Resonances measurement in pp and Pb-Pb collisions with the ALICE detector

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Outline

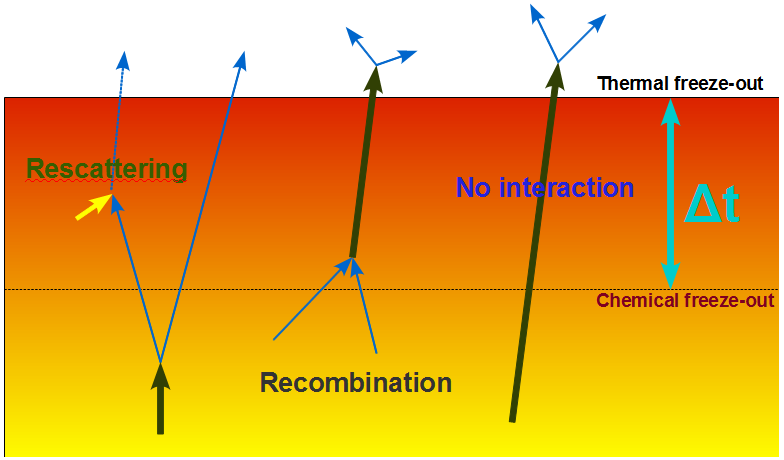
- Introduction
  - motivations
  - the ALICE detector
- Analysis
- Results
  - pp @ $\sqrt{s}$ = 7 TeV
  - Pb-Pb @ $\sqrt{s_{NN}}$ = 2.76 TeV
- Conclusions

Motivations: resonances in pp collisions

- Event structure
  - investigating hadron formation mechanisms
  - tune QCD-inspired models
    - basic method to describe the soft part of the underlying event
- Baseline for understanding Pb-Pb results
  - masses and widths
  - ratios to stable particles

Motivations: resonances in AA collisions

	Mass (MeV)	Width (MeV)	cτ(fm)	Decay
$K^*(892)^0$	896	50	4	K π
φ(1020)	1019	4	46	K K
Σ(1385)	1385	33	6	Λ π
Ξ(1530)	1530	9	22	Ξ π

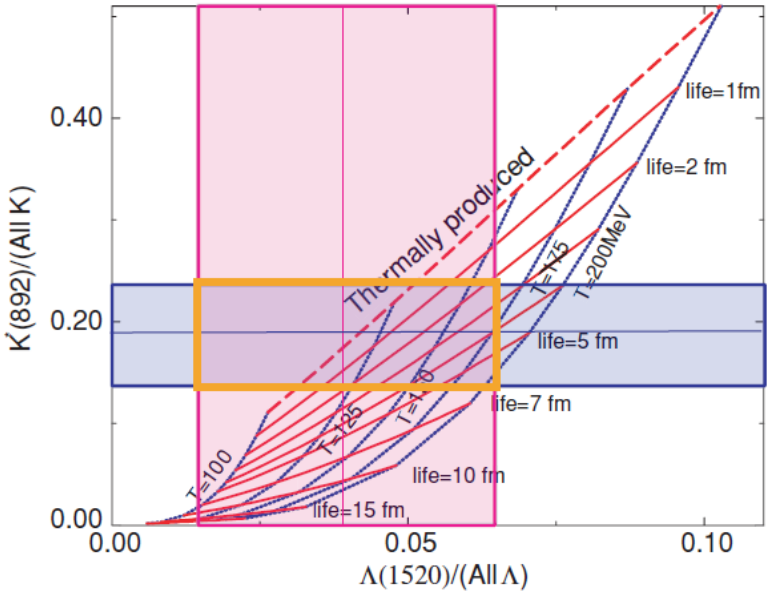


Resonance / stable particle ratios
→ estimate fireball temperature and lifetime

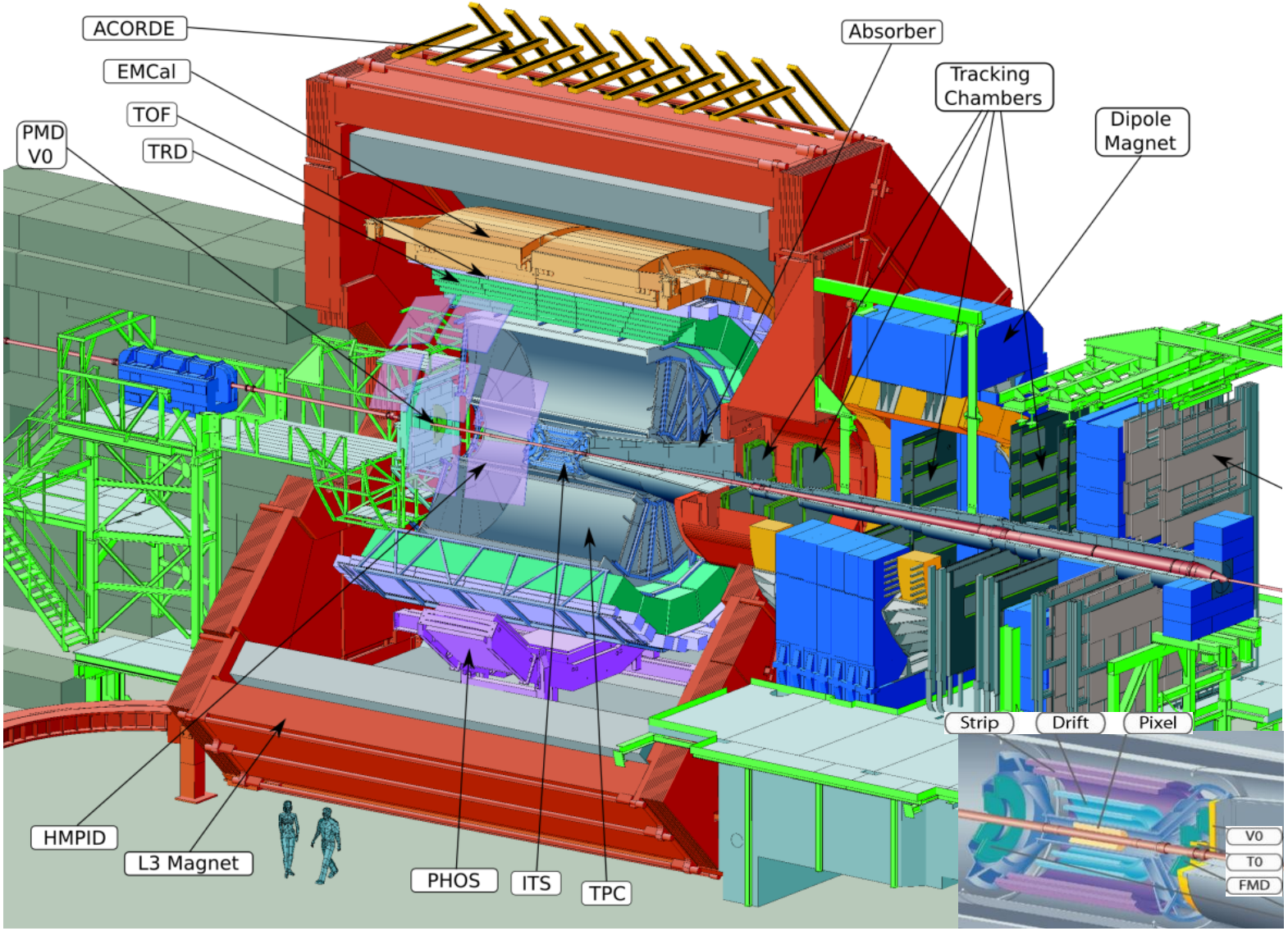
G. Torrieri and J. Rafelski, Phys. Lett. B509 (2001), 239

