PATask Force & Sensors issues

8th BelleII VXD Workshop, Trieste 9-11 Sept. 2015

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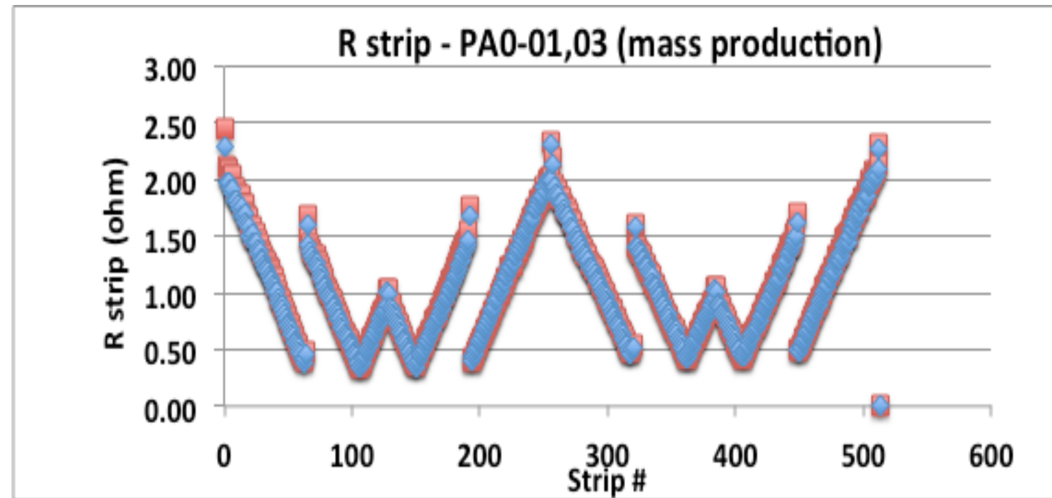
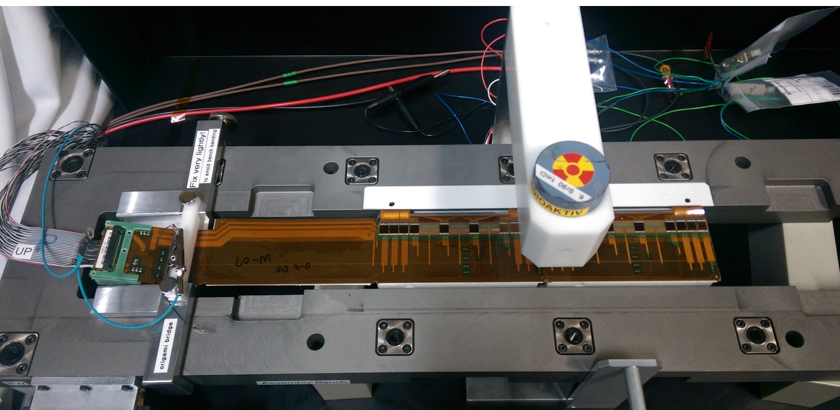
PATask Force: Summary

- **PA0 crack problem finally solved after 1 year!**
  - Several months of investigations, optimization of the process in close collaboration with the company, and a new design implemented: stronger against cracks and with wide sensor pads
  - Detailed QA procedure implemented: several electrical tests and visual inspection during production & assembly
  - Specifications documents for PA0 & ORIGAMI written.
    - ORIGAMI doc completed but still need sign-off
- First PA0 pre-production (batch0) successfully produced & assembled on 12 ORIGAMI circuits (March-July):
  - Several intermediate electrical test & pad distance measurements & detailed visual inspections done: a few unexpected issues found and fixed
  - No cracks: only 2-3 small cracks on pads over ~6k lines
  - PA0 pre-prod. Yield ~75% (due to shorts), reasonable.

