Wigner 121
Scientific Symposium

Wigner Research Centre for Physics
Institute For Particle And Nuclear Physics
Department of High Energy Physics
Standard Model and New Physics Research Group

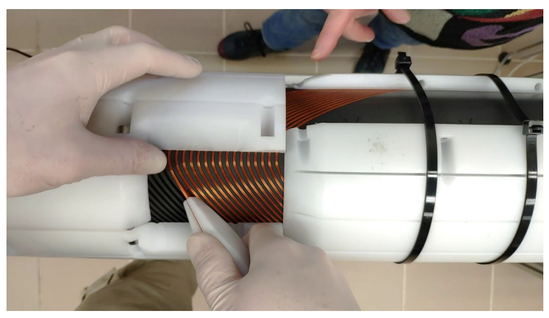
Introduction

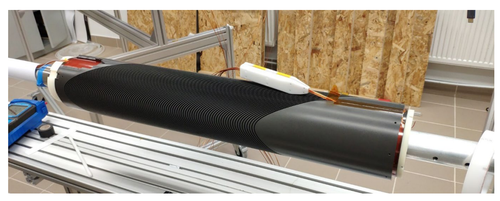
The Standard Model and New Physics Research Group was established to study the properties and behavior of elementary particles and to search for discrepancies from the standard model of particle physics and new phenomena in high energy proton-proton collisions.
The group has two main activities: we participate in the research and development of future particle accelerators and semiconductor detectors, and perform physics analyses on data collected at the Large Hadron Collider (LHC), in collaboration with the Compact Muon Solenoid (CMS) experiment and various R&D projects at the European Organization for Nuclear Research (CERN).

Future particle accelerator R&D

We are contributing to the development of superconducting magnets for new generation particle accelerators, such as the „SuShi septum", to be used for beam extraction at the Future Circular Collider (FCC).

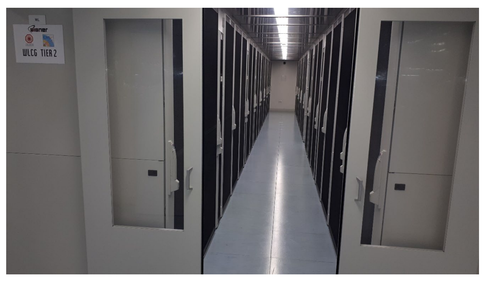
- Development of NbTi and high temperature (HTS) canted-cosine-theta (CCT) superconducting magnet prototypes
- Development of wax impregnation method of CCT magnet
- Training and quench testing of the „SuShi septum" magnet prototype
- Development of design tools for HTS winding geometries
- Participation in the I.FAST and HITRI+ European projects to develop a compact superconducting synchrotron for proton and carbon ion treatment of tumors





Computing infrastructure

We operate a Tier 2 WLCG (Worldwide LHC Computing Grid) site which serves the Alice and CMS experiments at CERN. 4000 CPU cores and 3.6PB of disk storage are housed in a recently built computing center with 100Gb network connection (LHCONE) and modern, high efficiency cooling and UPS equipment.



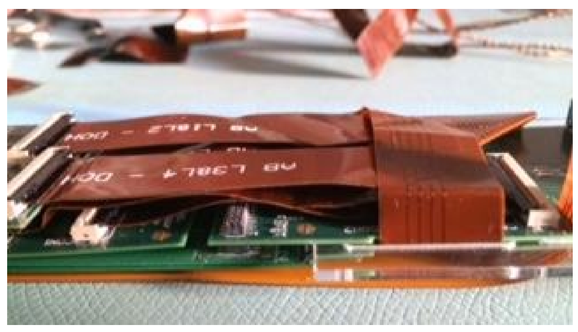
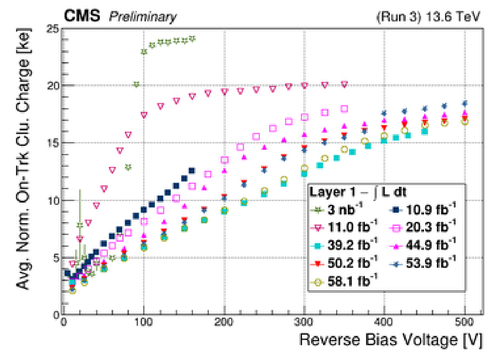
Publications

1) CMS Tracker Collaboration, *The CMS Phase-1 Pixel Detector Upgrade*, JINST 16 (2021) P02027
2) CMS Tracker Collaboration, *The DAQ and control system for the CMS Phase-1 pixel detector upgrade*, JINST 14 (2019) P10017
3) Viktor Veszprémi, *Status of the CMS pixel detector*, PoS(Pixel2022)008 , 13 p. (2023)
4) CMS Tracker Collaboration, *Test beam performance of a CBC3-based mini-module for the Phase-2 CMS Outer Tracker before and after neutron irradiation*, JINST 18 (2023) P04001
5) CMS Collaboration, *Inclusive search for supersymmetry in pp collisions at √s = 13 TeV using razor variables and boosted object identification in zero and one lepton final states*, JHEP 1903 (2019) 031
6) E. De Matteis et al., *Straight and curved Canted Cosine Theta superconducting dipoles for ion therapy: comparison between various design options and technologies for ramping*, IEEE Transactions on Applied Superconductivity 33 (2023), 1-7
7) D. Veres, T. Vaszary, E. Benedetto, D. Barna, *A New Algorithm for Optimizing the Field Quality of Curved CCT Magnets*, IEEE Transactions on Applied Superconductivity 32 (2022), 4900914
8) D. Barna et al., *The Superconducting Shield (SuShi) septum magnet prototype*, Proceedings of MT27, IEEE Transactions on Applied Superconductivity 32 (2022), 1-5

