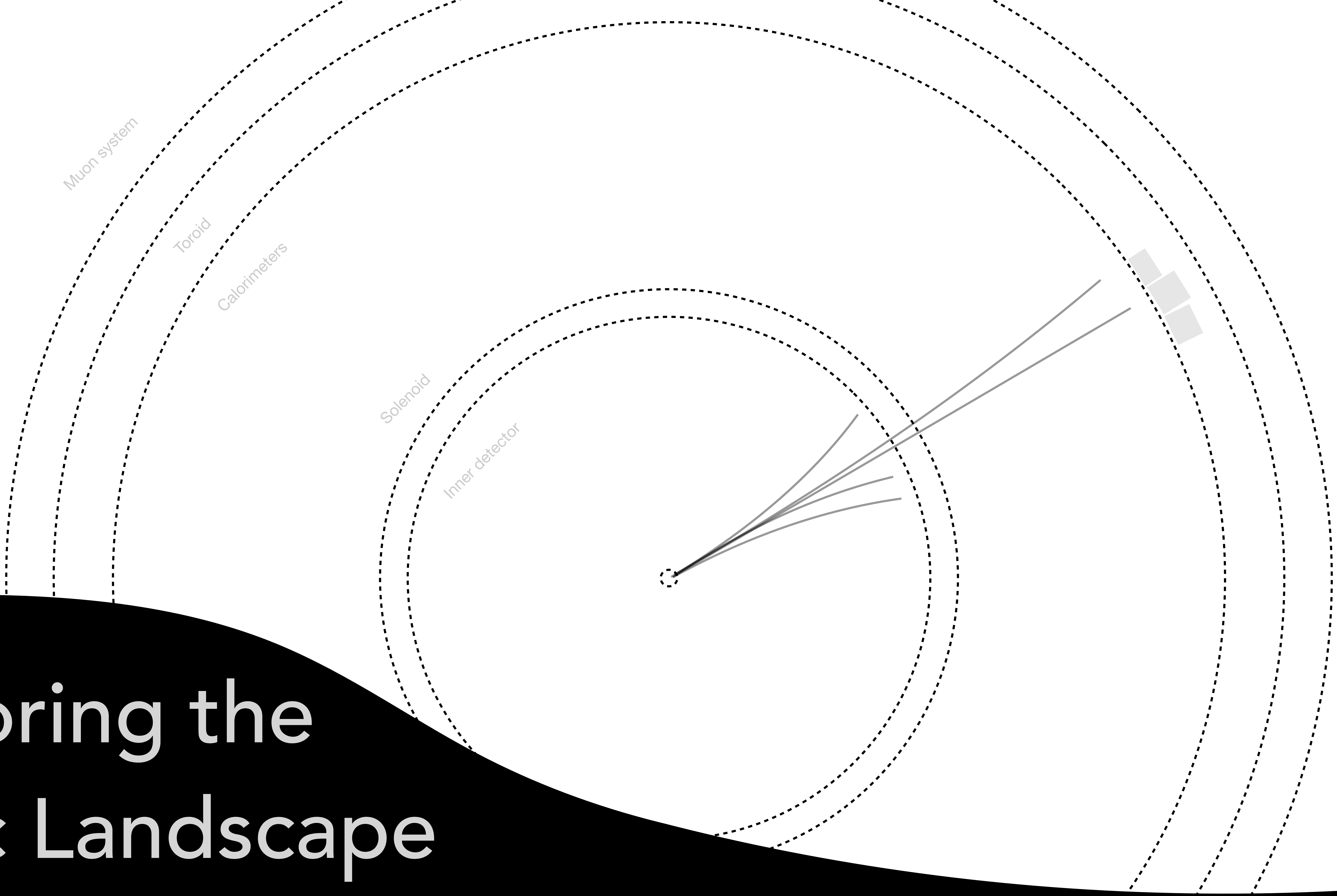

Exploring the hadronic Landscape

a novel search in multijet events at the ATLAS experiment

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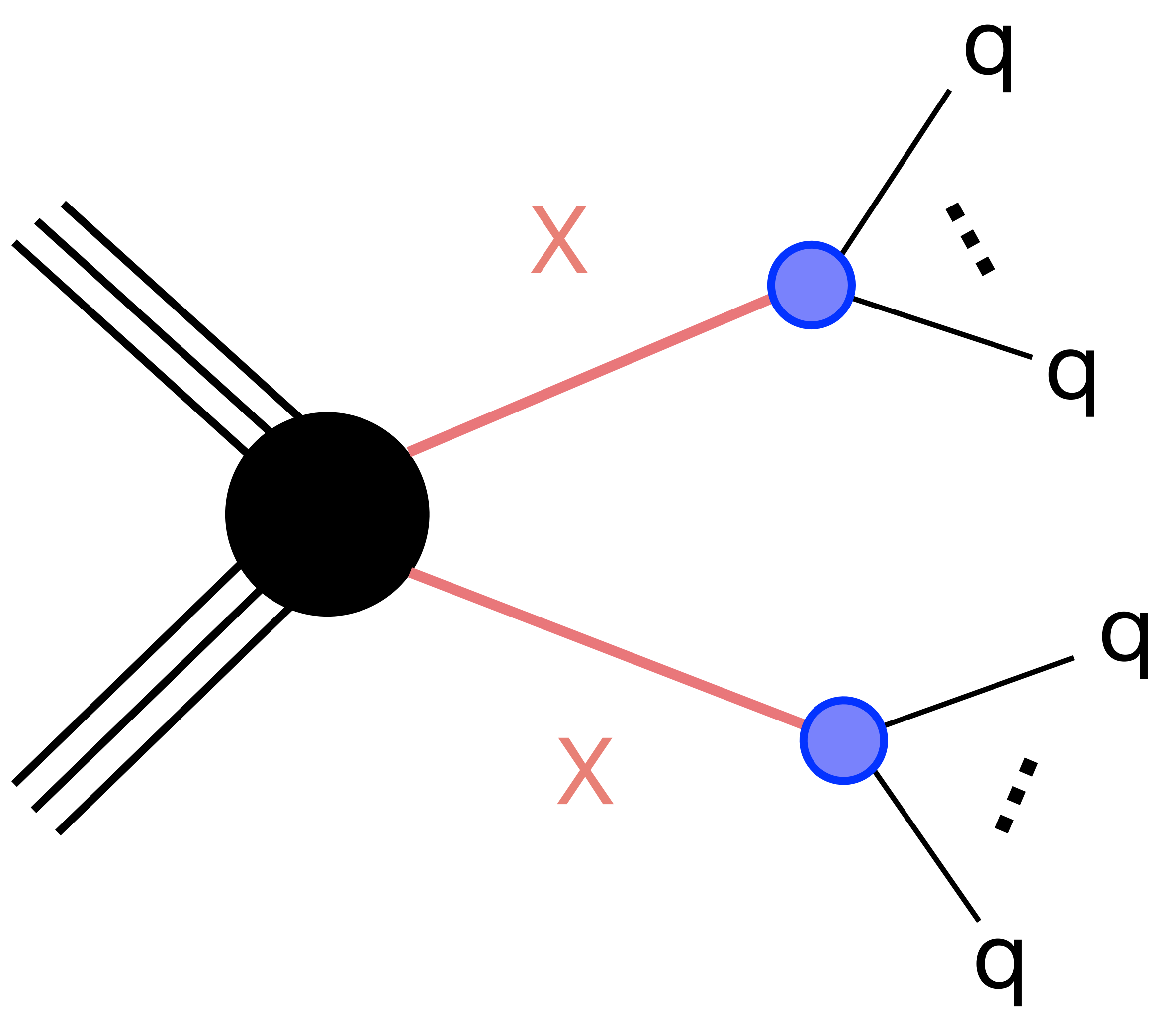
University of Chicago

