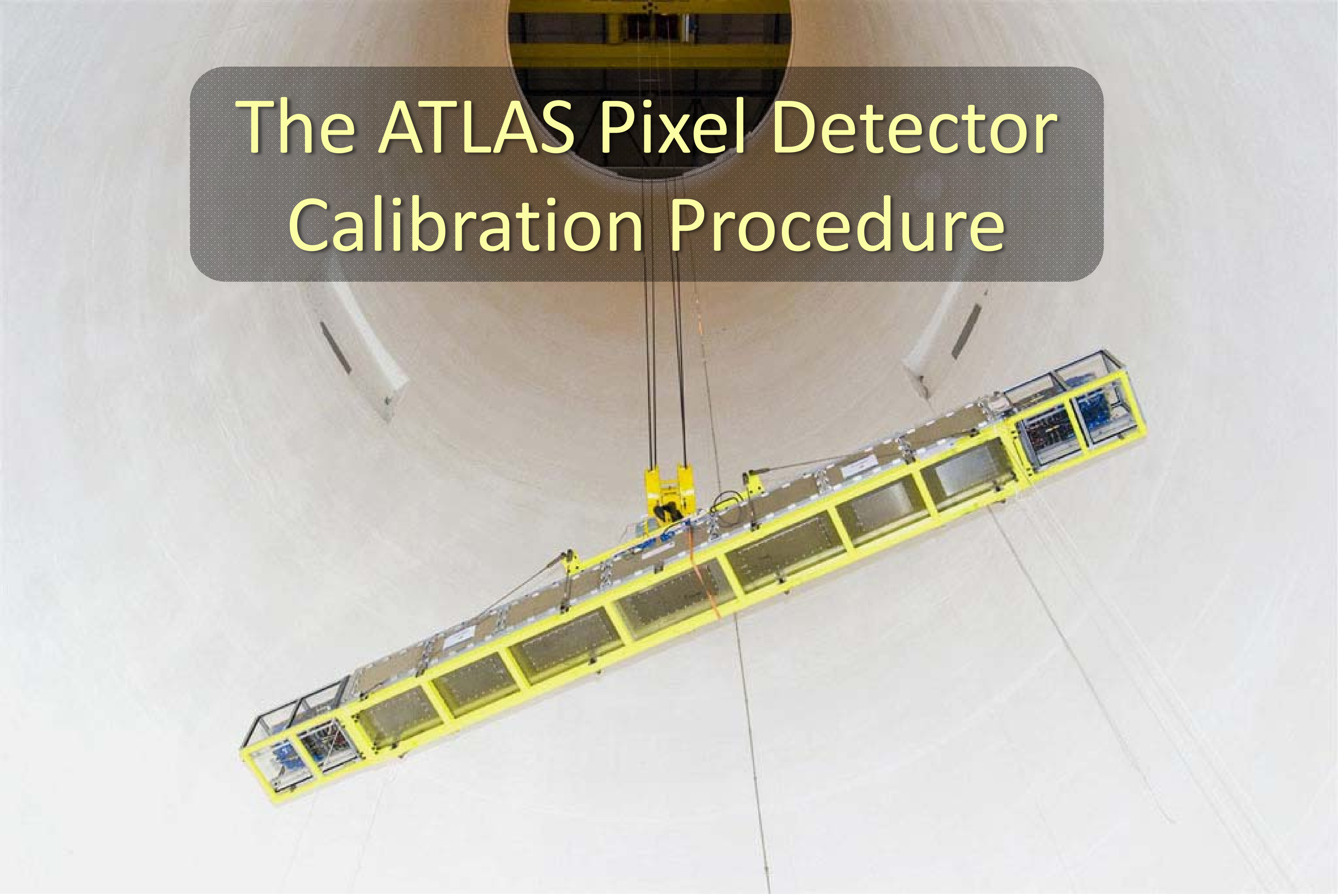


The ATLAS Pixel Detector Calibration Procedure

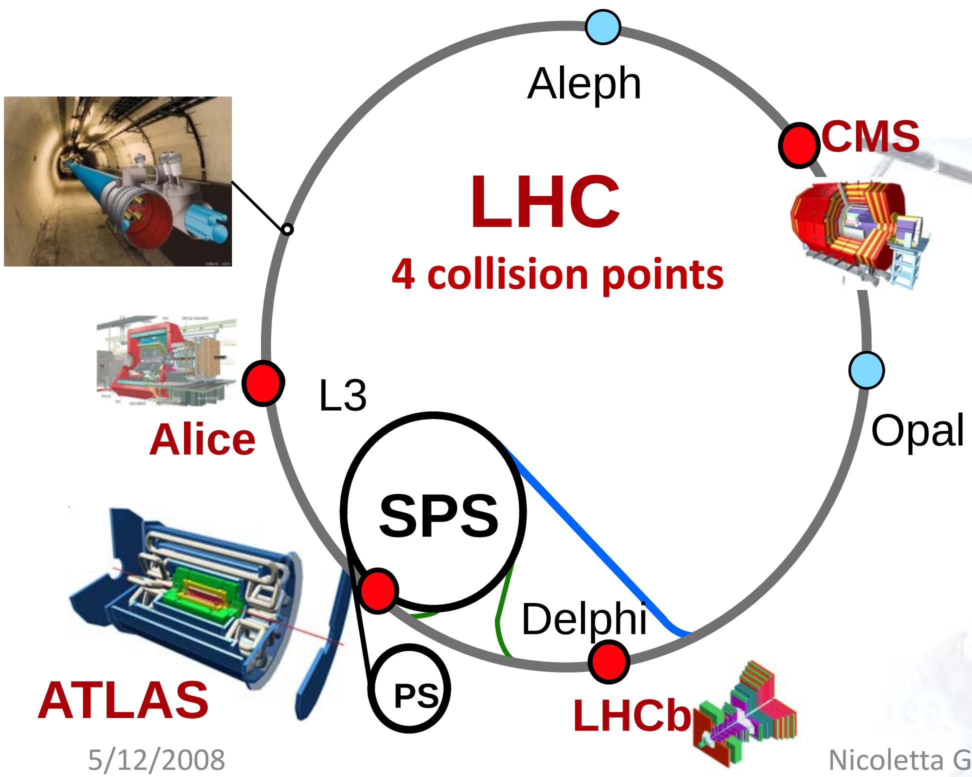
Nicoletta Garelli

INFN & University Genoa

Large Hadronic Collider

MOTIVATION: Find Higgs Boson and New Physics Beyond the Standard Model

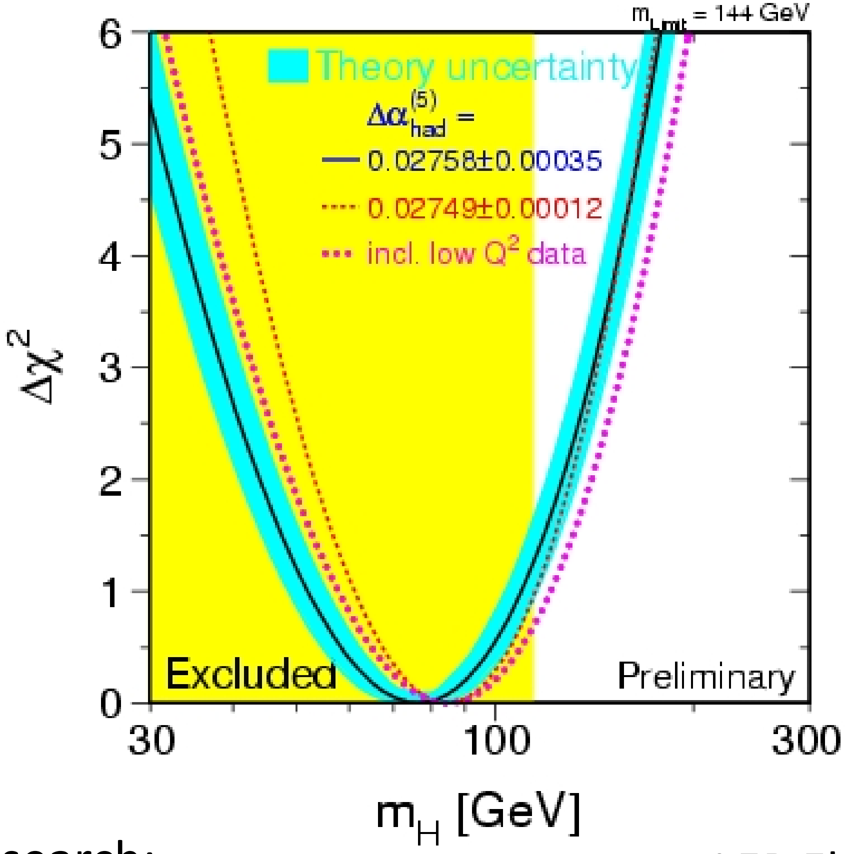
LHC is being built in a circular tunnel 27 *km* in circumference, 50-175 *m* underground.



Machine	Beams	Energy	Luminosity
LHC	p p	14 *TeV*	$10^{34}\ cm^{-2}s^{-1}$
LHC	Pb Pb	5.5 *TeV*	$10^{27}\ cm^{-2}s^{-1}$
Tevatron	p anti-p	2.0 *TeV*	$10^{32}\ cm^{-2}s^{-1}$
LEP	$e^+ e^-$	200 *GeV*	$10^{32}\ cm^{-2}s^{-1}$

- Beams inside continuous vacuum guided by **superconducting magnets.**
- **Bunch cross every 25 *ns*** ➲ 600 million collisions per second

SM Higgs Boson



LEP direct search:
m_H>114.4 *GeV/c²* @95%CL

LEP Electroweak Fit Limit:
m_H<144 *GeV/c²* @95%CL

Higgs Mass Range – Detector Requirements

$114.5 < M_H < 130$ *GeV*
Golden channel: $H \rightarrow \gamma\gamma$
But small decay rate!
QCD background.

