

Strong interactions in UHECRs

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arXiv:1206.2400

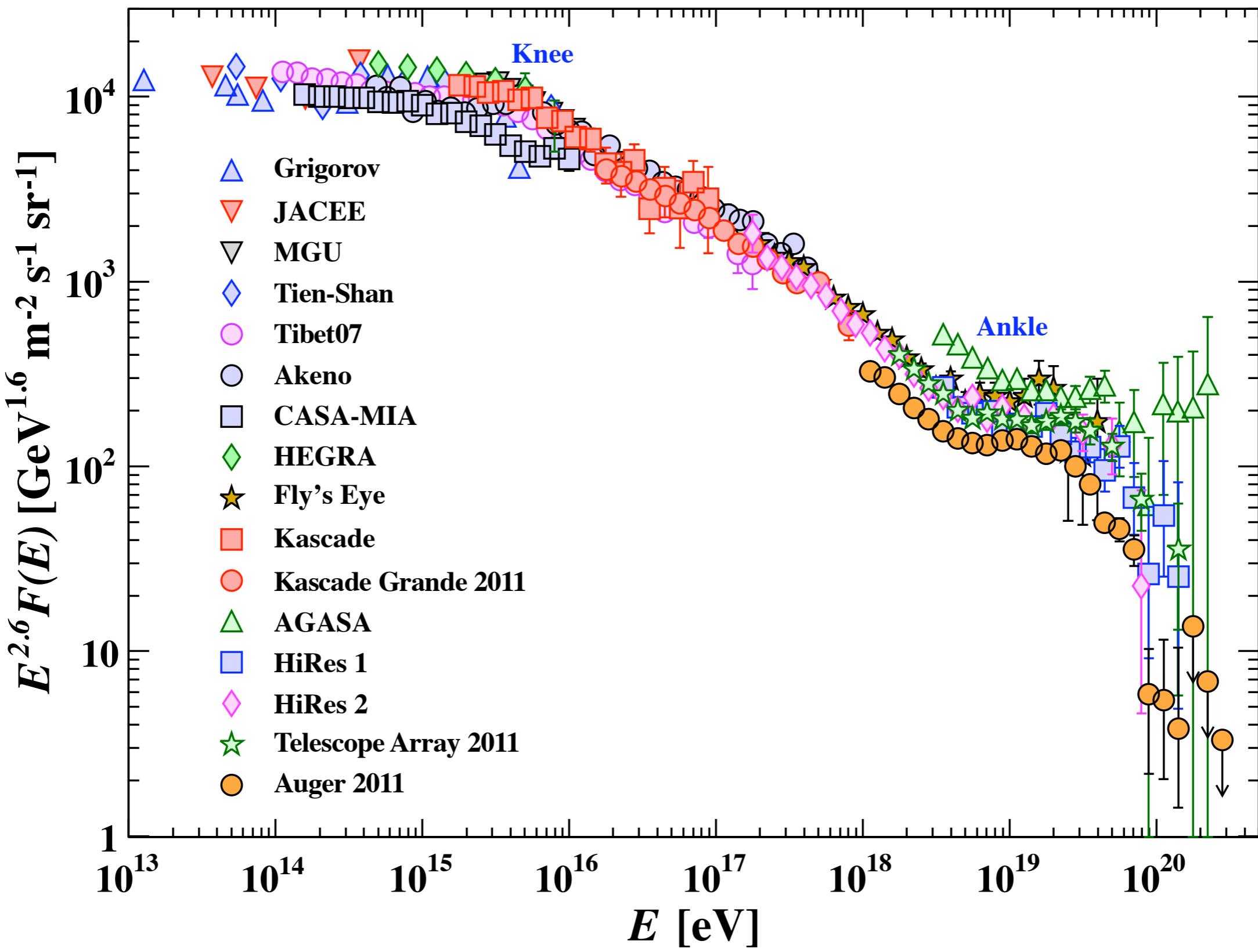
Motivation

- DEWSB mechanism hard to catch
 - e.g., energy frontier
 - UHECR $s > (100\text{TeV})^2$
 - air showers (photomultiplier)
- explain structure in spectrum ?

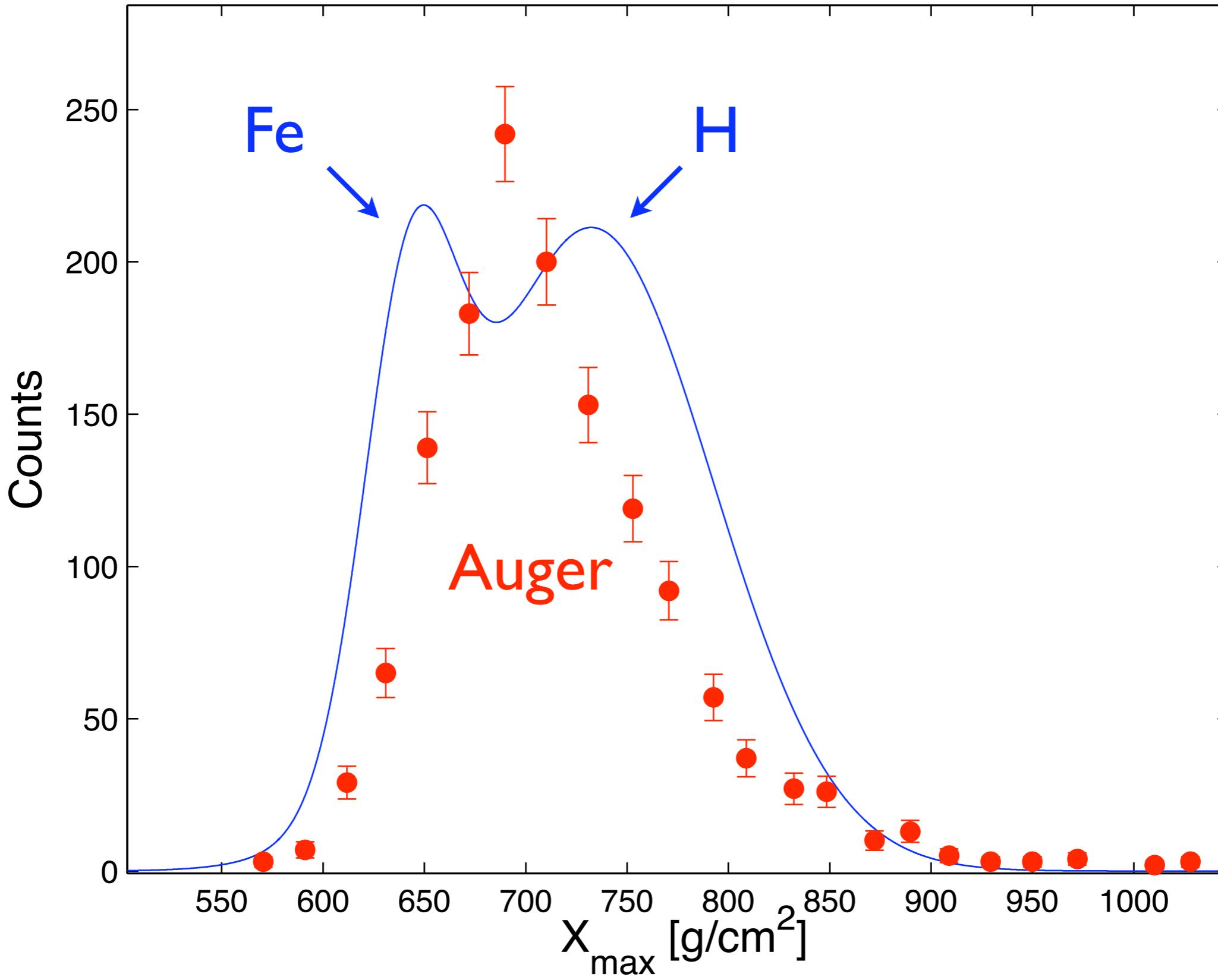
Air showers



Spectrum (all particles)



Composition ?



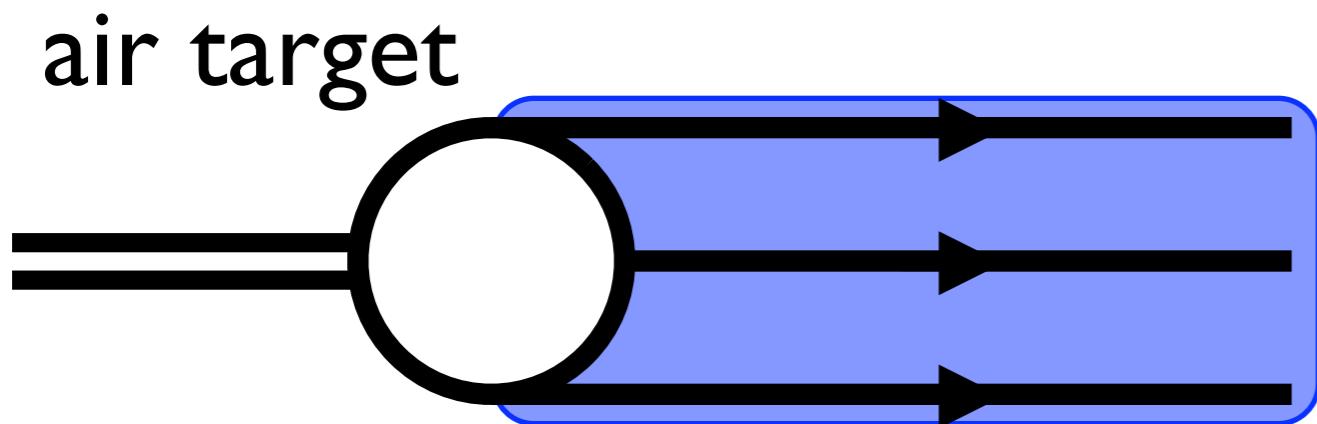
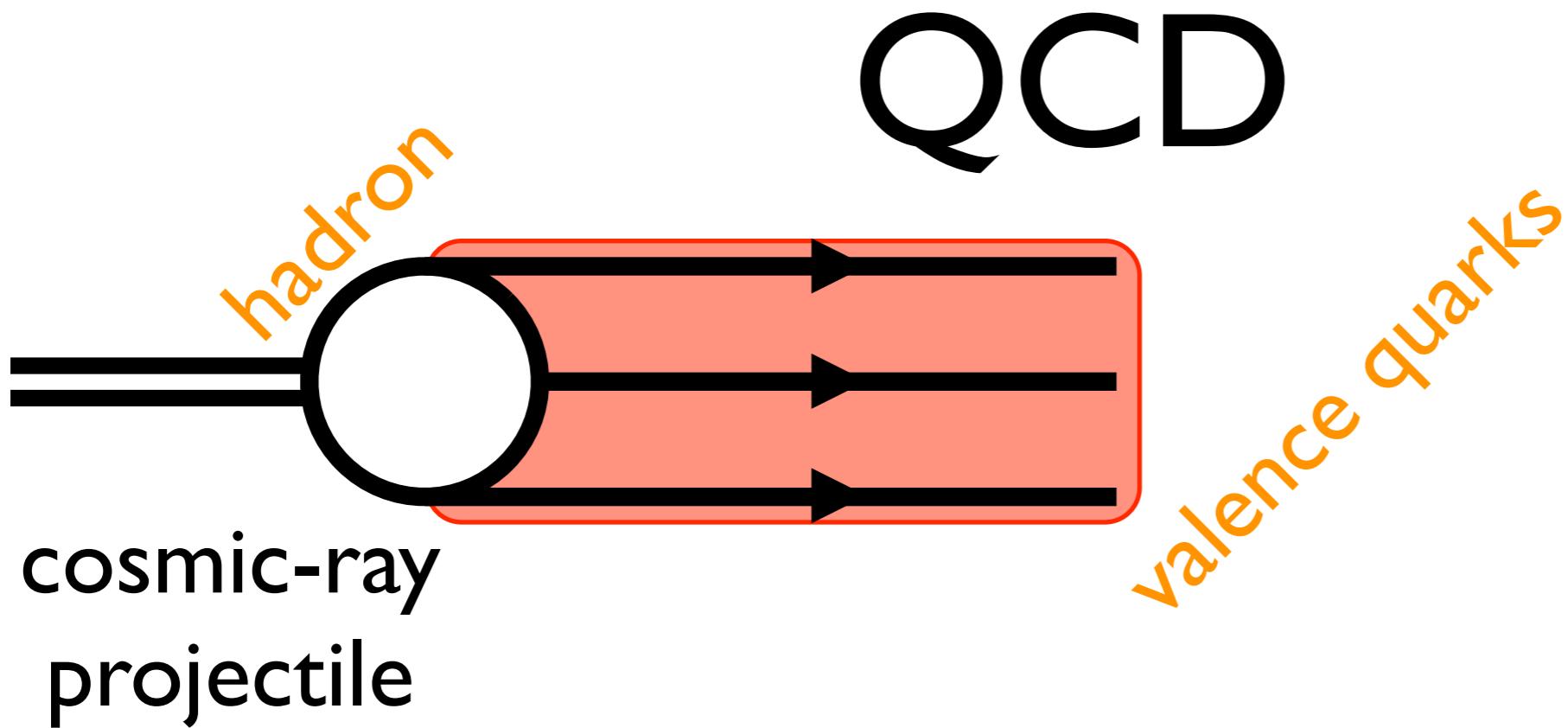
adapted from Shaham & Piran arXiv:1204.1488

