Boosted H/Z from TeV scale Z' resonance: Zh-llbb

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In reconstructing a full story of Z'

What is not well understood

despite its importance ?

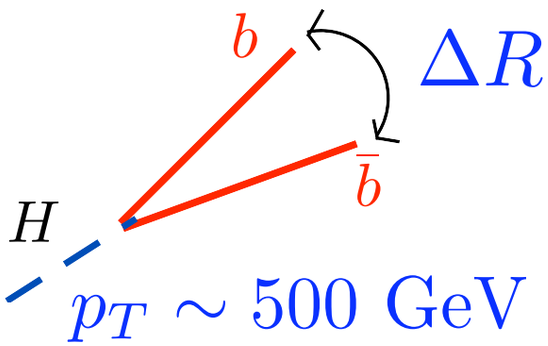
Zh/W+W-

: unique in that it measures the coupling of Higgs to Z'
DIRECTLY (... crucial to understand the nature of Z')

In this talk we will focus on **Zh-llbb** for mH = 120 GeV

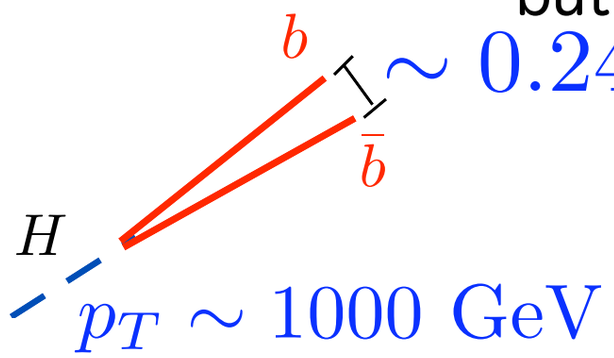
Difficulty in tagging Boosted Higgs

1 TeV Z' : well separated (bigger than Rjet=0.4)

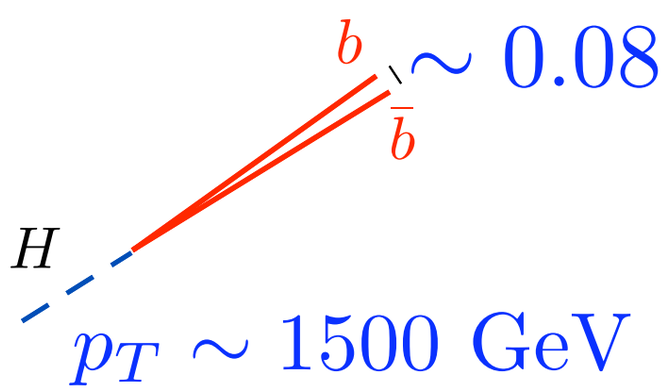


2 TeV : likely merges into single jet

but still better than HCAL resol.(~ 0.1)



3 TeV : smaller than HCAL resol.



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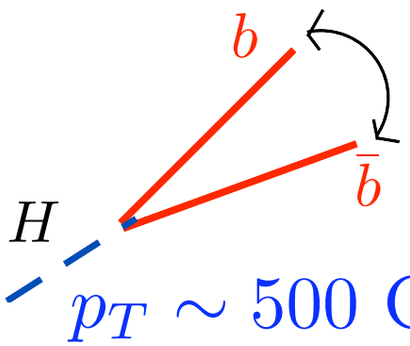

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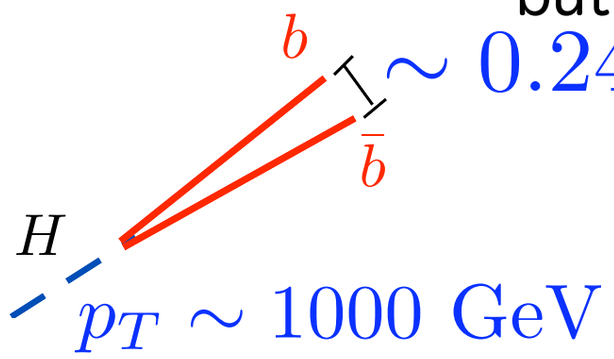

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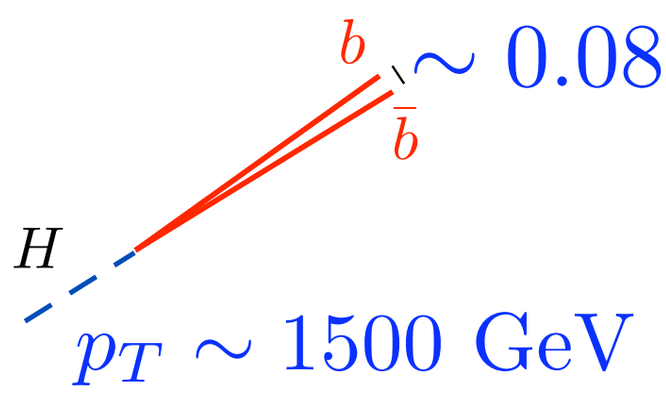

Complication:

how do we match low-mass dijet search onto high-mass monojet search ?

Worry:

1. artificial shapes might be introduced into joint Z'/Higgs mass distribution.
2. might lose Higgs mass resol. at high boost. are we swamped by Z + jet bkgs. ?
3. b-tagging gets worse at high pT.

Some prelim work

LHC Signals for Warped Electroweak Neutral Gauge Bosons

K. Agashe et. al [arXiv : 0709.0007]

Search for the decays $Z_H \to Zh$ and $W_H \to Wh$ in the Little Higgs model assuming $m(h) = 120$ GeV

J. E. Garcia et. al [ATL − PHYS − 2004 − 001]

Some prelim work

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: Parton Level Study

Search for the decays $Z_H \to Zh$ and $W_H \to Wh$ in the Little Higgs model assuming $m(h) = 120$ GeV

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: Traditional jet-clustering w/ Rjet = 0.4 with merging jet for 1 and 2 TeV Z'

Jet Substructure

In situations with merged jets, substructure can help

Various techniques have been developed which look promising for the application to the current problems

WW scattering at the CERN LHC — substructure of W jet

J. M. Butterworth et al [ph/0201098]

Jet substructure **as a new Higgs search channel at the LHC**

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substructure of H jet

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substructure of H jet

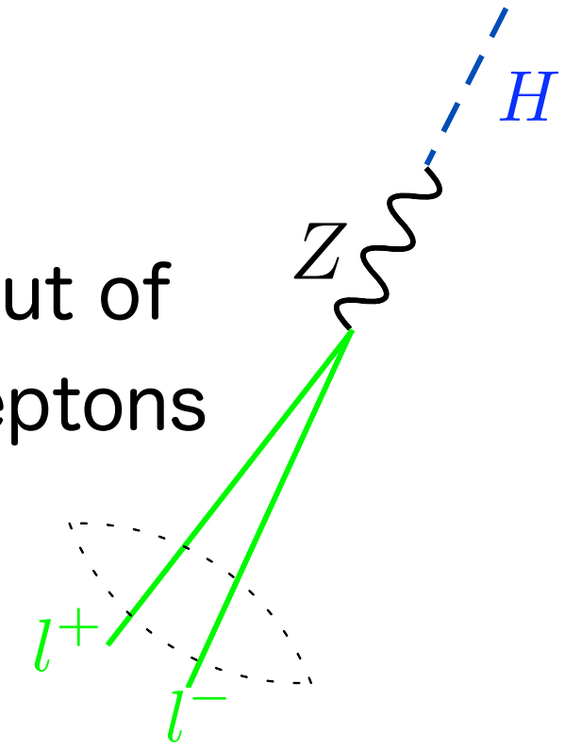
then why do not we take advantage of it ?

