The LHC Magnetic Model (FiDeL)

Adapted from L.Bottura *by jpk*

following several, long brainstorming sessions with

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L. Walckiers, R. Wolf

MARIC - March 1st, 2006

Background 1

On-line magnetic references for the LHC?

- YES in the tunnel (1990's)
- YES but not in the tunnel (DEWG 1996)
- NO need to have reference magnets (RMS Review, July 2004)

Hence the Field Model will rely on off-line magnetic measurements done *before or after* the start-up.

Background 2

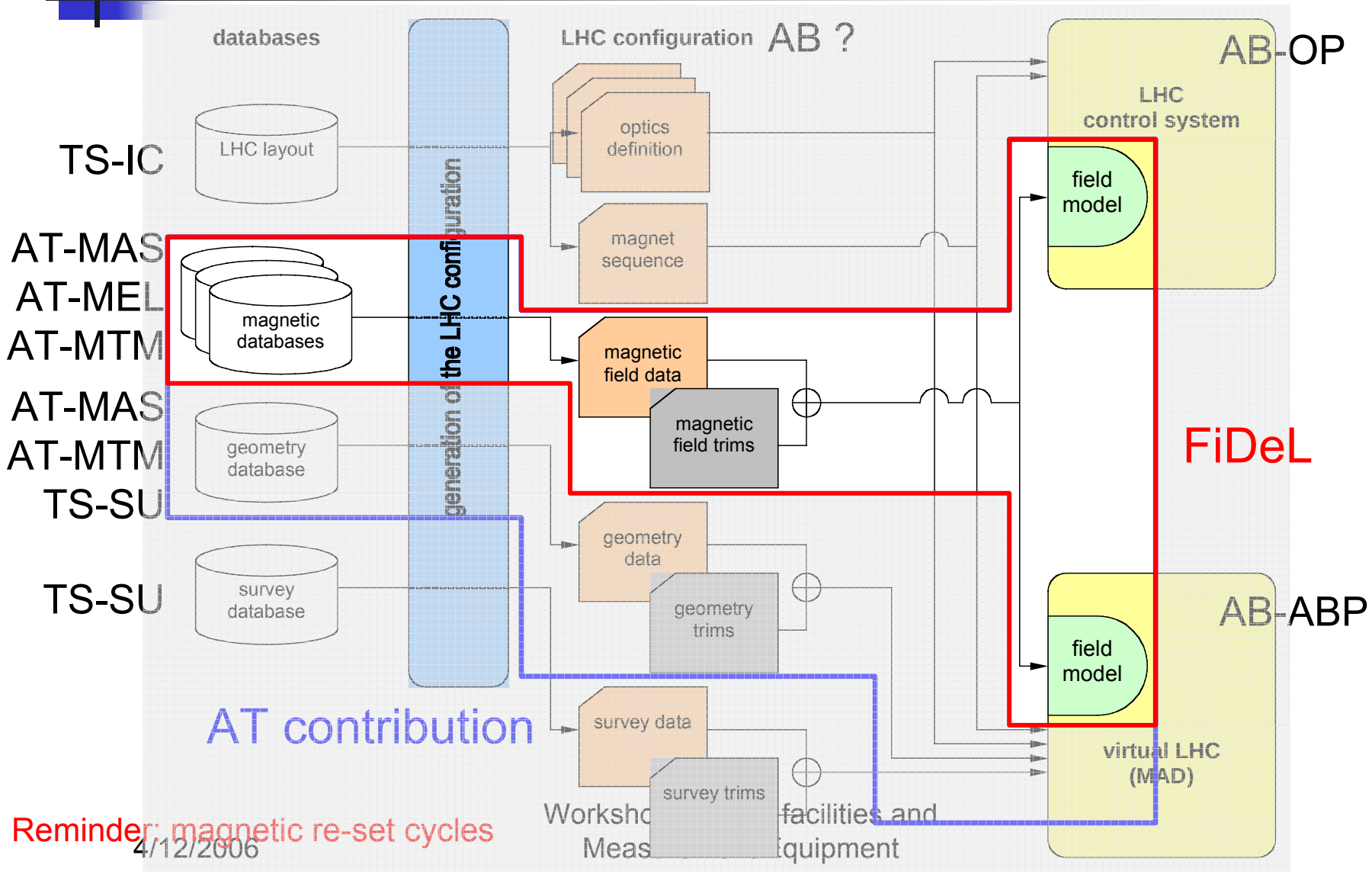
expected errors & correction goals for injection, ramp, and/or squeeze!

