CERN Summer Student 2021

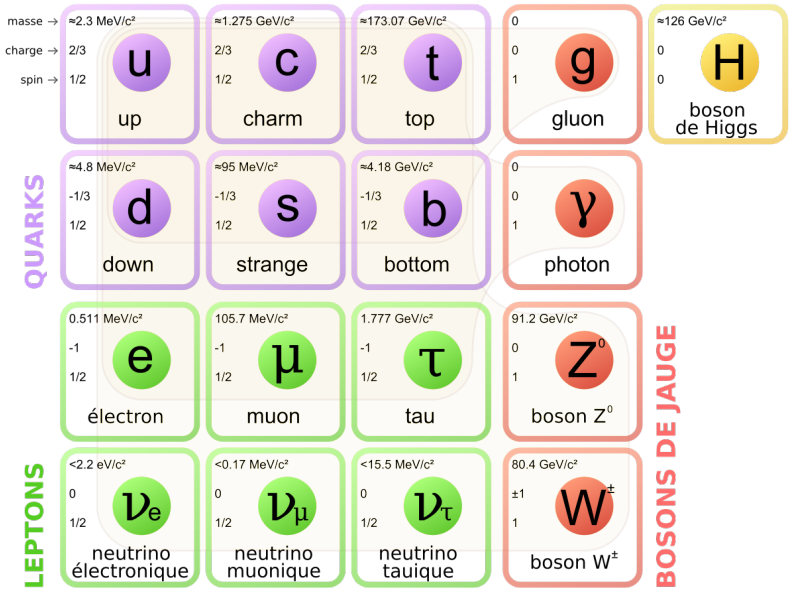
Semi-visible Jets

Study of semi-visible jets with machine learning method

Augustin Tribolet

Supervisors: Deepak Kar, Sukanya Sinha, Tasnuva Chowdhury

Extension of SM: Dark Matter



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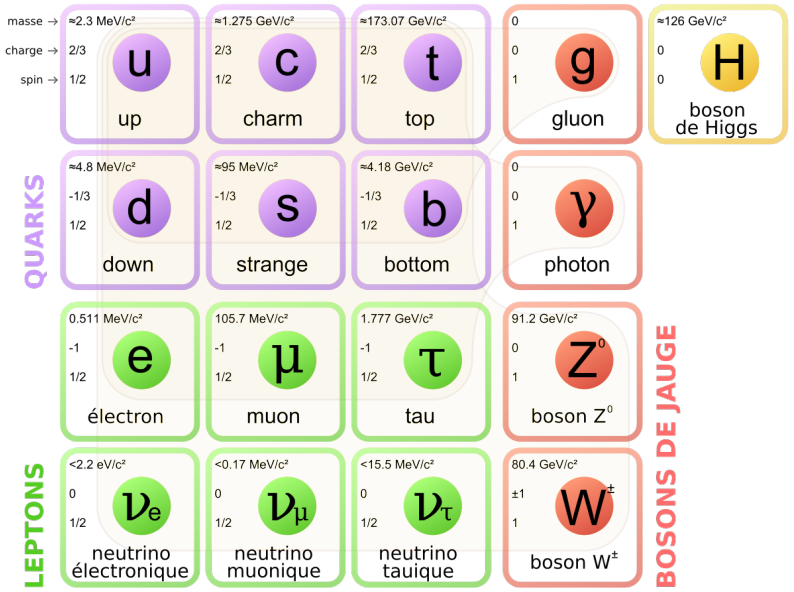

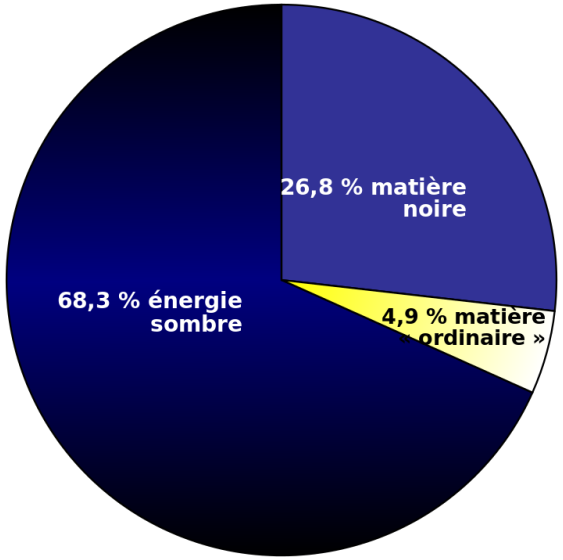

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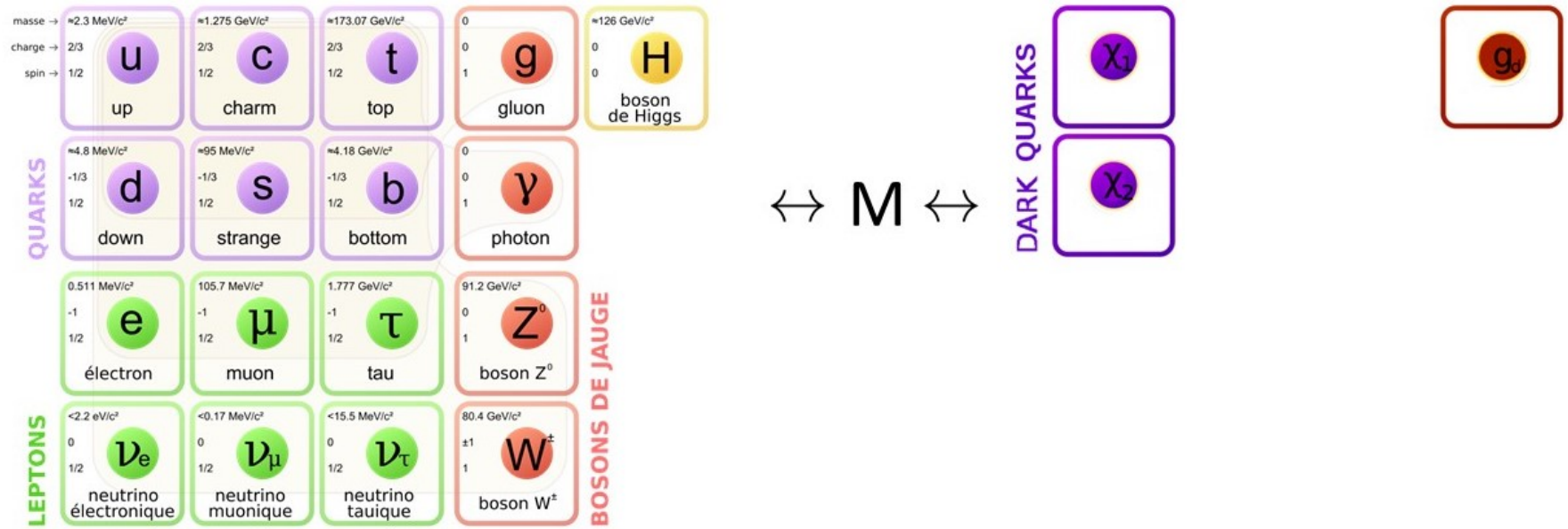

