Research Activities & Interests

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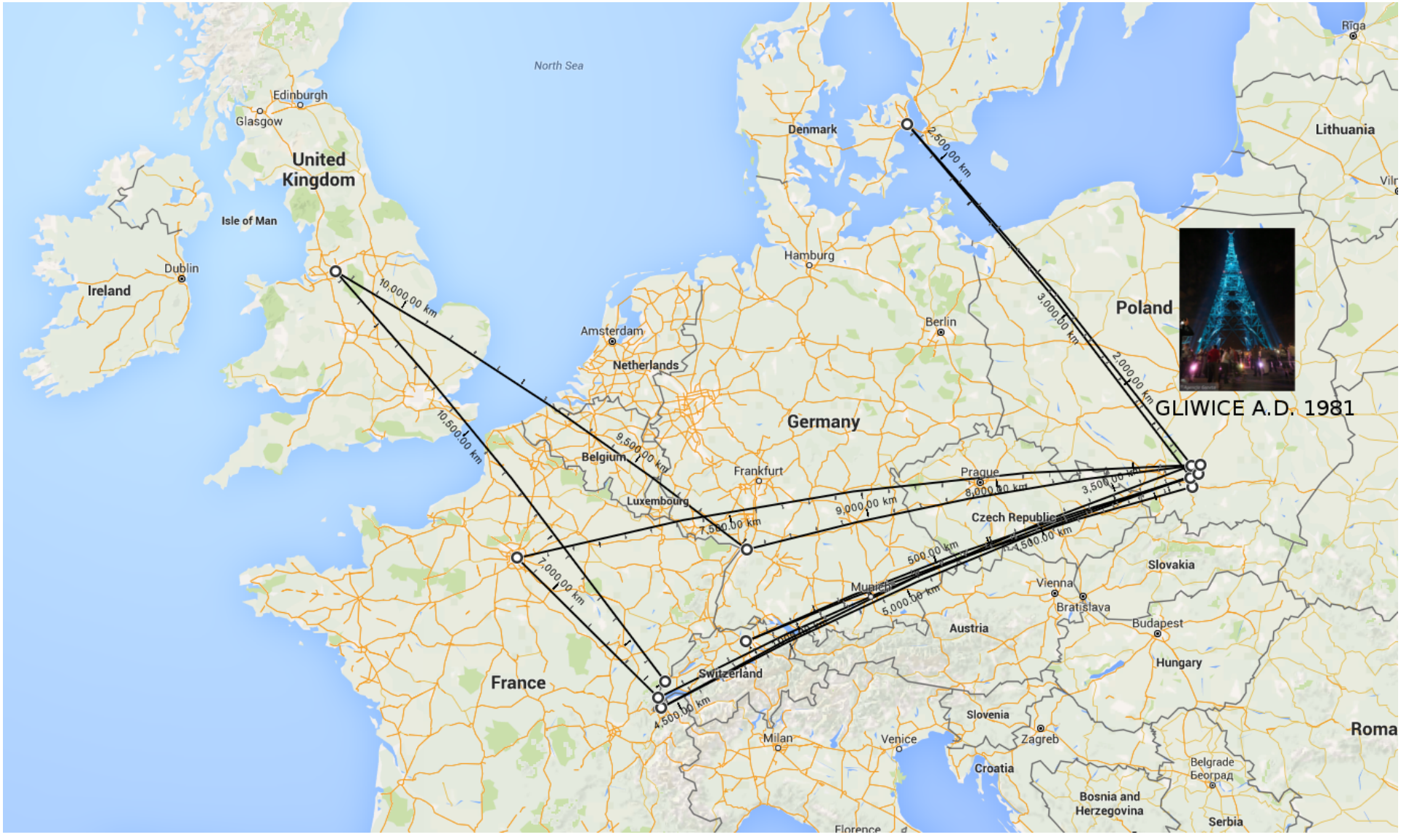
CERN Theory Group Retreat 2015,
Les Houches Centre de Physique

CV very briefly (6 countries in $\sim$ 10 years)



