Possible Collimation Priorities

June 13th, 2005

- Collimation Project made significant progress for phase 1:
  - Successful tests of phase 1 collimator prototypes (Nov04)
  - Design and execution drawings for major collimators completed (Apr05)
  - Contract for series production for all 125 required collimators (May05)
  - Commitment on total budget and approval by management (May 05)
- Last major open point: **Production & installation schedule**
- This CWG: Should we define priorities and if so, what are these?
- Today's meeting:
  - Don't expect final decisions and installation plan (too early).
  - Expect **detailed input on all relevant aspects for establishing a plan for collimator production and installation**.

What needs to be installed?

Phase	Acronym	Material	Length [m]	Number	Locations	INJ	TOP	Purpose
	Scrapers							
1	**TCHS**	tbd	tbd	6	**IR3, IR7**			Beam scraping
2	***TCHS***	tbd	tbd	2	**IR3, IR7**			*Skew beam scraping*
	Collimators							
1	**TCP**	C-C	0.2	8	**IR3, IR7**	**Y**	**Y**	Primary collimators
1	**TCSG**	C-C	1.0	30	**IR3, IR7**	**Y**	**Y**	Secondary collimators
1	**TCSG**	C-C	1.0	2	**IR6**	**Y**	**Y**	Help for TCDQ set-up
2	***TCSM***	tbd	tbd	30	**IR3, IR7**			*Hybrid secondary collimators*
4	***TCS4***	tbd	tbd	10	**IR7**			*Phase 4 collimators*
	Diluters							
1	**TDI**	Sandwich	4.2	2	**IR2, IR8**	**Y**		Injection protection
1	**TCLI**	C	1.0	4	**IR2, IR8**	**Y**		Injection protection
1	**TCDI**	C	1.2	14	**TI2, TI8**	**Y**		Injection collimation
1	**TCDQ**	C-C	6.0	2	**IR6**	**Y**	**Y**	Dump protection
	Movable Absorbers							
1	**TCT**	Cu/W	1.0	16	**IR1, IR2, IR5, IR8**		**Y**	Tertiary collimators
1	**TCLA**	Cu/W	1.0	18	**IR3, IR7**	**Y**	**Y**	Showers from collimators
1	**TCL/TCLP**	Cu	1.0	4	**IR1, IR5**		**Y**	Secondaries from IP
3	***TCL/TCLP***	Cu	1.0	4	**IR1, IR5**		**Y**	*Secondaries from IP*

Series Production Overview

- Now included 6 different types for a **total of 125 collimators**:

				Design differences with TCP/TCS design					
Design type	# total	# spares in total	Drawings	Mech. Table	Tank	RF contacts	Flanges	Jaw assembly	Jaws type
TCP/TCS (reference)	**49**	*7*	**yes**	**no**	**no**	**no**	**no**	**no**	**CC clamped**
TCT	**33**	*3*	**yes**	**no**	**no**	**no**	**no**	**yes**	**Cu/W screwed**
TCLP	**10**	*2*	**yes**	**no**	**no**	**no**	**no**	**yes**	**Cu screwed**
TCDI	**16**	*2*	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**C not cooled**
TCHS	**9**	*3*	**no**	*similar?*	*similar?*	*similar?*	**no**	**yes**	**tbd**
TCT/TCLI (2beam)	**8**	*2*	**no**	*similar?*	**different!**	**different!**	**yes**	**yes**	**Cu/W and CC**

- Baseline is **start of production with TCP/TCS reference design** (most difficult and most important) ➔ If we can build them all others are “easy”.
- All 3 CERN prototypes are of type TCS!
- TDI, TCDQ, TCDS, … are not affected by this production.

Original and New Approach

- Original production approach:
  - **Two different production sites for parallel production** of LHC collimators.
  - European industry: All TCP and TCS. Possibly other most important.
  - Novosibirsk: All other types (transfer line, tertiary, …).
  - Split production risk and avoid bottle-necks.
- New approach:
  - **Only one producer: European industry with twice peak production rate.**
  - Peak production rate is 10 collimators/month!
  - Two production lines but common bottle-necks exist!
  - Increased production risk!
  - New possibility and requirement to define priorities!
- General worries about possible problems similar to QRL!

