ATLAS LNF activity Status Report

M. Antonelli
on behalf of the ATLAS LNF group

The ATLAS LNF Group

The Group:

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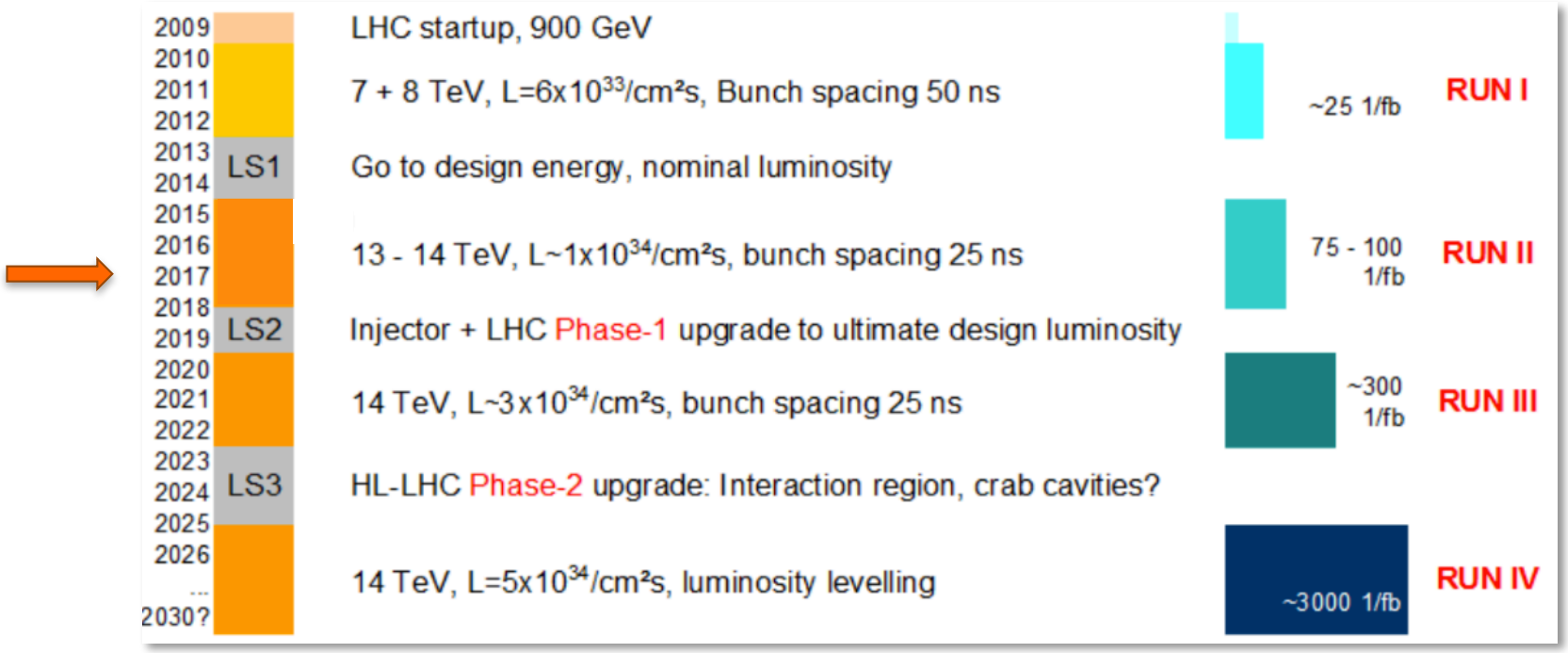
A. Sansoni, M. Testa, S. Tomassini, T. Vassilieva, E. Vilucchi

- **ATLAS upgrade**
  - **FTK:** Trigger upgrade with fast tracks reconstructions (Phase 1)
  - **NSW:** Muon spectrometer upgrade with the construction of the New Small Wheels (Phase 1)
  - **ITk:** Inner Tracker upgrade for HL-LHC (Phase 2)

The ATLAS Upgrade Program



Phase 0 Upgrade:

– Consolidation + Insertable B-Layer (IBL) in LS1 already in for Run 2 -> DONE!

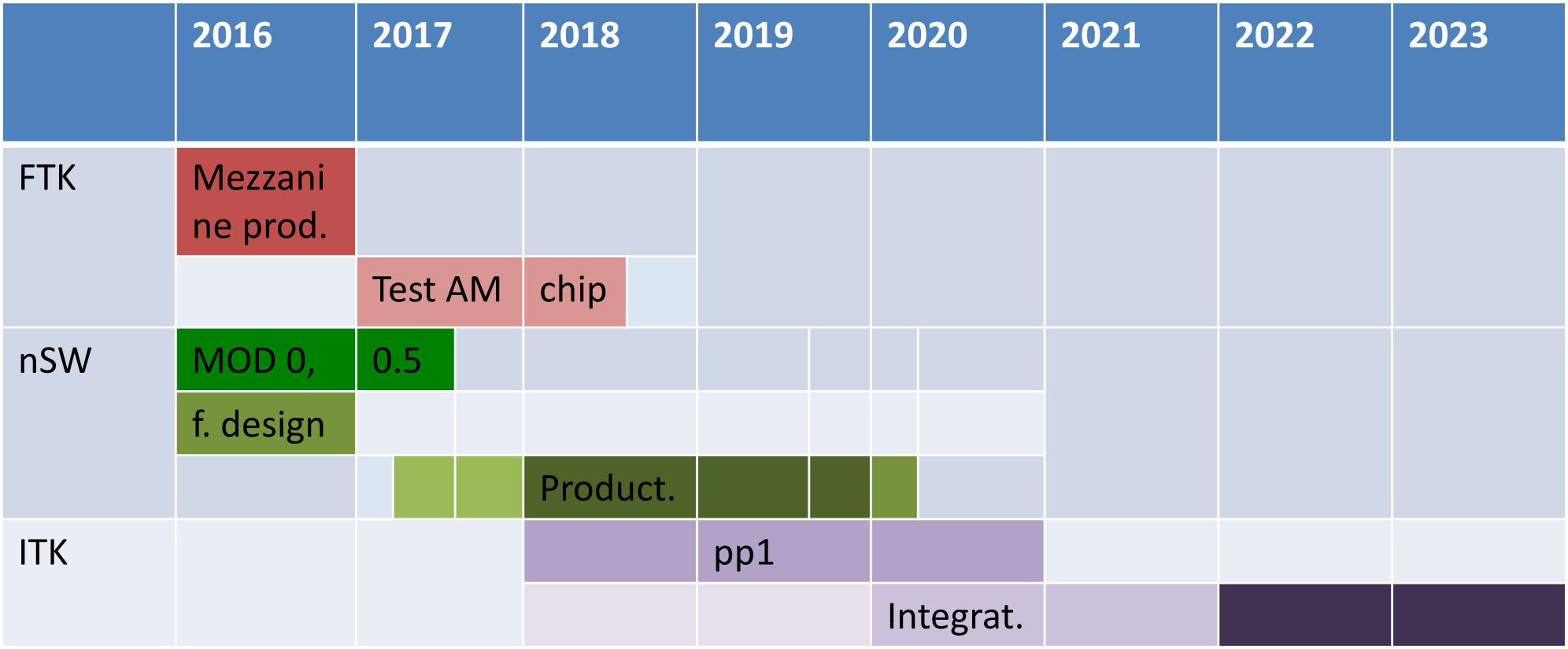
- **Phase 1 Upgrade**

– New Small Wheel, Calorimeter trigger upgrade, FTK

- **Phase 2 Upgrade**

– Inner Tracker

-> LNF group already fully involved in Phase 1 and Phase 2 upgrades!

