Boost 2018:
Theory Summary

Jesse Diaz Thaler

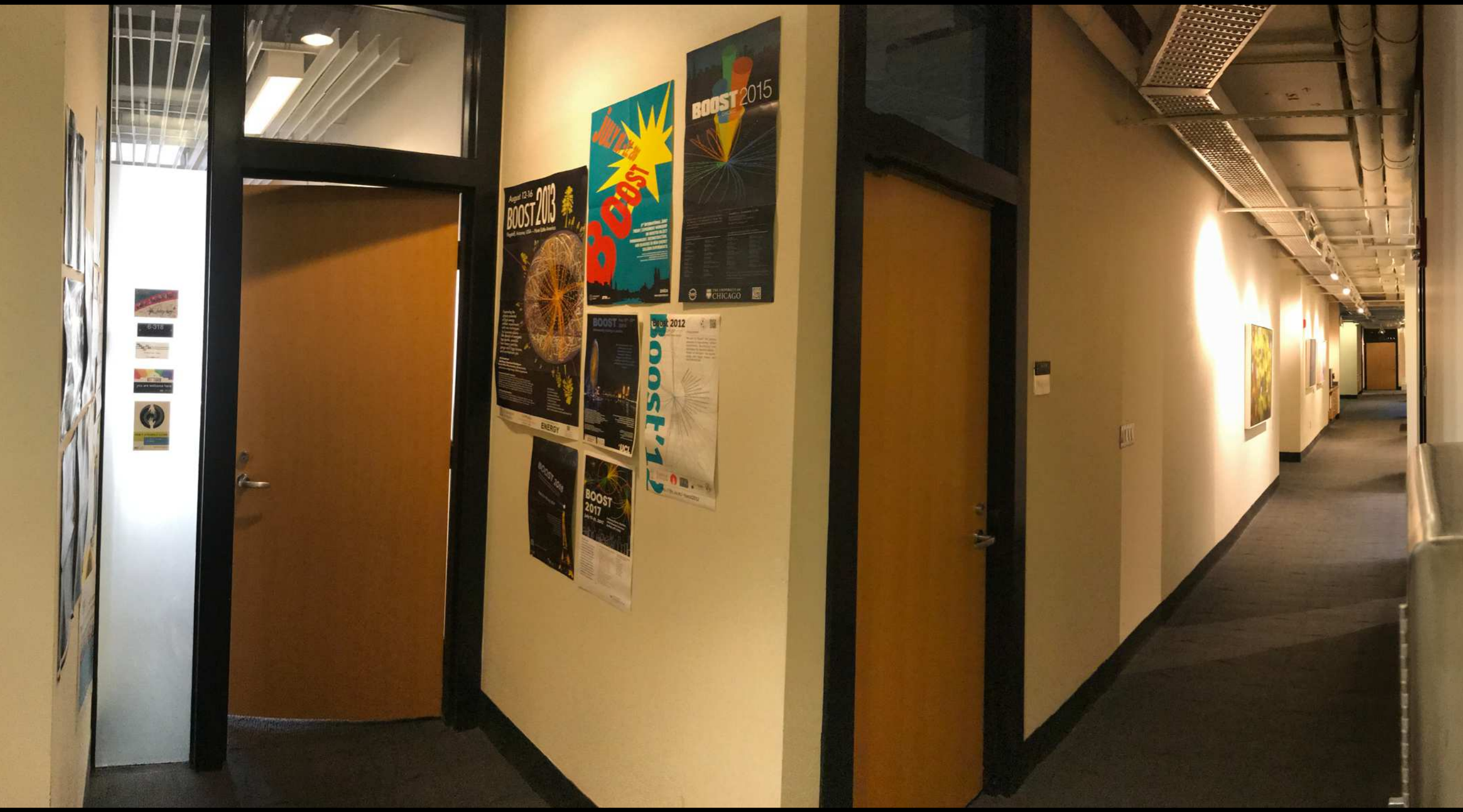
(Contrary to Inspire,
Kempner → Diaz in 2007)

Boost 2018, Paris — July 20, 2018

Boost 2018: Theory Summary

Has realized: “Jets!”

Boost 2018, Paris — July 20, 2018



Gonna need a bigger wall…

Celebrating 10 Years of Jet Substructure*

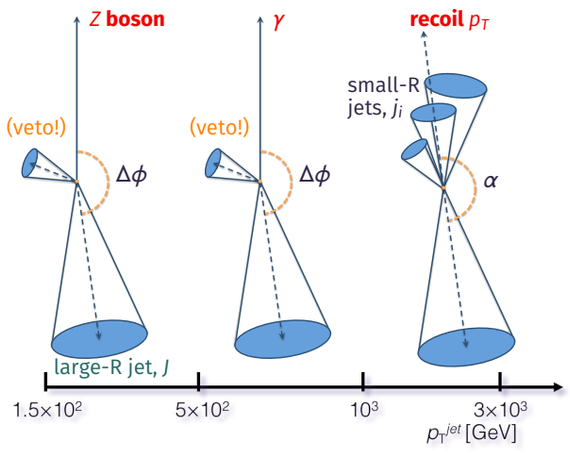
What was true in 2016…

"The Most Lively Event in Particle Physics" — *M. Vos*

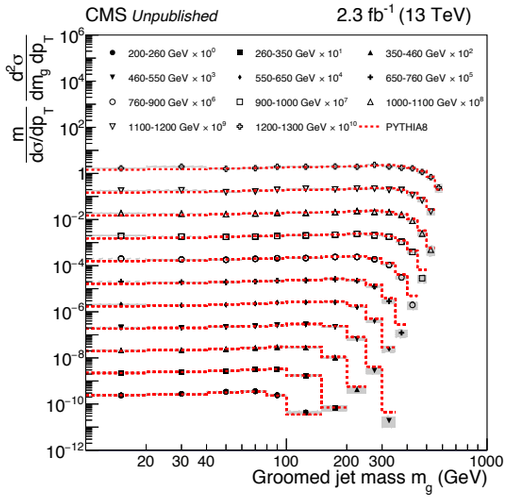
…is still true today!

Innovative Approaches to Extreme Kinematics

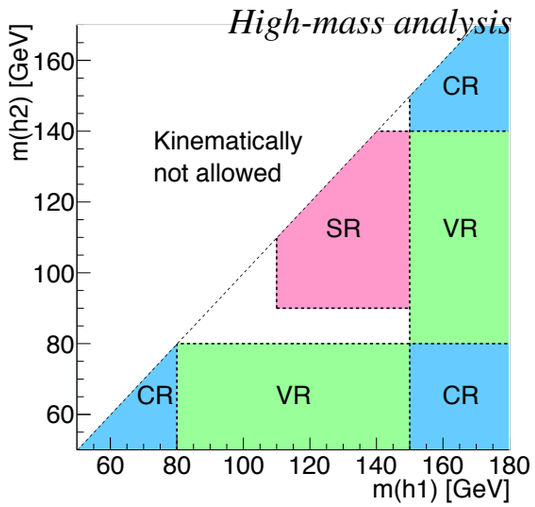
Caterina's Talk



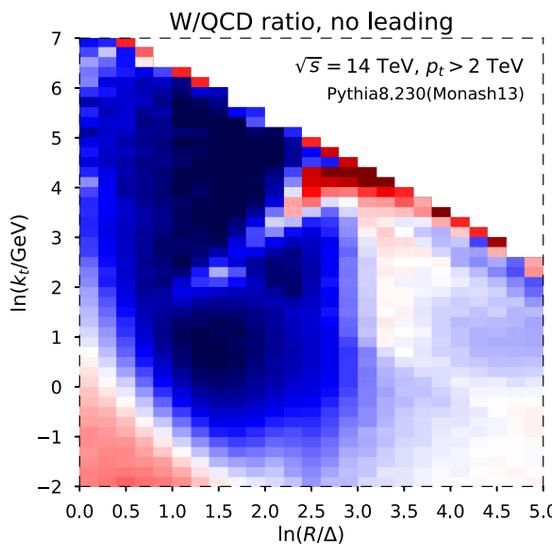
Performance



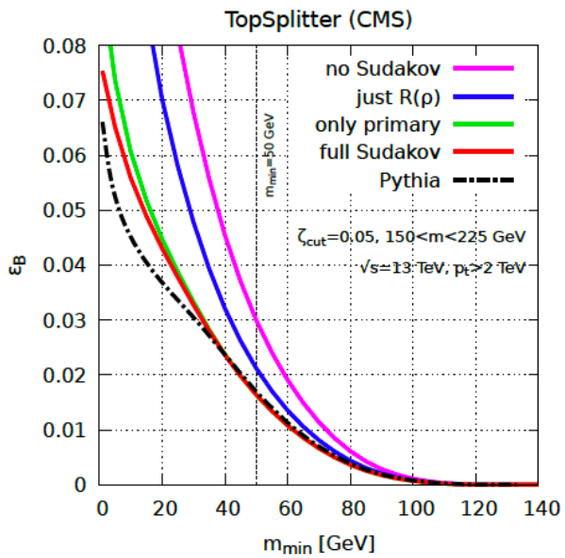
Measurements



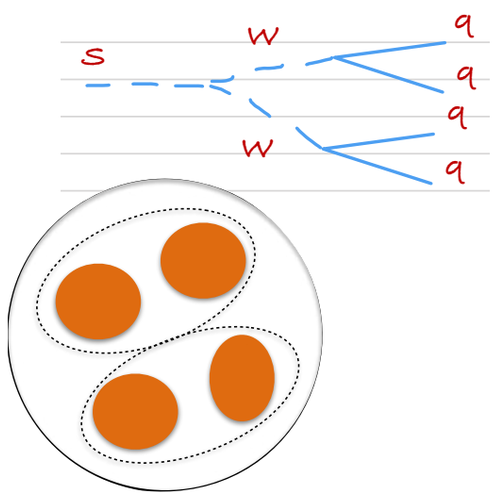
Searches



Strategies

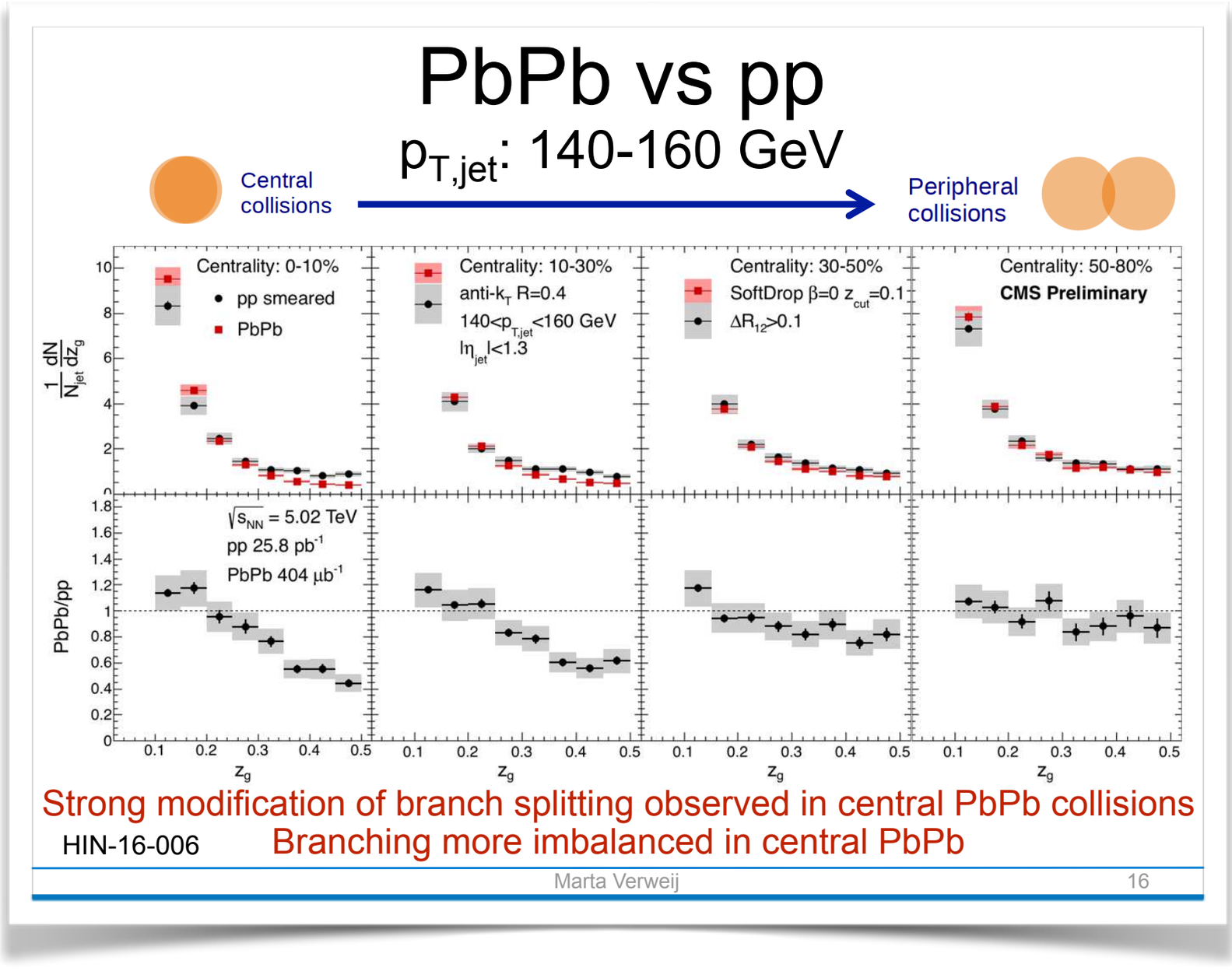


Calculations



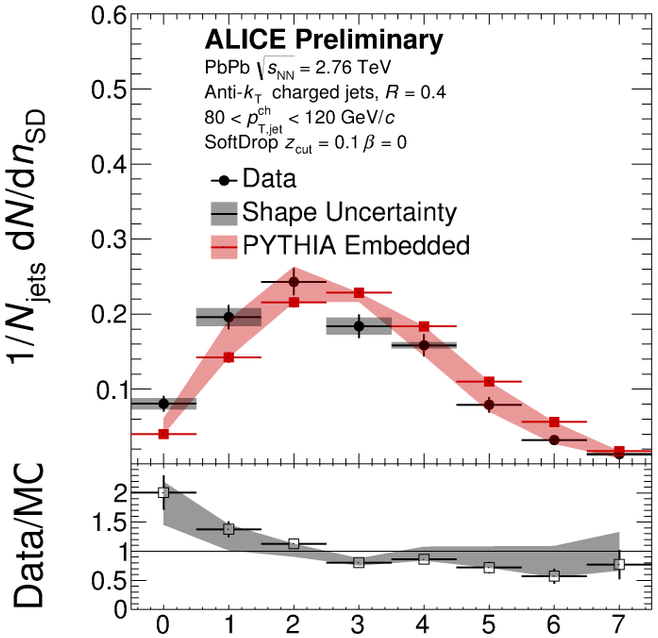
Applications

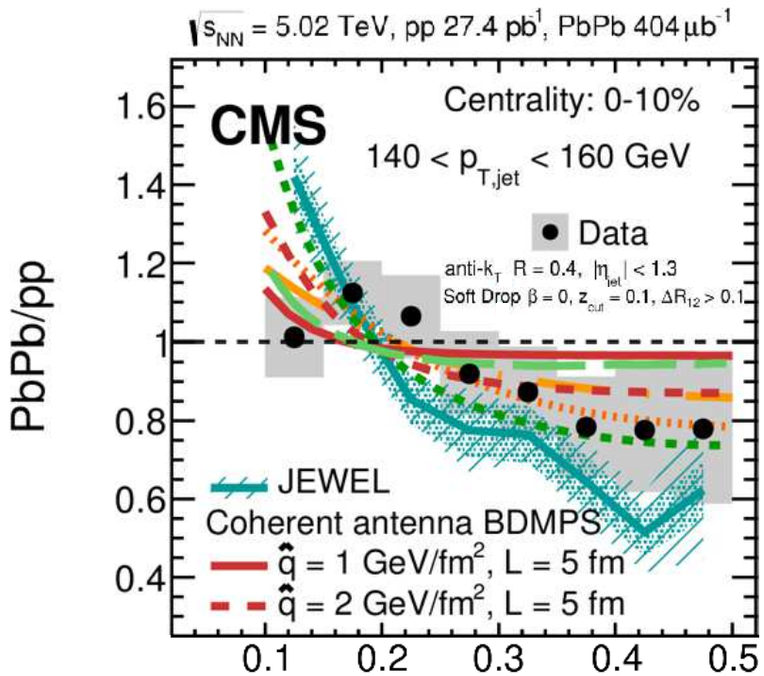
What was just beginning in 2016…

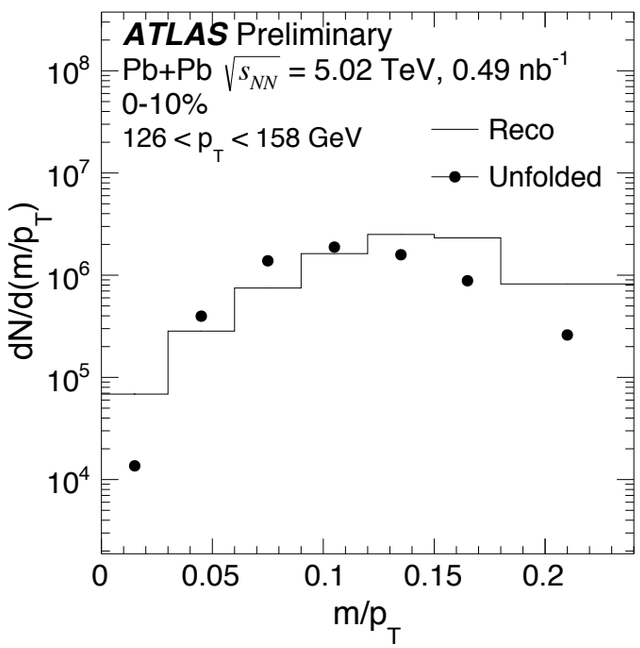


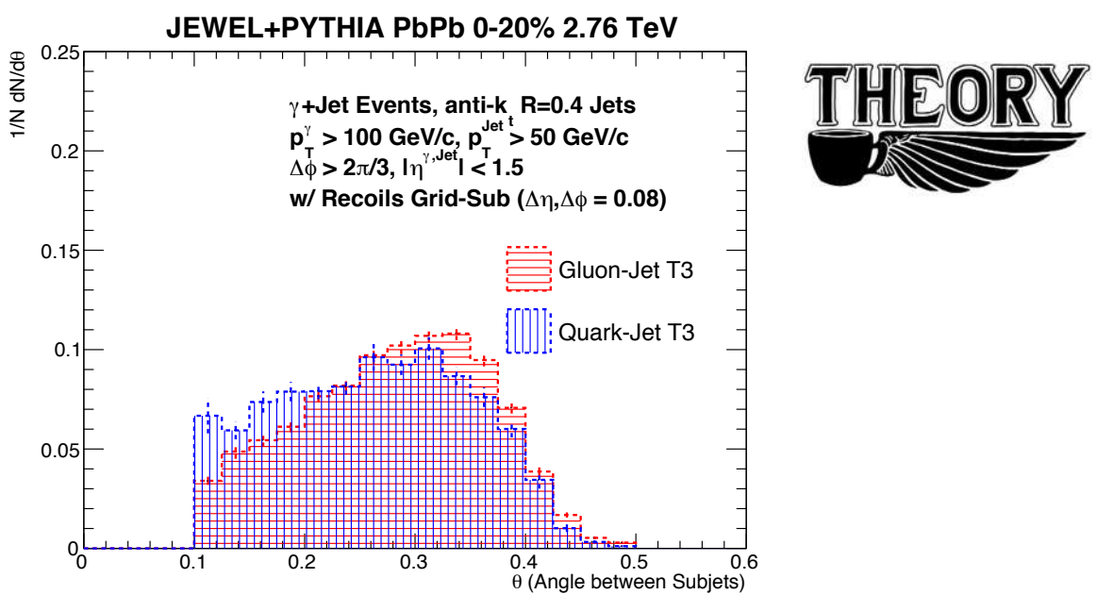
…now has a dedicated session!

