QA strategy in the CMS Tracker

1st Workshop on
Quality Assurance Issues
in Silicon Detectors
CERN 17-18 May, 2001

- Let me introduce my self:
  - I have worked in Aerospace Industry for 8 years.
  - I have been working since 1996 in High Energy Physics in issues linked to Project Management and Quality Assurance.
  - In the 1999, I got the title of Quality System Manager from ASPQ (Sponsored by ETH-Z, my home Institute).

- Let me remember the Quality Assurance definition given in the ISO 8402:
  - *"Quality Assurance: All the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfill requirements for quality"*

- Why does it look so more complicated today than yesterday *"to provide adequate confidence that an entity will fulfill requirements for quality"?*

- The answers is in the Tracker numbers.

- People involved in the realization of a silicon detector:
  - Yesterday ~ 20
  - CMS Tracker ~600 (30 times more)
- Costs
  - Yesterday ~2 Millions CHF
  - CMS Tracker ~75 Millions CHF (40 times more)
- Surface
  - Yesterday ~ .25 m^2
  - CMS Tracker ~ 220 m^2 (880 times more)

- Intrinsic Efficiency.
  - Without taking into account the production layout, let suppose to have 20 persons, each working at 99% of their capabilities, we assume that each person has the same capabilities of his colleagues, the total efficiency associated to the team will be an “X” number. Let do the same exercise for a team made by 600 persons, the total efficiency associated to the team will be an “Y” number. We can not calculate the exact numbers but we can always say that “X” will be much greater than ”Y”.

- Then we need Quality Assurance today than yesterday because …
  - The first answer is in the CMS Tracker numbers.
  - The second answer is linked to the risks associated to the possible extra costs in the Tracker project, that for sure are not peanuts.

- We had three major question to answer
  - Who has to introduce Quality Assurance issues inside the Tracker Project?
  - When to introduce Quality Assurance issues inside the Tracker Project?
  - How to introduce Quality Assurance issues inside the Tracker Project?

- **Who has to introduce Quality Assurance issues inside a project?**

(What we did inside the Tracker Project)

- Different professional figures in different moments.

