International Workshop on Semiconductor Pixel Detectors for Particles and Imaging (PIXEL2014)

Report of Contributions

Contribution ID: **120** Type: **ORAL**

3D Integration Technology for Pixel Detector and Image Sensor using 3-μmφ Au Cone Bump Junctions

Thursday 4 September 2014 16:20 (25 minutes)

Abstract
A 3D IC is an effective solution for reducing the manufacturing costs of advanced 2D LSI while ensuring equivalent device performance and functionalities. This technology allows a new device architecture of stacked detectors/sensor devices with a small dead sensor area and facilitates hyper-parallel data processing. In pixel detectors or image sensor devices, many transistors are required to be accommodated per pixel area without increasing the pixel size. Consequently, many methods to realize 3D-LSI devices have been developed to meet this requirement by focusing on the unit processes of 3D-IC technology: (1) through-silicon via (TSV) formation and (2) bonding electrically and mechanically between tiers of the stack. The bonding process consists of several unit processes such as bump or metal contact formation, chip/wafer alignment, chip/wafer bonding, and underfill formation, and many combinations of the processes have been reported. Our research focuses on the bonding technology with the objective of realizing a versatile bonding technology for silicon LSI devices, compound semiconductor devices, and MEMS devices at temperatures less than 200 ⊠C for heterogeneous integration. The gold cone bump formed by the NpD (nanoparticle deposition) method is one of the promising candidates for this purpose.
This paper presents the experimental results of the prototype pixel detector with 3-μmφ gold cone bump connections with adhesive injection. The as-deposited cone bump consists of gold nanoparticles and is easier to deform compared to plating gold. Consequently, the collapsibility of the gold cone bump allows for low-stress bonding, resulting in a compliant and reliable junction. The bump size is determined by photoresist patterning, and the bump connection does not protrude largely during junction formation, in contrast with the melting type bump connections. In addition, the shrink ratio of the volume is larger than that of the surface area. So the bump resistance of an easily oxidized metal with a diameter of few microns is affected by the bonding atmosphere. On the other hand, gold is an oxidation-resistive material; therefore, bonding with a micro gold cone bump does not adversely affect the electrical characteristics. Figure 1 shows a 3-μmφ gold cone bump array, while Figure 2 shows the bump resistance of the daisy chain TEG. The resistance per bump is approximately 6 Ω.

Author: MOTOYOSHI, Makoto (Tohoku-MincroTec Co., Ltd (T-Micro))

Co-authors: Prof. IKEBE, Masayuki (Hokkaido University); MIYOSHI, Toshinobu (KEK); ARAI, Yasuo (High Energy Accelerator Research Organization (JP))

Presenter: MOTOYOSHI, Makoto (Tohoku-MincroTec Co., Ltd (T-Micro))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **121** Type: **POSTER**

Silicon avalanche-photodiode linear array detector with multichannel scaling system for pulsed synchrotron X-ray experiments

Tuesday 2 September 2014 17:37 (1 minute)

We have been developing an X-ray detector system using a 64-pixel silicon avalanche- photodiode (Si-APD) linear array (pixel size: 100 μm × 200 μm) and pulse counting electronics for multichannel scaling (MCS). The Si-APD linear array consists of 64 pixels 100 × 200 μmˆ2, with a pixel pitch of 150 μm and a depletion depth of 10 μm. The fast response of Si-APD and the MCS system are used for time-resolved X-ray diffraction and nuclear resonant scattering experiments using pulsed synchrotron X-rays. The detector system can resolve successive X-ray pulses at 2 ns intervals and record the pulse counts with a rate of >10ˆ7 cps per channel and position of X-rays coming to each pixel of the linear array. The time resolution of 1.4 ns (FWHM) was obtained. The electronics consisting of an ultrafast application-specific integrated circuit, field-programmable gate arrays and a network processor was developed for the linear array system. The detector successfully recorded nuclear resonant small-angle scattering on Fe-57 by scanning the detector position.

Author: KISHIMOTO, Shunji (KEK)

Co-authors: Prof. TANAKA, Manobu (KEK); IKENO, Masahiro (High Energy Accelerator Research Organization (KEK)); Mr SAITO, Masatoshi (KEK); Dr HARUKI, Rie (KEK); Mr SHIMAZAKI, Shoichi (KEK); Dr TANIGUCHI, Takashhi (KEK); Dr MITSUI, Takaya (JAEA); Dr YODA, Yoshitaka (JASRI)

Presenter: KISHIMOTO, Shunji (KEK)

Session Classification: Poster Session

Contribution ID: **122** Type: **POSTER**

Pixel module production and qualification for the Phase 1 Upgrade of CMS

Tuesday 2 September 2014 17:41 (1 minute)

The instantaneous luminosity of the Large Hadron Collider (LHC) is being increased in several steps over the next 10 years to maximize its discovery potential for new physics. However, at a luminosity of twice the design luminosity of the LHC of 1×10^{34} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$, the performance of the current CMS pixel detector is degraded by substantial deadtime incured by the readout chip (ROC). To make full use of the proton-proton collisions being provided by the LHC, CMS will replace its pixel detector during the extended winter shutdown in 2016-17 by a new detector with four barrel layers and three disks in each endcap. Module production includes bump bonding, wire bonding, and gluing processes, as well as a series of functionality tests, calibrations and thermal cycling. One of the calibration steps is the x-ray calibration, which provides an absolute energy calibration of an internal calibration circuit. This circuit injects charge into the preamplifier to simulate a signal, and is used to define several parameters of the readout chip, including the threshold. Therefore, an absolute calibration is required in order to know the threshold in units of electrons. In this talk the barrel module assembly is explained, with a special focus on the x-ray calibration of the pixel detector.

Author: MINANO MOYA, Mercedes (National Taiwan University (TW))

Presenter: MINANO MOYA, Mercedes (National Taiwan University (TW))

Session Classification: Poster Session

Contribution ID: **124** Type: **POSTER**

A high rate test beam of the CMS Phase 1 Upgrade pixel chip

Tuesday 2 September 2014 17:36 (1 minute)

The CMS collaboration will upgrade the CMS pixel detector in 2016/2017. For this upgrade the readout chip (ROC) had to be modified. An improved readout logic, larger data buffers and the digital readout scheme promise a significant increase in hit detection efficiency at the high particle flux expected in the LHC environment of a luminosity of 2×10^{34} cm^{-2}s^{-1}. To test the chip's high rate capabilities a test beam was performed at the Fermilab Test Beam Facility (FTBF). The chip was tested in a telescope with rates of up to 500 MHz/cm^2. This talk will describe the new ROC, the telescope electronics and show results from the test beam.

Author: KORNMAYER, Andreas (KIT - Karlsruhe Institute of Technology (DE))

Presenter: KORNMAYER, Andreas (KIT - Karlsruhe Institute of Technology (DE))

Session Classification: Poster Session

Contribution ID: **127** Type: **POSTER**

Simulation of the Dynamic Inefficiency of the CMS Pixel Detector

Tuesday 2 September 2014 17:40 (1 minute)

The Pixel Detector is the innermost part of the CMS Tracker. Therefore it has to prevail in the hardest environment in terms of particle fluence and radiation. Also it is one of the most important detectors of CMS: it gives essential information for vertex reconstruction which is crucial for every analysis.

The efficiency of the Pixel Detector can decrease throughout a run by several reasons. It is mainly caused by DAQ problems and/or SEUs (Single Event Upset). Besides that there is still a smaller but significant efficiency loss called the dynamic inefficiency. It is caused by various data loss mechanisms inside the ROC (Read Out Chip) and depends strongly on the data occupancy. In the 2012 data, at high values of instantaneous luminosity the efficiency reaches 98% (for the first layer) which is not negligible. In the 2015 run higher instantaneous luminosity is expected, which will result in lower efficiencies, therefore the simulation of this effect is necessary. A data-driven method has been developed to simulate dynamic inefficiency in which the efficiency is parametrised as a function of instantaneous luminosity and detector geometry using past data. This way the dynamic inefficiency is independent of the quality of the physics simulation, but has to be calibrated for different run conditions. With this method the dynamic inefficiency is successfully simulated resulting in a much improved description of the Pixel Detector.

Author: BARTOK, Marton (University of Debrecen (HU))

Presenter: BARTOK, Marton (University of Debrecen (HU))

Session Classification: Poster Session

Contribution ID: **130** Type: **ORAL**

Experience from Construction and Operation of the STAR PXL MAPS Based Vertex Detector

Monday 1 September 2014 14:00 (25 minutes)

A new silicon based vertex detector called the Heavy Flavor Tracker (HFT) was installed at the STAR experiment for the RHIC 2014 heavy ion run to improve the vertex resolution and extend the measurement capabilities of STAR in the heavy flavor domain. The HFT consists of 4 concentric cylinders around the STAR interaction point composed of three different silicon detector technologies based on strips, pads and for the first time in an accelerator experiment CMOS monolithic active pixels (MAPS). The two innermost layers at a radius of 2.7cm and 8 cm from the beam line are constructed with 400 high resolution MAPS sensors arranged in 10-sensor ladders mounted on 10 thin carbon fiber sectors giving a total silicon area of 0.16 m2. Each sensor consists of a pixel array of nearly 1 million pixels with a pitch of 20.7 um with column-level discriminators, zero-suppression circuitry and output buffer memory integrated into one silicon die with a sensitive area of ˜3.8 cm2. The pixel detector has a low power dissipation of 170 mW/cm2, which allows air cooling. This results in a global material budget of 0.5% radiation length per layer for detector used in this run. A novel mechanical approach to detector insertion allows for the installation and integration of the pixel sub detector within a 12 hour period during an on-going STAR run. The detector specifications, experience from the construction and operation, lessons learned and initial measurements of the PXL performance in the 200 GeV Au-Au run will be presented.

Author: GREINER, Leo (Lawrence Berkeley National Laboratory)

Co-authors: CONTIN, Giacomo (LBNL); WIEMAN, Howard (Lawrence Berkeley National Lab); SCHAMBACH, Joachim (University of Texas (US)); SZELEZNIAK, Michal (Lawrence Berkeley National Laboratory); SUN, xiangming (CCNU)

Presenter: GREINER, Leo (Lawrence Berkeley National Laboratory)

Session Classification: Monolithic Devices

Contribution ID: **131** Type: **POSTER**

Characterization of thin irradiated epitaxial silicon sensors for the CMS phase II pixel upgrade

Tuesday 2 September 2014 17:32 (1 minute)

The high luminosity upgrade of the Large Hadron Collider (HL-LHC) foreseen for 2022 will allow the experiments at the collider to collect data at a luminosity of 5×10^{34} cm^{-2}s^{-1}, enhancing the discovery potential for new physics.
The precise determination of vertices in the high radiation environment close to the HL-LHC interaction points demands the development of solid state detectors that can withstand unprecedented fluences.

The CMS experiment strategy to overcome this challenge consists in the replacement of the whole tracking system, the so-called phase II tracker upgrade.
The innermost layers of the upgraded pixel detector will experience fluences in the order of $\phi_{eq} \approx 10^{16}$ cm^{-2} after an integrated luminosity of 3000 fb^{-1}.
Several options are under investigation to provide a material and a design still operational after such fluences.
Thin planar silicon sensors are candidates to achieve this goal since they show a less severe degradation of the charge collection efficiency with irradiation than thicker devices.

The University of Hamburg and DESY are carrying on the characterization of highly irradiated epitaxial silicon sensors with an active thickness of 100 μm.
The investigation includes diodes and strip detectors irradiated up to a fluence of $\phi_{eq} = 1.3 \times 10^{16}$ cm^{-2}.
The properties of the diodes are determined through their current- and capacitance-voltage characteristics, while their charge collection efficiency is measured using laser and radioactive sources.
A test beam campaign has been carried out at the DESY II test beam facility to characterize the strip detectors.
A beam telescope has been used to determine precisely the impact position of beam particles on the sensor.
This allows an unbiased measurement of the charge deposit in the strip sensor and reduces the effects of the noise.

In this talk the results of the diode characterization and of the strip sensor test beam are presented.

Authors: JUNKES, Alexandra (Hamburg University (DE)); ECKSTEIN, Doris (DESY); GARUTTI, Erika (DESY); Dr STEINBRUECK, Georg (Hamburg University (DE)); CENTIS VIGNALI, Matteo (Hamburg University (DE)); EICHHORN, Thomas (DESY)

Presenter: CENTIS VIGNALI, Matteo (Hamburg University (DE))

Session Classification: Poster Session

Contribution ID: **132** Type: **ORAL**

The PixFEL Project: development of advanced X-ray pixel detectors for application at future X-FEL facilities

Wednesday 3 September 2014 16:20 (25 minutes)

The PixFEL project aims to develop an advanced X-ray camera for imaging suited for the demanding requirements of next generation free electron laser (FEL) facilities. The deployment of new technologies and innovative solutions, already under study for future pixel detectors for tracking, can also boost the performance of imaging instrumentations.

In the first phase of the PixFEL project, recently approved by the INFN, the focus will be on the development of the microelectronics building blocks, carried out with a 65 nm CMOS technology, implementing a low noise analog front-end channel with high dynamic range and compression features, a low power ADC and high density memory.

At the same time the collaboration will investigate and implement some of the enabling technologies to assembly, in a second phase of the project, a seamless large area X-ray camera composed by a matrix of multilayer four-side buttable tiles. In order to minimize the dead area on the sensor tiles, a pixel matrix with active edge will be developed.
Vertical interconnection of two CMOS layers, with low density and high density through silicon vias, will be explored to build a four-side buttable readout chip with small pixel pitch and all the on-board required functionality.

The ambitious target requirements of the pixel device under development are: single photon resolution, 1 to 10^4 photons @ 1 keV to 10 keV input dynamic range, 10-bit analog to digital conversion up to 5 MHz, 1 kevent in-pixel memory and 100 um pixel pitch.
The final goal of a longer term research program will be the construction of a versatile X-ray camera for application to high frame rate X-FEL operated either in burst mode, up to 5 MHz, like at the European X-FEL, or in continuous mode with the high repetition rates foreseen for the upgrade phase of the LCLS-II at SLAC.

Summary

After the success of first generation free electron lasers (FEL) in the investigation of the microscopic structure of organic and inorganic materials in many fields (i.e. biology, chemistry, material science, atomic and molecular science), many reaserch centers worldwide have started studying, designing and building new FEL facilities with unique X-ray beam proprerties, in term of peak brilliance, short pulse duration, high repetition rates.
To fully exploit the potential of next generation X-FEL facilities new X-ray imaging detectors need to be developed in order to match the very demanding requirements like space and amplitude resolution, input dynamic range, frame rate and frame storage capability.

The PixFEL Collaboration, formed by several groups from INFN and University of Bergamo, Pavia, Pisa and Trento, has been recently approved by the INFN to carry on a research program for the development of a two-dimensional pixelated imaging camera for application at future FELs facilities, with advanced performance with respect to the state-of-art imaging instrumentation.
The most innovative solutions and new technologies, now beeing investigated in the HEP comunity for new pixel detectors for tracking, will be explored by our collaboration to improve the performance of pixel device for photon science.

As a reference for the target requirements of the PixFEL developments the operability in the Eu-

ropean X-FEL experiments has been taken as benchmark, since with its 4.5 MHz maximum pulse rate, in burst operation mode with 1\% duty cycle, this is one of the most challenging environments.
The possibility to operate the device in continuous mode FEL facilities will be also considered, in particular to cope with the high repetition rates foreseen for the upgrade phase of the LCLS at SLAC, where frame rates as high as 1 MHz have been proposed.

