Field Quality
Follow Up and Checkpoints
for LHC Cryomagnets

Laurent Deniau

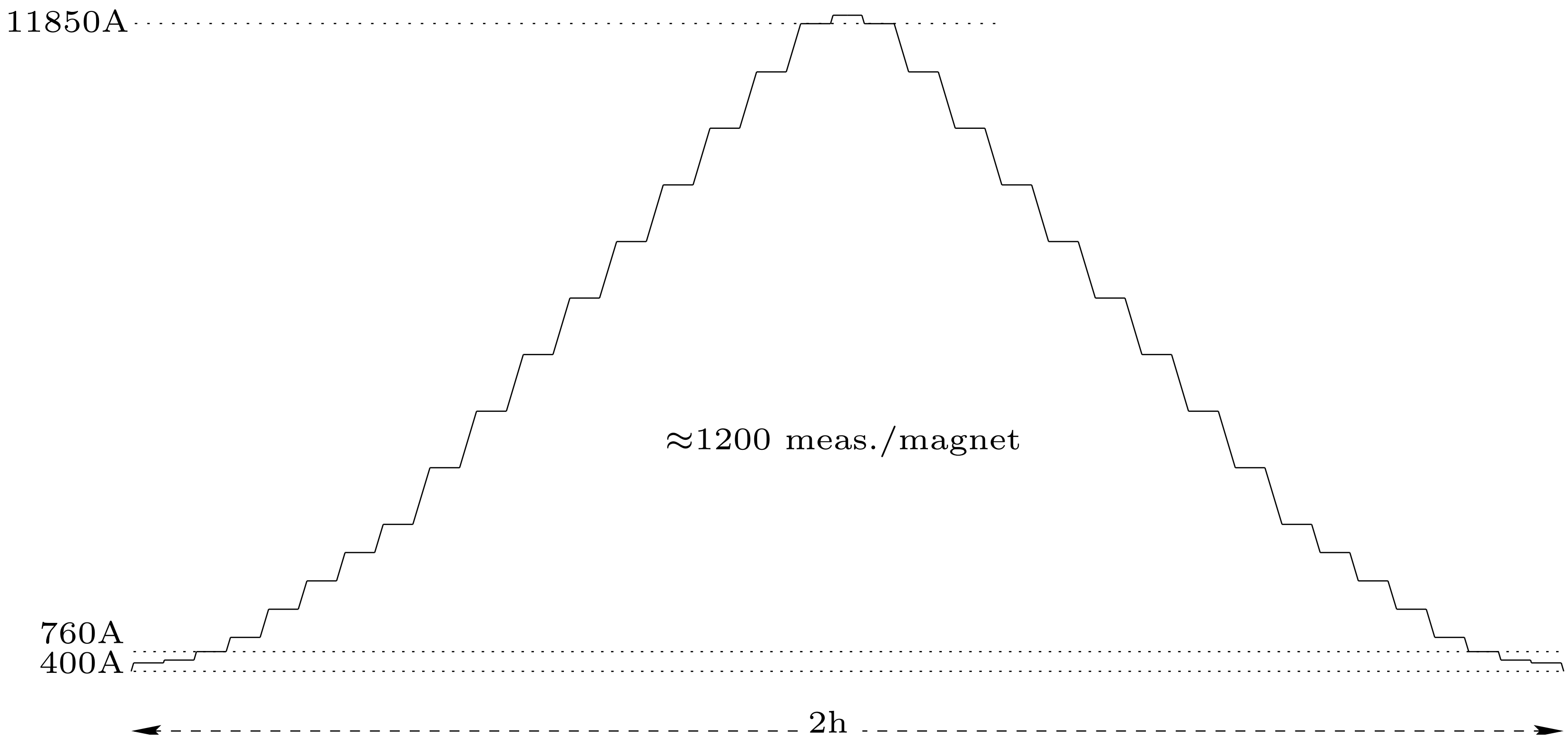
Laurent.Deniau@cern.ch

Field Quality Workshop

20-21 March 2003

Standard MM Cold Test Program (I/III)

