Status and plans of the COMPASS Experiment

Fulvio Tessarotto on behalf of the COMPASS Collaboration

1. COMPASS data and analyses
2. Hadron data analyses
3. DVCS, SIDIS and Drell-Yan analyses
4. Preparation for the 2021 run

> 200 physicists, 24 Institutions, 13 Countries
### COMPASS Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Experiment Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2003</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2004</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2005</td>
<td>CERN accelerators shut down</td>
</tr>
<tr>
<td>2006</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2007</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2008</td>
<td>hadron spectroscopy</td>
</tr>
<tr>
<td>2009</td>
<td>hadron spectroscopy</td>
</tr>
<tr>
<td>2010</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2011</td>
<td>nucleon structure with 190 GeV μ</td>
</tr>
<tr>
<td>2012</td>
<td>Primakoff &amp; DVCS / SIDIS test</td>
</tr>
<tr>
<td>2013</td>
<td>CERN accelerators shut down</td>
</tr>
<tr>
<td>2014</td>
<td>Test beam Drell-Yan process with π beam and T polarised proton target</td>
</tr>
<tr>
<td>2015</td>
<td>Drell-Yan process with π beam and T polarised proton target</td>
</tr>
<tr>
<td>2016</td>
<td>DVCS / SIDIS with μ beam and unpolarised proton target</td>
</tr>
<tr>
<td>2017</td>
<td>DVCS / SIDIS with μ beam and unpolarised proton target</td>
</tr>
<tr>
<td>2018</td>
<td>Drell-Yan process with π beam and T polarised proton target</td>
</tr>
<tr>
<td>2021</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
<tr>
<td>2022</td>
<td>nucleon structure with 160 GeV μ</td>
</tr>
</tbody>
</table>
### COMPASS main active analyses

**Channel** | **Status** | **Details**
--- | --- | ---
**Hadron data**
Measurement of chiral anomaly in $\pi^-\gamma \rightarrow \pi^-\pi^0$ | update | study of systematic effects
Measurement of chiral dynamics in $\pi^-\gamma \rightarrow \pi^-\gamma$ | update | study of systematic effects
Triangle singularity as the origin of the $a_1(1420)$ in $\pi^- p \rightarrow \pi^-\pi^-\pi^+ p$ | final | Accepted for publication by PRL PRD method paper in drafting stage
$\pi_1(1600)$ in the $1^{-+}1^{++} p(770)\pi^+ P$ wave | final | paper in final drafting stage to be submitted to PRD
Study of excited kaons in $K^- p \rightarrow K^-\pi^-\pi^+ p$ | update | preliminary results from PWA
Study of non-resonant processes in $\pi^- p \rightarrow \pi^-\pi^-\pi^+ p$ | update | fit of double-Regge models at large $m_{\pi^-\pi^-\pi^+}$ improvements of data sample and MC
Study of non-resonant processes in $\pi^- p \rightarrow \pi^-\pi^-\pi^+ p$ | update | fit of multi-Regge models at large $m_{3\pi}$ improvements of data sample and MC
Study of $\pi_1(1600)$ in $\pi^- p \rightarrow (b_1(1235)\pi^-) p$ and $f_1(1285)\pi^- p$ | new | event selection
Study of resonances in $\pi^- p \rightarrow K^-\pi^- K^0_S p$ and $K^- p \rightarrow \pi^- K^0_S p$ | new | event selection

**Study of exclusive reactions with 2012 data**
SDME for exclusive $\omega$ | final | EPJC (2021) 81 126
SDME for exclusive $\rho$ | final | study of systematics, paper being written
SDME for exclusive $\phi$ | ongoing | analysis done, cross check is needed

**Study of exclusive reactions with 2016-2017 data**
DVCS cross section and $t$-slope | update | preliminary results shown at DIS-2021, processing full data (2016/2017)
$\pi^0$ cross section $t$ and $\phi$ dependence | ongoing | analysis and cross-check activities
$J/\psi$ cross section | ongoing | preliminary results obtained, processing full data (2016/2017)