The main requirements set as a target in PixFEL include: a wide dynamic range, from 1 to 10^4 photons at fixed energy, that may vary from 1 keV to 10 keV depending on the specific experiment; pixel pitch of 100 um; single photon resolution up to 100 collected photons; capability to record one image every 200 ns and to store on chip as many images as possible to read them during the pulse down time typical of burst operation (with the goal to store up to 1000 images on chip); tolerance to very high radiation dose, up to 10 MGy.

A large area seamless X-ray camera with these tight specifications can be realized as a matrix of four-side buttable tiles. Each tile consists of a multilayer device made of a high resistivity pixel sensor, with active edge technology to minimize the dead area at the physical edge of the sensor tiles, interconnected to several two tiers CMOS front-end chips, realized with high density and low density through silicon vias (TSV) to obtain a four-side buttable readout chip with a small pixel pitch and all the needed on board functionality.

The three main goals of the first phase of the PixFEL project are: the development of the microelectronics building blocks, the exploration of the enabling technology for the multilayer tile, and the study of readout architectures for application in burst mode and in continuous mode operation.

The development of the front-end chip, will be carried out with a 65 nm CMOS technology to take full advantage of the synergy with similar activities starting in the HEP comunity for future detector development and at the same time to get increased in-pixel functionality and storage capability while reducing the pixel pitch.
The very challenging design of a front-end channel with the wide input dynamic range and single photon resolution at small signal, has already started: a dynamic compression of the signal is based on non-linear features of a MOS capacitor used in the feedback network of the charge preamplifier.
With respect to other solutions proposed to this issue by other collaborations, the PixFEL channel has the advantage of being based on standard CMOS technology and on a single channel with dynamically changing gain, instead of a parallel cofiguration with different switchable gains.
The analog to digital conversion will be in-pixel with a 10-bit successive approximation register (SAR) ADC, now being designed. This solution provides an acceptable compromise between clock frequency and resolution; with 10 bits it may garantee single photon resolution at small signal and quantization noise smaller than the Poisson noise for large signals, retaining some margin for parameters dispersion and noise.
A first small prototype chip, with an 8x8 pixel matrix with the basic functionality of the front-end channel, 100 um pitch and a simple readout architecture will be submitted in Autumn 2014.

The minimization of the dead area in the sensor layer will be pursed in PixFEL by adopting planar active edge pixel sensors. In this technology, to extend the sensitivity of the sensor up to a few micron from its physical edge, the cut lines of each detector tile are realized with etched and heavily doped deep trenches, to act as wall (ohmic) electrodes.
For the specific application for FEL instrumentation, in the energy range between 1 to 10 keV, the development of relatively thick (about 450 um) pixel sensors with active edge,
needs anyway to be optimized.
One important aspect for this application is the impact of plasma effect, possible in case a high number of photons (up to 10^4) hit a single pixel, resulting in high charge density that could affect charge collection, point spread function and response time. Specific TCAD device simulations, performed
to investigate this issue, indicate that this effect can be mitigated by increasing the bias voltage, with results in good agreement with experimental data reported by other collaborations.
Furthermore to deplete these relative thick sensors a large bias voltage is needed.
Since in active edge sensors early breakdown voltage could become a limiting factor, specific TCAD

simulation of different edge terminations are now underway to optimize the pixel sensor design and find the best trade off between the minimization of the edge region and the sensor breakdown voltage.

A detailed description of the PixFEL project plans, and a summary of the main results from circuit and device simulations will be presented at the time of the conference.

Author: RIZZO, Giuliana (INFN & University - Pisa)

Presenter: RIZZO, Giuliana (INFN & University - Pisa)

Session Classification: X-Ray Imaging Applications

Contribution ID: **133** Type: **ORAL**

Large area pixel modules for HL-LHC Tracker Upgrades

Tuesday 2 September 2014 14:30 (25 minutes)

To meet the challenges of tracking at the luminosities delivered by the HL-LHC requires replacing and upgrading the tracking systems. To be able to perform pattern recognition and vertexing in events with pile-up of up to 200 requires a larger area pixel system within the tracker. The increase in area requires the development of large area planar detectors for pixel layers at large radii and the pixel endcaps. The paper reports on the development of large area sensors of area 2x2cm2 have been fabricated and mounted onto 4 FE-I4 readout ASICs, so called quad-modules, and their performance evaluated in the laboratory and testbeam. The current-voltage characteristics of the sensors have been studied and this has been used to improve the design of the biasing, guard rings and doping of the dicing streets. The assembled modules have been characterised in the laboratory to evaluate noise, threshold and bump-bond yield. A particular challenge in producing thinned large area modules is the bump-bonding, where low yield can be observed due to bowing of the sensor and readout chip during the bonding process. A new bump-bonding process using backside compensation to address the issue of low yield will be discussed. The performance of the modules in testbeams will also be presented.

Author: BUTTAR, Craig (University of Glasgow (GB))

Co-authors: Dr BLUE, Andrew (University of Glasgow); STEWART, Andrew (University of Glasgow (GB)); FORSHAW, Dean Charles (University of Liverpool-Unknown-Unknown); CASSE, Gianluigi (University of Liverpool (GB)); HAYWARD, Helen (University of Liverpool (GB)); TSURIN, Ilya (University of Liverpool (GB)); PATER, Joleen (University of Manchester (GB)); ASHBY, Joseph (University of Glasgow (GB)); DOONAN, Kate (University of Glasgow (GB)); WRAIGHT, Kenneth Gibb (University of Glasgow (GB)); MILOVANOVIC, Marko (University of Liverpool (GB)); WORMALD, Michael (University of Liverpool (GB)); DERVAN, Paul (Department of Physics-Oliver Lodge Laboratory-University of Liv); Prof. ALLPORT, Philip Patrick (University of Liverpool (GB)); BATES, Richard (University of Glasgow (GB)); CRAWLEY, Samuel Joseph (University of Glasgow (GB)); BURDIN, Sergey (University of Liverpool (GB)); WONSAK, Sven (University of Liverpool (GB)); MCMULLEN, Thomas (University of Glasgow (GB)); O'SHEA, Val (University of Glasgow (GB))

Presenter: BUTTAR, Craig (University of Glasgow (GB))

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **135** Type: **ORAL**

New Concept For Forward Tracking In LHC Experiments

Thursday 4 September 2014 17:20 (25 minutes)

Extensive discussions are underway to refine the physics goals and scope of detector upgrades for the future LHC runs, following the Higgs boson discovery. New opportunities for improving performance of the ATLAS and CMS tracking detectors in the very forward region are of particular interest to future Higgs and other measurements, which are central to the ATLAS and CMS physics programs. We propose a new concept for Pixel detectors for very forward tracking in LHC experiments, which consists of two (or more) closely spaced Pixel layers placed very close to the beam line. This design relies on the fact that a length of the pixel cluster depends on the particle's incidence angle and can be used to determine particle's origin and angle respect to the beam-line. We will discuss how availability of this information from the very first pixel layer can be used to improve tracking performance.

Author: PRANKO, Aliaksandr (Lawrence Berkeley National Lab. (US))

Co-author: GARCIA-SCIVERES, Mauricio (Lawrence Berkeley National Lab. (US))

Presenter: PRANKO, Aliaksandr (Lawrence Berkeley National Lab. (US))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **136** Type: **ORAL**

Novel Active Signal Compression in Low-noise Analog Readout at Future XFEL Facilities

Wednesday 3 September 2014 12:30 (25 minutes)

This work presents the design of a low-noise front-end implementing a novel active signal compression technique. This feature can be exploited in the design of analog readout channels for application to the next generation free electron laser (FEL) experiments. The readout architecture includes the low-noise charge sensitive amplifier (CSA) with dynamic signal compression, a time variant shaper used to process the signal at the preamplifier output and a 10 bit successive approximation register (SAR) analog-to-digital converter (ADC). The channel will be operated in such a way to cope with the high frame rate (exceeding 1 MHz) foreseen for future XFEL machines. The choice of a 65 nm CMOS technology has been made in order to include all the building blocks in the target pixel pitch of 100 um. This work has been carried out in the frame of the PixFEL project funded by Istituto Nazionale di Fisica Nucleare (INFN), Italy. The members of the PixFEL Collaboration are affiliated with Università di Bergamo, Università di Pavia, Università di Pisa, Università di Trento and INFN, Italy.

Summary

X-ray free electron laser (FEL) experiments require electronic instrumentation able to cope with severe requirements in terms of space and amplitude resolution, frame rate, input dynamic range and frame storage capability. Covering the extremely wide input dynamic range from 1 to 10ˆ4 photons at fixed energy (which may change between about 1 keV and 10 keV according to the specific experiment) while preserving single photon resolution at small signals (up to about 10ˆ2 photons) is one of the most challenging tasks in developing readout channels for FEL applications. This wide dynamic range can be fitted into a reasonable signal swing at the channel output, only if a compression is achieved at sensor level, as in the case of the DSSC device [1], or front-end level, like in the LPD detector [2].

In this work, an innovative solution, based on the non-linear features of a MOS capacitor [3] used as the feedback network of a charge amplifier, is proposed. The gate of the device forms one capacitor terminal connected to the amplifier input which is held at a fixed voltage (Vin), whereas the drain and source terminals are shorted together to form the other capacitor terminal connected to the amplifier output (Vout). The device polarity is chosen in relation with the detector characteristics: a PMOS for a detector collecting electrons and an NMOS for one collecting holes. With this choice, if the voltage of the gate connection is properly fixed (close to gnd for PMOS and close to VDD for NMOS) the device is operated in inversion, yielding a strongly non-linear C-V characteristic and thus providing a compression at the output of the amplifier. Since low energy photons generate an output voltage step with amplitude |ΔVout| much lower than the device threshold Vth, the equivalent feedback capacitance Cf provided by the MOS device is set at its minimum and is mainly due to the overlap gate-to-source Cgs,ov and gate-to-drain Cgd,ov capacitances. Therefore, Cf,min ≈ 2W ΔLCox, where W is the device channel width, ΔL is the extension of the overlap region and Cox is the gate oxide capacitance per unit area. Therefore, in the low energy range (<10ˆ2 photons) the gain of the preamplifier is almost independent of the MOS channel length L and can be adjusted by carefully choosing the channel width W. For high energy photons, the output voltage is expected to exceed the threshold thus showing a maximum Cf which is mainly given by the gate-to-channel Cgc capacitance Cf,max ≈ W LCox. Therefore, in the high energy range (>10ˆ3 photons) the gain depends on the MOS gate area WL and can be set with a suitable design of the MOS channel length L (once W has been properly chosen for the low energy gain setting). With respect to other compression solutions under investigation for FEL experiments, the one proposed here has the advantage of being based on a standard CMOS technology (not on a customized process, as in the case of the DSSC device) and on a single channel with dynamically changing gain (not on the parallel configuration of channels with different gain, like in the case of the LPD and the Percival detectors).

The full readout processor developed in the frame of the PixFEL project includes, beside the charge amplifier with signal compression, the shaping stage, the Sample&Hold capacitor and a 10-bit SAR ADC. Since the readout channel will be bump-bondend to a hole collecting pixel sensor, an NMOS has been used as the non-linear feedback capacitor. Starting from the compression idea proposed above, a more complex feedback network has been worked out as will be shown at the time of the conference. The device dimensions have been chosen to have a low energy gain of about 0.4 mV/ph and an output dynamic range of the amplifier of 500 mV. The forward stage of the amplifier is realized with a classical folded cascode architecture with a PMOS input device to cope with the bias requirements of the feedback MOS. Moreover, an improved output stage has been used to provide the high current values required during the integration and reset phases. The second stage of the analog chain is a linear transconductor introduced to convert the voltage at the output of the charge amplifier into a current, which is then fed to the input of the subsequent shaping stage. Since FEL facilities generate events with a known repetition rate, a time-variant shaping stage has been adopted in this work. The proposed architecture is based on the Flip Capacitor Filter (FCF) idea [4], which applies a Correlated Double Sampling (CDS) technique to obtain, with a single integrator stage and a flipped feedback capacitor, a trapezoidal weighting function. The channel has been simulated by referring to the time constraints of the European XFEL laser, whose beam structure consists of macro bunches of light pulses separated from each other by 200 ns. As a first attempt, in the shaper operation the period can been subdivided into four equal intervals of 50 ns each. In agreement with the CDS sequence, the readout cycle starts with the baseline integration. Then the charges generated by the laser pulse are collected by the detector and the FCF feedback capacitor gets flipped. A second integration is performed in the subsequent period measuring both the signal and the baseline (the baseline being subtracted due to the feedback capacitor flipping) to give the final output voltage. At the end of the cycle the feedback capacitances of the charge amplifier and filter are reset. With the simulated 50 ns integration time, an Equivalent Noise Charge (ENC) of 51 electrons rms has been obtained, thus providing a signal-to-noise ratio of 5.5 for a single photon with an energy of 1 keV. At the time of the conference a thorough analysis of the readout processor and the details of the simulation results will be presented.

[1] M. Porro et al., "Expected performance of the DEPFET sensor with signal compression: a large format X-ray imager with mega-frame readout capability for the European XFEL", Nucl. Instrum. Methods, vol. A624, pp. 509-519, 2010.

[2] H. Graafsma, "Requirements for and development of 2 dimensional X-ray detectors for the European X-ray Free Electron Laser in Hamburg", 2009 JINST 4 P12011, doi:10.1088/1748- 0221/4/12/P12011.

[3] R.L. Bunch et al., "Large-Signal Analysis of MOS Varactors in CMOS-Gm LC VCOs", IEEE J. Solid State Circuits, vol. 38, no. 8, pp. 1325-1332, Aug. 2003.

[4] L. Bombelli, C. Fiorini, S. Facchinetti, M. Porro, and G. De Vita, "A fast current readout strategy for the XFEL DePFET detector", Nucl. Instrum. Meth., vol. 624, pp. 360-366, 2010.

Author: MANGHISONI, Massimo (Università di Bergamo - Italy)

Presenter: MANGHISONI, Massimo (Università di Bergamo - Italy)

Session Classification: Pixel Front End Electronics Development

Contribution ID: **137** Type: **ORAL**

Low power, high resolution MAPS for particle tracking and imaging

Wednesday 3 September 2014 11:30 (25 minutes)

This contribution describes a Monolithic Active Pixel Sensor (MAPS) specifically designed to improve current MAPS state of the art for particle tracking when very high speed, low power consumption and/or small pixels (down to micron size) are required. The low power target is especially important as one of the design goal is to provide a cheaper and easier to implement alternative to present state of the art strip sensors in large volume tracking detectors.

The key innovation implemented to improve performance is the OrthoPix architecture, a compressing readout scheme specially developed for tracking high rate particles over large area pixel detectors. Such architecture has been specifically designed to read out with efficiency the large area (10 cmˆ2 or bigger) MAPS which stitching technique now allow to produce. Being the compression passive, with no active elements embedded into the pixel cell, the pixel size can shrink down to the micron level (if necessary) and power dissipation over the matrix area is minimal. Depending on pixel pitch, a particle rate of many tens of MHz / cmˆ2 can be sustained at full efficiency.

To demonstrate the validity of this novel design a 255 × 255 pixel array (10 μm pitch) prototype has been realized in the Tower-Jazz 0.18 μm quadruple-well CMOS process on a 18 μm thick high resistivity (1 kΩ cm) epitaxial layer. The epitaxial layer can therefore be reverse biased at low bias voltages (<10 V) and used as the sensitive volume. Measurements which highlights the device actual performances will be shown, discussed, and compared with simulations to assess the potentiality of future developments. An overview of how the proposed technology could find applications in High Energy Physics, Medical Imaging, and Electronic Microscopy will be also discussed.

