# Progress report

Jan Loder

Helsinki Institute of Physics

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# $\rho$ invariant mass reconstruction

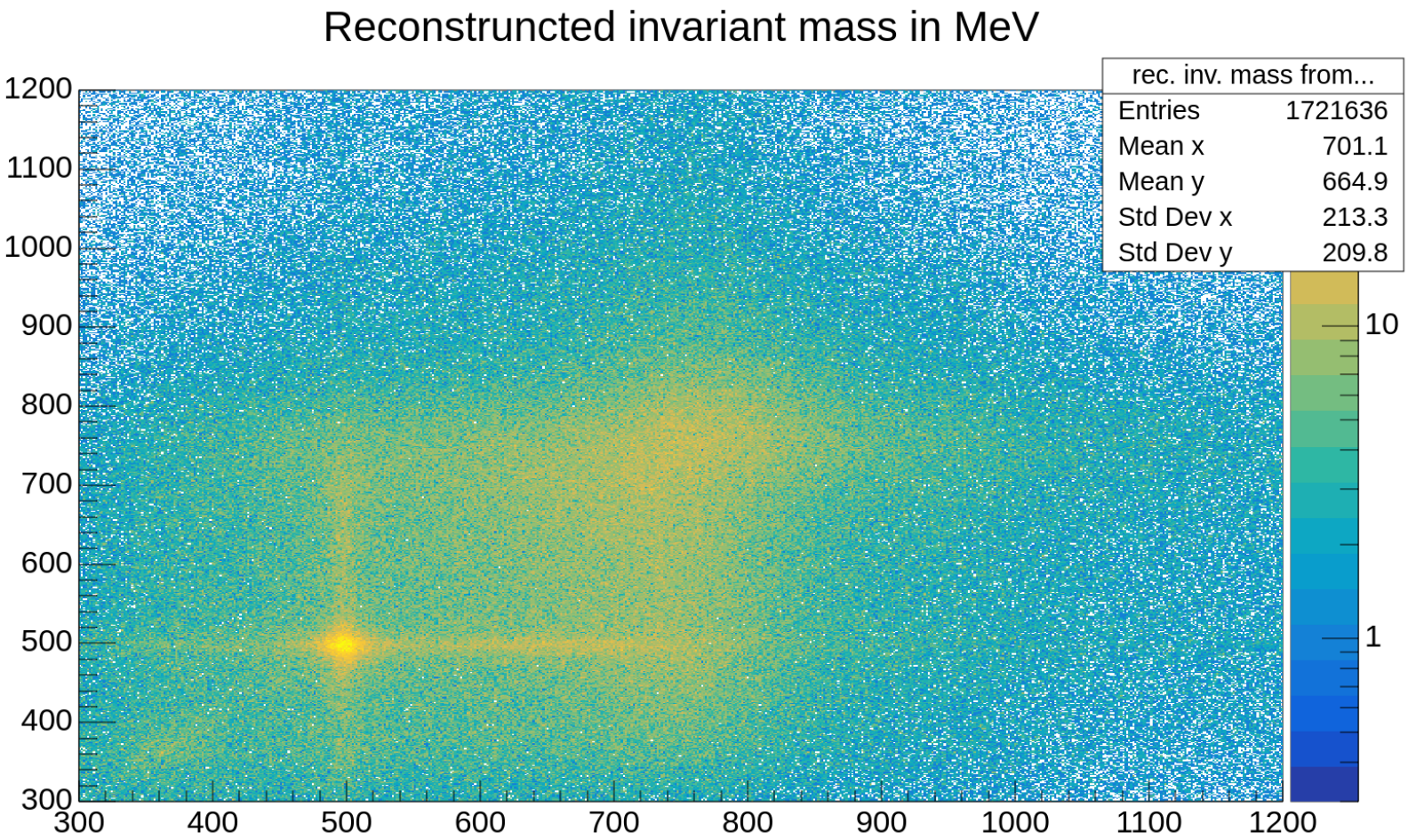



Figure: TOTEM2

# $\rho$ invariant mass reconstruction

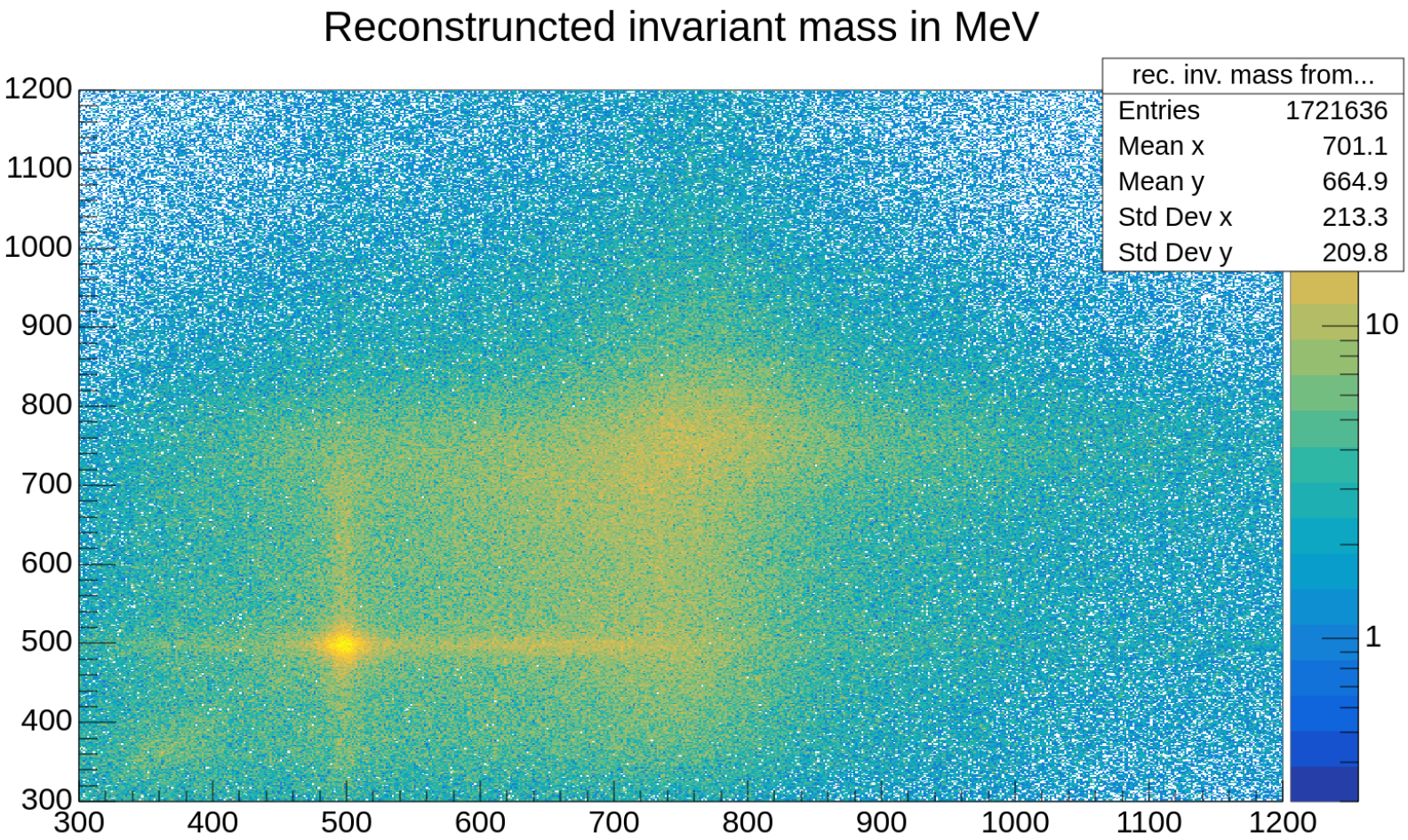



Figure: TOTEM4

# Introducing $\chi^2$-like variables

- We use the combined data sets TOTEM2 and TOTEM4
- Define new variable

$$\chi^2 := \sum_{i=1}^{ntrk=4} \frac{(\mu_x - x_i)^2}{\sigma_x^2}, \text{ for } x \in \{\text{zPV}, \text{dxy/dxyerr}, \text{dz/dzerr}\} \quad (1)$$

- Not normalised because $|\mu_x| \ll 1$
- $\mu_x$ is constant coming from gaussian fit of $x$ over entire data set
- $\sigma_{\text{zPV}}$ comes from gaussian fit, for dxy/dxyerr and dz/dzerr already included
- Every event has multiple $\chi^2$s on which we can cut

