2015 COMPASS Status Report

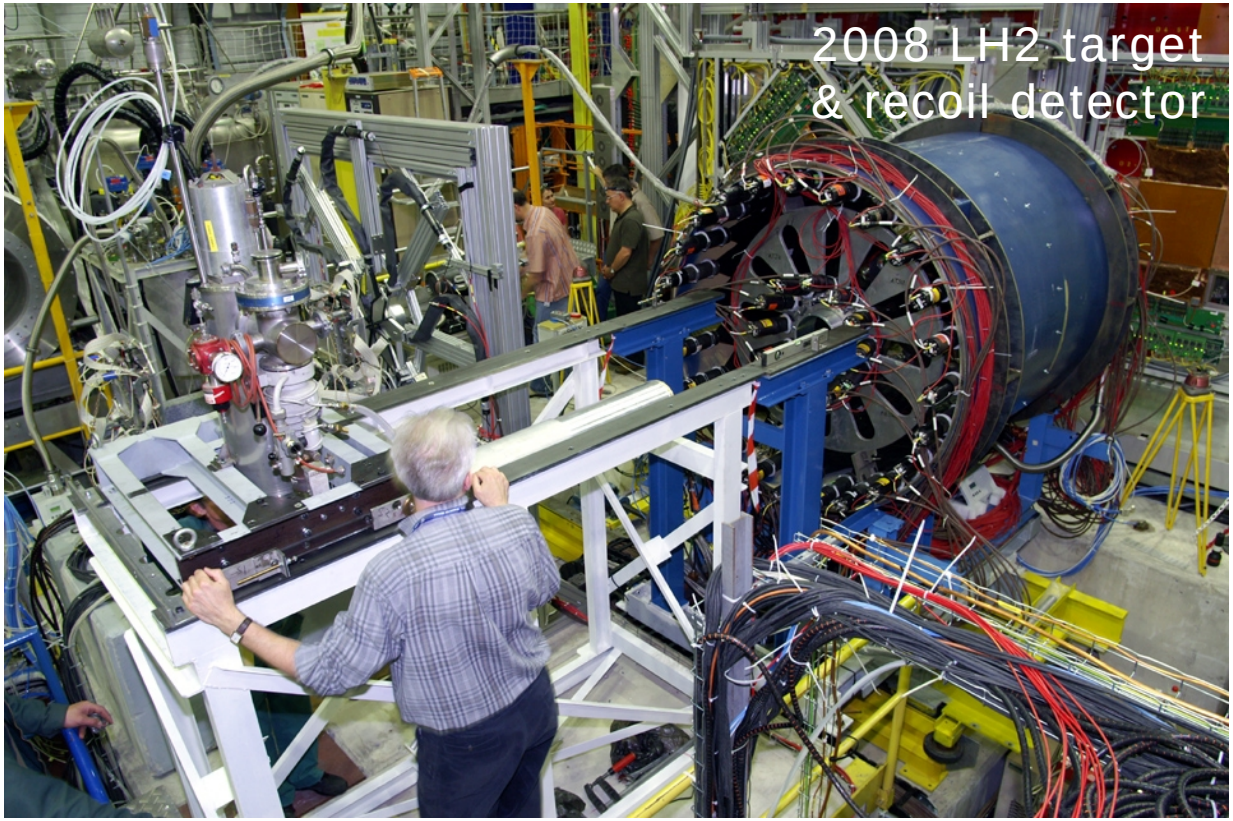
COMPASS

CERN

Outline

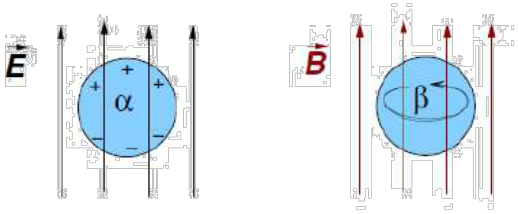
- Hadron beam results
  - pion polarizability publication (2009 data)
  - 2012 Primakoff data
  - news on the $a_1(1420)$ 1^{++} iso-vector meson
- Muon beam results
  - g_1 structure function
  - gluon polarisation
  - transverse structure of the nucleon
  - exclusive omega production
  - multiplicities and fragmentation functions
- GPD & DY
  - 2012 analysis of DVCS
  - 2014 analysis of DY
- Hardware and status of the 2015 Run

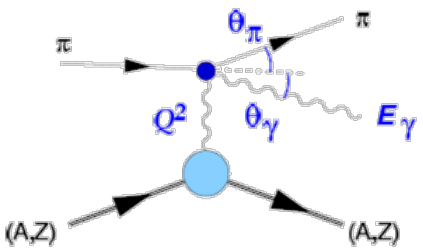
Hadron beam results

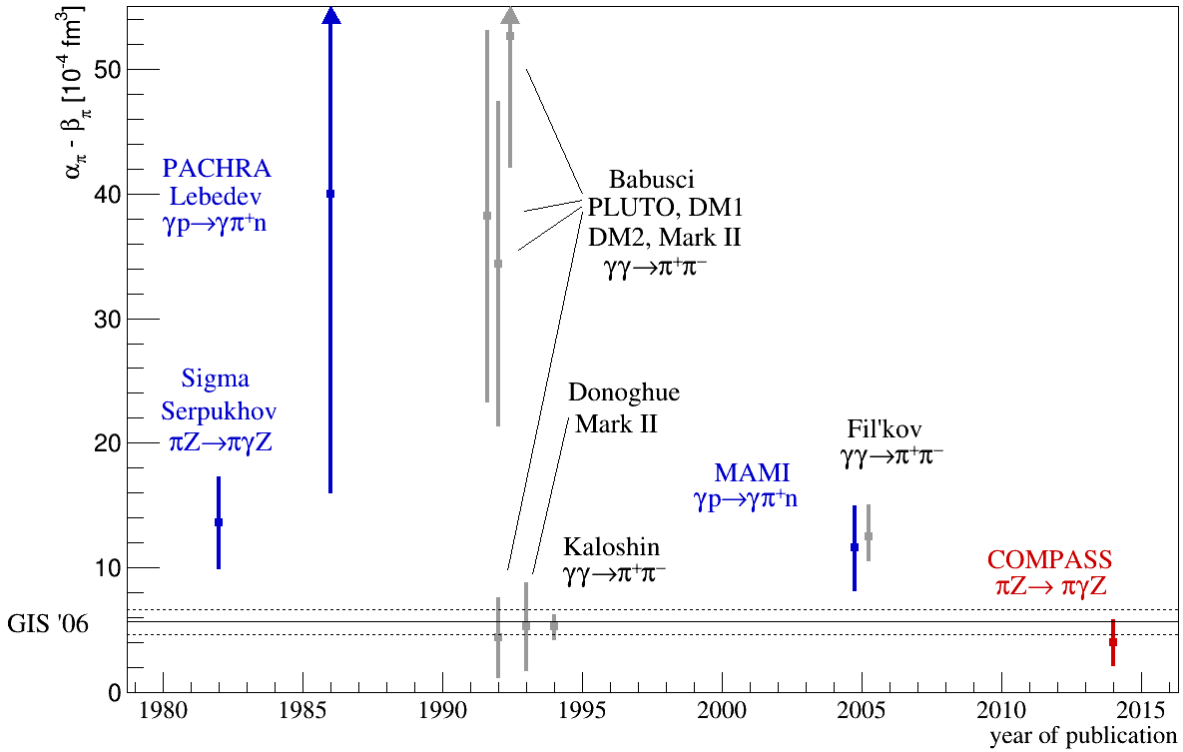


Pion polarisability

- Paper
  - $\alpha = (2.0 \pm 0.6 \pm 0.7)\ 10^{-4}$ fm^3, assuming $\alpha + \beta = 0$
  - submitted to PRL May 2014, accepted Dec 2014
  - main discussion on higher chiral loops vs dispersion relations
  - published Feb 2015; PRL 114 (2015) 062002

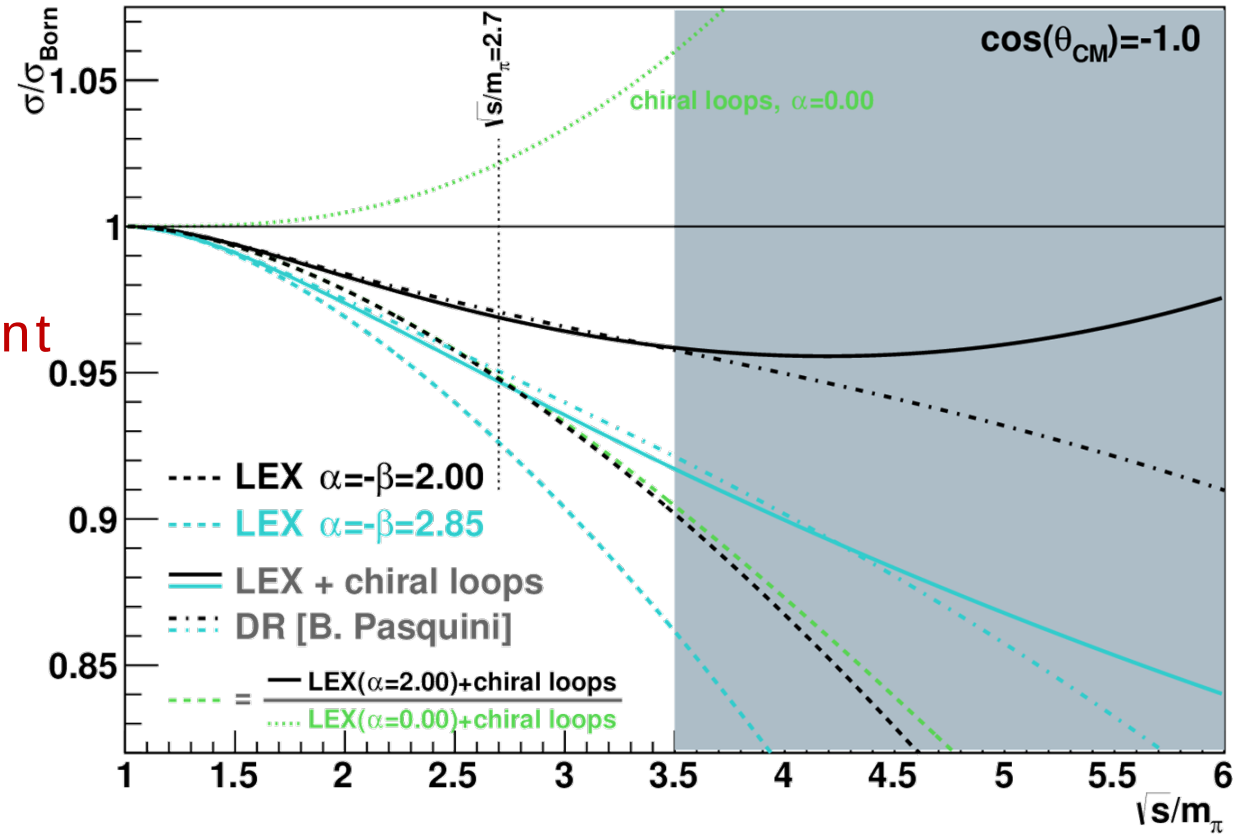






Pion polarisability

- low energy expansion (LEX)
- corrections
  - chiral loops
  - dispersion relations, D. Drechsel, B. Pasquini
- excellent agreement of CL and DR in COMPASS range



Press (from EP Seminar by J.Friedrich)

Press ec

ScienceDaily
Your source for the latest research news

Featured Research

CERN experiment brings precision to a corne physics

Date: February 11, 2015
Source: CERN
Summary: The COMPASS experiment at CERN reports a key measure the strong interaction. The strong interaction binds quarks in and neutrons, and protons and neutrons into the nuclei of at elements from which matter is built. Inside those nuclei, par gluons made up of a quark and an antiquark, mediate the inte strong interaction theory makes a precise prediction on the polarisability of pions – the degree to which their shape can stretched. This polarisability has baffled scientists since th when the first measurements appeared to be at

Новости События Архи
Конкурсы Новости партне

НАУКА И ЖИЗНЬ / Новости науки и техн

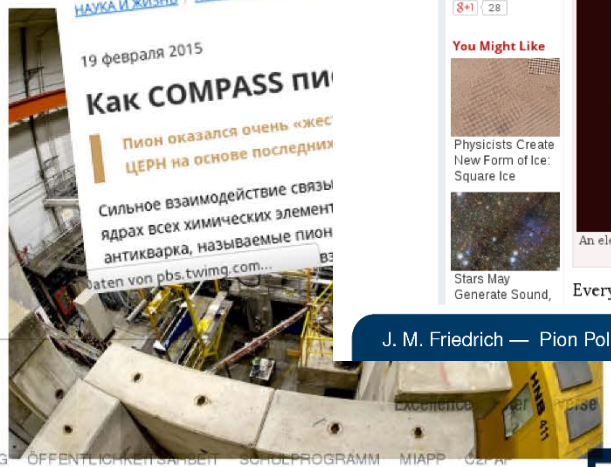
19 февраля 2015

Как COMPASS пи

Пион оказался очень «жес
ЦЕРН на основе последних

Сильное взаимодействие связы
ядрах всех химических элемент
антикварка, называемые пион

Daten von pbs.twimg.com...



Intro: Pions & ChPT COMPASS Pion polarisability Summary and Outlook

Press echo in spring 2015

Technische Universität München

Sci-News.com

Top Headlines:
Astronomers Detect Possible Saturn-Like Rings around Chiron

HOME ASTRONOMY SPACE EXPLORATION ARCHAEOLOGY PALEONTOLOGY BIOLOGY PHYSICS MEDICINE GENETICS GEOLOGY MORE

CERN Physicists Measure Polarizability of Pion

Feb 16, 2015 by Sci-News.com « PREVIOUS | NEXT »

Published in
Physics

Tagged as
CERN
COMPASS
LHC
Pion
Strong interaction

Follow
Gefällt mir 15.665

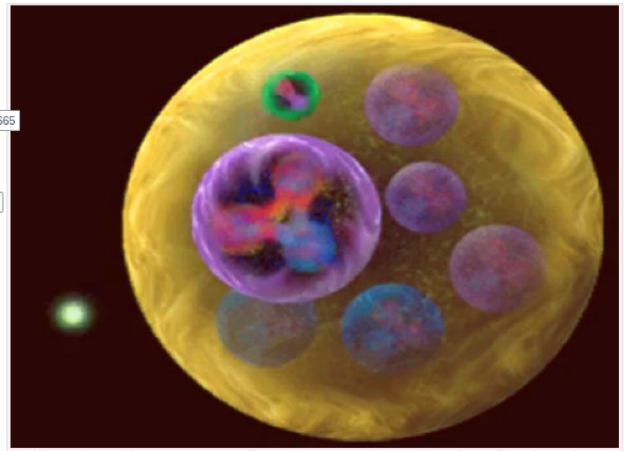
Share
Tweet 30
Gefällt mir 63
+1 28

You Might Like

Physicists Create New Form of Ice: Square Ice

Stars May Generate Sound,

Scientists from CERN's COMPASS collaboration have made the most precise measurement ever of the polarizability of pion – the fundamental low-energy parameter of strong interaction.



An electron (green) hits a proton in a nucleus, creating a pion (green-skinned particle) and transforming the proton into a neutron. Image credit: Joanna Griffin / Jefferson Lab.

