

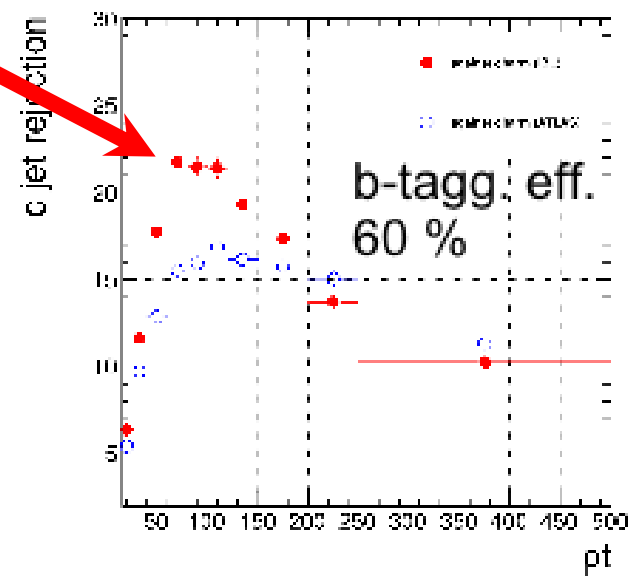
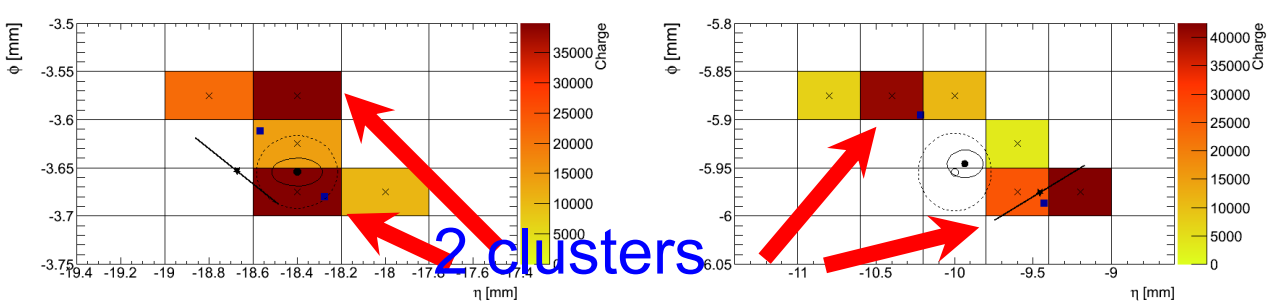
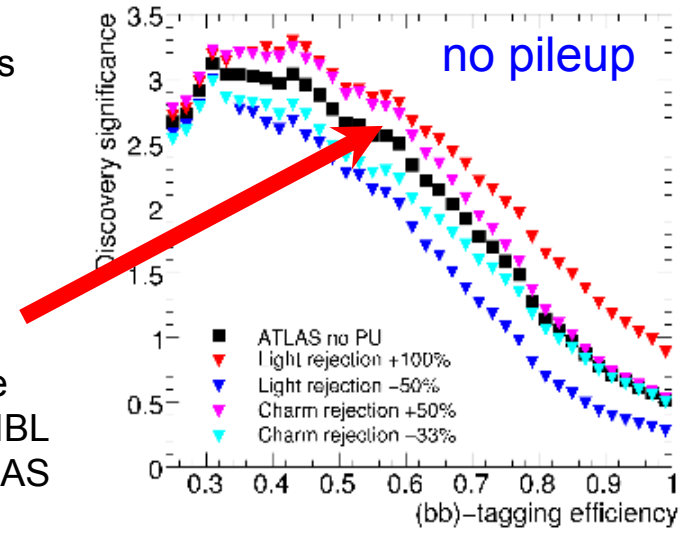
IBL TDR : Questions and Answers

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on behalf of the IBL collaboration

