LHC Commissioning and the ATLAS BCM

- Status of the LHC machine commissioning
- Plans for first beams
- The ATLAS BCM
- Commissioning Plans
- Beam abort scenarios

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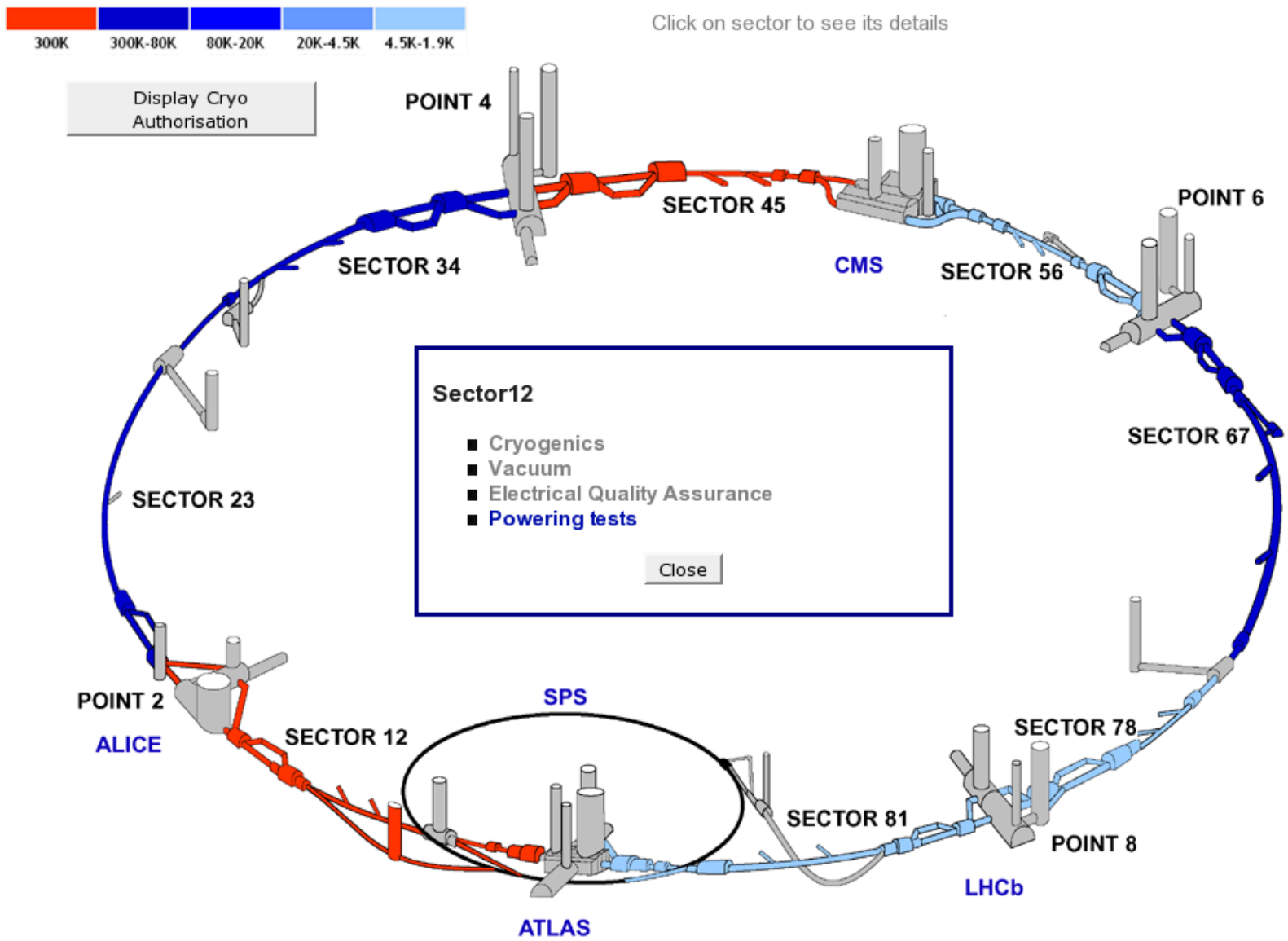
April 26, 2008

