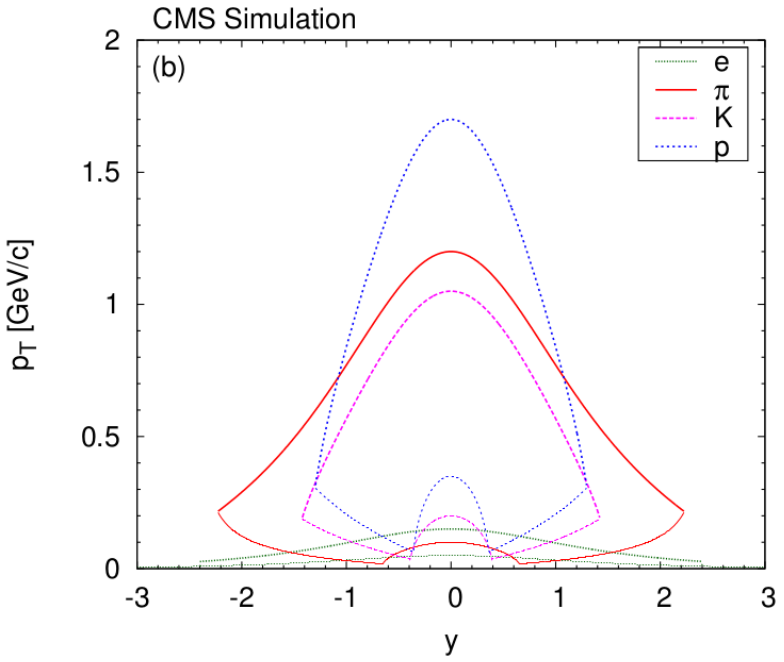
Measurement of hadron production in pPb collisions in CMS

Krisztián Krajczár

on behalf of the CMS Collaboration

Introduction

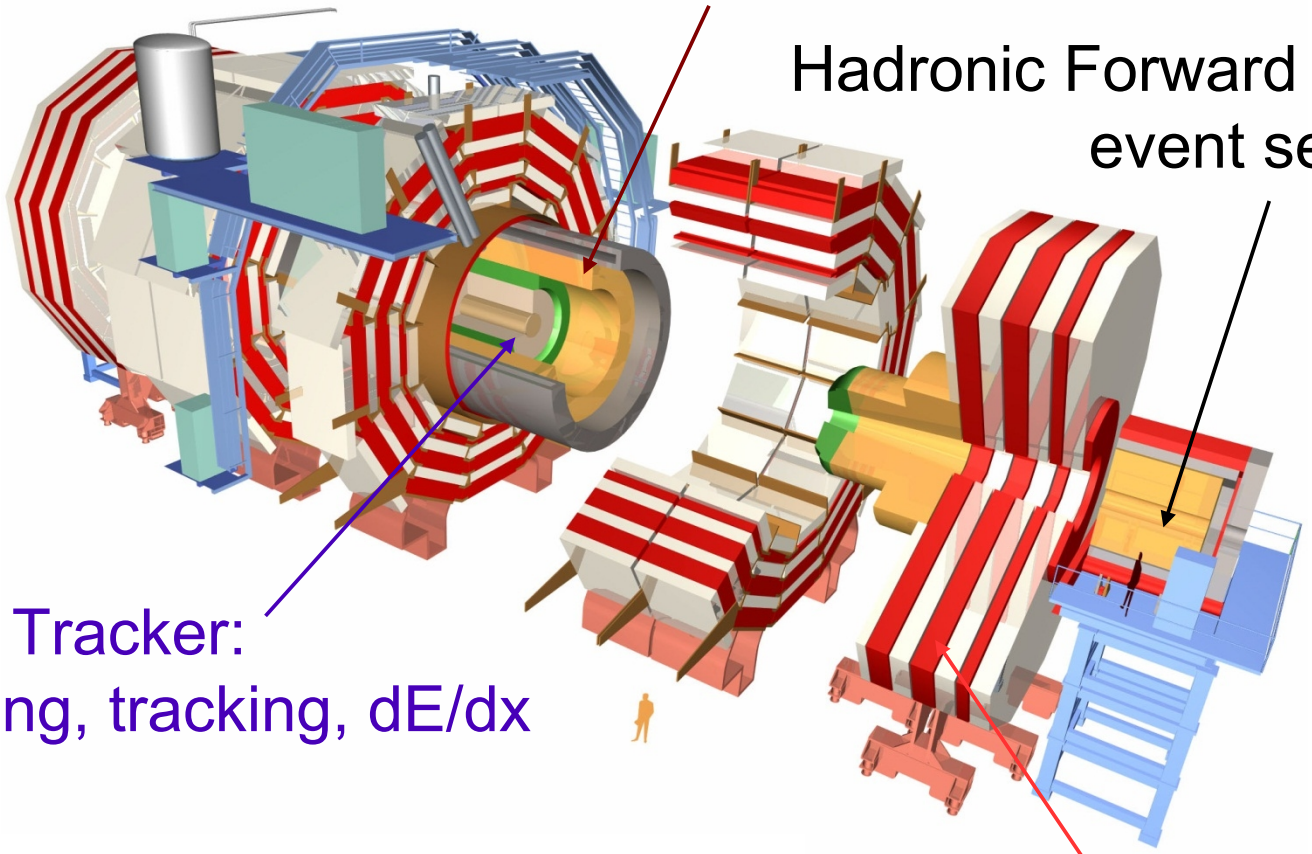
- Hadron spectra:
  - Long history both in high energy and nuclear physics
  - Test area of the implementations of non-perturbative QCD processes in MC event generators
  - pPb: also a reference for Heavy Ion collisions
- Setting up the scene:
  - PID: $p<1.20$ for $\pi^{\pm}$, $p<1.05$ for $K^{\pm}$, and $p<1.70$ GeV/c for p/p
  - Accessible region limited by Tracker acceptance
  - Results are given for $|y|<1$



CMS Detector

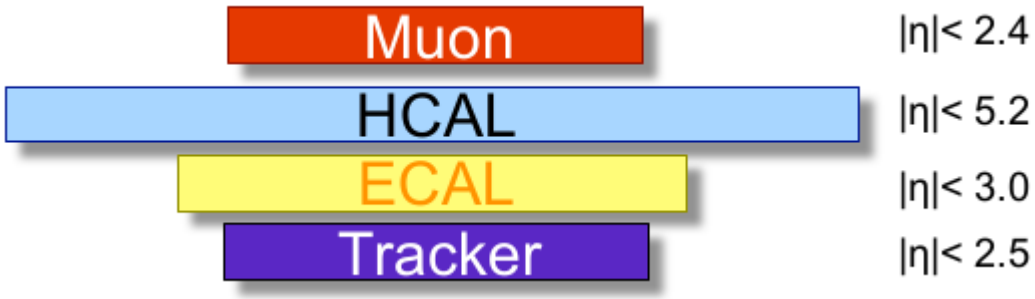
EM and Hadronic calorimeters

Hadronic Forward (HF) calorimeter: event selection



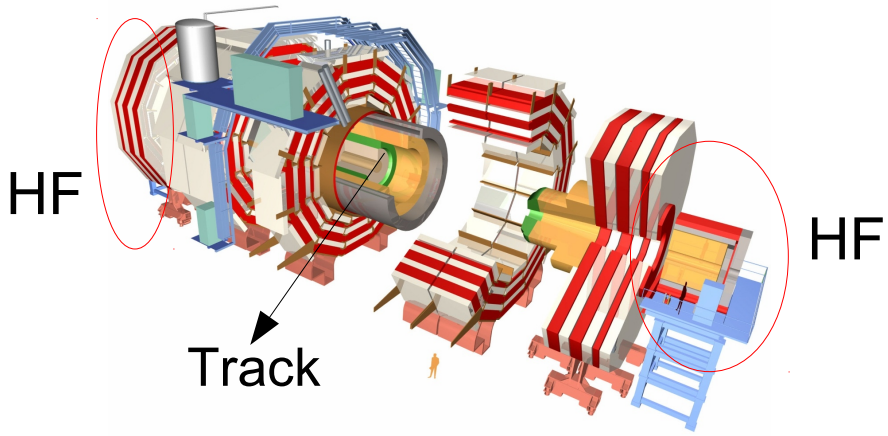
Silicon Tracker: triggering, tracking, dE/dx

