Measurements of Bose-Einstein correlations with the ATLAS detector

Ivan Sýkora

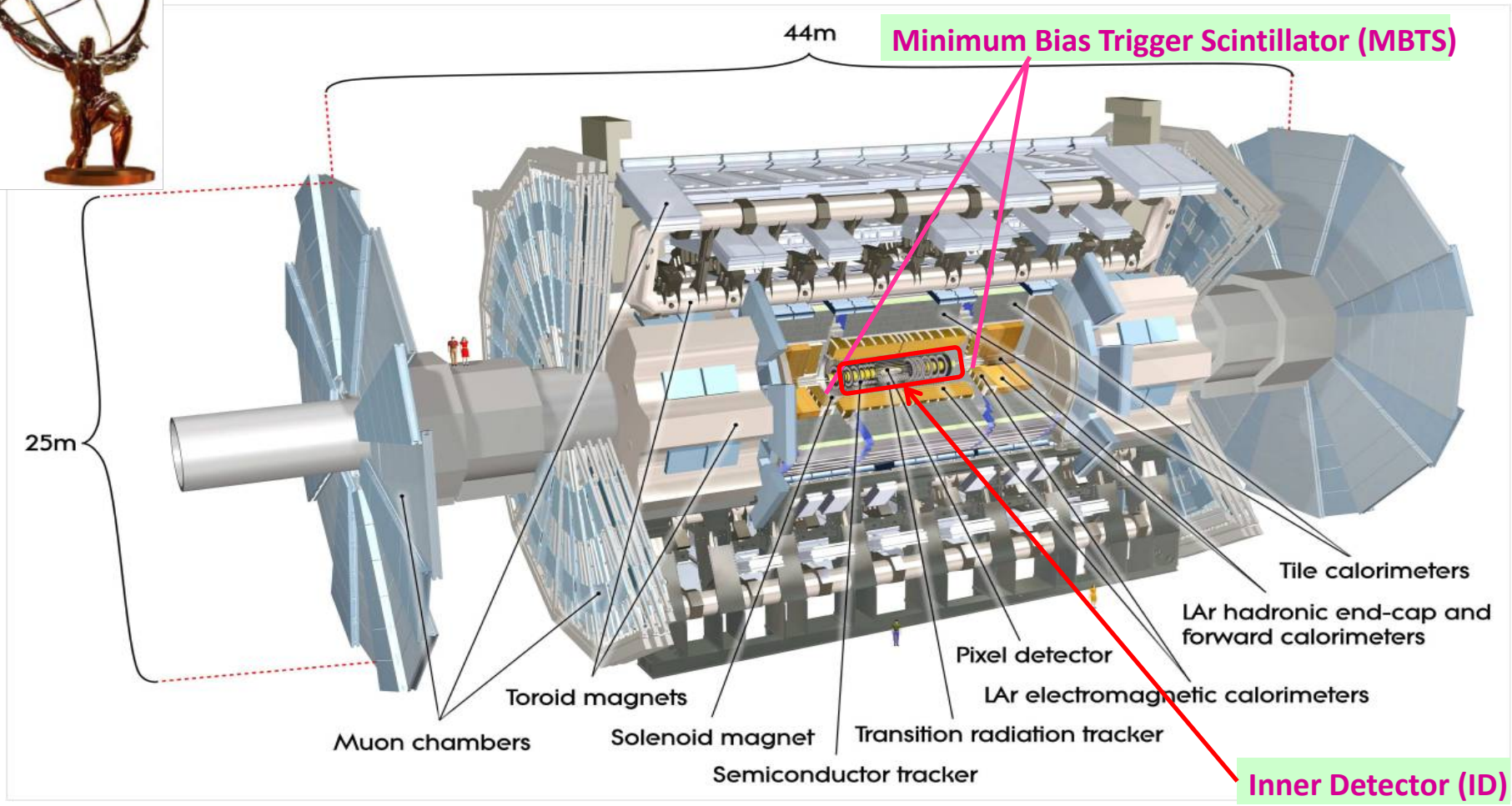
on behalf of the ATLAS collaboration

Outline

- Bose-Einstein correlations
- Two-particle correlation function
- Data and Monte Carlo samples
- Parameterizations of BEC
- Applied corrections
- Results
- Conclusions

ATLAS detector

A Toroidal LHC ApparatuS



Proton–proton collisions at centre-of-mass energies of 0.9 and 7 TeV

Bose-Einstein Correlations

- **First ATLAS BEC results** publication → **arXiv:1502.07947** - **submitted to EPJC** (Feb. 2015)

- Bose-Einstein correlations - correlations between two identical bosons (consequence of the symmetry of identical bosons wave function) - **BEC effect** corresponds to an enhancement in two identical boson **correlation function** when the two particles are near in momentum space.

- **BEC** - sensitive probe of the space-time geometry of the hadronization region - allows the determination of the size and the shape of the source from which particles are emitted.

- Dependence of BEC on particle multiplicity and transverse momentum - helps to understand the multiparticle production mechanism.

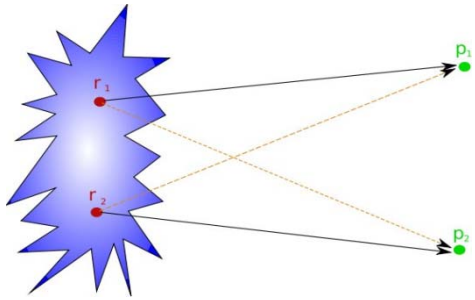
Two particle correlation function

Probability to observe two particles with momenta p_1 and p_2

$$C_2(q) = \frac{P(p_1, p_2)}{P(p_1)P(p_2)}$$

$$q = p_1 - p_2 \quad , \quad p = p_1 + p_2$$

$$Q = \sqrt{|p_1 - p_2|^2}$$



Probability to observe one particle with momenta p_1 or p_2

Density function - parameterized in terms of the Lorentz invariant four-momentum difference squared: $Q^2 = -(p_1-p_2)^2$

normalization constant

$$C_2(Q) = C_0[1 + \Omega(\lambda, QR)](1 + \varepsilon Q)$$

long distance correlation

BEC effect - described by a function with **two** parameters:

- the **effective radius R** and
- the **strength parameter** λ - incoherence or chaoticity factor.

Two particle correlation function

The **$C_2(Q)$ correlation function** is a ratio of
like-sign (LS) particle (track) pairs Q distribution – **signal distributions N(Q)** with BEC
and particle (track) pairs Q distribution - **reference distribution $N_{ref}(Q)$ with** no BEC,

Experimentaly constructed $C_2(Q)$ correlation function

$$C_2(Q) = \frac{N^{ls}(Q)}{N^{ref}(Q)}$$

double ratio correlation function

$$R_2^{DR}(Q) = \frac{C_2^{Data}(Q)}{C_2^{MC}(Q)}$$

Basic reference distributions :

- ✓ **unlike-sign track pairs (UCP) –** pairs of non-identical particle (with opposite charge) taken from the same event,
- ✓ **mixed-event** (like-sign track pairs created from different events),
- ✓ **opposite-hemisphere pairs** (OHP- one of track: $p_x \rightarrow -p_x$, $p_y \rightarrow -p_y$, $p_z \rightarrow -p_z$) with ++-- track combinations),
- ✓ **rotated track technique** (one of track: $p_x \rightarrow -p_x$, $p_y \rightarrow -p_y$) with ++-- track combinations).

