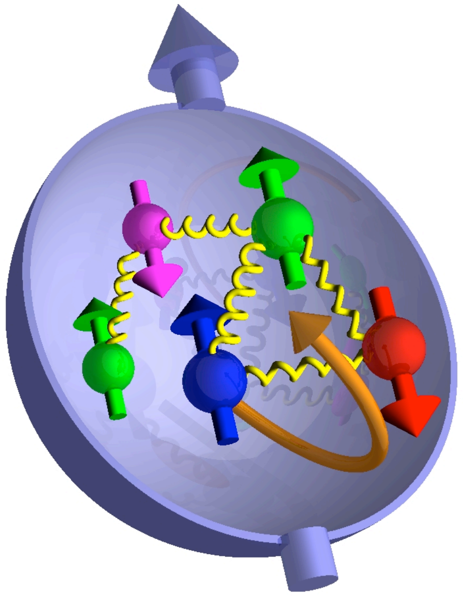
GDR -INTERACTIONS SIMPLES ET MULTIPLES ENTRE PARTONS DANS LES NUCLÉONS

DRELL-YAN MEASUREMENTS AT COMPASS

NOVEMBER 10, 2016 - MARCO MEYER

INTRODUCTION



- Introduction to the **Drell-Yan process**

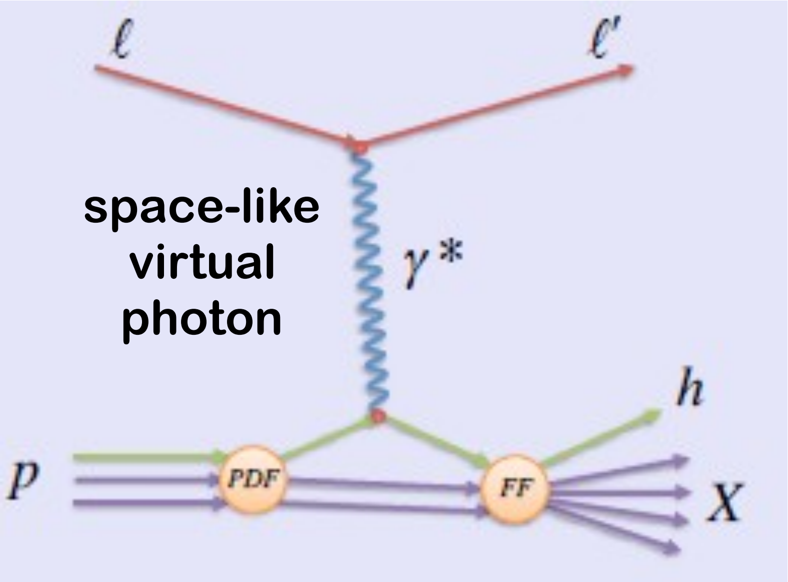
- The **COMPASS experiment** - Setup of 2015

- **Personal on going analysis** for Drell-Yan 2015

- Conclusion & Outlook

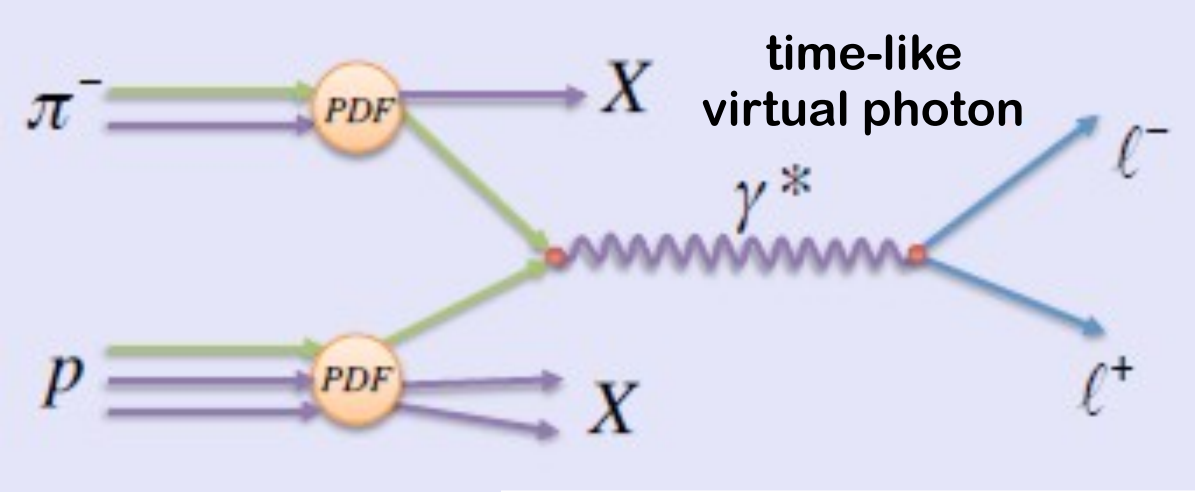
(SI)DIS

PDF ⊗ FF



Drell-Yan (DY)

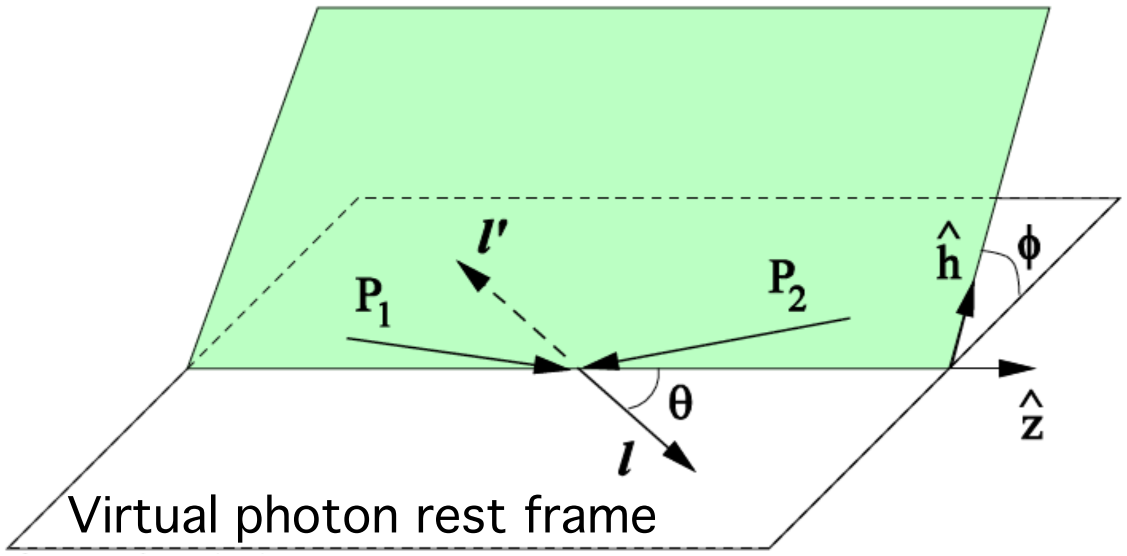
PDF ⊗ PDF



$$f_{1T}^{\perp}(DY) = -f_{1T}^{\perp}(SIDIS)$$ Sivers function

$$h_1^{\perp}(DY) = -h_1^{\perp}(SIDIS)$$ Boer-Mulders function

Main goal for COMPASS is to measure the sign change..



Naive Drell-Yan:

EM process only

$$\frac{d\sigma}{d\Omega} \propto 1 + \cos^2\theta$$

NO SPIN CONSIDERATION

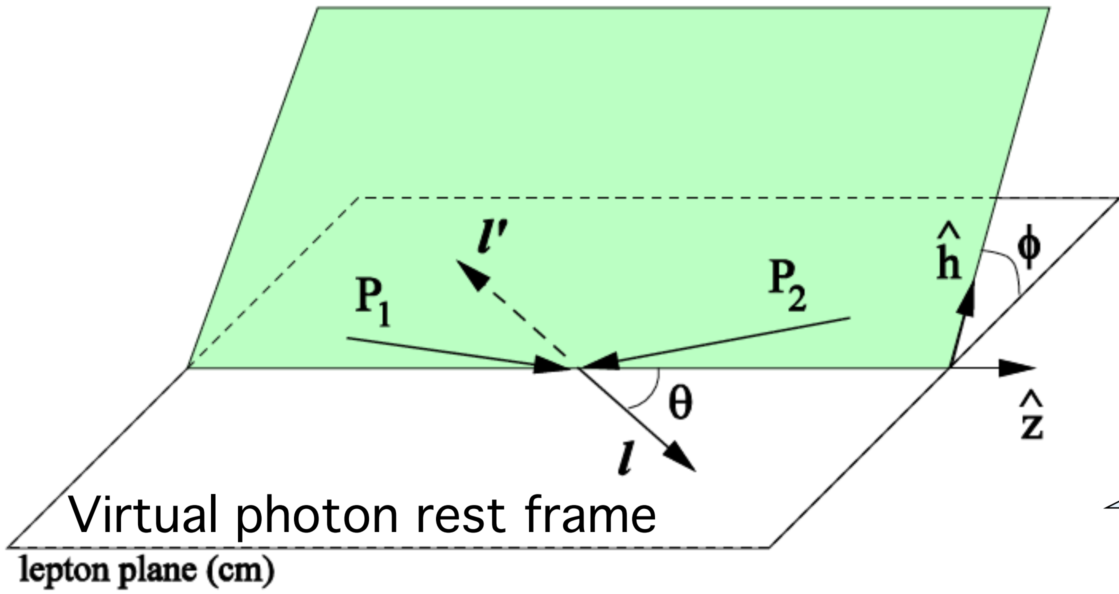
Drell-Yan at higher order :