$130 < M_H < 800$ *GeV*
Golden channel: $H \rightarrow ZZ/ZZ^* \rightarrow 4l$
Huge Background

$800 < M_H < 1000$ *GeV*
$H \rightarrow WW \rightarrow l\nu jj$
E_T missing

- **Powerful inner tracking systems** in magnetic field with high granularity and secondary vertex reconstruction capability. Crucial for background rejection.

- **High granularity hadronic calorimeter with full coverage** for good missing E_T resolution, jet trigger and reconstruction.

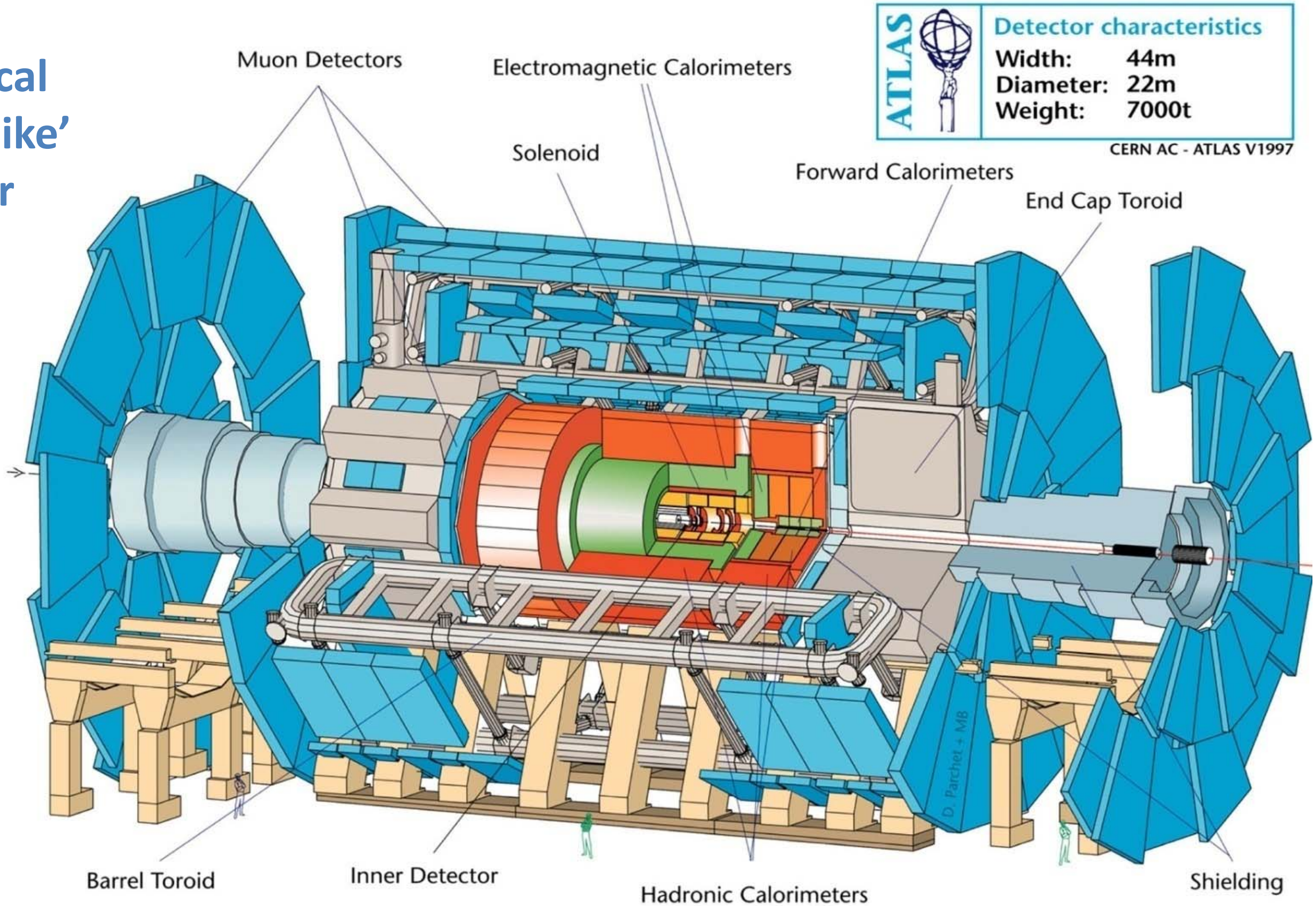
- **Electromagnetic calorimeter** with good energy and spatial resolution, capability to separate γ/π^0.

- **Efficient muon spectrometer** for identification, trigger, and momentum measurement of high energetic muons.

