ATLAS RPC Phase 2 Upgrade

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On behalf of RPC group

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Outline

➢ RPC software simulation

- CST PCB studio readout simulation
- Garfield++ simulation

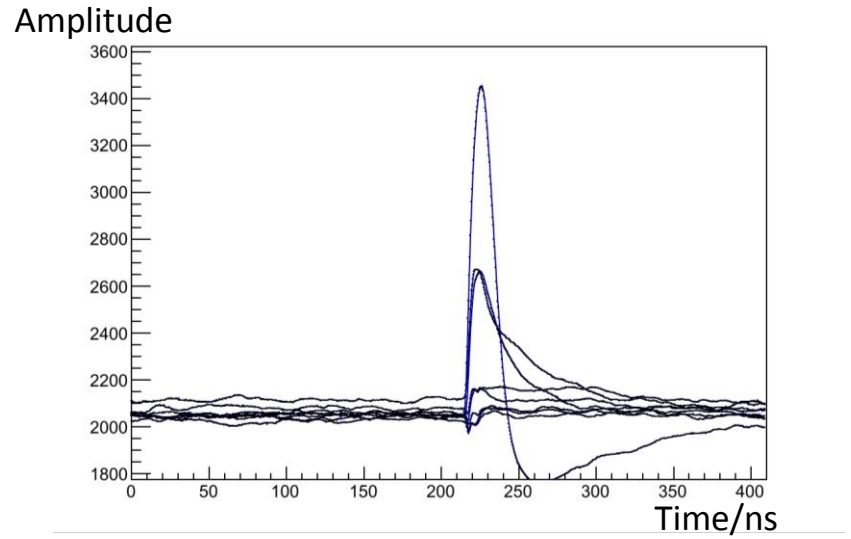
➢ RPC laboratory construction

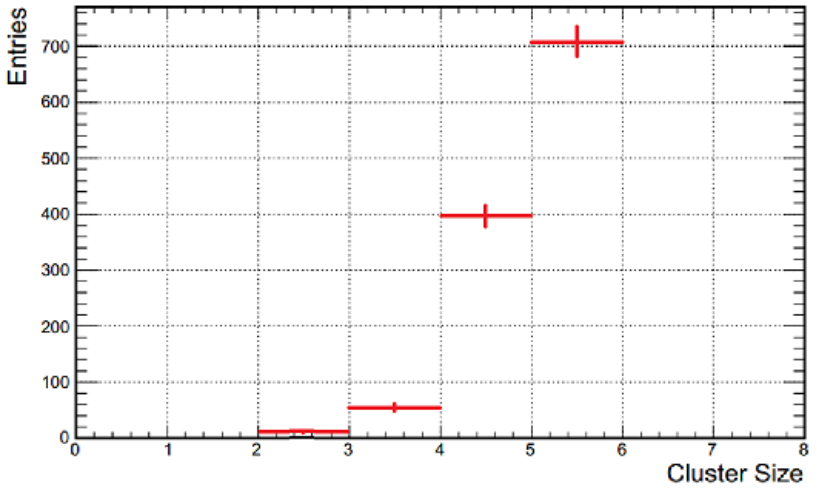
- Chamber assembling and FEE production
- Cosmic ray test system

RPC software simulation

CST PCB studio simulation

- ➢ Purpose:
- Too large cluster size was found in the beam test previously
- The online trigger accuracy will be influenced
- ➢ Simulation with CST PCB studio:
- Study the process of signal transmission
- ➢ Detailed study on several factor:
- Resistivity of graphite layer
- Metal wire between strips
- Matched resistance in front end and back end
- Length of strips
- Position of Hit
- Others

