



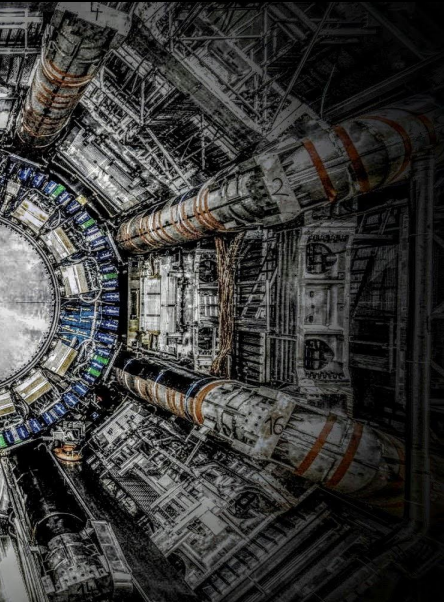
Variable-Radius Track Jets in a Boosted $hh \rightarrow 4b$ Search



UNIVERSITY OF
OXFORD

Santiago Paredes Saenz
santiago.paredes@physics.ox.ac.uk

IOP HEPP Conference
Imperial College, London
April 2019



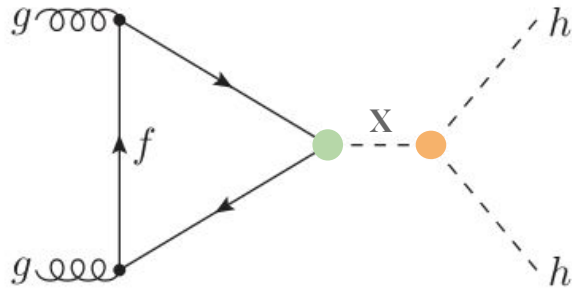
Overview

- **Motivation** for di-higgs searches
- Search **Strategy**
- **Introducing Variable-Radius** track jets to the search
- **Summary**

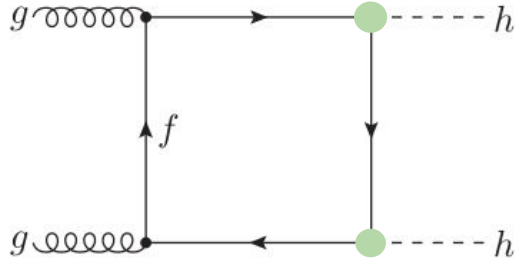
Motivation



Why di-higgs?



- Standard Model (**SM**)
 - ↳ Sensitive to the higgs **self-coupling** ● \rightarrow if $\mathbf{x} = h$
 - ↳ Also to the **tth** ● vertex



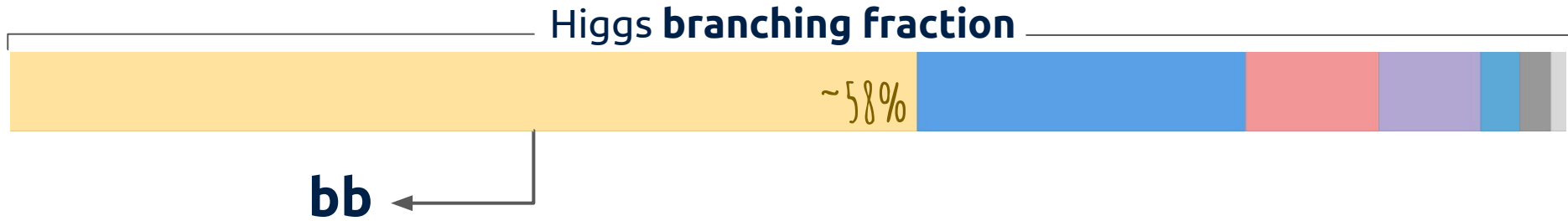
- Beyond the SM (**BSM**)
 - ↳ **New physics** effects in ● & loops
 - ↳ **Exotic particles** \rightarrow $\mathbf{X} = \begin{cases} \text{KALUZA-KLEIN GRAVITON} \\ \text{HEAVY HIGGS} \end{cases}$
- decaying to di-higgs

Why di-higgs decaying to 4b?

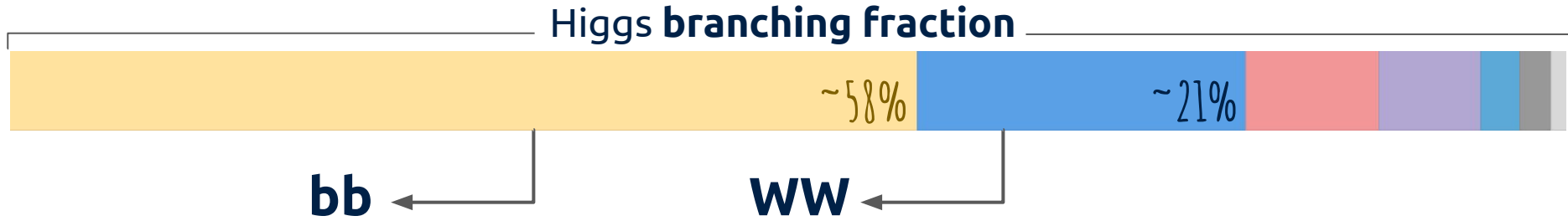
Higgs branching fraction



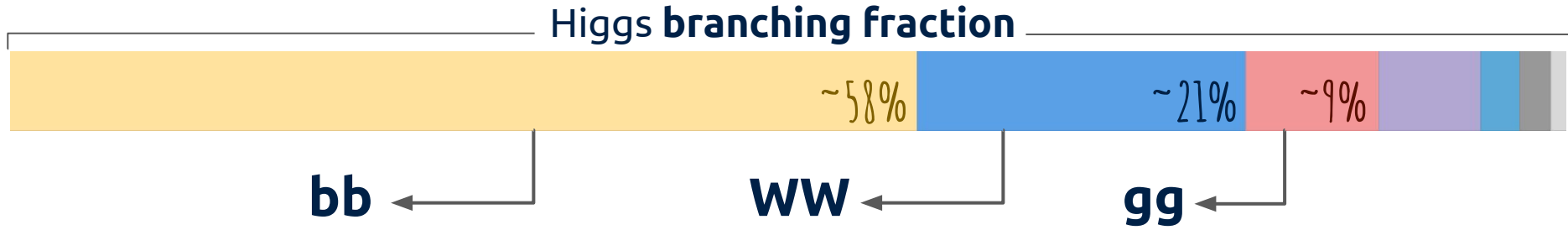
Why di-higgs decaying to 4b?



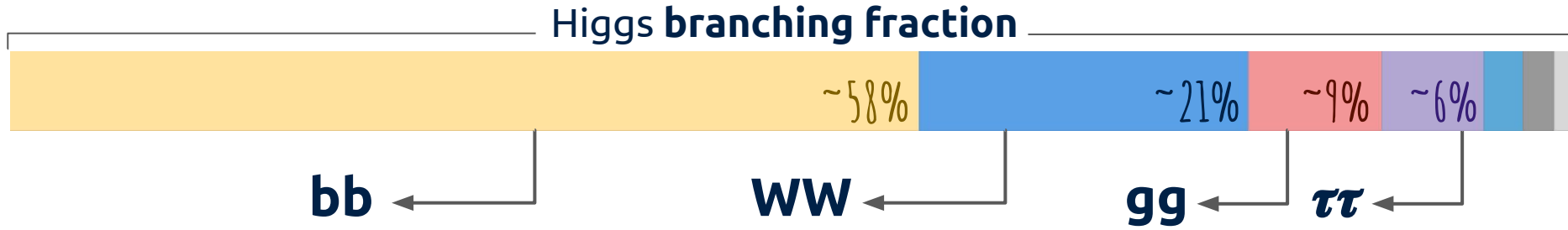
Why di-higgs decaying to 4b?



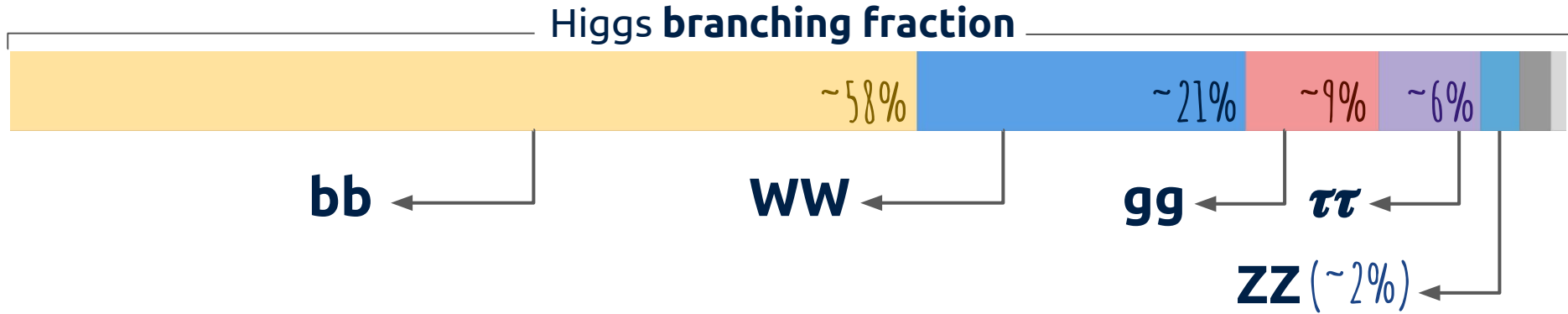
Why di-higgs decaying to 4b?



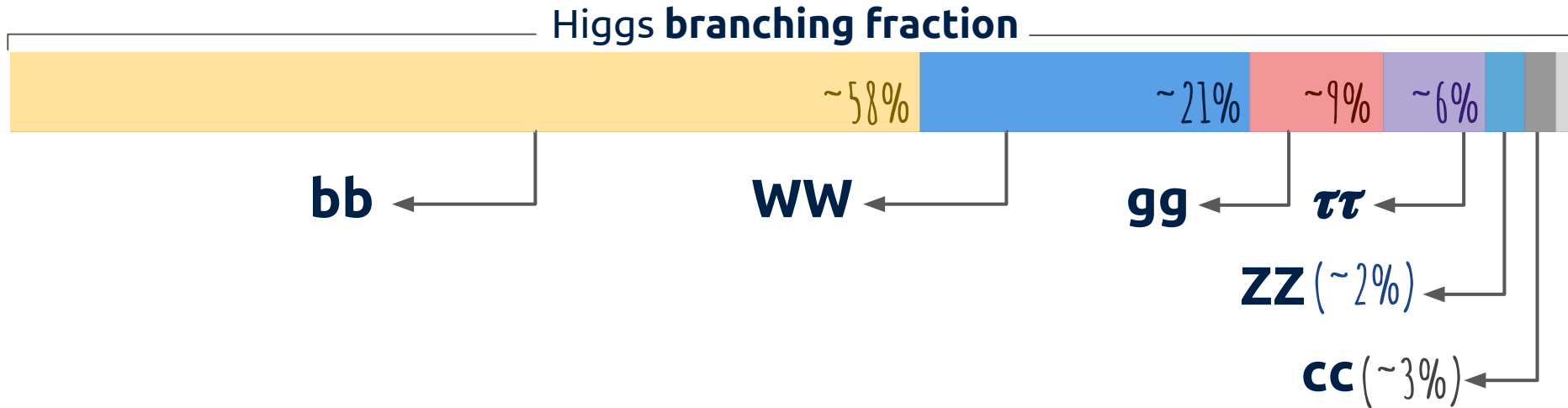
Why di-higgs decaying to 4b?



