# DEPARTMENT OF EXPERIMENTAL PARTICLE PHYSICS F-9

***Departmental research is devoted to experimental studies of elementary particles, to reveal the ultimate building blocks of matter and the nature of the interactions between them. Experiments are carried out within large collaborative programmes at international centres for particle physics at CERN near Geneva and at KEK in Tsukuba. The department is also engaged in developing and applying the technologically advanced particle detectors that are demanded by such measurements. Astroparticle physics is an emerging field, applying the experimental techniques of particle physics to solve astrophysical problems. Slovenian researchers are participating in measurements of ultra-high-energy cosmic rays with the Pierre Auger observatory spread over a surface of 3000 km² near Malargue in Argentina.***

Head:
***Prof. Marko Mikuž***

In order to reveal the ultimate secrets of nature in the world of elementary particles, accelerators with higher and higher energies are needed. Their cost, both in terms of money and human resources, has grown to the level where they are affordable only as joint international enterprises. Thus, future accelerators will be unique facilities of their kind, the first being the Large Hadron Collider (LHC), just completed at the European Organization for Nuclear Research (CERN) near Geneva. Researchers will exploit this facility to perform experiments in presently inaccessible regions of energy, which, though pushed higher and higher, still remain minute compared to that of the vast blast of the Big Bang that led to the creation of the Universe.

Together with colleagues from the Physics Department of the Faculty of Mathematics and Physics and the Faculty of Electrical Engineering of the University of Ljubljana, and from the Faculty of Chemistry and Chemical Technology of the University of Maribor, we are performing measurements at CERN and the Japanese centre KEK in Tsukuba. We are taking part in two experiments, each conducted as an international collaboration:

- ATLAS at the Large Hadron Collider (LHC) at CERN (2900 researchers, 172 institutions from 37 countries),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (409 researchers, 62 institutions from 15 countries)

In the field of astroparticle physics, we are part of the Pierre Auger collaboration (250 researchers, 94 institutions from 17 countries), which uses a giant-scale (3000 km2) observatory near Malargue in Argentina for the detection of ultra-high-energy cosmic rays. This endeavour is carried out in collaboration with colleagues from the University of Nova Gorica.

A more detailed report on 2009's activities follows, focused on the contributions of our researchers:

**ATLAS experiment**

The year 2009 was the turning point for the ATLAS collaboration, as the LHC accelerator began its successful operation. The LHC circulated its first beams on 10 September 2008, but suffered a serious malfunction nine days later. A failure in an electrical connection led to serious damage, and CERN spent over a year repairing and consolidating the machine to ensure that such an incident cannot happen again. Re-commissioning the LHC began in the summer of 2009, and successive milestones have been regularly passed since then. Particles were injected on 23 October, but not circulated. On Monday 23 November, two beams circulated together for the first time, and the four big LHC detectors recorded their first collision data. Both LHC beams were accelerated to 1.18 TeV on 30 November. This is the highest energy ever achieved in accelerators. We are confident of achieving proton energies of 3.5 TeV in 2010, with good prospects of boosting them to 5 TeV.

In the period before the start of the accelerator we commissioned the ATLAS spectrometer. The work of our group was concentrated on the Beam Conditions Monitor (BCM), designed and built to warn of a possible beam loss and to prevent damage to the detector. Diamond detectors record the passage of charged particles with a time resolution a few nanoseconds, which enables the separation of events due to collisions of individual bunches and

*Figure 1: Researchers in the ATLAS control room expecting the first collisions detected with the ATLAS spectrometer.*

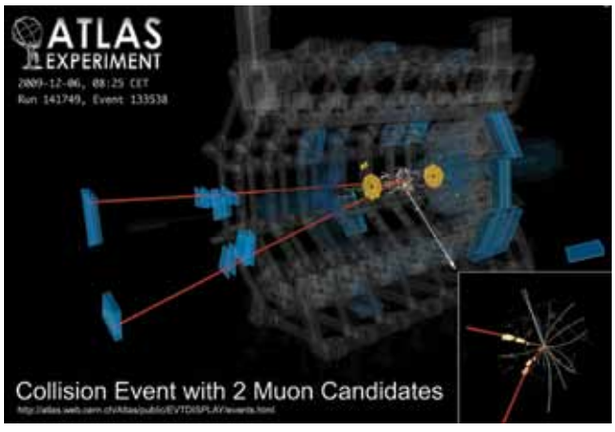


*Figure 2: The display of an event with two reconstructed muons in the forward region. The proton energy in the collisions was 450 GeV.*

