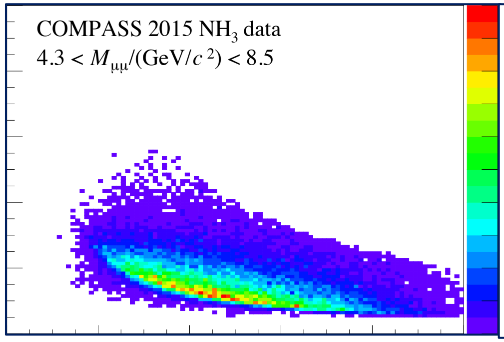
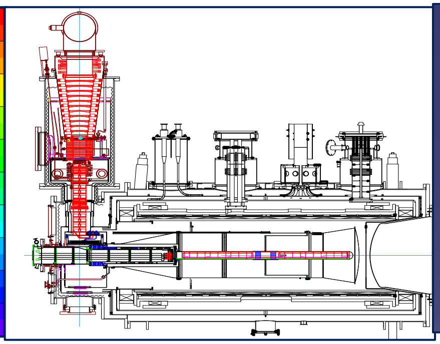
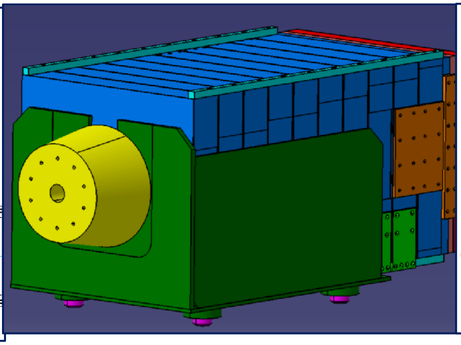
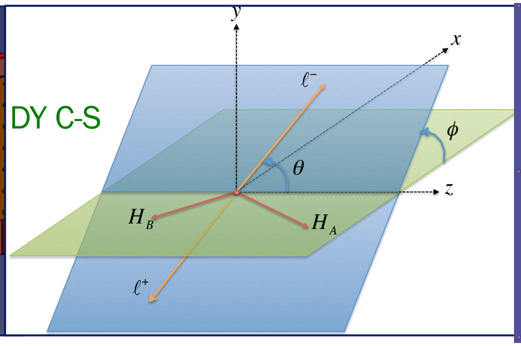
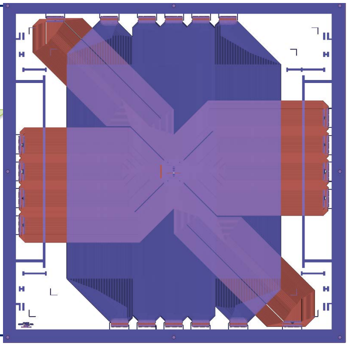
Status of Meson PDFs
Available measurements and "global fits"



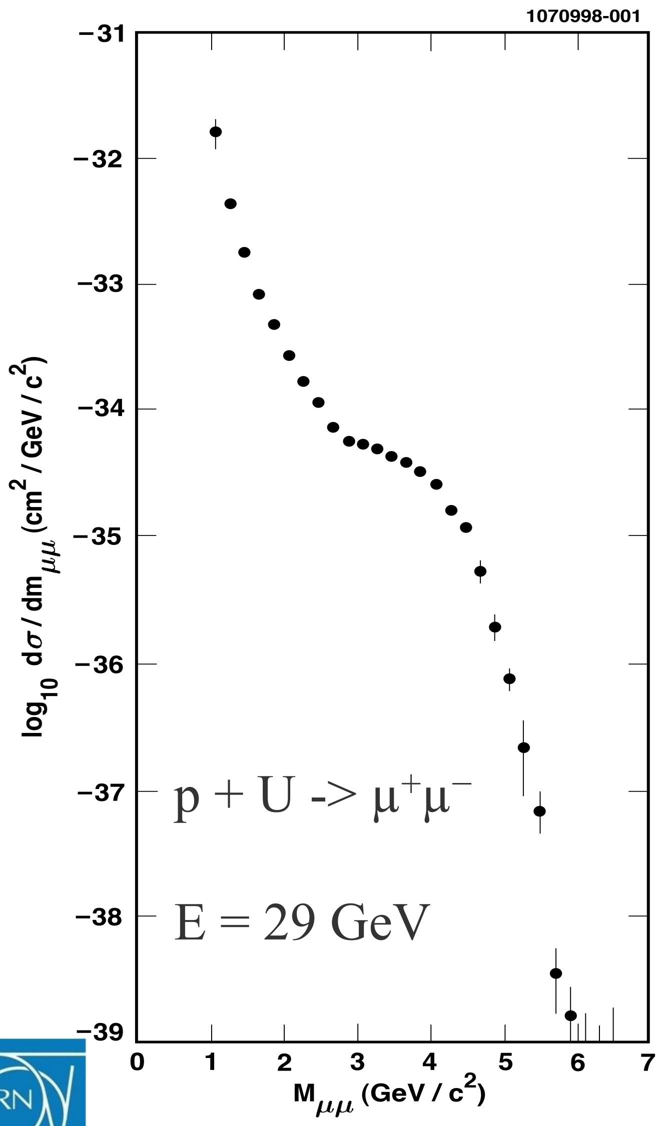


Stephane Platchkov

Paris-Saclay University, CEA/IRFU, France

The Drell-Yan (-Lederman) process

Christenson et al., PRL 25 (1970) 1523

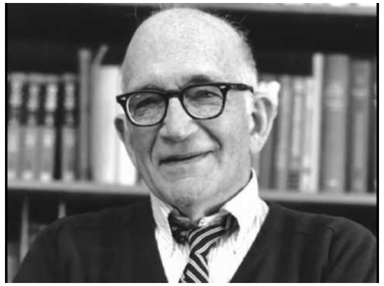


- First dimuon experiment at the AGS, made in 1968
  Leon Lederman's team was looking for the W
  - Rapid fall-off: $\sim M_{\mu\mu}^{-4}$
  - Remark: shoulder at around 3-4 GeV, the authors missed the J/ψ
    ... and the parton structure of the nucleon...

- Explanation by Drell and Yan (1970)

Drell and Yan, PRL 25 (1970) 316

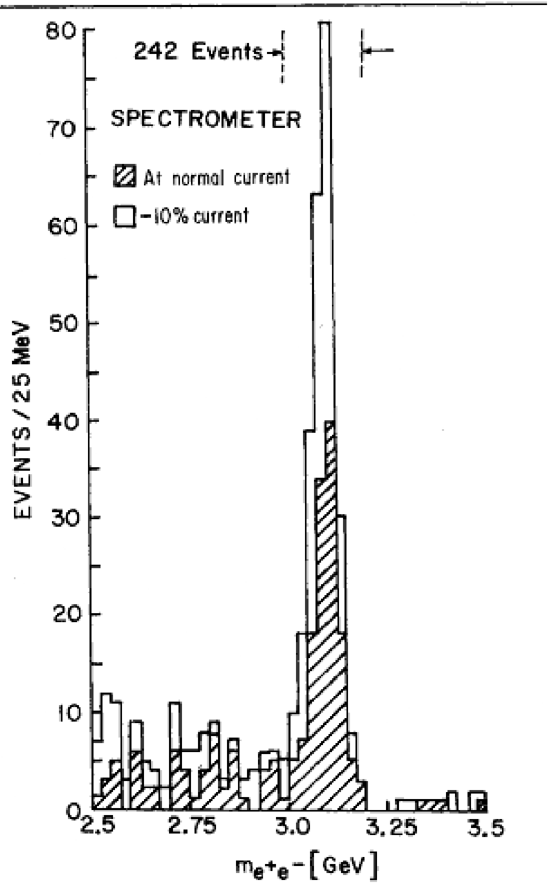
  - Process explained using Feynman's parton model
  - First application of the parton model besides the SLAC DIS exp't



“DY” - type experiments – a great historical background

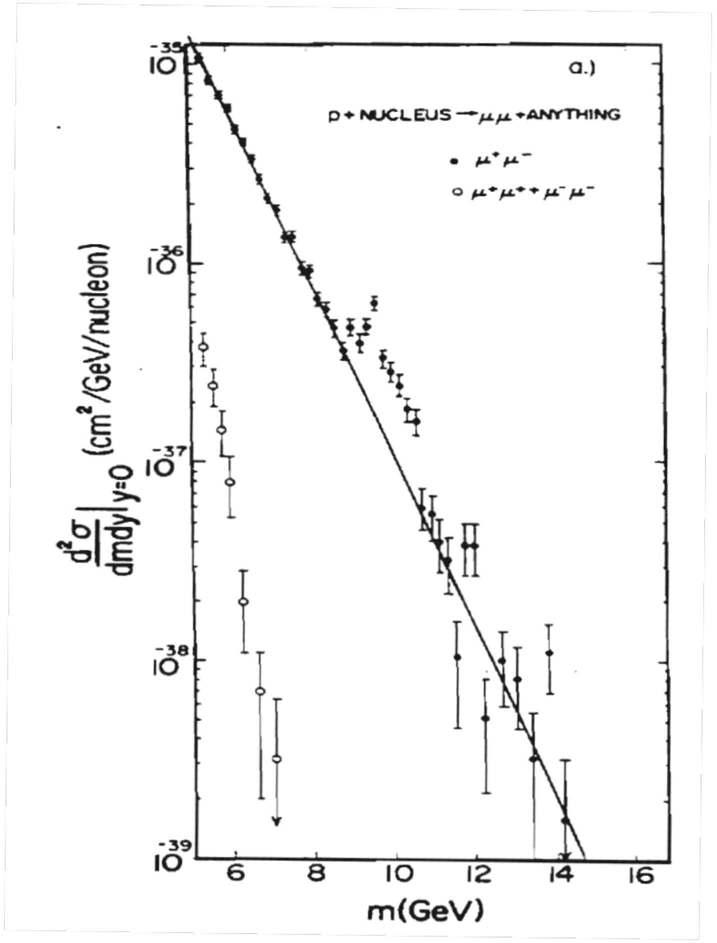
- Discovery of the J/ψ

“1974: Ting, Richter



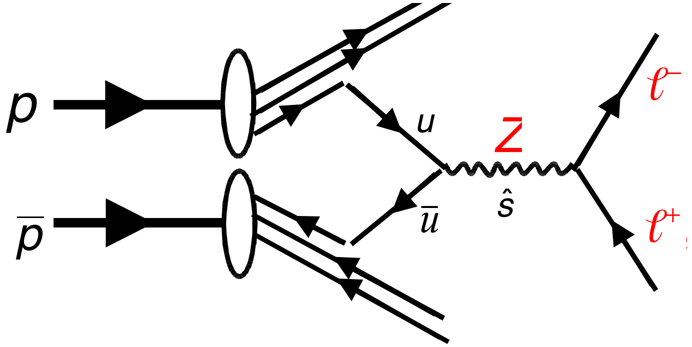
- Discovery of the Υ

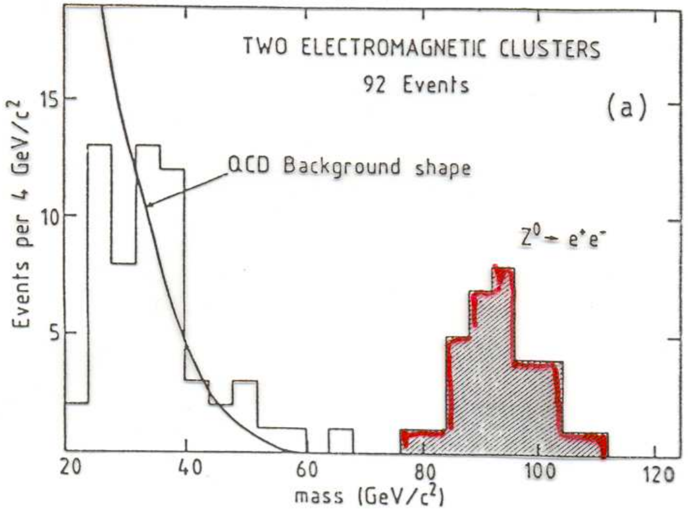
1977: Lederman



- Discovery of the W,Z

1983: Rubbia, van der Meer

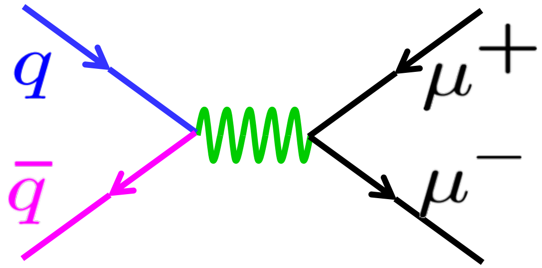




Drell-Yan cross section

- Convolution of two PDFs

$$\frac{d^2\sigma}{dx_1 dx_2} \propto \sum_{i=u,d,s} e_i^2 \left[f_i^{\pi}(x_1,Q^2).\bar{f}_i^{A}(x_2,Q^2) + \bar{f}_i^{\pi}(x_1,Q^2).f_i^{A}(x_2,Q^2) \right]$$



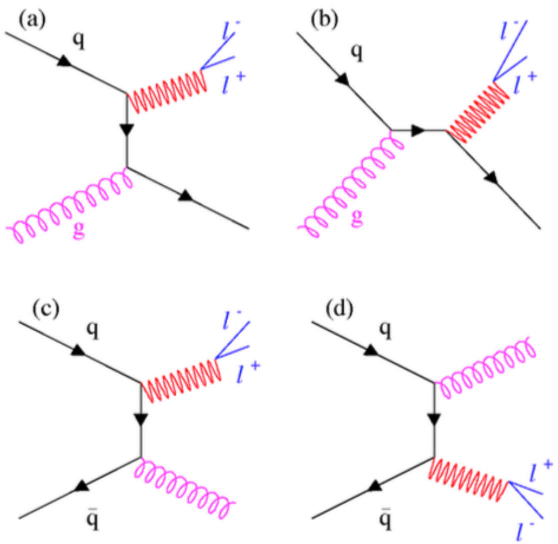
- At order (α_s^0) : a purely electromagnetic process

- NLO (α_s^1) corrections are well known

- NNLO (α_s^2) corrections are also known

QCD Compton

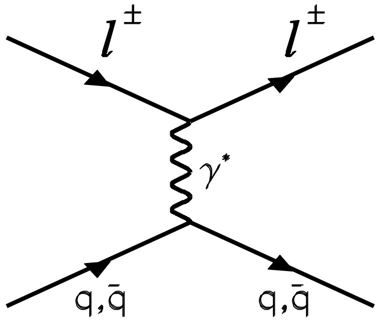
Gluon production



Drell-Yan is a well understood process

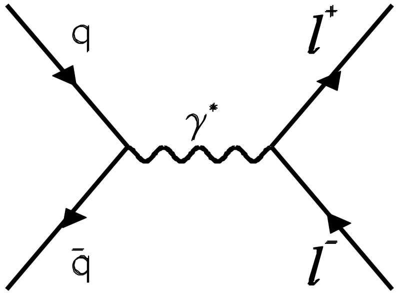
Complementarity between DIS and Drell-Yan

- Space-like virtual photon
- Time-like virtual photon



DIS

Drell-Yan



Similarly to DIS, Drell-Yan is used to determine PDFs

- Meson-induced Drell-Yan (presently at CERN) – several advantages :
  - Valence antiquarks (ū in π−): probe the valence quarks in the target (sea quarks with a p beam)
  - Allows access to the meson structure (no meson targets) ☞ Meson PDFs
  - Can be used to probe flavor dependence
  - p_T-dependence, access to TMDs
  - etc...