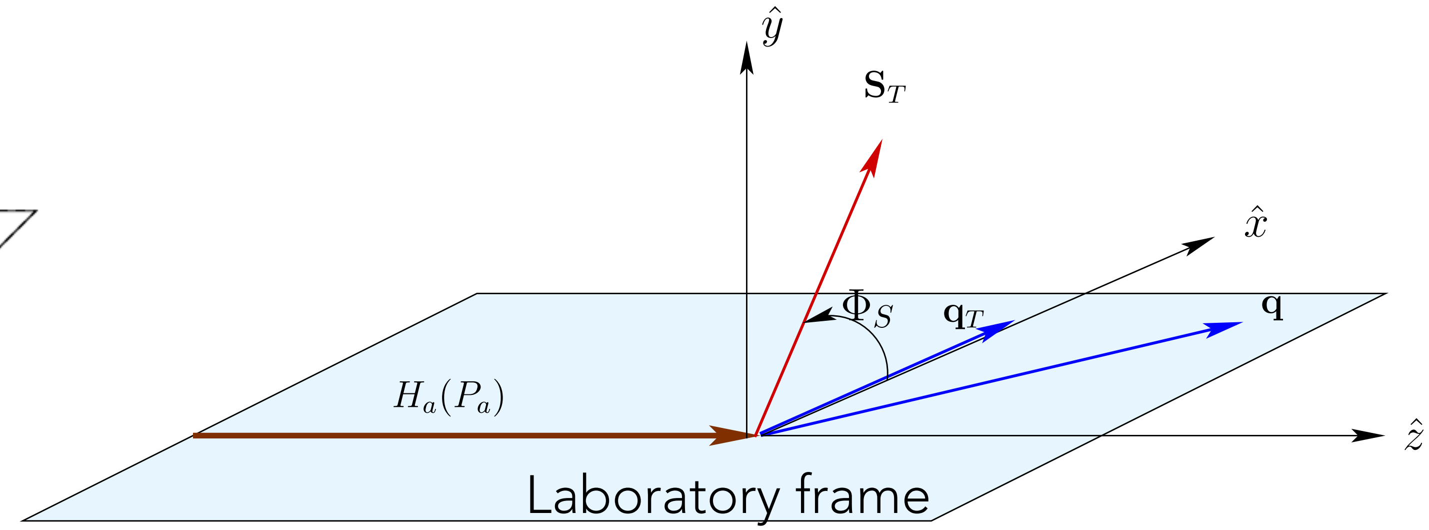
include quark momentum + gluon exchanges + higher O(α_S):

$$\frac{d\sigma}{d\Omega} \propto 1 + \lambda \cos^2\theta + \mu \sin(2\theta)\cos\phi + \frac{\nu}{2}\sin^2\theta\cos(2\phi)$$

Lam-Tung relation
C.S. Lam and W.K. Tung, PRD 18 (1978) 2447

$$1 - \lambda = 2\nu$$





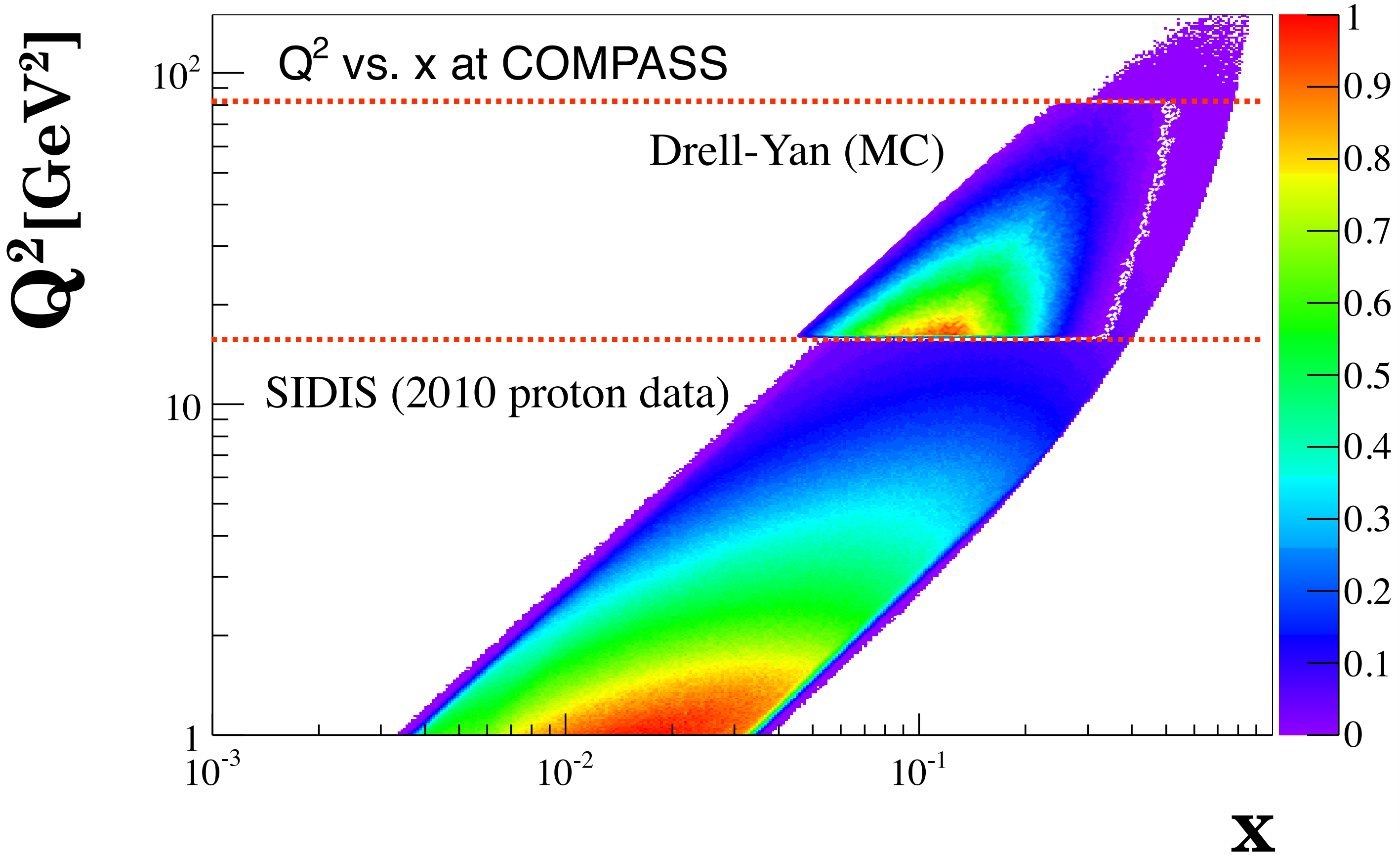
Drell-Yan including spin effects :

