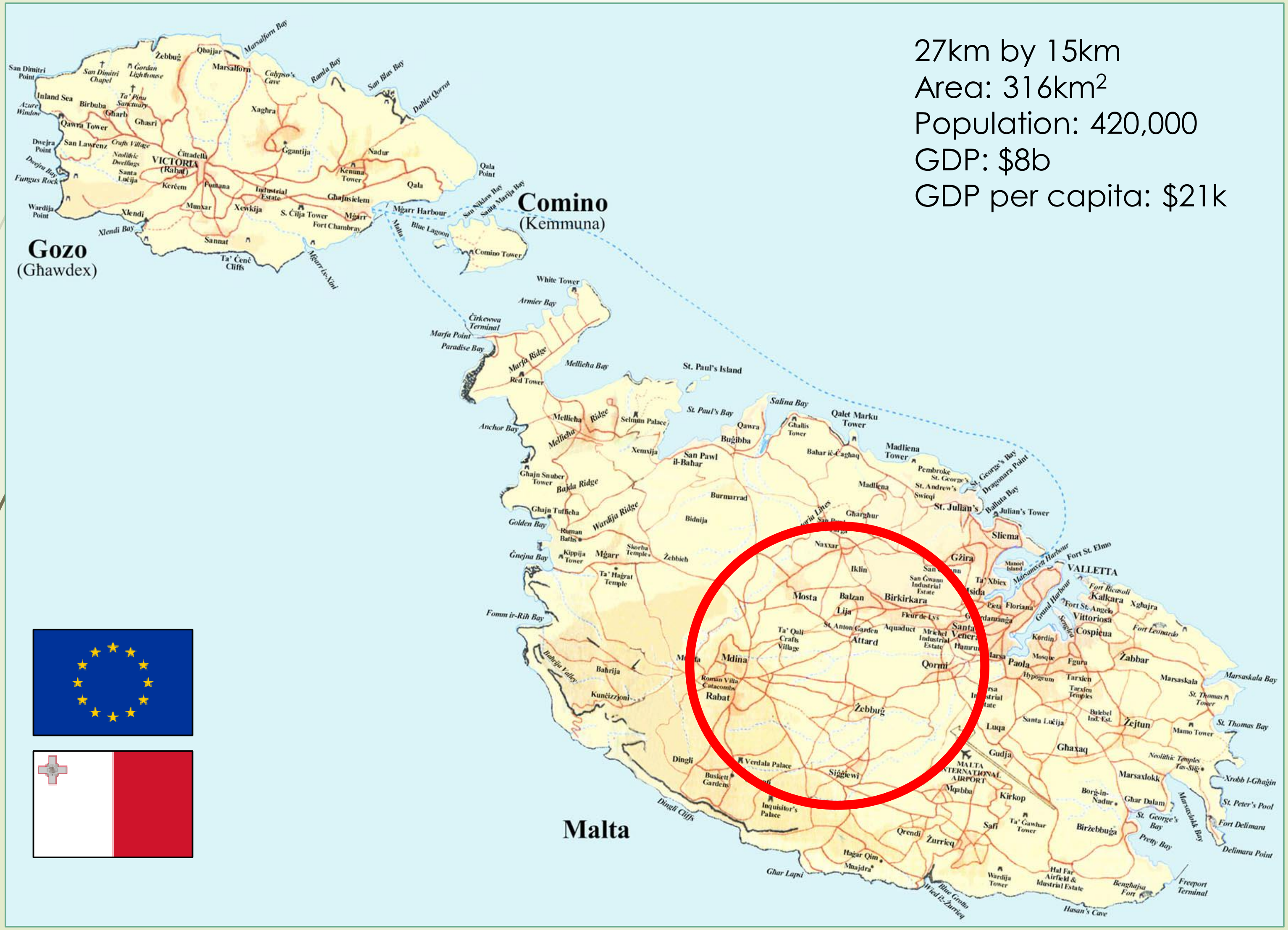
The University of Malta

by Nicholas Sammut

15th October 2013

The Maltese Islands

27km by 15km
Area: 316km^2
Population: 420,000
GDP: $8b
GDP per capita: $21k



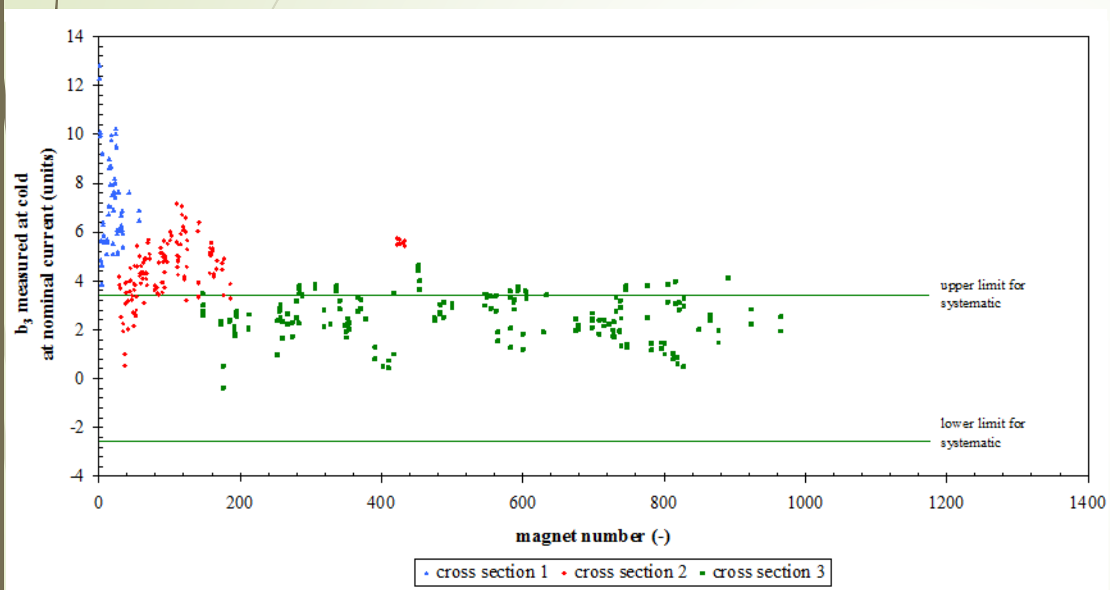
The University of Malta

- Set up in 1592
- 11,000 students
- The only university & highest teaching institution in Malta
- 3,000 students graduate annually
- Faculty of Engineering (Electronics, Systems, Power, Metallurgy, Mechanical and Manufacturing)
- Faculty of Information, Communications and Technology (Micro and Nanoelectronics, Communications and Computer Architecture, Computer Science, Computer Information Systems, Intelligent Computer Systems
- Faculty of Science; Department of Physics
- About 300 students graduate from the university each year in the technical subjects
- Very strict grading system that results in very high quality students

