# Running in the Hidden Valley

(To appear!)

## Exploring near-conformal dark sector theories

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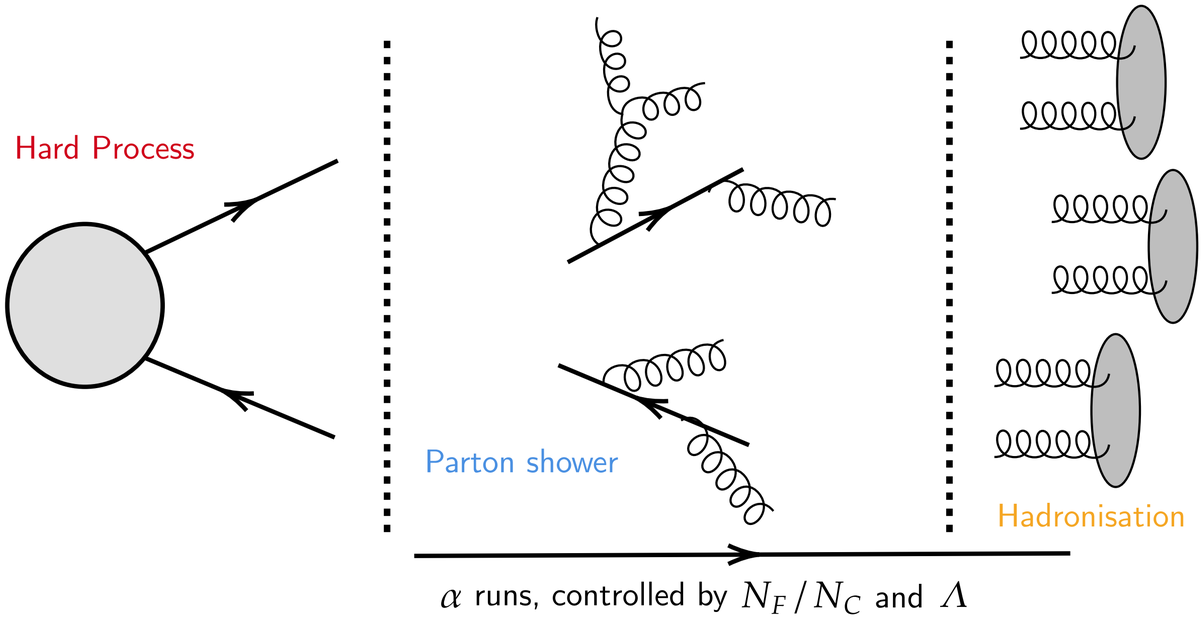
# Near-conformal dark sector signatures




$$\mu^2 \frac{d\alpha}{d\mu^2} = \beta(\alpha) = -\alpha^2 \left(\beta_0 + \beta_1 \alpha\right) \qquad \text{(at 2-loop)}$$

$$N_C\,\alpha = f(N_F/N_C, \mu/\Lambda) \; + \mathcal{O}(N_F/N_C^3) \text{ corrections}$$

