

The Study of Short-Lived Resonances with the ALICE Experiment at the LHC



Ayben Karasu Uysal

Yildiz Technical University,
Istanbul

for the ALICE Collaboration



ICPP - II
20-25 June 2011

Outline

- ❑ Introduction
 - motivations
 - the ALICE detector
- ❑ Analysis
- ❑ Results
 - p+p @ $\sqrt{s} = 7$ TeV
 - Pb+Pb @ $\sqrt{s_{NN}} = 2.76$ TeV
- ❑ Conclusions

Resonances are strongly decaying particles which have lifetimes of about a few fm/c ($\tau_{\text{resonance}} \sim \tau_{\text{fireball}}$)

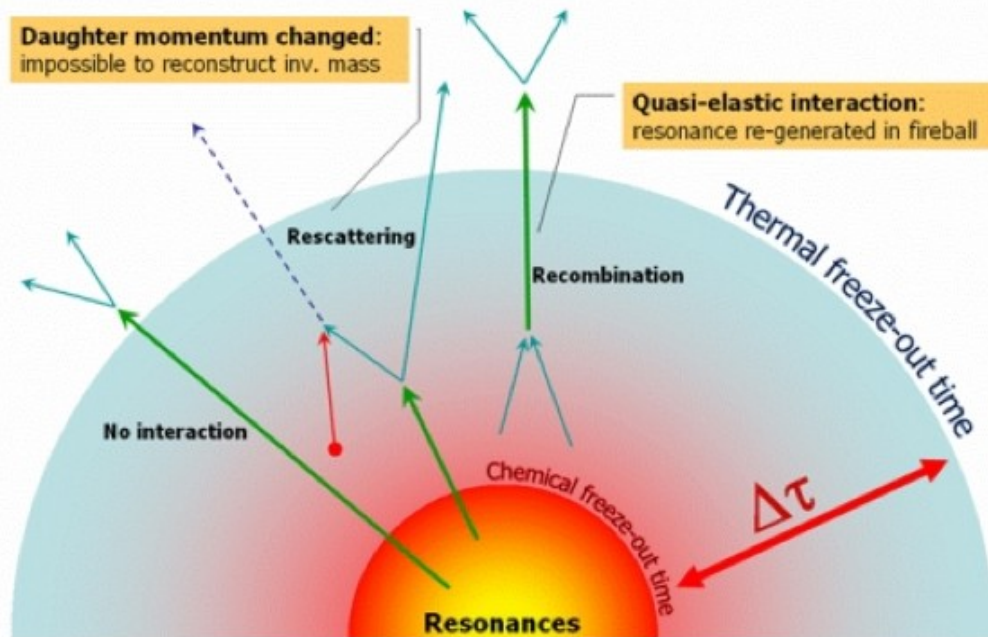
Interaction of the resonances and/or their daughters with fireball medium resulting the modifications of properties of resonances (peak,width)

Chiral symmetry restoration
→ modifications in mass and/or width

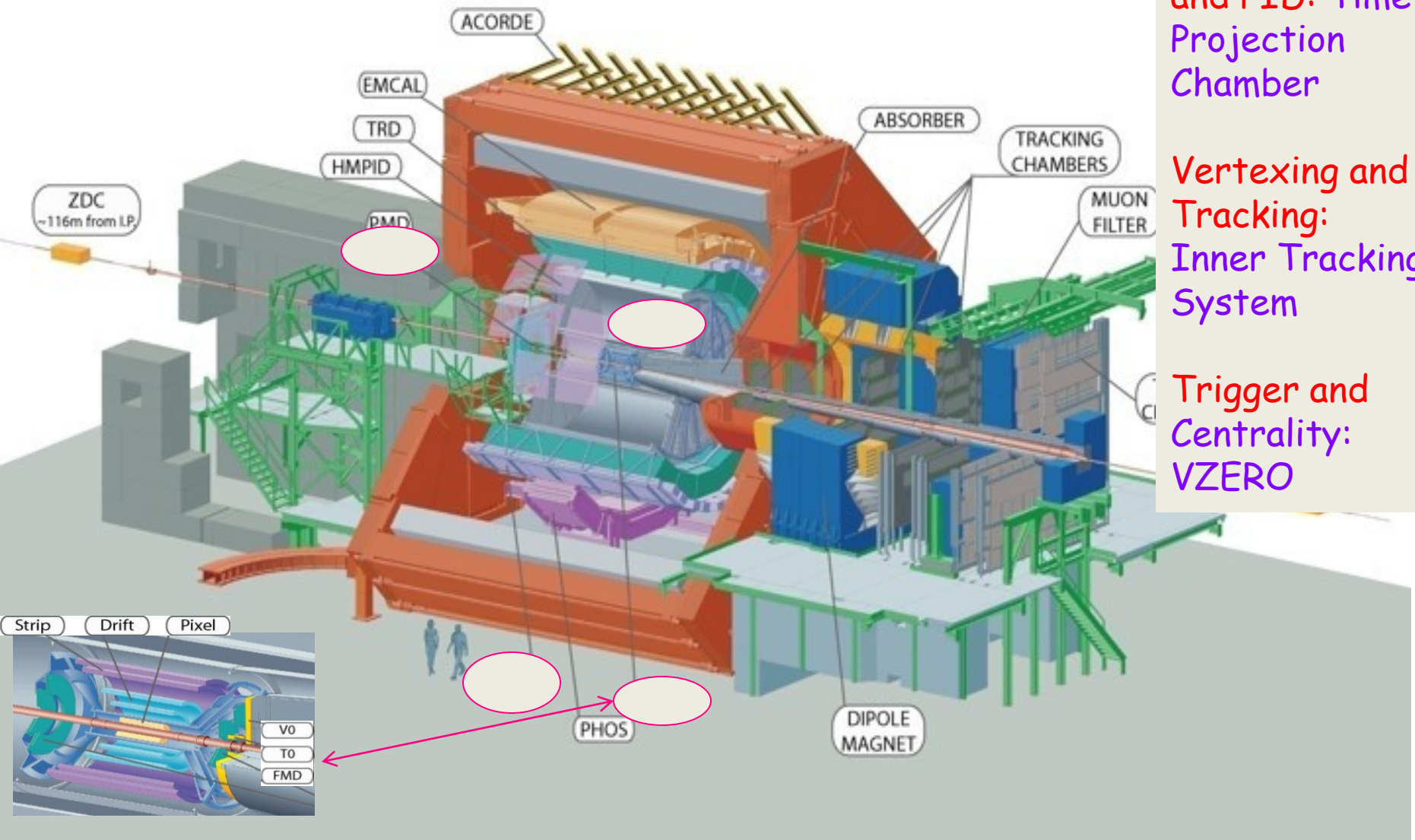
R. Rapp and J. Wambach, Adv. Nucl. Phys. 25 (2000), 1

Resonance / stable particle ratios
→ estimate fireball temperature and lifetime

G. Torrieri and J. Rafelski, Phys. Lett. B509 (2001), 239



$\Lambda^*(1520)$	pK^- (22.5%)	13	15.6
$\Xi^*(1530)$	$\pi^+\Xi^-$ (100%)	22	9.1



Main Tracking and PID: Time Projection Chamber

Vertexing and Tracking: Inner Tracking System

Trigger and Centrality: VZERO

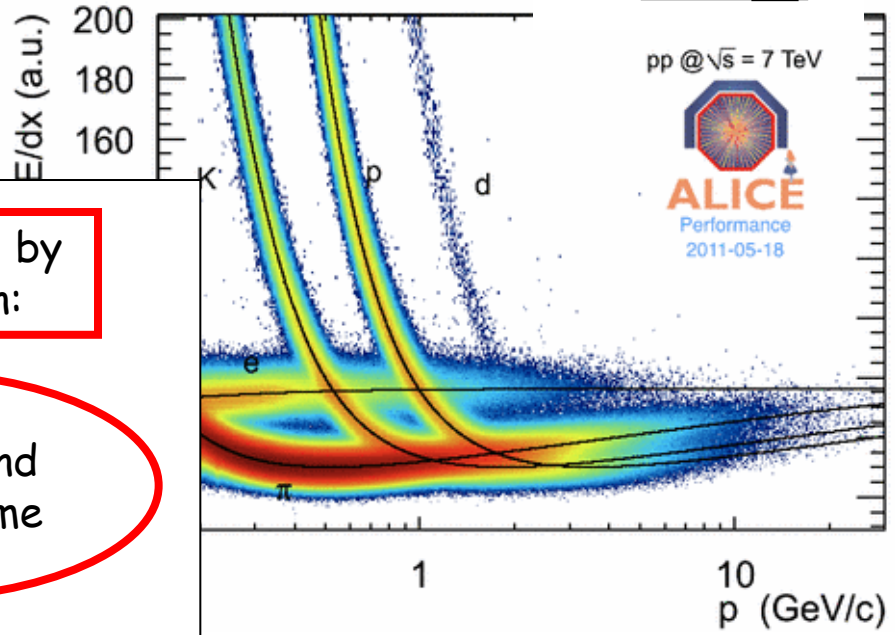
Basic identification strategy: fit **response function** in p_T bin

25 - 295 * 10⁶ min. bias events

For resonances, VO and cascade analysis PID by a cut (3σ) on the relative difference between:

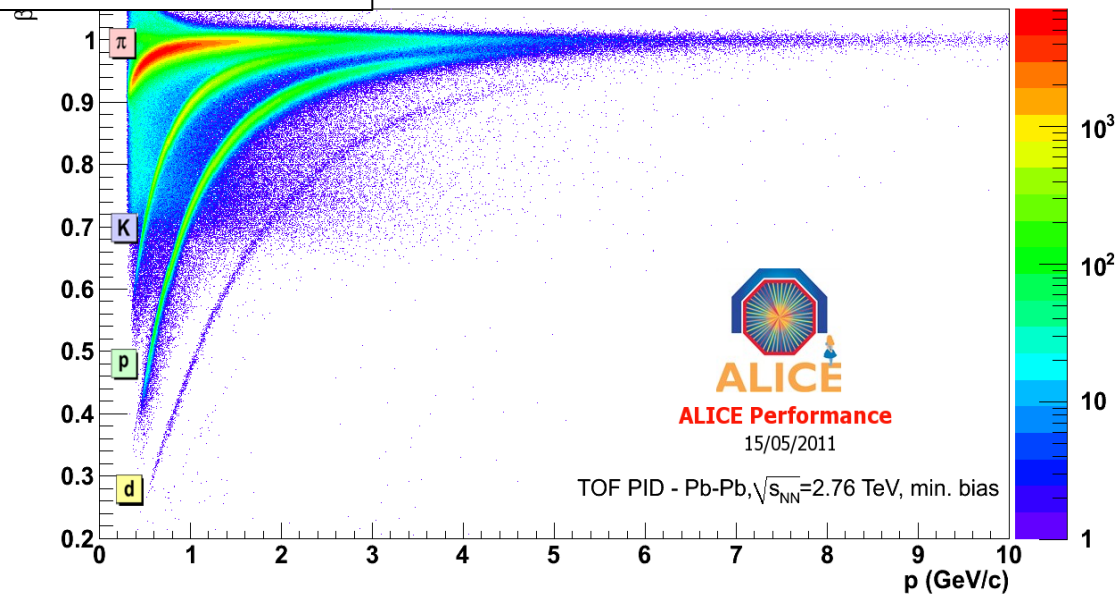
TPC signal and Bethe-Bloch function

TOF signal and integrated time



p_T range of separation within 3σ (GeV/c)

	TPC	TOF
π	0.2 ÷ 0.7	0.5 ÷ 2.0
K	0.3 ÷ 0.6	0.5 ÷ 2.0
p	0.5 ÷ 1.0	0.5 ÷ 2.5

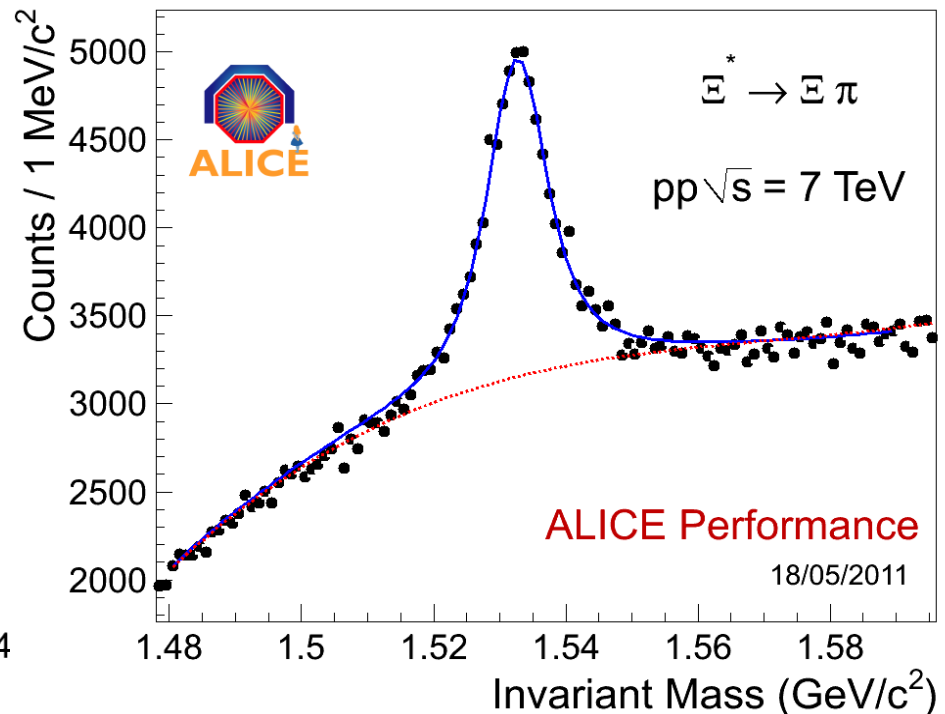
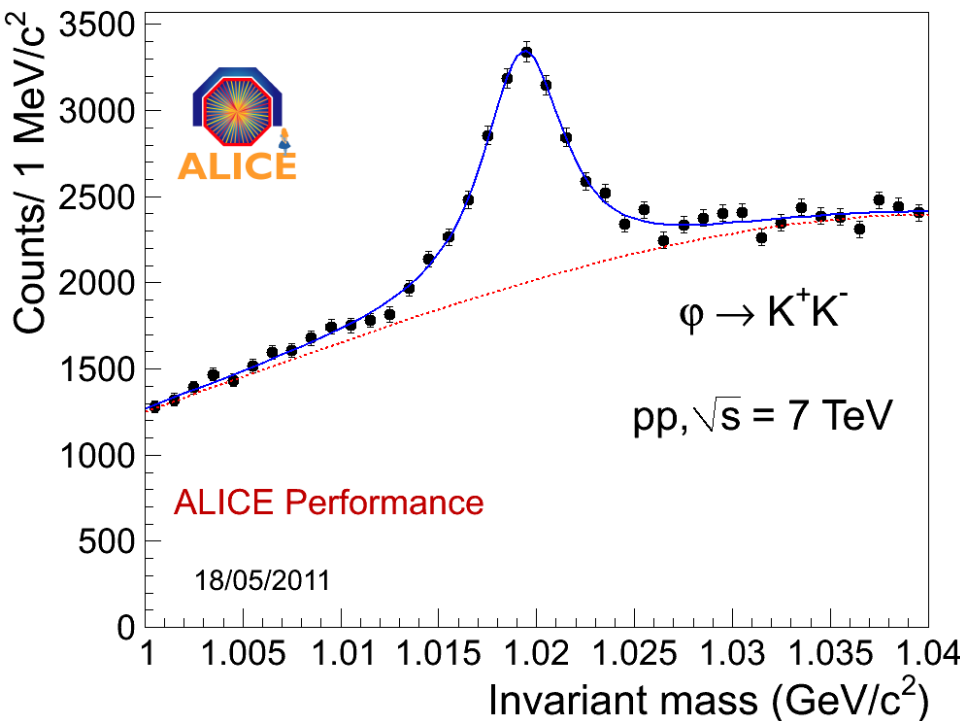


- **Fit:** poly + Breit-Wigner convolution with Gaussian (= "Voigtian")
 - take into account inv. mass resolution
 - estimate from MC (ϕ : $\sim 1 \text{ MeV}/c^2$)

- **Raw counts:** Voigtian full integral

ϕ ($|\eta| \leq 0.5$) Ξ^* ($|\eta| \leq 0.8$)

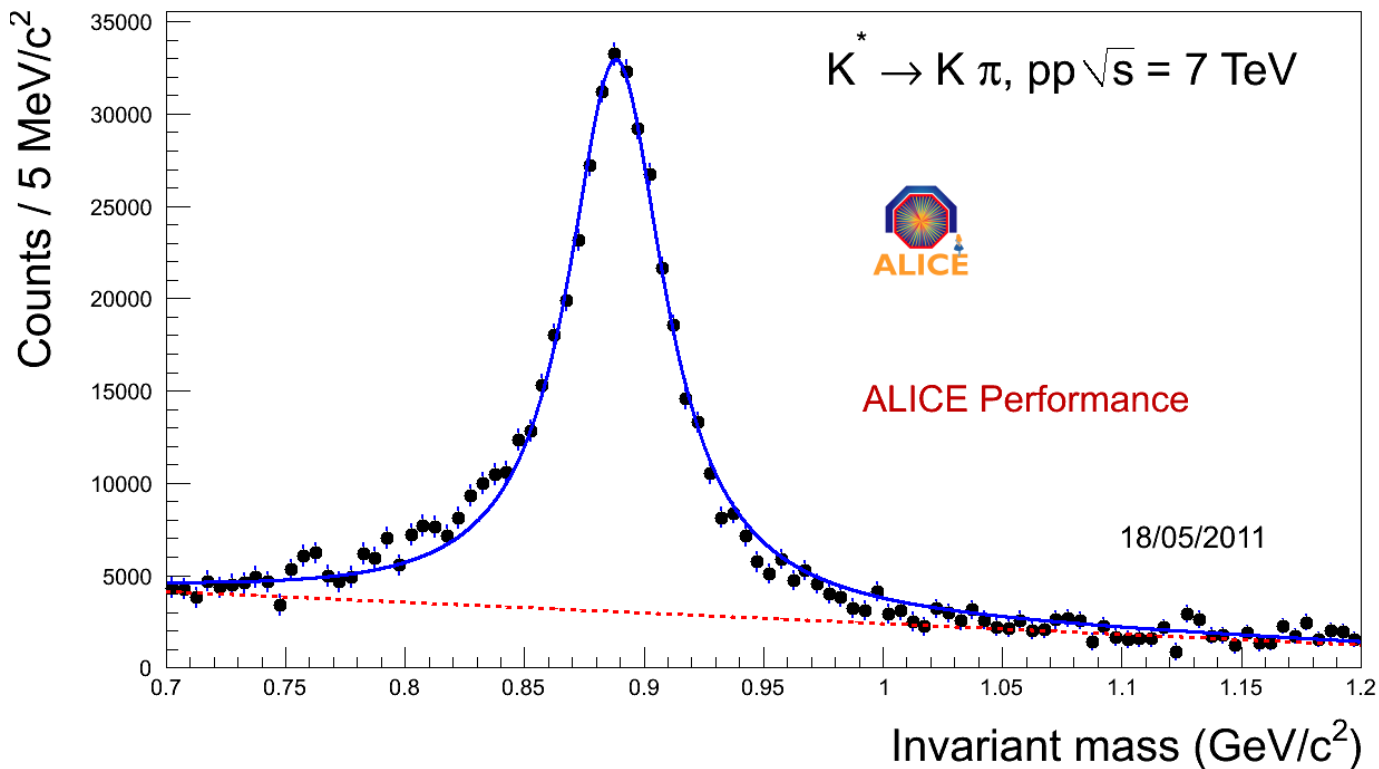
p_T bin	(GeV/c)	0.7 - 0.8	1.2 - 1.6
PDG Mass	(MeV/c ²)	1019.46	1531.8
PDG Γ	(MeV/c ²)	4.26	9.1
Fit Mass	(MeV/c ²)	1019.30 \pm 0.10	1531.5 \pm 0.4
Fit Γ	(MeV/c ²)	4.52 \pm 0.01	<i>Fixed to PDG</i>
Fit σ	(MeV/c ²)	<i>Fixed to 1.2</i>	2.0 \pm 0.5