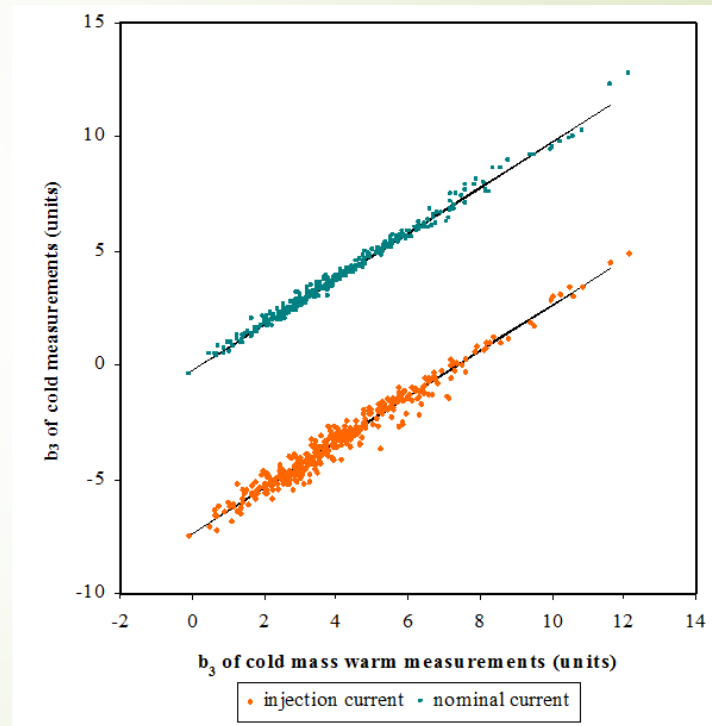
The University of Malta and CERN

- Started institutional collaboration in 2002
- Started National collaboration in 2008
- 23 Summer Students
- 4 PhDs
- 2 Fellows
- Involvement in Magnetic Measurements and Instrumentation of Superconducting Magnets in SM18
- Development and Integration of Magnet Control system in the CERN Control Centre
- Development and Integration of Collimator Control Systems
- Studies of Collimator Materials in LHC Accident Scenarios
- Involvement in FP7 EUCARD and FP7 EUCARD2
- High Energy LHC Workshop in Malta in 2010

Magnetic Measurements and Instrumentation of Superconducting Magnets in SM18

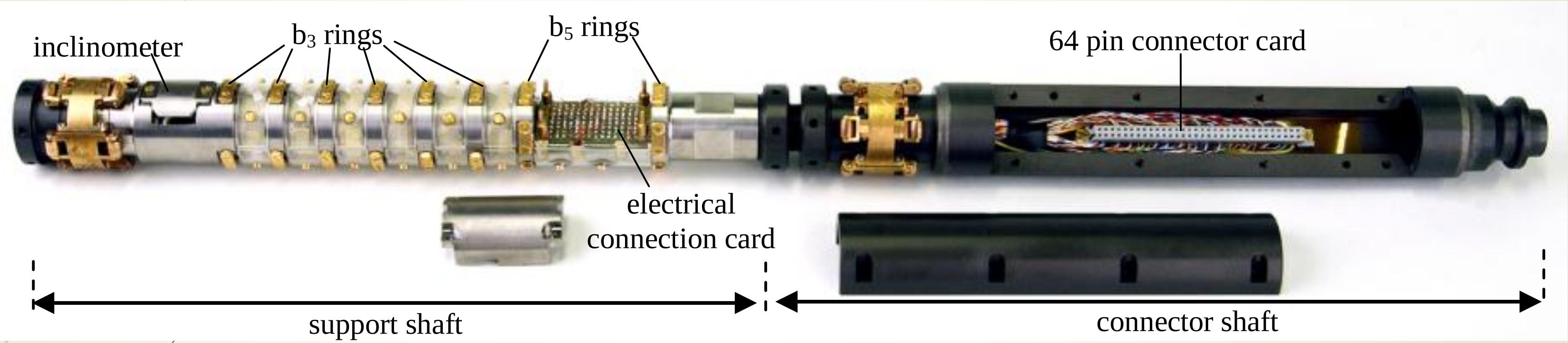


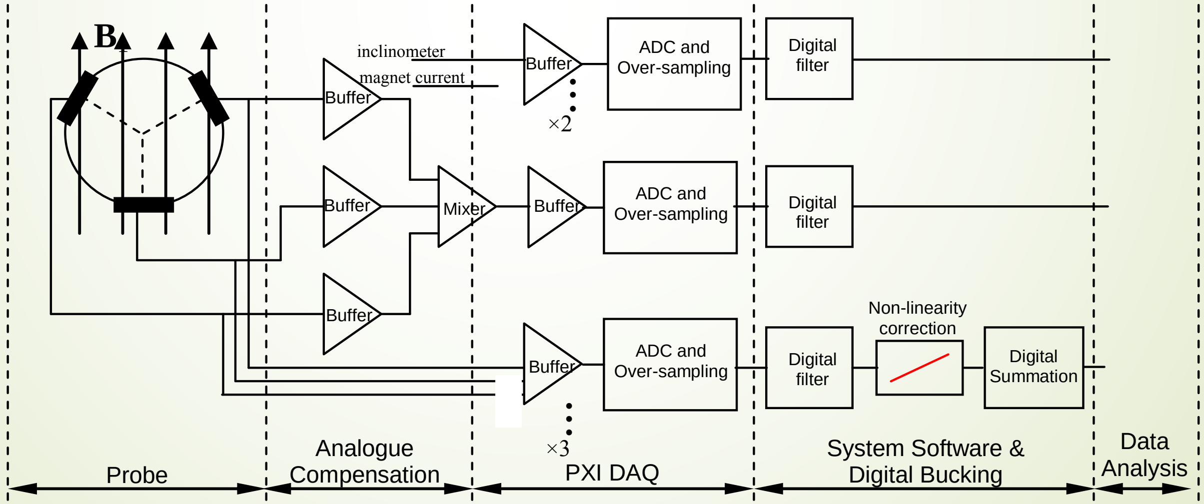
Monitoring of Field Quality @ Cold during Production



