Production readiness HU & DESY-Z

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HELMHOLTZ SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN

DESY.

HUMBOLDT-UNIVERSITÄT ZU BERLIN

DESY.

Answers to specific questions 1

- At ITk we answered specific questions and would like to reiterate those (slightly expanded) here with you

- HU / DESY (Zeuthen) site performs
  - Sensor IV / reception
    - Ingo is the only one currently
  - HV tabbing
    - Martin is the only one currently
  - hybrid building (R0, R1, R3 and R5)
    - glueing: expert: Carl, non-expert Mandy, Oliver, Martin, Ingo
    - metrology: expert: Martin, non-expert: Mandy, Oliver
    - visual inspection: expert: Carl, non-expert: all others
    - bonding: expert: Martin, non-expert: Ingo
    - el QC: expert: Ben, non-expert: Ingo
  - module building (R0, R1, R3 and R5)
    - operators are the same as for hybrids

Answers to specific questions 1.1

- **Where are you in terms of the project stages (prototyping, PPA, PPB, production)?**
  a. advanced hybrid and module PPA right now
  b. missing 4 of 33 SQ qualification steps
     i. PB tests, Burn-In, Thermal Cycling, Single module electrical tests
     ii. for all of these we are either already done preparing the input and ‘just’ have to document or still wait for the first PPA module to be ready for testing
  c. PPA progress towards PPB
     i. 2 hybrids of each type built and burned-in
     ii. 1 complete set of module types is glued, currently being bonded
     iii. once tested we will discuss with AC if we need to rebuild a specific module type or proceed to PPB

Answers to specific questions 2

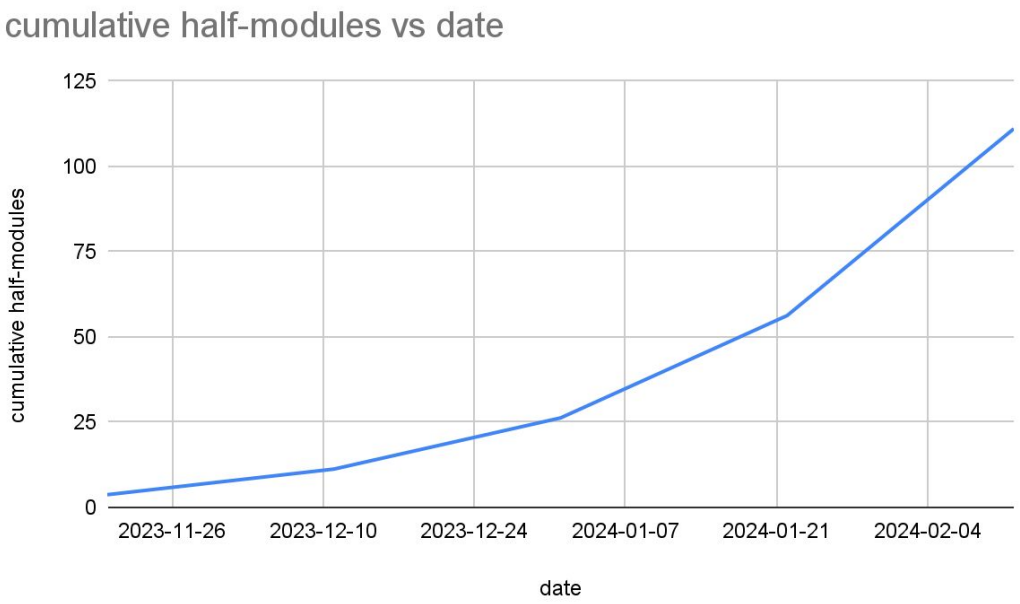
- **What, if anything, is holding up your transitions through the stages?**
  a. **large number of module and hybrid types** makes automation and optimisation rather time consuming
     i. 10 hybrid types, 6 module types
        1. for each type need tool practise, glue program, metrology program, bond program, ITSDAQ test configurations and all of their optimisations
           a. not complaining, but this explains in parts why it takes us quite long to be production ready with all automatisation steps
        2. after PPA many of these steps have to be adjusted for PPB geometry
        3. still, these automation steps are needed to hit the required throughput for production
  b. **transition from polaris to Eccobond** F112 (True Blue) took quite some adjustment time for glue robot programs and calibration adjustments
  c. **quality of tooling** (specifically R1 tools) is hindering progress
  d. **some "overall ITk items"** have been binding personnel (thus delaying progress through stages), e.g.
     i. PB tester development
     ii. Burn-In development
     iii. Building test beam modules

