BEC of π^0 Pairs from Hadronic Z^0 Decays

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Plan

- Introduction/Motivations
- Events Selection
- Analysis Method and Results
- Compare to Existing Results; Compilation!
- Conclusion

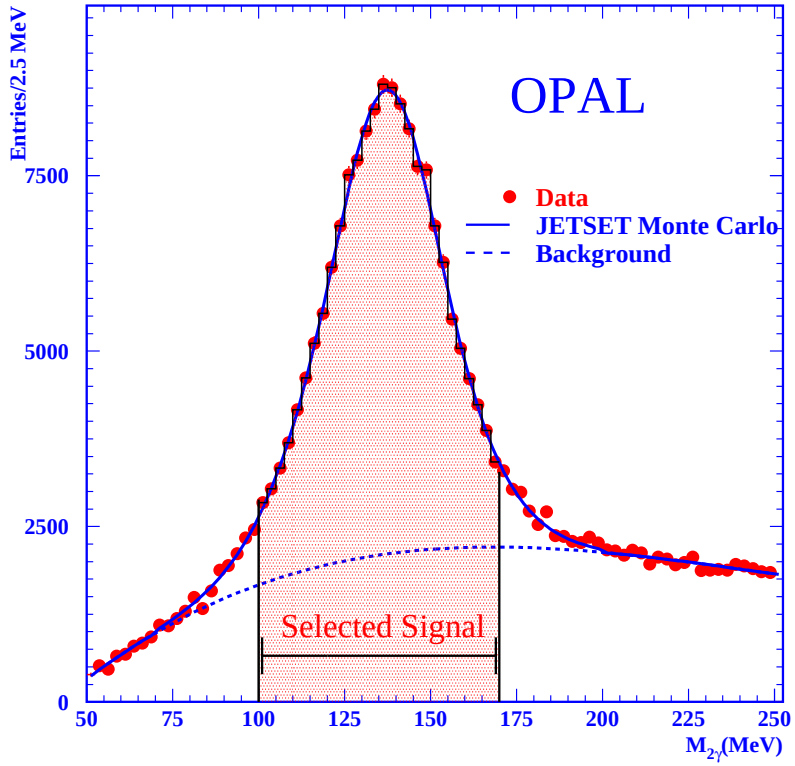
Introduction

- **BEC and FDC $\leftarrow QM$ effect!**
  Which level it occurs in Z decays?;
- **BEC in π^0 not studied (only L3),**
  γ and $\pi^0 s$ difficult to reconstruct within jets;
- **Would allow Tests of Fragmentation Models:**
  String and Cluster Models;
- **... also Isospin link between $\pi^0\pi^0$ and $\pi^{\pm}\pi^{\pm}$;**
- **Get a better idea for a better MC implementation !**

Event Selection

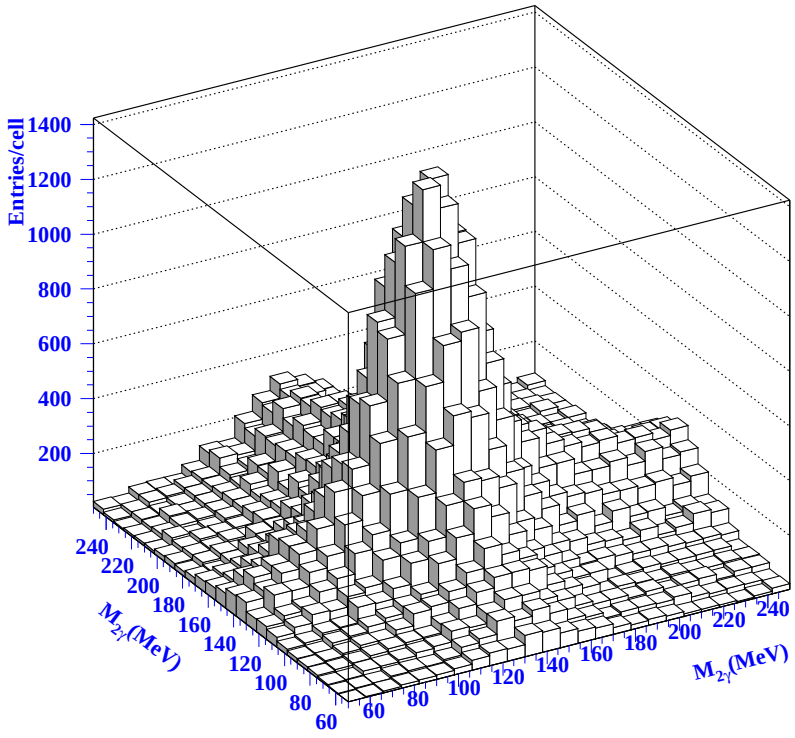
- **Select $\mathbf{Z^0} \rightarrow$ hadron events (bkgnd < 1 %);**
  - $\mathbf{E}_{vis} > 50\%\sqrt{s};\ N_{ch} > 7;\ P_{trk} > 150\ MeV/c$
  - $\theta_{trk} < 0.98;\ \theta_{Thrust} < 0.82\ (barrel)$
  - $\mathbf{E}_{cluster,em} > 250\ MeV\ for\ \gamma$
- **Reconstruct $\pi^0 \rightarrow \gamma\gamma$; At-least 1 π^0 pair.**
- **Select only $\mathbf{P}^0_\pi s > 1$ GeV (see later why?)**
- **Select 2-jet back-to-back events (MIXING)**
- **Background and Efficiencies with MC (no BEC): JESTSET (8M) and HERWIG (4M).**