Establishment of Warm-Cold Correlation

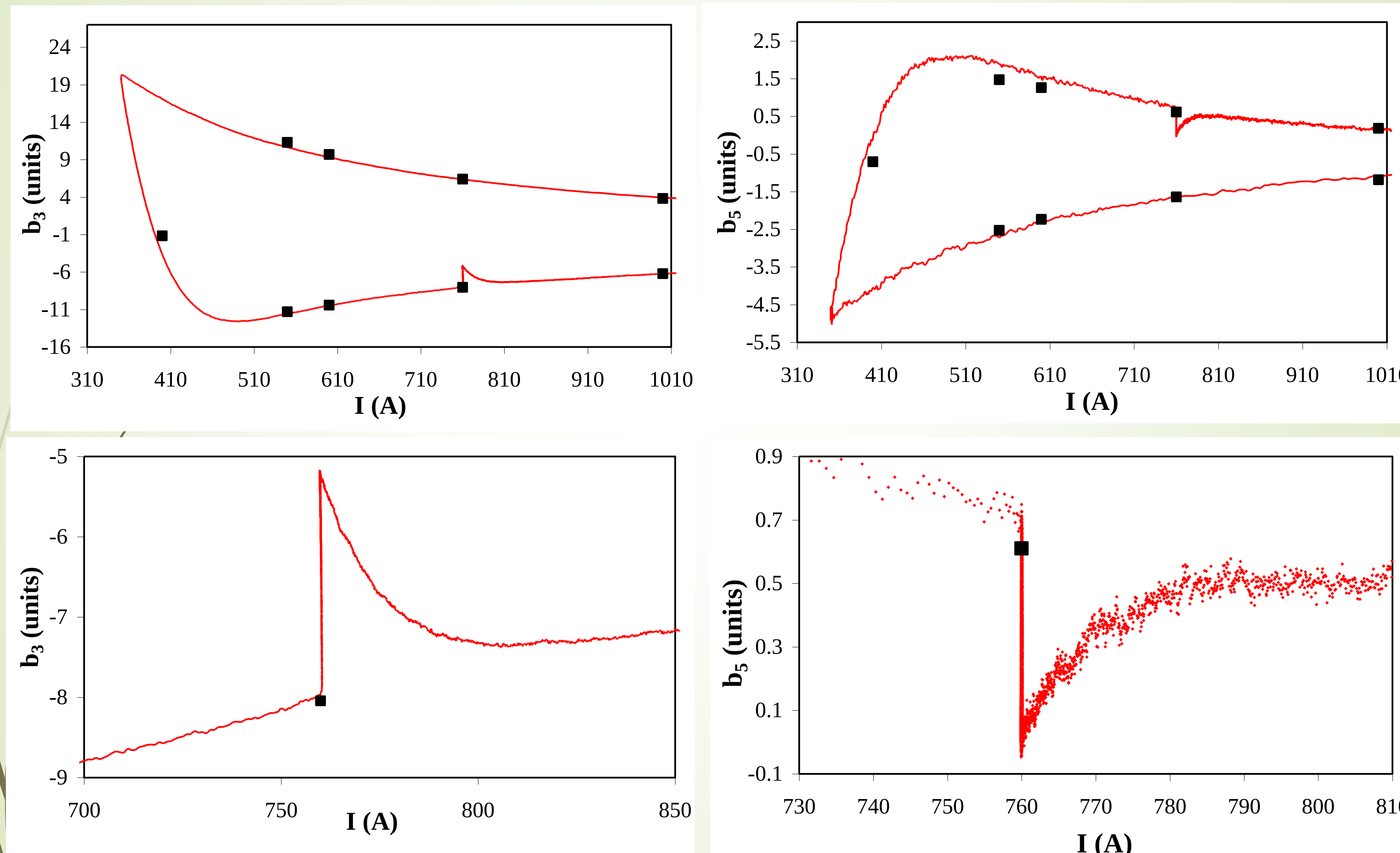
The Snapback Analyser





Digital System	b_3	b_5
Random Noise	2.2 ppm	7.6 ppm
Drift (over 6000 s)	12 ppm	20 ppm

Snapback Measurements



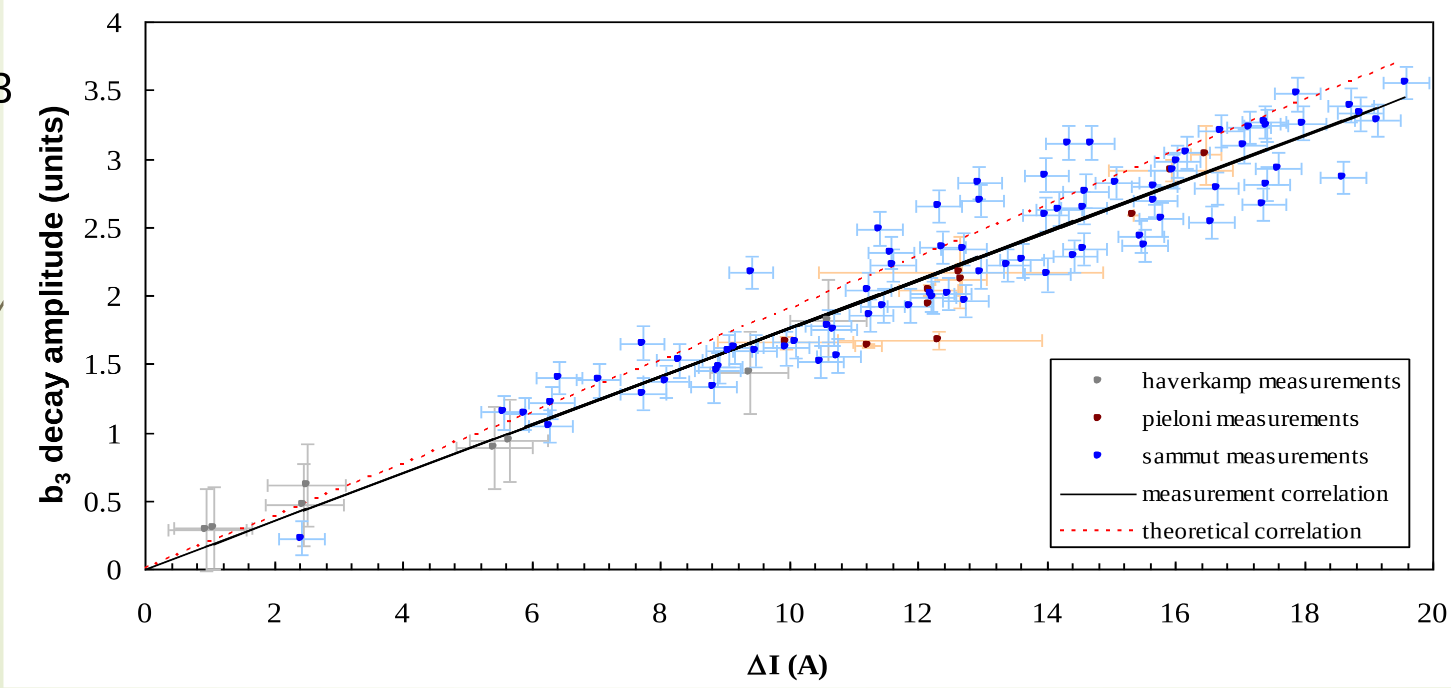
Unprecedented Results

Snapback Correlation

- Δc_n obtained from the decay scaling at end of injection
- ΔI obtained from fitting parameter correlation

– snapback scaling law

b_3



$$\mathbf{c}_n^{snap-back} = \Delta \mathbf{c}_n^{decay} e^{-\frac{I(t)-I_{injection}}{\Delta I}}$$

$$\Delta I = \frac{\Delta c_n}{\xi_n}$$

Median error

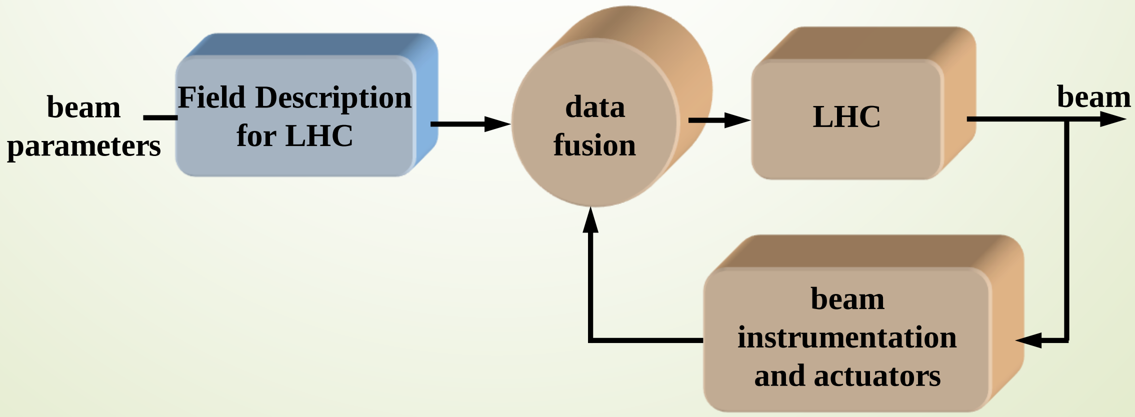
b_3 – 0.14 units

Development and Integration of Magnet Control system in the CERN Control Centre

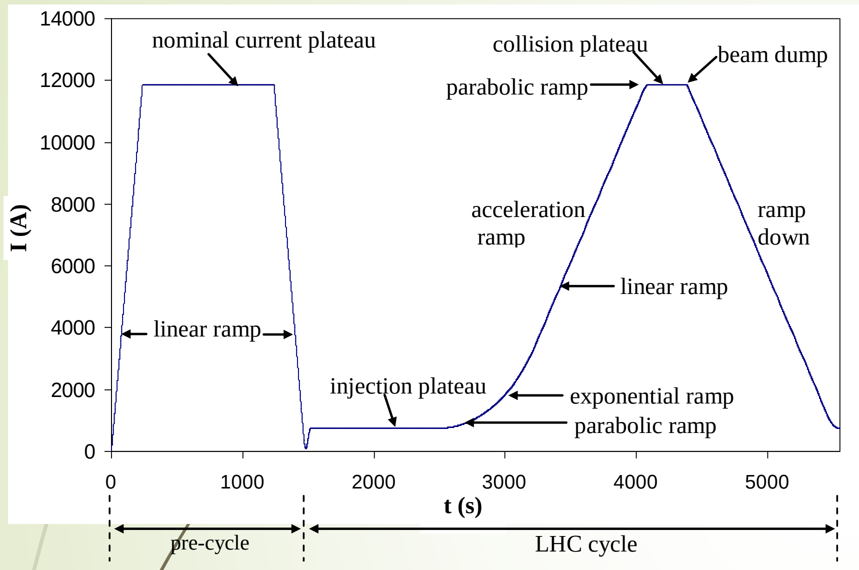
- Beam based measurements:
  - May be destructive and may cause undesirable emittance growth
  - Some of the beam dynamics may not be easily determined from beam measurements
  - The beam diagnostics may not be fast enough (particularly during snapback)

