Technical Benchmarks of Monte Carlos

ECFA Higgs Factories: 2nd Topical Meeting on Generators
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Overview

❖Introduction

❖Benchmark Aims

❖First steps

❖Outlook

Introduction

As part of the ECFA report WG2 has "ordered" a chapter on Monte-Carlo Generators.

One part of this report will be the **technical benchmarking** of Monte Carlo event generators

Monte Carlo generators do an amazing job of simulating data.

Hard to imagine collider physics without them

Monte Carlo Tools

Process Specific

General Purpose MC

RacoonWWW

KKCM

YFSWW

SHERPA

PYTHIA

TAUOLA

KoralW

HERWIG7

WHIZARD

BabaYaga@NLO

MadGraph5_aMC@NLO

Monte Carlo Tools

Process Specific

RacoonWWW

KKCM

YFSWW

TAUOLA

KoralW

BabaYaga@NLO

❖ Well validated against e^+e^- data

❖ Most benchmarked for LEP

❖ New versions released

➡ Benchmarked by authors

❖ Good Standard candles to compare against

❖ Some still state of the art

Monte Carlo Tools

❖ Well validated in LHC environment

❖ Compared against LEP date e.g tuning

❖ Some detailed validatiation already done for
e^+e^-

    ❖ Whizard vs Madgraph **Pia Bredt** **Thesis**

    ❖ Sherpa YFS vs LEP YFS **AP** **Thesis**

General Purpose MC

SHERPA

PYTHIA

HERWIG7

WHIZARD

MadGraph5_aMC@NLO

MC Contacts

- **Herwig7**: Simon Plaetzer

- **Madgraph5_aMC@NLO**: Stefano Frixione

- **Pyhtia**: Ilkka Helenius

- **Sherpa**: Alan Price*

- **Tauola** et al: Zbigniew Was

- **Whizard**: Juergen Reuter

- **Powheg**: Emanuele Re

- **BabaYaga**: Carlo Carloni Calame

- **Geneva**: Simone Alioli

- **Guinea Pig**: Daniel Schulte

- **CIRCE**: Thorsten Ohl

❖ Point of first contact for the benchmark study

Benchmark Aims

❖ Overall idea, to ensure generators are in agreement at technical level

➡ "Apples with apples" comparison between the codes
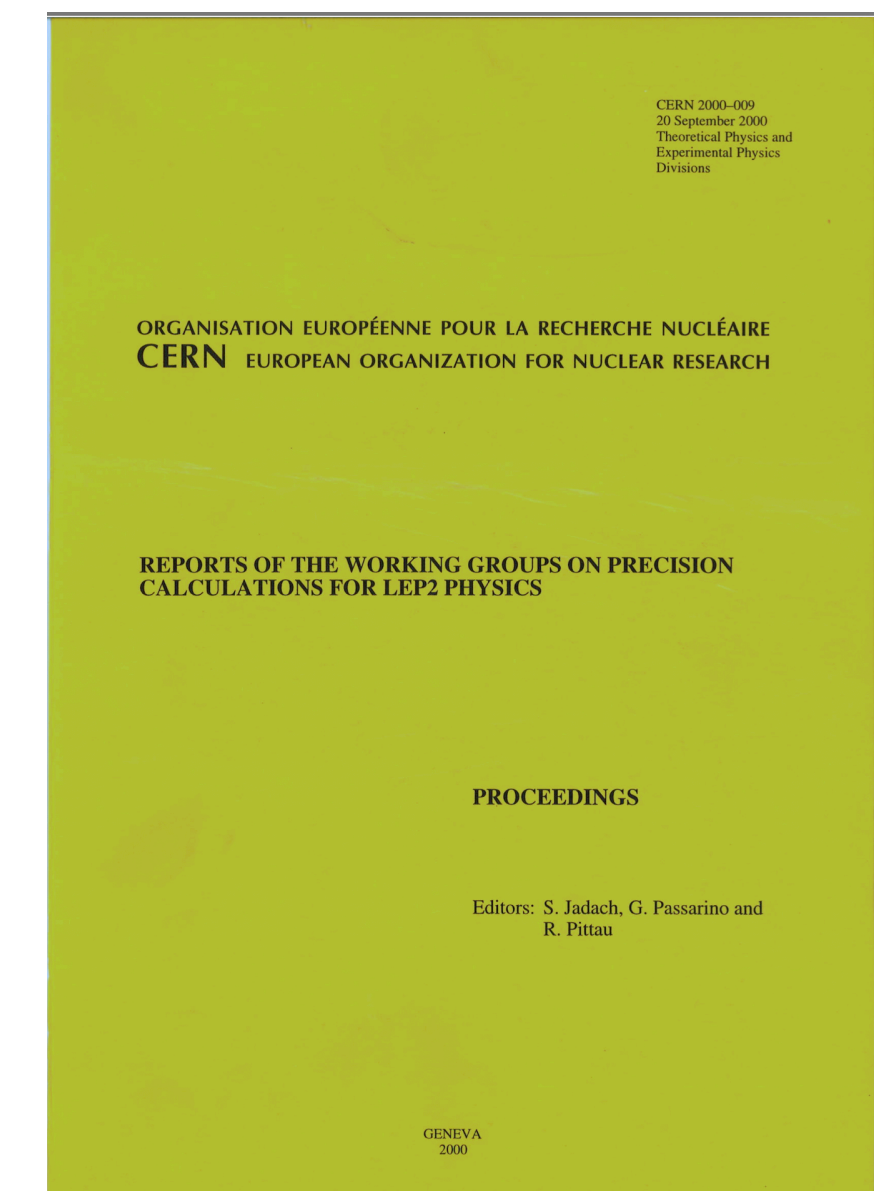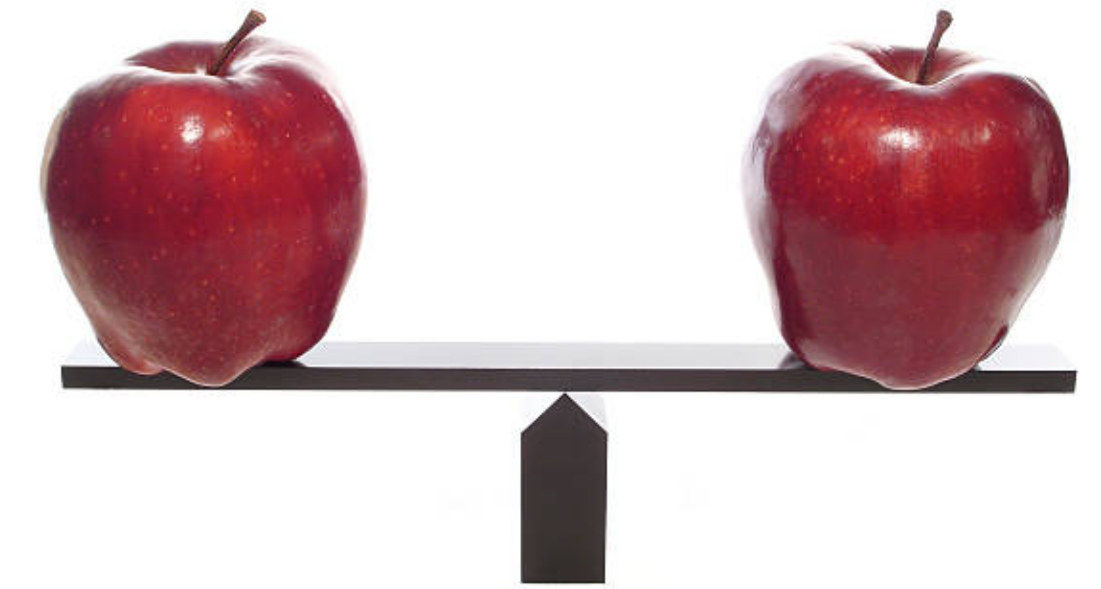

❖ Identify any deviations between generators

❖ Expected? Bug?

❖With the authors, try to identify and resolve issues

❖If necessary, try to quantify an error budget for deviations

❖ Learn for LEP benchmarks (see F. Piccinini's talk)

Benchmark Aims

❖ It will not be an "Apples vs oranges"

