

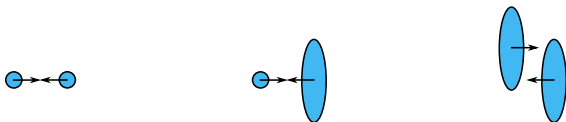
Recent results from CMS

Émilien Chapon
on behalf of the CMS experiment

CERN

SQM 2017
Strangeness in Quark Matter





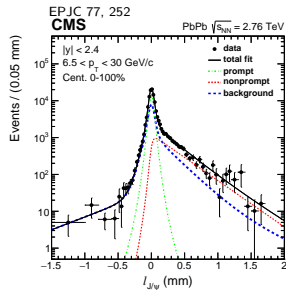
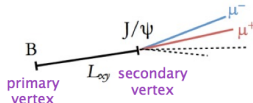
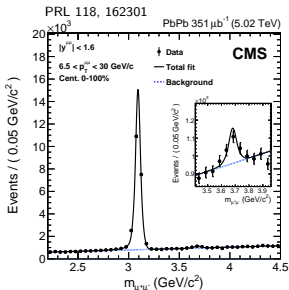
From **pp** to **pPb** and **PbPb** collisions:

- Light flavours, strange and multi-strange hadrons
- Heavy flavours, charm and beauty: quarkonia, open HF, HF jets

Looking at **several observables**:

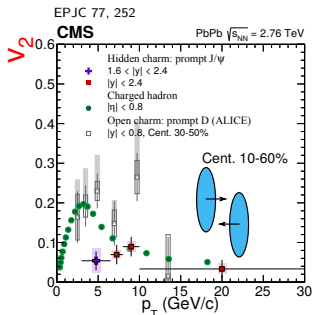
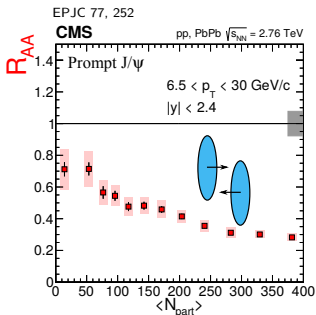
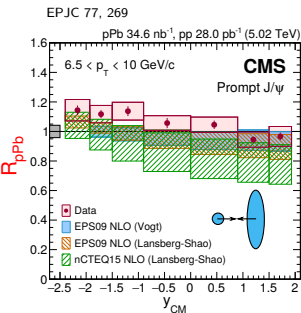
- Cross sections and nuclear modification factors
 - Debye screening in charmonia, etc.
- Collective flow: Fourier harmonics, event by event fluctuations, ...
 - eg collectivity in small systems
- Momentum imbalance in pair production
 - flavour dependence of parton energy loss





- Extract the different resonances (J/ψ , $\psi(2S)$) from a fit to $M_{\mu^+\mu^-}$
- B meson feed-down vs prompt J/ψ : 2D fit of $(M_{\mu^+\mu^-}, l_{J/\psi})$
- Prompt J/ψ also include χ_c and $\psi(2S)$ feed-down

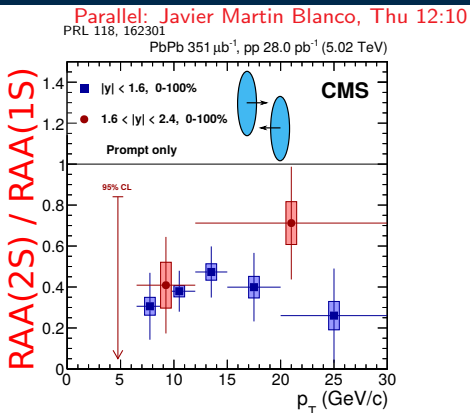
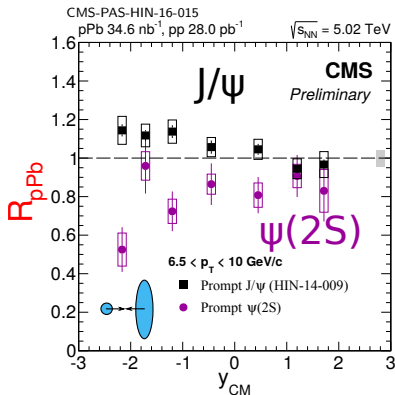




- **Some modification** in pPb collisions
- Higher suppression in central PbPb collisions: **melting**
- v_2 : **path length dependence** of energy loss?



