

Probing DEWSB with cosmic rays

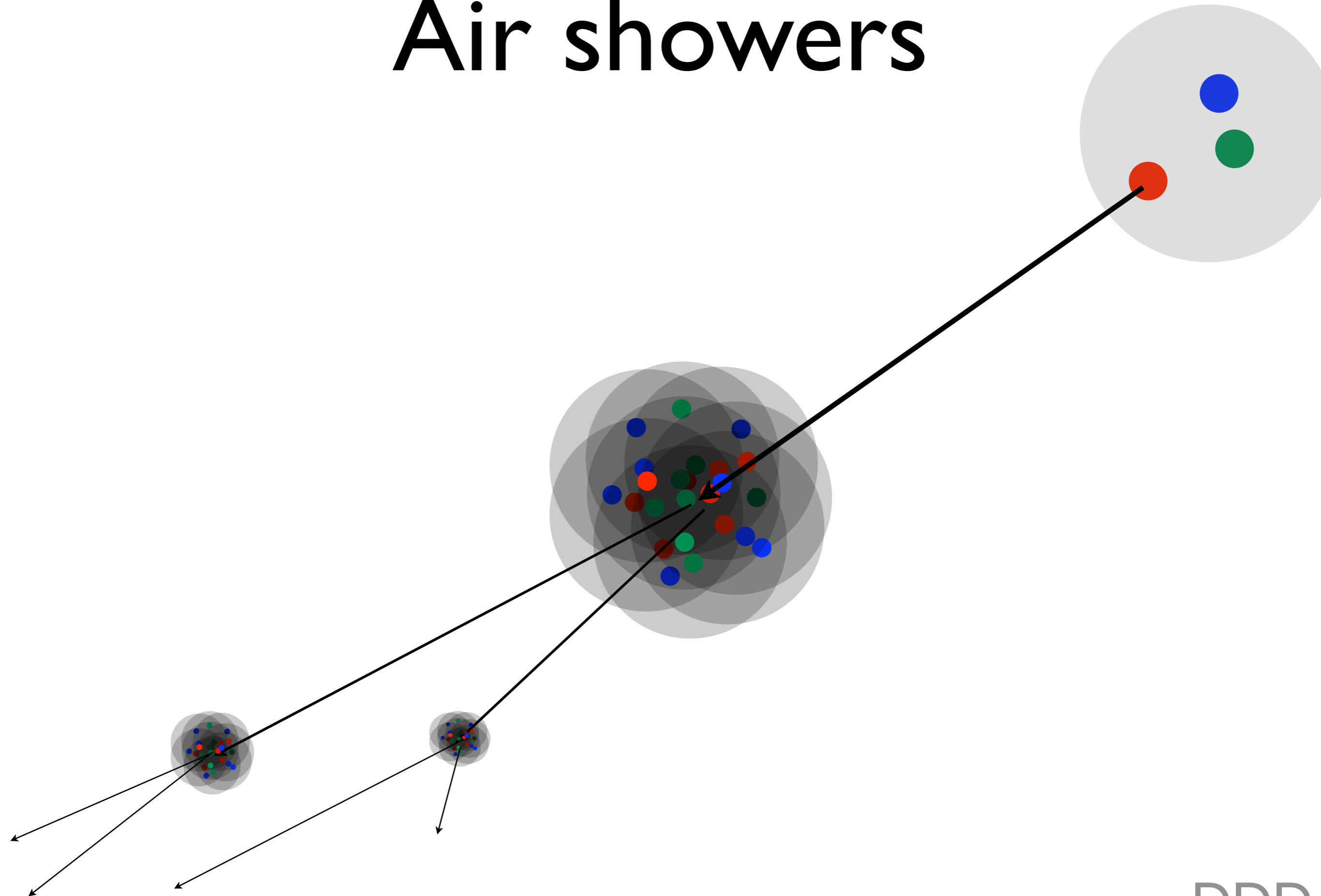
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Goethe-Universität, Frankfurt am Main

Planck 2013
From the Planck Scale to the Electroweak Scale
Bonn, May 21, 2013

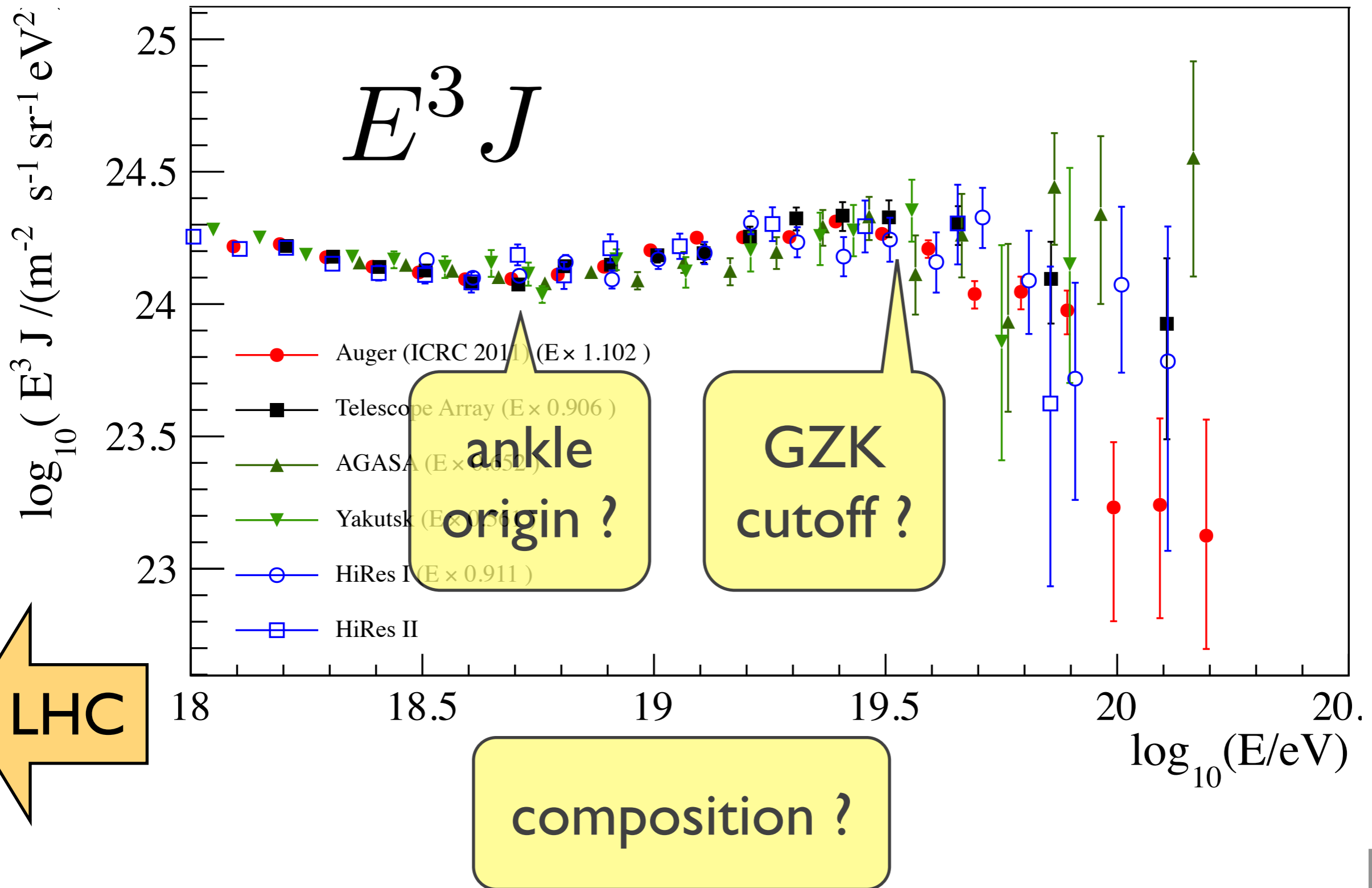
Outline

- Introduction
 - Ultrahigh energy cosmic rays
 - Dynamical electroweak symmetry breaking
- Projectiles
 - Hadrons
 - Neutrinos
 - Bound states
- Conclusion

Air showers



Spectrum (all particles)

