Testing and QA in iTPC MWPC mass production

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USTC/SDU

Outline

- iTPC MWPC production requirement
- Content of the work in SDU
  - ✓ production procedure
  - ✓ travelers
- Quality control
  - ✓ material preparation
  - ✓ mass production– wire winding, mounting, gluing, soldering
  - ✓ testing items
- Preliminary testing results on first prototype

iTPC MWPC production requirement

Wire tension: Anode +/- 5g

Wire plane height precision： <10μm

Wire pitch precision: <10μm

Clean， No dust pollution， No gas pollution

iTPC MWPC production requirement

Parameter	Threshold value	Ultimate value
dE/dx resolution for pions/muons at BES-II energies	-	<6.9% $\|\eta\| \le 0.1$ < 8.0% $1.0 < \|\eta\| \le 1.2$
Gain at Nominal Voltage	~2000 at 1150 Volts	-
Tension on Anode Wires	0.50 Newtons ± 0.05	-
Fully working sectors delivered to BNL (and/or repairable at BNL)	20 (6)	-
HV sections operational after installation	>95%	-
Compatible with STAR DAQ-1000 system	< 8% @ 1kHz and 30% @ 2 kHz dead time from iTPC at BES-II energies	< 5% @ 1kHz and 20% @ 2 kHz dead time from iTPC at BES-II energies
Operational electronics fraction	Less than 8% dead channels (for all sources combined: bad padplane connectors, bad FEE channels or FEEs, bad RDO interconnects or RDOs, bad power supplies or various trigger, power & fiber cables)	Less than 3% dead channels
Electronic Signal to Noise	20:1	-
Electronics gain Uniformity	<10%	<2%

Content of the mass production

- The iTPC upgrade project needs 26 qualified module
  - ✓ 12 module each side * 2 sides
  - ✓ 2 backup modules

- Scope of the work in SDU：
  - ✓ iTPC MWPC module production (wire related parts)
  - ✓ Quality control in mass production
  - ✓ Testing on MWPC performance
  - ✓ Building the data base for quality tracking and QA
  - ✓ Shipping

Procedure of production

iTPC Production Procedure

iTPC 丝室制作流程

目录

iTPC 丝室制作流程

Procedure of QA in production

iTPC 制作检查簿

iTPC Travellers Book (SDU)

