Measurement of the Λ_b^0 diff. cross section in pp collisions @ 7 TeV

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2014 New Perspectives - Fermilab

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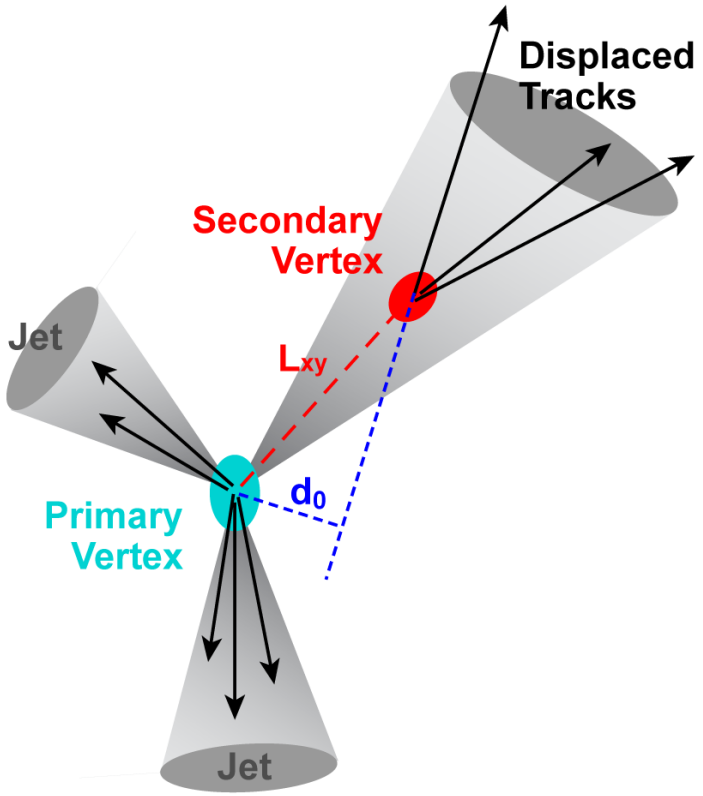
Introduction

- ✓ Cross sections for b-quark production. (centre-of-mass 0.63 – 1.96 TeV @ $p\bar{p}$ colliders , and 7 TeV @ pp colliders at LHC)

- ✓ Progress has been achieved in understanding heavy-quark production. It has helped to resolve discrepancies in theoretical predictions and approaches.

- ✓ It is a window for various searches: Exotic new physics signatures with b quarks.

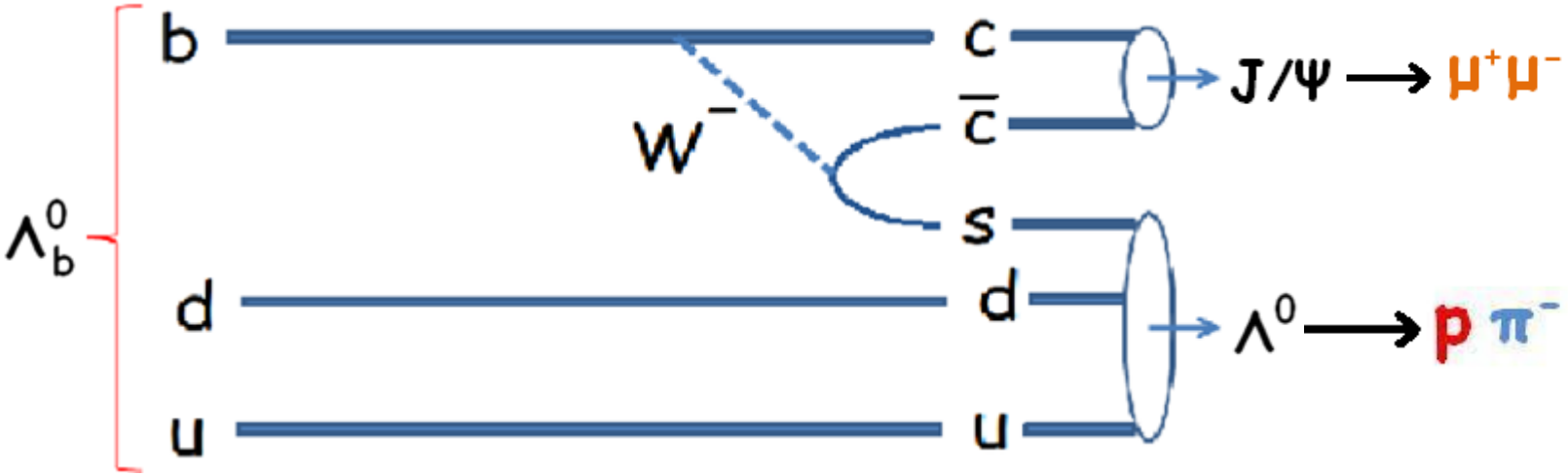


Introduction

- We present a measurement of the cross section of the b-baryon Λ_b^0 in reconstruction of the decay

$$\Lambda_b^0 \longrightarrow \Lambda^0 J/\psi$$

in pp collisions @ LHC with $\sqrt{s}$ = (7 TeV)



Introduction

- ✓ Events with Λ_b^0 baryons from $\Lambda^0 J/\psi$ final state are used to measure the differential cross sections as functions of Λ_b^0 transverse momentum p_T

$$\frac{d\sigma}{dp_T^{\Lambda_b^0}} \times B(\Lambda_b^0 \to \Lambda^0 J/\psi)$$

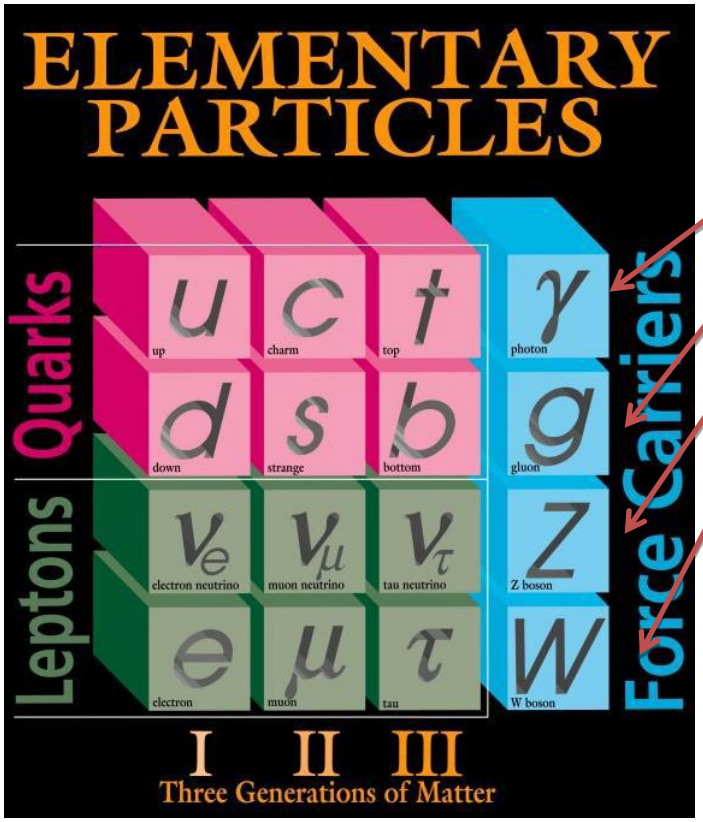
and rapidity |y|

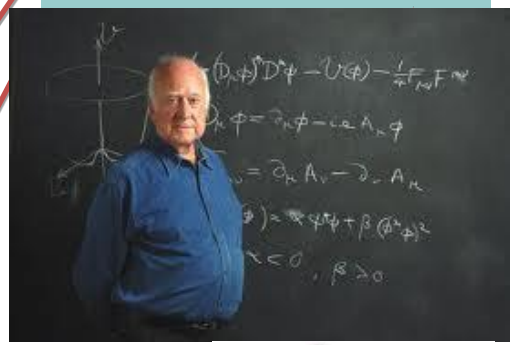
$$\frac{d\sigma}{dy^{\Lambda_b^0}} \times B(\Lambda_b^0 \to \Lambda^0 J/\psi)$$

in the $p_T^{\Lambda_b^0} > 10$ GeV and $y^{\Lambda_b^0} < 2.0$ range.