- ❑ Subtract like-sign background
- ❑ **Fit:** Breit-Wigner + straight line
- ❑ **Raw counts:** BW full integral

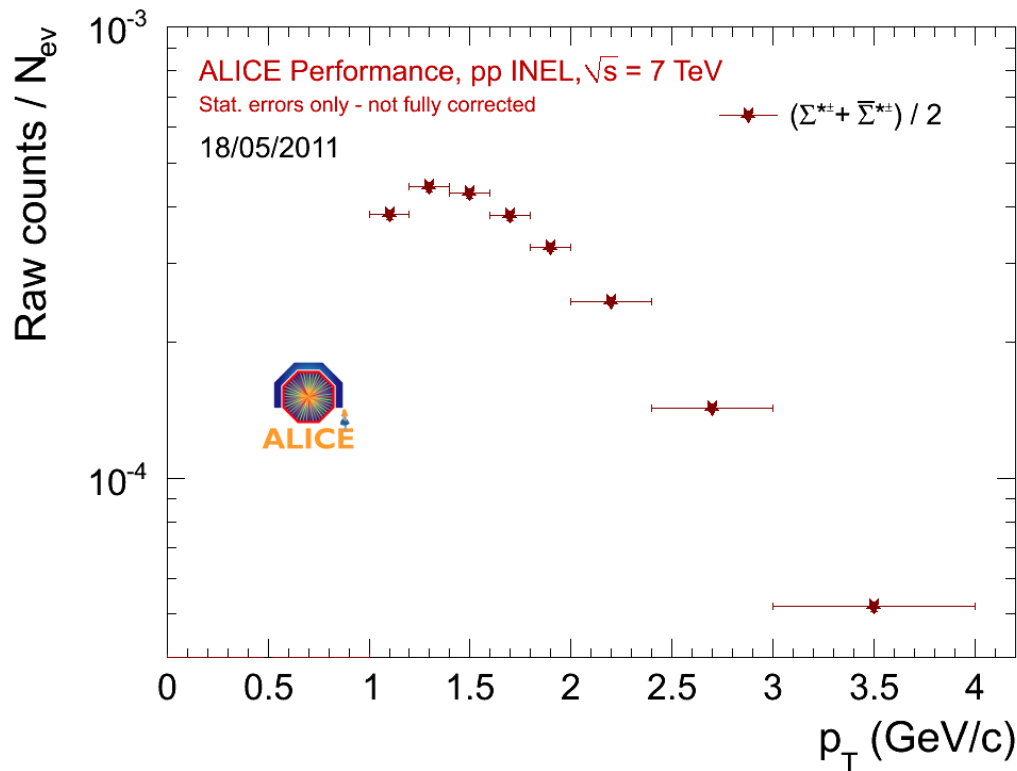
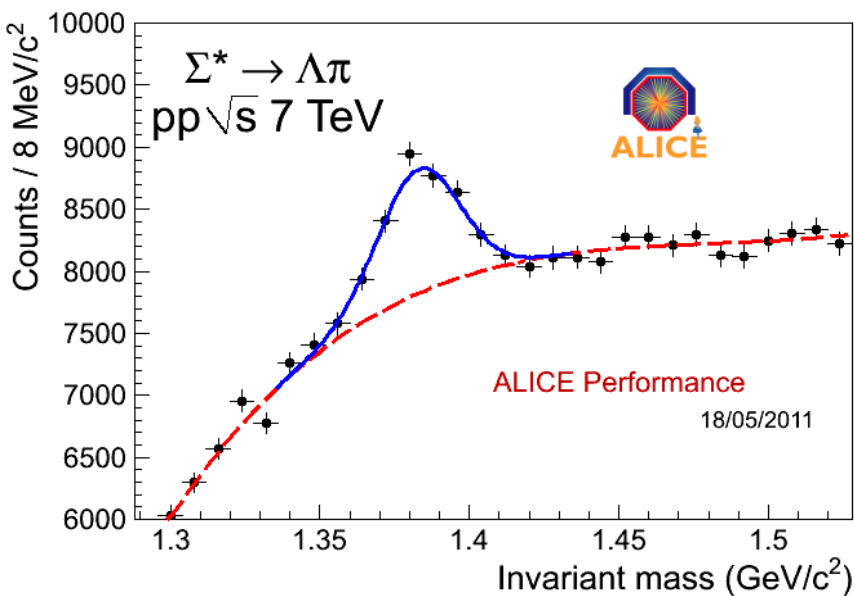
- ❑ **Rapidity range:** $|y| \leq 0.5$

p_T bin	(GeV/c)	2.0 - 2.5
PDG Mass	(MeV/c ²)	895.9
PDG Γ	(MeV/c ²)	48.7
Fit Mass	(MeV/c ²)	893.4 ± 0.5
Fit Γ	(MeV/c ²)	54.0 ± 2.0



- ❑ **Fit:** Gaussian + negative power law
- ❑ Subtract background function
- ❑ **Raw counts:** bin count
 - 3σ around peak center.
- ❑ **Rapidity range:** $|y| \leq 0.8$

p_T bin (GeV/c)	0.7 - 0.8	
PDG Mass (MeV/c ²)	1382.8 (Σ^{*+})	1387.2 (Σ^{*-})
PDG Γ (MeV/c ²)	35.8 (Σ^{*+})	39.4 (Σ^{*-})
Fit Mass (MeV/c ²)	1383 \pm 1	
Fit Γ (MeV/c ²)	33 \pm 3	

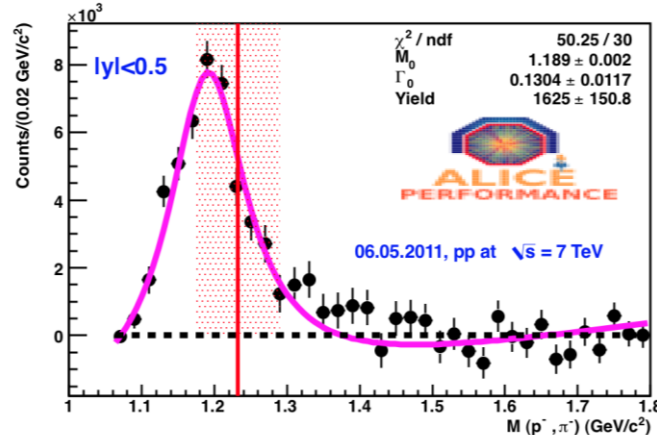
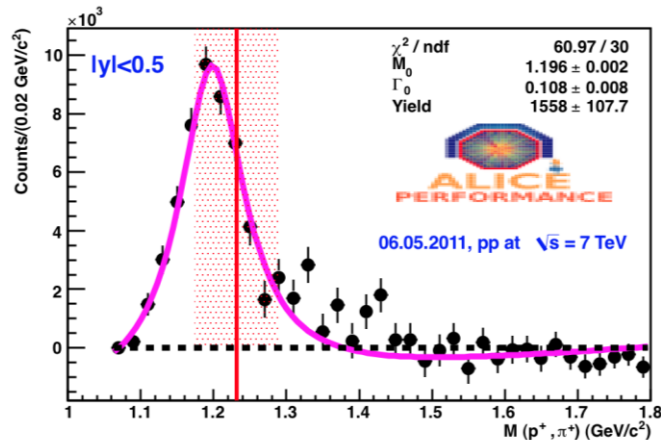
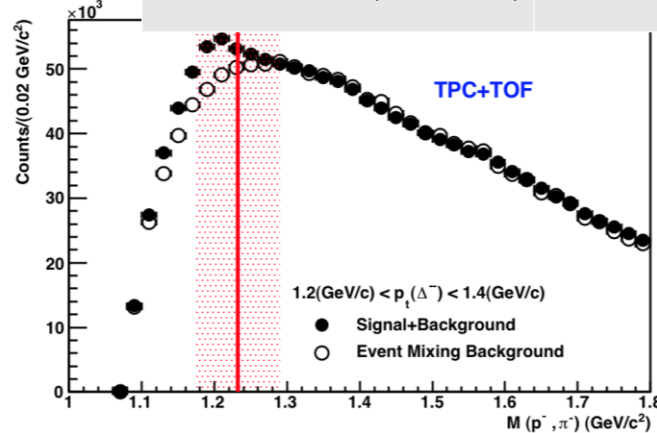
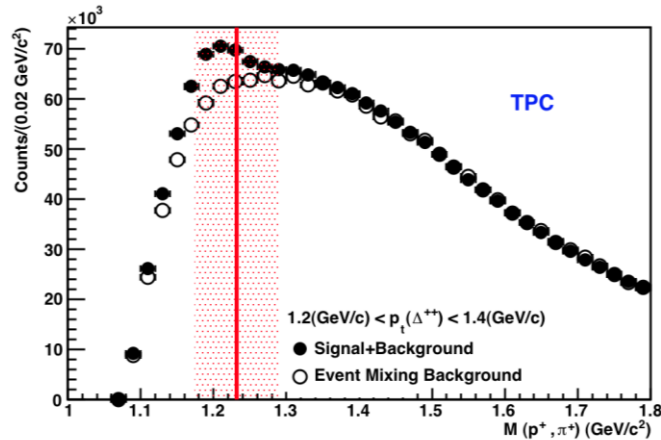


