



# COMPASS Annual Review

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Meeting with spokespersons on June 8, 2021

142<sup>nd</sup> SPSC Meeting, June 11 2021

# Overview of COMPASS Current Analyses

Channel	Status	Details
<b>Hadron data</b>		
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 $1^-+1^+$ $\rho(770)\pi P$ 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 $\pi^- p \rightarrow \pi^- \eta^{(\prime)} p$	update	fit of double-Regge models at large $m_{\eta^{(\prime)}\pi}$ 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 $\pi^- p \rightarrow K^- K_S^0 p$ and $K^- p \rightarrow \pi^- K_S^0 p$	new	event selection
<b>Study of exclusive reactions with 2012 data</b>		
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
<b>Study of exclusive reactions with 2016-2017 data</b>		
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)
<b>Multiplicities</b>		
$\bar{p}/p$ 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)

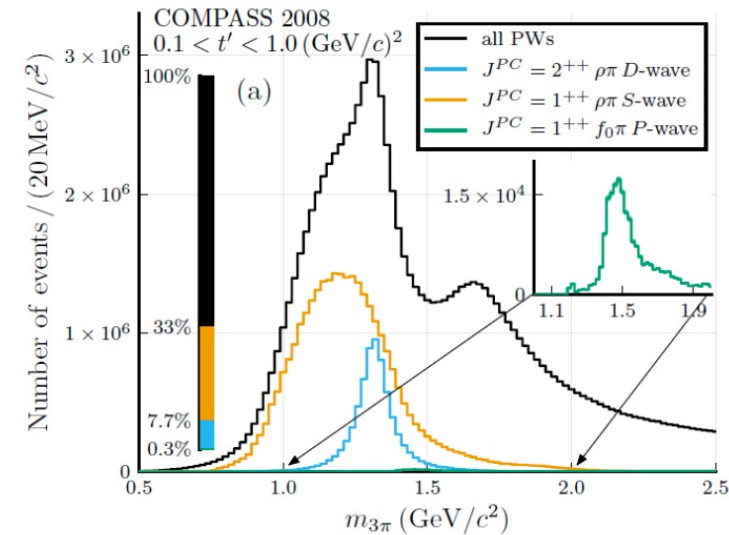
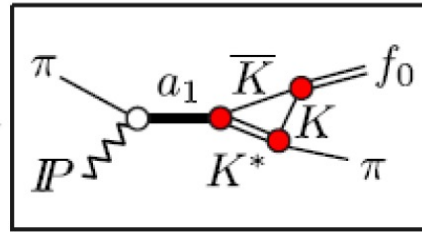
Channel	Status	Details
<b>Transverse spin and TMD analyses</b>		
Other $P_T$ -weighted transverse spin asymmetries (SIDIS 2010 data)	ongoing	study of systematics
MultiD analysis of transverse spin asymmetries (SIDIS 2010 data)	ongoing	VM contribution study
Inclusive $\rho^0$ Collins and Sivers asymmetries, proton 2010 data	new	preliminary results shown at DIS-2021, paper planned
Measurement of $g_2^p$ (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/D 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
<b>Drell-Yan and Charmonium analyses</b>		
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 unpolarised 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

~2/3 publications/year

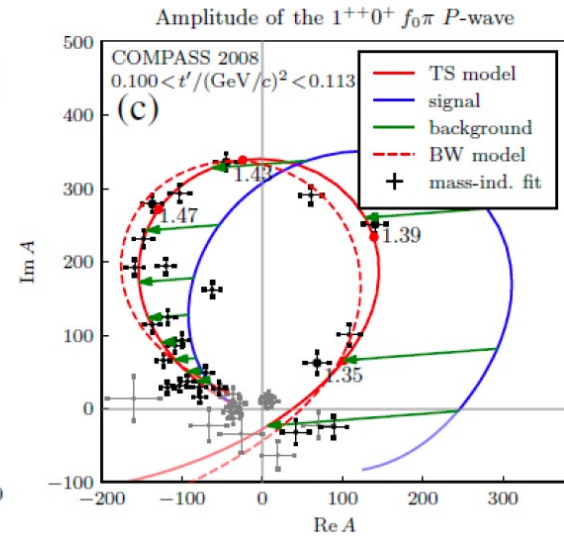
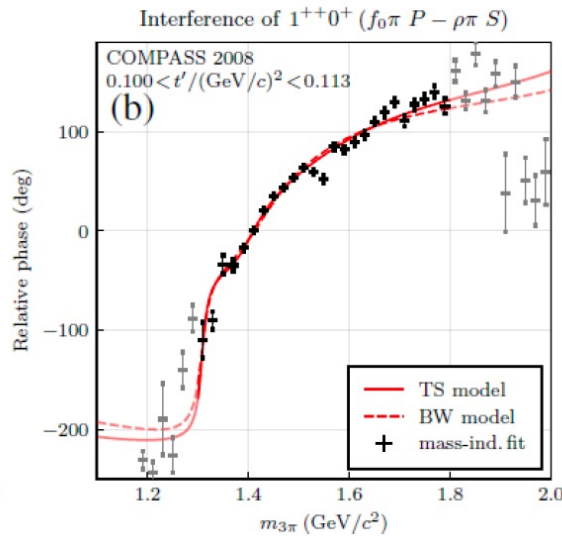
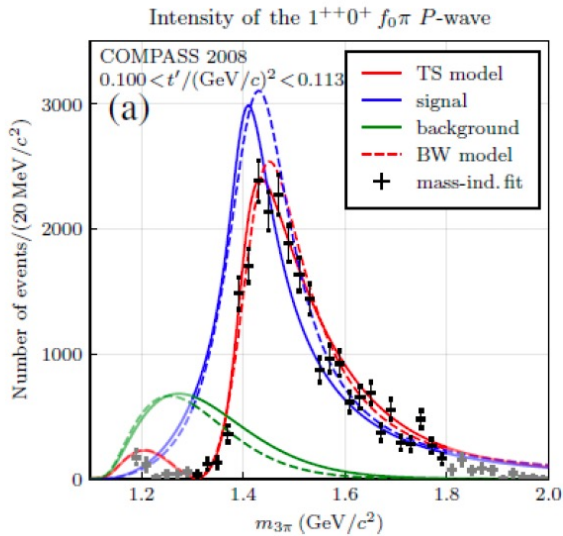
# Origin of the Resonance-like Signal $a_1(1420)$