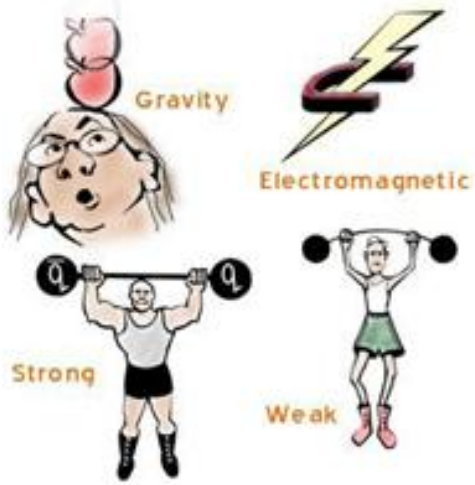
Introduction
The Standard Model

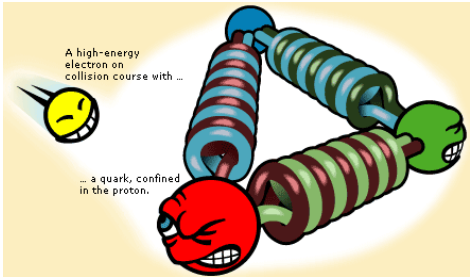
- ✓ Is a theory that describes the interactions between elementary particles consistent with the quantum mechanics and the special relativity.





