BESIII

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1 The BESIII experiment

The BESIII experiment [1)] is taking data at the BEPCII electron-positron collider at IHEP, Beijing. The center-of-mass energy region from 2 to 4.9 GeV offers vast and diverse physics opportunities at the boundary between the perturbative and non-perturbative regimes of QCD. Results from BESIII are playing an important role in the understanding of the Standard Model and will also provide important calibrations for the Lattice Gage community. Studies of tau-charm physics could reveal or indicate the possible presence of new physics in the low energy region.

BESIII is a multi-purpose detector designed to study physics in the tau-charm energy region of BEPCII double ring electron-positron collider. The rich physics program includes:

- tests of electroweak interactions with high precision in both the quark and lepton sectors
- high statistics study of light hadron spectroscopy and decay properties
- study of the production and decay properties of J/ψ, $\psi(3686)$, $\psi(3770)$ states with large data samples and search for glueballs, quark-hybrids, multi-quark states and other exotic states via charmonium hadronic and radiative decays
- studies of XYZ states
- studies ot tau-physics
- precision measurements of QCD parameters and CKM parameters
- barion form factors measurements via ISR process and via energy scan
- search for new physics by studying rare and forbidden decays, oscillations, and CP violations in c-hadron and tau-lepton sectors.

The LNF group is involved in the upgrade of the BESIII Inner tracker (IT) with a new Cylindrical GEM (CGEM) detector. The project, among Ferrara and Turin INFN sections, also includes groups from Mainz, Uppsala and IHEP, has been recognized as a Great Relevance Project within the Executive Program for Scientific and Technological Cooperation between Italy and P.R.C. for the years 2013-2015, it has been funded by the European Commission within the BESIIICGEM RISE-MSCA-H2020-2014 project which lasted until 2018, while in 2019 it received funding within the FEST RISE-MSCA-H2020-2020 project, which started in 2021 due to Covid-19 delays. The group is also involved, together with the Perugia group, in the analysis of several physics processes involving baryons and light hadrons.

2 Physics analysis

Study of the complex structure of the ratio G_E^Λ/G_M^Λ

We are preparing the theoretical procedure [2)] developed on the first BESIII measurement of the modulus and the phase of the ratio between the electric, G_E, and magnetic, G_M, form factors of the Λ baryon, to analyze the new BESIII data. These data are promising because are more precise of the previous ones, and the energy points cover a wider interval hence they provide compelling constraints in determining crucial features of form factors as space-like zeros.

A microscopic model for nucleon form factors

Recent near threshold BESIII data for the nucleon time-like effective form factors are investigated by means of microscopic model. The model is constructed by using light cone distribution amplitude expansions, where non-perturbative effects are accounted for by considering energy-dependent coefficients. The free parameters are determined by fitting the obtained theoretical descriptions to the data. The aim is to identify the origin of the observed oscillations and distinguish between intrinsic dynamical mechanisms and final state interactions.

The $\Lambda\bar{\Sigma}^0$ transition form factors

Since the strong interaction conserves isospin, the decay process $J/\psi \to \Lambda\overline{\Sigma}^0$ has to proceed only electromagnetically. It follows that the total electric and magnetic $\Lambda\overline{\Sigma}^0$ transition form factors, i.e. the amplitudes of the $\sin^2(\theta)$ and the $\left(1+\cos^2(\theta)\right)$ angular distribution components, are proportional to the pure electromagnetic form factors. As a consequence, the phase and the modulus of the ratio of the total form factors, measured at the J/ψ mass correspond to the phase and the modulus of the ratio of the electromagnetic ones.

We are studying the possibility of an isospin-violating contribution using the $e^+e^- \to \Lambda\overline{\Sigma}^0$ cross section values measured outside the J/ψ mass. It has been estimated [3)] that the intensity of such a contribution can vary between the 15% and the 215% of the electromagnetic one, depending on the interference.

