Cascade group meeting

Conferences & new papers

- EPS conference: https://indico.desy.de/event/34916/
  - Abstract deadline extended: 9 June 2023 (tomorrow)
  - Proposals:
    - back-to-back correlations (multijet and Zjet) (Luis Ignacio)
    - intrinsic kt determination (Sara)
  - what else can be presented as a group ?

Discussion on Intrinsic kt determination - paper

- Many comments received, thanks so much.
  - it looks like the paper discussion in a bigger collaboration – which is very good.
  - we prepare an answer file, where all the comments will be addressed
    - it will be circulated, before the final release

- Today we will address a few of the major comments

Sudakov and all that

- The plus prescription:

$$\int_0^1 \frac{f(z)}{(1-z)_+} dz = \int_0^1 \frac{f(z) - f(1)}{1-z} dz$$

$$\int_0^1 [F(z)]_+ = 0$$

- Have a look at QCD and MC 2016 Lecture (page 48), where this is used to calculate the virtual contribution

- The splitting function (see Hautmann, F., Jung, H., Lelek, A., Radescu, V., and Zlebcik, R. (2018). Collinear and TMD quark and gluon densities from Parton Branching solution of QCD evolution equations, JHEP, 01(2018), 070)

$$\begin{aligned} P_{ab}(z,\alpha_s) &= [P(z,\alpha_s)]_+ \\ &= D_{ab}(\alpha_s)\delta(1-z) + K_{ab}(\alpha_s)\frac{1}{(1-z)_+} + R_{ab}(z,\alpha_s) \end{aligned}$$

Evolution equation with $[P(z)]_+$:

$$
\begin{aligned}
\mu^2 \frac{\partial f_a(x,\mu^2)}{\partial \mu^2} &= \sum_b \int_x^1 \frac{dz}{z} P_{ab}(z)\; f_b\left(\frac{x}{z},\mu^2\right) \\
&= \sum_b \int_0^1 \frac{dz}{z} P_{ab}(z)\; f_b\left(\frac{x}{z}\right) - \sum_b \int_0^x \frac{dz}{z} P_{ab}(z)\, f_b\left(\frac{x}{z}\right) \\
&= \sum_b \int_0^1 dz\, \hat{P}_{ab}(z) \left(\frac{1}{z} f_b\left(\frac{x}{z}\right) - f_b(z)\right) - \sum_b \int_0^x \frac{dz}{z} \hat{P}_{ab}(z)\; f_b\left(\frac{x}{z}\right) \\
&= \sum_b \int_x^1 \frac{dz}{z} \hat{P}_{ab}(z)\; f_b\left(\frac{x}{z}\right) - f_a(x) \sum_b \int_0^1 dz\, \hat{P}_{ab}(z) \\
&= \sum_b \int_x^1 \frac{dz}{z} \hat{P}_{ab}(z)\; f_b\left(\frac{x}{z}\right) + f_a(x) \frac{\mu^2}{\Delta_a} \frac{\partial \Delta_a}{\partial \mu^2}
\end{aligned}
$$

Using $[P(z)]_+$:

- Defining the Sudakov as:

$$\Delta_a(\mu^2) = \exp\left(- \sum_b \int_{\mu_0^2}^{\mu^2} \frac{d\mu'^2}{\mu'^2} \int_0^{1-\epsilon} dz \hat{P}_{ab}(\alpha_s, z) \right)$$

- we obtain the evolution equation:

$$\mu^2 \frac{\partial}{\partial \mu^2} \frac{f_a(x,\mu^2)}{\Delta_a(\mu^2)} = \sum_b \int_x^1 \frac{dz}{z} \; {}_{ab}\left(z\right) \; \frac{f_b\left(\frac{x}{z},\mu^2\right)}{\Delta_a(\mu^2)}$$

Evolution equation with $1/[(1\text{-}z)]_+$:

- Using splitting fct with $1/(1-z)_+$ leads to:

$$
\begin{aligned}
\mu^2 \frac{\partial f_a(x,\mu^2)}{\partial \mu^2} &= \sum_b \int_x^1 \frac{dz}{z} \, P_{ab}(z) \, f_b\left(\frac{x}{z},\mu^2\right) \\
&= \sum_b \int_0^1 \frac{dz}{z} \left(D_{ab}\delta(1-z) + K_{ab}\frac{1}{(1-z)_+} + R_{ab}(z) \right) f_b\left(\frac{x}{z}\right) \\
&= \sum_b \int_0^1 \frac{dz}{z} \left(\frac{K_{ab}}{1-z} + R_{ab}(z) \right) f_b\left(\frac{x}{z}\right) \\
&\quad -f_a(z) \int_0^1 dz \left(\frac{k_a}{(1-z)} - d_a\delta(1-z) \right)
\end{aligned}
$$