F. Zimmermann/Chamonix 2006

	tolerance	error / tolerance
orbit change	$1\sigma \rightarrow 0.3\sigma$ (~50 μm)	~6
beta beat	21%	1 – 20
coupling κ	0.01→0.001	20 - 200
tune change	0.015→0.003/0.001	~300
chromaticity Q'	5±5→2±1	~300
2^{nd} order Q''	1000/2000	~25
energy	10^{-4}	~10

***Anticipation**, measurement and correction are mandatory!*

The *helicopter* view



Reminder: magnetic re-set cycles

Aim of the FiDeL Project

- A Field Description of the LHC to:
  - **Describe the magnetic state of the LHC**
  - Provide **settings** in the main magnets (MB, MQ, MQM, MQY, MQXx) and in the corrector circuits to prepare the LHC for injection, program the ramp, and reach known and corrected coast conditions
  - Provide **trims** for correction circuits during constant current plateaus, and especially to follow the field drift at injection
  - Provide **trims** for correction currents during the energy ramp, and especially during the snap-back at the beginning of the acceleration

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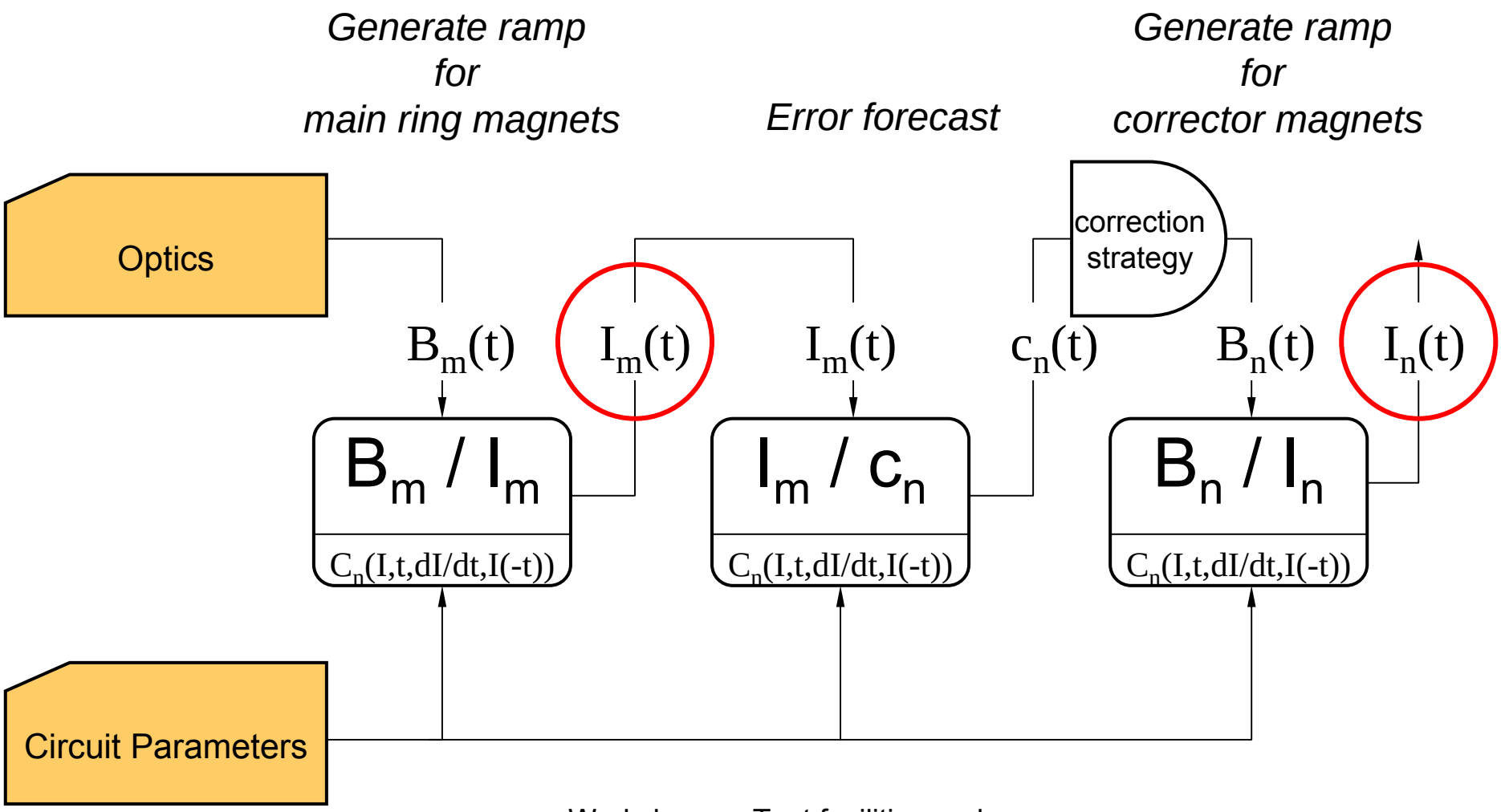
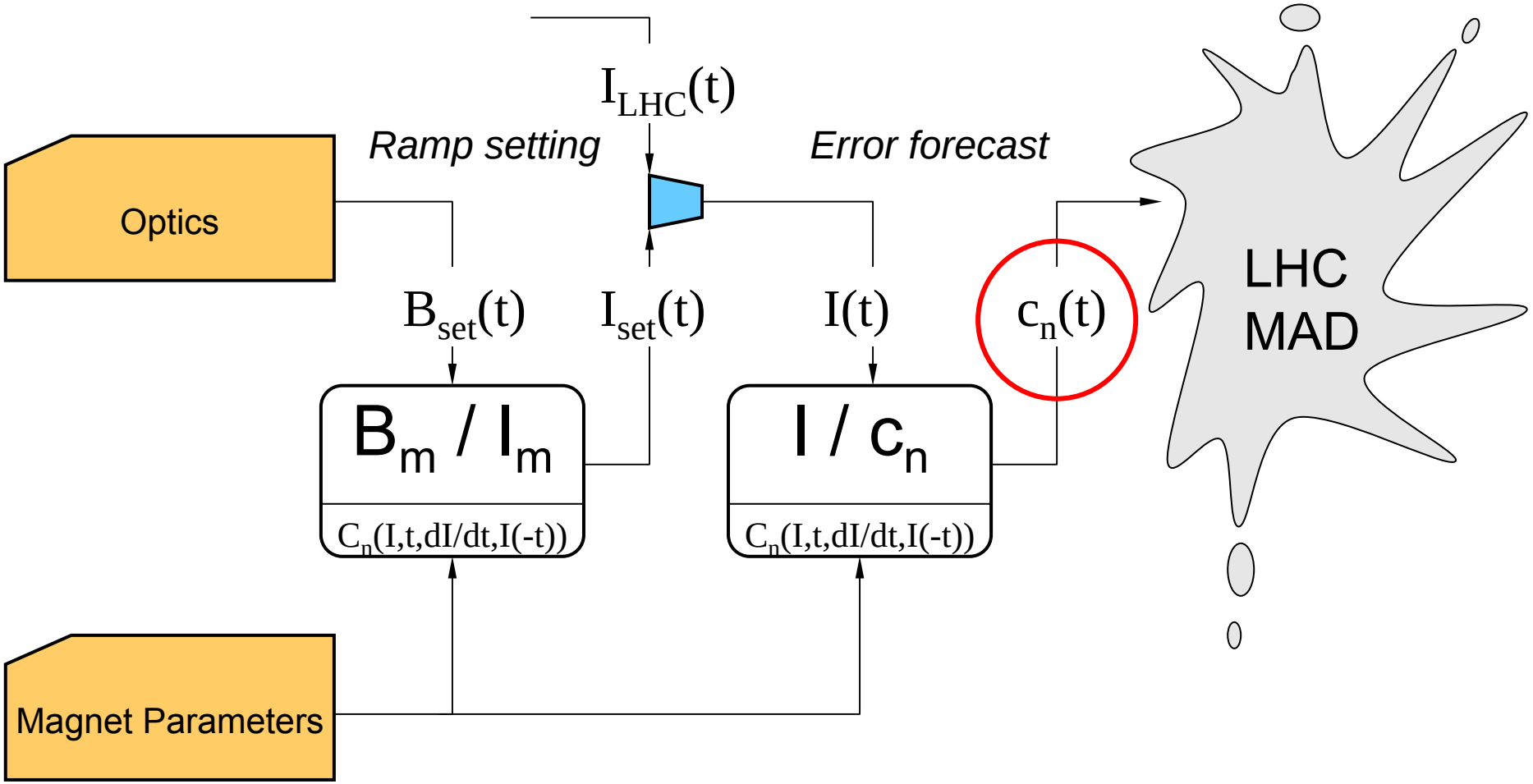
FiDeL Concept