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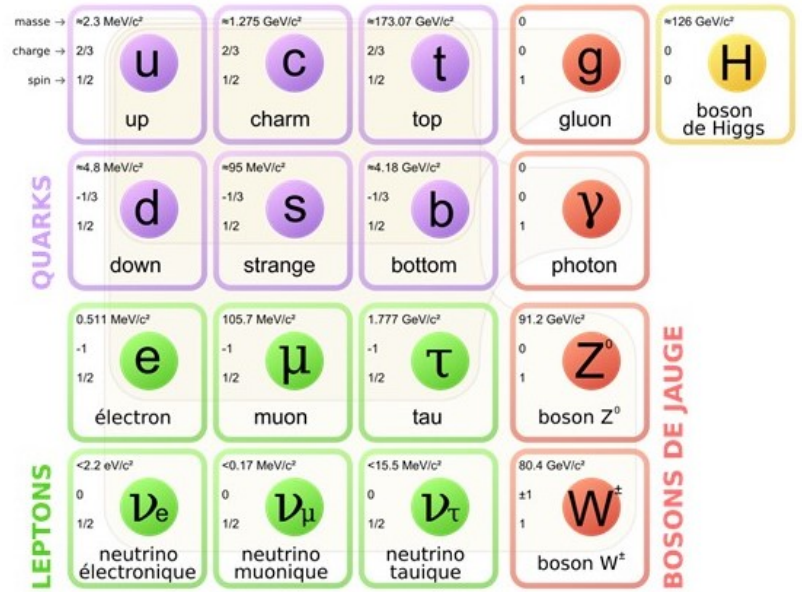

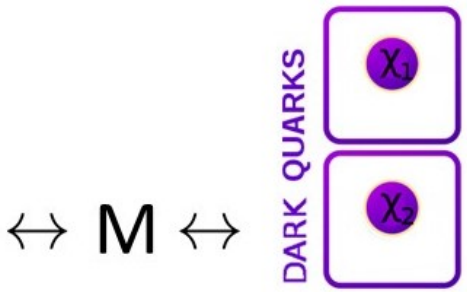

Hidden Valley:

- 2 dark quarks
- 1 dark gauge boson (for the strong interaction)
- 1 mediator between the two sectors

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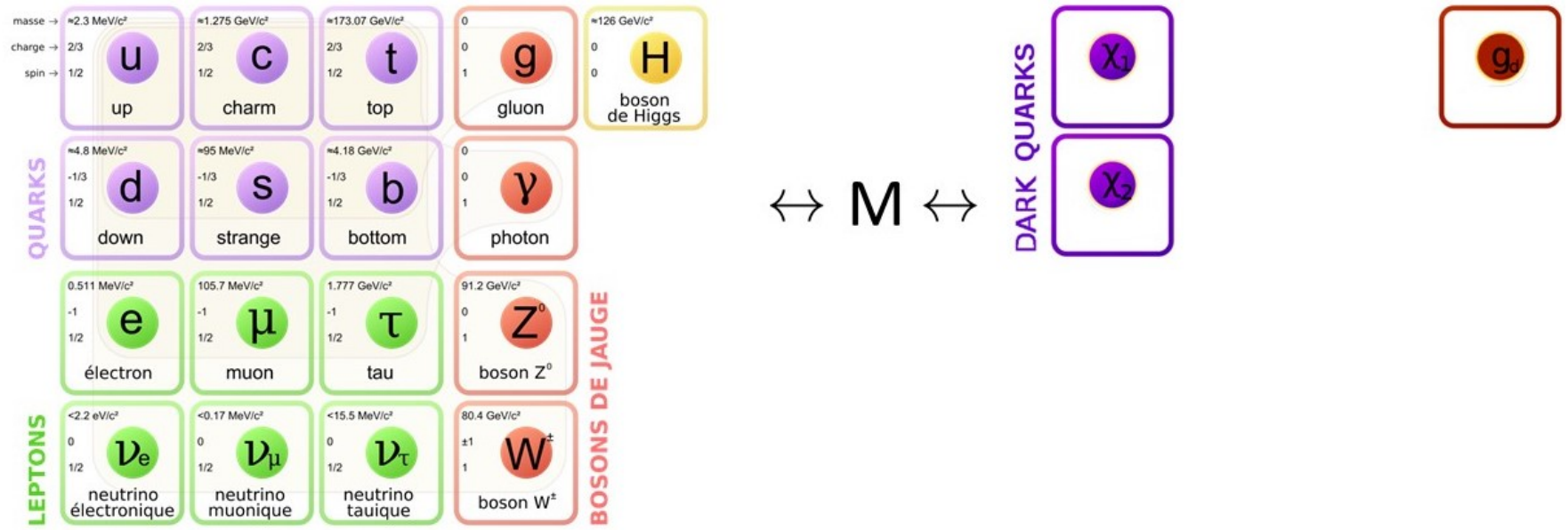

$$\mathcal{L}_{\mathcal{QCD}} = -\frac{1}{4}G^{\mu\nu}G_{\mu\nu} - \overline{\psi}(i\not{D} - m)\psi$$

$$\mathcal{L} = -\frac{1}{4}F^{d}_{\mu\nu}F^{d\,\mu\nu} - \overline{\chi}_a(i\not{D} - M_{d,a})\chi_a$$

