In search of Super Charm

Search for Scalar Charm Quark Pair Production in pp Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector

arxiv:1501.01325 [hep-ex], Phys. Rev. Lett. 114, 161801

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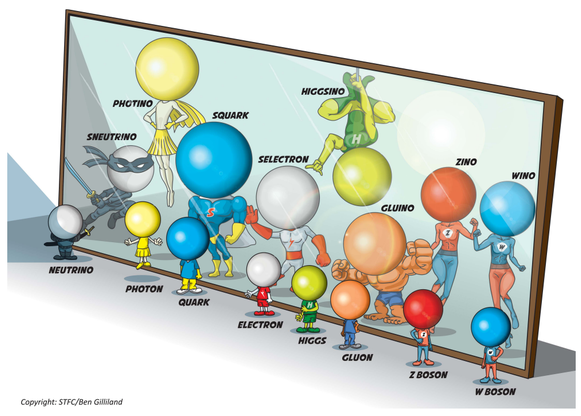
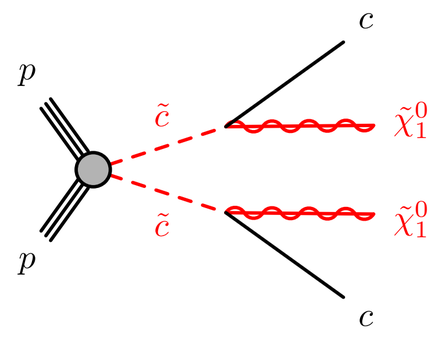
Supersymmetry

- Supersymmetry is an extension to the standard model (SM) of particle physics, predicting that each SM particle has a 'superpartner'
- This extension helps solve various outstanding questions in particle physics, such as the nature of dark matter, the low value of the Higgs boson mass and the unification of 3 of the 4 fundemental forces



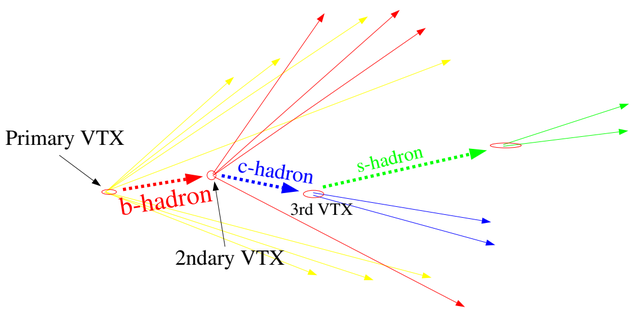
Super Charm

- Here, we search for the partner of the charm quark ($\tilde{c}$) known as 'scalar charm', 'scharm' or (informally) 'super charm'
- If they exist, scharms will be produced in pairs, and each quickly decay to a charm quark and a 'neutralino' - an invisible SUSY particle that might explain dark matter



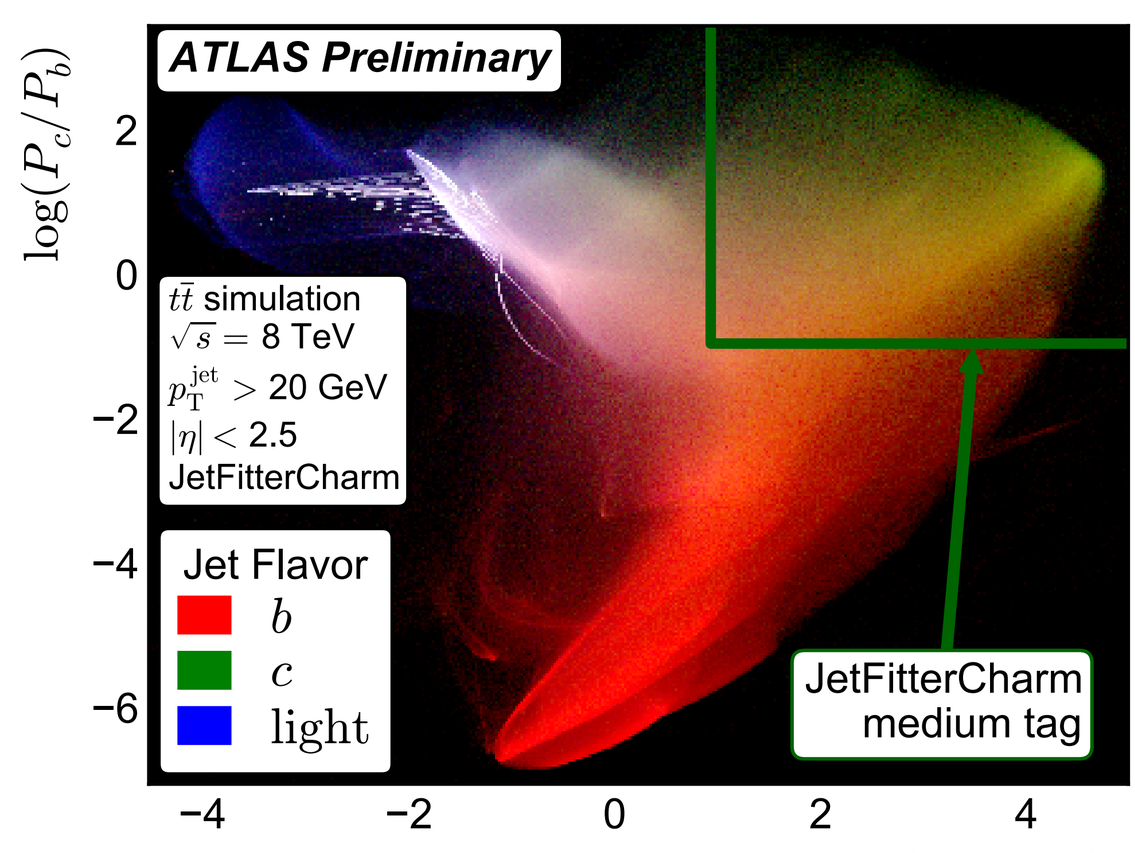
Signature: two high-momentum c-jets (from c-quarks), and large missing transverse momentum ($E_{\mathrm{T}}^{\mathrm{miss}}$)

