PrimEx-2 Relative Tagging Ratio Stability Test

PrimEx note 81

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Abstract

This analysis was encouraged by beam signal drop off by few percent observed by pgp detector for certain silicon run period (see for example Fig.13,14 [1]). The general idea was to investigate if this effect was caused by relative tagging ratio drop or other effects not related to the tagging ratio stability (for example rate drop off caused by beam shift from the center of the scintillator straw to the edge or something else). For this purpose stability of π^0 yield (normalized to beam flux) has been studied for silicon target (runs after 64700).

The photon beam alignemnt have been checked using position of the mean intersection points of the line between two clusters (π^0 candidates) and coordinate axes.

1 Event analysis

The silicon production runs (64716 – 64988) have been divided into 10 intervals. Normalized (to the photon beam flux) π^0 yield has been extracted for each such an interval.

Events were selected using the following requirements:

- A selected event must be triggered by HyCal total sum trigger.
- Event must have 2 or more clusters with energy above 0.5 GeV each.
- First 18 T-counters have been used.
- Time difference window size (between HyCal and Tagger signals) was 6 ns.
- Beam trips have been excluded.
- All 2 cluster combinations in event were analized. Any such a pair has been accepted if it had invariant mass above 100 MeV and at least 1 cluster wasn't match by Veto.

2 Stability of π^0 yield

The invariant mass of all the π^0 candidates passed through selection is presented on Fig. 1 (page 4). The fitting function (red curve) was in form of 2 Gaussian plus second order polinomial:

$$NF(x) = N1(X, \mu1, \sigma1) + N2(X, \mu2, \sigma2) + B0 + B1 * (X - \mu1) + B2 * (X - \mu1)^2$$

Since we need total number of signal events we used sum of N1 and N2. So we modified the fitting function and introduced NS and effective angle *phi* in the following way:

$$N1 = NS \times cos(\phi)^2, N2 = NS \times sin(\phi)^2$$

As a result we got real error for the sum of two gaussians number of events (which is π^0 yield) from the Minuit fit. The fitted number of π^0 in all intervals is 299500 ± 627, signal shape parameters for overall fit were

- 74% give $\mu_1 = 135.7, \sigma_1 = 2.4$ MeV
- 26% give $\mu_2 = 135.5, \sigma_2 = 4.3$ MeV.

The mass spectra in 10 run groups were processed the same way. These spectra and fit results are given in Fig. 2 – 6 (pages 5 – 7). The measured yields versus Run number are presented in fig. 7. The hypothesis that π^0 yield doesn't depend on time of data taken has $\chi^2 = 12$ at 9 degrees of freedom (NDF) (statistical errors only).

Elasticity distribution (ratio of π^0 and photon beam energy) is shown on fig. 8. We correct gamma energies from π^0 decay taking into account beam energy, cluster energy resolutions by requiring energy conservation (recoil energy is negligible). Invariant mass was recalculated with these corrected energies (energy constraint mass). This procedure of course is valid only for elastic process, when π^0s were produced exclusively. The constraint mass spectrum was fitted the same way as on fig. 7. The resulting mass spectrum is shown in fig. 9 (page 10). The number of π^0s here is 109900 ± 486, signal shape parameters for the fit:

- 78% give $\mu_1 = 135.2, \sigma_1 = 1.2$ MeV
- 22% give $\mu_2 = 137.2\sigma_2 = 3.3$ MeV

(note, that ω background was not included in the fit).

The measured yields versus run interval are presented on fig. 10 (page 11). The signal is about 3 times less than for unconstraint spectrum, but a major contribution comes from more narrow peak of elastic π^0s. The hypothesis that π^0 yield doesn't depend on time of data is acceptable in terms of stat. errors, and that is important the normalized yield drop off by few percent is clearly not observed.

3 Alignment of the vertex position

HyCal alignment was checked using π^0 events. The X,Y coodinates of 2 clusters from $\pi^0 \to \gamma\gamma$ decay were used to calculate the point of the beam intersection with HyCal face plane. We selected π^0 in mass window of $\pm$ 3 MeV. On fig. 11 (page 12) we show X(Y) distributions used in this procedure for all silicon runs. In fig. 12 we present alignment results calculated for selected 10 group of runs. The resulting position are compatible with zero.One one group containing Run 64800 is a possible outlier.

4 Conclusion

- The drop off of normalized pion yield at the end of silicon data is not confirmed. We don't see any strong dependence on time of the data taken.
- The HyCal alignment is statistically consistent with (0,0). One group of runs has values out of normal position. This could be double check in the nearest future.

