Full Reconstruction of B Mesons with the ALICE Inner Tracker Upgrade

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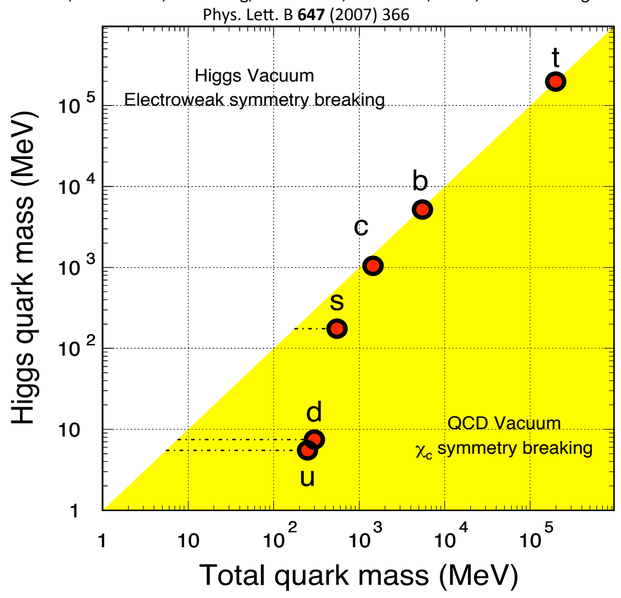
Heavy Flavour Probes of the Quark Gluon Plasma

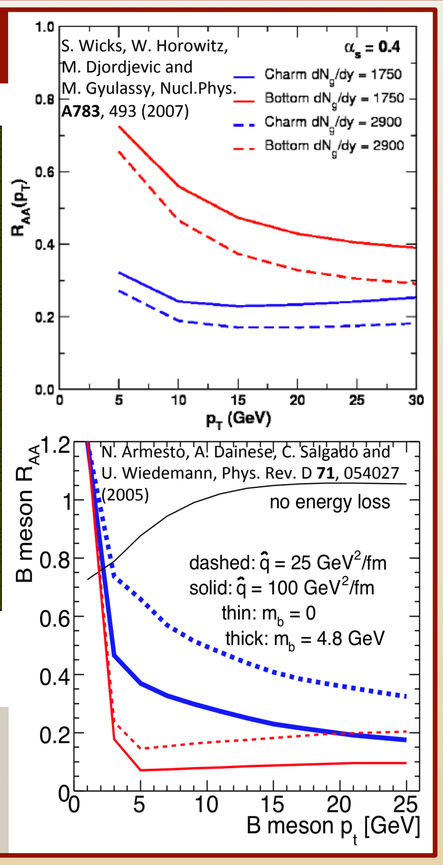
- **A L**arge **I**on **C**ollider **E**xperiment studies strongly interacting matter at extreme energy densities in high-energy nuclear collisions at the Large Hadron Collider at CERN
- Heavy flavour quarks as probes of the medium
- Large masses almost exclusively from Higgs field → $m_{b,c} \approx$ const., $m_{u,d,s} \neq$ const.
- Produced in initial hard scatterings → $m_{b,c} >> \Lambda_{QCD}$
- Lifetime much longer than medium lifetime
- Number of heavy quarks conserved → $m_{b,c} >> T_{QGP}$
- Ideal probes of medium

X. Zhu, M. Bleicher, S.L. Huang, K. Schweda, H. Stöcker, N. Xu, and P. Zhuang Phys. Lett. B **647** (2007) 366



Heavy flavour energy loss ⟷ Nuclear modification factor $R_{AA} = \frac{dN_{AA}/dp_T}{\langle T_{AA} \rangle d\sigma_{pp}/dp_T}$

Hadronization mechanism, in-medium thermalization ⟷ Collective Flow



B Meson Production in Pb–Pb in ALICE

- Kinematic reconstruction via **$B^+ \to \overline{D}^0\pi^+$ ($\overline{D}^0 \to K^+\pi^-$)**
- f(b→B^+($|\bar{b}u\rangle$)): 41.8 % [1]
  - m_B = 5279.25 ± 0.17 MeV/c^2 [2]
  - m_D = 1864.86 ± 0.13 MeV/c^2 [2]
  - $B^+ \to \overline{D}^0\pi^+$ - BR: 0.484 ± 0.015 % [2]
  - $\overline{D}^0 \to K^+\pi^-$ - BR: 3.88 ± 0.05 % [2]
- Central barrel acceptance: $|\eta| < 0.9$
- B^+ production scaled from FONLL for $|y| < 0.5$
- Estimates for R_{AA} and $\langle T_{AA} \rangle$ (nuclear overlap function from Glauber model) for 10 % most central events [3]