Drell-Yan : valence and sea quark contributions

- Drell-Yan cross section $$\frac{d^2\sigma}{dx_1 dx_2} \propto \sum_{i=u,d,s} e_i^2 \left[f_i^\pi(x_1,Q^2).\bar{f}_i^A(x_2,Q^2) + \bar{f}_i^\pi(x_1,Q^2).f_i^A(x_2,Q^2) \right]$$

- Example: negative pion (ūd) beam on a proton (uud) target:
  - all combinations of : $$(\bar{u}d) + (uud)$$

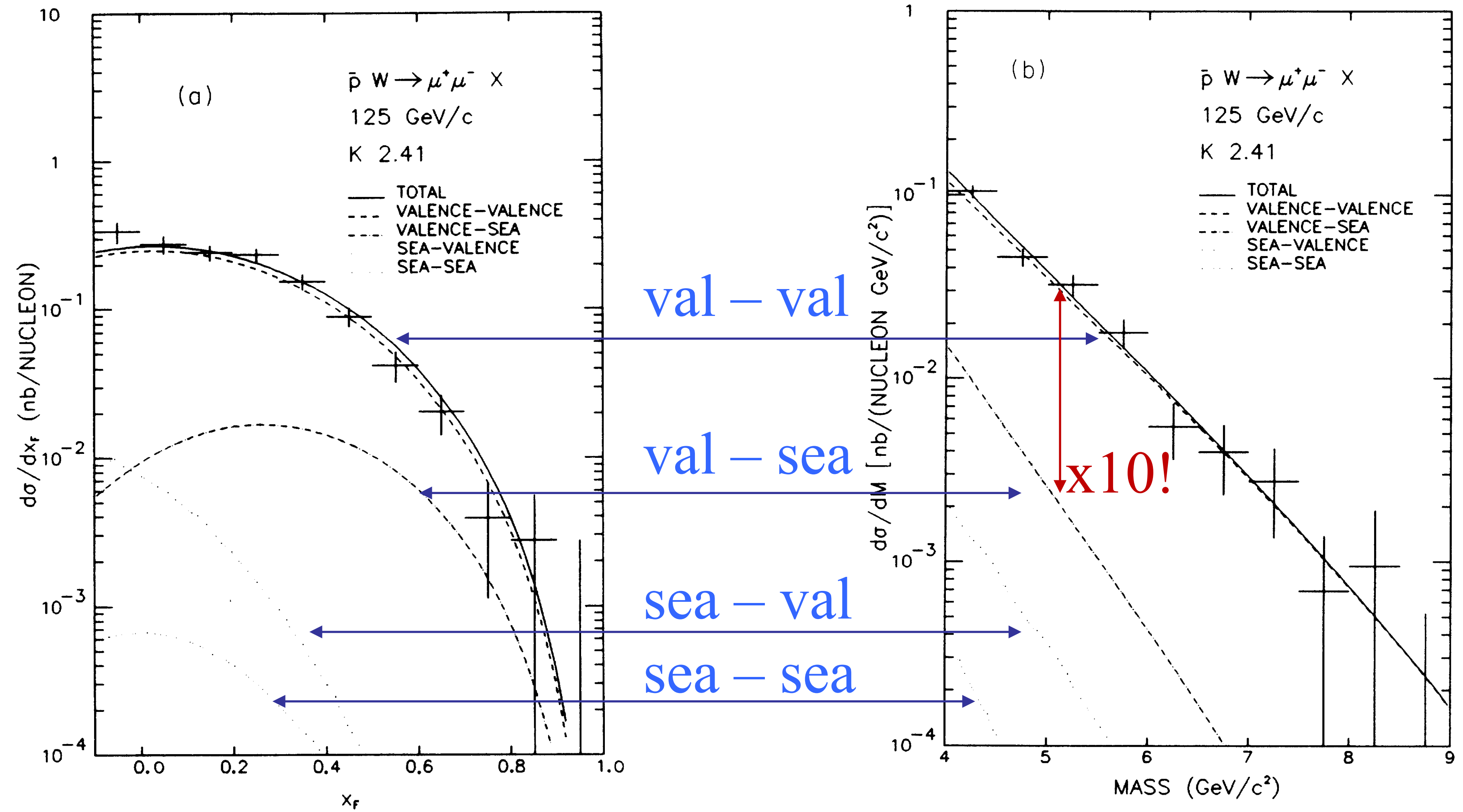
- 4 terms :
  - Valence-valence: $\bar{u}_\pi u_p$
  - Valence-sea: $d_\pi \bar{d}_p + \ldots$
  - Sea-valence: $\bar{d}_\pi d_p$
  - Sea-sea: $u_\pi \bar{u}_p + \ldots$

Valence – valence terms dominate the cross section

Drell-Yan: valence and sea contributions

- E537, antiprotons with E = 125 GeV, W target

Anassontziset al., PRD 38, 1377 (1988)



Valence – valence terms largely dominate the cross section

Pion and kaon PDFs : where are we today ?

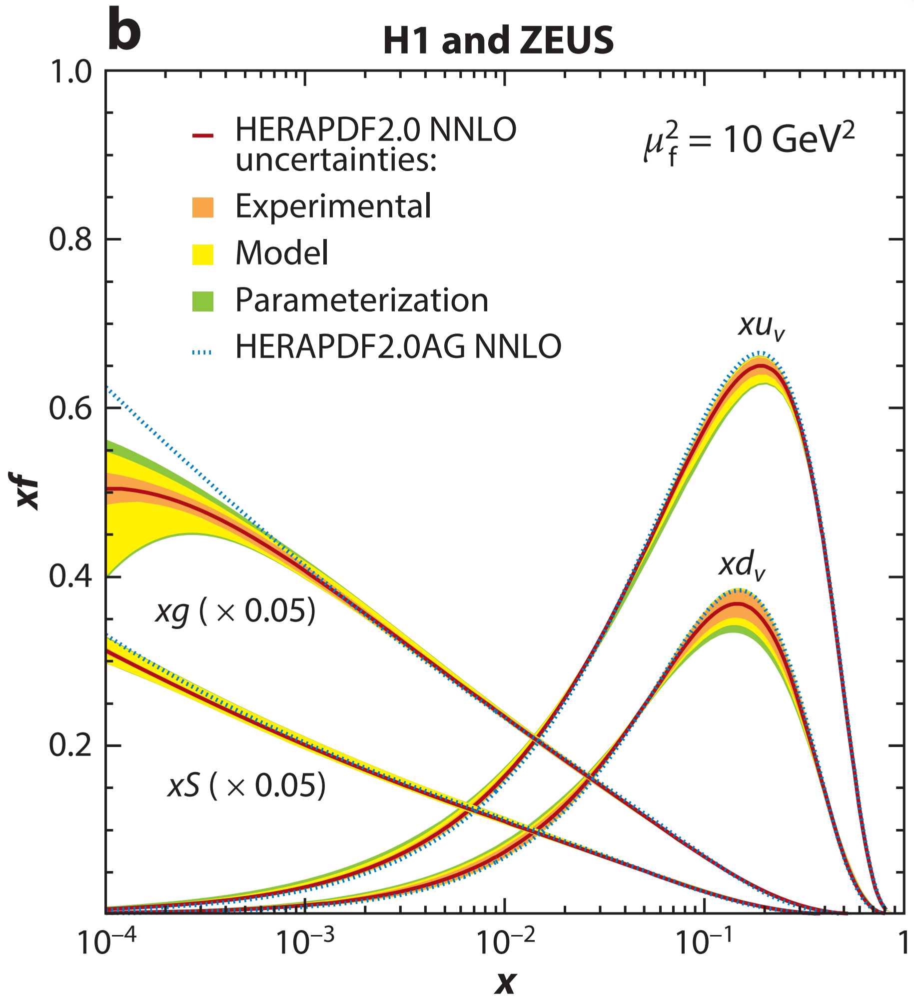
A tentative overview

Proton (unpolarized) structure (HERA)

- The nucleon PDFs have been extensively studied for many years in a large number of experiments
  - example: the HERAPDF2.0 set
  - Other sets: CTEQ, MRST....

- Well know in a (very) large domain of x
  - generic form:

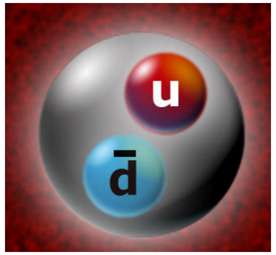
$$xf(x) = Ax^B(1-x)^C(1+Dx+Ex^2),$$



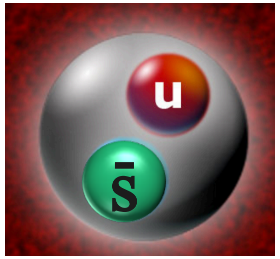
In contrast, the meson PDFs are essentially unknown

Why study meson PDFs ?

- The lightest mesons have a double nature (☞ talk by C. Roberts)
  1. The simplest hadrons and the lightest quark-antiquark pairs
  2. Massless Nambu-Goldstone bosons that acquires mass through DCSB
     - Craig Roberts (2016): *"Thus, enigmatically, the properties of the massless pion are the cleanest expression of the mechanism that is responsible for almost all the visible mass in the universe."*



- Pion and Kaon structure
  - Can be accesses using DSE, LQCD….
  - Quark PDFs different than that of the proton
  - The *s* quark in the kaon is heavier: how is the total momentum shared?
  - What is the behavior of the kaon and pion PDFs at large x ?
  - Are kaon and pion gluon distributions identical?



Needed is: experimental information on valence, sea and gluon PDFs

Pion valence quark distributions

Only from DY data : 1979 – 1989

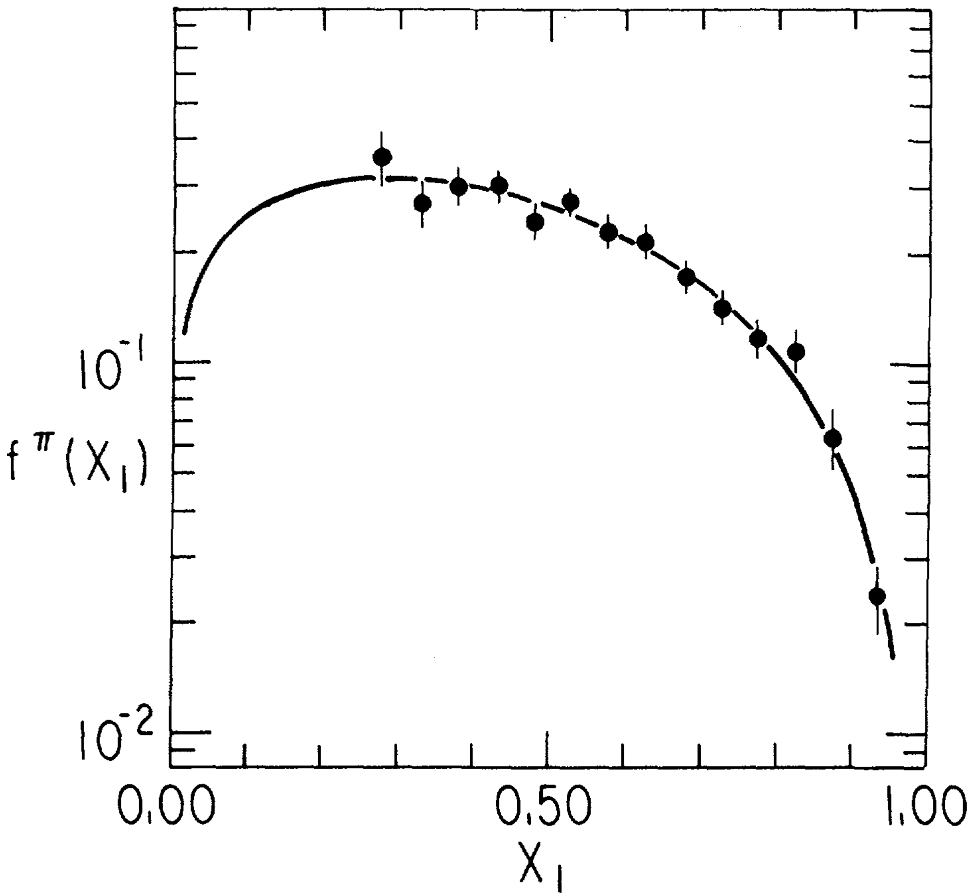
No other experimental information available

E444 experiment at Fermilab (1979)

- E331/E444 experiment (Chicago-Princeton)
  - E = 225 GeV
  - Targets: C, Cu, W
  - Mass range: 4 – 8.75 GeV
  - LO analysis

- First ever results on the pion
  - Pion valence: $0.8x^{0.5}(1-x)^{1.23}$
  - Pion momentum : “about” 40%

Newman et al., PRL 42, 951(1979)