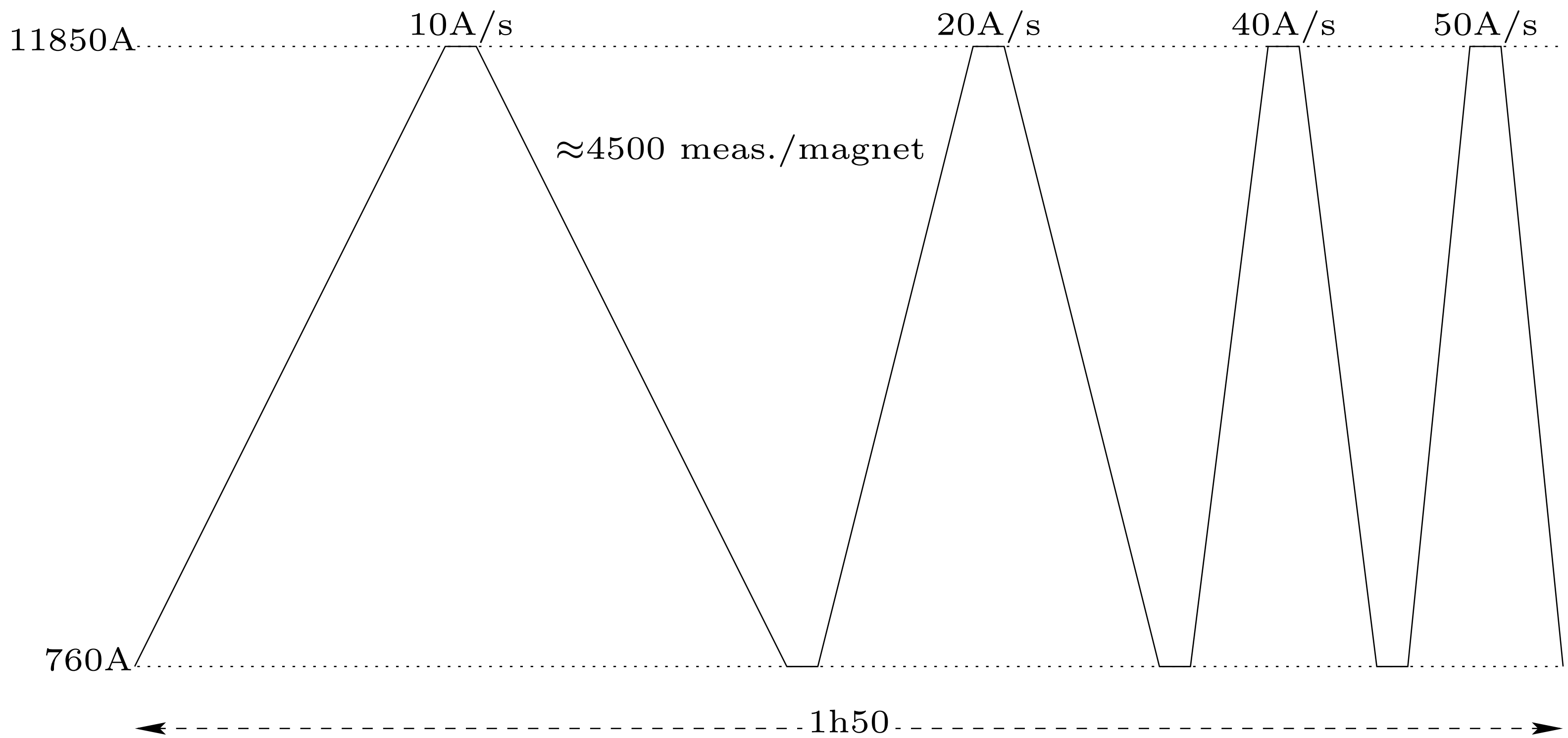
Full Loadline Cycle



- Local and integrated field, angle and transfer function.
- Static field errors: geometry, persistent current, iron saturation.