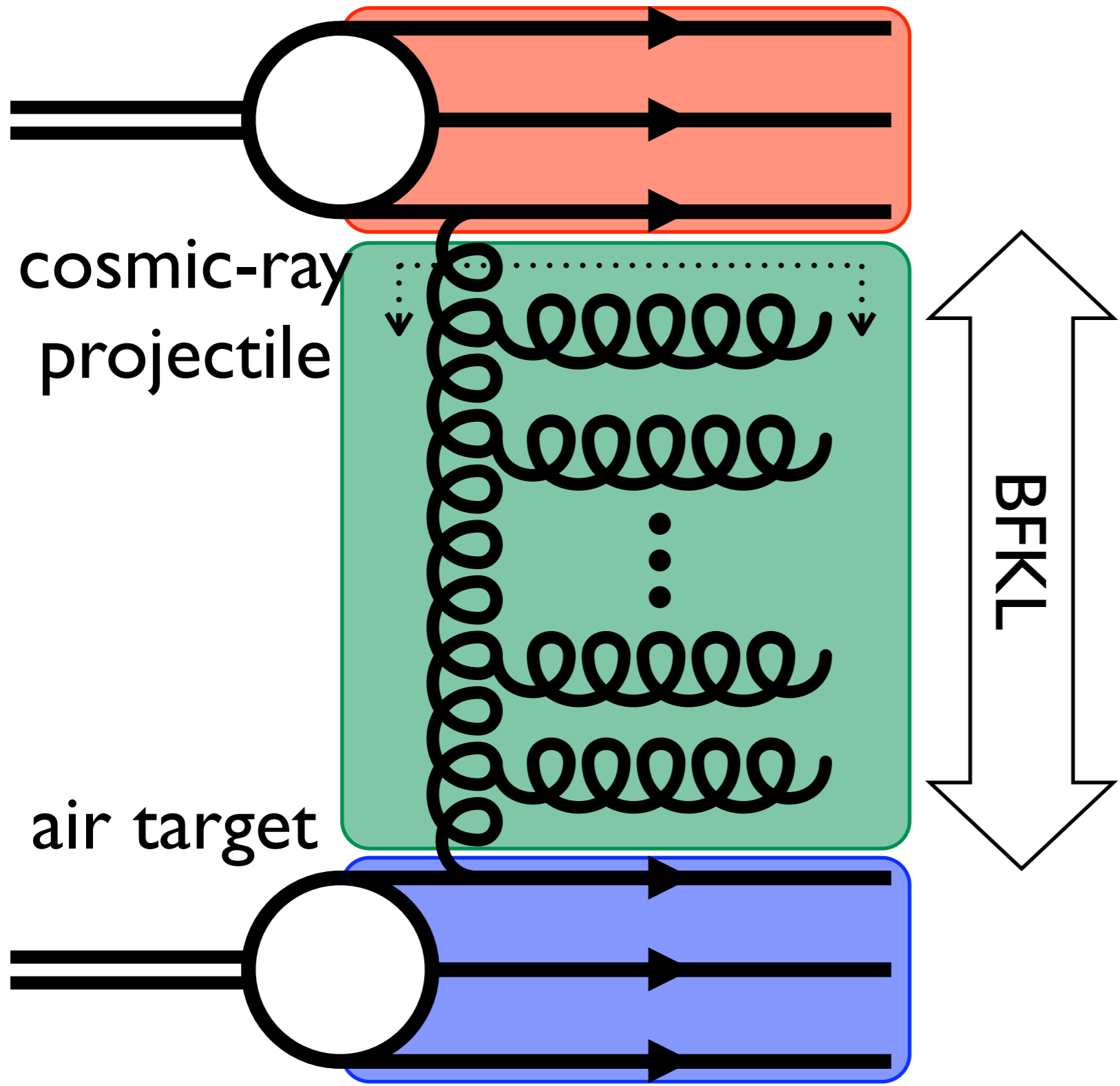


DEWSB

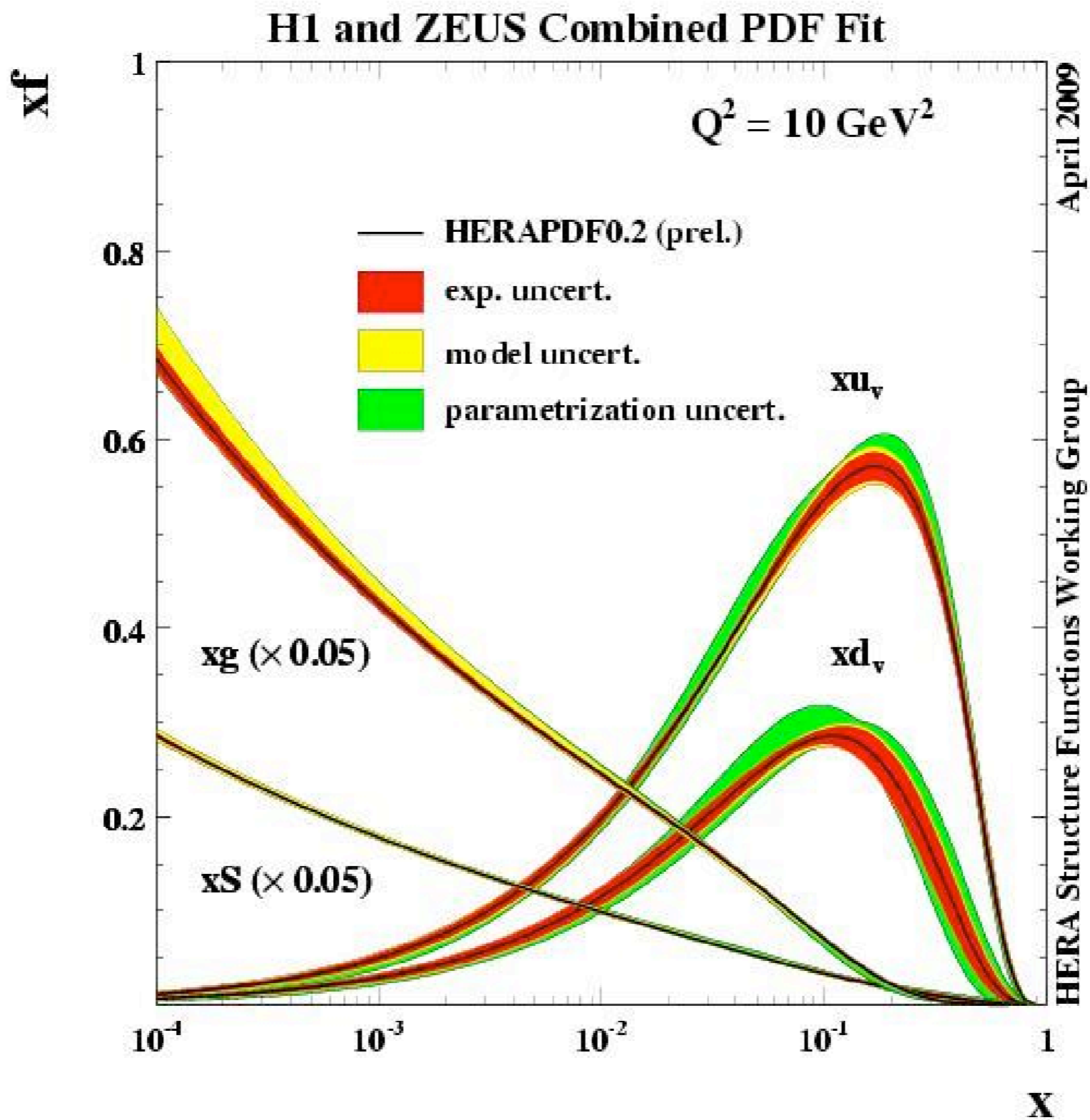
- Technicolour
 - Extended technicolour
 - Topcolour
- Composite Higgs
- Little Higgs
- ▶ Probe new gauge sector
- ▶ Features of the spectrum