MoriondEW
26 March 2024
2401.16333

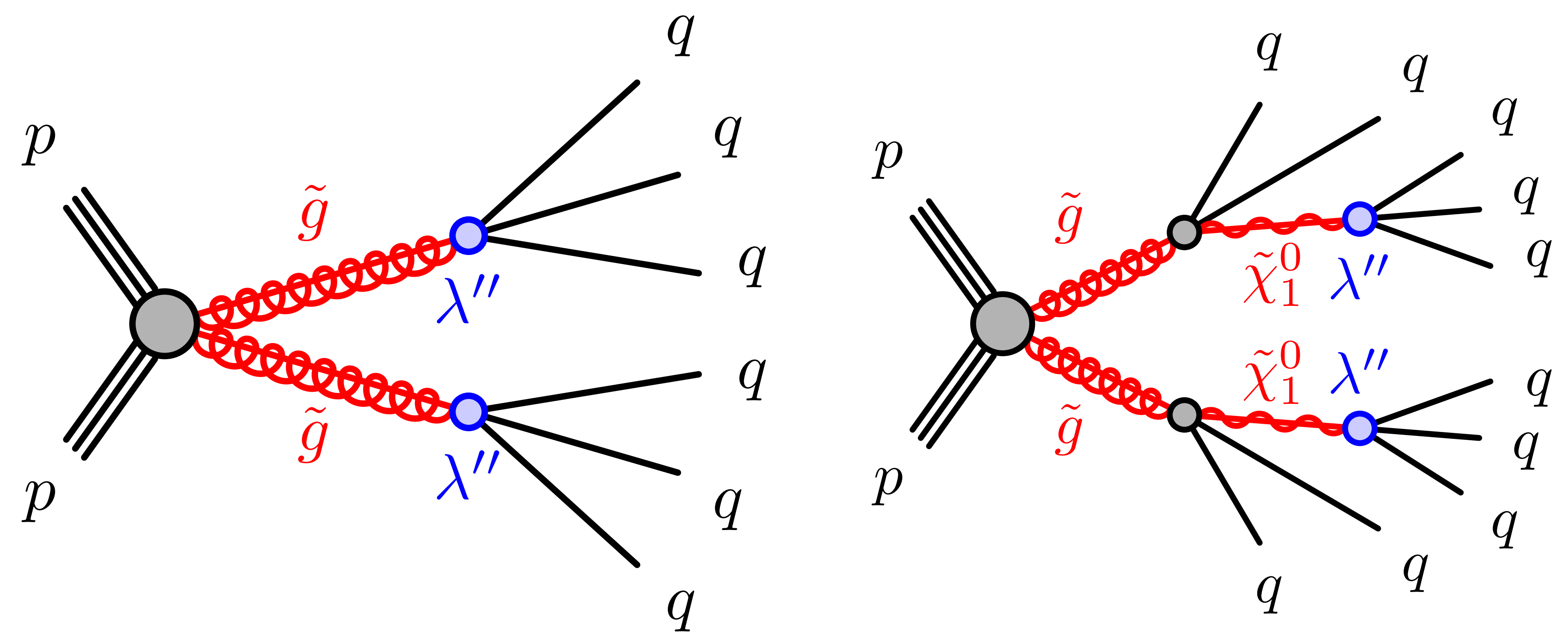
Signature

Many BSM models give rise to multijet signatures

Challenging because of the QCD bkg and high jet multiplicity



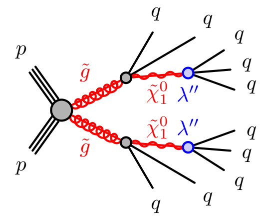