Chiral symmetry restoration
→ modifications in mass and/or width

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



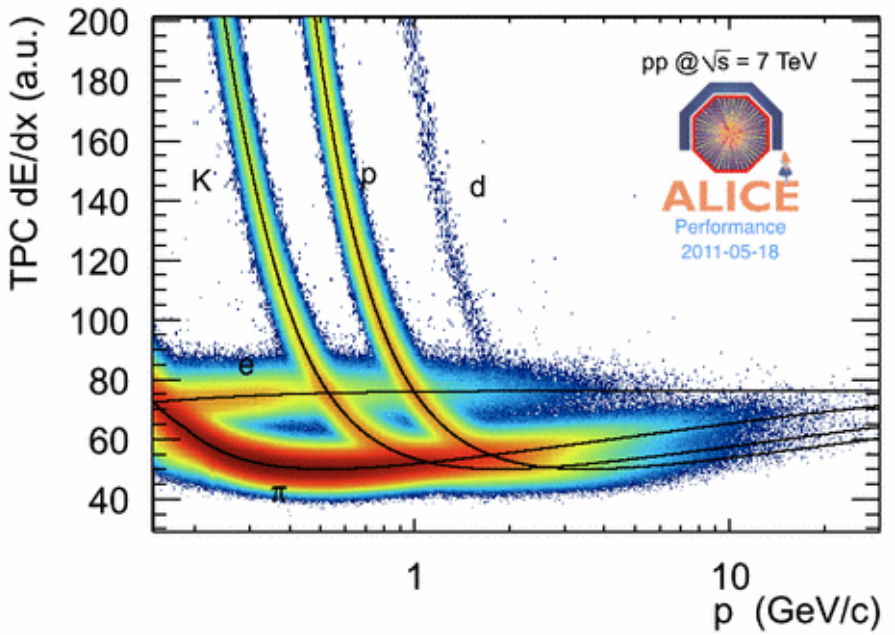
The ALICE detector



detailed talk: J. Schukraft

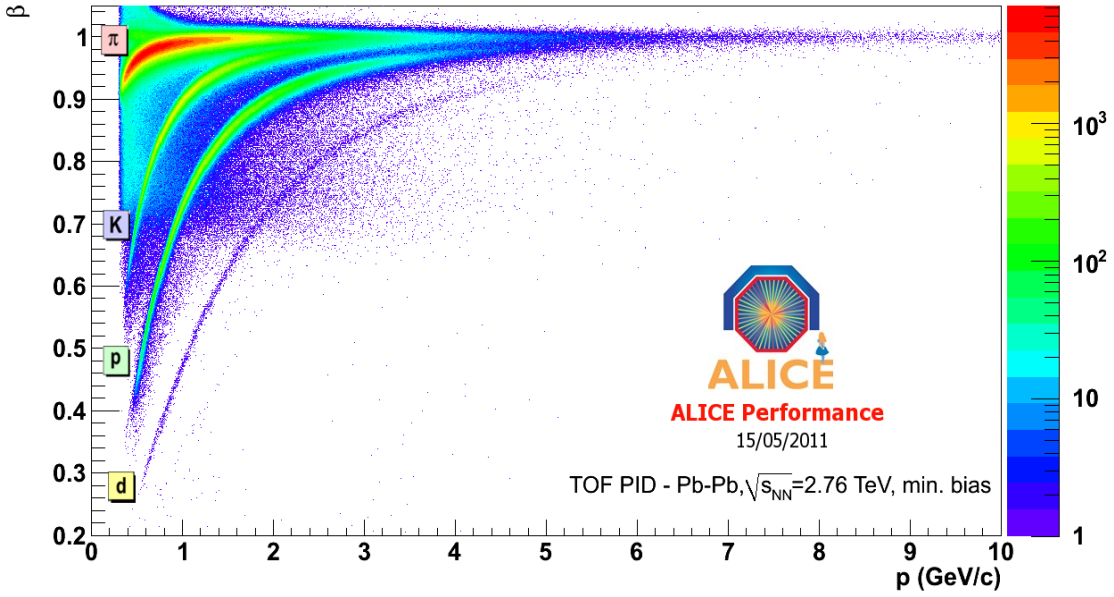
Event and track selection

- Event selection
  - selected (for different resonances) $25 \div 155 * 10^6$ min. bias events
  - primary vertex reconstructed with tracks or SPD tracklets ($|V_Z| \lesssim 10$ cm)
- Track selection
  - quality → optimize momentum resolution
  - particle identification → minimize background



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

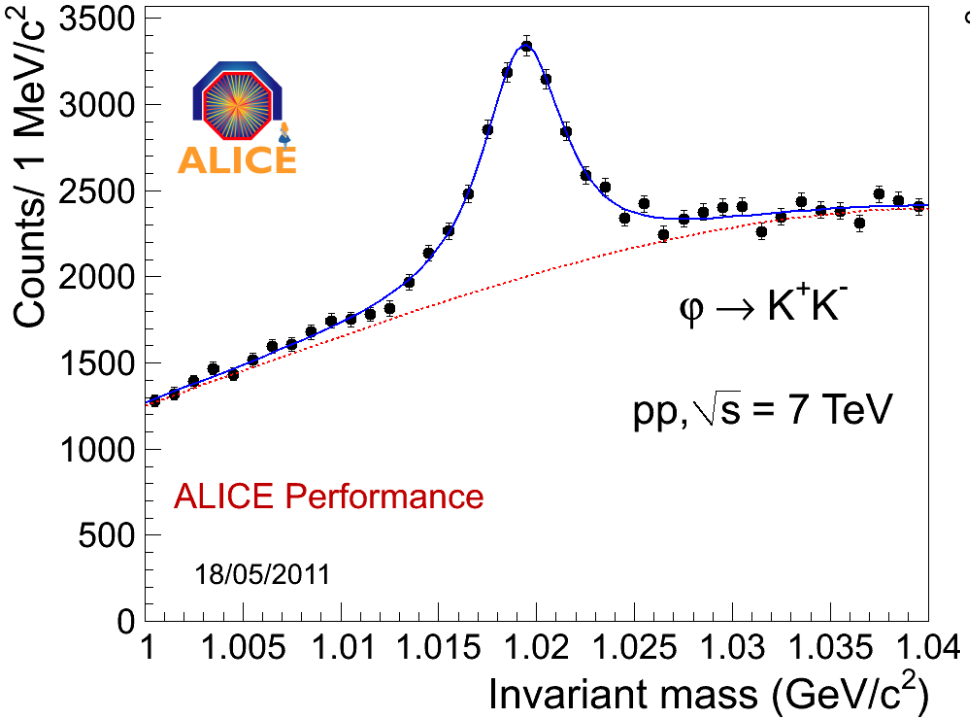


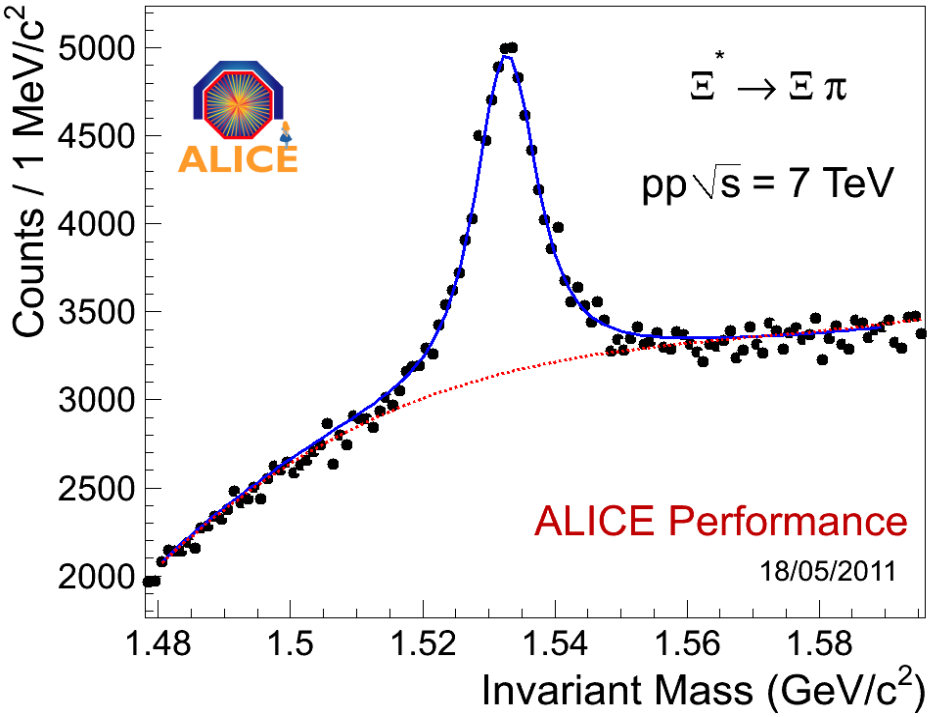
see talk from A. Kalweit

Signal extraction: φ and Ξ*

- Fit: poly + Breit-Wigner convolution with Gaussian (= "Voigtian")
  - take into account inv. mass resolution
  - estimate from MC (φ: ~ 1 MeV/c^2)
- Raw counts: Voigtian full integral

		φ (|y| ≤ 0.5)	Ξ* (|y| ≤ 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 ± 0.10	1531.5 ± 0.4
Fit Γ	(MeV/c^2)	4.52 ± 0.01	*Fixed to PDG*
Fit σ	(MeV/c^2)	*Fixed to 1.2*	2.0 ± 0.5

