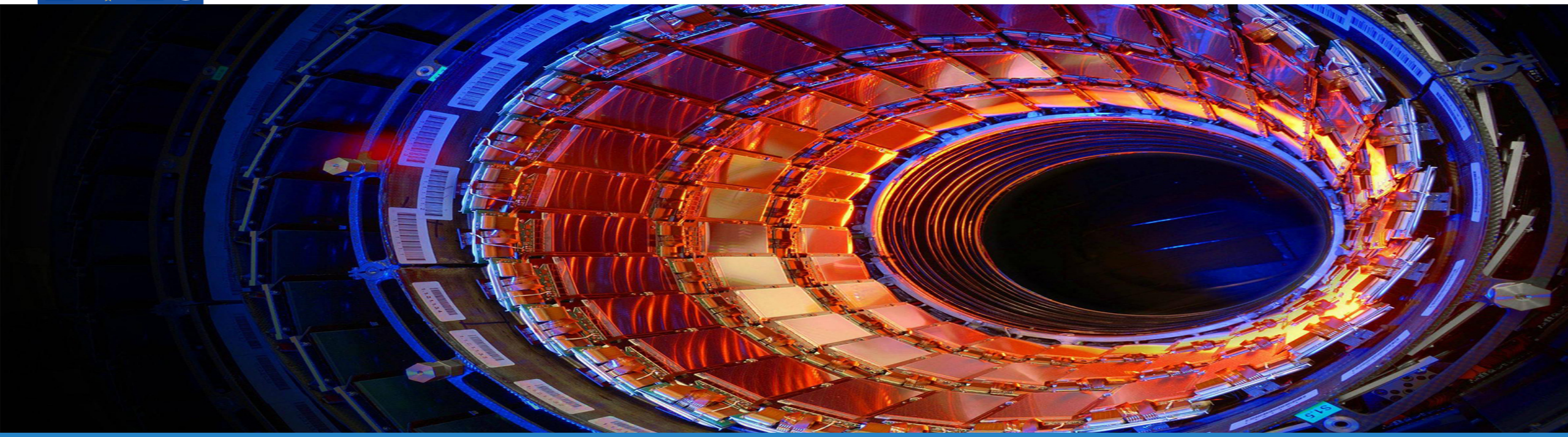


VA2-3DPartons/WP11: Virtual Access to 3DPartons

H. Moutarde (CEA, Irfu)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

Work performed from the beginning of the project

From independent research initiatives to common tools

STRONG-2020 Annual Meeting, October 14-15, 2020

Reminder

*3DPartons gives access to **open-source code** necessary for high precision phenomenology in the field of 3D hadron structure, with a specific emphasis on GPDs and TMDs.*

*It consists of **several libraries organized within a fully modular and open architecture**, which allows the possibility of permanent improvement by the addition of new models, channels or theoretical refinements.*

Galaxy of existing computing codes

As it stands, 3DPartons will be based on parts of, or offer interfaces to, various existing codes:

- *PDF (LHAPDF, APFEL, xFitter),*
- *GPD (PARTONS, Gepard),*
- *TMD (arTeMiDe, TMDlib, xFitter, CASCADE).*

Interface between codes: aims

1 Make sure we can use existing codes **together** (*do not reinvent the wheel*: use specialized libraries, benefit from regular improvements, provide homogeneous access to users, etc.)