Ex. R-parity-violating SUSY



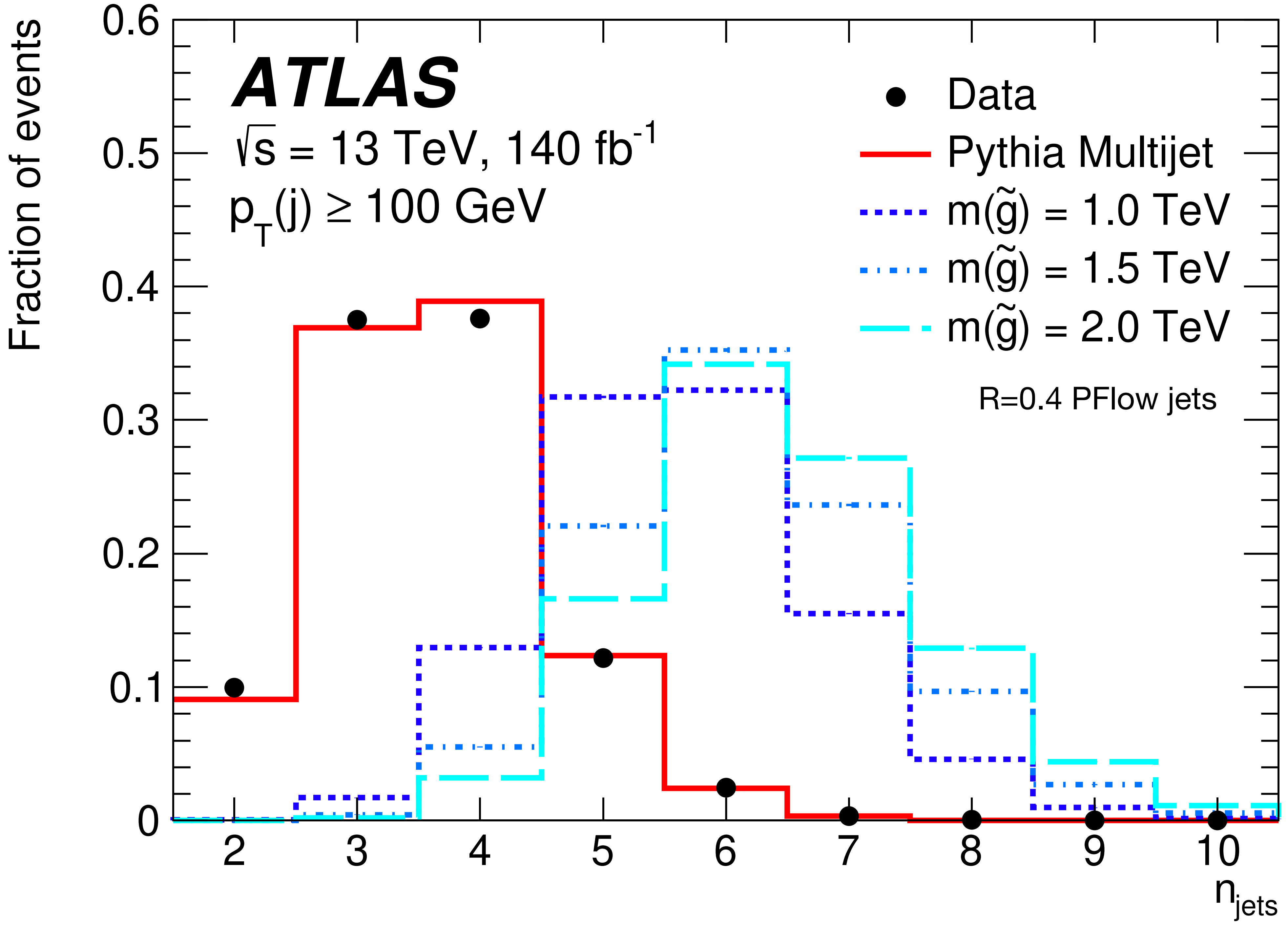
Suppressing QCD

Select isotropic events with large numbers of high p_T jets

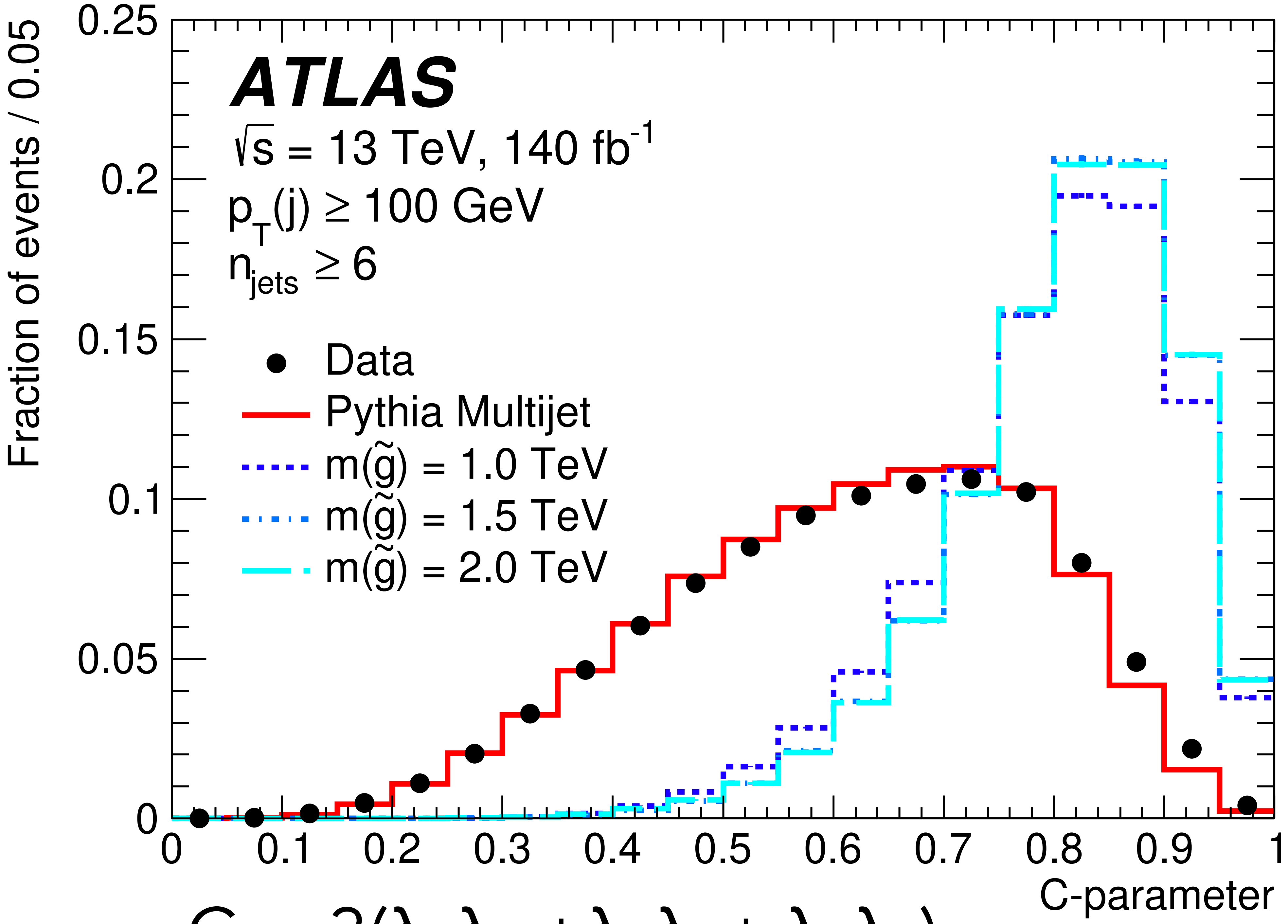
basis for jet counting method which is great for the 2x5 model