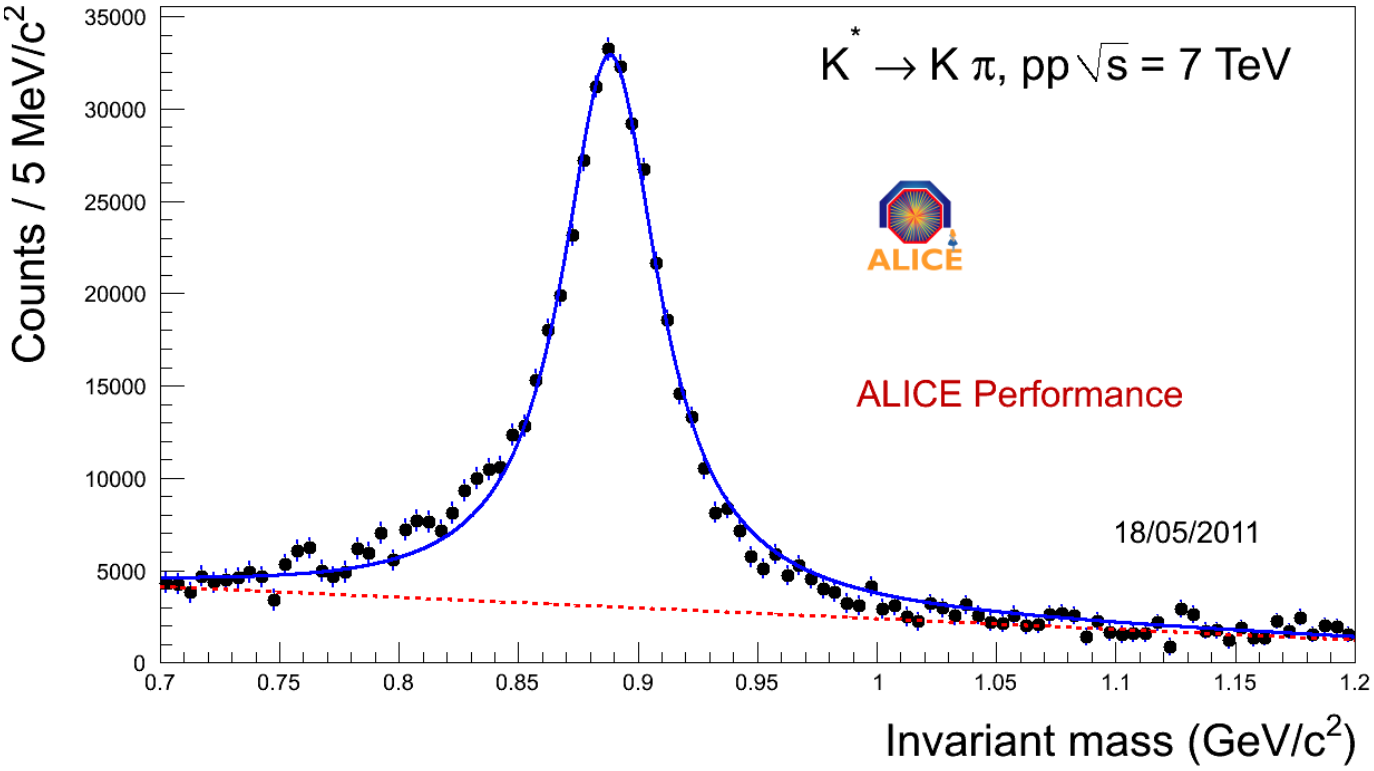




Signal extraction: K*

- 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

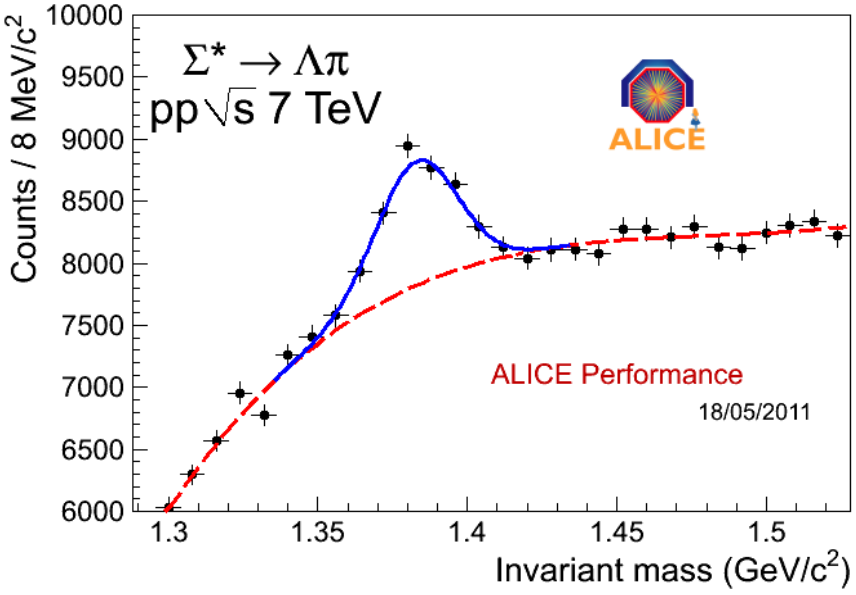


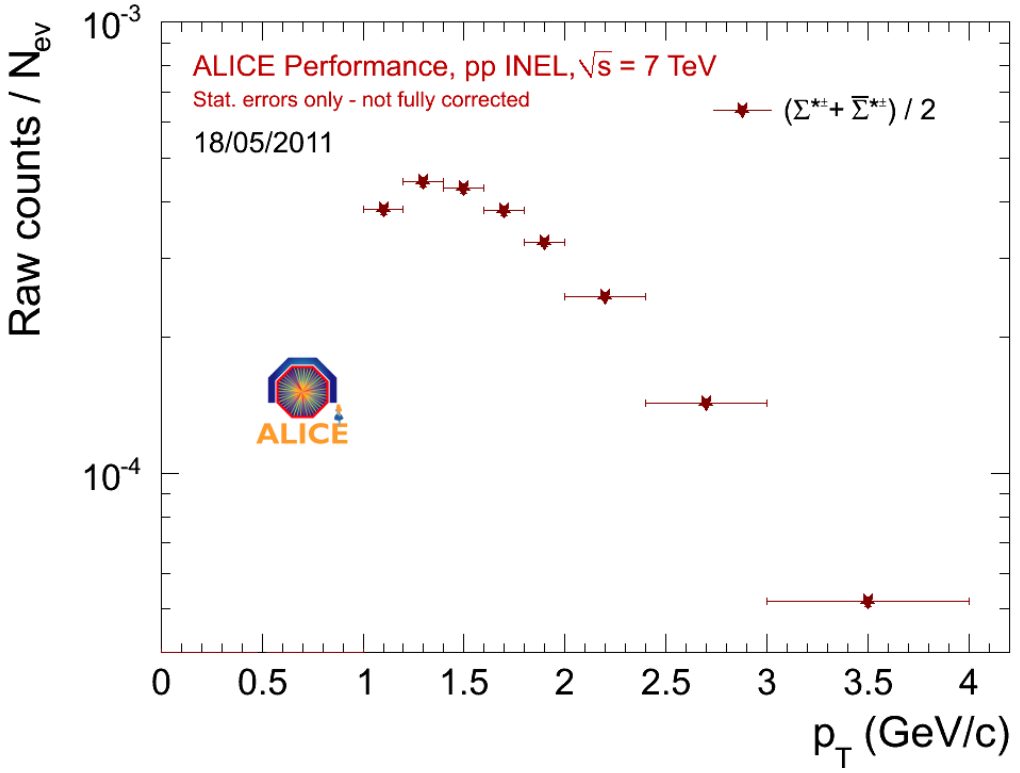
Signal extraction: Σ*

- Fit: Gaussian + negative power law
- Subtract background function
- Raw counts: bin count
  - 3σ around peak center.