Answers to specific questions 3

- **What is your schedule for completing each remaining step of site qualification?**
  a. remaining steps are
    i. **build PPA modules** – first set of modules completed within 3-4 weeks
      1. expected done by CW 41 (±1 week, as there will be an extended wire bonder service inbetween)
    ii. SQ docs: write, submit, go through review
      1. 6.2 PB electrical tests (relevant Person: Ben)
        a. we have run the full tests, need to write up and submit for review
        b. expected submitted by CW 39 (±1 week as relevant person is stretched between several work items)
      2. 8.8 Hybrid burn-in (relevant Person: Ben)
        a. finished >100h burn in
        b. need to write up and submit for review
        c. expected submitted by CW 40 (±1 week as relevant person is stretched between several work items)
      3. 11.10 Module thermal cycling (relevant Person: Ingo, Carl)
        a. need a PPA module for this, but already did >10 cycles with preprod modules
        b. plus need to write up
        c. expected submitted by CW 41 (±1 week)
      4. 11.11 Single module electrical tests (relevant Person: Ingo, Carl)
        a. on same timeline as 11.10
        b. expected submitted by CW 42 (±1 week as this has to run in parallel with 11.10)

Answers to specific questions 4

- **What is your schedule for completing pre-production and being production ready?**
  a. after finalising the PPA modules we hope to proceed to PPB
     i. expect to enter PPB in CW 44 (±2 weeks, due to uncertainty e.g. from wire bonder service, potential need to build more PPA modules to be allowed to enter PPB and parts delivery)
  b. PPB duration depends dominantly on how many PPB modules will have to be built
     i. last minimum PPB module numbers we got are
        1. R0: 8 modules
        2. R1: 4 modules
        3. R3: 4 modules
        4. R5: 6 => total of 32 half modules
     ii. at full production speed this would take 2 weeks, aka done by CW 46 (not at all realistic)
     iii. assume speedup doubling build numbers every 3 weeks, starting from 1 module every 4 days
        1. => expect having finished 32 half modules by early Jan 2024



Answers to specific questions 5

- **Is there anything the project can do to support completion of site qualification and pre-production?**
  a. the ITk Strips community is providing amazing amount of help & code (as well as emotional support & friendship) so, please do not take below as criticism
  b. provide sufficient material to build modules (limited mostly by powerboards and hybrids currently)
     i. we had some slow down due to limited amount of PPA material making it necessary to be inventive with dummy material rather then going for modules right away, limiting what could be learned
  c. reduce # of DB interactions (make steps in DB less time consuming, **more central automation**, …, I know, being worked on)
  d. reduce # of QC steps (I know, being worked on)
  e. outsourcing hybrids (max. potential 25% build speed increase => 4,56 Modules per day)
  f. try to reduce time spent in meetings (Ingo's slides)

Answers to specific questions 6

- **When do you expect to be able to hit peak production rates and what is the biggest limitation for you getting there?**
  a. if all needed material available, hope to reach full production speed shortly after the end of PPB (in about Feb 2024)
  b. Production plan (and tool set) set up for even set of module types. If we have to build more of a certain module type than of other types (unbalanced production), this would likely reduce overall throughput
  c. Uncertainty as to how well the flow plan will work
     i. In PPA could not exercise final production plan/flow due to the very few PPA parts we had
     ii. hope this limitation will be lifted in PPB and we can get towards a more production like flow
  d. However production plan (for 3.65 half-modules a day) is quite detailed and uses times measured during individual steps as input for overall production time estimates
     i. according to that plan we should manage the required throughput with a bit of buffer
  e. We currently are FTE limited - mostly due to very many and rather long health or care related out-times
     i. way beyond what could have been expected/predicted
        1. unclear how situation will evolve, though currently things look up
     ii. it is unlikely that the site institutes will be able to provide step-in personnel
        1. also it takes about 3 month of training for each relevant production step before someone can take over
        2. however, Cigdem and Klaus will try to move one ATLAS-Z scientist position into an Upgrade tech. We hope this will work and we will find a qualified person.