we will focus on BDRS style (C/A filtering)

good background rejection and mass resolution

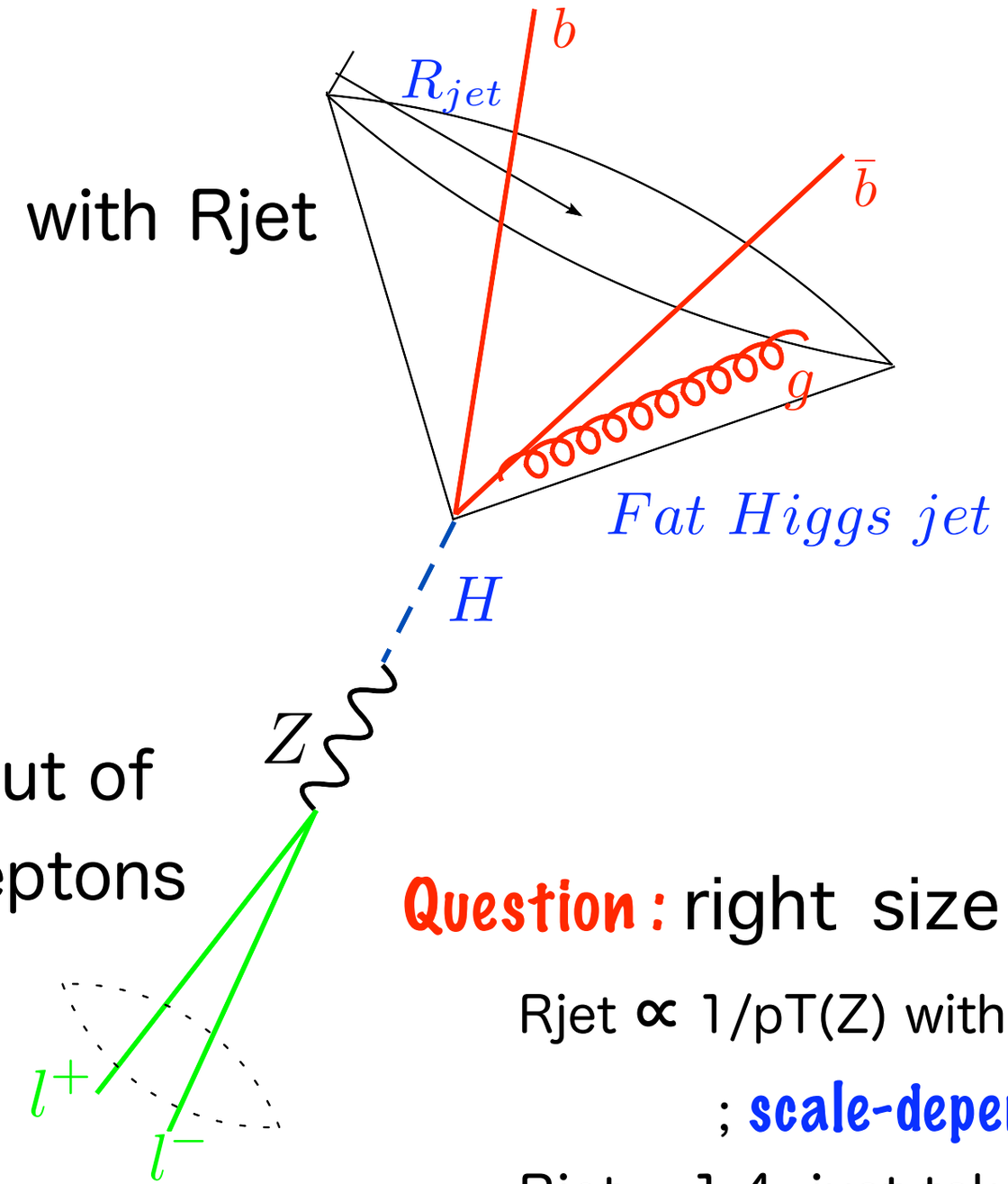
Sequential Procedure with jet Substructure

1. reconstruct Z out of two isoloated leptons



Sequential Procedure with jet Substructure

2. jet clustering with Rjet



1. reconstruct Z out of two isoloated leptons

Question : right size of Rjet ?

Rjet ∝ 1/pT(Z) with pT from recon. Z-boson

; **scale-dependent Jet size**

Rjet = 1.4 just take a max. size

; **scale-Independent Jet size**

Sequential Procedure with jet Substructure

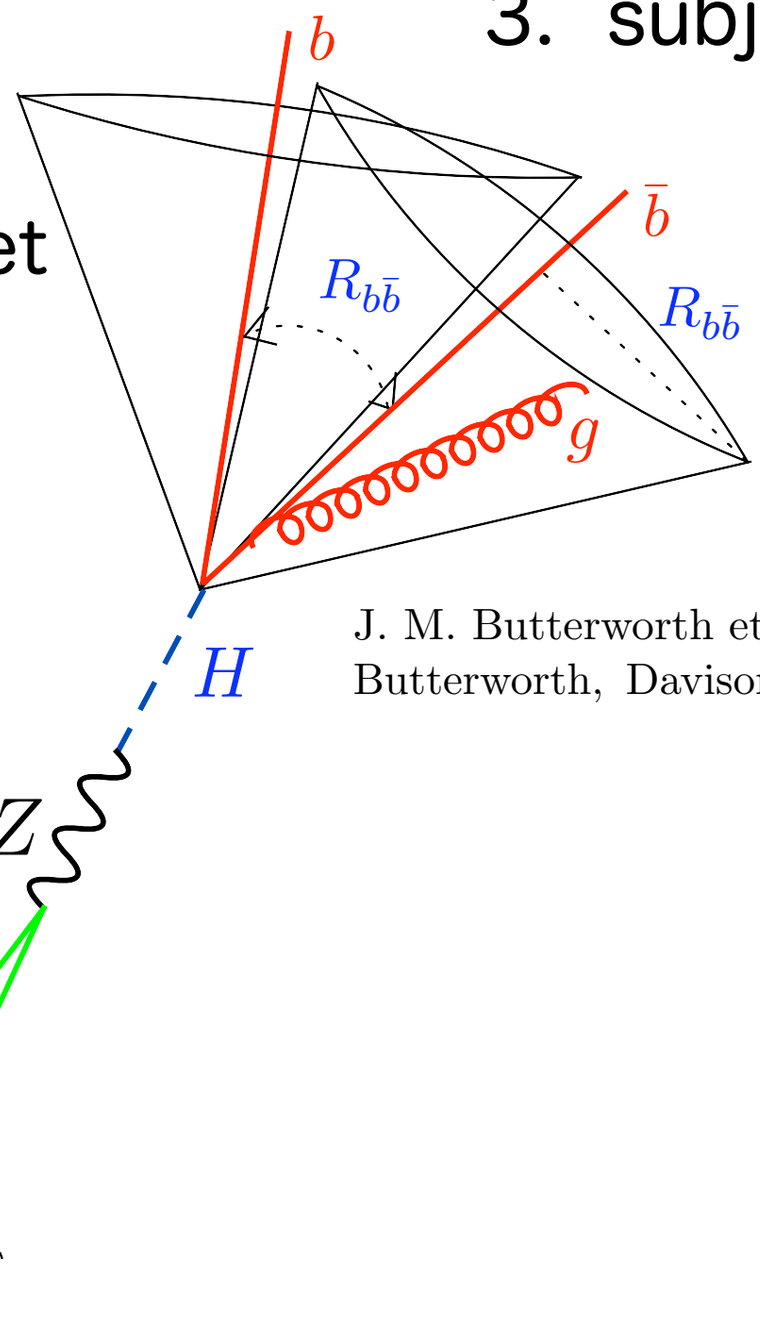
3. subjet-decomposition

mass drop/asym.