Sector＃编号：_____

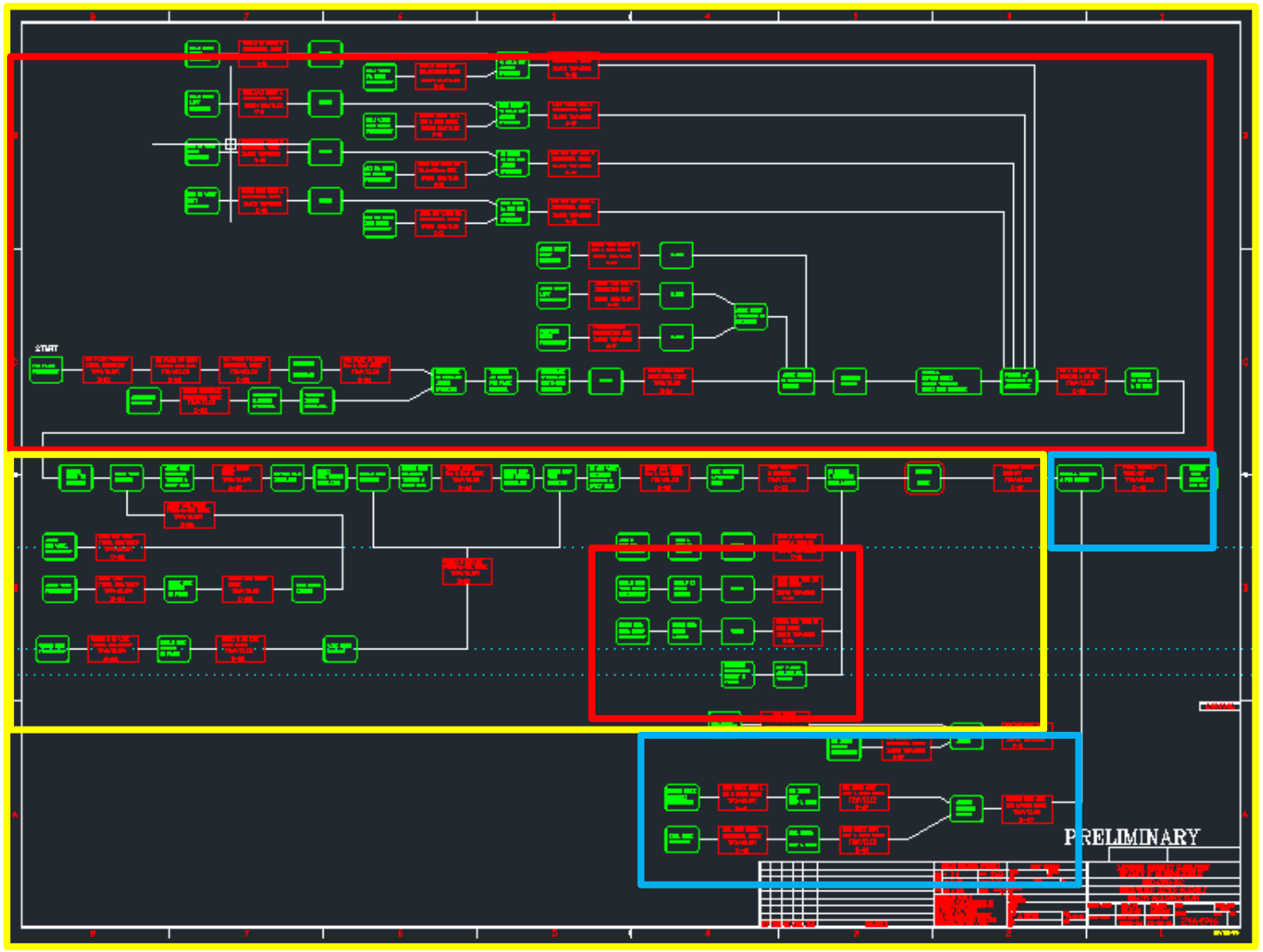
Date 制作时间：_____

iTPC 制作进程跟踪表，v11262016

步骤	项目/item	检查表 Traveller	进度 Status
1	丝轴线检查/wire	Traveler 1	
		Traveler 2	
		Traveler 3	
2	绕丝/wire winding		
3	丝框张力检测/wire tension	Traveler 4	
		Traveler 5	
		Traveler 6	
4	丝框存储/wire frame storage		
5	阳极丝框用前检测/anode wire frame prior	Traveler 7	
6	阳极丝粘接/epoxying anode wire		
7	阳极丝焊接/anode wire soldering		
8	阳极丝面检查/anode wire plane	Traveler 8	
9	阳极丝连通性、短路、高压检测/A continuity	Traveler 9	
10	阴极丝挂载安装/shield wire mounts inst.	Traveler 10	
12	阴极丝框用前检查/shield wire frame	Traveler 11	
13	阴极丝粘接/shield epoxying		
14	阴极丝焊接/shield soldering		
15	阴极丝面检查／shield wire plane check	Traveler 12	
16	阴极丝连通性检测/shield wire continuity	Traveler 13	
17	门极丝挂载安装/gated wire mounts inst.	Traveler 14	
18	门极丝框用前检查/gated wire frame	Traveler 15	
19	门极丝粘接/epoxying gated wire plane		
20	门极丝焊接/gated wire soldering		
21	门极丝短路、连通性检测/gated wire cont.	Traveler 16	
22	iTPC 封装测试前检查	Traveler 17	
23	iTPC 测试	Traveler 18	

Procedure flow diagram and travelers

About 40 travelers, 25 of them are related to us. Combined into 18.