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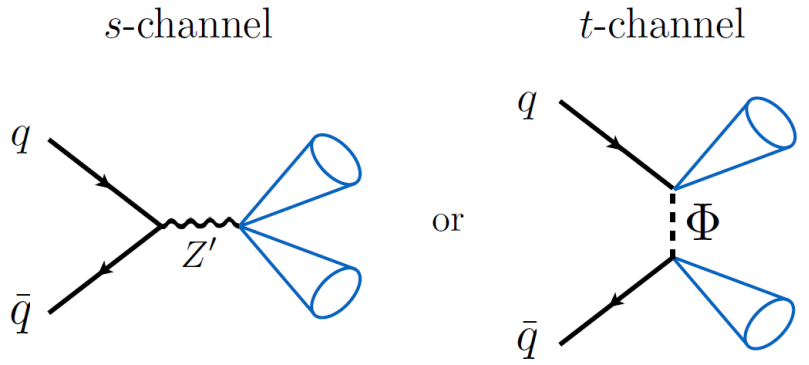

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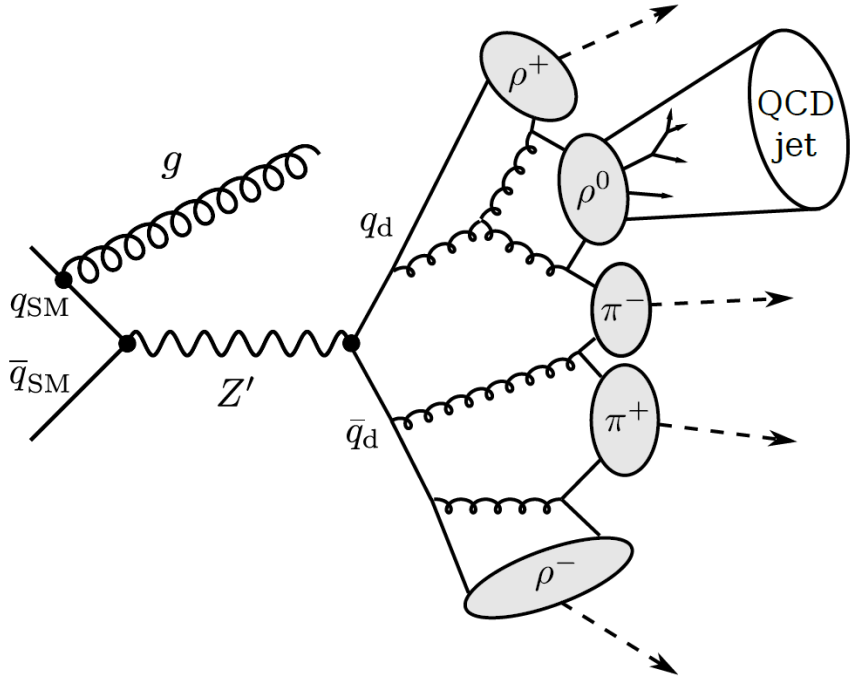

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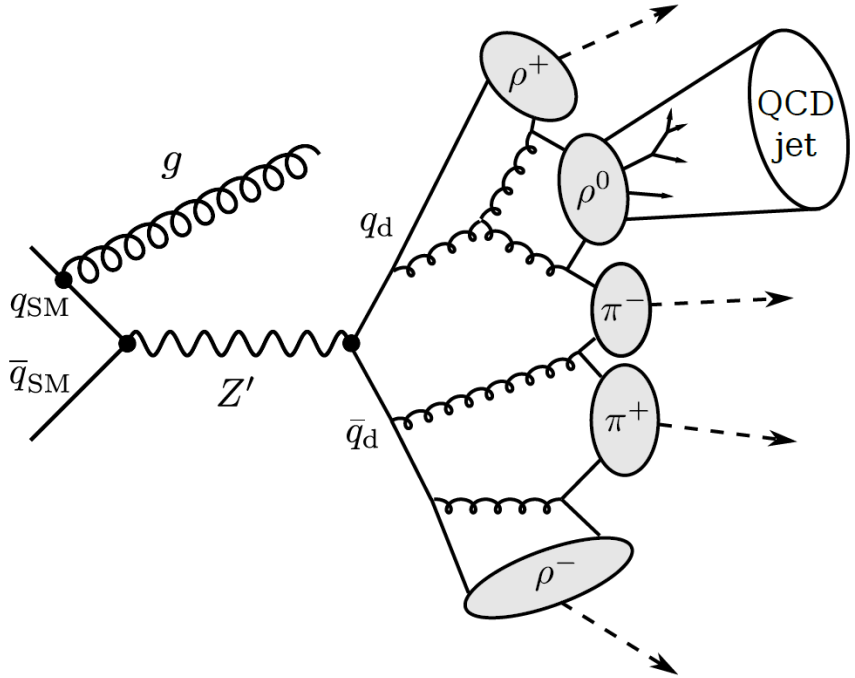