Production procedure at site

- Procedure anchors on bonding, as bond time is time driver, glueing etc happens in shadow of bond time
  a. This is an assumption

Bonding What?				Bond-Time (minutes)		Hybrid Glueing	PB Glueing	Metrology	EI QC Test	Pull tests	Burn In	Cold Box
Hybrids	Bonder 1	Bonder 2		Bonder 1	Bonder 2	(ignore tab)	(ignore tab)	(ignore tab)				
Monday	2xR0	1xR3		60	48	2xR1, 1xR3	-	2xR0, 1xR3	2xR0, 1xR3		2xR5, 2xR1	
Tuesday	2xR1	1xR3		74	48	1xR3, 2xR5, tab	-	2xR1, 1xR3	2xR1, 1xR3		2xR0, 1xR3	
Wednesday	1xR3	2xR5, tab		48	40	1xR3, 2xR0	-	1xR3, 2xR5, tab	1xR3, 2xR5, tab		2xR1, 1xR3	
Thursday	1xR3	2xR0		48	60	2xR5, tab, 2xR1	-	1xR3, 2xR0	1xR3, 2xR0		1xR3, 2xR5	
Friday	2xR5, tab	2xR1		40	74	2xR0, 1xR3	-	2xR5, tab, 2xR1	2xR5, tab, 2xR1		1xR3, 2xR0	
Modules	Bonder 1	Bonder 2		Bonder 1	Bonder 2							
Monday	2xR0	1xR3		152	132	2xR1, 1xR3	2xR0, 1xR3	2xR5, tab, 2xR1	2xR5, 2xR1			2xR5, 2xR1
Tuesday	2xR1	1xR3		178	132	1xR3, 2xR5, tab	2xR1, 1xR3	2xR0, 1xR3	2xR0, 1xR3			2xR0, 1xR3
Wednesday	1xR3	2xR5, tab		132	198	1xR3, 2xR0	1xR3, 2xR5, tab	2xR1, 1xR3	2xR1, 1xR3			2xR1, 1xR3
Thursday	1xR3	2xR0		132	152	2xR5, tab, 2xR1	1xR3, 2xR0	1xR3, 2xR5, tab	1xR3, 2xR5			1xR3, 2xR5
Friday	2xR5, tab	2xR1		198	178	2xR0, 1xR3	2xR5, tab, 2xR1	1xR3, 2xR0	1xR3, 2xR0			1xR3, 2xR0

Backup slides

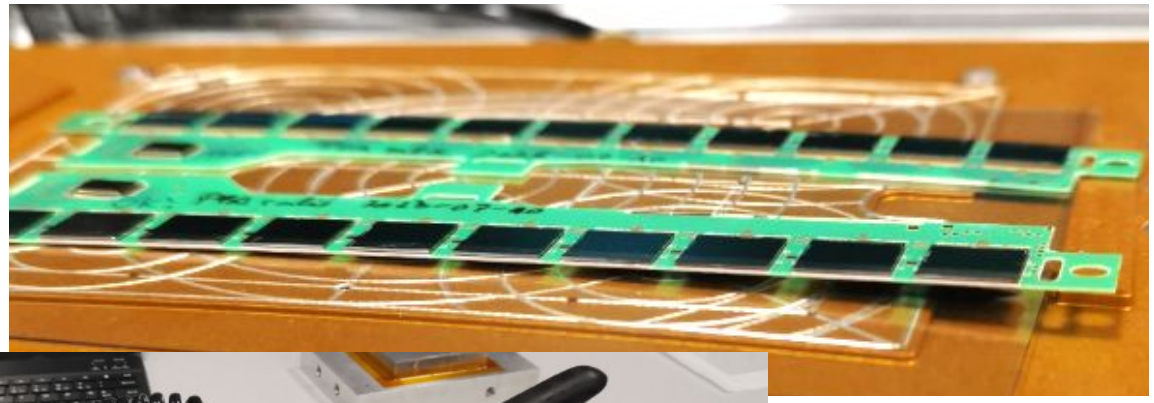
Tool “specialties”

- Specially time consuming: find out which tool works with which counterpart
  a. do they fit such that the pickup can slide into the design position at all?
  b. do they build modules that are in spec
  c. established large lookup table for all tool combinations

Hybrid / PB	PickUpTool	Hybrid.jig/PowerBoard.jig	Chiptray	StarPanel/Hybrid testing.jig	Modul.jig
R0SPB	4 7 8 10	5 6 7 / 5 6 7 / 5 6 7 / 5 6 7	/	/	1 4 9 / 1 4 9 / 1 4 9 / 1 4 9
R1H0	1 2	1 / 1	1 / 1	1 2 3 / 1 2 3	1 2 / 1 2
R1H1	1 2	1 / 1	1 / 1	1 2 3 / 1 2 3	1 2 / 1 2
R1SPB	1 2	1 2 3 / 1 2 3	/	/	1 2 / 1 2
R3H0	4 5 6	3 4 5 / 3 4 5 / 3 4 5	3 Tasche für ABC zu klein / 4 Tasche für ABC zu klein / 5 Tasche für ABC zu klein / 11 12 13 / 11 12 13 / 11 12 13		
R3H1	4 5 6	3 4 5 / 3 4 5 / 3 4 5	3 Tasche für ABC zu klein / 4 Tasche für ABC zu klein / 5 Tasche für ABC zu klein / 8 9 10 16 17 / 8 9 10 16 17 / 8 9 10 16 17		
R3H2	4 5 6	3 4 5 / 3 4 5 / 3 4 5	3 Tasche für ABC zu klein / 4 / 5 / 11 12 13 / 11 12 13 / 11 12 13		
R3H3	4 5 6	3 4 5 / 3 4 5 / 3 4 5	3 Tasche für ABC zu klein / 4 Tasche für ABC zu klein / 5 / 9 10 11 16 17 / 9 10 11 16 17 / 9 10 11 16 17		
R5H0	1 3 9	1 3 6 / 1 3 6 / 1 3 6	1 3 7 / 1 3 7 / 1 3 7		
R5H1	1 3 7	1 3 7 / 1 3 7 / 1 3 7	3 6 7 / 3 6 7 / 3 6 7		