$m_{sj}/m_j < 67\ \%$

$p_{t\,sj<}/p_{t\,sj>} > 9\ \%$

2. jet clustering with Rjet



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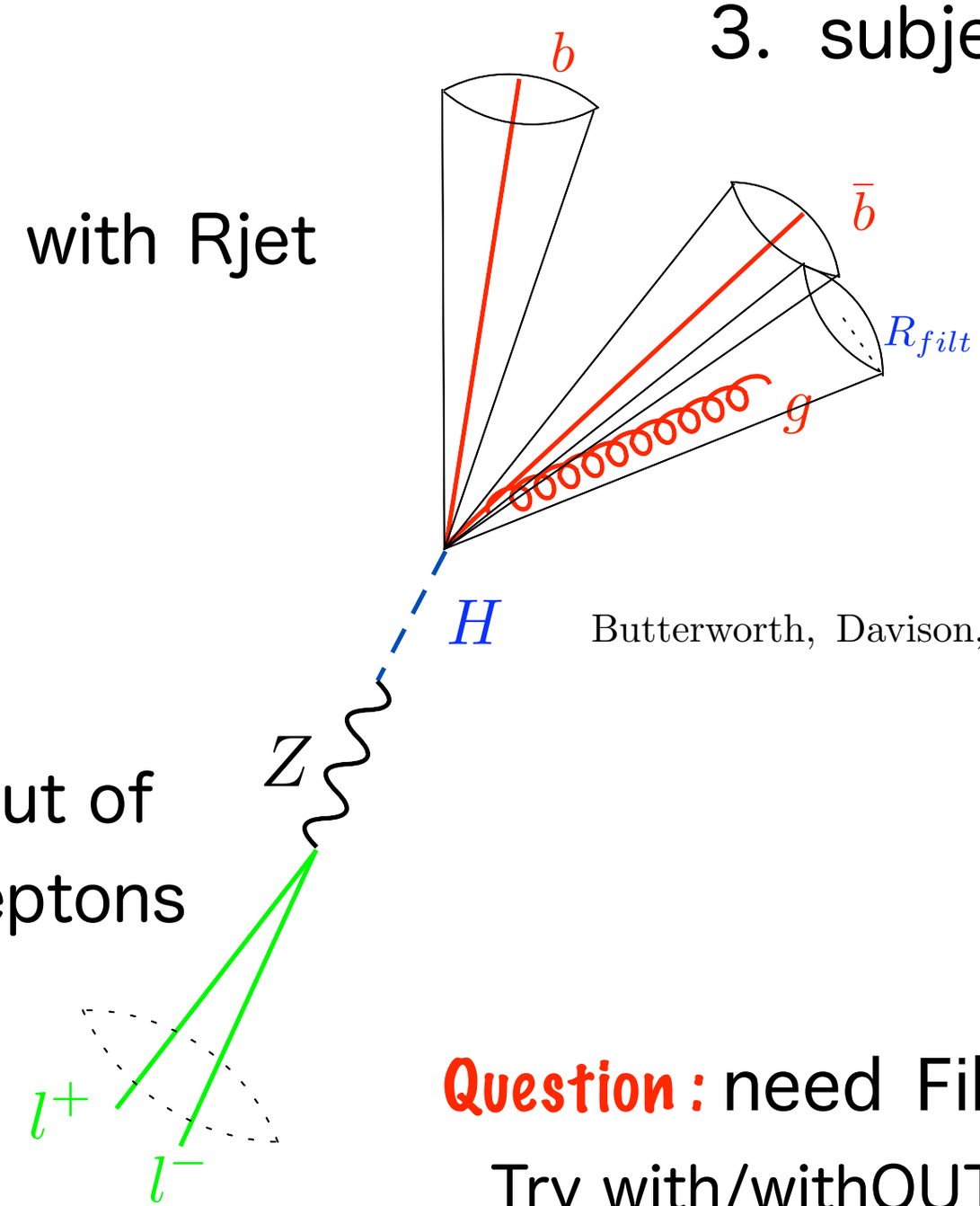


mass drop/asym.

filter

$$R_{filt} = \min(0.3,\ R_{b\bar{b}}/2)$$

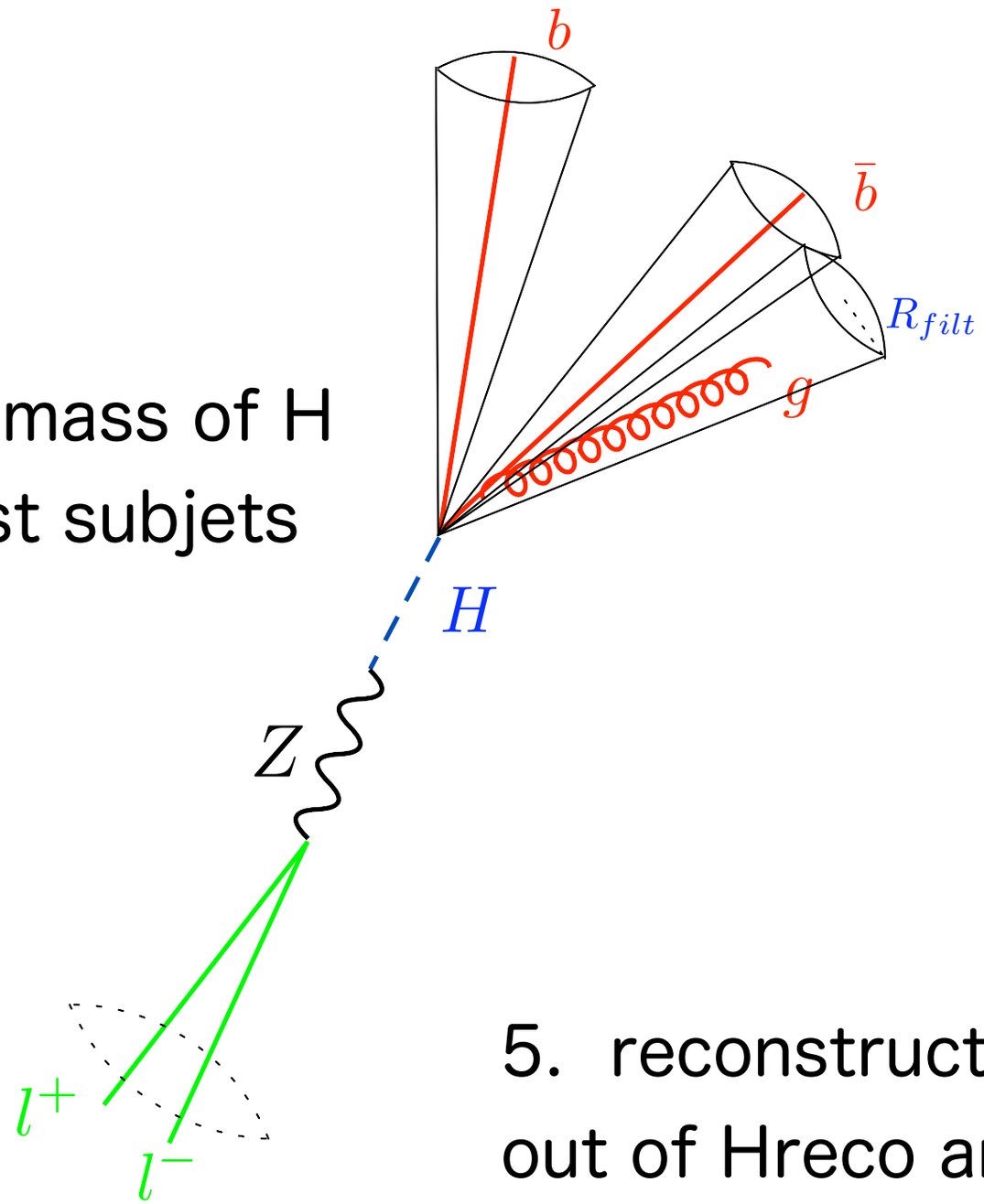
Butterworth, Davison, Rubin and Salam [PRL 100 (2008)]

Question : need Filter at high pT ?