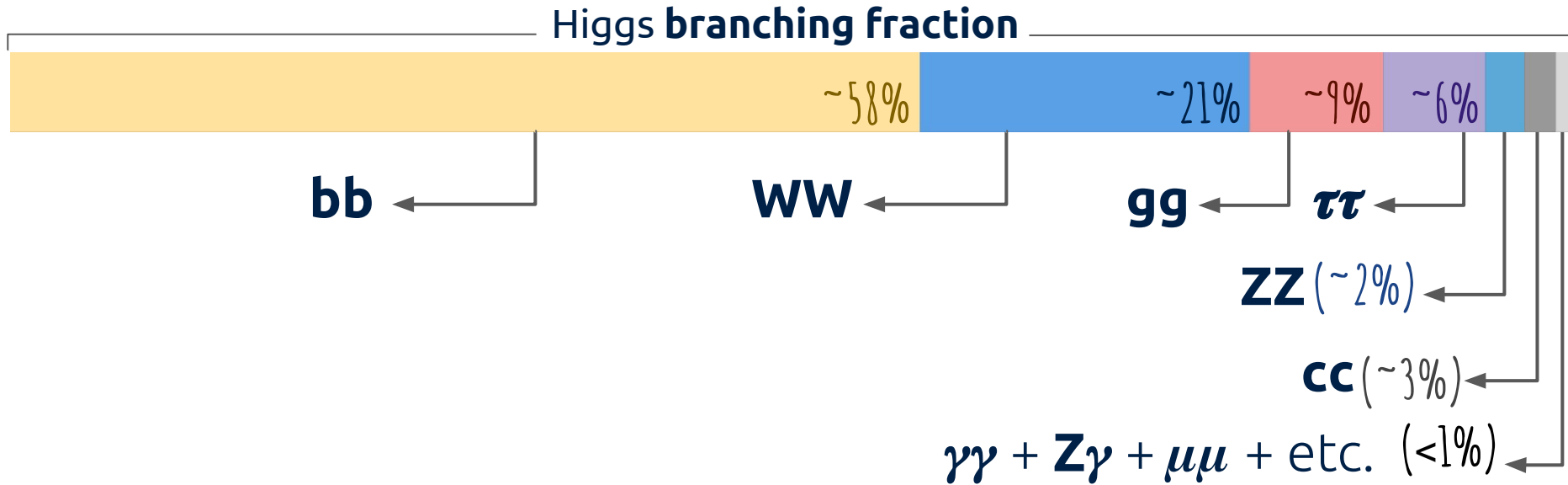
Why di-higgs decaying to 4b?



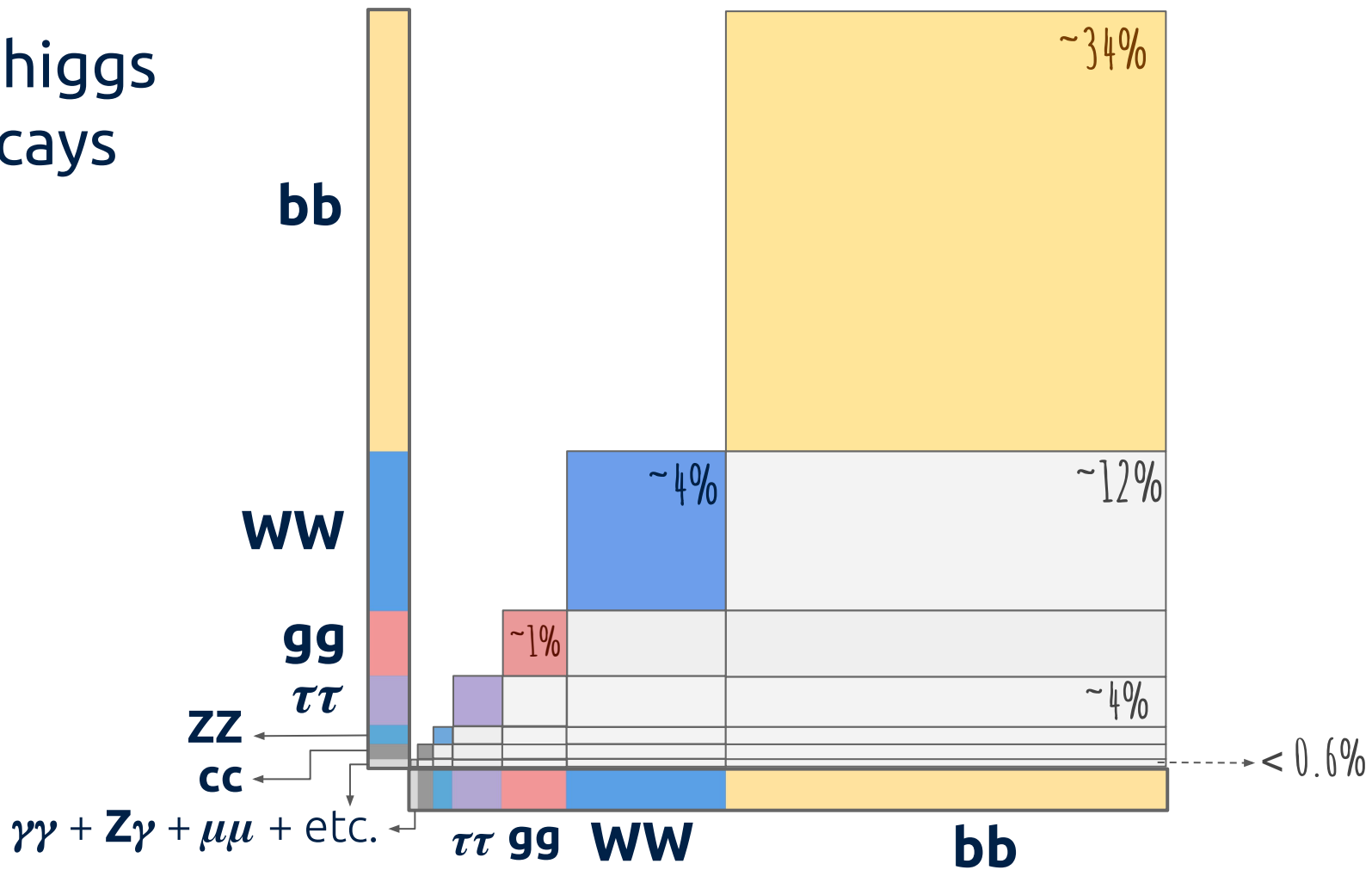
Why di-higgs decaying to 4b?



Why di-higgs decaying to 4b?