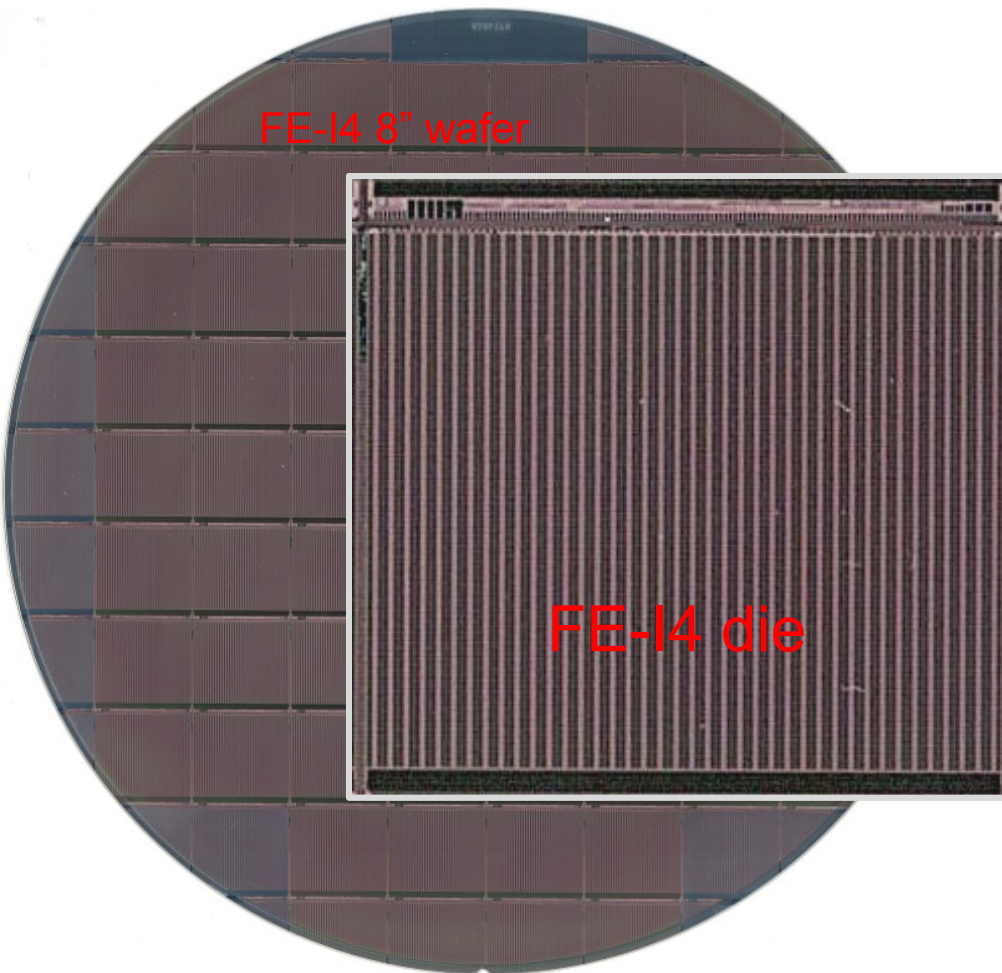
- We would like to thank the LHCC and reviewers for their time dedicated to the careful reading of the TDR.
- We give today a preliminary answer to most of the questions
- We have prepared a (nearly complete) draft document which summarizes our answers: ATU-GE-MR-0017
 - <https://edms.cern.ch/document/1105210/1>
- The answers to a few questions we have to report at a later time, as tests are ongoing now.

Analysis of $W(H \rightarrow bb)$ with IBL (Q 2-2)

- extension of IBL performance studies presented in TDR
 - ➔ control effects of $2 \cdot 10^{34} \text{cm}^{-2} \text{s}^{-1}$ pileup on all aspects of analysis
- examples:
 - ➔ jet-jet invariant mass resolution and jet veto against top
 - ✓ new pileup noise correction recovers jet energy resolution
 - ✓ so-called “Jet-Vertex-Fraction” allows to recover jet veto
- main backgrounds in WH analysis contain charm jets
 - ➔ both in top events and as well in W+jets
 - ▶ gain in charm and light rejection is important for significance
 - ➔ developed special charm tune of ATLAS “JetFitter” tagger for IBL
 - ✓ IBL improves charm rejection significantly compared to ATLAS
- cluster merging limits b-tagging in boosted $H \rightarrow bb$ jet(s)
 - ➔ problem in Pixel clustering software identified
 - ➔ Pixel Clustering Task Force in place
 - ▶ goal is to have new clustering software in place for release 17
 - ▶ in time for February reprocessing of 2010 ATLAS data
 - ▶ and will then be used for further IBL studies



FE-I4 V1 chip received (Q 3-2, Q 11-1)



FE-I4 Production

- 3 wafers received 27/9
- 7 more wafer expected by (2/12) - foundry is full: our production delayed
- 6 more held back

One wafer partially diced

- 6 chips put on boards
- All 6 worked well
- First wafer fully probed

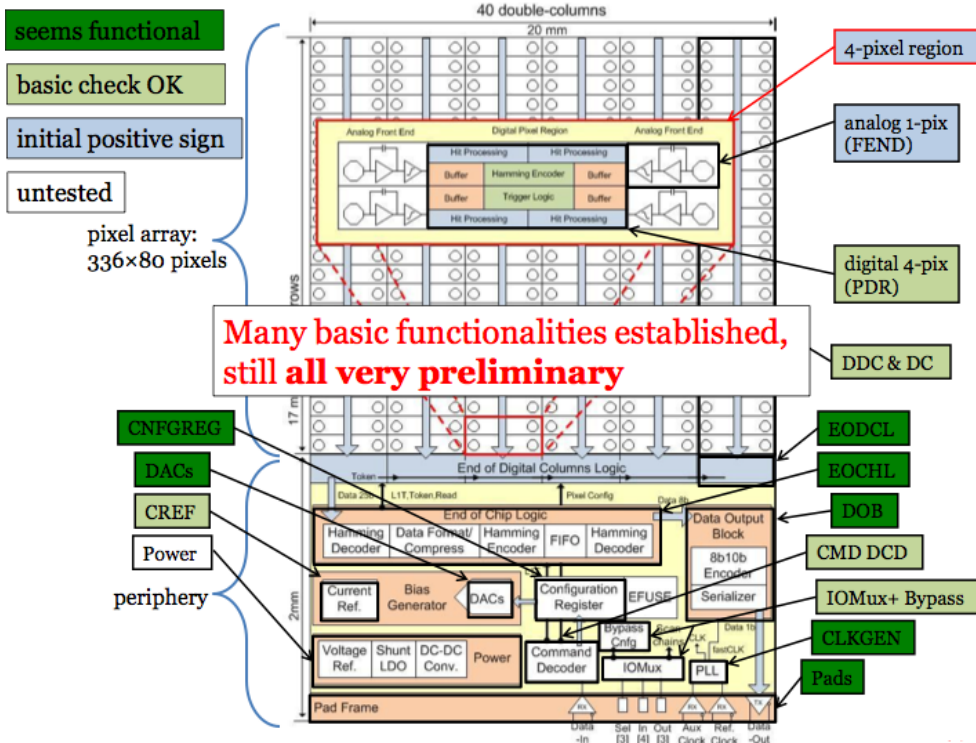
Module qualification program has started