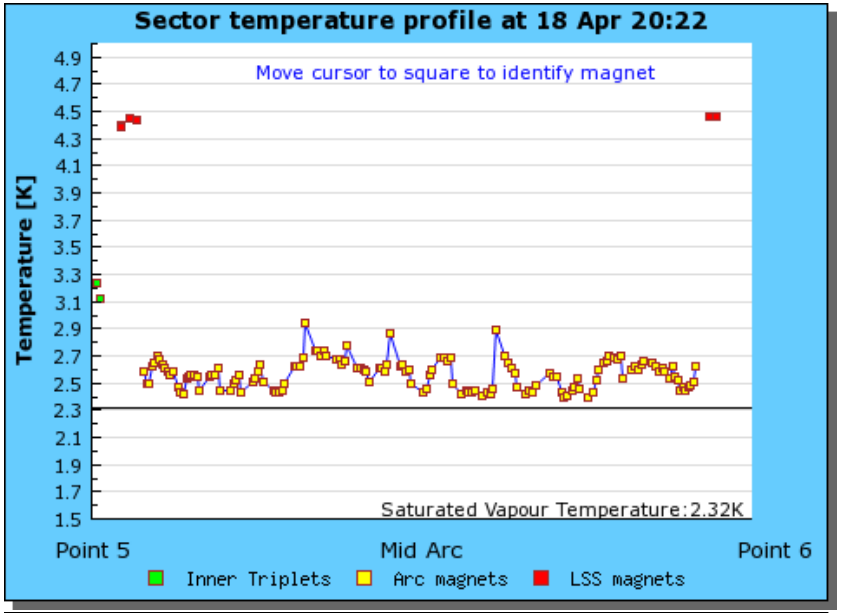
The LHC Climate

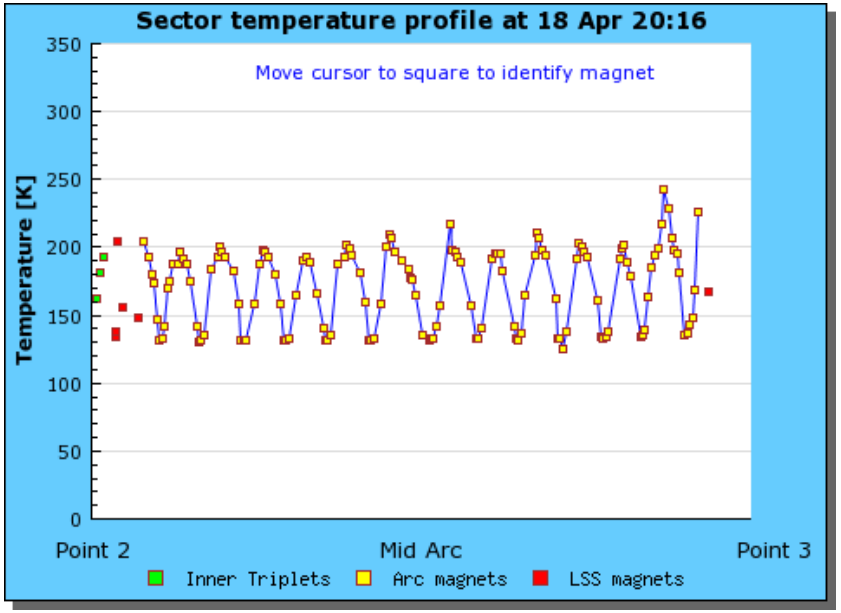


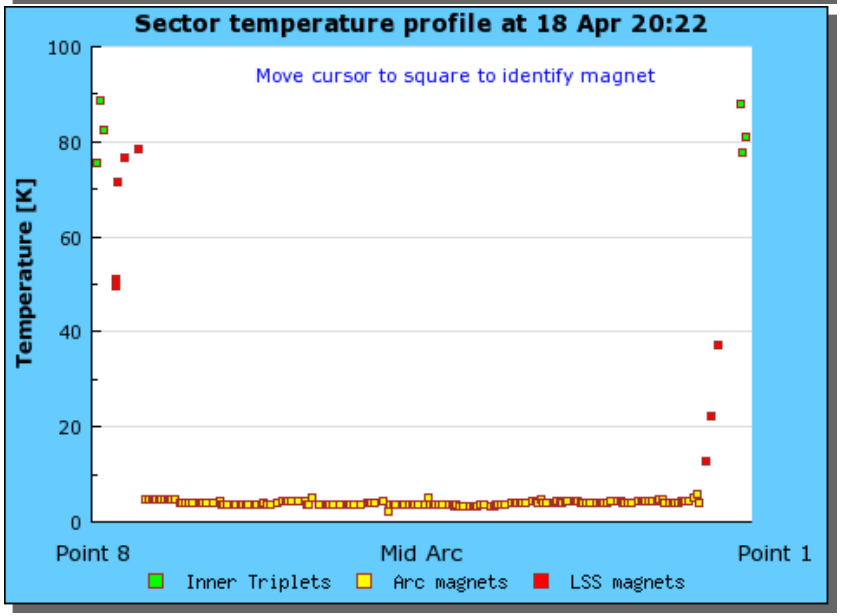
http://hcc.web.cern.ch/hcc/field.php

Local Weather Forecasts

- Cool several sectors in parallel
- Sector cool-down becoming routine

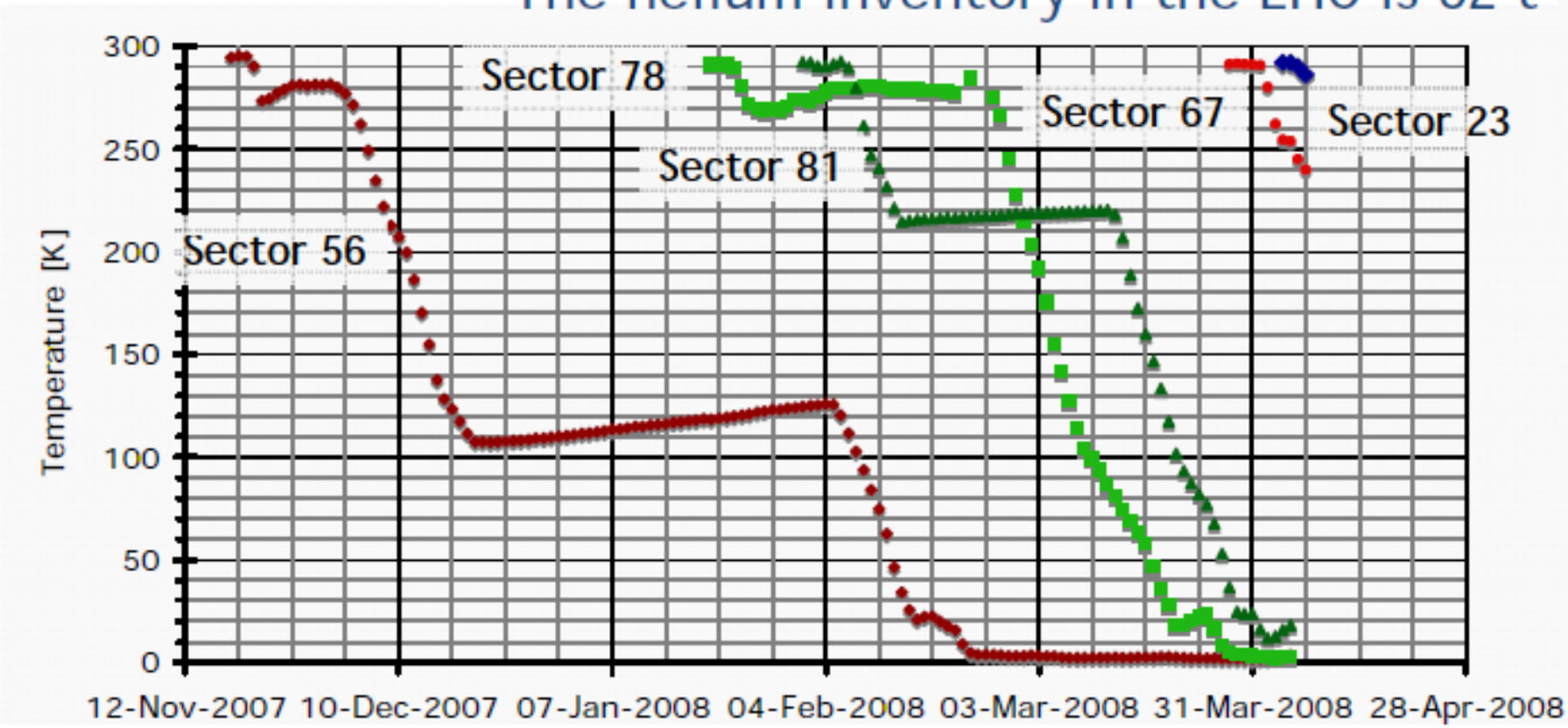




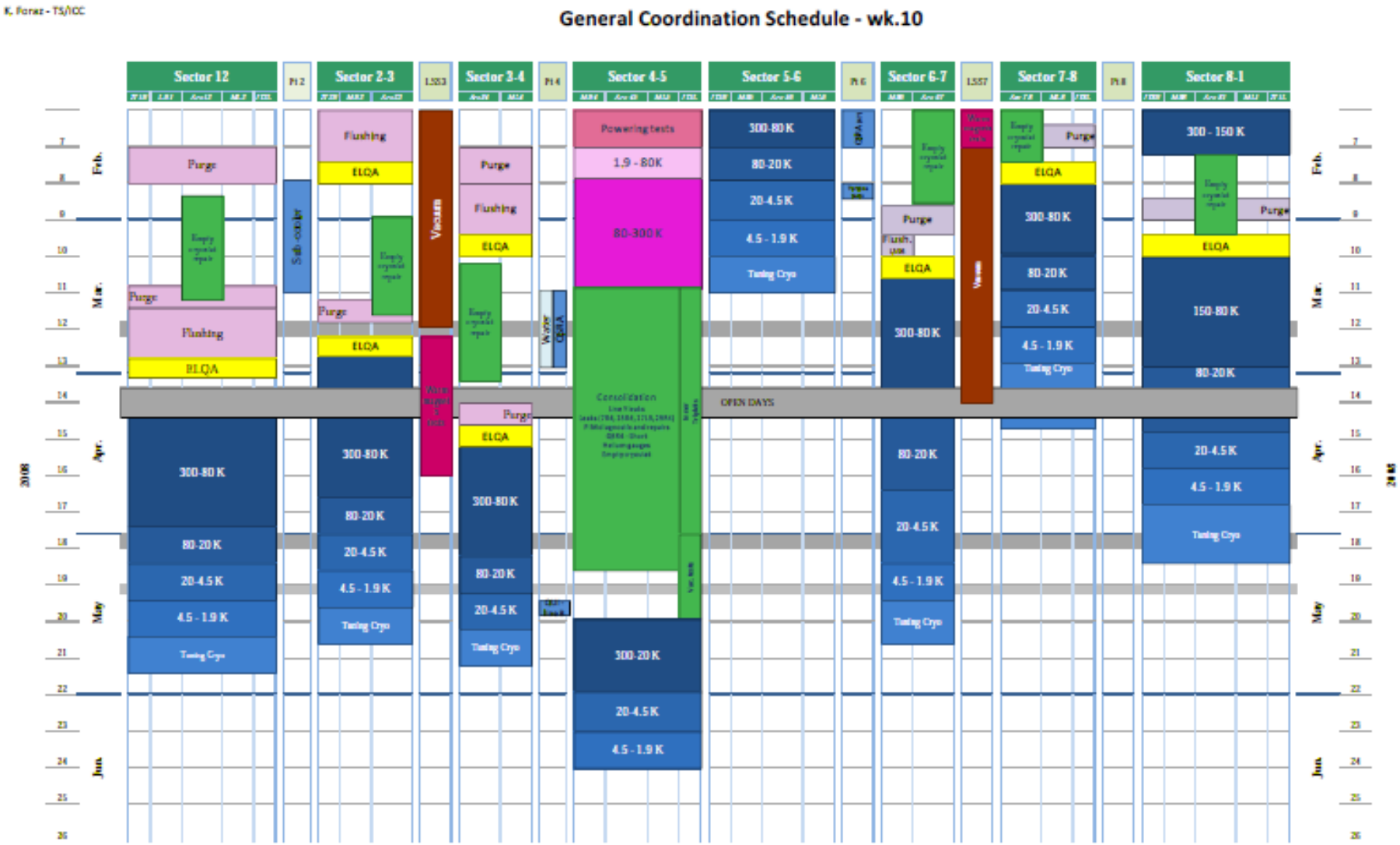


Current experience with Cooldown

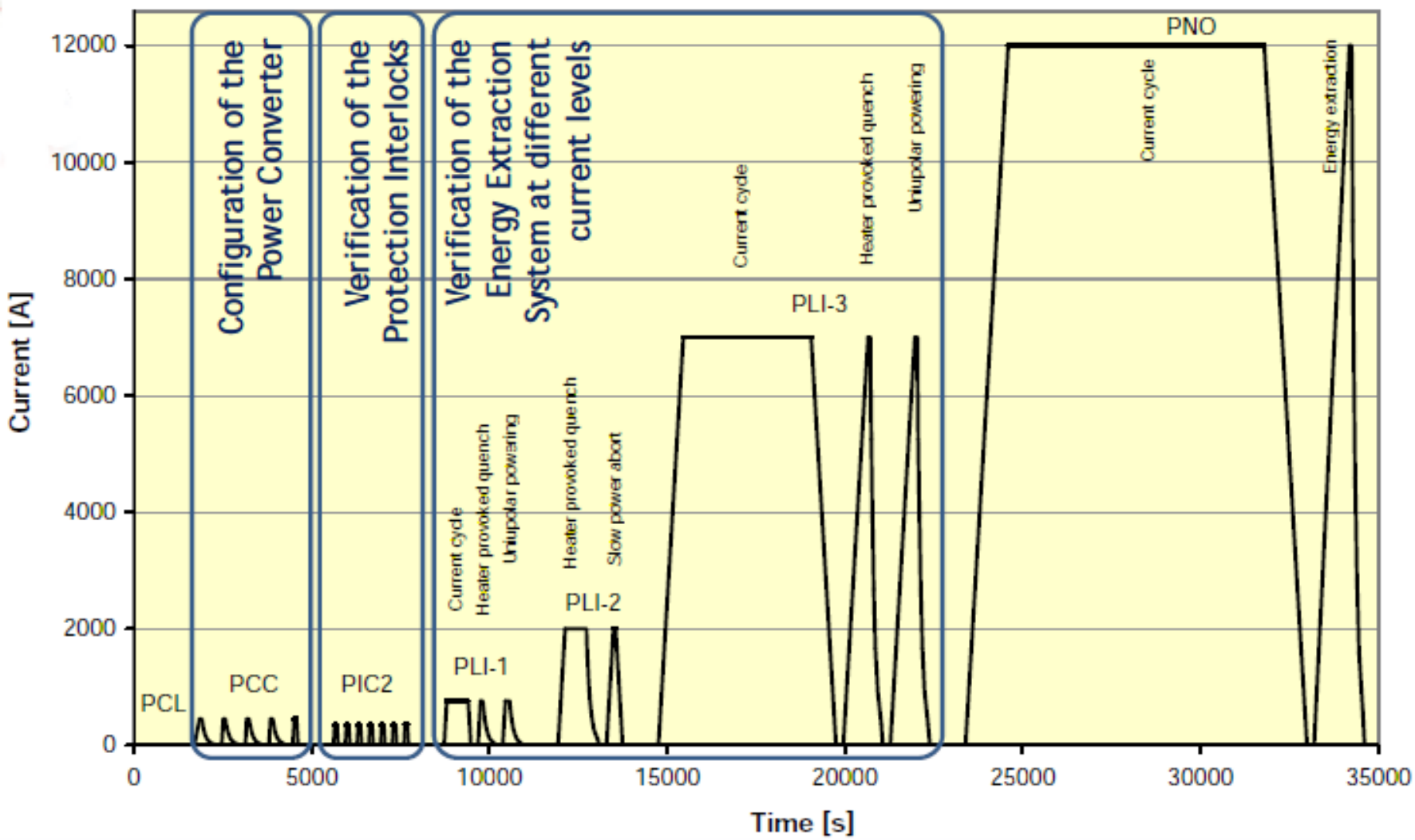
Presently two sectors are below 2K
The helium inventory in the LHC is 62 t



The Current Outlook for Cooldown



Commissioning the Power Circuits

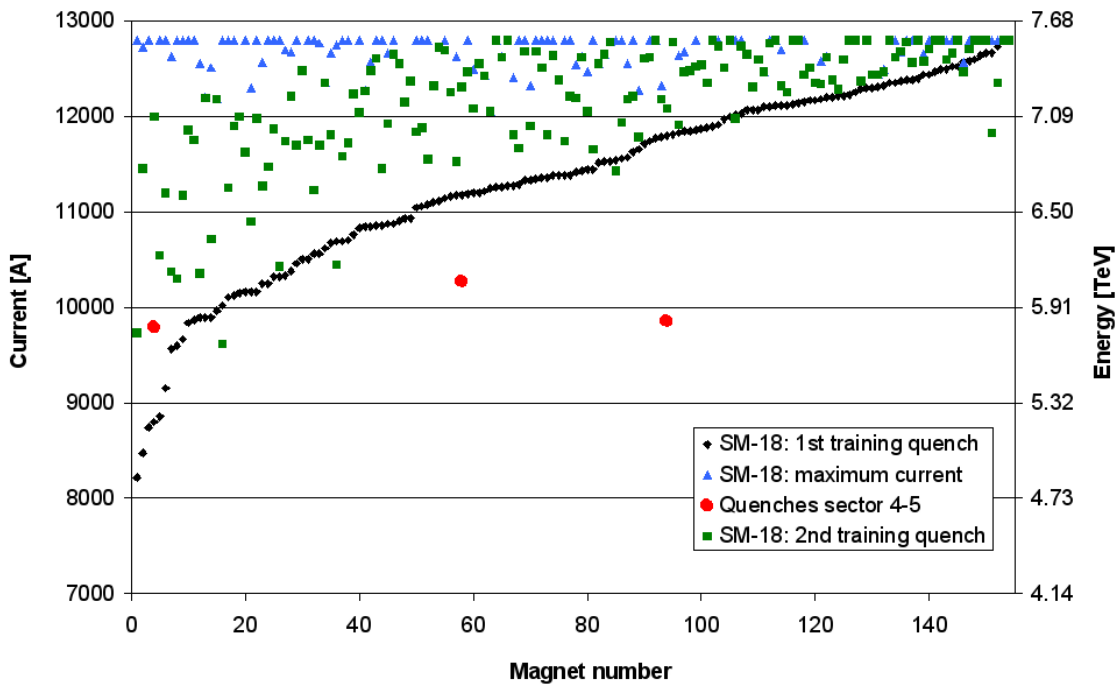


Commissioning the Power Circuits

"The earliest that the machine could be ready for beam commissioning to 7 TeV is late August, without taking resources into account". ICC Feb'08

Commissioning the Power Circuits

- Sector 4-5 was the first to be cooled down
- Discovered fatal flaw with low-beta quads
- Last summer/fall it was commissioned to 7 TeV



INDICO event 28066

- Clear it will take longer to commission to 7 TeV
- Decision has been taken to only run at 5 TeV in 2008

After the Machine is Powered?

- Once machine is turned over to operations

		Ring factor	Total Time [days] both rings
1	Injection and first turn	2	4
2	Circulating beam	2	3
3	450 GeV - initial	2	4
4	450 GeV - detailed	2	5
5	450 GeV - two beams	1	1
6	Snapback - single beam	2	3
7	Ramp - single beam	2	6
