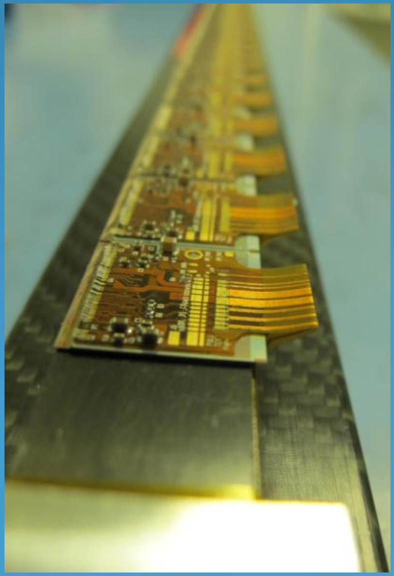
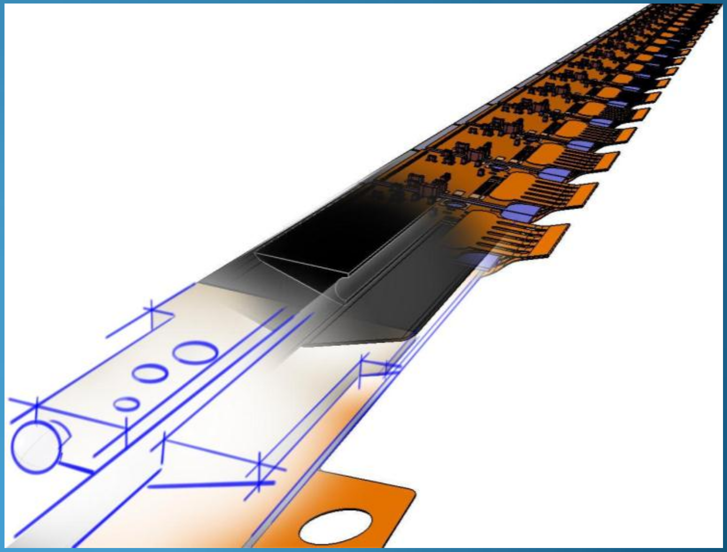
Experience from ATLAS IBL

Eric Vigeolas, July the 3rd 2012





Status

- The IBL detector construction already started and the components assembly (flex, modules, stave loagin) will start in Sept, Oct this year
- Due to fast track schedule initiated one and half year ago the production and qualification have been pursue in parallel
- The first demonstrator stave (“stave 0”) have been assembled and stave commissioning is on going
- Stave review (PRR) is scheduled July the 10th

