DIS2026

AMBER

Apparatus for Meson and Baryon Experimental Research

Meson structure study via Drell-Yan production at AMBER

ZOË EARNSHAW ON BEHALF OF AMBER

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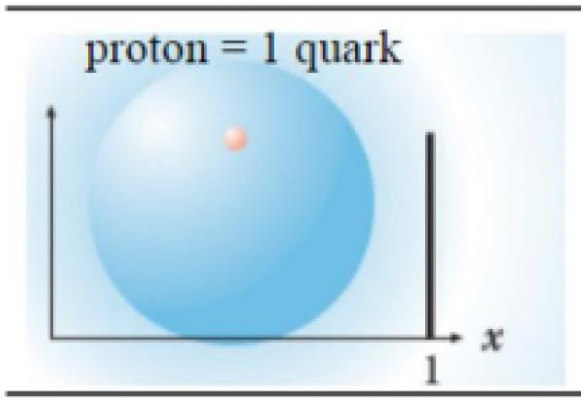
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

Proton PDF

Momentum P of composite proton is shared between constituent partons

PDFs measured experimentally

Well understood for proton



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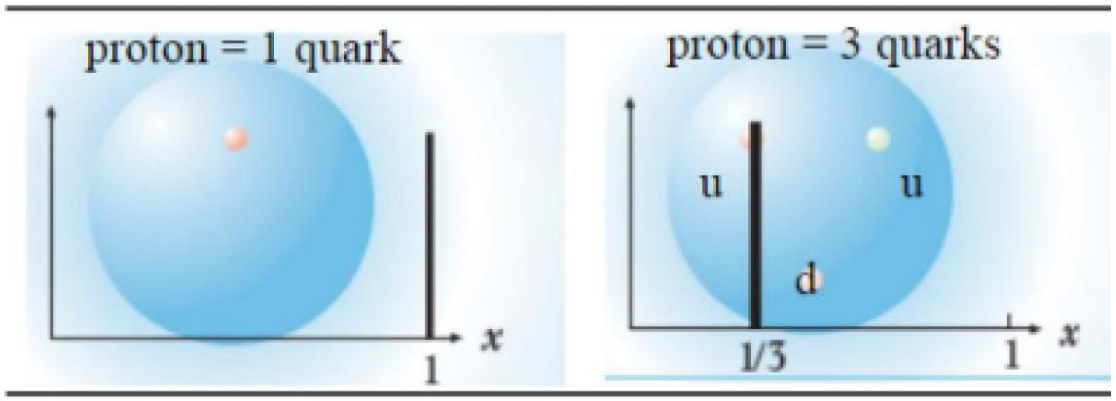

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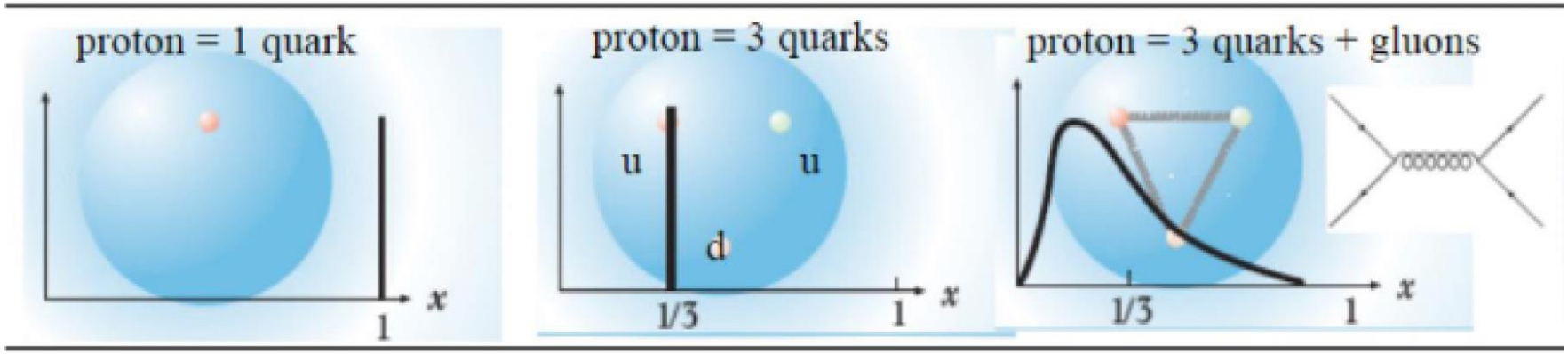

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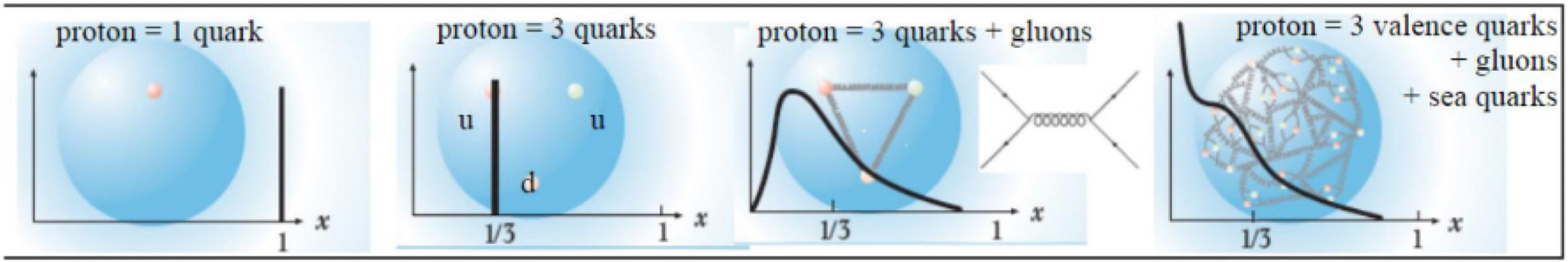

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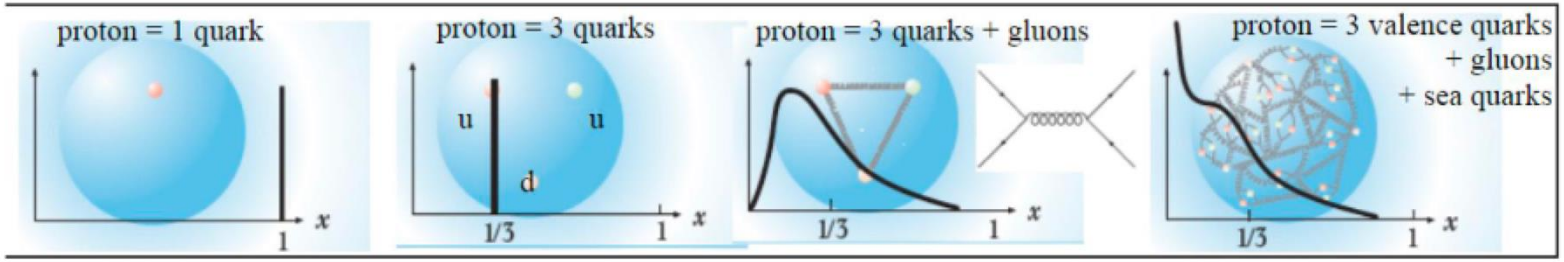
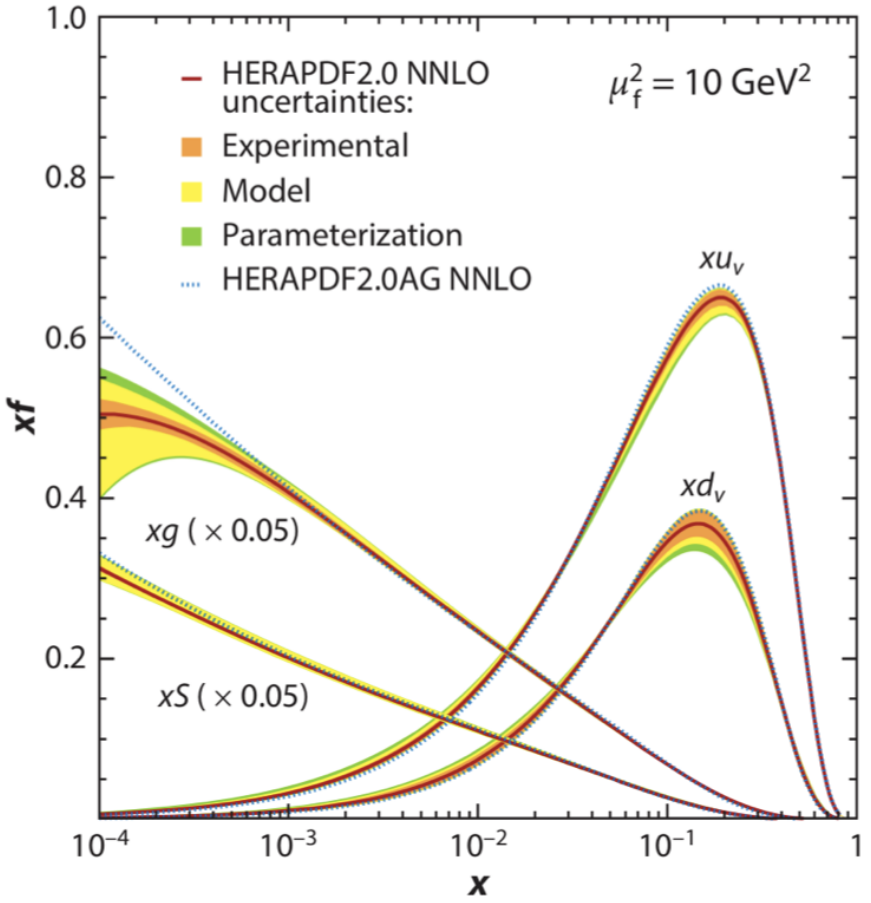