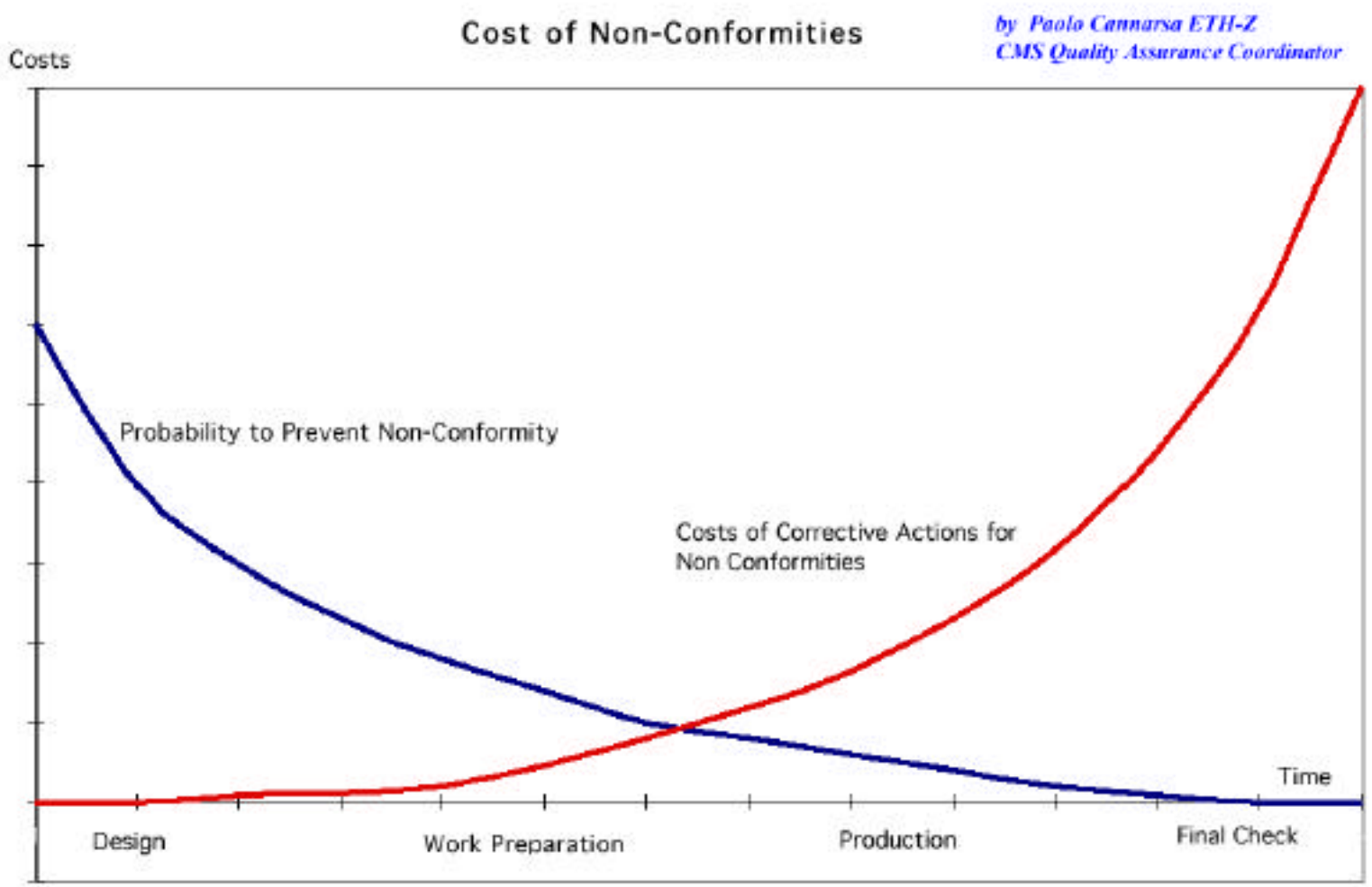
DUTIES
WHO
PHASES
To endorse and to support the introduction of the Quality Assurance inside the project and to help the consultant in doing his job.
The external consultant has two duties the first is to see where are the critical points inside the project the second duty to help the project in founding the solutions.
Has to audit the section of the project under the responsibility of the relevant Level 2 Manager
Has to coordinate and supervise the activities between the Level 2 Manager and the External QA Consultant
Has to implement the proposed corrective and preventive action, if any, into the project.
Has to keep all the information on quality methodologies to apply them in the future.
Top Management (Level 0)
External QA Consultant
External QA Consultant
Technical Coordinator
Management Level 2
Tracker Quality Assurance Coordinator
First Phase
Second Phase