Everything we see in the Universe is made up of fundamental particles called

LATEST NEWS


New Method Precisely Measures Rotation Period of Saturn
Mar 28, 2015 | Astronomy


Physicists Create New Form of Ice: Square Ice
Mar 27, 2015 | Physics


Colliding Galaxy Clusters Offer Clues to Dark Matter
Mar 26, 2015 | Astronomy


Astronomers Discover Two Extremely Old Stars in Sculptor Dwarf Galaxy
Mar 25, 2015 | Astronomy


Stars May Generate Sound, Physicists Say
Mar 24, 2015 | Physics

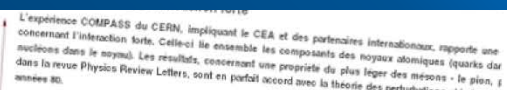

Pristimantis mutabilis: Scientists Discover Shape-Shifting Frog in Ecuador
Mar 24, 2015 | Biology


Metoposaurus algarvensis: Fossils of Giant Salamander-Like Amphibian Found in Portugal
Mar 24, 2015 | Paleontology


Geologists Discover New Layer in Earth's Mantle
Mar 24, 2015 | Geology

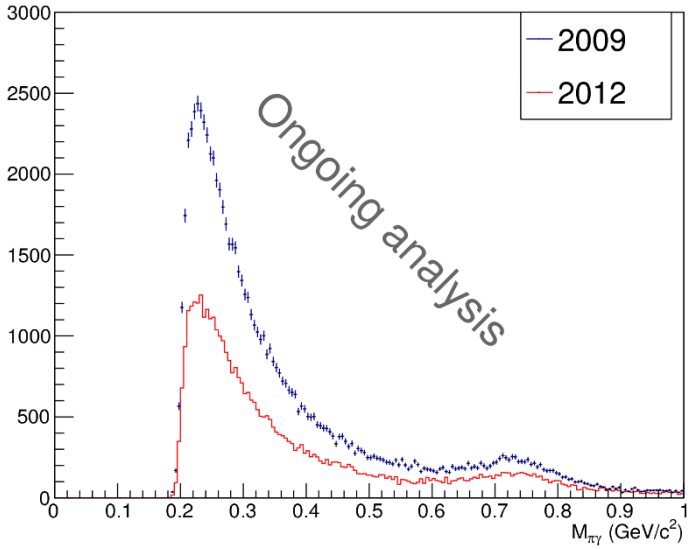

Inner Solar System May Have Harbored Super-Earths 4.5 Billion Years Ago
Mar 24, 2015 | Astronomy

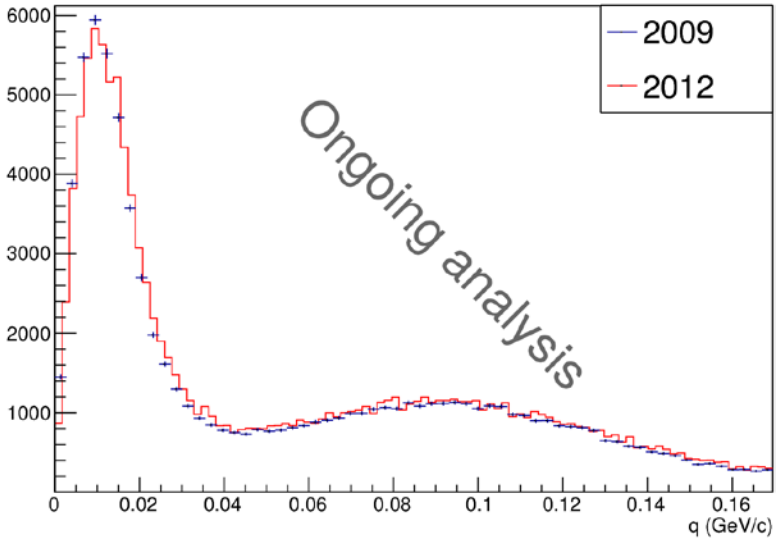

Hubble Sees Edge-On Spiral Galaxy



2012 Primakoff data

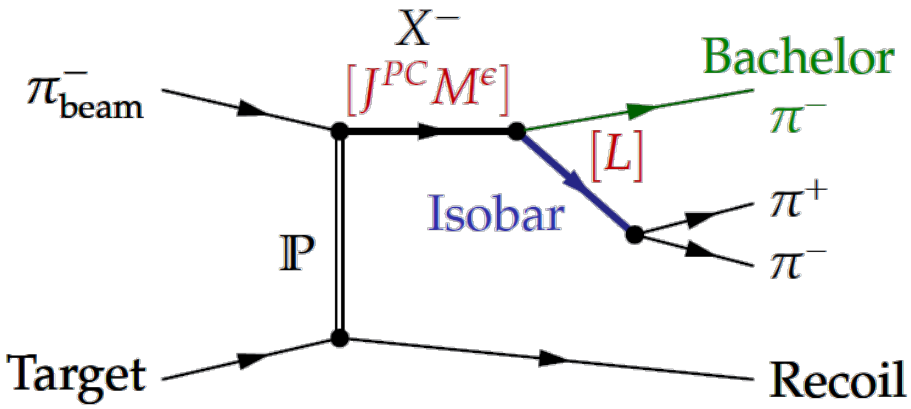
- $\pi\gamma$ mass spectrum for one week 2012 vs 2009 total
- expect 4–5 times 2009 statistics for 2012
- Calibration of calorimeters complete (new: fast Fourier transform)
- Reconstruction of full data set started
- goal: separate determination of $\alpha + \beta$ in extended kin. range





PWA of $\pi^- p \to \pi^- \pi^+ \pi^- p$

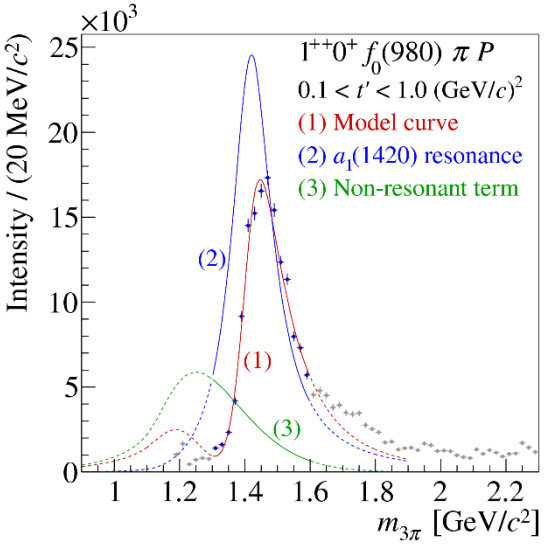
- Isobar model:

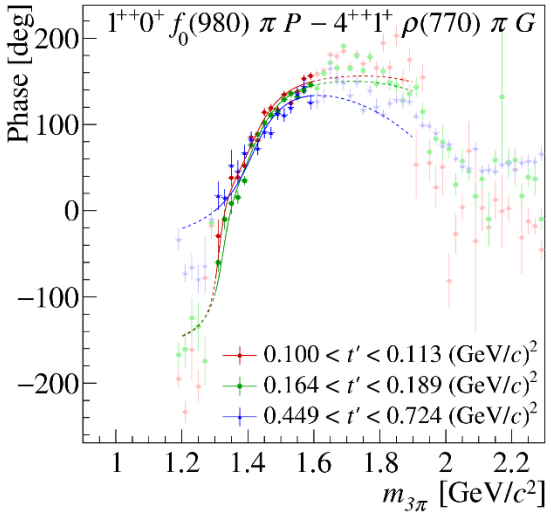


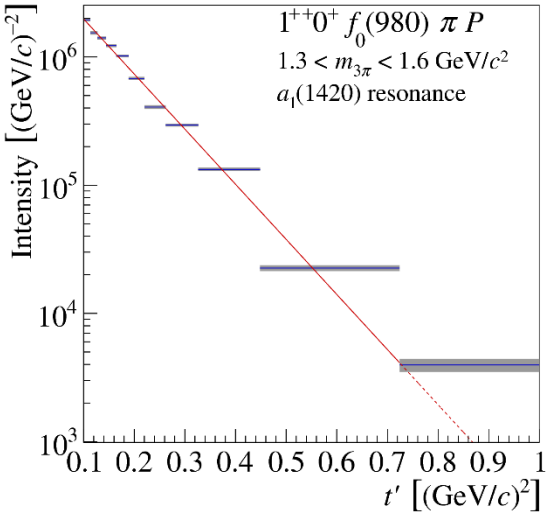
X decay is chain of successive two-body decays

- Analysis:
  - Partial wave analysis (PWA) in mass bins with 88 waves labelled J^{PC} M^{ε} Isobar L in 11 t' bins
  - fit of spin-density matrix for major waves as function of mass
  - unprecedented statistical precision
- Discovery of isovector $a_1(1420)$
  - finalised and submitted to PRL in January
- Long paper on PWA almost ready (78 pages)
  - Method of 'de-isobaring' for $\pi\pi$S wave

$a_1(1420)$ in $1^{++}0^+f_0(980)\,\pi P$ wave







- unknown nature
  - tetra-quark state
  - triangular diagram in $a_1(1260) \rightarrow K^*\bar{K}$; $K^*\pi$ and $K\bar{K} \rightarrow f_0(980)$
  - ...

sub. PRL; CERN-PH-EP/2015-015; hep-ex/1501.05732

Press

The Society | Science News | Science News for Students | Student Science | Newsletter Sign Up | Log In or Join | Donate

Explore

LATEST | MOST VIEWED

HOW BIZARRE
Big exoplanet may be surrounded by helium
BY CHRISTOPHER CROCKETT JUNE 21, 2015

NEWS
Fast-spreading crack threatens giant Antarctic ice shelf
BY THOMAS SUMNER JUNE 19, 2015

SCIENCE TICKER
Evidence mounts for active volcanoes on Venus
BY CHRISTOPHER CROCKETT JUNE 19, 2015

SCIENCE TICKER
NASA moves ahead with a mission to Europa
BY CHRISTOPHER CROCKETT JUNE 18, 2015

NEWS
When baboons travel, majority rules
BY BRUCE BOWER JUNE 18, 2015

SPONSOR CONTENT
Collecting trash in space

NEWS
Ivory DNA pinpoints poaching hot spots
BY MEGHAN ROSEN JUNE 18, 2015

Science Ticker

YOUR DAILY ROUNDUP OF RESEARCH NEWS
SCIENCE NEWS STAFF

SN

SCIENCE TICKER PARTICLE PHYSICS

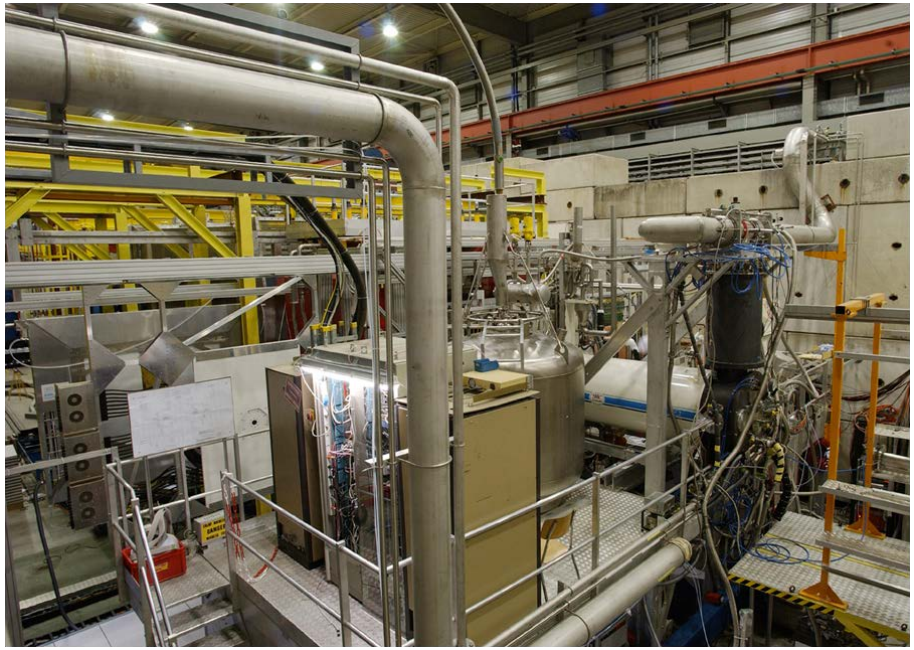
New particle may be made of four quarks

BY ANDREW GRANT 4:48PM, FEBRUARY 2, 2015

CERN's COMPASS installation has detected evidence of a particle that may be made up of four quarks.

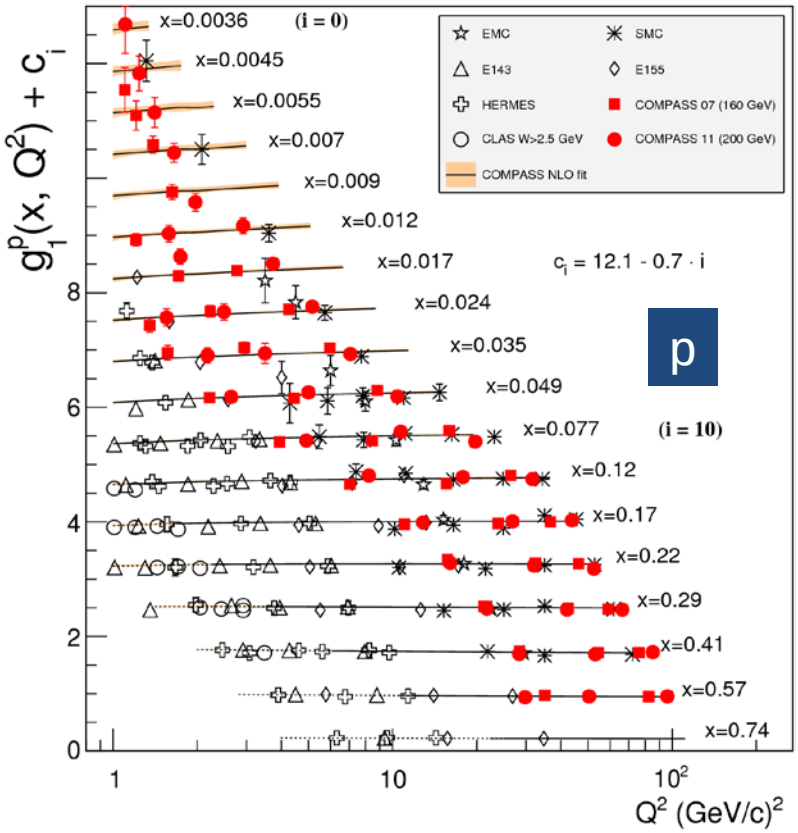
Muon beam results

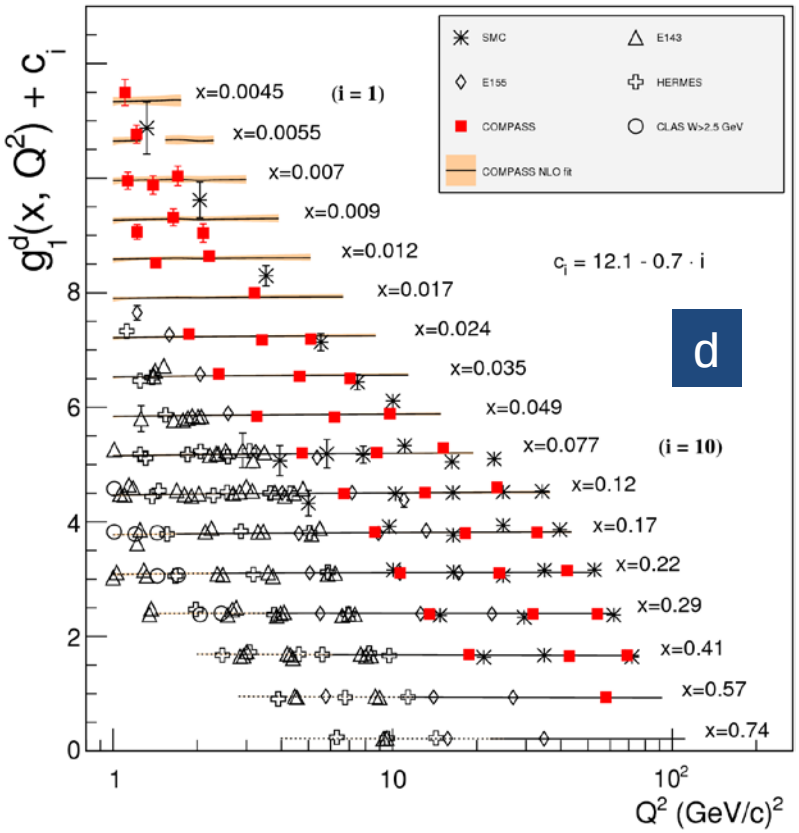
longitudinal spin



g_1 structure function

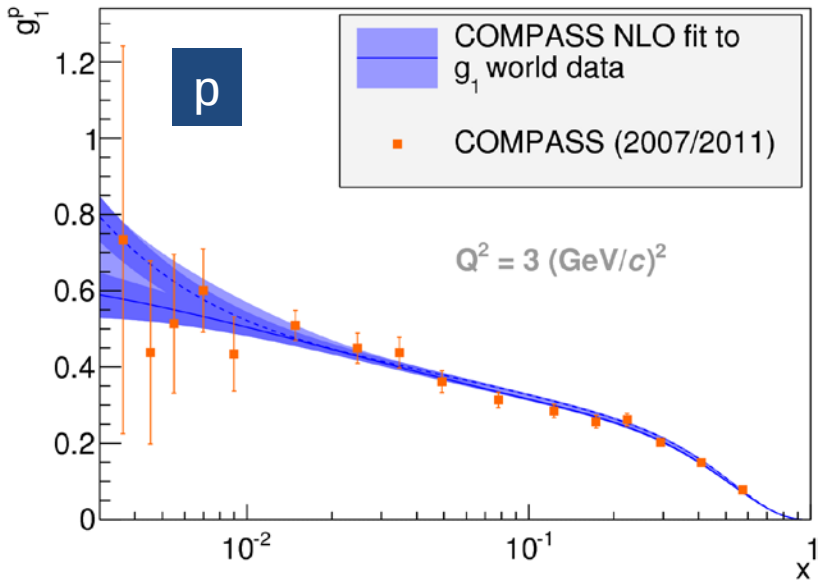
- final analysis of 2007/2011 proton data
- NLO fit to g_1/A_1 world data, W>10 GeV^2