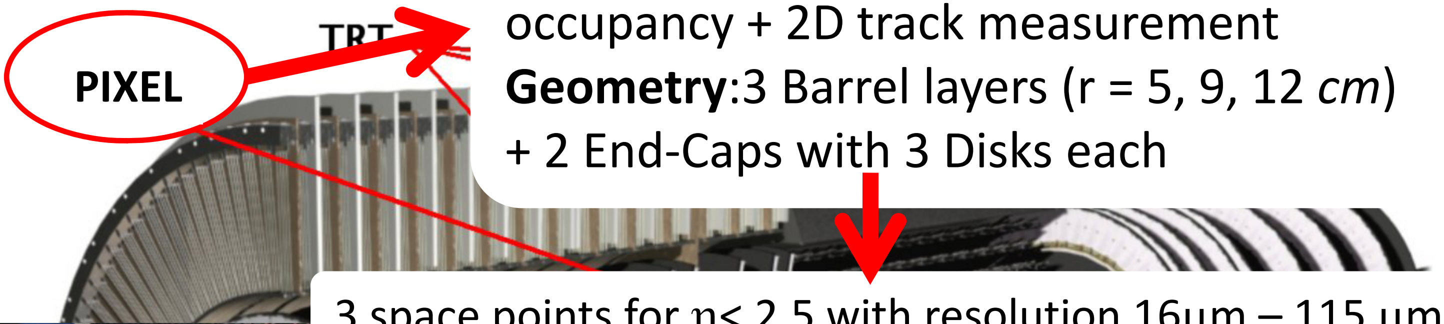
ATLAS

A Thoroidal LHC ApparatuS

Cylindrical 'Onion-like' Detector



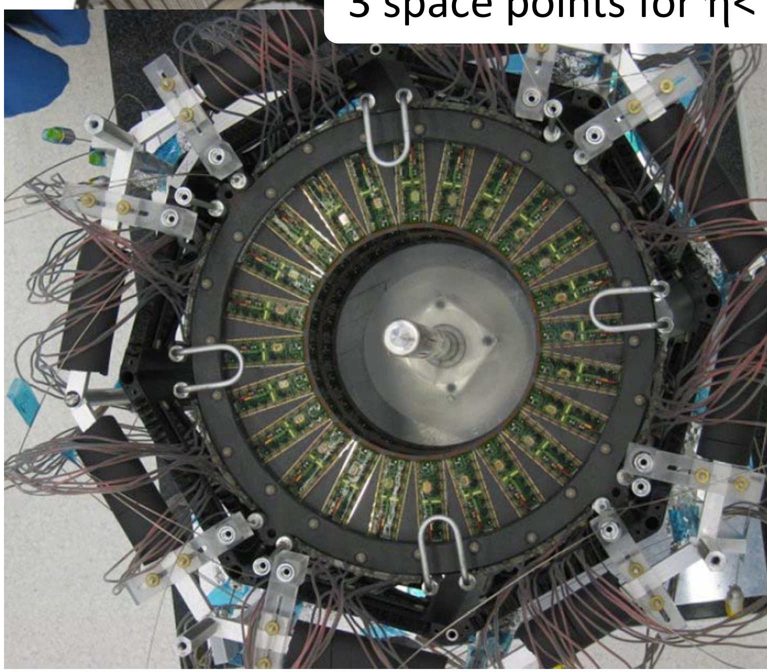
The ATLAS Inner Detector

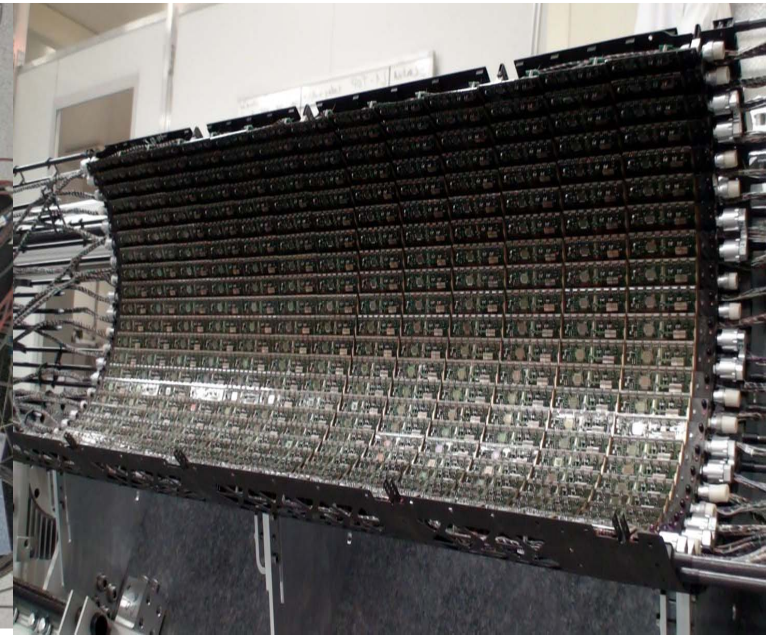


Technique: high granularity + low occupancy + 2D track measurement

Geometry:3 Barrel layers (r = 5, 9, 12 *cm*) + 2 End-Caps with 3 Disks each

3 space points for η< 2.5 with resolution 16μm – 115 μm