- IZM has started with FEI4 UBM
- First sensors already processed

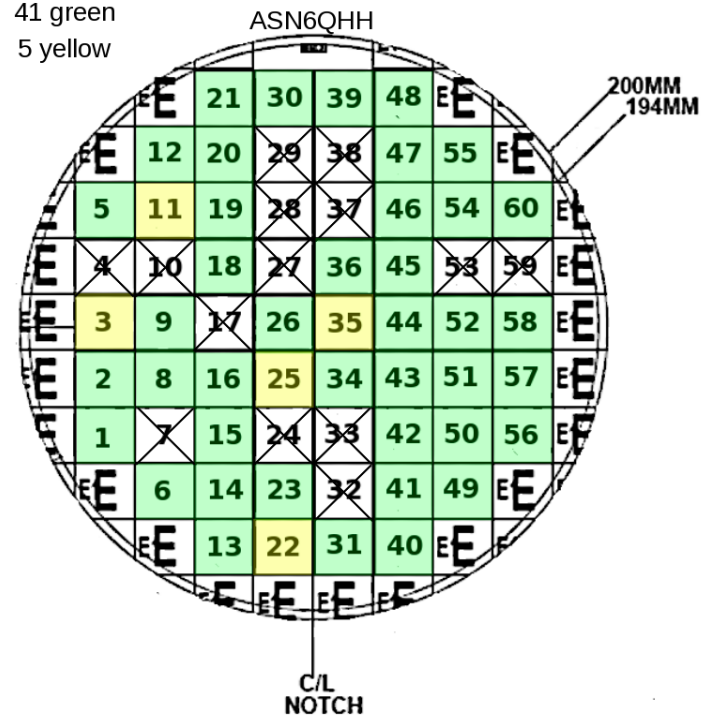
Expect V2 submission fall 2011

FEI4 Tests on-going and very encouraging

- First tests focused on digital/communication section, next on analog
- Wafer testing for first wafer completed with 41 good chips of 60 on wafer



41 green
5 yellow



- FEI4 and first Sensor Batches are at IZM for under-bump metallization and flip-chipping:
 - One wafer is IZM now for UBM and dicing
 - This wafer will remain thick
 - Goal for this wafer is to get a reasonable number modules with all three sensor technologies
 - Irradiations and test beam
- We will start to compile a list of tests that we want to have completed until next summer's sensor choice
 - Including irradiations, testbeams, lab measurements, stability measurements
 - Document production, assembly, yield, losses at different steps
- This will serve as main input to the external sensor review prior to sensor technology choice.
- With those modules we will determine FEI4 operation parameters (e.g. minimal threshold for each sensor type) and basic module performance parameters (resolution, efficiency near columns, edges, signal before and after irradiation with FEI4)
- We will compile a sensor technologies' overview table when we have the results (Q 3-14, Q 9-1)

- **Planar (Q 3-7)**

- Nov: CIS n-in-n 250 μ m conservative and slim guard ring: UBM is done, start bonding when FEI4 available in the following priority: 8 conservative SC, 8 slim SC, 1 DC conservative, 1 DC slim
- Nov/Dec: CIS n-in-n 150 μ m, UBM done now, 2 SC bonding when time available(~ Dec)
- Discuss 6 inch n-in-p offline (handling wafer question, availability)

