Incontri di Fisica delle Alte Energie
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Multi-strange particle production in Pb-Pb collisions at the LHC with ALICE

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for the ALICE Collaboration

Motivation

- Multi-strange baryons in HIC
  - ✓ Strange particle production
    - ➪ investigate properties of strongly interacting system
  - ✓ Multi-strange
    - ➪ special probe of the early stages of the collision

- Strangeness enhancement wrt pp
  - ✓ Signature of the QGP
  - ✓ Observed at SPS/RHIC energies
  - ✓ Trend with $\sqrt{s_{NN}}$ to be confirmed/further understood
    - yields in A-A and p-p collisions at LHC energies
    - ➪ would provide additional constraints from ALICE data

Particle identification

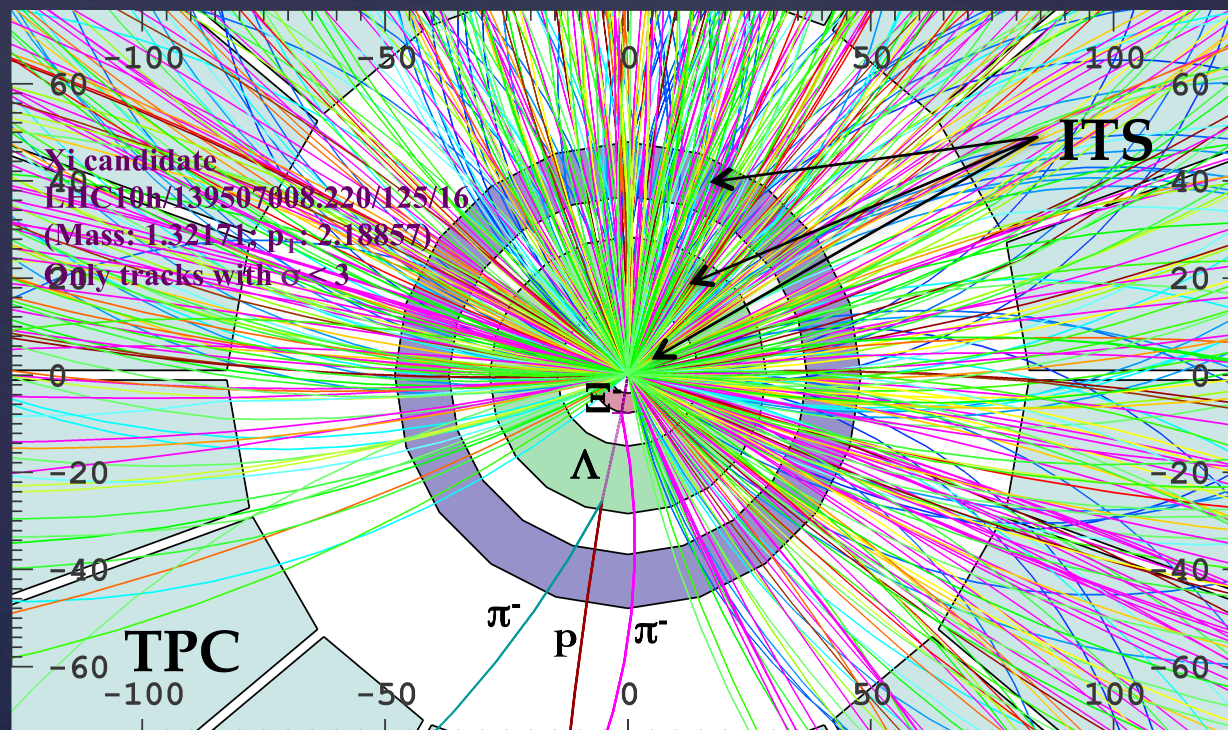
- Multi-strange baryons in ALICE
  - ✓ reconstructed via their (cascade) decay topology in Inner Tracking System and Time Projection Chamber
  - ✓ specific ionization (in the TPC) used to identify daughters
  - ✓ during event reconstruction, Cascade candidates founded combining reconstructed tracks and applying loose cuts on geomentry and kinematics
  - ✓ cuts are tightened to reduce background at the analysis level

$$\Xi^-(dss) \rightarrow \Lambda\pi^- \rightarrow p\pi^-\pi^- \quad (B.R.\ 69.9\%)$$

$$\overline{\Xi}^+(\overline{dss}) \rightarrow \overline{\Lambda}\pi^+ \rightarrow \overline{p}\pi^+\pi^+ \quad (B.R.\ 69.9\%)$$

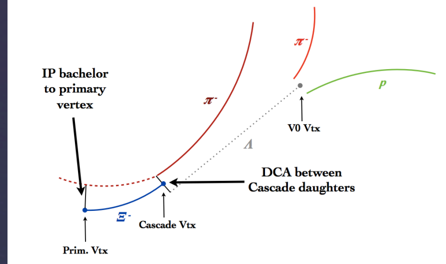
$$\Omega^-(sss) \rightarrow \Lambda K^- \rightarrow p\pi^- K^- \quad (B.R.\ 43.3\%)$$

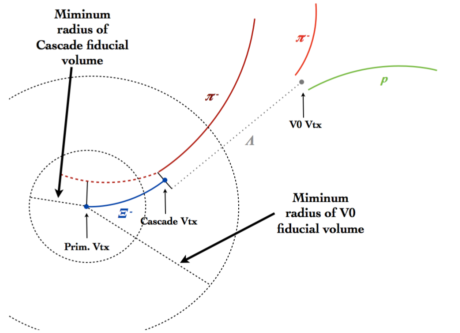
$$\overline{\Omega}^+(\overline{sss}) \rightarrow \overline{\Lambda}K^+ \rightarrow \overline{p}\pi^+ K^+ \quad (B.R.\ 43.3\%)$$



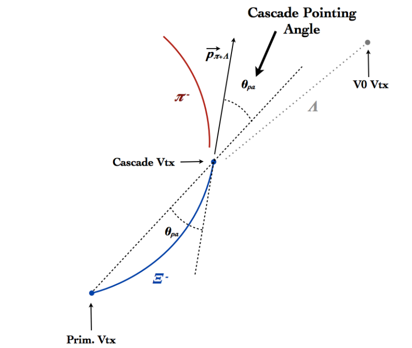
Topological cuts

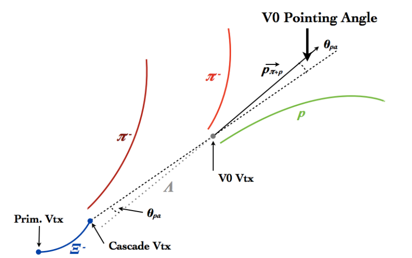
- Cuts on geometry and kinematics for cascade and V0 reconstruction

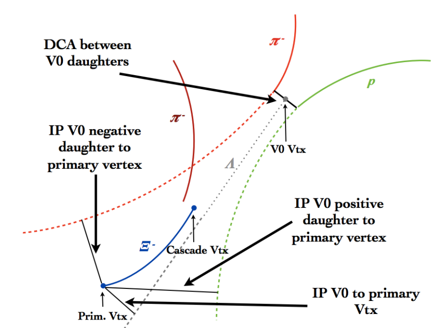




Cuts for cascades	Loose reconstruction	Tuned for analysis
Max allowed χ^2	33.	33.
Min allowed V0 DCA (cm)	0.05	**0.1**
Window around V0 mass (MeV/c^2)	0.008	**0.005**
Min allowed bachelor DCA (cm)	0.03	0.03
Max allowed DCA cascade daughters (cm)	0.3	0.3
Min allowed cosine of cascade PA	0.999	**0.9993**
Min radius of the fiducial volume (cm)	0.9	**1.5**
Max radius of the fiducial volume (cm)	100.	100.
Window around M(Λ,π) for Ω (GeV/c^2)	-	**0.008**
Cuts for V0s	**Loose reconstruction**	**Tuned for analysis**
Max allowed χ^2	33.	33.
Min allowed DCA for 1° daughter (cm)	0.1	0.1
Min allowed DCA for 2° daughter (cm)	0.1	0.1
Max allowed DCA daughter tracks (cm)	1.0	**0.6**
Min allowed cosine of V0 PA	0.998	0.998
Min radius of fiducial volume (cm)	0.9	**4.0**
Max radius of fiducial volume (cm)	100.	100.