Di-higgs decays



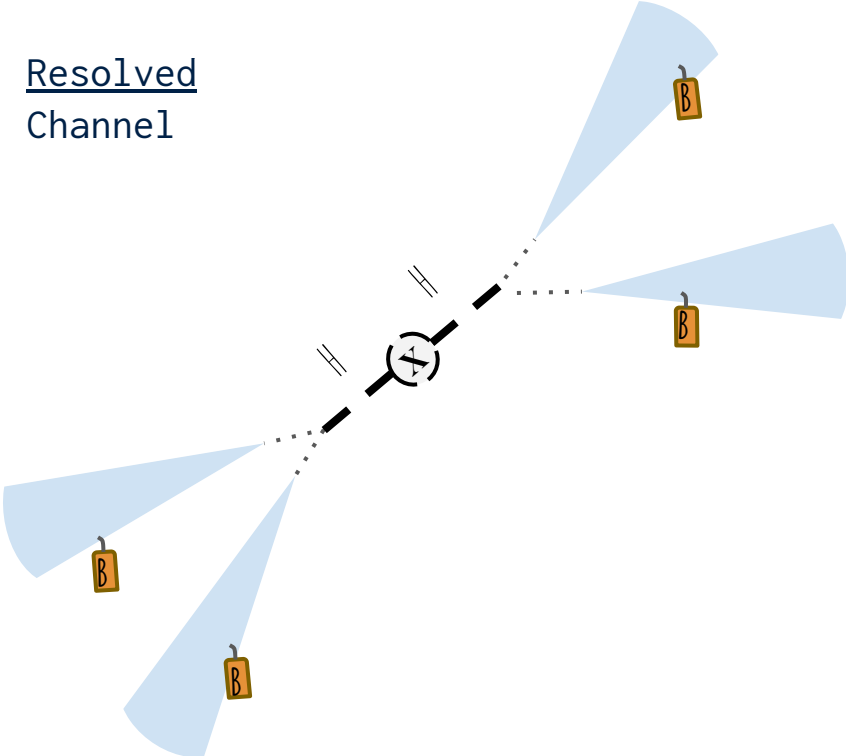
Search Strategy

ATLAS hh→4b paper: <https://arxiv.org/abs/1804.06174>

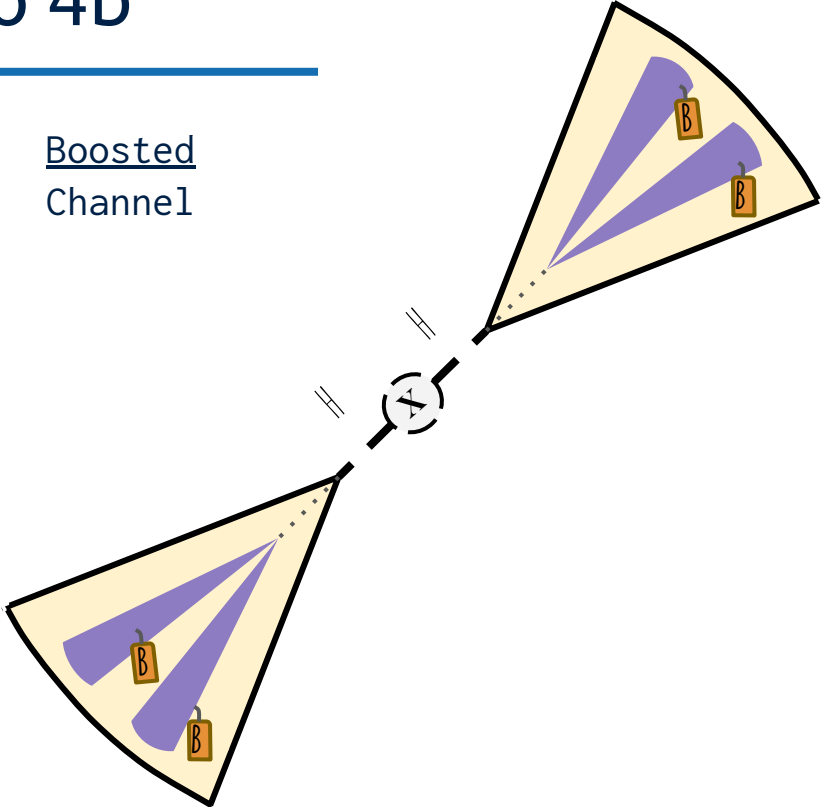


Boosted di-higgs decaying to 4b

Resolved
Channel



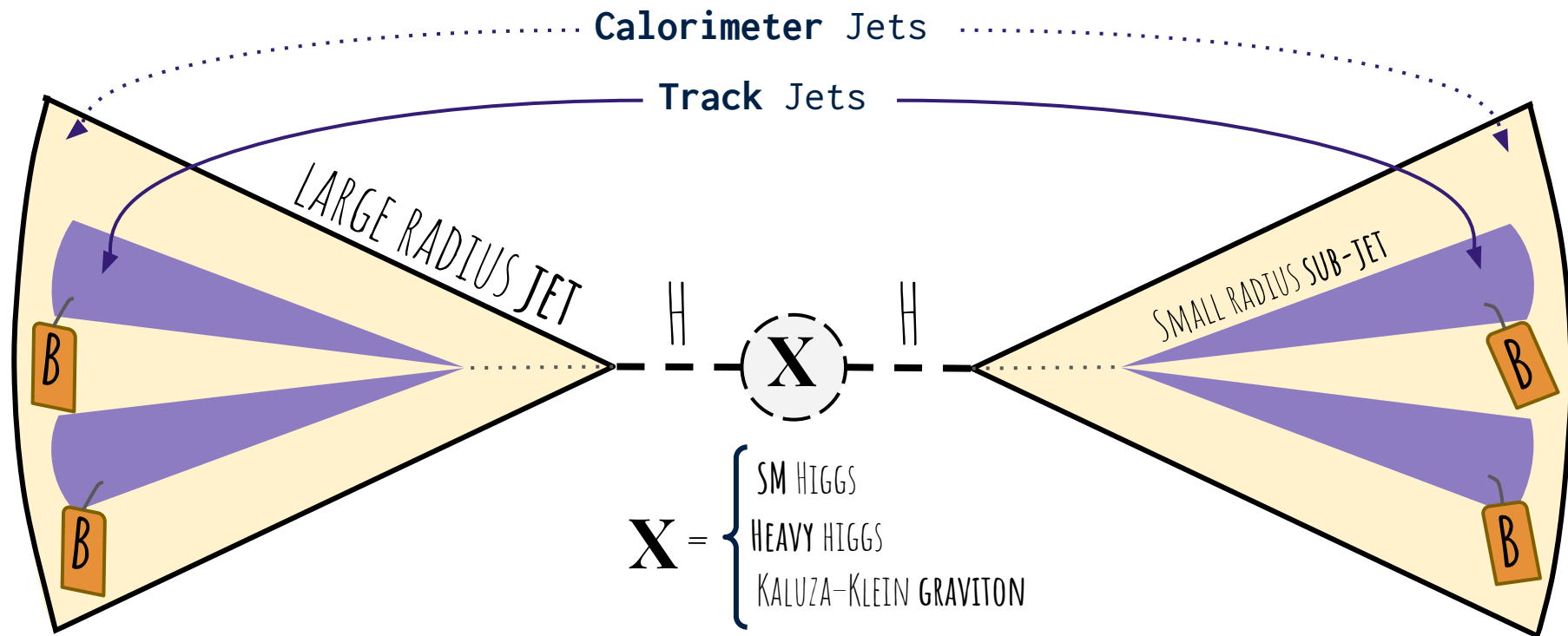
Boosted
Channel



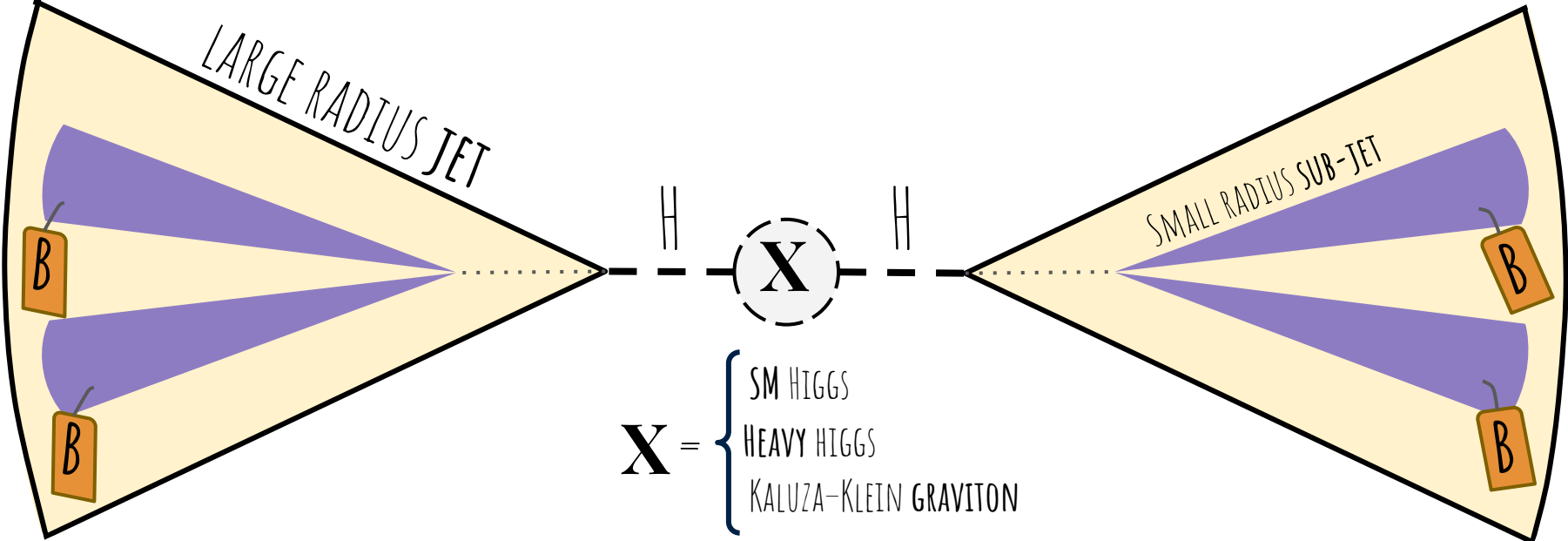
Low higgs p_T

High higgs p_T

Signal Event Topology

