Particle Physics Phenomenology

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Outline

- ▶ Event Generators and Lund
- ▶ Precision and Accuracy
- ▶ Higher Energy and Luminosity
- ▶ Low energy and Heavy Ions
- ▶ Rivet and Professor

Event Generators = Lund

- ► MCnet ITN (LL)
- ► ERC Avanced Grant (Sjöstrand)
- ► VR research environment (Sjöstrand)
- ► KAW project (Christiansen)

You will always need Event Generators . . .

- ▶ . . . to plan for new acceleartors & detectors
- ▶ . . . to understand your detectors
- ▶ . . . to understand your signals
- ▶ . . . to understand your backgrounds
- ▶ . . . to understand your theory

Precision

The big change in the last decades is the availability of higer-order perturbative calculations matched with general purpose parton shower based event generators.

- ▶ Multi-leg is standard
- ▶ NLO QCD is standard
- ▶ NLO + multi-leg works
- ▶ NNLO is coming
- ▶ Higher order EW corrections ($\alpha_s^2 \sim \alpha_{\mathrm{EM}}$) on its way
- ▶ NNLO + multi-leg maybe
- ▶ NNNLO?

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Precision is becoming limited by the precision of the shower models.

- ► Currently Leading Logarithmic approximation (+ some NLL)
- ► We need full NLL or higher
- ► Currently Leading colour approximation ($N_c \approx \infty$)
- ► We need $N_C = 3$
- ► We need EW resummation ($\log p_{\perp jet}/m_W$)

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Accuracy

Formal precision is not enough, we need to understand the accuracy.

- ▶ PDF variations
- ▶ Scale variations
- ▶ Shower variations
- ▶ Non-perturbative variations

Understanding how non-perturbative models affects the accuracy of perturbative calculations is crusial.

Higher Energy means . . .

- ▶ . . . more phase space
- ▶ . . . harder jets
- ▶ . . . more jets
- ▶ . . . more underlying event
- ▶ . . . more jets in the underlying event

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Higher Luminosity

Do we really understand minimum bias physics well enough?

► How well do we describe multi-mini-jet events.

► What's up with jet universality at high multiplicities?

► Why do high multiplicity events exhibit collective effects?

Heavy Ions

We need event generators for Heavy Ions collisions that are fully rooted in a standard description of *pp* collisions.

- ▶ Strangement enhancement
- ▶ Flow and ridge effects
- ▶ Jet quenching
- ▶ Also cosmic ray showers

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Lower energies?

- ► Spin physics
- ► Electon Ion Collider
- ► Precision decay physics
- ► . . .

Lots and lots of data . . .

Should we start to discuss data preservation for future
experiments already now?

Should we consider the data paradigme used in Astronomy?

What about analysis preservation?

RIVET

A program for publishing measurements in a way usable for everyone.

A set of tools that can be used to build analysis routines for comparison of a given measurement with event generators.

Philosophy:

- ► The actual analysis (with all kinematical cuts)
- ► Detector-independent (unfolding)
- ► Generator-independent
- ► Model-independent (no non-fiducial extrapolations)

Defines a clean division between the experiment and the underlying physics based on final state observables.

Professor and Countur

Any analysis published in Rivet can be used for (semi-automatic) tuning of parameters in event generators using the Professor framework

Any analysis published in Rivet can be used for constraining new theories using the Contur program.

The bottom line . . .

Whatever strategy for the future of Particle Physics experiments we decide on, the development of event generators and the phenomenologigal models they build on will be an essential component.

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