Muon chambers



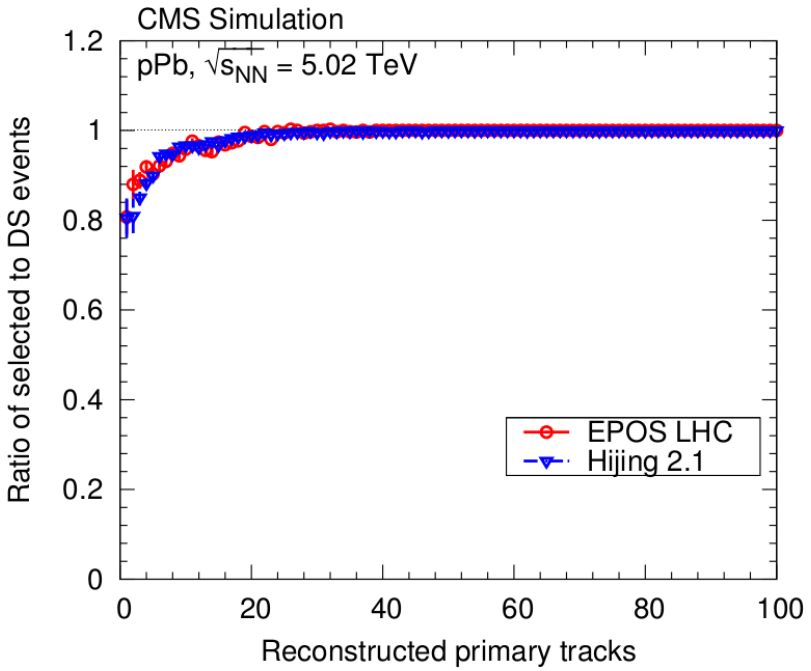
Triggering and event definition

- Data:
  - Low pile-up (0.15%) data collected in Sep. 2012, 2 M events
- Online and offline event selection:
  - Simultaneous presence of bunches in both beams
  - At least 1 “pixel” track (p_T>400 MeV/c)
  - Coincidence of at least one HF tower above 3 GeV on each side
  - Beam-induced background events are suppressed

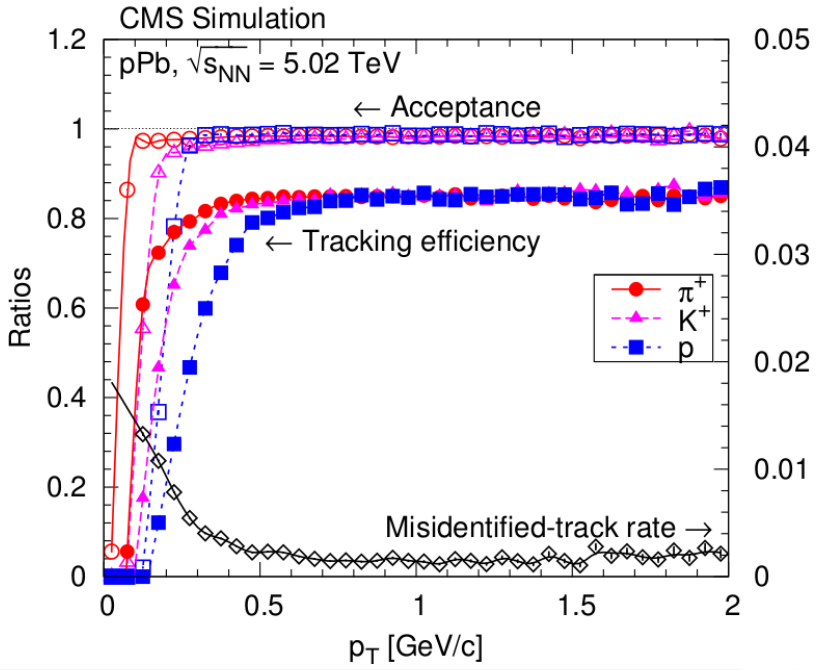


Track reconstruction

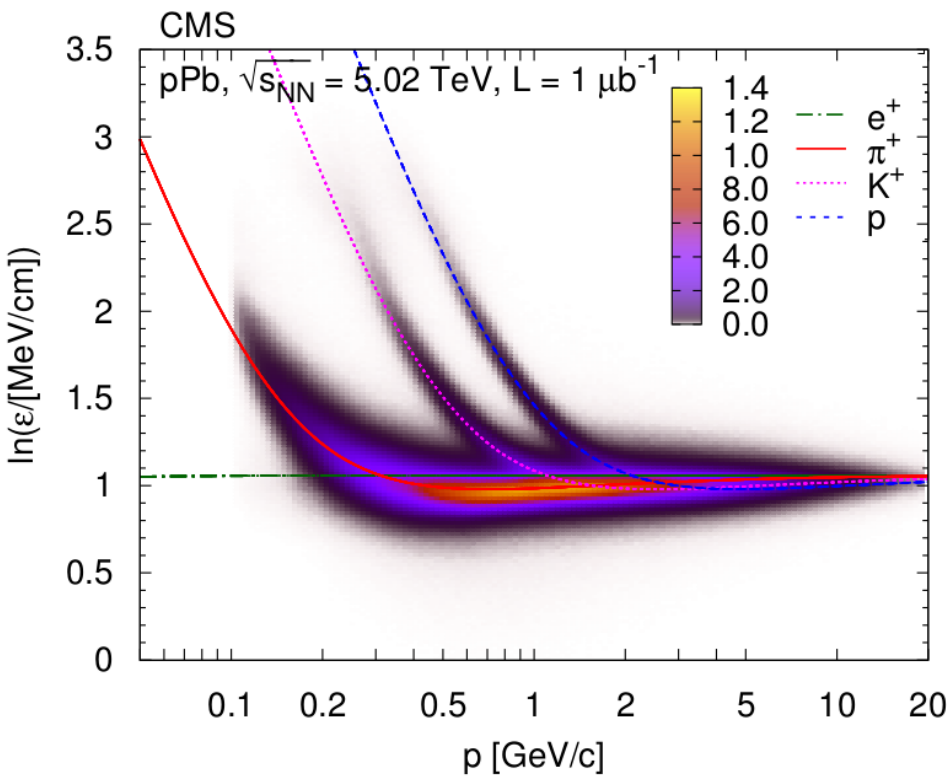
- Particle yields are for:
  - Double-sided (DS) selection: at least one particle with E>3 GeV on both sides (3<|η|<5)
  - DS: 94-97% of inelastic collisions

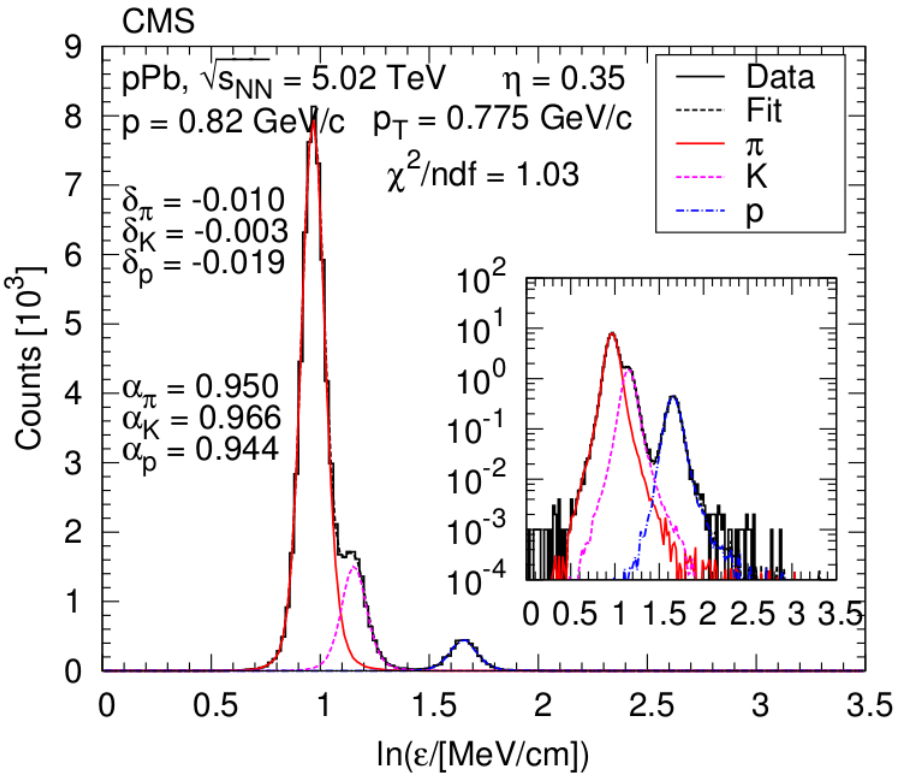


- Track reconstruction:
  - Special algorithm reconstructs pions down to p_T=100 MeV/c
  - Secondary particle fraction tuned via measuring K^0_S and Λ/Λ