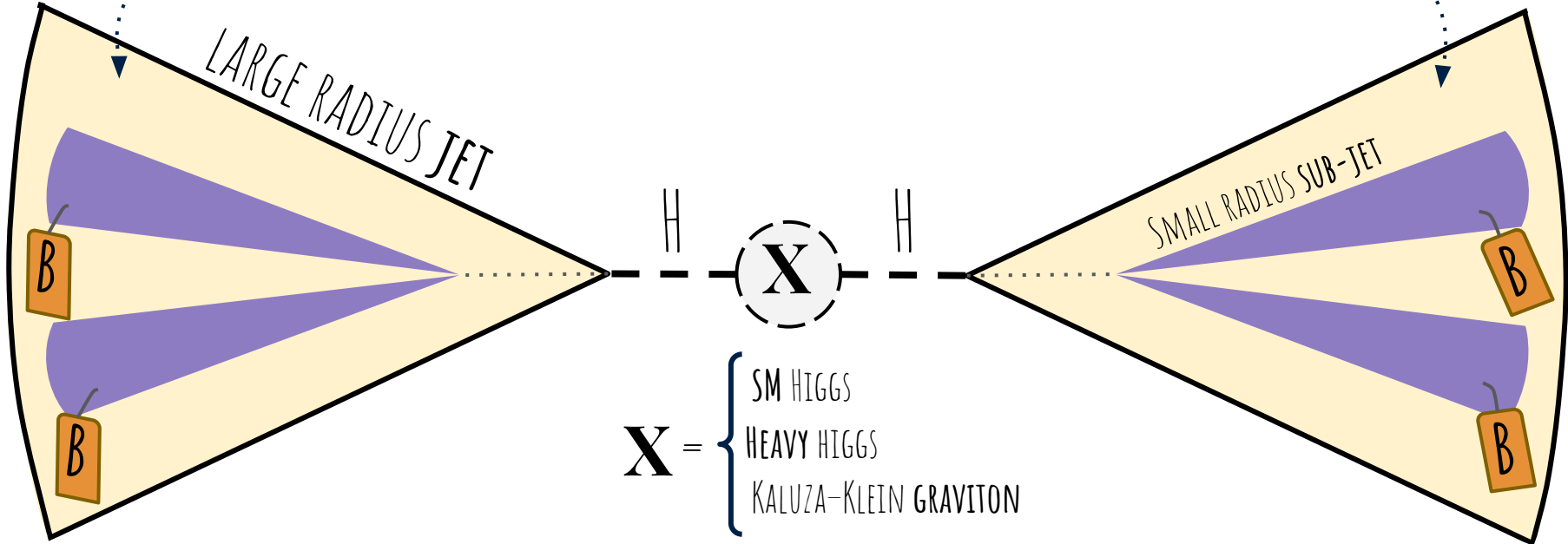


Event Selection



Event Selection

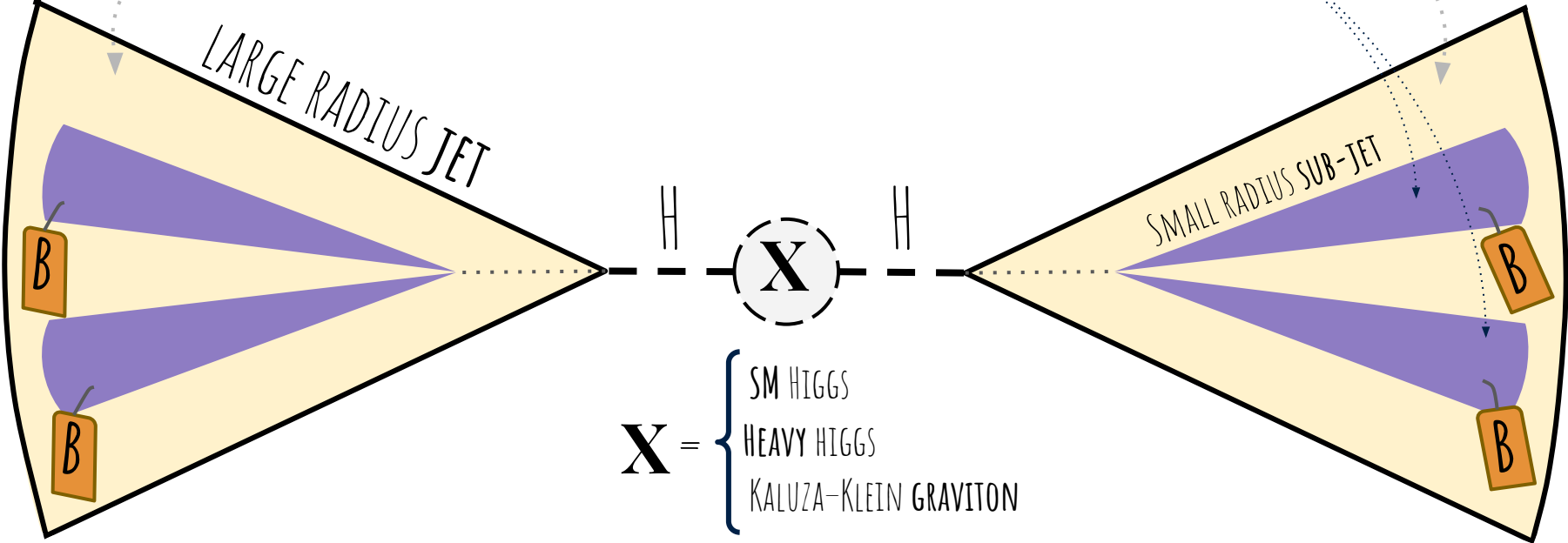
Two large radius(LR) jets



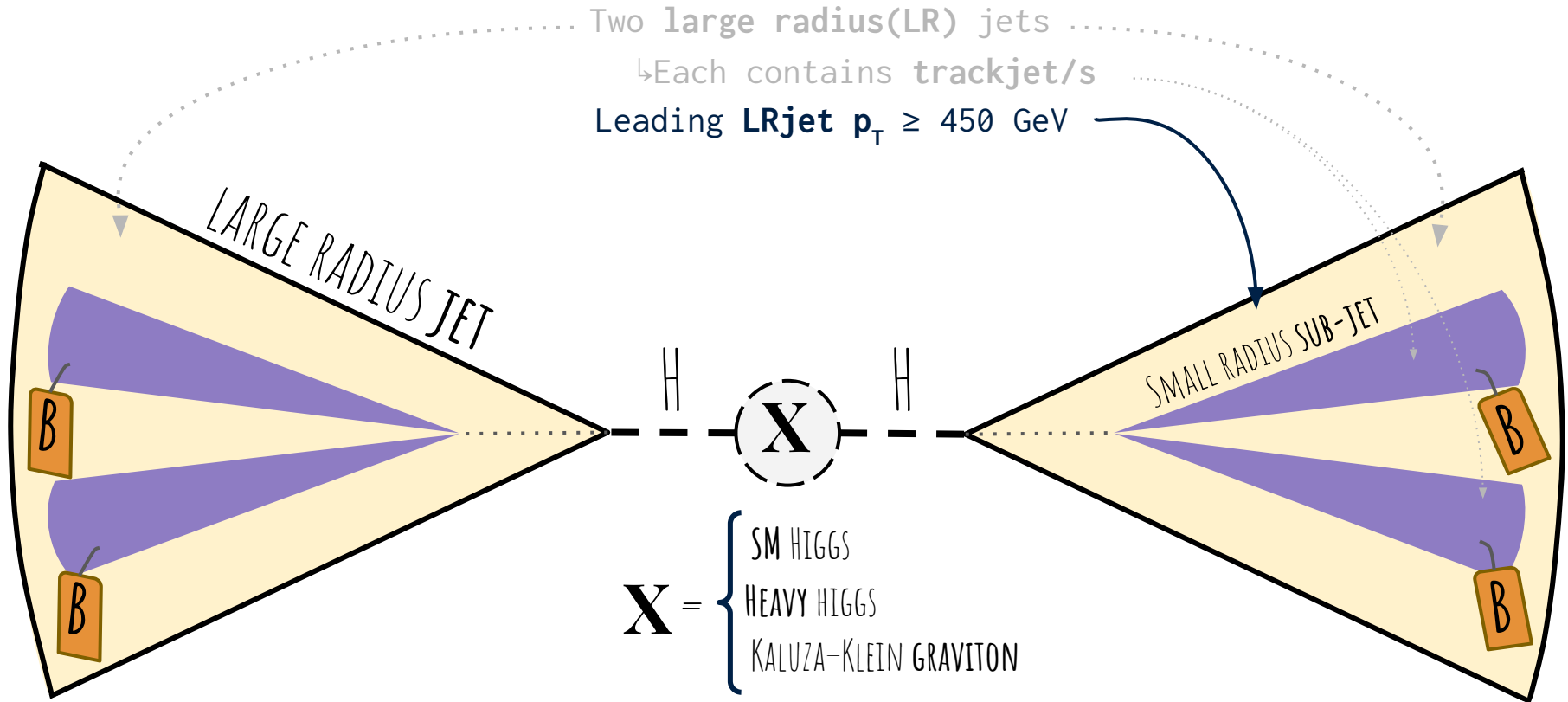
Event Selection

Two large radius(LR) jets

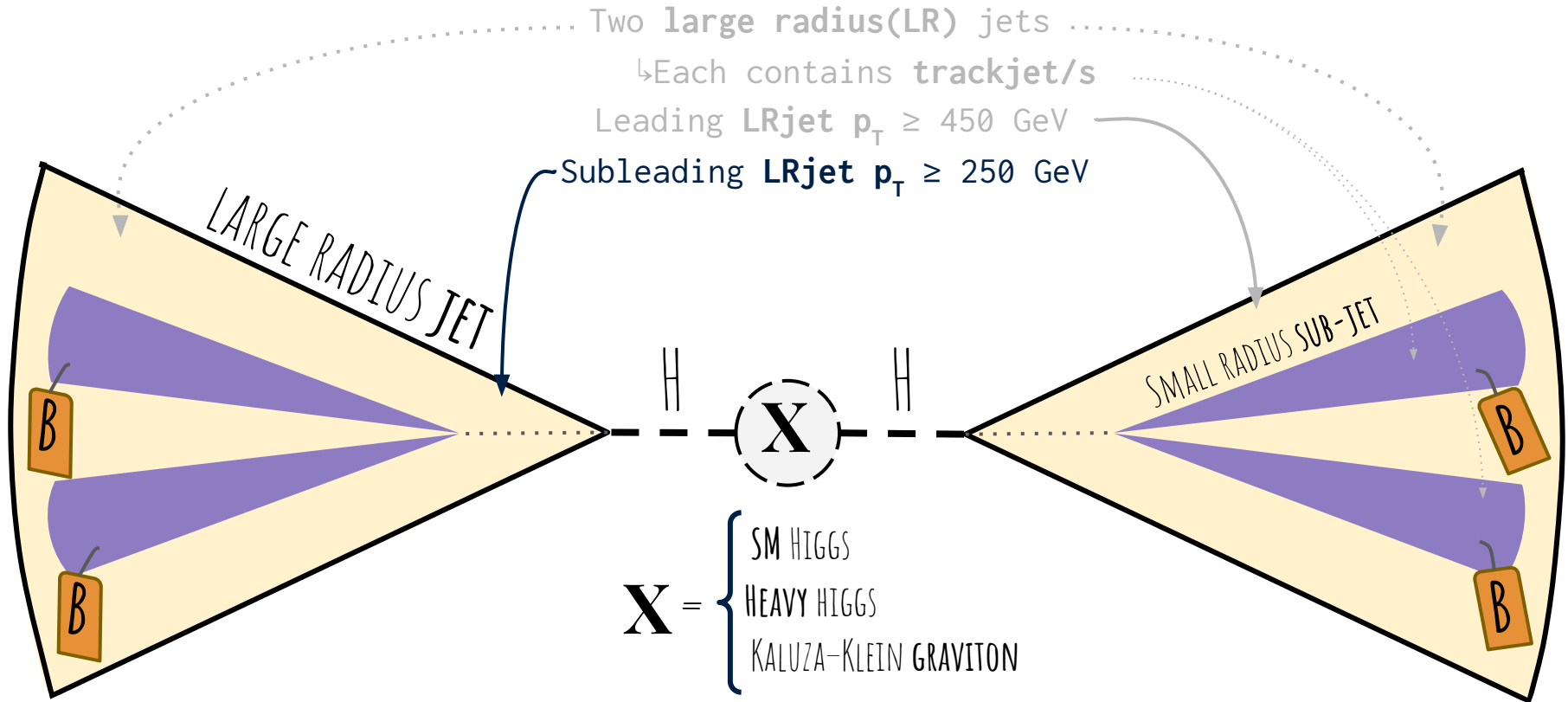
↳ Each contains trackjet/s



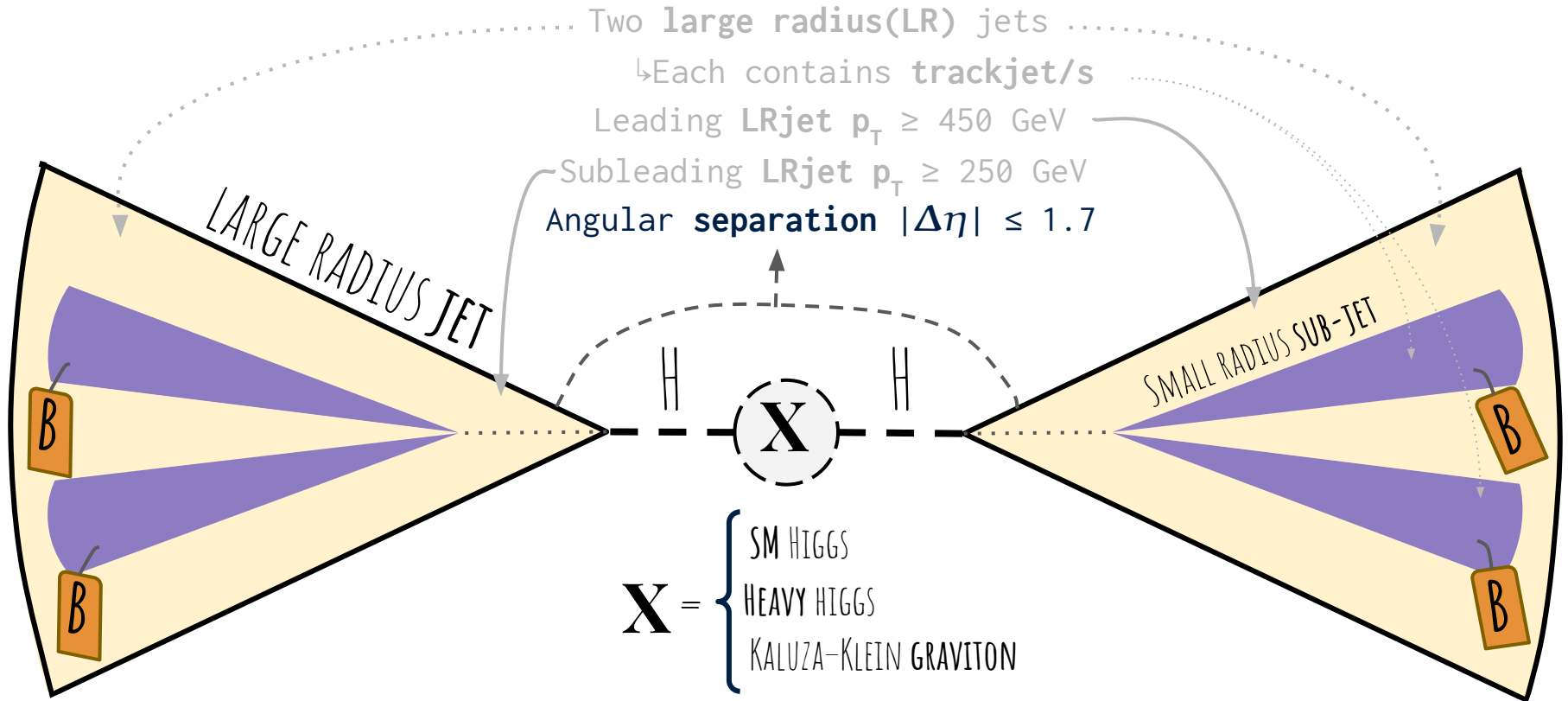
Event Selection



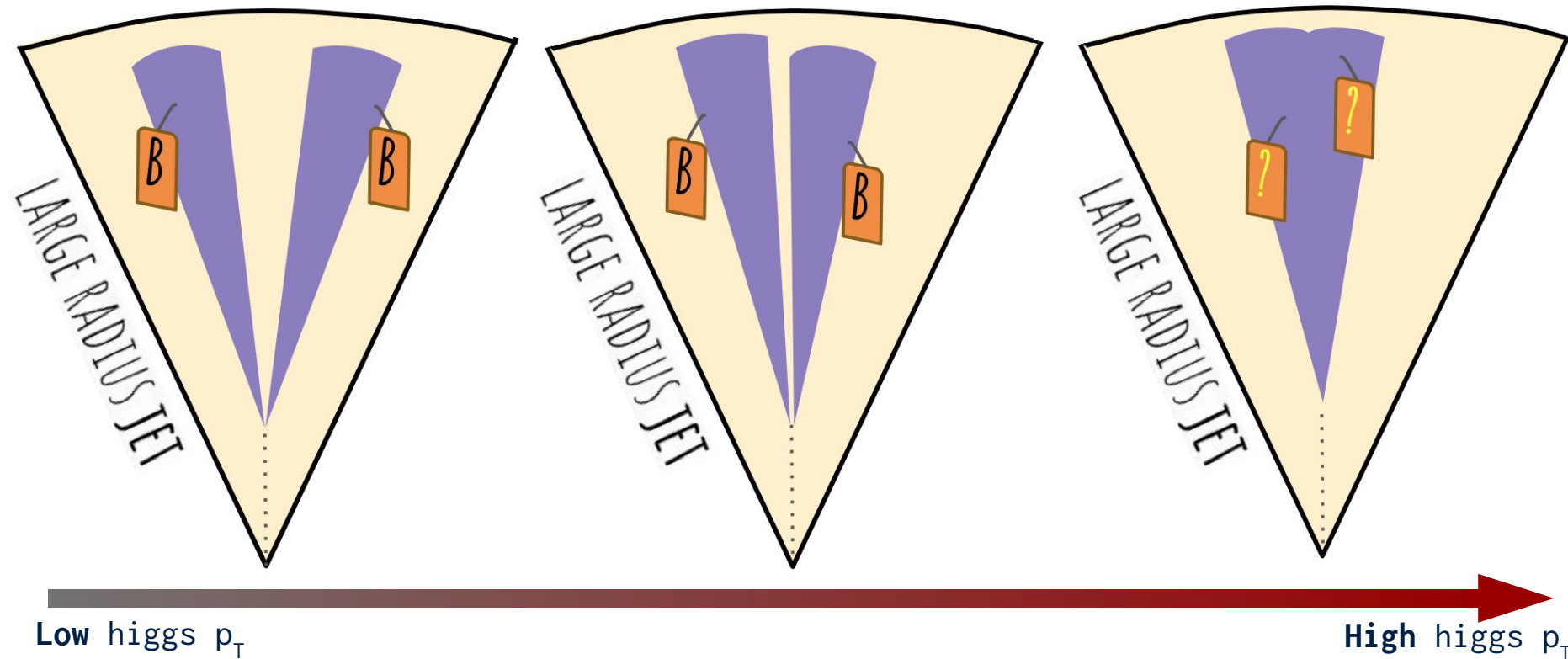
