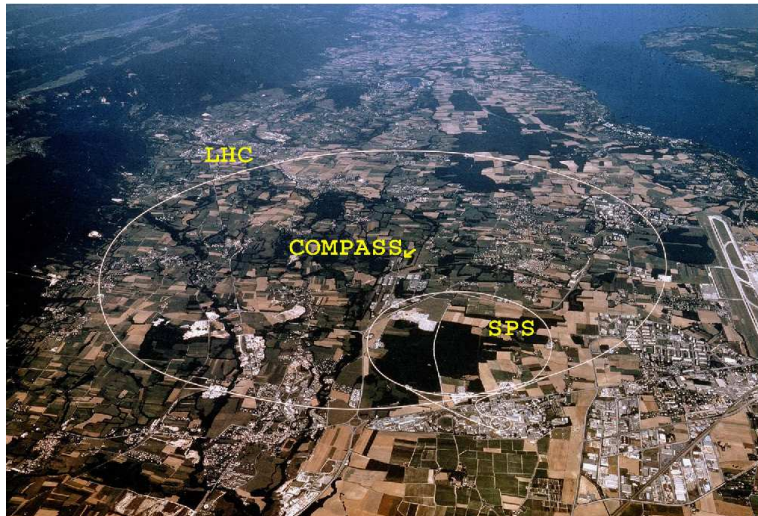


Research opportunities in COMPASS & AMBER

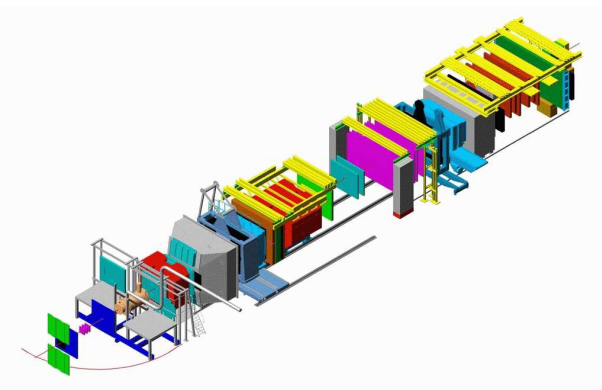
Marcin Stolarski
LIP Lisboa
19-V-2023

- The Group
 - C. Quintans (group leader), P Faccioli, M. Stolarski (researchers)
 - R. Sivla, G. Almeida (students)
 - Ch. Pires (engineer)
- Responsibilities:
 - Various analysis tasks
 - Analysis of real data
 - MC simulations (physics, detectors)
 - Software improvements of the existing hardware
 - Detector Control System of COMPASS/AMBER experiment
- contact: mstolars@lip.pt, quintans@lip.pt

COMPASS and AMBER CERN



COMPASS ended last year, AMBER 1st data taking starting **this weekend...**

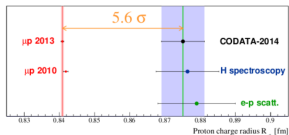


- COLLABORATION
 - about 210 physicists
 - 13 Countries
- DETECTOR
 - 60 m length
 - 2 (3) magnets
 - about 350 detector planes
- BEAM
 - μ beams 80-200 GeV
 - π , p , K beams
- TARGET
 - polarised LiD, NH_3
 - unpolarised LH, Tungsten, Pb, Ni, Cu...

BIG questions to be answered by COMPASS @ AMBER

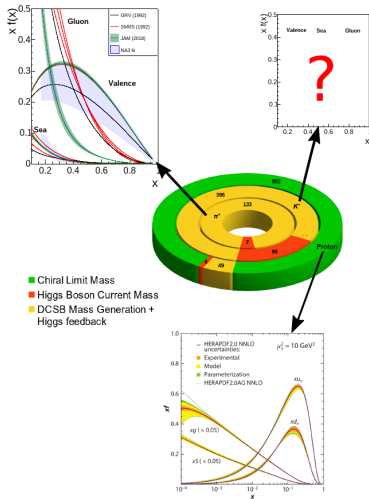
- Where does mass of hadrons comes from?
- Why pion is 7x lighter than proton?
- How quarks dress into hadrons?
- What is radius of the proton...?

proton charge radius



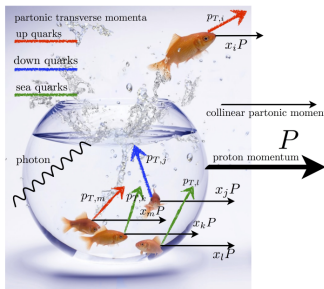
RP, Gilman, Miller, Paschoski, Annu. Rev. Nucl. Part. Sci. 63, 175 (2013);

...from muon-proton elastic scattering



Interested in physics...

- Protons are quite complex objects...



