UniCal* & INFN-Gruppo Collegato di Cosenza

Atlas ITk Italia, 8-9 febbraio 2017

Mechanics and Cooling

Manpower 2017

- Carmine Maletta, ricercatore universitario
- Marco Alfano, ricercatore universitario
- Luigi Bruno, professore associato

+ supporto tecnico laboratorio.

Possibile coinvolgimento parziale nel progetto dei dottorandi e assegnisti (4 in totale) del gruppo.

* Dipartimento di Ingegneria Meccanica, Energetica e Gestionale

Attività prevista per il 2017

In corso collaborazione con la sezione di Milano (contatto con Danilo Giugni al Cern) per attività di caratterizzazione meccanica dei materiali, in particolare misure di costanti elastiche e coefficienti di dilatazione termica.

Prove di caratterizzazione effettuate nei laboratori dell'Unical.

Interesse nella partecipazione alla eventuale attività di costruzione ma necessario valutare attentamente se perseguibile in base alle **competenze e infrastrutture richieste** e al manpower disponibile.

Machine shop/rapid prototyping laboratory

Equipped with systems for milling/turning and for additive manufacturing

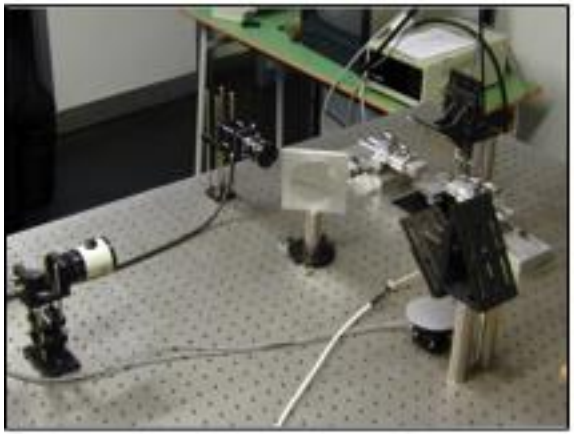
- ✓Mazak Nexus 410 CNC 4 axis vertical machining centre
- ✓Mazak Integrex milling/turning centre
- ✓Mazak 5 axis machining centre
- ✓EOS EOSINT M280 – Additive manufacturing of metals.
- ✓EOS EOSINT P800 - Additive manufacturing of polymers.
- ✓AEG Elotherm electro discharge machining centre
- ✓Coord 3D Universal CMM system

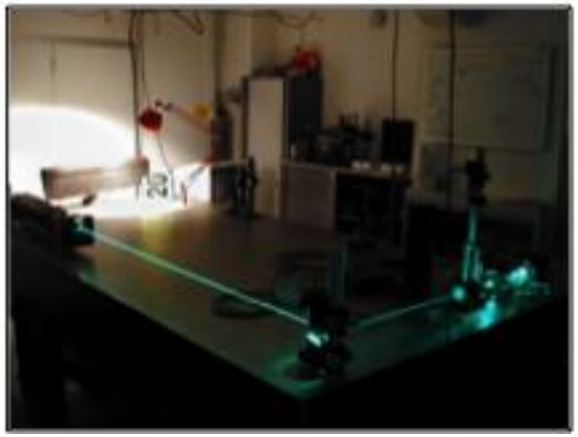
Experimental mechanics laboratory

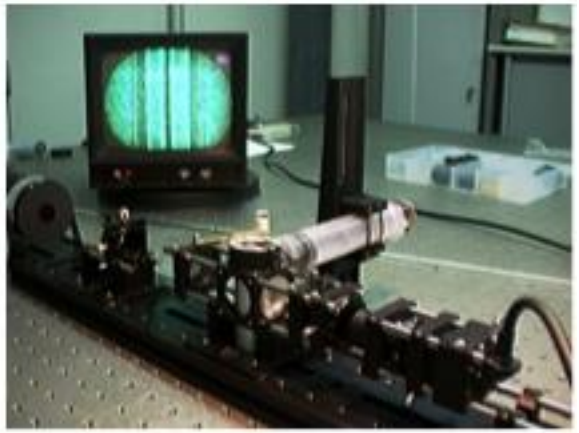
Equipped with optical systems for interferometric applications

Testing equipments

- ✓ Optical anti-vibrating benches
- ✓ Laser *COHERENT VERDI 2W*
- ✓ Laser *COHERENT INNOVA 90 2W*
- ✓ *He-Ne* lasers

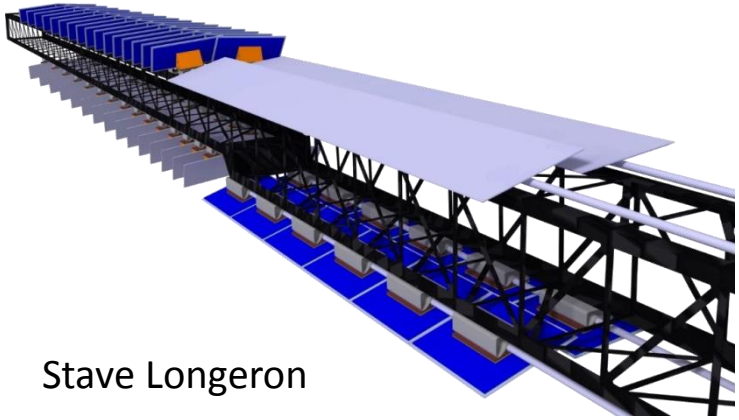






INFN-Sezione di Milano

ACTIVITIES IN PROGRESS IN THE FOR THE ATLAS UPGRADE/ITK



Stave Longeron

SLIM Local Support for
Inclined Layout

1. SLIM Longeron prototype: manufacturing of aluminum moulding
2. Thermal figure of merit: thermal radiation effect FEA studies
3. Thermo-mechanical FEA: evaluation of the stress in the cell critical interfaces
4. Thermal performance deterioration: measurement and qualification of the cell solder/tim interfaces before and after cooling/pressure cycles
5. CO_2 test of cooling circuit critical components with 2PACL TRACI unit