Event Selection



Event Selection

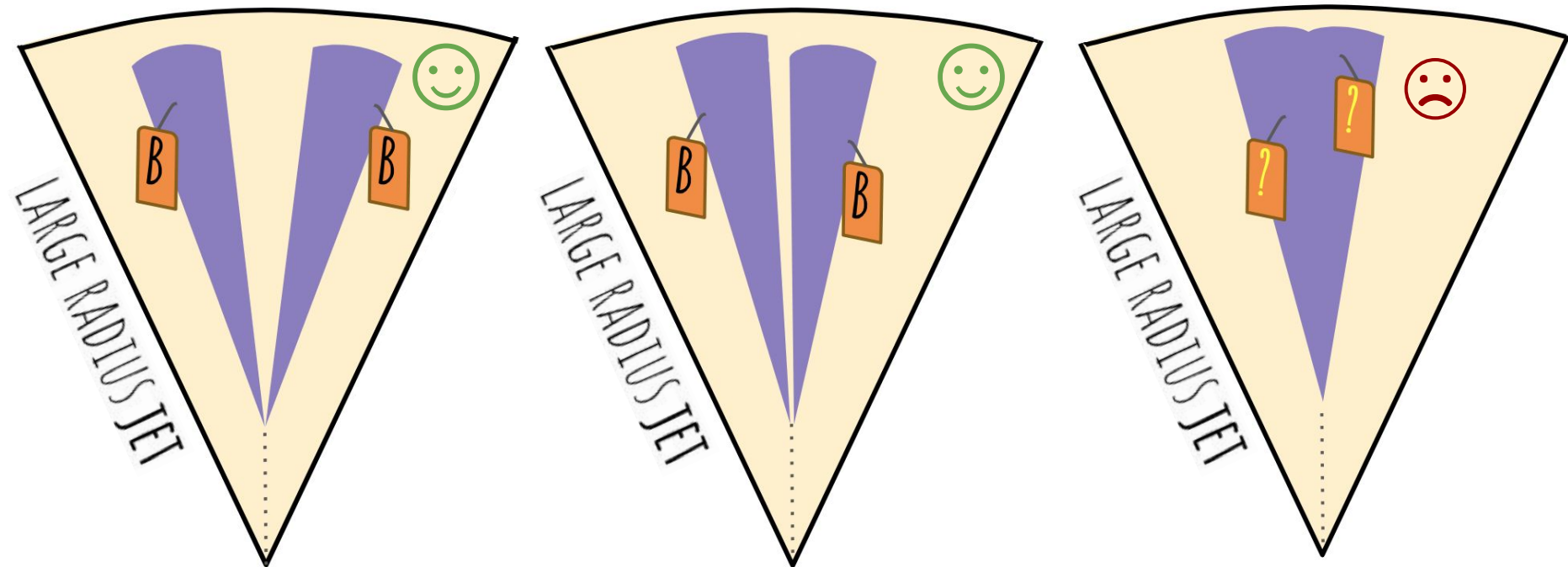


Highly Boosted Higgs Jets



Highly Boosted Higgs Jets

Fixed-Radius track jets overlap
in highly boosted events



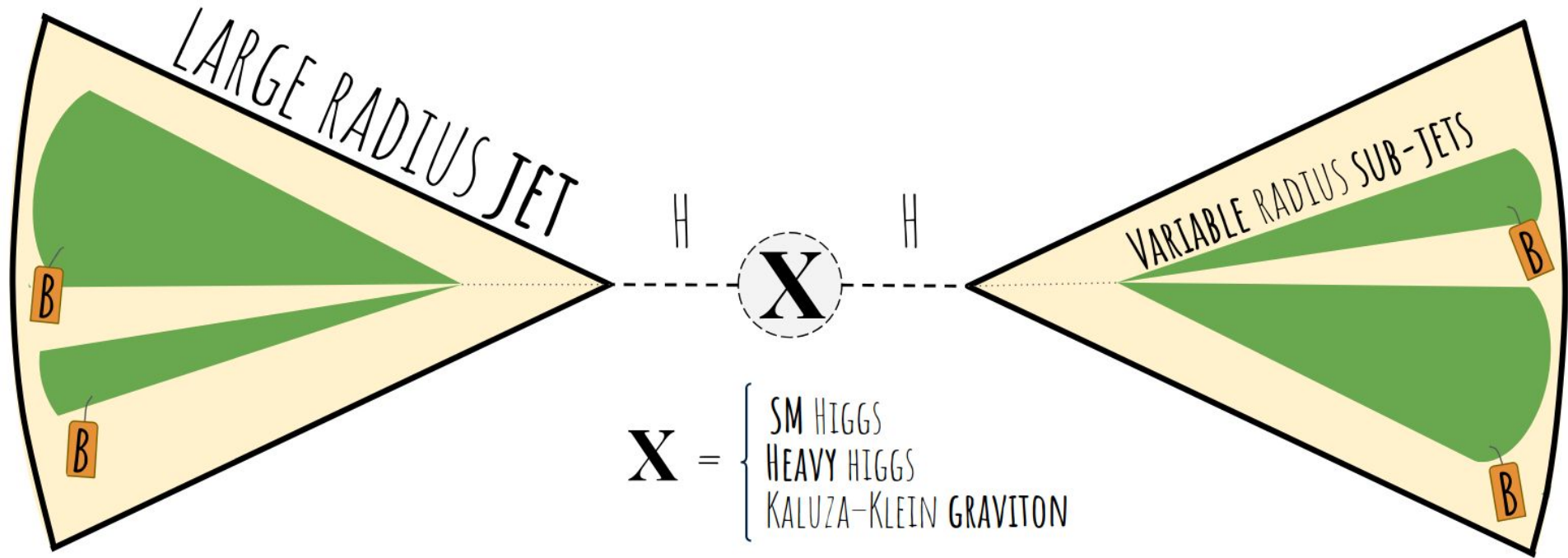
Low higgs p_T

High higgs p_T

Variable-Radius Track Jets



Variable Radius (VR) Track Jets

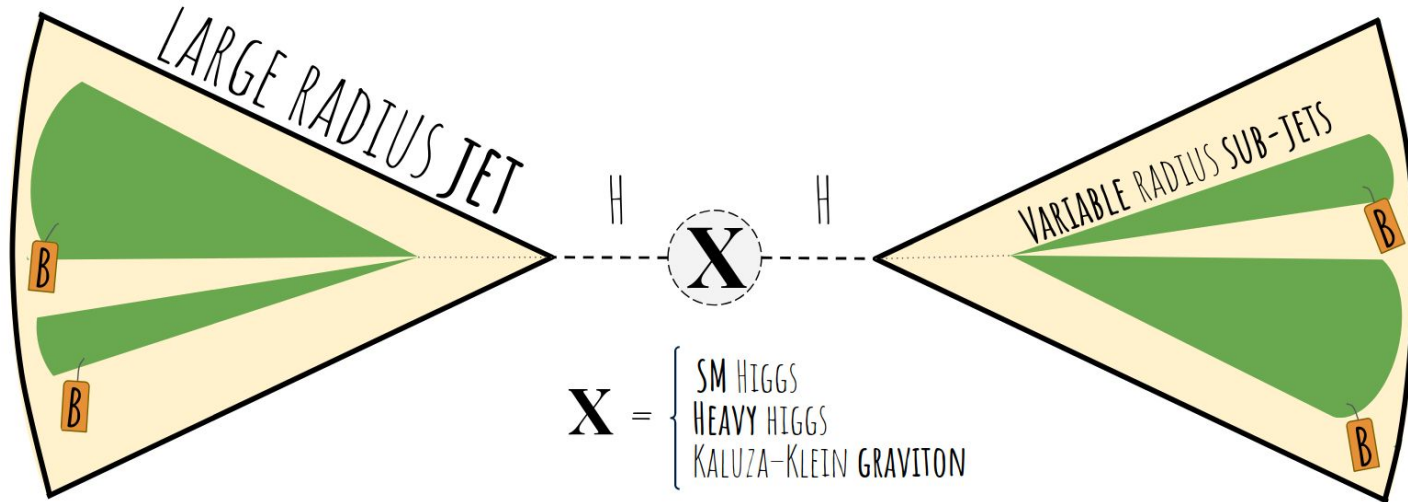