- ❑ **Fit:** p wave Breit Wigner*phase space factor+linear background
- ❑ Subtract event mixed background
- ❑ **Raw counts:** BW full integral
- ❑ **Rapidity range:** $|y| \leq 0.5$
- ❑ **TPC and TOF have been used**

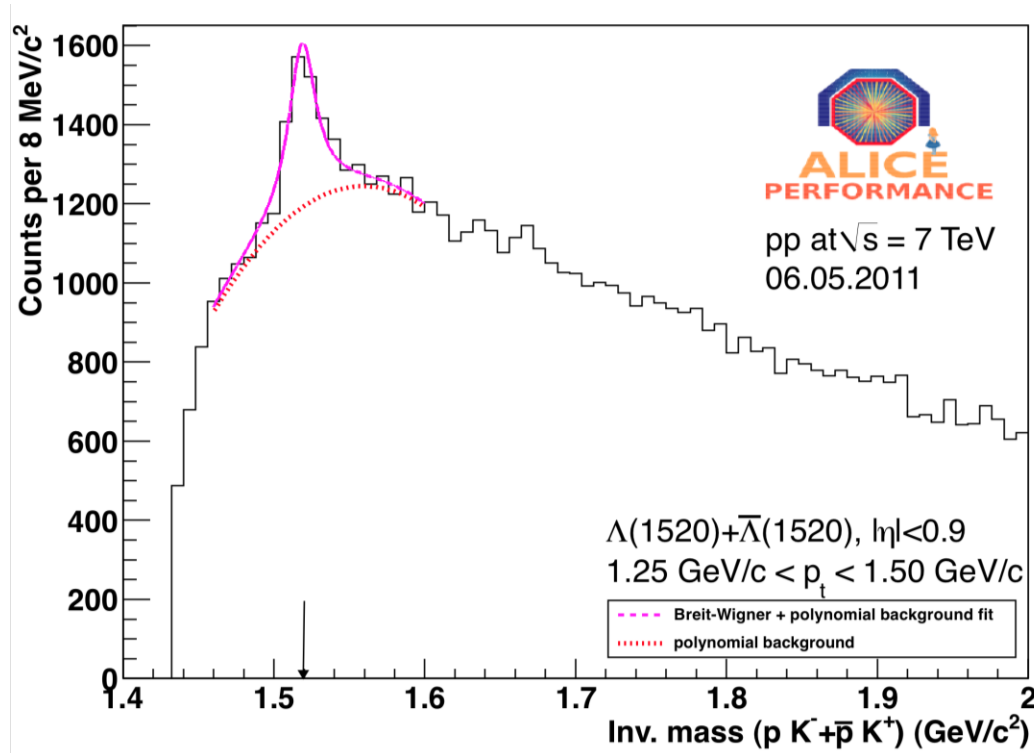
TPC

TOF

p_T bin (GeV/c)	1.2- 1.4	1.2 - 1.4
PDG Mass (MeV/c ²)	1232	1232
PDG Γ (MeV/c ²)	116	116
Fit Mass (MeV/c ²)	1196 \pm 0.002	1189 \pm 0.002
Fit Γ (MeV/c ²)	0.108 \pm 0.008	0.1304 \pm 0.0117

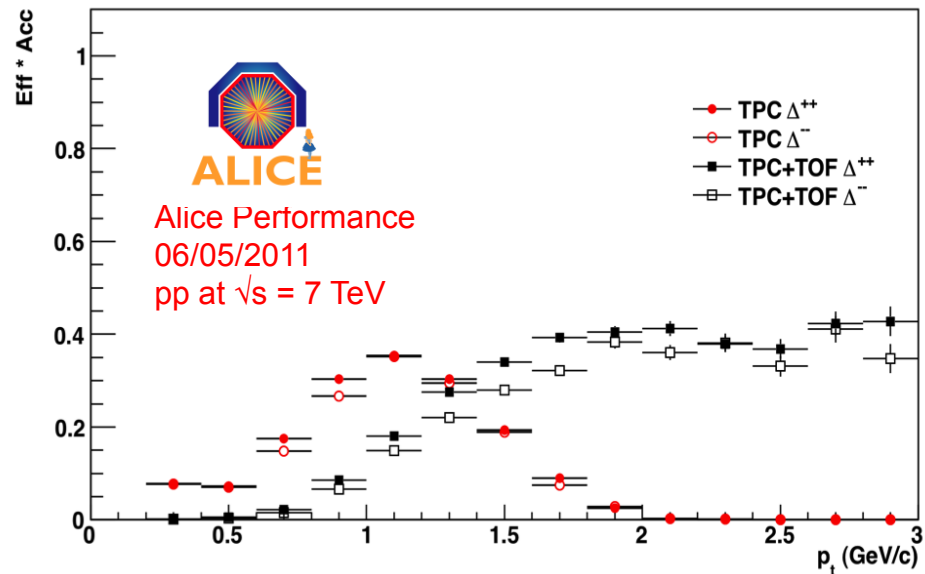
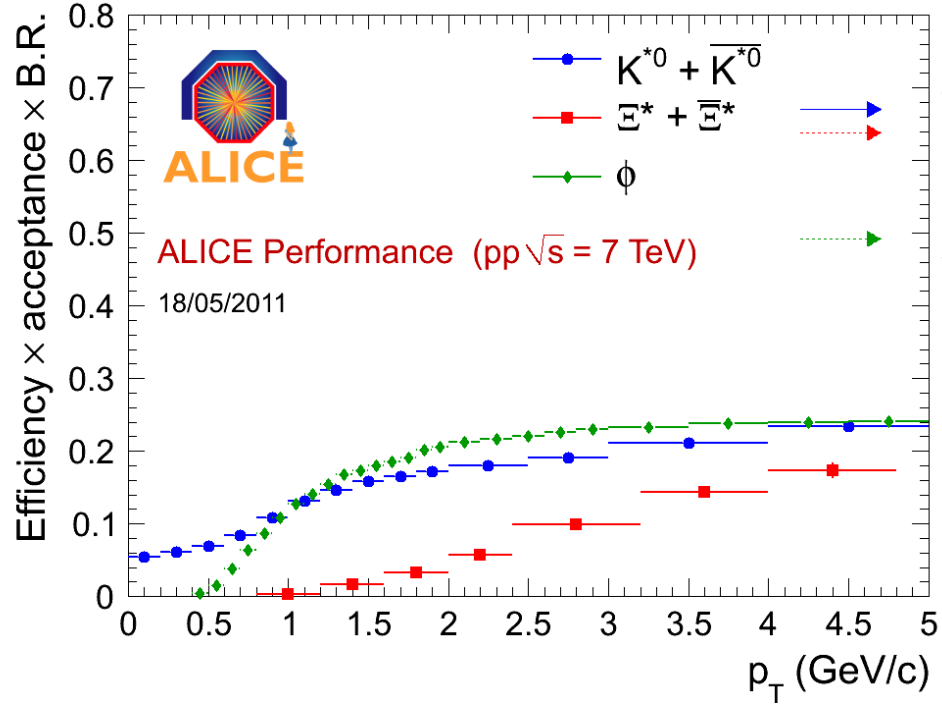


- ❑ Subtract event mixed background
- ❑ **Fit:** Breit-Wigner + polynomial background
- ❑ **Raw counts:** BW full integral
- ❑ **Pseudorapidity range:** $|\eta| \leq 0.9$