- The baseline for LHC control requires a system based on feed-forward control to reduce the burden on the beam based feed-back

- Hybrid Control System



The Field Description for the LHC

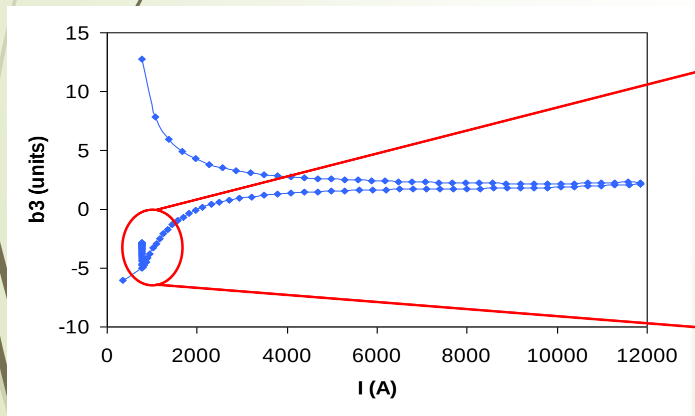


- Harmonics of 2nd, 3rd, 4th, 5th order exist in the LHC superconducting magnets

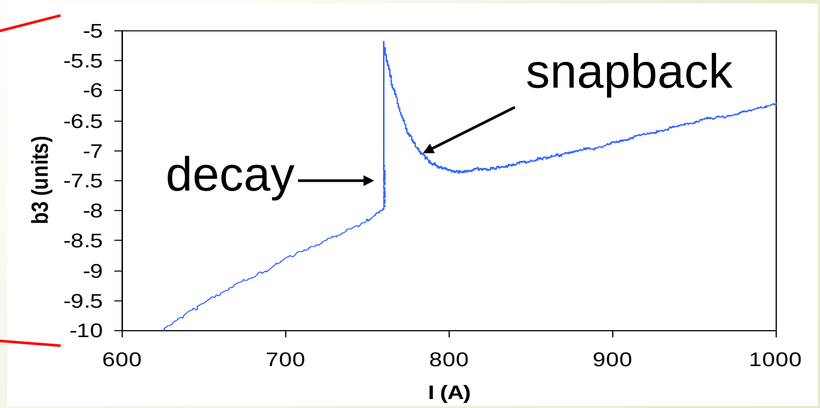
- Without correction, the LHC will not work or will take years to commission

- Harmonics vary statically and dynamically as a function of current, time, powering history