Try with/withOUT filtering/reclustering

Sequential Procedure with jet Substructure

4. reconstruct inv mass of H out of three hardest subjets



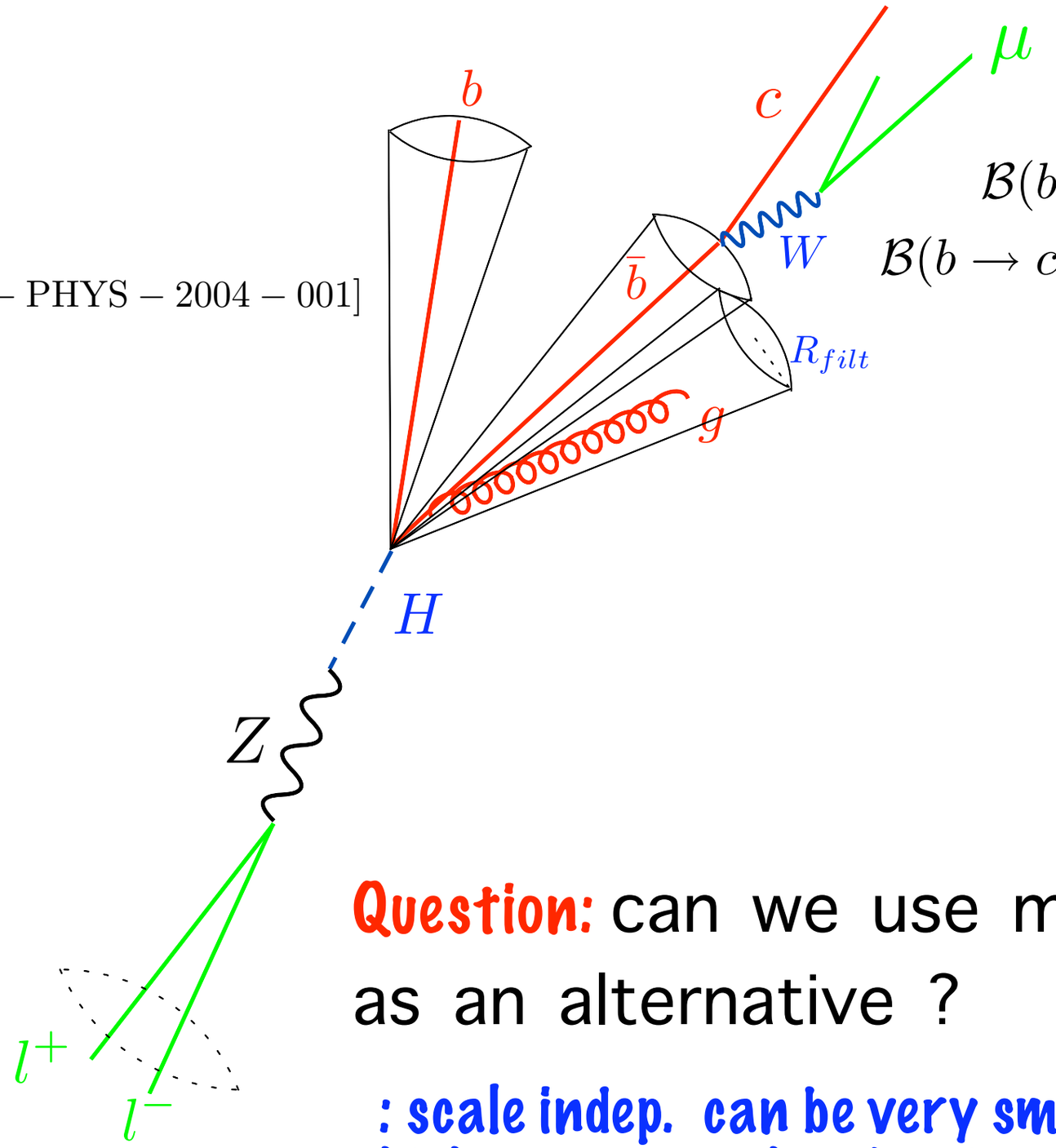
5. reconstruct inv mass of Z' out of Hreco and Zreco

Sequential Procedure with jet Substructure

6. b-tagging

ref. ATLAS/CMS TDR

J. E. Garcia et. al [ATL − PHYS − 2004 − 001]



$$\mathcal{B}(b \to \mu\nu\, X) = 11\ \%$$

$$\mathcal{B}(b \to c \to \mu\nu\, X) = 10\ \%$$

Question: can we use muon-tagging as an alternative ?

: scale indep. can be very smoothly applied to high-mass search w/o being destroyed

Question :

Does jet Substructure technique do better than a traditional style ?

perform jet clustering w/ Rjet = 0.4

→ If two hardest jets are not too asym. (i.e. pT asym. < 9 %),
take dijet to reconstruct Higgs inv. mass (* also without asymmetry cut)

repeat above, but
→ If two hardest jets are too asym., take only hardest jet (monojet) to
reconstruct Higgs inv. mass → merged jet

Zh-llbb for a light Higgs with mH = 120 GeV

$$\mathcal{B}(H \to b\bar{b}) \times \mathcal{B}(Z \to ll) \sim 0.7 \times 2/30 = 4.7\ \%$$

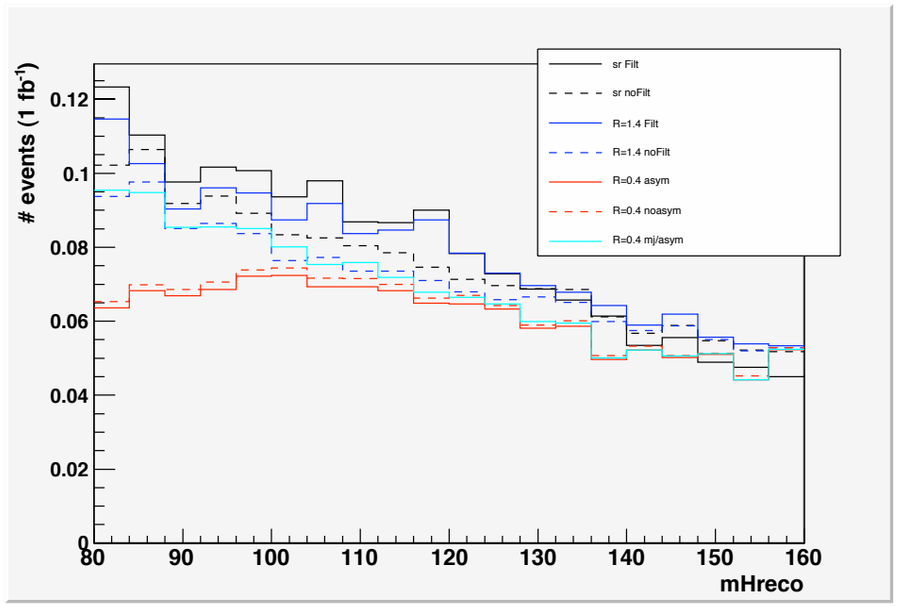
Signal Events (Z' - Zh - llbb) : Madgraph/Event 4.4.32

