From Jet Topology Towards Jet Tagging

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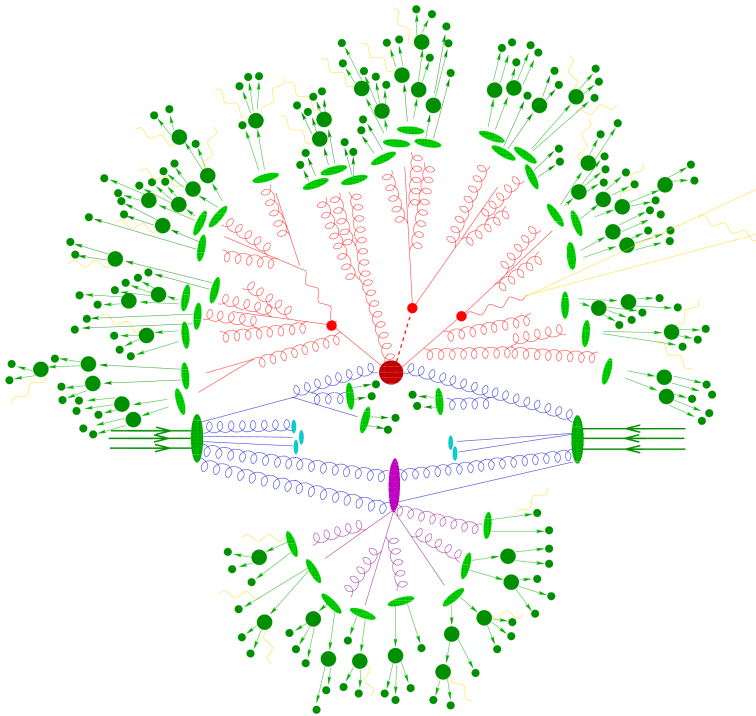
Outline

Motivation

- Let's skip the broad introduction...
- Quark/gluon tagging could be very useful
- How to define quark/gluon jet? Look at Les Houches report 2015 [arXiv:1605.04692]

Jet Pseudo-tagging Algorithm

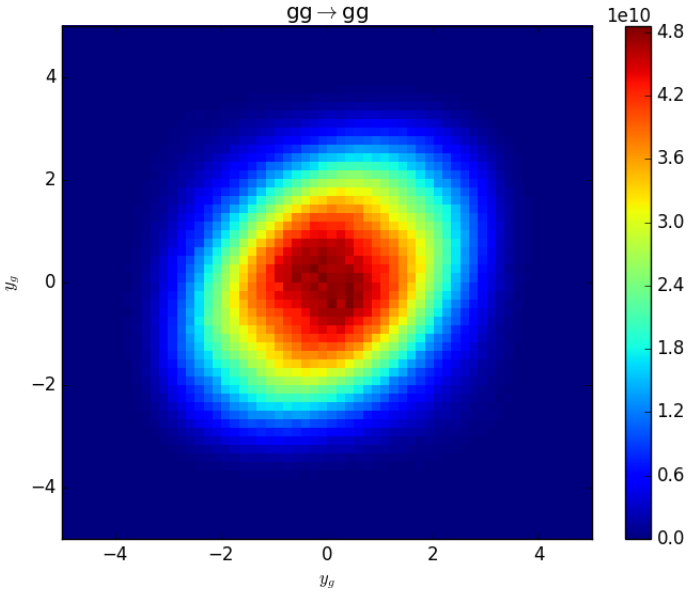
- With Monte Carlo full event record we can trace back the history of any final state particle
- Asking only for children - parent relation through event record does not give us unambiguous result
- We have to put some requirements on the algorithm

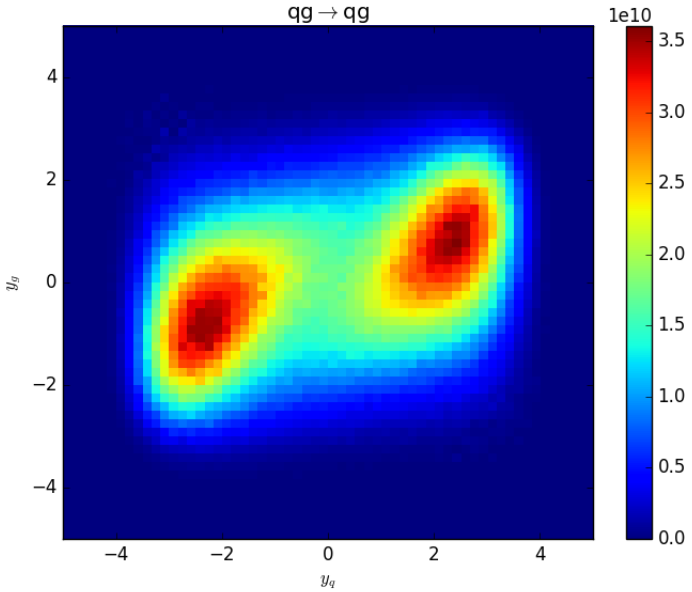


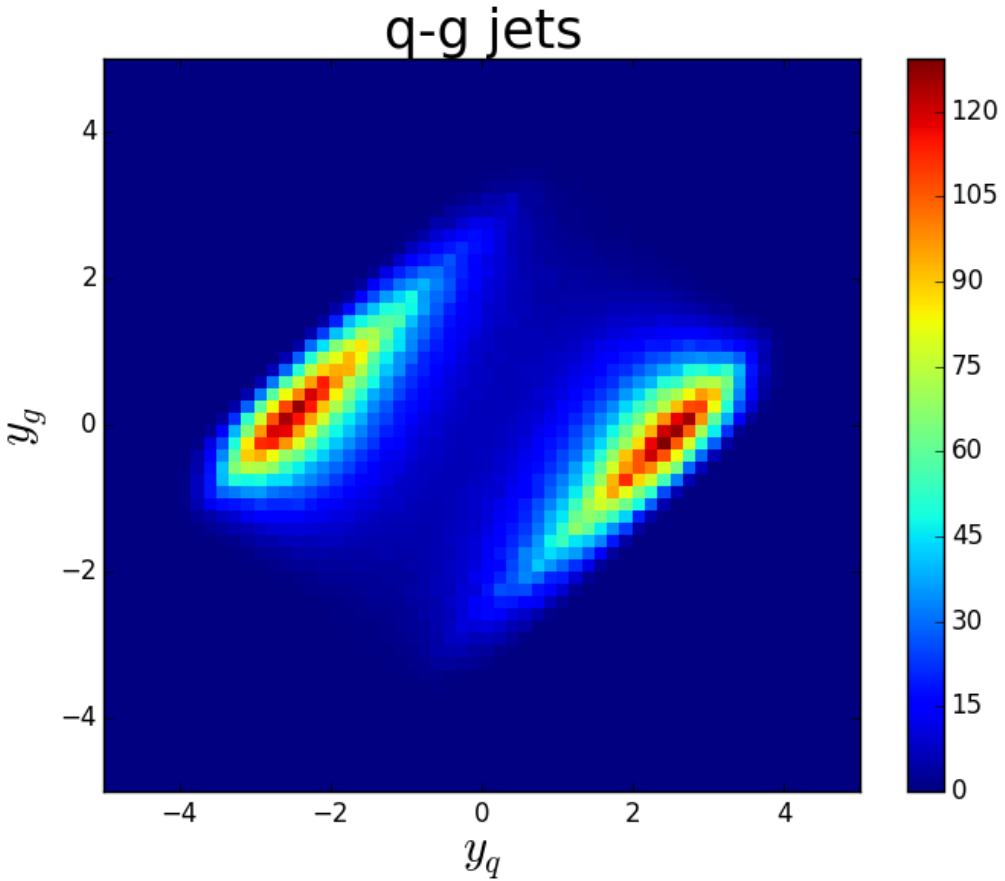
Algorithm Requirements

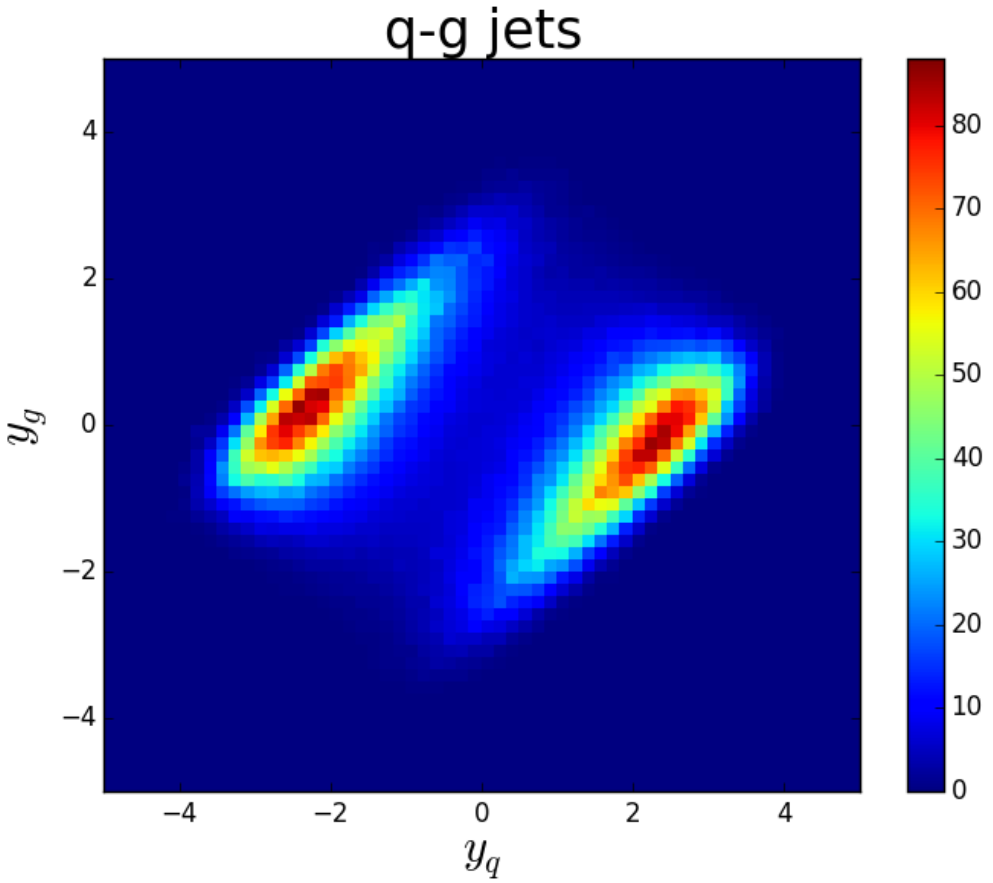
- Algorithm does not depend on jet clustering method
- Algorithm works on any level of Monte Carlo simulation (Fixed order, Parton Shower, Hadronization)
- Algorithm returns single parton as a jet initiating particle

