PRECISE PREDICTIONS AND PERTURBATIVE QFT

BERNHARD MISTLBERGER

It is a fantastic honor to receive this award!

I would like to express my deep gratitude to the many people in our field that have made it such an exciting journey to explore the fundamental nature of interactions. In particular, I'd like to thank my friends and colleagues

Babis Anastasiou, Claude Duhr, Johannes Henn and Lance Dixon

SLAC

VLADIMIR NAUMOVICH GRIBOV

1930–1997

A giant of the field

- Confinement of strong interactions
- Regge Theory
- Evolution of quarks - D**G**LAP
- Quantization of non-abelian gauge theory
- Neutrino physics
- Solid state theory
- …

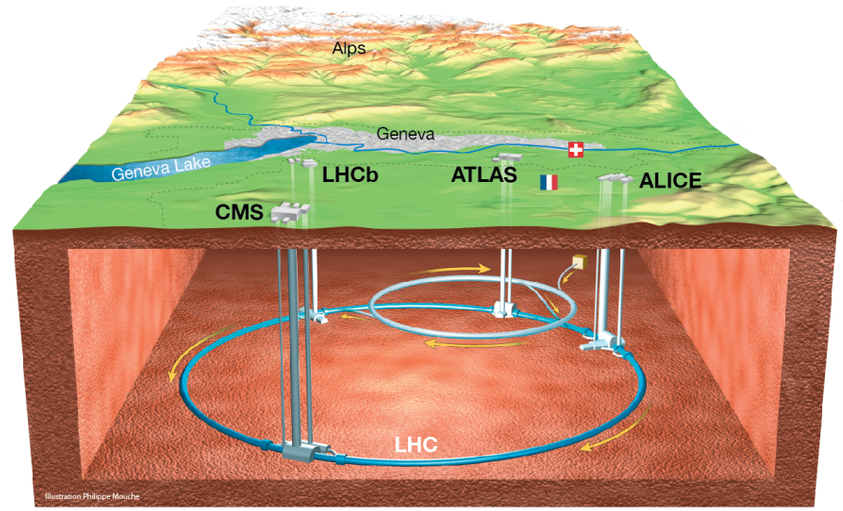
The impression I gained of Gribov, is one of an incredibly curious and passionate physicist that sought to describe the fundamental interactions of our universe. Guided by intuition and a deep understanding of particle phenomenology, he shaped our current understanding and drew us a "picture" of how fundamental forces work.

PHYSICS IN THE LHC ERA

Today, nearly all observable physics is described by - or believed to be described by - the Standard Model of particle physics.

However, the picture is incomplete!

- Our understanding is insufficient to describe many macroscopic phenomena of the world - and therefor lacking understanding.
- The limitations of this picture are known to us - and we have experiments like the LHC to test and explore them!



Quests in the age of the Higgs:

