

ATTRACT TWD Symposium: Trends, Wishes and Dreams in Detection and Imaging Technologies



Contribution ID: 70

Type: **not specified**

CUBIX - Highly sensitive radiation imaging detector with fully 3D segmentation

CUBIX is a concept of innovative radiation imaging/tracking detector with high 3D granularity and high absorption for common radiation types. The basic hybrid sensor module is of a cubic shape of roughly 3 cm³ consisting of 128x128x128 voxels (2 Mega voxels). Good absorption for penetrating radiation is achieved by large detector volume (1.5 cm thickness or more, sensitivity of 25-50% for 511 keV gamma can be achieved with silicon). Thanks to its 3D segmentation the detector maintains good spatial resolution regardless of the total thickness. The whole detector device can be of hand-held size operated at room temperature.

The proposed detector records a complete information for every event. This way the undesired influences of undesired radiation background or e.g Compton scattering can be greatly reduced or even further exploited (directional sensitivity, polarization sensitivity, Compton camera ...).

There are many applications of such ultimate imaging detector and hand-held tracker: Medical imaging (scintigraphy, SPECT, PET) and Non-destructive-testing with isotopes or low power X-ray sources, radiation monitoring and security, environmental and geological research, exploration and mining, scientific experiments, education etc. Many other applications would be probably enabled by this technology in future.

The proposed detector combines latest CERN technology of imaging/tracking readout chips such as Timepix3 with unique technology of thin silicon sensors with active edges (sometimes called edgeless sensors). The edgeless technology allows to bring sensor electrodes over the sensor edge (e.g. strips, or double sided crossed strips). Therefore even when many of such sensor layers are stacked their contacts are still accessible for connection of readout electronics. This way the fully 3D sensitive structure can be made and flip-chip bonded e.g. to pair of Timepix3 readout chips. The basic detector structure is shown in the image here.

The proposed CUBIX structure presents a next level in 3D integration of sensors. This technology of imaging detector can be a significant technological breakthrough in field of radiation imaging and radiation protection. It combines and extends cutting-edge purely European technologies of particle counting detectors Medipix/Timepix developed in CERN with technology of edgeless sensors developed in VTT Finland.

Summary

CUBIX is a concept of innovative radiation imaging/tracking detector with high 3D granularity and high absorption for common radiation types. The basic hybrid sensor module is of a cube shape of roughly 3 cm³ consisting of 128x128x128 voxels (2 Mega voxels). The ultimate configuration which (probably beyond current technological limits) would allow even 16 Mega voxels. Such detector unit is 3 sides buttable. 4 sides buttability could be also achieved with small gap of about 250 microns among modules. The proposed sensor material is silicon. Good absorption for penetrating radiation is achieved by large detector volume (1.5 cm thickness or more => even sensitivity of 25-50% for 511 keV gamma can be achieved). Thanks to its 3D segmentation the detector maintains good spatial resolution regardless of the total thickness. The whole detector device can be of hand-held size operated at room temperature with low biasing voltage.

The proposed detector concept allows recording of up to 80 million hits per second. The detector would be operated in list mode providing the 3D coordinates, energy and time-stamp for every hit. The complete information recorded for every event allows for reconstruction of full chain of interactions for every particle (tracking mode). This way the undesired influences of radiation background or e.g Compton scattering can be greatly reduced or even further exploited (directional sensitivity, polarization sensitivity, Compton camera ...).

There are many applications of such ultimate imaging detector and hand-held tracker: Medical imaging (scintigraphy, SPECT, PET) and Non-destructive-testing with isotopes or low power X-ray sources, radiation monitoring and security, environmental and geological research, exploration and mining, scientific experiments, education and many others.

The proposed detector combines latest CERN technology of imaging/tracking readout chips such as Timepix3 with unique technology of thin silicon sensors with active edges (sometimes called edgeless sensors). The edgeless technology allows to avoid need of guard rings and bring sensor electrodes over the sensor edge (e.g. strips, or double sided crossed strips). Therefore even when many of such sensor layers are stacked on top of each other their contacts are still accessible on sides for connection of readout electronics. This way the fully 3D sensitive structure can be made and flip-chip bonded e.g. to pair of Timepix3 readout chips.

The proposed CUBIX structure presents a next level in 3D integration of sensors. This technology of imaging detector can be a significant technological breakthrough in field of radiation imaging and radiation protection. It combines and extends cutting-edge purely European technologies of particle counting detectors Medipix/Timepix developed in CERN with technology of edgeless sensors developed in VTT Finland.

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