& Higgs boson





Hadrons

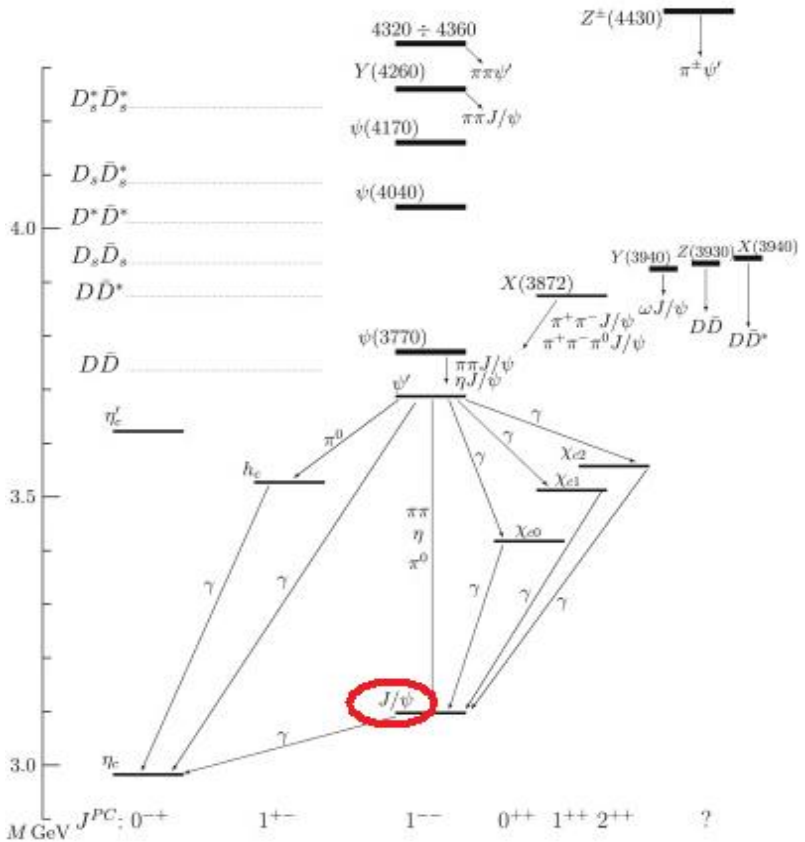
- Baryons
- Mesons

Introduction

- **Mesons (quark - antiquark)** $q\bar{q}$

Meson	Mass (GeV/c²)
Ψ(1s)(J/Ψ)	3.096±0.01

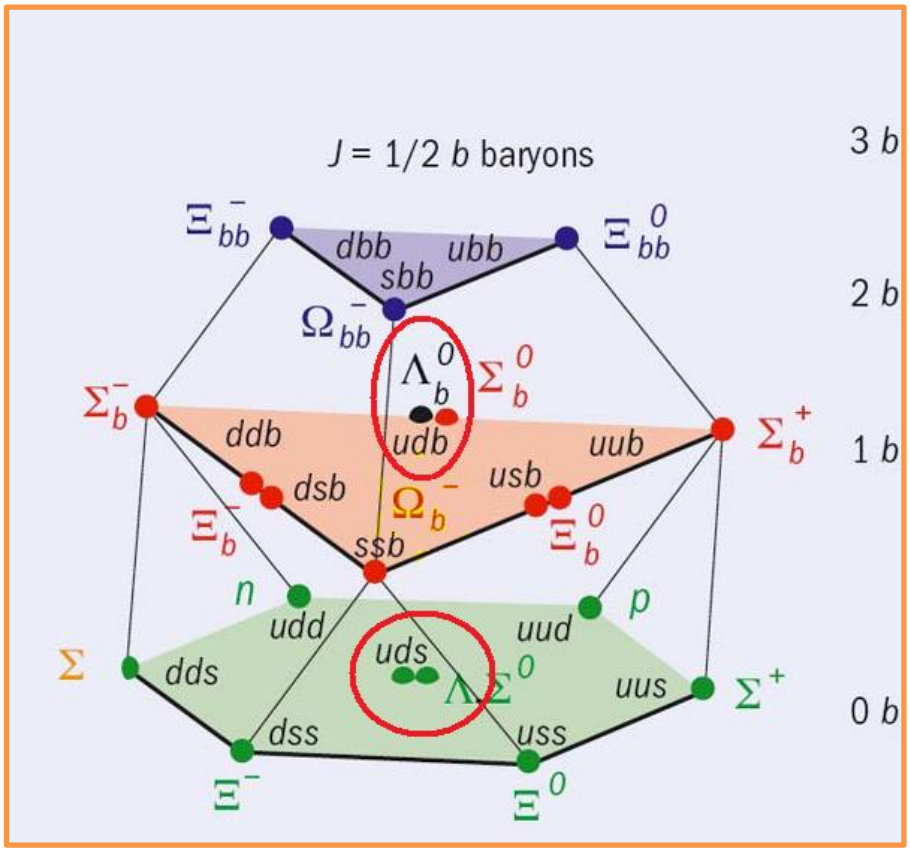
J/Ψ $(c\bar{c})$ **state**



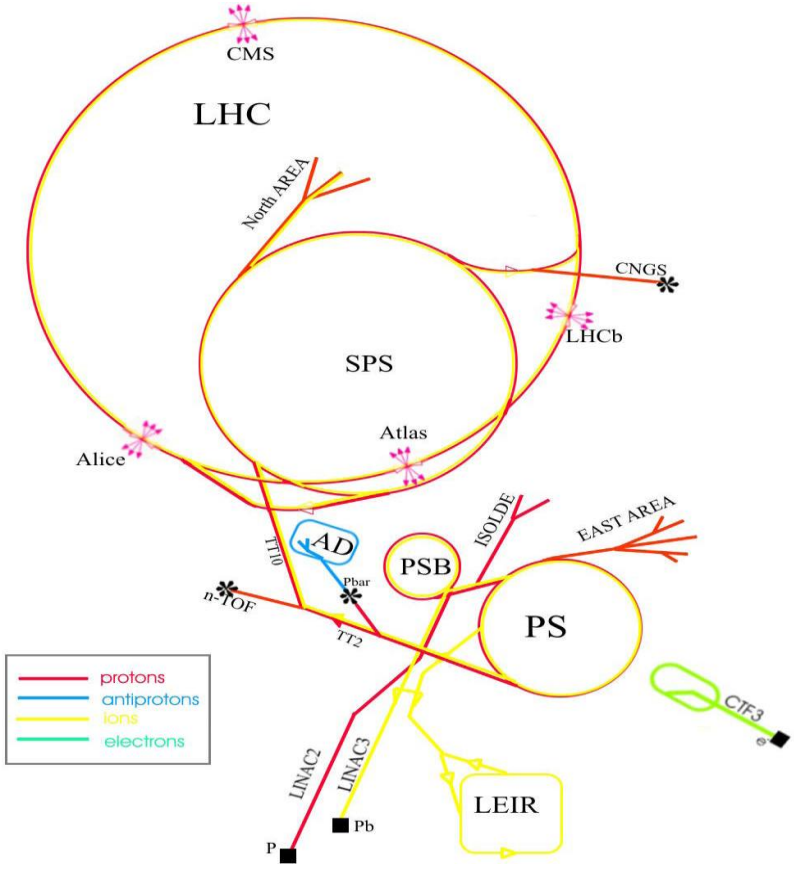
- **Baryons :**

(3 quarks) qqq (3 anti-quarks) $\bar{q}\bar{q}\bar{q}$

Baryon	Mass (GeV/c²)
Λ^0(uds)	1.115±0.006
Λ^0_b(udb)	5.620±0.04



Introduction
Large Hadron Collider



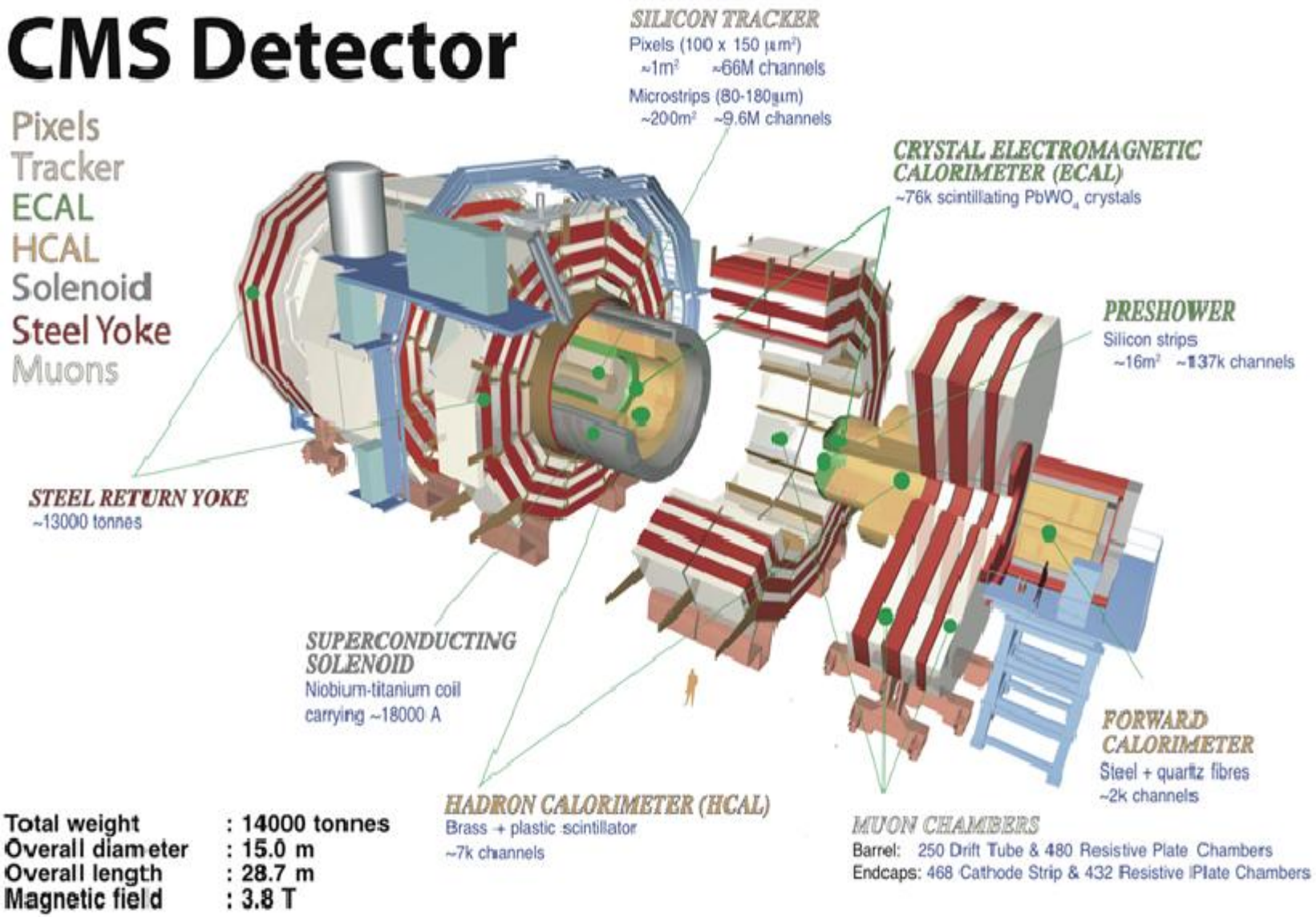
The largest and most powerful particle collider, built by (CERN) to allow physicists test the predictions of different theories of particle physics and high-energy physics.

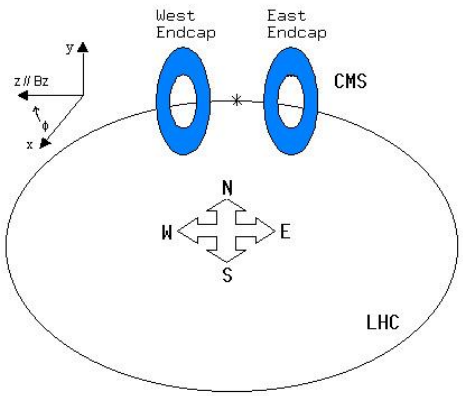
- 27 km circunference
- Collides pp at center-of-mass energy $\sqrt{s}$ = (7 TeV) (8 TeV) (14TeV).

- Proton bunches collide every 25 ns.
- 11000 turns/sec.
- $L = 10^{34}\ cm^{-2}\ s^{-1}$

Introduction

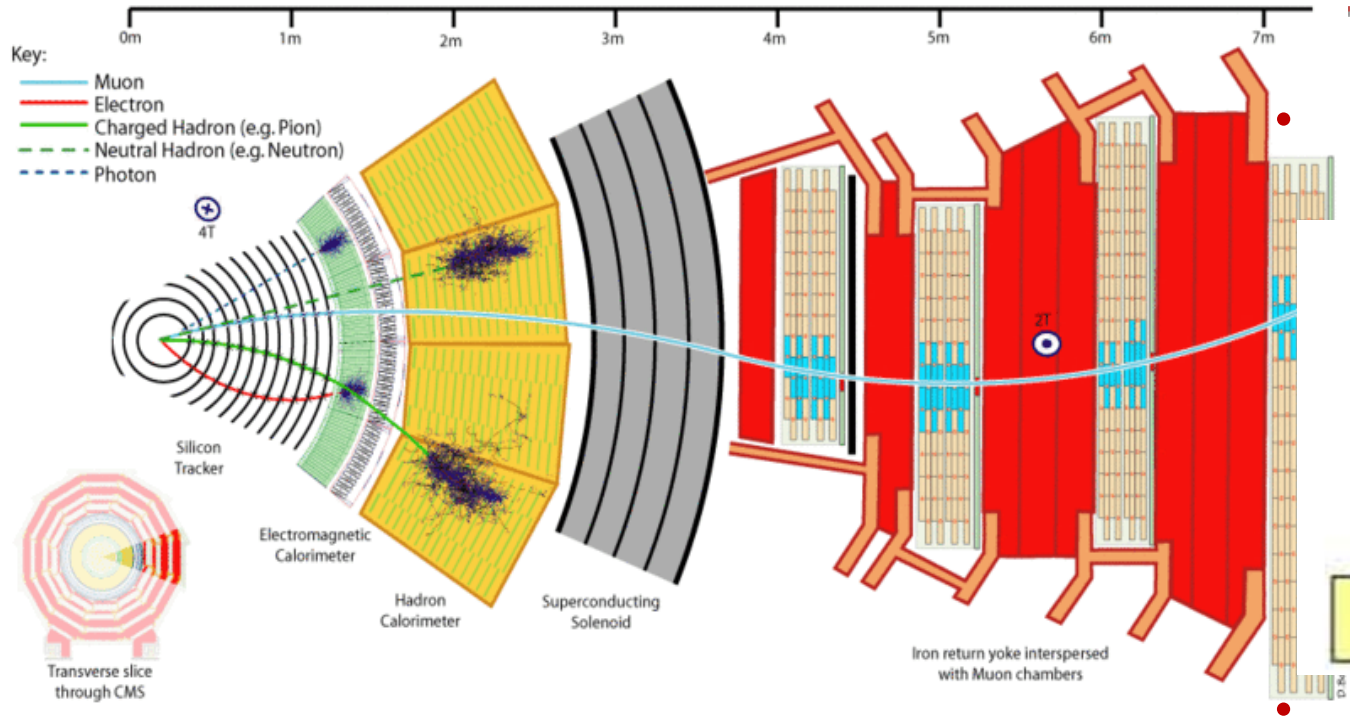
The Compact Muon Solenoid (CMS)