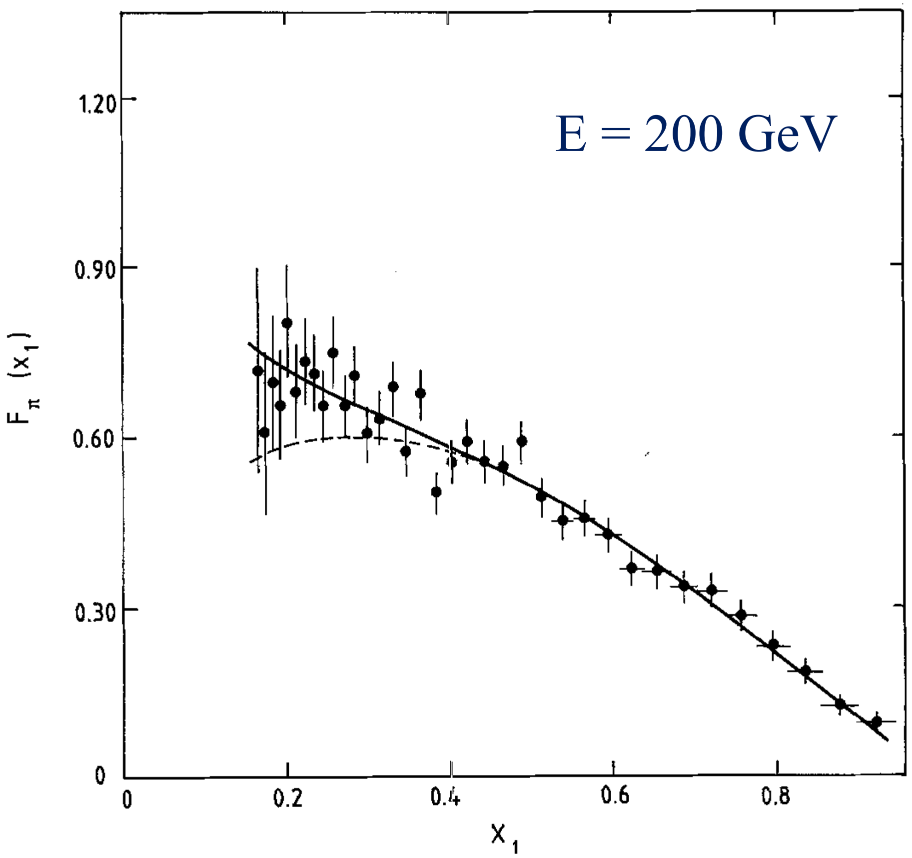
NA3 experiment at CERN (1983)

- NA3 experiment : 150, 200, 200 GeV
  - Target : ^{195}Pt

Table 1. Number of dimuon events collected at 150, 200 and 280 GeV on the 6 cm Pt target in the mass interval 4.2 to 8.5 GeV/c^2

P_{inc}	Particle	No. events	Luminosity (cm^{-2})
150 GeV/c	π^-	15,768	$5.0 \pm 0.7 \cdot 10^{38}$
200 GeV/c	π^-	4,961	$11.4 \pm 1.3 \cdot 10$
	π^+	1,767	$8.8 \pm 1.0 \cdot 10^{37}$
	p	1,048	$11.9 \pm 1.5 \cdot 10^{37}$
280 GeV/c	π^-	11.559	$2.8 \pm 0.3 \cdot 10^{38}$

Badier et al., Z. Phys. C18, 281 (1983).



- Analysis (LO)
  - Assume SU(2) and SU(3) symmetry
  - Nucleon PDF: from CDHS (1979)
  - Determine valence pion: $Ax^{0.45}(1-x)^{1.17}$

NA10 experiment at CERN (1985)

- NA10 results:

Observation of Anomalous Scaling Violation in Muon Pair Production by 194 GeV/c π^--Tungsten Interactions

NA10 Collaboration

Betev et al., Z. Phys. C28, 15 (1985).

  - Target: W, E = 194 GeV, beam = π−, N = 155 000 events
  - Main purpose: study the K-factor within the DY model
  - Also: fit of the pion PDF (several different fits)
  - Results: table with different options – with no figure for the pion PDF.
  - Analysis: LO
  - Pion PDF parametrization:

$$Ax^{0.39}(1-x)^{0.98}$$

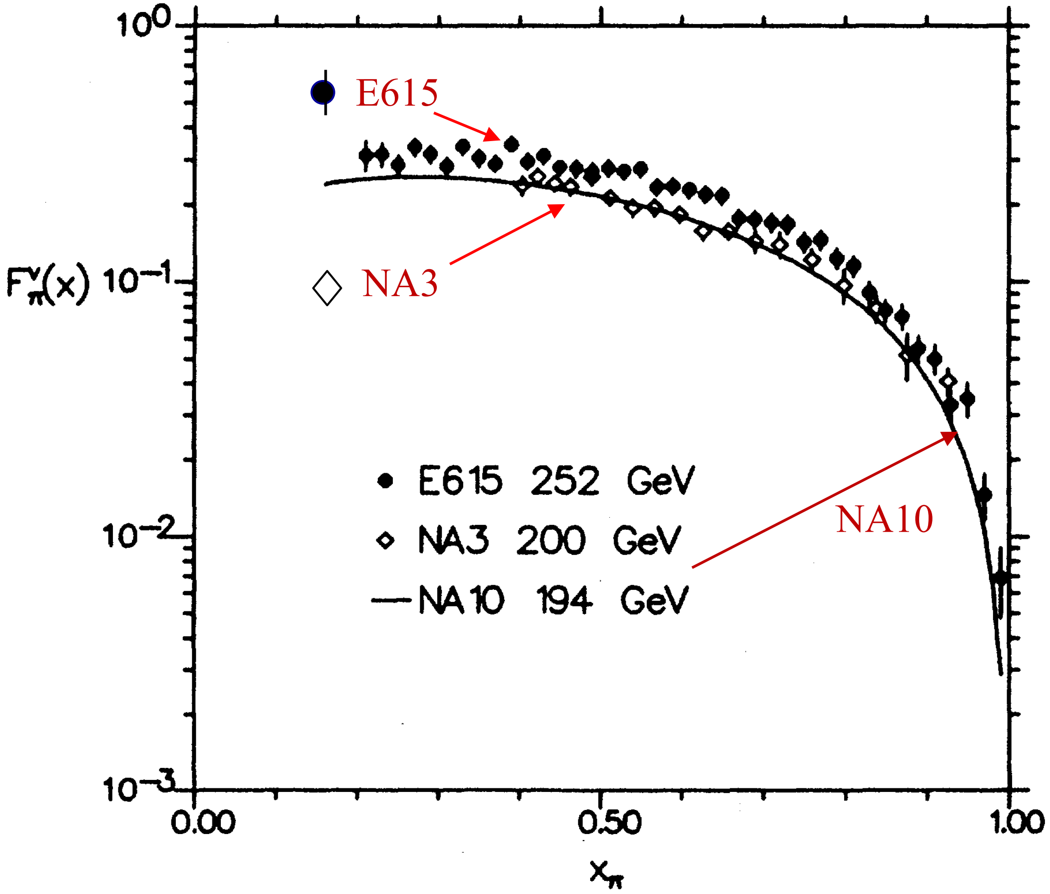
Table 2. Results of fits of pion valence parameters, at $M_0^2 = 25\,\text{GeV}^2$, for different model assumptions. $\langle K \rangle$ is the mean normalization factor between data and model resulting from the fits. Nucleon structure parameters are from [10, 11]; pion sea parameters are those of [4]. HYBR = pion structure functions without evolution. Only statistical errors are given

Model	α_0	α_1	β_0	β_1	K-factor	χ^2/d.o.f.	Confidence level (%)	χ^2 (below Υ)	χ^2 (above Υ)
Fit region: $0.24 < \sqrt{\tau} < 0.72$									
DY [10, 11]	0.44 ± 0.03	–	1.18 ± 0.04	–	2.60 ± 0.11	199.2/42	0.0	83.7	115.6
LLA [10, 11]	0.39 ± 0.02	-0.07 ± 0.01	0.98 ± 0.04	0.56 ± 0.002	2.78 ± 0.12	56.0/42	7.1	37.4	18.6
NLLA [10, 11]	0.40 ± 0.03	-0.07 ± 0.01	1.03 ± 0.04	0.57 ± 0.002	1.61 ± 0.07	57.5/42	5.3	36.4	21.2
HYBR [10, 11]	0.44 ± 0.03	–	1.13 ± 0.04	–	2.62 ± 0.12	53.0/42	11.8	28.4	24.6
Fit region: $0.24 < \sqrt{\tau} < 0.42$									
DY [10, 11]	0.41 ± 0.03	–	1.09 ± 0.04	–	2.71 ± 0.13	75.3/36	0.0	75.3	134.8
LLA [10, 11]	0.41 ± 0.03	-0.07 ± 0.01	1.02 ± 0.04	0.57 ± 0.002	2.69 ± 0.12	36.6/36	44.7	36.6	20.2
NLLA [10, 11]	0.41 ± 0.03	-0.07 ± 0.01	1.04 ± 0.04	0.57 ± 0.002	1.58 ± 0.07	36.0/36	47.4	36.0	21.7
HYBR [10, 11]	0.44 ± 0.03	–	1.14 ± 0.04	–	2.58 ± 0.12	28.2/36	18.1	28.2	25.0
Fit region: $0.24 < \sqrt{\tau} < 0.30$									
DY [10, 11]	0.42 ± 0.05	–	1.07 ± 0.11	–	2.67 ± 0.21	7.1/7	–	–	–

E615 – determination of the pion valence PDF (1989)

- Pion PDF data
  - E615 : 252 GeV, W target
- Analysis
  - Sea quarks subtracted: use NA3 data
  - Correct for A-dependence
  - Analysis at LO only
- Results
  - Pseudo-data PDF points (LO)
  - Pion PDF: $Ax^{0.6}(1-x)^{1.26}$

Conway et al., PRD 39, 92 (1989).

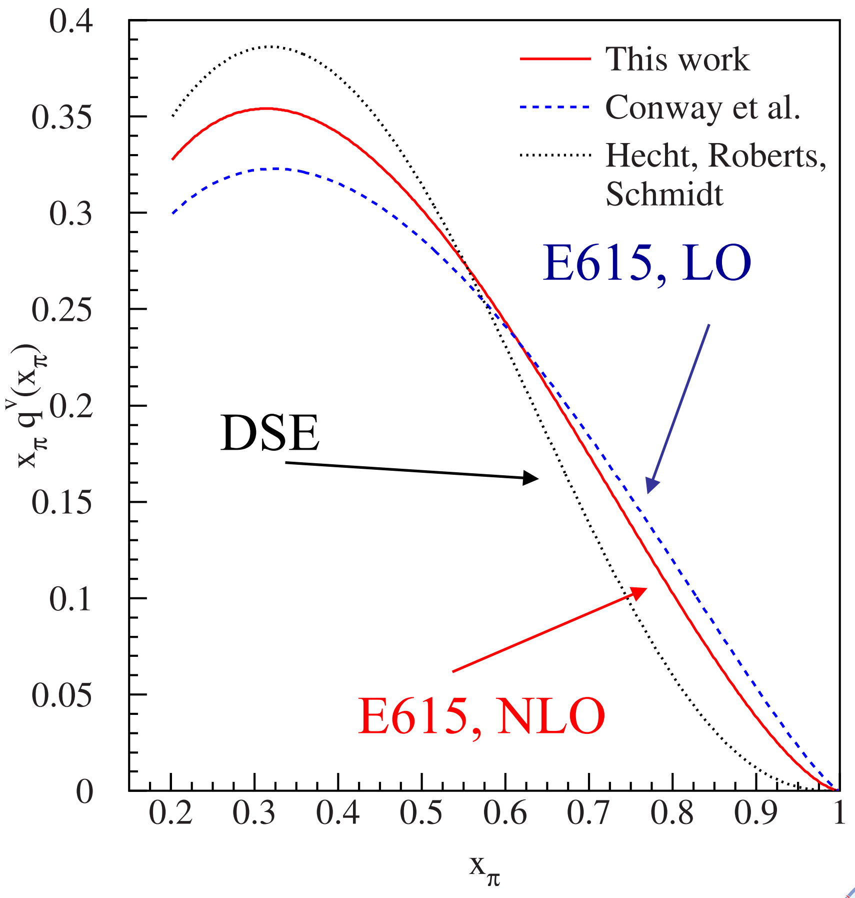


up to 20% difference in cross sections between NA3/NA10 and E615

Pion PDF – NLO reanalysis (2005)

- Reanalysis at NLO :
  - data: pion-induced DY from E615
- Fits :
  - Nuclear corrections
  - More recent nucleon PDFs: CTEQ5M, MRST,
- Results :
  - small depletion at low x
  - weak HT effect
  - some increase at high-x: $(1-x)^{1.55}$

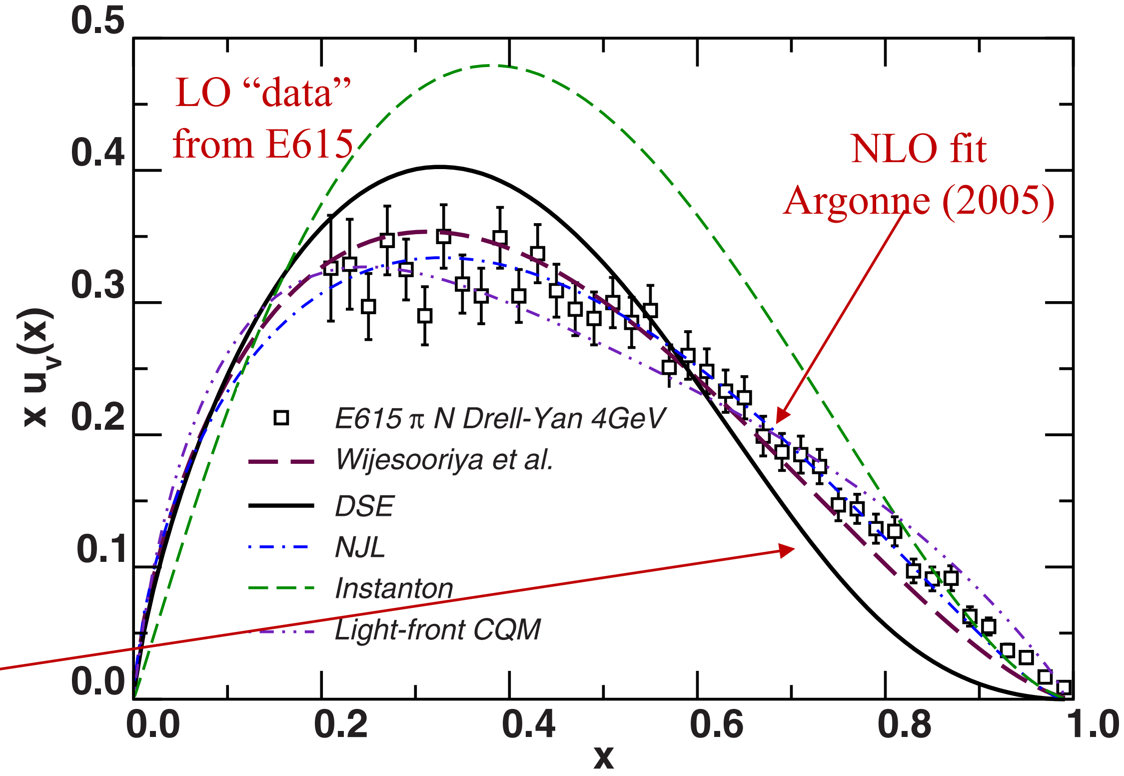
Wijesooriya et al., PR C72, 065203 (2005).



