AMBER

Apparatus for Meson and Baryon Experimental Research

Drell-Yan Physics at COMPASS and AMBER

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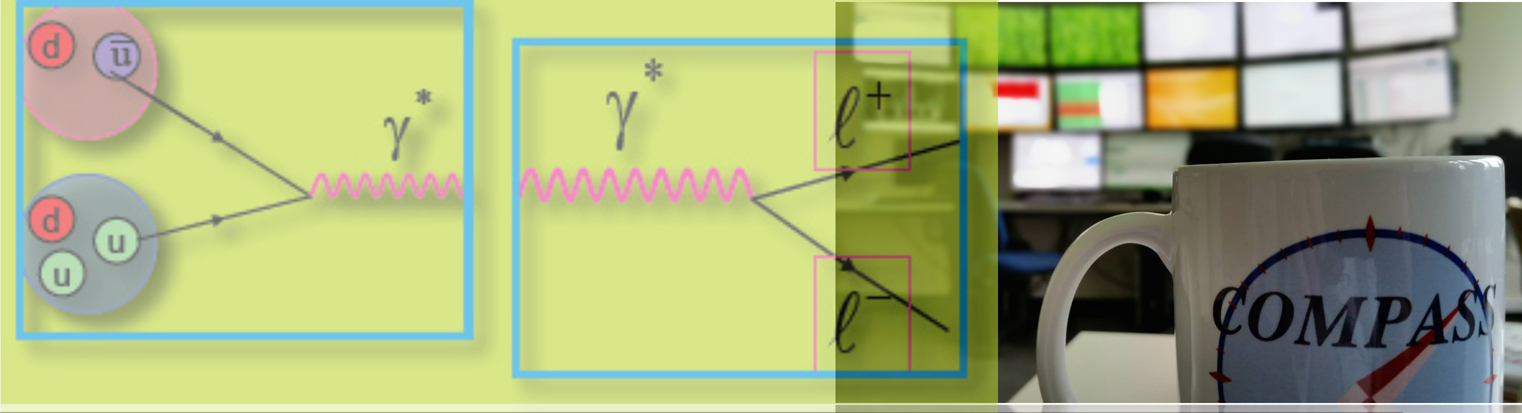
Sar WorS 05 Jun - 07 Jun 2023

UNIVERSITÀ DI TORINO

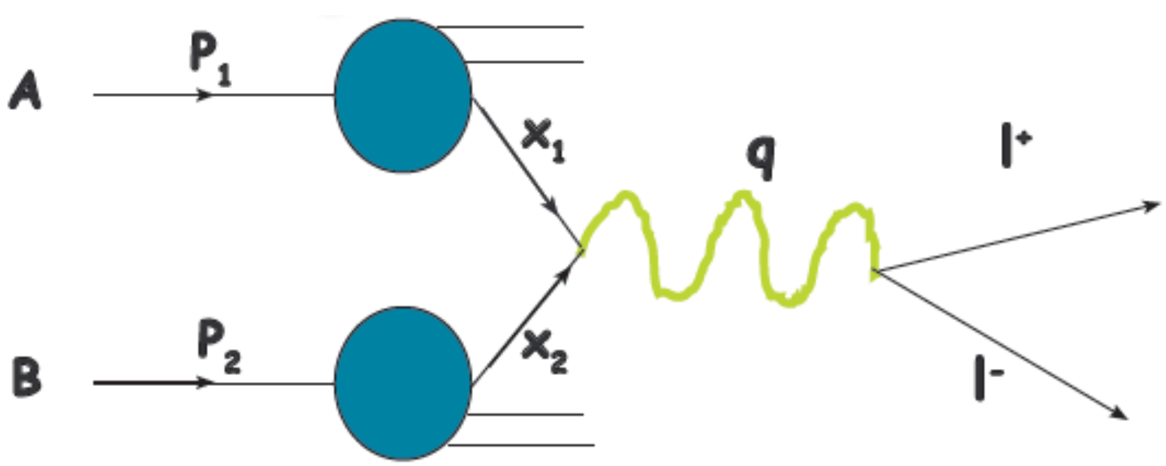
INFN



Drell-Yan process

"The process of lepton pair production is so well understood in perturbative QCD that it has now become an important and powerful tool in search of new physics information"

T-M. Yan, Talk given at the Drell Fest, July 31, 1998, SLAC on the occasion of Prof. Sid Drell's retirement
arXiv:hep-ph/9810268v1 6 Oct 1998



Kinematic variables:

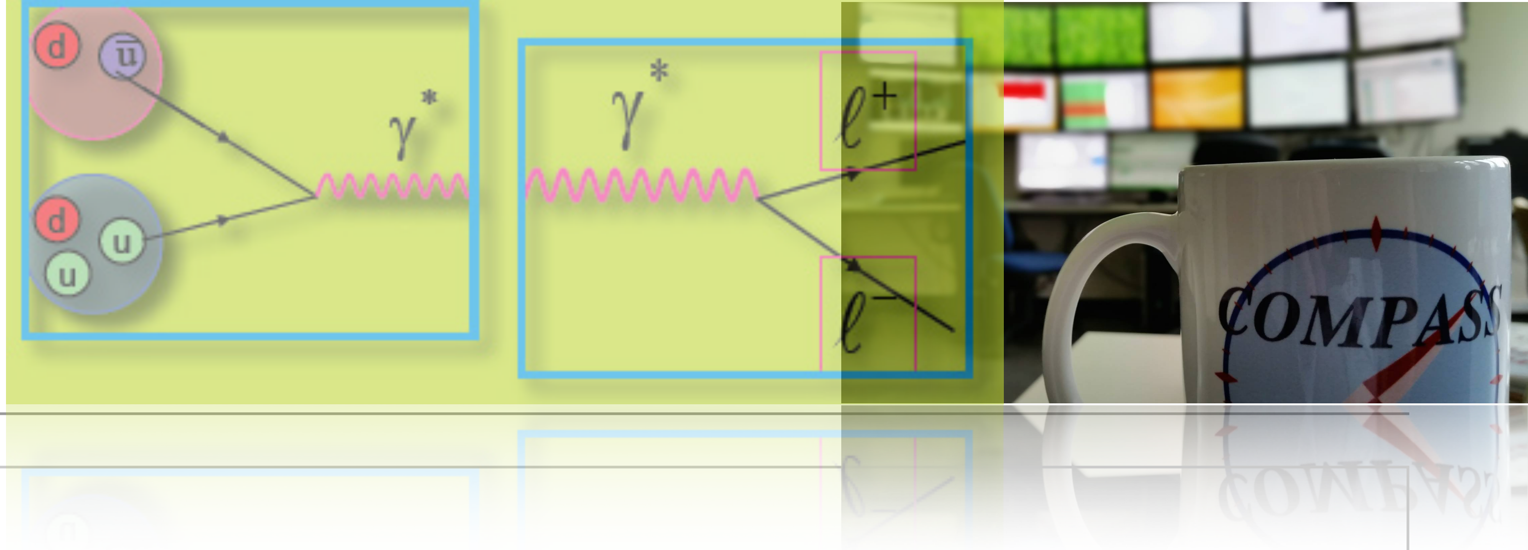
$s^2 = (P_1 + P_2)^2$

$x_1 = Q^2/2P_1 \cdot q$

$x_2 = Q^2/2P_2 \cdot q$

$$x_F \approx 2p_L/\sqrt{s} = x_1 - x_2$$
$$M^2_{\mu^+\mu^-} = s x_1 x_2$$

Drell-Yan process



what can the Drell-Yan experiments offer in probing and understanding the nucleon and mesons structure?

Convolution of two PDFs

DY
PDF ⊗ PDF

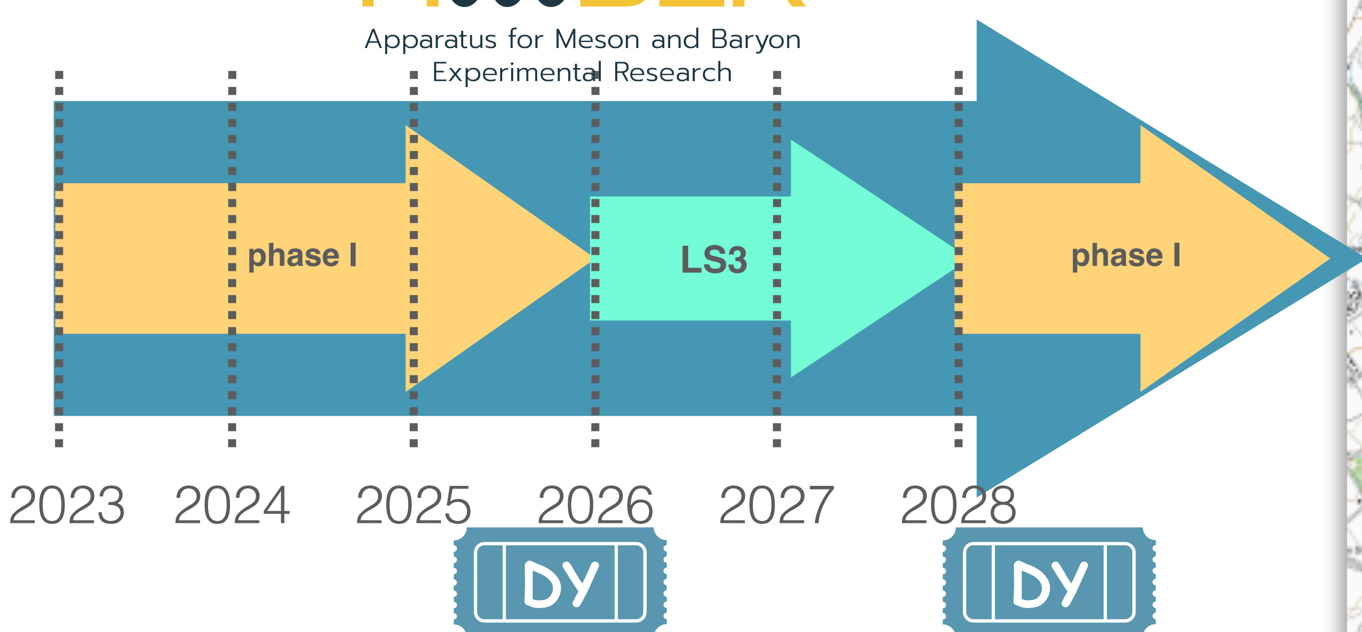
- Access to mesons and antiproton PDFs (with mesons and antiproton beam)
- Access to the nucleon PDFs
- Study of the modification of quark and gluon PDFs in bounded nucleons by a nuclear environment
- Study of the Lam-Tung Relation
- Crucial test of TMD formalism:
  experimental confirmation of the sign change prediction of the Sivers and the Boer-Mulders functions between SIDIS and Drell-Yan reactions

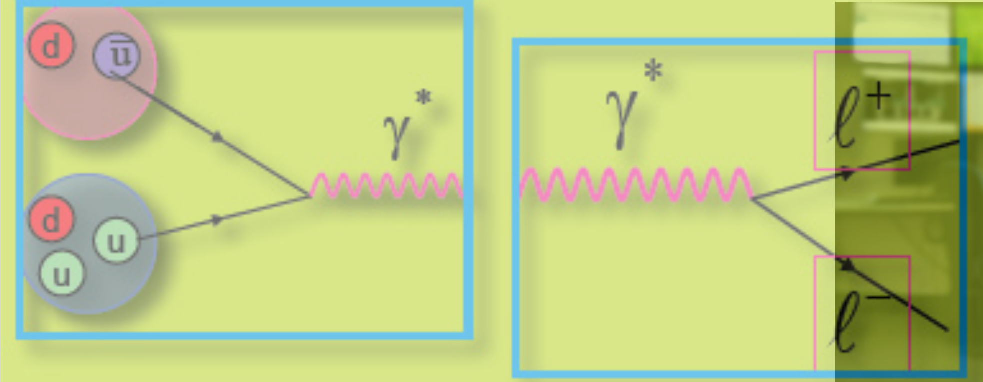
The COMPASS and the AMBER Experiments

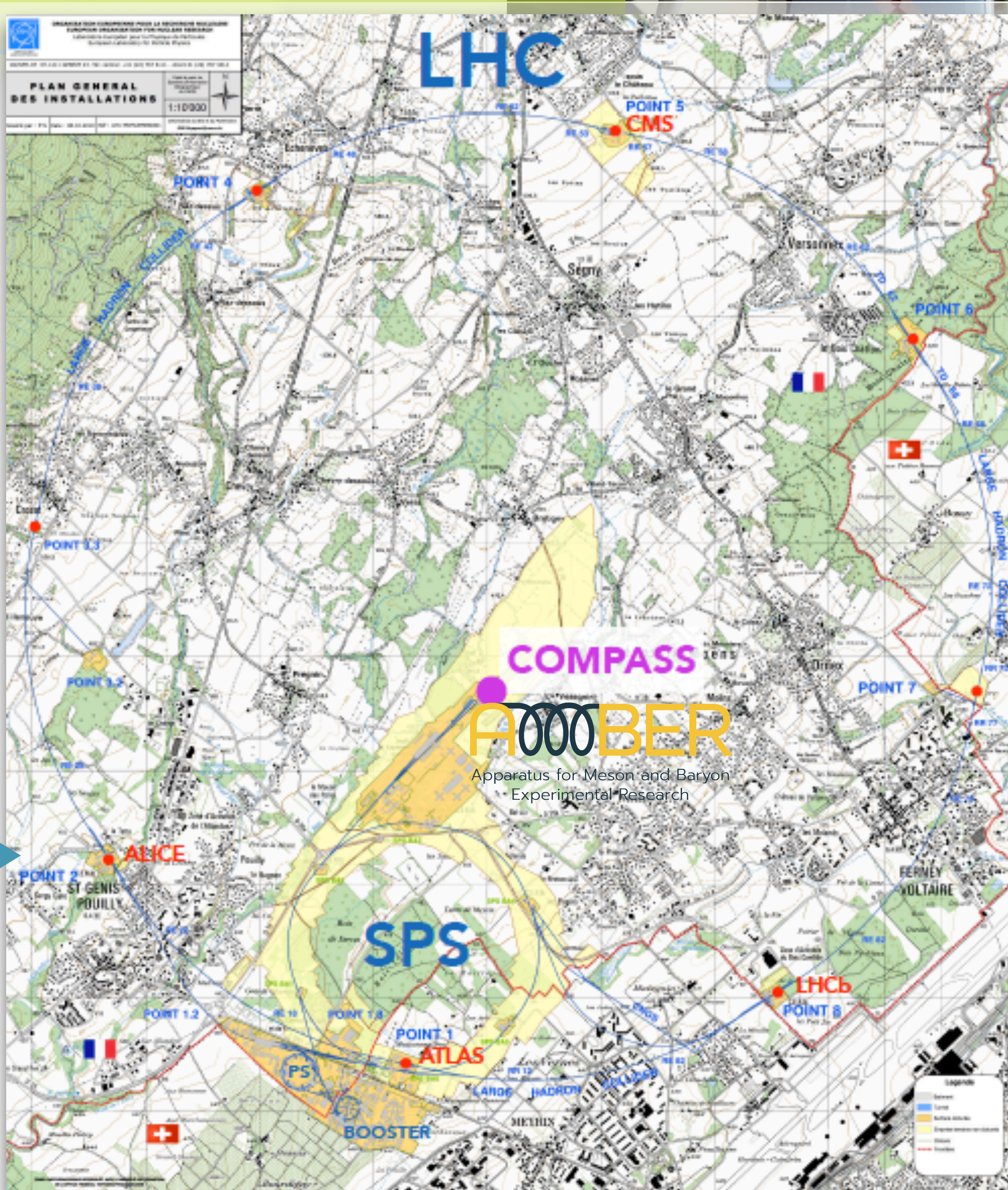
Phase I (2002 – 2011)
- Hadron spectroscopy
- Nucleon spin structure (L/T p/d Targets)

Phase II (2012 – 2018, 2021)
- Primakoff + DVCS pilot run (2012)
- **Drell-Yan (2015, 2018)**
- DVCS + Unpolarized SIDIS(2016-2017)
- T-polarized SIDIS (D target) (2021,2022)

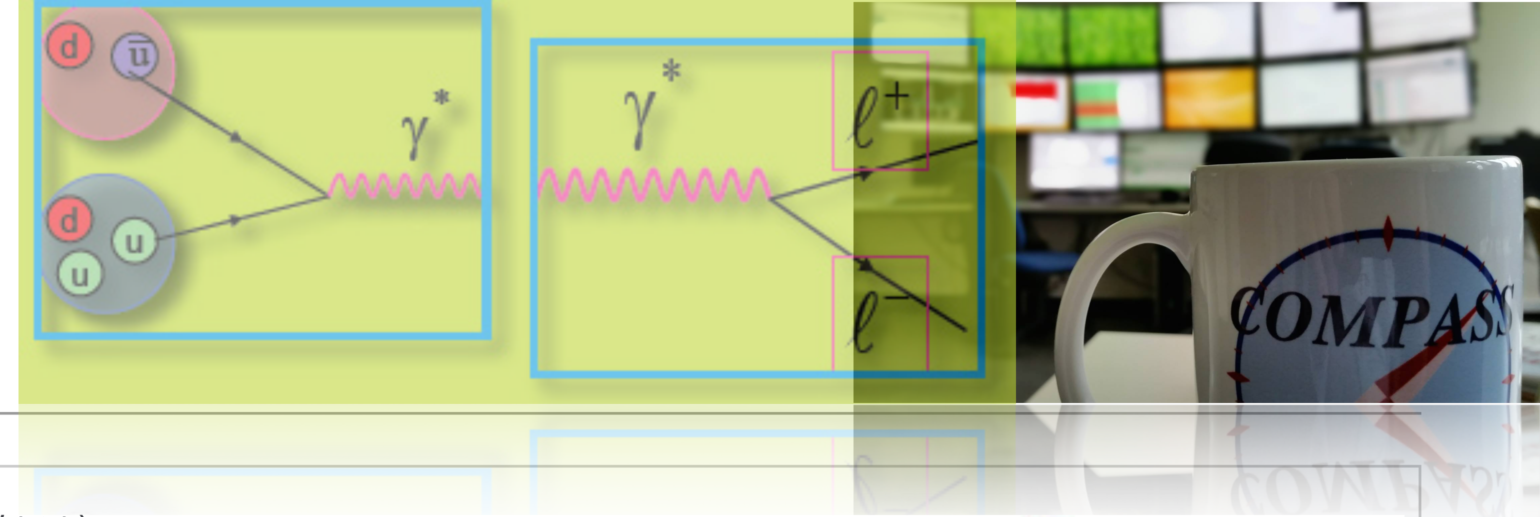
AMBER
Apparatus for Meson and Baryon Experimental Research







The COMPASS DY Apparatus



190 GeV/c negative hadron beam (π/K/p 97/2/1%)
(from 400 GeV/c SPS protons onto conversion target)

Average Beam Intensity: 10^8 particles / sec

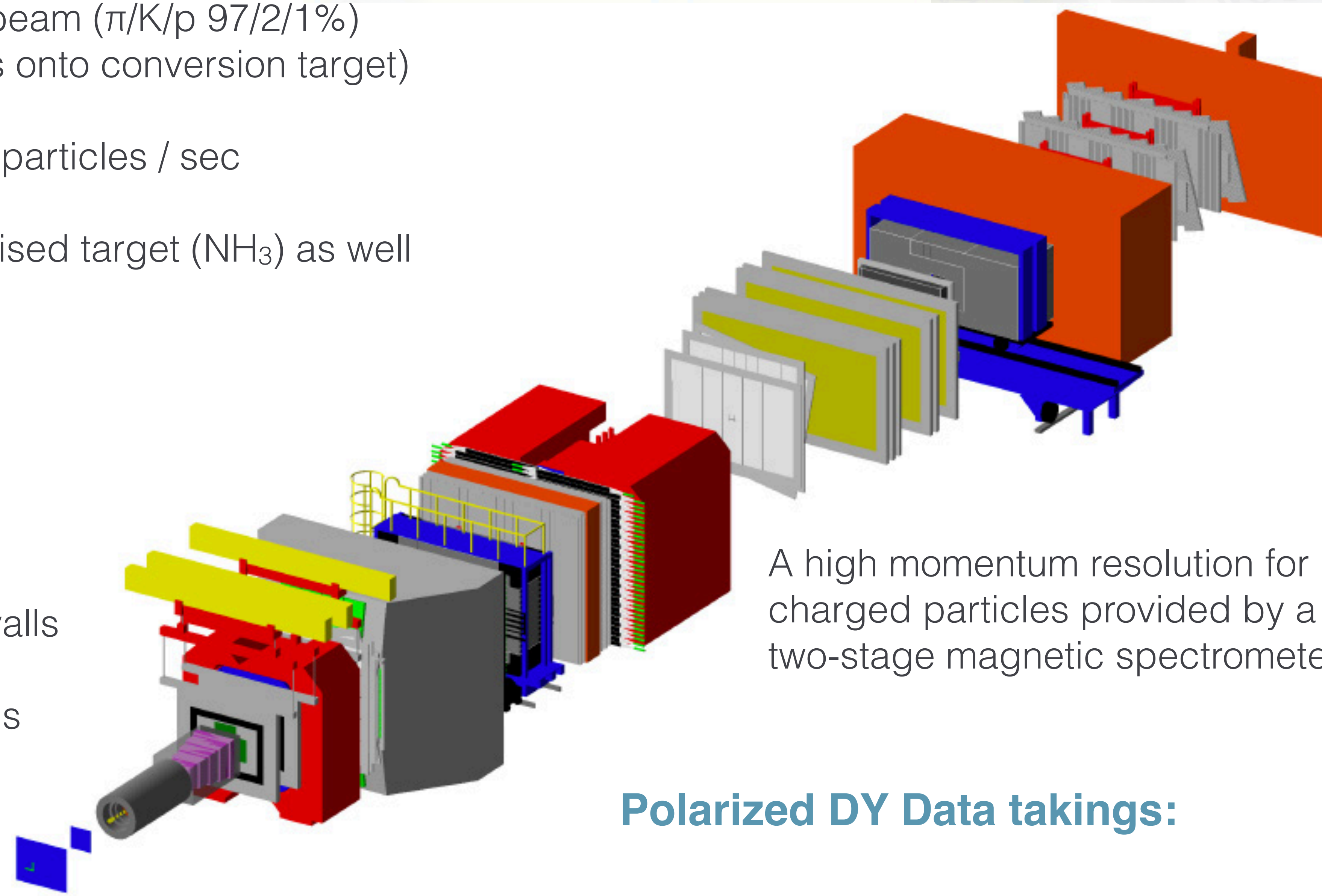
Solid state transversely polarised target (NH_3) as well as nuclear targets (Al, W)

Hadron absorber

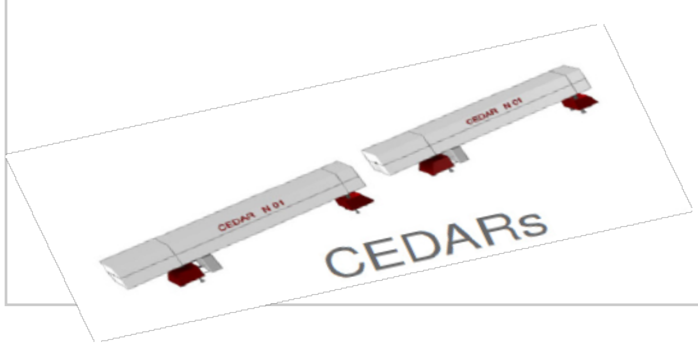
Powerful tracking system:
~ 400 tracking planes

