SM and B physics results

with an emphasis on B physics

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on behalf of Swiss institutes participating in the CMS collaboration
(ETHZ, PSI, UZH)

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Overview

Introduction

A new baryon: Ξ_b^{*0}

Testing the SM: $B_s \to \mu^+\mu^-$

- Generic pixel resolution study for $B_s \to \mu^+\mu^-$

b-Hadrons

- Λ_b lifetime

Other measurements worth mentioning

Conclusions

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Introduction

Besides the exciting results on the search for the Higgs...

- There is other interesting physics in its shadow
- Solid understanding of SM properties crucial for all searches
- Some SM physics is sensitive to possible new physics
- A large number of analysis in this field with a lot of Swiss contributions

I want to talk about some of these exciting things. I had to make a certain choice for this talk and I take all blame on me for doing possibly wrong choices.

All images courtesy CMS and the respective working groups (except where explicitely stated)

Credits given to institutes involved are in brackets.

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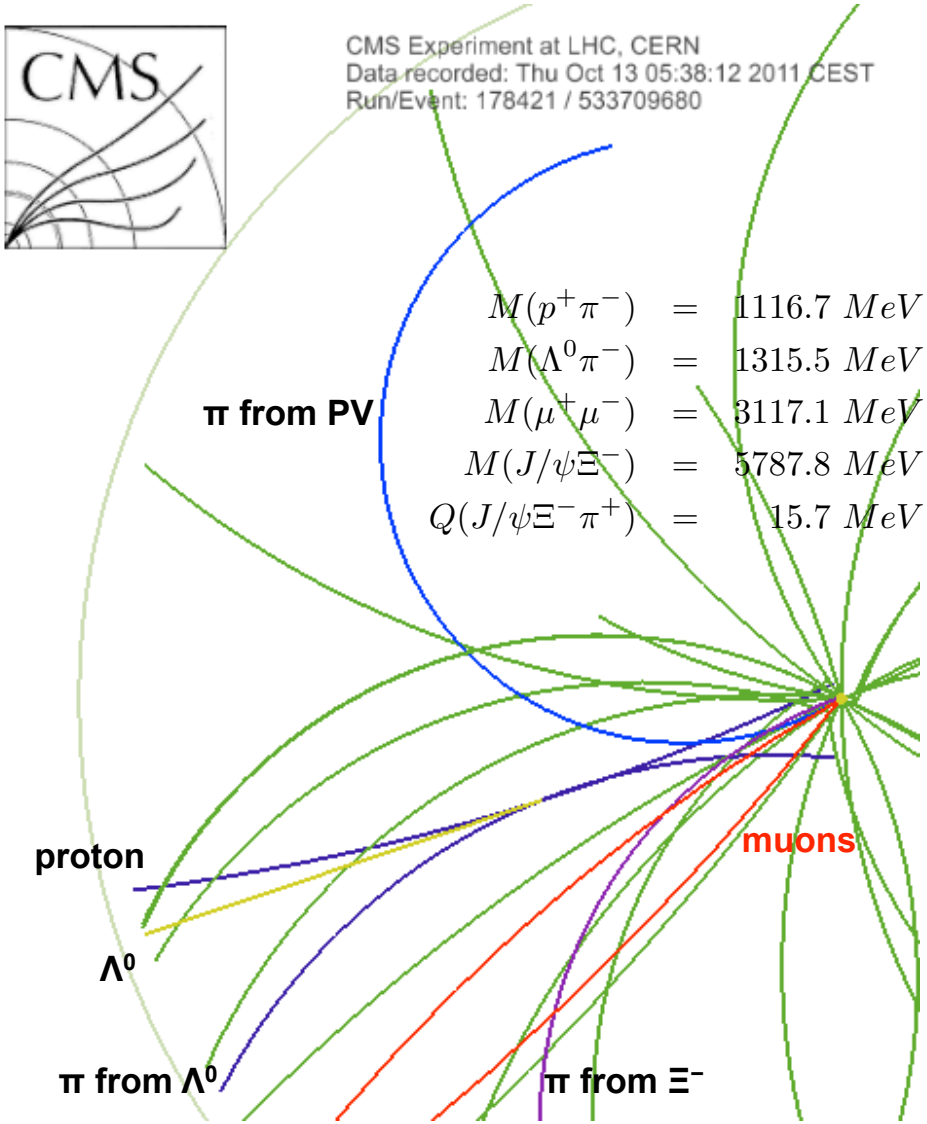
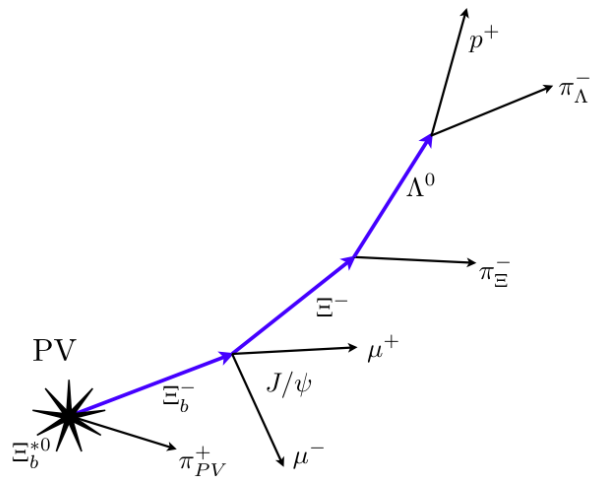
A new baryon: Ξ_b^{*0}



