Systematic studies of background subtraction under Σ^0 mass peak measured at LHC with ALICE in pp collisions at $\sqrt{s} = 13$ TeV

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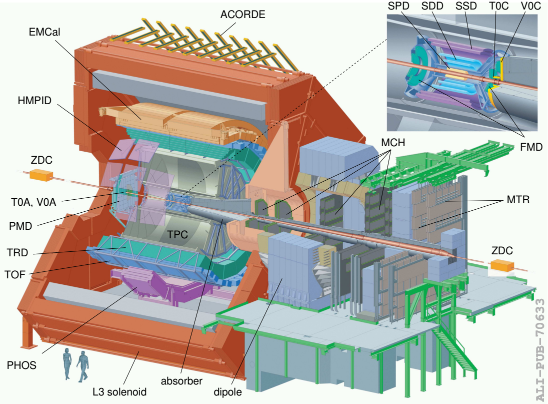
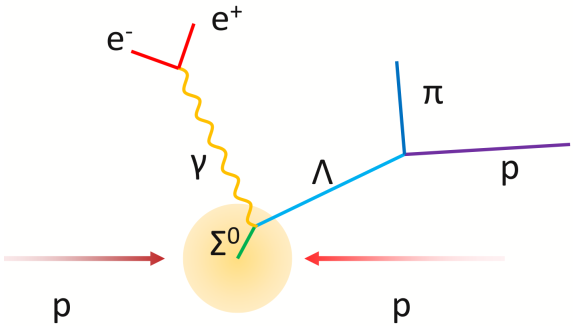
ALICE



ITS, TPC and TOF are mainly used for reconstruction and identification of tracks
V0A+V0C and ZDC for multiplicity, centrality, trigger and timing.
Unique particle identification, high granularity, tracking down to = 0.1 GeV/c.

Σ^0 hyperon

1. Consists of u, d, s quarks
2. $\sim 100\% \; \Sigma^0 \rightarrow \Lambda + \gamma$
3. Life time $\tau = 7 * 10^{-20}$ s
4. $m_{\Sigma^0} = 1192.6 \; \frac{MeV}{c^2}$



$\gamma \rightarrow e^+ + e^-$ is detected through the secondary V^0 vertex with Photon Conversion Method (PCM) in the central barrel detectors

Λ Reconstruction

Applied cuts:

- Opposite charged V0 tracks, without kinks
- $N_{\sigma_p} < 4$, $N_{\sigma_\pi} < 4$
- p^+ DCA_{PV} > 0.02 cm
- π^- DCA_{PV} > 0.02 cm
- DCA_{tr} < 1.5 cm
- r_{V0} < 180 cm
- $\cos\theta_{pointing}$ > 0.995
- 0.2 < α < 0.95
- 50 $\frac{MeV}{c}$ < q_T < 140 $\frac{MeV}{c}$

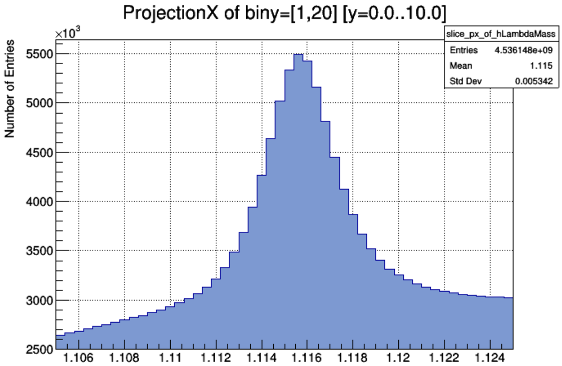


Figure: $p^+\pi^-$ invariant mass

γ in e^-e^+ pair conversion reconstruction

Restrictions on e^- and e^+:

- Opposite charged V0 tracks
- On-fly status
- $N_{\sigma\ TPC} < 4$
- TPC clusters crossed > 30
- $\alpha < 0.7$
- $q_T < 25\ \frac{MeV}{c}$
- $\cos\theta_{pointing} > 0.8$
- e^+e^- inv.mass < 100 $\frac{MeV}{c^2}$
- 3 cm < r_{V0} < 220 cm

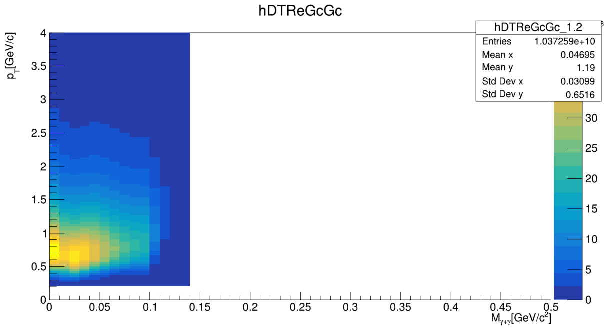
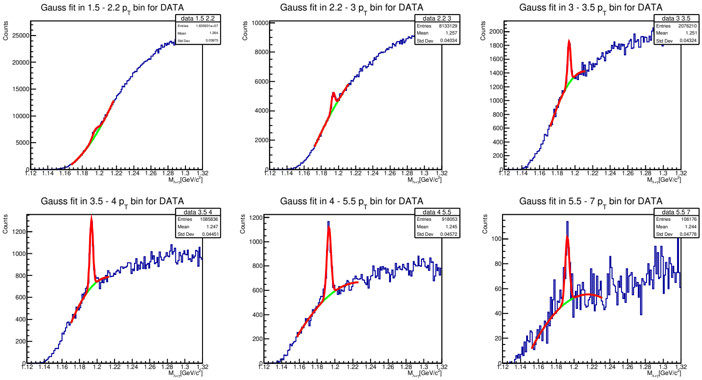


Figure: $\gamma\gamma$ invariant mass

Gaussian yield calculation



A polynomial function approximates the background

$$p(x) = a_3x^3 + a_2x^2 + a_1x + a_0$$

A Gaussian distribution approximates the peak

$$g(x) = \frac{N}{\sigma\sqrt{2\pi}} \times e^{-(x-m)^2/2\sigma^2}$$

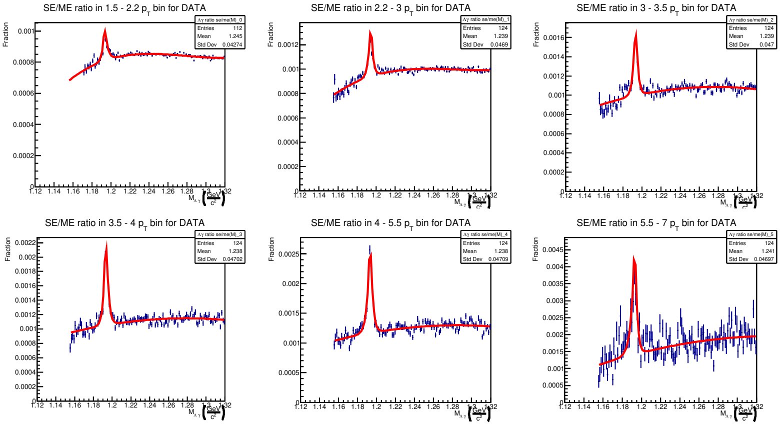
where m is Σ^0 mass according to PDG

Mixed background subtraction

1. Making invariant mass histograms of $\gamma + \Lambda$ taken from same event and from mixed events
2. Calculate their ratio in each bin
3. Fit obtained distribution with exponential function for signal and polynomial function for background
4. Normalize mixed invariant mass histogram via polynomial function
5. Subtract mixed event from same event invariant mass histogram
6. Fit signal peak and integral function to get yields

