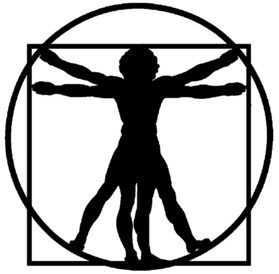


Vincia in Pythia 8.304

C. Preuss, P. Skands, R. Verheyen

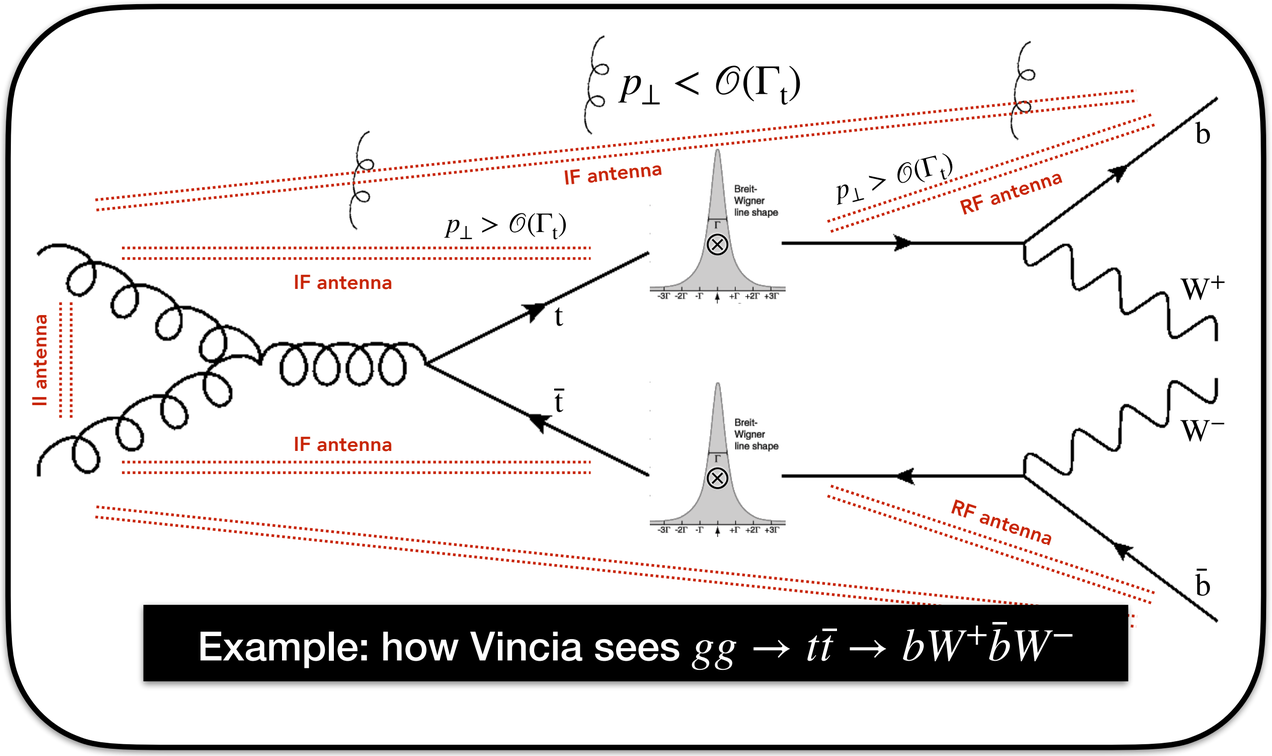
Coherent Resonance-Final Antennae
Relevant for top decay

Coherent Initial-Final Antennae
Esp relevant for VBF; also top, jets, …

Sophisticated treatment of Finite Widths
Relevant for top, W, Z

(**Fully coherent multipole QED shower**
+ option for electroweak shower) Not discussed explicitly in these slides

Dedicated CKKW-L Merging Implementation
"Sector Merging" (efficient scaling with N_{Legs})