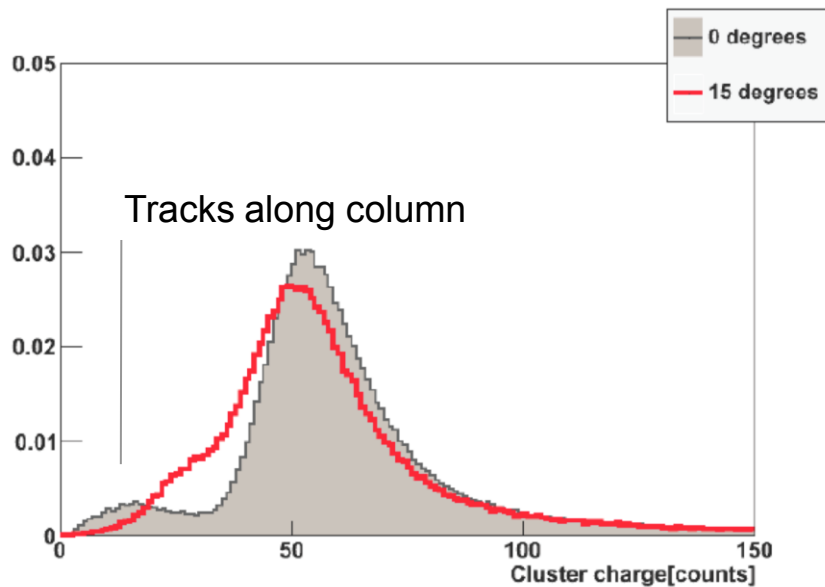
- **3D**

- 2nd half Nov/DEC: FBK ds UBM followed by 8 SC modules bonding (Dec)
- Dec: UBM for Sintef/Stanford ss and UBM for CNM ds
- Jan/Feb: bonding of 8 Stintef/Stanford ss SC mods + 8 CNM ds SC mods

- **Diamond**

- End Nov/Dec: UBM of 6 DDL SC diamonds followed by bonding of 4 DDL SC
- Dec: now prepare 4 II-VI SC diamonds (thinning) to go to Bonn & IZM

- **Q 3-3 & Q 3-4: Amplitude and efficiency on 3D**
 - Tracks directly along column show lower signal
 - TB measured efficiencies with FEI3: (a) perpendicular tracks \rightarrow efficiency $\sim 96.5\%$ ($B=1.6$ T) $\div 96.7\%$ ($B=0$) % (b) for tracks inclined by 10-15 degrees : $\sim 99.9\%$
 - Very small fraction ($<1\%$) with perpendicular tracks in η and ϕ .



Very small fraction of tracks aligned with columns
(most tracks inclined in η and/or ϕ)

- **Q 3-5: Maximum operation voltage of 1000V agreed with sensor R&D groups**
 - Compromise of signal amplitude and system design specification
 - HV components, flex, cable, connector limitation due to very tight space constraints
 - Above 1000V more power dissipation to cool and less experience with long-term reliability of planar sensor operation well above 1000V
- **Q 3-8: Change of signal amplitude with irradiation**
 - Give in figures 45, 49a, 56 of TDR; further measurements to come of sensors with FEI4
 - Expect S/S_0 at $3 \times 10^{15} \text{ n/cm}^2$:
 - Planar $\sim 55\%$ at regular thickness, $\sim 70\%$ if thin ($\sim 150\mu\text{m}$)
 - 3D silicon $\sim 75\%$
 - CVD diamond $\sim 75\%$
- **Q 3-1: 3D sensor single chip**
 - More complicated processing than planar, therefore plan on single chip modules for better sensor yield
 - In active edge 3D sensor: distance active edge to physical edge $\sim 10\text{-}15\mu\text{m}$, therefore no real penalty in single chip modules
- **Q 3-17 : Double chip modules**
 - 2 chips placed by pick & place on top of sensor, followed by re-flow
 - Present ATLAS pixel module done with 16 chips on one sensor

- Stave baseline is frozen (Q 4-1)

- Ti pipe 2mm ID, ~100 μ m wall thickness
- Coolant = CO₂

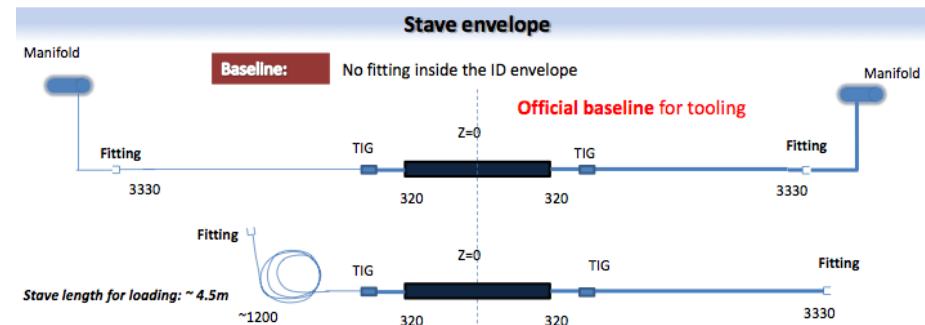
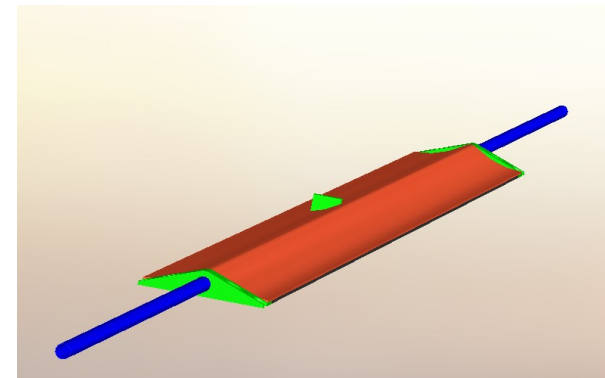
	Pixel Staves	IBL Ti-Stave
<i>Lineique weight g/mm</i>	0.067	0.037
<i>X/X0 (%)</i>	1.8	0.7
<i>Thermal perf. (°C cm²/w)</i>	19.6	10