- with Sudakov

$$
\Delta_a^S(\mu^2) = \exp\left(- \int_{\mu_0^2}^{\mu^2} \frac{d\mu'^2}{\mu'^2} \int_0^{1-\epsilon} dz \left[\frac{k_a}{(1-z)} - d_a\delta(1-z) \right] \right)
$$

What happens for $\alpha_s((1-z)\mu)$

- What happens for $\alpha_s((1-z)\mu)$ when $z \to 1$:
  - In expansion of plus prescription:

$$\int_0^1 \frac{f(z)}{(1-z)_+} dz = \int_0^1 \frac{f(z) - f(1)}{1-z} dz$$

  - $\alpha_s((1-z)\mu)$ is not affected, since wither there is dynamical z_{dyn} or $\alpha_s(q_t)$ is frozen for $q_t \leq q_{cut}$ such that $z=1$ is not allowed.
  - See for example: *Amati, D., Bassetto, A., Ciafaloni, M., Marchesini, G., and Veneziano, G. A treatment of hard processes sensitive to the infrared structure of QCD, Nucl. Phys., B173(1980), 429*

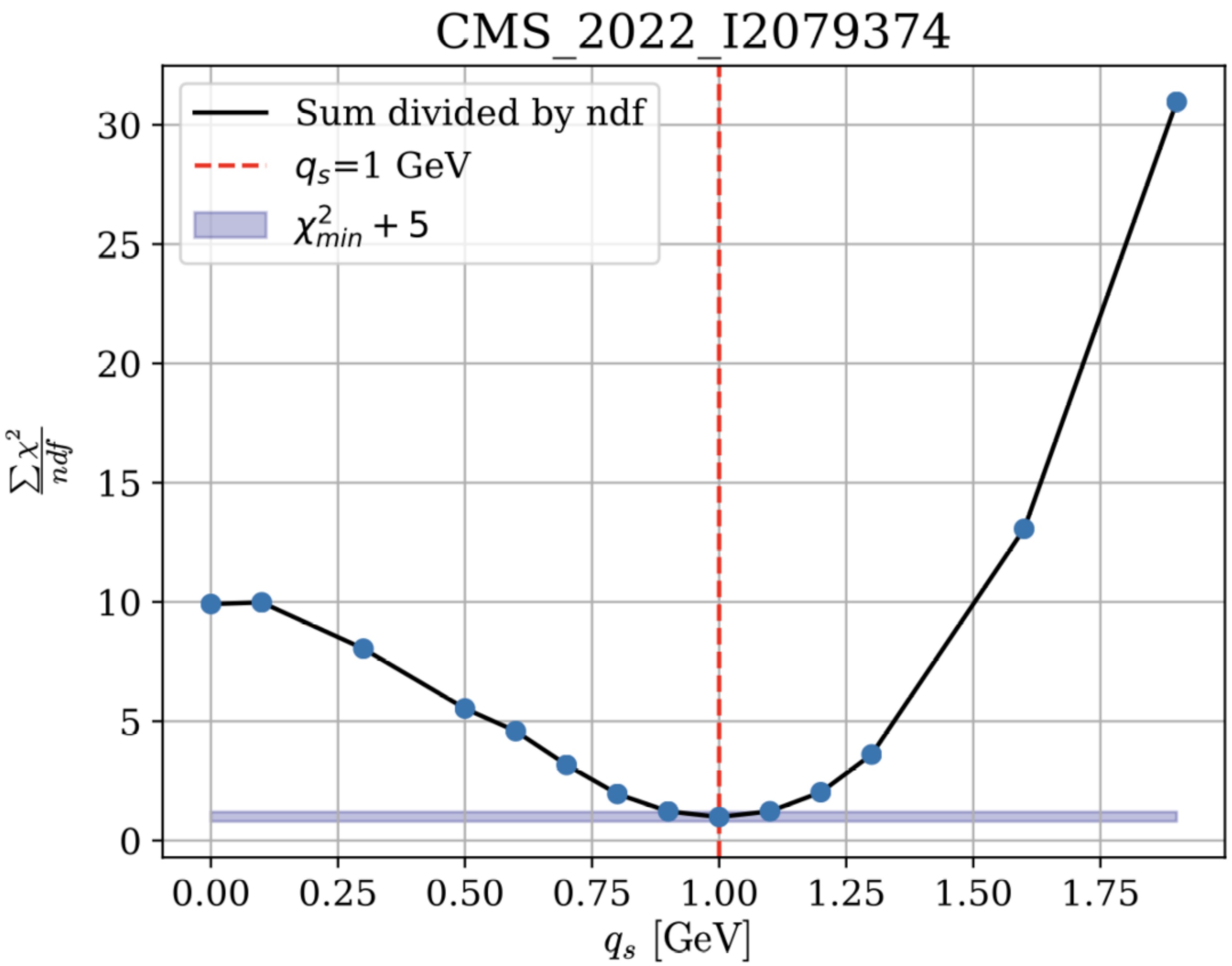
Is PB Set1 and PB Set 2 DGLAP evolution ?

