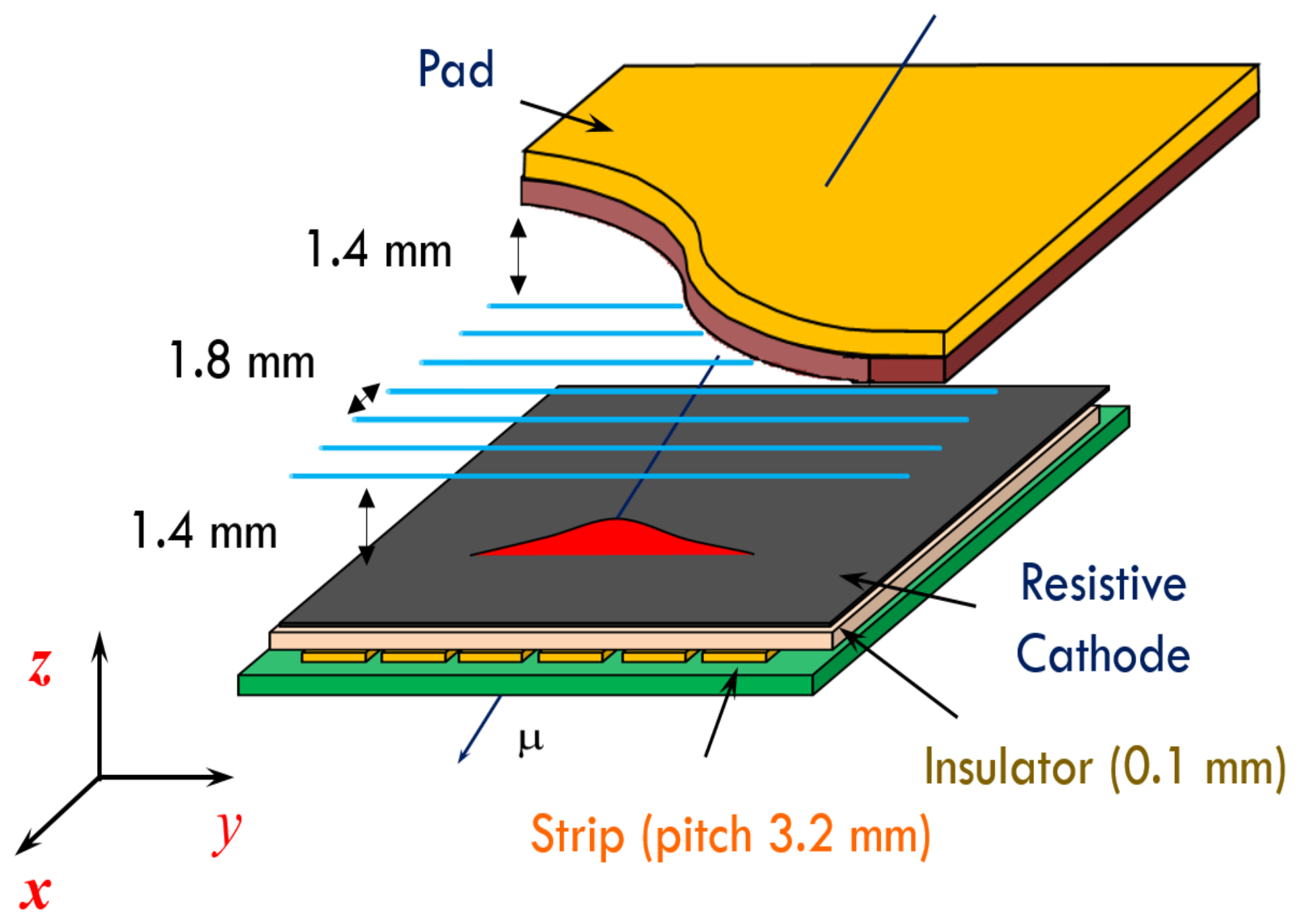
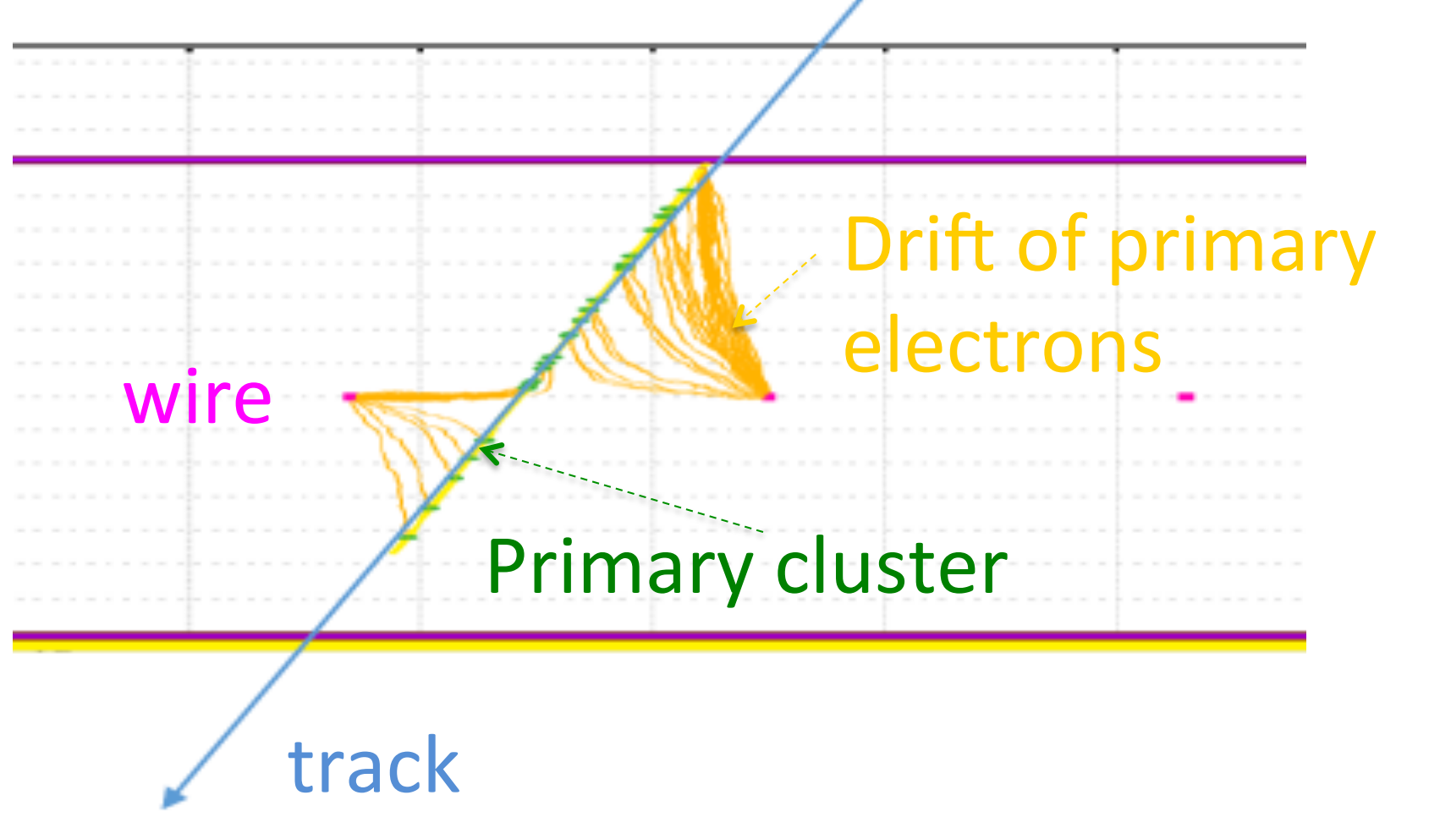
Simulation for ATLAS nSW Thin Gap Chambers

