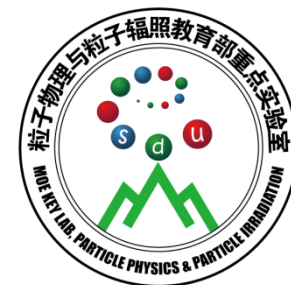




# MWPC construction and performance test for STAR inner TPC upgrade

Fuwang Shen  
Shandong University  
for SDU iTPC collaboration

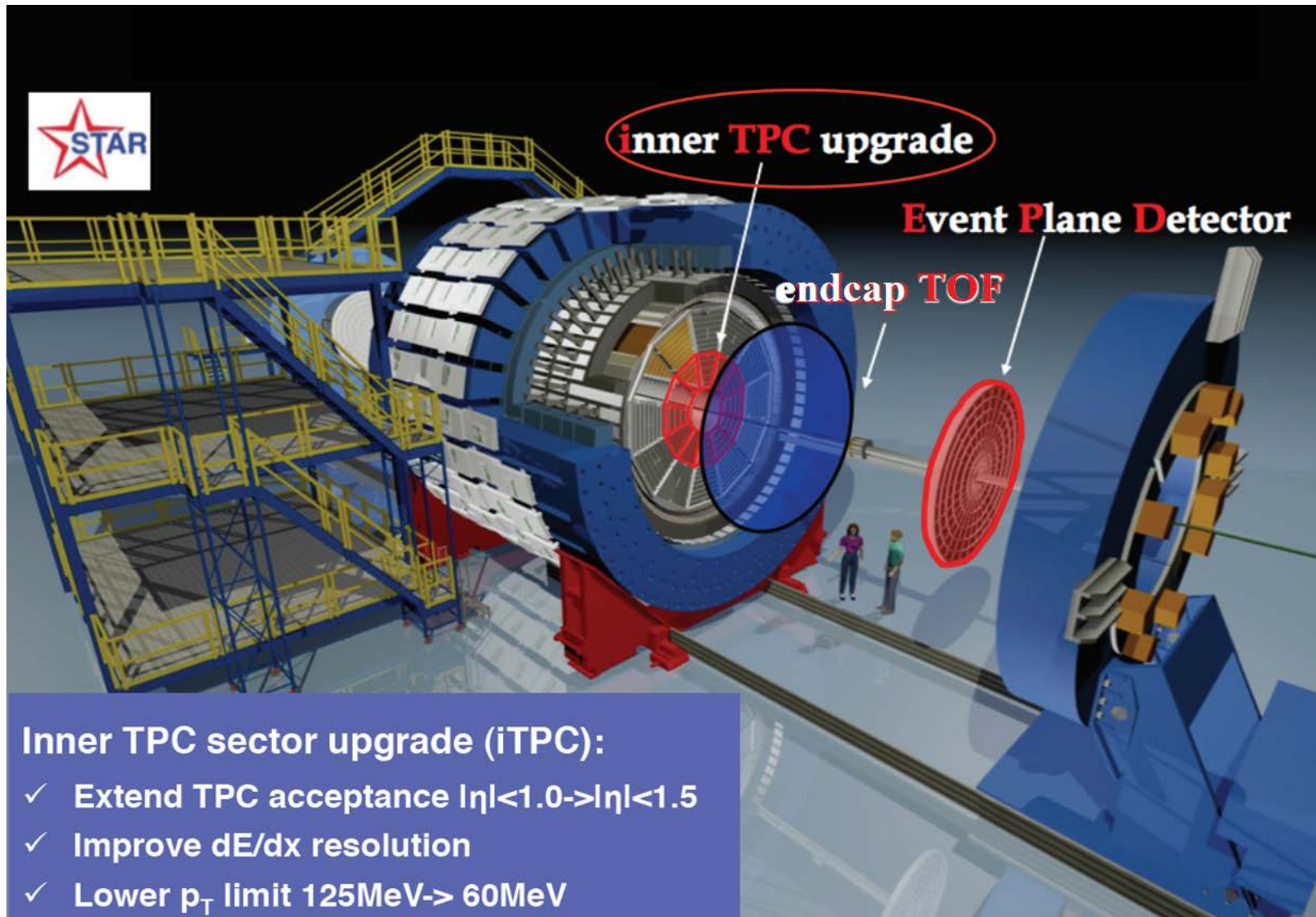


# Out line

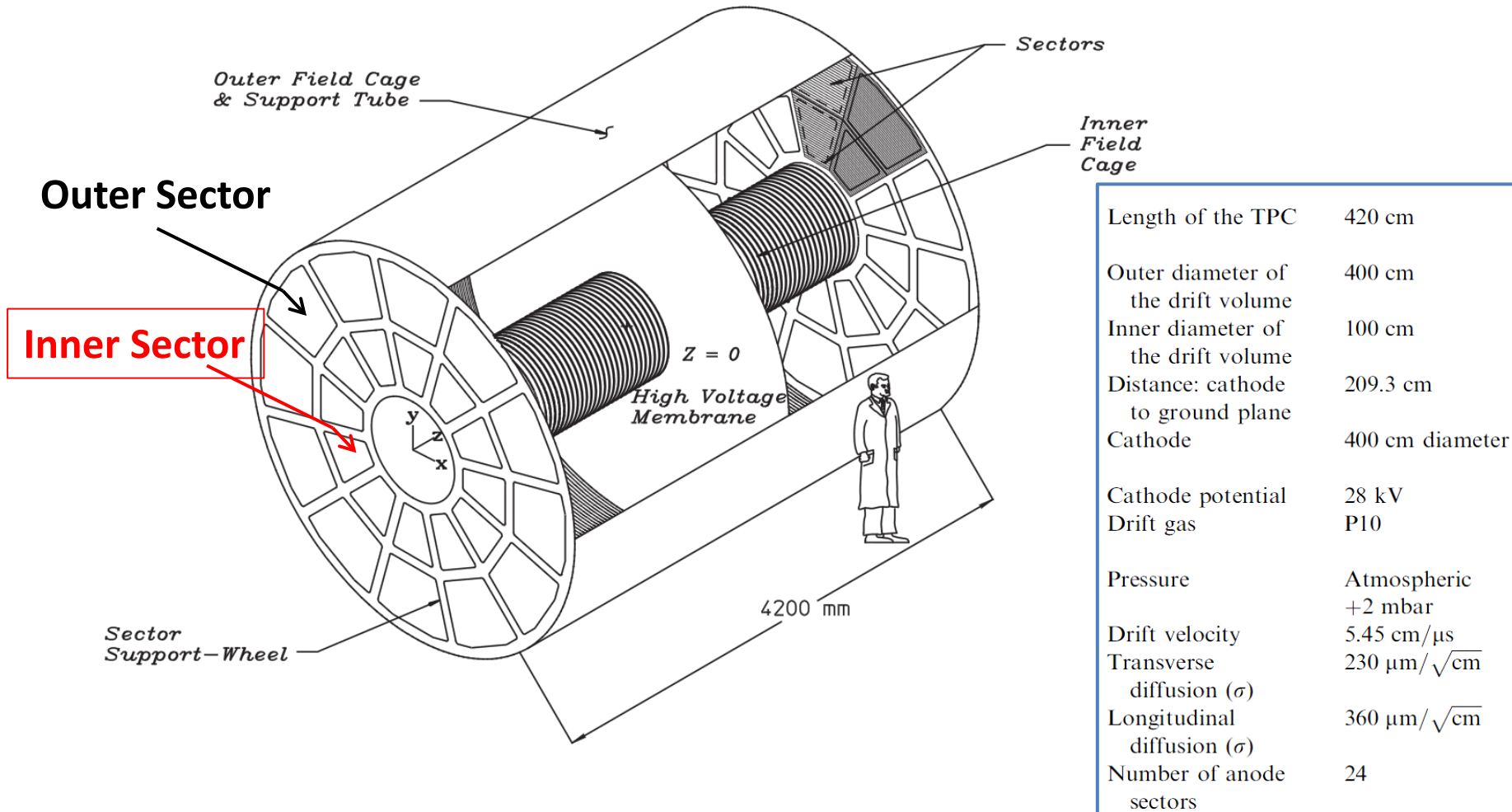
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- STAR inner TPC upgrade
- MWPC constructions
  - wire tension & pitch control
  - mass production & QA
- MWPC performance test
  - system setup
  - DAQ electronics calibration
  - $^{55}\text{Fe}$  X-ray spectrum
  - Gas gain
  - Resolution
- Sector installation
- Outlook and summary