Charm Tagging - JetFitterCharm Algorithm (ATL-PHYS-PUB-2015-001)



http://acfahep.kek.jp/acfareport/node35.html

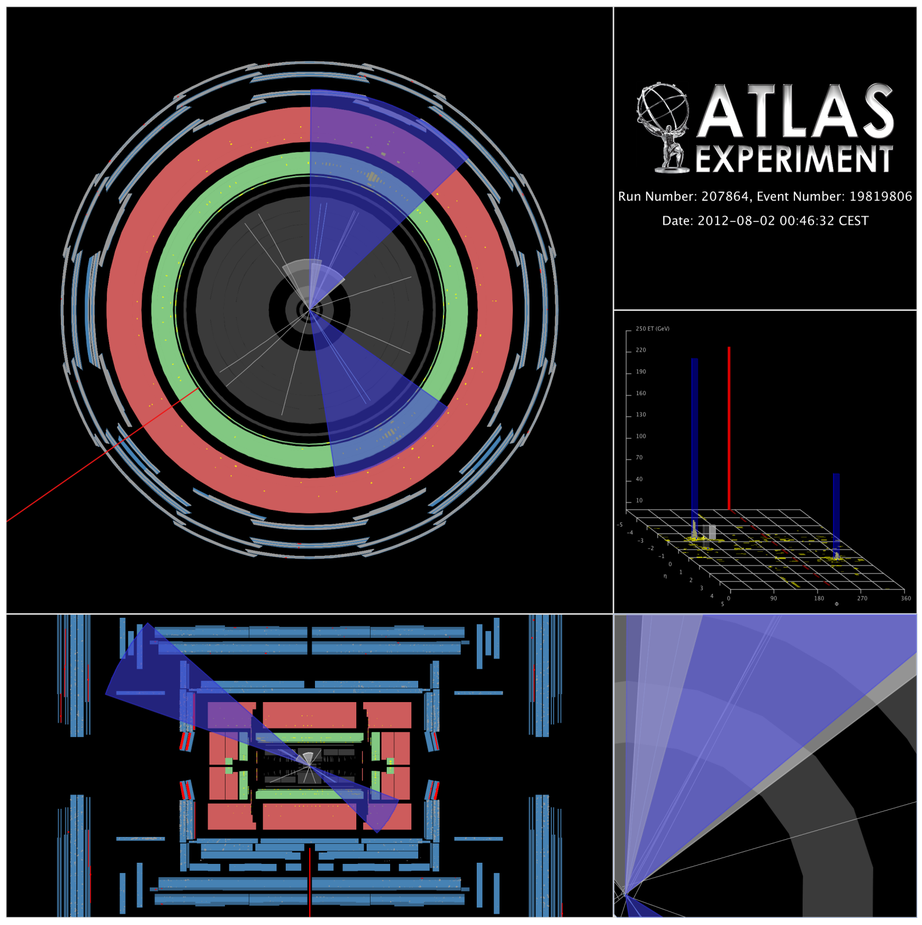
- b-hadrons fly $\sim$ mm before decaying
- Reconstructed tracks can reveal these secondary decay vertices
- 'Light' jets (from u, d, s quarks and gluons) do not have these features
- c-jets are an intermediate, since c-hadrons fly a measurable but smaller distance than b-hadrons and b-hadrons decay via c-hadrons



Distribution of tagging algorithm outputs for c, b and light jets in $t\bar{t}$ simulation