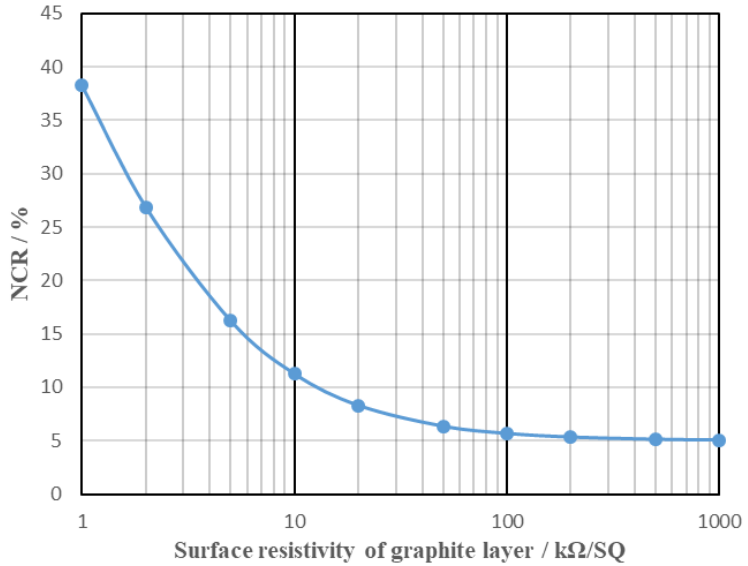


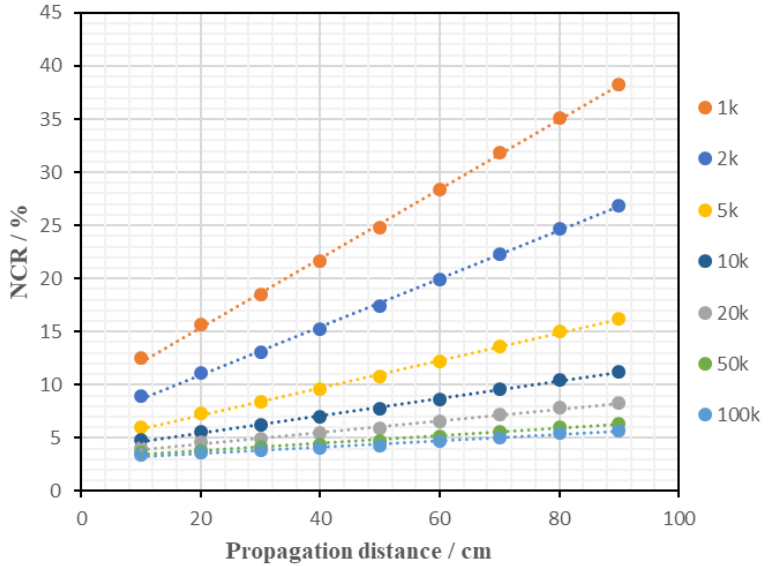


Dominant contribution

NCR —— Neighbor Center Ratio, the ratio of the peak value of neighbouring strip and that of central strip

Propagation distance: the distance between the avalanche and the readout terminal.





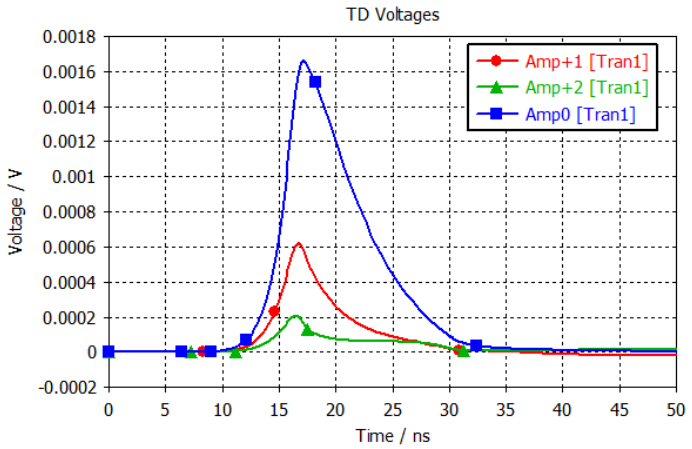
- The relationship between NCR and the surface resistivity of graphite layer at propagation distance = 90 cm
- Knee point is 20 kΩ/SQ.

- The relationships between NCR and propagation distance under different surface resistivity
- Both causations have linear relationship with propagation distance.
- Low surface resistivity would lead to large CS.

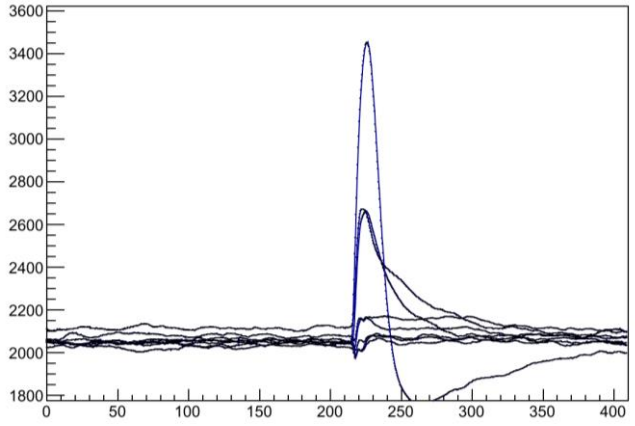
Comparison between reality and simulation

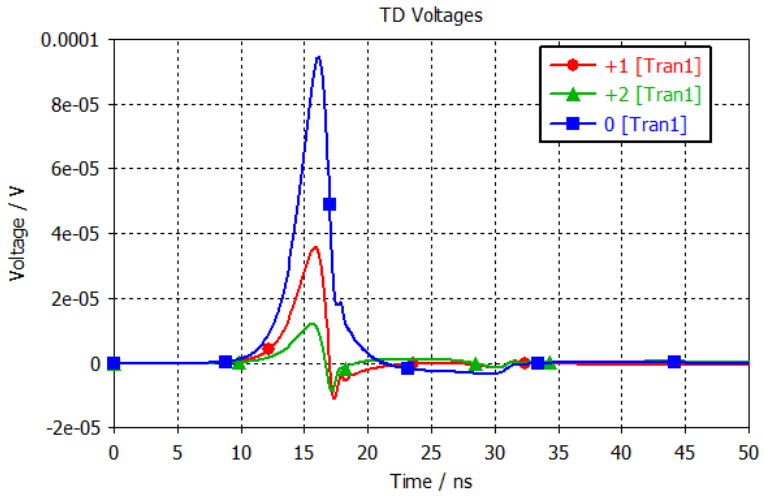
- The phenomenon is similar for simulation and reality.
- The level of resistivity is not matched.
- The 120 kΩ/SQ graphite layer is measured to be 16 kΩ/SQ.