Most probable energy loss rate





- Estimation of logε: Corrected deposits, minimalization of joint energy-deposit χ^2 for a track
- Template fits: Non-gaussians, energy deposits regenerated with an analytical energy loss parametrization

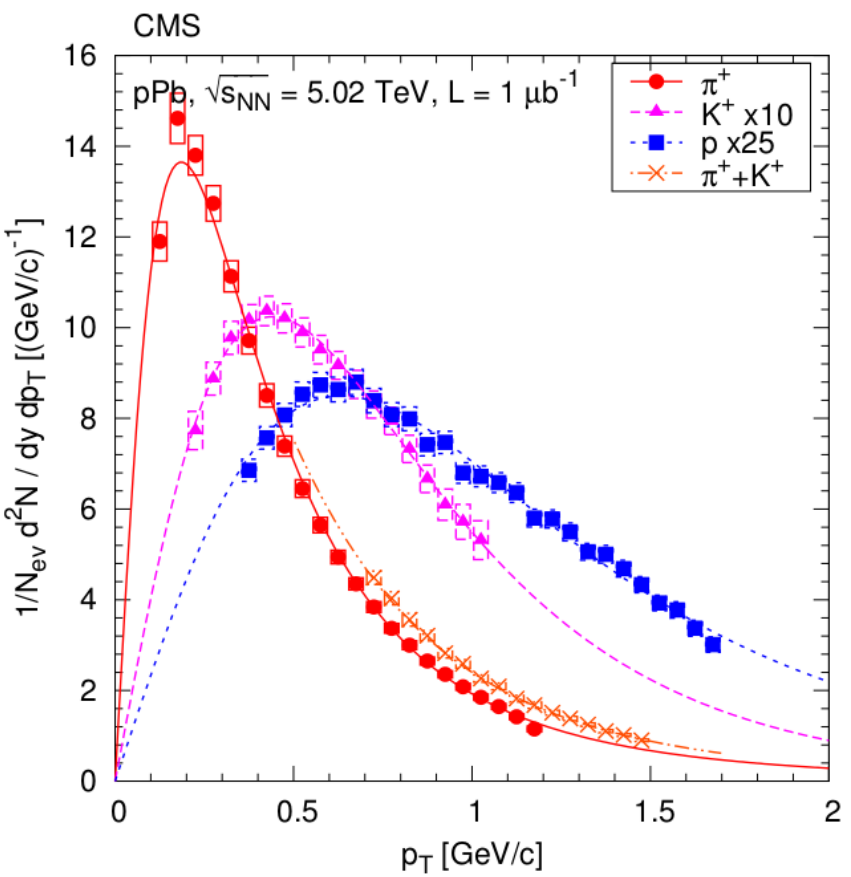
Systematic uncertainties

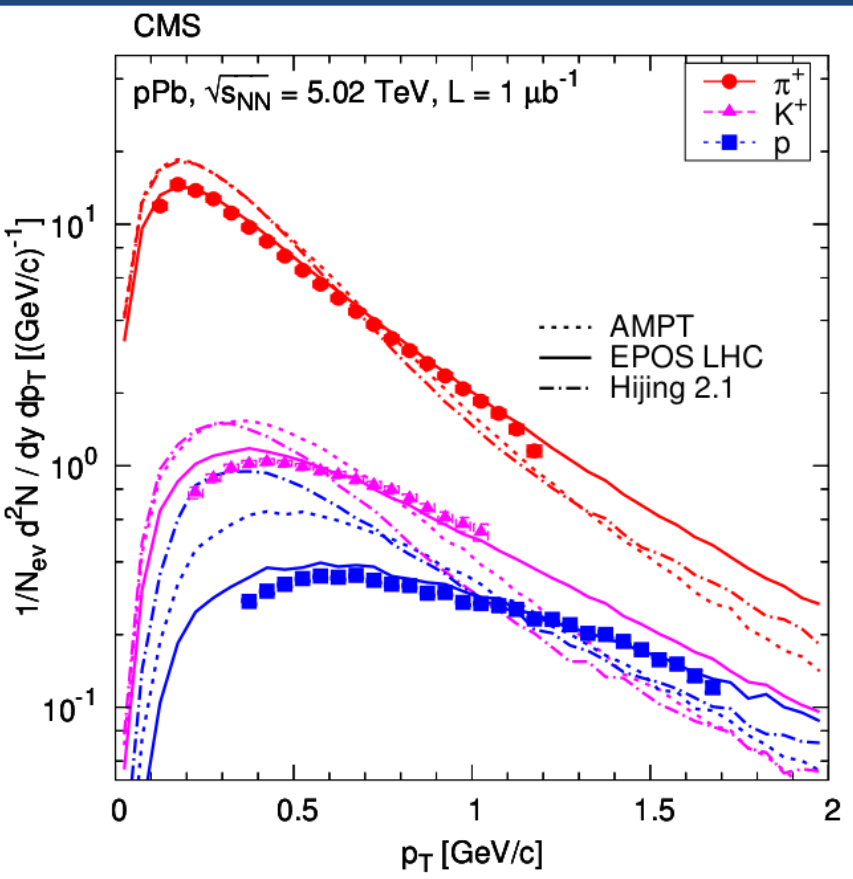
Source	*Uncertainty of the source* [%]	*Propagated yield uncertainty* [%]		
Fully correlated, normalisation				
Correction for event selection	3.0 (1.0)	3.0 (1.0)		
Pileup correction (merged and split vertices)	0.3			
Mostly uncorrelated				
Pixel hit efficiency	0.3	0.3		
Misalignment, different scenarios	0.1			
Mostly uncorrelated, (y, p_T) dependent		π	K	p
Acceptance of the tracker	1–6	1	1	1
Efficiency of the reconstruction	3–6	3	3	3
Multiple-track reconstruction	50% of the corr.	–	–	–
Misreconstructed-track rate	50% of the corr.	0.1	0.1	0.1
Correction for secondary particles	20% of the corr.	0.2	–	2
Fitting $\log \varepsilon$ distributions	1–10	1	2	1