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

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



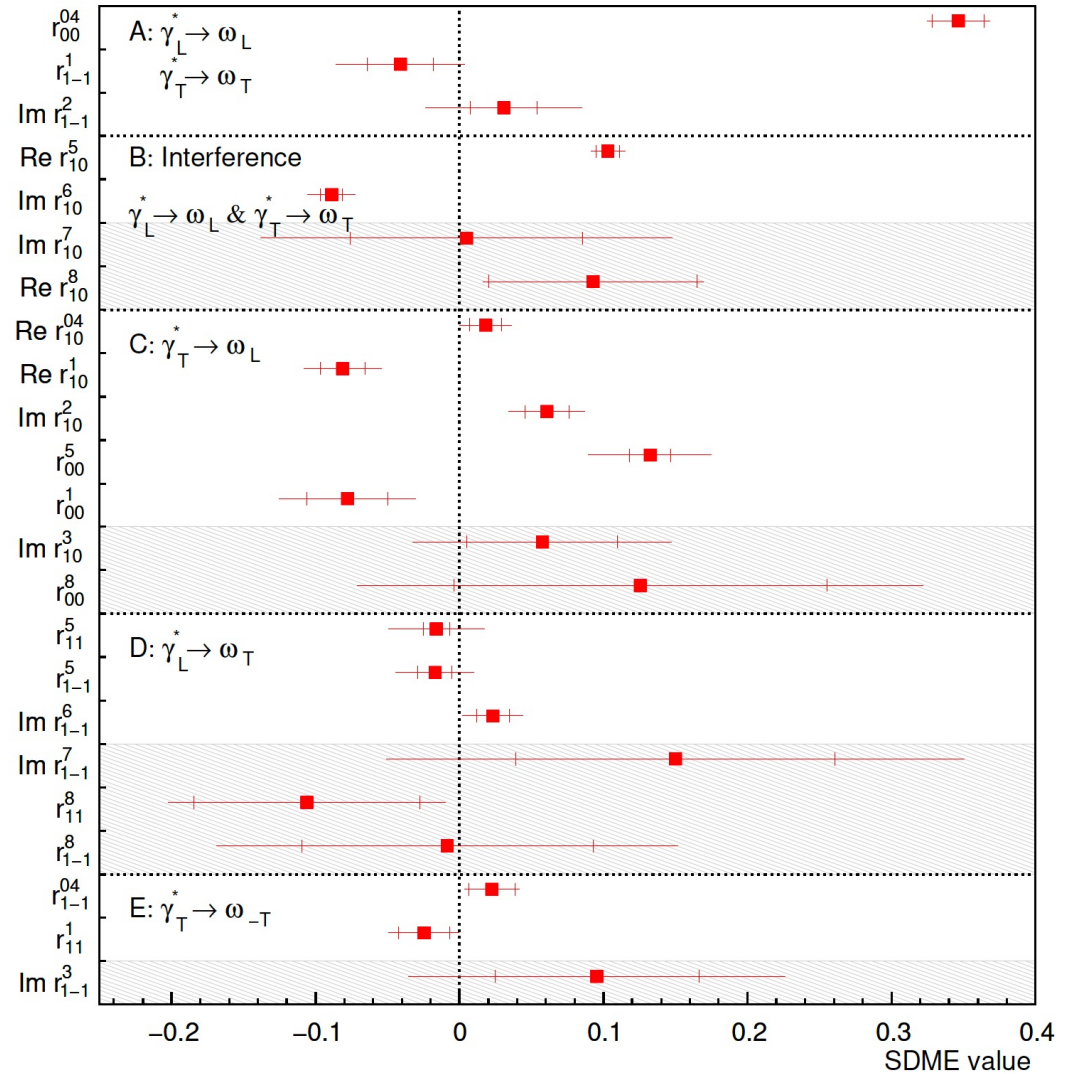
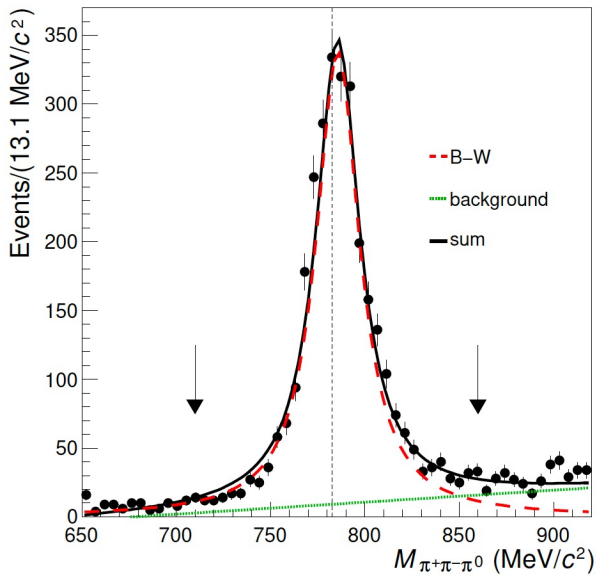
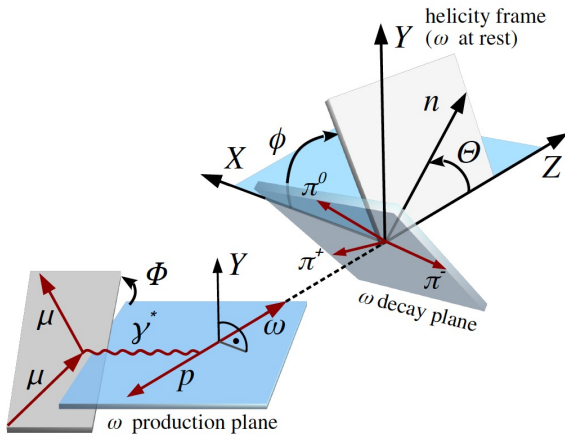
Article accepted for publication in PRL (May 2021)



# Exclusive $\omega$ electroproduction

EPJC 81 (2021) 126

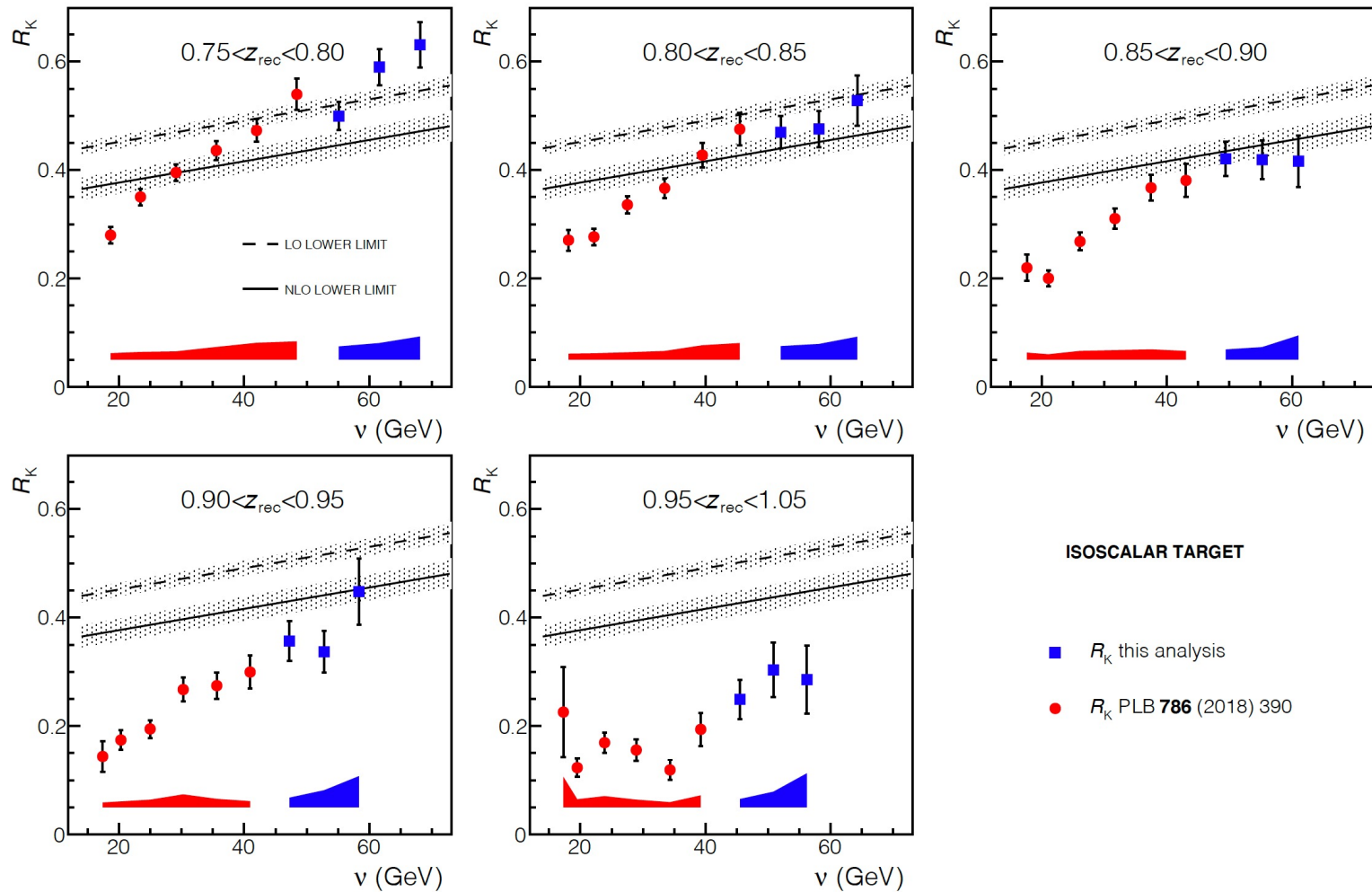
$$\mu + p \rightarrow \mu' + p' + \omega,$$