**Multiplicities**
$\bar{p}/p$ and $K^-/K^+$ multiplicity ratio | final | 2006 data, PLB 807 (2020) 135600
Pion and kaon multiplicities | ongoing | data analysis ongoing (re-processed 2016 data), processing full data (2016/2017)
$\bar{p}/p$ and $K^-/K^+$ multiplicity ratio | ongoing | data analysis ongoing (re-processed 2016 data), processing full data (2016/2017)

**Transverse spin and TMD analyses**
Other $P_T$-weighted transverse spin asymmetries (SIDIS 2010 data) | ongoing | study of systematics
MultiD analysis of transverse spin asymmetries (SIDIS 2010 data) | ongoing | VM contribution study
Inclusive $P_T$ Collins and Sivers asymmetries, proton 2010 data | new | preliminary results shown at DIS-2021, paper planned
Measurement of $g_2^T$ (SIDIS 2010 data) | ongoing | study of systematics
TMD transverse and longitudinal spin asymmetries (SIDIS 2007, 2010 and 2011 data) | ongoing | study of systematics and models, paper drafting
Transversity induced $\Lambda/\bar{\Lambda}$ polarisation (SIDIS 2010 data) | final | paper drafting over, submitted to PLB
Dihadron $P_T$ transverse spin asymmetries with PID | update | paper drafting ongoing
Azimuthal asymmetries in SIDIS on unpolarised proton data (2016/17) | update | preliminary results shown at DIS-2021, study of systematics
$P_T$ distributions in SIDIS on unpolarised proton data (2016/17) | update | preliminary results shown at DIS-2021, paper drafting

**Drell-Yan and Charmonium analyses**
Drell-Yan transverse spin asymmetries in 2018 data | ongoing | re-processing 2015 data (2018 done), study of systematics
Transverse spin asymmetries in $J/\psi$ mass range | ongoing | re-processing 2015 data (2018 done), study of systematics
Drell-Yan unpolarized azimuthal asymmetries in 2018 data | new | preliminary results shown at DIS-2021, study of systematics
Double $J/\psi$ production cross section | update | re-analysis (re-processed 2018 data), paper being drafted
Drell-Yan cross section and nuclear dependent effects | ongoing | analysis and cross-check activities
Unpolarized asymmetries in $J/\psi$ production | ongoing | MC production, study of systematics
Neural network techniques for Drell-Yan event tagging | ongoing | studying the impact on TSAs
Beam particle identification analysis (CEDARs) | update | recent progress in CEDAR analysis
Spectroscopy: diffractive $3\pi$ production

Squared four-momentum transferred $t'$ by Pomeron $P$

Exclusive measurement

$46 \times 10^6$ exclusive events

Rich structure in $\pi^-\pi^+\pi^-$ mass spectrum:
Intermediate states $X$ 

Also structure in $\pi^+\pi^-$ subsystem:
Intermediate states $\varepsilon$ (isobar)

The exotic meson $\pi_1(1600)$ with $J^{PC} = 1^{-+}$ and its decay into $\rho(770)\pi$

The COMPASS Collaboration

Abstract

We study the spin-exotic $J^{PC} = 1^{-+}$ amplitude in single-diffractive dissociation of 190 GeV/c pions into $\pi^-\pi^-\pi^+$ using a hydrogen target and confirm the $\pi_1(1600) \rightarrow \rho(770)\pi$ amplitude, which interferes with a non-resonant $1^{-+}$ amplitude. We demonstrate that conflicting conclusions from previous studies on these amplitudes can be attributed to different analysis models and different treatment of the dependence of the amplitudes on the squared four-momentum transfer and we thus reconcile their experimental findings. We study the non-resonant contributions to the $\pi^-\pi^-\pi^+$ final state using pseudo-data generated on the basis of a Deck model. Subjecting pseudo-data and real data to the same partial-wave analysis, we find good agreement concerning the spectral shape and its dependence on the squared four-momentum transfer for the $J^{PC} = 1^{-+}$ amplitude and also for amplitudes with other $J^{PC}$ quantum numbers. We investigate for the first time the amplitude of the $\pi^-\pi^+$ subsystem with $J^{PC} = 1^{-+}$ in the $3\pi$ amplitude with $J^{PC} = 1^{-+}$ employing the novel freed-isobar analysis scheme. We reveal this $\pi^-\pi^+$ amplitude to be dominated by the $\rho(770)$ for both the $\pi_1(1600)$ and the non-resonant contribution. We determine the $\rho(770)$ resonance parameters within the three-pion final state. These findings largely confirm the underlying assumptions for the isobar model used in all previous partial-wave analyses addressing the $J^{PC} = 1^{-+}$ amplitude.
Interpretation of the $a_1(1420)$