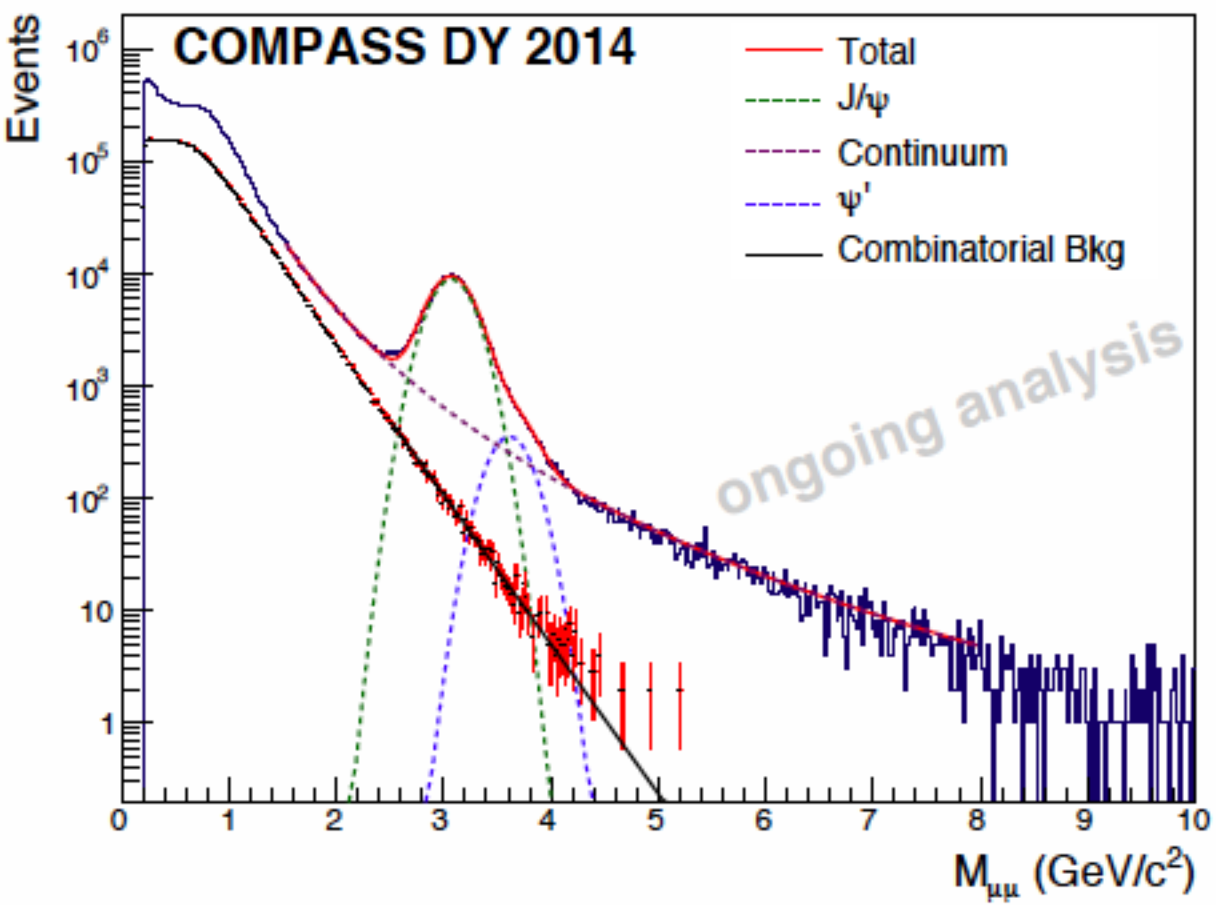
$$
\begin{aligned}
d\sigma(\pi^- p^\uparrow \to \mu^+\mu^- X) = 1 &+ \overline{h}_1^\perp \otimes h_1^\perp \cos(2\phi) \\
&+ |S_T|\ \overline{f}_1 \otimes f_{1T}^\perp \sin\phi_S \\
&+ |S_T|\ \overline{h}_1^\perp \otimes h_{1T}^\perp \sin(2\phi + \phi_S) \\
&+ |S_T|\ \overline{h}_1^\perp \otimes h_1 \sin(2\phi - \phi_S)\Big]
\end{aligned}
$$

beam		target	
(BM)	⊗	(BM)	
(f_1)	⊗	(Sivers)	Measurement of interest
(BM)	⊗	(Pretzelosity)	
(BM)	⊗	(Transversity)	

TRANSVERSELY POLARIZED TARGET

INTRODUCTION TO THE DRELL-YAN PROCESS





Drell-Yan data taking :

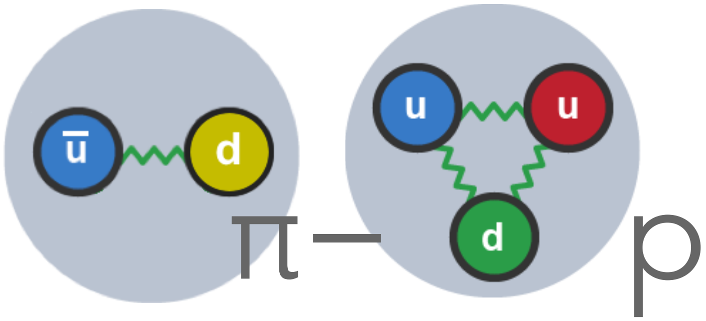
- 2008 : test run
- 2014 : pilot run (no transversaly polarized target)
- 2015 : main run (NH3 target, transversaly polarized)
- 2018 : 2nd data taking (approved by SPS)

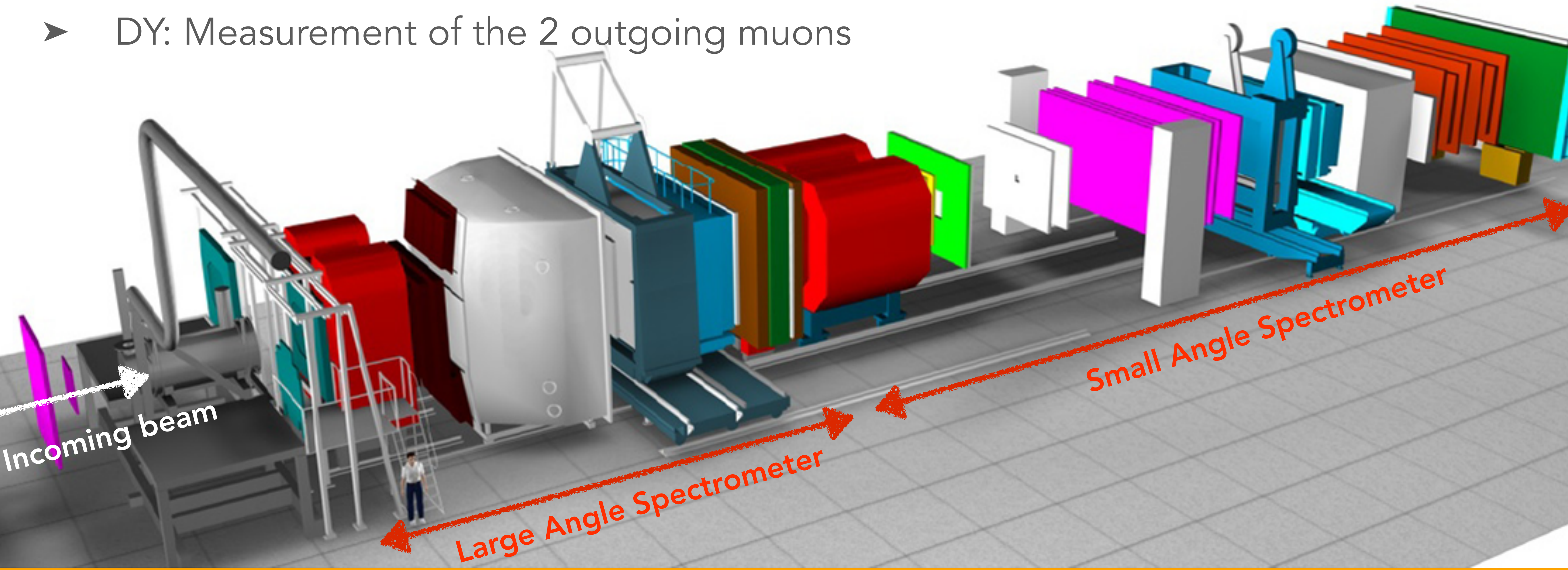
Goals:

- ➤ Asymmetry measurements
- ➤ PDF/TMD PDFs determination
  Structure functions determination
- ➤ Absolute cross-section measurement

THE COMPASS EXPERIMENT - SETUP FOR 2015

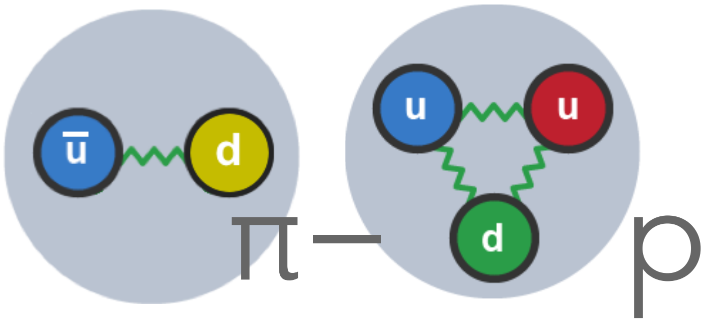
- COMPASS is an high-energy physics experiment on the Super Proton Synchrotron (SPS) at CERN
- **190 GeV negative hadron beam** (π/K/p 97/2/1%) (from 400 GeV SPS protons onto conversion target)
- **Beam intensity 2015:** ~10^8 particles/s
- DY: Measurement of the 2 outgoing muons