# Multiplicity Ratios

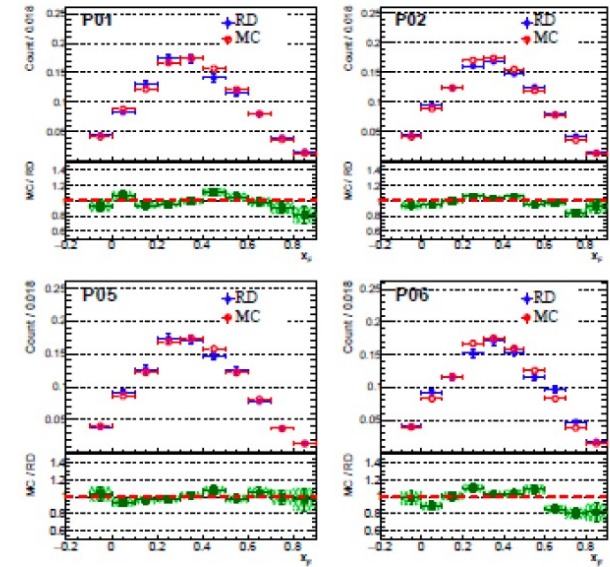
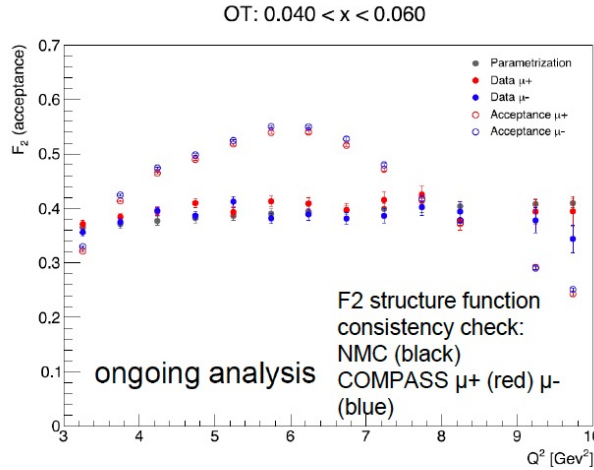
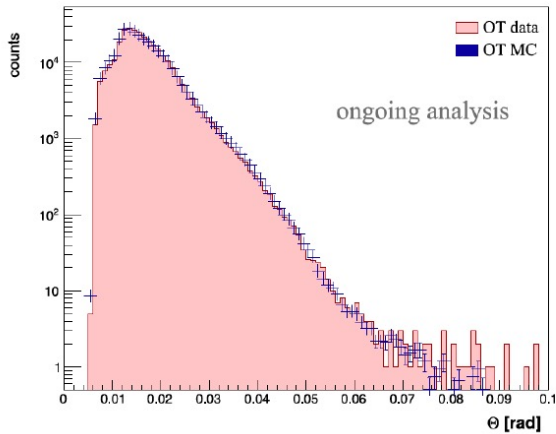
Study made for  $\bar{p}$  over  $p$  and  $K^-$  over  $K^+$

PLB 807 (2020) 135600

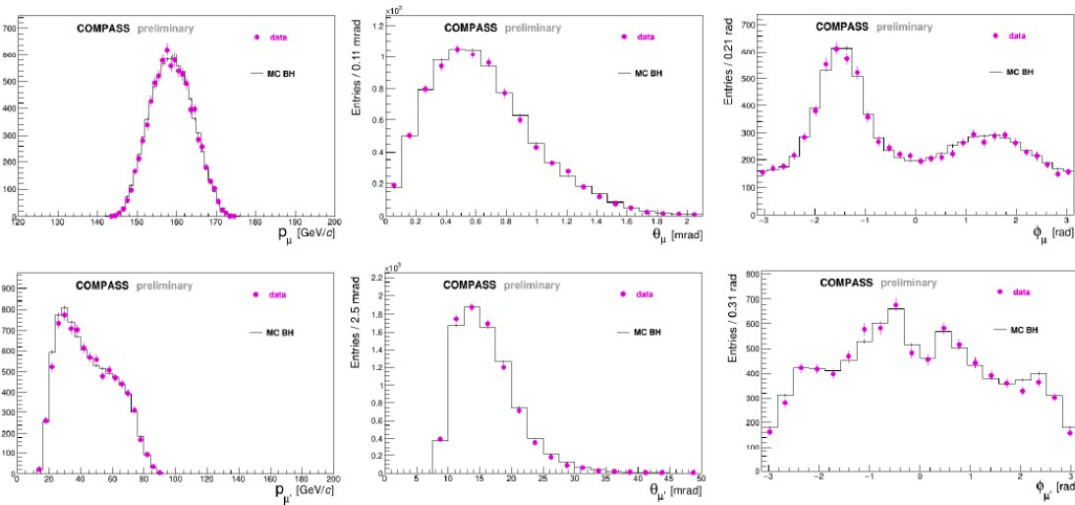


# MC – Data Agreement

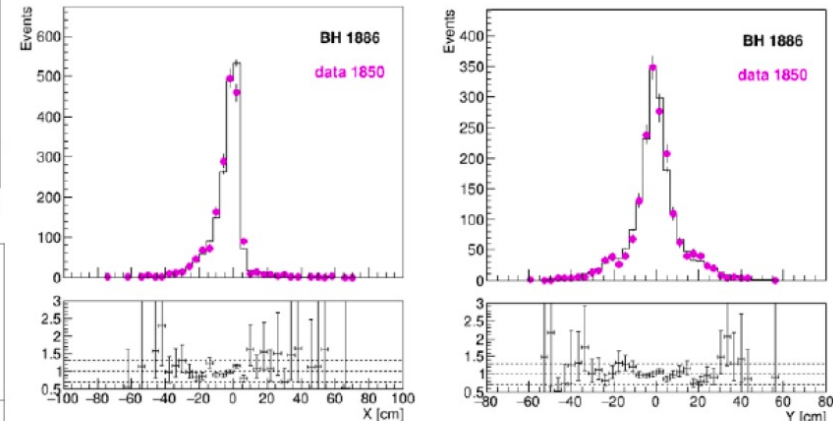
DY 2018 NH<sub>3</sub>



Data-MC comparison for scattered  $\mu$  angle



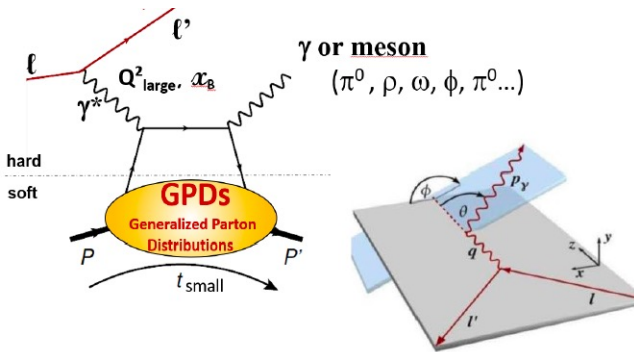
Data-MC comparison for the incoming and scattered  $\mu$  kinematic variables



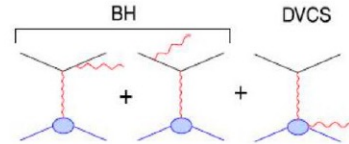
Calorimeter cluster position

greatly improved  
MC – data agreement.

