Hoang, Plätzer, Samitz – arXiv:1807.06617 (to appear in JHEP)
Cormier, Plätzer, Reuschle, Richardson, Webster – arXiv:1810.06493

Top Quarks and Parton Showers

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Particle Physics, University of Vienna

at the
CMS Top Group Workshop
CERN | 6 November 2018

EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

The Top Quark Mass Parameter

[Hoang, Plätzer, Samitz – arXiv:1807.06617]

Top ‘particle’ interpretation does not apply, always accompanied by gluon cloud.

Top mass is a scheme dependent parameter in perturbative calculations, scheme of parton showers is unclear, even in presence of NLO matching.

Relate to pole mass, for definiteness:

$$m_t^{\mathrm{MC}} = m_t^{\mathrm{pole}} + \Delta_m^{\mathrm{pert}} + \Delta_m^{\mathrm{non\text{-}pert}} + \Delta_m^{\mathrm{MC}}$$

Perturbative shift: Scheme definition

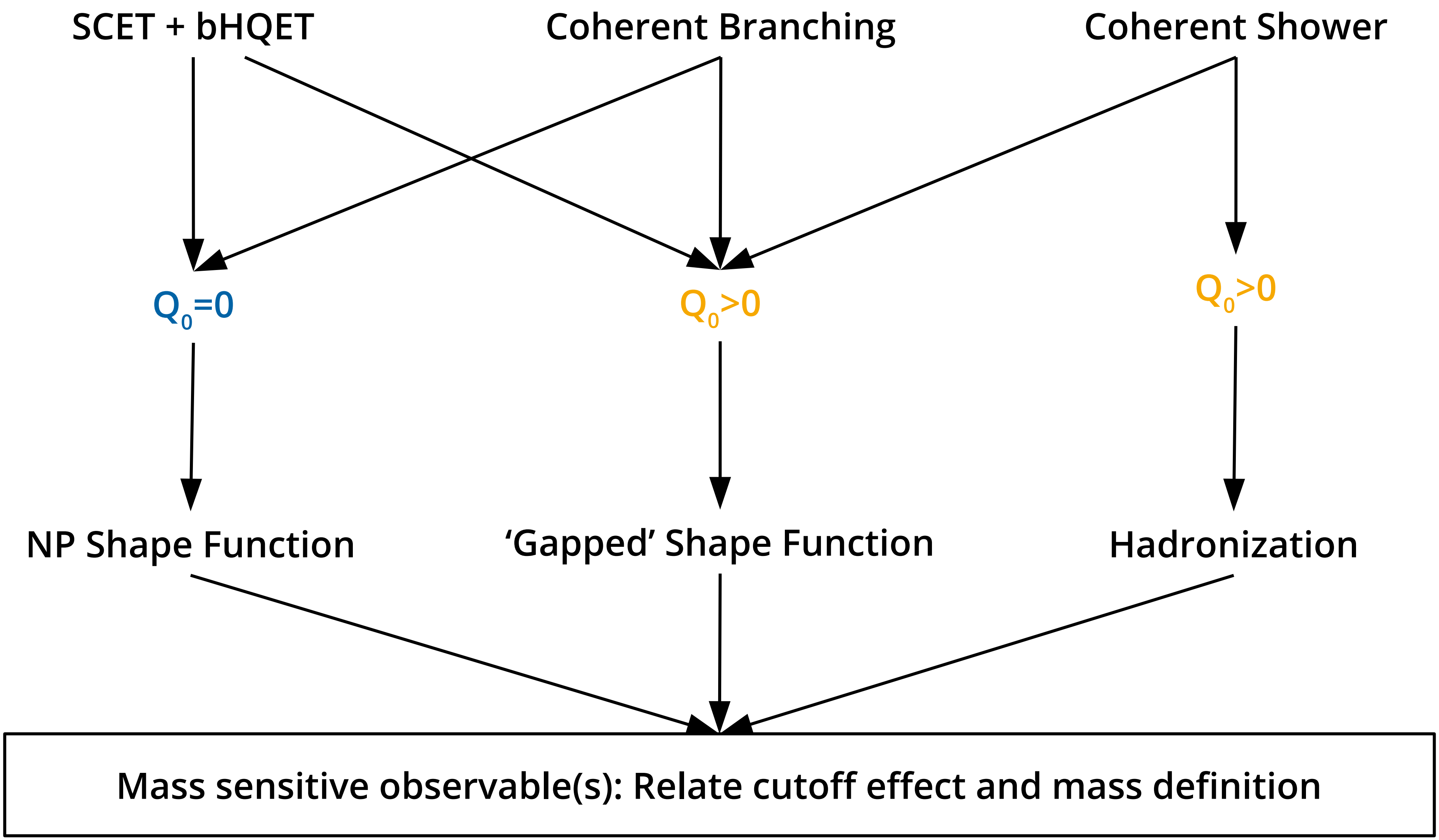
Hadronization contributions

Modeling uncertainties

Effect of parton shower cutoff Q_0 crucial to identify contributions.