Examples below are presented for DATA. MC is in good agreement with DATA

Steps 2 and 3 - ratio fit



A polynomial function approximates the background

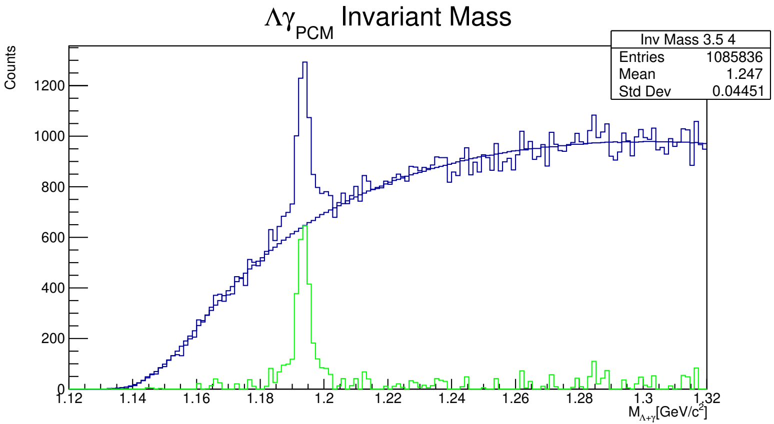
$$g(x) = a_3x^3 + a_2x^2 + a_1x + a_0$$

An exponential function approximates the peak

$$f(x) = \begin{cases} N \times e^{-(x-m)/a}, & x > m \\ N \times e^{(x-m)/b}, & x < m \end{cases} \quad (1)$$

where m is Σ^0 mass according to PDG

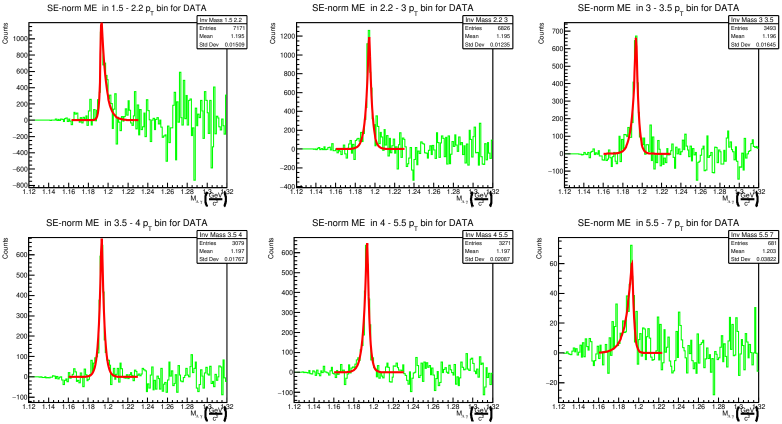
Step 4, 5 - histogram subtraction



In this plot:

- Signal histogram (subtraction result)
- Normalized mixed invariant mass histogram
- Invariant mass histogram

Step 6 - yield calculation

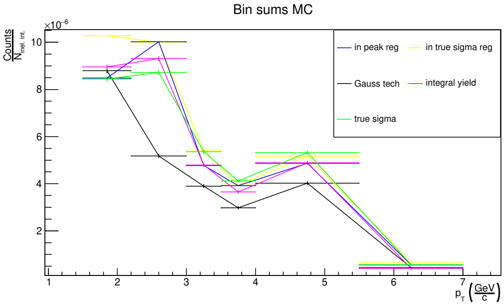


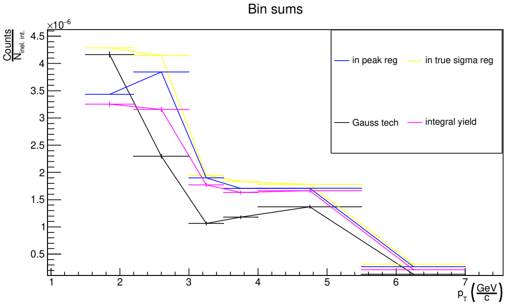
An exponential function approximates the peak