# STAR upgrades for RHIC Beam Energy Scan II



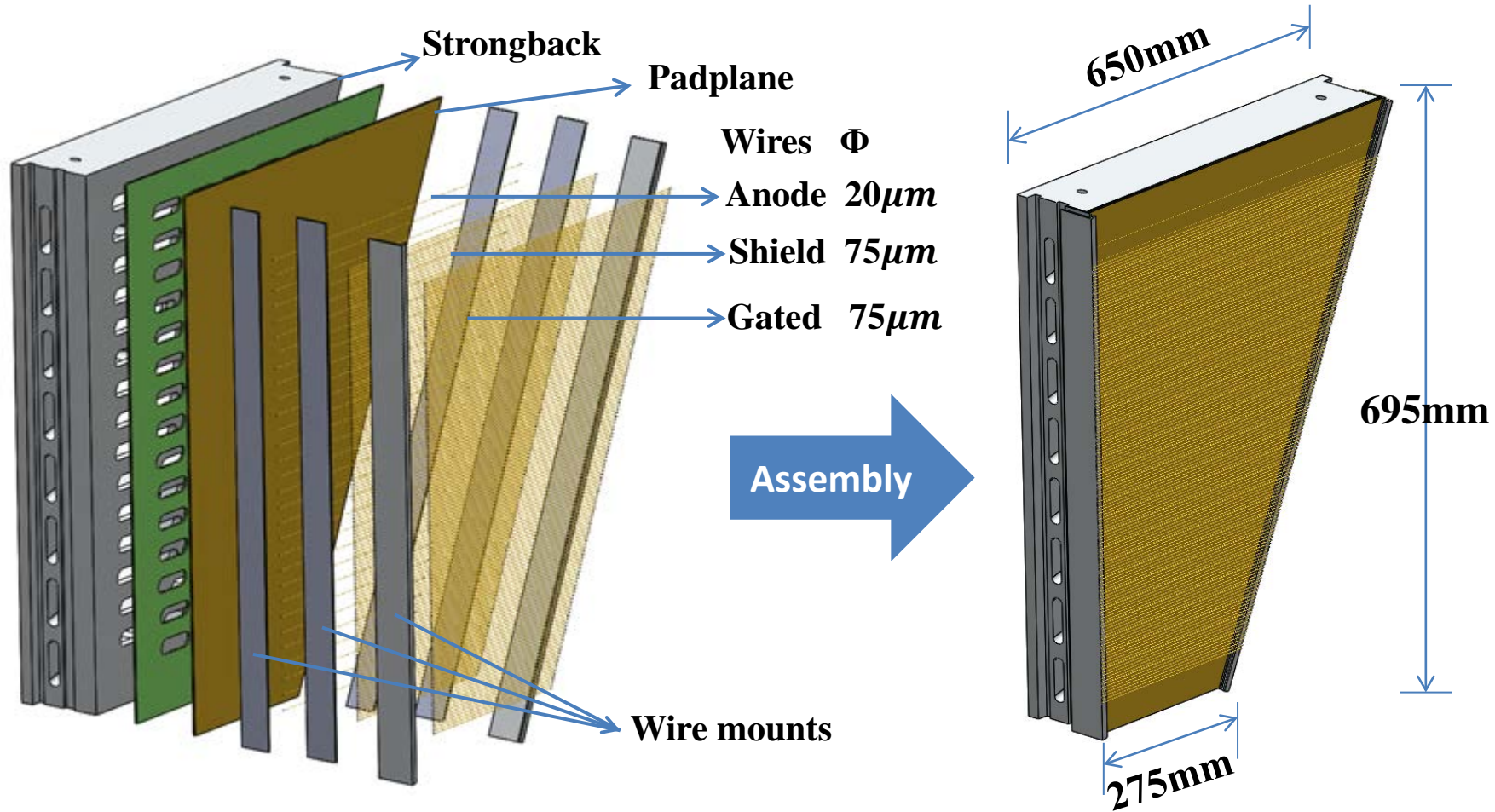
# STAR TPC geometry



- STAR TPC NIM, M. Anderson et al., Nucl. Instrum. Meth. A 499, 659 (2003).

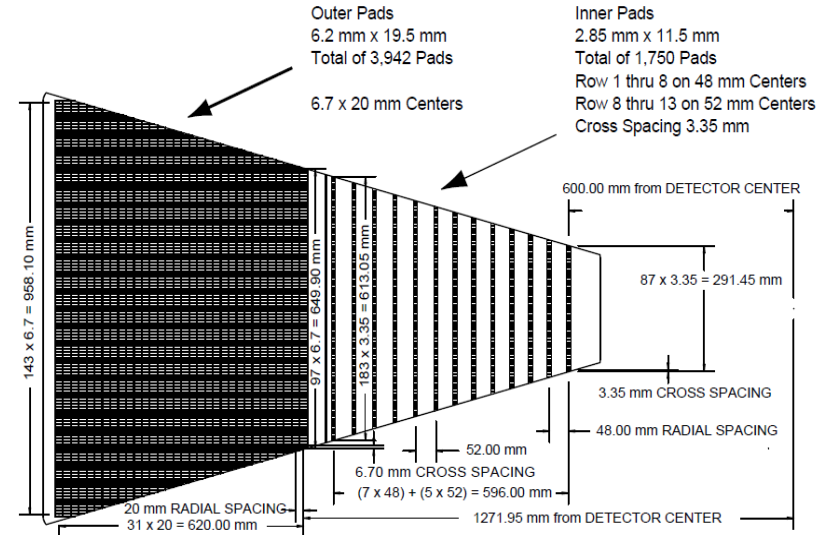
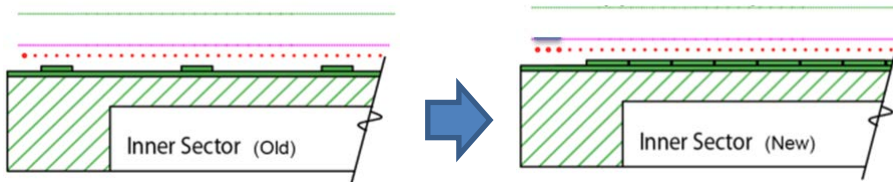
# iTPC sector

