ATLAS UPGRADE PROGRAM

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ATALS ACTIVITY

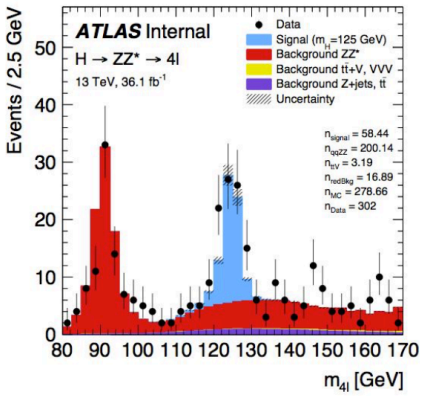
- ANALYSIS: H4L, H prospects(M. Testa convener), MET DQ
- TIER 2
- UPGRADE:
  - PHASE 1: FTK, nSW
  - PHASE 2: interest in ITK

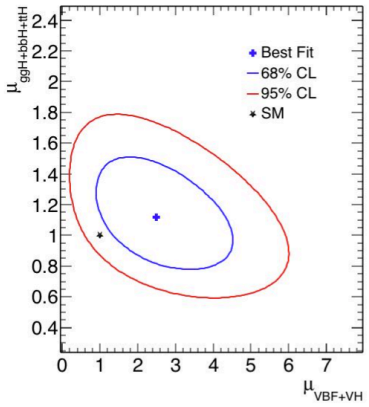
Tier2 di Frascati

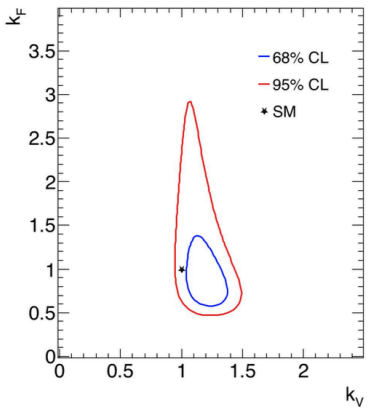
- Esperimenti supportati
  - Finanziati: ATLAS, PADME (dal 2017)
  - Non finanziati: Belle2, CTA, KM3net, VO LHC
- CPU: 24 kHS06
- Storage: 1.5 PBn (1.9 PBr)
- Attività:
  - ATLAS VO management
  - Test e sviluppo per il software di gestione dello storage in Grid DPM
  - Test e sviluppo: Dynafed e Storage Federation

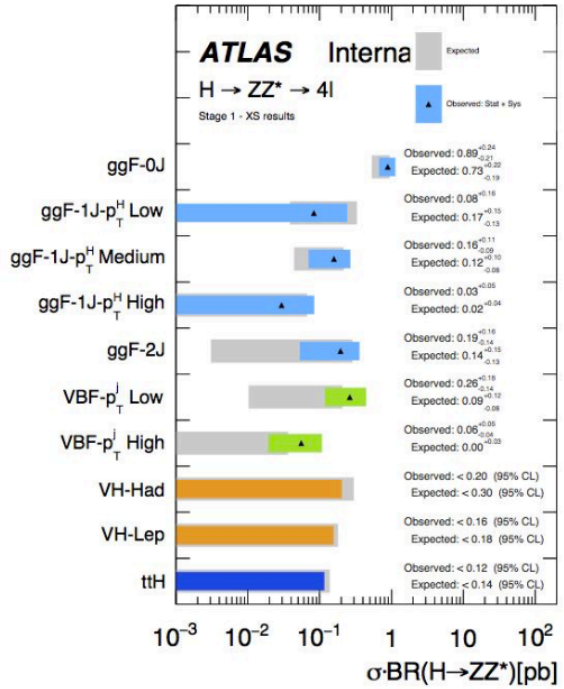
H4l – Couplings Analysis

- 36.1 fb^{-1} @13 TeV data
- Approved on 19th May
- Categories enriched in production modes to extract XS BR: further splitting in pT4l, pT1j to probe possible BSM contributions





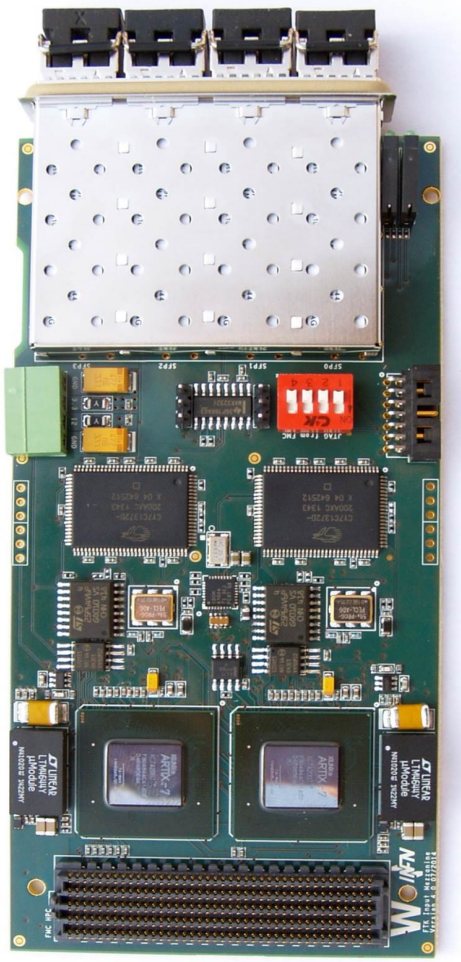




Analysis category	Signal ggF + $b\bar{b}H$	VBF	VH	ttH	Background ZZ^*	Z + jets, $t\bar{t}$	Total expected	Observed
0-jet	26.2 ± 1.9	0.29 ± 0.08	0.253 ± 0.018	0.00025 ± 0.00016	13.7 ± 0.7	2.23 ± 0.31	42.7 ± 2.1	49
1-jet $p_T^{4\ell}$ < 60 GeV	8.1 ± 0.9	0.507 ± 0.025	0.230 ± 0.017	0.00068 ± 0.00030	3.09 ± 0.29	0.53 ± 0.07	12.5 ± 0.9	12
1-jet 60 GeV< $p_T^{4\ell}$ < 120 GeV	4.5 ± 0.7	0.64 ± 0.08	0.227 ± 0.015	0.0010 ± 0.0004	0.88 ± 0.11	0.38 ± 0.05	6.7 ± 0.7	9
1-jet $p_T^{4\ell}$ > 120 GeV	1.11 ± 0.22	0.270 ± 0.035	0.095 ± 0.004	0.00080 ± 0.00013	0.139 ± 0.018	0.045 ± 0.007	1.65 ± 0.22	3
2-jet VH-enriched	2.8 ± 0.5	0.214 ± 0.025	0.580 ± 0.031	0.031 ± 0.004	0.65 ± 0.13	0.187 ± 0.021	4.4 ± 0.5	3
2-jet VBF-enriched p_T^{j1} < 200 GeV	3.9 ± 0.7	2.00 ± 0.15	0.285 ± 0.018	0.065 ± 0.007	1.08 ± 0.25	0.40 ± 0.04	7.7 ± 0.7	16
2-jet VBF-enriched p_T^{j1} > 200 GeV	0.33 ± 0.09	0.183 ± 0.020	0.0500 ± 0.0034	0.0159 ± 0.0018	0.093 ± 0.031	0.054 ± 0.005	0.72 ± 0.10	3
VH-leptonic-enriched	0.0139 ± 0.0016	0.00307 ± 0.00013	0.263 ± 0.016	0.038 ± 0.004	0.049 ± 0.007	0.0137 ± 0.0013	0.380 ± 0.018	0
ttH-enriched	0.056 ± 0.013	0.009 ± 0.005	0.0196 ± 0.0019	0.301 ± 0.029	0.014 ± 0.005	0.07 ± 0.04	0.47 ± 0.05	0
Total	47.0 ± 3.3	4.11 ± 0.18	2.00 ± 0.11	0.45 ± 0.04	19.7 ± 1.3	3.9 ± 0.5	77 ± 4	95

FTK IM (Input Mezzanine)

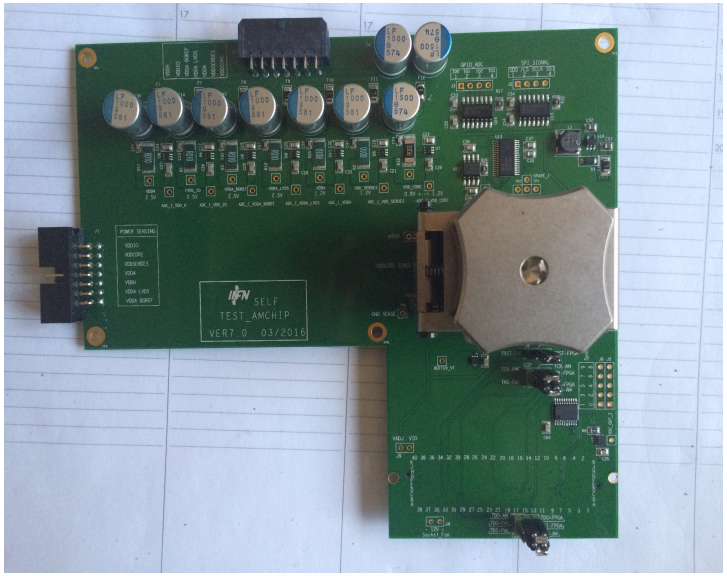
- Artix mezzanine produced by LNF are all installed
- No working problems even with new pixel IB layer
- Up to now no intervention or maintenance are needed
- Actually we give help and support to Japanese group in debugging firmware for Spartan6 IM mezzanine



FTK IM board designed at LNF

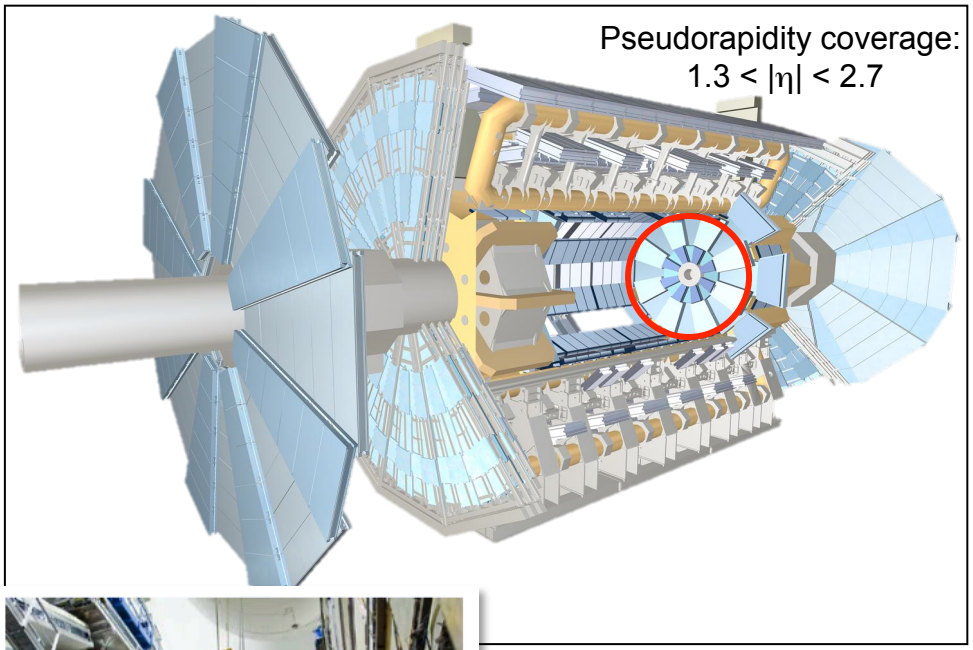
FTK AMchip06

- First bunch of 8000 chip are produced and test is under way
- Test are performed by external company: Microtest
- Problems during test with Amchip socket, it shows signs of strain
- In anticipation of testing other 10000 chips we decide to change the socket with a more reliable one.
- Yeld of the Amchip06 first batch of production is about 85%
- Actually we follow the company for the tests and maintenance of test stand.
- We have plan to complete the tests of the remaining production in the beginning of next year.

