SM parallel summary

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DESY ATLAS SM group meeting

25th February 2025

HELMHOLTZ

DESY.

ATLAS EXPERIMENT

Context

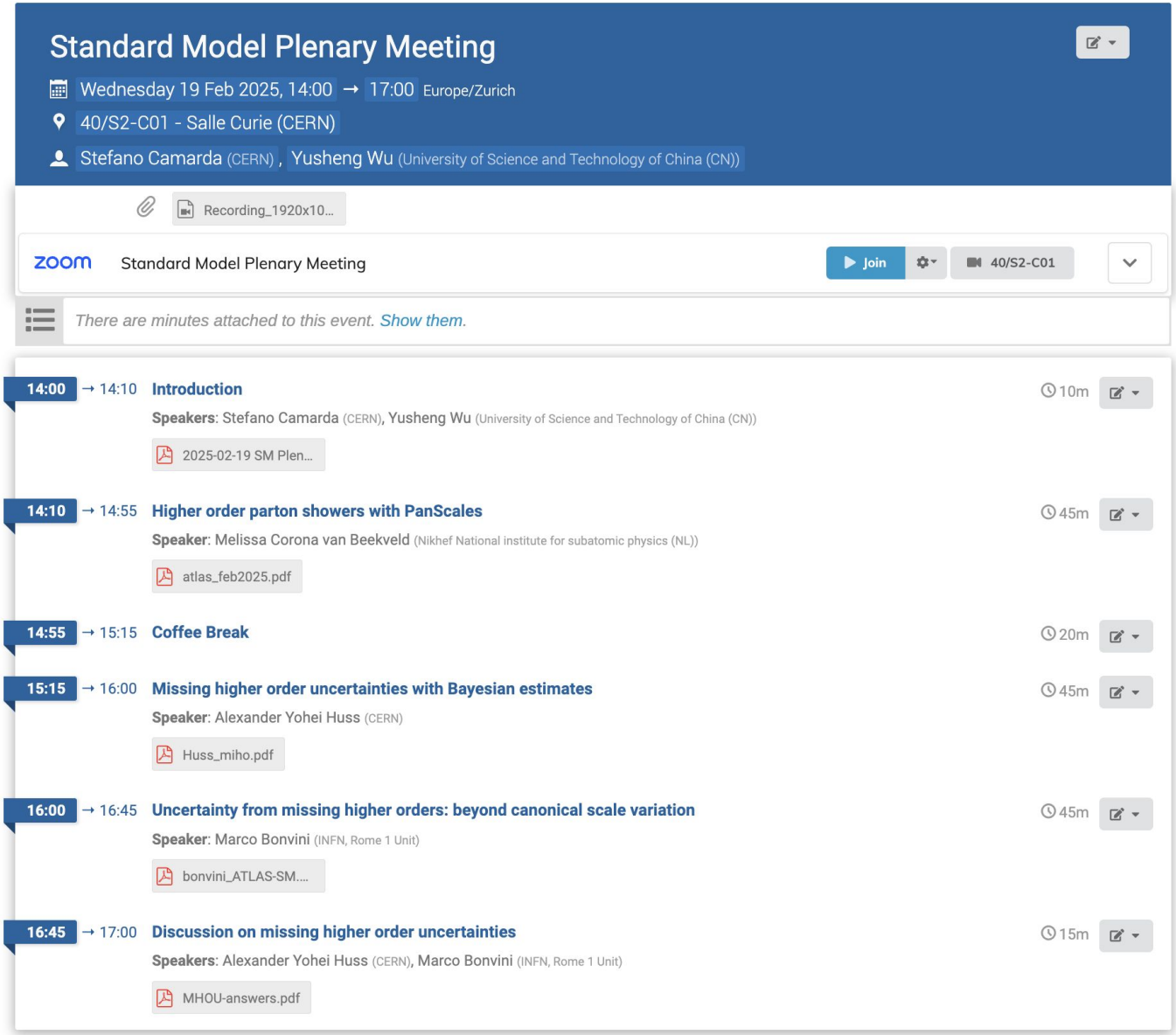
- SM parallel session during ATLAS week: indico.cern.ch/event/1503605/