- Questions, whether PB Set1 and PB Set2 are DGLAP evolutions:
  - integrated pdf from PB Set1 is DGLAP, since it uses the same expressions as in std DGLAP (with $\alpha_s(\mu)$), and DGLAP evolution is correctly reproduced *(see Bermudez Martinez, A., Connor, P., Hautmann, F., Jung, H., Lelek, A., Radescu, V., and Zlebcik, R. . Collinear and TMD parton densities from fits to precision DIS measurements in the parton branching method, Phys. Rev. D, 99 (2019), 074008 and Hautmann, F., Jung, H., Lelek, A., Radescu, V., and Zlebcik, R. Collinear and TMD quark and gluon densities from Parton Branching solution of QCD evolution equations, JHEP, 01(2018), 070)*

  - integrated pdf of PB Set2 uses $\alpha_s(q_t)$
    - is called modified DGLAP when also z_{dyn} is used *(see Amati, D., Bassetto, A., Ciafaloni, M., Marchesini, G., and Veneziano, G. (1980). A treatment of hard processes sensitive to the infrared structure of QCD, Nucl. Phys., B173(1980), 429)*
    - also using z_{dyn}: *CMW (Catani, S., Webber, B. R., and Marchesini, G. QCD coherent branching and semiinclusive processes at large x, Nucl. Phys. B, 349(1991), 635*

    - perhaps we call it “extended DGLAP” ?

How to determine $\chi^2{}_{min}$



- use linear interpolation between chi2 points.
  - suggestion by Markus:
    - use spline interpolation to obtain smooth curve.
    - Does it really make a difference ?

DY measurements

Analysis	$\sqrt{s}$	Collision types	ndf
CMS_2022_I2079374 [27]	13 TeV	pp	25
LHCb_2022_I1990313 [41]	13 TeV	pp	5
CMS_2021_I1849180 [46]	8.1 TeV	pPb	5
ATLAS_2015_I1408516 [42]	8 TeV	pp	8
CDF_2012_I1124333 [45]	1.96 TeV	$p\bar{p}$	6
CDF_2000_S4155203 [44]	1.8 TeV	$p\bar{p}$	5
D0_2000_I503361 [43]	1.8 TeV	$p\bar{p}$	4
PHENIX_2019_I1672015 [47]	200 GeV	$p\bar{p}$	12
E605_1991_I302822 [48]	38.8 GeV	pp	11
Total			81

- We use CMS over wide mass range to determine q_s
  - we have a detailed breakdown of different uncertainties, and for the very first time we use correlated and uncorrelated uncertainties in an Monte Calo approach
  - we also use correlated theory uncertainties for the first time
- all other measurements are used to x-check the results and to show that there is no m_{DY} and $\sqrt{s}$ dependence
- Does it pay off to have all available measurements checked, although knowing that some are very old and not reliable ?

Further comments

- “252” Shouldn't just data stat and unfolding stat be uncorrelated, and the rest correlated?
- 267” 5 = magic number?
- “284” As above. The efficiency is uncorrelated in lepton pt/eta (or at least it has a large stat component) but that does not mean decorrelation in pt(ll). In m(ll) it might be true due to correlation with lepton pt, though.
- “296” Doesn't that procedure give you very flat correlated scale uncertainties with almost 0 impact? You could allow for some flexibility using partial decorrelation among bins, like 50% correlated and 50% uncorrelated (-> fractions sqrt(2)). The most famous example is top pt where the NNLO prediction is outside the NLO band if taken as correlated/normalized…
- “323” Why are the D0 and CDF chi2s so low? It seems they are not sensitive at all Also, we are jumping between chi2/ndf and chi2, should this be unified?
- “335” Improve with interpolation
- “Figure 13” * Make sure the most precise on-peak results are well visible and not hidden behind the measurements with larger error bars. Or just remove the low-precision measurements from this plot, it would become much nicer!

AOB

- Further news ?