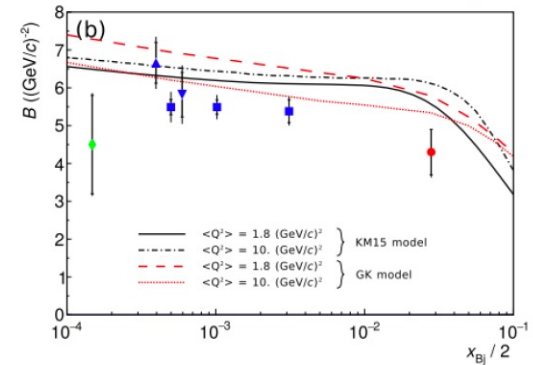
# DVCS Analysis '16-'17



$$\mu p \rightarrow \mu \pi^0 p$$

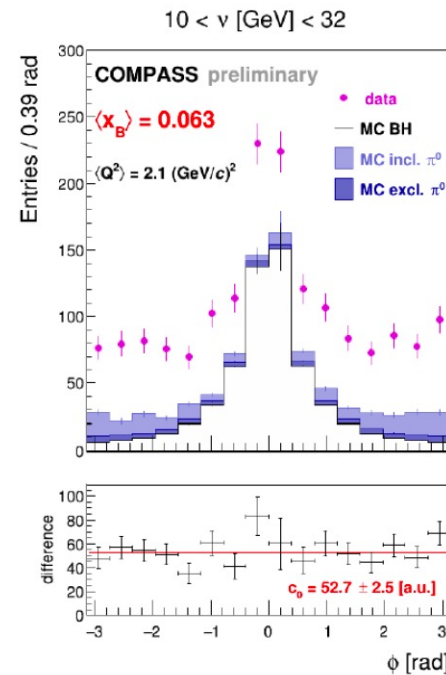
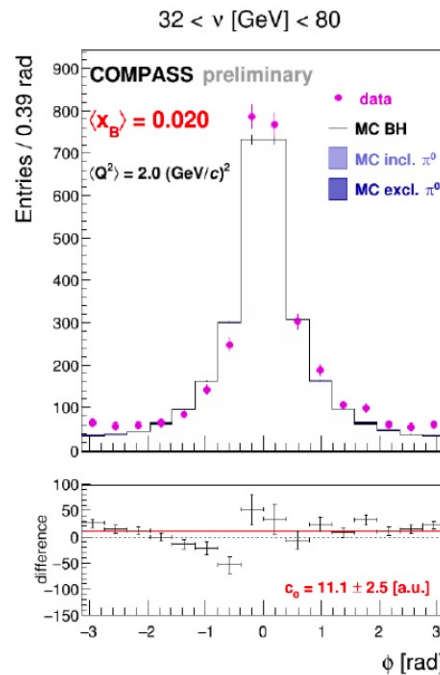
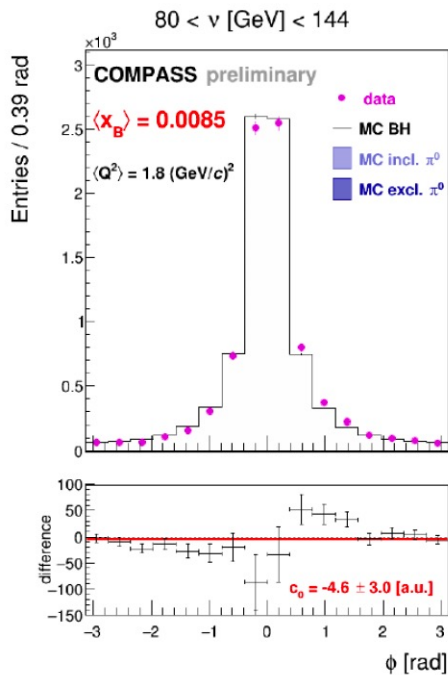


$$d\sigma \propto |T_{BH}|^2 + \text{Interference Term} + |T_{DVCS}|^2$$



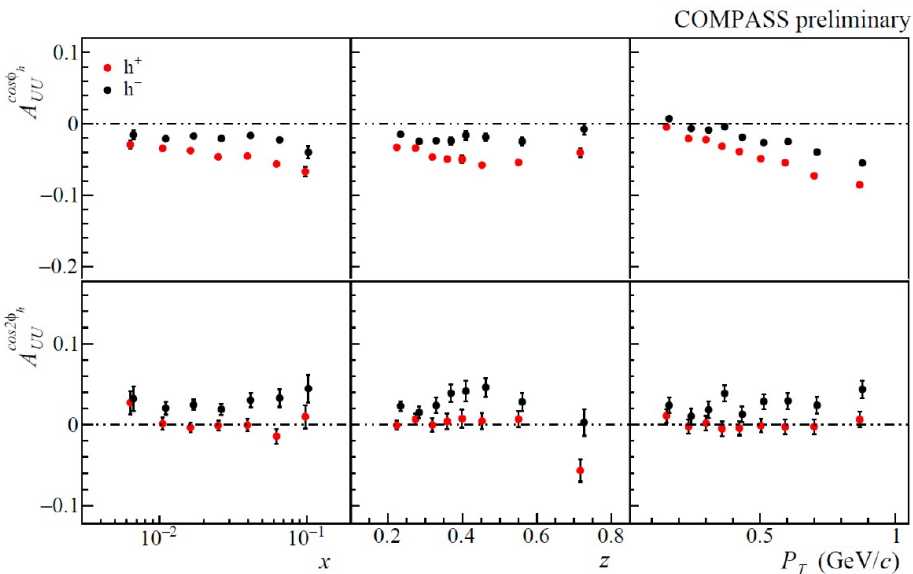
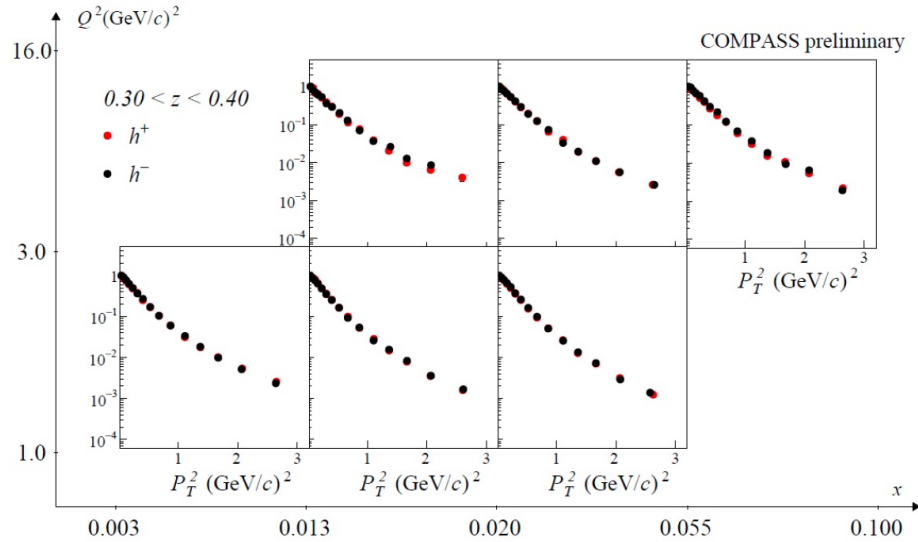
COMPASS 2012 data: PLB 793 (2019) 188

2016 exclusive single photon distribution as function of  $\phi_{\gamma^* \gamma}$