Large numbers of high pT jets

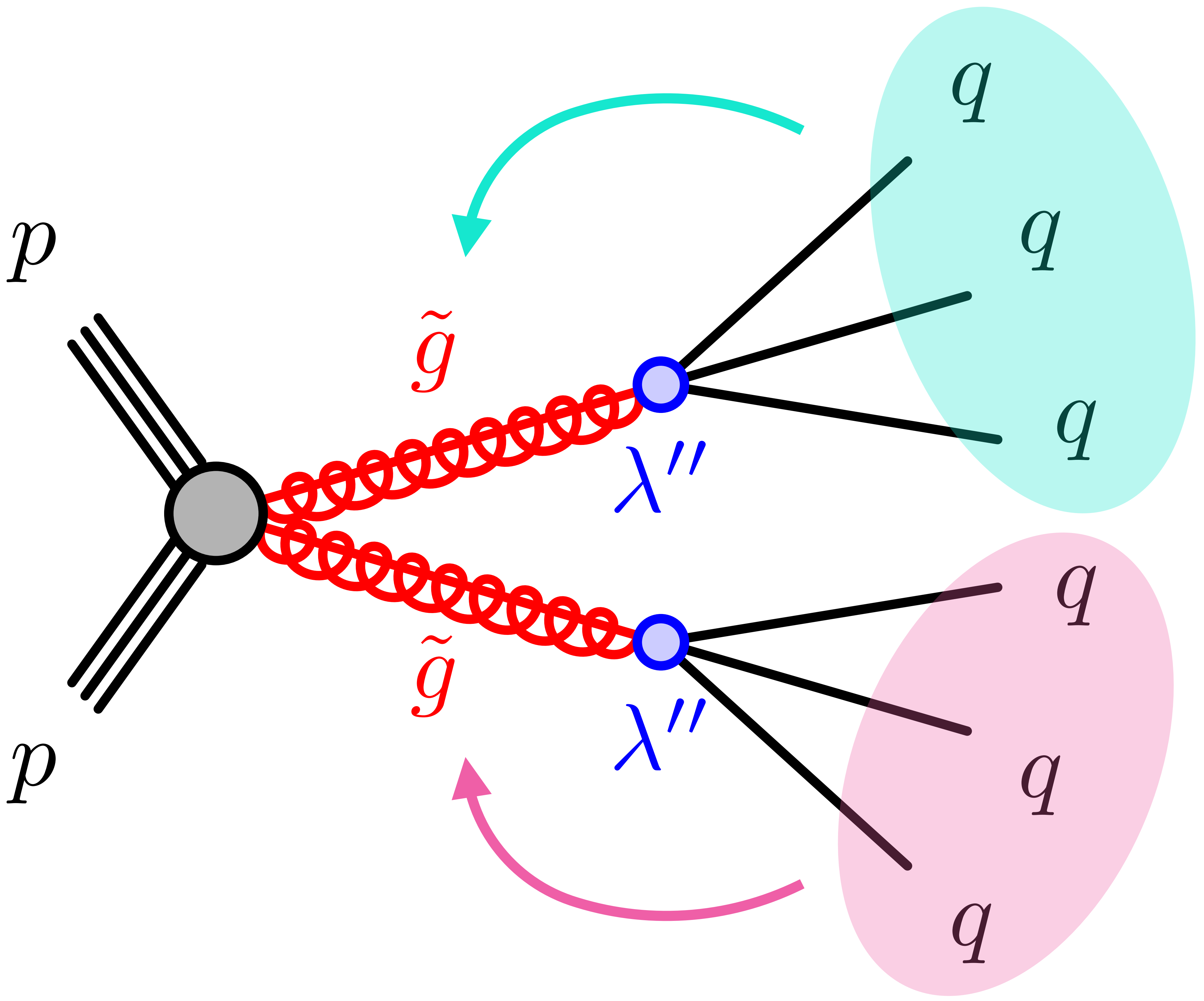


Isotropic energy spread



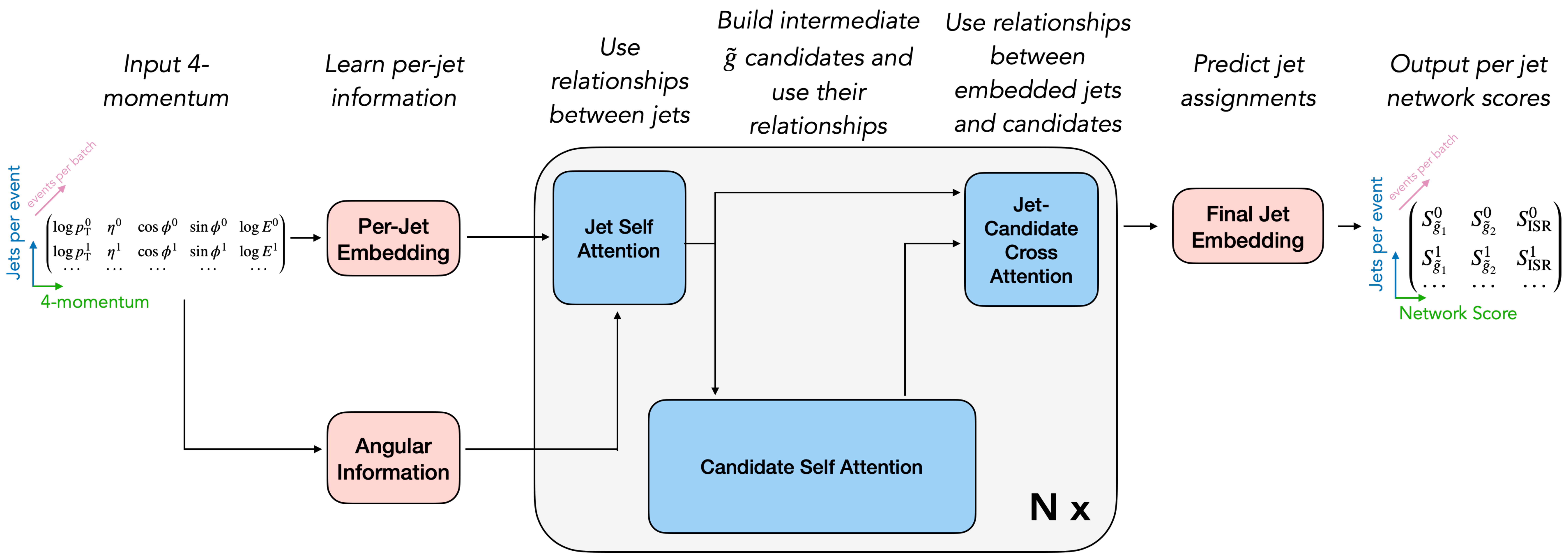
$$C = 3(\lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3)$$

We'd like to predict jet groupings!