Leading Twist TMDs

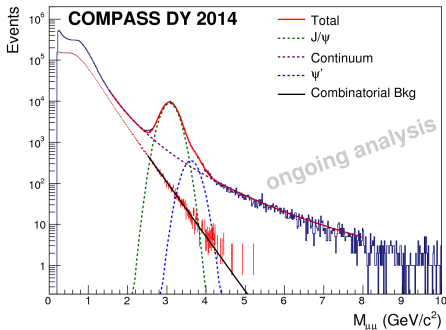
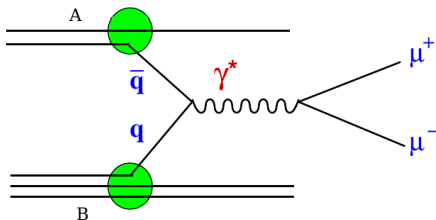


		Quark Polarization		
		Un-Polarized (U)	Longitudinally Polarized (L)	Transversely Polarized (T)
Nucleon Polarization	U	$f_1 = \odot$		$h_1^\perp = \uparrow \odot - \downarrow \odot$ Boer-Mulders
	L		$g_{1L} = \odot \rightarrow - \odot \rightarrow$ Helicity	$h_{1L}^\perp = \uparrow \rightarrow - \downarrow \rightarrow$
	T	$f_{1T}^\perp = \uparrow \odot - \downarrow \odot$ Sivers	$g_{1T}^\perp = \odot \leftarrow - \odot \leftarrow$	$h_1 = \downarrow \odot - \uparrow \odot$ Transversity $h_{1T}^\perp = \uparrow \rightarrow - \downarrow \rightarrow$

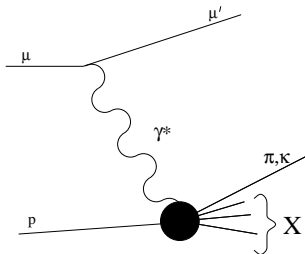
- other hadrons too...
- still a lot of mysteries awaits to be discovered and understood...
- Drell-Yan and SIDIS processes can help reveal some of them...

Interested in physics - Drell-Yan Process

- Quark-antiquark annihilation with production of leptons in the final state
- COMPASS took data in 2014, 2015 and 2018
- Future AMBER data with pion, kaon, proton beams!



Interested in Physics - SIDIS



- **Semi-Inclusive Deep Inelastic Scattering (SIDIS)**

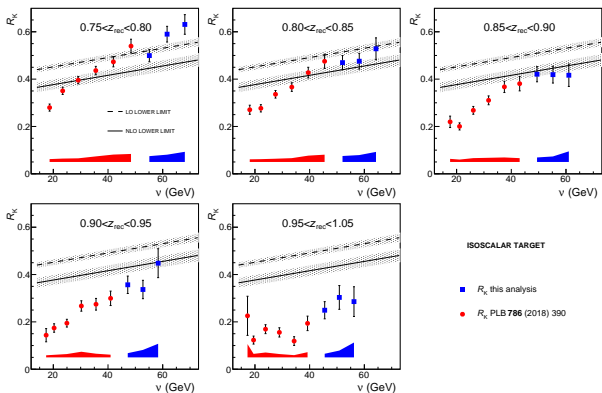
- what is probability that a quark of type q fragments into a hadron type h ?
- a new non perturbative object needed - **Fragmentation Functions**

- Fragmentation functions can be extracted from measurements of kaon multiplicities, i.e. number of kaons per DIS event

- QCD predicts that:

- $$\frac{M^{K^-}}{M^{K^+}} > \frac{\bar{u} + \bar{d}}{u + d}$$

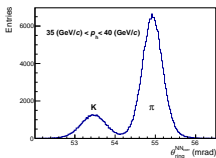
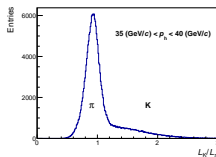
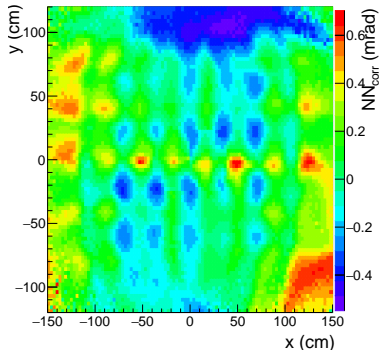
- Reality ???



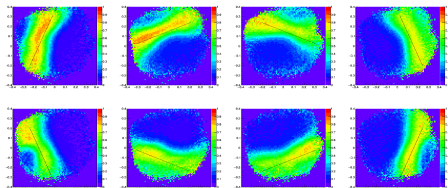
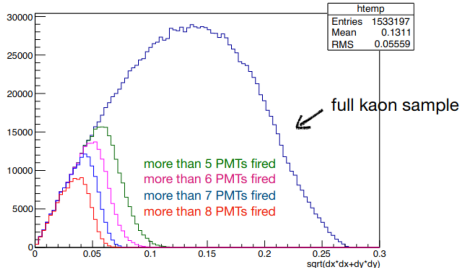
- It turned out that data are below expected lower limit...
- z is momentum fraction of the virtual photon energy ν carried by kaon
- Is it mistake?.. We have new 2018 data on proton target
- you may check it by yourself ;-)

Interested in Neural Networks applications...

RICH @ COMPASS



CEDAR @ COMPASS and AMBER



Thank you!