DDD

QCD as benchmark

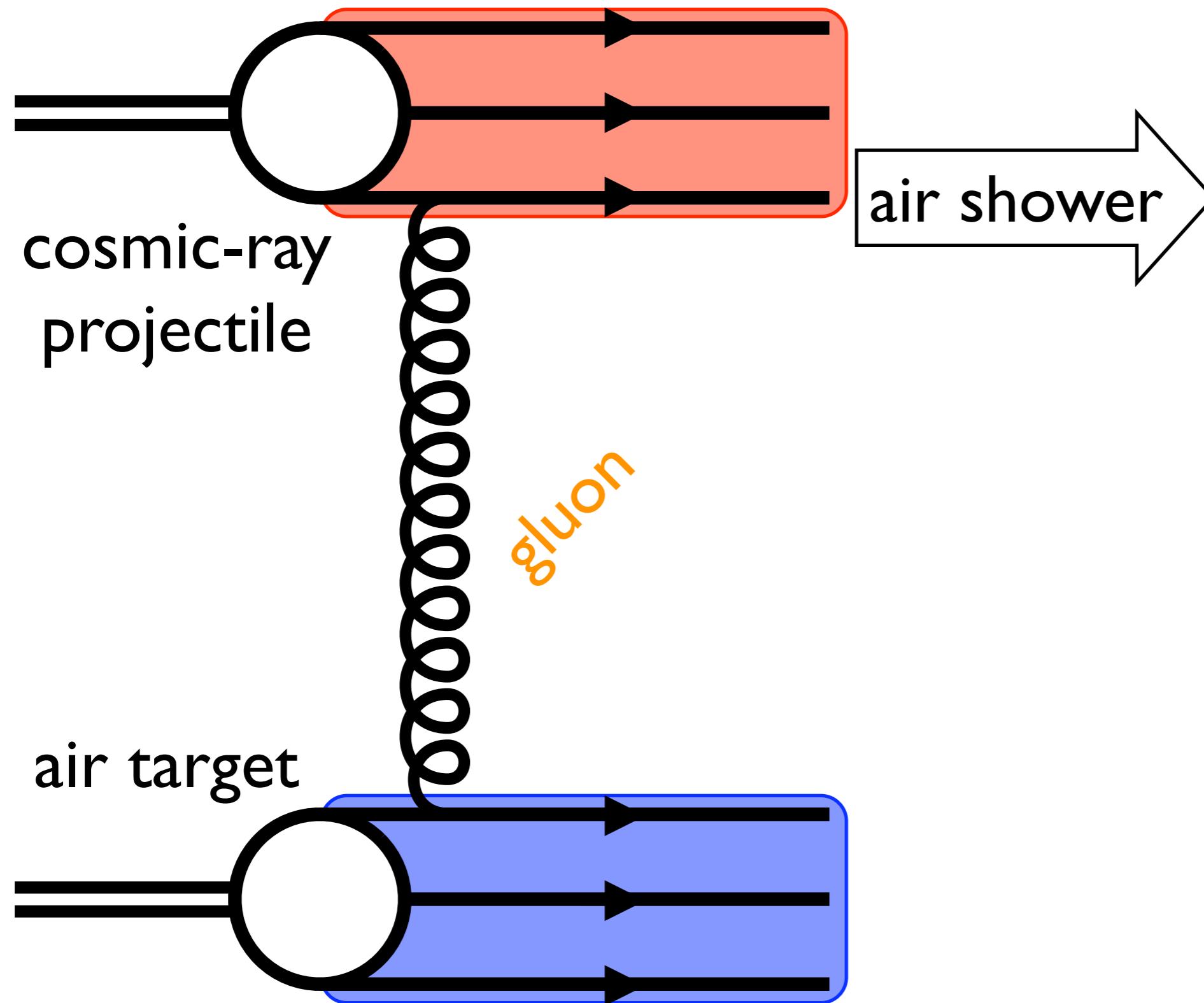
Air showers





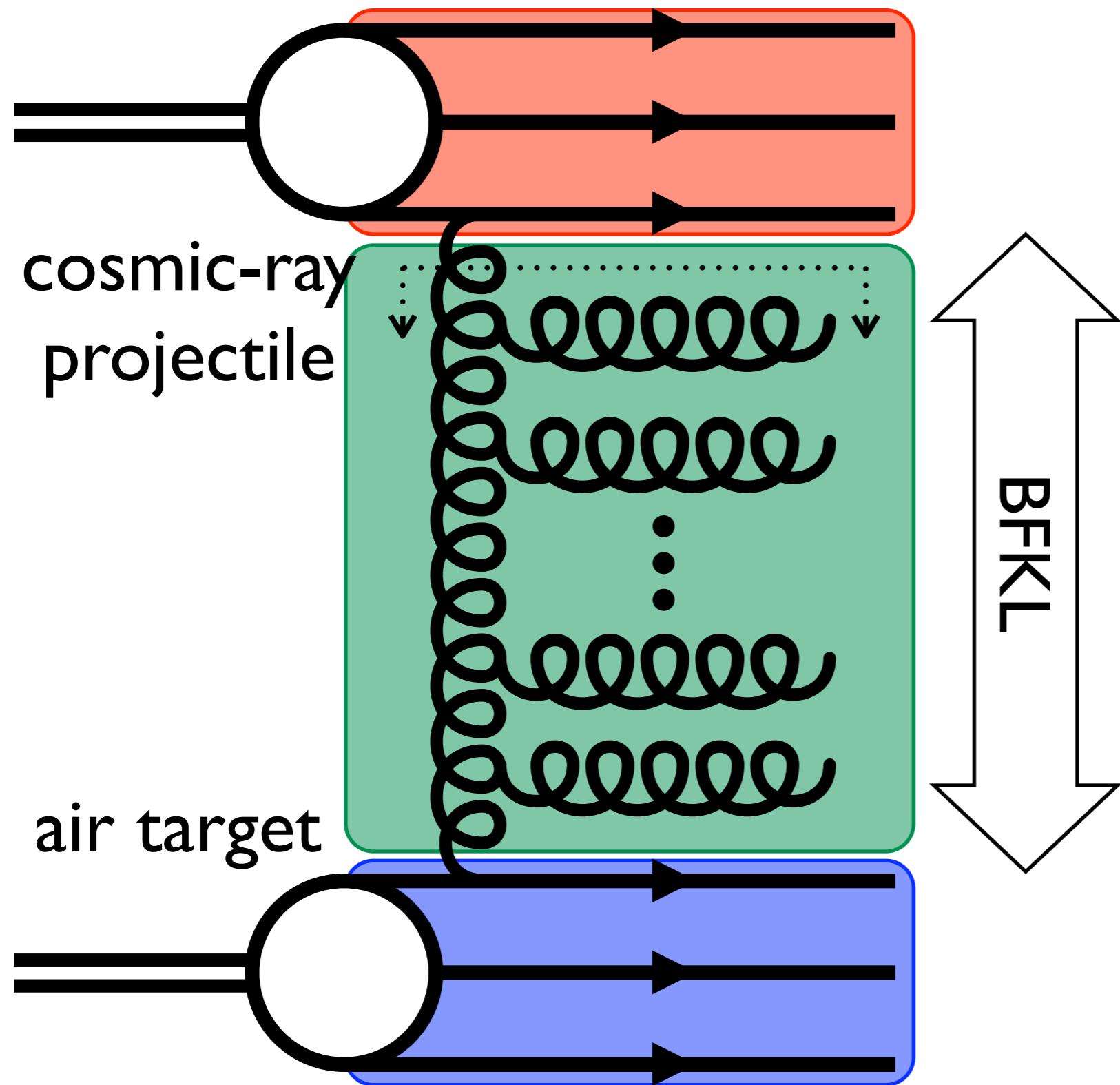
DDD

QCD

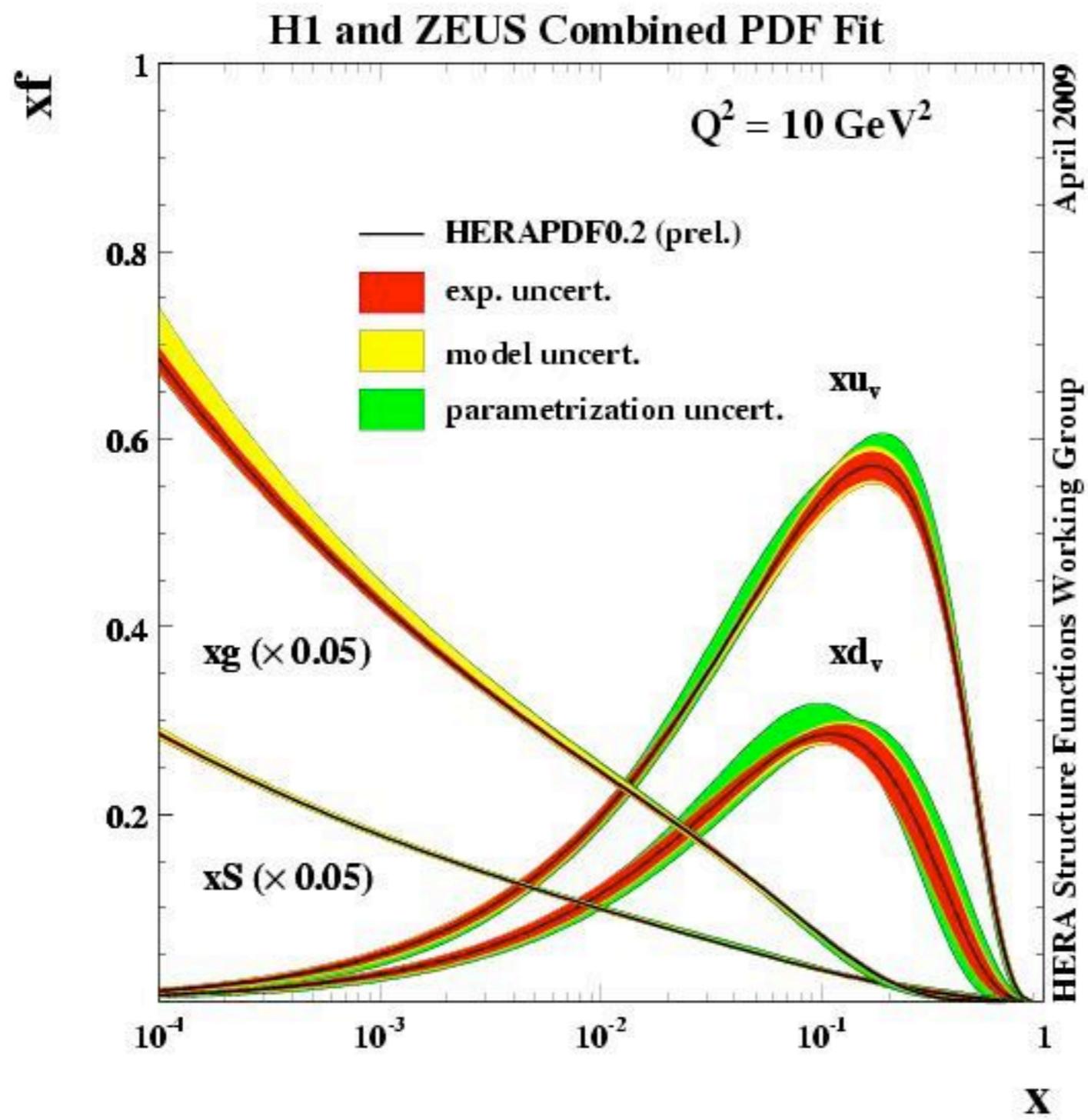


DDD

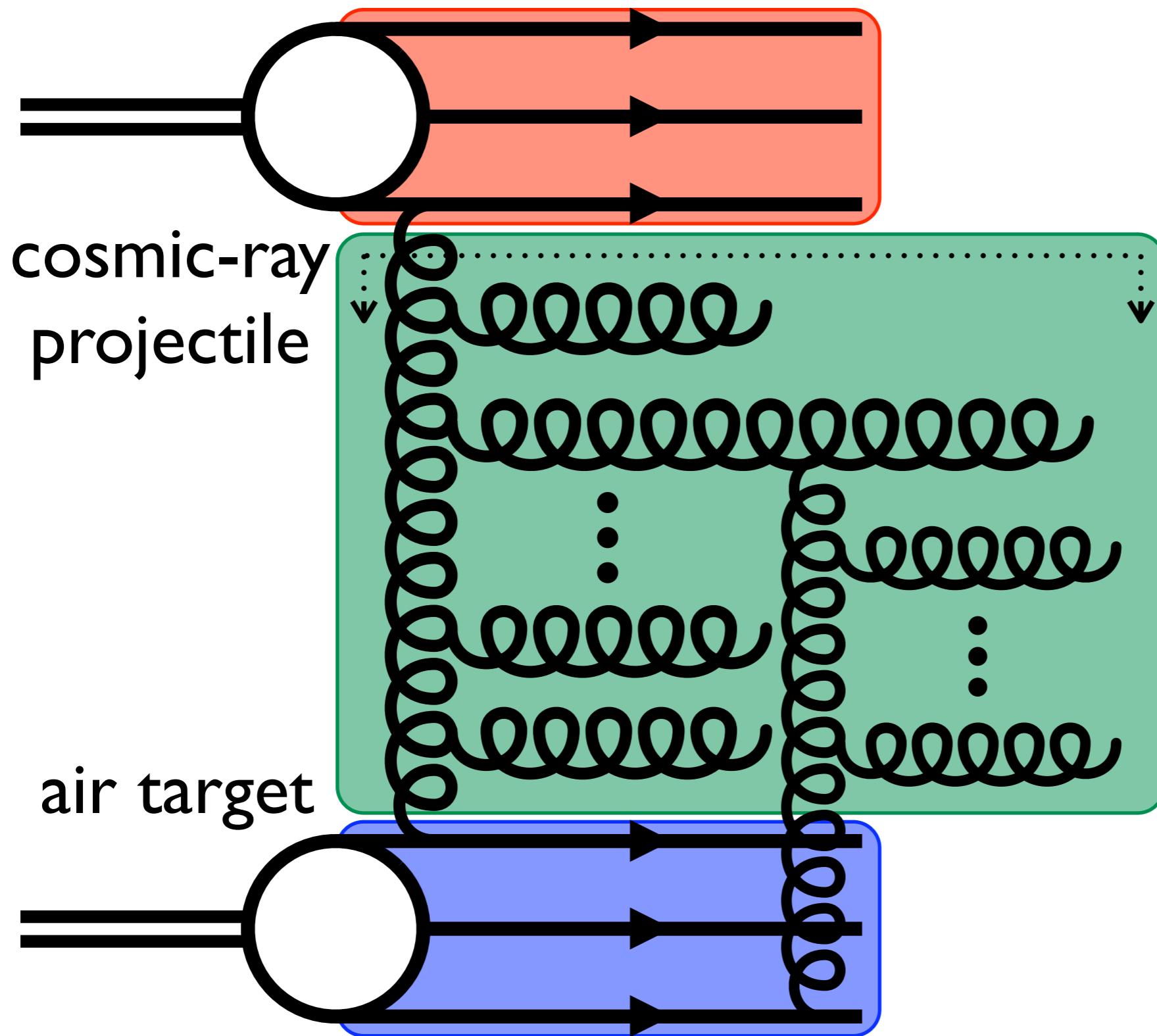
QCD



HERA

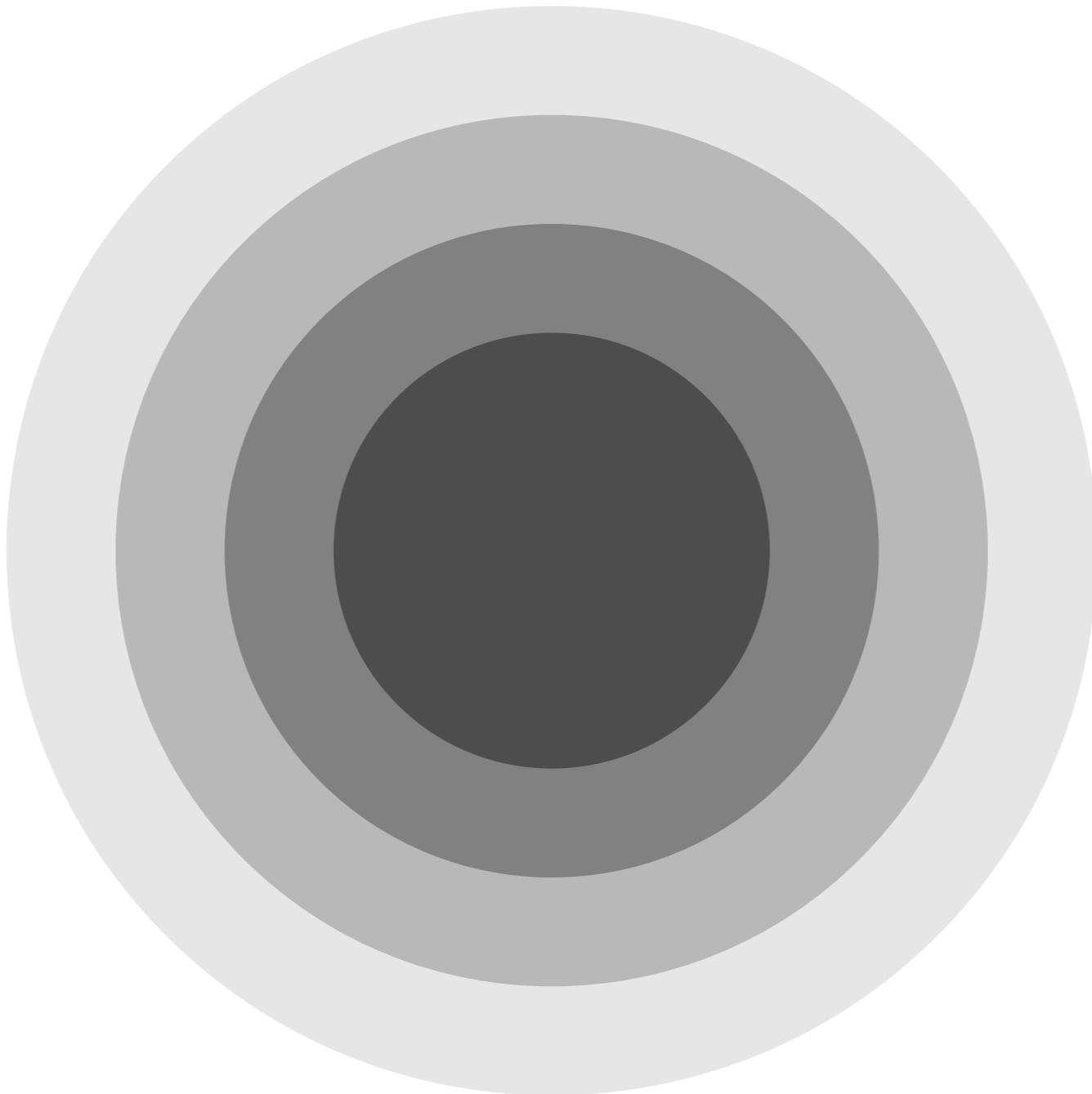


Saturation