$$f(x) = \begin{cases} \mathrm{N} \times e^{-(x-m)/a}, & x > m \\ \mathrm{N} \times e^{(x-m)/b}, & x < m \end{cases} \qquad (2)$$

where m is Σ^0 mass according to PDG

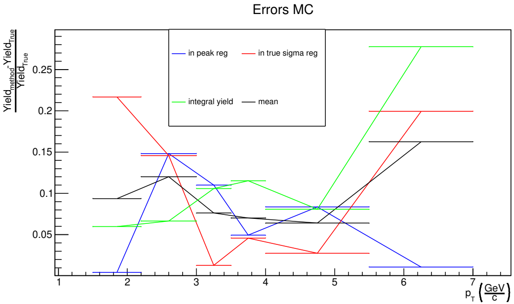
Results: yields in MC and Data

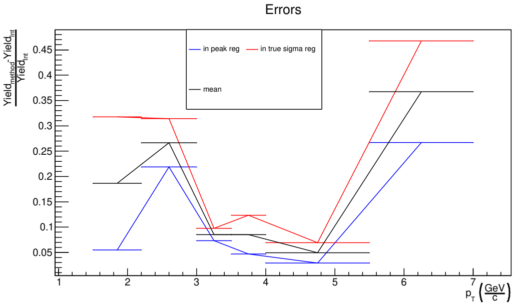




Integration under the peak is the best method

Results: systematic studies in MC and Data



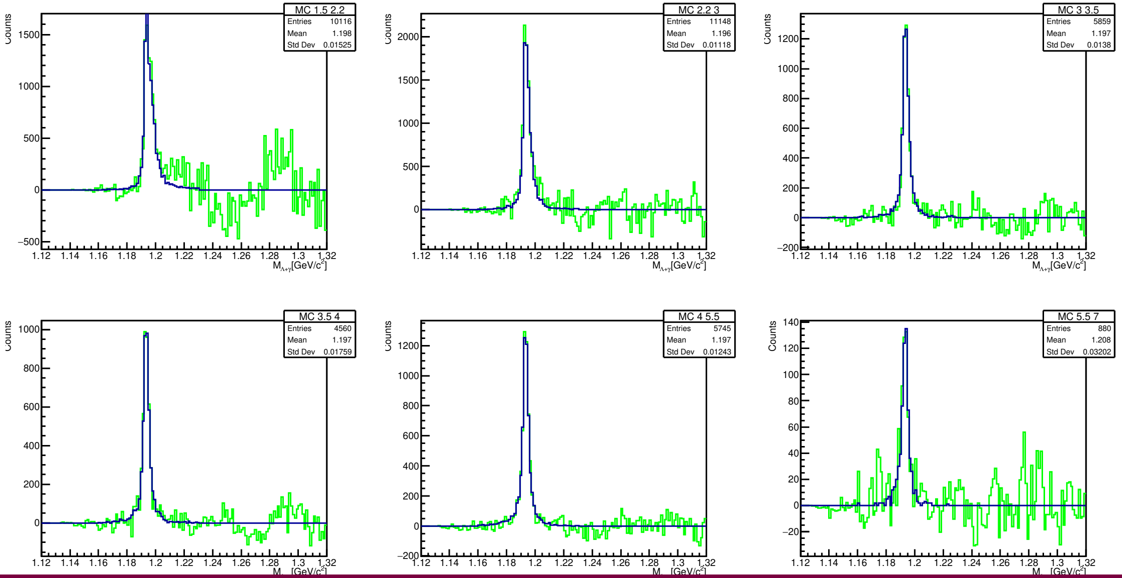


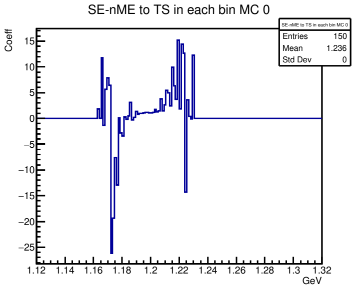
Estimated uncertainty is about 10% in MC and 15% in Data