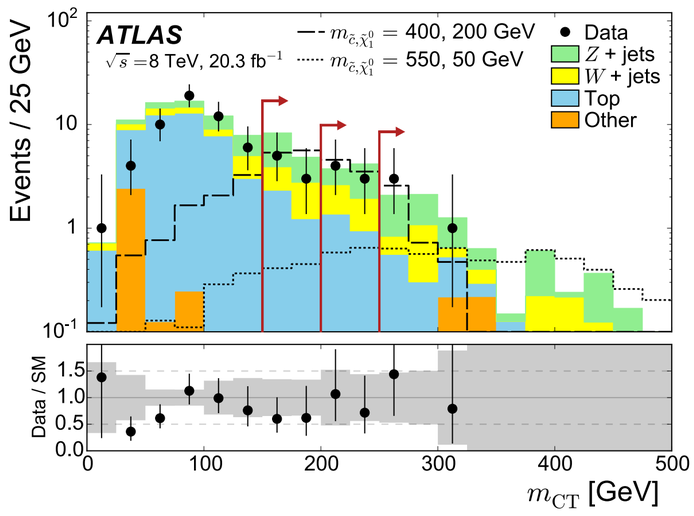
- Tracking information input to neural network (algorithm trained to distinguish c from b and light)
- Gives probabilities P_c, P_b, P_{light}
- Cuts in 2D plane: distinguish c jets from both b and light (u,d,s, g) jets
- Plot description: each jet falls somewhere on (P_c/P_{light}, P_c/P_b) plane. At this point, pixel colour value is incremented by (R,G,B) for jet flavour = (b, c, light)
- b-jets at bottom, light jets at top left, c-jets at top right, comination in middle (white region)
- Patterns due to discrete inputs (e.g. number of vertices with ≥ 2 tracks)
- Performance: $\varepsilon_c \sim 17\%$, $\varepsilon_b \sim 12\%$, $\varepsilon_{\mathrm{light}} \sim 0.8\%$

Signal Candidate Event Display



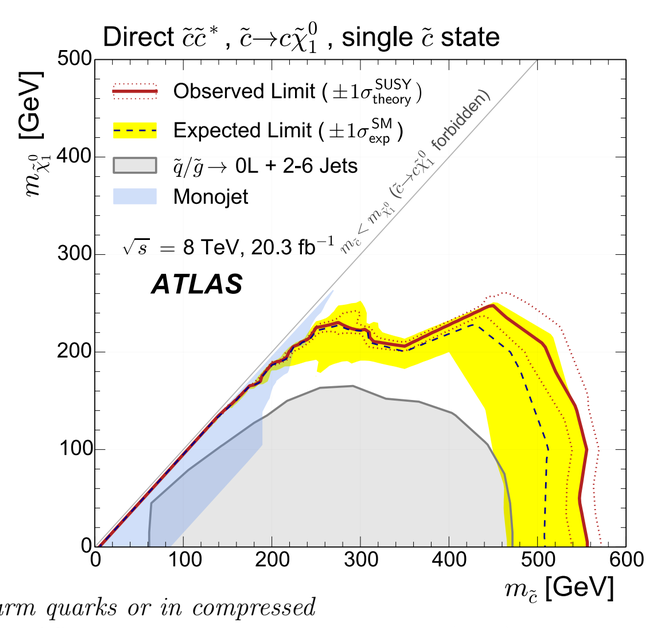
Two high-p_{T} c-tagged jets and high $E_{\mathrm{T}}^{\mathrm{miss}}$, m_{cc} and m_{CT}
Lower right panel shows a displaced vertex in a c-tagged jet

Selection and Results



- To distinguish signal from large backgrounds, require two c-tagged jets as well as high jet p_{T} and high $E_{\mathrm{T}}^{\mathrm{miss}}$
- Use kinematic variables m_{CT} (plotted) and m_{cc} to exploit topology of signal
- Measure backgrounds in dedicated regions, extend to search regions with simulation

- Unfortunately, data matched the background-only predictions → no sign of $\tilde{c}$
- Set limits on $\tilde{c}$ masses that can exist
- In combination with the 'stop-to-charm' search[1], limits are a significantly stronger then previous best ('inclusive'[2], in grey)



[1] *Search for pair-produced third-generation squarks decaying via charm quarks or in compressed supersymmetric scenarios in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector*, Phys. Rev. D 90, 052008 (2014)
[2] *Search for squarks and gluinos with the ATLAS detector in final states with jets and missing transverse momentum using $\sqrt{s} = 8$ TeV proton–proton collision data*, JHEP 09 (2014) 176

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Super Charm ATLAS | Super Charm Oxford | Scharm paper PRL | Stop-to-charm PRD | Inclusive JHEP | JetFitterCharm

ATLAS EXPERIMENT