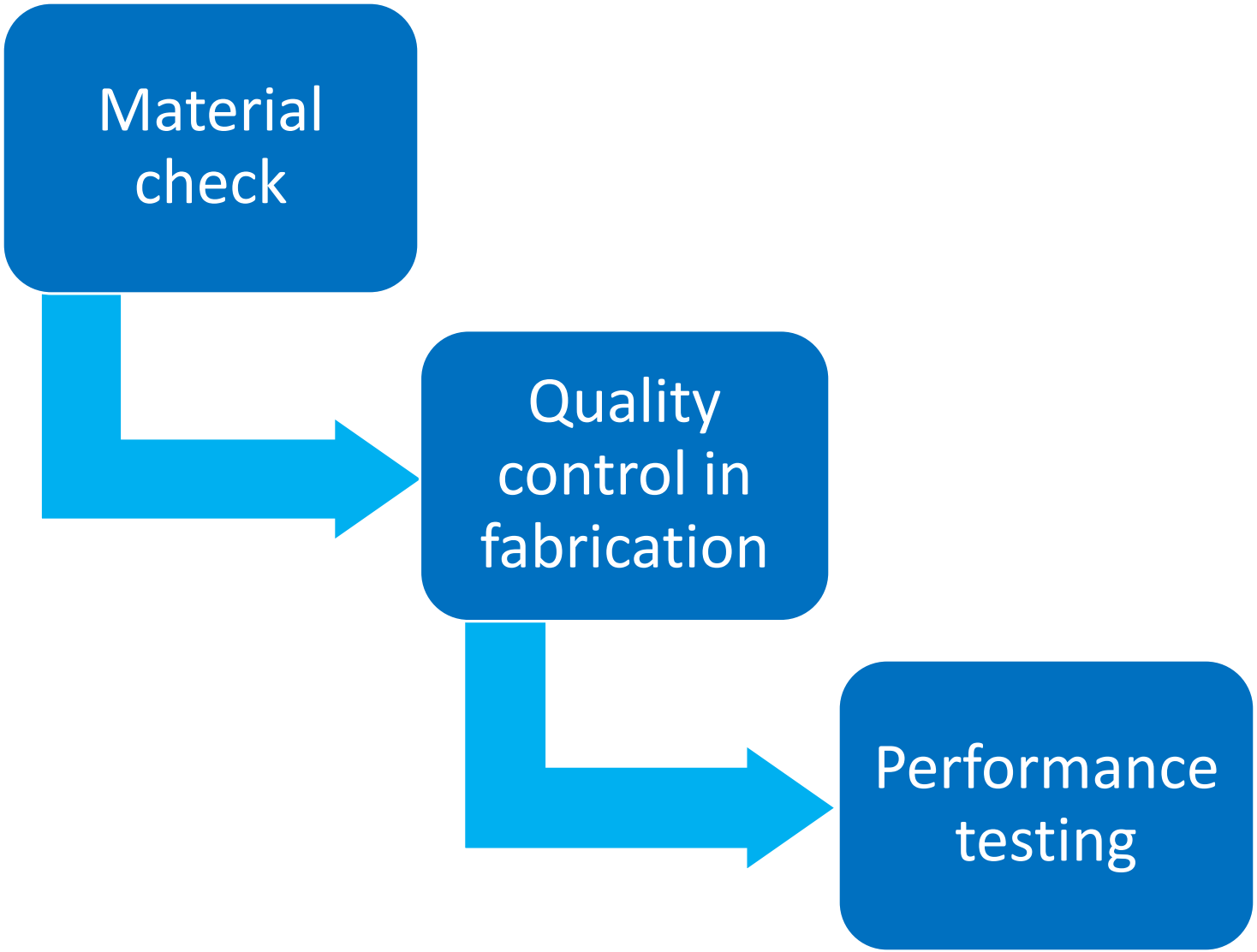


Finished in US
Re-check in SDU

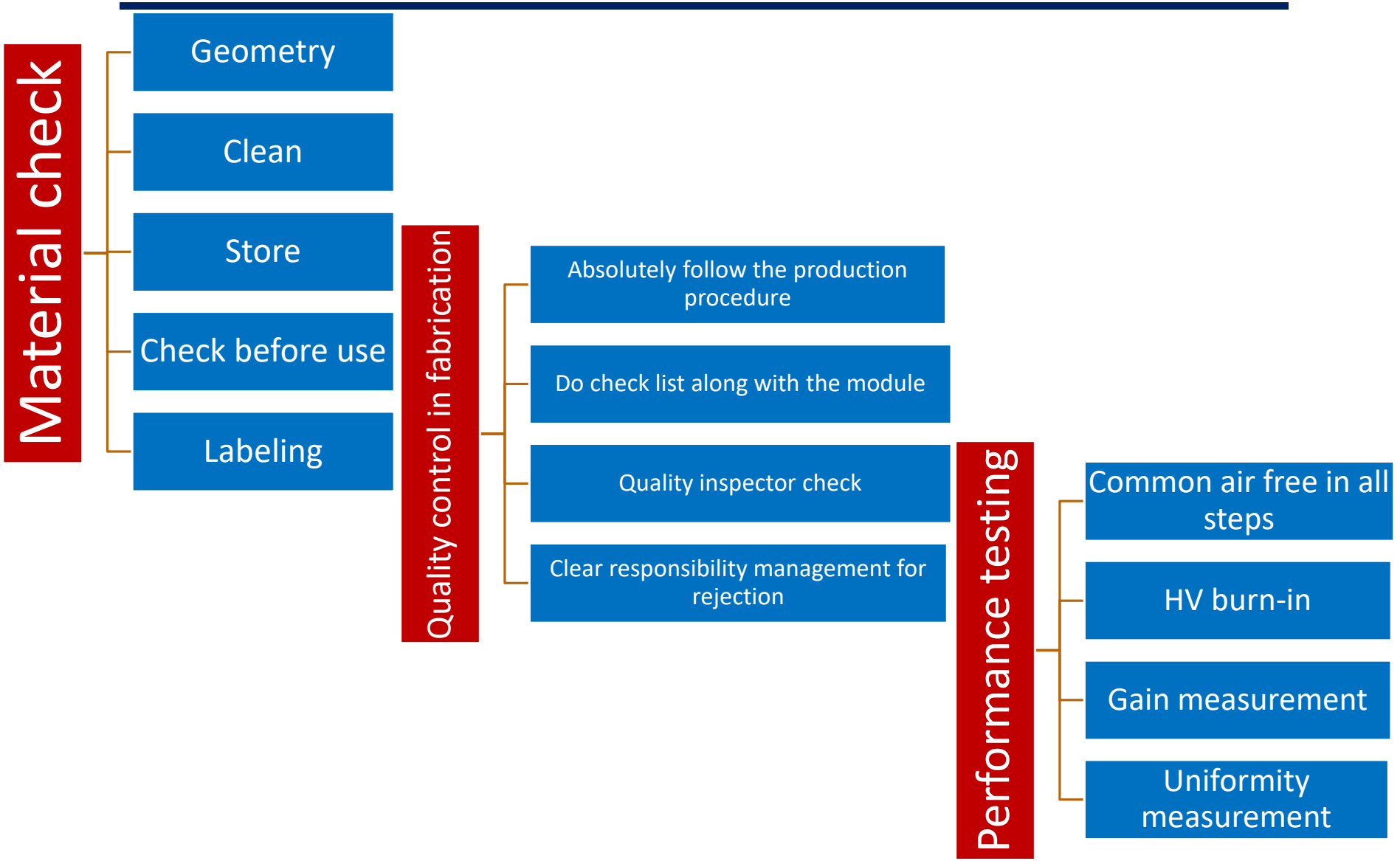
Finish in SDU

Finish in US

Quality control



Quality control key points



Quality control

- ✓ All check procedure are more detailed listed in the new revised travelers.
- ✓ All “DO” and “DO NOT” are included in the new revised travelers.
- ✓ The travelers are translated into Chinese.

We just list some of the points in the travelers here.

Material Preparation

Material List (per module)

Name	Type / Factory	**Comment**	#
Anode wire mount	NEMA-G10		2
Shield wire mount	NEMA-G10		2
Gated grid wire mount	NEMA-G10		2
Au-plate W wire	LFA	Φ 20μm	250m
Be-Cu wire	LFA	Φ 75μm	1000m
Be-Cu wire	LFA	Φ 125μm	15m
Stongback	LBL	ALUM. ALLOY 6061-T651 per ASTM B209	1
PPPCB	NEMA-G10		1
ABDB	NEMA-G10		8
LOAB	NEMA-G10		1
Copper crew		10-32*1/2 inch	18
Copper dowel			18
Glue	EPON Resin 826	60%	90ml
Glue	VERSAMID 140	40%	60ml
Soldering tin	BALVER ZINN	Sn63% Pb37%	

Aarldite 2011, used now, need some investigation

Production area：

- Clean Room： cleanliness ~ 10000
- Temperature： 26C°±2℃ Humidity：<40%

Quality Control -- Material check

- **Strongback**
  - **Visual：flat，bright，no scratch，no stain，smooth cut，no defect**
  - **Tooling and screw hole：right position，clean inside**