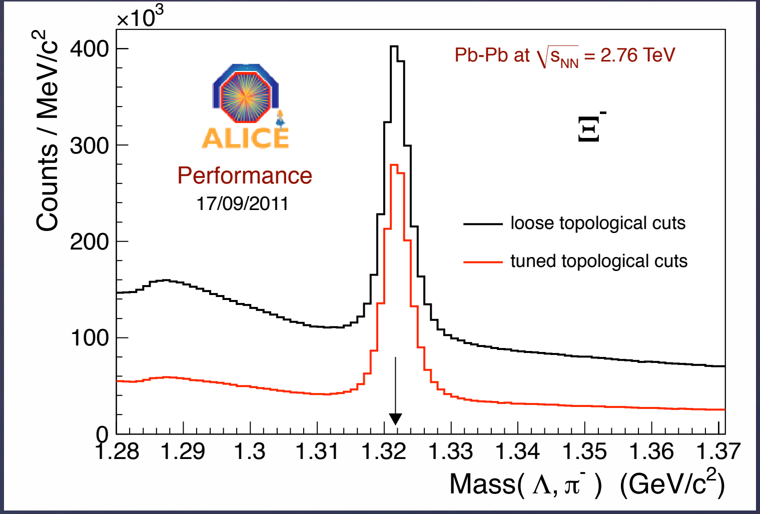




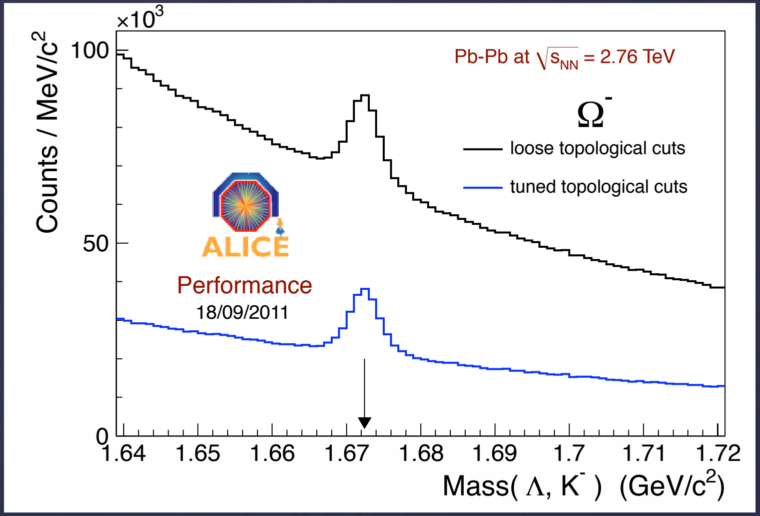


Towards signal extraction

Ξ mass from PDG: 1.321 GeV/c^2



Ω mass from PDG: 1.672 GeV/c^2



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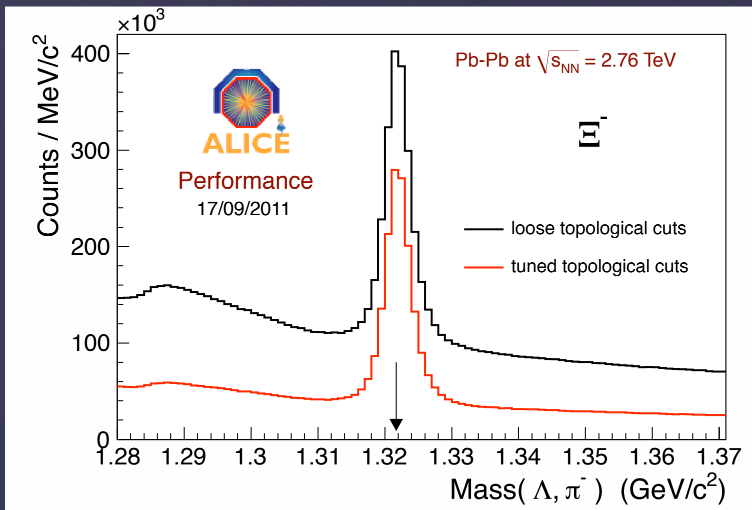
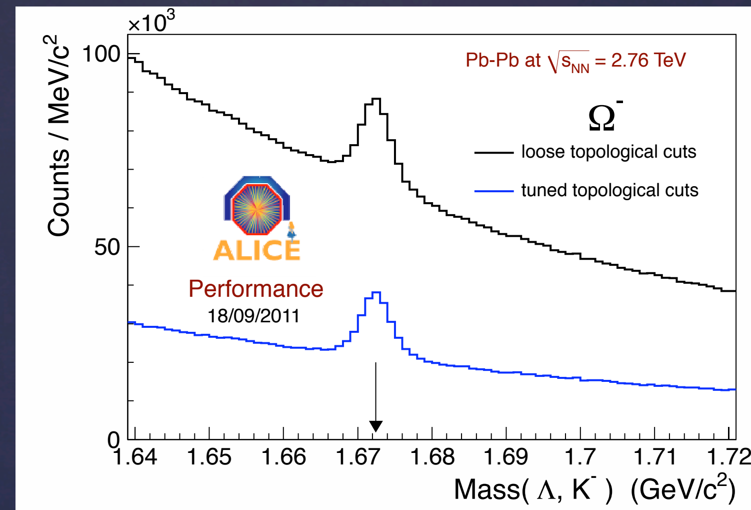
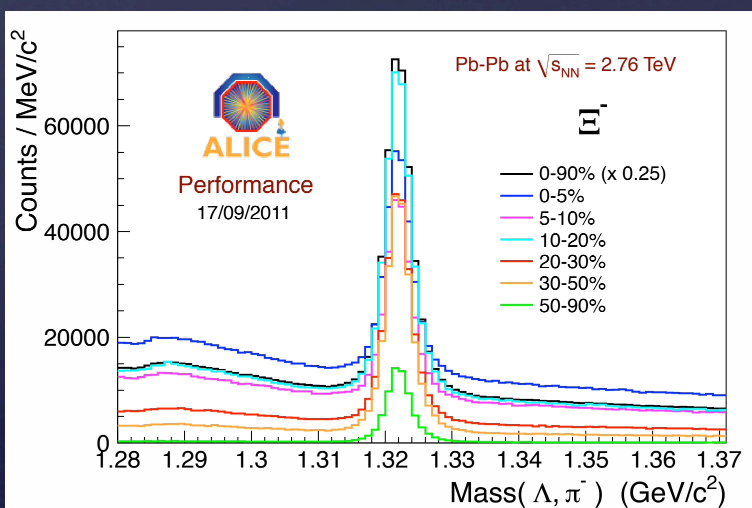
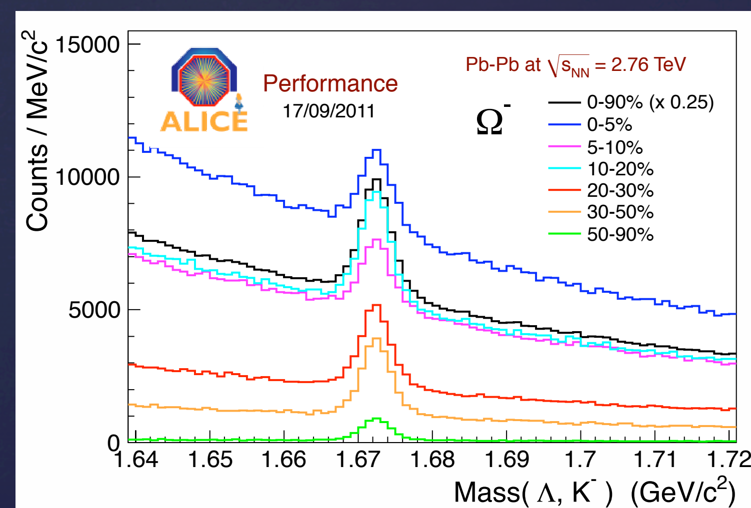
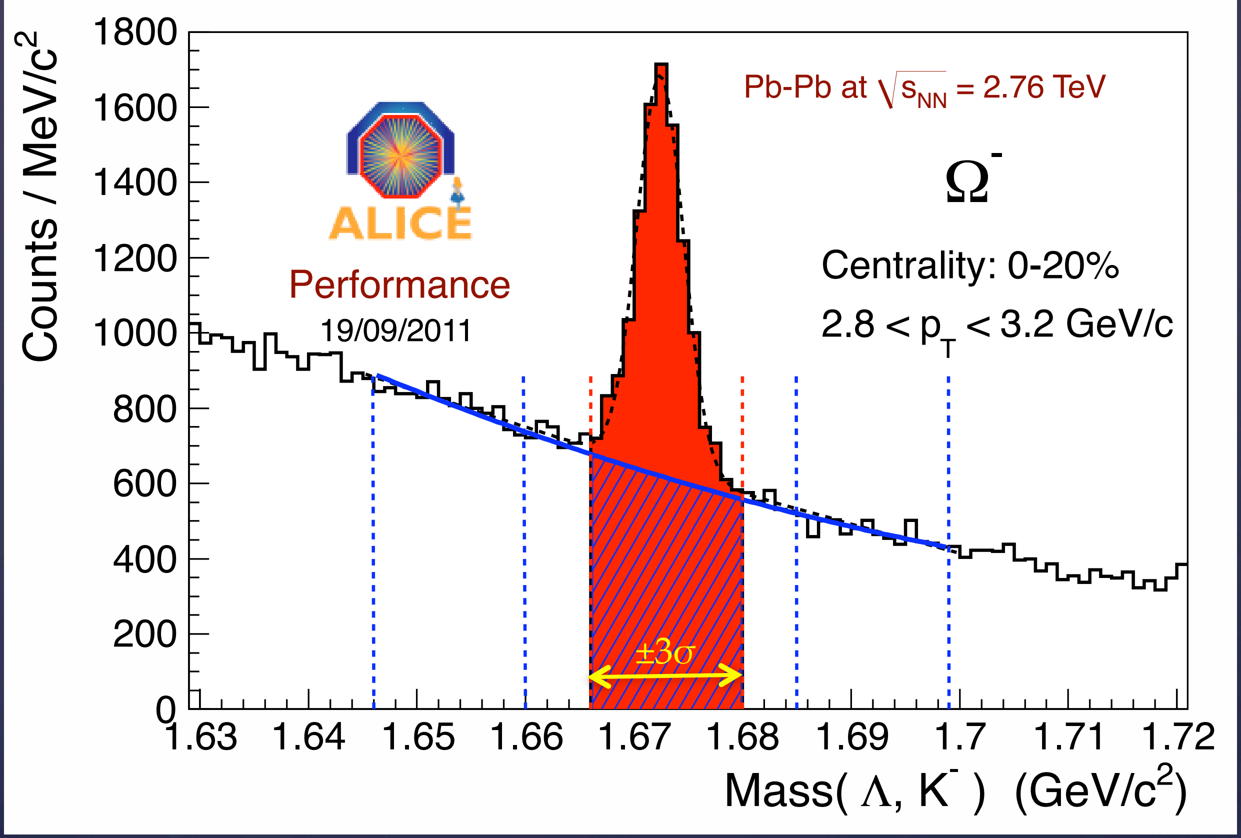