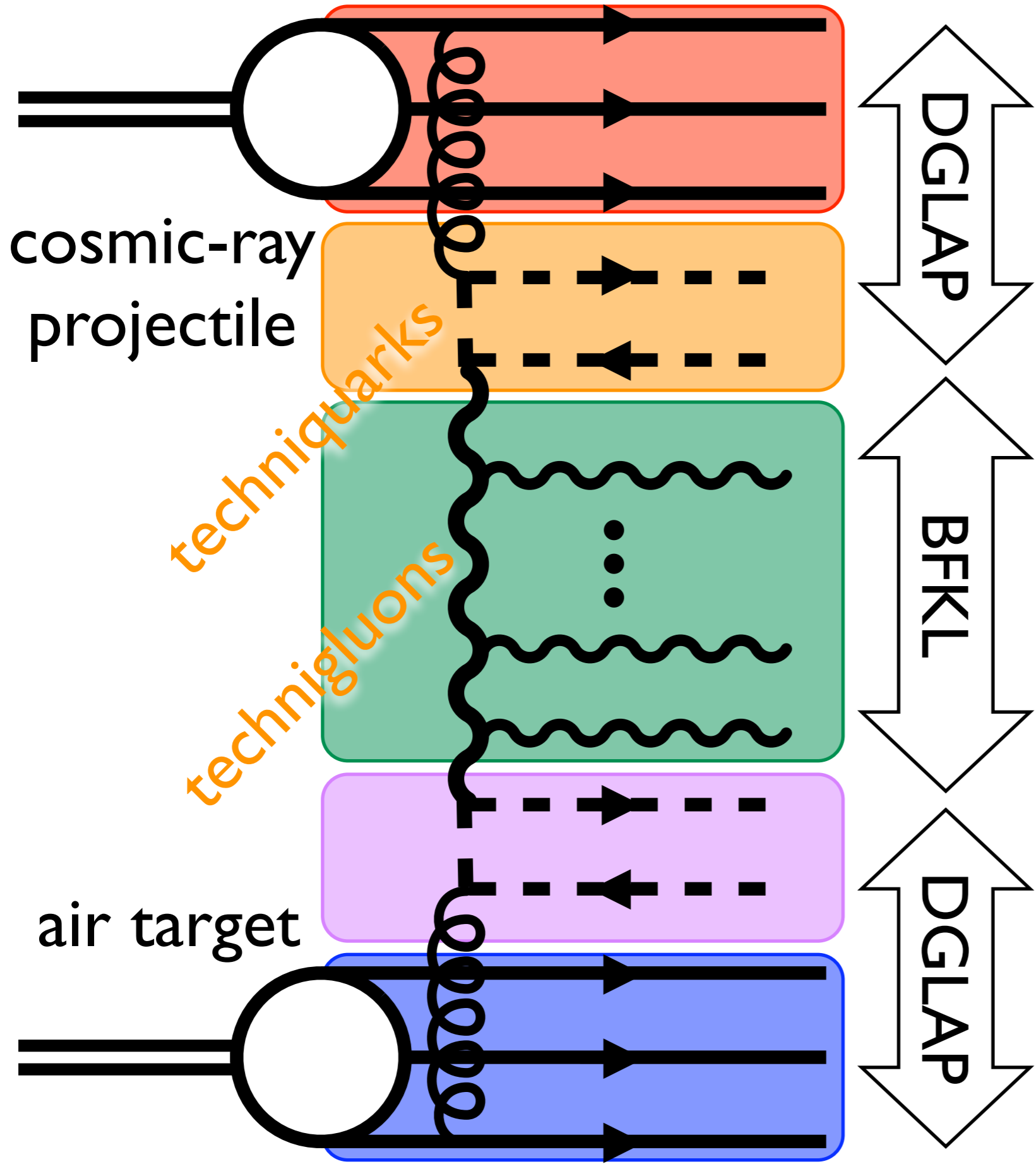
QCD prototype & benchmark

D.D.Dietrich, arXiv:1206.2400 [hep-ph]