- Manufacturing tolerances result in a spread in these effects

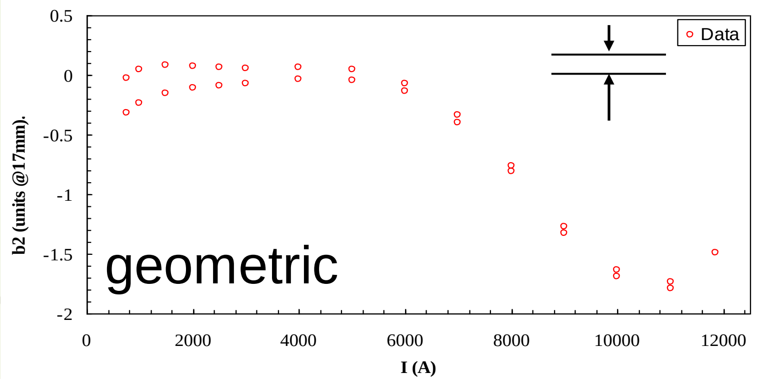


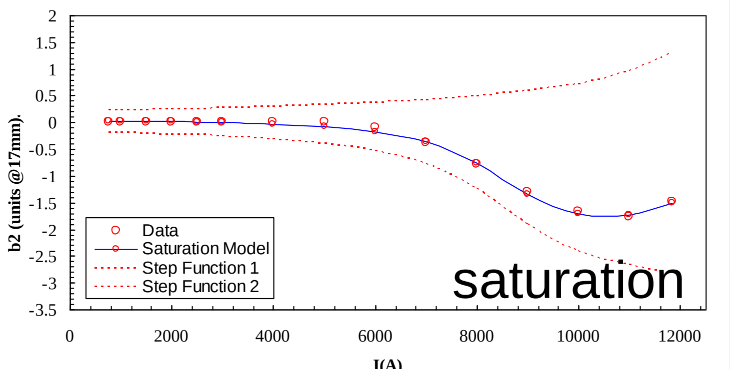
Static Effects

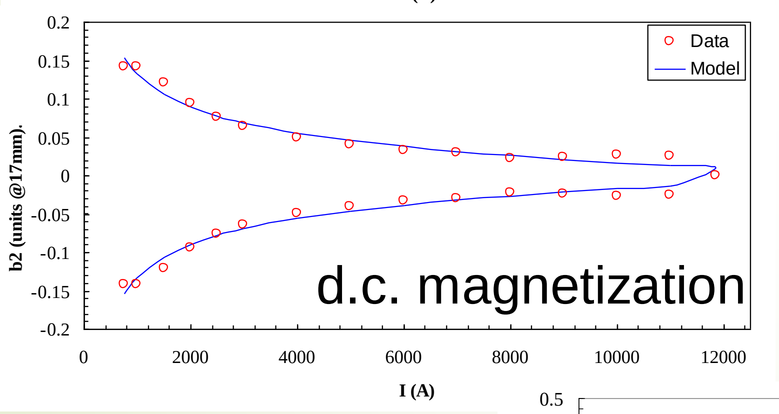


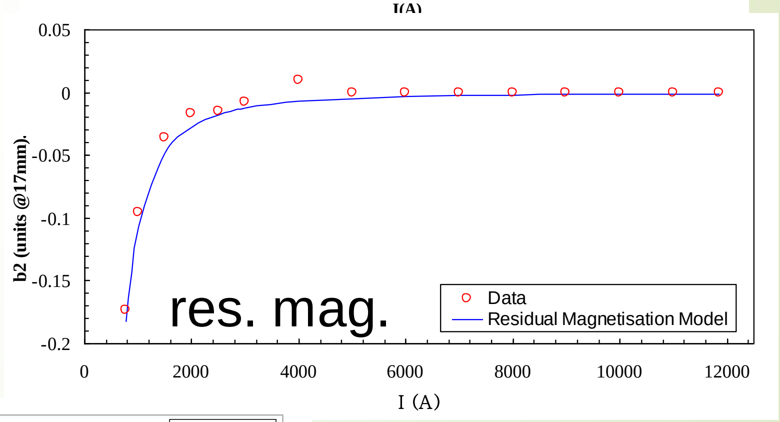
Dynamic Effects

Computing Parameters of Static Field Model

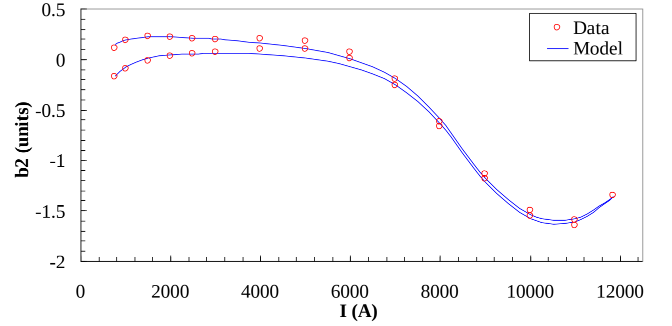






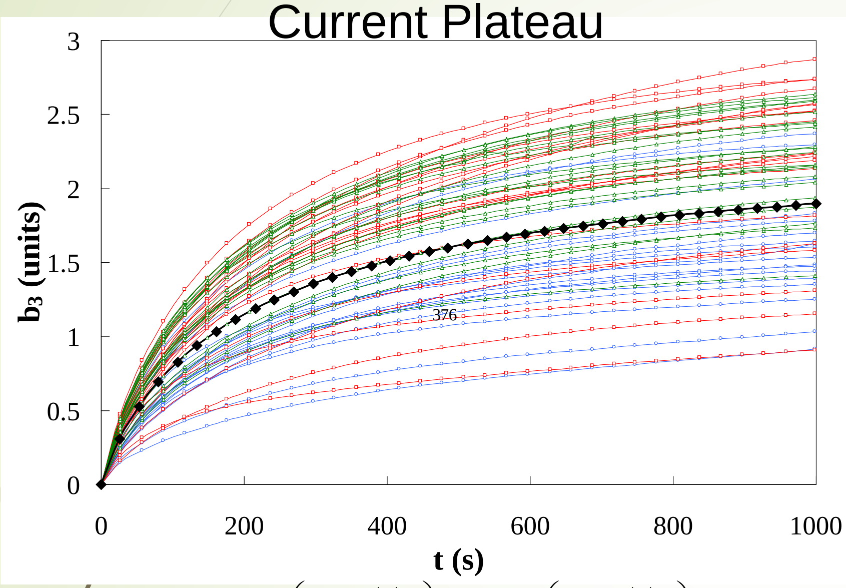


result

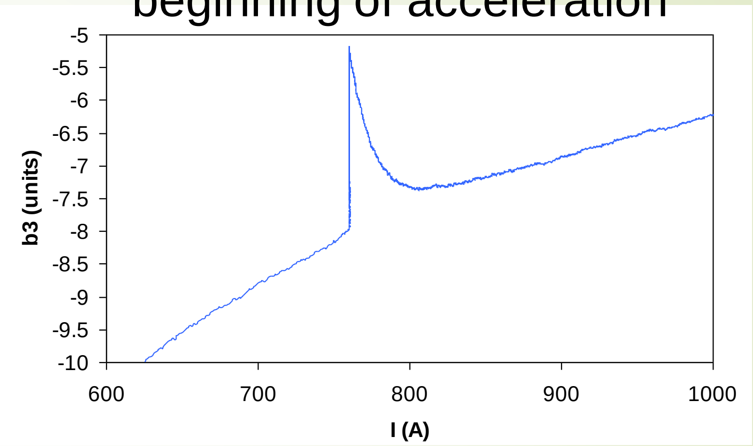


The Dynamic Effects

Field decay on Constant Current Plateau

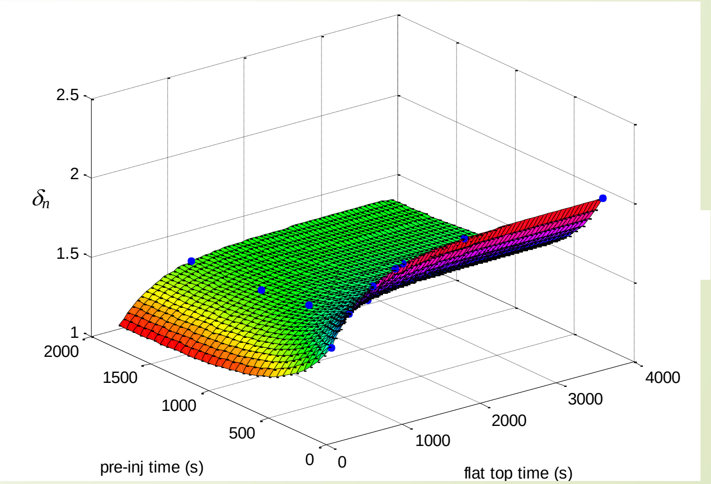


Field snapback at beginning of acceleration



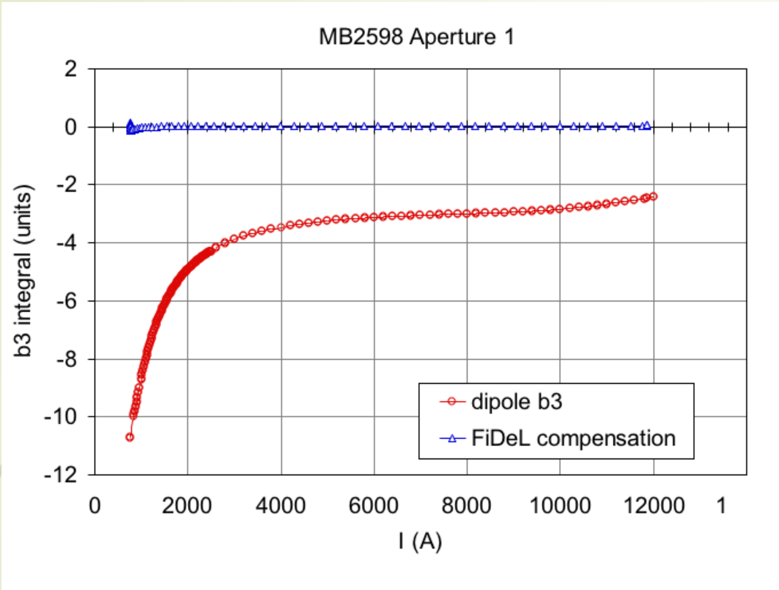
$$\Delta\left(t,t_{inj},\tau,d\right)=d\left(1-e^{-\frac{t-t_{inj}}{\tau}}\right)+\left(1-d\right)\left(1-e^{-\frac{t-t_{inj}}{9\tau}}\right)$$

$$\delta_n=\delta_{std}\left(\frac{E_0^n-E_1^n e^{-\frac{I_{FT}}{\tau_E^n}}}{E_0^n-E_1^n e^{-\frac{I_{FT}^{std}}{\tau_E^n}}}\right)\left(\frac{T_0^n-T_1^n e^{-\frac{t_{FT}}{\tau_T^n}}}{T_0^n-T_1^n e^{-\frac{t_{FT}^{std}}{\tau_T^n}}}\right)\left(\frac{P_0^n+P_1^n e^{-\frac{t_{preperation}^{std}}{\tau_P^n}}}{P_0^n+P_1^n e^{-\frac{t_{preperation}^{std}}{\tau_P^n}}}\right)$$