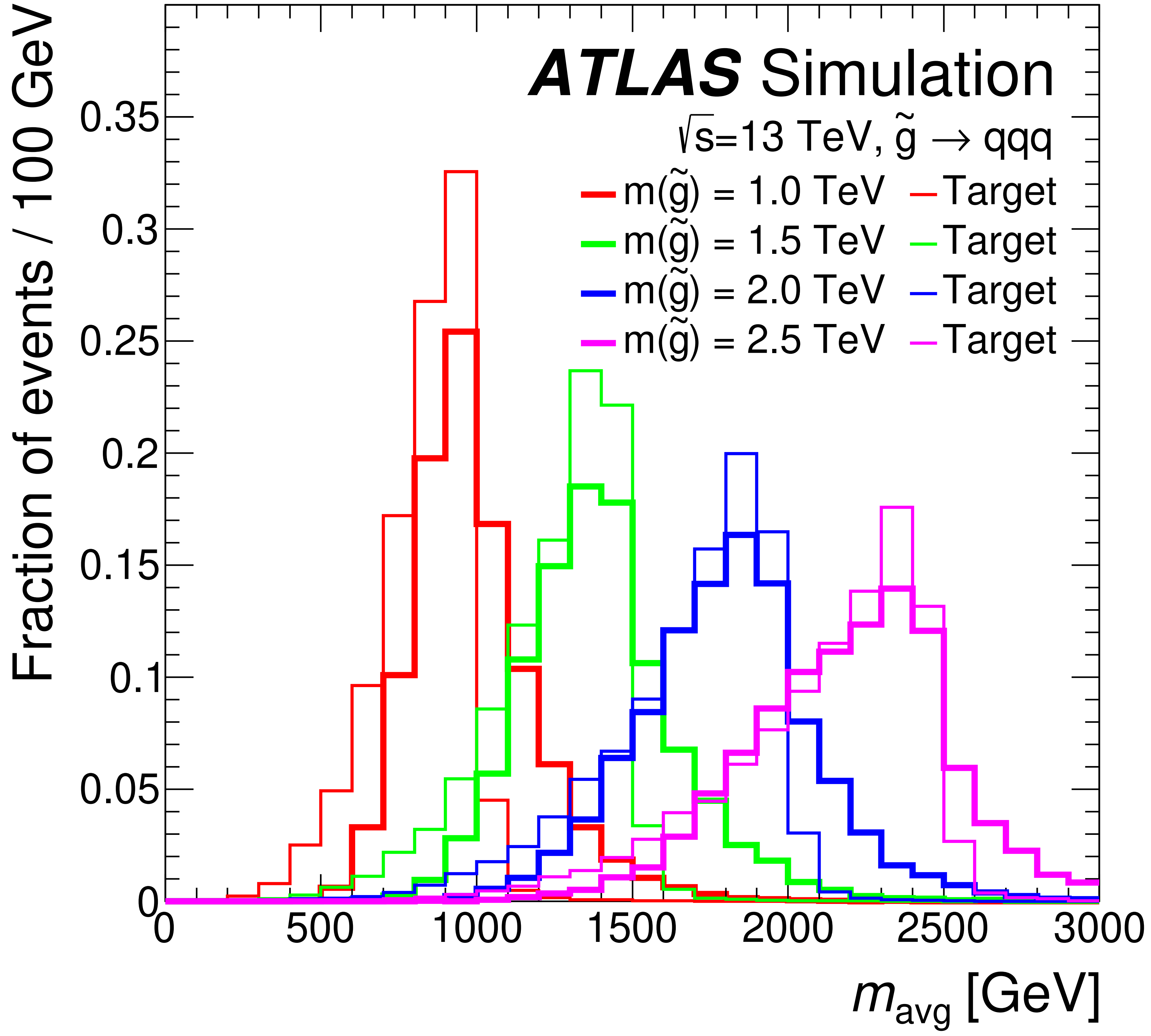
Predicting jet groupings

Attention based architecture designed to predict jet pairings by creating intermediate candidates

