Two-Particle Correlation in e⁺e⁻ Collisions at 91-209 GeV with Archived ALEPH Data

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In collaboration with Austin Baty (Rice), Anthony Badea (Harvard), Chris McGinn (CU Boulder), Jesse Thaler (MIT), Gian Michelle Innocenti (CERN), Tzu-An Sheng (MIT)



Motivation



- No significant ridge signal observed yet in e⁺e⁻ (at Z pole and Belle energies) and ep from ZEUS
 - Exciting to go to even higher collision energy data
 - Access to larger event multiplicity and different physics processes

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The ALEPH Detector



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High Multiplicity Event in e⁺e⁻ Collisions in LEP1

Highest multiplicity event in ALEPH LEP1 data Collision Energy = 91 GeV





Anthony Badea Austin Baty



Chris McGinn Michael Peters Jesse Thaler



Paoti Chang Tzu-An Sheng

+ YJL



55 Charged Particles Thrust T=0.71



Beam Axis Analysis





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- Search for ridge signal with beam axis: enhance number of charged particle pairs with large $\Delta \eta$ gap and similar Φ (small $\Delta \Phi = \Phi_1 \Phi_2$)
- Ex: Sensitive to "pressure driven expansion" of the medium in the direction perpendicular to the beam axis

Yen-Jie Lee (MIT)



Thrust Axis Analysis



Thrust axis analysis to follow the "direction of color string"

Yen-Jie Lee (MIT)

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Thrust Axis Analysis



Pseudorapidity (η) and azimuthal angle (Φ) are calculated with respect to the Thrust Axis



Thrust Axis Analysis



Thrust axis analysis to follow the "direction of color string" Pseudorapidity (η) and azimuthal angle (Φ) are calculated with respect to the **Thrust Axis**

See also:

LEP1 Results at 91 GeV



Paoti Chang Tzu-An Sheng Chris McGinn Michael Peters Jesse Thaler Gian Michele Innocenti Anthony Badea Austin Baty

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Charged Particle Multiplicity Distributions in LEP2 Data



Two-Particle Correlation Function: 1D Projection





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Hadronic e⁺e⁻ Events at LEP 2 (no multiplicity cut)







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Hadronic e⁺e⁻ Events at LEP 2 (10<=N_{trk}<20)





Hadronic e⁺e⁻ Events at LEP 2 (20<=N_{trk}<30)





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Hadronic e⁺e⁻ Events at LEP 2 (30<=N_{trk}<40)





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Hadronic e⁺e⁻ Events at LEP 2 (40<=N_{trk}<50)







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Hadronic e⁺e⁻ Events at LEP 2 (N_{trk}>=50)





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Fourier Coefficients (v_n)





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Extracted v_n vs. Charged Particle p_T

Low multiplicity 10<=N_{track}<20

High multiplicity N_{track}>=50



Good agreement between data and MC

Larger v_2 and v_3 magnitudes than MC



Difference between Data and Archived MC



- Difference between data and MC v_2 is studied differentially in p_T bins*
- Data v_2 is systematically higher than MC simulation between $0 < p_T < 3 \text{ GeV}$
- Significance of this signal is under investigation

* p_T calculated with respect to thrust axis



Δv_2 in e⁺e⁻ vs. v_2^{sub} in pp



• Similar trend between e⁺e⁻ data and pp data



Summary

LEP2, √s = 183-209 GeV Archived ALEPH data • The first measurement of two-particle correlation function ≳ 0.5 Preliminary CMS pp 13 TeV, v^{sub}₂{2} and elliptic flow in high energy e⁺e⁻ collisions up to 209 GeV $N_{track} \ge 50$ CMS pp 7 TeV, v_sub{2} 0.4⊢ Thrust axis CMS pp 5 TeV, v^{sub}₂{2} 0.3 • No significant ridge like signal is observed in e⁺e⁻ collisions at 91 GeV 0.2 Preliminary LEP2 result with Thrust axis: Difference between data and archived MC is seen in events with more than 50 charged particles Data - Archived MC -0. MOD • A long-range near-side correlation signal shows up at p_(GeV) high multiplicity ALEPH e⁺e⁻, √s=183-209 GeV $N_{trk} \ge 50$ Thrust Axis • The extracted elliptic flow (v_2) is systematically higher than $\frac{1}{N_{trk}^{corr}} \frac{d^2 N^{pair}}{d\Delta \eta d\Delta \phi}$ Monte Carlo simulated e^+e^- collisions in the investigated p_T range ($p_T = 0$ to 3 GeV) Significance of this signal is under investigation

0.5



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Backup Slides





Hadronic Event Selection

- Track Selection:
 - Particle Flow Candidate 0, 1, 2
 - Number of TPC hits for a charged tracks >= 4
 - |d0| < 2 cm
 - |z0|< 10 cm
 - |cosθ|<0.94
 - $p_T > 0.2 \text{ GeV}$ (transverse momentum with respect to beam axis)
 - N_{TPC} >=4
 - $x^2/ndf < 1000$.
- Neutral Hadron Selection:
 - Particle Flow Candidate 4, 5 (ECAL / HCAL object)
 - E> 0.4 GeV
 - |cosθ|<0.98
- Event Selection:
 - Number of good charged particles >= 5 (including charged hadrons and leptons)
 - Number of good ch+neu. Particles >= 13
 - E_{charged} > 15 GeV
 - $|\cos(\theta_{\text{sphericity}})| < 0.82$



Comparison to pp data





Difference between Data and MC