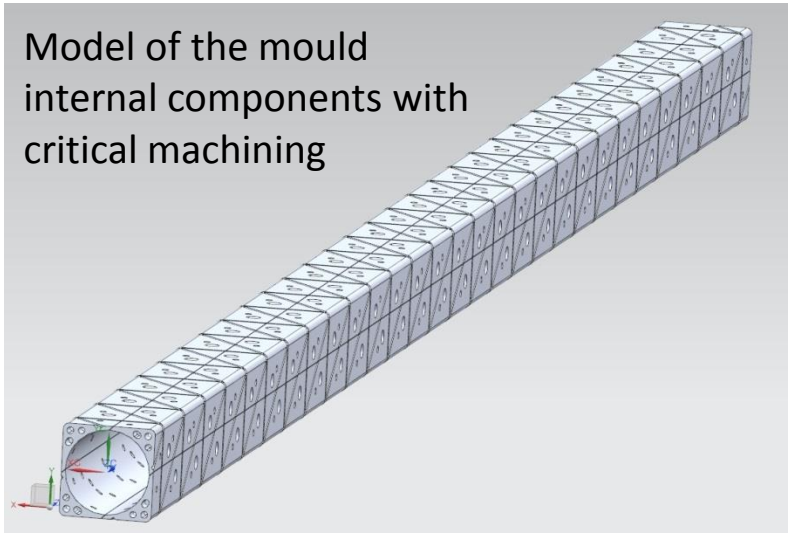
Simone Coelli – Milano ATLAS Group
INFN – Sezione di Milano

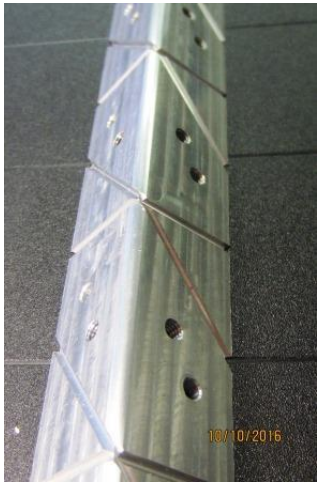
SLIM LONGERON PROTOTYPE PRODUCTION: MANUFACTURING OF ALUMINUM MOULDS

Structure aluminum moulds for:

- Test prototypes
- Full length components

For the production of the carbon fiber Longeron



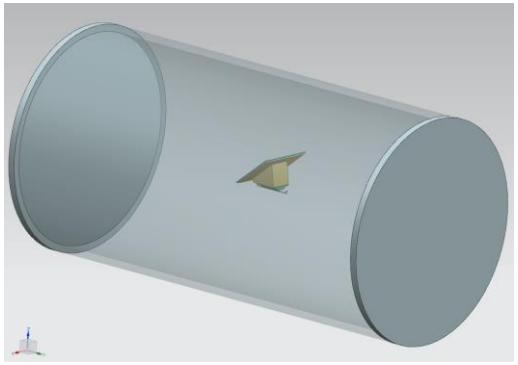


Al mould short prototype (200 mm) produced in Milano mechanical workshop and sent to cern to test the de-moulding properties

Examples of carbon fiber longeron structures under test

FEA STUDY: EFFECT OF THE THERMAL RADIATION ON THE THERMAL FIGURE OF MERIT

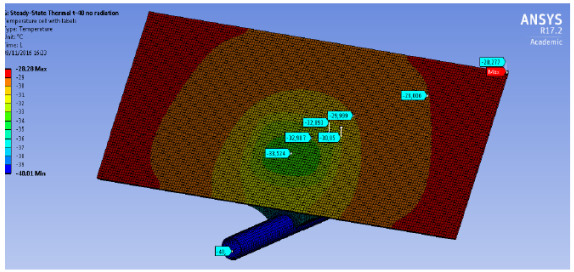
Thermal radiation effect model: cell in a closed cylinder envelope to simulate the energy exchange with the surrounding environment due to the infrared radiation.