Jiaming Yu(University of Michigan) on behalf of Atlas Muon collaboration



Small-strip Thin Gap Chamber (sTGC)

The basic sTGC structure consists of a group of 50 μm gold-plated tungsten wires (anode) with a 1.8 mm pitch, sandwiched between two cathode planes at a distance of 1.4 mm from the wire plane. The cathode planes are made of a graphite-epoxy mixture with typical surface resistivity of 100kΩ/☐ sprayed on a 100 μm thick G-10 plane. Strips and pads are located on the opposite side of the sTGC detector, on a 1.6mm thick PCB with the shielding ground on the other side. The strip pitch is 3.2 mm(2.7 mm strip width + 0.5 mm gap), and the pad size is about 8.7cm×8.7cm.

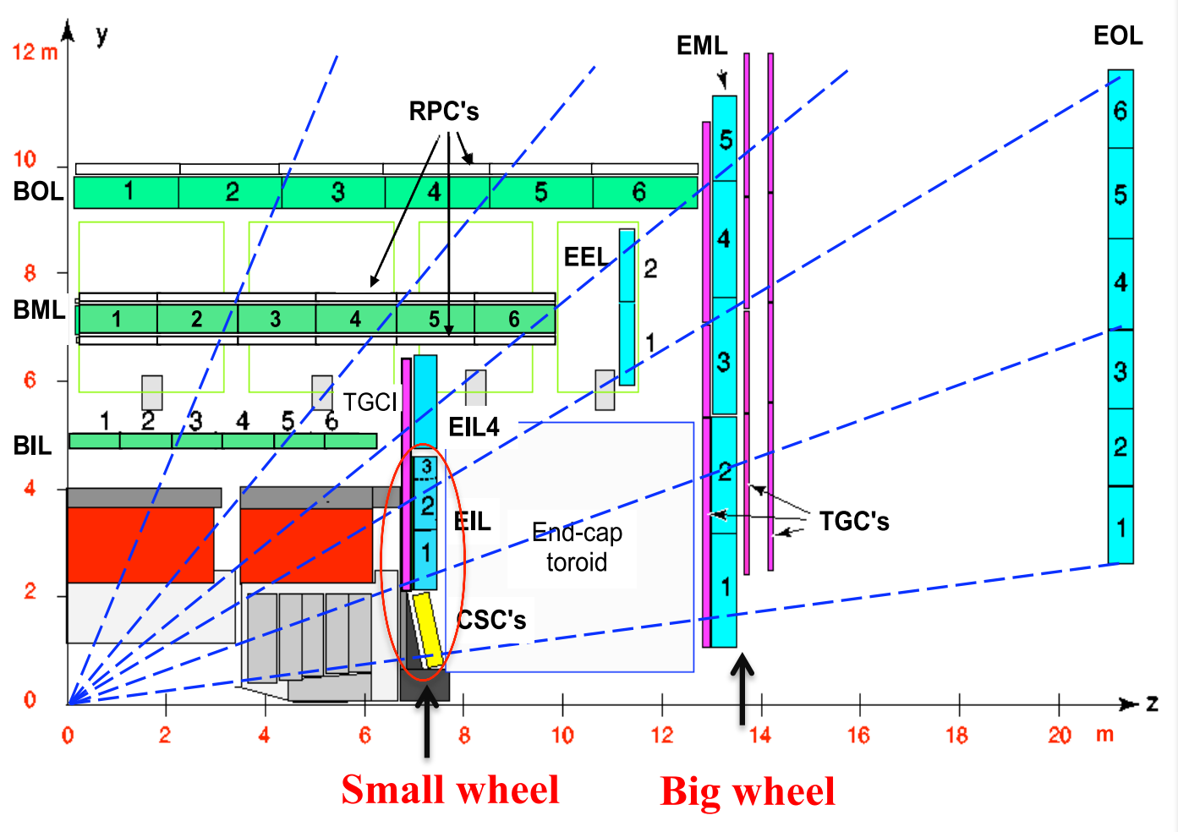


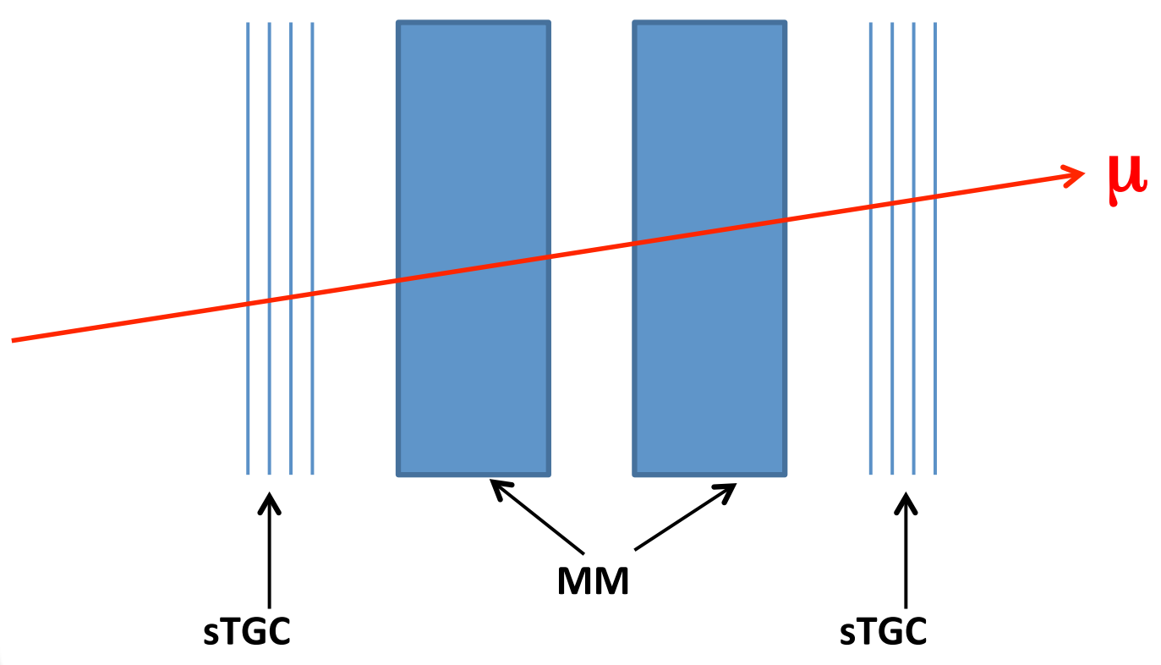
The operational gas is a mixture of CO_2 and n-pentane (C_5H_{12}) with a ratio of 55: 45 at one atmospheric pressure.