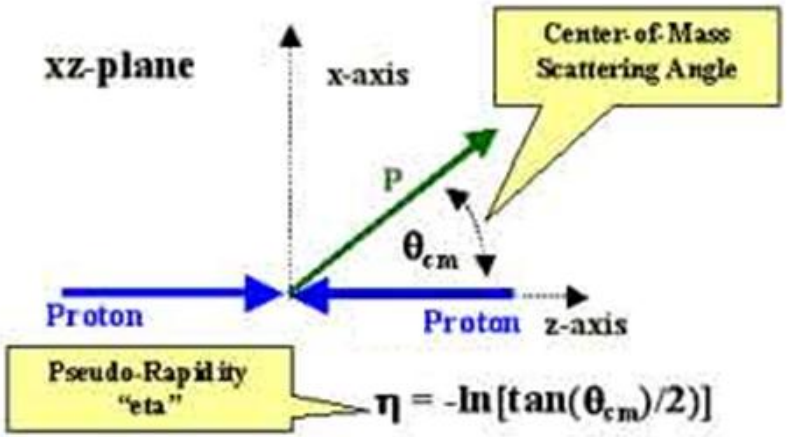


- CMS is an experiment to investigate a wide range of physics, including the search for the Higgs boson, extra dimensions, and particles that could make up dark matter.