Emissivity cases studied

- Ɛ = 1 (black body)
- Ɛ = 0.5 (gray body)

STEADY STATE SIMULATION OF THE TILTED CELL V2 WITHOUT RADIATION EFFECT
ONLY CONDUCTIVE TFOM CALCULATED WITH T_{PIPE} = - 40 °C



INITIAL TEMPERATURE: +20 °C

PIPE TEMPERATURE: -40 °C

MAX TEMPERATURE: -28.28 °C

MAX ΔT: 11.72 °C

CONDUCTIVE TFOM
TFM_K = 16,74 °C cm² W⁻¹

BARREL CELL V4 - THERMAL FEA RESULTS

INPUT			OUTPUT		
HEAT FLUX [W cm^{-2}]	PIPE TEMPERATURE [°C]	RADIATION EMISSIVITY	MAX TEMPERATURE (SENSOR) [°C]	MAX ΔT (CELL) [°C]	TFM [°C cm^2 W^{-1}]
0,7	-20	0	-10,94	9,06	12,94
		0,5	-10,67	9,33	13,33
		1	-10,40	9,60	13,71
	-40	0	-30,94	9,06	12,94
		0,5	-30,54	9,46	13,51
		1	-30,14	9,86	14,09

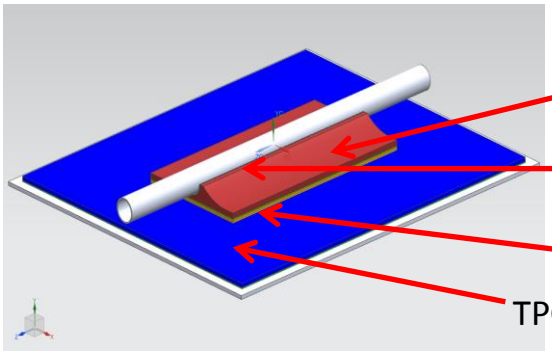
THERMO-MECHANICAL FEA: EVALUATION OF THE STRESS IN THE CELL CRITICAL INTERFACES

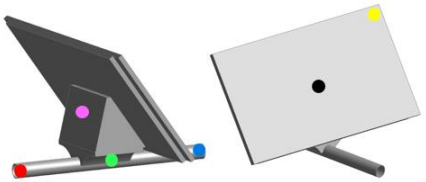
Slim cell critical interfaces:

- Soldering (brazing) between pipe and cooling block
- Phase-change-thermal interface-material

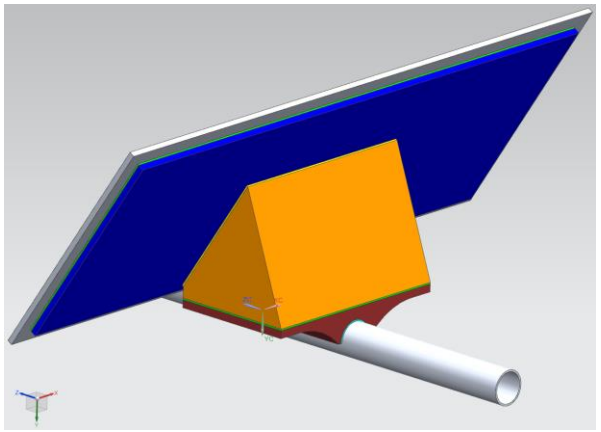
Material CTE and Young modules under investigation – use of advanced materials (all data not available)
FEA calculation of the stress in the interfaces

BARREL CELL

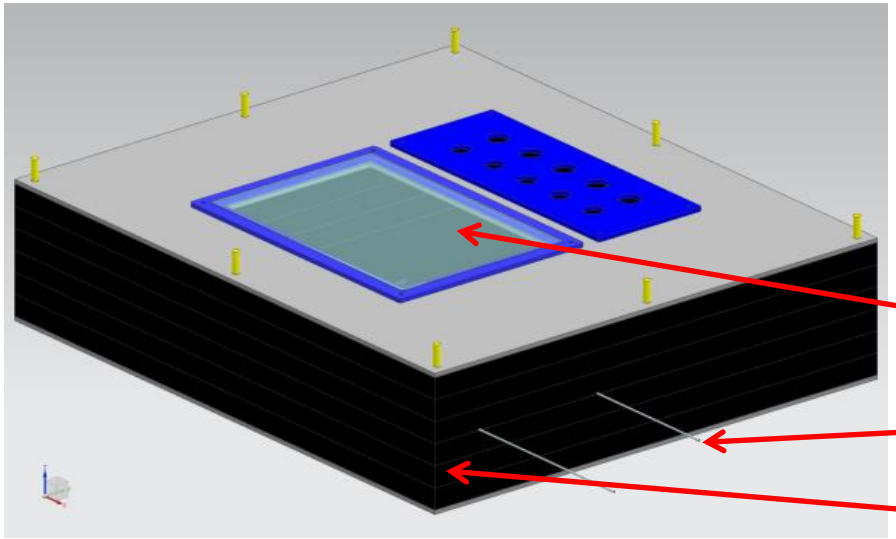




TILTED CELL



THERMAL PERFORMANCE DETERIORATION: MEASUREMENT AND QUALIFICATION OF THE CELL SOLDER/TIM INTERFACES BEFORE AND AFTER COOLING/PRESSURE CYCLES