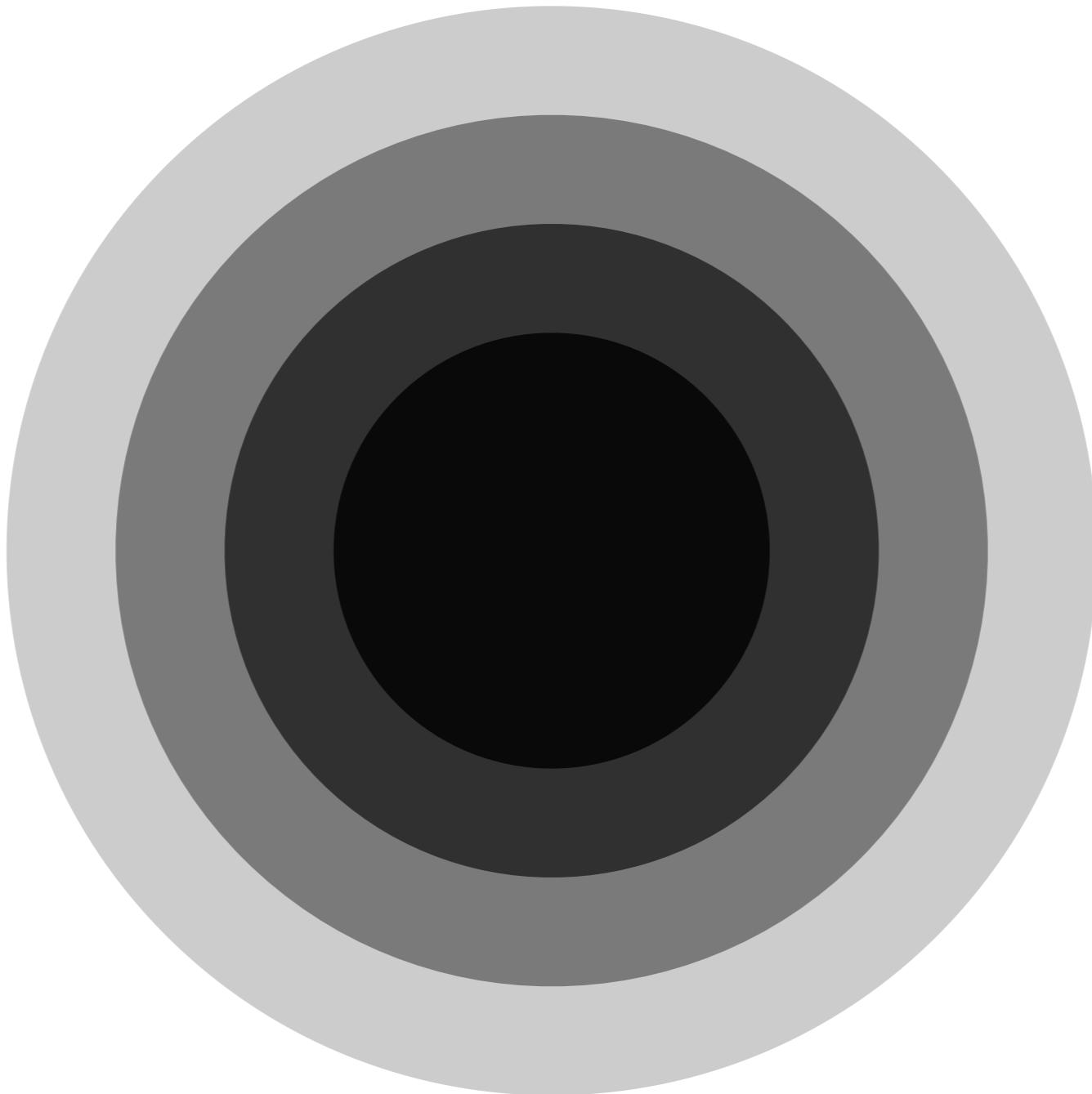


DDD

Black disc limit

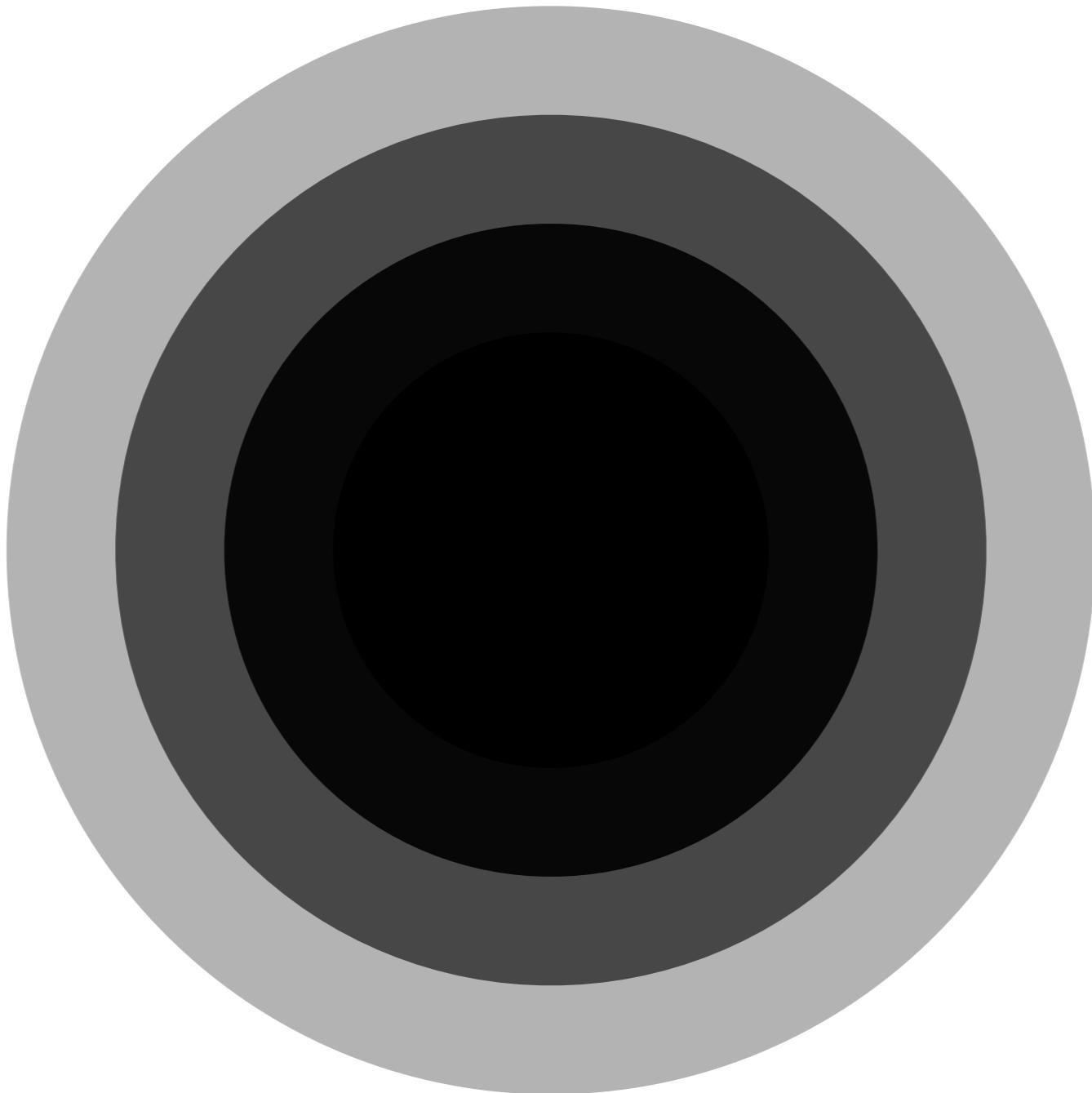


Black disc limit

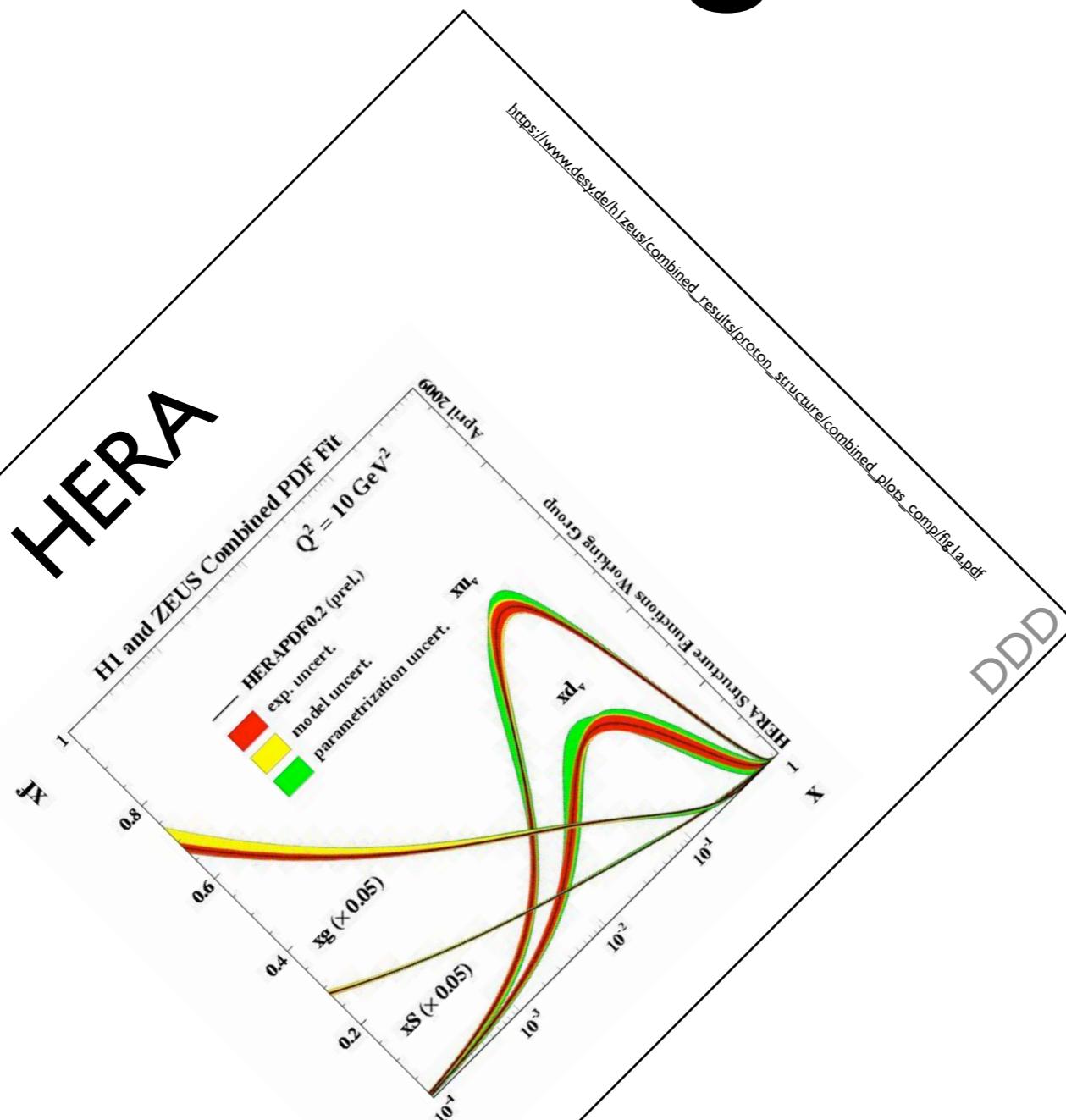


DDD

Black disc limit



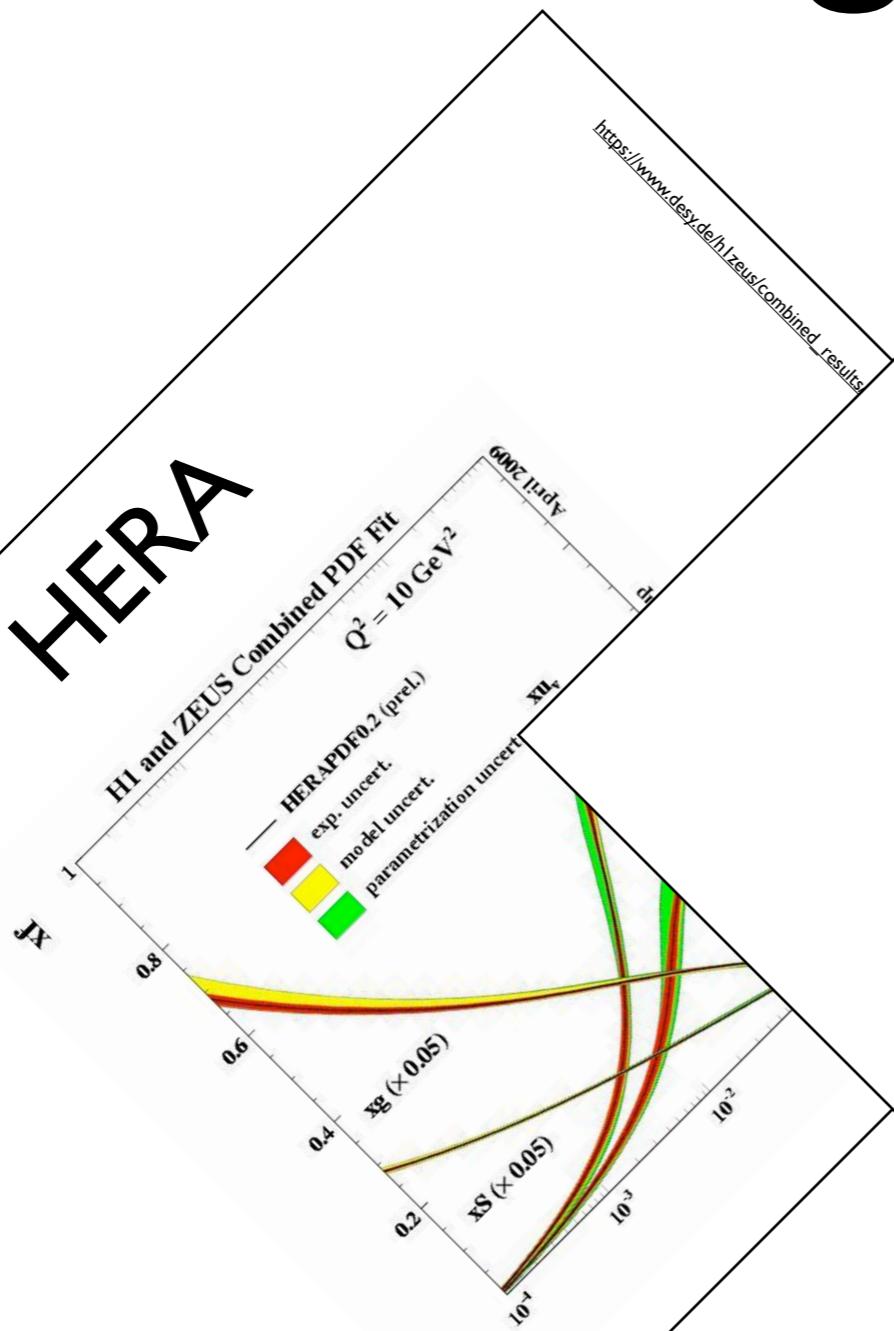
Taking stock



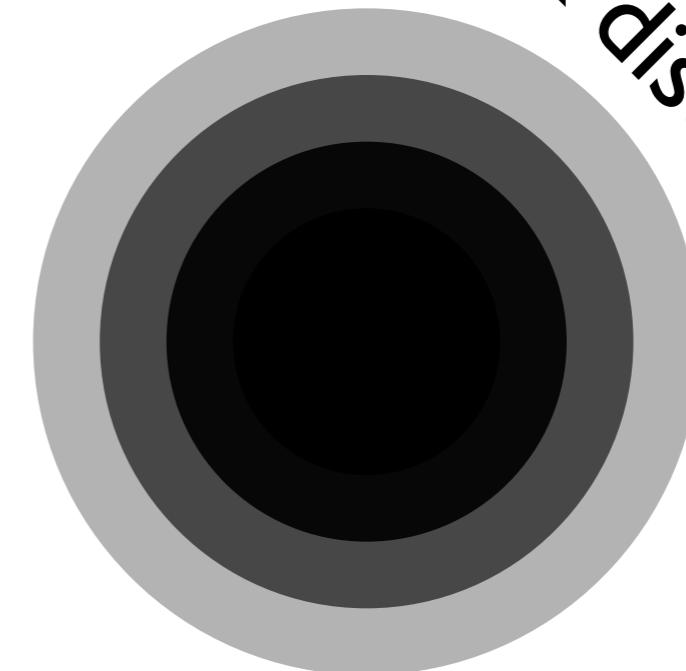
