# Precision calculation in QCD for the LHC

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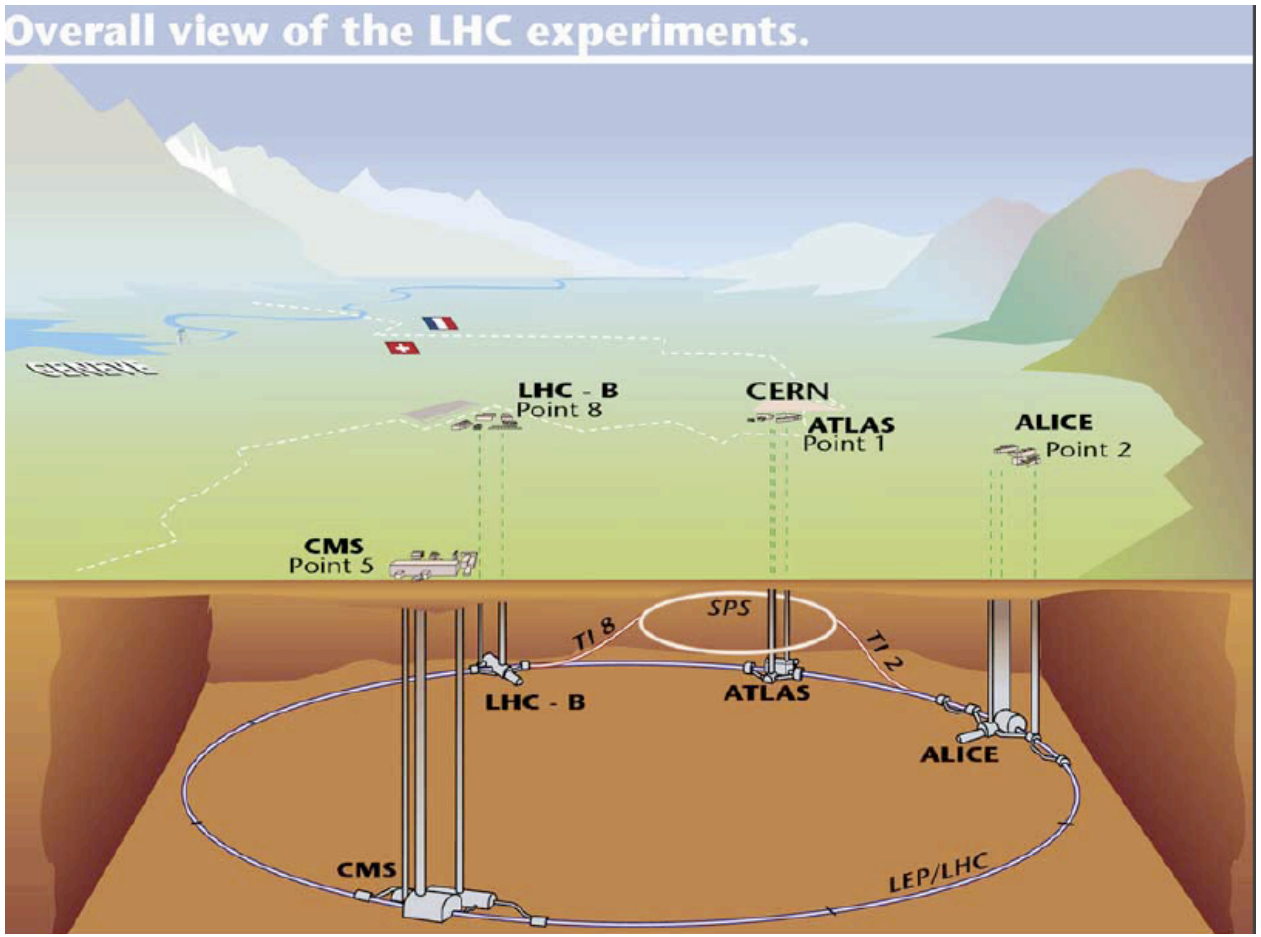
1. Production of prompt photons at the LHC in POWHEG.
2. Production of photon and b-quark jets at the LHC.
3. The Golem Project.

**QCD describes gluons and quarks $\longrightarrow$ Colliding objects are hadrons**

**$\nwarrow$ detected objects are also hadrons $\swarrow$**



# QCD for the LHC and LHC for the QCD

## LHC requires from QCD theory:

- Precise inputs: the "$\alpha_s$" and the "Pdfs".