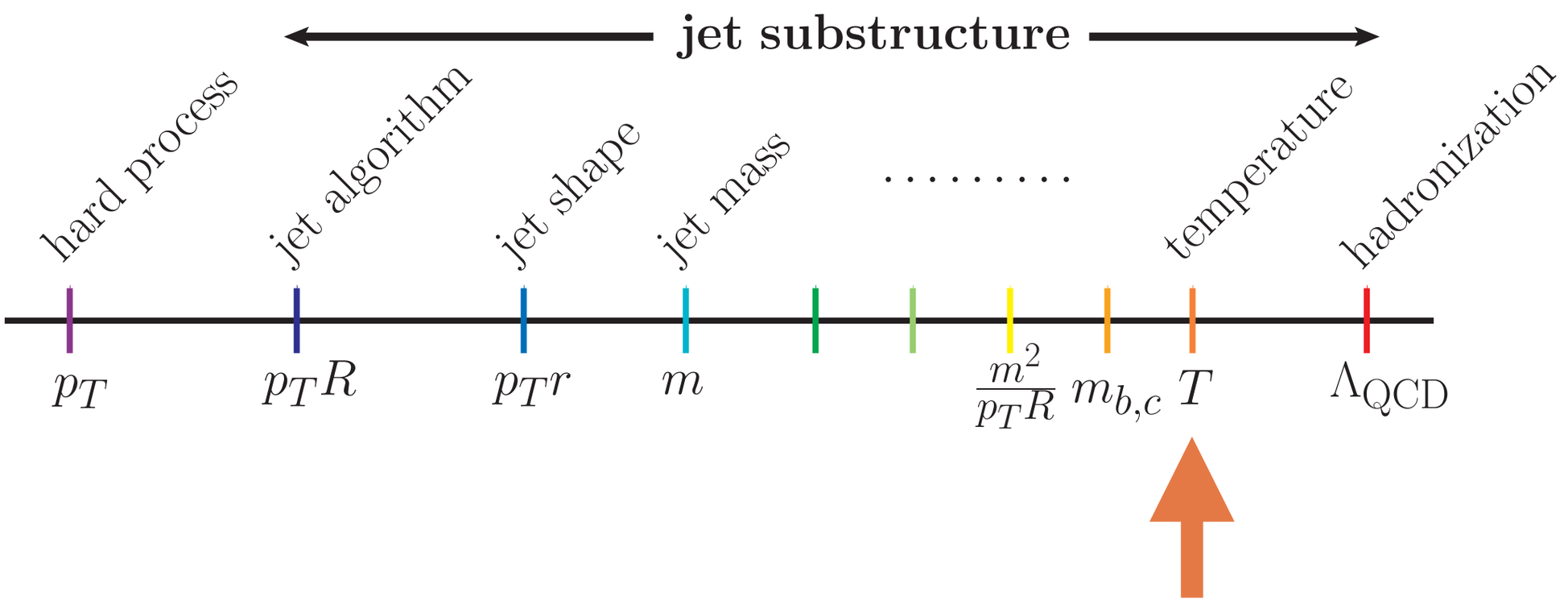
BOOST goes Nuclear










jet substructure
hard process
jet algorithm
jet shape
jet mass
.....
temperature
hadronization
p_T
$p_T R$
$p_T r$
m
$\frac{m^2}{p_T R}$
$m_{b,c}$
T
$\Lambda_{\rm QCD}$

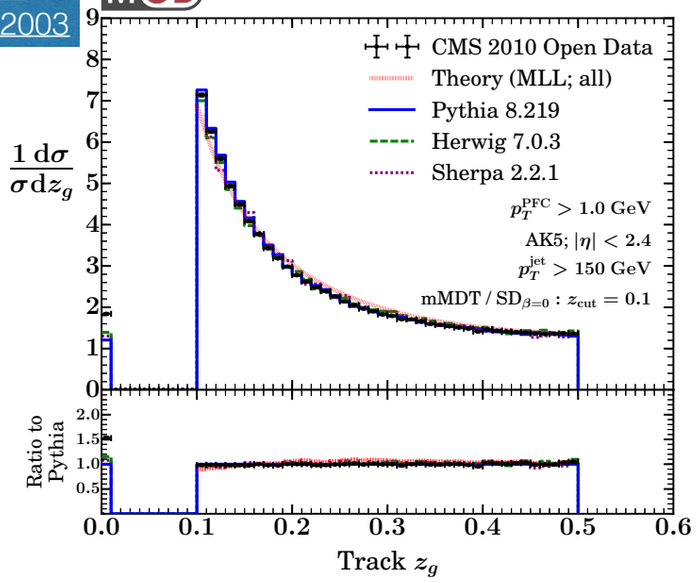
One important clarification…

Analysis

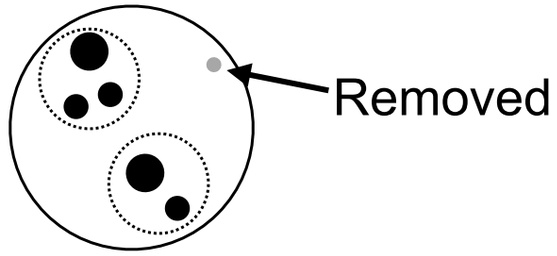
~~Measurement~~ of z_g in pp w/ Open Data

PRL 119 (2017) 132003

MOD



Work back thru clustering history



Identify subjets satisfying condition:

$$\frac{\min(p_{\mathrm{T},i}, p_{\mathrm{T},j})}{p_{\mathrm{T},i} + p_{\mathrm{T},j}} > z_{\mathrm{cut}} \left(\frac{\Delta R_{ij}}{R_0}\right)^{\beta}$$

- Successful application in open data with tracks in 7 TeV pp
- Good description by theory and generators

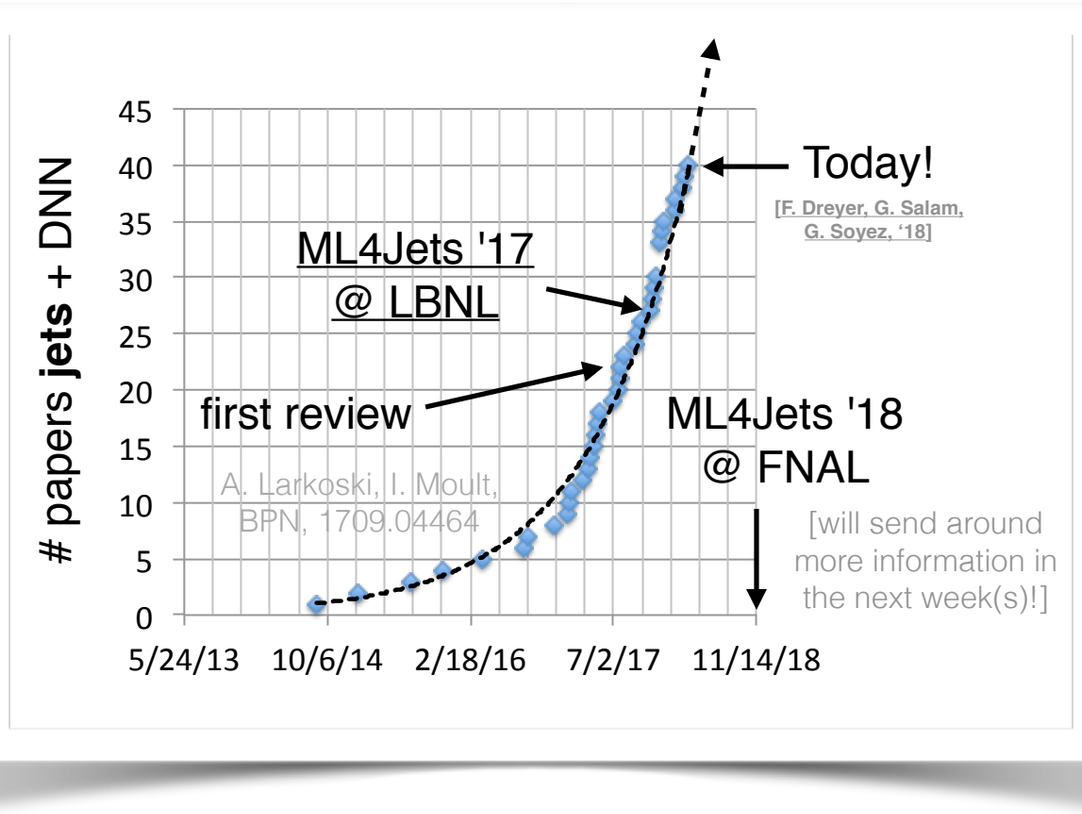
Christopher McGinn 7

A peace offering to ATLAS. May I analyze your data, s'il vous plaît?

What was disquieting in 2016…

"Deep Learning" vs. "Deep Thinking"

…is now a vibrant subfield!



Machine Learning for Jets Physics

14-16 November 2018
Fermilab
America/Chicago timezone

https://indico.cern.ch/event/745718/

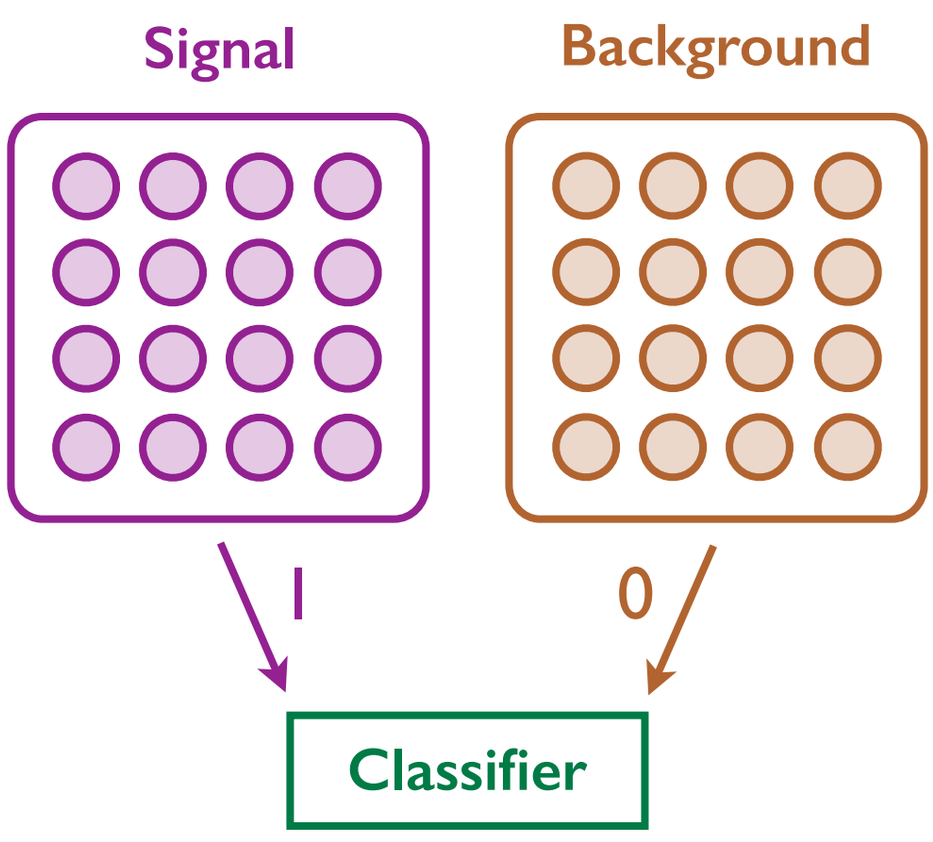
A Cartoon of Machine Learning

For fully-supervised jet classification

(also regression, generation, modeling, etc.)

$$\ell_{\text{MSE}} = \Big\langle (h(\vec{x}) - 1)^2 \Big\rangle_{\text{signal}} + \Big\langle (h(\vec{x}) - 0)^2 \Big\rangle_{\text{background}}$$

Classifier Inputs



Minimize Loss Function

(assuming infinite training sets)

$$h(\vec{x}) = \frac{p_{\text{sig}}(\vec{x})}{p_{\text{sig}}(\vec{x}) + p_{\text{bkgd}}(\vec{x})}$$

Optimal Classifier (Neyman–Pearson)

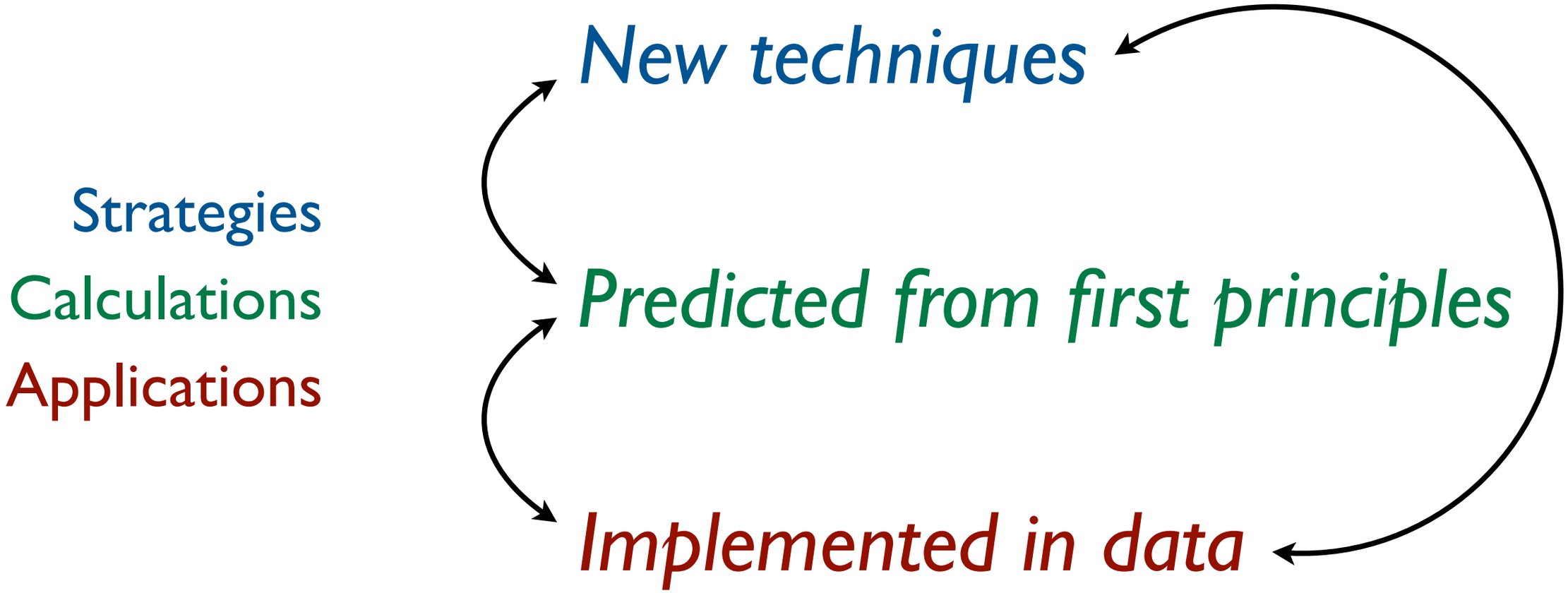
The Broader Lesson

"Deep Learning" & ~~vs.~~ "Deep Thinking"

New first-principles studies of QCD
facilitated by advances in
statistics, mathematics, and computer science

Desired Outcomes ⇔ Algorithms/Observables

My Favorite Theory Threads



Great for pushing the boundaries of our field!

Not so great for writing a theory summary talk…

Broad Range of Theory Topics/Themes

Strategies

SIFT: Scale-Invariant Jet Finding
Diverse Representations of Jets
Novel Observables from Machine Learning
Jet Tagging with RecNNs
Infrared Safety of CNN Top Tagging
Novel Taggers from Encoded Data
Weak Supervision in High-Dimensional Spaces
Jet Topics for Quark/Gluon Definitions
Probabilistic Modeling with JUNIPR
Energy Flow Networks
Learning from the Lund Plane

Exploiting Symmetries

Machine Learning

Data-Driven Methods

Unsupervised Learning

Using Domain Knowledge

Calculations

Educating the Next Generation
Quarks Jet Rates in Multi-Jet Final States
Analytic Perspective on Top Taggers
Calculating the Pull Angle
Soft Gluons and Non-global Observables
Non-perturbative Effects in Grooming
Top Quark Mass in the Parton Shower
Improving Quark/Gluon Jets in Herwig

Beyond Single Prongs

Soft/NP QCD Effects

Heavy Quark Physics

Parton Shower Progress

Applications

Physics Program for Precision Jet Substructure
All-hadronic W Mass Measurement
Jet Substructure for Medium Modifications
Searching for Stealth Bosons
Bump Hunting with CWoLa
Deep Learning on FPGAs

Precision Measurements

Heavy Ion Physics

Searches for Exotica

Transformative Triggers

Strategies

A Strategies Meta-Narrative

Exploiting Symmetries	BOOST will always welcome new techniques based on theoretical insights into high-energy particle collisions
Machine Learning	But machine learning has set a new standard for versatility and performance which cannot be ignored
Data-Driven Methods	The rise of data-driven strategies has significantly mitigated concerns about "black box" algorithms
Unsupervised Learning	The rise of unsupervised strategies has opened the door to the machine teaching us, instead of vice versa
Using Domain Knowledge	Still, machine learning will be most powerful and robust when joined to theoretical insights

SIFT: Scale-Invariant Jet Finding

Joel Walker

SCALE INVARIANT

$$\delta_{AB} \equiv \frac{\Delta M_{AB}^2}{E_{\mathrm{T}A}^2 + E_{\mathrm{T}B}^2}$$

New clustering metric

FILTER

$$\delta_{AB} < \frac{2E_{TA}^2 E_{TB}^2}{(E_{TA}^2 + E_{TB}^2)^2}$$

Grooming in the clustering

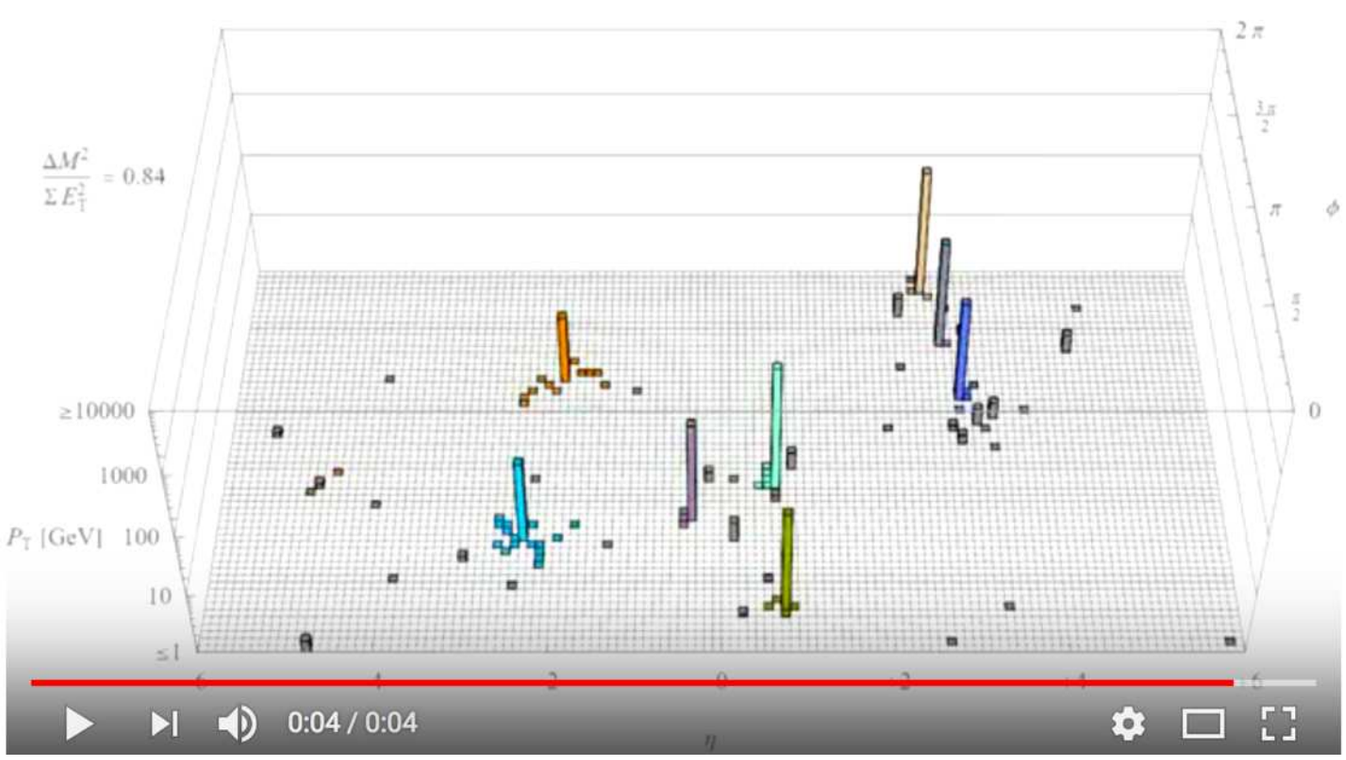
TREE

"Balanced KD-Tree" framework

$\mathcal{O}(N \log N)$

Fast implementation

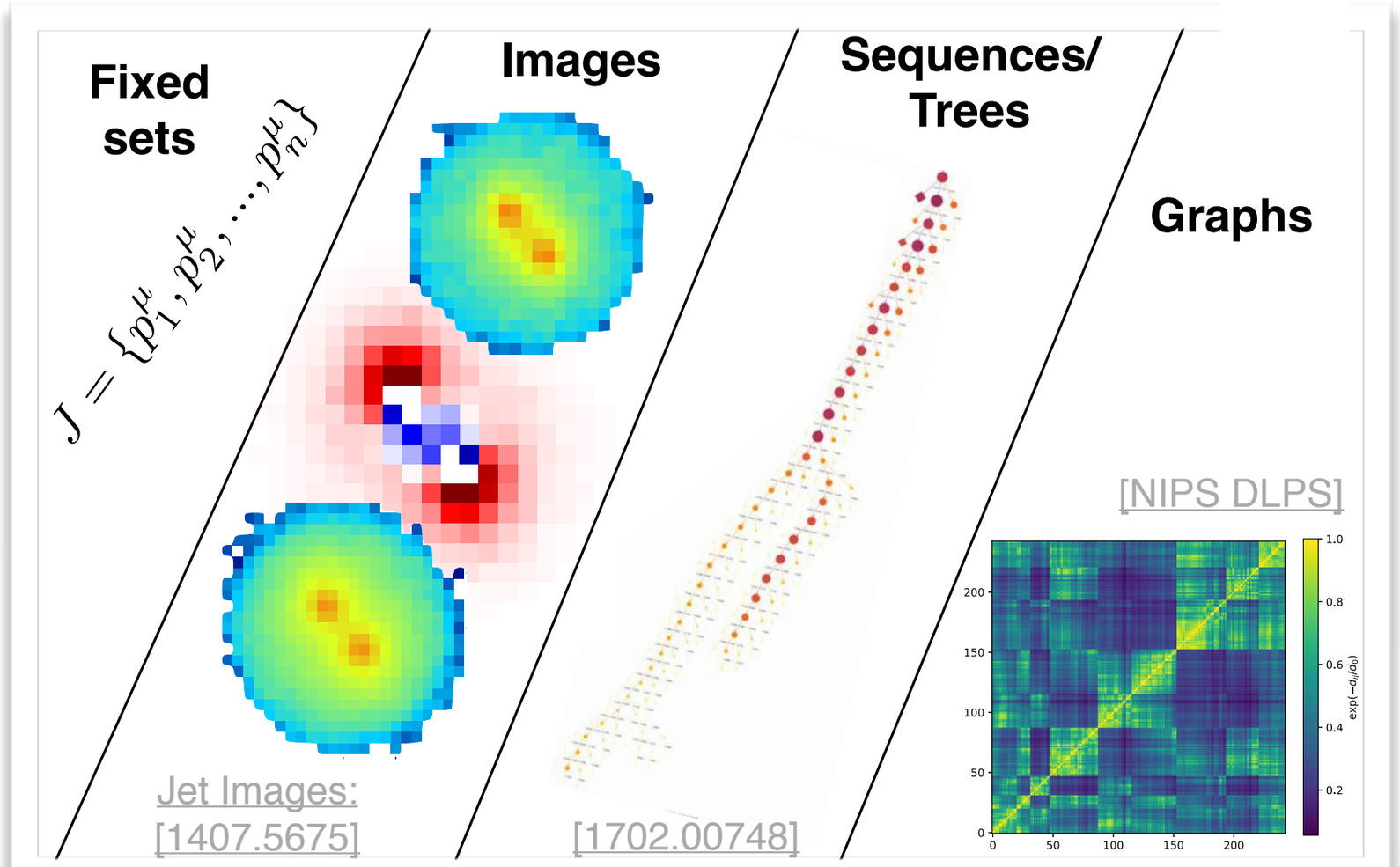
Hadronic TTbar SIFT-ing:



Diverse Representations of Jets

Ben Nachman (more later)

Different ML inputs…



…have corresponding natural ML tool!