Pion PDF

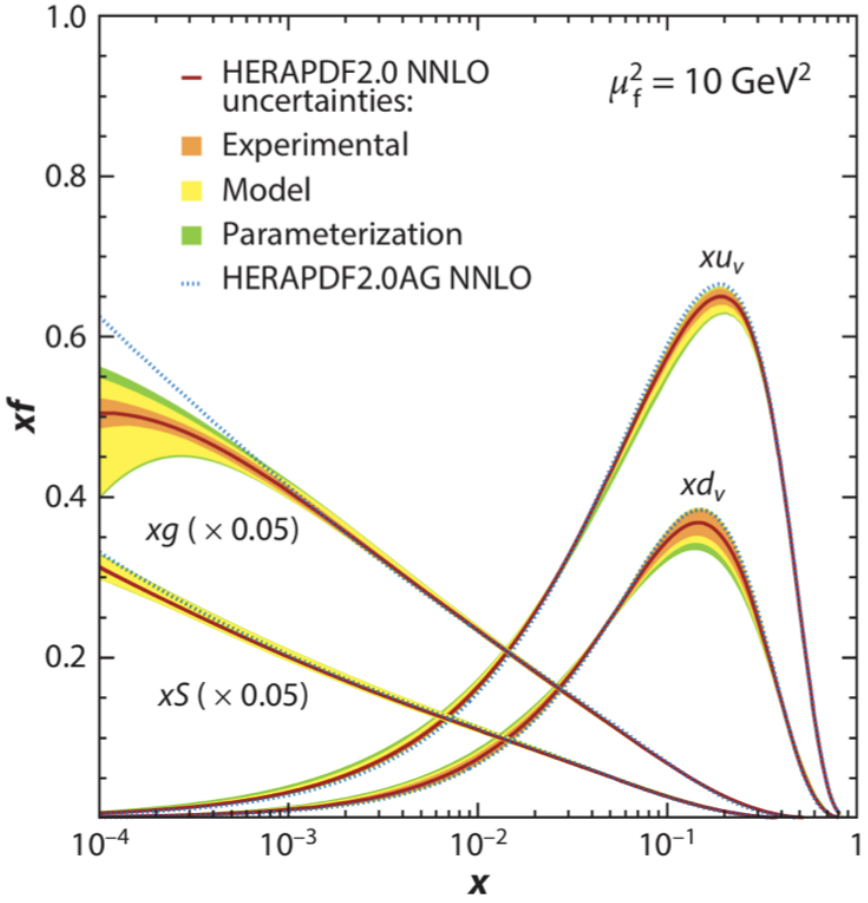
Apparatus for Meson and Baryon Experimental Research

Pion PDF relatively poorly constrained

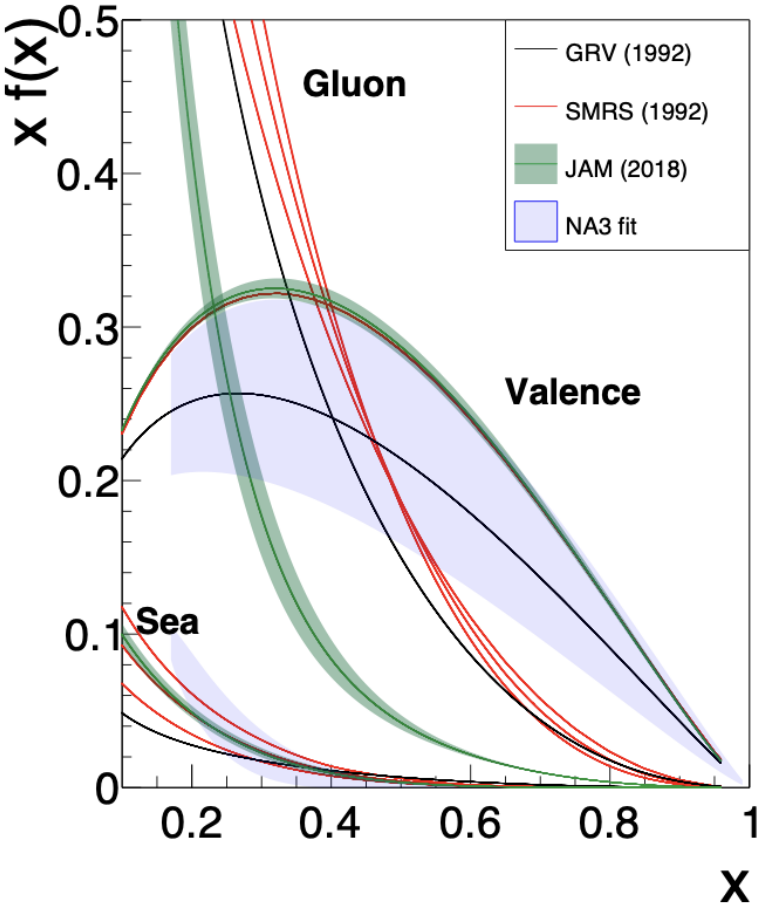
Limited data from experiments with heavy nuclear targets