- **The first collisions of protons in the LHC collider were observed in the ATLAS spectrometer on 23 November 2009. By the end of the year, the energy of protons was raised to 1.18 TeV. This is the highest energy achived in the accelators.**
- **Slovenia applied for full CERN membership in 2009 and will soon join the 20 CERN member states. Cern was established in 1954.**

the unwanted background. We completed the logic circuit (FPGA), which indicates the danger of a beam loss and records the luminosity of individual, colliding bunches of protons. The performance was first tested with cosmic rays in July. During the accelerator's operation in November and December, the BCM was finally commissioned and proved to be able to detect the potentially dangerous beam losses in the detector and abort the LHC beam. The other parts of the ATLAS spectrometer have also been successfully tested, which ensures that we will measure interesting physics events in 2010.

The ATLAS experiment will produce about a PB of data per year, corresponding to a quantity of data that can be written on 1.5 million CDs. It will be impossible to store and process the data within a single computing centre. The network infrastructure is, as a result, an additional bottleneck. One cannot expect such a quantity of data to be sent over the internet more than once: from CERN, where the experiment will take place, to one of the computing centres, where the data will actually be stored, and where particular data-processing procedures and physics analyses will take place according to the needs of the ATLAS collaboration. The use of Grid technology is the only solution, facilitating a rapid data transfer from the collider to remote centres, where such quantities of data can be stored at a sufficient rate. Due to the quantity of data and the complexity of the processing it is mandatory to also use Grid technologies for the data processing, since none of the research centres has enough storage and computing capacity.

Tier-2 SiGNET is a member of the EGEE-III and Nordugrid international grid projects. The cluster of 600 cores and 300TB of storage will double the capacity at the beginning of 2010. SiGNET was participating in the production and reconstruction of the data taken with the ATLAS detector at the LHC, making a significant contribution to the production among the 200 computing centres. We have actively participated in the development, testing and deployment of the ARC middleware. In collaboration with Arnes, the Slovenian NGI joined the computing centres within the European EGI initiative.

**Belle experiment**

One of the important unsolved questions of contemporary science is why we live in a universe in which matter (particles) completely dominates over antimatter (antiparticles). A necessary condition for this is the violation of CP symmetry, which can be measured in the world of subatomic particles. It corresponds to a small difference between the decays of particles and their anti-particles. The main purpose of the Belle detector operating at the electron-positron collider KEKB in Tsukuba, Japan, is to measure the CP violation in the system of B mesons, particles composed of heavy beauty quarks. After more than a decade of data acquisition the scientists in the Belle collaboration have experimentally confirmed the difference in the behaviour of particles and antiparticles with an unprecedented precision. The extent of the CP violation in the subatomic world, however, is not large enough to explain the large matter-antimatter asymmetry of the Universe. There must exist yet unobserved particles and processes, not included in the current theoretical explanation, that are responsible for the asymmetry. While no definite measurement of such processes exists so far, there are some measured hints of discrepancies with predictions of theoretical models. One of such hints emerged in 2009, when Belle scientists measured the angular distribution of the electron and positron in the decay of a B meson into a kaon, electron and positron. The measured data seems to be more in agreement with predictions incorporating yet unobserved supersymmetric particles than with the predictions of the Standard model of interactions among elementary particles (Fig. 3). In order to verify this and other hints of so far unknown physics processes, scientists from the Jožef Stefan Institute collaborate in the upgrade of the Belle detector, Belle II, using cutting-edge technologies to further improve the performance of the detector and the precision of the measurements. The Belle II detector is scheduled to start operating in 2013.