Author: GIUBILATO, Piero (Universita e INFN (IT))

Co-authors: MARIN TOBON, Cesar Augusto (Valencia Polytechnic University (ES)); BISELLO, Dario (Universita e INFN (IT)); PANTANO, Devis (Universita e INFN (IT)); POZZOBON, Nicola (Universita e INFN (IT)); MATTIAZZO, Serena (Universita e INFN (IT)); KUGATHASAN, Thanushan (CERN); SNOEYS, Walter (CERN)

Presenter: GIUBILATO, Piero (Universita e INFN (IT))

Session Classification: Pixel Front End Electronics Development

Contribution ID: **138** Type: **ORAL**

Development of KEK/HPK Planar p-type Pixel Sensor and Lead-free Bumpbonding for HL-LHC

Tuesday 2 September 2014 14:00 (25 minutes)

We have been developing a planar-process pixel sensor in p-type 6-in. silicon wafer for an application in ATLAS detector for the luminosity upgrade of the large hadron collider (HL-LHC). Our motivation is to develop highly radiation-tolerant and cost-effective sensors for covering large area of the pixel detector. After irradiations and beamtests, inefficient regions in detecting passing-through charged particles in pixel structures were identified in the 1st prototype pixel sensors. The 2nd prototype sensors with new pixel structures were fabricated and are shown to improve the inefficiency associated with the bias rail greatly.
The pixel sensor are readout with an ATLAS pixel readout ASIC FE-I4 being bumpbonded. The bumpbonding has been successful for a thick sensor and a thick ASIC with a Lead-free (SnAg) solder bumps. In reducing the material, usage of thin sensors and thin ASIC's are envisaged. The difficulty associated with the thin sensor and ASIC's was experienced and the sources of difficulty have been identified. The latest bumpbonding has been successful by improving the flatness of the thin ASIC's and the vacuum chucking area of both the thin sensor and the ASIC's.

Author: UNNO, Yoshinobu (High Energy Accelerator Research Organization (JP))

Presenter: UNNO, Yoshinobu (High Energy Accelerator Research Organization (JP))

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **139** Type: **POSTER**

Qualification of a new supplier for silicon particle detectors

Tuesday 2 September 2014 17:38 (1 minute)

Silicon based sensors have become the dominant technology for the tracking systems of most modern particle physics experiments. The demand for these sensors is increasing and the existing production capabilities might not be sufficient to fulfill the demands of the future upgrades of the LHC experiments.
To establish a new supplier for the production of silicon strip and pixel sensors a process for p-on-n strip sensors has been developed in a cooperation between the Institute of High Energy Physics of the Austrian Academy of Sciences (HEPHY) and the European semiconductor manufacturer Infineon Technologies Austria AG.

Summary

The first prototype runs have shown a promising quality with only a small fraction of weak channels. After an extensive electrical characterization, the performance of several sensors has been evaluated during beam tests with hadrons at CERN and electrons at DESY. The results of both beam tests, which confirm the good quality of the sensors, will be presented.

Author: TREBERER-TREBERSPURG, Wolfgang (Austrian Academy of Sciences (AT))

Co-authors: DRAGICEVIC, Marko (HEPHY-Vienna); BERGAUER, Thomas (Austrian Academy of Sciences (AT))

Presenter: TREBERER-TREBERSPURG, Wolfgang (Austrian Academy of Sciences (AT))

Session Classification: Poster Session

Contribution ID: **140** Type: **ORAL**

DEPFET Based Ultra-light All-silicon Modules for Vertexing at a Future Linear Collider

Monday 1 September 2014 15:00 (25 minutes)

The DEPFET Collaboration develops highly granular, ultra-thin active pixel detectors for high-performance vertex reconstruction at future collider experiments. A fully engineered vertex detector design, including all the necessary supports and services and a novel ladder design with excellent thermo-mechanical properties, is being developed for the Belle II experiment. The self-supporting all-silicon ladder combined with the low power density of the DEPFET array and a cooling strategy that relies on forced convection of cold air to cool the active area allow for a very thin detector. I this paper, the technical implementation of the all-silicon concept of Belle II is extended to the extremely material senstive forward region of a vertex detector at the ILC. In addition, a novel cooling concept based on fully integrated micro-mechanical cooling channels in the support silicon will be discussed on the basis of simulations and measurements on realistic thermally active all-silicon samples.

Author: ANDRICEK, Laci (MPG Semiconductor Lab)

Presenter: ANDRICEK, Laci (MPG Semiconductor Lab)

Session Classification: Monolithic Devices

Contribution ID: **141** Type: **ORAL**

TDCpix - Pixel Read-out ASIC with 100 ps Time-tagging Capability for the NA62 Gigatracker Experiment

Wednesday 3 September 2014 11:00 (25 minutes)

Abstract

The TDCpix is a pixel readout ASIC designed for the NA62 Gigatracker detector at the CERN Super Proton Synchrotron. Each of the three hybrid pixel Gigatracker detector stations provides tracking and time stamping of individual particles with a time resolution of 200 ps rms. The TDCpix features 45 × 40 square pixels of 300 × 300 μm^2 and a peripheral region including an array of 720 TDC channels providing a time binning of 100 ps. This contribution will describe the complete design, test results and integration of the TDCpix ASIC.

Summary

The TDCpix is a pixel readout ASIC designed for the NA62 Gigatracker detector at the CERN Super Proton Synchrotron. Each of the three Gigatracker detector stations, directly placed in the beam vacuum, provides on-beam tracking and time stamping of individual particles with a time resolution of 200 ps rms. The peak flux of particles crossing the detector modules reaches 1.27 MHz/mm^2 for a total rate of about 0.75 GHz. Ten TDCpix chips will be bump-bonded to every silicon pixel sensor. The TDCpix chip has been designed in a 130 nm CMOS technology and features 45 × 40 square pixels of 300×300 μm^2. In pixel time-over-threshold discriminators are used to compensate the time walk due to the sensor signal rise time being slow compared to the required timing precision. An array of 720 TDC channels in the ASIC periphery records the signal arrival time and pulse width. The read-out of the ASIC works trigger-less, sending all registered hits on four high speed serializers with a maximum bandwidth of 12.8 Gbit/s or 210 Mhits/s.
This contribution will describe the complete design, test results and integration of the TDCpix ASIC. The test results demonstrate the key performance figures such as a time resolution of the front-end ASIC processing chain of less than 100 ps rms and the capability of time stamping charged particles with planar silicon sensors with an overall resolution below 200 ps rms.

Authors: KLUGE, Alex (CERN); Dr AGLIERI RINELLA, Gianluca (CERN); KAPLON, Jan (CERN); POLTORAK, Karolina (AGH University of Science and Technology (PL)); NOY, Matthew (CERN); MOREL, Michel (CERN); BONACINI, Sandro (CERN)

Presenter: NOY, Matthew (CERN)

Session Classification: Pixel Front End Electronics Development

Contribution ID: **143** Type: **ORAL**

Calibration, Simulation and test-beam characterization for hybrid-pixel readout assemblies with ultra-thin sensors

Tuesday 2 September 2014 15:50 (25 minutes)

A vertex-detector concept based on the hybrid planar pixel-detector technology is currently under development for the proposed Compact Linear Collider (CLIC). The low material budget of only 0.2% X0 per layer corresponds to an equivalent thickness of 200 um of silicon and includes the infrastructure for powering and mechanical support. To reach this material budget, sensors and readout ASICs will each have to be thinned down to approximately 50 um. In a first phase of R&D, assemblies were produced using thin planar pixel sensors (50-300 um) hybridised to Timepix read-out ASICs. Both standard thickness ASICs and ASICs thinned to 100 um are used. Sensors include active-edge sensors from Advacam with 50 um thickness and Micron semiconductor sensors with 100 um thickness hybridised by IZM. The assemblies have been calibrated with sources and X-ray fluorescence measurements and characterised in beam telescope tests at DESY with a 5.5 GeV electron beam. In this talk we present the current status of sensor calibration, test-beam analysis and comparison with GEANT4 simulation using a sensor and electronics digitization model. We also show first measurement results for the recently produced CCPDV3 active HV-CMOS sensors matching the 25 um pitch of the 65 nm CLICpix readout ASIC prototypes.

Author: BENOIT, Mathieu (CERN LCD)

Presenter: BENOIT, Mathieu (CERN LCD)

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **144** Type: **ORAL**

Linear Collider Physics Benchmarks and the CLIC vertex detector

Monday 1 September 2014 16:50 (25 minutes)

The precision physics needs at TeV-scale linear e+e- colliders (ILC and CLIC) require a vertex-detector system with excellent flavour tagging capabilities through a measurement of displaced vertices. This is essential for example for an explicit measurement of the Higgs decays to pairs of b-quarks, c-quarks and gluons. Efficient identification of top quarks in the decay t—>Wb will give access to the ttH coupling measurement. In addition to those requirements from the physics, the CLIC bunch structure calls for hit timing at the few-ns level. As a result, the CLIC pixel detector system shall have excellent spatial resolution, full geometrical coverage extending to low polar angles, extremely low mass, low occupancy facilitated by time-tagging, and sufficient heat removal from sensors and readout. These considerations push the technological requirements to the limits. A detector concept based on hybrid pixel-detector technology is under development for the CLIC vertex detector. It comprises fast, low-power and small pitch readout ASICs implemented in 65 nm CMOS technology (CLICpix) coupled to ultra-thin planar or active HV-CMOS sensors via low-mass interconnects. The power dissipation of the readout chips is reduced by means of power pulsing, allowing for a cooling system based on forced gas flow. This talk reviews the requirements and design optimisation for the CLIC vertex detector and gives an overview of recent R&D achievements in the domains of cooling, supports, powering, detector integration, sensors and readout.

Author: DANNHEIM, Dominik (CERN)

Presenter: DANNHEIM, Dominik (CERN)

Session Classification: Monolithic Devices

Contribution ID: **146** Type: **ORAL**

Experience on 3D Silicon Sensors for ATLAS IBL

Tuesday 2 September 2014 11:30 (25 minutes)

To extend the physics reach of the Large Hadron Collider (LHC), upgrades to the accelerator are planned which will increase the peak luminosity by a factor 5-10. To cope with the increased occupancy and radiation damage, the ATLAS experiment plans to introduce an all-silicon inner tracker with the high luminosity upgrade (HL-LHC). The detector proximity to the interaction point will require new radiation hard technologies for both sensors and front end electronics. 3D silicon sensors, where plasma micromachining is used to etch deep narrow apertures in the silicon substrate to form electrodes of PIN junctions, represent possible solutions for inner layers.
Based on the gained experience with 3D silicon sensors for the ATLAS IBL project and the on-going developments on light materials, interconnectivity and cooling, we will discuss possible solutions to these requirements as well as
key design aspects and device fabrication plans.

Author: DARBO, Nanni (Universita e INFN (IT))

Presenter: DARBO, Nanni (Universita e INFN (IT))

Session Classification: New Sensor Technologies

Contribution ID: **148** Type: **POSTER**

IBL modules construction experience and developments for future upgrade

Tuesday 2 September 2014 17:34 (1 minute)

The first upgrade of the ATLAS Pixel Detector is the Insertable B-Layer (IBL), just installed in May 2014 in the core of ATLAS. Two different silicon sensor technologies, planara n-in-n and 3D, were used, connected with the new generation 13o0nm IBM CMOS FE-I4 readout chip via solder bump-bonds.
Production quality control tests were set up to verify and rate the performance of the modules before integration into staves. An overview of module design and construction, the quality control results and production yield will be discussed, as well as future developments foreseen for future detector upgrades.

Author: MOTOHASHI, Kazuki (Tokyo Institute of Technology (JP))

Presenter: MOTOHASHI, Kazuki (Tokyo Institute of Technology (JP))

Session Classification: Poster Session

Contribution ID: **149** Type: **POSTER**

Firmware development and testing of the ATLAS Pixel Detector / IBL ROD card

Tuesday 2 September 2014 17:35 (1 minute)

The ATLAS Experiment is reworking and upgrading systems during the current LHC shut down. In particular, the Pixel detector is inserting an additional inner layer called Insertable B-Layer (IBL). The Readout-Driver card (ROD), the Back-of-Crate card (BOC), and the S-Link together form the essential frontend data path of the IBL's off-detector DAQ system. The strategy for IBLROD firmware development focused on migrating and tailoring HDL code blocks from PixelROD to ensure modular compatibility in future ROD upgrades, in which a unified code version will interface with IBL and Pixel layers. Essential features such as data formatting, frontend-specific error handling, and calibration are added to the ROD data path. An IBLDAQ testbench using realistic frontend chip model was created to serve as an initial framework for full offline electronic system simulation. In this document, major firmware achievements concerning the IBLROD data path implementation, tested in testbench and on ROD prototypes, will be reported. Recent Pixel collaboration efforts focus on finalizing hardware and firmware tests for IBL. Time plan is to approach a final IBL DAQ phase by the end of 2014.

Author: GABRIELLI, Alessandro (Universita e INFN (IT))

Presenter: GABRIELLI, Alessandro (Universita e INFN (IT))

Session Classification: Poster Session

Contribution ID: **150** Type: **POSTER**

Firmware development and testing of the ATLAS IBL Back-Of-Crate card

Tuesday 2 September 2014 17:30 (1 minute)

ATLAS is one of the four big LHC experiments and currently its Pixel-Detector is being upgraded with a new innermost 4th layer, the Insertable B-Layer (IBL). The upgrade will result in better tracking efficiency and compensate radiation damages of the Pixel-Detector. Newly developed front-end electronics and the higher than originally planned LHC luminosity will require a complete re-design of the Off-Detector-Electronics consisting of the Back-Of-Crate card (BOC) and the Read-Out-Driver (ROD).
The main purpose of the BOC card is the distribution of the LHC clock to all Pixel-Detector components as well as interfacing the detector and the higher-level-readout optically. It is equipped with three Xilinx Spartan-6 FPGAs, one BOC Control FPGA (BCF) and two BOC Main FPGAs (BMF). The BMF are responsible for the signal processing of all incoming and outgoing data.
The data-path to the detector is running a 40 MHz bi-phase-mark encoded stream. This stream is delayed by a fine delay block using Spartan-6 IODELAY primitives. The primitives are reconfigured using partial reconfiguration inside the FPGA. The 160 MHz 8b10b-encoded data-path from the detector is phase and word-aligned in the firmware and then forwarded to the ROD after decoding. The ROD will send out the processed data which is then forwarded to the higher-level readout by the BOC card.
An overview of the firmware, which has been developed, will be presented together with the results from production tests and the system test at CERN. One focus will be the partial reconfiguration and results of the fine delay measurements.

Author: STRAMAGLIA, Maria Elena (Universitaet Bern (CH))

Presenter: STRAMAGLIA, Maria Elena (Universitaet Bern (CH))

Session Classification: Poster Session

Contribution ID: **152** Type: **ORAL**

Irradiation and Testbeam of KEK/HPK Planar p-type Pixel Modules for HL-LHC

Tuesday 2 September 2014 16:20 (25 minutes)

In the ATLAS detector upgrade for the high luminosity LHC (HL-LHC), a n-in-p planar pixel sensor-module is being developed with HPK. The modules were irradiated at the cyclotron radioisotope center (CYRIC) using 70 MeV protons. For the irradiation, we have designed a novel irradiation box that carries 16 movable slots to irradiate the samples slot-by-slot independently, to reduce the time for replacing the samples by hand, thus reducing the irradiation to human body. The box can be moved horizontally and vertically to scan the samples for an area of 11 cm x 11 cm at the maximum. We have then carried out tests with beam at CERN by using 120 GeV pions, at DESY 4 GeV electrons, and at SLAC 13 GeV electrons. We describe the analyses of the testbeam data of the KEK/HPK sensor-modules, focussing on the comparison of the performance of old and novel designs of pixel structures, together with a reference of the simplest design (no biasing structure). The novel design has shown as good performance as the no-structure design in detecting passing-through charged particles.