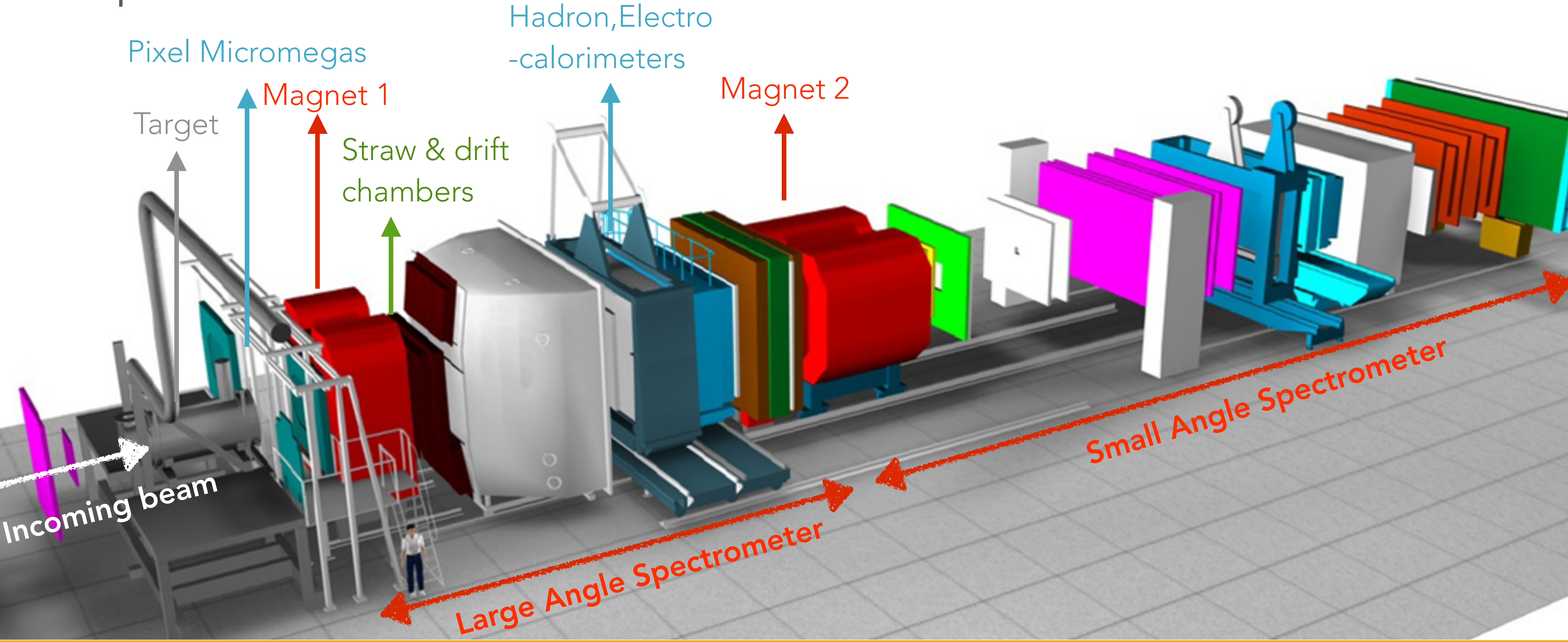


THE COMPASS EXPERIMENT - SETUP FOR 2015

- COMPASS is a 2-stage spectrometer: (~350 tracking planes)
  "LAS": 35 mrad < θ_μ < 180 mrad
  "SAS": 18 mrad < θ_μ < 35 mrad

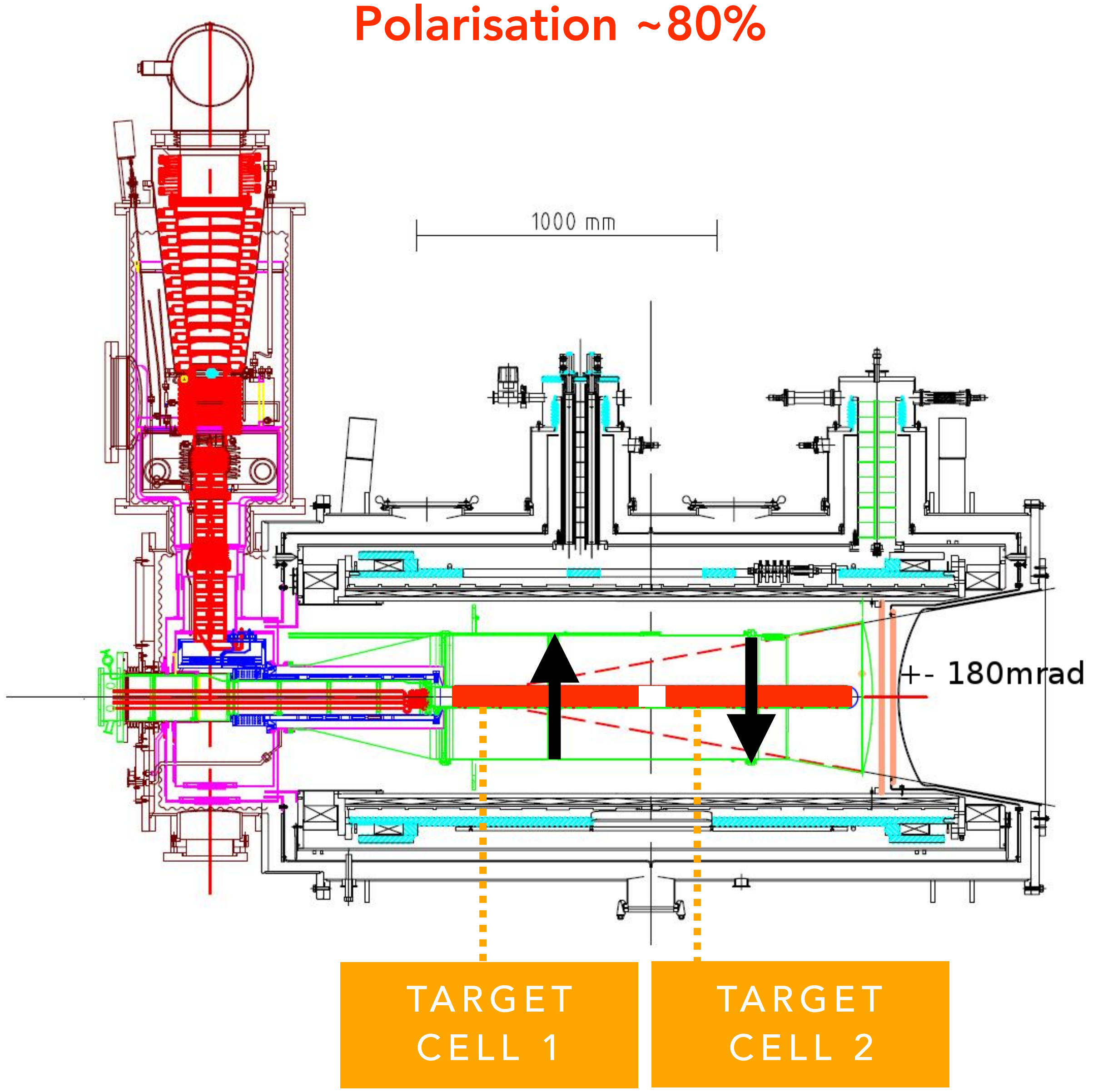


- **Measurements performed** : Track reconstruction, momentum measurement, particle identification