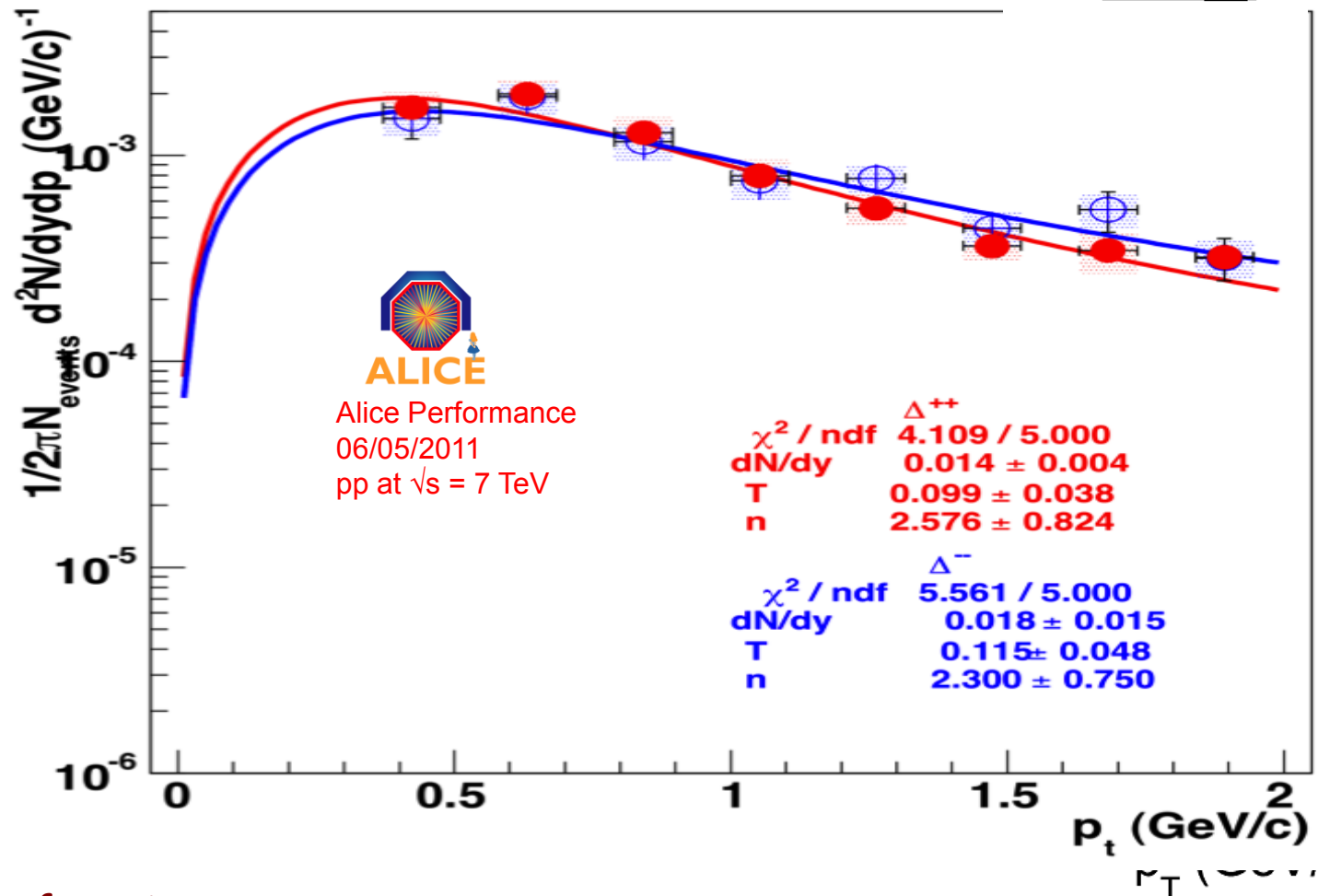




Reconstruction efficiency of ϕ , K^* , Ξ^* and Δ^{++}



- ### Systematics
- PID cuts
 - topological selection (Ξ^*)
 - background subtraction
 - material budget
 - track selection
 - normalization

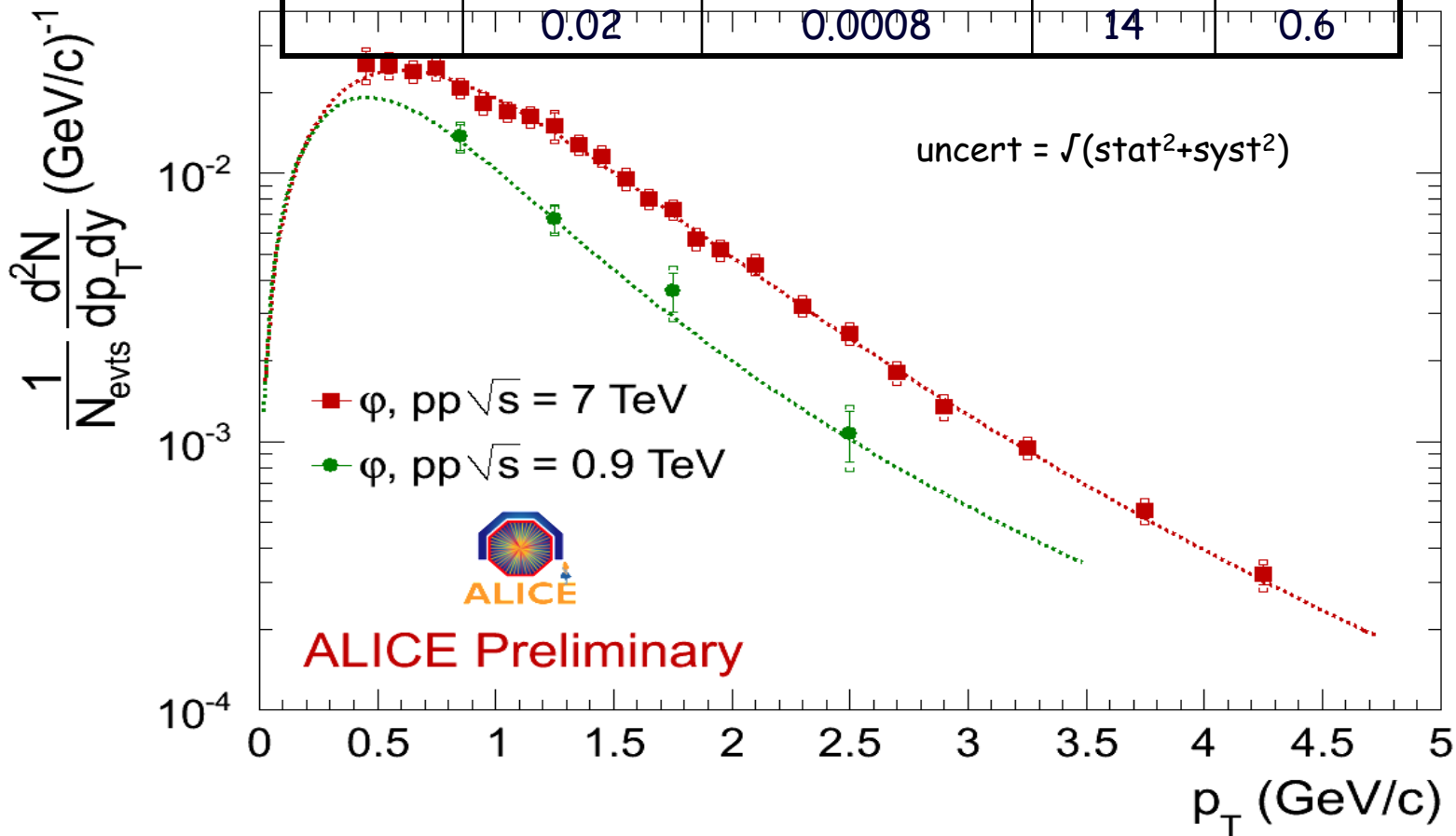


Fit: Levy / Tsallis function

$$\frac{d^2 N}{dy dp_T} = \frac{(n-1)(n-2)}{nT[nT + m(n-2)]} \times \frac{dN}{dy} \times p_T \times \left(1 + \frac{m_T - m}{nT} \right)^{-n}$$

dN_ϕ/dy increases proportionally to dN_{ch}/dy from 900 GeV to 7 TeV

\sqrt{s}	$\langle p_T \rangle$	dN/dy	T	n
900 GeV	1.00 ± 0.24	0.021 ± 0.005	164 ± 91	4.2 ± 2.5
7 TeV	1.112 ± 0.02	0.0334 ± 0.0008	286 ± 14	7.0 ± 0.6