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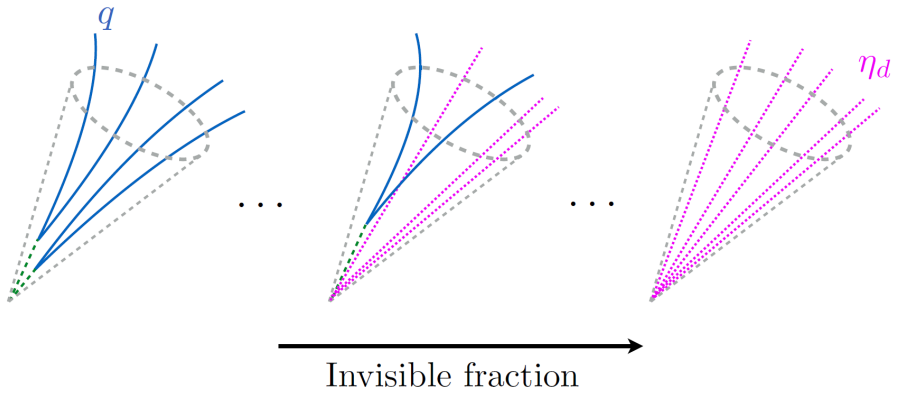
- Stable hadrons: Dark Matter
- Unstable hadron: ρ_0



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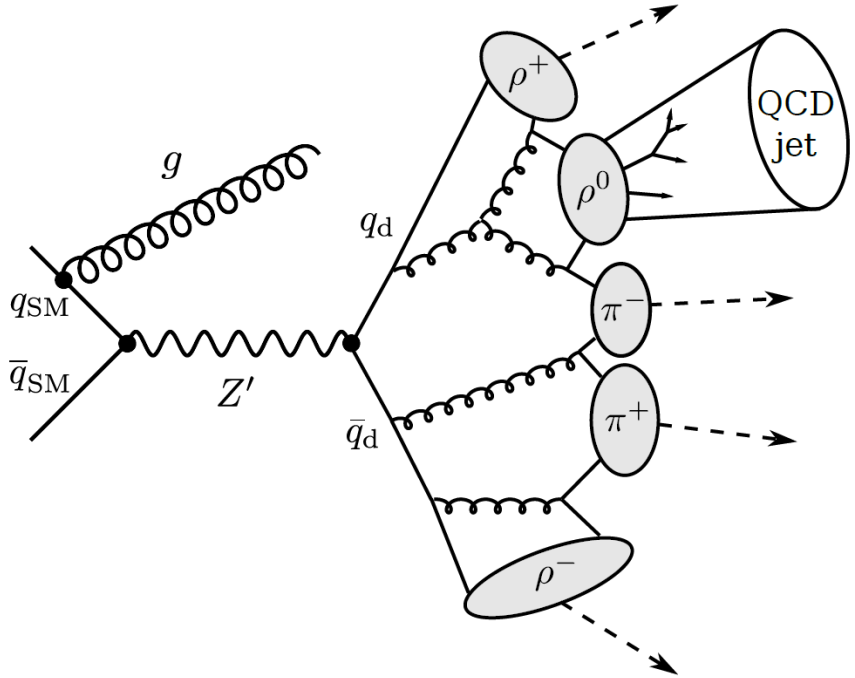

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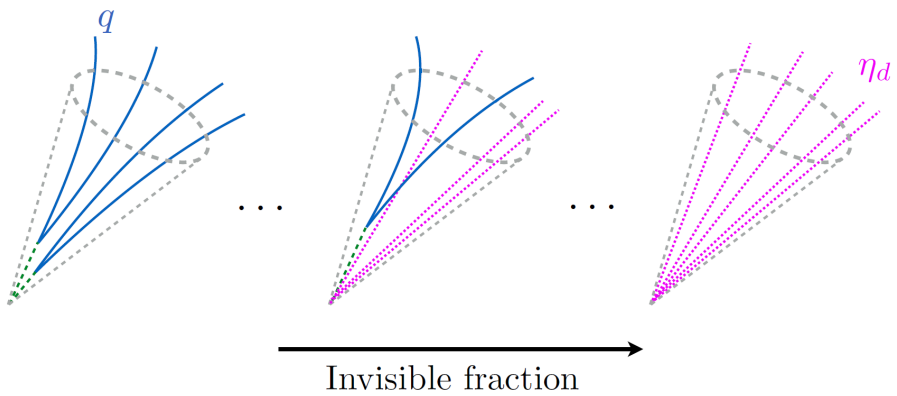
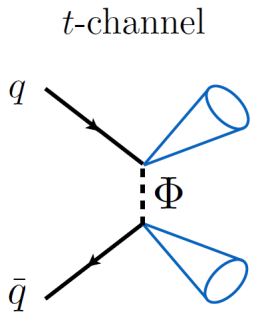


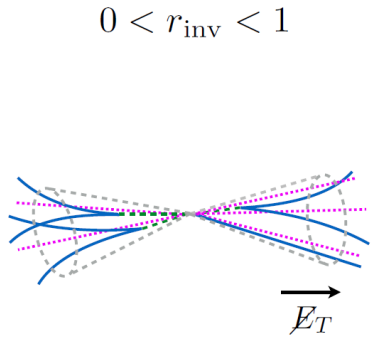
$$r_{inv} = \frac{\#\ of\ stable\ dark\ hadrons}{\#\ of\ dark\ hadrons}$$

Semi-visible Jets: Properties

- Project:



Characteristic: Two jets



Characteristic: Two visible jets

Signature: Subleading jet aligned with MET
(less pT bc more stable hadrons)