- Sector: strongback + padplane + wire frames



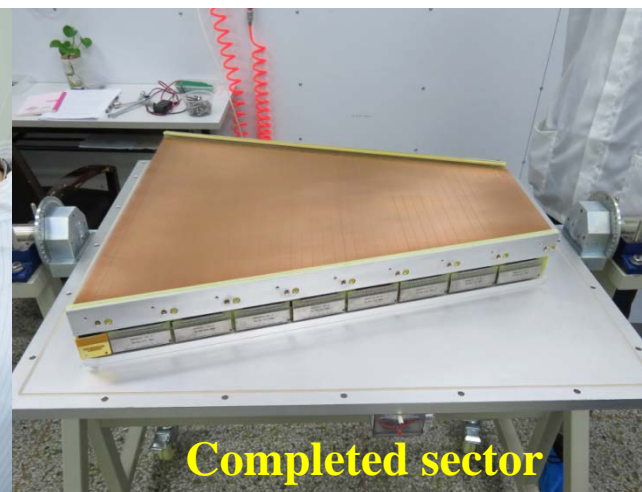
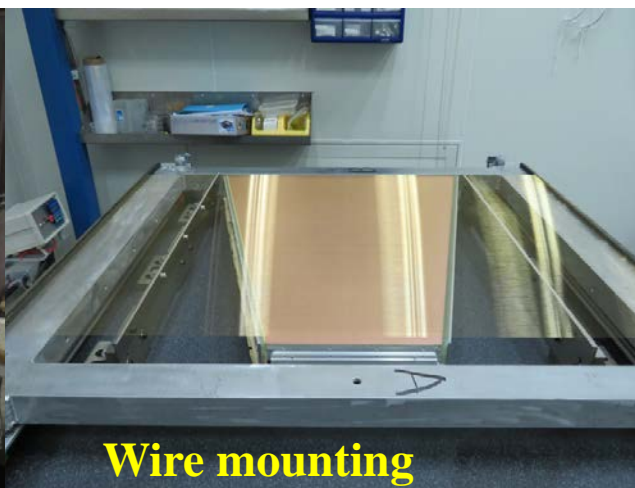
# iTPC upgrade contents

- **Replace all 24 inner sectors :**
  - ✓ Increase readout pad rows from 13 to 40  
*pad coverage: 20% -> ~100%*
  - ✓ Renew all three wire frames  
*replace aging wires*

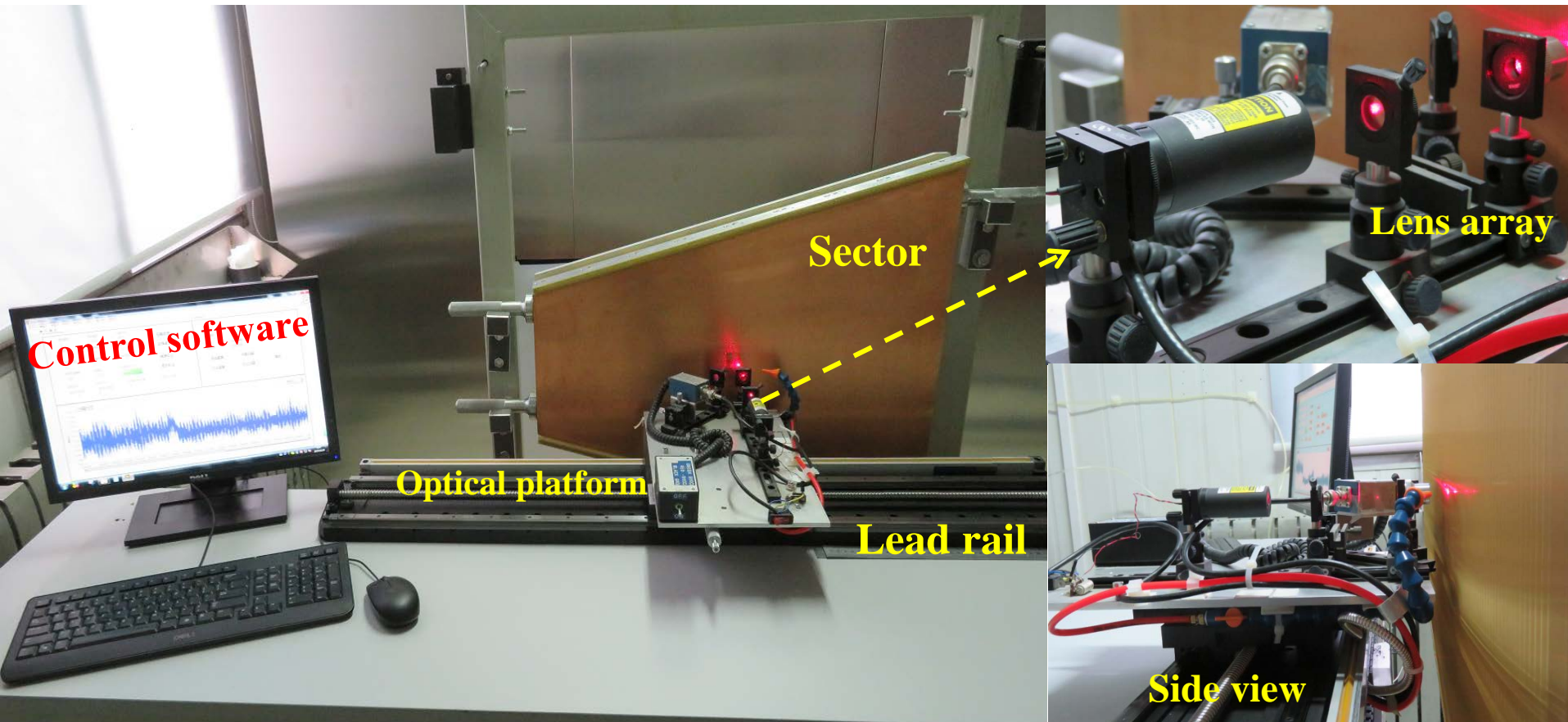


- **MWPC performance requirement**
  - ✓ Gas gain: ~2000 at 1120V (anode voltage)
  - ✓ Gas gain uniformity(RMS/Mean): <10%
  - ✓ Gas gain energy resolution(Sigma/Mean): <15%
- **Construction**
  - ✓ padplane to strongback and side mounts assembly at LBL
  - ✓ MWPC building and performance test at SDU
- **Planned to be completed for RHIC run2019**