- **PCB**
  - **Visual： flat，bright，no scratch，no stain，smooth surface，no defect**
  - **Geometry： height of three wire mounts**

Compare to the pre-test results from LBL

SD-TRAVELER S - 10

SHIELD WIRE MOUNT PINNING, GAP, AND HEIGHT CHECK　阴极丝挂载销钉、缝隙和高度检验

StrongBack Serial No._____

StrongBack 编号_____

After answering each of the following questions please initial your name.

完成下列检查后请签名。

VISUAL INSPECTION　外观检验

1. Are there any dowel pins incorrectly installed?

(Note: 18 pins must be placed 9 pins on each side flush with outer surface of the gated grid wire mount).

有无任何定位销钉安装错误？

(注意:18根销钉必须每边9根)　　**Yes___，No___**

2. Is there gap between Anode wire mount and Shield wire mount ?

阳极丝挂载和阴极丝挂载之间存在缝隙吗　　**Yes___，No___**

IF THE ANSWER TO ANY QUESTION ABOVE IS **YES** NOTIFY COGNIZANT ENGINEER

如果上述问题的答案任何一个是 **YES**，通知相关工程师。

HEIGHT INSPECTION　高度检验

3. MEASURE the height of the Shield wire mounts. Check for high spots along the full length of each wire mount. The wire mounts should be .004'' to .007'' below the height(3.5635'') standard for that wire mount.

测量阴极丝挂载的高度，挂载的高度应当比标准90.51mm低0.10~0.17毫米。　　**Yes___，No___**

IF HEIGHT INSPECTION HAS FAILD THEN NOTIFY COGNIZANT ENGINEER.

如果高度检验未通过，通知相关工程师。

IF THE PROBLEM CAN NOT BE REPAIRED TAG THE PART "**REJECTED SHIELD WIRE MOUNT**".