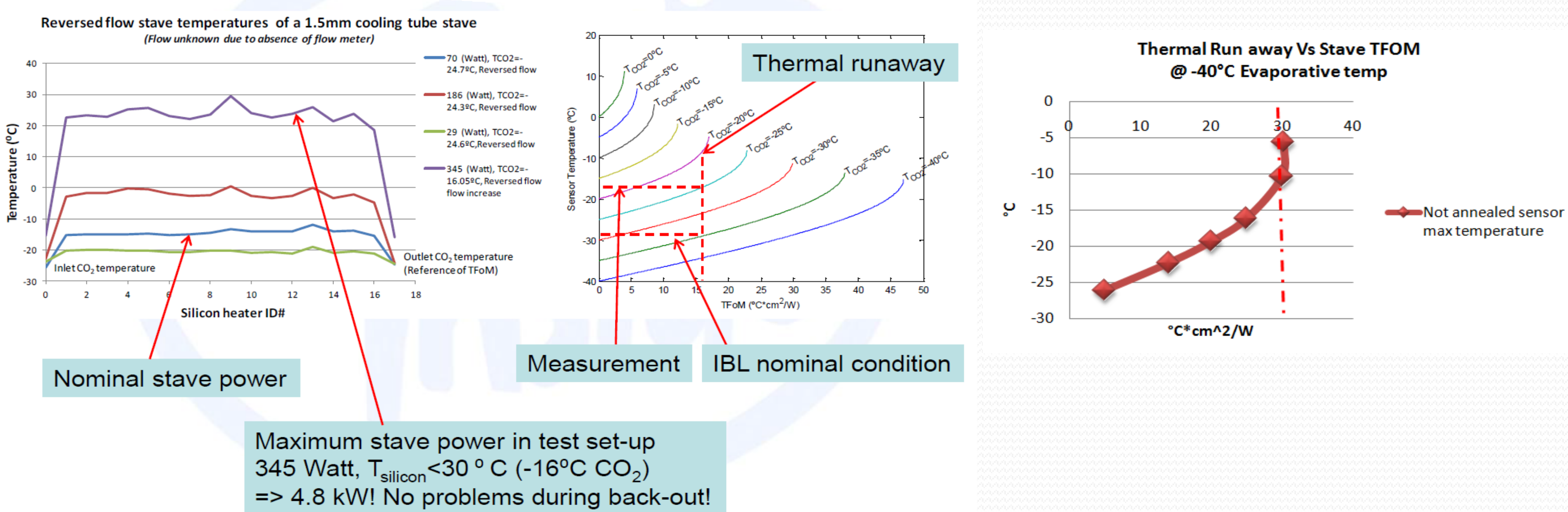
IBL Local supports requirements

- The most important requirements which has been set for IBL detector are:
  - The material reduction → IBL bare stave weight = 26 grams, Pixel bare stave weight = 45 grams
  - The operating module temperature → Pixel module are between 0°C to -7°C, IBL modules will be bellow -15°C
  - The radiation conditions are 3 times higher on IBL than Pixel
  - Stave deformations (Thermo-mechanical, gravity sag ...) have been relaxed to 150 μm compare to 30 μm for pixel detector
  - CO_2 cooling have been chosen instead of C_3f_8 → high pressure resistance cooling lines (150 Bars)
- Compare to Pixel detector important progress have been done in most of performances parameters

Item	Requirement
Normal Operating Thermal Conditions at Full Power	
Max thermal figure of merit Γ over the full lenght	≤ 30 K·cm^2/W
Operational temperature range	-40 °C to $+60$ °C
Storage and/or non operational temperature range	-60 °C to $+80$ °C
Normal operating pressure conditions	
Nominal operational pressure	10.0 bara
Max design pressure	100.0 bara
Structural safety factor for composite pipe	$SF \geq 4$
Structural safety factor for metal pipe	$SF \geq 2$
Radiation Conditions	
Total integrated dose	350 MRad
Material Budget	
Radiation length of the mechanics (active region) - goal	$\leq 0.7\%\ X_0$
Miscellaneous Conditions	
Dynamic stability as supported -goal	≥ 100 Hz
Conducting particles from carbon or other materials	Not allowed
Corrosion from all sources	Prevent
Erosion from fluid flow	Prevent
Surface characteristics	Compatible with module
Maximum leak rate of boiling channel	10^{-7} atm · cc/s of He
Maximum leak rate of each connection	10^{-5} atm · cc/s of He
Envelopes and tolerances	
Max deviation from nominal shape	0.25 mm
Module interface planarity	0.05 mm
Stave Stability Tolerances	
Max displacement during cool-down	0.15 mm

Thermal performances

- IBL thermal performances are driven by the impact of radiations on planar sensors (“Thermal run away”)
- Performances are evaluated looking to the “Thermal Figure Of Merit” (TFOM) of the local supports
- Long term testing was performed (thermo cycling, pressure cycling, combine temperature and pressure cycles) → Stave performances remain unchanged (> 400 cycles done)