# iTPC sector construction at SDU



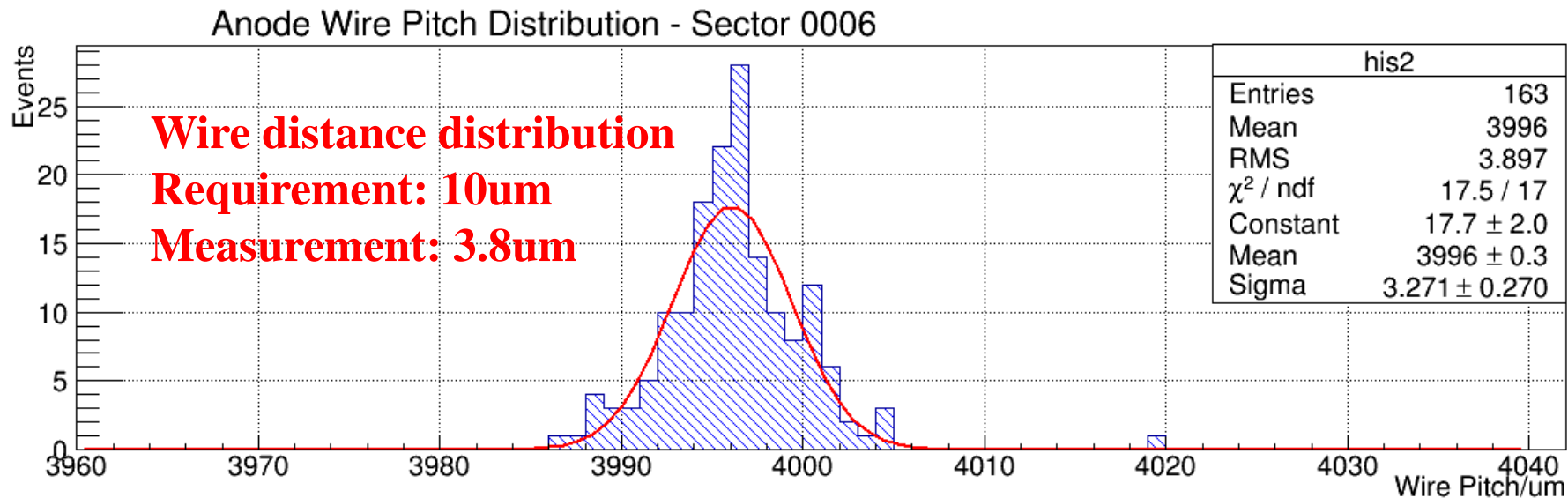
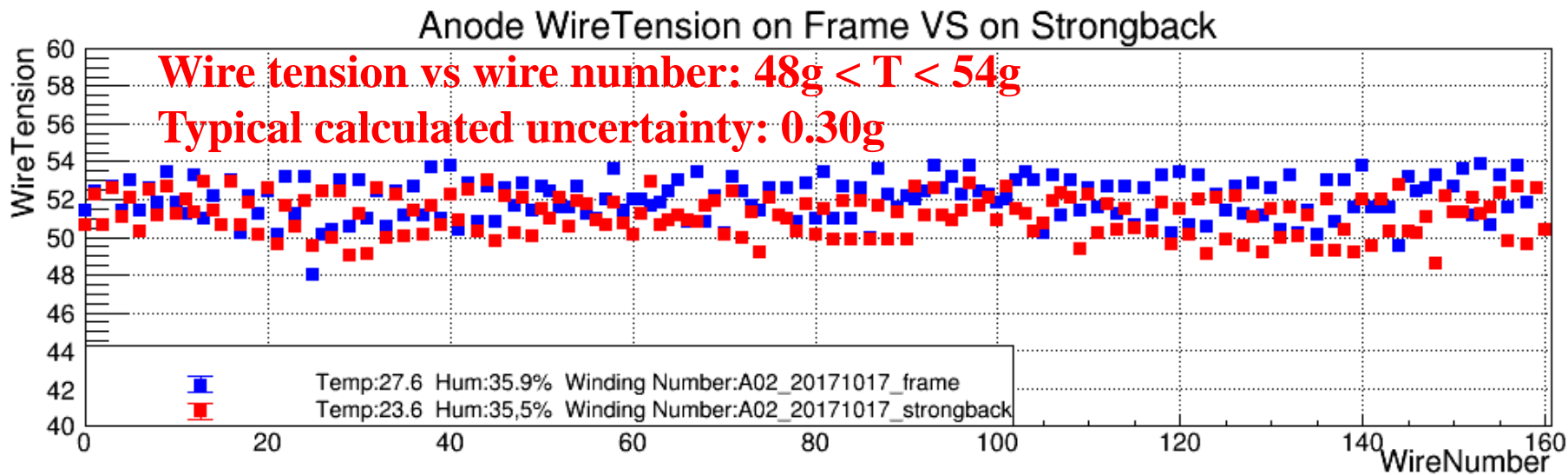
# Wire tension and pitch measurement system



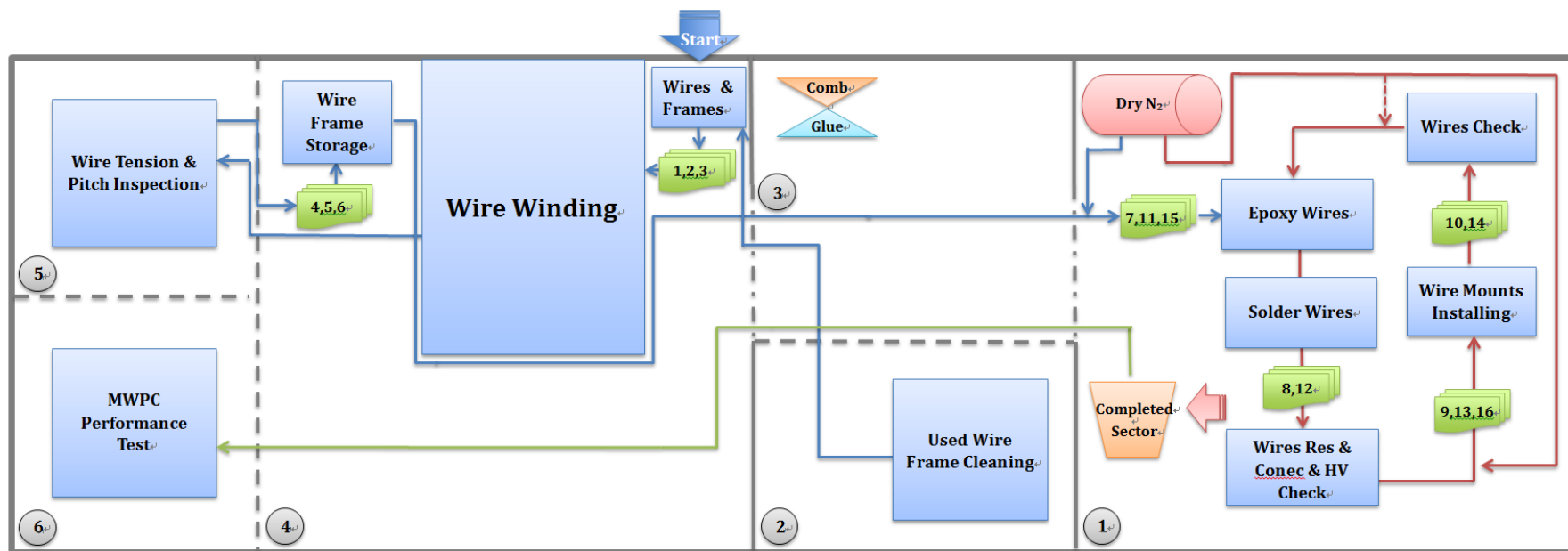
- A laser-based optical system.
- The wires vibration will be transformed to photoelectric signals, and tension is determined by the wire length, mass density and the fundamental vibration frequency.
  - X. Wang, et al., *Nucl. Instrum. Meth. A* 859 (2017) 90-94.