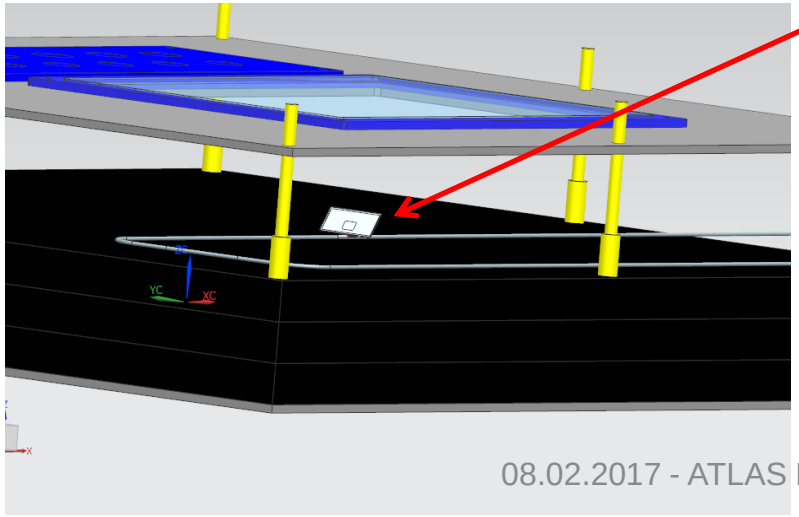
Dedicated cold box

- Design completed
- Construction work in progress
- Temperature probes attached to the system under test

DRY-AIR FLUXED CHAMBER WITH INTERNAL DEW POINT MEASUREMENT

CO_2 COOLING SUPPLY FROM 2PACL TRACI COOLING UNIT

ARMAFLEX INSULATION



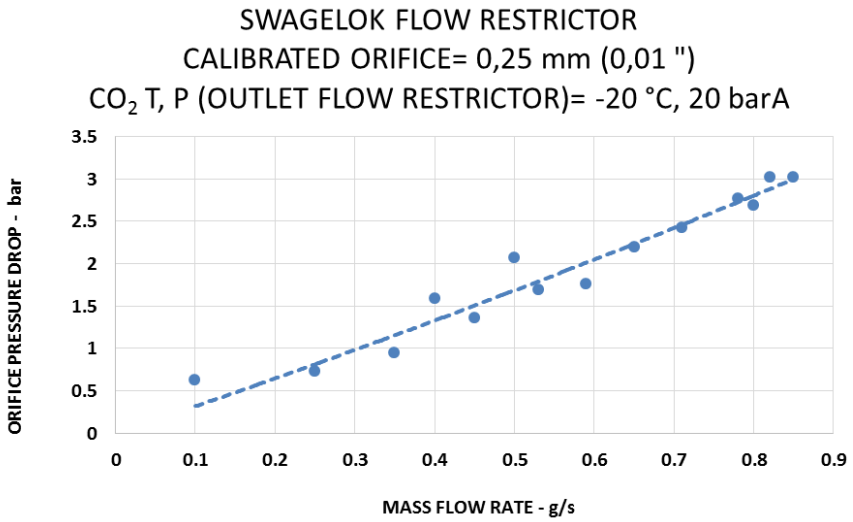
SLIM BARREL/TILTED CELL UNDER TEST

Pre-qualification using a dummy prototype (Power supply for heater dummy load)

Cooling the cell using the CO_2 supply from the TRACI Unit

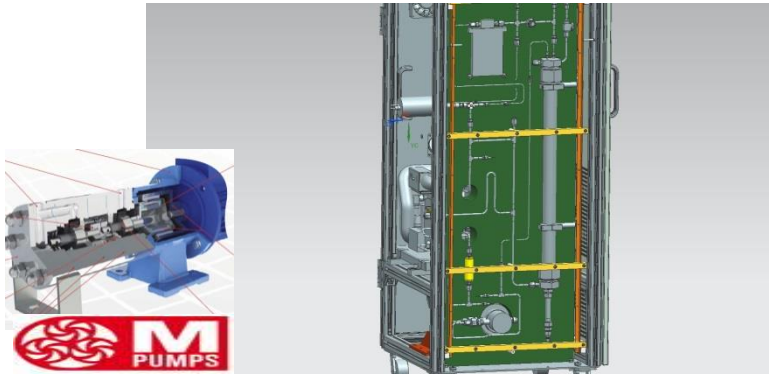
Measurement of the TFOM before and after thermal cycles

CO_2 TEST OF COOLING CIRCUIT CRITICAL COMPONENTS WITH 2PACL TRACI UNIT



CO_2 fluid-dynamic characterization

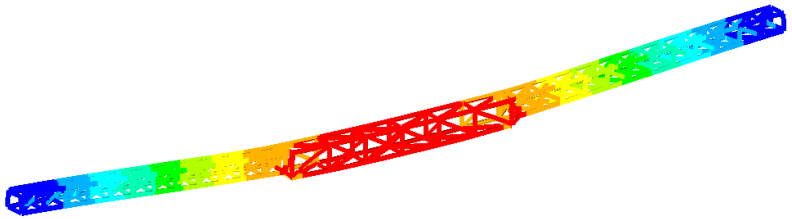
MILANO COOLING LAB. 2PACL TRACI V.3 UNIT



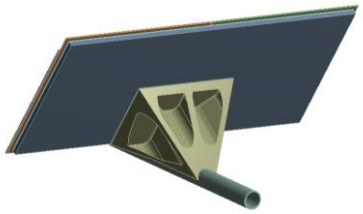
Solved the problems found in the pump: new gasket to withstand explosive de-compression