Two particle correlation function, parametrizations

GSSg model. The Goldhaber spherical source model of a static Gaussian source in the plane-wave approach.

$$C_2^{(G)} = C_0\left(1+\lambda e^{-R^2Q^2}\right)\cdot\left(1+Q\varepsilon\right)$$

GSSe model. **The exponential parameterization of a static source - assumes a radial Lorentzian distribution of the source**.

$$C_2^{(E)} = C_0\left(1+\lambda e^{-RQ}\right)\cdot\left(1+Q\varepsilon\right)$$

λ is the ***incoherence factor*** *(0, 1)*

QOg model. Quantum Optics model - Gaussian form.

$$C_2^{(GO)} = C_0\left(1+2p\left(1-p\right)e^{-R^2Q^2} + p^2 e^{-2R^2Q^2}\right)\cdot\left(1+Q\varepsilon\right)$$

QOe model. Quantum Optics model - exponential form

$$C_2^{(EO)} = C_0\left(1+2p\left(1-p\right)e^{-RQ} + p^2 e^{-2RQ}\right)\cdot\left(1+Q\varepsilon\right)$$

p is the chaoticity: =0 (=1) for purely **coherent** (**chaotic**) sources.

Data and MC samples

- Study based on the Min Bias data sets and MC samples generated by PYTHIA 6 with ATLAS MC09, DW, Perugia runes, Phojet 1.12.1.35, and EPOS 1.99 .

- Statistics: at 900 GeV: **3.6×10^5 events with 4.5×10^6 tracks** and at 7 TeV: **1×10^7 events with 2.1×10^8** tracks passed selection criteria.

- High Multiplicity (HM) dataset at 7 TeV was studied for the first time in BEC analyses. Statistic for 7 TeV (HM) **1.8×10^4 events (2.7×10^6 tracks)** were selected (integrated luminosity ~ 12.4 nb^{-1}).

- Integrated luminosities: 7 μb^{-1} at 0.9 TeV and 190 μb^{-1} at 7 TeV.

- Track and event selection criteria applied (details in backup s.24)

- Tracking and event efficiencies, unfolding to particle level.

Applied corrections

Coulomb correction

The measured N(Q) distribution for the like or unlike signed particle pairs in presence of the Coulomb interaction is given by:

$$N_{meas}(Q) = G(Q)N(Q)$$

where $N_{meas}(Q)$ is the measured distribution, N(Q) is the distribution free of Coulomb interaction.

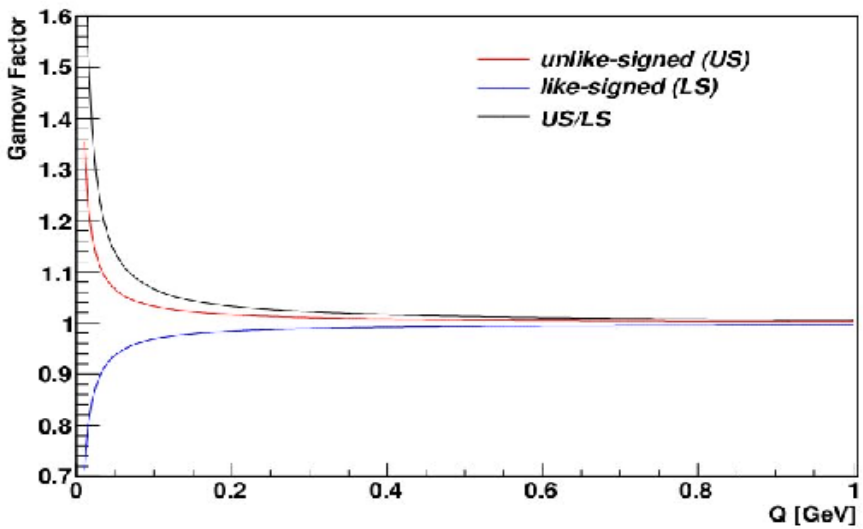
Sommerfeld parameter η

$$\eta = \frac{\pm \alpha m}{|Q|}$$

Gamow penetration G(Q) factor

$$G(Q) = \frac{2\pi\eta}{e^{2\pi\eta} - 1}$$

The size of this correction not to exceed 20% for Q > 0.03 GeV.



Event corrections

- The trigger efficiency – $\varepsilon_{trig}(n)$,
- The vertex reconstruction efficiency – $\varepsilon_{vert}(n)$,

Trigger efficiency $\varepsilon_{tr}(n)$ at 7 TeV:

$\varepsilon_{tr}(1) = 0.968$
$\varepsilon_{tr}(2) = 0.978$
$\varepsilon_{tr}(3) = 0.993$
$\varepsilon_{tr}(>5) = 1.0$

We use the formula:

$$w(n) = \frac{1}{\varepsilon_{trig}(n) \cdot \varepsilon_{vert}(n)}$$

For multiplicities $n \geq 3$ these corrections are close to 1

The multiplicity distributions - corrected to the **particle level** using an iterative method (Bayesian approach).
The **unfolding matrix** is built using the ATLAS MC09 PYTHIA tune.

Fraction of pile-up in the HM events

Fraction of events with pile-up: 1-2%, $\Rightarrow$ charged particle from the pile-up vertex do not contribute much to each primary vertex (negligible).

Track reconstruction corrections

Performed corrections for:

1. The track reconstruction efficiency – $\varepsilon\,(p_t,\eta)$,
2. The fraction of secondary particles – $f_{sec}(p_t,\eta)$,
3. The fraction of selected tracks for which the corresponding primary particles are outside the kinematic range – $f_{okr}(p_t,\eta)$,
4. The fake tracks – $f_{fake}(p_t,\eta)$,

We use the formula:

$$w_i(p_t,\eta) = \frac{\left(1-f_{\sec}(p_t,\eta)\right)\cdot\left(1-f_{okr}(p_t,\eta)\right)\cdot\left(1-f_{fake}(p_t,\eta)\right)}{\varepsilon(p_t,\eta)}$$

We take measured ATLAS $\varepsilon\,(p_t,\eta)$ and $f\,(p_t,\eta)$ distributions.

- The effect of events lost due to the trigger and vertex reconstruction - corrected using event-by-event weights applied to each pair of particles.
- The resolution of Q - obtained to be better than 5 MeV - to exclude track fake reconstruction the Q-threshold 20 MeV was taken.