Bkgs Events (Z + jet) : PYTHIA 6.4.11

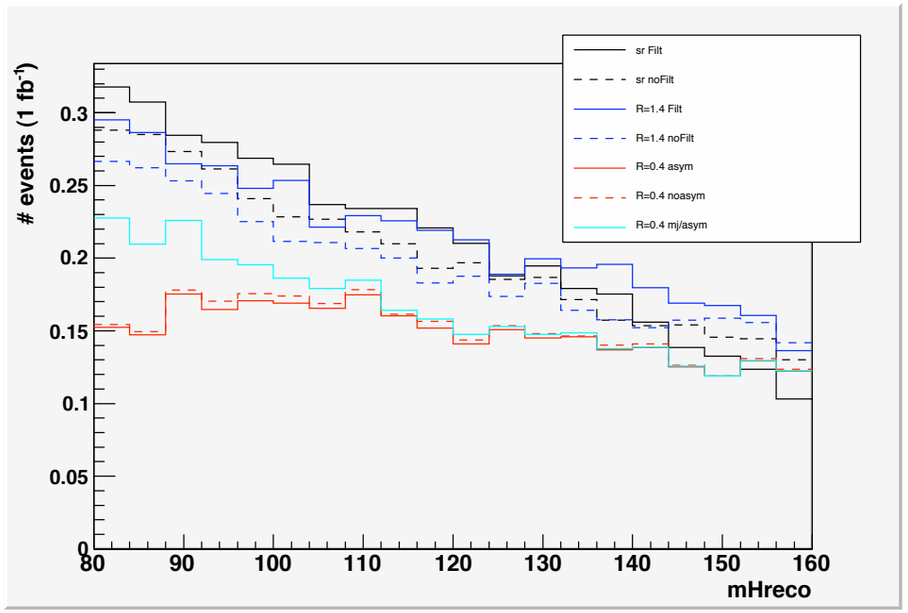
** jet clustering : fastjet-2.4.1

Reconstruced inv Higgs mass by many variants

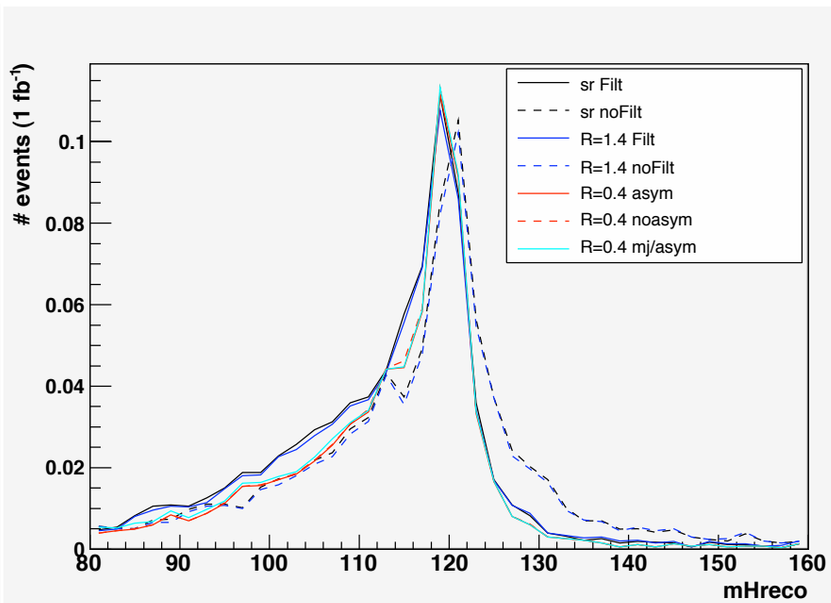
1 TeV $q\bar{q} - gZ$



$qg - qZ$



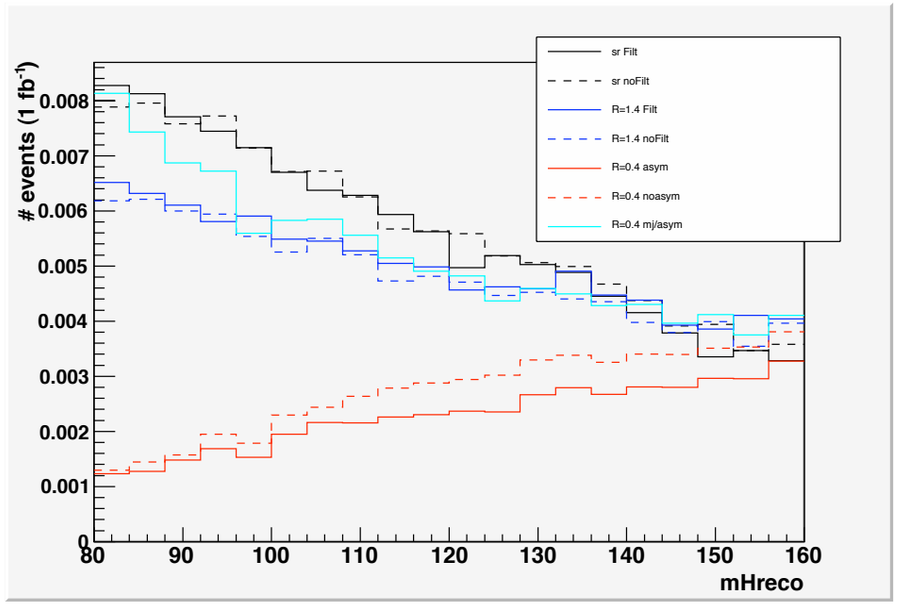
$q\bar{q} - Zh - b\bar{b}l^+l^-$



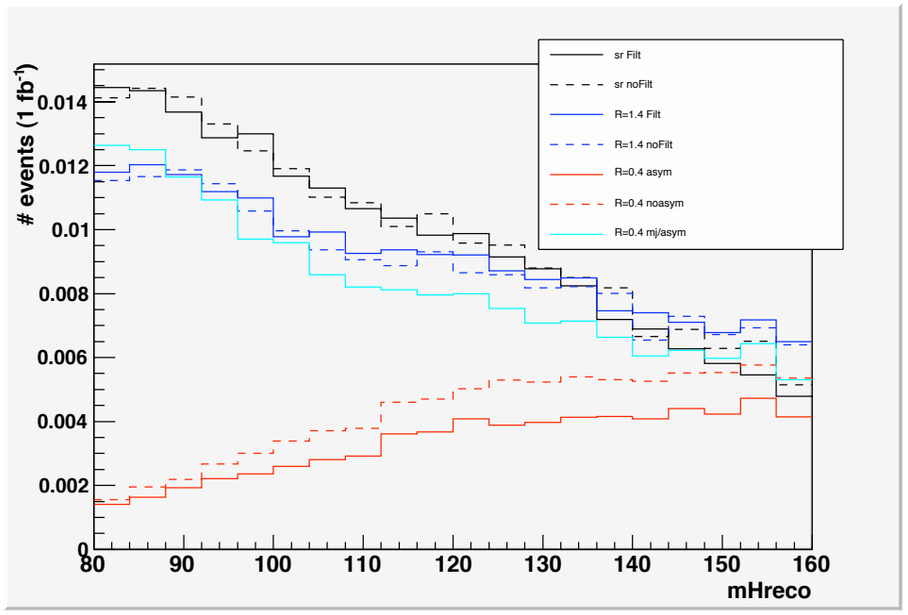
1. filtering effect is very slight
2. all procedures perform equally good
   (slight diff. can be improved by tuning pars.)