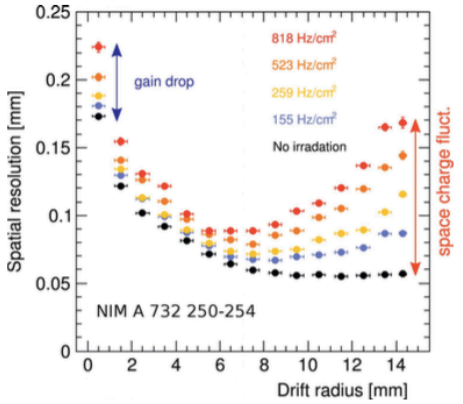


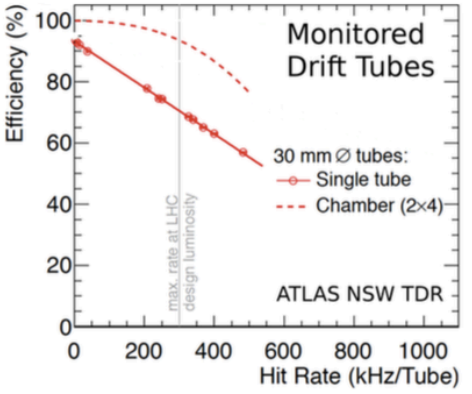
AMchip06 test board designed at LNF

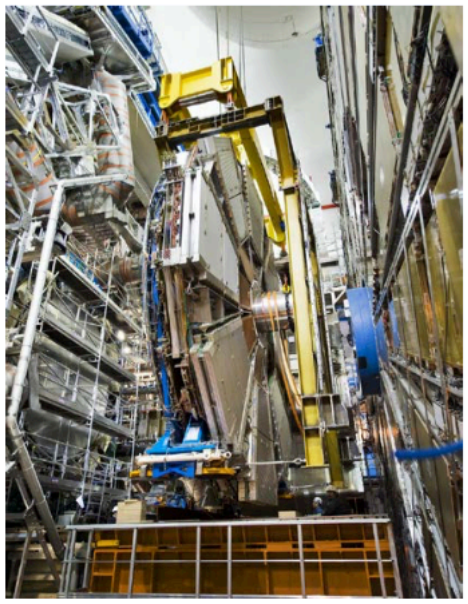
The NSW: The Actual Small Wheel



Small Wheel designed for Luminosity up to 10^{34} $cm^{-2}s^{-1}$

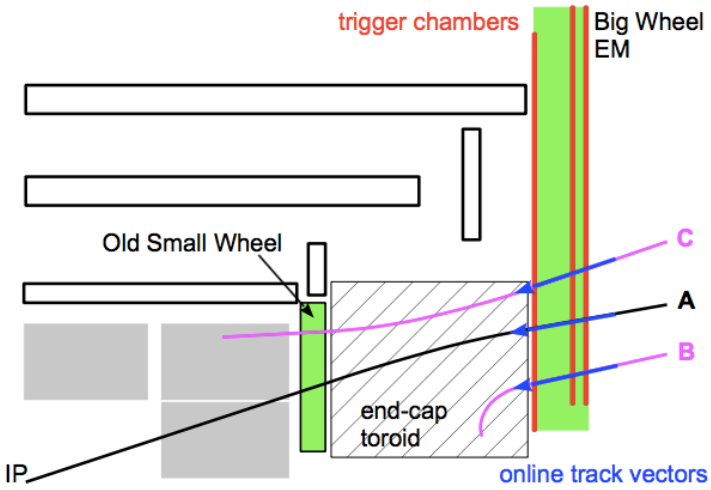






Small Wheel Detectors:

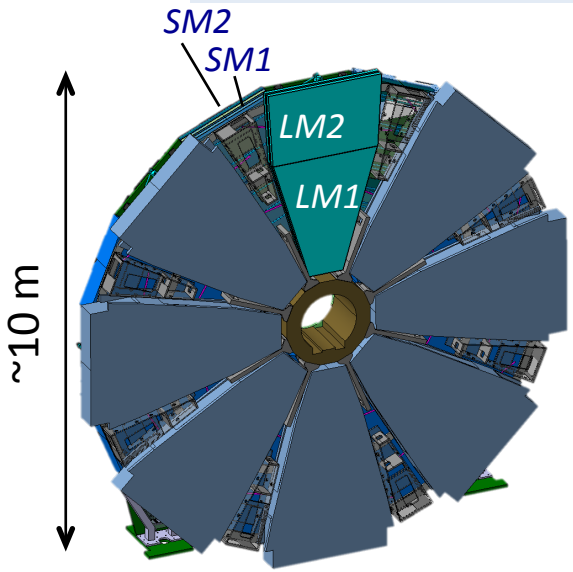
- Atlas Tubes (MDT) 30mm dia.
- Cathode Strip Chamber (CSC) in the inner part
- TGC for 2nd coordinate



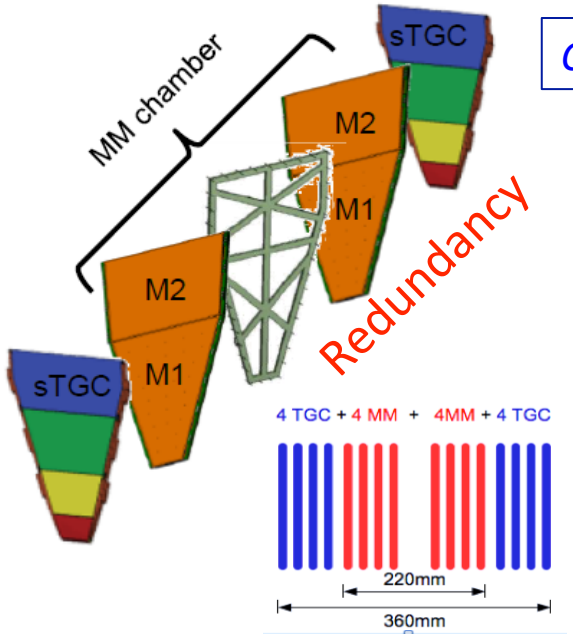
- currently: tracks A, B, C create Level 1 trigger

The NSW

Main ATLAS upgrade during the Long Shutdown 2 (2019/20) (Phase-1)



Each NSW has 16 sectors
8 Large + 8 Small



CERN-LHCC-2013-006 ATLAS-TDR-020

Two different technology:
- MM (main role tracking)
- sTGC (main role trigger)

NSW Requirements

- 15% P_T resolution at 1 TeV

→ ~100 μm resolution per plane

- Keep single muon trigger under control

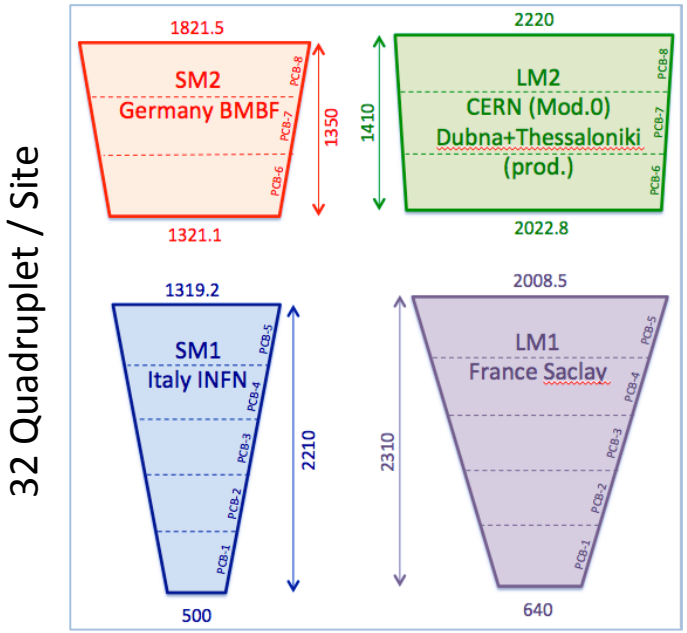
→ 1 mrad online angular resolution

About 15kHz / cm^2 at L ≈ 5 x 10^{34} $cm^{-2}s^{-1}$

S/L M1 : 5PCB
S/L M2 : 3PCB

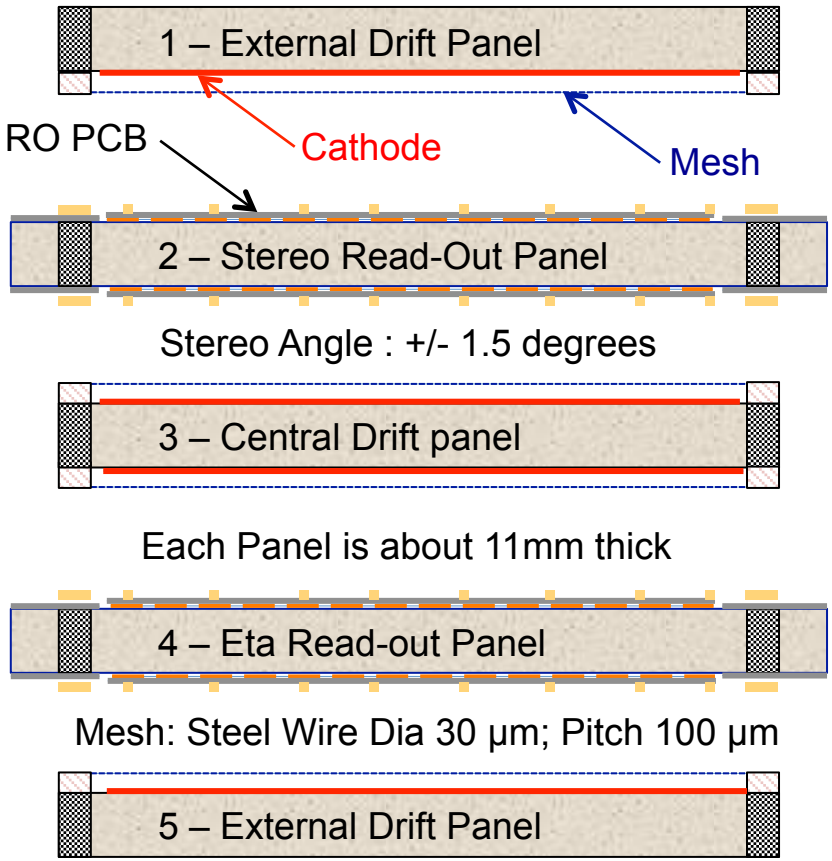
PCB:
~ 420mm wide
1024 Strips

MM Sharing



ATLAS MM : Structure

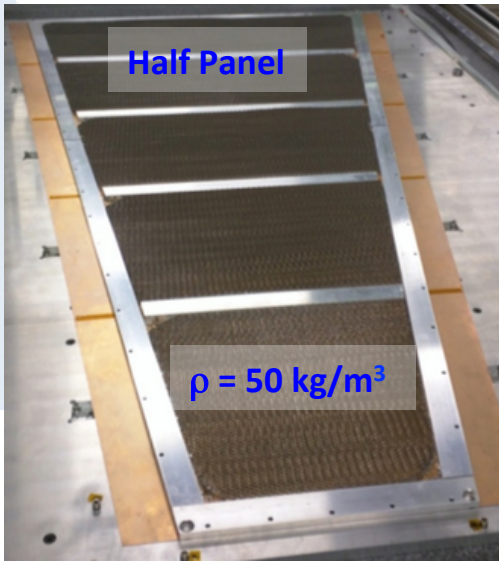
MM Quadruplet Exploded View



Five panels joined to make a detector unit (Quadruplet) with 4 gas layers.