❖ Will not compare different physics approaches which is purview of WG1

❖ E.g for a technical benchmark it does it make sense to compare different parton showers
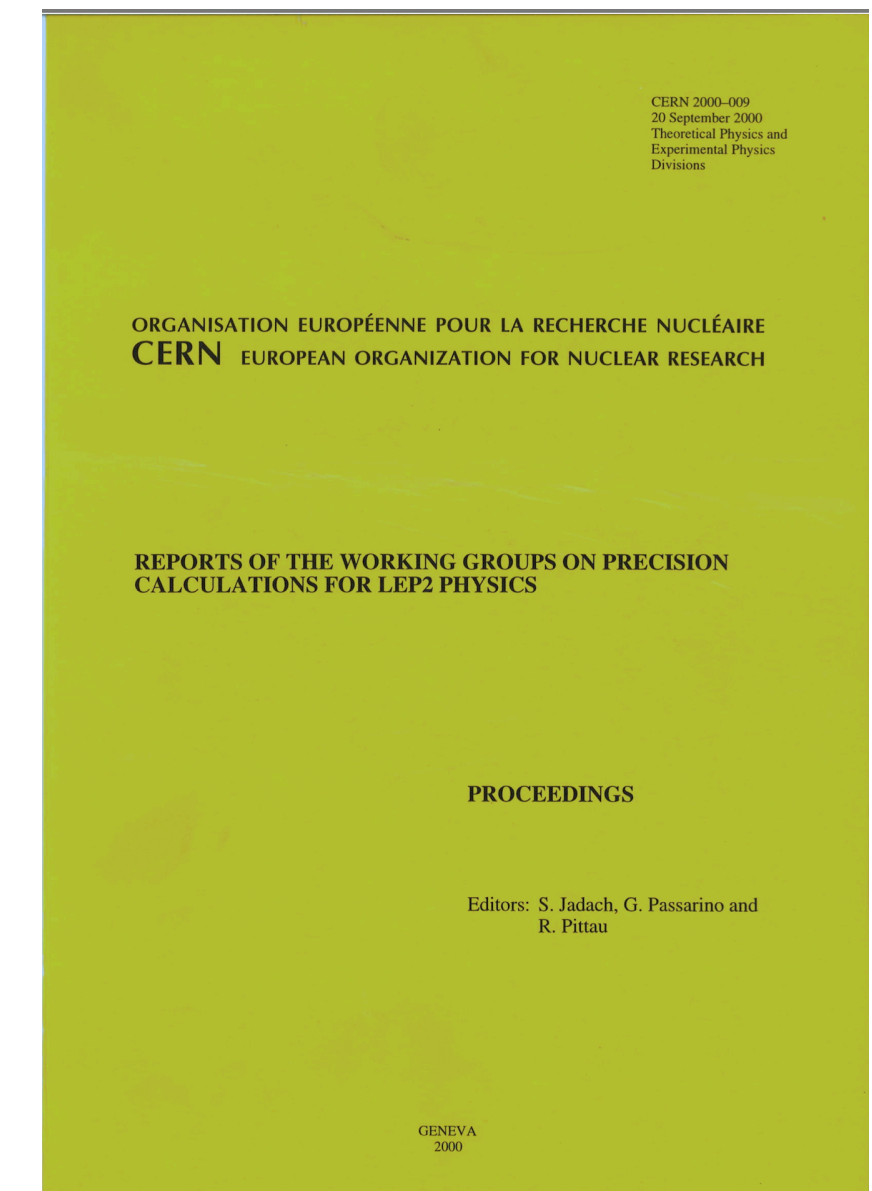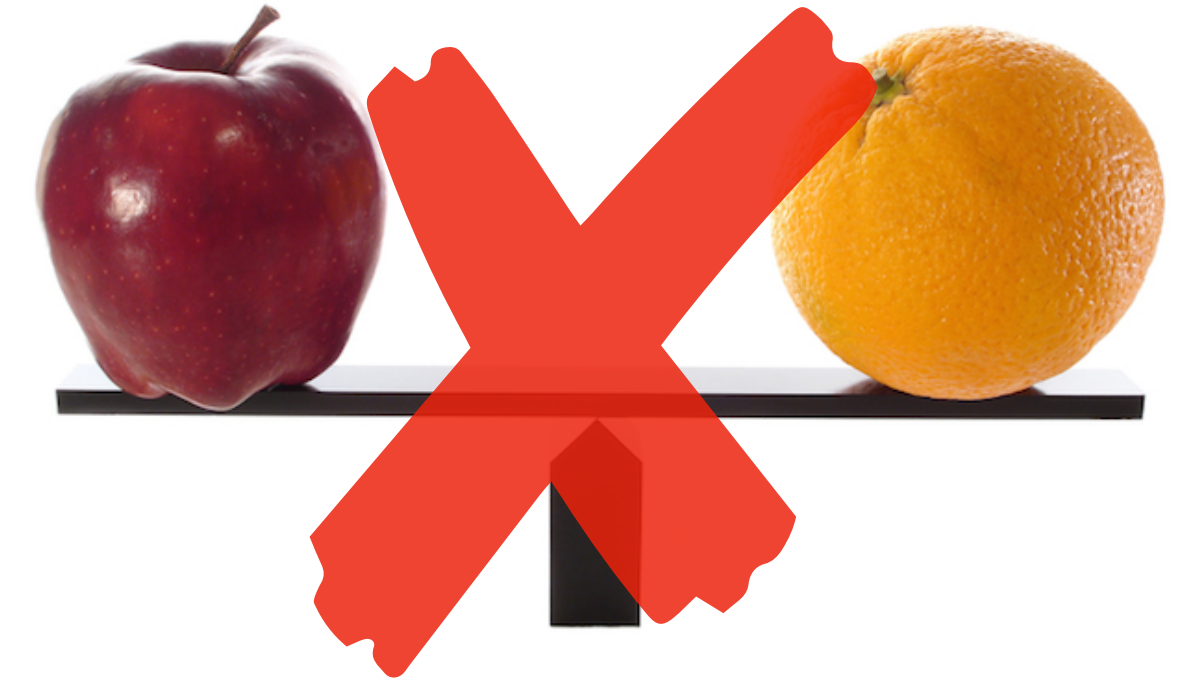
How to Begin

❖Think about reproducibility!