# Wire tension and pitch measurement results



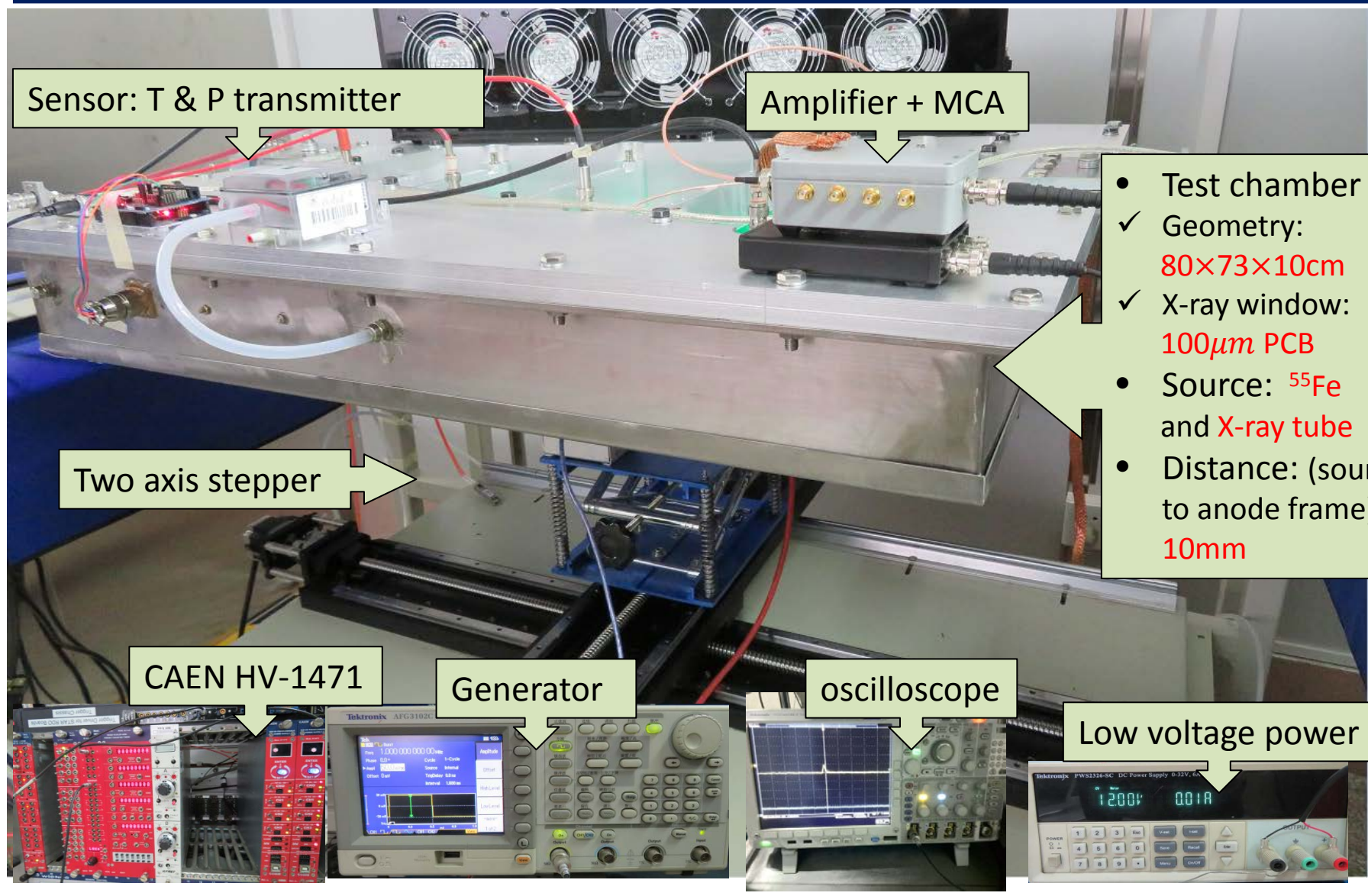
# Mass production and QA



iTPC PROCEDURE IN HEPG-LAB	
①	SUPER CLEAN ROOM
②	TRANSITION REGION
③	TRANSITION REGION
④	WINDING ROOM
⑤	TEST REGION
⑥	TEST REGION
	TRAVELER 1-16

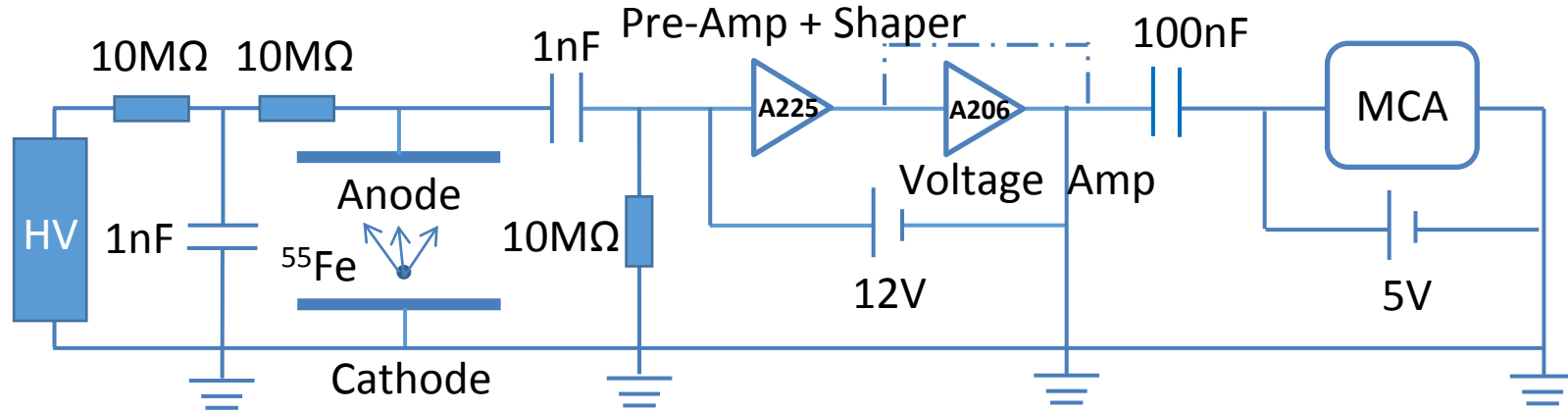
- Mass production flow diagram
- iTPC lab was divided into 6 regions
- Every sector should be inspected with engineers step by step
- About 2 weeks per sector

# MWPC performance test system setup

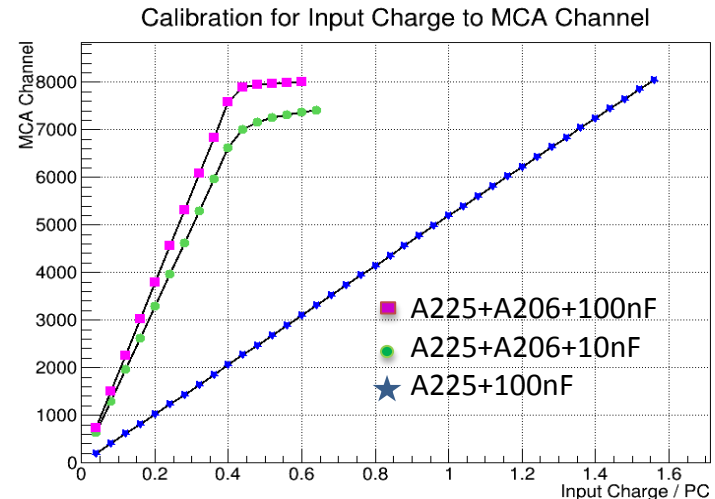
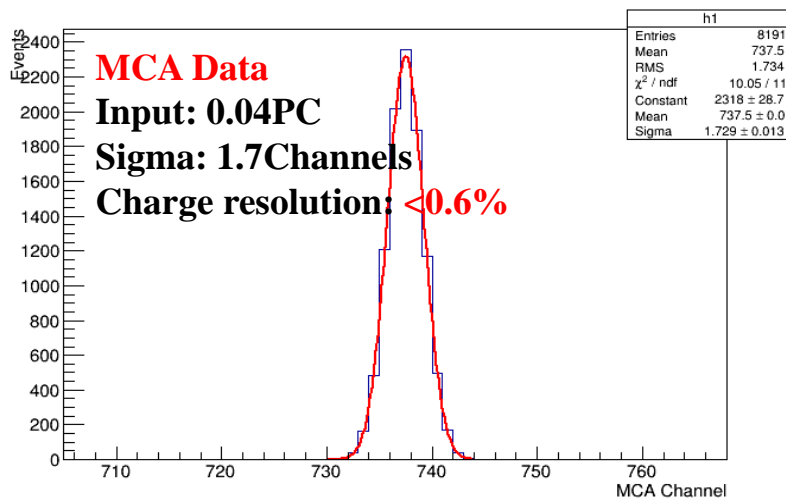