Muon identification – Muon walls

Beam identification – CEDARs



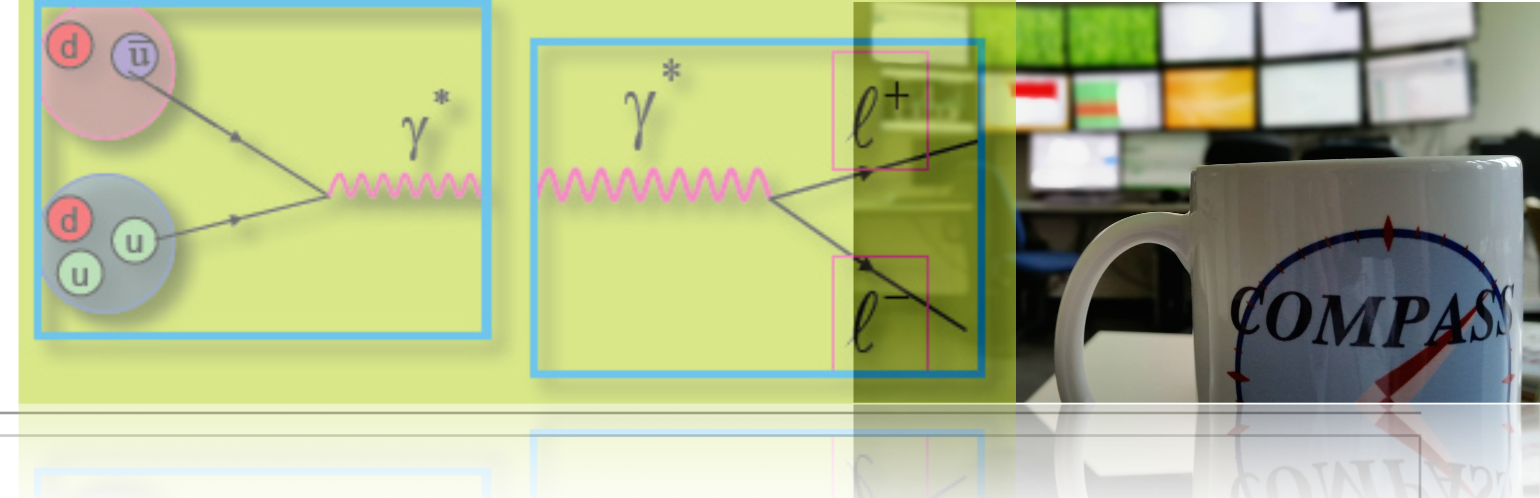
A high momentum resolution for charged particles provided by a two-stage magnetic spectrometer

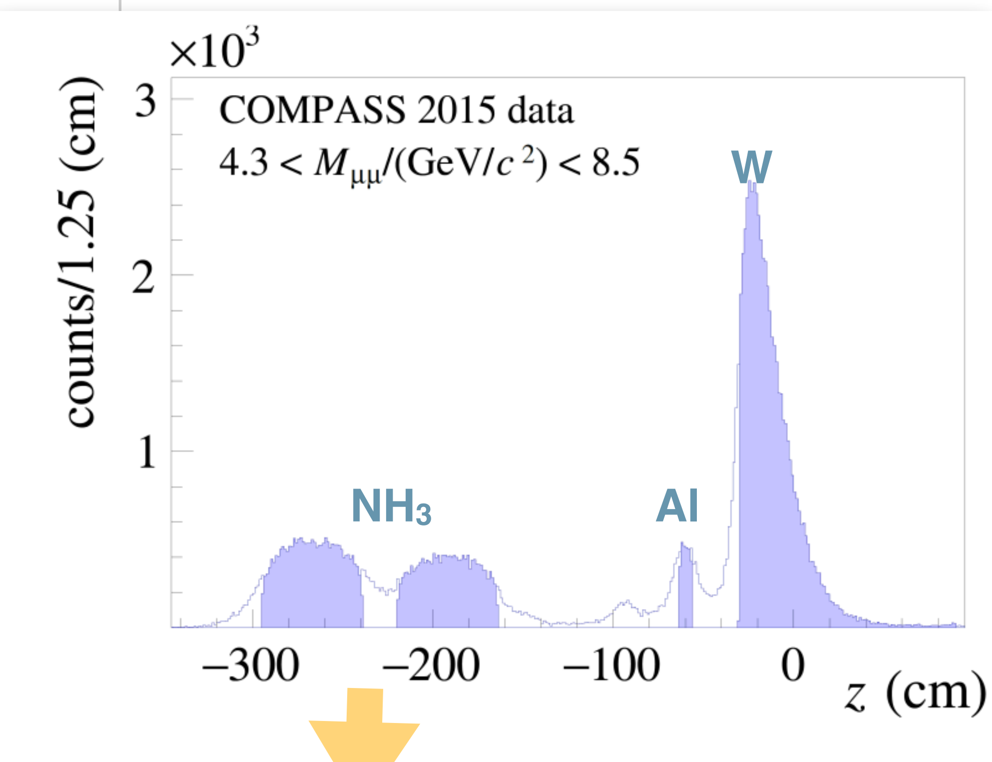


Polarized DY Data takings:

- 2015 run ~ 4 months;
- 2018 run ~ 6 months;

The COMPASS DY Apparatus

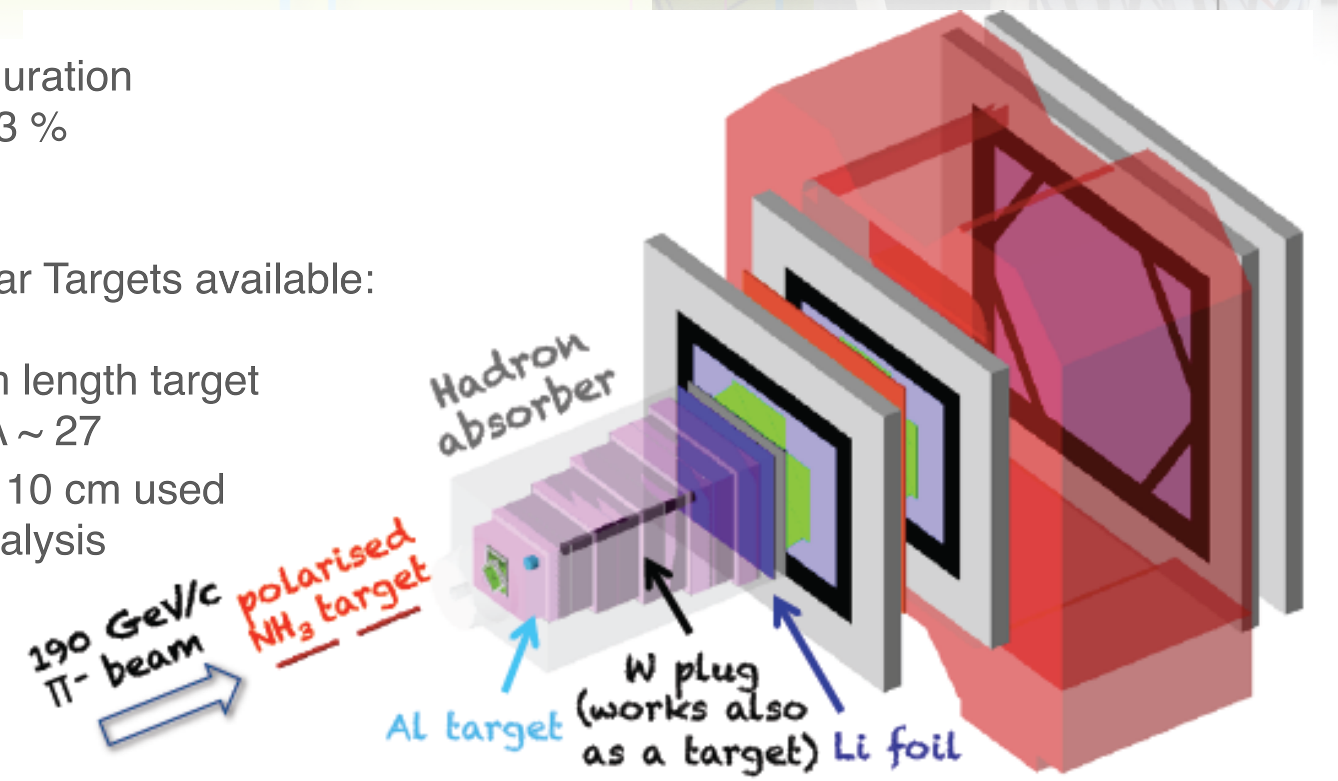




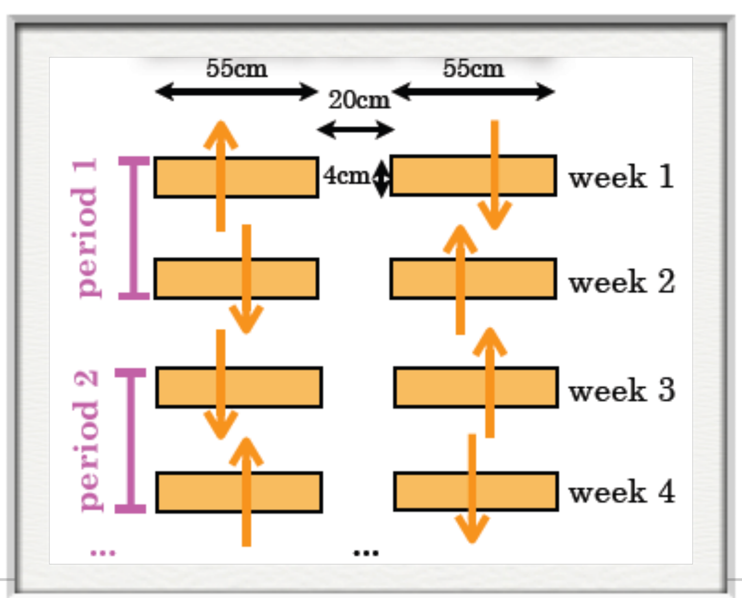
NH₃ 2-cell configuration
Polarization T~73 %
f ~ 0.19

Additional Nuclear Targets available:

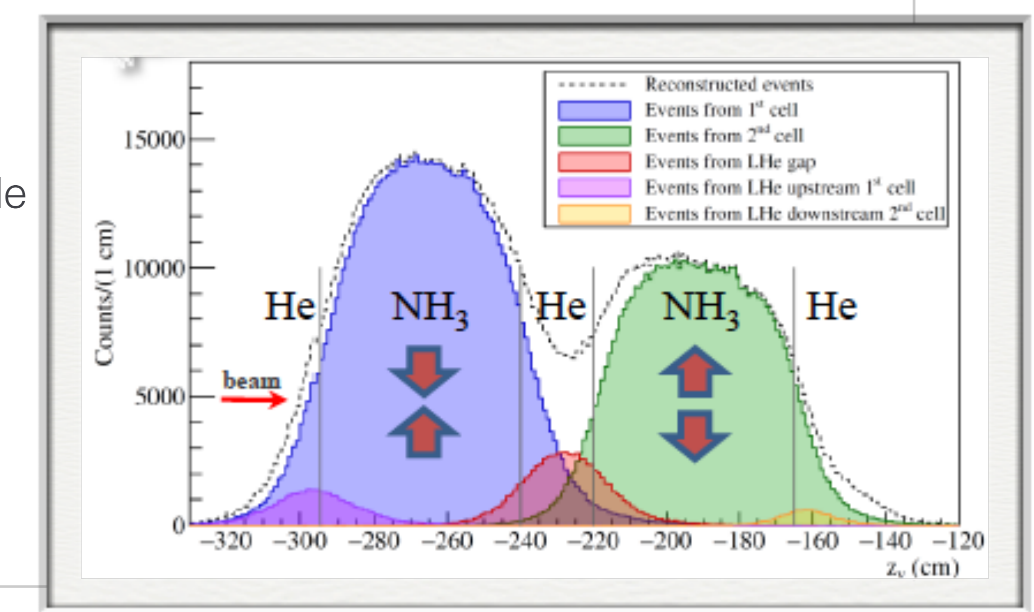
- Aluminum 7cm length target
  Intermediate A ~ 27
- Tungsten first 10 cm used
  for physics analysis
  Large A ~ 184



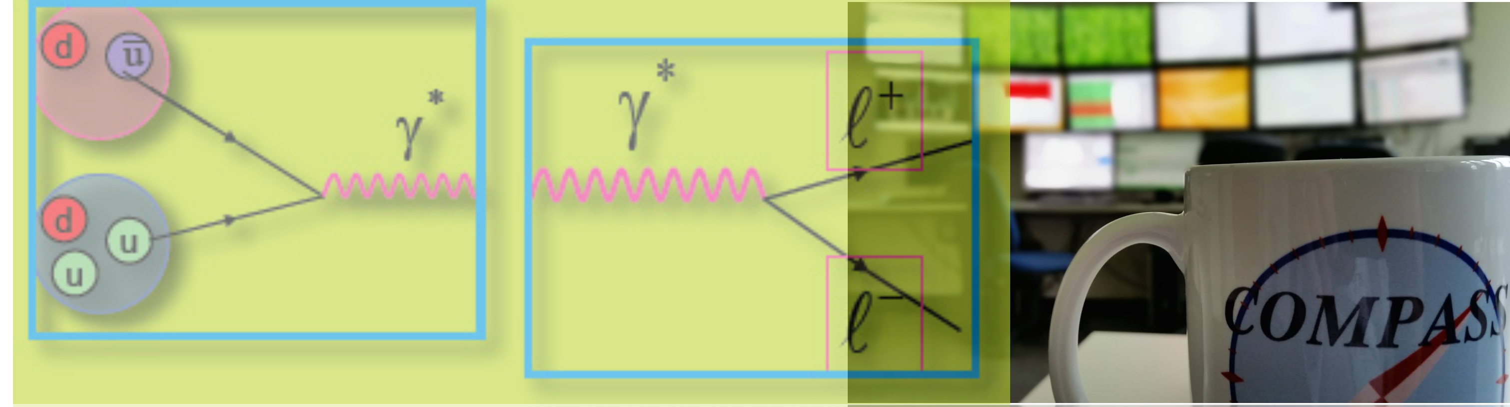
Periodic polarization reversal to minimise systematic effects



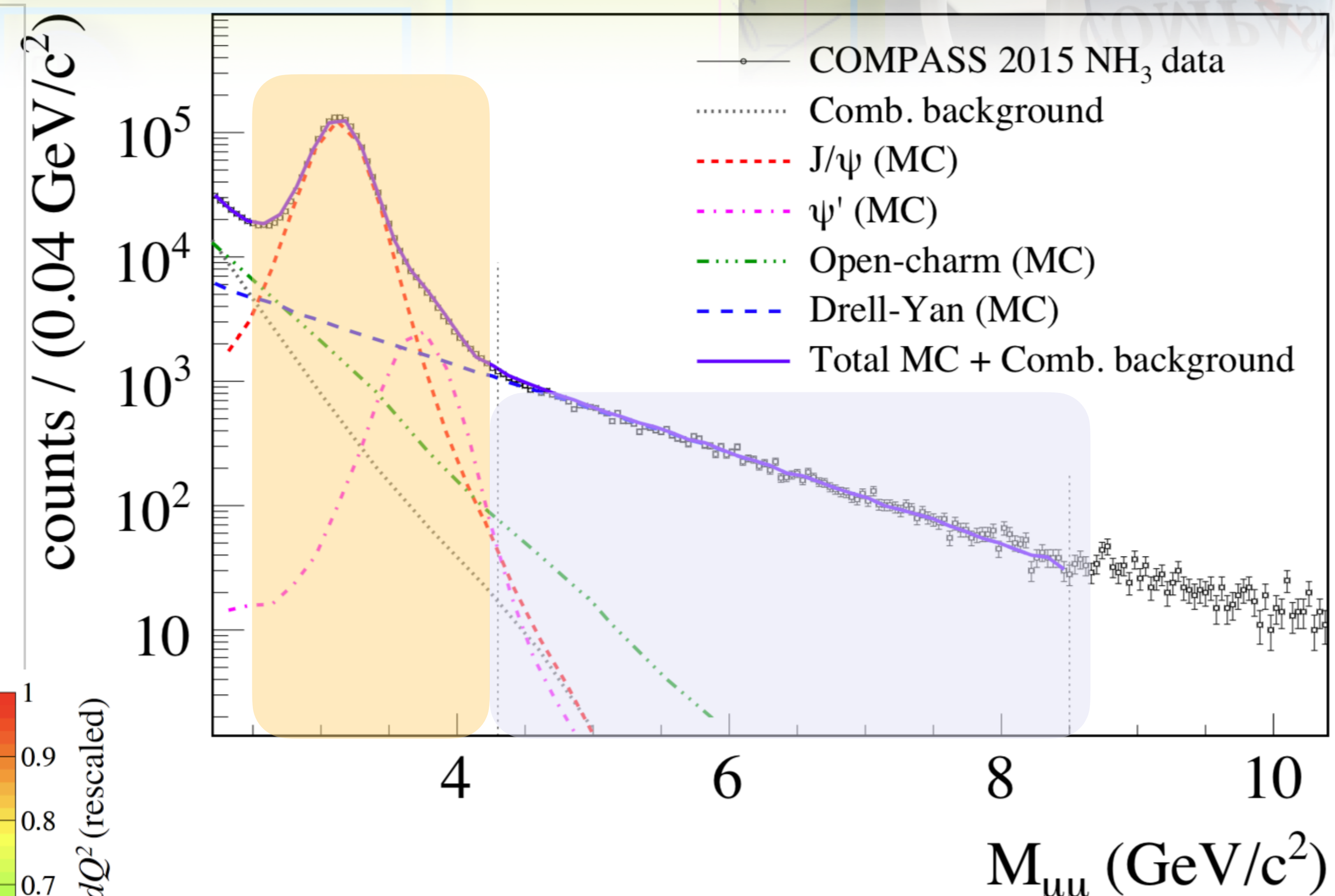
The dilution factor (the fraction of polarizable material in target) is corrected to account for the migration of events from one cell to the other (obtained with MC simulation)

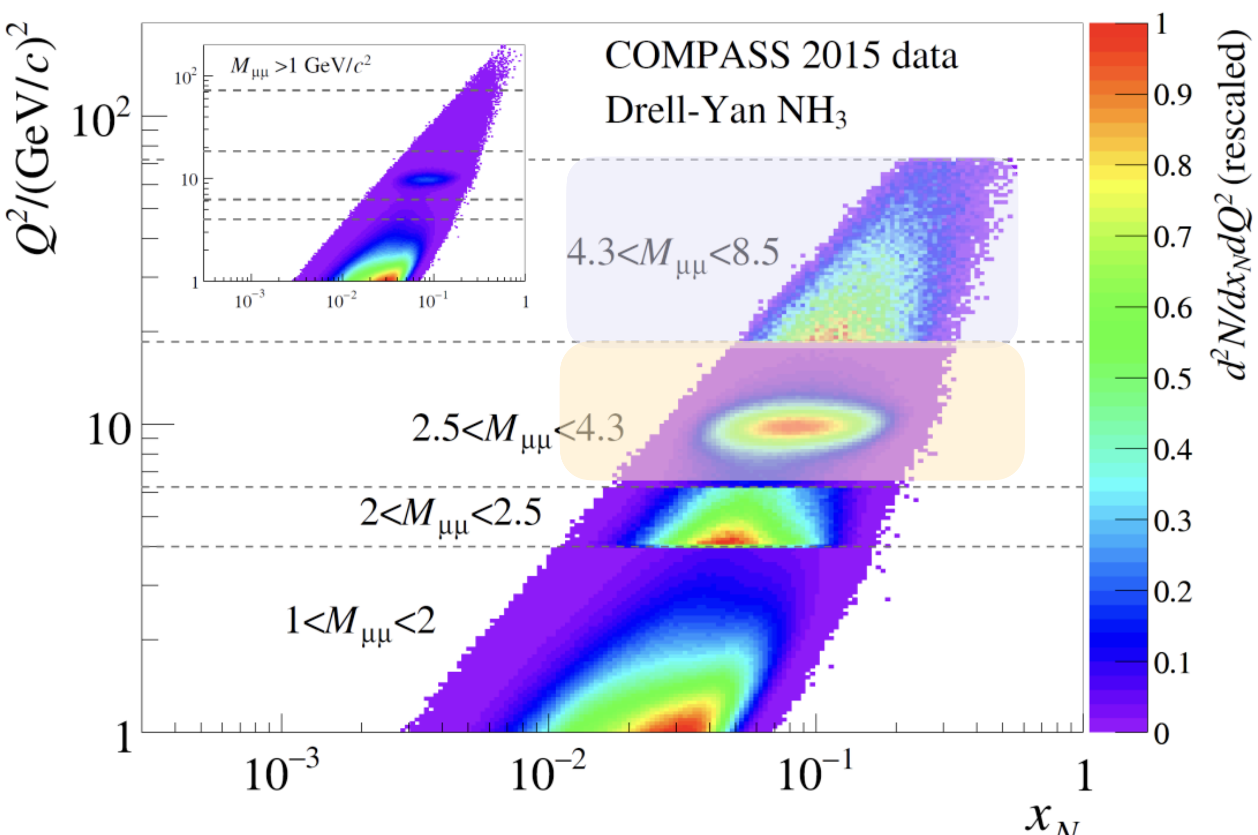


Kinematic Coverage

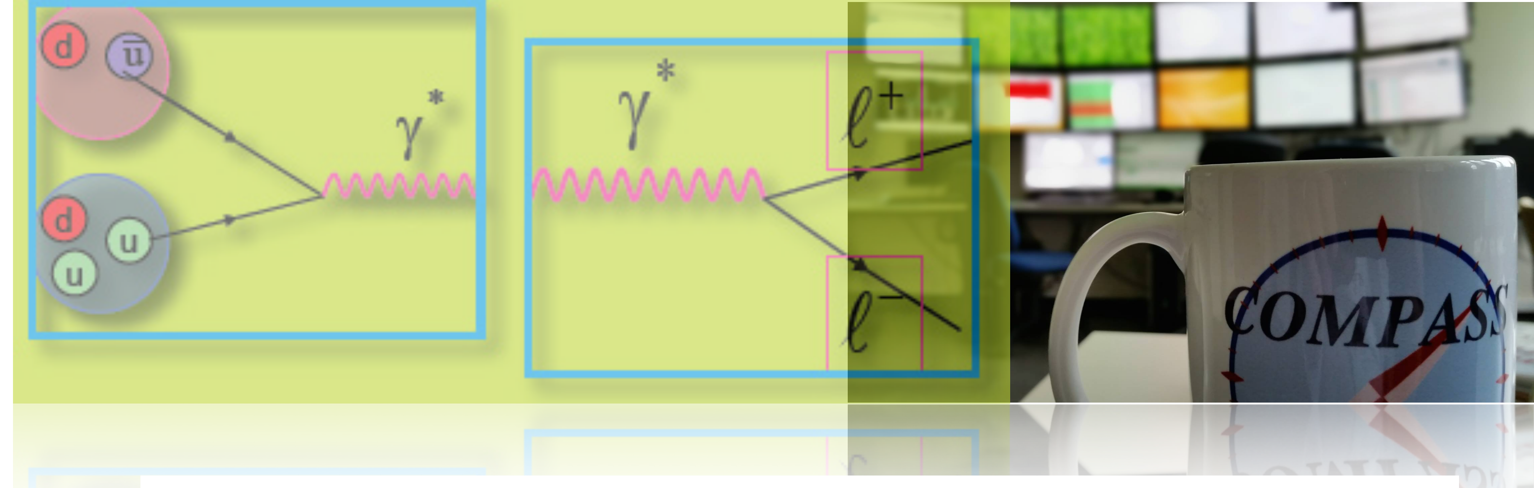


- 1 < $M_{\mu\mu}$/(GeV/c²) < 2 — "Low Mass Region"
  - Large background contamination
- 2 < $M_{\mu\mu}$/(GeV/c²) < 2.5 — "Intermediate mass"
- 2.5 < $M_{\mu\mu}$/(GeV/c²) < 4.3 — "Charmonia mass"
  - Good signal/background ratio (large statistics)
  - J/ψ peak — Production mechanism study
- 4.3 < $M_{\mu\mu}$/(GeV/c²) < 8.5 — "DY High mass range"
  - Background contamination < 4%
  - Valence-quark region (Larger asymmetries)





High Mass Region



❋ 1 < $M_{\mu\mu}$/(GeV/c²) < 2 — “Low Mass Region”
- Large background contamination

❋ 2 < $M_{\mu\mu}$/(GeV/c²) < 2.5 — “Intermediate mass”

