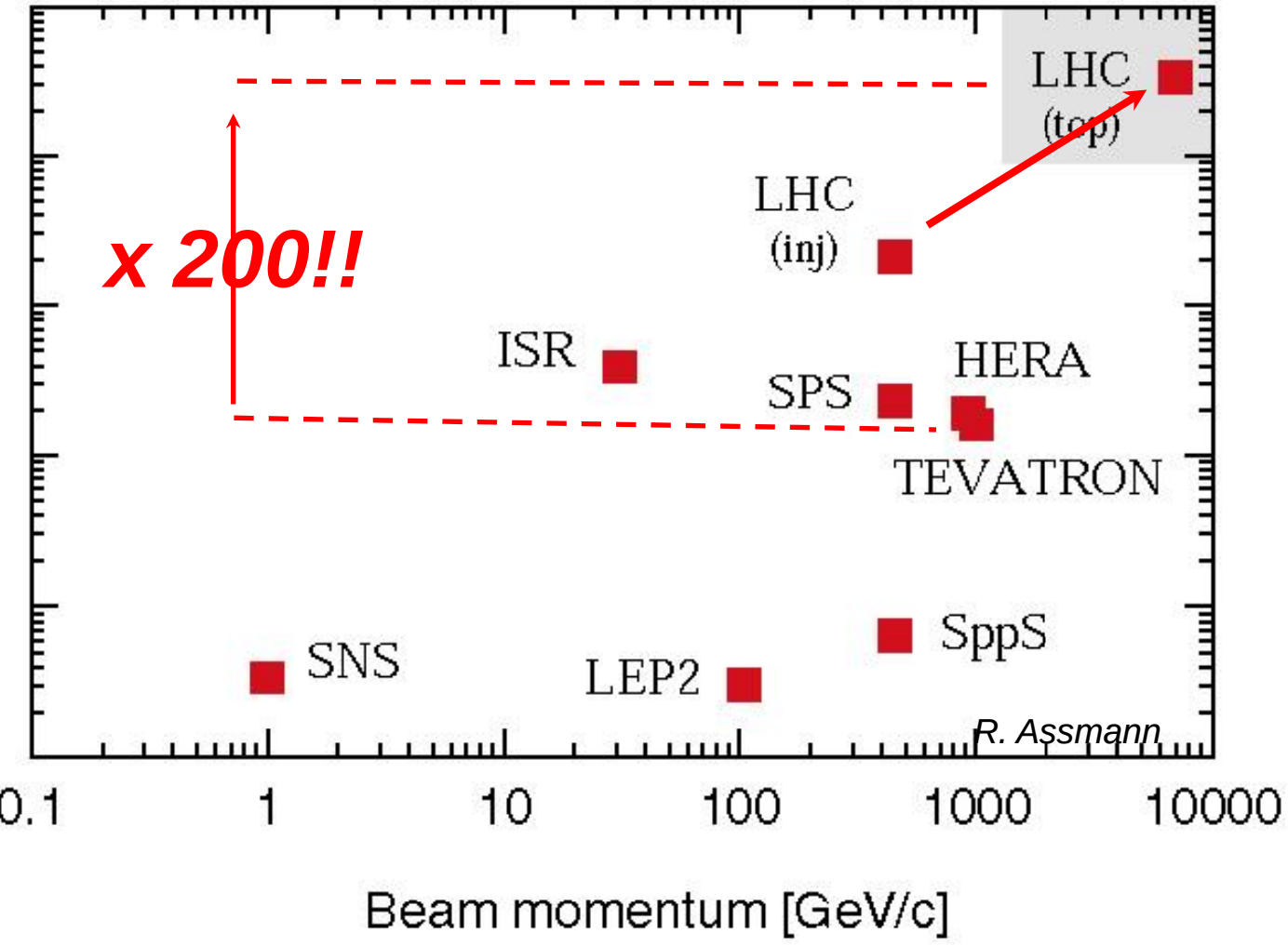
The LHC Collimation System

S. Redaelli, AB-OP

Based on discussions with

R. Assmann, M. Jonker and T. Weiler

- **Introduction**
- **LHC collimation system**
  - Layout, design and people
  - Controls and operational challenges
  - Tools available
- **Commissioning without beam**
  - Plans for commissioning without beam
  - Deliverables of cold checkout
  - Contributions from OP
- **Interfaces to other systems**
- **Conclusions**



E_b = 7 TeV - I_b = 3.4x10[1

Stored energy	**~ 2 x 3(**
Quench limit	~ 10 mJ
Damage (metal)	~ 50 kJ

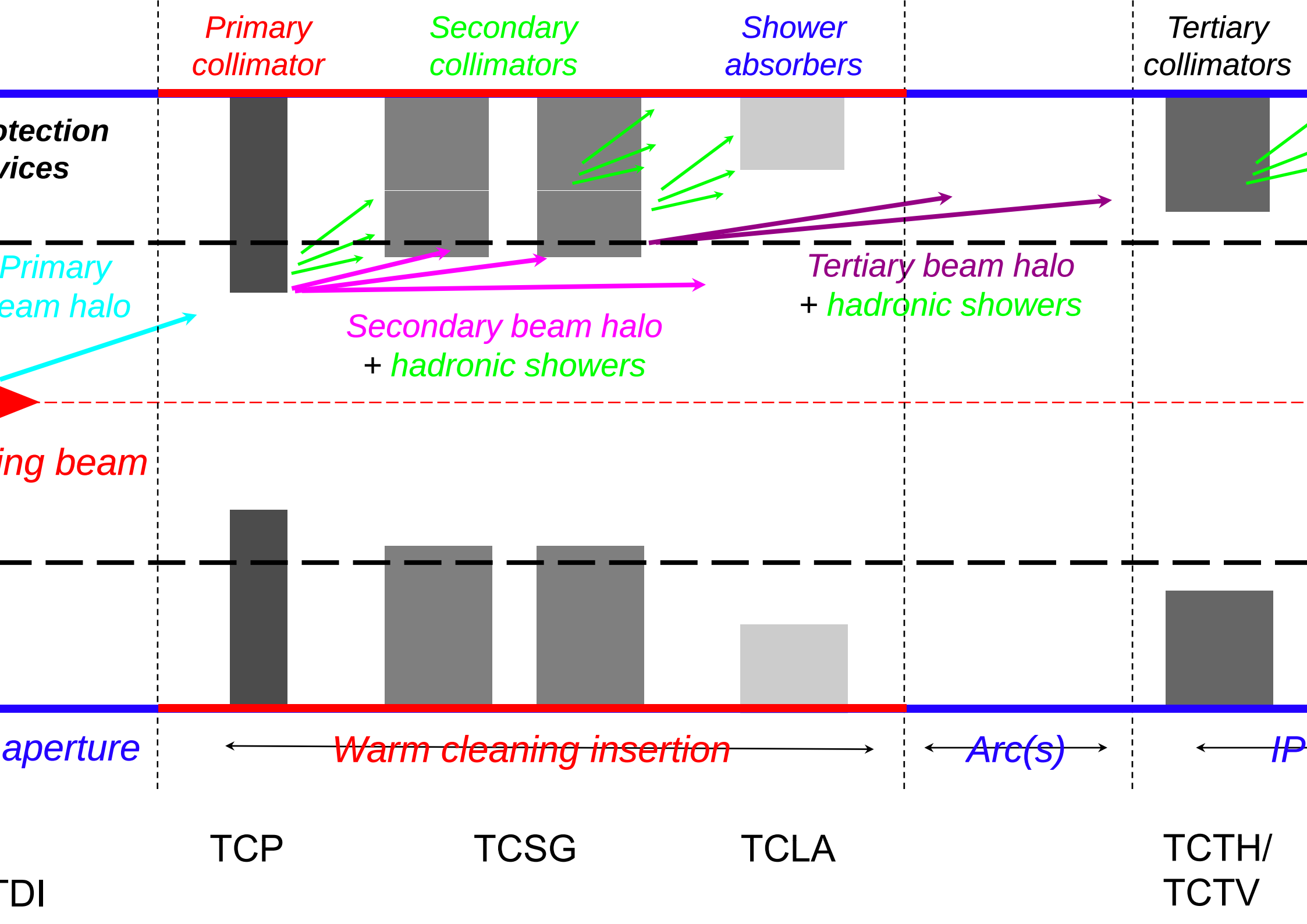
Cleaning

Protection

C enters in a ***new territory*** for handling
ra-intense beams in a super-conducting
vironment!