Standard MM Cold Test Program (II/III)

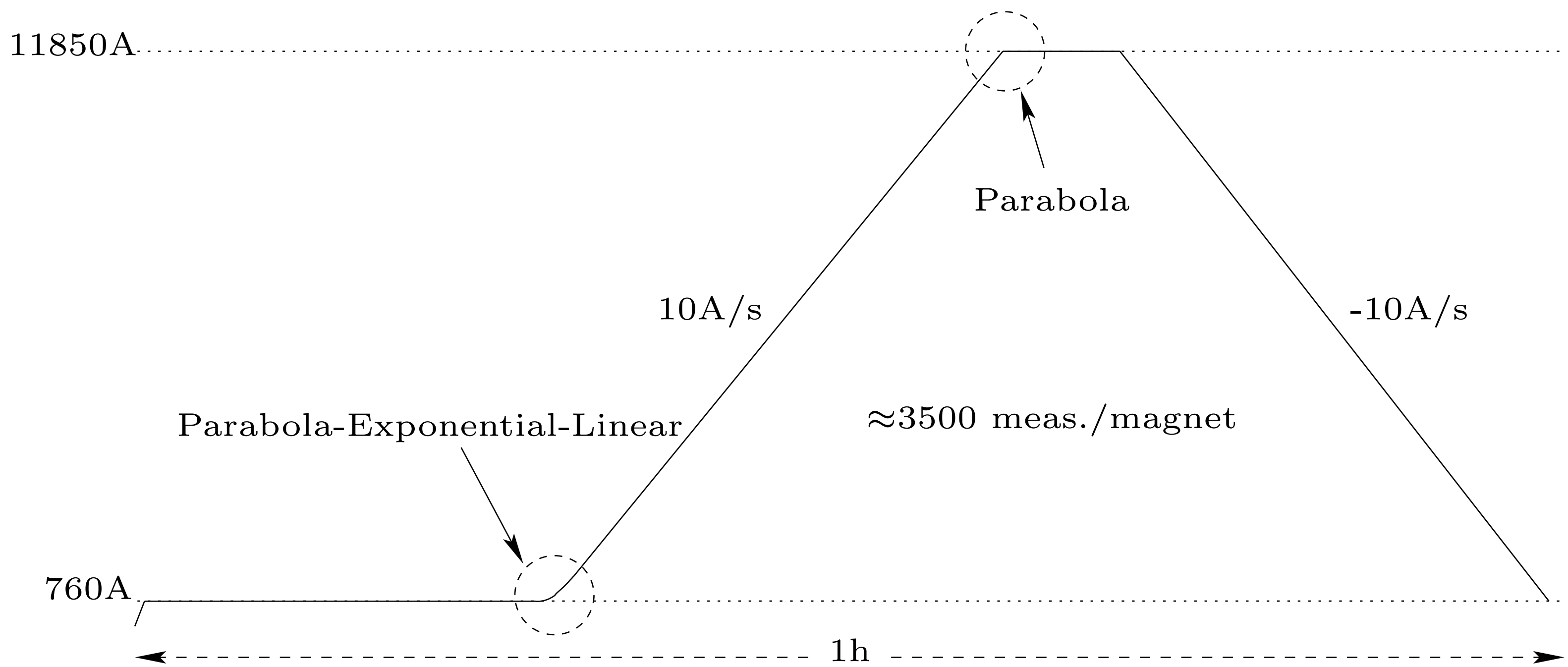
Ramp Cycle



- Dynamic field errors: cable coupling currents contribution.