❋ 2.5 < $M_{\mu\mu}$/(GeV/c²) < 4.3 — “Charmonia mass”
- Good signal/background ratio (large statistics)
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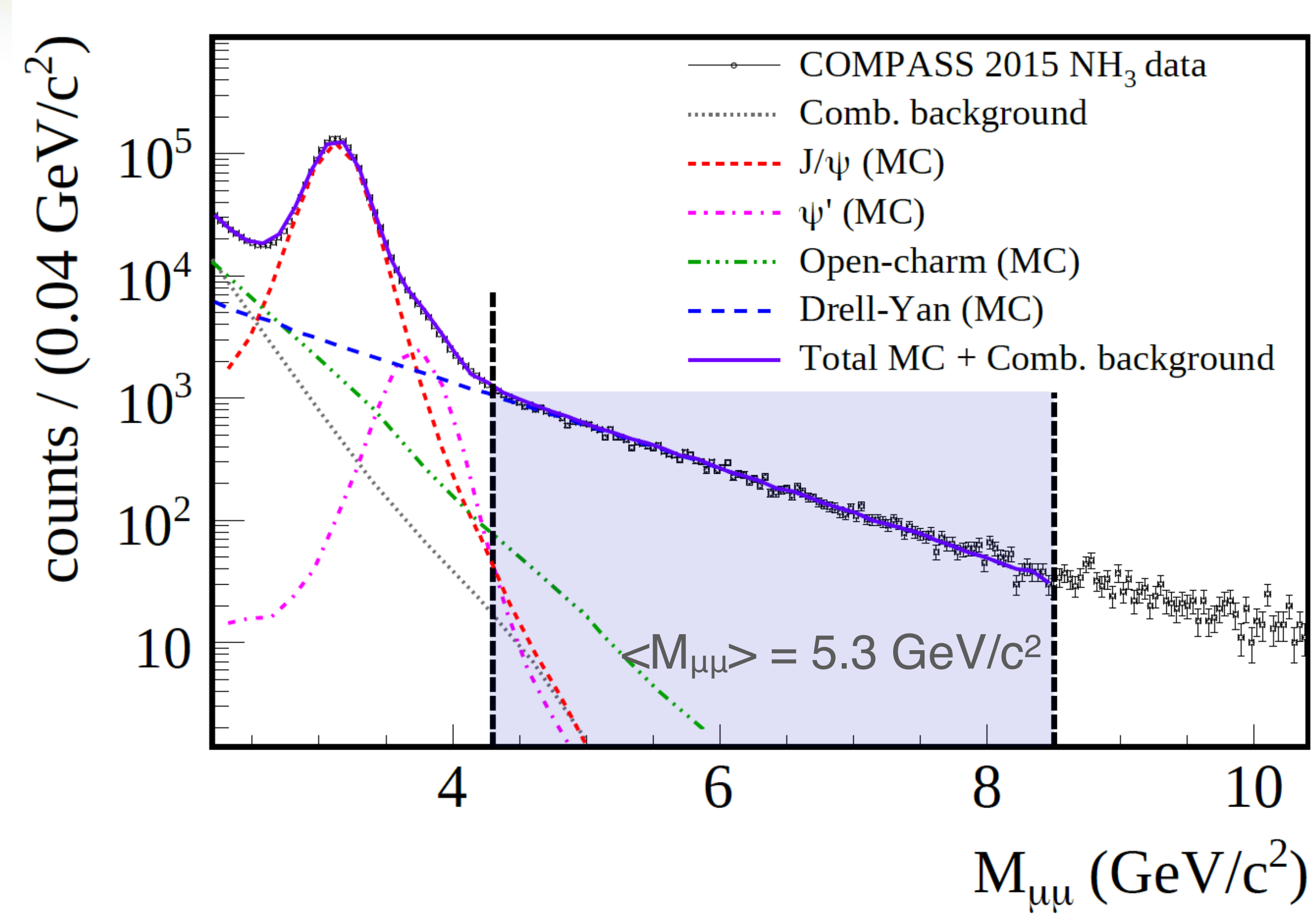
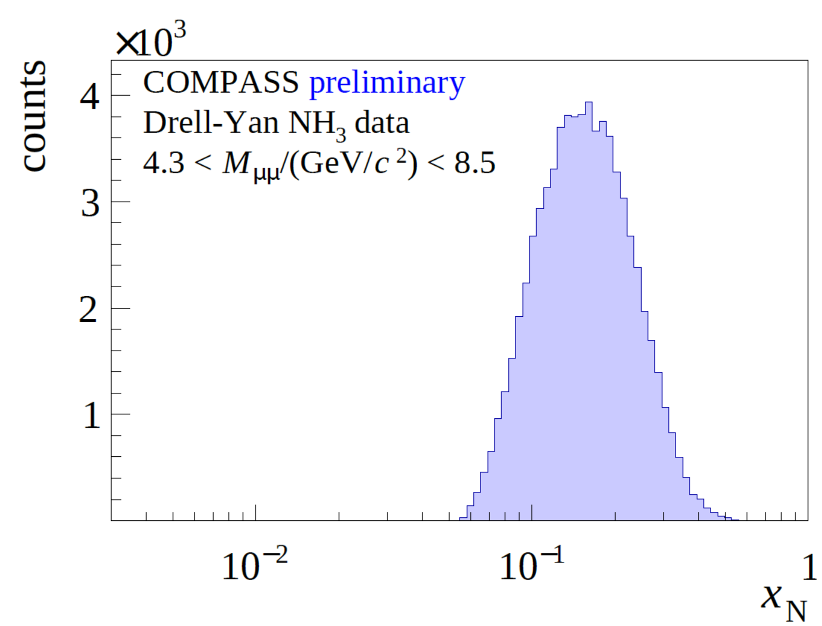
❋ 4.3 < $M_{\mu\mu}$/(GeV/c²) < 8.5 — “DY High mass range”
- Background contamination < 4%
- Valence-quark region (Larger asymmetries)
- But low cross-section

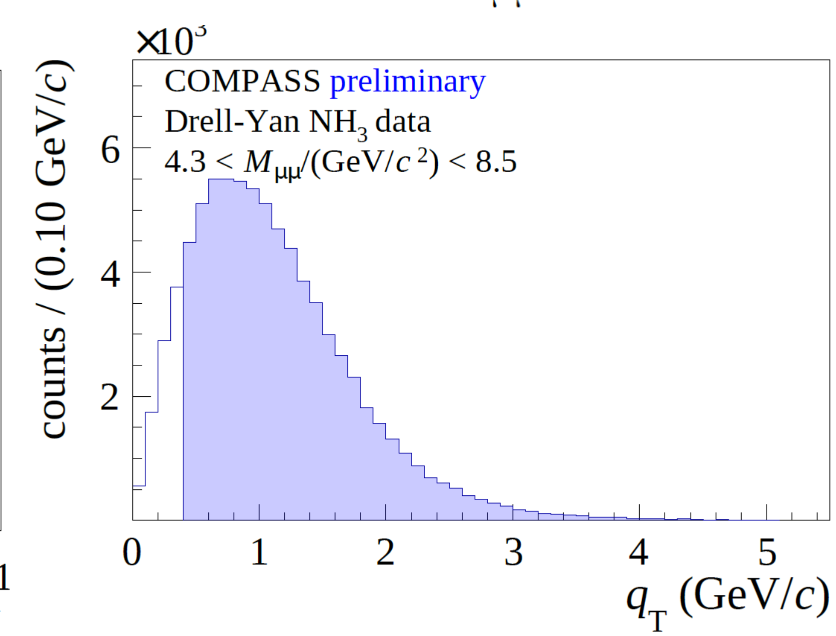


Valence region dominance $\bar{u}_\pi u_p$
Probing: <x_N> ~ 0.17. <x_π> ~ 0.5

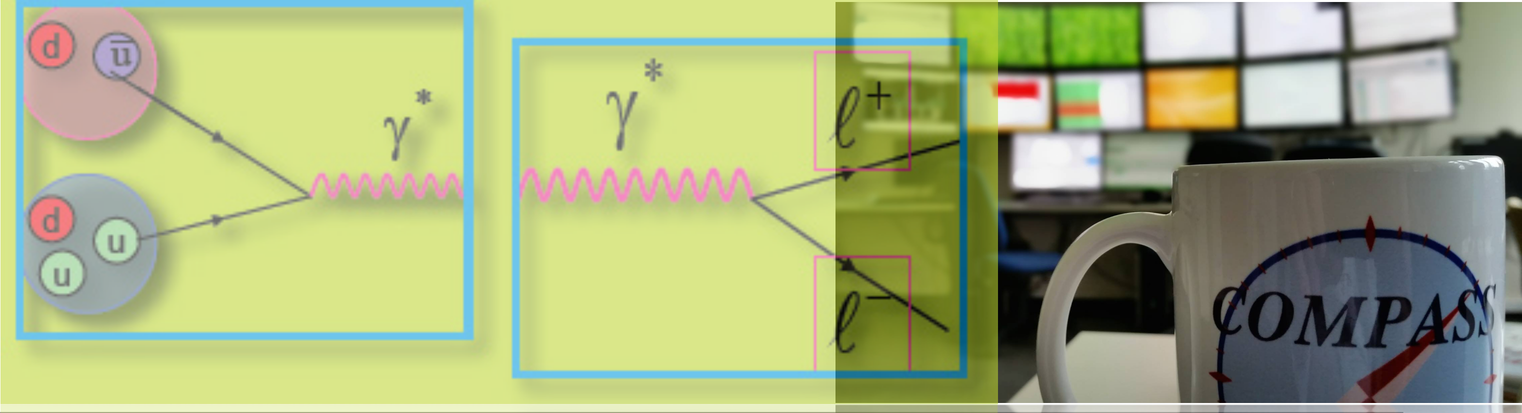
<q_T> = 1.17 GeV/c , q_T > 0.4 GeV/c
<$M_{\mu\mu}$> = 5.3 GeV/c²

TMD approach validity

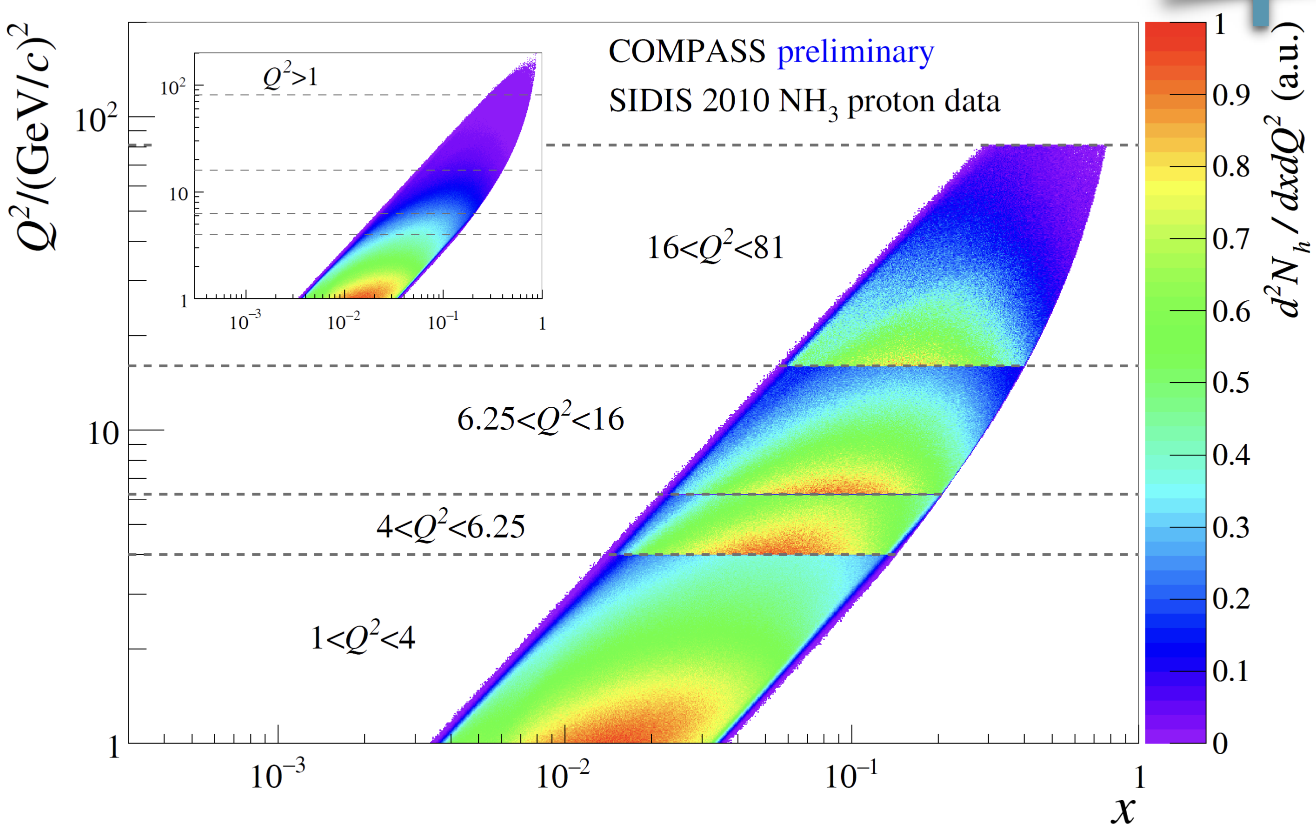




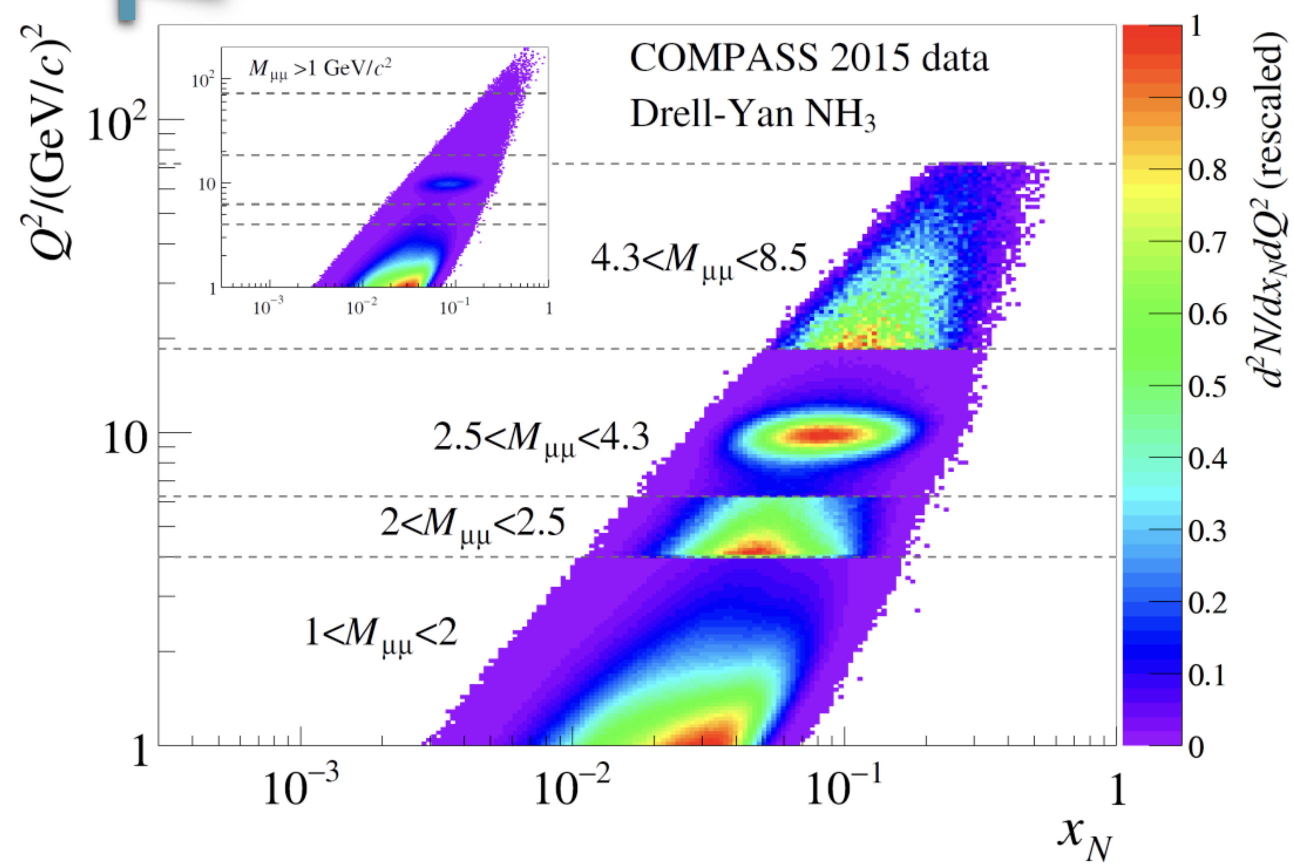
DY-SIDIS Bridge at COMPASS



SIDIS on transversely polarised proton
COMPASS 2007, 2010
PLB 770 (2017) 138



Pion-induced transversely polarised Drell-Yan
COMPASS 2015, 2018
PRL 119 (2017) 112002

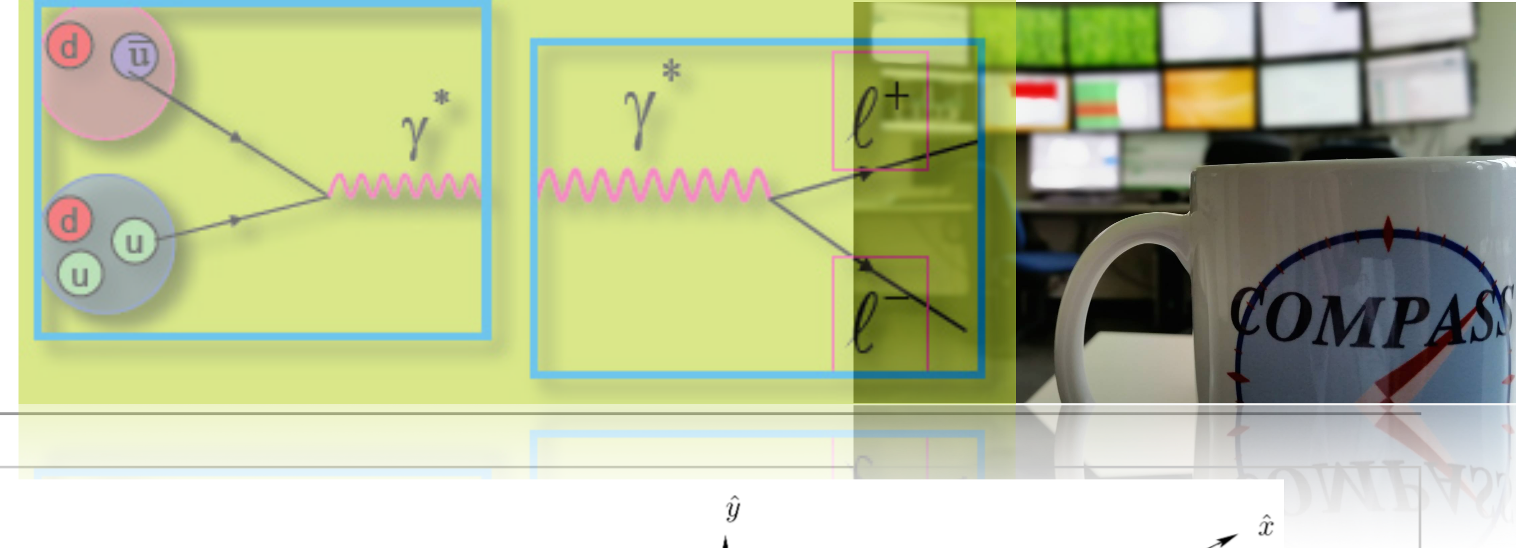


comparable x:Q² kinematic coverage

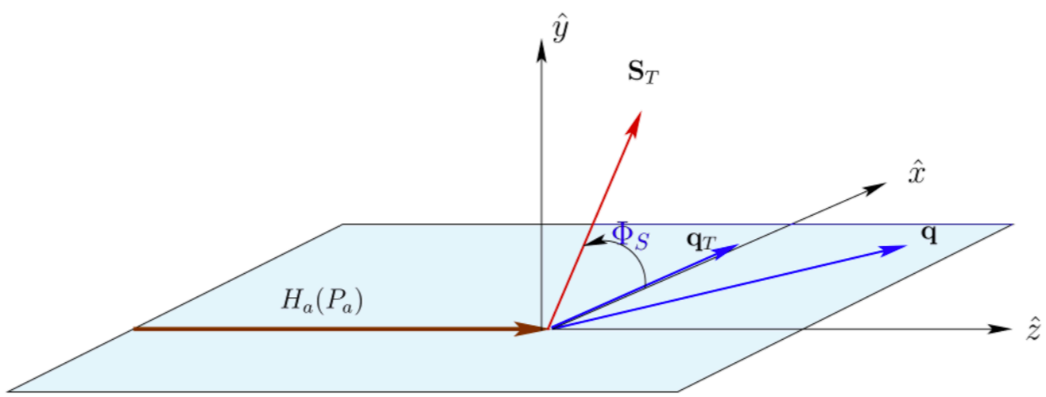
minimisation of possible Q² evolution effects

Unique experimental environment to test TMD universality

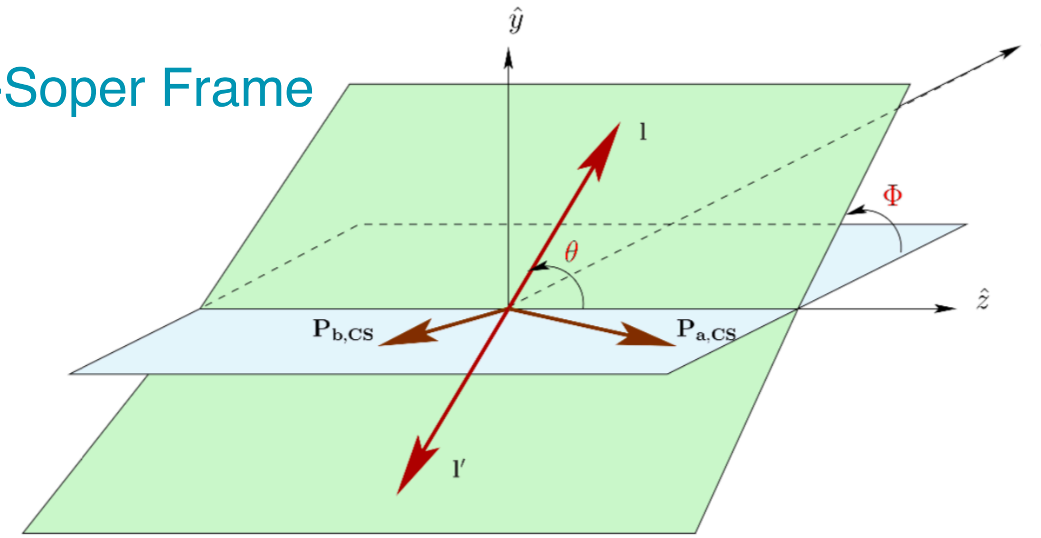
Single Polarized Drell-Yan @COMPASS



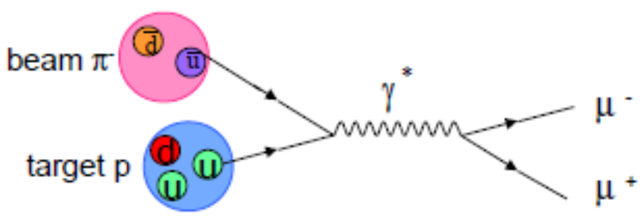
Target Rest Frame



Collins-Soper Frame



(b)



Measure magnitude of spin-dependent azimuthal modulations in cross section: "Single-Spin Asymmetries "

$$f_{\bar{u}|\pi} \otimes f_{u|p}$$

pion proton

At LO:

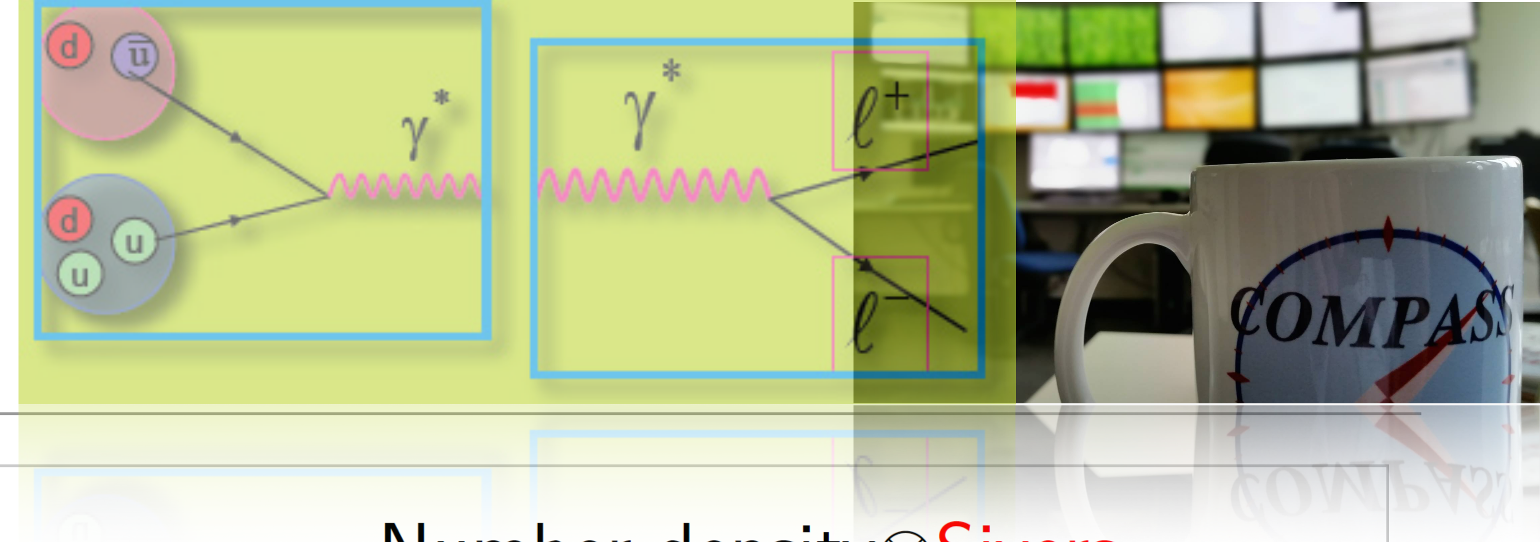
$$\mathrm{d}\sigma(\pi^- p^\uparrow \to \mu^+\mu^- X) = 1 + \boxed{\bar{h}_1^\perp} \otimes \boxed{h_1^\perp} \cos(2\phi) \qquad (\mathrm{BM})_\pi \otimes (\mathrm{BM})_p$$

$$+|S_T| \boxed{\bar{f}_1} \otimes \boxed{f_{1T}^\perp} \sin\phi_S \qquad (f_1)_\pi \otimes (\mathrm{Sivers})_p$$

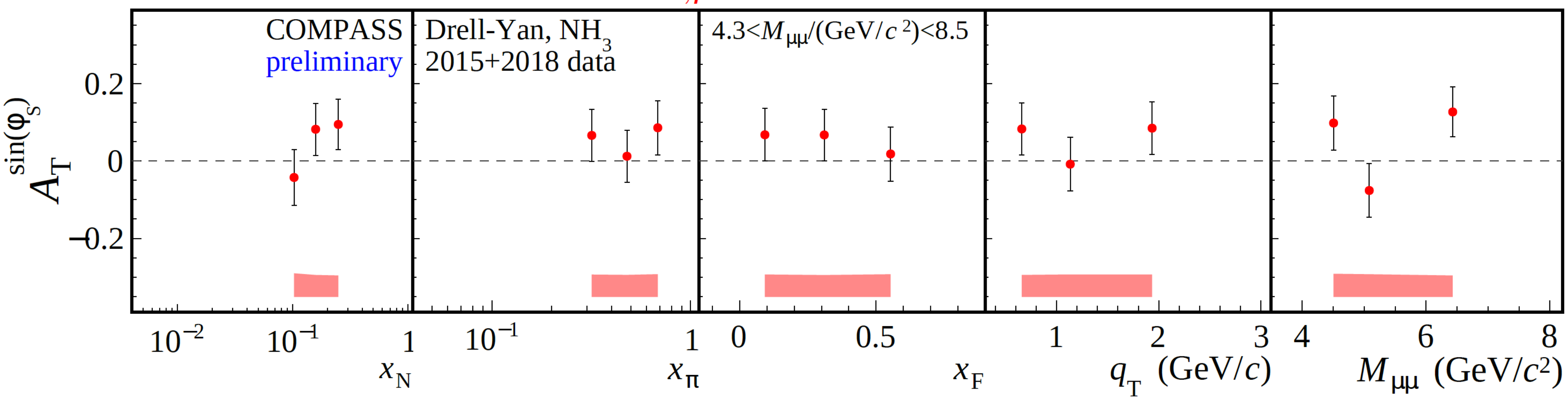
$$+|S_T| \boxed{\bar{h}_1^\perp} \otimes \boxed{h_{1T}^\perp} \sin(2\phi + \phi_S) \qquad (\mathrm{BM})_\pi \otimes (\mathrm{Pretzelosity})_p$$

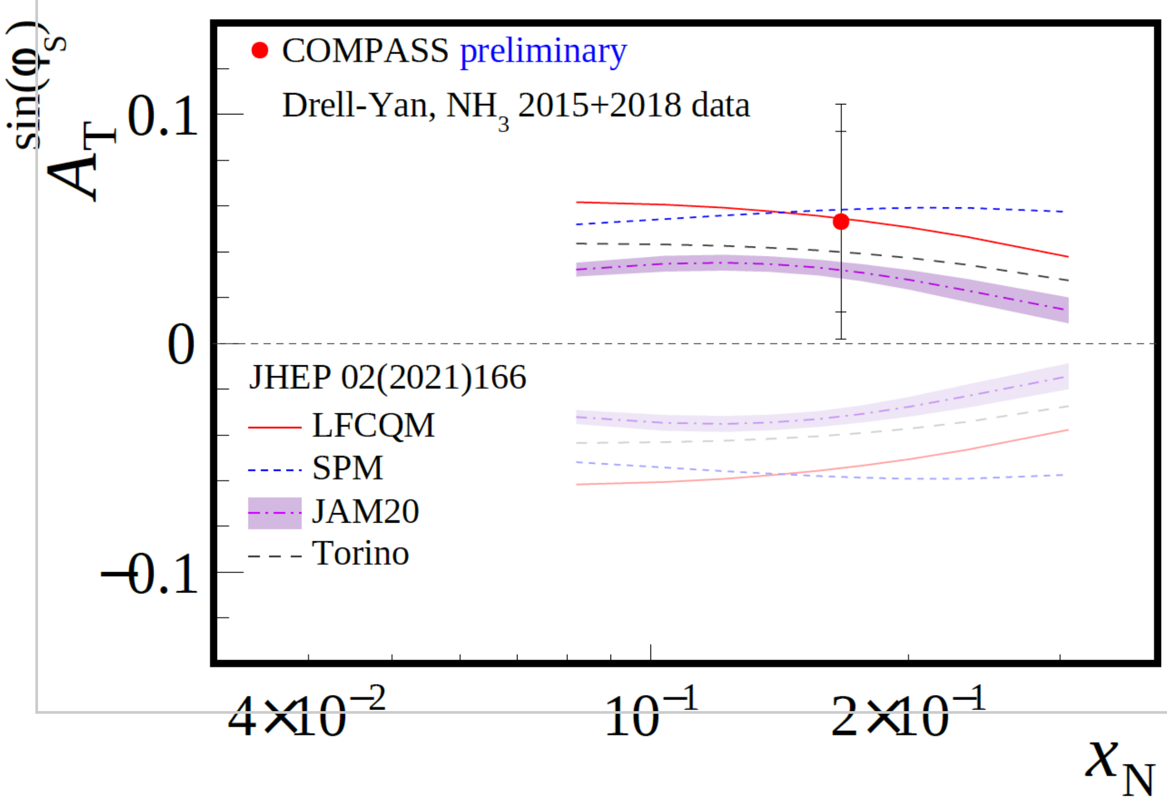
$$+|S_T| \boxed{\bar{h}_1^\perp} \otimes \boxed{h_1} \sin(2\phi - \phi_S) \qquad (\mathrm{BM})_\pi \otimes (\mathrm{Transversity})_p$$

High mass Drell-Yan region: Sivers



$A^{\sin(\phi_S)} \propto f_{1,\pi} \otimes f_{1T,p}^{\perp}$ Number density⊗Sivers



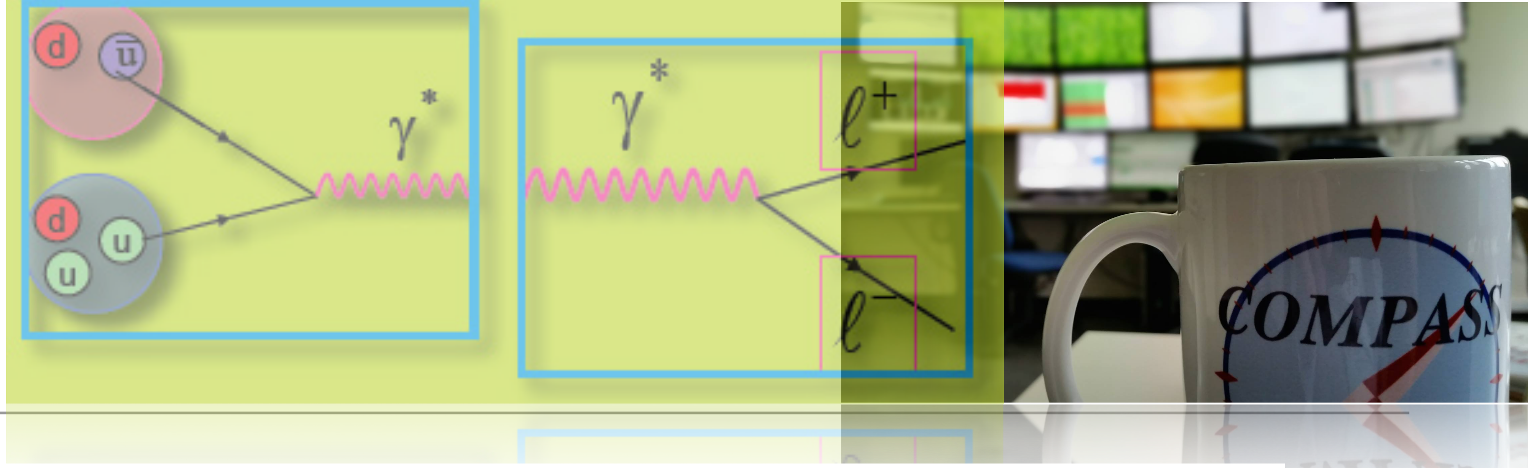


No significant kinematic dependence

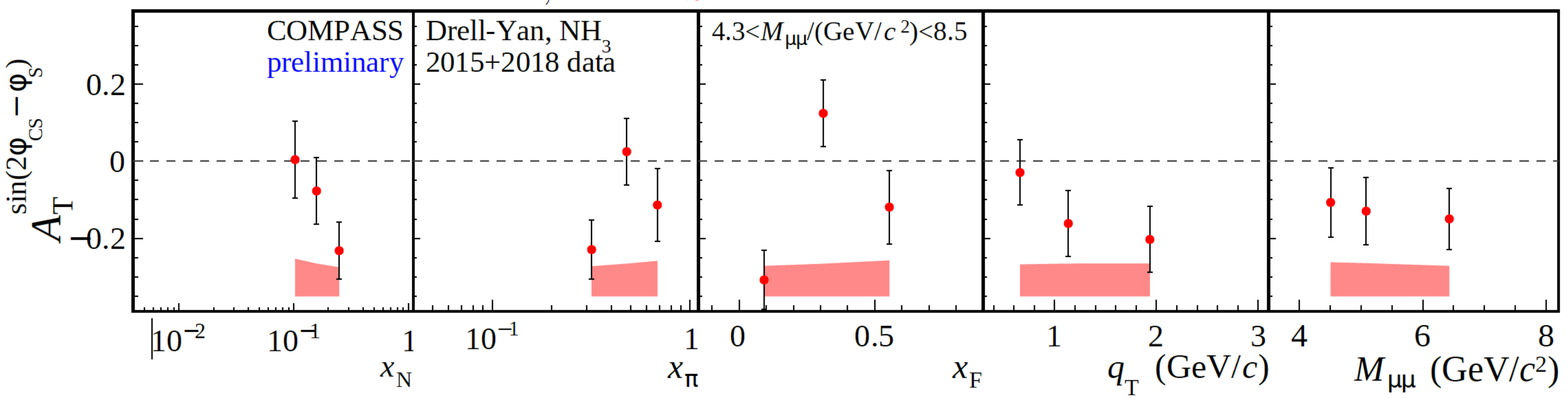
Overall positive with ∼ 1 σ significance

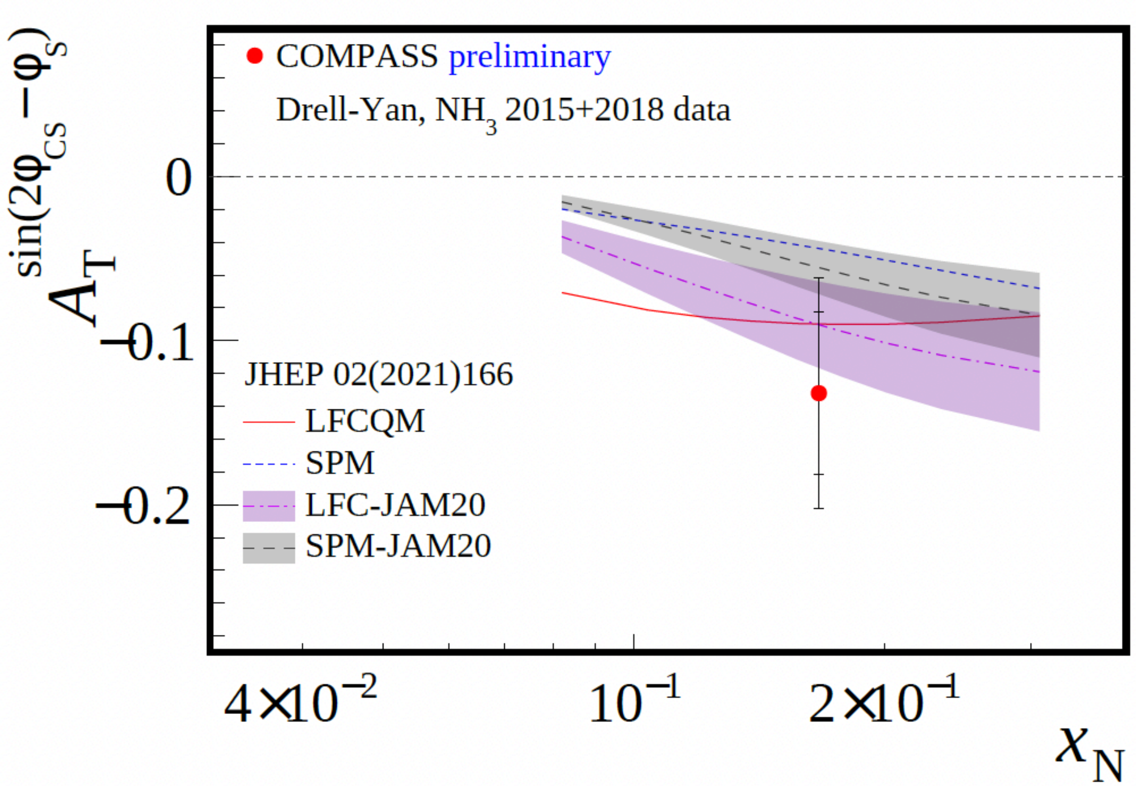
Favours sign change scenario

High mass Drell-Yan region: Transversity



$A^{\sin(2\phi_{CS}-\phi_S)} \propto h^{\perp}_{1,\pi} \otimes h_{1,p}$ Boer-Mulders⊗Transversity



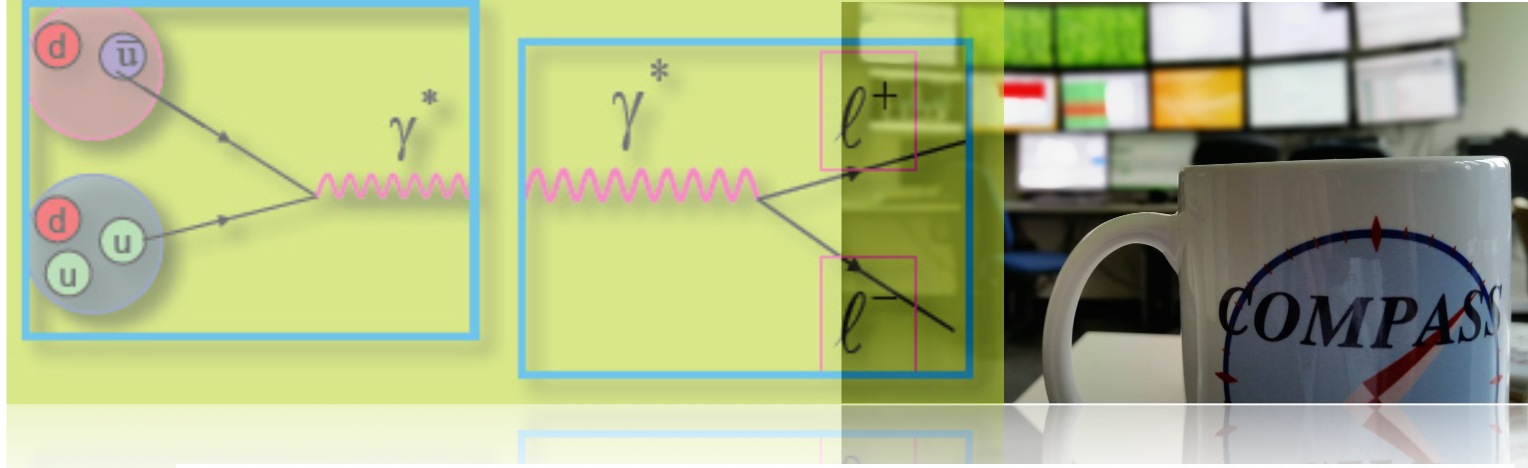


No significant kinematic dependence

Overall negative with ∼ 1.5 σ significance

In agreement with model predictions

DY TSAs : Results in High Mass Range

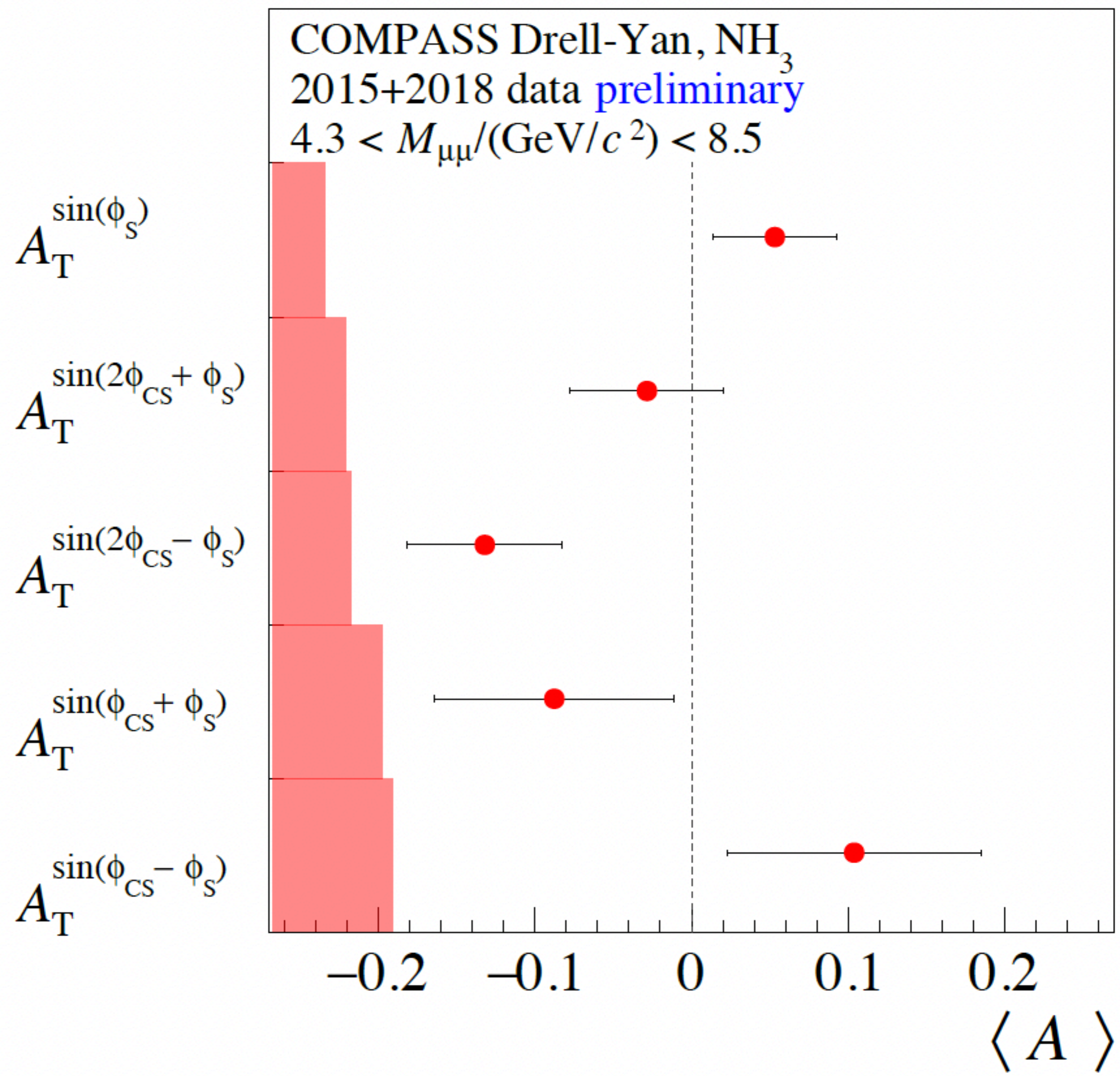


$$d\sigma^{DY} \propto 1 + D_{[\sin 2\theta]} A_{UU}^{\cos\phi} \cos\phi + D_{[\sin^2\theta]} A_{UU}^{\cos 2\phi} \cos 2\phi$$
$$+ S_T \left[D_{[1+\cos^2\theta]} A_{UT}^{\sin\phi_S} \sin\phi_S \right.$$
$$+ D_{[\sin^2\theta]} \left(A_{UT}^{\sin(2\phi-\phi_S)} \sin(2\phi-\phi_S) + A_{UT}^{\sin(2\phi+\phi_S)} \sin(2\phi+\phi_S) \right)$$
$$\left. + D_{[\sin 2\theta]} \left(A_{UT}^{\sin(\phi-\phi_S)} \sin(\phi-\phi_S) + A_{UT}^{\sin(\phi+\phi_S)} \sin(\phi+\phi_S) \right) \right]$$