Resonance-like signal $a_1(1420)$ \textit{PRL 115, 082001 (2015)} not fitting into the $q\overline{q}$ scheme of ordinary mesons Interpretations: tetraquark, molecule-like, etc.

Triangle Singularity model fitted to partial-wave data. Less parameters than BW, better quality fit.

Article accepted for publication in PRL (May 2021)
The PDG lists 25 kaon states, 12 of which need confirmation. We have 728,000 exclusive $K^-\pi^-\pi^+$ events in the range $1.0 < m_{K\pi\pi} < 3.0$ GeV/$c^2$ and $0.1 < t' < 1.0$ (GeV/$c$)$^2$.

2.4% $K^-$ in the 190 GeV/$c$ negative hadron beam. (CEDAR)

We have 720,000 exclusive $K^-\pi^-\pi^+$ events in the range $1.0 < m_{K\pi\pi} < 3.0$ GeV/$c^2$ and $0.1 < t' < 1.0$ (GeV/$c$)$^2$. 

$K_2^*(1430)$
Multi dimensional structure of the nucleon

Transversity Momentum Distributions: TMD ($x,k_T$): probe the transverse parton momentum dependence

Generalized Parton Distributions: GPD ($x,b_T$): probe the transverse parton distance dependence

COMPASS explores the multi dimensional structure of the nucleon via SIDIS, D-Y and DVCS
MC improvements

Many improvements:
2-D efficiency maps for trackers and hodoscopes, trigger efficiency, beam characteristics, calorimetry, detailed material budget, ...

DY 2018 trigger hodoscope efficiencies:

Very detailed description of the hodoscope scintillating slabs implemented in GEANT4-based MC

Greatly contributed to improve the data – MC agreement for most analyses
Data-MC comparison for scattered $\mu$ angle

Data-MC comparison for the incoming and scattered $\mu$ kinematic variables

**MC improvements**

OT: $0.040 < x < 0.060$

F2 structure function consistency check:
NMC (black) COMPASS $\mu^+$ (red) $\mu^-$ (blue)

**DY 2018 NH3**

Calorimeter cluster position

greatly improved MC – data agreement.
**DVCS analysis of 2016-17 data**

**Good agreement between exclusivity variables distributions for μ⁺ and μ⁻ beams**

Visible π⁰ candidates

Two-photon invariant mass in the exclusive single photon sample
DVCS and SIDIS analyses of 2016-17 data

\[ \mu p \rightarrow \mu \pi^0 p \]

2016 exclusive single photon distribution as function of \( \phi_{\gamma \gamma} \)

2016 and 17 statistics \( \sim 10 \times 2012 \) one

COMPASS 2012 data: PLB 793 (2019) 188
Unpolarised SIDIS data 2016

Unpolarized SIDIS → access to the **number density TMD** and to the still unknown **Boer-Mulders TMD** $h_1^T$

<table>
<thead>
<tr>
<th>Quark</th>
<th>U unpolarized</th>
<th>L longitudinally polarized</th>
<th>T transversely polarized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleon</td>
<td>$f_1^u(x, k_T^2)$ number density</td>
<td>$g_1^l(x, k_T^2)$ helicity</td>
<td>$h_1^l(x, k_T^2)$ Boer-Mulders</td>
</tr>
<tr>
<td>U unpolarized</td>
<td>$f_1^u(x, k_T^2)$ Sivers</td>
<td>$g_1^l(x, k_T^2)$ Kotzinian-Mulders worm-gear L</td>
<td>$h_1^l(x, k_T^2)$ pretzelosity</td>
</tr>
<tr>
<td>L longitudinally polarized</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T transversely polarized</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**To order 1/Q (i.e., twist-3):**