sTGC for ATLAS nSW

ATLAS new Small Wheel (nSW) (phase-I upgrade in 2018)

- Two stations of MicroMegas(MM) sandwiched between two stations of sTGC
- MM: precise muon hit position measurement
- sTGCs: trigger detector



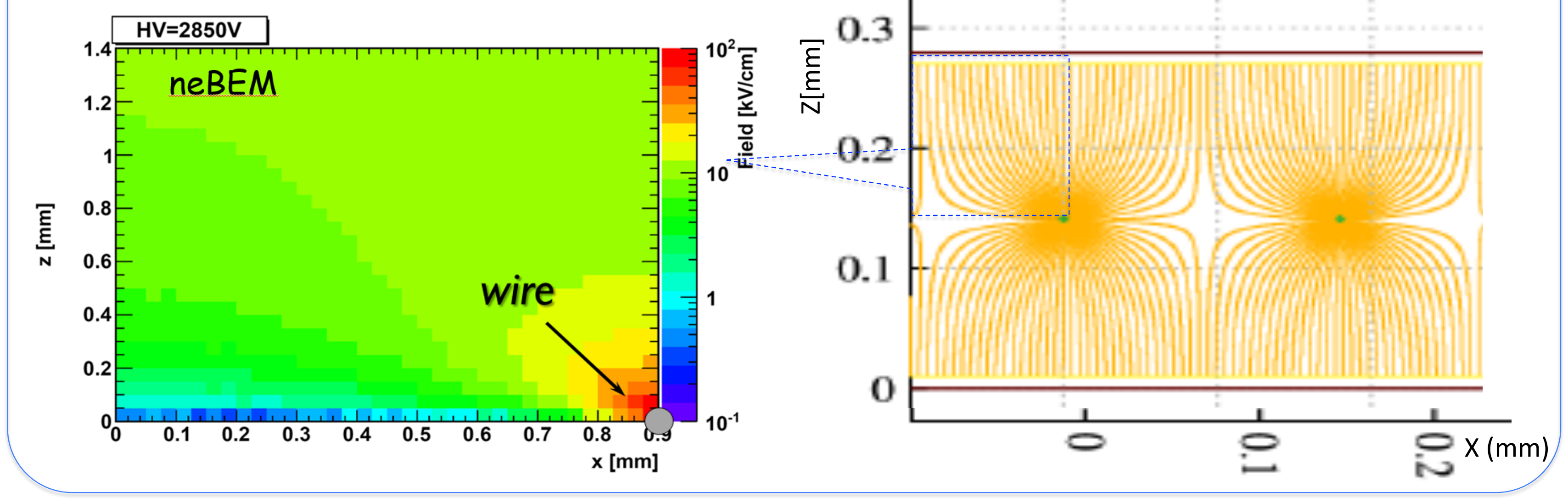


The requirements for sTGC as the trigger detector:

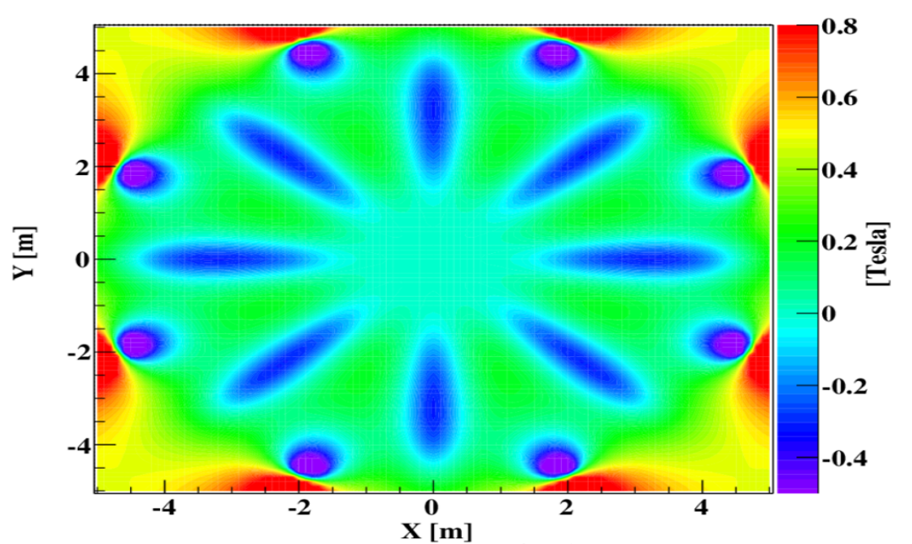
- Good time resolution for the bunch crossing (25ns) identification
- An angular resolution of 1mrad for L1 trigger track segments