    ❖With such a long timeline for lepton colliders results should be easily reproduced

❖Develop in house tool that will automatically:

    ❖Download and install MC (optional)

    ❖Run all MC from one input card, allows for easy setting of global parameter

    ❖Collect and compare final results e.g Cross-sections

    ❖Allow for easy comparison of differential distributions

```
Processes:
  - 13 -13
  - 14 -14
  - 15 -15
  - 16 -16

Generators:
  - KKMC
  - Madgraph
  - Sherpa: {Version: "2.2.11"}
  - Whizard

Particles:
  23: {Mass: 91.1876}

Analysis:
  - CosTheta:
      Xmax: 1
      Xmin: -1
      Bins: 20
```

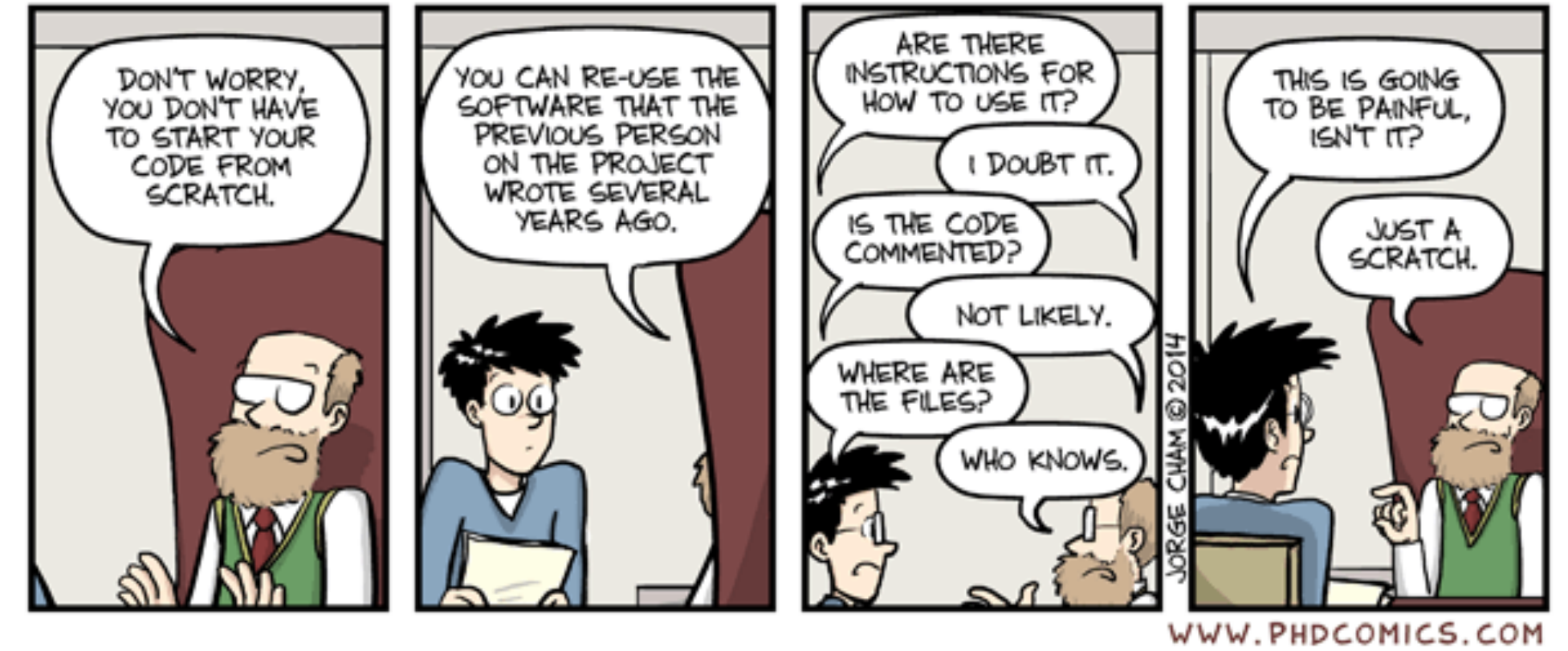# Reproducibility

Paper with parameters

Reproducible with some effort

+ Run-card

Easily Reproduced

+ Analysis Files

Easily Reproduced

And trivially to validate

Reproducibility