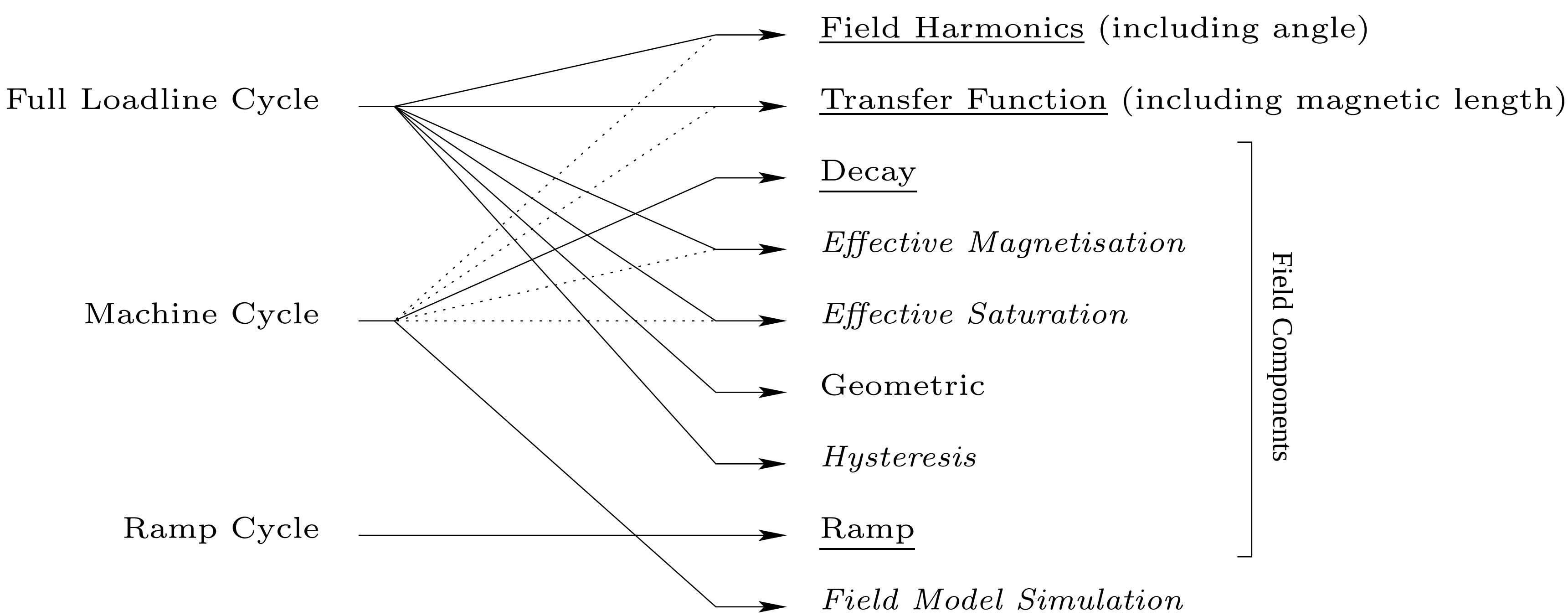
Standard MM Cold Test Program (III/III)

Machine Cycle



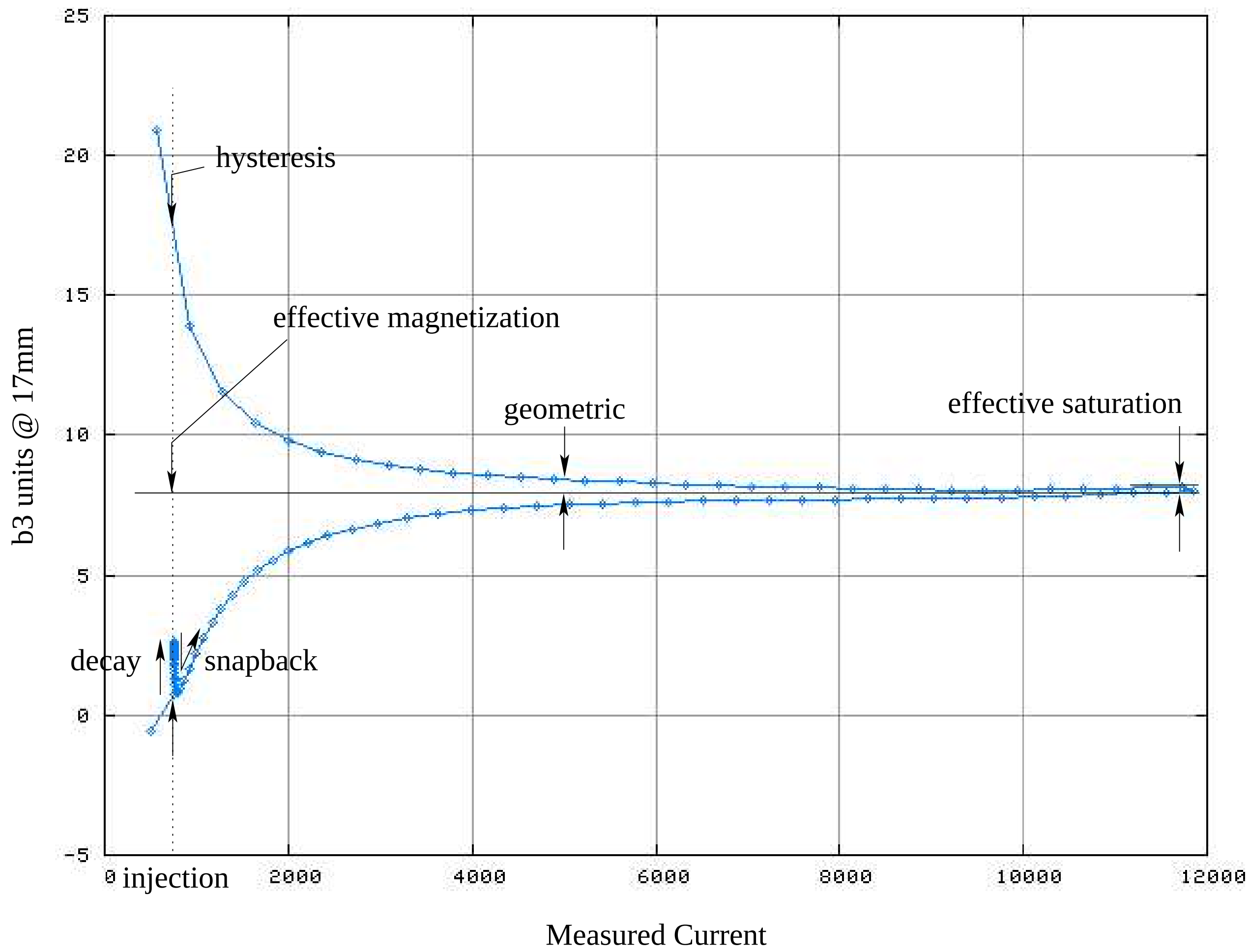
- Field in simulated conditions of the machine.
- Dynamic field errors: decay and snapback contribution.
- Preceded by a quench and a pre-cycle 30 min at 11850A.