HERA



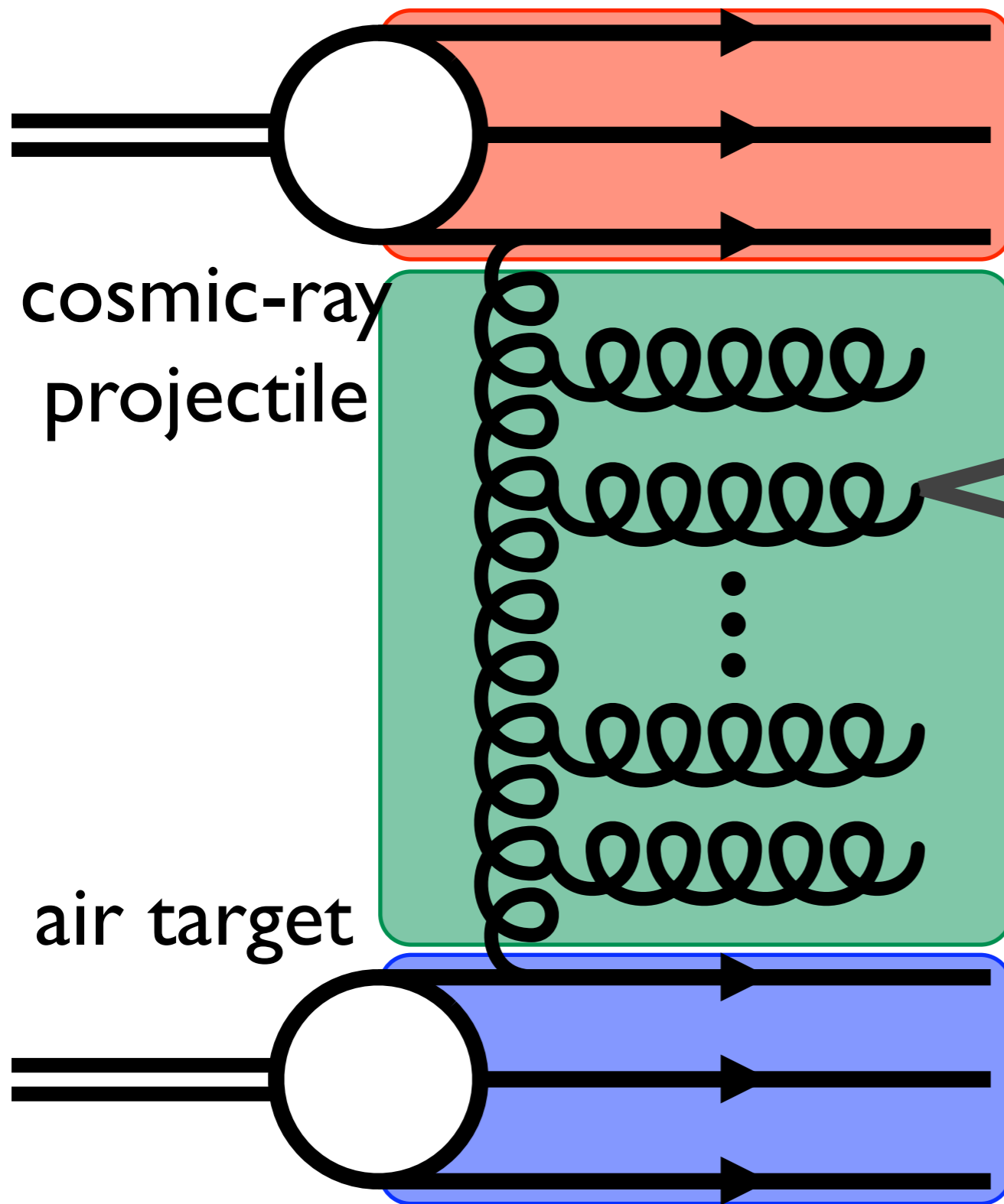


Techni-colour

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

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

more QCD background



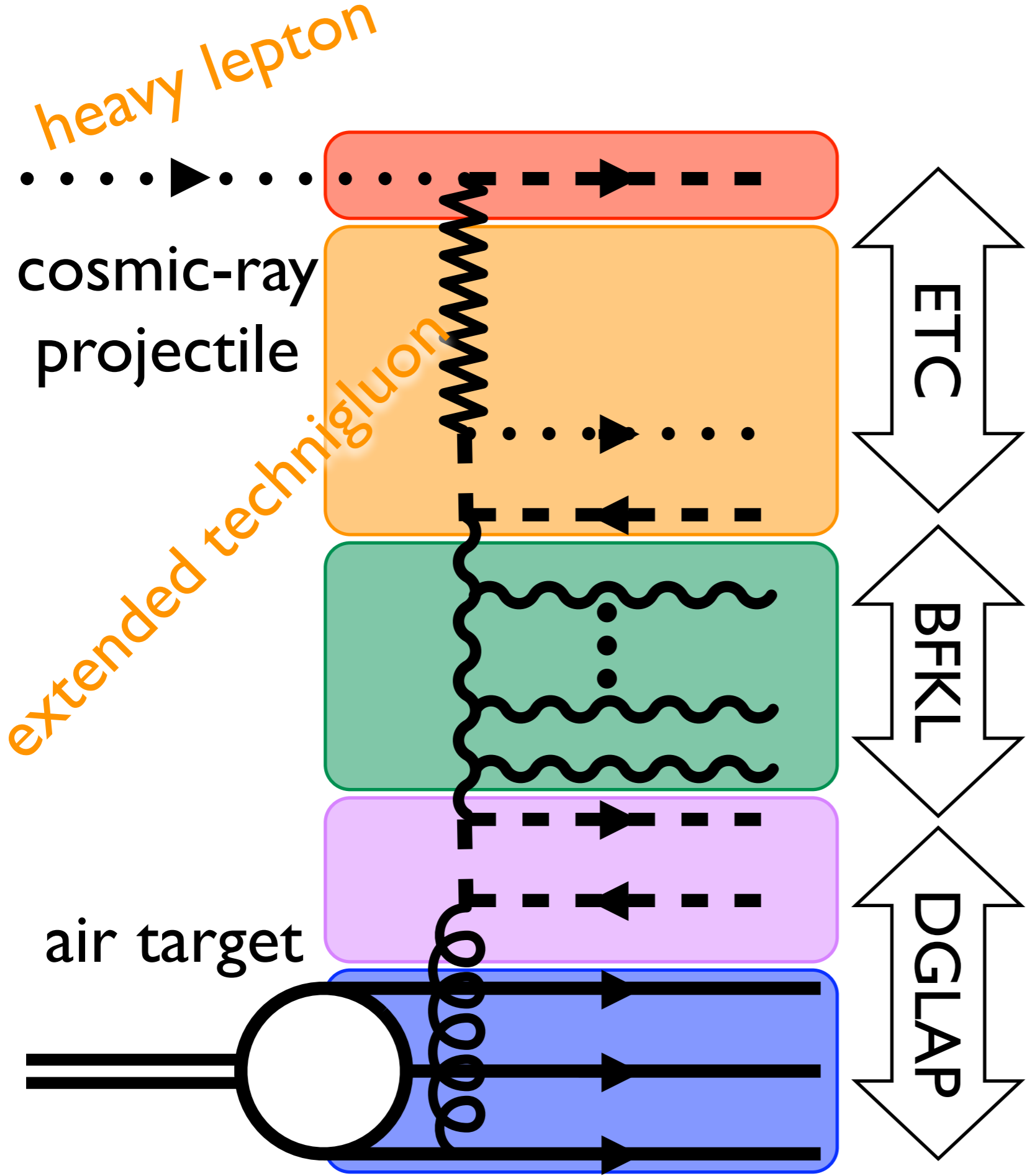
top antitop

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

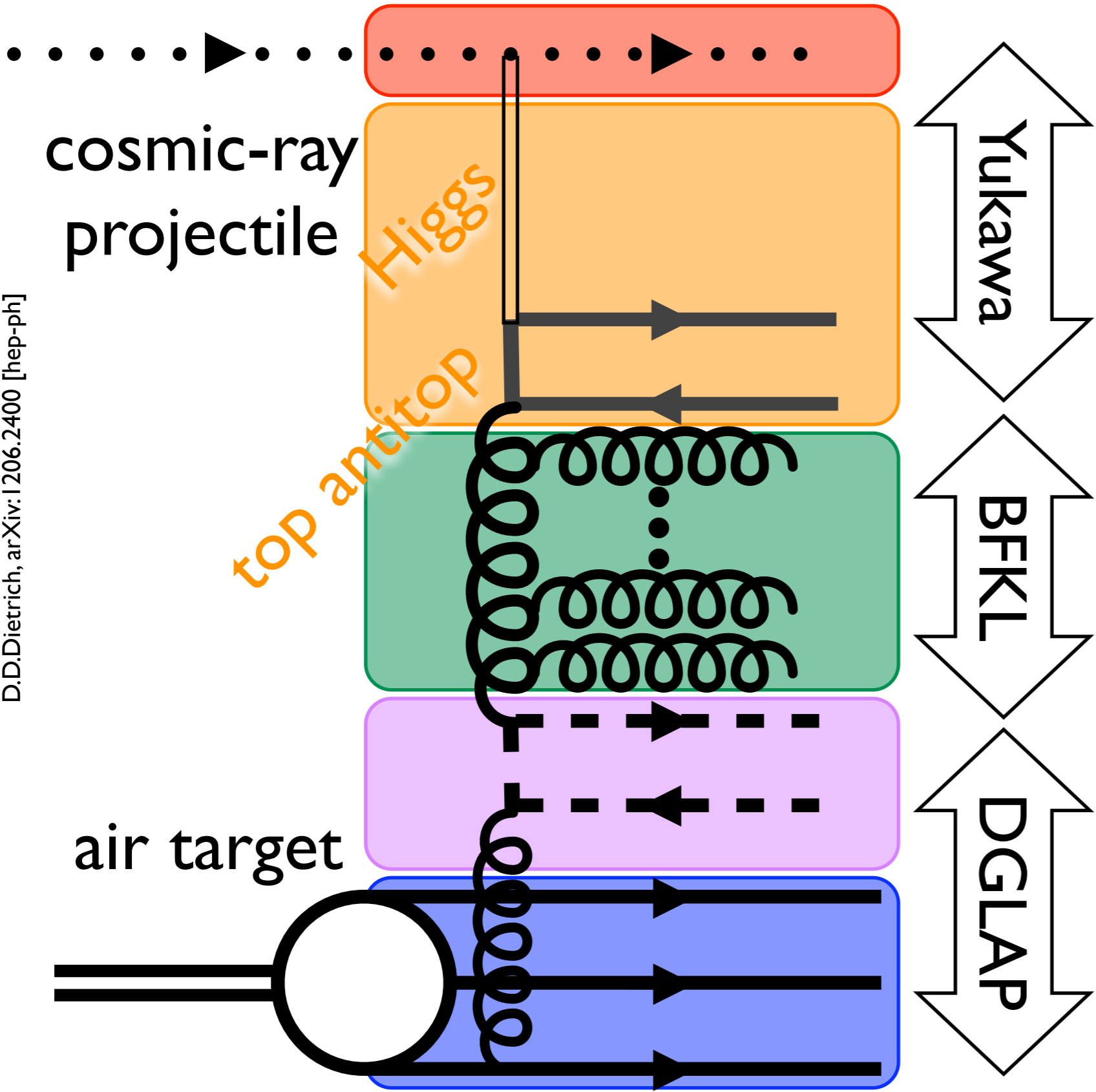
$$\frac{\sigma_{\text{tot}}^{\text{TC}}}{\sigma_{\text{tot}}^{\text{QCD}+t\bar{t}}} \frac{\Lambda_{\text{TC}}}{2m_t} \approx O(1)$$

Fast forward

- Technicolour
 - 3rd generation ETC few TeV
- Topcolour - if unification w/ $SU(3)_{\text{QCD}}$
 \Rightarrow small coupling
- Composite Higgs $\xi = (v/f)^2 \approx 1$ “TC limit”
requires UV completion to judge in detail
- Little Higgs - heavy $SU(2) \approx 2\text{TeV}$
- $SU(2)_L$ - coupling to weak