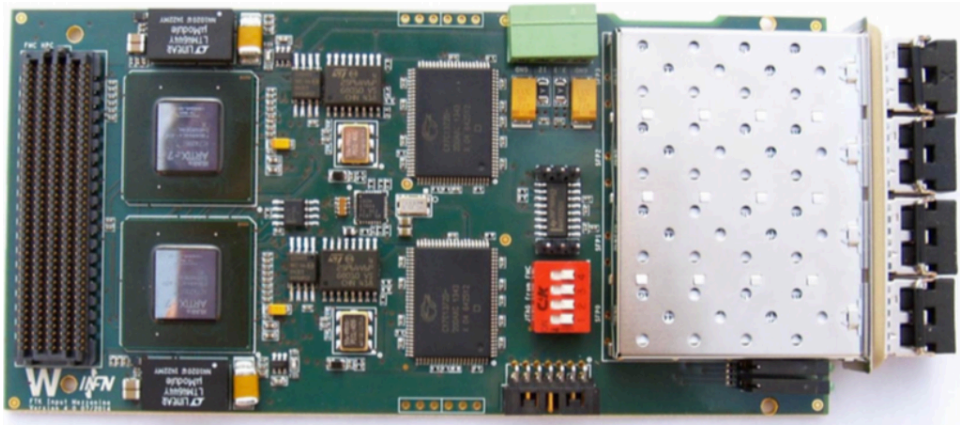

2016
2017
2018
2019
2020
2021
2022
2023
FTK
Mezzani ne prod.
Test AM
chip
nSW
MOD 0,
0.5
f. design
Product.
ITK
pp1
Integrat.

LNF: leading activity in the Associative Memory chip and Input Mezzanine production and tests

Input Mezzanine:

- IM Artix7 (LNF): IBL compatible FTK Input Mezzanine
- receives 4 inputs links from 2 SCT and 2 Pixel or 2 IBL
- perform the hit clustering by FPGA
- send the clustered hit data to Data Formatter board (DF) that sort the hits in their FTK η/ϕ towers and delivers them to processing units (PU)

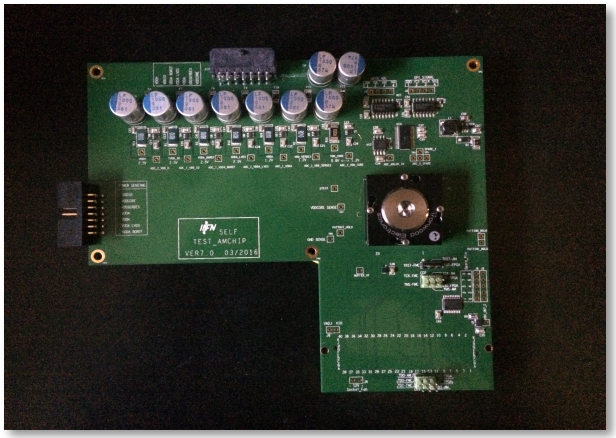
- ✓ all IM boards have been produced and tested and installed in ATLAS
- ✓ the firmware works fine -> optimization in progress
- ✓ maintenance of the IM boards under our resposibility
- ✓ up to now only one board has been sent back for repair



FTK status: Associative Memory chip

Associative Memory chip:

- AM06 Chip (LNF - INFN Milano - LPNHE Paris) 160mm2 65nm ASIC (400M transistors)



Test is LNF Resposibility:

- ✓ up to now we have tested about 10000 Amchip06
- ✓ during these tests some problems of reliability of the test system have been solved
  - improved reliability of contacts changing the socket with one having metallic spring contacts (guaranteed for massive production tests)
  - new test board produced
  - All test under LNF responsibility finished

8000 chip under production

Delivery

Ready for january 2018

Test

Ready for mounting summer 2018

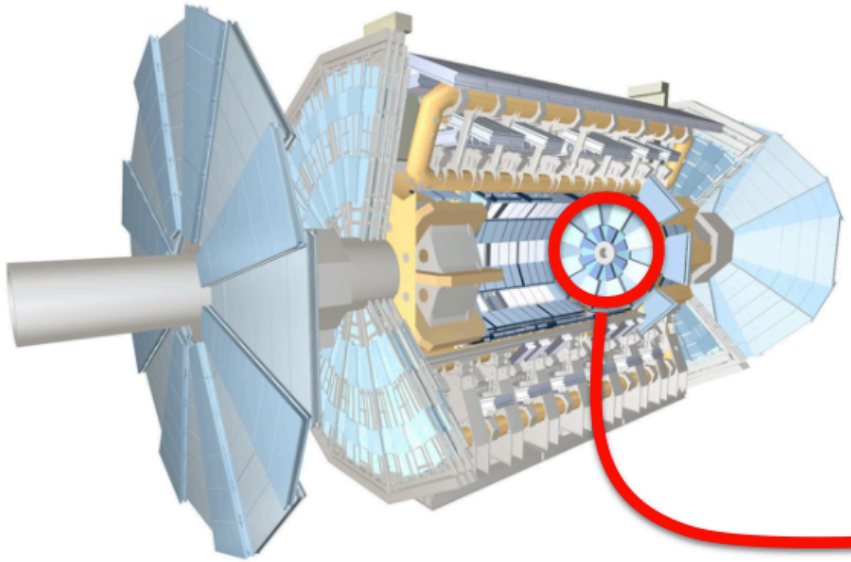
ATLAS muon spectrometer is realized by:

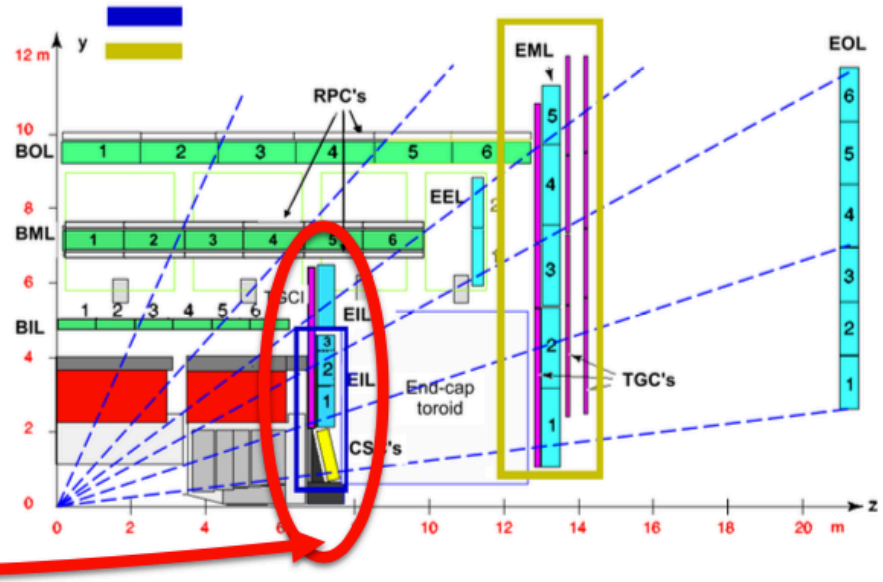
- RPC(trigger) and MDT (tracking) in the barrel region (|eta| <1)
- CSC, MDT (tracking) and TGC (trigger) in the endcap