rrespondingly, a powerful **collimation**
stem will be needed

→*Control losses 1000 time*
than the state-of-the-art!
→*Need collimation at all m*
states: injection, ramp,
squeeze, physics
→*Important role of collimat*


Primary collimator
Secondary collimators
Shower absorbers
Tertiary collimators
otection
vices
Primary
eam halo
Secondary beam halo
+ hadronic showers
Tertiary beam halo
+ hadronic showers
ing beam
aperture
Warm cleaning insertion
Arc(s)
IP
TCP
TCSG
TCLA
TCTH/
TCTV
TDI

o warm cleaning insertions

IR3: Momentum cleaning

- 1 primary (H) → TCP [C]
- 4 secondary (H,S) → TCS [C]
- 4 shower abs. (H,V) → TCLA [W]

IR7: Betatron cleaning

- 3 primary (H,V,S)
- 11 secondary (H,V,S)
- 5 shower abs. (H,V)
- 3 beam scrapers (H,V,S)

cal cleaning at triplets

- 8 tertiary (2 per IP)→ TCT [W]

sics debris absorbers [Cu]

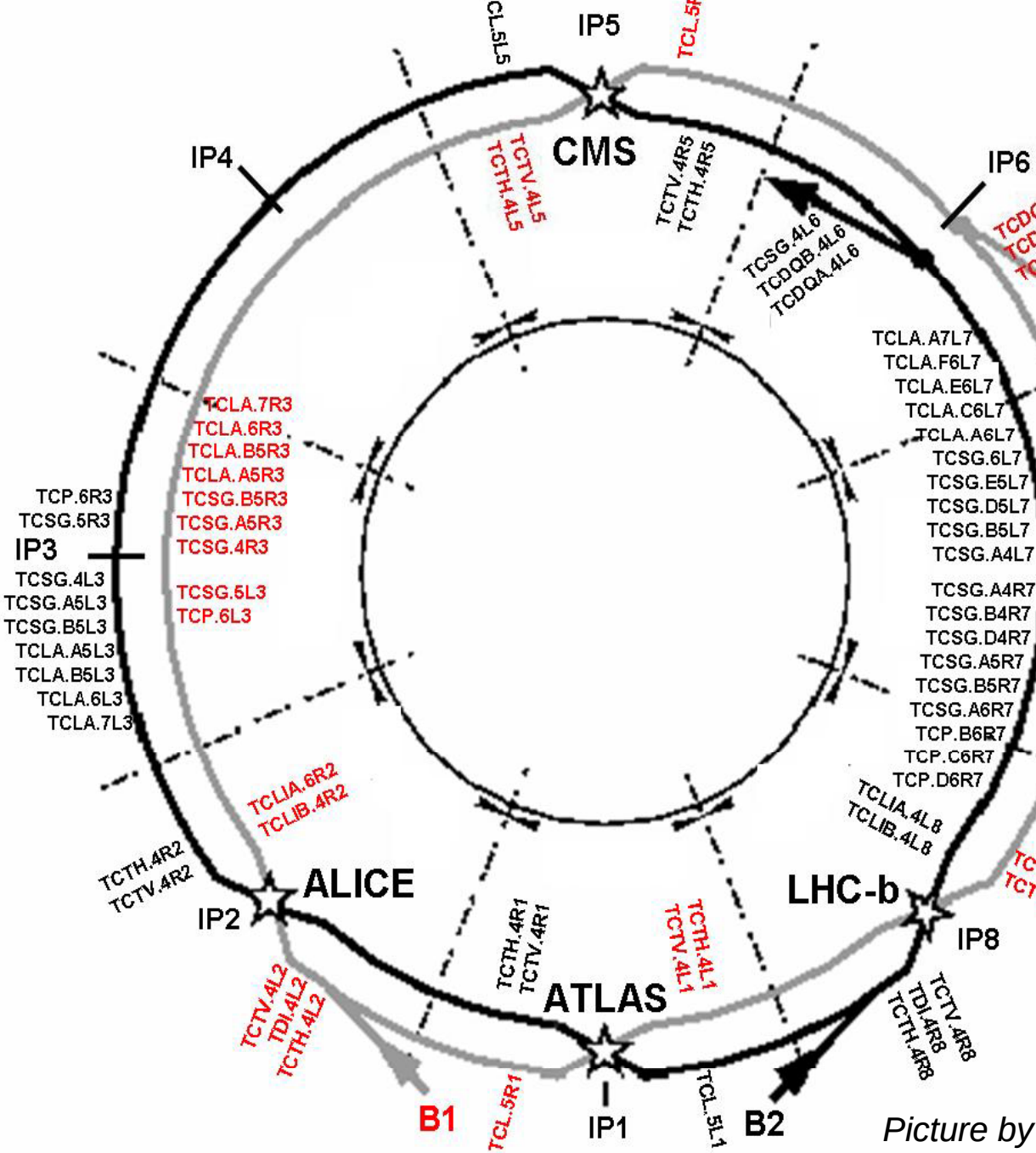
- 2 TCLP's (IP1/IP5)

tection (injection/dump)

- 10 elements →TCLI/TCDQ [C]

nsfer lines

- 13 collimators → TCDI [C]



Picture by

*41 movable **ring***

*Detailed documentation in a recent note by Ralph: ECR **LHC-TC-EC-0001-00-10***

the tunnel, as of today:			
	Ring:	IR7 (TCP's, TCSG's)	18
		IR6 (TCSG's)	2
		IR5 (TCT's)	3
		IR8 (TCT's)	2
	TL's:	TI8	6
		TI2	5
		Total	***36***

Expected for first run to 7 TeV: 71*

*(Nominal Phase I system: **98**)*

** Rely on production schedules of CERCA and TS workshop*
After the crisis, fully on track for the moment!

No expected performance limitations for first physics run (Stage A
For checkout matters, no differences from the final system

(inside mandate of the LHC collimation project)