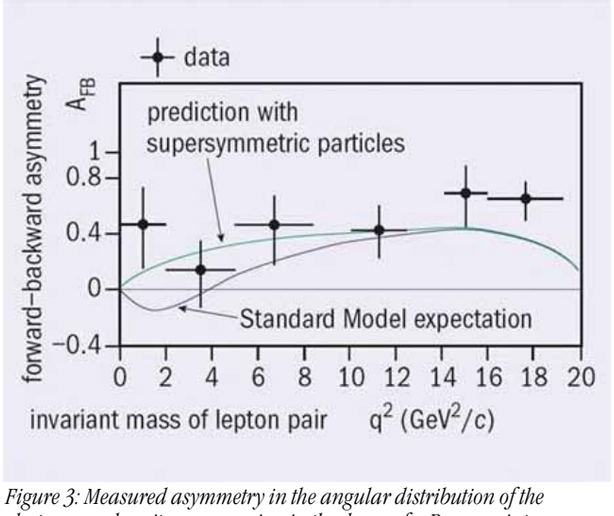


*Figure 3: Measured asymmetry in the angular distribution of the electrons and positrons emerging in the decay of a B meson into a kaon, electron and a positron. The agreement with the Standard Model prediction is not good, but data from the future Belle II detector will enable significantly more precise measurements. Adopted from J.-T. Wei et al. (Belle), Phys. Rev. Lett. 103, 171801 (2009).*

**Pierre Auger observatory**

The Pierre Auger collaboration has constructed a huge high-energy cosmic-ray observatory in Argentina covering more than 3000 km$^2$. The Auger Observatory is a "hybrid detector", employing two independent methods to detect high-energy cosmic rays. One technique detects high-energy particles through their interaction with water in more than 1600 Čerenkov detectors placed in a so-called Ground array. The other tracks the development of air shower s by detecting the ultraviolet light emitted high in Earth´s atmosphere. The observatory, originally sensitive to cosmic rays with energies above $10^{19}$ eV, was recently upgraded with the HEAT (High Elevation Auger Telescope), which extends the sensitivity to lower energies. The main physics results in 2009 are a confirmation of the correlation of the highest-energy cosmic rays with nearby active galactic nuclei and the suppression of the flux of cosmic rays above $10^{19}$ eV. An analysis of the cosmic-ray photon fraction and the diffuse flux of ultra-high-energy tau neutrinos was also published in 2009. Our group is involved in data analysis, the LIDAR system operation, the development of an offline data analysis package and the detectors' simulation and calibration.

*Figure 4: Čerenkov detectors placed in the so-called Ground array. More than 1600 such detectors measure high-energy particles through their interaction with water*

**Detector development**

In collaboration with CERN, University of Valencia, University of Michigan, Ann Arbor and Ohio State University we have continued the development of the Compton camera and a novel PET apparatus, based on position-sensitive silicon detectors. Work on a high-resolution PET probe utilizing the same technology was continued in the framework of "MADEIRA", a 7th FP EU project. We developed the technology for the production of multilayer flexible circuits with a small spacing between the lines (100 microns) in cooperation with the company ELGOLINE Podskrajnik. This will allow a more compact layout of the detectors, thereby improving the spatial resolution.

Based on a successful measurement with the silicon photomultiplier detector module, we created a new type of apparatus for positron tomography (PET) and measured its energy and time resolution. Such a counter is an extremely interesting candidate for dual-modality medical imaging, where a PET apparatus is embedded in a MRI imager, and the light sensors have to operate in magnetic fields exceeding 2 T. This research is a part of a FP7 research project aimed at the development of novel detection methods for particle physics and medical imaging. In preparation for the next generation of measurements of rare phenomena in B meson decays with the Belle II spectrometer, we continued the study of sensors for two ring imaging Cherenkov detectors. In collaboration with leading producers in this area, Hamamatsu (Japan) and Photonis (France), we studied the characteristics of photomultiplier tubes with micro-channel plates and hybrid photon detectors with avalanche photodiodes as the photoelectron detectors.

We continued with the development of silicon detectors operating in high radiation fields. We irradiated the detectors at the Reactor Centre Podgorica to high neutron doses ($10^{16}$ cm$^{-2}$), and measured the multiplication of free charge carriers near the electrodes. This phenomenon will allow the successful use of Si detectors in the upgrade of ATLAS spectrometer.

- **In more than a decade of data acquisition the scientists in the Belle collaboration have experimentally confirmed the difference in the behaviour of particles and antiparticles with an unprecedented precision.**
- **The Pierre Auger Observatory confirmed the correlation of the highest-energy cosmic rays with nerby active galactic nuclei and the suppresion of the flux of cosmic rays above $10^{19}$ eV**
- **Multiplication of the free charge carriers near the electrodes discovered after irradiations with neutrons will allow the successful use of Si detectors in the upgrade of the ATLAS spectrometer.**