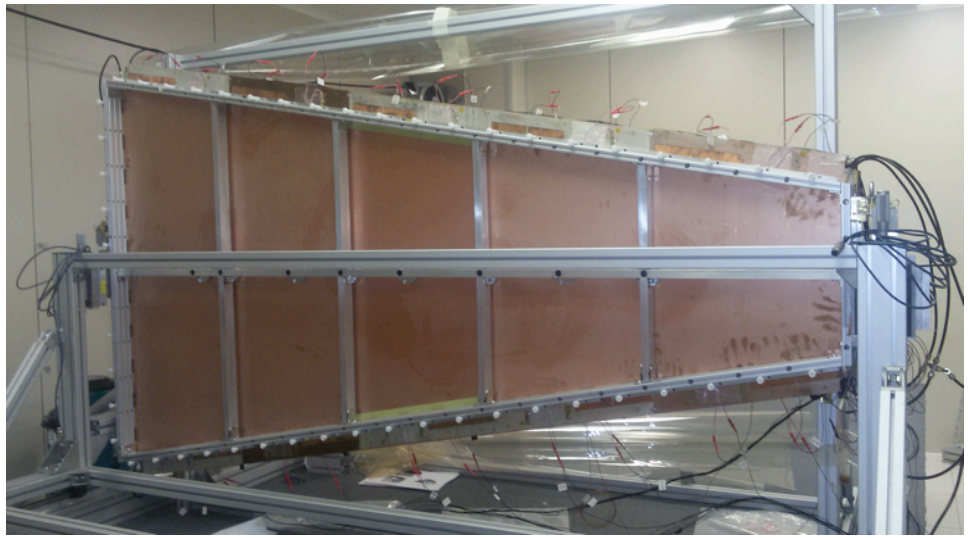
Building Large Area MM

- Panel is a sandwich of 0.5 mm PCB skin with honeycomb in the middle and frames in the perimeter and in the joint of two adjacent PCB. Honeycomb and frames are in Al.
- Different Panels are needed for a Quadruplet
  - RO Panels (Eta and Stereo)
  - N.2 External Drift Panels
  - One Central Drift Panel
- For each gas layer a unique Mesh is glued on the drift panel, using a custom frame that define the 5 mm height.
- Slow bi-component epoxy is used as glue.



SM1 module 0 and 0.5 and production

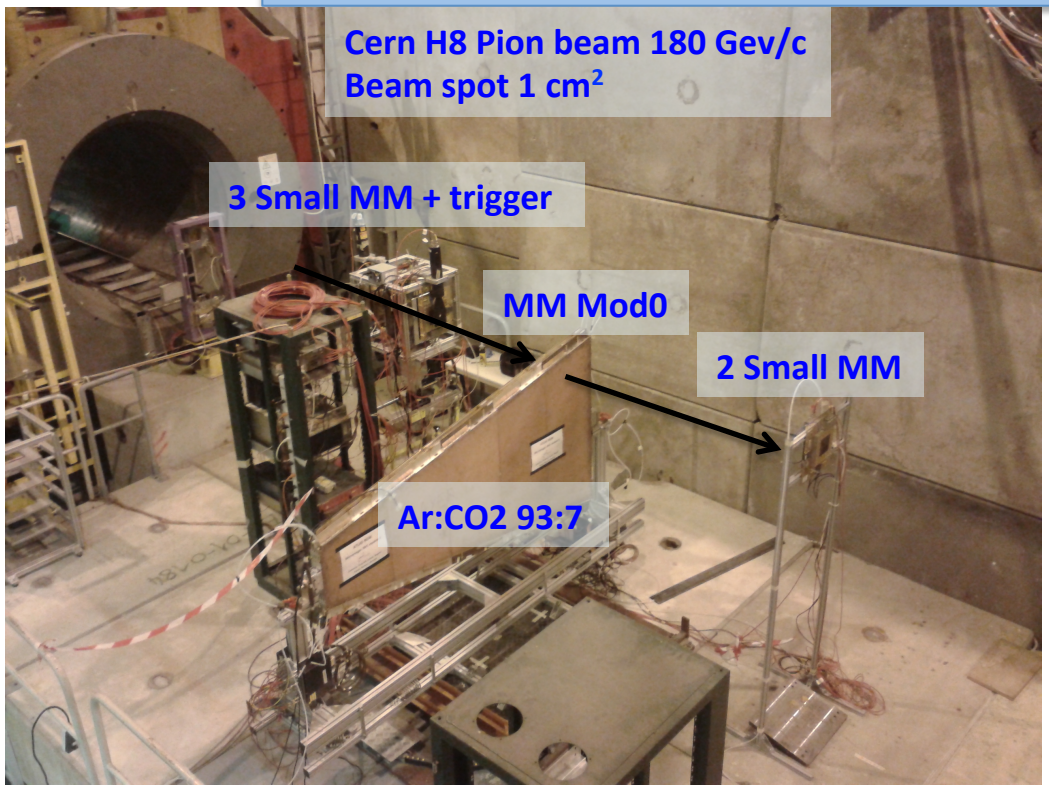
- Module 0:
  - Finished in mid April 2016 (first to be completed by far)
  - Several tests:
    - QA-QC (LNF)
    - Test beam (CERN)
    - Operation with deformations (CERN)
    - Installation (CERN)
    - At CR Test stand @LNF
- Module 0.5:
  - Finished mid May 2017
    - QA-QC (LNF)



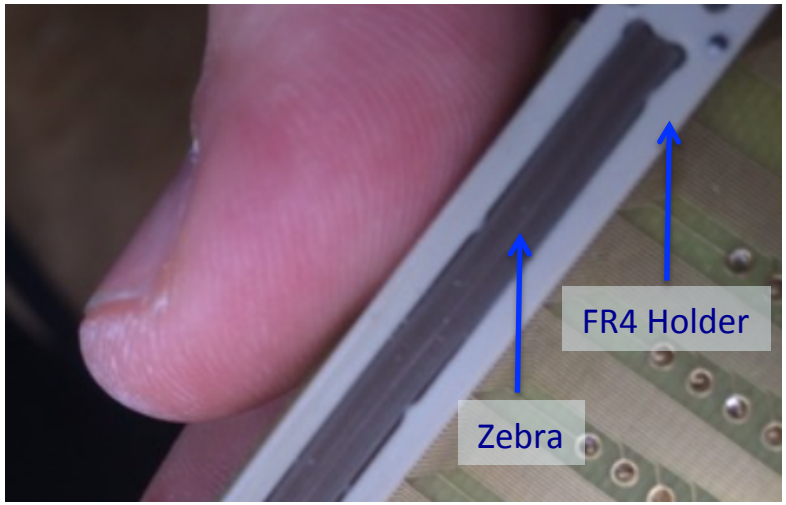
- Production:
  - PRR just passed
    - Review after construction of 4 modules (to check pcb quality)

Production already started!

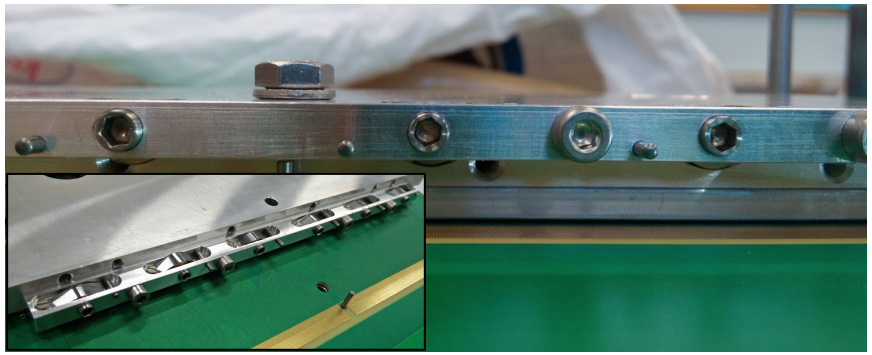
MicroMegas Test Beam at Cern H8



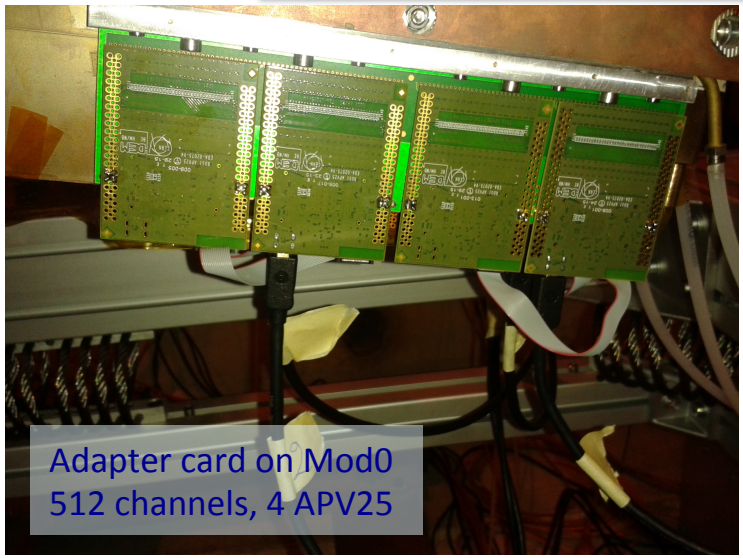
Used final Zebra connectors to Read-Out the strips with some adapter boards to use the APV25 being the final electronic not jet available.



Zebra connector is a rubber strips with high contacts density inside (typical pitch 50-100 μm).
The Read-Out card has the identical footprint of the PCB and the zebra get connection.
Zebra needs to be pressed in order to get contact, this is done via a compression bar.



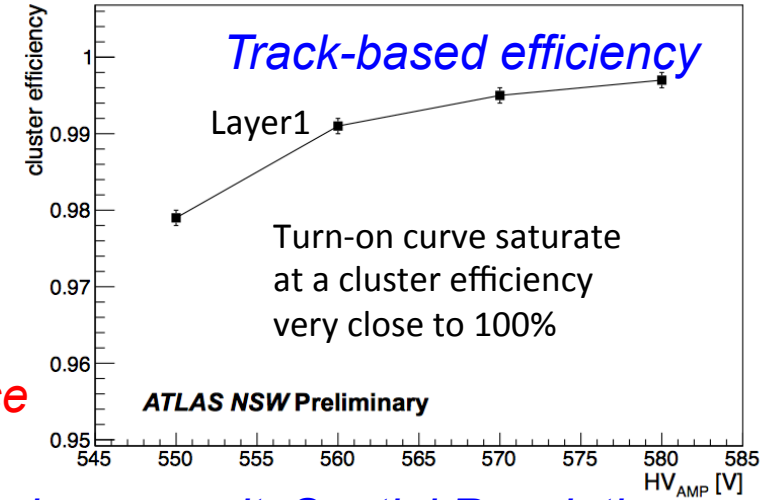
MicroMegas Test Beam at Cern H8



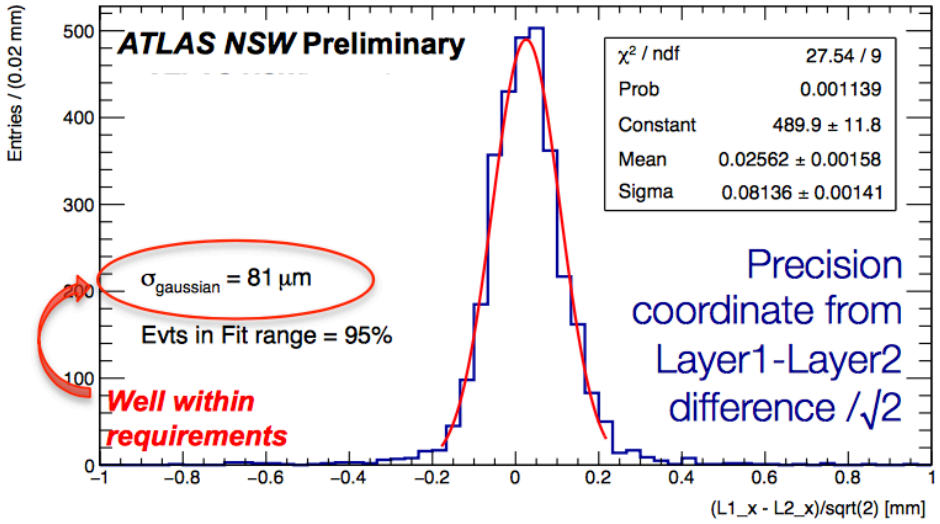
One cluster within given distance from the reference track impact.