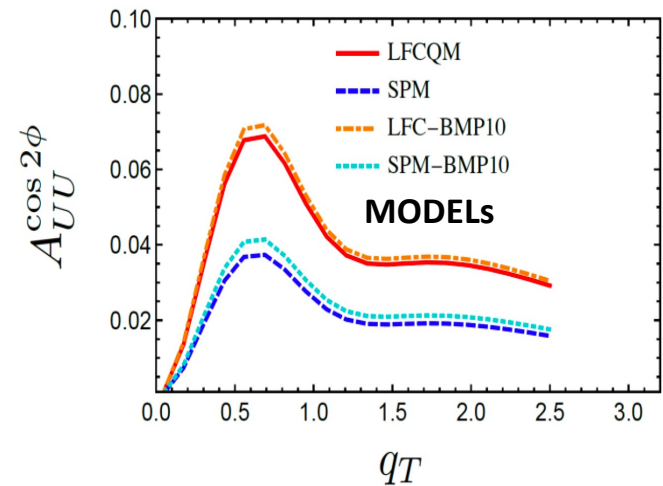
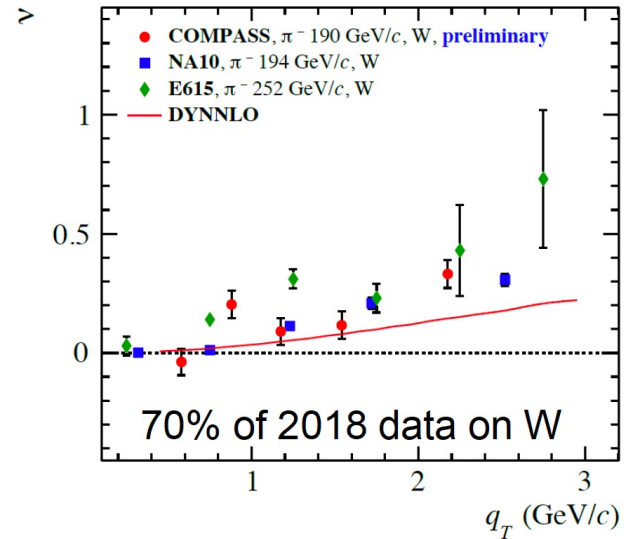


2016 and 17 statistics  $\sim 10$  x 2012 one

## Deep-inelastic scattering



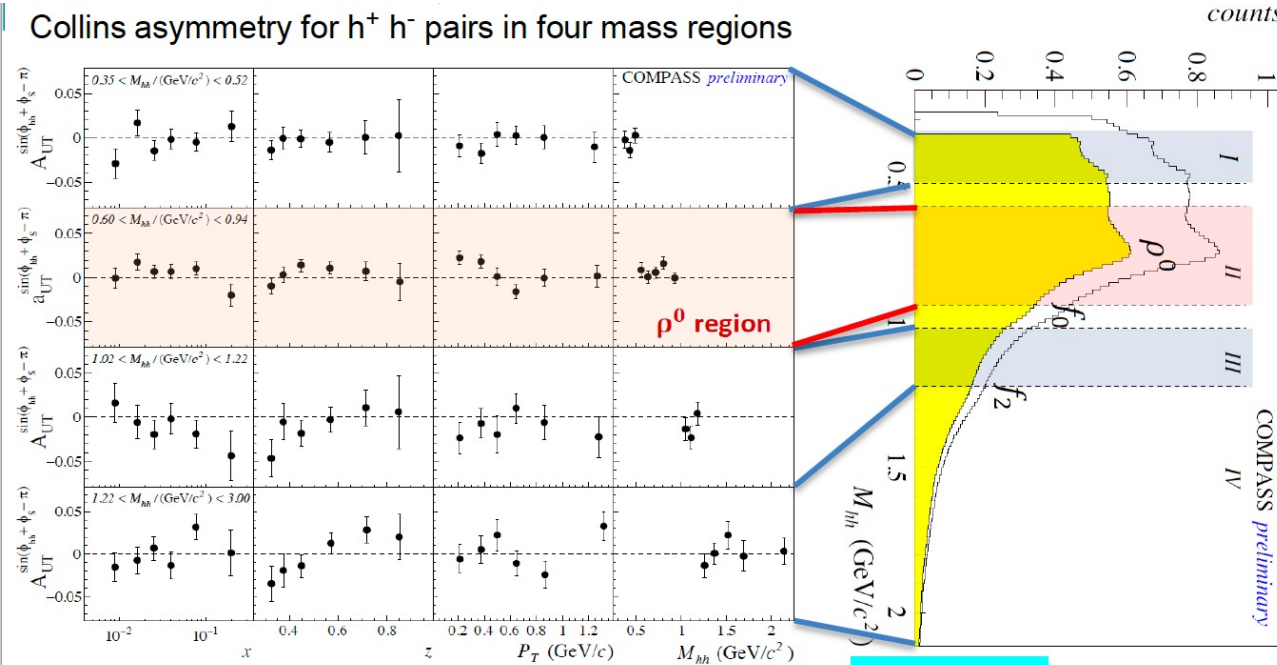
## Drell-Yan



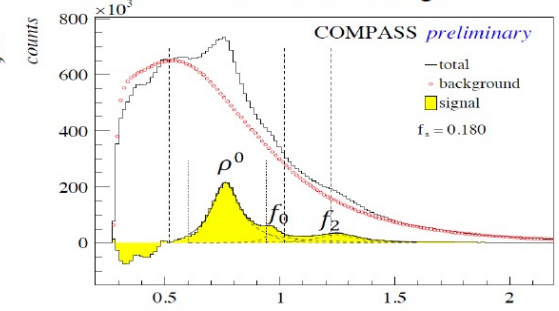


# QCD Spin-Orbit effect in Fragmentation

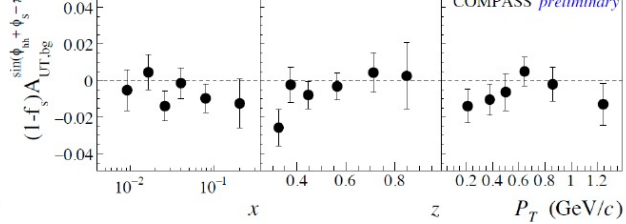
Collins asymmetry for  $h^+ h^-$  pairs in four mass regions



background estimated using pairs of hadrons with the same charge



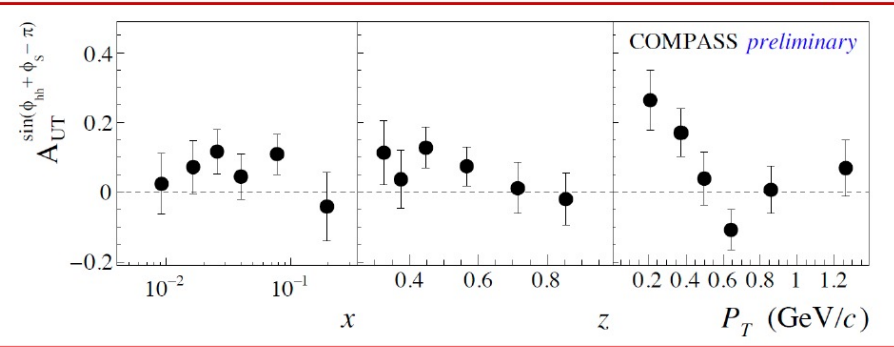
background contribution to the Collins asymmetry:



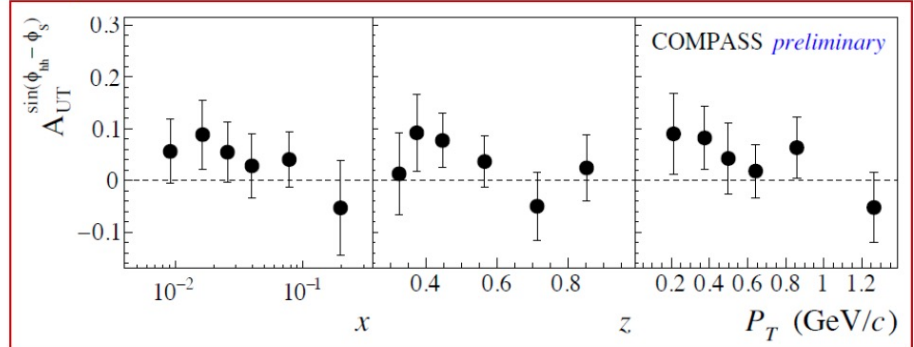
First measurement of Collins asymmetry for inclusive  $p^0$