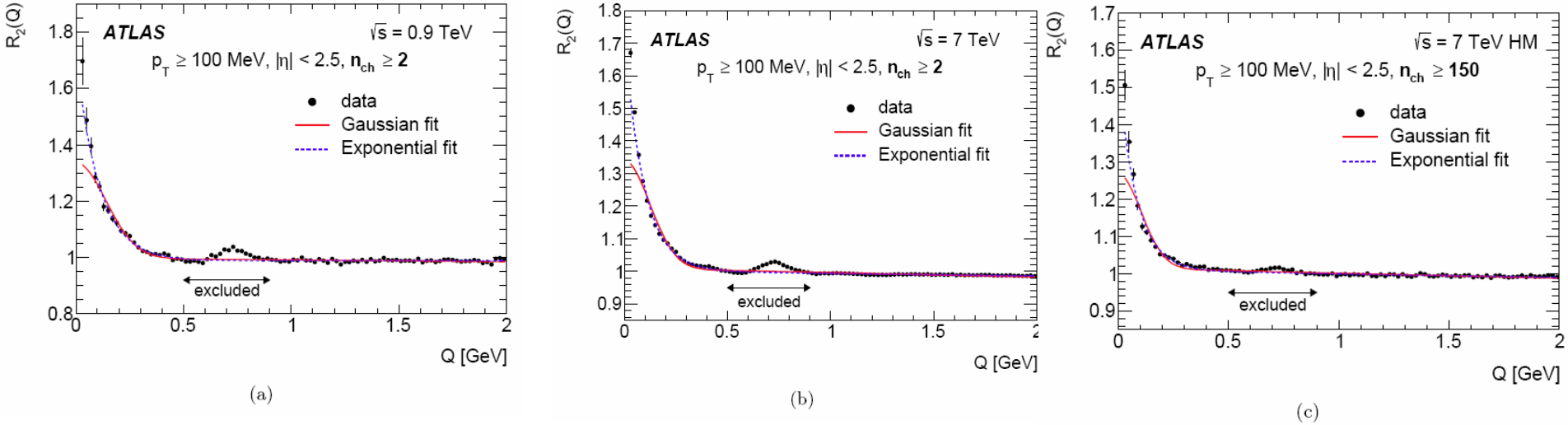
Systematic uncertainties

Systematic uncertainties on λ and R for the **exponential fit** of the two-particle double-ratio correlation function **$R_2(Q)$** in the full kinematic region
at √s =0.9 and 7 TeV for minimum-bias and high-multiplicity (HM) events.

	0.9 TeV		7 TeV		7 TeV (HM)	
Source	λ	R	λ	R	λ	R
Track reconstruction efficiency	0.6%	0.7%	0.3%	0.2%	1.3%	0.3%
Track splitting and merging	negligible		negligible		negligible	
Monte Carlo samples	14.5%	12.9%	7.6%	10.4%	5.1%	8.4%
Coulomb correction	2.6%	0.1%	5.5%	0.1%	3.7%	0.5%
Fitted range of Q	1.0%	1.6%	1.6%	2.2%	5.5%	6.0%
Starting value of Q	0.4%	0.3%	0.9%	0.6%	0.5%	0.3%
Bin size	0.2%	0.2%	0.9%	0.5%	4.1%	3.4%
Exclusion interval	0.2%	0.2%	1%	0.6%	0.7%	1.1%
Total	14.8%	13.0%	9.6%	10.7%	9.4%	10.9%

Results

Correlation function $R_2(Q)$: Gaussian and exponential fits

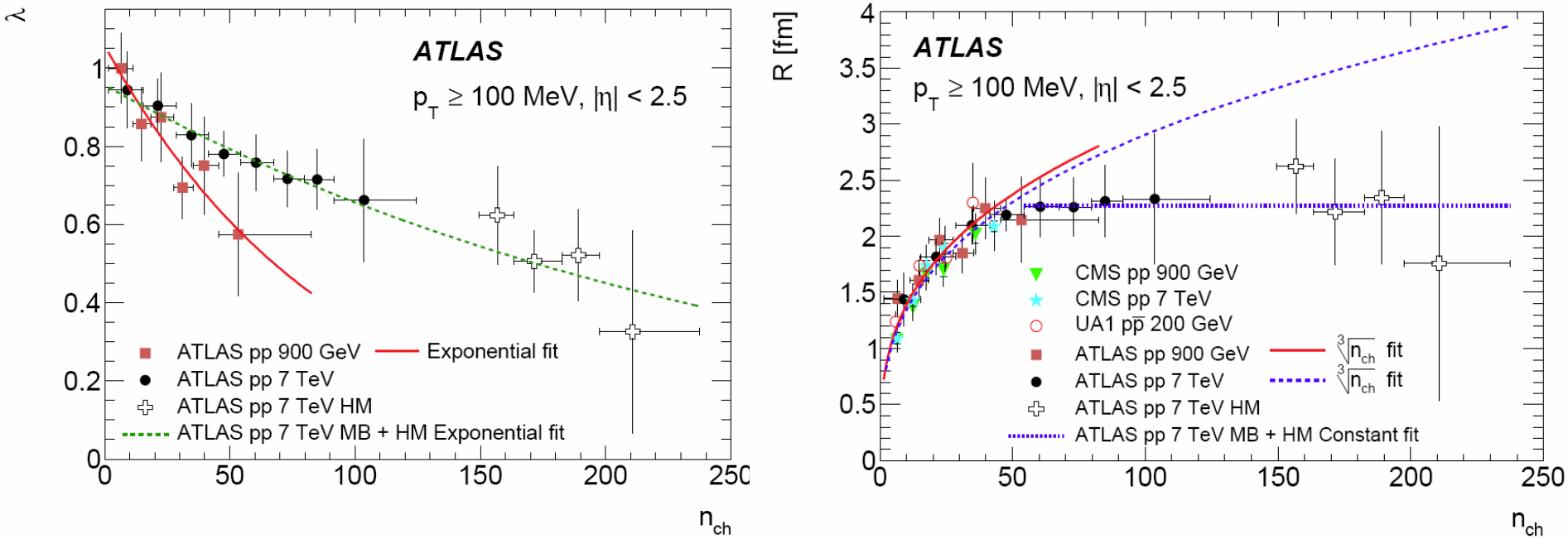


The two-particle double-ratio correlation function $R_2(Q)$ in pp collisions at (a) √s =0.9 TeV, (b) 7 TeV and (c) 7 TeV high-multiplicity events. Region **excluded** from the fits - bump is due to an overestimate of $\rho \rightarrow \pi^+\pi^-$ decays in the Monte Carlo simulation. Only statistical uncertainties shown.