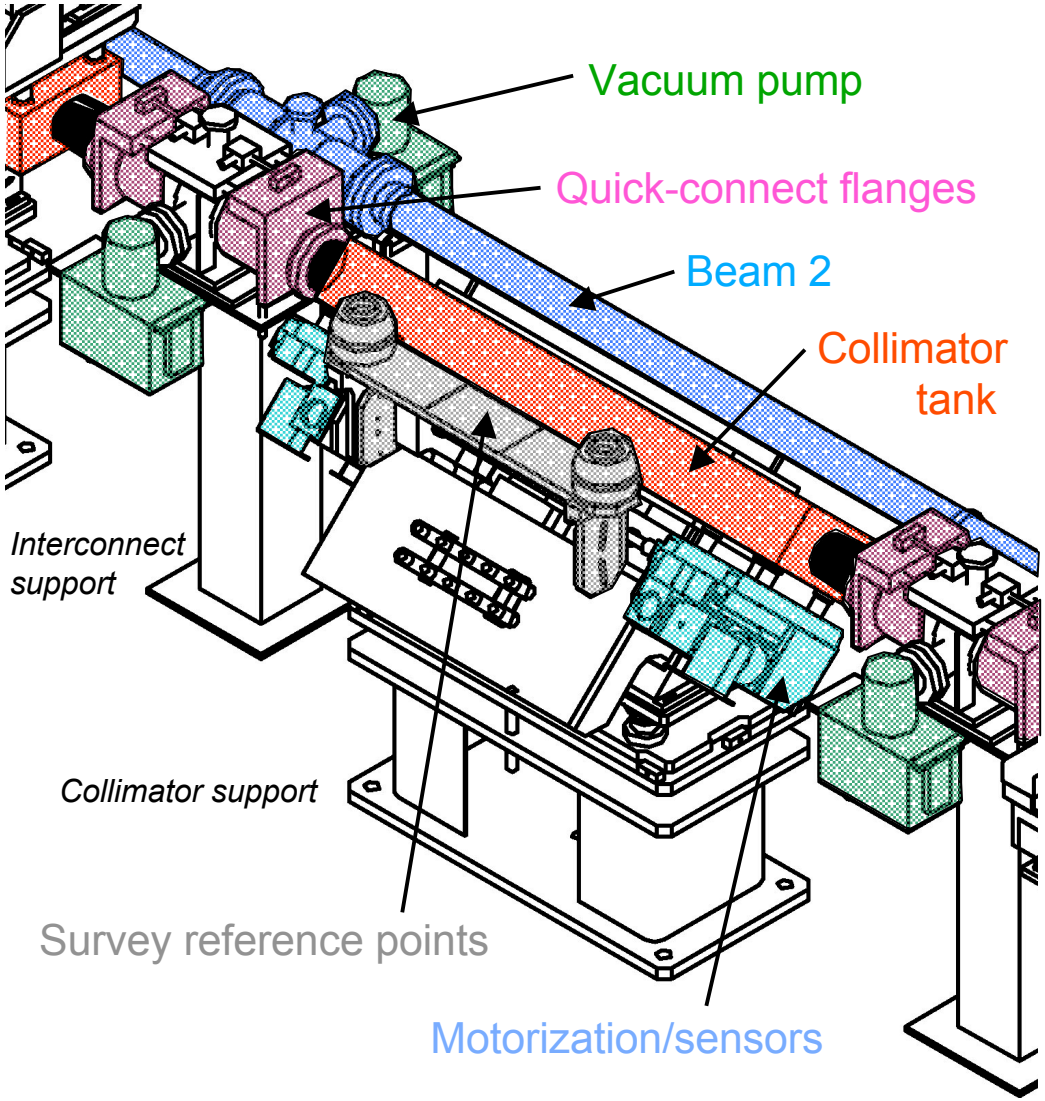
Collimators Requirements

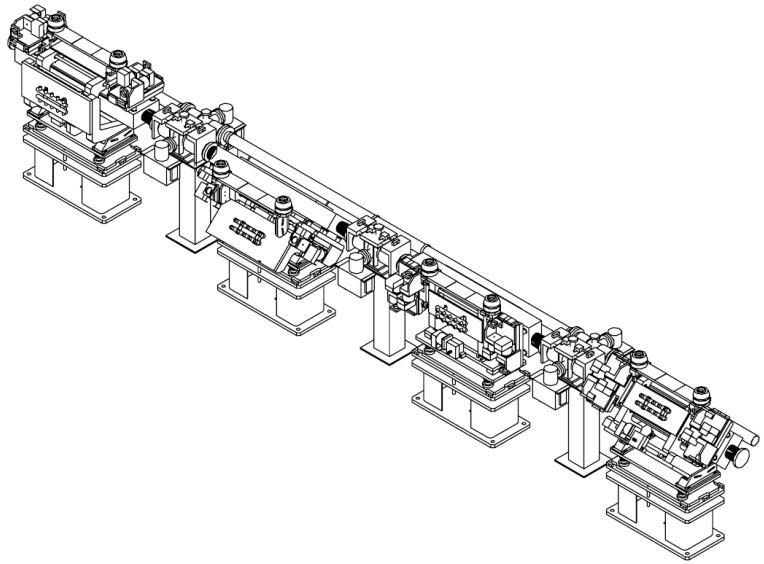
- LHC collimators are very different from magnets or QRL where all elements are required before start-up of the LHC!
- **LHC can be commissioned without any collimators or with missing collimators if intensity is restricted:**
  - 1 pilot bunch: No collimators.
  - ~46 nominal bunches @ 7 TeV: 60% of phase 1 collimators.
    (~ 3 times Tevatron)
  - ~1000 nominal bunches @ 7 TeV: All phase 1 collimators.
    (~ 65 times Tevatron)
  - 2808 nominal bunches @ 7 TeV: Phase 1 + phase 2 + phase 3.
    (~ 200 times Tevatron)
- Even with delays we can support increasing LHC intensities with partial installations: Big difference to QRL and magnets!
- Ignoring installation schedule implies cost and additional work!

How to Produce?

- Two priorities are possible:
  1. Produce and install in order to optimize LHC performance reach at any time.
     - Advantages: LHC ready for first year operation after 60% of production and installation, most of production with 2 types, more time for equipping and testing collimators, …
     - Disadvantages: Increased installation effort, potential need for temporary installations, need for multiple interventions, …
  2. Produce and install according to the LHC installation schedule.
     - Advantages: Minimize installation effort, avoid temporary installations, avoid multiple interventions, …
     - Disadvantages: LHC ready for first year operation only after installation of last batch, production of up to 3-4 collimator types in parallel, reduced time for equipping and testing collimators, …
- Decision on approach will be taken at CERN: **What is the preferred approach for us?**

What needs to be installed?





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Original “Collimator Installation Policy”

- Collimators are late and should not be taken as a driving constraint for installation schedule.
- There is no interference of collimators with installation of “cold” machine parts, which is highest priority and on the critical path.
- For minimal impact the following scenario was agreed (S. Weisz):
  - Installation of all infrastructure (cables, water connections, …) during the standard infrastructure installation campaigns. Still true to my knowledge: all input defined.
  - Installation of all collimator supports (including phase 2) during standard machine installation campaigns, including connection of quick plug-ins and alignment of supports.
  - Installation of phase 1 collimators (as soon as available) in quick plug-in fashion (for radiation optimization): _ hour per collimator!?
  - In case required: Installation of simple vacuum pipes (2 kCHF/piece) for missing collimators to not hold up general progress.
- Now it is time to define details…