Novel Observables from Machine Learning

Kaustuv Datta

Determine the *M*-body phase space at which discrimination power saturates

$$\left\{\tau_1^{(0.5)}, \tau_1^{(1)}, \tau_1^{(2)}, \tau_2^{(1)}, \tau_2^{(2)}\right\}$$

Construct a function of these 3*M* - 4 variables with tunable parameters

$$\beta_3 = \left(\tau_1^{(0.5)}\right)^a \left(\tau_1^{(1)}\right)^b \left(\tau_1^{(2)}\right)^c \left(\tau_2^{(1)}\right)^d \left(\tau_2^{(2)}\right)^e$$

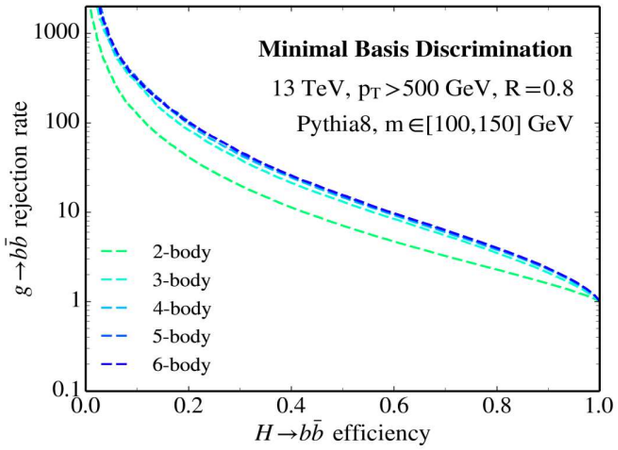
Fix parameters by maximizing a discrimination metric

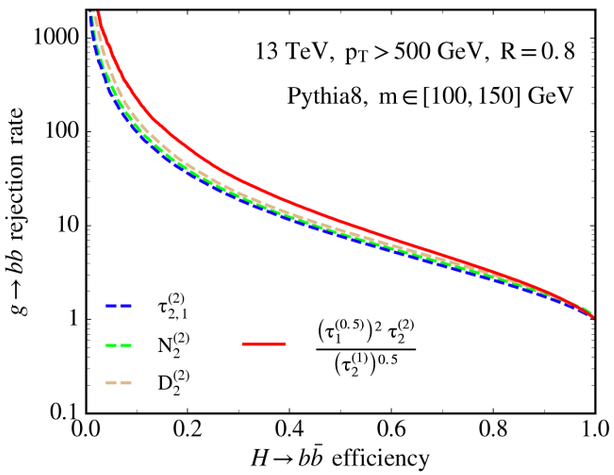
e.g. Ungroomed Case, g → bb vs. H → bb

Random Scan: $\beta_3 = \dfrac{\left(\tau_1^{(0.5)}\right)^2 \left(\tau_2^{(1)}\right)^{0.5}}{\tau_2^{(2)}}$

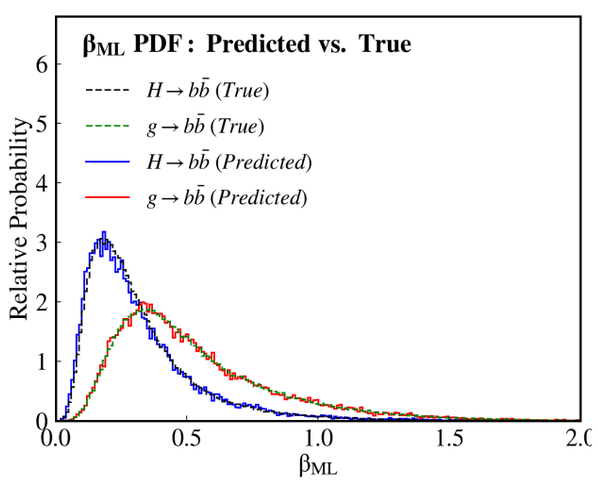
Machine Learning: $\beta_{ML} = \left(\tau_1^{(0.5)}\right)^{-1.67} \left(\tau_1^{(1)}\right)^{0.2} \left(\tau_1^{(2)}\right)^{-0.34} \left(\tau_2^{(1)}\right)^{-1.84} \left(\tau_2^{(2)}\right)^{1.72}$

Using ML to extract single interesting observable





Outperforms standard observables



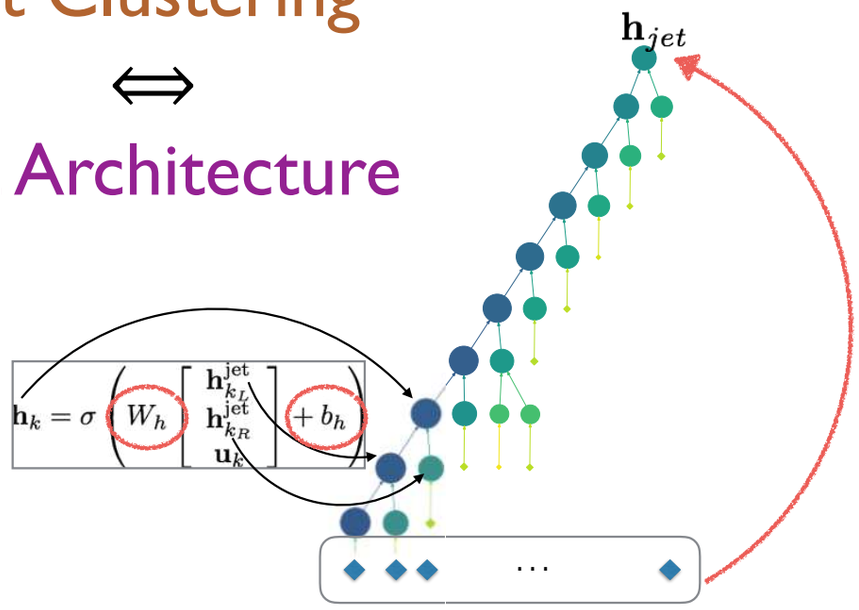
Jet Tagging with RecNNs

Taoli Cheng

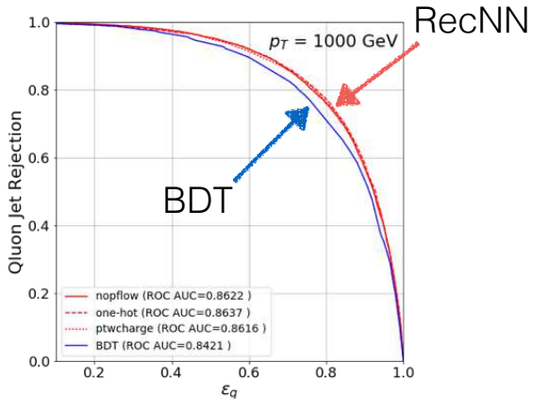
Jet Clustering

$\Longleftrightarrow$

ML Architecture



e.g. Quark/Gluon Discrimination



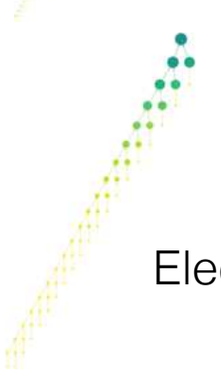
Variants	AUC	$R_{\epsilon=50\%}$
Baseline	0.8344	12.9
R=0.7	0.8210	12.4
$W_h \to R^{q\times 2q}$	0.8268	12.3
$W_h \to R^{q\times 2q}$ with one-hot	0.8313	13.7
$\mathbf{x}=(p_T, \eta, \phi)$	0.8291	11.8
$\mathbf{x}=(\eta, \phi)$	0.8249	11.9
$\mathbf{x}=(p_T)$	0.8264	11.6
only one-hot	0.8255	11.9
$\mathbf{x}=(Q^{\text{rec}}_{\kappa=50\%})$	0.8234	11.3

the discriminating information for q/g tagging is RecNN mainly reside in the tree structure itself

Visualizing Learned Information:

q/g Tagging

QCD Radiation



u/d Tagging

Electroweak

Tagging Application

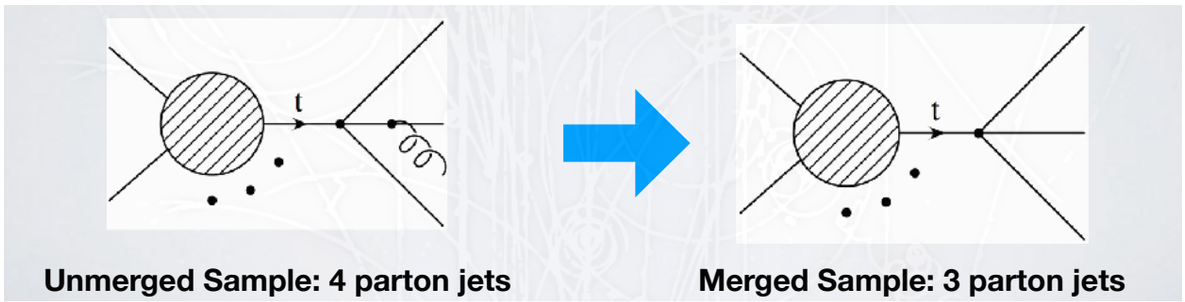
$\Longleftrightarrow$

Underlying Physics

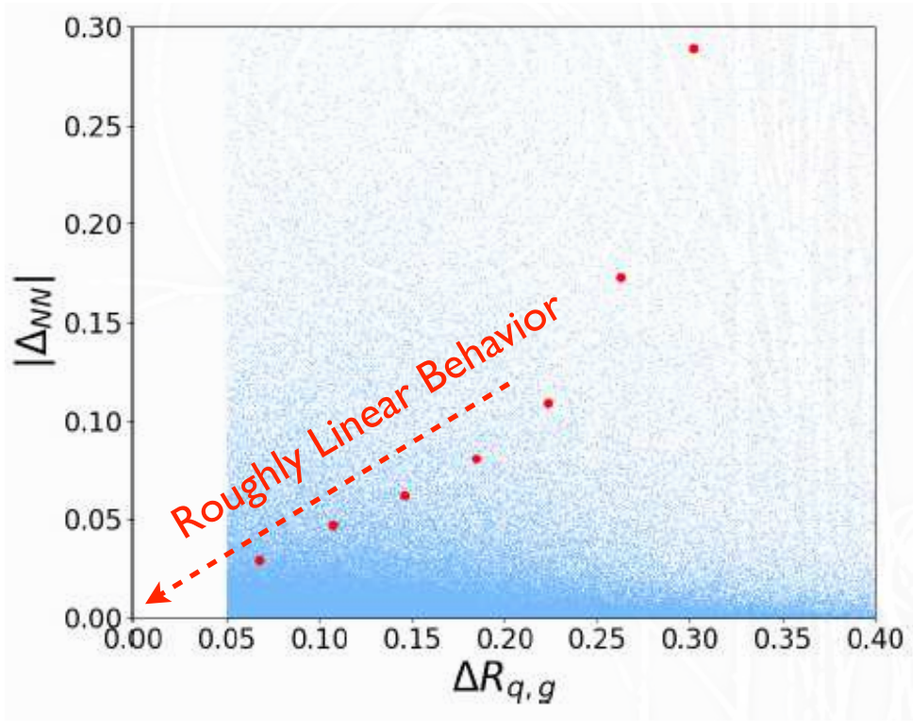
Infrared Safety of CNN Top Tagging

Seung Lee

Test degree of sensitivity to soft/collinear emissions



e.g. Collinear Scaling



Key Question:

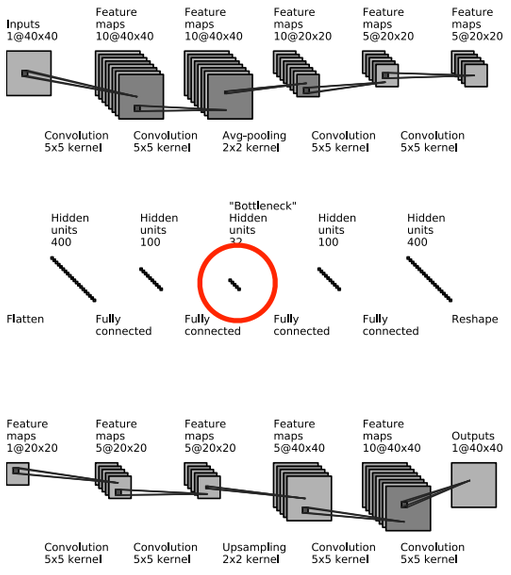
Can NN-based taggers trained on MC samples be used in real data analysis?

➜ depends on whether the features of jet substructure that are identified by machine learning as important for classification are in fact accurately modeled by the MC generator.

IRC safety is one probe of algorithm resilience

Novel Taggers from Encoded Data

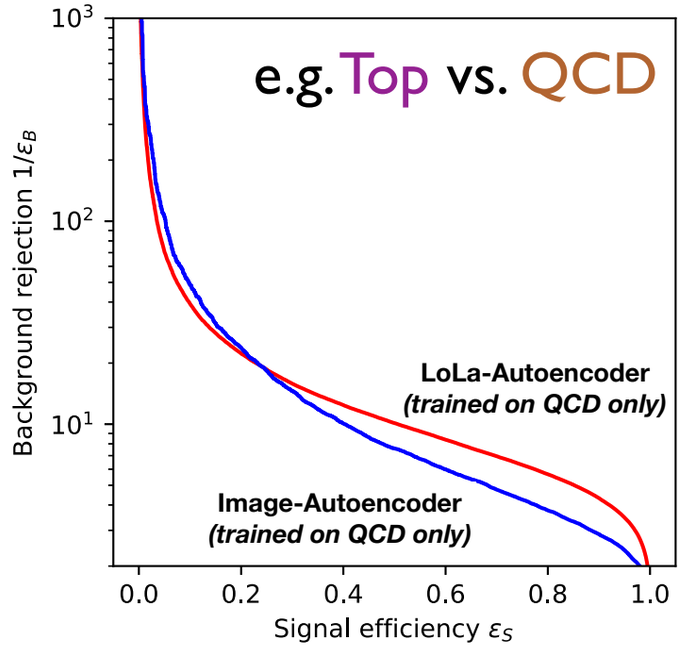
Jennifer Thompson



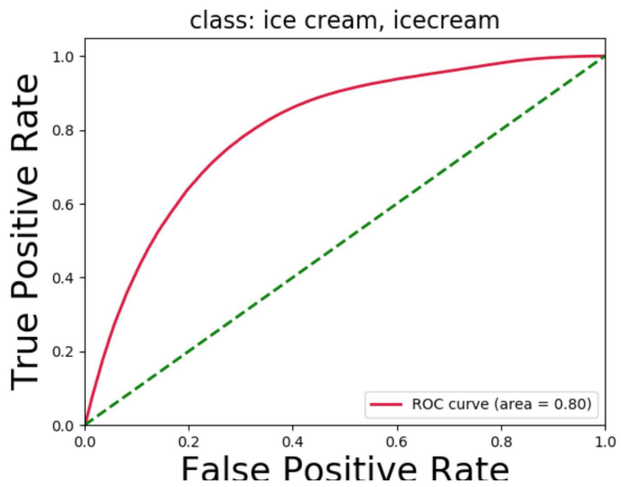
Autoencode data (= background)

e.g. Jet image through bottleneck

- **AUC=0.88 $\rightarrow$ with a network that has never seen signal**



Or train with a network that has seen neither signal nor background…

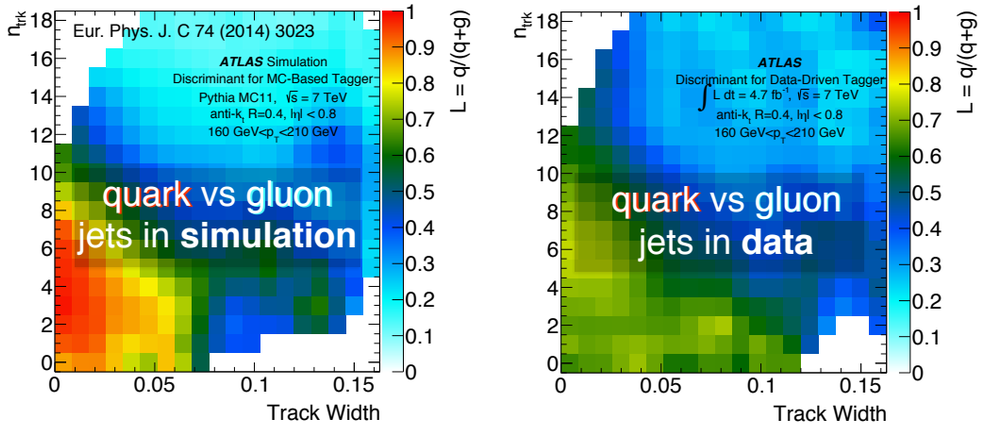


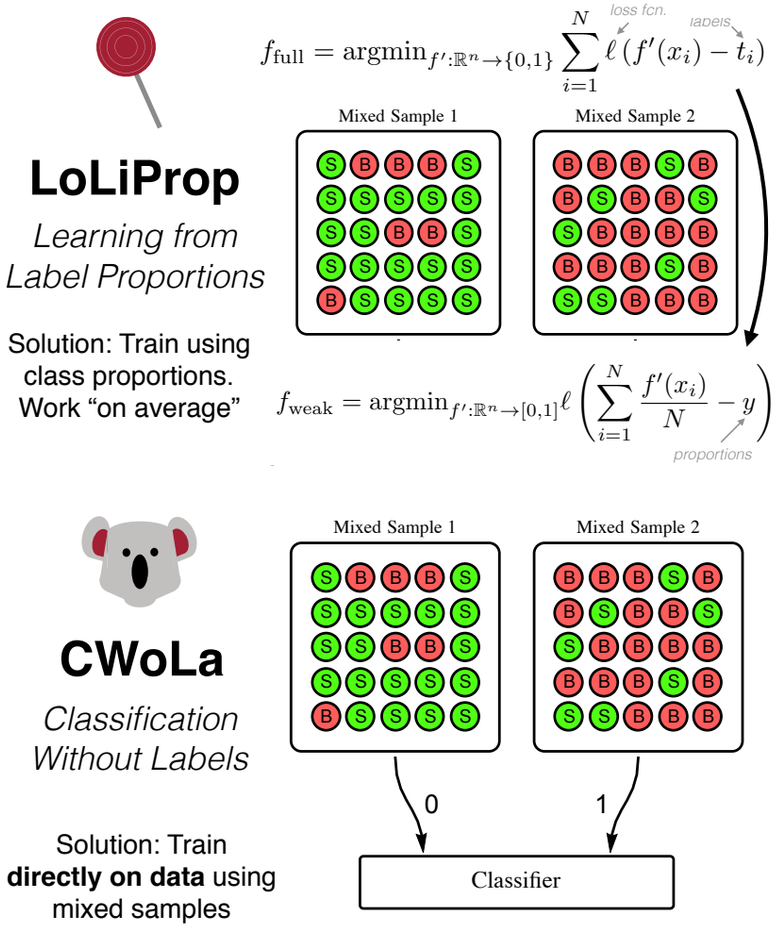
Samples are available: https://goo.gl/XGYju3

Weak Supervision in High-Dimensional Spaces

Ben Nachman

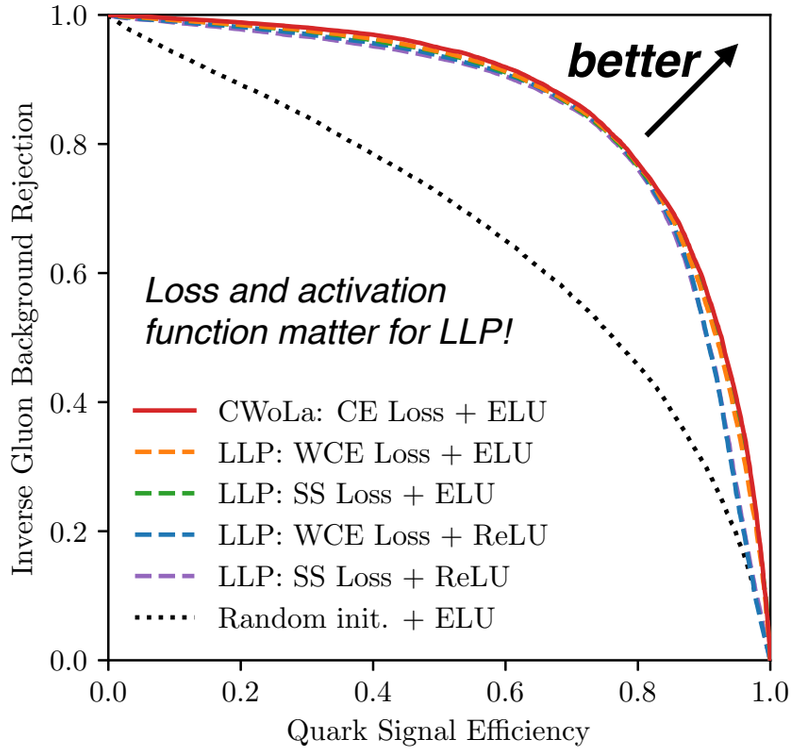
Training on simulation is suboptimal





Learn directly from data!