8	Ramp - both beams	1	2
9	7 TeV - setup for physics	1	2
10	Physics un-squeezed	1	-
	TOTAL to first collisions		30
11	Commission squeeze	2	6
12	Increase Intensity	2	6
13	Set-up physics - partially squeezed.	1	2
14	Pilot physics run		

- Considering single-sector injection to expedite this phase

And then?

- When beam is circulating
- Step-by-step proton current increases
- Dictated by safe machine operation

$$L = \frac{N_b^2 n_b f_r \gamma}{4\pi\varepsilon_n \beta^*} F$$

N_b number of particles per bunch
n_b number of bunches
f_r revolution frequency
ε_n normalised emittance
β^* beta value at Ip
F reduction factor due to crossing angle

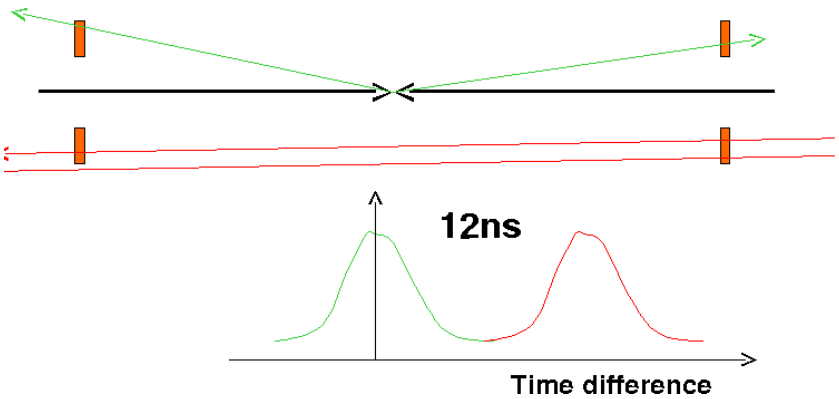
	beta* [m]	Bunch intensity	Luminosity [$cm^{-2}s^{-1}$]	Event rate/cross
1 x 1	18	10^{10}	10^{27}	low!
43 x 43	18	$3\ 10^{10}$	$3.8\ 10^{29}$	0.05
43 x 43	4	$3\ 10^{10}$	$1.7\ 10^{30}$	0.21
43 x 43	2	$4\ 10^{10}$	$6.1\ 10^{30}$	0.76
156 x 156	4	$4\ 10^{10}$	$1.1\ 10^{31}$	0.38
156 x 156	4	$9\ 10^{10}$	$5.6\ 10^{31}$	1.9
156 x 156	2	$9\ 10^{10}$	$1.1\ 10^{32}$	3.9

	beta* [m]	Bunch intensity	Luminosity [$cm^{-2}s^{-1}$]	Event rate/cross	%Total I
936 x 936	10	$4\ 10^{10}$	$2.3\ 10^{31}$	0.13	0.12
936 x 936	4	$4\ 10^{10}$	$5.6\ 10^{31}$	0.32	0.12
936 x 936	2	$4\ 10^{10}$	$1.1\ 10^{32}$	0.64	0.12
936 x 936	2	$6\ 10^{10}$	$2.5\ 10^{32}$	1.14	0.17
936 x 936	2	$8\ 10^{10}$	$4.5\ 10^{32}$	2.6	0.23
936 x 936	1	$6\ 10^{10}$	$5\ 10^{32}$	2.9	0.17