Fixed order - LO

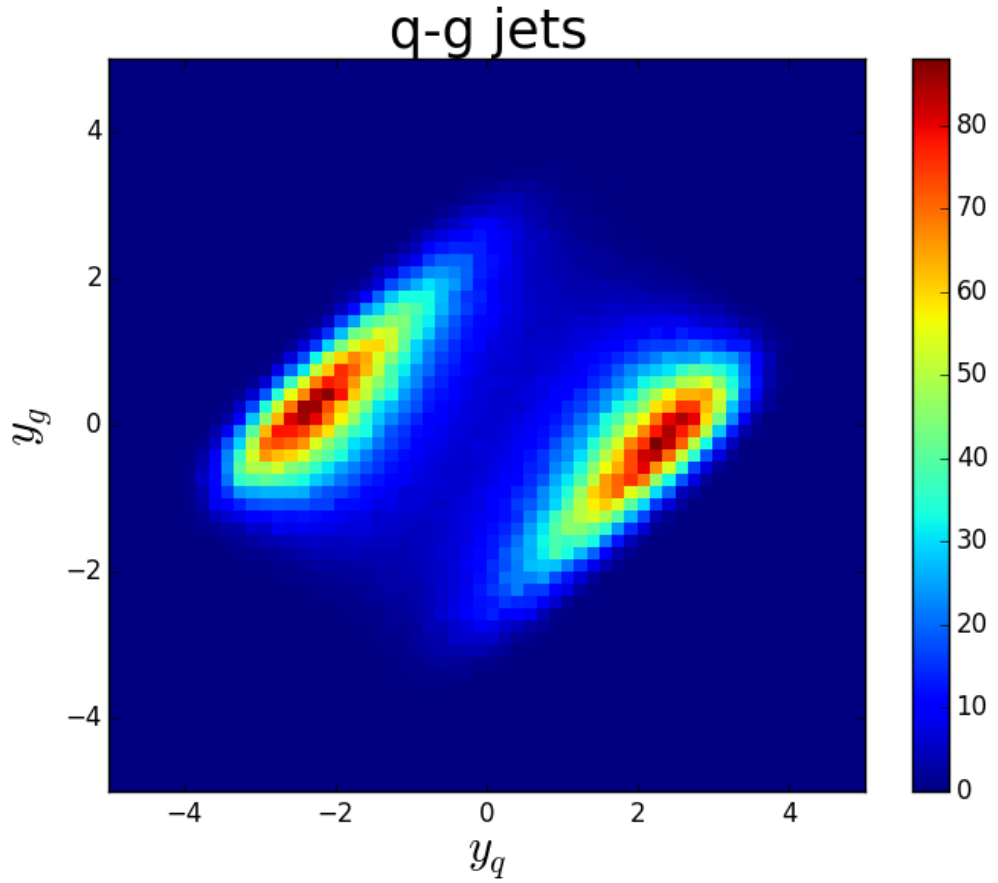





q-g jets
y_g
y_q
4
2
0
−2
−4
−4
−2
0
2
4
120
105
90
75
60
45
30
15
0

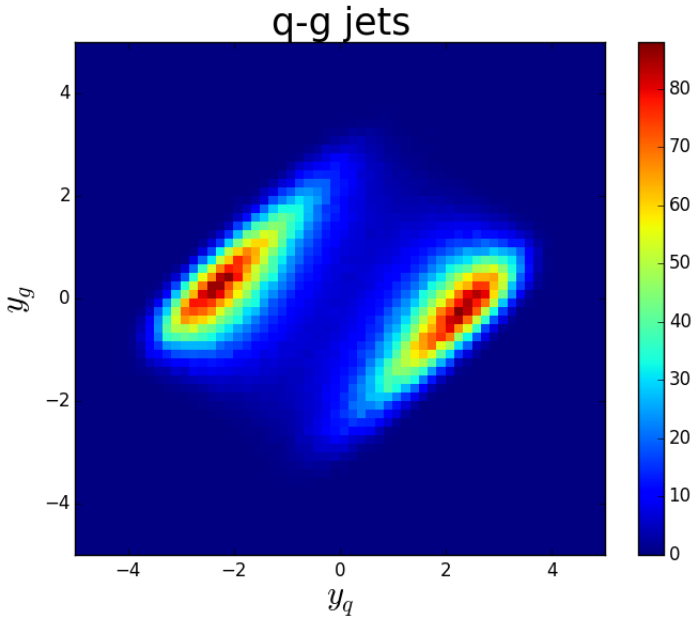

q-g jets
y_g
y_q
4
2
0
−2
−4
80
70
60
50
40
30
20
10
0

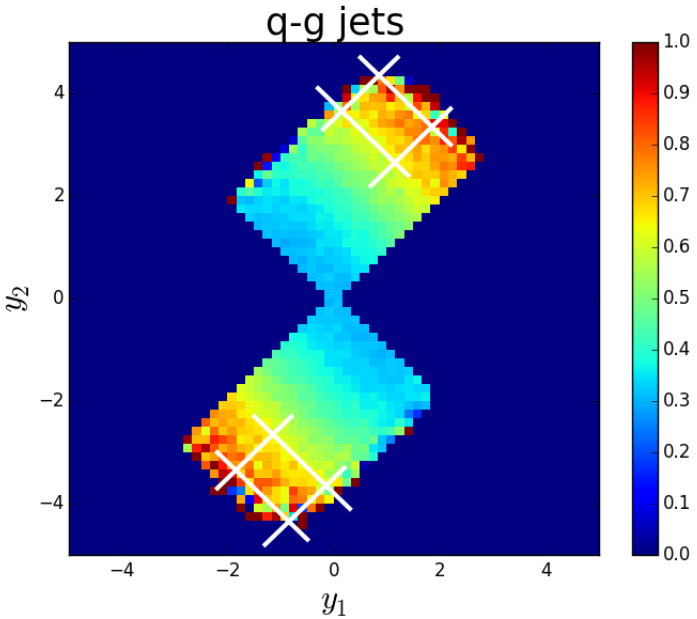
LO + Shower + UE + Hadron. $m_{jj} \in (400 - 600\ \text{GeV})$

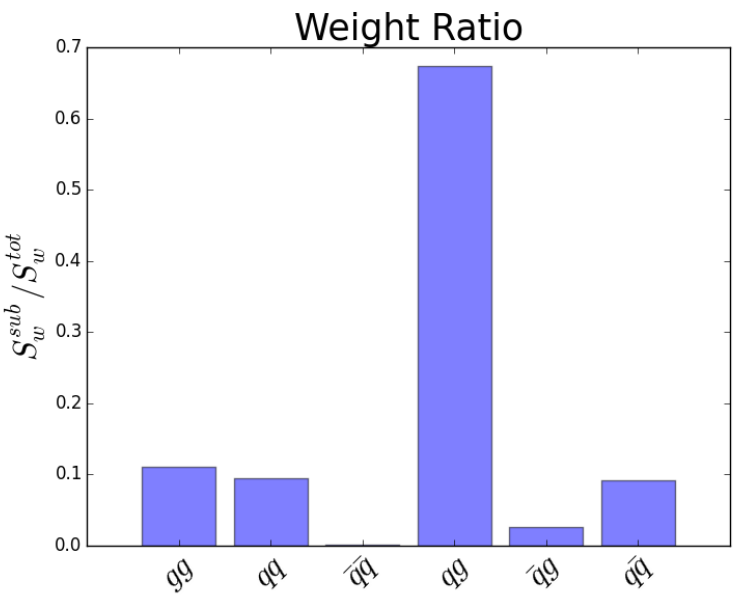


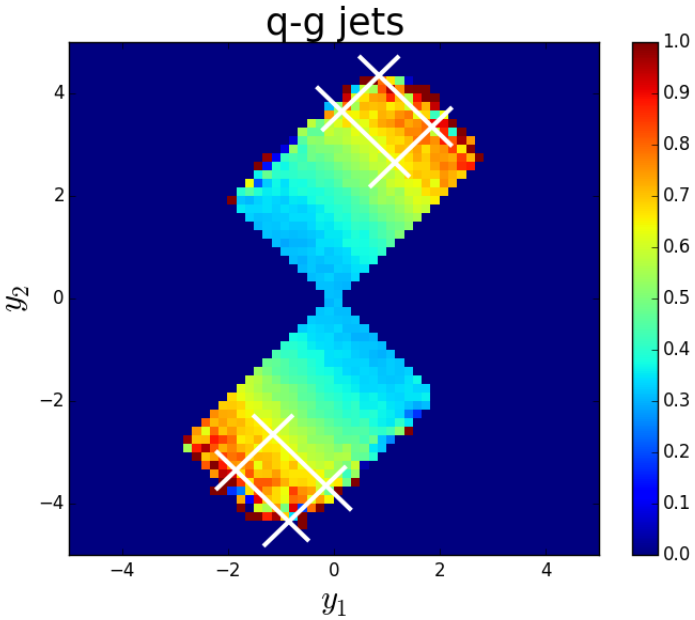
Efficiency

$m_{jj} \in (400 - 600\ \text{GeV})$






Weight Ratio
S_w^{sub}/S_w^{tot}
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
gg
$q\bar{q}$
$\bar{q}\bar{q}$
qg
$\bar{q}g$
$q\bar{q}$


q-g jets
y_2
y_1
4
2
0
−2
−4
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Towards jet tag

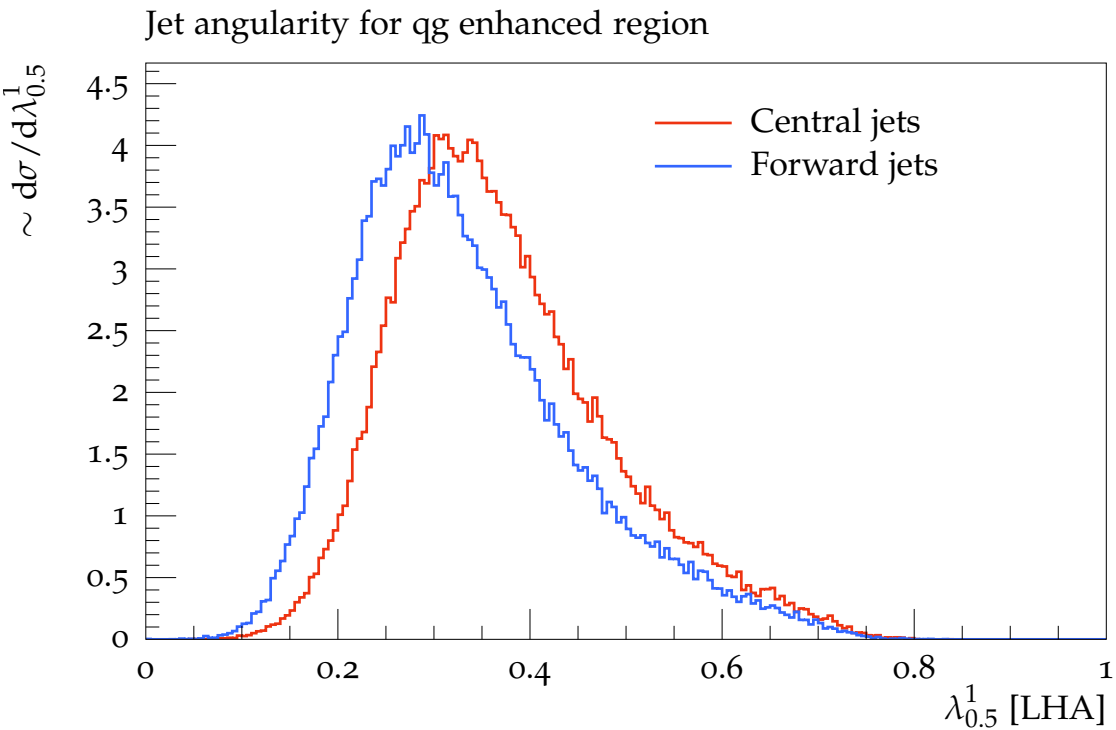
- A wide variety of quark/gluon discriminants have been proposed
- Lets use the one proposed at 2015 Les Houches workshop - Generalized Angularities

$$\lambda_\beta^\kappa = \sum_{i \in jet} z_i^\kappa \theta_i^\beta \tag{1}$$

$$z_i \equiv \frac{p_i^T}{\sum_{j \in jet} p_j^T} \qquad \theta_i \equiv \frac{R_{\hat{n}i}}{R} \tag{2}$$