- **Rapidity range: |y| ≤ 0.8**

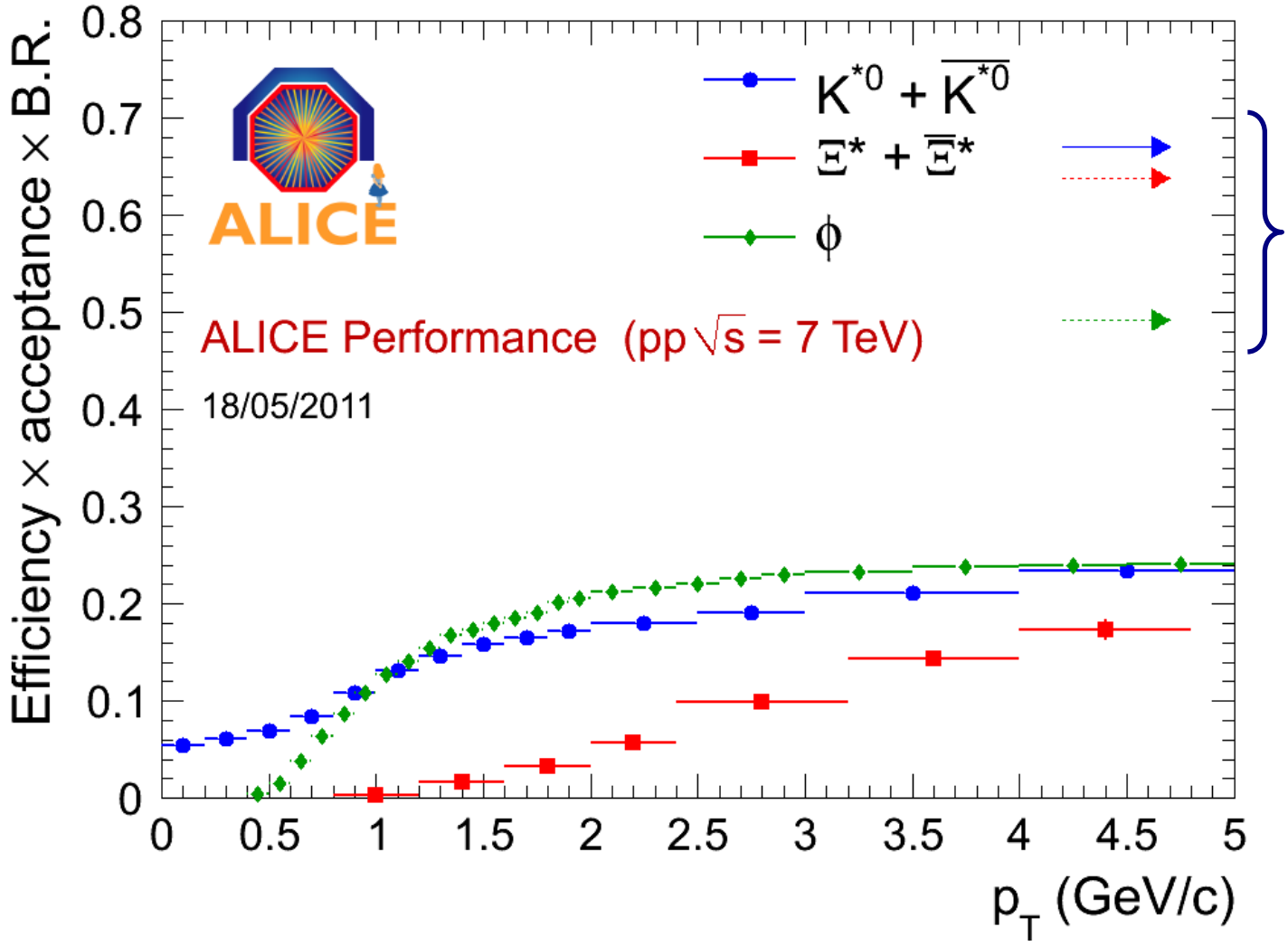
p_T bin (GeV/c)	0.7 – 0.8	
PDG Mass (MeV/c^2)	1382.8 (Σ^{*+})	1387.2 (Σ^{*-})
PDG Γ (MeV/c^2)	35.8 (Σ^{*+})	39.4 (Σ^{*-})
Fit Mass (MeV/c^2)	1383 ± 1	
Fit Γ (MeV/c^2)	33 ± 3	





Reconstruction efficiency of φ, K* and Ξ*

Ξ* efficiency includes also reconstruction efficiency for previous decay steps (Ξ decay reconstruction)



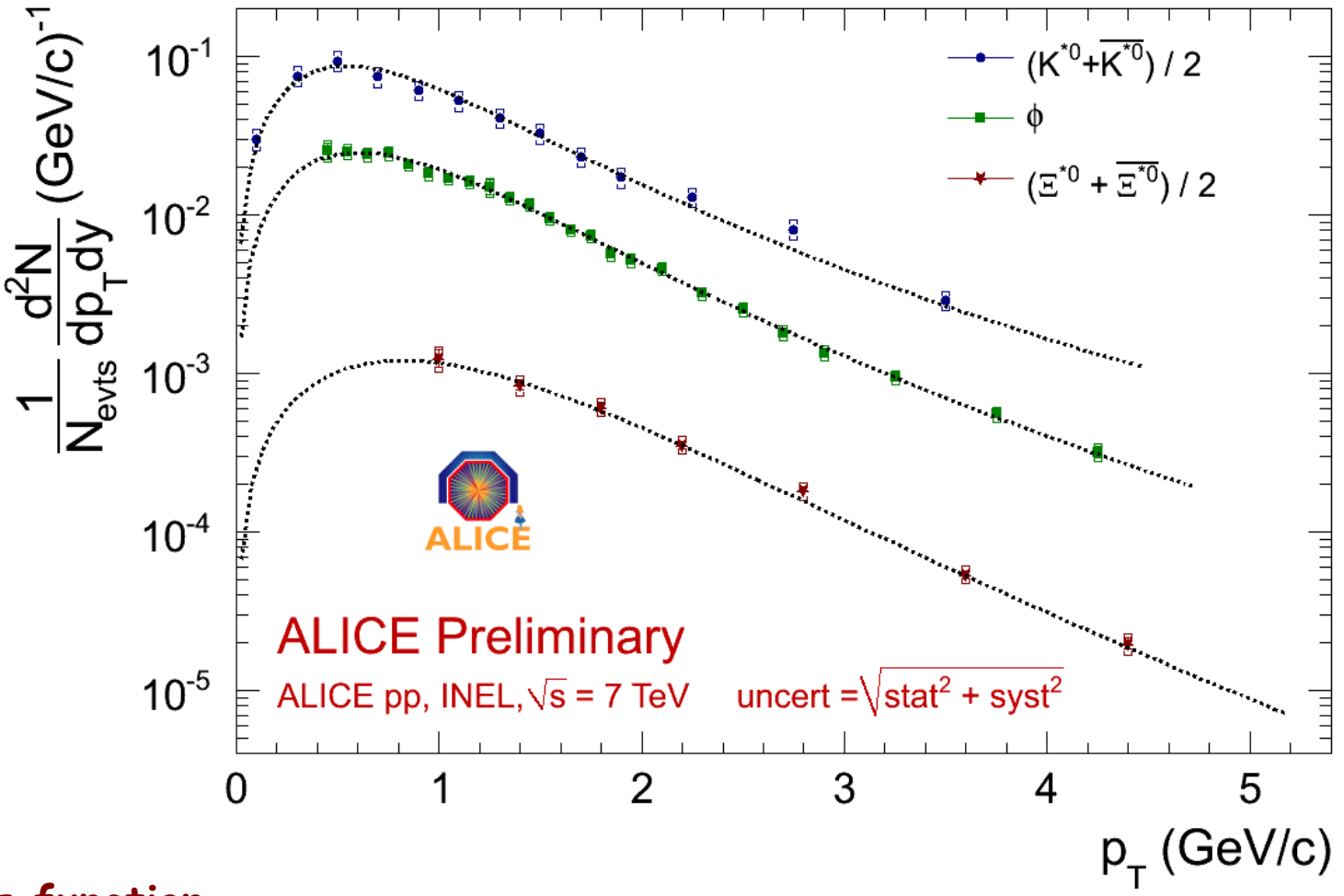
Branching ratio limits

Corrected spectra of φ, K* and Ξ*

Normalized to INEL
(talk by K. Oyama)