Method

[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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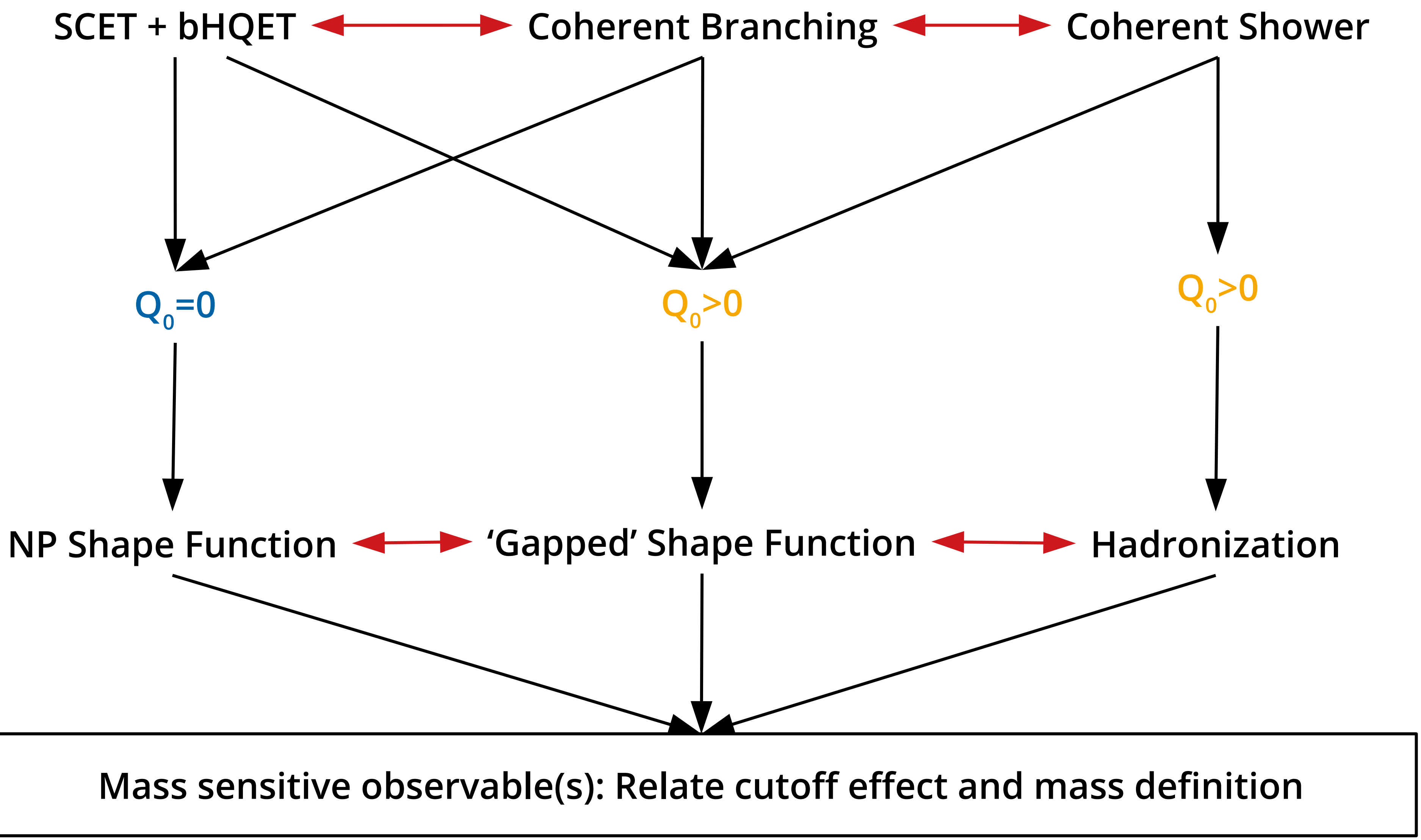
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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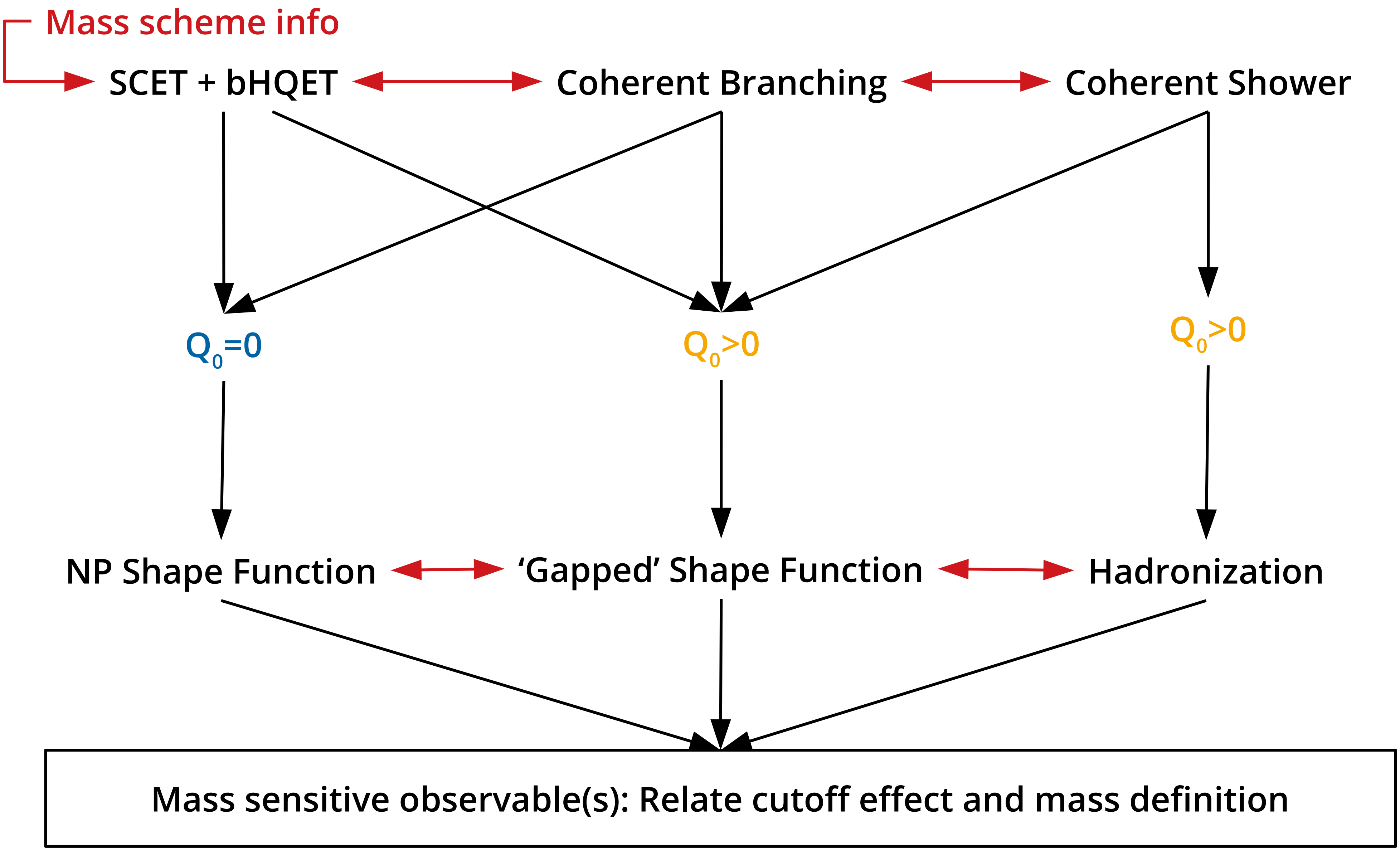