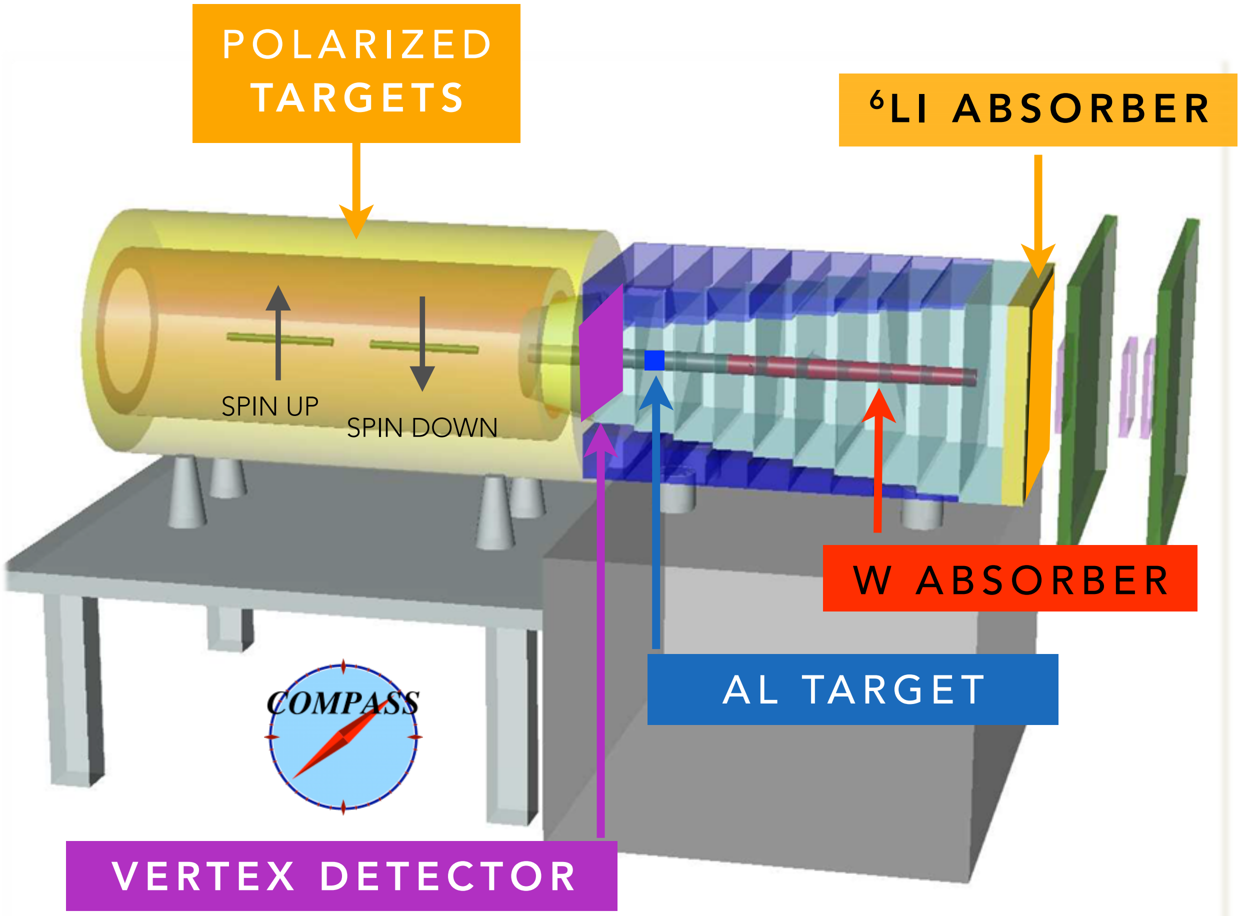


Polarized target

^{3}He – ^{4}He dilution refrigerator (T~50mK)
Solenoid 2.5T
Polarisation ~80%



Absorber



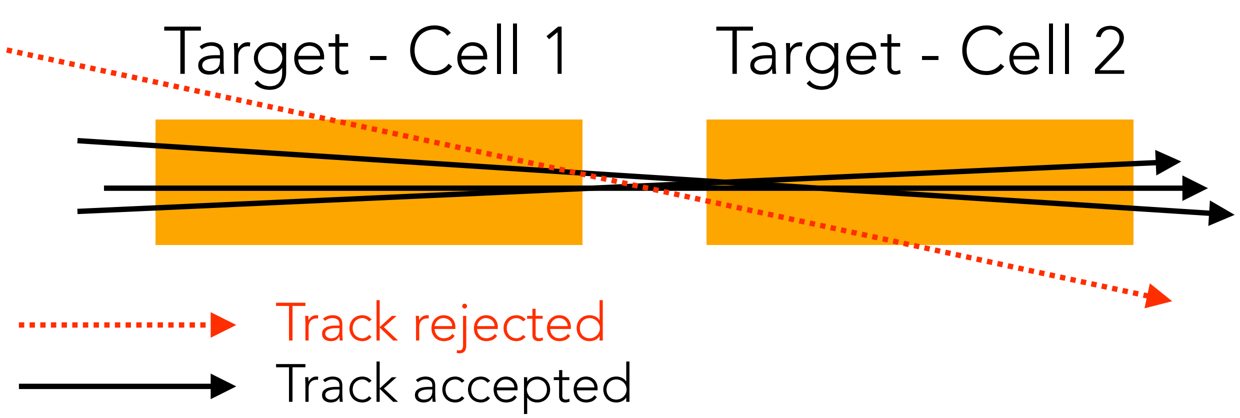
Cross section measurement ?

$$\sigma = \frac{N}{\mathcal{L}}$$

- N → Number of events (Classical physics analysis)
- $\mathcal{L}$ → Integrated luminosity

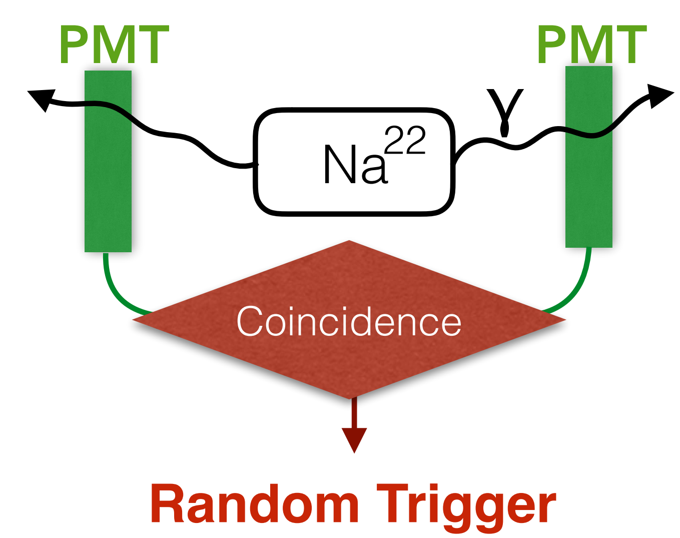
How to get the integrated luminosity ?

- Using Randomly Triggerred Events



Why do we use the Random Trigger method ?

- Not be correlated with physics triggers



FLUX MEASUREMENT FOR DRELL-YAN 2015

How to calculate the flux ?

Integrated flux $= \dfrac{N_{beam}}{N_{RT}\ \Delta t}\,\Delta T_{spill}$

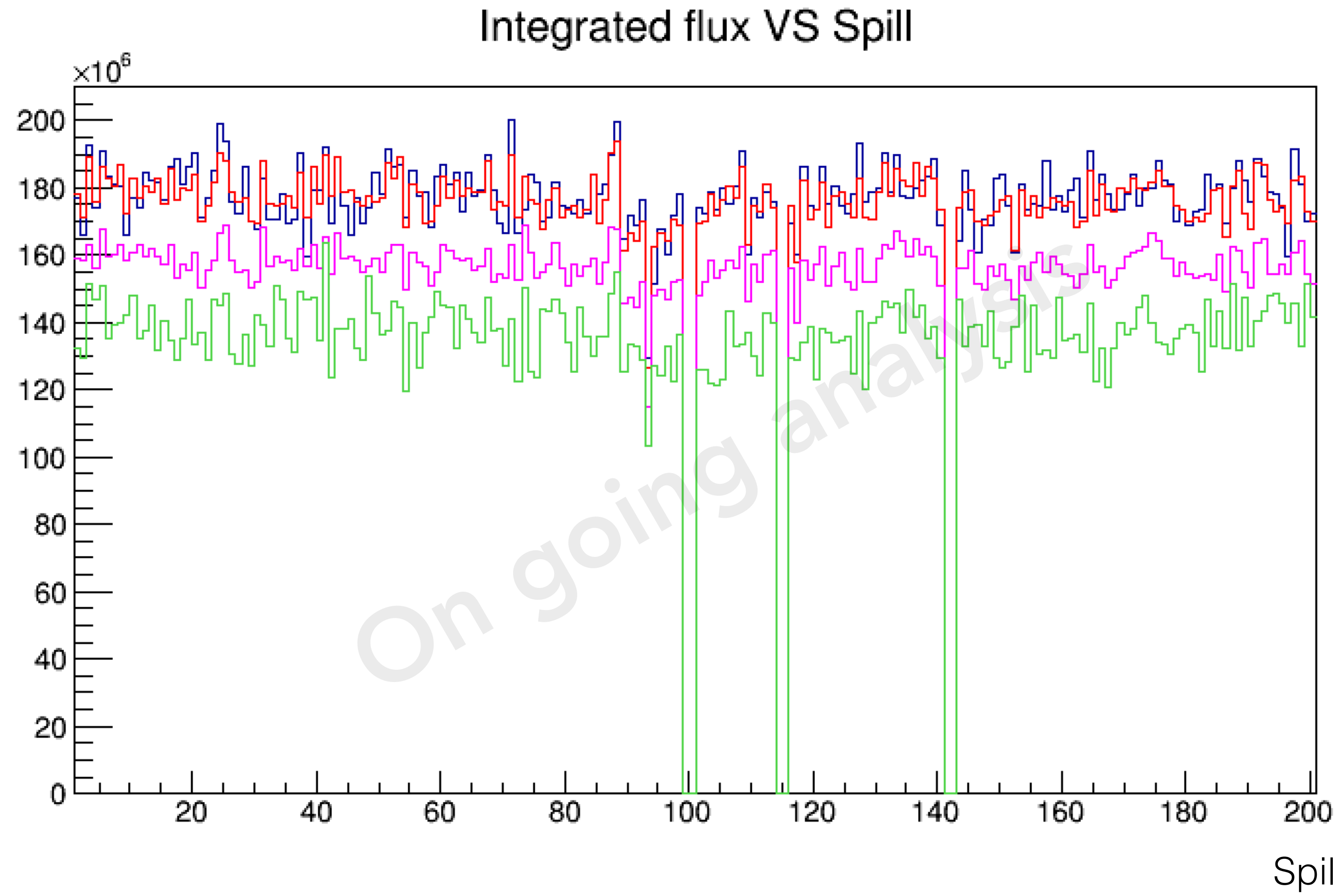
(spill per spill)