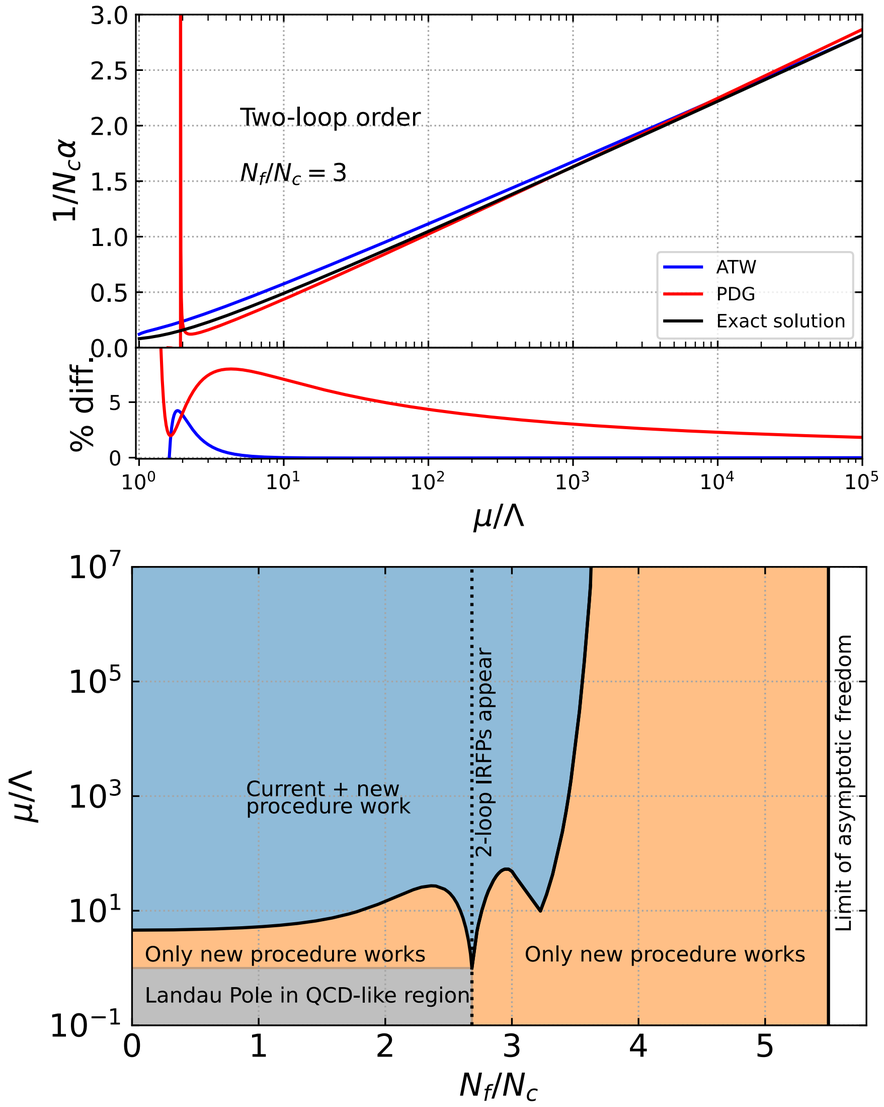
Non-trivial fixed point: $\alpha_* = -\dfrac{\beta_0}{\beta_1}$ ; $> 0$ for $N_F/N_C \gtrsim 2.7$


arXiv:0604261, M.J. Strassler et al.

arXiv:1503.00009, T. Cohen et al.


- We study the simulation of jet-like signatures of Hidden Valley models featuring a confining $SU(N_C)$ dark sector for a wide range of $N_F$ and $N_C$.
- Focus on dark parton showering, governed by the t' Hooft gauge coupling, $N_C\,\alpha$. Parton shower ends near scale $\Lambda$, which characterises breakdown of perturbative expansion of $\alpha$, thus scaling $\alpha$ as $\alpha(\mu/\Lambda)$.
- $\alpha$ is governed by the Renormalisation Group Equations (RGE). For $N_F/N_C \gtrsim 2.7$, $\alpha$ flows to an infra-red fixed point (IRFP). New procedures are needed to understand jet-like signatures within this region.

# Modelling of dark parton showers




- The current approximation used within event generators (the PDG formula) is insufficient to describe two-loop $\alpha$ for high $N_F/N_C$ since it neglects effects of the IRFP.
- By taking this IRFP into account, we establish a framework of two solutions to the RGE that allow for parton showering to be simulated across a wide range of parameter space.

$$\alpha = \alpha_* \left[ W_{-1}\left( -\frac{1}{e}\left(\frac{\mu^2}{\Lambda^2}\right)^{\beta_0\alpha_*} \right) + 1 \right]^{-1} \quad ; \quad \alpha = \alpha_* \left[ W_0\left( \frac{1}{e}\left(\frac{\mu^2}{\Lambda^2}\right)^{\beta_0\alpha_*} \right) + 1 \right]^{-1}$$