Version 1: Production and Installation

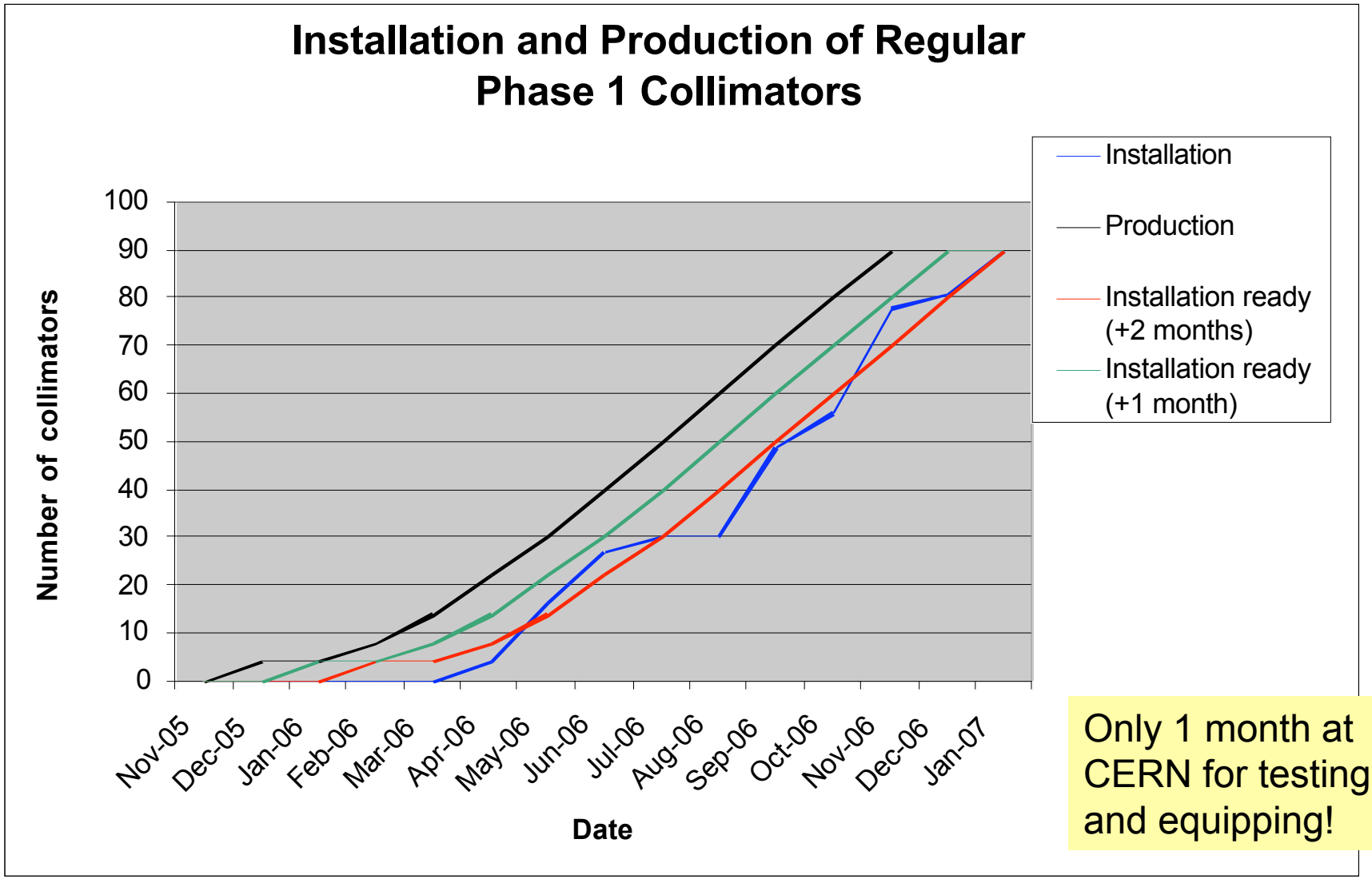
- A general installation schedule has been established for the LHC.
- A collimator installation plan has been drafted in order to fit into the general installation plan.
- Production can barely fit the present installation plan for standard phase 1 collimator, assuming:
  - No delays in production schedule.
  - Just in time production of collimators of the 4 different types, according to installation plan.
  - Reduction of time for equipping and testing collimators at CERN from 2 months to 0-1 month.
- Possible installation-oriented production schedule is extremely critical:
  - Delays will result in incompatibility with installation schedule.
  - **Delays can postpone the first LHC physics run!**
  - High risk and visibility, so we need accurate information and commitments!

Draft of Collimator Installation

- Based on **presentation by K. Foraz on June 1st, 2005**.
  Remarks:
  - Added transfer line collimators to the presented installation schedule.
  - Produced only in 2007: 6 TCHS and 6 TCT/TCLI (2-beam) designs (requires temporary installations in IR2, IR3, IR7, IR8).
  - Does not include the passive absorbers in IR3 and IR7 (2 per IR).
  - Does not include devices which are not produced by the collimation project: 8 TCDD, 2 TCLIM, 2 TDI.
- Production **just in time for the sector to be installed next**.
- Betatron cleaning completed after LSS7R installation in Nov 06:
  - Missing primary collimators, absorbers, secondary collimators before this date.
  - Not a functioning system for either beam before this date.
- Momentum cleaning completed after LSS3L installation in Jan 07:
  - Missing primary collimators, absorbers, secondary collimators before this date.
  - Not a functioning system for either beam before this date.
- **Last collimators to be produced are among the most important of the LHC.**