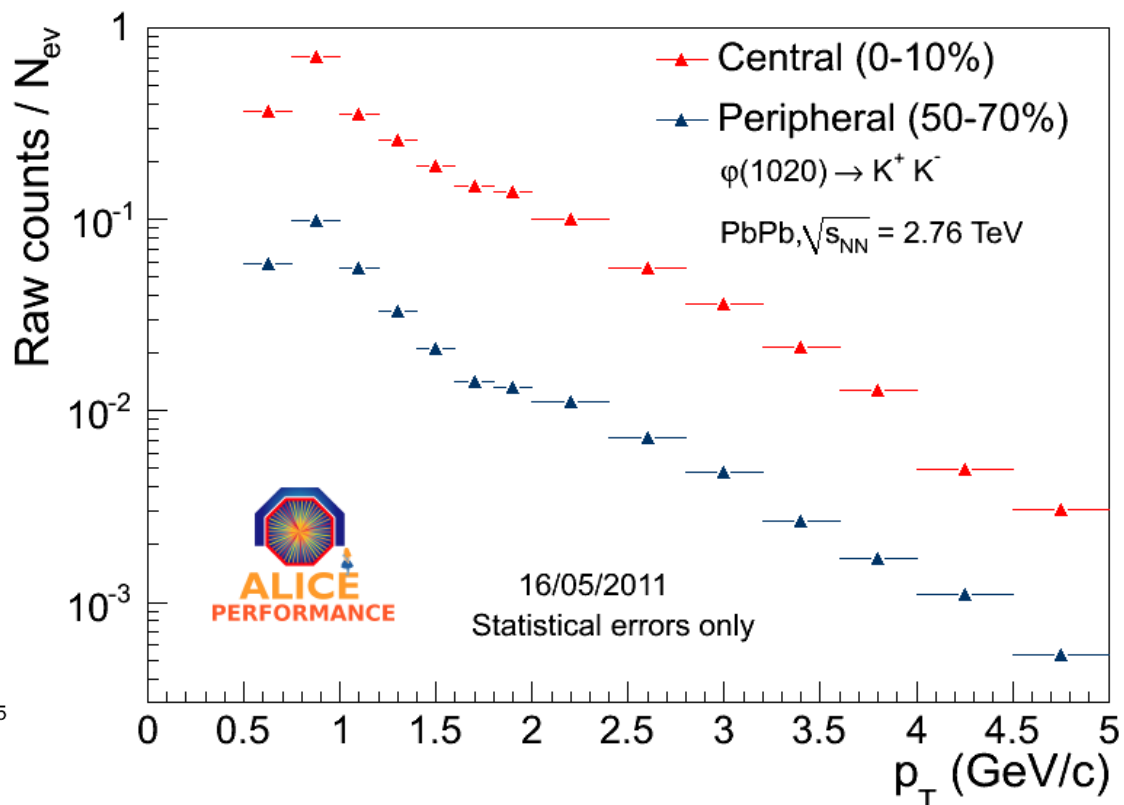
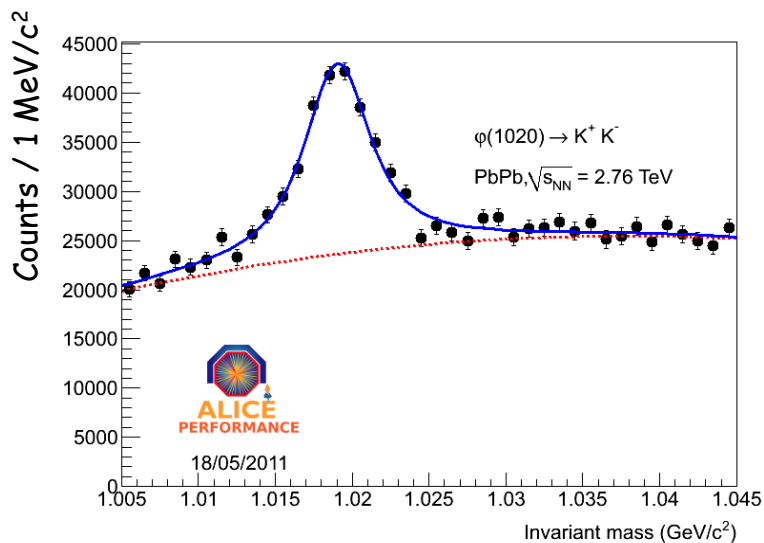
ϕ @ 900 GeV : ALICE Collaboration, Eur. Phys. Journal C 71 (2011), 1594

charged multiplicity @ 900 GeV and 7 TeV: ALICE Collaboration, Eur. Phys. Journal C 68 (2010), 345

- ❑ Smaller signal / background
 - tighter Particle ID cuts with TPC and TOF
 - require TOF for tracks with $p_T > 600 \text{ MeV}/c$
 - subtract like-sign background
- ❑ **Fit:** Voigtian + polynomial
- ❑ **Raw counts:** Voigtian full integral

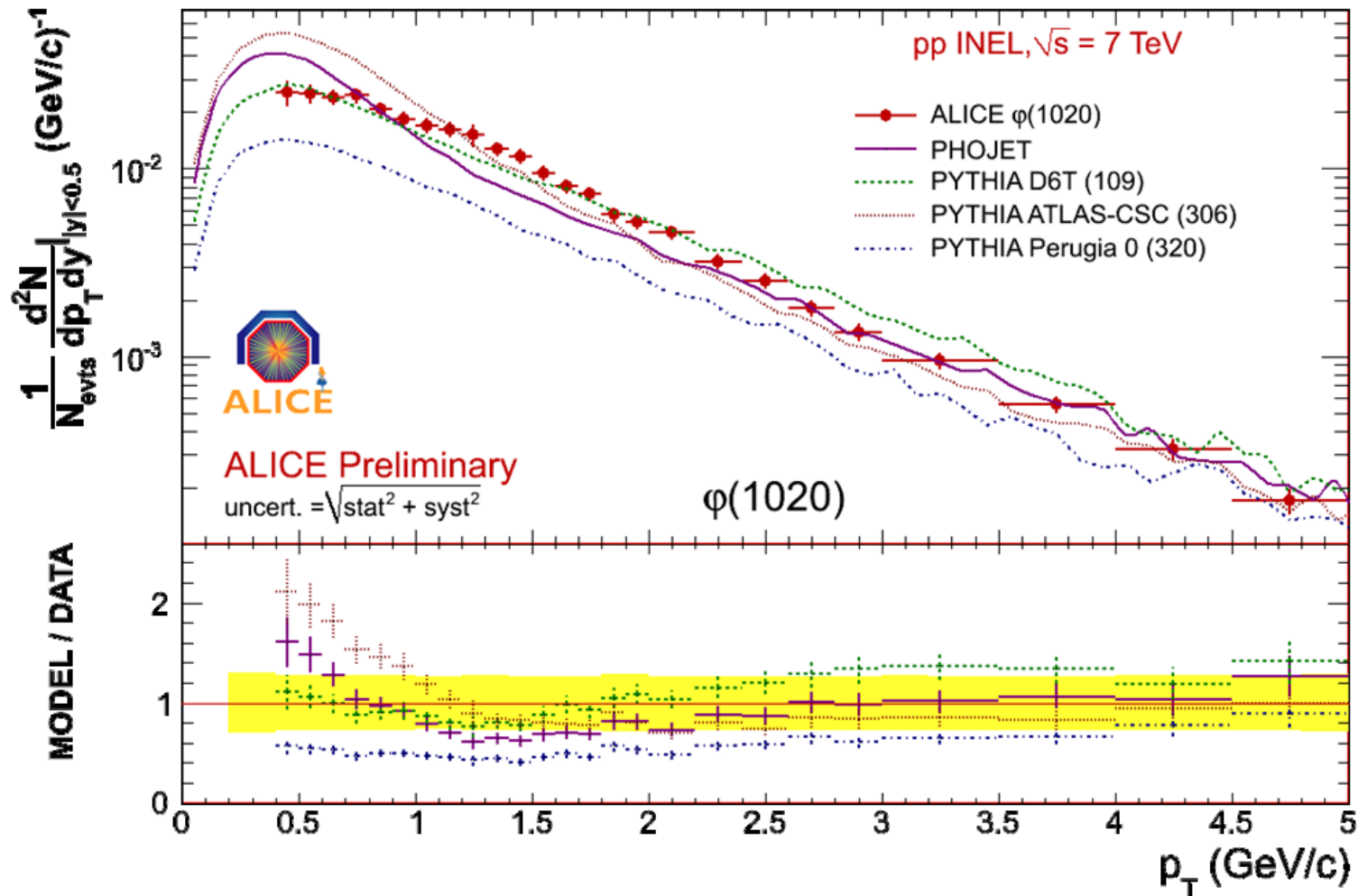
p_T bin (GeV/c)	1.2 - 1.6
PDG Mass (MeV/c ²)	1019.46
PDG Γ (MeV/c ²)	4.26
Fit Mass (MeV/c ²)	1019.03 ± 0.02
Fit Γ (MeV/c ²)	4.75 ± 0.06