PATask Force: Summary

- PA0 mass production started in August.
  - 149 circuits produced & tested with ~60% yield (shorts)
  - Additional circuits already in production to assemble 141 ORIGAMI needed.
  - No impact on global ORIGAMI mass production schedule.





- New PA0/ORIGAMI (batch0) tested on a full ladder (L5.001 -class B)
- Electrical test and source scan confirmed new PA0 design is ok.
- Final thermal test on L5.001 (this week?) before starting ORGIMI mass production (141 circuits ready to be asseblembled)
  - NEED to complete by Sept. 15th the sign-off for the ORIGAMI specs, specs already sent to the company for final agreement.

ORIGAMI mass production

- ORIGAMI mass production will progress in 3 batches:
  - batch 1 (CE 12,-Z 18,+Z 8 tot 38)
  - batch 2 (CE 24,-Z 30, +Z13 tot 67)
  - batch 3 (CE 12,-Z 18,+Z 6 tot 36)
- In each batch splitting in minibatches of ~ 10 circuits each:
  - + Z circuits, that need the pre-bending, will be assembled first
  - Pre-bending @ IPMU then back to complete the assembly @ company.
- A fine tuning of the minibatch splitting inside batch 1 is under discussion with the company to optimize ladder assembly schedule

Origami batch 1 (CE 12,-Z 18,+Z 8 tot 38)			**start date**	**end date**	
Origami reflow soldering	REPIC	38 Origamis, +Z first	02/10/15	27/10/15	17
PA0 electrical test #3 (after reflow)	Daiei	mandatory	14/10/15	29/10/15	1
PA0 evaluation	KEK	Check electrical test by SVD each time they are available before proceed to next step, NO optical inspections needed.	16/10/15	02/11/15	1
Origami +Z prebending and aging	IPMU	aging of a week	20/10/15	26/10/15	5
Origami APV gluing and wire bonding	REPIC	38 Origamis	28/10/15	20/11/15	17
H/C-shape gluing	REPIC	H/C-shape貼付 (H/C-shapeの最初の3日分を計算)	30/10/15	26/11/15	3
Delivery Origami batch 1	REPIC	delivered by mini batches	16/11/15	30/11/15	[illegible]
Electrical test batch 1	KEK	APVDAQ + visual inspection for crack (1 Origami / minibatch)	17/11/15	09/12/15	[illegible]
Shipment to assembly sites	KEK	Duration depends on assembly site (IPR)			

- HEPHY can be ready to assemble next L5 class A from ~Nov, BUT if new ORIGAMI from batch1 are not received in Vienna by the beginning of Dec. the assembly will slip to Jan. 2016
  - **Paper work for shipment @ KEK need to be prepared in advance.**