Signal extraction



Fit polynomial+gaussian to get signal mean and σ

Bin counting in the signal region (±3σ)

Fit background sampled on both sides of the signal region

Integral *of background fit function in the signal region*

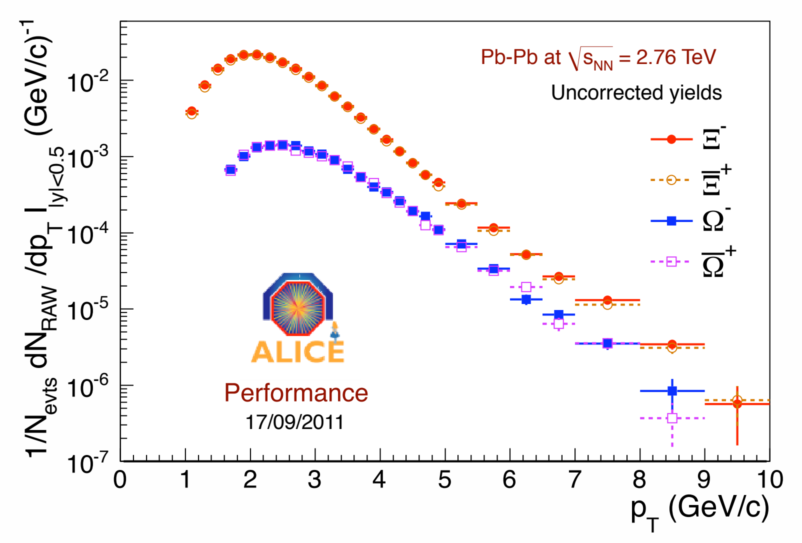
Signal = **Bin counting** - ***Integral***

Results

First Pb-Pb data taking

- ✓ end of 2010
- ✓ $\sqrt{s_{NN}}$ = 2.76 TeV
- ✓ about 30M nuclear interaction MB triggers collected
- ✓ about 20M events selected for this analysis

Transverse momentum spectra in |y|<0.5



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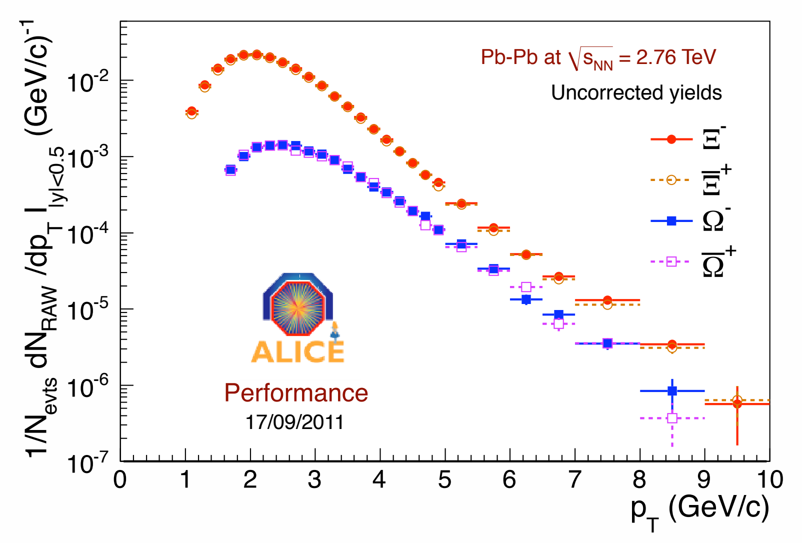