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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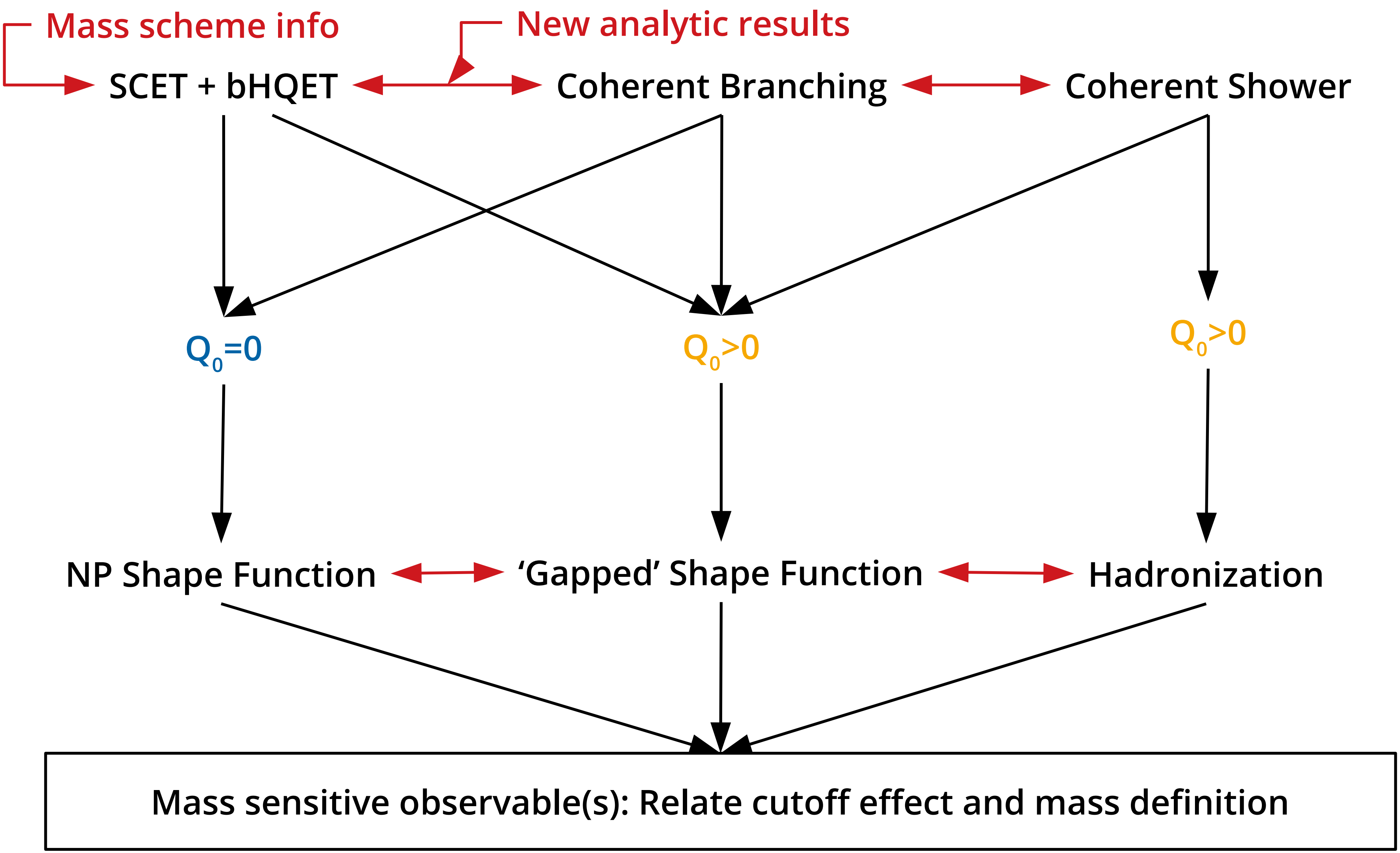
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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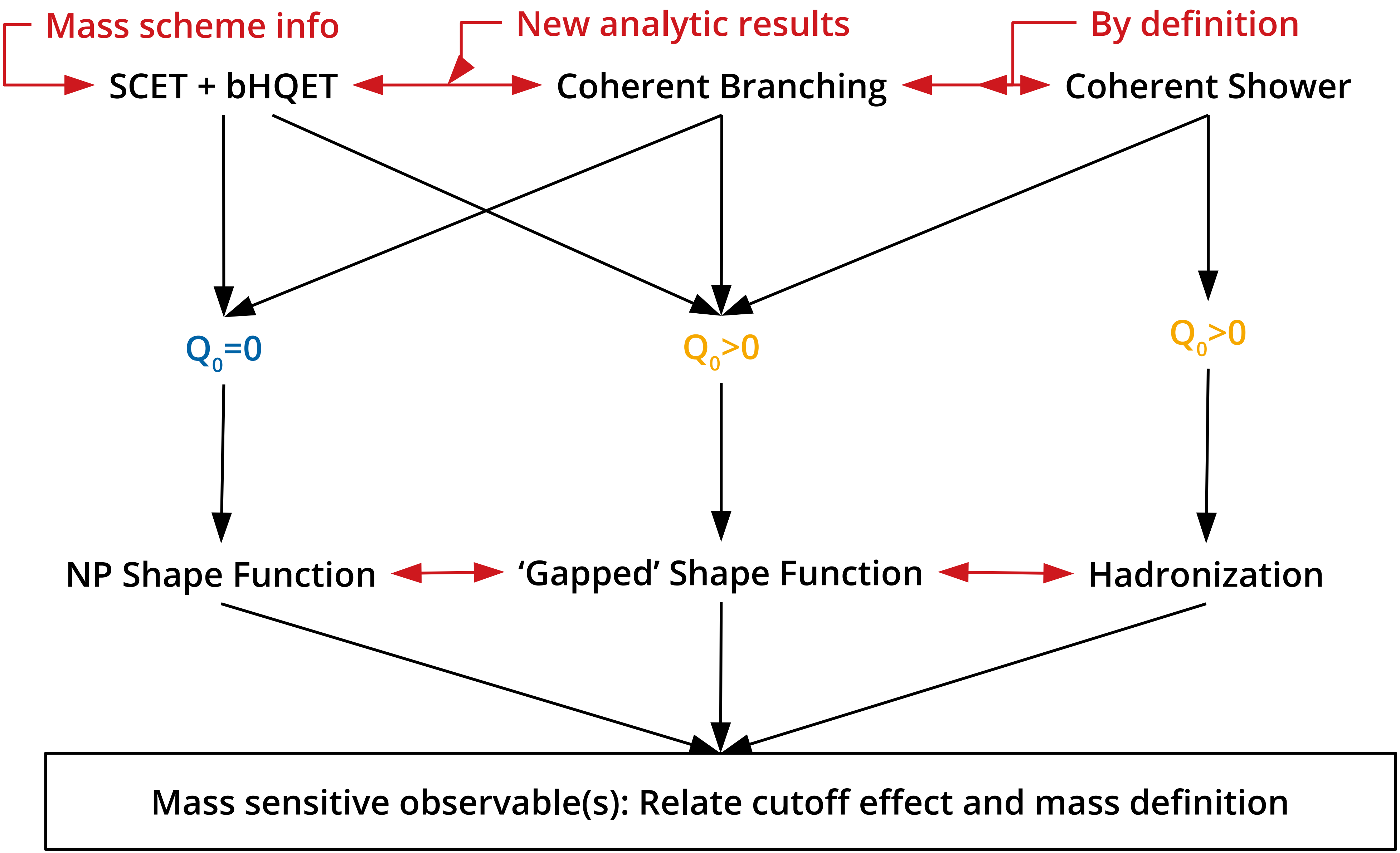