Simulation: 1 kΩ/SQ

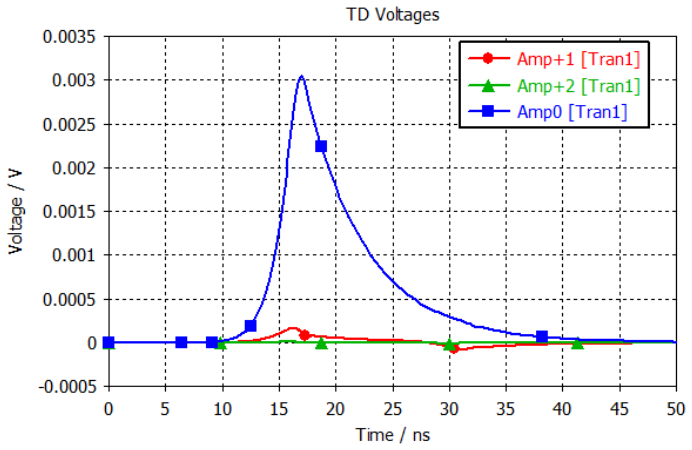


Reality: 120 kΩ/SQ

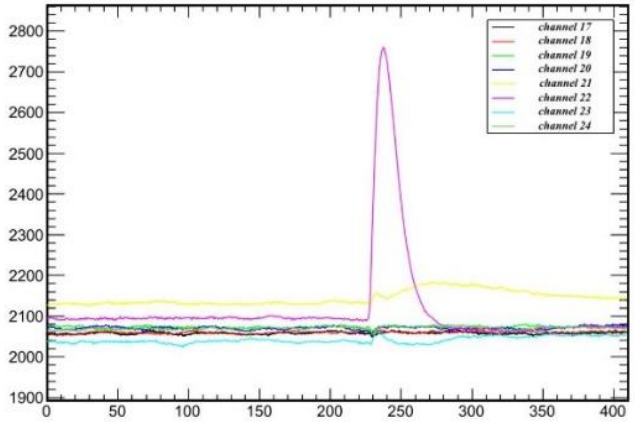




Simulation: 1 kΩ/SQ
(Before amplifier)



Simulation: 100 kΩ/SQ



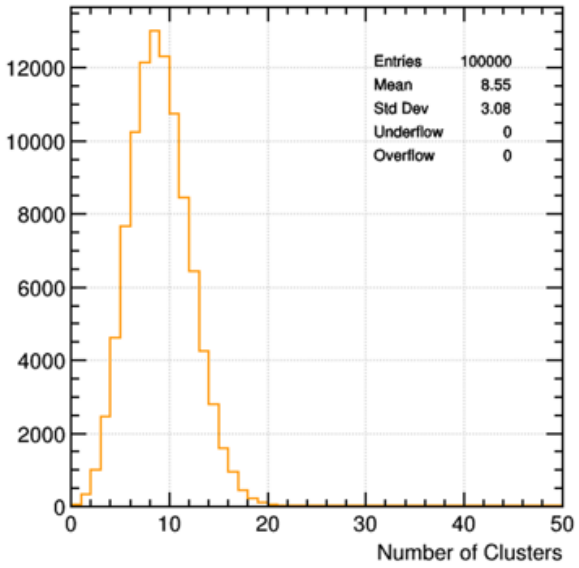
Reality: 620 kΩ/SQ

Garfield++ simulation

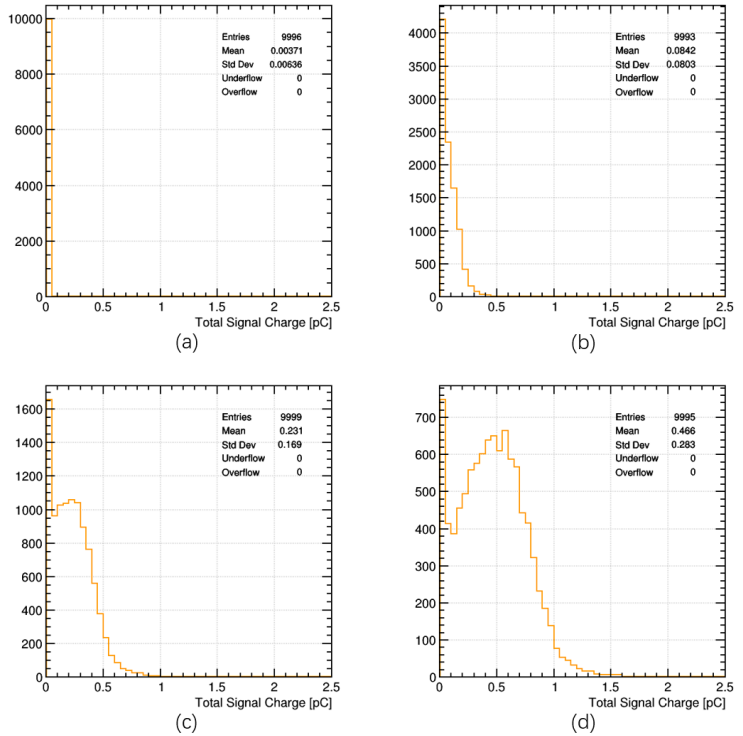
- Purpose:
  - Understand the process of avalanche in the gas gap
  - Get the theoretical performance of RPC
- Simulation with Garfield++:
  - Study the process of avalanche in gas gap
- Detailed study on several factor:
  - Primary ionization
  - Gas mixture and pressure
  - Induced signals
  - Theoretical time resolution