- **A new interaction: Yukawa!**

- **The mechanism of electro-weak symmetry breaking**

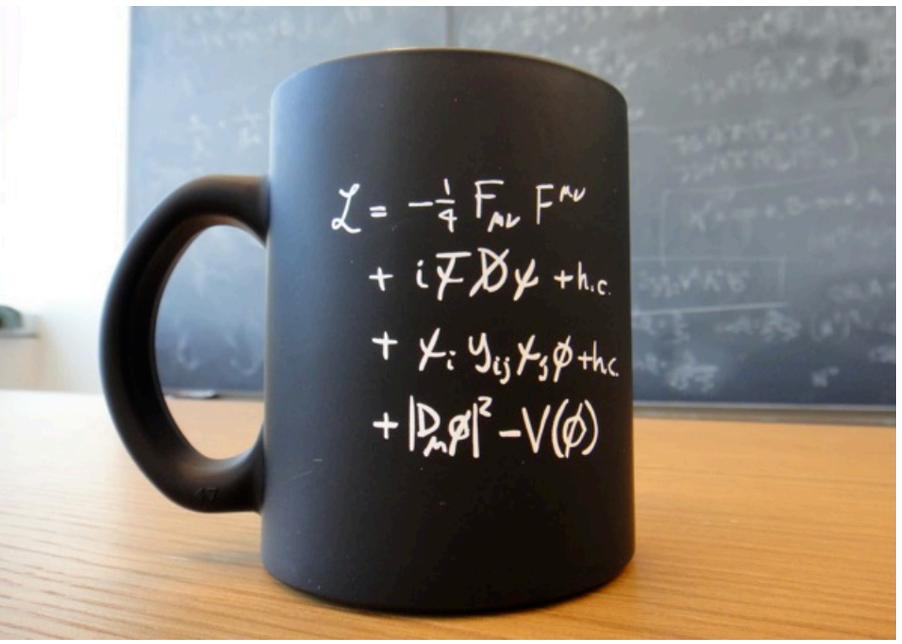
- **Generation of fundamental masses**

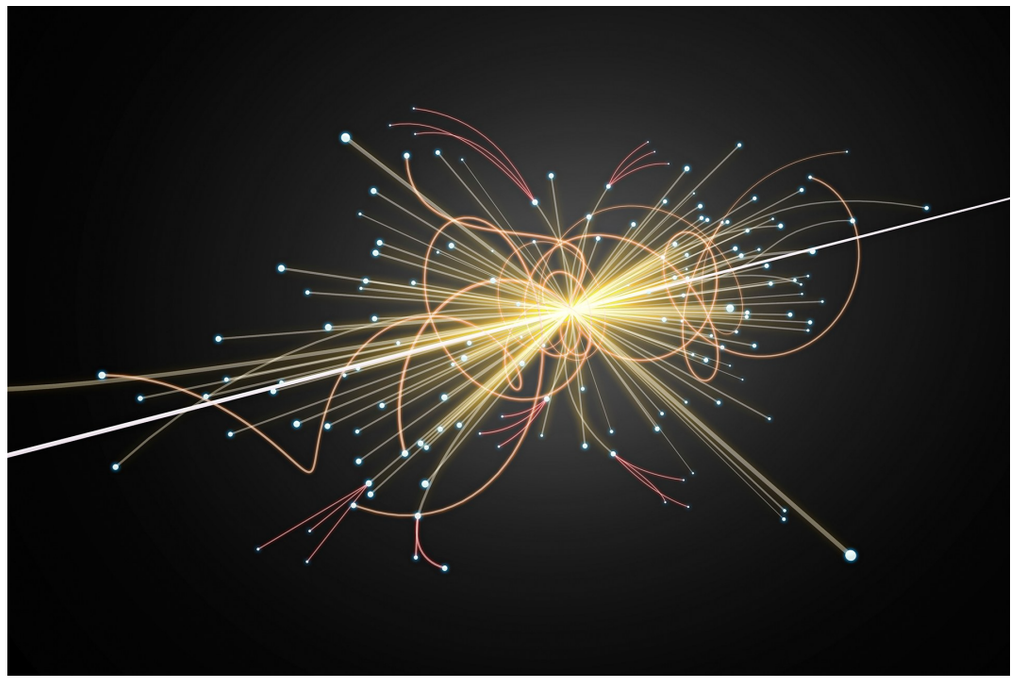
- **Determine couplings / interactions with established matter** $H \heartsuit \mu$?

$W \heartsuit W \heartsuit W \heartsuit W$?

- **Explore the limitations of the Standard Model of particle physics**

EXPLORING THE HIGH ENERGY FRONTIER OF INTERACTIONS





From first principle QFT ... **... to real life measurement**

- Describing the real world starting from the simple, concise formulation of the SM of particle physics is a huge challenge.
- My goal is to sharpen our **picture** of fundamental interactions such that the precision in our description of nature allows us to learn from very precise measurements.

How many Higgs bosons are produced by the LHC?

- Predict using perturbative QCD

LO **NLO** **NNLO** **N3LO**

$$\hat{\sigma} = \hat{\sigma}^{(0)} + \alpha_S^1 \hat{\sigma}^{(1)} + \alpha_S^2 \hat{\sigma}^{(2)} + \alpha_S^3 \hat{\sigma}^{(3)} + \dots$$