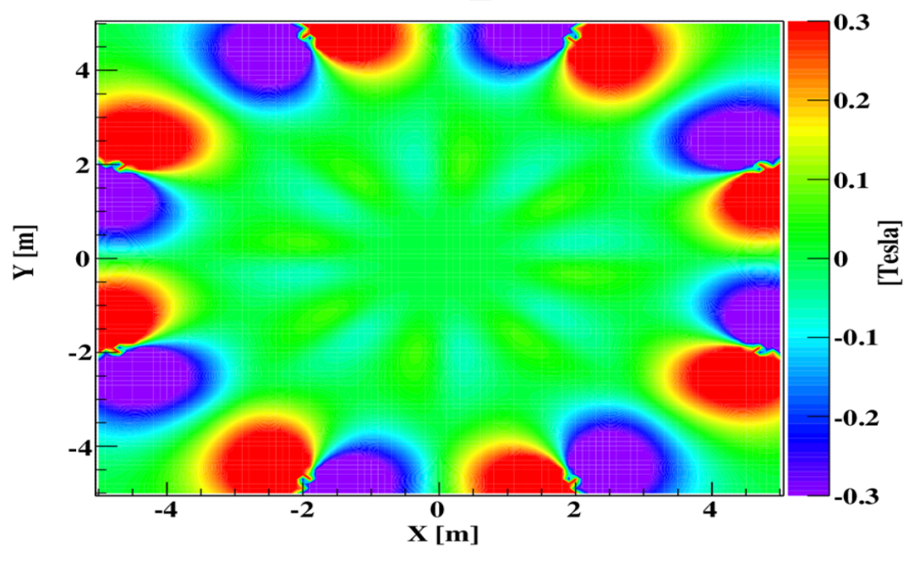
Electric field

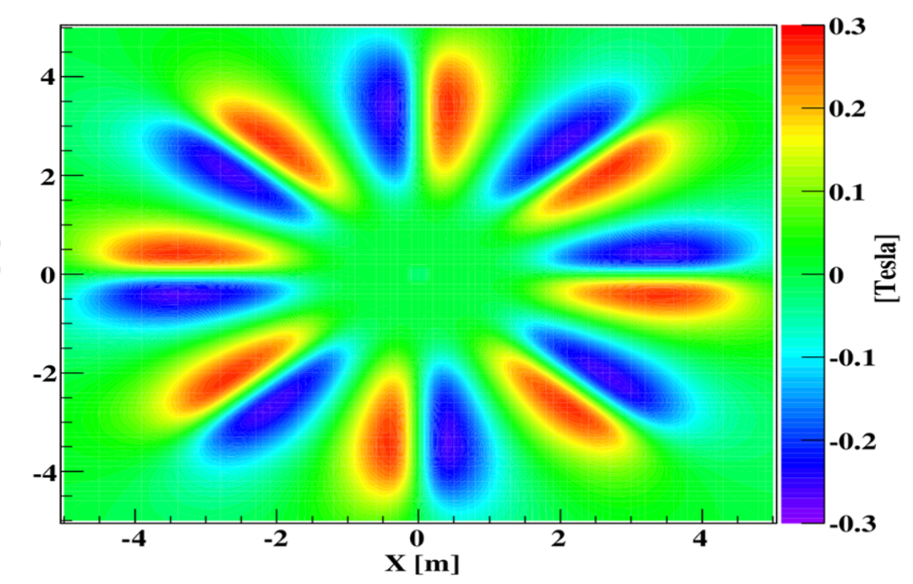
The 3D electric field is simulated using the nearly exact boundary element method. For a typical operating high voltage of 2.85kV, the drift field is a few kV/cm, and the electron avalanches are usually developed within a few tens of microns close to the wire where strong electric fields are present.