$(0,0)$	$(2,0)$	$(1,0.5)$	$(1,1)$	$(1,2)$
multiplicity	p_T^D	LHA	width	mass

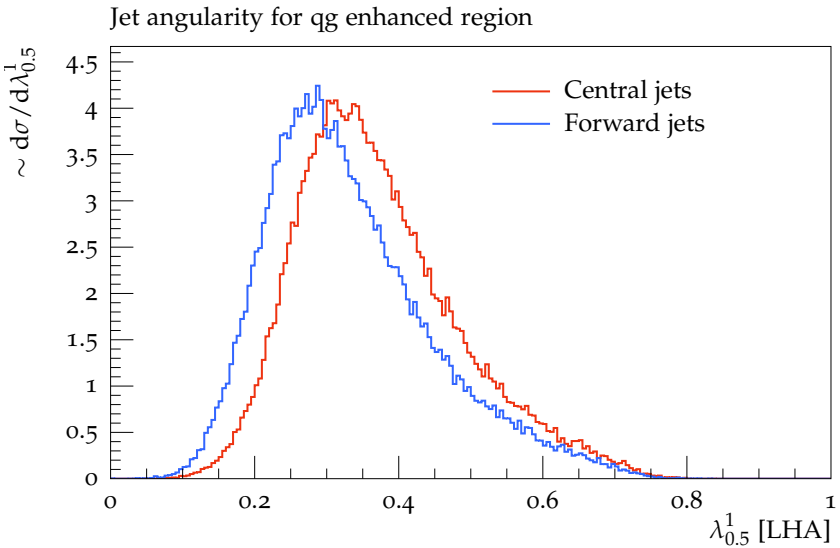
Checking the hypothesis



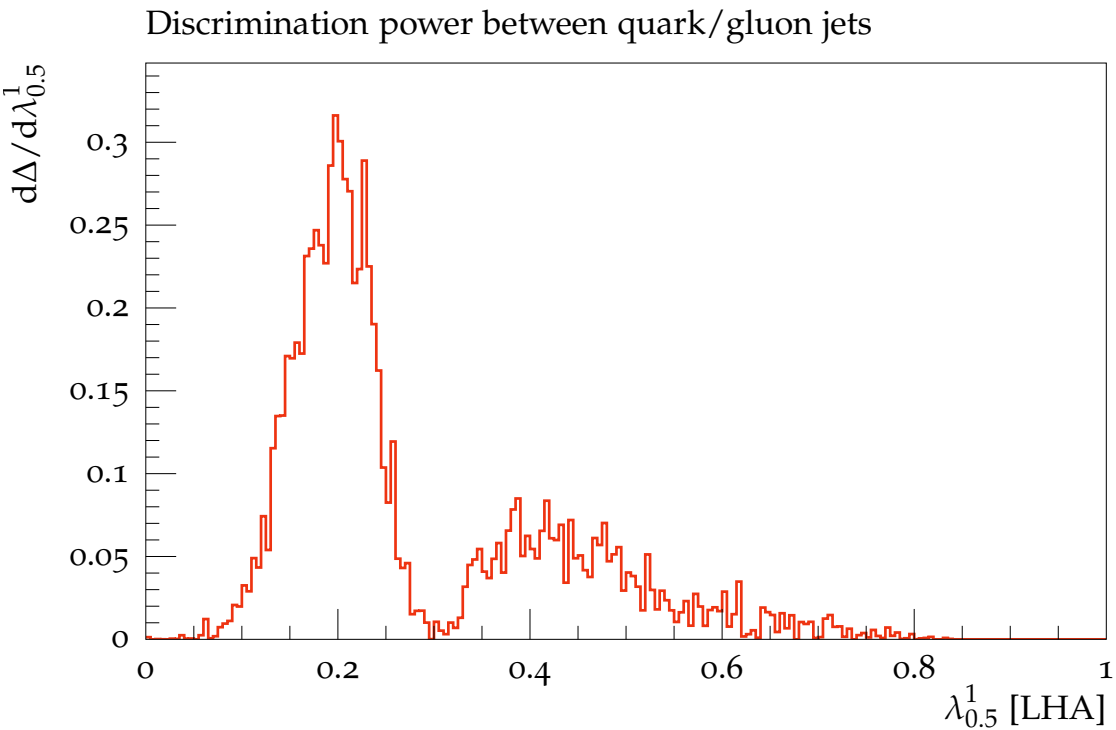
Checking the hypothesis

- We need to quantify quark/gluon separation power

$$\frac{\mathrm{d}\Delta}{\mathrm{d}\lambda} = \frac{1}{2}\frac{\left(p_f(\lambda) - p_c(\lambda)\right)^2}{\left(p_f(\lambda) + p_c(\lambda)\right)} \tag{3}$$



Checking the hypothesis



Color Coherence Effect

- Partons carry color charge and therefore they interfere with each other also during the fragmentation phase
- Naively two partons are scattered back-to-back in hard scattering and third parton can be radiated by one of them
- Color coherence can be measured by angular correlations between jets [arXiv:1311.5815]

Color Coherence Effect

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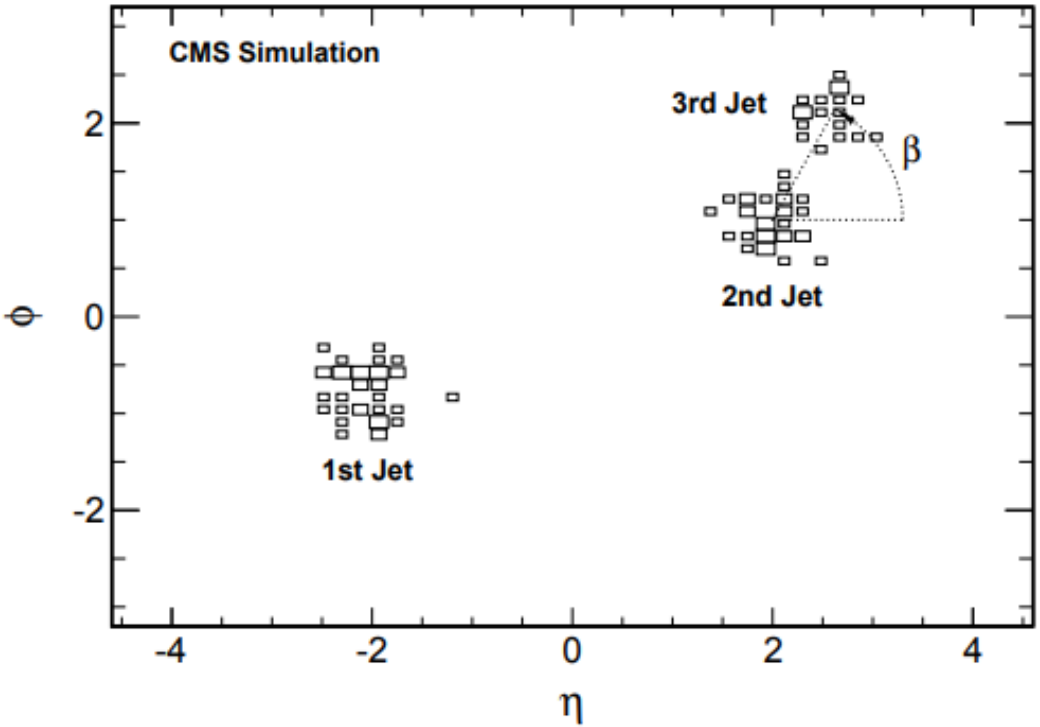
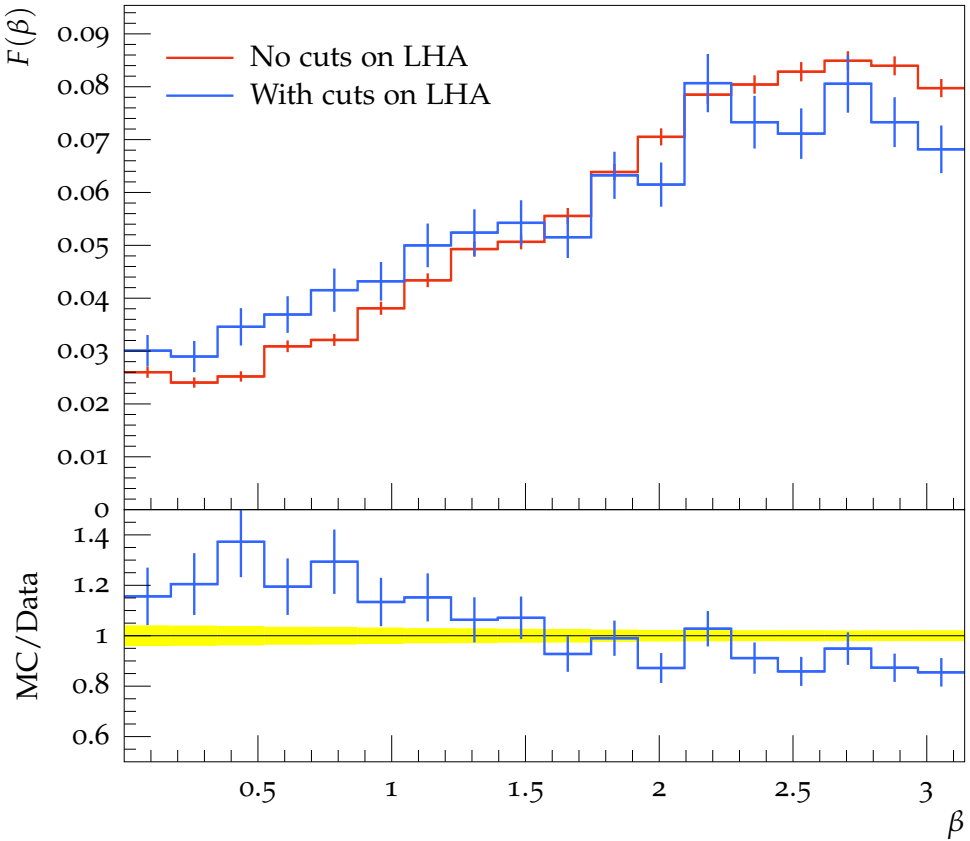
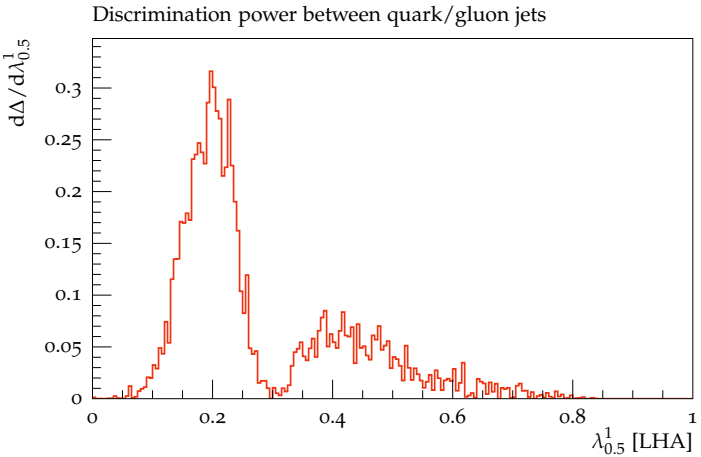
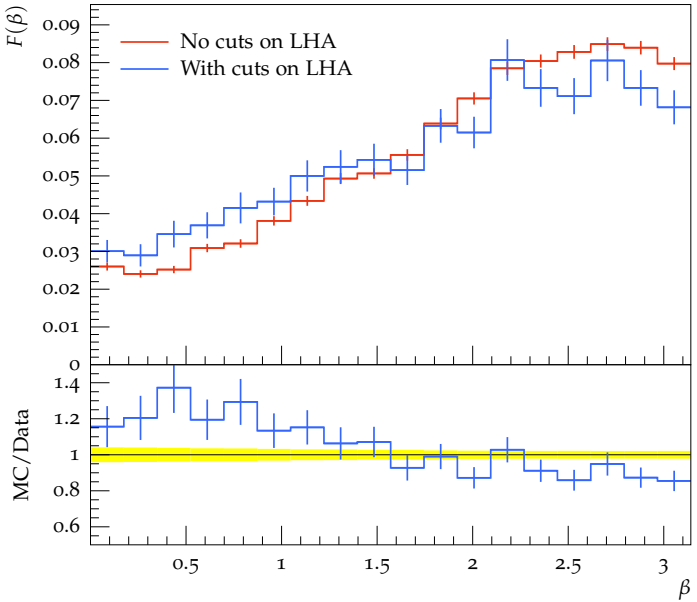