UNDER FINAL COMMISSIONING AT CERN

NEXT FEA TASKS: ANSYS ACP FINITE ELEMENT ANALYSIS



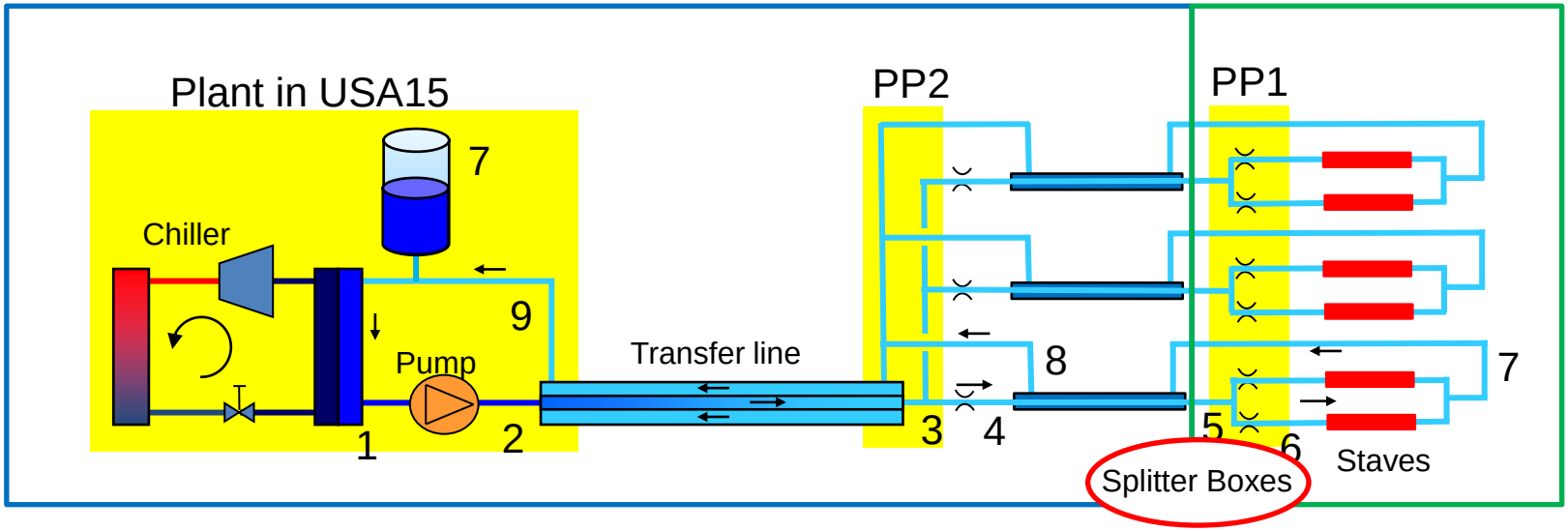
Slim Longeron FEA performance. Rigidity, vibration frequencies, thermo-mechanical stability, mounting fixations and detail studies



Example of optimization process for the tilted cell cooling block

INFN-Genova

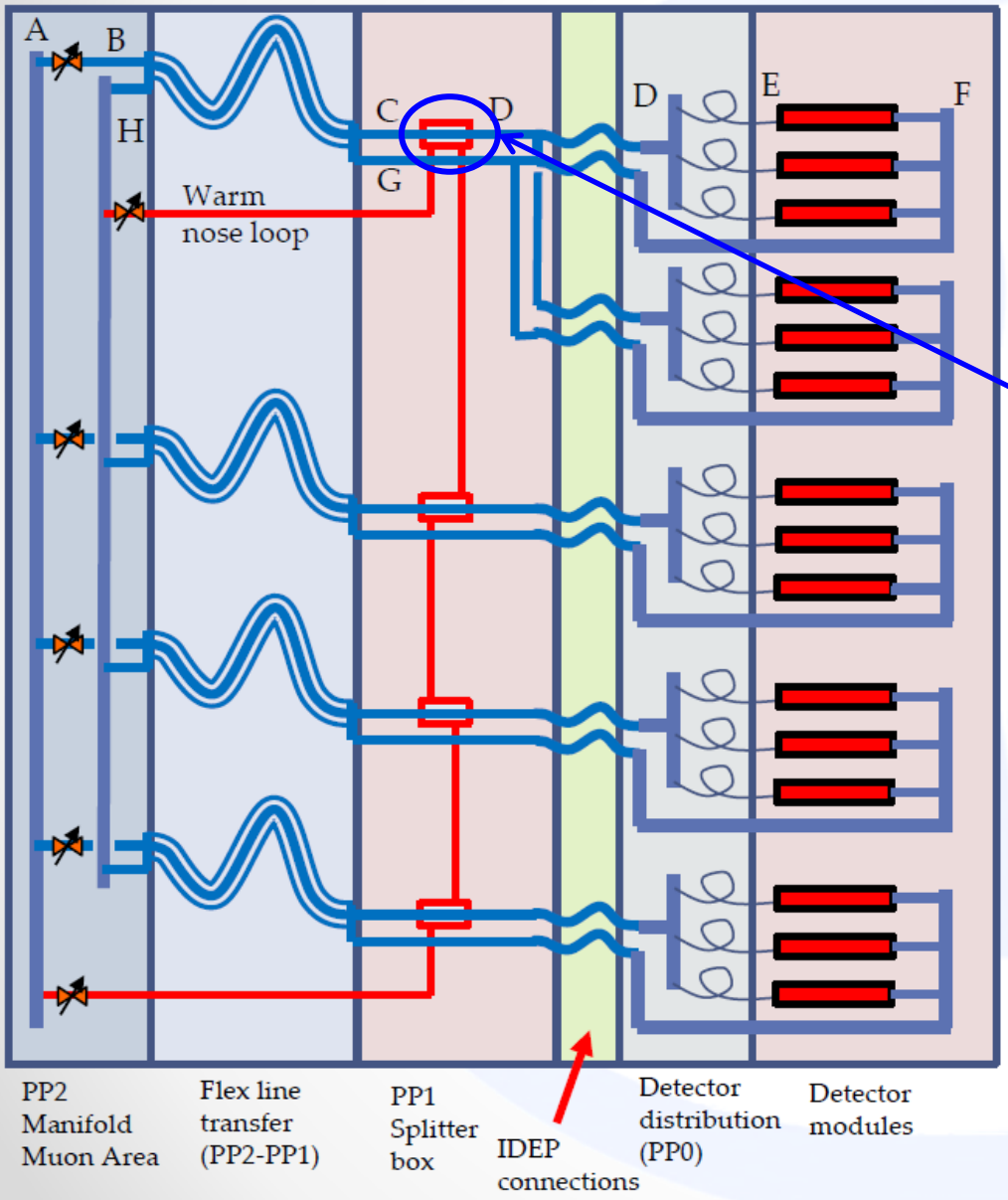
Genova is working on the splitter boxes located between the flexible lines and the detector lines for Baby DEMO.