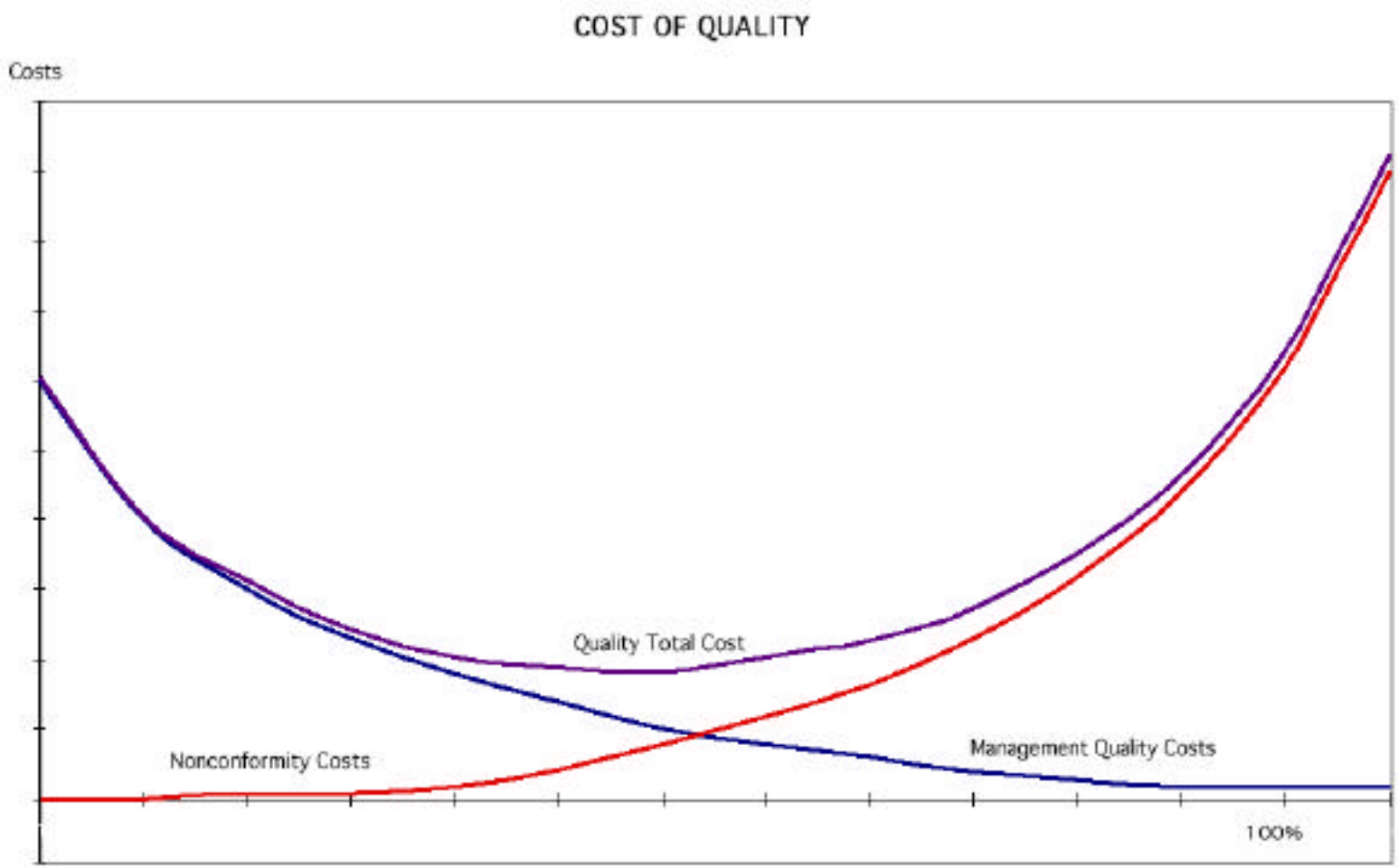
When has to be introduced Quality Assurance inside a project?

- The be in line with the ISO 9001 Quality should be present from the beginning of a project. But we have to take into account the Project Boundary Conditions and the Quality Costs.

Project Boundary Conditions :

- We are in the the HEP and often in this environment the people works on the technology edges where ideas and solutions evolve continuously. For this reasons it is arduous to apply Quality Assurance in the earliest phases of the project.
- CMS Tracker. I have been contacted after a strong project reengineering that corresponded in some how to the end of R&D phase. I thing that this was a good moment to start because during this phase the system was still enough flexible to accommodate possible modifications, and enough well defined to be kept under control.