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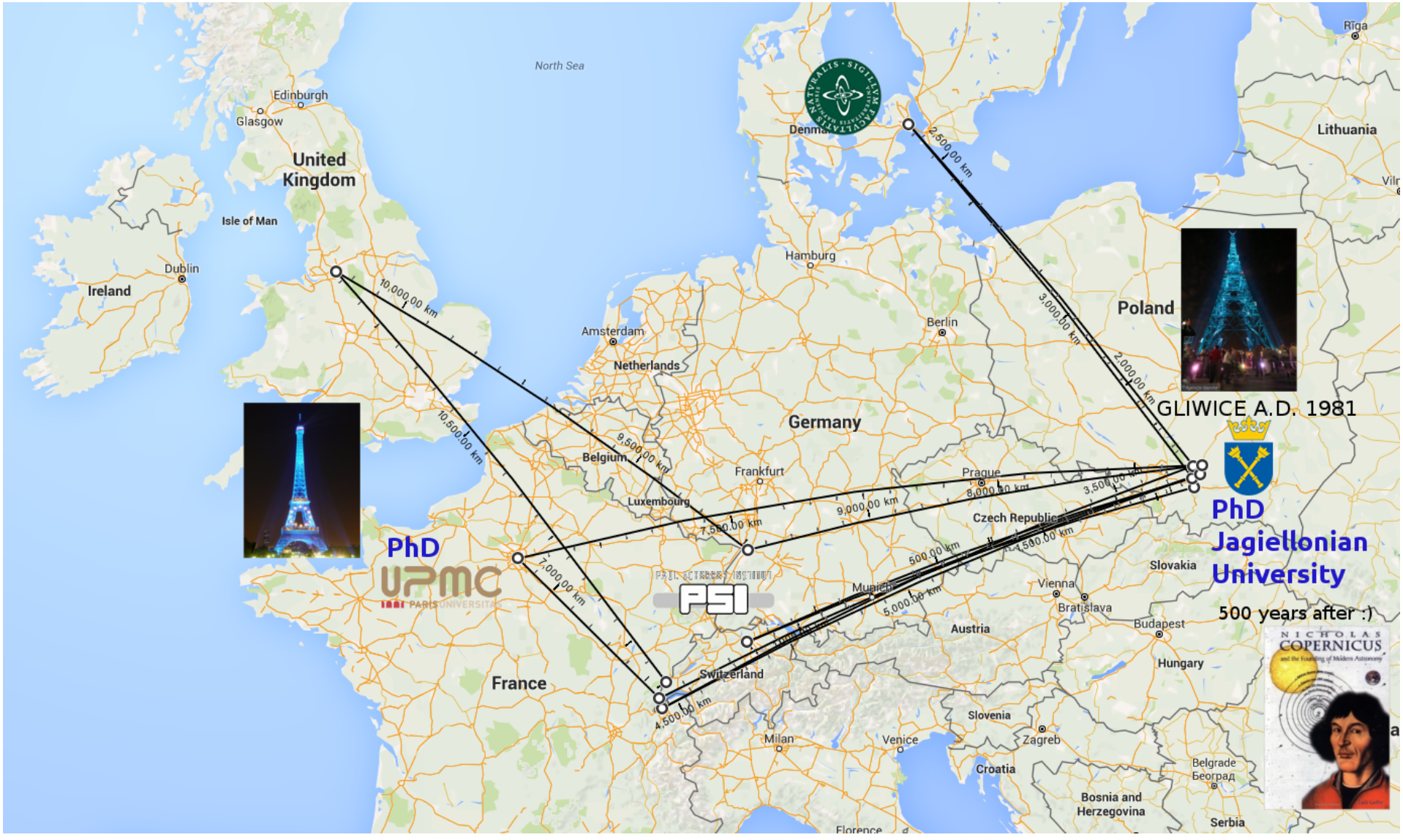

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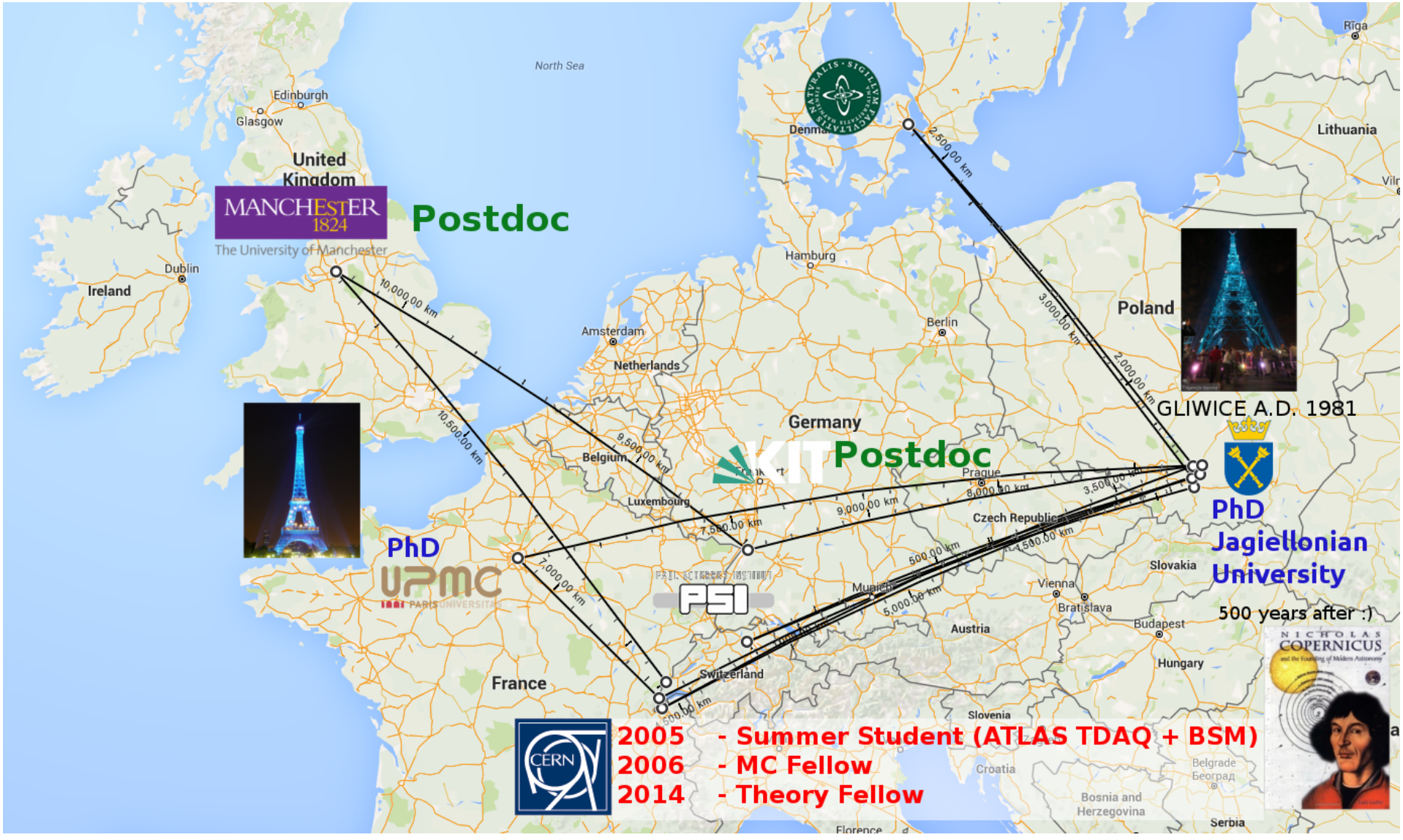