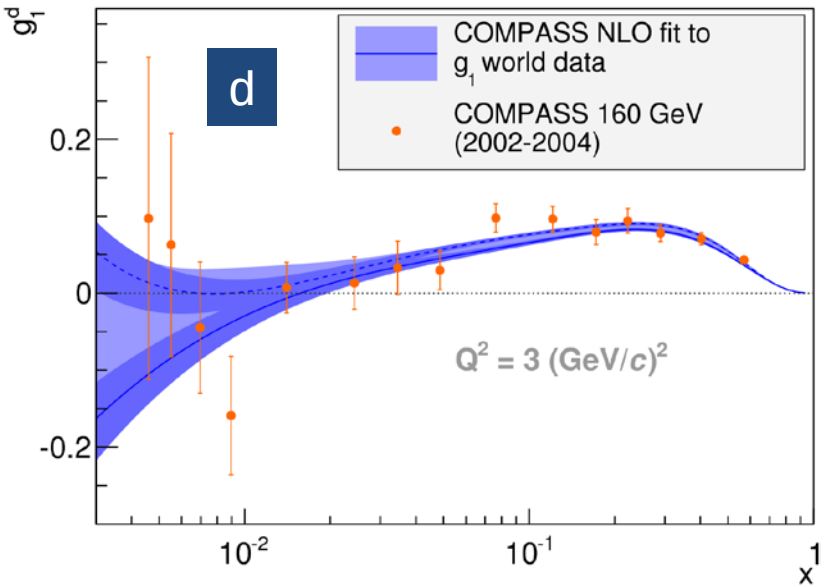




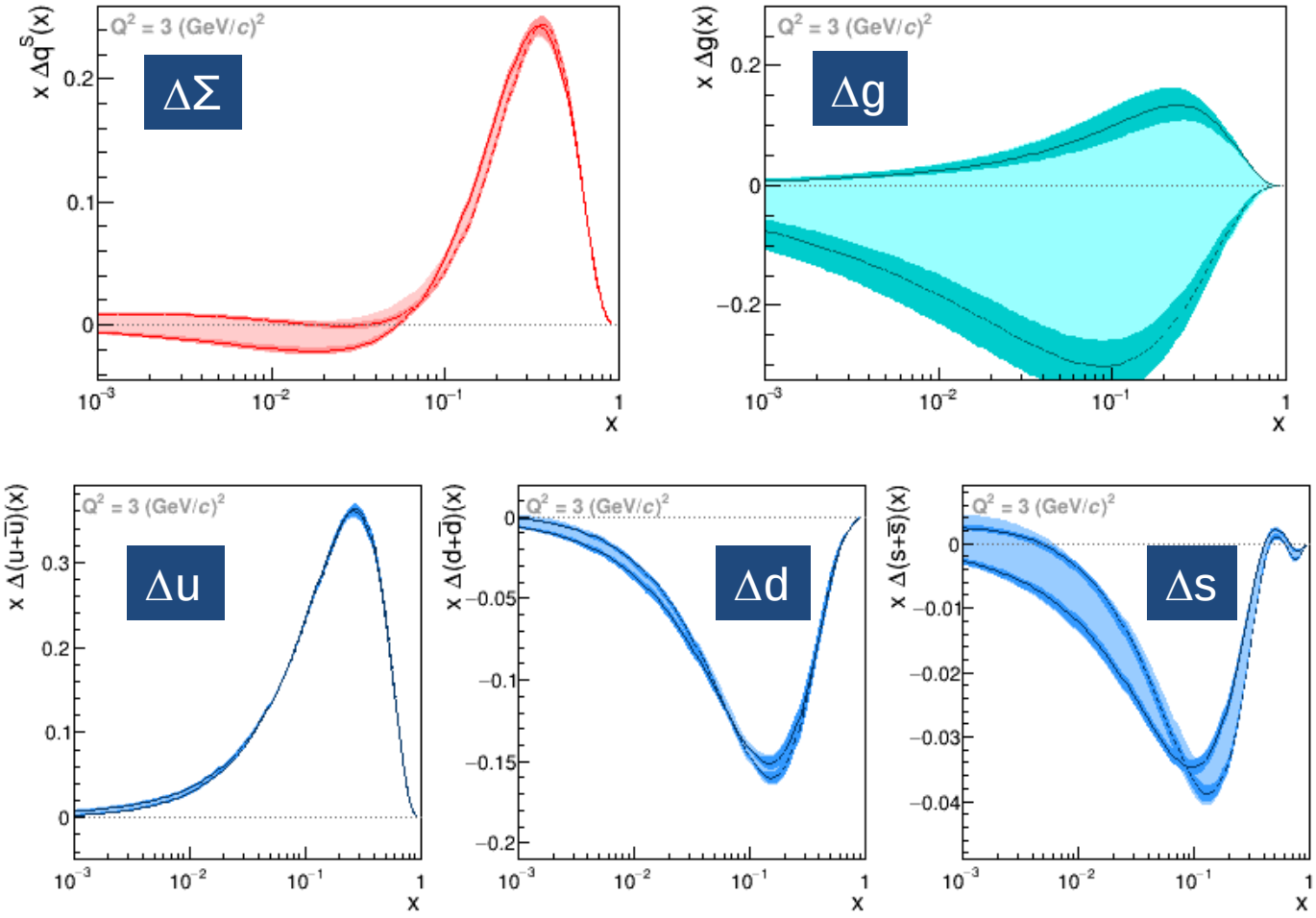
g_1 structure function

- Q = 3 GeV^2/c, COMPASS data
- ——— $\Delta G > 0$ solution
- - - - - $\Delta G < 0$ solution





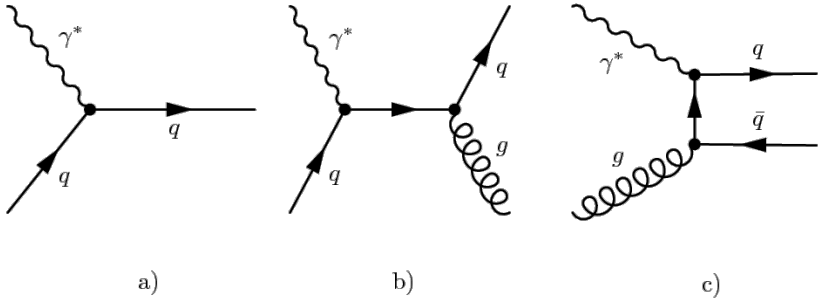
NLO fit PDFs

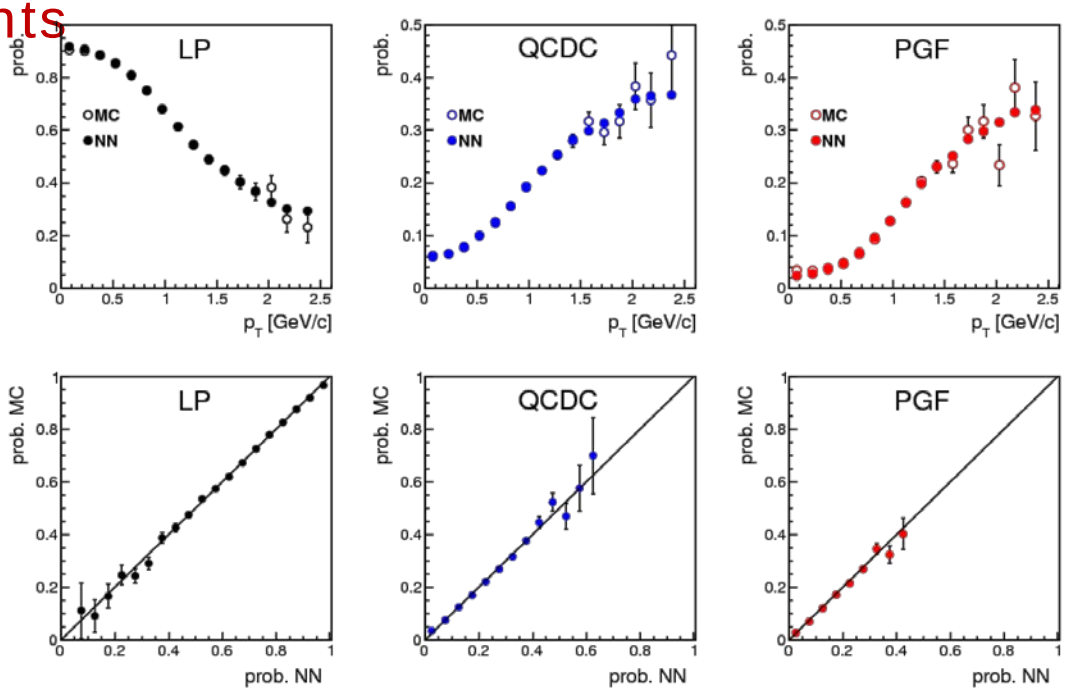


sub. PLB; CERN-PH-EP/2015-085, hep-ex/1503.08935

Gluon polarisation from PGF

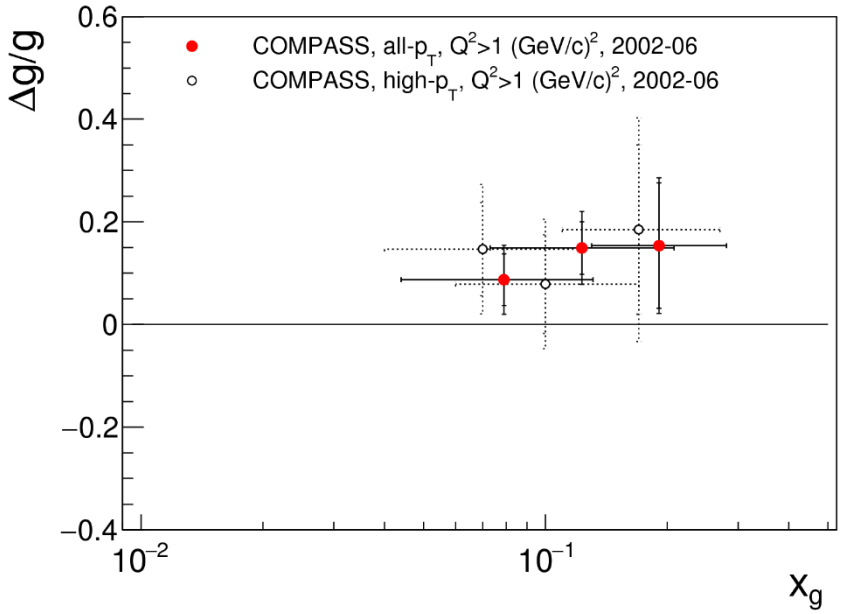
- LO reanalysis of 2002-2004, 2006 deuteron data
- $Q^2 > 1\ GeV^2$
- novel method using events with any p_T and NN weights
- simultaneous determ. of leading order asym. reduces syst. uncertainty
- determination of $\Delta g(x)$ in 3 x ranges

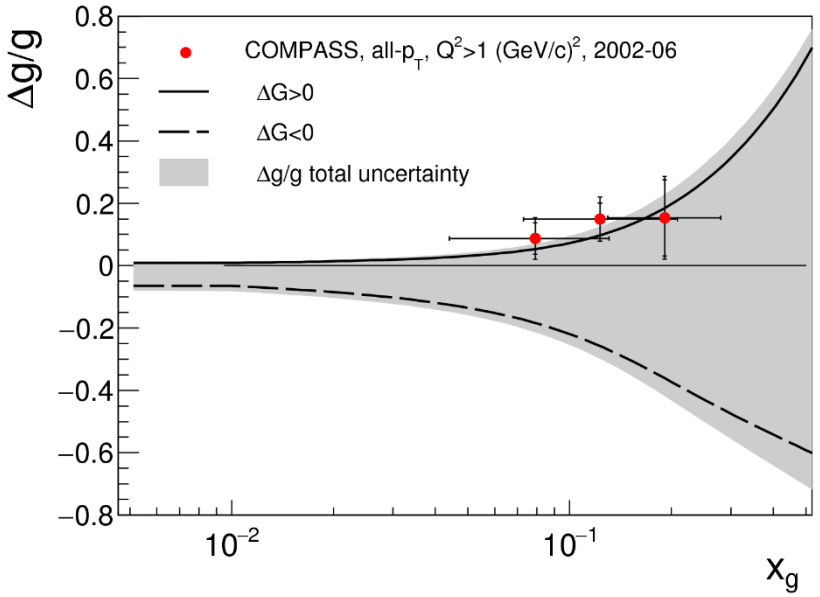




Gluon polarisation from PGF

- $\Delta g(x) = 0.113 \pm 0.038 \pm 0.036$ with $\langle x_g \rangle = 0.10$ at 3 GeV^2
- no x dependence visible
- error reduction 1.6 stat, 1.8 syst
- positive $\Delta g(x)$ preferred

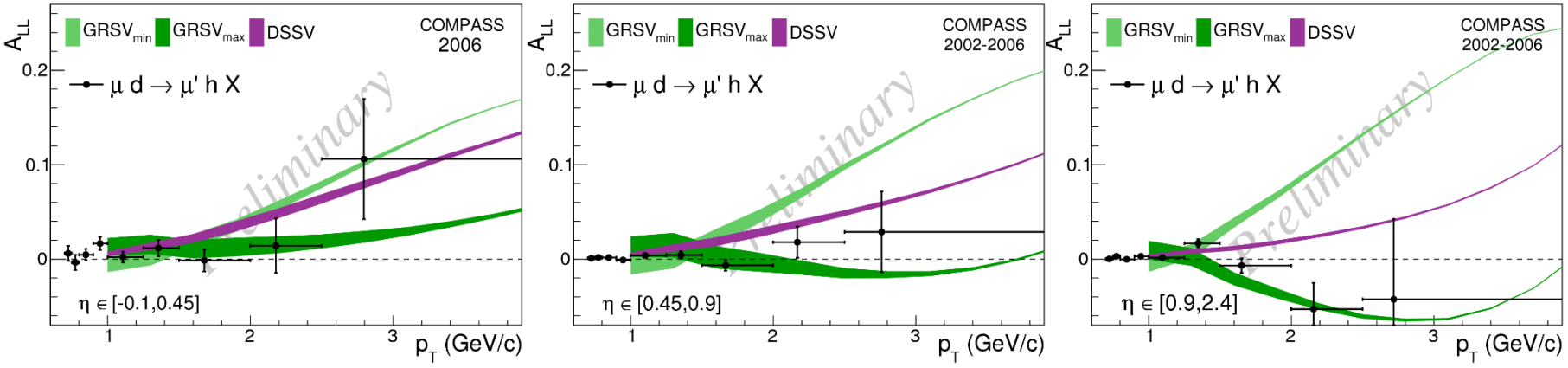




Paper ready, circulation within collaboration this week

Gluon polarisation from single hadron

- NLO analysis of complete proton & deuteron data set
- $Q^2 < 1\ GeV^2$, least 1 hadron with $0.4\ GeV < p_T < 4\ GeV$
- using code of Vogelsang et al., cross-section in COMPASS kinematics ($\sqrt{s} = 18\ GeV$) well described with LL resummation (not available for polarised case)
- evaluated in 3 bins of pseudorapidity η
- positive gluon polarisation preferred