References

[1] V. Tarasov, PrimEx note 71 June 7, 2013

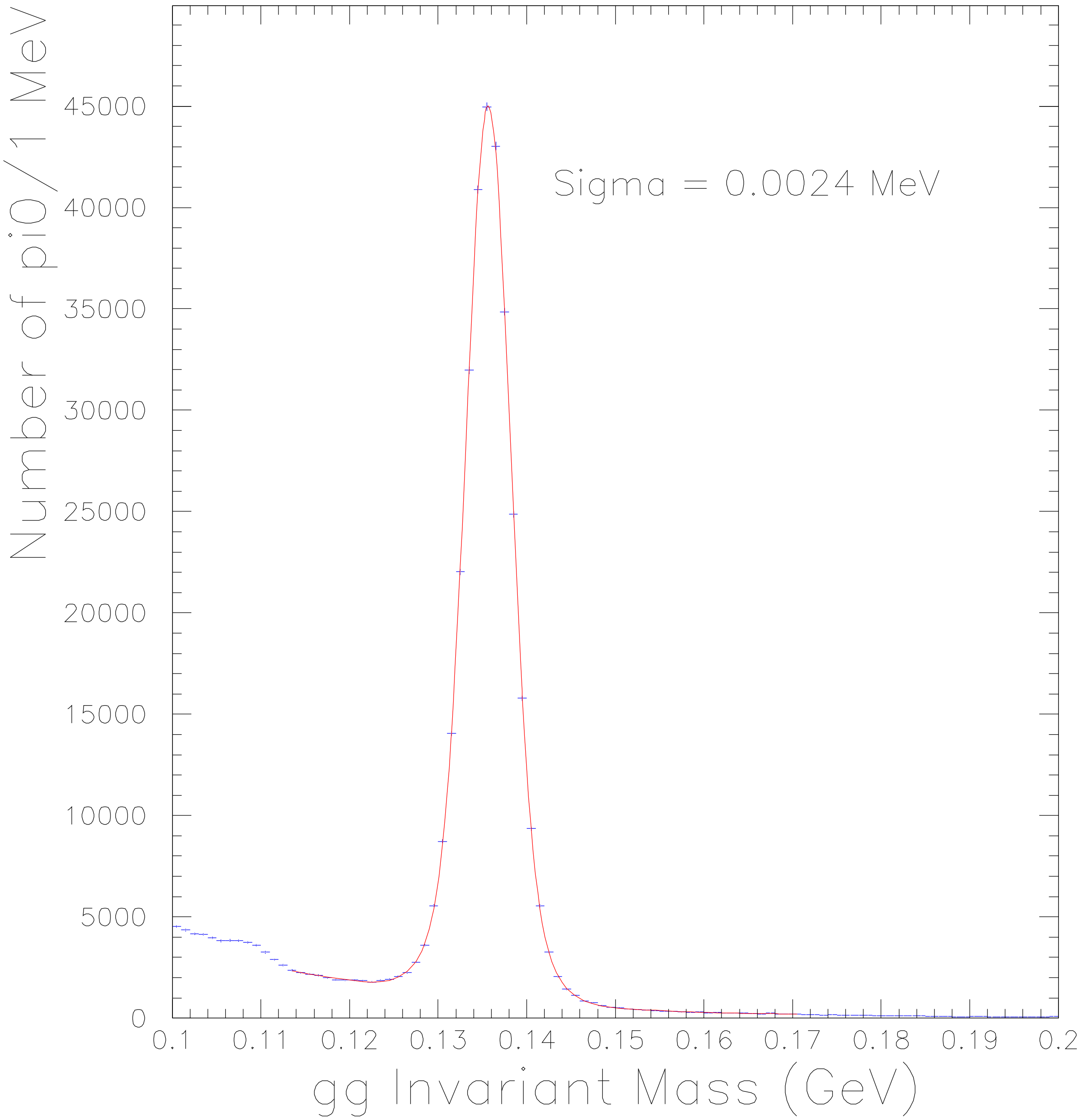

Figure 1: Mass of two gammas for all selected events

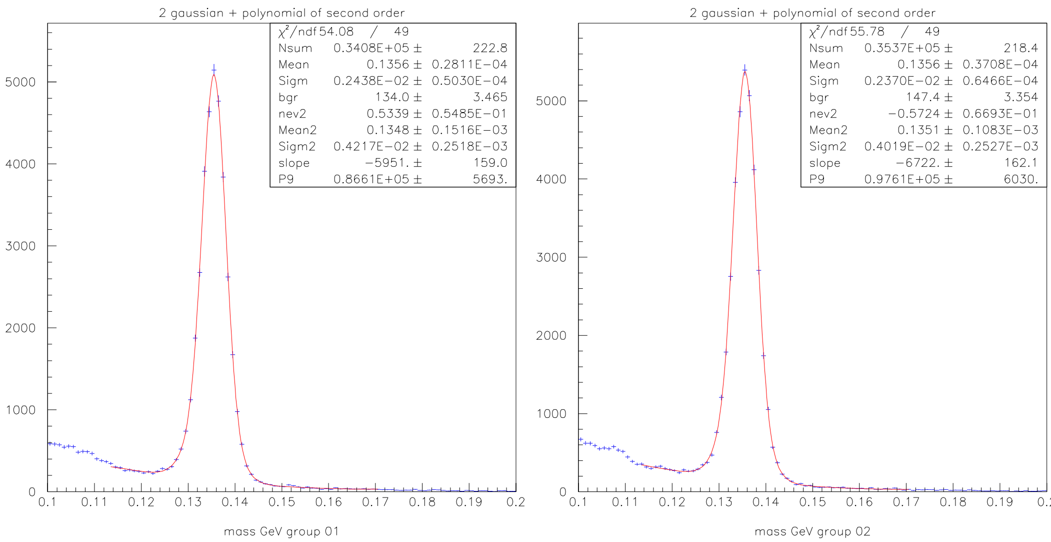

Figure 2: Invariant mass of π^0 candidates for Run intervals 1 (left), 2 (right)

