Using Graph Neural Networks for Flavour Tagging in Heavy Ion Collisions

PIC2

Pedro Esperanço, 100249

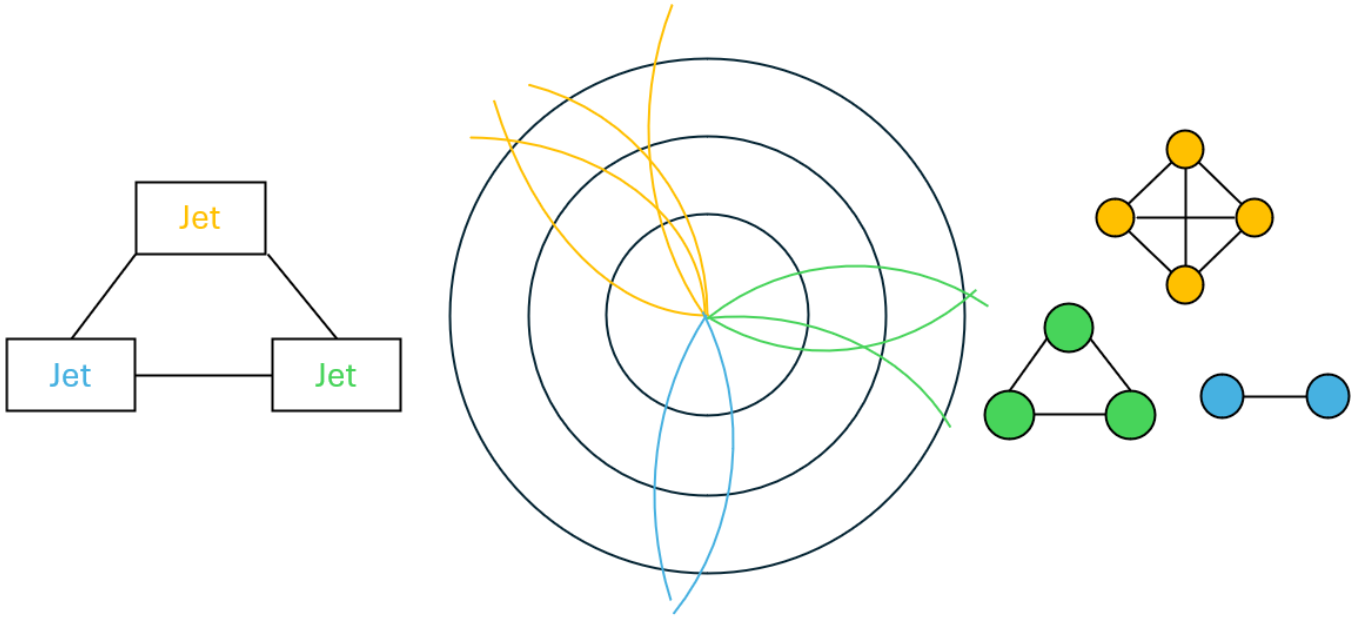
Supervisors:

Helena Santos

Patricia Conde Muíño

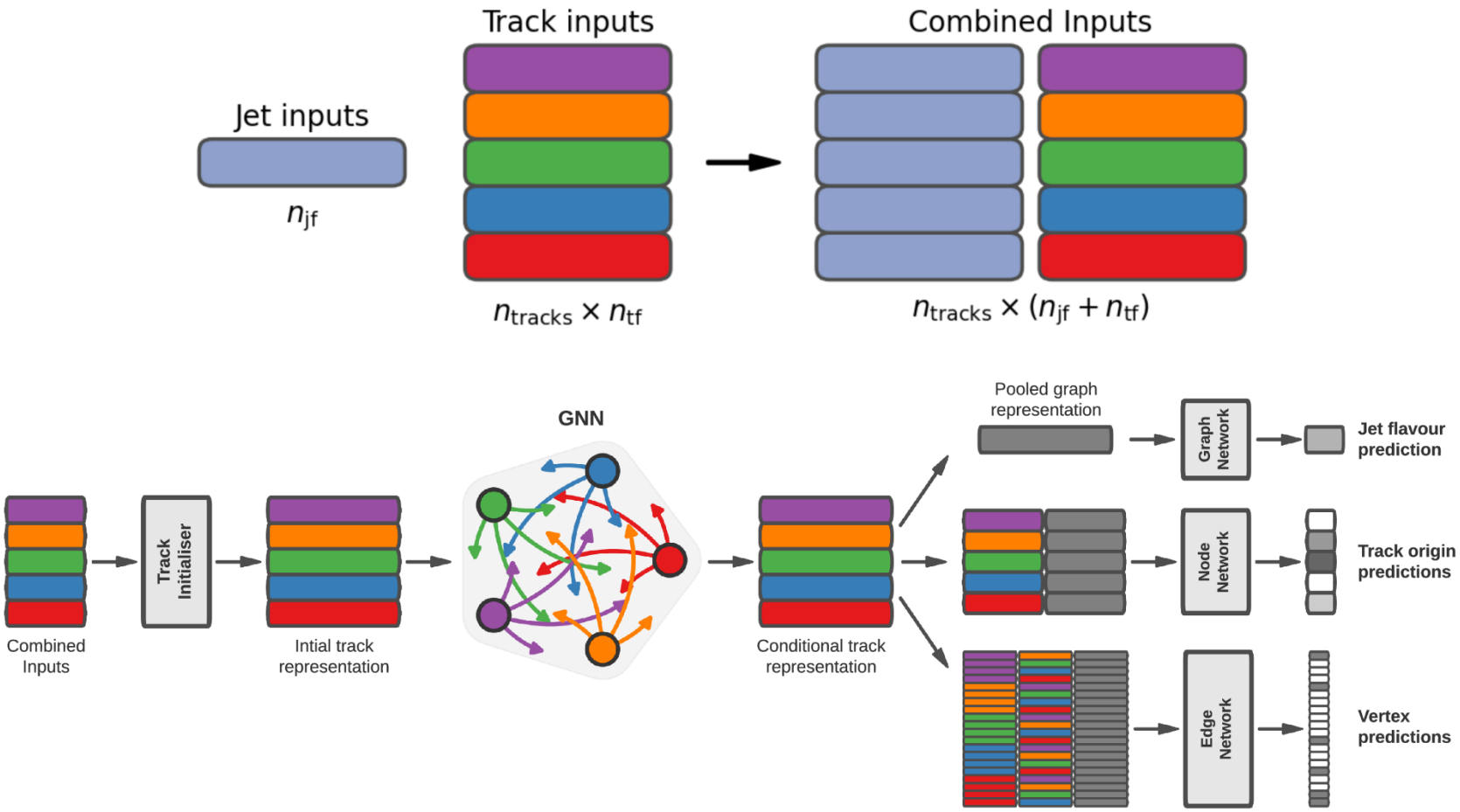
Graph Neural Networks

- Graphs allow for the representation of data with variable size and can represent several different physical objects