# $\chi^2$ Cuts

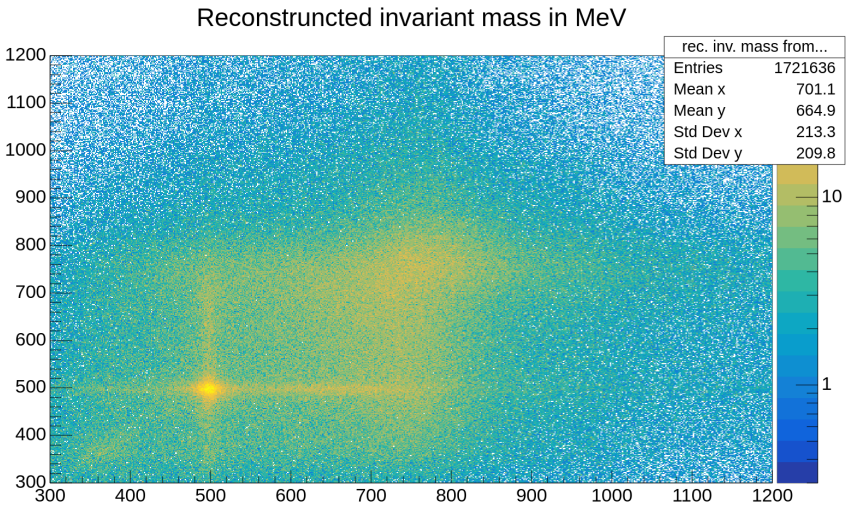



Figure: TOTEM2 before $\chi^2$ cut

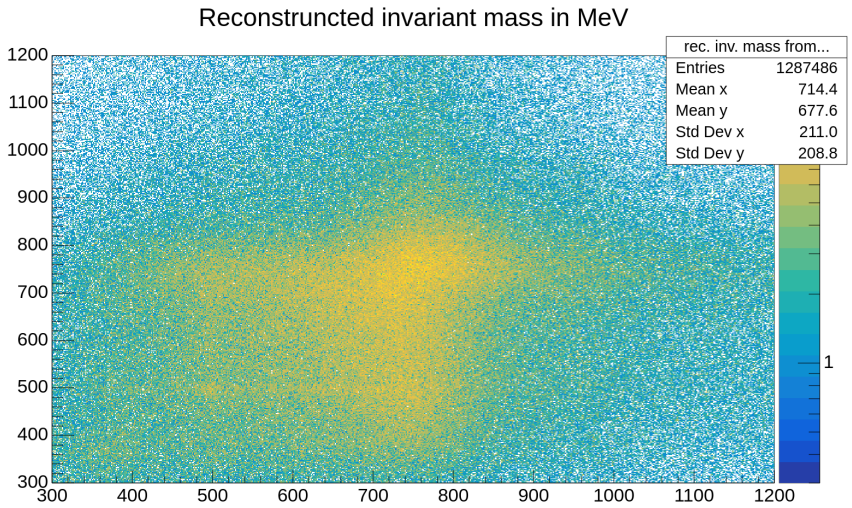
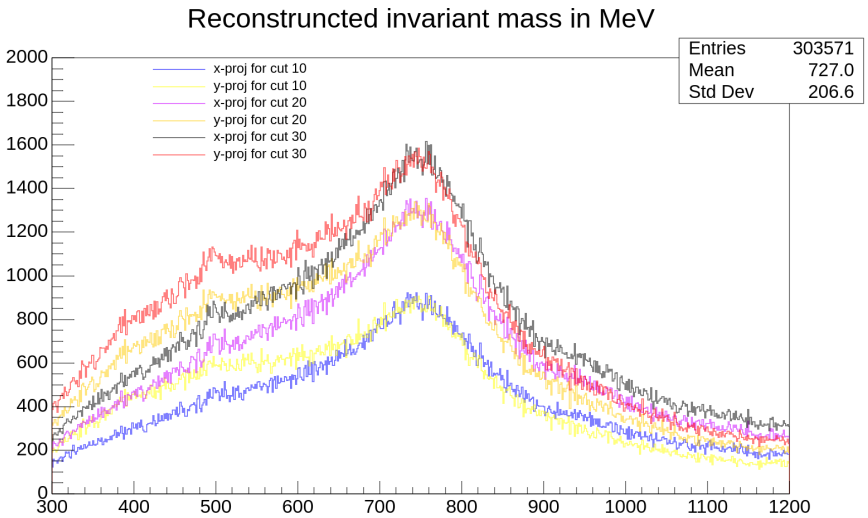
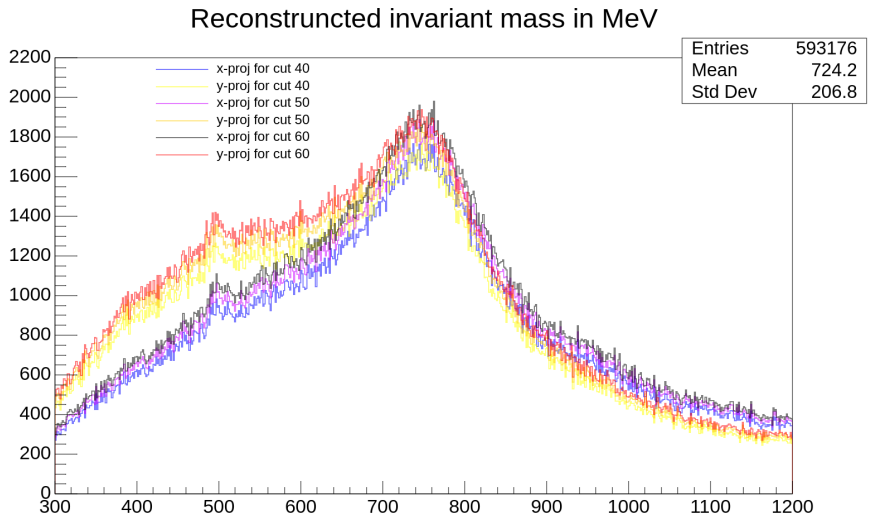


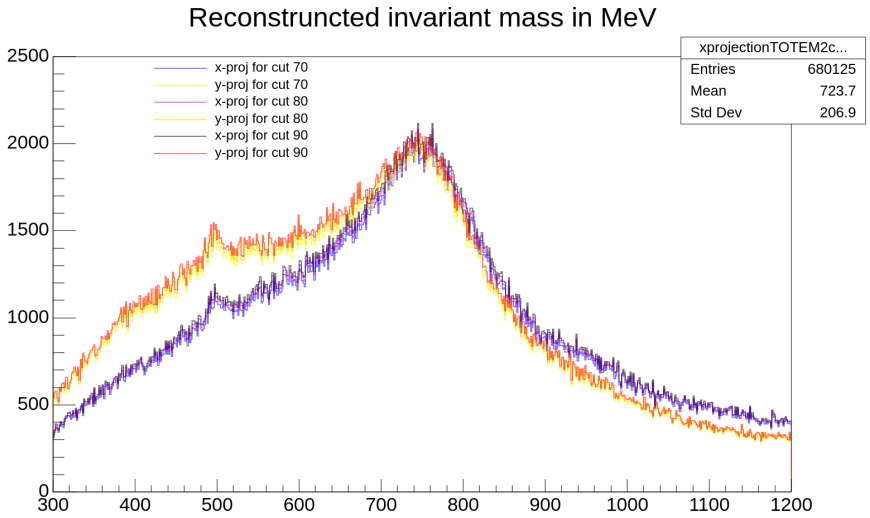

Figure: TOTEM2 after $\chi^2$ cut

- Cuts at $\chi^2_{\text{zPV}} < 50$ and $\chi^2_{\text{dxy/dxyerr}} < 50$ $\chi^2_{\text{dz/dzerr}} < 50$