Author: NAKAMURA, Koji (High Energy Accelerator Research Organization (JP))

Presenter: NAKAMURA, Koji (High Energy Accelerator Research Organization (JP))

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **153** Type: **ORAL**

3D Pixel Detectors for the AFP Experiment

Tuesday 2 September 2014 12:00 (25 minutes)

Pixel detectors with cylindrical electrodes that penetrate the silicon substrate (so called 3D detectors) offer advantages over standard planar sensors in terms of radiation hardness, since the electrode distance is decoupled from the bulk thickness. In the framework of the ATLAS Forward Physics (AFP) program, work has been carried out to study the suitability of 3D pixel devices for forward proton tracking. The AFP tracker unit will consist of an array of six pixel sensors placed at 2-3˜mm from the Large Hadron Collider (LHC) proton beam. The proximity to the beam is essential for the AFP physics program as it directly increases the sensitivity of the experiment. Thus, there are two critical requirements for the AFP pixel detector. First, the dead region of the sensor has to be minimized. Second, the device has to be able to cope with a very inhomogeneous radiation distribution. Results of the characterization and beam test studies of inhomogeneously irradiated and slim-edged 3D pixel sensors produced at CNM-Barcelona will be presented.

Author: LANGE, Joern (IFAE Barcelona)

Co-authors: CAVALLARO, Emanuele (IFAE Barcelona (ES)); LOPEZ PAZ, Ivan (Universitat Autònoma de Barcelona (ES)); GRINSTEIN, Sebastian (IFAE/ICREA Barcelona)

Presenter: LANGE, Joern (IFAE Barcelona)

Session Classification: New Sensor Technologies

Contribution ID: **154** Type: **ORAL**

Recent Progress of the SOI Pixel Detector

Monday 1 September 2014 17:20 (25 minutes)

We are developing monolithic pixel detectors based on 0.2 um fully-depleted Silicon-on-Insulator technology fabricated Lapis Semiconductor Co Ltd. for high energy physics experiments, X-ray applications and so on.
To employ SOI devices on such radiation environments, we have to solve effects of total ionization damage for the transistors which are enclosed in the oxide layers.
The holes which are generated and trapped in the oxide layers after irradiation affect characteristics of near-by transistors due to its electric field.
We have been developing double SOI sensors that have independent electrode in middle of buried oxide layer to adjust the potential for compensation of radiation effect.
Performances of double SOI devices are presented.
In addition, a new sensor processing scheme "PIXOR (PIXelOR)" which
reduces the number of readout channels and avoid degradation of position resolution due to large circuit area has been developing.
It is a metric of "superpixel" which consists of 4, 8 or 16 strips in X and Y direction.
This feature performs high resolution, low occupancy and signal processing of on-sensor at the same time.
Recent progress of other SOI device is also shown in this presentation.

Author: YAMADA, Miho (High Energy Accelerator Research Organization (JP))

Presenter: YAMADA, Miho (High Energy Accelerator Research Organization (JP))

Session Classification: Monolithic Devices

Contribution ID: **155** Type: **POSTER**

Diamond pixel detector for beam profile monitoring in the COMET experiment at J-PARC

Tuesday 2 September 2014 17:31 (1 minute)

We present the design and initial prototype results of a pixellized proton beam profile monitor
for the COMET experiment at J-PARC. The active element of the detector is single crystal diamond grown
by chemical vapor deposition (sc-cvd). The goal of the COMET experiment is to look for charged lepton flavor
violation by direct μ to e conversion at a sensitivity of 10^{-18}. In the first phase, an 8 GeV proton beam
pulsed at 100 ns with current corresponding to 10^{10} protons/second will be be used to create muons through
pion production and decay. In the final experiment, the proton flux will be raised to 10^{14} protons/sec to
increase the sensitivity with an intense muon beam. These requirements of harsh radiation tolerance and fast
readout have led us into developing a sc-cvd diamond based pixel detector to profile the proton beam.
The design details and first prototype readout results of the detector will be presented.

Author: SARIN, Pradeep (Bhabha Atomic Research Centre (IN))

Co-author: Mr JADHAV, Manoj (IIT Bombay Department of Physics)

Presenter: SARIN, Pradeep (Bhabha Atomic Research Centre (IN))

Session Classification: Poster Session

Contribution ID: **156** Type: **ORAL**

Evaluation of SOI Pixel Detector with Charge Sensitive Amplifier Circuit for Event-Driven X-ray Readout

Wednesday 3 September 2014 12:00 (25 minutes)

We have been developing monolithic active pixel detectors, "XRPIX", with the silicon-on-insulator (SOI) technology for future X-ray astronomical satellite missions. XRPIX is wide-band (0.3 –40 keV) fine imaging spectrometer and the advantage is low background. Our objective performance are high coincidence time resolution (~ 1 μs), superior hit-position readout time (~ 10 μs) in order to reduce the non-X-ray background by cosmic rays. XRPIX contains comparator circuit in each pixel to detect an X-ray photon injection; it offers intra-pixel hit trigger (timing) and two-dimensional hit-pattern (position) outputs.
Therefore, it is capable of direct access to selected pixels to read out the signal amplitude. X-ray readout by this function is called ''Event-Driven readout". By introducing an anti-coincidence method between the hit signal and the external active shield detector, the back ground can be greatly reduced. It realizes about 1 % of low background of CCD at 20 keV.

In our previous study, we developed prototype of XRPIX and demonstrated the acquisition of X-ray spectra in Event-Driven readout. The energy resolution are 900 eV (FWHM) for Frame mode and 1.2 keV (FWHM) for Event-Driven mode at 22.2 keV. And the readout noise is 68 e- (rms) for Frame mode.

Recently, we designed a new prototype which has charge sensitive amplifier (CSA) in each pixel in order to increase the gain and improve energy resolution. Then, the readout noise reached 33 e- (rms) and the energy resolution is about 300 eV (FWHM) at 5.9 keV. The Event-Driven X-ray readout by CSA circuit is under evaluation now. In this presentation, we report the present status of development focusing on spectrum performance.

Author: TAKEDA, Ayaki (Kyoto University)

Co-authors: Mr MATSUMURA, Hideaki (Kyoto University); Mr KAMEHAMA, Hiroki (Shizuoka University); Dr KAGAWA, Keiichiro (Shizuoka University); Dr YASUTOMI, Keita (Shizuoka University); Dr MORI, Koji (University of Miyazaki); Mr TAKENAKA, Ryota (University of Miyazaki); Dr NAKASHIMA, Shinya (JAXA); Prof. KAWAHITO, Shoji (Shizuoka University); Mr SUMEET, Shrestha (Shizuoka University); Dr TANAKA, Takaaki (Kyoto University); Dr KOHMURA, Takayoshi (Tokyo University of Science); Prof. TSURU, Takeshi (Kyoto University); Prof. ARAI, Yasuo (High Energy Accelerator Research Organization (JP)); Mr NISHIOKA, Yusuke (University of Miyazaki)

Presenter: TAKEDA, Ayaki (Kyoto University)

Session Classification: Pixel Front End Electronics Development

Contribution ID: **157** Type: **ORAL**

High Resolution Digital Flat-Panel X-ray Detector Based on Large Area CMOS Image Sensor for Mammography and Fluoroscopy

Friday 5 September 2014 12:00 (25 minutes)

With the help of steady efforts to overcome the size limitations of CMOS image sensors, the development of high resolution flat-panel x-ray detectors based on CMOS technology have been greatly valued. Especially, CMOS active pixel sensors (APSs)-based detectors, which have low-noise, high-speed characteristics, are considered to be appropriate for mammography and fluoroscopy applications. This paper introduces a high resolution X-ray detector to acquire high quality images for real-time display.
The high resolution x-ray detector consists of three components: the 12 x 12 (cm2) three-side-tileable CMOS images sensor integrating ADC, a control component, and a host program. The sensor comprises 1200 x 1200 pixels and column-parallel 14 bit digital output. The control component includes on FPGA-based controller to generate control signals for integrating ADC and to acquire and transmit high-resolution image data. This controller is designed to be optimized for a special structure of sensor, which has physically repeated pattern caused by stitching process. Also, it is able to deal with simple image data processing in real time. Lastly, the acquisition data transmit to the host program via Hi-speed USB 2.0 port. In the full-resolution mode, 1 frame data (2.5MB) can be deal within 33.3ms (30fps). In 2 x 2 binning mode, sensor provided, 1 frame data become a quarter of full-resolution data and transmit to end program within 16.7ms (60 fps).
The experiment to evaluate the detector was conducted in two stages: the optical response and performances under the visible light conditions and then x-ray imaging analysis using scintillator. At first, with a visible light source at a wavelength of 550nm, we measured optical characteristics of the CMOS image sensor. Using Photon Transfer Curve (PTC), the performance parameters of the sensor including read noise, full well capacity, and dynamic range were evaluated under specific operating conditions. Also, temporal image characteristics such as Image lags were measured using a visible light source at the maximum frame rate. The parameters from this experiment should be highly regarded for the fluoroscopy and high-frame-rate applications. For the next step, we obtained the x-ray images by attaching on the active pixel area, which converts x-ray to visible light of wavelength 550nm. The x-ray source operating condition was operated at 75 kVp, 64 mA. Additionally, the spatial resolution of our x-ray detector system was evaluated by calculating MTF performances from images of the line pair set
In this paper, we provide details on the architecture of the high resolution flat-panel x-ray detector and present the results of evaluation for characteristics.

Author: KIM, Chorong (KERI)

Co-authors: Dr CHA, Bo Kyung (KERI); Dr SUNGCHAE, Jeon (KERI); Dr KIM, Ryun Kyung (KERI); Dr KEEDONG, Yang (KERI)

Presenter: KIM, Chorong (KERI)

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **158** Type: **ORAL**

The DEPFET Pixel Detector for the Belle II Experiment at SuperKEKB

Monday 1 September 2014 15:30 (25 minutes)

A pixel detector built with the DEPFET technology will be used for the two innermost layers of the Belle˜II experiment at the e^+e^- SuperKEKB collider at KEK. The physics goals of the experiment impose challenging requirements to the design of the pixel detector in terms of performance, material budget and power consumption. The DEPFET technology has proven to be a suitable solution for the Belle II requirements and has been chosen as the baseline for the detector. This paper reviews the DEPFET pixel detector for Belle II and the various system aspects that have driven its final design.

Summary

The SuperKEKB collider, an upgrade of the former KEKB, is under construction at KEK. It is an asymmetric (4 GeV, 7 GeV) e^+e^- collider working at the center of mass energy of the $\Upsilon(4S)$ resonance. The design peak luminosity is 8×10^{35} cm^{2}s^{-1}, about 40 times larger than KEKB, aiming at an integrated luminosity of 50 ab^{-1}.

To fully exploit the higher luminosity the former Belle detector is being upgraded. This new detector must cope with the higher backgrounds and event rates and the corresponding larger radiation damage, occupancy and fake hit production. As a consequence, improved vertexing and tracking capabilities are needed in the Belle II detector. This converts the vertex detector in one of the key elements that drive the physics performance. It consists of four layers of double-sided silicon strip detectors in the outer radii, SVD, and two layers of highly granular pixel sensors in the innermost part, known as PXD.

The PXD, built with DEPFET pixel detectors, is intended to improve vertex resolution. As a consequence of the low momentum of the particles in the final state (< 1 GeV/c), the hit position determination is intrinsically limited due to the multiple Coulomb scattering. This sets a lower limit of 10μm for the spatial resolution in the PXD that can be achieved with a moderate pixel size of 50×50 μm^2. This pixel size is also enough to cope with the expected occupancy of 0.4 hits μm^{-2}s^{-1}. For the same reason the material budget must be kept low, up to a maximum of $\sim$0.2 % X$_\circ$ per layer, implying a thickness of 75 μm of the sensitive part of the sensor. The acceptance of the detector must cover the range 17°-155° in azimuth angle. The detector will be read continuously with a frame time of 20 μs keeping the occupancy below 3%. This continuous readout means that ASICs are ON all the time, which together with the restrictions on the material budget sets the requirements for cooling. Finally, according to the simulations, the radiation dose expected in the inner region of the detector is around 2 Mrad/yr.

Author: KODYS, Peter (Charles University (CZ))

Presenter: KODYS, Peter (Charles University (CZ))

Session Classification: Monolithic Devices

Contribution ID: **159** Type: **ORAL**

First characterization results of the MÖNCH hybrid pixel detector

Wednesday 3 September 2014 16:50 (25 minutes)

MÖNCH is a novel hybrid silicon pixel detector based on charge integration and analog readout, featuring a challengingly small pixel size of 25x25 µm2. It is a research project which aims to push the development of hybrid pixel detectors to its limits in terms of photon flux, position resolution, energy information and low energy detection.
MOENCH02 is a fully functional, small scale prototype of 4x4mm2, containing an array of 160x160 pixels, designed in UMC 110nm technology [1]. This array is subdivided in five sub blocks, each featuring a different pixel architecture. The first block targets high resolution, low flux synchrotron applications, as RIXS (resonant inelastic X-ray scattering) or X-ray tomography with X-ray tubes. In this case the charge sharing effect between pixels, together with the signal analog readout, can be exploited to interpolate the hit position with a precision that could reach the sub-µm resolution. The first characterization results of this sub block of MÖNCH02 in terms of bump-bonding yield, linearity, dynamic range and energy resolution will be shown. The noise performance will be presented in more detail, showing a total noise as low as <40 e-, as well as an overview of the noise contribution of the different blocks, from the amplifier to the off-chip buffer. The latest version of the interpolation algorithm and tests showing its effectiveness in obtaining sub-pixel resolution will also be shown.

The encouraging results obtained lead to the design of a bigger size prototype, MÖNCH03. MÖNCH03 has an active area of 5x10mm2 and it contains an array of 200x400 identical pixels, based on the first block of MÖNCH02. Several improvements are implemented in the chip periphery and in the readout system, which should result in a final frame rate of ˜8 kHz.

Summary

MÖNCH is a novel hybrid silicon pixel detector based on charge integration and analog readout, featuring a challengingly small pixel size of 25x25 µm2. It is a research project which aims to push the development of hybrid pixel detectors to its limits in terms of photon flux, position resolution, energy information and low energy detection.
MOENCH02 is a fully functional, small scale prototype of 4x4mm2, containing an array of 160x160 pixels. The first characterization results of the main sub block of MÖNCH02 in terms of bump-bonding yield, linearity, dynamic range and energy resolution will be shown, as well as latest results on sub-micron resolution using interpolation algorithms.

