accurate detection of grain pile height and locate the foreign bodies in the silo. Suffice it to say that our method lays the technical basis for the extraction of effective target echo [12].

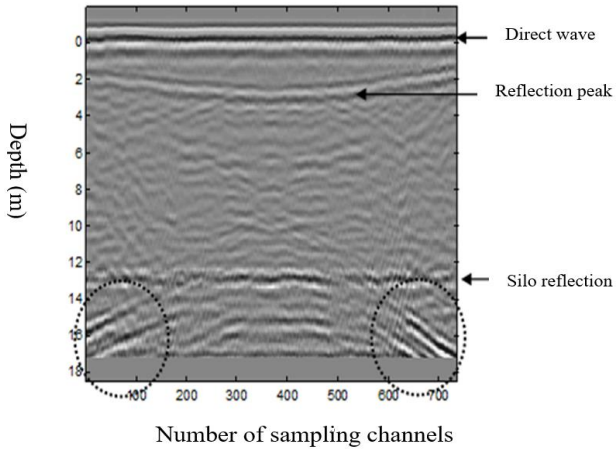

Figure 9. GPR image of the target silo

6. CONCLUSIONS

In light of the features of grain and silos, this paper designs an electromagnetic way to detect grain pile density and height in silos. Firstly, the mean dielectric constant of the target silo was derived from the estimated velocity of the GPR wave. Then, relationship between dielectric constant and density was established by free-space transmission detection method. After that, the mean dielectric constant was substituted into the relationship model to determine the mean grain density. In addition, the proposed method was applied to simulation and experiments on actual silos. The research results show that the GPR detection performance in grain silos depends on the following factors: silo shape [13], actual height of grain pile, the electromagnetic features of grain, reflection surface, antenna parameters, and detection frequency.

The free-space transmission detection method and the proposed relationship model can be applied to measure the properties of other agricultural products with small particle size and determine their density in storage. Of course, the model parameters should be redefined through experiments. The research findings lay a theoretical basis and provide technical support to the selection of the performance parameters of the GPR in silo detection.

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