Reconstruced inv Higgs mass by many variants

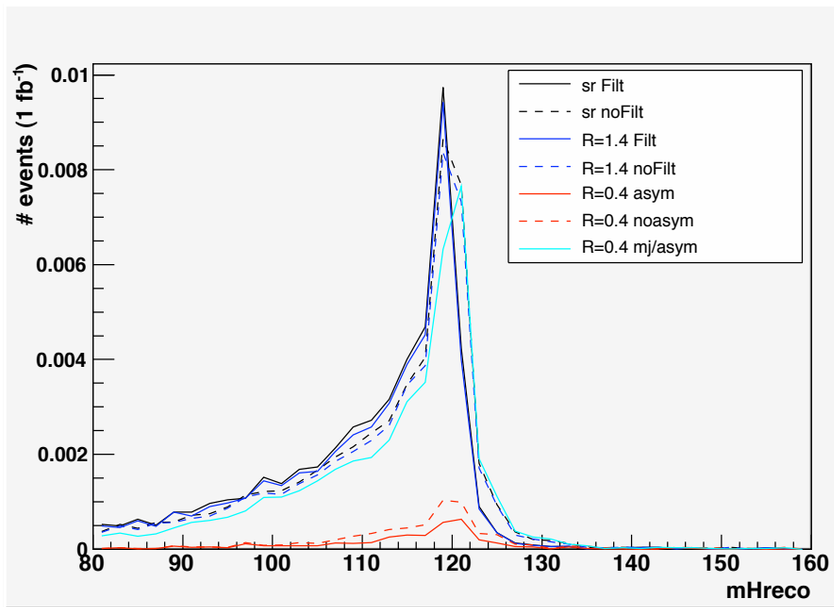
2 TeV $q\bar{q} - gZ$



$qg - qZ$



$q\bar{q} - Zh - b\bar{b}l^+l^-$



1. filtering effect is gone
2. roughly half of dijets merge into monojet
3. trad. jet technique with merged jets persists to work

Reconstructed Higgs invariant mass

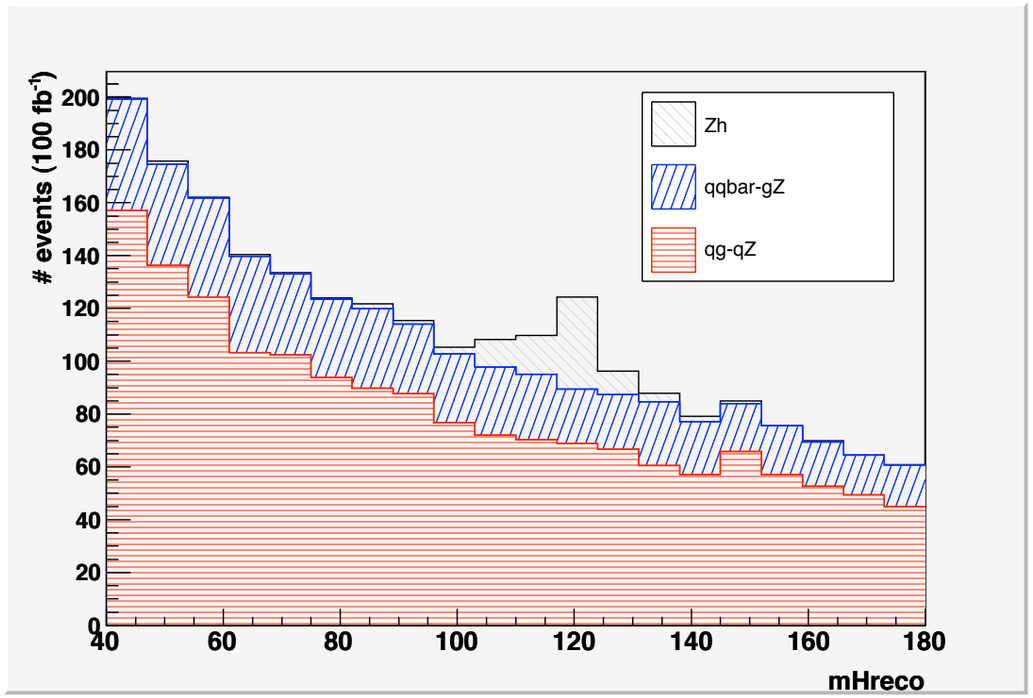
showing you only the cases with perfect tagging Eff.