Author: DINAPOLI, Roberto (Paul Scherrer Institut)

Co-authors: BERGAMASCHI, Anna (PSI); SCHMITT, Bernd (Paul Scherrer Institut); GREIFFENBERG, Dominic (PSI); TINTI, Gemma (PSI); SMITH-JUNGMANN, Julia Helga (Unknown); CARTIER, Sebastian Francis (PSI); SHI, Xintian (PSI); MOZZANICA, aldo (PSI)

Presenter: DINAPOLI, Roberto (Paul Scherrer Institut)

Session Classification: X-Ray Imaging Applications

Contribution ID: **161** Type: **ORAL**

Measurements on HV-CMOS active sensors after irradiation to HL-LHC fluences

Tuesday 2 September 2014 09:40 (25 minutes)

Deep-submicron HV-CMOS processes feature moderate bulk resistivity and HV capability and are therefore good candidates for drift-based radiation-hard monolithic active pixel sensors (MAPS). It is possible to apply 60-100V of bias voltage leading to a depletion depth of ˜10-20 µm. Thanks to the high electric field, charge collection is fast and nearly insensitive to radiation-induced trapping. Alternatively, CMOS Imaging Processes often feature high-resistive substrates, thinning, stitching and backside processing, which makes them also interesting to study.

We explore the concept of using such processes to produce active pixel sensors (APS) that contain simple circuits to amplify and discriminate the signal. A readout chip (ROC) is still needed to receive and organize the data from the active sensor and handle high-level functionality such as trigger management. This chip can follow the pixel chip concept with the readout circuits distributed over the area of the chip, or the strip concept with one or few rows of pads along one (or more) sides of the chip. The connection between APS and ROC can be made in a "traditional" way (wire/bump-bonding) or by capacitive coupling (e.g. gluing) which could lower the production cost significantly.

The active sensor approach offers many advantages with respect to standard silicon sensors: fabrication in commercial CMOS processes costs less than traditional diode sensors, aggressive thinning is resulting in much lower mass, bias voltage and operation temperature requirements are favorable. From a practical perspective, maintaining the traditional separation between sensing and processing functions lowers development cost and makes use of existing infrastructure.

Test ASICs compatible with ATLAS readout chips were produced in a variety of processes. Pixel-like, strip-like and limited standalone readout could be selected on most devices. Measurements were done on chips either in standalone mode or capacitively coupled by gluing with less than about 10 µm of glue layer thickness. Results of their characterization will be shown, in particular also after irradiation to HL-LHC fluences (10^{15} n_{eq}/cm² to 10^{16} n_{eq}/cm² and up to 1GRad of dose). In addition, dedicated TCT and edge-TCT measurements have been conducted to study in detail the charge collection homogeneity and extension within the silicon bulk; first results will be shown.

Finally, plans for further submissions and improvements (e.g. production on high-resistivity (HR) substrates to increase the signal charge) and perspectives for the use of HV/HR-CMOS active sensors in the Inner Tracker upgrade of the ATLAS detector will be outlined.

Author: RISTIC, Branislav (Universite de Geneve (CH))

Presenter: RISTIC, Branislav (Universite de Geneve (CH))

Session Classification: New Sensor Technologies

Contribution ID: **162** Type: **ORAL**

Measurements and 3D simulation of novel ATLAS planar pixel detector structures including edgeless and alternative bias grid geometries for the HL-LHC upgrade

Tuesday 2 September 2014 15:00 (25 minutes)

In 2022, the LHC accelerator complex will be upgraded to the High-Luminosity-LHC to substantially increase statistics for the various physics analyses. These modifications will result in an increase in occupancy and of radiation damage to the ATLAS Inner Detector (ID). In order to operate under these challenging new conditions, and maintain excellent performance in track reconstruction and vertex location, the ATLAS pixel detector must be substantially upgraded and a full replacement is expected.

A vital selection parameter for the innermost layers of the ATLAS pixel detector will be radiation hardness, which can be achieved through the thinning of sensors. Through new pixel designs, such as active edges and alternative bias rail geometries, minimisation of inactive regions and reductions in efficiency loss can be obtained, allowing sensors to be placed adjacent to each other. This layout is preferable to shingling as it reduces the material budget of the ID as well as cooling requirements and power consumption.

Characterisation of novel pixel designs in a laboratory environment will be presented, including IV and CV measurements, and charge collection measurements with a laser, radioactive sources and cosmic muons. Non-perpendicular particle tracks, forming clusters of charge within the pixel devices, have been analysed. Pixel designs studied include novel layouts for coupling to the ATLAS FE-I4 readout chip and also reduced pixel pitch designs (50 x 50 μm) for the new 3D OmegaPIX front-end chip.

Processing techniques for novel pixel designs are optimised through 3D simulations with Technology Computer Aided Design (TCAD). Comparison of simulation with Secondary Ion Mass Spectrometry (SIMS) measurements to study the doping profile of structures will also be included.

Author: NELLIST, Clara (LAL-Orsay (FR))

Co-authors: LOUNIS, Abdenour (Universite de Paris-Sud 11 (FR)); Dr DINU, Nicoleta (Universite de Paris-Sud 11 (FR)); GKOUGKOUSIS, Vagelis (Universite de Paris-Sud 11 (FR))

Presenter: NELLIST, Clara (LAL-Orsay (FR))

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **163** Type: **ORAL**

The VELO Pixel Upgrade

Thursday 4 September 2014 10:50 (25 minutes)

The LHCb Vertex Detector (VELO) will be upgraded in 2018 to a lightweight hybrid pixel detector capable of 40 MHz readout at a luminosity of 2x1033 cm-2 s-1 and operation in very close proximity to the LHC beams. The pattern recognition and track reconstruction precision is enhanced relative to the current VELO detector even at the high occupancy conditions of the upgrade, due to the pixel geometry and a closest approach to the LHC beams of just 5 mm. The pixel modules must withstand non-uniform irradiation levels reaching 8 x 1015 neq/cm2 at the regions closest to the beam, over the lifetime of the upgraded VELO. In order to achieve this, radiation hard technologies are employed for the sensors and electronics, and the sensors must be efficiently cooled. The pixel modules are mounted onto silicon plates which provide cooling via bi-phase CO2 circulating in microchannels etched within the silicon. The entire detector is split into two retractable halves, with the modules occupying a secondary vacuum volume separated from the primary vacuum by a thin, corrugated foil.

The detector contains 41 million 55 x 55 um square pixels, read out by the custom developed VeloPix front end ASIC. This ASIC, which is a development in common with the Medipix family of ASICs, most tolerate rates of over 900 Mhits/s and be capable of reading out every bunch crossing, leading to data rates of above 16 Gbits/s. The ASIC operates with a data driven readout and on-chip data packing into super pixels. The high speed signals are transmitted via electrical and optical links to the off detector electronics which incorporate FPGAs to time order and process the data for delivery into the software farm where the trigger is implemented.

The current status of R&D for the VELO upgrade, together with the prototyping results will be reviewed.

Author: JANS, Eddy (NIKHEF (NL))

Presenter: JANS, Eddy (NIKHEF (NL))

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **164** Type: **ORAL**

Evaporative CO2 Microchannel Cooling for the LHCb VELO Pixel Upgrade

Thursday 4 September 2014 14:00 (25 minutes)

The LHCb Vertex Detector (VELO) will be upgraded in 2018 to a lightweight, pixel detector capable of 40 MHz readout and operation in very close proximity to the LHC beams. The thermal management of the system will be provided by evaporative CO2 circulating in micro channels embedded within thin silicon plates. This solution has been selected due to the excellent thermal efficiency, the absence of thermal expansion mismatch with silicon ASIC's and sensors, the radiation hardness of CO2, and very low contribution to the material budget.

Although micro channel cooling is gaining considerable attention for applications related to microelectronics, it is still a novel technology for particle physics experiments, in particular when combined with evaporative CO2 cooling. The R&D effort for LHCb is focusing on the design and layout of the channels together with a fluidic connector and its attachment which must withstand pressures in excess of 200 bars. This talk will describe the design and optimization of the cooling system for LHCb together with latest prototyping results.

Even distribution of the coolant is ensured by means of the use of restrictions implemented before the entrance to a race-track layout of the main cooling channels. The coolant flow and pressure drop has been simulated together with the thermal performance of the device. The design of a suitable low mass connector, together with the vacuum soldering technique to the cooling plate will be described.

Long term reliability as well as resistance to extremes of pressure and temperature is of prime importance. The setup and operation of a cyclic stress test of the prototype cooling channel designs will be described.

Author: DE AGUIAR FRANCISCO, Oscar Augusto (Univ. Federal do Rio de Janeiro (BR))

Co-author: COLLINS, Paula (CERN)

Presenter: DE AGUIAR FRANCISCO, Oscar Augusto (Univ. Federal do Rio de Janeiro (BR))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **165** Type: **ORAL**

VeloPix: The Pixel ASIC for the LHCb VELO Upgrade

Wednesday 3 September 2014 10:10 (25 minutes)

The LHCb Vertex Detector (VELO) will be upgraded in 2018 along with the other subsystems of LHCb in order to enable full readout at 40 MHz, with the data fed directly to the software triggering algorithms. The upgraded VELO is a lightweight hybrid pixel detector operating in vacuum in close proximity to the LHC beams.

The readout will be provided by a dedicated front end ASIC, dubbed VeloPix, matched to the LHCb readout requirements and the 55 x 55 um VELO pixel dimensions. The chip is closely related to the Timepix3, from the Medipix family of ASICs. The principal challenge that the chip has to meet is a hit rate of up to 900 Mhits/s, resulting in a required effective bandwidth of more than 16 Gbit/s. The occupancy is also very non uniform, and the radiation levels reach an integrated 400 MRad over the lifetime of the detector.

VeloPix is a binary pixel chip with a data driven readout, designed in 130 nm technology. The pixels are combined into groups of 2x4 super-pixels, enabling a shared logic and a reduction of bandwidth due to combined address and timestamp information. The pixel hits are combined with other simultaneous hits in the same super-pixel, timestamped, and immediately driven off-chip. The analog front end must be sufficiently fast to accurately timestamp the data, with a small enough dead time to minimize data loss in the most occupied regions of the chip. The data is driven off chip with a custom designed high speed serialiser.

The current status of the ASIC design, performance simulations and prototyping will be described, along with recent lab and testbeam results.

Author: POIKELA, Tuomas (University of Turku (FI))

Presenter: POIKELA, Tuomas (University of Turku (FI))

Session Classification: Pixel Front End Electronics Development

Contribution ID: **167** Type: **ORAL**

Laboratory and testbeam results for thin and epitaxial planar sensors for HL-LHC

Tuesday 2 September 2014 16:50 (25 minutes)

The High-Luminosity LHC (HL-LHC) upgrade of CMS pixel detector will require the development of novel pixel sensors which can withstand the increase in instantaneous luminosity to $5 \times 10^{34} cm^{-2} s^{-1}$ and collect ˜3000 fb^{-1} of data. The innermost layer of the pixel detector will be exposed to doses of about $1 \times 10^{16} neq/cm^2$. Hence, new pixel sensors with improved radiation hardness needs to be investigated. A variety of silicon materials (Float-zone, Magnetic Czochralski and Epitaxially grown silicon), with thicknesses from 50 μm to 320 μm in p- and n-type substrates have been fabricated at one company (Hamamatsu Photonics K.K.) using single-sided processing. The effect of reducing the sensor active thickness to improve radiation hardness by using various techniques (deep diffusion, wafer thinning, or growing epitaxial silicon on a handle wafer) have been studied. The results for electrical characterization, charge collection efficiency, and position resolution of various n-in-p and n-in-n pixel sensors with different substrates and different pixel geometries (different bias dot gaps and pixel implant sizes) will be presented.

Summary

A variety of pixel technologies (3D technologies, diamond, HV-CMOS) are being proposed for the HL-LHC upgrade of CMS experiment. These technologies offer improved radiation hardness but are expensive and difficult to produce compared to planar sensors. In order to continue using planar sensors for HL-LHC upgrade of CMS, radiation hardness needs to be improved. The radiation hardness of planar silicon sensors can be improved by reducing the active thickness of the bulk (50 μm to 120 μm), while collecting good charge above the chip threshold. Various techniques have been used to reduce sensor active thickness (deep diffusion, wafer thinning, and growing epitaxial silicon on a handle wafer). Epitaxial technology allows reducing the sensor active thickness down to 50 μm. Using the new CMS Phase 1 Upgrade readout chip allows reducing the threshold to about 2,000 electrons. Thus, extremely thin epitaxial sensors can be used which improves radiation hardness by reducing charge trapping. Charge multiplication effects have been reported in epitaxial sensors after heavy irradiation, which can improve radiation hardness. We report laboratory and testbeam measurements results for various thin n-in-p sensors with both p-spray and p-stop isolation. The results for electrical characterization, charge collection efficiency, and position resolution will be presented.

Also, a variety of bulk sensor materials (Float-zone, Magnetic Czochralski and Epitaxially grown silicon), with thicknesses from 50 μm to 320 μm in p- and n-type substrates have been fabricated at one company (Hamamatsu Photonics K.K.) using single-sided processing. Parylene-N is used to prevent arcing between sensor and readout chip. Radiation hardness of parylene have been investigated after heavy irradiation. In order to study the effect of pixel implant size and bias dot gap, six different pixel geometries have been investigated. The results for electrical characterization,

charge
collection efficiency, and position resolution of various n-in-p and
n-in-n pixel sensors with different substrates and different pixel
geometries (different bias dot gaps and pixel implant sizes) will
be presented.

Author: BUBNA, Mayur (Purdue University (US))

Co-authors: Mr PROSSER, Alan (Fermilab); DIERLAMM, Alexander (KIT - Karlsruhe Institute of Technology (DE)); Mr KRZYWDA, Alexander (Purdue University); GODSHALK, Andrew (SUNY at Buffalo); Dr KUMAR, Ashish (SUNY/Buffalo); LEI, C. M. (Fermi National Accelerator Lab. (US)); Dr BORTOLETTO, Daniela (Purdue University (US)); MENASCE, Dario (Universita & INFN, Milano-Bicocca (IT)); BOLLA, Gino (Purdue University (US)); SHIPSEY, Ian (Purdue University (US)); CUMALAT, John (Unknown); Mr ARNDT, Kirk Thomas (Purdue University (US)); PERERA, Lalith (University of Mississippi (US)); Dr UPLEGGER, Lorenzo (Fermilab); MORONI, Luigi (INFN Sezione di Milano (INFN)); Mr VIGANI, Luigi (INFN Milano); Mr GARCIA, Marcos Fernandez (Karlsruhe Institute of Technology); Mr BROSIUS, Richard (Purdue University); RIVERA, Ryan Allen (Fermi National Accelerator Lab. (US)); WAGNER, Steve (SLAC)

Presenter: BUBNA, Mayur (Purdue University (US))

Session Classification: HL-LHC/LC Sensor Developments

Contribution ID: **168** Type: **POSTER**

Operation and testbeam results of HV/HR-CMOS active sensors with pixel readout

Tuesday 2 September 2014 17:39 (1 minute)

In the Phase-II Upgrade of the Large Hadron Collider, the instantaneous
luminosity will be increased up to about 5*10³⁴ cm⁻²s⁻¹, which creates many
challenges for future detectors. This necessitates a fundamental redesign of the
ATLAS Inner Tracker (ITk) to cope with increased radiation damage and increased occupancy in the sub-detectors.
Several industrial CMOS foundries offer a High Voltage (HV) and High Resistivity (HR) design option, allowing the creation of a deep depletion zone, suitable for particle detection with active pixel detectors. These so-called HV/HR-CMOS detectors offer new in-pixel signal processing solutions, reduced clustersizes and are potentially more cost eective than current hybrid detectors.
An ATLAS R&D project has been started to qualify commercial HV/HR-CMOS technologies suitable for Pixel Detectors for the ATLAS ITk. To optimize the performance of the active sensors together with the readout chips, intricate tuning procedures are implemented in a easy-to-use test system for the collaboration to use. The latest results from characterization measurements in the lab, using the newly developed tuning procedures, and in beam tests of prototypes from several vendors will be presented.