Parameters in the simulation

- 120 GeV muons as object
- Gas gap: 1mm
- Temperature: 293.15K
- Gas mixture:
  - 94.7%C2F4H2+5%iso-C4H10+0.3%SF6 (ATLAS standard mixture),
  - 96.7%C2F4H2+3%iso-C4H10+0.3%SF6,
  - 96.9%C2F4H2+3%iso-C4H10+0.1%SF6
- Pressure: 0.9, 1.0 and 1.1 atmospheric pressure
- Transport properties:
  - Default Townsend coefficient, attachment coefficient and drift velocity

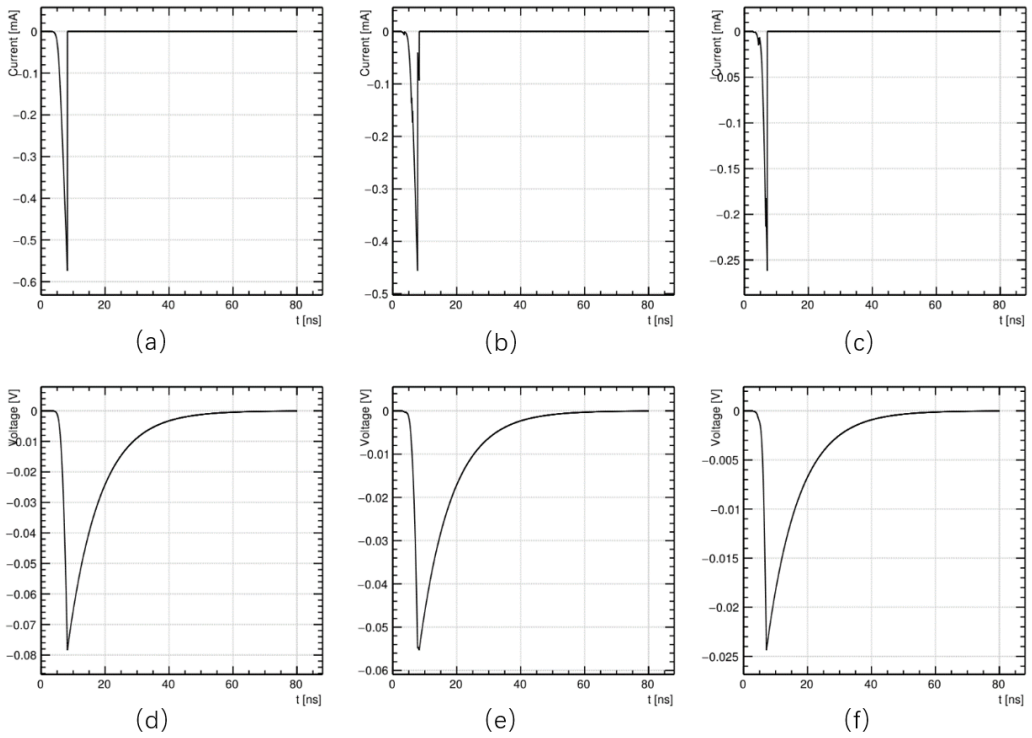


Distribution of primary ionization

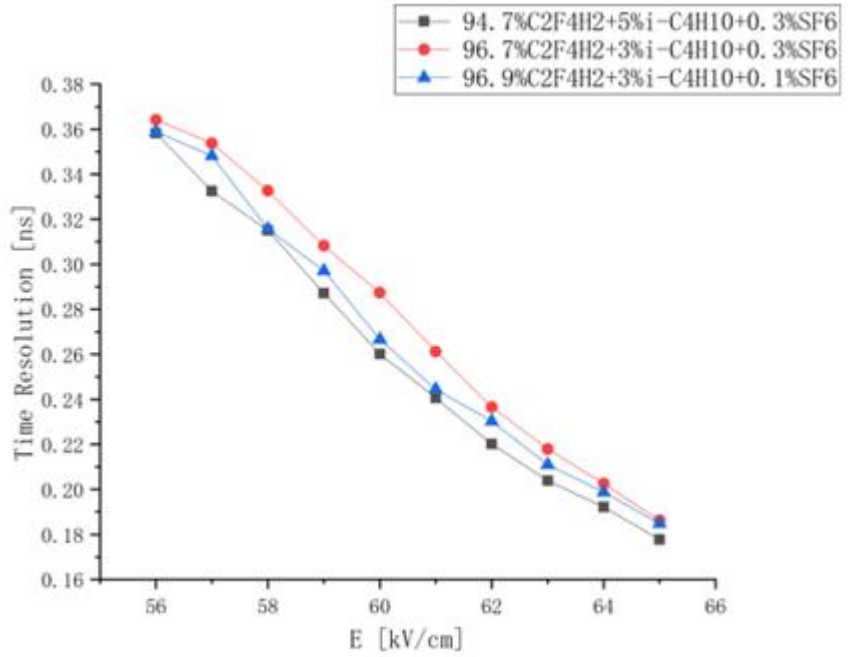


The variation of charge spectra vs applied voltage.
(a):5000V; (b): 5400V;
(c): 5600V; (d): 5800V.