Systematics

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



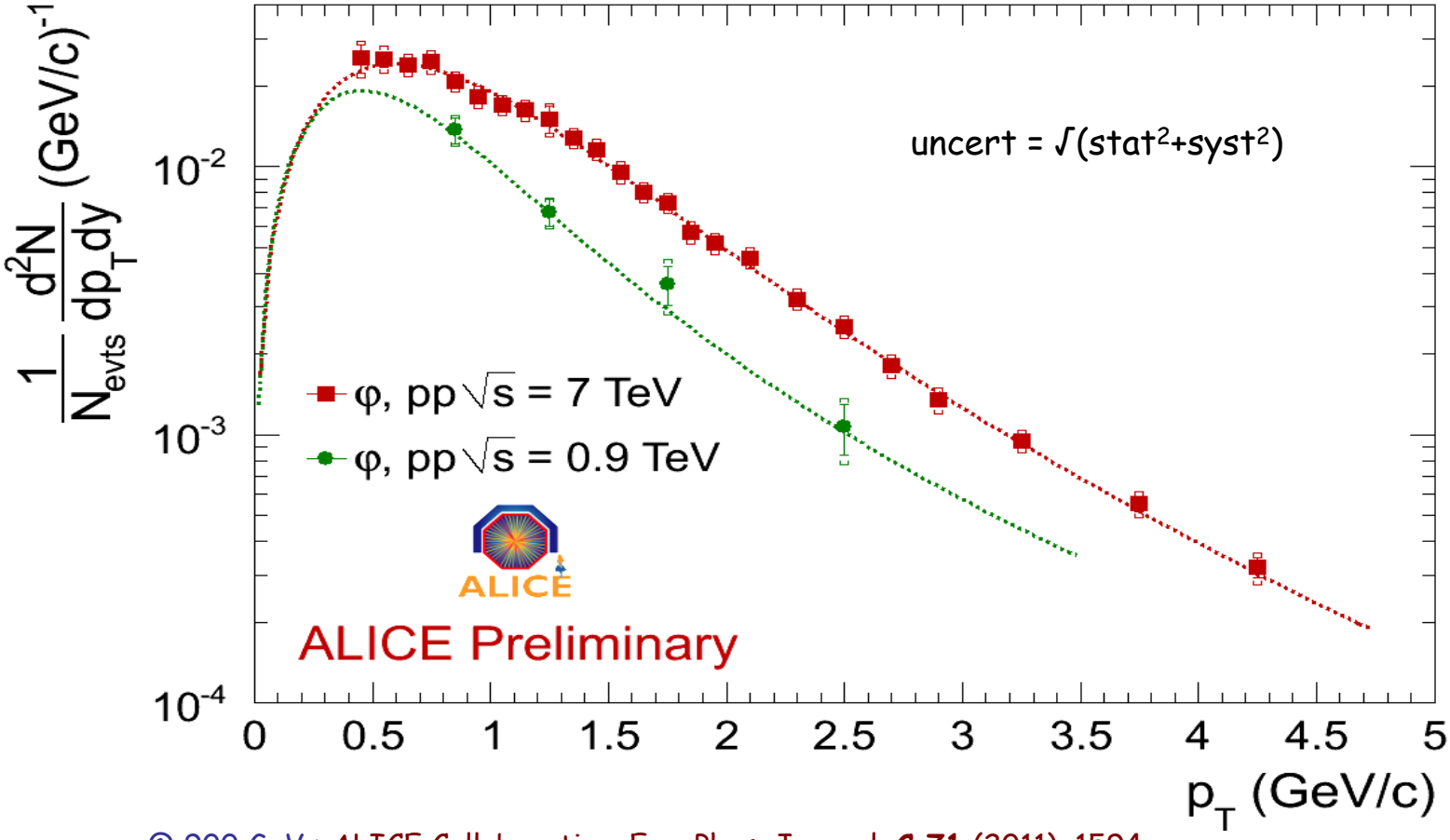
Fit: Levy / Tsallis function

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

φ resonance: comparison with 900 GeV

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

√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

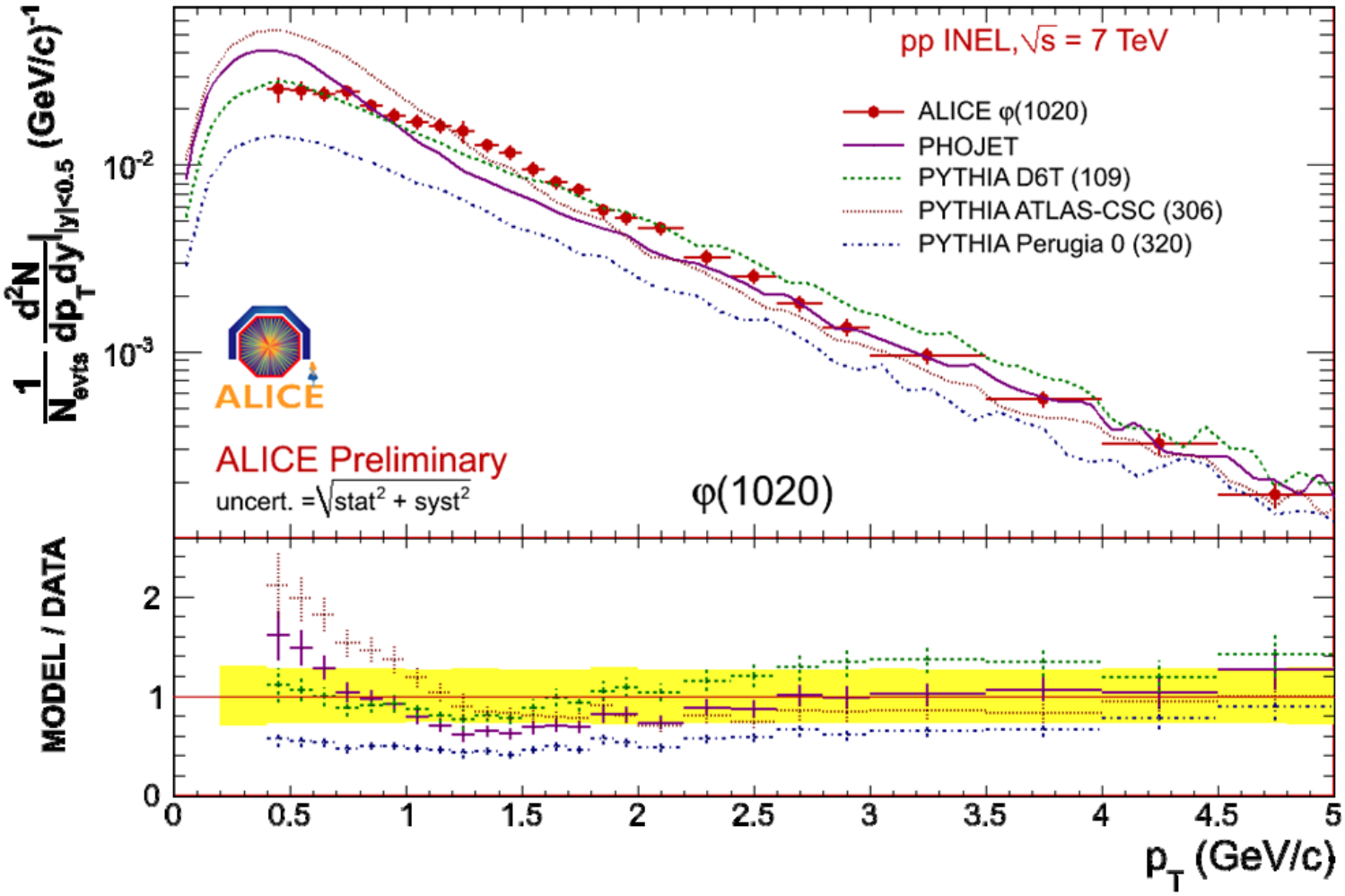


φ @ 900 GeV : ALICE Collaboration, Eur. Phys. Journal **C 71** (2011), 1594
charged multiplicity @ 900 GeV and 7 TeV: ALICE Collaboration, Eur. Phys. Journal **C 68** (2010), 345

