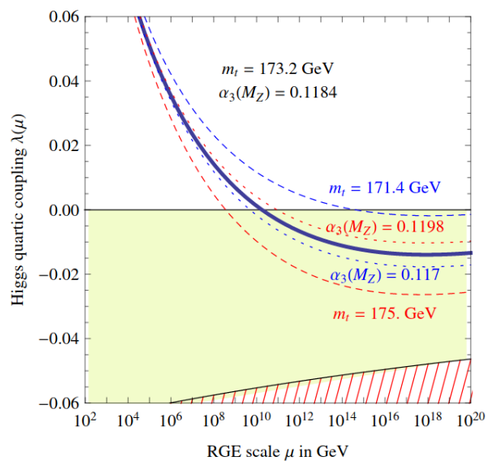
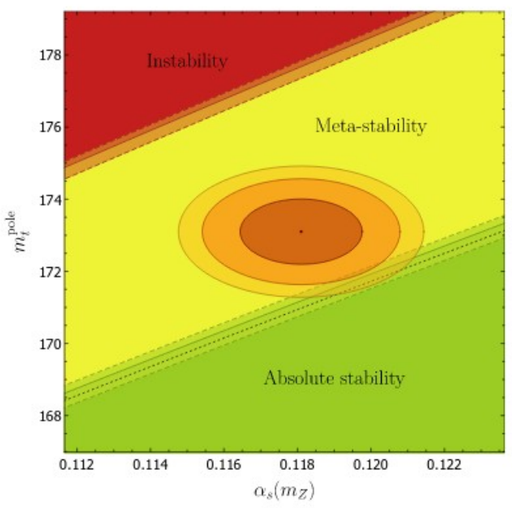
Strong-coupling constant from the Z-boson transverse momentum

Why?

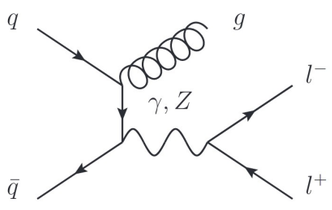
The strong coupling is the least known fundamental force of nature	Electro-magnetism	Weak Interaction	Gravitation	Strong Interaction
Relative uncertainty	10^{-10}	10^{-7}	10^{-5}	10^{-2}

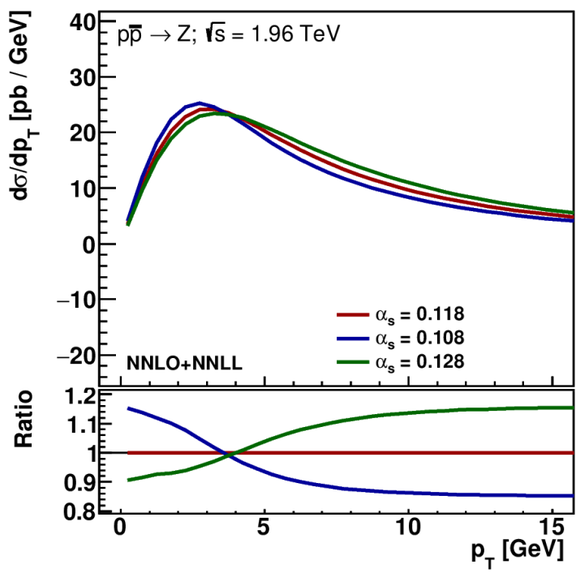
Precise knowledge of the strong-coupling impacts physics at the Planck scale





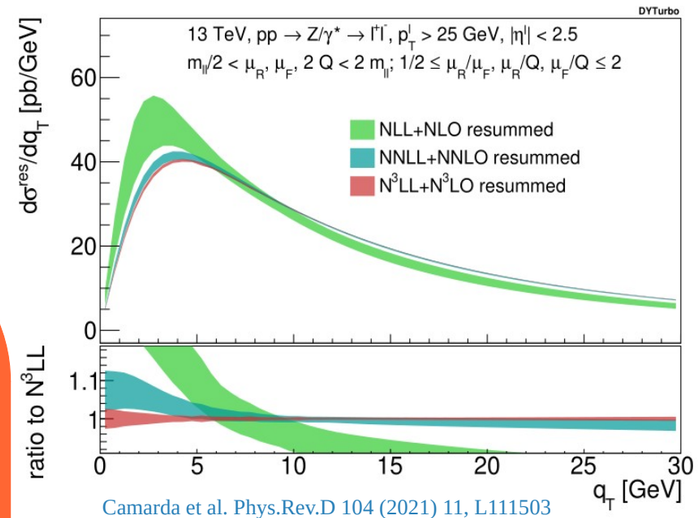
How?