DDD

Taking stock

HERA



Black disc limit



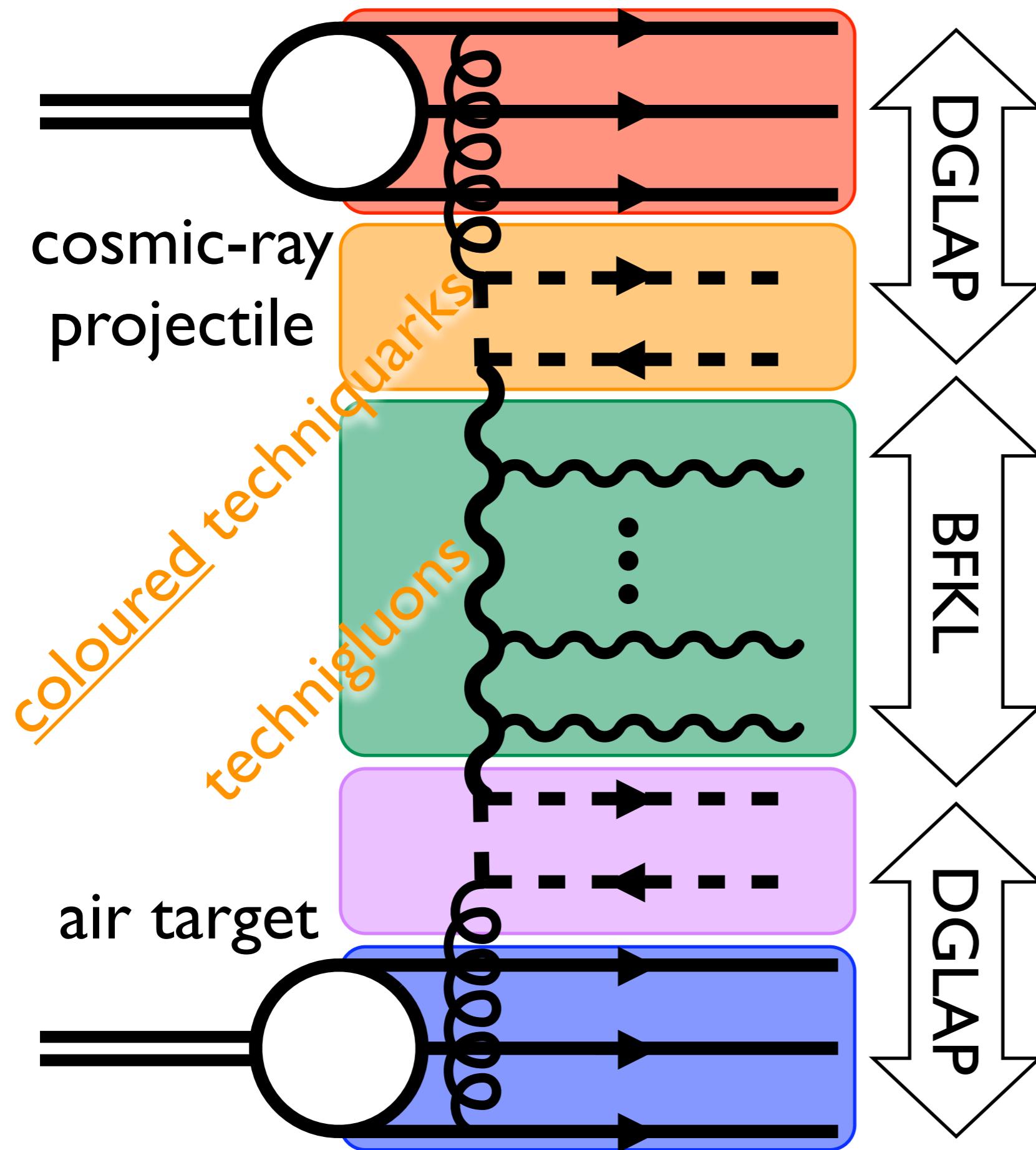
DDD

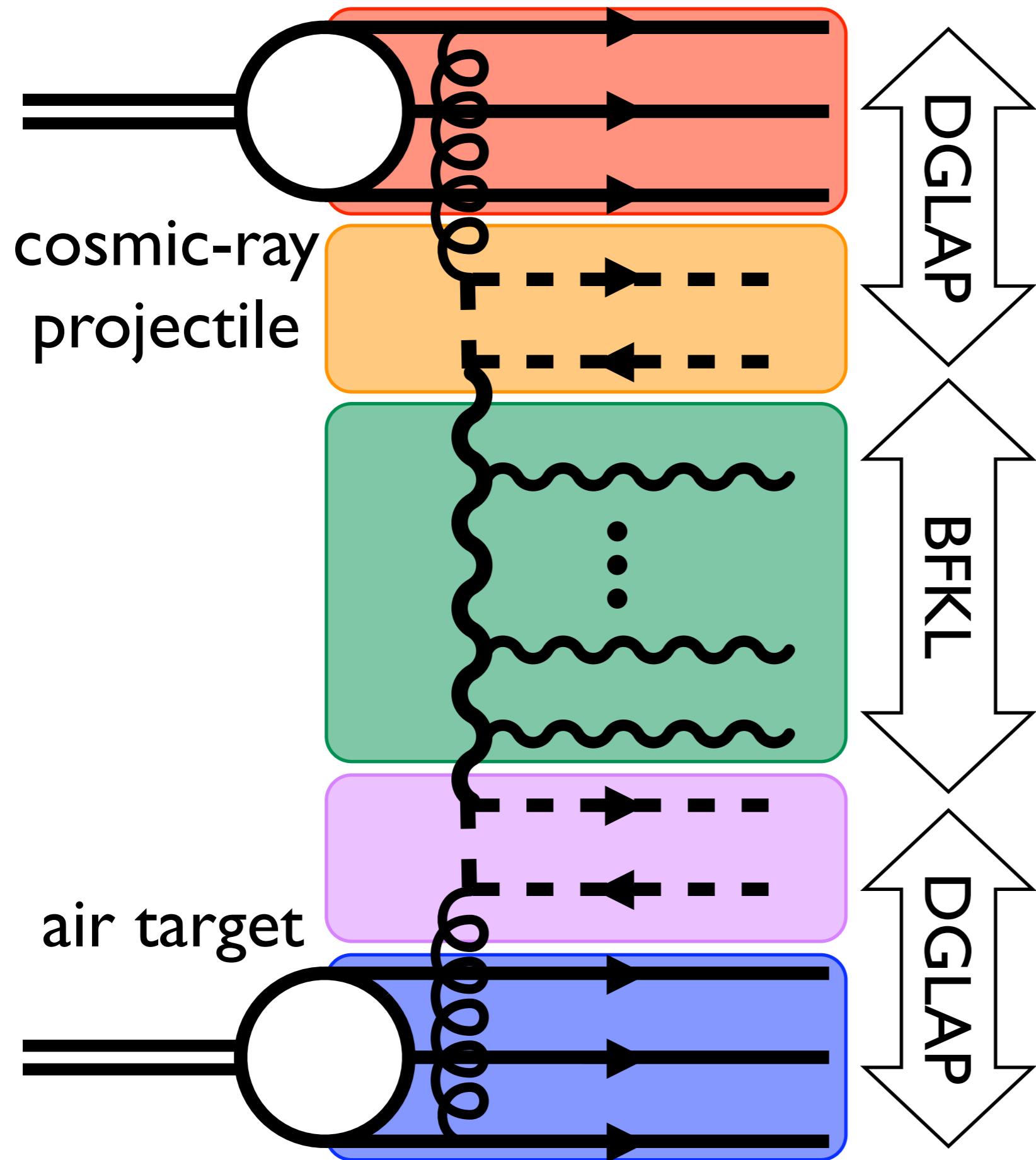
DDD

BSM contributions to hadron-hadron

Techni-colour

-

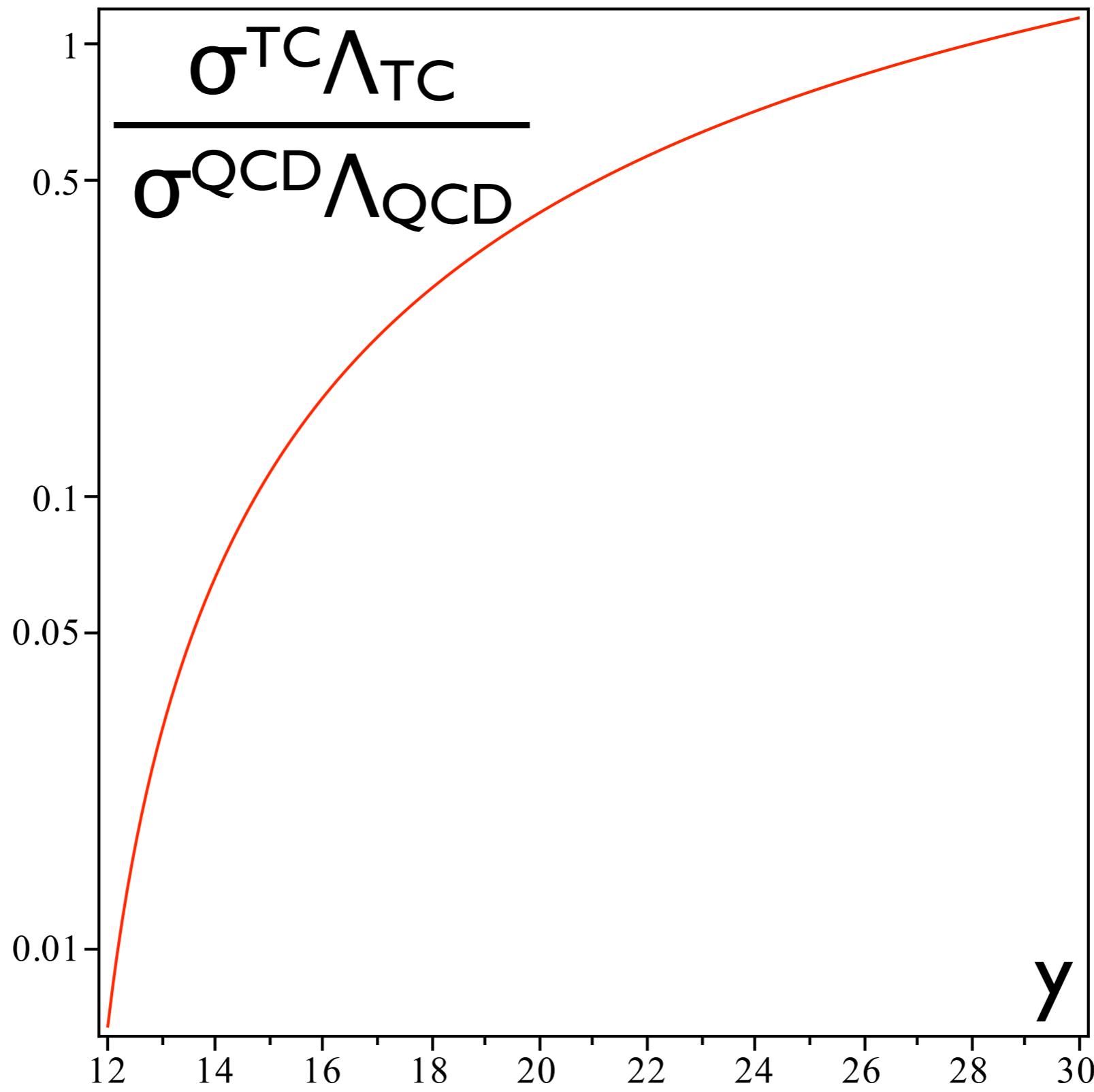




Techni-colour

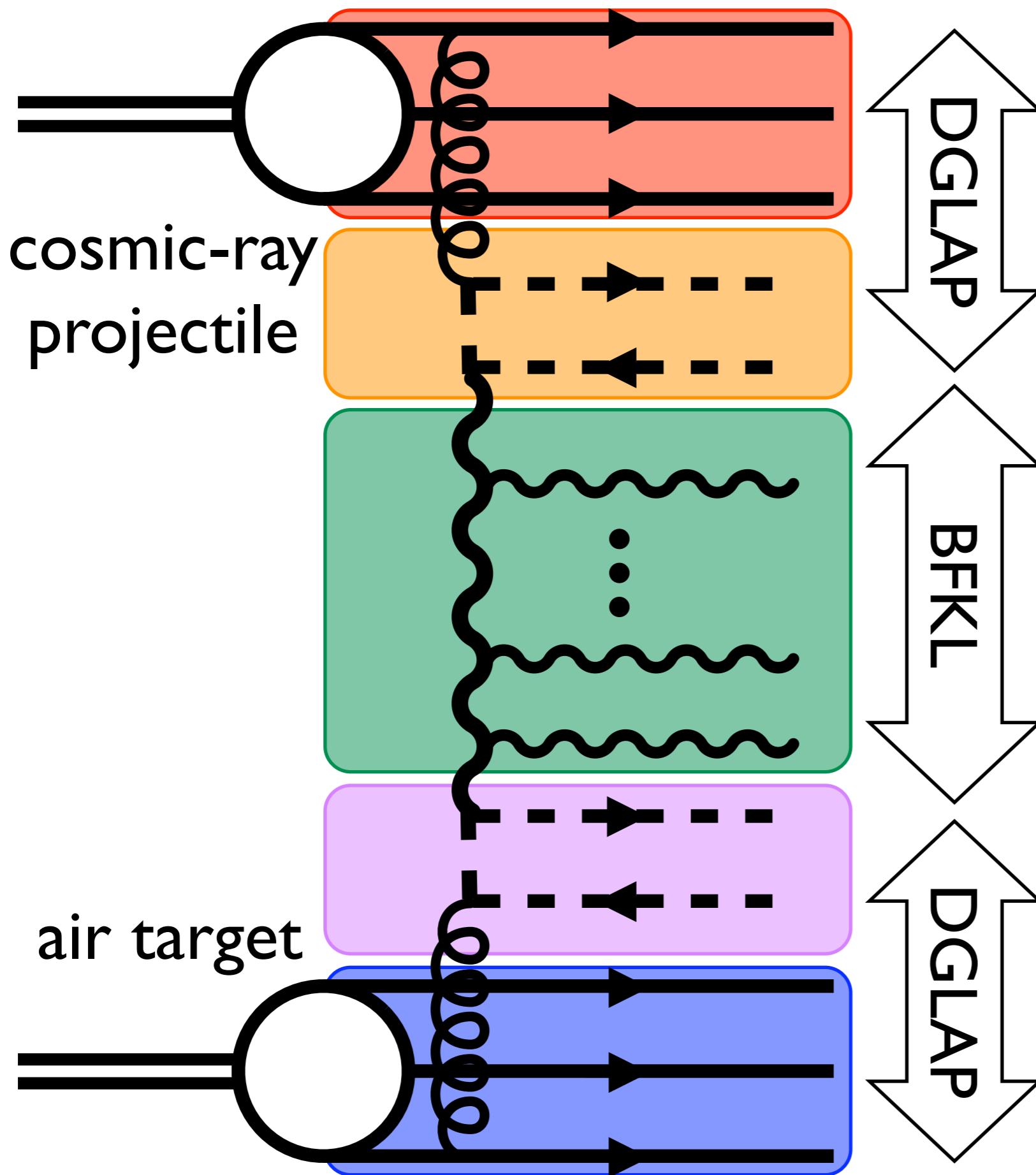