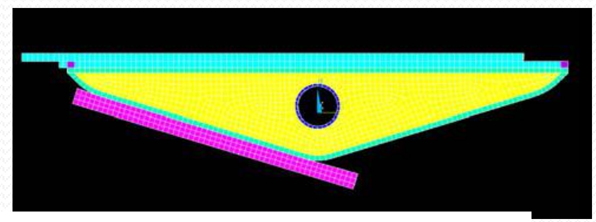


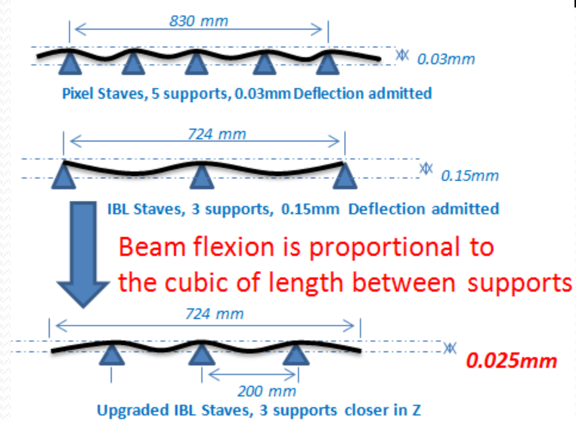
Thermo mechanical performances

- The Stave deformation depend on many factors:
  - CTE mismatch between parts composing the stave assembly
  - Stave material mechanical properties
  - The stave assembly scheme (how many fixation points and cinematic..)
- IBL stave was designed to minimize the CTE mismatch → Except the type o flex circuit which impact the stave deformation and stress → Services integration need to be studied early in the design
- The staves fixations points are from the theatrical point of view more important that the material properties → Detector integration with support tubes or global structures needs to be carefully studied

Istituto Nazionale di Fisica Nucleare
Sezione di Milano
Via Celoria 16 - 20133 MILANO

INFN	FE ANALYSIS OF THE IBL STAVE DEFORMATIONS RESULTS SUMMARY TABLE			Prepared: Mauro Monti Checked: Simone Coelli	Date: 17/10/2011
	BOUNDARY CONDITION A SIMPLY SUPPORTED AT THE ENDS WITHOUT MIDDLE SUPPORT			BOUNDARY CONDITION B SIMPLY SUPPORTED AT THE ENDS WITH MIDDLE SUPPORT	
	IBL STAVE LAYOUT 1 WITHOUT MODULES	IBL STAVE LAYOUT 2.1 WITH MODULES FULLY BONDED	IBL STAVE LAYOUT 2.2 MODULES GLUED ON THE CORNERS	IBL STAVE LAYOUT 1 WITHOUT MODULES	IBL STAVE LAYOUT 2.2 MODULES GLUED ON THE CORNERS
STATIC STRUCTURAL	MAX DEFORMATION UZ (BOW) [µm]			DEFORMATION (BOW) [µm]	
GRAVITY	123	172	198	7	12
THERMO-MEHCANICAL $\Delta T = -60°C$	749	252	618	159	131
GRAVITY + $\Delta T = -60°C$	873	N.E.	N.E	N.E	N.E
MODAL	1ST FREQUENCY [Hz]			1ST FREQUENCY [Hz]	
	51	43	40	174	138





Lessons from IBL construction

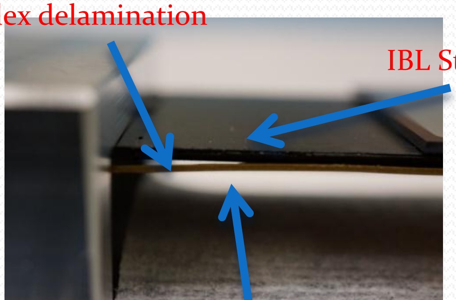
- The small number of staves inside IBL (14 parts) permit us to produce more than twice the amount without impacting the cost → luxury situation but mandatory when the schedule is tight
- Early decision was taken to produce large number of prototypes (11 parts made up to now) in nominal conditions (tools and process) to evaluate the quality and uniformity → This is very important and useful to not restrict prototyping to one or two staves
- Stave 0 program was one of the most instructive prototypes while all the assembly steps have been tested. We have in hand a fully functional stave which will suffer stress tests to evaluate the design stiffness

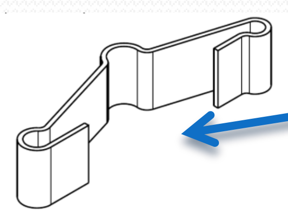
Lessons from IBL construction

- Flex delamination @ Ends Of Staves → This is a lesson we should have learnt from Pixel
- EOS are areas where stress are concentrate especially handling stress→ Designing glue less structures should consider this point

Flex delamination

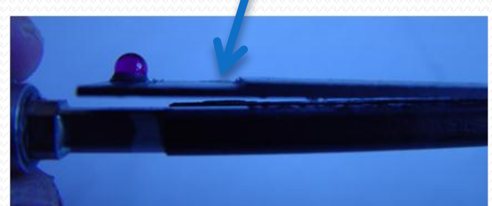
IBL Stave

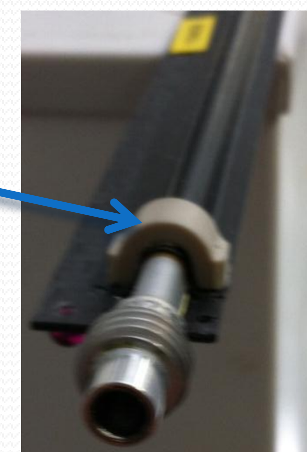




Carbon Clip will be added at the Stave ends to clamp the flex on the stave. Glue deposition has been improved for better contact surface

