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JDC data errors.

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Abstract : 95 % of all $p\overline{p}$ annihilation contain 2,4 and 6 "prongs". They represent at least 50 % of the "terra incognita" which remains to be discovered. To explore this field, we need to use JDC data, i.e. , the 3 momenta (p, φ, λ) of the charged particles produced in the annihilations (and, possibly, their dE/dx).

In this note we propose a method to estimate possible systematic errors on the evaluation of (p, φ, λ).

1 Introduction

We start from the principle that, given a sample of events of well defined nature, i.e.

$$p\overline{p} \rightarrow \pi^+\pi^- \quad (1)$$

a kinematic fit of these events, constraining the variables to fulfil energy-momentum conservation , will yield fitted values closer to the "truth" and will tend, in the limit of a pure sample (no background), and statistically correctely measured variables (with their errors) to yield exactly the "correct physical values" :

$$V_m \rightarrow V_v$$

V_m : measured value of the variable V. V_v : correct physical value of this variable.

Of course, this principle is only applicable when:
1) the measured values are not too different from the truth.
2) the measurement errors (and correlation matrix) are gaussian and correctly estimated.
3) the sample is pure (i.e. all events submitted to the kinematic fit are example of the kinematic hypothesis applied to them).

In practice, we find that condition 1 is fulfilled for JDC data (at least for "long tracks"); condition 2 is in general satisfied with the present errors, within 20% to 30% (no need for scaling !). condition 3 is more delicate to satisfy. For reaction (1), for instance, background as

$$p\overline{p} \rightarrow \pi^+\pi^-\gamma, p\overline{p} \rightarrow K^+K^-, p\overline{p} \rightarrow \pi^+\pi^-\pi^0...$$

will shift down the momenta so that $(P_m - P_v)$ for these events will be shifted downwards.

The same remark is valid for

$$p\overline{p} \rightarrow 2\pi^+2\pi^- \quad (2)$$

(with a contamination due mainly to $2\pi^+2\pi^-\pi^0$).

In practice, we introduce severe selection criteria before and after kinematic fit: For reaction (1),(2) and (3):

$$p\overline{p} \rightarrow \pi^+\pi^-\pi^0 \quad ,\pi^0 \rightarrow 2\gamma \quad (3)$$

we enter into kinematic fit only events which satisfy:

$$P_{tot} < 100MeV/c$$

$$1780MeV < E_{tot} < 1980MeV$$

(for annihilation at rest).

After kinematic fit , we keep only events which fit hypothesis (1),(2) or (3) with $CL > 20\%$.

A quantitative estimation of possible biases, distortions, systematic errors is now possible by inspection of the pull distributions:

$$P(V) = \frac{V_m - V_v}{\sqrt{\sigma_m^2 - \sigma_v^2}}$$

If there are no distortions, the pulls should be centered on zero, and if , in addition , the errors on the measurements are correctly estimated, $P(V)$ should be a normal gaussian distribution (RMS=1.). We are now primarily interested in the shift from zero, for the central value of the pulls. For some run periods,(see below), this shift was found to be very significant for $\frac{1}{P_{xy}}$, indicating that a spurious curvature may have to be added (or substracted) to the true curvature , so that

$$\frac{1}{P_m} = \frac{1}{P_v} \pm \frac{1}{D} \quad (4)$$

Note that this systematic distorsion will affect the measured variable $\frac{1}{P_{xy}}$ in a momentum dependent way. Indeed, the shift observed for the pulls increases with P_m as was shown for reaction (2) and (3). [D is a "first order correction" which we can introduce to eliminate a possible systematic error on P . In cloud chamber and bubble chamber experiments, it was known as the "Maximum Detectable Momentum" and it was introduce, in general, not to correct for systematic distorsion , but to give a lower limit to the momentum measurement error :

$$\Delta P_D = \frac{\pm P_m^2}{D} \quad (5)$$

How to override the fudge factors (for jun91) and how to introduce D .

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SUBROUTINE USER

   IF(ICH.GT.0) Q(JTTKS+41)=Q(JTTKS+41)/FUDGE(1)
IF(ICH.LT.0) Q(JTTKS+41)=Q(JTTKS+41)/FUDGE(2)
Q(JTTKS+41)=Q(JTTKS+41)+1./D
Q(JTTKS+46)=Q(JTTKS+46)/(FUDGE(5)*FUDGE(5))
Q(JTTKS+47)=Q(JTTKS+47)/(FUDGE(5)*FUDGE(3))
Q(JTTKS+48)=Q(JTTKS+48)/(FUDGE(3)*FUDGE(3))
Q(JTTKS+49)=Q(JTTKS+49)/(FUDGE(5)*FUDGE(4))
Q(JTTKS+50)=Q(JTTKS+50)/(FUDGE(3)*FUDGE(4))
Q(JTTKS+51)=Q(JTTKS+51)/(FUDGE(4)*FUDGE(4))
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2 Results

