Feasibility of $\rho(770)^0 \to \pi\pi$ measurement with standalone MFT tracks with ALICE

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1. Motivation

Hadronic resonances are ideal probes to characterize heavy-ion collisions. The resonances with a lifetime comparable to the hadronic phase (~ 1 - 10 fm/c) may be **sensitive to re-scattering and regeneration** which are expected to occur after chemical freeze-out (Fig. 1). The final state yields can be suppressed by the re-scattering and can be increased by regeneration. The cumulative effect depends, among other parameters, on the lifetime of the hadronic phase and the resonance and medium density. The production of $\rho(770)^0$, $K^*(892)^0$ and $\Lambda(1520)$ [1-3](Fig. 2) at midrapidity has been observed consistent with prediction including these effects in the hadronic phase. $\rho(770)^0$ measurement at forward rapidity with different hadron density from midrapidity can provide further insight into the dynamics in the hadronic phase.

In this poster, we will show the **feasibility of measuring $\rho(770)^0$ at forward rapidity in pp at $\sqrt{s}$ = 13.6 TeV**.

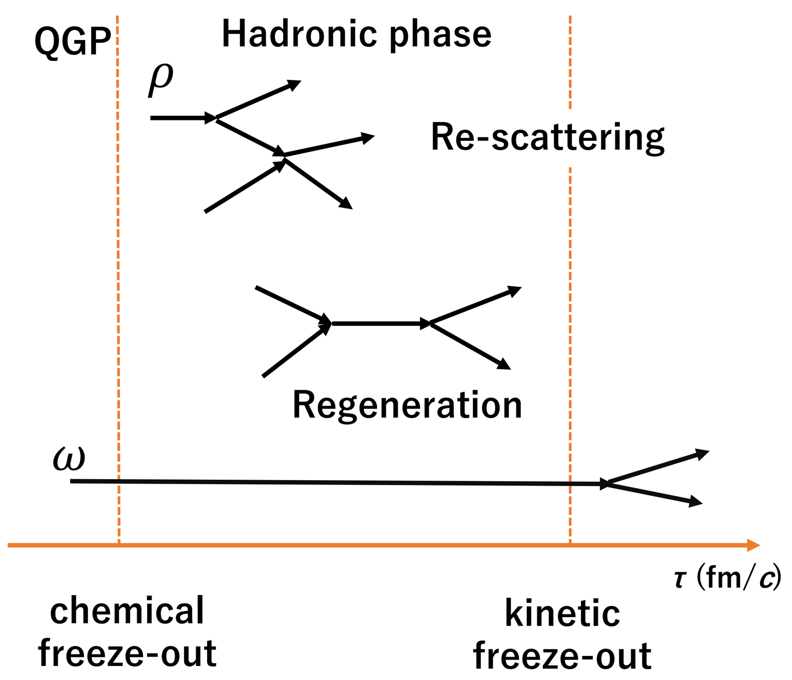

Fig. 1 Illustration of re-scattering and regeneration

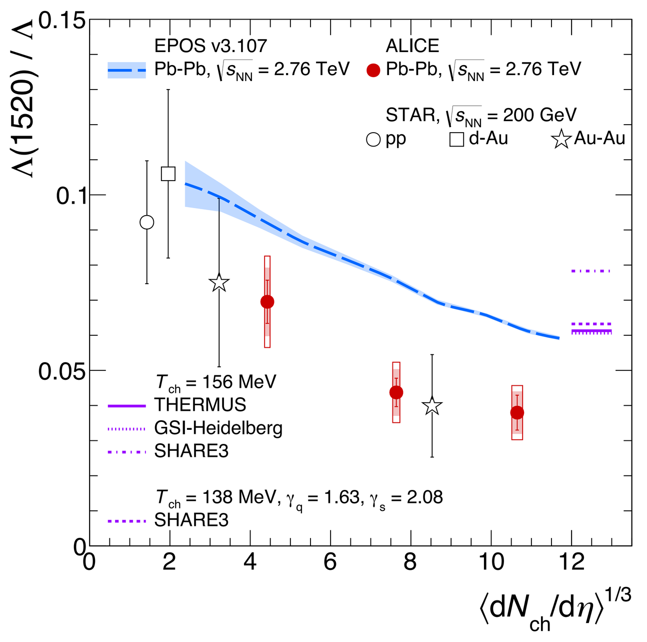

Fig. 2 p_T-integrated ratio of $\Lambda(1520)/\Lambda$ production as function of $\Lambda\langle dN_{ch}/d\eta\rangle^{1/3}$