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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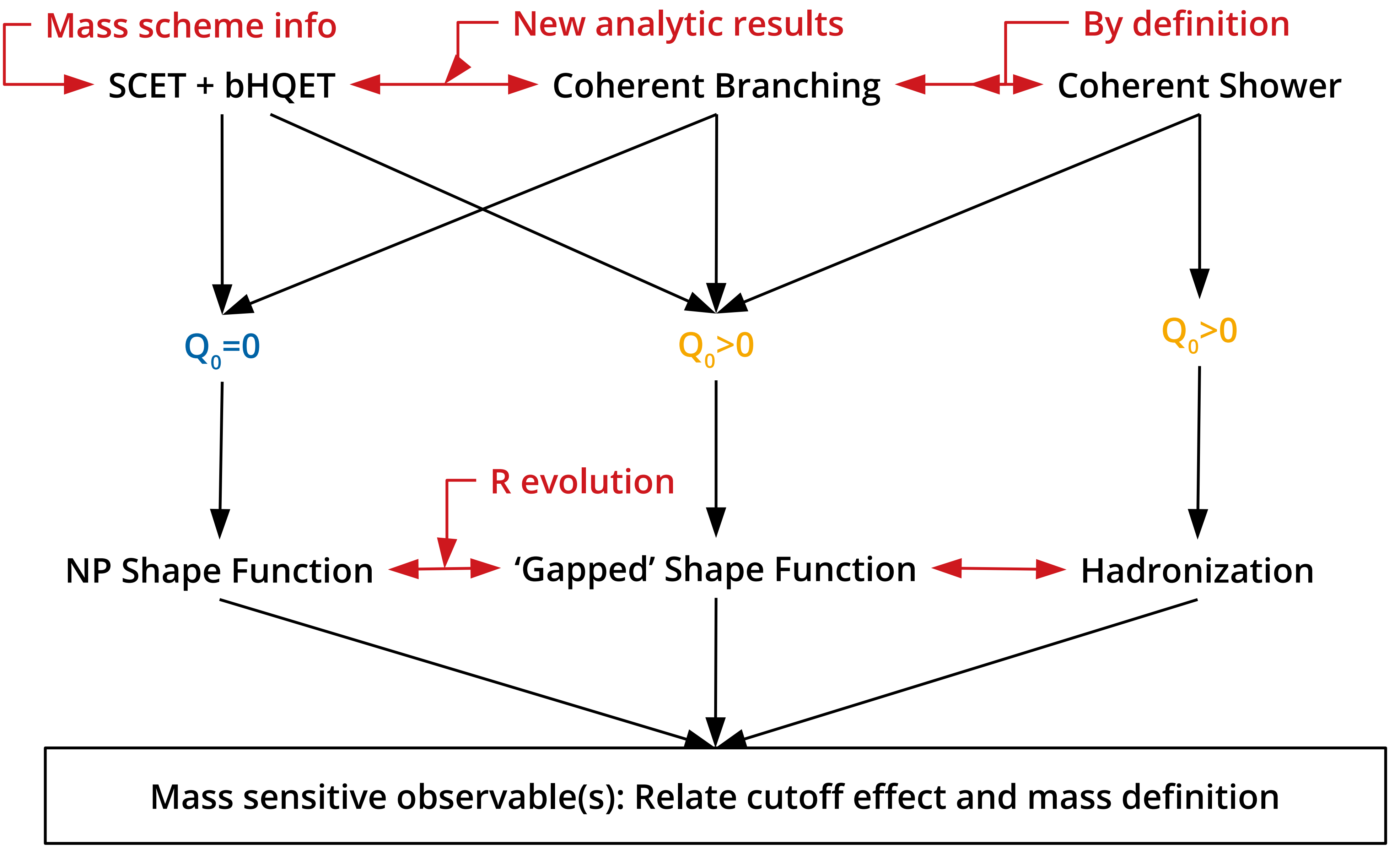
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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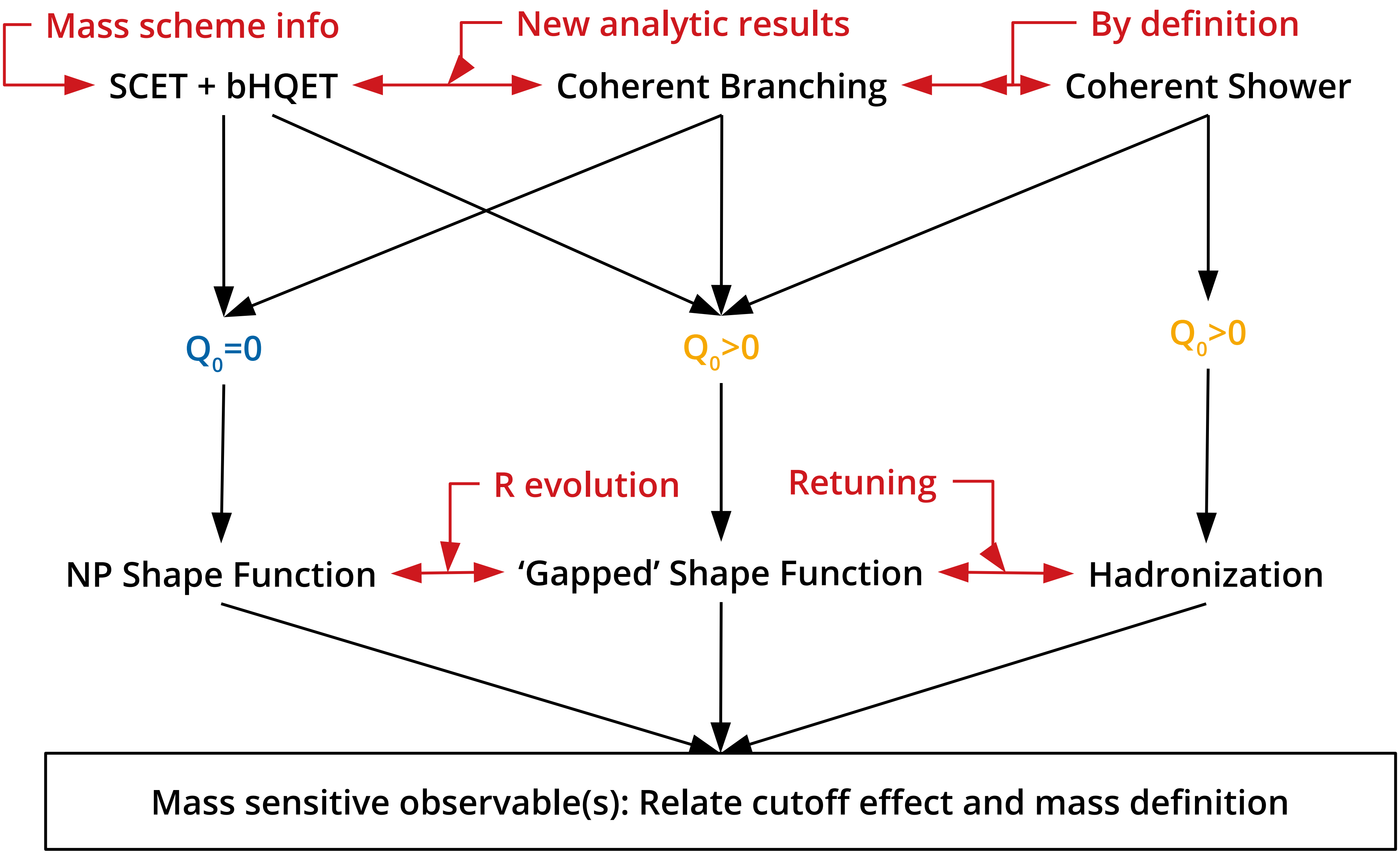
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