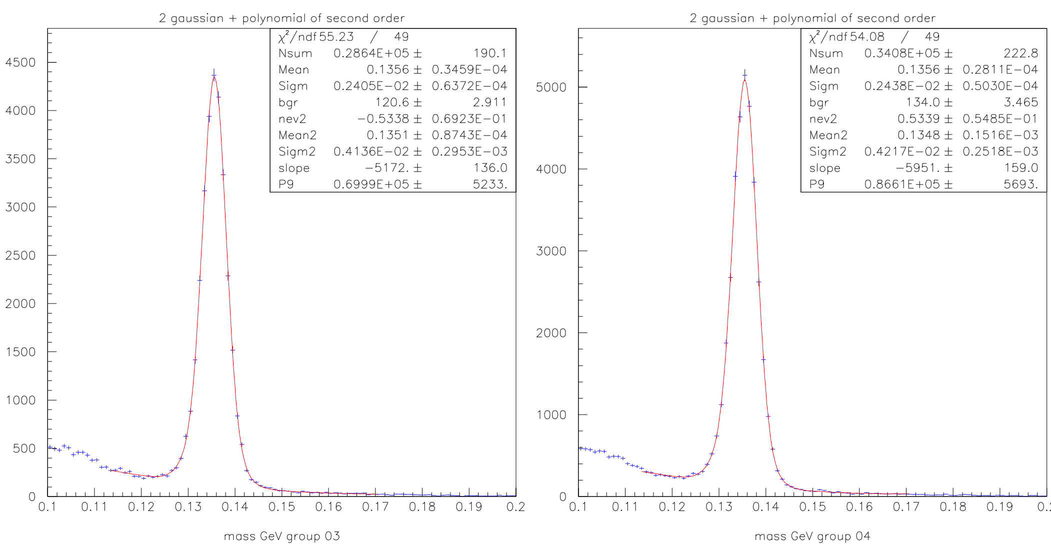

Figure 3: Invariant mass of π^0 candidates for Run intervals 3 (left), 4 (right)

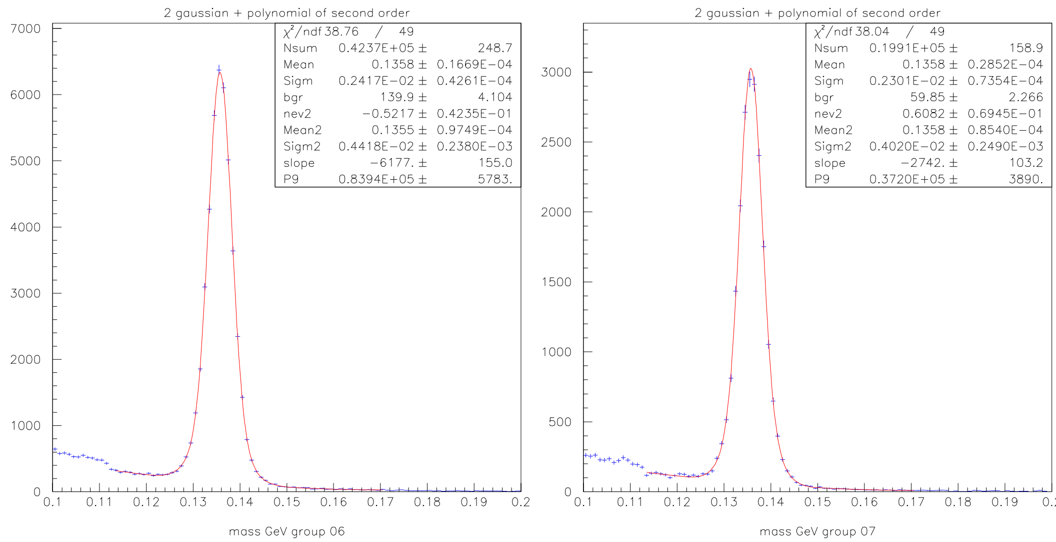

Figure 4: Invariant mass of π^0 candidates for Run intervals 6 (left), 7 (right)