A. Kerbizi, DIS 2021

First measurement of Sivers asymmetry for inclusive  $p^0$

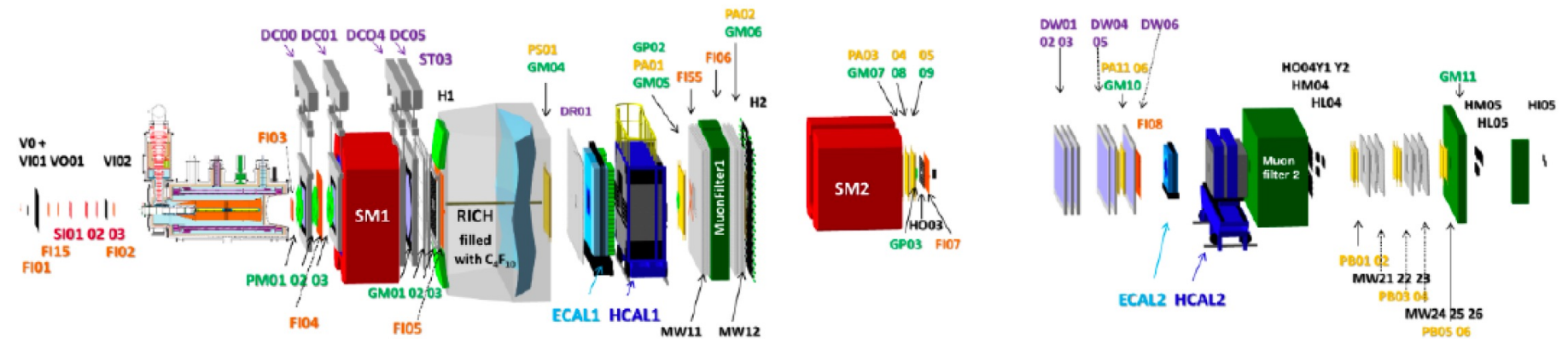


COMPASS preliminary result in line with string+3P0 predictions



indication for positive Sivers for inclusive  $p^0$

# COMPASS Readiness for Run



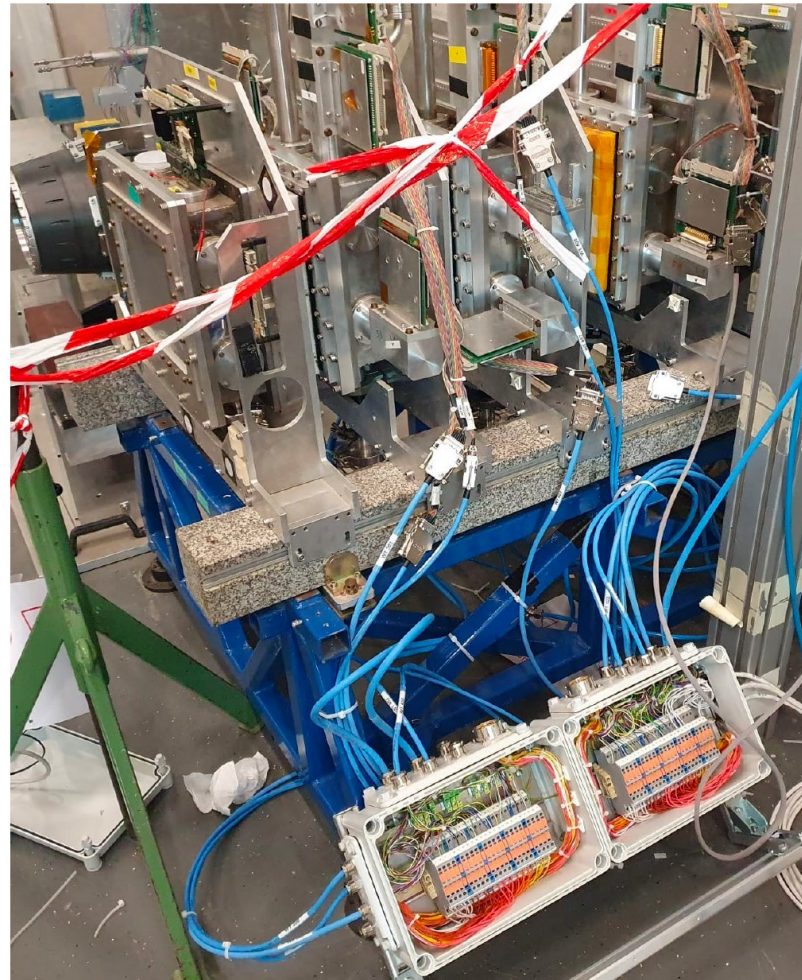
Detector	Readiness	Comments
BMS	✓	Ready.
Silicon Trackers	✓	Tracker stations to be installed, refurbished nitrogen cooling system to be tested.
Polarised Target	✓	Isolation vacuum leak to be fixed, polarised target to be commissioned, new microwave system to be tested.
Scintillating Fibres	✓	Ready.
Trigger and Veto hodoscopes	✓	All hodoscopes ready except H1 which has been refurbished and needs to be installed and tested.
Micromegas	✓	Ready.
GEM Trackers	✓	Ready. Two new stations being produced.
Drift Chambers	✓	DC5 detector planes Y,Y' to be repaired. DC0, DC1 and DC4 ready.
Straw Drift Chambers	✓	Ready.

RICH	✓	$C_4F_{10}$ radiator gas cleaned, FEE tested.
RICH-WALL	✓	RICH WALL refurbished and reassembled. To be installed and commissioned.
ECAL1-ECAL2	✓	Ready, apart the monitoring system of ECAL1.
HCAL1-HCAL2	✓	Ready.
MWPCs	✓	Damaged detectors repaired. New FEE electronic to be installed on one detector.
Muon Walls	✓	Ready.
W45	✓	Ready.
DAQ HW	✓	Ready, including spare components.
DAQ SW	✓	New DAQ software and library tested during the 2020 dry run.
DCS	✓	New HW integrated in the DCS system, tests to be completed.

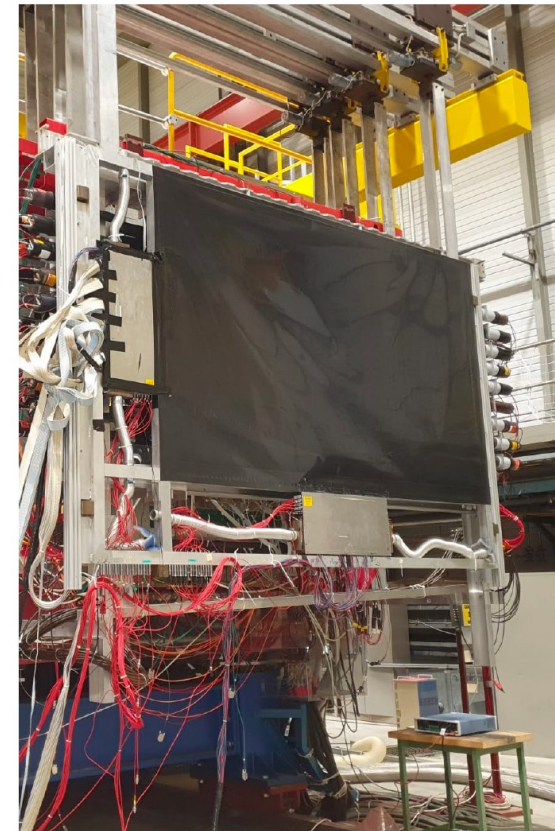
# Silicon Microstrip Detectors



new LN<sub>2</sub> cooling  
system control  
for Si (EP-DT)