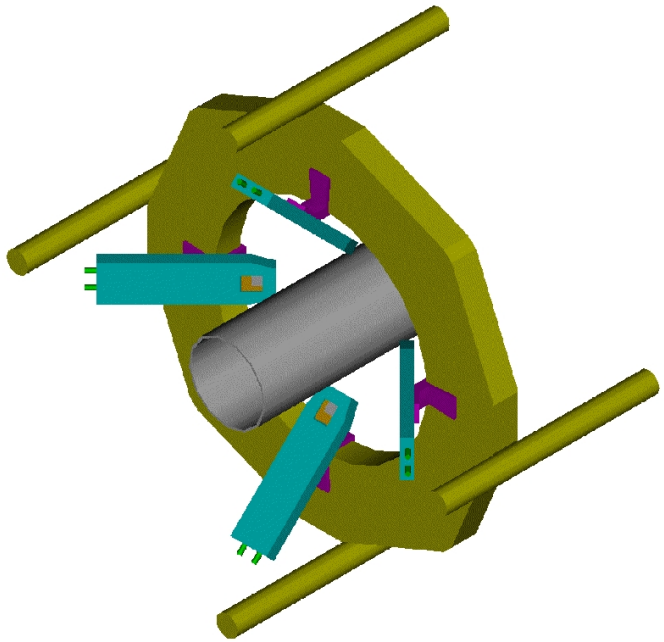
	beta* [m]	Bunch intensity	Luminosity [$cm^{-2}s^{-1}$]	Event rate/cross	%I total
2808 x 2808	4	$4\ 10^{10}$	$1.7\ 10^{32}$	0.32	0.35
2808 x 2808	2	$4\ 10^{10}$	$3.4\ 10^{32}$	0.64	0.35
2808 x 2808	0.55	$4\ 10^{10}$	$1.2\ 10^{33}$	2.3	0.35
2808 x 2808	2	$6\ 10^{10}$	$7.6\ 10^{32}$	1.4	0.52
2808 x 2808	0.55	$6\ 10^{10}$	$2.8\ 10^{33}$	5.2	0.52

ATLAS Beam Conditions Monitor

- ATLAS plans to use time of flight to distinguish beam collisions from background

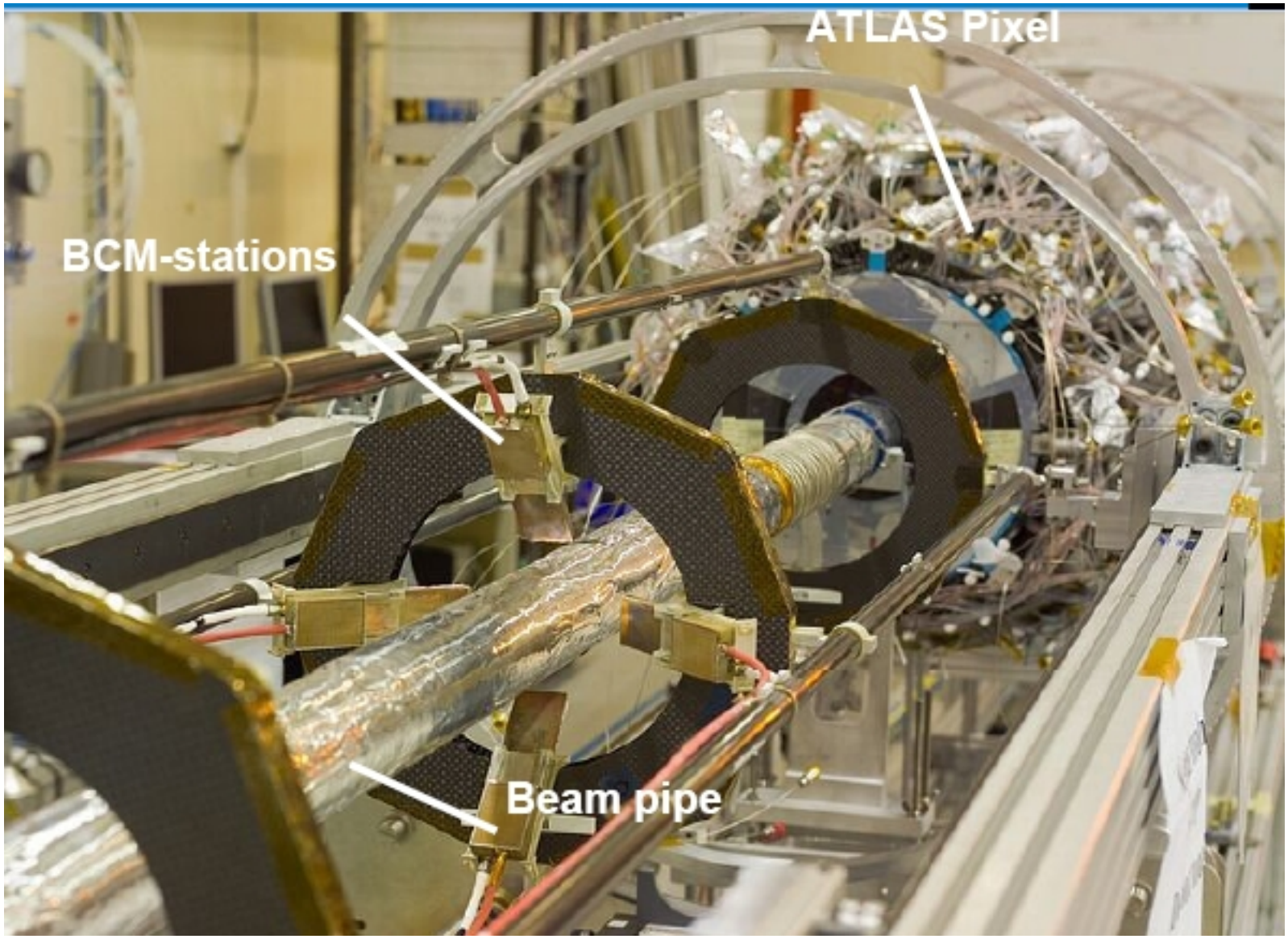


- Optimal separation is 4.1m
- Ideal support in pixel space-frame 3.8m apart



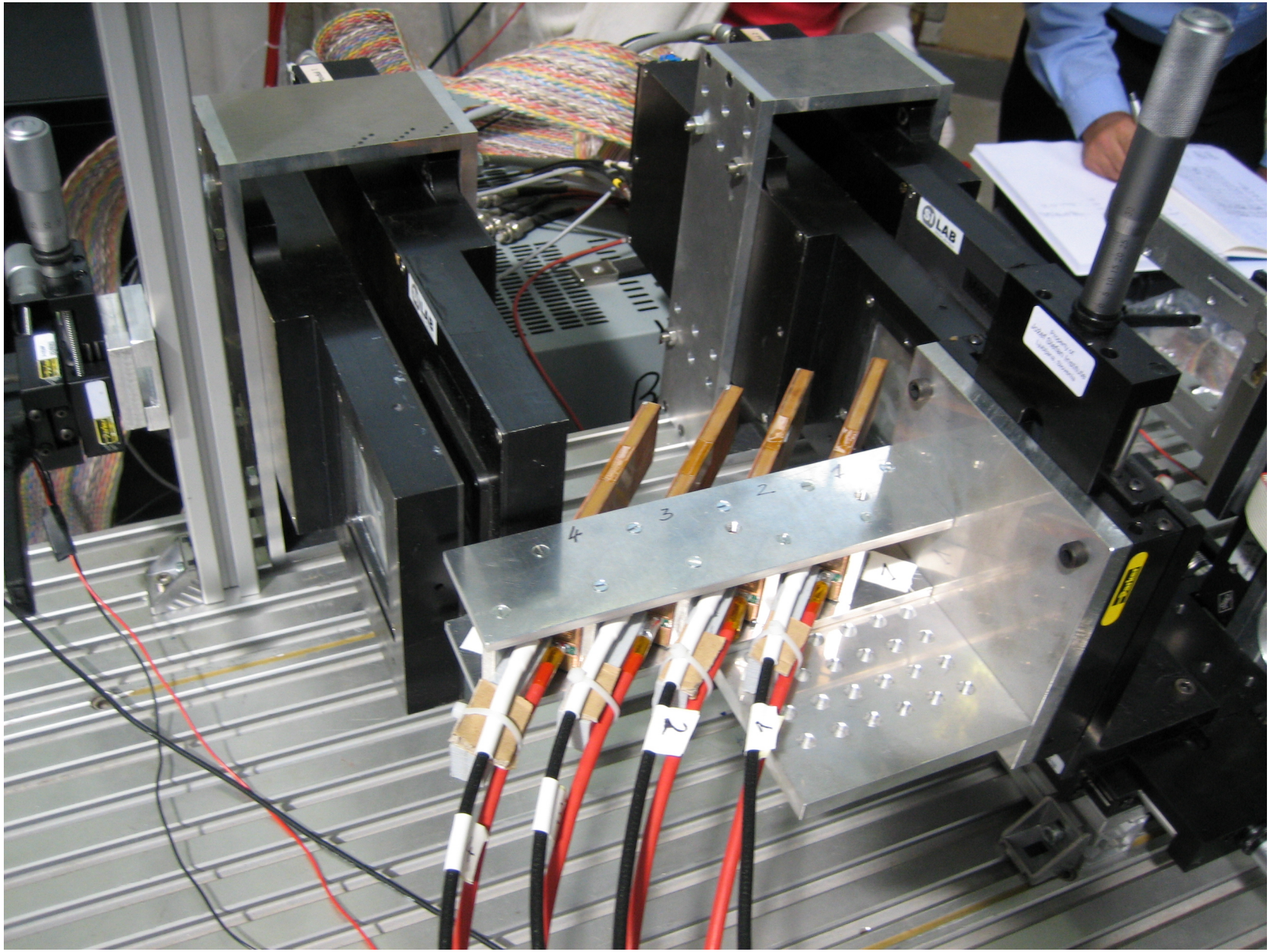
- Use CVD diamond sensors
  - 10x faster and 10x more radiation hard than silicon
- Very fast, rad hard GaAs front end amplifier