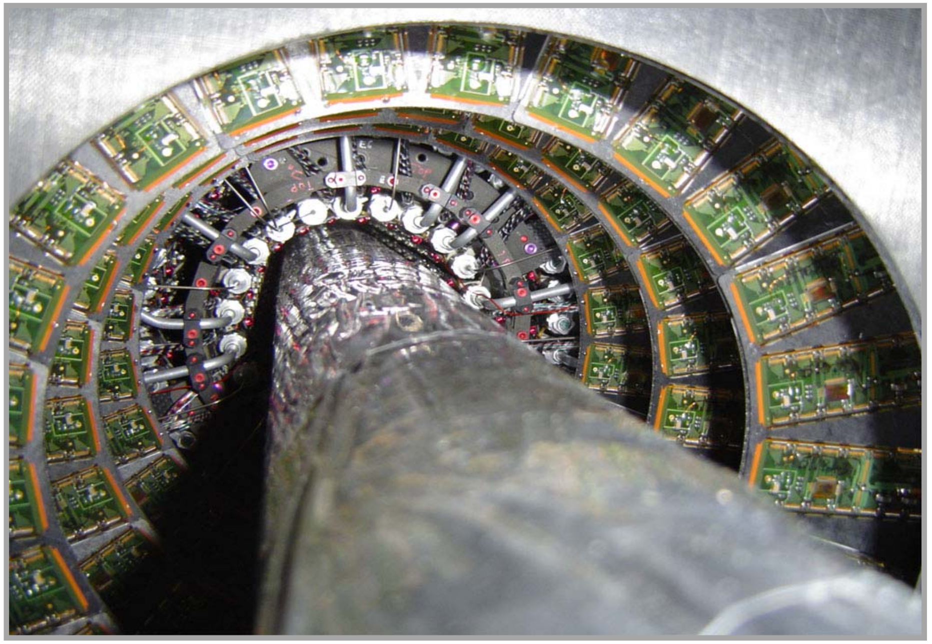




The Pixel Detector

High multiplicity tracking detector:
~ 1200 tracks per bunch crossing ⇒ high granularity (80 million channels!)

High impact parameter resolution:
~ 12 *μm* vertex resolution – secondary vertex reconstrution



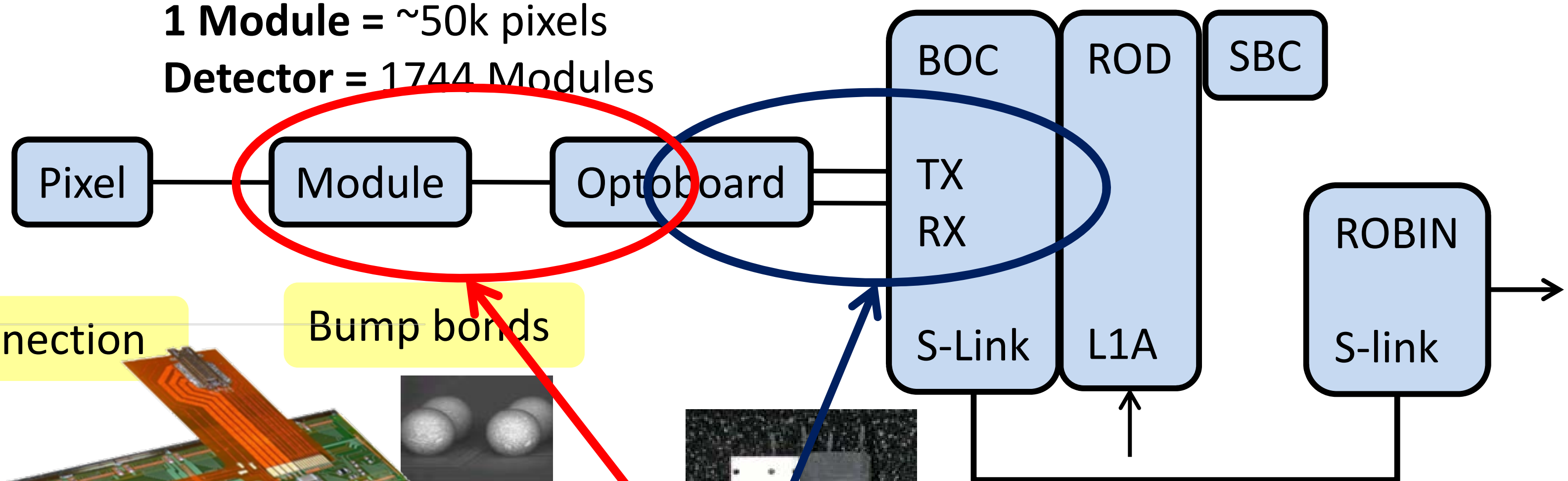
High time resolution:
40 *MHz* bunch crossing rate