Normal Incidence

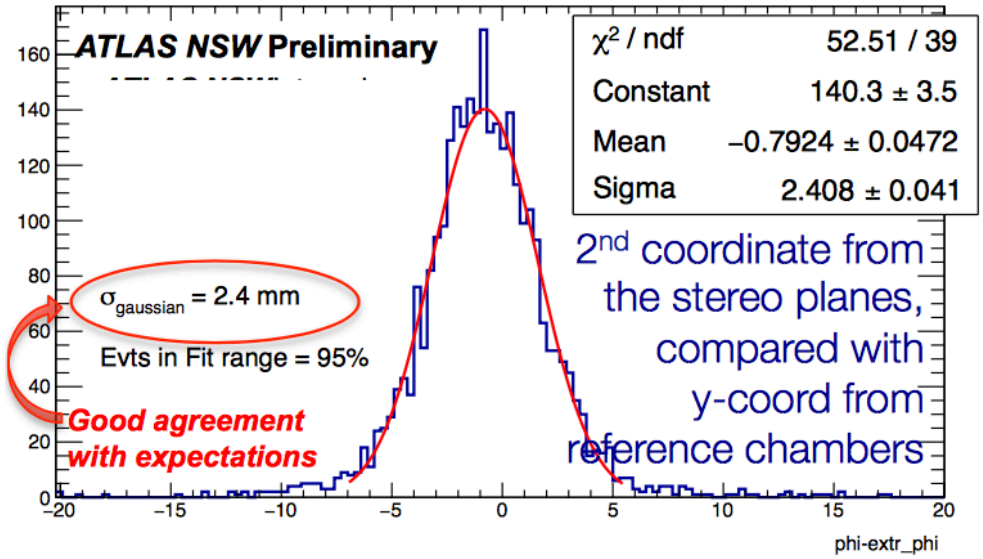
Cluster efficiency Vs Amplification HV



Preliminary result: Spatial Resolution of the precision coordinate



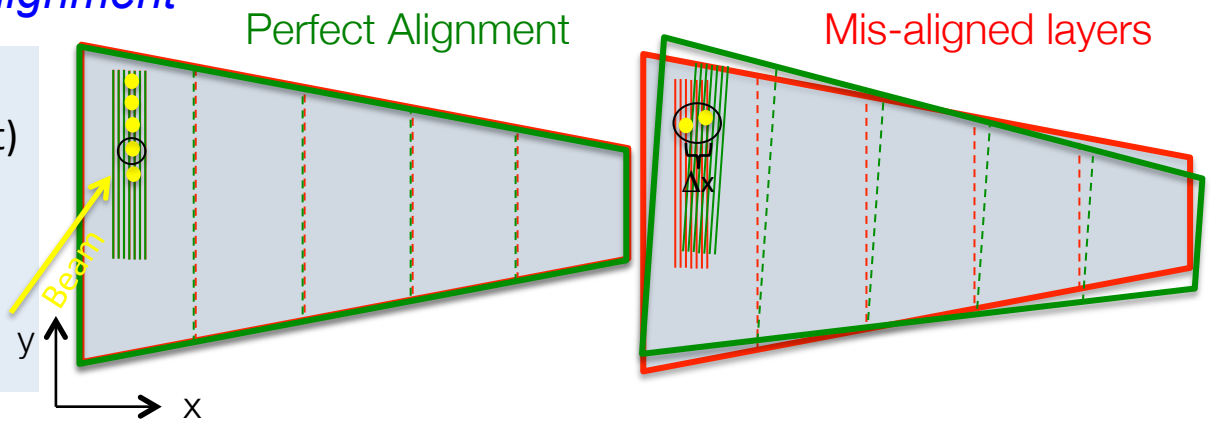
Preliminary result: Spatial Resolution of the second coordinate.

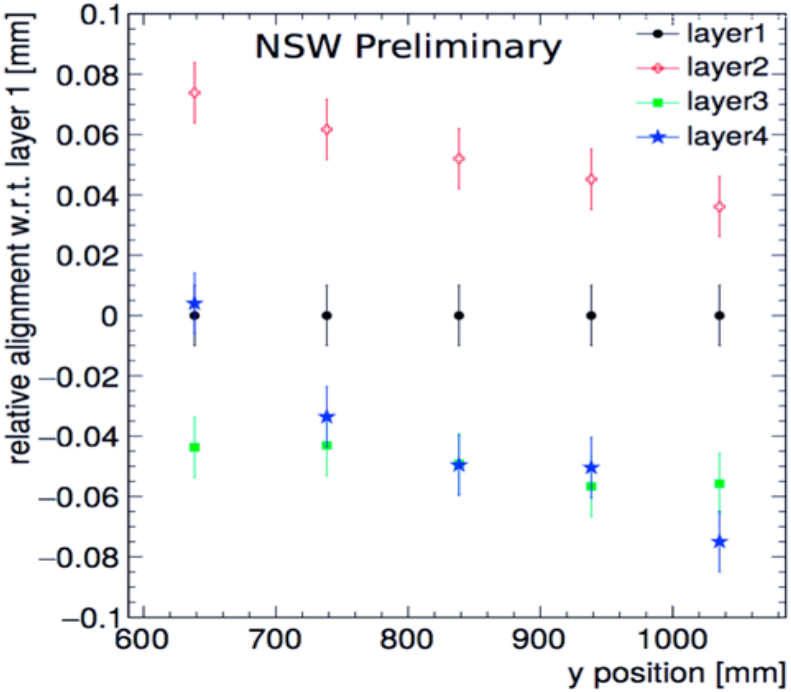


Evaluation of Layers Relative Alignment

Measurements at different vertical positions, along the strips. (yellow spot)

For each y-position measure Δx between *layer_i* and *layer-1* using reference tracks defined by the small bulk MM in the beam setup





$\Delta x = x_{layer\_i} - x_{layer\_1} = 0$ $\Delta x = x_{layer\_i} - x_{layer\_1} \neq 0$

Relative Alignment wrt Layer_1 :

- Measured a maximum deviation of +/- 80 μm
- The effects are both shifts and rotation
- Under investigation at the construction site
- Before production start a second Mod0 (called 0.5) will be built using the control system based on C-CCD.

General Organization of SM1 chambers production

Construction “sub-sites”

Roma-1: Drift Panel construction
(RM1 team - resp. F.Lacava)

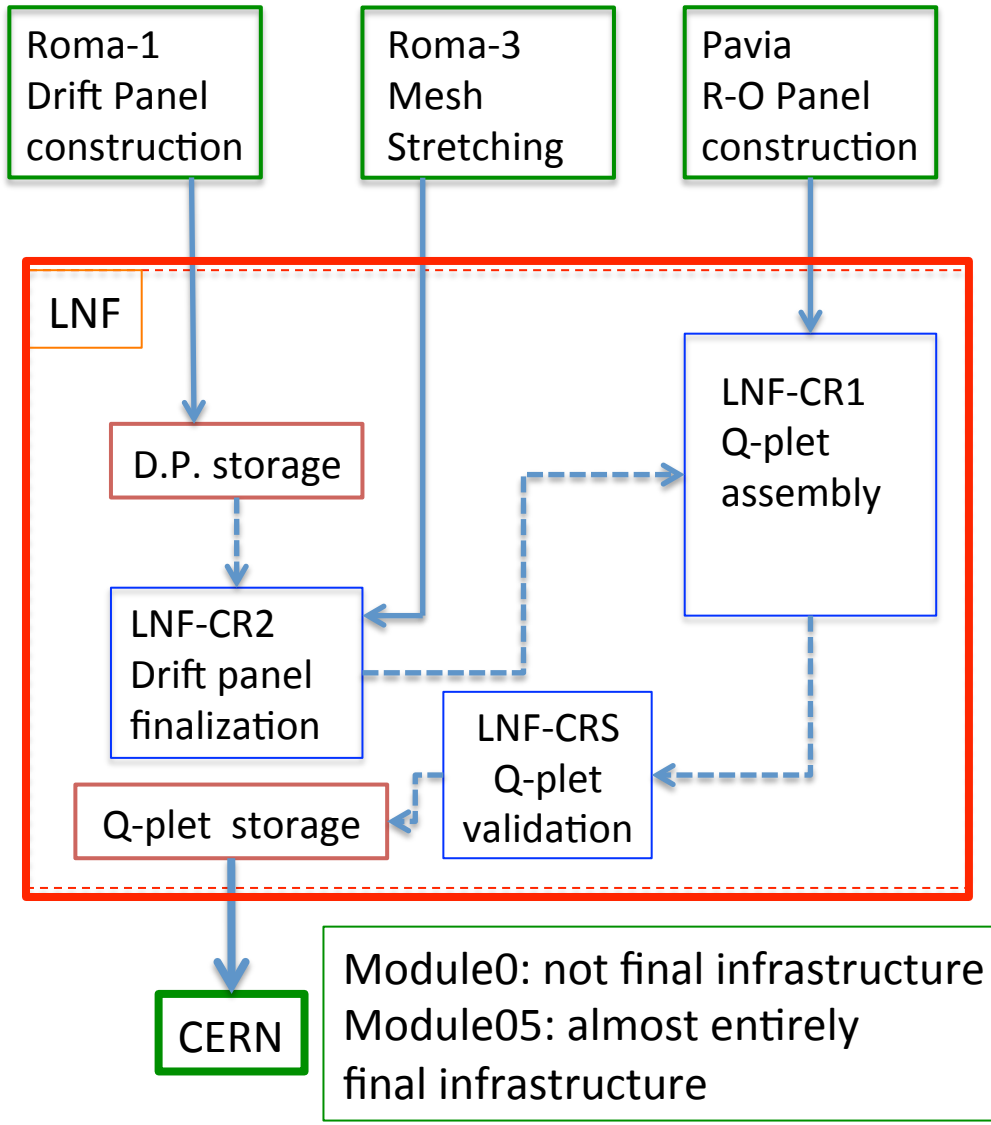
Pavia: Read-Out Panel construction
(PV team - resp. G.Introzzi)

Roma-3: Mesh stretching
(RM3 team – resp. M.Iodice)

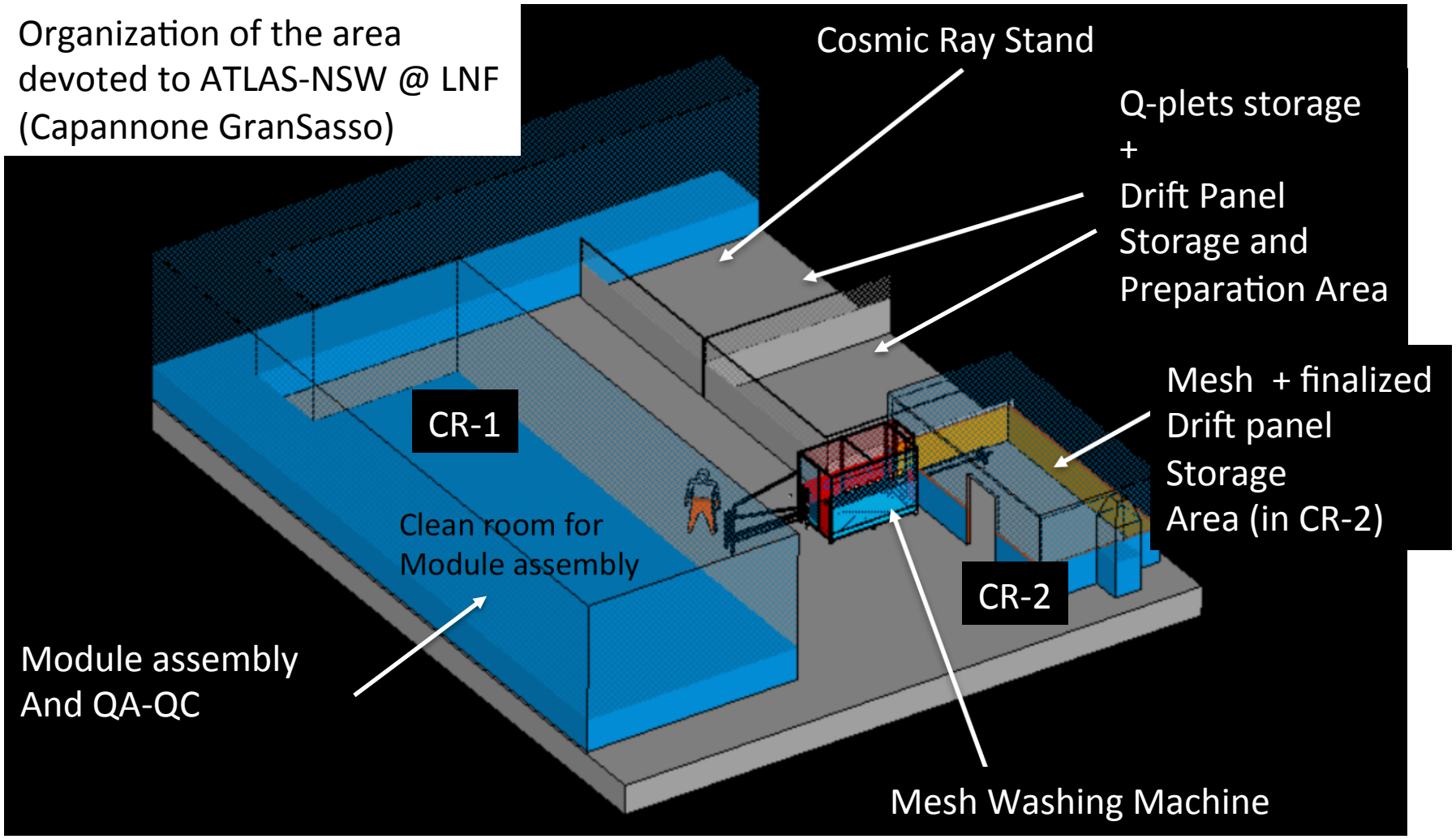
LNF-CR2: Drift Panel finalization
(CS-LE-NA-RM3 team – resp. M.Iodice, M.Schioppa)