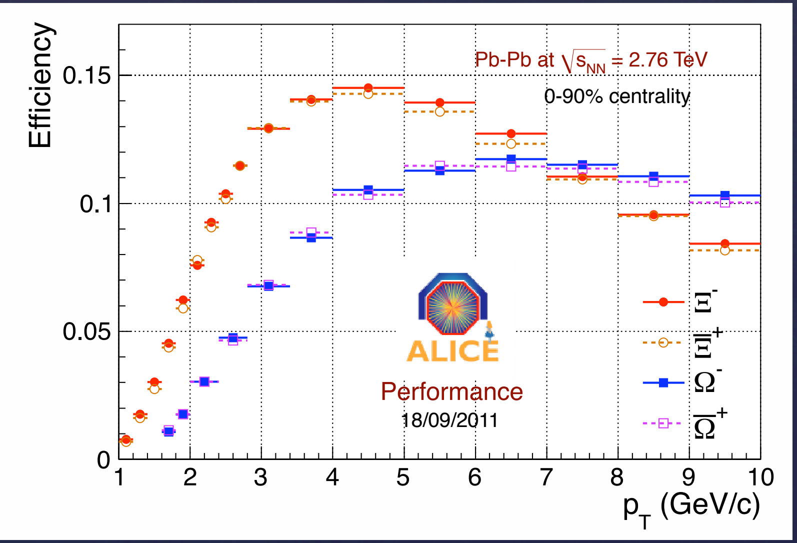

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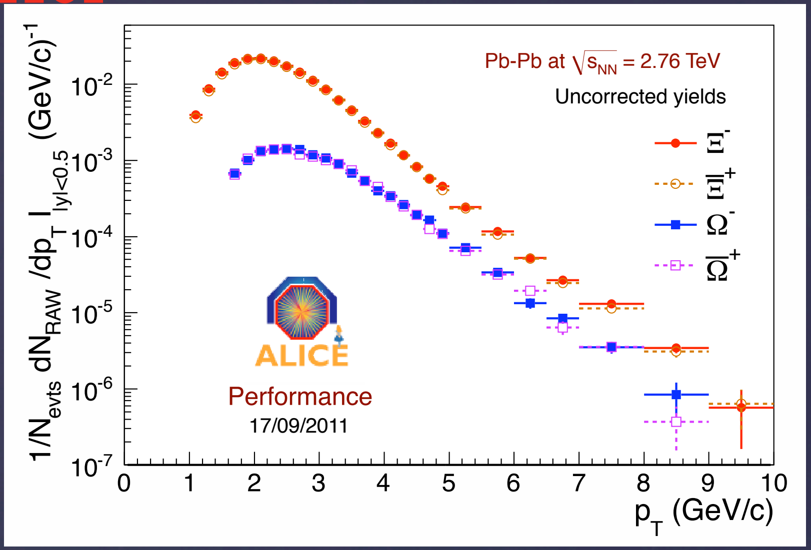

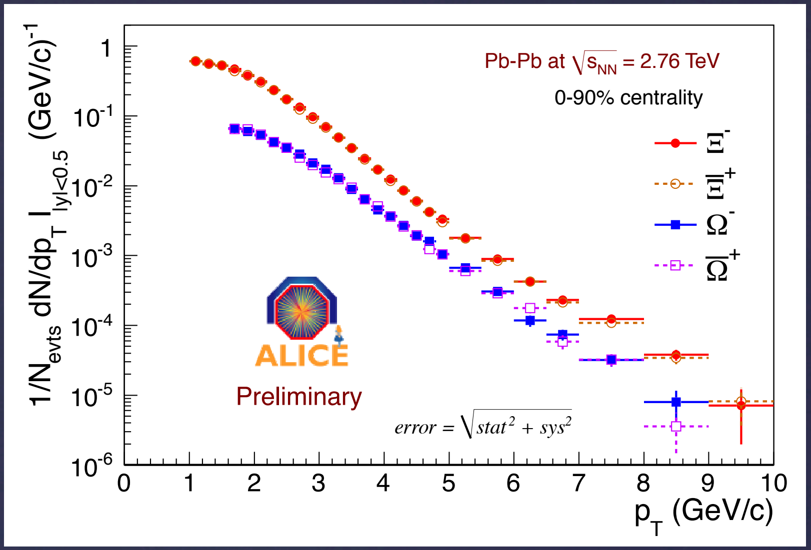

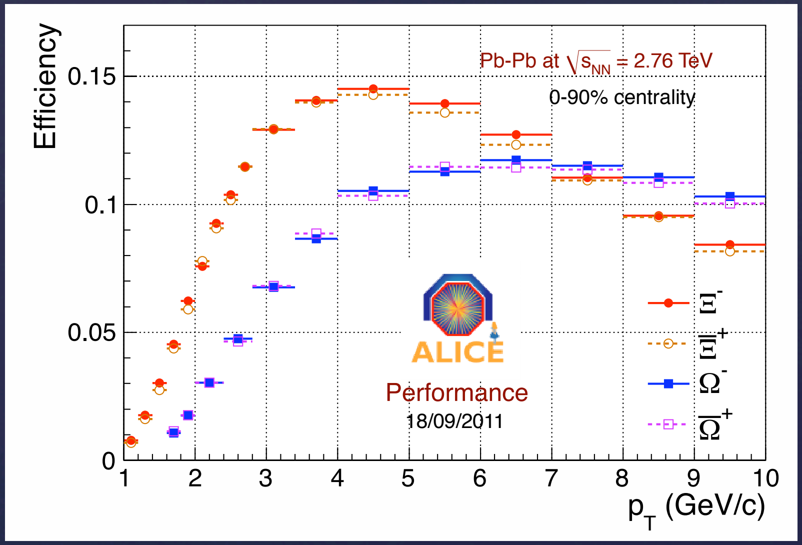

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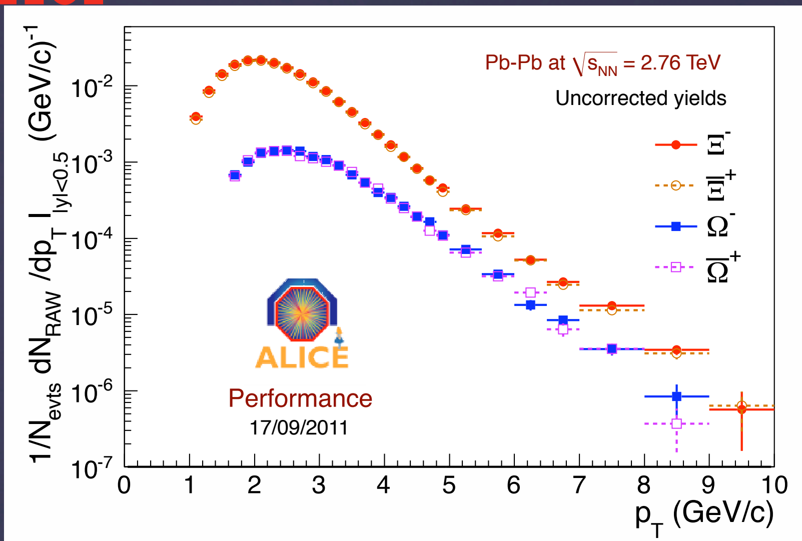
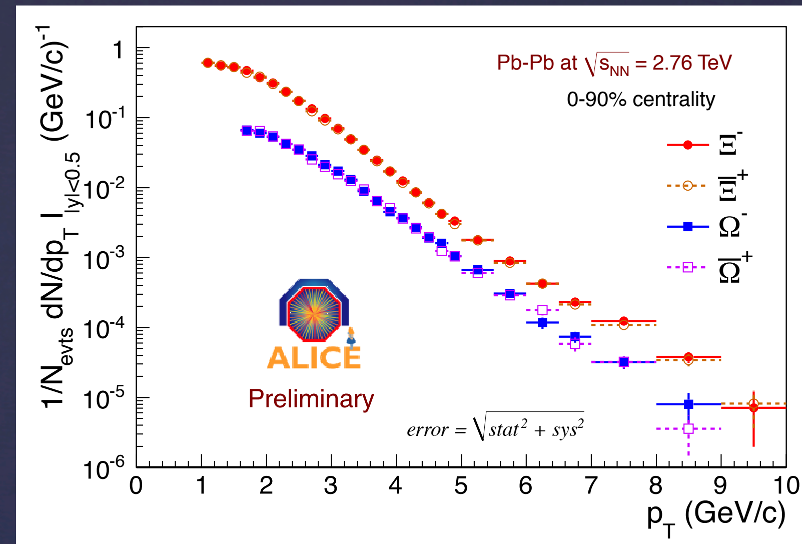
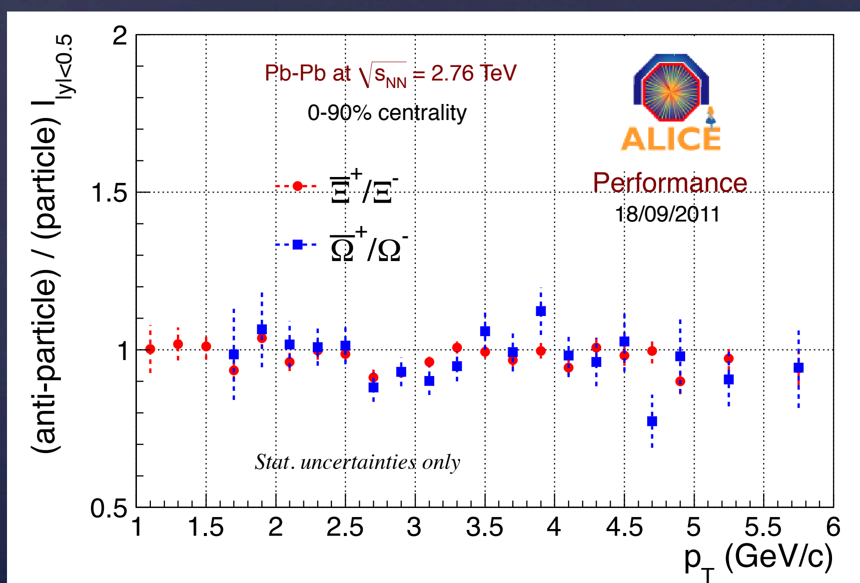
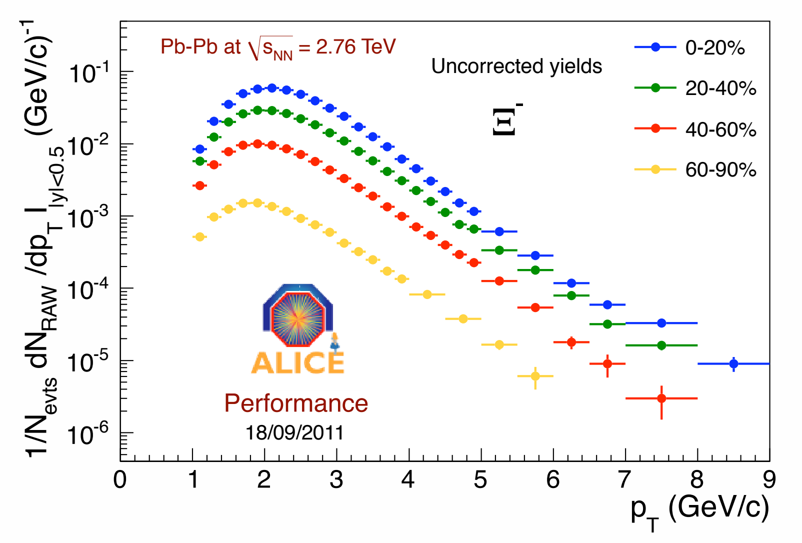