Pion and Pion-pair Signals



$\simeq$ 80% Purity

OPAL

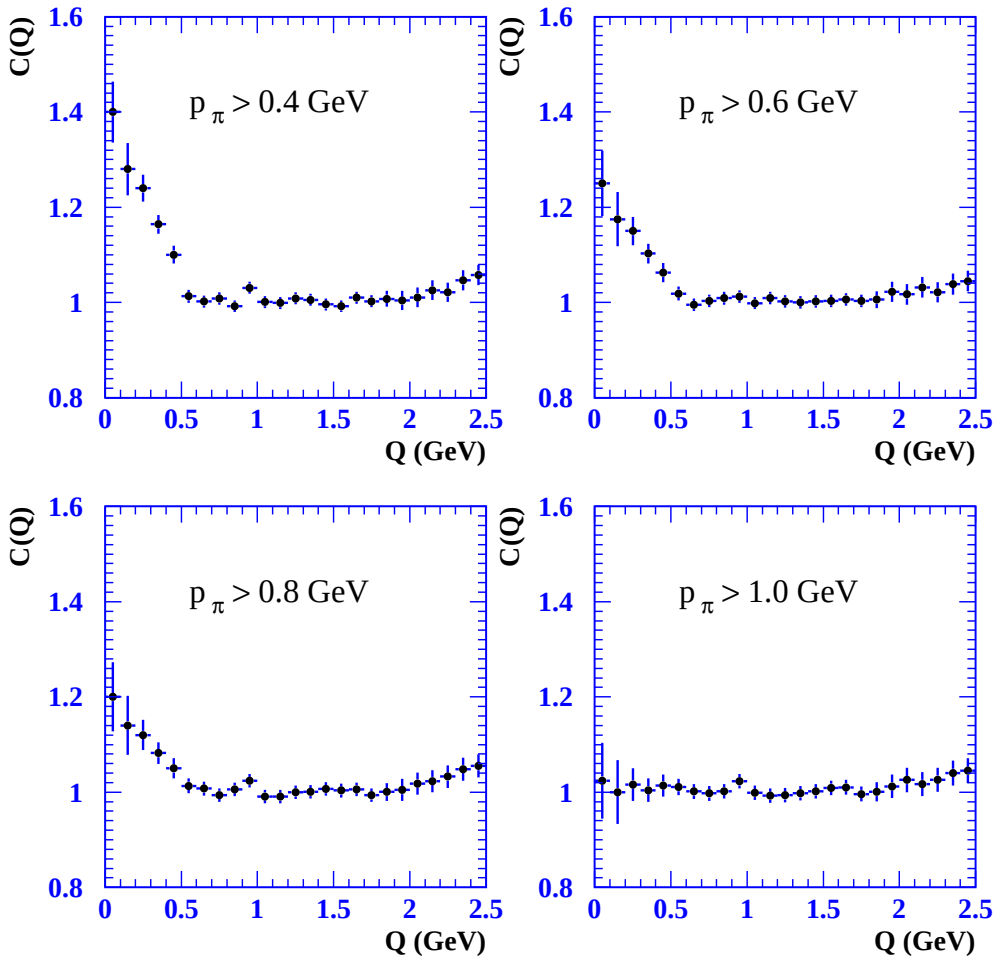


$\longrightarrow \simeq$ 60% Purity

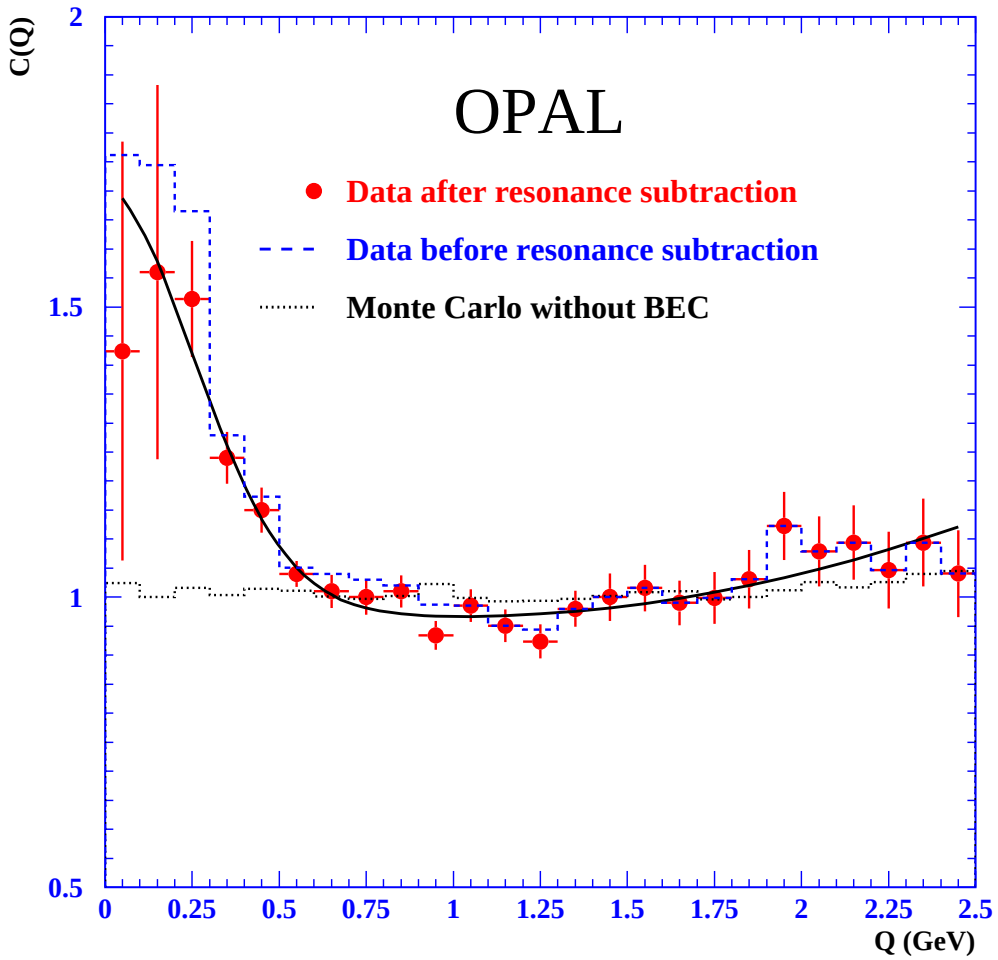
Analysis Method

- **Construct** $C(Q) = \frac{\rho(p_1,p_2)}{\rho(p_1)\rho(p_2)}$; $LI : Q = -(p_1 - p_2)^2$
  - **Reference** $\rho(p_1)\rho(p_2)$ **use data: Mixing**
  - **Estimate and subtract bkgnds:**
    Combinatorial + Resonances
- **Fit distribution with:**
  $C(Q) = N(1 + \lambda \exp(-R^2Q^2))(1 + \delta Q + \epsilon Q^2)$
- **Full study of systematics;**
- **Obtain** R **and** λ **with corresponding errors.**