ORIGAMI assembly global schedule

Origami batch 1 (CE 12,-Z 18,+Z 8 tot 38)			**start date**	**end date**	
Origami reflow soldering	REPIC	38 Origamis, +Z first	02/10/15	27/10/15	17
PA0 electrical test #3 (after reflow)	Daiei	mandatory	14/10/15	29/10/15	1
PA0 evaluation	KEK	Check electrical test by SVD each time they are available before proceed to next step, NO optical inspections needed.	16/10/15	02/11/15	1
Origami +Z prebending and aging	IPMU	aging of a week	20/10/15	26/10/15	5
Origami APV gluing and wire bonding	REPIC	38 Origamis	28/10/15	20/11/15	17
H/C-shape gluing	REPIC	H/C-shape貼付 (H/C-shapeの最初の3日分を計算)	30/10/15	26/11/15	3
Delivery Origami batch 1	REPIC	delivered by mini batches	16/11/15	30/11/15	1
Electrical test batch 1	KEK	APVDAQ + visual inspection for crack (1 Origami / minibatch)	17/11/15	09/12/15	16
Shipment to assembly sites	KEK	Duration depends on assembly site (IPR)			
Origami batch 2 (CE 24,-Z 30, +Z13 tot 67)					
Origami reflow soldering	REPIC	67 Origamis, +Z first	28/10/15	09/12/15	29
PA0 electrical test #3 (after reflow)	Daiei	mandatory	09/11/15	11/12/15	1
PA0 evaluation	KEK	Check electrical test by SVD each time they are available before proceed to next step, NO optical inspections needed.	11/11/15	15/12/15	1
Origami +Z prebending and aging	IPMU	aging of a week	13/11/15	19/11/15	5
Origami APV gluing and wire bonding	REPIC	67 Origamis	24/11/15	05/01/16	29
H/C-shape gluing	REPIC	H/C-shape貼付 (H/C-shapeの最初の3日分を計算)	26/11/15	08/01/16	3
Delivery Origami batch 2	REPIC	delivered by mini batches	10/12/15	13/01/16	1
Electrical test batch 2	KEK	APVDAQ + visual inspection for crack (1 Origami / minibatch)	11/12/15	26/01/16	30
Shipment to assembly sites	KEK	Duriation depends on assembly site (IPR)			
Origami batch 3 (CE 12,-Z 18,+Z 6 tot 36)					
Origami reflow soldering	REPIC	36 Origamis, +Z first	10/12/15	04/01/16	16
PA0 electrical test #3 (after reflow)	Daiei	mandatory	21/12/15	06/01/16	1
PA0 evaluation	KEK	Check electrical test by SVD each time they are available before proceed to next step, NO optical inspections needed.	24/12/15	08/01/16	1
Origami +Z prebending and aging	IPMU	aging of a week	28/12/15	04/01/16	5
Origami APV gluing and wire bonding	REPIC	36 Origamis, +Z first	06/01/16	28/01/16	16
H/C-shape gluing	REPIC	H/C-shape貼付 (H/C-shapeの最初の3日分を計算)	08/01/16	01/02/16	3
Delivery Origami batch 3	REPIC	delivered by mini batches	25/01/16	03/02/16	1
Electrical test batch 3	KEK	APVDAQ + visual inspection for crack (1 Origami / minibatch)	26/01/16	17/02/16	16
Shipment to assembly sites	KEK	Duriation depends on assembly site (IPR)			

PATF Pending issues

1. ORIGAMI specs completion before mass production (Sept. 15th)
   - Any feedback from the company? final document supplied last week
   - Need to do the formal sign-off this week!
   - H-C shape still to be completed (send comment to Hara-san if not done)
2. Answer from the company on the splitting inside batch1: impact on the global ladder assembly schedule.
3. APV chips availability (1410 + contingency needed)
   - APV chips thinned last year after decision to reproduce ORIGAMI (done at chip level not on wafer).
   - During visual inspection done in June (for batch0 assembly) discovered chips were dirty and several were damaged:
     - 1099 good chips available for mass production.
     - 100 thinned good chips still available in HEPHY
     - Cleaning performed on dirty chips and 387 more are recovered
     - Visual inspection is still ongoing to evaluate mech. damages on them and how many are usable
   - There are enough good chips for batch 1+2 (1055 + spares)
   - Batch3 will assemble APV chips in Jan. (360+spares)

- Need to understand soon if more APV chips have to be thinned to complete batch3 (~2 months process, Markus?)

Ladder assembly & ORIGAMI schedule

- Dates for ladder assembly extrapolated from my knowledge of the status at the assembly sites