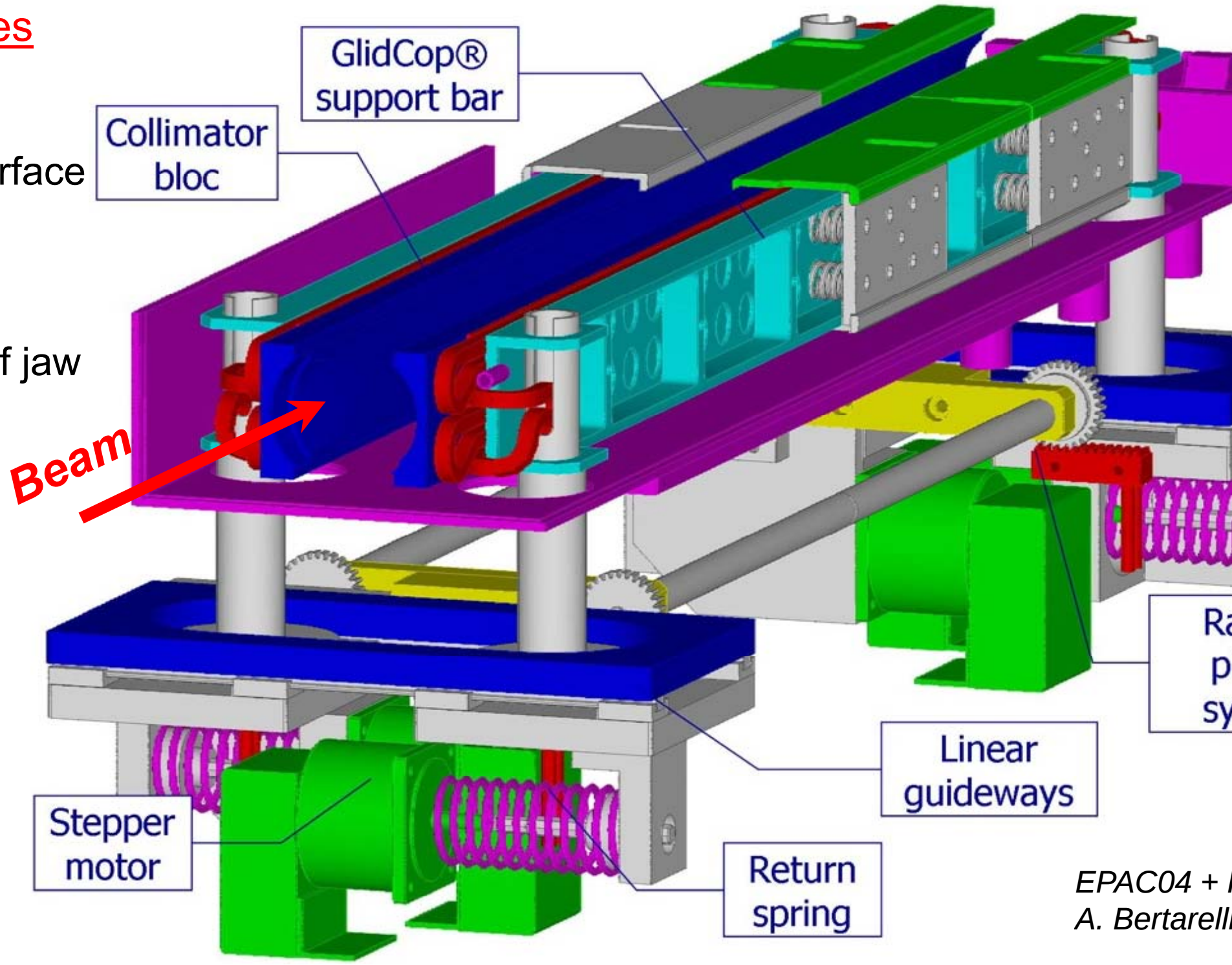
m commissioning:	R. Assmann, T .Weiler	AB-ABP
	S. Redaelli	AB-OP
	M. Jonker, *M. Sobczak*	AB-CO
	R. Losito, A. Masi + team	AB-ATB (low-le
	O. Aberle, R. Chamizo, Y. Kadi + team	AB-ATB (hardw

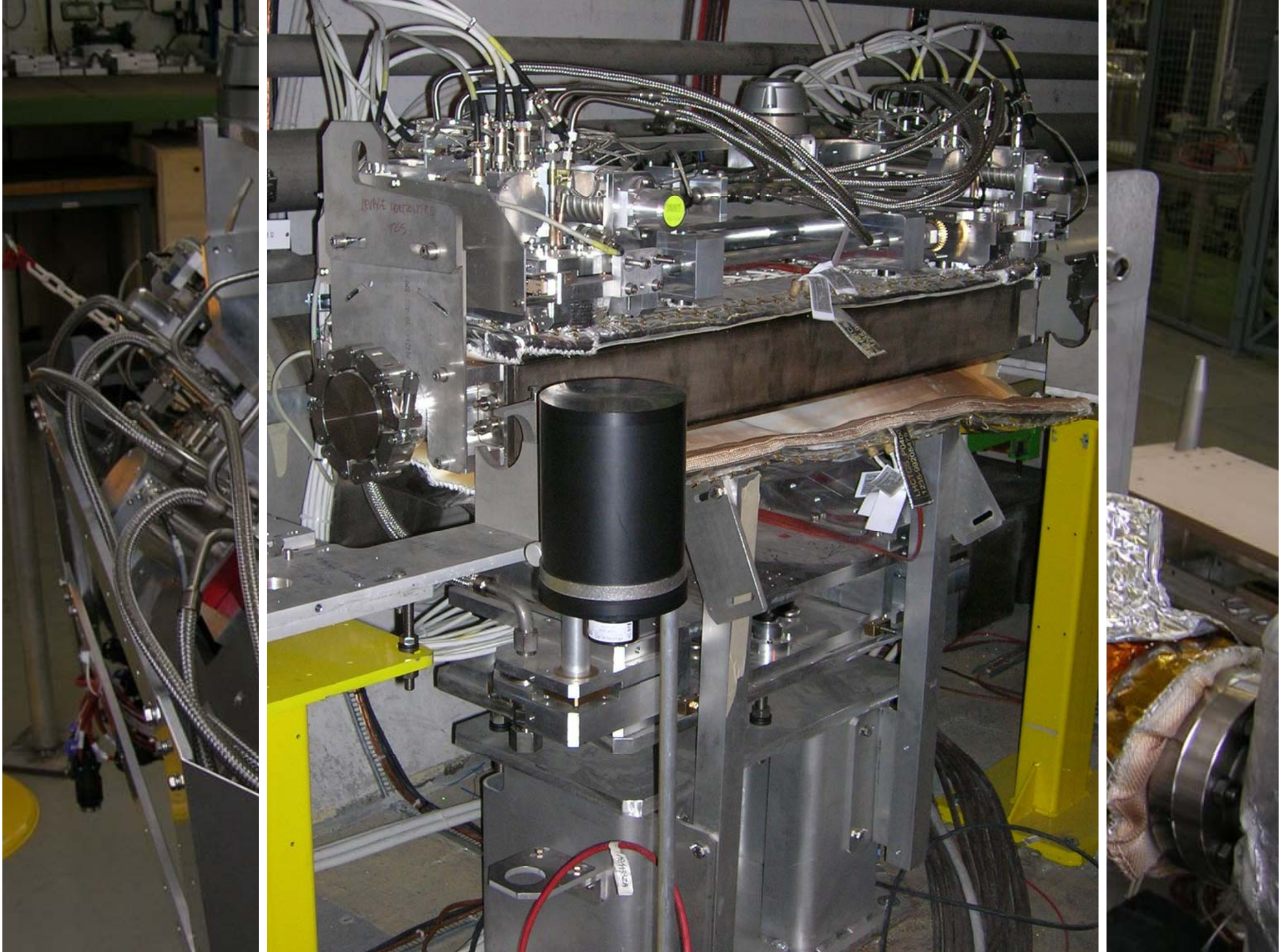
al functionalities	Injection team, Dump team,	(with beam onl
ction, physics,...)	Ion collimation team, TOTEM, ...	