Cost of Non-Conformities
by Paolo Cannarsa ETH-Z
CMS Quality Assurance Coordinator
Costs
Probability to Prevent Non-Conformity
Costs of Corrective Actions for
Non Conformities
Time
Design
Work Preparation
Production
Final Check


COST OF QUALITY
Costs
Quality Total Cost
Nonconformity Costs
Management Quality Costs
100%

How to introduce Quality Assurance issues inside a project?
(How we did for the CMS Tracker)

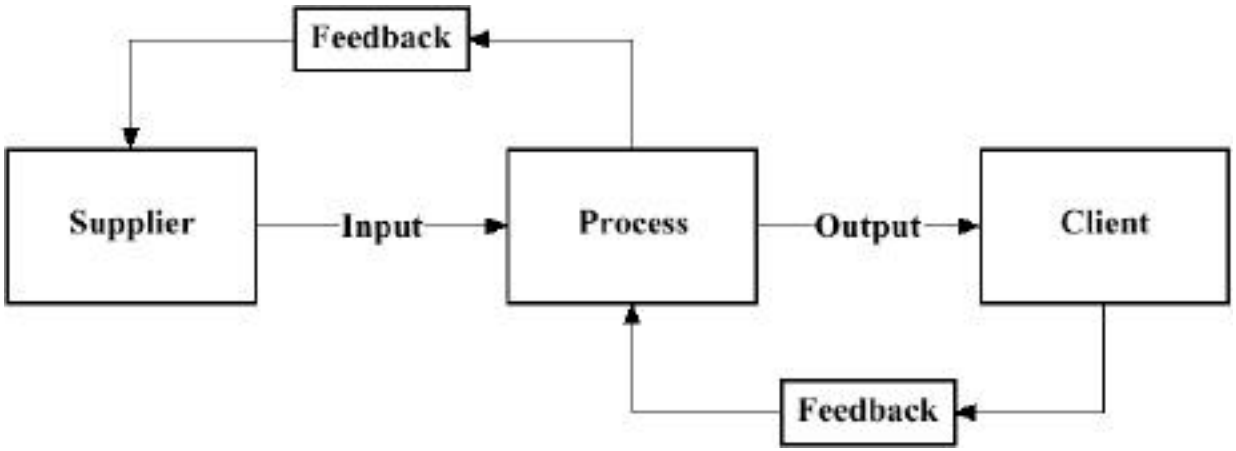
- I have two important points that drive my personal Quality Strategy inside each CMS Projects.
  - I think that we can not apply the same pre-defined solutions to every sub-detector, because each sub-detector has specific problems that require specific solutions.
  - It is the Quality Assurance that has to found the way to help the project and is not the project that have to adapt itself to the quality rules.

How did I do?