Author: WEINGARTEN, Jens (Georg-August-Universitaet Goettingen (DE))

Presenter: WEINGARTEN, Jens (Georg-August-Universitaet Goettingen (DE))

Session Classification: Poster Session

Contribution ID: **169** Type: **ORAL**

X-CSIT: a toolkit for simulating 2D pixel detectors

Friday 5 September 2014 11:30 (25 minutes)

A new, modular toolkit for creating simulations of 2D X-ray pixel detectors, X-CSIT (X-ray Camera SImulation Toolkit), is being developed. The toolkit uses three sequential simulations of detector processes including photon interactions, electron charge cloud spreading with a high charge density plasma model and many electronic components used in detector readout. In addition, because of the wide variety in pixel detector design, X-CSIT has been designed as a modular platform so that existing functions can be modified or additional functionality added easily if the specific design of a detector demands it. X-CSIT is under development at UCL for European XFEL, and will be used to create simulations of the three bespoke 2D detectors at European XFEL, AGIPD, LPD and DSSC. These simulations and X-CSIT will be integrated into the European XFEL software framework, Karabo, and through that be available to users to aid with planning of experiments and analysis of data. In addition X-CSIT will be released standalone publicly for other users, collaborations and groups to create simulations of their own detectors.

Authors: JOY, Ashley (UCL); KUSTER, Markus (European XFEL GmbH); WING, Matthew (UCL); HAUF, Steffen (European XFEL GmbH)

Presenter: JOY, Ashley (UCL)

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **170** Type: **ORAL**

The Pixel Detector of the ATLAS Experiment for Run2 at the Large Hadron Collider

Thursday 4 September 2014 09:00 (25 minutes)

The Pixel Detector of the ATLAS experiment has shown excellent performance
during the whole Run-1 of LHC. Taking advantage of the long showdown, the detector was extracted from the experiment and brought to surface, to equip it with new service quarter panels, to repair modules and to ease installation of the Insertable B-Layer (IBL).
IBL is a fourth layer of pixel detectors, and has been installed in May 2014 between the existing Pixel Detector and a new smaller radius beam-pipe at a radius of 3.3 cm.
To cope with the high radiation and pixel occupancy due to the
proximity to the interaction point, a new read-out chip and two
different silicon sensor technologies (planar and 3D) have been developed.
Furthermore, the physics performance will be improved through the
reduction of pixel size while, targeting for a low material budget,
a new mechanical support using lightweight staves and a CO2 based cooling system have been adopted.

An overview of the refurbishing of the Pixel Detector and of the IBL project as well as the experience in its construction will be presented, focusing on adopted technologies, module and staves production,qualification of assembly procedure, integration of staves
around the beam pipe and commissioning of the detector.

Author: PERNEGGER, Heinz (CERN)

Presenter: PERNEGGER, Heinz (CERN)

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **171** Type: **ORAL**

Performance Tests During the IBL Stave Integration

Thursday 4 September 2014 12:20 (25 minutes)

In preparation of the ATLAS Pixel Insertable B-Layer integration, two detector components, so called staves, were mounted around the Beryllium ATLAS beam pipe and tested using production quality assurance measurements as well as dedicated data taking runs to validate a correct grounding and shielding schema. Each stave consists of 32 FE-I4 readout chips of ˜ 2x2cm size which sums up to over 860k pixels per stave. The integration tests include verification that neither the silicon n-in-n nor the silicon 3D sensors were damaged by mechanical stress, and that their readout chips, including their bump bond and wire bond connections, did not suffered from the integration process. Evolution of the IBL performance during its integration will be discussed as well as its final performance before installation

Author: JENTZSCH, Jennifer (Technische Universitaet Dortmund (DE))

Presenter: JENTZSCH, Jennifer (Technische Universitaet Dortmund (DE))

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **172** Type: **ORAL**

Radiation Experience with the ATLAS Pixel Detector

Monday 1 September 2014 11:30 (25 minutes)

With the increasing radiation dose accumulated by the ATLAS Pixel Detector at the LHC, effects of radiation damage become more and more visible due to the creation of silicon crystal defects. The monitoring of the detector reveals an increase in the leakage current, which is proportional to the rising radiation dose. Measurements of the effective depletion voltage show a general trend of reduction due to the decrease of the effective n-doping concentration. The most recent measurement of the radiation damage is presented along with a comparison to the theoretical model.

Author: GORELOV, Igor (University of New Mexico (US))

Presenter: GORELOV, Igor (University of New Mexico (US))

Session Classification: Hybrid Pixel Experience

Contribution ID: **173** Type: **ORAL**

Physics Performance with the ATLAS Pixel Detector

Monday 1 September 2014 09:10 (25 minutes)

The ATLAS Pixel Detector is the innermost detector of the ATLAS experiment at the Large Hadron Collider at CERN, providing high-resolution measurements of charged particle tracks in the high radiation environment close to the collision region.
The operation and performance of the Pixel Detector during the first years of LHC running are described. More than 96% of the detector modules were operational during this period, with an average intrinsic hit efficiency larger than 99 %. The evolution of the noise occupancy is discussed, and measurements of the Lorentz angle, delta-ray production and energy loss presented. The alignment of the detector was found to be stable at the few-micron level over long periods of time.

Author: MIGLIORANZI, Silvia (Abdus Salam Int. Cent. Theor. Phys. (IT))

Presenter: MIGLIORANZI, Silvia (Abdus Salam Int. Cent. Theor. Phys. (IT))

Session Classification: Hybrid Pixel Experience

Contribution ID: **174** Type: **ORAL**

LHC Phase 2 upgrade of the ATLAS Pixel Detector

Thursday 4 September 2014 11:20 (25 minutes)

From 2024, the HL-LHC will provide unprecedented pp luminosities to ATLAS, resulting in an additional integrated luminosity of around 2500 fb-1 over ten years. This will present a unique opportunity to substantially extend the mass reach in searches for many signatures of new physics, in several cases well into the multi-TeV region, and to significantly extend the study of the properties of the Higgs boson. The increased luminosity and the accumulated radiation damage will render the current Inner Tracker no longer suitable for long term operations. It will need to be replaced with a new all silicon tracker to maintain tracking performance in the high occupancy environment and to cope with the increase of approximately a factor of ten in the total radiation fluence. New technologies are used to ensure that the system can survive this harsh radiation environment and to optimise the material distribution.
Present ideas and solutions for the pixel detector will be discussed in this talk.

Author: MORETTINI, Paolo (INFN Genova)

Presenter: MORETTINI, Paolo (INFN Genova)

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **175** Type: **ORAL**

RD-53 Progress on High Rate Pixel Readout chip

Wednesday 3 September 2014 09:10 (25 minutes)

This talk will introduce the RD-53 collaboration and focus on on-going work in defining the next generation pixel readout chi for the ATLAS and CMS experiments. Will focus on particular on the issue on high data hit rate with MHz trigger rate readout. Will cover issues and possible solutions for internal data flow within the chip, which impacts layout, and options for data compression.

Author: GARCIA-SCIVERES, Maurice (Lawrence Berkeley National Lab. (US))

Co-author: RD53 COLLABORATION, www.cern.ch/RD53 (CERN)

Presenter: GARCIA-SCIVERES, Maurice (Lawrence Berkeley National Lab. (US))

Session Classification: Pixel Front End Electronics Development

Contribution ID: **176** Type: **ORAL**

RD53 investigation of CMOS radiation hardness up to 1Grad

Thursday 4 September 2014 14:30 (25 minutes)

This talk will review progress and status of testing of deep submicron CMOS technology for tolerance to radiation with total ionizing dose up to 1Grad, and also for tolerance to single event effects. Multiple prototypes have been fabricated and tested with x-rays, gamma rays, and protons. Devices tested range from single transistors to full circuits. A summary of results obtained so far will be presented.

Author: MENOUNI, Mohsine (Centre National de la Recherche Scientifique (FR))

Co-authors: GARCIA-SCIVERES, Mauricio (Lawrence Berkeley National Lab. (US)); RD53 COLLABORATION, www.cern.ch/rd53 (CERN)

Presenter: MENOUNI, Mohsine (Centre National de la Recherche Scientifique (FR))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **177** Type: **ORAL**

MAPS Development for the ALICE Upgrade

Monday 1 September 2014 14:30 (25 minutes)

The Monolithic Active Pixel Sensor (MAPS) technology offers the possibility to build pixel detectors with very high spatial resolution and low material budget; at the same time they can be produced in commercial CMOS processes. They are therefore very interesting for the innermost tracking layers of particle physics experiments. Significant progress has been made in the field of MAPS in the recent years, such that they are now considered a viable option also for the upgrades of the LHC experiments.

This contribution will focus on MAPS detectors developed for the upgrade of the ALICE ITS and manufactured in the TowerJazz 180 nm CMOS imaging sensor process on wafers with a high resistivity epitaxial layer. Within the currently ongoing R&D program, several sensor chip prototypes have been developed and produced to optimise both charge collection and readout circuitry. The chips have been characterised before and after irradiation by means of electrical measurements as well as with lasers, radioactive sources and in test beams. The tests indicate that the sensors satisfy the requirements of the experiment and first prototypes with the final size of 1.5×3cm2 have been produced in the first half of 2014. This contribution summarises the characterisation measurements from the R&D program and presents first results with the full-scale chips.

Author: YANG, Ping (Central China Normal University CCNU (CN))

Presenter: YANG, Ping (Central China Normal University CCNU (CN))

Session Classification: Monolithic Devices

Contribution ID: **178** Type: **ORAL**

Physics Benchmarks for the Belle II Pixel Detector

Monday 1 September 2014 16:20 (25 minutes)

SuperKEKB, the massive upgrade of the asymmetric electron positron collider KEKB in Tsukuba, Japan, aims at an integrated luminosity in excess of 50 ab^{-1}. It will deliver an instantaneous luminosity of 8 10^{35} $cm^{-2}s^{-1}$, which is 40 times higher than the world record set by KEKB.

At this high luminosity, a large increase of the background relative to the previous KEKB machine is expected. This and the more demanding physics rate ask for an entirely new tracking system. The expected increase of background would in fact create an unacceptable high occupancy for a silicon strip detector, making an efficient tracks reconstruction and vertexing impossible. The solution for Belle II is a pixel detector which intrinsically provides three dimensional space points.

The new two layers silicon pixel vertex detector, based on the DEPFET technology, will be mounted directly on the beam pipe. It will provide an accurate measurement of the tracks position in order to precisely reconstruct the decay vertex of the short living particles.

In this talk we will discuss the physics performance of the Belle II pixel vertex detector which will be essential for the precise measurement of the CP parameters in various B and D decay channels.

Author: LI GIOI, Luigi (Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D)

Presenter: LI GIOI, Luigi (Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D)

Session Classification: Monolithic Devices

Contribution ID: **179** Type: **ORAL**

Diamond Pixel Detector Systems in High Energy Physics

Tuesday 2 September 2014 10:10 (25 minutes)

With the first three years of the LHC running complete, ATLAS and CMS are planning to upgrade their innermost tracking layers with more radiation hard technologies. Chemical Vapor Deposition (CVD) diamond is one such technology. CVD diamond has been used extensively in beam condition monitors as the innermost detectors in the highest radiation areas of BaBar, Belle, CDF and all LHC experiments. More recently the first diamond based hybrid pixel detector system with state-of-art front-end electronics, the ATLAS FE-I4 pixel chip, was built and installed into ATLAS. This talk will describe the lessons learned in constructing diamond-based pixel systems in high energy physics, specifically the ATLAS Diamond Beam Monitor (DBM) and the CMS Precision Luminosity Telescope (PLT).

Author: HUEGGING, Fabian (University of Bonn)

Presenter: HUEGGING, Fabian (University of Bonn)

Session Classification: New Sensor Technologies

Contribution ID: **183** Type: **ORAL**

Silicon as Pixel Sensor Material at Extreme Fluences up to 10ˆ17 n/cmˆ2

Thursday 4 September 2014 15:00 (25 minutes)

Raising the electric field so as to provoke charge multiplication of electrons has enabled silicon to provide measurable signals from sensors irradiated to unprecedented radiation levels up to 1.6x10ˆ17 n_eq/cmˆ2, making it a contender also for HL-LHC very forward tracking and calorimneters. A simple scaling of collected charge vs. applied bias has been established experimentally for fluences above 10ˆ15 n_eq/cmˆ2 for planar strip sensors. Field investigations by edge-TCT have been carried out to 10ˆ16, 10ˆ17 is in the planning. Distinct features as a SCR and ENB with a sizable electric field were observed. Leakage current generation seems confined to the SCR, therefore the observed departure from linear scaling of leakage current vs. fluence at fixed voltage is not surprising. While experimental results are obtained with strip detectors, their scaling to pixel geometry will be discussed, and expected differences pointed out.

Author: MIKUZ, Marko (Jozef Stefan Institute (SI))

Co-authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); MANDIC, Igor (Jozef Stefan Institute (SI)); ZAVRTANIK, Marko (Jozef Stefan Institute (SI)); CINDRO, Vladimir (Jozef Stefan Institute (SI))

Presenter: MIKUZ, Marko (Jozef Stefan Institute (SI))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **184** Type: **ORAL**

The RD50 Activity in the Context of Future Pixel Detector Systems

Thursday 4 September 2014 15:30 (25 minutes)

The CERN/RD50 collaboration is dedicated to the radiation hardening of semiconductor sensors for future super-collider needs. It is therefore natural that the findings of our collaboration in this field are relevant to the pixel devices for the LHC experiment upgrades. A summary of the consistent amount of results on radiation tolerance enhancement of silicon sensors from RD50 will be presented. Moreover, the research towards radiation hardening has highlighted, and increased knowledge on properties of sensors that are relevant to other applications. For example radiation hardening relies on the speed of signal collection in irradiated devices. As a consequence, the methods envisaged for increasing this collection speed turn out to be promising for significantly enhancing the performance of time resolved, high spatial resolution systems. Another technology strongly emerging for future pixel sensor systems is HV-CMOS. RD50 results provide relevant information for this technology regarding the behaviour of the deep collecting electrode (deep n-well) for this type of devices after irradiation. Moreover, the methodology we have developed for the radiation tolerance studies could be a very good framework for comparing the new devices with the current state of the art.

Author: CASSE, Gianluigi (University of Liverpool (GB))

Presenter: CASSE, Gianluigi (University of Liverpool (GB))

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **185** Type: **ORAL**

Overview of HV/HR-CMOS Pixel Sensors

Tuesday 2 September 2014 09:10 (25 minutes)

HV-CMOS sensors are presently considered for the use in Mu3e experiment, ATLAS and CLIC. These sensors can be implemented in commercial HV-CMOS processes. HV-CMOS sensors feature fast charge collection by drift and high radiation tolerance. The sensor element is an n-well diode in a p-type substrate. This talk will give the overview of the detector- and readout architectures, such as capacitively coupled pixel detectors, segmented strips or 3D-integrated HV-CMOS sensors. The detector improvements such as the use of substrates with higher resistivity (HV/HR-CMOS sensors) or additional implants will be discussed as well.

Author: PERIC, Ivan (Ruprecht-Karls-Universitaet Heidelberg (DE))

Presenter: PERIC, Ivan (Ruprecht-Karls-Universitaet Heidelberg (DE))

Session Classification: New Sensor Technologies

Contribution ID: **186** Type: **ORAL**

Similarities and Differences of Recent Pixel Detectors for X-ray and High Energy Physics

Wednesday 3 September 2014 14:00 (25 minutes)

Hybrid pixel detectors are being developed for both photon science and high energy physics. In the talk we will cover similarities and differences in pixel detectors for both applications using as examples two of the pixel detectors developed at Paul Scherrer Institute (Switzerland): the EIGER photon counting detector and the psi46dig chip, which has been developed for the Compact Muon Solenoid (CMS) tracking pixel detector upgrade.