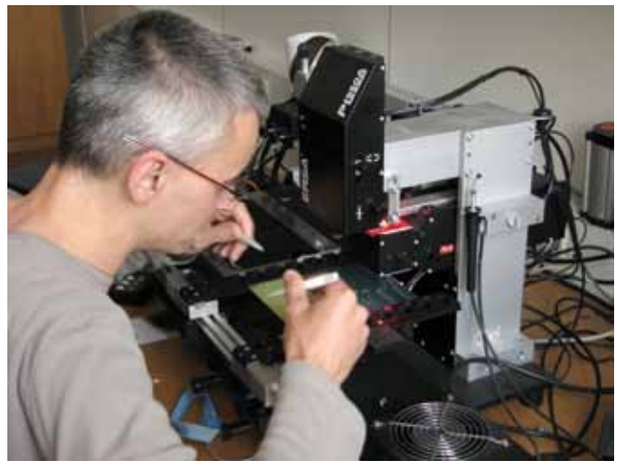

*Figure 5: Assembly of the detector module using BGA (Ball Grid Array) technology*

## Some outstanding publications in the past three years


1. The Pierre Auger Collaboration, J. Abraham et al.: Correlation of the Highest-Energy Cosmic Rays with Nearby Extragalactic Objects, Science Vol. 318. no. 5852 (2007) 938 – 943.
2. The Belle Collaboration, S.-W. Lin et al. : Difference in direct charge-parity violation between charged and neutral B meson decays , Nature 452 (2008) 332-335.
3. The ATLAS Collaboration, G Aad et al.: The ATLAS Experiment at the CERN Large Hadron Collider, 2008 JINST 3 S08003.

## Awards and appointments

1. Ilija Bizjak: Golden Emblen of Jozef Stefan for 2009, Ljubljana, Jožef Stefan Institute, Award for excellence of the doctoral thesis in the field of science: "Measurement of /Vub / Using Inclusive Semileptonic Decays on a Sample of Reconstructed B mesons with the Belle Detector".

## Organization of conferences, congress and meetings

1. Workshop 7. OP MADEIRA, Jožef Stefan Institute, meeting room F-9, 5. 5. – 6. 5. 2009

# INTERNATIONAL PROJECTS

1. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
   MONDILEX
   7. FP, 211938
   EC; Institute of Mathematics and Informatics of the Bulgarian Academy of Science, Sofia, Bulgaria
   Jan Jona Javoršek, B. Sc., Asst. Prof. Tomaž Erjavec
2. Marie Curie Training Network on Particle Detectors
   MC-PAD
   7. FP, 214560, PITN-GA-2008-214560
   EC; Seamus Hegarty, CERN, Geneve, Switzerland
   Prof. Peter Križan
3. Joint Research on Various Types of Radiation Dosimeters
   RADDOS
   7. FP, 207122
   EC; University College Cork, National University of Ireland, Tyndall National Institute, Cork, Ireland
   Dr. Gregor Kramberger
4. Enabling Grids for E-sciencE III
   EGEE-III
   EGEE-SA1, EGEE-NA2, EGEE-NA4
   7. FP, 222667
   EC; Dr. Bob Jones, Anna Cook, CERN IT-EGE, Geneve, Switzerland
   Prof. Marko Mikuž
5. Minimizing Activity and Dose with Enhanced Image Quality by Radiopharmaceutical Administrations
   MADEIRA
   7. FP – EURATOM, 212100
   EC; GSF - Forschungszentrum für Umwelt und Gesundheit GmbH, München Neuherberg, Germany
   Prof. Marko Mikuž
6. Image-based Navigation in Multimedia Archives
   IMAGINATION
   6. FP, 034626
   EC; Clemens van Dinther, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
   Prof. Marko Mikuž, Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc.
7. Semantic Web Services Interoperability for Goespatial Decision Making
   SWING
   6. FP, 026514
   EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim; SINTEF ICT, Oslo, Norway
   Prof. Marko Mikuž, Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
8. Safe Production and Use of Nanomaterials
   NANOSAFE2
   6. FP, NMP2-CT-2005-515843
   EC; Commissariat a l` Energie Atomique, Grenoble, France
   Andrej Detela, B. Sc., Asst. Prof. Maja Remškar, Marko Žumer, B. Sc., Prof. Boris Turk
9. Collaboration DELPHI
   Dr. Jan Timmermans, CERN, Geneve, Switzerland
   Asst. Prof. Borut Paul Kerševan
10. Collaboration HERA-B
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    Prof. Peter Križan
11. Collaboration ATLAS
    Prof. Peter Jenni, dr. Fabiola Gianotti CERN, Geneve, Switzerland
    Prof. Marko Mikuž
12. Collaboration CERN RD-39
    Dr. Jaako Haarkonen, HIP, Finland
    Dr. Zheng Li, BNL, USA
    Prof. Marko Mikuž
13. Collaboration CERN RD-42
    Prof. Peter Weilhammer, CERN, Geneve, Switzerland
    Prof. Marko Mikuž
14. Collaboration CERN RD-50
    Prof. Mara Bruzzi, University of Florence, Florence, Italy
    Dr. Michael Moll, CERN, C
    Prof. Marko Mikuž
15. Collaborations Belle in Belle II
    Prof. Masanori Yamauchi, KEK, Tsukuba, Japan
    Prof. Peter Križan
16. Collaboration CIMA
    Cameras for Imaging in Medical Applications
    Prof. Peter Weilhammer, CERN, Geneve, Switzerland
    Prof. Marko Mikuž
17. Study of Top Events produced at the LHC for the Commissioning of the ATLAS Detector
    BI-IT/05-08-003
    Dr. Marina Cobal, Università di Udine, Udine, Italy
    Asst. Prof. Borut Paul Kerševan
18. Development of New Detectors for PET Imaging
    BI-US/09-12-042
    Prof. Neal Clinthorne, University of Michigan, Dept. of Radiology, Ann Arbor, MI, USA
    Prof. Marko Mikuž