Required to reconstruct

- 5 tracks, 2 vertices (Λ^0 and J/ψ) to form a Ξ_b^-
- combine additional track from primary vertex (PV)

all in harsh environment.



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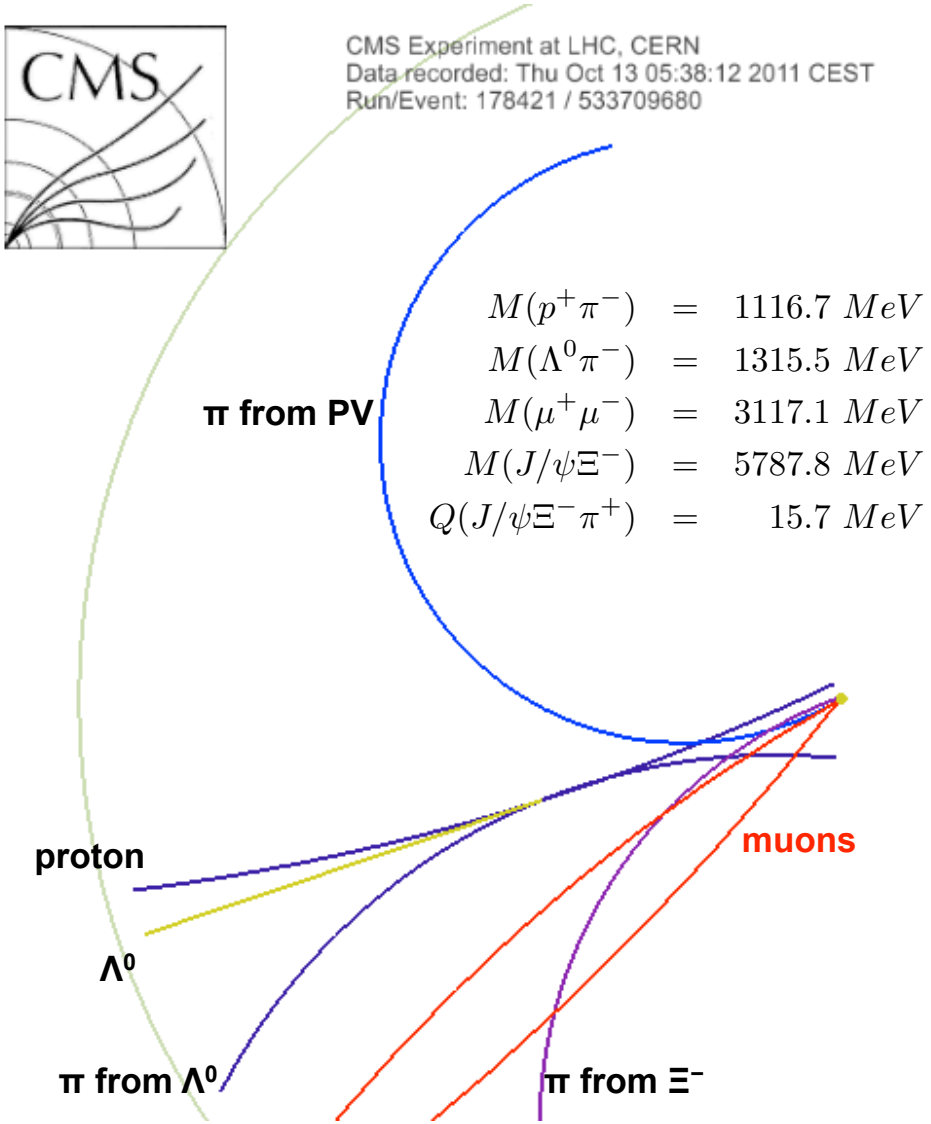
A new baryon: Ξ_b^{*0}



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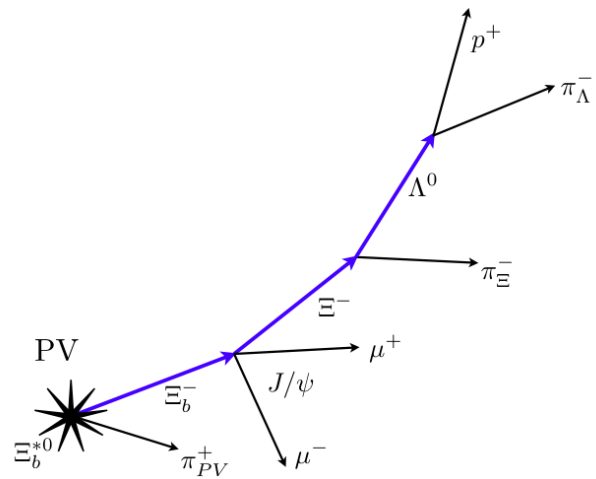