如果问题很严重，且无法修复，标记 "**驳回阴极丝挂载**"

Engineer's signature　　Inspection date

工程师签名_____　　检验日期:____/____/201_

Inspector's signature　　Inspection date

检验员签名_____　　检验日期:____/____/201_

PASS 通过_____　　**REJECTED** 驳回_____

In this part, we may more focus on：

- ✓ Height of wire mounts, especially when installed on strongback. The height from wire mounts upper side to granite table should be ~150μm lower than the wire
- ✓ The gap between different wire mounts after installed <10μm
- ✓ Re-clean before use
- ✓ Extra glue leaked out
- ✓ Dowel labeling and angle mark
- ✓ Protect on PPPCB surface
- ✓ Clean and visual check
- ✓ Tooling line position

Quality Control -- Material check

- **Wire check：**
  - **Visual： packed well， no folding, bright, smooth**
  - **Stress： pull out 3m wire and check if it crimp automatically**
  - **Wire： cut off 3m wire and use analytical balance**
  - **Guide wire to other wheel： if primary wheel is not suitable for winding**
  - **Label： can be tracked to the primary wire wheel and batch#**

- **Wire frame check：**
  - **Visual ： smooth on the surface for wire**
  - **Wire winding machine tension input： calibration on each wire frame for gated grid wire**
  - **Label**

Quality Control-Material clean and store

Wire frame, Strongback, PPPCB, Screw, Nut, Dowel：

- **Alcohol->deionized water->dry nitrogen**
- **Store in gas tight box or clean room**

Wire：

- **Store in constant temperature humidity chamber（26℃， humidity 25%）**

Glue：

- **Low temperature, gas tight**
- **Mix before use, vacuum pumping, use within 15min after mixing**

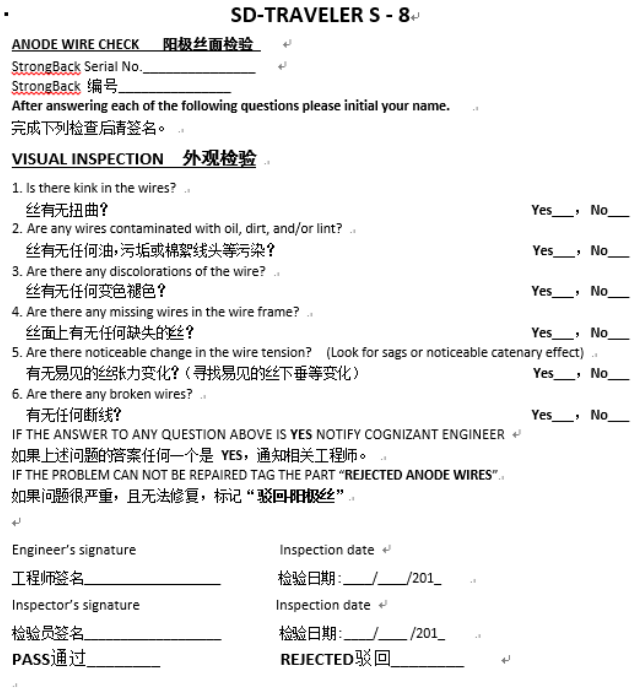
Fabrication

Quality Control – Fabrication

Fill the corresponding check list (all included in the revised travelers)

Clear responsibility to certain people

- **Material check**
- **Wire winding check**
- **Production procedure check**
- **Quality check**



SD-TRAVELER S - 8

ANODE WIRE CHECK 阳极丝面检验

StrongBack Serial No._____

StrongBack 编号_____

After answering each of the following questions please initial your name.

完成下列检查后请签名。

VISUAL INSPECTION 外观检验

1. Is there kink in the wires?
   丝有无扭曲? **Yes___, No___**
2. Are any wires contaminated with oil, dirt, and/or lint?
   丝有无任何油,污垢或棉絮线头等污染? **Yes___, No___**
3. Are there any discolorations of the wire?
   丝有无任何变色褪色? **Yes___, No___**
4. Are there any missing wires in the wire frame?
   丝面上有无任何缺失的丝? **Yes___, No___**
5. Are there noticeable change in the wire tension? (Look for sags or noticeable catenary effect)
   有无易见的丝绷张力变化?（寻找易见的丝下垂等变化） **Yes___, No___**
6. Are there any broken wires?
   有无任何断线? **Yes___, No___**

IF THE ANSWER TO ANY QUESTION ABOVE IS **YES** NOTIFY COGNIZANT ENGINEER

如果上述问题的答案任何一个是 **YES**，通知相关工程师。

IF THE PROBLEM CAN NOT BE REPAIRED TAG THE PART "**REJECTED ANODE WIRES**"

如果问题很严重，且无法修复，标记"**驳回阳极丝**"

Engineer's signature　　Inspection date

工程师签名_____　　检验日期:____/____/201_

Inspector's signature　　Inspection date

检验员签名_____　　检验日期:____/____/201_

PASS通过_____　　**REJECTED**驳回_____

Will install camera in clean room, record the production process

Take pictures on all soldering points, save in docs

Quality Control – Wire Mounting

- Production equipment and area clean

  --- lint free paper

- Protection on wire plane when moving
- Do not drag the wire frame on the granite table surface
- Check the height and flatness on wire comb straight edge