Comparison with MC: φ

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

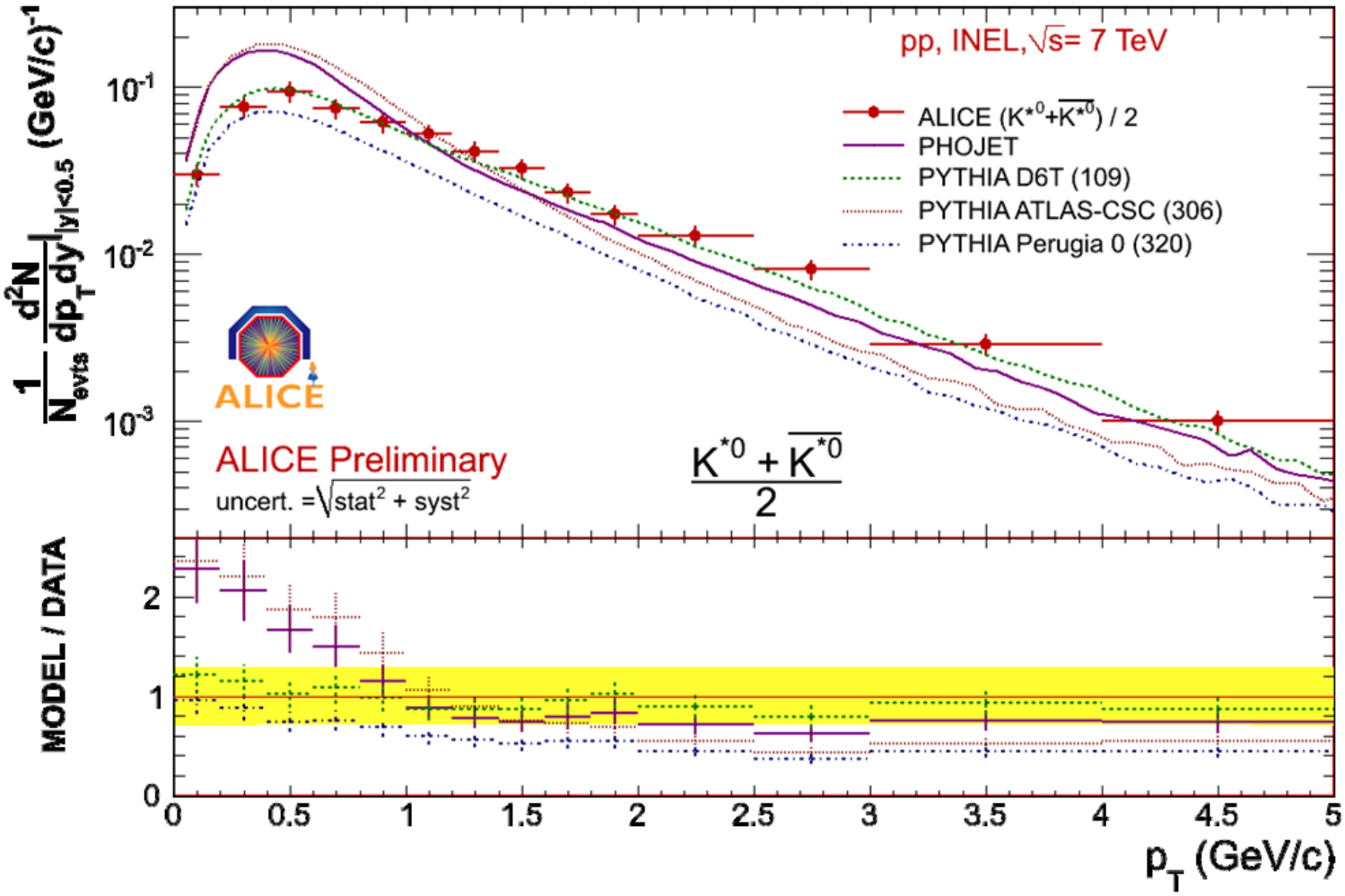
$p_T \geq 2$ GeV/c: good agreement with PHOJET