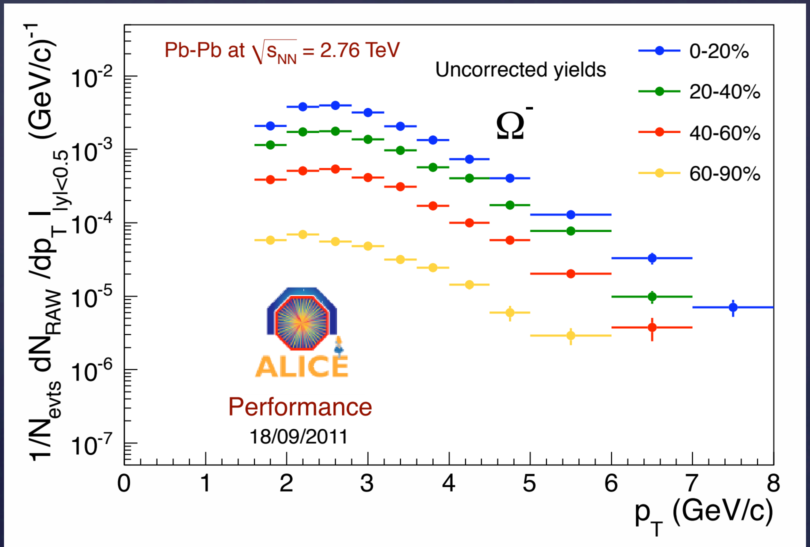




Ratios anti-particle/particle in agreement with 1 (as expected at the LHC energies)

Transverse momentum spectra in |y|<0.5





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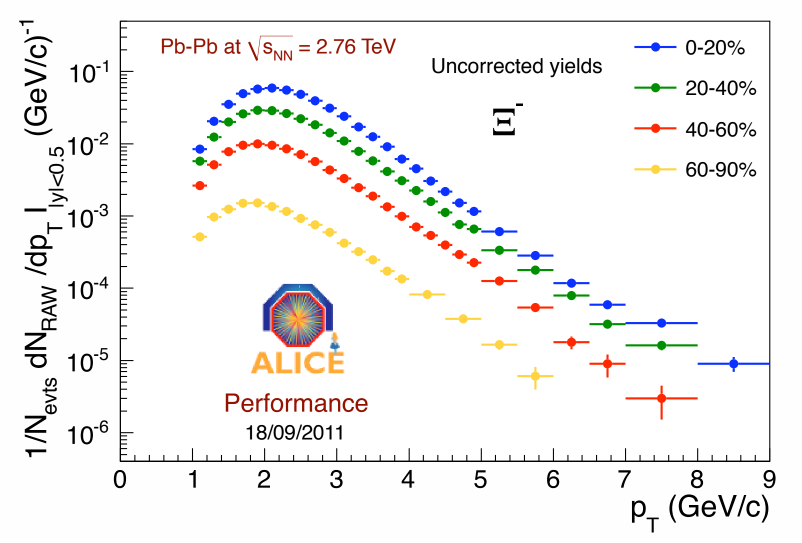
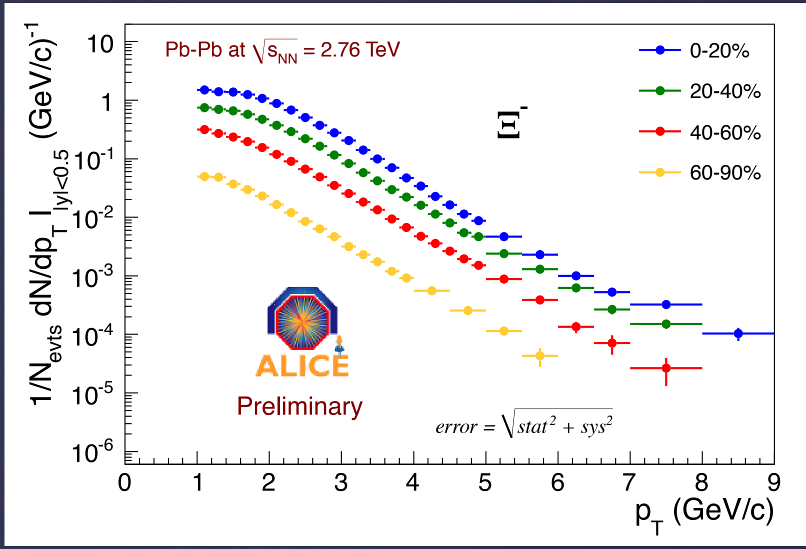
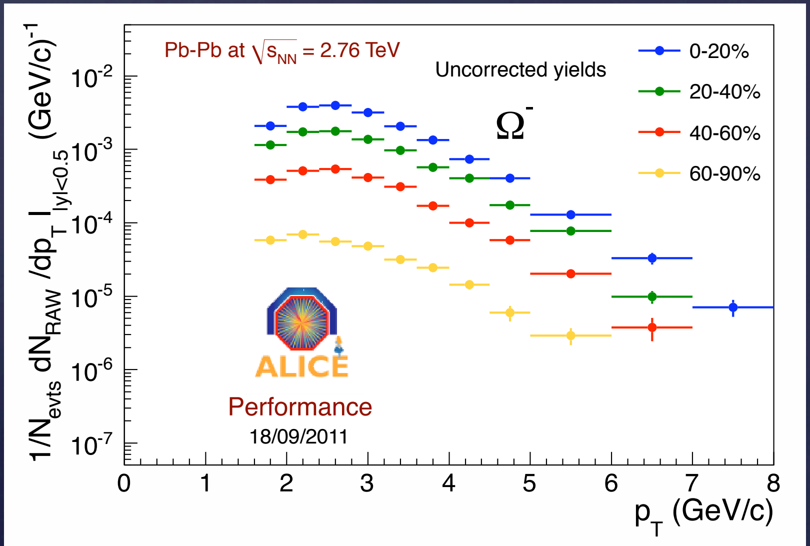
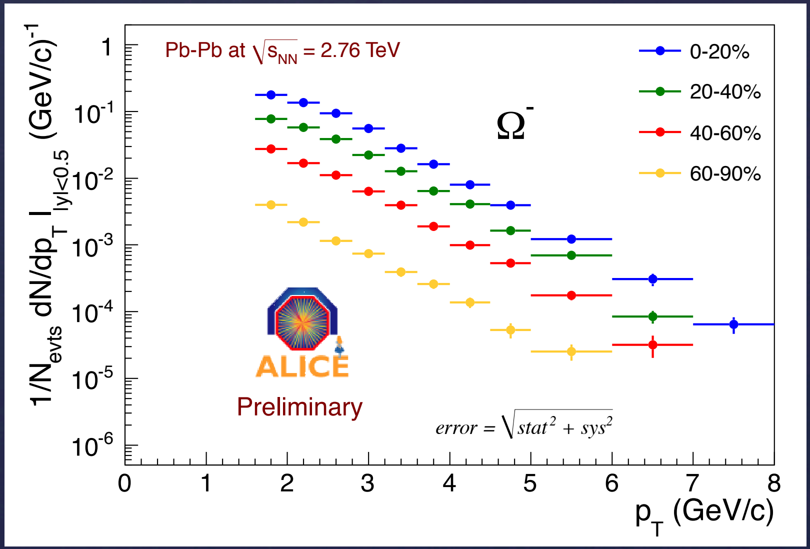