# Projections $\chi^2$ Cuts




Same cuts applied on all three $\chi^2$

# $\rho$ mass fits

- We project onto $x$ and $y$ axis in the range 600 MeV to 900 MeV
- Formula for fit

$$f(M) = f_{\text{bg}}(M) + f_{\text{sg}}(M) = A(M - B)^C \mathrm{e}^{DM} + N \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

# $\rho$ mass fits TOTEM2

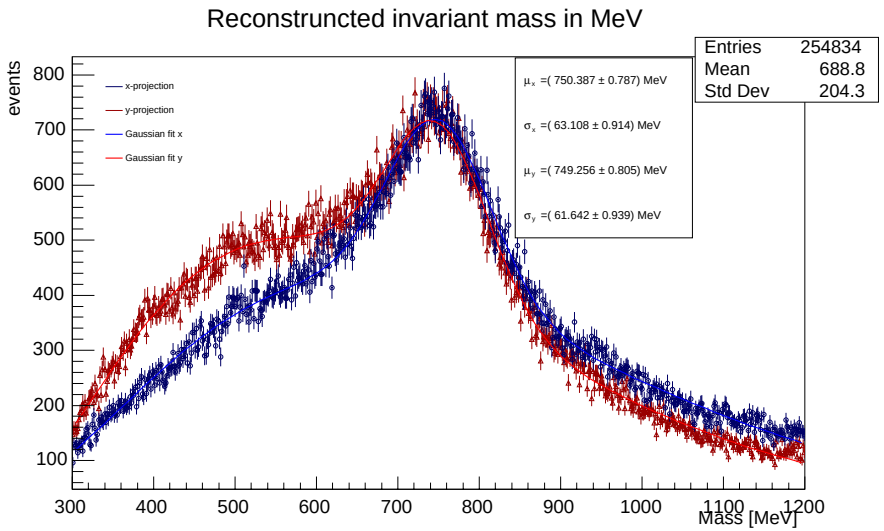



Figure: Cuts $\chi^2 < 10$ for all three

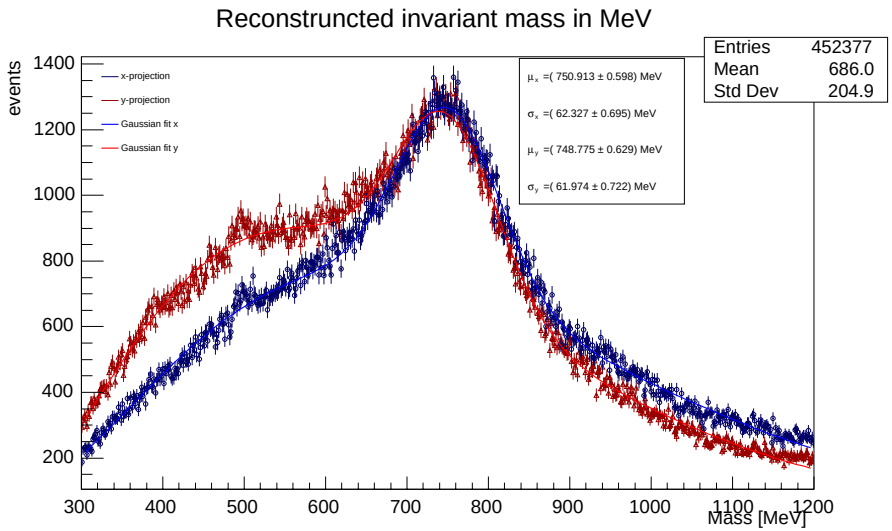



Figure: Cuts $\chi^2 < 30$ for all three

- $\langle \mu_2 \rangle_{\chi^2<10} = 749.823(796)\,\text{MeV}$
- $\langle \sigma_2 \rangle_{\chi^2<10} = 62.375(927)\,\text{MeV}$

- $\langle \mu_2 \rangle_{\chi^2<30} = 749.844(614)\,\text{MeV}$
- $\langle \sigma_2 \rangle^{(2)}_{\chi^2<30} = 62.151(709)\,\text{MeV}$

$\Rightarrow$ No big differences, but smaller fit uncertainty for less restrictive cuts