LNF-CR1: Q-plet assembly
(LNF team – resp. G.Maccarrone)

LNF-CRS: Q-plet validation
(Team of people from all groups
- resp. G.Maccarrone)



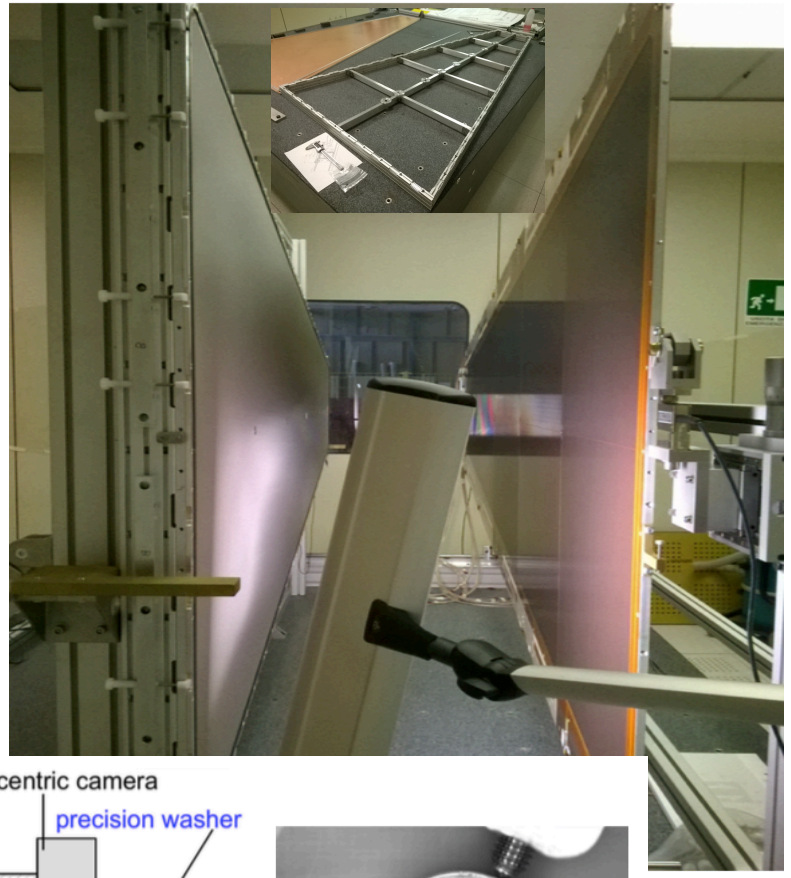
Logistics at LNF

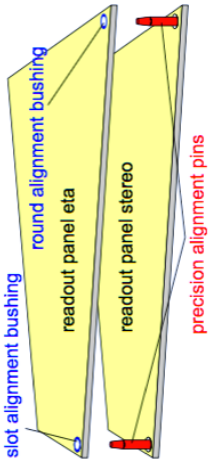


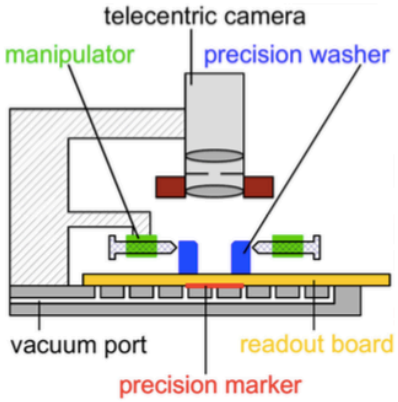
Vertical Panel Assembly

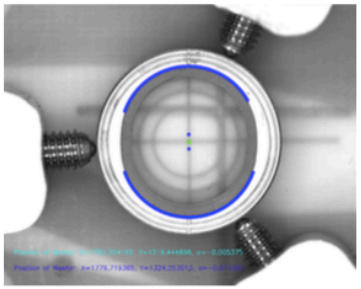
- Cleanliness
- No panel deformation under its own weight
- Panel deformation because of the mesh

External drift panel, because of the mesh tension, is deformed, with a sagitta of about few mm, when put in vertical.
During the assembly a support structure called stiff-frame is used and visible on the left part of the picture (fixed part);
RO (stereo) panel on the right (movable part)
Precise pins/slot are glued on the RO panels for relative alignment



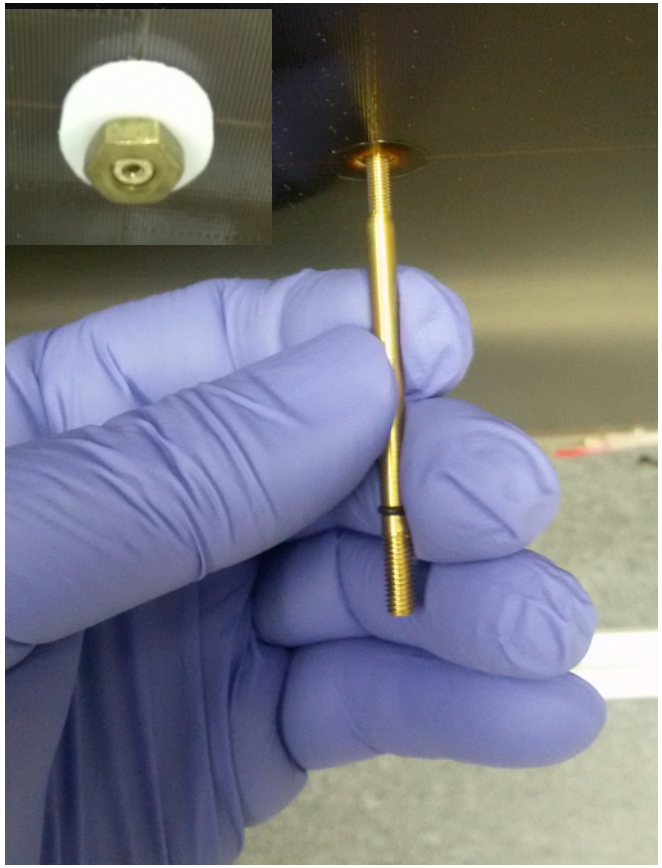






Assembly QA/QC : Gas Leak

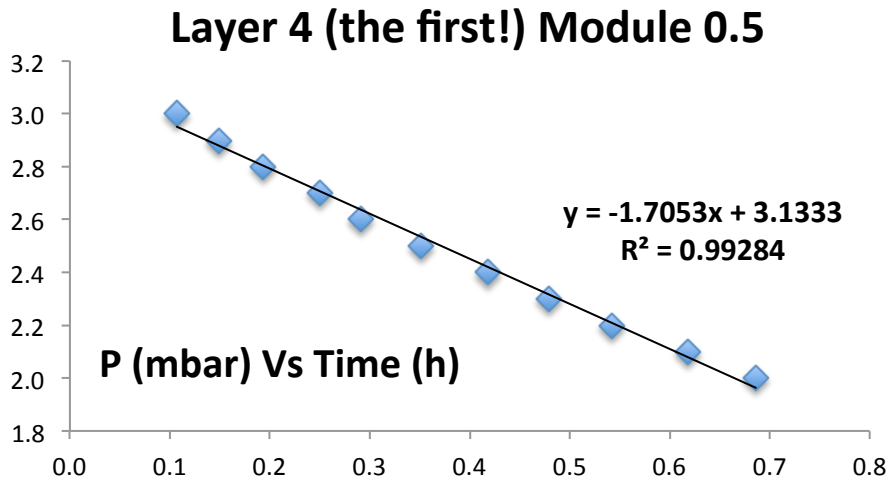
To close the Layers Gas Volumes during the assembly (when the Q-plet is not completed), it is needed to close the interconnections hole.



The SM1 M0 was characterized by a poor gas tightness.

Further studies, mainly done by the Cern group, demonstrated that the main reason was the small O-Ring diameter (6mm).
In M0.5 we adopt the final solution with O-Ring of 7mm diameter.

Leak measurement are done using a differential manometer.
Assuming rigid volumes the limit in pressure drop is 0.6 mbar/h at the working point of about 3mbar overpressure.



The Layers gas volume cannot be closed when two layers (three panels) are assembled, this is due to the geometry of the distribution scheme.

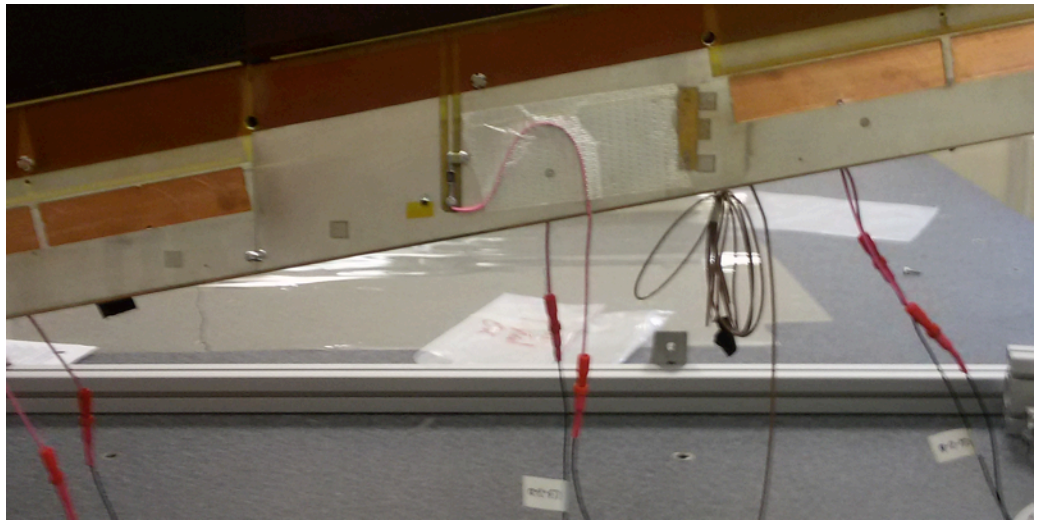
Assembly QA/QC : HV

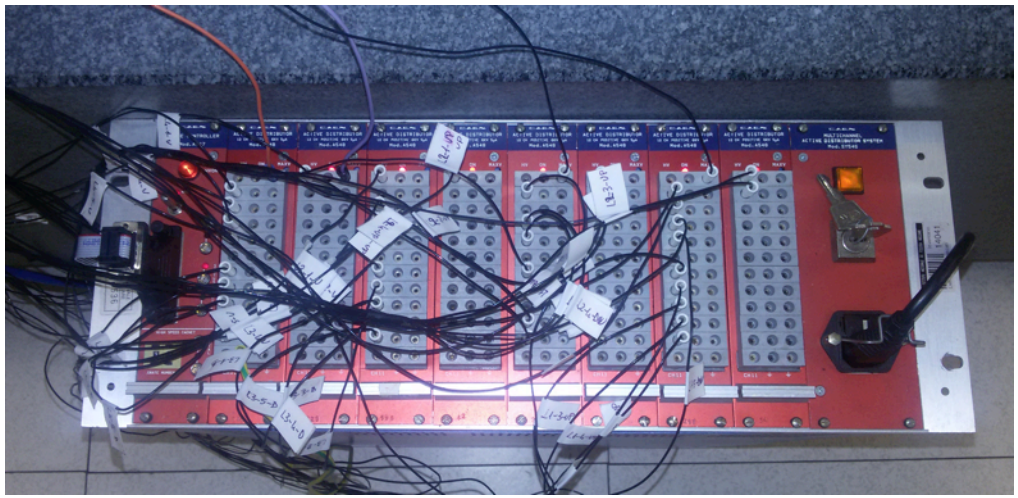
In a SM1 Q-plet there are 40 sectors, 10 sectors per layer with 5 different PCB, each PCB is divided into two halves. Needs 40 independent HV channels.