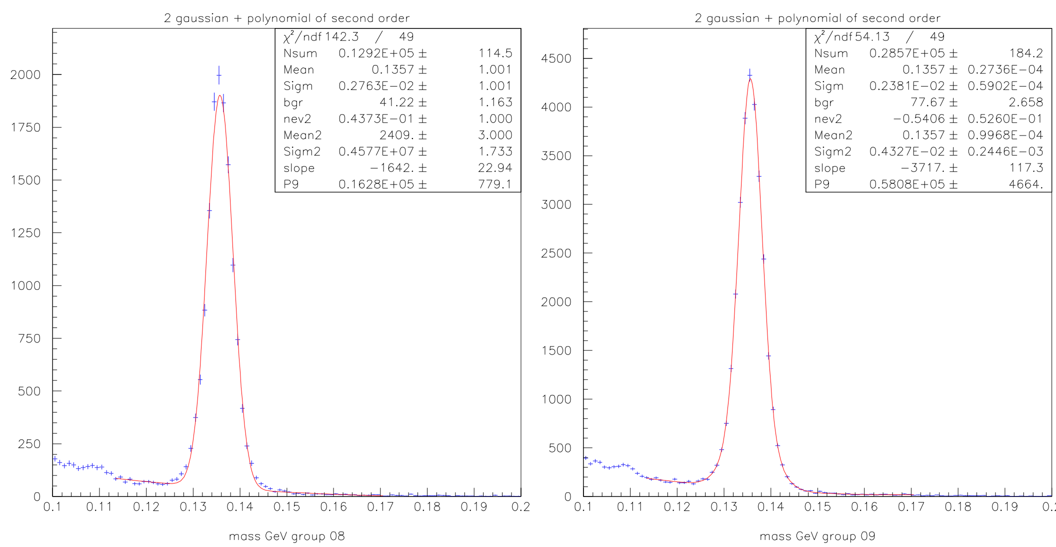

Figure 5: Invariant mass of π^0 candidates for Run intervals 8 (left), 9 (right)

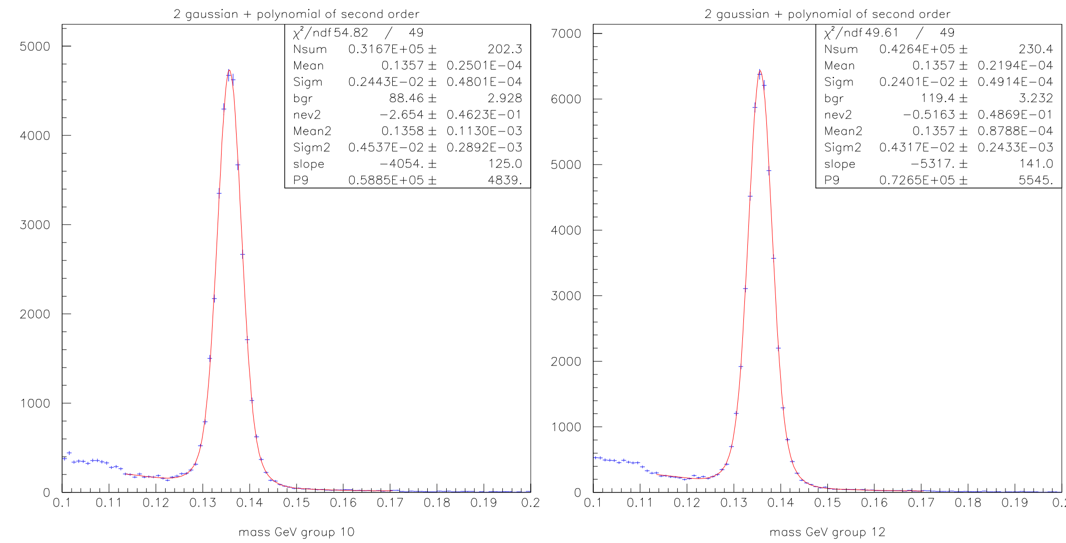

Figure 6: Invariant mass of π^0 candidates for Run intervals 10 (left), 12 (right)