N_{beam} ~4000

N_{RT} ~6000

Δt ~16 ns

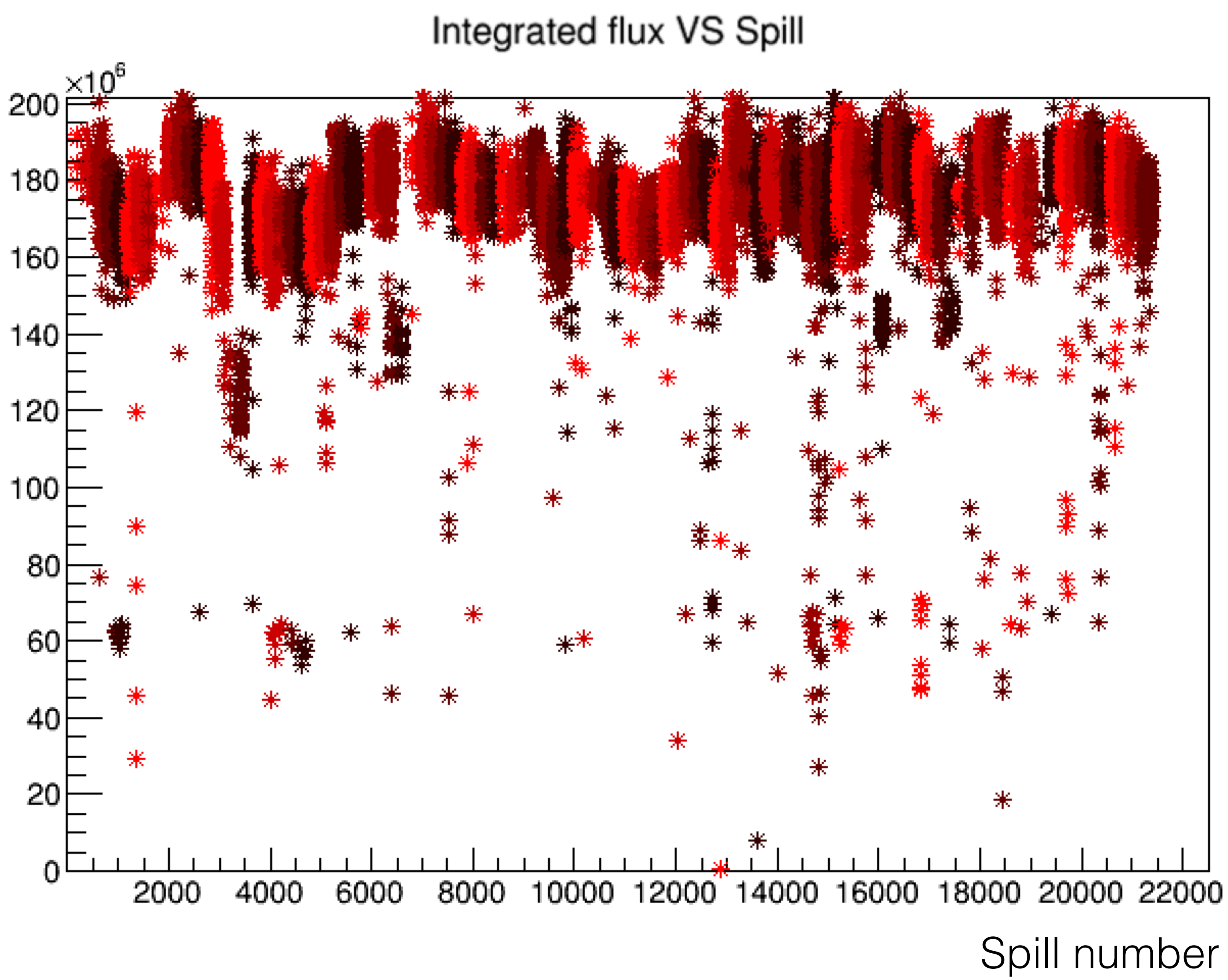
ΔT_{spill} 5 s



N_{RT} → ΔT_{SPILL} = time in the spill

N_{BEAM} → Δt = beam time

- **Total flux integrated** **for 2 weeks (~ 100 runs ~ 4TB of reconstructed data)**



=> 2 weeks (~ 100 runs)

DY 2015 ~ 30 weeks data taking~ 1 PB

~ 16 weeks has been produced

~ 2758 runs ~ 31557 files

~ 100 TB

Next question : how to analyse quickly this amount of data ?

- Use a computing model with **parallel data processing:**

Hardware-wise

- Using Blue Waters, a Petascale computing facility, Located at Illinois, USA
- Especially well designed parallel computing center
- Cf. Blue Waters Talk (Meyer M.) 22nd International Spin Symposium (Illinois, 2016)

Gain of time by a factor x90, using parallel queue (Relative gain)

Software-wise

Developping PROOF packages for data analysis

Gain of time by a factor x10 in my analysis (Relative gain)

Logarithmic complexity => Double the amount of data doesn't double the time needed to analyse them

PROOF = Parallel ROOT Facility

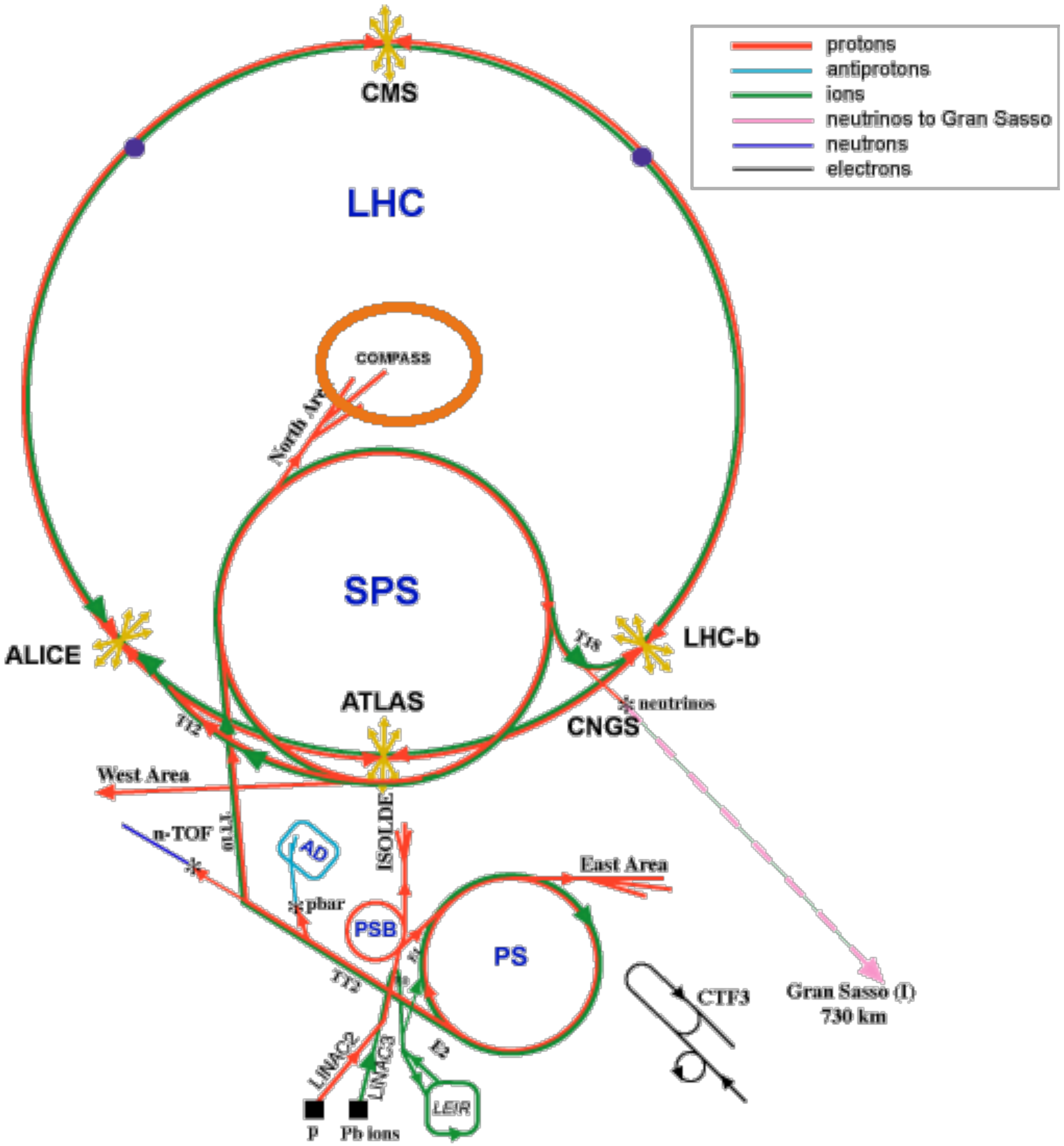
CONCLUSION AND OUTLOOK

- Overview of Drell-Yan process measured at COMPASS
- **COMPASS data analysis ongoing on Drell-Yan 2015. Expected result in Spring 2017**

Thank you for your attention !