The results of BEC parameters for fits (exponential) of $R_2(Q)$, the unlike-charge particle reference sample used:

$$\lambda = 0.74 \pm 0.11,\ R = 1.83 \pm 0.25 \text{ at } \sqrt{s} = 0.9 \text{ TeV for } n_{\rm ch} \geq 2,$$
$$\lambda = 0.71 \pm 0.07,\ R = 2.06 \pm 0.22 \text{ at } \sqrt{s} = 7 \text{ TeV for } n_{\rm ch} \geq 2,$$
$$\lambda = 0.52 \pm 0.06,\ R = 2.36 \pm 0.30 \text{ at } \sqrt{s} = 7 \text{ TeV for } n_{\rm ch} \geq 150.$$

Parameters λ and R vs particle multiplicity



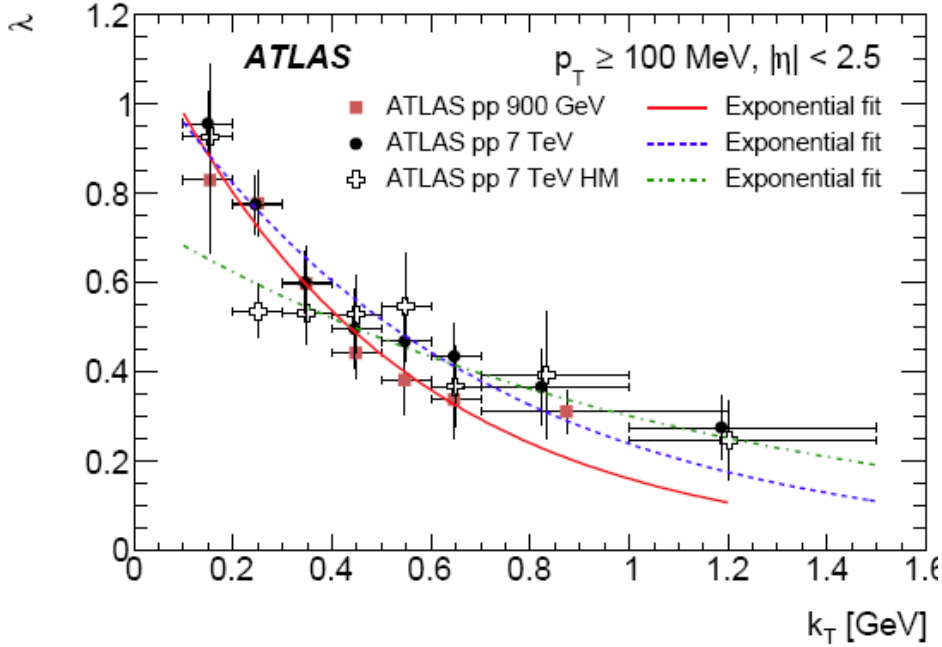
(a) (b)

Multiplicity, n_{ch}, **dependence** of (a) λ and (b) **R** from the exponential fit to $R_2(Q)$ functions at √s = 0.9 and 7 TeV, compared to measurements of the **CMS** and **UA1** experiments.
The curves are the results of (a) **the exponential** and (b) $\sqrt[3]{n_{ch}}$ for $n_{ch} < 55$ fits.

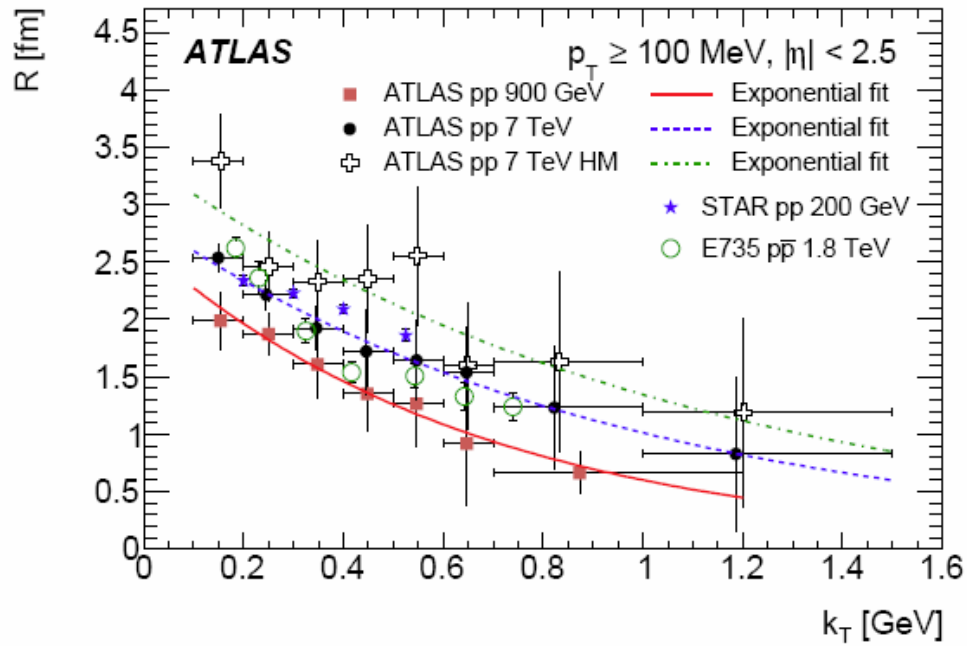
The dotted line in (b) is a result of a **constant fit** to minimum-bias and high-multiplicity events data at 7 TeV for $n_{ch} \geq 55 \Rightarrow$ saturation of R at high multiplicities: $R[fm] = 2.28 \pm 0.32$
- expected in a Pomeron-based model

The error bars - quadratic sum of the statistical and systematic uncertainties.

Parameters λ and R vs track pair k_T



(a)



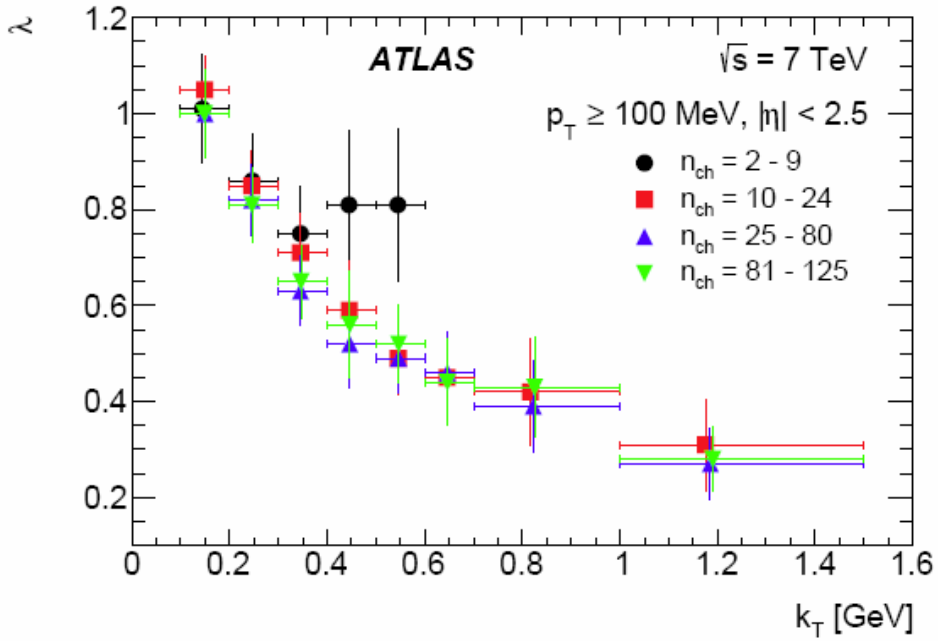
(b)

The k_T dependence of λ (a) and R (b) - from the exponential fit to two-particle double ratio at √s = **0.9 TeV**, **7 TeV** and **7 TeV** high-multiplicity events. The curves - results of the exponential fits.