Yellow band: data systematics

Comparison with MC: K*

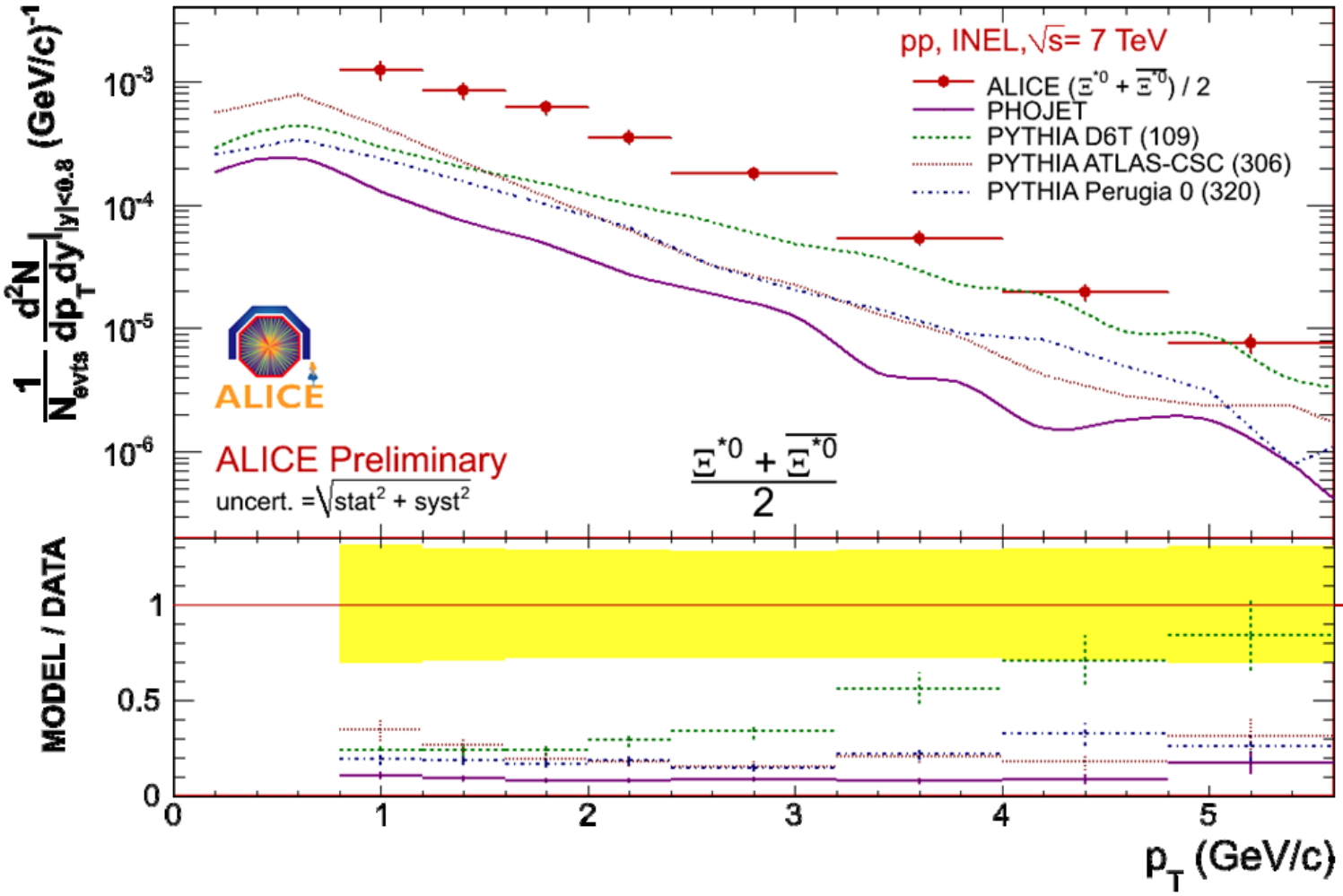
All p_T: good agreement with PYTHIA D6T



Yellow band: data systematics

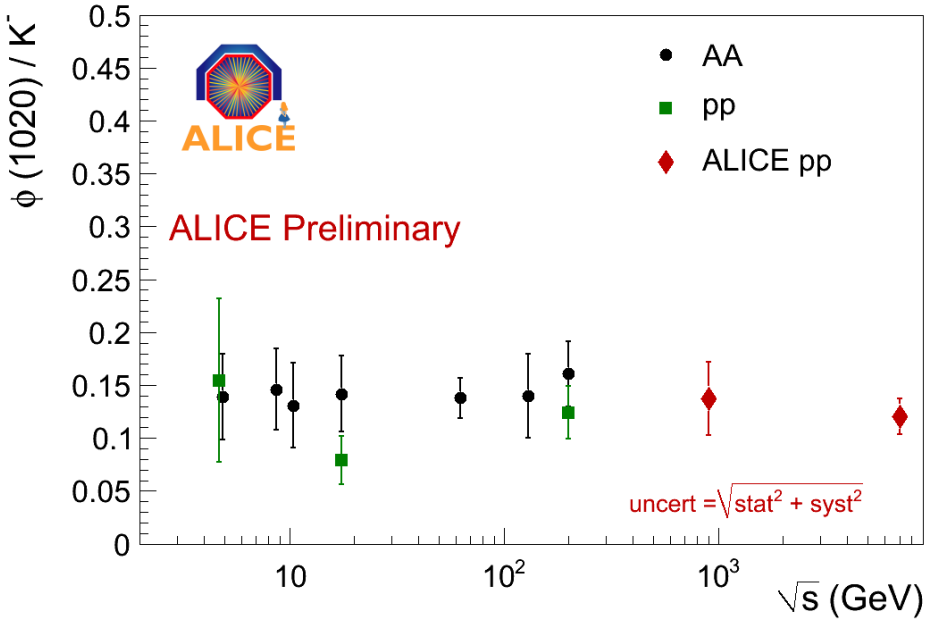
Comparison with MC: Ξ*

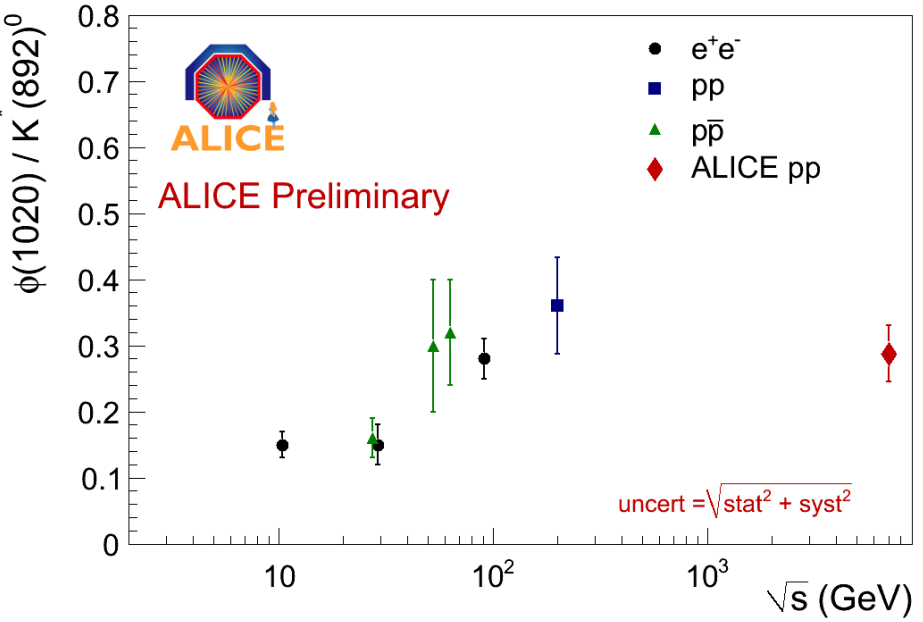
All p_T: underestimated

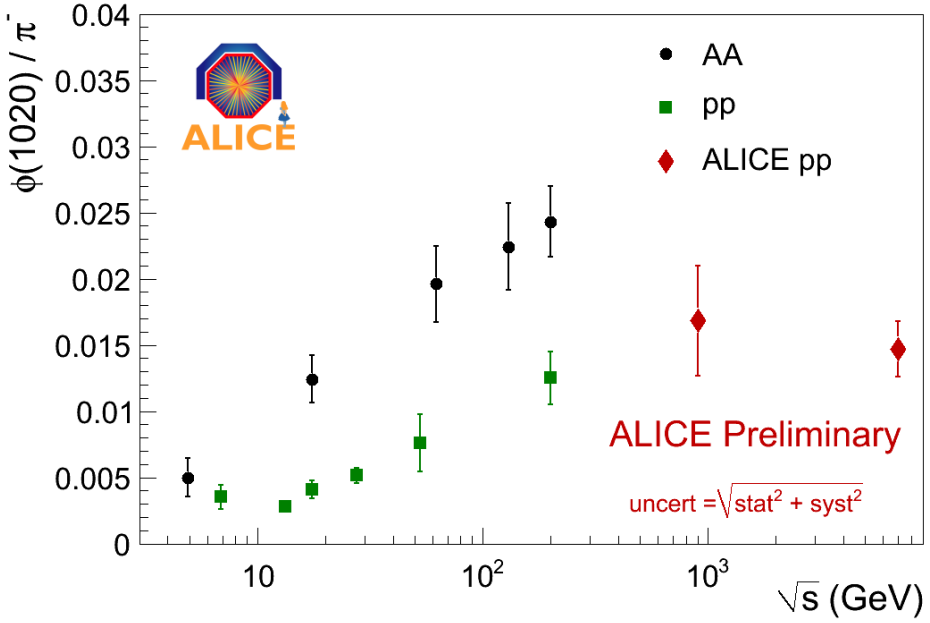


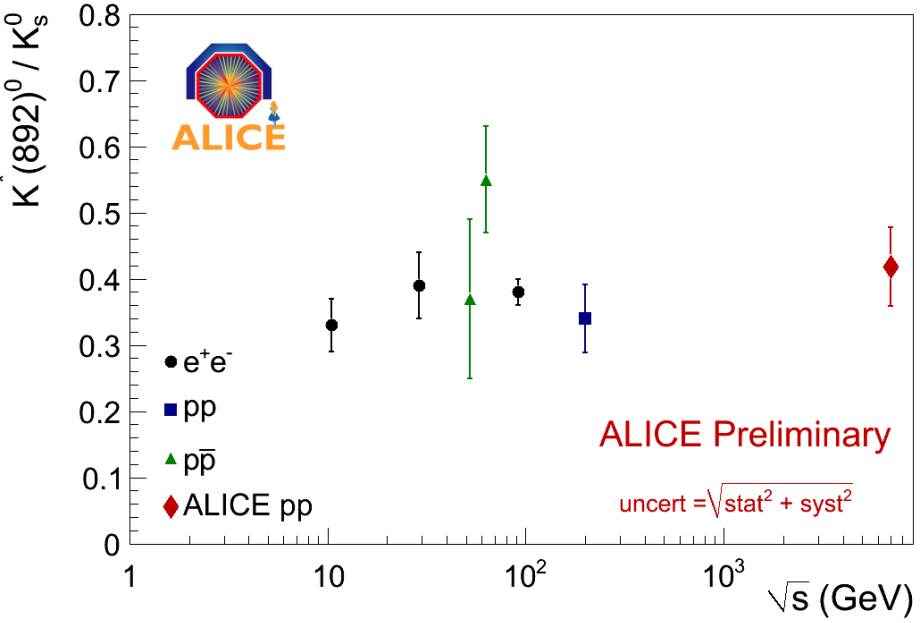
Yellow band: data systematics

Ratios to stable particles









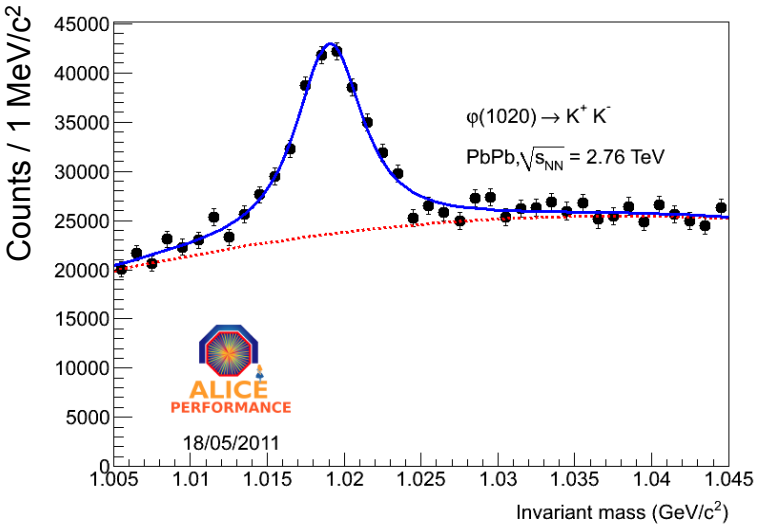
φ signal extraction in Pb-Pb collisions

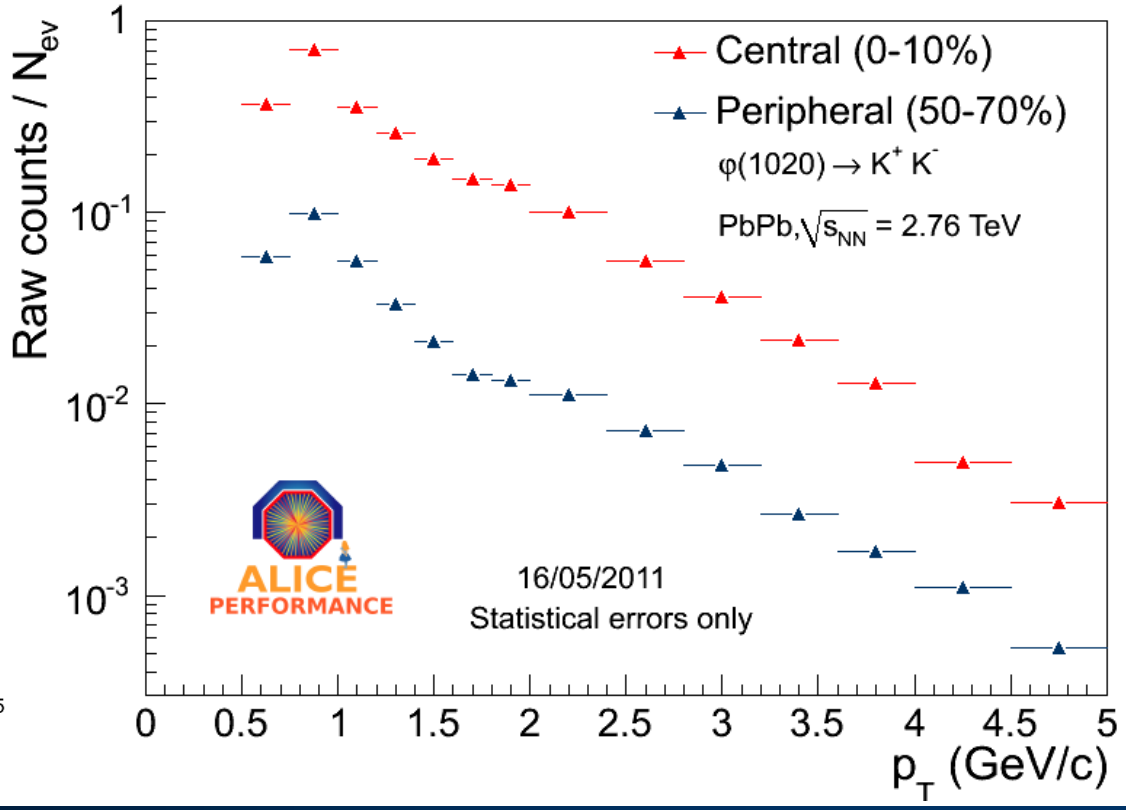
- Smaller signal / background
  - tighter Particle ID cuts with TPC and TOF
  - require TOF for tracks with p_T > 600 MeV/c
  - subtract like-sign background

- 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 ≤ p_T ≤ 5 GeV/c





Conclusions

- Measured dN/dp_T for φ, K* and Ξ* at mid-rapidity in pp collisions at $\sqrt{s}$ = 7 TeV
- 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
  - even φ / π saturates
- Analysis of Pb-Pb collisions started, need to deal with a higher background
  - tightened PID cuts
  - extracted **φ** signal for $0.5 \leq pT \leq 5$ GeV/c
- **Outlook:**
  - **finalize Σ* analysis in pp collisions at $\sqrt{s}$ = 7 TeV**
  - **finalize φ in PbPb ($\rightarrow R_{CP}$)**
- **More results on resonances in ALICE @ QM2011:**
  - talk (A. De Falco): measurement of **φ** → **μμ** at forward rapidity ($2.5 \leq y \leq 4$)
  - poster (A. Karasu Uysal, B. Dönigus): measurement of **Δ(1232)** and **Λ(1520)**
  - poster (D. Madagodahettige Don, F. Blanco): **φ, K*** correlation with leading particle

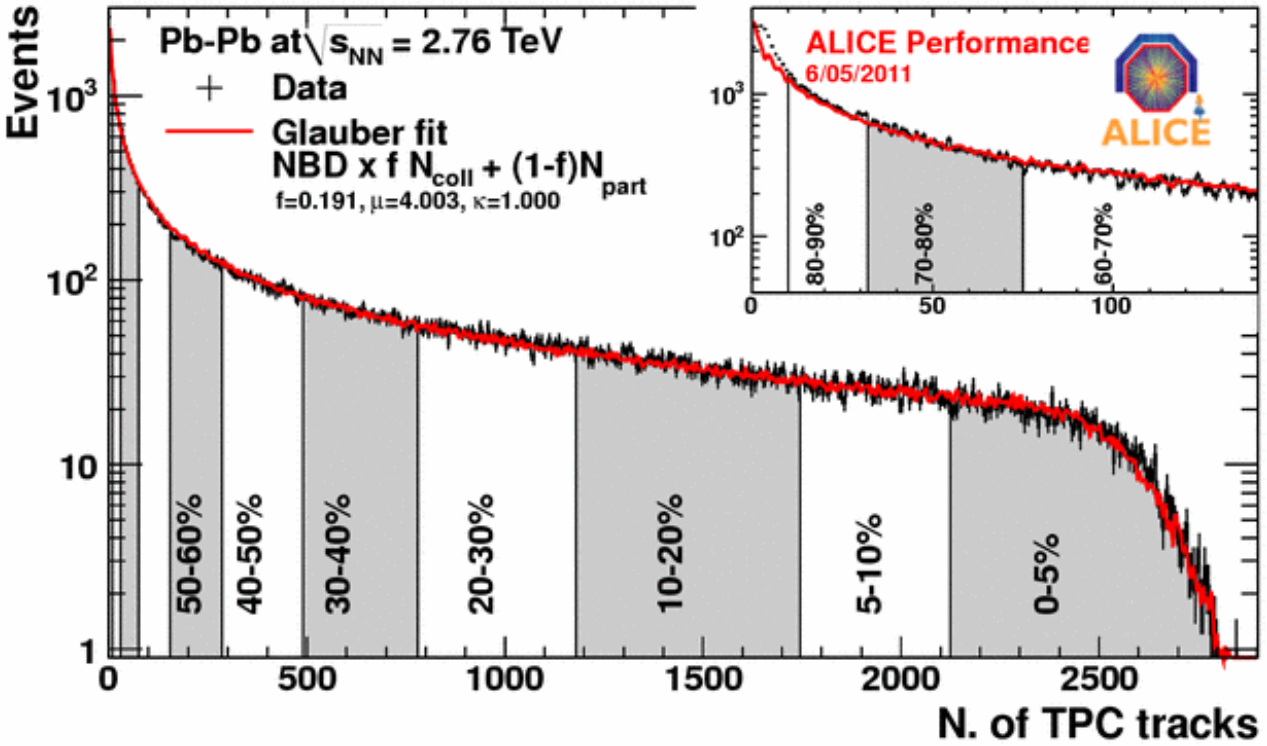
Thank you!

Normalization to INEL

- Physics Selection
  - get number of good min-bias events
  - estimate background events
- Van der Meer scans 2010
