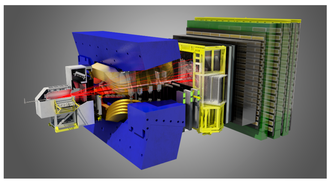
Romanian Participation in the Large Hadron Collider beauty Collaboration

LHCb Romanian Group
http://www.nipne.ro/dpp/Collab/LHCb/index.html

LHCb

Large Hadron Collider beauty

1. single-arm spectrometer studying the decays and production of beauty and charm hadrons,
2. does precise tests of Standard Model of Elementary Particles Physics (SM),
3. searches for indirect evidence of New Physics.

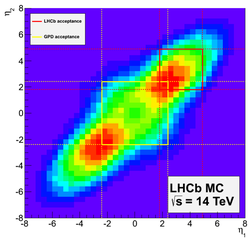


LHCb detector 3D view - preset

4. SM can not cope with the large baryon to anti-baryon asymmetry in the early universe,
5. SM can not explain the mass hierarchy problem, from photons to Planck scale.

- Physics studied at LHCb: Charge-Parity CPV parameters in beauty and charm sectors, B_0 and B_s mixing observables, CKM angle and parameter determination, Beauty decay to charm-less states, Semileptonic decays and semileptonic asymmetry, Flavor-Changing-Neutral-Currents (FCNC), angular and polarization analyses of complex decay channels, right handed currents, EW and gluonic "penguin" transition, spectroscopy, etc..

LHCb Forward physics:



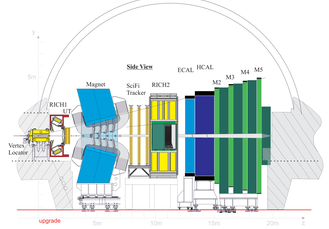
$b\bar{b}$ quark pairs in LHCb and GPD detectors

1. 25 % of produced beauty could be accessible to LHCb.
2. spectrometer is fully instrumented in forward region.

LHCb Upgrade

A very ambitious program of Upgrade is foreseen for the next long shut-down of LHC.

1. The future LHCb detector should collect 10-20 times more signal data compared with the ongoing phase.
2. It is expected that almost the same scientific, technological and financial effort will be invested in this complete redesign of detector, relative to its construction.
3. It would allow to increase significantly the detection efficiency and detection rate by taking full advantage of LHC beam. .

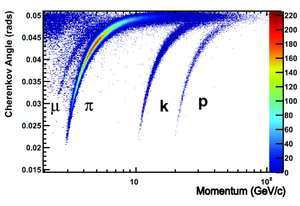


LHCb detector sectional view - after Upgrade most sub-components modified technologically

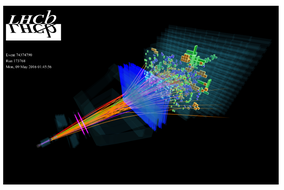
LHCb RICH Upgrade

Ring Imaging Cherenkov Detectors : RICH1/RUCH2

- Cherenkov light detectors determine the identity of particles in the final state after LHC hadron-hadron collision.
- Light is to be collected on thousands of Multianode Photo Multiplier Tubes (MaPMT) with high quantum efficiency.
- The electronics and MaPMT system need to operate at 40 MHz read-out rate, currently the sensors do not exceed 1 MHz rate.
- Electronics and sensors need to survive for more than 10 years in harsh LHC environment.



Cherenkov angle versus particle momentum - present detector



Full reconstruction of an LHCb event in the 2016 data, Kaon, pion and other particle tracks visible

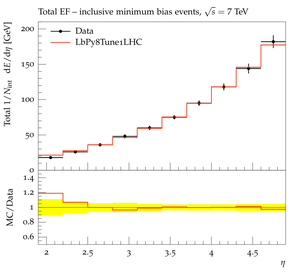
IFIN-HH and USV in LHCb Collaboration

IFIN-HH is party to the LHCb Memorandum of Understanding - MoU 2000 and 2002 - since beginning, and the first Romanian involvement in LHCb Collaboration could be traced back to 1996 soon after the LHCb Letter of Intent was sent to CERN management..