B field at nSW

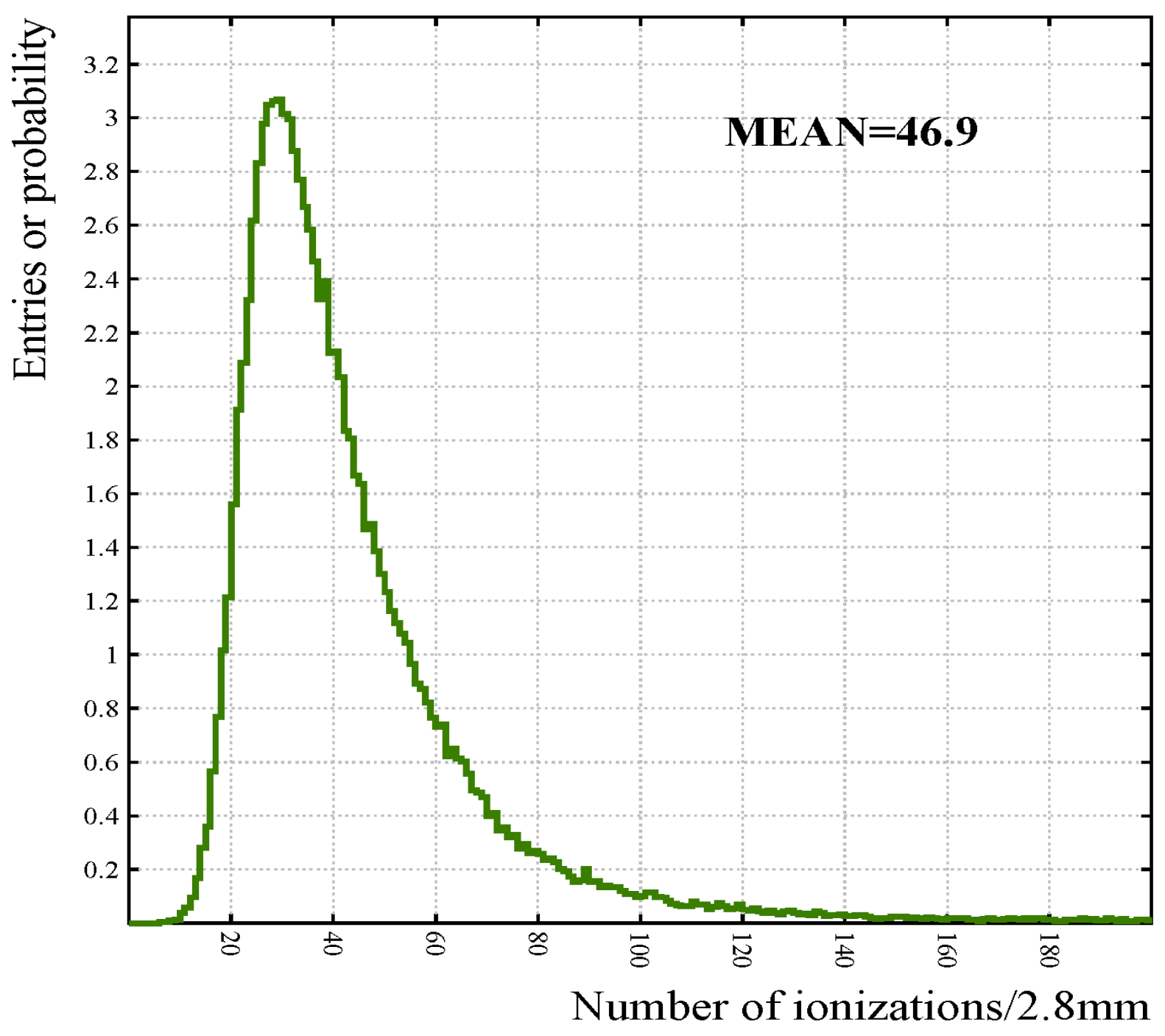

B_phi


B_r


B_z

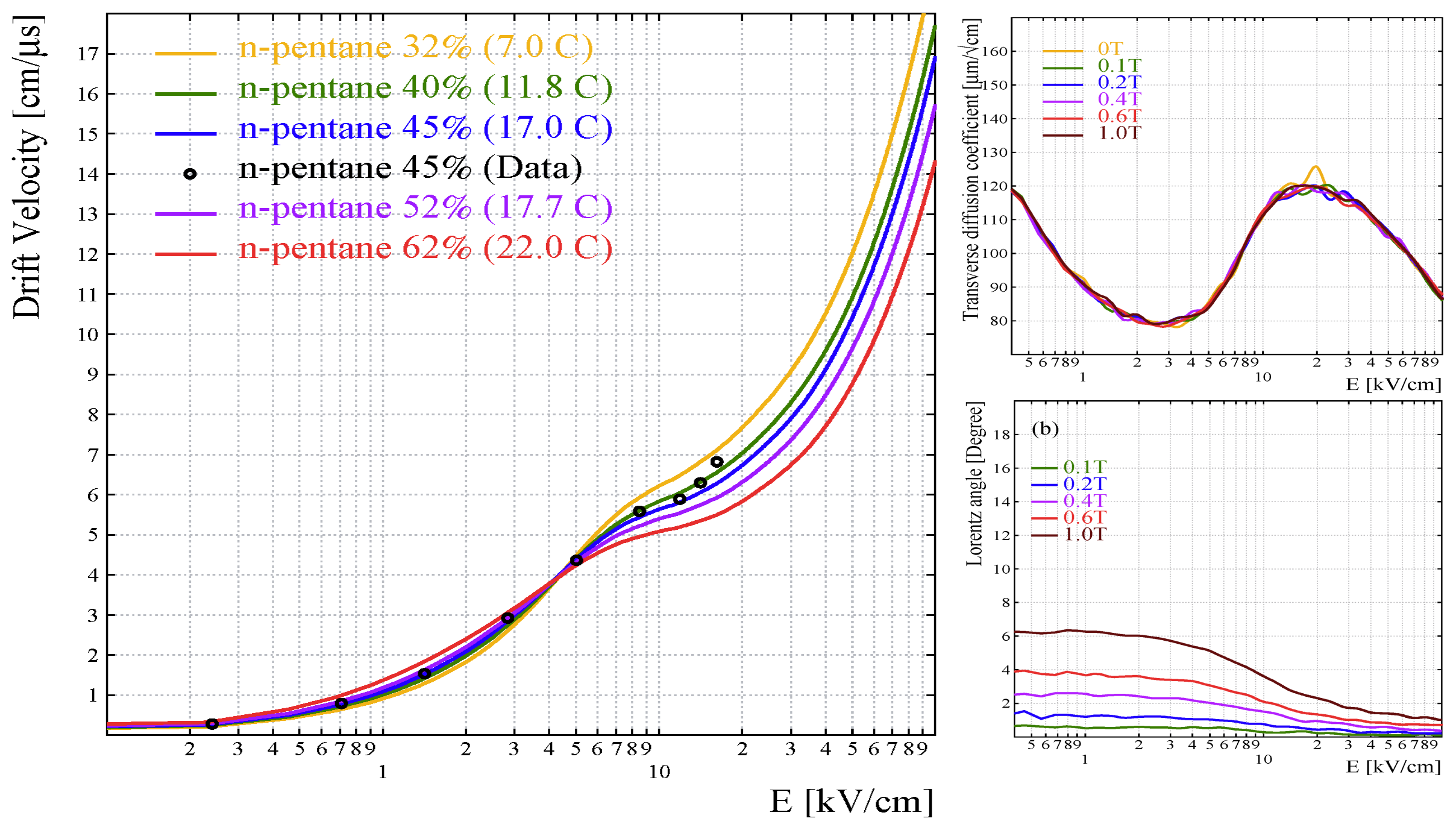
Electron transportation

Ionization



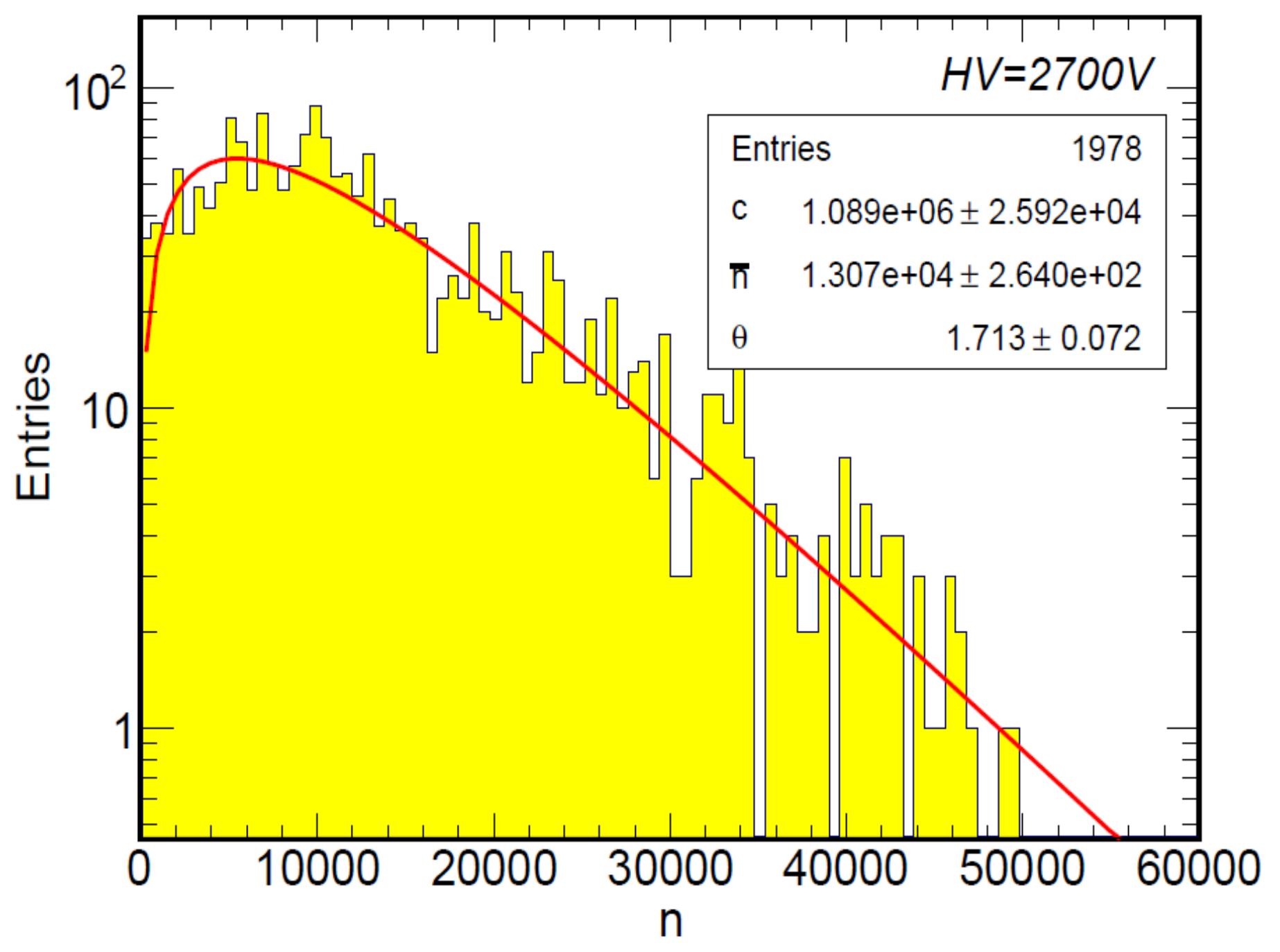
On average there are 46.9 primary electron-ion pairs produced when a 180 GeV muon passing through the 2.8 mm gas gap.