Item	Start-date	End-date	Comment
ORIGAMI batch0		27-Jul	
Test with sensor @ HEPHY - first L5 class B with new ORIGAMI (batch0)	15-Aug	15-Sep	after this test and ORIGAMI specs ready we start ORIGAMI assembly for mass production
L5 First Class A with new ORIGAMI (ORIGAMI from batch 0)	06-Oct	27-Oct	
First Class B with batch0 in L6 (last class C evaluation needed before)	6-Oct	05-Nov	class C and presentation to QCG/evaluation needed before
First Class B with batch0 in L4 (last class C evaluation needed before)	31-Oct	30-Nov	class C and presentation to QCG/evaluation needed before
First Class A with batch0 in L6 (Final site review needed before)	12-Nov	03-Dec	Final site review needed before
First Class A with batch0 in L4 (Final site review needed before)	07-Dec	28-Dec	Final site review needed before
DELIVERY for ORIGAMI batch1 (38) (ready for shipment to assembly sites after APVDAQ test)	17-Nov	09-Dec	WE NEED a fine tuning of minibacthes assembly @ REPIC AND paper work readiness for shipment @ KEK, to have in Vienna the +CE and -Z ORIGAMI ready by beg. Of Dec.
DELIVERY for ORIGAMI batch2 (67) (ready for shipment to assembly sites after APVDAQ test)	11-Dec	26-Jan	
DELIVERY for ORIGAMI batch3 (36) (ready for shipment to assembly sites after APVDAQ test)	26-Jan	16-Feb	
First Class A with ORIGAMI from mass production (batch1) in L5	2-Dec	23-Dec	
First Class A with ORIGAMI from mass production (batch1) in L6	16-Dec	06-Jan	???
First Class A with ORIGAMI from mass production (batch1) in L4	4-Jan	25-Jan	???

Ladder assembly & ORIGAMI schedule

- Dates for ladder assembly extrapolated from my knowledge of the status at the assembly sites

Site	Site review status (Aug-2015)	final class C - start date	Intermediate SVD/QCG presentation evaluation	class B with new ORIGAMI - start date	Final review for class A	class A - start date
SFW-SBW - Pisa	Qualified for class A	ok	ok	ok	ok	ok
L5 - HEPHY	Qualified for class A	15-Sep	ok	15-Aug	ok	06-Oct
L4 - TIFR	Qualified for class B but additional class C + presentation at QCG needed	30-Sep	date? Mid Oct?	31-Oct	date? Mid Nov?	01-Dec
L6 - IPMU	Qualified for class B but additional class C + presentation at QCG needed	05-Sep	date? End Sept?	06-Oct	date? Beg. Nov?	06-Nov

Sensors situation

HPK large Sensors

- HPK sensor grading revised in April:
  - AC defects: can kill the APV chan connected→ weight=1
  - DC defects: less severe than AC, but can cause Noise increase and/or Signal reduction:
  - Weight<1 applied to DC defects based on their severity
  - HPK large sensor grading:
    - Sensor ID > 25,
    - CLASS A: tot % defects_weighted < 1% + I_tot<10 uA
    - CLASS B: tot % defects_weighted > 1% + I_tot <20 uA
- To have some early feedback on this grading I analyzed first assembled SFW and SBW modules to compare sensors defects vs defects seen by APVDAQ test

Sensor vs module defects seen on APVDAQ

- Study done on 9 SBW (HPK sensors) + 7 SFW (Micron sensors)
  - Sensor data from HPK or TS/Vienna tests
  - APVDAQ data + aDefectFinder analysis used
  - In total 16 sensors → 20k strips connected to APV chans
- **AC defects: 28 on sensors**
  - Pinholes, AC_AL_open, Shorts, are severe defects that can kill the APV chan, Weight=1 assigned for HPK sensor grading.
  - AC sensor defects always match defects found with APVDAQ test except:
    - 6 pinholes on HPK do not match (wrong data sheet for n side on sensor HPK 61)
    - 1 new pinhole found + 3 new pinholes found on scratched sensor
- **DC defects: ~200 on sensors**
  - In general less severe than AC defects, different weight assigned for HPK sensor grading, depending on the expected severity (S/N can be lower)
  - Do not expect to see all of them during APVDAQ testing.
  - 200 DC defects flagged on sensors and only 3 matched during APVDAQ tests (all are high leakage strips on first and last strip of the sensors, that are anyway always noisy on APV)
  - In some cases a slight increase in noise is found for p_implant_short on sensor