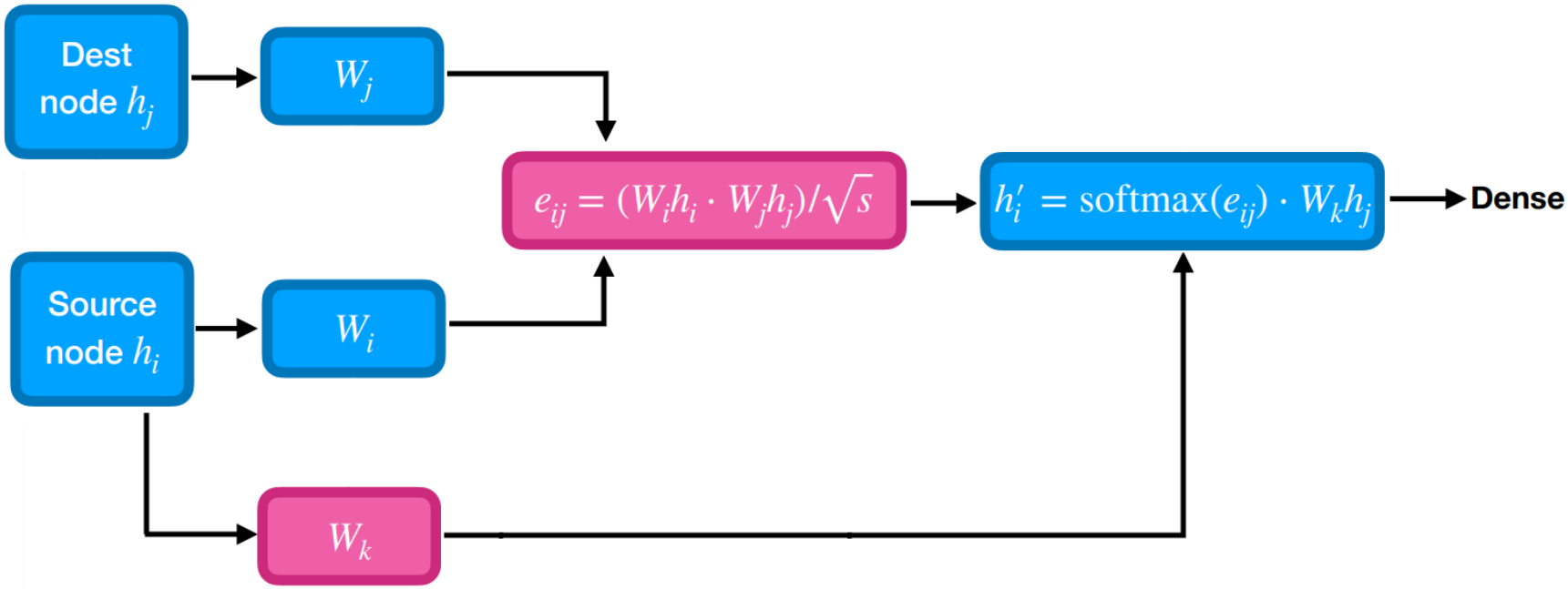
- GNNs are used to find new representations of a graph

GN2



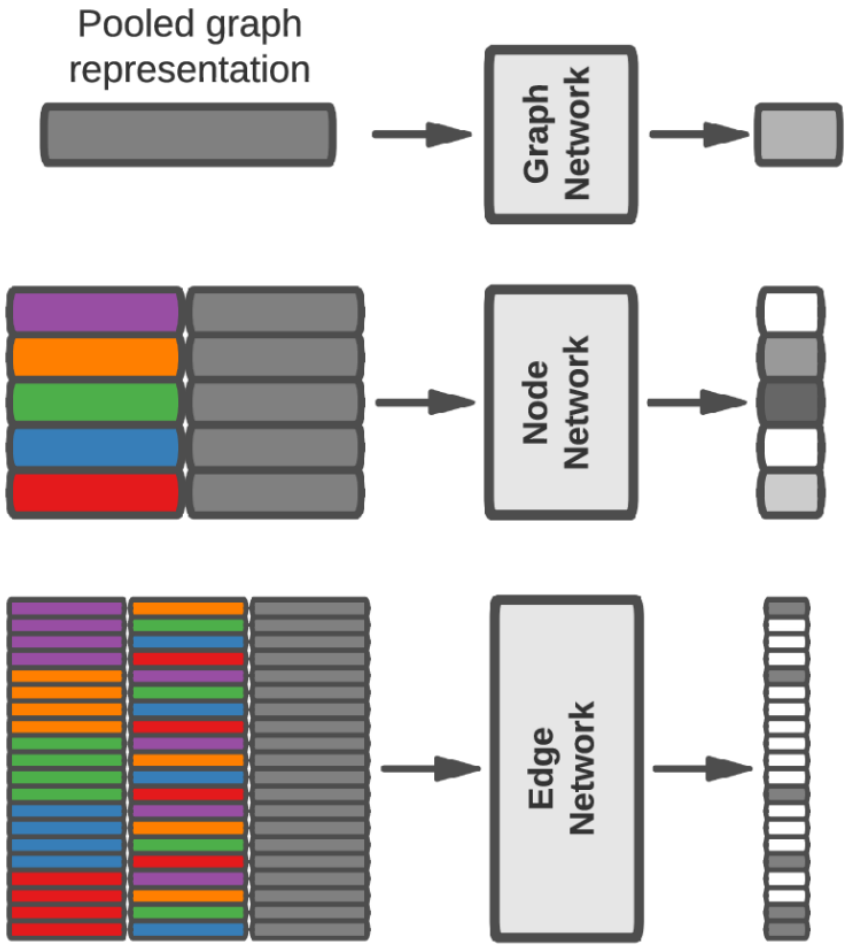
Graph Neural Network Jet Flavour Tagging with the ATLAS Detector. Tech. rep. All figures including auxiliary figures are available at https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2022-027. Geneva: CERN, 2022. URL: https://cds.cern.ch/record/2811135.