Transportation of primary electrons



The typical drift velocity is a few cm/μs, the transverse diffusion is less than 40 μm over 1.4 mm drift length in sTGC. The attachment process and a magnetic field up to 1T have negligible effect on the electron drift.

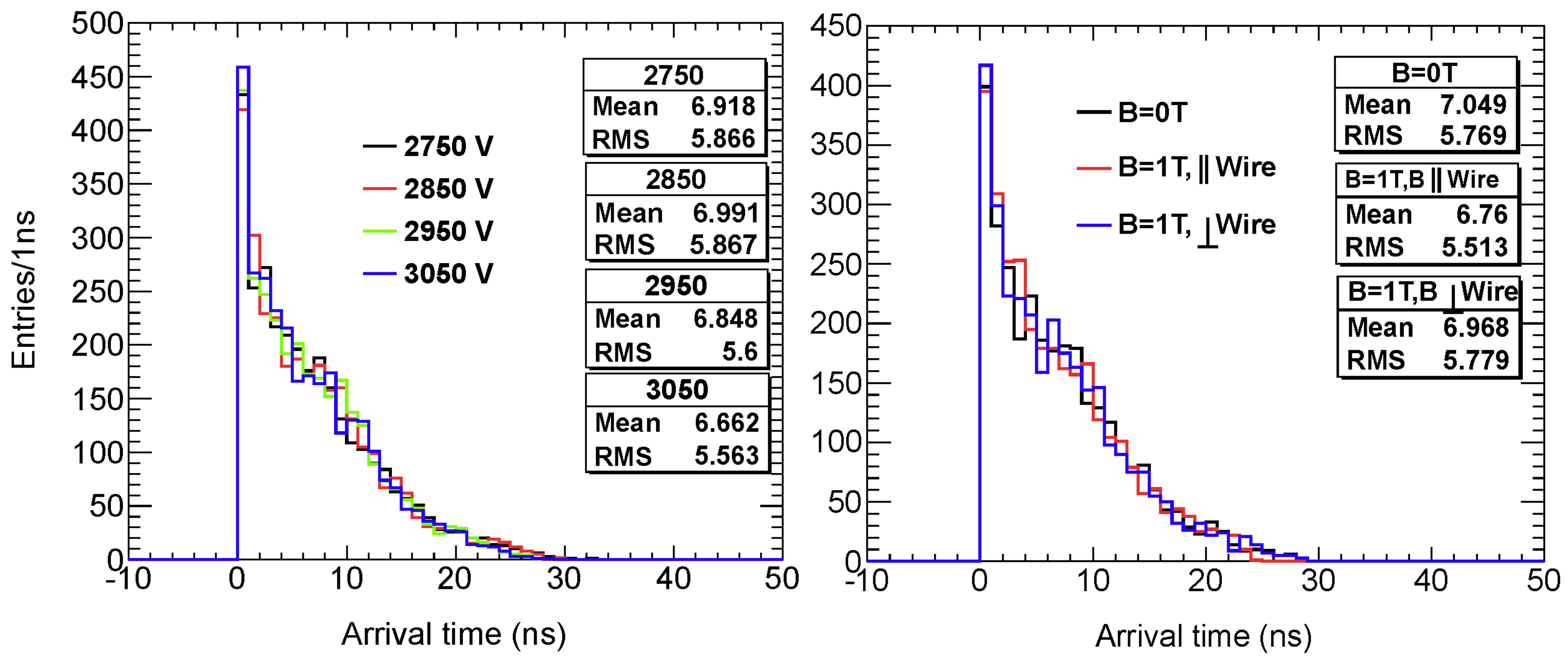
Electron avalanche



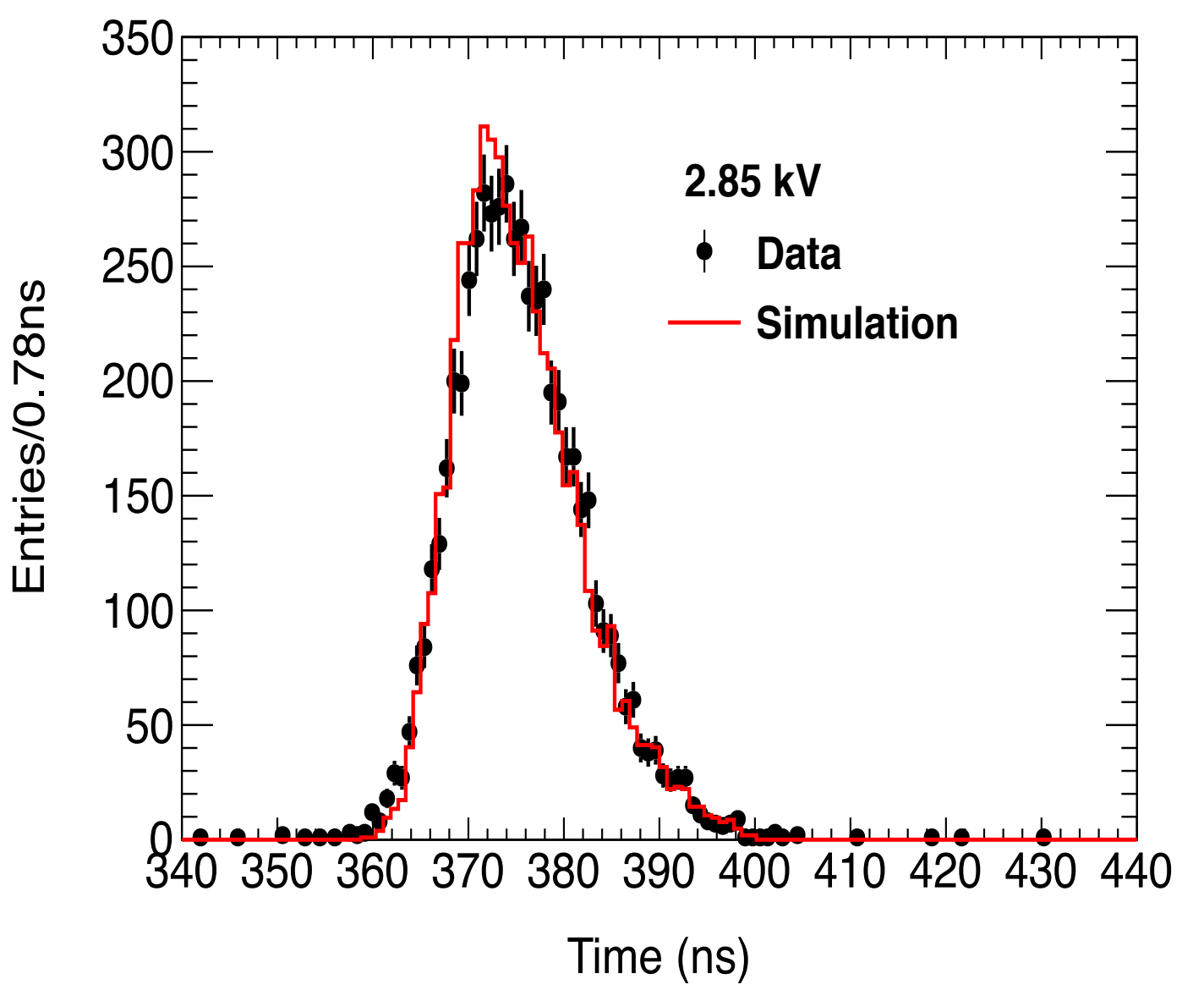
The avalanche fluctuation of a single electron could be described by **Polya** distribution