- Definition of the HX configuration **almost finished**
- Investigation on the available technologies (orbital welding, metal 3D printing, …) **done**
- Definition of the configuration of the splitter box (including geometrical boundary conditions) **ongoing**
- Definition of the test criteria
- First generation prototype fabrication (Installation Readiness: End of Summer 2017)
- Qualification tests (@ INFN-Genova & CERN)

Cecilia Rossi – INFN
Sezione di Genova

ATLAS ITk – INFN – Genova



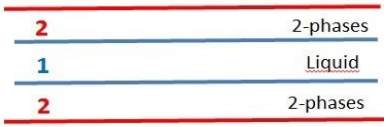
From Bart Verlaat

The modularity of the splitter boxes depends on their location
(R&D: modularity 1 → 4)

Geometrical constrains (100 mm)

The most critical part of the splitter boxes is the heat exchanger.

HX dimensioning:



→ parallel counterflow pipes, liquid in stainless steel pipes, 2-phase not channeled to reduce the pressure loss (Δp → ΔT), P ≈ 500 W/line

BD2 - Splitter box HX

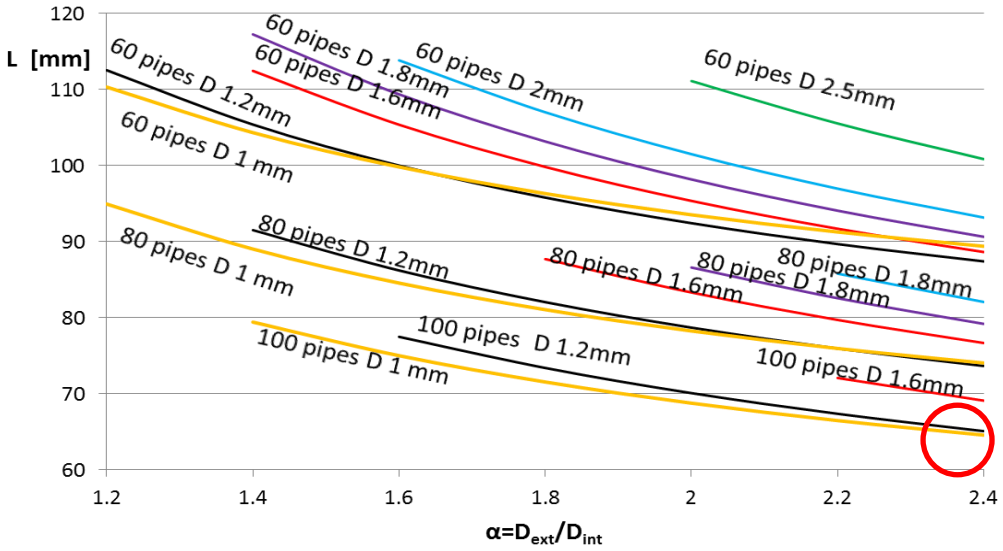
Liquid lines dimensioning

N_pipes = 100, Dext = 1 mm, Dint = 0.4 mm, L = 65mm , Δp = 588.4 mbar, U = 3.1 m/s, Reynolds = 7629 → Turbulent

2-phase dimensioning

Raw evaluation done considering gas values → 763 mbar for i=3.5mm

Precise evaluation ongoing



Technologies:

Commercial pipes: too big

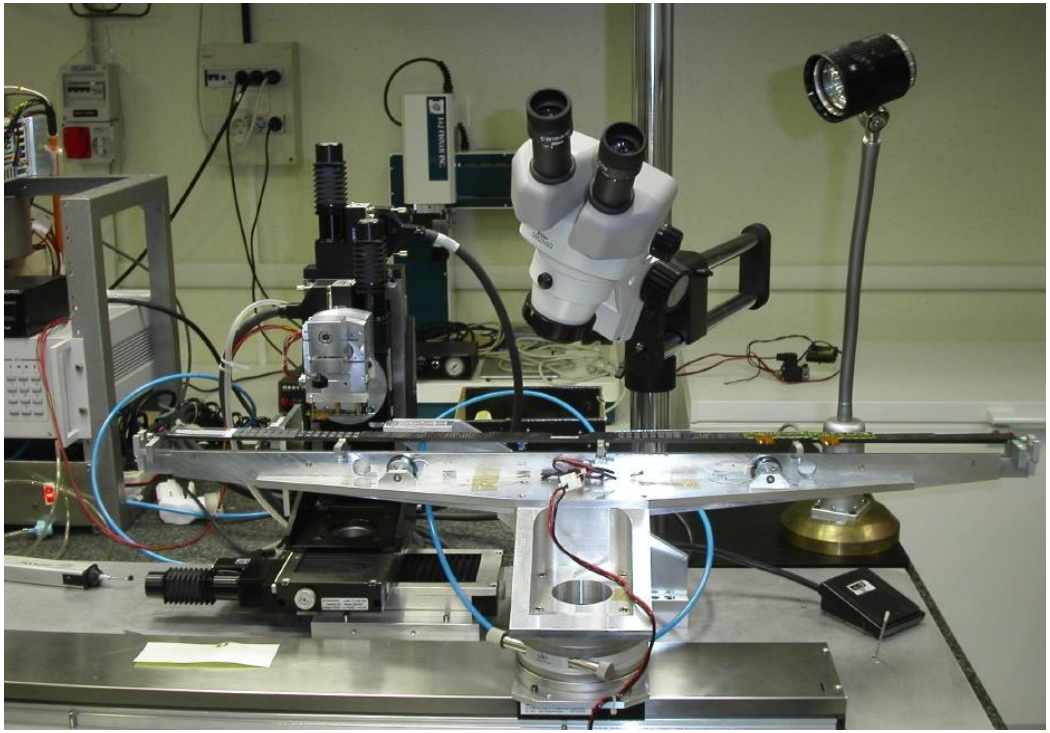
Micropipes: large range available on market but none characterized for high pressure (MDP=130 bar)

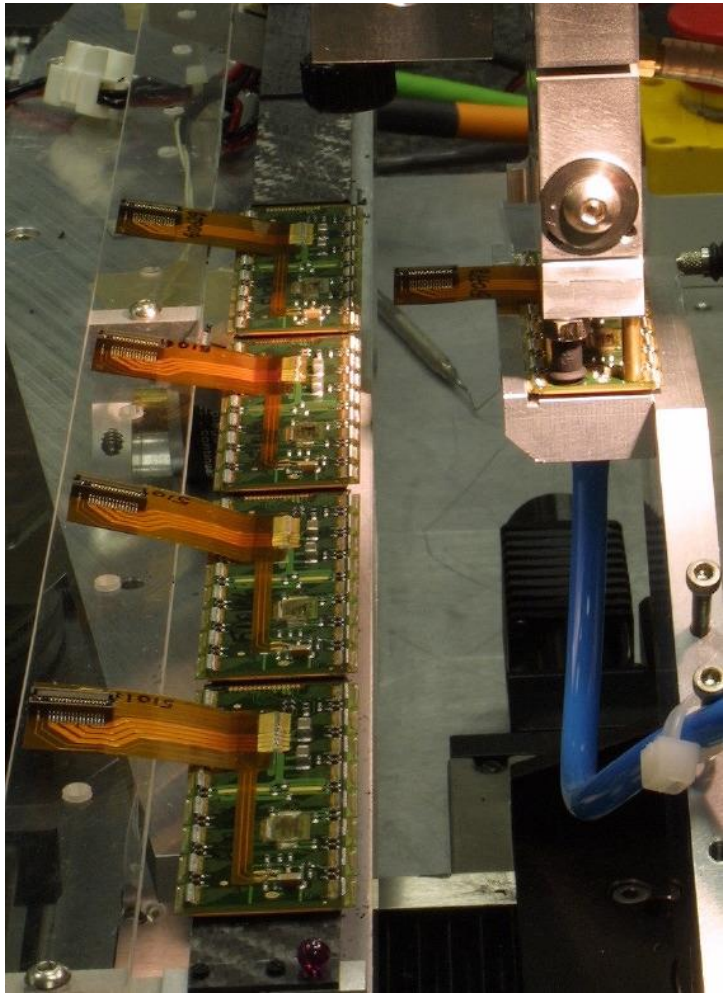
Metal 3D printing: A set of companies was identified (collaboration with Cosenza INFN?).

→ HX will be done in metal 3D printing.

→ The design will be modified in the following weeks and is continuously evolving

End Cap:
Genova is interested in contributing to the module loading.
Expertise and manpower are available (see next slides).





Pictures illustrating the set-up used for the first ATLAS pixel detector.