Semi-visible Jets: Properties

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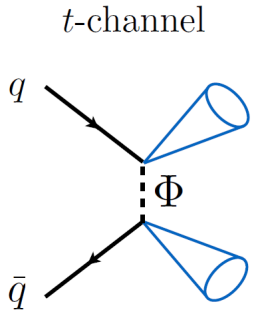
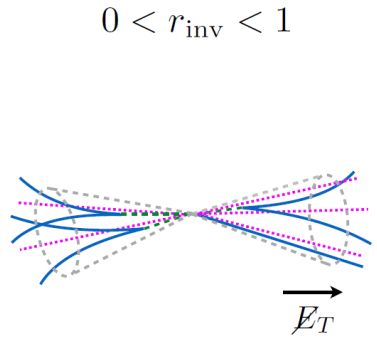
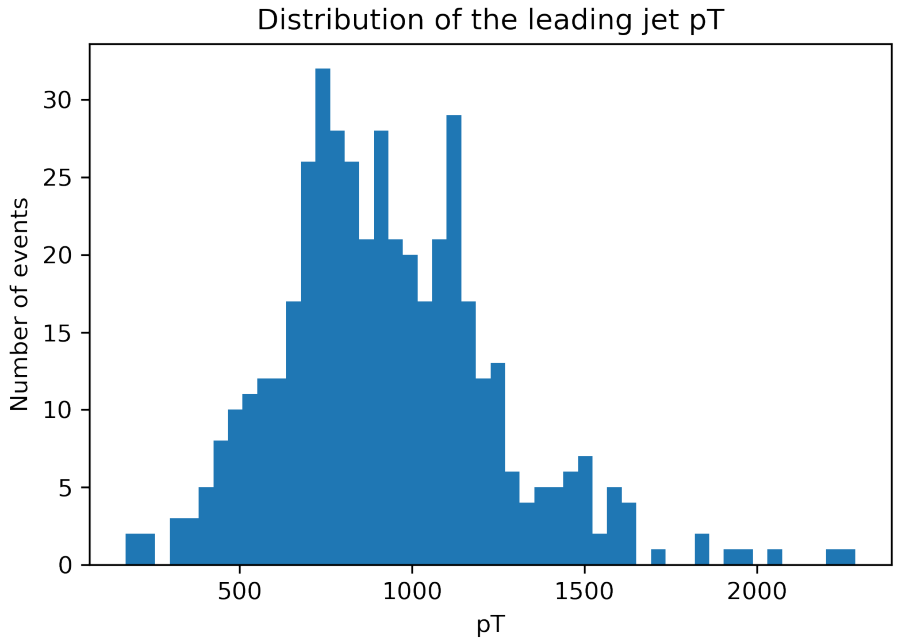
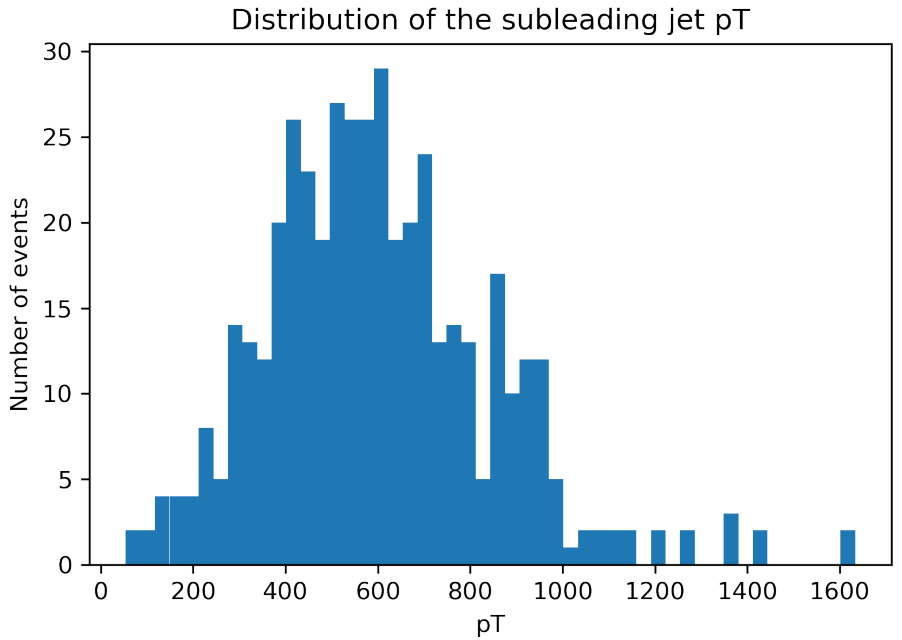




- Generation of the data using Hidden Valley module of Pythia:





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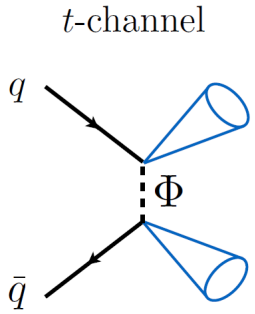

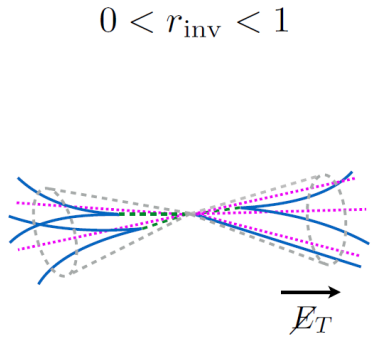

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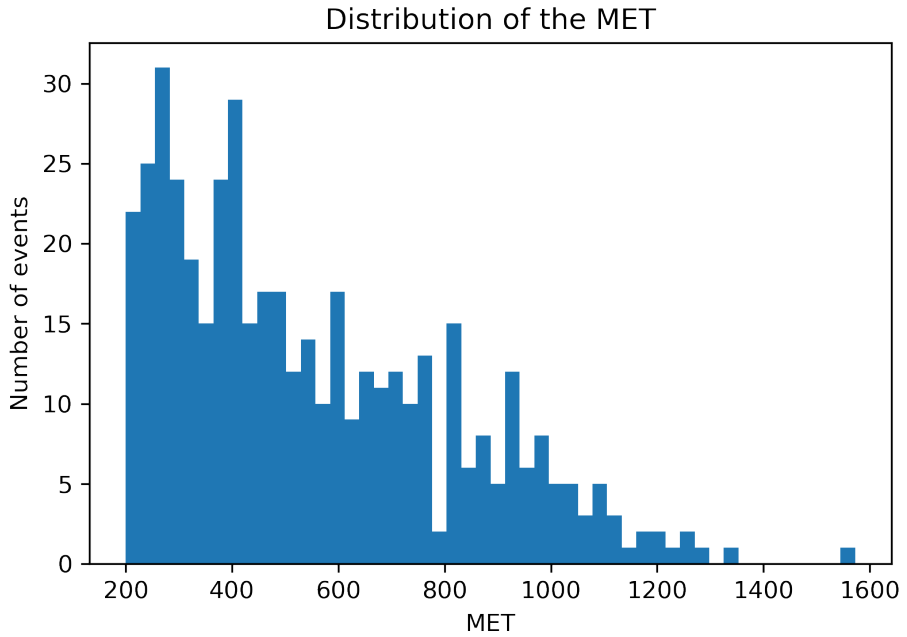