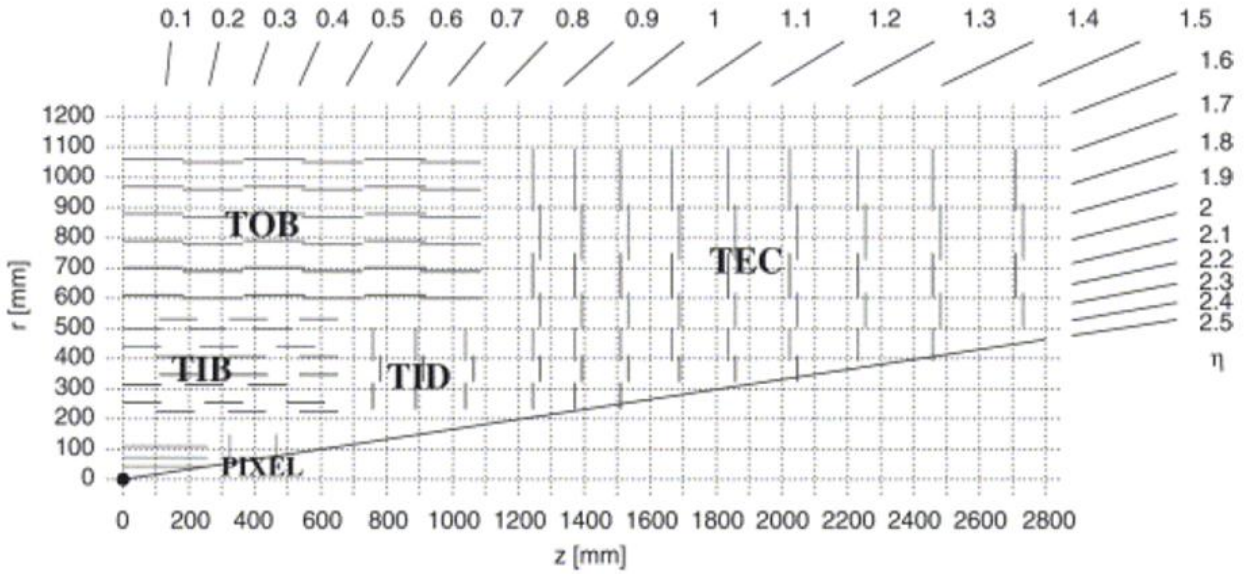
- Transversal view



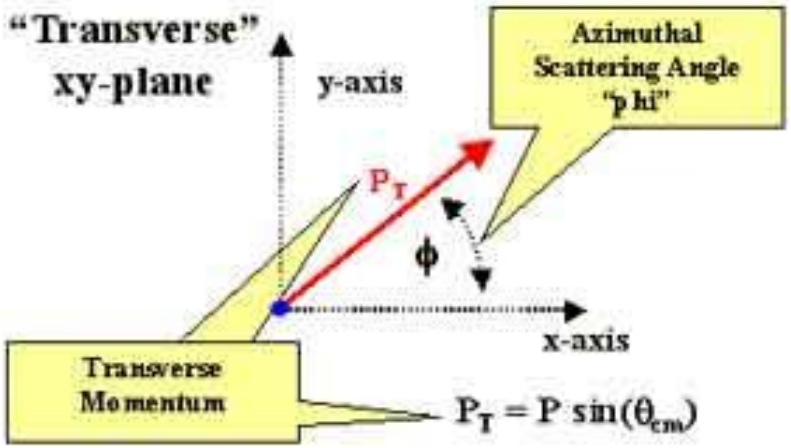
- Pseudorapidity η



- Longitudinal view

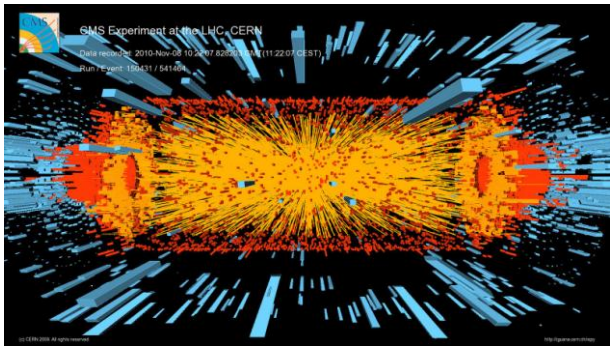


- Transverse momentum P_T



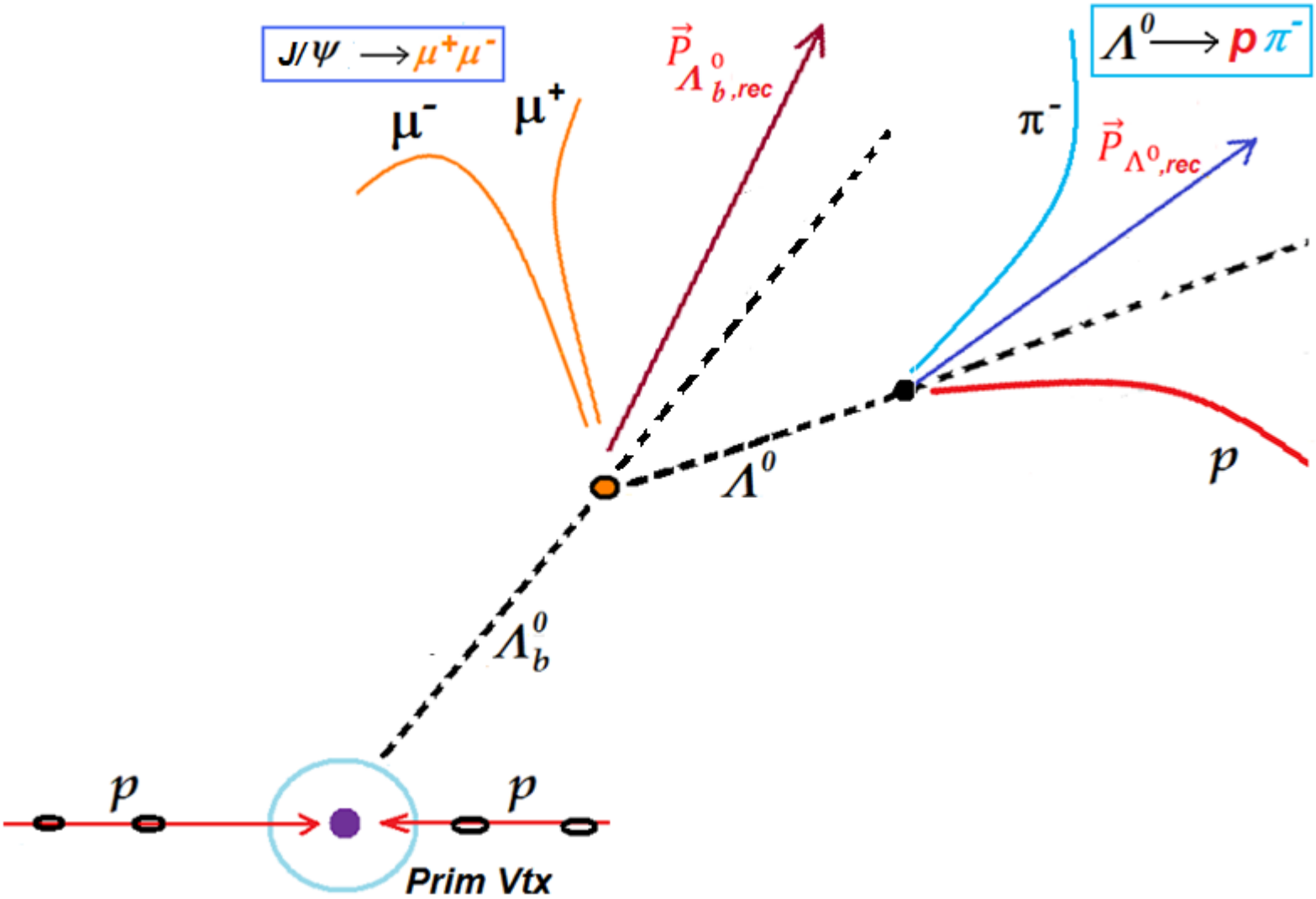
Data

- Collected by the CMS Experiment recorded in 2011
- Integrated Luminosity : 1.86 fb^{-1}
- Center-of-mass energy : $\sqrt{s}$ = 7 TeV



Λ_b^0 Topology decay

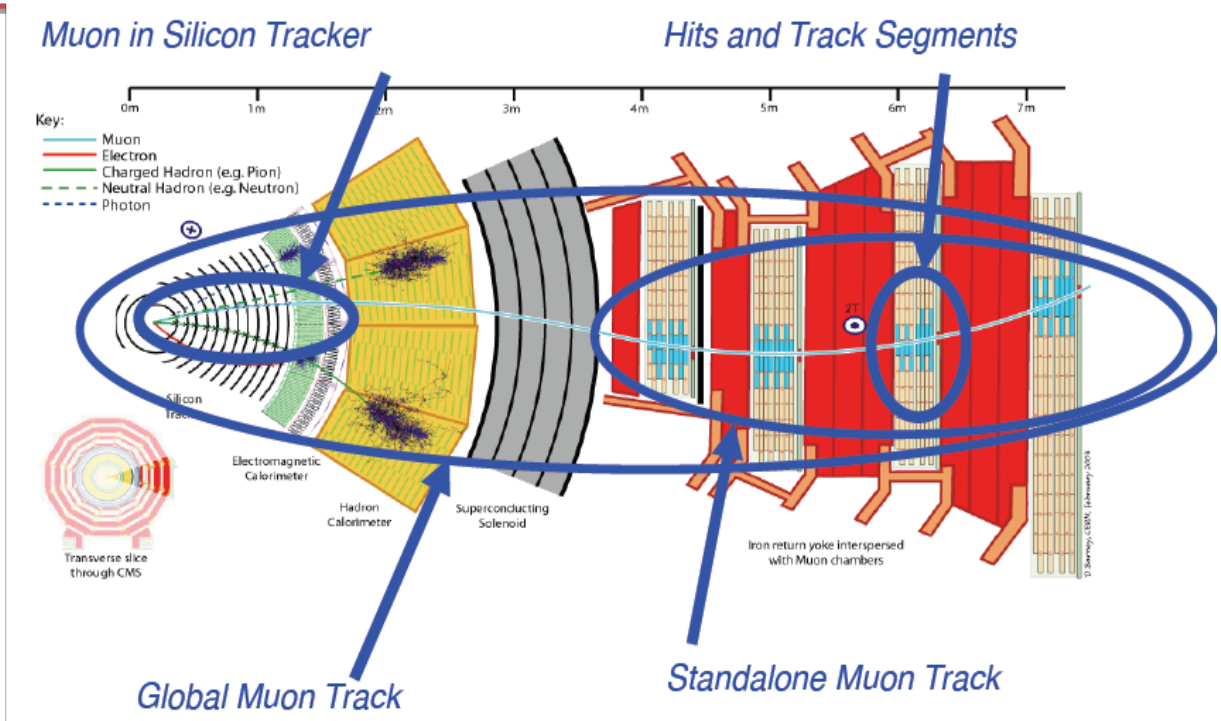
CMS Volume



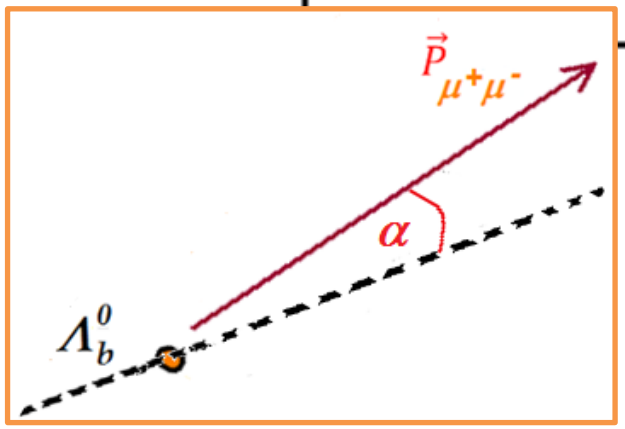
Event selection

$\mu^+\mu^-$ Candidates

- ✓ Opp. Charged dimuon pair
- ✓ $P_T^{\mu^+\mu^-} > 6.9$ GeV
- ✓ Displacement from prim. Vtx. (Signif.)
  $(L / \sigma_L)_{xy} > 3$
- ✓ Vtx Conf. Level $CL_{Vtx}^{\mu^+\mu^-}$ >0.5 %
- ✓ Pointing angle primary Vtx.- Λ_b^0
  $\cos(\alpha_{prim-\mu^+\mu^-}) > 0.95$



$$\cos\alpha_{prim-\mu^+\mu} = \frac{(\vec{V}_{\mu^+\mu} - \vec{V}_{primary}) \cdot \vec{P}_{\Lambda_b^0}}{|\vec{V}_{\mu^+\mu} - \vec{V}_{primary}||\vec{P}_{\Lambda_b^0}|}$$