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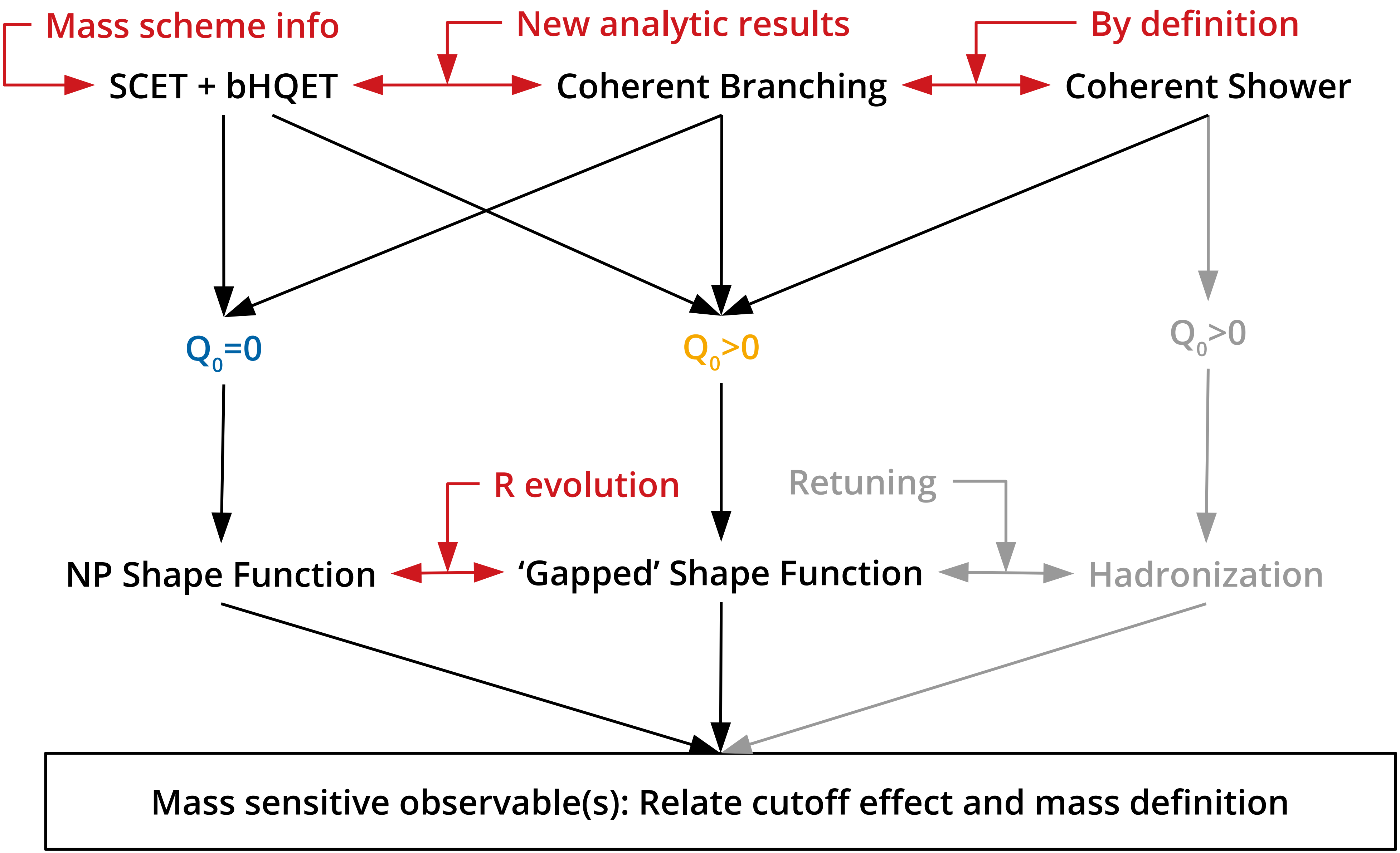
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