Pion valence PDF – fall-off at large *x*?

Pion PDF parametrization : ~ $A x^{\alpha}(1-x)^{\beta}$

- Fall-off from original data (LO !)
  - NA3 : $\beta = 1.17$
  - E615 : $\beta = 1.26$
- Fall-off from 2005 re-analysis (NLO)
  - E615 : $\beta = 1.55$
- Fall-off from theory:
  - pQCD : $\beta > 2.0$
  - DSE : $\beta > 2.0$



A puzzle, …. until 2010 …

Pion (valence) PDF – reanalysis with NLL resummation (2010)

- New fit of E615 data
  - NLO, NLL
  - sea + gluons: from GRSh – 1999 ☹
  - take into account nuclear effects
  - Valence PDF:

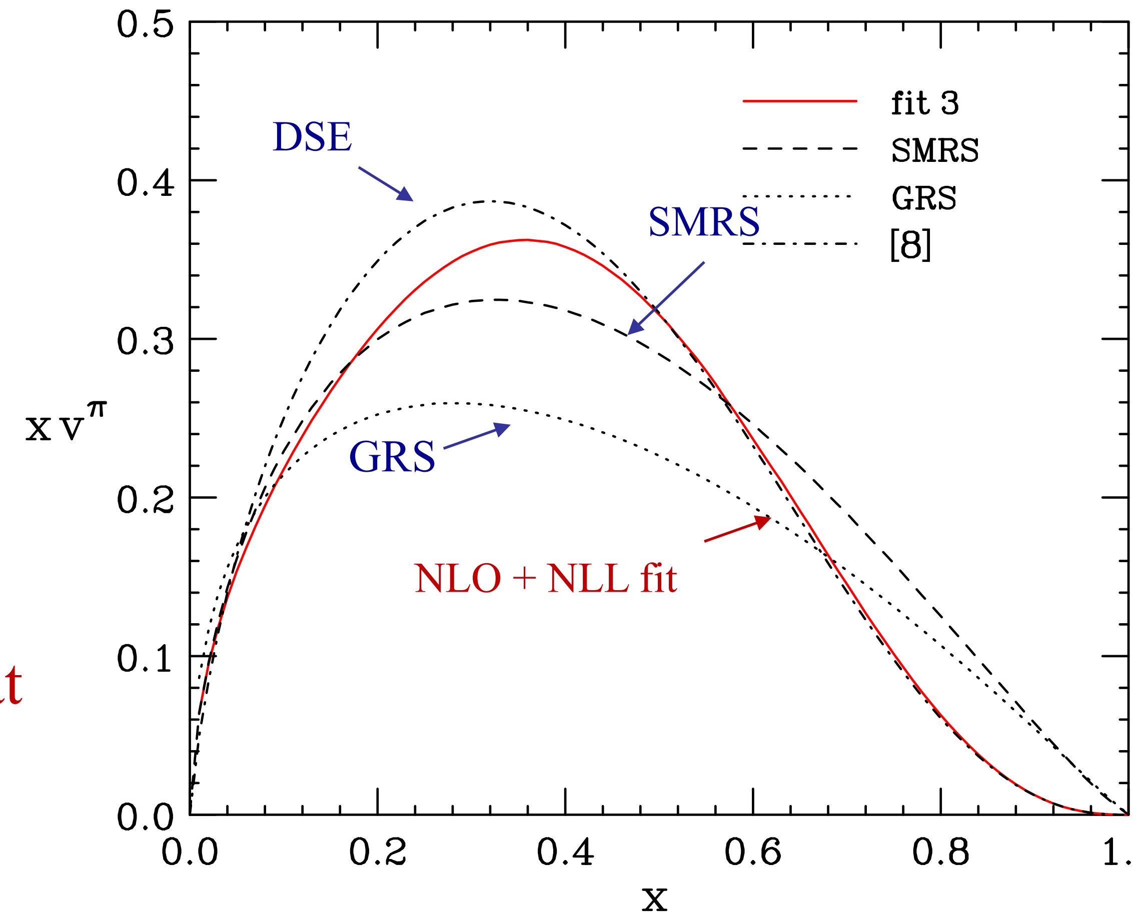
$$xv^{\pi}(x) = Nvx^{\alpha}(1-x)^{\beta}(1+\gamma x^{\delta})$$

Falloff at Q = 4 GeV: $\beta = 2.34$

Agreement with pQCD, DSE

NLL : makes the valence distribution softer at high *x;* OK vs DSE

Aicher, Schäfer and Vogelsang, PRL 105, 252003 (2010).

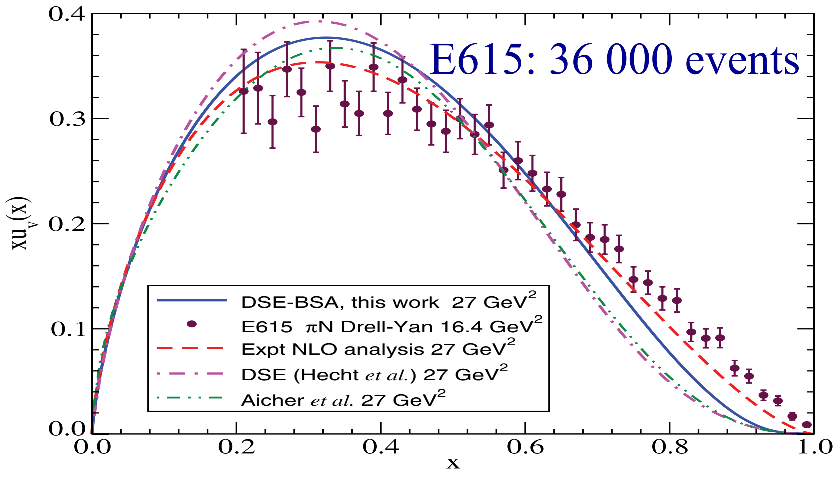


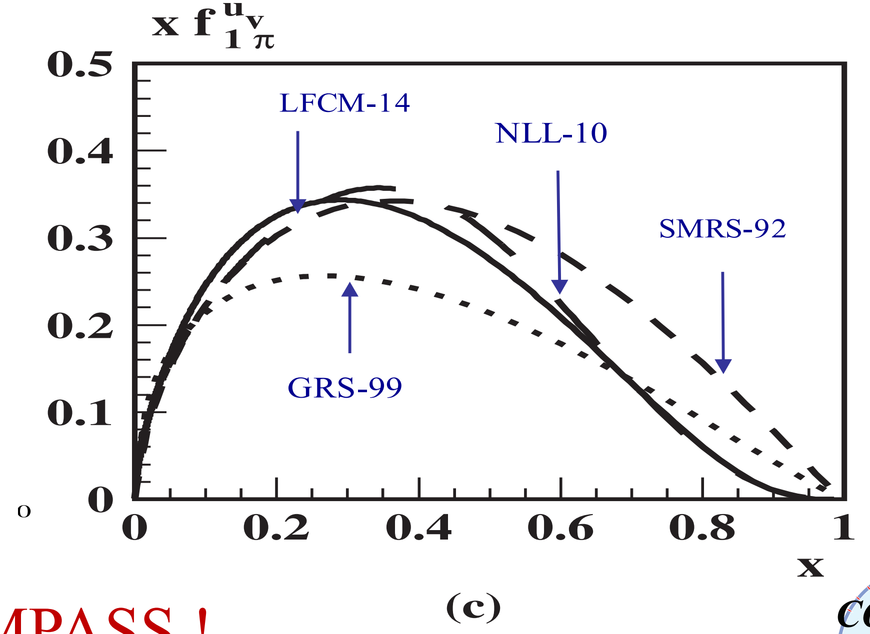
"Our results overall demonstrate that threshold resummation effects will be important in the analysis of future COMPASS data."

(Some of the) recent calculations of the pion PDF

- E615 data re-analysis
  - NLO : Wijesoorija, Reimer, Holt, 2005
  - NLO + NLL : Aicher, Shaffer, Voglesang, 2010

- Model calculations
  - DSE : Nguyen et al., 2011, Chen et al., 2016
  - LFCM : Pasquini et al., 2014
  - NLChQM: Nam, 2012





New, higher statistics data from COMPASS !

What do we know about the pion sea?

NA3 experiment at CERN (1983)

- NA3 experiment : 150, 200, 200 GeV
  - Target : ^{195}Pt

Badier et al., Z. Phys. C18, 281 (1983).

Table 1. Number of dimuon events collected at 150, 200 and 280 GeV on the 6 cm Pt target in the mass interval 4.2 to 8.5 GeV/c^2

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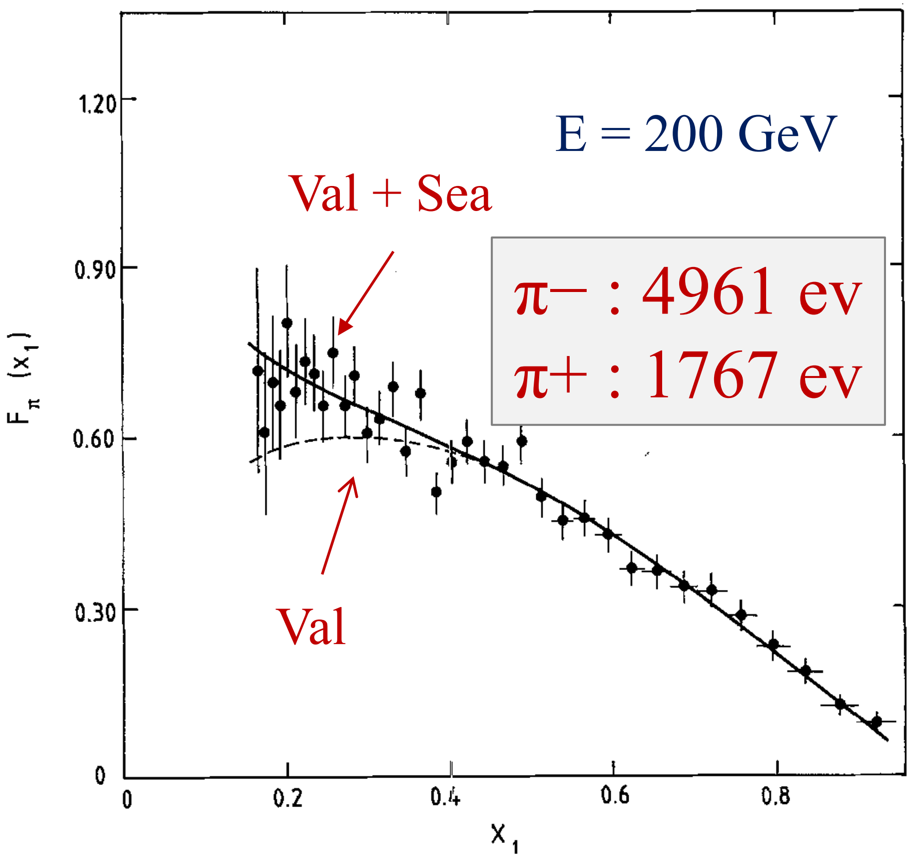


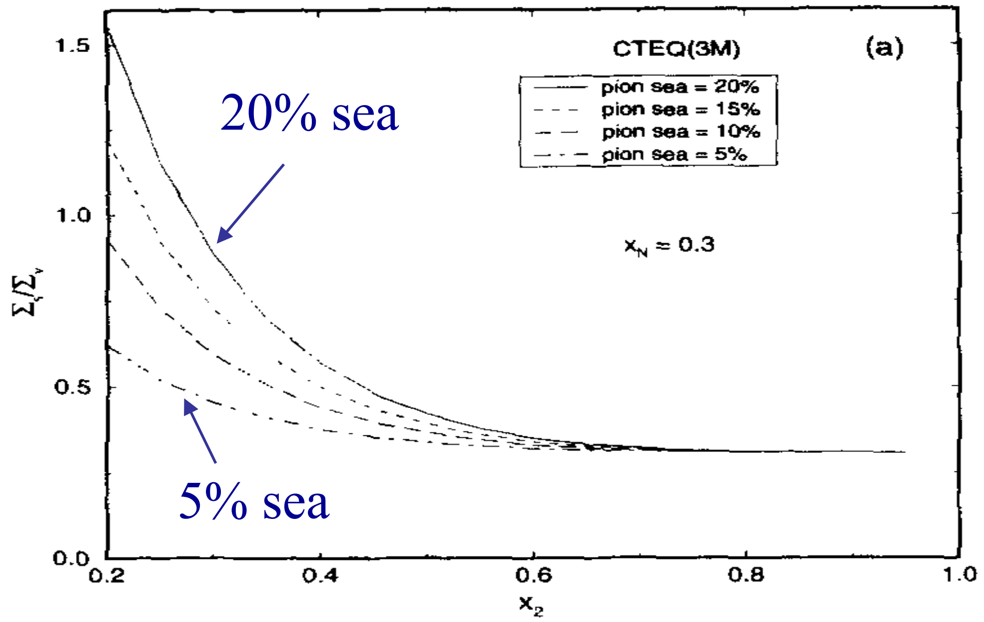
- Analysis (LO)
  - Assume SU(2) and SU(3) symmetry
  - Nucleon PDF: from CDHS (1979)

The only available today valence/sea separation

Valence sea separation in the pion

- Two linear combinations :
  - assume SU(2) and charge invariance
  - Sea : $\Sigma_{sea}^{\pi D} = 4\sigma^{\pi^+ D} - \sigma^{\pi^- D}$ no valence-valence terms
  - Valence: $\Sigma_{val}^{\pi D} = -\sigma^{\pi^+ D} + \sigma^{\pi^- D}$ only valence-va

Londergan, Liu and Thomas, PL B361, 110 (1995).