GNN



Samuel Van Stroud. “ATLAS GNN Flavour Tagging. ATLAS GNN Flavour Tagging”. In: (2023). URL: https://cds.cern.ch/record/2851395.

Auxiliary Tasks



Network	Hidden layers	Output size
Node classification network	128, 64, 32	7
Edge classification network	128, 64, 32	1
Graph classification network	128, 64, 32, 16	3

$$L_{\text{total}} = L_{\text{jet}} + \alpha L_{\text{vertex}} + \beta L_{\text{track}}$$

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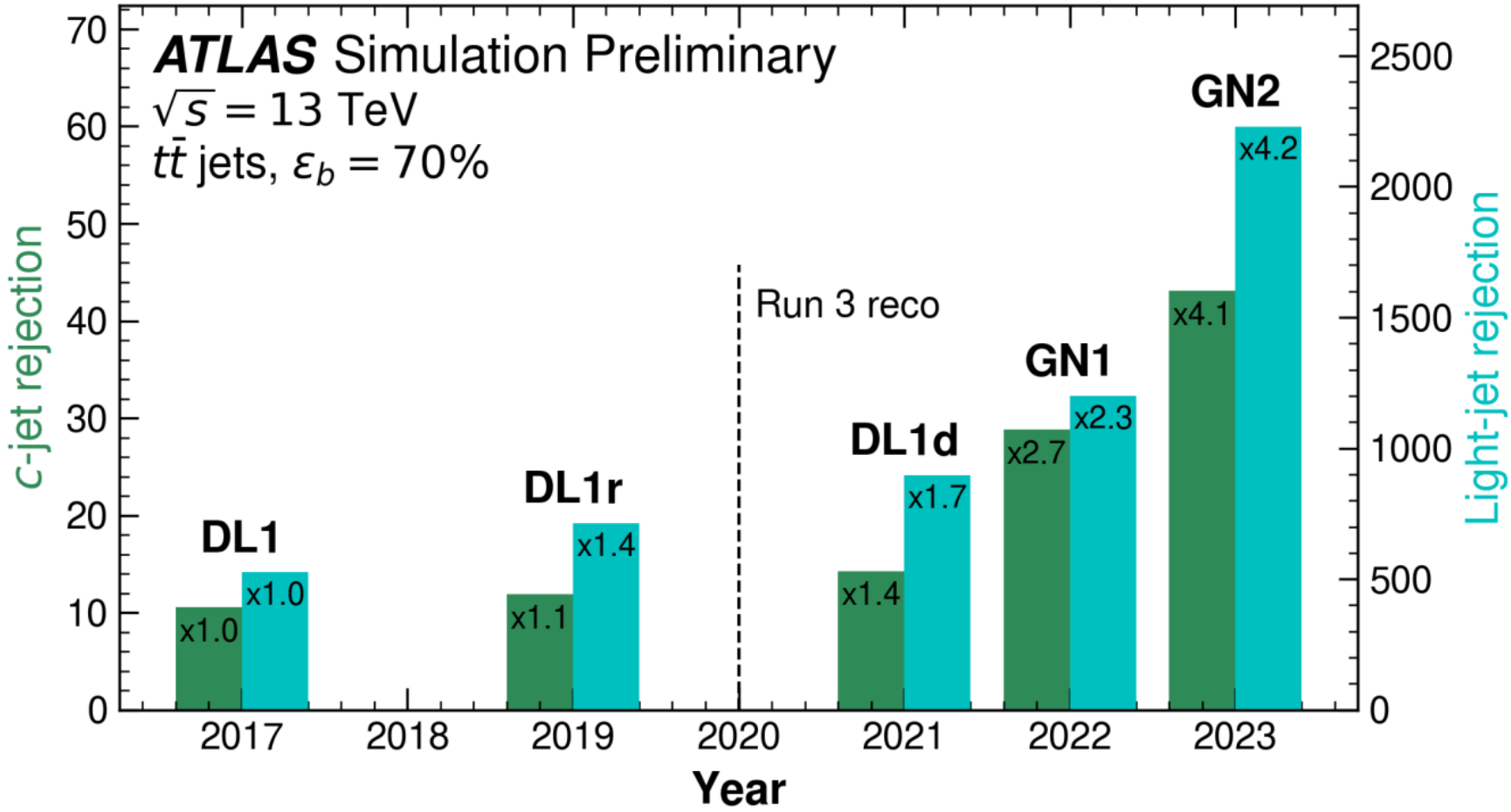
Performance



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Thank you!