$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{tot}}^{\text{QCD}}} \approx O(10^{-3})$$

Transverse momentum



DDD

Techni-colour



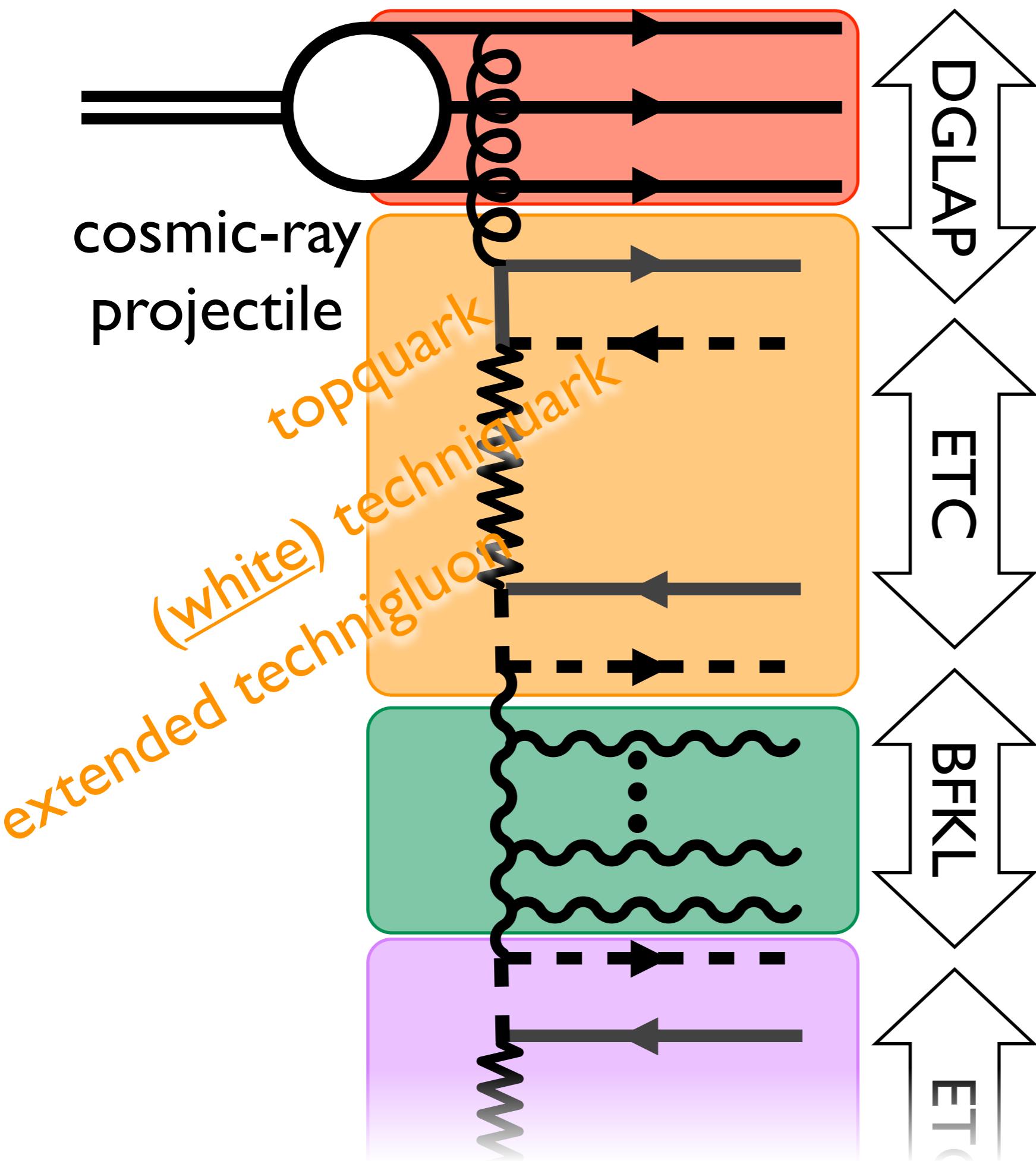
$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{tot}}^{\text{QCD}}} \approx O(10^{-3})$$