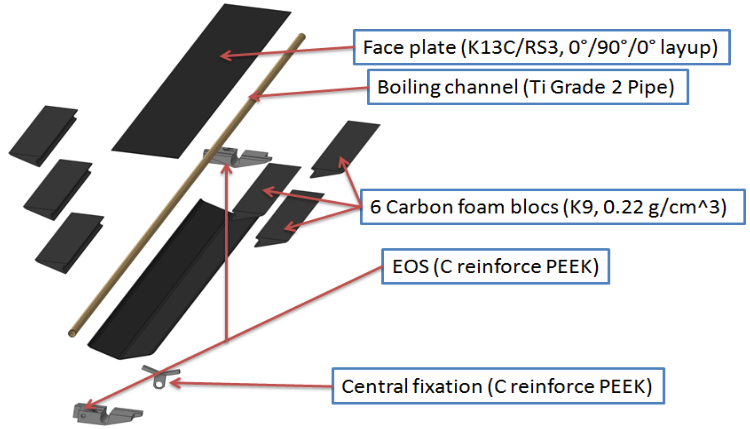
Pixel Omega delamination @ EOS
Peek reinforcement bloc have been added which solved the problem

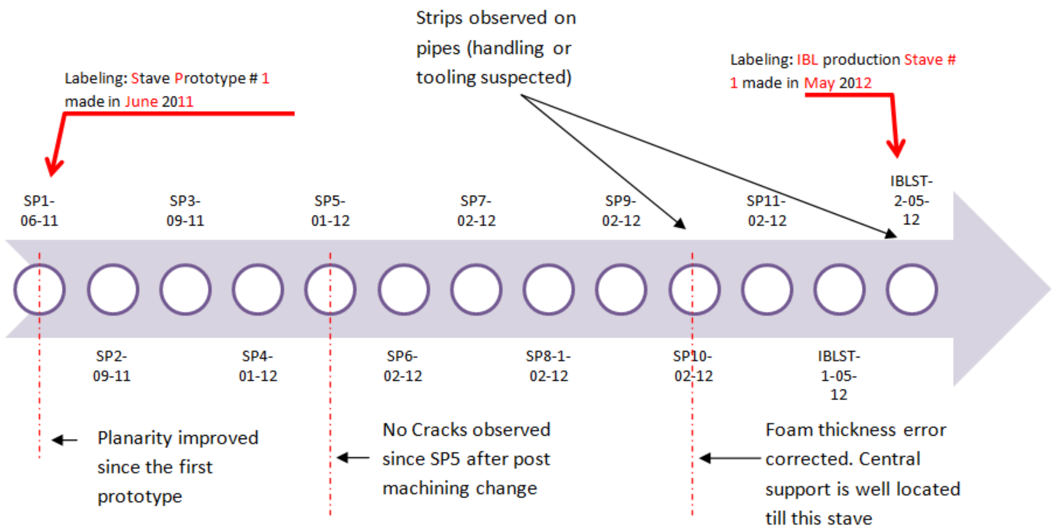


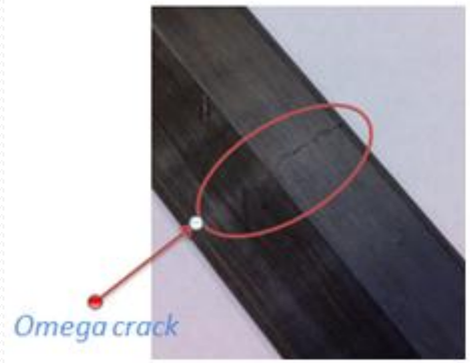


Lessons from IBL construction

- 11 prototypes manufacturing permit us to identify early some problems in the tasks sequence and improvements were applied
- An IBL stave is an assembly of 12 parts in a 13 steps process → We keep improving this process