Top Physics with Vincia

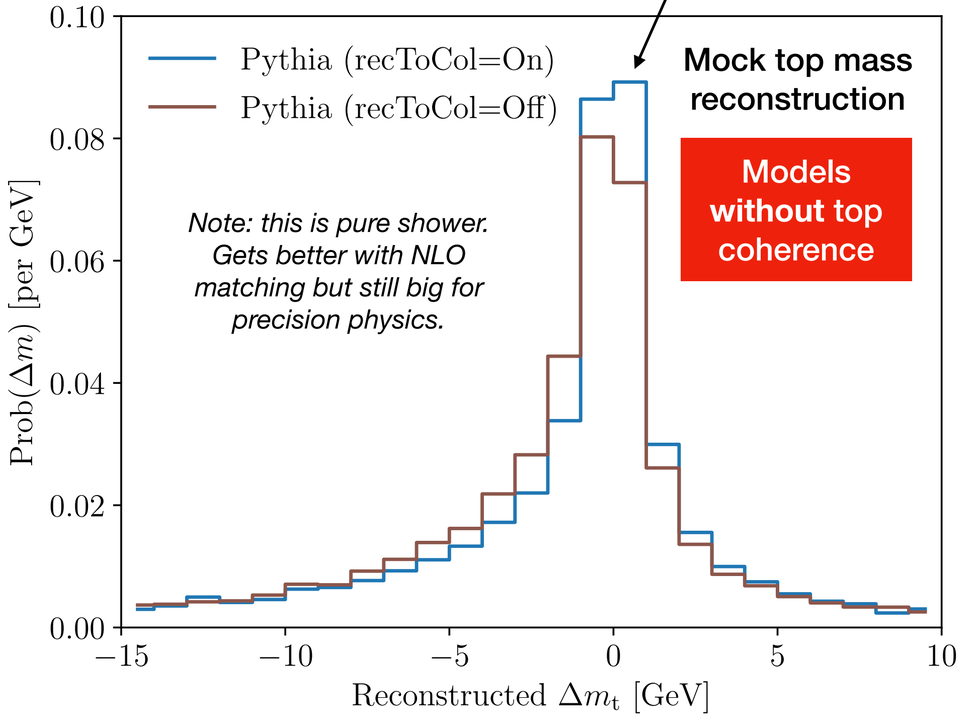
Note: tutorial that reproduces these plots: http://skands.physics.monash.edu/slides/files/Pythia83-VinciaTute.pdf

- **Ambiguities** in Pythia's baseline shower for **colour flows through decays** (i.e., top decays). Can persist through NLO matching.

E.g.: Ferrario Ravasio et al, Eur.Phys.J.C 78 (2018) 6, 458, Eur.Phys.J.C 79 (2019) 10, 859 (addendum)

recoilToColoured = on/off

Affects radiation patterns & reconstructed Δm_t



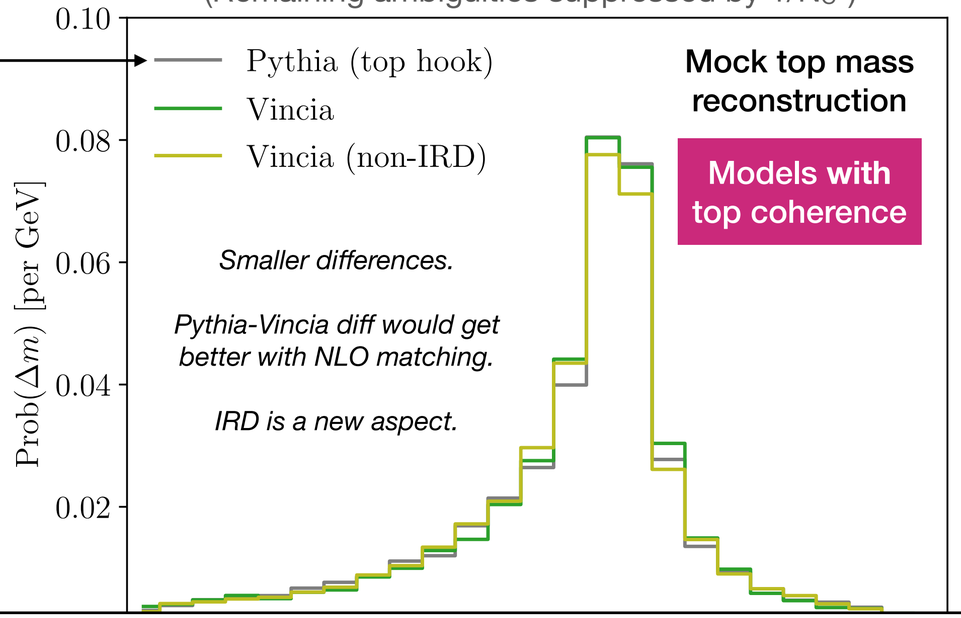
Note: Pythia (top hook) is a UserHook that corrects recToCol=off for coherence. Included in tutorial above.