Method

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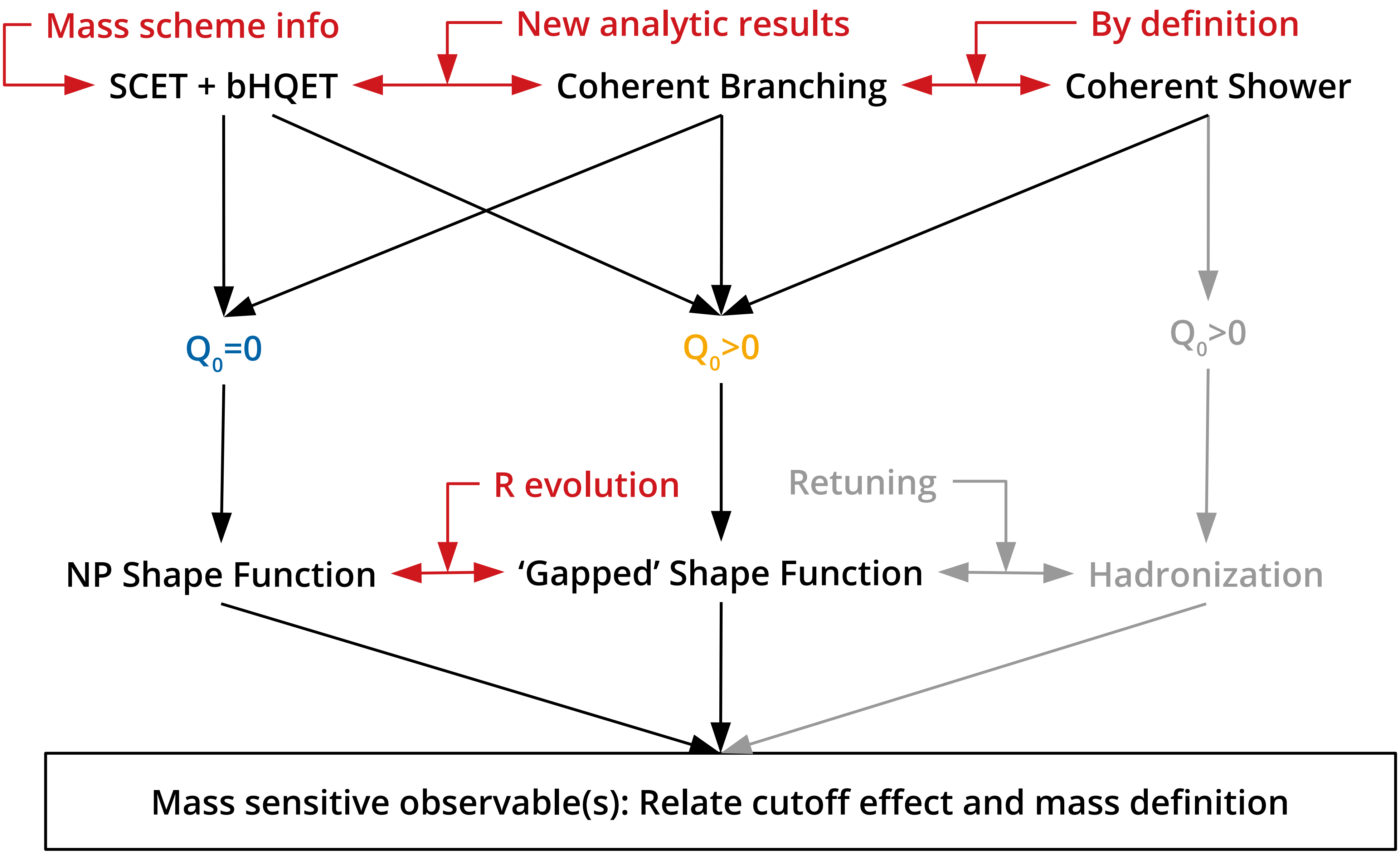
[Hoang, Plätzer, Samitz – arXiv:1807.06617]



+ massless case as (simpler) cross check

The Mass Parameter for Coherent Branching

[Hoang, Plätzer, Samitz – arXiv:1807.06617]

Consider **two-jetiness in e+e- as a benchmark:** EFT calculation, direct QCD analysis (coherent branching), and actual event generator (Herwig 7) at hand.

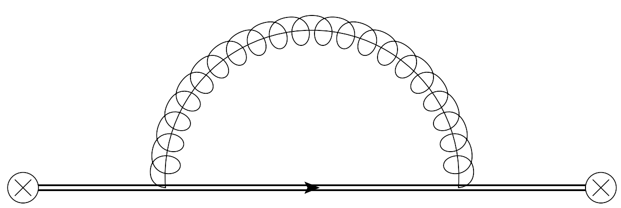
Boosted regime for quasi-collinear shower approximation to be valid, observable insensitive to decay details. No finite lifetime effects (yet).

Effective theory and direct QCD calculation agree on cutoff-dependent shift of peak, massless calculation identifies large-angle soft contribution compensated by hadronization and ultracollinear radiation affecting the mass scheme.

Parton shower unitarity transfers IR cutoff effect to effectively change pole of heavy quark propagator.

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

Recover the pole mass in absence of a cutoff.

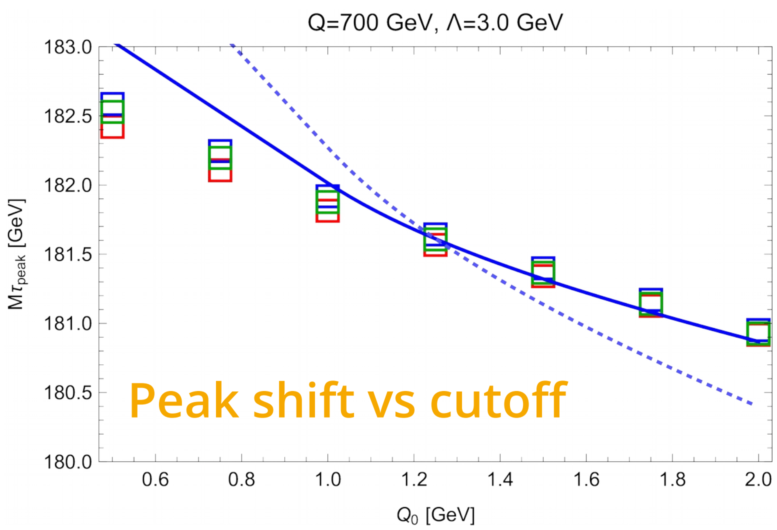


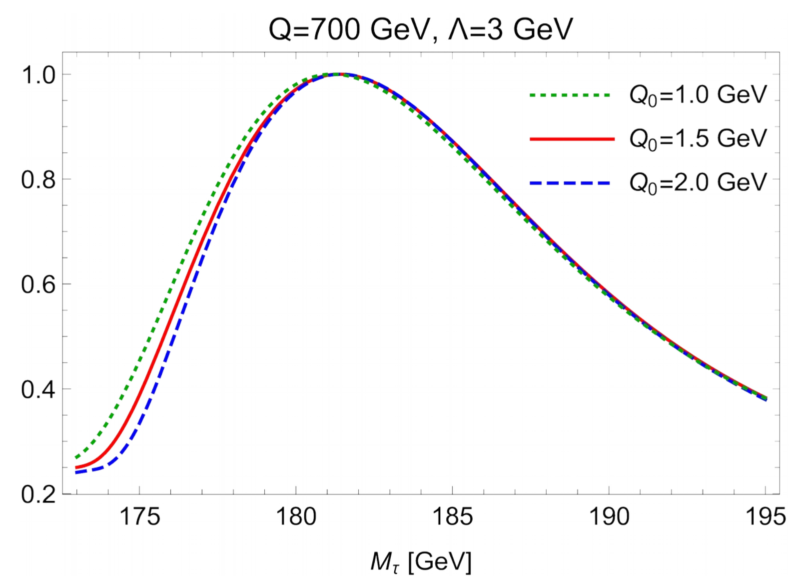
Comparison to Herwig 7 AO Shower

[Hoang, Plätzer, Samitz – arXiv:1807.06617]

Massless and massive coherent branching calculation and **Herwig 7 angular ordered** shower in full agreement in the log-enhanced peak region, NLL accurate.