Prompt J/ψ vs prompt $\psi(2S)$ in pPb and PbPb

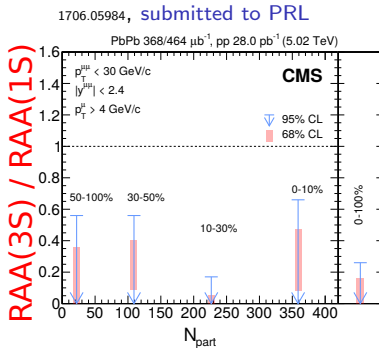
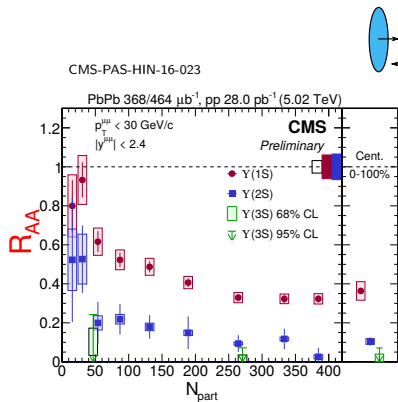


Higher suppression of the **excited state** than the **ground state**?

- Both in **pPb** and **PbPb**
- Importance of final state effects
- Challenging **theoretical understanding**, especially in pPb

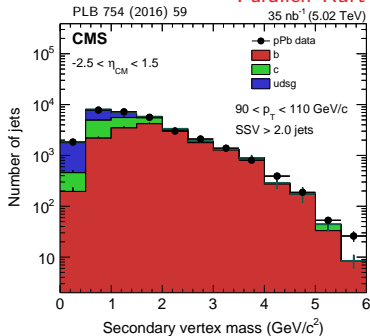
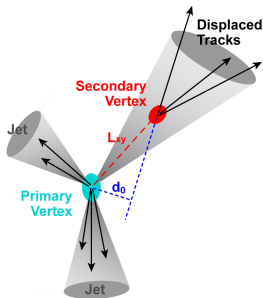


What about $\Upsilon(1S,2S,3S)$?



- Stronger suppression in central events
- Stronger suppression for excited states (where is $\Upsilon(3S)$?)

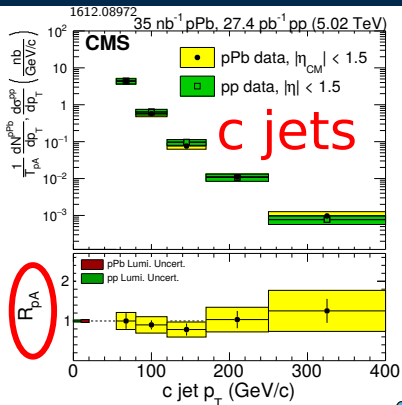




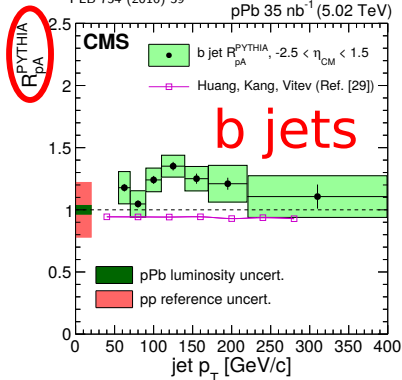
Heavy flavour jets

- Charm and bottom production at high p_T (> 55 GeV/c)
- Including all hadron species
- Comparison with light jets
- Extract HF jet contribution from templates of a discriminator

HF jets: R_{pA}



Parallel: Kurt Jung, Thu 10:50
PLB 754 (2016) 59



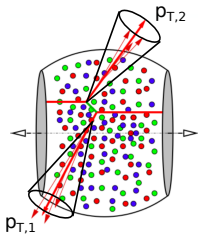
Are HF jets modified in pPb collisions with respect to pp?