Vincia = QCD antennae ➤ no ambiguity at LC*

Coherent Resonance-Final Antennae

Brooks & Skands *Phys.Rev.D* 100 (2019) 7, 076006 • e-Print: 1907.08980 [hep-ph]

*(Remaining ambiguities suppressed by $1/N_C^2$)



*(Remaining ambiguities suppressed by $1/N_C^2$)

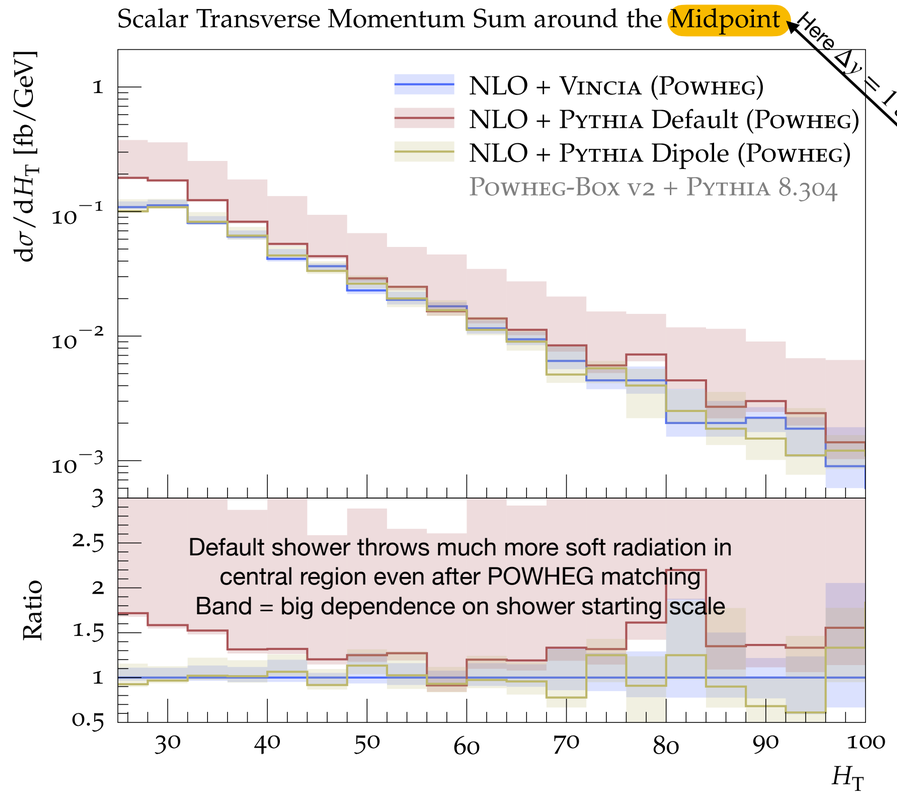
+ Interleaved Resonance Decays (resonances decayed during shower, at scale = offshellness; allows interferences beyond narrow-width approximation; paper in progress)

Vector Boson Fusion with Vincia

Paper in progress, including effects of NLO merging (POWHEG) and LO multi-jet merging (CKKW-L) up to six jets

- **Ambiguities** in Pythia's baseline shower for **colour flows through hard process** (such as VBF). Can persist through NLO matching.