# R &D GRANTS AND CONTRACTS

1. Construction of test beam telescope
   Dr. Andrej Gorišek
2. Research of mixing and symmetry braking in D^0 mesons
   Prof. Marko Starič
3. A combined method for particle detification
   Prof. Samo Korpar
4. Gridification of data analysis in particle physics: pilot project of Slovenian Grid Initiative
   Prof. Marko Mikuž
5. Development of high-resolution PET probe
   Dr. Dejan Žontar
6. Development and implementation of tools for the physics research with the ATLAS detector in the grid environment
   Prof. Borut Paul Kerševan
7. Verification of radioactive sources positioning during brachytherapy
   Dr. Gregor Kramberger
8. Optimizing of direct drive system for electric two-wheel vehicles
   Andrej Detela
9. Unknown manuscripts of Slovenian literature of the 17th and 18th century: IT supported register, original research presentations and analysis
   Jan Jona Javoršek
10. Slovene terminology web portal
    Jan Jona Javoršek
11. Positron emission tomography with a novel photodetector
    Prof. Peter Križan

# RESEARCH PROGRAMS

1. Astroparticle physics
   Asst. Prof. Marko Zavrtanik
2. Experimetnal particle physics
   Prof. Marko Mikuž

# NEW CONTRACTS

1. Co-financing L2-9212-0106-06: Verification of radioactive sources positioning during brachytherapy
   Elgoline, d. o. o.
   Dr. Gregor Kramberger
2. Development of an innovative numerical simulation environment by incorporating hybrid parallelization processes based on discontinuous Galerkin methods
   Arctur, d. o. o.
   Prof. Andrej Filipčič

# VISITORS FROM ABROAD

1. dr. Bruce Yabsley, University of Sydney, Australia, 22. 5. – 27. 5. 2009
2. dr. Vladimir Khomenkov, University of Hamburg, Germany, 2. 2. – 14. 2. 2009
3. dr. Luciano Bosisio, INFN, Trieste, Italy, 3. 9. 2009

# STAFF

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12. Asst. Prof. Tomaž Podobnik*
13. Prof. Aleš Stanovnik*
14. Prof. Marko Starič
15. Asst. Prof. Marko Zavrtanik
16. Prof. Danilo Zavrtanik*
17. Asst. Prof. Tomi Živko
18. Dr. Dejan Žontar*

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25. Dr. Matevž Tadel
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31. Marko Petrič, B. Sc.
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33. Luka Šantelj, B. Sc.
34. Andrii Tykhonov, B. Sc.
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40. Ruben Verheyden, B. Sc.