  - measured cross section for events which raise a signal in both ALICE collision point detectors (VZERO)
  - estimated INEL and min-bias cross-sections
- Final estimate: $N_{INEL} = N_{MB} * \sigma_{INEL} / \sigma_{MB}$

Centrality computation

- Multiplicity distributions from several detectors (VZERO, SPD, TPC) after Physics Selection
- Recalibrate variables
  - channel-to-channel linearize VZERO to SPD
- Correct SPD for V_Z dependence
- Fit with simulation based on MonteCarlo Glauber model
  - anchor point at 90% of total Glauber cross section



Topological selections for Σ^* and Ξ^*

Candidate Ξ

Minimum transverse decay radius	> 0.2 cm
DCA to primary vertex [a]	> 0.01 cm
DCA between V0 daughter tracks	< 0.5 cm
Cosine of V0 pointing angle	> 0.97
DCA of V0 to primary vertex	> 0.001 cm
V0 invariant mass	> 1110 MeV/c^2
V0 invariant mass	< 1122 MeV/c^2
DCA between V0 and bachelor track	< 3.0 cm
Cosine of cascade pointing angle	> 0.85
Cascade invariant mass	> 1315 MeV/c^2
Cascade invariant mass	< 1327 MeV/c^2
[a] for bachelor and each V0 daughter.	

Candidate Λ

DCA between V0 daughter tracks	< 0.50 cm
Cosine of V0 pointing angle	> 0.99
DCA of V0 to primary vertex	< 0.3 cm
V0 invariant mass	> 1110 MeV/c^2
V0 invariant mass	< 1122 MeV/c^2

Particle IDentification selections (detail)

TPC cuts depend on the momentum p_{TPC} at the inner edge of the detector barrel

TOF cuts depend on the momentum p_V at the primary vertex

	TPC	TOF
φ	p_{TPC} < 350 MeV/c: **5σ** p_{TPC} > 350 MeV/c: **3σ**	**3σ**
K*	it TOF is matched: **5σ** if TOF is not matched: ❑ p_{TPC} < 350 MeV/c: **5σ** ❑ p_{TPC} in 350 ÷ 500 MeV/c: **3σ** ❑ p_{TPC} > 500 MeV/c: **2σ** ❑ (kaons: up to 700 MeV/c)	p_V < 1.5 GeV/c: **3σ** p_V > 1.5 GeV/c: **2σ**
Ξ*	pions: **4σ** protons with p_{TPC} < 700 MeV/c: **5σ** protons with p_{TPC} > 700 MeV/c: **5σ**	UNUSED