Color Coherence Effect



Color Coherence Effect

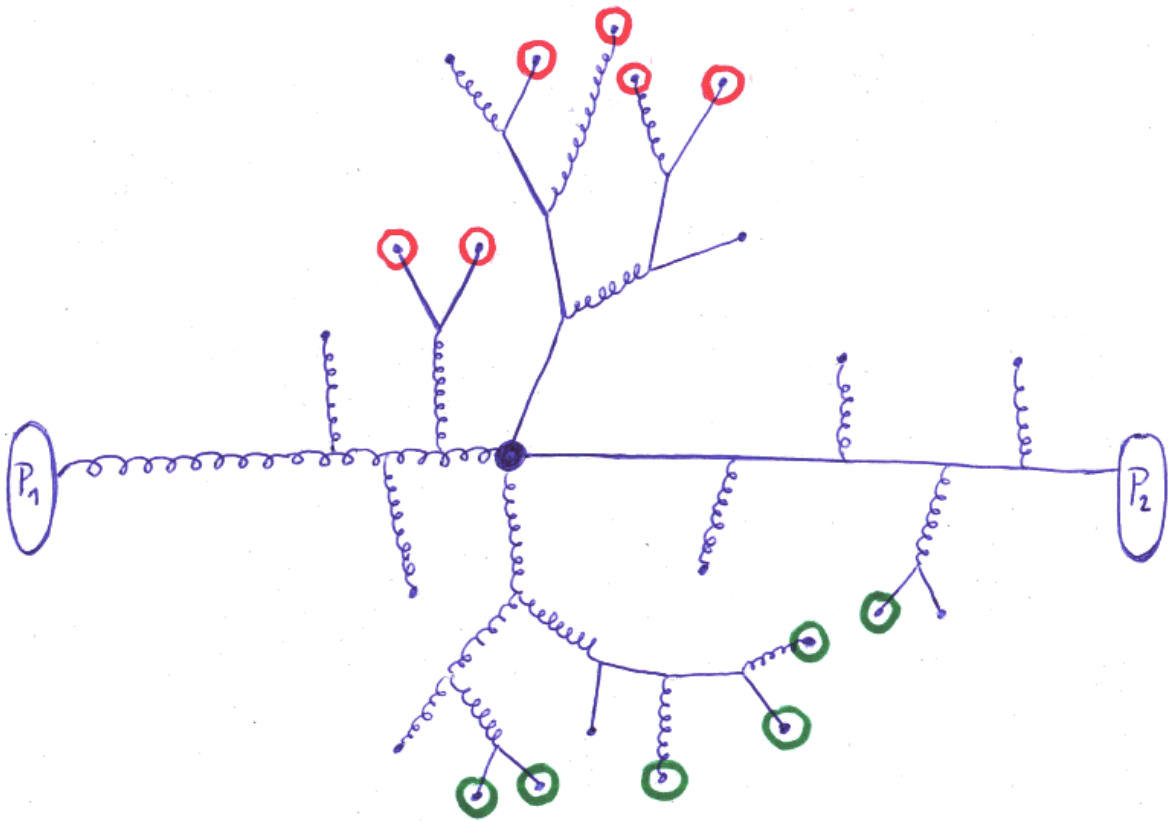




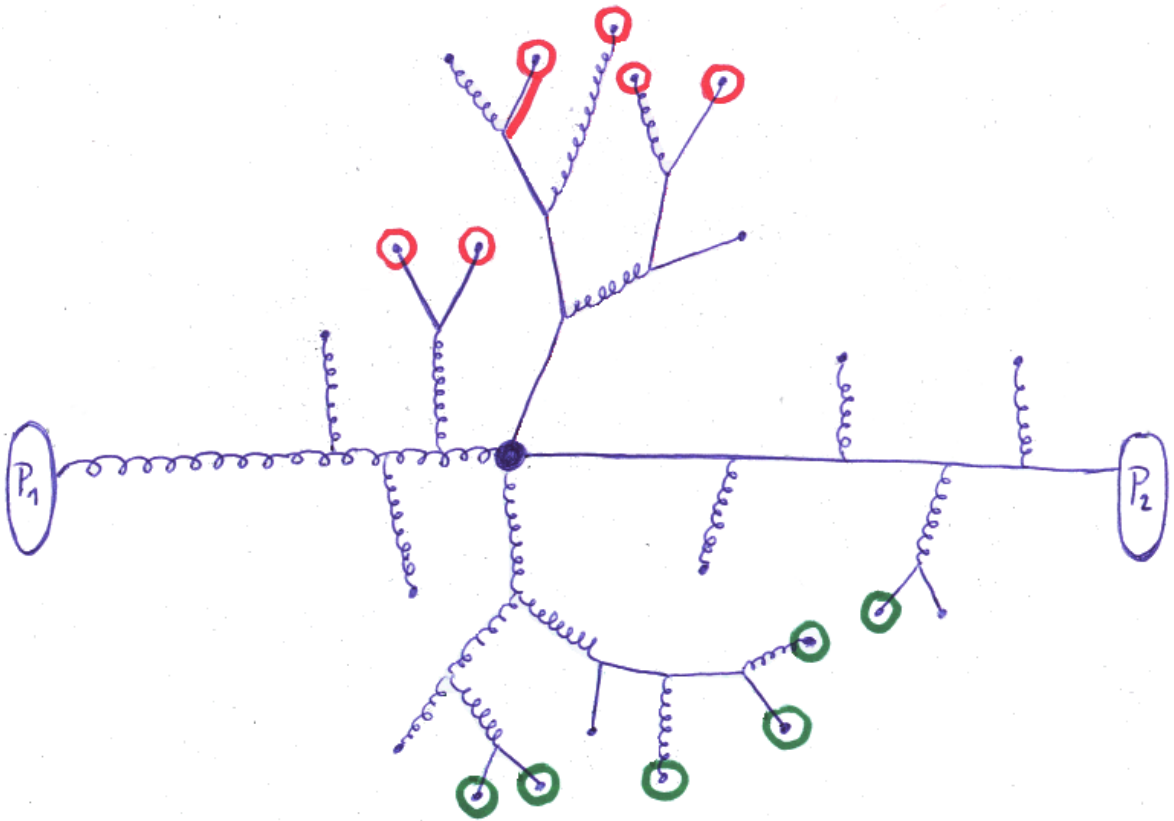
Summary

- We observe asymmetry in in qg jet events topology
- The specific signature is present on all levels of MC simulation (Fixed order, shower, ...)
- Specific kinematic cuts and jet topology can be used for enhancing jet tagging efficiency which has been confirmed by independent methods
- Effect on the observable which probe color coherence is obvious