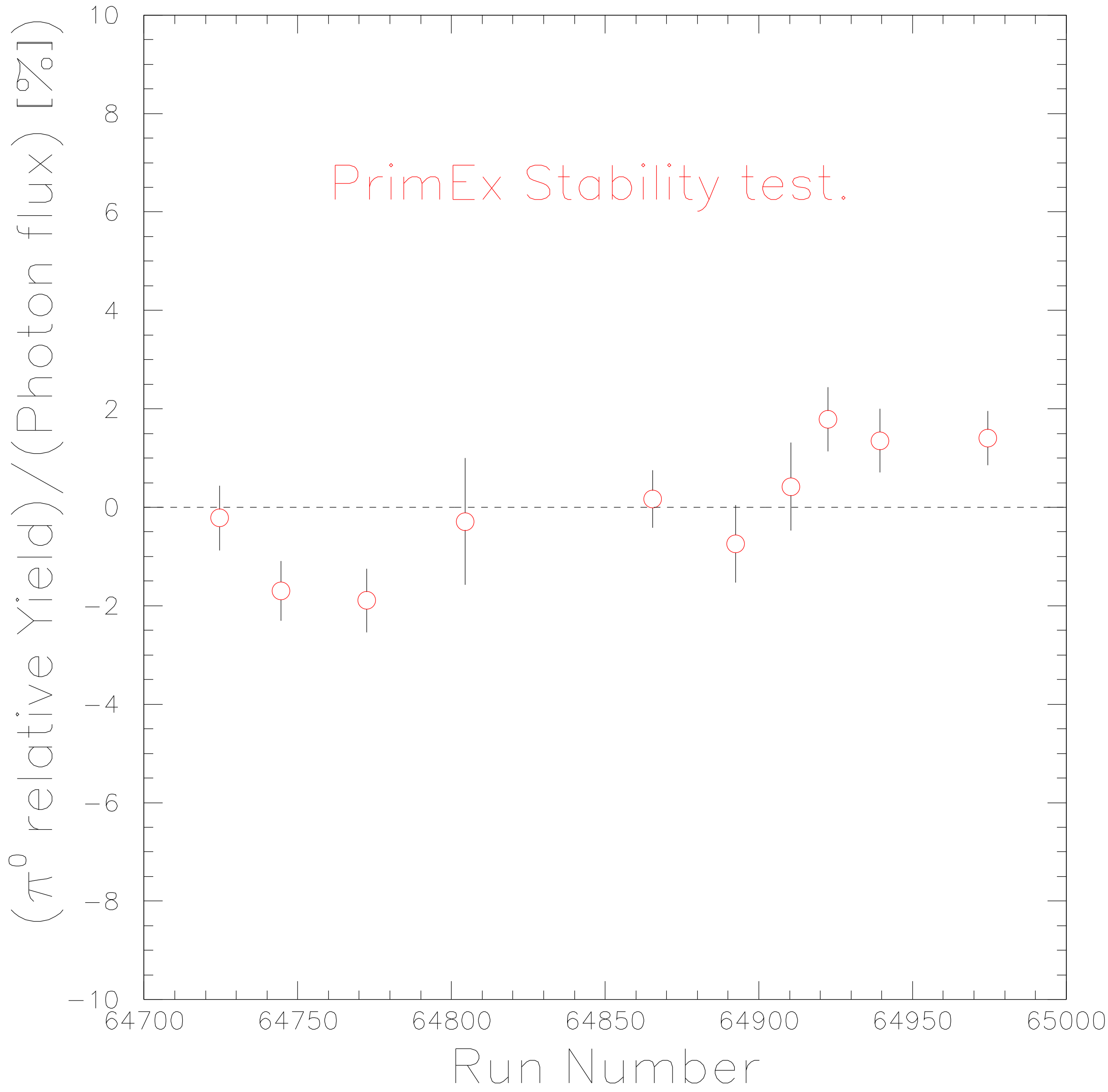

Figure 7: Normalized π^0 yields (deviation from 0 in percent) for selected run intervals