- Plan to build 20-25 staves (Q 4-5)

- Will build 2x more modules than installed
- Enough modules for up to 28

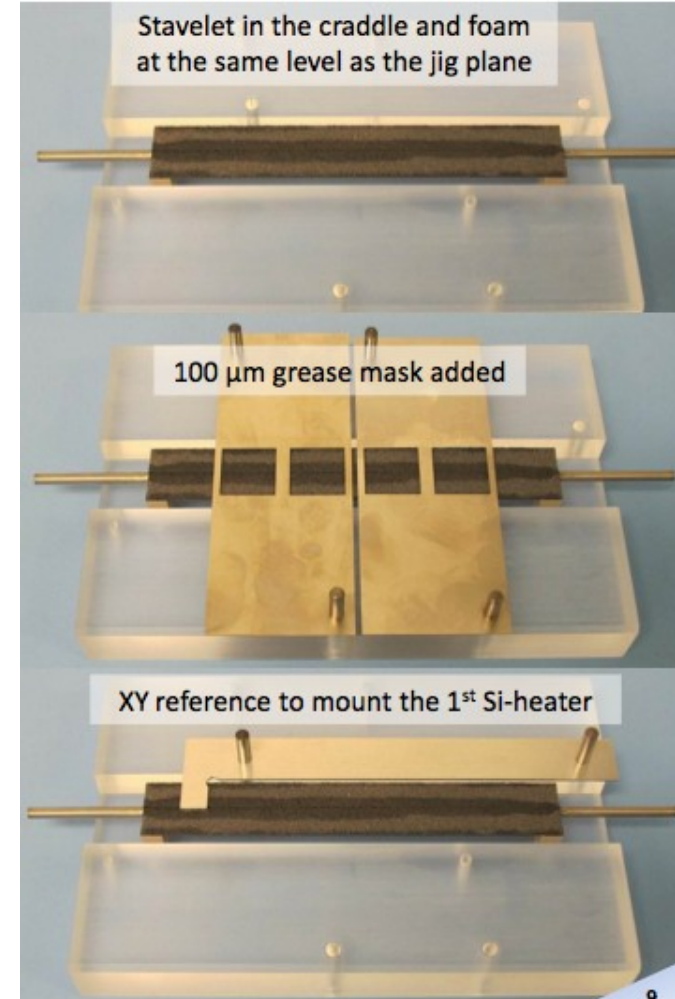
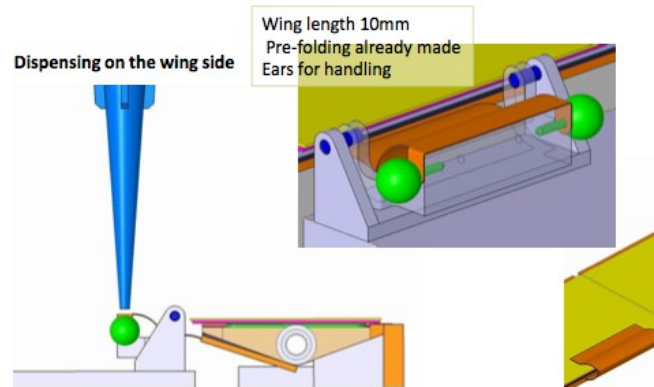
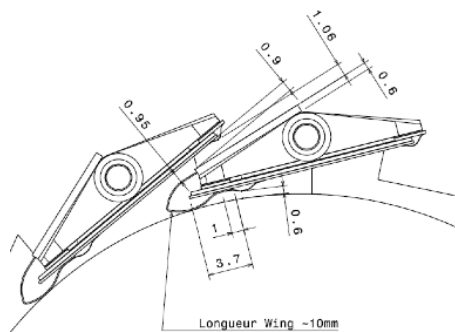
- Cooling pipe & connection (Q 4-2, Q 4-3)

- Pipe Max Design pressure 100bar, ASTM code safety factor 1.5
- All qualification of pipe/joints have been done after 150bar pressure test and passed
- Elastic limit 200bar, burst pressure 400bar
- welding and braising considered for connection to inlet and outlet