Paper ready, circulation within collaboration this week

Muon beam results

transverse spin

Gluon Sivers asymmetry

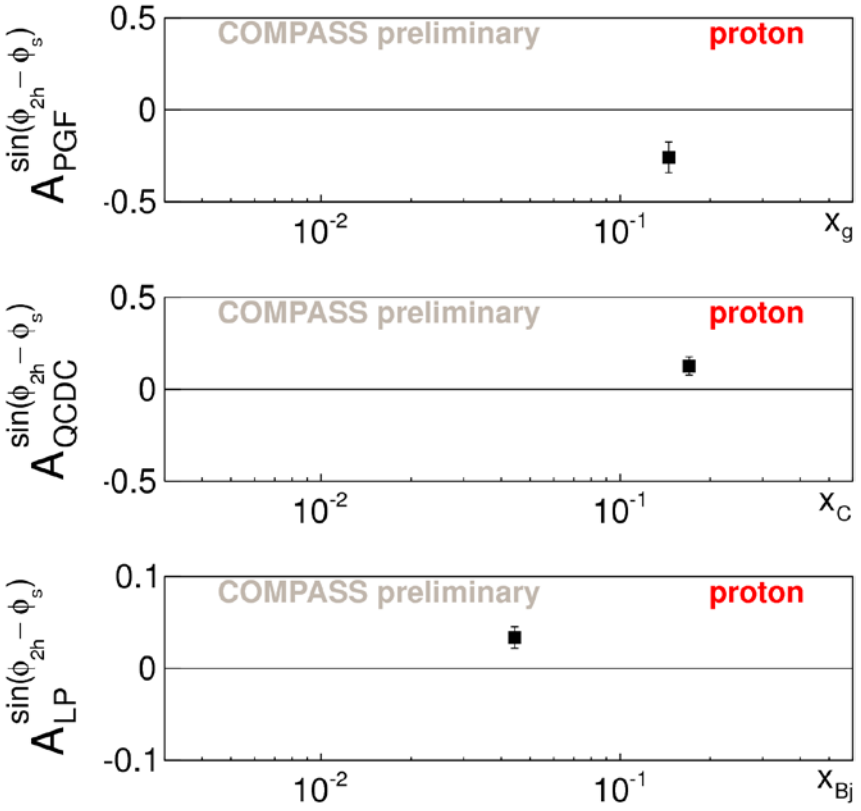
- Sivers asymmetry related to orbital angular momentum
- analysis similar to that of gluon polarisation (LO)
- $Q^2 > 1$ GeV, 2 hadrons with high p_T (>0.7 and >0.4 GeV)

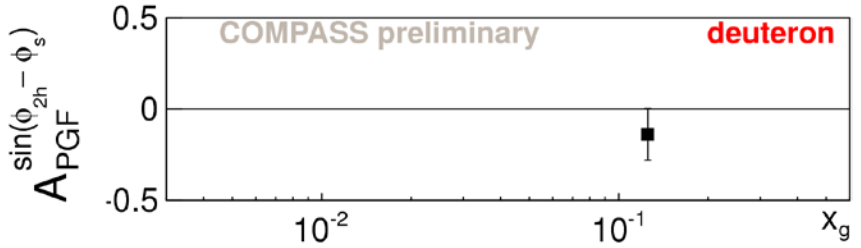
$$A_{UT}^{\sin(\phi_{2h}-\phi_s)} = R_{PGF} A_{PGF}^{\sin(\phi_{2h}-\phi_s)}(x_G) + R_{LP} A_{LP}^{\sin(\phi_{2h}-\phi_s)}(x) + R_{QDCC} A_{LP}^{\sin(\phi_{2h}-\phi_s)}(x_C)$$

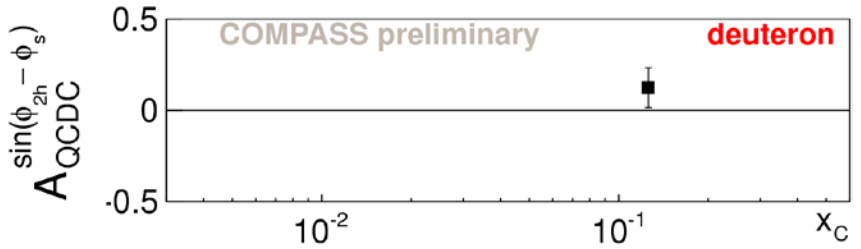
- NN to determine R's
- result for deuteron released last year
- new result for the proton
- proton: $A_{PGF}^{\sin(\phi_{2h}-\phi_s)} = -0.26 \pm 0.09 \pm 0.08$
- deuteron: $A_{PGF}^{\sin(\phi_{2h}-\phi_s)} = -0.14 \pm 0.15 \pm 0.06$

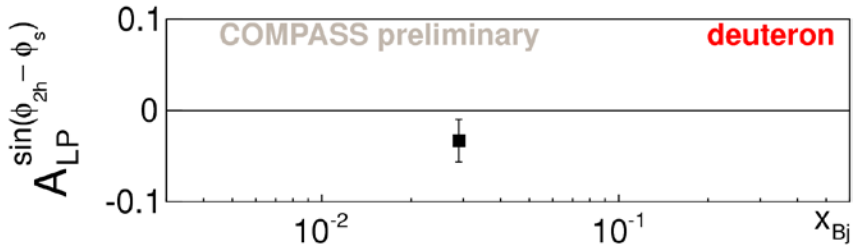
Gluon Sivers asymmetry

- proton and deuteron $A_{PGF}^{\sin(\phi_{2h}-\phi_s)}$ compatible
- both negative







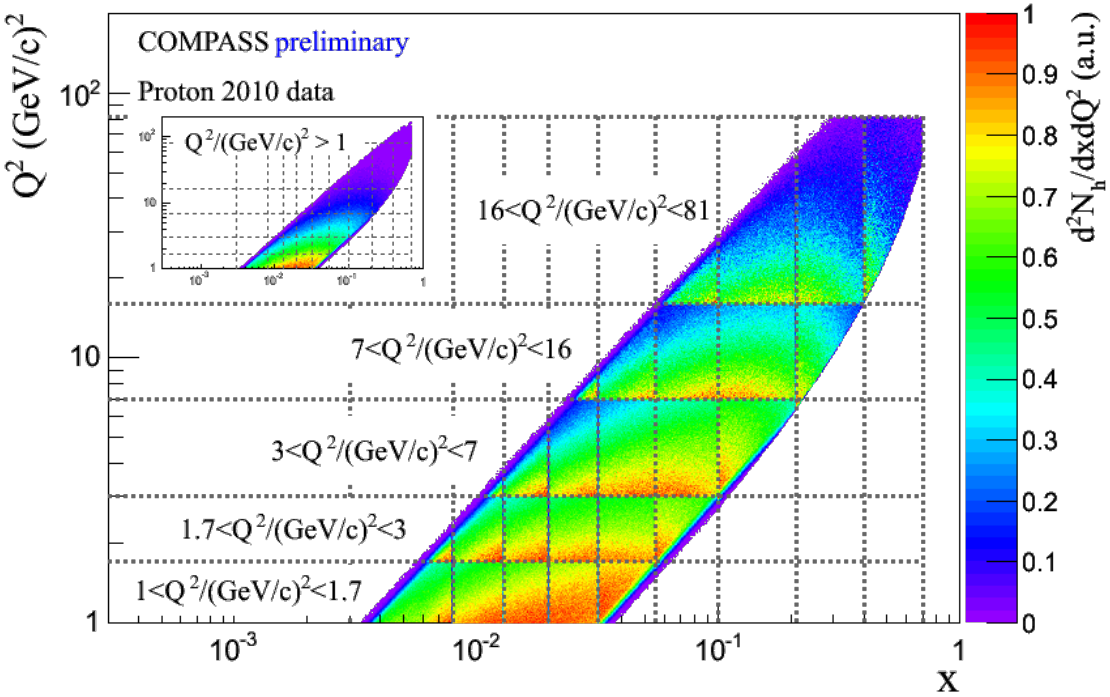


Azimuthal asym. multiD analysis

- 8 azimuthal asymmetries related to convolutions of TMD distributions and fragmentation functions.

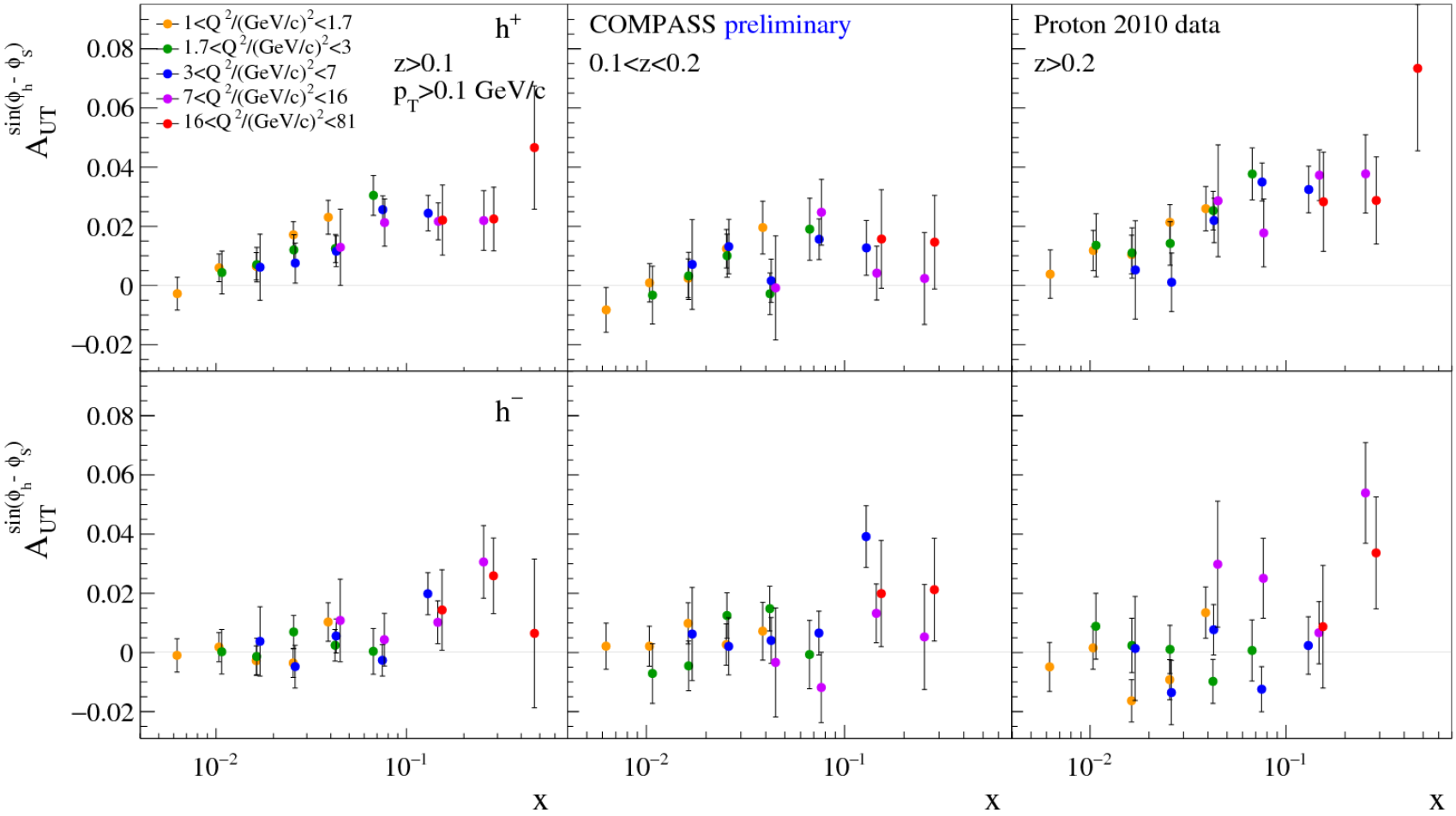
$$A_{UT}^{\sin(\phi_h-\phi_S)} \propto f_{1T}^{\perp q} \otimes D_{1q}^{h}, \qquad A_{UT}^{\sin(\phi_h+\phi_S-\pi)} \propto h_1^q \otimes H_{1q}^{\perp h}$$
$$A_{UT}^{\sin(3\phi_h-\phi_S)} \propto h_{1T}^{\perp q} \otimes H_{1q}^{\perp h}, \qquad A_{LT}^{\cos(\phi_h-\phi_S\ \ )} \propto g_{1T}^{q} \otimes D_{1q}^{h}$$

- 2010 proton data
- asymmetries fitted in bins of x, Q^2, and various z and p_T ranges



Example: Sivers asymmetry

- Important input for TMD Q^2 evolution



1h & 2h azi. asym. in 2h sample

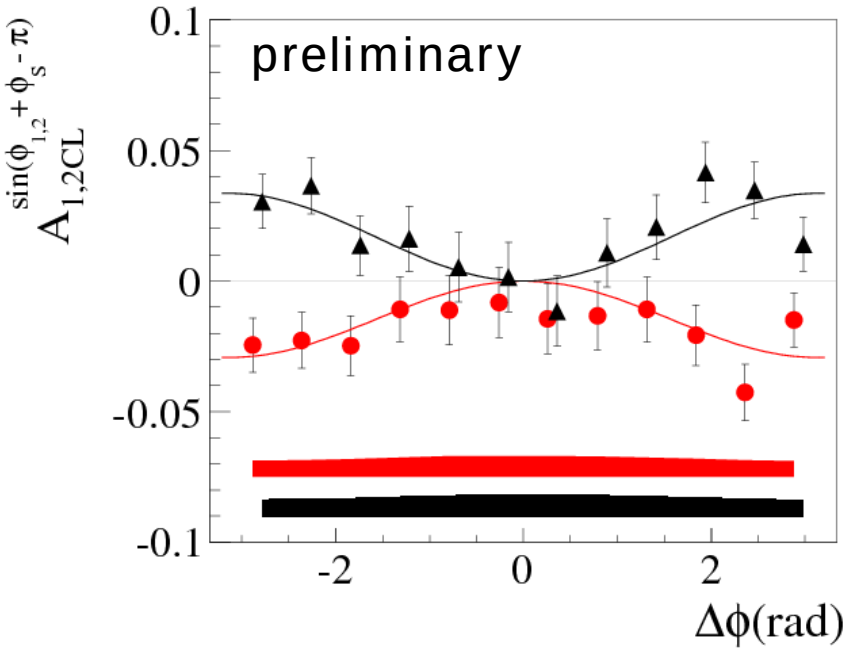
- starting point:
  - transversity couples to Collins FF (single hadron)
  - transversity couples to IFF (hadron pair)
  - observation: asymmetries are very similar, opposite for h^+ and h^-
- is there a common mechanism in Collins and IFF fragm?
- look at single hadrons in 2h sample `Collins-like' asym.
  $\sigma^{h_1 h_2} \propto \sigma_U + S_T(\sigma_S + \sigma_C)$ and $\sigma_C = \sigma_{1C}\sin(\phi_{1+}\phi_S - \pi) + (1 \leftrightarrow 2)$
- this can be rewritten in $\Delta\phi = \phi_1 - \phi_2$ and ϕ_1 or ϕ_2