- Study the ratio: $R_{S/V} = \frac{\Sigma_{sea}^{\pi D}}{\Sigma_{val}^{\pi D}}$,

- Experimental requirements :
  - Need π^- and π^+ beams
  - High energy - > low x

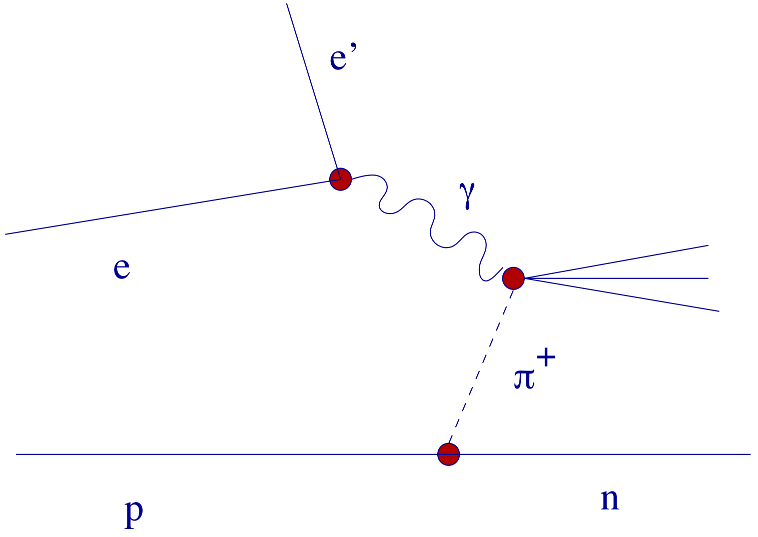
Measurement only possible at CERN - ☞ talks by C. Quintans and V. Andrieux

Pion PDF at low x via DIS at HERA

- Idea: scattering from the pion cloud (Sullivan, 1972):
  - Pion cloud: the proton is a bare proton plus other states:

$$|p\rangle = a|p\rangle + b|n\pi^+\rangle + c|p\pi^0\rangle + \ldots.$$

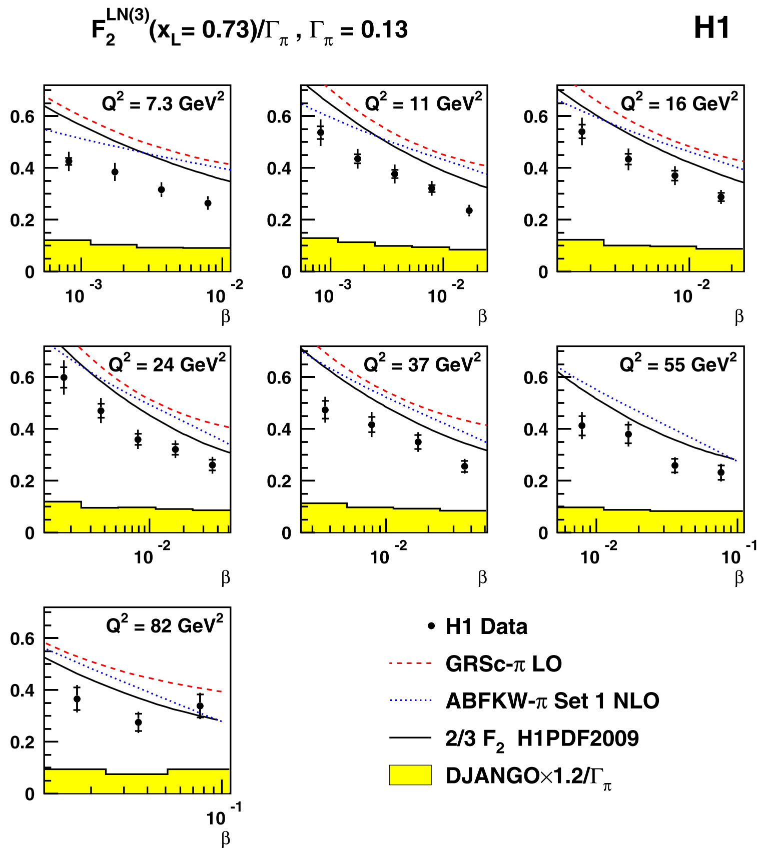
- HERA (Zeus and H1)
  - the proton fluctuates into a $n\pi^+$ state
  - H1: study the process: $ep \rightarrow e'nX$
  - Detect leading neutrons



Pion PDFs at low x via DIS at HERA

- Main findings:
  - the shape of the pion sea is quite similar to the one of the nucleon (solid curve)
  - magnitude of the sea: ~about 1/3 instead of expected 2/3.
  - Large uncertainties on the estimate of the "pion flux"

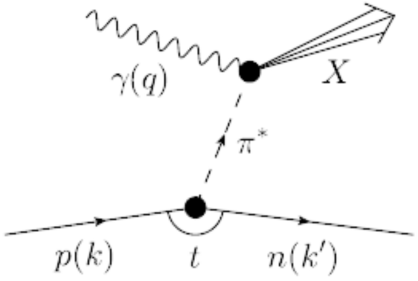
Aaron et al., Eur. Phys. J. C68, 381 (2010)

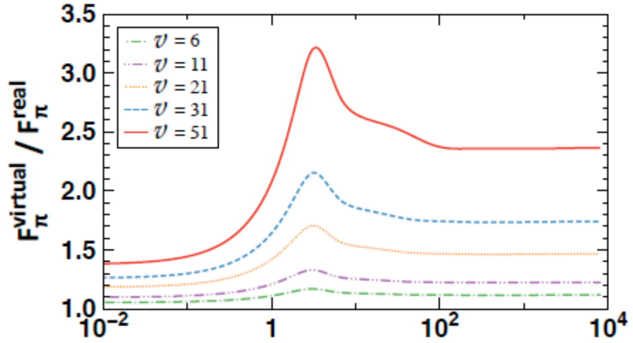


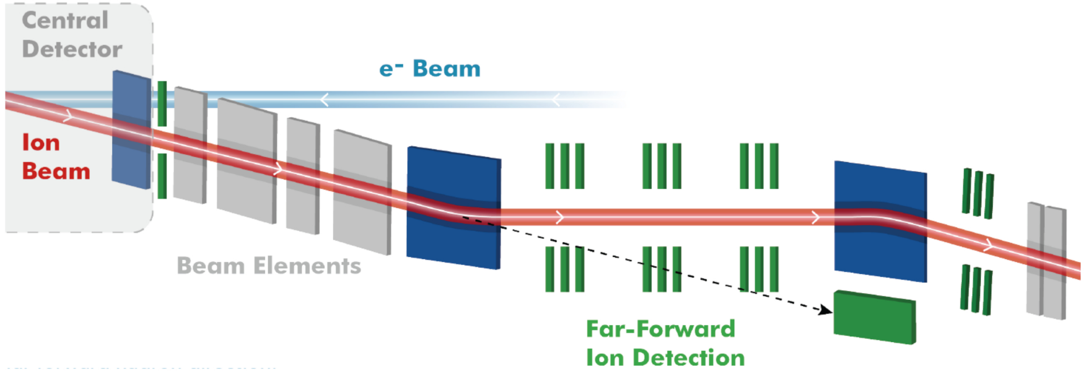
Pion and Kaon Structure at an Electron-Ion Collider

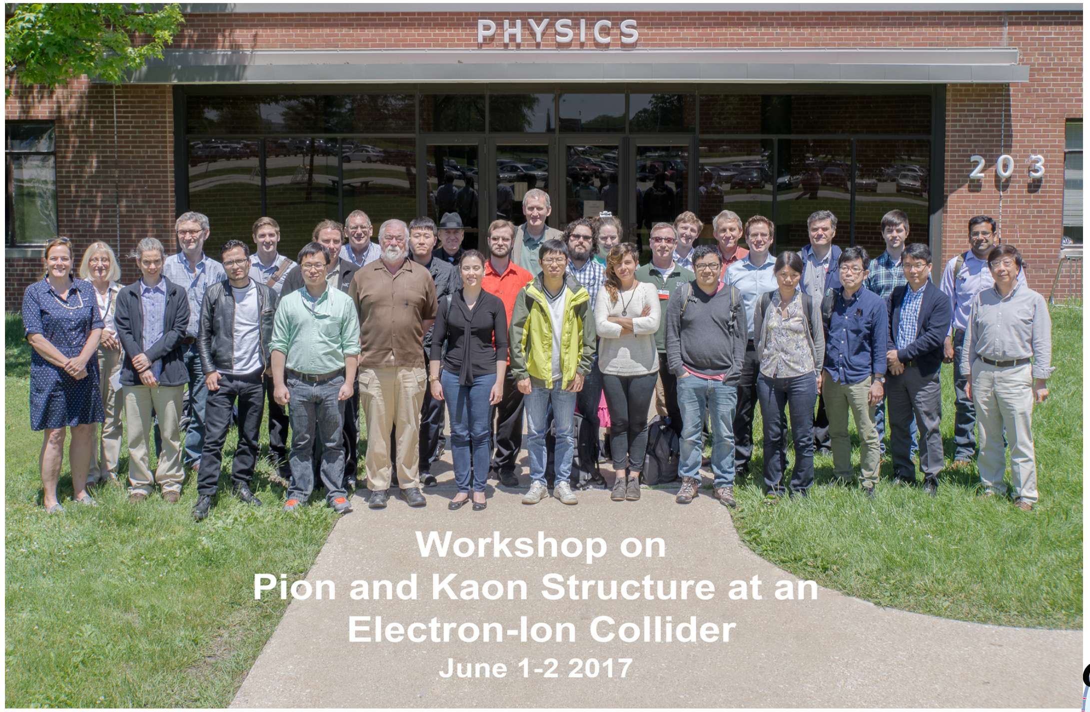
1–2 June 2017, Physics Division, Argonne National Laboratory

Argonne NATIONAL LABORATORY





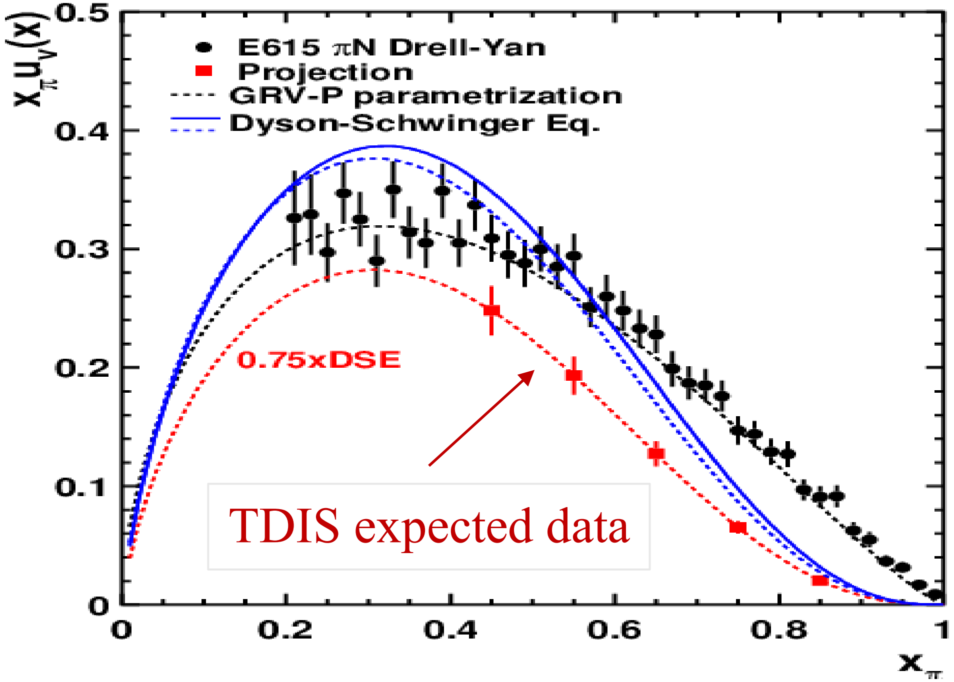




Pion PDF at high x (DIS on the pion at JLAB)

- JLAB experiment (Tagged DIS, 2015)
  - use the pion cloud model to study the pion PDF (p and d targets)
  - detect leading protons

We here propose to measure the semi-inclusive reactions $H(e,e'p)X$ and $D(e,e'pp)X$ in the deep inelastic regime of $8 < W^2 < 18$ GeV^2, $1 < Q^2 < 3$ GeV^2, and $0.05 < x < 0.2$, for very low proton momenta in the range 60 MeV/c up to 400 MeV/c.