Section	Installation date
LSS8R	April-06
LSS1L	April-06
LSS5L	May-06
LSS8L	May-06
TI8	May-06
LSS3R	June-06
LSS6L	June-06
LSS6R	June-06
LSS5R	July-06
	August-06
LSS7L	September-06
TI2	October-06
LSS1R	November-06
LSS7R	November-06
LSS2L	December-06
LSS2R	December-06
LSS3L	January-07

Just-In-Time Collimator Production with Contract

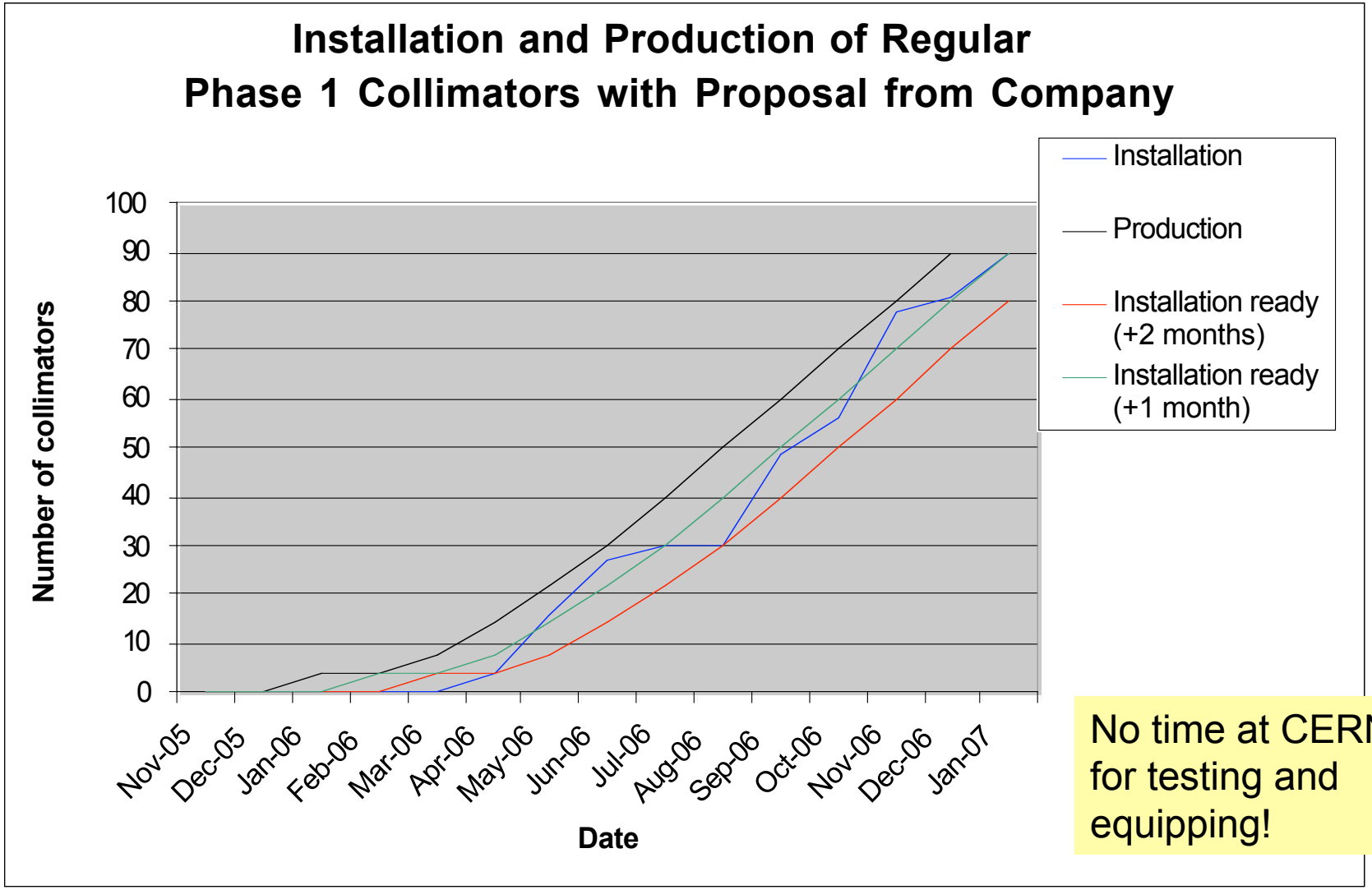


Only 1 month at CERN for testing and equipping!