# QCD for the LHC and LHC for the QCD

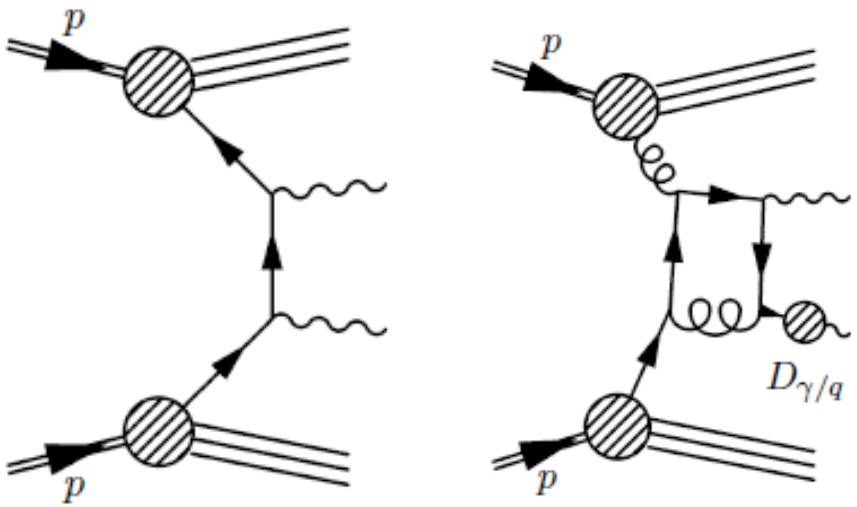
## LHC requires from QCD theory:

- Precise inputs: the "$\alpha_s$" and the "Pdfs".
- Accurate calculation: "NLO", "NNLO" and re-summation of large logarithms.

# Prompt photons production at the LHC

- **Why?**
  - Higgs at weak mass
  - Test perturbative QCD
  - Study of Photon fragmentation functions and gluon distributions

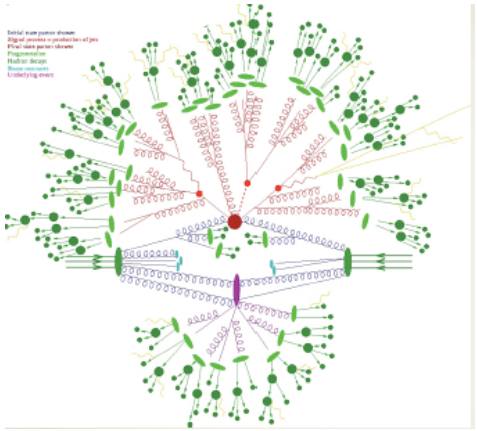
- **Production at LHC:**
  - Direct production
  - From fragmentation




- **Using DiPhox to calculate the full cross section at NLO**

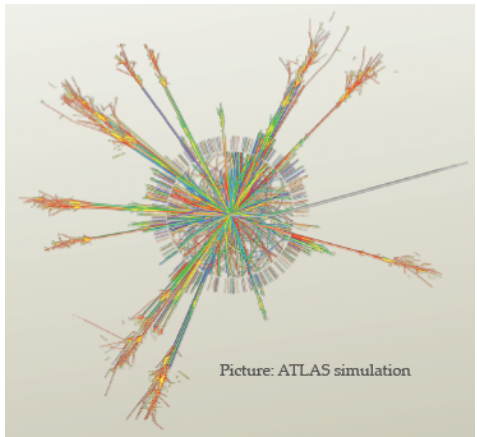
# Merging NLO QCD with parton shower

- **Motivations:**
  - NLO accuracy for exclusives finals states.
  - Best simulation of the detector.



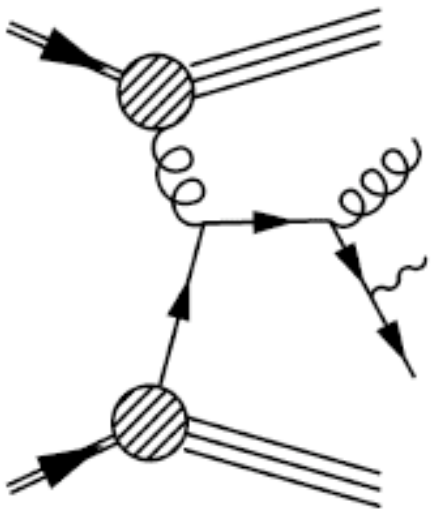
- **Why POWHEG?**
  - Avoid double-counting.
  - Generate positive weights.
  - It can be interfaced with any PS (PYTHIA, HERWIG, SHERPA, ...).