Results of the simulation



Current signals of 3 specific events(a, b, c) simulated with 1.0atm ATLAS standard gas mixture and 5800V applied voltage, as well as corresponding voltage signals(d, e, f).



Simulation result of time resolution.

RPC Laboratory Construction

Chinese Universities in ATLAS RPC Phase II Upgrade

- SDU:
- Professors: Cunfeng Feng, Haifeng Li
- SJTU:
- Professors: Haijun Yang, Jun Guo
- Post-doc: Francois Lagarde
- Student: Xiangke Zhang, Xi Wang, Qiuping Shen
- USTC:
- Professors: Zhengguo Zhao(team leader), Yanwen Liu, Hao Liang, Yongjie Sun
- Students:

  Detector: Quanyin Li, Xiangyu Xie, Xiaotian Liu, Chuanshun Wei, Zhibo Wu, Tao Wang

  Front End Electronics(FEE): Jiajin Ge, Zhengwei Xue

This project is supported by National Key Programme for S&T Research and Development.

RPC Laboratory in USTC

- Purposes:
- RPC Chamber assembling, Performance measurement, Performance and structure optimization
- RPC factory built for ATLAS RPC Phase II Upgrade
- Status:
- Bakelite, gas gap and readout panel from Italy
- Front End Electronic (FEE) Board produced by USTC and INFN
- Mechanical support will be customized from factory
- Assembling RPC chamber with gap, FEE board and mechanical support
- Cosmic ray test system constructed for the performance measurement
- Laboratory in SJTU and SDU is also under construction.

USTC RPC laboratory

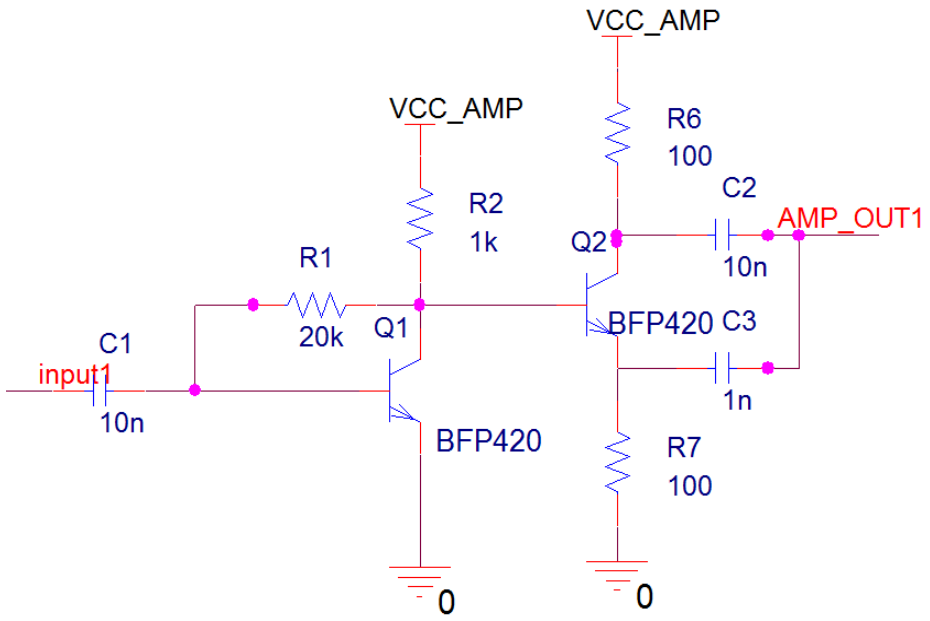
- Material of RPC:
  - gas gap
  - readout panel
- Size:
  - 50cm X 50cm
  - 50cm X 100 cm

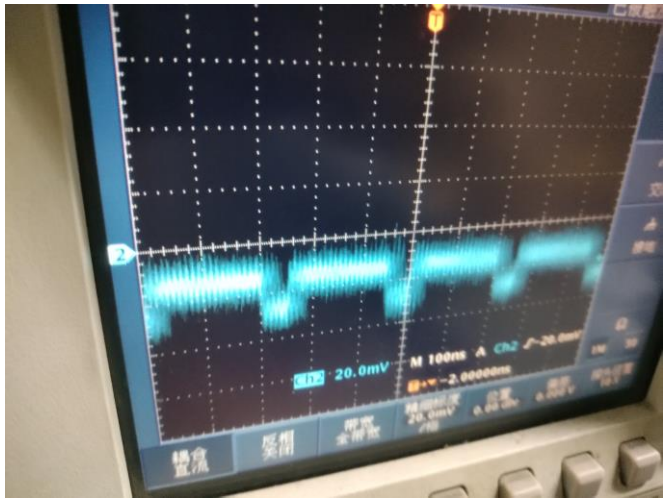
- Gas distribution machine:
  - ATLAS standard gas mixture
  - C2F4H2: 94.7%
  - Iso-C4H10: 5%
  - SF6: 0.3%

