FKPPL ALICE-b [2017]

b-Jet Tagging in Heavy-ion collisions at the LHC

FKPPL ALICE-HF [2018-]

Heavy flavour measurement with ALICE detector at the LHC

MinJung Kweon
on behalf of the ALICE-b and ALICE-HF project

2019 Joint workshop of FKPPL and TYL/FJPPL
May 8-10, 2019
Jeju Island

Introduction

- Heavy-ion (HI) collisions at the LHC energies
  - QGP phase expected (lifetime ~ *O*(10 fm/c))

- **Why heavy flavours and heavy-flavour jets?**
  - $m_{c,b} \gg \Lambda_{QCD}$ → **pQCD initial production**
  - $m_{c,b} \gg T_{RHIC,LHC}$ → **negligible thermal production**
  - $\tau_0 \approx 1/2m_Q$ (<0.1 fm/c) $\ll \tau_{QGP}$ (*O*(10fm/c)) → **witness of all the QGP**

    ⇨ **"Calibrated probes" of the medium**

- ALICE: dedicated detector for QGP study at the LHC

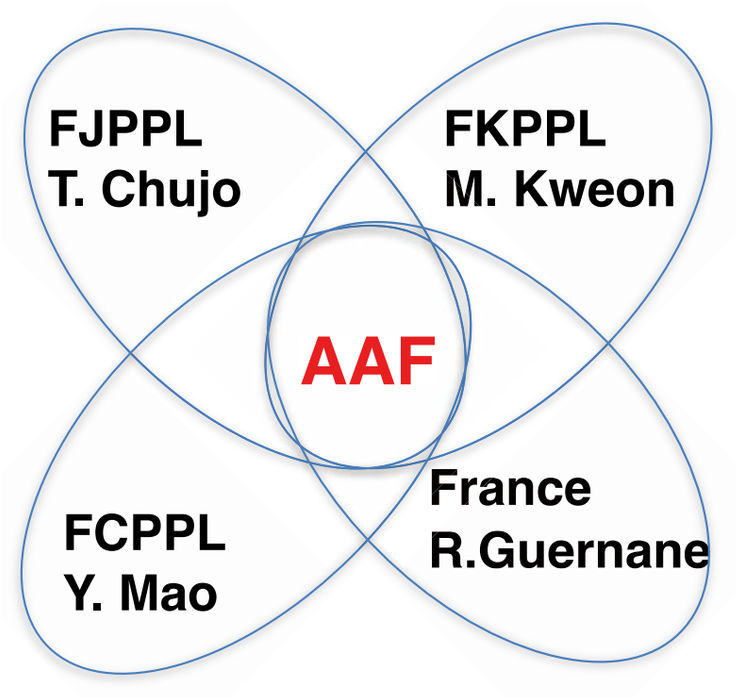
- **ALICE-b [2017], ALICE-HF [2018-] projects goal**
  - determine **medium properties** and **energy loss mechanism** (color and mass dependence of the parton energy loss).
    - measurement of **heavy flavour hadrons** (B mesons, Λ_c, , Ξ_c…) and **b-tagged jets**
  - understand **hadronization mechanism** (fragmentation, recombination, …)
    - charmed **baryon** to **meson** ratio (Λ_c/D^0, Ξ_c/D^0, …)

Members [FKPPL ALICE-HF]

- Main investigators: **Inha University** (5), **LPSC & IPHC** (8)

Acronym: ALICE-HF	**Full title:** Heavy flavor measurements with ALICE detector at the LHC		**Main French and Korean institute:** CNRS/IN2P3, Inha U.		
Domain: Experimental high energy physics					
List of participants	**French Group**			**Korean Group**		
	Name	**Position**	**Lab./Institute**	**Name**	**Title**	**Institute**
	Leader: Rachid GUERNANE	CR	LPSC	Leader: MinJung KWEON	PR	Inha U.
	Christophe FURGET	PR	LPSC	Jiyeon KWON	PHD	Inha U.
	Julien FAIVRE	MCF	LPSC	Jin-Hee YOON	PR	Inha U.
	Ingo SCHIENBEIN (TH)	MCF	LPSC	Jinjoo SEO	Master Student	Inha U.
	Gustavo CONESA BALBASTRE	CR	LPSC	Jonghan PARK	PHD	Inha U.
	Jaime NORMAN	Postdoc	LPSC			
	Yves SCHUTZ	DR	IPHC			
	Iouri BELIKOV	DR	IPHC			

Organization: ALICE Asian France developed by F(X)PPL



- A long standing collaboration started from FJPPL in ALICE (2010)
- **FKPPL ALICE-b from 2017** (b-tagging in pp and p-Pb collisions, charmed baryon measurement)
- Physics analysis and Calorimeter system operation in F[C/J/K]PPL ALICE TF
  - Regular annual workshops
  - Weekly AAF meeting

Annual Workshops and visits [FKPPL ALICE-b, ALICE-HF]

Workshops

- 2017. 12 Inha University (1st):

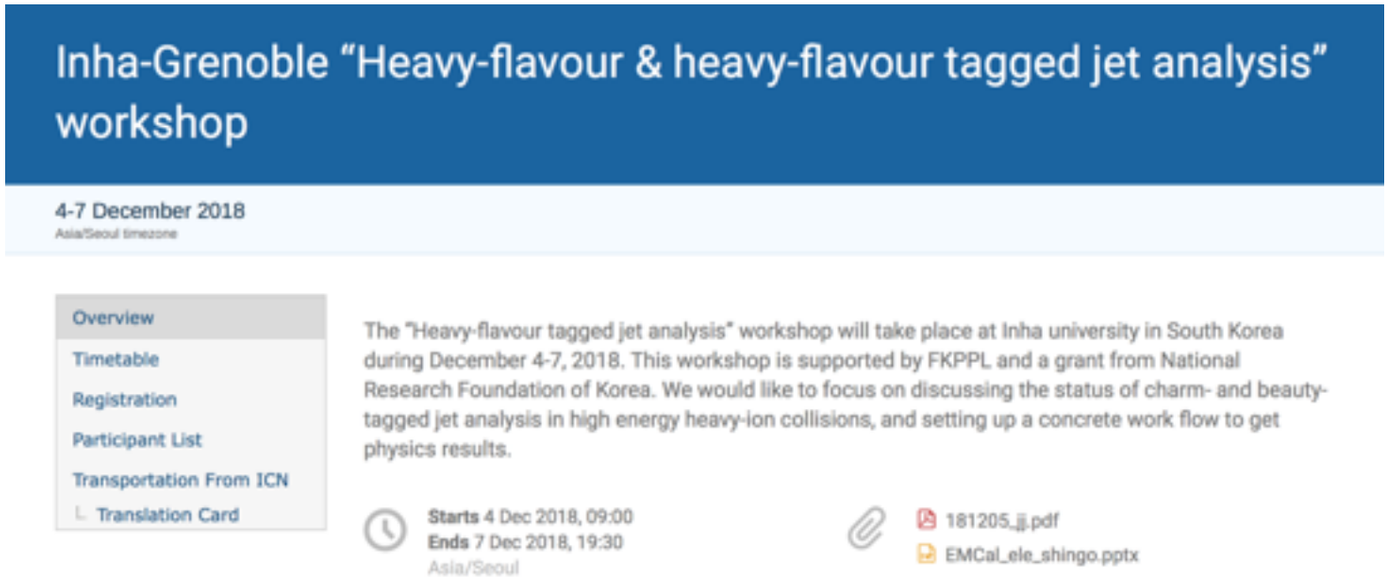
  Heavy-flavour tagged jet analysis workshop