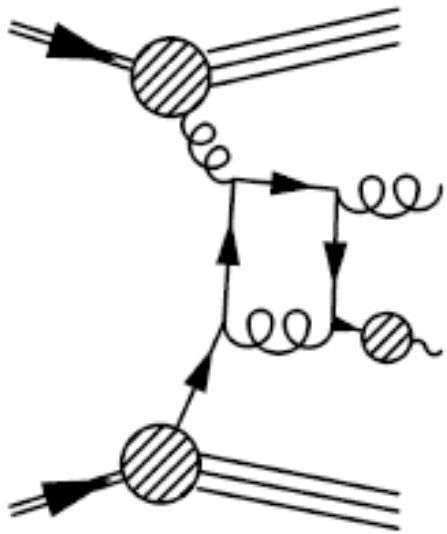
- **What we did?**
  - Rewrite DiPhox using FKS method.
  - Rewrite DiPhox using POWHEG boosts.
  - Genration of the hardest radiation!
  - Interface with Monte Carlo parton shower!



# From "$\gamma$+jets" to "$\gamma$+ b-quark jets"

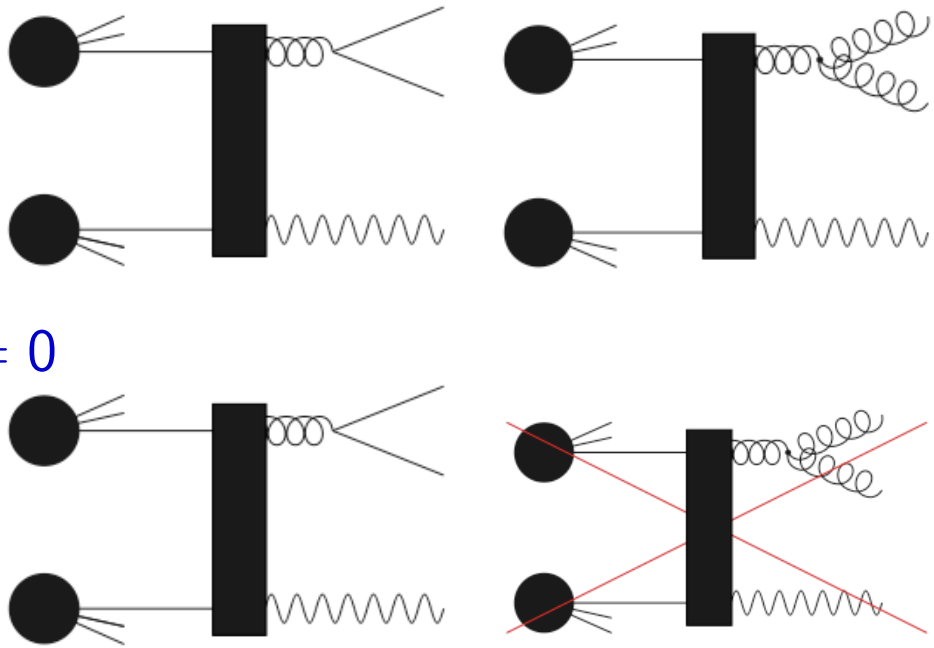
- **Motivations:**
  - Study of the new physics at LHC.
  - LHC experimentalists (ATLAS) will measure the cross section in the near future.
- **Idea:**
  - **JetPhox** calculates **"$\gamma$+jets"** in the final state .
  - Modify it to: **"$\gamma$+ b-quark" jets** in the final state.





# The problem of collinear divergences

**Sum over degenerates states** $\Longrightarrow$



$$\sim \frac{1}{\epsilon}\int_0^1 z\Big(2n_f\, p_{qg}(z) + p_{gg}(z)\Big)\,dz = 0$$