  - study π PDF at high *x*;
  - normalize flux to to the DY data

Pion cloud idea used for JLab and EIC measurements - ☞ talk by R. Yoshida

Extraction of the pion gluon distribution (1983 – 1995)

Three possible methods for extracting $g_\pi(x)$:

- Prompt photon production
- Leading π^+/π^- comparison in high-p_T jets
- Using J/ψ production

Gluon PDF – Method-1: high-p_t prompt photons ☞ talk by A. Guskov

IRFU

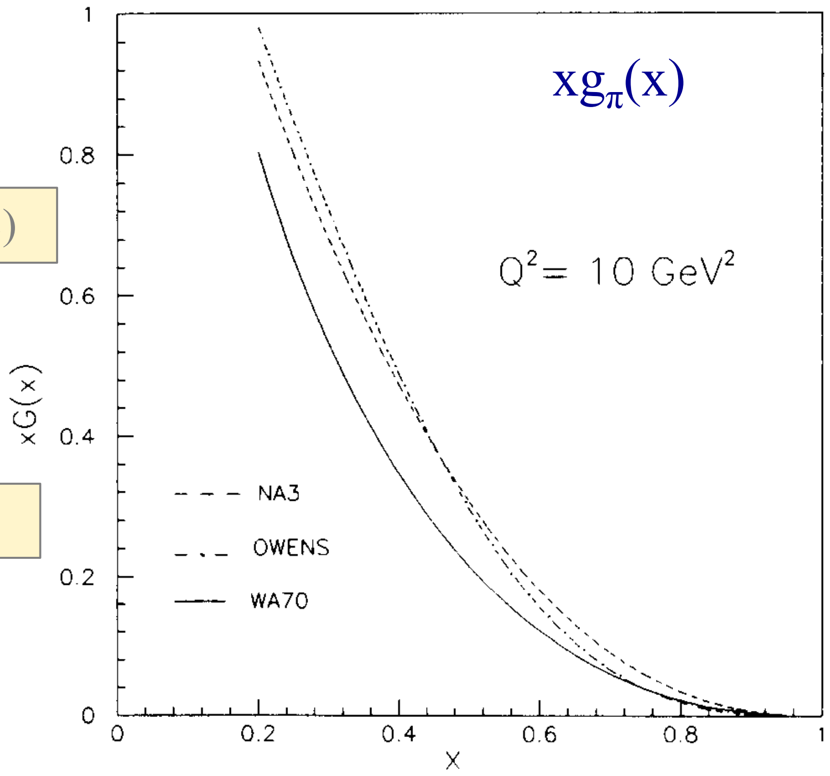
- High-pt prompt photons in $\pi + p \rightarrow \gamma + X$ (π^+ and π^- beams)
  - two processes: $qg \to \gamma q$ and $q\bar{q} \to \gamma q$
  - known up to $O(\alpha_s^2)$
  - Data from WA70 (CERN) at 280 GeV on a H target

Bonesini et al., Z.Phys. C37, 535 (1988)

  - $\pi-$ cross section ratio dominated by: $qg \to \gamma q$
  - Note that $\sigma(\pi^+) - \sigma(\pi^-)$ is sensitive to $q\bar{q}$

Aurenche et al, PLB 233, 517 (1989)

- Data analysis
  - Data cut for high p_t : 4 GeV/c
  - $g_\pi \sim (1-x)^{1.94 \pm 0.20 \pm 028}$



Results for xG(x) rely on the knowledge of Valence and Sea

No new data since then!

COMPASS

Gluon PDF – Method-2: leading π+ and π− in high-p_t di-jets

- Fermilab experiment (E609)
  - E = 400 GeV protons, E = 200 GeV pions
  - Target: liquid H_2

Bodner et al., Z. Phys. C72, 249 (1995)

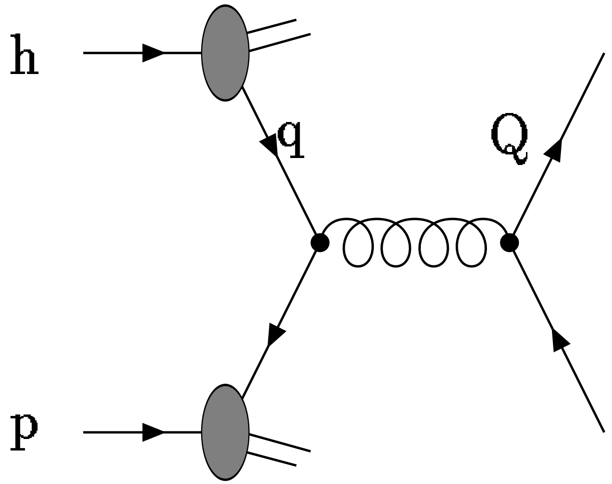
$xG(x)$	Reactions	Subprocess	Reference
$(1-x)^3$	$\pi N \to \psi$	$GG \to c\bar{c}$	[4], (1980)
$(1-x)^{1.9\pm0.3}$	$\pi^- Be \to \psi$	$GG \to c\bar{c}$	[5],(1983), WA11
$(1-x)^{2.38\pm0.06\pm0.1}$	$\pi^\pm Pt \to \psi$	$GG \to c\bar{c}$	[6], (1983)
$\sim (1-x)^{3.1}$, evolves with Q^2	$\pi p \to \psi, \pi^\pm X$	$GG \to c\bar{c}$	[7], (1984)
$(1-x)^{2.3^{+0.4+0.1}_{-0.3-0.5}}$	$\pi^- W \to \Upsilon$	$GG \to b\bar{b}$	[8], (1986) NA10
$(1-x)^{1.94^{+0.39}_{-0.17}}$	$\pi^\pm p \to \gamma X$	$QG \to \gamma Q$	[10], (1989) WA70
$(1-x)^{2.1\pm0.4}$	$\pi^+ p \to \gamma X$	$QG \to \gamma Q$	[11], (1991)
$(1-x)^{2.75\pm0.40\pm0.75}$	$\pi^- p \to dijets$	$QG, GG \to dijets$	This paper

- Data analysis
  - Ratio of data for two jets
  - p_t cut: > 7 GeV for two jets
  - About 2 x 5000 events survive cuts

- Result: $g_\pi \sim (1-x)^{2.75\pm0.40\pm0.75}$

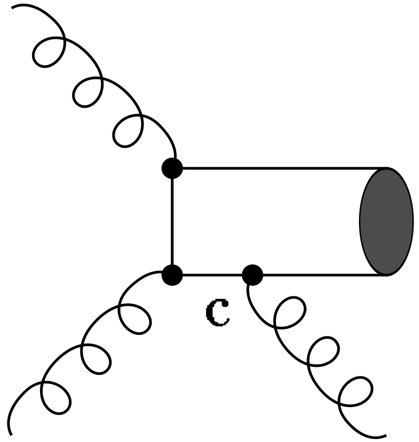
Gluon PDF – Method-3 : from J/ψ production

- Main processes contributing to J/ψ



$q\bar{q}$

$q\bar{q}$ annihilation



gg

gg fusion

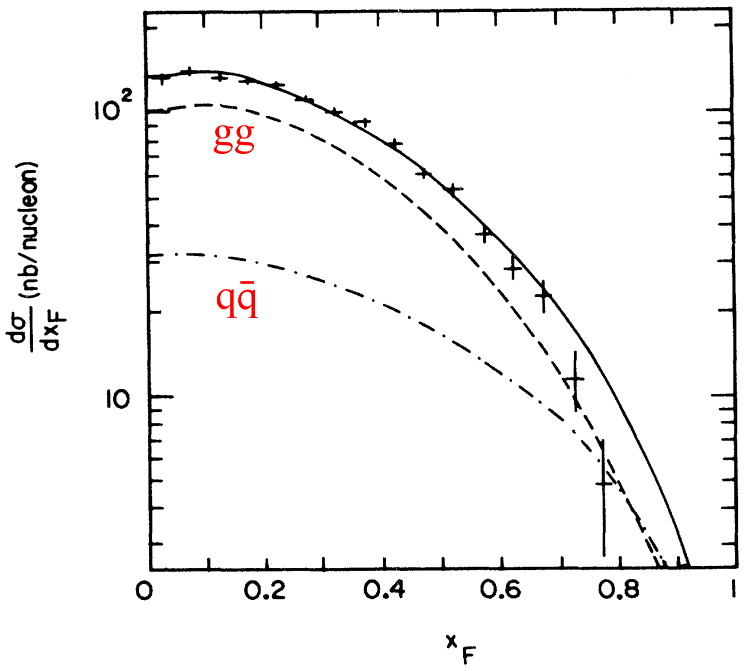
- Pion-induced J/ψ production:
  - NA3 (E = 150, 200 GeV)
  - E537 (E = 125 GeV)
  - WA11 (E = 190 GeV)
  - NA10 (Υ prod, E = 286 GeV)

$$xg_{\pi}(x) = A(1-x)^{\beta}$$

Gluon PDF extraction – examples

- E537: 125 GeV/c: W target

Akerlof et al., PRD48, 5067 (1993)

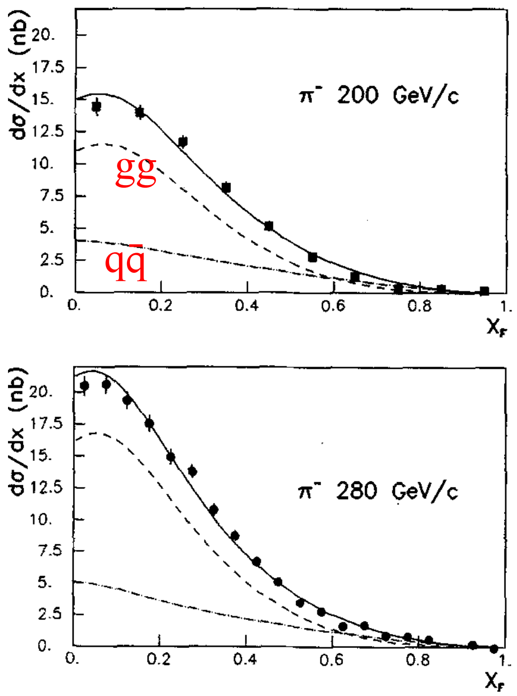


$xG(x) = (1.49\pm0.03)x(1-x)^{1.98\pm06}$ on W

$xG(x) = (1.10\pm0.10)x(1-x)^{1.20\pm20}$ on Be

- NA3: 200/280 GeV/c: Pt target

Badier et al., ZPhys, C20, 101 (1983)



$xG(x) = 1.0x(1-x)^{2.38\pm06\pm10}$ on Pt

Quite different results: ß varies from 1.20 to 2.38

Comparison of DY and J/ψ processes

- Drell-Yan
  - Mainly electromagnetic process : clean and well known probe 😀
  - Access to valence and sea quark PDFs
  - Low cross sections 🙁

- J/ψ production
  - Strong interaction process
  - Depends on quark and gluon PDFs (at FT regime)
  - Large cross sections ! 😀
  - Model dependence 🙁 - a really powerful probe if we can get rid of it !

☞ talk by J.-C. Peng

“Global” fits of the pion PDFs

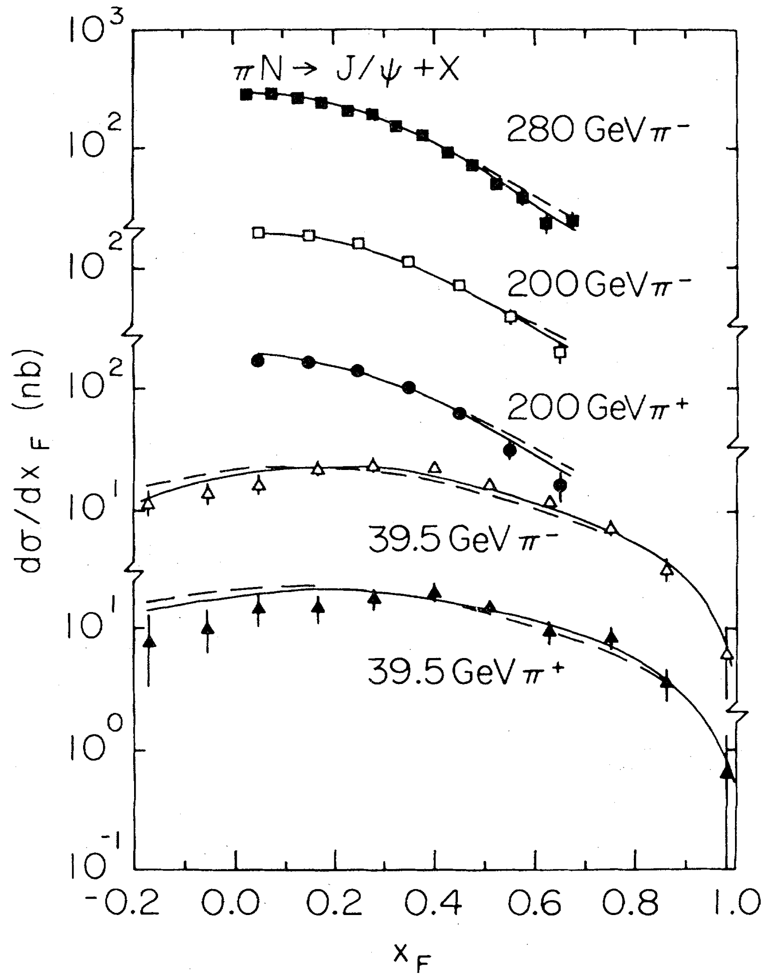
Global fits

- In 2017: still only four global fit parametrizations (1984 – 1992)
  - Owens (OW) — Phys. Rev. D30, 943 (1984)
  - Aurenche et al. (ABKFW) — Phys. Lett. 233, 517 (1989)
  - Sutton et al. (SMRS) — Phys. Rev. D45, 2349 (1992)
  - Gluck et al., (GRV/S) — Z. Phys. C53, 651 (1992), Eur. Phys. J. C10, 313 (1999)