- **c-jets**: first measurement in pp and pPb!
- **b-jets**: first measurement in pPb!
- Compatible spectra in pp and pPb

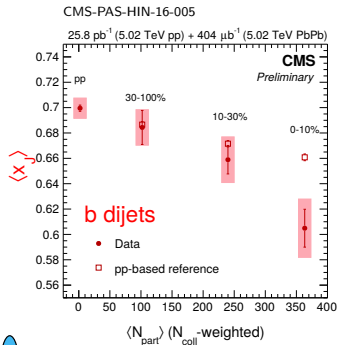
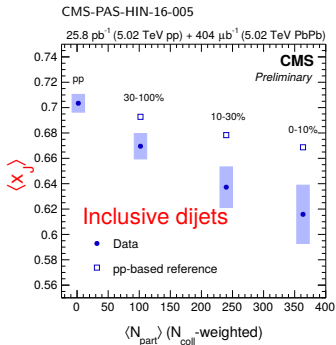


HF dijets: momentum imbalance in PbPb

Parallel: Kurt Jung, Thu 10:50



$$\langle x_J \rangle = \left\langle \frac{p_{T,2}}{p_{T,1}} \right\rangle$$

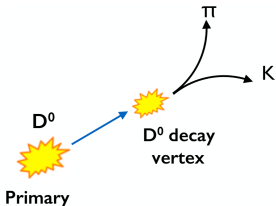


What about heavy quark energy loss?

- Larger light jet momentum imbalance $\langle x_J \rangle$ in PbPb than in pp
- No significant difference between light and b jets
- Importance of different processes: gluon splitting vs flavour creation?

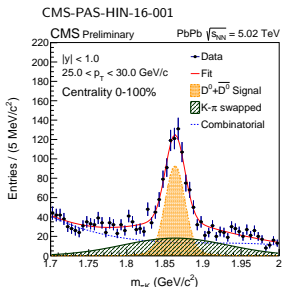


Open heavy flavour: D and B mesons

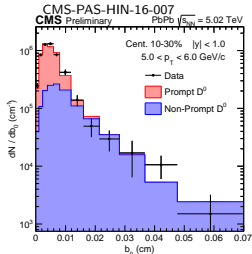
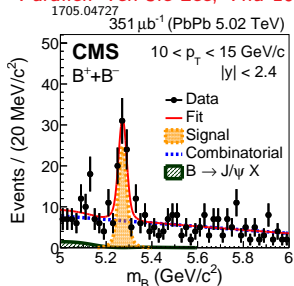


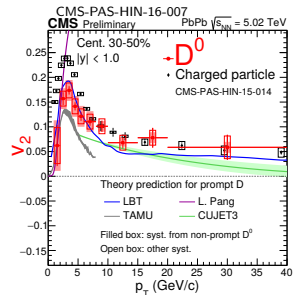
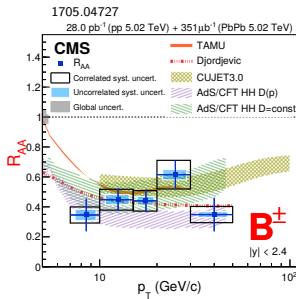
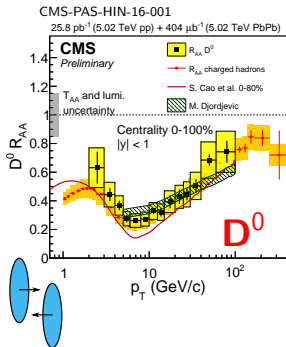
Open charm and beauty via D and B

- Measuring $D^0 \rightarrow K\pi$, $B^\pm \rightarrow J/\psi K$
- Down to 2 GeV/c for D^0 mesons
- Separating the prompt D^0 from the nonprompt