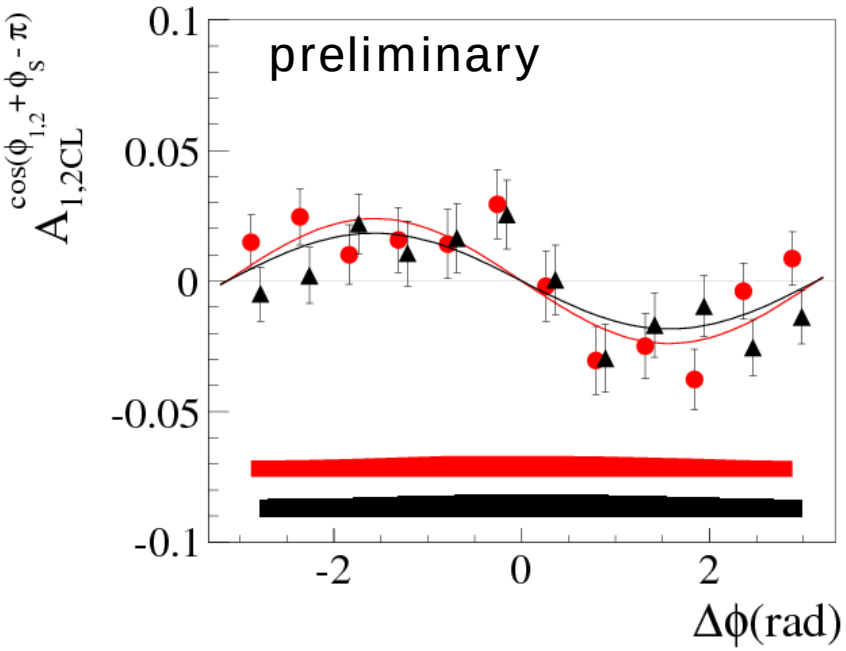
$$A_{1CL}^{\sin(\phi_1+\phi_s-\pi)} \propto \sigma_{1C} + \sigma_{2C}\cos\Delta\phi$$

- If $\sigma_{1C} = -\sigma_{2C}$ this causes a mirror symmetry for the pos. (1) and neg. (2) hadron for the sine and to equal asym. for cosine

1h & 2h azi. asym. in 2h sample

- this is what we observe
- (1) red, positive hadron, (2) black, negative hadron



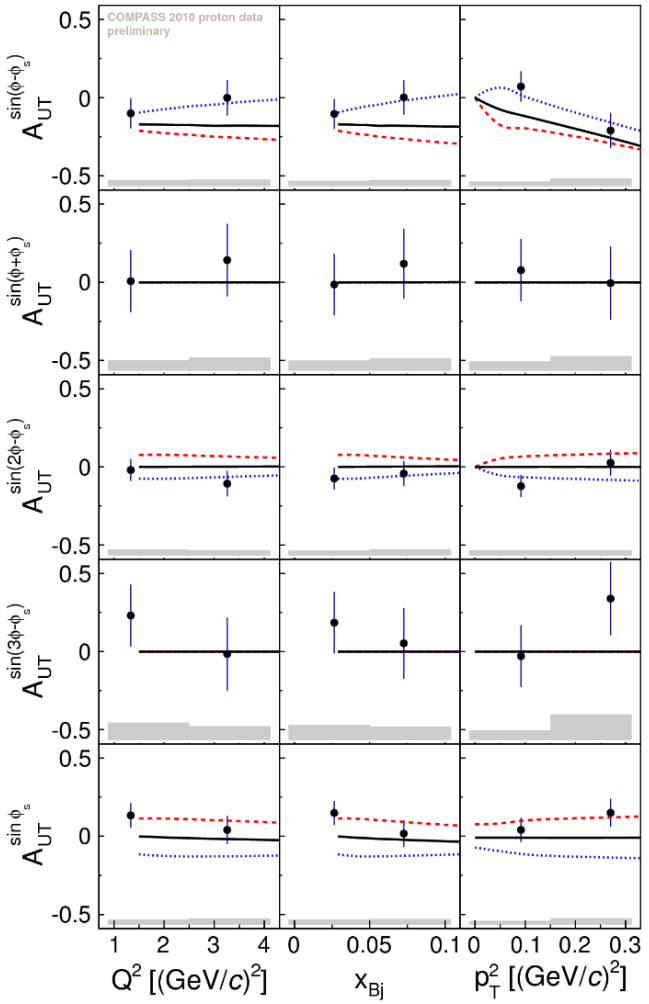


Paper ready, circulation within collaboration this week

GPD and excl. ω production

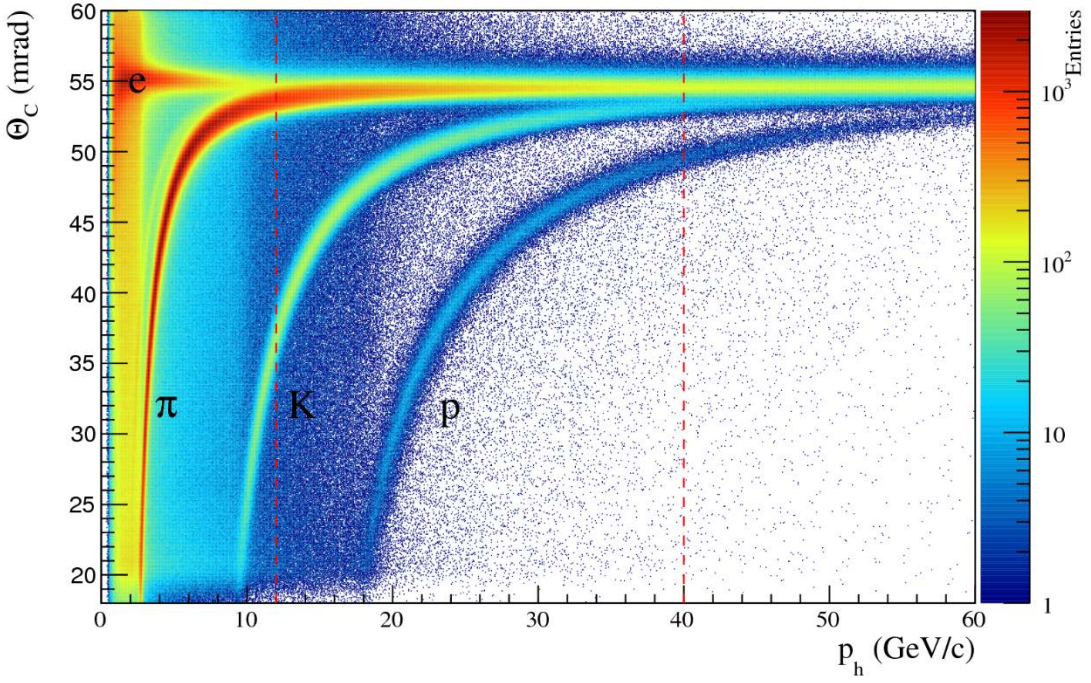
- analysis like excl. ρ prod
  PLB B731 (2014) 19
- 2010 proton data
- access to GPD E

$$\frac{1}{\sqrt{2}}\left(\frac{2}{3}E^u - \frac{1}{3}E^d + \frac{3}{8}E^g\right)$$



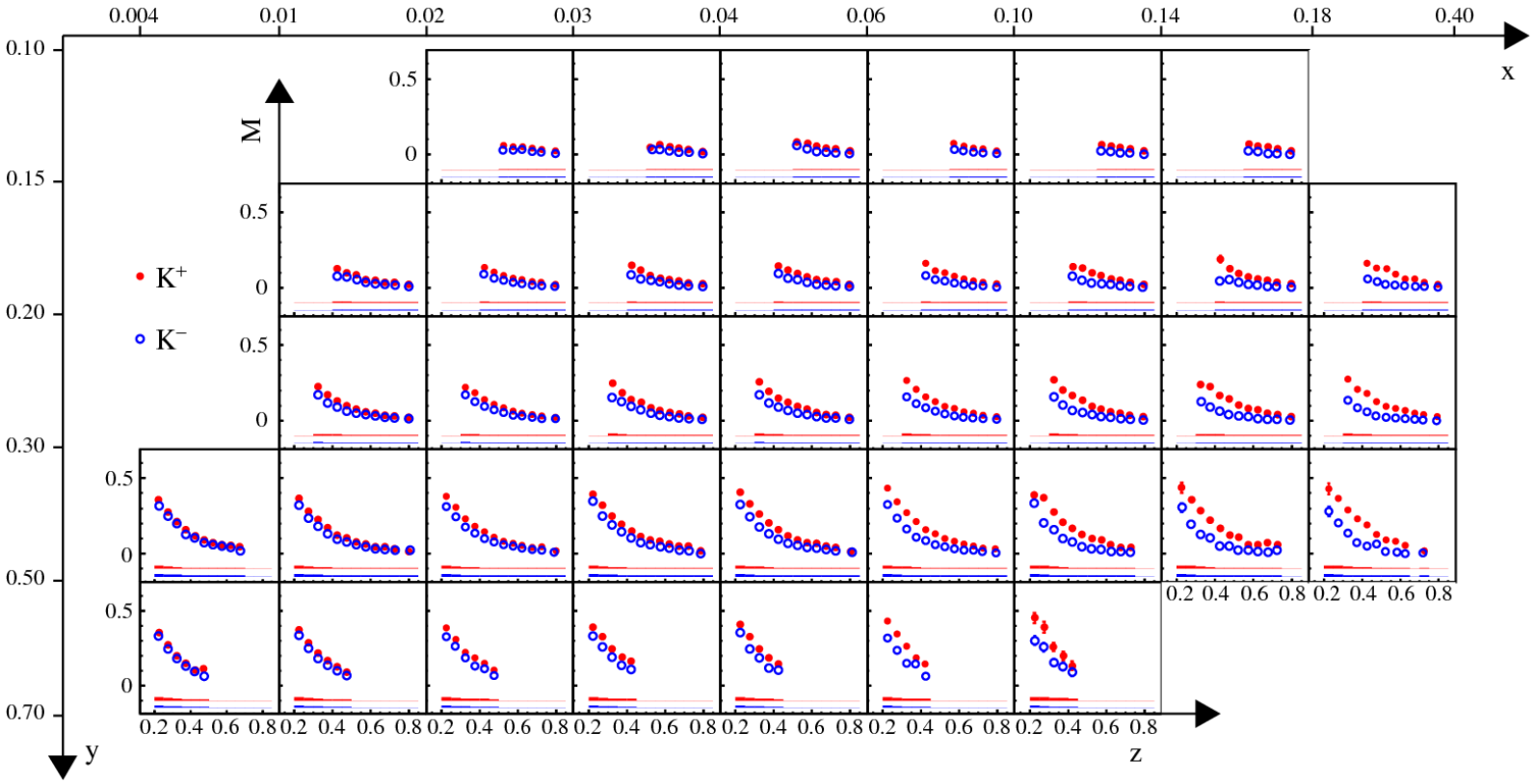
Muon beam results

multiplicities (unpolarised)



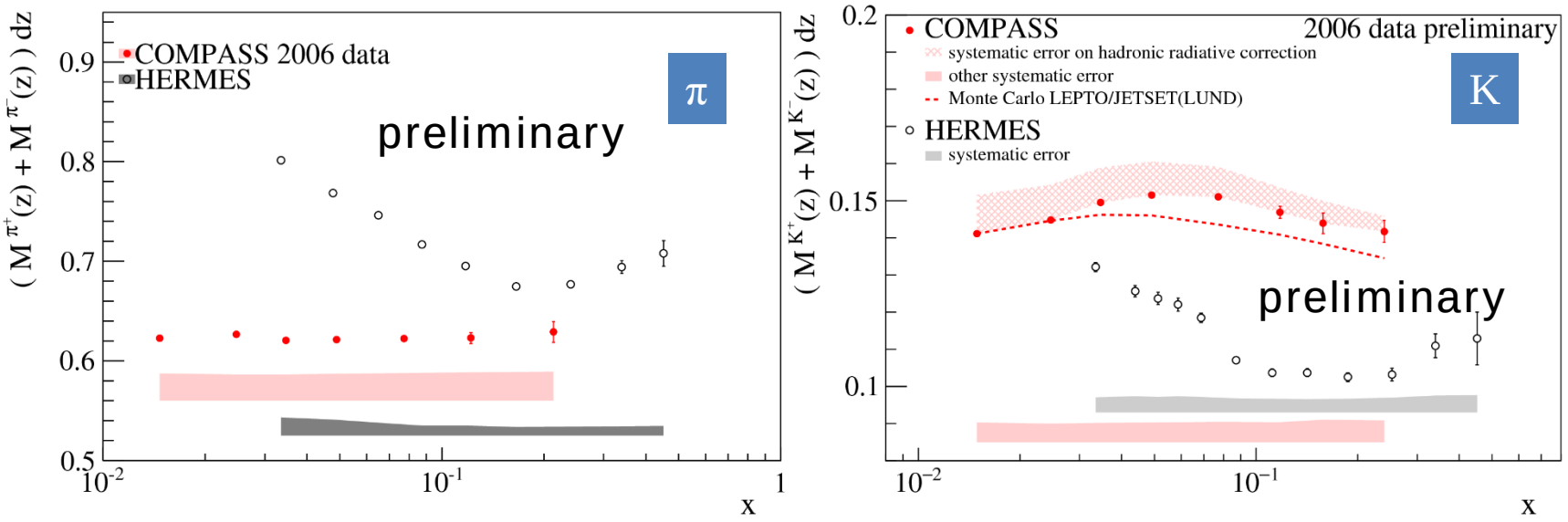
Kaon multiplicities

- 2006 LiD isoscalar data, $Q^2 > 1\ GeV^2$, $W > 5\ GeV$
- multiplicities for identified kaons in x, y, z (pions last year)



Integrated multiplicities

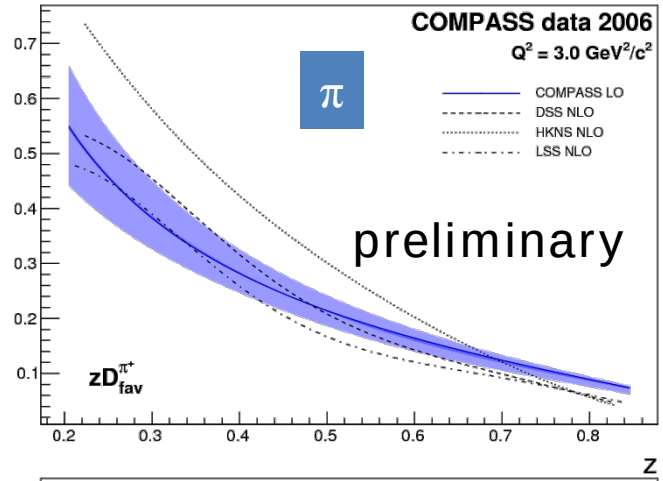
- integrated multiplicities
- note zero suppressed scale
- discrepancy between HERMES and COMPASS not understood yet