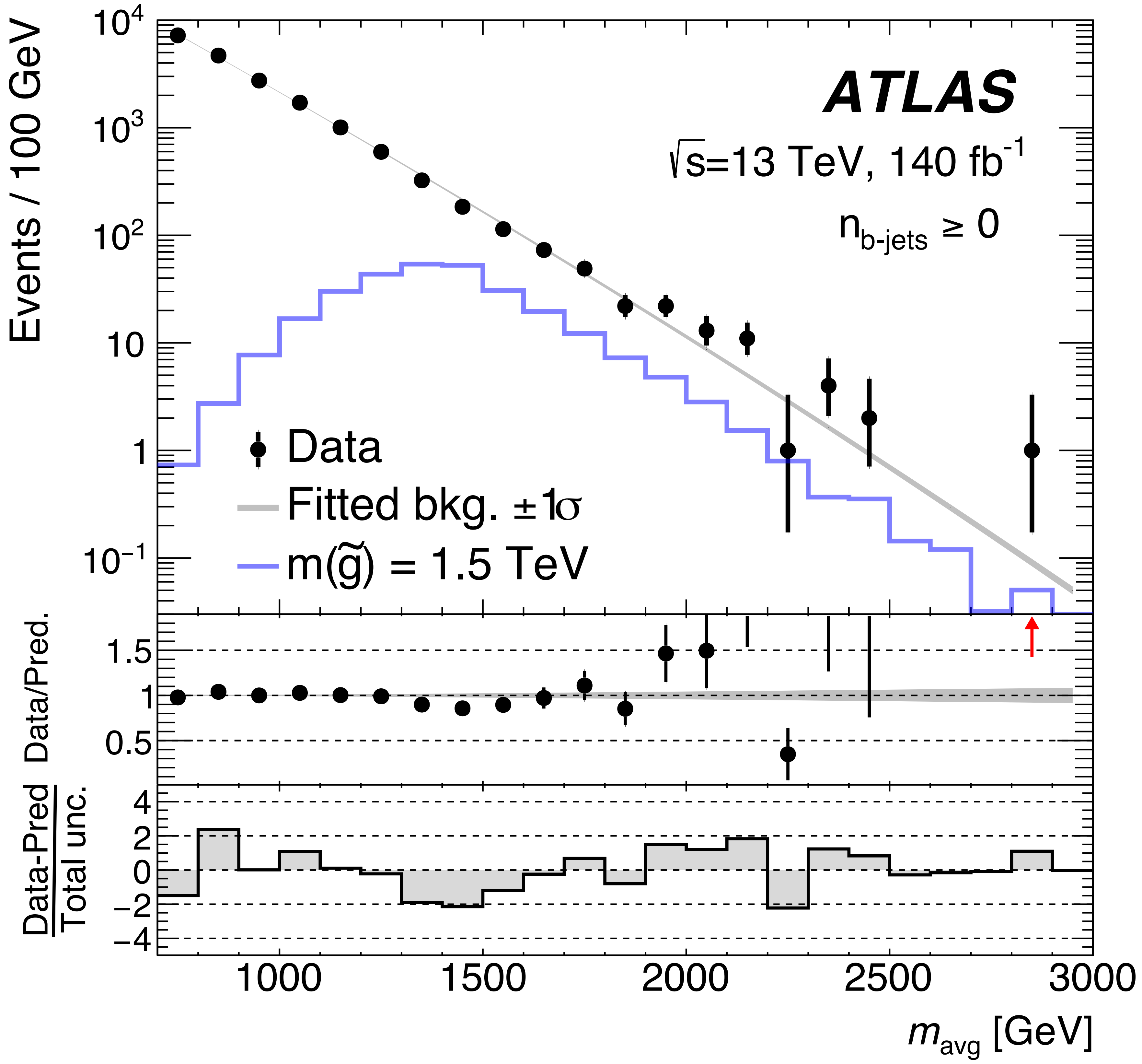


Mass resonance and fitting

Predicted average mass distributions of parent gluinos



Data-driven background estimate via fitting empirical function



Results

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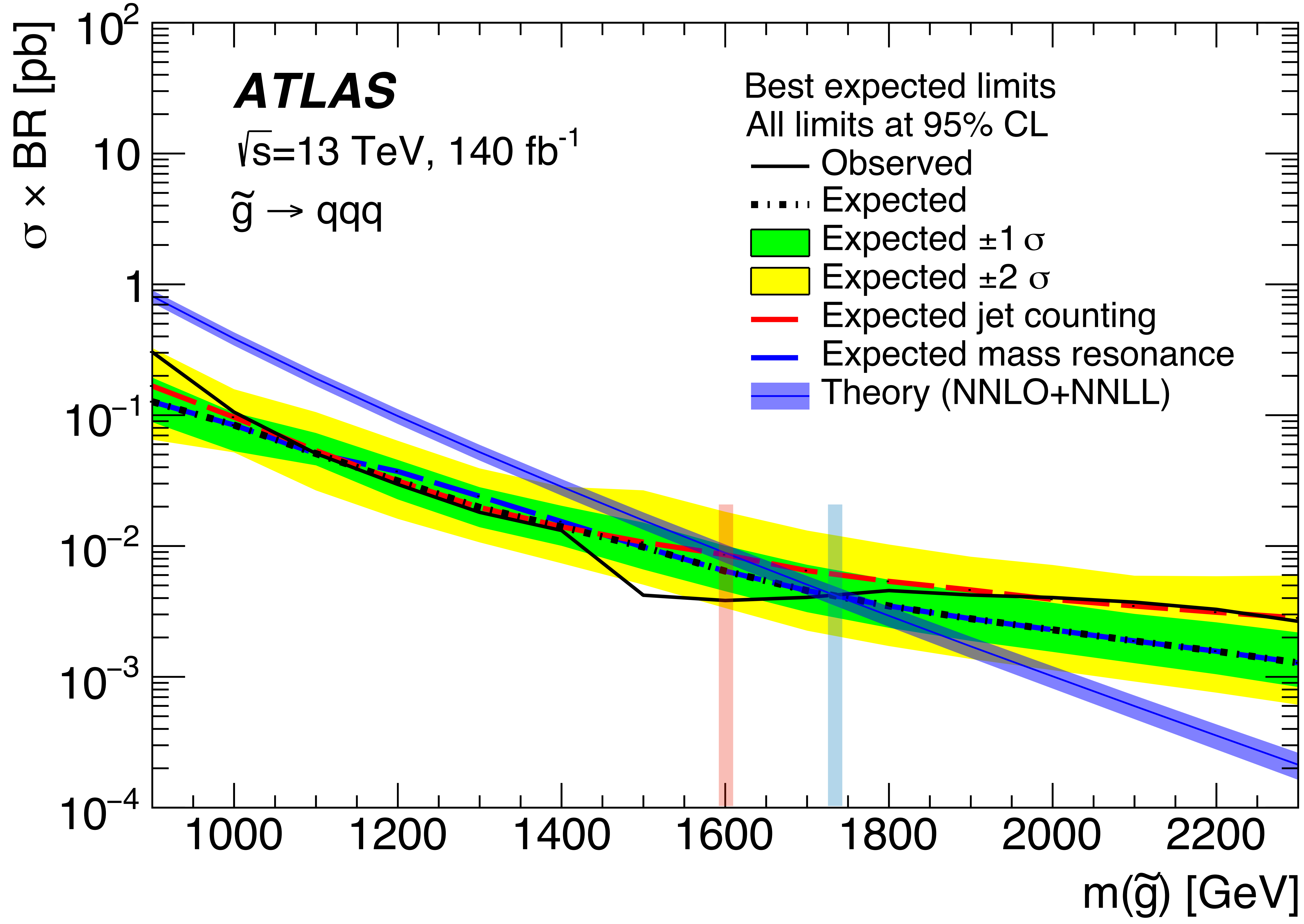


Expected sensitivity gain of ~150 GeV or ~3 times lower σ using mass resonance method, scaling S/√B would require ~9x more data

I'm sad didn't find BSM but happy with new technique

Theory xsec notes: squarks decoupled for $qq \to \tilde{g}\tilde{g}$ via t-channel $\tilde{q}$, RPV large enough to have prompt decays, goes with α_S and gluino mass $m(\tilde{g})$

Why I find this exciting

2205.07715
2309.05728

Leading constraints on R-parity-violating multijet scenario

First experimental demonstration using ML to handle event reconstruction combinatorics