**Technical and administrative staff**

41. Andreja Butina
42. Jurij Eržen
43. Dejan Lesjak
44. Erik Margan

Note:
* part-time JSI member
** young researcher financed by industry

# BIBLIOGRAPHY

## Original Articles


1. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (600 authors), "Direct measurement of the W production charge asymmetry in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 18, pp. 181801-1-181801-7, 2009.
2. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Evidence for a narrow near-threshold structure in the $J/\psi\phi$ mass spectrum in $B^+ \to J/\psi\phi K^+$ decays", *Phys. rev. lett.*, vol. 102, no. 24, pp. 242002-1-242002-7, 2009.
3. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (599 authors), "First direct bound on the total width of the top quark in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 4, pp. 042001-1-042001-7, 2009.
4. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (603 authors), "First measurement of the $t\bar{t}$ differential cross section $d\sigma/dM_{t\bar{t}}$ in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 22, pp. 222003-1-222003-8, 2009.
5. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "First measurement of the ratio of branching fractions $B(\Lambda_b^0 \to \Lambda_c^+ \mu^- \bar{\nu}_\mu / B(\Lambda_b^0 \to \Lambda_c^+ \pi^-)$", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 3, pp. 032001-032001-36, 2009.
6. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (600 authors), "First observation of $\bar{B}_s^0 \to D_s^{\pm} K^{\mp}$ and measurement of the ratio of branching fractions $Br(\bar{B}_s^0 \to D_s^{\pm} K^{\mp})/Br(\bar{B}_s^0 \to D_s^{+} \pi^{-})$", *Phys. rev. lett.*, vol. 103, no. 19, pp.191802-1-191802-7, 2009.
7. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (602 authors), "First observation of electroweak single top quark production", *Phys. rev. lett.*, vol. 103, no. 9, pp. 092002-1-092002-8, 2009.
8. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "First observation of vector boson pairs in a hadronic final state at the Tevatron collide", *Phys. rev. lett.*, vol. 103, no. 9, pp. 091803-1-091803-7, 2009.
9. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (598 authors), "First simultaneous measurement of the top quark mass in the lepton + jets anddilepton channels at CDF", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 9, pp. 092005-1-092005-23, 2009.
10. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (599 authors), "Global search for new physics with 2.0 fb $^{-1}$ at CDF", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 1, pp. 011101-1-011101-9, 2009.
11. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (600 authors), "Inclusive search for squark and gluino production in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 12, pp. 121801-1-121801-7, 2009.
12. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (600 authors), "Measurement of particle production and inclusive differential cross sections in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 11, pp. 112005-1-112005-22, 2009.
13. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (599 authors), "Measurement of resonance parameters of orbitally excited narrow $B^0$ mesons", *Phys. rev. lett.*, vol. 102, no. 10, pp. 102003-1-102003-7, 2009.

14. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (598 authors), "Measurement of the $k_T$ distribution of particles in jets produced in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 23, pp. 232002-1-232002-8, 2009.
15. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Measurement of the $t\bar{t}$ cross section in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV using dilepton events with a lepton plus track selection", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 11, pp. 112007-1-112007-41, 2009.
16. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Measurement of the $t\bar{t}$ production cross section in $2fb^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV using lepton plus jets events with soft muon b-tagging", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 5, pp. 052007-1-052007-25, 2009.
17. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Measurement of the b-hadron production cross section using decays to $\mu^- D^0 X$ final states in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 9, pp. 092003-1-092003-21, 2009.
18. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (598 authors), "Measurement of the fraction of $t\bar{t}$ production via gluon-gluon fusion in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 3, pp. 031101-1-031101-8, 2009.
19. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Measurement of the top quark mass at CDF using the "neutrino ϕ weighting" template method on a lepton plus isolated track sample", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 79, no. 7, pp. 072005-1-072005-18, 2009.
20. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (605 authors), "Measurement of the top quark mass using the invariant mass of lepton pairs in soft muon b-tagged events", *Phys. rev., D Part. fields gravit. cosmol.*, vol. 80, no. 5, pp. 051104-1-051104-9, 2009.
21. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (600 authors), "Measurement of the top quark mass with dilepton events selected using neuroevolution at CD", *Phys. rev. lett.*, vol. 102, no. 15, pp. 152001-1-152001-8, 2009.
22. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (598 authors), "Measurement of W-boson helicity fractions in top-quark decays using cos$\theta^*$", *Phys. lett., Sect. B*, vol. 674, no. 3, pp. 160-167, 2009.
23. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (603 authors), "Observation of exclusive charmonium production and $\gamma\gamma \to \mu^+\mu^-$ in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 24, pp. 242001-1-242001-7, 2009.
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## Review Articles and Chapters in Books

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## Published Conference Papers

### Invited Papers

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### Regular papers

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