks for participating and I hope you had fun in the challenge!!