See the Table for the statistics which have been used. For the June 91 data, we find that it is necessary and sufficient to introduce an MDM of D= 20 GeV(± 5 GeV) to shift the pulls in $1/P_{xy}$ from 0.54 (positive tracks) and 0.39(negative tracks) to 0.03(positive) and 0.02(negative) for the sample of 2 prong 2 γ. The same MDM D = 20 (± 3) GeV is needed for the 4 prong 0 γ sample to obtain a similar effect.Note that the sigma of the pulls, σ 0.8 is what we expect for a sample defined by a CL cut at 20 % :

Repeating the same procedure with various CL cut, we find that samples of $\pi^+\pi^-\pi^0$ and $2\pi^+2\pi^-$, with CL cut extrapolated to 0, and with D=20 GeV, yield pulls distributions centered to 0 ($\pm 5\%$) and with $\sigma = 1.0(\pm 0.10)$ (see Fig.1-4).

Note also that the number of good events fitting $\pi^+\pi^-\pi^0$ and $2\pi^+2\pi^-$ increases significantly once D=20 GeV has been introduced.

The same procedure applied to the June 94 sample shows that the corresponding MDM is much larger (-120 GeV), i.e. no significant distortion is detected in these data.

According to Christoph Strassburger, the Bonn team, applying the same procedure to deuterium data (1 prong: $\pi^-\pi^0\pi^0$) and (3-prong: $\pi^+\pi^-\pi^-$) found similar results for October 91 data (MDM of 18 GeV is needed), whereas for June 94, no MDM is necessary.

Comparing the errors obtained by Locater to ΔP_D of eq.(5): we see that the distorsion observed with the "old" JDC does not introduce a significant additional error, which therefore do not need to be modified (and do not need "scaling" factors).

	June 91		June 94
	4 prng 0 γ	2 prng 2 γ	2 prng 2 γ
N ev.	31 150	9604	3224
N ev. fitted D is $\propto$ CL 20%	11 400	2008	
N ev. fitted D=20 GeV, CL 20%	15357	4998	
N ev. fitted D=-120 GeV, CL 20%			2022