Unp. PDF ⊗ Sivers

Boer-Mulders ⊗ Transversity

Boer-Mulders ⊗ Pretzelosity

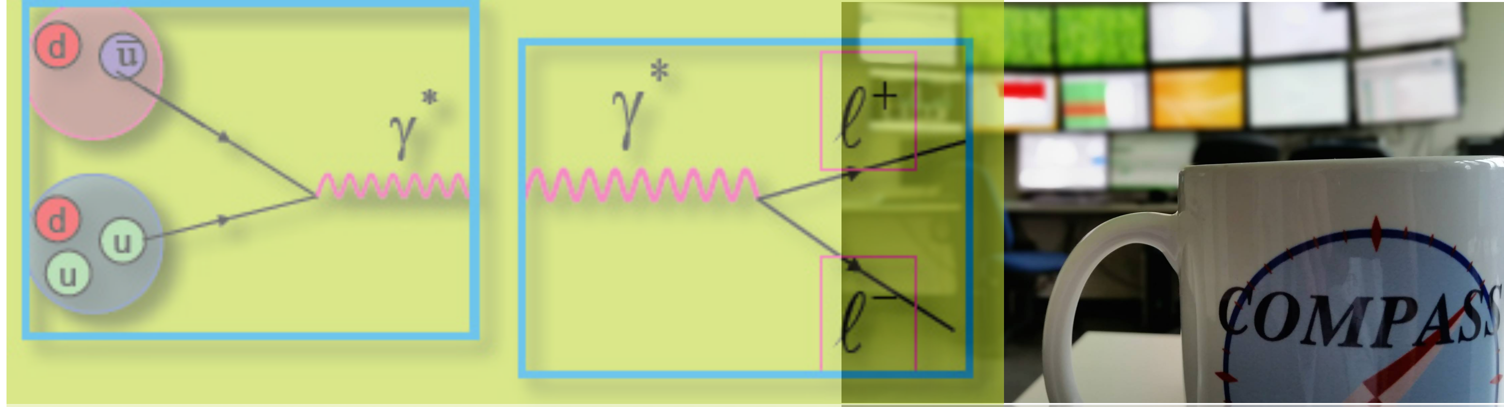


Full 2015+2018 combined Drell-Yan TSA data analysis is completed

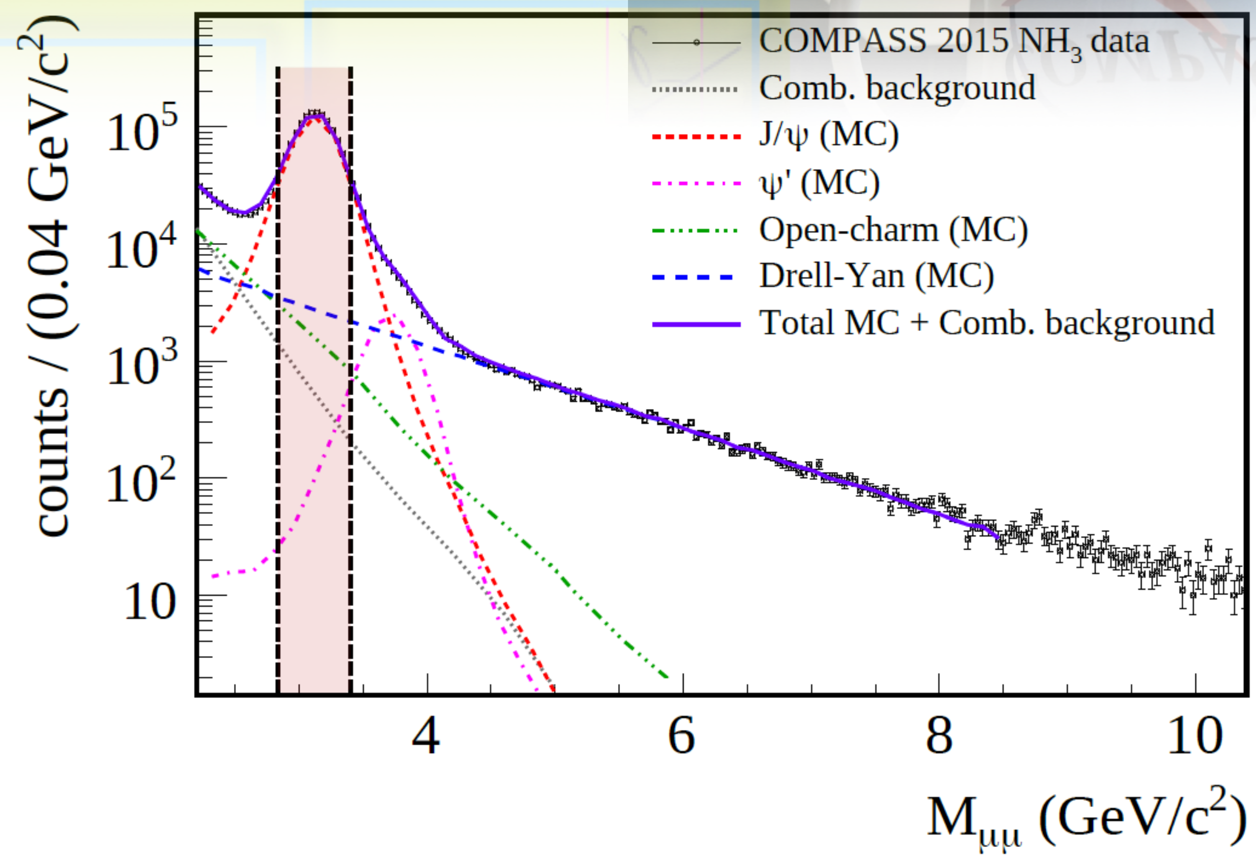
- Sivers found to be positive, ~1 σ away from zero
- Transversity found to be negative, ~1 .5 σ away fro
- Pretzelosity found to be compatible with zero

- COMPASS SIDIS and Drell-Yan TSAs measurements represent a unique experimental input to study the universality of TMD PDFs

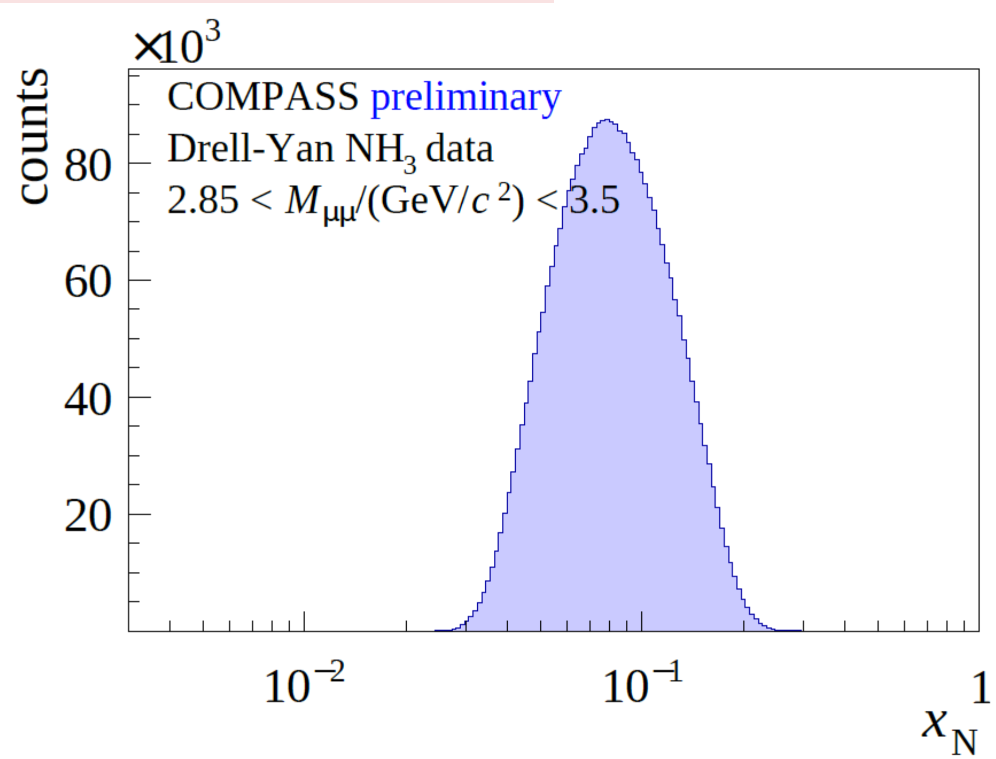
J/Ψ Region

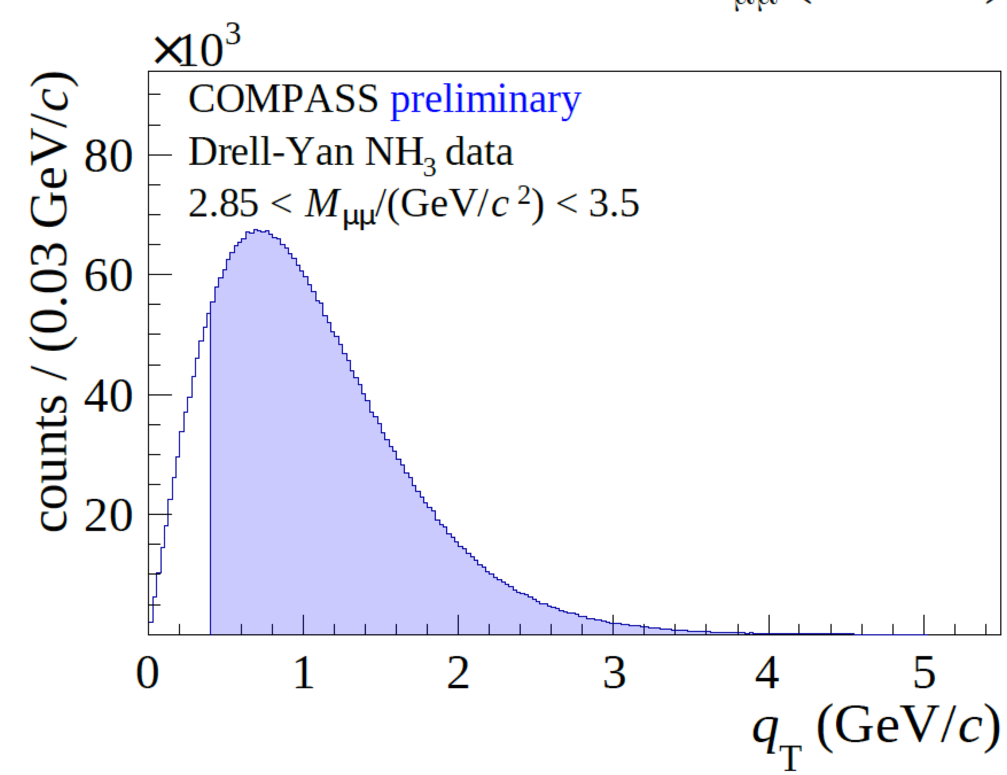


- Restrict the analysis to $2.85 < M_{\mu\mu}/(\mathrm{GeV}/c^2) < 3.4$
- Larger cross-section ~ 30x more data compared to high-mass Drell-Yan region
- J/ψ purity: 92%

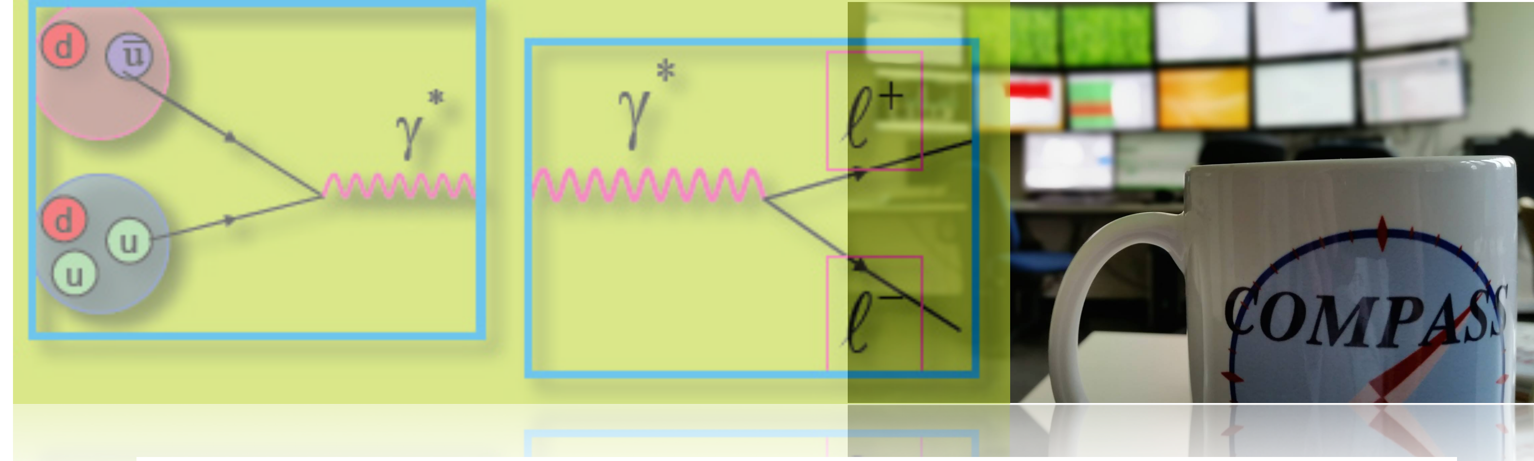


Probing: $\langle x_N \rangle \sim 0.09$: ≈ Valence domain
$\langle q_T \rangle = 1.05$ GeV/c , $q_T > 0.4$ GeV/c





J/Ψ Region



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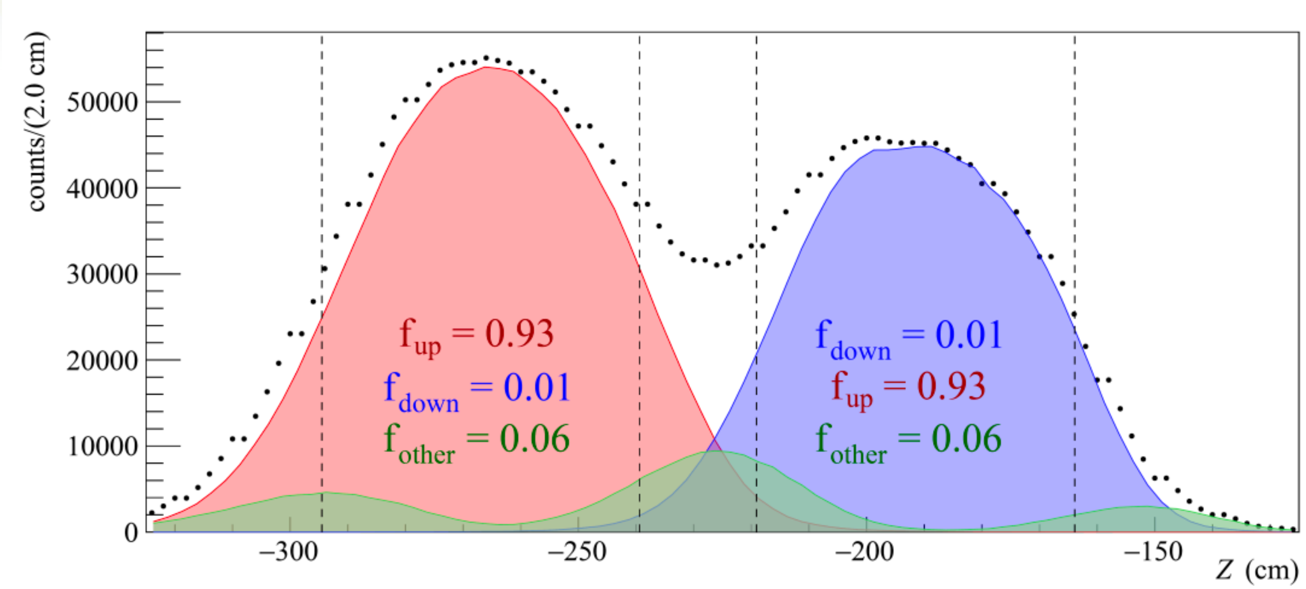


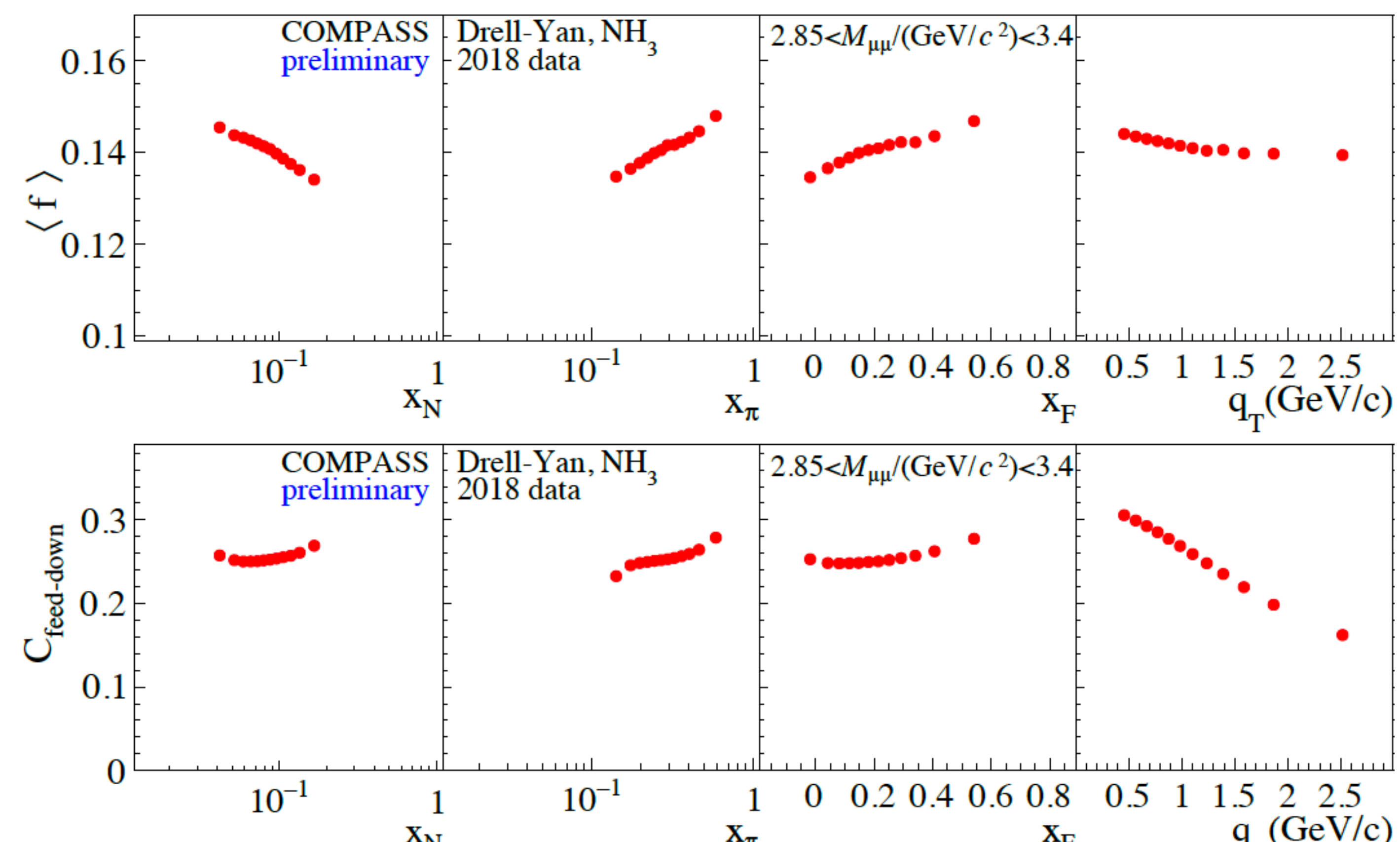
Event migration between target cells stronger in this mass range

Other challenges:
evaluation of the dilution factor*

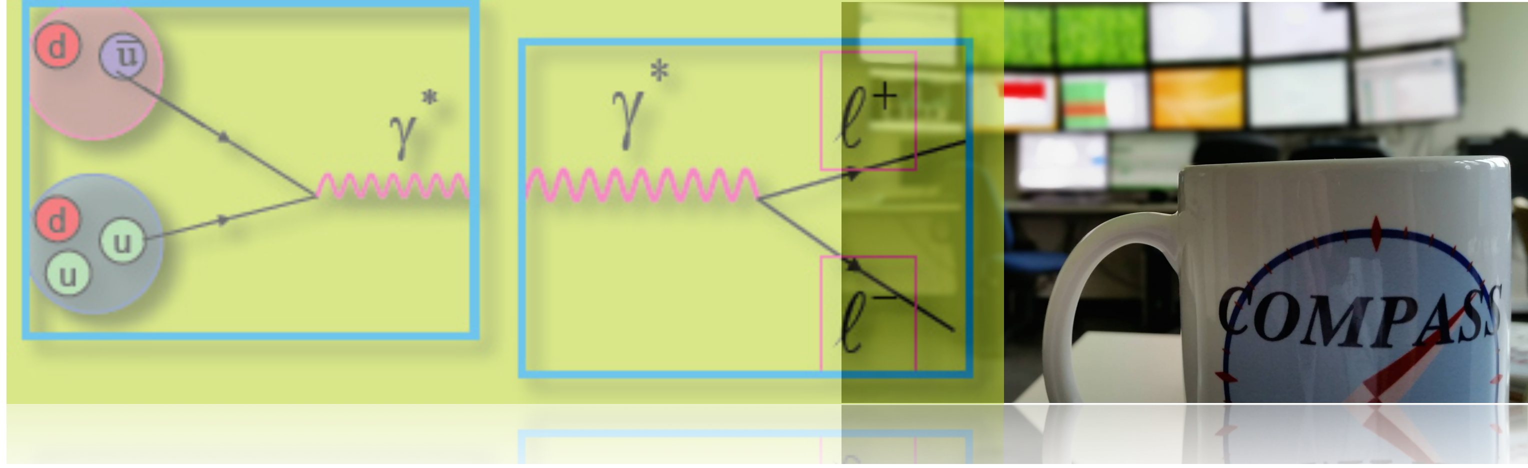
evaluation of feed-down contribution* from higher charmonium states (Ψ(2S) and the χ_c family, namely)

A^1_U assumed to be = 0

***calculated within the parton Reggeization approach**



TSAs for J/Ψ

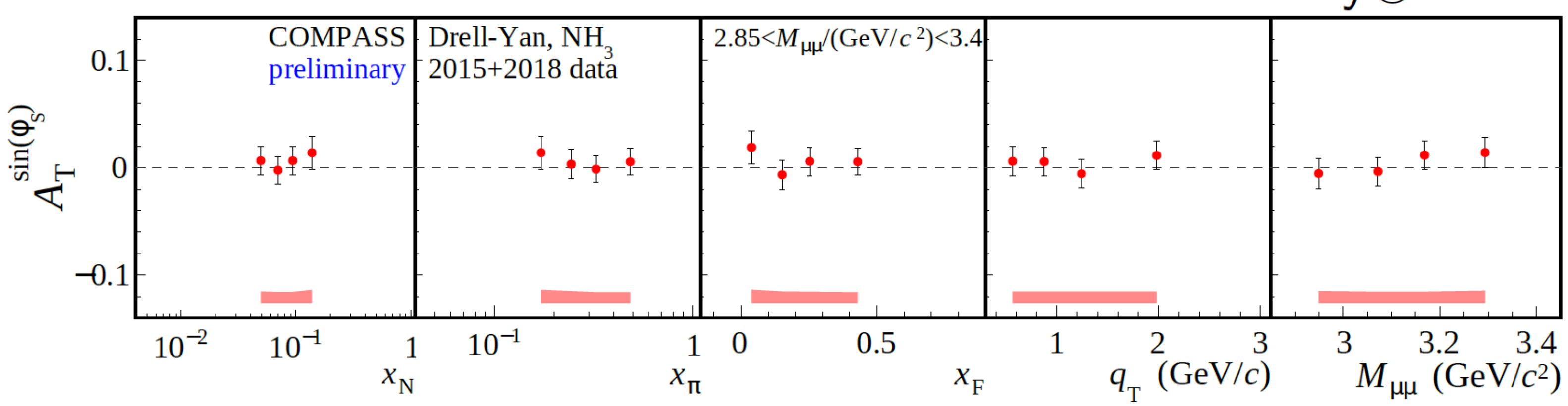


No significant kinematic dependence

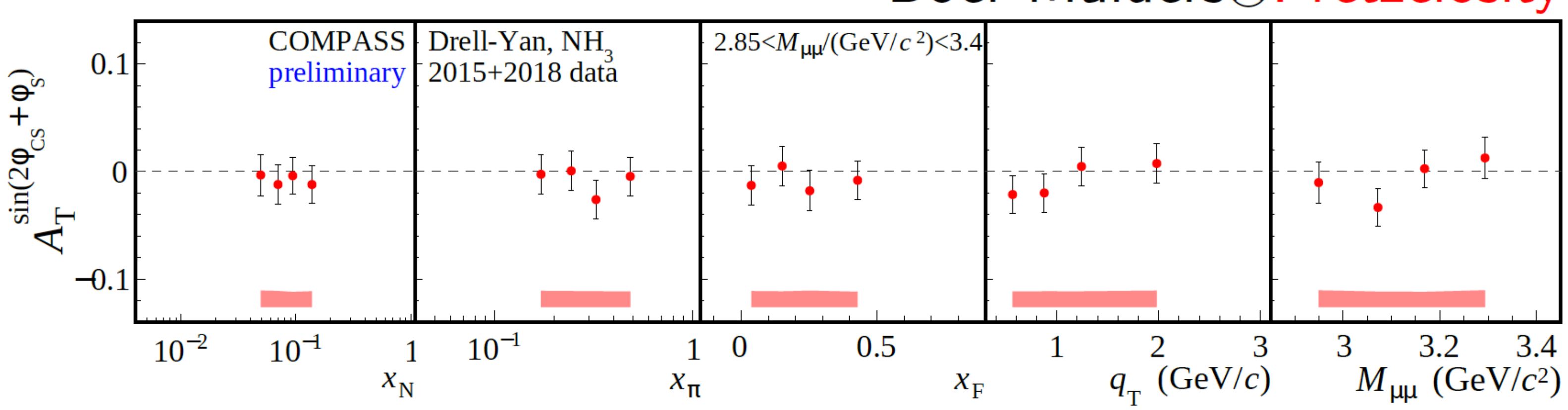
All TSA are compatible with zero
Additional scale uncertainty ~ 10% not shown due to dilution factor, $A^1_U = 0$ & polarisation