Questions?

Backup Slides

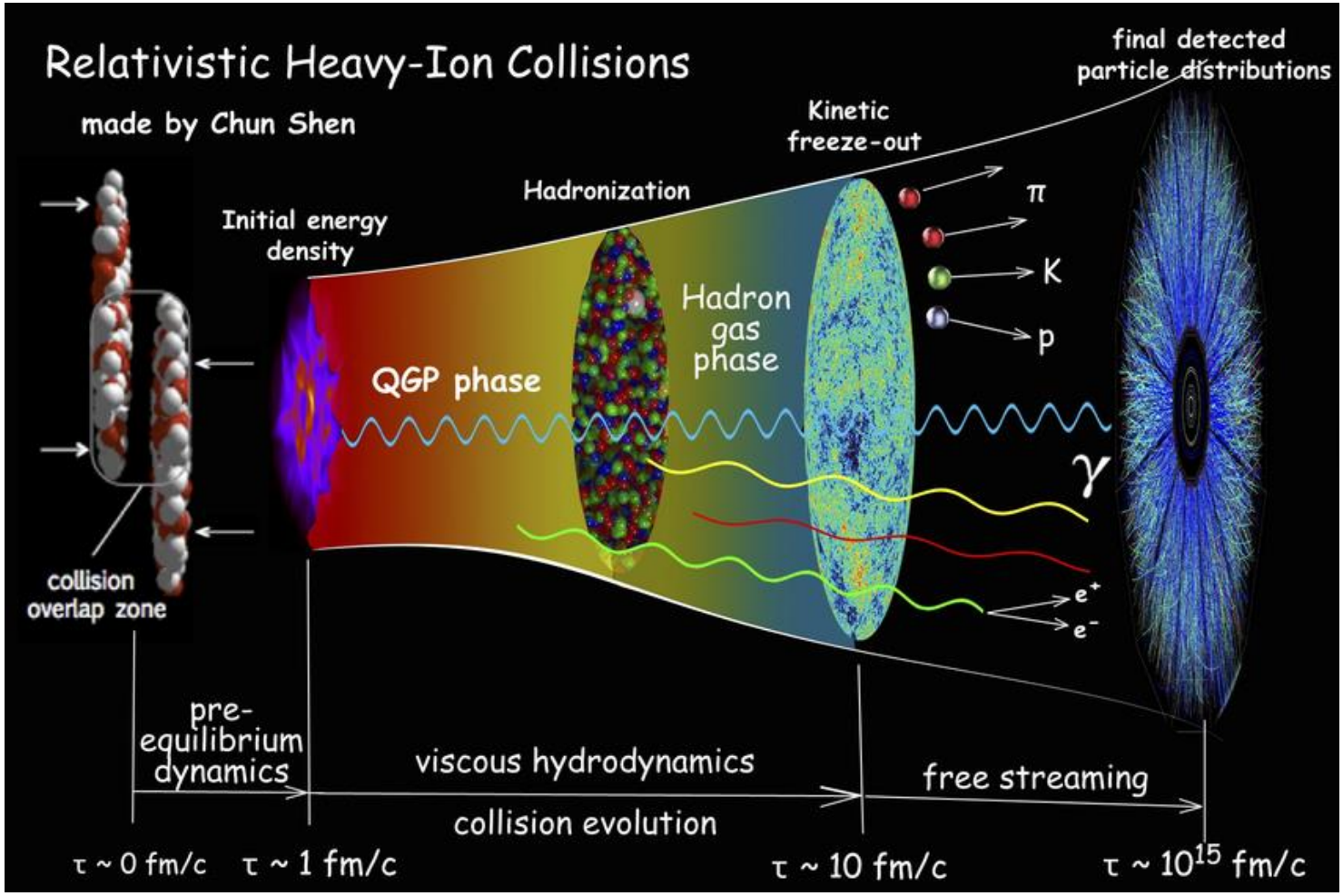
Inputs

Jet Input	Description
p_{T}	Jet transverse momentum
η	Signed jet pseudorapidity
Track Input	**Description**
q/p	Track charge divided by momentum (measure of curvature)
$\mathrm{d}\eta$	Pseudorapidity of the track, relative to the jet η
$\mathrm{d}\phi$	Azimuthal angle of the track, relative to the jet ϕ
d_0	Closest distance from the track to the PV in the longitudinal plane
$z_0 \sin\theta$	Closest distance from the track to the PV in the transverse plane
$\sigma(q/p)$	Uncertainty on q/p
$\sigma(\theta)$	Uncertainty on track polar angle θ
$\sigma(\phi)$	Uncertainty on track azimuthal angle ϕ
$s(d_0)$	Lifetime signed transverse IP significance
$s(z_0)$	Lifetime signed longitudinal IP significance
nPixHits	Number of pixel hits
nSCTHits	Number of SCT hits