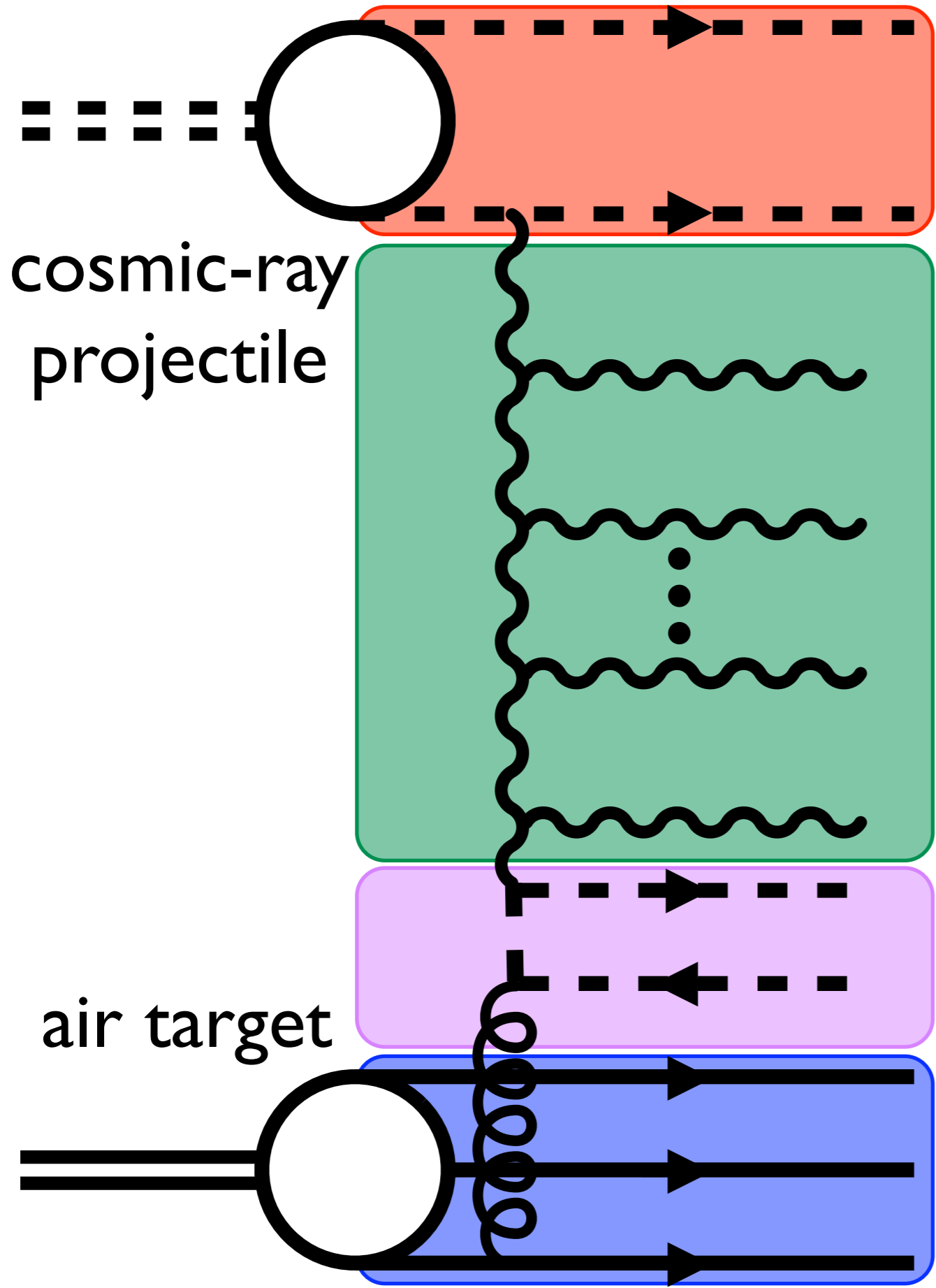
Heavy lepton (e.g. ν)



Heavy lepton (e.g. ν)

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

$$\frac{\sigma_{\text{tot}}^{\text{TC}\nu}}{\sigma_{\text{tot}}^{\text{QCD}\nu}} \frac{\Lambda_{\text{TC}}}{2m_t} \approx O(1)$$



BSM bound state

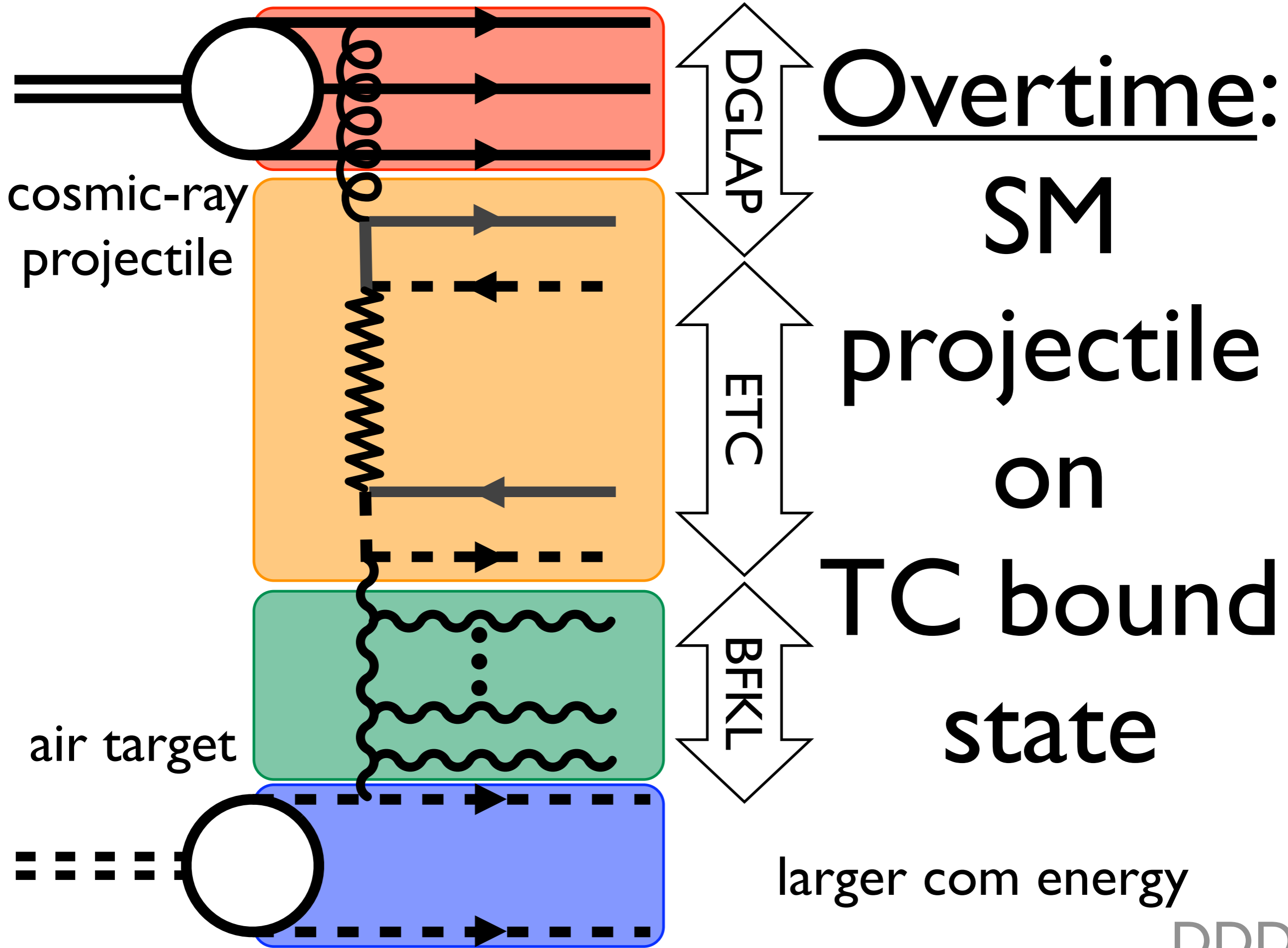
BFKL

DGLAP

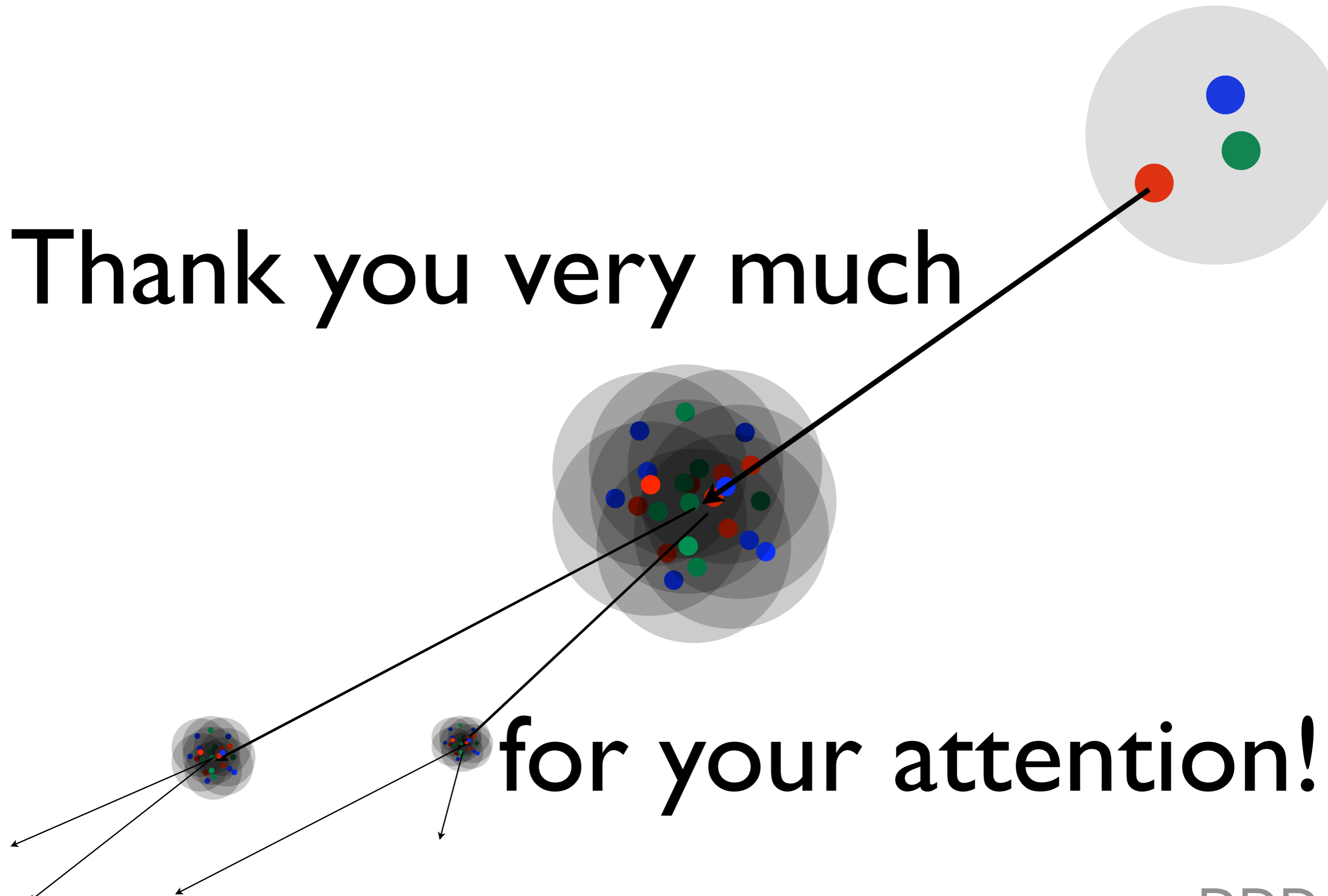
$$\frac{\sigma_{\text{tot}}^{\text{TCx}}}{\sigma_{\text{tot}}^{\text{QCD}}} \frac{\Lambda_{\text{TC}}}{\Lambda_{\text{QCD}}} \approx O(10^{+2})$$