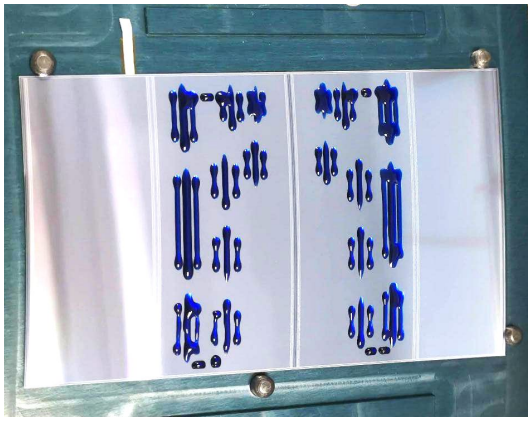
Tool “specialties”

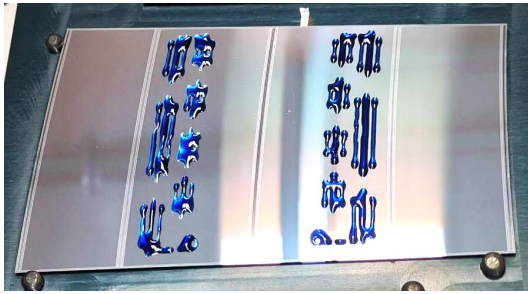
- R1 toolset not usable - even with brute force clamping only every 3rd module comes out in spec
- New tools are being produced and we await their arrival with great anticipation

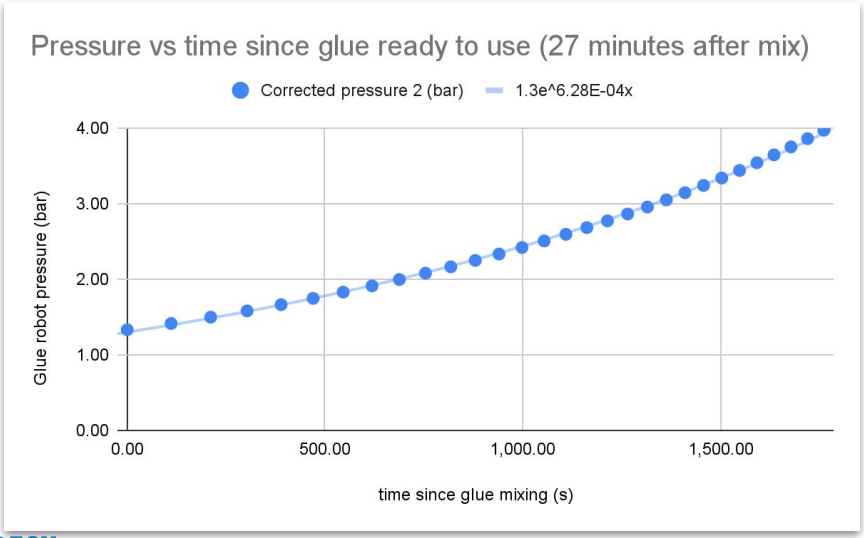


Polaris → True Blue

- Moved to True Blue
- For glue robot: needed some ‘field work’
  - “Pressure curve” to set pressure for constant volume depending on time since ready to use (starts 27 min after mixing)
    - determine time ranges (“slot”) for each pressure
    - adjusted curve used for Hamburg glue robot and iterated to work for the HU/Z setup (identical setups in principle! Have to still understand what the differences are, but likely differences in temperature between the two clean rooms)
    - good reproducibility with found curve
  - Dispensing line speeds in glue programs scaled to required True Blue dispensed mass







R0 Hybrids dispense trials (target: 230 ± 35)