Cutoff shifts peak in absence of compensating change in hadronization.





Similar observations in endpoint of lepton/b-jet mass observed. Detailed analysis of hadronization effects now underway.

Top Mass: Further remarks

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NLO matching does not affect any of the logic presented here. Proven analytically, and confirmed numerically with Herwig 7 Matchbox subtractive matching. This applies generically to all existing matching paradigms.

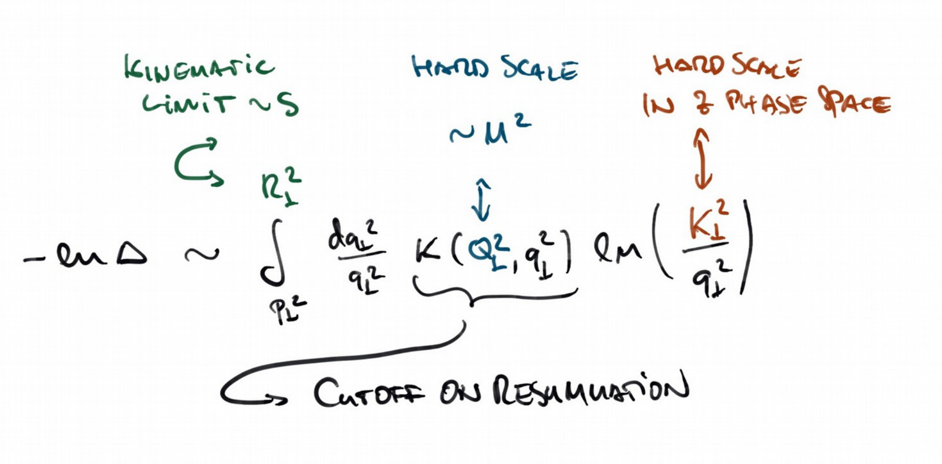
Dipole showers have yet escaped an analytic approach comparable to the coherent branching result: Effectively nothing is known beyond a single emission, and claims on logarithmic accuracy should be taken carefully. see [Dasgupta, Hamilton, Monni, Salam 2018]

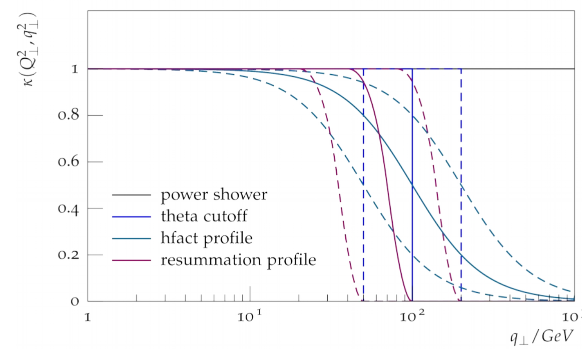
Hadronization effects need detailed investigation, which is in progress. Comparison in between different models is desirable.

NLL accuracy is an observable-dependent statement, and needs to be investigated in detail on a case-by-case basis.

Shower variations

[Bellm, Nail, Plätzer, Richardson, Siodmok – EPJ C 76 (2016) 665]

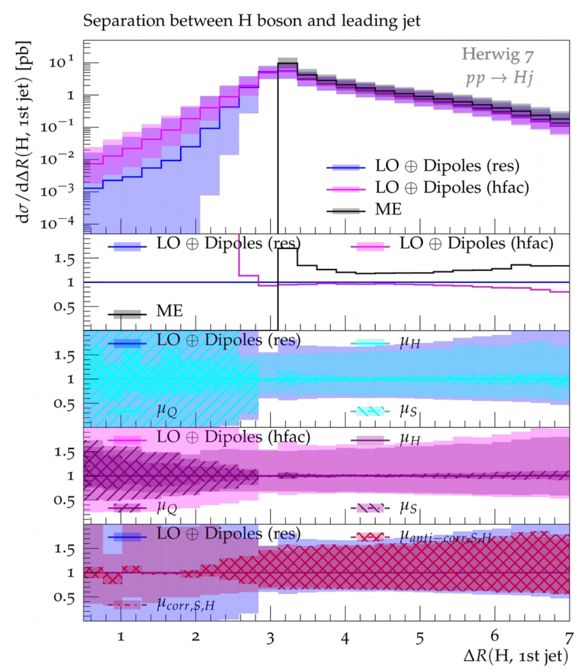


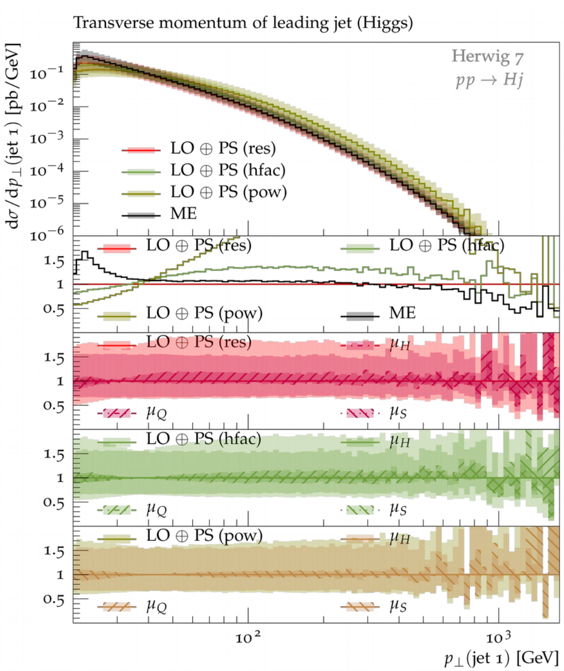


Fast cutoff of the resummation is crucial to produce 'controllable' uncertainties:

Need to reflect reliability of showering and to preserve relevant hard process properties .

Comparable between angular ordered and dipole shower.