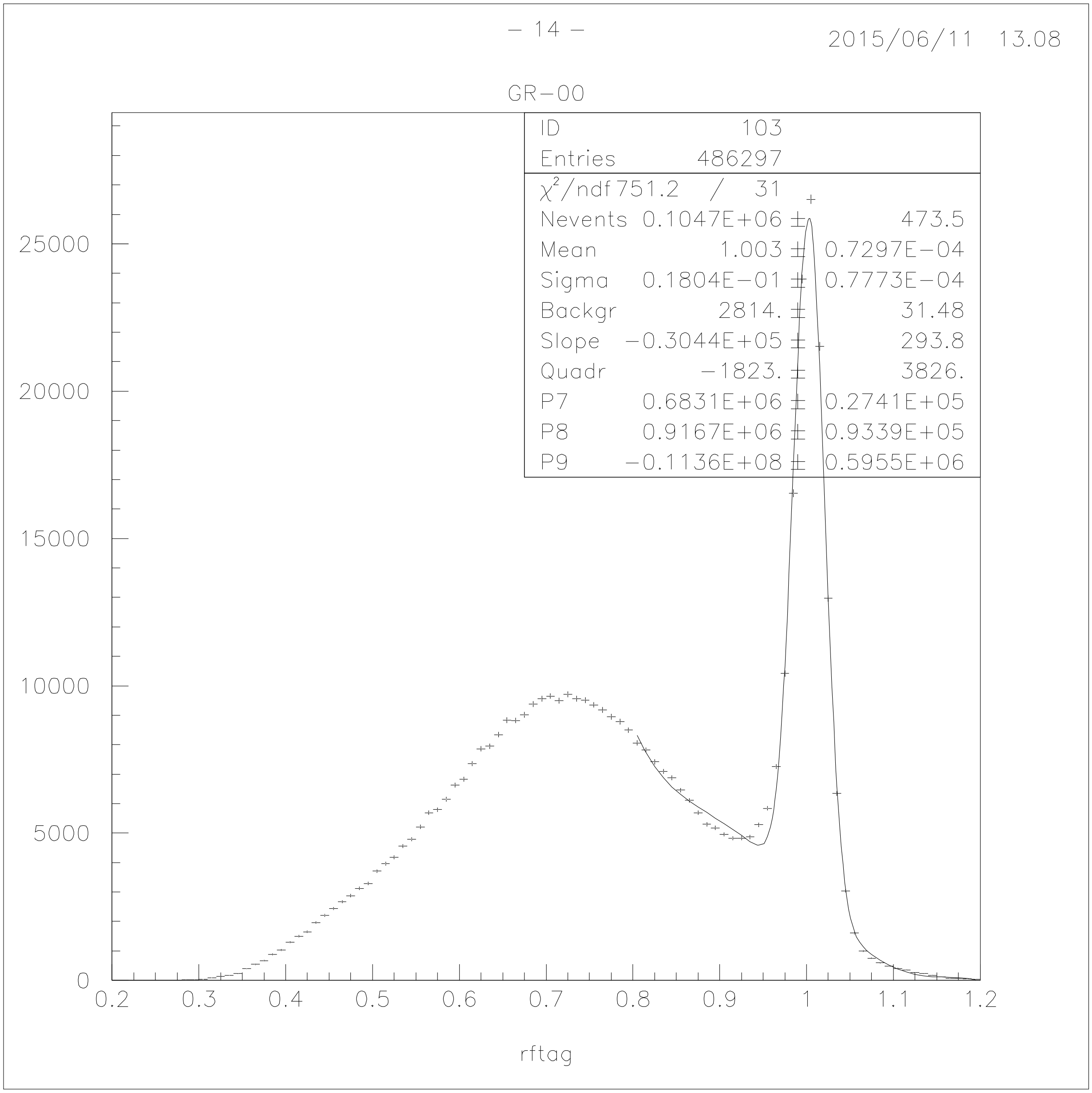

Figure 8: Elasticity distribution for selected events

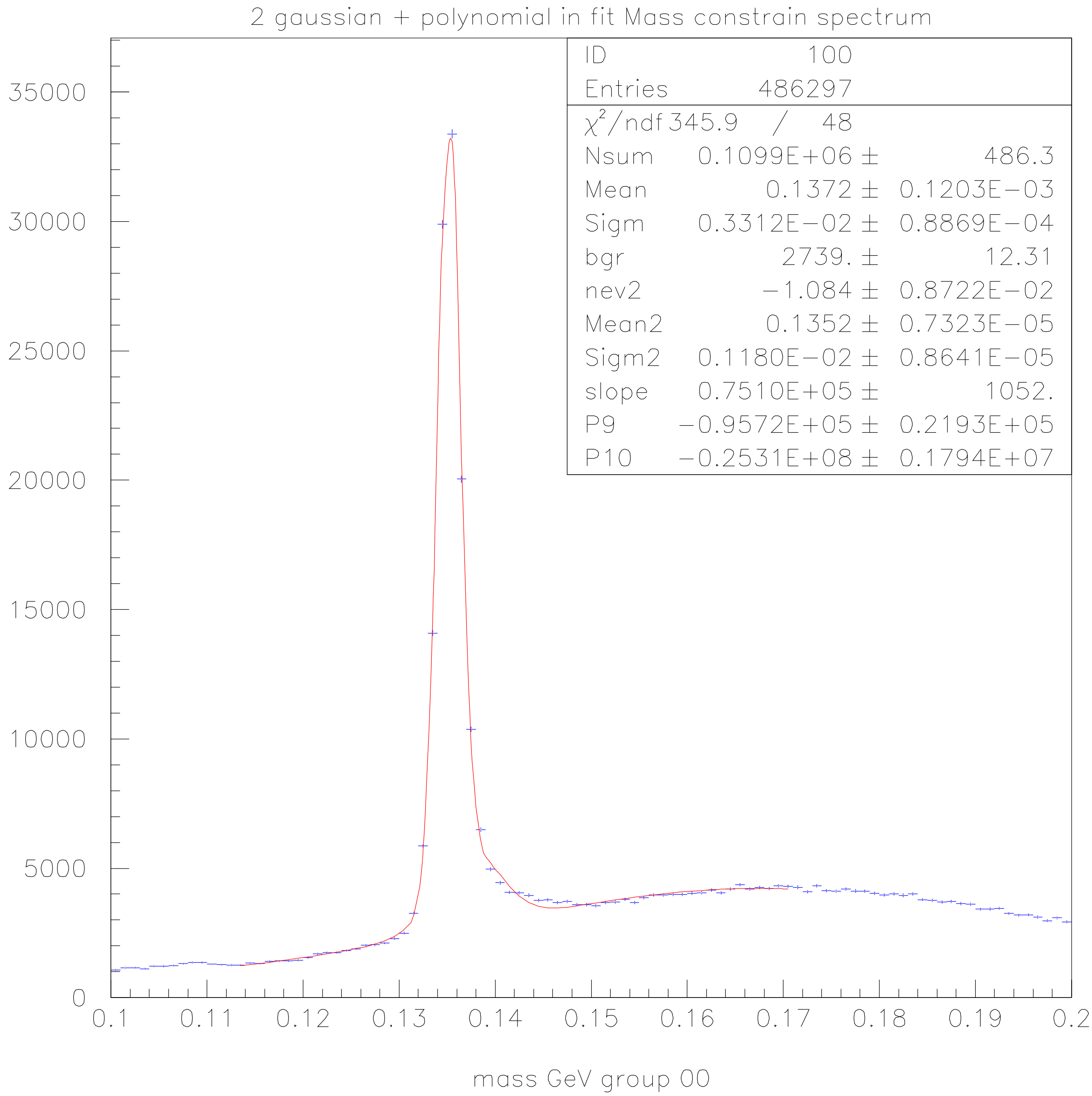

Figure 9: π^0 mass with elasticity contraint for all events