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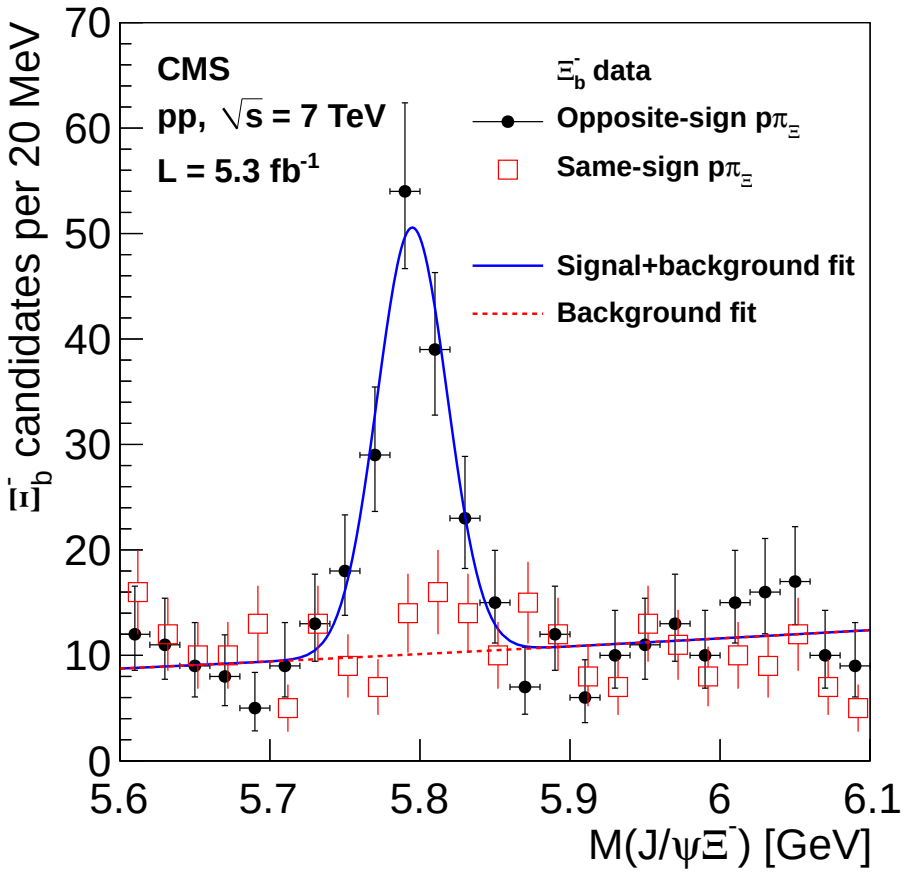
A new baryon: Ξ_b^{*0}



And all this lead to the first new baryon detected at CMS. (UZH, Phys. Rev. Lett. 108, 252002 (2012))

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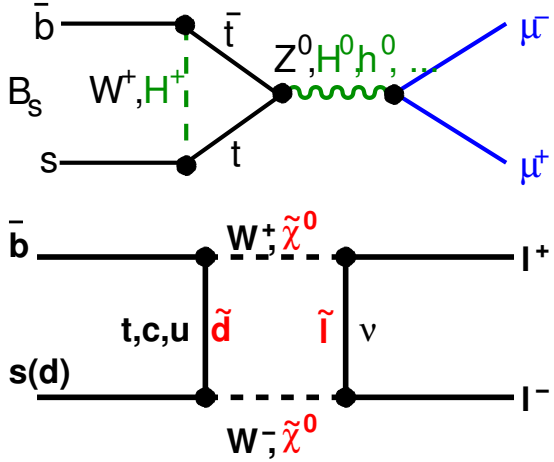
Testing the SM: $B_s \to \mu^+\mu^-$



- Highly suppressed in SM
  $BF(B_s \to \mu\mu) = (3.2 \pm 0.2) \cdot 10^{-9}$
  $BF(B^0 \to \mu\mu) = (1.0 \pm 0.1) \cdot 10^{-10}$
- Has sensitivity to new physics and poses constraints to parameter regions in several BSM models

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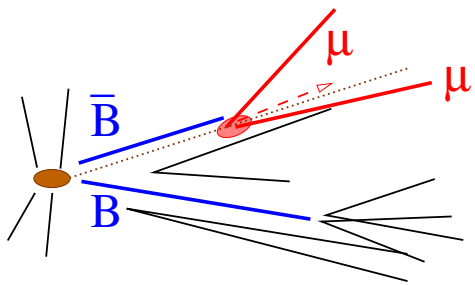