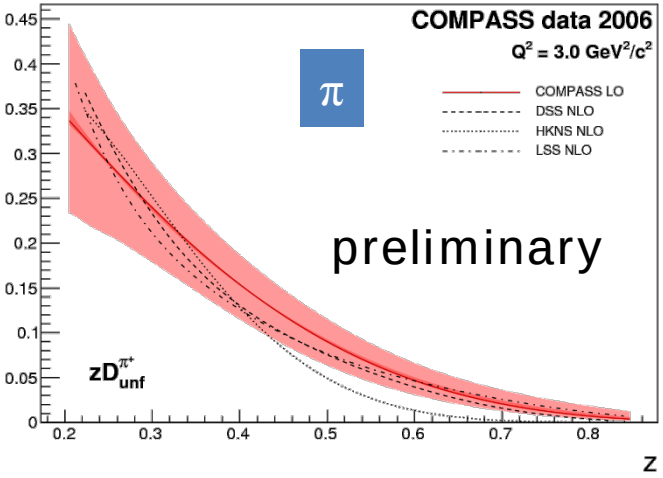


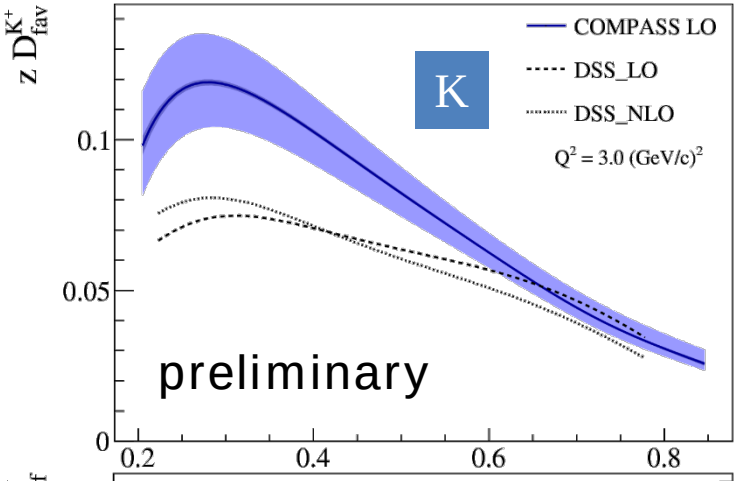
Multiplicities & FF

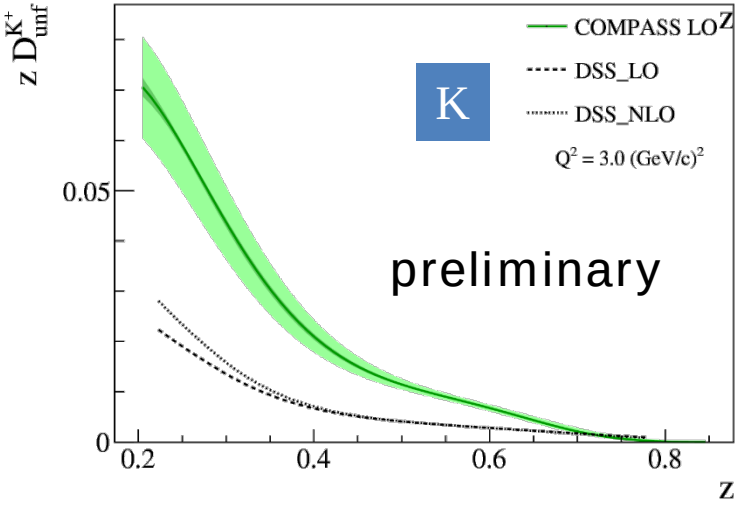
- multiplicities related to FF D_q^h

$$M^h = \frac{1}{N^{DIS}(x,Q^2)} \frac{\mathrm{d}N^h}{\mathrm{d}x\,\mathrm{d}z\,\mathrm{d}Q^2} = \frac{\sum_q e_q^2 q(x,Q^2) D_q^h(z,Q^2)}{\sum_q e_q^2 q(x,Q^2)}$$





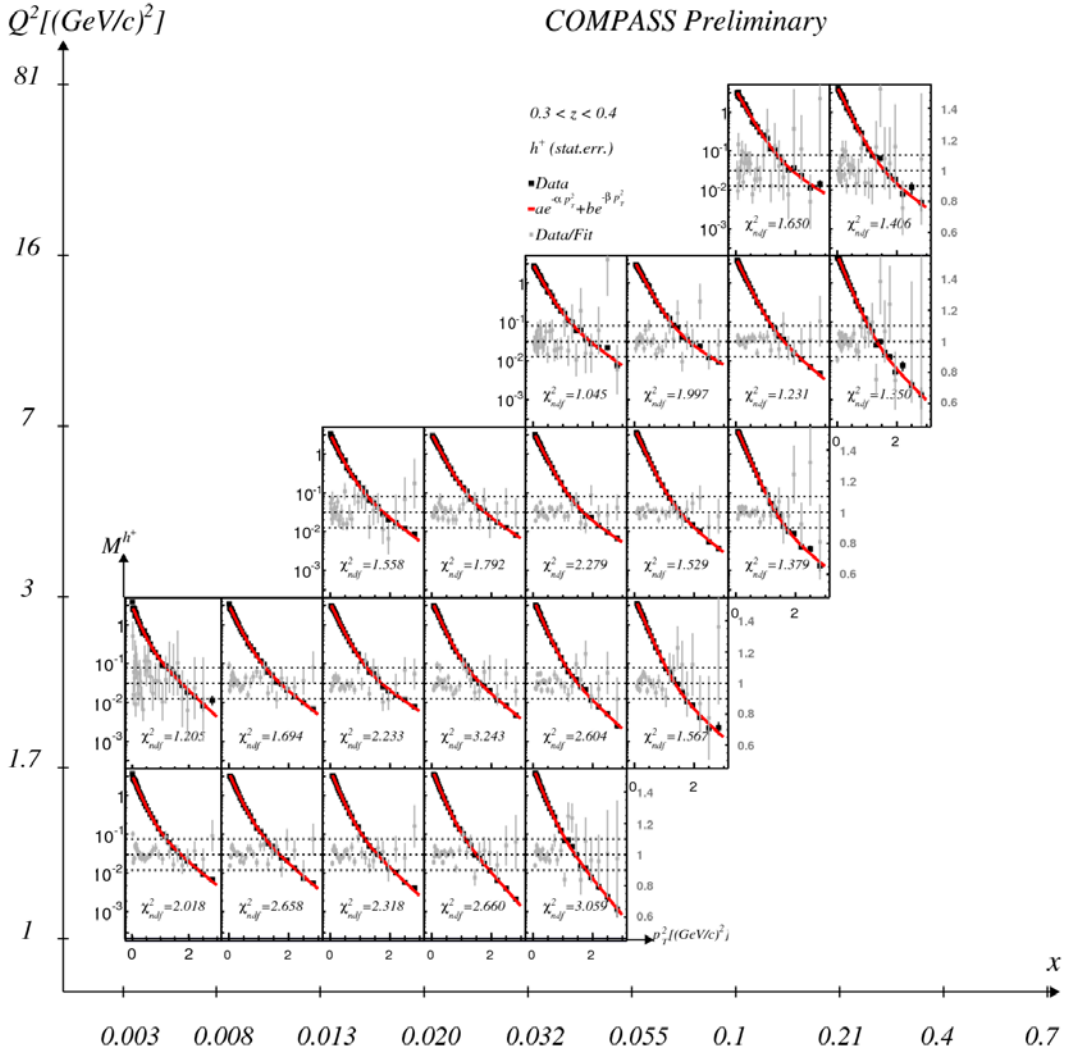




TMD of multiplicities

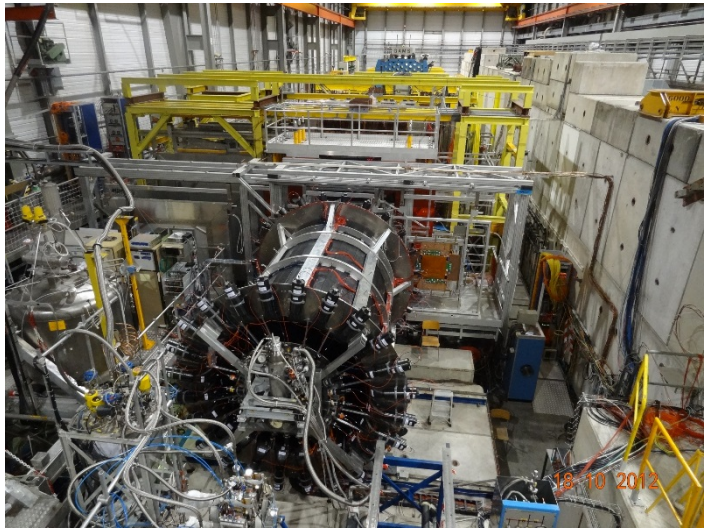
- 2006 isoscalar LiD data
- study p_T dependence in bins of x and Q^2 for 2 z ranges
- fit requires 2 exponentials
- goal: learn about intrinsic k_T and $p_\perp$

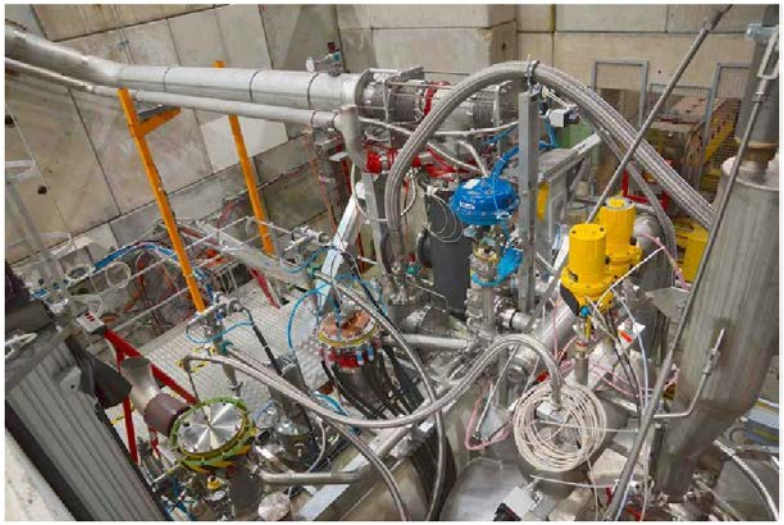
$$\frac{\mathrm{d}^4 M^h(x,Q^2,z,p_T^2)}{\mathrm{d}x\,\mathrm{d}Q^2\,\mathrm{d}z\,\mathrm{d}p_T^2} = \frac{\sum_q e_q^2 f_q(x,k_\perp,Q^2) D_{h/q}(z,p_\perp,Q^2)}{\sum_q e_q^2 f_q(x,k_\perp,Q^2)}$$