- Scintillator and RPC:
  - Coincidence of 2 scintillator as trigger
  - 3 gas gaps in the middle of the system

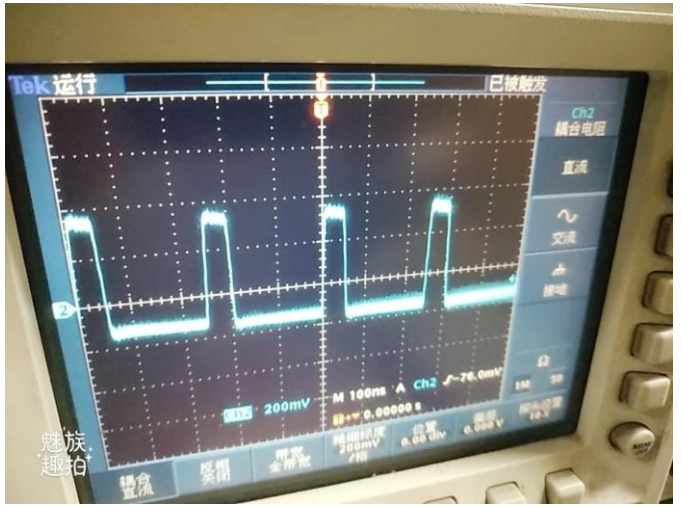
- Power and digitizer:
  - HV module for RPC and LV system for FEE
  - V6742 for data taking

FEE board

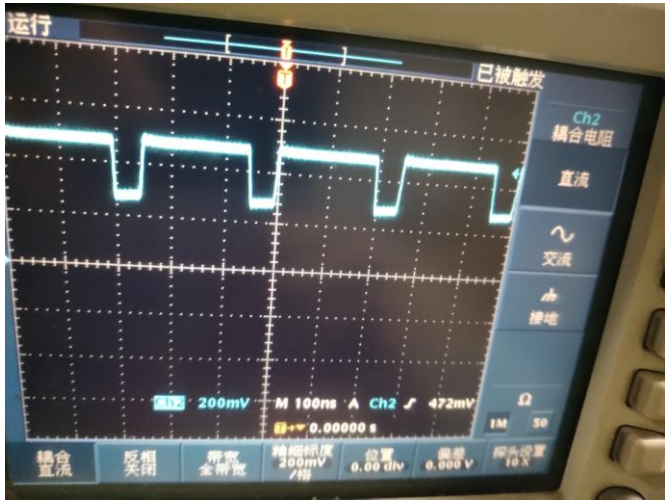




Input signal： 20mV(negative)



Inverting Amplifier: 520mV(~26)



Amplifier: 220mV(~11)

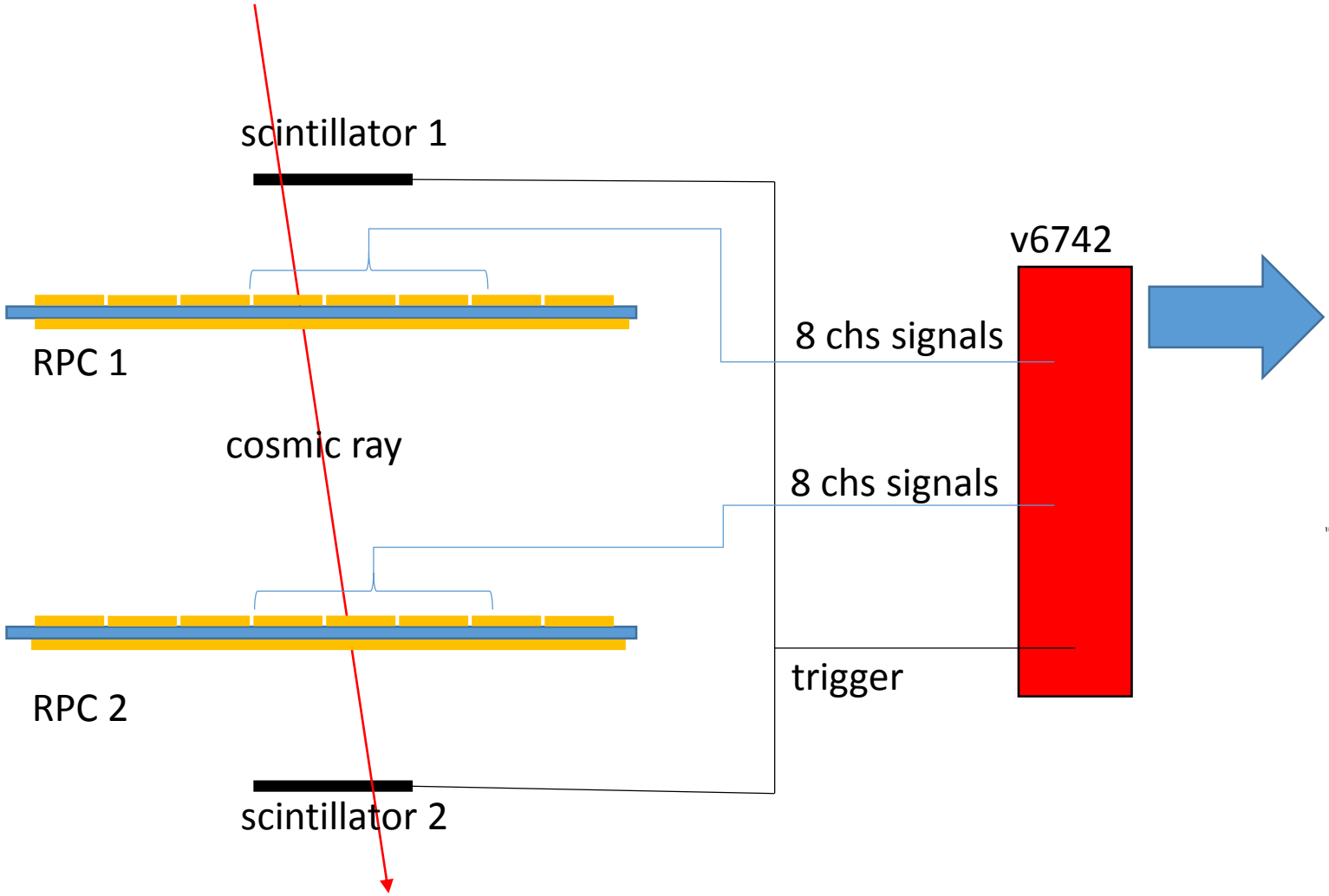
Two-stage transistor circuit is used for the pre-amplifier of the FE board.