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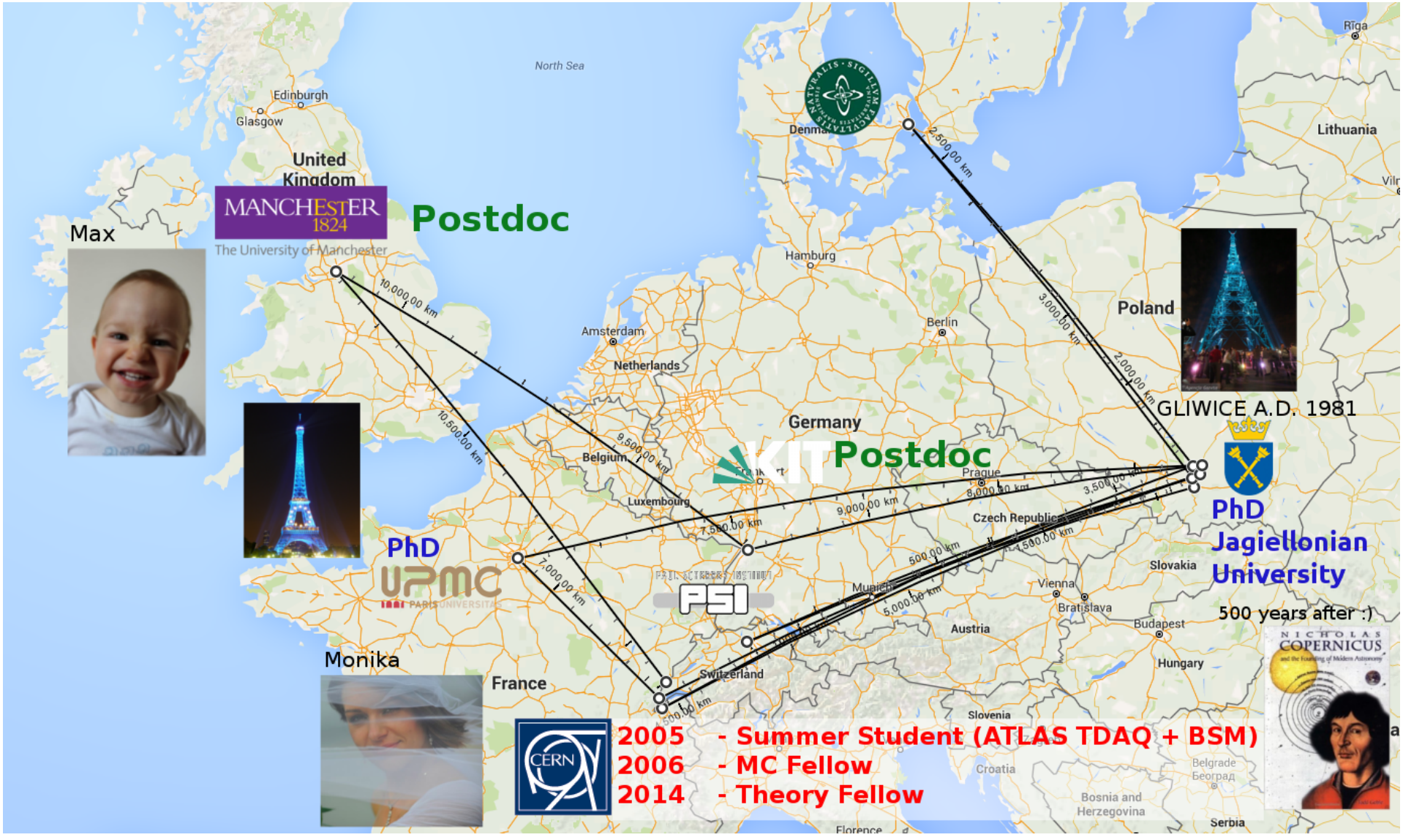
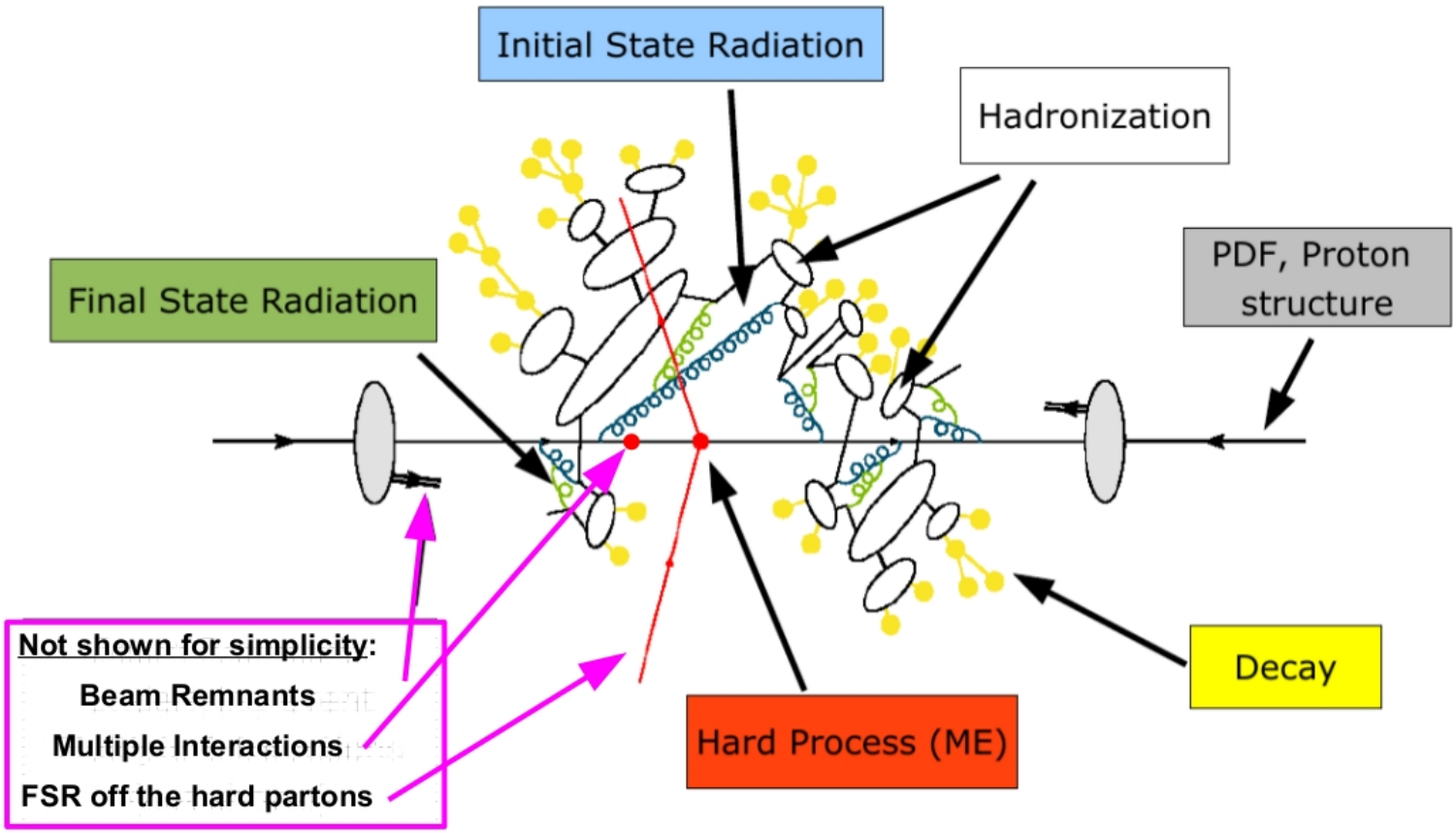