$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{tot}}^{\text{QCD}}} \frac{\Lambda_{\text{TC}}}{\Lambda_{\text{QCD}}} \approx O(1)$$

DDD

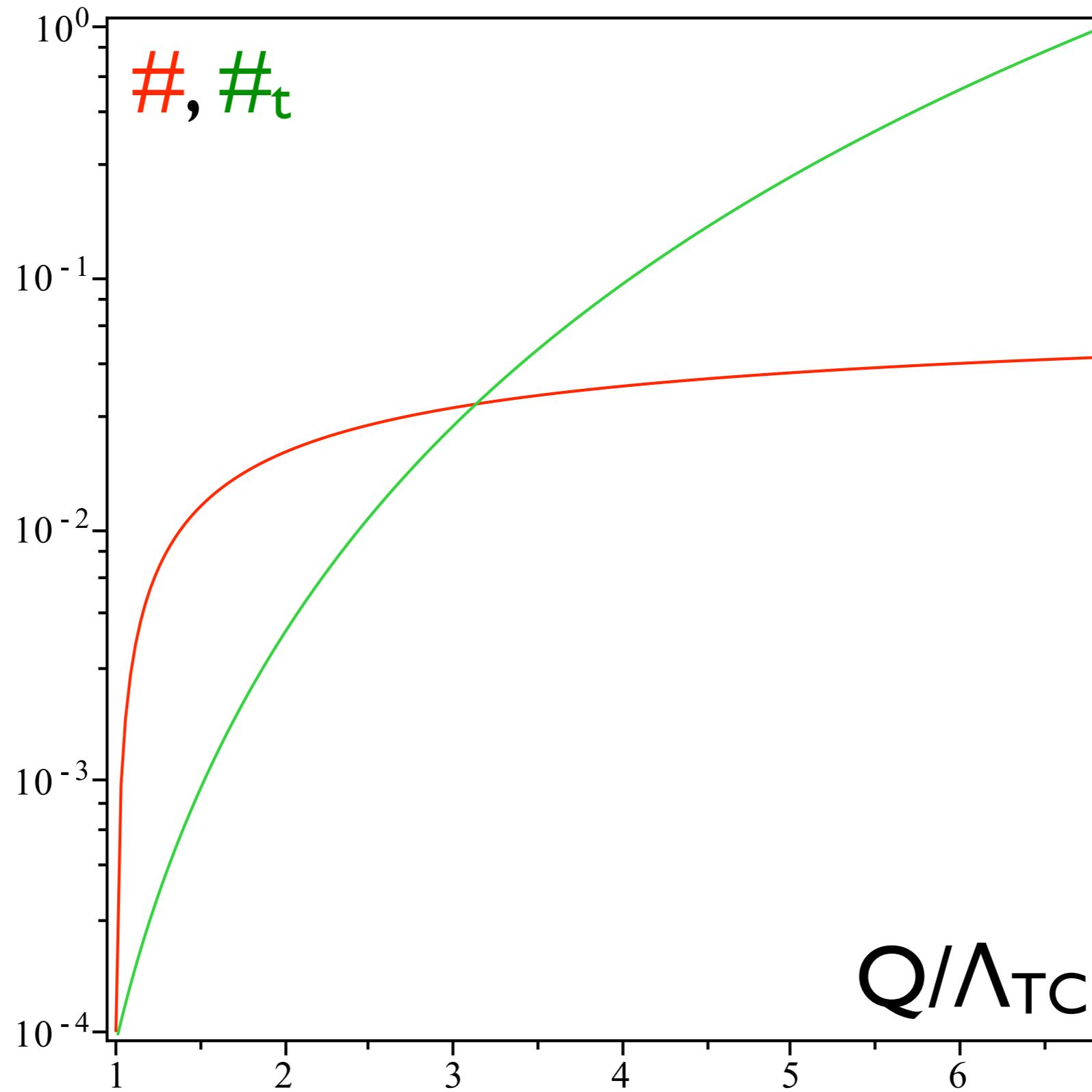
Techni-colour

2

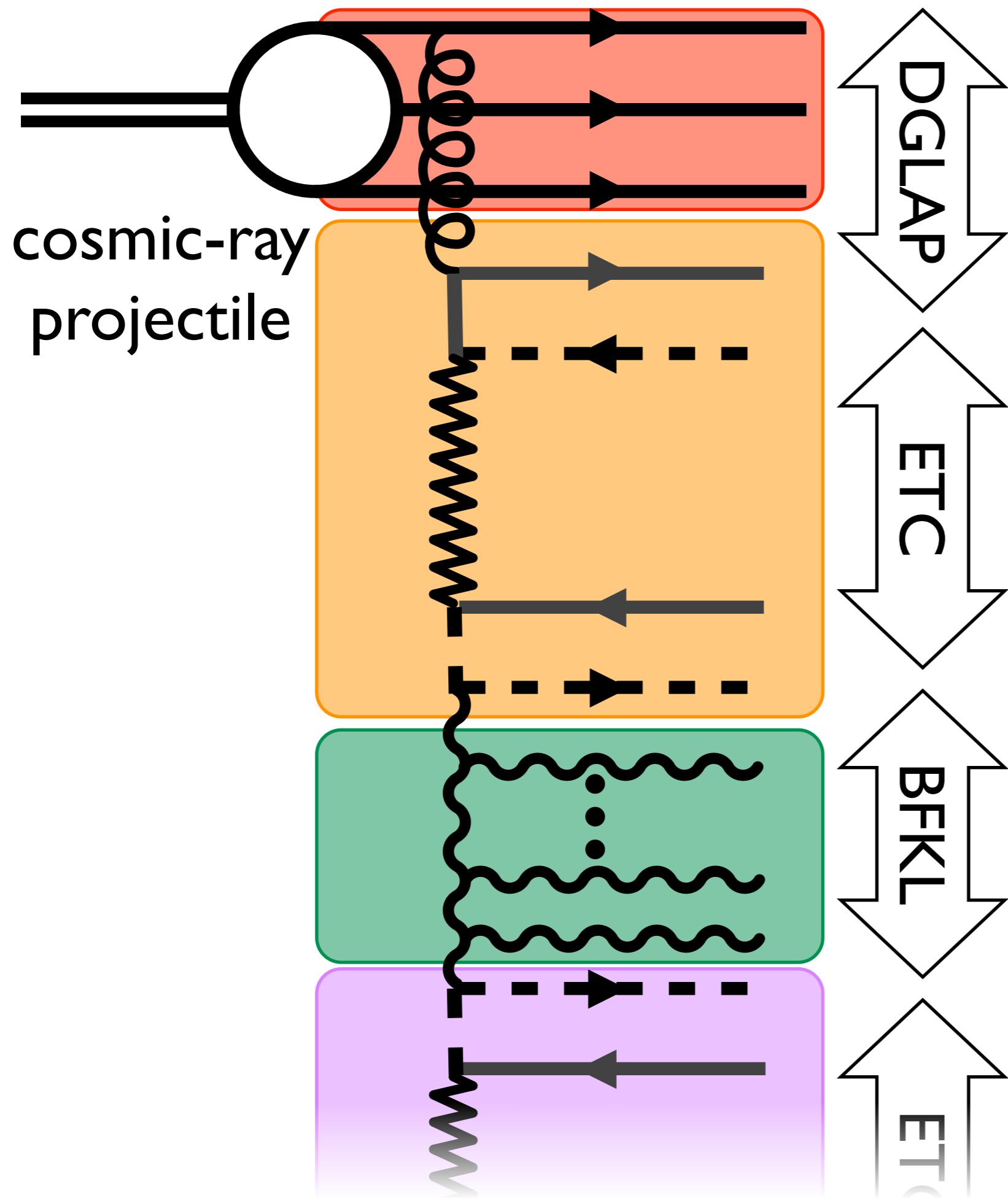


DDD

TC1 vs. TC2



DDD



$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{QCD}}^{\text{tot}}} \approx O(10^{-3})$$

$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{QCD}}^{\text{tot}}} \frac{\Lambda_{\text{TC}}}{\Lambda_{\text{QCD}}} \approx O(1)$$

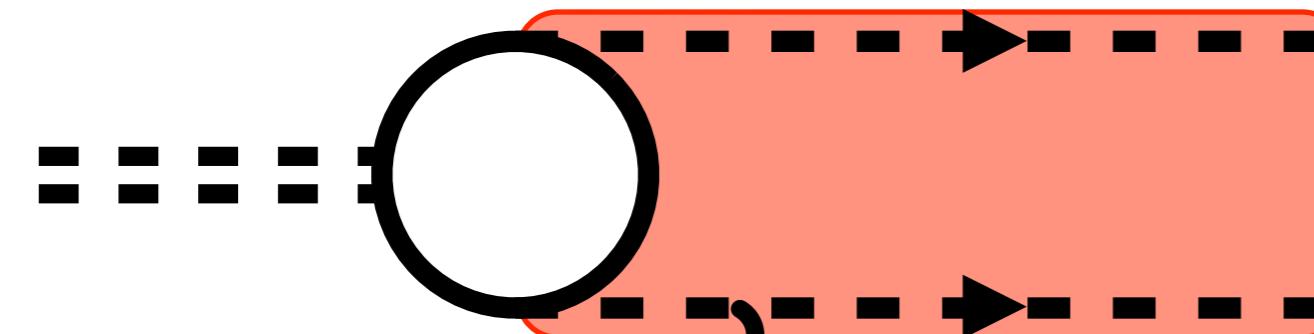
DDD

Fast forward

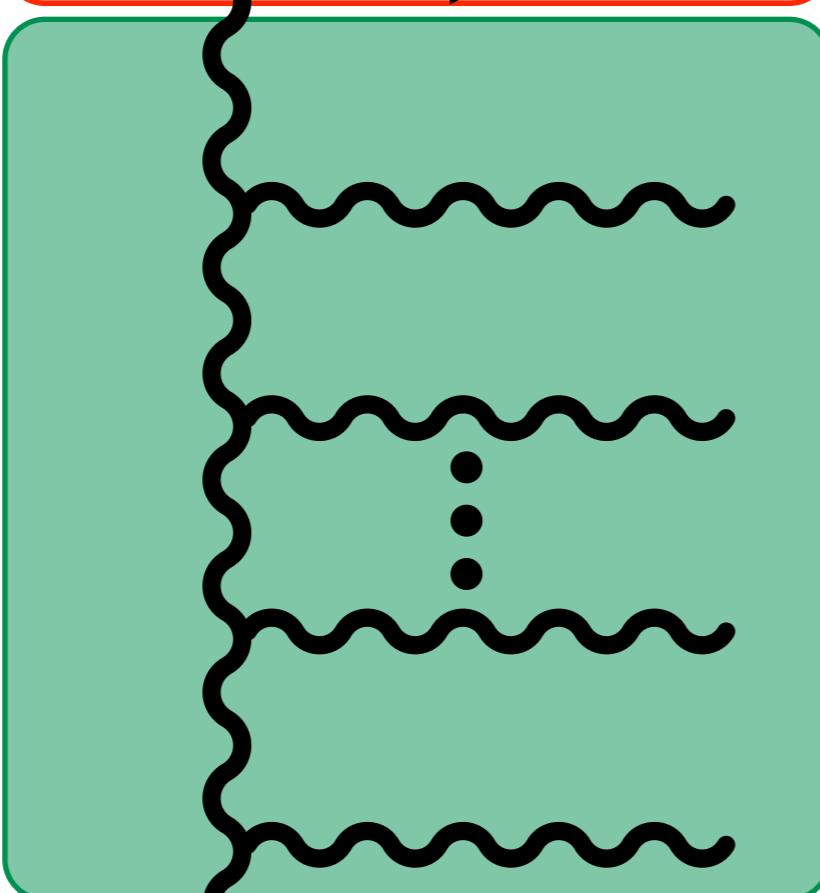
- Technicolour
 - 3rd generation ETC few TeV
 - Topcolour - if unification w/ SU(3)
 ⇒ small coupling
 - Composite Higgs $\xi = (v/f)^2 \approx 1$ “TC limit”
 requires completion to judge !?
 - Little Higgs - heavy SU(2) ≈ 2 TeV
 - $SU(2)_L$ - coupling to weak