nIBLHits	Number of IBL hits
nBLHits	Number of B-layer hits
nIBLShared	Number of shared IBL hits
nIBLSplit	Number of split IBL hits
nPixShared	Number of shared pixel hits
nPixSplit	Number of split pixel hits
nSCTShared	Number of shared SCT hits
nPixHoles	Number of pixel holes
nSCTHoles	Number of SCT holes
leptonID	Indicates if track was used in the reconstruction of an electron or muon (only for GN1 Lep)

Truth origins

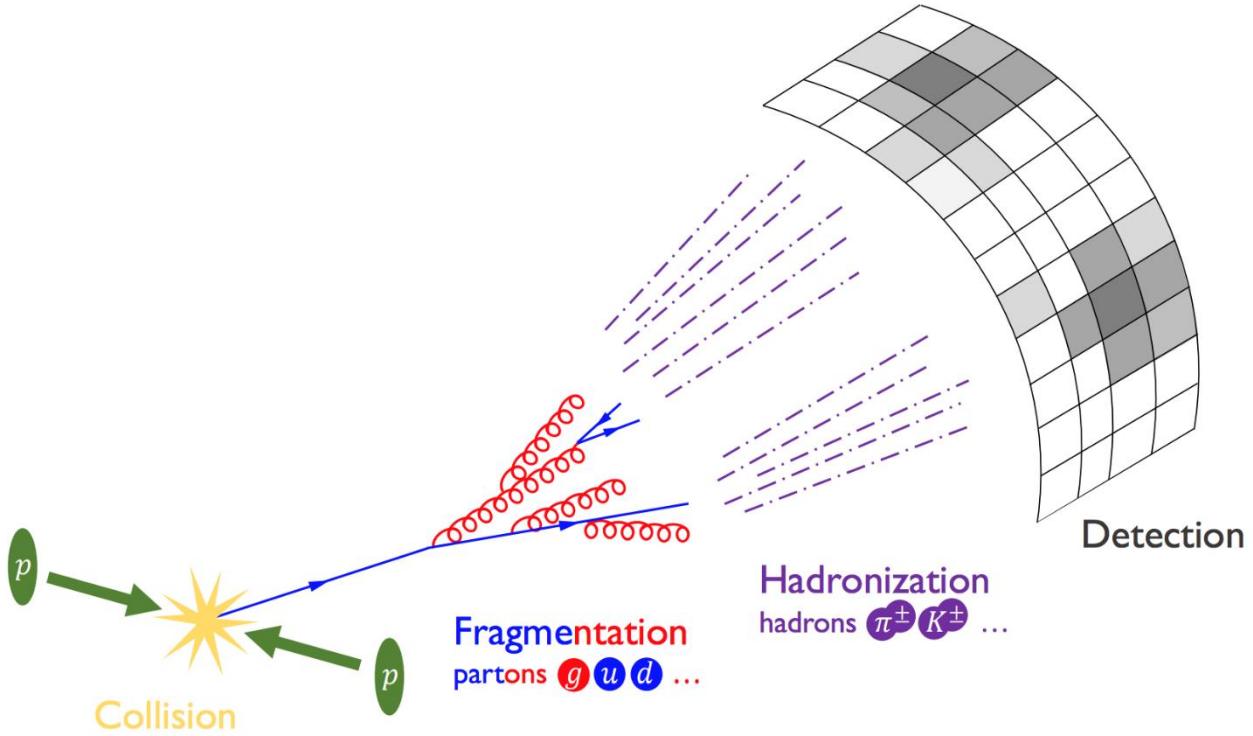
Truth Origin	Description
Pileup	From a pp collision other than the primary interaction
Fake	Created from the hits of multiple particles
Primary	Does not originate from any secondary decay
fromB	From the decay of a b-hadron
fromBC	From a c-hadron decay, which itself is from the decay of a b-hadron
fromC	From the decay of a c-hadron
OtherSecondary	From other secondary interactions and decays