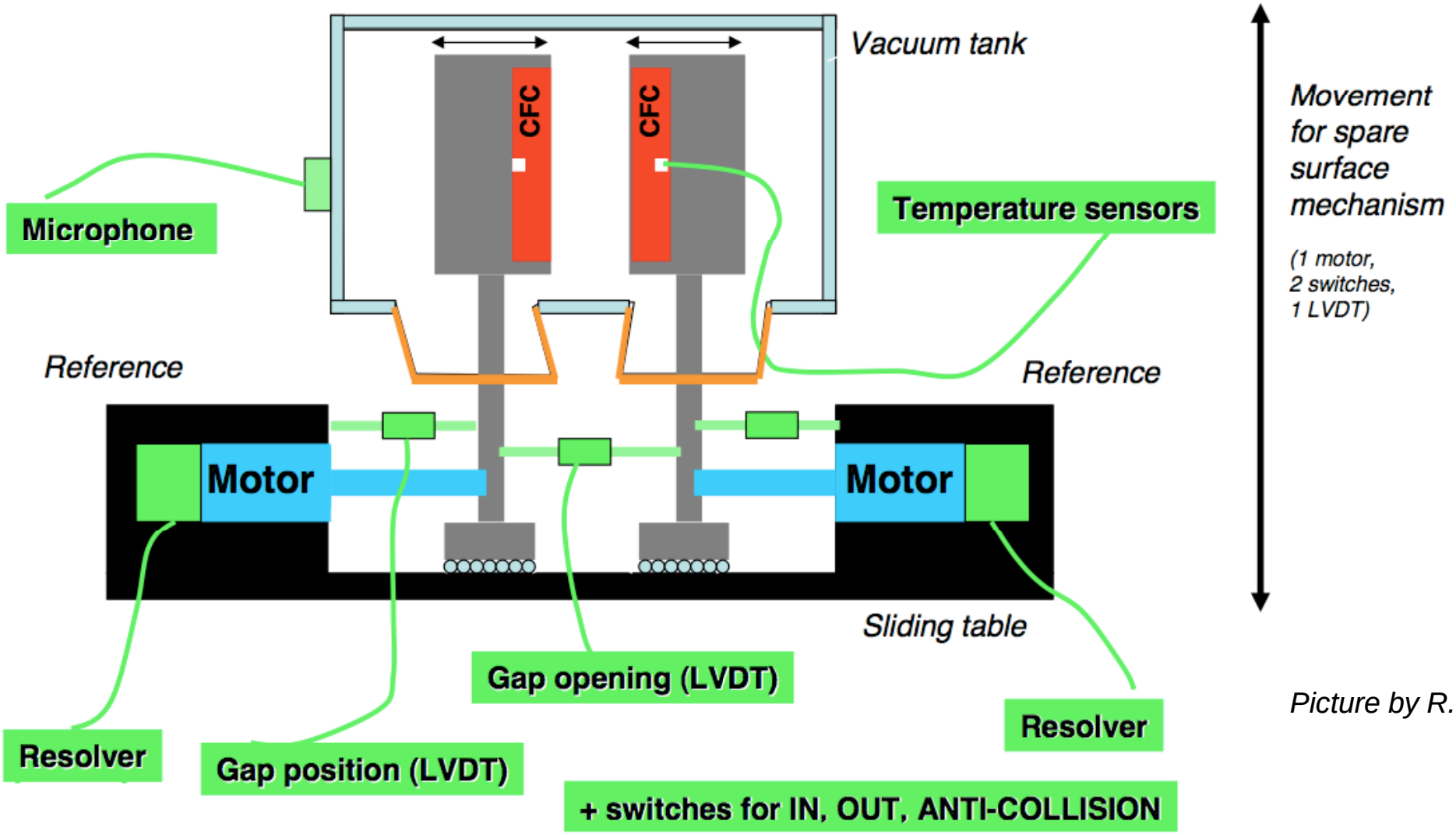
al project internal **meetings** to drive the various activities (Collimation project ste
ation Working Group, Controls, ...). *Links given in OP-wiki for documentation*.

esign features

vs, 4 motors
and angle)
t of spare surface
or)
t azimuthal
H,V,S)
l reference of jaw
(LVDT)
traction
ers
oling







Picture by R. Assmann

tings:

vey:

2 jaws → 4 motor positions; 1 motor for tank position.

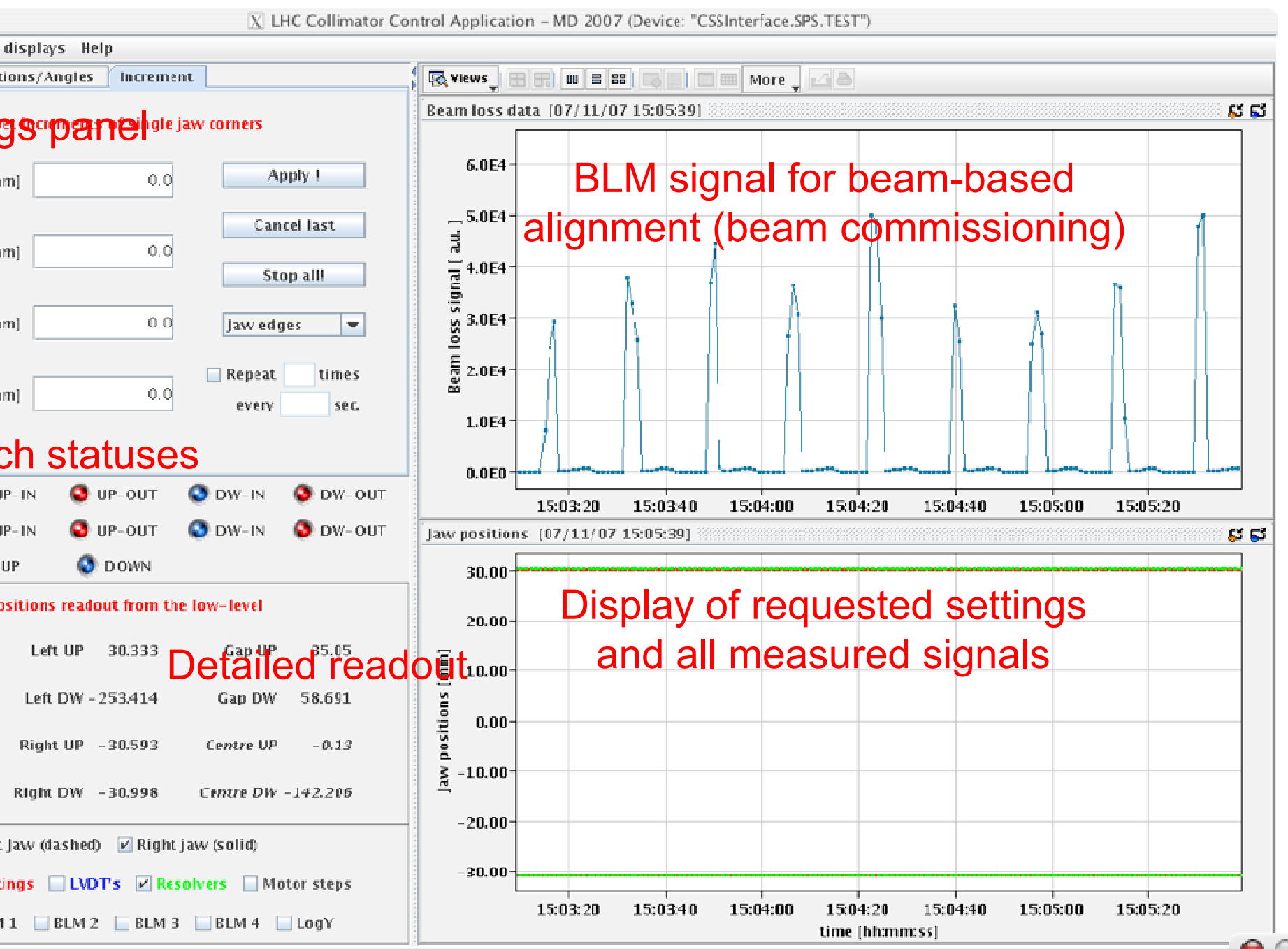
7 position measurements (4 corners + 2 gaps + tank)

4 motor resolvers

5 temperature sensors (1 per jaw corner + water temperature)

10 switch statuses (full-in, full-out, anti-collision)