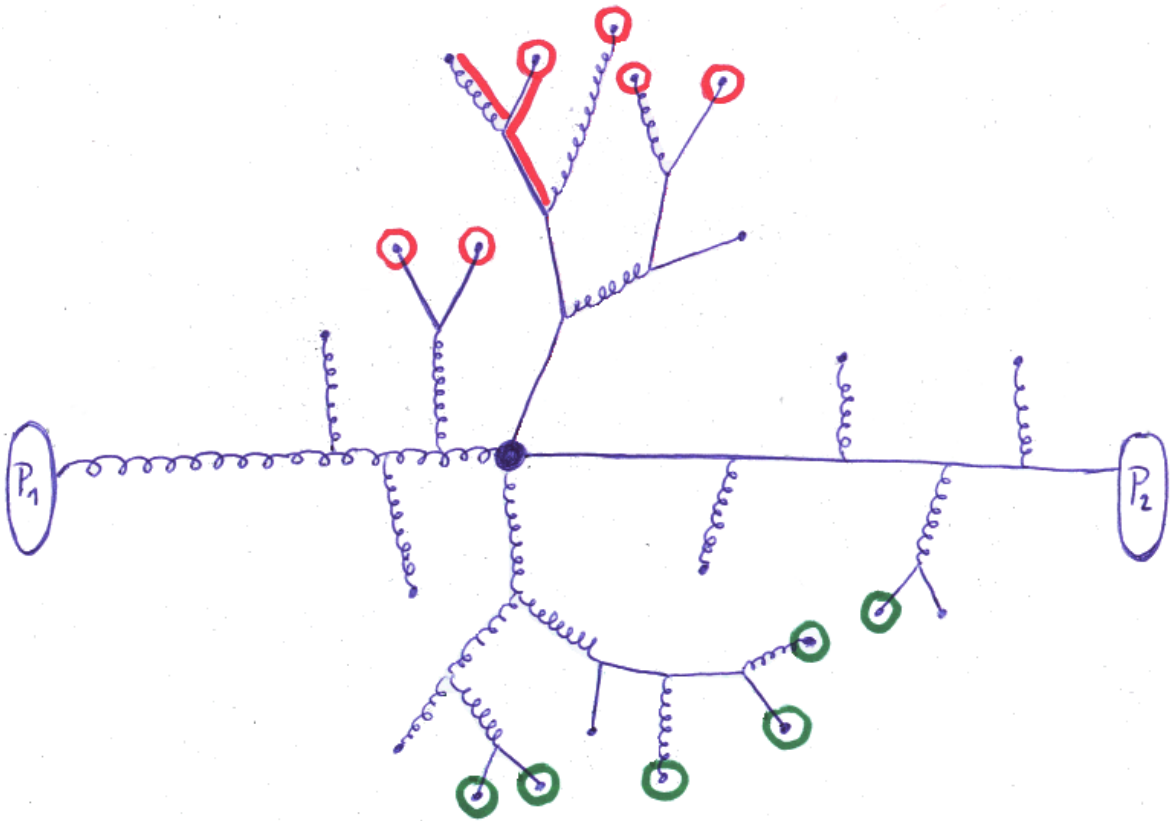
Pseudo-tag candidate



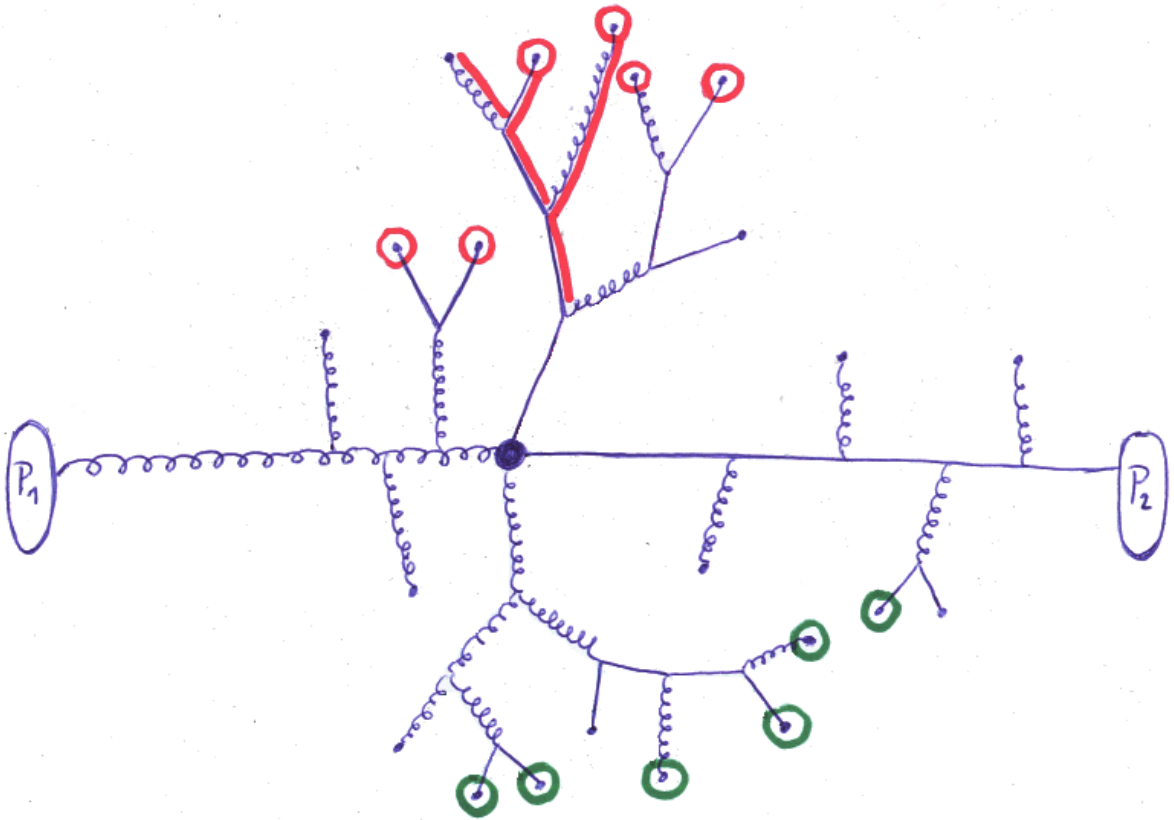
Pseudo-tag candidate



Pseudo-tag candidate



Pseudo-tag candidate



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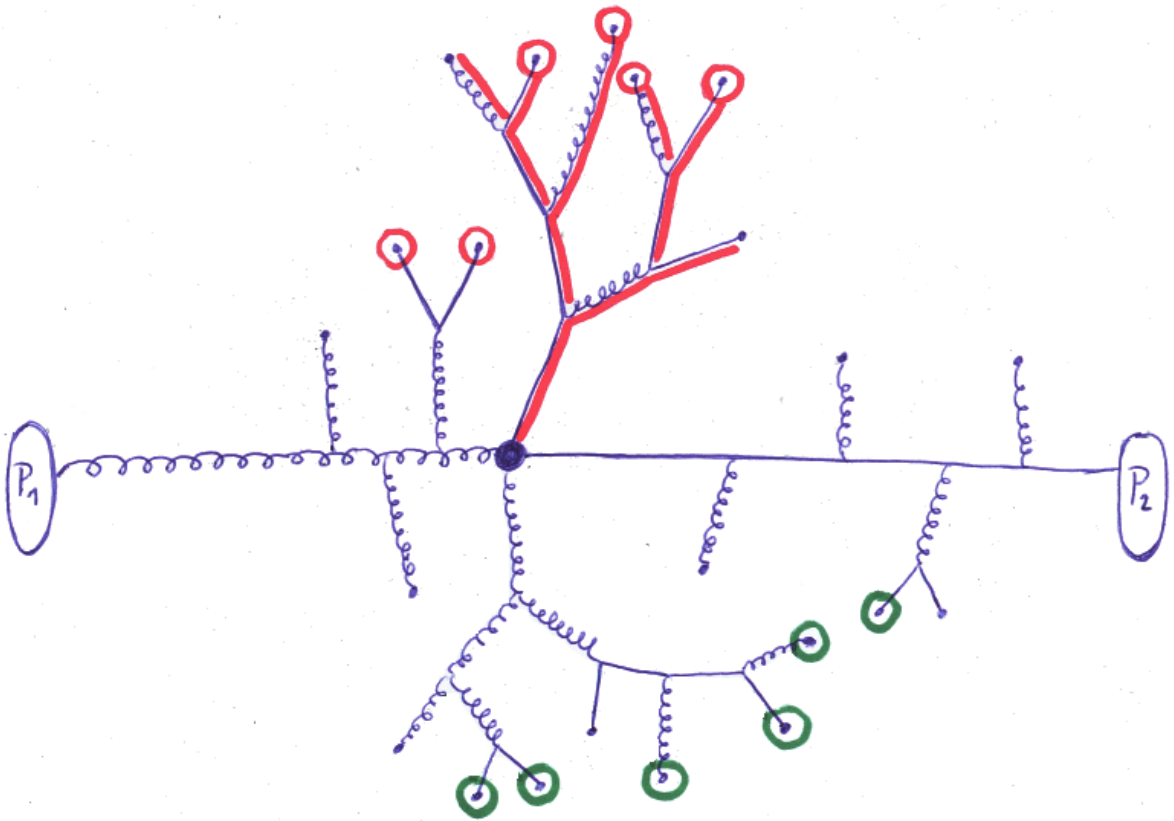

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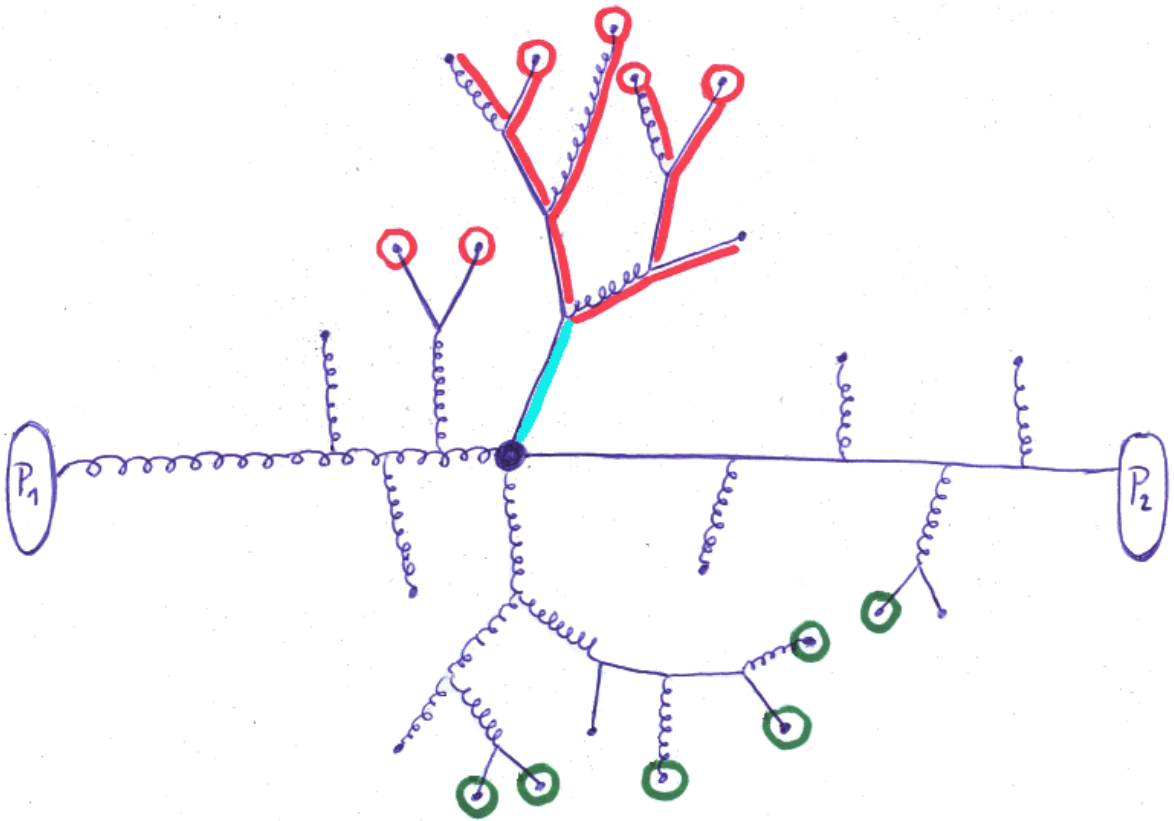

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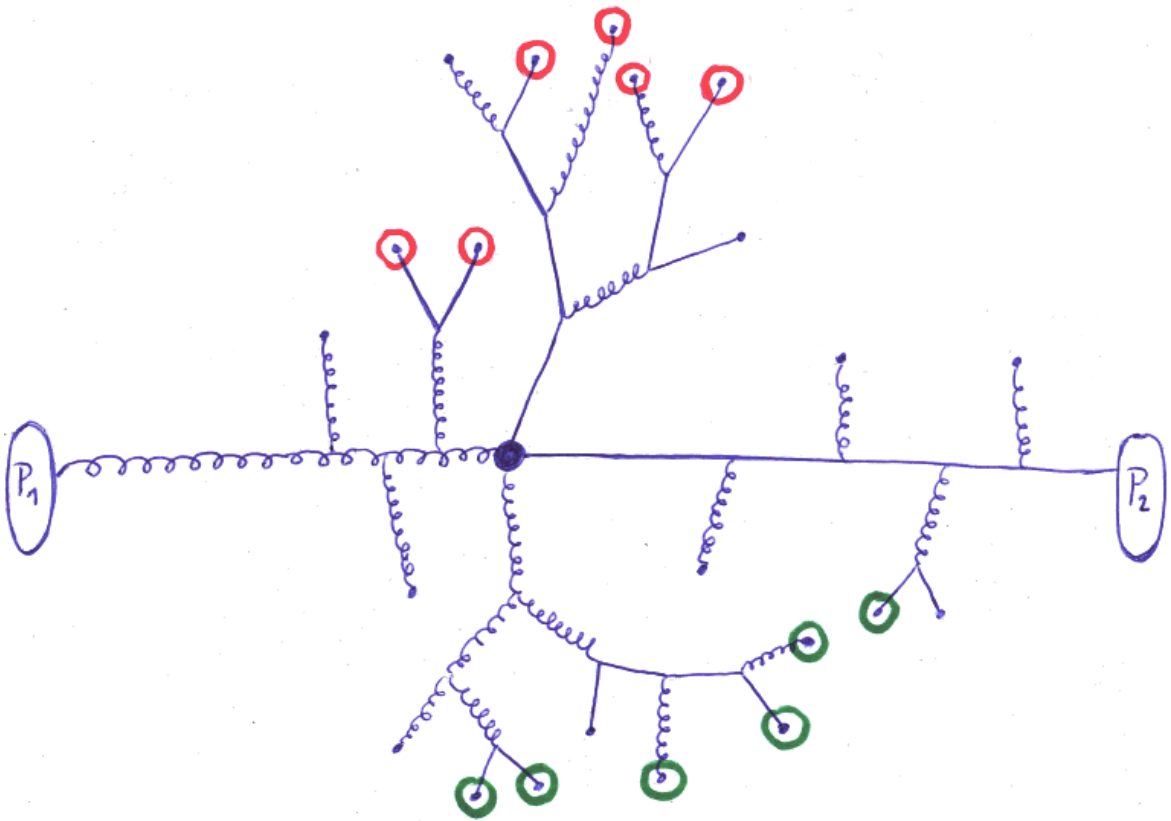