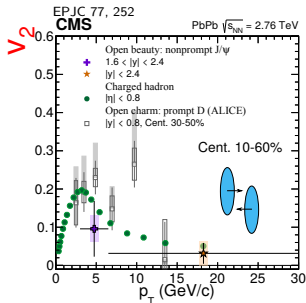
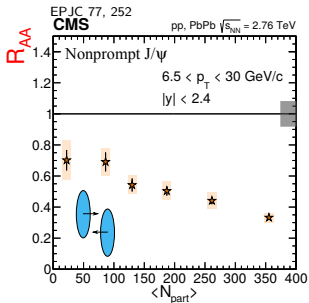
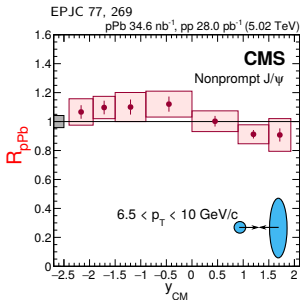


Parallel: Yen-Jie Lee, Thu 10:00





- **Similar suppression** for B, D mesons and light hadrons in PbPb collisions
- D^0 v_2 compared to light hadrons :
 - low p_T : mass ordering
 - high p_T : flavour independence of path length dependence of energy loss?



Nonprompt J/ψ : B meson production (open beauty)

- Up to 30 GeV/c
- **No large modification** in pPb
- **Strong suppression** in PbPb
- Large uncertainties on v_2



From heavy to light flavours



charm



bottom



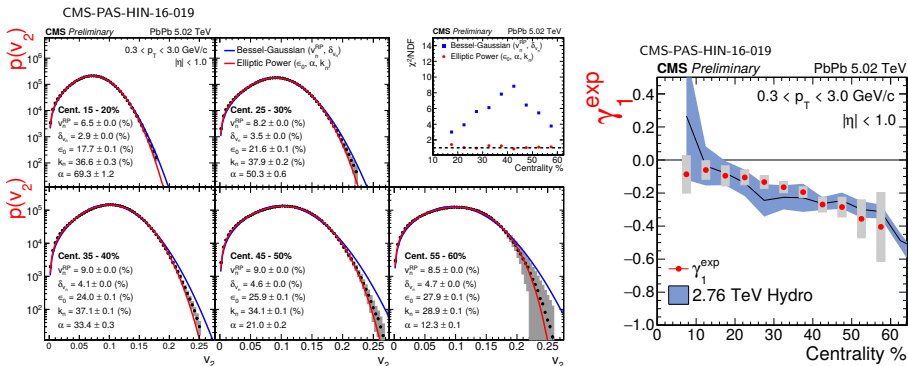
strange



up



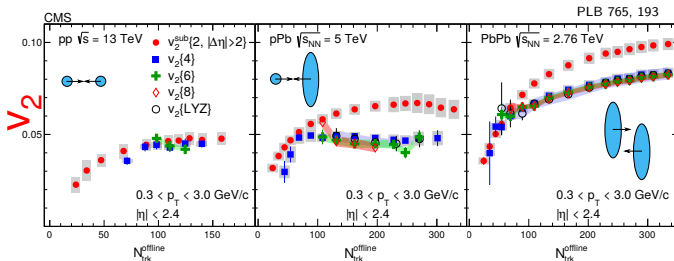
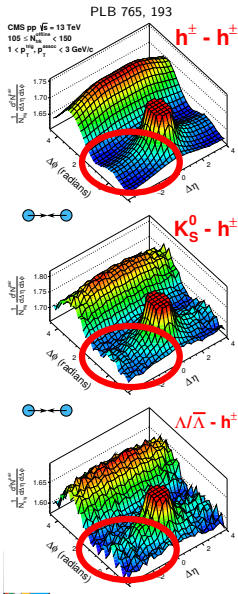
down



Extraction of the unfolded event by event $p(v_2)$ fluctuations

- Extraction of the **skewness** γ_1^{exp}
- Observations suggest **non-Gaussian fluctuations** of the eccentricity