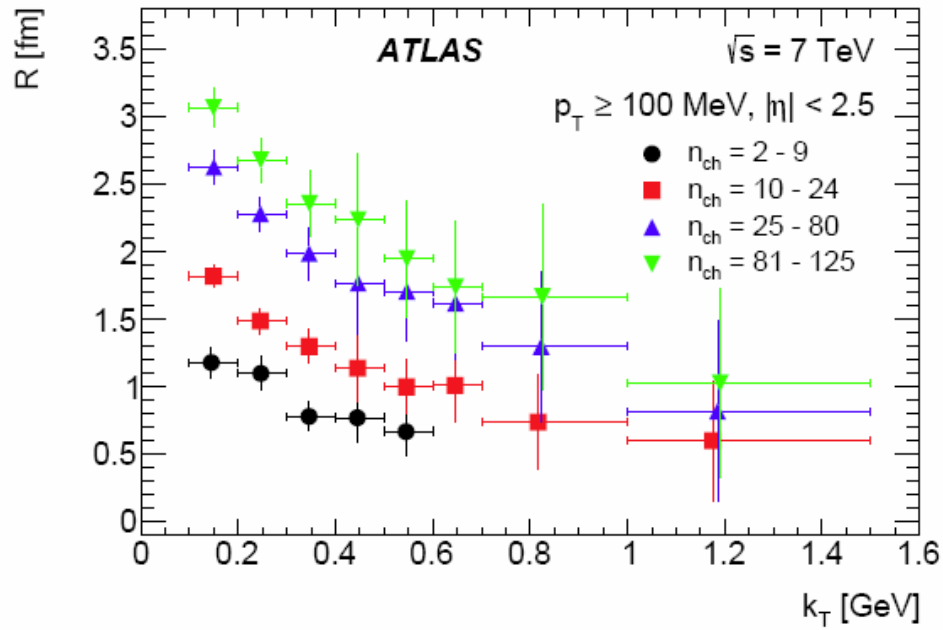
The average transverse momentum k_T of the particle pairs $k_T = |p_{T,1} + p_{T,2}|/2$. Results - compared to measurements by the **E735 experiment** (Tevatron) , and by the **STAR experiment** (RHIC) .

The error bars - the quadratic sum of the statistical and systematic uncertainties.

k_T dependences of λ and R for different multiplicity regions



(a)



(b)

The k_T dependence of λ (a) and **R** (b) - from the exponential fit to $R_2(Q)$ function at √s = 7 TeV for the different multiplicity regions:

$2 \le n_{ch} \le 9$ (circles), **$10 \le n_{ch} \le 24$** (squares), **$25 \le n_{ch} \le 80$** (triangles) and **$81 \le n_{ch} \le 125$** (inverted triangles).

The decrease of λ with k_T is nearly independent of multiplicity for $\mathbf{n_{ch}} > 9$

R-parameter decreases with k_T and exhibits an increase with increasing multiplicity

The error bars - the quadratic sum of the statistical and systematic uncertainties.

Full phase-space results

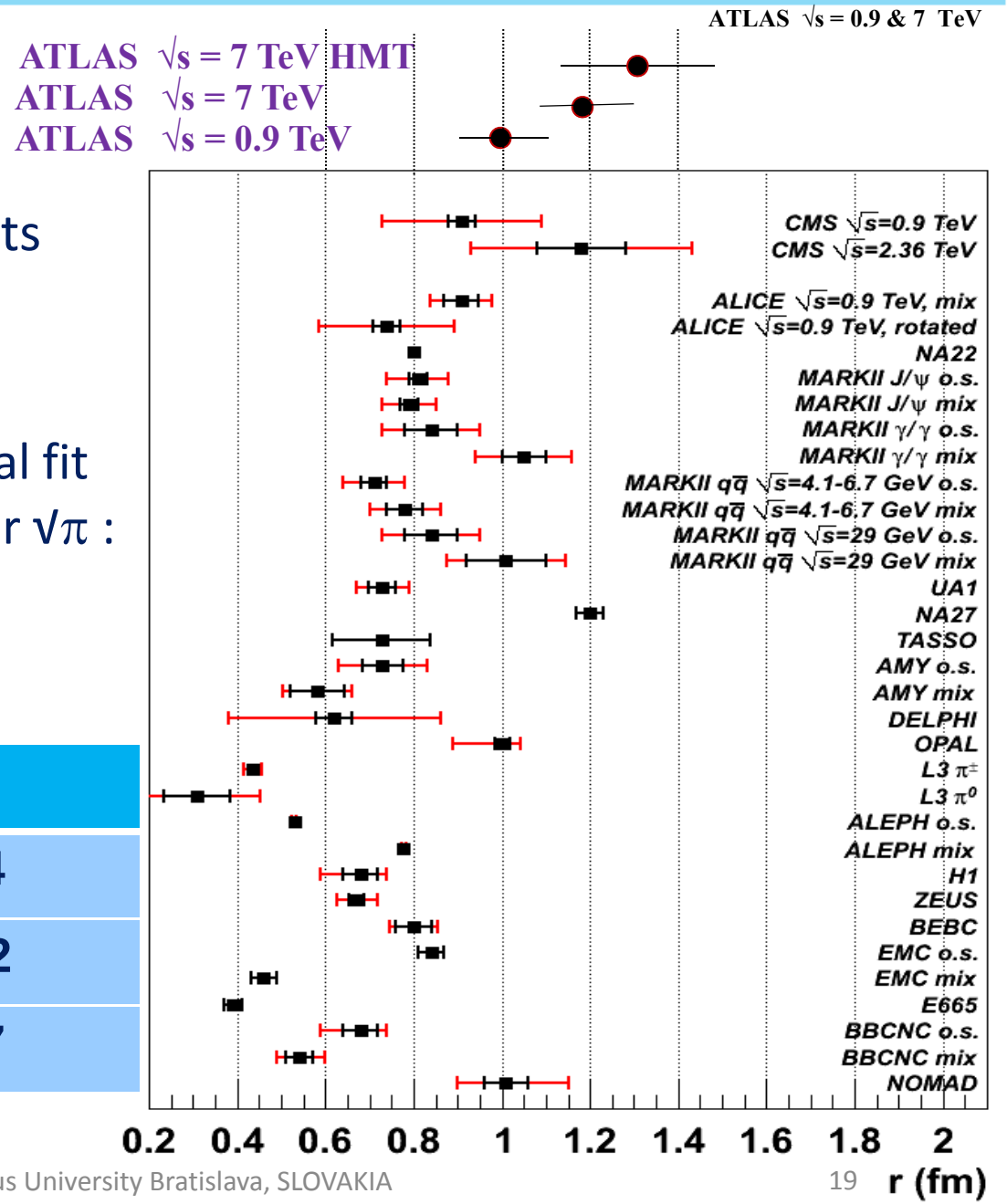
Comparison with previous measurements

Most of the previous experiments provided **R** measurement with a Gaussian fit.