Event selection

$\mu^+\mu^-$ Candidates

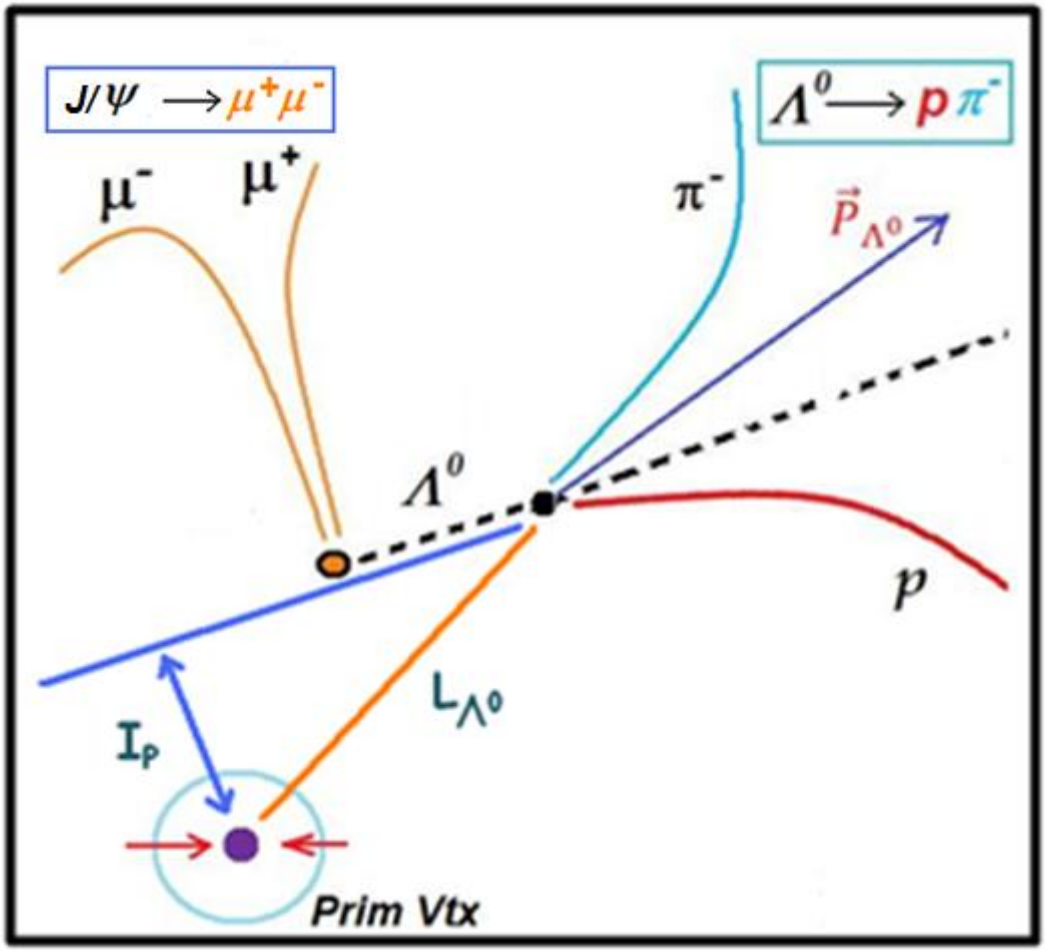
- ✓ $P_T^{\mu} > 3.5$ GeV
- ✓ Track muons be inside $|\eta_\mu| < 2.2$ region
- ✓ Dimuon pair required to be within 150 MeV/c^2 around J/Ψ nominal mass

$$| M_{\mu^+\mu^-} - M^{PDG}_{J/\psi} | < 150 \text{ MeV}/c^2$$

Event selection

Λ^0 —> p π^- Candidates

- ✓ Imp. Parameter (I_p / σ) > 0.5
- ✓ Displacement from prim. Vtx. (L / σ_L) $_{xy}$ > 5
- ✓ | $M_{p\pi}$ – $M^{PDG}_{\Lambda^0}$ | < 8 MeV/c^2



Event selection

Λ_b^0 Candidates

✓Combination of Λ^0 and J/Ψ candidates.

✓ Fit dimuon at the Vtx by constraining $M_{\mu^+\mu}$ to the nominal mass J/Ψ if $M_{\mu^+\mu^-}$ falls around 150 MeV/c^2 around J/Ψ resonances.