QCD-like (no IRFP) — IRFP-region

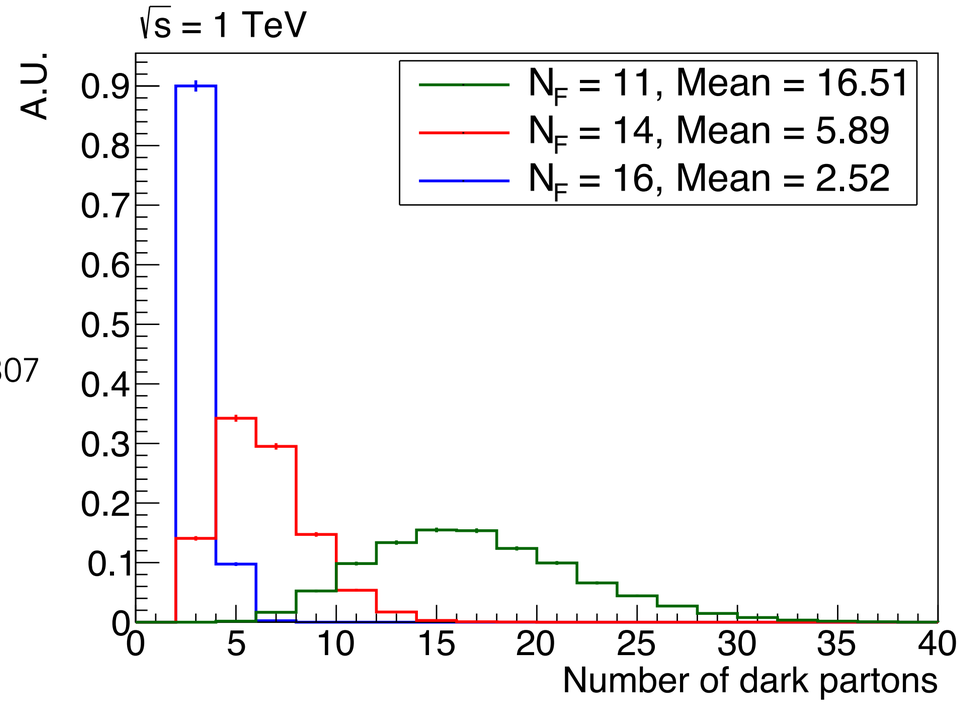
- To implement within event generators, regions with IRFPs require a combination of approximation and interpolation to cover all of the $N_F/N_C$ — $\mu/\Lambda$ space.

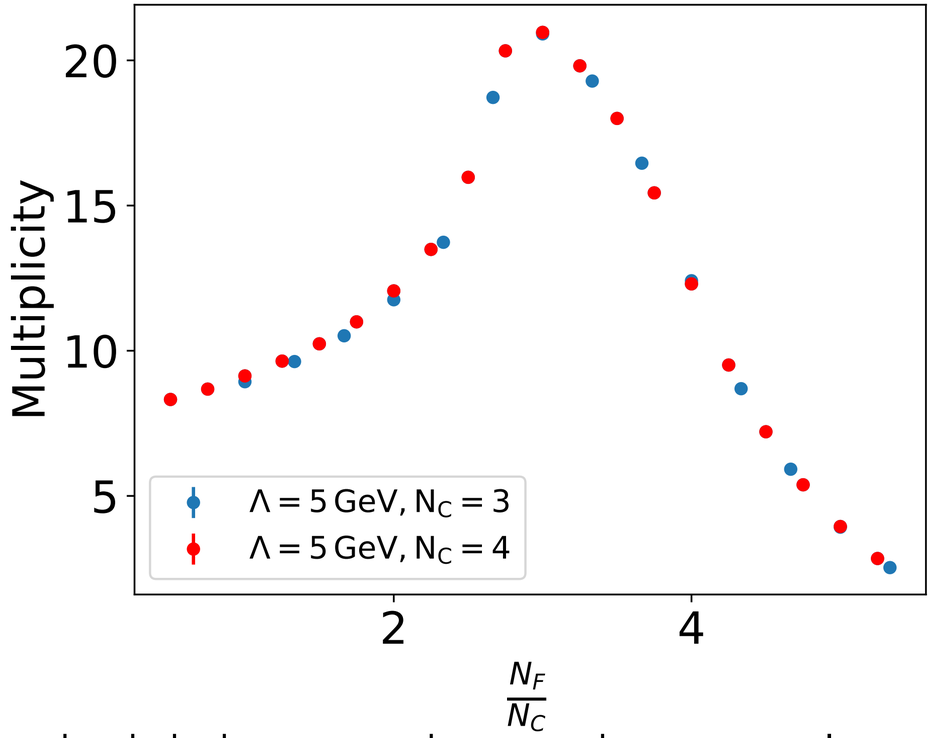
arXiv:9602385, T. Appelquist et al.

arxiv:9810192 - E. Gardi et al.

# Simulation of dark parton showers

Simulated with custom Pythia 8.307




- Only theories at large $N_F/N_C$ (~5) depart drastically from standard dark parton shower phenomenology.
- Average multiplicity dependent on parton splitting, which is proportional to $|\alpha_*|$; decreases in presence of IRFPs.
- This new procedure will allow the simulation and exploration of a variety of near-conformal Hidden Valley theories and their subsequent collider signatures.

Thank you!
Questions?