  (https://indico.cern.ch/event/687697/)

- 2018. 12 Inha University (2nd):

  Heavy-flavour & heavy-flavour tagged jet analysis workshop

  (https://n-ext.inha.ac.kr/event/320/overview)



School & visits

- Jinjoo Seo was enrolled in the ESIPAP 2018 edition (European School of Instrumentation in Particle & Astro-particle Physics)
- 2018 Feb. M. Kweon visits Grenoble
- 2019 Feb. M. Kweon visits Grenoble

Annual Workshops and visits [FKPPL ALICE-HF]

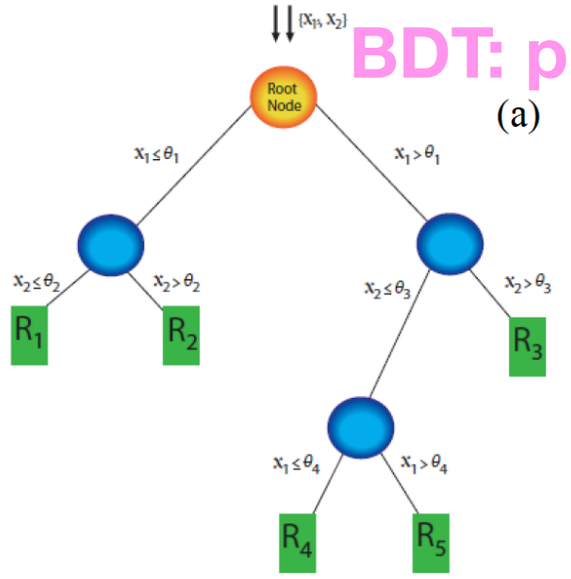
During the workshop,
Machine learning (HAND ON) tutorial session given by J. Norman (LPSC)

- 2018. 12 Inha University (2nd):

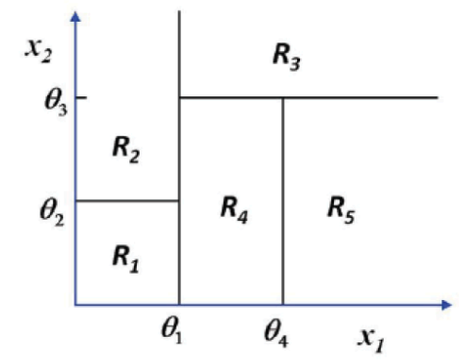
  Heavy-flavour & heavy-flavour tagged jet analysis workshop

  (https://n-ext.inha.ac.kr/event/320/overview)

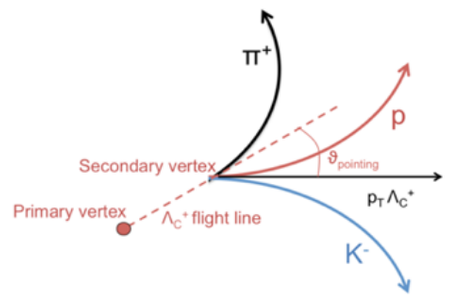
BDT: principle, examples

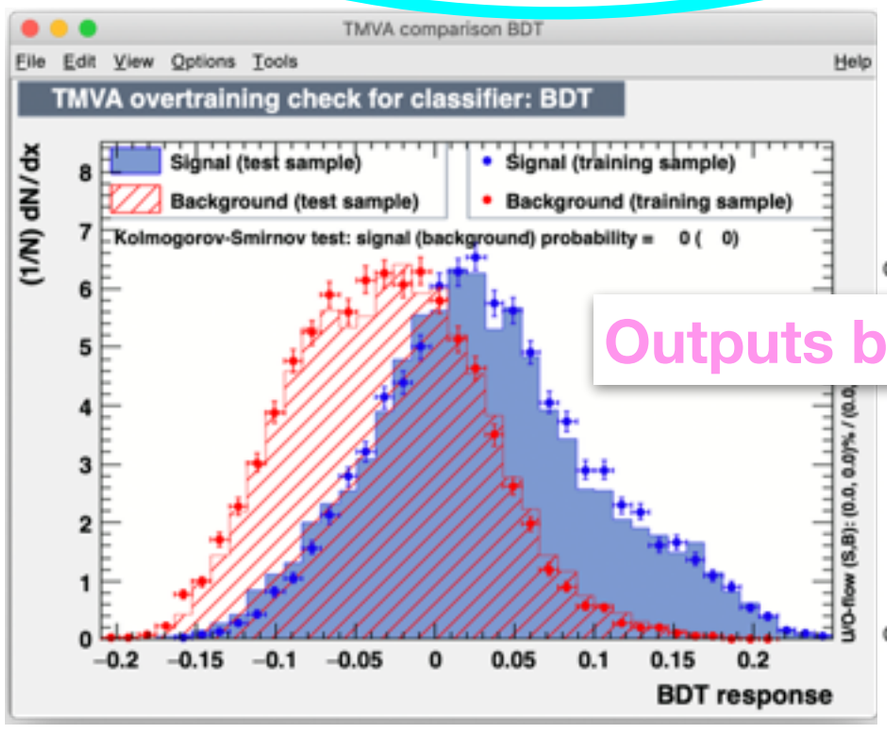


(a) (b)