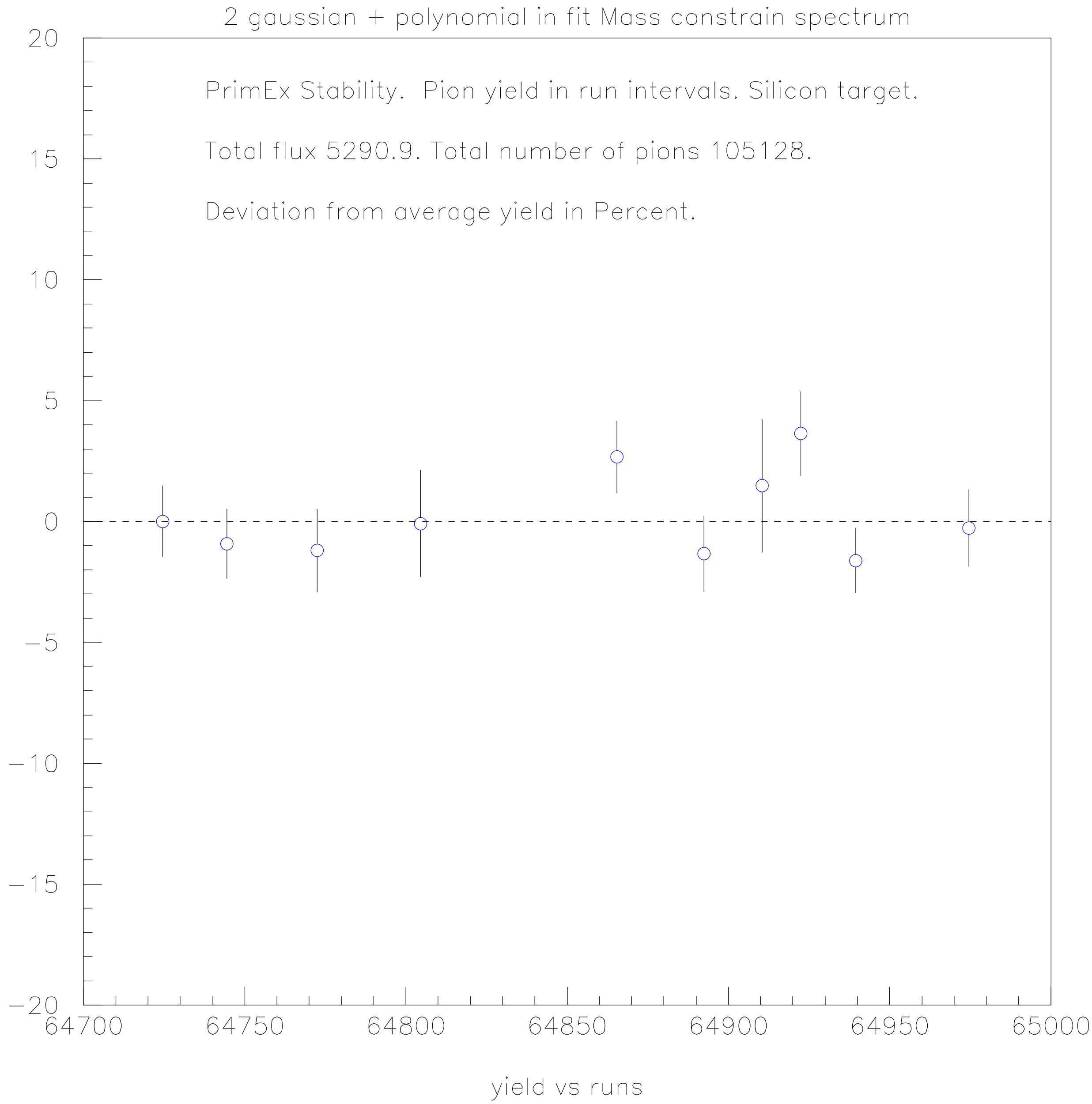

Figure 10: Stability plot: normalized π^0 yields (deviation from 0 in percent) for selected run intervals. Elasticity constraint is applied for calculating signal

