

Letter of intent: SIDIS-3D-EXP

Please specify an acronym, a project title and the name(s) of the project leader(s)

Project acronym: **SIDIS-3D-EXP**

Project title: **SIDIS observables for TMDs**

Possible project leader: **A. Bressan** (INFN-TS)

In the sections below, please provide details on:

1. Research objectives

The exploration of the internal structure of hadrons is one of the core missions of hadronic physics and semi-inclusive deep inelastic scattering is the “**golden channel**” for these studies. The future Electron-Ion Collider in the US and JLab24 with their high luminosity will project the field of SIDIS and transverse momentum dependent (TMD) observables in the era of high precision and we have to prepare for it by learning as much as possible from data recently collected (COMPASS at CERN) or that will become available in the near future (JLab12 experiments).

SIDIS-3D-EXP will coordinate efforts of experimentalists and theorists focused on improving the **mapping of the transverse spin and momentum dependent distributions of partons, more specifically the u and d quarks, in a 3D space**, i.e. the transverse momentum dependent parton distribution functions or TMD PDFs. These functions connect with the peculiar dynamics of the strong force in the confined state and with fundamental quantities like the tensor charge entering BSM searches.

The work package will focus on constructing common tools and analysis chains for future analysis, and their use on available data, in a close collaboration between experimental and theoretical physicists. To this end, the SIDIS data on proton and deuteron from COMPASS and CLAS12 are a unique opportunity, in particular thanks to the complementary and partially overlapping phase space. In the three to four years’ running of the work package, we will concentrate on TMD observables and competing processes for a precision mapping of the 3D partonic structure of the nucleon. In terms of concrete objectives, SIDIS-3D-EXP plans to:

- Fully exploit the large statistics collected by COMPASS with 160 GeV longitudinally polarized muons and transversely polarized targets and eventually also the one with 190 GeV muons and longitudinally polarized targets.
- Use the data collected by CLAS12 with longitudinally polarized beams and targets and collect first transversely polarized data to extract information on the mostly unknown high- x region (valence) of TMD PDFs
- Construct common analysis tools to improve the treatment of diffractive vector mesons contaminations, higher twists and radiative electro-magnetic effects in SIDIS.
- Improve the knowledge of d -quark TMDs and transversity, and get a deeper insight in the Collins fragmentation function by further developing the 3P_0 fragmentation model.
- Pave the way for precise simulations of combined SDME and TMD effects at the ePIC experiment at EIC.

It is important also to emphasize that:

- The full year of deuteron data collected by COMPASS in 2022, as well as those collected in 2010 with protons will very likely remain unique for the next decade.
- CLAS12 is preparing for collecting transversely polarized data before 2030.
- There is a strong need to form young scientists capable of dealing with the future challenges posed by EIC high precision analysis
- For this endeavor to be successful, it requires a strong collaboration between experimentalists and theoreticians.

Concerning synergies and connections with **Transnational Access** and **Virtual Access**

- All the knowledge acquired will be made available in the **Virtual Access** facility **3D Portal**.
- The WP will use CERN infrastructure for data analysis and simulation, meetings and workshops organized by the participants.

Hereafter a first draft of the tasks that will constitute the WP

Task1: SSA/wTSA Analysis of COMPASS data (INFN-TS-TO, CU):

- Multi dimensional measurements of TSA and wTSA on deuteron and proton

Task2: Unpolarized cross sections Analysis of COMPASS data: (INFN-TS, CU, NCNR)

- Endeavor to understand the flavour-dependence of the partonic transverse momentum and the Boer-Mulders function.
- Explore the use of new tools for measuring single and hadron pair production.

Task3: Unpolarized cross sections and SSA Analysis of CLAS12 data (INFN-FE, INFN-LNS)

Multi dimensional measurements with enhanced sensitivity to the valence

Task4: Run preparation for CLAS12 transversely polarized data (INFN-FE, INFN-LNS)

- Design of the best experimental configuration and impact study

Task4: Theory support (INFN-PV, INFN-BO)

- Interpretation of the new data including effect of VM and higher twist
- Impact studies of new data, preparation for future measurements

Task5: **General and common** effort to (all participating institutions):

- Develop common analysis tools and chains for COMPASS and CLAS12 to investigate deeply their dependence
- Develop and test GPU-based algorithms for the analysis of SIDIS observables.
- Develop and use of MC event generators with TMD PDFs and spin effects in the fragmentation with String-Spinner developments.
- Perform impact studies via full simulations and reconstructions using the software stack that is presently developed by the ePIC collaboration at the EIC.

2. Connection to Transnational Access infrastructures (TAs) and / or Virtual Access projects (VAs)

TA: CERN, for COMPASS, ePIC and for meeting and workshop

VA: TMD Portal, as (but not limited to) a container of the successors of Nanga-Parbat and TMDlib

3. Estimated budget request

500 kEur, 90% for contract for hiring co-funded PostDocs, 10% for travels and meetings, excluding overhead (600 with overhead).

4. Participating and partner institutions

Participants: INFN (Ferrara, Frascati, Pavia, Torino, Trieste), Charles University (Prague), National Centre for Nuclear Research (Warsaw), IRFU(Saclay)

Partner institutions: JLab, Yerevan