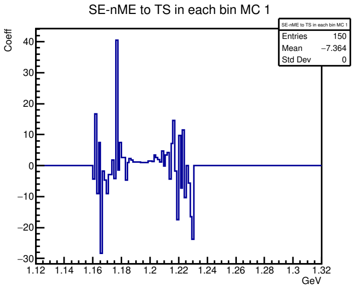
Summary

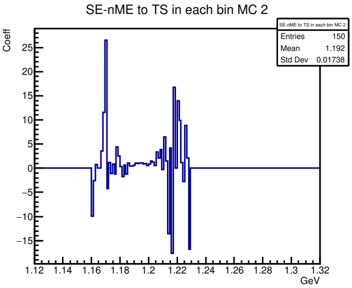
- Mixed technique is considered to be better than a gaussian yield calculation
- Integration under the the peak is accepted as the best method
- Uncertainties are estimated at 10$\%$
- These results enable to obtain Σ^0 srectrum

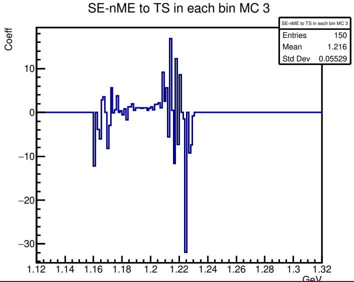
Thank you for your attention!

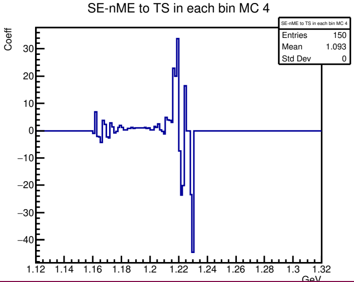

MC 1.5 2.2
Entries 10116
Mean 1.198
Std Dev 0.01525
MC 2.2 3
Entries 11148
Mean 1.196
Std Dev 0.01118
MC 3 3.5
Entries 5859
Mean 1.197
Std Dev 0.0138
MC 3.5 4
Entries 4560
Mean 1.197
Std Dev 0.01759
MC 4 5.5
Entries 5745
Mean 1.197
Std Dev 0.01243
MC 5.5 7
Entries 880
Mean 1.208
Std Dev 0.03202
Counts
$M_{\Lambda+\gamma}$[GeV/c^2]

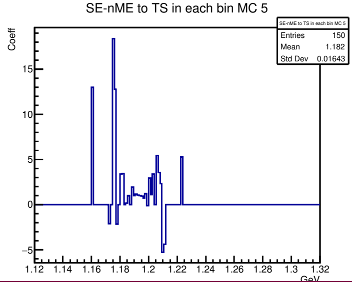

SE-nME to TS in each bin MC 0
SE-nME to TS in each bin MC 0
Entries 150
Mean 1.236
Std Dev 0
Coeff
GeV


SE-nME to TS in each bin MC 1
SE-nME to TS in each bin MC 1
Entries 150
Mean −7.364
Std Dev 0
Coeff
GeV


SE-nME to TS in each bin MC 2
SE-nME to TS in each bin MC 2
Entries 150
Mean 1.192
Std Dev 0.01738
Coeff
GeV


SE-nME to TS in each bin MC 3
SE-nME to TS in each bin MC 3
Entries 150
Mean 1.216
Std Dev 0.05529
Coeff


SE-nME to TS in each bin MC 4
SE-nME to TS in each bin MC 4
Entries 150
Mean 1.093
Std Dev 0
Coeff


SE-nME to TS in each bin MC 5
SE-nME to TS in each bin MC 5
Entries 150
Mean 1.182
Std Dev 0.01643
Coeff