Sensor vs module defects seen on APVDAQ

- This analysis confirmed the choice to assign a weight on DC defects (used for HPK sensor grading) is reasonable
- BUT it's still important to identify DC defect on sensors since some of them even if not visible on APVDAQ test can still have an impact on resolution (p_implant_short/bad_isolation)

DC defect type	Comment	Possible effect on APV- Noise	Possible effect on APV - Collected	S/N reduction	Severity	Observed effect on APV (9 HPK+7 Micron sensors)	frequency of defect on sensors	Weigth applied for HPK grading
p_implant short	permanent defects (confirmed by visual inspection)	up	down	yes	2	50 HPK strips flagged, only a few sligthly noisy, 2 flagged in Micron (TS) NOT seen on APV	medium	0.5
p_bad_isolation	not related to visual inspection, can be due to effects on surface and low oxide charge, can change with time and with applied Vsep (>0 can cure it on p side)	up	down	yes	2	10 strips flagged, NOT seen on APV	medium	0.25
I leakage	shot noise still small with 50 ns and 50 nA	up	no	yes	1	3 flagged in Micron (TS (first and last det strips!),), Seen on APV	very low on Micron, none on HPK	0.25
P_poly_silicon_short	reduced Rbias, parallel noise probably negligibile with 50 ns peaking time	negligible?	no	no	0	8 strips flagged, NOT seen on APV	low	0
P_implant open	p strip is anyway biased by punch through ?	no	no	no	0	56 flagged HPK strip not seen on APV, 80 flagged in Mcron (TS) NOT seen on APV	high	0
P_poly_silicon_open	strip is biased by punch through from the other side (depends on design)	no	yes	yes	2	?	low	0.5

SBW module quality

Detector	Module	side	class	Module	% AC defects on sensor	% DC defects on sensor (not weighted)	% DC defects on sensor (weighted)	% AC+DC defects weighted	% defects on module from APVDAQ	Comment
202012000084	SBW993	p	B	L5.903	0.00	3.39	0.85	**0.85**	**0.00**	
202012000084	SBW993	n	B	L5.903	0.00	0.00	0.00	**0.00**	**1.37**	noisy
202012000029	SBW990	p	B	L6.901	0.26	2.60	0.26	**0.52**	**0.91**	
202012000029	SBW990	n	B	L6.901	0.00	0.00	0.00	**0.00**	**3.32**	several opens introduced on purpose
202012000061	SBW991	p	B	L4.905	0.00	1.17	0.00	**0.00**	**1.95**	noisy/high laser hit
202012000061	SBW991	n	B	L4.905	1.17	0.00	0.00	**1.17**	**1.95**	noisy
202012100076	SBW001	p	B		0.13	4.17	1.07	**1.20**	**15.90**	Strange noise not understood
202012100076	SBW001	n	B		0.00	0.00	0.00	**0.00**	**2.34**	5 opens strips, Due to glue
202012008196	SBW002	p	B	L5.001	0.13	2.99	1.04	**1.17**	**0.78**	
202012008196	SBW002	n	B	L5.001	0.00	0.00	0.00	**0.00**	**0.59**	
202012008170	SBW003	p	B		0.13	4.17	1.69	**1.82**	**0.65**	
202012008170	SBW003	n	B		0.00	0.00	0.00	**0.00**	**1.56**	
202012005097	SBW005	p	B		0.52	3.78	0.52	**1.04**	**2.60**	4 open, are these new?
202012005097	SBW005	n	B		0.00	0.00	0.00	**0.00**	**0.78**	
202012000079	SBW006	p	A		0.00	4.56	0.26	**0.26**	**1.17**	
202012000079	SBW006	n	A		0.00	0.00	0.00	**0.00**	**0.98**	
202012100074	SBW004	p	A		0.13	2.08	0.23	**0.36**	**1.17**	
202012100074	SBW004	n	A		0.00	0.00	0.00	**0.00**	**1.56**	noisy