Paper with parameters

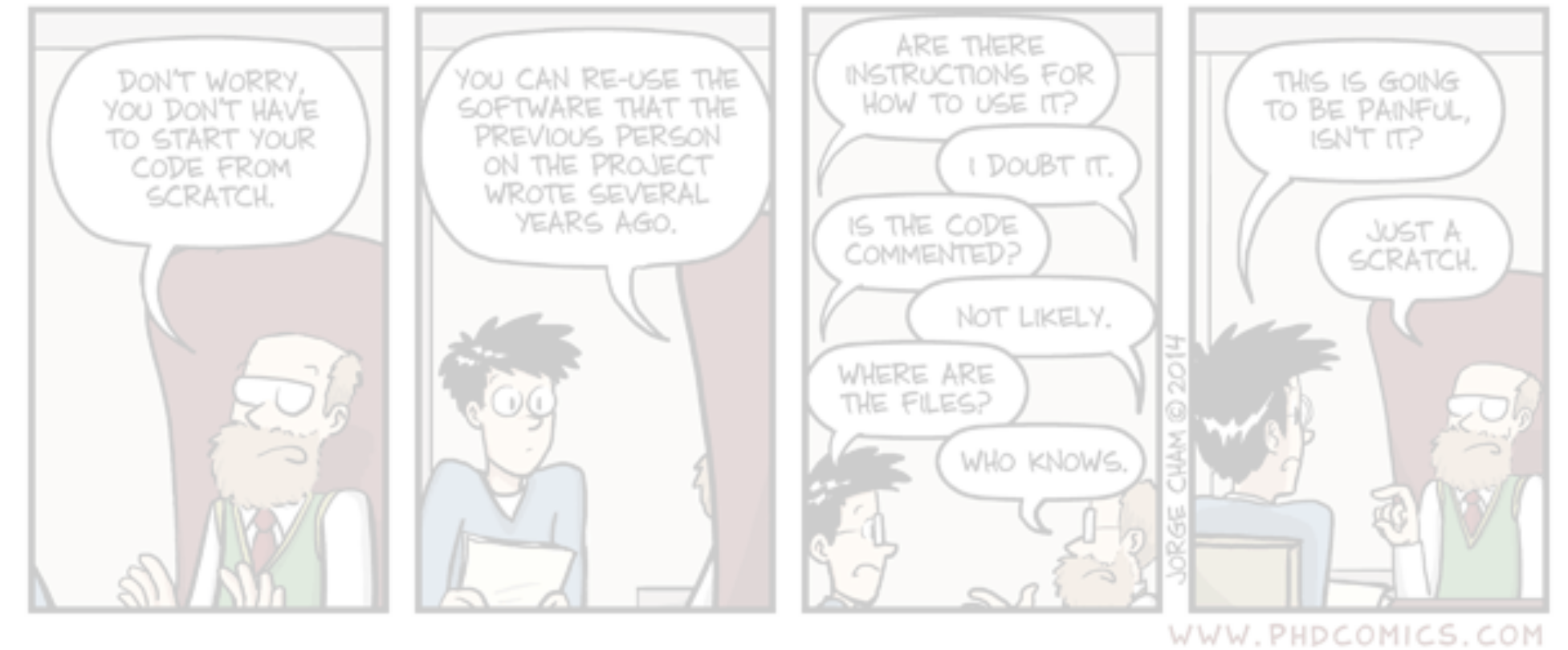Reproducible with some effort

+ Run-card

This should be our aim!
- Repository of results with:
  - Meta data e.g version number
  - Runcards
  - Analysis outputs e.g histfiles
- Initially a git repo
- More advanced? Interactive website/twiki
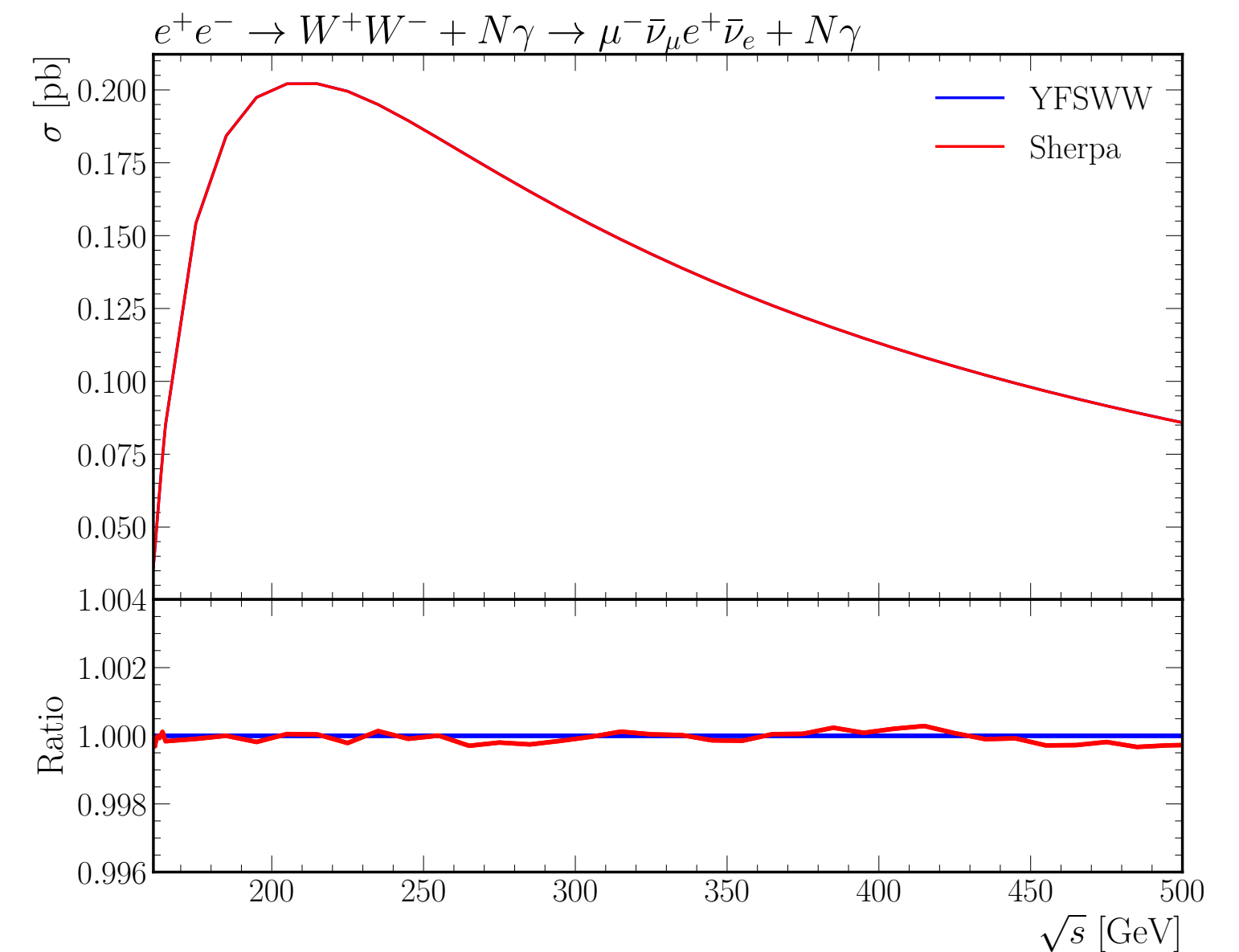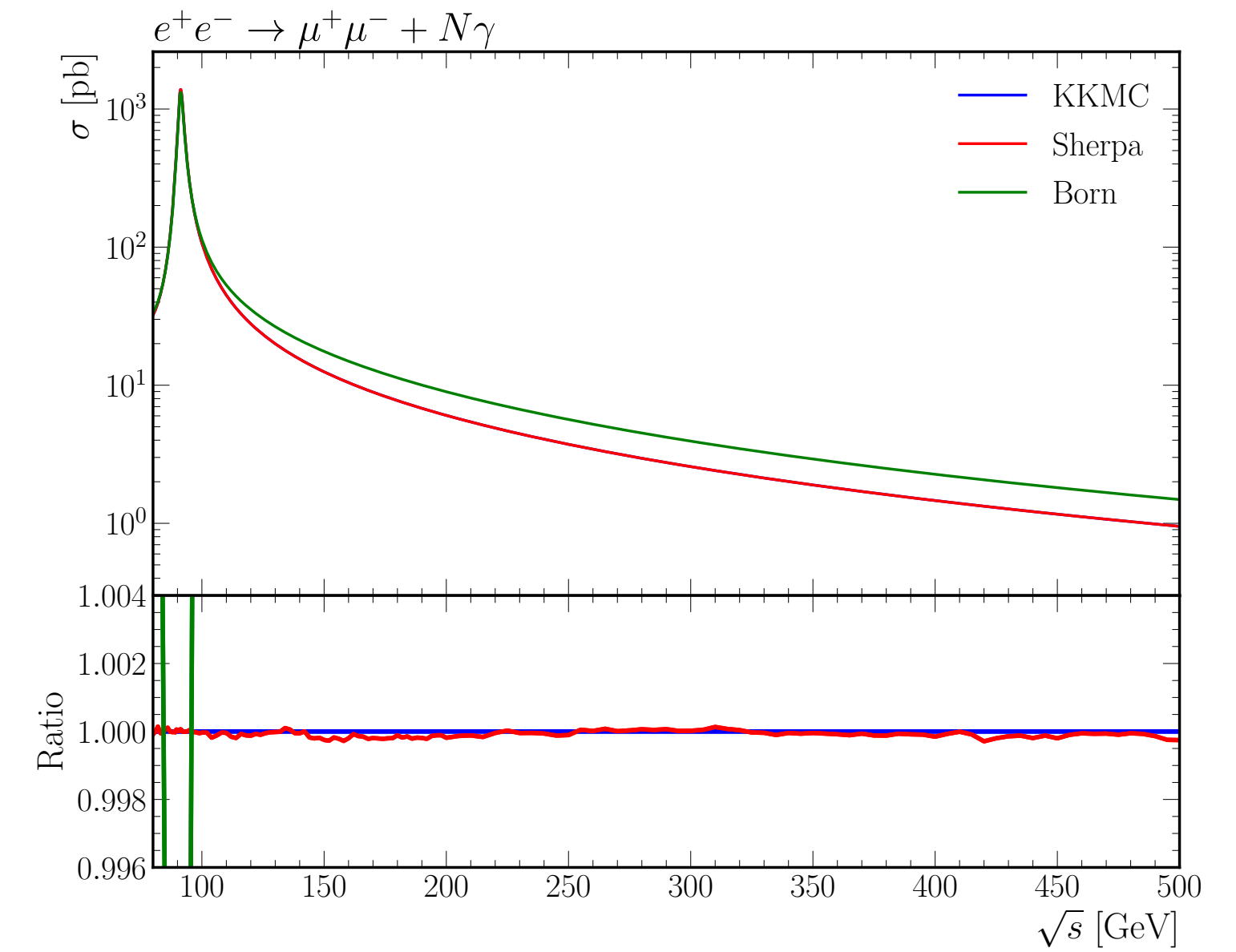- Other ideas/help more than welcome