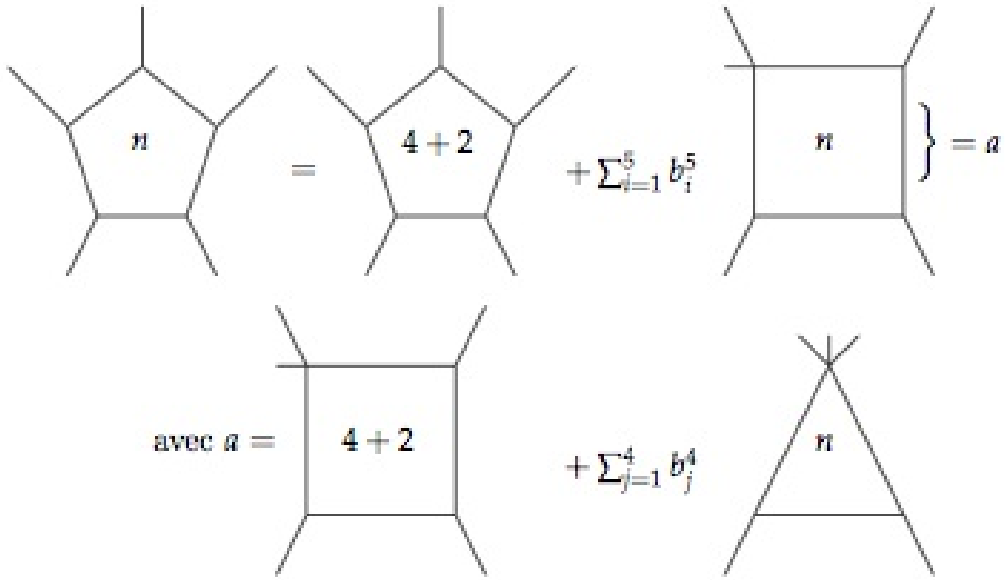
- **Introduce a mass to b-qurks pairs "fixed flavor schemas".**
- **Introduce a fragmentation function of light to heavy quarks.**

# Basic Golem functions

## Golem: General One-Loop Evaluator for Matrix Element

- **Motivations:**
  - **Calculate multi-legs one loop Feynman diagrams.**
  - **Study of multi-particles production at LHC.**
- **The idea of Golem:**

$$I_N^n(S) = \overbrace{I_{div}}^{divIR(S)} + I_{fin}(S)$$

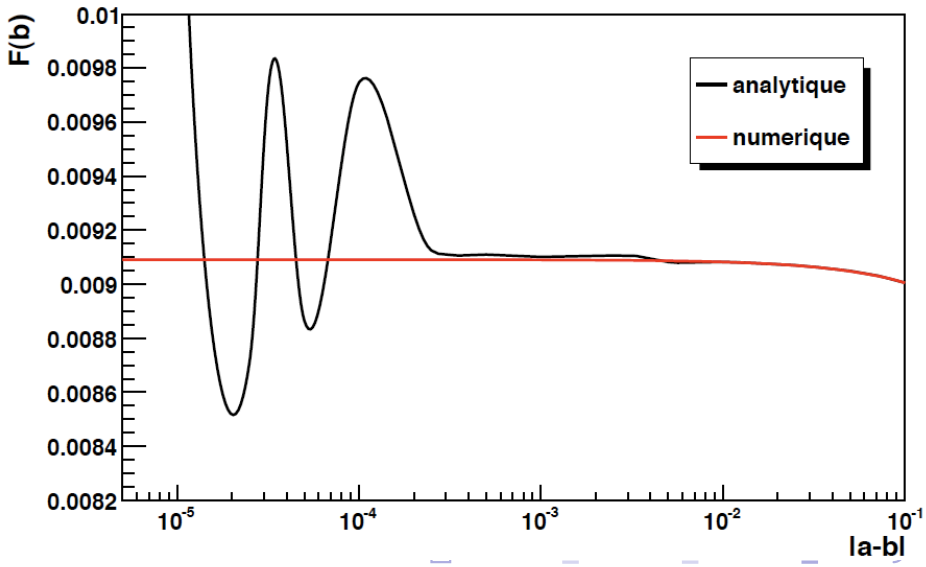


# Golem challenges

- Avoid gram determinant.
- Numerical stable evaluation of the loop integrals.

$$F(b) = \int_0^1 \frac{dx}{(x-a)(x-b)} \quad (1)$$

$$= \frac{1}{a-b}\left[\ln\left(\frac{1-a}{-a}\right) - \ln\left(\frac{1-b}{-b}\right)\right] \quad (2)$$



# Golem for massive particles

- **Goal:**
  - Generalization of Golem95 library for internal (complex) massive cases.
- **Massive three points functions:**
  - Analytical formulae and One dimensional representation: "Done".
  - Implemented in the library: "Done".
- **Massive four points functions $I_4^6$:**
  - Analytical formulae and One dimensional representation: "Done".
  - Verification and implementation: "Not yet ".

Merci — dankie — faleminderit — amesegenallo — danke — thank you — شكراً — eskerrik — asko — благодаря — 謝謝 — 고맙습니다 — hvala — tak gracias — tøkk vinaka — kiitos — tank — ευχαριστώ — aguyjé — mahalo — הדות — köszönöm — terima kasih — grazie — ありがとう — akun — khob chai — weebale — баярлалаа — фала — misoatra — dank — dzękuję — obrigado — mulţumesc — спасибо — хвала — vďaka — tangi — tack asante — salámat — khob khun — teşekkür — ederim — дякую — cám — jëre-jëf — ngiyabonga...