Example: Λ_c



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: Transformation applied to input variables : None
: ----------------------------------------------------
: Cut[ 0]:     1.2497 <          Ptp <=    7.43324
: Cut[ 1]:   0.453183 <          PtK <=    4.98971
: Cut[ 2]:   0.847078 <         Ptpi <=    4.19725
: Cut[ 3]:   0.871415 <         CosP <=    1.82295
: Cut[ 4]:  0.0106533 <      DecayL <=   0.378458
: Cut[ 5]: 0.00178967 <      Dist12 <=   0.238537
: Cut[ 6]: 0.00272726 <     SigVert <=     0.0405
: Cut[ 7]: 0.000699961 <         DCA <=  0.0509093
: Cut[ 8]:   0.297375 < DecayLXYSig <=    24.7165
: ----------------------------------------------------
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: Corresponding background efficiency       : 0.4328
: Transformation applied to input variables : None
: ----------------------------------------------------
: Cut[ 0]:     1.4876 <          Ptp <=    6.27735
: Cut[ 1]:   0.370967 <          PtK <=    6.02901
: Cut[ 2]:   0.759493 <         Ptpi <=    4.19846
: Cut[ 3]:   0.800424 <         CosP <=    1.89974
: Cut[ 4]: -0.00194159 <      DecayL <=    0.33112
: Cut[ 5]: 0.00513014 <      Dist12 <=   0.421242
: Cut[ 6]: 0.00179349 <     SigVert <=  0.0457336
: Cut[ 7]: 0.00129039 <         DCA <=   0.045092
: Cut[ 8]:  0.0874312 < DecayLXYSig <=    23.4249
: ----------------------------------------------------
: Cut values for requested signal efficiency: 0.8
: Corresponding background efficiency       : 0.5764
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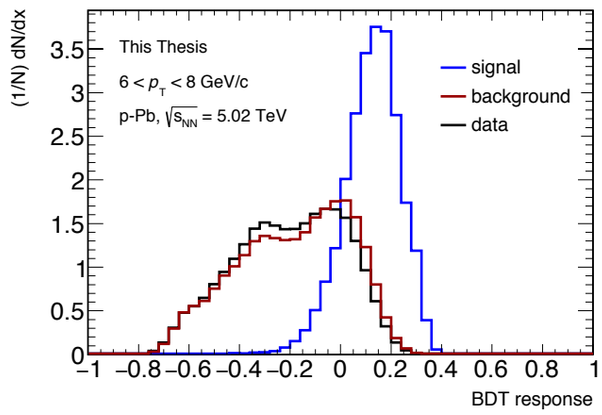
: Cut[ 1]:   0.449847 <          PtK <=    5.99651
: Cut[ 2]:   0.621941 <         Ptpi <=    4.95804
```

CutsSA

CutsSA

Outputs by Inha students



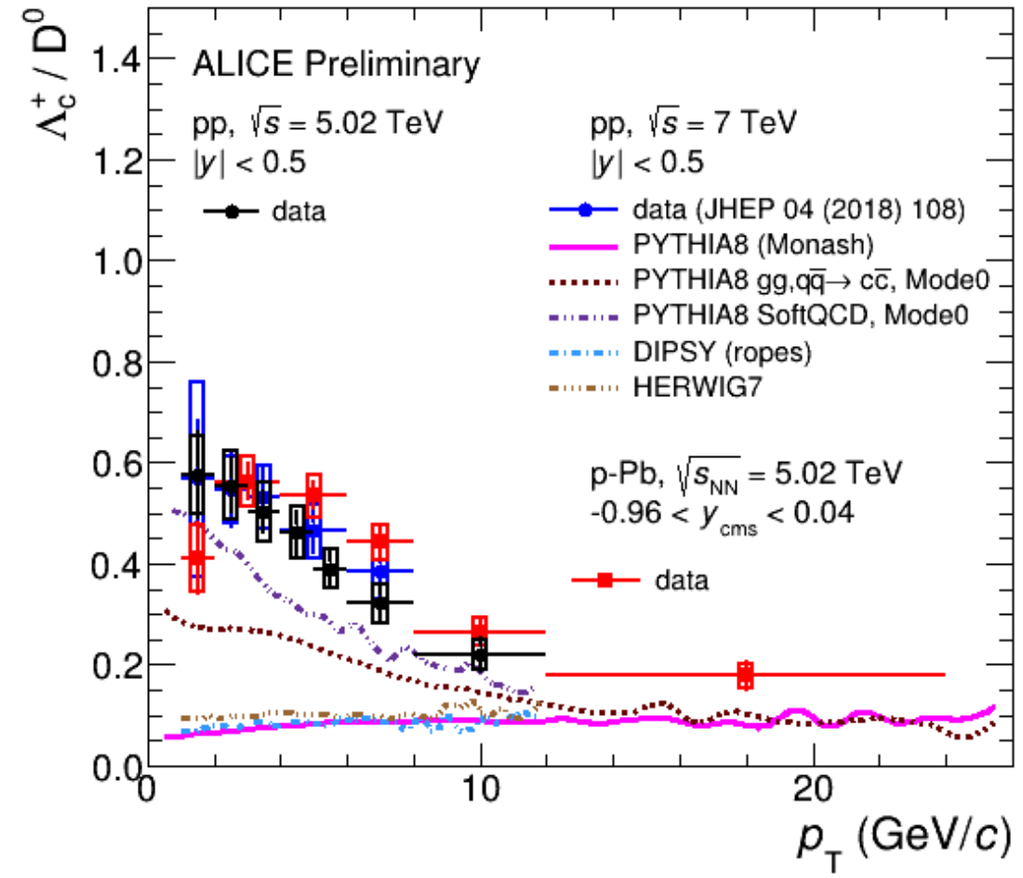
Thesis defense [FKPPL ALICE-b]

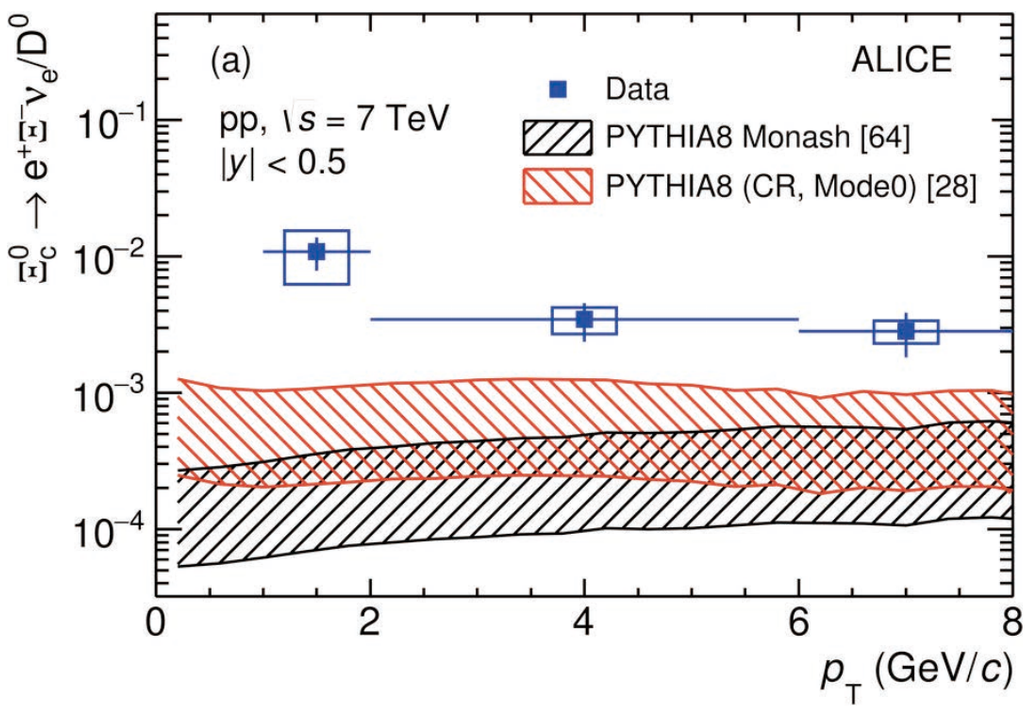
- On February 19th, 2019, Mr. **Hadi Hassan** presented the results of his doctoral research dedicated to "**modeling and measuring the b-jet nuclear modification factor in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with the ALICE experiment at the LHC**".