Interests

- Perturbative and non-perturbative QCD
- Monte Carlo event generators (Herwig++/Herwig 7)

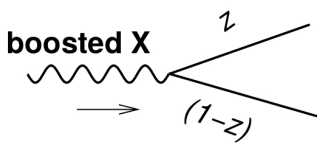


taken from Stefan Gieseke©

- LHC phenomenology (for example jet substructure)

On jet substructure methods for signal jets

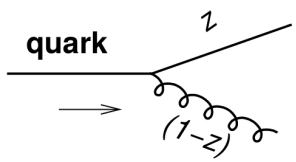
Signal



Splitting probability for Higgs:

$$P(z) \propto 1$$

Background



Splitting probability for quark:

$$P(z) \propto \frac{1+z^2}{1-z}$$

Jet substructure

Boosted techniques are very useful $\Rightarrow$ very active research field.
Many (complex) techniques available with several parameters.

Questions

Potential duplication and redundance? Robustness, dependence on parameters, jet algorithms, kinematics etc? Performance?

Can we get some guidance from analytical calculation? Yes, we can!

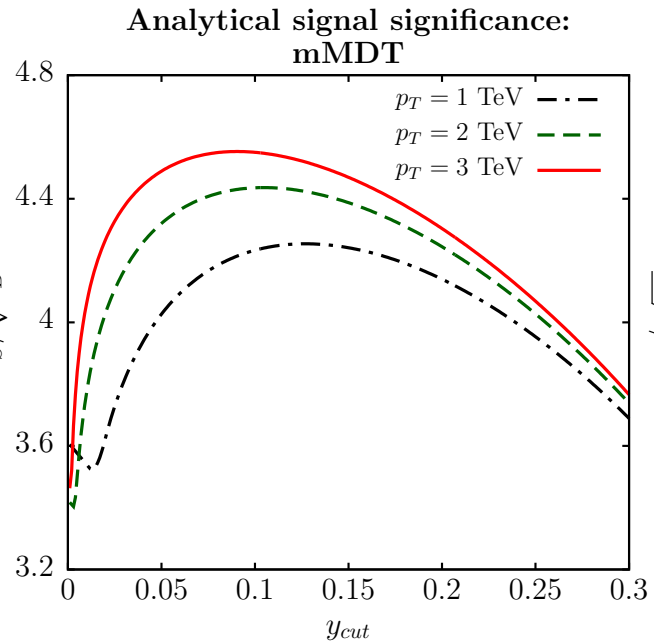
M. Dasgupta, A. Fregoso, S Marziani G. P. Salam JHEP 1309 (2013) 029,
"Towards an understanding of jet substructure" - focus on background QCD jets

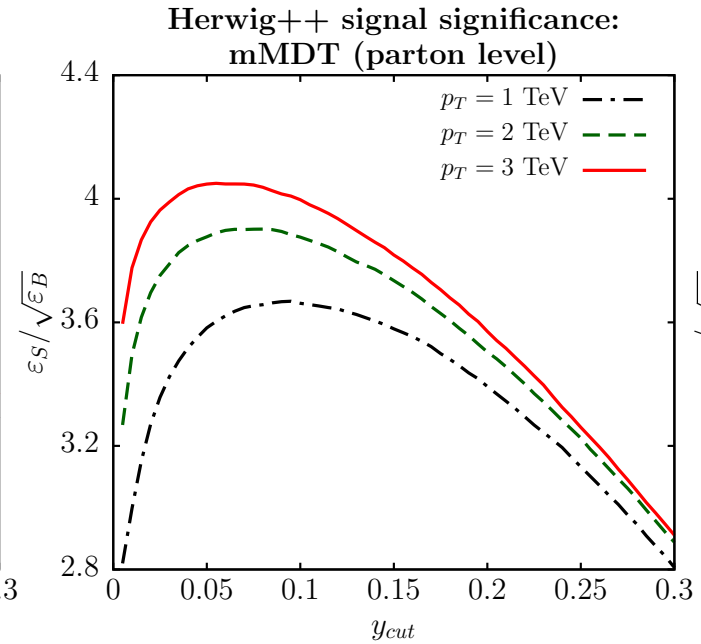
"... We look forward to continued future work on this subject. This may include the extension of our analysis to signal processes, ..."

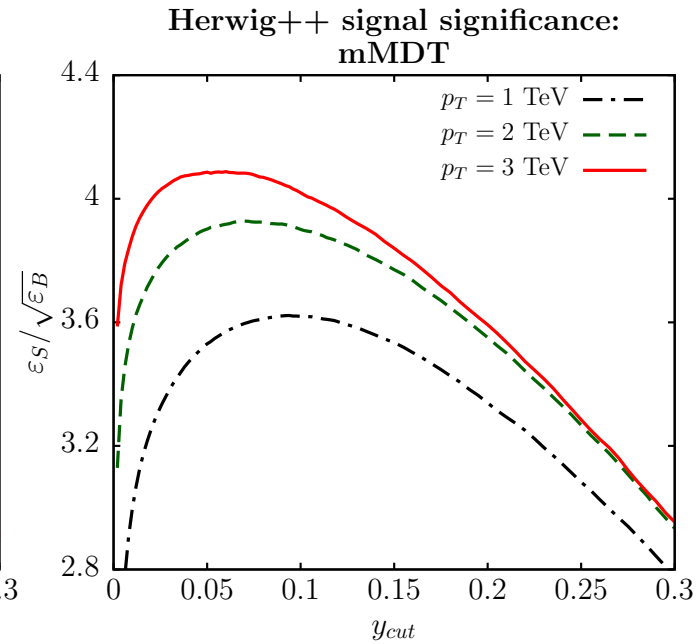
M. Dasgupta, A. Powling, AS [JHEP 1508 (2015) 079]
"On jet substructure methods for signal jets" - focus on the signal ($H \to b\bar{b}$)

Optimal values - mMDT:

We use can use analytical expressions (for signal and bkg) to derive values of parameters that maximize the signal significance