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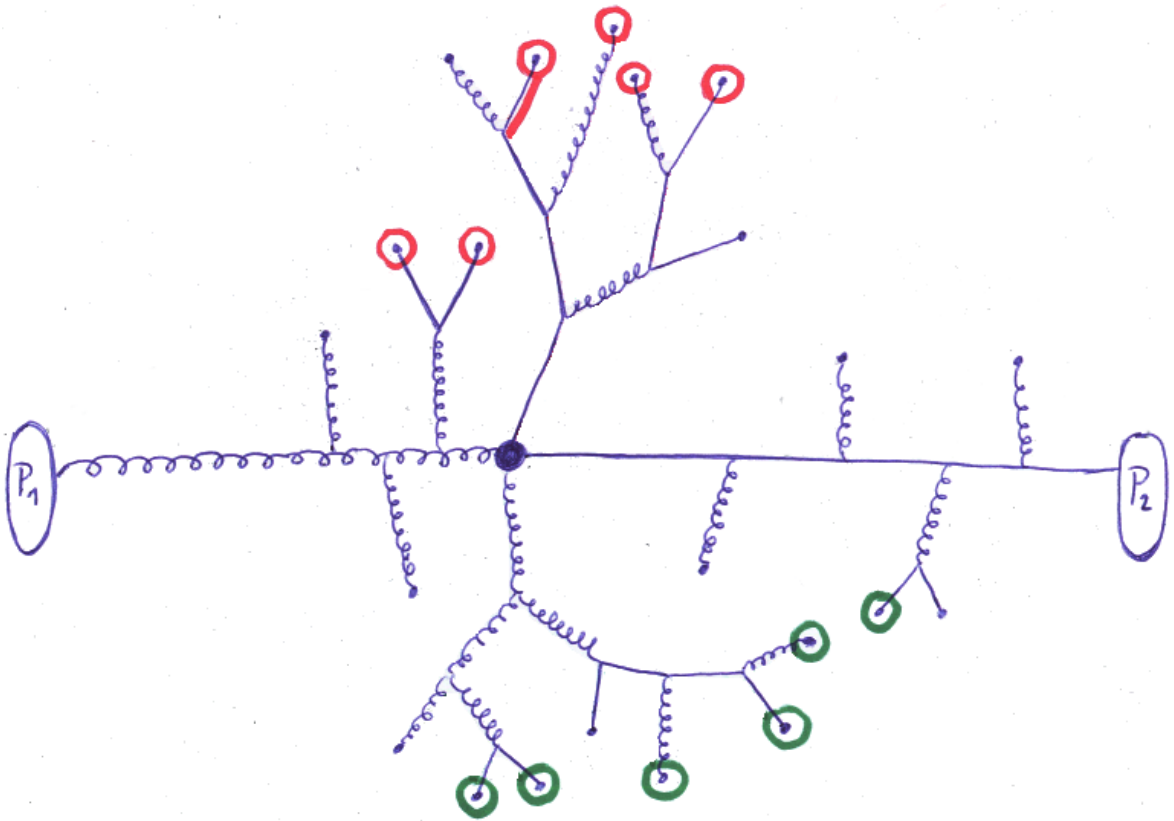

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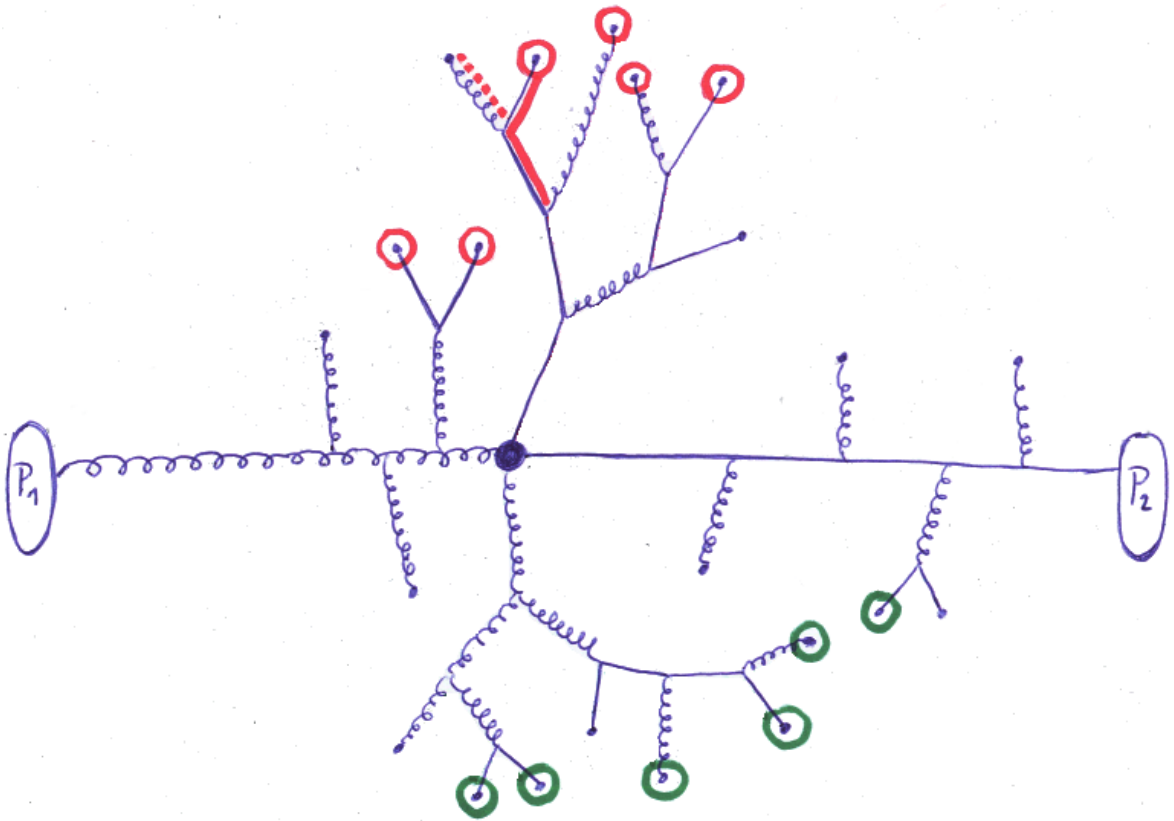

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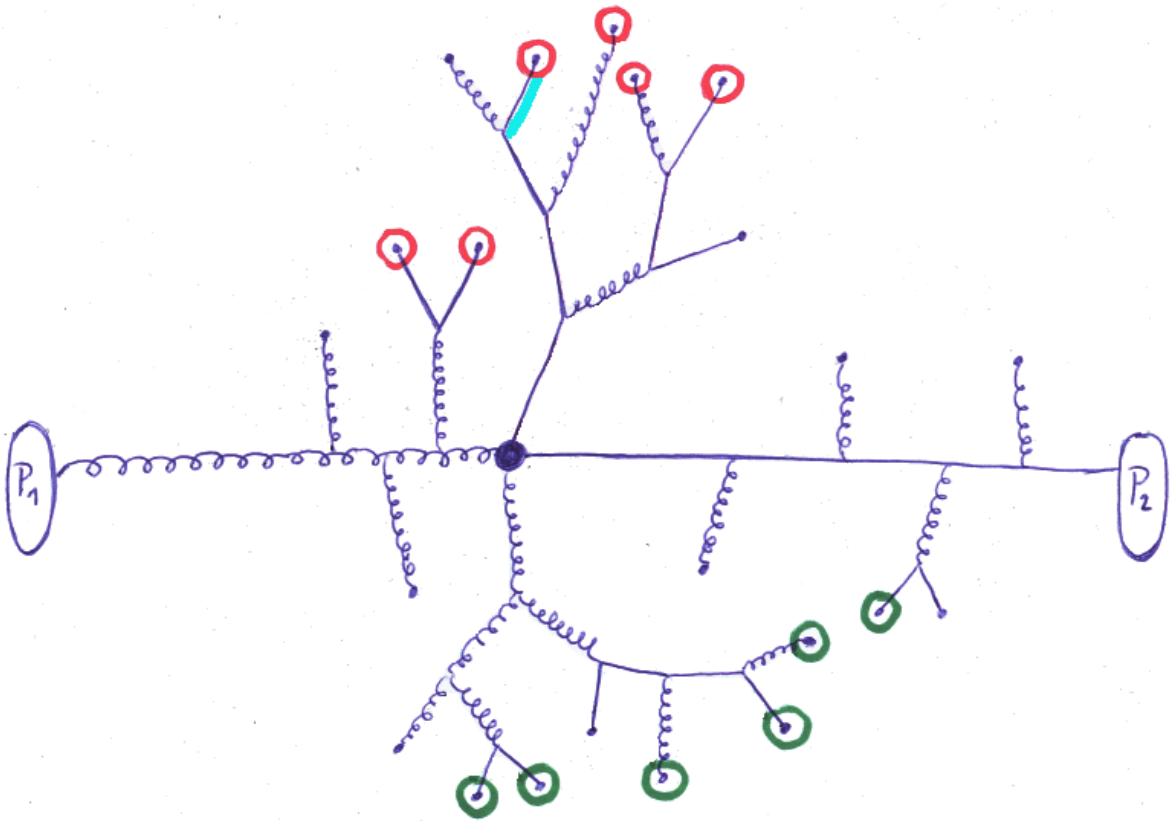