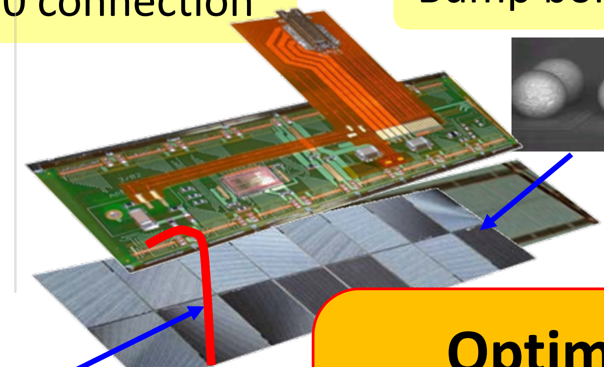
Low interaction length:
~10% χ_0

High radiation dose tolerance:
~50 *Mrad*

The Readout System

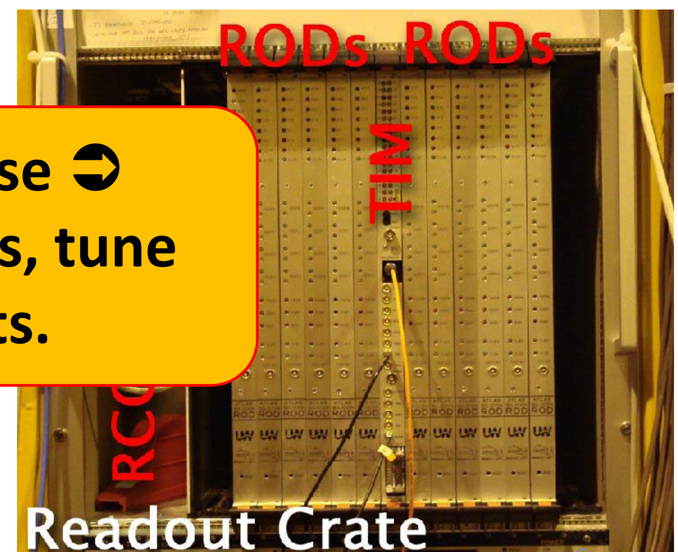
1 Module = ~50k pixels
Detector = 1744 Modules





Optimize detector response ➲ calibrate readout electronics, tune on-line and store results.

Signal: discriminator decision on amplified charge deposition within the pixels.

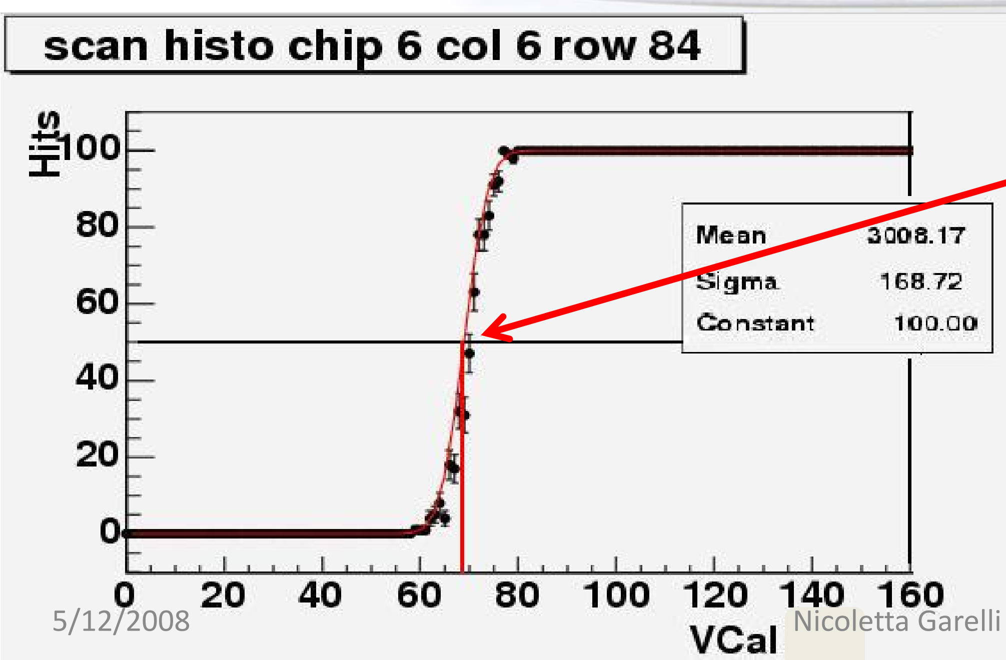


Module Tuning

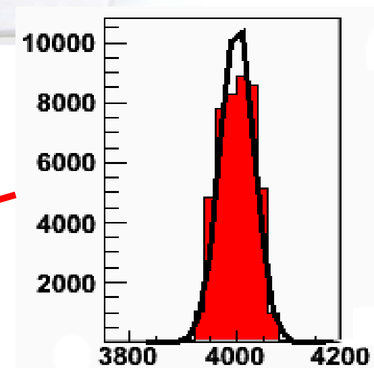
Motivation: Mean energy loss in pixels changes in time due to irradiation
Calibration source: Directly inject charge (*VCal*) - No sensor involved (except dedicated scans)
Calibration procedures: Many! Vary *VCal* and determine distribution for