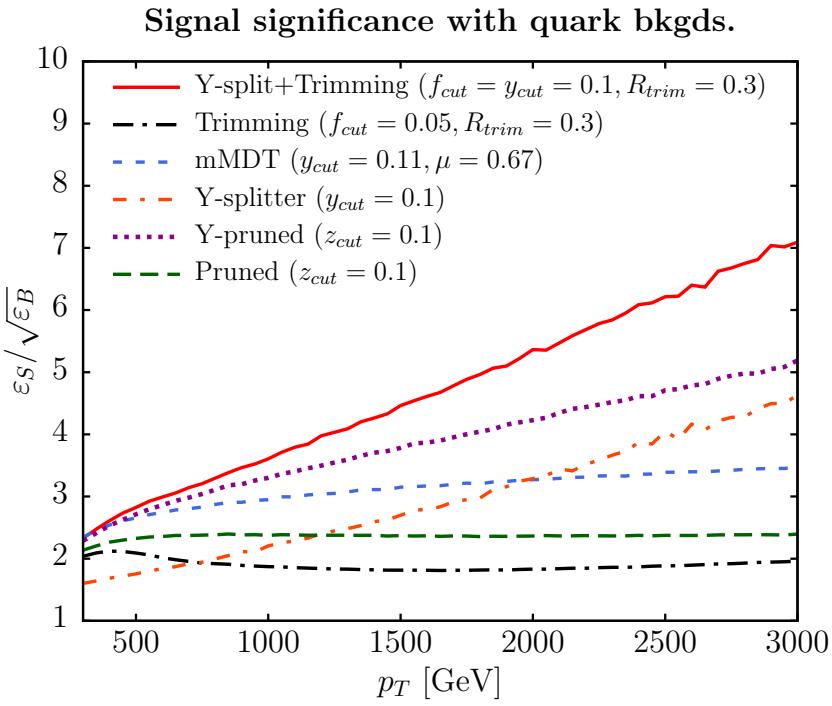


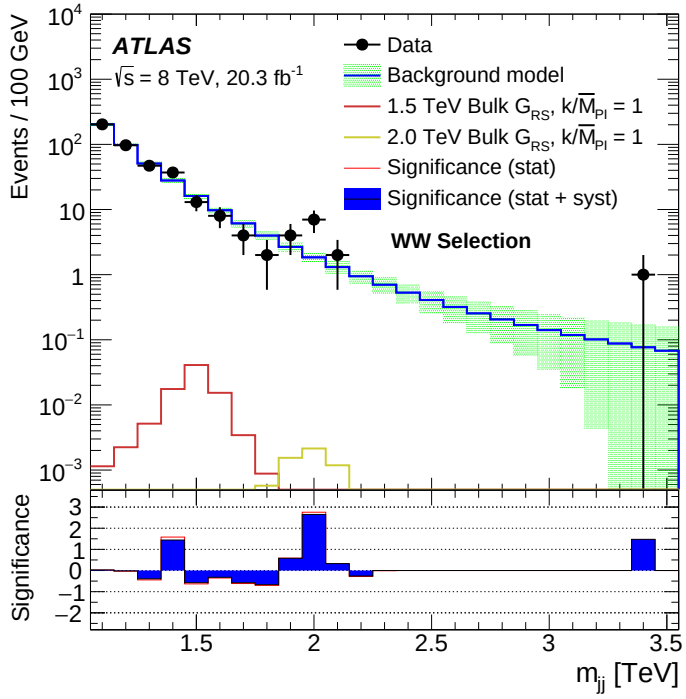


- Herwig parton level agrees with analytics (both the peak positions and the evolution of opt. *ycut* with p_T).
- hadronisation and UE do not change the picture significantly
- peaks are broad $\Rightarrow$ slightly non-optimal *ycut* is still ok.
- good degree of overlap within tolerance band between full MC and analytical estimates.

Signal significance

Hadronic W jets with quark (left panel)





- Y-splitter with trimming[1] outperforms the other taggers discussed over a range of p_T. (For H similar results particularly at high p_T)
- A detailed study of optimal parameters for Y-splitter+trimming will be presented in forthcoming work.

[1] Preliminary studies for Y-splitter+mMDT/pruning/soft drop give a similar qualitative effect.

KrkNLO - NLO+Parton Shower matching

- MC@NLO and POWHEG are by now well established and mature techniques.
- **Why would you like another method of NLO+PS matching?**
  - The method is extremely simple.
  - No negative weight events.
  - In angular ordered PS - no need for a truncated shower.
  - Simple at NLO $\Rightarrow$ you may hope that pushing the method to NNLO+NLO PS should be possible.

Basic idea of the MC scheme

Drell-Yan cross section at NLO in collinear $\overline{\text{MS}}$ factorization for the $q\bar{q}$ channel:

$$\sigma^1_{\text{DY}} - \sigma^B_{\text{DY}} \quad = \quad \sigma^B_{\text{DY}} \, D_1^{\overline{\text{MS}}}(x_1, \mu^2) \otimes \frac{\alpha_s}{2\pi} C_q^{\overline{\text{MS}}}(z) \otimes D_2^{\overline{\text{MS}}}(x_2, \mu^2) \,,$$

where

$$C_q^{\overline{\text{MS}}}(z) = C_F \left[4\,(1+z^2) \left(\frac{\ln(1-z)}{1-z} \right)_+ - 2 \frac{1+z^2}{1-z} \ln z + \delta(1-z) \left(\frac{2}{3}\pi^2 - 8 \right) \right].$$

All solutions for NLO + PS matching which use $\overline{\text{MS}}$ PDFs, need to implement terms of the type $4\,(1+z^2) \left(\frac{\ln(1-z)}{1-z} \right)_+$ that are technical artefacts of $\overline{\text{MS}}$ scheme.