Conclusion

- hadron and heavy lepton projectiles:
 - TC & QCD with top similarly hard
 - ➔ must look at details of shower
- new bound state projectile
 - TC harder than QCD even with top
 - does not see GZK cut off in any case
 - if GZK for hadrons: stability bound for bound state
 - ➔ impact on viability as dark matter
 - if only accelerator limit: ?



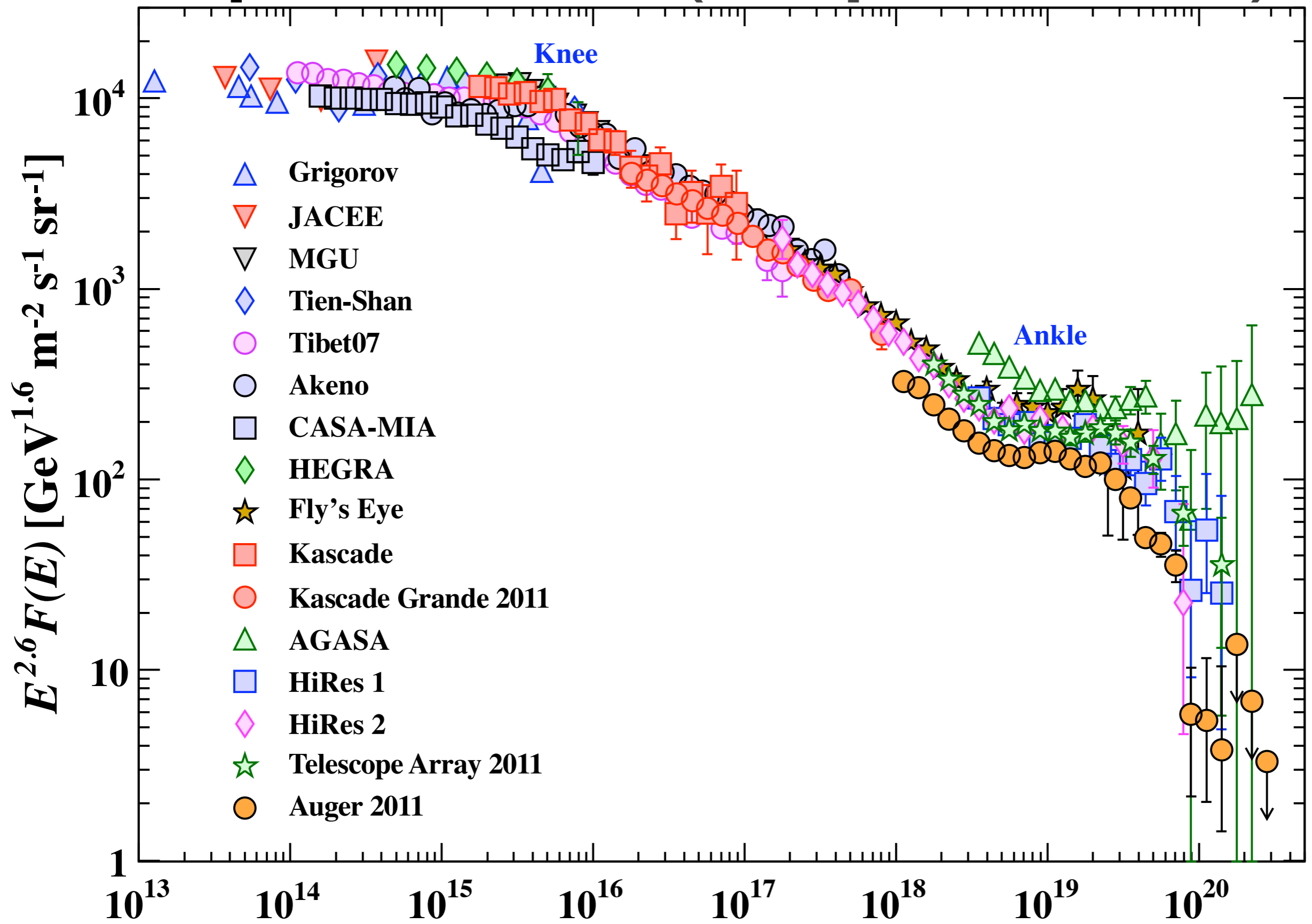
Thank you very much



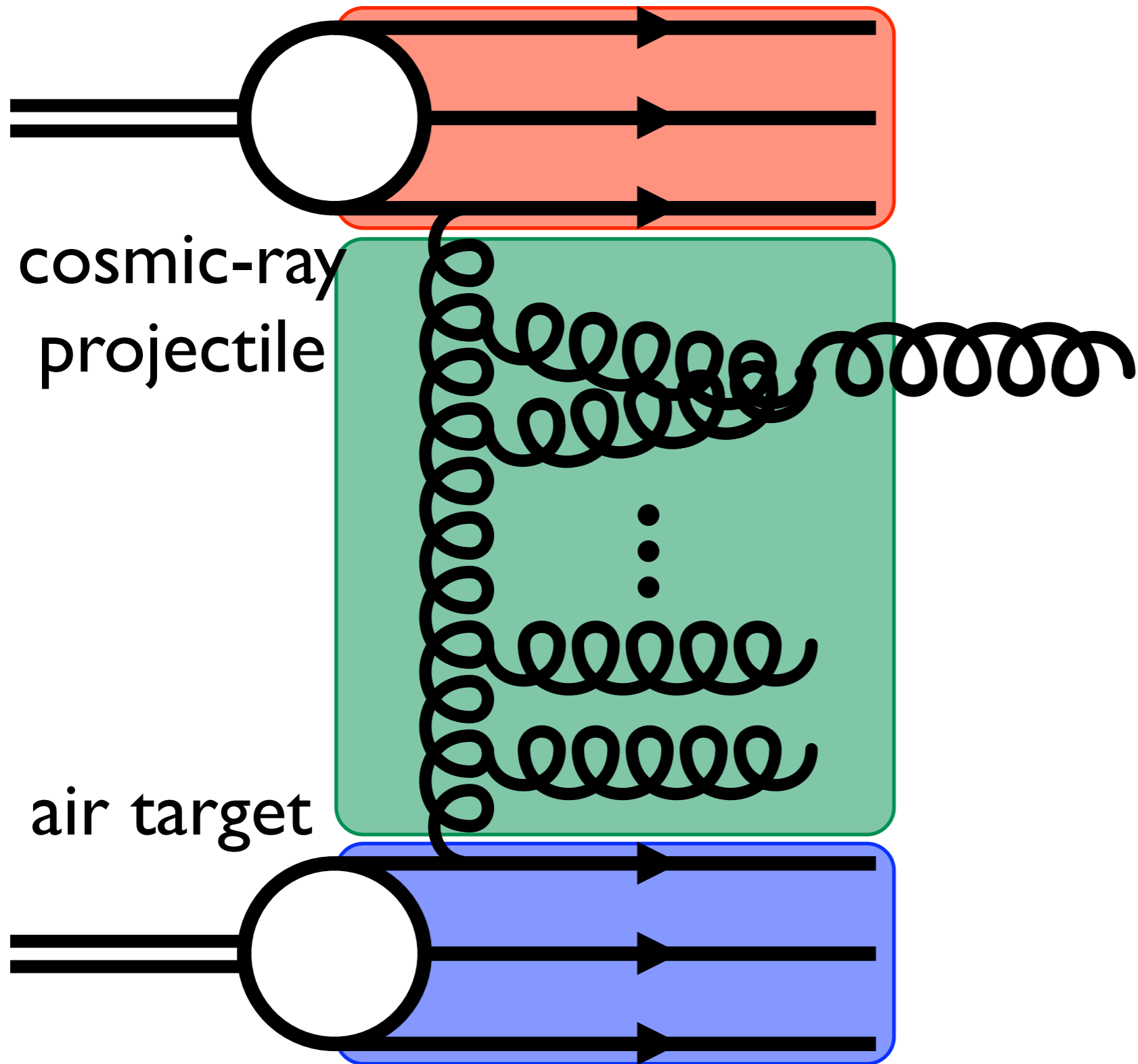
for your attention!