- I applied what is described in the paragraph 2.4 of ISO 9000:2000(E) Page 2

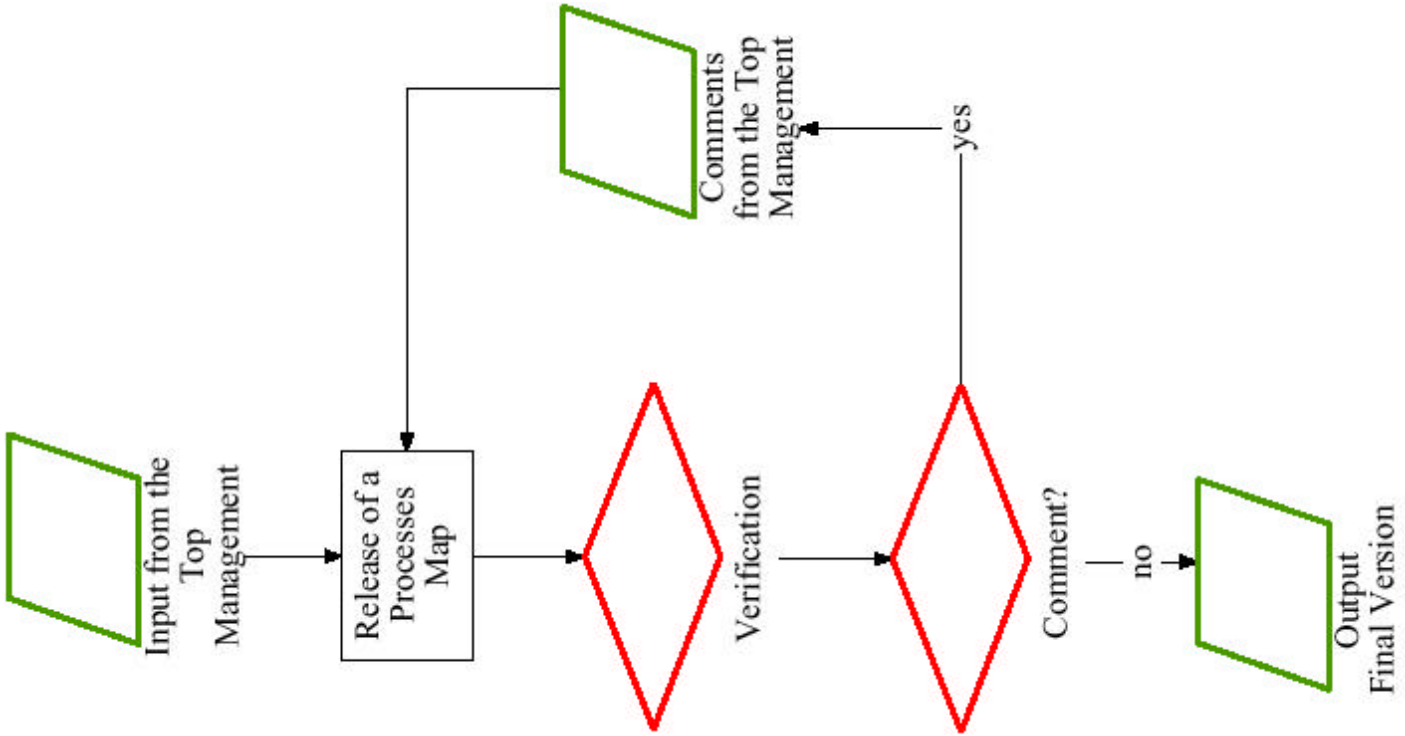
"Any activity, or set of activities that uses resources to transform inputs to outputs can be considered as a process. For organizations to function effectively, they have to identify and to manage numerous interrelated and interacting processes. Often the output from one process will directly form the input into the next process. The systematic identification and management of the processes employed within an organization and particularly the interactions between such processes are referred as the process approach."

- Then we introduced in this moment two important and powerful Quality Assurance tools :
  - **Process & Map of Processes**



- How did I use this powerful concept of the process in a profitable way?

  - I asked the top management of CMS Tracker to identify the “numerous interrelated and interacting processes” that exist inside the Tracker, and I started a process as described in the following figure


Input from the Top Management
Release of a Processes Map
Verification
Comment?
yes
Comments from the Top Management
no
Output Final Version

- After many iterations, when I finished the job with the top management we got the following output:
  - The general layout for the tracker module production was well defined and optimized
  - All the processes were linked each other coherently
  - All the logical constraints were clear
  - For each process, we identified the owner at the level of Institutions.
  - All the critical point associated to the production were well known

The job continued with the Level 2 Management everything supervised and fully supported by the Tracker Technical Coordinator (Management Level 1). Together with them, we better defined the granularity of their map of processes going deeper in the following sub-projects:

- Silicon Sensor Production & Test.
  - Automatic Module Assembly.
- Module Production Flow (*to be done*)

- We did the analysis of the sub-projects trying to define which were the main critical points. Looking at the Map of Processes, *(I am speaking about Silicon Sensors)*, we highlighted the following critical points
  - Many production centers (7 Institutes)
  - Too widely distributed (5 Countries)
  - Logistic & networking to be organized
- Then was evident the an appropriate strategy of standardization and control was required

- Better definition of process owner. It is important to know that for each Process it exists and is well identified a responsible