SFW module quality

Detector	Module	side	class	Module	% AC defects on sensor	% DC defects on sensor (not weighted)	% DC defects on sensor (weighted)	% AC+DC defects weighted	% defects on module from APVDAQ	Comment
3049-7	SFW988	p	B	L4.905	not avalaible yet	not avalaible yet	not avalaible yet		**1.57**	laser defects excluded
3049-7	SFW988	n	B	L4.905	not avalaible yet	not avalaible yet	not avalaible yet		**1.17**	laser defects excluded
30066-23	SFW989	p	B	L6.901	not avalaible yet	not avalaible yet	not avalaible yet		**1.99**	laser defects excluded
30066-23	SFW989	n	B	L6.901	not avalaible yet	not avalaible yet	not avalaible yet		**0.60**	
3078-2	SFW993	p	B	L5.903	not avalaible yet	not avalaible yet	not avalaible yet		**6.00**	scratched sensor
3078-2	SFW993	n	B	L5.903	not avalaible yet	not avalaible yet	not avalaible yet		**0.03**	
2965-12	SFW001	p	B		0.5	1.6	1.6	**2.1**	**2.21**	2 open, 3x2 shorts?
2965-12	SFW001	n	B		0.2	0	0	**0.2**	**2.15**	1x2 short?, laser
3084-15	SFW002	p	B		0	0.1	0.1	**0.1**	**0.91**	1 open new ?
3084-15	SFW002	n	B		0	0	0	**0**	**1.56**	laser
3084-20	SFW003	p	B	L5.001	0	4.8	4.8	**4.8**	**0.26**	
3084-20	SFW003	n	B	L5.001	0	0.1	0.1	**0.1**	**1.37**	noisy, laser
3084-25	SFW004	p	A		0.1	0.1	0.1	**0.2**	**0.52**	
3084-25	SFW004	n	A		0.6	0.1	0.1	**0.7**	**1.95**	

8 more SFW/SBW still to be tested/analysed

HPK small sensors

- L3 available sensors were a bit marginal
- Some additional sensors ordered (?) to HPK to have enough sensors+safety
- Several class A sensors have metal scratches (there during HPK test and seen by visual inspection recently)
- Irina will go to Melbourne to separate them in Sept.

Micron sensors

- Micron sensors tested in Vienna and Trieste
  - Trieste's sensors fully qualified and list of defects known
  - Vienna's sensors tested but the list of defects was not produced
- Detailed visual inspection done in Pisa (reception), on all Micron sensors, revealed scratches presents on most of them ~36/60 (done during test or thermal test in Vienna)
  - Additional defects introduced by scratches: pinholes (not recoverable) & shorts (can be separated)
- Scratched sensors (36!) retested in TS and shorts separated.
  - Full analysis is still to be done, but after a first look the pinholes added due to scratches are > 1% in only 2 sensors.
- Manfred V. (in contact with the sensor experts) worked hard over the summer to implement the analysis of the sensors tested in Vienna.
- Analysis is being finalized in these days and results will be available soon.

Sensors situation

Item	Installed	Spare	Class-B	HPK large class A sensors	Micron class A sensors	HPK small class A sensors
L6 ladder	16	4	2	80	20	
L5 ladder	12	3	2	45	15	
L4 ladder	10	2	2	24	12	
L3 ladder	7	2	2			18
TOT class A sensors for installed+spares				149	47	18
TOT class A sensors needed + safety				179	57	22
TOT class A sensors available				175	57	
TOT class B sensors available (after completion of class B ladders, allocated for L4 (1+1) and L6(3+1)				7	2	

- HPK sensors: can use some of the remaining class B in case we need them
- Micron sensors: after scratch/retest ~ 30 should be re-analyzed.
- After a first look only 2/57 class A Micron sensors have > 1% pinholes due to scratches