Supplementary material

Spectrum (all particles)



Saturation

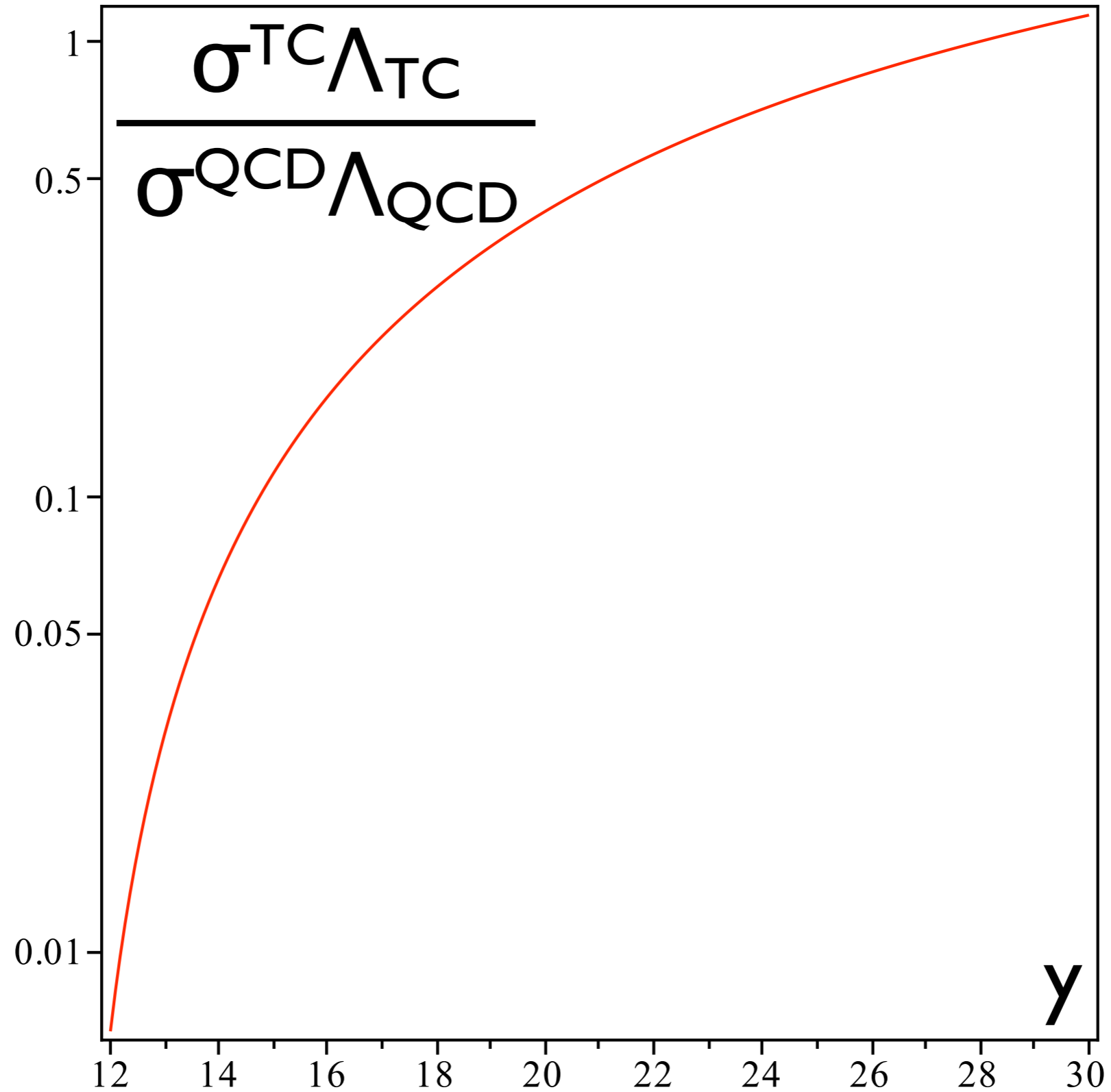


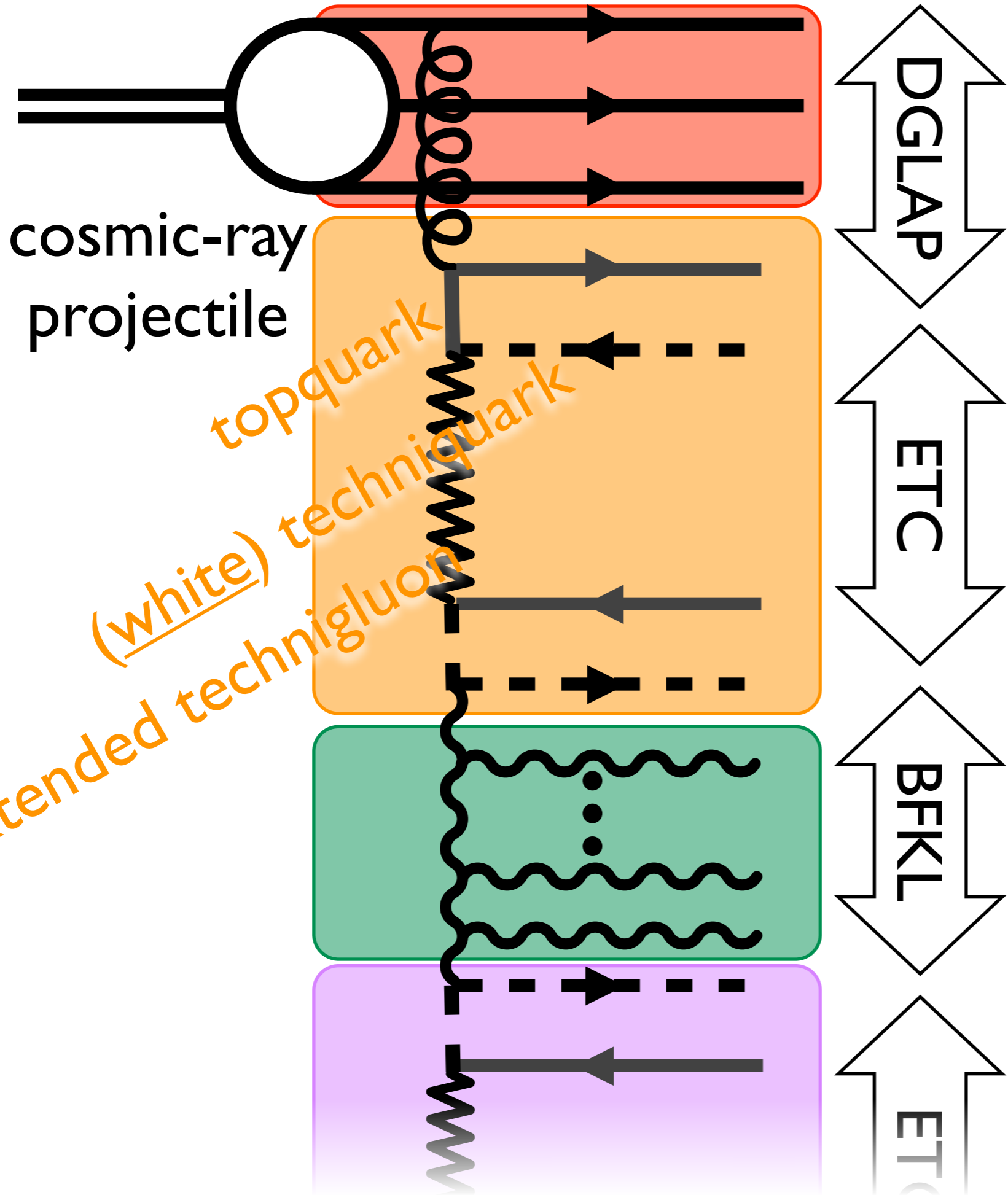
D.D.Dietrich, arXiv:1206.2400 [hep-ph]