\[
F_{UU,T} = \mathcal{C}[f_1^1D_1] + \text{Boer-Mulders term}
\]

\[
F_{UU} = \frac{2M}{Q} \mathcal{C} \left[ -\frac{\langle \hat{h}\cdot \hat{k}_T \rangle}{M} f_1^1D_1 - \frac{\langle \hat{h}\cdot \hat{p}_L \rangle}{M^2 M_h} h_1^T H_1^T \right] + \ldots
\]

\[
F_{UU} = \mathcal{C} \left[ -\frac{2}{M M_h} \frac{\langle \hat{h}\cdot \hat{k}_T \rangle (\hat{h}\cdot \hat{p}_L) - \hat{h}\cdot \hat{p}_L}{M M_h} h_1^T H_1^T \right] + \ldots
\]

\[
\mathcal{C}[f_1^1D_1] = \sum_n \epsilon_n \int d^2 k_T \int d^2 \hat{p}_L \delta^2(\hat{p}_T - \hat{k}_T - \hat{p}_L) f(x, z) D^2(x, \hat{p}_L)
\]

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10/06/2021 142th SPSC meeting - CERN

Fulvio Tessarotto
Unpolarised SIDIS data 2016

important W dependence seen too
Pion-nucleon Drell-Yan cross-section on unpolarised protons:

\[
\frac{dN}{d\Omega} = \frac{3}{4\pi} \frac{1}{\lambda + 3} \left[ 1 + \lambda \cos^2 \theta_{CS} + \mu \sin 2\theta_{CS} \cos \varphi_{CS} + \frac{\nu}{2} \sin^2 \theta_{CS} \cos 2\varphi_{CS} \right]
\]

M. Lambertsen, W. Vogelsang *PRD93, 114013 (2016)*

70% of 2018 data on W

models for COMPASS kinematics
measured SIDIS TSAs:

HERMES (p target, 27.5 GeV/c beam)
COMPASS (p, d target, 160 GeV/c beam)
JLab (3He, 5.6 GeV/c beam)

for \( h^+, h^-, \pi^+, \pi^-, \pi^0, K^+, K^-, K^0, p \)

\[ s=1 \rightarrow 3x3 \text{ SDM} \]

predictions from string+3P0 model

A. Kerbizi, PhD th.
AK, hep-ph: 2004.00524

2010 COMPASS data

DIS on transv. pol. NH\(_3\) target

hadron pair selection
\( E_{\text{miss}} > 3 \text{ GeV} \)
\( 0.3 < z < 0.95 \)
\( 0.1 < P_T < 4.0 \text{ GeV/c} \)
\( 0.35 < M_{hh} < 3.0 \text{ GeV/c}^2 \)

missing energy
fractional energy of the pair \( z = z_{h_1} + z_{h_2} \)
transverse momentum of the pair \( \vec{P}_T = \vec{P}_{1T} + \vec{P}_{2T} \)
invariant mass

\[
A_{UT}^{\sin \phi X} = \frac{1}{f_S} \left[ a_{UT}^{\sin \phi X} - (1 - f_S) A_{UT,bg}^{\sin \phi X} \right]
\]

\( X = \text{Collins, Sivers} \)
Collins asymmetry for $h^+ h^-$ pairs in four mass regions

First measurement of Collins asymmetry for inclusive $\rho^0$

A. Kerbizi, DIS 2021

First measurement of Sivers asymmetry for inclusive $\rho^0$

COMPASS preliminary result in line with string+3P0 predictions

Indication for positive Sivers for inclusive $\rho^0$
Probing Transversity by $\Lambda$ and $\bar{\Lambda}$ polarisation

Polarisation of fragmenting quark (transversity) $\rightarrow$ $\Lambda$ polarisation via the FF $H_{1}^{\Lambda/q}$

$\Lambda \rightarrow p\pi^{-}$ self-analysing: angular asymmetry of the decay $p$