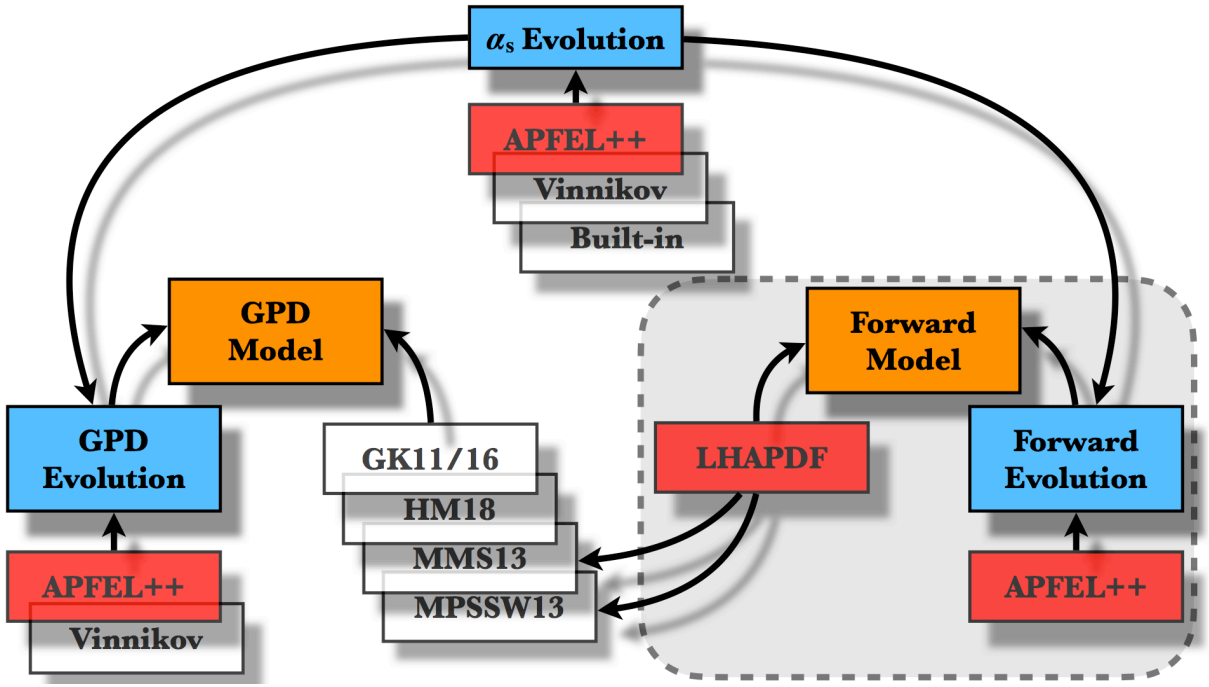
2 **Mutualize** common tools (integration routines, interpolation routines, statistical data tools, parsers, loggers, database transactions, visualizing tools, etc.).

3 **Save time** for future developments by building on existing tools or solutions. STRONG-2020 impact!

4 **Devise common solutions** for similar problems from **different subfields**. STRONG-2020 impact!

5. Allow for **faster original research**. STRONG-2020 impact!

Interface between codes: example within VA2




```
<!-- Define physics assumptions -->
<computation_configuration>

  <!-- Select collinear distribution model -->
  <module type="CollinearDistributionModule" name="CollinearDistributionLHAPDF">

    <!-- Indicate name of the LHAPDF set, member, and type -->
    <param name="setName" value="CT14nnlo" />
    <param name="member" value="0" />
    <param name="collinear_distribution_type" value="UnpolPDF"/>

    <!-- Select collinear distribution evolution model and its parameters -->
    <module type="CollinearDistributionEvolutionModule" name="CollinearDistributionEvolutionApfel">
      <param name="muF2Ref" value="1.677025" />
      <param name="qcd_order_type" value="NNLO" />
      <param name="collinear_distribution_type" value="UnpolPDF" />
      <param name="thresholds" value="0 0 0 1.3 4.75 172" />
      <param name="masses" value="0 0 0 1.3 4.75 172" />
      <param name="subgridNodes" value="100 60 50 50" />
      <param name="subgridLowerBounds" value="0.0001 0.1 0.6 0.8" />
      <param name="subgridInterDegrees" value="3 3 3 3" />
      <param name="tabNodes" value="100" />
      <param name="tabLowerBound" value="1" />
      <param name="tabUpperBound" value="1000" />
      <param name="tabInterDegree" value="3" />

      <!-- Select alpha_s model -->
      <module type="RunningAlphaStrongModule" name="RunningAlphaStrongVinnikov">
      </module>
    </module>
  </module>
</computation_configuration>
```

Code development

1 **Continuous upgrades of existing tools**

- New physics features *(*extra channels, higher orders, new parton distribution datasets, etc.*)*
- New tools *(*interactive use with jupyter notebooks, dissemination with Docker Hub, homebrew, dataset formats, etc.*)*

2 **Interactions between tools and teams** STRONG-2020 impact!