$$P(n\,|\,\bar{n},\theta)=\frac{1}{\bar{n}}\frac{\theta^{\theta}}{\Gamma(\theta)}\left(\frac{n}{\bar{n}}\right)^{\theta-1}e^{-n\theta/\bar{n}}$$

Timing performance



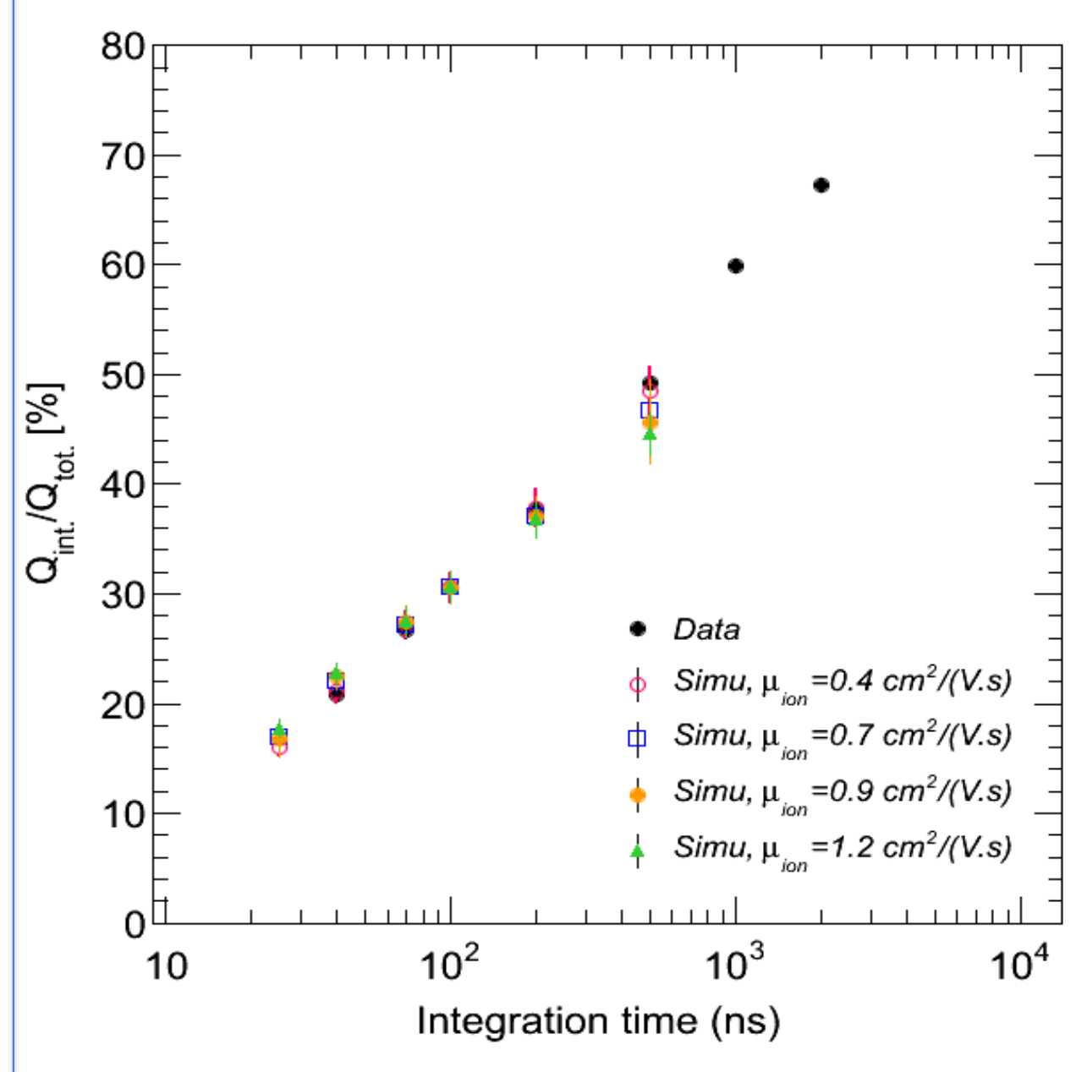
Usually the first few clusters near the wire will create a signal exceeding the discrimination threshold. Therefore the fluctuations of the minimum drift time of clusters gives the physical limit of the detector time jitter.