Sea and gluon content especially poorly measured

Proton



Pion



Kaon PDF

Currently only 700 events from NA3

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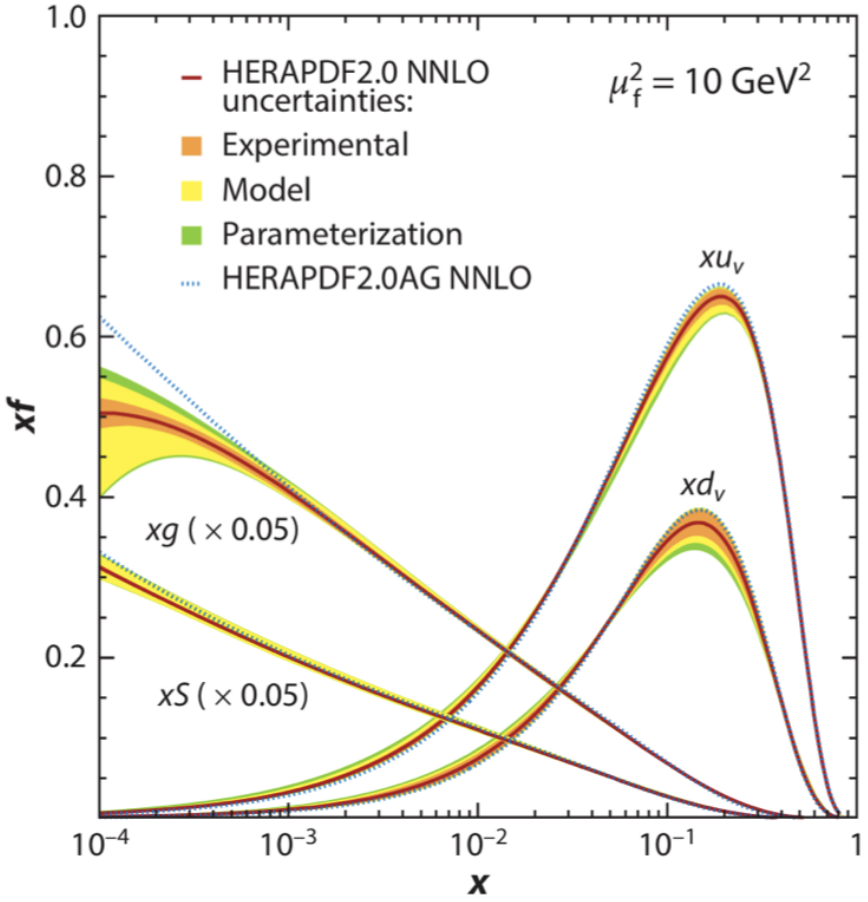
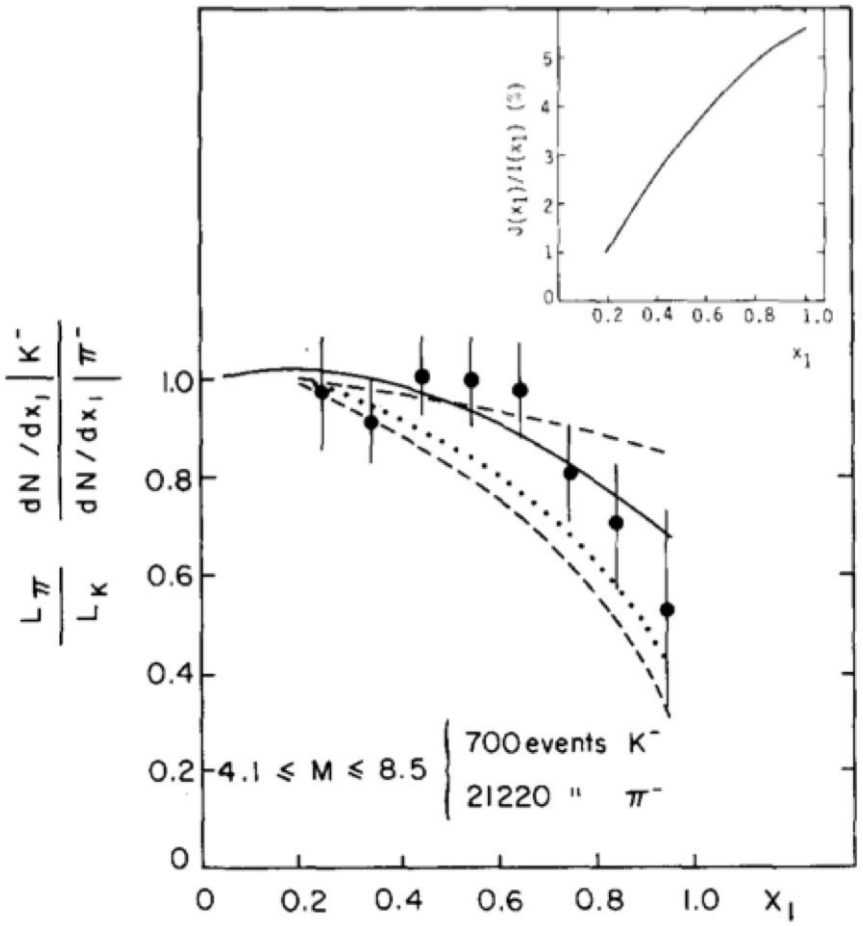
Proton



Kaon



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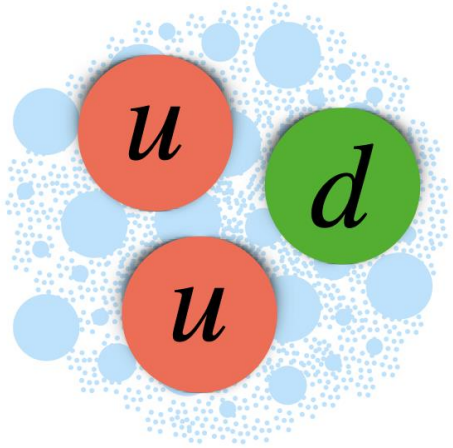
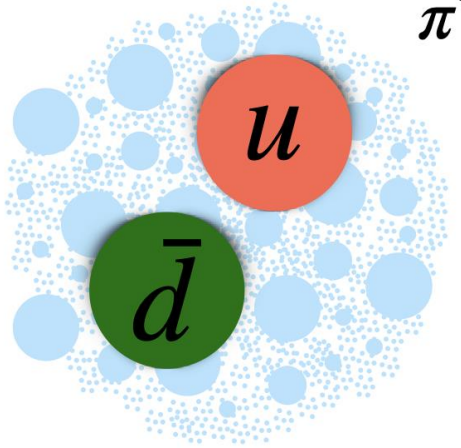
Proton



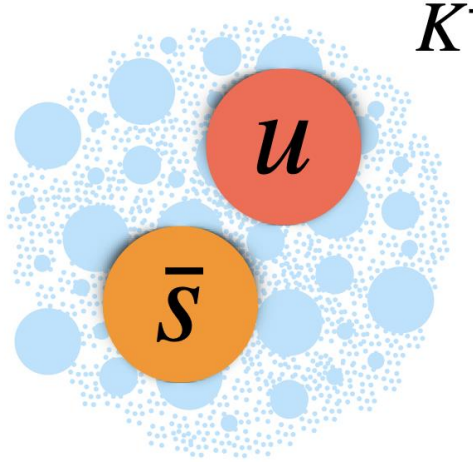
$M_p \sim 940\ MeV/c^2$

Pion



$M_\pi \sim 140\ MeV/c^2$

Kaon



$M_K \sim 490\ MeV/c^2$

Small difference in quark content, significant difference in mass, nucleon mass primarily from QCD → emergence of hadron mass

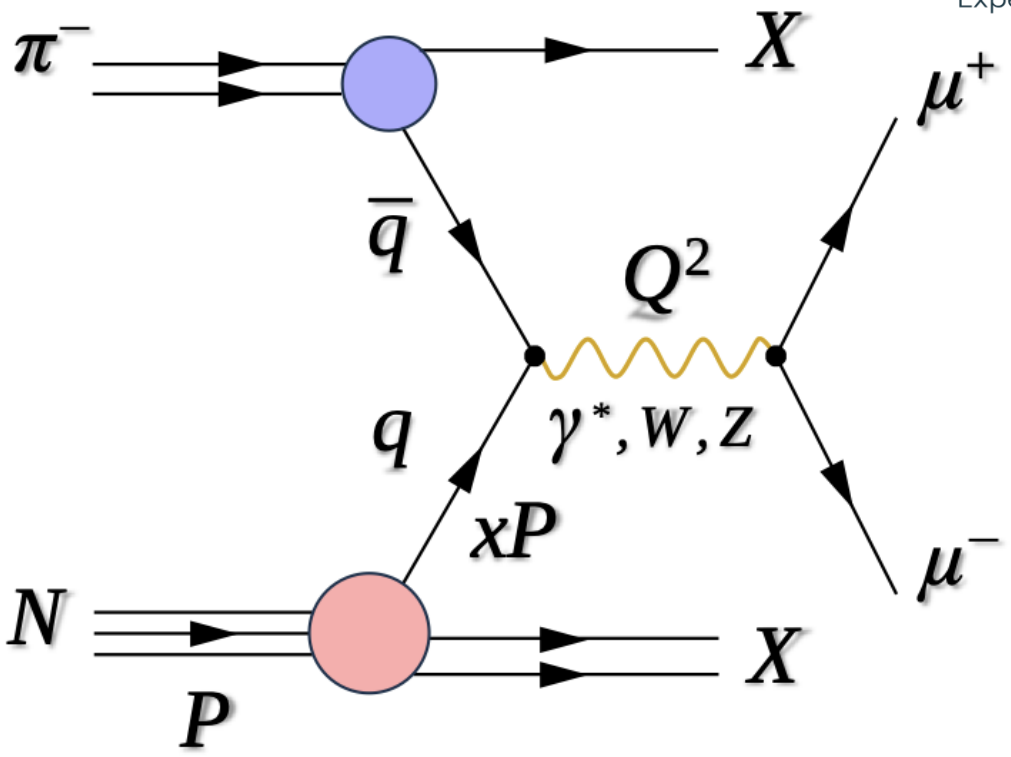
Further measurement of meson PDFs needed