Variable Radius Track Jet Algorithm

- Track jet radius R varies with track jet p_T as:

$$R \propto \frac{\rho_{const}}{p_T}$$

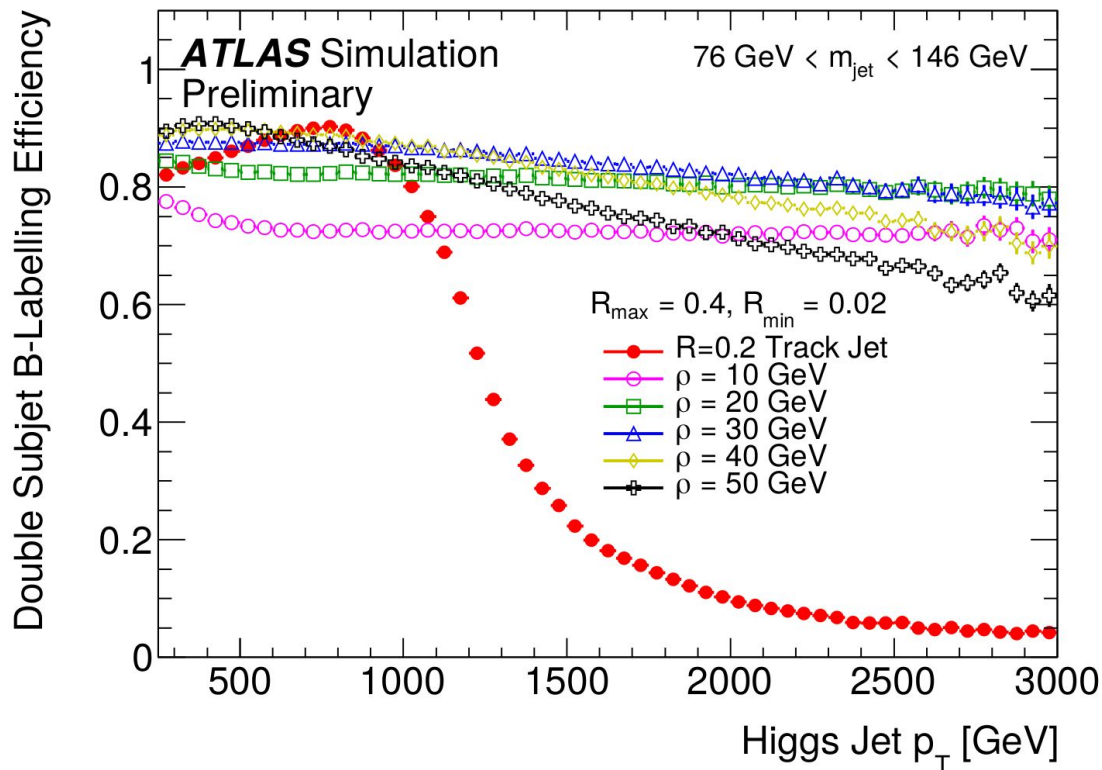
- Maximum** and **minimum** radius size limits are set



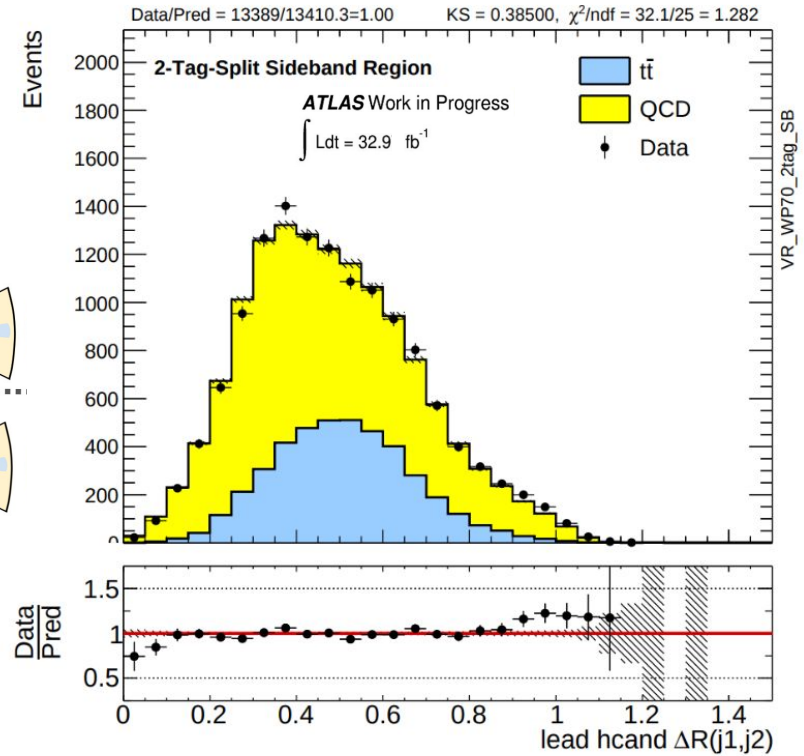
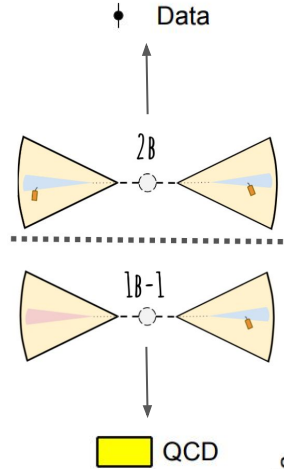
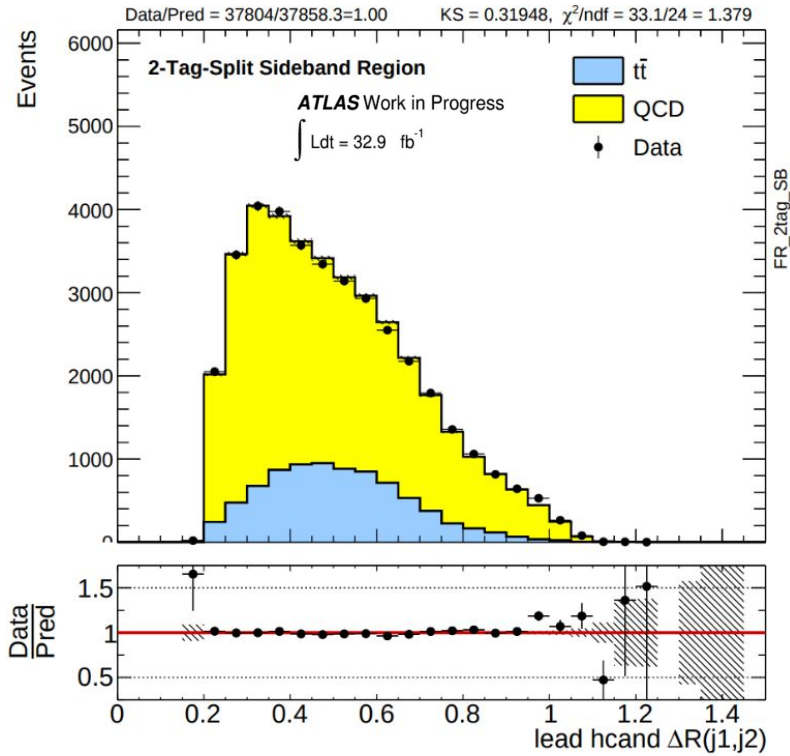
Variable Radius Track Jet Algorithm