EPJC 72 (2012) 1945

Physics results

Measured spectra

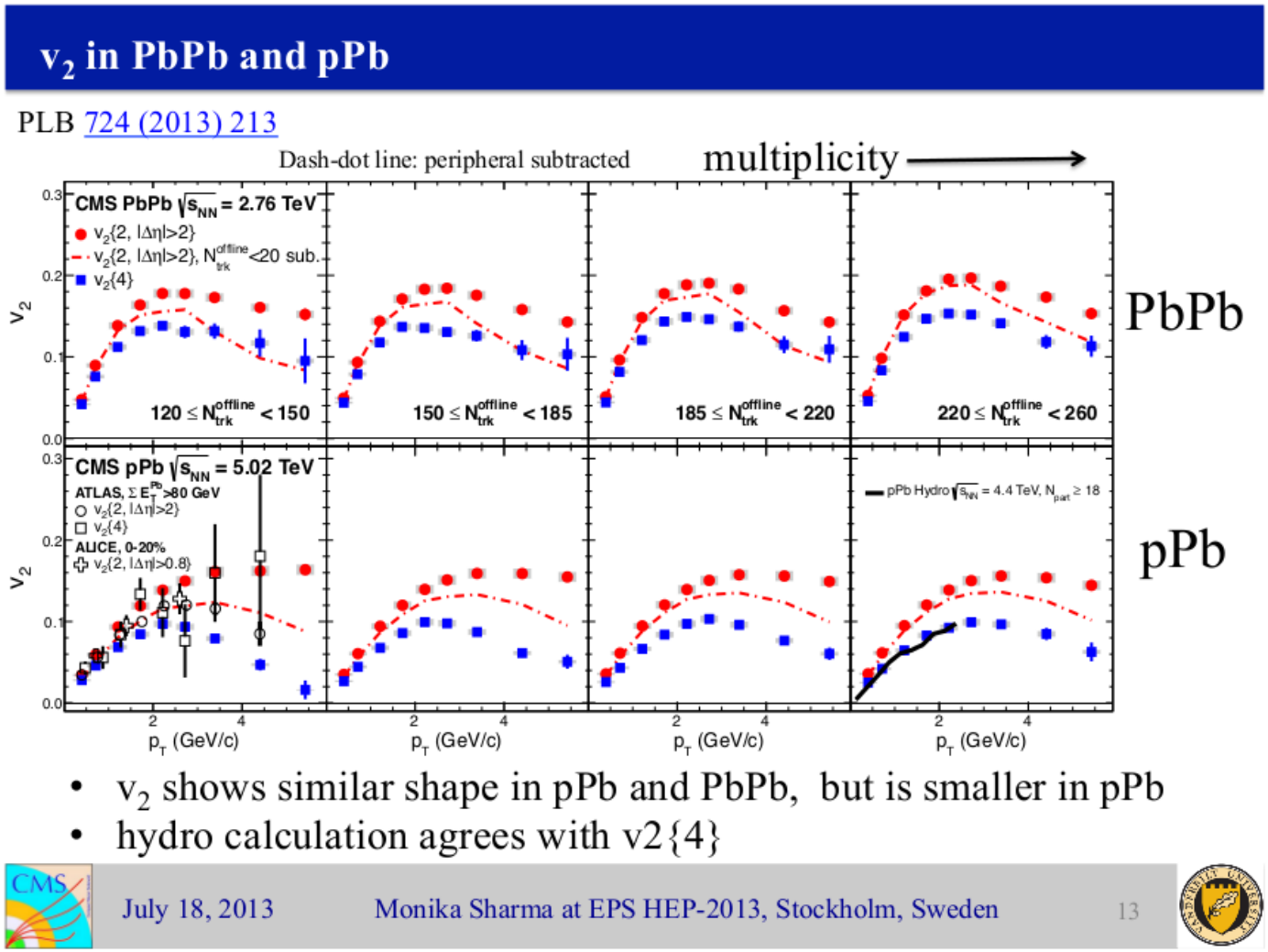




- Spectra: Statistical (bars) and systematic uncertainties (boxes), good quality Tsallis-Pareto fits
- Generator predictions: EPOS LHC gives good description, AMPT and Hijing predicts steeper p_T distribution than in data

Measured spectra

- EPOS LHC: 3D viscous event-by-event hydrodynamic treatment



Monika Sharma
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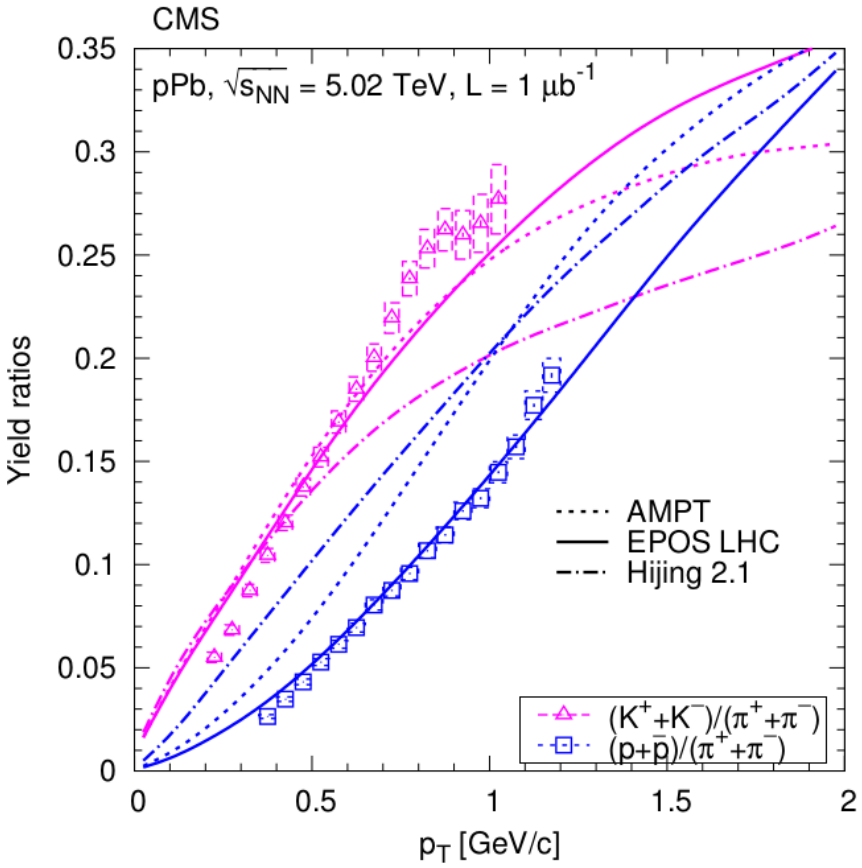
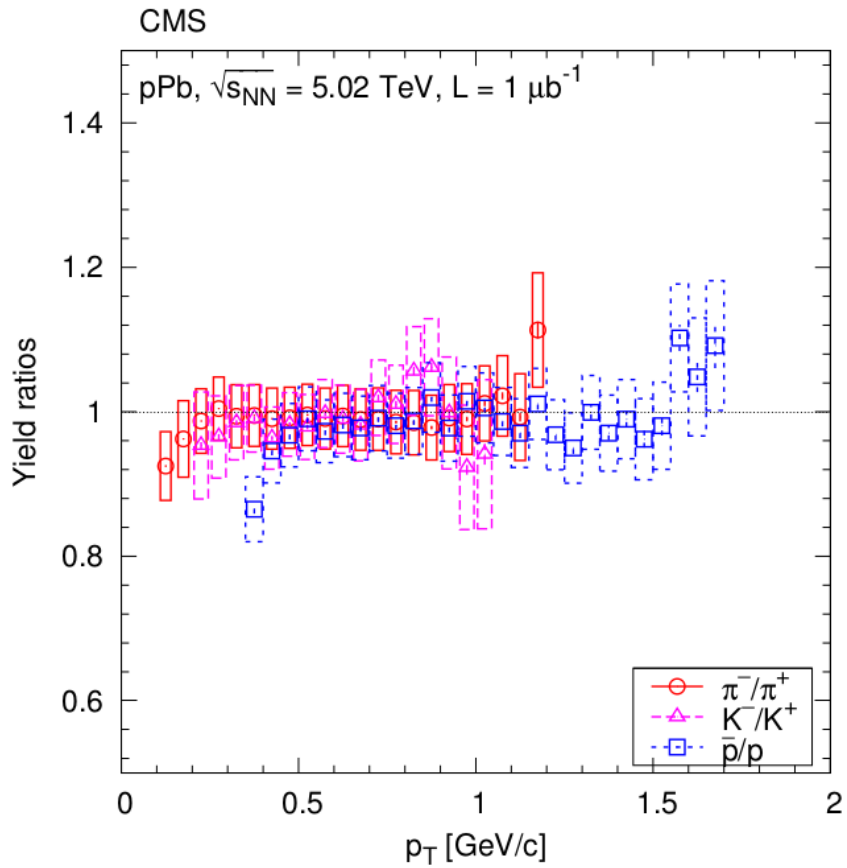
p_T dependence of relative yields





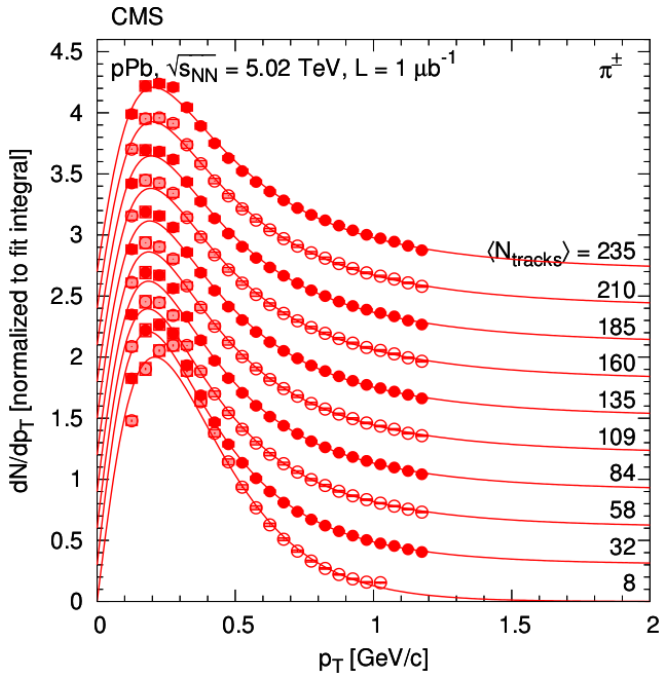
- p_T dependence of relative particle yields:
  - AMPT is capable of describing K/π, but only EPOS LHC describes both K/π and p/π
  - Ratio of the yields of oppositely charged particles close to 1