Drell-Yan

Apparatus for Meson and Baryon Experimental Research

Pion beam in Drell-Yan → able to probe pion PDF

Kaon beam → kaon PDF



$$\sigma_{\pi p} = \sum_{a,b} \int_0^1 dx_\pi \, dx_N \, f_a(x_N, \mu_F^2) \, f_b(x_\pi, \mu_f^2) \, \hat{\sigma}_{ab}$$

AMBER

Multipurpose experiment at M2 beamline

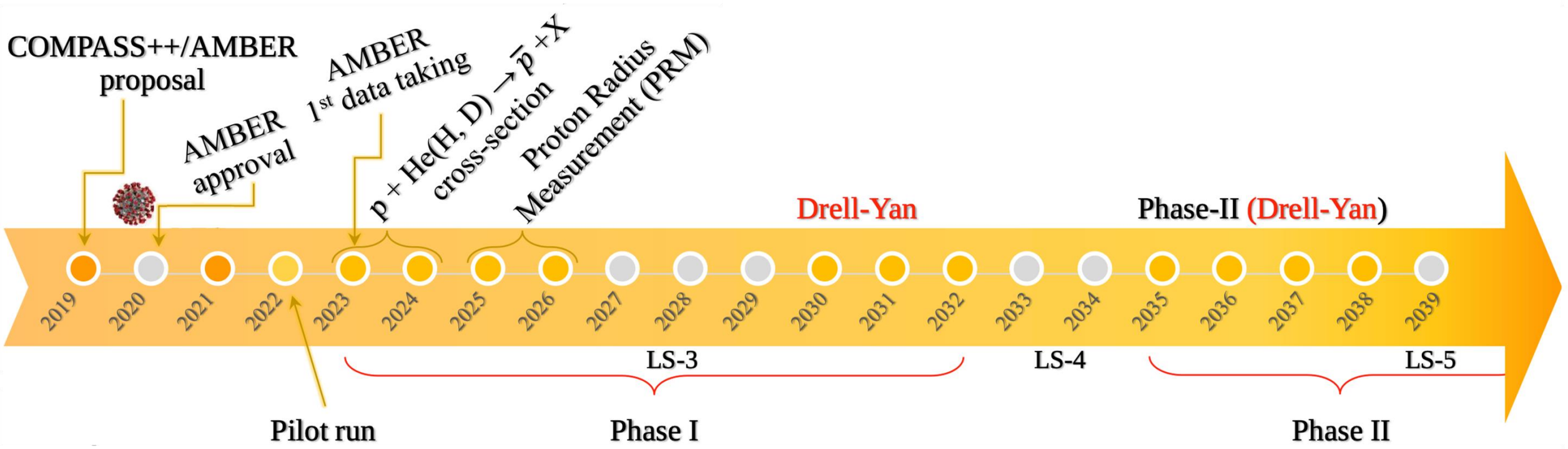
~200 members

Successor to COMPASS

AMBER – timeline

Apparatus for Meson and Baryon Experimental Research

Phase I includes ~280 days of Drell-Yan data taking over two years after LS3



AMBER – timeline

Apparatus for Meson and Baryon Experimental Research

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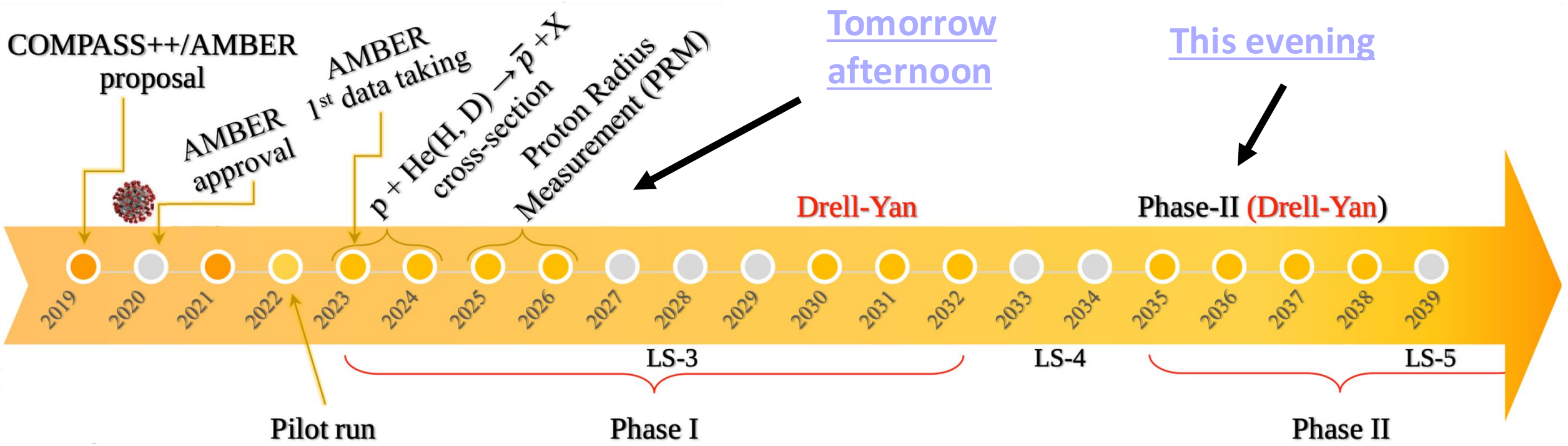