# MWPC performance test circuit and calibration

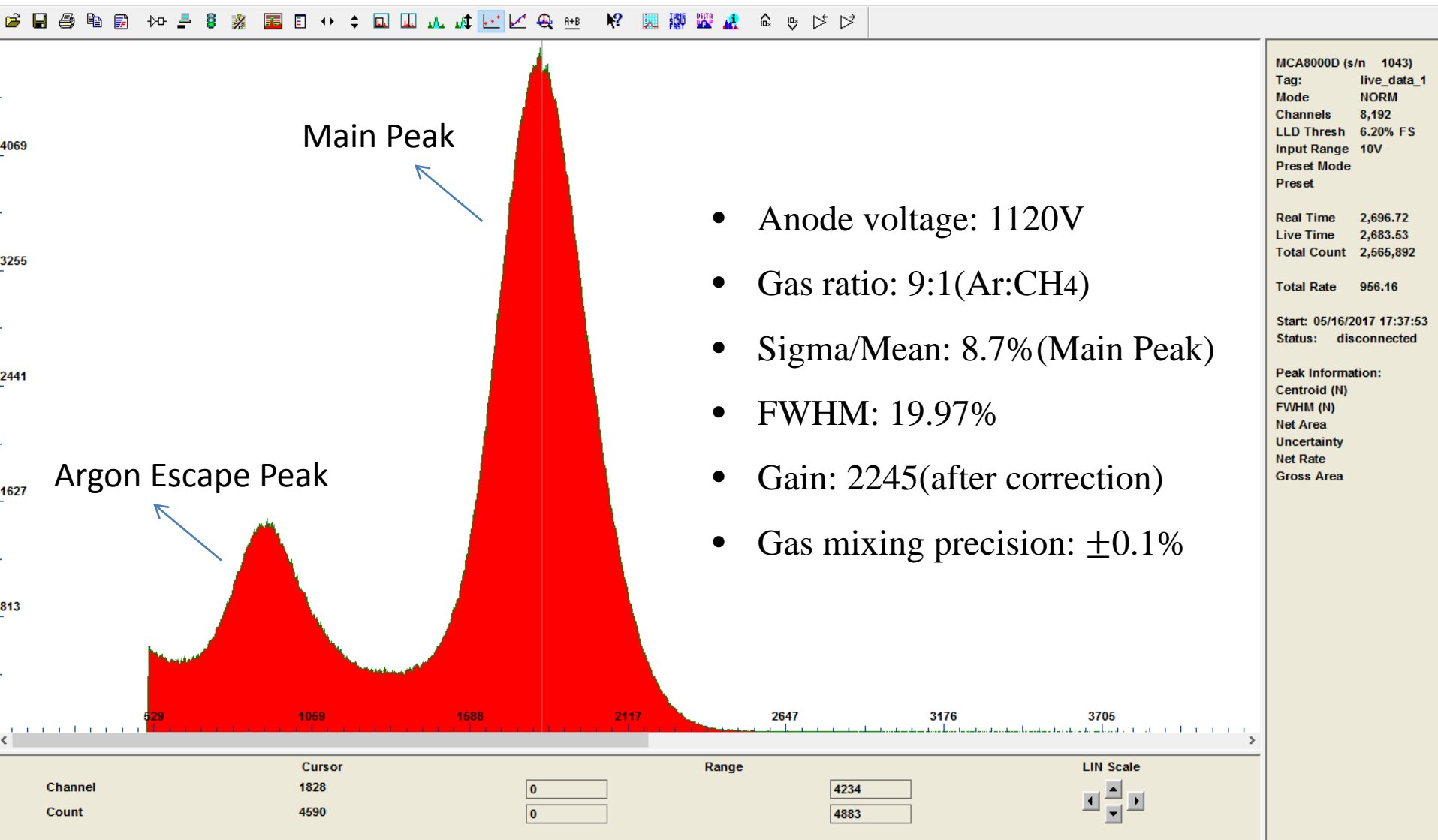
- Circuit diagram



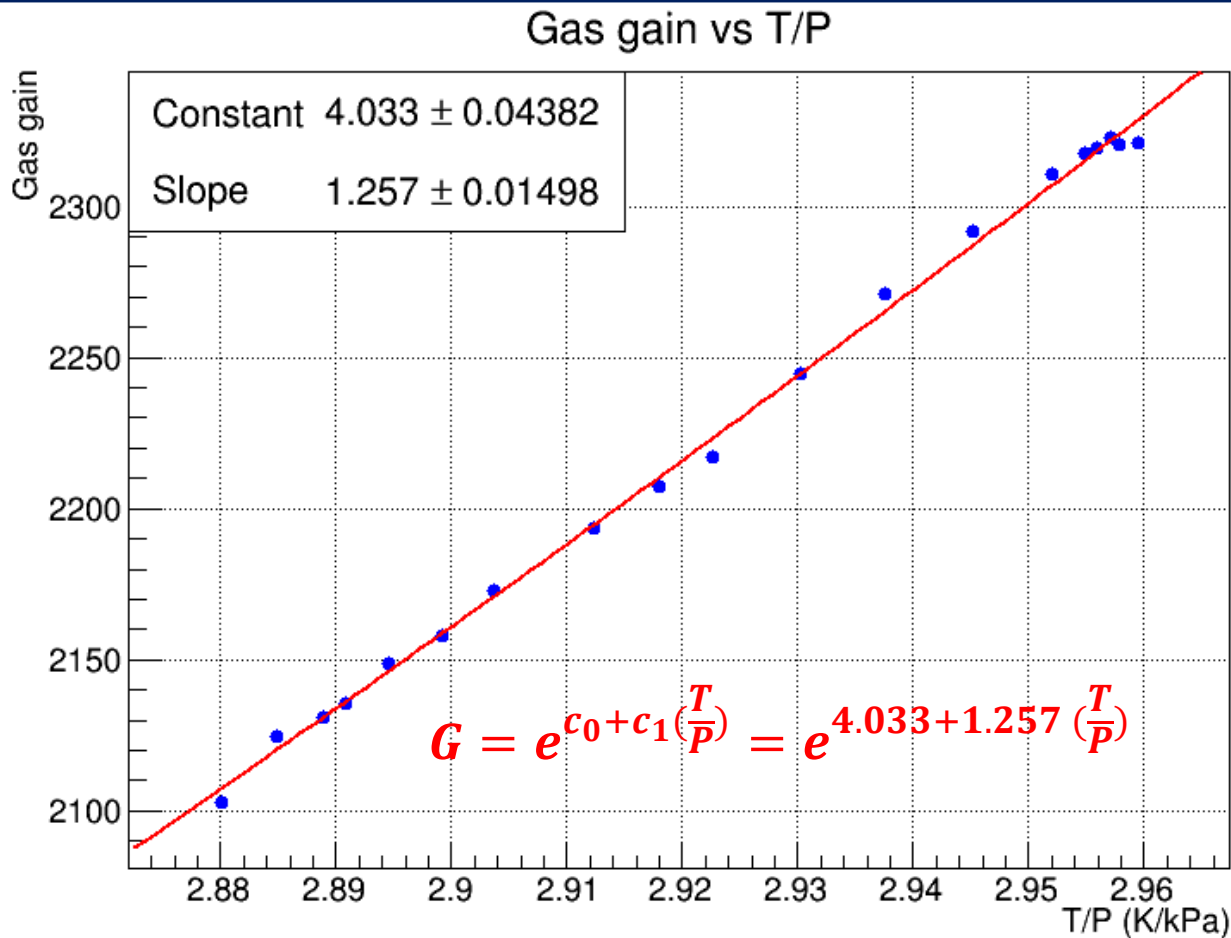
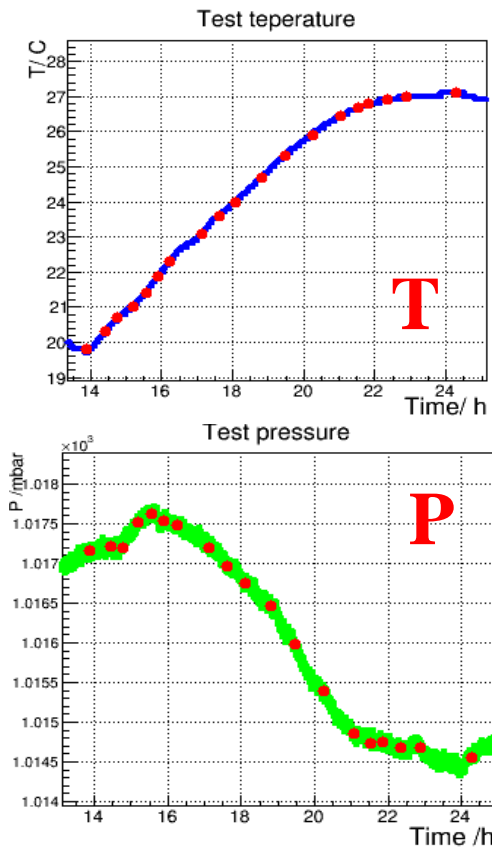
- DAQ electronics calibration