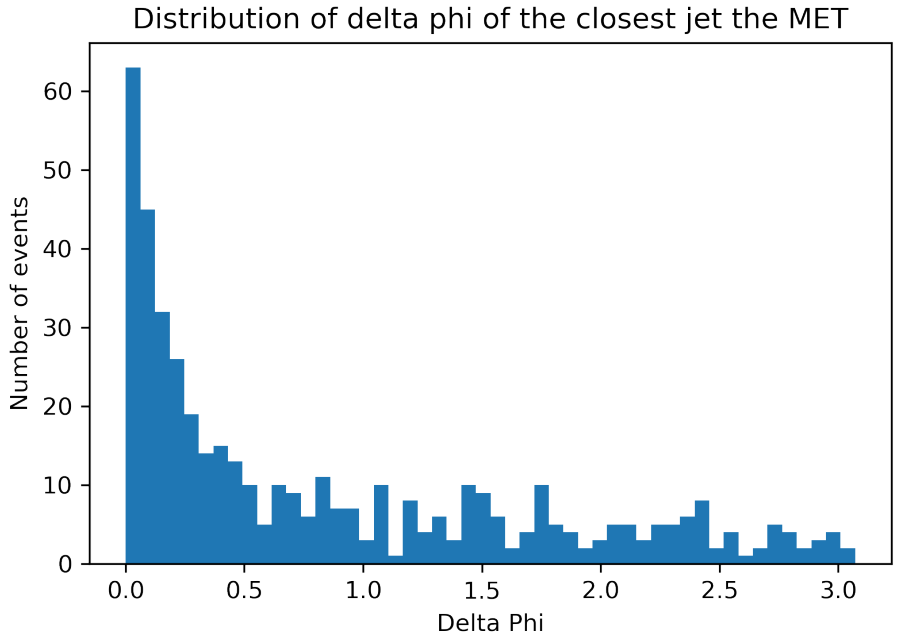

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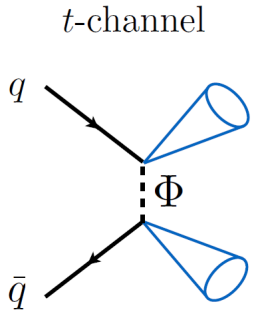

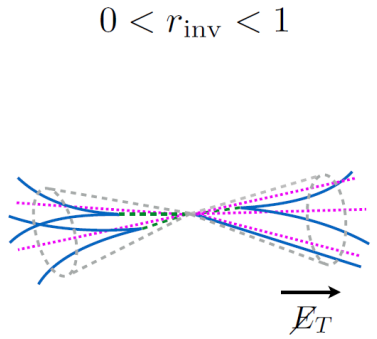

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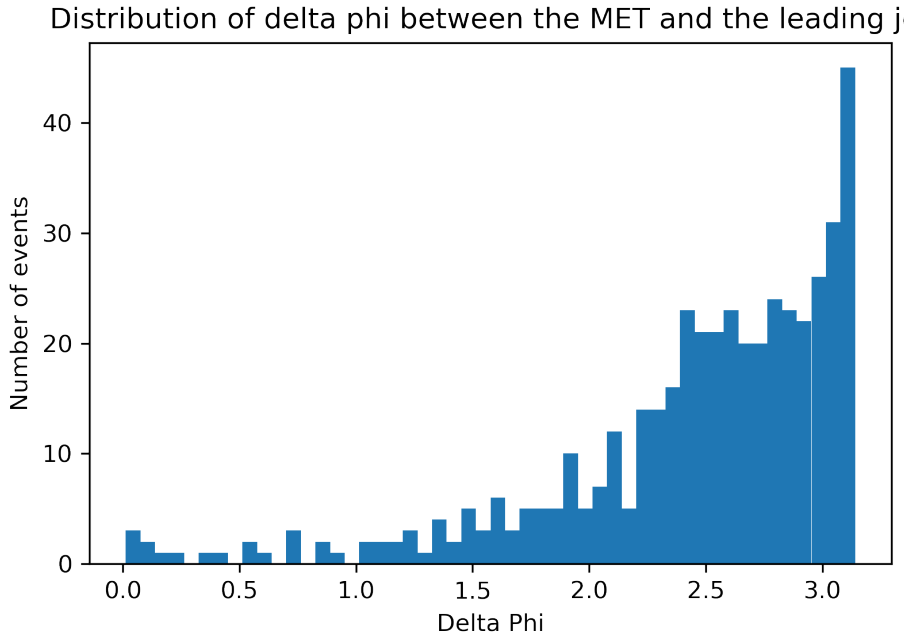
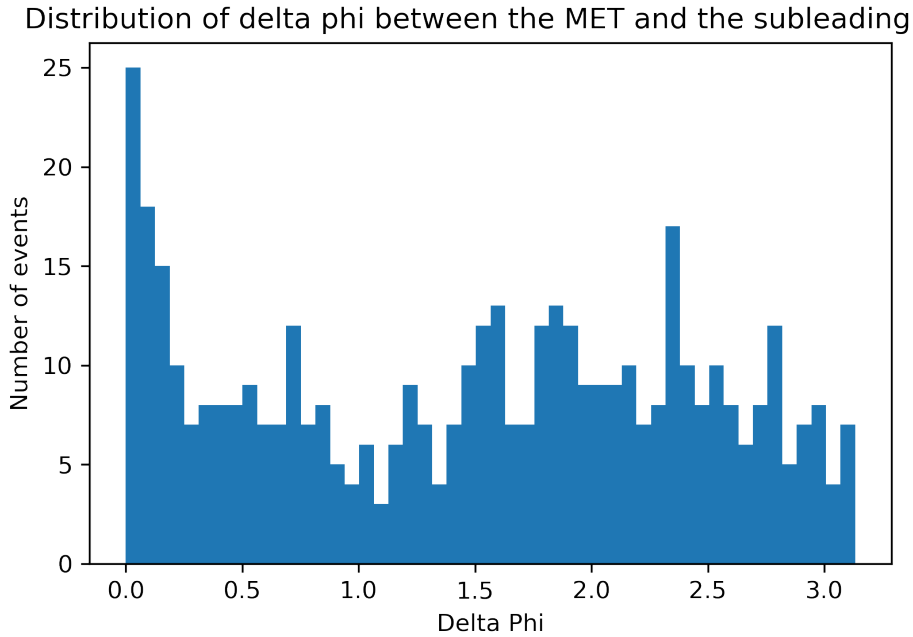
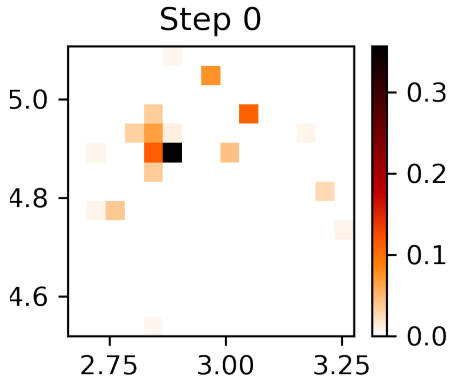