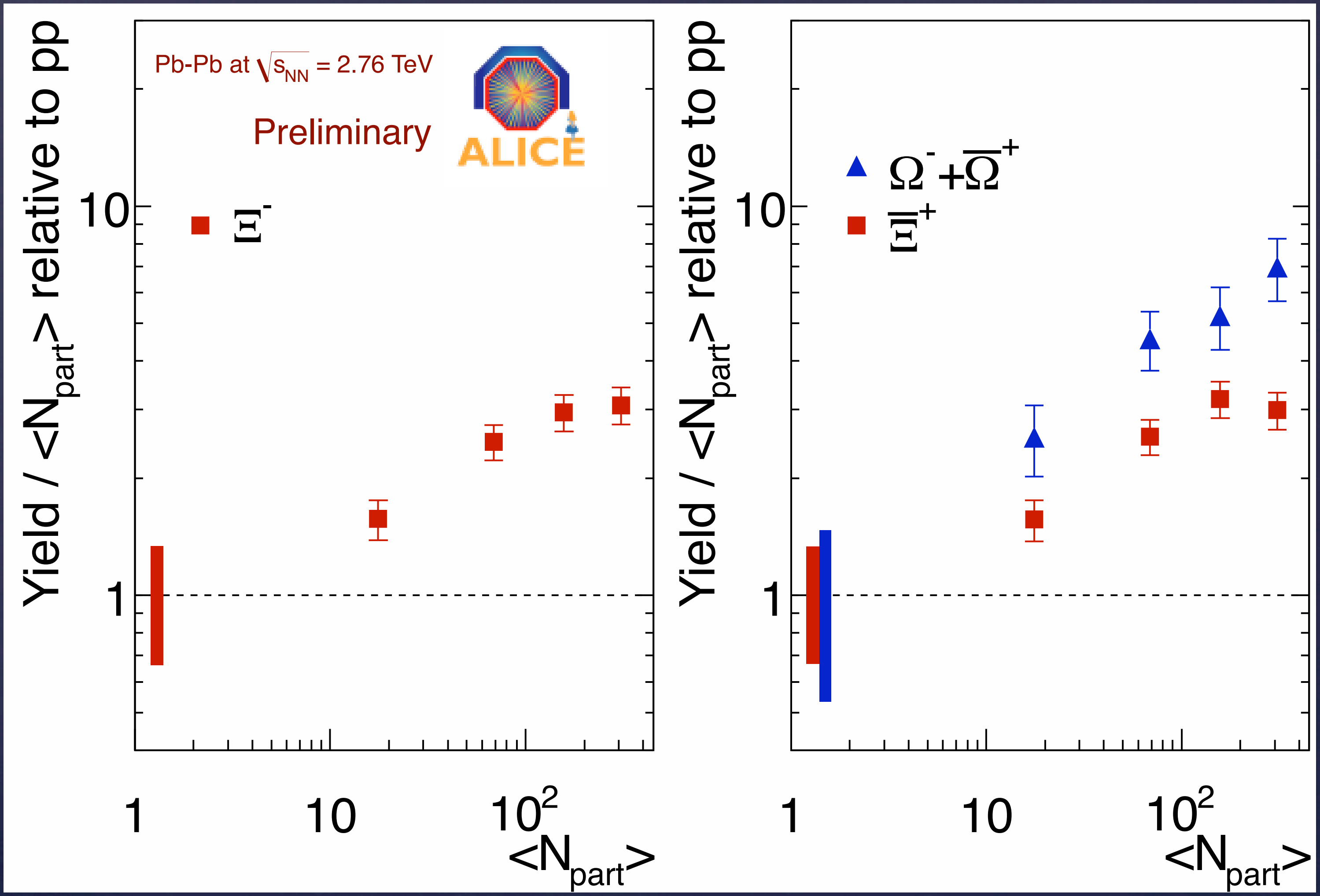




Strangeness enhancement

- Enhancements in |y|<0.5

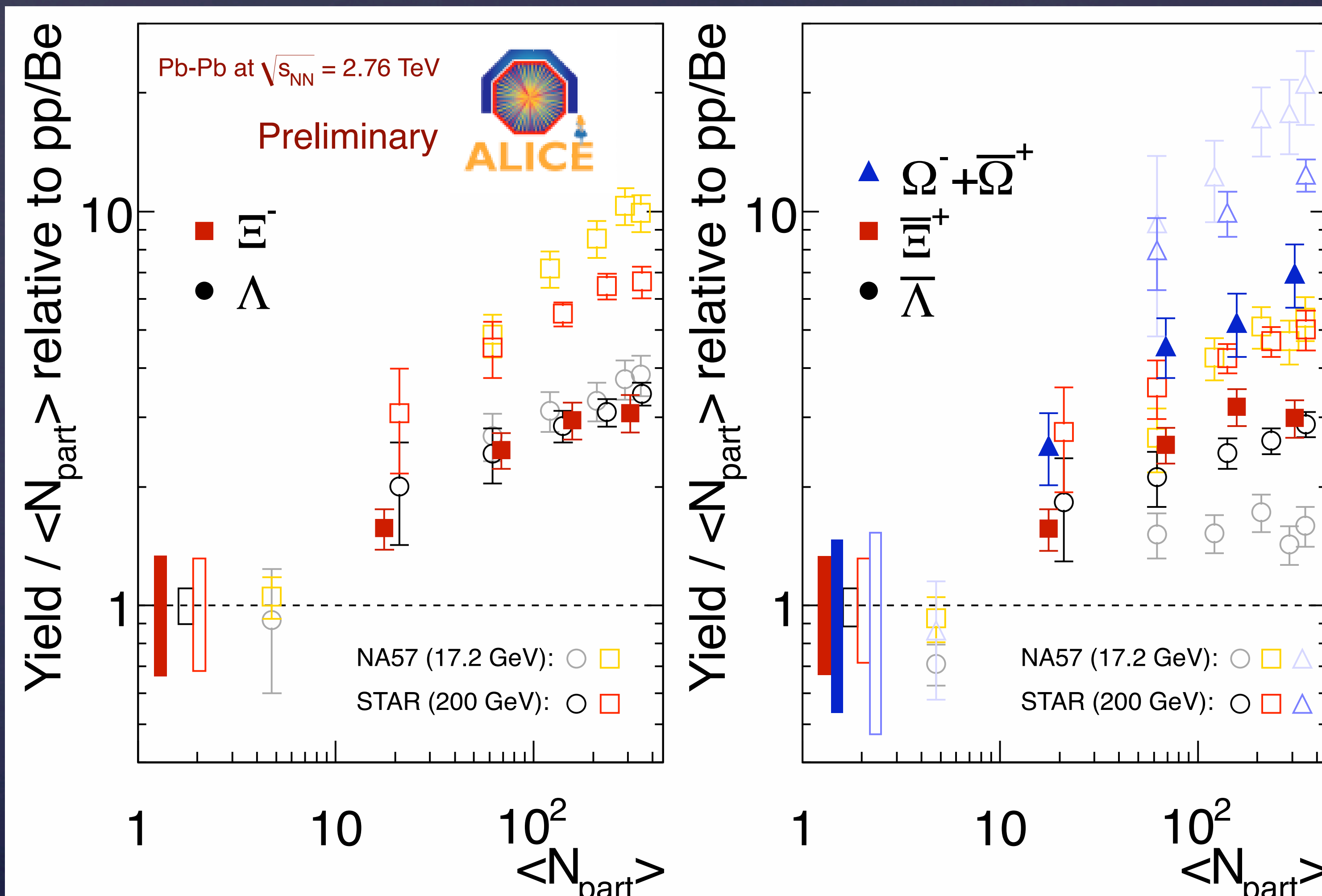
$$E = \frac{Yield_{PbPb} / < N_{part} >}{Yield_{pp} / 2}$$