~400 de
of free



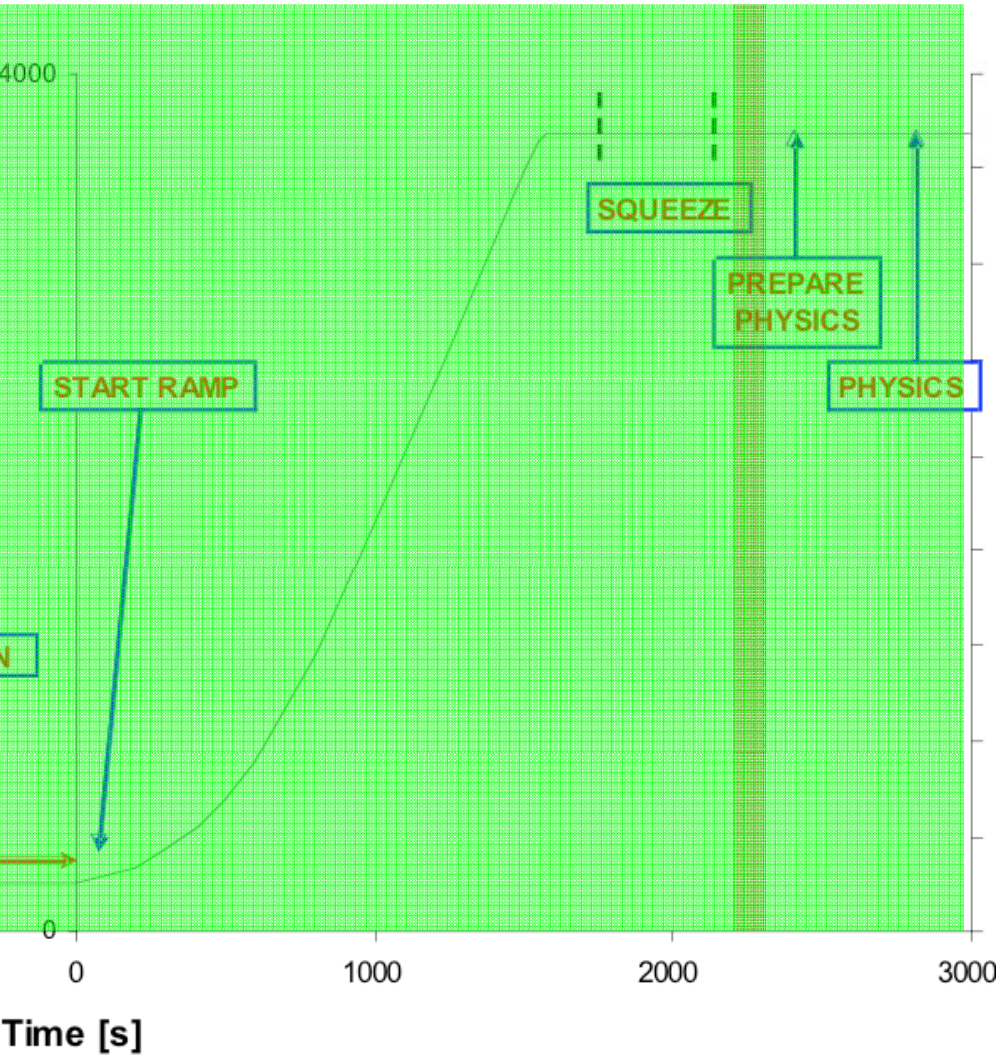
Tools **adequa**
the HW
commission
collimato

Will include r
for HWC proc
if neede

Additional disp
temperature, t
beam loss
availabl

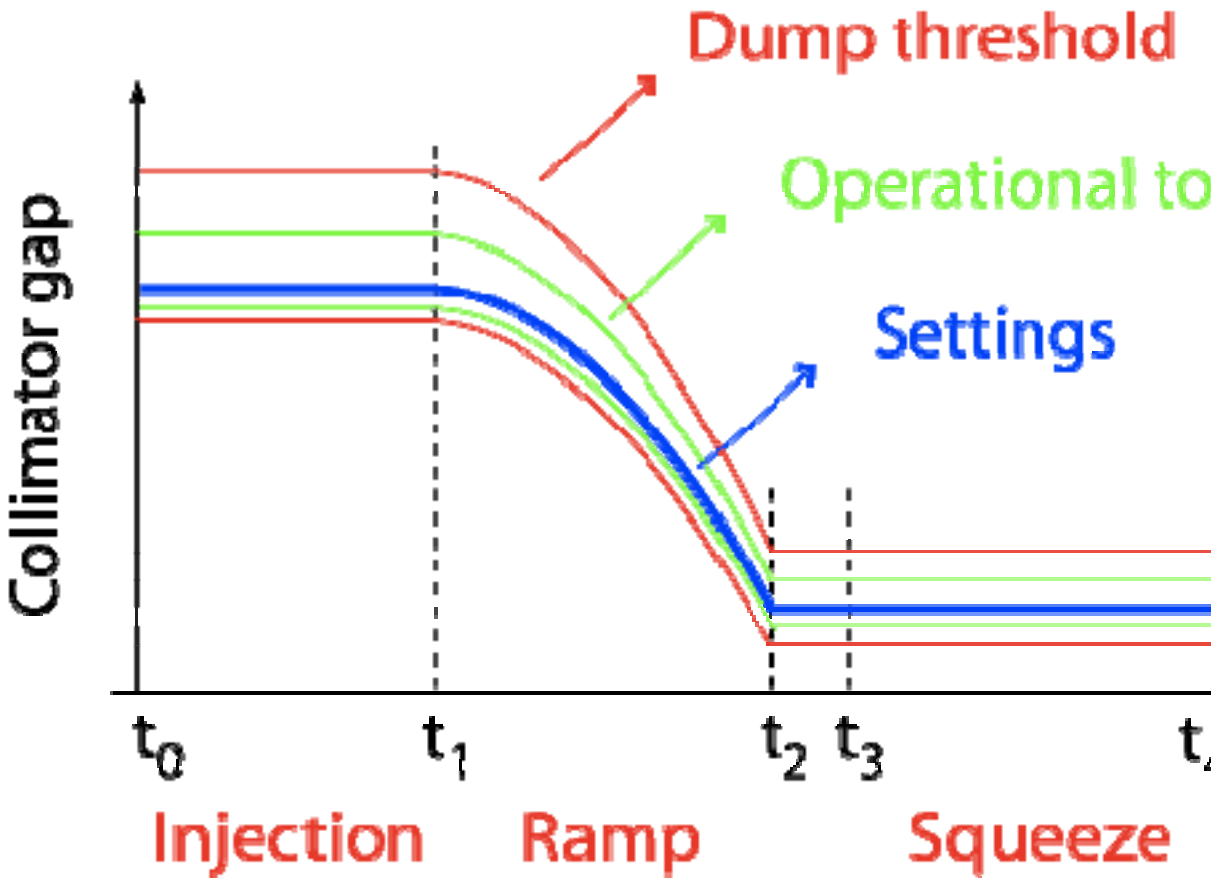
Additional exp
access direct
level control
calibratio

Tevatron



eaning and protection **required** all time: injection → 7 TeV → physics!