Submitted to PLB

new input from 2021 run
Exclusively produced $\rho^0$ mesons

$$\gamma^U \cdot L (\Phi, \phi, \cos \Theta) = \gamma^U (\Phi, \phi, \cos \Theta) + P_H \gamma^L (\Phi, \phi, \cos \Theta).$$

$$\gamma^U (\Phi, \phi, \cos \Theta) \quad \begin{align*}
= \frac{3}{8\pi^2} \left[ \frac{1}{2} (1 - r_{00}^{04}) + \frac{1}{2} (3r_{00}^{04} - 1) \cos^2 \Theta \\
- \sqrt{2} \text{Re} [r_{10}^{04}] \sin 2\Theta \cos \phi - r_{10}^{04} \sin^2 \Theta \cos 2\phi \\
- \epsilon \cos 2\Phi (r_{11}^{01} \sin^2 \Theta + r_{00}^{01} \cos^2 \Theta) \\
- \sqrt{2} \text{Re} [r_{10}^{01}] \sin 2\Theta \cos \phi - r_{10}^{01} \sin^2 \Theta \cos 2\phi \right] \\
- \epsilon \sin 2\Phi \left( \sqrt{2} \text{Im} [r_{10}^{01}] \sin 2\Theta \sin \phi \\
+ \text{Im} [r_{10}^{01}] \sin^2 \Theta \sin 2\phi \right) \\
+ \sqrt{2} \epsilon (1 + \epsilon) \cos \Phi \left( r_{11}^{05} \sin^2 \Theta + r_{00}^{05} \cos^2 \Theta \right) \\
- \sqrt{2} \text{Re} [r_{10}^{05}] \sin 2\Theta \cos \phi \\
- r_{10}^{05} \sin^2 \Theta \cos 2\phi \right].
\end{align*}$$

$$\gamma^L (\Phi, \phi, \cos \Theta) \quad \begin{align*}
= \frac{3}{8\pi^2} \left[ \sqrt{1 - \epsilon^2} \left( \sqrt{2} \text{Im} [r_{10}^{05}] \sin 2\Theta \sin \phi \\
+ \text{Im} [r_{00}^{05}] \sin^2 \Theta \sin 2\phi \right) \\
+ \sqrt{2} \epsilon (1 - \epsilon) \cos \Phi \left( \sqrt{2} \text{Im} [r_{10}^{05}] \sin 2\Theta \sin \phi \\
+ \text{Im} [r_{00}^{05}] \sin^2 \Theta \sin 2\phi \right) \\
+ \sqrt{2} \epsilon (1 - \epsilon) \sin \Phi \left( r_{11}^{05} \sin^2 \Theta + r_{00}^{05} \cos^2 \Theta \\
- \sqrt{2} \text{Re} [r_{10}^{05}] \sin 2\Theta \cos \phi \\
- r_{10}^{05} \sin^2 \Theta \cos 2\phi \right) \right].
\end{align*}$$

A: $\gamma_L \to \rho_L^0$, $\gamma_T \to \rho_T^0$

B: Interference $\gamma_L \to \rho_L^0$ & $\gamma_T \to \rho_T^0$

C: $\gamma_L \to \rho_L^0$

D: $\gamma_L \to \rho_T^0$

E: $\gamma_T \to \rho_T^0$

SDME value
COMPASS recent and ongoing publications

Published in 2019 - 2021

- Transverse extension of partons in the proton probed by deeply virtual compton scattering PLB 793 (2019) 188
- Measurement of $P_T$-weighted Sivers asymmetries in leptoproduction of hadrons. NPB 940 (2019) 34
- Measurement of the cross section for hard exclusive $\pi^0$ leptoproduction. PLB 805 (2020) 135454
- Exclusive processes contribution to the measured SIDIS azimuthal asymmetries. NPB 956 (2020) 115039
- A Triangle Singularity as the origin of the $a_1(1420)$. Accepted for publication in PRL
- Probing transversity by measuring $\Lambda$ polarisation in SIDIS Submitted to PLB
- SDMEs in Exclusive omega meson muoproduction at COMPASS EPJC (2021) 81 126