$$R \propto \frac{\rho_{const}}{p_T}$$

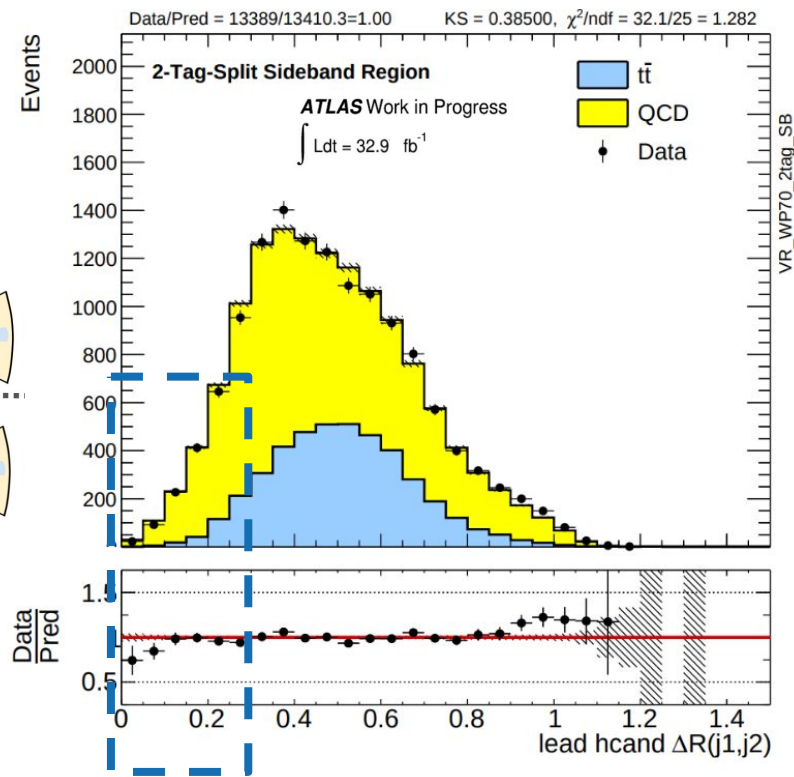
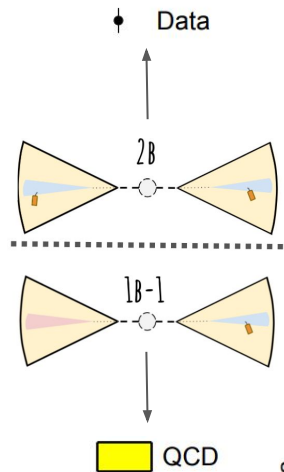
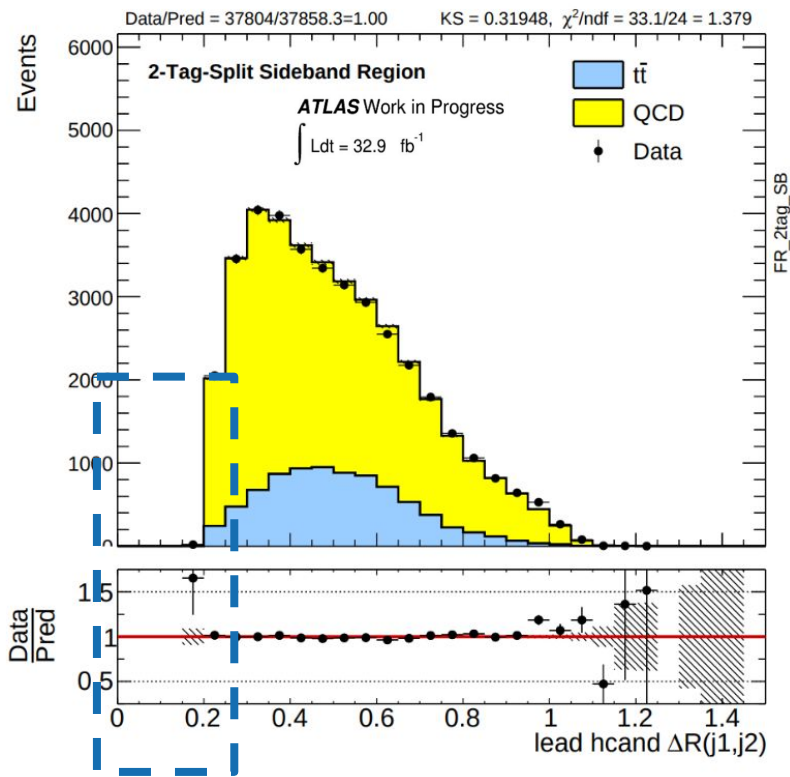
- Constant parameter ρ captures how fast the **radius shrinks** with p_T
 - Chosen to **optimize efficiency** over a range in large-R jet mass



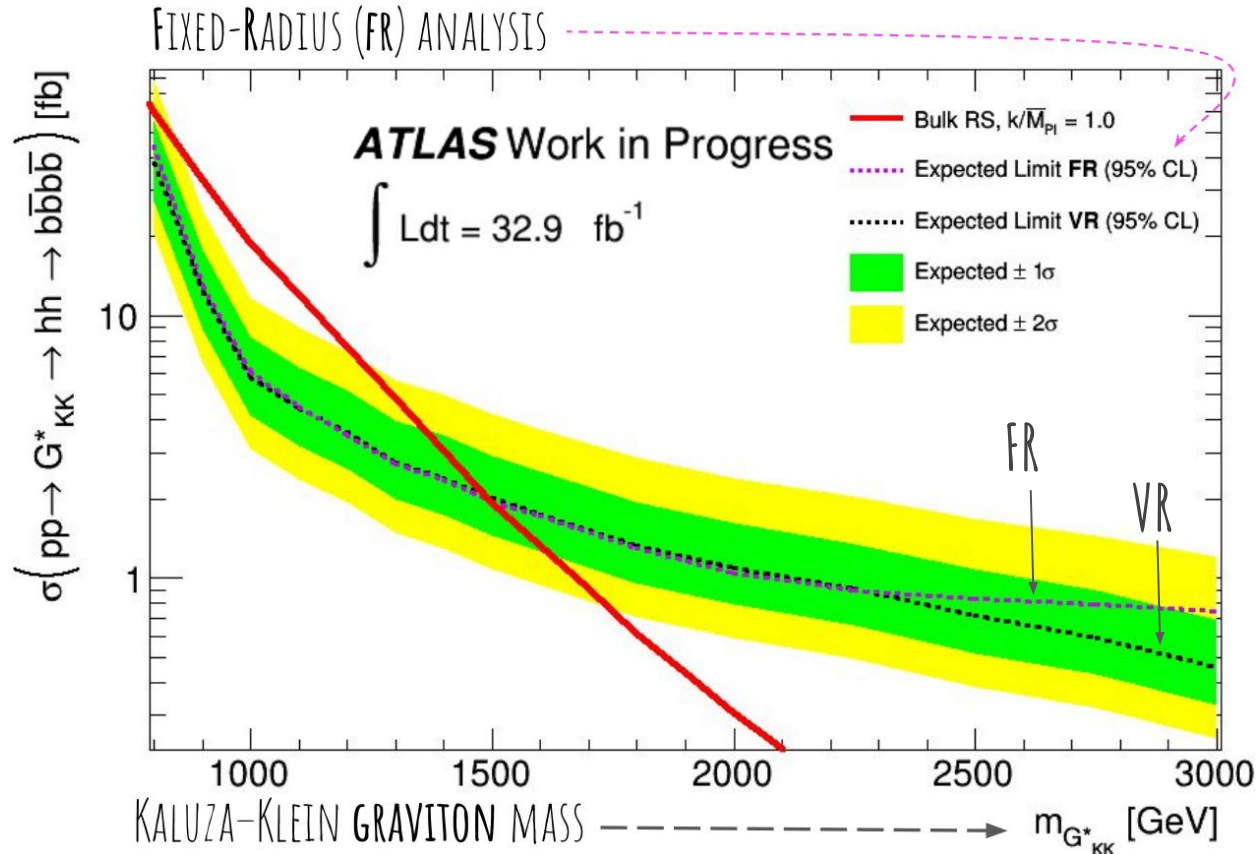
Performance of VR Track Jets



Performance of VR Track Jets



Impact on the Expected Limit



* No systematic uncertainties included

Summary

- Di-higgs is a rich area for both **SM** and **BSM** searches
- The impact of using **VR track jets** in the boosted analysis is currently being studied
- Preliminary results show **improvements** in events with **highly boosted** topologies

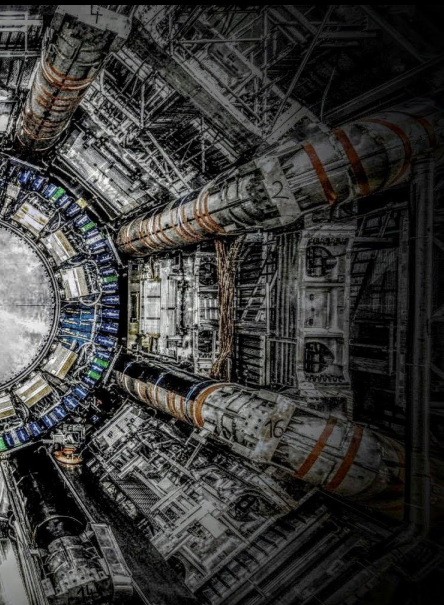


UNIVERSITY OF
OXFORD

Thanks!

Santiago Paredes Saenz
santiago.paredes@physics.ox.ac.uk

IOP HEPP Conference
Imperial College, London
April 2019



ATLAS hh→4b paper: <https://arxiv.org/abs/1804.06174>

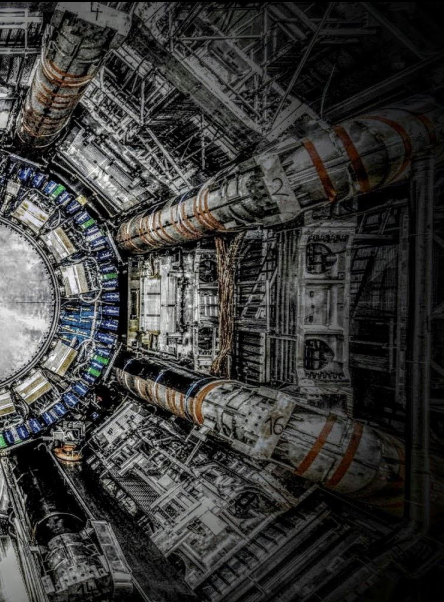


UNIVERSITY OF
OXFORD

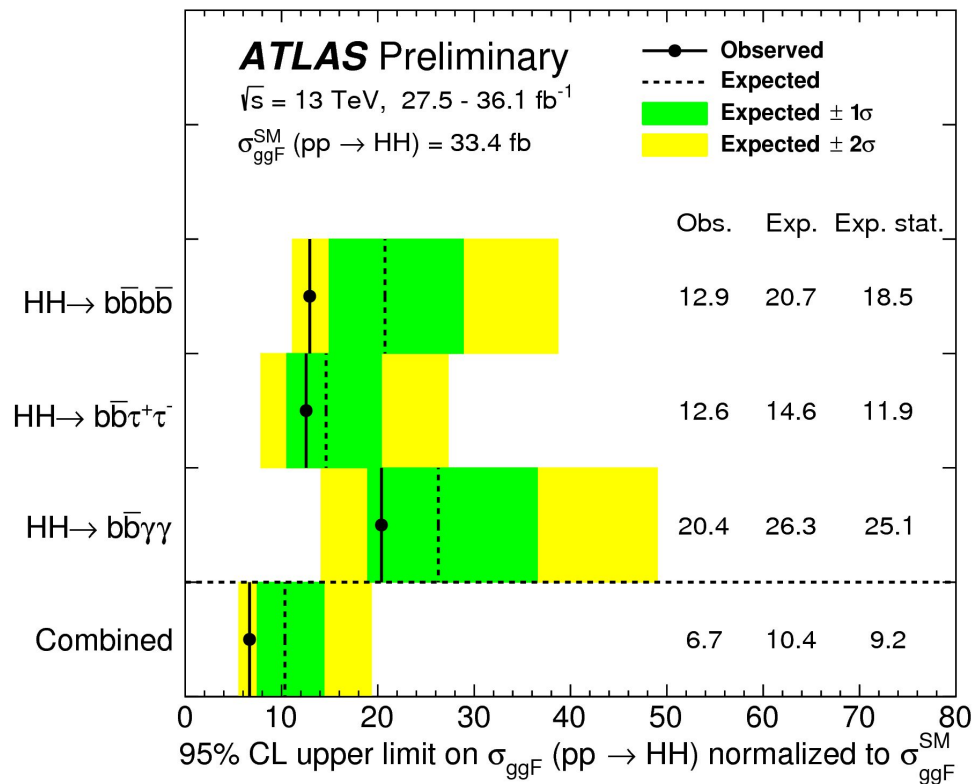
Backup

Santiago Paredes Saenz
santiago.paredes@physics.ox.ac.uk

IOP HEPP Conference
Imperial College, London
April 2019



Why di-higgs decaying to 4b?