$m_{Z'} = 1$ TeV

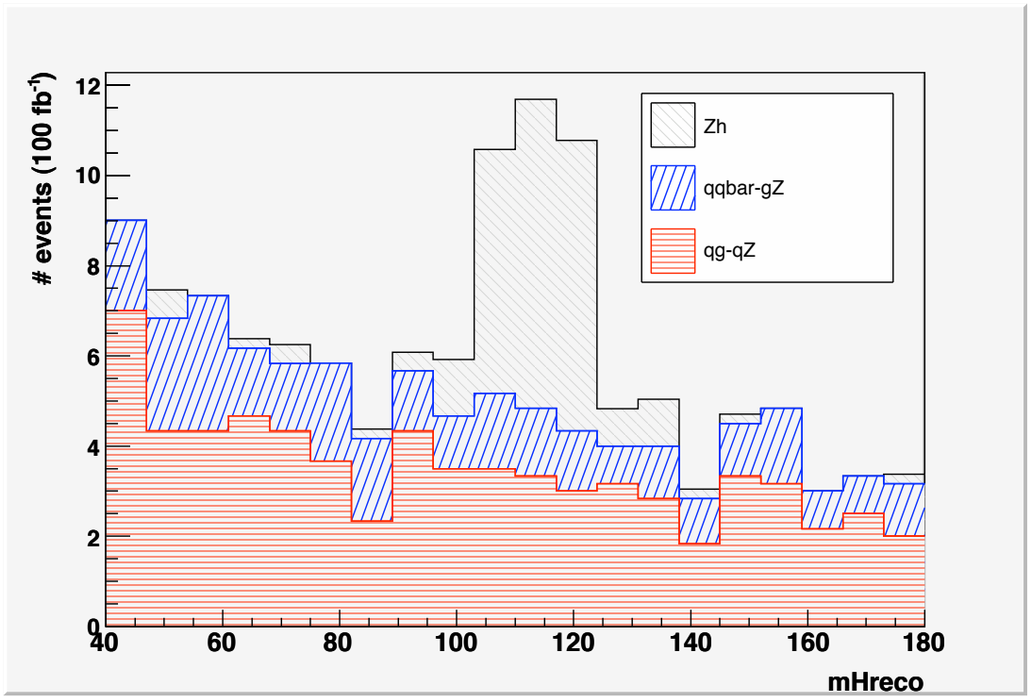
$900 < m_{Z'} < 1100$ GeV

Rescaled $\mathrm{Y} - \mathrm{seq.}$
$R_{jet} = 1.4$
no Filter

no tagging



perfect one soft muon-tagging

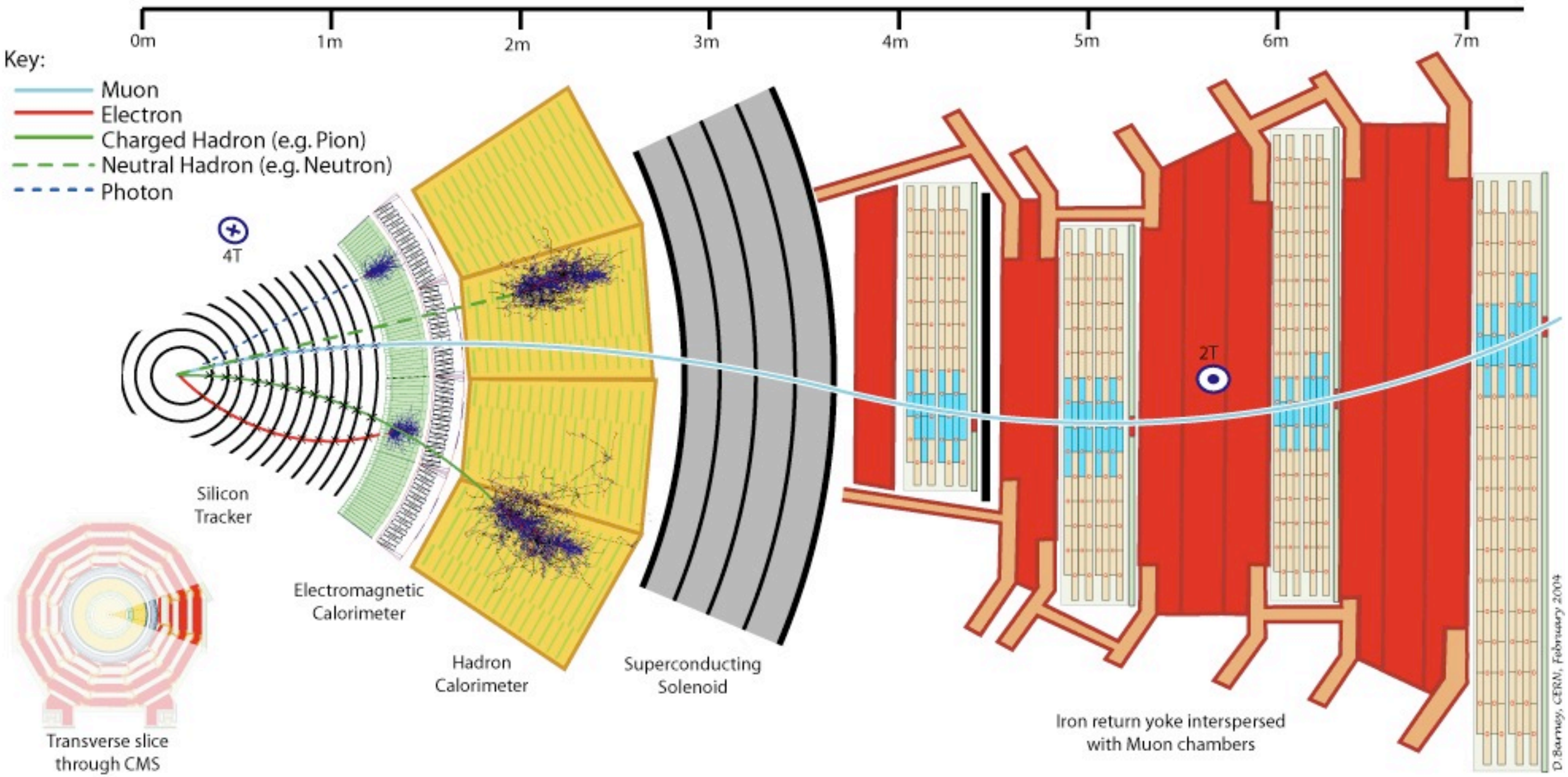


The reality will be an admixture of the above cases

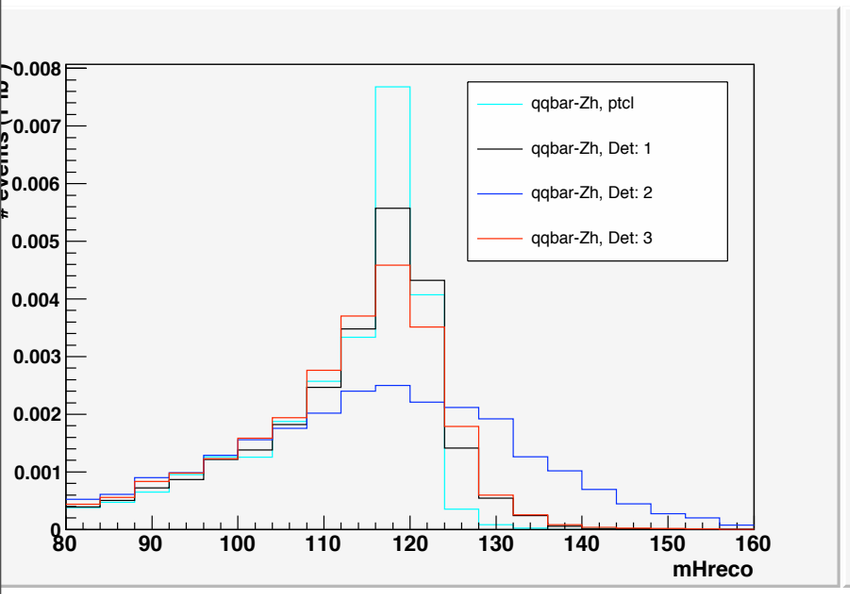
experimentalists need to figure it out !

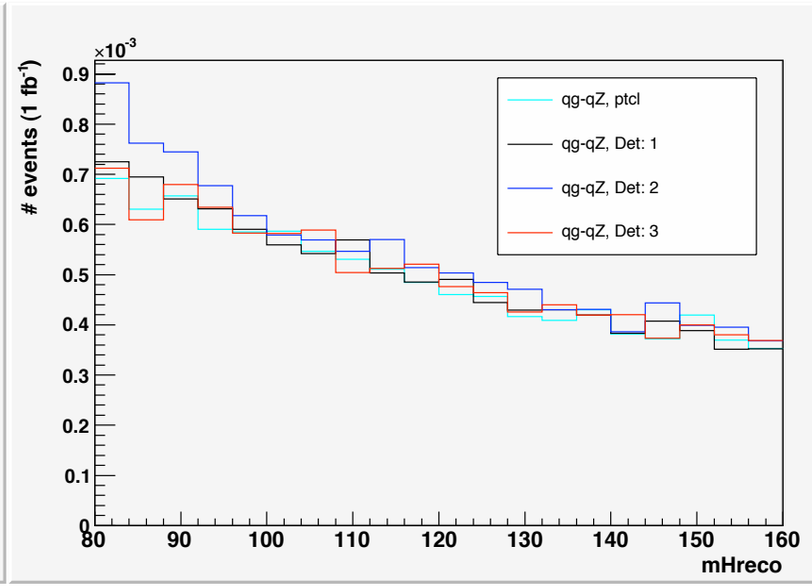
For 3 TeV Z' analysis

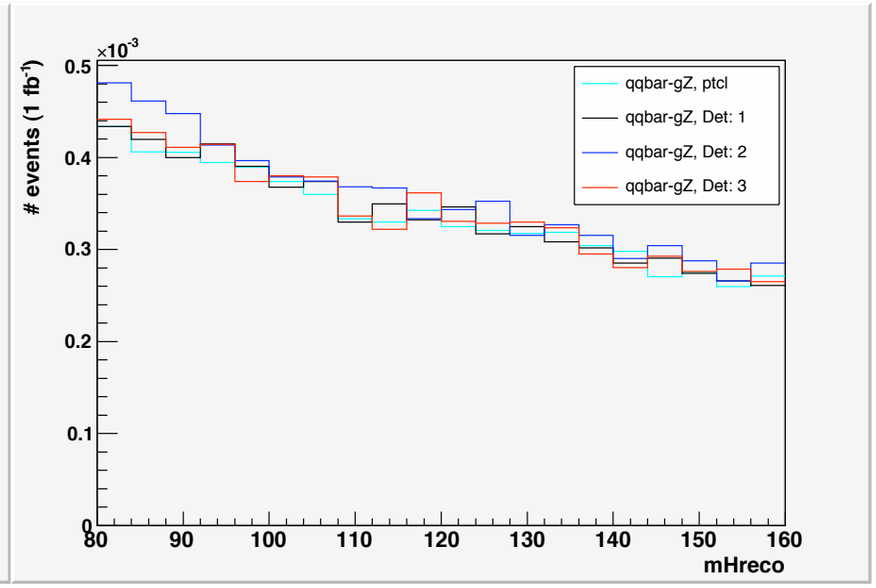
We take into account a possible impact of detector effect