(works even on 33x33 pixel jet image)



Jet Topics for Quark/Gluon Definitions

Eric Metodiev

Les Houches Logorrhea

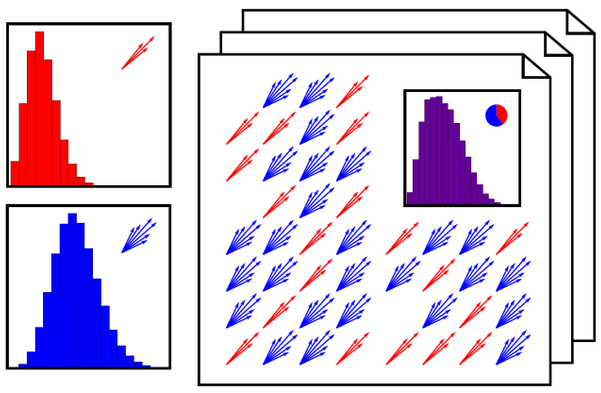
A phase space region (as defined by an unambiguous hadronic fiducial cross section measurement) that yields an enriched sample of quarks (as interpreted by some suitable, though fundamentally ambiguous, criterion)

$\Rightarrow$

Operational Definition

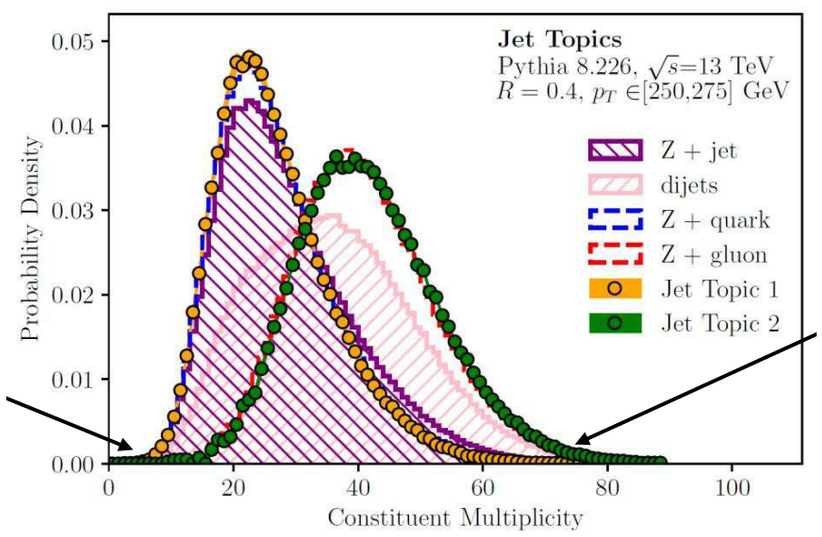
$$p_{\text{quark}}(x) \equiv \frac{p_A(x) - \kappa_{AB}\, p_B(x)}{1-\kappa_{AB}} \qquad p_{\text{gluon}}(x) \equiv \frac{p_B(x) - \kappa_{BA}\, p_A(x)}{1-\kappa_{BA}}$$

Use insights from topic modeling

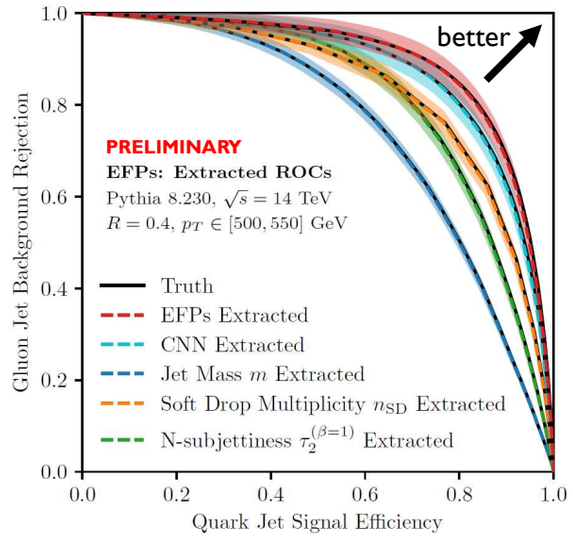


Key: Anchor Bins

"…and then you just solve."



Towards self-calibrated classifiers

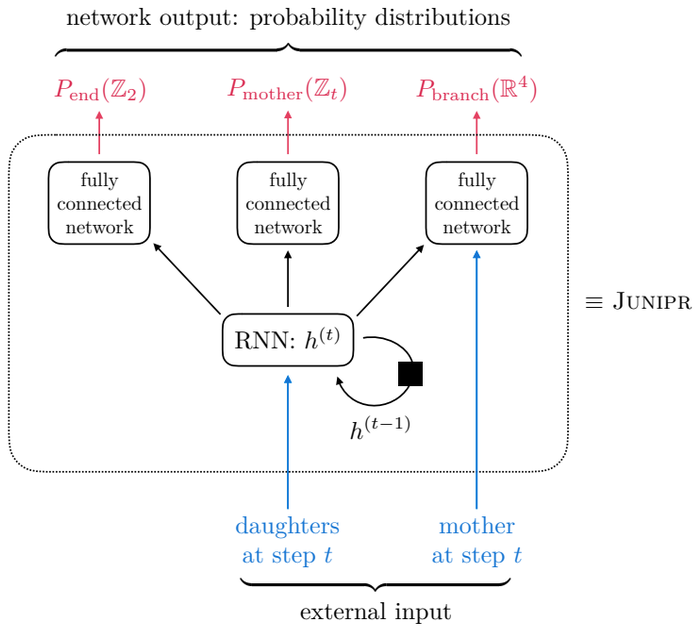


Probabilistic Modeling with JUNIPR

Christopher Frye

Learning from the machine:

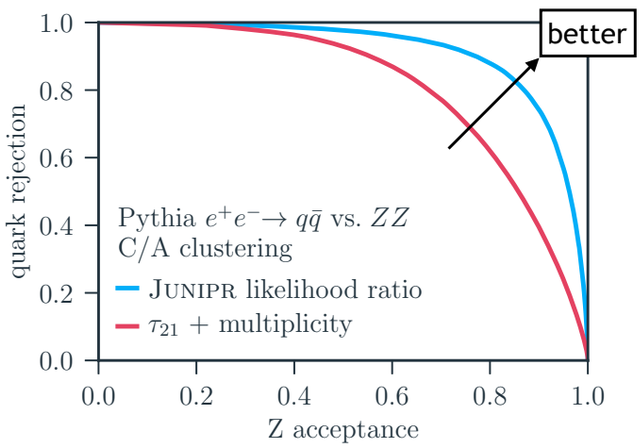
$$P_{\text{jet}}(\{p_1 \dots p_n\}) = \prod_{t=1}^{n} P_t$$



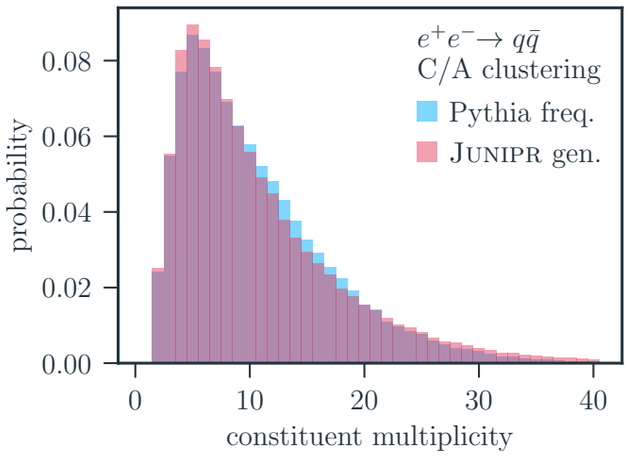
≡ JUNIPR

- inspired by QCD shower
- but fit any non-QCD structure
- interpret output from intermediate layers!

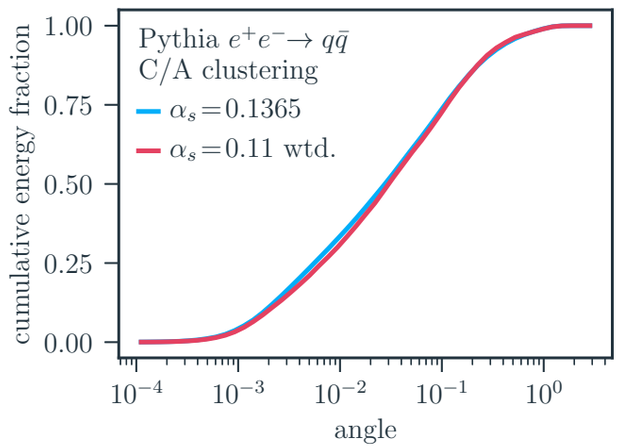
Discrimination from likelihood ratio



Generative model from probability



Novel reweighting procedure



Energy Flow Networks

Patrick Komiske

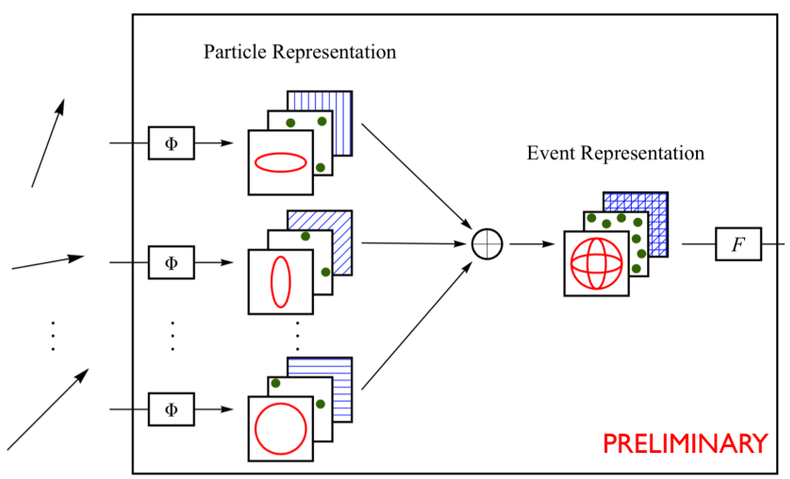
Act 1: Relabeling symmetry: Particle index is arbitrary

Act 2: Desire a manifest relabeling symmetry of model

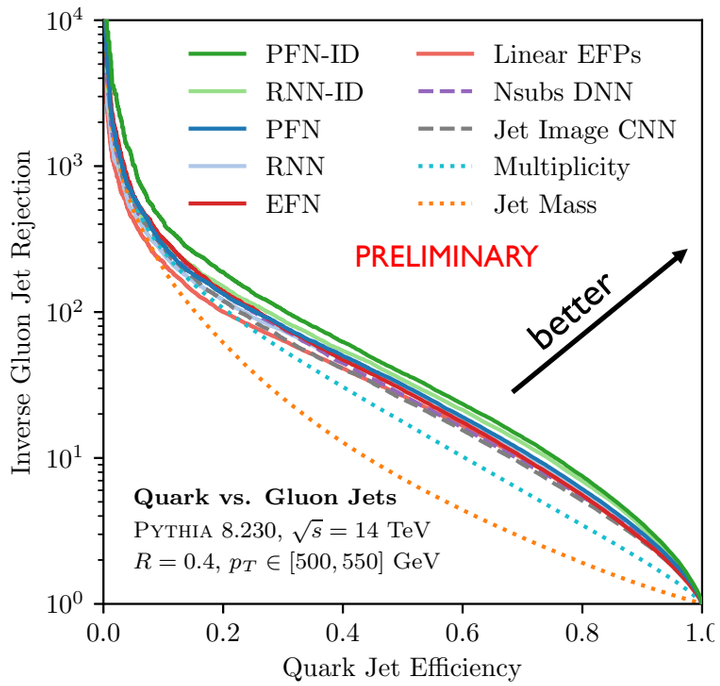
"If in the first act you have hung a pistol on the wall, then in the following one it should be fired." — Chekhov

Symmetry-Based Architecture

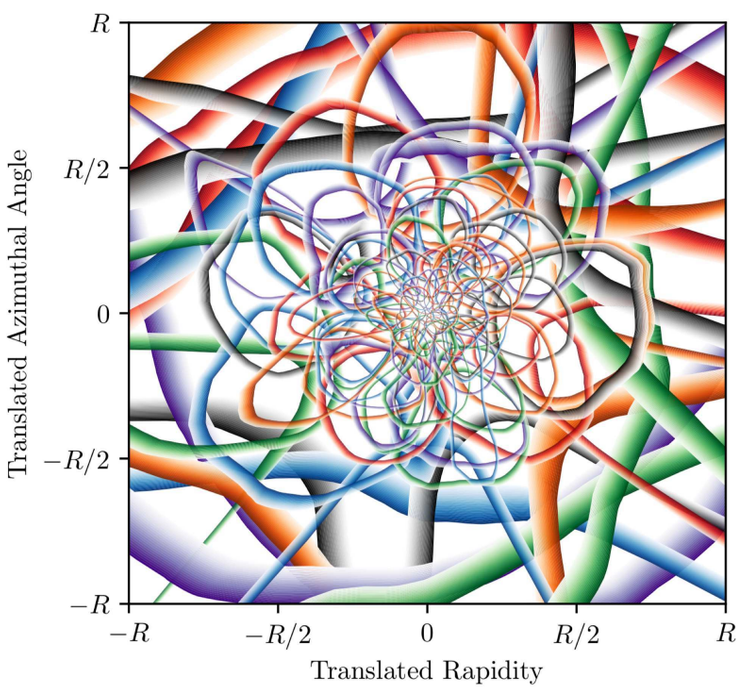
$$\mathrm{EFN}\left(\{p_1^\mu, \ldots, p_M^\mu\}\right) = F\left(\sum_{i=1}^{M} z_i \boldsymbol{\Phi}(\hat{p}_i)\right)$$



Good Tagging Performance



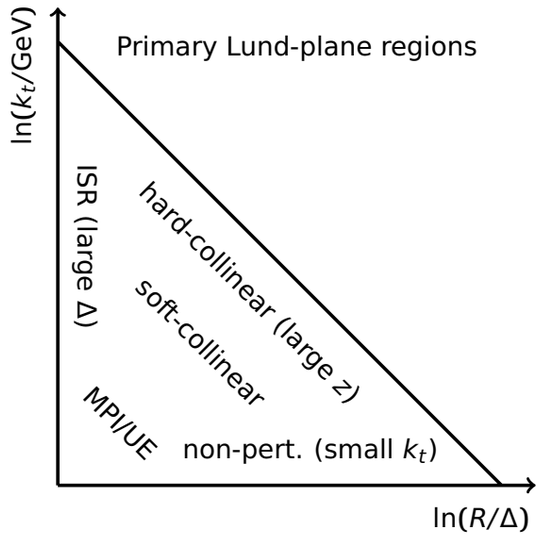
Psychedelic Visualization

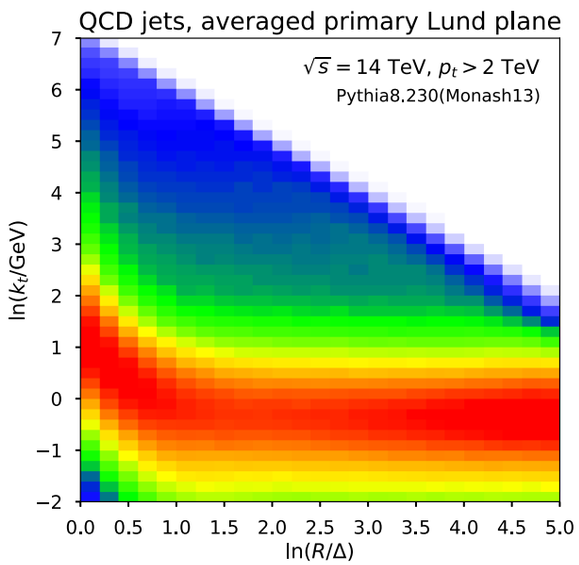


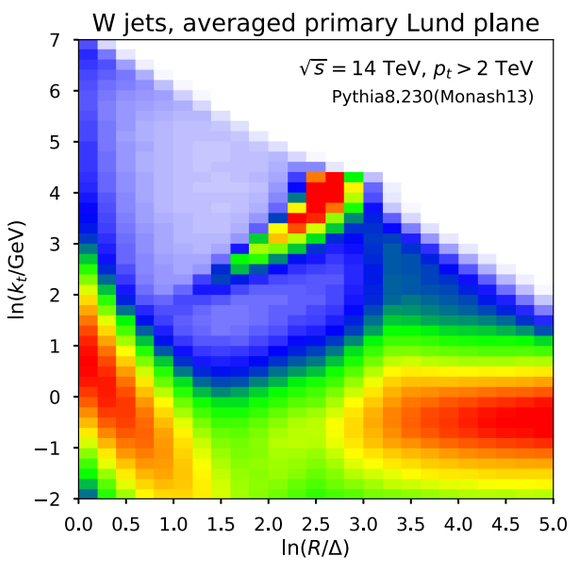
Learning from the Lund Plane

Frédéric Dreyer

Instructive Visualization of Primary Jet Emissions:

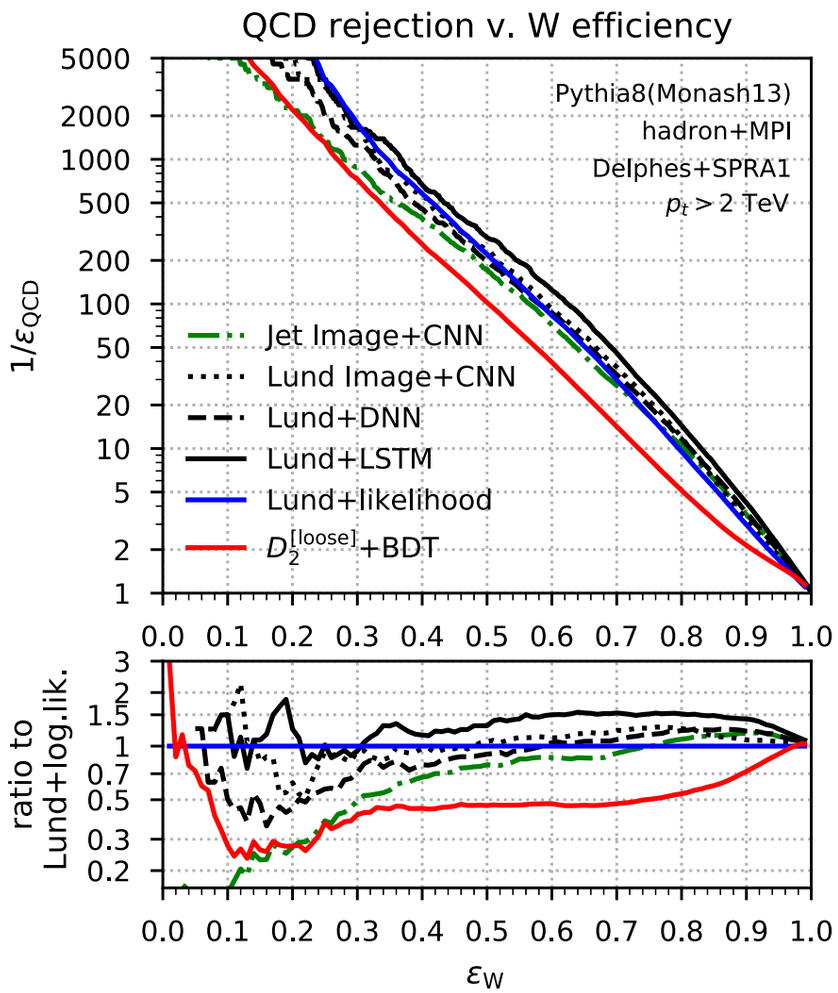






Jet Tagging Applications

(Direct Likelihood or Deep Network)



Broad Range of Theory Topics/Themes

Strategies

SIFT: Scale-Invariant Jet Finding
Diverse Representations of Jets
Novel Observables from Machine Learning
Jet Tagging with RecNNs
Infrared Safety of CNN Top Tagging
Novel Taggers from Encoded Data
Weak Supervision in High-Dimensional Spaces
Jet Topics for Quark/Gluon Definitions
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Top Quark Mass in the Parton Shower
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Beyond Single Prongs

Soft/NP QCD Effects

Heavy Quark Physics

Parton Shower Progress

Applications

Physics Program for Precision Jet Substructure
All-hadronic W Mass Measurement
Jet Substructure for Medium Modifications
Searching for Stealth Bosons
Bump Hunting with CWoLa
Deep Learning on FPGAs

Precision Measurements

Heavy Ion Physics

Searches for Exotica

Transformative Triggers

Calculations

A Calculations Meta-Narrative

Beyond Single Prongs — Analytic calculations are now mature enough to handle multi-prong observables, providing essential insights