- All members of the thesis review committee attended the defense.

Heavy-flavour production [ALICE-HF]

Charmed baryon production, pp and p-Pb

- **Charmed baryon-to-meson ratio** probes **hadronisation mechanisms**
- Baryon production measured to be **larger than expectations** from MC generators
  - Colour reconnection modes within PYTHIA aim to model hadronisation in multi-parton system
  - Colour reconnection modes qualitatively describe the data





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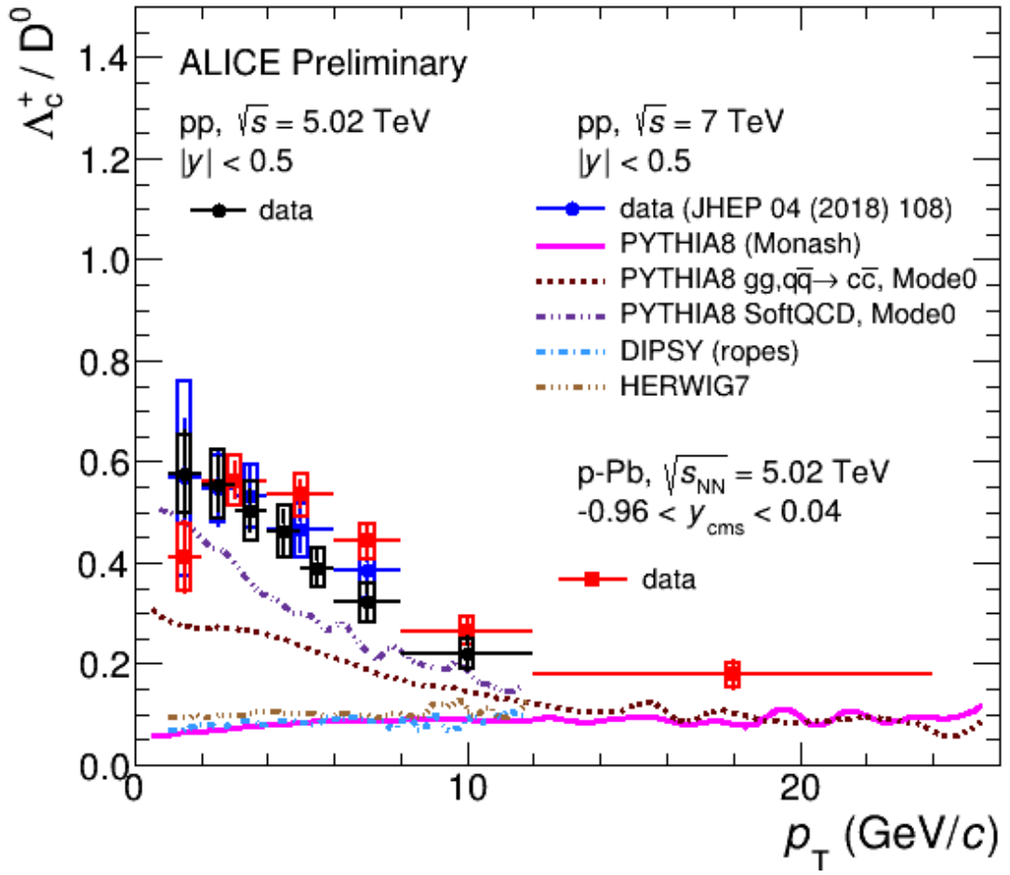
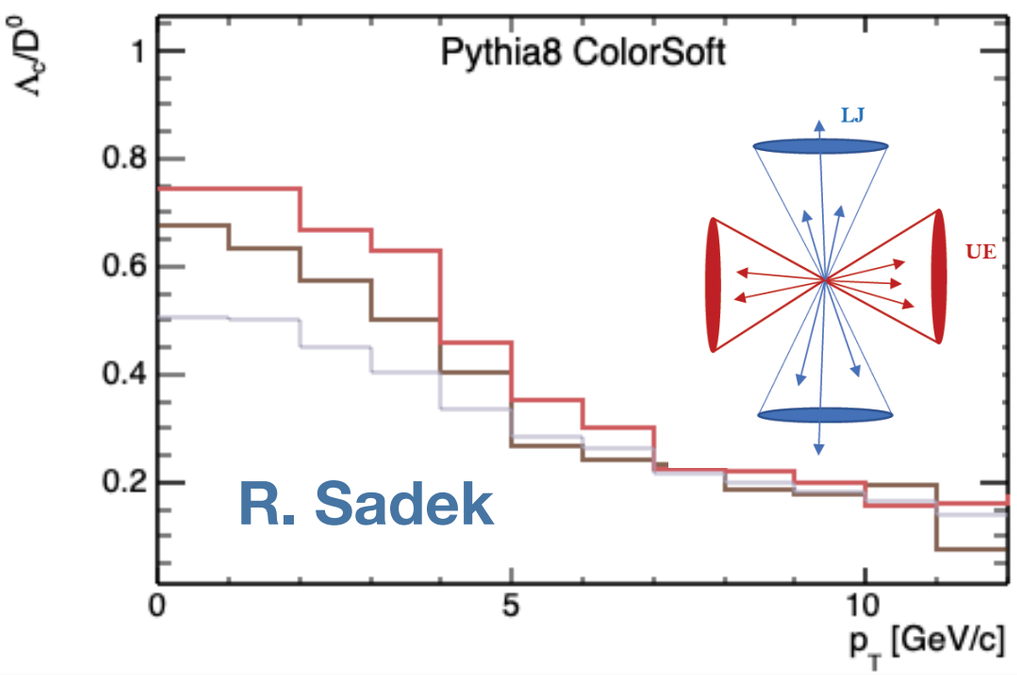


- To further probe hadronisation mechanisms, one can **correlate baryon and meson production** with:
  - Multiplicity
  - Hard scale of event
    - Production within jet
    - Production within underlying event
- Comprehensive simulation and measurement feasibility studies ongoing

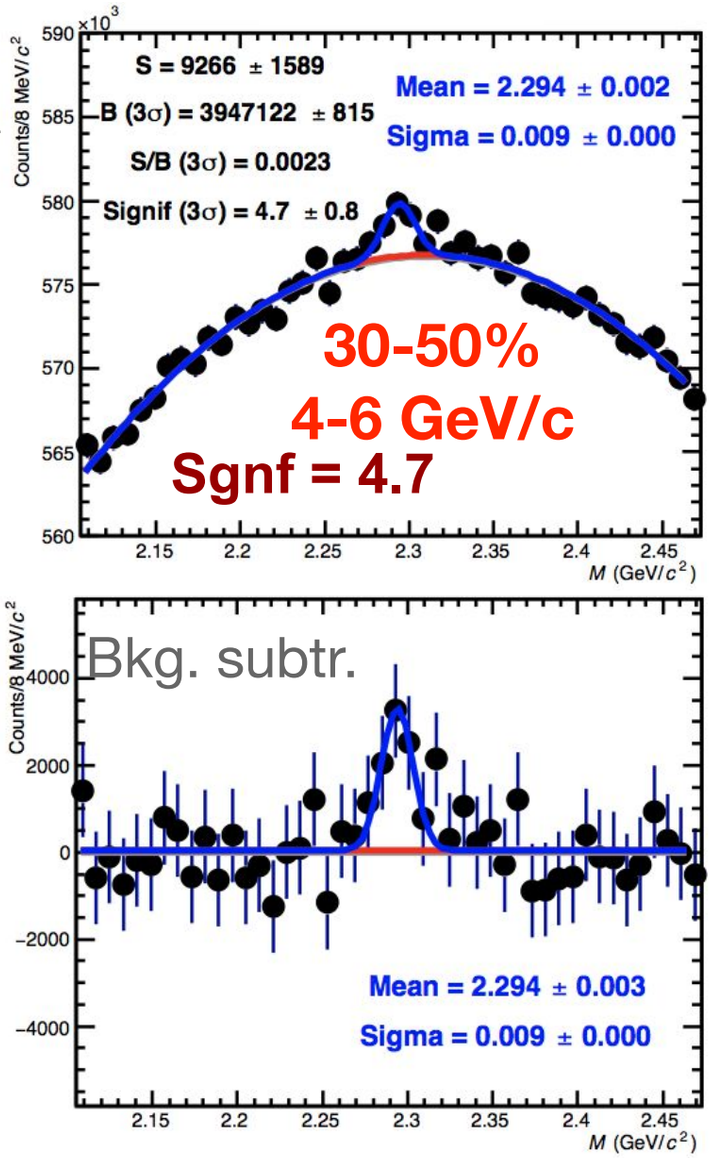


Heavy-flavour production [ALICE-HF]

Charmed baryon production, Pb-Pb

Λ_c, Pb-Pb @ 5 TeV

- Analysis of Pb-Pb data to measure heavy-flavour observables well underway