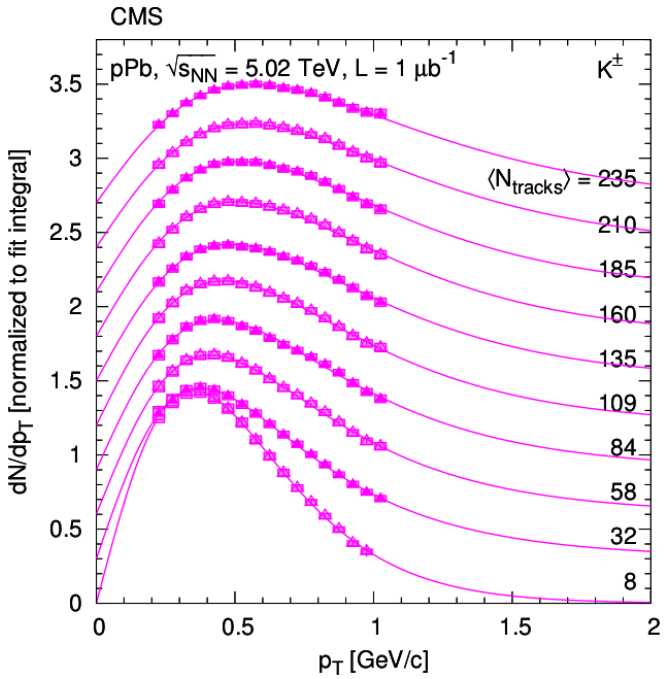
Multiplicity classes

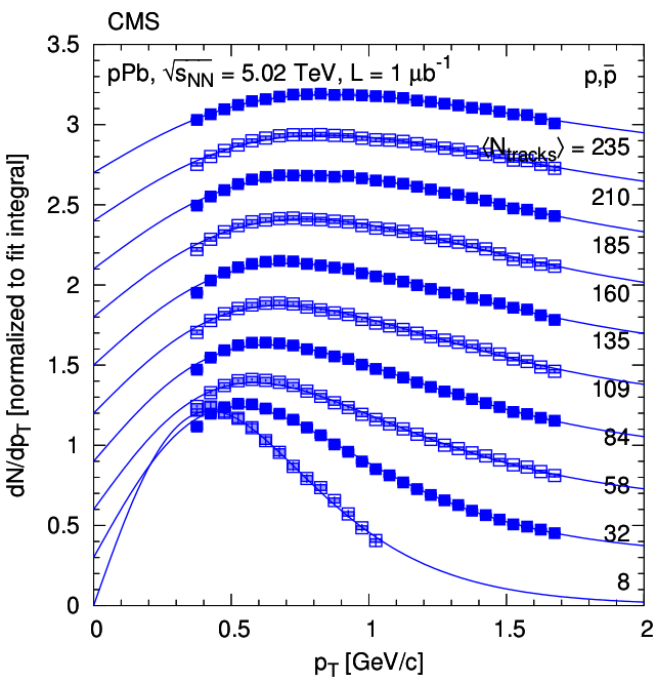
- Event multiplicity classes
  - Take the measured $d^2N/d\eta dp_T$ values
  - Take PID ratios from data to adjust the MC corrections
  - Correct for p_T<100 MeV/c part assuming a linear startup
  - Fully corrected number of hadrons are given in $|\eta|<2.4$: N_{tracks}

N_{rec}	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120-129	130-139	140-149	150-159	160-169	170-179	180-189
$\langle N_{tracks} \rangle$	8	19	32	45	58	71	84	96	109	122	135	147	160	173	185	198	210	222	235
$\langle N_{tracks} \rangle_{p_T>0.4\,GeV/c}$	3	8	15	22	29	36	43	50	58	65	73	80	87	95	103	110	117	125	133

Spectra in multiplicity classes

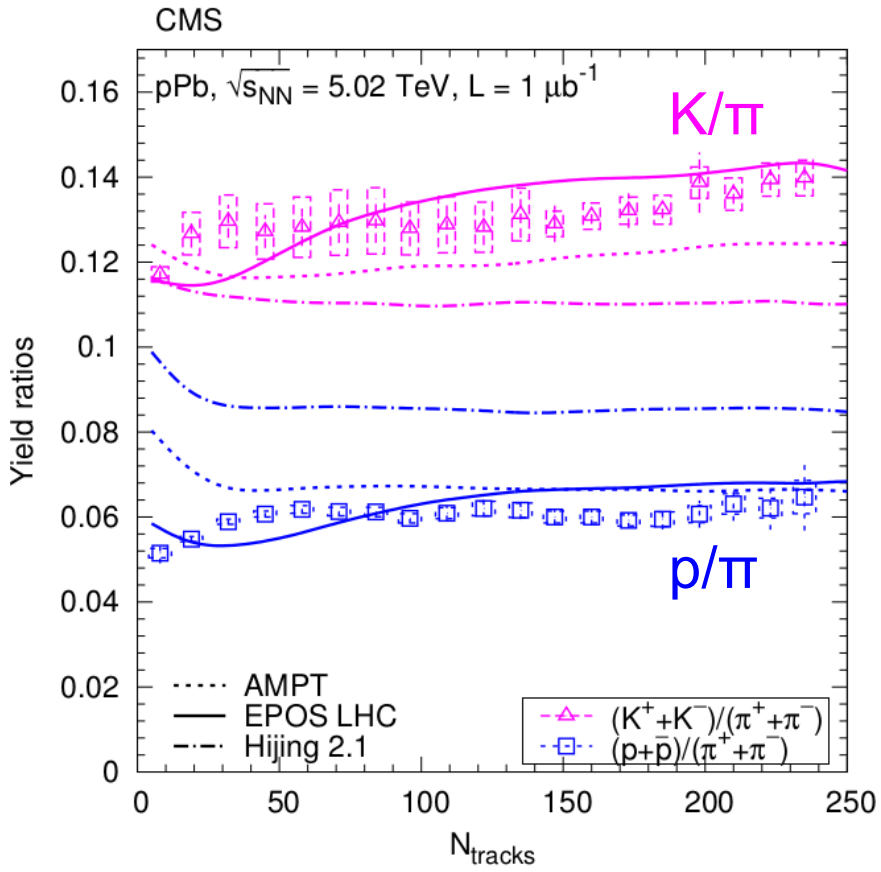


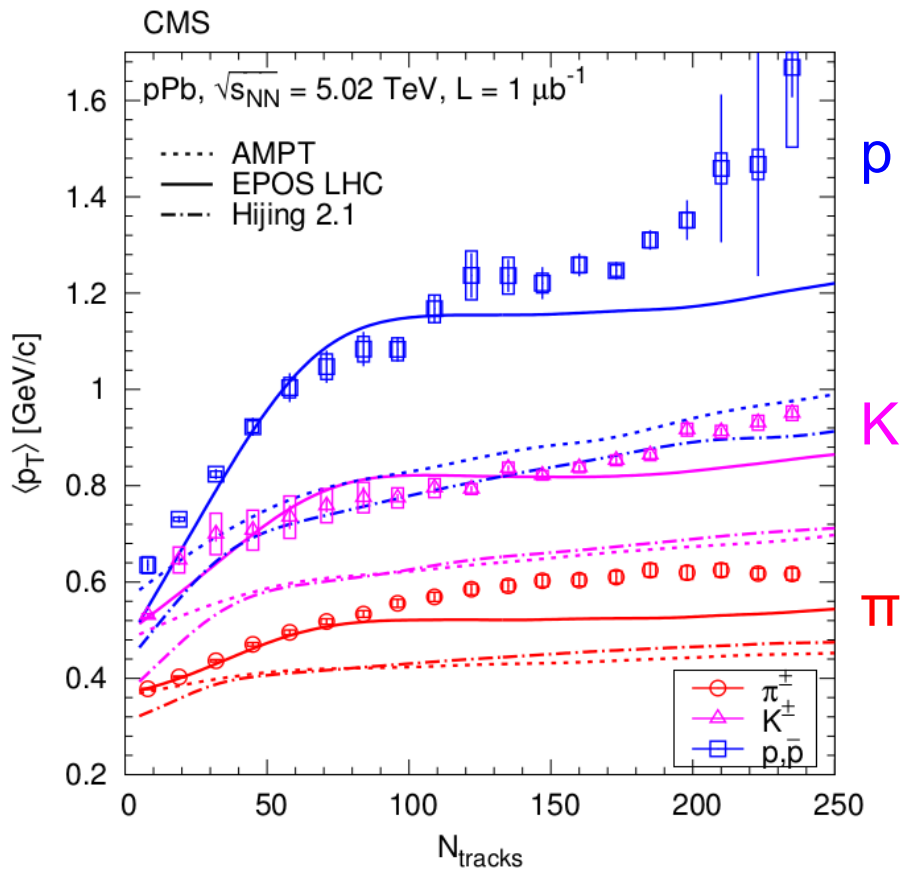




- Pion, kaon, and proton yields measured in bins of multiplicity
- Spectra for increasing multiplicity are shifted by 0.3 units, Tsallis-Pareto fits are shown
- Spectral shape changes for kaons and protons