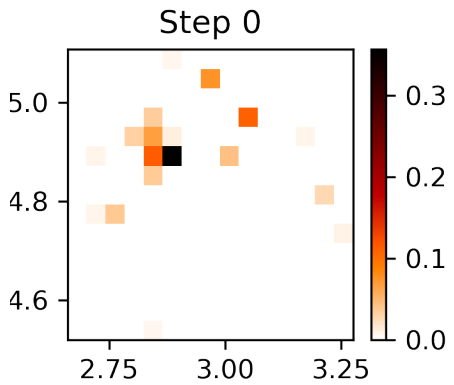
Jets Images

- Machine Learning part: Use Jet Images

- Jets images: Distribution of transverse energy of each constituents into the azimuthal and the pseudorapidity plane

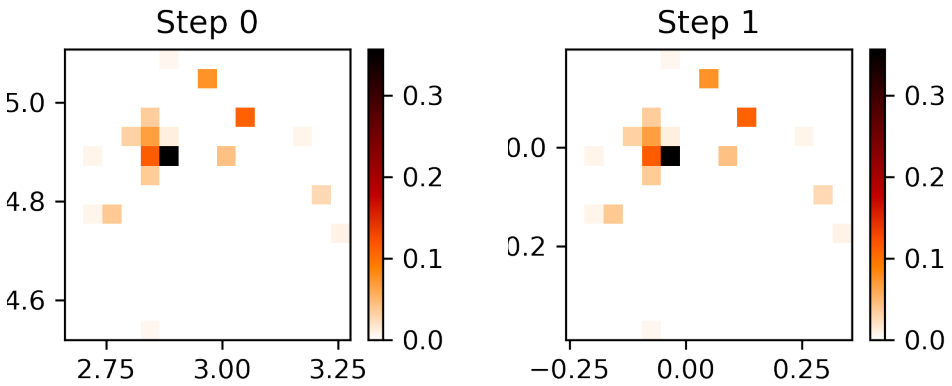


Jet Images: Preprocessing



Jet Images: Preprocessing

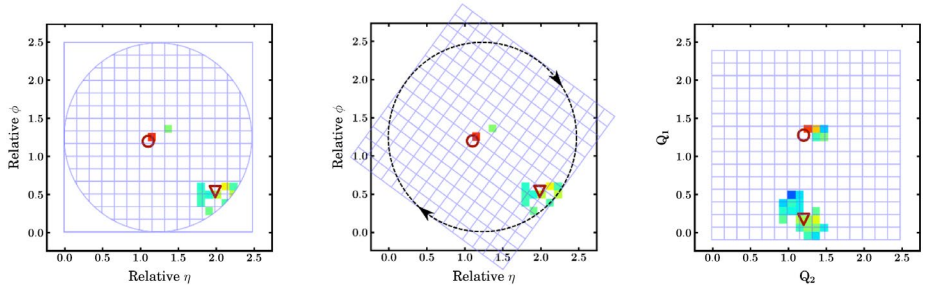
- Step 1: Centering the axes on the center of the jet