The implementation is not easy since those terms correspond to the collinear limit but Monte Carlo lives in 4 dimensions and not in the phase space restricted by $\delta(k_T^2)$.
The idea behind the MC scheme is to absorb those terms to PDF.

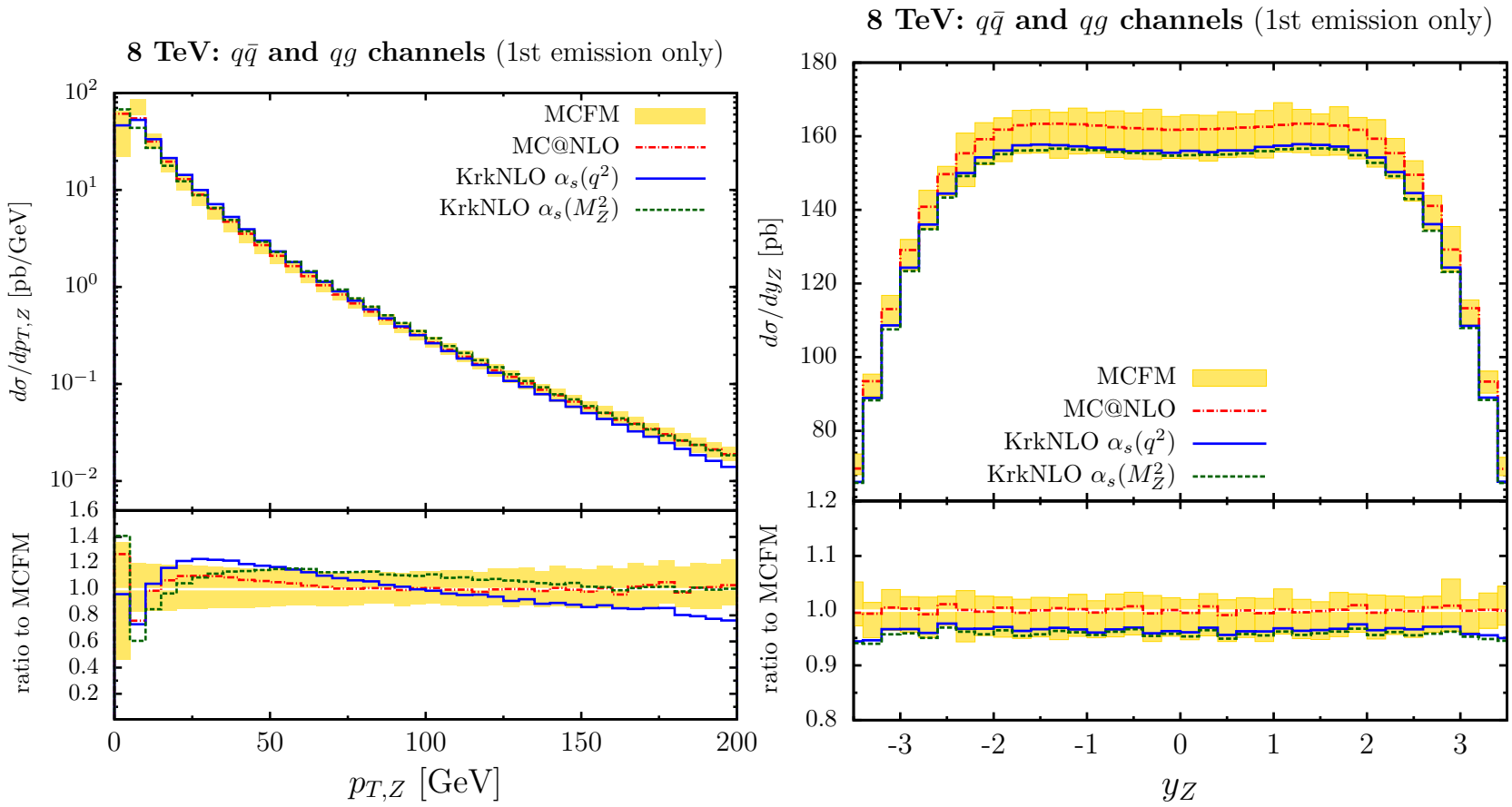
KrkNLO (Drell-Yan $q\overline{q} \to Z \to l^+l^-$)

[S. Jadach, W. Płaczek, S. Sapeta, A.S. and M. Skrzypek - JHEP 1510 (2015) 052]

- Collinear terms are dealt with by putting them to PDFs. This amounts to change of factorization scheme from $\overline{\text{MS}}$ to MC. We provide a recipe how to get PDF MC from $\overline{\text{MS}}$
- Real emissions are corrected by simple reweighting.
- Virtual correction is just a constant and does not depend on Born kinematics.