Extracted ϕ signal in 14 bins for $0.5 \leq p_T \leq 5 \text{ GeV}/c$

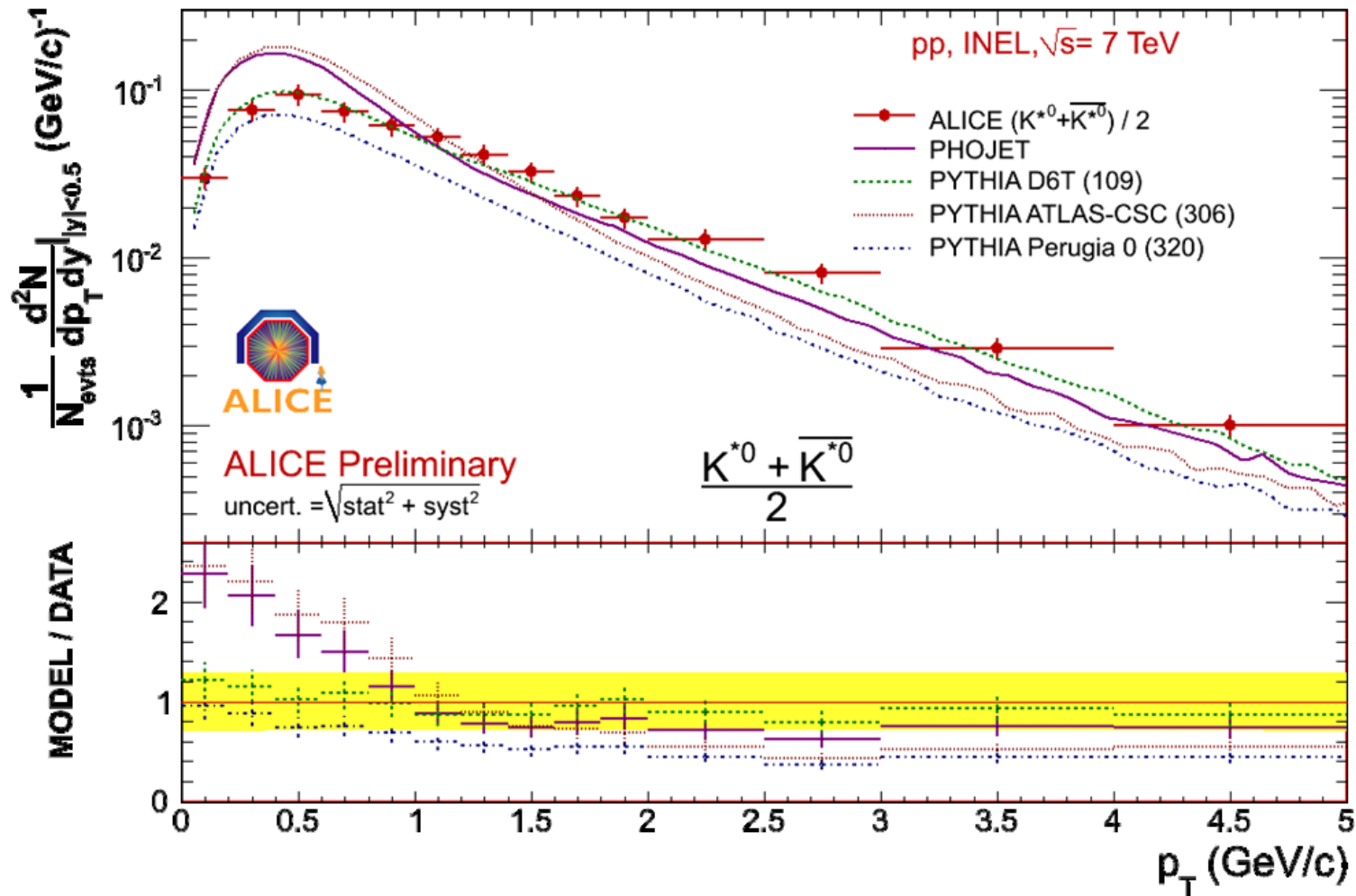


$p_T \leq 2 \text{ GeV}/c$: good agreement with PYTHIA D6T

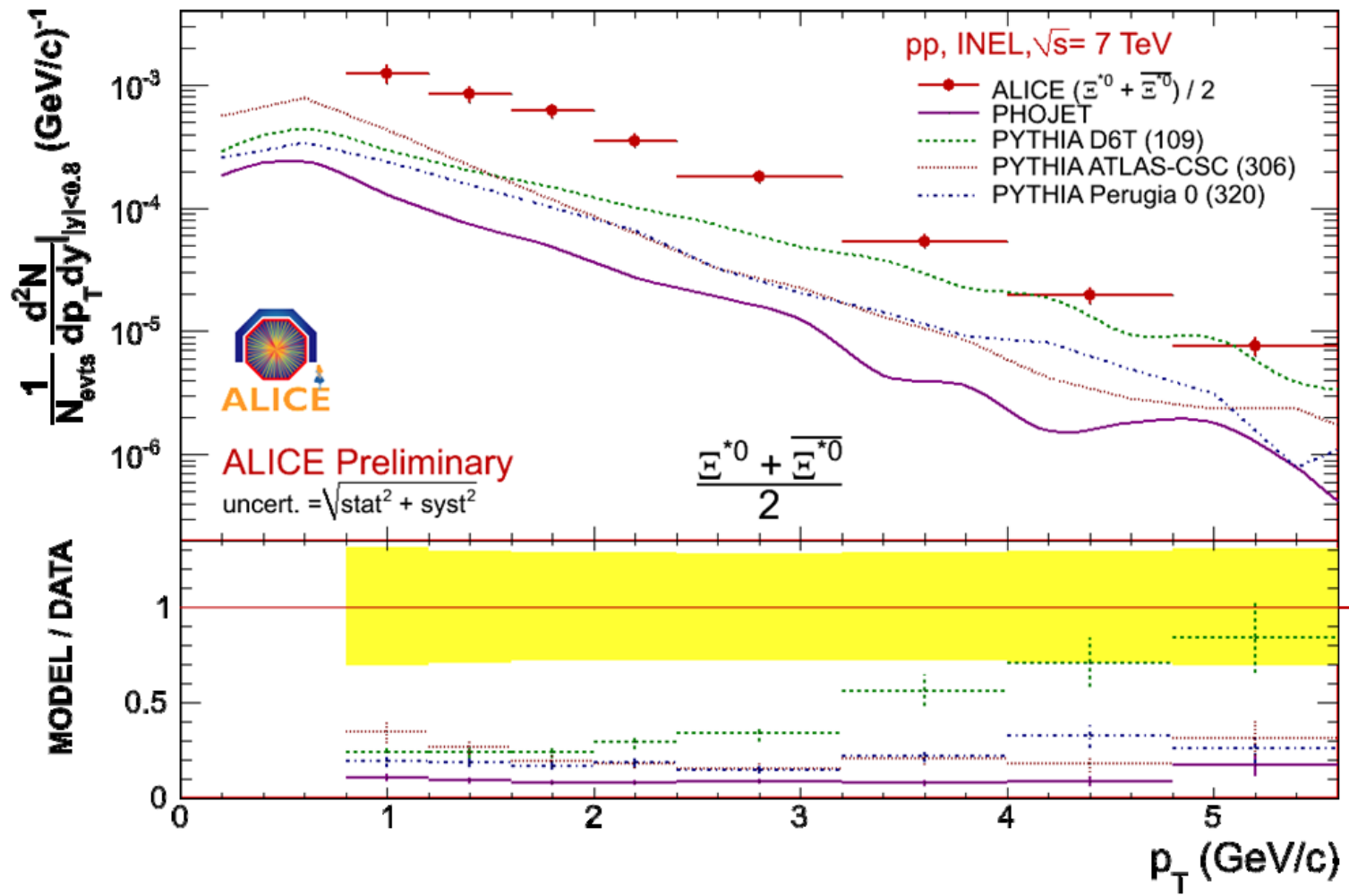
$p_T \geq 2 \text{ GeV}/c$: good agreement with PHOJET



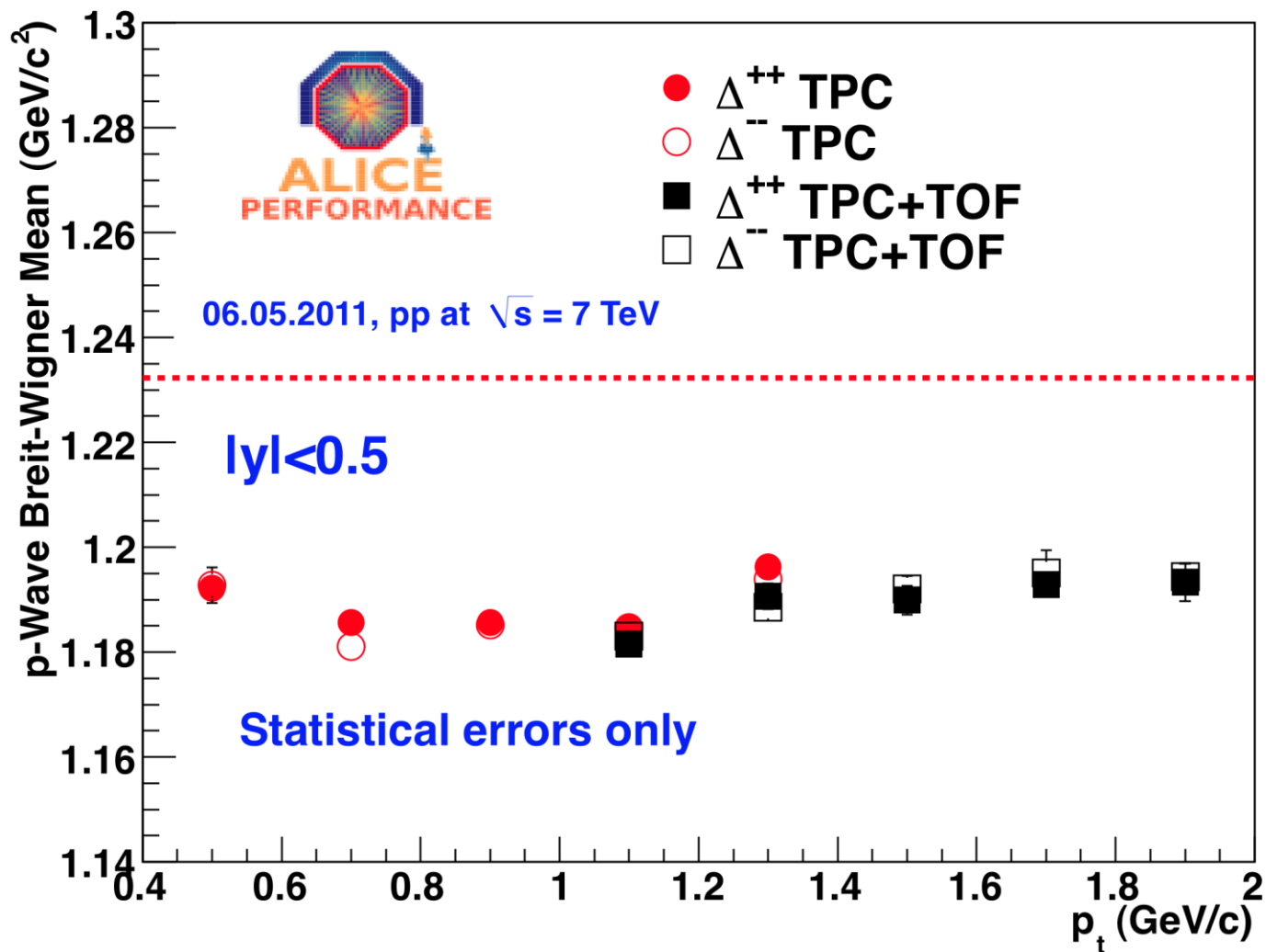
All p_T : good agreement with PYTHIA D6T