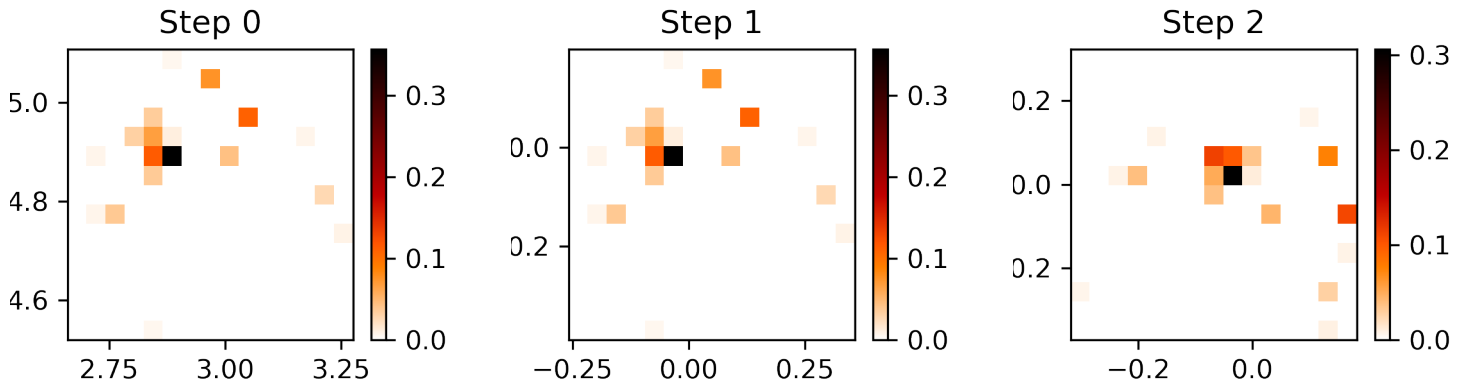


Jet Images: Preprocessing

- Step 1: Centering the axes on the center of the jet

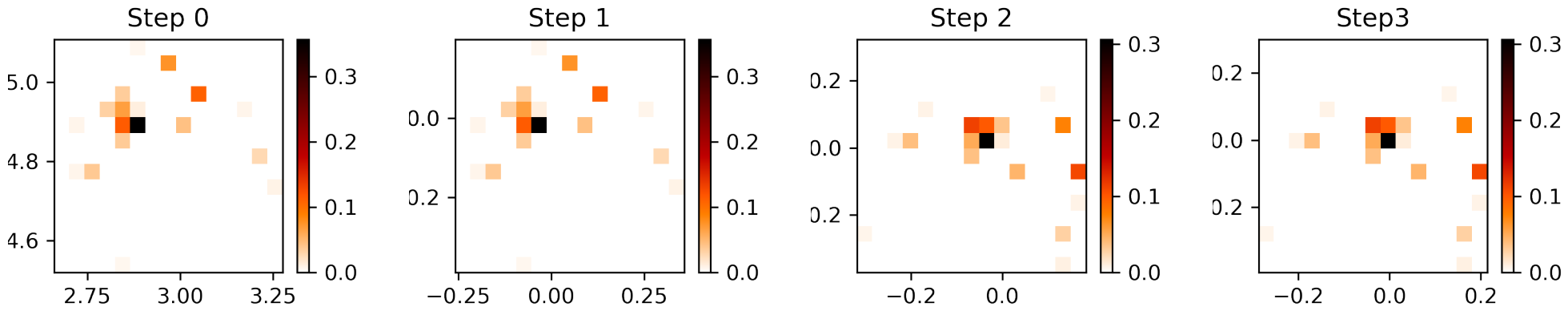
- Step 2: Rotation of the jet (first and second highest pT particle parallel to the phi axis)





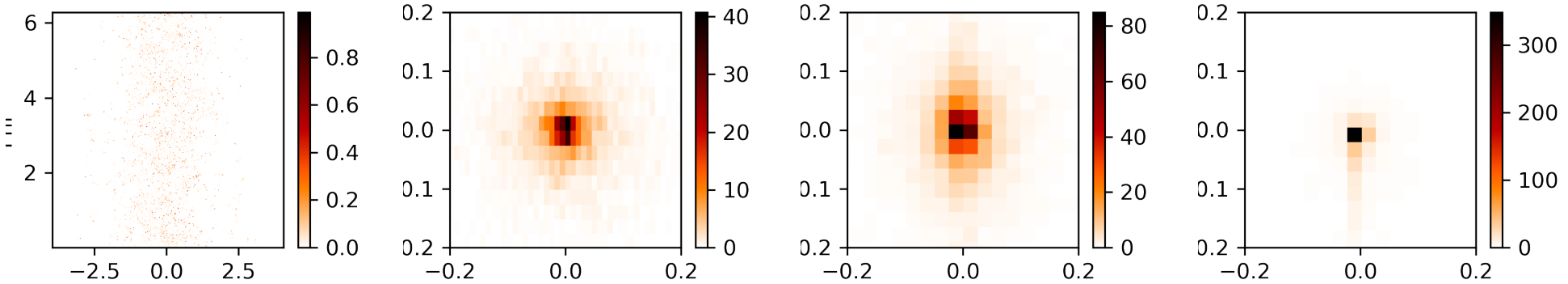
Jet Images: Preprocessing

- Step 1: Centering the axes on the center of the jet
- Step 2: Rotation of the jet (first and second highest pT particle parallel to the phi axis)
- Step 3: Translation of the highest pT constituents to the center of the images

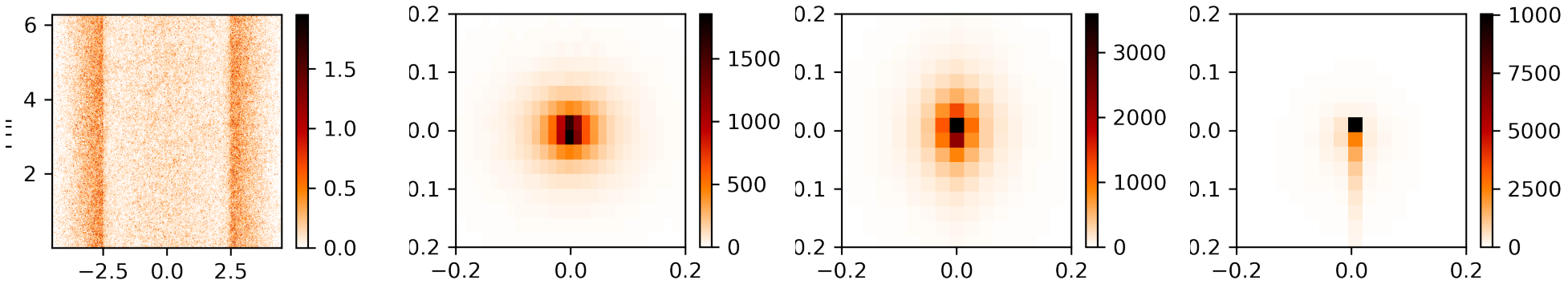


Jet Images: Preprocessing

- Average images for signal events



- Average images for background events



Machine Learning

- Third step of the project: On Going

- At the end: **Would jets formed partially from dark matter particles have a unique footprint, amenable to Machine Learning methods?**

- Future: Application on LHC data if positive answer

Thank you for your attention!