# $\rho$ mass fits TOTEM4

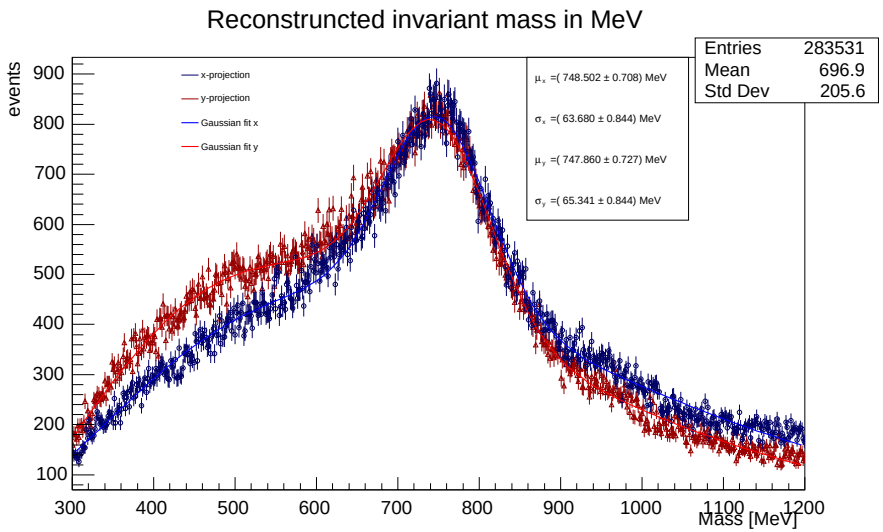



Figure: Cuts $\chi^2 < 10$ for all three

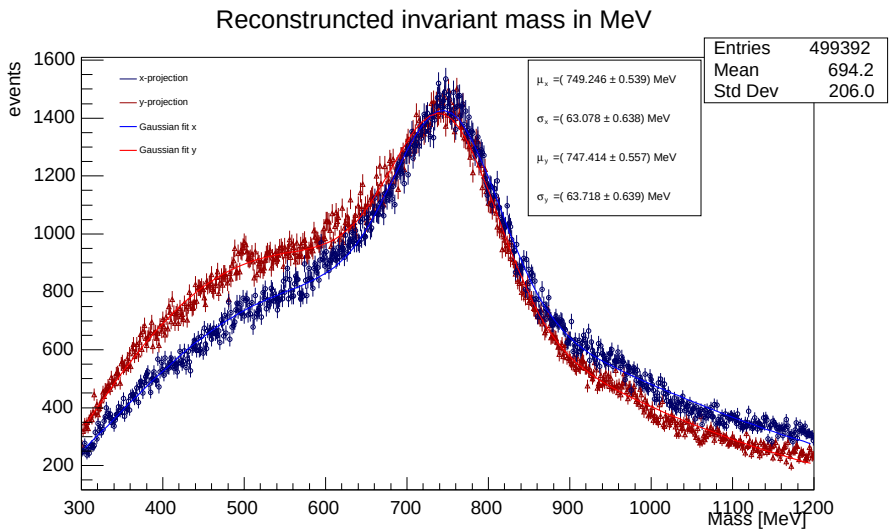



Figure: Cuts $\chi^2 < 30$ for all three

- $\langle \mu_4 \rangle_{\chi^2<10} = 748.181(718)\,\text{MeV}$
- $\langle \sigma_4 \rangle_{\chi^2<10} = 64.511(844)\,\text{MeV}$

- $\langle \mu_4 \rangle_{\chi^2<30} = 748.330(548)\,\text{MeV}$
- $\langle \sigma_4 \rangle_{\chi^2<30} = 63.398(639)\,\text{MeV}$

$\Rightarrow$ No big differences, but smaller fit uncertainty for less restrictive cuts

# Comparison to PDG

| Source | $K$ mass in MeV | $\rho$ mass in MeV | $\rho$ $\Gamma$ in MeV |
|---|---|---|---|
| TOTEM2 | 497.903(173) MeV | 749.844(614) | 146.366(1670) |
| TOTEM4 | 497.865(164) MeV | 748.330(548) | 150.008(1505) |
| PDG | 497.677(13) MeV | 766.5(11) | 150.2(24) |

# $\chi^2$ variable for $\rho$ mass from TOTEM2 data

- Based on $\chi^2 < 30$ data, added branches *chi2_rhoMass_pair1* and *chi2_rhoMass_pair2* to tree