EIGER is a single photon counting hybrid pixel detector for applications at synchrotron light sources in an energy range from a few to 25 keV. It is characterized by a small pixel size, high count rate capability (10^6 counts/pixel/s)
and very high data rate, which reaches 6 Gb/s for a 256×256 pixel chip.
The CMS pixel detector has been designed to provide charge information from the pixels in the harsh Large Hadron Collider environment. The short time between bunches of 25 ns and the high event rate at peak luminosities up to $10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ require a fast detector, which retain timestamp information for the hits. The readout architecture is based on the transfer of hits from the pixels to the periphery, where the trigger verification is performed before the data transfer. The data rates of the digitized output reach 160 Mb/s for a 52×80 pixel chip.

In addition to address the specific timing and rate requirements for the detectors, the talk will cover the analog performances (minimum threshold, threshold dispersion and noise), power consumption and radiation hardness requirements. To conclude, an overview on the future developments based on mutual learning and common solutions will be discussed.

Author: TINTI, Gemma (p)

Co-authors: BERGAMASCHI, Anna (PSI); Mr MEIER, Beat (ETHZ); SCHMITT, Bernd (Paul Scherrer Institut); Dr MEZZA, Davide (Paul Scherrer Institute); Dr GREIFFENBERG, Dominic (Paul Scherrer Institute); Dr KAESTLI, Hans-Christian (Paul Scherrer Institut (CH)); Dr JOHNSON, Ian (Paul Scherrer Institute); Dr JUNGMANN-SMITH, Julia (Paul scherrer Institute); Dr DINAPOLI, Roberto (Paul Scherrer Institut); HORISBERGER, Roland (Paul Scherrer Institut (CH)); CARTIER, Sebastian Francis (P); ERDMANN, Wolfram (Paul Scherrer Institut (CH)); MOZZANICA, aldo (PSI)

Presenter: TINTI, Gemma (p)

Session Classification: X-Ray Imaging Applications

Contribution ID: **187** Type: **ORAL**

Performance and Qualification of CdTe Pixel Detectors for the Spectrometer/Telescope Imaging X-rays

Friday 5 September 2014 09:40 (25 minutes)

The Spectrometer/Telescope Imaging X-rays (STIX) is a remote sensing instrument developed to perform X-ray imaging and spectroscopy of solar flares. The imaging is realized by a Fourier-imaging technique using tungsten grid collimators in front of CdTe pixel detectors.
The detectors are used for an X-ray spectrometer unit based on the IDeF-X HD ASIC front-end to perform high resolution spectroscopy in the 4-150 keV energy range (< 1 keV @ 6 keV). 32 of such detector modules are mounted inside the Detector Electronics Module of the instrument. STIX will fly on-board the Solar Orbiter satellite to be launched in 2017.

1 mm thick Acrorad CdTe detectors with a plane Aluminum Schottky contact are used as basis for a subsequent patterning process into eight big (9.8 mm2) and four small (1 mm2) pixels. A guard ring is surrounding all twelve pixels. The anode patterning is done by means of microfabrication technologies. The cathode, a thin Platinum plane electrode operates as radiation entrance window. The size of the STIX CdTe pixel detectors is 10 x 10 x 1 mm3.

Test equipment has been developed in collaboration with ETH for selecting the best detectors in terms of performance prior shipment to CEA and for qualification purposes. The vacuum setup allows serial dark current measurements pixel by pixel at low temperature. The knowledge of the pixel dark current is the most important parameter since currents higher 60 pA create excess noise in the ASIC. Best pixels show dark currents below 10 pA at -300V bias and -20℃. Spectroscopic measurements with Ba-133 sources confirm the detector operation.

For the qualification model more than 60 CdTe pixel detectors have been processed, characterized, and partially delivered to CEA. We show in this paper the CdTe pixel detector performance meeting flight model requirements. Qualification measures including some results will be presented.

Author: GRIMM, Oliver (Eidgenoessische Tech. Hochschule Zuerich (CH))

Co-authors: MEURIS, Aline (CEA/DSM/Irfu, Gif-sur-Yvette, France); HURFORD, Gordon (FHNW, Institute of 4-D Technologies, Switzerland); BIRRER, Guy (Paul Scherrer Institute, Laboratory of Micro- and Nanatechnology, Switzerland); BEDNARZIK, Martin (Paul Scherrer Institute, Laboratory for Micro- and Nanotechnology, Switzerland); LIMOUSIN, Olivier (CEA/DSM/Irfu, Gif-sur-Yvette, France); KRUCKER, Sam (FHNW, Institute of 4-D Technologies, Switzerland); COMMICHAU, Volker (ETH Zurich, Institute for Particle Physics, Switzerland)

Presenter: GRIMM, Oliver (Eidgenoessische Tech. Hochschule Zuerich (CH))

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **188** Type: **ORAL**

Upgrades for the ALICE Inner Tracking System

Thursday 4 September 2014 10:00 (25 minutes)

ALICE (A Large Ion Collider Experiment) is studying the physics of strongly interacting matter, and in particular the properties of the Quark-Gluon Plasma (QGP), using proton-proton, proton-nucleus and nucleus-nucleus collisions at the CERN LHC (Large Hadron Collider). The ALICE Collaboration is preparing a major upgrade of the experimental apparatus, planned for installation in the second long LHC shutdown in the years 2018-2019. A key element of the ALICE upgrade is the construction of a new, ultra-light, high-resolution Inner Tracking System (ITS). The primary focus of the new ITS is on improving the performance for detection of heavy-flavour hadrons, and of thermal photons and low-mass di-electrons emitted by the QGP. With respect to the current detector, the new ITS will significantly enhance the determination of the distance of closest approach to the primary vertex, the tracking efficiency at low transverse momenta, and the read-out rate capabilities. This will be obtained by seven concentric detector layers based on a 50μm thick CMOS pixel sensor with a pixel pitch of about 30$\times$30μm^2. A key feature of the new ITS, which is optimized for high tracking accuracy at low transverse momenta, is the very low mass of the three innermost layers, which feature a material thickness of 0.3% X0 per layer. This contribution presents the design goals and layout of the new ALICE ITS, a summary of the R&D activities, with focus on the technical implementation of the main detector components, and the projected detector and physics performance.

Author: KEIL, Markus (CERN)

Presenter: KEIL, Markus (CERN)

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **189** Type: **ORAL**

Operational Experience with the ALICE Pixel Detector

Monday 1 September 2014 11:00 (25 minutes)

The ALICE Silicon Pixel Detector (SPD) constitutes the two innermost layers of the ALICE experiment, which is the LHC experiment dedicated to the investigation of strongly interacting matter in heavy-ion collisions.
The SPD consists of ˜10 million silicon pixels organized in two layers at radii of 39 mm and 76 mm that cover a pseudorapidity range of $|\eta|<2$ and $|\eta|<1.4$, respectively.
It provides the position of the primary and secondary vertices, and it has the unique feature of generating a trigger signal that contributes to the L0 trigger of the ALICE experiment.
Installed in 2007, the SPD started to record data since the first LHC collisions. This contribution presents the main features of the SPD, the detector performance and the operational experience, including calibration and optimization activities, since installation in ALICE. The ongoing consolidation activities carried out to prepare the detector for the data taking during the Run2 of LHC will also be described.

Author: CAVICCHIOLI, Costanza (Acad. of Sciences of the Czech Rep. (CZ))

Presenter: CAVICCHIOLI, Costanza (Acad. of Sciences of the Czech Rep. (CZ))

Session Classification: Hybrid Pixel Experience

Contribution ID: **190** Type: **ORAL**

Physics Performance with the ALICE Silicon Tracker

Monday 1 September 2014 12:30 (25 minutes)

The detailed characterization of quark gluon plasma (QGP) produced in heavy-ion collisions is the main goal of the ALICE experiment at CERN LHC. The analysis of heavy quarks via the decays of their short-lived hadrons is among the prominent measure to address the in-medium properties of QGP. To efficiently reconstruct these decays ALICE comprises a precise Inner Tracking System (ITS) made out of six layers of silicon detectors based on three different technologies, namely two layers of pixels, two of drifts and two of double-sided microstrip.
The two-layer pixel barrel is the innermost detector of ALICE and therefore it plays a key role in the determination of the position of the primary vertex as well as for the measurement of the impact parameter of secondary tracks originating from the weak decays of strange, charm and beauty particles.
In this contribution the main physics measurement, which have been accomplished thanks to the successful operation with proton and lead beam of the ALICE pixel detector will be discussed.

Author: MANZARI, Vito (INFN - Bari)

Presenter: MANZARI, Vito (INFN - Bari)

Session Classification: Hybrid Pixel Experience

Contribution ID: **191** Type: **ORAL**

Results from the Pilot Runs and Beam Tests of Diamond Pixel Detectors

Tuesday 2 September 2014 11:00 (25 minutes)

Progress in experimental particle physics in the coming decade depends crucially upon the ability to carry out experiments at high energies and high luminosities. These two conditions imply that future experiments will take place in very high radiation areas. In order to perform these complex and perhaps expensive experiments new radiation hard technologies will have to be developed. Chemical Vapor Deposition (CVD) diamond has been developed as a radiation tolerant material for use very close to the interaction region where detectors must operate in extreme radiation conditions. During the past few years many CVD diamond devices have been manufactured and tested. As a detector for high radiation environments, CVD diamond benefits substantially from its radiation hardness, very low leakage current, low dielectric constant, fast signal collection and ability to operate at room temperature. As a result CVD diamond has now been used extensively in beam condition monitors at every experiment in the LHC. In addition, CVD diamond is now being considered as a sensor material for particle tracking detectors, closest to the interaction region where the most extreme radiation conditions exist. We will present the state of the art results of diamond radiation hardness. We will also present results from the pilot run of the Pixel Luminosity Telescope (PLT), a luminosity monitor for the CMS detector based on single-crystal CVD diamond pixel sensors. During the pilot run the PLT sensors experienced high fluences of incoming particles, at which time the sensors showed a deviation from the results of diamond radiation hardness. In order to understand this deviation, a series of beam tests with pixel and pad detectors have been performed. The results of these beam tests will be presented and will shed the light on the anomalous behavior of the PLT sensors.

Author: WALLNY, Rainer (Eidgenoessische Tech. Hochschule Zuerich (CH))

Presenter: WALLNY, Rainer (Eidgenoessische Tech. Hochschule Zuerich (CH))

Session Classification: New Sensor Technologies

Contribution ID: **192** Type: **ORAL**

The CMS Pixel Readout Chip for the Phase 1 Upgrade

Wednesday 3 September 2014 09:40 (25 minutes)

The present CMS pixel Read Out Chip (ROC) has been designed for operation at 25 ns and to be efficient up to the nominal instantaneous luminosity of 10^{34} $cm^{-2}s^{-1}$. Based on the excellent LHC performance to date, and the upgrade plans for the accelerators, it is anticipated that the instantaneous luminosity could reach 2×10^{34} $cm^{-2}s^{-1}$ before Long Shutdown (LS) 2 in 2018, and well above this by LS3 in 2022. That's why a new ROC has been designed and a completely new pixel detector will be built with a scope of its installation in CSM during an extended winter shutdown in 2016/17. The ROC for the upgraded pixel detector is an evolution of the present architecture. It will be manufactured in the same 250 nm CMOS process. The core of the architecture is maintained, with enhancement in the performance in three main areas: readout protocol, reduced data loss and enhanced analog performance. The main features of the new CMS pixel ROC are presented together with measured performance of the chip.

Author: STARODUMOV, Andrei (Eidgenoessische Tech. Hochschule Zuerich (CH))

Presenter: HITS, Dmitry (Eidgenoessische Tech. Hochschule Zuerich (CH))

Session Classification: Pixel Front End Electronics Development

Contribution ID: **194** Type: **ORAL**

Sensors and Front-end Electronics for the LSST Camera

Friday 5 September 2014 09:10 (25 minutes)

Over the next 5 years, the Large Synoptic Survey Telescope collaboration will construct a new 8m-class ground-based telescope and 3 Gpixel camera to perform an all-sky survey in the optical and near IR. Science themes of LSST include fundamental cosmology (testing the lambda-CDM paradigm and search for new physics), galactic astronomy (assembly history of the Milky Way), Solar System astronomy (asteroids and Kuiper belt objects), and optical transients. To accomplish these goals, focal plane components (sensors and front-end electronics) must satisfy stringent optical, mechanical, and electronic requirements.

LSST's science focal plane incorporates 189 high resistivity, fully-depleted CCDs in a modular arrangement of 21 "raft towers". Each tower is an autonomous, fully-functional camera with complete control, signal processing, diagnostic, and housekeeping functions for 9 CCDs (144 video channels). The sensors, electronics, mechanical, and thermal management elements of the tower are housed in a rectangular enclosure roughly 13 x 13 x 23cm inside the vacuum cryostat. Thanks to the high degree of parallelism, frame readout time is 2s at a pixel rate of 550kpix/s. Video data has a noise floor of about 9 e-, a dynamic range of 86dB and channel-to-channel crosstalk below -62dB. Locating the FE electronics in vacuum necessitates a low power budget; during readout the tower electronics dissipates less than 50W (350mW/channel). We will review performance results from pre-production towers and describe the ongoing characterization and scale-up studies.

Author: O'CONNOR, Paul (Department of Physics)

Presenter: O'CONNOR, Paul (Department of Physics)

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **195** Type: **ORAL**

Operational Experience with the CMS Pixel Detector

Monday 1 September 2014 10:10 (25 minutes)

Since the beginning of its operation the CMS Silicon Pixel detector performed very well. The operational challenges included the maximization of data taking efficiency, dealing with beam gas interactions and single event upsets, and the recovery of lost modules. The data acquisition techniques also had to adapt to the rapidly changing LHC beam conditions. In order to maximise the physics potential and the quality of the data, online and offline calibrations were performed on a regular basis. The timing calibration which took place in the commissioning periods ensured maximal hit and charge collection efficiency. The position resolution was improved by pixel charge thresholds, gain and various other online calibrations. By the end of Run I, 3.7% of the modules were not operational of which most have been already recovered during the current shutdown. In this talk the operational challenges of the silicon pixel detector in Run I are presented, and the expectations for the next LHC data taking period in 2015 are discussed.

Author: KARANCSI, Janos (University of Debrecen (HU))

Presenter: KARANCSI, Janos (University of Debrecen (HU))

Session Classification: Hybrid Pixel Experience

Contribution ID: **196** Type: **ORAL**

Radiation Experience with the CMS Pixel Detector

Monday 1 September 2014 12:00 (25 minutes)

The CMS pixel detector is the innermost component of the CMS tracker occupying the region around the center of CMS, where the LHC beams are crossed, between 4.3 cm and 30 cm in radius and 46.5 cm along the beam axis. They are operated in a high-occupancy and high-radiation environment created by particle collisions in the LHC. Studies of radiation damage effects to the sensors were performed throughout the first running period of the LHC. Leakage current, depletion voltage, pixel read-out thresholds, and hit finding efficiencies were monitored as functions of the increasing particle fluence. The methods and results of these measurements will be described in the presentation together with their implications to detector operation as well as to performance parameters in offline hit reconstruction.