From Measured Data To Processed Data

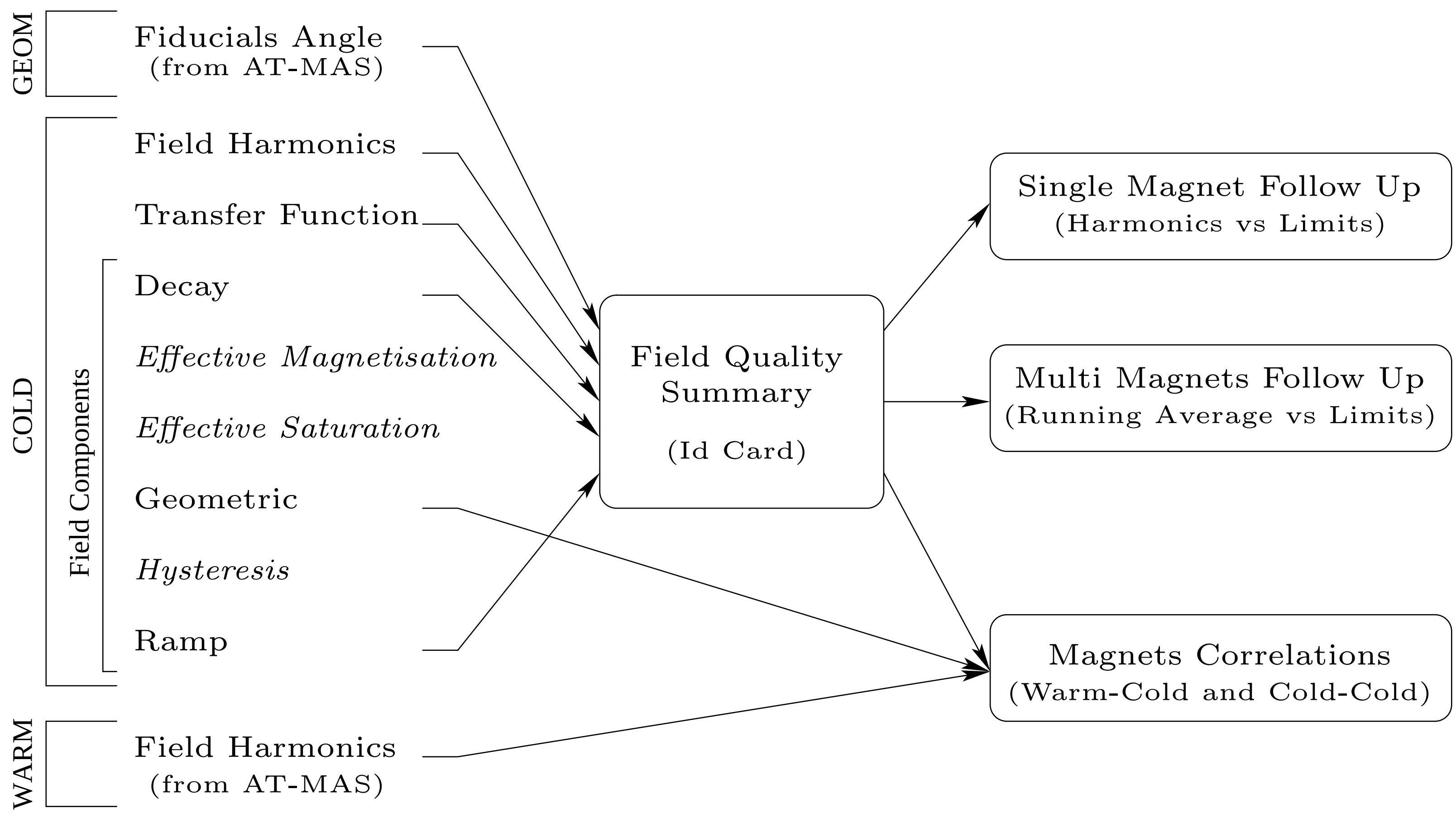


- Properties: underlined → id card, italicized → operation only.
- The dotted lines are very difficult to achieve. For example, the transfer function requires a synchronized current vs field measurement at better than few milliseconds!

Components details (Machine Cycle)



From Processed Data To Follow Up



- Italicized components are only for operation.

Running Averages and RMS (I/II)

User Defined Memory

Considering a sequence of N magnets to be studied. The Running Average of memory M for magnet $k = 1, ..., N$ is defined by:

$$\bar{b}_n(k, M) = \frac{1}{k - m} \sum_{i=m+1}^{k} b_n(i)$$

and its Running RMS for $k = 2, ..., N$ is defined by:

$$\hat{\sigma}_{b_n}(k, M) = \sqrt{\frac{1}{k - m - 1} \sum_{i=m+1}^{k} \big(b_n(i) - \bar{b}_n(k, M)\big)^2}$$

where $m = \max(k - M, 0)$.

Running Averages and RMS (II/II)

Auto Memory

Same as User Defined but the memory M is automatically computed from the expected field error tables:

$$M = \max\left(5, \left(\frac{2\sigma_{b_n}}{b_n^{(S)}}\right)^2\right)$$

Adaptive Memory

Same as User Defined but the adaptive memory $M(k)$ is automatically computed for each $k = 2, .., N$ using a local estimation of the $\hat{\sigma}_{b_n}(k, M_0)$ of the production over the Auto memory M_0. Hence:

$$M(k) = \max\left(5, \left(\frac{2\hat{\sigma}_{b_n}(k, M_0)}{b_n^{(S)}}\right)^2\right)$$

Actions Based on Follow Up

Corrective action

- Slow feedback: warm-cold delay is about 100 magnets for pre-series and it could be more than 250 magnets at nominal rate.
- No C/NC: bad field quality at cold does not trigger any NC.
- Still important: quality control of warm magnetic measurements through warm-cold correlations.

Consultative action

- Important for the MEB: Cryomagnet acceptance is based on performances at cold (eg. Id Card).
- Important for the operation: performances tolerances are up to two order of magnitude tighter than for production (eg. $b_3^{(P)} \leq 3$ units, $b_3^{(O)} \leq 0.03$ units to be achieved by MF-BD-CL).

Future Plans

- Improvement of tests quality using online alarms (eg. about 15000 meas./magnet performed vs. 10000 meas./magnet expected).

- Improvement of analysis tools for follow up and correlation:
  - Geometric vs shims and coil size
  - B_1 and $B\,\mathrm{d}l$ vs iron pack weight
  - Persistent vs cable magnetization
  - RR vs cable Rc

  Waiting for unified links with other DBs (MAS DB or MTF).

  See MAS presentations for work in progress.

- From 2004 we focus on the machine operation (eg. improvement of analysis and model for the Multipoles Factory).