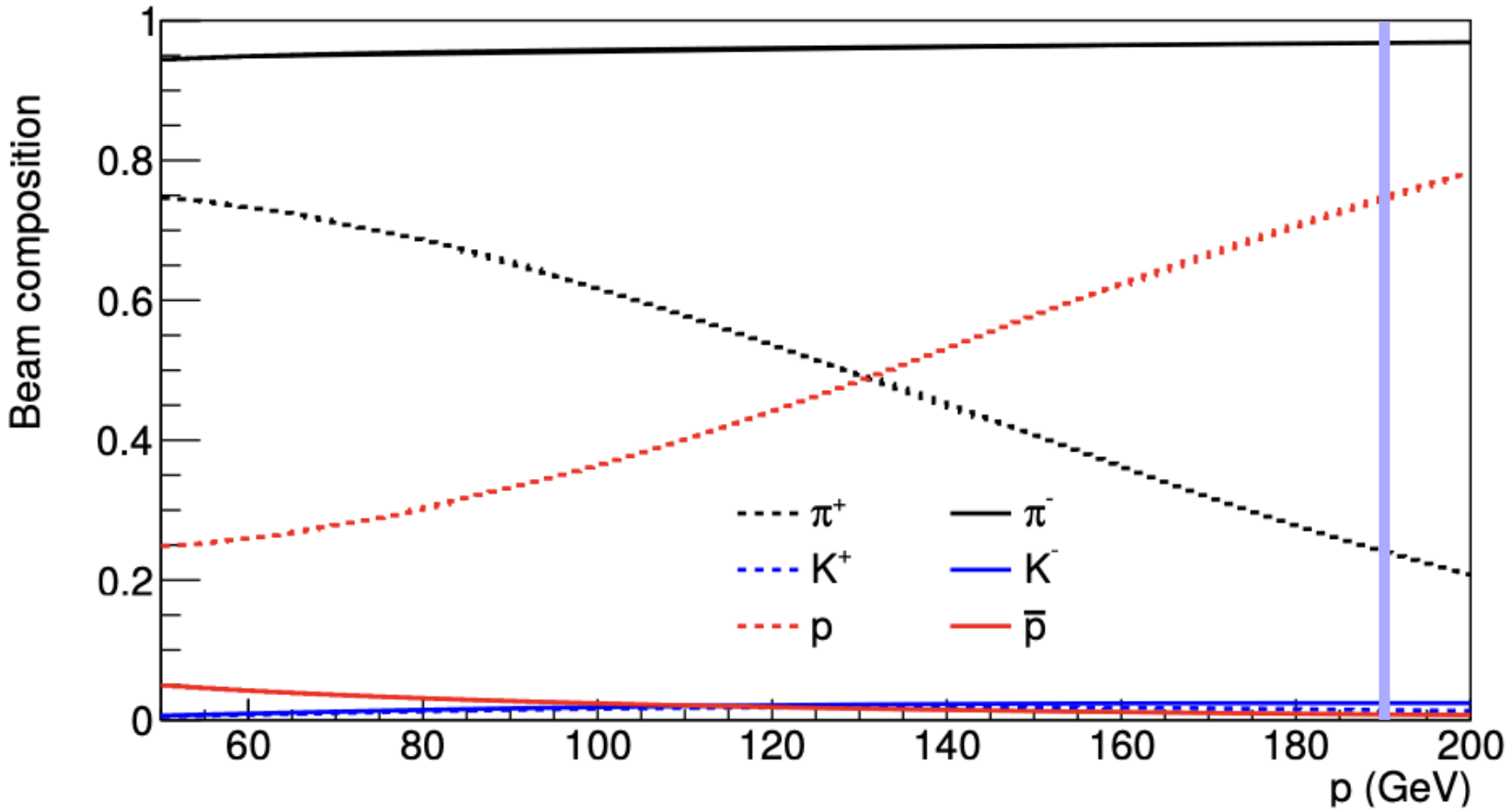
AMBER – beam structure

Apparatus for Meson and Baryon Experimental Research

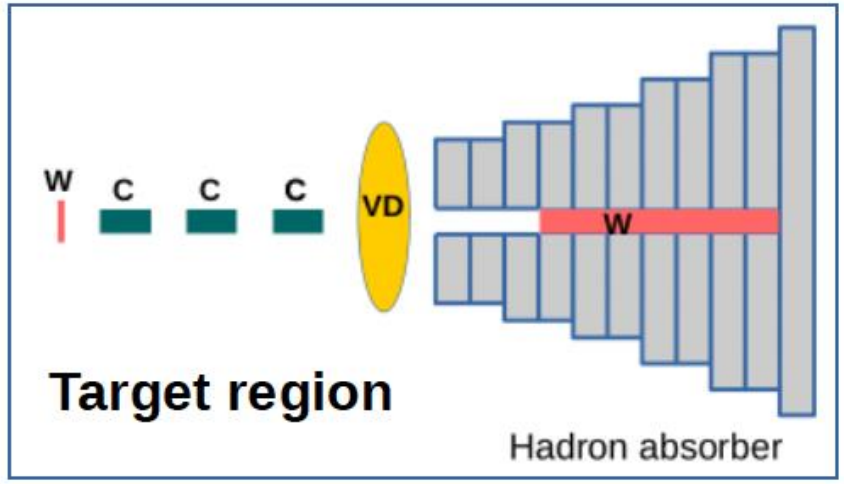
Positive and negative hadron beam at 190 GeV

3:1 positive:negative

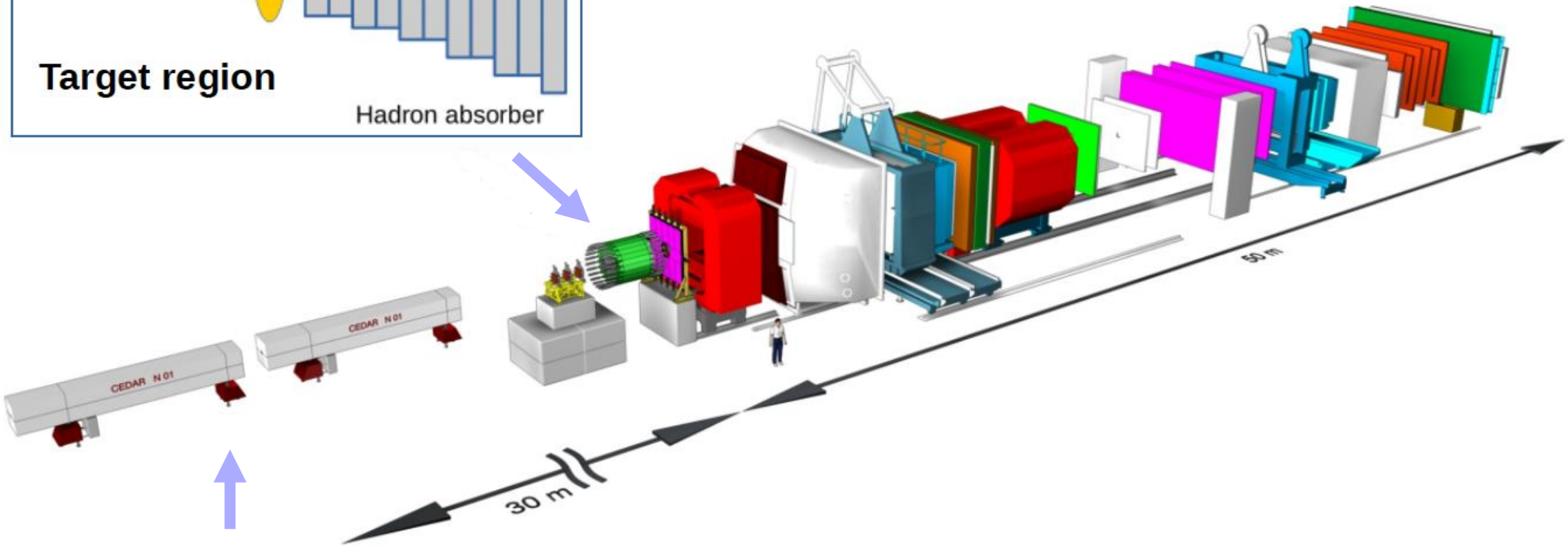
~ 2% kaons



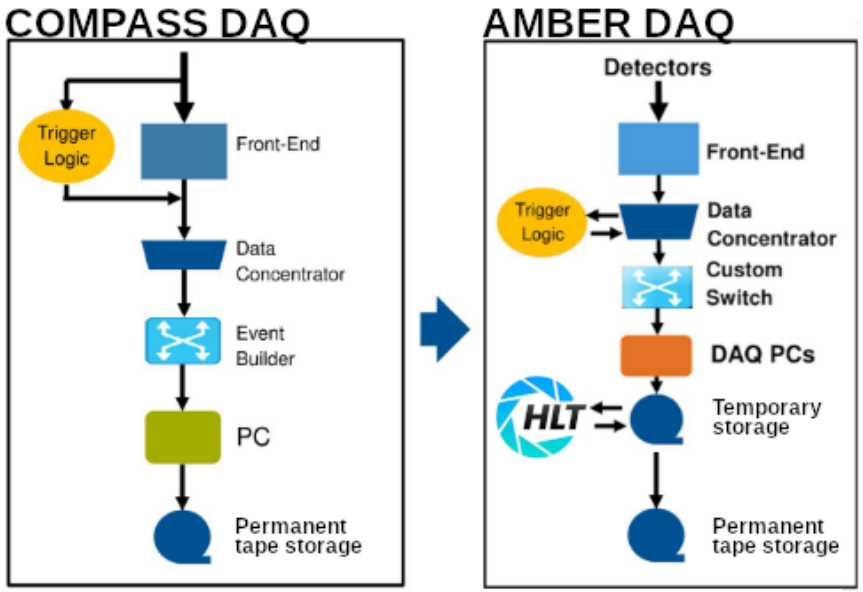
Apparatus for Meson and Baryon Experimental Research



Target region varies by program – for Drell-Yan data taking, carbon, tungsten, vertex detector