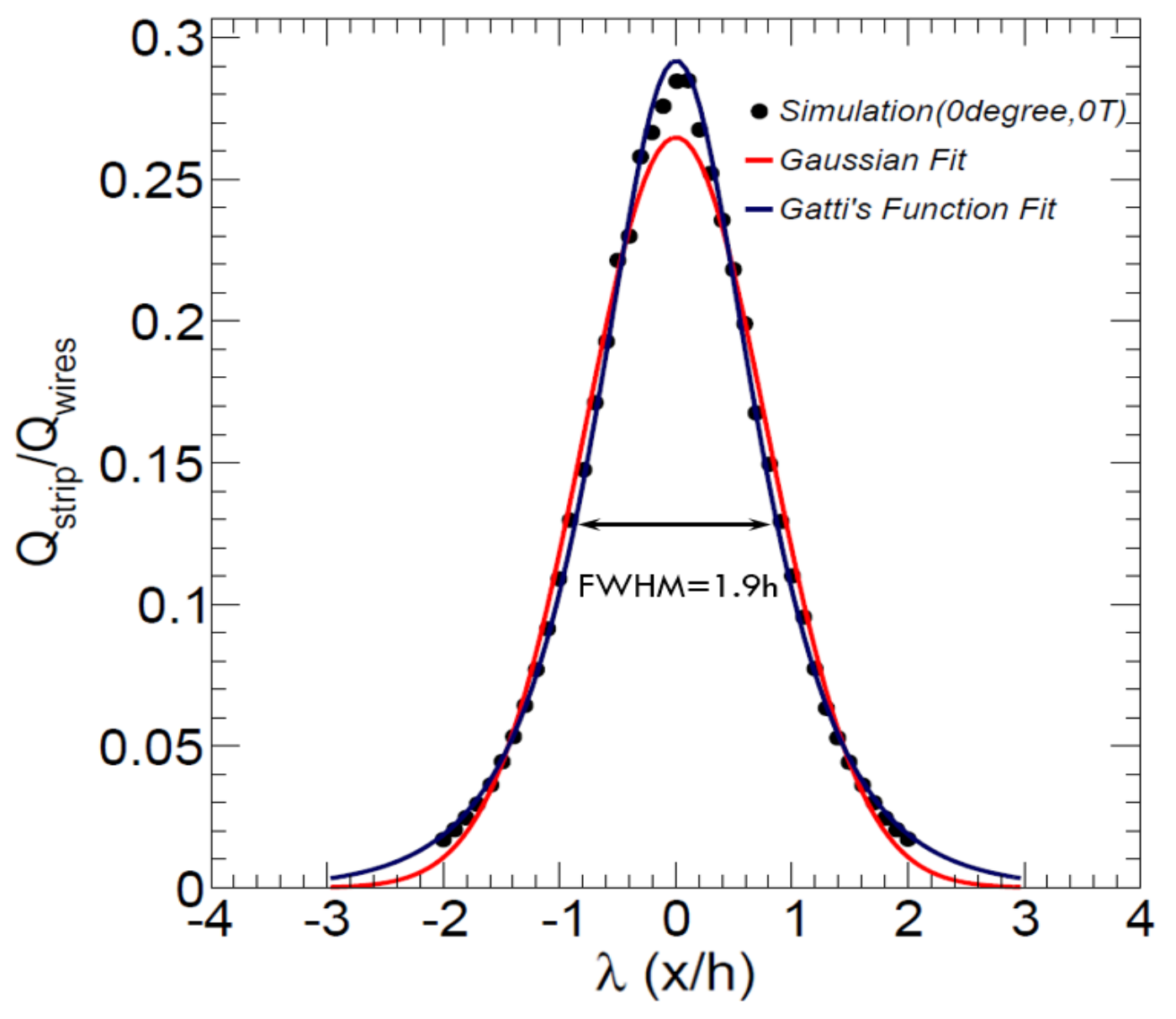
- Electronics threshold : 10fC
- Electronics and other external jitter : smearing the intrinsic detector time response with a 2 ns Gaussian distribution
- 95% events can be contained within 25 ns time window

Charge sharing among readout strips

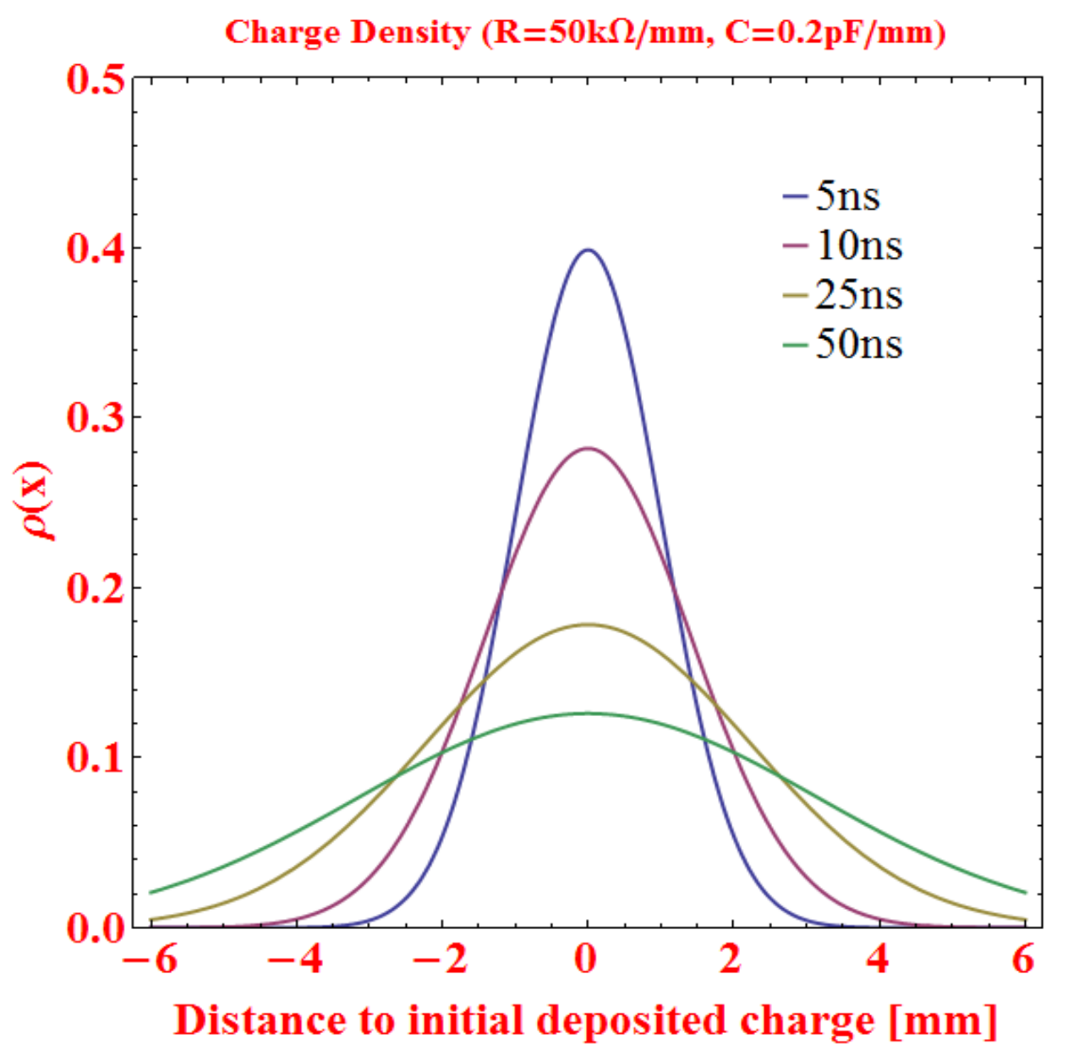
The spread of the induced charge on the cathode is similar to the size of the gas gap. The localized charge on the cathode plane will diffuse through the resistive layer to the ground and charges could be collected on the readout strips.



(a) Ratio of induced charge on wire to total produced charge in avalanche as a function of integration time.



(b) Induced charge density on a cathode plane due to a point charge deposited on the wire; h is the wire-cathode plane distance(1.4 mm).



(c) The charge diffusing through a 1-D RC network for a point charge deposited at x=0, t=0.