Application of GridPix Detectors

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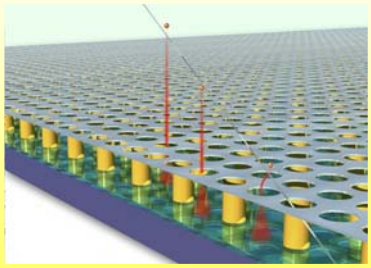
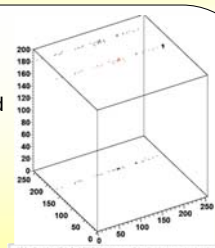
GridPix Detectors: An Introduction

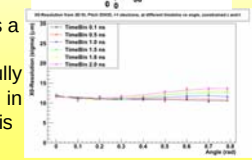
The Gridpix detector is able to measure 3D information of single electrons with very high precision. The chip is based on a CMOS pixel detector with an internal clock and is developed by the Medipix Consortium. By applying MEMS technology on chip wafers, a grid is integrated onto the chip.
A Gas layer is placed in top of the chip, there is a small electric field between the kathod and the grid and a large field between the grid and the chip resulting in electrons drifting down in de drift volume creating a measurable avalanche in the region between the grid and the chip.



Several GridPix prototypes have been build, simulations are done en upgrades are planned:



-The DICE detector (Delft Internal Conversion Experiment) has a 20 mm driftgap and is placed in a 0.3 T B-field, one prototype has been build and is tested succesfully with cosmics, radioactive sources and in a test beam (no analysed results yet, a typical event shown right).



-GOSSIP (Gas On Slimmed Silicon Pixel) has a 1 mm drift gap and is studied for MIPS (no magnetic field) in MC Simulations, is succesfully tested with radioactive sources. Will be tested in testbeam next month. The angular resolution is in the ~few degrees, X-res is shown right as function of angle wrt the chip:

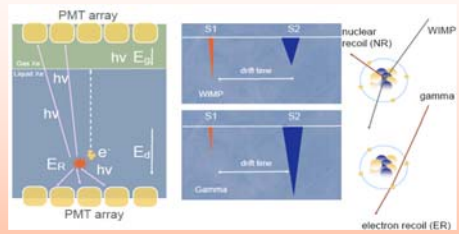
GridPix for WIMP search:

WIMPS (Weakly Interacting Massive Particles) are dark matter candidates. WIMPS could be detected by their collisions with nuclei in underground experiments, such a discovery would be a milestone in physics. However signal rates are small and background might spoil the measurements, therefore large massive detectors are needed. To avoid background domination, detectors should be placed underground in an ultra-low background environment.

DARWIN (Dark Matter WIMP search with Noble Liquids) is a recent proposal for future WIMP experiments, with as goal to try and detect WIMPS. Results from noble liquid detectors have recently shown that they are among the most promising technology to push the sensitivity of direct WIMP searches far beyond existing limits into the physically regime of theoretical predictions.

This should be done in a large tank filled with liquid a noble liquid like Xenon and a gas layer in top of it. The high Z-value of Xenon results in self shielding for background events. The walls of the tank are covered with PMTs made of non-radioactive material. A WIMP comes in collides with a Xenon atom, an electron is kicked out and the Xenon-ion starts moving and ionizing other atoms, electrons are drifting from the liquid through the gas.

For WIMP search experiments one of the setups is to cover the tank with PMTs, to detect all photons coming from an event, as can be seen below for the XENON experiment.



Principle from the XENON experiment: S1 is the prompt signal from the direct interaction, S2 is the proportional signal from charged particle in the gas. In XENON PMTs are used.

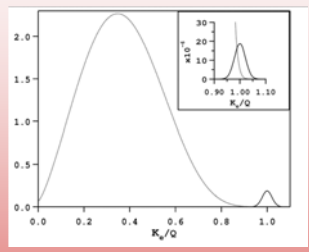
Picture from Talk of Jose A. Matias Lopes 12-2008

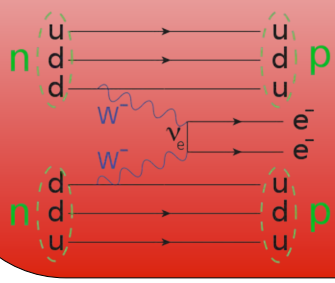
In DARWIN one of the proposed scenarios is to replace the top layer of PMTs in the gas by GridPix detectors. Electrons are drifting through the gas toward the Grid where an avalanche is created that is measured on the pixel. Typically a few electrons per event can be seen. The gas layer should be small in order to reduce the contribution of the gas diffusion. Due to the excellent resolution of a GridPix detector together with the PMTs signal, a very secure measurement can be done. The fact that two signals are used for measurements reduces the probability for background events.

GRIDPIX for Neutrinoless Double Beta Decay:

Many isotopes are, in theory, capable both of double-beta decay and other decays. In most cases, the double-beta decay is rare and hard to observe against the background of other radiation. In double beta decay two neutrons are decaying in two protons while emitting two electrons and two electron neutrino's.

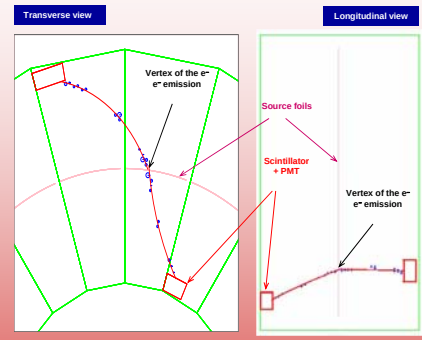
Neutrinoless double beta decay is a process where two virtual neutrino's annihilate, and two electrons are emitted. Annihilation is only possible when the neutrino is it's own anti-particle i.e. a Majorana particle. A neutrinoless double beta decay, can only be observed if there is no missing energy (from neutrino's flying away)





Neutrinoless double beta decay when observed would be a major breakthrough in the investigation of physics beyond the Standard Model, besides that it can contribute to the determination of the neutrino

In Neutrinoless Double Beta Decay experiments like NEMO mainly use the principle of wire chambers together with scintillating electrons and catching the electrons with PMTs as is shown below in the NEMO case.



GridPix detectors are ideal detectors for detecting single electrons, resolutions are pretty good compared with classical PMTs combined with wire chambers. Due to the good angular resolutions it is expected that GridPix detectors give significantly better results in Double Beta Decay Experiments based on drifting electrons.

GridPix detectors are ideal detectors for detecting single electrons, resolutions are good. It is expected that GridPix detectors give significantly better results in Double Beta Decay Experiments based on drifting electrons. The magnetic field reduces the diffusion contribution to the measurement of the drifting electrons. GridPix detectors are made of non-radioactive materials, background contribution is small.

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