- Z bosons produced in hadron collisions recoil against QCD initial-state radiation
- The QCD recoil has a Sudakov peak at 4 GeV
- The position of the peak is sensitive to the strong-coupling constant

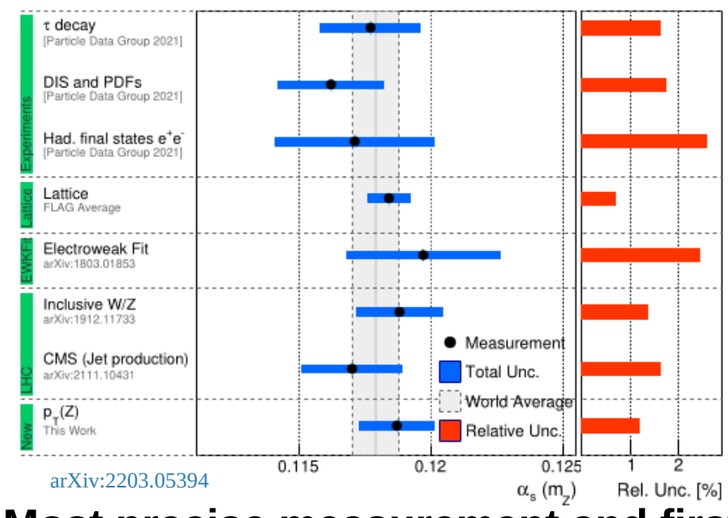
The Z-boson p_T is precisely predicted at third order in QCD



Camarda et al. Phys.Rev.D 104 (2021) 11, L111503

Result

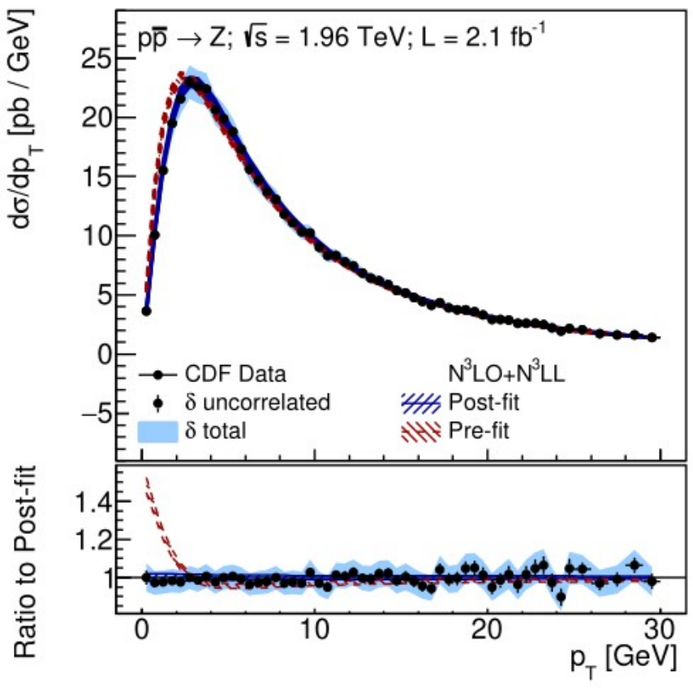
$\alpha_s(m_Z) = 0.1185 \pm 0.0015$



arXiv:2203.05394

Most precise measurement and first N³LO analysis at hadron colliders

Tevatron measurement

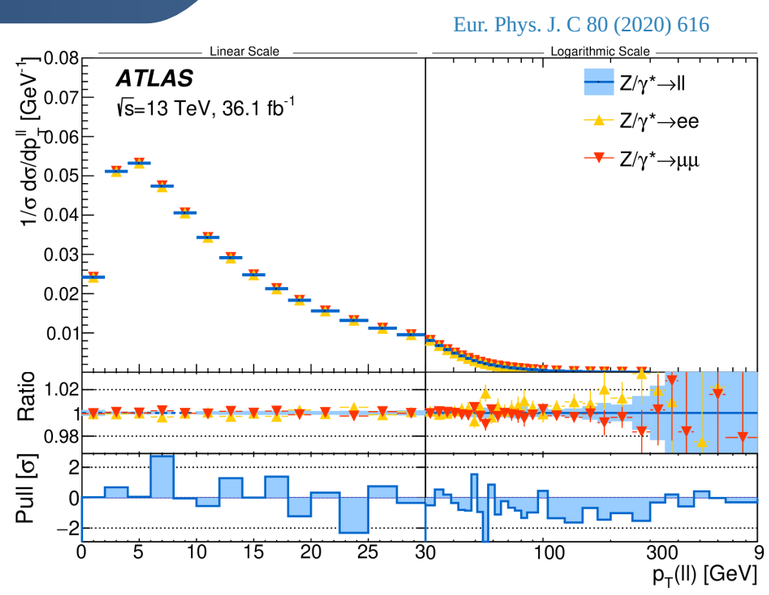


	$\delta\alpha_s(m_Z)$
Exp. unc.	0.0007
PDF unc.	0.0008
Scale var.	0.0009
Theory unc.	0.0006

Simultaneous fit of $a_s(m_Z)$ and primordial k_T to the p_T < 30 GeV Sudakov region

LHC prospects

Eur. Phys. J. C 80 (2020) 616



- Z-boson p_T measurements at the LHC have reached permille precision
- Potential to reach subpercent precision on $a_s(m_Z)$
- Theory issues: heavy flavours initiated prduction, gluon PDF, small-x resummation

LHCP 2022, 16th- 20th May 2022

Stefano Camarda, Giancarlo Ferrera, Matthias Schott