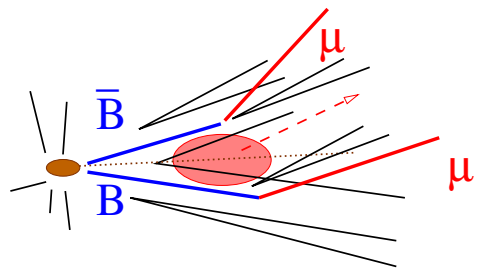

Signal has just two muons from one vertex of a long living B at a known invariant mass

Background:

- two semileptonic B decays
- semileptonic + misidentified muon
- other rare decays

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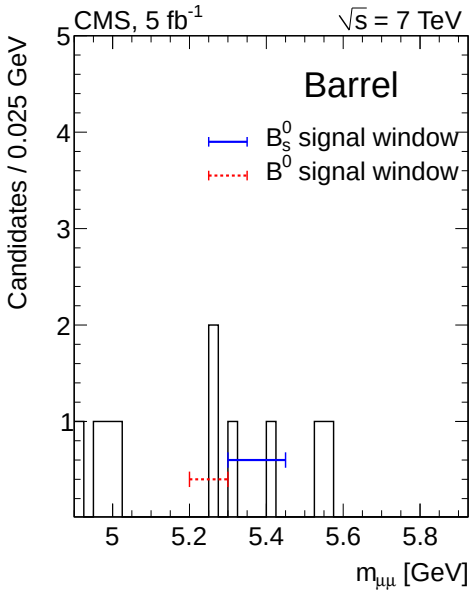
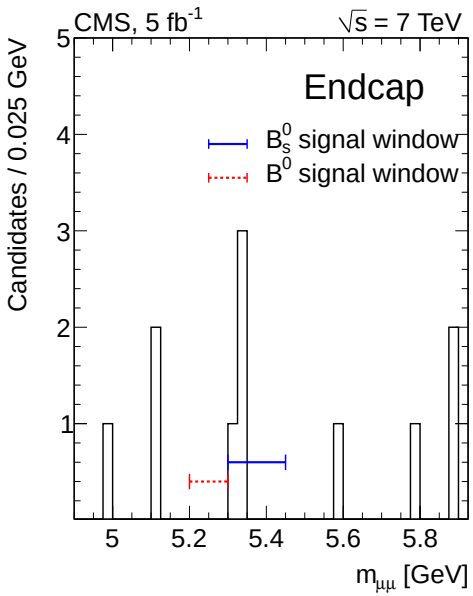
Testing the SM: $B_s \to \mu^+\mu^-$





- Blind analysis
- Observed upper limits:

	95%CL	expected
$BF(B_s \to \mu\mu)$:	$7.7 \cdot 10^{-9}$	$(3.2 \pm 0.2) \cdot 10^{-9}$
$BF(B^0 \to \mu\mu)$:	$1.8 \cdot 10^{-9}$	$(1.0 \pm 0.1) \cdot 10^{-10}$

J. High Energy Phys. 04 (2012) 033

- Analysis will be updated:
  - more integrated luminosity
  - more sophisticated statistical methods under development to increase sensitivity (multivariate analysis)

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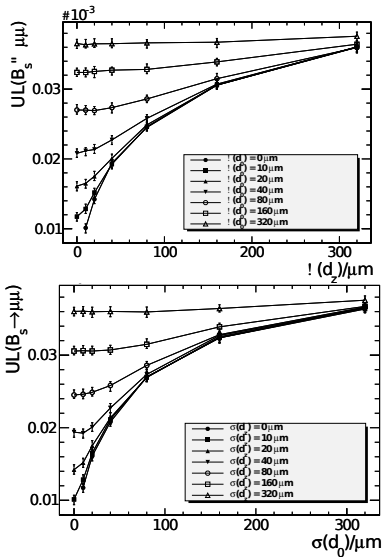
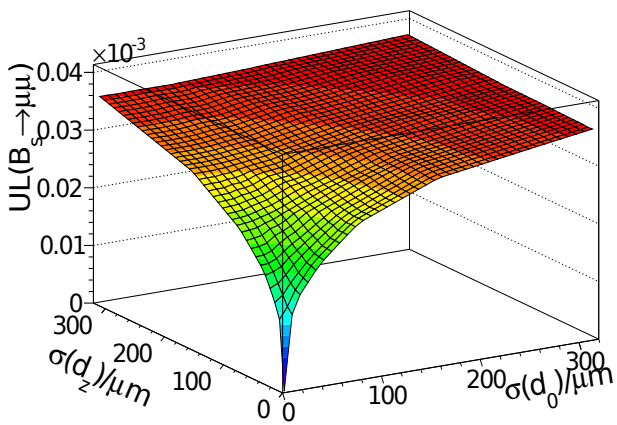
Testing the SM: $B_s \to \mu^+\mu^-$

pixel detector resolution (impact parameter) $\leftrightarrow$ physics performance e.g. $B_s \to \mu^+\mu^-$





$$\sqrt{\sigma^2(d_z) + \sigma^2(d_0)} = 1/\text{"Quality"}$$

Generic impact resolution study with CMS like $B_s \to \mu^+\mu^-$ analysis to understand optimal detector design choice