+ Analysis Files

Easily Reproduced

And trivially to validate

First Steps

$e^+e^- \rightarrow \mu^+\mu^- + N\gamma$

❖ Decide on "wish-list" of benchmarks (after coffee discussion)

❖ Simple Fixed-Order LO checks

❖ Differential distributions - e.g $\cos(\theta),$ invariant mass… - Fairy cheap these days

❖ Allow us to confirm our setups between MC

$e^+e^- \rightarrow W^+W^- + N\gamma \rightarrow \mu^-\bar{\nu}_\mu e^+\bar{\nu}_e + N\gamma$

Next Steps

❖ Consider more advance setups

    ❖ QED for ISR, FSR and IFI

    ❖ NLO-EW predictions

    ❖ Beam Polarisation

    ❖ Multiphoton kinematics

    ❖ ?

❖ QCD

    ❖ How to technically validate different Showers?

    ❖ Hadronization?
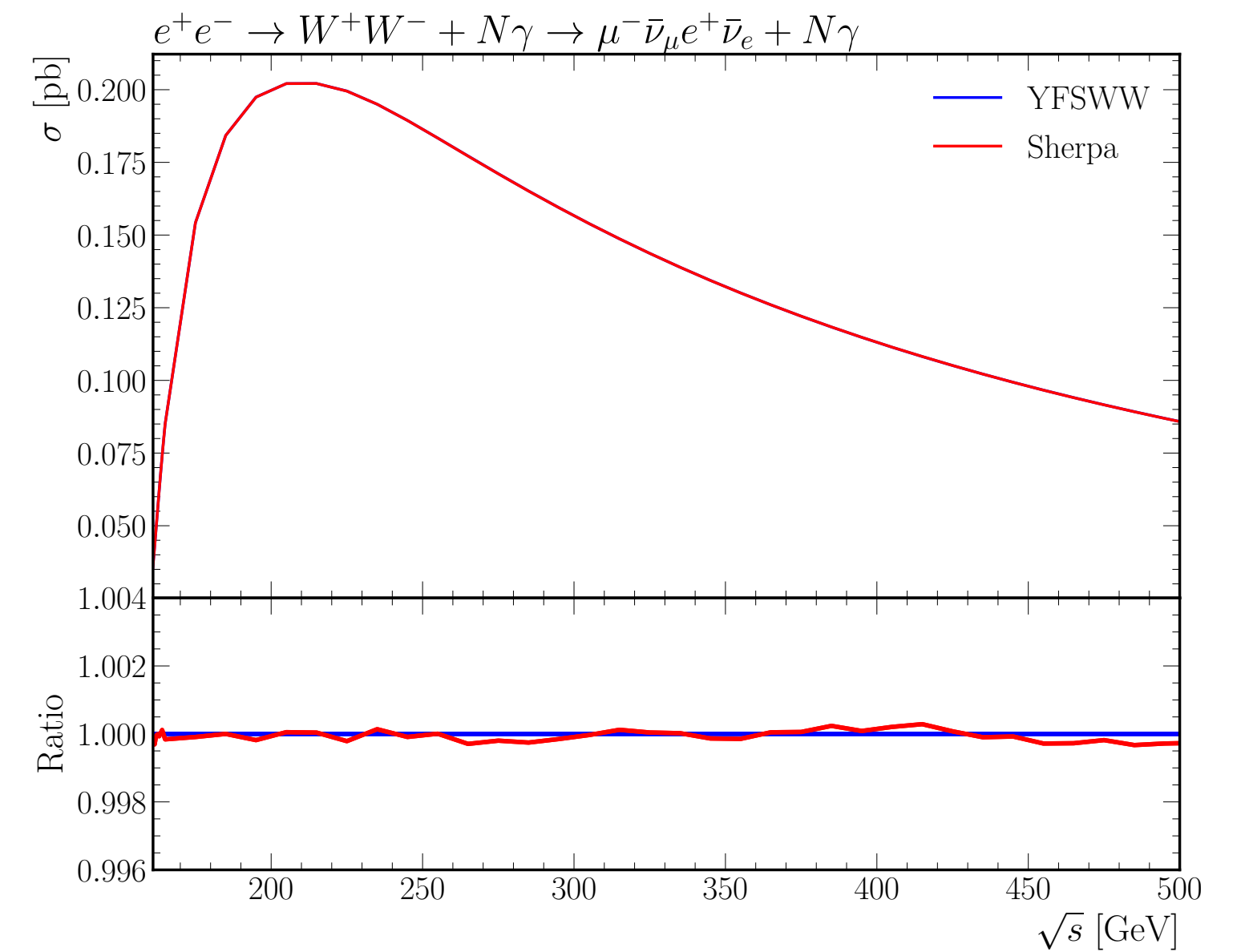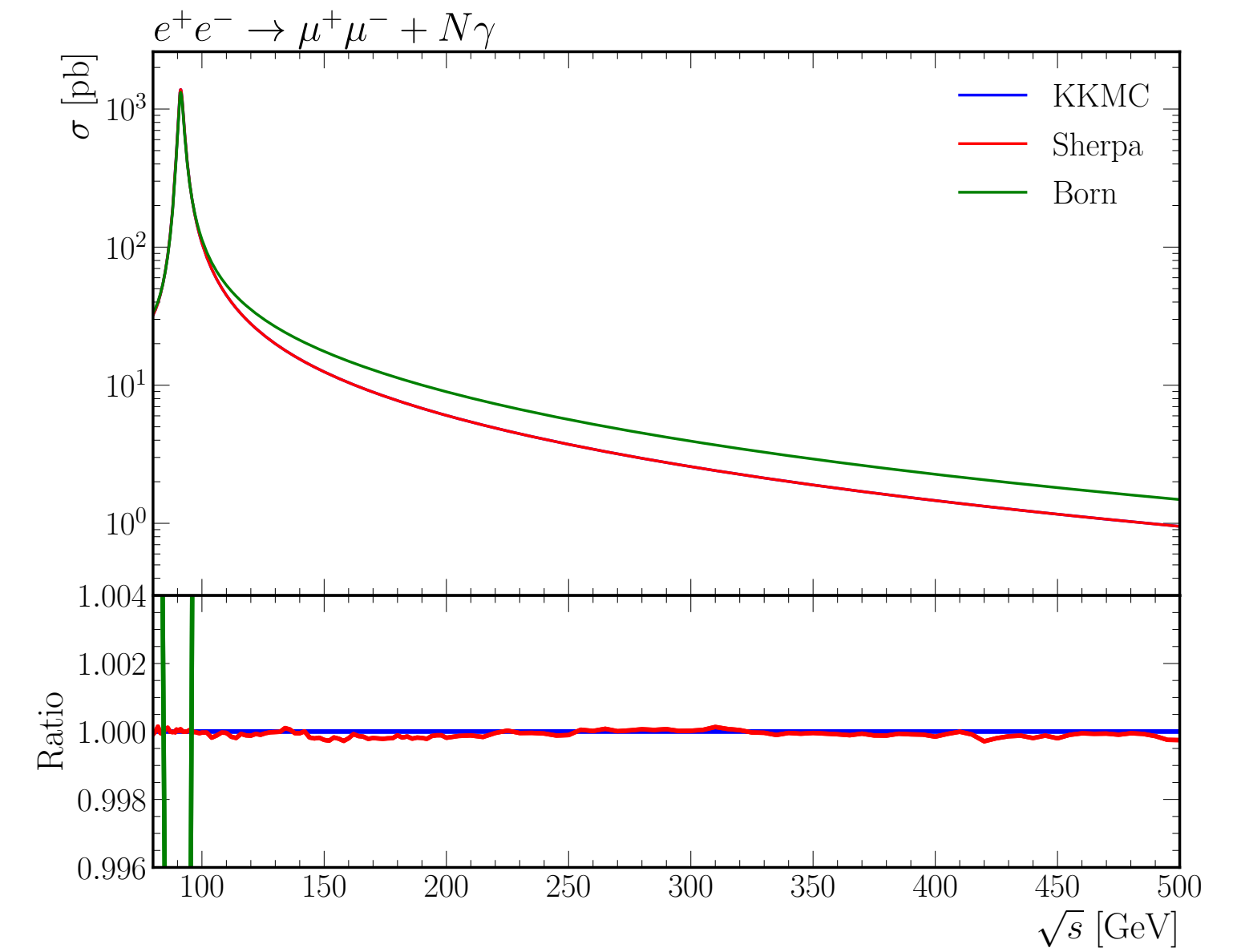
Timeline

❖European Strategy Update is provisionally expected in **2026–27**

➡ target spring **2025** for ECFA study final report

❖ Still have some time but we should agree on milestones

❖ Between now and next ECFA workshop (11th October) have results for "first step"

➡ For simple Fixed-Order I think is doable

❖When do we expect first draft?

Conclusion

❖ Technical benchmarks are of huge importance

    ➡ **IF** there are issues, better to identify them sooner than later

❖ This is not uncharted territory

    ➡ At LEP many benchmarks were already preformed

    ➡ Also, MC authors themselves will have done validation checks

❖ Encourage ECR to join the effort