Cold Silicon Stations to be  
installed soon



Sci Fi stations reinstalled

# RICH Wall



**RW disassembling 2019**



**Refurbished RW now reassembled**

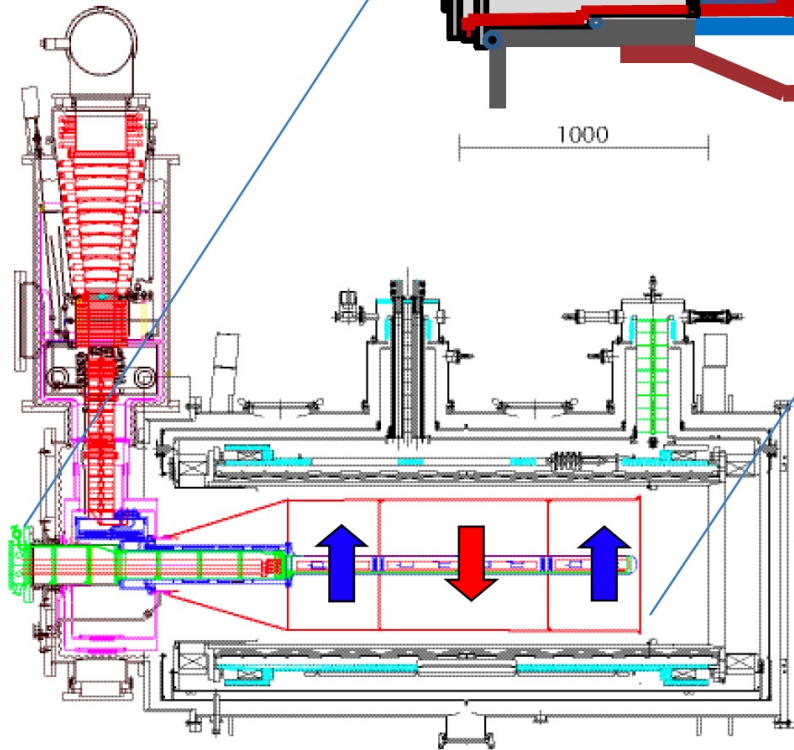


**RW tubes repair over by May**

## COMPASS

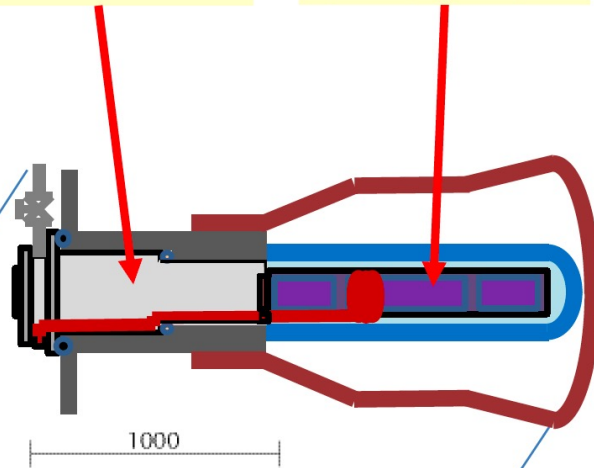
### Polarised Target

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



Target holder vacuum chamber

Mixing chamber (3-target-cell)



## Cooling in 2021

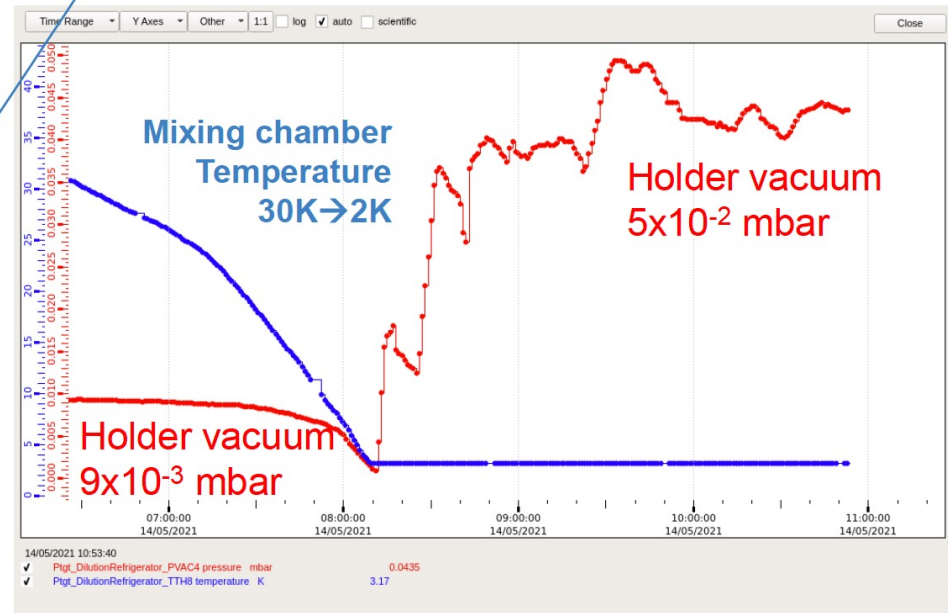
March 29 : Precooling of Magnet

April 28 : Target Material loading

May 5 : liquid helium filling to Mixing chamber

May 14 : Leak of target holder vacuum found

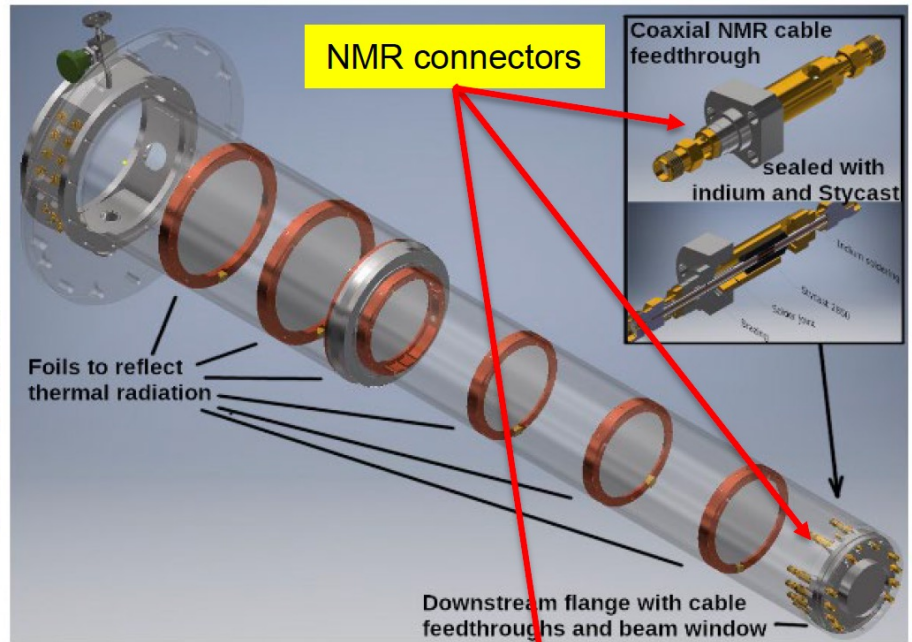
May 27 : Target material unloading



# Target Holder



Target holder with the cells mounted.



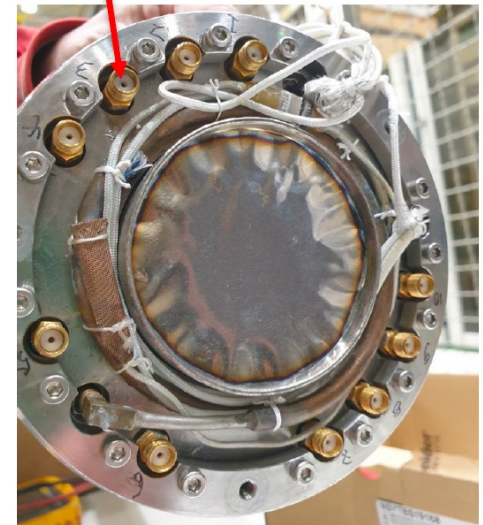
3D model of the target holder.