Why Cut Momentum at 1 GeV



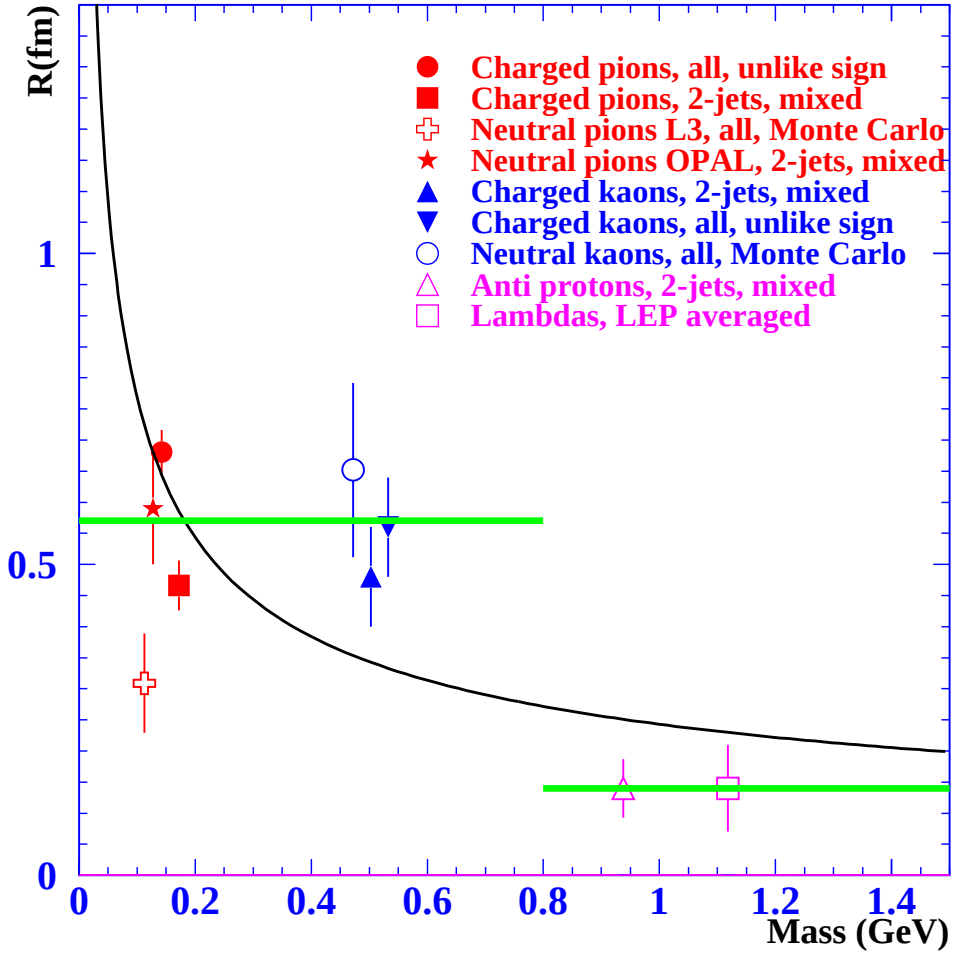
RESULTS


OPAL
Data after resonance subtraction
Data before resonance subtraction
Monte Carlo without BEC
C(Q)
Q (GeV)
2
1.5
1
0.5
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5

Results

- **Neutral Pions Pairs:**
  $R = (0.59 \pm 0.08 \pm 0.05)\text{fm},\ \lambda = 0.55 \pm 0.10 \pm 0.10$
  - **Phase space restricted to $P_{\pi^0} > 1$ GeV**
  - **Reference sample from event mixing; only 2-jet events**
- **Former OPAL results for Charged Pions:**
  $R = (1.002 \pm 0.016^{+0.023}_{-0.096})\ \text{fm}$
  - **Larger phase space: $P_{\pi^0} > 0.1$ GeV**
  - **Reference sample from unlike-sign; all events**
- **LEP (inclusive) on Charged pion Pairs:**
  $R = (0.74 \pm 0.01 \pm 0.14)\ \text{fm}$

Results Compilation at the Z



Test of Fragmentation Models

The reconstructed $\pi^0\pi^0$ pairs can be:

- **1 (string, string) or (cluster, cluster)**
- **2 (string, x) or (cluster, x)**
- **3 (resonance, resonance) subtracted**
- **4 (resonance 1, resonance 2) i.e. from different strong decays**

We find from MC (JETSET and HERWIG) that our sample is mostly (99%) of type 4.

We conclude:

- **No sensitivity to test fragmentation models;**

Conclusion

We observe BEC in $\pi^0\pi^0$ from Z^0 decays:

- **Restricted phase space ($P_{\pi^0} > 1$ GeV)**
- **Back-to-back 2-jet events; reference sample from event mixing.**

For the first time we conclude that:

the correlations are between $\pi^0 s$ from different strong decays.

This is not implemented (yet) in any of the MC models.

Aware that present implementation is bad for:

- **Dependence of Source radius R versus Hadron Mass**
- **Independence of R from $\sqrt{s}$**
- **R increases with final state multiplicity**