Ongoing drafting

- Properties of the exotic meson $\pi_1(1600)$ with $J^{PC}=1^{-+}$ and its decay into $\rho(770)\pi$ (soon subm. PRD)
- Study of double $J/\psi$ production
- Target transverse polarization dependent azimuthal asymmetries in muon-proton SIDIS
- Multidimensional transverse polarization dependent azimuthal asymmetries in muon-proton SIDIS
- Target longitudinal polarization dependent azimuthal asymmetries in muon-proton
- Dihadron transverse spin asymmetries for pions and kaons on $p$ and $d$
- Hadron transverse momentum distributions in muon-proton deep inelastic scattering
- Spin Density Matrix Elements in exclusive $\rho^0$ meson muoproduction

From COMPASS to AMBER: exploring fundamental properties of hadrons. EP Newsletter (11thDecember 2020)
### Detector Readiness

<table>
<thead>
<tr>
<th>Detector</th>
<th>Readiness</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td>Silicon Trackers</td>
<td>✓</td>
<td>Tracker stations to be installed, refurbished nitrogen cooling system to be tested.</td>
</tr>
<tr>
<td>Polarised Target</td>
<td>✓</td>
<td>Isolation vacuum leak to be fixed, polarised target to be commissioned, new microwave system to be tested.</td>
</tr>
<tr>
<td>Scintillating Fibres</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td>Trigger and Veto hodoscopes</td>
<td>✓</td>
<td>All hodoscopes ready except H1 which has been refurbished and needs to be installed and tested.</td>
</tr>
<tr>
<td>Micromegas</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td>GEM Trackers</td>
<td>✓</td>
<td>Ready. Two new stations being produced.</td>
</tr>
<tr>
<td>Drift Chambers</td>
<td>✓</td>
<td>DC5 detector planes Y,Y’ to be repaired. DC0, DC1 and DC4 ready.</td>
</tr>
<tr>
<td>Straw Drift Chambers</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td><strong>RICH</strong></td>
<td>✓</td>
<td>$C_4F_{10}$ radiator gas cleaned, FEE tested.</td>
</tr>
<tr>
<td><strong>RICH-WALL</strong></td>
<td>✓</td>
<td>RICH WALL refurbished and reassembled. To be installed and commissioned.</td>
</tr>
<tr>
<td><strong>ECAL1-ECAL2</strong></td>
<td>✓</td>
<td>Ready, apart the monitoring system of ECAL1.</td>
</tr>
<tr>
<td><strong>HCAL1-HCAL2</strong></td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td>MWPCs</td>
<td>✓</td>
<td>Damaged detectors repaired. New FEE electronic to be installed on one detector.</td>
</tr>
<tr>
<td>Muon Walls</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td>W45</td>
<td>✓</td>
<td>Ready.</td>
</tr>
<tr>
<td><strong>DAQ HW</strong></td>
<td>✓</td>
<td>Ready, including spare components.</td>
</tr>
<tr>
<td>DAQ SW</td>
<td>✓</td>
<td>New DAQ software and library tested during the 2020 dry run.</td>
</tr>
<tr>
<td>DCS</td>
<td>✓</td>
<td>New HW integrated in the DCS system, tests to be completed.</td>
</tr>
</tbody>
</table>
new LN$_2$ cooling system control for Si (EP-DT)

Cold Silicon Stations to be installed soon

Sci Fi stations reinstalled
Micromegas and Large Drift Chambers

Micromegas: ready

DC4 repaired and reinstalled

W45: ready

DC5 Y,Y’ repair under discussion
H1 trigger hodoscope refurbished

H1 scintillator slabs showing signs of deformation

H1 refurbished and ready for assembling and installation
The RICH Wall has been fully refurbished

RW disassembling 2019

RW tubes repair over by May

Refurbished RW now reassembled
11 GEM stations ready for the 2021 run.
2 new GEMs in construction

- Triple GEM stack
- Foils segmented on one side: 12 sectors + centre
- All tracks guided through one corner with coverlay protection
- Foils rotated by 90 degree
- Cu thickness reduced
- Silver connections (Via)
The RICH radiator gas (650 kg C$_4$F$_{10}$) has been purchased from F2 Chemicals and cleaned to rich good VUV transparency.

It required long and delicate gas cleaning work.