To perform HV test a provisional cabling is needed.

In M0 we used a prototype of the final distribution scheme.

In M0.5 we decide to adopt the provisional solution we will use in production.





This HV Power Supply was developed for an experiment using old Iarocci's Tubes.

It meets all needs and we are successfully using for M0 and M0.5 (we have three!).
It was designed more than 20 years ago, and we are experiencing difficulties in have it read out using a PC for control and values recording.

Hope to solve this, or we have to get some more "modern".

Q-Plet Validation : Mechanics

Mechanical measurements are done at LNF with the support of the "Metrology Service"

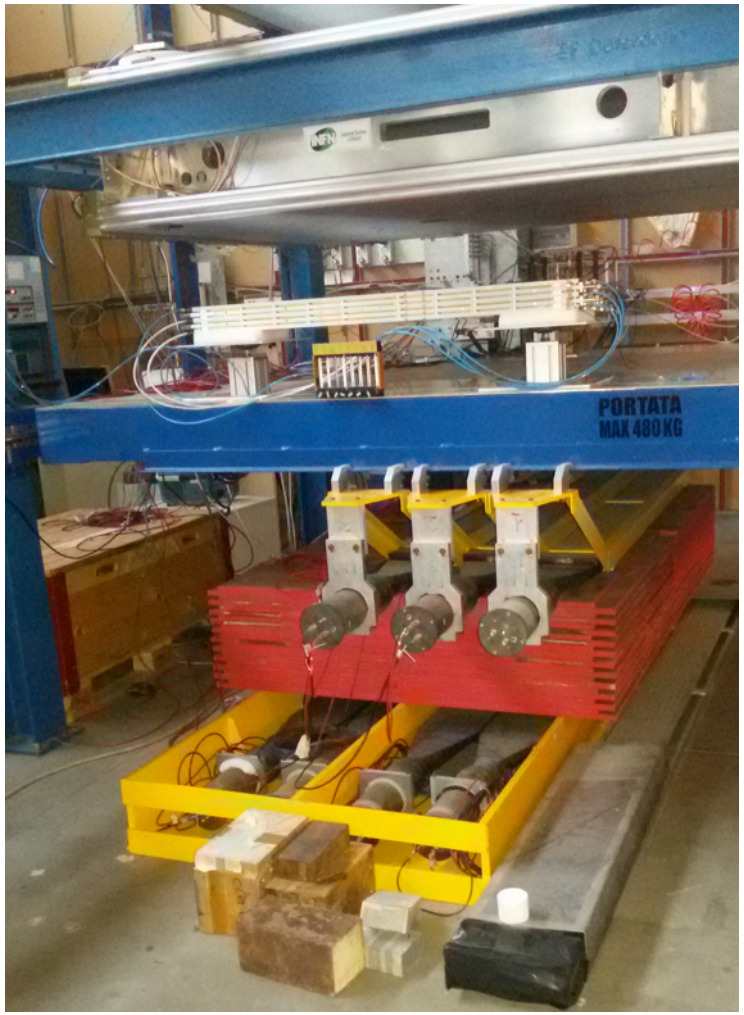
Two different tools can be used:

- Laser Tracker (in background in the pic)
- Laser Arm (in close up in the pic)

Laser Tracker is used with a sphere in contact with the object to measure, so cannot be used with the detector in vertical.
Laser Arm is used without any contact but is limited by the Arm dimension and movement.
Laser Tracker is more precise than the Laser Arm.

For M0 we used both as test of the validation procedure with the detector in vertical position as in the experiment.
The initial idea was to measure in one run only: Planarity, Thickness and the position on the Rasmask present on the PCB on both side of the Q-plet. This provide a measurement of the two RO panels relative alignment.

Q-Plet Validation : Cosmic Stand



The Cosmic Stand is the one built for the MDT test, some changes have been done to be used for MM, 30cm of Iron provides a good low momentum cut.

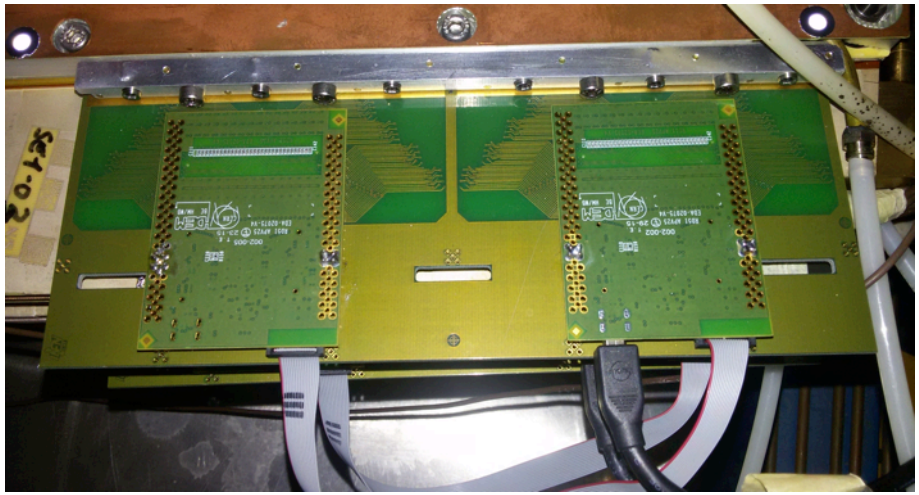
The trigger is provided by 8 scintillators of about 0.2x1.8 m^2, under the Iron, in 4 couple to have some information (20cm resolution) on the coordinate along the scintillators.
Three more identical couple are placed on top of the Iron and are movable.

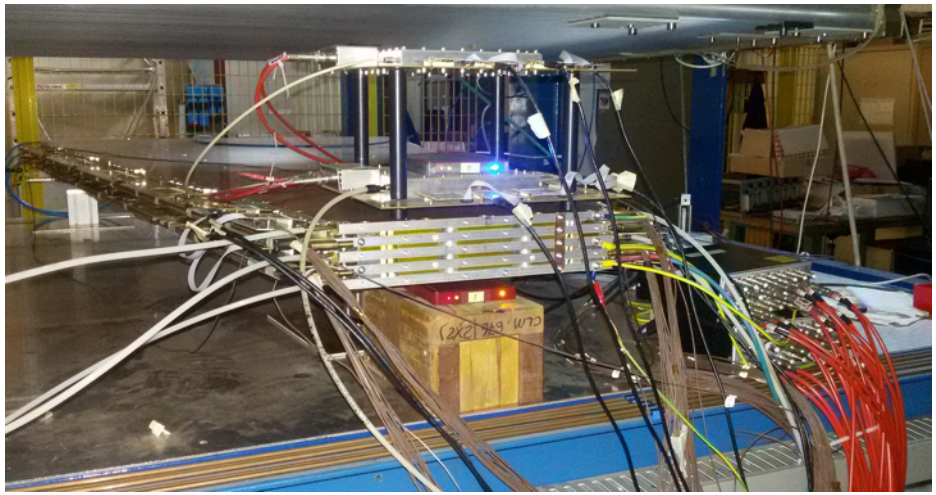
One MDT is fully operational and used as external device.
Work is in progress now to increase the rate capability of the DAQ joining the MM and the MDT.

With an extrapolation error of the order of mm, the MDT can be used to evaluate the efficiency not the resolution

In the Pic on the right the installation of the M0 in the Cosmic Stand is shown.

Q-Plet Validation : Cosmic Stand





The validation test in the Cosmic Stand is not done with the final Electronic Cards.

APV25 chip, plus the SRS system for the RO, has been used in many test beams for MM prototypes.
It works reasonably good, therefore we decide to use it to test the Chambers in production.

The pic on the left shows the interface card produced in Italy to use APV25 for our MM. One channel readout two not adjacent strips, this to reduce the number of channels both for costs and DAQ speed.
As a remind in a SM1 we have 20k strips!

We have channels to read out 3/5 of one SM1 MM (6k electronics channels), we have to repeat the measurement twice…with some overlapping.

In the pic on the the right the actual setup is shown, a small trigger and two MM prototypes.

Assembly QA/QC : HV

HV Test Procedure:

- HV test can be performed in Air and/or in Gas
- Test in Air requires a HV value higher than in Gas (typical values are 580-600V in Standard Mix and 800V in Air)
- Test in Gas is more robust but need more time and in one case is not feasible (three panels/ two gas gaps assembled)
- Both tests can be used depending on time availability (for results see later…)

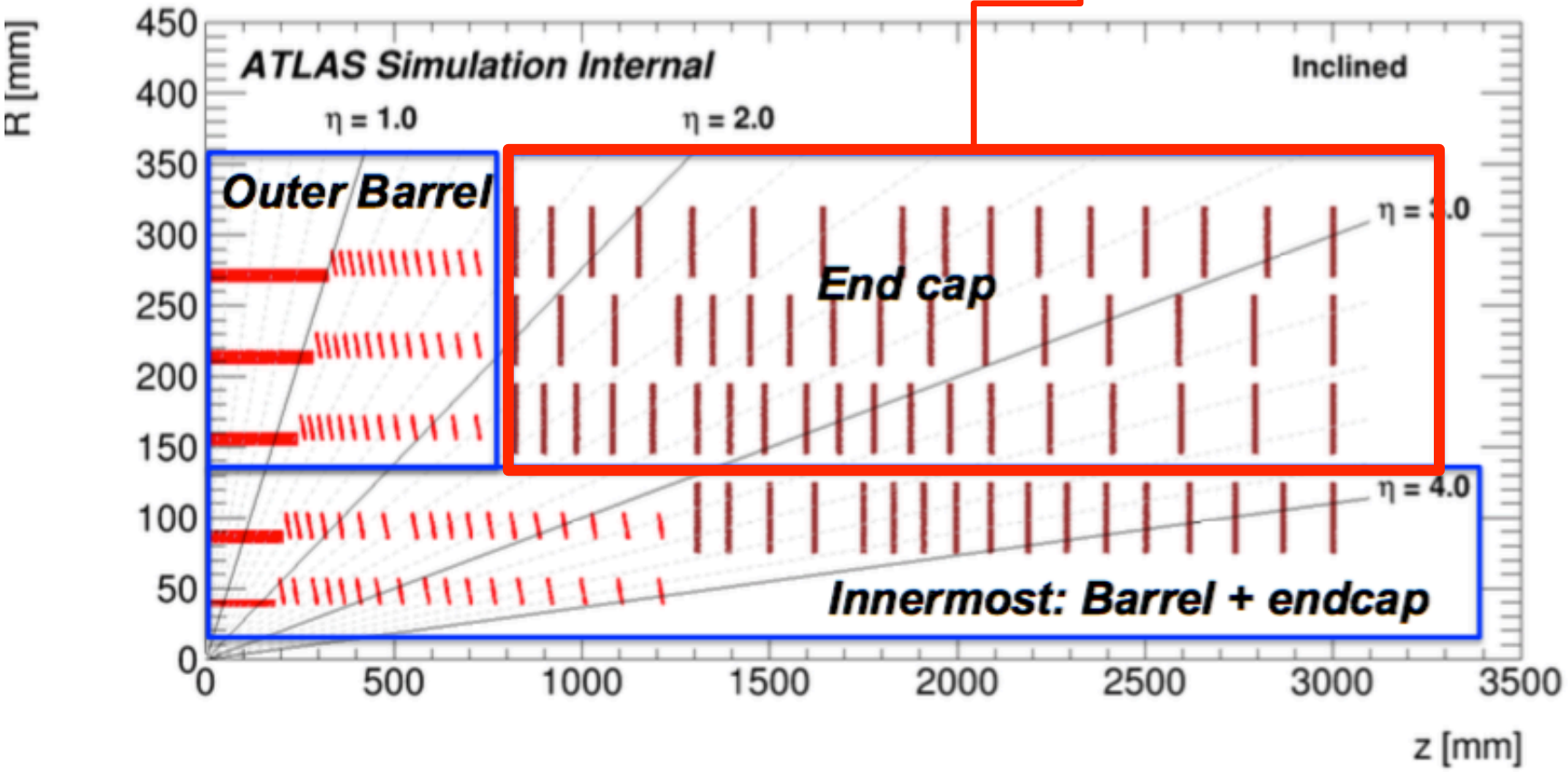
Assembly Schedule

- The mechanical part of the assembly is relatively fast, a gap can be mounted in a day.
- Test is more time consuming.
- The initial approach is to reserve two days for each gap and leave two more day for final test and Q-plet dismounting from the assembly tooling. Two weeks per Q-plet.