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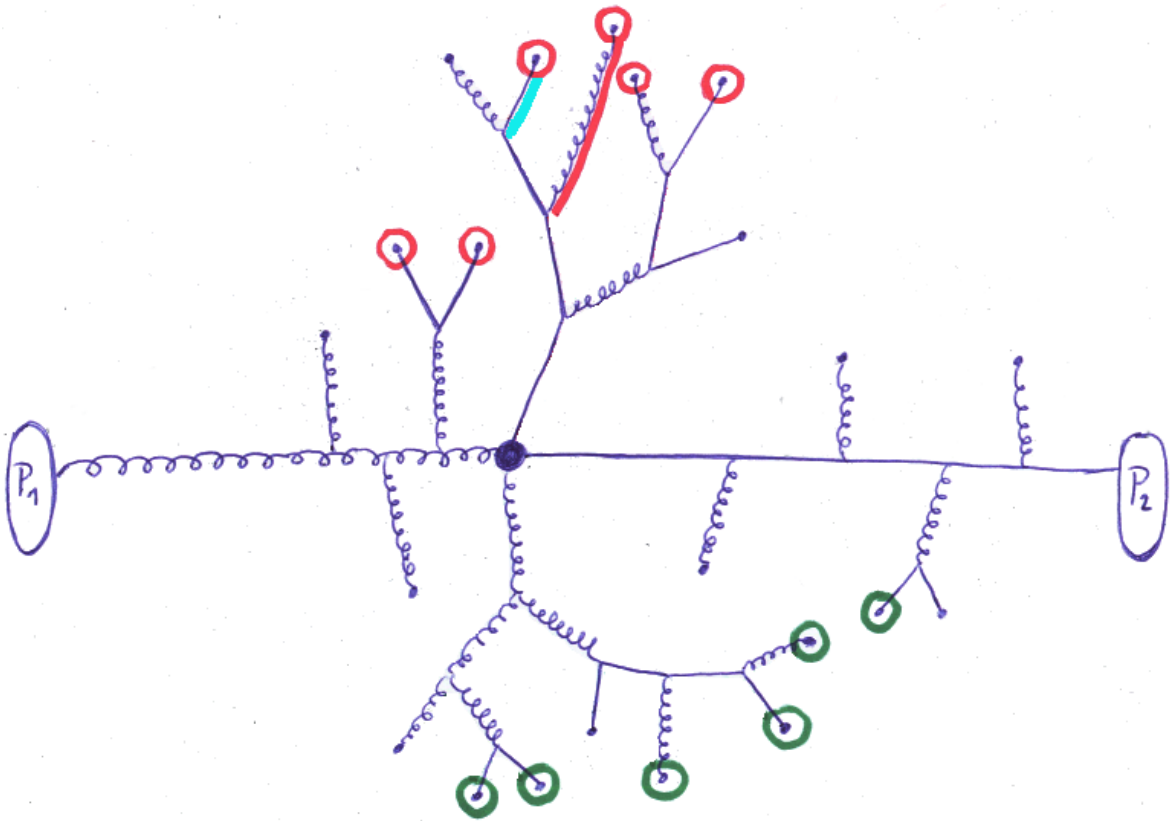

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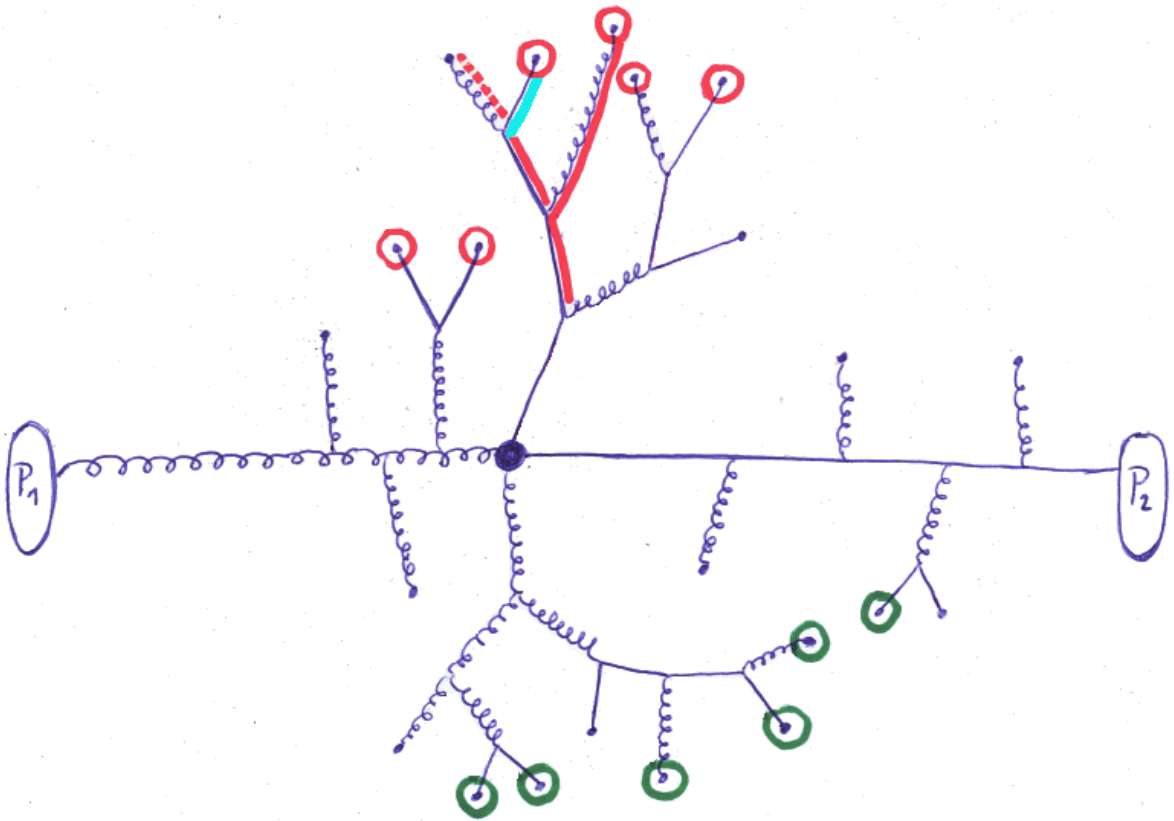

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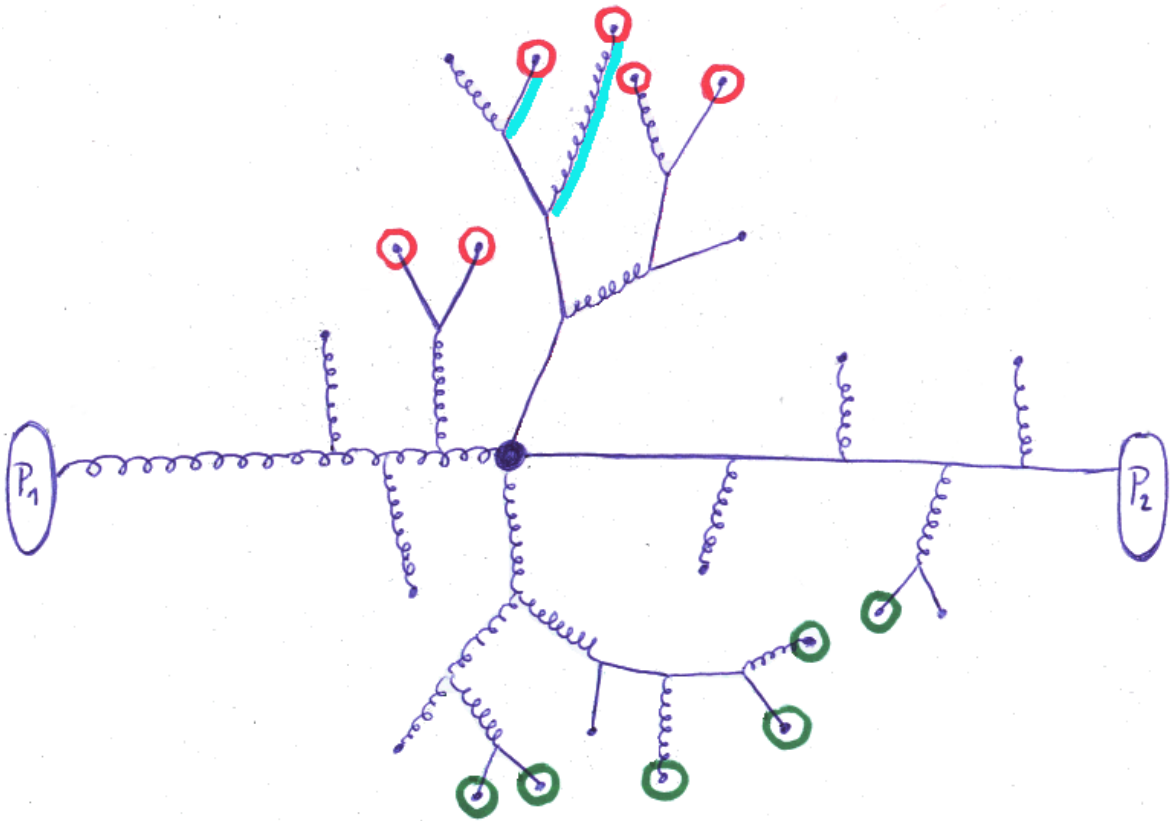
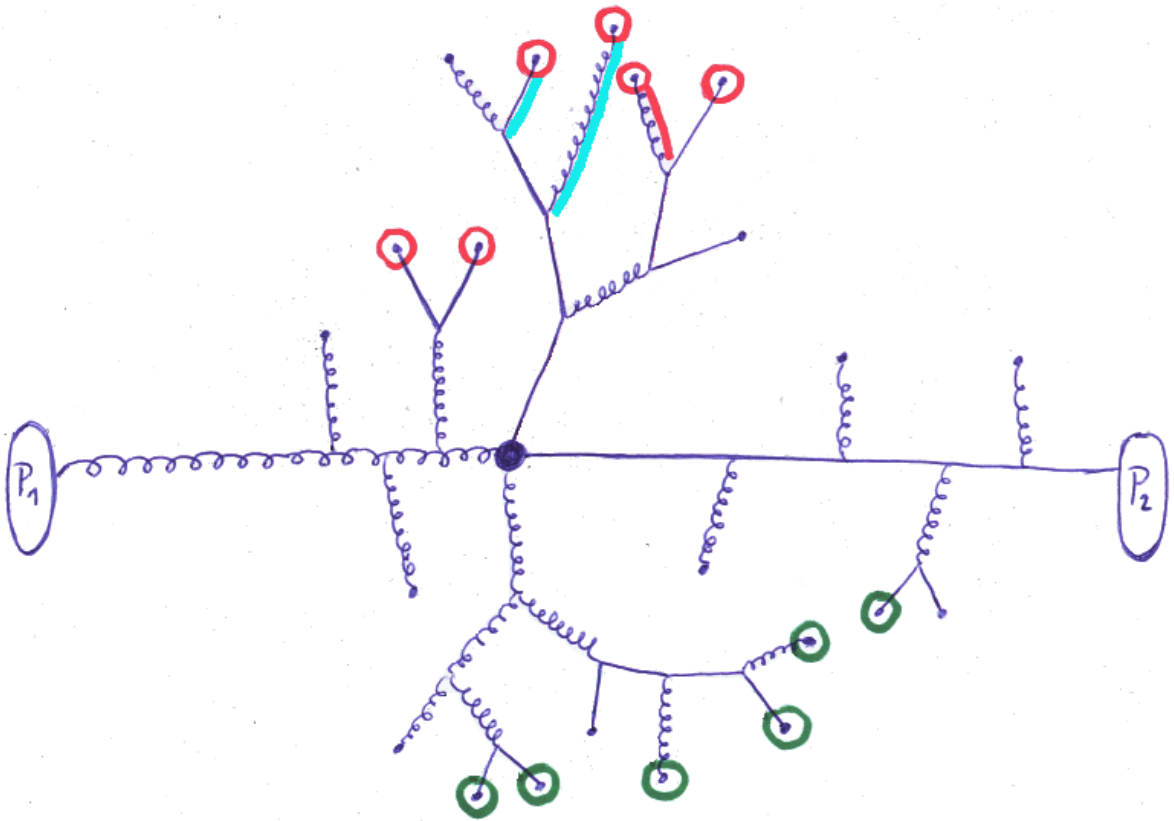