The comparison to the exponential fit can be done using the scale factor $\sqrt{\pi}$:

$$R^{(G)} = R^{(E)} / \sqrt{\pi}$$

Energy [GeV]	R [fm]
0.9	1.03 ± 0.14
7	1.16 ± 0.12
7 (HM)	1.33 ± 0.17



Conclusions

- The Bose-Einstein correlations of the pairs of identical charged particles have been measured in $|\eta|<2.5$ and $p_T>100$ MeV in ***pp*** collisions at 0.9 and 7 TeV with the ATLAS detector at the LHC.
- A clear signal of BEC enhancement was observed in the region of small relative momentum. The studies are carried out using the double ratio correlation function.
- Multiplicity dependence of the BEC was investigated up to very high multiplicities (≈240). A saturation effect in multiplicity dependence of the extracted BEC radius was observed at level $R = 2.28 \pm 0.32\ fm$.
- Dependence of the BEC parameters on track pair k_T and on particle p_T was investigated.

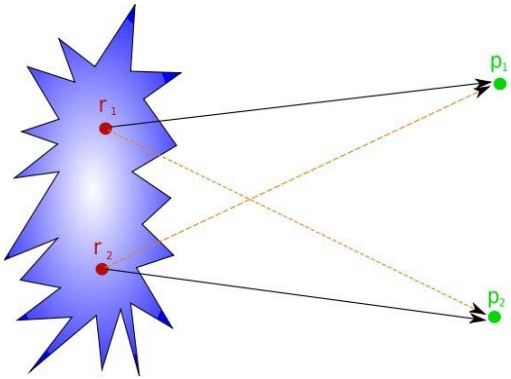
Thank you for attention

Back-up slides

Bose-Einstein Correlations of Particles

- Two plane-waves:

$$\Psi_1 = e^{-ik_1x_1}$$
$$\Psi_2 = e^{-ik_2x_2}$$



- (Identical) bosons need to be symmetrized

$$\Psi_{1,2} = \frac{1}{\sqrt{2}}(e^{-ik_1x_1}e^{-ik_2x_2} + e^{-ik_1x_2}e^{-ik_2x_1})$$

- Spectrum:

$$N_1(k_1) = \int S(x_1,k_1)|\Psi_1|^2 dx_1$$

S(x,k) is the source distribution

- Two-particle spectrum (momentum distribution):

$$N_2(k_1,k_2) = \int S(x_1,k_1)S(x_2,k_2)|\Psi_{1,2}|^2 dx_1 dx_2$$

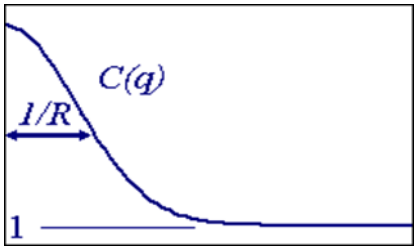
Incoherent sum is taken: integration of $|\Psi|^2$ (and not Ψ) is done!

- The invariant correlation function depends on relative and average moments

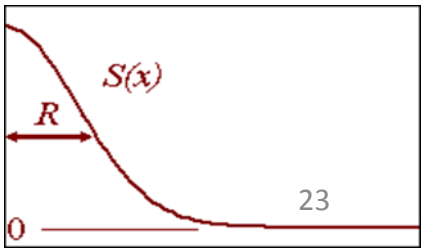
$$C_2(k_1,k_2) = \frac{N_2(k_1,k_2)}{N_1(k_1)N_1(k_2)} \simeq 1 + \left|\frac{\tilde{S}(q,K)}{\tilde{S}(0,K)}\right|^2$$

$$C(q) - 1 \sim \exp\left(-q_x^2R_x^2 - q_y^2R_y^2 - q_z^2R_z^2\right)$$

$$q = k_1 - k_2, K = 0.5(k_1 + k_2)$$



- We can give the information about the size of the emitting source from identical boson correlations



Data Analysis for MB and HM triggers

Tracks characteristics at 0.9, 7 TeV MBT

Trigger:

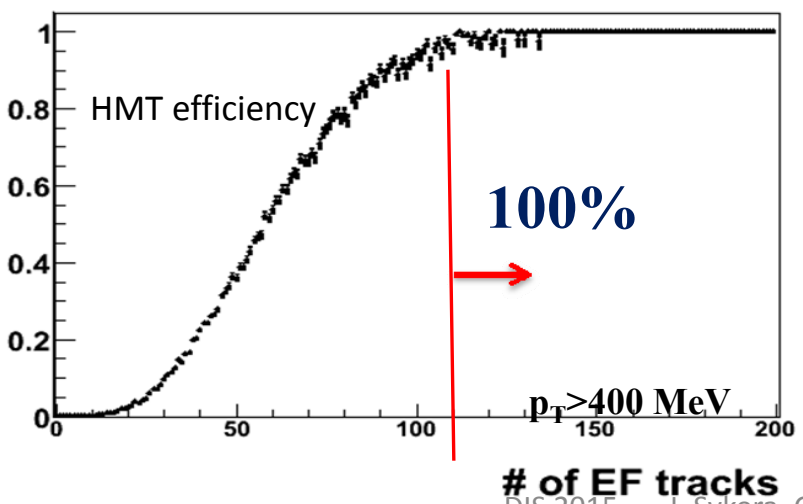
- L1_MBTS_1 | L1_MBTS_2 | L1_MBTS_1_1 trigger
- good run/lumiblocks

Vertex Selection:

- Pile-up Removal cut
- Only one vertex
- ≥ 2 "selected" track (as vertex requires 2 tracks)

Track Selection:

- $p_T \geq 100.$ MeV
- $|\eta| < 2.5$
- $|d_0| < 1.5$ mm
- $|z_0 \sin\theta| < 1.5$ mm
- b-layer hit if one expected
- ≥ 1 pixel hit
- $\geq 2,4,6$ SCT hits for $p_T > 100,200,300$ MeV
- χ^2 prob > 0.01 for $p_T > 10$ GeV (to remove the mis-measured tracks).



Tracks characteristics at 7 TeV HMT

Trigger:

- mbSpTrkVtxMh
- Another Luminosity blocks

Vertex:

- only one good primary vertex (type 1). Removed pile-up cut as defined by the MB 2.0 analysis. Instead if second vertex has higher multiplicity than the primary, skip event.