see, e.g., Drescher, Dumitru & Strikman, PRL 94 (2005) 231801

Transverse momentum

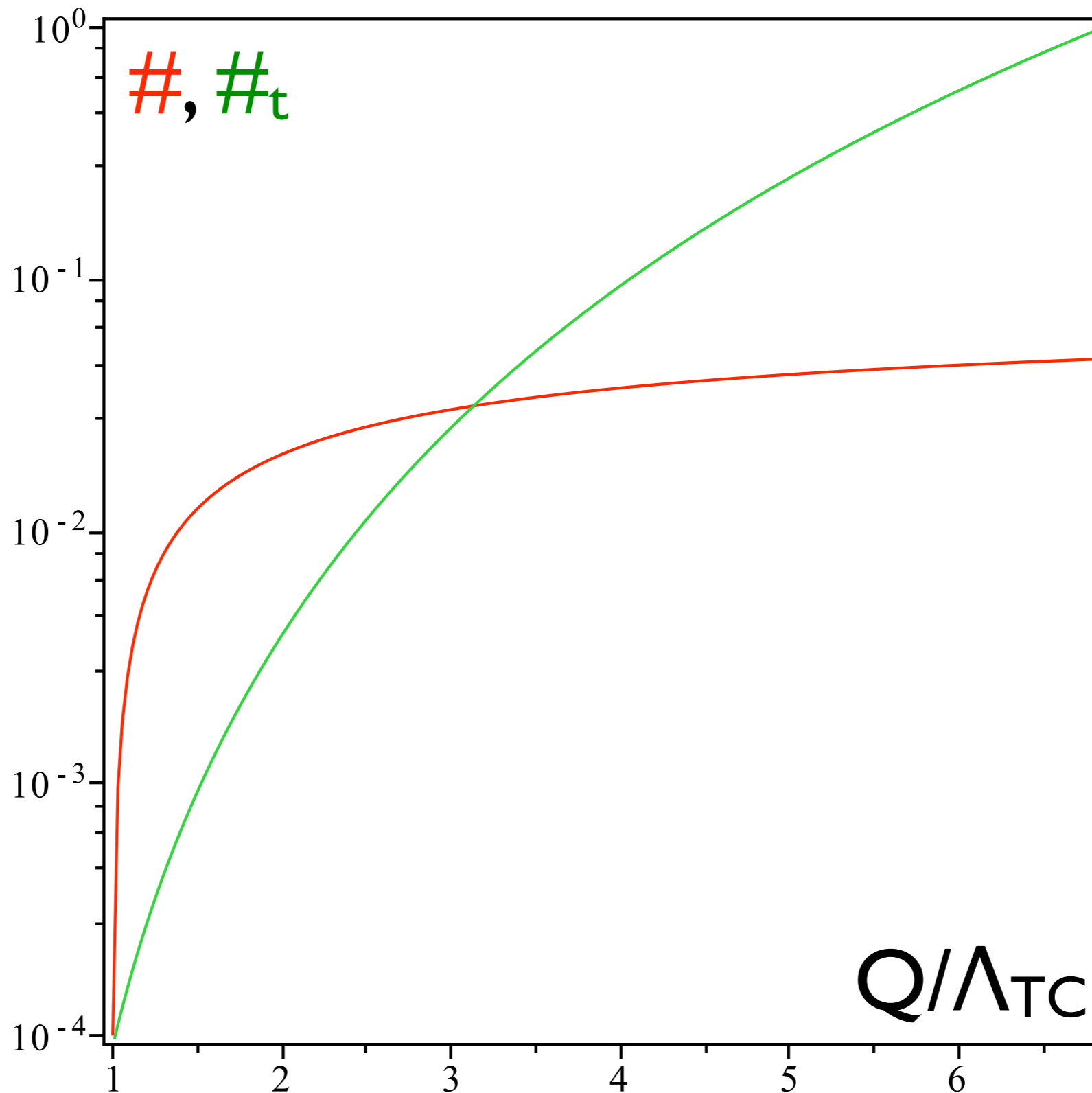
D.D.Dietrich, arXiv:1206.2400 [hep-ph]

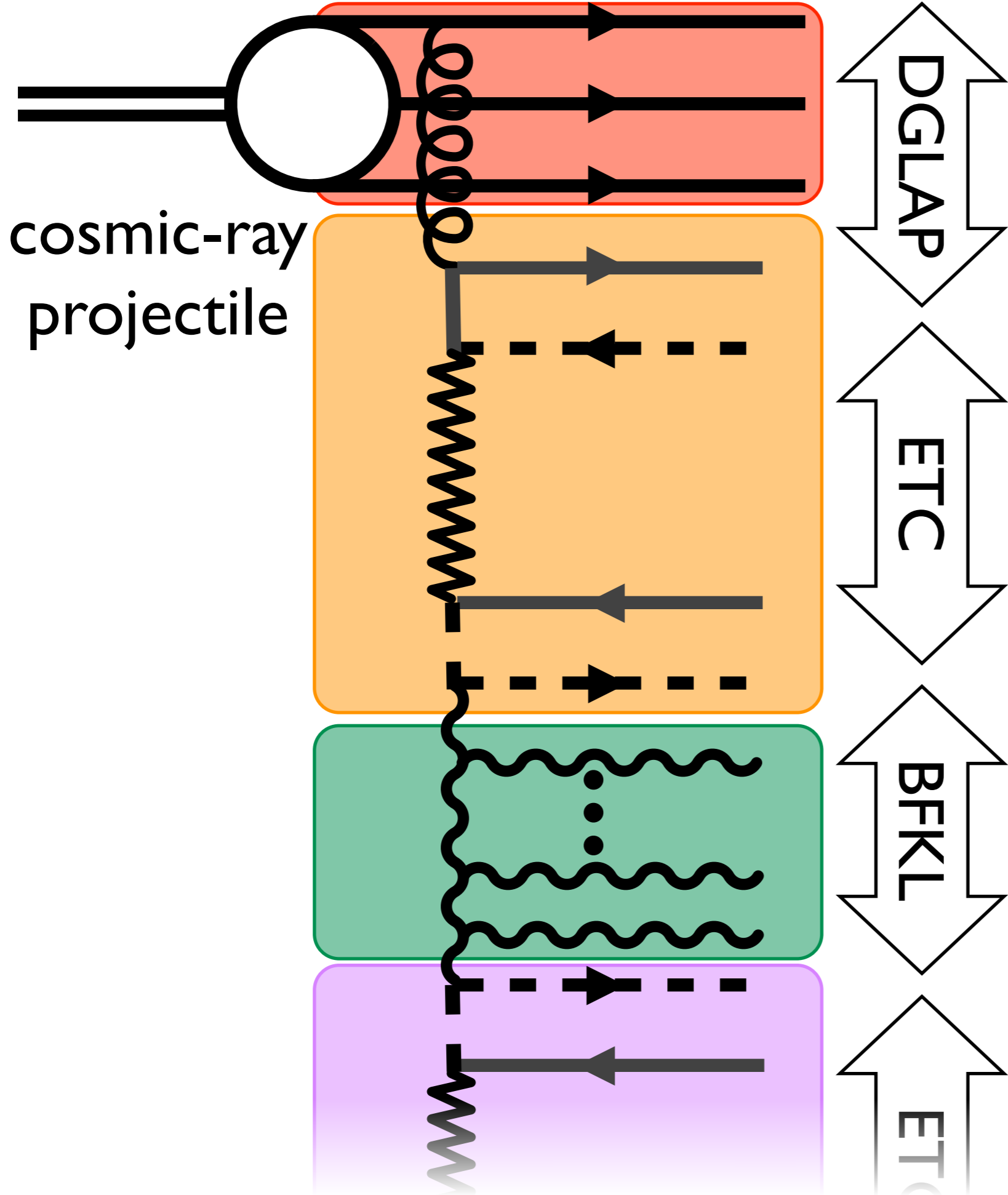




Techni-colour 2

TC1 vs. TC2





Techni-colour 2

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

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