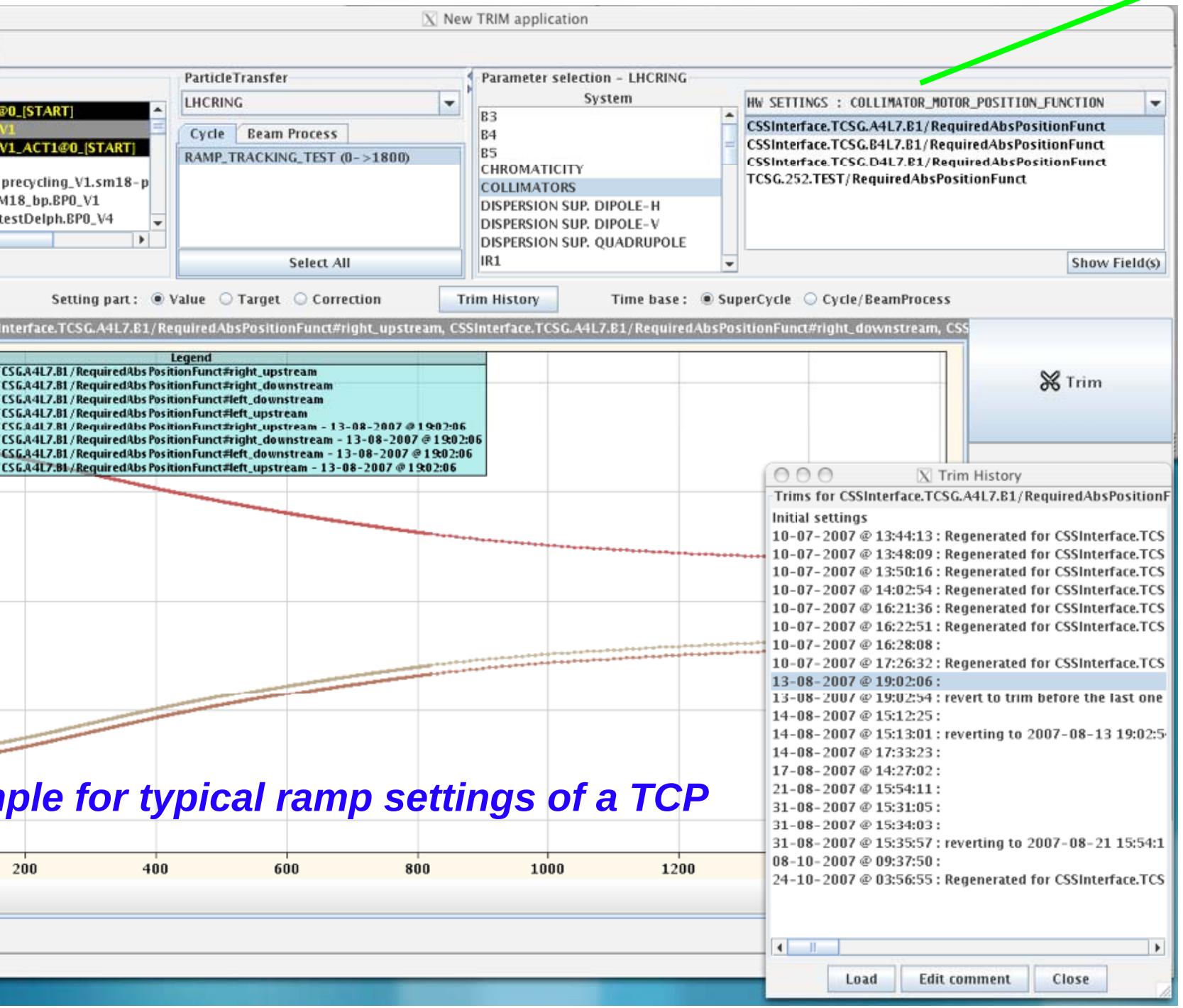
Example of collimator settings



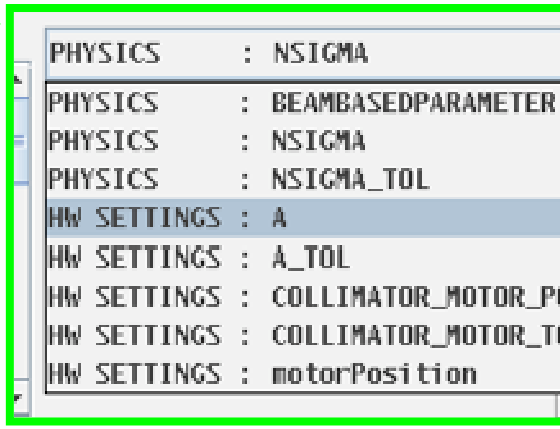
Each "critical" collimator **setting** will hav **functions** for **dump thresholds** and **operational tolerance** windows.

Functions and "actual" settings needed!

Beam safety: system detects internally



nple for typical ramp settings of a TCP



Implementation into **s**
LSA tools: TRIM, ge
makerules, ...
Dedicated application
as needed.

Function-driven mo
not yet operational f

Main **challenge** for t
months.

Test stand setup
collimator workshop,
expected by Decemb

THE LHC Operation Web Site

and APPLICATION LAUNCHER

Documentation and Application	LHC Meetings and documents	LHC Related Link

Link to on-line collimation DB

Thanks to R. Billen (
D. Jacquet (DB-OP)
Veyrunes (web)

LHC Collimation Project

Home of the Project for the LHC Collimation System

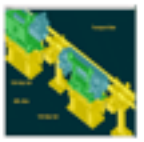
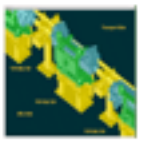
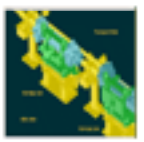
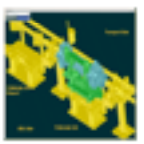
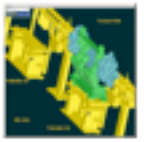
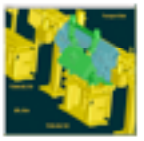
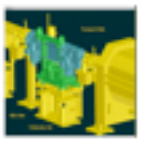
Top	Project Team	Notes	Collimator List	Sounds/Movies	Meetings
Links	Papers	Talks (WG)	Layout IR3/7	AB Departm.	Pictures