Plot shows resolution limited case (no multiple scattering)

Balanced choice: $\sigma(d_z) \approx \sigma(d_0)$

Presented at Pixel2012 (PSI/ETHZ)

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b-Hadrons

- **B_s lifetime difference**

  $\Delta\Gamma_s$ is probably sensitive to new physics, ϕ_s is it. CMS will soon have a $\Delta\Gamma_s$ measurement, plans for ϕ_s evolving. (UZH)

- **Λ_b lifetime**

  Still a puzzle. I will elaborate more on that (PSI/ETHZ)

- **Λ_b polarization**

  Not much is known about b-Hadron production. Double differential cross-section done by CMS, polarization under way. (UZH)

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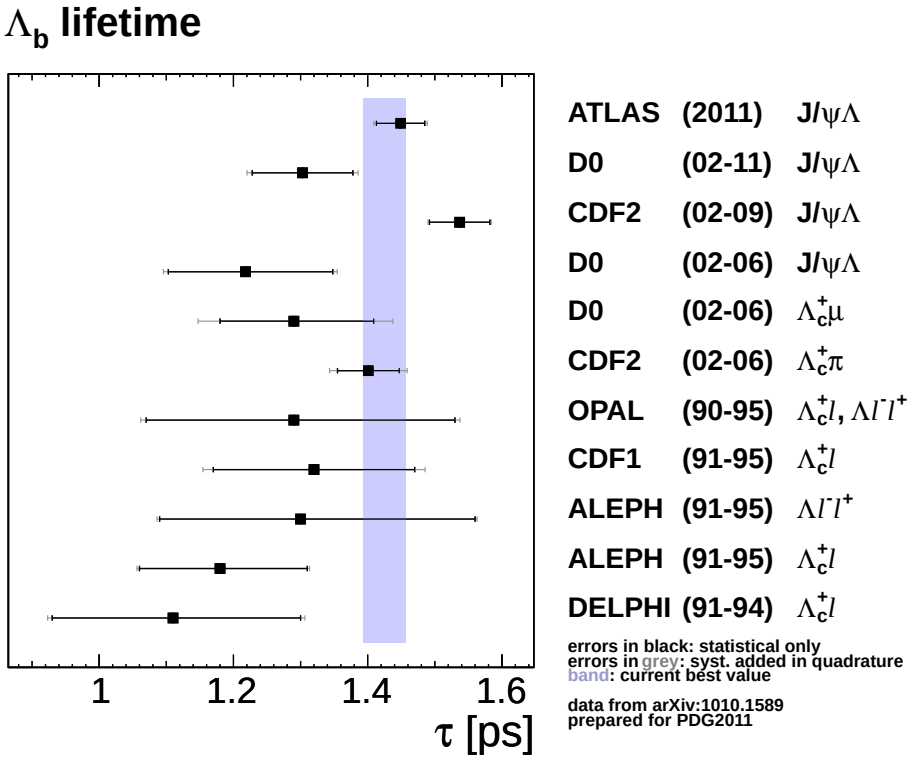
b-Hadrons: Λ_b lifetime



- Still a puzzle
- Theory:

$$\tau(B_c^+) \ll \tau(\Lambda_b)$$

$$< \bar{\tau}(B_s^0) \approx \tau(B^0) < \tau(B^+)$$

- CMS has a measurement soon

Some measured values (arXiv:1010.1589):

Lifetime ratio	Measured value	Predicted range
$\tau(B^+)/\tau(B^0)$	1.081 ± 0.006	$1.04 - 1.08$
$\bar{\tau}(B_s^0)/\tau(B^0)$	0.973 ± 0.015	$0.99 - 1.01$
$\tau(\Lambda_b)/\tau(B^0)$	0.939 ± 0.022	$0.86 - 0.95$