Parallel analyses ongoing on unpolarised angular distribution and absolute cross-section to provide

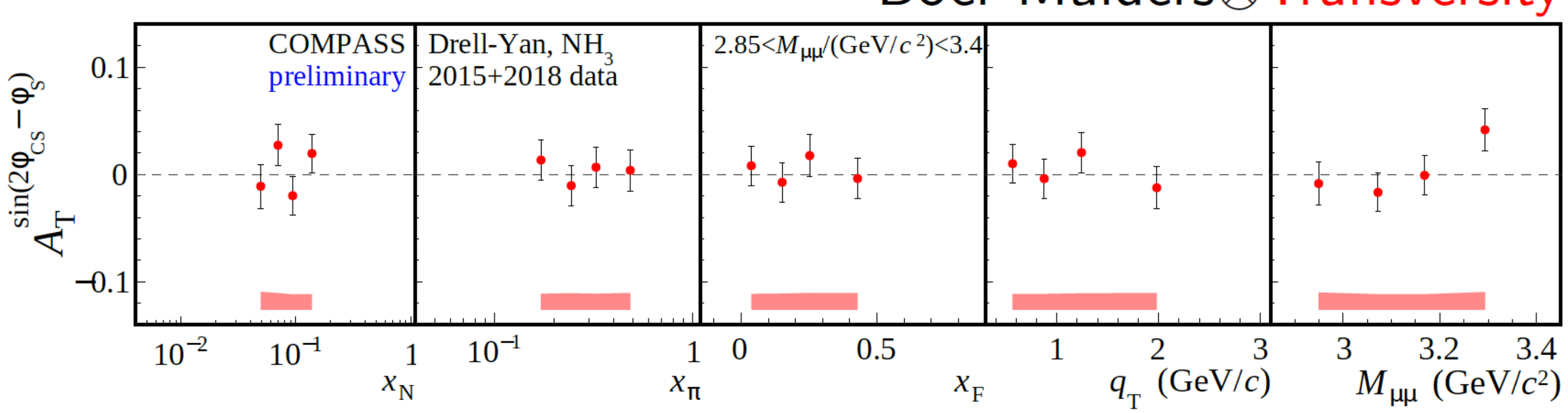
Number density⊗Sivers



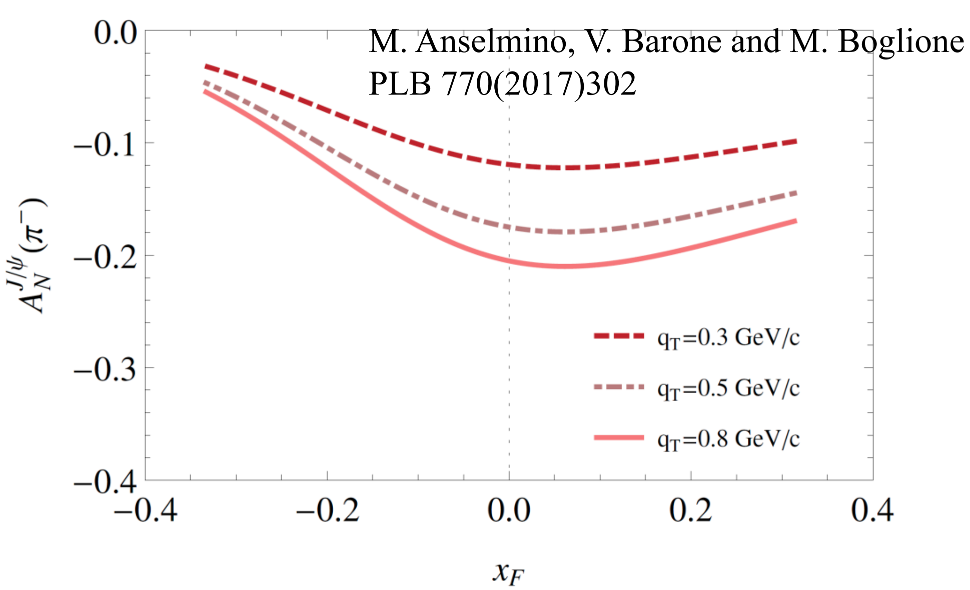
Boer-Mulders⊗Pretzelosity



Boer-Mulders⊗Transversity



Assuming q qbar dominance
neglecting feed-down J/ψ contribution
⇒ Large signal expected



From Compass to Amber

AMBER: at the North Area of the CERN-SPS

In the COMPASS experimental hall:

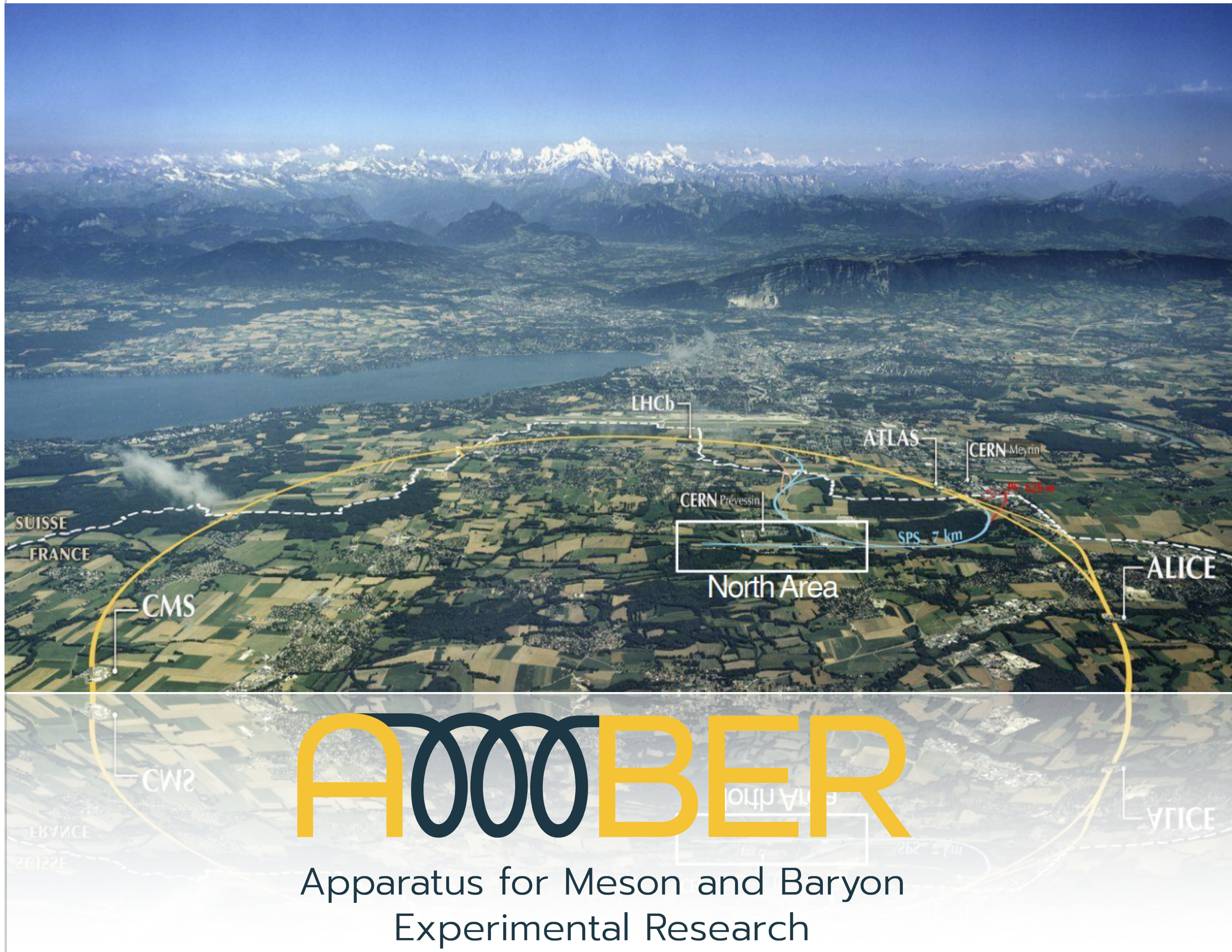
Availability of both hadron and muon (unique!) beams (M2 beam line)

Both beam charges available, and in wide range of energies (50-280 GeV/c)

Re-use of large aperture dipole magnets from COMPASS

Re-use of some of the most recent COMPASS detectors

Possible upgrade of the M2 beam line:
Using radio-frequency separation method, obtain kaon-enriched and antiproton-enriched beams



Physics possibilities at AMBER

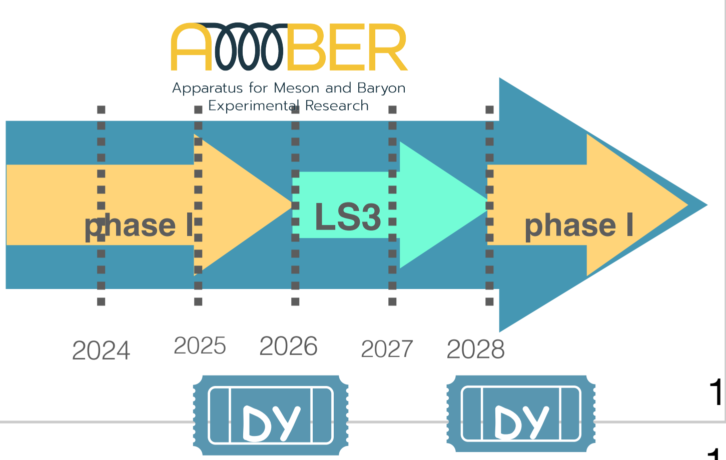
Program	Physics Goals	Beam Energy [GeV]	Beam Intensity [s^{-1}]	Trigger Rate [kHz]	Beam Type	Target	Earliest start time, duration	Hardware additions
muon-proton elastic scattering	Precision proton-radius measurement	100	$4 \cdot 10^6$	100	$\mu^\pm$	high-pressure H2		active TPC, SciFi trigger, silicon veto,
Hard exclusive reactions	GPD E	160	$2 \cdot 10^7$	10	$\mu^\pm$	$NH_3^\uparrow$		recoil silicon, modified polarised target magnet
Input for Dark Matter Search	$\overline{p}$ production cross section	20-280	$5 \cdot 10^5$	25	p	LH2, LHe		liquid helium target
$\overline{p}$-induced spectroscopy	Heavy quark exotics	12, 20	$5 \cdot 10^7$	25	$\overline{p}$	LH2		target spectrometer: tracking, calorimetry
Drell-Yan	Pion PDFs	190	$7 \cdot 10^7$	25	$\pi^\pm$	C/W		
Drell-Yan (RF)	Kaon PDFs & Nucleon TMDs	$\sim$100	10^8	25-50	$K^\pm, \overline{p}$	$NH_3^\uparrow$, C/W		"active absorber", vertex detector
Primakoff (RF)	Kaon polarisa-bility & pion life time	$\sim$100	$5 \cdot 10^6$	> 10	K^-	Ni		
Prompt Photons (RF)	Meson gluon PDFs	≥ 100	$5 \cdot 10^6$	10-100	$K^\pm$ $\pi^\pm$	LH2, Ni		hodoscope
K-induced Spectroscopy (RF)	High-precision strange-meson spectrum	50-100	$5 \cdot 10^6$	25	K^-	LH2		recoil TOF, forward PID
Vector mesons (RF)	Spin Density Matrix Elements	50-100	$5 \cdot 10^6$	10-100	$K^\pm, \pi^\pm$	from H to Pb		

As expressed in the LOI: https://arxiv.org/pdf/1808.00848.pdf

Phase-I
AMBER Proposal Phase-I: http://cds.cern.ch/record/2676885?ln=en

Approved by CERN

Phase-II
Proposal in preparation



19

Physics possibilities at AMBER

Program	Physics Goals	Beam Energy [GeV]	Beam Intensity $[s^{-1}]$	Trigger Rate [kHz]	Beam Type	Target	Earliest start time, duration	Hardware additions
muon-proton elastic scattering	Precision proton-radius measurement	100	$4 \cdot 10^6$	100	$\mu^\pm$	high-pressure H2		active TPC, SciFi trigger, silicon veto,
Hard exclusive reactions	GPD E	160	$2 \cdot 10^7$	10	$\mu^\pm$	$NH_3^\uparrow$		recoil silicon, modified polarised target magnet
Input for Dark Matter Search	$\bar{p}$ production cross section	20-280	$5 \cdot 10^5$	25	p	LH2, LHe		liquid helium target
$\bar{p}$-induced spectroscopy	Heavy quark exotics	12, 20	$5 \cdot 10^7$	25	$\bar{p}$	LH2		target spectrometer: tracking, calorimetry
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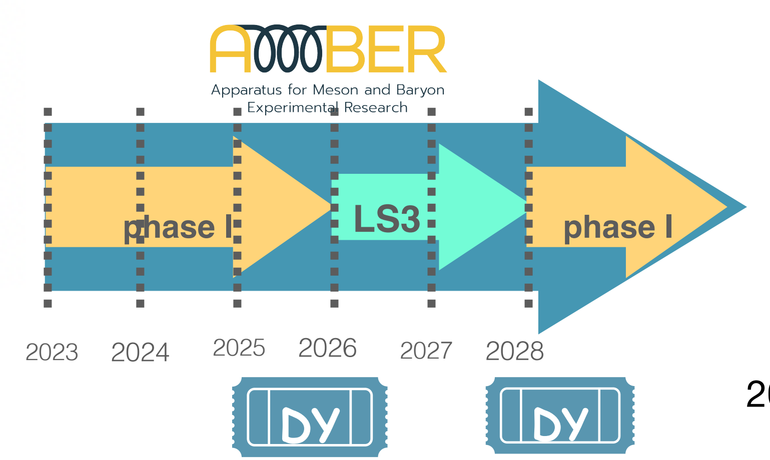
As expressed in the LOI:
https://arxiv.org/pdf/1808.00848.pdf

Phase-I
AMBER Proposal Phase-I:
http://cds.cern.ch/record/2676885?ln=en

Meson Structure at AMBER

Phase-II
2029 and beyond
Proposal in preparation



DY physics possibilities at AMBER

Near term future:

- The structure of the pion: determination of the pion valence and sea-quark distributions
- Investigation of flavour-dependent effects in nuclear targets

Long term future:

- Unprecedented studies of kaon structure

Charmonia measurements —> study of the production mechanism and possible access to the pion and kaon gluon PDFs

What do we know about pion structure?

Pion-induced Drell-Yan data collected by NA3, NA10, WA39 (CERN) and E615 (Fermilab), more than 30 years ago —> access valence and sea (NA3 and WA39) distributions in the pion

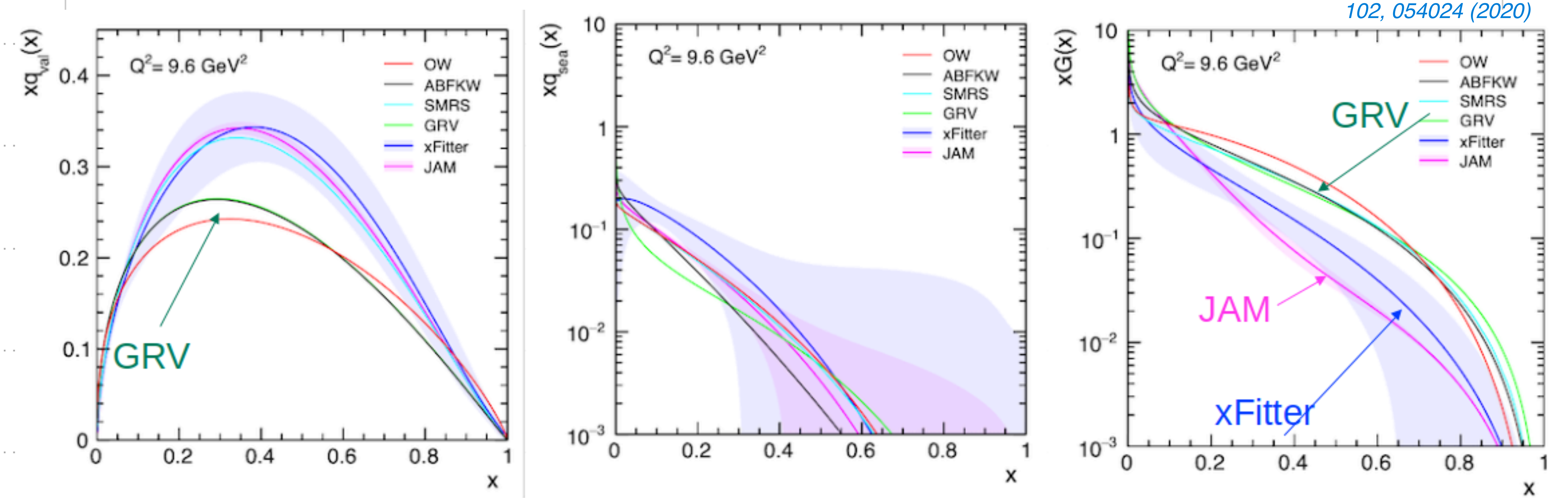
Available data from direct-photon production also obtained at that time, by WA70 and NA24(CERN)

limited data sets —> sea quark distribution was derived from momentum-sum-rule conservation

GRV set of pion PDFs - Drell-Yan, charmonia and prompt photon production experiments (E615, NA10, WA70, NA24)

JAM set - production of leading neutrons in DIS at HERA (ZEUS, H1)

Chang et al. PRD 102, 054024 (2020)



What do we know about pion structure?

- Mostly heavy target
  —> nuclear effects
- Some did not publish cross-sections
- Limited data sets
  —> sea quark distribution was derived from momentum-sum-rule conservation
- Some did not measure with both beam charges
  —> no sea/valence separation

Isoscalar target

Both beam charges

High statistics

Table 7: Statistics collected by earlier experiments (top rows), compared with the achievable statistics of the proposed experiment (bottom rows), in 213 days (π^+ beam) + 67 days (π^- beam).

Experiment	Target type	Beam energy (GeV)	Beam type	Beam intensity (part/sec)	DY mass (GeV/c^2)	DY events
E615	20 cm W	252	π^+ π^-	17.6×10^7 18.6×10^7	4.05 – 8.55	5000 30000
NA3	30 cm H_2	200	π^+ π^-	2.0×10^7 3.0×10^7	4.1 – 8.5	40 121
	6 cm Pt	200	π^+ π^-	2.0×10^7 3.0×10^7	4.2 – 8.5	1767 4961
NA10	120 cm D_2	286 140	π^-	65×10^7	4.2 – 8.5 4.35 – 8.5	7800 3200
	12 cm W	286 194 140	π^-	65×10^7	4.2 – 8.5 4.07 – 8.5 4.35 – 8.5	49600 155000 29300
COMPASS 2015 COMPASS 2018	110 cm NH_3	190	π^-	7.0×10^7	4.3 – 8.5	35000 37000
AMBER	75 cm C	190	π^+	1.7×10^7	4.3 – 8.5 4.0 – 8.5	21700 31000
		190	π^-	6.8×10^7	4.3 – 8.5 4.0 – 8.5	67000 91100
	12 cm W	190	π^+	0.4×10^7	4.3 – 8.5 4.0 – 8.5	8300 11700
		190	π^-	1.6×10^7	4.3 – 8.5 4.0 – 8.5	24100 32100

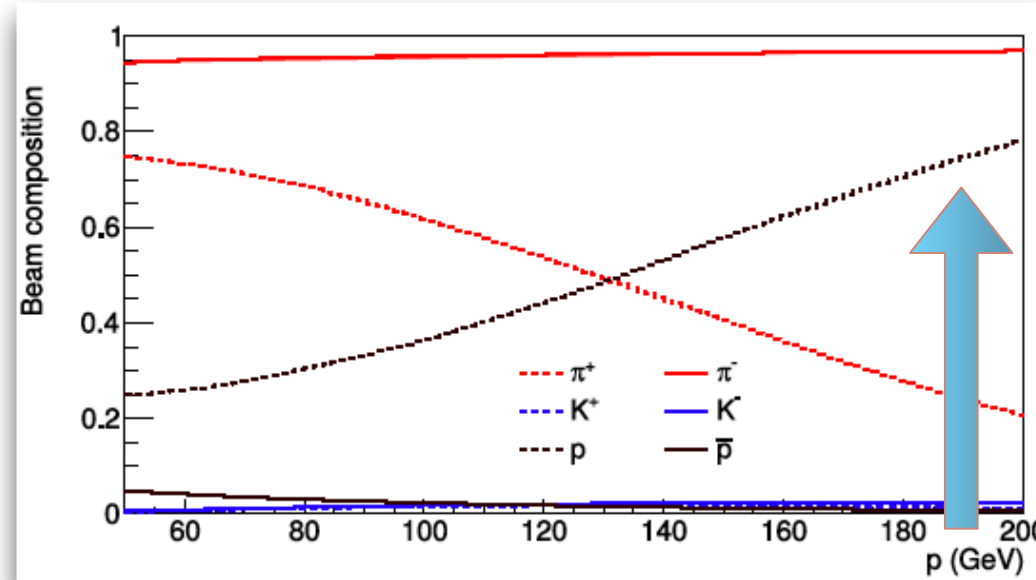
Pion-induced Drell-Yan at AMBER

➤ High energy and intensity pion beams

Example @ 190 GeV/c

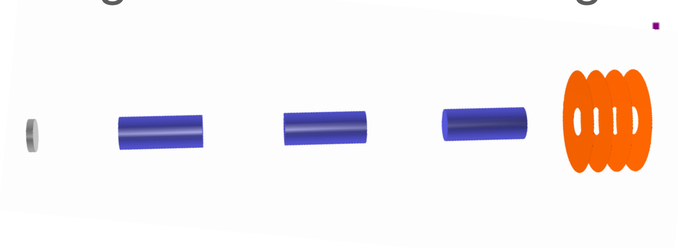
$I_{\pi^-} \sim I_{beam} = 7.0 \times 10^7$/s

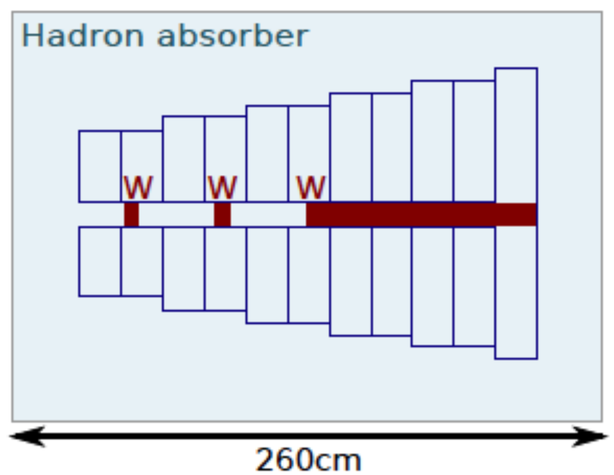
$I_{\pi^+} \sim 25\%\ I_{beam} = 1.7 \times 10^7$/s