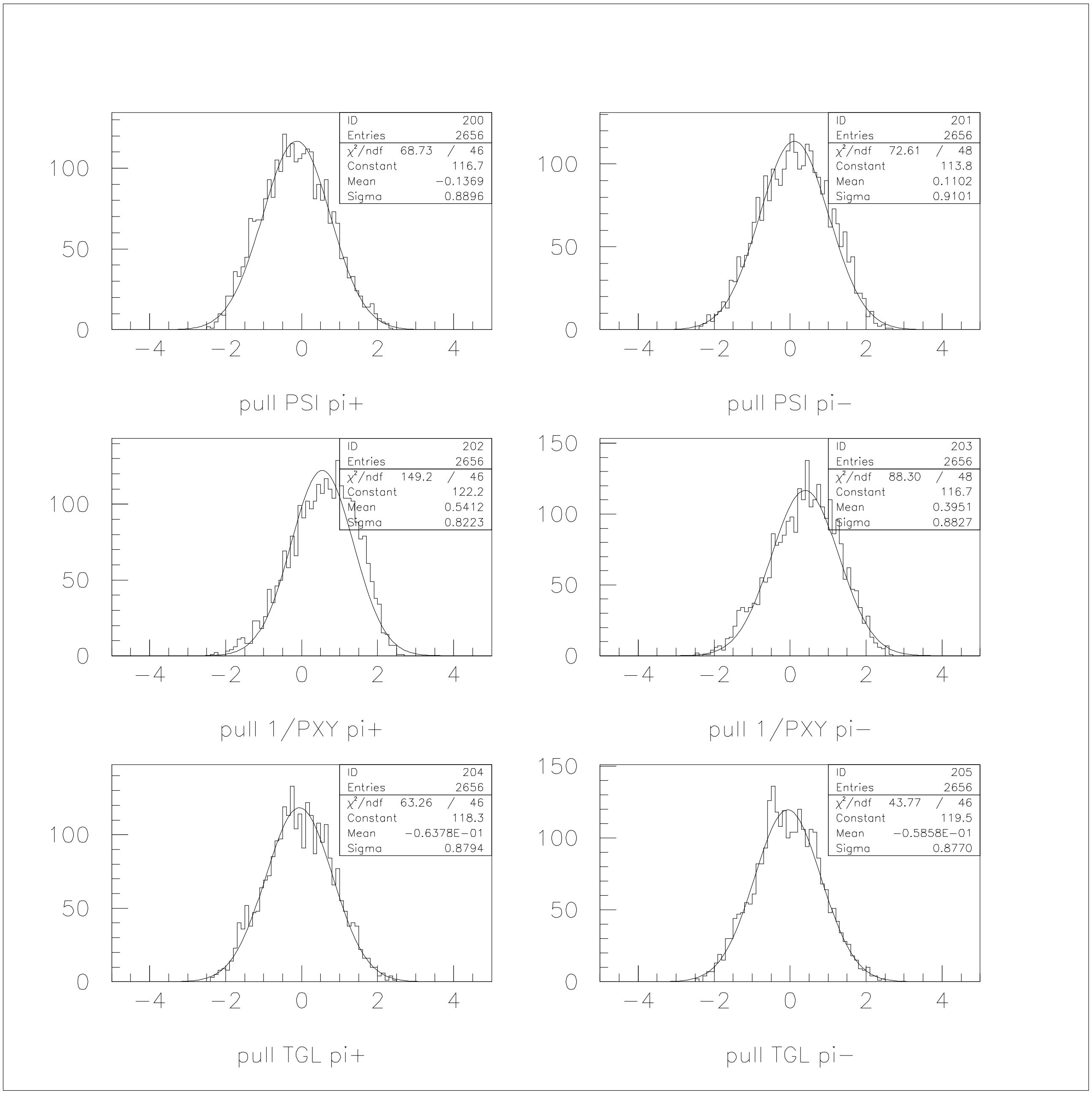

Figure 1: $pulls\ for\ pi + pi - pi0\ \ beforecorrection.$

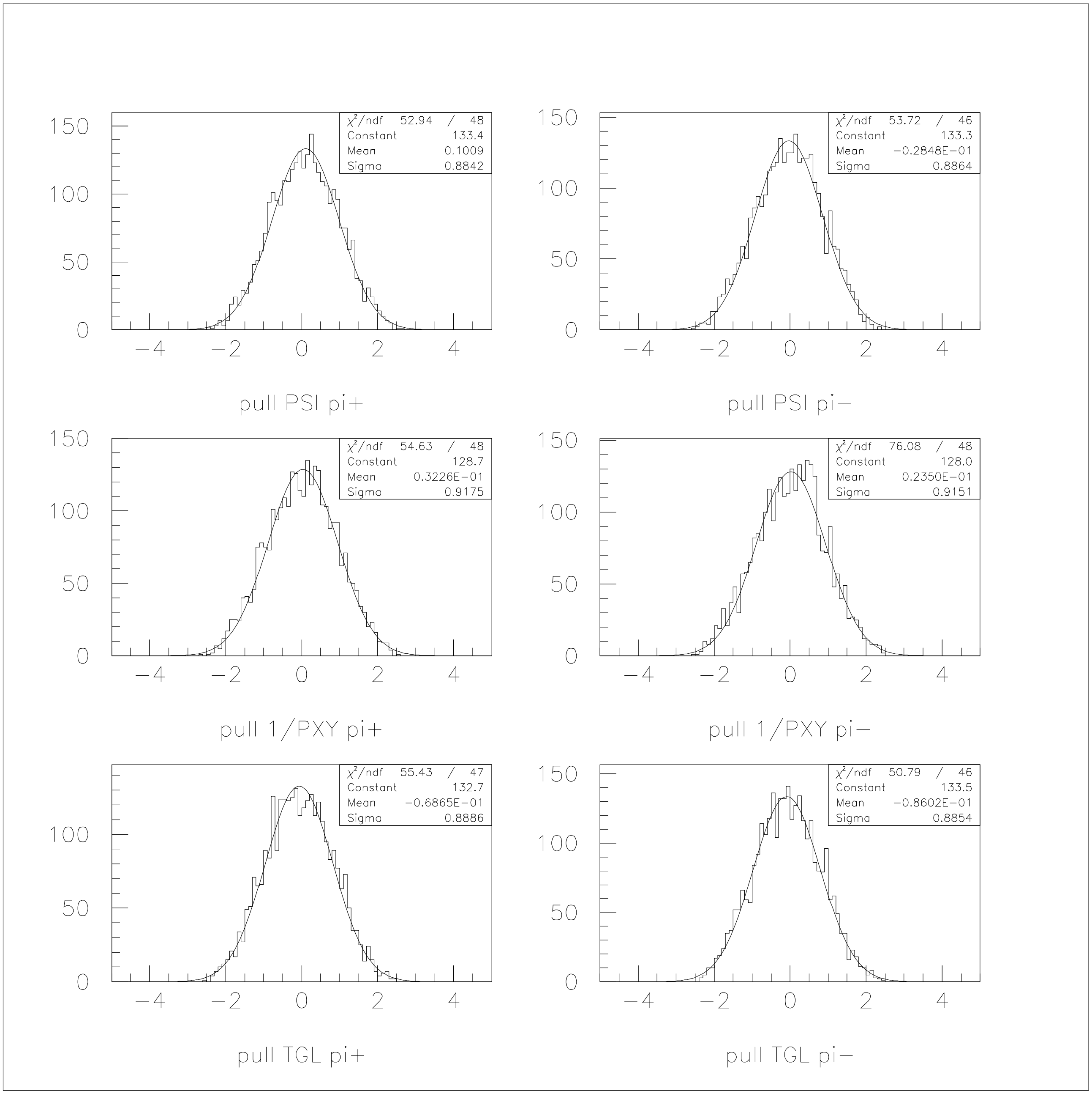