Remarks on Company Schedule

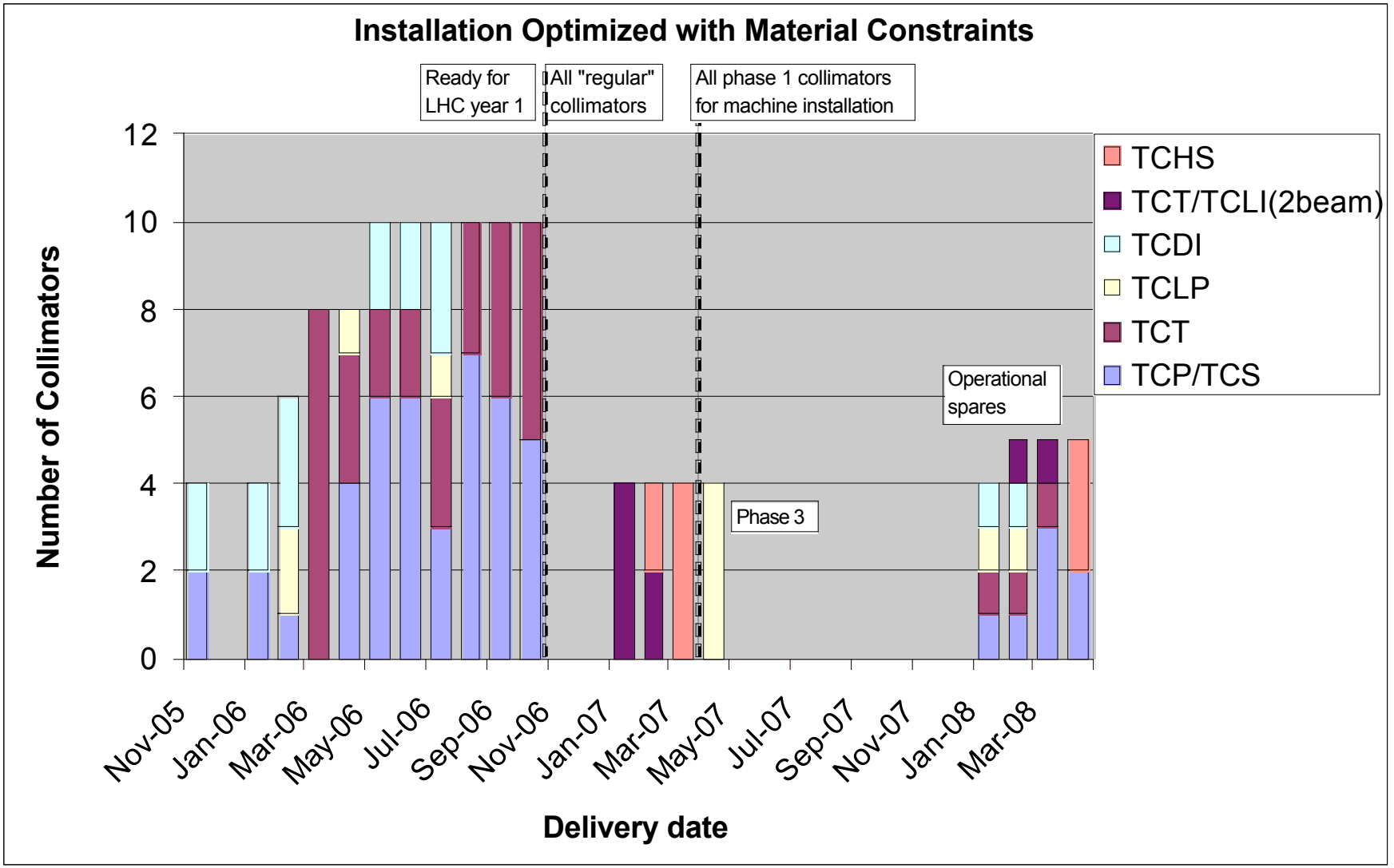
- Previous slide presented the contractual production schedule.
- Company schedule proposes **6 weeks delay** for samples and **1 month delay** for all series production.
- Company schedule relies on some optimistic assumptions:
  - Approval of several 10 new sub-contractors in the next weeks (possible if no bad surprise?).
  - Approval to start series production before qualification samples have been received and tested by CERN.
  - All material for first 10 collimators to company in the next two weeks (1 month earlier than agreed).
  - Some crucial production processes (calibration & referencing) have not yet been defined in detail by the company (additional time required).