Stave loading

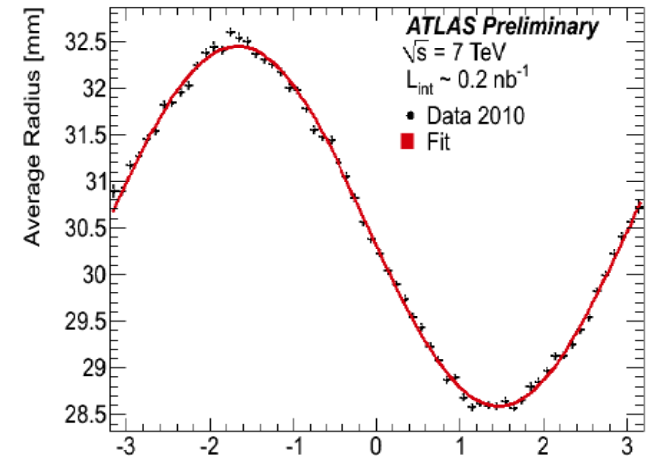
- Constructed stavelets for module loading tests and detailed procedure to attach modules and stave flex to modules (Q 4-4, Q 4-6, Q 4-7)
 - Module glued to stave but allow for removal
 - Soft glue, as used for present modules, not appropriate as glue surface 3x smaller
 - Use 2 glue dots for attachment of modules to staves and 50-100 μ m thermal grease for thermal conductivity
 - Flex wing folded on jig and glued to module flex, followed by wire bonding



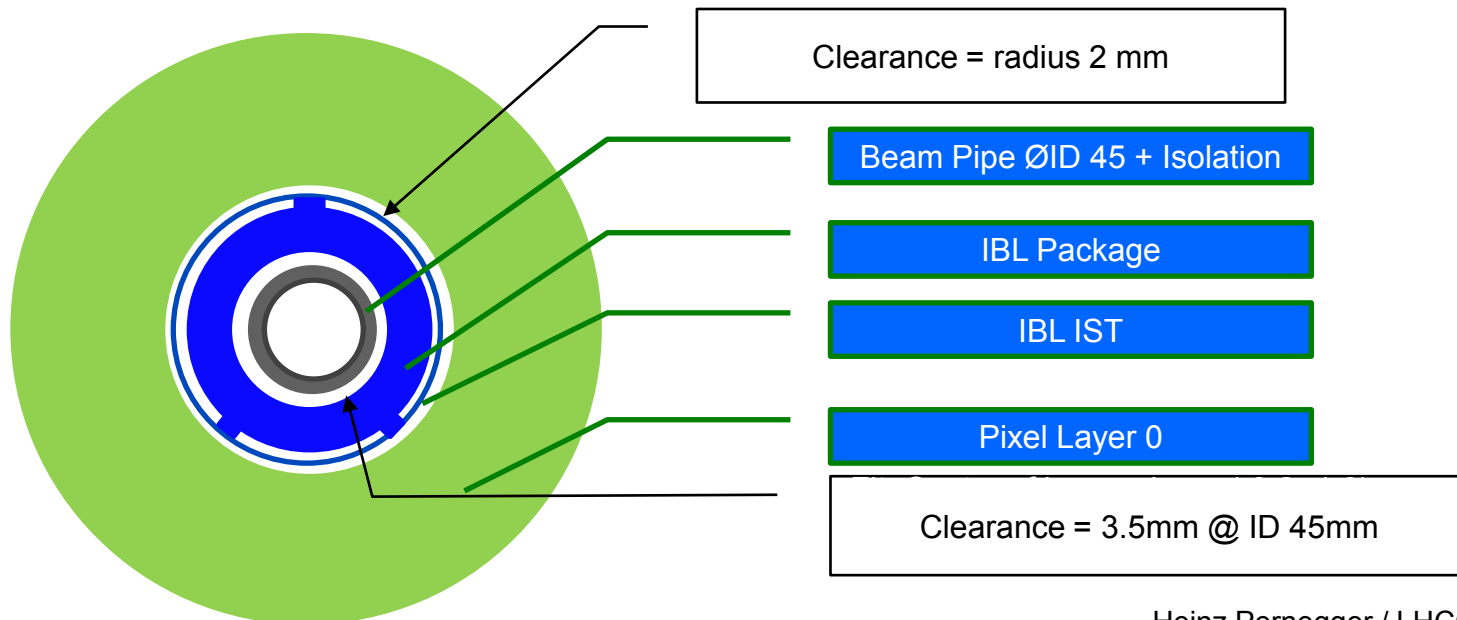
- IBL beam pipe for 2016 was discussed with LEB group and other experiments again on November 4
 - See presentations <http://indico.cern.ch/conferenceDisplay.py?confId=112547>
- ATLAS has requested beam pipe with 45mm ID (over full length)
 - Old beam pipe radius of 29mm had 15mm mechanical tolerance included to take up any misalignment of LHC vs experiment
 - alignment of experiments is much better known and beam well centered, which allows to reduce this number significantly
 - Cavern floor moves less than expected
- With the TDR layout of IBL detector this will increase envelop clearance between beam pipe and IBL module sensor envelope from 1mm to 3.5mm
- We assume that ATLAS and CMS will go for same diameter and, following current spare beam pipe policy, that a center BP is available as spare in the future
- LEB is studying this request currently
 - Aim at “go-ahead” this year so that IBL Beam pipe can be available as ATLAS spare from the shutdown 2012 onwards
 - Present beam pipe alignment will be measured again in this shutdown