Heavy Ion Collisions and Quark Gluon Plasma



Jets

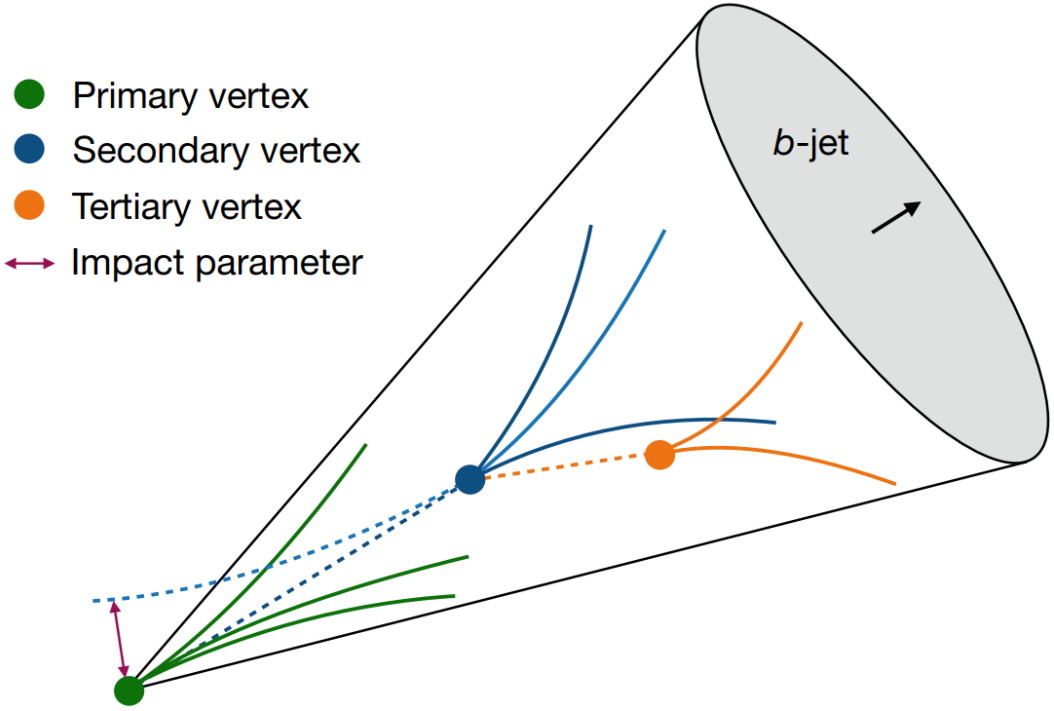
- Jets are created around the same time as the QGP, and they reach the detector.
- Well studied in proton-proton collisions.
- Compare jets from *pp* and HI collisions to learn about the QGP.



Eric M. Metodiev. The fractal lives of jets. 2020. URL: https://www.ericmetodiev.com/post/jetformation/.

Flavour-Tagging

- The process of identifying which particle gave origing to the jet.
- Take advantage of intrinsic differentiating characteristics of the jets.



Brian Moser. “Flavour Tagging”. In: The Beauty and the Boost: A Higgs Boson Tale: Measurements of Higgs Boson Production at High Energy in Decays to Bottom Quarks and Their Interpretations with the ATLAS Experiment at the LHC. Cham: Springer Nature Switzerland, 2023, pp. 77–91. ISBN: 978-3-031-39442-3. DOI: 10.1007/978-3-031-39442-3_6 . URL: https://doi.org/10.1007/978-3-031-39442-3_6 .