  --- distance to tooling ball mid-line

- Wire comb can only be touched by wires once it is fixed
- Use view machine to check the consistency between wire comb and tooling line on PPPCB
- When adjust the height of wire comb, use height keeping tool to keep the height of other part

Quality Control – Wire Mounting

- Must go through pre wire mounting, make sure all equips works well in wire mounting
- Do not do any other work above wire plane, i.e. passing tools
- Do not touch wire plane
- Do not use other force except tooling force to adjust wire frame
- Operate at both sides together when adjust the height of wire plane
- Try to keep the wire plane horizontal when laying down
- Use soft brush “scan” the wires on straight edge(long side to short side), see if there is resistance or wire shaking. Make sure all wires are physically touching straight edge
- Visual check to see if all wires are in their expected combs

Quality Control – Wire Gluing

- Fully mixed, vacuum pumping
- Use within 15mins
- Fix the gluing machine position
- Fix the injection tube position, can only be moved vertically
- Same injection tube caliber
- Pre gluing, check the flux and shape
- Special protection cover, supporting tool
- Start and end outside the wire mount
- Relations between flux and inject tube radius, between flux and pressure
- Gluing direction, strongback long side to short side
- Visual check the possible wire shift after gluing
- Notice when freezing

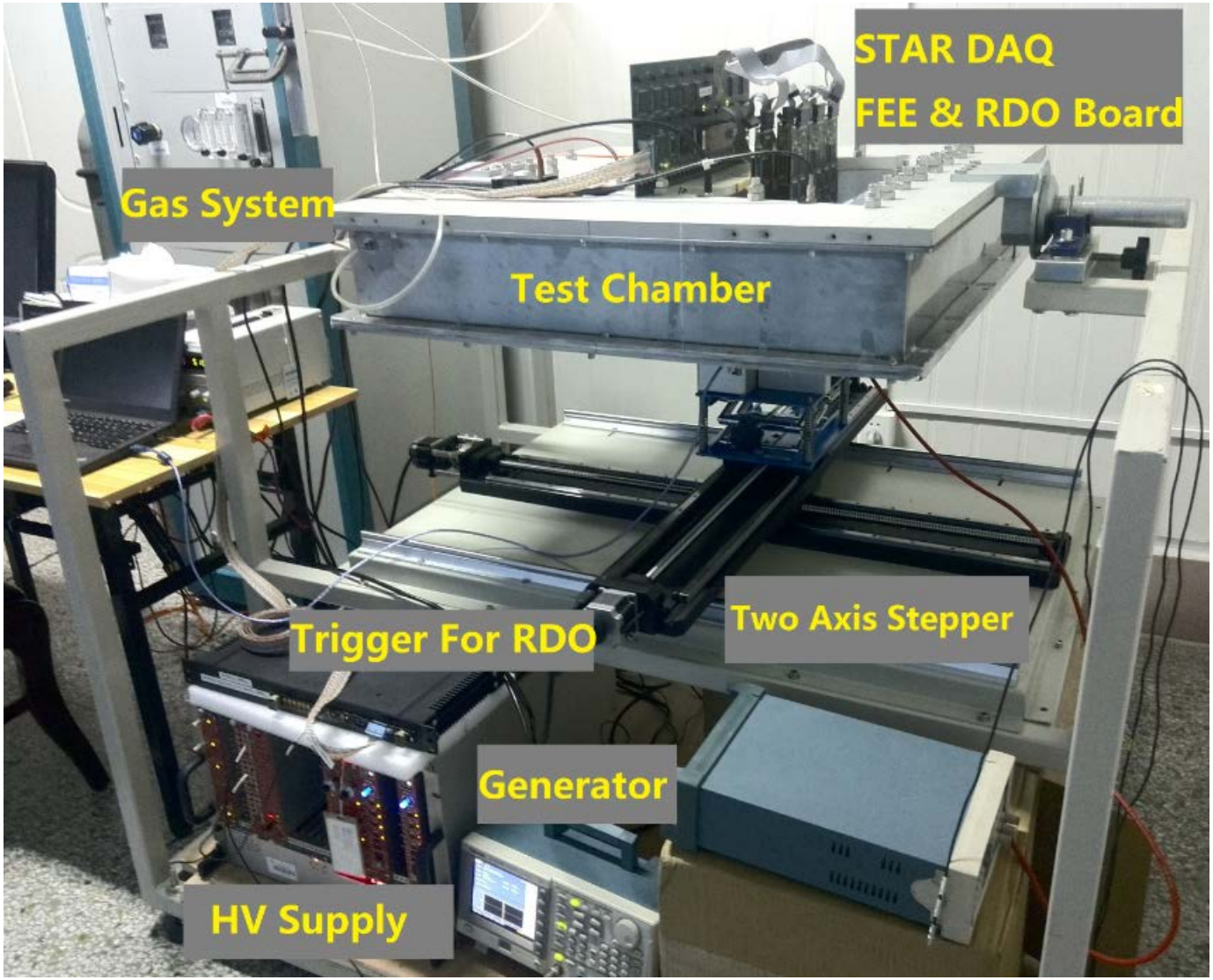
Quality Control – Wire Soldering

- use absolute ethyl alcohol clean the bonding pad
- lint free paper
- pre-clean and post-clean
- Welding gun temperature 315℃
- Soldering time 3-4s
- Smooth bonding point
- Height of soldering tin < 0.025”