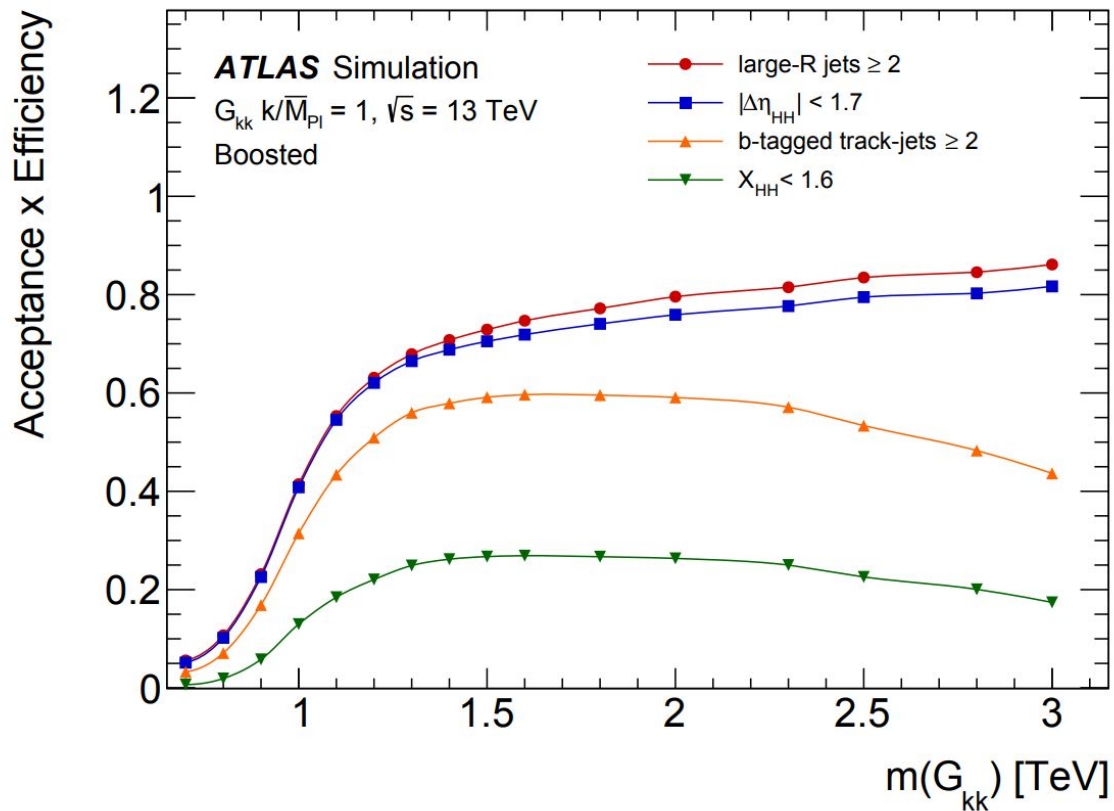
- One of the **most sensitive channels!**

* Plot from combination note



<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2018-043/>

Cut efficiency with FR

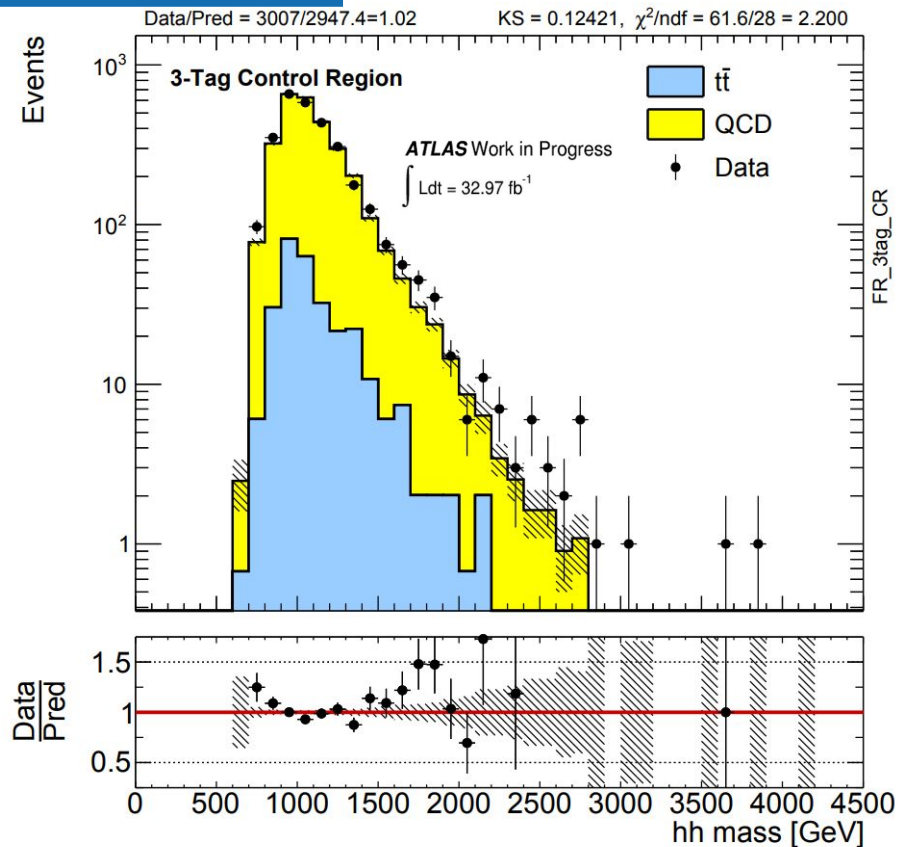
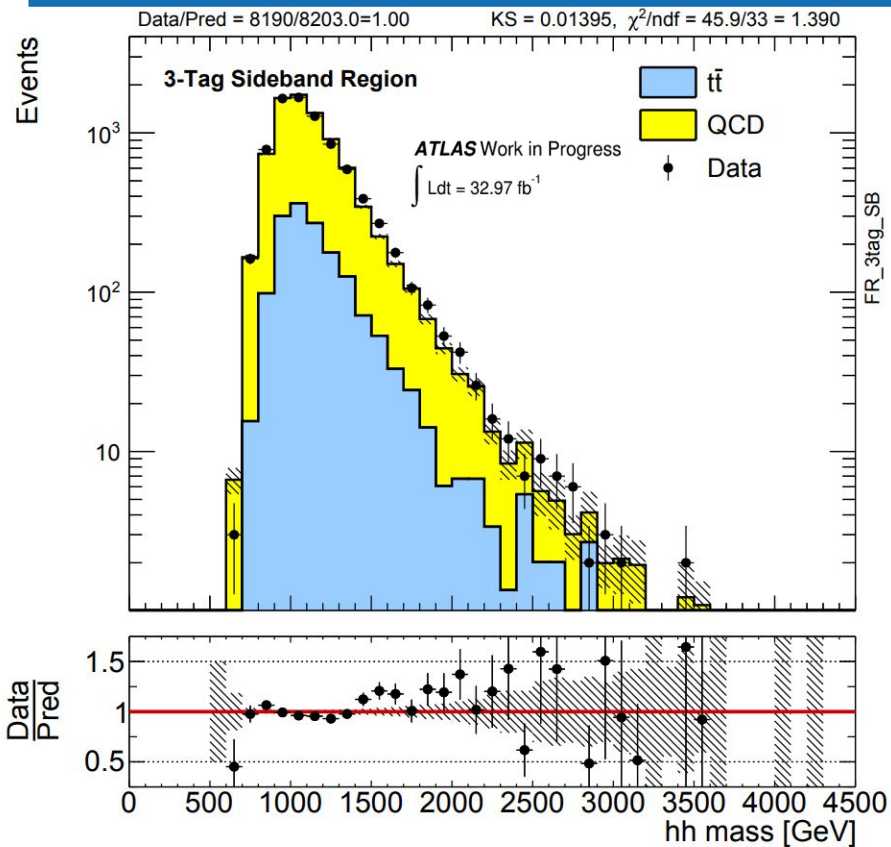
From <https://cds.cern.ch/record/2313703/files/1804.06174.pdf>



Background Estimation

- QCD multi-jet 
 - ↳ Estimated using **data**
 - ↳ **Biggest** contribution by far
- ttbar 
 - ↳ **Shape** from Monte Carlo
 - ↳ **Normalized** with data

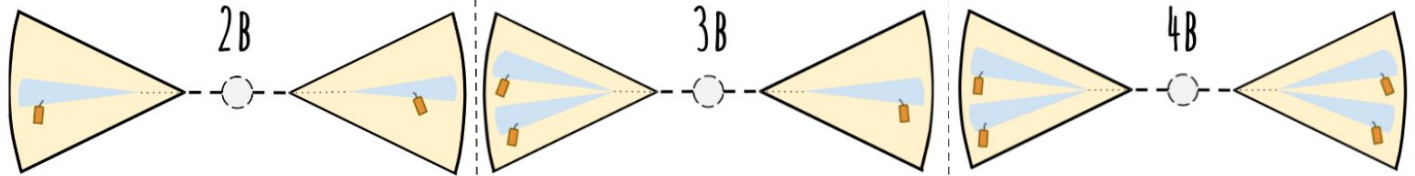
Background estimation (FR)



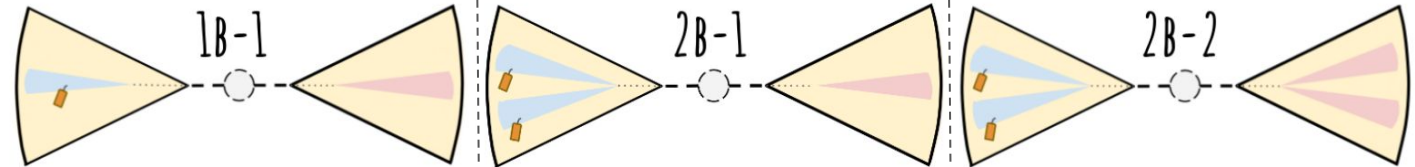
QCD Background Estimation

Estimate QCD background in the **n-tagged signal** region

N-TAGGED



LOW-TAGGED



By using the **corresponding low-tag** sample

Mass Plane Region Definition

- Sideband
- Control
- Signal