- In the next years we expect
  - → Slow but steady increase in integrated luminosity
  - → None or marginal increase in $\sqrt{s}$
  - → Breakthroughs in calibration techniques leading to reduced experimental systematic uncertainties

- Physics modelling is an important uncertainty in many SM analyses and could begin to dominate in the future if action is not taken to reduce theoretical uncertainties in line with experimental ones

- To reach our physics goal we are looking for
  - → **Developments in MC generators**
  - → **Improved understanding of theory uncertainties**

The agenda


Standard Model Plenary Meeting
Wednesday 19 Feb 2025, 14:00 → 17:00 Europe/Zurich
40/S2-C01 - Salle Curie (CERN)
Stefano Camarda (CERN) , Yusheng Wu (University of Science and Technology of China (CN))
Recording_1920x10...
zoom Standard Model Plenary Meeting
Join
40/S2-C01
There are minutes attached to this event. Show them.
14:00 → 14:10 Introduction
10m
Speakers: Stefano Camarda (CERN), Yusheng Wu (University of Science and Technology of China (CN))
2025-02-19 SM Plen...
14:10 → 14:55 Higher order parton showers with PanScales
45m
Speaker: Melissa Corona van Beekveld (Nikhef National institute for subatomic physics (NL))
atlas_feb2025.pdf
14:55 → 15:15 Coffee Break
20m
15:15 → 16:00 Missing higher order uncertainties with Bayesian estimates
45m
Speaker: Alexander Yohei Huss (CERN)
Huss_miho.pdf
16:00 → 16:45 Uncertainty from missing higher orders: beyond canonical scale variation
45m
Speaker: Marco Bonvini (INFN, Rome 1 Unit)
bonvini_ATLAS-SM....
16:45 → 17:00 Discussion on missing higher order uncertainties
15m
Speakers: Alexander Yohei Huss (CERN), Marco Bonvini (INFN, Rome 1 Unit)
MHOU-answers.pdf

NNLL parton showers with PanScales

- Parton showers are a key part of MC generation
- Emission of additional particles: denominator in kinematic factor leads to logarithmic enhancements that need to be resummed to all orders
- **PanScales** project is aiming to build the next generation of **N**ext-to-**N**ext-to-**L**eading-**L**og parton showers

Emission of a soft gluon: the eikonal Feynman rule

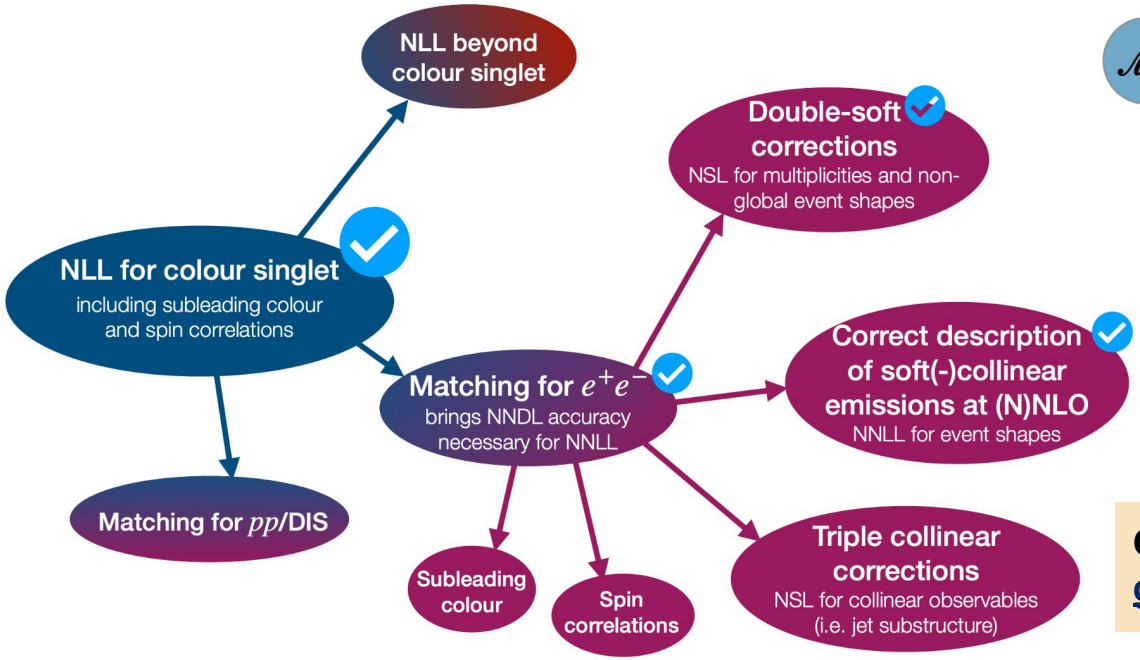
$$\mathcal{M} \xrightarrow{k^\mu \to 0} \propto g_s \frac{p^\mu}{p \cdot k} \mathbf{T} \otimes \mathcal{M}$$