NLO Matching Systematics & Uncertainties

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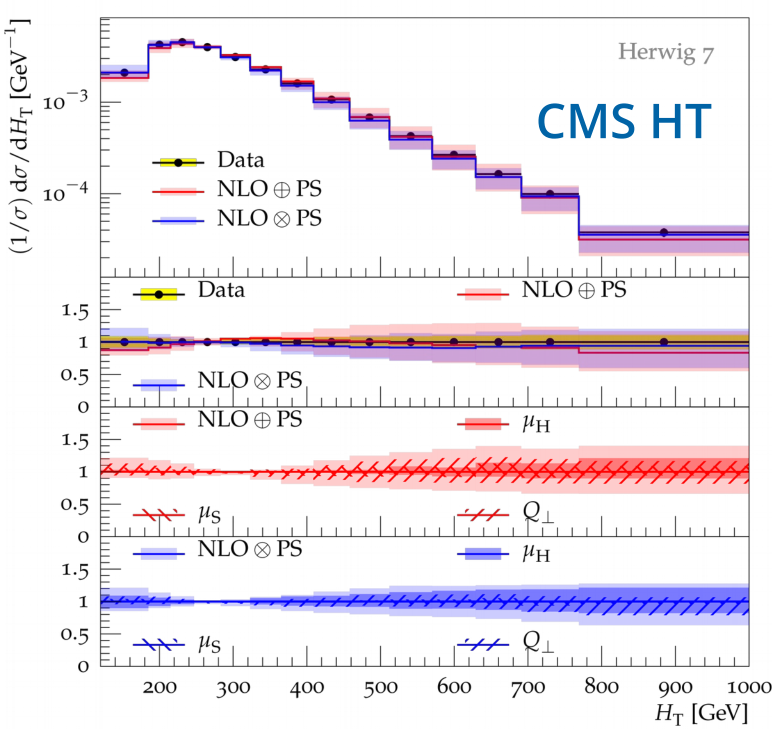
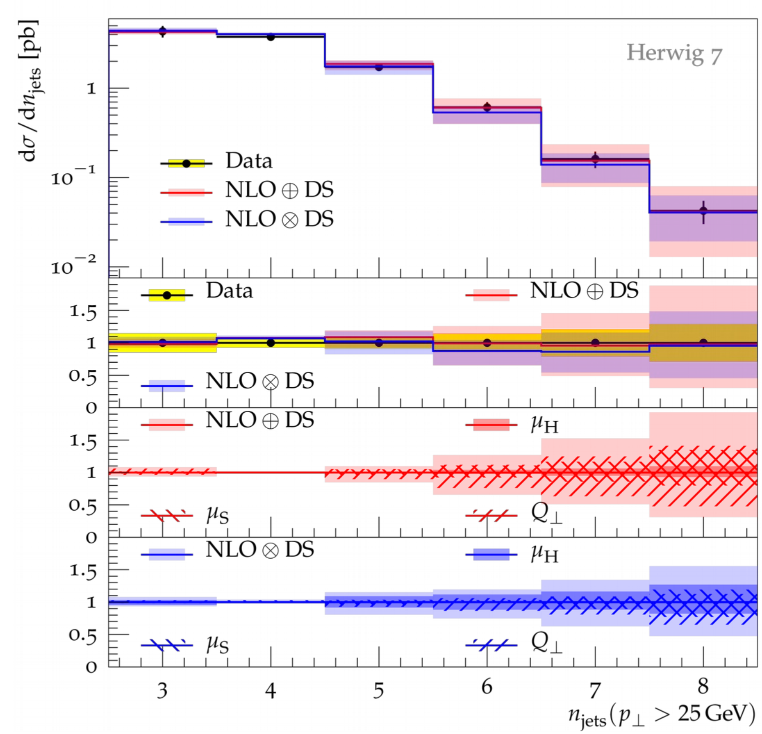
[Cormier, Plätzer, Reuschle, Richardson, Webster – arXiv:1810.06493]

Study NLO matching in detail using Herwig shower modules and Matchbox.

Revised treatment of massive quark evolution in dipole shower, and evolution of decay systems. Matching now available for **production and decays**, and angular ordered and dipole shower.

ATLAS jet multis





Matching & Uncertainties: Further Remarks

We can not claim that shower variations form a reliable set of uncertainties. This is only a starting point for investigating event generator uncertainties in a global prescription, and full uncertainties require the next order to be available.

Variations should therefore not be performed by assuming compensation patterns. In all of our matching/uncertainty studies we have identified regions driven by one or the other of the possible scales.

Cross-validation in the same framework is crucial, Herwig 7 provides unique features with two shower algorithms and two matching paradigms, and spin correlations in both showers, and on-the-fly reweighting for shower variations.

[Richardson, Webster – arXiv:1807.01955]
[Bellm, Plätzer, Richardson, Siodmok, Webster – PhysRev D94 (2016) 4028]

A careful choice of hard veto scale is needed for matched calculations.

Variations should also be confronted with retuning.

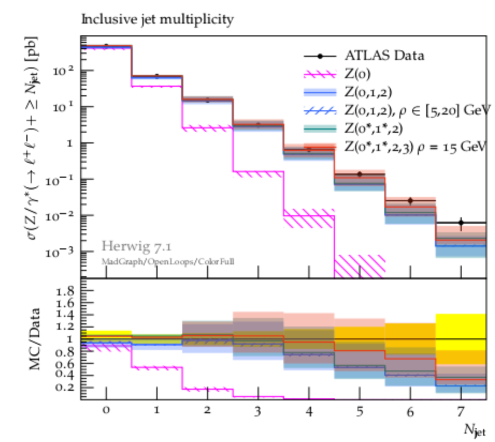
[see LH17 studies]

Herwig 7

Herwig 7.0 series

[Herwig collaboration – Eur.Phys.J. C76 (2016) 665]

- NLO matching for angular ordered and dipole shower
- MC@NLO-type and Powheg-type algorithms
- Matchbox central [Plätzer, Bellm, Rauch, Reuschle, Wilcock – unpublished]



Herwig 7.1 series

[Herwig collaboration – arXiv:1705.06919]

- Shower variations and reweighting

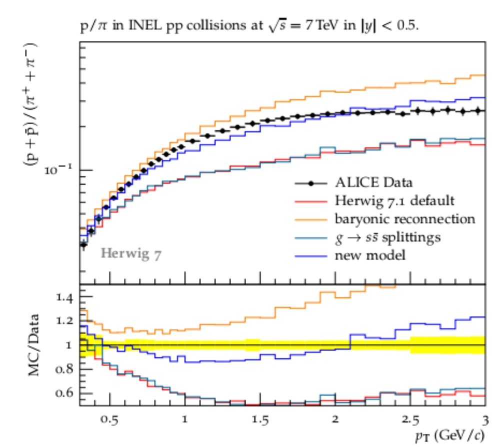
  [Bellm, Nail, Plätzer, Schichtel, Siodmok – EPJ C76 (2016) 665]
  [Bellm, Plätzer, Richardson, Siodmok, Webster – PhysRev D94 (2016) 4028]

- NLO multijet merging with the dipole shower

  [Plätzer – JHEP 1308 (2013) 114]
  [Bellm, Gieseke, Plätzer – EPJ C78 (2018) 244]

- Colour reconnection and soft model improvements

  [Gieseke, Loshaj, Kirchgaesser – EPJ C77 (2017) 156]
  [Gieseke, Kirchgaesser, Plätzer – EPJ C78 (2018) 99]



Current release 7.1.4 – much more to come …

Thank you!