Target holder construction time foto.



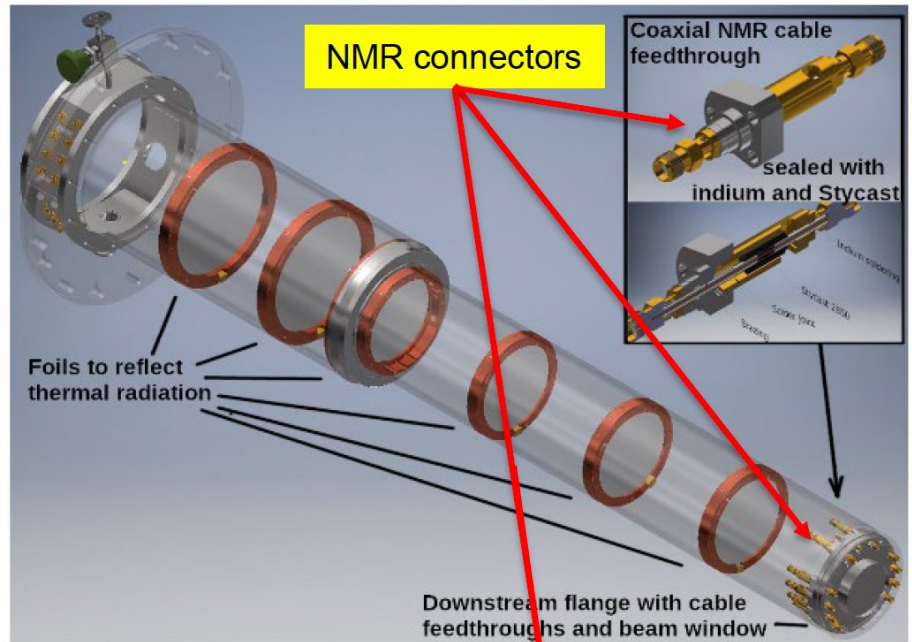
downstream flange



# NMR Connectors



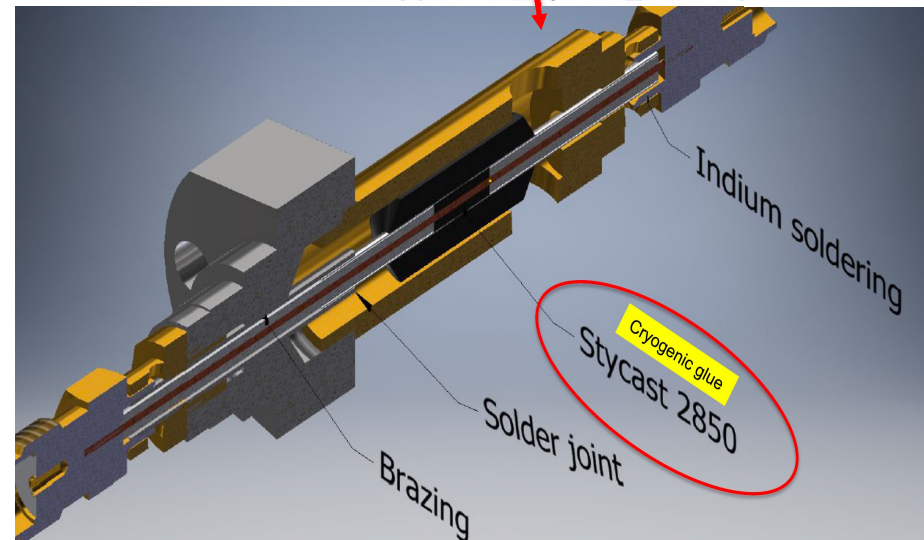
Target holder with the cells mounted.



3D model of the target holder.



Target holder construction time foto.



A similar problem happened in 2014

# NMR Connectors

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

June 1 : 1<sup>st</sup> 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

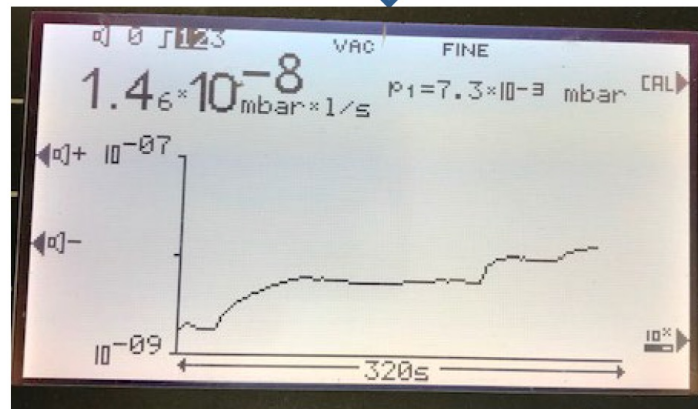
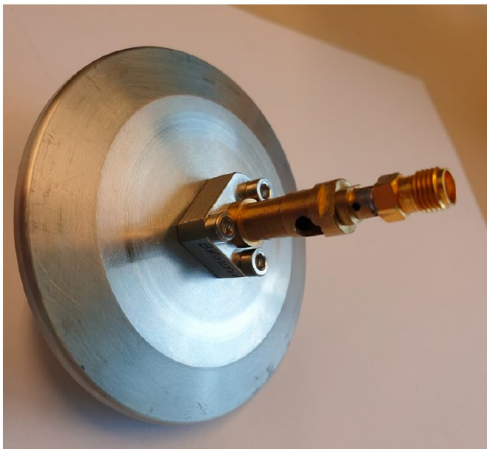
June 4- : preparing tests with LHe @ CryoLab

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



NMR connector

## leak tests at CryoLab



1<sup>st</sup> leak test with LN2

A prioritization of COMPASS requests to the CERN main mechanical workshop for small emergency machining would be of great help to minimize waiting time.

Plan to isolate step by step part of the connectors with teflon cups (method to be validated)



Fulvio Tassarotto message:

We received a suggestion from Johan Bremer (Cryolab boss):  
ask for some priority for emergency mechanical machining at CERN:  
COMPASS is in priority 1 at Cryolab, but waiting for the machining of  
pieces needed for the leak search should be minimized.

Scenario 1: leak located by June 23  
repair and validation in the next 2 weeks  
polarise material is loaded before mid July  
regular commissioning and run

Scenario 2: leak and repair takes about 6 weeks (~ 1 month delay)  
polarised target material is loaded in the first half of August  
COMPASS physics run can start before the end of August  
to reach a minimum of 42 days implies a beam schedule change

## 138<sup>th</sup> SPSC Meeting:

The SPSC **congratulates** the COMPASS Collaboration on their publications on exclusive  $\pi^0$  production and on the contribution of exclusive diffractive processes to azimuthal asymmetries in semi-inclusive DIS.

The Committee **takes note** of the wide range of ongoing analyses and is looking forward to their publication.

The SPSC **notes** with pleasure the progress achieved by the collaboration in preparing the experimental setup for the coming run.

## Suggested minutes of the 142<sup>th</sup> SPSC meeting:

The SPSC **congratulates** the COMPASS Collaboration on their publications on spin-density matrix elements in exclusive omega meson muon-production, on the antiproton over proton and K<sup>-</sup> over K<sup>+</sup> multiplicity ratios in deep-inelastic scattering, **and on their studies clarifying the nature of the a<sub>1</sub>(1420) signal.**

The SPSC **acknowledges** the effort devoted by the Collaboration and the CERN EP-DT group to solve the leak of the target holder vacuum and minimize the possible impact on the COMPASS physics run.