Quality Control – Performance testing

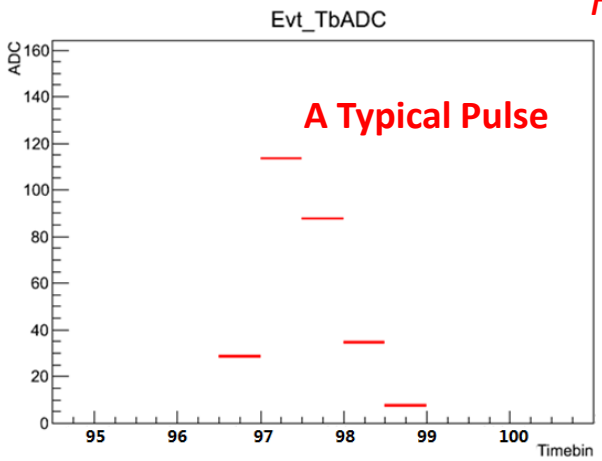
- HV burn-in and gas tight check
  - -- 10% above nominal voltage, 24 hours, track HV current
- Gain uniformity measurement
  - -- 2-3 points each wire both wire side and pad side
- X-ray scan on pads
  - -- quick scan on pads, check the response from pads
- Radiation hard check
  - -- high rate X-ray tube, long time

Test system

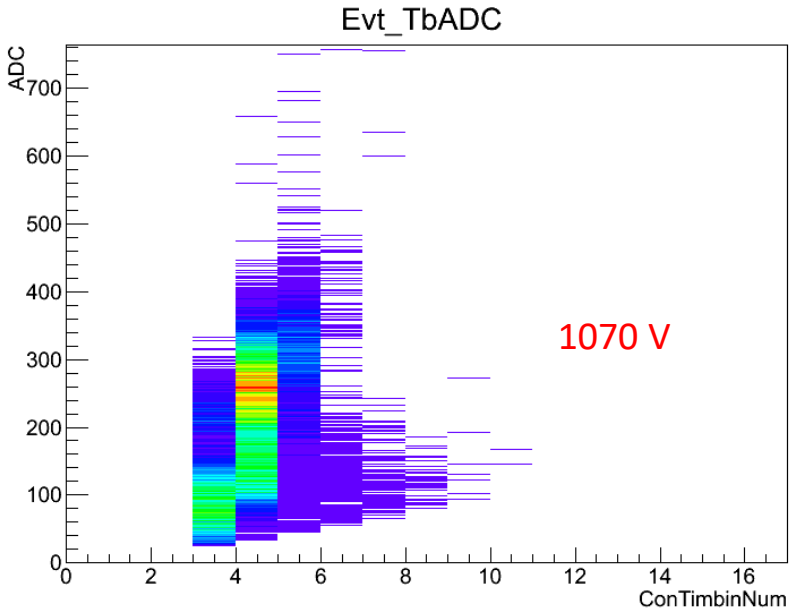

STAR DAQ
FEE & RDO Board
Gas System
Test Chamber
Trigger For RDO
Two Axis Stepper
Generator
HV Supply

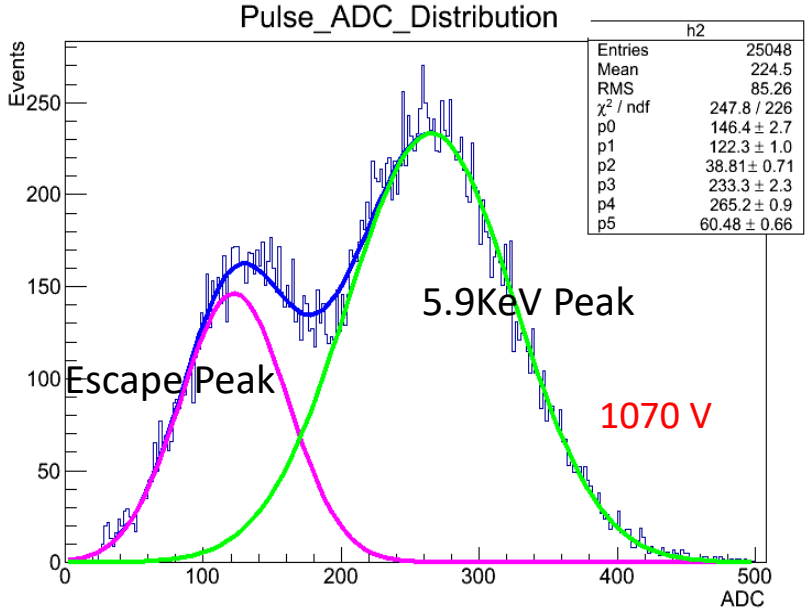
Preliminary results – Fe 55 (pad side)