Mechanical Installation (January 2007)

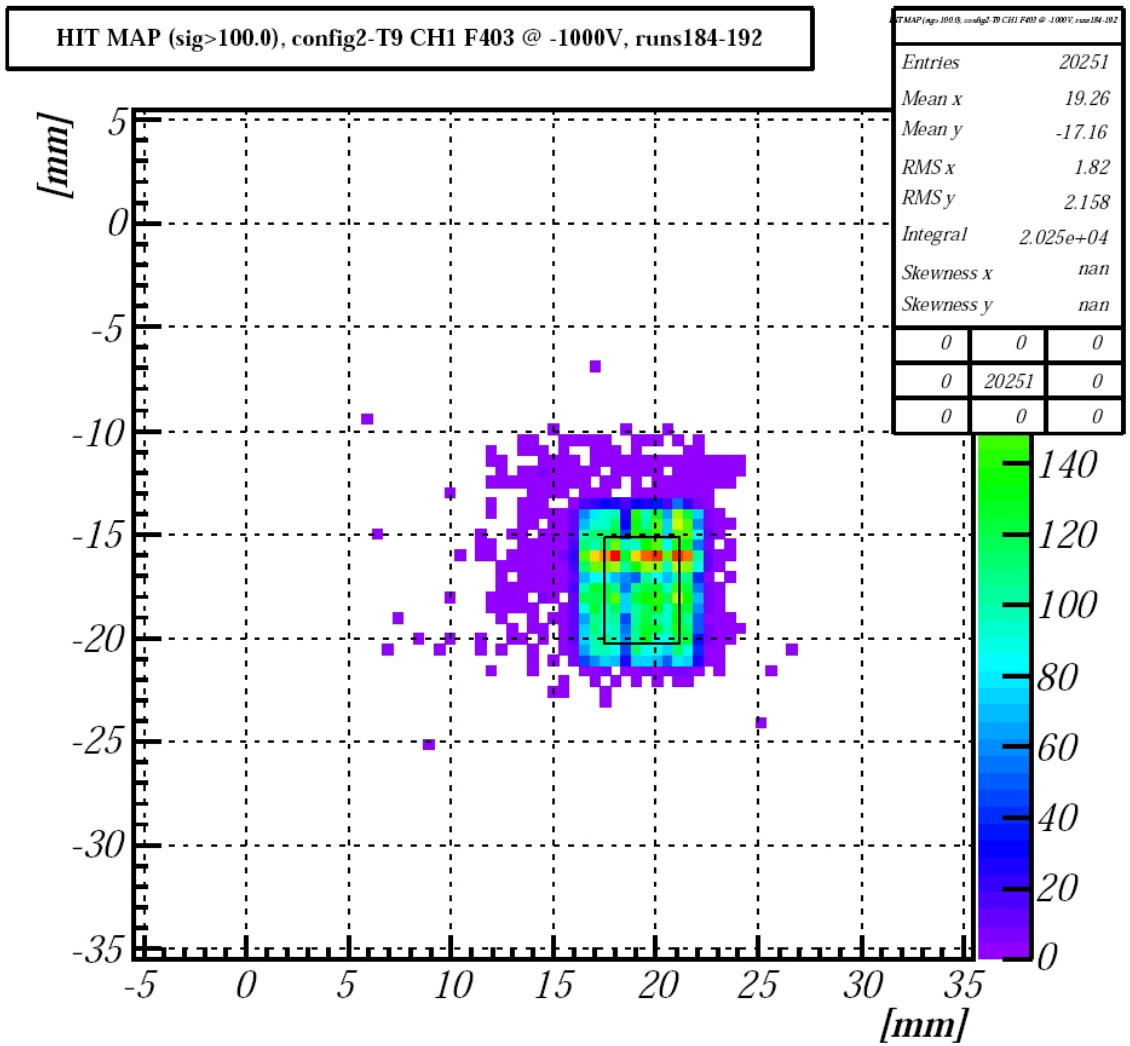


- Cables connected this week

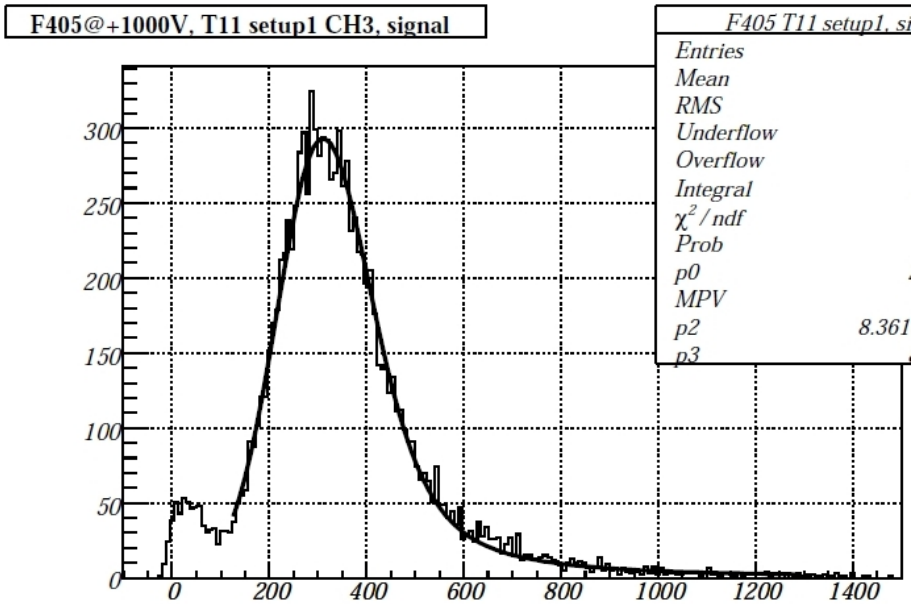
Testbeam Setup at CERN

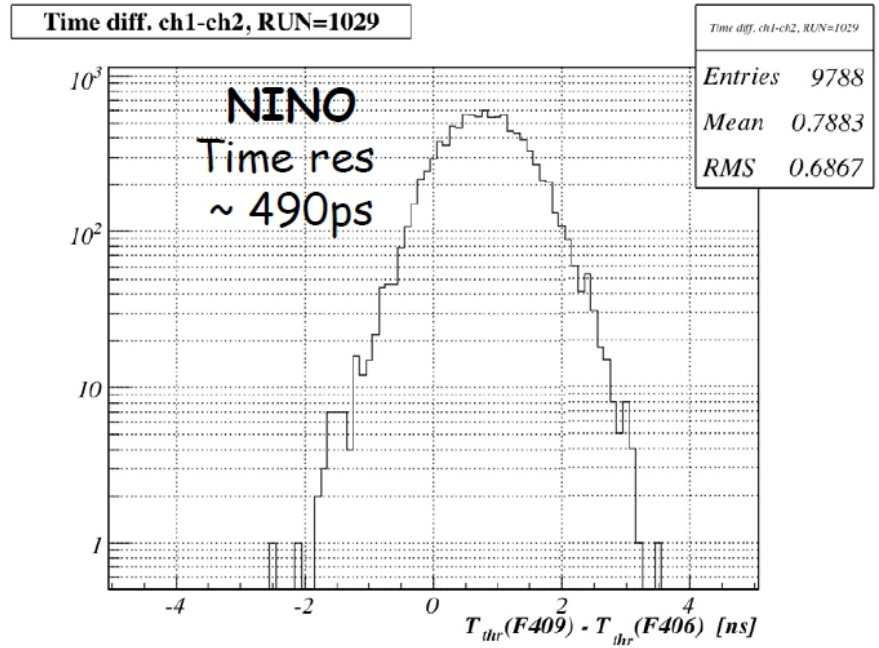


Beam Profile and BCM Hit Efficiency



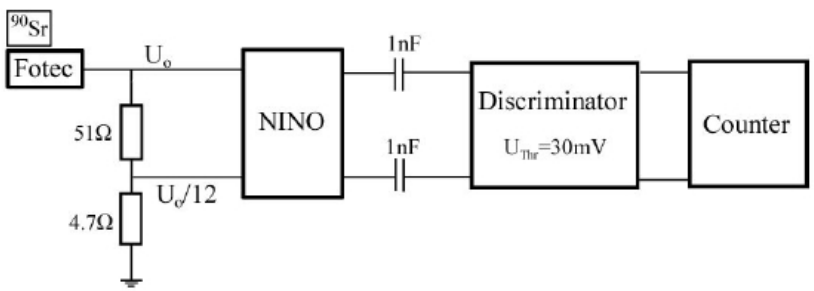
Testbeam Signal Distributions