Strangeness enhancement

- Comparison with lower energy data

$$E = \frac{Yield_{PbPb} / < N_{part} >}{Yield_{pp} / 2}$$



Conclusions

- Summary

  Ξs and Ωs in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV:

  ✓ 30M minimum bias nuclear interactions from 2010 run

  ✓ mid-rapidity p_T spectra (and yields) measured
    - very good p_T reach (up to 6-9 GeV/c)
    - as a function of collision centrality (4 centrality classes)

  ✓ preliminary results
    - enhancements wrt pp collisions ➜ confirmed hierarchy based on the strangeness content of the particle
    - comparison with lower energy data ➜ enhancements decreasing as energy increases (same trend observed between SPS and RHIC)

- Outlook

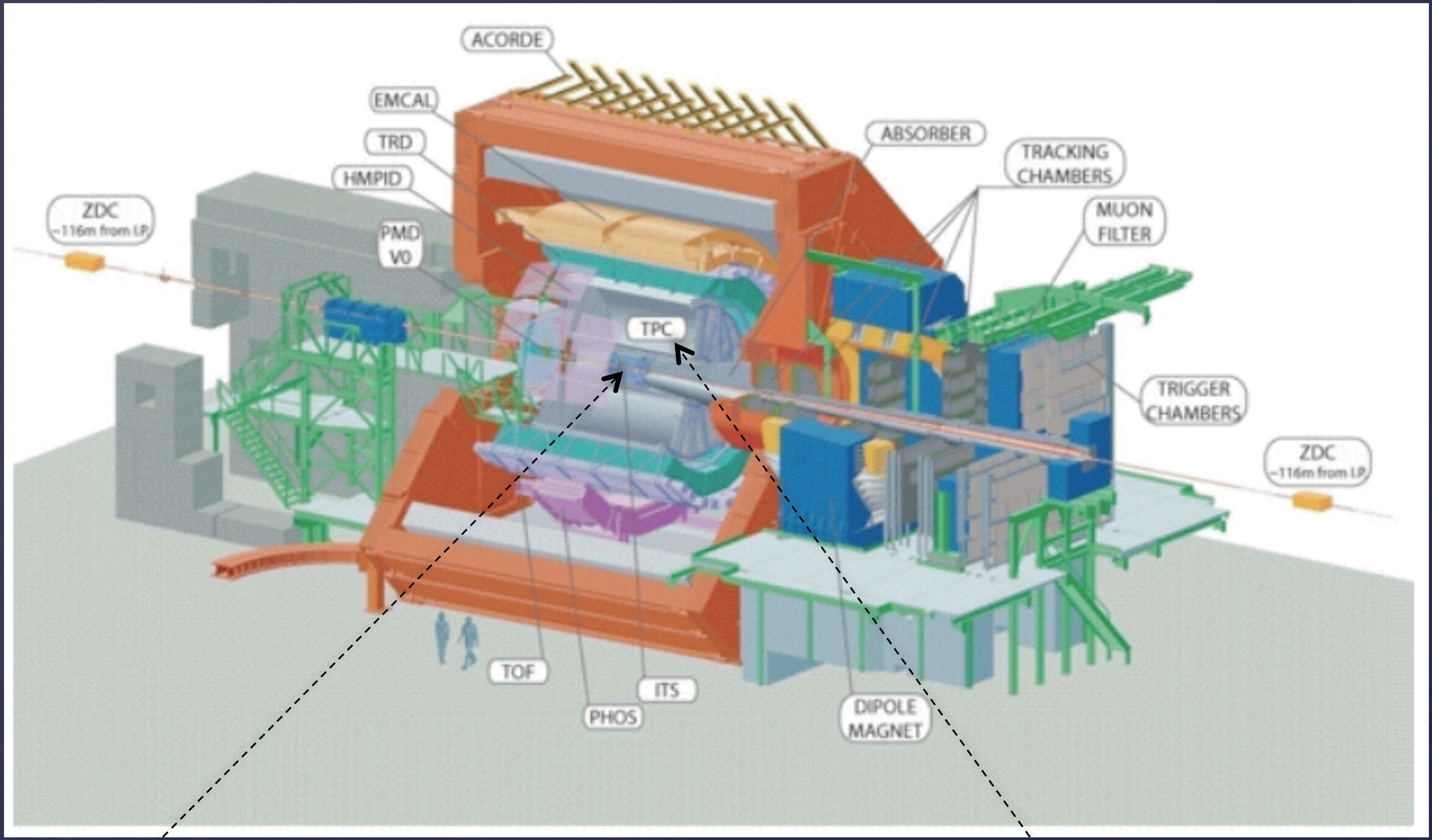
  ✓ working for final results: finer centrality bins and lower min-p_T's

Backup slides

Event selection criteria

- Event and track selections
  - background events rejection (beam-background and electromagnetic interactions)
  - 90% most central events
  - vertex in $|z|<10$ cm
  - quality cuts for tracks

ALICE

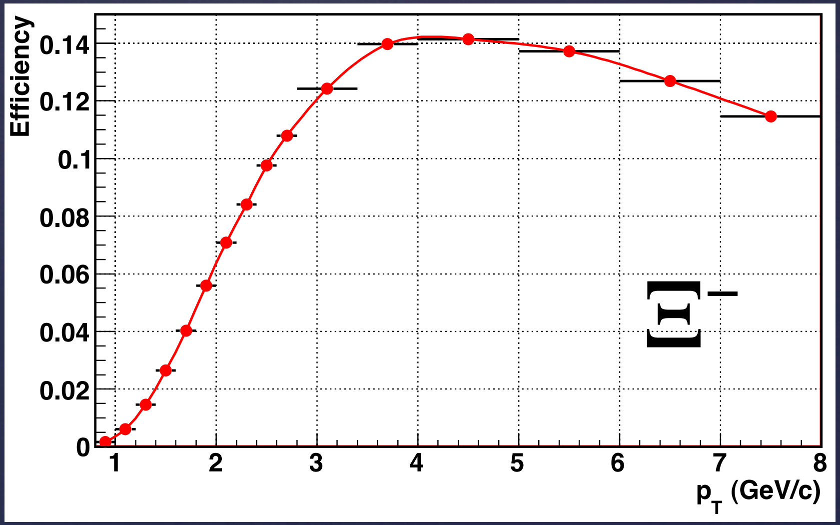


ITS:
- six silicon layers
- $|\eta|<0.9$
- 3.9 cm$<r<$43 cm

TPC:
- $|\eta|<0.9$
- 85 cm$<r<$247 cm

Efficiency correction

- Main ingredients:
  - Monte Carlo HIJING with injected cascades
    - about 3M events generated
    - one Ξ/Ω per species/event
  - Geant-Fluka correction
  - interpolation with a cubic spline