- Field Model
  - Unified description of the field and field errors C_n applicable to all LHC magnets
  - Set of parametric equations for 7 physical components
    - Geometric
    - Persistent
    - Saturation
    - Residual magnetization
    - **Decay**
    - **Snap-back**
    - **Ramp**
- Field parameters
  - Adapt the parametric equations to fit the measured or expected behaviours of the magnets
  - Set of ≈20 parameters, classified in 2 categories:
    - *Shape parameters*, equal for all magnets of the same type and family (e.g. all MB's with inner cable 01B)
    - *Amplitude parameters*, specific to each magnet (e.g. geometric C_n)

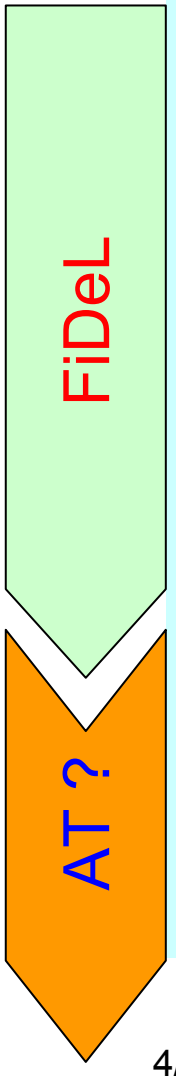
Use of FiDeL - LHC control



Use of FiDeL - Optics studies



AT involvement vs MM



- Short term (2006 to sector test/commissioning)
  - **Collect, prune, and complement data for all magnet types**
- Medium term (2007-2008): initial LHC performance
  - **Adapt the parameters sets and create parameters trims tables during sector test/commissioning**
  - **Define, perform and analyse measurements on off-line benches (see: FaMe): understand the trims, study un-anticipated magnetic states.**
- Long term (> 2008): nominal LHC performance
  - **Depending on former experience, the accuracy of the magnetic model may have to be improved.**

Who ?

- Mandate the FQWG to
  - Complete the definition of the project (interfaces, responsibilities, deliverables)
  - Compile above in a RDD to be agreed with AB-OP (LHC controls) and AB-ABP (MAD)
  - Propose participation of AT groups (MEL/MAS/MTM are natural candidates)
  - Provide the structure for coordination and follow-up of progress
  - Spin-off the team that will be in charge of the LHC *magnetics*

Since then…

- Brain storming in FQWG done.
- 5 group delegatess preparing the list of tasks, the evaluation in man-years and how to share the work: E. Todesco (MAS), R. Wolf (MEL), L. Bottura(MTM), M. Giovannozzi (AB/ABP), M. Lamont (AB/OP). Report within weeks.
- Milestones: control of a magnet on a bench, sector test, commissioning.

Conclusion

- The work on the magnetic model is being prepared.
- It requires “extended” magnetic measurements and it seems an illusion to ambition anticipating all possible magnetic states before start-up.
- Hence measurements in a test station during and after commissioning shall be anticipated.
- The Field Model will be initially simple. Practical experience is necessary to predict its evolution and the requirements in term of magnetic measurements on medium term. It may be useful to improve accuracy but as well to investigate shortcuts (e.g. on cycling) to improve $\int L dt$