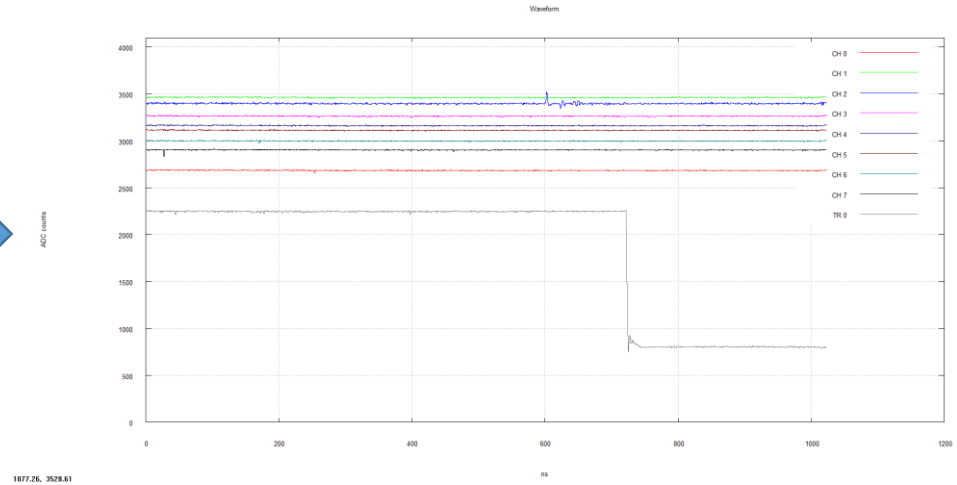
The BFP420 is a high speed transistor with low noise, whose transition frequency reaches 25GHz.

C2 and C3 is selectively soldered because the signal polarity of parallel and orthogonal strips is in contrast.

This board is produced by USTC(Lab of Prof. Hao Liang). The similar boards are bought from Italy.