Fuwang Shen, Shuai Wang

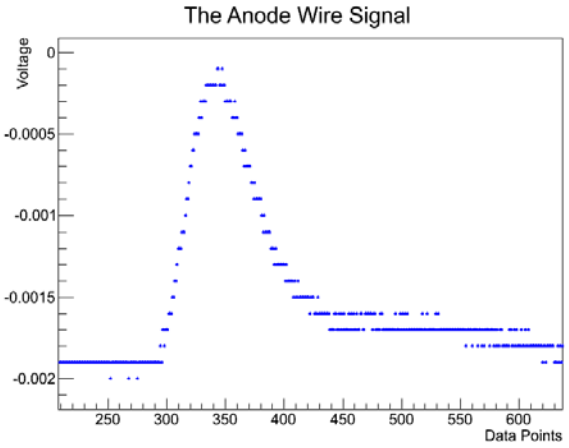


Old PPPCB design for the first prototype





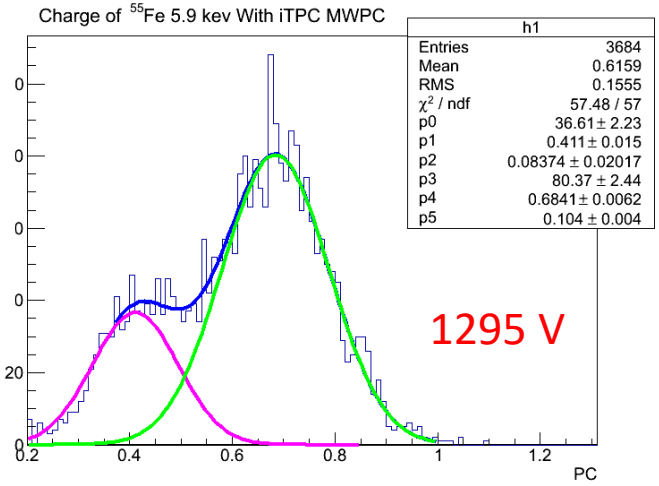
Preliminary results – Fe 55 (anode wire side)

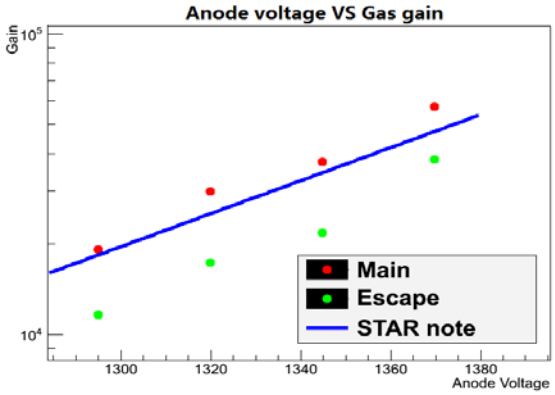


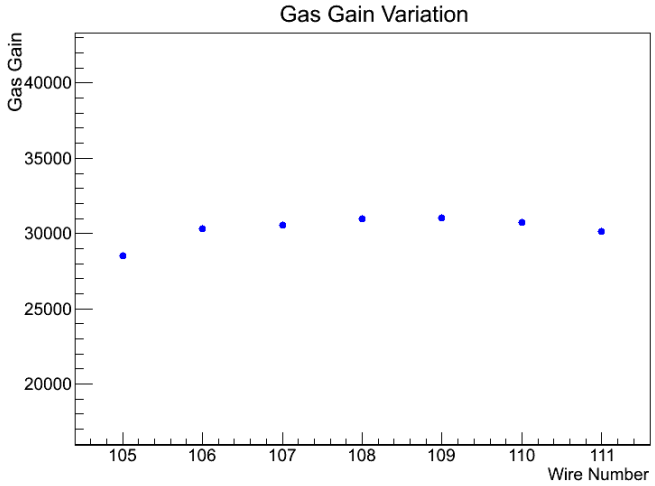
Anode wire signal to oscilloscope

Will use pre-amplifier and QDC

Fuwang Shen, Shuai Wang







The difference between maximum and minimum is ~ 8.7%

The effects of temperature needs further investigation. 2~3% effects from previous STAR measurements.

Summary

- ✓ **All material、 storage and checking ---- record**
- ✓ **All material treating processes ---- record**
- ✓ **All production steps and check list ---- record**
- ✓ **All performance testing and QA ---- record**

Produce all MWPC modules with required precision and high qualification rate

Safety shipment to BNL