2. Muon Forward Tracker

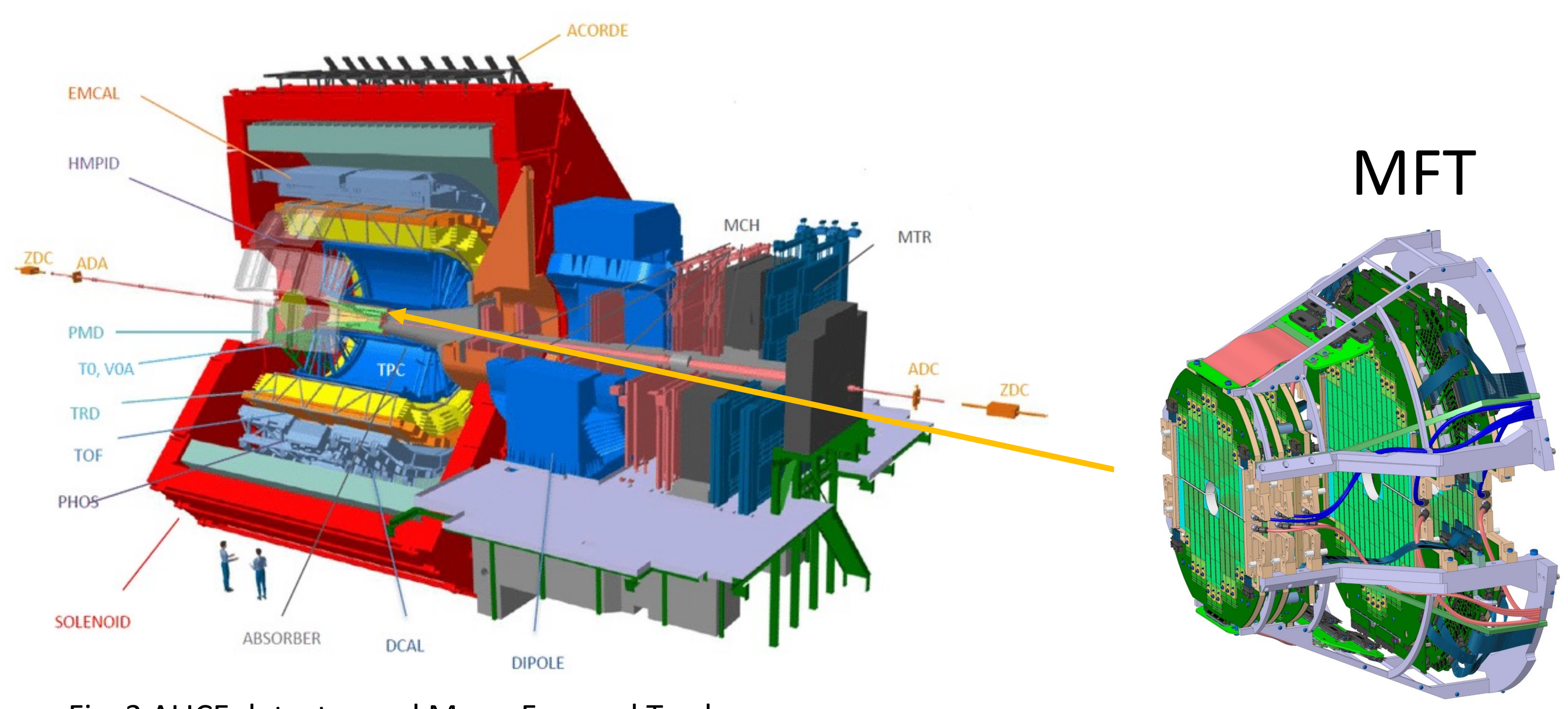

Fig. 3 ALICE detector and Muon Forward Tracker

Muon Forward Tracker (MFT) was a precise silicon pixel detector with 5 layers and was newly equipped in front of the hadron absorber in 2021 (Fig.3). The acceptance is covered for 2.45<$|\eta|$<3.6 and -π<φ< π. In addition to precise tracking, the weak magnetic field is applied from the solenoid, allowing the determination of <u>transverse momentum with a resolution of 50 %.</u>

3. Mass reconstruction method

$\rho(770)^0$ can be reconstructed via the invariant mass of a pion pair, which is effective since $\rho(770)^0$ decays into two pions with its BR of approximately 100%. However, the MFT cannot identify particles. It is **assumed that all particles detected by the MFT are pions**, because 80% of the injected into the MFT are pions.