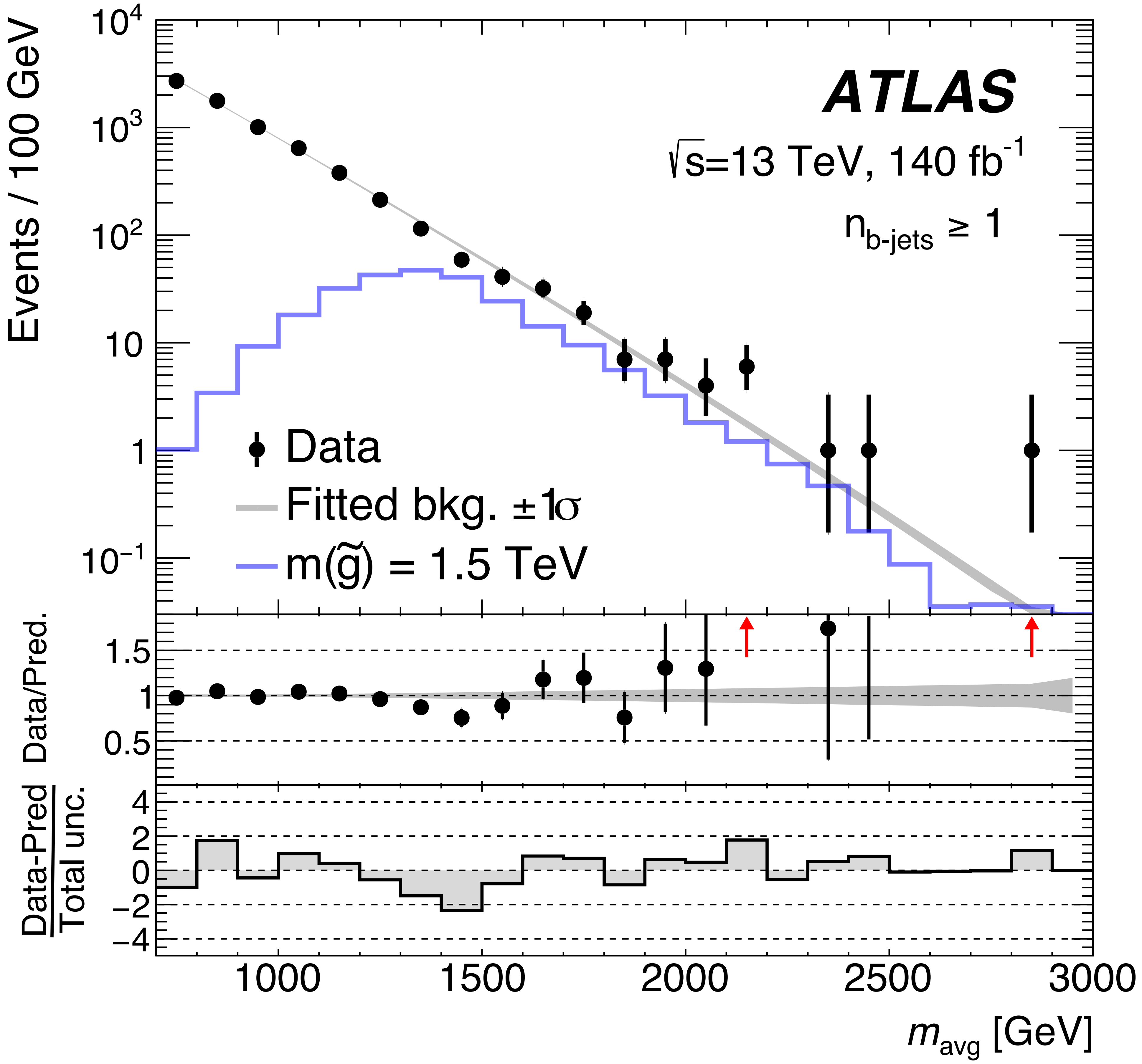
Plenty of compelling future routes

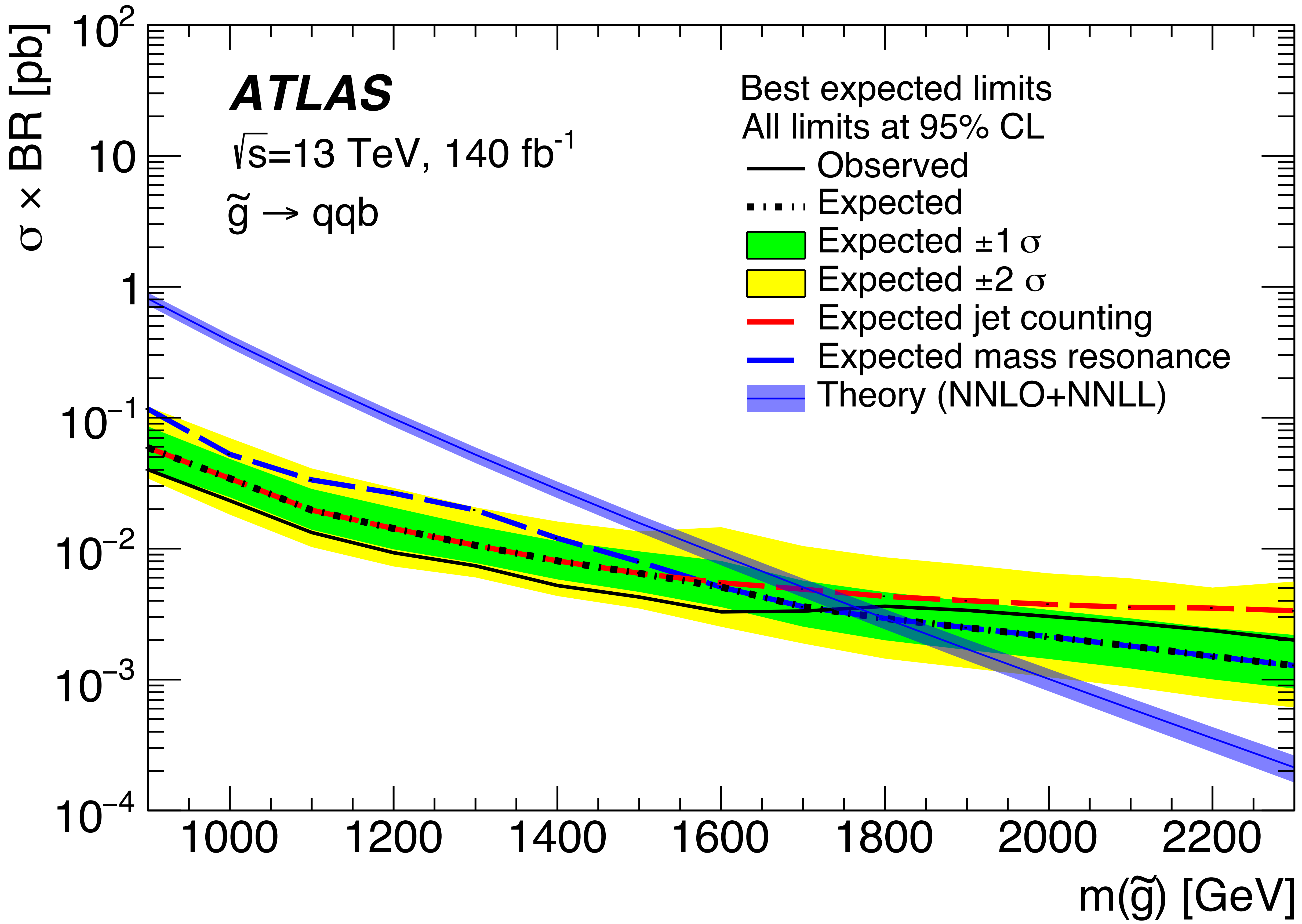
- model agnostic multijet searches using unsupervised learning
- apply method in other systems (ex. ttH CP)
- …