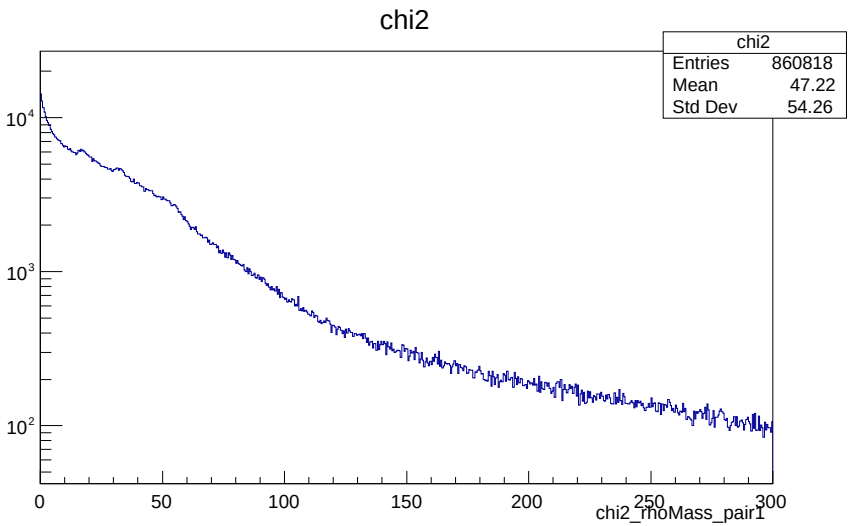



Figure: Mass pair 1

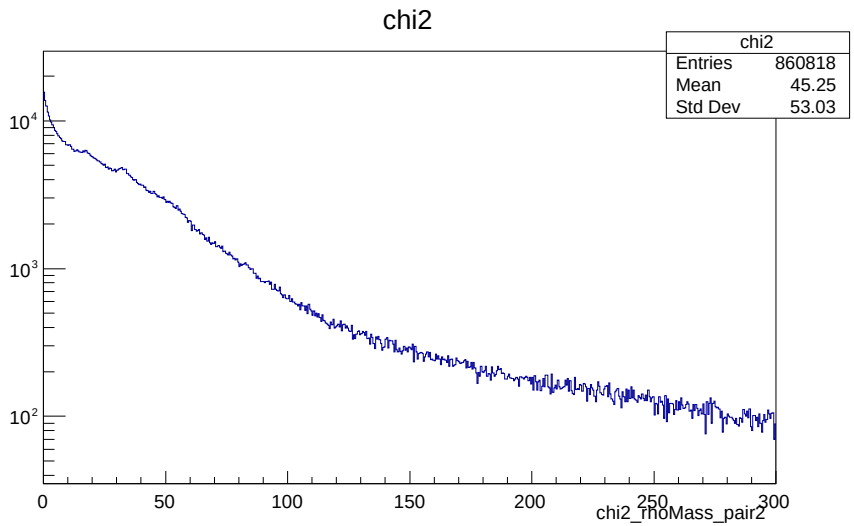



Figure: Mass pair 2

# $\chi^2$ variable for $\rho$ mass from TOTEM4 data

- Based on $\chi^2 < 30$ data, added branches *chi2_rhoMass_pair1* and *chi2_rhoMass_pair2* to tree

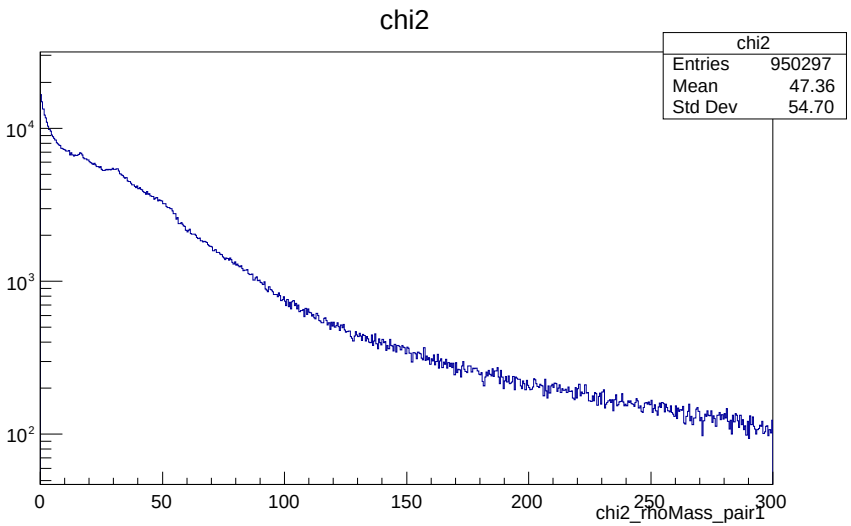



Figure: Mass pair 1

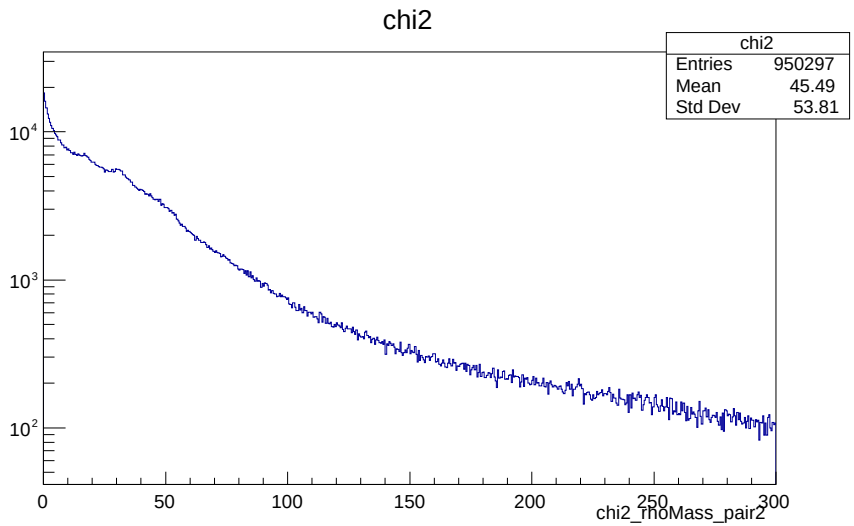



Figure: Mass pair 2

- Comparing $\chi^2_m$ of the pairs on event to event basis $\Rightarrow$ Identify correct mass pairing