Using $\bar{\tau}(B_s^0) = 1/\Gamma_s = 2/(\Gamma_L + \Gamma_H)$

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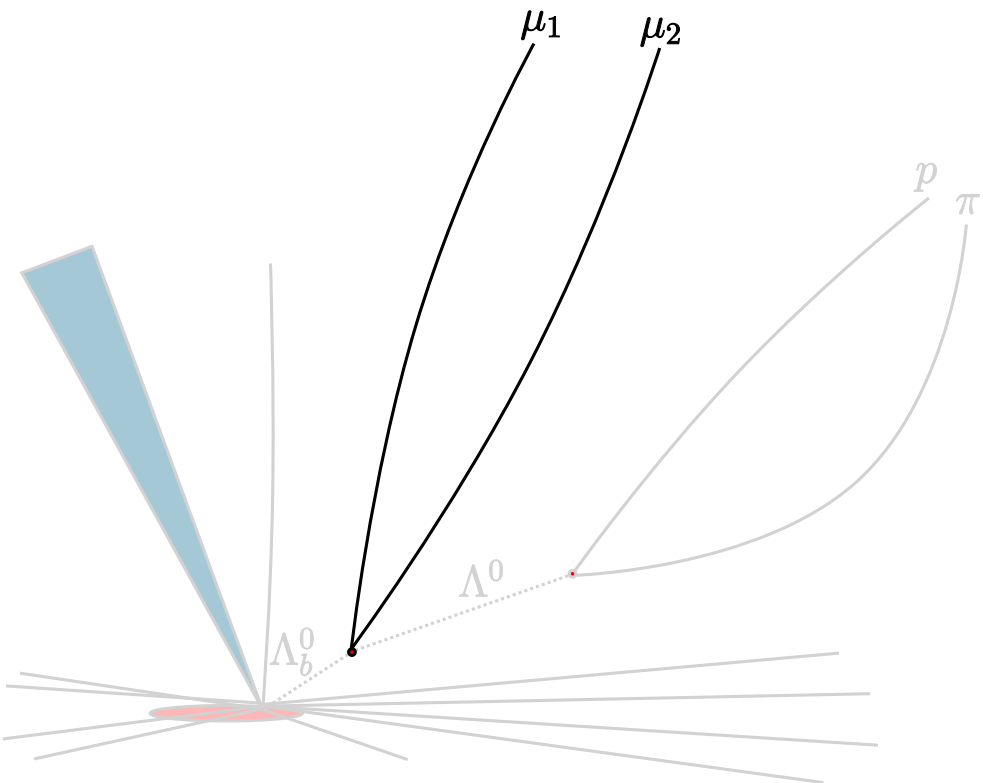
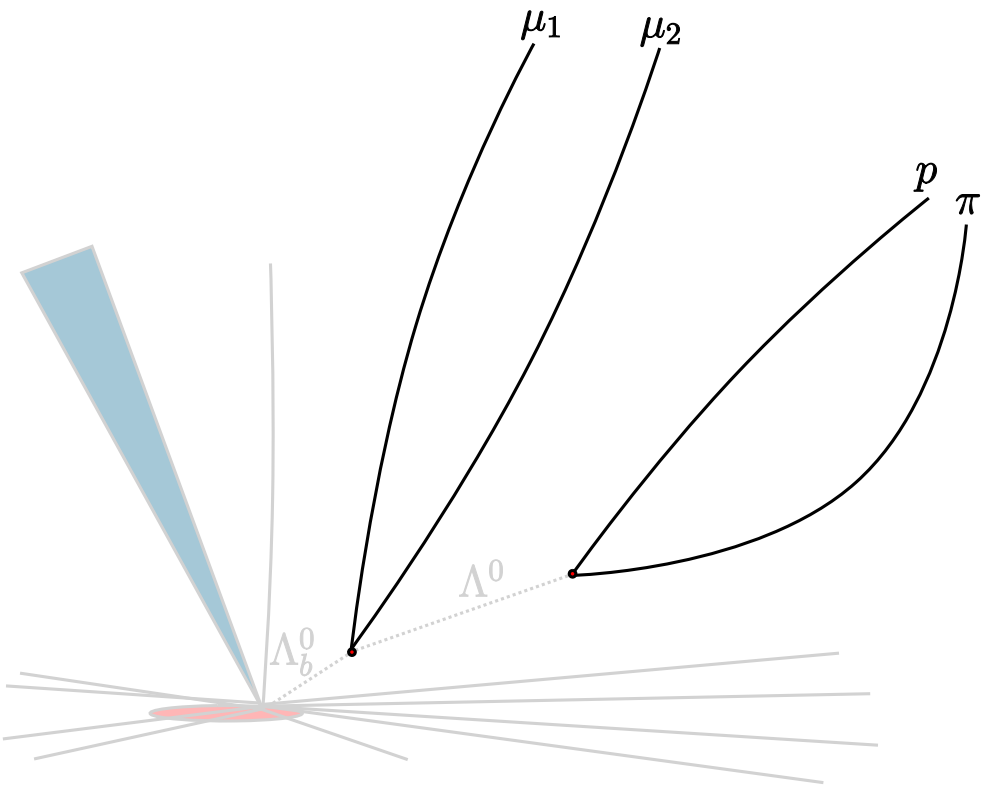
b-Hadrons: Λ_b lifetime event selection



We trigger on two muons fulfilling an invariant mass around $m(\mathrm{J}/\psi)$

Certain triggers also ask for a detached primary vertex but we don't use them.