2012 & 2014

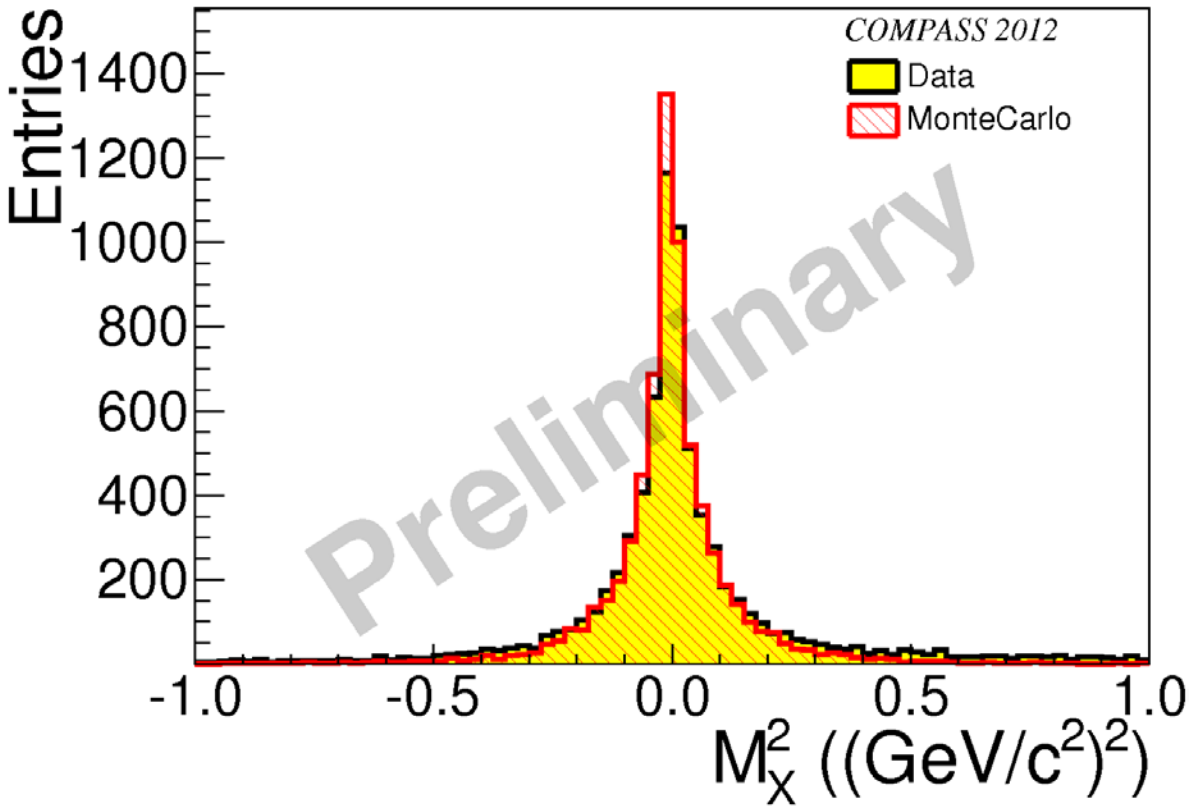
DVCS DY





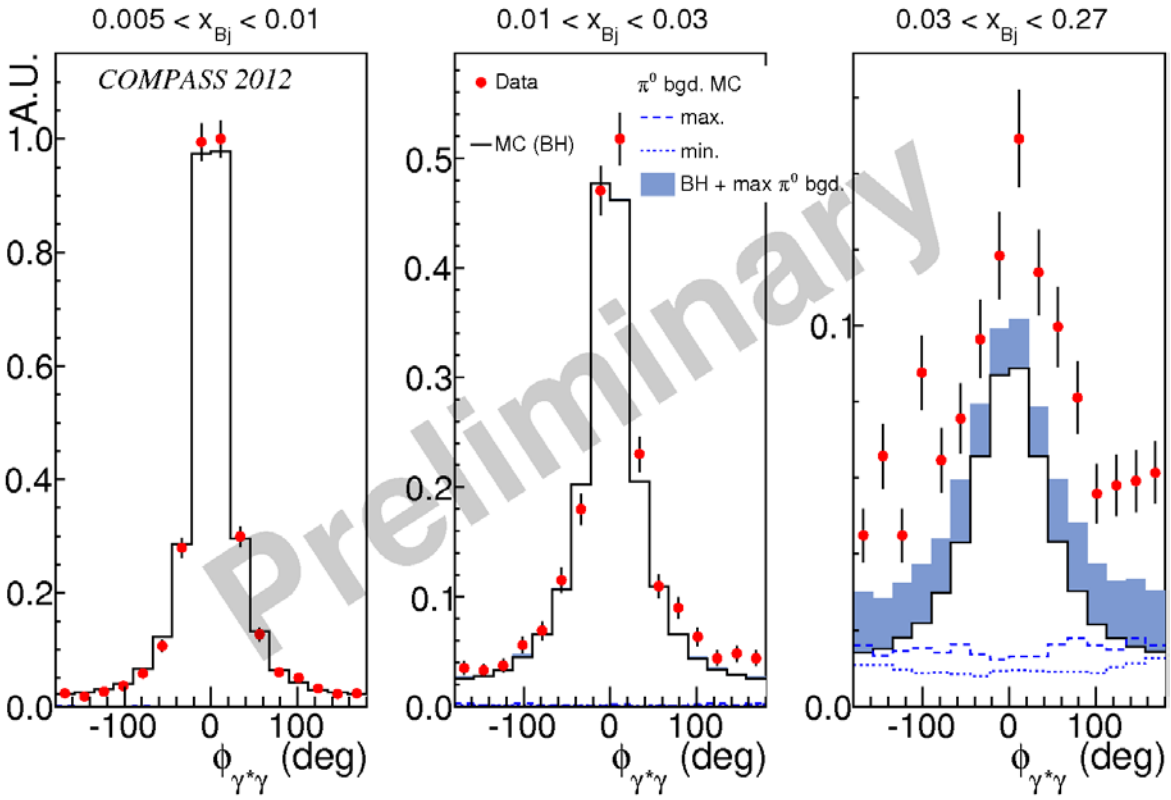
2012 DVCS status

- Comparison of HEPGEN/BH+DVCS MC and data



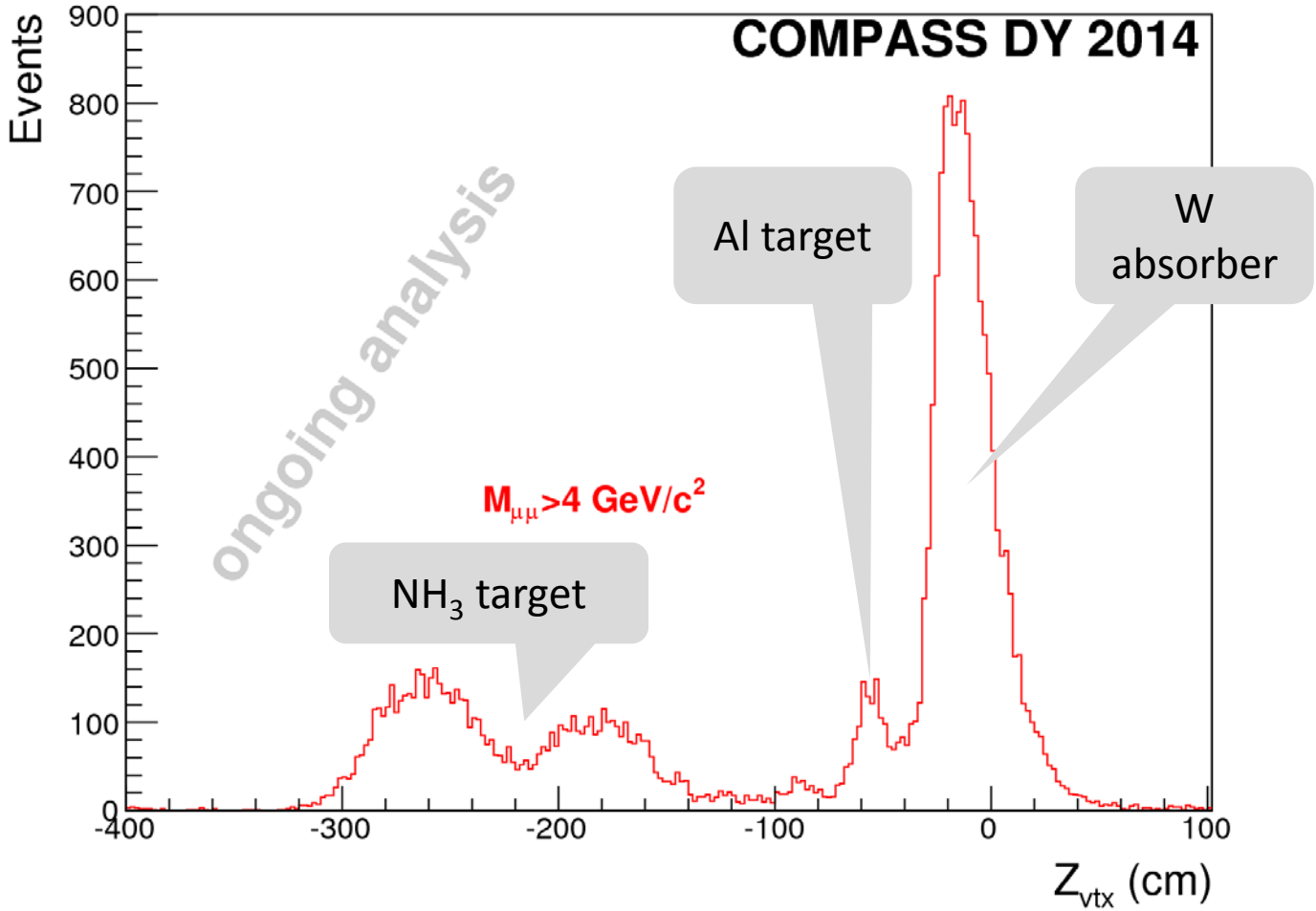
2012 DVCS status

- DVCS contribution in 0.03 < x < 0.27
- BH normalised at small x



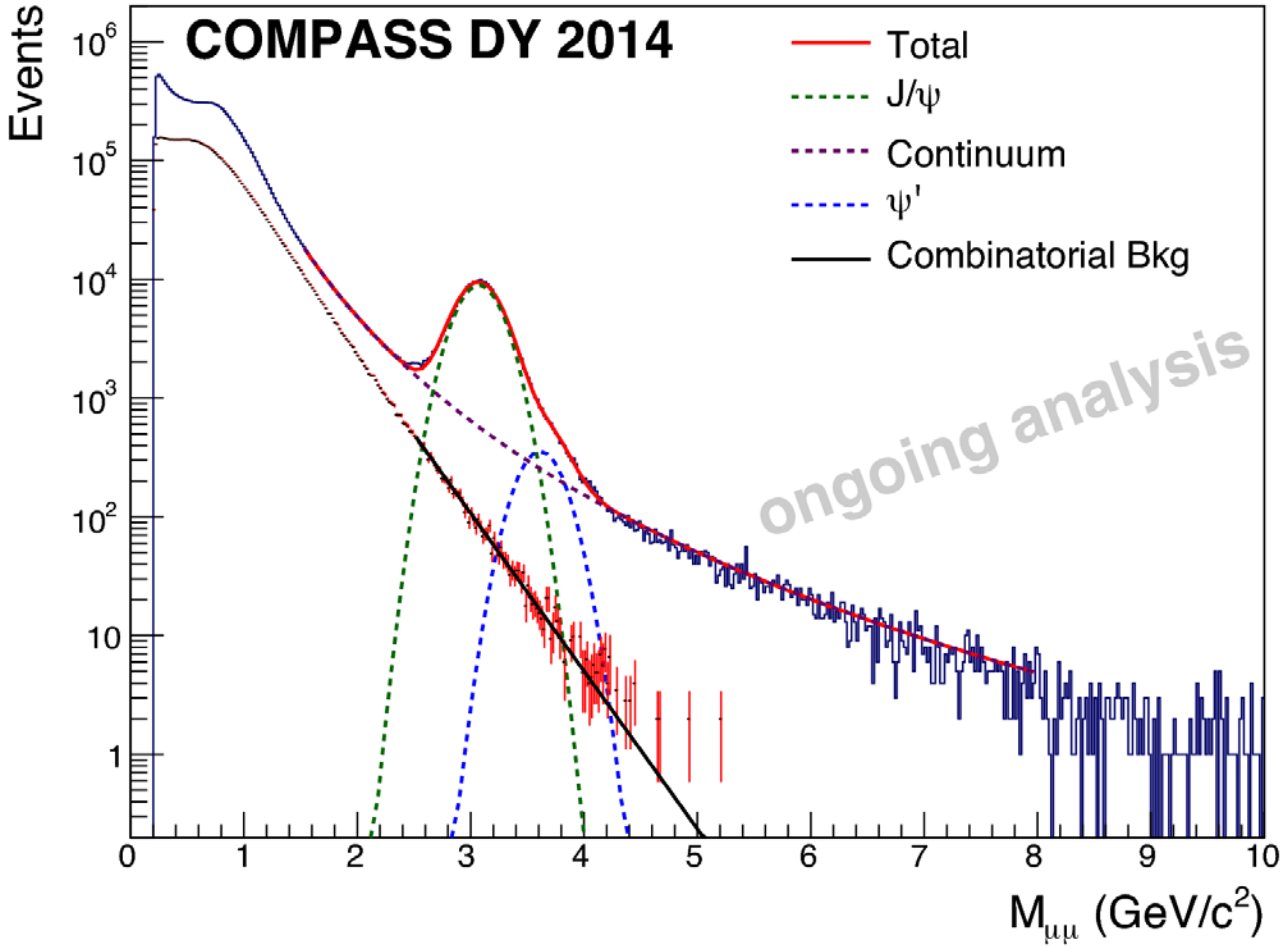
2014 DY status

- vertex distribution



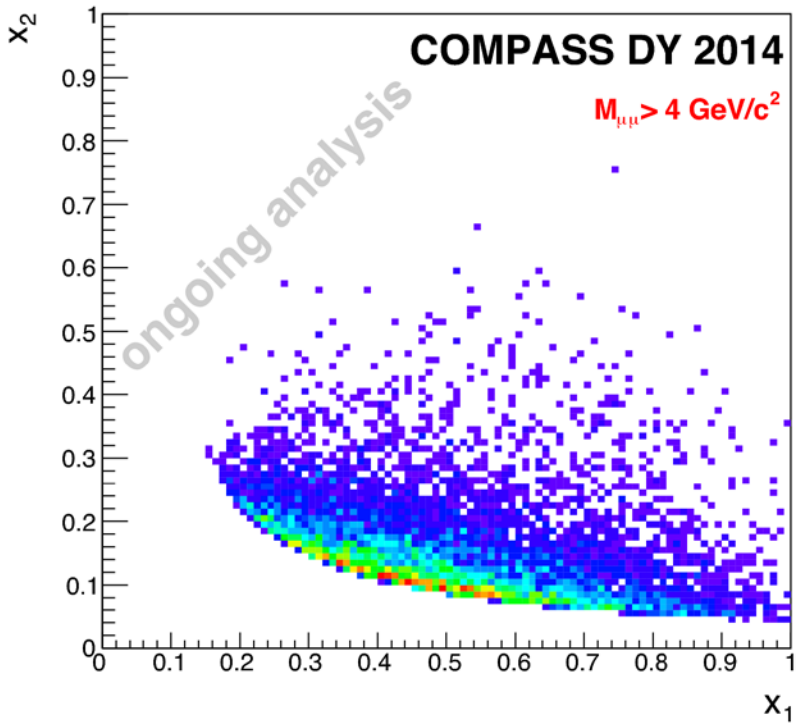
2014 DY status

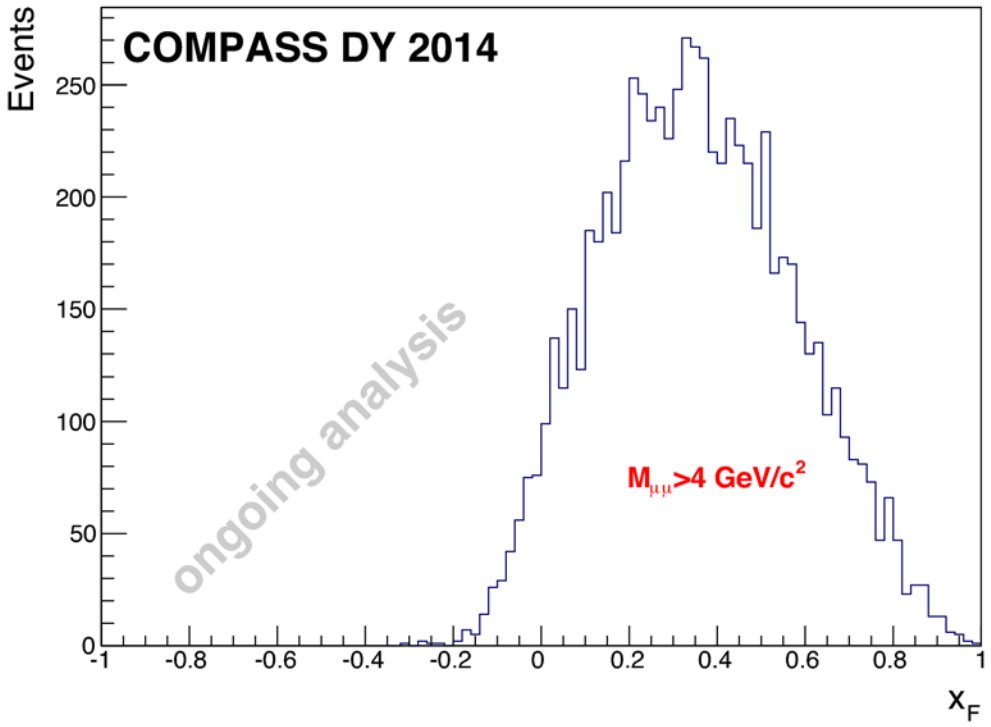
- μμ-mass spectrum



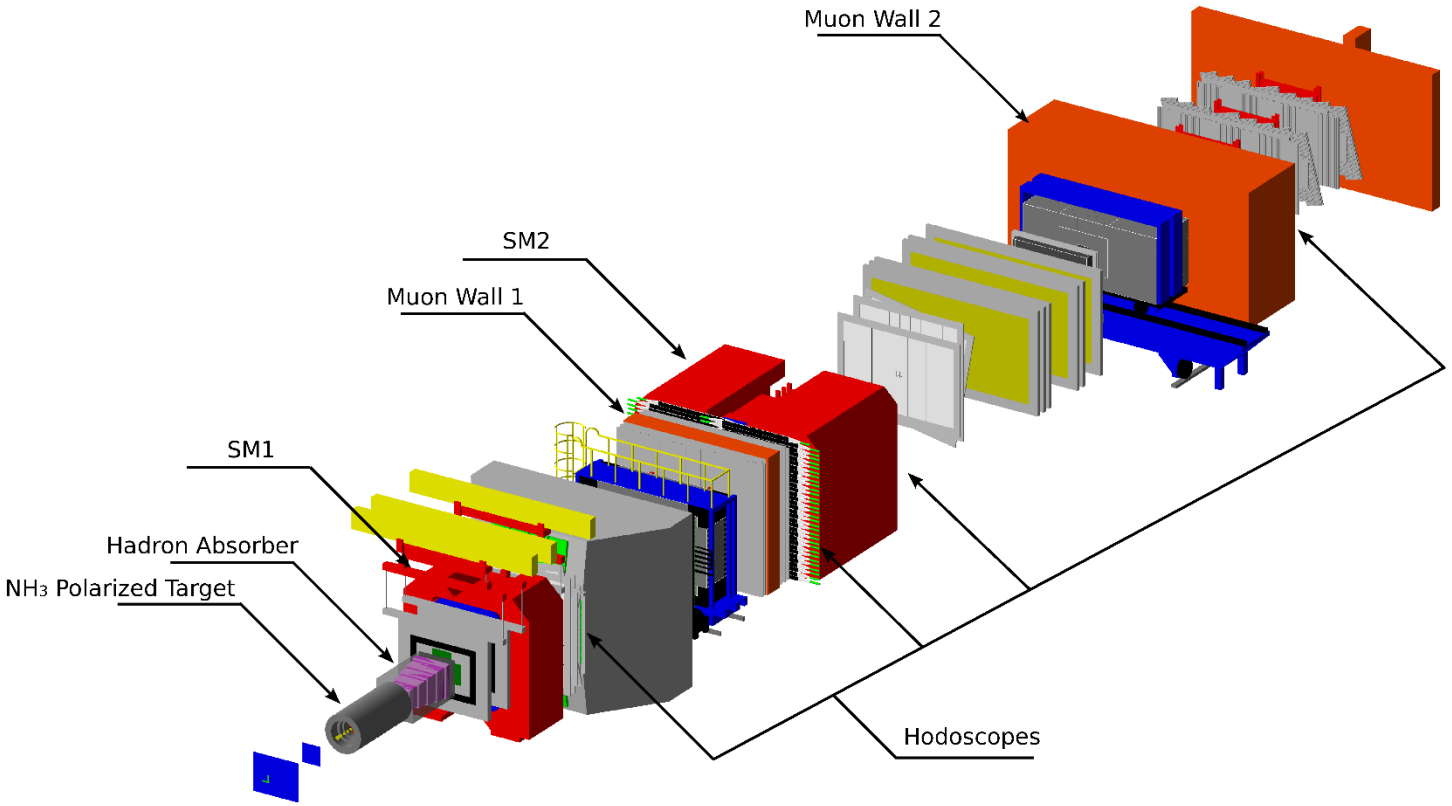
2014 DY status

- x_1 vs x_2 and x_F



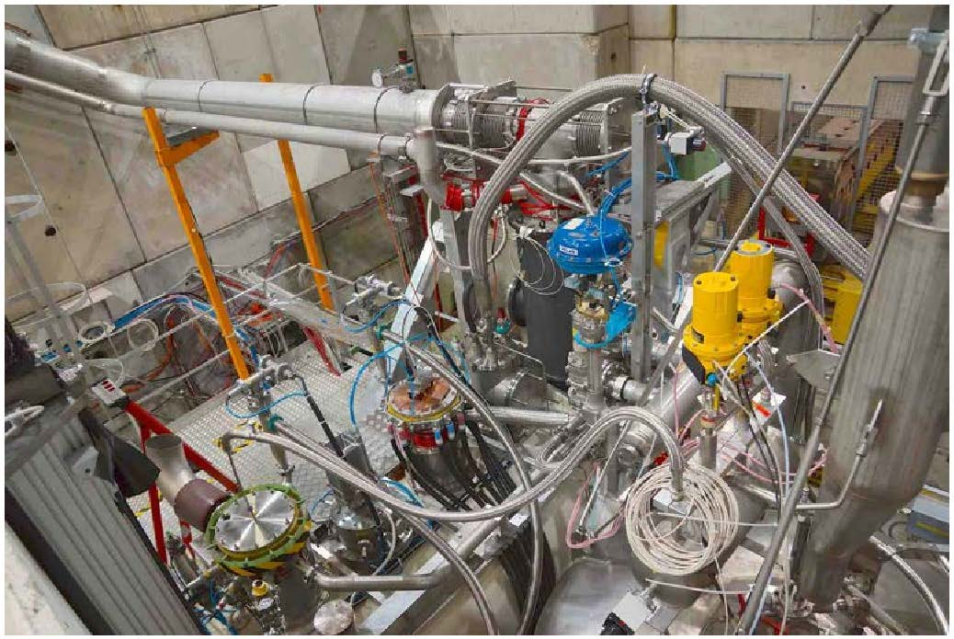


Hardware


Muon Wall 2
SM2
Muon Wall 1
SM1
Hadron Absorber
NH3 Polarized Target
Hodoscopes

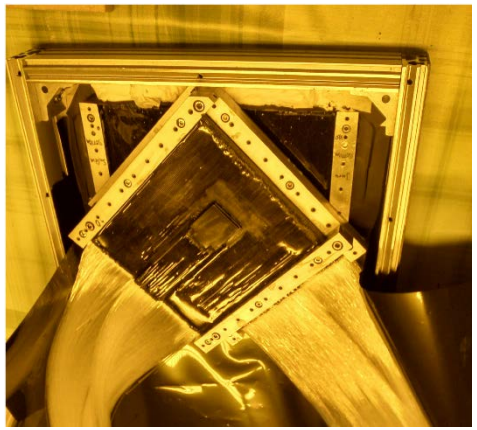
2015 run

- Polarised target
  - control system fully operational
  - power supplies fully operational
  - polarisation of 80-90% reached
  - built-up time < 2 days