Beam pipe and clearances

- **Layout :**
 - Beam pipe \varnothing 45 ID (ID50mm is max. possible for IBL)
 - IBL with 14 staves
 - IST \varnothing : 85mm ID - 87mm OD
- The ATLAS beam pipe was mechanical inserted at -1.5 mm in Y and at 0 in X
 - to anticipate possible cavern movements, which are smaller than expected
- The beam spot analysis tell us that the precision of this operation was at least 0.5mm
- Adjustment, if necessary is done by adjusting calorimeters

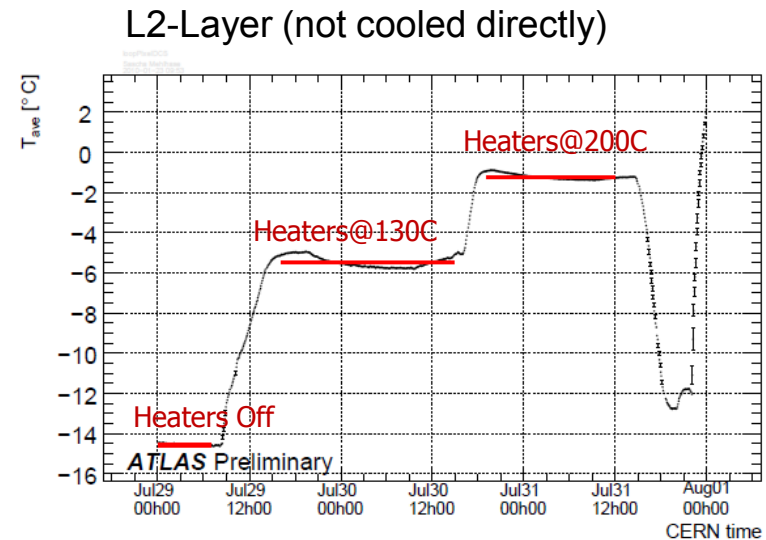
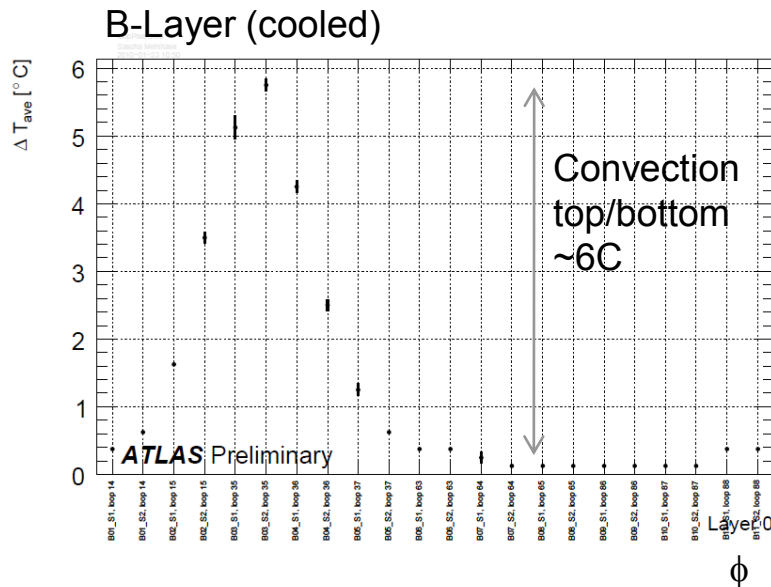


Fit: Center of beam pipe $\sim (-0.2, -1.9)^\phi$



Beam pipe bake-out (Q 10-1, Q 10-2)

- Bake out of present beam pipe with Pixel
- Stave and modules at low temperature during all times
 - See note in additional documentation