b-Hadrons: Λ_b lifetime event selection



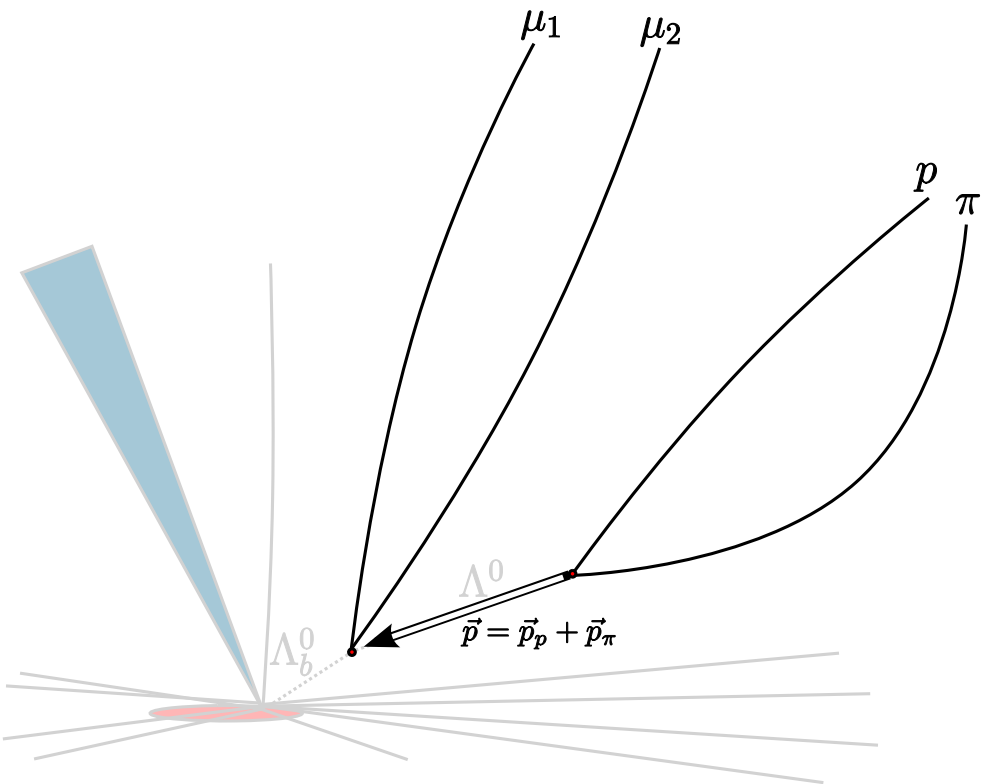
Then look for two more tracks in the event.

We assign the particle hypothesis grace to $p(\mathrm{p}) > p(\pi)$ (holds throughout our kinematic regime)

We proceed if their invariant mass is around $m(\Lambda^0)$.

$m(\mathrm{J}/\psi) = 3.095, m(\Lambda^0) = 1.116, m(p) = 0.938, m(\pi) = 0.1396$ all in GeV/c^2

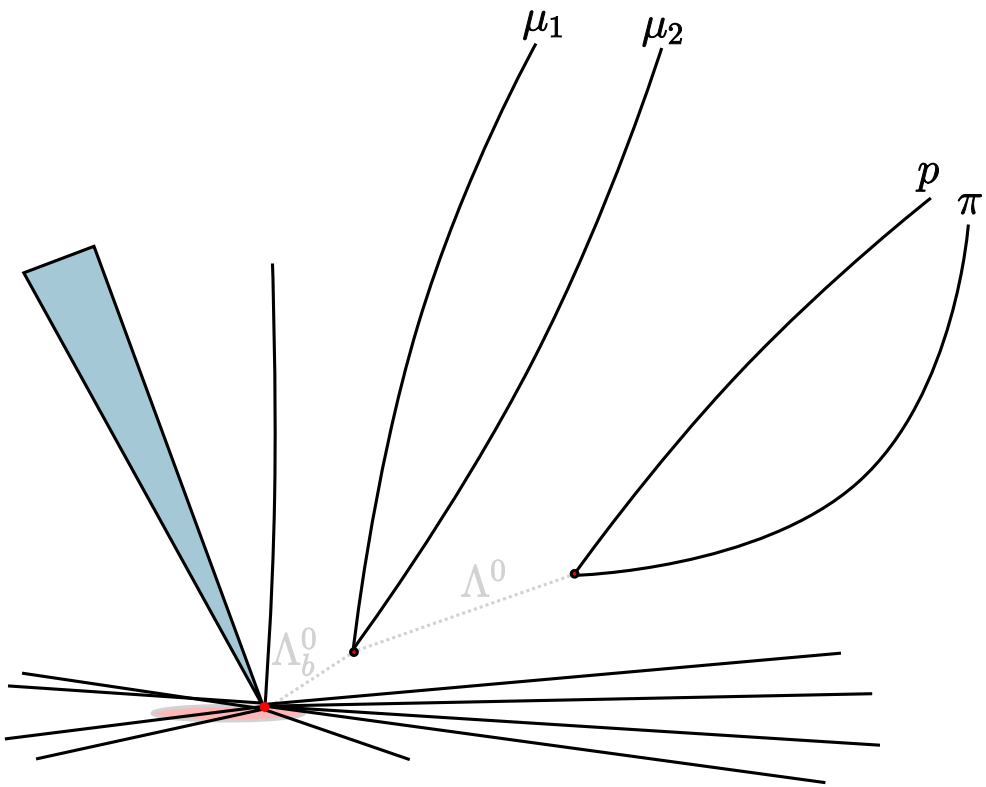
b-Hadrons: Λ_b lifetime event selection



And we ask the vector sum of the two tracks to point towards the J/ψ-vertex.