BSM cosmic-ray projectile

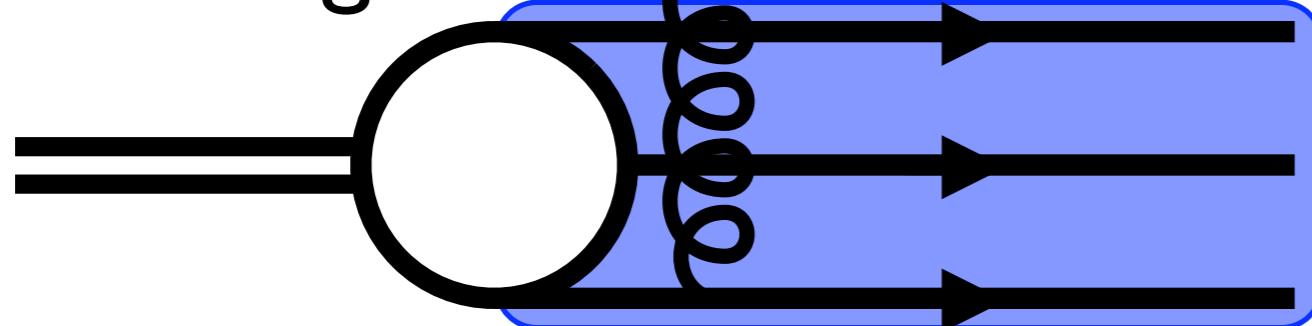
techni bound state



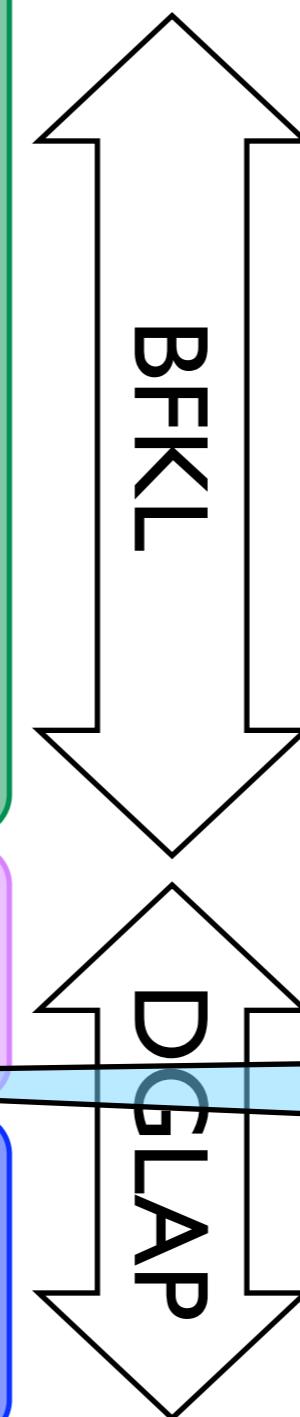
cosmic-ray
projectile



air target



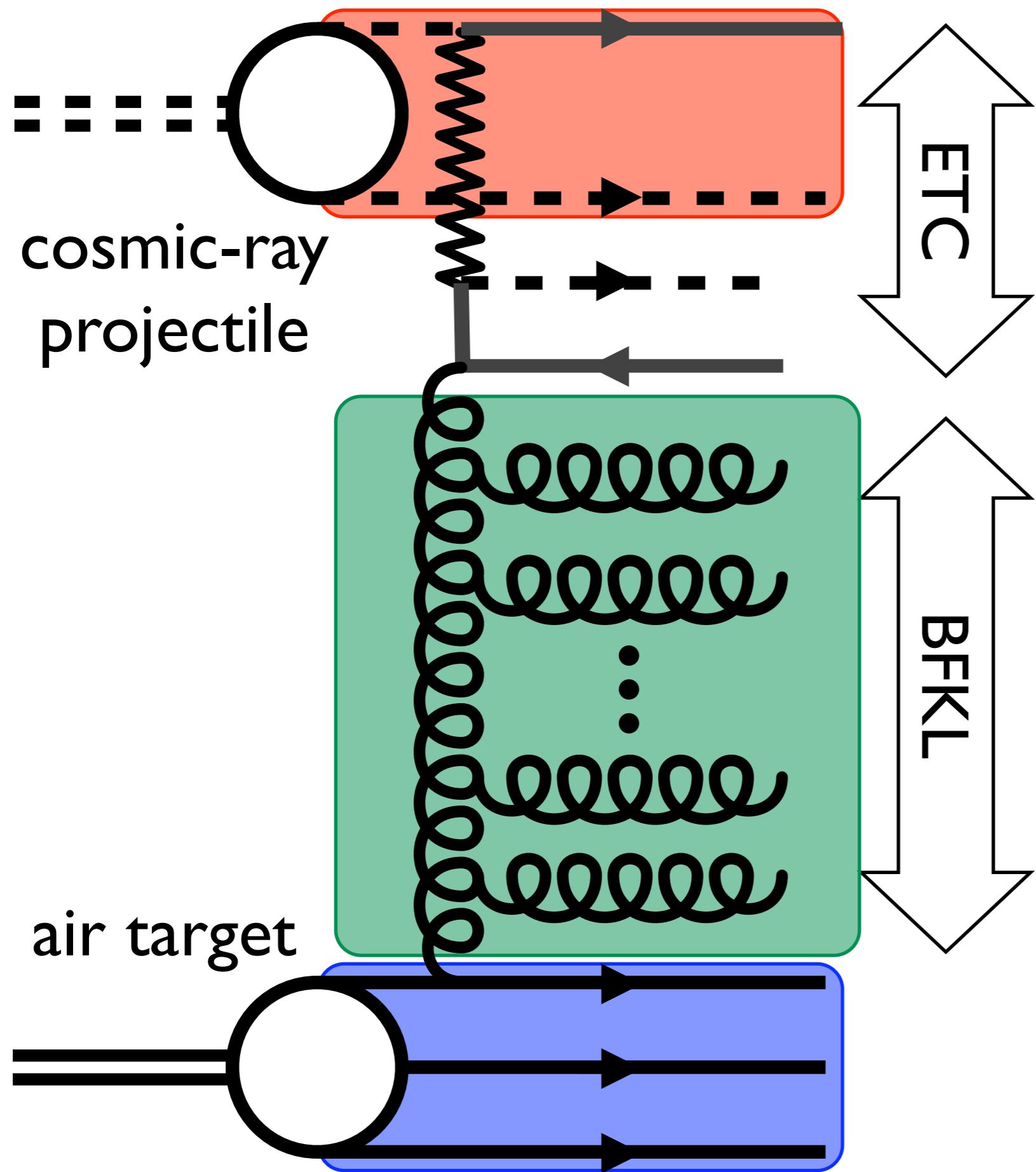
non-SM
cosmic
ray



$$\frac{\sigma_{\text{tot}}^{\text{TCx}}}{\sigma_{\text{tot}}^{\text{QCD}}} \approx 70 \times O(10^{-3})$$

alternatively
top-quark portal

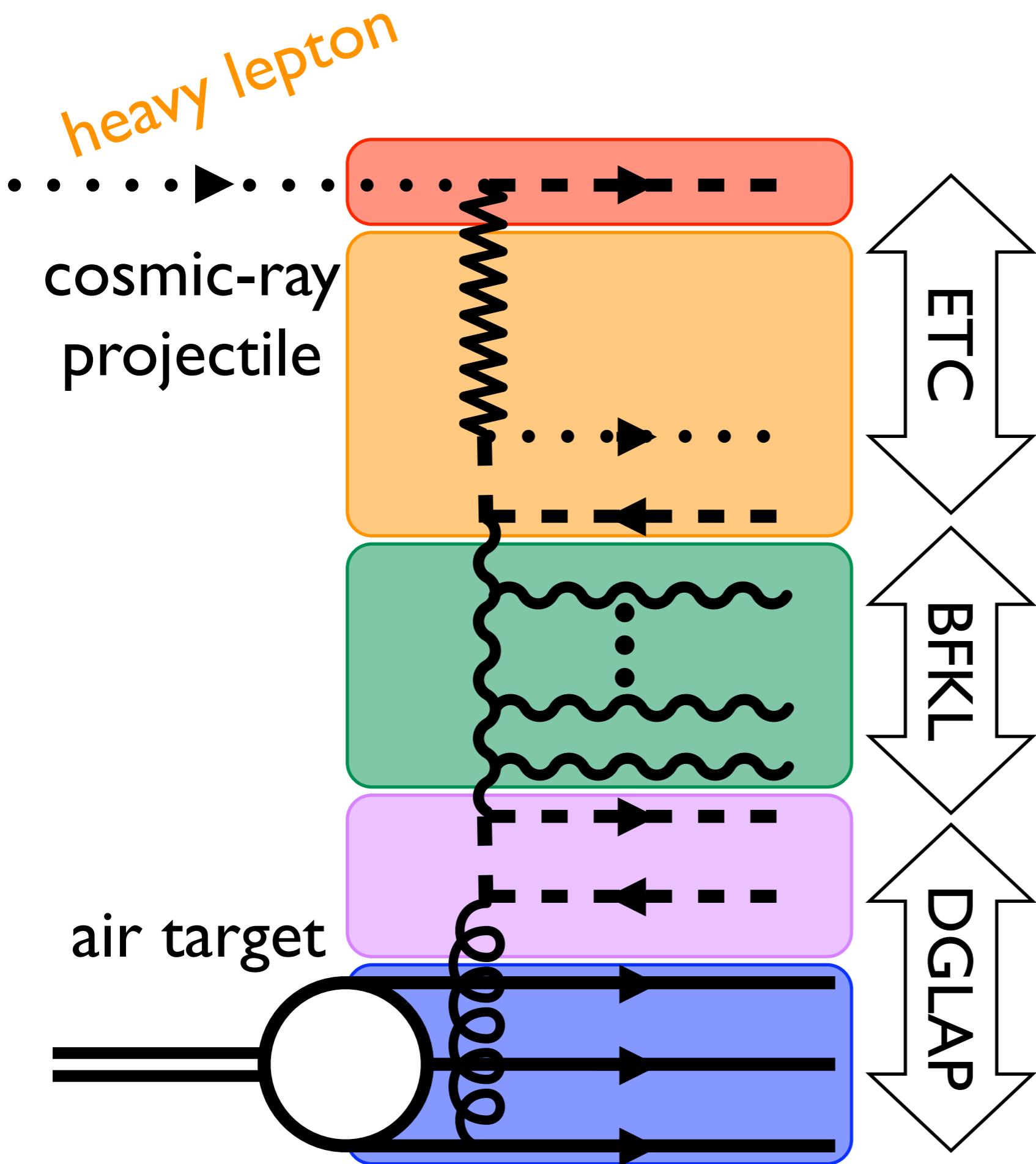
DDD



non-SM
CR
& QCD

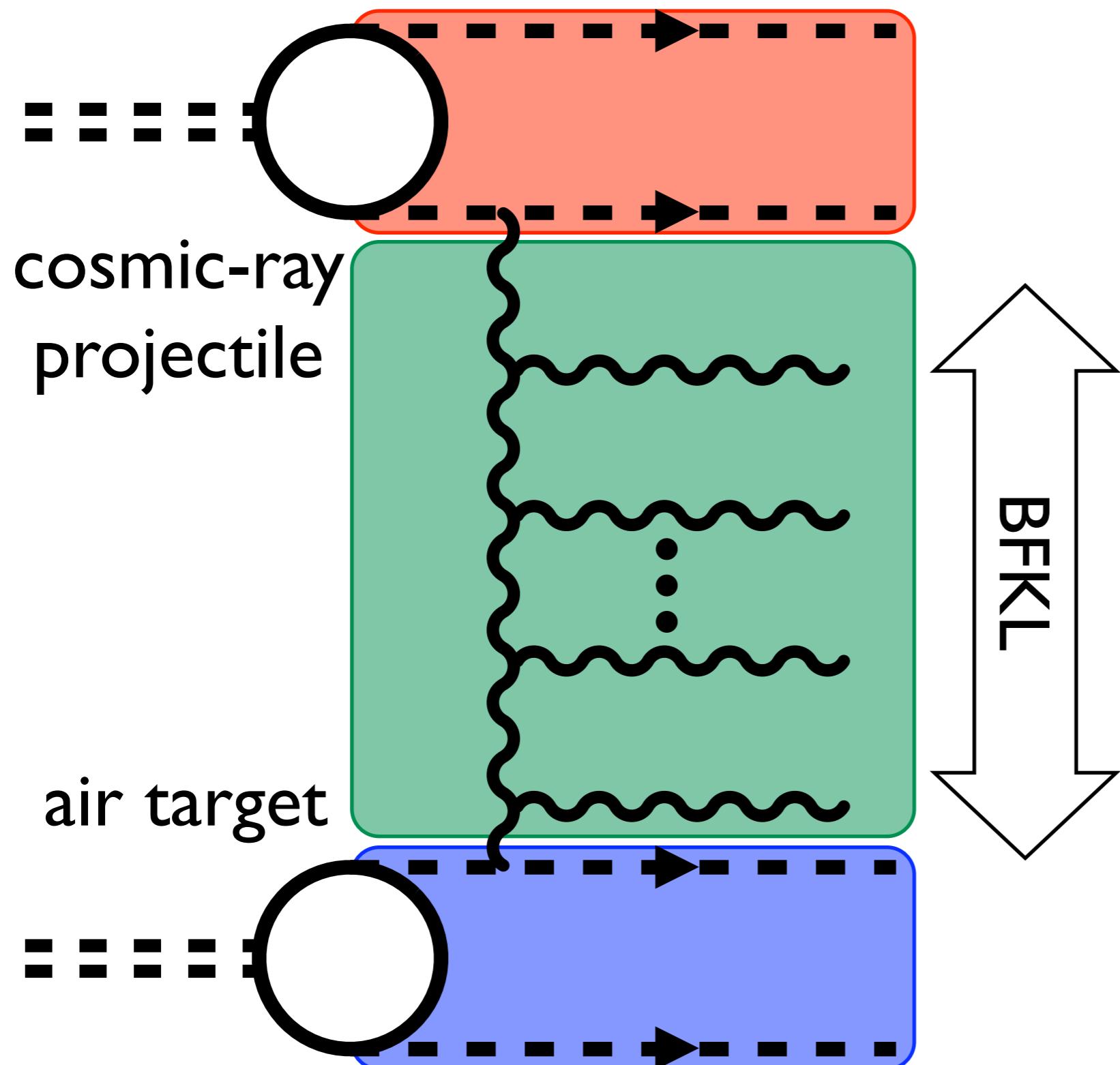
DDD

Heavy
lepton
(e.g. ν)