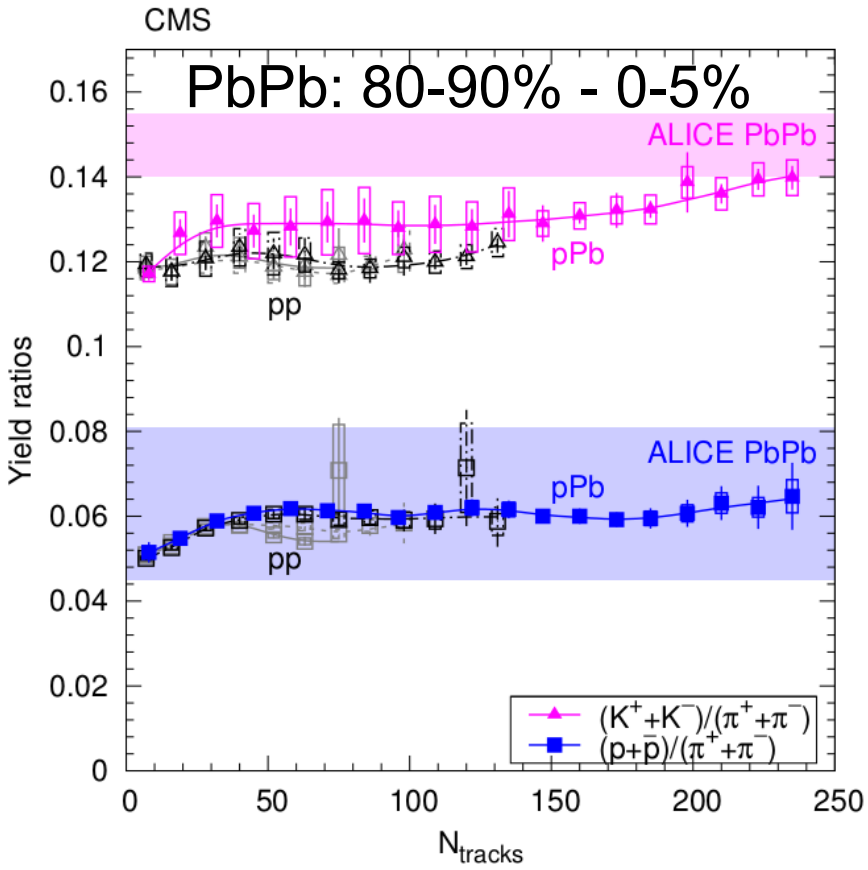
Yields and average p_T

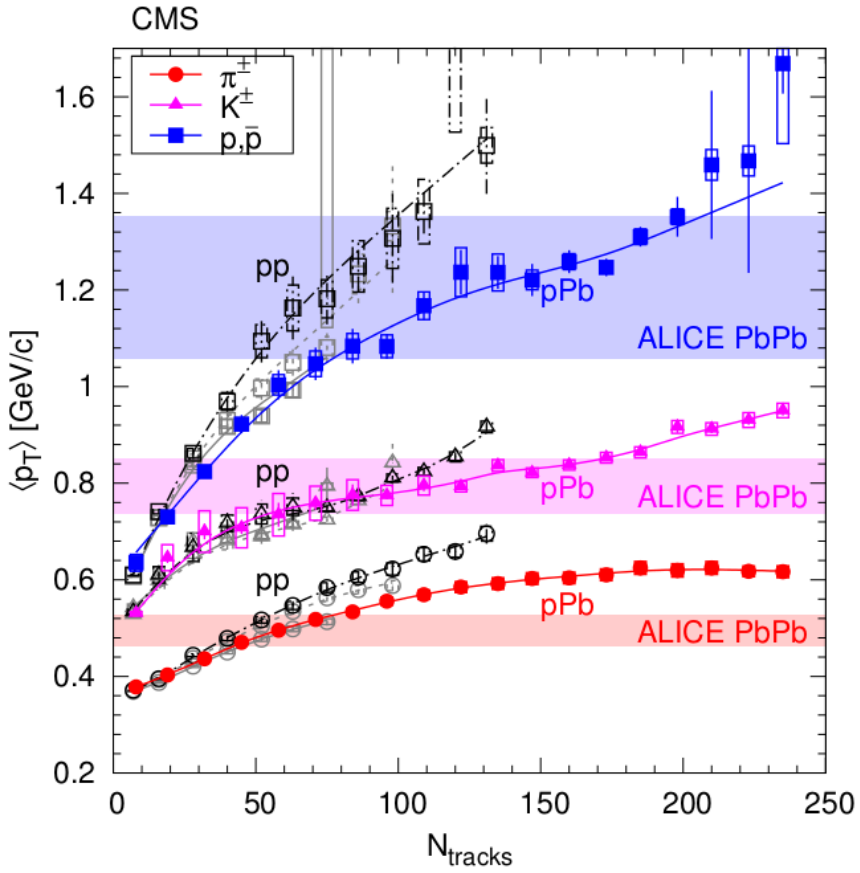




- Yields obtained by integrating the Tsallis-Pareto fits
- K/π and p/π ratios slowly rising, EPOS LHC looks the best
- Average p_T values much higher than in AMPT or Hijing