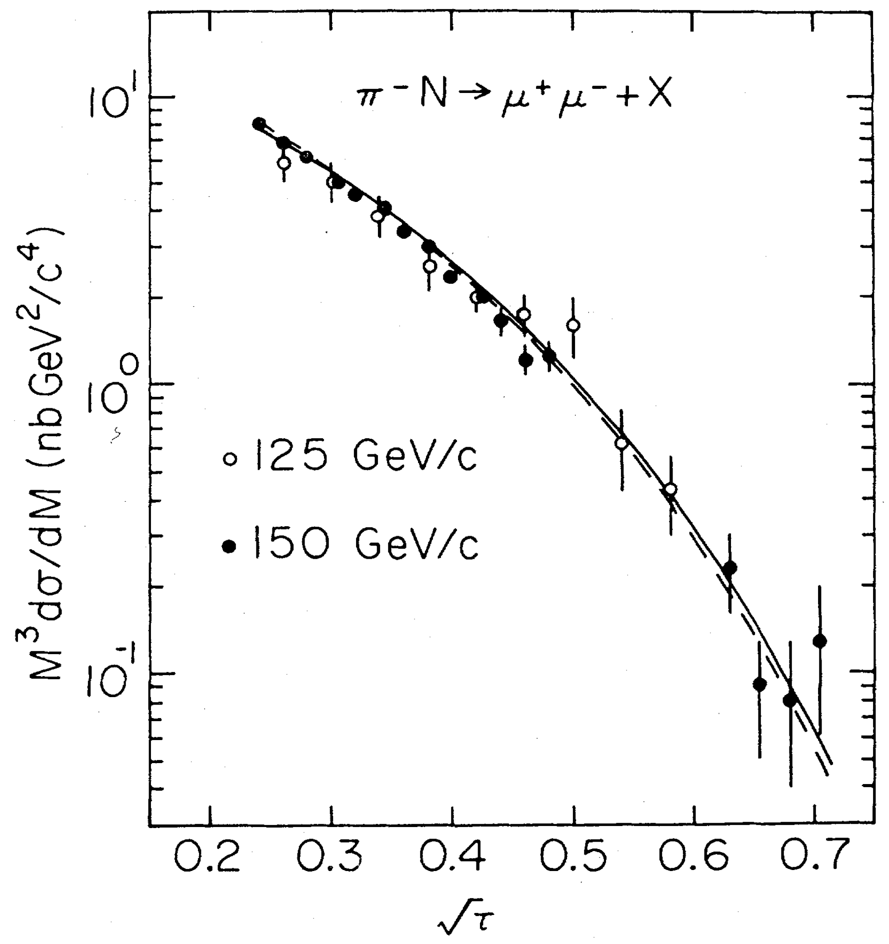
- Constraints for the pion
  - Number of quarks $$\int_0^1 u_\pi(x)dx = \int_0^1 v_\pi(x)dx = 1$$
  - Momentum sum rule $$\int_0^1 x\left[2v_\pi(x)+6s_\pi(x)+g_\pi(x)\right]\mathrm{dx}=1$$
  - SU(2) and charge symmetries $$u_\pi(x)=\bar{u}_\pi(x)=d_\pi(x)=\bar{d}_\pi(x)$$

Pion global fits – Owens

- DY data
  - E537 (125 GeV)
  - NA3 (150 GeV)
- J/ψ data
  - NA3 (200 + 280 GeV)
  - WA39 (40 GeV)
- Analysis
  - LO with a K-factor
  - Q^2-dependence



Owens: PRD 30, 943 (1984).

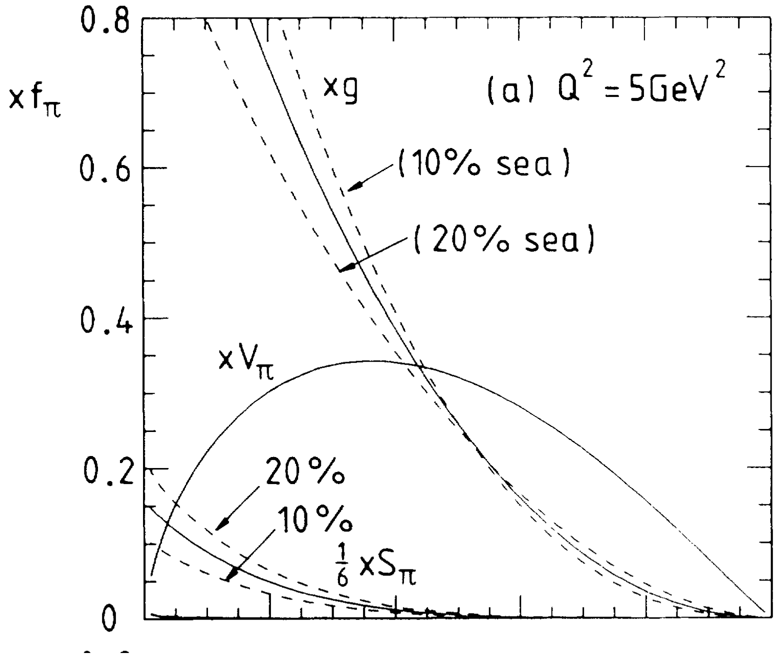


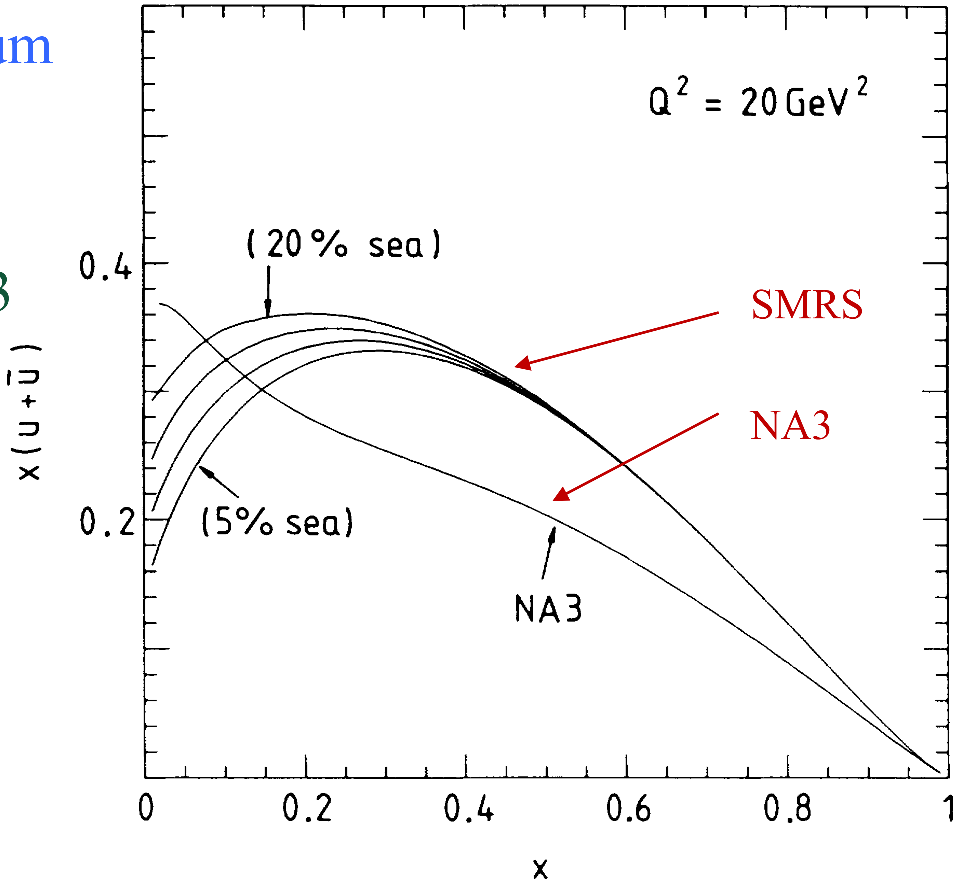
Owens parametrizations are still in use today

Pion global fit – SMRS

Sutton, Martin, Roberts and Stirling, PRD 45, 2349 (1992).

- SMRS : fit at NLO
  - valence quarks: DY data from NA3, NA10, E615
  - sea: vary from 5% to 20% of the total pion momentum
  - gluons: use $\pi p \rightarrow \gamma X$ data from WA70 (1989)
  - First moments @4 GeV^2
    - valence: 0.47, sea: 0.10 – 0.20, gluons:0.43 – 0.33





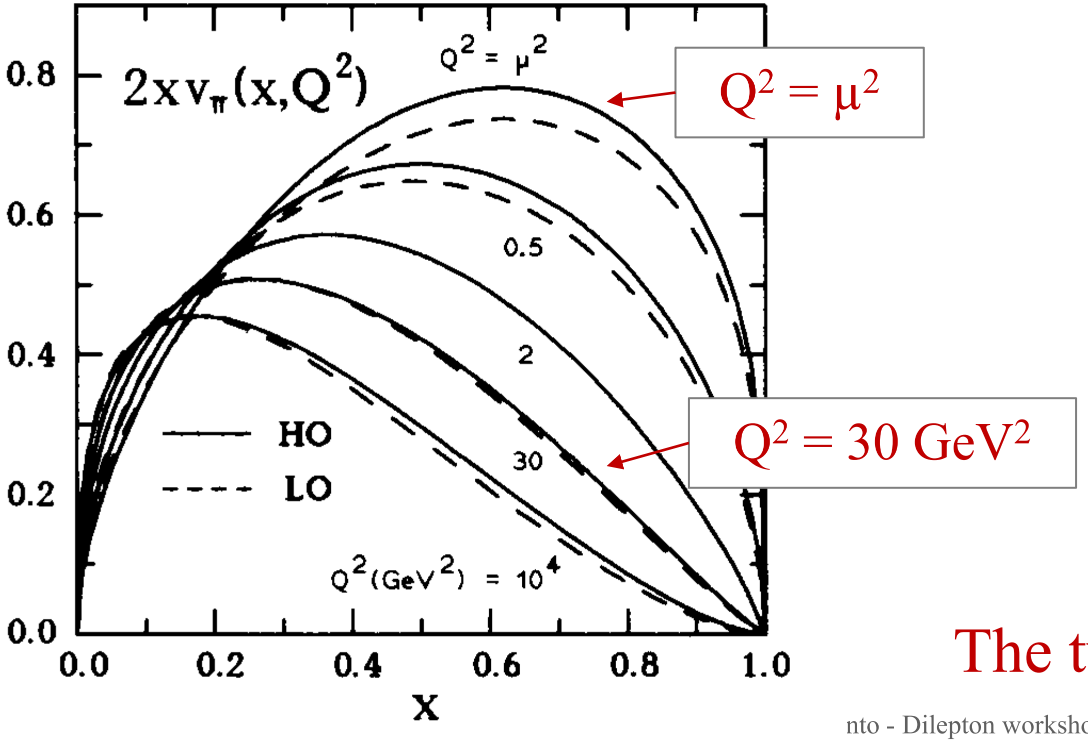
SMRS: "tension" with NA3 data

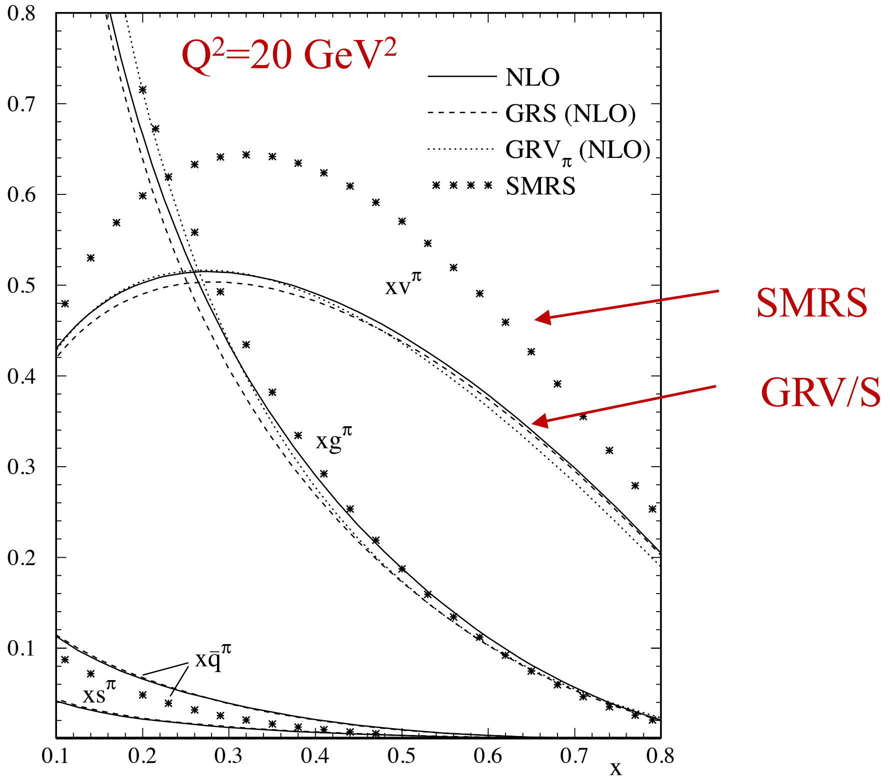
Pion global fits – GRV/S

- GRV fits at NLO:
  - 1992: π-induced DY from NA3, NA10, E615
  - 1999: Constituent Quark Model constraints
  - Gluons: π-induced prompt photon data
  - Q^2 – evolution

GRV: Z Phys C53, 651 (1992).

GRS: Eur Phys J C10, 313 (1999).