# $^{55}\text{Fe}$ X-ray spectrum

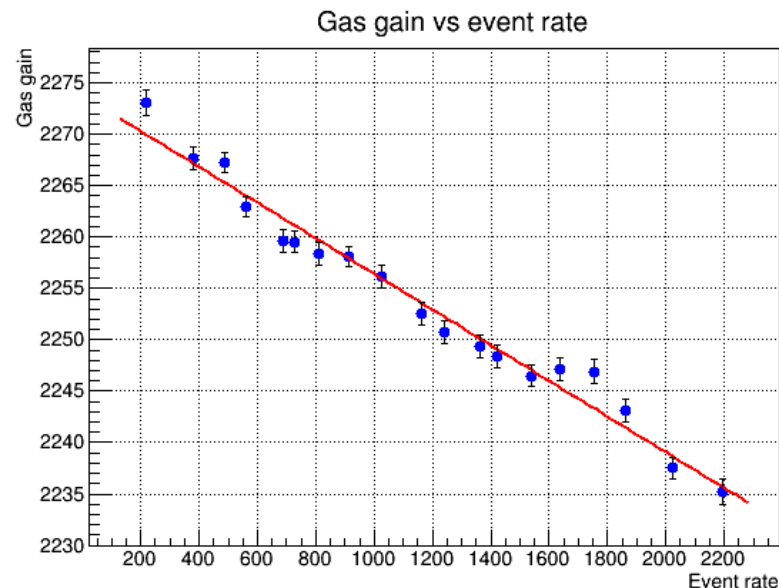
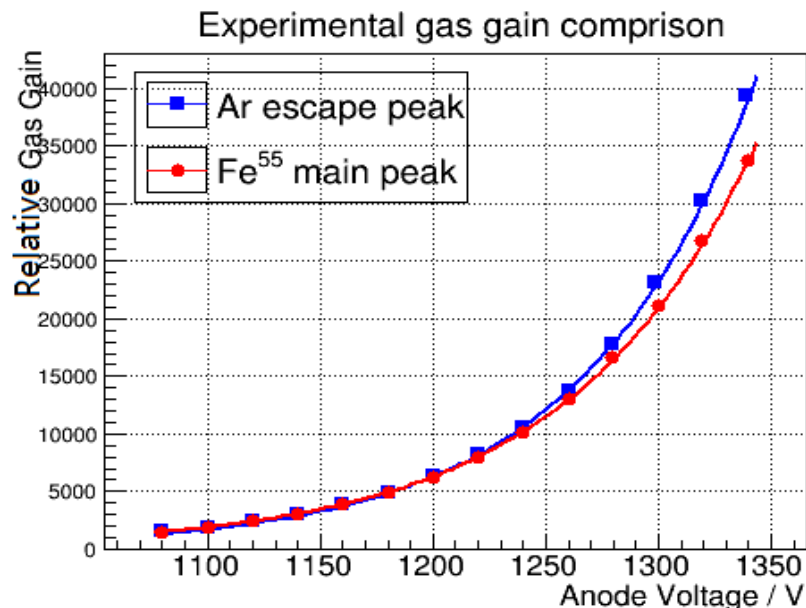


# Gas gain vs T/P



- 10 hours gas temperature and pressure data as shown in left two pictures
  - Gas gain increases with the T/P ratio, fit with a exponential function
- 王运永等, 核电子学与探测技术, 第16卷第2期 (1996), 118~124

# Gas gain vs HV, event rate and gas ratio



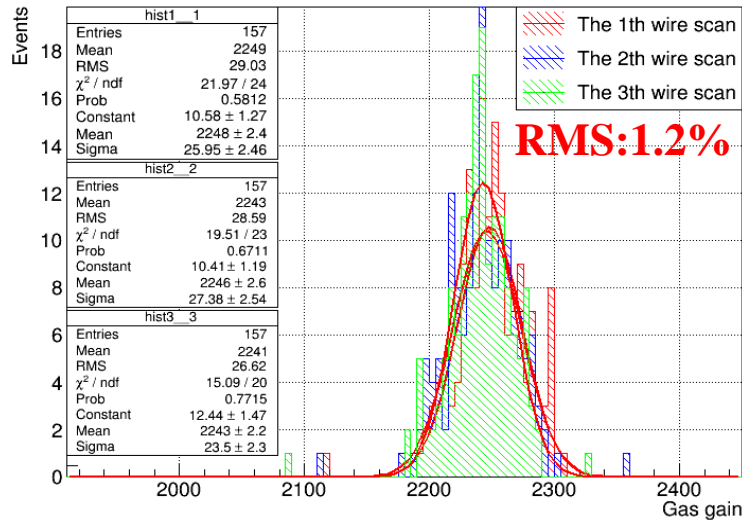
- The gas gain exponentially increases with the high voltage.
- Fit function(Main peak):  $G = e^{0.012V-5.8}$
- Gas gain decrease about 2% with x-ray event rate from 200~2200
- Gas gain varies about 10%~11% with 1% variation of gas ratio

Wire number	Gas Ratio / %		$\Delta G/G_0$
	90:10	91:9	
82	2262	2517	11.3%
83	2276	2522	10.8%
84	2269	2513	10.8%
85	2271	2504	10.3%
86	2244	2473	10.2%
87	2242	2480	10.6%
88	2233	2474	10.8%
89	2240	2467	10.1%
90	2239	2469	10.3%
91	2264	2503	10.6%