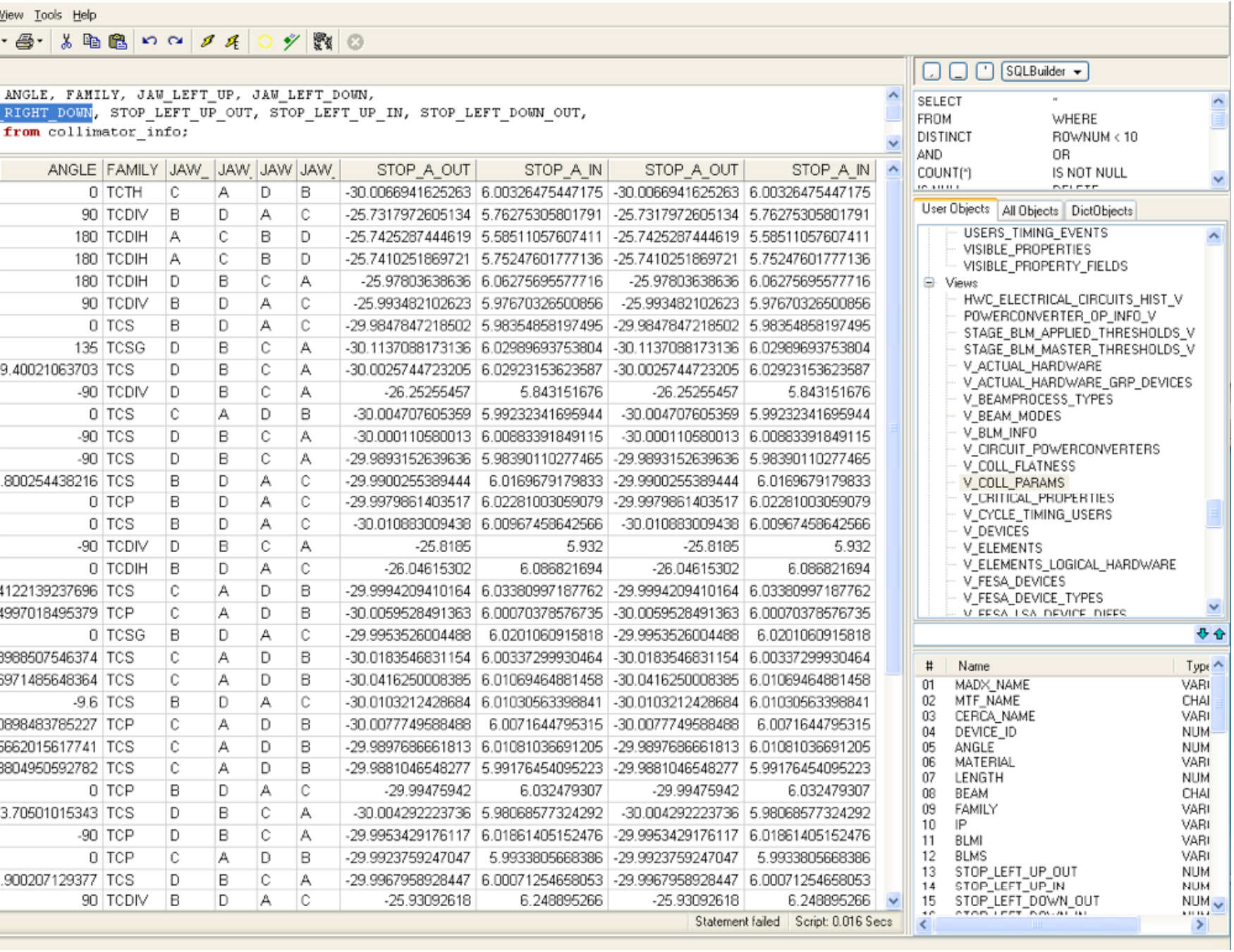
Collimator operational information

IP/BEAM	B1	B2
1	X	X
2	X	X
3	X	X
5	X	X
6	X	X
7	X	X
8	X	X
TI	X	X
ALL	X	X

Configuration file

NAME	MTF link	FAMILY	IP	BEAM	ANGLE	Config Angle	Jaw Orientation	Summary	Photo 252	Photo LHC	3D Layout	Last

E_NAME	MTF link	FAMILY	IP	BEAM	ANGLE	Config Angle	Jaw Orientation	Summary	Photo 252	Photo LHC	3D Layout	La m
52.TEST		TCSG	7	B1	135.0							
L7.B1	TCP109 Acceptance (extra)	TCP	7	B1	90.0	-90.0	D/B/C/A	xls/pdf				31
L7.B1	TCP101 Acceptance (extra)	TCP	7	B1	0.0	0.0	C/A/D/B	xls/pdf				31
L7.B1	TCP102 Acceptance (extra)	TCP	7	B1	127.0	-53.1	C/A/D/B	xls/pdf				01
6L7.B1	TCS020 Acceptance (extra)	TCS	7	B1	141.2	-38.9	C/A/D/B	xls/pdf				01
5L7.B1		TCS	7	B1	143.5							
5L7.B1	TCS021 Acceptance (extra)	TCS	7	B1	40.7	-139.3	D/B/C/A	xls/pdf				25
4L7.B1	TCS029 Acceptance (extra)	TCS	7	B1	90.0	-90.0	D/B/C/A	xls/pdf				10



Includes all req
critical *configu*
(BLM's) and cali
data and operatio

Merges*:*
layout informat
production and
measuremen
results of appro
nominal optic

Will be updated w
results of the ***H***
(e.g.: updated calib
switch positio

es inserted in the production database as of today!
ic tool provided by CO-DM; consistency checks.

- Introduction
- LHC collimation system
  - Layout, design and people
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  - Tools available
- **Commissioning without beam**
  - **Plans for commissioning without beam**
  - **Deliverables of cold checkout**
  - **Contributions from OP**
- Interfaces to other systems
- Conclusions

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the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-AB

CERN Div./Group or Supplier/Contractor Document No.
AB/ABP, AB/ATB

EDMS Document No.
000-2007-1234

Date: 2002-04-15

Test Procedure

LLIMATOR FINAL ASSEMBLY AND
DWARE COMMISSIONING FOR LHC

Page 3 of 30

Table of Contents

daelli
ban
eiler

HWC procedures specified (EDMS docum
T. Weiler): cover all production phases.

HW commissioning in preparation of beam
operation **MTF structures**.

Close collaboration: **ABP**, **ATB**, **OP**, **CO**, **H**

MTF
Equipment Management Folder

Profile Workflow

Final validation of single collimator functionalities!

Profile for **TC**
Description: **Collimator**

Main | Profile data | Workflow

Actions : Add step

Workflow diagram

No Workflow Diagram defined

Workflow Steps

Step	Other name	Description name
MTF013485	()	10-BS Cooling Water Infrastructure
MTF013486	()	12-BS Final Cabling and Plug-in Check
MTF013487	()	14-TE Removing Blocking of Jaws
MTF013488	()	16-TE Water Tightness - Flow Rate Adj
MTF013489	()	18-TE Jaw Movement and Pos. Sensor
MTF013490	()	20-TE Temperature Sensor Response C
MTF013491	()	22-FS Auto-retraction Test
MTF013492	()	24-FS LVDT and Resolver Calibration
MTF013493	()	26-FS Interlock Chain Check
MTF013494	()	28-FS Communication Check
MTF013495	()	30-FSV Auto-Retraction Tests
MTF013496	()	32-FSV Measurement of Mechanical Pla
MTF013497	()	34-FSV LVDT and Resolver Calibration
MTF014798	()	IN010. Initial alignment

portant to verify hardware functionality and ensure that remote operation is safe

- Final sensor calibration in accelerator environment (long cables)
- Repeat measurements after transport (e.g. verify switch position)
- Are we sure that the collimators perform as in surface??

om last
Ralph's
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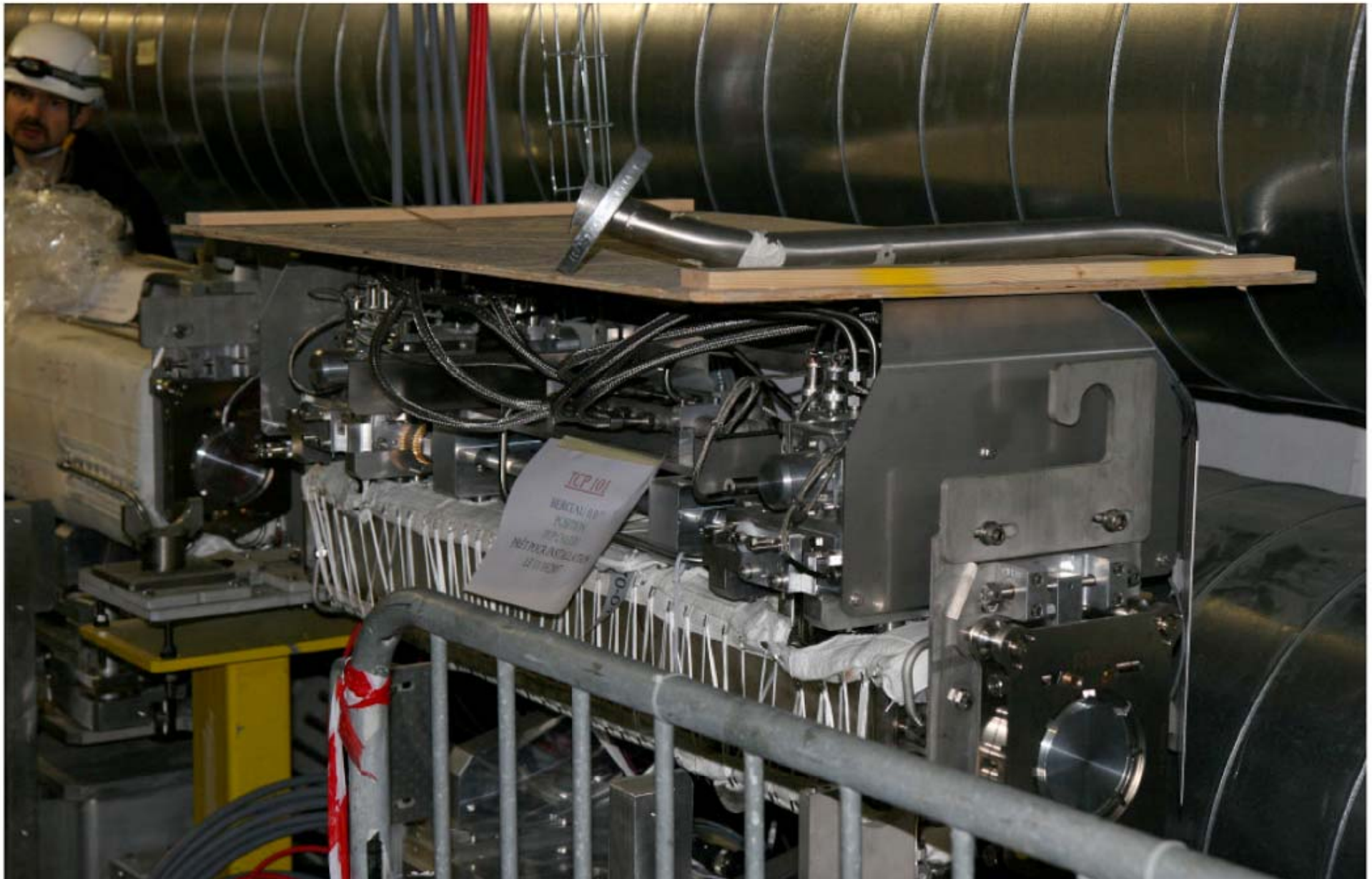