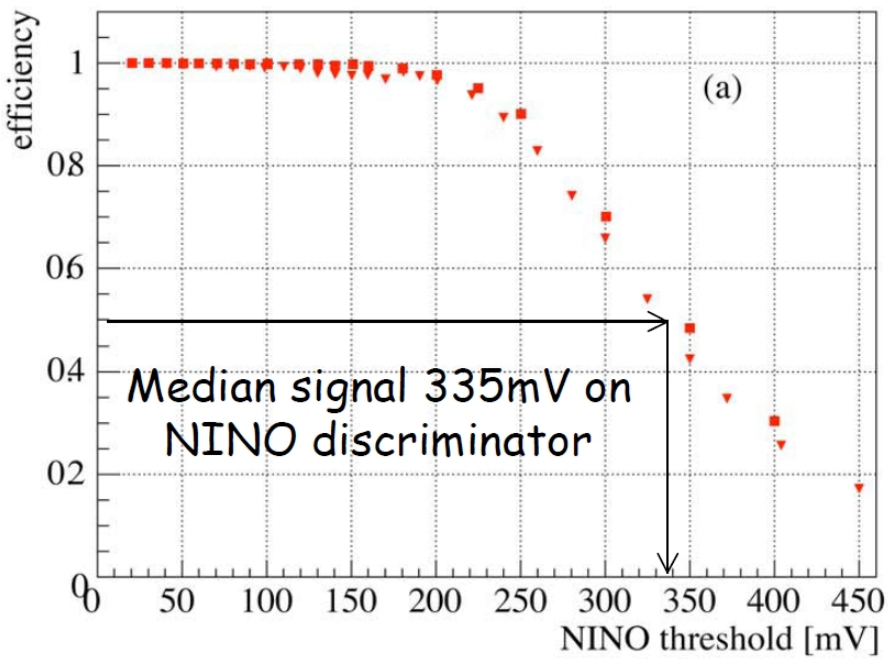


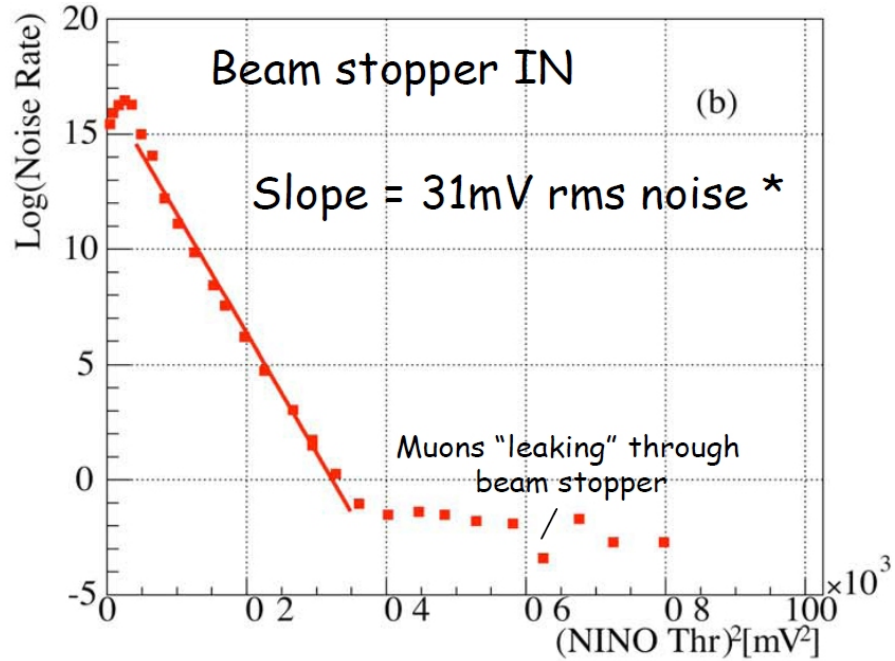


Digitisation Performance

- Using ALICE-TPC standard ADC (NINO) digitiser

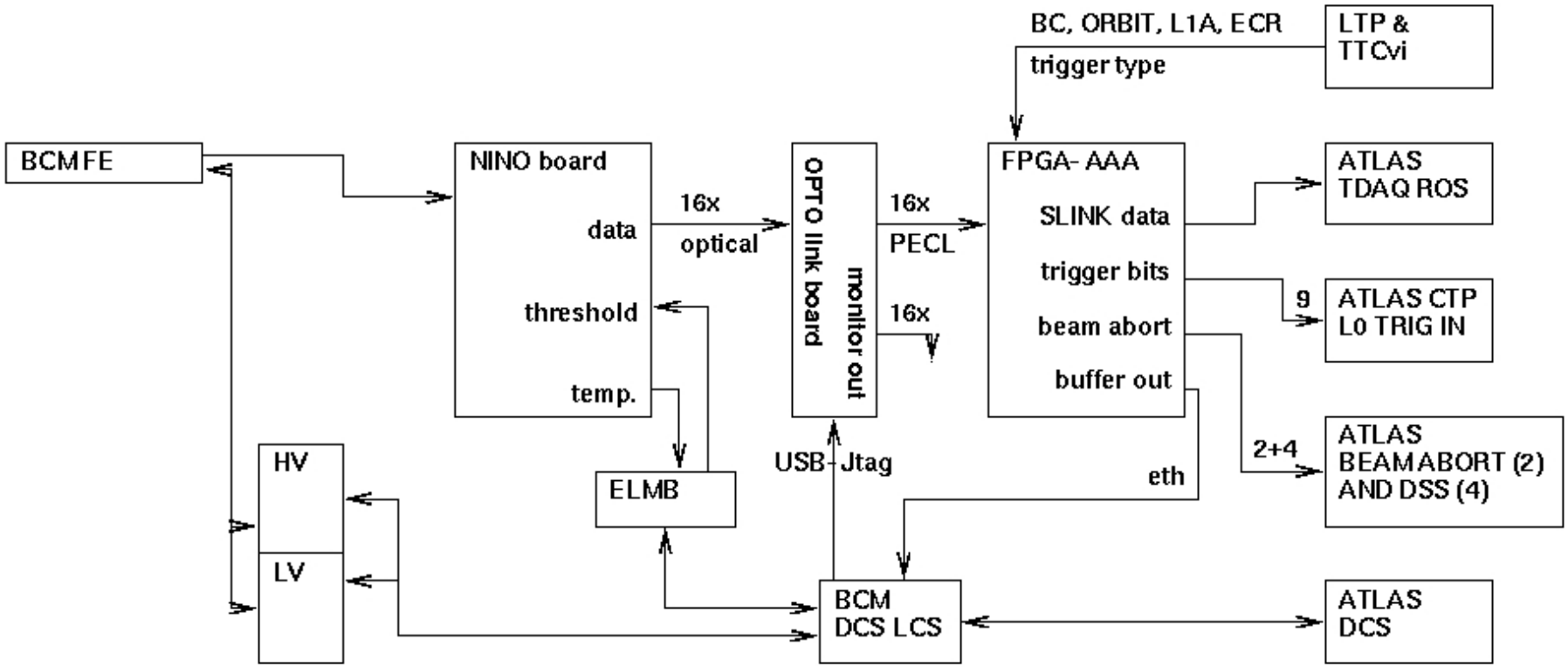




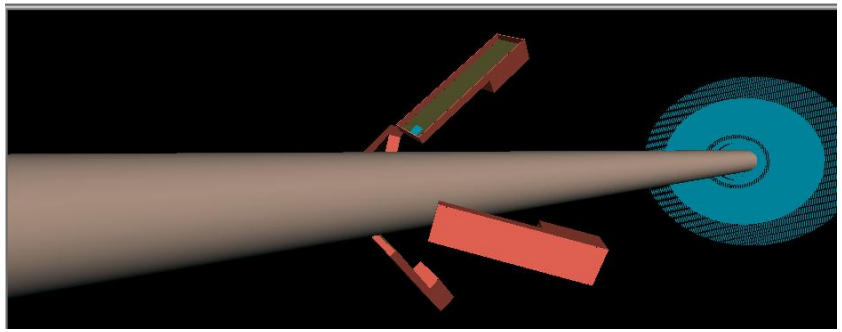


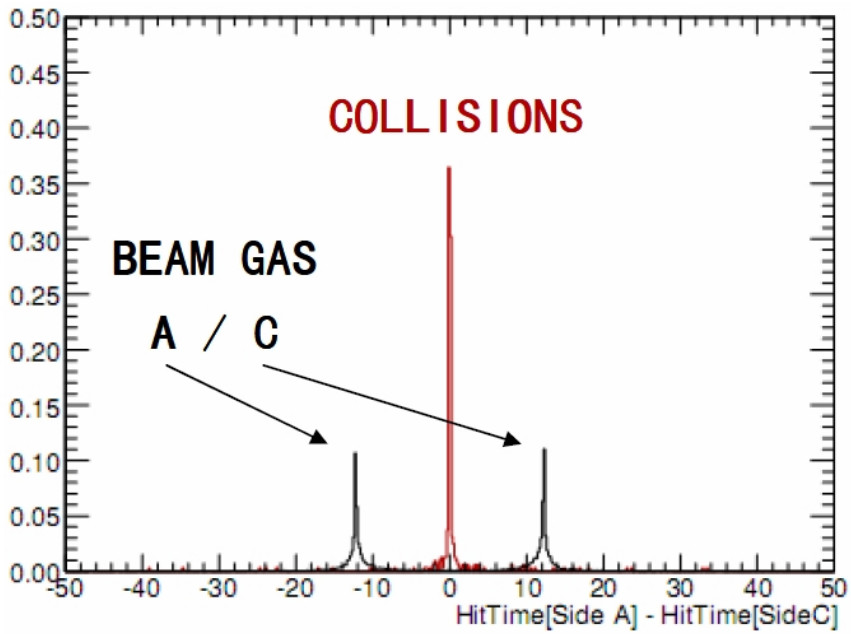