COMPASS RICH-1 is ready for the 2021 run.
Polarised Target preparation in 2021

**COMPASS**

**Polarised Target**
- 50 mK dilution refrigerator
- 2.5 T solenoid + 0.6 T dipole
- 3 target cells (30-60-30 cm)
- 70 GHz microwave

**Cooling in 2021**
- March 29 : Precooling of Magnet
- April 28 : Target Material loading
- May 5 : liquid helium filling to Mixing chamber
- May 14 : Leak of target holder vacuum found
- May 27 : Target material unloading

**Temperature**
- Mixing chamber: 30K→2K
- Holder vacuum: 9x10^{-3} mbar
- Holder vacuum: 5x10^{-2} mbar
Components Suspected of possible leaks

Target holder with the cells mounted.

3D model of the target holder.

Target holder construction time foto.

downstream flange
Default scenario

• The leak is located by June 23

• Repair and validation tests are then completed within the following 2 weeks

• The Polarised Target material will be loaded before mid July

• The spectrometer commissioning (3 weeks requested) will be completed as originally scheduled

• COMPASS physics run can start at the beginning of August as originally foreseen (65 days of transversity data taking)
Possible Scenario 2

• The leak location and repair (new target holder isolation vacuum) takes about 6 weeks (maximum “tolerable” delay)

• The Polarised Target material can be loaded in the first half of August

• COMPASS physics run can start by the end of August

• One month delay
  • only 35 days of transversity data taking (according to the preliminary schedule)

➔ COMPASS will ask for rediscussing of the 2021 beam allocation.
Summary

- The COMPASS Experiment is advancing in the analysis of the collected data

- Important progress on all research lines: Spectroscopy, GPDs, SIDIS and Drell-Yan

- The spectrometer preparation is well advanced

- Polarised target preparation status
  - May 14: leak found (target isolation vacuum)
  - Large effort ongoing to fix the problem
  - Expected to be fixed in a few weeks.
  - If not, the start of the COMPASS 2021 run will be delayed (different scenarios are being evaluated)
### Foreseen run preparation schedule

<table>
<thead>
<tr>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MON</td>
<td>2 FRI</td>
<td>3 WED</td>
<td>4 THU</td>
<td>5 FRI</td>
<td>1 SAT</td>
<td>12 MON</td>
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**SM1-SM2**

**D7**

**CERN**

**Fulvio Tessarotto**
Polarised Target preparation in 2021

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<th>Feb</th>
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<td>Leak check</td>
<td>Cooling</td>
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<td>Cooling by He</td>
<td>4He</td>
<td>Material Loading (~20/4)</td>
<td>TE calibration</td>
<td>DNP</td>
<td>Dilution &amp; DNP test</td>
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<td>2.5T Sol. &amp; 0.6 T Dip.</td>
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<td>Trim coils tuning</td>
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The preparations were on schedule until the beginning of May.
We started early, keeping a safety margin before the run (constrained by liquid He supply).
The magnet was tested already in November 2020.
On 28 April the target was loaded with $^6$LiD.
NMR connector feed-through
Leak search and repair

May 31: room temperature $1.3 \times 10^{-9}$ mbarl/s BG no leak

June 1: 1st leak test with LN2

$1.3 \times 10^{-9}$ mbarl/s BG $\rightarrow 1.5 \times 10^{-8}$ mbarl/s

Some amount of gas trapped after superfluid leak.

June 2-4: Leak tests with LN2 for three times

No leak found

June 4+: preparing tests with LHe @ CryoLab

Great help from EP-DT CryoLab (COMPASS in priority: thanks)

A prioritization of COMPASS requests to the CERN main mechanical workshop for small emergency machining would be of great help to minimize waiting time.
SIDIS hadron multiplicity ratios at high $z$

$K^-$ over $K^+$ multiplicity ratios published: PLB 786 (2018) 390

$p\bar{p}$ over $p$ below prediction over the full $z$ range

PLB 807 (2020) 135600
Comparison of the SDMEs of hard exclusive $\omega$ mesons measured by COMPASS with calculations of the GPD model of Goloskokov and Kroll, EPJ A50 (2014) 146

SDMEs of hard exclusive $\omega$ mesons

$\mu p \rightarrow \mu' p' \omega 
\rightarrow \pi^+ \pi^- \pi^0 
\rightarrow \gamma \gamma$