Soft/NP QCD Effects — The theory community is tackling thorny issues in challenging regions of QCD phase space

Heavy Quark Physics — The time is right to incorporate insights from heavy quark effective theory into jet substructure

Parton Shower Progress — Parton showers remain a collider physics workhorse and are evolving to incorporate lessons from BOOST

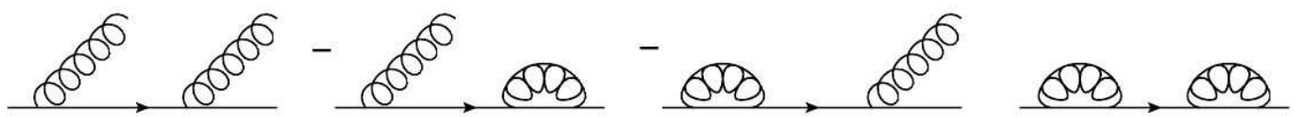
Educating the Next Generation

Lais Schunk (and Steven Schramm)

BOOST Camp 2018

Simple example : jet mass

- Only interested at the dominating term ~ $\alpha_s \log(1/\rho)^2 \rightarrow$ **Leading Logarithm (LL)**
- Virtual emissions → cancel out soft and collinear divergences.



$$\Sigma(\rho) = 1 - \frac{\alpha_s C_F}{\pi} \exp\left[\underbrace{-\frac{\alpha_s C_F}{2\pi} \log\left(\frac{1}{\rho}\right)^2}_{\text{Sudakov exponent}}\right]$$

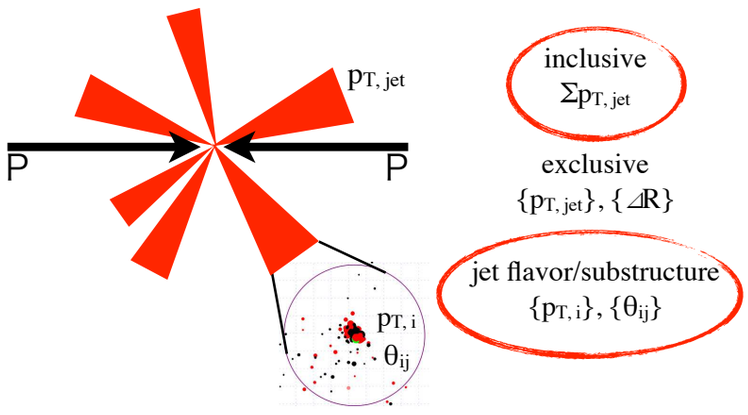
44

QCD theory fundamentals still essential for jet substructure intuition

Quarks Jet Rates in Multi-Jet Final States

Yasuhito Sakaki

From single quark/gluon discrimination to N-quark cross section

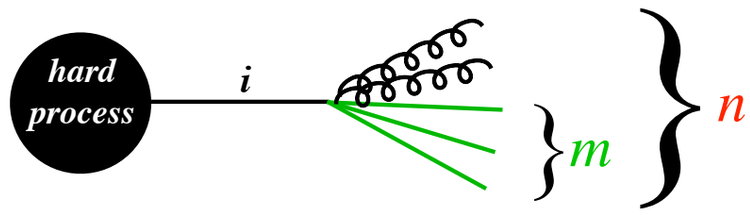


inclusive
$\Sigma p_{T,\,jet}$

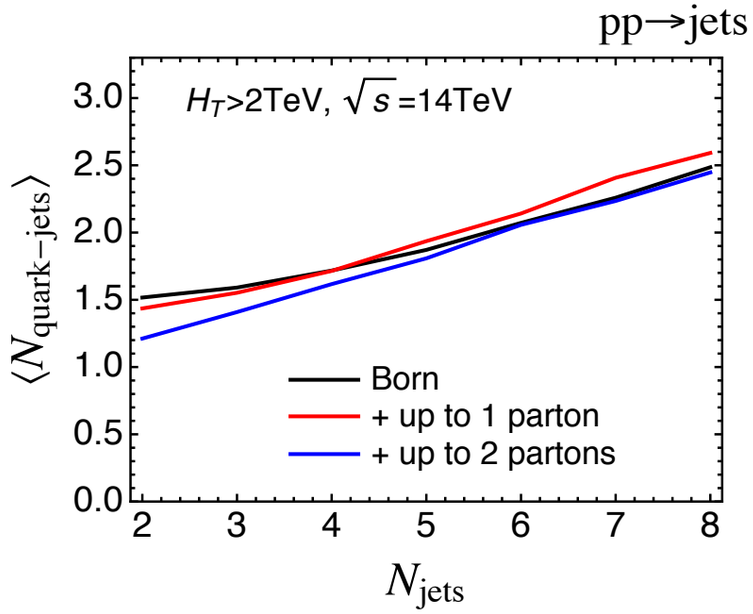
exclusive
$\{p_{T,\,jet}\}, \{\Delta R\}$

jet flavor/substructure
$\{p_{T,\,i}\}, \{\theta_{ij}\}$

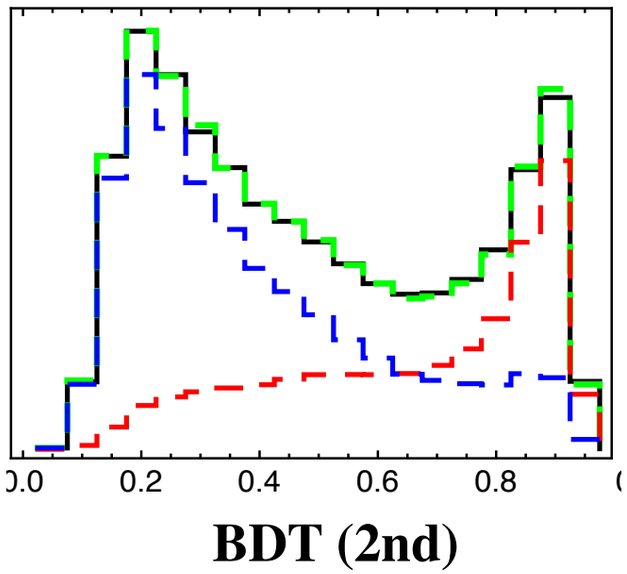
$R^{i}_{n,m}$: Probability that i emits n jets in which m quark jets are contained



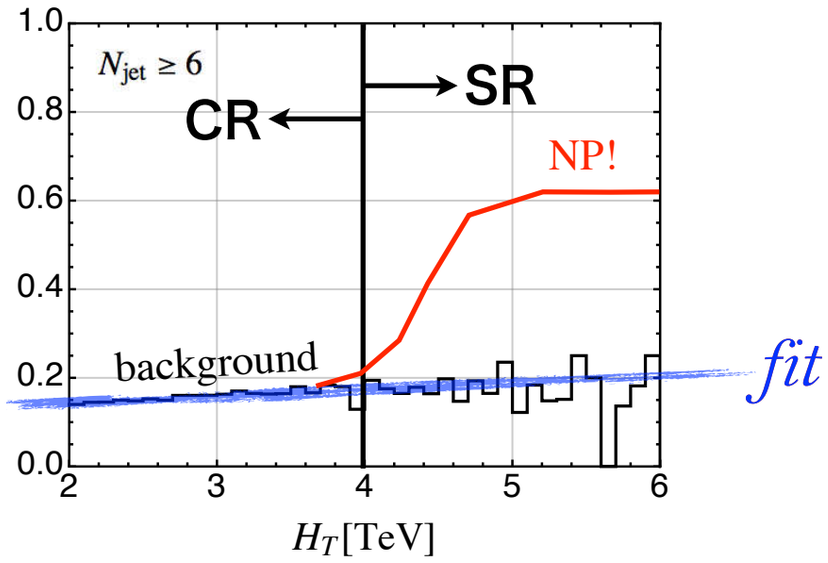
Predict with generating functionals



Extract with template analysis



Apply to BSM searches



Analytic Perspective on Top Taggers

Marco Guzzi

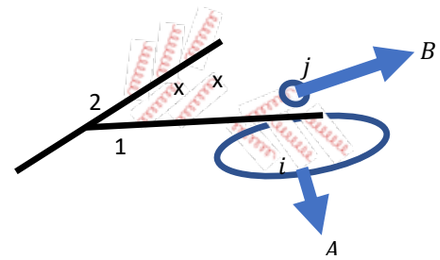
Modified Strategies:

CMS Top tagger

This method is collinear unsafe!

inspires ⇒

`Top-splitter` tagger

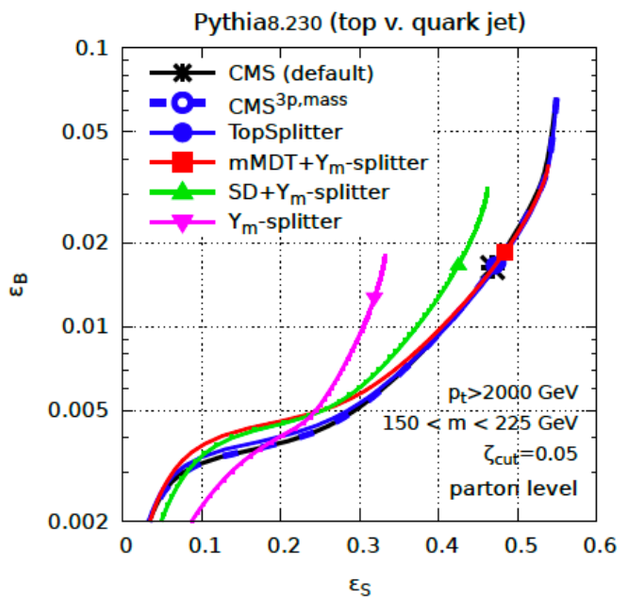


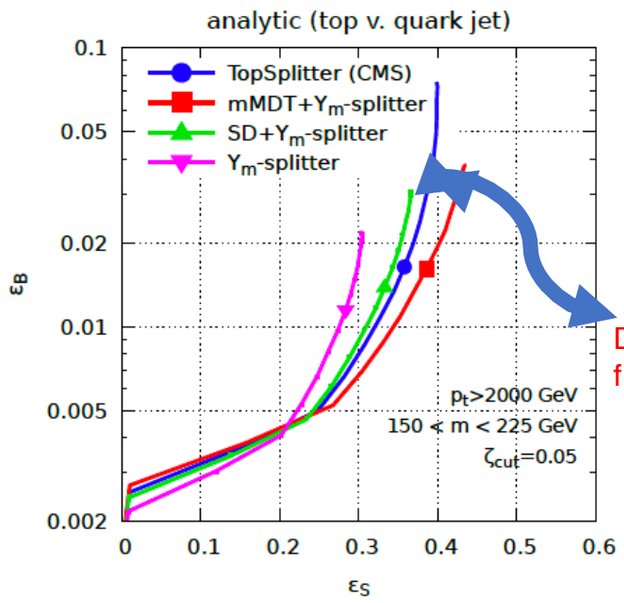
Modified LL Calculation:

Triple collinear splitting functions

Inclusion of a Sudakov Form Factor

Importance of resummation for signal modeling:





Differences come from the signal

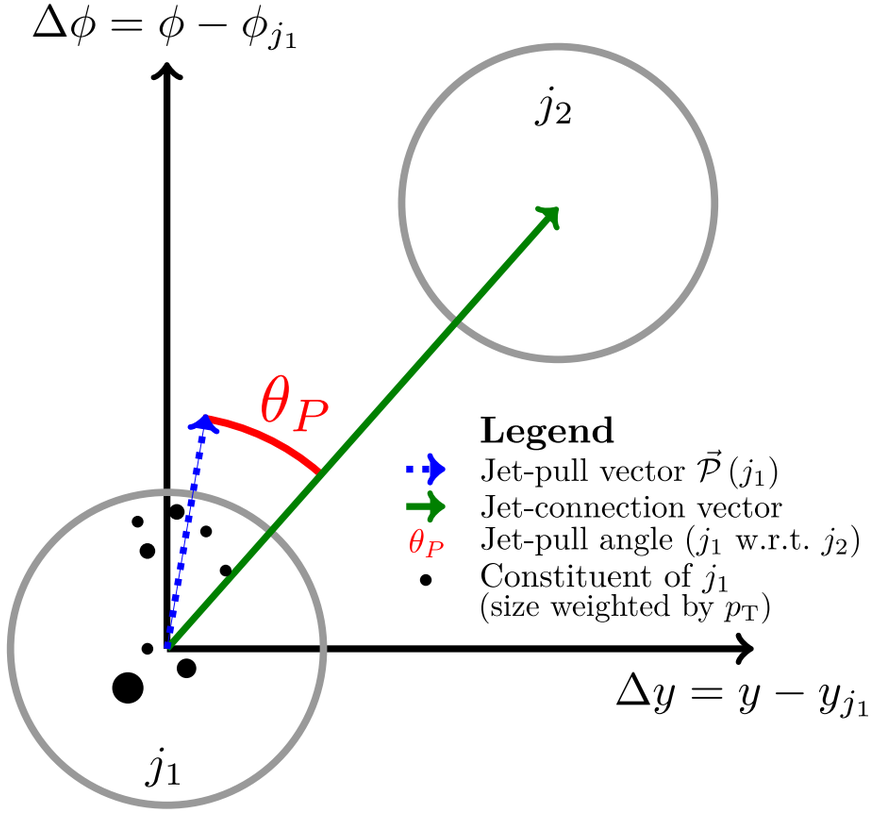
Calculating the Pull Angle

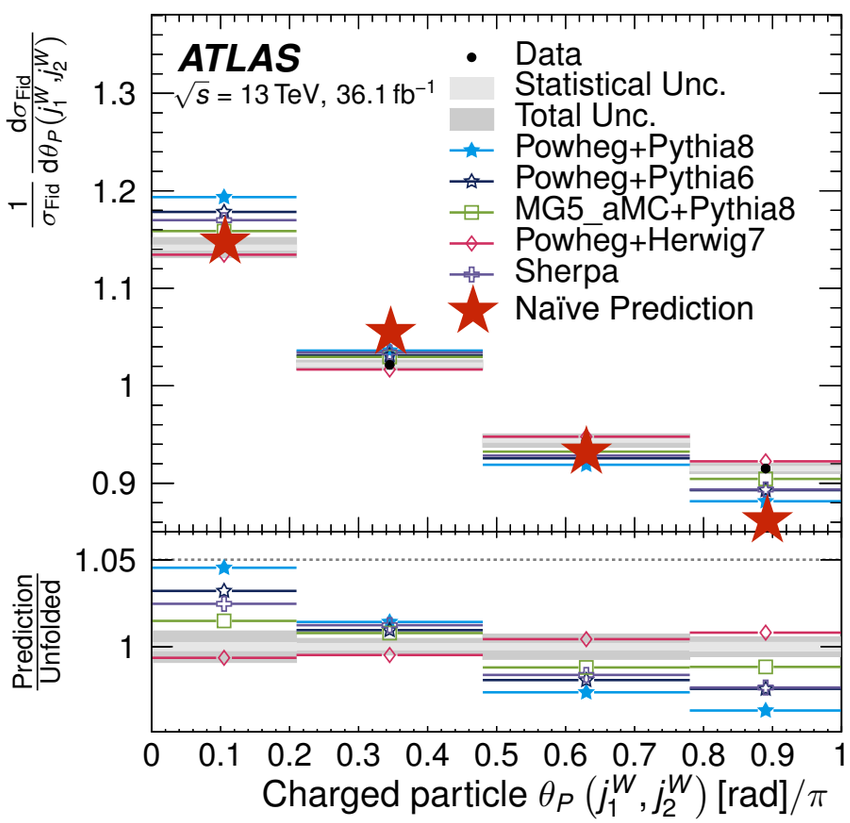
Andrew Larkoski

Not infrared or collinear safe

Nevertheless, it is Sudakov safe[TM] ← Theoretical Machinery

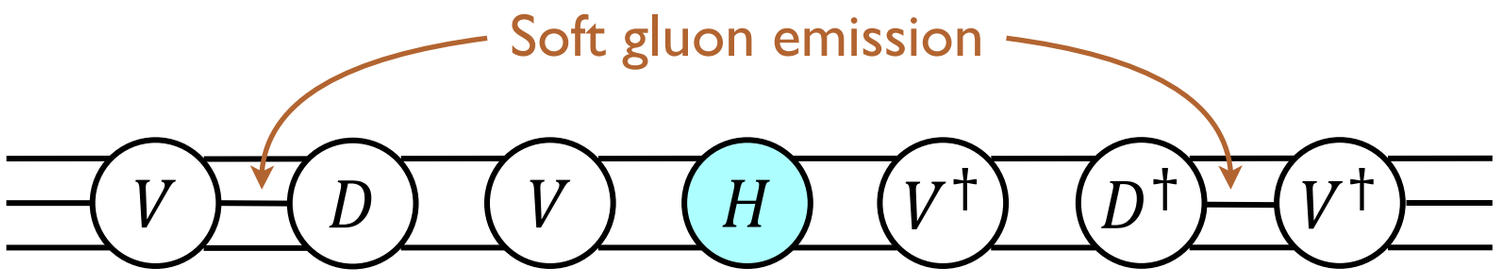
$$\text{IRC unsafe} \longrightarrow \frac{d\sigma}{d\theta_P} \equiv \int dt\, \frac{d^2\sigma}{dt\, d\theta_P} \longleftarrow \text{IRC safe} \qquad = \int dt\, \Delta_{\text{Sud}}(t)\, \frac{d^2\sigma^{\text{fo}}}{dt\, d\theta_P}$$

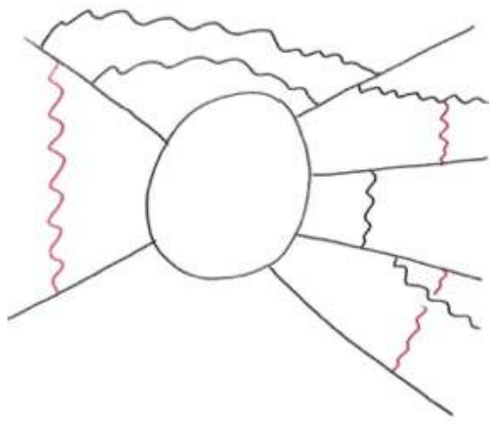




Soft Gluons and Non-global Observables

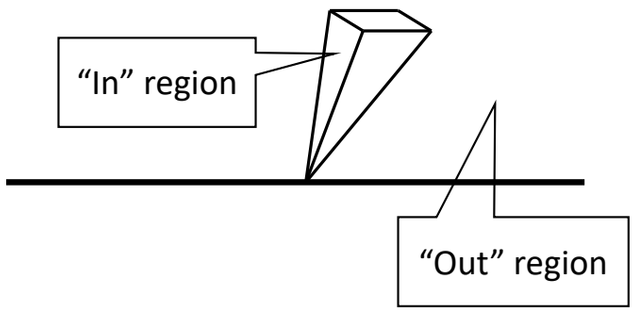
Mike Seymour





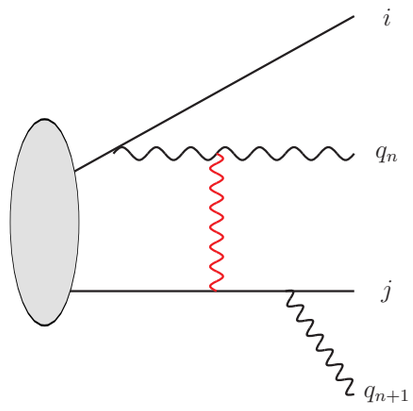
Build an "amplitude-level parton shower"?