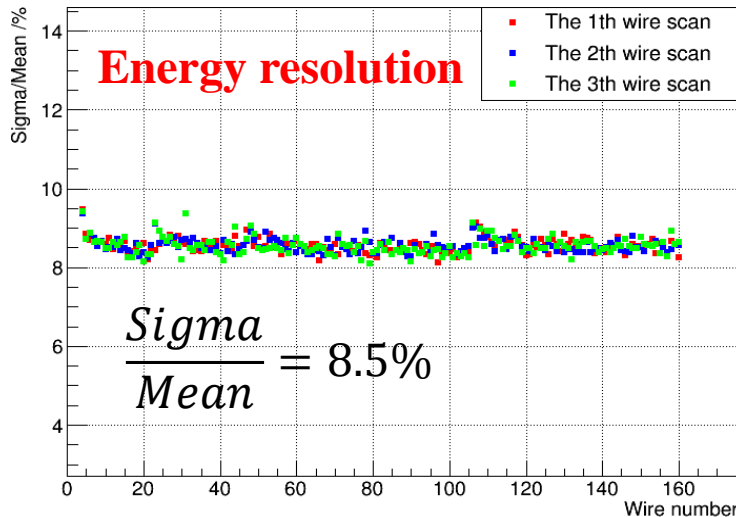


# Gas gain uniformity and strong X-ray test

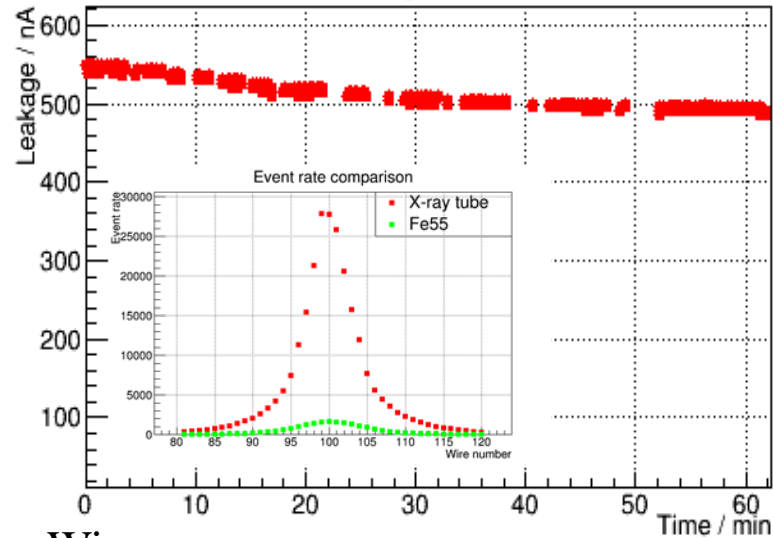
Gas gain uniformity of 3 wire scan results



Sigma/Mean of 160 wires X-ray spectrums



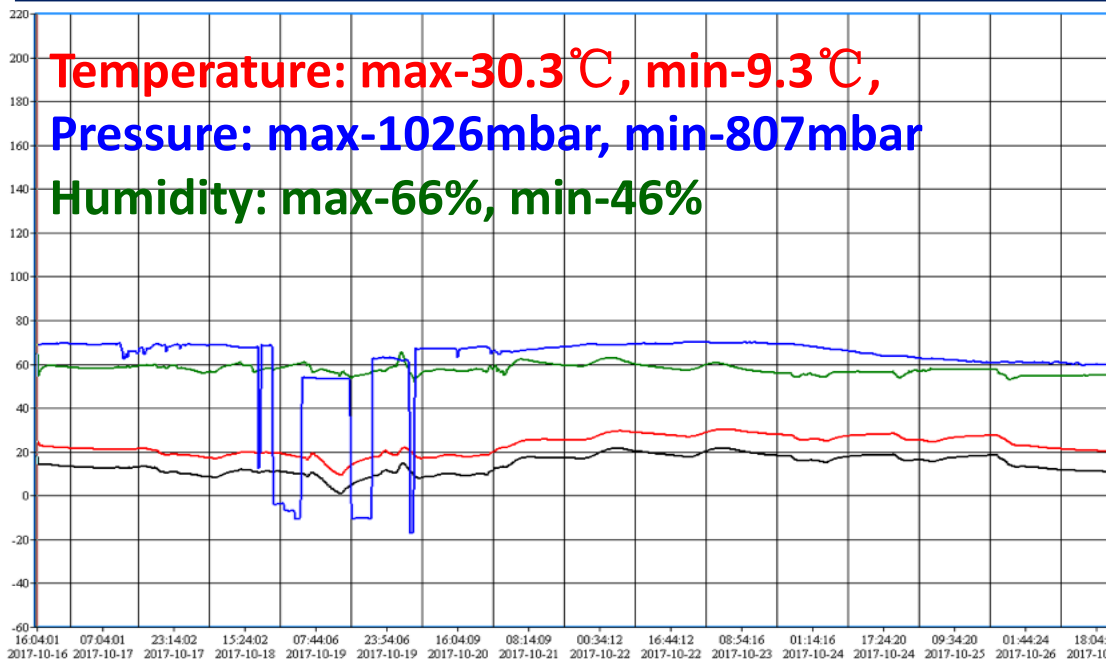
Leakage vs time



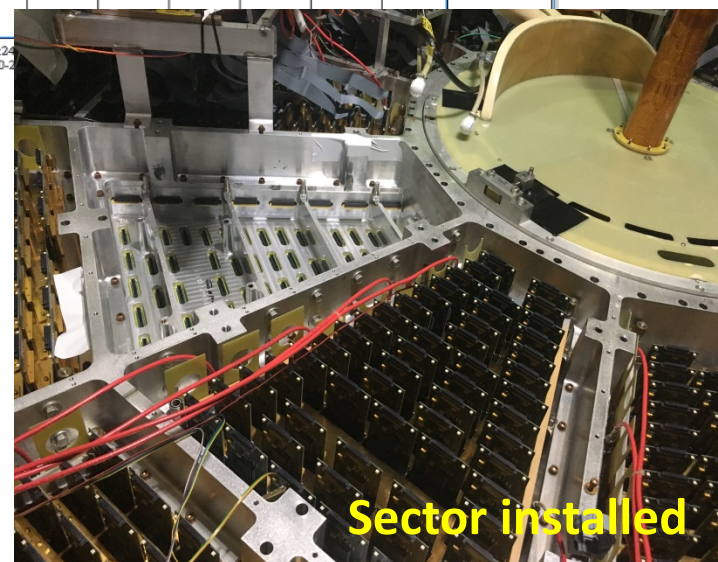
- Wire scan
  - ✓ 160 wires, 3 different positions for each wire
  - ✓ Gas gain uniformity(RMS/Mean): 1.2%
  - ✓ Energy resolution (Sigma/Mean): 8.5%
- Strong X-ray test
  - ✓ Total rate: 240k Hz
  - ✓ 40 wires could be covered (one HV channel)
  - ✓ MWPC leakage > 500nA
  - ✓ Leakage monitoring for 4 channels, 1 hour for each channel
  - ✓ No trip, little decrease



# Sector shipping and installation



- Temperature, humidity and pressure tracker in shipping process
- STAR TPC was firstly opened after 20 years smooth operation.
- First iTPC sector was installed at STAR on October 5, 2017 successfully
- Ready for commissioning during run18



# Outlook and summary

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- 30 sectors need to be produced at SDU, 5 completed,
- 2 sectors shipped to BNL, 1 installed at STAR
- MWPC mass production at SDU ongoing
  - ✓ Qualified wire tension and pitch
  - ✓ Gas gain uniformity/RMS ~1.5%
  - ✓ Energy resolution Sigma/Mean ~8.5%
  - ✓ Good stability under 240k Hz X-ray
- Mass production to be completed by Sep. 2018