The invariant mass of pion pair is calculated as

$$M_{\pi\pi} = \sqrt{(E_0+E_1)^2 - (p_{x_0}+p_{x_1})^2 - (p_{y_0}+p_{y_1})^2 - (p_{z_0}+p_{z_1})^2}$$

where, energy of a pion is calculated as $E_i = \sqrt{M_\pi^2 + p_{x_i}^2 + p_{y_i}^2 + p_{z_i}^2}$ (i = 0,1) and p_{j_i} (i = 0,1, j=x,y,z) is three momentum of a pion.

4. Pion pair mass spectrum

The invariant mass spectrum of pion pairs (Fig. 4) was calculated using the MFT tracks using Monte-Carlo simulation data in pp at $\sqrt{s}$=13.6 TeV by PYTHIA (Monash 2013). It is found **that ρ meson is dominant in the mass region above 0.8 GeV/c**, and the main component of the high mass tail shown due to MFT's resolution is ρ meson.

the mass of ω meson is about 782 MeV/c, but the peak of ω meson in the invariant mass spectrum is shifted. This is because ω meson decays into $\pi^0\pi^-\pi^+$, but π^0 cannot be detected by the MFT as silicon pixel detectors.

As a result, we **can measure the final state yield of ρ meson by fitting with Breit-Wigner above 0.8 GeV/c.**

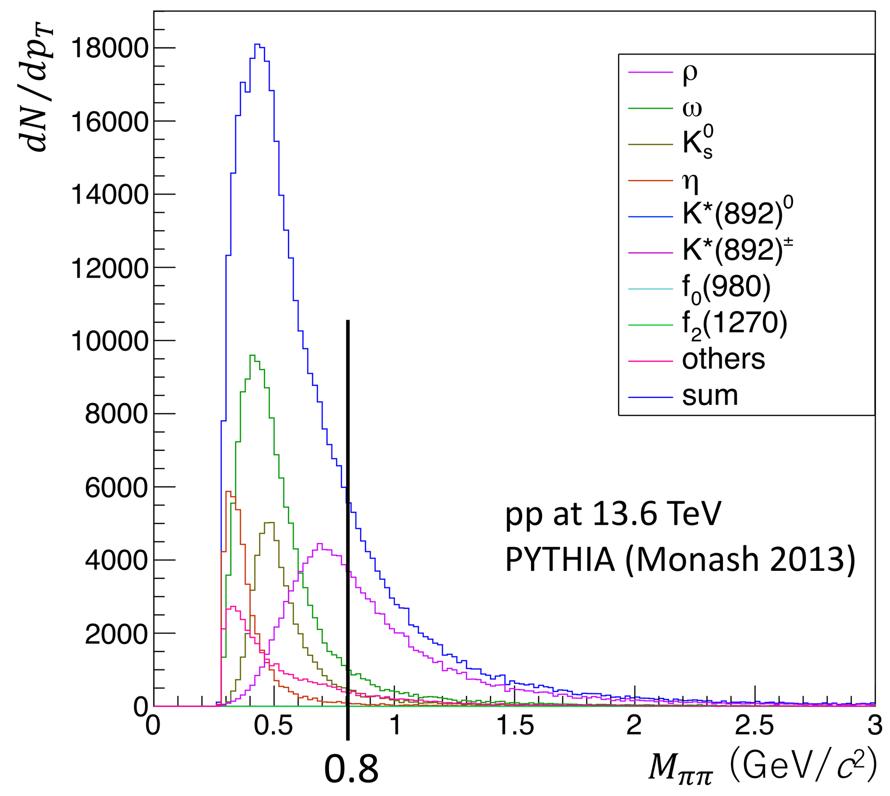

Fig. 4 Pion pairs mass spectrum in pp at 13.6 TeV

5. Subtraction of uncorrelated background

The invariant mass spectrum (Fig. 4) does not include the uncorrelated background. The uncorrelated background is subtracted with the like-sign pair method. In the simulation data, the black line in Fig. 5 (a) represents the result after subtracting the uncorrelated background using

$$\frac{dS}{dm} = \frac{dN^{\pm}}{dm} - 2\sqrt{\frac{dN^{++}}{dm}\frac{dN^{--}}{dm}}.$$

where, dS/dm is the number of signals (ρ -> ππ), $dN^{\pm}/dm$ is the number of unlike sign pion pairs, dN^{++}/dm is the number of positive pion pairs dN^{--}/dm is the number of negative pion pairs .