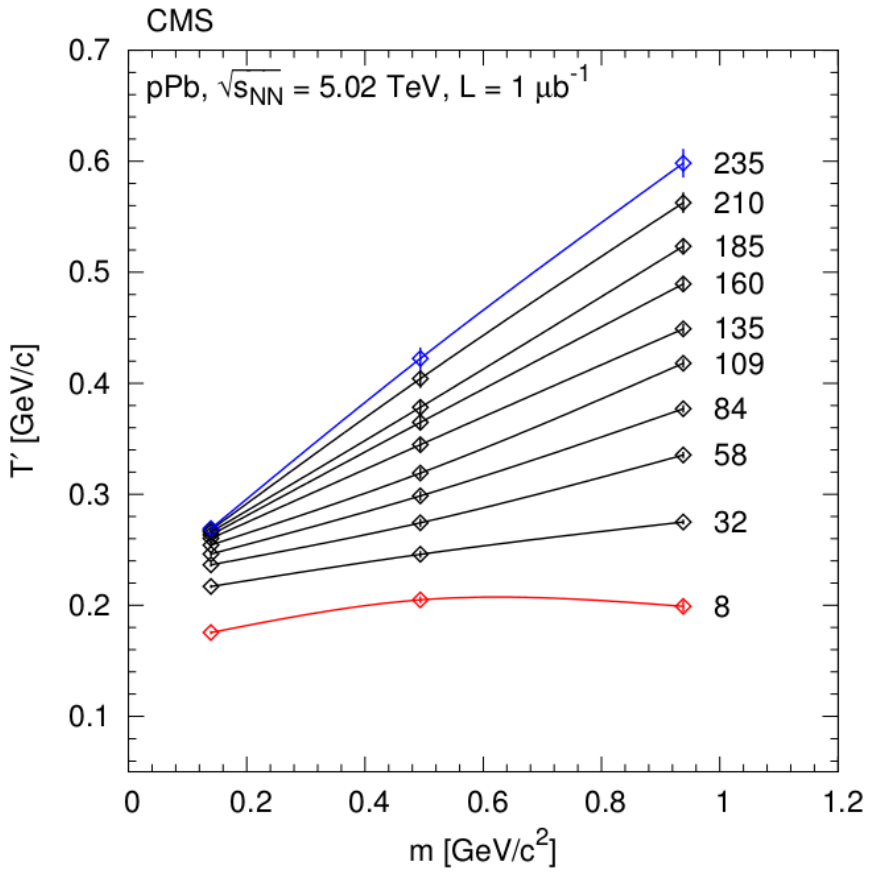
Yields and average p_T

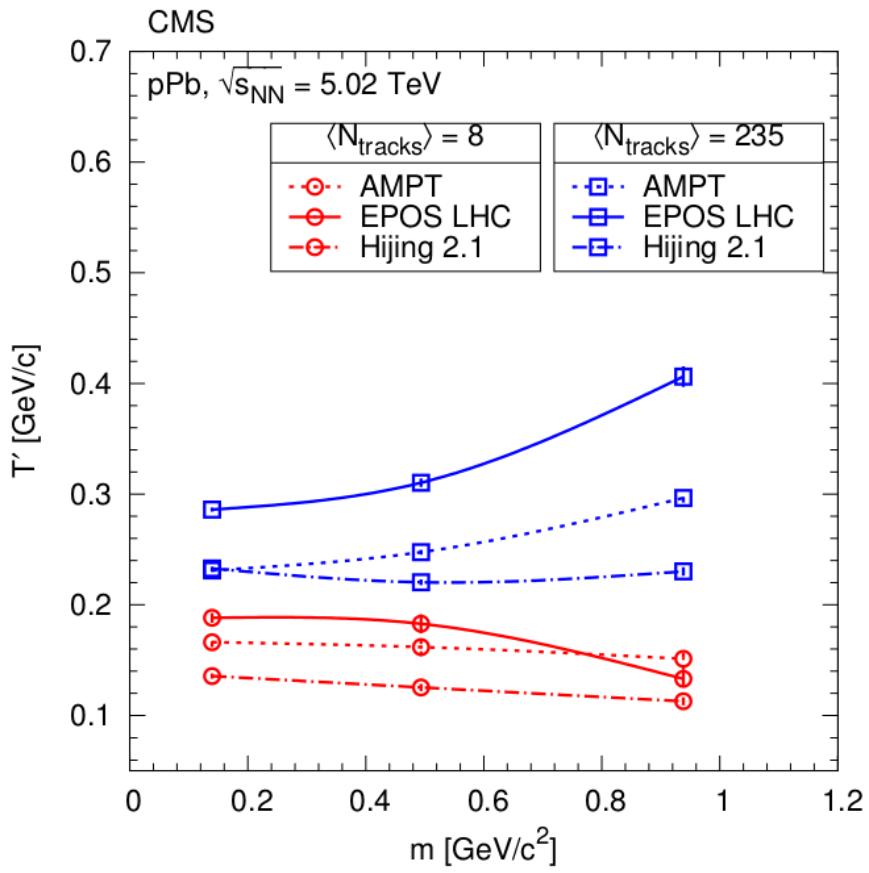




- Yield ratios: similar in pp and pPb
- $\langle p_T \rangle$: pPb behaves similar to pp for N_{track}<40, but it is flatter for N_{tracks}>50
- $\langle p_T \rangle$ grows higher than in PbPb: mix of soft and hard collisions

Inverse slope parameter





- Inverse slope parameter from $p_T exp(-m_T/T')$ fits
- Linear dependence on mass with a slope that increases with particle multiplicity
- Generator predictions are flatter than what data show

Summary

- Spectra of identified changed hadrons measured in pPb collisions as a function of track multiplicity

- Particle production is strongly correlated with event multiplicity, rather than with collision energy / the mass of the colliding nuclei
- Highest multiplicity pPb interactions yield higher p_T than in central PbPb
- Inverse slope parameter: linear dependence on particle mass
- Paper: arxiv:1307.3442

CMS Heavy Ion Physics Results

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

CMS Heavy-Ion Public Physics Results

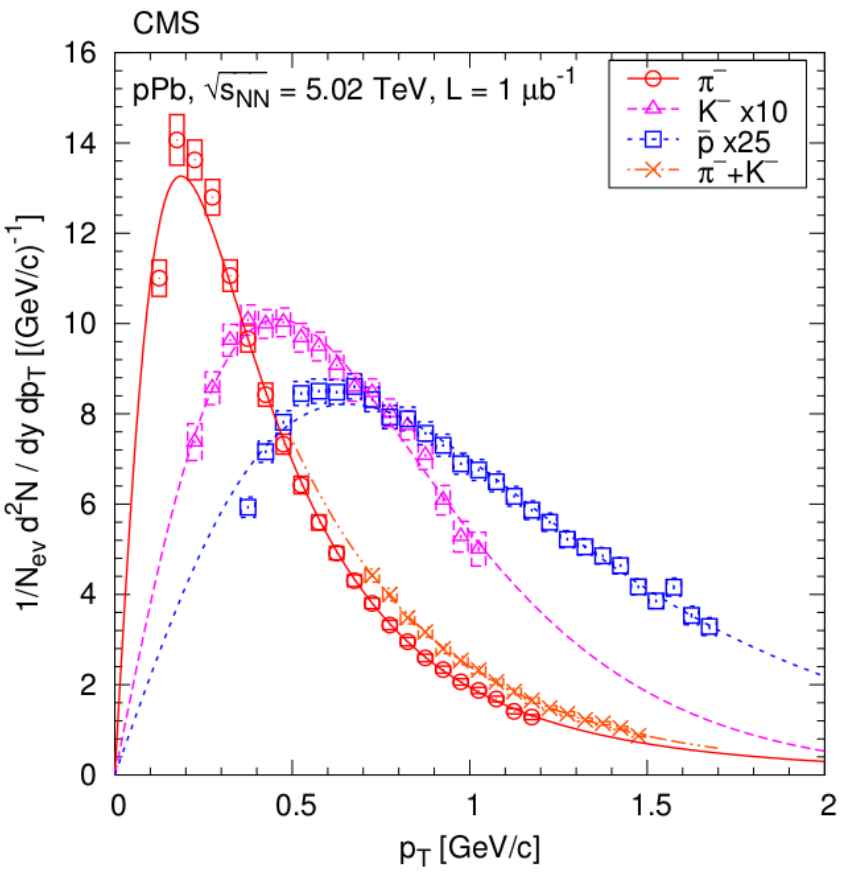
Final Results

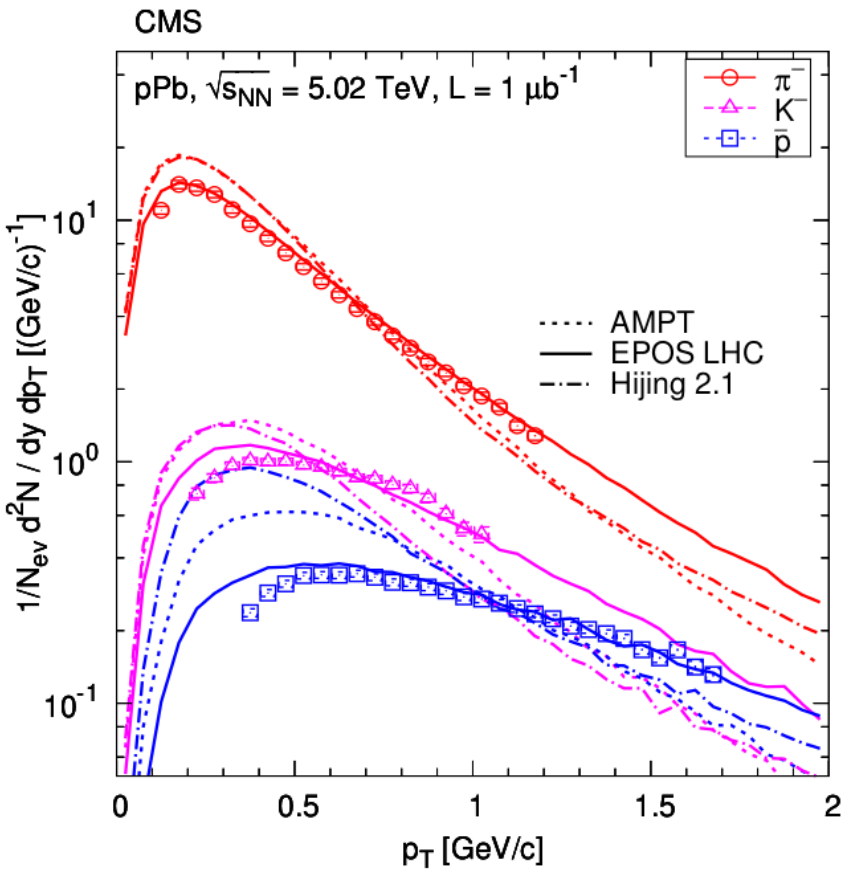
The table contains papers and public results, with links to arXiv, CERN preprint, and the final paper, if available.
Plots are provided through dedicated twiki pages, the CERN Document Server database, and the arXiv source.