-> Trigger & Tracking strongly affected when LHC lumi will be above the design values

Full new muon detector (including electronics & services): New Small Wheels to be placed in the ATLAS cavern during LS2 (2019-2020)

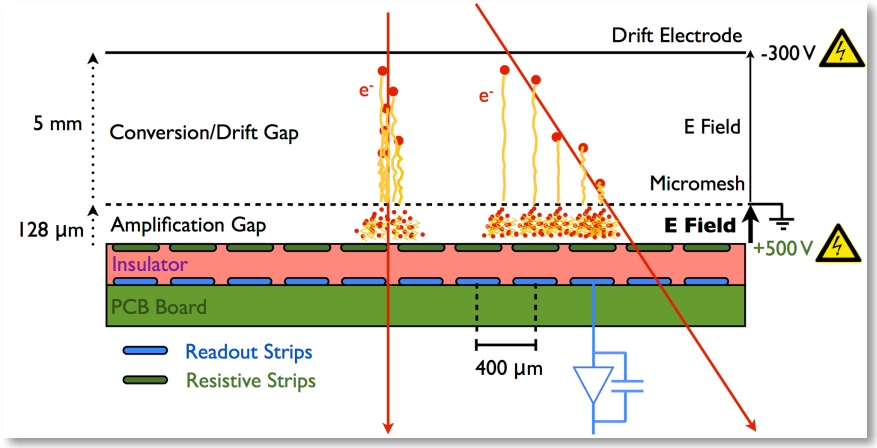
- will replace the innermost end-cap stations of the Muon Spectrometer
- good tracking capability (p_T resolution ~15% for 1TeV)
- high rate capability (15 kHz/cm^2)

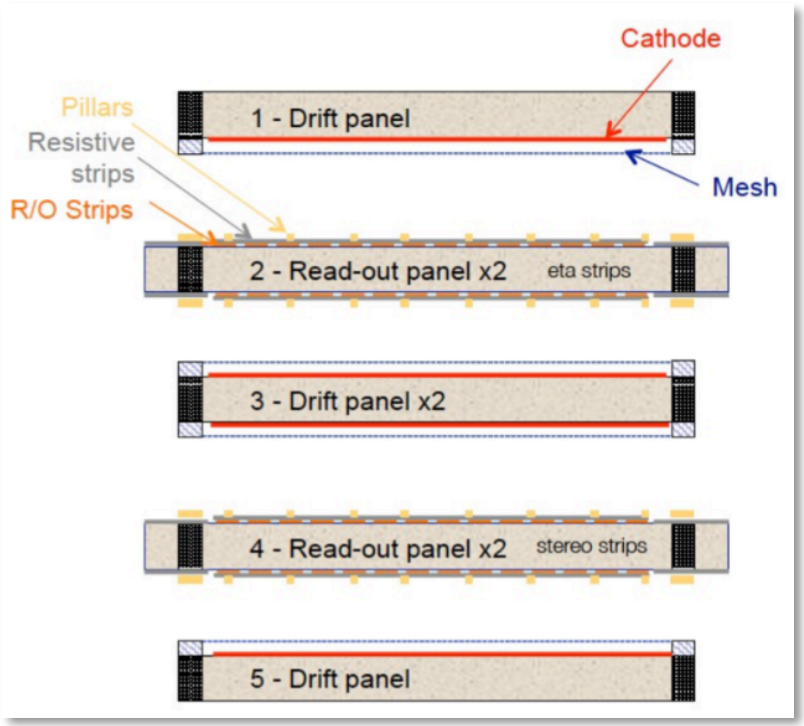




Micromegas (Micro Mesh Gas Detectors) are micro pattern gaseous detectors

- Charged particles ionize the detector gas (100 e/cm in Ar:CO 93:7 by muons)
- Electrons from the ionization are amplified in avalanche between a fine micro mesh and the readout strips (resistive strips, anode)
- High resolution: strip width 300 μm, strip pitch 425 to 450 μm
- fast evacuation of positive ions: 100 ns, high-rate capability (tested with flux densities of 7MHz/cm^2 and above)
- In two out of the four layers the strips are inclined by ±1.5° to allow for the measurement of a second coordinate (track, goal 100 μm resolution)

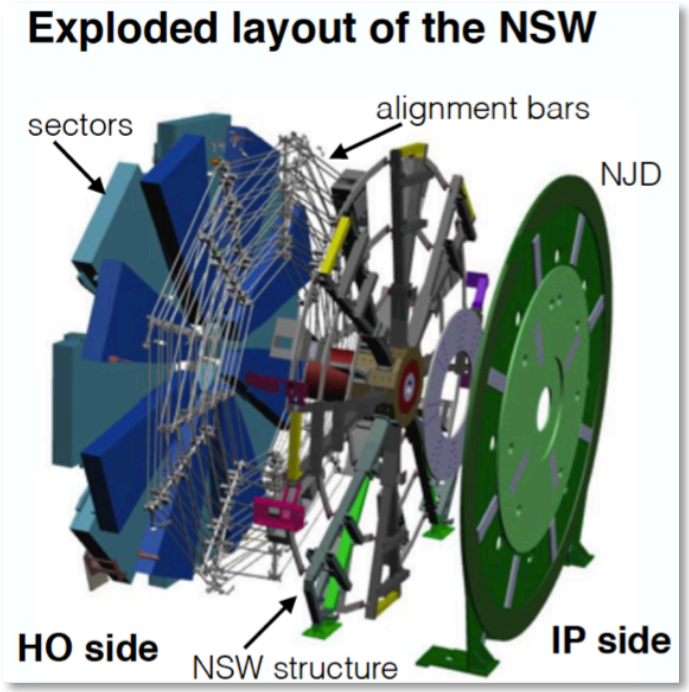


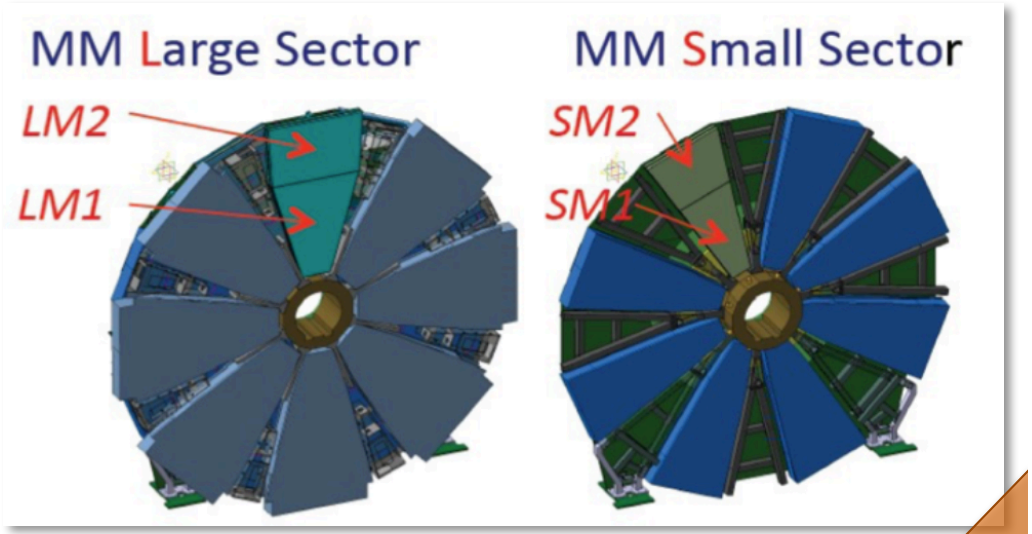


NSW Layout

Wheel-like design:

- 8 large and 8 small sectors (2 modules per sector, 4 MM quadruplets)
- main focus: precision tracking (sandwiched by sTGC quadruplets for trigger)
- 4 different chamber types: LM 1-2, SM 1-2
- Production distributed over several institutes and some components from industry
  - Italy(SM1), Germany(SM2), France(LM1), Russia/Greece/CERN (LM2)

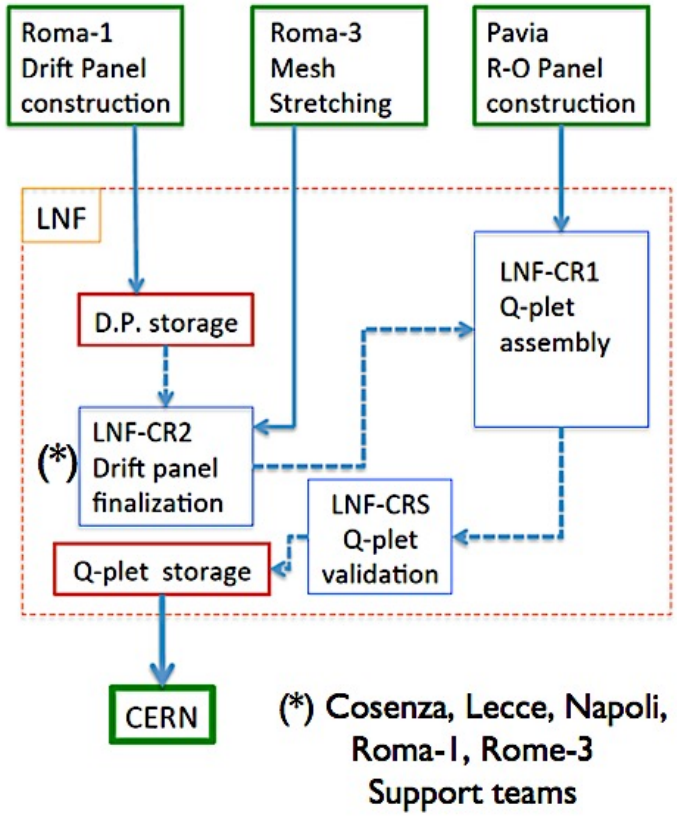


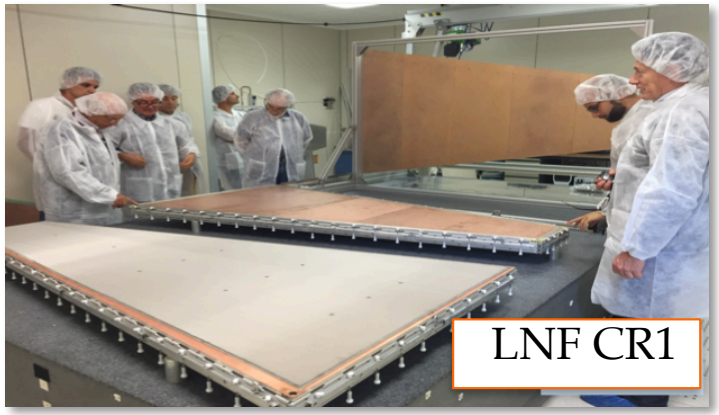


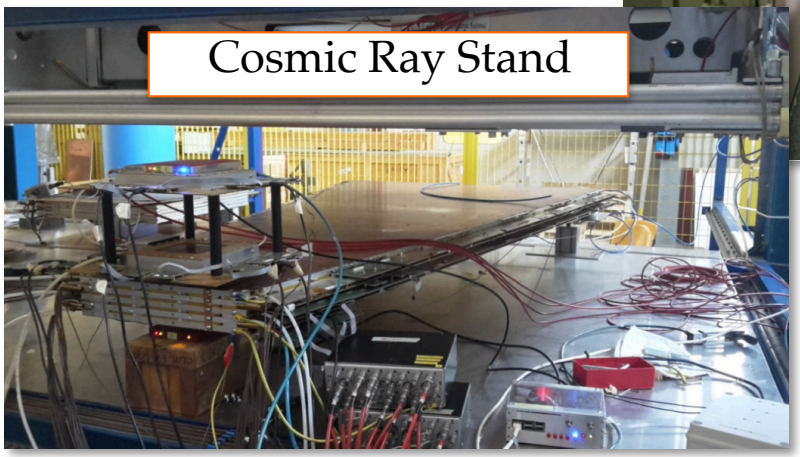
2 Module0 constructed and tested!

1st done among all the collaboration!

NSW production scheme







STATUS

- Production in standby until:
  - Build and test 4/32 chamber with new cleaning procedure (M1->M4)
  - Validate it and restart asap
- 2 successful visits to Frascati:
  - ATLAS management
  - Rui's team
- Today: M3 in assembly phase (last layer)

Cleaning procedure

RO preparation:

Optimized during site visit

- Capacitors measurements
- kapton on side frames
- Visual inspection

RO cleaning procedure:

- wash external and active zones (cif + brush) and rinse
- Panels need to stay always wet
- Rinse with warm water and clean b
- Rinse with de-ionized water
- Rinse the sides carefully
- High pressure Kärcher used for rinsing both with tap and de-ionized water
- No rotation of the panel right after the wet cleaning -> let it drop few hours before turning it vertically

Cleaning procedure

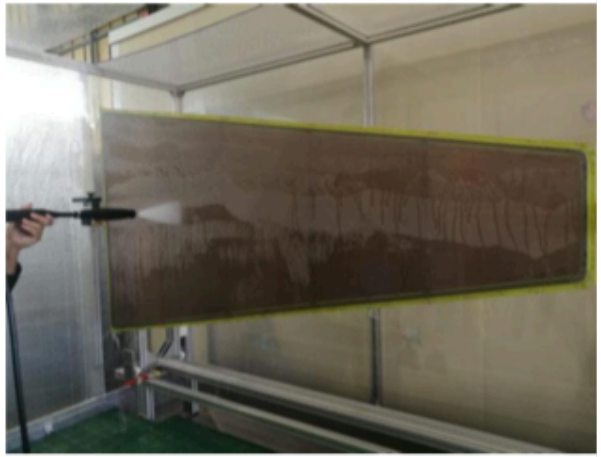
Preparation:

- Visual inspection
- Polished with 2500 sand paper (M2 outer drift L1)
  -> quite fast procedure
- No gap frames mounted
- Kapton tape to prevent water inside the panel (no M3)

Drift cleaning:

- Washing with NGL + brush
- Rinse with warm water and clean brush
- Rinse with de-ionized water (high purity water from the Dafne water cooling)

De-ionized water resistivity: 2.5MΩ
in barrel and 1.5 at Karcher outlet



O-ring:

- Washed in immersion
  in NGL
- Rinse with warm water
  + de-ionized water
- Dried with clean room tissue

Cleaning procedure

- Panel delamination -> new gluing technique (Athina's talk)
- still water trapped in the panel after several days (kapton tape during washing procedure and eventually drilling holes)

Cleaning procedure

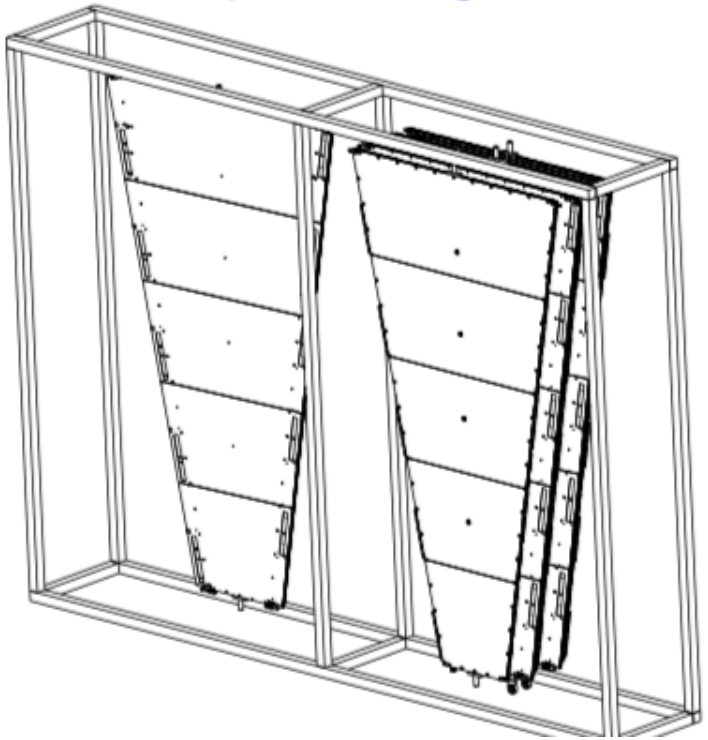
M3 on -> vertical* drying in CR

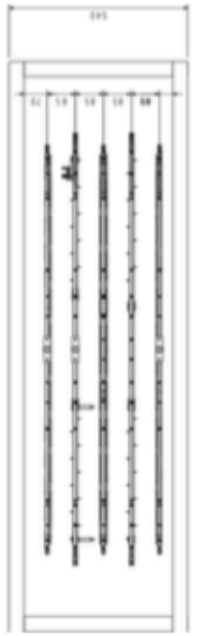
M1 dried horizontally in CR

Drying Box for M4 on:

- Box with warm air ~ 40 C
- Can host 2 complete sets of panels
- Drawings and material ready
- under construction (ready ~1st week July)

-> After drying extra space will be available inside the CR1 for panel storage





Cleaning procedure effects

Experience with Eta Doublet, M05, M1, M2:

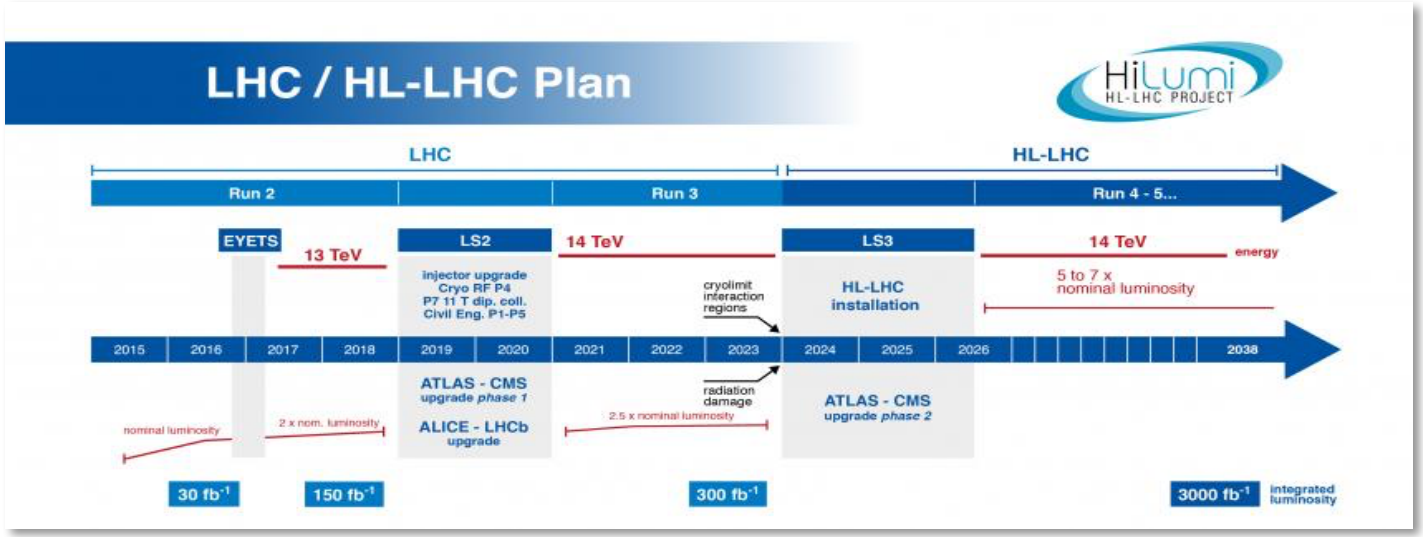
- **Eta Doublet cleaned and tested at CERN:**
  - delamination problems
  - tested in air but assembled horizontally
  - HV test in air were ~ok, ~ok results in Ar-CO_2 soon after, not reproducible later on
  - Now back in PV to try to repair
- **M05 cleaned at LNF (eta twice), dried in CR1 at 22 C:**
  - Small delamination problems
  - HV test before and after cleaning shows good impact on solving the ionic contamination problem
  - assembled horizontally*
  - under test @ CRS for the finalization of the acquisition

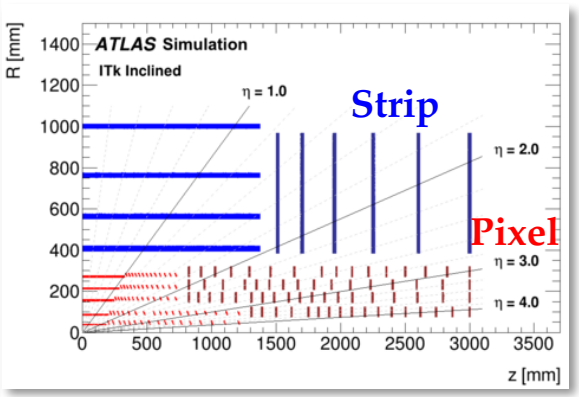
M05: impact on ionic contamination

590 V	Pre-	Post-washing
L1-1U	1	
L1-1D	1	
L1-2U	1	
L1-2D	0	
L1-3U	314	<20
L1-3D	196	<20
L1-4U	1	
L1-4D	1	
		<100 @ 580
L1-5U	385	*
L1-5D	324	<20
L2-1U	1	
L2-1D	1	
L2-2U	2	
L2-2D	0	
L2-3U	0	
L2-3D	6	
L2-4U	2	
L2-4D	0	
L2-5U	1	
L2-5D	0	