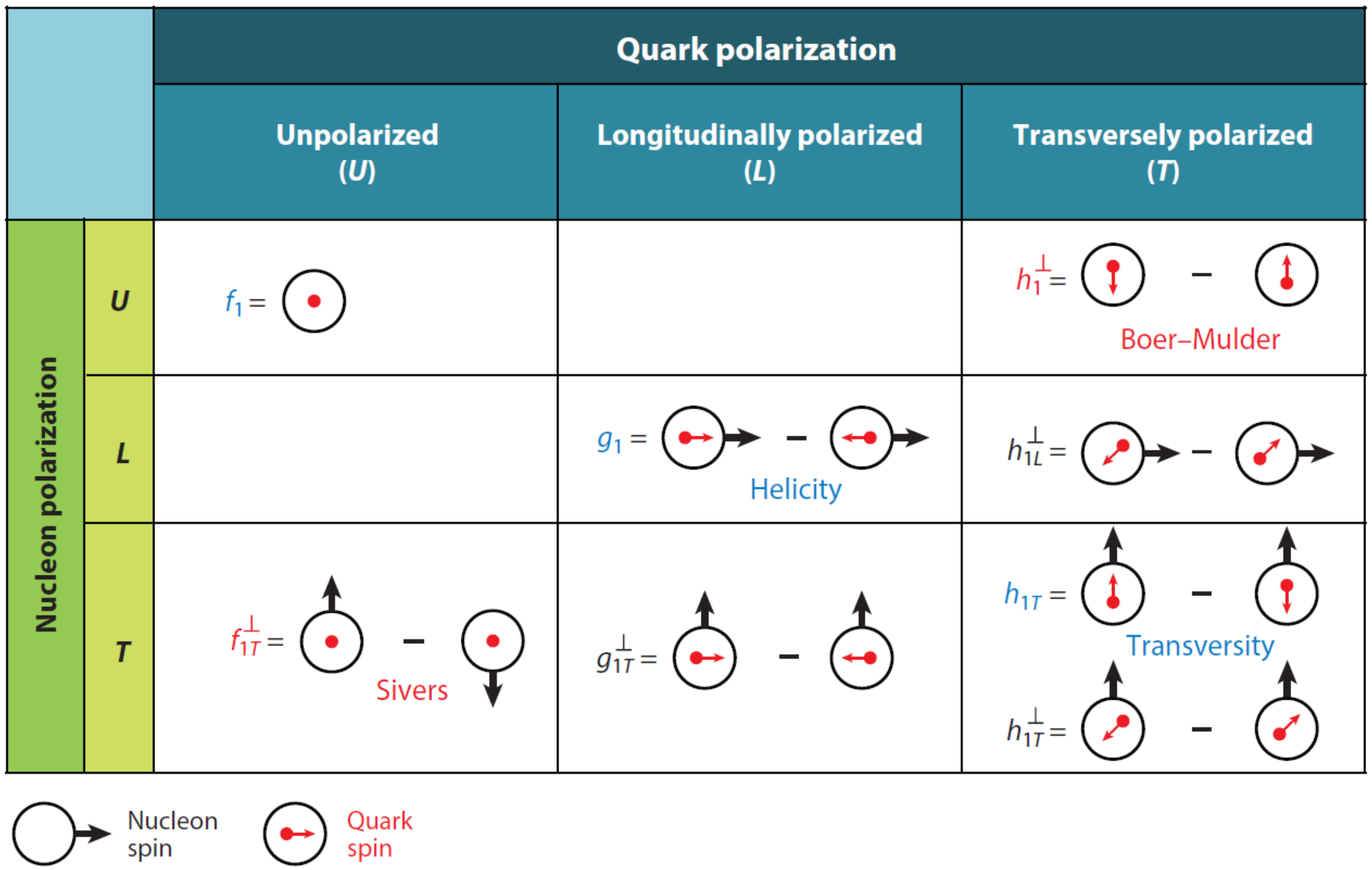
EXTRA SLIDES

EXTRA SLIDES



INTRODUCTION TO THE DRELL-YAN PROCESS

Structure functions



beam target

$$d\sigma(\pi^- p^\uparrow \to \mu^+\mu^- X) = 1 + \overline{h}_1^\perp \otimes h_1^\perp \cos(2\phi) + |S_T| \, \overline{f}_1 \otimes f_{1T}^\perp \sin\phi_S + |S_T| \, \overline{h}_1^\perp \otimes h_{1T}^\perp \sin(2\phi+\phi_S) + |S_T| \, \overline{h}_1^\perp \otimes h_1 \sin(2\phi-\phi_S) \Big]$$

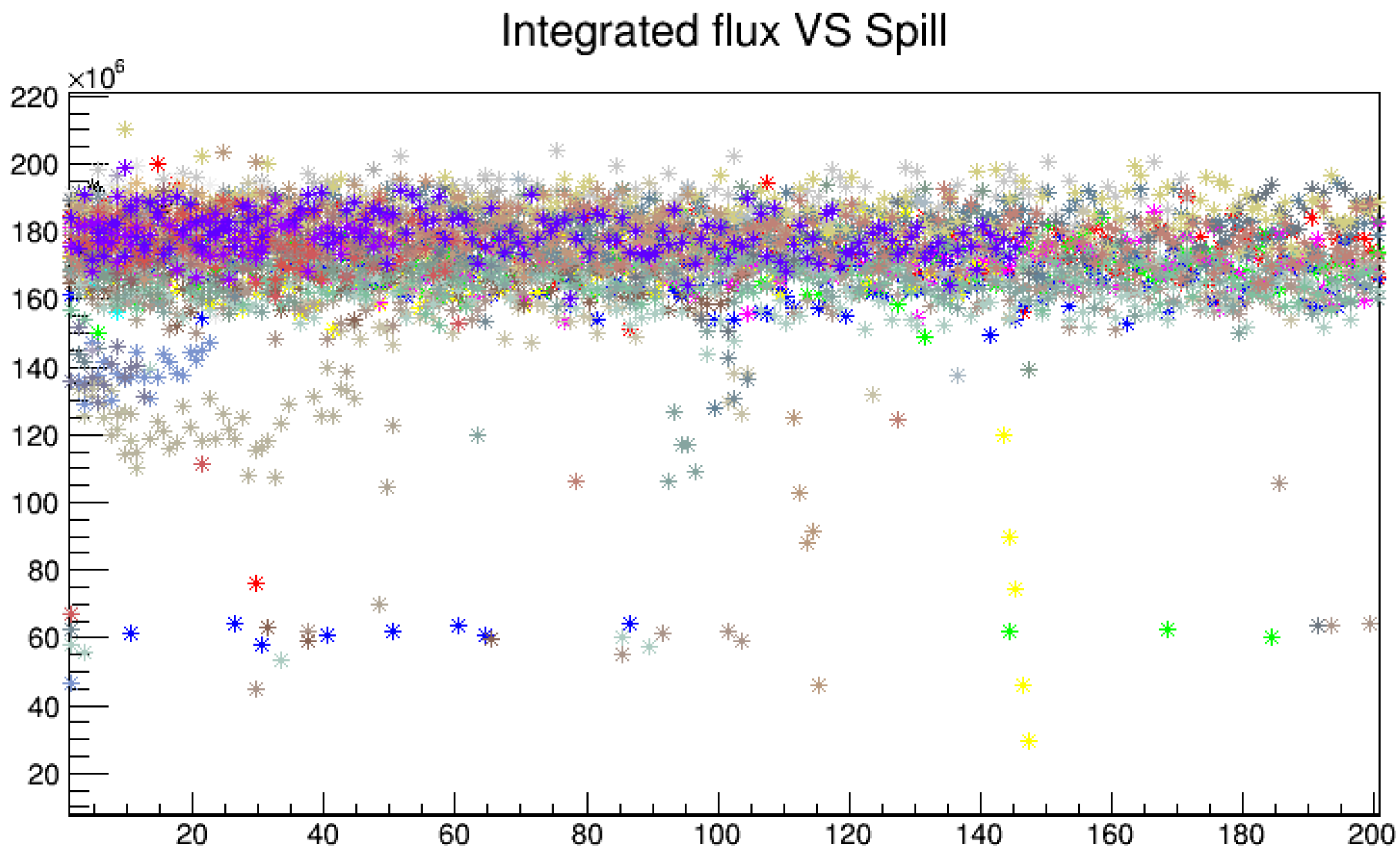
(BM) ⊗ (BM)

(f_1) ⊗ (Sivers)

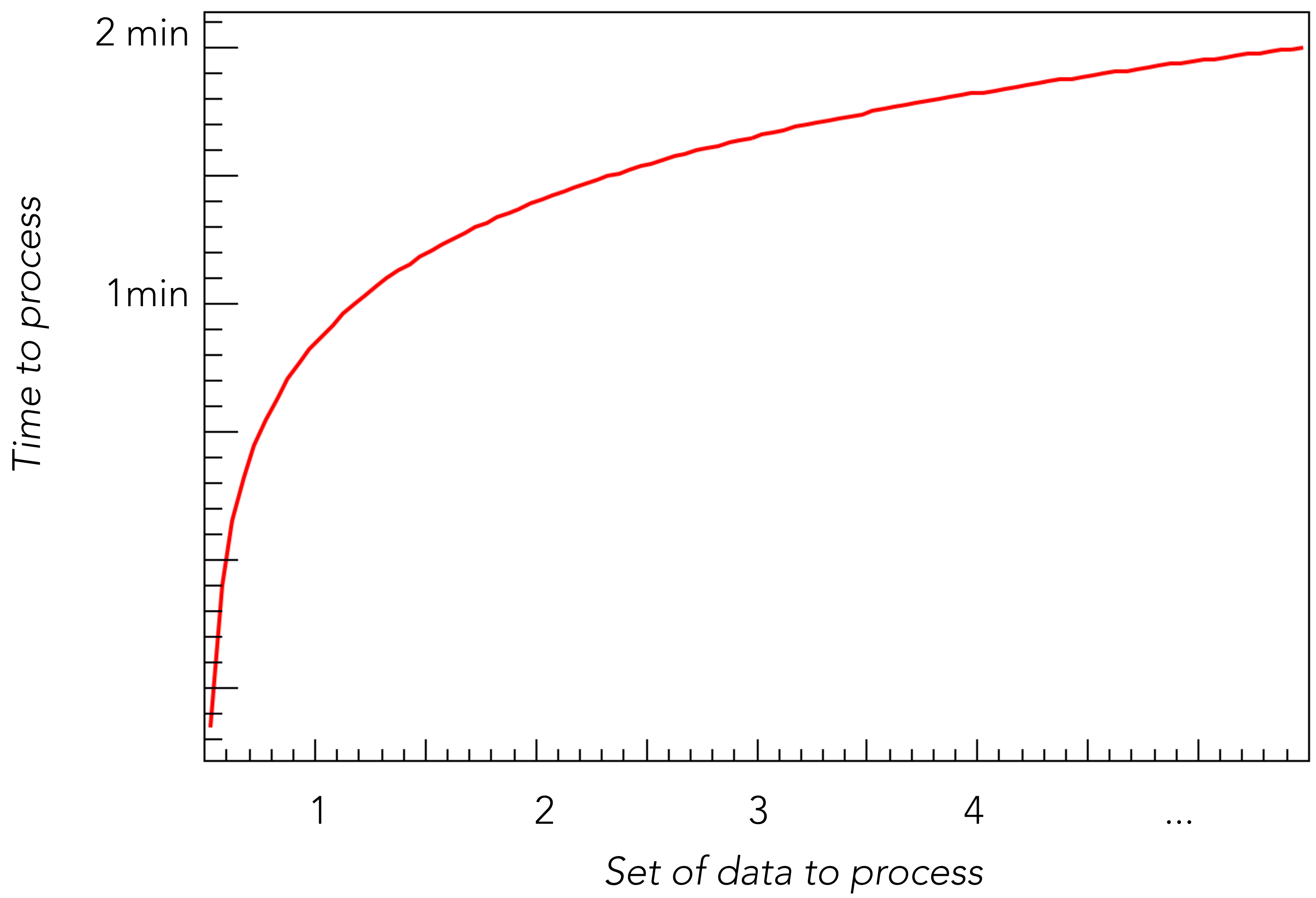
(BM) ⊗ (Pretzelosity)