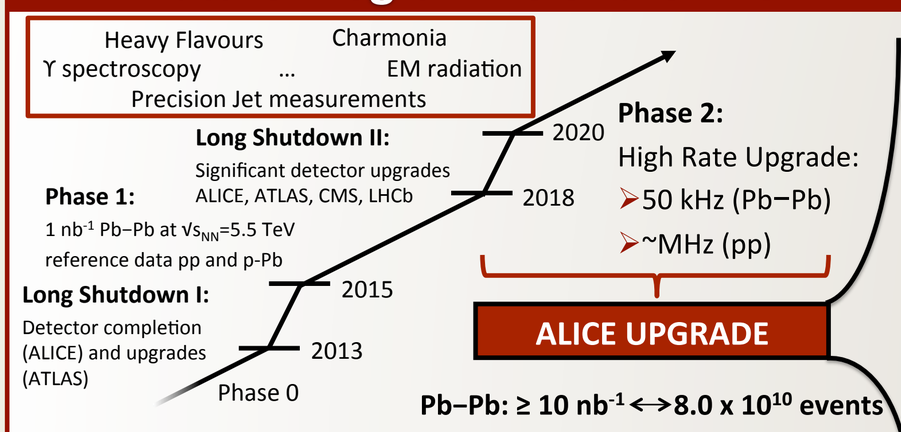
$$\frac{S}{ev} = 2 \cdot R_{AA}^{B^+} \cdot \int_{p_T^{min}}^{p_T^{max}} \left(\frac{d\sigma}{dp_T}\right)_{FONLL}^{B^+} dp_T \cdot B.R. \cdot \langle T_{AA} \rangle$$

- **9 x 10^5 B Mesons** in the decay channels inside the ALICE central barrel for L_{int} = 10 nb^{-1} for central (0-10 %) Pb–Pb at $\sqrt{s_{NN}}$ = 5.5 TeV

→ Reduced by reconstruction & selection efficiencies (ca. 6 % at p_T = 10 GeV/c)

Future Programme of the LHC

Heavy Flavours Charmonia
ϒ spectroscopy … EM radiation
Precision Jet measurements



ALICE UPGRADE

Pb–Pb: ≥ 10 nb^{-1} ↔ 8.0 x 10^{10} events

ALICE Upgrade Concept [4]

1. **Upgrade of readout and online systems**
   - ➢ Continuous data readout of Pb-Pb and pp collisions
   - ➢ Online data compression based on clusters and tracks
2. **Improved vertexing and tracking**
   - ➢ **New inner tracking detector**
3. **Upgrade of TPC with GEMs [5]**
4. **Muon Forward Tracker [6]**
5. **Readoutelectronics, online systems, …**

ITS Upgrade Design Goals [7]

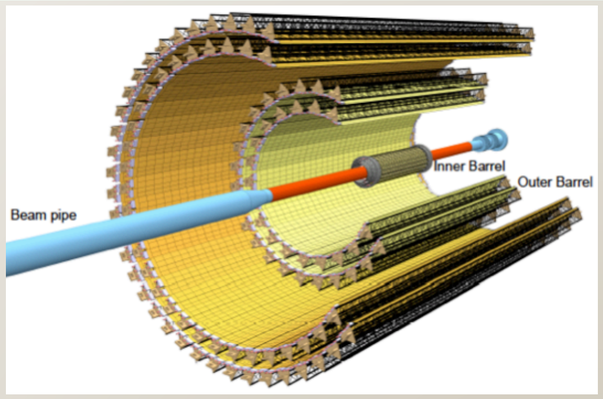
1. **Improved impact parameter resolution**
   - First detection layer closer to interaction point: **39 mm → 23 mm**
   - Ultra low material budget (x/X_0) per layer: **1.14 % → 0.30 – 0.8 %**
   - Reduced pixel size **from 50 x 425 µm²**
     - Monolithic Active Pixel Sensors → **O(20 x 30 µm²)**
2. **Improved tracking efficiency and p_T resolution**
   - Increased number of channels: **6 → 7 layers & smaller pixels**
3. **Fast data readout of each interaction**
   - **1 kHz → Up to 100 kHz in Pb–Pb collisions**
4. **Easy detector access**