- Interfaces between codes and data formats (*e.g.* use in event generation)
- Common standards (*e.g.* YAML, HEPData, C++xx) within particle and nuclear physics communities (adopt robust solutions, enlarge community of users, cross small community barriers)
- Addition of common tools and opportunity for new physics research (*e.g.* impact studies, fits)

International assessment board

Eight researchers with **complementary experience** in

- experimental and theoretical aspects of GPDs and TMDs,
- PDF fits,
- event generators,
- code development
- statistical data analysis.

- BOBIN, Jérôme (IRFU, CEA, Université Paris-Saclay)
- BRESSAN, Andrea (INFN, Trieste)
- CHAPON, Damien (IRFU, CEA, Université Paris-Saclay)
- DIEHL, Markus (DESY)
- GLAZOV, Alexander (DESY)
- HAUTMANN, Francesco (Oxford and Antwerpen)
- PASQUINI, Barbara (INFN, Università Di Pavia)
- SOKHAN, Daria (University of Glasgow)

First meeting planned during the first half of November.

Deliverables and milestones

Continuous release of codes for 3D hadron structure

Offer users a longterm guarantee about ***robust, flexible, validated and up-to-date code****.*

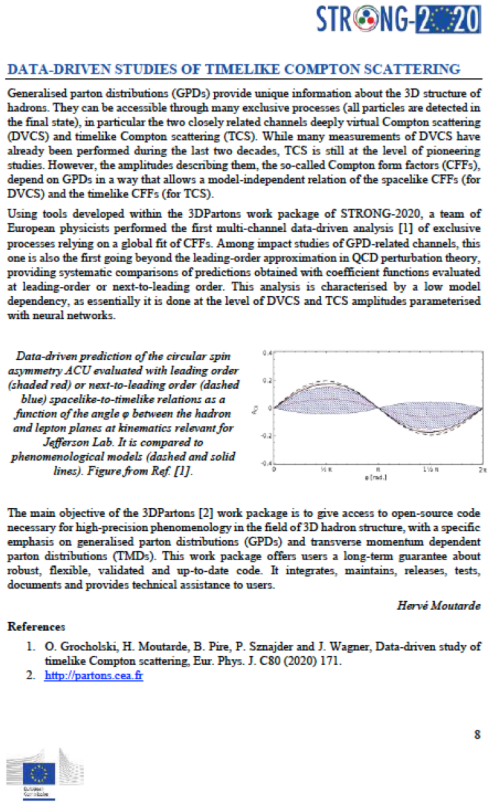
Aggregate and improve existing codes *written by physicists from the GPD and TMD communities.*

Responsible of the ***integration, maintenance, release*** *(including multi-platform compilation),* ***testing*** *(including nonregression),* ***documentation and technical assistance*** *to users.*

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D11.1	Virtual Access provision - multi annual implementation plan over the first 18 months (month 1-18) (D11.1)	24 - CEA	Report	Confidential, only for members of the consortium (including the Commission Services)	18
D11.2	Virtual Access provision - multi annual implementation plan over the next 18 months (month 19-36) (D11.2)	24 - CEA	Other	Public	36

Papers, talks and on-going studies

- Grocholski *et al.*, Eur. Phys. J. **C80** (2020) 171
- Cosyn *et al.*, Phys. Rev. **D102** (2020) 054003
- Cuic *et al.*, arXiv:2007.00029 [hep-ph],
- Bacchetta *et al.*, JHEP **07** (2020) 117
- van Haevermaet *et al.*, Eur. Phys. J. **C80** (2020) 610
- Maciula, Phys. Rev. **D102**, (2020) 014028
- Various talks, participation to EIC Yellow Report studies, etc.
- Development of third-party libraries *e.g.* HPC PARTONS.