Figure 2: $pulls\ for\ pi+pi-pi0\ \ aftercorrection.$

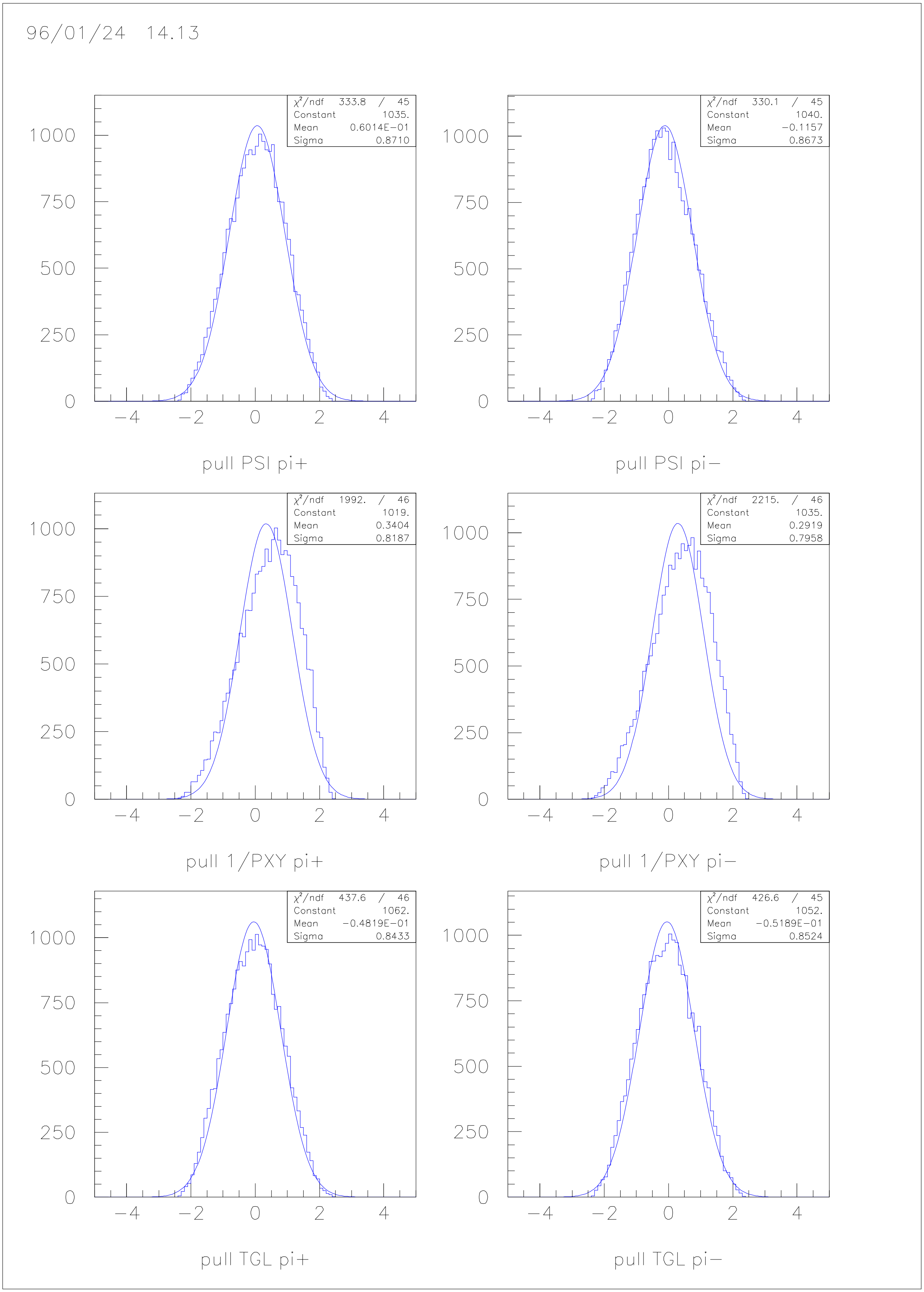

Figure 3: *pulls for* $\pi^+\pi^{8}\pi^+\pi^-$ *beforecorrection.*

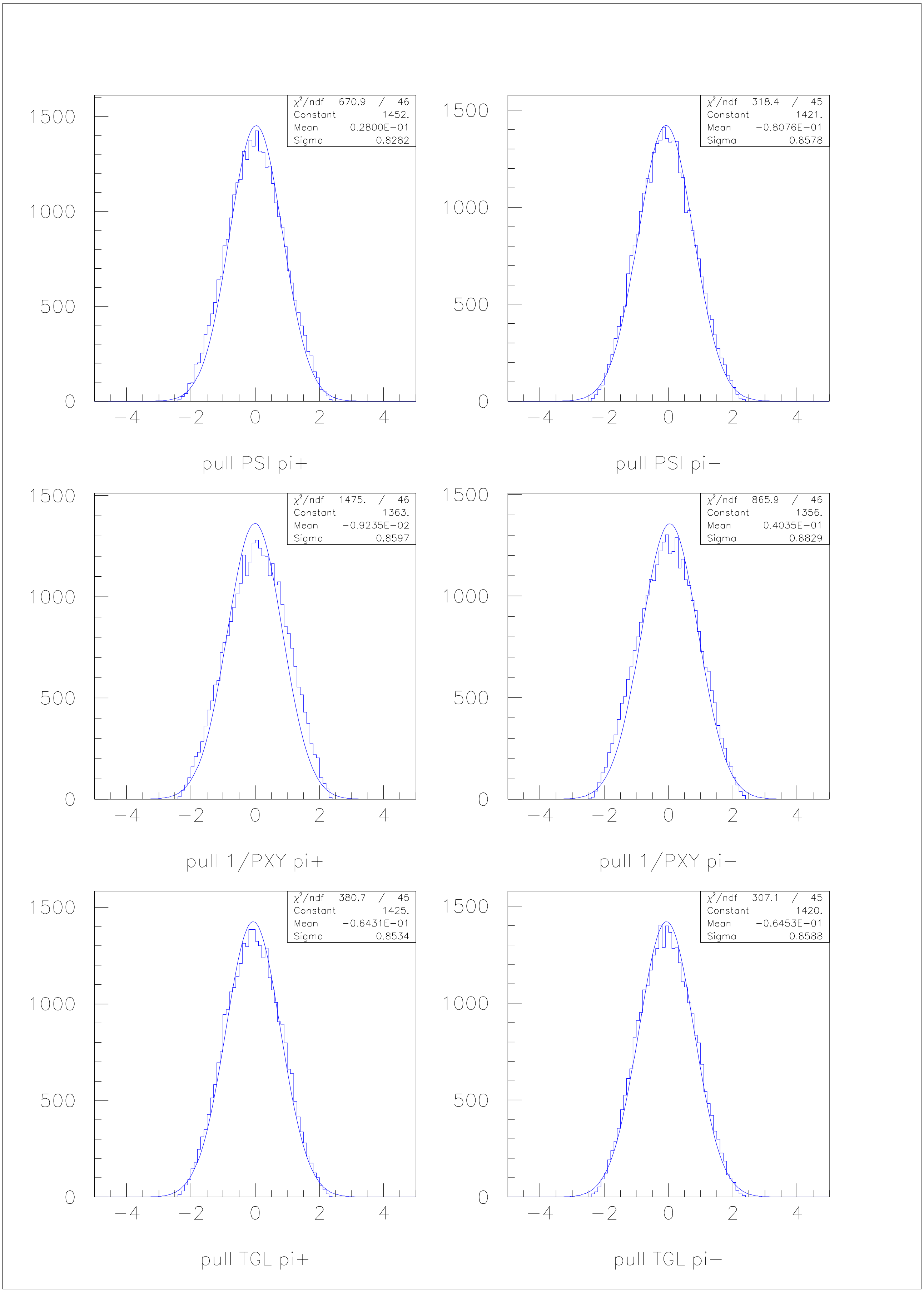

Figure 4: *pulls for* $\pi^+\pi^-\pi^+\pi^-$ *aftercorrection.*