$\mathbf{T}$ is a colour-generator
- Spin dependence is factorised
- Colour dependence is not

Emission of a collinear particle: Splitting functions $P_{(ij)a}$

$$\mathcal{M} \xrightarrow{k \to zp} \propto g_s \frac{1}{p \cdot k} P_{(ij),a}(z) \otimes \mathcal{M}_a$$

a is a spin index
- Colour dependence is factorised
- Spin dependence is not



Panscales [2312.13275]

Code publicly available: gitlab.com/panscales/panscales-0.X

All of these ingredients will ultimately be needed for a full NNLL-accurate shower

Melissa van Beekveld

Missing higher order uncertainties

- various sources that contribute to Δ_{TH}:
  - Δ_{α_s}, Δ_{param}: parametric uncertainties ⇝ exp. extraction
  - Δ_{PDF}: parton distribution functions (PDFs) ⇝ fits to data, lattice(?), …
  - $\Delta_{non\ pert.}$: intrinsic k_T, hadronisation, UE, … ⇝ TMD, parton showers, …
  - $\Delta_{pert.}$: *missing higher-order* corrections ⇝ conceptually tricky

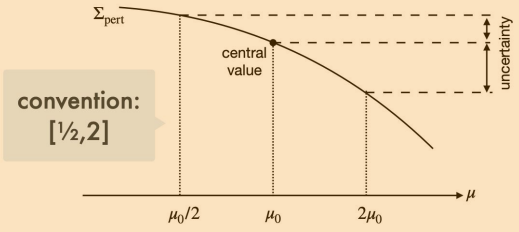
MHO = **M**issing **H**igher **O**rder

Focus here

- MHO uncertainties traditionally estimated via scale variation
- Main issues with scale variation are
  - → Choice of the central scale μ_0
  - → No probabilistic interpretation
  - → No correlation model

$$d\sigma^{N^nLO} = d\sigma^{(0)} + \alpha_s\, d\sigma^{(1)} + \ldots + \alpha_s^n\, d\sigma^{(n)} \quad (d\sigma^{(0)} \propto \alpha_s^{n_0})$$

$$\mu \frac{d}{d\mu}\sigma^{N^nLO}(\mu) = \mathcal{O}(\alpha_s^{n_0+n+1}) = \mathcal{O}(\Delta_{pert.})$$



- Bayesian inference is a powerful framework to estimate Δ_{MHO}
  - probabilistic interpretation ⇝ $P(\delta_{n+1}|\delta_n)$
  - exposes our *assumptions & biases* clearly ⇝ model & priors
  - *but:* it is not more reliable than scale variation ⇝ careful analysis required

relying on a single prescription for TH unc. in *precision measurements* is potentially dangerous!

Summary

To conclude

Don't ask for a recipe from the theory community

It is important to understand what is going on, and to choose wisely

Interactions TH-EXP like this one are very important!