All p_T : underestimated

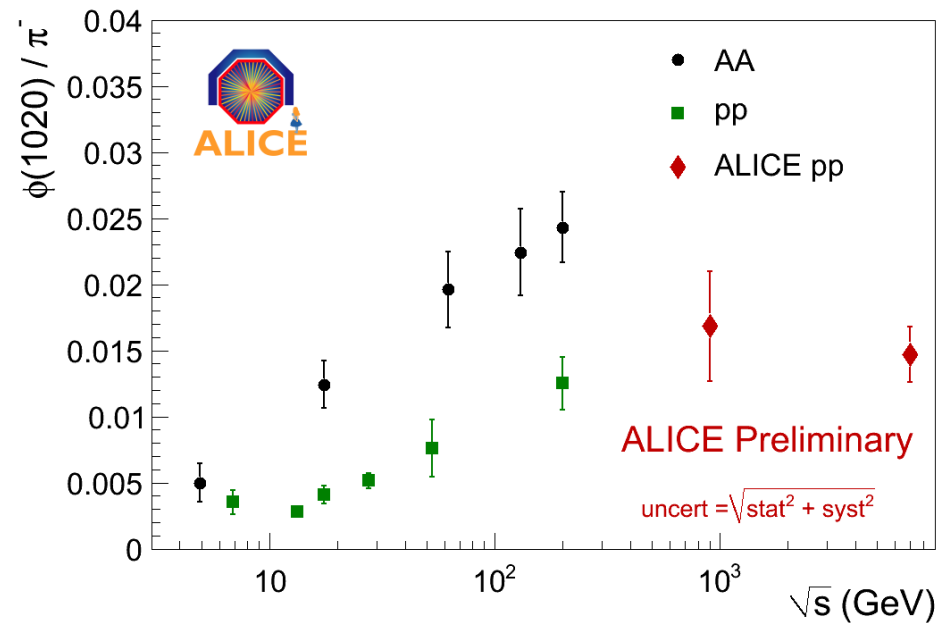
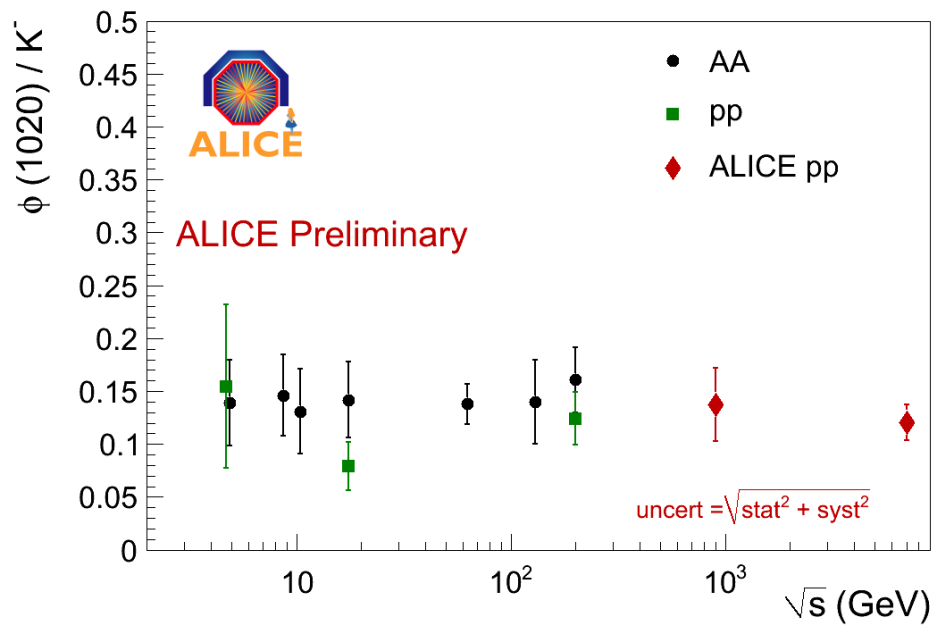


Yellow band: data systematics

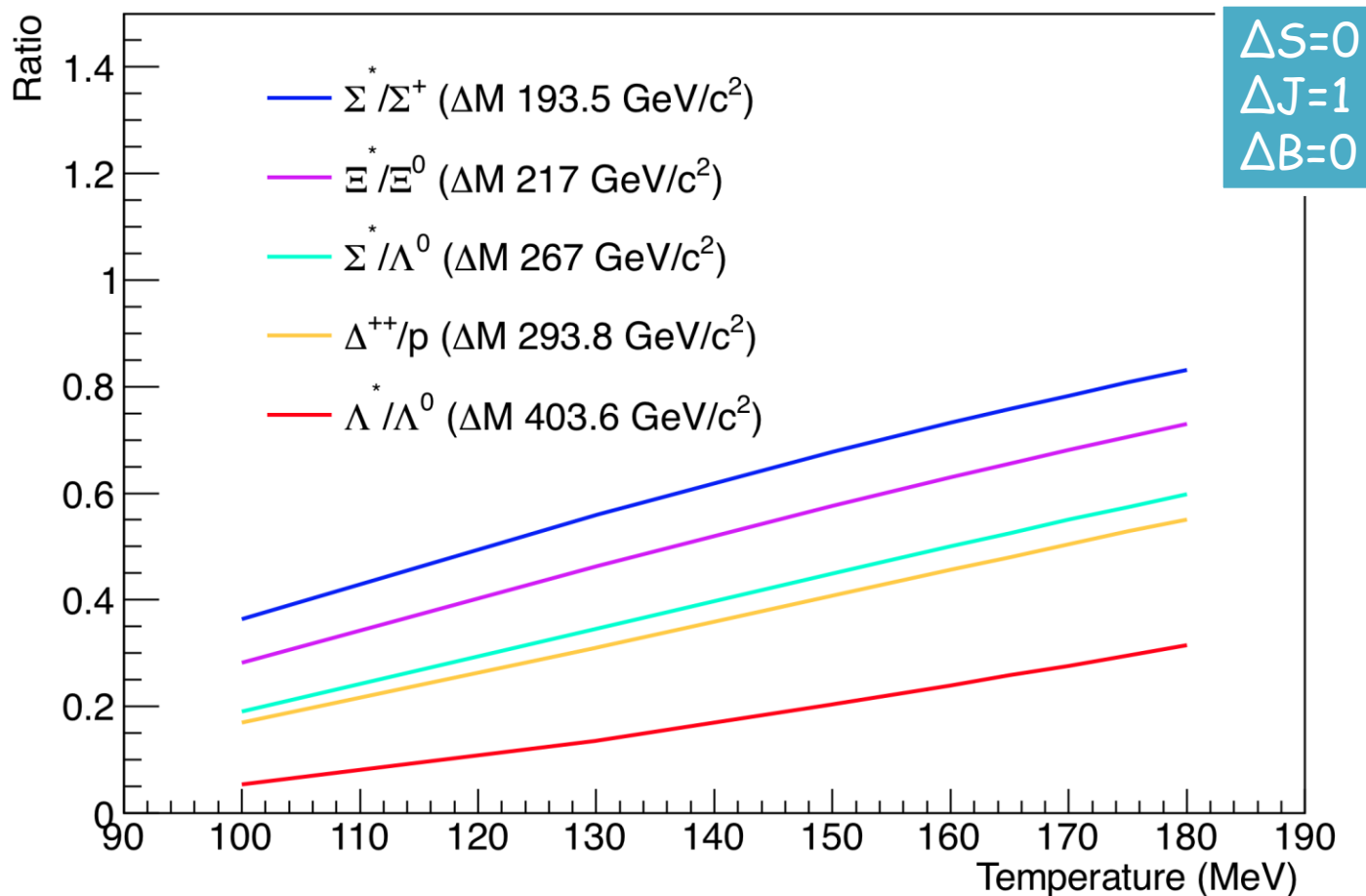




Ratios to stable particles



- ✓ Ratio proportional with the T
- ✓ Ratio inversely proportional with the mass difference



- Measured dN/dp_T for φ , K^* , Ξ^* , Λ^* and Δ^{++} at mid-rapidity in p+p collisions at $\sqrt{s} = 7$ TeV
- 30-50 MeV/c² of mass shift for Δ^{++} observed. No clear variation with p_T
- Measured spectra have been compared with MC
 - φ well reproduced by PYTHIA D6T below 2 GeV/c, by PHOJET above
 - K^* well reproduced by PYTHIA D6T
 - Ξ^* underestimated by a factor ~ 5 in all cases
- Ratios to stable particles don't increase w.r. to lower energy values
 - could be hint for constant T
- Analysis of Pb+Pb collisions started, need to deal with a higher background
 - tightened PID cuts
 - extracted φ signal for $0.5 \leq p_T \leq 5$ GeV/c
- **Outlook:**
 - **finalize Σ^* and Λ^* analysis in p+p collisions at $\sqrt{s} = 7$ TeV**
 - **finalize φ in PbPb ($\rightarrow R_{CP}$)**
 - **Particle ratios to extract the lifetime and temperature of fireball**

Thank you !