# Cutted TOTEM2 2D invariant mass plot

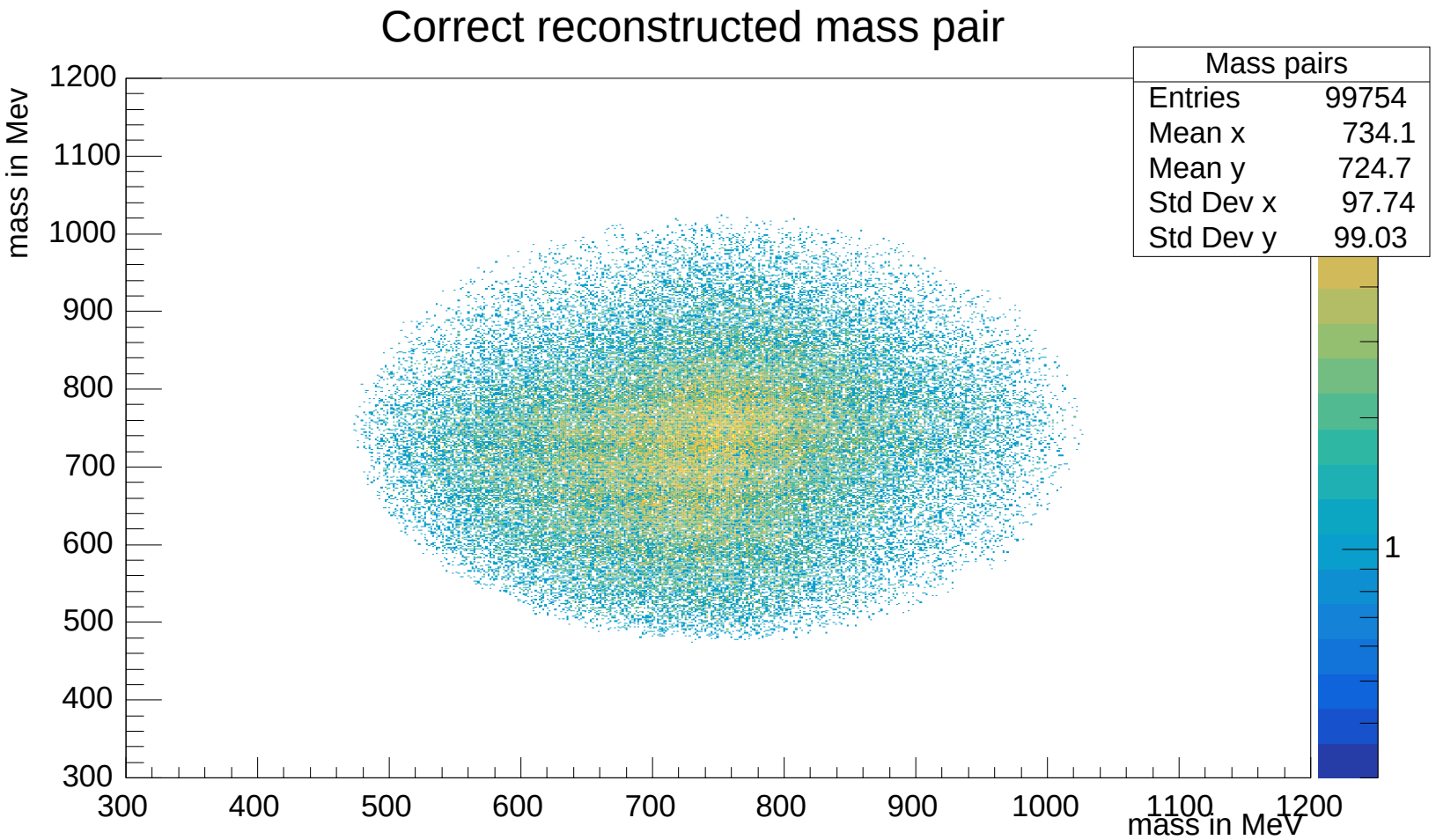



Figure: Only correct mass pairs with cuts $\chi^2_{zPV}, \chi^2_{dxy}, \chi^2_{dz} < 40$ and $\chi^2_m < 30$