IR-finite reorganization

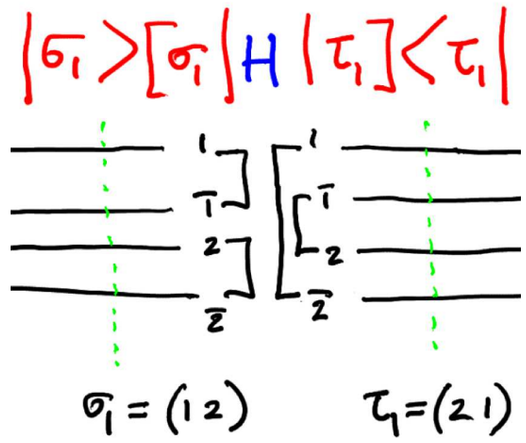


"out-of-gap gluon" expansion

Careful treatment of ordering variable

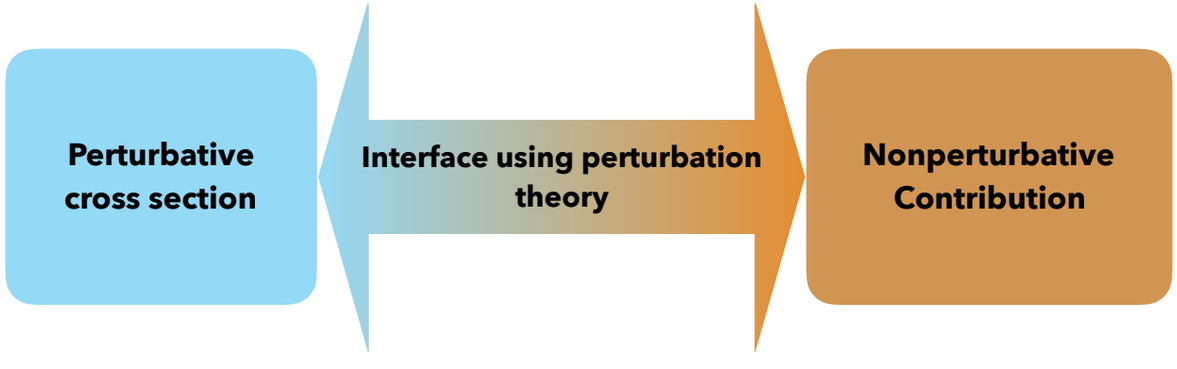


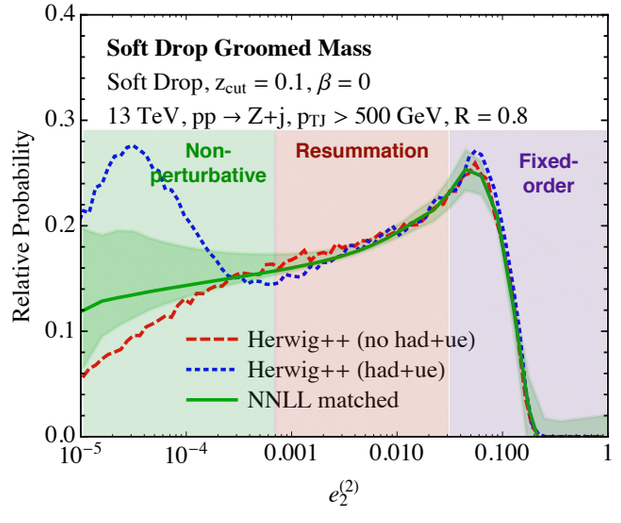
Transform to color flow basis



Non-perturbative Effects in Grooming

Aditya Pathak





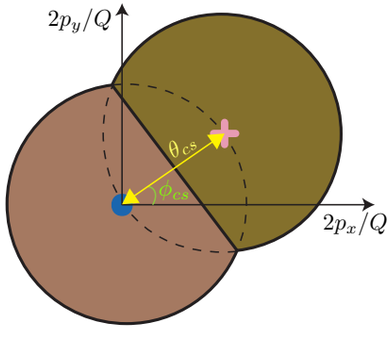
NLL Convolution:

$$\frac{d\sigma}{dm_J} = \sum_{\kappa=q,g} D_\kappa(\Phi_J, z_{\rm cut}, \beta, \mu) \int d\ell^+ \, J_\kappa\left(m_J^2 - Q\ell^+, \mu\right)$$
$$\times \int dp_\Lambda^+ \int [dr_{cs}^i] \, S_C^\kappa \left[\ell^+ - p_\Lambda^+, Q_{\rm cut}, \beta, \{r_{cs}^i\}, \mu\right]$$

NP Shape Function ⟶

$$\times \, \tilde{F}_{\rm SD}^\kappa(p_\Lambda^+, Q_{\rm cut}, \beta, \{r_{cs}^i\})$$

⟶ Depends only on θ_{cs}, ϕ_{cs} !



Universality: We observe that the power corrections depend only on beta and the parton channel, and no other parameters.

Top Quark Mass in the Parton Shower

Daniel Samitz

Perennial question:

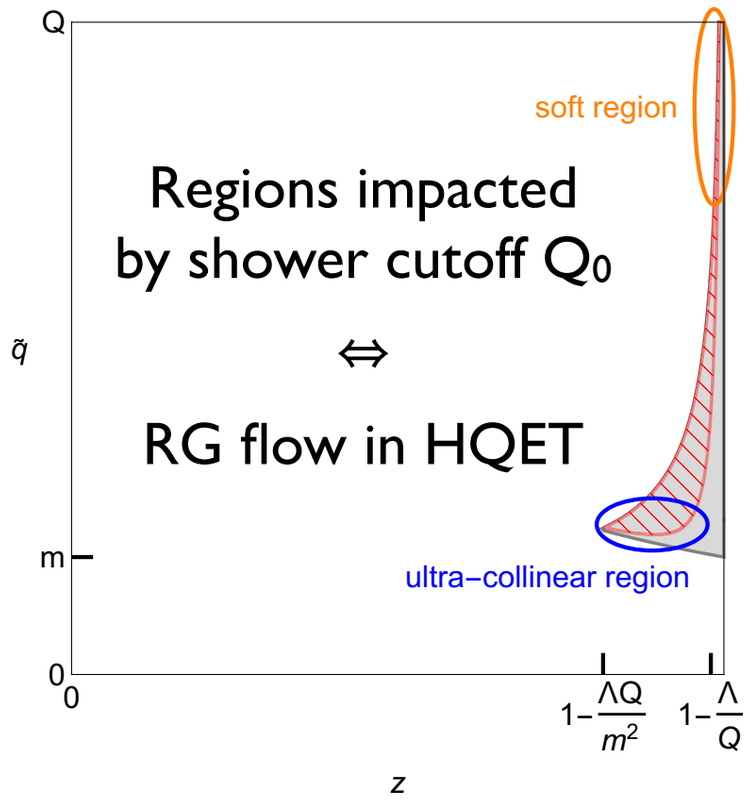
$$m_t^{\mathrm{MC}} = 172.44 \pm 0.49\,\mathrm{GeV}\ (\mathrm{CMS})$$
$$m_t^{\mathrm{MC}} = 172.84 \pm 0.70\,\mathrm{GeV}\ (\mathrm{ATLAS})$$

= m^{pole}?

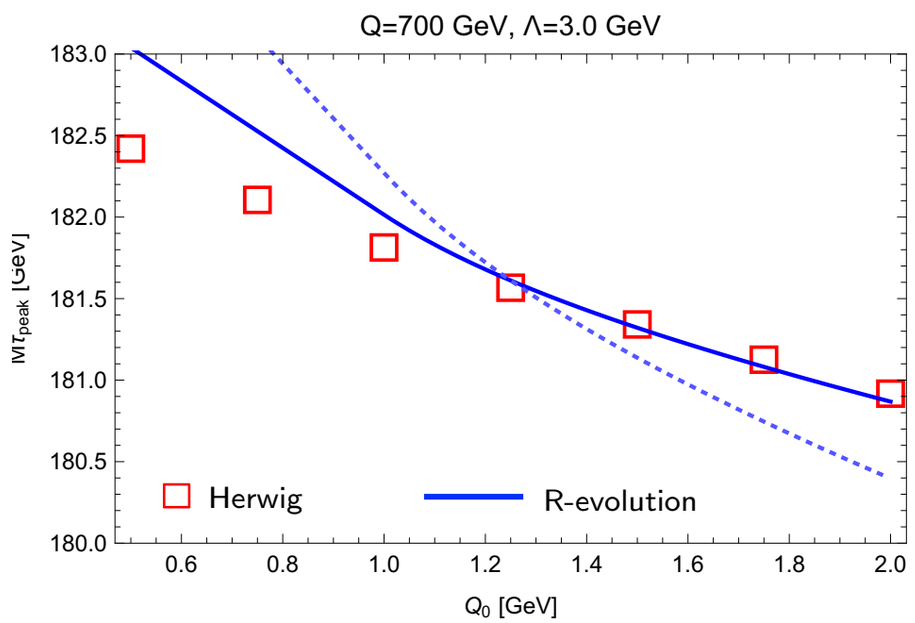
New answer:

mass scheme of coherent branching algorithm with cutoff:

$$m^{\mathrm{CB}}(Q_0) = m^{\mathrm{pole}} - \frac{2}{3}\alpha_s(Q_0)Q_0 + \mathcal{O}(\alpha_s^2)$$

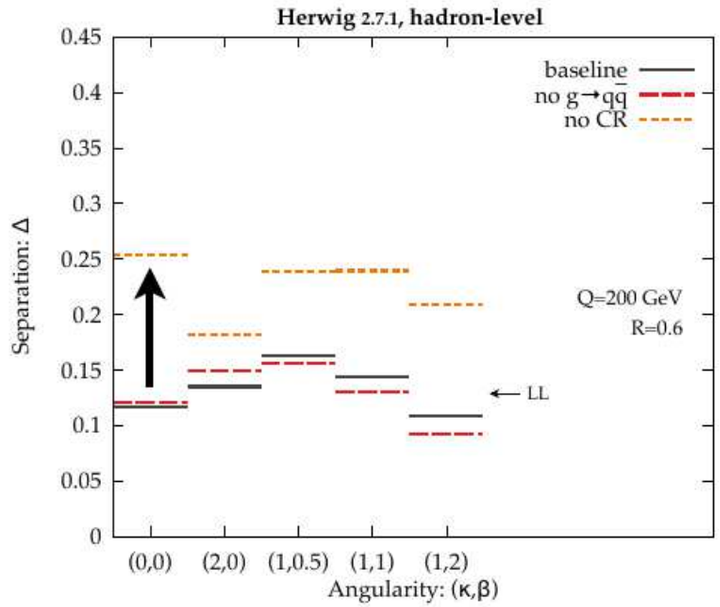


Consistent with shift of hemisphere mass peak



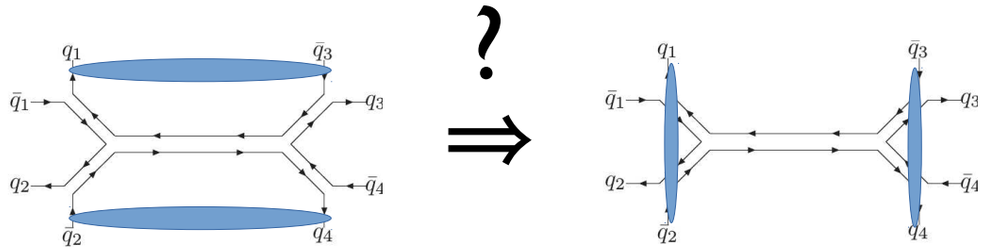
Improving Quark/Gluon Jets in Herwig

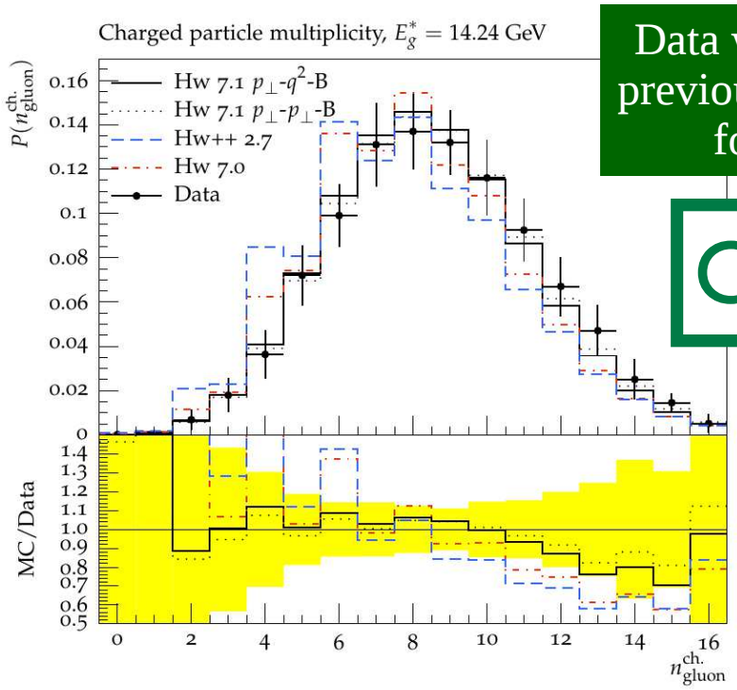
Andrzej Siódmok



From Les Houches 2015 Q/G study

Huge effect of color reconnection – very unexpected!





Data which has not previously been used for tuning.

OPAL

Clear goal for the future:
Use (more) LHC measurements in MC tuning

"This highlights the substantial improvement in the description of gluon jets in the latest version of Herwig"

Agreed!

Broad Range of Theory Topics/Themes

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Heavy Quark Physics

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Jet Substructure for Medium Modifications
Searching for Stealth Bosons
Bump Hunting with CWoLa
Deep Learning on FPGAs

Precision Measurements

Heavy Ion Physics

Searches for Exotica

Transformative Triggers

Applications

An Applications Meta-Narrative

Precision Measurements

The amazing performance of the LHC detectors has made precision standard model studies a reality

Heavy Ion Physics

BOOST goes Nuclear: the substructure toolbox is ideally suited to probing the quark/gluon plasma

Searches for Exotica

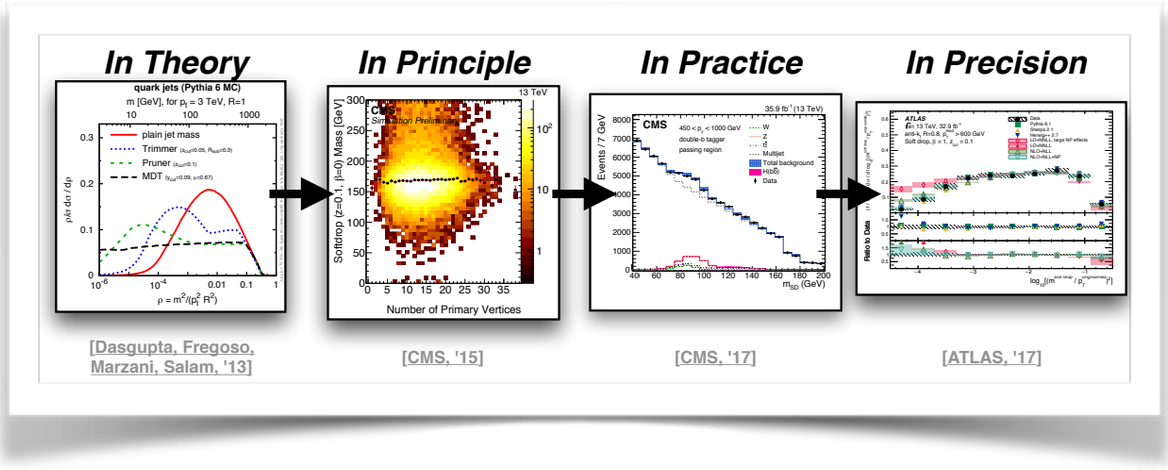
BSM searches are a key target for BOOST but we must open our eyes to exotic substructure signatures

Transformative Triggers

Our work will not be done until core boosted technology is running at 40 MHz

Physics Program for Precision Jet Substructure

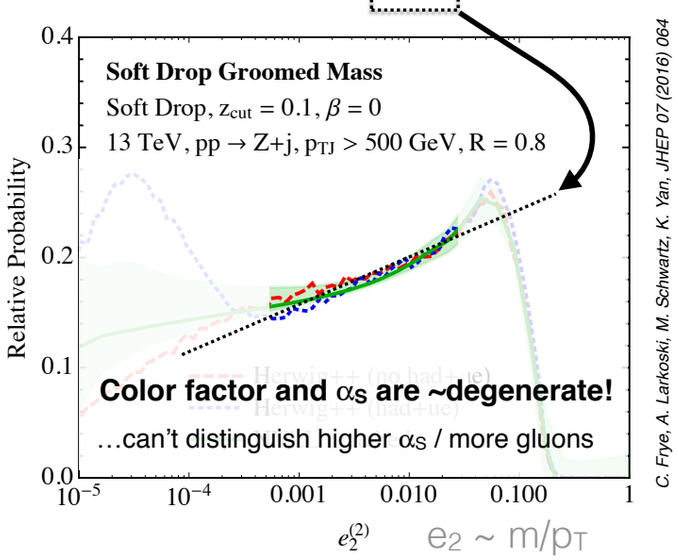
Ben Nachman

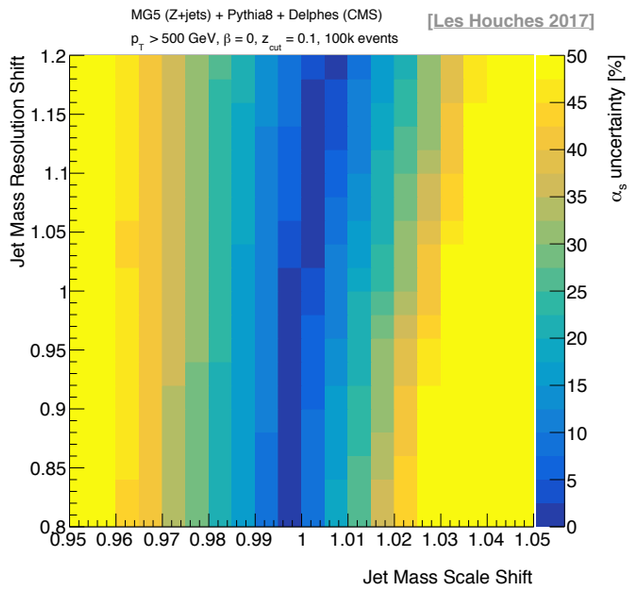


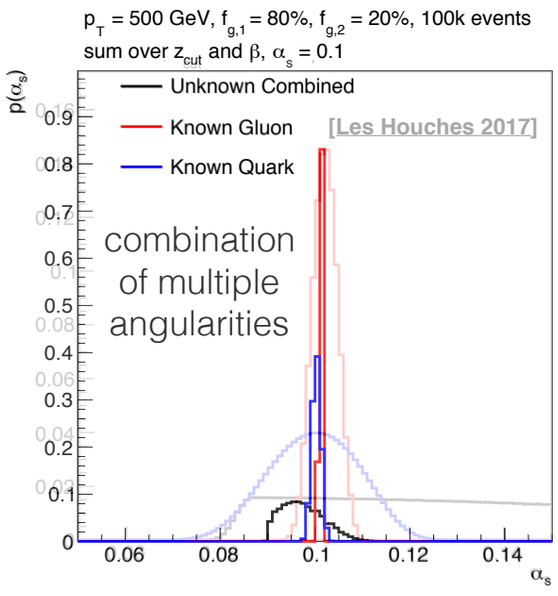
1) Fundamental Parameters
2) BSM Sensitivity
3) Quantum Properties
4) Improve Modeling
5) Heavy Ions

e.g. Les Houches 2017: Measure α_S to 10% (!?)

$$\frac{e_2^{(2)}}{\sigma}\frac{d\sigma}{de_2^{(2)}} \approx -\frac{\alpha_s C_i}{\pi}[\log(z_{\rm cut}) - B_i]\exp\left[-\frac{\alpha_s C_i}{\pi}[\log(z_{\rm cut}) - B_i]\log(e_2^{(2)})\right]$$







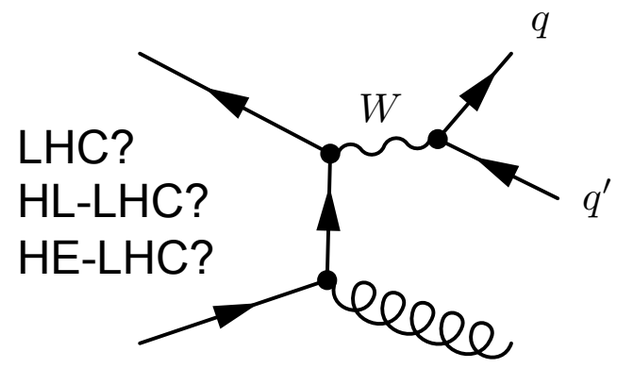
All-hadronic W Mass Measurement

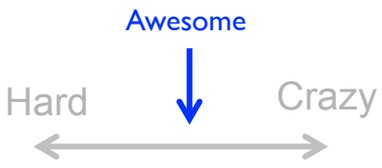
Andreas Hinzmann

ATLAS (Eur. Phys. J. C 78 (2018) 110):
lv: ± 7 (stat) ± 11 (exp. syst.) ± 14 (mod. syst.) MeV

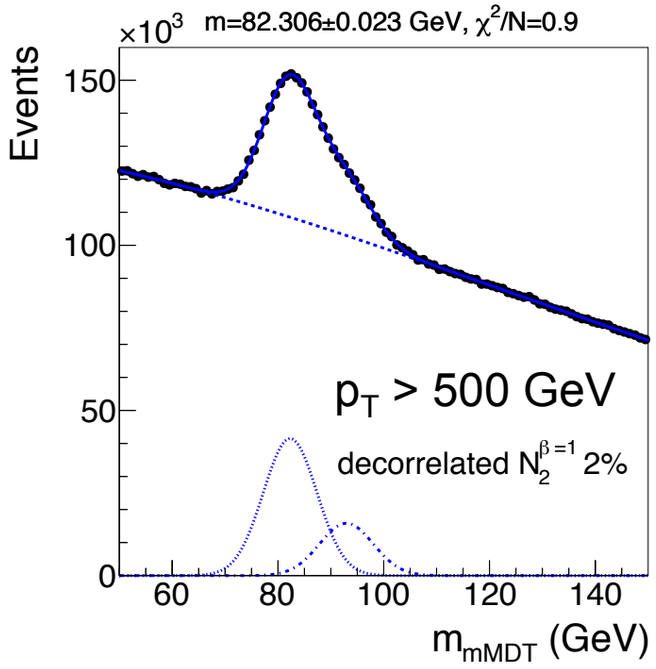
vs.

LHC?
HL-LHC?
HE-LHC?