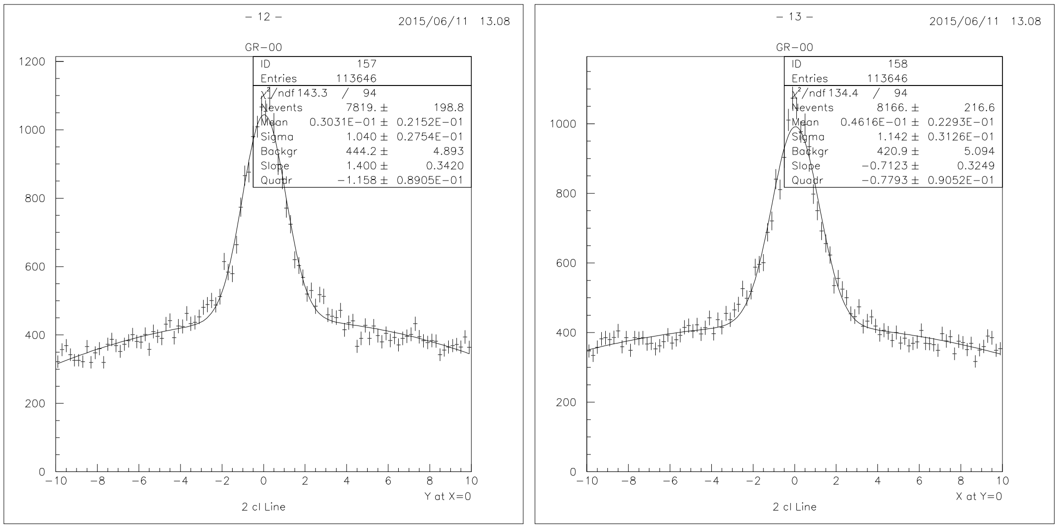

Figure 11: Beam instersection with HyCal face point: left Y, right X

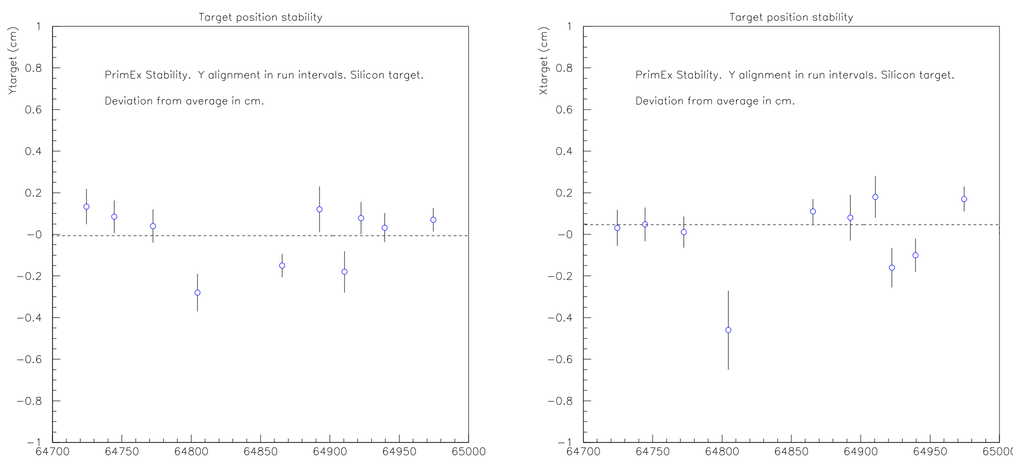

Figure 12: Obtained X,Y alignment vs run group: left Y, right X