b-jet identification in the ATLAS Experiment at CERN

Paula Martínez Suárez
Institut de Física d'Altes Energíes (IFAE-BIST)

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ATLAS EXPERIMENT

Institut de Física d'Altes Energies

Universitat Autònoma de Barcelona

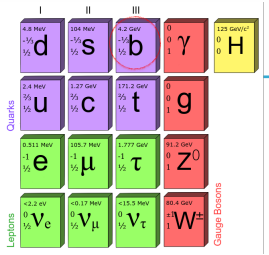
Why are *b*-quarks so important?

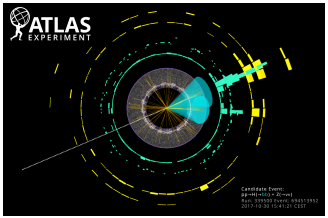
- Main decay channel of the **Higgs boson**: BR($H \to bb$) $\sim$ 60%

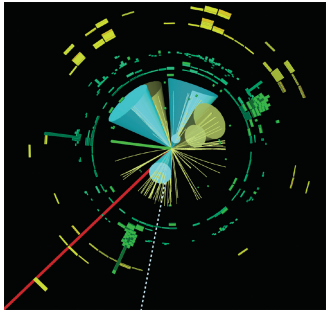
  $\Rightarrow$ very important channel in Higgs and di-Higgs searches.
- Main decay channel of any particle with **Yukawa-like couplings** with $m < 2m_t$

  $\Rightarrow$ BSM scalar searches.
- Main decay channel of the **top quark**: BR($t \to Wb$) $\sim$ 100%

  $\Rightarrow$ Top quark studies, top-associated production of SM and BSM particles, searches for very heavy particles decaying to top...

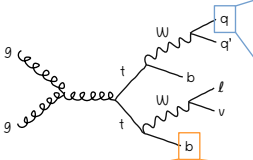




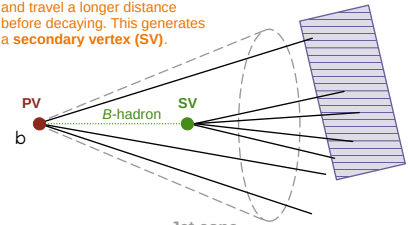


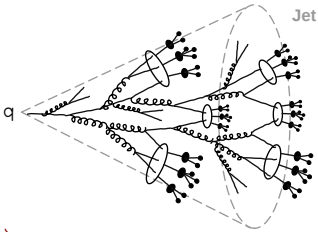
How can we identify them?

Example:
pp → tt via gluon-gluon fusion.



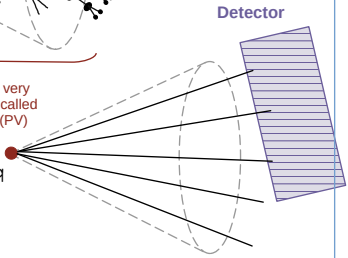
Hadrons containing *b*-quarks have a longer lifetime (~1.5 ps) and travel a longer distance before decaying. This generates a **secondary vertex (SV)**.



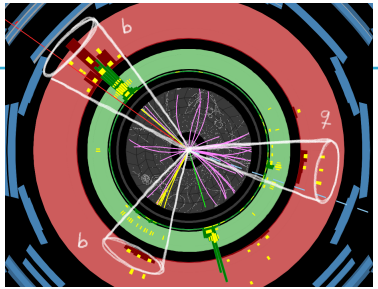


Quarks and gluons produce a cascade of QCD particles that eventually hadronise and decay.

All this happens at a very small scale in what is called the **primary vertex** (PV)



A more detailed look at *b*-jet detection



Particle tracks

- The innermost part of the detector is made of **silicon and gas sensors**.
- Any **charged particle** from the collision will interact with the material, leaving a **track** that can be reconstructed using pattern recognition algorithms.

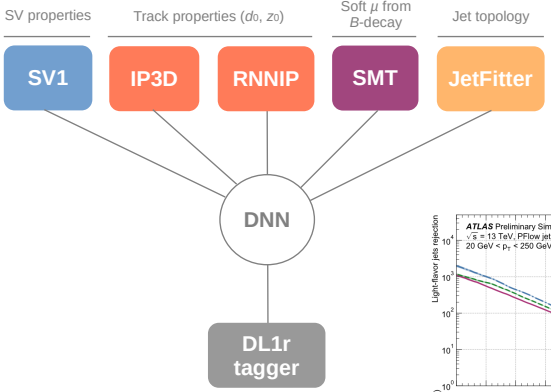
Primary and secondary vertices

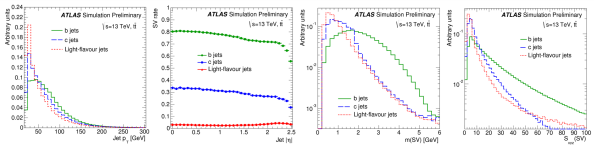
- Vertices are found by **extrapolation** of the measured tracks.
- The **PV** is the main interaction point and defines de **coordinate system** of the event.
- **SVs** are any other vertices displaced from the main interaction point.

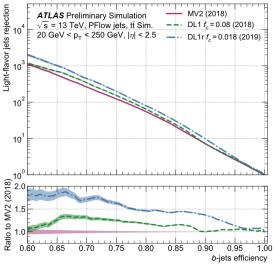
Calorimeter hits

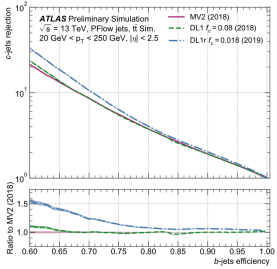
- When the jet reaches the **calorimeter**, it interacts strongly with the material and **deposits all its energy**.
- This information is **combined** with the tracks in order to maximise performance.

Introducing *b*-jet tagging



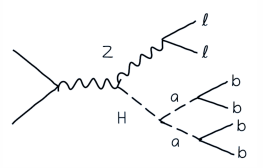






Application of different *b*-tagging techniques in a BSM search

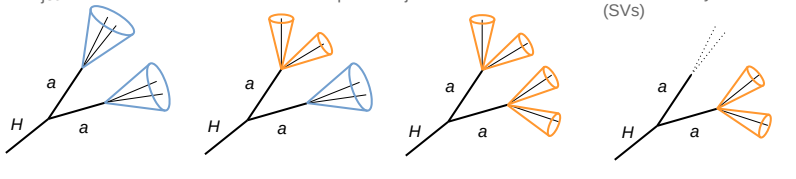
Example: $H \rightarrow aa \rightarrow 4b$ analysis



Collimated *bb* decays are reclustered into a *B*-jet

Resolved *bb* decays are are identified as 2 separate *b*-jets

Very soft bb decays are retrieved by looking for soft secondary vertices (SVs)



Boosted regimes

Resolved regimes

X → bb tagger (B)
DL1r tagger (b)
TC_LVT tagger (v)

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