STRONG-2020

DATA-DRIVEN STUDIES OF TIMELIKE COMPTON SCATTERING

Generalised parton distributions (GPDs) provide unique information about the 3D structure of hadrons. They can be accessible through many exclusive processes (all particles are detected in the final state), in particular the two closely related channels deeply virtual Compton scattering (DVCS) and timelike Compton scattering (TCS). While many measurements of DVCS have already been performed during the last two decades, TCS is still at the level of pioneering studies. However, the amplitudes describing them, the so-called Compton form factors (CFFs), depend on GPDs in a way that allows a model-independent relation of the spacelike CFFs (for DVCS) and the timelike CFFs (for TCS).

Using tools developed within the 3DPartons work package of STRONG-2020, a team of European physicists performed the first multi-channel data-driven analysis [1] of exclusive processes relying on a global fit of CFFs. Among impact studies of GPD-related channels, this one is also the first going beyond the leading-order approximation in QCD perturbation theory, providing systematic comparisons of predictions obtained with coefficient functions evaluated at leading-order or next-to-leading order. This analysis is characterised by a low model dependency, as essentially it is done at the level of DVCS and TCS amplitudes parameterised with neural networks.

Data-driven prediction of the circular spin asymmetry A_{CU} evaluated with leading order (shaded red) or next-to-leading order (dashed blue) spacelike-to-timelike relations as a function of the angle φ between the hadron and lepton planes at kinematics relevant for Jefferson Lab. It is compared to phenomenological models (dashed and solid lines). Figure from Ref. [1].

The main objective of the 3DPartons [2] work package is to give access to open-source code necessary for high-precision phenomenology in the field of 3D hadron structure, with a specific emphasis on generalised parton distributions (GPDs) and transverse momentum dependent parton distributions (TMDs). This work package offers users a long-term guarantee about robust, flexible, validated and up-to-date code. It integrates, maintains, releases, tests, documents and provides technical assistance to users.

Hervé Moutarde

References

1. O. Grocholski, H. Moutarde, B. Pire, P. Sznajder and J. Wagner, Data-driven study of timelike Compton scattering, Eur. Phys. J. C80 (2020) 171.
2. http://partons.cea.fr

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Access to the facility

I can give an example from the PARTONS website, see enclosed document. It was opened on December 13th, during the Transversity Conference (where the opening was announced). The enclosed document (generated from ***Google Analytics****) shows the number of accesses between the opening date and today. […] Concerning users, people from the GPD, TMD, EIC and small-x work packages are natural candidates. Depending on the simulation requirements for EIC, I would expect between about 100 users. We can add 50 users from the physics programs of Jefferson Lab. I do not have a clear view of the number of hadron structure physicists involved in LHC experiments.* ***150 users may be on the safe side regarding what Google calls « users » in the PARTONS case****.*