- Clear Λ_c signal seen, analysis ongoing



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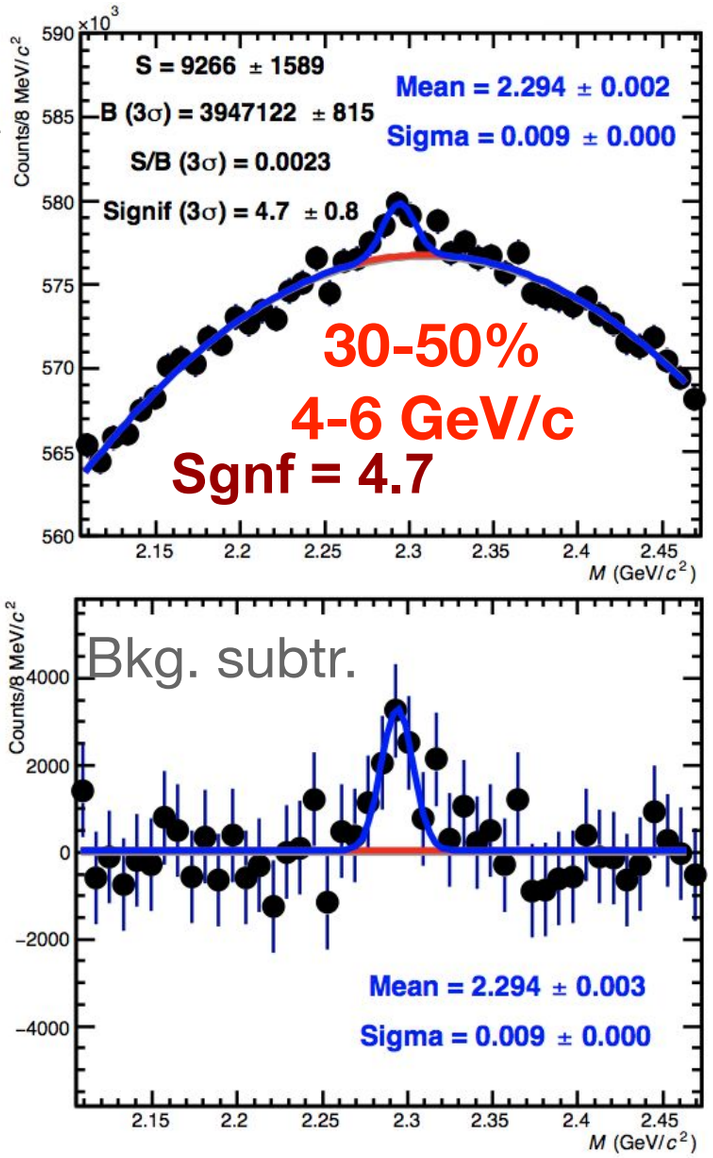
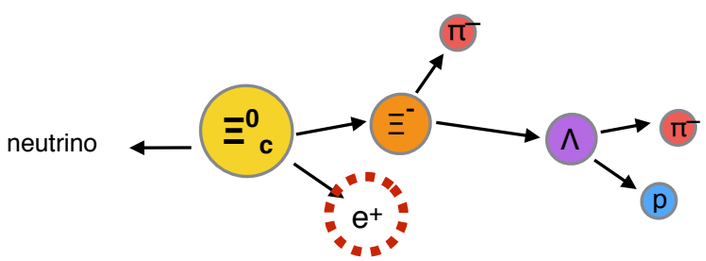
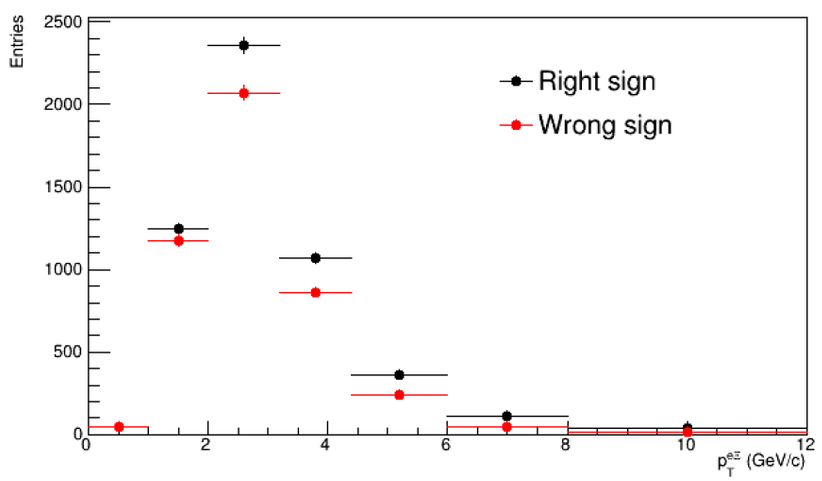


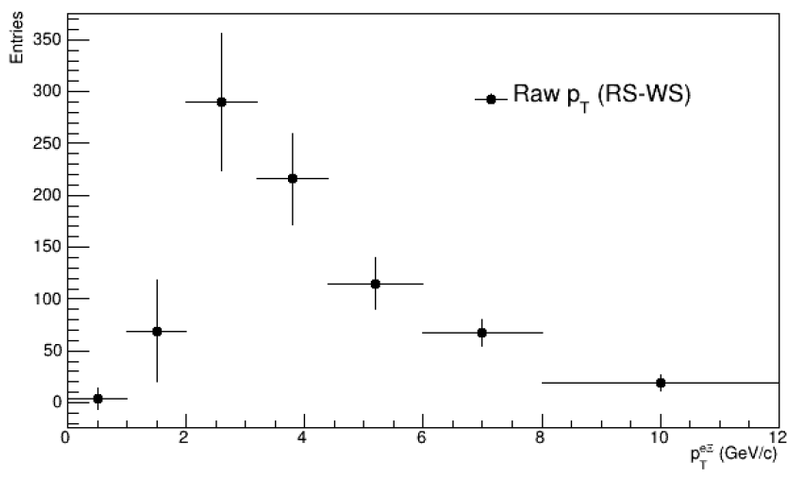
Ξ_c, pp @ 13 TeV

- Measure Ξ_c in pp collisions at 13 TeV using semi-leptonic decay channel
- Subtract wrong sign spectra from right sign spectra, then correct the raw spectra, well underway





eΞ pair pt



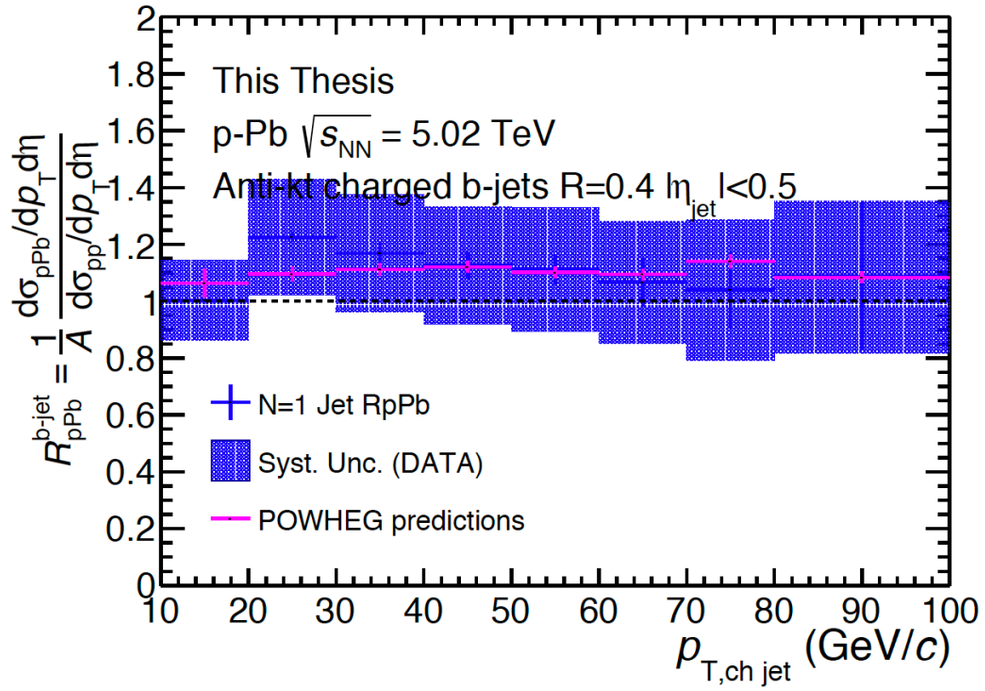
eΞ pair pt raw yield

Heavy-flavour production [ALICE-b, ALICE-HF]

Heavy-flavour jets, pp and p-Pb

b-jet, pp and p-Pb @ 5 TeV

- B-jet production in pp and p-Pb collisions measured
  - Consistent with NLO predictions
  - R_{pPb} consistent with unity
  - Plan to request propose paper in coming months



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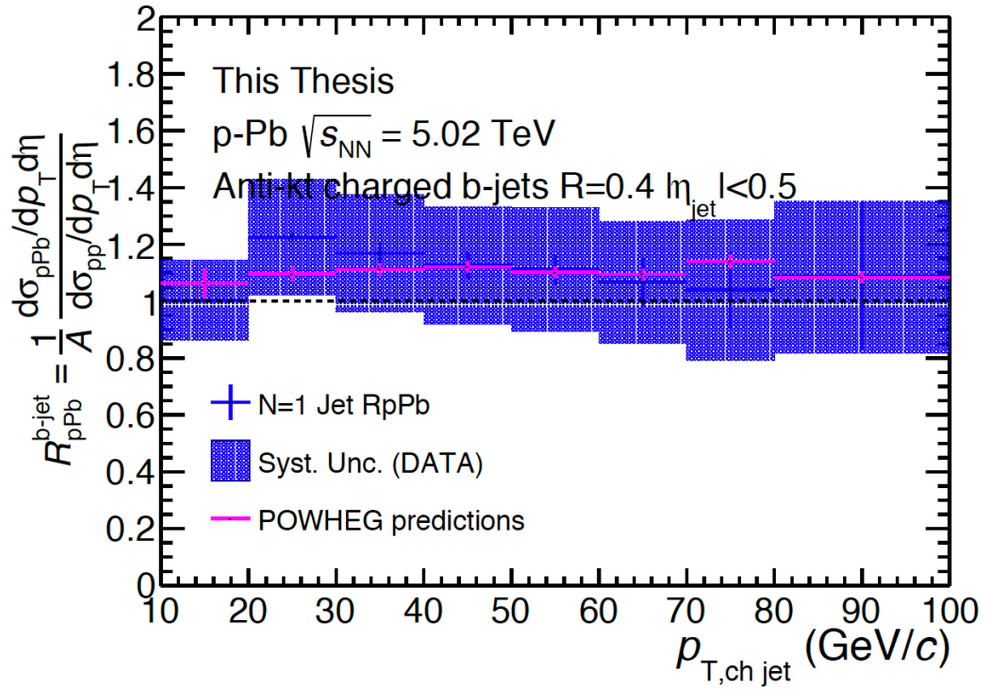
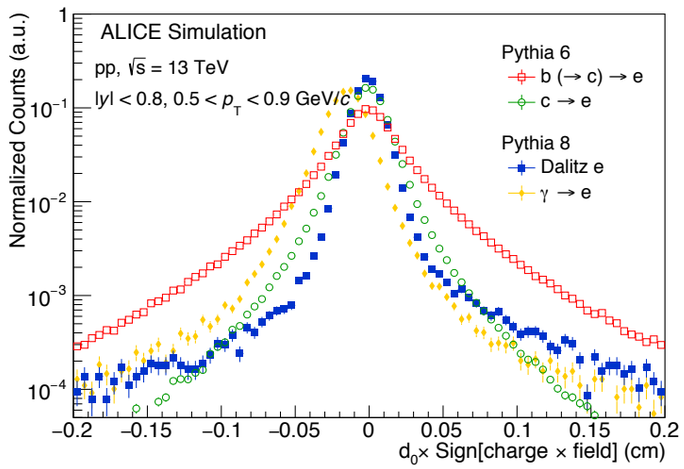
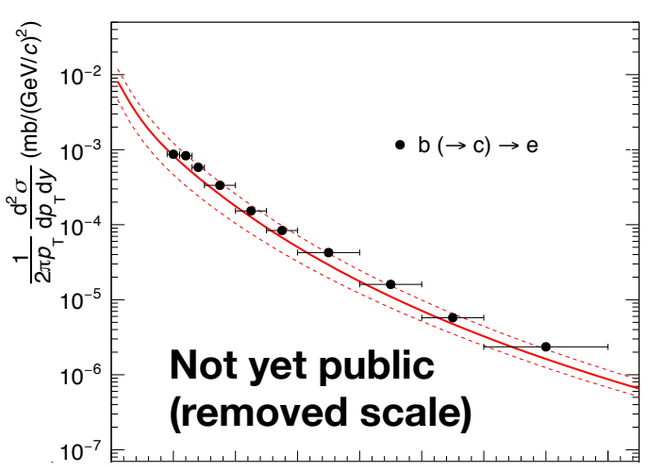


Beauty hadrons, pp and Pb-Pb