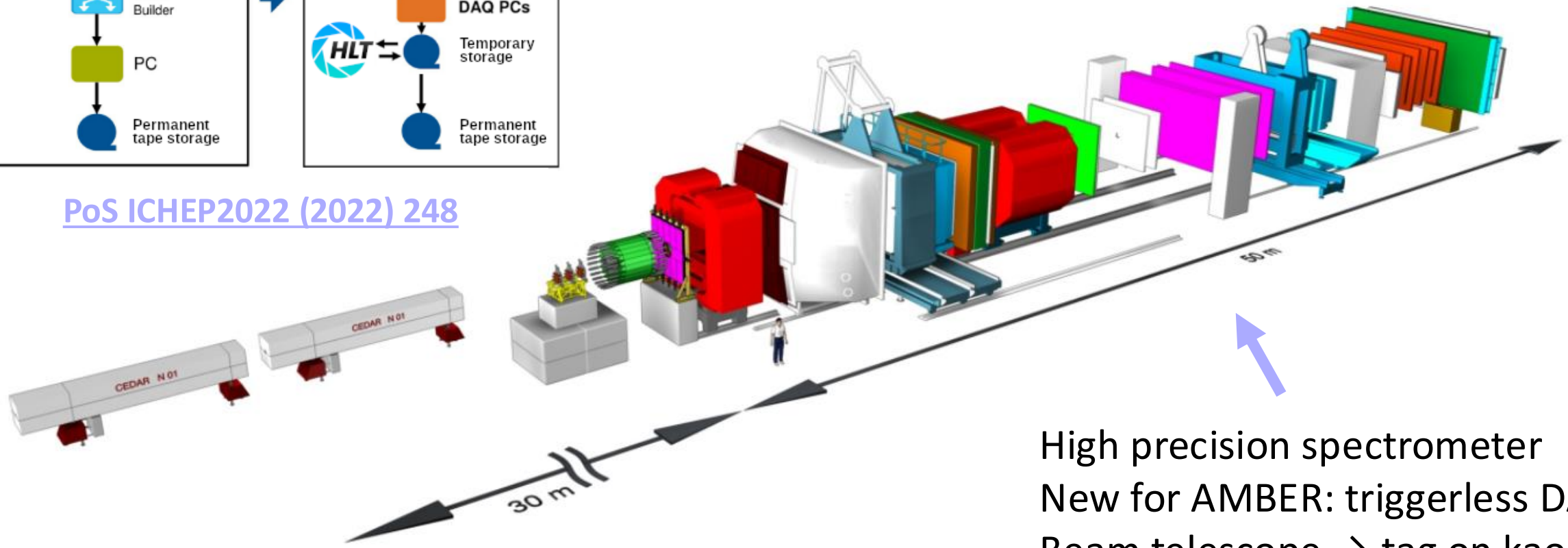


CEDARs for beam PID



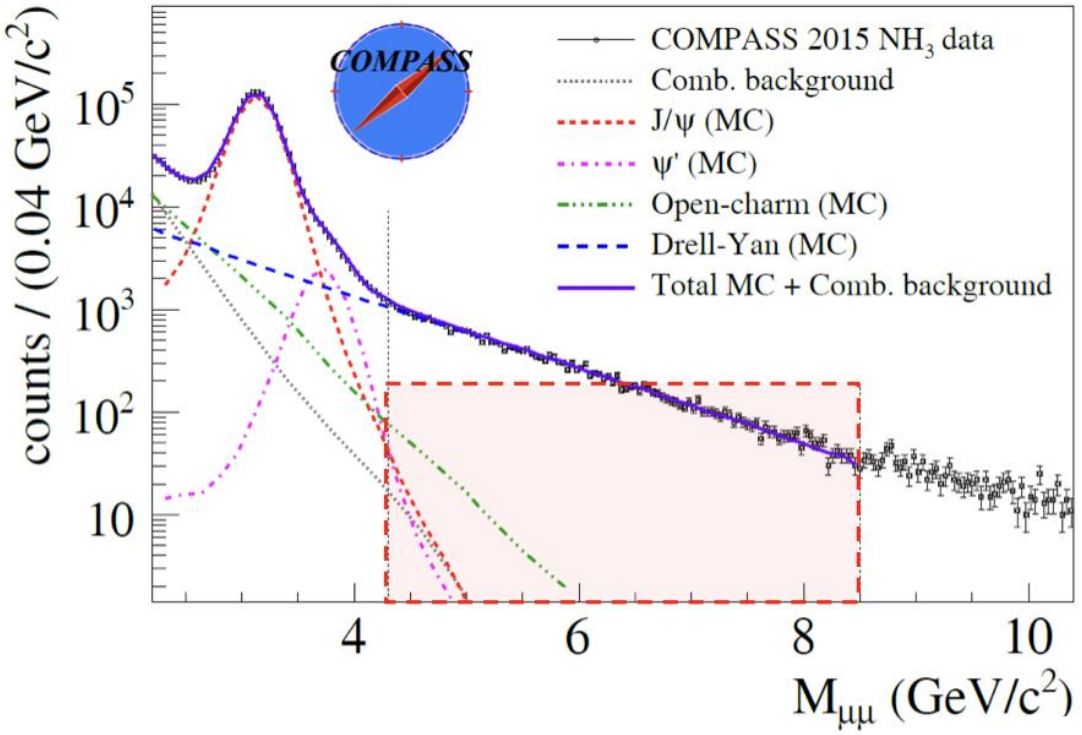
Apparatus for Meson and Baryon Experimental Research

[PoS ICHEP2022 (2022) 248]



High precision spectrometer
New for AMBER: triggerless DAQ
Beam telescope → tag on kaons