At least 108 tracks with:

- $|\eta| < 2.5$
- $p_T \geq 100.$ MeV
- Reconstructed by the inside-out or low- p_T tracking algorithms.
- ≥ 1 pixel hit*
- $\geq 2,4,6$ SCT hits for $p_T > 100,200,300$ MeV
- $|d_0| < 1.5$ mm
- $|z_0 \sin\theta| < 1.5$ mm
- fit probability ≥ 0.01 for $p_T > 10$ GeV

*No b-layer requirement. After MB 2.0 definition of expectHitInBLayer changed.
**http://indico.cern.ch/getFile.py/access?contribId=6&resId=0&materialId=slides&confId=106091

High multiplicity trigger efficiency is 100% for multiplicity more than 120 EF tracks

HM trigger conditions:
1. Seeded by L1 TE20 (L1 calo ETsum> 20 GeV)
2. At least 1999 SCT (Semicond. tracker) space-points at L2.
3. At least 125 tracks on a single vertex at EF (p_T>400 MeV)

Systematic uncertainties for track reconstruction efficiency

Table 6 from ATL-PHYS-INT-2011-001. Summary of all tracking efficiency systematic. The tracking efficiency systematic are given in bins of track *p*T and η. **All numbers are in percent and relative to the corresponding tracking efficiencies.** The total uncertainty is the sum in quadrature of the listed components: a) MC material description, b) track selection, and (if given) c) the *p*T turn-on systematic. For tracks with *p*T>10 GeV, an additional uncertainty of 10% due to the χ^2 cut, the systematic uncertainties due to badly-measured tracks, as well as the impact of the degraded core *p*T resolution in data (up to ~7%) have to be considered.

pT bin [MeV]	|η| < 1.3	1.3 < |η| < 1.9	1.9 < |η| < 2.1	2.1 < |η| < 2.3	2.3 < |η| <2.5
100 < pT ≤ 150	8 ⊕ 1 ⊕ 5	8 ⊕ 1 ⊕ 5	10 ⊕ 1 ⊕ 5	10 ⊕ 1 ⊕ 5	15 ⊕ 1 ⊕ 5
200 < pT ≤ 250	3 ⊕ 1	5 ⊕ 1	6 ⊕ 1	7 ⊕ 1	12 ⊕ 1
250 < pT ≤ 300	2 ⊕ 1	4 ⊕ 1	6 ⊕ 1	6 ⊕ 1	11 ⊕ 1
300 < pT ≤ 350	2 ⊕ 1	4 ⊕ 1	5 ⊕ 1	6 ⊕ 1	9 ⊕ 1
350 < pT ≤ 400	2 ⊕ 1	4 ⊕ 1	5 ⊕ 1	5 ⊕ 1	8 ⊕ 1
400 < pT ≤ 450	2 ⊕ 1	3 ⊕ 1	4 ⊕ 1	5 ⊕ 1	8 ⊕ 1
450 < pT ≤ 500	2 ⊕ 1	3 ⊕ 1	4 ⊕ 1	4 ⊕ 1	7 ⊕ 1
500 < pT	2 ⊕ 1	3 ⊕ 1	4 ⊕ 1	4 ⊕ 1	7 ⊕ 1

Multiplicity and momentum intervals

- Bins chosen to have similar pair statistics
- Small bins to be comparable with other LHC and pre-LHC data

Table 3: The multiplicity binning statistics.

0.9 TeV		7 TeV		7 TeV high-multiplicity	
n_{ch}	Fraction of pairs (%)	n_{ch}	Fraction of pairs (%)	n_{ch}	Fraction of pairs (%)
2 – 11	6.4	2 – 15	36.9	138 – 163	2.8
12 – 18	14.1	16 – 28	25.0	164 – 182	26.4
19 – 27	21.2	29 – 41	14.9	183 – 197	28.7
28 – 35	20.7	42 – 54	9.5	198 – 237	37.6
36 – 45	19.9	55 – 67	6.0		
46 – 82	17.4	68 – 79	3.6		
		80 – 91	2.0		
		≥ 92	2.0		

Table 6: The pair transverse momentum binning statistics.

	0.9 TeV	7 TeV	7 TeV high-multiplicity
k_T (MeV)	Fraction of pairs (%)		
100 – 200	2.4	12.6	9.2
200 – 300	13.6	16.5	13.0
300 – 400	19.4	15.5	13.9
400 – 500	18.2	12.6	12.9
500 – 600	14.4	9.6	11.1
600 – 700	10.7	7.2	9.2
700 – 1000		12.1	18.2
700 – 2000	21.4		
1000 – 1500		6.4	12.5

Table 9: The transverse momentum binning statistics.

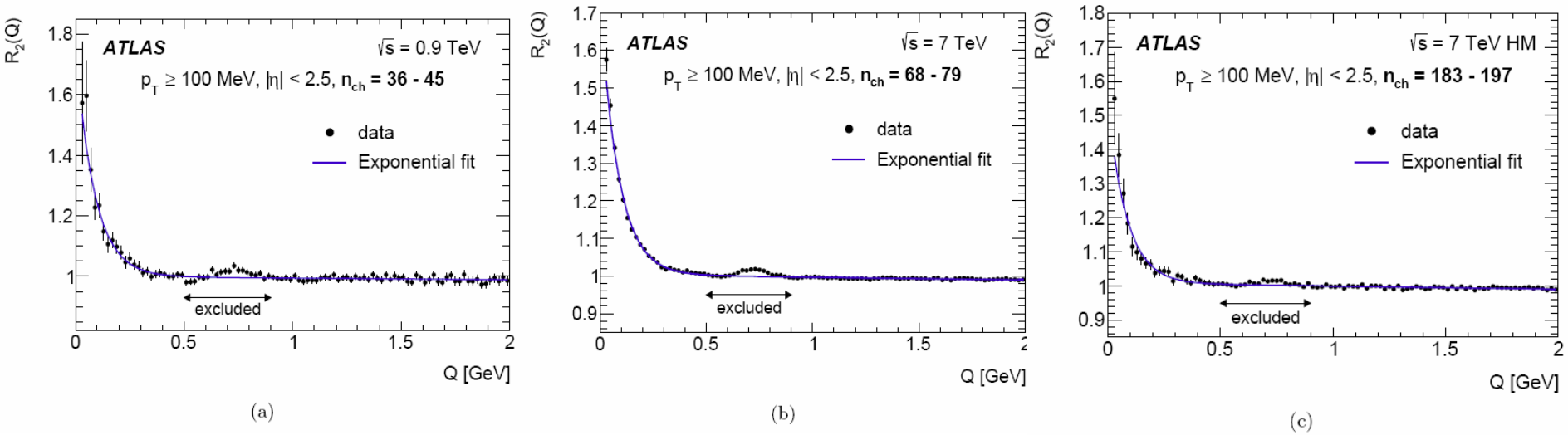
	0.9 TeV	7 TeV	7 TeV high-multiplicity
p_T (MeV)	Fraction of pairs (%)		
100 – 300	30.9	26.3	12.2
300 – 500	32.7	27.4	20.5
500 – 1000	36.4	30.9	47.7
1000 – 2000		5.0	19.6

Size of the BE correlation source for all models

Table 1: The results of fits of the R_2 BEC double-ratio function for 0.9 TeV and 7 TeV events with the unlike-charge reference sample for different parameterisations of Ω. The first (only) error shows the statistical uncertainty and the second error shows the systematic uncertainty.