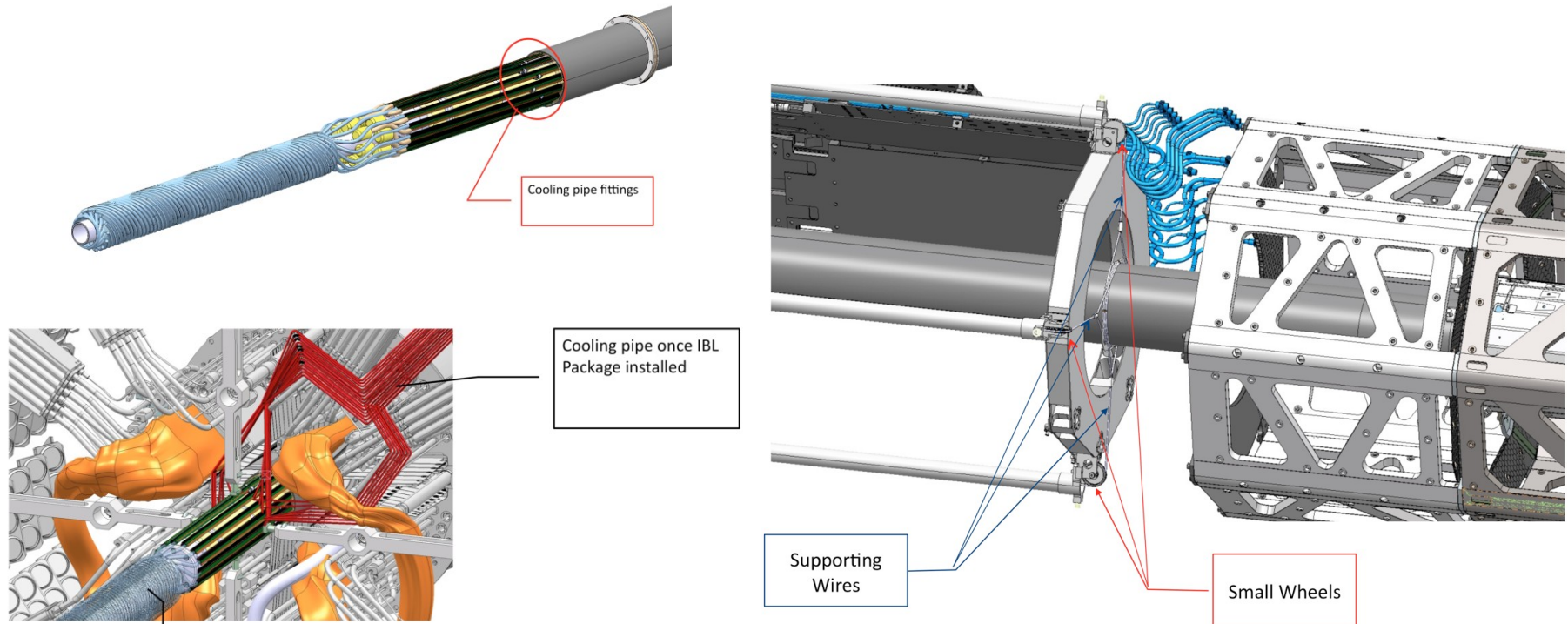
- Precautions for IBL cooling plant interrupt:
 - Interlock to beam pipe heater system
 - In case of cooling plant failure, the system turns automatically to “blow-off” CO2 system to maintain cooling of modules (see document for details)

Tests: currently build test mockup to verify FEA simulation

- Beam pipe includes thermal insulation foam (currently 3mm), which could be increase in thickness

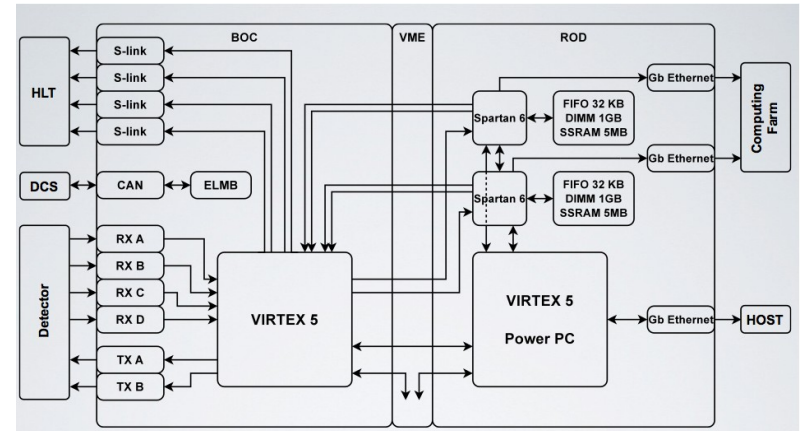
Installation (Q 7-1, Q 7-2, Q 7-3)

- Procedure of Beam pipe extraction and IST installation: Main risks associated with (a) Touching the B-Layer -> damage on B-Layer and (b) Loss of support wire
- Exercise extensively on IBL 1:1 mockup in Bat 180
- IST supported on 4 points, with 2 close to middle, sagging in middle < 0.3mm from FEA



Services wrapped for the insertion of the IBL Package inside the IST

- **Q 6-1:** rack and service space requirements are with ATLAS TC. Empty racks are identified and service routing on-going -> no show-stopper
- **Q 6-2 :** The IBL ROD could be used for Pixel and could provide some advantages in monitoring, calibration and synchronization. However the costs for upgrading the Pixel system are significant.
- **Q 6-3 :** Opto-links improvements: Consider to use commercial VCSEL packages on BOC for TX links to detector. Up-sending VCSELs are located out side pixel package in an accessible place. Furthermore consider an opto-redundancy scheme (some prototyping started)



- Former TX Plugins have serious lifetime issues
- An optical component including laser and driver can be bought off the shelf
 - ➔ Reliability known and exchange in case of failure possible
- Unclear whether power can be regulated
- Codec (BPM) and Timing functions have been embedded into FPGA firmware and deliver a working replacement



- FEI4 chip received and first tests look very promising
- Several prototype sensors available in different technologies already
- Established work program with IZM for bump-bonding to give us planar, 3D and diamond modules. First modules expected just before christmas, which will be evaluated before sensor review in summer
- IBL beam request has been transmitted to LEB (45mm ID). We hope to get positive feedback this year still to launch fabrication soon
- We hope that we could answer most questions, much further detail is available in the draft EDMS document ATU-GE-MR-0017, which we hope to complete soon.
- We would like to thank LHCC and reviewers.