# TOTEM2 invariant mass rojections

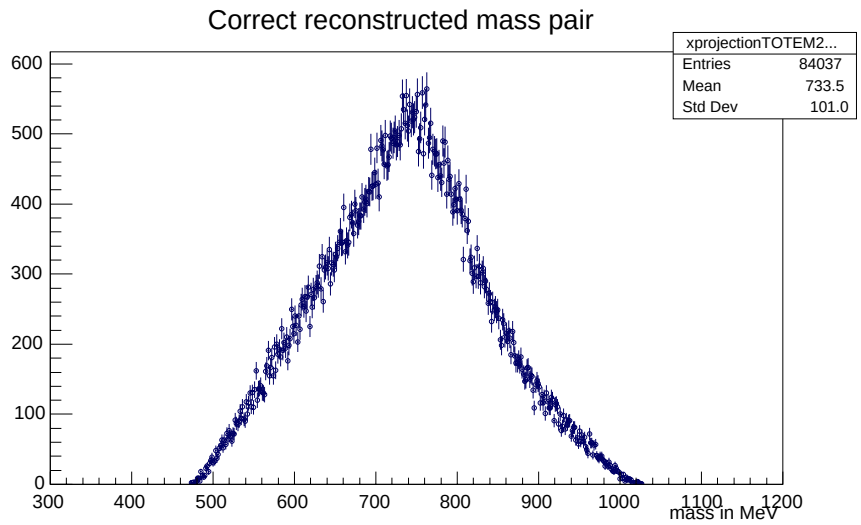



Figure: $x$-projection, of 2D histogram from previous slide

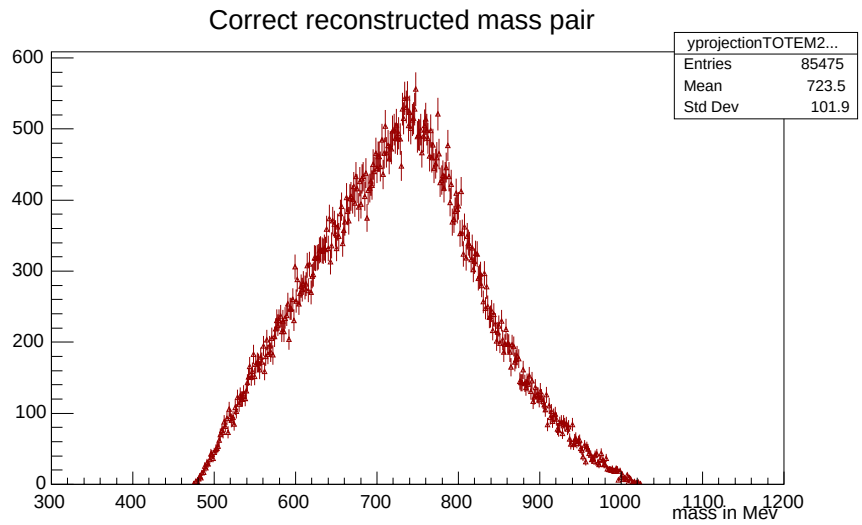



Figure: $y$-projection, of 2D histogram from previous slide

# Summary Data Analysis Workflow

1. Combining TOTEM20 + TOTEM21 + TOTEM22 + TOTEM23 = TOTEM2 (likewise TOTEM4)
2. Gaussian fits on zPV, dxy/dxyerr and dz/dzerr
3. Adding branches for reconstructed mass of $\pi^+\pi^-$ pairs
4. Projecting and Fitting on Kaon masses
5. Adding branches for $\chi^2_{zPV}, \chi^2_{dxy}$ and $\chi^2_{dz}$ using previous fit parameters
6. Cut on $\chi^2 < 30$ for all three
7. Projections and Gaussian + background fit on $\rho$ mass
8. Add $\chi^2_m$ branch to uncut TOTEM2 based on Gaussian fit results from previous steps
9. Remove wrong mass pairs
10. Enforce $\chi^2_{zPV}, \chi^2_{dxy}, \chi^2_{dz} < 40$ and $\chi^2_m < 30$
11. On data from previous step perform 4 trk invariant mass reconstruction

# Preliminary 4 trk invariant mass plot

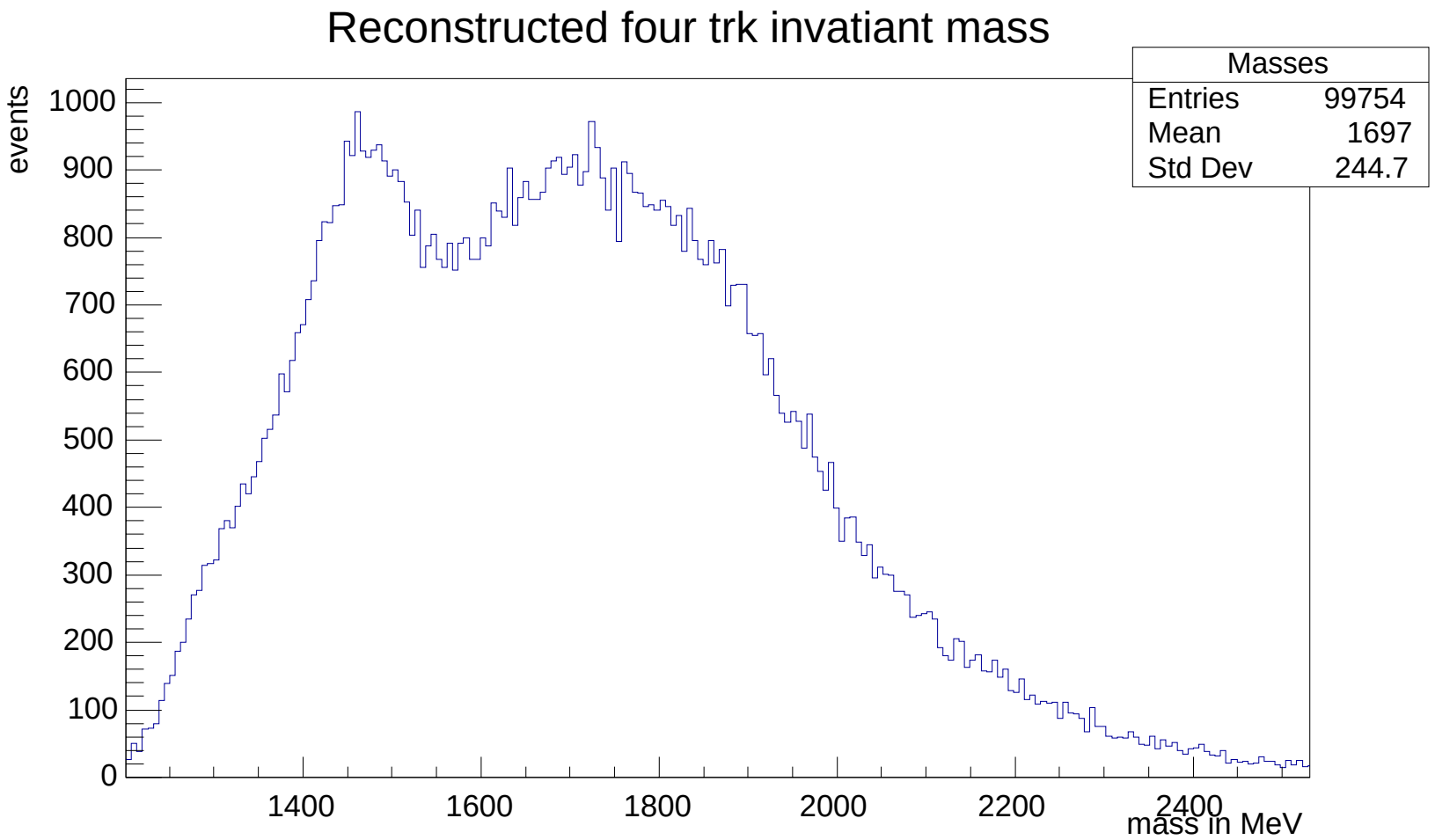



Figure: 4 trk mass reconstruction on correct mass pairs with cuts $\chi^2_{zPV}, \chi^2_{dxy}, \chi^2_{dz} < 40$ and $\chi^2_m < 30$