- discriminator threshold
- noise (slope of signal rise)
- *Time-Over-Threshold* (ToT) indirect charge deposit measurement
- …

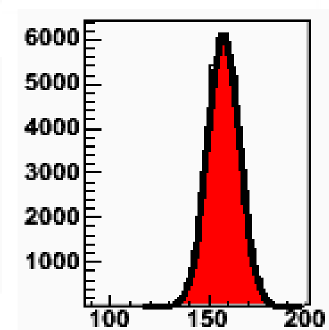
for all pixels in modules

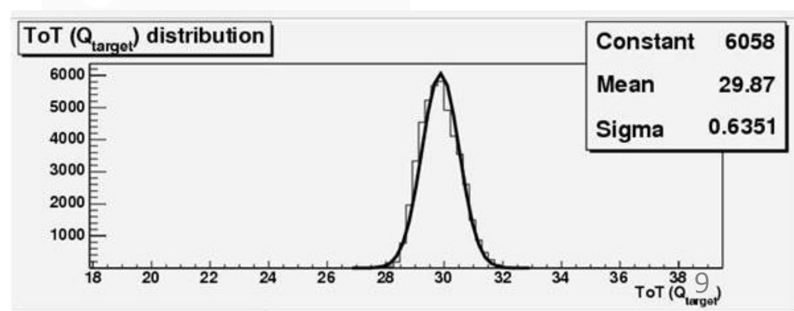


Threshold



Noise



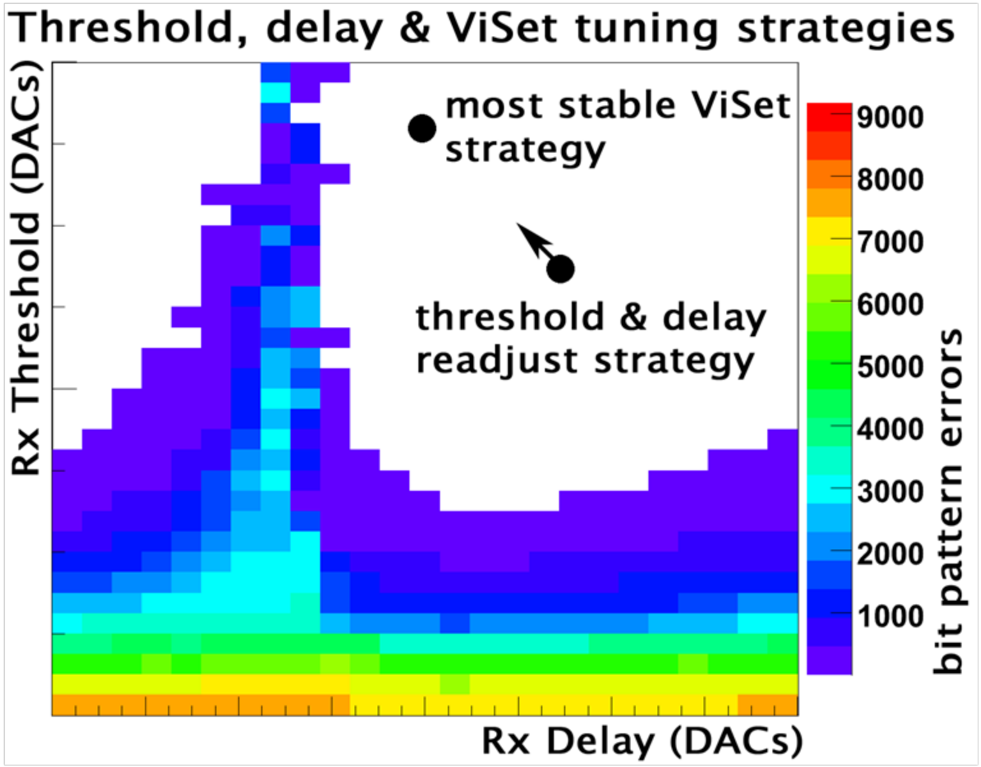


Optical Communication Tuning

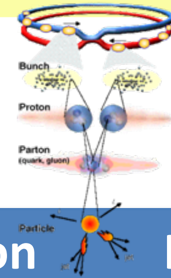
Tune link between on-detector Optoboards and off-detector Back-Of-Crate cards:

1. Laser Power for the Optoboard (ViSet)
2. Threshold at the BOC
3. Delays at the BOC

Find optimal values for individual module by varying the three parameters



Calibration Procedures



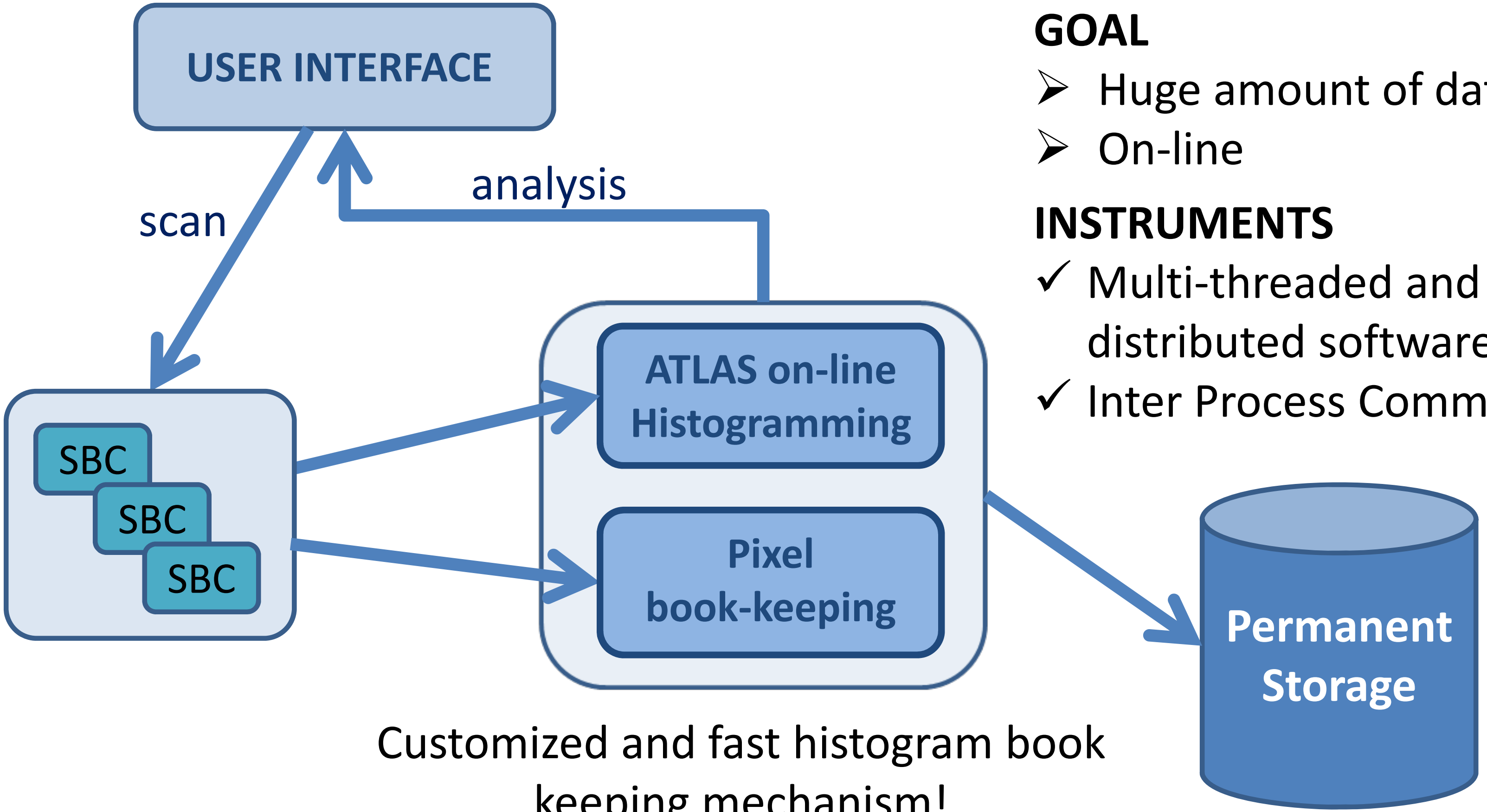
Scan type	LHC condition	How often?	How long?
Threshold Scan	Stable beam	Every Fill(1)	30 *min*
ToT Scan	Stable beam	Every Fill	30 *min*
Optical Tuning	-	Weekly	1 *h*
Threshold Tuning	A "Threshold Scan" at each discriminator threshold value		
ToT Tuning	A "ToT Scan" at each amplifier feedback current value		
Leakage current	Study of the sensor radiation damage		

(1): Fill = LHC beam injection. A fill lasts ~10*h*

Huge amount of histograms → **On-line** / **Off-line**

Need efficient on-line histogram dispatching system

Histogram Dispatching



GOAL

- ➢ Huge amount of data
- ➢ On-line

INSTRUMENTS

- ✓ Multi-threaded and distributed software
- ✓ Inter Process Communication

Customized and fast histogram book keeping mechanism!

Currently in use during commissioning

Summary

- ***Pixel Detector Challenge:*** read out and calibrate 80 million pixels!
- ***Calibration Procedure:*** read out electronic response, optimized for on-line use
- ***Histogram Dispatching:*** developed fast calibration result dispatching system within a highly distributed environment