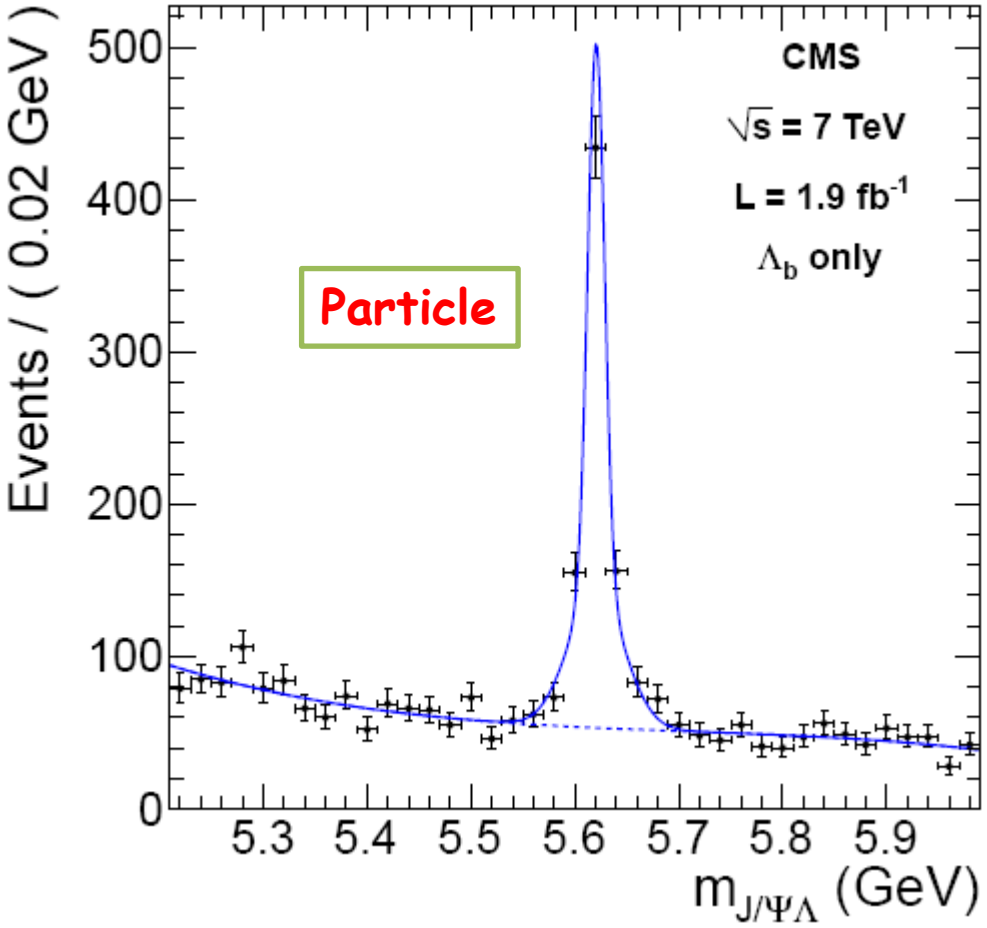
✓ Cl_{massC} > 1%

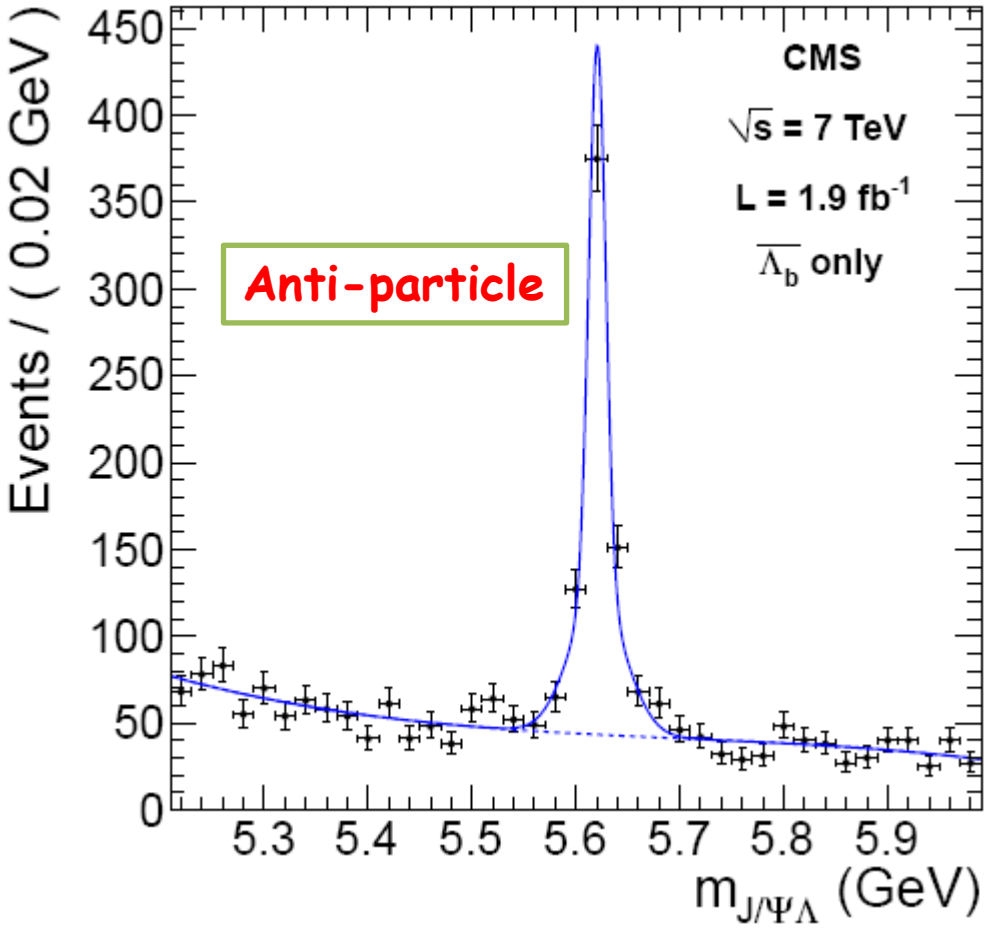
✓5.2 < $M_{J/\Psi\Lambda^0}$ < 6.0 GeV/c^2

Results

Fitting procedure:

✓ $M_{J/\psi\ \Lambda^0}$ is adjusted in signal through double-Gaussian function and background is modeled with 3rd order polynomial.





Results

✓ Λ_b^0 differential cross section is calculated in bins of $P_T^{\Lambda_b^0}$

$$\frac{d\sigma(pp \to \Lambda_b^0 X)}{dP_T^{\Lambda_b^0}} \times B(\Lambda_b^0 \to J/\Psi \Lambda^0) = \frac{n_{sig}}{2 \cdot \epsilon \cdot B \cdot L \cdot \Delta P_T^{\Lambda_b^0}}$$

…& similar for |y|

Bin size

for Branching fractions

$B(J/\Psi \to \mu^+\mu^-) = (5.93 \pm 0.06) \times 10^{-2}$

×

$B(\Lambda^0 \to p\pi^-) = 0.639 \pm 0.005$

ϵ -> Efficiency for Λ_b^0 & $\bar{\Lambda}_b^0$ to pass selection criteria

L -> Luminosity

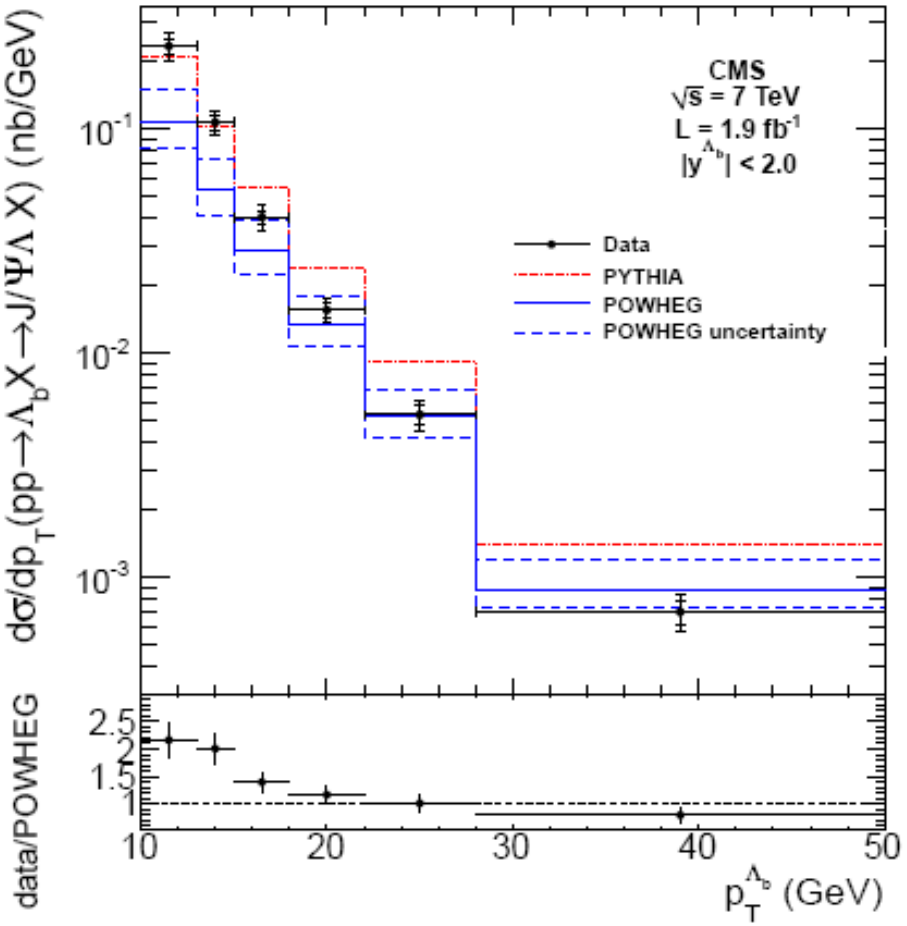
Results

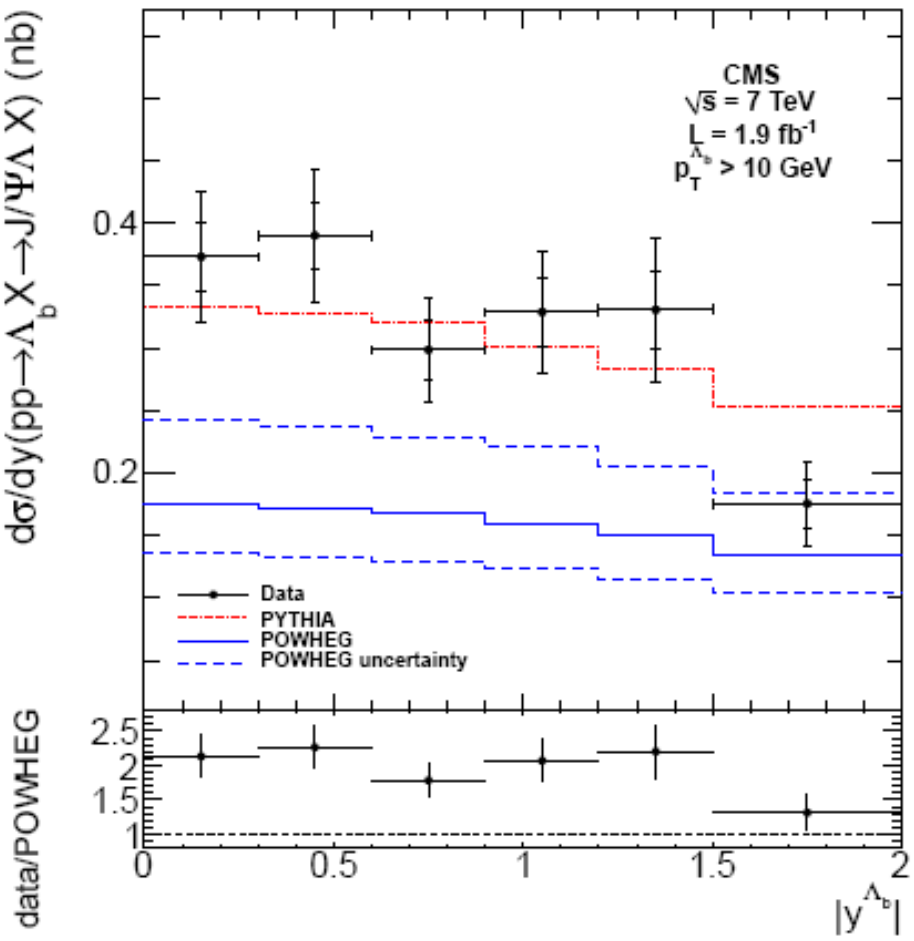
Fitted signal yields in bin of Λ_b^0 P_T and |y|