DDD

BSM target



cosmic-ray
projectile

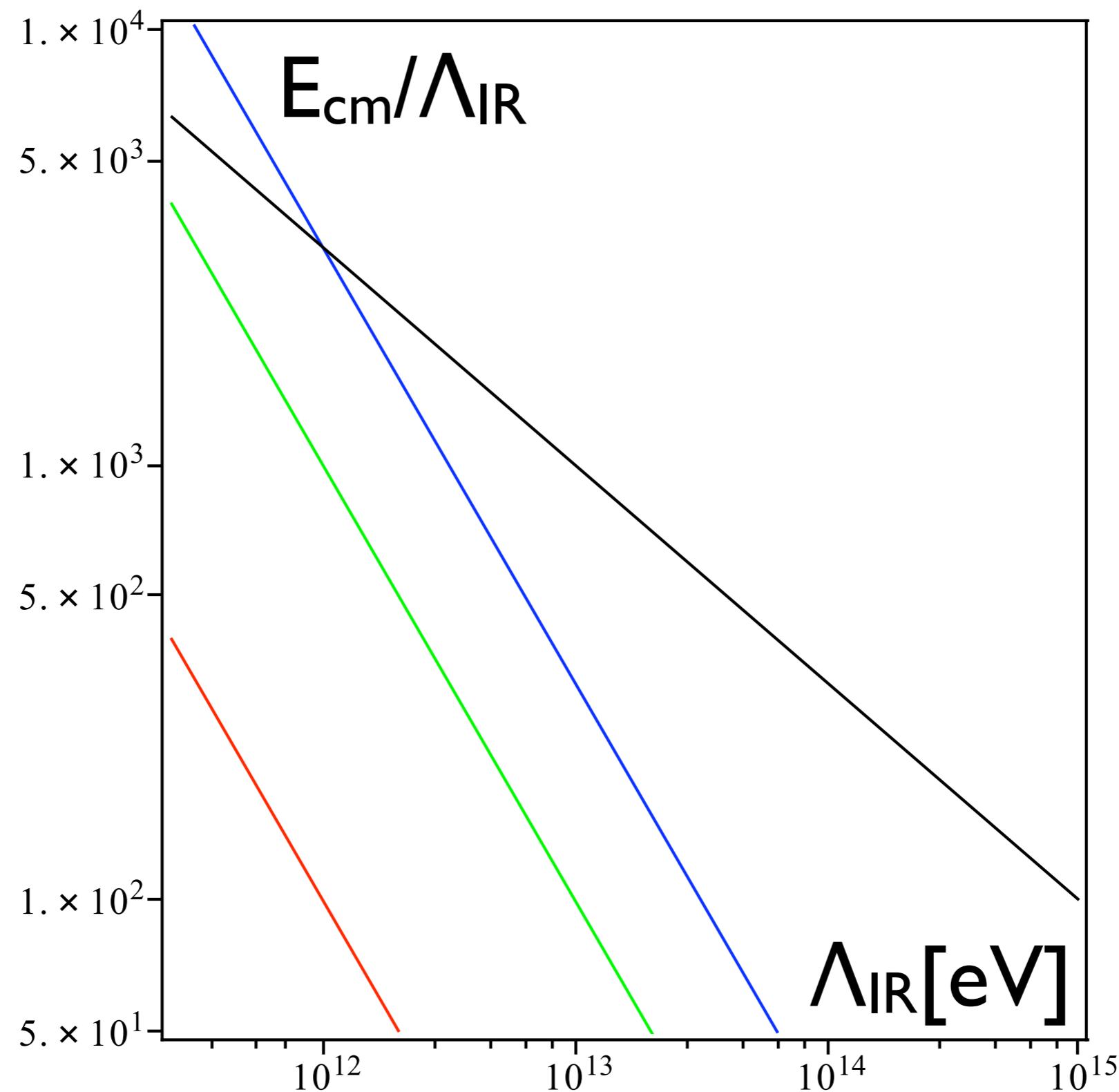
air target

+ non-SM
target

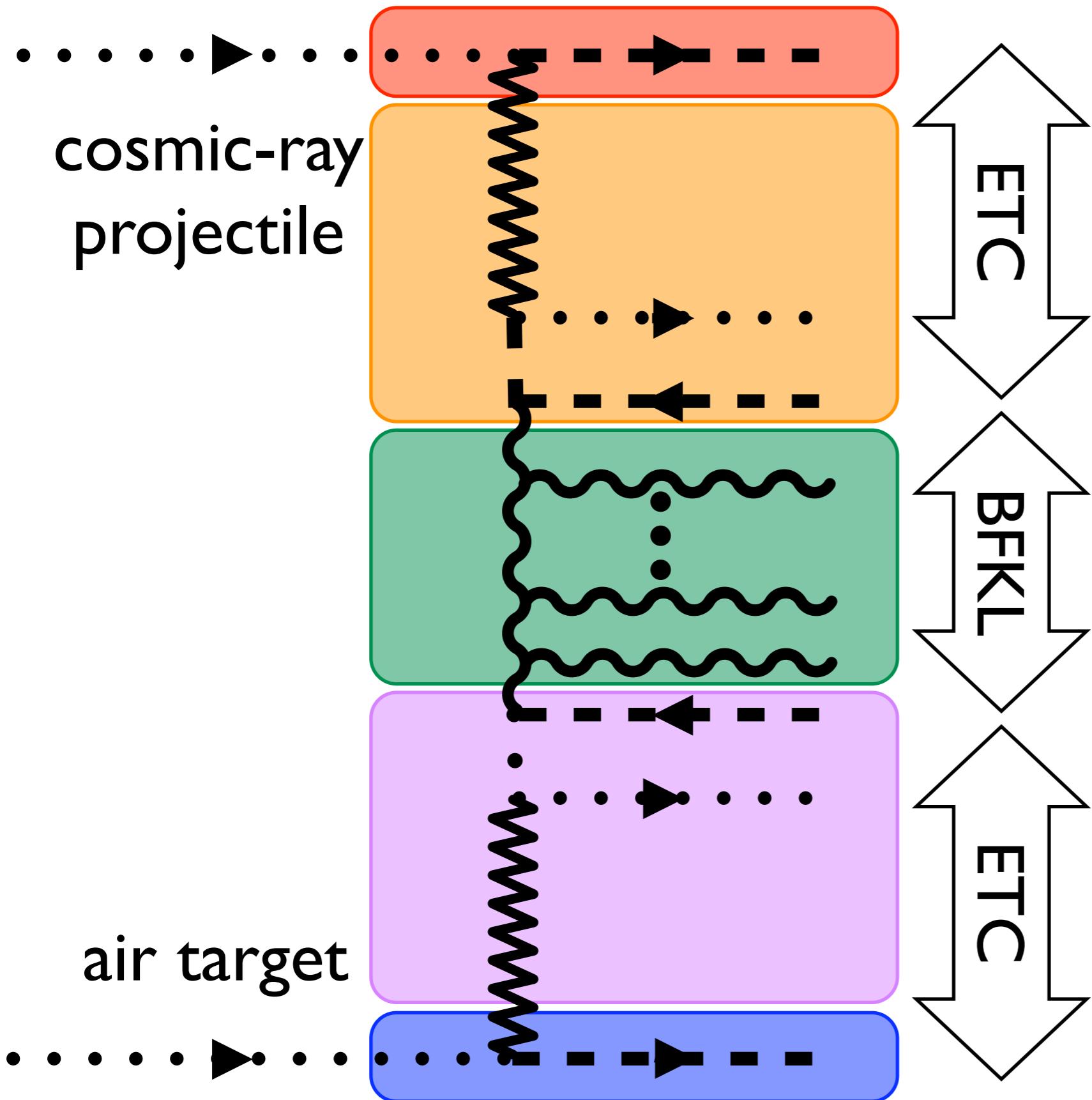
similarly: heavy neutrino

DDD

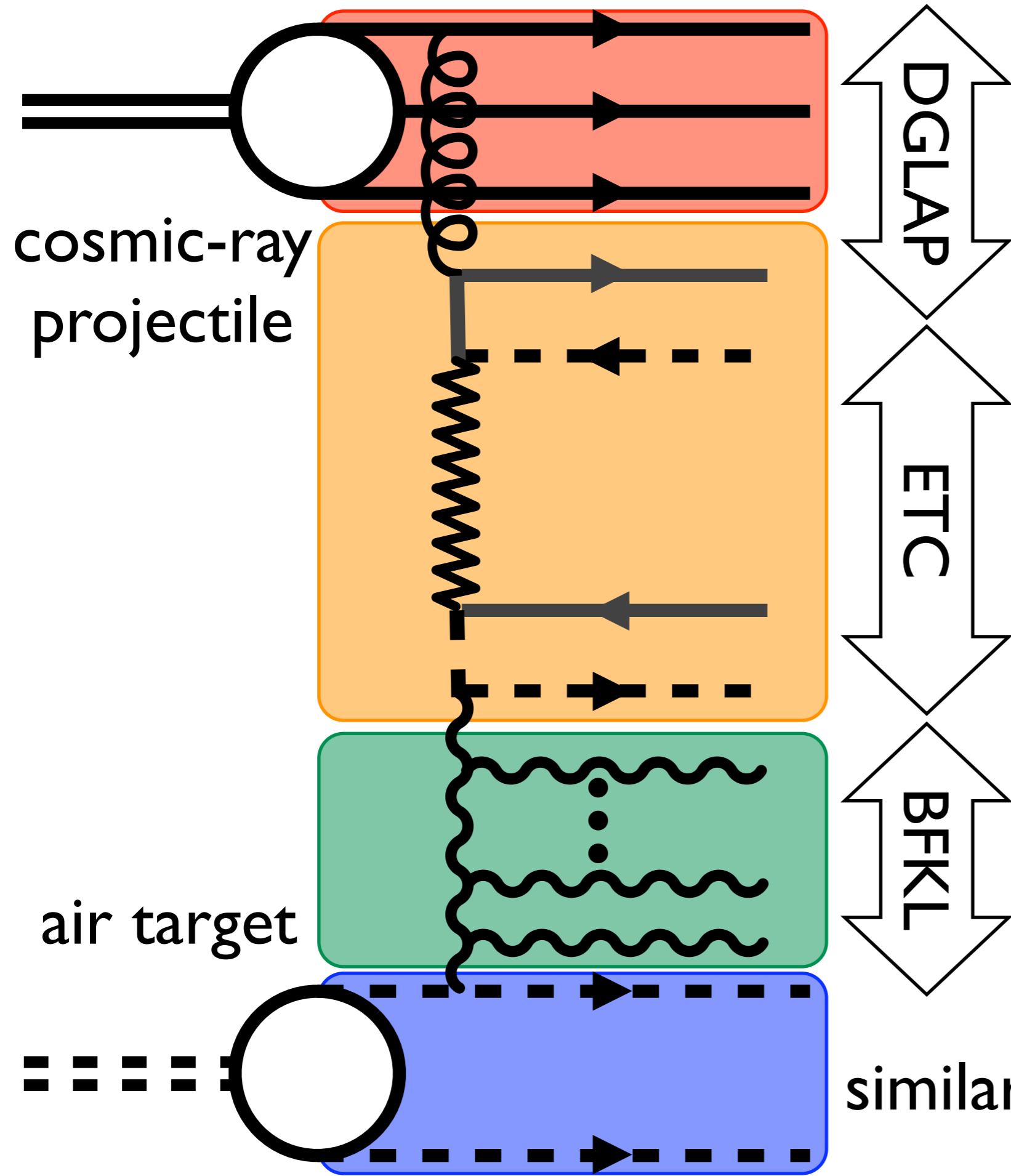
Number of emissions



Two
heavy
leptons



DDD



cosmic-ray
projectile

air target

=====
=====

SM
projectile
on TC

similarly, on heavy neutrino

DDD

Summary

- ankle structure where (low-scale) DEWSB would modify cross section
- @ composition: larger amount of produced p_t
 $X_{\max} \searrow$ lateral spread \nearrow
- CR distinguish between elementary and effective theories (probe new gauge interactions)
- @ GZK: DEWSB bound states & associated heavy leptons do not see cutoff
- required: more data on growth of (QCD) cross section from colliders, i.e., $pA@LHC$



**Thank you very much
for your attention!**