Phase 2: HL-LHC

The current Inner Detector (ID) will need to be replaced to keep the excellent tracking performance at HL-LHC environment (inner most layers approaching end of life during Run 3 due to radiation damage)



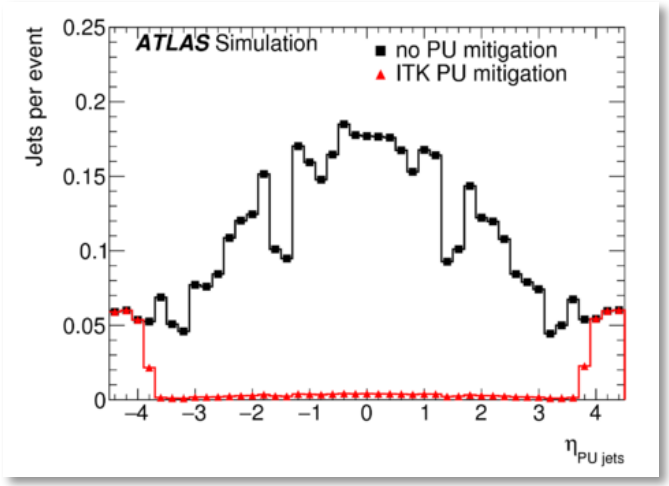


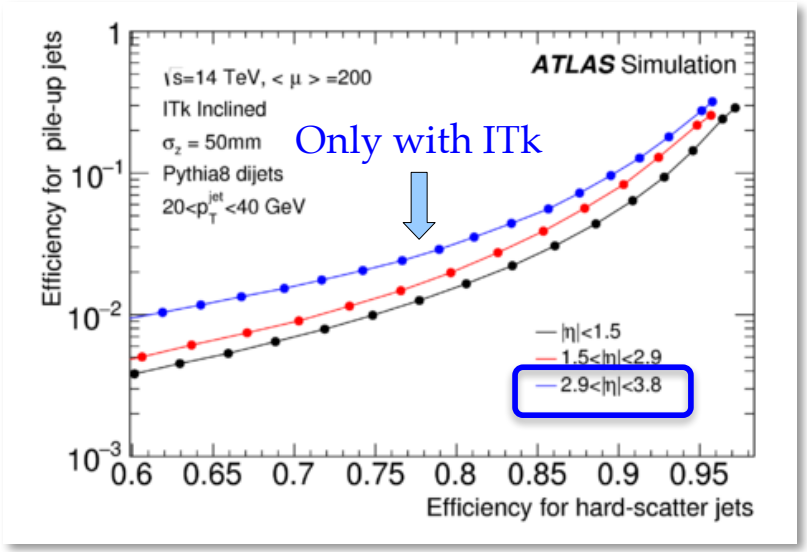
HL-LHC environment demands:

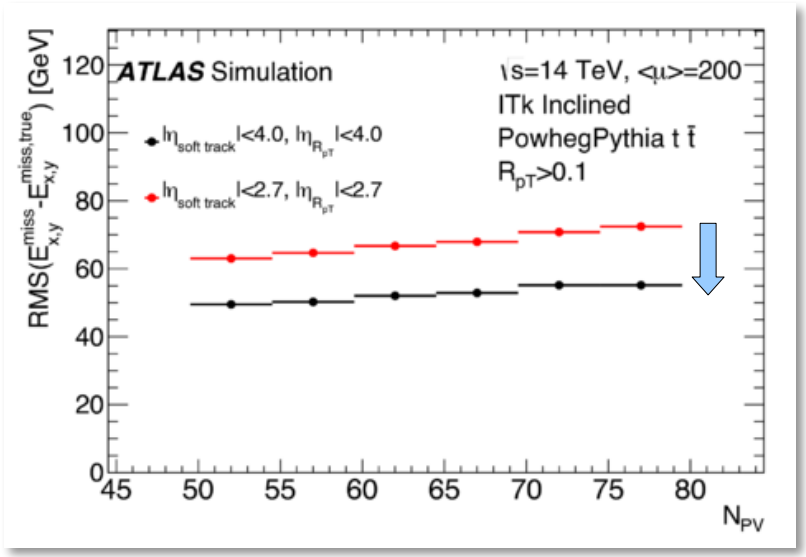
- increased radiation hardness
- higher granularity of pixel detector to reduce the occupancy and to handle the high pile-up environment (μ=200 increasing the peak luminosity by ~4)
- reduction of material to benefit tracking and calorimeter performance
- extended coverage of the tracking volume up to $|\eta| < 4.0$ mainly to identify pile-up jets and mitigate their effect

Design of ITk for jet and E_t^{miss} reconstruction

- **Pile-up suppression in jet and E_T^{miss} reconstruction main motivation for increased acceptance up to $|\eta| < 4.0$** (currently $|\eta| < 2.5$)
  - could suppress pile-up jets in the forward region using tracking information
  - improve E_T^{miss} resolution
- critical for layout decision
- main contribution from LNF