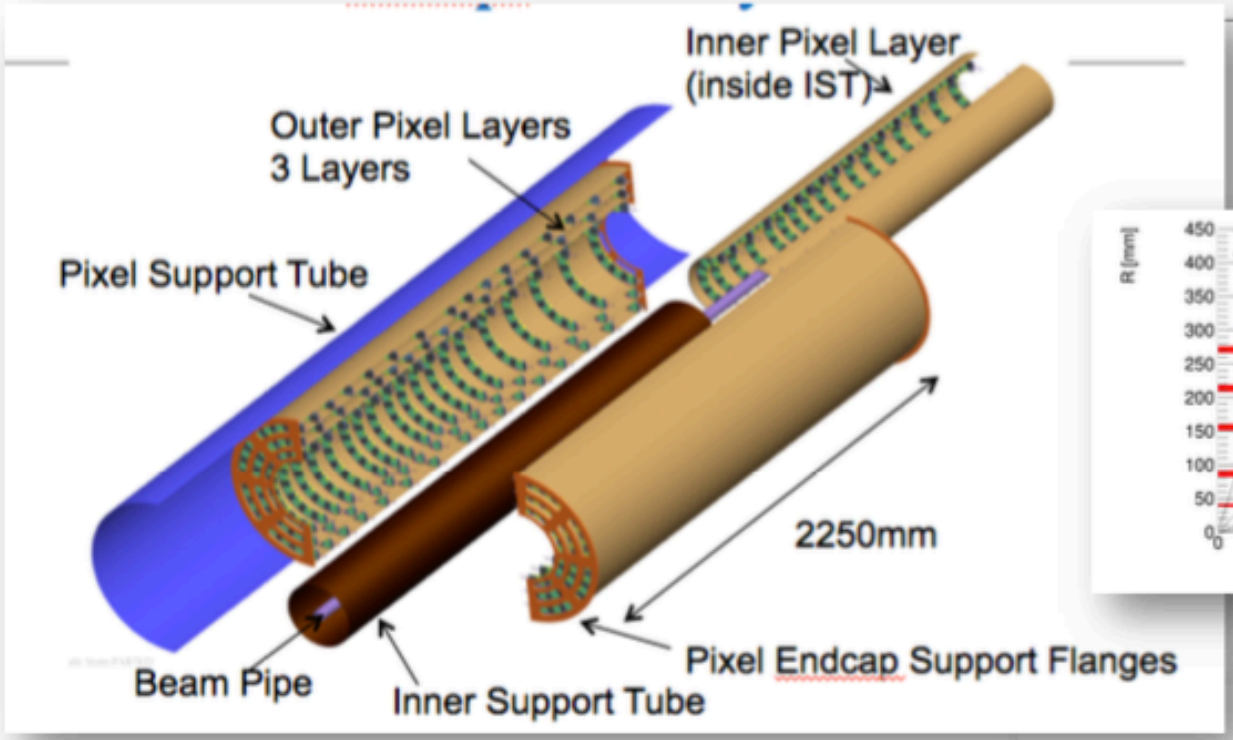
ITK

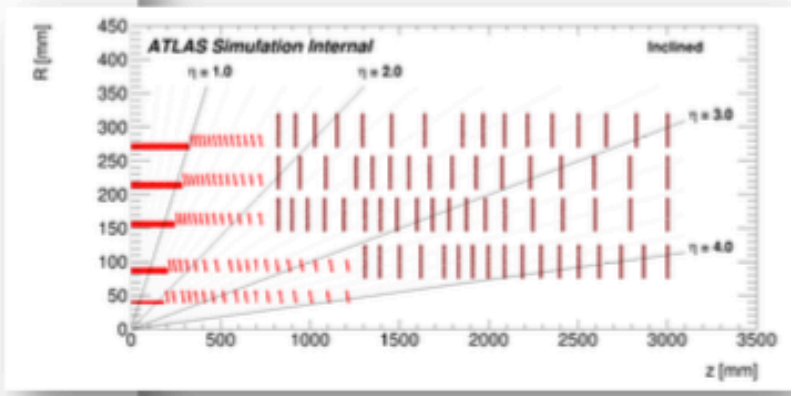
Atlas Phase II Track Upgrade

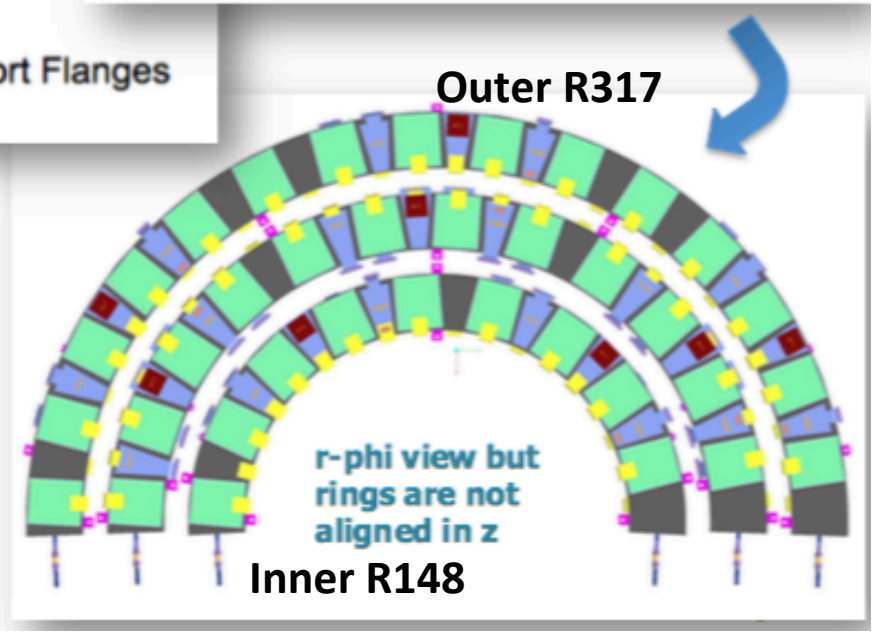
- **INFN interested in 1 Endcap:**
  - **~2m long, 70cm diameter, 3m^2 active area!,**
  - **> 50 rings (100 half-rings), 2500 modules**
- **The other one built in England**



Endcap overview







19 Inner Rings
16 Middle Rings
16 Outer Rings

Inner: 18 modules/half-ring
Middle: 24 modules/half-ring
Outer: 30 modules/half-ring
36 x 19 = 684
48 x 16 = 768
60 x 16 = 960

2412 modules (will be reduced 1/2)
(2538 with spares)

INFN possible Activities

1. Module building
2. Half-ring Ring Building
3. **Electric Services (PP1)**
4. **Loading of modules to the half-rings**
5. **Endcap building**

} LNF

LNF possible activities (<u>still under negoziation</u>)

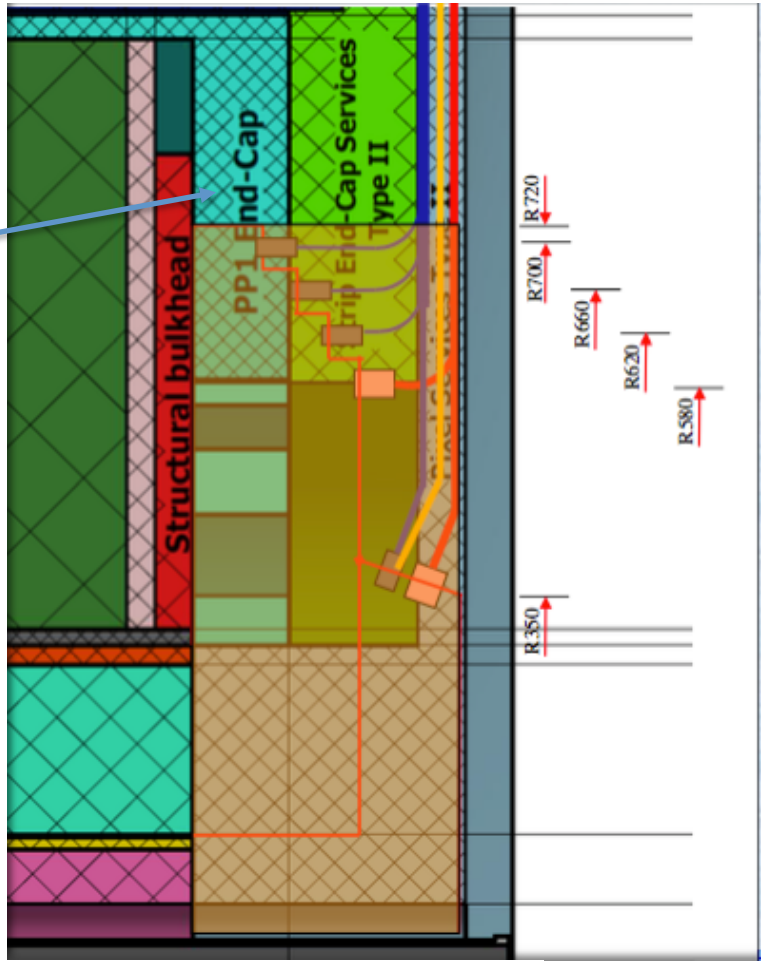
-Services electric responsibility (pp1) in synergy with muon services responsibility

- up to 1/3 of module loading

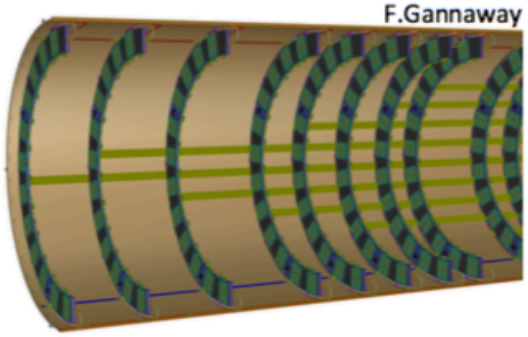
- LNF can be the integration site (man power from all Italian groups)