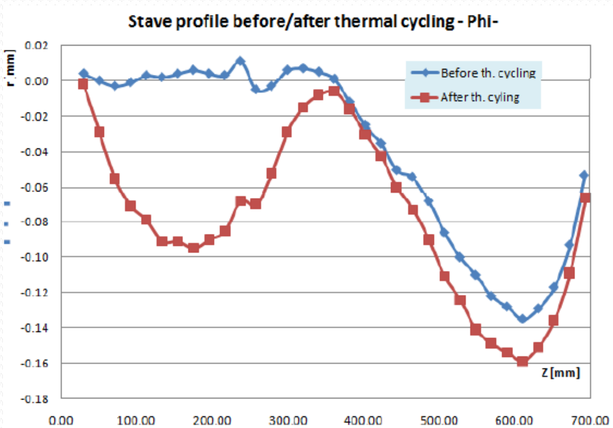




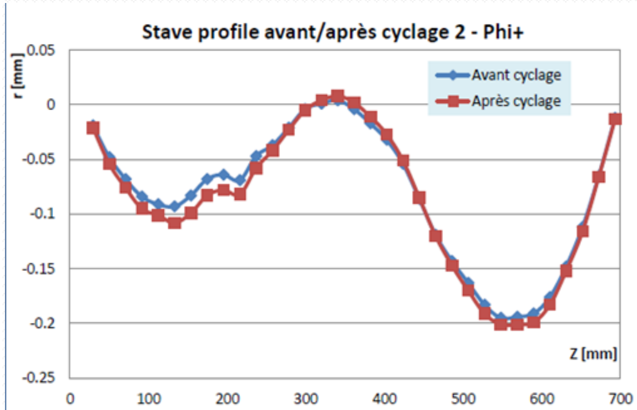
Remaining problems under improvement

- Thermal chocks and Cycles was applied on Pixel detector and reveal most of the problems (wire bond potting detachment, omega delamination …)
- IBL stave thermal cycles are part of the QA and module metrological survey is done before and after cycles (which was not done on Pixel) → UniGe observed an asymmetric deformation of the stave without modules and with modules
- The stave/Jig/Flex CTE mismatch is suspected(even if srews are relaxed during cycles)
- The Glue Glass transition temperature is also suspected → A post curing step of the bare stave have been added in the taks sequence → Detail stave relaxing procedure and Metrology process are under improvement

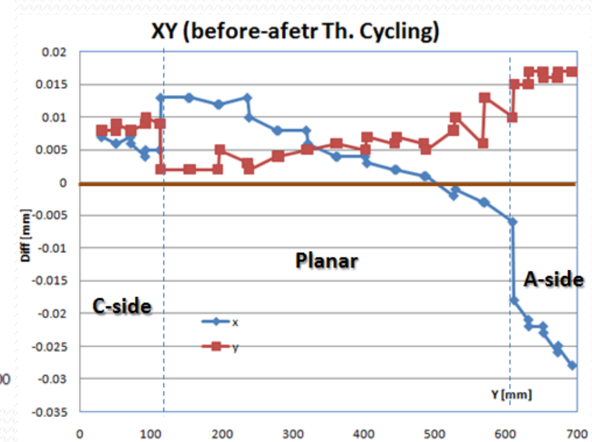
Stave0 unloaded - Profile before and after 1st th. cycling



Stave0 unloaded - Profile before and after 2nd th. cycling



Loaded stave0 - Metrology results before and after thermal cycling



IBL design, any improvements?

- One of the major change between Pixel and IBL detector is the use of micro-cable for pixel and Flex circuits for IBL
- The flex is glued directly on the stave and impact the flexibility of the assembly → while on Pixel cable were floating along the stave and glued only bellow the connector on the module side
- A lot of design changes was driven by our past experience on Pixel and aimed to improve the reliability
- IBL will be the good proof of reliability improvement with flex circuits → too early to reply
- The global electrical chain will provide important informations on type one services management
- Local support should integrate early the services and more embedded design should be preferred

Conclusion

- We are a the beginning of the story, a lot will be discovered and corrected
- Many tasks remain to be tested :
  - PPo brazing
  - Stave integration around the beam pipe
  - Stave long term testing and burn in
  - Detector insertion inside IST
  - …
- IBL is a good improvement of the pixel staves