➤ COMPASS-like apparatus

➤ Segmented Carbon target





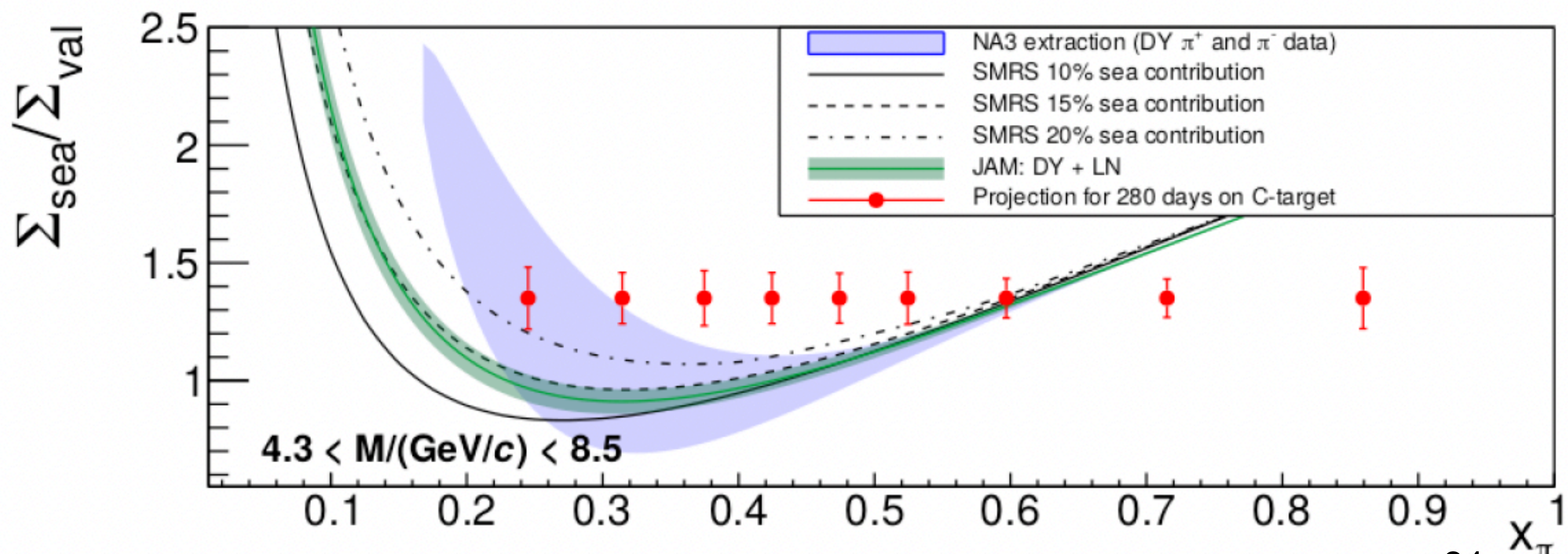
➤ Flavour dependent nuclear PDFs

Positive and negative pion beam on Carbon and Tungsten target

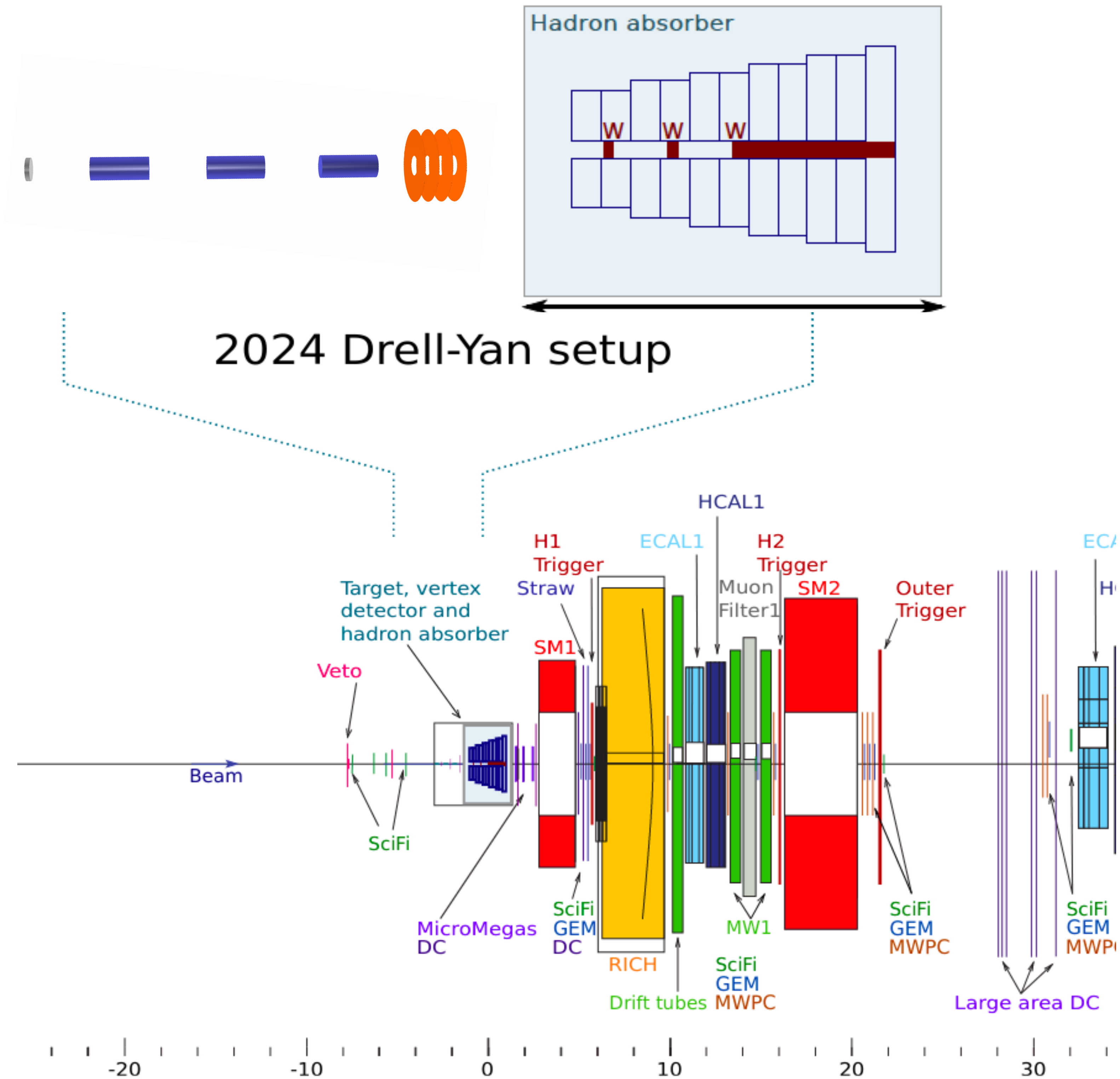
➤Aim at the first precise direct measurement of the pion sea contribution

$$\frac{\Sigma_{sea}}{\Sigma_{valence}} = \frac{4\sigma^{\pi^+C} - \sigma^{\pi^-C}}{-\sigma^{\pi^+C} + \sigma^{\pi^-C}}$$

LO: only sea-val and val-sea terms
LO: only val-val terms



Pion-induced Drell-Yan at AMBER



Drell-Yan process is a low cross-section process:

High intensity hadron beam

Hadron absorber to protect Spectrometer from a very high secondary flux

Vertex Detector to compensate loses in resolution because of the absorber in order to improve mass and space resolution

Large surface: ±20cm

CEDARs

π-K separation beneficial for π-induced DY

Essential for K-induced DY

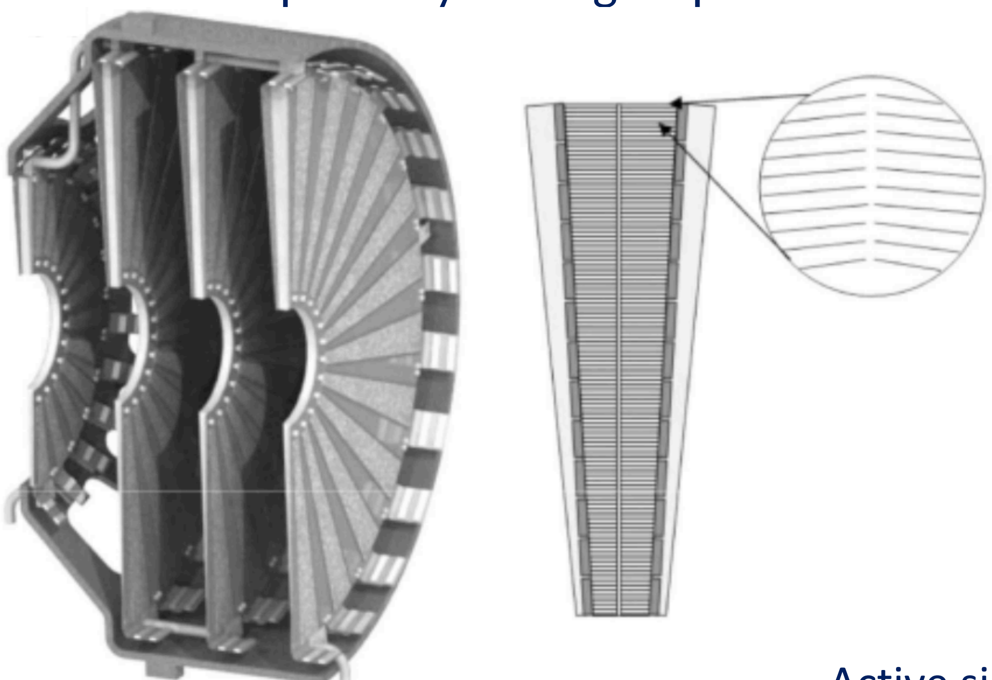
Efficient majority discrimination

—> low divergence

Pion-induced Drell-Yan at AMBER

Apparatus for Meson and Baryon Experimental Research

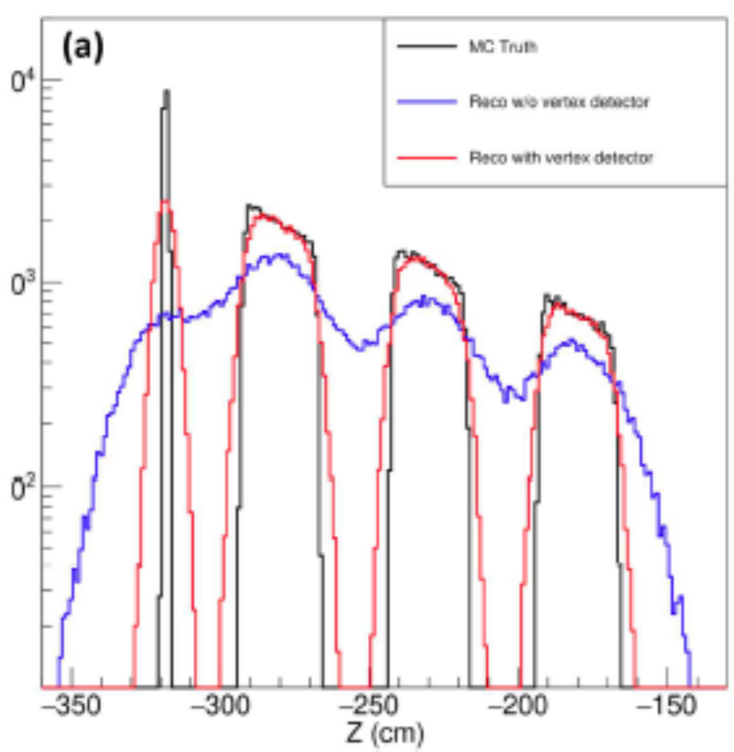
Proposal by LANL group to reuse PHENIX FVTX Silicon Vertex Detector



Parameters	Values
Silicon sensor thickness (μm)	320
Strip pitch (μm)	75
Strips per column	1664
Inner radius (mm)	44.0
Strip columns per plane	96
Time resolution (ns)	10

Active silicons mini-strip sensors plus front-end ASIC, the FPHX chip bonded directly on sensors

- Time resolution: $\sim$ ns
- Spatial resolution: $\sim 20\mu$m



Simulations and optimisation of the apparatus and reconstruction ongoing

Preliminary:
$\rightarrow \sigma_{\mu\mu} \sim 110$ MeV$/c^2$

$M_{\mu\mu} > 4.3$ GeV$/c^2 \rightarrow M_{\mu\mu} > 4.0$ GeV$/c^2$:
$\Rightarrow \sim 50\%$ gain in DY statistics

J/ψ production: an access to the pion gluon content

Apparatus for Meson and Baryon Experimental Research

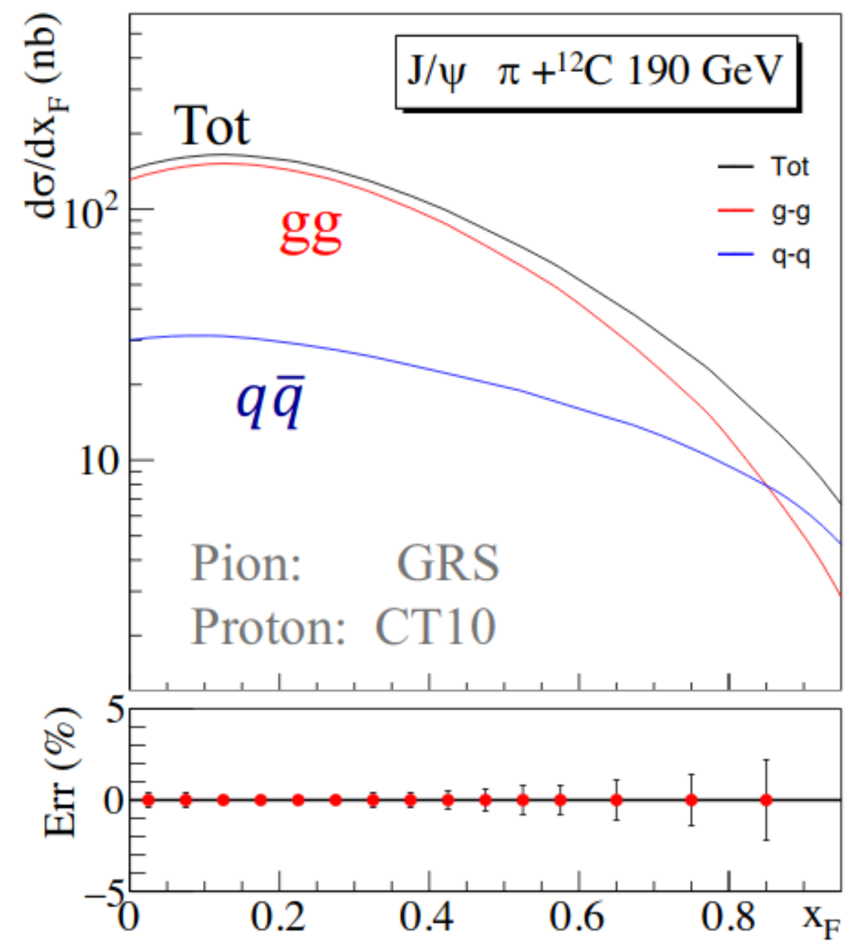
Two main mechanisms of J/ψ production in hadron collisions: *$gg \rightarrow gJ/\psi$ and $\bar{q}q \rightarrow J/\psi$*

1) test of charmonia production mechanisms: CEM vs NRQCD

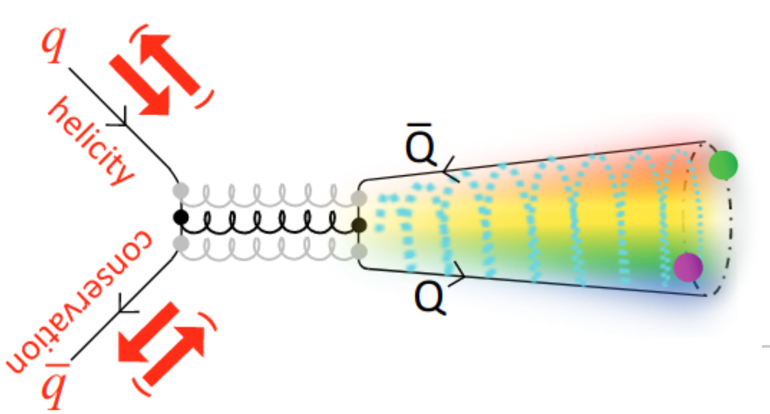
2) Model-dependent separation of gg and qq contributions using data collected with both positive and negative beams

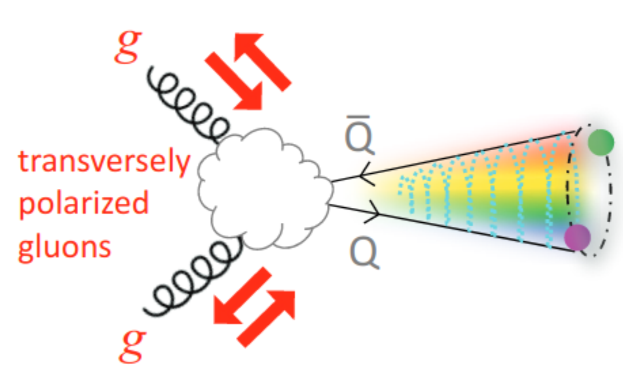
3) probe of gluon and quark PDFs

@AMBER: large statistics J/ψ production at dimuon channel, differential cross-section measurements, low-pT regime, expected significant feed-down: ψ(2S), χc1, χc2



Color Evaporation Model (ICEM)
Cheung and Vogt, PRD98, 114029 (2018)
and priv. comm.





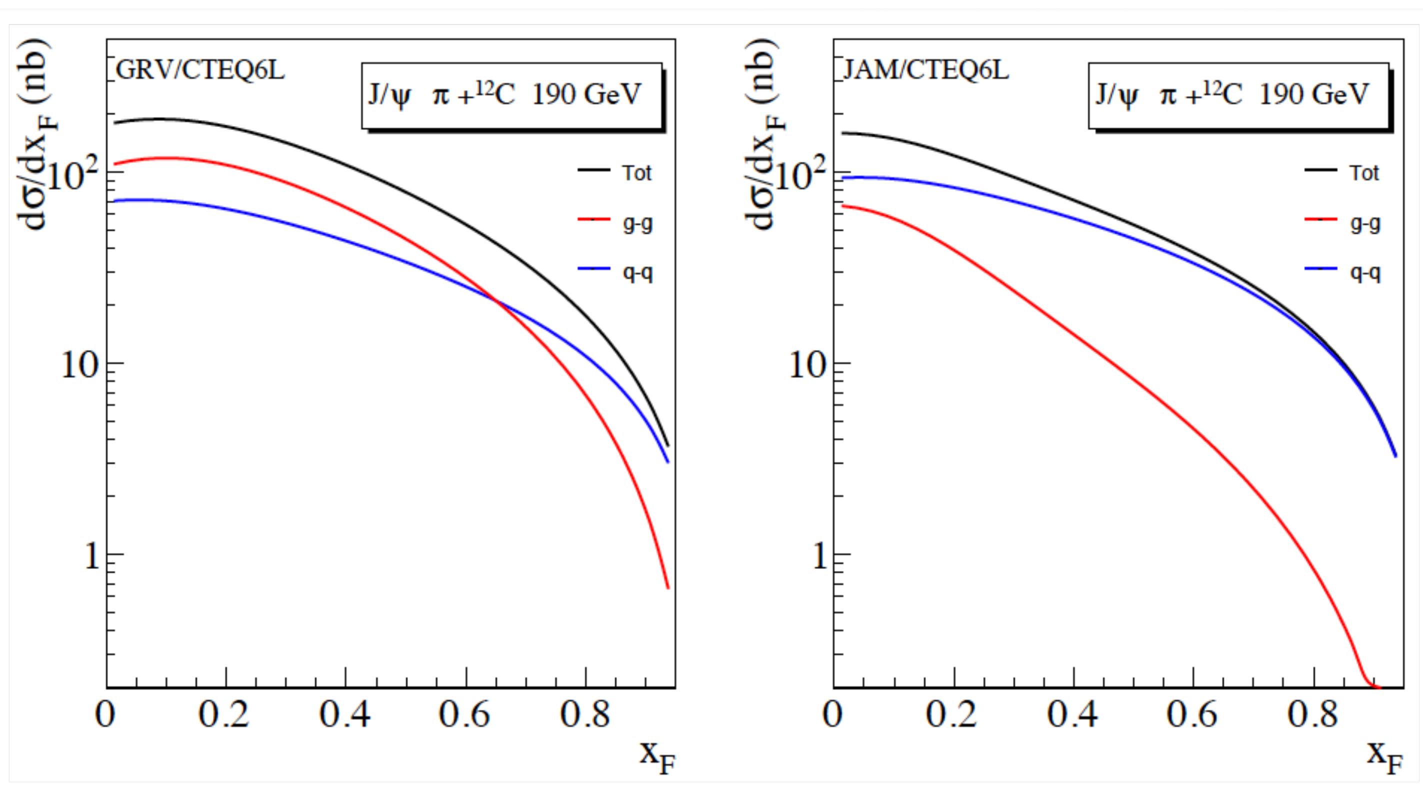
J/ψ production: an access to the pion gluon content

Apparatus for Meson and Baryon Experimental Research

In the energy domain of AMBER and for sufficiently high xF values, the $q\bar{q}$ component has a magnitude comparable or larger to that of the gg component.

The relative amount of both components is given by the overall amplitude and shape of the corresponding quark and gluon densities in the Bjorken x region between 0.05 and 0.95 for the pion and between 0.05 and 0.4 for the nucleon.

Data may be used to infer the gluon distribution in the pion, within the uncertainties of the hadronization model.



Experiment	Target type	Beam energy (GeV)	Beam type	J/ψ events
NA3 [76]	Pt	150	π^-	601000
		280	π^-	511000
		200	π^+	131000
			π^-	105000
E789 [129, 130]	Cu	800	p	200000
	Au			110000
	Be			45000
E866 [131]	Be, Fe, Cu	800	p	3000000
NA50 [132]	Be	450	p	124700
	Al			100700
	Cu			130600
	Ag			132100
	W			78100
NA51 [133]	p	450	p	301000
	d			312000
HERA-B [134]	C	920	p	152000
COMPASS 2015	110 cm NH_3	190	π^-	1000000
COMPASS 2018				1500000
AMBER	75 cm C	190	π^+	1200000
			π^-	1800000
			p	1500000
	12 cm W	190	π^+	500000
			π^-	700000
			p	700000

What do we know about kaon structure?

Apparatus for Meson and Baryon Experimental Research

Sole measurement from NA3

J. Badier et al., PLB93 354 (1984)

- 200 GeV K^- beam on 6 cm Pt target
- 700 kaon-induced Drell-Yan events

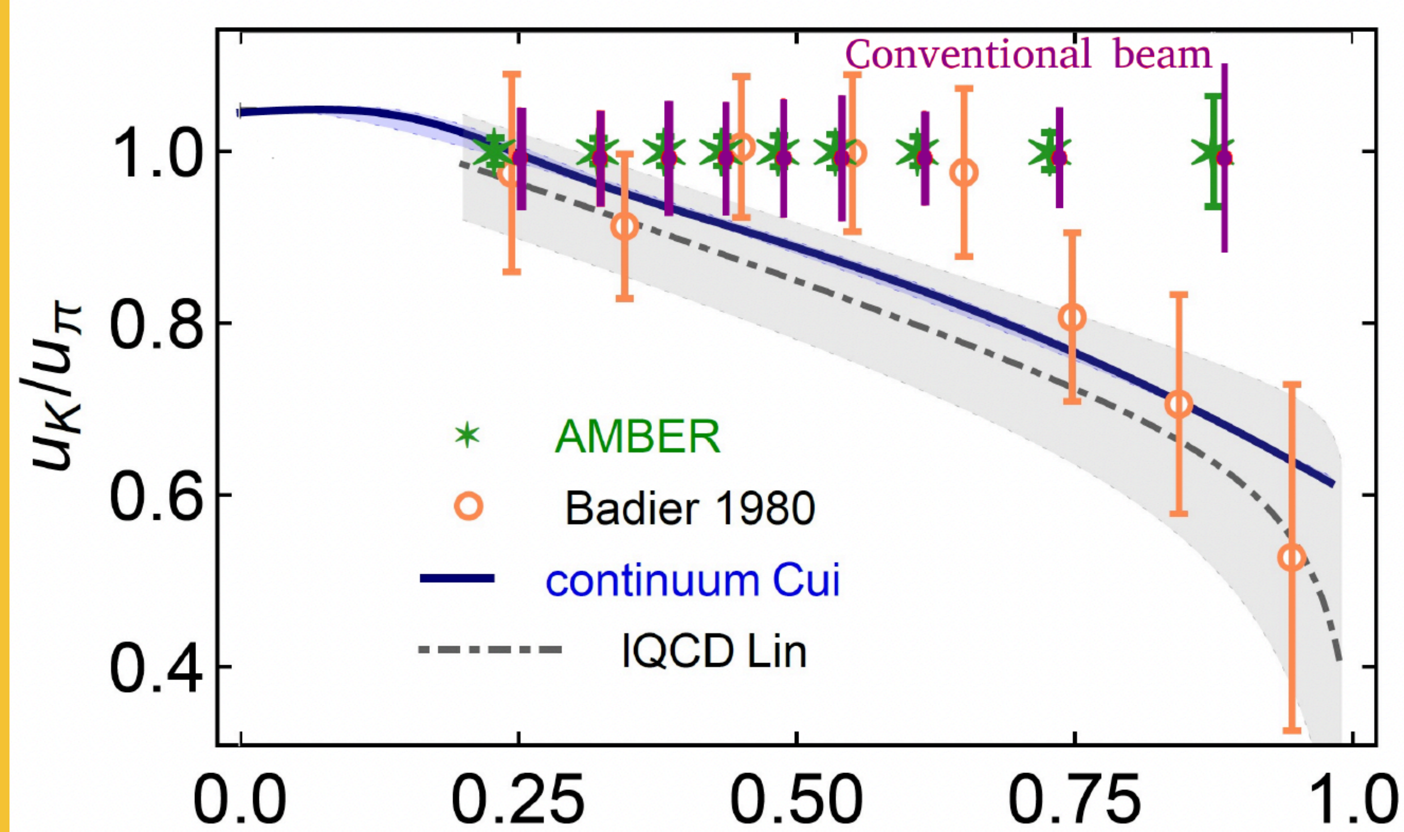
Interesting hint: At hadronic scale gluons carry only 5% of K's momentum vs 30% in π

- Scarce data on u-valence
- No measurements on gluons
- No measurements on sea quarks

➤ How to improve the situation?