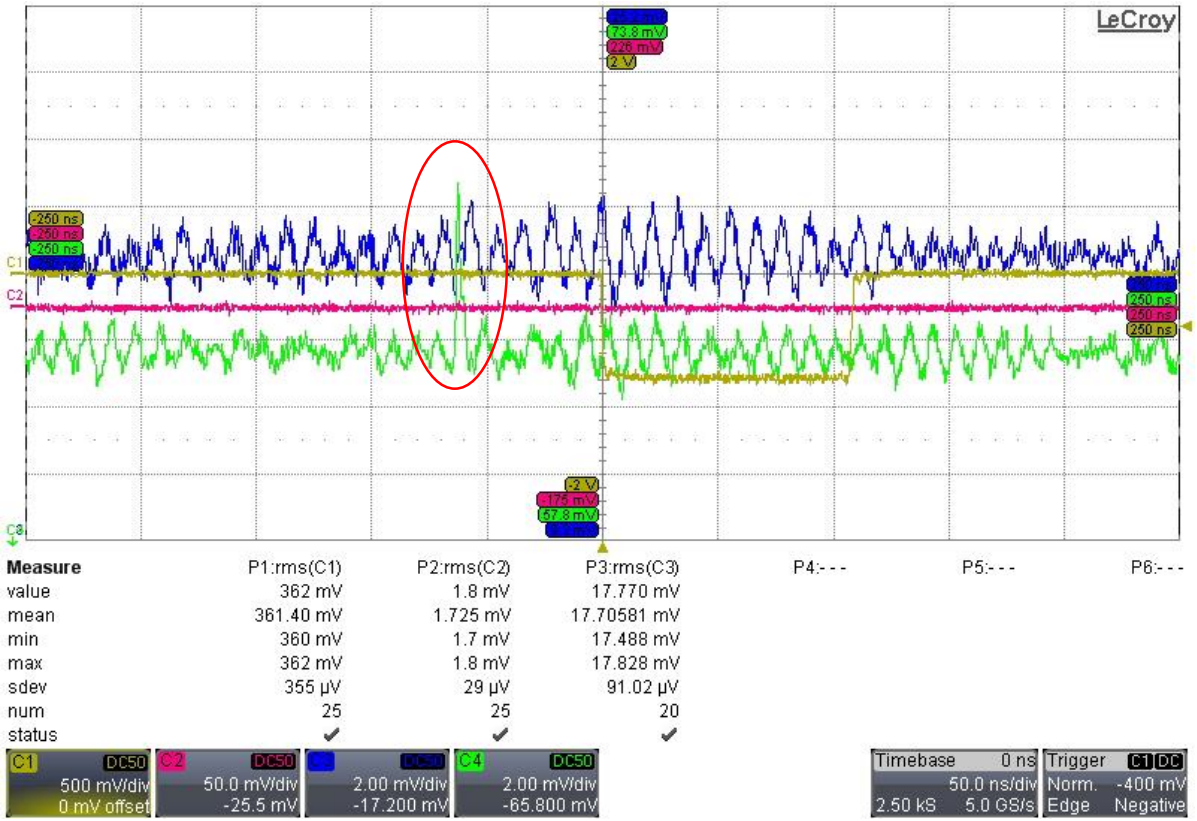
Cosmic ray test system



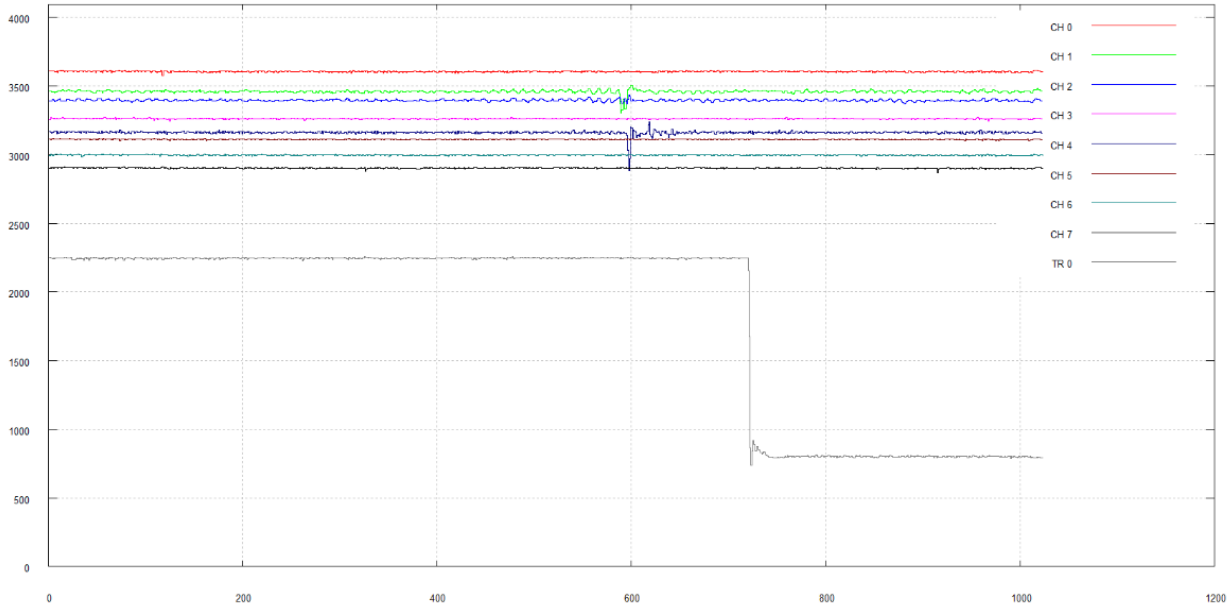


The waveform recorded by v6742.
8 signals channels + 1 trigger channel

Signal searching



Possible signal without pre-amplifier



- Waveform recorded by the digitizer.
- Ch0~Ch3: signal after the Italian pre-amplifier.
- Ch4: signal after the USTC pre-amplifier
- Signals with specific time information

Summary and Plan

➢ Summary:

- The 2 simulations give excellent results to understand and improve the detector
- Some small discrepancy between simulation and reality
- New FEE board produced by USTC/Italy are completed
- Excellent progress in assembling detector and building laboratory

➢ Plan:

- PCB studio: Further study about the graphite layer is still in progress.
- Garfield: Some parameters will be optimized according to the reality.
- FEE board with discriminator and signal converter
- Solve the problems of noise with better shield
- Improve the performance based on the study and simulation result
- Accumulate experience for the RPC factory in the future