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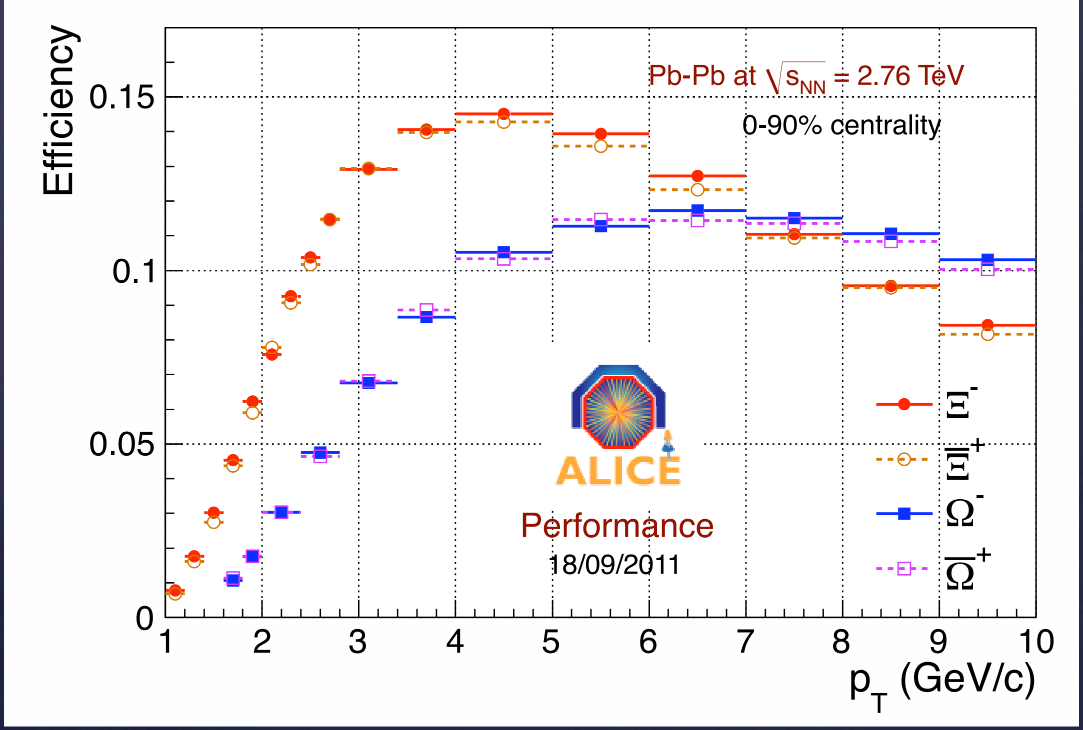

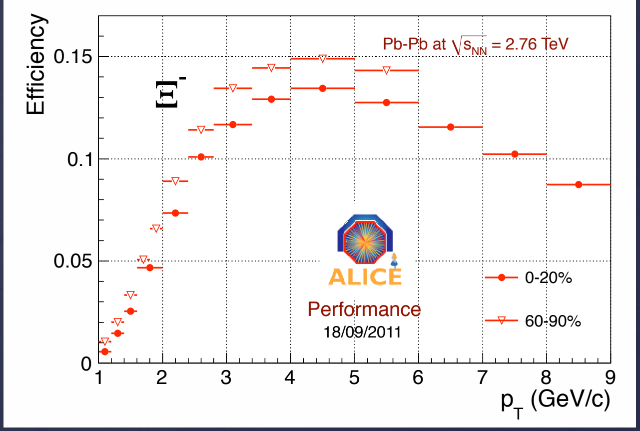

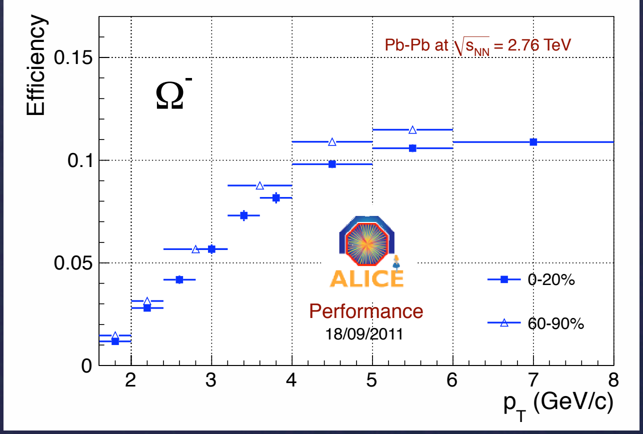

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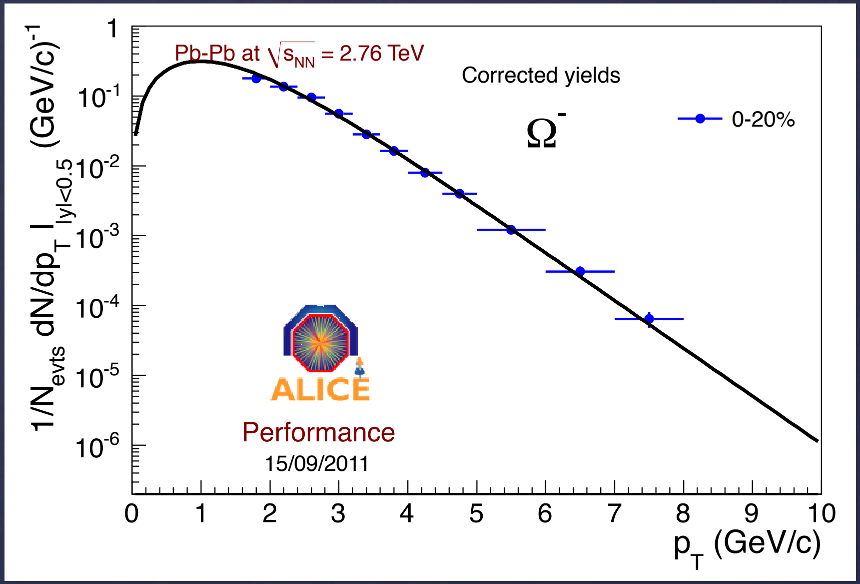
Yields from blast wave fits

- For the yields we use the data where we have them; over we need to extrapolate. Blast Wave parametrization:
  - gives the best fit to individual particles
  - from PHOBOS we have evidence that this paramerization gives a good description to very low p_t



Blast wave is an hydrodynamically inspired model, which assumes a transversely expanding emission source. The parameters of this model are the kinetic freeze-out temperature T and the transverse flow velocity β_T. Assuming a linear radial velocity profile, the spectrum can be computed from:

$$\frac{1}{m_T}\frac{dN}{dm_T} \propto \int_0^R r dr I_0\left(\frac{p_T sinh\rho}{T}\right) K_1\left(\frac{m_T cosh\rho}{T}\right); \qquad \rho = tanh^{-1}\beta_r$$

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Systematics

- Main sources checked
  - topological cuts:
    - use 3 different sets of cuts (looser and tighter)
  - signal extraction procedure:
    - vary the window for signal estimation (2.5 and 4 sigmas vs 3)
    - enlarge the windows for bkg estimation
    - vary the method for bkg estimation (bin counting vs fit)
  - efficiency correction:
    - use histogram point (larger p_T-bins) instead of interpolation
    - use centrality bin different wrt data

Systematics

	Yield Ξ	ΔY/Y (%)	Yield Ω	ΔY/Y (%)
Standard analysis 0-20%	**3.00201**	**-**	**0.588797**	**-**
Loose cuts	2.98463	**-0.6**	0.592346	**+0.6**
Tight cuts	3.07891	**+2.6**	0.593405	**+0.8**
Very tight cuts	3.12095	**+3.9**	0.585960	**-0.5**
M(Λ,π) cut for Ω	-	**-**	0.600859	**+2.0**
NO WEIGHTING of gen and acc	2.93121	**-2.4**	0.583435	**-0.9**
4-sigma window in signal extraction	2.99851	**-0.1**	0.572497	**-2.8**
2.5-sigma window in signal extraction	2.97201	**-0.9**	0.596949	**+1.4**
Background by bin counting in signal extraction	2.99897	**-0.1**	-	**-**
8-sigma window for background in sign extract	3.03588	**+1.1**	0.586520	**-0.4**
Corrected with efficiency histo (no spline)	2.86200	**-4.7**	0.595412	**+1.1**
Corrected with efficiency in 10-30%	2.67271	**-10.9**	0.573613	**-2.6**
Shift pt-bin position	3.00159	**10^{-4}**	0.622394	**+5.7**
Standard analysis 20-40%	**1.63339**	**-**	**0.239420**	**-**
Corrected with efficiency histo (no spline)	1.55103	**-5.0**	0.233368	**-2.5**
Corrected with efficiency in 30-50%	1.47984	**-9.4**	0.216540	**-9.5**