ATLAS ITk – INFN – Sezione di Genova

INFN – Genova resources

- C. Rossi, Engineer – head of the mechanical design office
- G. Gariano, ATLAS Technician – electronics/mechanics
- A. Rovani, ATLAS Technician – mechanics/hydraulics
- E. Ruscino, ATLAS Technician – electronics

Experts in setting up test system, data acquisition and analysis

Support of the mechanical design office

CAD Software Creo PTC

Additive manufacturing:

1) Stratasys, Dimension Elite
2) Projet MJP 2500 Plus

	Technology	Material	Layer thickness	Accuracy	Built size
1)	FDM	ABS plus	178 µm	0.178 – 0.254 mm	203 x 203 x 305 mm
2)	Multijet	Transparent/opaque resins, elastomer	32 µm	0.05 – 0.25 mm	295 x 211 x 142 mm

ATLAS ITk – INFN – Sezione di Genova

Support of the mechanical workshop

Milling machine, lathe machine, 5 axis milling machine, wire EDM, …

Lab facilities

Coordinate Measuring Machine CMM DEA Mistral	Axis lengths [mm]: X=660 Y=710 Z=460 Accuracy: 4.5 + 5 L/1000 (ISO 10360) (calibration showed an average accuracy ±4.5 µm)
Dynamic climate chamber BINDER MK53	T range (-40÷180)°C; T uniformity (0.4÷2)°C, depending on set point; T fluctuation (0.1÷0.5)°C, depending on set point
Chiller LAUDA RK 20 KS	T range (-40÷150)°C; T accuracy 0.1°C; Bath volume (11÷18)L;Cooling capacity at 20°C 8kW
Chiller LAUDA Proline RP 855	T range (-55÷200)°C; T accuracy 0.01°C; Bath volume (5.5÷8)L; Cooling power at 20°C 1.6kW
Thermal Imaging Camera FLIR SC 620	Accuracy ±2°C or ±2% of reading; Thermal sensitivity 40 mK at 30°C; T range (-40÷500)°C
120 keV x-ray inspection machine X-TEK, Vacuum Pump, PLC Siemens S7-300	

INFN-Lecce

Premesse

1. Si tiene conto solo di infrastrutture esistenti e personale INFN disponibile
2. Si tiene conto solo della fase di costruzione e della sua preparazione

Ci aspettiamo comunque più persone coinvolte (personale universitario e studenti) e di prenderci carico di qualche R&D o sviluppi utili al progetto. Aspetti legati alla organizzazione ed alle scelte della comunità ATLAS pixel Italia.

Esperienze costruttive rilevanti a Lecce

- Costruzione in camera pulita e test camera a drift prototipo in scala reale di KLOE
- Costruzione di tutti gli RPC di ATLAS e certificazione di qualità di 1/3 del totale
- Costruzione con robot in camera pulita dei layer multifili della camera a drift dell'upgrade di MEG (non oltre il 2017)
- Costruzione moduli a fibre scintillanti per l'upgrade di AUGER (non usa camera pulita e finisce ben prima del 2020)
- Costruzione meccanica (tutti i componenti in fibra di carbonio) del calorimetro di Mu2e al Fermilab

G. Chiodini - INFN Lecce
S. Spagnolo - Uni. Salento & INFN Lecce

Infrastrutture e tools disponibili

Spazi di lavoro

- Capannone
- Carroponte
- Laboratori
- Sistema di distribuzione del gas
- Camera pulita (classe 10000)

Sistemi di costruzione

- Robot di assemblaggio camere a fili
- tre tavoli di granito thorlabs
- Saldatrice laser per circuiti automatica e di precisione

Servizio di meccanica (ben fornito)

- Progettazione meccanica CAD
- Progettazione circuiti stampati CAD
- Frese e torni a controllo numerico
- Impianti con Vuoto

Sinergie locali

- Solidisti
- Nanotecnologi
- CNR

Infrastrutture e tools disponibili

Servizio di elettronica (ben fornito)

- Progettazione elettronica
- Macchina per prototipo circuiti stampati
- Stampante 3D

Strumentazione elettronica (qualche highlight)

- Pattern generator e Logic state analyser
- DCA-X 86100D (test di integrità linee di trasmissioni elettriche e bus dati)

Sorgenti di test

- Sorgente a raggi-X
- Sorgente beta Sr90
- Sorgente alfa Am241
- Laser UV ad azoto

Personale

Dal 2018 fino all'inizio costruzione (2021-22)

- 2 meccanici+2 elettronici:
  0.5 FTE tecnico per l'integrazione (o loading)
- 2 fisici:
  0.5 FTE fisico per l'integrazione (o loading)

Dalla costruzione fino al commissioning (fine 2024)

- 1 meccanico+1 elettronico:
  1 FTE tecnico per l'integrazione (o loading)
- 2 fisici:
  1 FTE fisico per l'integrazione (o loading)

Possibile contributo di Lecce

1. Giusto share QC dei moduli italiani e degli Half Ring italiani
2. Assemblaggio + servizi sui supporti globali + QC di un End cap o in alternativa giusto share loading degli Half Ring italiani

NB: la realizzazione dei moduli richiede un wirebonder che non abbiamo, quindi al momento la realizzazione dei moduli a Lecce non è stata presa in considerazione.
NB: non si assume nessun progetto di sviluppo relativo al rivelatore ma solo sviluppi legati al loading, integrazione o QA.

Infrastrutture, tools and QA per integrazione di un End-cap

- Camera pulita con controllo di temperatura e umidità
- Capacità di storage
- Tools di movimentazione
- Verifica online del posizionamento
- Quality Assurance