Electric Services for PP1

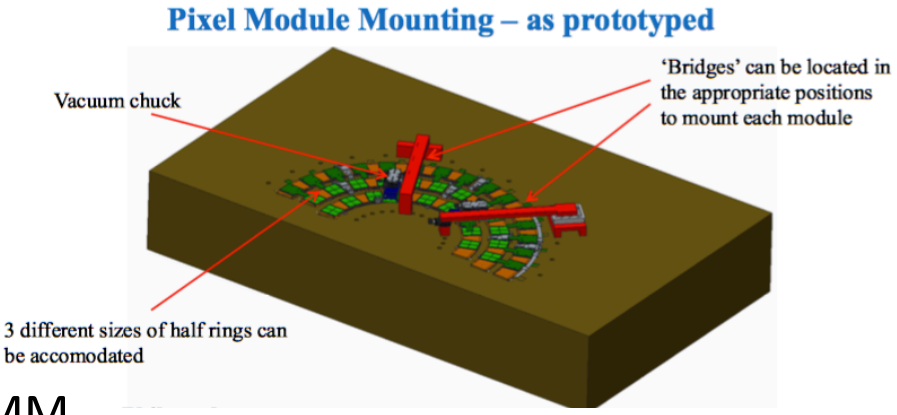
- Pietro Albicocco committed to design patch panel 1 (PP1)
- Need help from mechanical service to evaluate spaces, routing of cables inside endcap, etc
- Timeline : Gen 2018 - Dec 2019
- Requested ½ FTE from servizio elettronica and ¼ FTE from servizio progettazione



- Activity in synergy with the LNF responsibility (Beretta) for fase 2 upgrade of powering system for muons

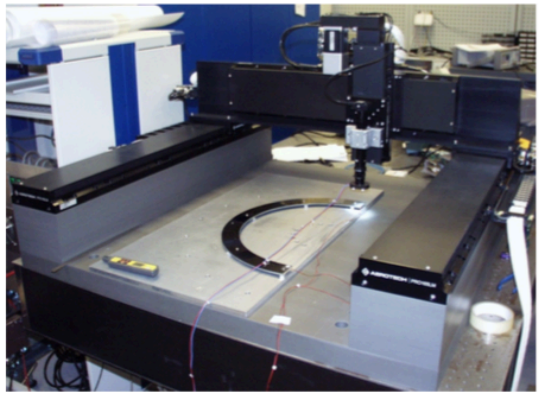


Module mounting on half rings



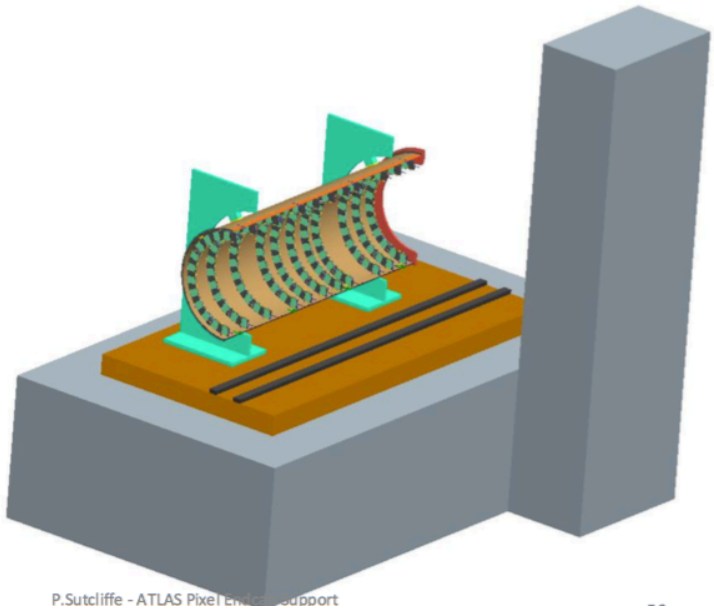
- Use ALICE competences and the existing CMM

- Timeline:
  - System design(with UK) and test by Dic 2020
  - Loading and QA Gen 21 – Gen 23
  - Alice timeline: Production: Sep 2017-February 2019
- Man power
  - Similar < Alice



- Infrastructure request:
  - CO2 cooling system ~2kW (Lukasz) 165 kE, to cool the populated half-ring
    - Needed also for test 10% of the whole integrated endcap

Integration



- LNF will be the integration site
  - tool development
  - include activity for PP1 design (SL 4)
- Timeline:

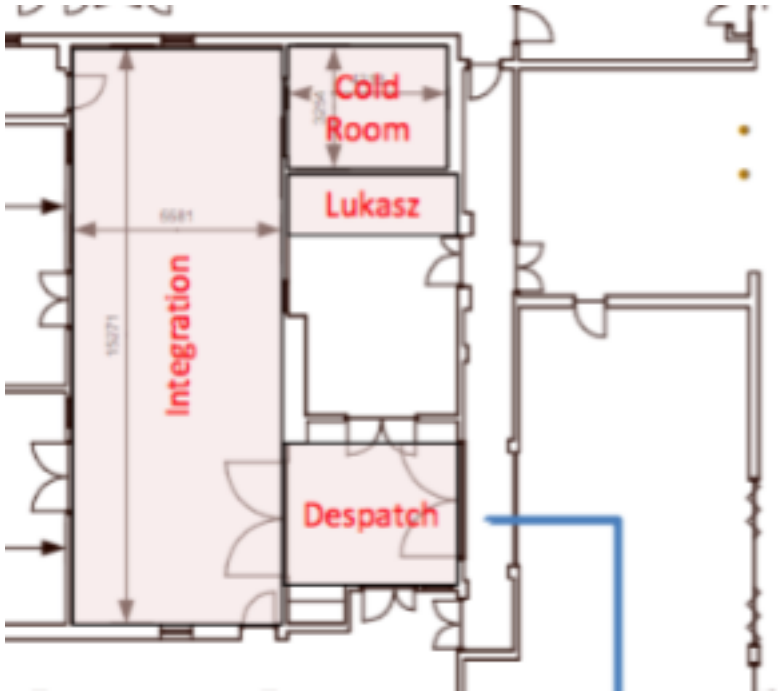
Integration

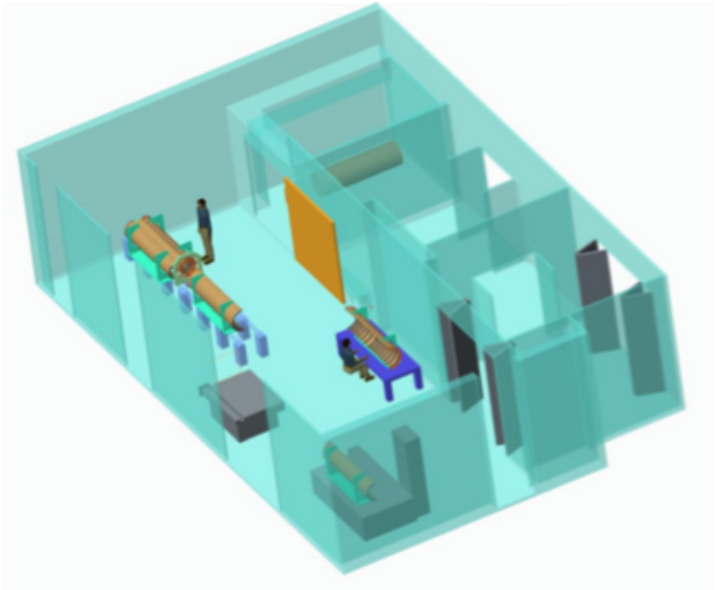
preparazione half shell	6		gen-22	May-22
montaggio half ring	52	half-ring	set-22	Mar-23
QA	6	half-shell	set-22	Mar-23
integrazione half shells	6	half-shell	giu-23	Jul-23

- Infrastructure request:
  - CO_2 cooling system ~2kW (Lukasz) 165 kE, to cool the populated half-ring
    - Needed also for cooling the half-ring (previous slide)
  - Climate chamber with controlled temperature and humidity (50kE)
    - to test the whole integrated endcap

Integration II

- Need renovation of rooms to let the cylinder pass:
  - ~ 10kE
- Issue with transfer of ASTRA building and where the CMM will be





Richieste ATLAS per il 2018

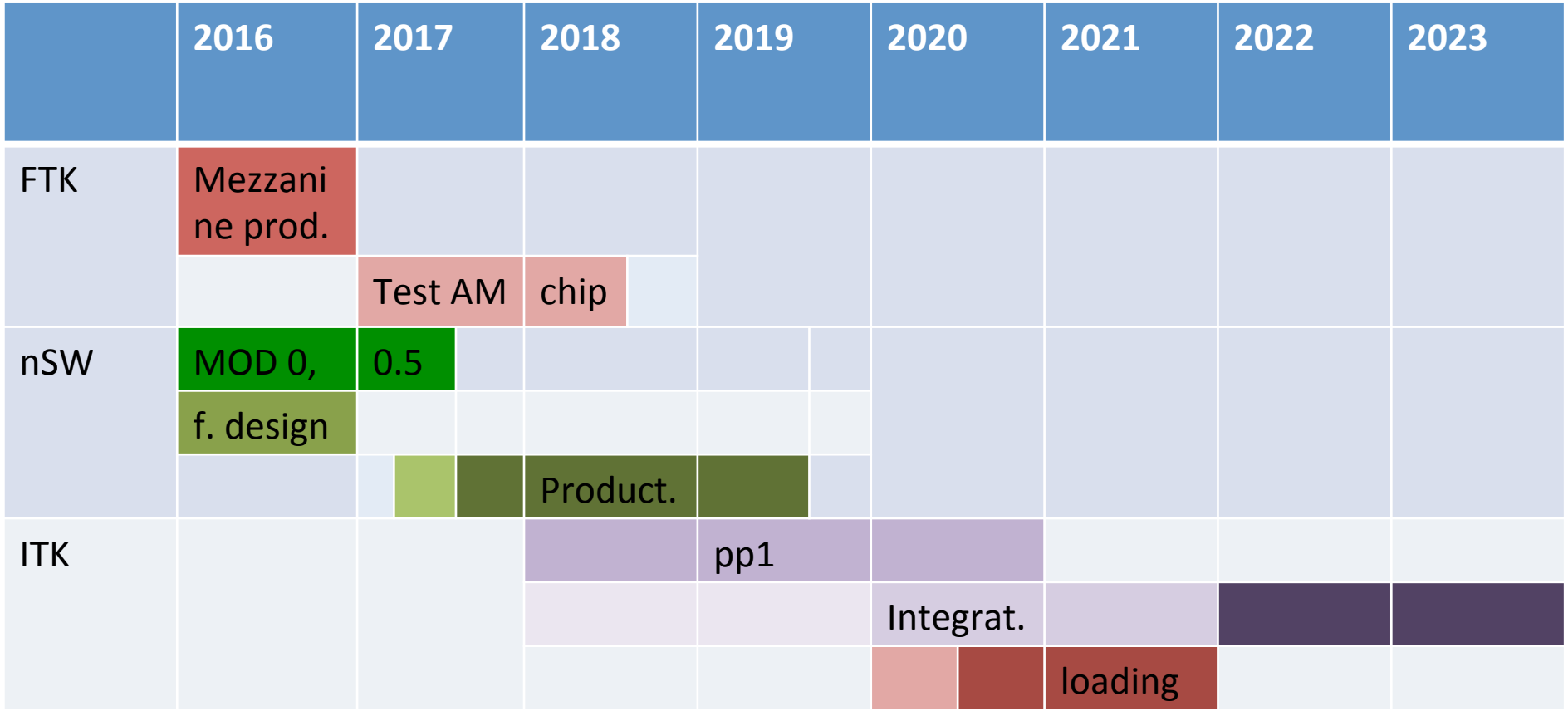
Preventivi di spesa preliminari (Keuro) (possibili aggiustamenti al ~10%):

Missioni Consumo C.Apparati/Inventario

98 45 150

Richieste I e II semestre 2018			
SEA	cad	5 mu	12 mu
	Staff	5 mu	
	contingenza	2 mu	
SPCM	Reparto carpenteria:	2 mu	4 mu
	Reparto meccanica:		
	Metrologia: ITK, nSW ?	2 mu	
SPAS	Test e perfezionamento assemblaggio nSW	6 mu	6 mu
	Servizi e assemblaggio ITK ?	4 mu	
	Tecnici gruppo esperti di meccanica nSW	13 mu	19 mu
	Tecnici gruppo esperti di elettronica nSW	6 mu	

	2016	2017	2018	2019	2020	2021	2022	2023
FTK	Mezzanine prod.							
		Test AM	chip					
nSW	MOD 0,	0.5						
	f. design							
			Product.					



- Details of ITK contributions under discussion.
- Some overlap between phase1 and phase 2 upgrade
  - Some phase 2 activities in standby