Operation of the CMS tracker detector at LHC

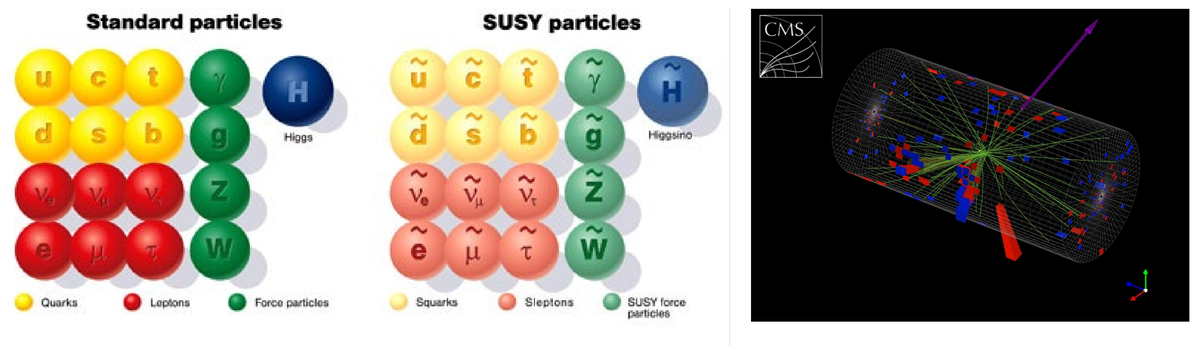
The CMS detector, situated at one of the collision points of the LHC, is a complex system comprised of various sub-detectors, each with different purposes. Our group is participating in the operation and construction of the **Tracker detector.** Some of our main contributions:

- Production of the control and read-out electronics (in collaboration with local companies) for the present barrel pixel detector, comissioned in 2017
- Software developments: reconstruction of raw measurement data and detector simulation
- Calibrations and performance studies of the pixel detector (e.g. radiation damage analysis)

Physics analyses at the CMS experiment

We are pursuing different analyses using high statistics proton-proton collision data collected by the CMS experiment at 13 TeV center-of-mass energy, in order to study the properties of the standard model with precision measurements and to search for any signs of new physics.

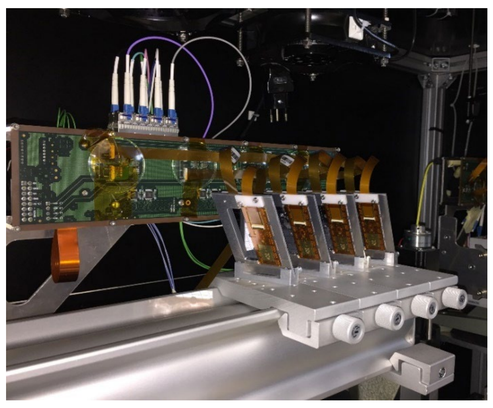
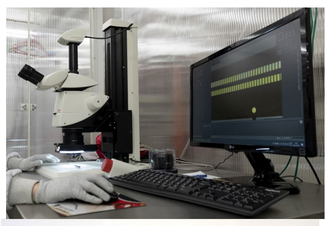


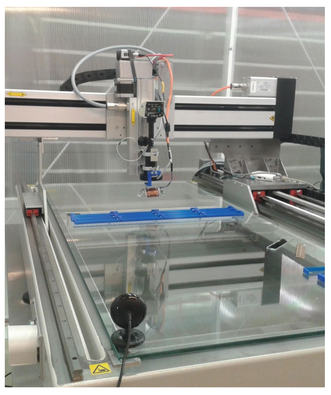
- Study of the Z boson production with two heavy flavor jets (both originating from b or from c quarks) and measurement of the σ(Z+bb)/σ(Z+cc) cross-section ratio
- Inclusive search for supersymmetry using razor variables and boosted object identification in zero- and one-lepton final states
- Search for supersymmetry in final states of photon, b-tagged jets and missing transverse momentum, motivated by the gauge mediated supersymmetry breaking model (in collaboration with MTA-ELTE Lendület CMS Particle and Nuclear Physics Group)

Phase 2 Upgrade of the CMS Tracker

The High Luminosity LHC (HL-LHC) will start colliding particles in 2029 at 14 TeV center-of-mass energy with unprecedently high proton collision rate. During the Long Shutdown 3, scheduled between 2026 and 2028, CMS will replace its entire tracking system for the start of the new data taking phase. We are participating in the development, prototype testing and construction of the new Phase 2 Tracker:

1) Front-end control board and reconstruction software for the CHROMIE test-beam telescope to be used for performing extensive prototype module testing
2) New FPGA-based μTCA back-end electronics system and firmware development for timing, trigger and control distribution for high-rate system tests
3) Visual inspection of about 20.000 Phase 2 Outer Tracker module components during the two years of the production period with stereo-microscopes and automated measurements using a large area optical scanner



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