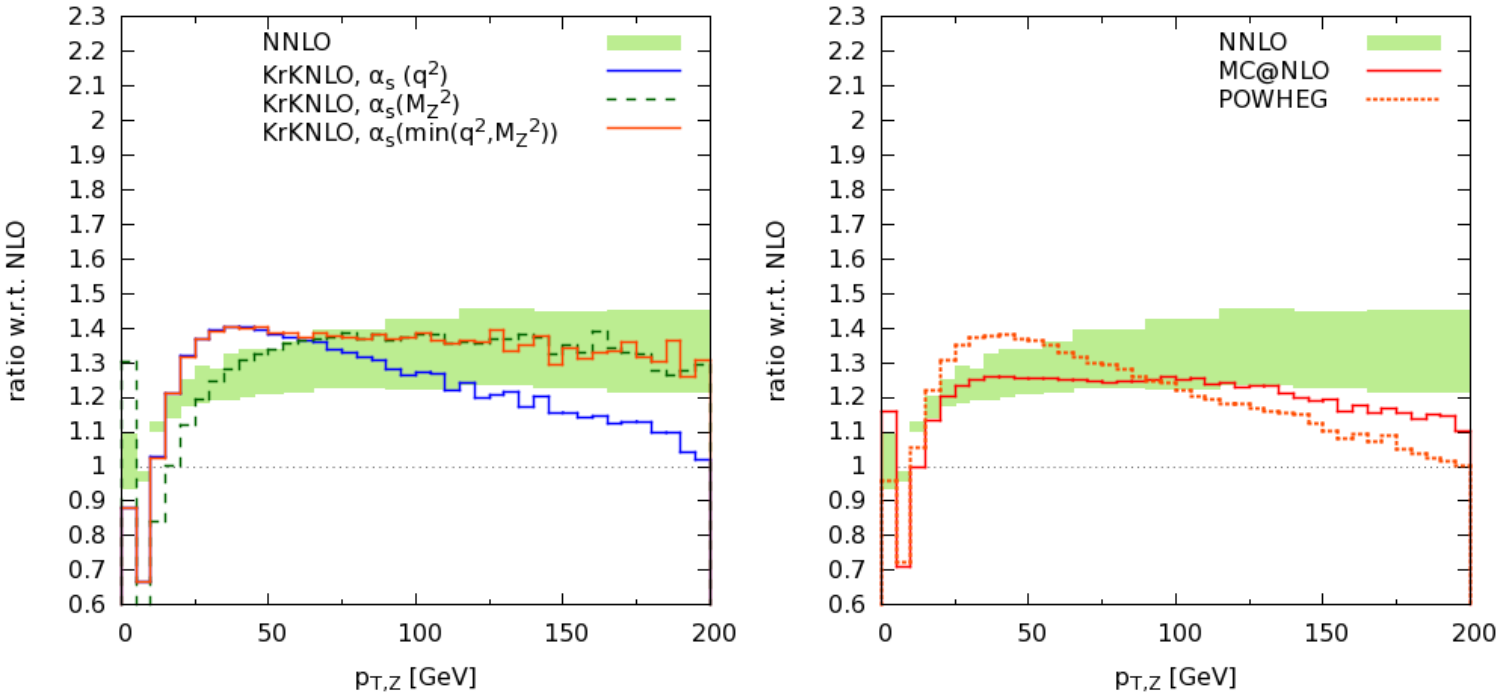
In principle one could even run LO Parton Shower with MC PDF and after, based on even recored re-weight it (for example in Rivet) to full PS+NLO.

Matched results: botch channels, 1st emission



- NLO fixed order MCFM band is an uncertainty estimate obtained by independent variation of μ_F and μ_R by a factor 1/2 and 2
- Moderate differences between KrkNLO $\alpha_s(q^2)$ and MC@NLO in the region below M_Z and between KrkNLO $\alpha_s(M_Z^2)$ and MC@NLO in the region above M_Z

Comparison with fixed order NNLO results (DYNNLO)



- DYNNLO green band is an uncertainty estimate obtained by independent variation of μ_F and μ_R by a factor 1/2 and 2
- KrkNLO $\alpha_s(min(q^2, M_Z))$ and NNLO results show the same trends (left).
- Similar comparisons for POWHEG and MCatNLO are also shown (right).

(Some) Next steps:

Perturbative QCD:

- KrkNLO:
  - Publicly available with Herwig 7
  - Full definition of MC PDF (so far only quarks)
  - Higgs boson production via gluon fusion
  - Pushing the method to (NNLO+) NLO PS
- Jet substructure: detailed analytical study of optimal parameters for Y-splitter+trimming

Non perturbative QCD:

- I plan to work more on Multiple Interaction Model in Herwig 7– (improvements colour reconnection model [Gieseke, Röhr, AS, EPJC 72 (2012)] , pp ridge, heavy ions? ...).

Since we are in Les Houches:

- Quark/Gluon Tagging studies (started in Les Houches this summer)
- Shower uncertainties (started in Les Houches this summer)

...

Next step to Hollywood?

Xmas Play 2014