$\sqrt{s}$ (TeV)	Ω	C_0	λ, p	R (fm)	ϵ (GeV^{-1})	χ^2/ndf
0.9	$\Omega^{(G)}$	0.998±0.002	0.34±0.01±0.03	1.00±0.03±0.08	−0.006±0.002	149/75
	$\Omega^{(GO)}$	0.997±0.002	0.19±0.01±0.02	0.98±0.03±0.07	−0.006±0.002	144/75
	$\Omega^{(E)}$	0.989±0.003	0.74±0.03±0.09	1.83±0.07±0.20	0.000±0.002	86/75
	$\Omega^{(EO)}$	0.987±0.002	0.61±0.06±0.21	1.55±0.03±0.22	0.001±0.002	87/75
7	$\Omega^{(G)}$	1.0034±0.0003	0.327±0.002±0.022	1.130±0.005±0.086	−0.0132±0.0002	4589/75
	$\Omega^{(GO)}$	1.0033±0.0003	0.186±0.002±0.015	1.111±0.005±0.084	−0.0131±0.0002	4368/75
	$\Omega^{(E)}$	0.9961±0.0003	0.718±0.006±0.062	2.067±0.012±0.182	−0.0083±0.0002	923/75
	$\Omega^{(EO)}$	0.9948±0.0003	0.635±0.014±0.108	1.779±0.007±0.148	−0.0074±0.0002	628/75
7 (HM)	$\Omega^{(G)}$	1.017±0.001	0.251±0.010±0.018	1.38±0.04±0.12	−0.015±0.001	397/75
	$\Omega^{(GO)}$	1.017±0.001	0.138±0.006±0.011	1.36±0.04±0.12	−0.015±0.001	387/75
	$\Omega^{(E)}$	1.013±0.001	0.531±0.024±0.046	2.46±0.08±0.22	−0.012±0.001	165/75
	$\Omega^{(EO)}$	1.012±0.001	0.363±0.026±0.056	2.35±0.07±0.22	−0.012±0.001	150/75

$R_2(Q)$ vs Multiplicity dependence

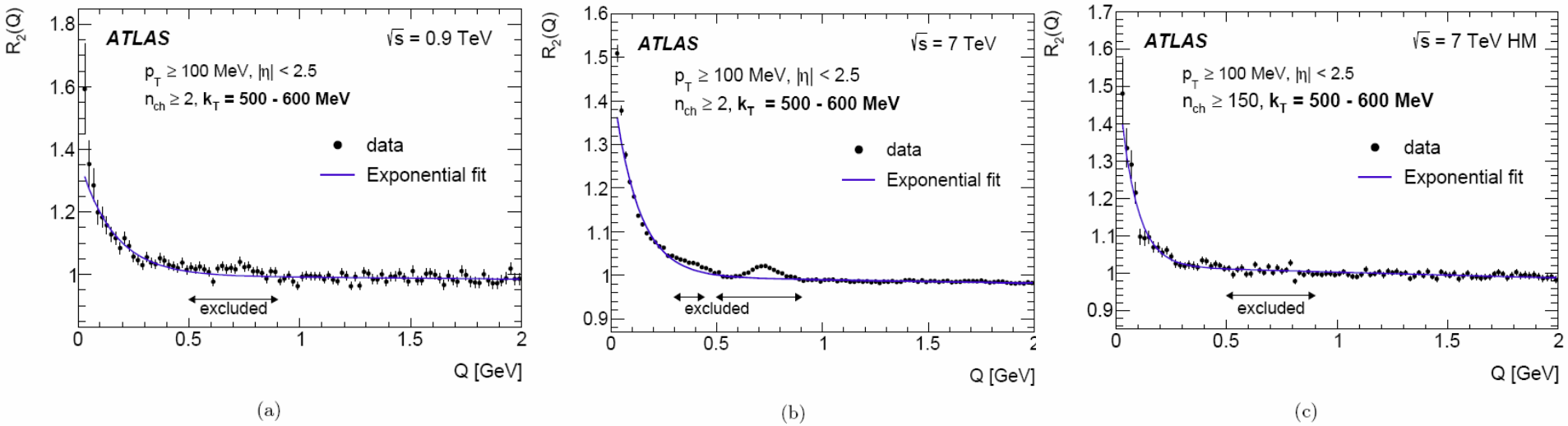


The two-particle double-ratio correlation function $R_2(Q)$ for charged particles in pp collisions for multiplicity intervals:

(a) $36 \leq n_{ch} < 45$ at √s =0.9 TeV, (b) $68 \leq n_{ch} < 79$ at 7 TeV and (c) $183 \leq n_{ch} < 197$ at 7 TeV high-multiplicity events.

The exponential fit used, the region excluded from the fits is indicated.
Only statistical uncertainties shown.

$R_2(Q)$ vs track pair k_T



The two-particle double-ratio correlation function $R_2(Q)$ for charged particles in pp collisions for $500 \leq k_T < 600$ MeV interval
at (a) √s =0.9 TeV, (b) 7 TeV and (c) 7 TeV high-multiplicity events.

The average transverse momentum k_T of the particle pairs is defined as
$k_T = |p_{T,1} + p_{T,2}|/2$.
The lines - exponential fits. The region excluded from the fits is indicated.
The error bars only the statistical uncertainties shown.

Fit summary

BEC param.	Fit function	0.9 TeV	7 TeV Minimum-bias events	7 TeV High-multiplicity events
$R(n_{ch})$	$p_0 \sqrt[3]{n_{ch}}$	$p_0 = 0.64 \pm 0.07$ fm ($n_{ch} \leq 82$)	$p_0 = 0.63 \pm 0.05$ fm ($n_{ch} < 55$)	—
	p_0	—	$p_0 = 2.28 \pm 0.32$ fm ($n_{ch} \geq 55$)	
$\lambda(n_{ch})$	$p_0\, e^{-p_1 n_{ch}}$	$p_0 = 1.06 \pm 0.10$ $p_1 = 0.011 \pm 0.004$	$p_0 = 0.96 \pm 0.07$ $p_1 = 0.0038 \pm 0.0008$	
$R(k_T)$	$p_0\, e^{-p_1 k_T}$	$p_0 = 2.64 \pm 0.33$ fm $p_1 = 1.48 \pm 0.67$ GeV^{-1}	$p_0 = 2.88 \pm 0.27$ fm $p_1 = 1.05 \pm 0.58$ GeV^{-1}	$p_0 = 3.39 \pm 0.54$ fm $p_1 = 0.92 \pm 0.73$ GeV^{-1}
$\lambda(k_T)$	$p_0\, e^{-p_1 k_T}$	$p_0 = 1.20 \pm 0.18$ $p_1 = 2.00 \pm 0.35$ GeV^{-1}	$p_0 = 1.12 \pm 0.10$ $p_1 = 1.54 \pm 0.26$ GeV^{-1}	$p_0 = 0.75 \pm 0.10$ $p_1 = 0.91 \pm 0.45$ GeV^{-1}

Results of fitting the multiplicity, n_{ch}, and the transverse momentum of the pair, k_T, dependence of the BEC parameters R and λ with different functional forms and for different data samples.

Errors - the quadratic sum of the statistical and systematic uncertainties.