With a conventional beam – from improved beamline and beam telescope – the AMBER statistics goal scales down, but **there would be important gain wrt NA3.**

Z-F. Cui, *et al.* EPJC80(2020)1064, H-W. Lin *et al.*, PRD103(2021)014516

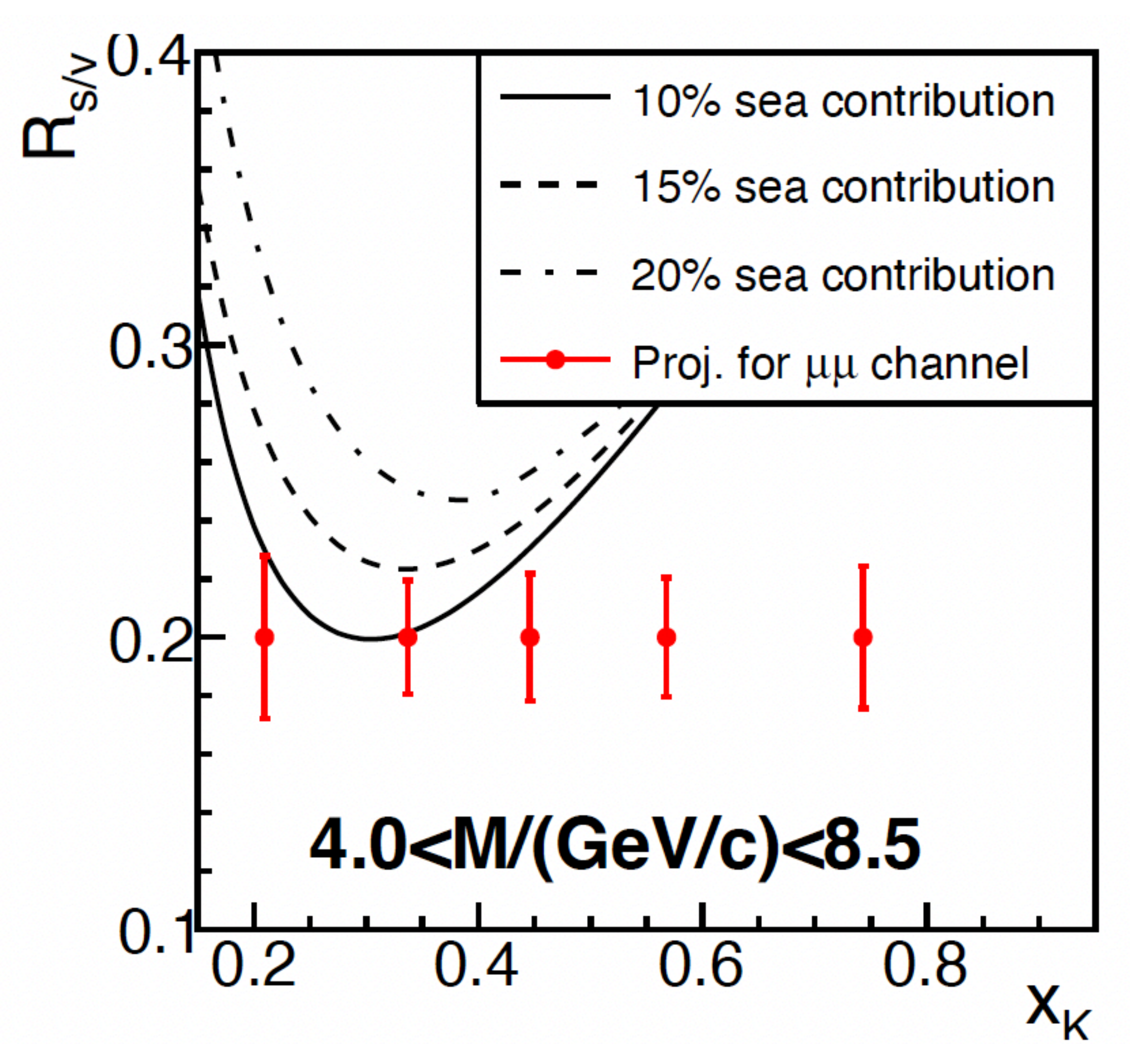


* AMBER (LoI):

Assumed an RF-separated beam of 2 x 10[7] kaons/second.

But: how high can the beam intensity be? Not enough for kaon-induced Drell-Yan…

kaon-induced Drell-Yan at AMBER



First-ever kaon sea-valence separation: using both charges kaon beams

$$R_{s/v} = \sigma^{K^+A} / \Sigma_{val}$$

$$\Sigma_{val} = \sigma^{K^-A} - \sigma^{K^+A}$$

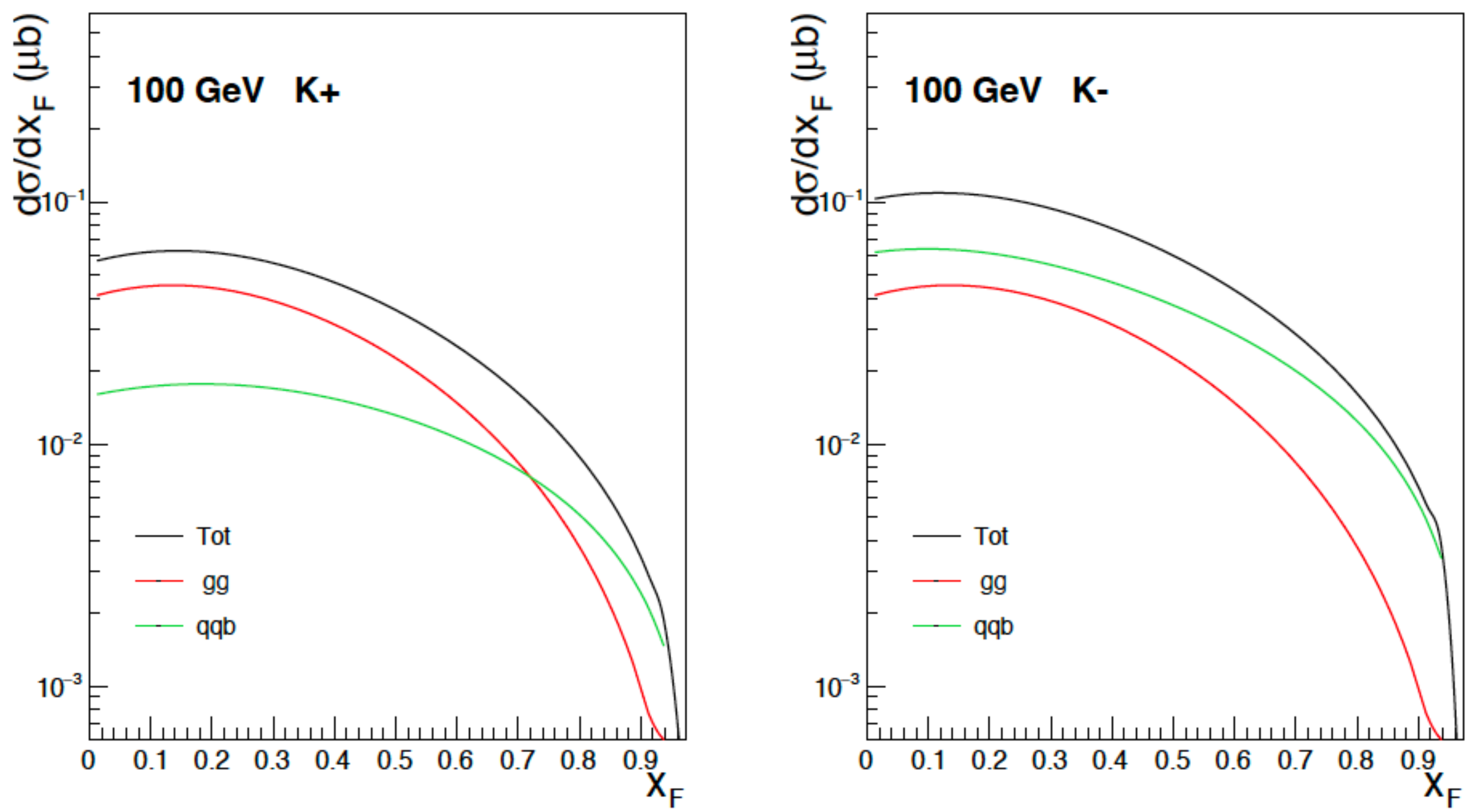
Higher beam momentum:
→ access to lower x_K

If using a conventional beam, it might be more advantageous to go for E_{beam}=190 GeV/c

J/ψ production: an access to the kaon gluon content

Using Color Evaporation Model (Int.J.Mod.Phys. A 10 (1995) 3043) and JAM18 “pion” PDFs (PRL 121, 152001 (2018))

- J/Ψ data collected in parallel with kaon-induced Drell-Yan
- Large statistics
- Model-dependent access to the gluon distribution in kaons
- J/Ψ production cross section (LO):



AMBER LOI

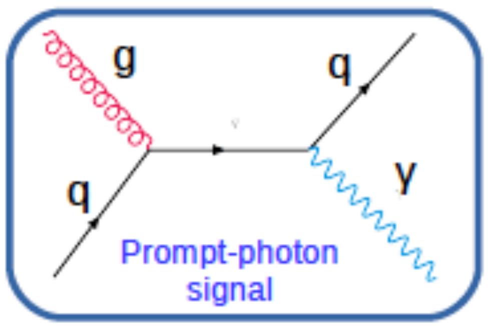
$$K^-(\bar{u}s)+p(uud)\propto gg+\left[\bar{u}_v^K u_v^p\right]+\left[\bar{u}_v^K u_s^p+s_v^K s_s^p\right]+\left[\bar{u}_s^K u_v^p\right]+\left[\bar{u}_s^K u_s^p+u_s^K\bar{u}_s^p+s_s^K\bar{s}_s^p+\bar{s}_s^K s_s^p\right]$$

$$K^+(u\bar{s})+p(uud)\propto gg+\left[---\right]+\left[u_v^K\bar{u}_s^p+\bar{s}_v^K s_s^p\right]+\left[\bar{u}_s^K u_v^p\right]+\left[\bar{u}_s^K u_s^p+u_s^K\bar{u}_s^p+s_s^K\bar{s}_s^p+\bar{s}_s^K s_s^p\right]$$

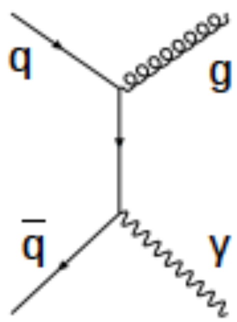
val-val | val-sea | sea-val | sea-sea

kaon-induced prompt-photon production at AMBER

clean access to the gluon distribution in kaon

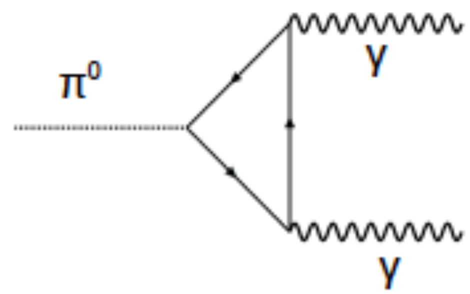


Direct access to the gluon PDF at $x_g^K > 0.05$, $Q^2 \sim p_T$



background

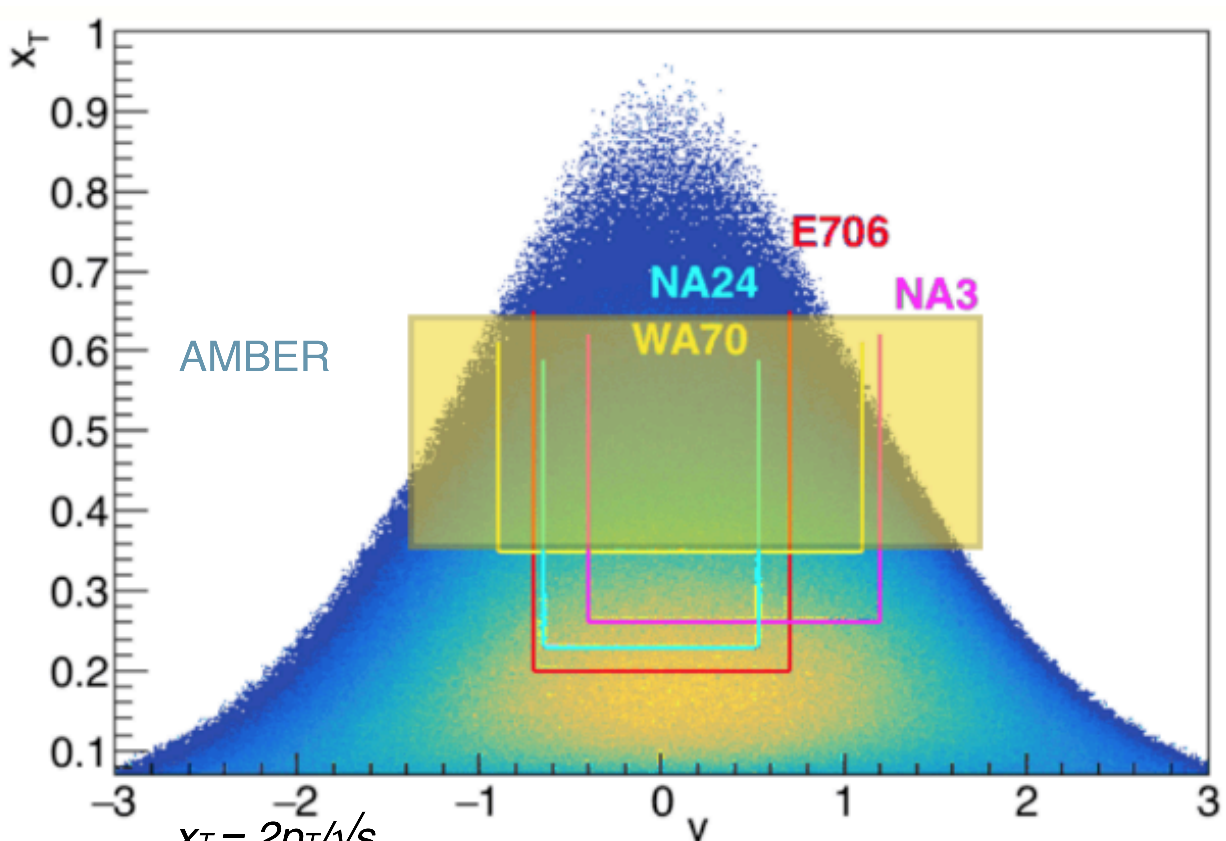
K^+ beam: minimize bkg

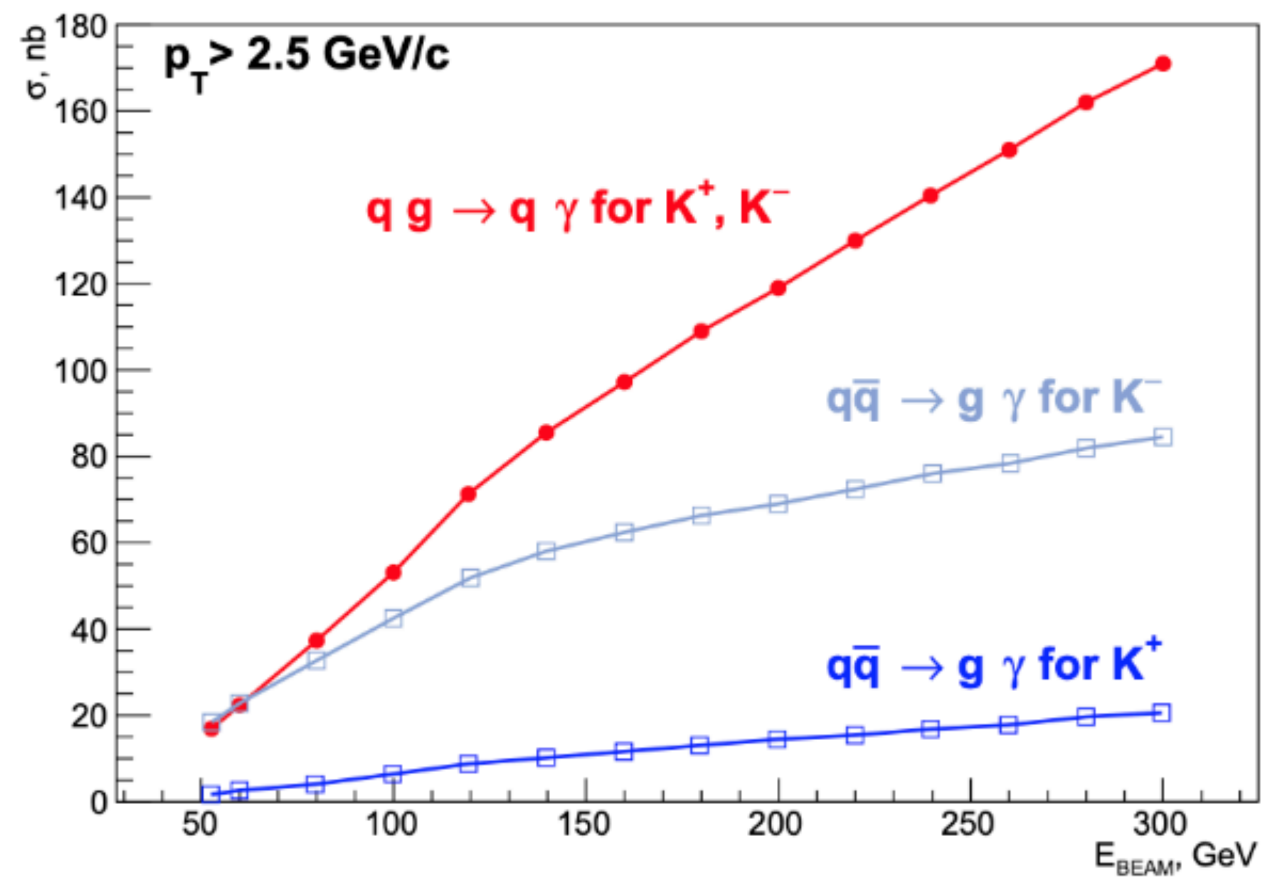


Minimum bias photons background

$p_T^\gamma > 2.5$ GeV/c: minimize photon bkg

- ➤ 100 GeV K+ beam on a long lH2 target

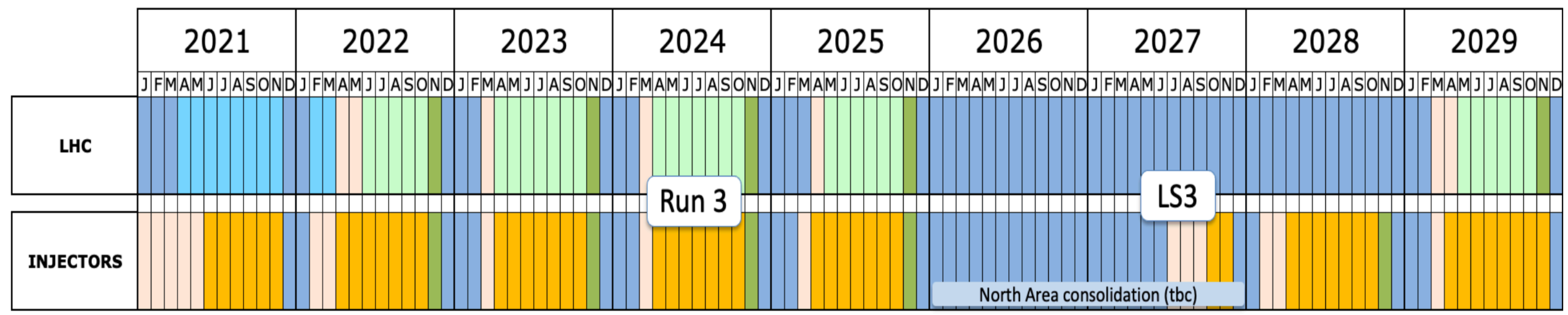


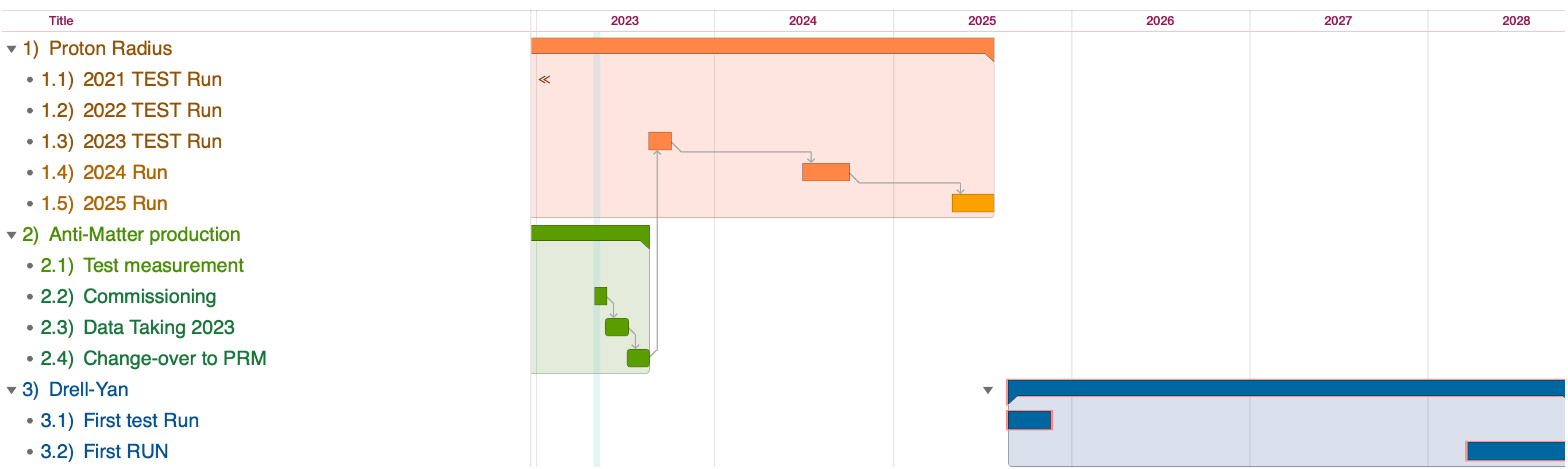


AMBER Phase-1 running plan

Milestones

1. May 1st 2023 – Antimatter production Run (Std. DAQ)
2. Sep. 1st 2023 – PRM pilot (FreeDAQ, very limited setup)
3. May 1st 2024 – PRM Run (FreeDAQ, limited setup)
4. Sep. 1st 2025 – DY Pilot (FreeDAQ, all trackers + mu id)
5. May 1st 2028 – DY Run (Full Spectr. Ex. RICH, Calorimeters)





Summary

A physics program fro nucleon and meson structure studies at COMPASS and AMBER

@ COMPASS

COMPASS successfully collected polarized Drell-Yan data in 2015 and 2018

Full 2015+2018 combined Drell-Yan TSA data analysis is completed

● TSAs measured both in Drell-Yan high-mass region and J/Ψ region → this talk

● Unpolarized Drell-Yan studies → see Filippo's talk

@ AMBER

A future Drell-Yan experiment to study meson structure

● Phase-I: Pion structure from pion-induced Drell-Yan and Charmonium production

● Phase-II: Kaon structure from kaon-induced Drell-Yan and Charmonium production, gluon content in the kaon from direct-photon production

Thank you for your attention