AMBER – Drell Yan projection

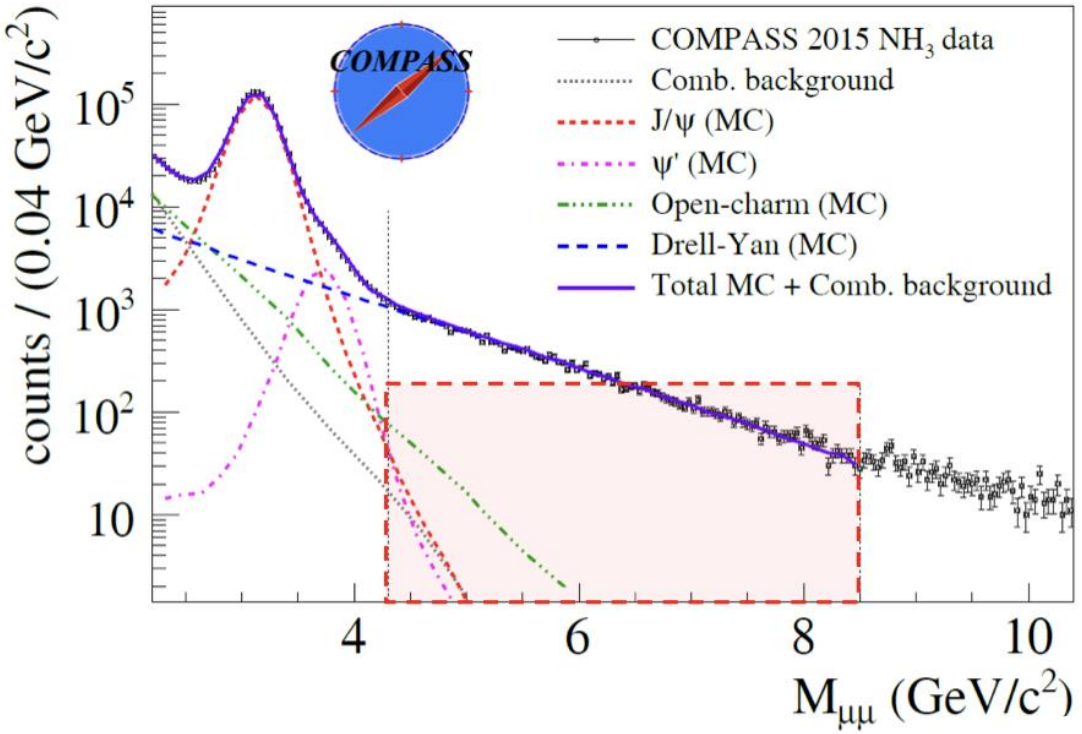


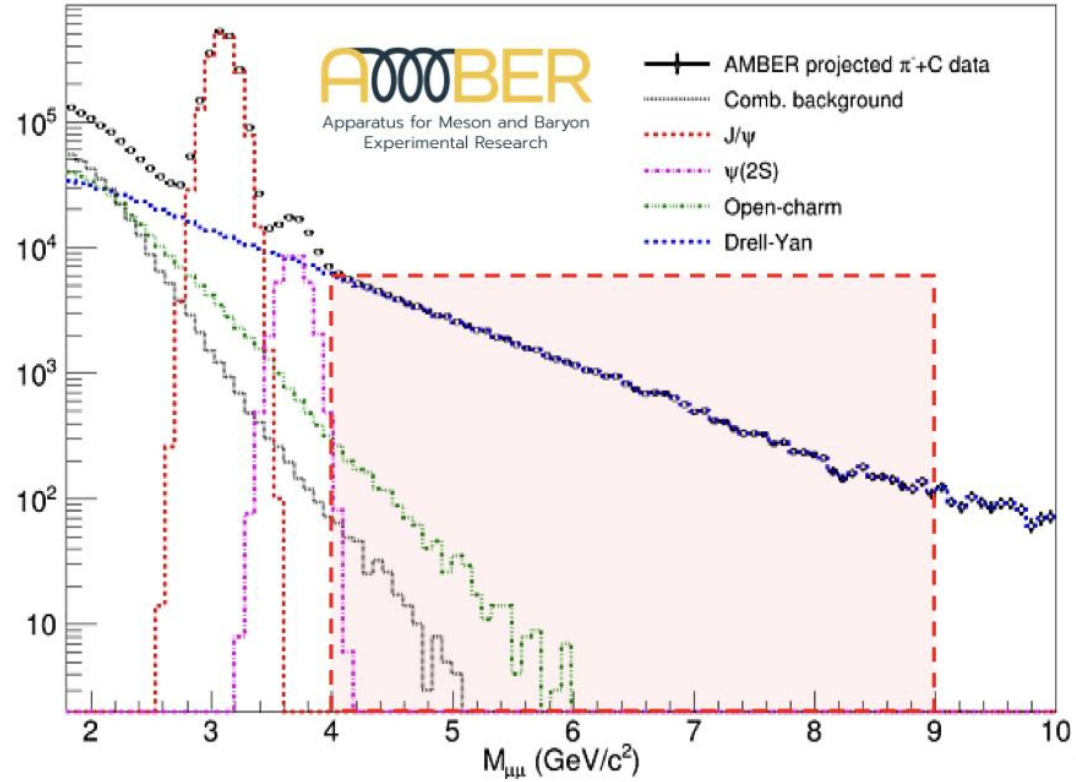
For COMPASS Drell-Yan ~30% background between 4.00 GeV and 4.36 GeV

arXiv:2312.17379

New silicon strip vertex detector improves vertex and mass reconstruction
→ improved Drell-Yan statistics
→ improved access to J/Ψ and Ψ’

AMBER – Drell Yan projection





New silicon strip vertex detector improves vertex and mass reconstruction

→ improved Drell-Yan statistics

→ improved access to J/Ψ and Ψ’

AMBER – pion PDF

Apparatus for Meson and Baryon Experimental Research

With expected statistics over 280 days AMBER projected to contribute precise measurements to the pion PDF

Target type	Beam energy (GeV)	Beam type	Beam intensity (part/sec)	DY mass (GeV/c^2)	DY events
100 cm C	190	π^+	1.7×10^7	4.3 – 8.5	23000
				3.8 – 8.5	37000
				2.0 – 8.5	170000
	190	π^-	6.8×10^7	4.3 – 8.5	22000
				3.8 – 8.5	34000
				2.0 – 8.5	161000
24 cm W	190	π^+	0.2×10^7	4.3 – 8.5	7000
				3.8 – 8.5	11000
				2.0 – 8.5	51000
	190	π^-	1.0×10^7	4.3 – 8.5	6000
				3.8 – 8.5	9000
				2.0 – 8.5	48000

arXiv:1808.00848

$$\sum_{sea}^{\pi C} = 4\sigma^{\pi^+ C} - \sigma^{\pi^- C} \qquad \sum_{val}^{\pi C} = -\sigma^{\pi^+ C} + \sigma^{\pi^- C}$$

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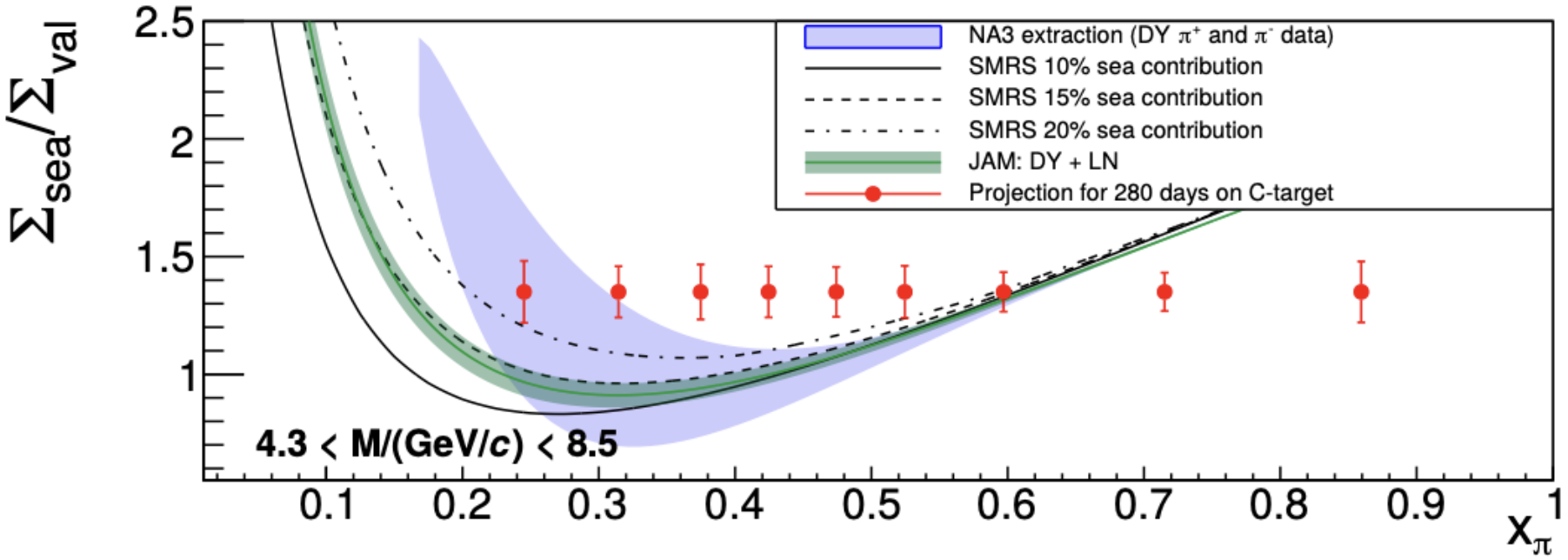
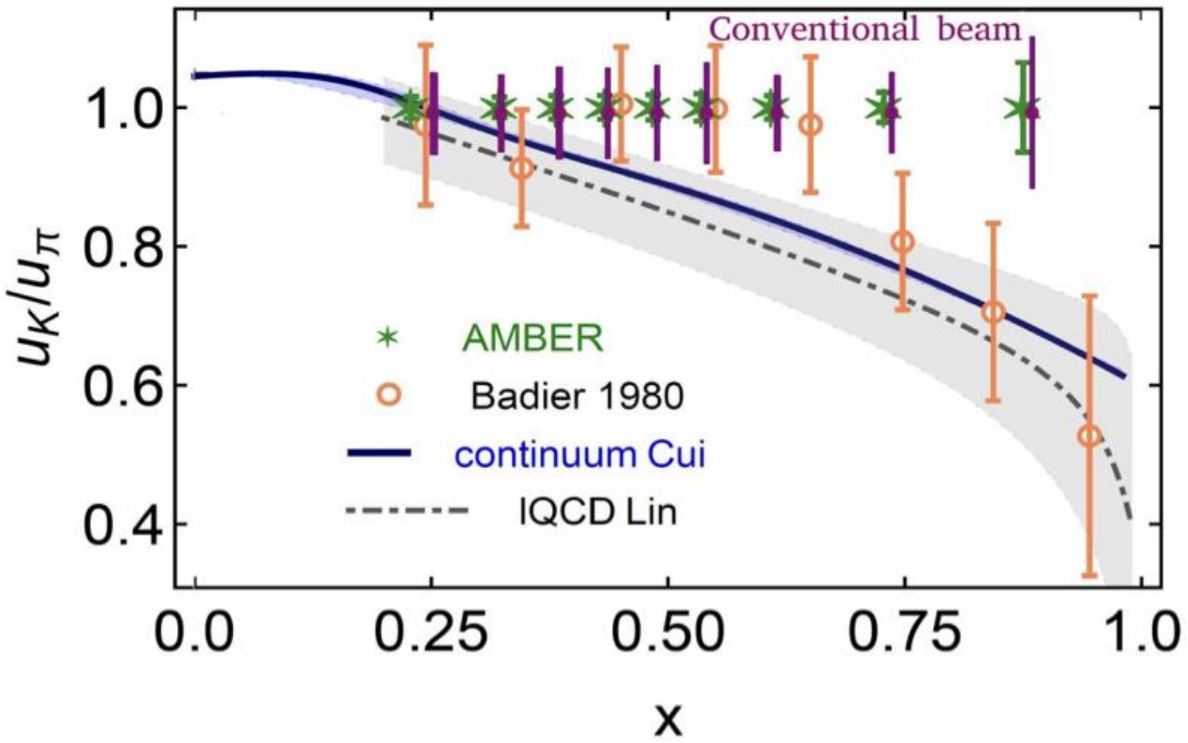


$$\sum_{sea}^{\pi C} = 4\sigma^{\pi^+ C} - \sigma^{\pi^- C} \qquad \sum_{val}^{\pi C} = -\sigma^{\pi^+ C} + \sigma^{\pi^- C}$$