<u>Ambiguous track means a track that has been associated with multiple collision events</u>. **More than 80% of MFT tracks are ambiguous tracks** in pp at 500 kHz. This leads to the possibility of uncorrelated background caused by the incorrect association between tracks and collisions. Therefore, using MC information, the uncorrelated background was subtracted with the like-sign method for cases with no ambiguous tracks. The result is shown in the Fig. 5 (b). It can be seen that **the subtracted result is almost consistent with the sum of the cocktail**.

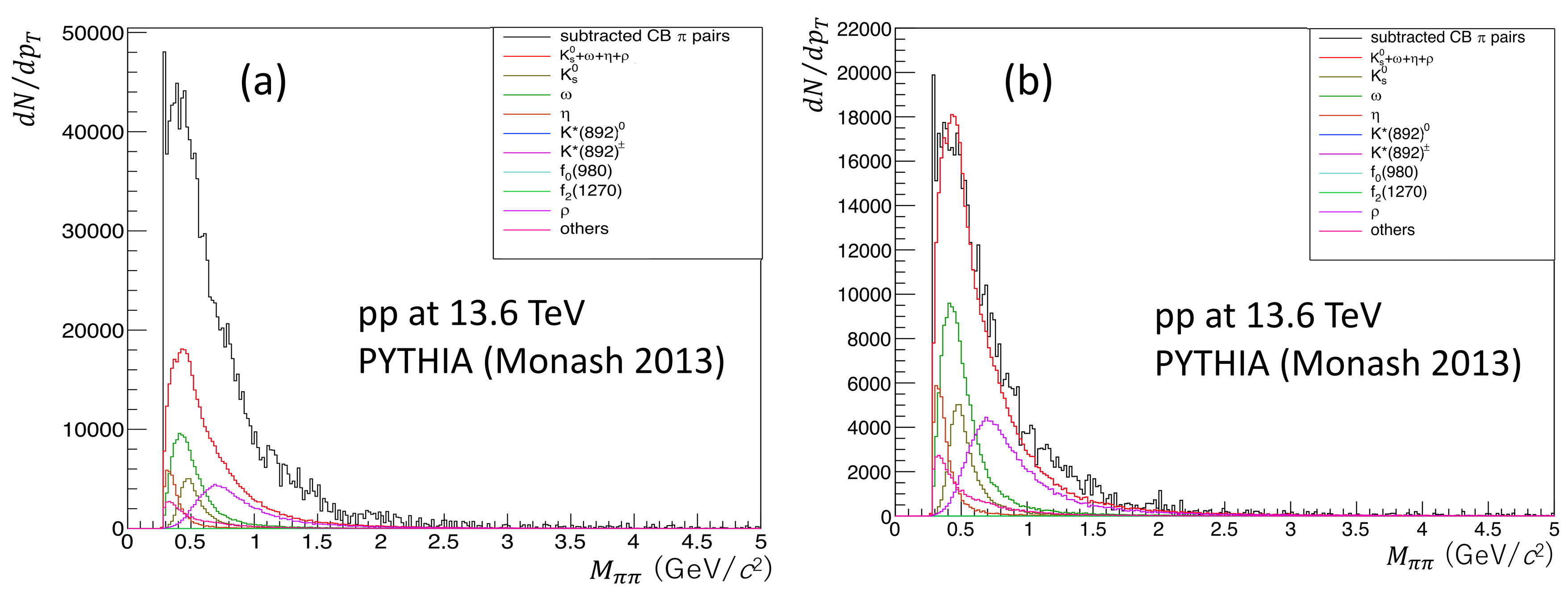

Fig. 5 Comparison between pion pairs cocktail and mass spectrum after subtraction of uncorrelated BG
(a) including ambiguous tracks, (b) no ambiguous tracks

6. Summary and Prospects

The short lifetime resonances such as ρ meson are expected to be affected by re-scattering and regeneration after chemical freeze-out at nuclear collisions. We plan to measure ρ meson with the standalone MFT tracks at forward rapidity. This poster shows the feasibility of ρ meson measurement. The yield of ρ meson is expected to measure for $M_{\pi\pi}$>0.8 GeV/c^2. We're reassigning ambiguous tracks to collisions to subtract the uncorrelated background precisely.

Reference

[1] ALICE collaboration, Phys. Rev. C 99, 064901 (2019)
[2] ALICE collaboration, Phys. Rev. C 91, 024609 (2015)
[3] ALICE collaboration, Phys. Rev. C 99, 024905 (2019)

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