(& Pythia 8.3 baseline multi-jet LO merging cannot handle VBF)

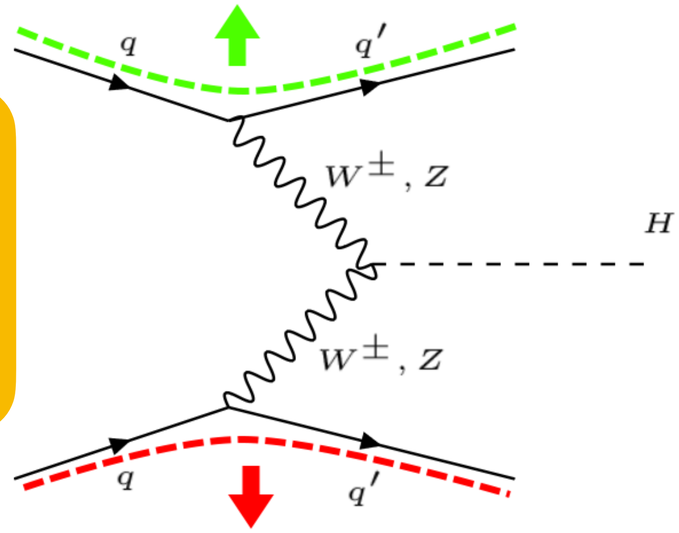


Vincia = QCD antennae ➤ no ambiguity at LC*

Coherent Initial-Final Antennae

Ritzmann, Kosower, Skands, *Phys.Lett.B* 718 (2013) 1345-1350 • e-Print: 1210.6345
Fischer, Prestel, Ritzmann, Skands, *Eur.Phys.J.C* 76 (2016) 11, 589 • e-Print: 1605.06142
Brooks, Preuss, Skands, *JHEP* 07 (2020) 032 • e-Print: 2003.00702

IF Coherence ➤ suppression of radiation between the 2 tagging jets



+ Sector Merging (dedicated CKKW-L implementation for Vincia's sector shower, can handle VBF; see same tutorial)

Brooks & Preuss e-Print: 2008.09468 [hep-ph]

*(Remaining ambiguities suppressed by $1/N_C^2$)

(Backup Slide: What are Interleaved Resonance Decays?)

Starting point same as usual: final-state resonances treated as stable (~ narrow-width approximation)

New: treat decays of unstable resonances **during shower evolution**, at scale ~ off-shellness $Q_R^2 \equiv |m^2 - m_0^2|$

$$\frac{\mathrm{d}\mathcal{P}}{\mathrm{d}Q^2} = \left(\frac{\mathrm{d}\mathcal{P}^{\mathrm{MPI}}}{\mathrm{d}Q^2} + \sum_{\mathrm{QCD}} \frac{\mathrm{d}\mathcal{P}^{\mathrm{ISR+FSR}}_{\mathrm{QCD}}}{\mathrm{d}Q^2} + \sum_{\mathrm{EW}} \frac{\mathrm{d}\mathcal{P}^{\mathrm{ISR+FSR}}_{\mathrm{EW}}}{\mathrm{d}Q^2} + \sum_{\mathrm{R}} \mathrm{BW}_{\mathrm{R}}(Q^2) \right) \times \exp\left(- \int_{Q^2}^{Q^2_{i-1}} \mathrm{d}Q'^2 \, \frac{\mathrm{d}\mathcal{P}^{\mathrm{MPI}}}{\mathrm{d}Q'^2} + \sum_{\mathrm{QCD}} \frac{\mathrm{d}\mathcal{P}^{\mathrm{ISR+FSR}}_{\mathrm{QCD}}}{\mathrm{d}Q'^2} + \sum_{\mathrm{EW}} \frac{\mathrm{d}\mathcal{P}^{\mathrm{ISR+FSR}}_{\mathrm{EW}}}{\mathrm{d}Q'^2} \right)$$

$\Longrightarrow$ Resonances replaced by their decay products (+shower) at an average scale ~ Γ_{res}

Resonance cannot act as emitter or recoiler below that scale; only its decay products can do that. (~ Formation time argument.)

The more off-shell a given resonance is, the higher the scale at which that resonance disappears ➤ Expect more interference in tails.

Roughly corresponds to strong ordering (as measured by propagator virtualities) in rest of shower.

Allows (suppressed) effects reaching scales > Γ

Note: $\sum_R \mathrm{BW}_R$ is absent from Sudakov since BW distribution is already unitary (a resonance-decay happens once and only once)

Example for top:

Successive decays can be nested iteratively