The frontier of perturbative QFT at the LHC

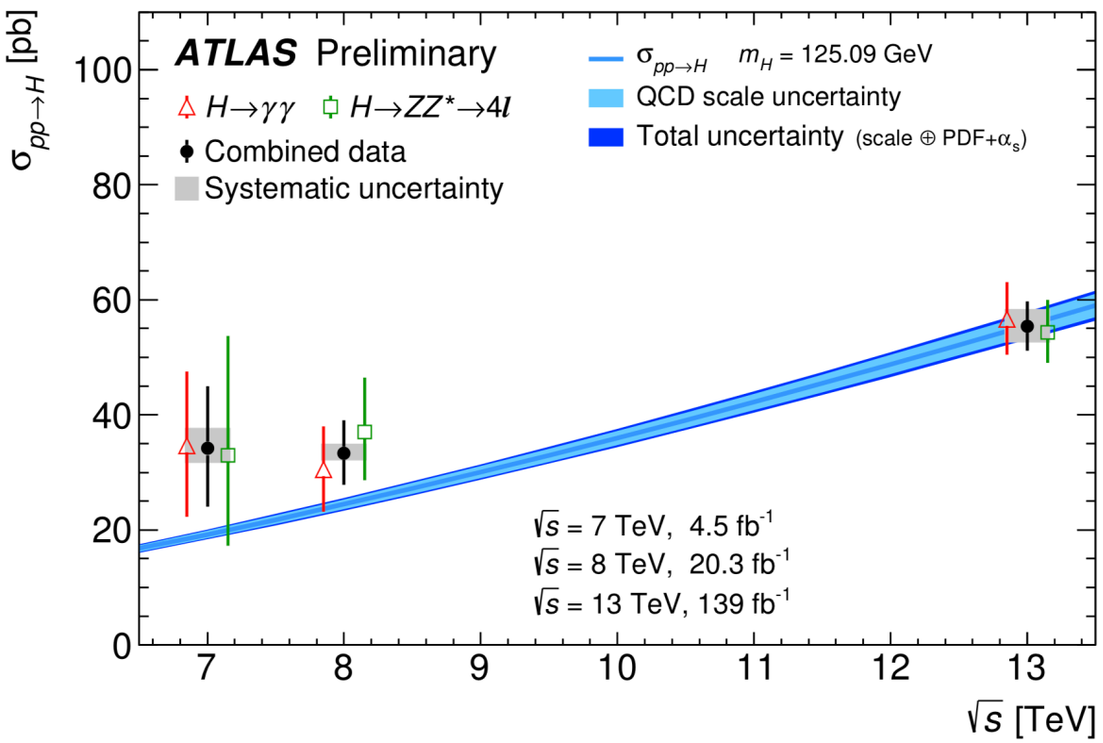
- Complexity of computing high orders in perturbative QFT challenges our methods and understanding.

~100,000 Feynman Diagrams

New mathematical structures

Vastly growing complexity

- The benefits are clear:
  - Measure couplings of the Higgs boson
  - Test a central prediction of the SM



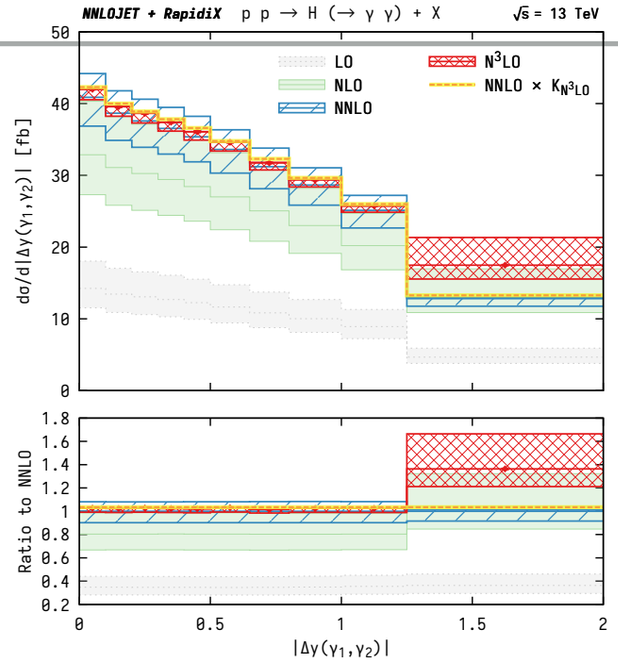
My research today

My goal is to find a better picture of nature to provide answers to our fundamental questions.

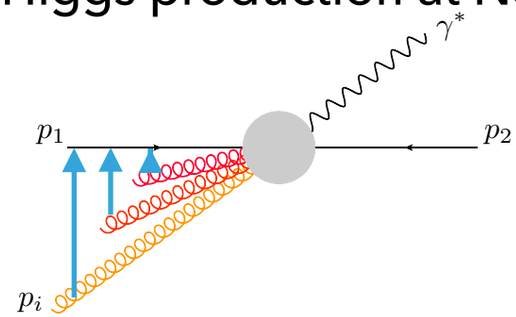
- **Develop N3LO predictions to be the backbone for LHC precision phenomenology now and in the future.**

- **Create new technology to improve our ability to predict**

- **Study and learn from the structure of perturbative QFT**



Fully differential predictions for Higgs production at N3LO



Collinear Expansion: New technology to approximate cross sections.

$$\Gamma_{\text{cusp}}\Big|_{\alpha_s^4} = -\left(\frac{\alpha_s N}{\pi}\right)^4 \left[\frac{73\pi^6}{20160} + \frac{\zeta_3^2}{8} + \frac{1}{N^2}\left(\frac{31\pi^6}{5040} + \frac{9\zeta_3^2}{4}\right)\right]$$

Cusp anomalous dimension at 4 loops.

Let’s improve the picture of our world!

Thank you!