beauty decay electrons, pp @ 13 TeV and Pb-Pb @ 5 TeV

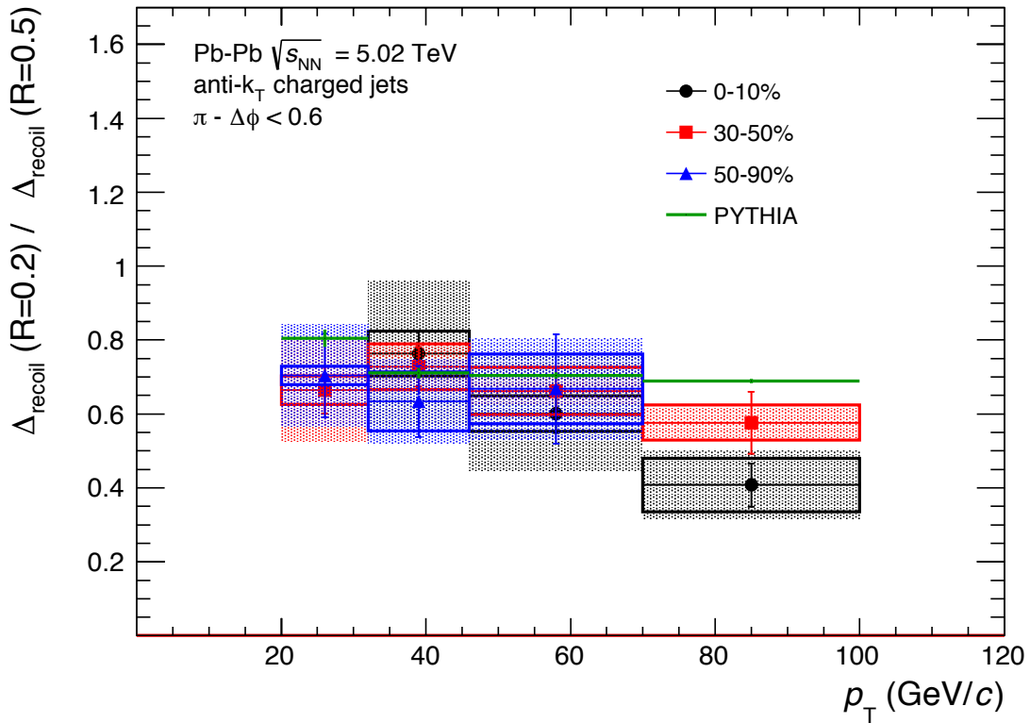


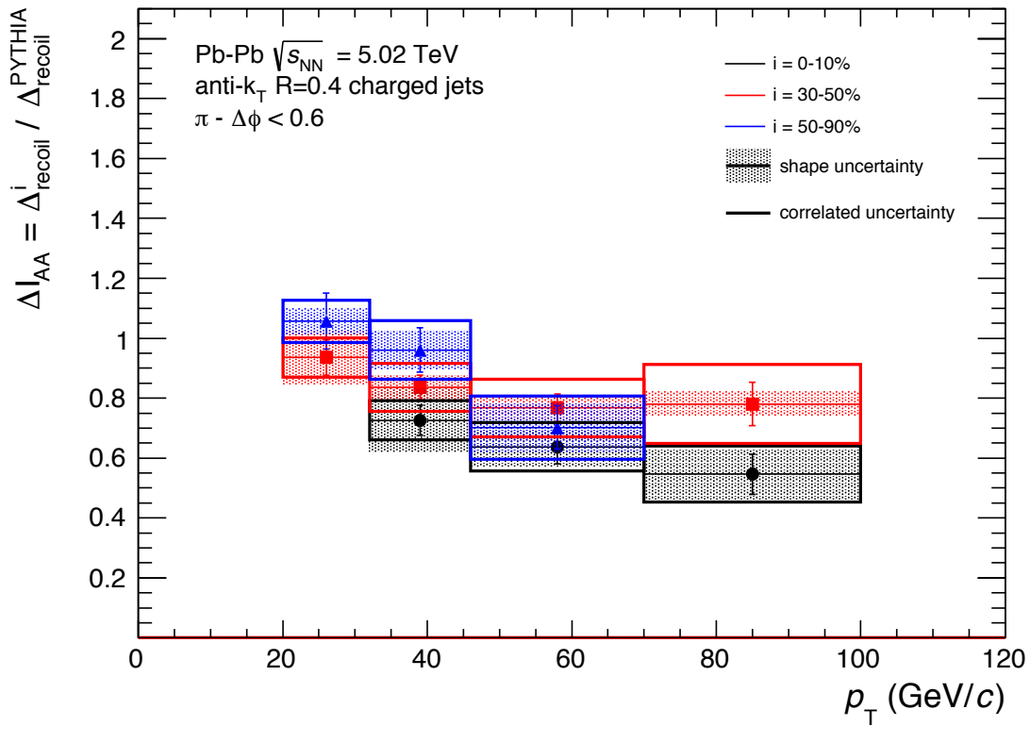


- Measurement of beauty decay electron production in pp @ 13 TeV and Pb-Pb @ 5 TeV is ongoing
  - B→e separation is based on the impact parameter distribution
  - Both analysis are close to the final, paper committee is being formed

Hadron+jet measurement [ALICE-HF]

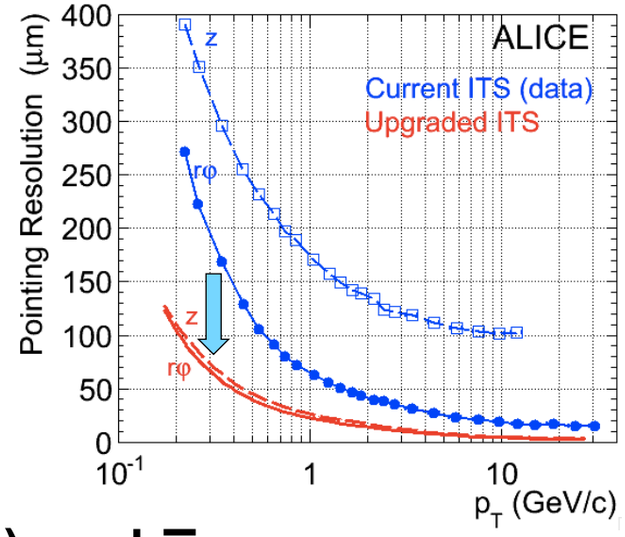
- Ratios of combinatorial background-subtracted recoil jet yield :
  - R=0.2 over R=0.5 consistent with PYTHIA expectation
    - Out-of-cone radiation predominantly to angles > 0.5
    - Consistent with run 1
  - Yield over PYTHIA expectation shows suppression of 20-40%
    - Consistent with run 1
- 2018 data will offer large increase in precision
  - ~x9 statistics in 0-10%
  - ~x3 statistics in 30-50%

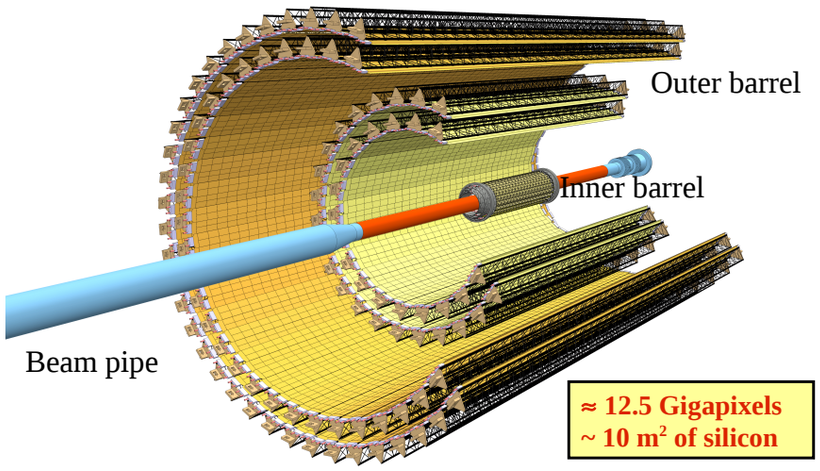




ALICE Inner Tracking System upgrade for LHC Run 3 & 4

- LHC Long Shutdown 2 [LS2] (2019-2020)
  - ALICE major upgrade including replacing Inner Tracking System (improve spacial precision on track and vertex position)
- High precision measurements of rare probes at low p_T
  - **D mesons**: high-precision measurement **down to zero p_T**
  - Exclusive reconstruction of the **charm baryon Λ_c** ($c\tau$, only 60 μm) and Ξ_c, even multi-charmed baryons
  - Exclusive reconstruction of **beauty mesons (B) and baryons (Λ_B)**





The new ITS design goals

- Improve vertex resolution
- High efficiency and p_T resolution
- Fast readout: 50 kHz (Pb-Pb), 400 kHz (pp)
- Fast insertion/removal

Inha university has been participated for **chip R&D, massive chip test** (over last year) and **HIC module assembly** (will over within 2 weeks), will participate detector commissioning at CERN until next year.

Summary and Plan

- **Heavy flavour analysis of b-tagged jets, charmed baryon production and beauty decay electrons are in good shape**
- **ALICE-HF continues this year**
- **Continue participating ALICE Inner Tracking System upgrade this year**
- **Annual workshop of ALICE-HF is planed to be on October, 2019**

Thank you for your attention!