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the
Large Hadron Collider
project

LHC Project Document No.

CERN Div./Group or Supplier/Contractor Document No.
AB/XX/XX

EDMS Document No.

Date: 2007-02-16

MPS Commissioning Procedure

OMMISSIONING OF THE LHC MACHINE PROTECTION SYSTEM

PS ASPECTS OF THE COLLIMATION SYSTEM COMMISSIONING

Abstract

ent describes the set of tests which will be carried-out to validate for operation e protection aspects of the **LHC collimation system.** The area concerned by extends over 7 out of the 8 long straight sections.

s include the Hardware Commissioning, the machine check-out and the tests to the extent that they are relevant for the machine protection functionality of

ared by :	*Checked by :*	*Approved by :*
Assmann l Jonker to Losito o Redaelli as Weiler	Roger Bailey Andy Butterworth Bernd Dehning, Brennan Goddard, Eva Barbara Holzer, Verena Kain, Mike Lamont, Blanca Perea Solano Rudiger Schmidt, Benjamin Todd, Jorg Wenninger, Markus Zerlauth	Rüdiger Schmidt

Commissioning of **machine protection functionality** documented.
Discussions at the MP-SubWG

Includes commissioning of relevant safety aspects (without and with beam) and handling of critical parameters.

Complementary to HWC procedure, more focused on **global system checks**.

No details discussed here.

Outcome of the **collimator hardware commissioning**:

- ☑ Validation of single collimator HWC, all relevant functionality
- ☑ Settings and sensor readouts (position, temperature, switches,...) verified
- ☑ Control of each collimator from CCC is declared "**safe**"
- ☑ Machine protection functionality (without beam) partially established

Cold checkout should be focused on

- ☑ **Perform global, simultaneous system checks**
  - Control an *ensemble* of collimators
  - Address timing and synchronization issue
  - Function-driven motion, "tracking" tests with other equipment
  - Establish full machine protection functionality without beam
- **Verify interfaces to other accelerator systems**
  - Beam loss monitors: configuration/acquisition of distributed system
  - Sequencer driven commands, machine modes
- **Management/validation of measurement data**
  - Verify logging of distributed systems (big data sets!)

- ☑ Top-level control, LSA implementation
- ☑ Check of system interfaces
- ☑ Participation to HWC, definition of procedures
- ☑ Preparation of operational and configuration data
- ☑ Database maintenance
- ☑ Web documentation (production phase)

eople: Stefano, Delphine (OP data, LSA parameter space),

Eric (web, soon software!).

All under Mike's blessing, obviously.

lore contribution expected for checkout tests from CCC, when the

	Application	XPOC	Analog Acquisition	Alarms	Software Interlocks	Critical Settings	Post Mortem	Timing
INJECTION KICKERS	☑	X	X	X		X	X	X
BEAM DUMP	☑	X	X	X		X	X	X
POWER CONVERTERS				X	X		X	X
COLLIMATORS	☑			X	X	X	X	X
RF	☑☑		X	X	X		X	X
LFB	☑		X	X		X	X	X
TFB	☑		X	X			X	X
MAGNETS				X			X	
MKQA				X	X		X	X
WARM MAGNETS				X	X		X	X
RADIATION MONITORS				X			X	
SPECTROMETERS				X	X		X	

Post-mortem / logging

1 Hz logging sufficient (synchr. to machine)
Consistency checks and analysis tools to be developed
TI2 as test-bed: 3 collimator x several days (seems promising)

iming

Essential! LSA will have to drive the hardware through machine timing
Settings + thresholds need to be synchronized and driven coherently

ritical settings

Limit functions in the LSA + FESA level ready for tests
Implementation of MCS functionality to be discussed
Detailed MP procedures are (will be) available

larms

List of relevant failure needs to be prepared (map the internal failures)

oftware interlock

Failures are mostly detected internally
→ Test that collimator beam permit (HW) is removed

- ☑ **Collimation system installation in good shape**
  - We need to be ready to handle the full Phase I system!
- ☑ **Hardware commissioning without beam** (within coll. proj. manda
  - Deliverable: collimator HW safe for operation from CCC
  - Procedures are available - *will be detailed further, as required*
  - Software tools basically available - *good feedback from TI2 tests*
  - Required function driven motion still to be demonstrated
- ? **Scope for the checkout - what we need for beam startup?**
  - System fully operational; synchronized functions
  - Machine protection functionality fully established (scope of Stage A)
  - Reliable interfaces to distributed BLM system!
- ? **Significant contributions from OP**
  - So far: involvement in HWC + software issues
  - Expected to grow during checkout - collimator experts still driving tes

Papers on the collimator layout:

1. Concept of multi-stage cleaning in the LHC Blue book, Vol. 1, Ch. 18
2. Detailed layout of the LHC collimation system layout (Phase I + slot allocations for subsequent phases)
    1. ECO for the final IR3 and IR7 layout (LHC-LJ-EC-0002), also listed in the LHC Collimation Project page
    2. ECO for Tertiary Collimators (TCT)
    3. ECO for Active absorbers
    4. ECO for Passive absorbers

System performance; system staging versus LHC performance:

1. G. Robert-Demolaize's PhD thesis CERN-THESIS-2006-069
2. Ralph at Chamonix 2006
3. Various presentations at the LHC collimation working group meeting (LCWG)

Procedures:

1. Hardware commissioning procedures (EDMS commissioning procedure)
2. System for the first year of operation (ECR LHC-TC-EC-0001)
3. Machine protection commissioning link
4. System commissioning during Stage A: talks at the LHCCWG (1, 2)

Specs of various controls levels

1. Top level: LHC-TCT-ES-0001-10-00
2. Middle level: under publication
3. Low level: under publication

Recent presentations:

1. Recent overview of the Phase I collimation: Stefano at HB2006
2. Readyness for the first year of operation: Ralph at the MAC

Web pages