$p_T^{\Lambda_b}$ (GeV)	n_{sig} events	ϵ (%)	$d\sigma/dp_T^{\Lambda_b} \times \mathcal{B}(\Lambda_b \to J/\psi\Lambda)$ (pb/GeV)
$10-13$	293 ± 22	0.29 ± 0.03	$240 \pm 20 \pm 30$
$13-15$	240 ± 18	0.79 ± 0.08	$108 \pm 8 \pm 12$
$15-18$	265 ± 19	1.54 ± 0.16	$41 \pm 3 \pm 4$
$18-22$	207 ± 16	2.34 ± 0.23	$15.6 \pm 1.2 \pm 1.6$
$22-28$	145 ± 14	3.21 ± 0.34	$5.3 \pm 0.5 \pm 0.6$
$28-50$	87 ± 11	3.96 ± 0.50	$0.70 \pm 0.09 \pm 0.09$
$\lvert y^{\Lambda_b} \rvert$	n_{sig} events	ϵ (%)	$d\sigma/dy^{\Lambda_b} \times \mathcal{B}(\Lambda_b \to J/\psi\Lambda)$ (pb)
$0.0-0.3$	233 ± 17	0.74 ± 0.09	$370 \pm 30 \pm 50$
$0.3-0.6$	256 ± 18	0.77 ± 0.09	$390 \pm 30 \pm 50$
$0.6-0.9$	206 ± 16	0.81 ± 0.09	$300 \pm 20 \pm 30$
$0.9-1.2$	196 ± 17	0.70 ± 0.08	$330 \pm 30 \pm 40$
$1.2-1.5$	189 ± 17	0.67 ± 0.09	$330 \pm 30 \pm 50$
$1.5-2.0$	162 ± 18	0.65 ± 0.09	$180 \pm 20 \pm 30$

Results

Measured diff. cross sec. times B vs. Λ_b^0 P_T and |y|



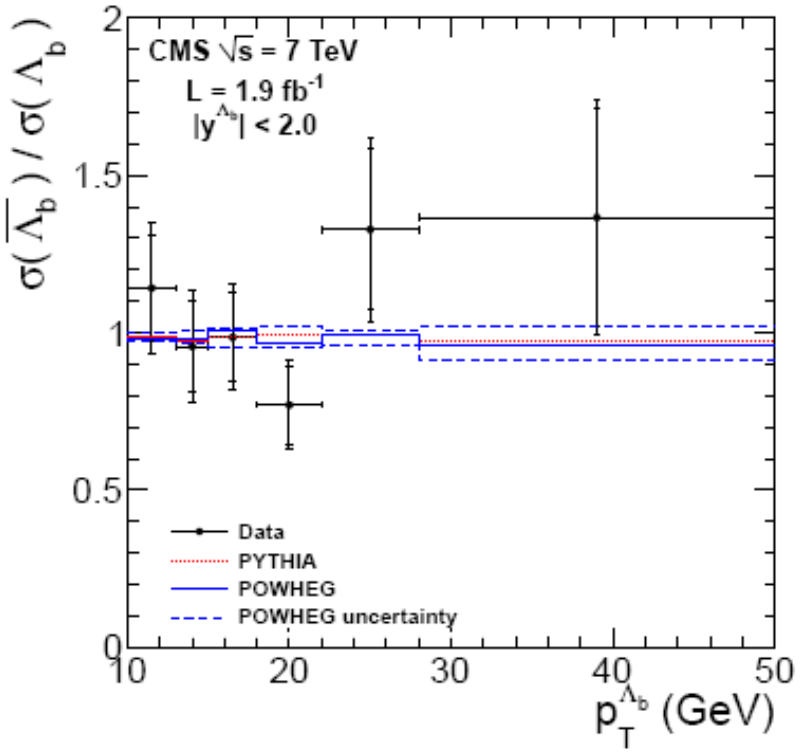


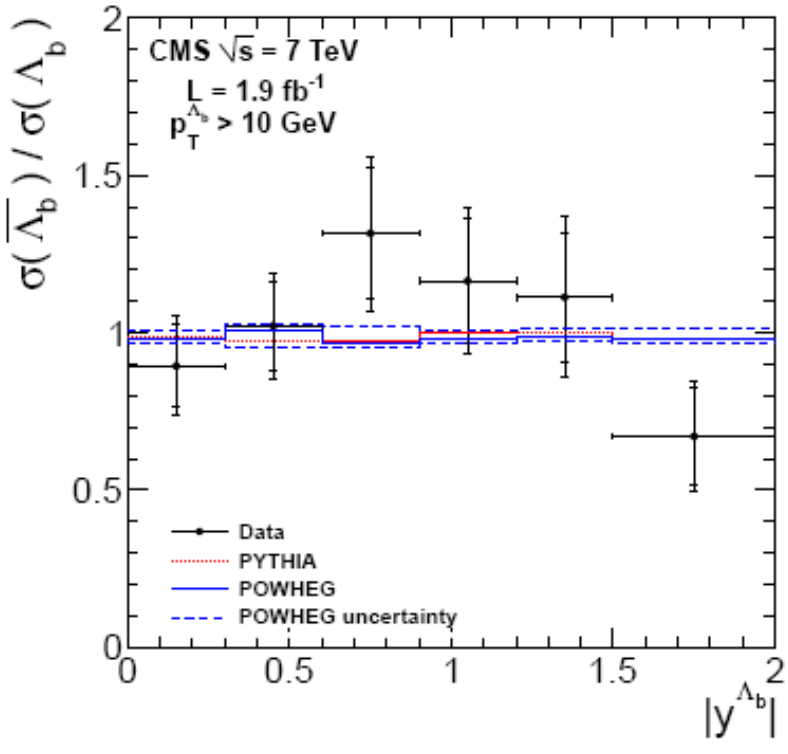
Conclusions

- Measurements of Λ_b^0 diff. cross sections in terms of its $P_T^{\Lambda_b}$ and $|y^{\Lambda_b}|$ have been presented.

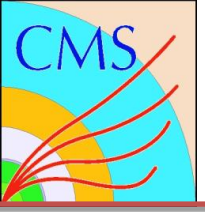
- The cross section anti-particle/particle ratio is also measured in $P_T^{\Lambda_b}$ or $|y^{\Lambda_b}|$ bins.

$$\sigma(\overline{\Lambda}_b)/\sigma(\Lambda_b) = \frac{n_{sig}^{\overline{\Lambda}_b}}{n_{sig}^{\Lambda_b}} \times \frac{\epsilon(\Lambda_b)}{\epsilon(\overline{\Lambda}_b)}$$





Phys. Lett. B 714 (2012) 136 – 157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Thank you

Questions…