Recon- Higgs mass for 3 TeV



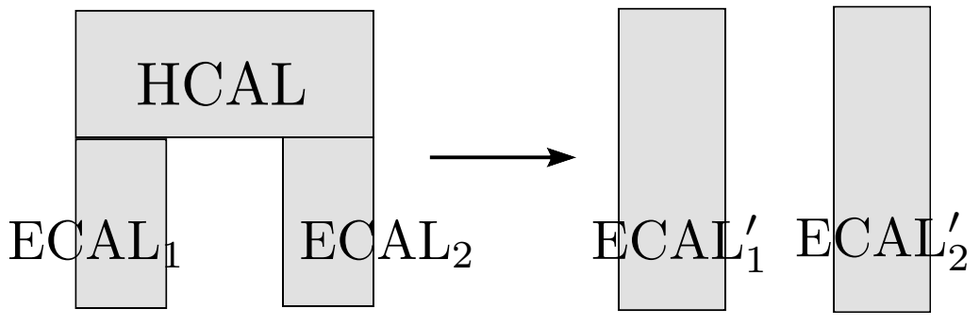




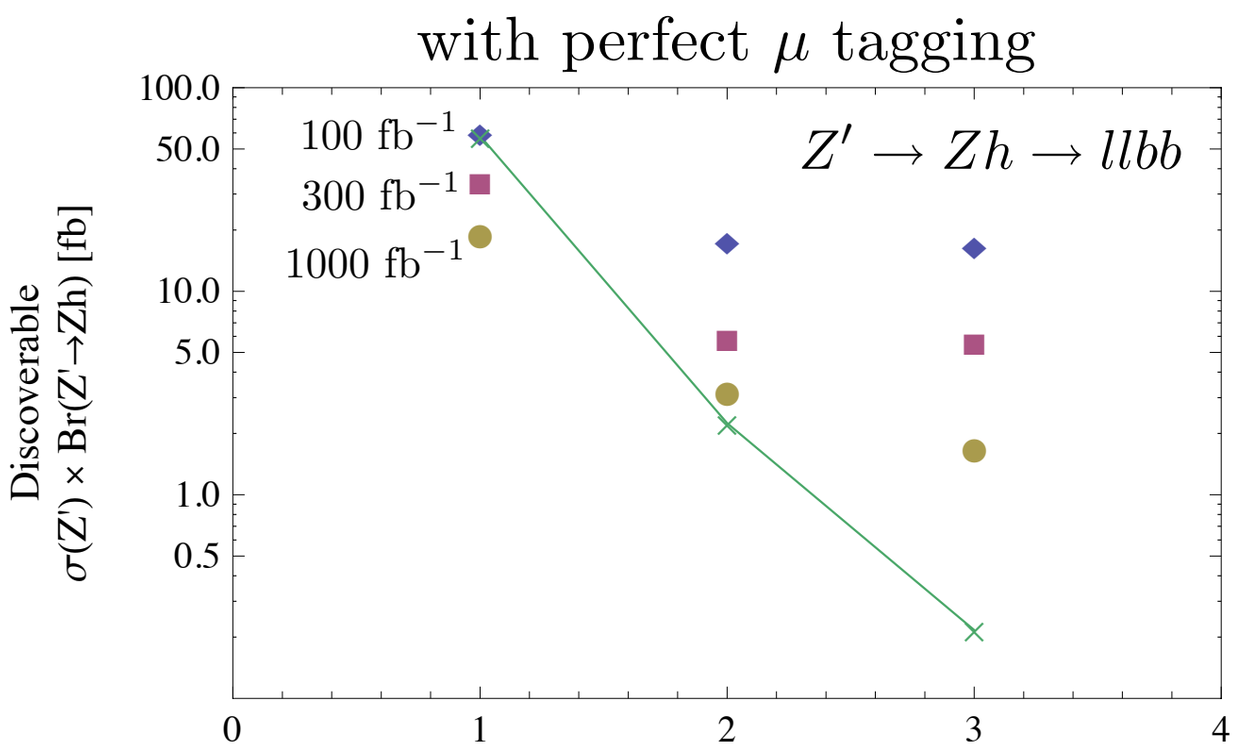
Detector model 1: use tracker, ECAL and HCAL

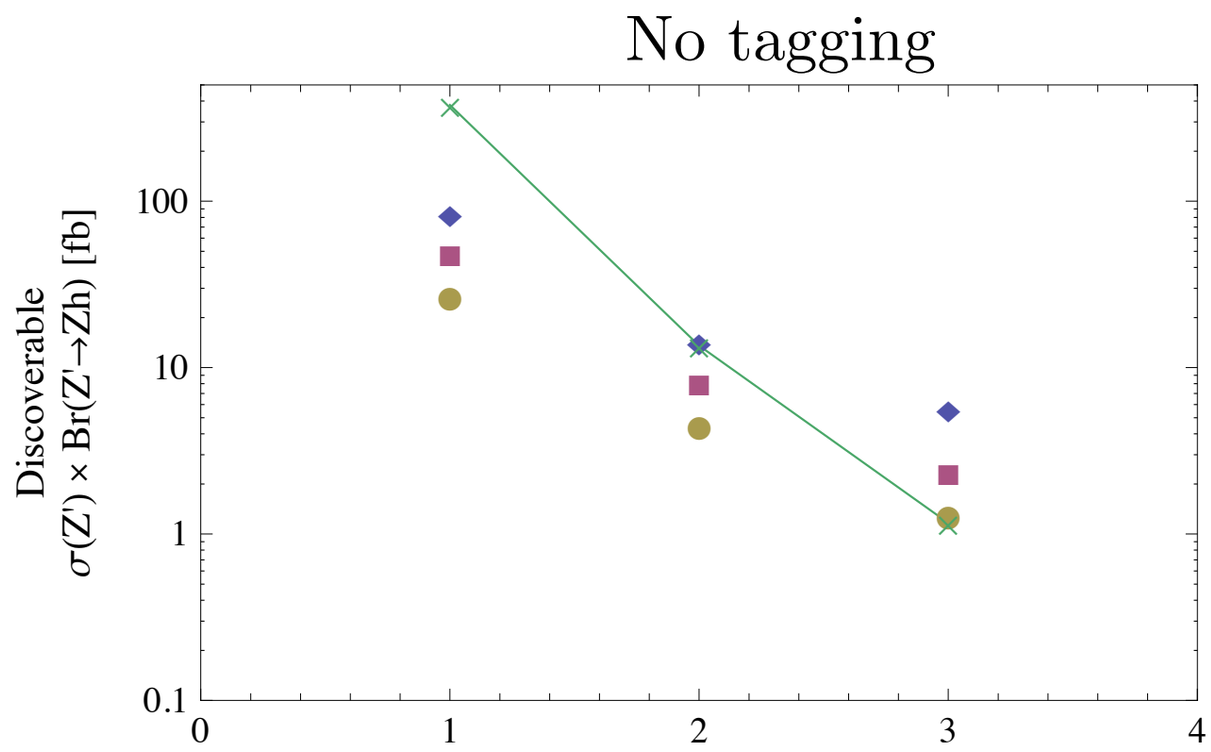
Detector model 2: ignore tracker, use only ECAL and HCAL

Detector model 3: as above Det. model 2 with ECAL rescaled to match full ECAL + HCAL energy (ECAL as tracker of jet energy flow)
E.g.



"Preliminary" LHC Reach Plot





$\mathrm{Max}\{(\sigma \cdot \mathrm{Br})_{5\,\sigma},\ (\sigma \cdot \mathrm{Br})_{\geq 10\ \mathrm{evts}}\}$, **Detector Model 3 for 3 TeV

$\times$: $\sigma(Z') \cdot \mathcal{B}(Zh)|_{S/B=1}$ $\quad 1 = \dfrac{N_s}{N_b} = \dfrac{(\sigma \cdot \mathcal{B})_s\, \epsilon_s}{\sigma_b\, \epsilon_b}$

$\sigma(Z') \cdot \mathcal{B}(Zh)$	Randall-Sundrum	Little Higgs	Y-sequential
1 TeV		~ 214 fb	~ 40 fb
2 TeV	~ 25 fb	~ 10 fb	~ 2 fb
3 TeV	~ 3 fb	$\cot\theta = 0.5$	$g_{Z'} = e/\cot\theta_W$