Analysis	Reports	Publication	Plots	Data	Comment
2- and 4-particle correlations in pPb	CMS-HIN-13-002 arXiv:1305.0609 CERN-PH-EP-2013-077	-			31/nb
Neutral pion v2 in PbPb collisions	CMS-HIN-11-009 arXiv:1208.2470 CERN-PH-EP-2012-231	PRL 110 (2013) 042301			3.5/ub
Elliptic flow and low-pt spectra	CMS-HIN-10-002 arXiv:1204.1409 CERN-PH-EP-2012-095	PRC 87(2013) 014902			3/ub
Ridge (2-particle correlations) in pPb	CMS-HIN-12-015 arXiv:1210.5482 CERN-PH-EP-2012-320	PLB 718 (2013) 795			1/ub
Gamma-jet correlations in PbPb collisions	CMS-HIN-11-010 arXiv:1205.0206 CERN-PH-EP-2012-089	PLB 718 (2013) 773		-	150/ub
Y suppression, 2011 data	CMS-HIN-11-011 arXiv:1208.2826 CERN-PH-EP-2012-228	PRL 109 (2012) 222301			pp: 230/nb PbPb: 150/ub
Jet fragmentation	CMS-HIN-11-004 arXiv:1205.5872	JHEP 10 (2012) 087		-	pp: 231/nb PbPb: 6.8/ub

Backup slides

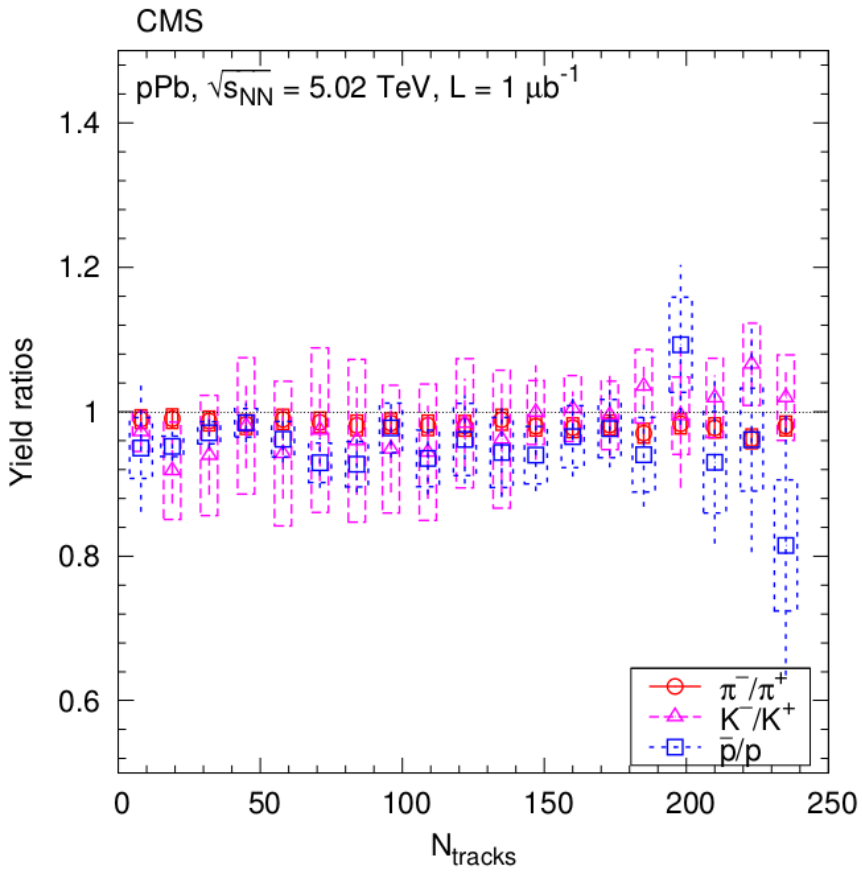
Measured spectra





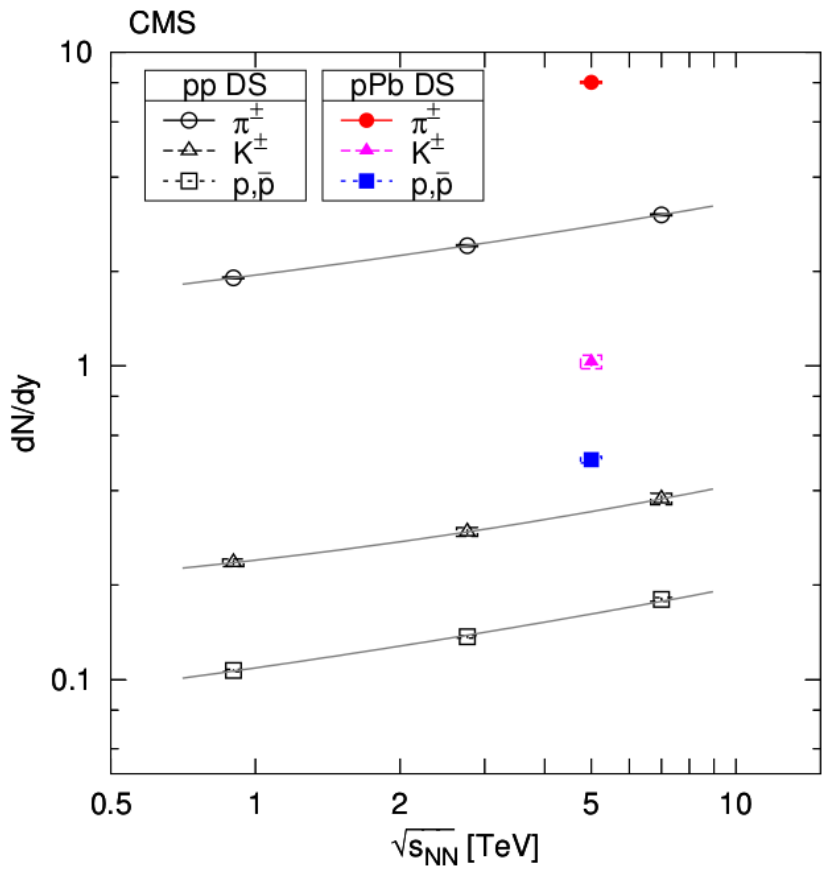
- Spectra: Statistical (bars) and systematic uncertainties (boxes), good quality Tsallis-Pareto fits
- Generator predictions: EPOS LHC gives good description, AMPT and Hijing predicts steeper p_T distribution than in data

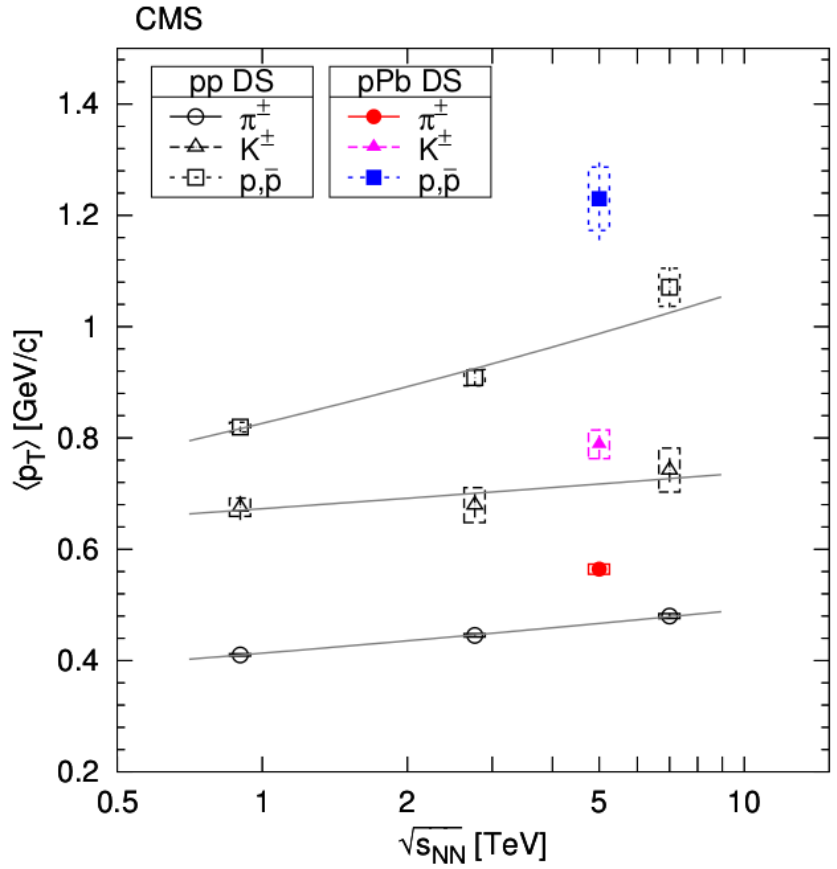
Relative particle yields



- Ratios of oppositely charged particles are compatible with 1 in all multiplicity bins

Average yield and transverse momentum





- pp and pPb data are for laboratory rapidity
- Parabolic (dN/dy) and linear ($<p_T>$) parameterizations on log-log scale