Sensor Test Centers Responsible Persons

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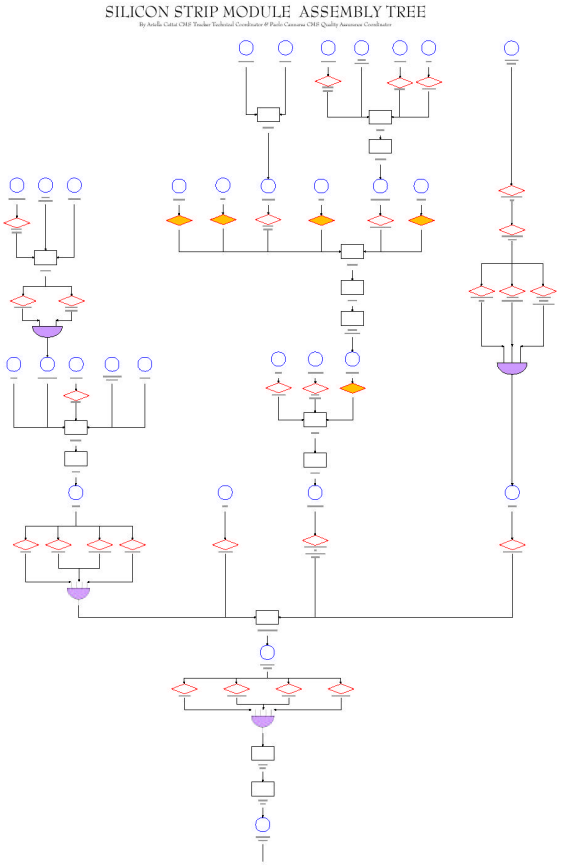
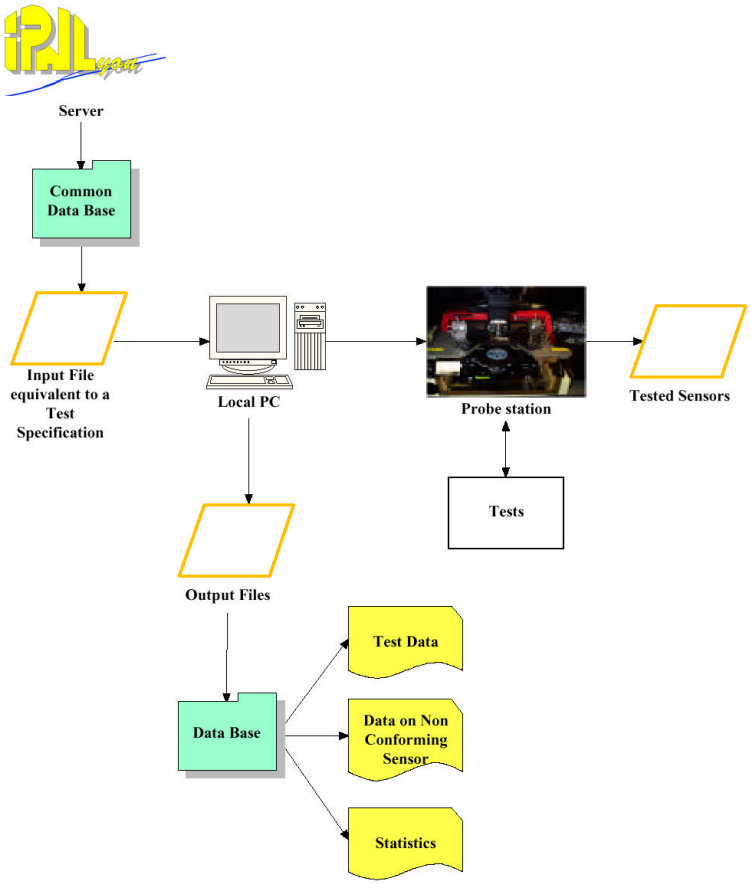
- Product trace-ability and identification
- It exists a system to barcode each part of the Tracker

Assembly & Test Flow

- In order to optimize the assembly and test sequences we produced assembly and test trees for same objects:
  - Module Production
  - Optical Link
  - Mechanics of Outer Barrel.