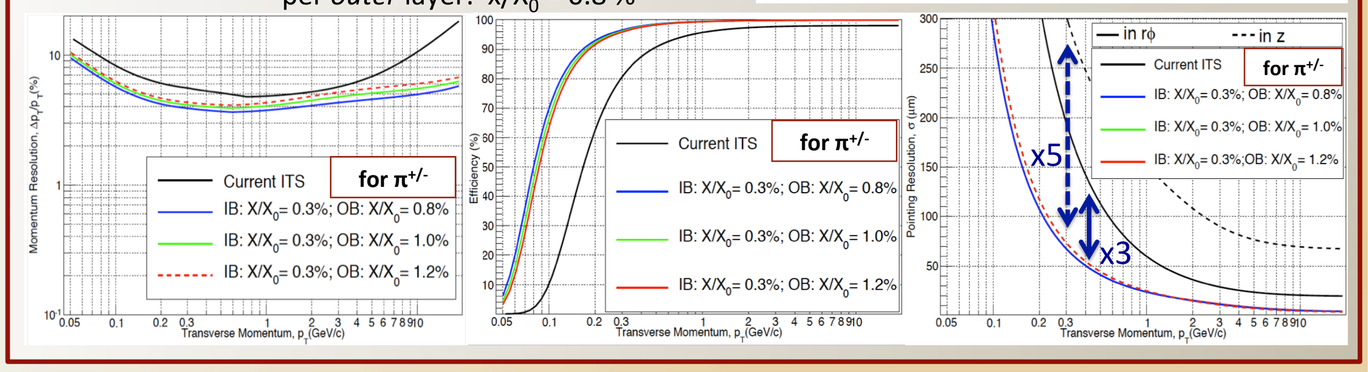
ITS Upgrade Performance

- **Inner Barrel** (0.17 m² active area)
  - 3 layers with 432 monolithic pixel modules
  - 20 x 30 µm²
  - $|y| \leq 2.0$
- **Outer Barrel** (9.24 m² active area)
  - 4 layers with 23688 monolithic pixels
  - 20 x 30 µm²
  - $|y| \leq 1.3$

→ Space point resolution down to $\sigma_{r\varphi} = \sigma_z$ = 4 µm

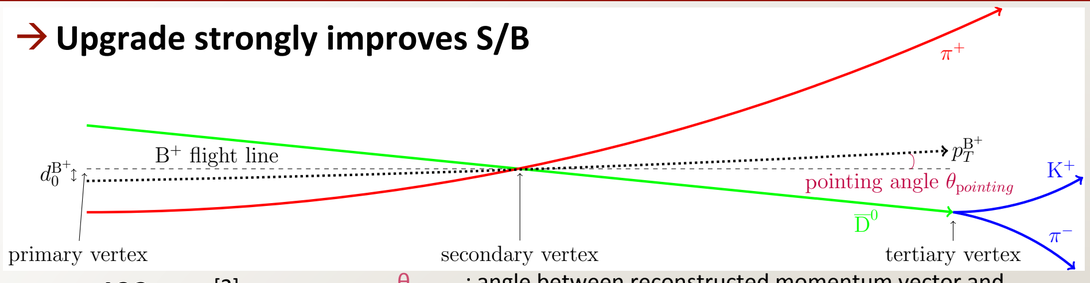
→ Material budget - per *inner* layer: x/X_0 = 0.3 %
- per *outer* layer: x/X_0 = 0.8 %