Pseudo-tag candidate



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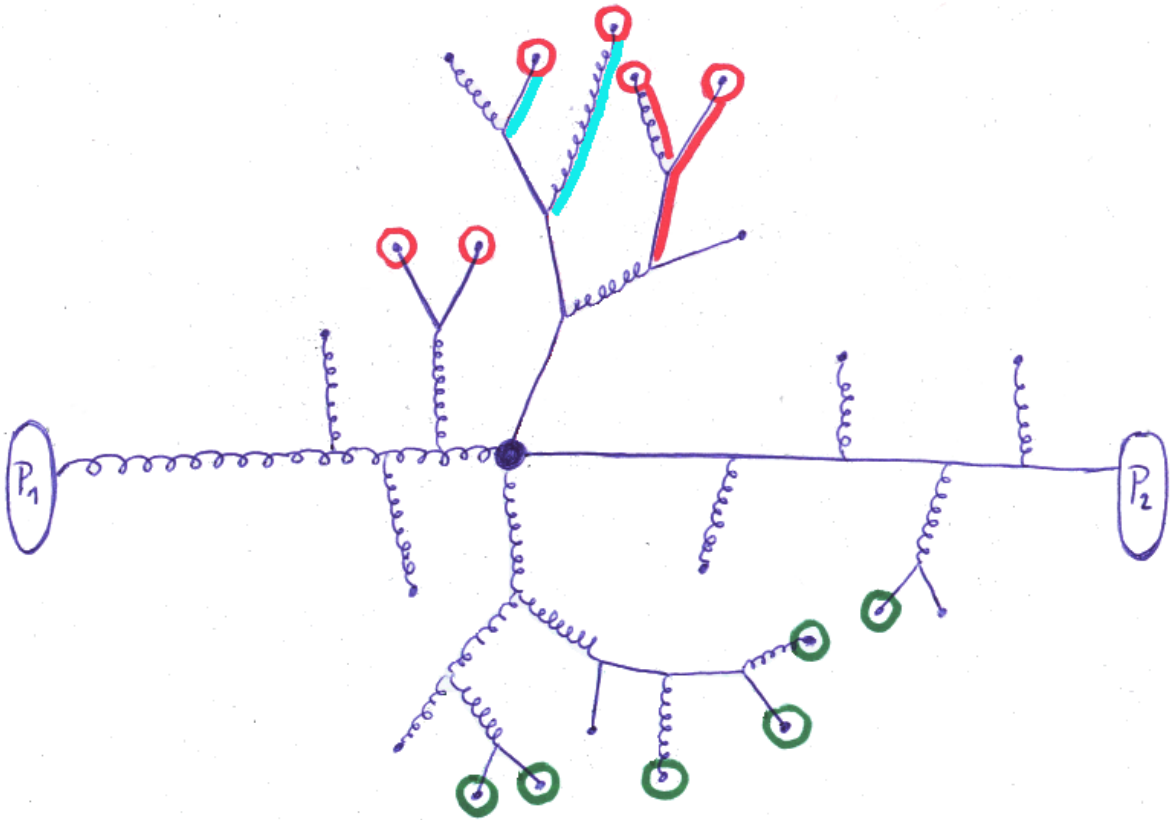

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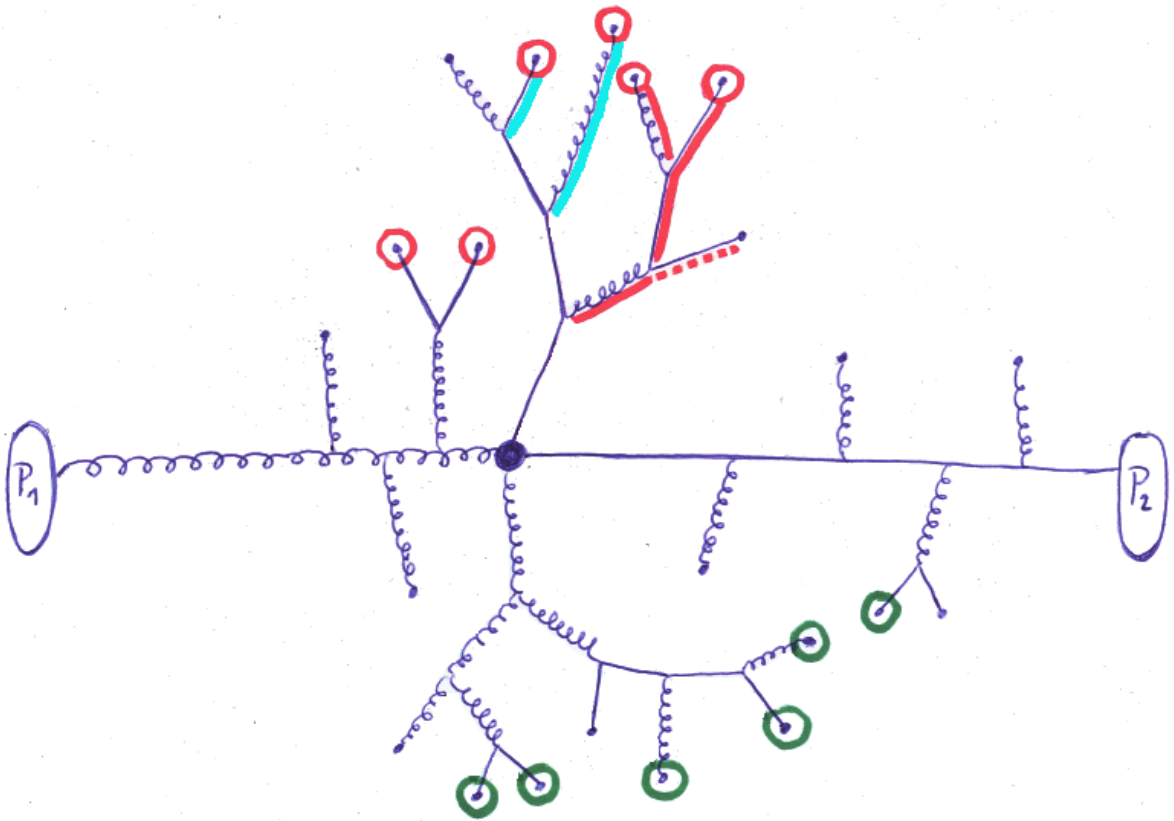

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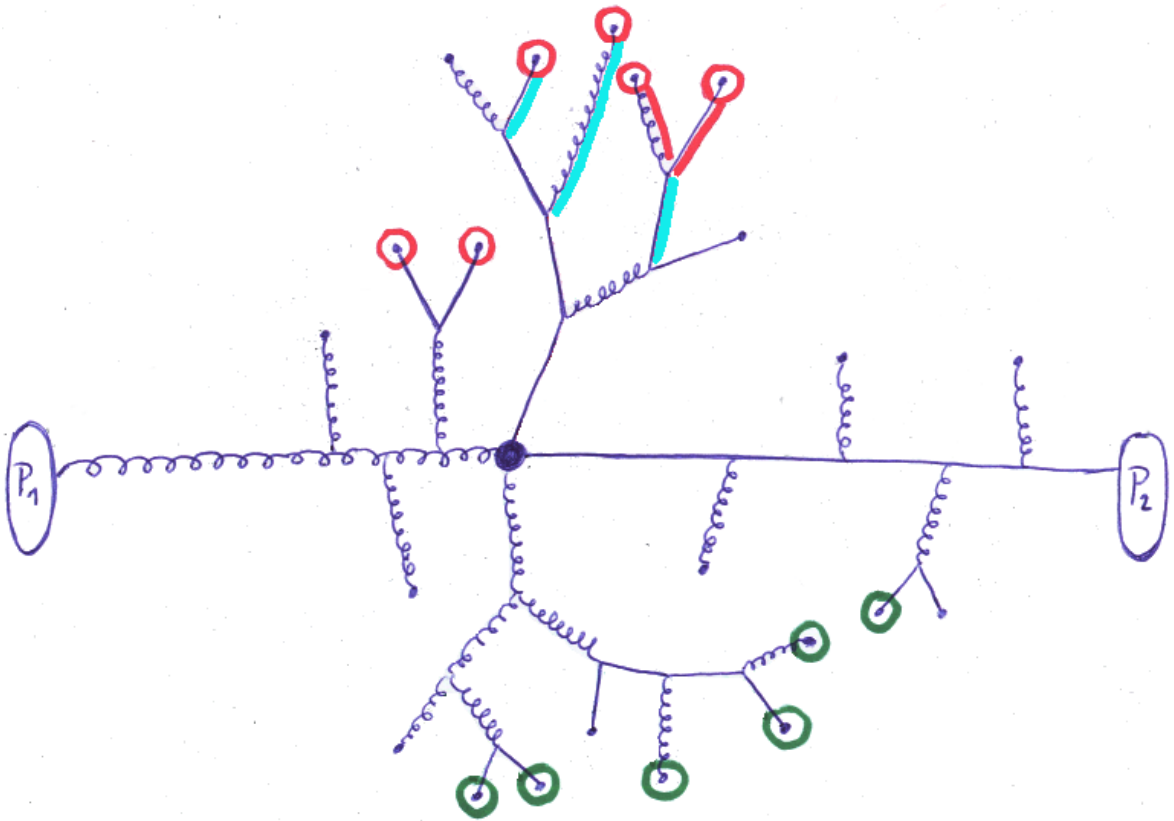
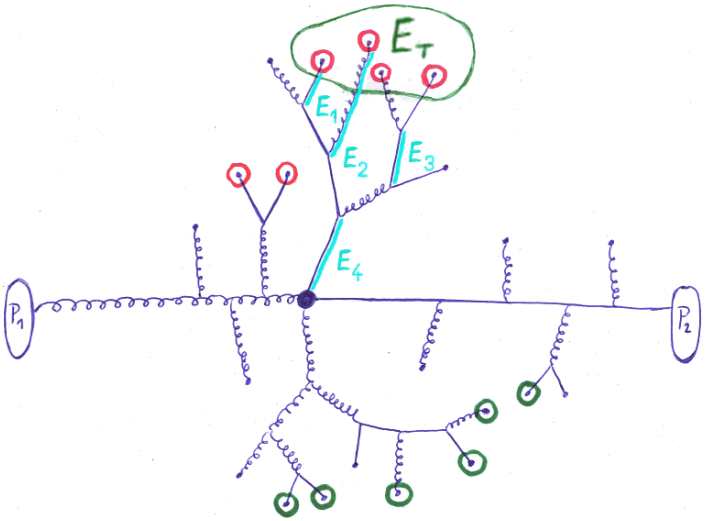


Selection of winning candidate

- To select the winning candidate we have to define few variables
- Sum of the energy of the jet constituents inside the tree E_T
- Set of initiating candidates S with energies E_1, E_2, E_3 and E_4
- We define energy excess fraction

$$f = \min_{x \in S} \left| \frac{E_T - E_x}{E_T} \right| \qquad (4)$$



Only gluon jets