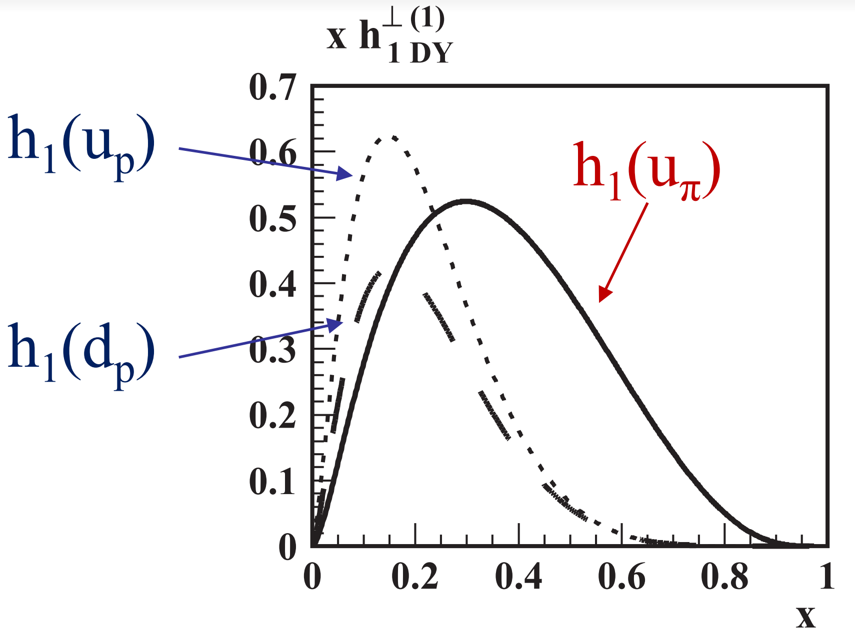
The two global fits are non-consistent

Pion TMDs

quark polarization \ nucleon polarization	U	L	T
U	f_1 number density		$f_{1T}^{\perp}$ -
L		g_1 - helicity	g_{1T} -
T	$h_1^{\perp}$ - *Boer-Mulders*	$h_{1L}^{\perp}$ -	h_1 - transversity; $h_{1T}^{\perp}$ -

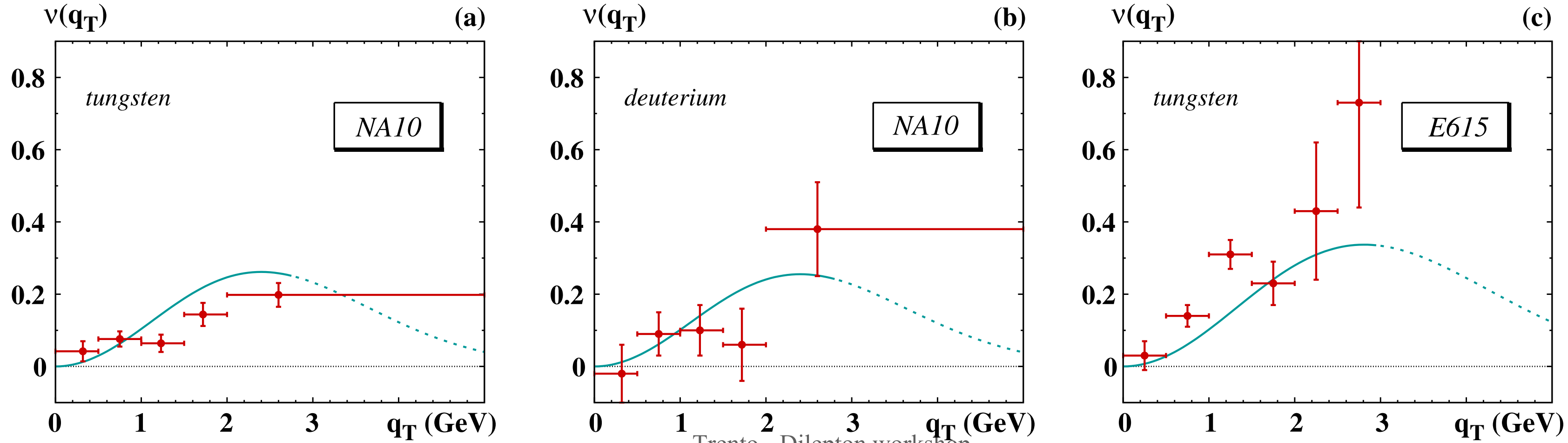
Only two TMDs (at LT)

Boer-Mulders pion PDF in the LFCM



Pasquini, Schwetzer PR D90, 014050, (2014)

PION TRANSVERSE MOMENTUM DEPENDENT PARTON … PHYSICAL REVIEW D **90,** 014050 (2014)



What about kaon PDFs?

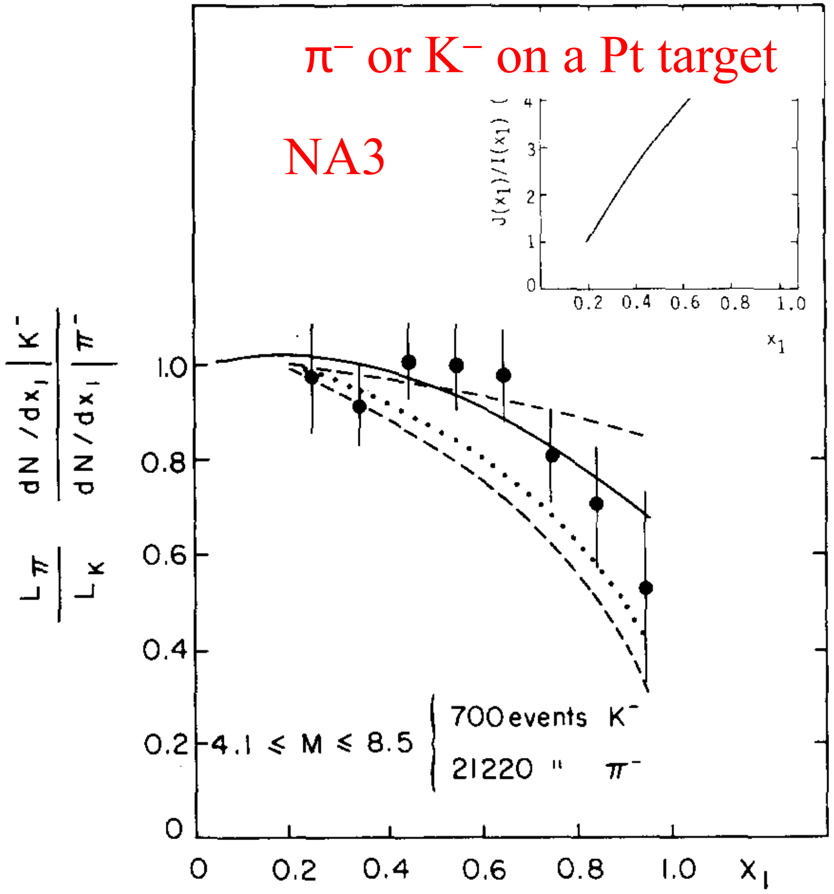
A single measurement (NA3) from 1983

- Results
  - The cross section ratio for K^- and π^- beams is proportional to:

$$\bar{u}^{K^-}(x)/\bar{u}^{\pi^-}(x)$$

  - At large x, the kaon ū(x) is smaller than the pion ū(x)
  - The heavier s quark carries a larger fraction of the kaon momentum

Badier et al, PL 93B, 355 1980.

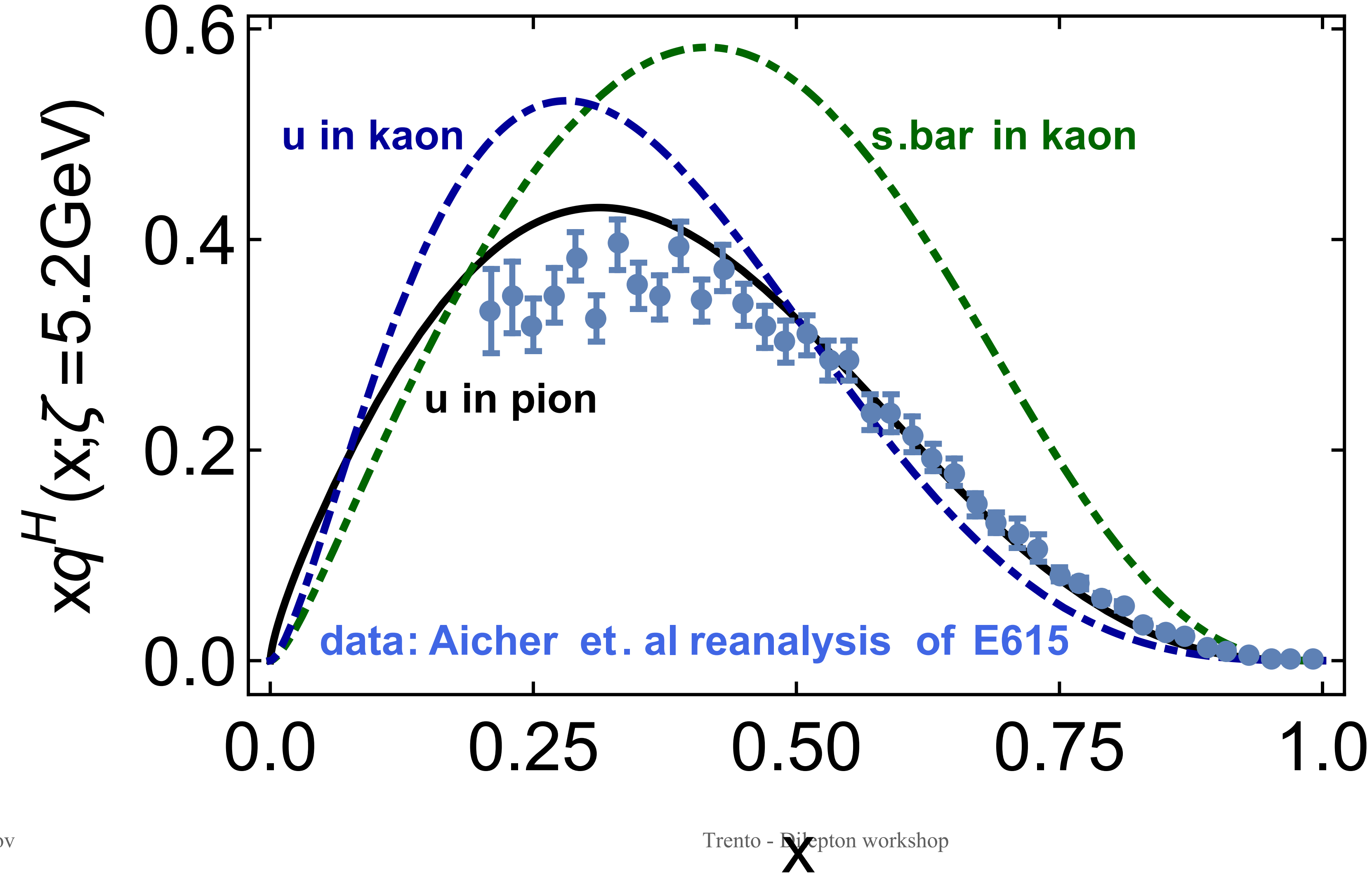


NA3 data: 700 events. We need more.

Kaon and pion PDFs (DSE)

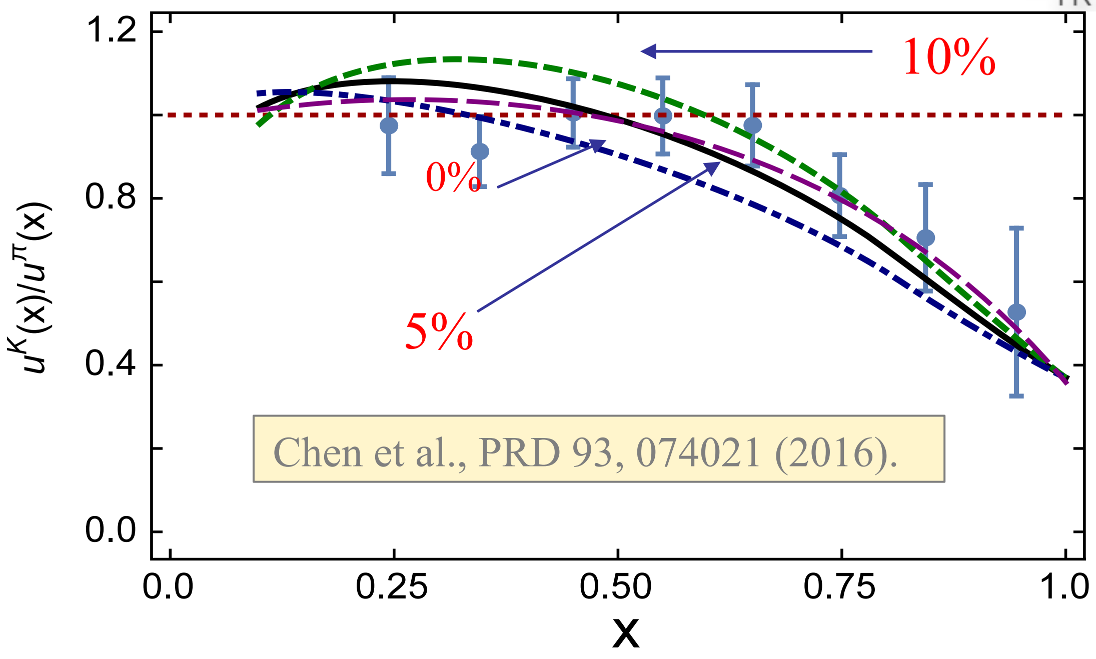
- DSE plot (courtesy C. Roberts)

Chen et al., PRD 93, 074021 (2016).



Gluon PDF for kaons?

- BS + DSE calculation (☞ C. Roberts' talk)
  - Derive valence distributions, then incorporate sea and gluons. Evolve.
  - Fit u(K)/u(π) ratio and adjust the gluon PDF.



- Chen et al. (challenging !) conclusion:
  - At the hadronic scale gluons carry only 5% of the momentum of the kaon BUT 35% of the momentum of the pion !

=> Another good reason for a measurement of the kaon PDFs

Present status of the meson PDFs

- Global fits of the pion PDFs
  - Present parametrizations have large uncertainties (compared to nucleon)
  - No new data since nearly 3 decades
  - New global fit analysis underway (Sato et al., , PIEIC, Argonne, 2017)

- Measurements on the pion ion PDFs
  - Valence PDF: data can be improved, particularly for $x < 0.5$
  - Sea PDF: unknown (except some nice HERA data at low x)
  - Gluon PDF: badly known,

- Measurements on the kaon PDFs
  - All valence, sea and gluons PDF are essentially unknown

New measurements at CERN can greatly improve both pion and kaon PDFs !

CERN is a unique place for such measurements

Planned and possible measurements at CERN

- Present: 2015 and 2018
  - Pion valence PDF : infer from NH_3 and W with good statistics (π^- beam)
- After LS2 : "near" future with "conventional" beams : ☞ talk by C. Quintans
  - valence – sea separation of the pion PDFs (π^+ and π^- beams)
- After LS3 : RF-separated kaon and antiproton beams : ☞ talk by J.Bernhard
  - Kaon valence PDF using DY ☞ talk by V. Andrieux
  - Kaon valence – sea separation with DY (K^+ and K^- beams)
  - Kaon valence – glue separation with J/ψ production on a proton target (K^+ and K^- beams)
  - Kaon and pion gluon PDFs using direct photons (K^- and π^- beams) : ☞ talk by A. Guskov

CERN is a unique place for such measurements