Author: VESZPREMI, Viktor (Wigner RCP, Budapest (HU))

Presenter: VESZPREMI, Viktor (Wigner RCP, Budapest (HU))

Session Classification: Hybrid Pixel Experience

Contribution ID: **197** Type: **ORAL**

Near Future Upgrades for the CMS Pixel Detector

Thursday 4 September 2014 09:30 (25 minutes)

The silicon pixel detector is the innermost component of the CMS tracking system, providing high precision space point measurements of charged particle trajectories. The performance of the current pixel detector has been excellent during Run 1 of the LHC. However, the foreseen significant increases of the instantaneous and integrated luminosities at the LHC necessitate an upgrade of the pixel detector in order to maintain the excellent tracking and physics performance of the CMS detector. The new pixel detector is planned to be installed during an extended LHC winter shutdown in 2016-17. The main new features of the upgraded pixel detector would be ultra-light mechanical design, an additional 4th layer in the barrel and two additional endcap disks, and a new digital readout chip with increased buffers to minimize data-loss. The other important features are a new two-phase CO2 cooling system and a new powering scheme via DC-DC converters. Each of these aspects will be summarized and the resulting improvements in physics performance will be discussed. Current status on module assembly and testing will also be reported.

Author: KUMAR, Ashish (State University of New York (US))

Presenter: KUMAR, Ashish (State University of New York (US))

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **198** Type: **ORAL**

Pixel sensors for the CMS phase-II upgrade

Thursday 4 September 2014 11:50 (25 minutes)

The high luminosity phase of the Large Hadron Collider (HL-LHC) requires a major pixel detector R&D effort to develop both readout chip and sensor that are capable to withstand unprecedented extremely high radiation damage. The target integrated luminosity of 3000 fb-1, that the HL-LHC is expected to deliver over about 10 years of operation, translates into a hadron fluence of 2x10ˆ16 1MeV eq. n / cm2 at about 3 cm from the interaction region where the first layer of the pixel detector could be located, and to a radiation dose of 10 MGy for the readout chip. The CMS collaboration has undertaken two baseline sensor R&D programs on thin n-in-p planar and 3D Silicon sensor technologies. Alternative technologies are also being investigated such as polycrystalline Diamond and HV-CMOS. Status, progresses, and prospects of this effort will be discussed.

Author: DINARDO, Mauro (Universita & INFN, Milano-Bicocca (IT))

Presenter: DINARDO, Mauro (Universita & INFN, Milano-Bicocca (IT))

Session Classification: LHC Upgrade Detector Designs

Contribution ID: **199** Type: **ORAL**

Physics Performance with the CMS Pixel Detector

Monday 1 September 2014 09:40 (25 minutes)

This talk presents the results of searches for various physics channels in proton-proton collisions at $\sqrt{s} = 7$ and 8 TeV delivered by the LHC and collected with the CMS detector. Many obtained results crucially depend on the performance of the CMS pixel detector. Among others b- and tau-tagging as well as primary and secondary vertex reconstruction algorithms are discussed. Application of these algorithms for searches of the Higgs boson and measurements of branching ratio of $\mathrm{B} \to \mu^+\mu^-$ will be presented.

Author: MEIER, Frank (University of Nebraska (US))

Presenter: MEIER, Frank (University of Nebraska (US))

Session Classification: Hybrid Pixel Experience

Contribution ID: **200** Type: **ORAL**

Development of High Performance X-ray Cameras at DESY: from prototypes to complete systems

Wednesday 3 September 2014 15:30 (25 minutes)

With the continual drive towards bigger, better and brighter light sources, whole new areas of scientific research are possible that would have been unimaginable or even believed impossible before.
However, even the best experiment or the best light source is worthless if the employed detection system is not up to the task at hand. This is especially true for light sources like the current and upcoming generation of Hard X-ray FELs, which introduce special challenges that are distinctly different from the challenges posed at current 3rd generation synchrotrons.
Cutting edge area-detector developments nowadays mostly, but not exclusively, provide a separate readout channel for each pixel, allowing sophisticated parallel signal processing. The hybrid pixel approach further makes it possible to optimize the sensor and the readout chip independently from each other, and profit from technological advances very quickly. Improvements in microchip production (Moore's law) make it possible to achieve faster readout, smarter signal processing and smaller pixels, while new sensor materials and designs can have a range of benefits such as better quantum efficiency.
In this talk, two hybrid pixel systems and one CMOS imaging system developed by the photon science detector group at DESY (FS-DS) are presented: The AGIPD system, a high dynamic range 4.5 MHz burst mode camera for use at the European XFEL, the LAMBDA system, a Medipix3 based large area detector with 55 um pixel size and the ability to support either silicon or high-Z sensors and is currently being commissioned at PETRA-III synchrotron beamlines, and the PERCIVAL system with 27 um pixels and large dynamic range, optimized for operation at soft x-ray energies between 250 eV and 1 keV at 120 Hz repetition rate.

Author: BECKER, Julian (DESY)

Co-authors: Dr WUNDERER, Cornelia (DESY); PENNICARD, David (DESY); GRAAFSMA, heinz

Presenter: BECKER, Julian (DESY)

Session Classification: X-Ray Imaging Applications

Contribution ID: **201** Type: **ORAL**

Pixel Detectors for the LCLS

Wednesday 3 September 2014 15:00 (25 minutes)

Fourth generation light sources such as the LCLS represent a unique and challenging environment in which to operate x-ray detectors. Their pulsed time structure, in which a large number of x-rays impinge on a sample essentially simultaneously, demands detectors capable of handling large signals while maintaining sensitivity to single photons. Both energy and absorption depth in silicon of the delivered x-rays vary by orders of magnitude. Under certain conditions during a single 50 femtosecond long burst, parts of a detector can absorb a radiation dose similar to that seen by the inner pixel layers at the LHC over a ten year period. These detectors enable a diverse range of science from fusion energy and biology to material science and chemistry. To meet all these needs a suite of detectors is being designed and manufactured.

Author: KENNEY, Chris (SLAC)

Presenter: KENNEY, Chris (SLAC)

Session Classification: X-Ray Imaging Applications

Contribution ID: **202** Type: **POSTER**

Development of High Spatial Resolution Silicon Based Neutron Detectors for the European Spallation Source

The aim of this project is to bring advanced silicon pixel detector technology to the world of neutron scattering. Such devices would revolutionize the resolution capabilities of detectors by an order of magnitude for detectors up to 1 sq m active area when tiled up. The Project is supported by the Subatomic Group at the University of Bergen (UiB) and SINTEF at Oslo, Norway where facilities and expertise on radiation physics, simulation, instrumentation and readout electronic will be provided .The pixel sensors would be primarily aim for the needs and requirements for the (ESS) European Spallation Source, Sweden. This experimental work would include electrical measurements on sensor level, investigation and understanding of different neutron converter material deposition, electronic and mechanical assembly of these sensors and characterization of sensors using neutron sources. Moreover, data analysis of all experimental data and drawing a physical understanding with the help of GEANT4 simulation will be carried out. In addition, radiation hardness due to the damage of alpha particles and detector's life time will also be studied.

Author: BANSAL, Yashika (U)

Co-authors: KOK, Angela (SINTEF); ROEHRICH, Dieter (University of Bergen (NO)); KANAKI, Kalliopi (University of Bergen (NO)); HALL-WILTON, Richard (ESS - European Spallation Source (SE))

Presenter: BANSAL, Yashika (U)

Contribution ID: **203** Type: **POSTER**

Characterization of Low Gain Avalanche Detectors (LGAD) irradiated with protons and neutrons

Tuesday 2 September 2014 17:33 (1 minute)

This work presents new avalanche pad detectors with low gain (LGAD) fabricated with a technology based on APD but with a modified doping profile, in order to have detectors suitable to be used for tracking in high energy physics experiments (such as colliders) and resistant to the high radiation fluencies expected in the future LHC upgrade at CERN. If a significant improvement of the collected charge is found after heavy irradiation, this geometry can be directly applied to microstrip and pixels sensors.
A Sentaurus TCAD simulation was performed to predict the electrical behavior of the proposed structures since some of the new technological solutions might compromise the voltage breakdown properties. The capacitance behavior of these new devices is to be studied too, since an increase of the capacitance value will increase the noise, worsening the signal to noise ratio, even for the highest gain values.
In this work we show the electrical measurements and charge collection studies obtained with MIP and alpha radiations before and after irradiations with neutrons and protons at fluences up to 1015 cm-2 1 Mev equivalent.

Author: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Presenter: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Session Classification: Poster Session

Contribution ID: **204** Type: **ORAL**

DAMIC: A Search for Dark Matter with CCDs

Friday 5 September 2014 10:10 (25 minutes)

The DAMIC experiment uses high resistivity, fully depleted CCD's as detectors to search for dark matter particles. The low electronic readout noise (RMS ˜2 electrons) of the CCD's make possible to reach a detection threshold below 50 eV of deposited energy by nuclear recoils in the silicon target. Owing to these characteristics, DAMIC has an unrivaled sensitivity to WIMPs with masses below 10 GeV. Early DAMIC runs demonstrated the high energy resolution, low energy threshold, and power for background characterizaction of CCDs, and also achieved the world's best cross-section limits on WIMPs with masses below 4 GeV. These results motivated the construction of DAMIC100, which will have a target mass of 100 grams of silicon and will be installed in SNOLAB during the Summer of 2014. This new detector will directly test the parameter space corresponding to the recent results obtained by CoGeNT and by CDMS-Si, which may be hinting at the presence of a low mass WIMP signal. In this talk we will discuss the challenges associated with the scale-up of the experiment, its current status, and the prospects for the first physics results after a one year run.

Author: TIFFENBERG, Javier (Fermi National Accelerator Lab. (US))

Presenter: TIFFENBERG, Javier (Fermi National Accelerator Lab. (US))

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **205** Type: **ORAL**

Astronomical Instrumentation for Dark Energy Using Superconductor Detectors (MKIDs)

Friday 5 September 2014 11:00 (25 minutes)

Dark Energy, the driving force for the accelerated expansion of the Universe, has become one of the largest mysteries in our current understanding of Nature. There are several ongoing, and planned astronomical projects to map large scale structure and geometry of the Universe to investigate this. During this talk we will present the newly developed Microwave Kinetic Inductance Detectors, and discuss how they could play an important role in this scientific quest.

Author: ESTRADA, juan (fermilab)

Presenter: MACUK, Emily (Fermilab)

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **206** Type: **ORAL**

Cornell Integrating Pixel Array Detector Development for Synchrotron X-ray Light Sources

Wednesday 3 September 2014 14:30 (25 minutes)

Synchrotron light sources are capable of producing x-ray synchrotron radiation of extreme brilliance and coherence. These sources create opportunities to exploit experimental techniques in both time-resolved and coherent x-ray imaging experiments, assuming the availability of area detectors designed to capture and record the relevant and desired x-ray information. Capturing this information presents challenges for both the speed and dynamic range of the imaging detectors. The on-going integrating detector development efforts at Cornell addressing these needs will be presented. These will include high-speed and high-dynamic range detectors that have been developed by the group and recently used in scientific collaborations at synchrotron sources; and less mature development efforts aimed at increasing detector capabilities with an eye on future light source and experimental capabilities.

Author: PHILIPP, Hugh (Cornell University)

Co-authors: Mr WEISS, Joel T. (Cornell University); Dr SHANKS, Katherine S. (Cornell University); Dr TATE, Mark W. (Cornell University); Mr PUROHIT, Prafull (Cornell University); Prof. GRUNER, Sol M. (Cornell University)

Presenter: PHILIPP, Hugh (Cornell University)

Session Classification: X-Ray Imaging Applications

Contribution ID: **207** Type: **ORAL**

2.5D and 3D Integrated Circuit Technology Capablilities and Industry Readiness

Thursday 4 September 2014 16:50 (25 minutes)

The term 3D integrated circuit covers a wide swath of technologies today. It can mean anything from chip stacking to interposers or "2.5D integration", to TSV'd wafer stacking or even the latest bleeding edge technology push into monolithic 3D devices. No matter which type, with scaling's advantages rapidly eroding, 3D integrated circuits appear to be gaining traction in the market.

Most designers are cognizant of the numerous possible benefits that can be obtained from advanced 3D integration, including higher density, lower power, and better performance. Perhaps the biggest benefit that separates 3D integration from world of simply More Moore, comes from 3D heterogeneous integration. The fundamental ability offered by 3D integration to separate circuits for implementation in the best suited technology while maintaining thousands or even millions of sub-circuit to sub-circuit interconnects changes fundamental semiconductor capabilities. The market winners need not be only those who can afford new multi-billion dollar investments in next generation lithography and deeper sub-micron technologies. 3D has the potential for reshaping markets. Those who pick the right version or versions of 3D and figure out how to use this new technology can become tomorrow's market leaders.

There is no doubt 3D technology has shown promise, but it has also plagued early adopters with numerous issues including processing inconsistencies, lack of adequate design tools and most importantly the lack reasonable of a supply chain. The question to be addressed is 3D integration really ready or is it like the infamous EUV lithography technology which has been 2 years away from production for almost 30 years.

The presentation will cover the available 2.5/3D processes and their capabilities, commercially available design tools and the current supply chain situation. The discussion will also review technical successes and failures and why, which, and how 2.5/3D is now ready industry adoption.

Summary

This presentation will cover various 3D integrated circuit technologies, tools, and supply chains discussing the readiness of the technology for volume production. Past successes and failures will be reviewed for lessons learned and examination of what hidden issues might still be lurking.

Author: PATTI, Robert (Tezzaron Semiconductor Corp.)

Presenter: PATTI, Robert (Tezzaron Semiconductor Corp.)

Session Classification: Cooling, Interconnections, Radiation Tolerance

Contribution ID: **208** Type: **not specified**

Introduction/Participant Orientation

Monday 1 September 2014 09:00 (10 minutes)

Presenter: TRISCHUK, William (University of Toronto (CA))

Session Classification: Hybrid Pixel Experience

Contribution ID: **209** Type: **not specified**

Participant Information

Tuesday 2 September 2014 09:00 (10 minutes)

Presenter: KAGAN, Harris (Ohio State University (US))

Session Classification: New Sensor Technologies

Contribution ID: **210** Type: **not specified**

Participant Information

Wednesday 3 September 2014 09:00 (10 minutes)

Presenter: TAYLOR, Wendy (York University (CA))

Session Classification: Pixel Front End Electronics Development

Contribution ID: **211** Type: **not specified**

Buses leave Sheraton

Wednesday 3 September 2014 17:45 (15 minutes)

Session Classification: Winery Dinner

Contribution ID: **212** Type: **not specified**

Hors d'oeuvres

Wednesday 3 September 2014 18:15 (45 minutes)

Session Classification: Winery Dinner

Contribution ID: **213** Type: **not specified**

Dinner

Wednesday 3 September 2014 19:00 (2 hours)

Session Classification: Winery Dinner

Contribution ID: **214** Type: **not specified**

First bus returns to Sheraton

Wednesday 3 September 2014 21:00 (2 minutes)

Session Classification: Winery Dinner

Contribution ID: **215** Type: **not specified**

Last bus returns to Sheraton

Wednesday 3 September 2014 21:28 (2 minutes)

Session Classification: Winery Dinner

Contribution ID: **216** Type: **not specified**

Participant Information

Friday 5 September 2014 09:00 (10 minutes)

Presenter: TRISCHUK, William (University of Toronto (CA))

Session Classification: Astrophysics and other Pixel Applications

Contribution ID: **217** Type: **not specified**

Farewell

Friday 5 September 2014 12:30 (5 minutes)

Presenter: KAGAN, Harris (O)

Session Classification: Astrophysics and other Pixel Applications