(BM) ⊗ (Transversity)

TRANSVERSELY POLARIZED TARGET


Integrated flux VS Spill
×10^6
220
200
180
160
140
120
100
80
60
40
20
20
40
60
80
100
120
140
160
180
200

Parallel processing = logarithmic complexity



- **Big data analysis :** How to play with the Drell-Yan 2015 data ?

  DY 2015 ~ 30 weeks total ~ 1 PB

  ~ 16 weeks produced ~ 2758 runs ~ 31557 files ~ 100 TB

- **Developpement of a data management software called :** ESCALADE

  1 input file = 1 output file; No error; All logfiles checked

- **PROOF :** Parallel ROOT Facility (developped at CERN)

  - **Standardized packages** (ready to use) and **parallel processing of trees**
  - **Logarithmic complexity** (2x amount of data to analyse != 2x time needed to analysis !
  - **On the flight analysis** (Need few minutes to analyze few million events)

Blue Waters project

- **Petascale computing center**, located in Urbana-Champaign
  (PetaFLOPS = Peta-FLoating point Operations Per Second = measurement of the computer performances)

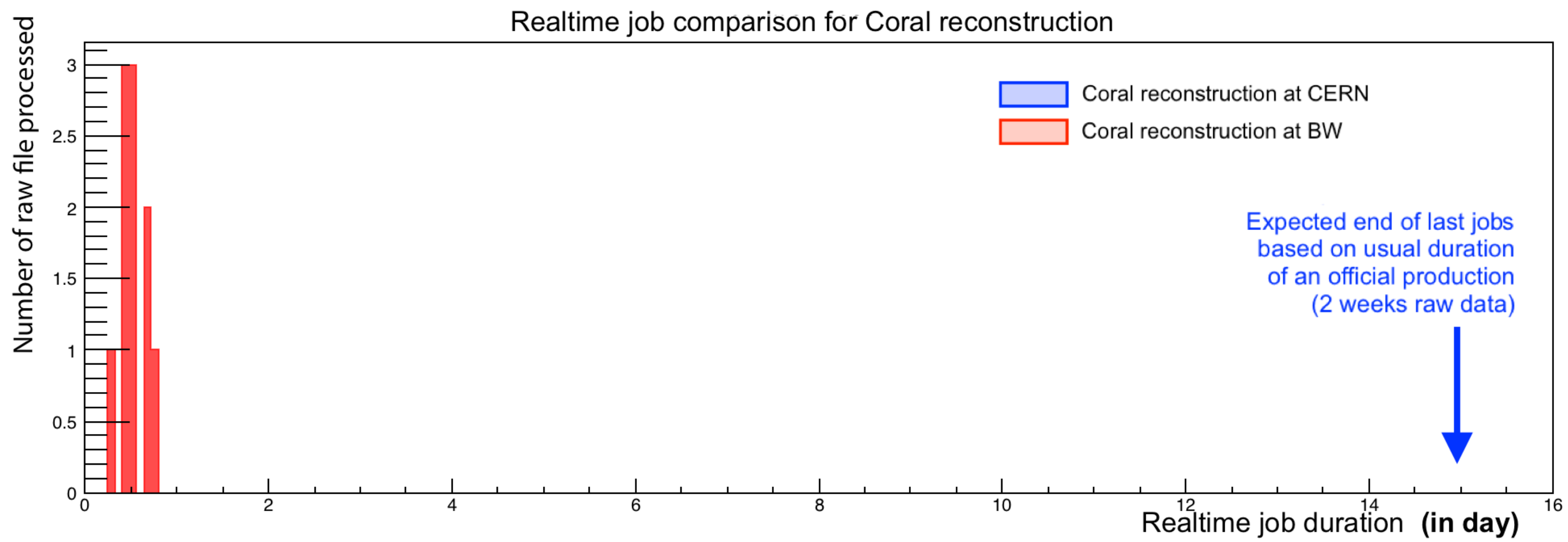
- A especially <u>well designed architecture</u>
  The keyword is the scalability : capacity to process data in parallel without any performance decrease

PARALLEL DATA PROCESSING FOR MASS ANALYSIS

	Usual time unit (realtime processing)
Data taking	7 months
First level production (event reconstruction)	2 weeks of data taking = 2 weeks of production
Second level of production (subselection of events)	2 weeks of data taking = 1/2 day of subselection

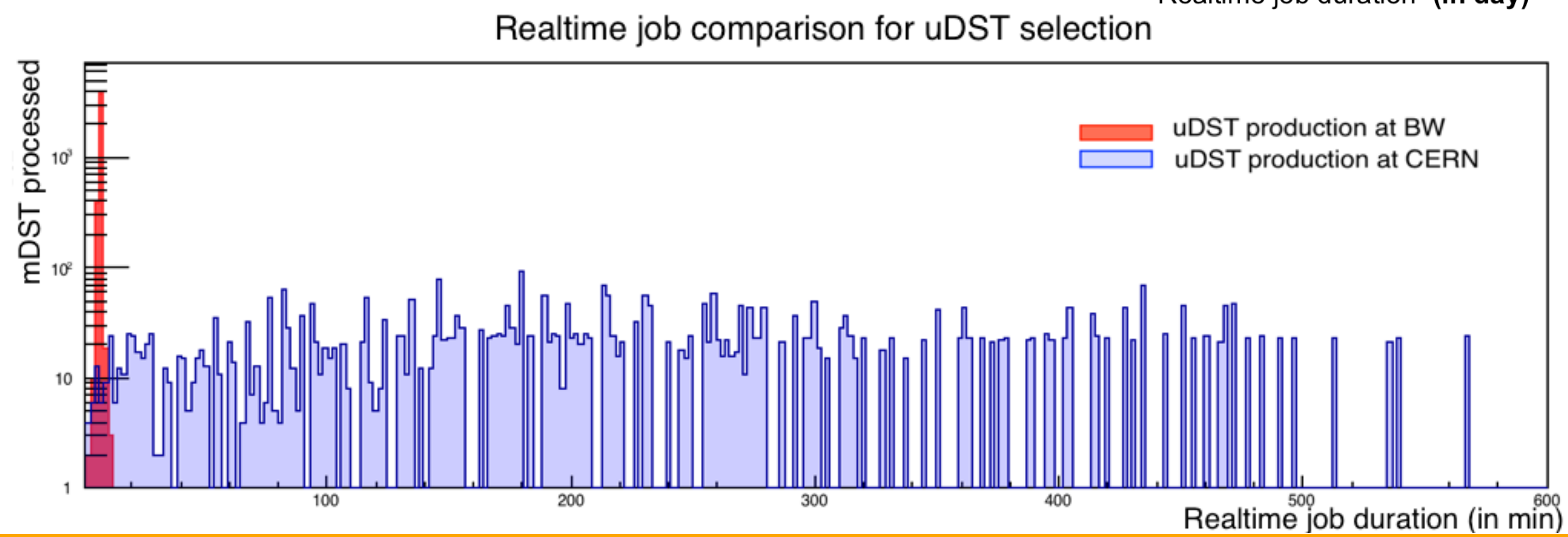
Comparison of first level production between CERN and BW

=> Gain by a factor x15



Comparison of second level production between CERN and BW

=> Gain by a factor x90



- No multi-threading means : **N files to process = only 1 cpu used**

- Multi-threaded software means : **N files are spread over N cpus**

1 file = a set of physics events