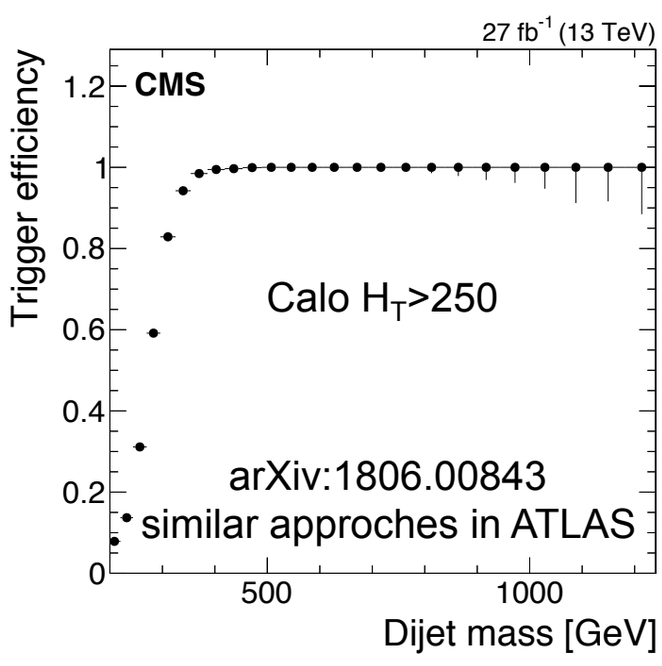




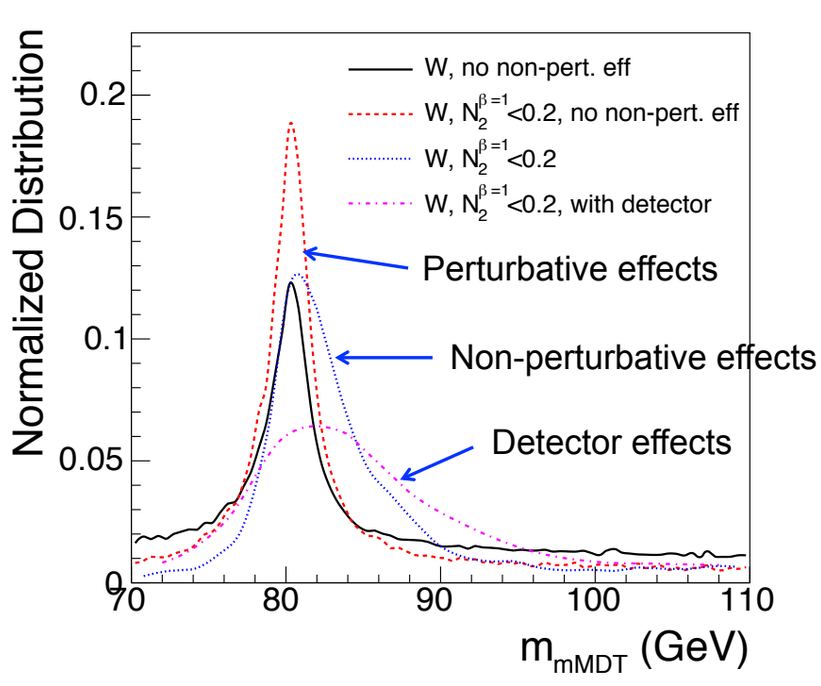
Extract m_W–m_Z with decorrelated tagger?



Lower trigger thresholds??



Control systematic uncertainties???



"Some small improvement would be needed…"

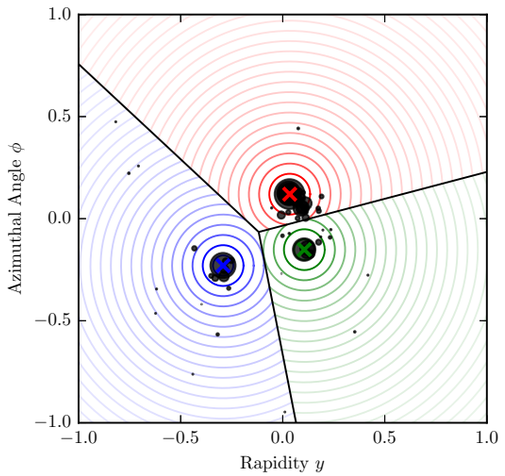
vivitek®

Vivid Color, Vivid Life

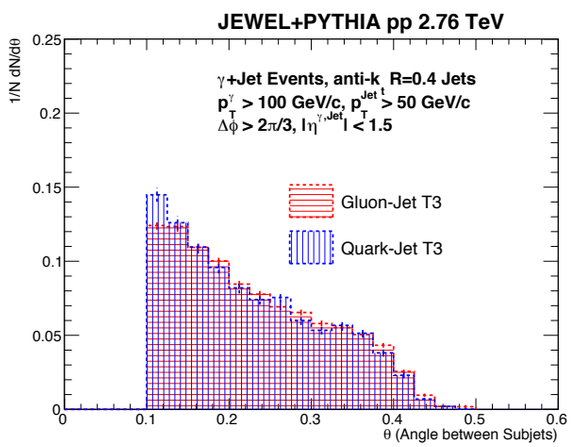
Jet Substructure for Medium Modifications

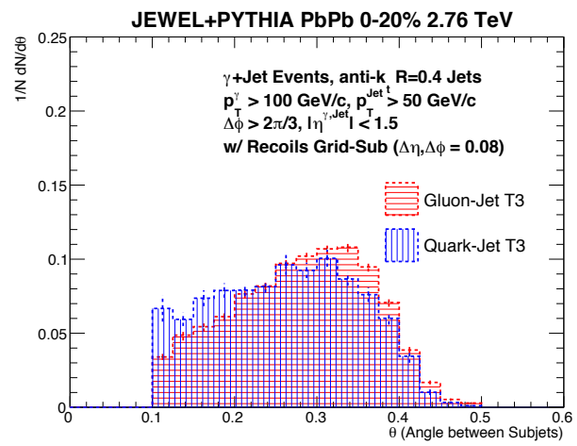
Yang-Ting Chien

Telescoping Deconstruction



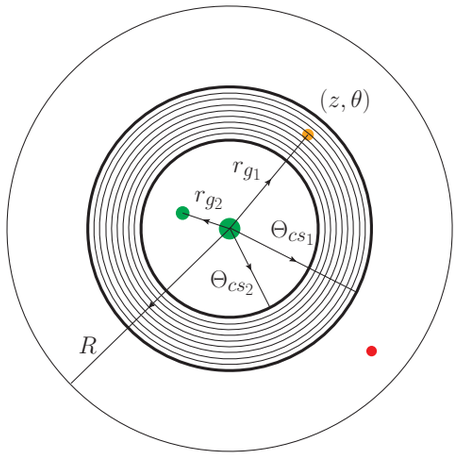
Subjet-angle with quark/gluon-tagging



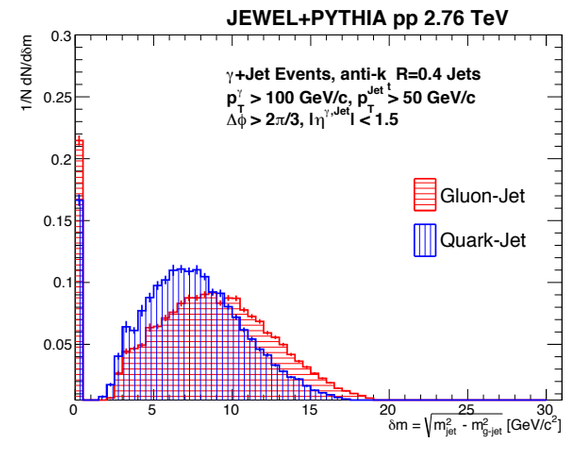


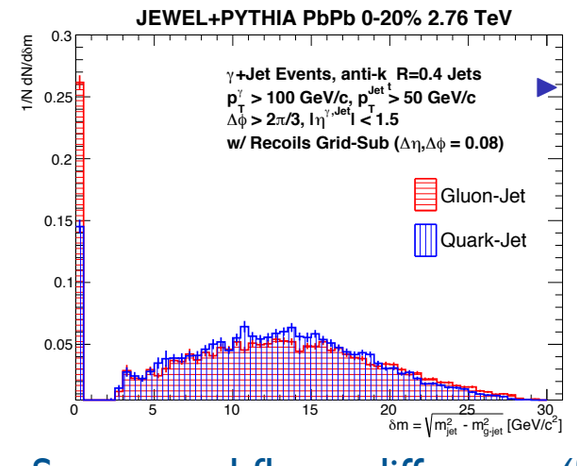
Enhanced flavor difference

Collinear Drop



Groomed mass difference with quark/gluon-tagging



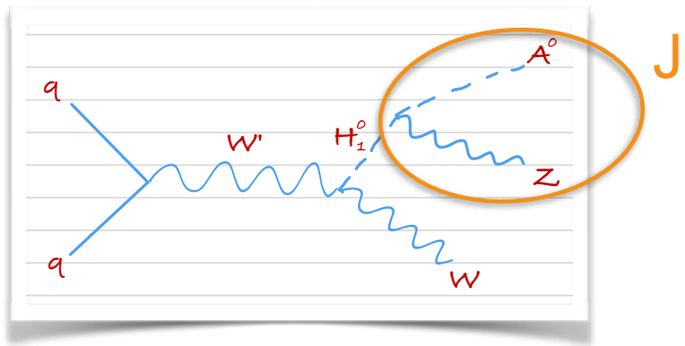


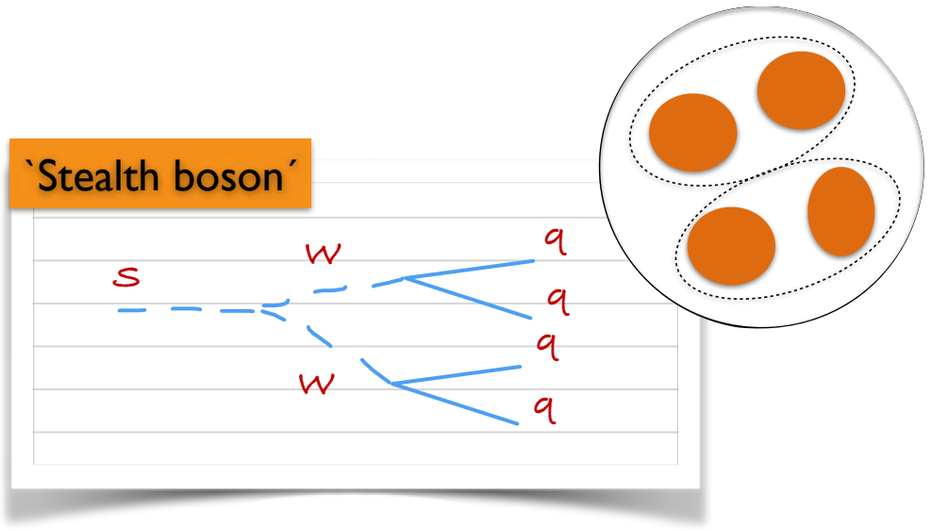
Suppressed flavor difference (!)

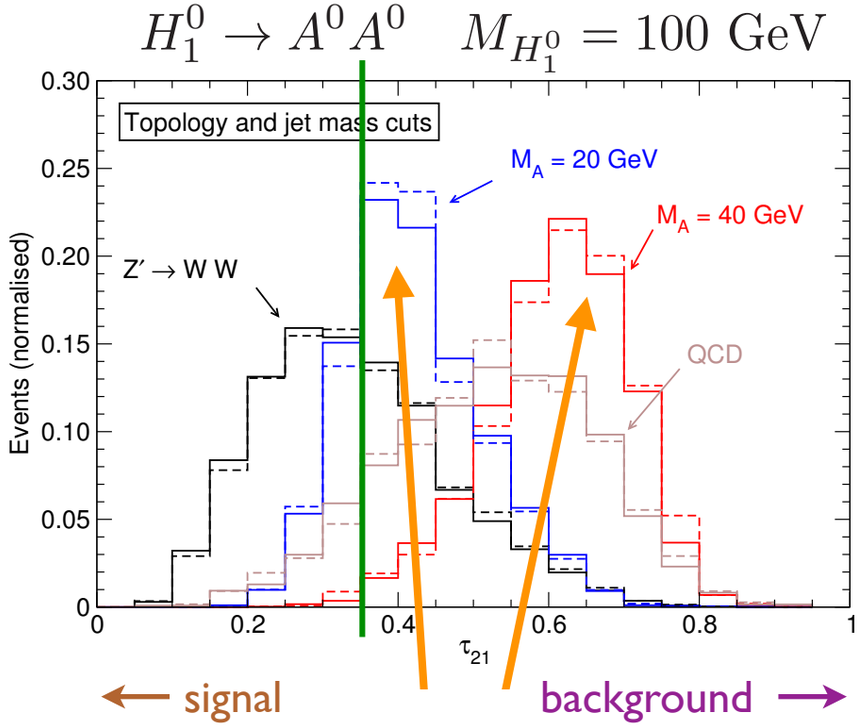
Searching for Stealth Bosons

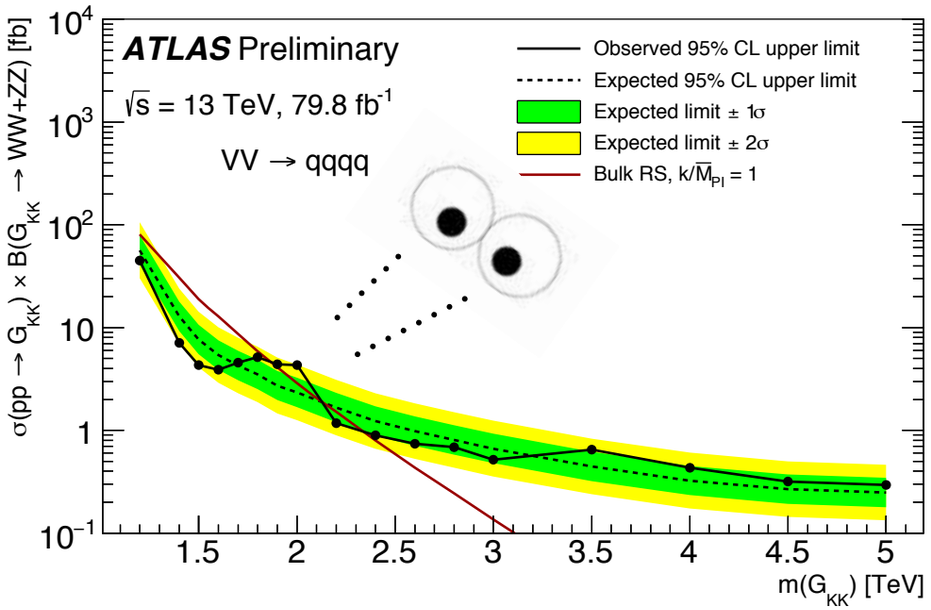
Juan Antonio Aguilar Saavedra

Multiboson signatures





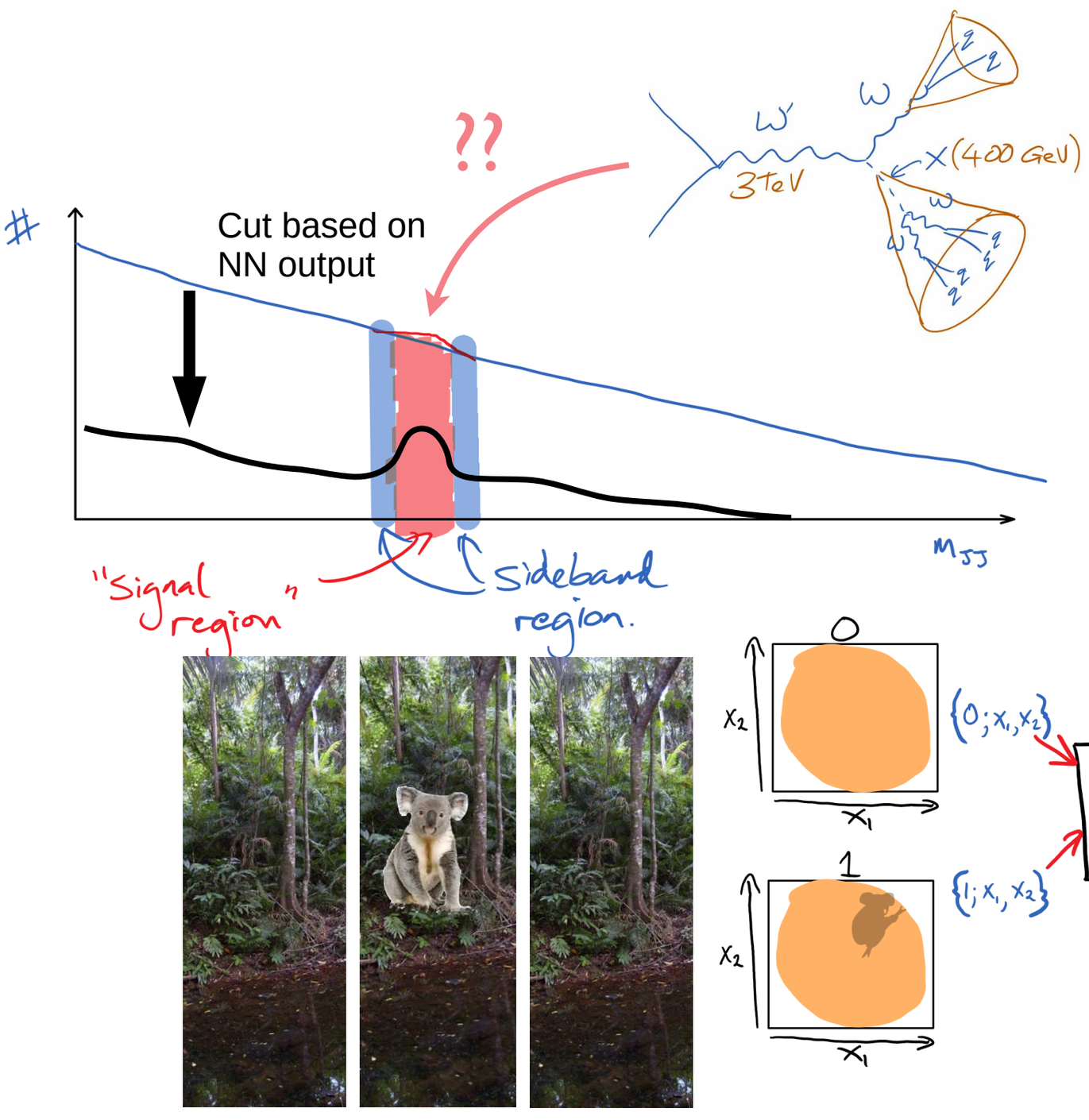


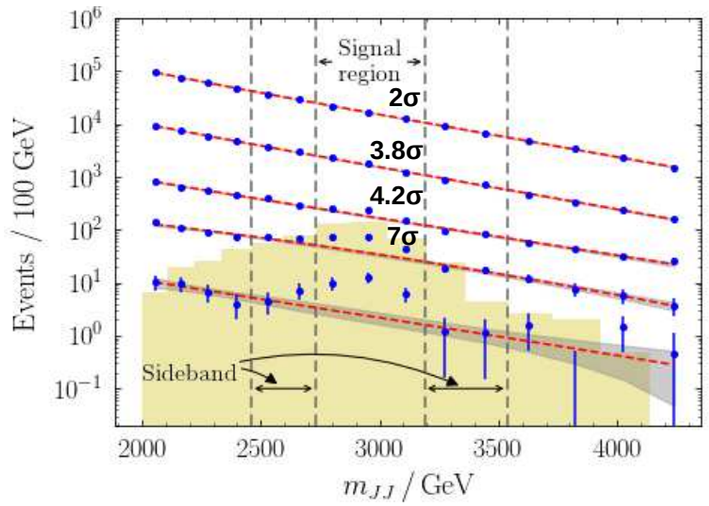


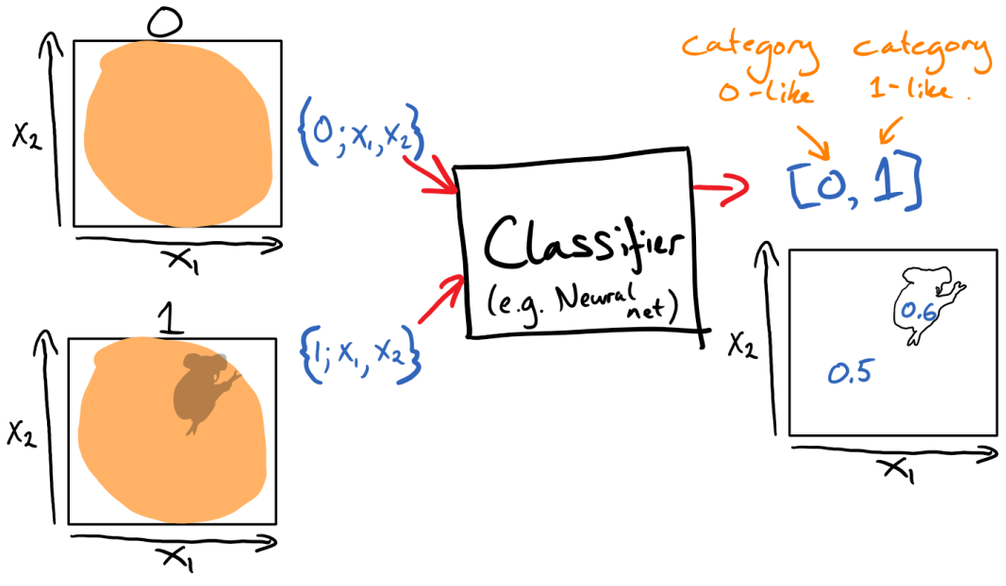
Never say you don't believe a bump may be something interesting because the other experiment doesn't see it.