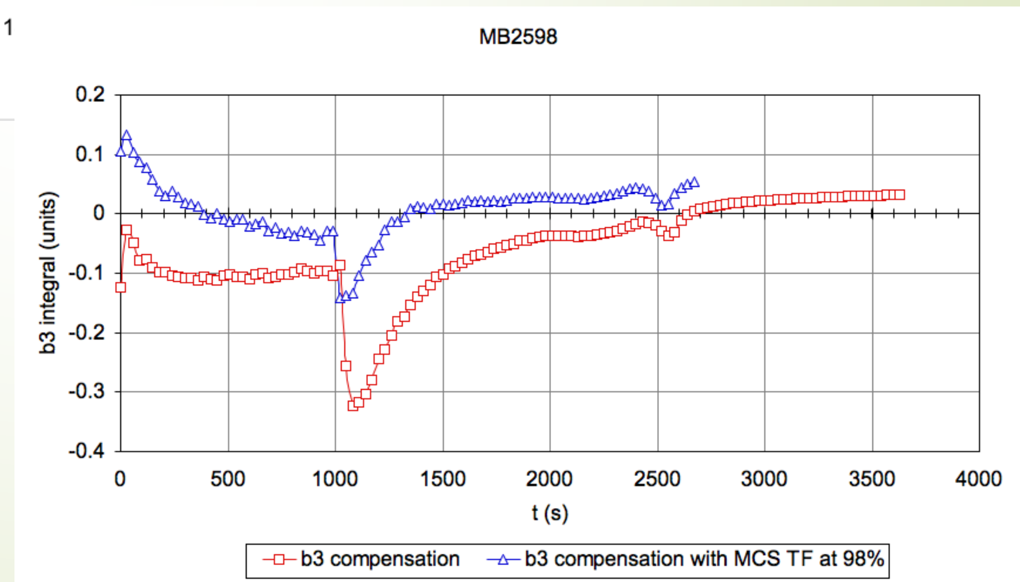


Decay and Snapback also depend on powering history!!

Results

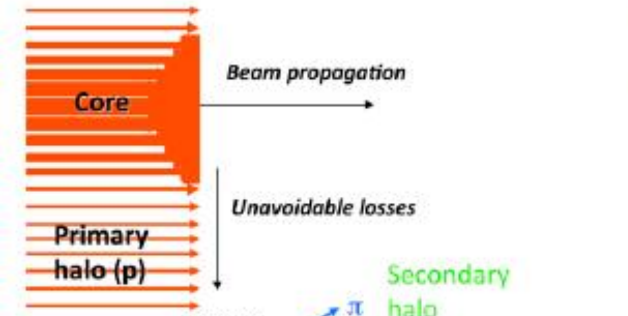


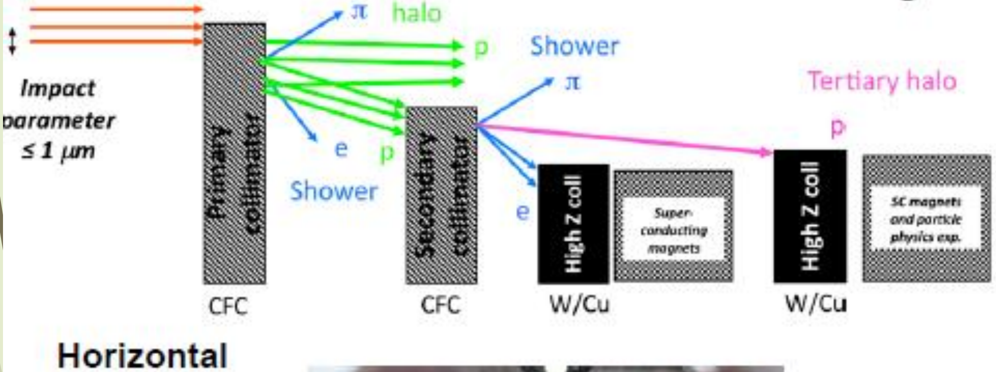
Prediction of b3 harmonic to less than 4%

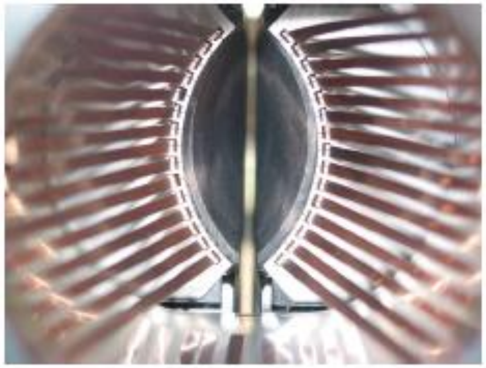


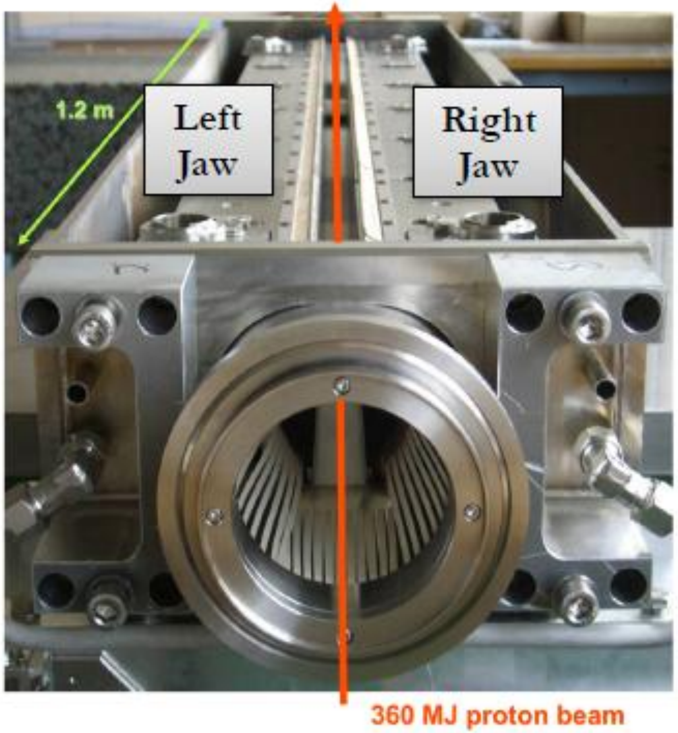
Development and Integration of Collimator Control Systems

- Particles have a natural tendency to drift to the beam halo over time.
- Collimators passively scatter and intercept beam halo particles to:
  - Prevent quenches of the super-conducting magnets.
  - Limit irradiation of sensitive devices.
  - Reduce signal background in the experiment detectors.