- Results from 2007 testbeam
  - Median signal: 335 mV
  - Inferred noise: 31 mV
  - System S/N = 11:1

BCM Signals for ATLAS



BCM Geometry in Simulation

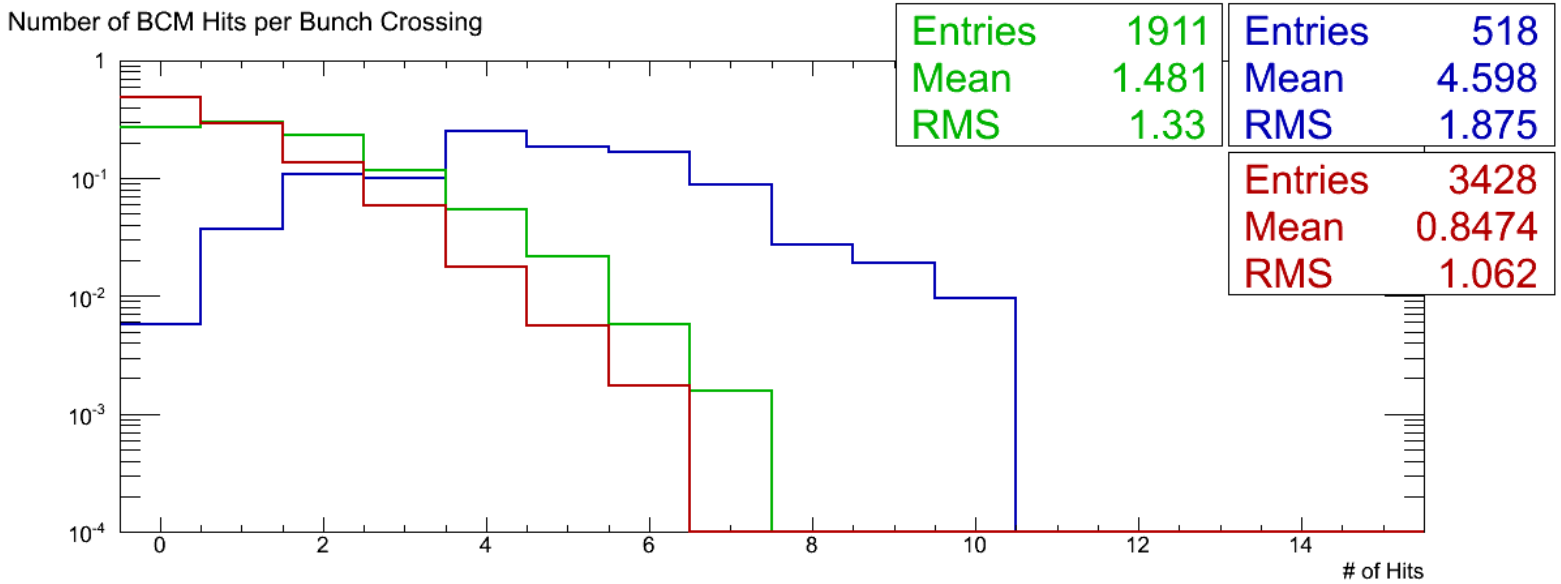


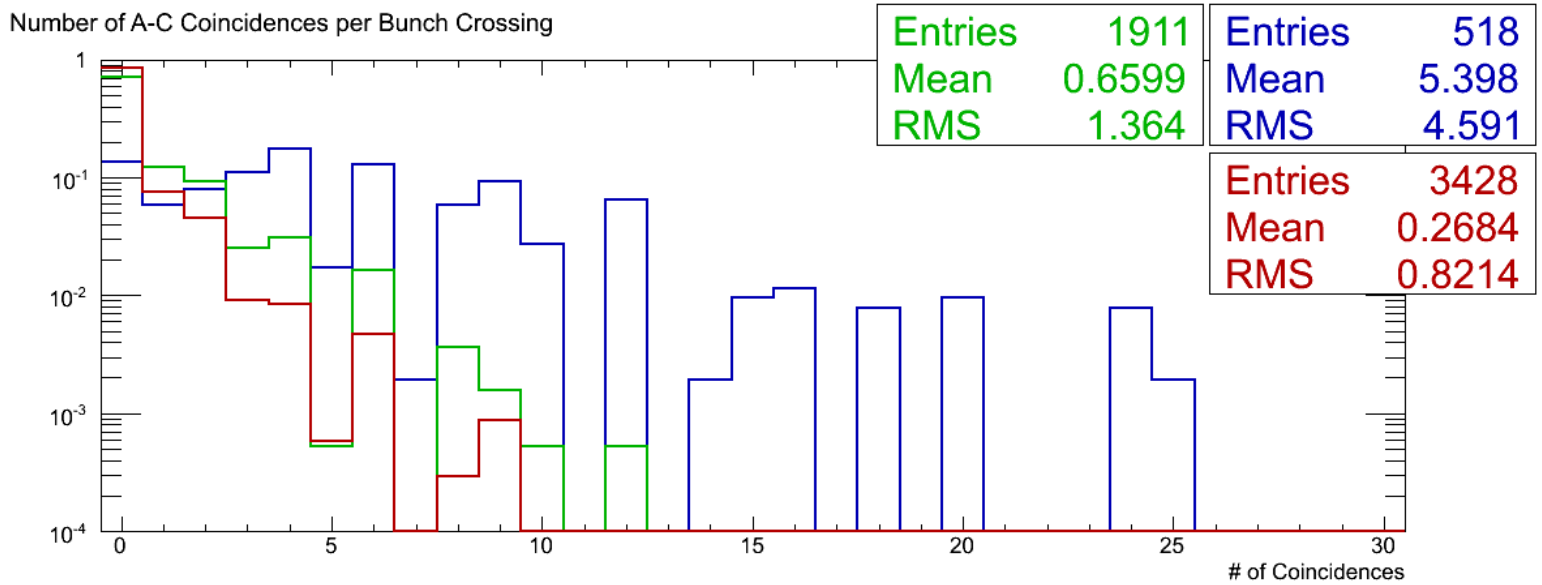


- Full GEANT model of BCM module boxes and support brackets
  - In ATLAS ID simulation

