

N3LOPHYSICS

Mid Term Review

Leandro Cieri



Research Project

N3LOPHYSICS

- First call. Starting date: 04/11/2019
 - Advisor: Stefano Catani
- **What we want to do?**

We describe and explain the data taken at the **Large Hadron Collider (LHC)** at CERN.

Our work comprehends two intrinsic related areas:

- Development of theoretical frameworks and formalisms
- Development of numerical tools (software for the **LHC**)

What **LHC** measures (the observable **O**) can be expressed in terms of a series expansion in the coupling α of the theory

$$\mathcal{O} = \mathcal{O}^{(0)} + \frac{\alpha}{\pi} \mathcal{O}^{(1)} + \left(\frac{\alpha}{\pi}\right)^2 \mathcal{O}^{(2)} + \left(\frac{\alpha}{\pi}\right)^3 \mathcal{O}^{(3)} + \dots$$

The current LHC standards

The New Standard — Fellini Project

Research Project



- Why we want to do that?
 - LHC impressive accuracy (theory must be at the same accuracy)
 - The precision of the LHC measurements will be further enhanced in the next runs and even more in the High-Luminosity upgrade of the LHC (HL-LHC)
 - New Colliders in the near future

ESPPU 2013

g) Europe should support a diverse, vibrant *theoretical physics programme*, ranging from abstract to applied topics, in close collaboration with experiments and *extending to neighbouring fields such as astroparticle physics and cosmology*. Such support should extend also to *high-performance computing and software development*.

- Great progress since last ESPP in development of (NLO) MC generators and higher-order calculations (e.g. Higgs production at N3LO, NNLO for 2→2 QCD processes) to match precision of LHC (and other) data. Vibrant community in Europe, which also contributed significantly to the study of future facilities. Crucial funding from H2020 (e.g. MCnet).
Note: strong support for theory is crucial for the future of the field: theoretical ideas have led to ground breaking developments in the understanding of nature and have inspired many experimental searches; MC developments and higher-order (signal and background) calculations are fundamental for current and future projects → HEP theory should be supported in Universities and labs and should be an integral part of planning for and funding of future colliders and other projects.

Fabiola Gianotti (Granada 2019)

“ Precise measurements of known particles and interactions are just as important as finding new particles

physicsworld

PARTICLE AND NUCLEAR | INTERVIEW

Preparing for a post-LHC future

22 Feb 2019

Richard Blaustein talks to CERN director-general **Fabiola Gianotti** about how the lab is planning the next big experiment in particle physics beyond the Large Hadron Collider



CERN director-general Fabiola Gianotti speaking at the 2019 AAAS meeting in Washington, DC. (Courtesy: Robb Cohen Photography & Video)

Research Network development



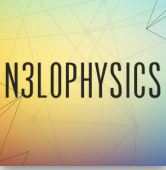
- **Host institution**

- Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Firenze
- Our Group:
 - Stefano Catani
 - Dimitri Colferai
 - Leandro Cieri

- **Collaborations**

- Zürich University
- Durham University
- CERN
- ICAS International Center for Advanced Studies (Buenos Aires) **[Recent published paper]**
- University of Buenos Aires
- Milano Statale University
- Milano Bicocca University
- University of Rome I, “La Sapienza”
- Max Planck Institute for Physics **[New with Fellini Fellowship] [Recent published paper]**
- Desy **[New with Fellini Fellowship]**
- Instituto de Física Corpuscular — IFIC (Valencia) **[Possibly host institution secondment]**
[Secondment unique opportunity Fellini Fellows]

Research skills and techniques



- **Acquired**

- Multicore/Thread programming (C++, Fortran) [Mandatory for Fellini Project]
- Mixed QED-QCD calculations/formalisms [Mandatory for Fellini Project]
- App design for Mobile phones and tablets
- Integrals of divergent integrands [Mandatory for Fellini Project]
- Analytic integration of N3LO soft currents [Mandatory for Fellini Project]

- **Planned to be improved**

- Machine learning applied to [Upgrade of Fellini Project]
 - Phase Space Integration
 - Monte Carlo generators

- **Course work**

- Fellini organized • A first training on public engagement (10/11 September) ✓
- Covid-19 e lavoro: cosa conoscere (19 May) ✓
- Sicurezza informatica — Base (25 September) ✓
- La prevenzione della corruzione (31 January) ✓
- Sviluppo App per dispositivi Mobili — IOS — Base (27 March) ✓
- Fellini organized • Training on European Research Project design — A focus on ERC (December)



- **Students Tutoring**

- Co-supervising PhD student Marco Rocco (Milano Bicocca)

- **Travel**

- Workshop on Resummation, Evolution, Factorization (REF 2019) [630.79€] (25-29 November 2019)
[Talk at REF]
- Scientific Collaboration with Prof. Daniel de Florian, Buenos Aires [3900€] (January 2020)
[Two published papers and two talks]

- **Scientific equipment**

- 16-inch MacBook Pro with Touch Bar: 2.3GHz 8-core 9th-generation Intel Core i9 processor, 16GB RAM, 1TB [2673.4€]
- 27-inch iMac Pro with Retina 5K display: 3.0GHz 10-core Intel Xeon W processor, 32GB RAM , 1 TB [4536.39€] [Multi Core/Thread programming]

- **Scientific Collaborations**

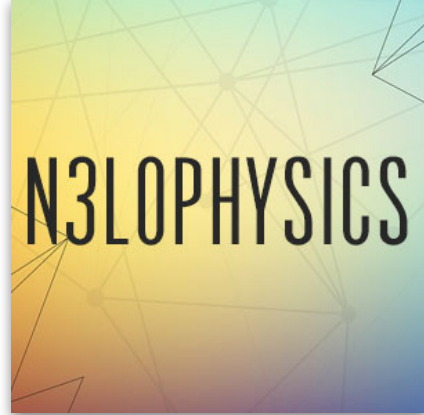
- Collaboration with researcher requested (uncertain situation due to COVID-19) [Funds for scientific collaborations only for Fellini Fellows]

- **Available (remaining) first year**

- **3886.28€**

Thank you !!!!!!!!

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$\alpha = \alpha_s,$
 $\alpha = \alpha_s \alpha_{ew}$

The current LHC standards

The New Standard — Fellini Project

Research Project

- **Goals**

- **qT-subtraction** formalism at N3LO in QCD (in a closed form)
- **qT-resummation** formalism at N3LO+N3LL in QCD (in a closed form)
- **qT-subtraction** formalism for mixed NNLO (QCD+QED)
 - Drell-Yan phenomenology at NNLO (QCD+QED)
- Application of precedent formalisms to
 - Higgs boson phenomenology at N3LO+N3LL
 - Drell-Yan phenomenology at N3LO+N3LL

- **Research development**

- **qT-subtraction** formalism for mixed NNLO (QCD+QED)
- Drell-Yan phenomenology at NNLO (QCD+QED)
- **qT-subtraction** formalism at N3LO in QCD (in a closed form)
- **qT-resummation** formalism at N3LO+N3LL in QCD
- Drell-Yan phenomenology at N3LO+N3LL
- Higgs boson phenomenology at N3LO+N3LL

Published



Unpublished