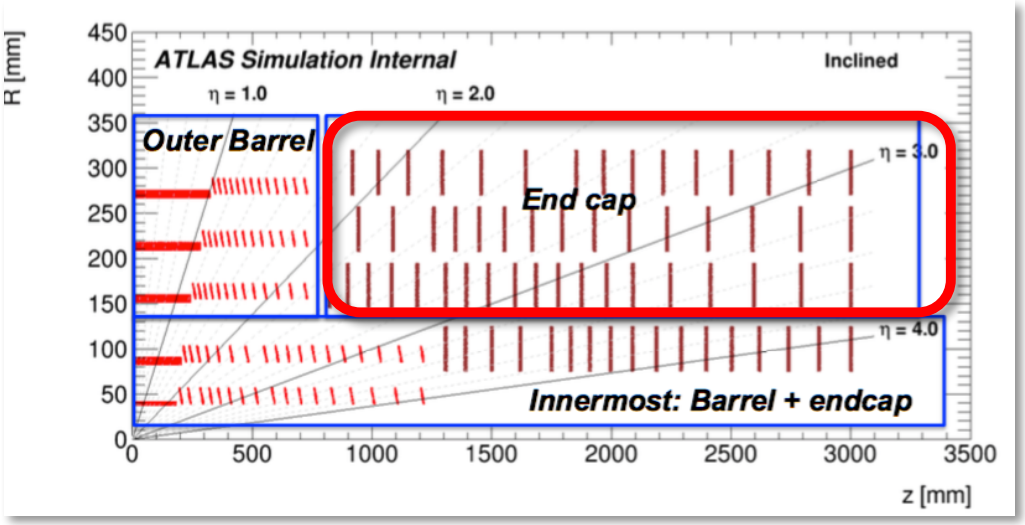


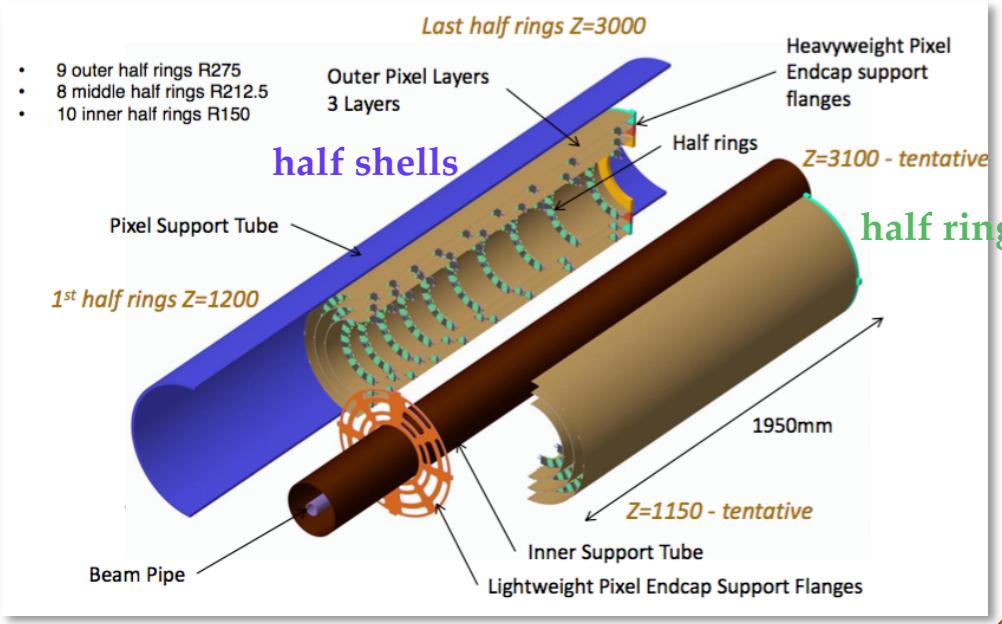


- Strip TDR
- Pixel TDR in preparation

Italy will build one endcap of the pixel ITk detector

- each Outer Endcap is an assembly of three coaxial cylinders each supporting a number of arc-shaped structures on which the modules are glued
- this design allows more flexibility in layout
- all mechanical supports are made of carbon composite material
- half shells to be built by UK partner, shared production for half rings
- short term plan is to produce first half ring prototypes and start their qualification



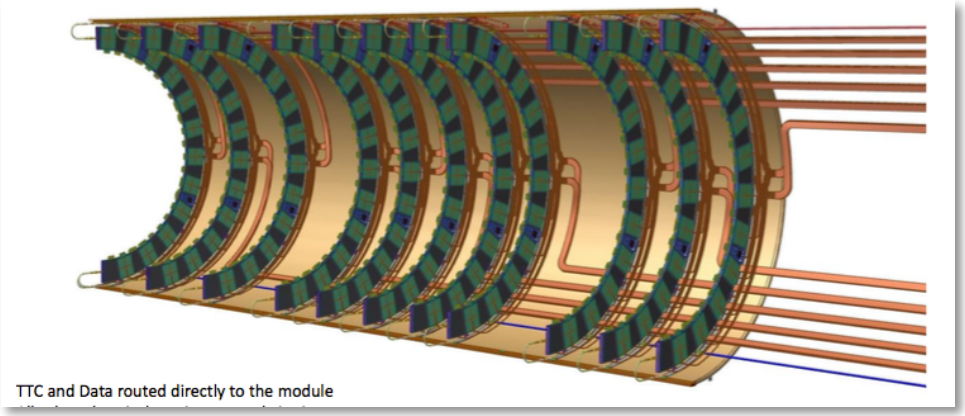


Integration of Pixel Endcap at LNF

LNF activities include:

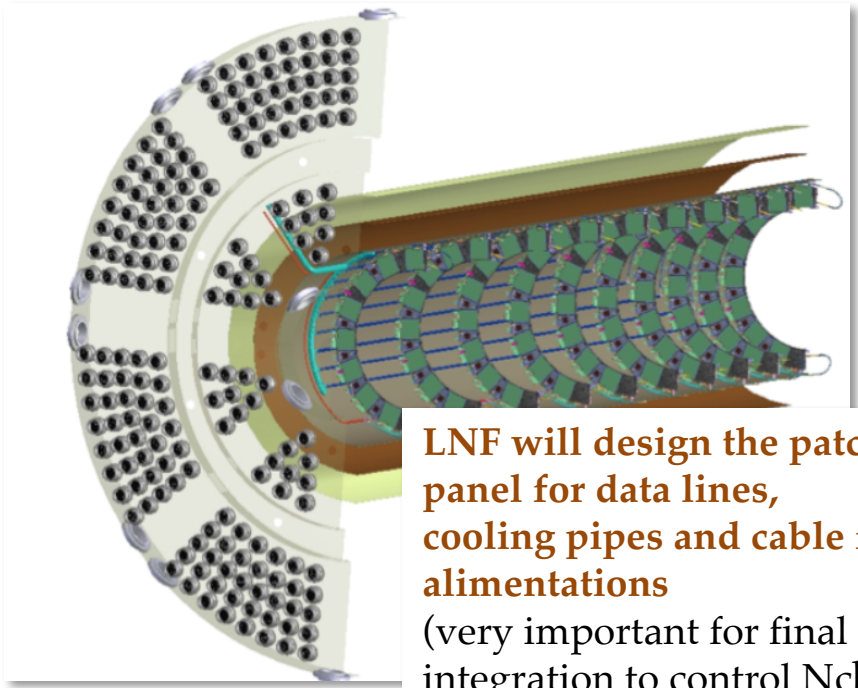
- reception tests of half-rings
- integration of half-rings in half-shell
- qualification of half-shell (*)
- assembly of a full shell (for all 3 layers)
- qualification of a full shell (*)
- assembly of the 3 full shells to the endcap
- qualification for the endcap (*)

(*) test of cooling system, thermal cycles, pressure cycles for cooling pipes, test of a module fraction per time



Multiple LNF divisions involved

- Research and Technical Division Mechanical Services
- Research Division Electronic Service
- Accelerators Division Cryogenic Group