We calculate one vertex position from the two muon tracks and the Λ^0 trajectory.

b-Hadrons: Λ_b lifetime event selection



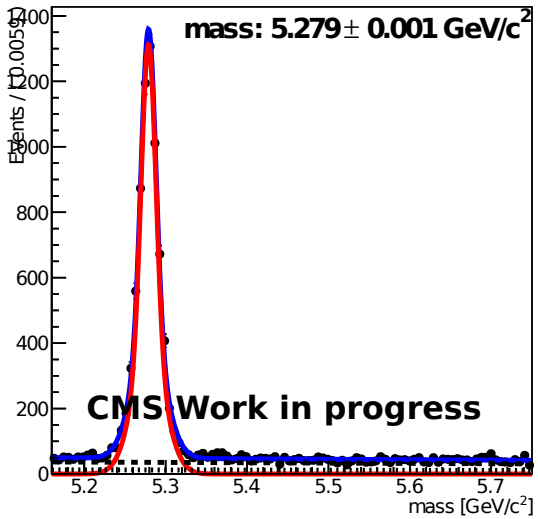
We need to know where the particle was created. For this we use the primary vertex

(There are resonances decaying to Λ_b, but they do this via strong decays)

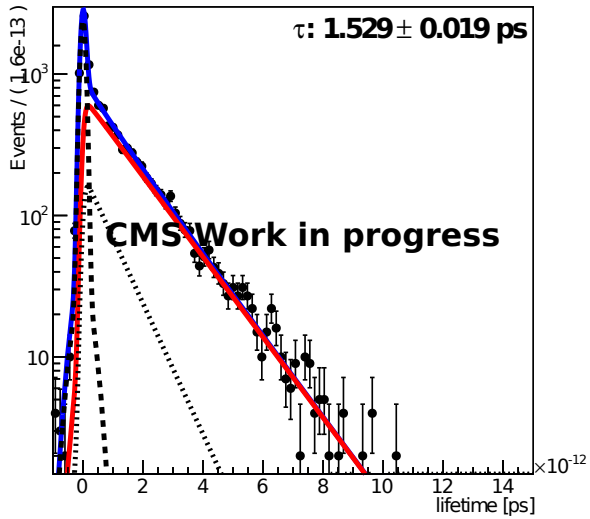
b-Hadrons: Λ_b lifetime

Let me come to the results:

Mass projection



Lifetime projection



Unfortunately I cannot yet show the Λ_b lifetime. But the one from B^0.

Reference channel $B^0 \to J/\psi K_s$. Very well in agreement with PDG values ($m = 5.27950 \pm 0.0003 \mathrm{GeV/c^2}$, $\tau = 1.525 \pm 0.009\,\mathrm{ps}$)

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Other measurements worth mentioning

Strong involvement in other measurements:

- **Z+jets azimuthal correlations**

  test of QCD MC predictions, and important background for searches (ETHZ, paper in prep.)

- W^+W^- **production**

  important SM process (ETHZ in collab. with other CMS institutes, CMS-PAS-SMP-12-013)

- **Angular correlation between B hadrons in** $pp \to Zbb$

  Important background for associated Z production with $H \to b\bar{b}$. (UZH+ETHZ, in prep.)

- **Study of** $Z \to bb$

  Important background for $H \to b\bar{b}$. (ETHZ, work in progress)

- $B\bar{B}$ **angular correlations**

  Further explore perturbative QCD and get precise measurement of a SM background in searches with $b\bar{b}$ signatures (ETHZ+UZH, J. High Energy Phys. 03 (2011) 136)

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Other measurements worth mentioning

Strong involvement in other measurements (continued):

- **First Measurement of Vector Boson Production Associated with Top-Antitop Pairs at 7TeV**

  First measurement of this rare process (ETHZ, CMS PAS TOP-12-014, paper in prep.)

- **Forward energy flow, central charged multiplicities and pseudorapidity gaps in W and Z events**

  Diffractive W and Z production, understanding the *underlying event* (ETHZ, Eur. Phys. J. C 72 (2012) 1839)

- **Hadronic events shapes**

  Important test of QCD and needed for tuning MC event generators (ETHZ, Phys. Lett. B 699 (2011) 48-67)

Conclusions

- CMS contributes to important physics in SM
- Outstanding achievement in $B_s \to \mu\mu$
- New particle found: Ξ_b^{*0} baryon
- Swiss institutes heavily involved in important B- and SM-physics

Thank you for your attention!

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