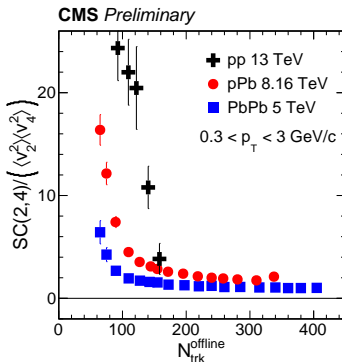
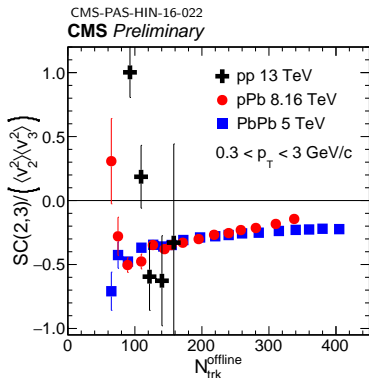




Collective behaviour even in small systems (pp, pPb)!

- Long-range correlations (“ridge”) observed also in high-multiplicity pp
- $v_2\{2\} > v_2\{4\} \approx v_2\{6\} \approx v_2\{8\} \approx v_2\{\infty\}$: **evidence for a collective origin** for the correlations





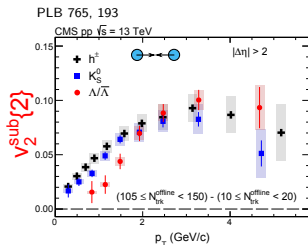
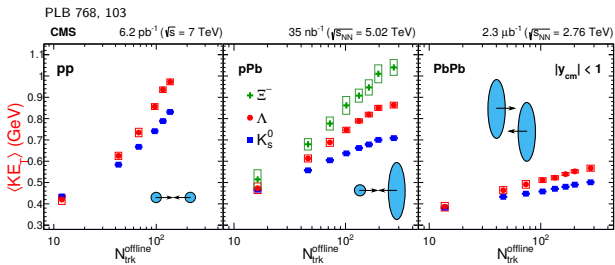
What are the **event by event correlations** between v_n and v_m ?

- v_2, v_3 : $SC(2,3) < 0$, **anti-correlation** (at high N_{tracks})
- v_2, v_4 : $SC(2,4) > 0$, **positive correlation**
- Similar trends in pPb and PbPb (and high mult. pp)



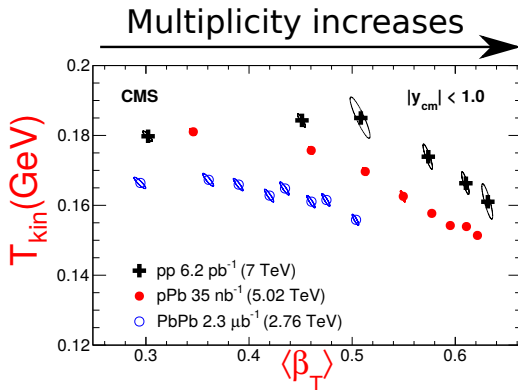
Strangeness in pp, pPb and PbPb collisions

Parallel: Hong Ni, Thu 12:10



- Higher transverse kinematic energy $\langle KE_T \rangle$ at higher multiplicities for all systems
- Faster increase for heavier particles and smaller systems
- Mass ordering also seen in v_2 in pp





Blast wave fits

- Model-dependent meaning of T_{kin} and β_T
- Similar trend with multiplicity in all systems
- Larger radial flow velocity in smaller systems



Summary



up



down



strange



charm



bottom

- **Many new CMS measurements**, from light flavours and strangeness, to charm and beauty
- **Modification of charm and beauty** production in heavy ion collisions
- Understanding **collectivity in small systems**

CMS detector

CMS DETECTOR

STEEL RETURN YOKE

SILICON TRACKERS

Charged particles, (displaced) vertices

SUPERCONDUCTING SOLENOID

MUON CHAMBERS

Muons

PRESHOWER

FORWARD CALORIMETER

**Centrality
determination**

CRYSTAL
ELECTROMAGNETIC
CALORIMETER (ECAL)

Jets

HADRON CALORIMETER (HCAL)