BACKUP

Result, 2x3, with b-tagging

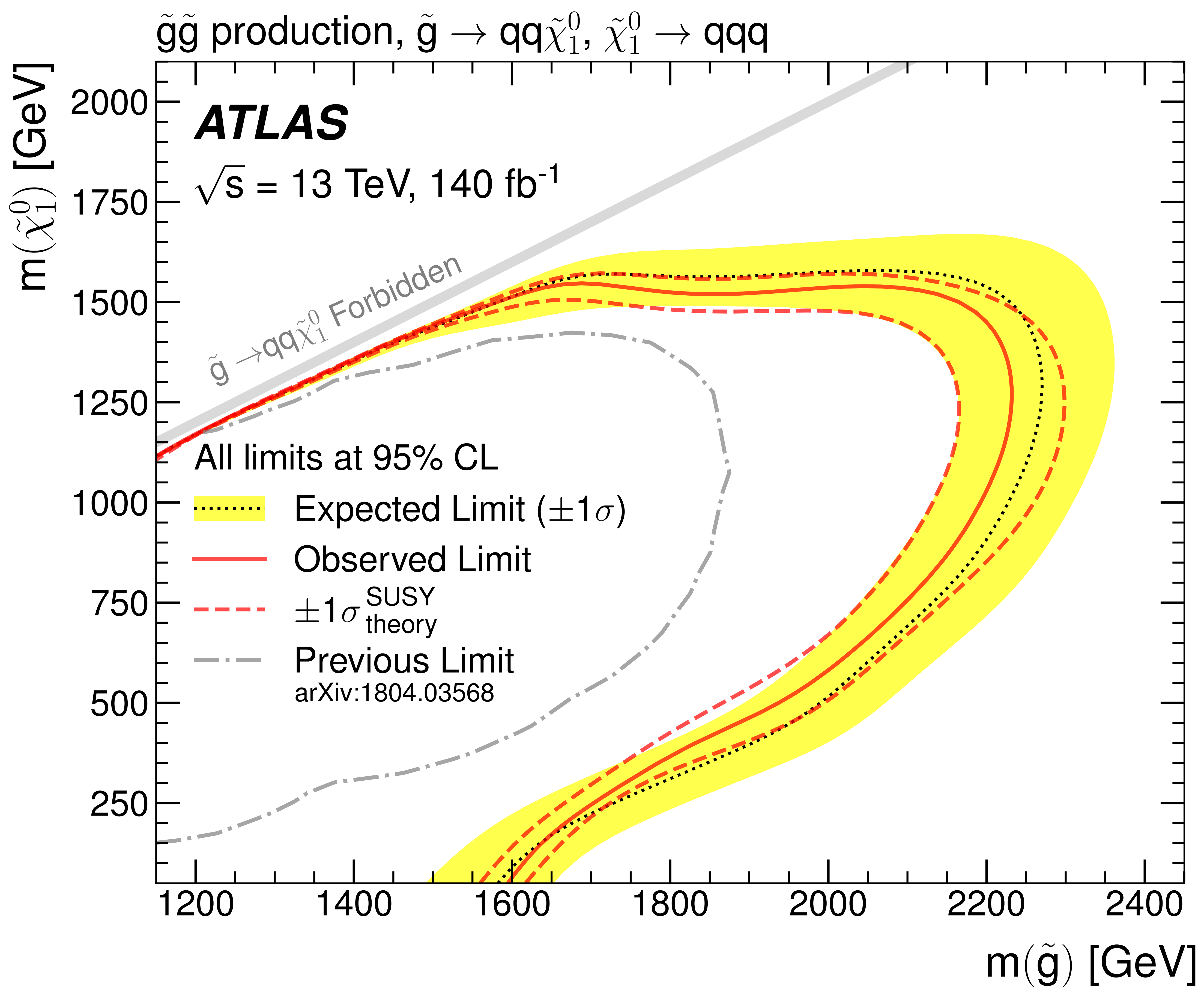
2401.16333

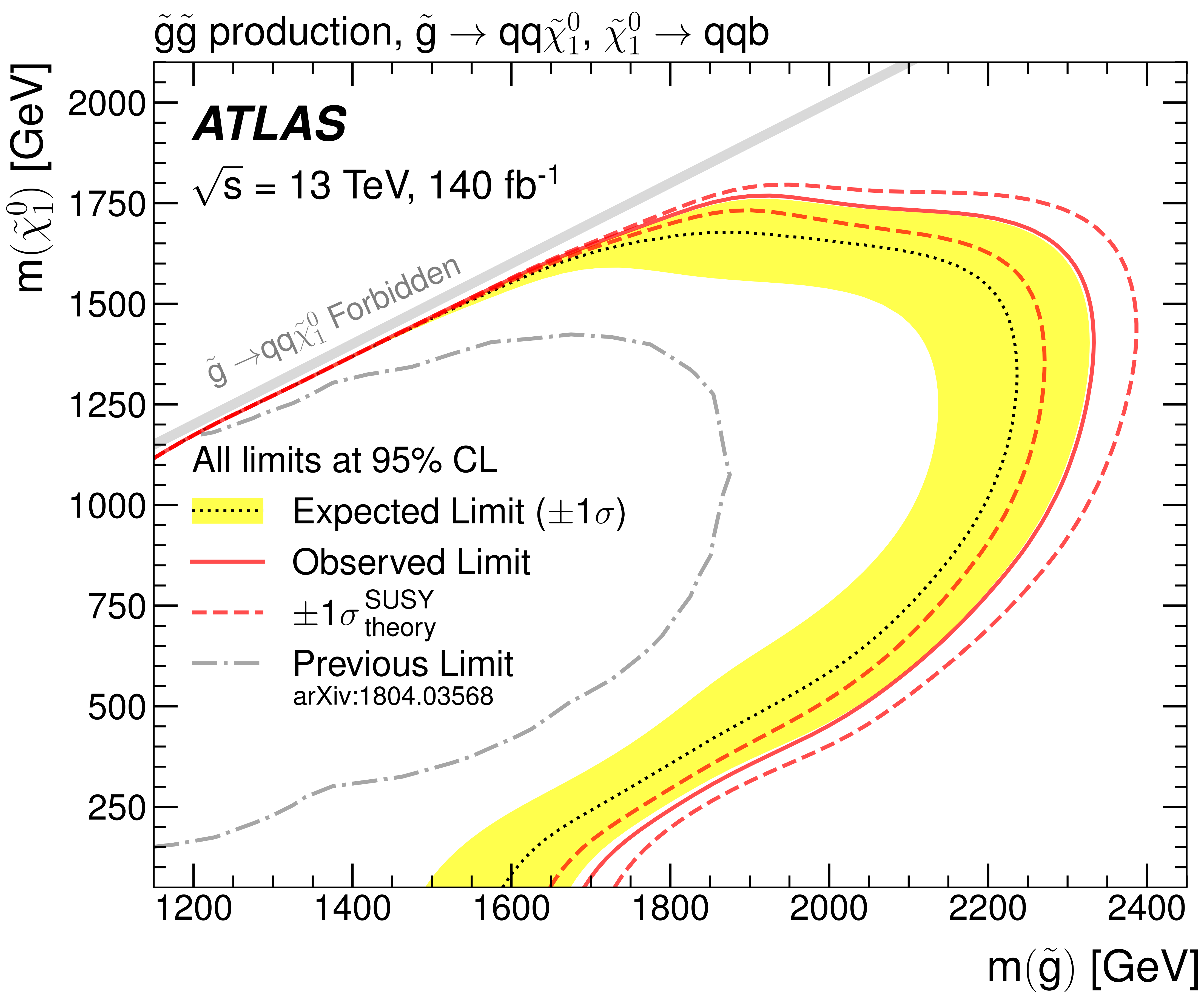




Results, 2x5

Using jet counting method 2340 GeV $\tilde{g}$ excluded with $\tilde{\chi}_0^1$ up to 1250 GeV





Sphericity tensor and eigenvalues

Linearized sphericity tensor

The eigenvalues of this tensor have a direct geometrical interpretation. Given the normalisation of the M_{xyz} tensor its eigenvalues (λ_i) are defined such that $\sum_i \lambda_i = 1$. When two of them are zero, the third one must be equal to one. In this case, the final state consists of two back-to-back jets. If there are three jets with the momenta lying on the same plane, one of the eigenvalues will be equal to 0. Instead, if the spread of the momenta in the final state is close to spherical, the eigenvalues will have similar values between each other, close to 1/3.

$$M_{xyz} = \frac{1}{\sum_i \vec{p_i}} \sum_i \frac{1}{\vec{p_i}} \begin{pmatrix} p_{x,i}^2 & p_{x,i}p_{y,i} & p_{x,i}p_{z,i} \\ p_{y,i}p_{x,i} & p_{y,i}^2 & p_{y,i}p_{z,i} \\ p_{z,i}p_{x,i} & p_{z,i}p_{y,i} & p_{z,i}^2 \end{pmatrix}.$$

Define ordered eigenvalues $\lambda_1 \geq \lambda_2 \geq \lambda_3$

Using eigenvalues can define useful geometric quantities

Sphericity	$S = 3/2(\lambda_2 + \lambda_3)$
Aplanarity	$A = 3/2 \cdot \lambda_3$
C-parameter	$C = 3(\lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3)$
D-parameter	$D = 27(\lambda_1\lambda_2\lambda_3)$

Allocated time for talk+questions = 5+2

Rehearsal indico: https://indico.cern.ch/event/1385435/

MoriondEW'24 indico: https://indico.cern.ch/event/1385435/#4-exploring-the-hadronic-lands