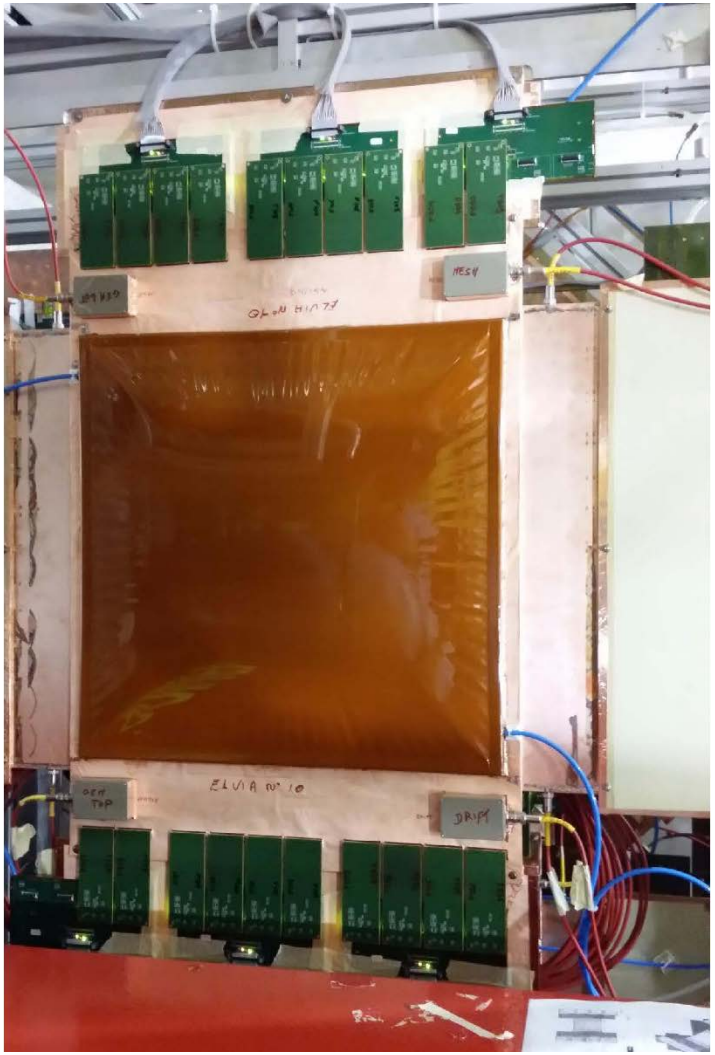
Vertex SciFi detector

- located just before the absorber, between the main absorber and the cone
- 0.7 mm pitch 15x15 cm^2
- hardware ok, time resolution < 680 ps
- not yet fully used in reconstruction



Pixel Micromegas

- hybrid MM with GEM foil
- inner part rectangular pixels with 400 µm pitch, outer part strips
- resolution 60 µm, 9 ns
- final 4 detector installed last week

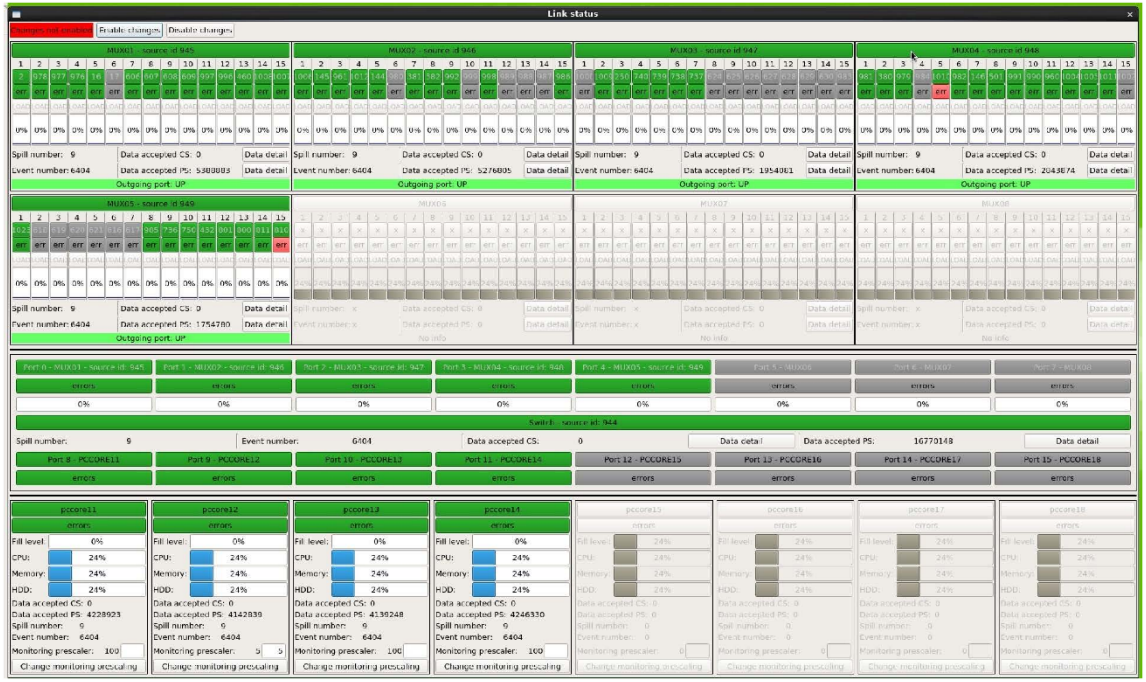


Drift chamber DC5

- 8 views YY'XX'VV'UU'
- major transport damage in 2014
- partly rewired
- installed on May 13
- broken wire, XX' lost
- tested with source ok
- problem with RJ45 sockets stopping to work in magnetic field affecting VV'UU'
- yesterday magnetic shielding tested successfully
- to be repaired before 2016 run

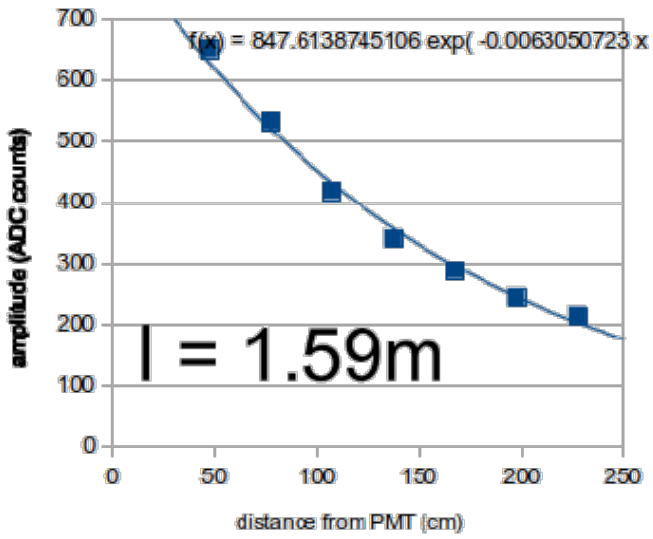
new DAQ

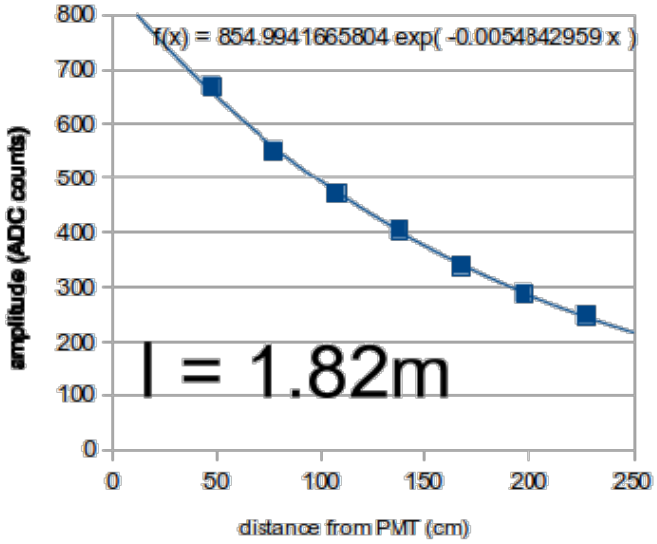
- working fine
- dead time reduced considerably
- new control room fully operational
- up to 40 kHz
- 23 kB event length



CAMERA recoil detector for 2016

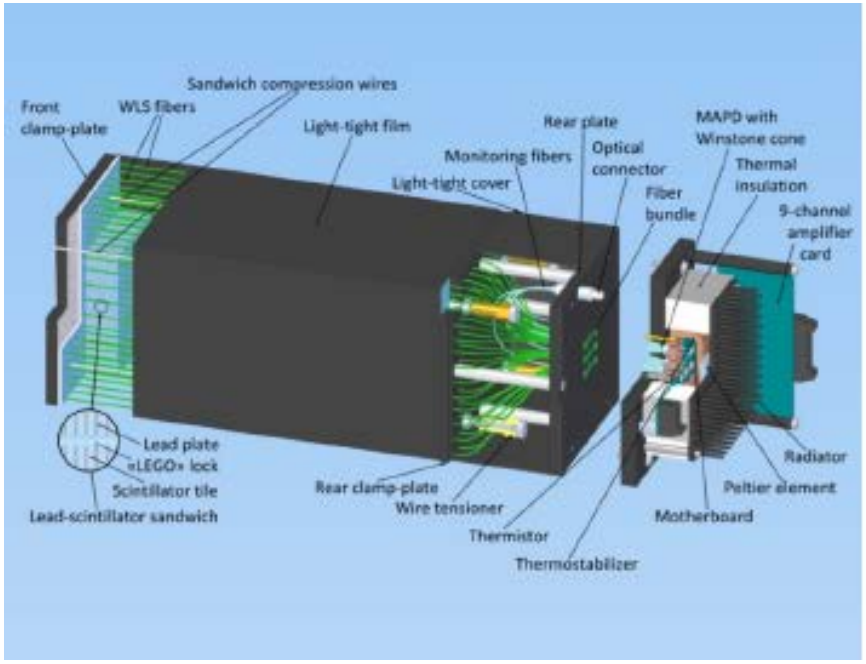
- replacement of poor scintillators in inner ring A being prepared, need attenuation length > 1.5 m
- scintillators ordered, attenuation tests performed at Eljen company, delivery July, preparation starts next week
- replacement of scintillators in September
- no problems expected
- a special start counter will tested in 2015

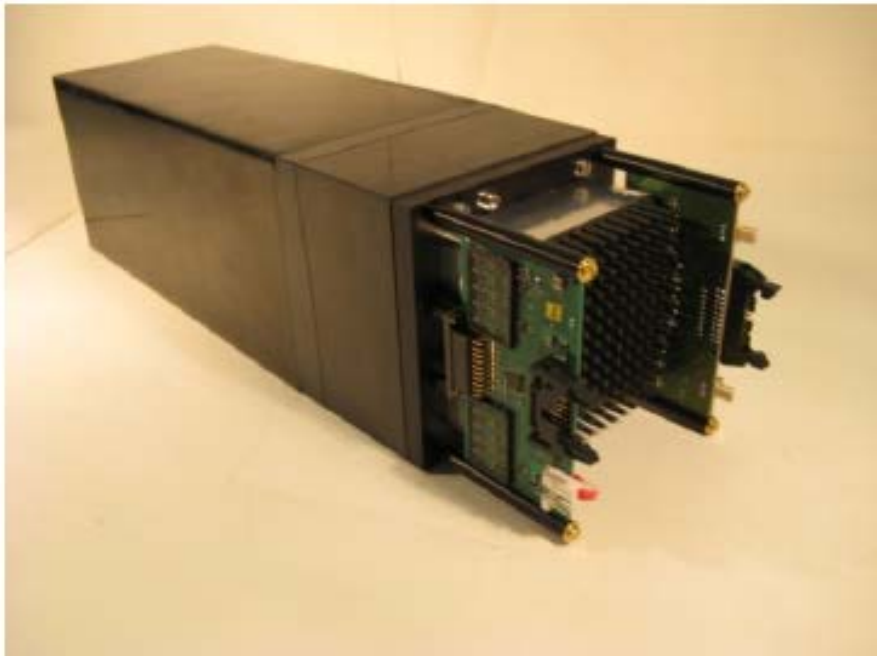




ECAL0

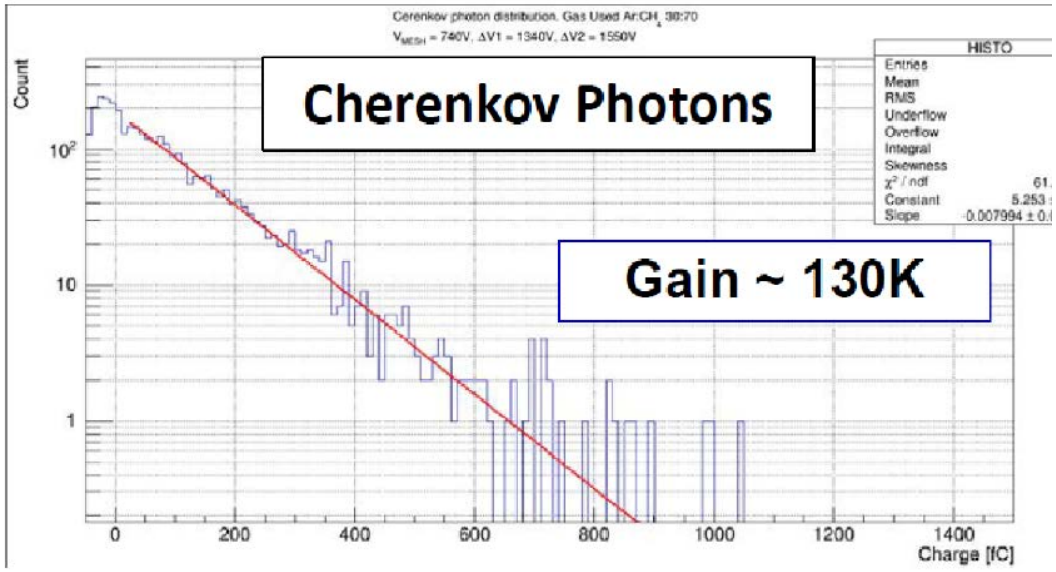
- present time line: completion February 2016
- modules are at CERN
- read-out will be test this week in test beam





RICH peripheral photon detection

- Thick GEM detectors validated, gain $5x10^4$
- 4 of the resent MWPCs will be changed in 2015-2016 shutdown
- increase of number of detected photons 10-20%



2015 Run

- ready to start physics data taking this Thursday
- the remaining run time is sufficient to reach the physics goal of 2015
- provided the expected supercycle length of 33.6 s or less with two 4.8 s spills can be provided by the SPS
- present average supercycle length 50 s

Thank you