B Invariant Mass Reconstruction via displaced D^0

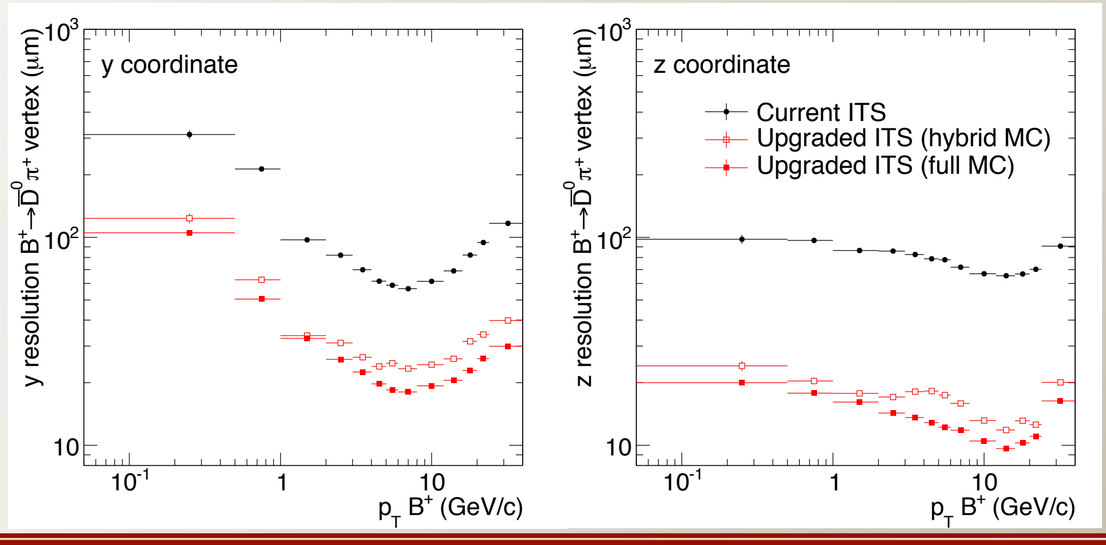
→ **Upgrade strongly improves S/B**



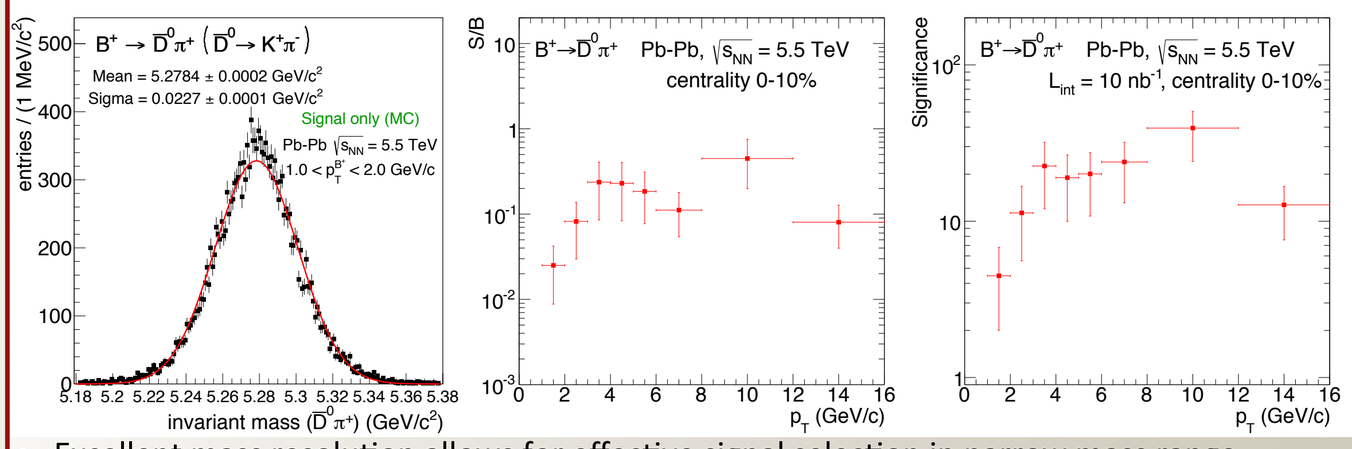
$\theta_{pointing}$: angle between reconstructed momentum vector and straight connection line between primary and secondary vertex

- $c\tau_B$ = 492 µm [2]
- $c\tau_D$ = 123 µm [2]

- Selection of signal via topological and kinematical cuts
  - Normalized D^0 decay length
  - Large p_T of π and D^0 (both from B)
  - Impact Parameter (d_0^{B+})
  - $\cos(\theta_{pointing})$
- Improved resolution on the vertex positions



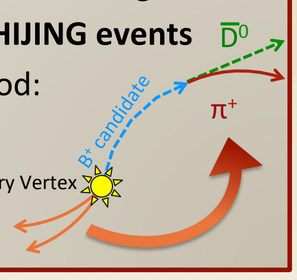
Full Reconstruction of B Mesons in ALICE



- Excellent mass resolution allows for effective signal selection in narrow mass range
- **Selection criteria reject *all* background in available 10^6 central Pb-Pb HIJING events**
- Generation of *combinatorial* background using the track rotation method:
  - → Rotation of momentum vector of uncorrelated tracks around primary vertex

→ **Significant measurement will be possible for p_T > 2 GeV/*c***

→ Extensive studies on correlated background sources are on-going



ITS Upgrade Timeline

- **2014: Research and Development**
- **2015: Final Design and Validation**
- **2015 – 2019: Construction and Installation**
- **2020: Pb–Pb collisions at full energy at high luminosity Pb–Pb at LHC**

[1] DELPHI Collaboration, *A measurement of the branching fractions of the b-quark into charged and neutral b-hadrons*, Phys. Lett. **B576** (2003)
[2] J. Beringer *et al.* (Particle Data Group), Phys. Rev. D**86**, 010001 (2012) and 2013 partial update for the 2014 edition
[3] ALICE Collaboration, *Centrality determination of Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV with ALICE*, Phys. Rev. C **88**, 044909 (2013)
[4] ALICE Collaboration, *Letter of Intent for the Upgrade of the ALICE Experiment*, CERN-LHCC-2012-012 ; LHCC-I-022
[5] ALICE Collaboration, *Technical Design Report of the ALICE TPC Upgrade*, CERN-LHCC-2013-020 ; ALICE-TDR-016
[6] ALICE Collaboration, *Addendum of the Letter Of Intent for the Upgrade of the ALICE Experiment: The Muon Forward Tracker*, CERN-LHCC-2013-014 ; LHCC-I-022-ADD-1
[7] ALICE Collaboration, *Upgrade of the ALICE Inner Tracking System*, CERN-LHCC-2013-024, ALICE-TDR-017

LHCC Students Poster Session
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