- We identify common Tests procedures & check list
- We planned calibration of different instruments in different places
  - Same method
  - Same samples



- We identify Common acceptance criteria for the analysis results.
- What we have is an heavy standardization, starting from the procedure, to the common way to represent the output data.

Sensor ID = 30210404439231

Date = 01–04–07 time 13.00.56 Operator = Nicoleta Dinu
Temperature (I–V) = 21. °C Humidity (I–V) = 44. %

V_{break} = 552. V I_{tot} at 300 V = 1846. nA
V_{dep} = 122. V I_{tot} at 450 V = 3145. nA
C_{tot} at V_{dep} = 1557. pF

Scan Measurements		# of Bad Strips	Flag
<Poly. Res.> (MΩ) =	1.40	0	.0.
$<I_{single\ strip}>$ (nA) =	4.35	1	.0.
$<C_{AC}>$ (pF) =	602.	3	.0.
$<I_{diel}>$ (nA) =	0.01	3	.0.
Total Nr. Bad Strips = 3 134 157 280		4	.0.
I–V measurement			.0.
C–V measurement			.0.
Global Status			.0.

Courtesy of Angarano

Non-Conformities

The Non Conformity followed what said in “ISO 8402 par. 2.10 is

“Non-conformity: Non Fulfillment of a specified requirement”

- For a project so widely distributed the N.C. can get critical. The N.C is not critical in itself, but it is critical not to record and not to keep informed the other colleagues working on the same tasks in others laboratories. The N.C. is one the most important feedback, inside a processes network and the correct communication of it is essential.

- Non conformities
  - Common Strategy
    - Definition
    - Identification
    - Reaction
  - Standard way to record them

- FMEA & Risk analysis
- What is an FMEA?
- An FMEA is a systematic method of identifying and preventing product and process problems before they occur.
- The FMEA has to be conducted in the product design or process development stages.

- The relative risk of a failure and its effects is determined by three factors:
  - **Severity** - The consequence of the failure should it occur.
  - **Occurrence** - The probability or frequency of the failure occurring.
  - **Detection** - The probability of the failure being detected before the impact of the effect is realized.

- How to use the concepts of
  - Severity
  - Occurrence
  - Detection

  to assess the risk?
- The answer is Risk Priority Number
- RPN=SxOxD

where each variable can range between 1 and 5 or between 1 and 10. Each scale is intended as a qualitative scale.

- Until now they applied FMEA to the maintenance of the Gantry Machine (Automatic Machine for Module Production)
- Redundancy evaluation

- Statistical Tools to evaluate the Process stability.
  - This issue it has been ever well taken into account by the Physicist from ever. Now is the moment to apply this concept also to the big number to evaluate is a machine or a process or what else is working properly or if same systematic mistake is going on. This is also important to evaluate if a non-conformity is just a random event during a production process or if something is going really wrong and for that is necessary to stop the production itself and start a serious trouble shooting.

- Training.
  - This issue will be well developed especially for the new tool and machines. to be used by technician in different laboratories.

- I said quite in the beginning that I used a process approach. Let me say now I am happy about this method, after my experience with the CMS Tracker project and with other projects too.

- With this approach we have a complete control at the system level
  - Each activity is inserted coherently in a general schema.
    - Helps in optimizations
  - It is possible to have an immediate evaluation of all possible consequences of a change in the system
- It is closer to the reality of a Project more than abstract rules stated inside a standard
- Each one knows exactly which is his position inside the project, and this makes the people happy and more motivated
- In this way is easy to get a functional organigram that helps a lot in the day by day activities.