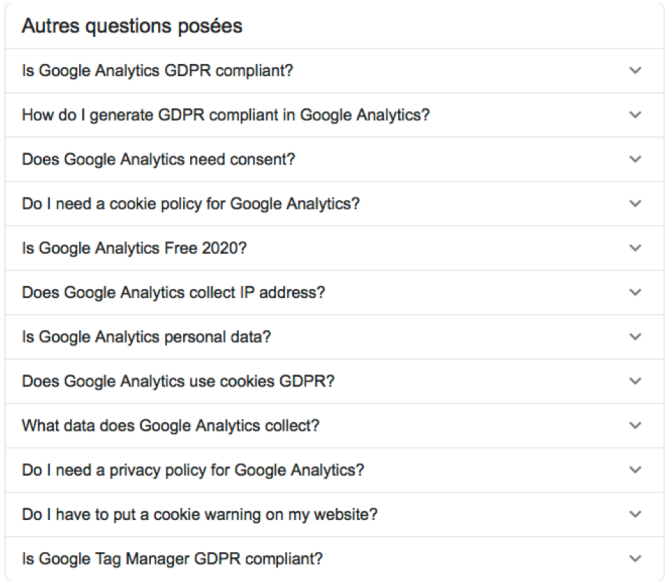
Access to the facility

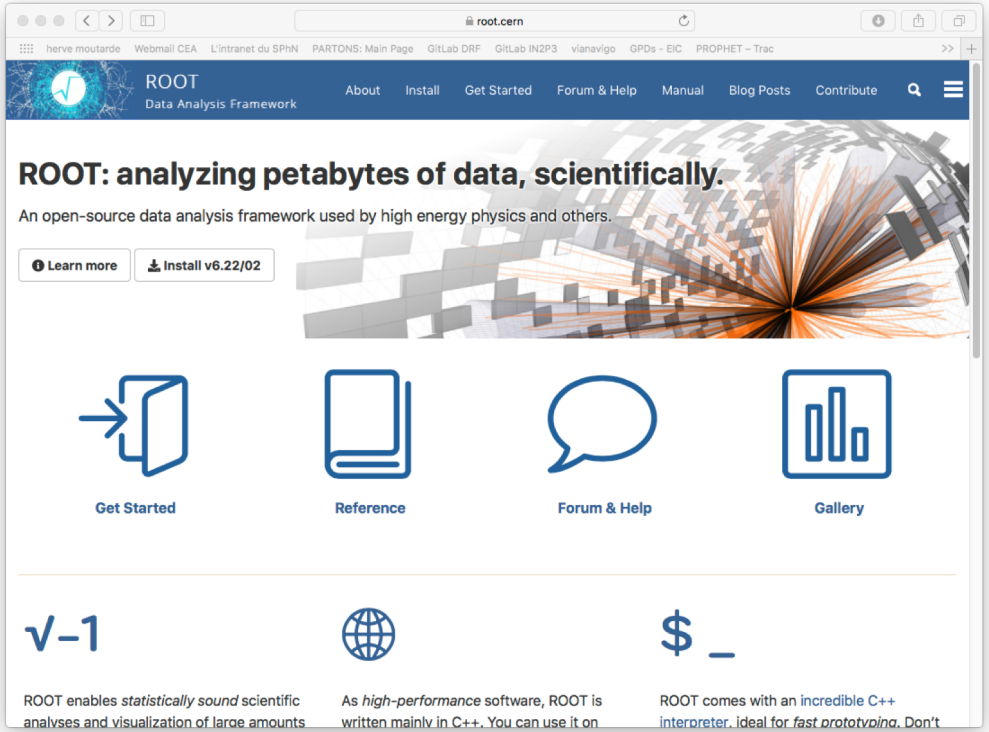
Between 01 June 2019 and 01 October 2020

- 4077 views
- 574 visitors including 18% of returning visitors
- **Google Analytics** is **the most popular** tool of this kind, see https://w3techs.com/technologies/overview/traffic_analysis (Web Technology Surveys)
- Other alternatives, including paid ones.

*« A main principle of open-source software development is peer production, with products such as **source code, blueprints, and documentation freely available to the public**. The open-source movement in software began as a response to the limitations of proprietary code. »* (Wikipedia)

Make sure adequate information is provided?





- Obtain visitor consent prior to tracking?
- Europa Analytics?

Progress and expected results

Towards greater code interoperability and joint developments

- Merge GPD and TMD computing chains in a **common framework** (start with PARTONS and NangaParbat).
- Further extension to **collections of parton distributions**: TMDlib, LHAPDF.
- Develop and connect to TMD and GPD related **event generators**.
- Provide **visualizing features** for easy comparisons between theory predictions and data, or between different models.
- Provide **generic statistical tools** for impact studies.
- Investigate **generic fitting tools**.