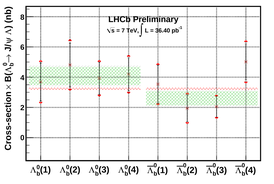
- USV and IFIN-HH groups are collaborating on LHCb-related projects since 2015 and the USV PhD and Master students are LHCb-Ro group members since 2013.
- LHCb-Ro is the Youngest Romanian CERN group with a large fraction of PhD and Master students

Romanian contributions to LHCb Construction, LHCb Physics and Monte Carlo studies, Grid and Computing, Upgrade (chronologically):

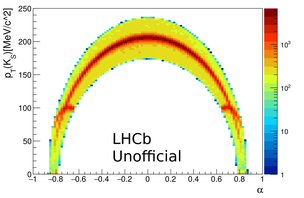
1. Hadronic CALorimeter (HCAL) construction and R&D,
2. Detector and online Software, Web Data Base for LHCb shifts,
3. LHCb-dedicated Grid computing Tier-2 sites,
4. Permanent MoU tasks on LHCb paper reviews, conferences, proceedings, organizing various Physics and Upgrade sub-groups, LHCb analyses reviewing, plus other tasks
5. An extended Outreach program,
6. Monte Carlo simulation and development for LHCb software,
7. Beauty Lambda-baryon production in the forward direction,
8. Light hadron production studies, strangeness production, soft-QCD and Minimum Bias Physics at LHCb,
   - Lead-proton collision studies of hyperon Ξ, Ω production
   - Strange neutral Kaon and Lambda baryon production
   - Production ratios
9. Monte Carlo tuning of PYTHIA generator for LHCb Simulation software,
10. Rare radiative decays of beauty Lambda baryons and hadrons, systematic error studies,
11. Particles correlation studies and QCD,
12. Physics QCD observations for non-perturbative domain,
13. Upgrade R&D,
    - RICH MaPMT acquisition and studies
    - Front-end electronics R&D
    - Radiation hardness studies of ASIC and FPGA chips
    - Beam testing of electronics.with hardware and software studies
14. Test firmware for FPGA radiation-hardness testing,
15. Construction of the new sob-modules for RICH Upgrade,.
16. Several PhD and Master students have worked and are working for IFIN-HH and USV LHCb groups.



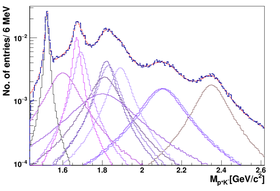
Energy flow for charged and neutral particles in LHCb Minimum Bias Events, RIVET superimposing of PYTHIA generator result over LHCb measurements - Recipe for Collision Generator tuning



LHCb Cross-section measurement for Λ_b production through $\Lambda_b \to \Lambda J/\Psi$ decay channel, collision energy in center of mass for LHC proton-proton system is 7 TeV



Armenteros-Podolansky plot of K_S and Λ in data



Intermediate resonances in $\Lambda_b \to \Lambda^* \left(p^+ K^-\right) \gamma$

LHCb-Romanian Upgrade R&D

Test of radiation hardness of Xilinx'Kintex-7 FPGA in a beam of high energy ions, at Centre de Ressources du Cyclotron at Louvain la Neuve, Heavy Ion Irradiation facility (HIF).

LHCb-Ro group has key R&D contribution to the RICH Upgrade program - Radiation hardness and aging studies for electronics and sensors:

- Tests on Omega MAROC3 at IFIN-HH using proton and X-ray beams,.
- Radiation hardness tests at Legnaro Laboratory and at Louvain University center HIF - the latter through AIDA2020 EU program - ion beam testing,
- Test of FPGA and ASIC radiation hardness at Paul Scherrer Institute - Proton Irradiation Facility,.
- Many other radiation hardness tests planned in the next year,

LHCb-Romanian Outreach program

Photo of the high-school classes attending the LHCb-CERN Master Classes on Particle Physics at University Bucharest, event organized by LHCb Romanian group in collaboration with CERN and LHCb.

- Master Classes on Particle Physics for LHCb/CERN, yearly event organized at USV and/or IFIN-HH.
- TEDxCERN events organized at IFIN-HH
- Various outreach local events in Bucharest and Suceava, for high-school and university students
- IFIN-HH open-gate program for the very young "Scoala Altfel"

LHCb Computing and Grid, Acknowledgments

LHCb Grid resources vs requirements

- Equivalent of tens of thousands CPU cores working continuously,
- 21.6 PB of tape and 16.9 PB of disk storage (used by end of 2015),
- LHCb physics signal events are stored to disk at a maximum rate of about 12 kHz, for Upgrade a average 100 kHz rate is foreseen,.
- Special considerations for computing model: trigger, reconstruction, stripping data analyzing,
- Simulation and Monte Carlo generation of various fundamental processes..

Romanian contribution to LHCb-Grid and Computing

- 2 Grid sites of Tier-2 Type: Ro-11 (LHCb-exclusive) and Ro-7 - this site is a Tier-2 D processing real data in addition to Monte Carlo and User Jobs,
- Hundreds of CPU available to LHCb Users, Monte Carlo and Data processing jobs,
- More than 300 TB disk space for LHCb processing of real data,
- Personal for Grid and LHCb Computing,
- Also, the LHCb Romanian Group has its own computing infrastructure for its own PhD, Master students and researchers. doing LHCb tasks.

Acknowledgments

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- We are grateful to CERN, LHCb and our external and national partners in the integration process and the pursuing of research, academic and scientific goals.