Bump Hunting with CWoLa

Jack Collins



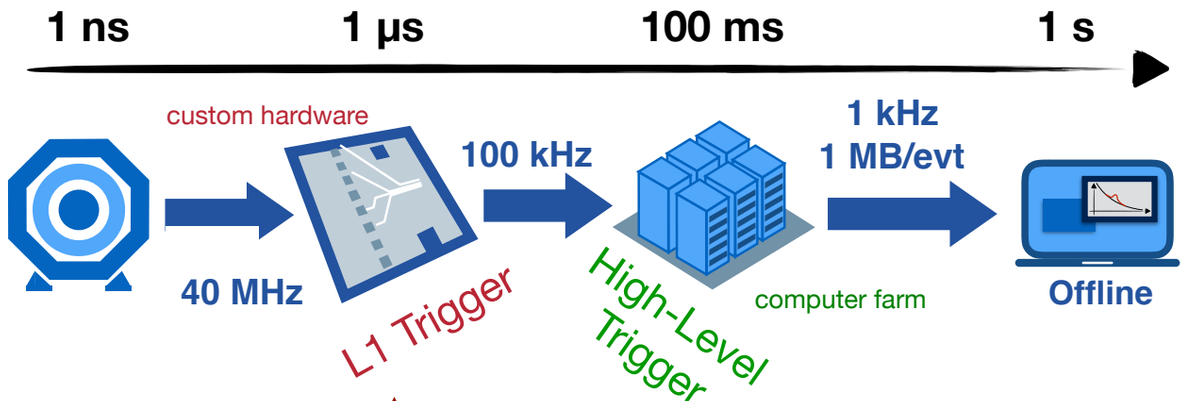




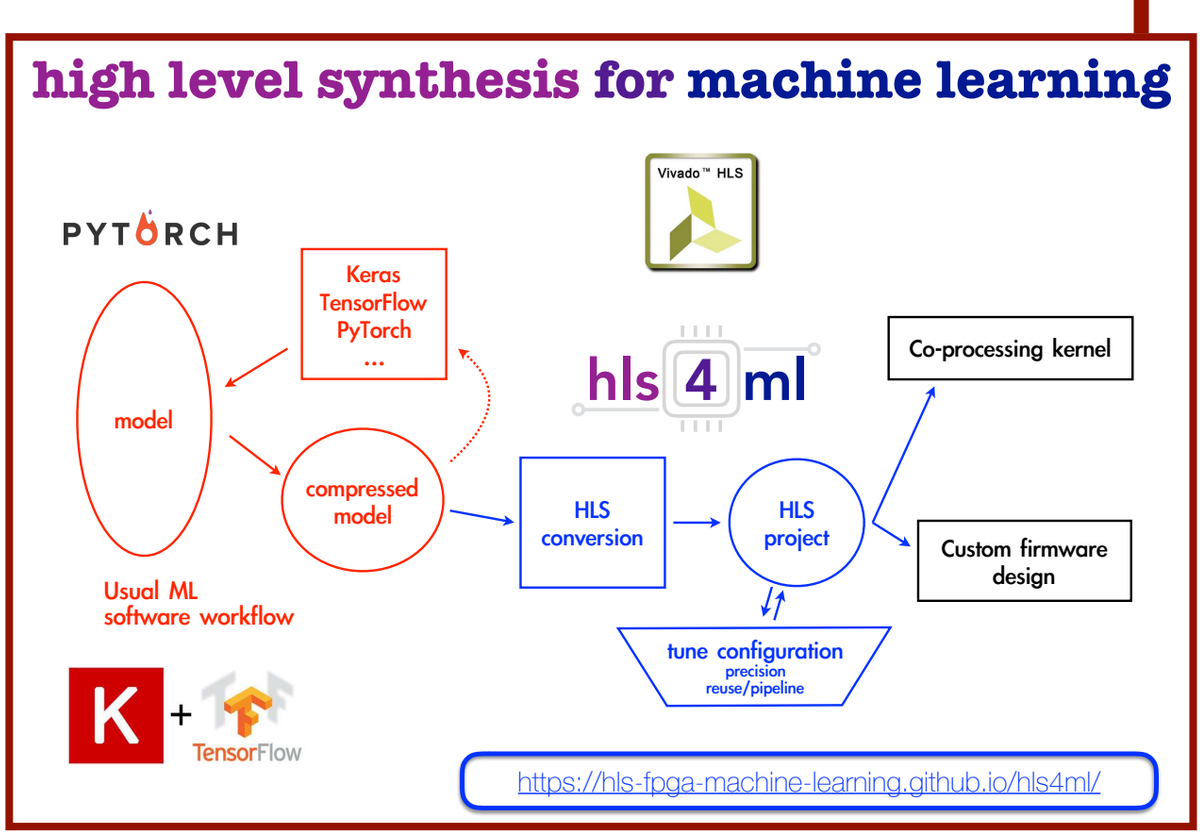
Deep Learning on FPGAs

Jennifer Ngadiuba

The Latency Landscape:

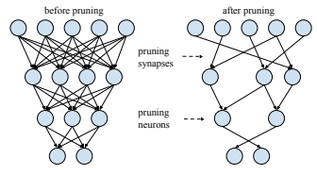


What can we do in < us on one FPGA?

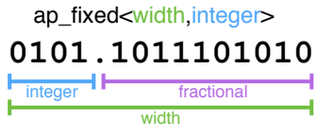


Enabled by…

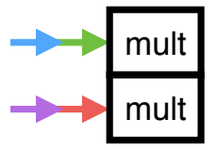
Compression:



Quantization:



Parallelization:



Broad Range of Theory Topics/Themes

Strategies

SIFT: Scale-Invariant Jet Finding
Diverse Representations of Jets
Novel Observables from Machine Learning
Jet Tagging with RecNNs
Infrared Safety of CNN Top Tagging
Novel Taggers from Encoded Data
Weak Supervision in High-Dimensional Spaces
Jet Topics for Quark/Gluon Definitions
Probabilistic Modeling with JUNIPR
Energy Flow Networks
Learning from the Lund Plane

Exploiting Symmetries

Machine Learning

Data-Driven Methods

Unsupervised Learning

Using Domain Knowledge

Calculations

Educating the Next Generation
Quarks Jet Rates in Multi-Jet Final States
Analytic Perspective on Top Taggers
Calculating the Pull Angle
Soft Gluons and Non-global Observables
Non-perturbative Effects in Grooming
Top Quark Mass in the Parton Shower
Improving Quark/Gluon Jets in Herwig

Beyond Single Prongs

Soft/NP QCD Effects

Heavy Quark Physics

Parton Shower Progress

Applications

Physics Program for Precision Jet Substructure
All-hadronic W Mass Measurement
Jet Substructure for Medium Modifications
Searching for Stealth Bosons
Bump Hunting with CWoLa
Deep Learning on FPGAs

Precision Measurements

Heavy Ion Physics

Searches for Exotica

Transformative Triggers

Implementation (!)

14:00

FastJet tutorial — *Salvatore Rappoccio*
Charpak Amphitheater, Paris — 14:00 - 14:15

Energy Flow tutorial — *Patrick Komiske*
Charpak Amphitheater, Paris — 14:15 - 14:30

Lund Jet Plane tutorial — *Frederic Alexandre Dreyer*
Charpak Amphitheater, Paris — 14:30 - 14:45

Jet topics tutorial — *Eric Metodiev*
Charpak Amphitheater, Paris — 14:45 - 15:00

15:00

Hand-on time
Charpak Amphitheater, Paris — 15:00 - 16:50

16:00

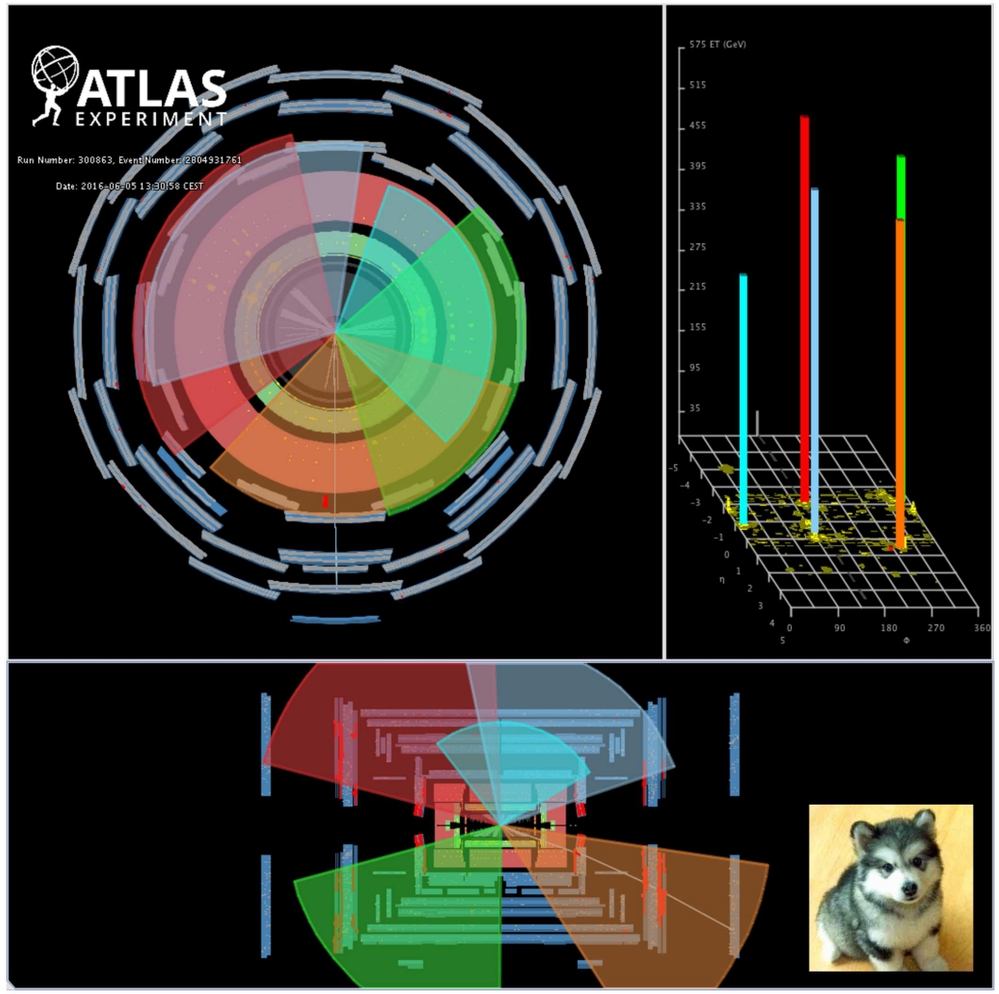
Additional material for self-study — *Gregor Kasieczka*
Charpak Amphitheater, Paris — 16:50 - 17:00

17:00

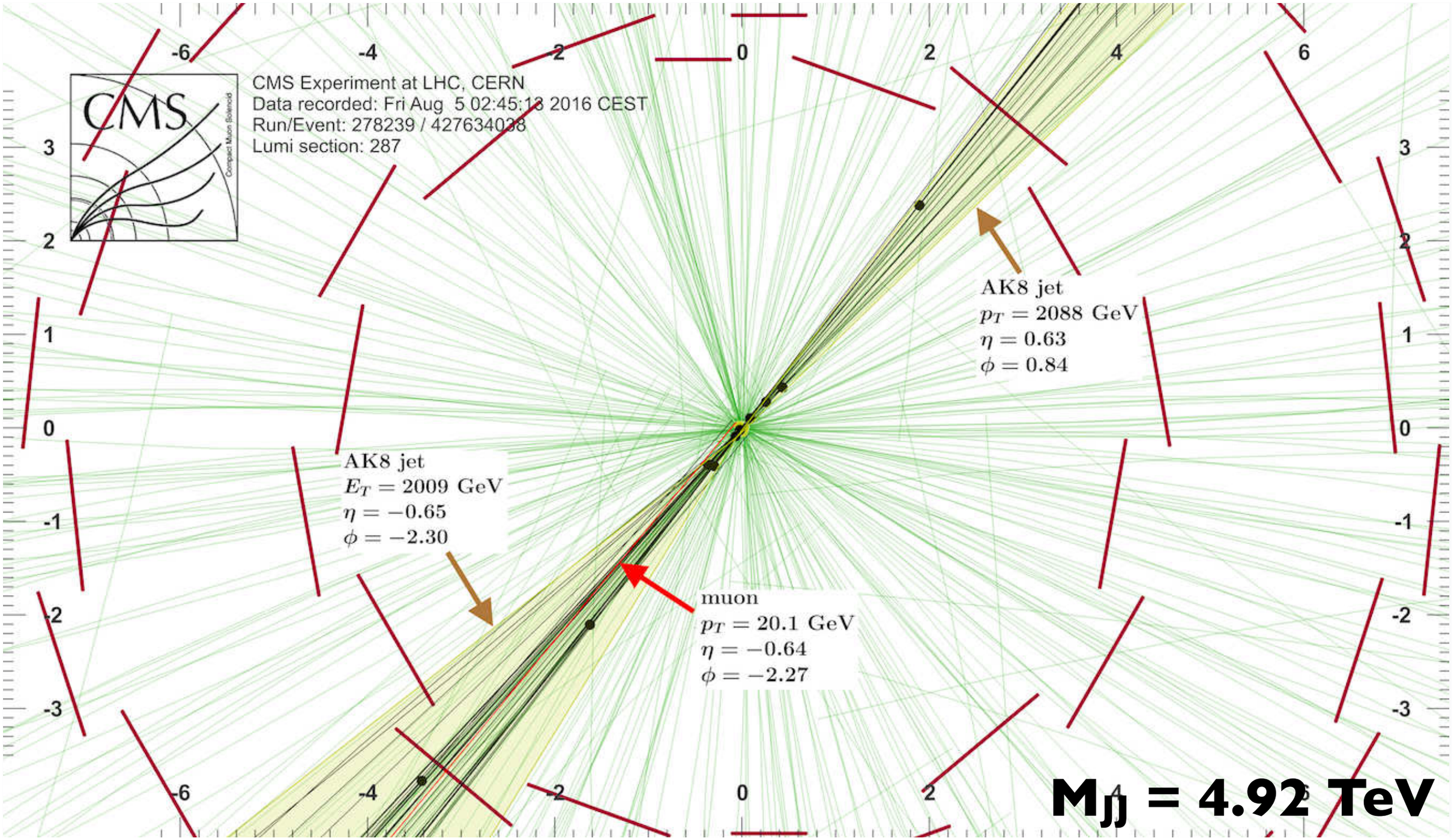
Seen/heard around BOOST


MAKE DNN
MEASURE
SOMETHING
imgflip.com

Cute


ATLAS
EXPERIMENT
Run Number: 300863, Event Number: 2804931761
Date: 2016-06-05 13:30:58 CEST
575 ET (GeV)
515
455
395
335
275
215
155
95
35
η
φ
0
90
180
270
360

Cuter


CMS Experiment at LHC, CERN
Data recorded: Fri Aug 5 02:45:13 2016 CEST
Run/Event: 278239 / 427634038
Lumi section: 287
AK8 jet
$p_T = 2088$ GeV
$\eta = 0.63$
$\phi = 0.84$
AK8 jet
$E_T = 2009$ GeV
$\eta = -0.65$
$\phi = -2.30$
muon
$p_T = 20.1$ GeV
$\eta = -0.64$
$\phi = -2.27$
M_{JJ} = 4.92 TeV

Cutest

In order to understand the universality of the NP corrections and how they ought to be combined with the perturbative cross section we open the black box:

"Sequentially encode jet's information in hidden representation...
is a good app for that the way it works. I would like it if you
could just read the email address or not."

Encouraging? Certainly.

Conclusive? Of course not!

"Because who cares about leptons?"

"Yes, it was optimal for that point, but in hindsight maybe not ideal…"

your boost may vary.

"tie the topics together in a coherent way":
that is what I look forward to from Jesse's summary

10 years of BOOST

A Meta Meta-Narrative

Strategies — Over the past decade, some the most innovative ideas in high-energy physics have been developed by the BOOST community

Calculations — Extreme kinematics requires extreme analytic control, and BOOST is pushing the boundaries of quantum field theory

Applications — The core of BOOST is searches for new phenomena and measurements of the standard model, but no need to stop there

A Meta Meta-Narrative

Strategies — *We build it*

Calculations — *We bring it*

Applications — *We boost it*

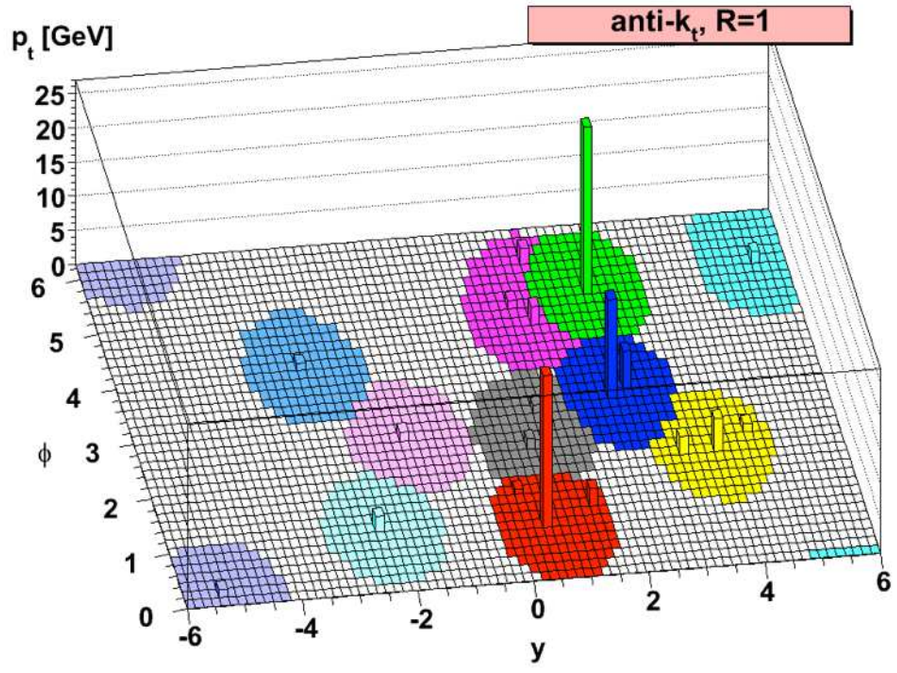
My Memory of 2008

September 19

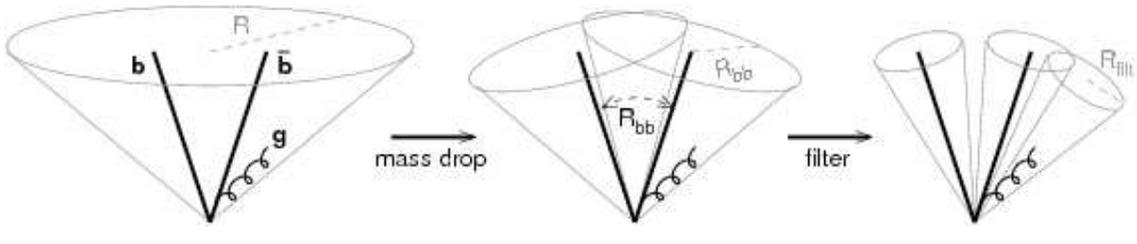
(We broke it)

My Memory of 2008

February 8



February 18



September 19

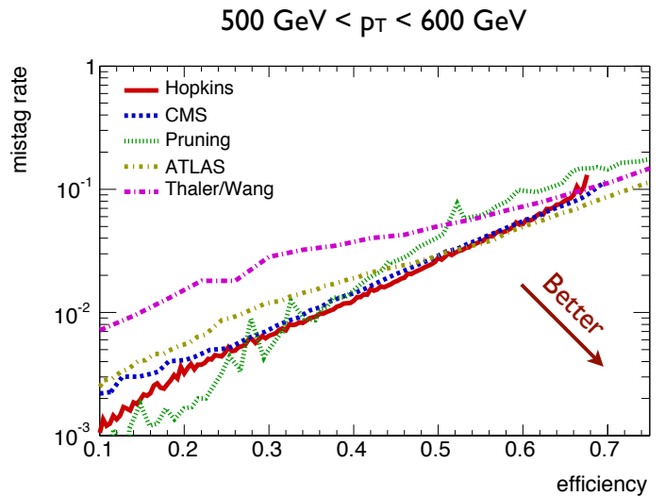
(We broke it)

[Cacciari, Salam, Soyez, 0802.1189;
Butterworth, Davison, Rubin, Salam, 0802.2470; see also Seymour, 1991, 1994]

My First BOOST

Princeton

Top Tagging c. 2010

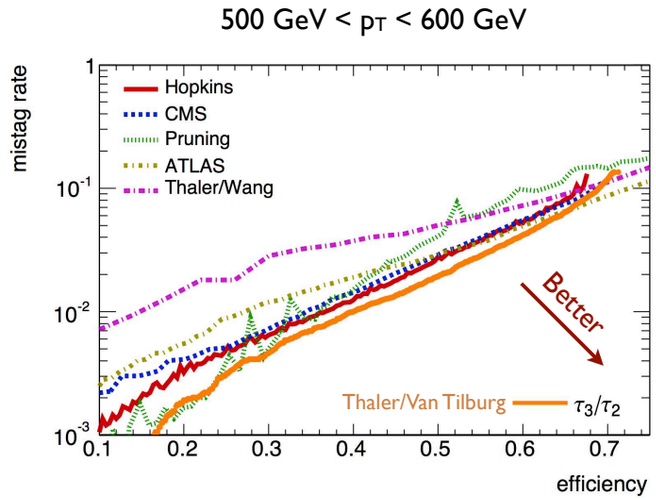


Jesse Thaler — N-subjettiness 2

My First BOOST

Princeton

Top Tagging c. 2011



fixed 160 GeV < m_{jet} < 240 GeV cut
one-dimensional cut on τ_3/τ_2

Jesse Thaler — N-subjettiness 3

Only possible with a vibrant, critical, ambitious, creative, persistent, fun, welcoming community

Looking to BOOST 2019

Innovative Approaches to Extreme Kinematics

Per-particle substructure calibrations?

N-prong RIVETized extravaganza?

Generic anti-QCD limits?

Performance

Measurements

Searches

Someone else's theory summary talk

Machine learning on entire events?

Parton shower with full soft correlations?

All-hadronic 19 parameter global fit of SM?

Strategies

Calculations

Applications

You have 365 days to do something awesome…

July 22–26 @ *MIT*

Welcome to the Hub!

Phil Harris has promised a motivational speech from local Massachusetts resident Justin "Sunny Boost" De Luca

Thanks Matteo, Reina & Gregory
for a magnifique BOOST 2018!