3 The BESIII CGEM Status

Based on the experience of the KLOE2-CGEM Inner Tracker, we started developing a three-layer triple-GEM detector [4)] with analog readout as IT for the BESIII experiment. The analog readout is the most important improvement with respect to KLOE2, and offers the best compromise between improved spatial resolution and reasonable number of instrumented channels.
L1 and L2 cylinders have been at IHEP in stable conditions taking cosmic rays events, since 2019. For the last cylinder L3 constrution, a hybrid procedure was followed: the five cilinders composing L3 (three Gem layers, cathode and anode) have been built in Ferrara, then they have been shipped in five different safe boxes to IHEP together with the Vertical Insertion Machine (VIM)from Frascati. At IHEP, in a reniewed clean room, the five cilynders have been assembled one into the other using VIM and following the procedure used in Frascati for the other layers, with the addition of peek greeds between each cylinder in order to improve the robustness of the biggest cylinder. By the end of 2023 the whole CGEM-IT was assembled, tested for gas leaks, equipped with front end electronics, HV/LV cables connected and is ready to take cosmic data for commissioning and calibration.

References

1. White Paper on the Future Physics Programme of BESIII BESIII Collaboration (M. Ablikim (Beijing, Inst. High Energy Phys.) et al.). Dec 12, 2019. 210 pp. HEP-Physics-Report-BESIII-2019-12-13 e-Print: arXiv:1912.05983 [hep-ex]

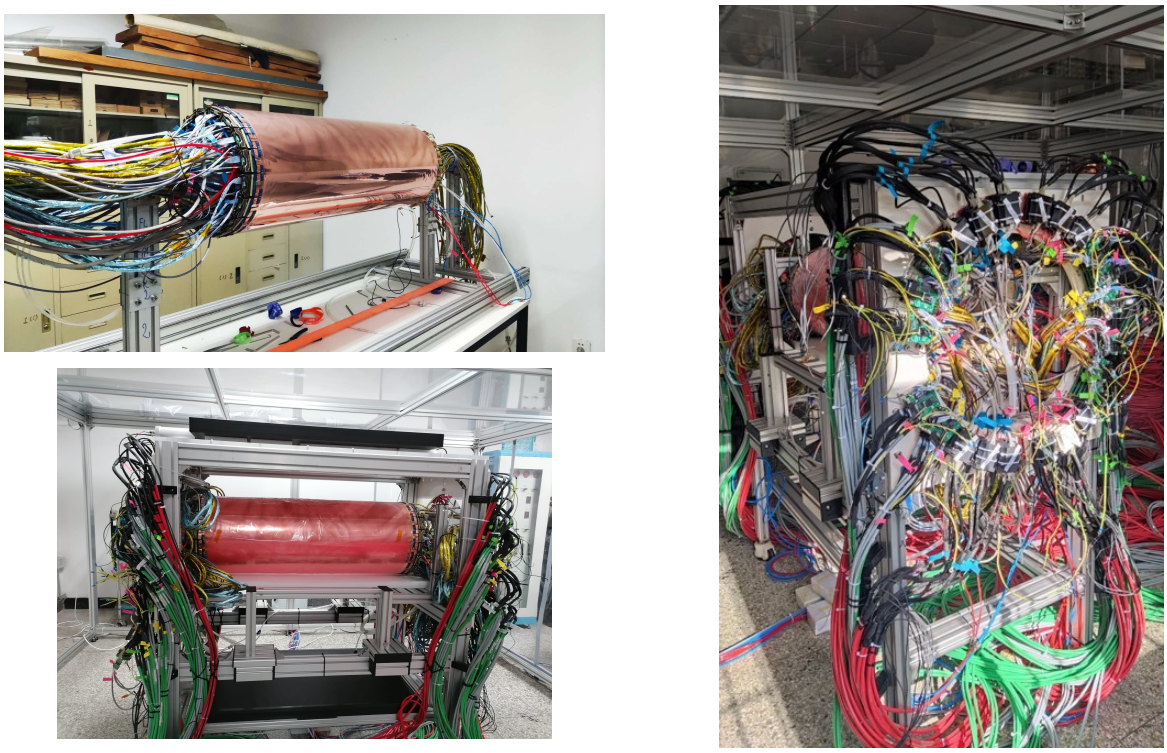

Figure 1: top left: L3 cylinder completed and cabled at IHEP, left and bottom right: front and lateral view of the completed CGEM-IT with cablings at IHEP

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3. R. B. Ferroli, A. Mangoni and S. Pacetti, Eur. Phys. J. C **80**, no.9, 903 (2020) doi:10.1140/epjc/s10052-020-08474-x [arXiv:2007.12380 [hep-ph]].

4. The BESIII Collaboration, "Conceptual Design Report: BESIII Cylindrical GEM Inner Tracker" (2014).