AMBER – kaon PDF

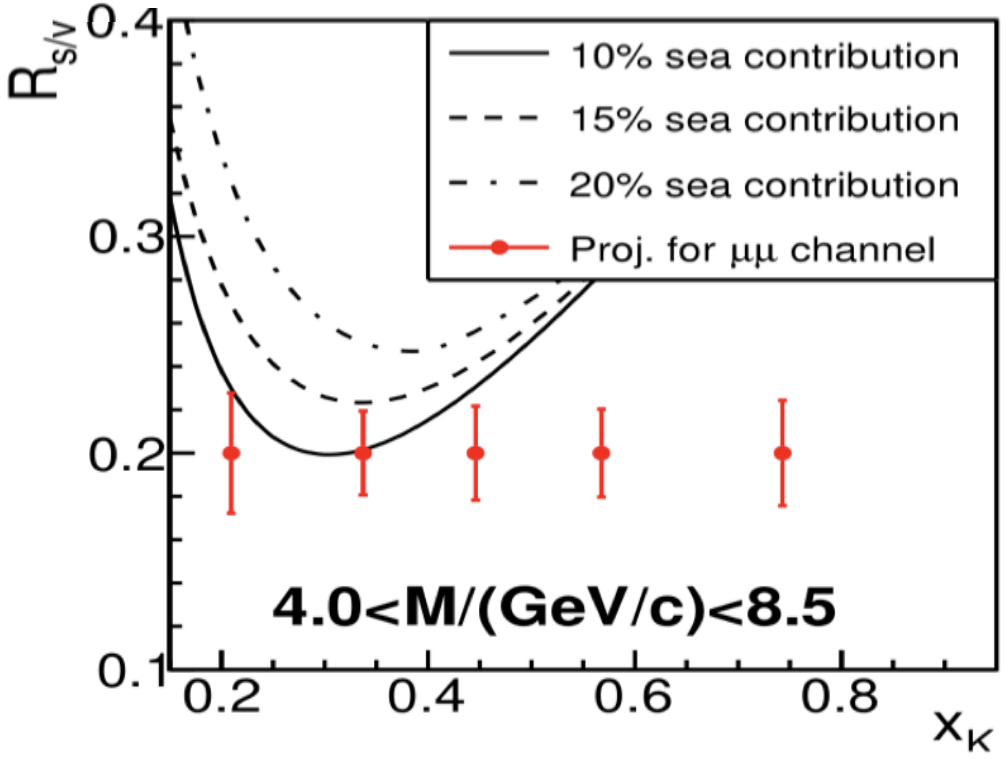
Apparatus for Meson and Baryon Experimental Research

Beam kaon component (~2%) allows structure measurements exceeding existing datasets



DY cross section ratio of K+C over π+C → kaon valance quark distribution

Difference between K^+ and K^- → sea quark distribution

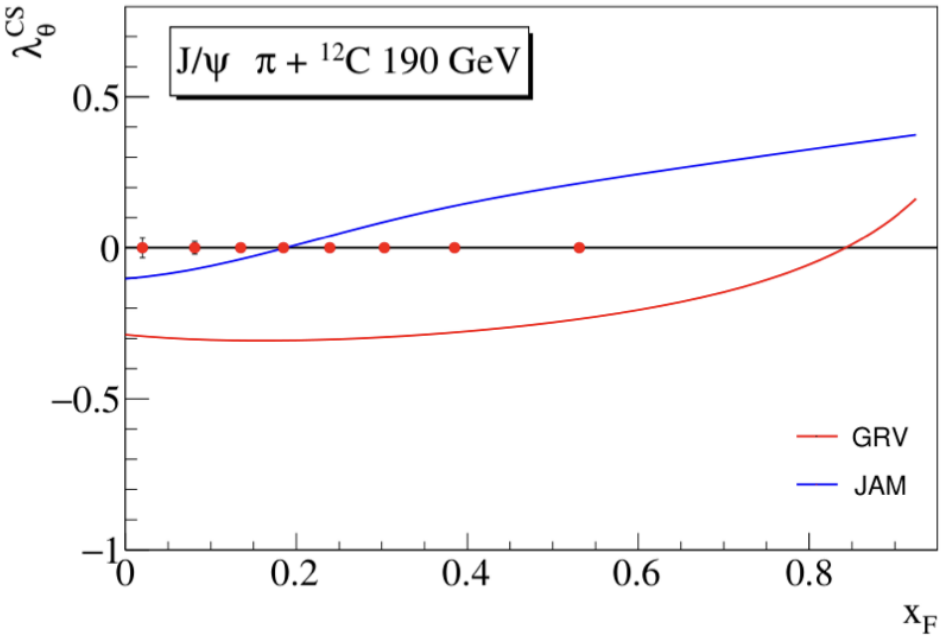


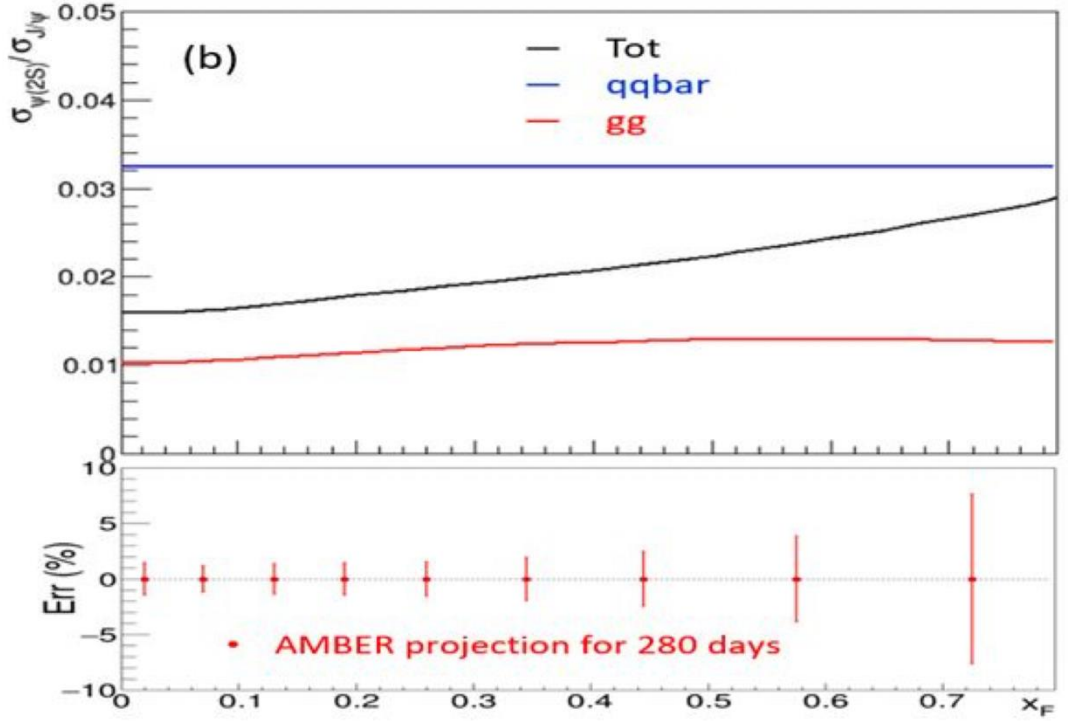
AMBER – charmonium

Apparatus for Meson and Baryon Experimental Research

J/Ψ polarisation: λ parameter in angular distribution can distinguish between production mechanisms, for gluon fusion λ = 1, for quark-antiquark annihilation, λ = -1

Ψ’ without feed down → clean signal





Conclusions

AMBER will perform Drell-Yan measurements with positive and negative hadron beams

- Largest pion-induced Drell-Yan sample within this decade, access to valence and sea PDFS
- Significant improvement to kaon PDF datasets
- Separate charmonium measurements available

Thank you for listening!