



# Review Movement & Motorization

November 4<sup>th</sup>, 2005



## Program

- Introduction & Charge – R. Assmann
- Mechanical design & SPS results – O. Aberle
- Mechanical calculations – A. Bertarelli
- Motorization – R. Losito
- Closing of open session – S. Myers
- Closed discussion

All talks on the collimation web site: <http://www.cern.ch/lhc-collimation-project>

**Thanks to everybody for coming and helping us**, especially to Dave Gassner from BNL and the colleagues at SLAC (Tom Porter, Tom Markiewicz, Eric Doyle, Doug McCormick) for getting up so early...



# Why this review?



- Collimation is so **critical for the success of the LHC** that we are always trying to get advise on important decisions.
- 07/2004: **External review of the full collimation project**. At this time still LEP solution for motorization. No review possible on movement and motorization.
- Planned: Another **full review of the collimation project** once first series collimators arrive (next spring).
- Decision to do a **special review on movement and motorization**:
  - Decision required on procurement of stepping motors (decide before next week). High risk: 555 motors, ~1.5 MCHF, reliability risk for the LHC.
  - Take maximum time to understand and solve the problems. Then present status and take a decision!
  - We must take some risk because not everything can be tested in the available time.



# Why are motors critical?



- **Some general collimation challenges for the LHC:**
  - **Small beam size** at the collimators:  $\sim 200 \mu\text{m}$
  - **Small collimator gaps:** down to 2 mm in standard operation and down to 1 mm in special low emittance conditions
  - **High damage potential** of the beams.
  - Large fraction ( $\sim 50\%$ ) of 106 collimators must respect set-up tolerances around  $20\text{--}40 \mu\text{m}$  at 7 TeV. Lengthy set-up!
  - Excellent reproducibility of jaw settings required for reestablishing reference settings without new set-up!
  - **Hostile conditions of the LHC cleaning insertions** ( $\sim \text{MGy/y}$  dose rates, heating from beam losses or bake-out, elevated levels of Ozone, ...).
  - 106 installed phase 1 collimators will be driven with **466 stepping motors**. Worry about precision, reproducibility and reliability.
- Much effort has been put on the design of a **precise and fail-safe mechanical movement system**.
  - The system has been made fail-safe by including the feature of auto-retraction: the jaws are opened by mechanical springs in case of motor failures.
  - Auto-retraction of jaws will in most cases allow LHC operation to continue and to repair the problem during a planned intervention period. This is possible with the built-in redundancy in the collimation system (2 opposite jaws).



# Decisions on movement & motorization have direct consequences for...

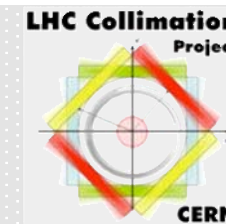


- **Operational efficiency** of the LHC:
  - Possibly we must exchange a whole collimator if a motor fails (takes 1-2 weeks including bake-out).
  - High number of motors requires high reliability.
  - Problems in reproducibility will require retuning of collimator during each fill (loose time while not achieving best possible performance).
- **Architecture of the control system:**
  - For reasons of simplicity we avoid feedback on motor commands during the movement based on read positions.
  - Position read-out is just a check for rare problems which would always lead to a beam dump.
- **Schedule:**
  - More studies and tests would lead to delays (install motors a posteriori, limited hardware commissioning, ...).

➔ Panel members selected to advise also on these risks!



# Scope

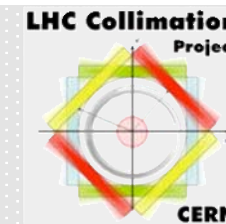


**Table 1 Summary of the different stepping motors required for the LHC both in the rings and the transfer lines. Motors on the support are used to remotely adjust the spare surface.**

Type	Number collimators		Motors (jaws)		Motors (support)	
	installed	spares	installed	spares	installed	spares
<b>TCP/TCS</b>	42	7	168	28	42	7
<b>TCLP</b>	8	2	32	8	0	0
<b>TCT</b>	12	1	48	4	0	0
<b>TCLA</b>	18	2	72	8	0	0
<b>TCDI</b>	14	2	56	8	0	0
<b>2-beam</b>	6	2	24	8	6	2
<b>TCHS</b>	6	3	12	6	6	0
<b>Total</b>	106	19	412	70	54	9



# Specifications



**Table 2 Summary of requirements for stepping motors and mechanical movement. The tolerances must be achieved for any concerned collimator under any foreseen orientation.**

Parameter	Requirement
Minimal possible step size	$< 10 \mu\text{m}$
Accuracy of movement	1 step
Reproducibility	the motor may not loose steps regularly: sensors are used as cross-check after movement and not as feedback information
Nominal speed	1 mm/s
Range in speed	0.5 – 4 mm/s
Synchronicity of motors	$20 \mu\text{m}$ (or 20 ms for 1 mm/s)
Overall mechanical play	$< 20 \mu\text{m}$
Auto-retraction	jaw retracts if motor power is cut or if a motor fails



# Project proposal



The members of the collimation project have agreed on a common proposal, based on our present knowledge:

1. Go ahead with the **procurement of the 555 motors, as specified.**
2. Do **not increase detent torque beyond the specified 80 N mm** but compromise on the maximum torque at the 20% level, if required.
3. Accept the **risk that auto-retraction does not fully work in a few collimators** but we expect it works in most.
4. Take care of **proper matching of mechanical system and motor during series production.**

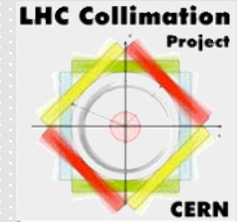
This agreement is the result of hard and excellent work of all involved, making the system work in the lab over the last 4 weeks:

[O. Aberle](#), [R. Losito](#), [R. Chamizo](#), [A. Masi](#), [P. Gander](#), [A. Bertarelli](#), [R. Perret](#), ...

Thanks to them and collaborators for their impressive efforts!



# Charge to the reviewers



The movement and the motorization for the LHC collimators shall be reviewed:

- Review the specifications and the achieved results of collimator motion for the various types of collimators and the various collimator orientations.
- Assess the overall status of the collimator mechanical actuation system and possible risks.
- Based on the above assessment, advice on the procurement of the LHC stepping motors.

*The decision on motor procurement (~1.5 MCHF) is time critical as we are planning to go to the December CERN Finance Committee for approval of the contract. Alternatively we can opt for the Finance Committee in March, inducing a delay in motor installation on many collimators (many collimators will be installed into the tunnel without motors). Any further delay would not be possible.*