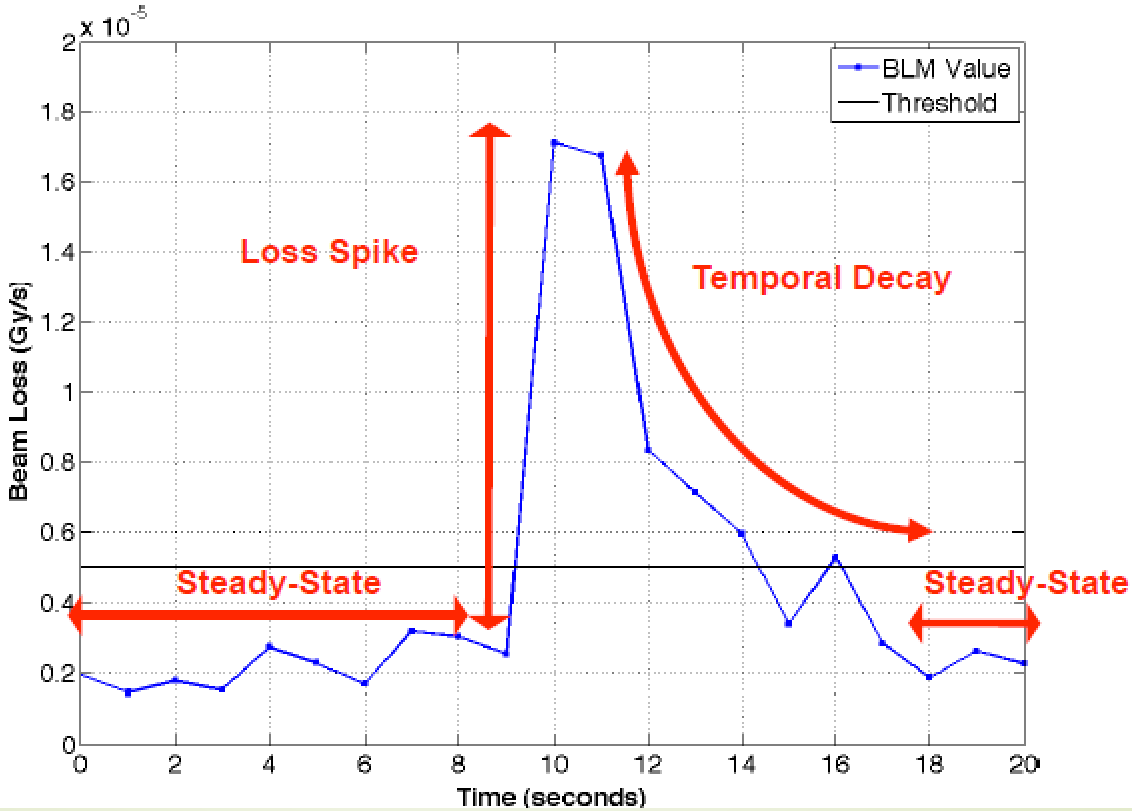




Modelling and Simulation of Beam Losses

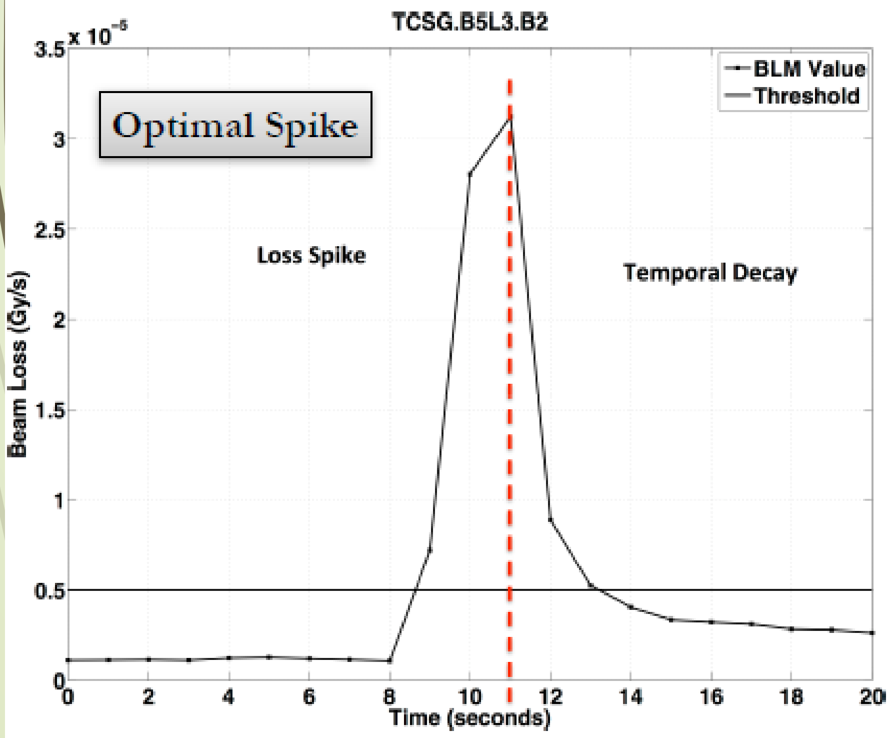
- **Motivation:** - allow offline tests of the automatic setup application without requiring beam.
  - gain knowledge of beam loss dynamics useful for automatic alignment.
- Loss spike consists of 3 components which have to be understood and modeled:

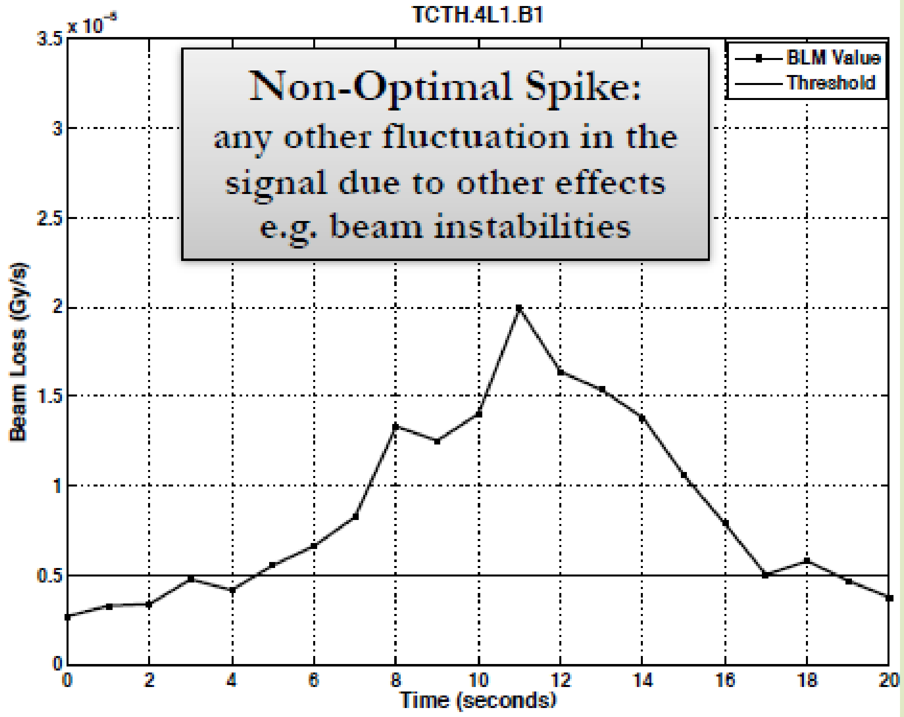
Typical Optimal Loss Spike



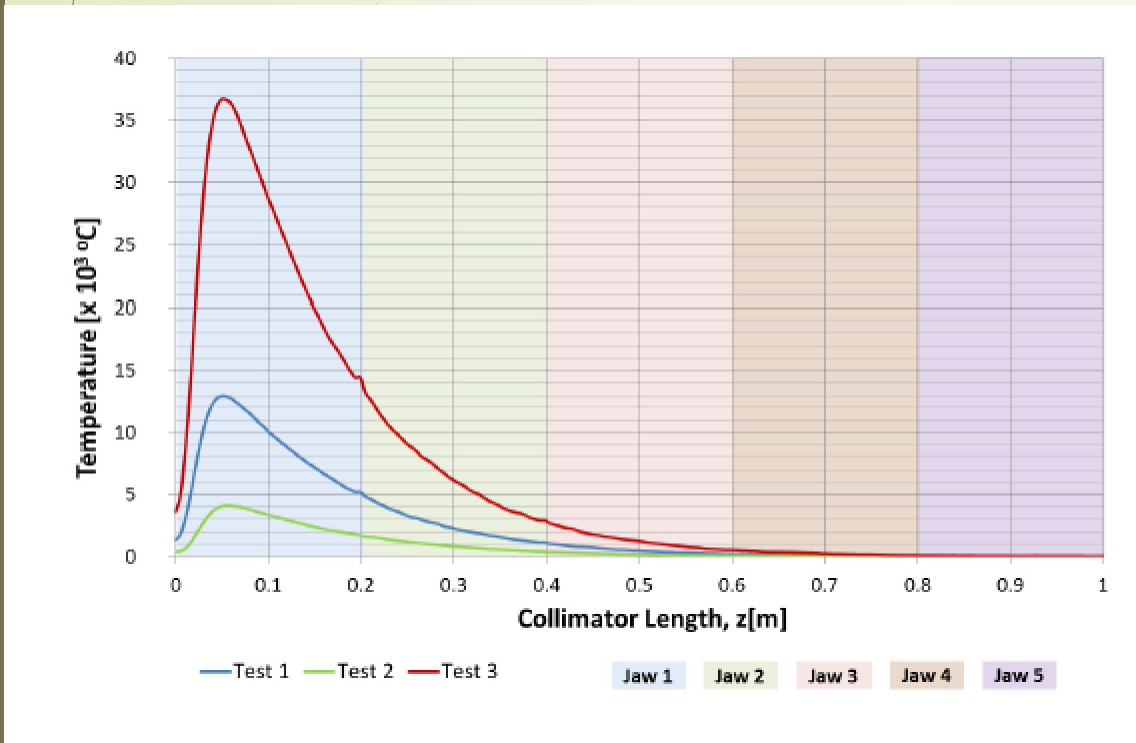
BLM Spike Recognition

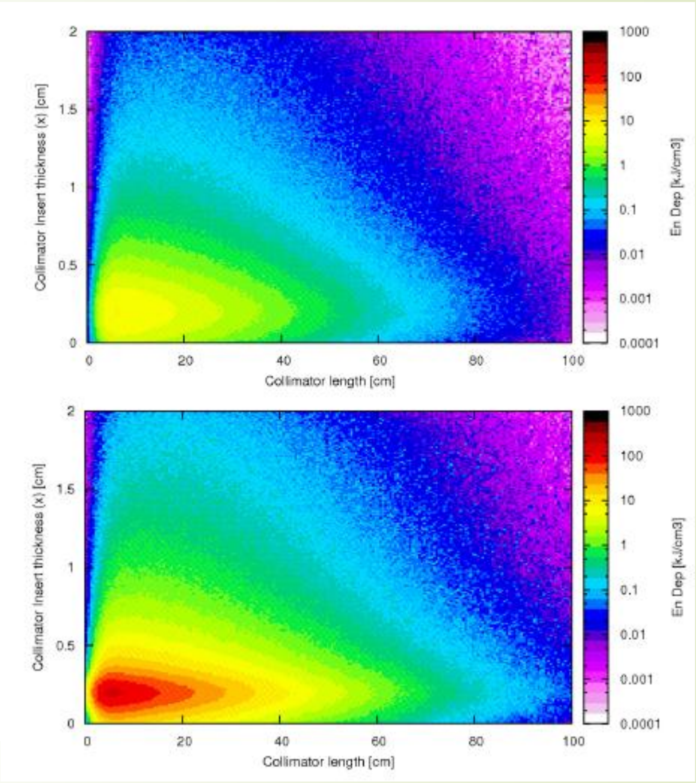
- Automatic classification of loss spikes is key to an automated setup procedure.
- **Support Vector Machines (SVM):** supervised-learning classification algorithm.
- A jaw is aligned to the beam when an **optimal spike** is observed.
- If the spike is **non-optimal**, the jaw has to be moved in again.





Collimator Materials in LHC Accident Scenarios





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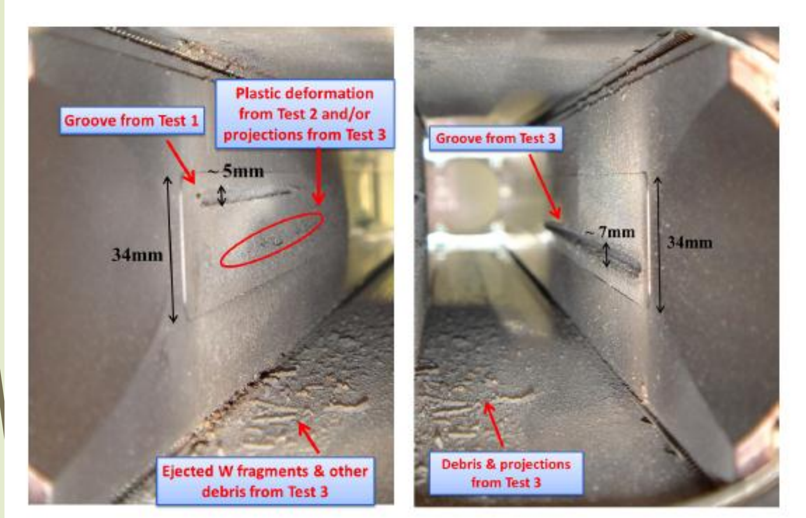

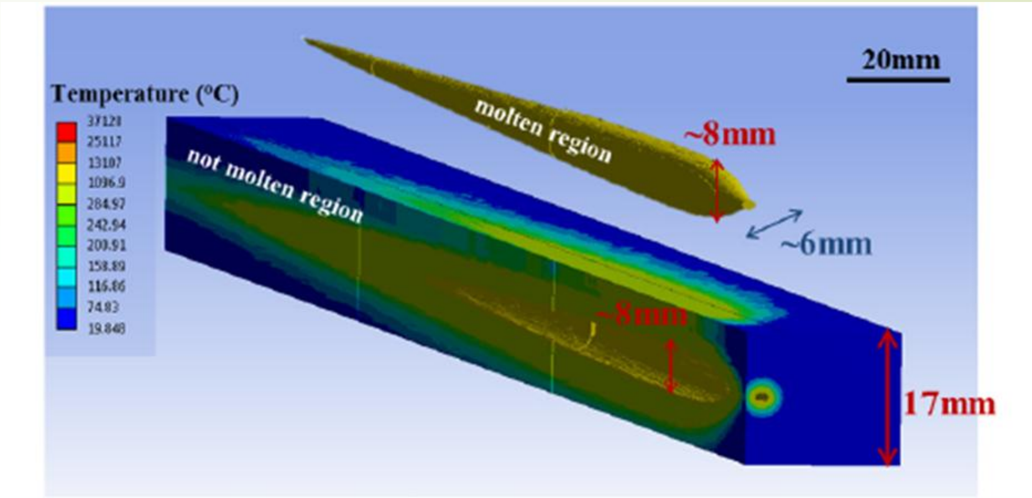

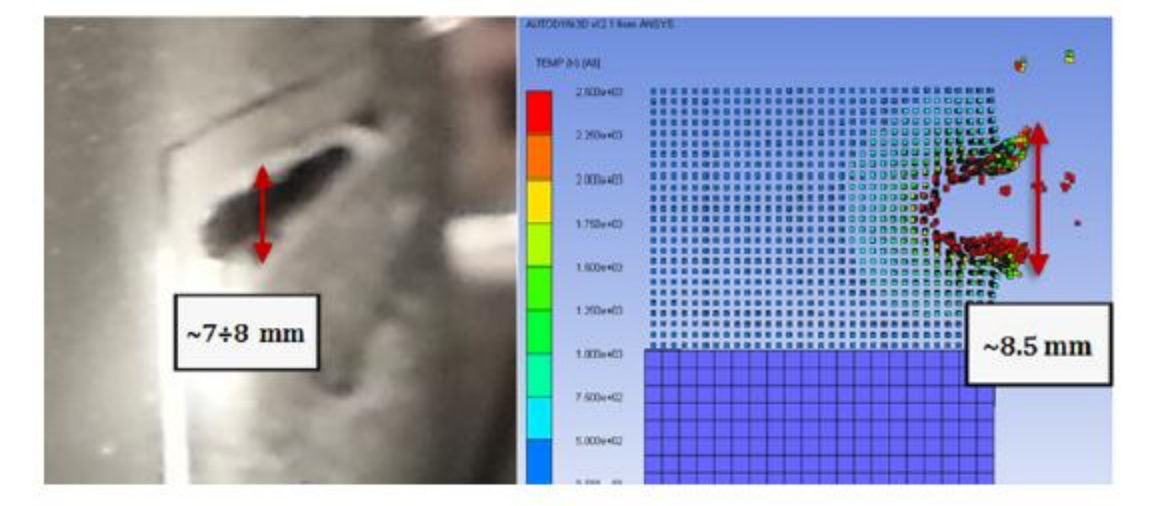

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