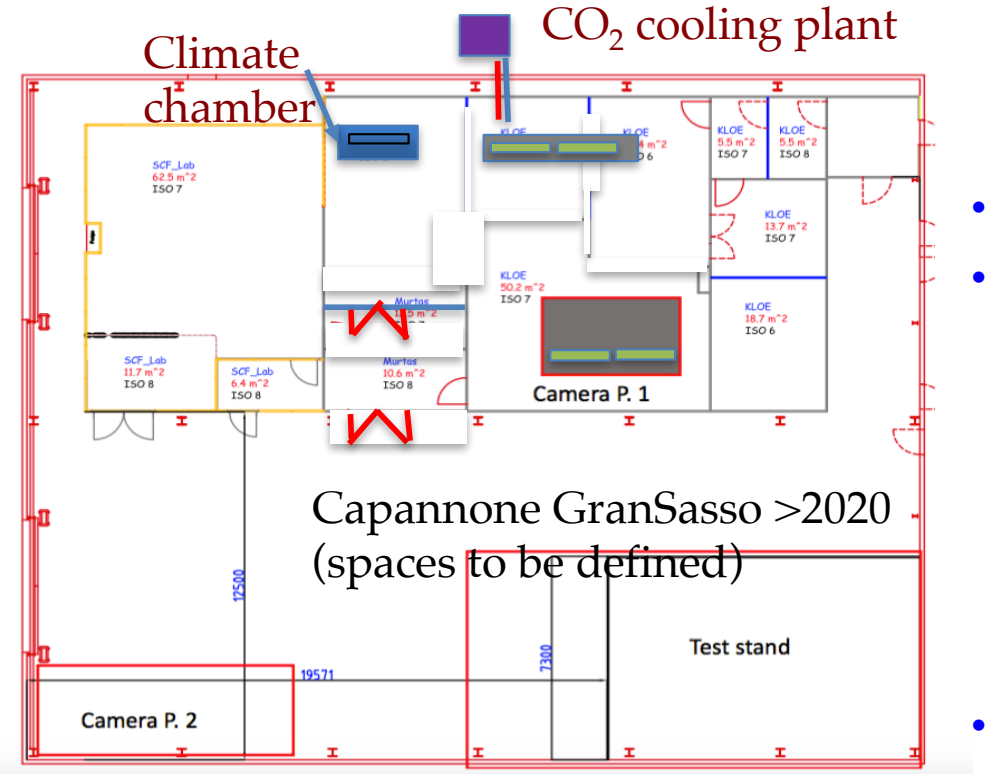


LNF will design the patch panel for data lines, cooling pipes and cable for alimentations
(very important for final integration to control Nch and spaces)

Plan toward integration of Pixel Endcap at LNF

Need new infrastructures

- CO_2 cooling system large at 2kW
- large climate chamber
- refurbishment of cleaning rooms



Plan toward integration at LNF:

- **Detector design with all services:**
  - cooling pipes, electrical services, data lines
- **Tools design:**
  - supports for half cilinders
  - rails for coaxial insertion of one cylinder into the other
  - measurement systems
- **Define system tests**
- **Strategy for transfer lines of the CO_2 cooling system**
  - define splitting box to send cooling lines to different working spaces
  - → decision on how to organize the spaces of the cleaning rooms
  - → preliminary tools and strategies during 2018
- **Design and mockup of patch panel in 2018**

Ongoing activity

- PP1 design and mechanical prototype
  - 1 small size prototype to test gas tightness
  - 1 ~ full size to test cabling
  - Status: drawings and part of mechanics ready
- Readout and test of single detector
- half cylinder mechanical prototype to test integration expected for 2019
- Cooling system (in collaboration)

Expected manpower need

LNF						18	19	20	21	22	23	24	25	81,8	
Marianna Testa	LNF	Scientist	Staff	ITk 2.1, 2.3	2.1.7	0,4	0,5	0,7	0,7	0,7	0,7	0,7	0,5	4,9	
Mario Antonelli	LNF	Scientist	Staff	ITk 2.1, 2.3	2.1.7	0,2	0,3	0,4	0,5	0,5	0,5	0,5	0,3	3,2	
Vitaliano Chiarella	LNF	Scientist	Staff	ITk 2.1, 2.3	2.1.7	0,5	0,6	0,6	0,6	0,6	0,6	0,6	0,4	4,5	
Sansoni Andrea	LNF	Scientist	Staff	ITk 2.1, 2.3	2.1.7	0,1	0,2	0,3	0,4	0,4	0,5	0,5	0,2	2,6	
Tomassini Sandro	LNF	Mech. Engineer	Staff	ITk 2.1, 2.3	2.1.7, 2.1.4	0,5	0,6	0,7	0,7	0,7	0,7	0,7	0,5	5,1	Progettista meccanico resp.
Emiliano Dane'	LNF	Mech. Engineer	Staff	ITk 2.1, 2.3	2.1.7	0,1	0,3	0,5	0,5	0,5	0,3	0,3	0,1	2,6	Progettista meccanico
Giovanni Delle Monache	LNF	Mech. Engineer	Staff	ITk 2.1, 2.3	2.1.7	0,1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	2,2	Progettista meccanico (linee trasferime
Pietro Albicocco	LNF	Electr. Engineer	Temporaneo	ITk 2.1, 2.3	2.1.4	0,2								0,2	Progettista elettronico
Dario Orecchini	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7, 2.1.4	0,7	0,7	0,6	0,6	0,6				3,2	Disegnatore meccanico
Luigi Pellegrino	LNF	Mech. Engineer	Staff	ITk 2.1, 2.3	2.1.7	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,8	Progettista meccanico (larser arm)
Sergio Cantarella	LNF	Mech. Engineer	Staff	ITk 2.1, 2.3	2.1.7			0,1						0,1	Resp. servizio imp. Fluidi
Tecnico 1	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7	0,5	1,0	0,8	0,9	1,0	1,0	1,0	1,0	7,2	Tecnico Gruppo
Tecnico 2	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7			0,7	0,8	1,0	1,0	1,0	1,0	5,5	Tecnico Gruppo
Tecnico 3	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7				0,8	1,0	1,0	1,0	1,0	4,8	Tecnico Gruppo
Tecnico 4	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7				0,8	1,0	1,0	1,0	1,0	4,8	Tecnico Gruppo
Tecnico 5	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7, 2.1.4			0,5	0,5	0,5	0,5	0,5	0,5	3,0	Tecnico serv. Elettronica
Tecnico 6	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7	0,2	0,5	0,5	0,5	0,5	0,5	0,5	0,5	3,7	Tecnico off. Meccanica
Tecnici 7	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7		0,3	0,3	0,3	0,3	0,3	0,3	0,3	2,1	Tecnico servizio criogenia
Tecnici 8	LNF	Technician	Staff	ITk 2.1, 2.3	2.1.7			0,3						0,3	Tecnico servizio imp.Fluidi
J. Doe (new request to INFN)	LNF	Electr. Engineer	Richiesto	ITk 2.1, 2.3	2.1.8, 2.1.7		1,0	1,0	1,0	1,0	1,0	1,0	1,0	7,0	Progettista elettronico
J. Doe (new request to INFN)	LNF	Mech. Engineer	Richiesto	ITk 2.1, 2.3	2.1.4, 2.1.7		1,0	1,0	1,0	1,0	1,0	1,0	1,0	7,0	Progettista meccanico
J. Doe (new request to INFN)	LNF	Technician	Richiesto	ITk 2.1, 2.3	2.1.7					1,0	1,0	1,0	1,0	4,0	Forza lavoro generica
J. Doe (new request to INFN)	LNF	Technician	Richiesto	ITk 2.1, 2.3	2.1.7						1,0	1,0	1,0	3,0	Forza lavoro generica

Infrastructure and manpower

- Infrastructures and man power request to Giunta esecutiva
  - Man power: 2 engineers + 1 technician
  - Cooling system CO_2 2KW 165KE
  - Camera climatica (-50^o) 70KE
  - Adeguamento camera pulita 60 KE

conclusion

- Phase 1:
  - FTK finished (just mezzanine maintenance)
  - nSW 4/32 chamber production started to prove specifications fulfillment:
    - Not trivial implementation of new cleaning procedure
    - 3/4 chambers assembled (expect to finish end of July)
    - September should have green light to continue
- Phase 2:
  - ITK activity is ongoing (PP1 design and mockup)
  - CTS in September to evaluate project structure and give green light for manpower and infrastructure requests