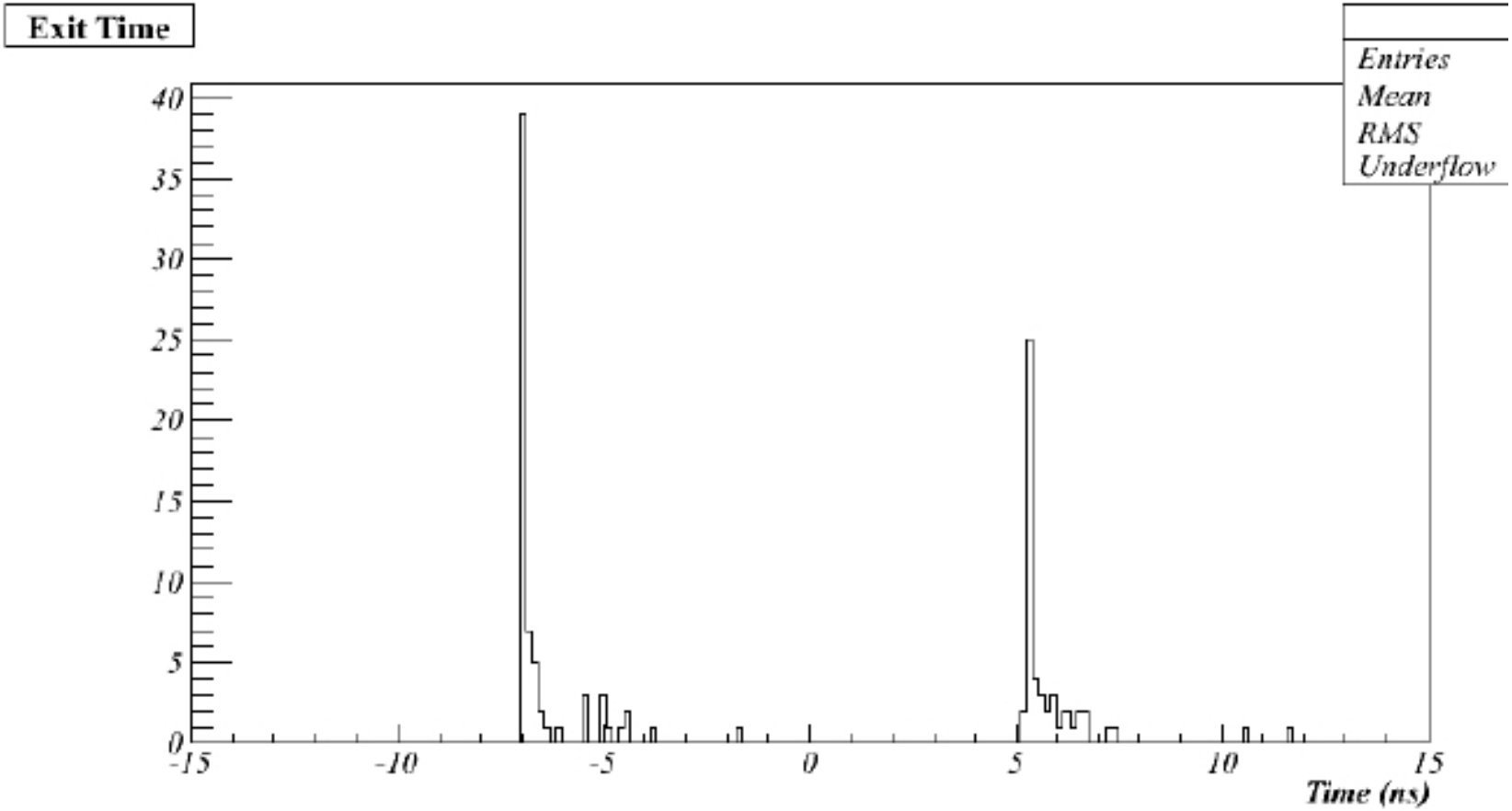
- Study occupancies and arrival times in minbias collisions
- First look at showers of lost particles

Minimum Bias Collisions

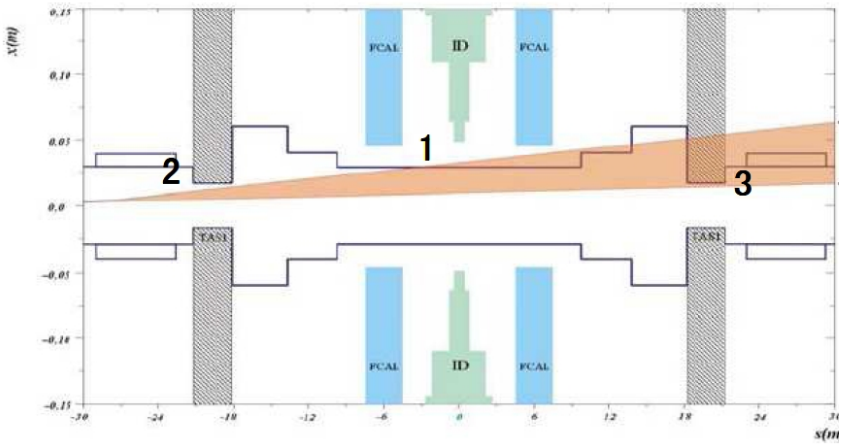


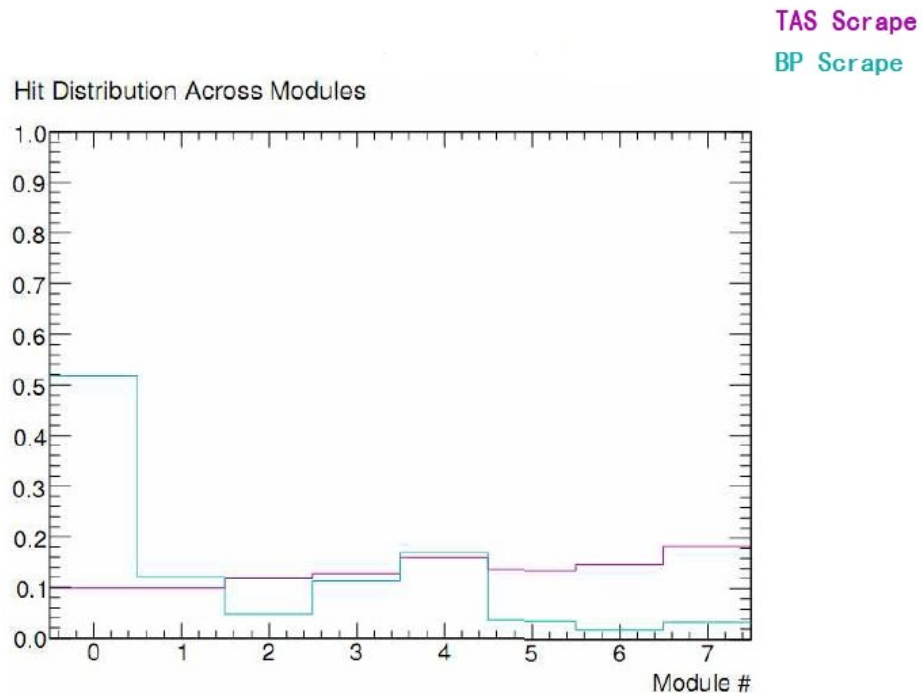


Simulated 7 TeV Lost Proton



Beam Scraping Simulations





- Three injection loss scenarios

  1. Scraping on ATLAS pipe
  2. Scraping on incoming TAS
  3. Scraping on outgoing TAS

- Angular distribution of BCM hits

Predicting Abort rates

- Look for hits in 2 ns window
  - Early modules: $\equiv -6$ ns
  - In-time modules: $\equiv 6$ ns

Alogrithm	Early	In-time
Noise-1	1	X
Noise-2	2	X
Lost p-1	1	1
Lost p-2	2	2

- P_x: Probability for single-p collision
- $R1_x$: Rate in one year (10^7s)
- $R2_x$: Rate in two successive crossings

- Study two BCM efficiencies

	$\varepsilon = 90\%$	$\varepsilon = 99\%$
P_{N1}	9×10^{-9}	2×10^{-4}
P_{N2}	3×10^{-17}	1×10^{-8}
P_{L1}	9×10^{-17}	3×10^{-8}
P_{L2}	1×10^{-33}	1×10^{-16}
$R1_{N1}$	1×10^{7}	2×10^{11}
$R1_{N2}$	4×10^{-2}	1×10^{7}
$R1_{L1}$	0.11	3×10^{7}
$R1_{L2}$	1×10^{-18}	0.16
$R2_{N1}$	0.11	3×10^{7}
$R2_{N2}$	1×10^{-18}	0.16
$R2_{L1}$	1×10^{-17}	1.2
$R2_{L2}$	2×10^{-51}	2×10^{-17}

Commissioning Plans

- Four distinct periods
  1. Cabled (no beam): Now to June
  2. Single beams: June to September?
  3. First Collisions: September to end 2008
  4. Increasing luminosity/danger: 2009
- Simulations providing inspiration
- Developing FPGA algorithms; Develop trigger definitions later
- Test noise/signal performance in ATLAS
- No substitute for on-the-job experience with LHC beams

Summary of BCM Capabilities

- The BCM is only sensitive to charged particles
- The BCM will be always on
- Disentangle backgrounds using timing and spatial distributions
- Working with LHC to define warning signals and levels
- We are well suited to distinguish losses from A or C sides
- Will measure bunch-by-bunch luminosity variations
- Could measure luminosity variation on a time-scale of seconds
- 2.5 ns displaced bunches will be a challenge. 5 ns OK?

Summary

- Deterministic LHC commiss'ning proceeding on-schedule: Known-knowns
- A significant number of un-deterministic tasks remain: Known-unknowns
- Hopefully we won't encounter any Unknown-unknowns

- Eight BCM modules installed in ATLAS June 2007
- First readout in pit March
- Now working on beam accident simulations
- Use simulations to guide design of beam abort logic
- Anticipate continuous operation by end of May