Just-In-Time Collimator Production with Company Dates



No time at CERN for testing and equipping!

Version 1: Installation Optimized



Important Dates for Version 1

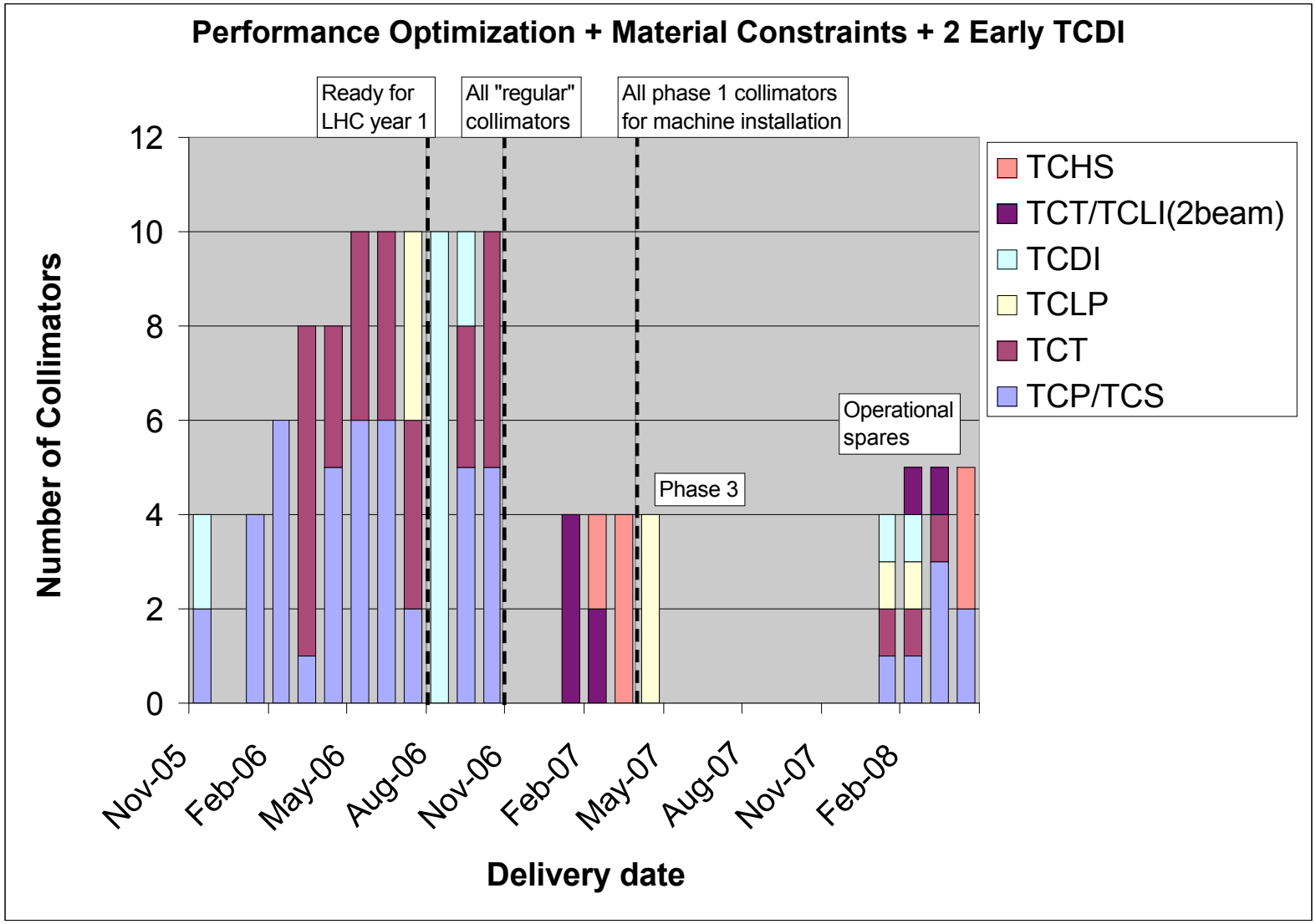
Date all delivered	Date all ready for installation	Status
(below is contract, company schedule: + 1 month)		
31/10/06	**31/12/06**	Ready for LHC year 1 *Up to 3% of intensity (43 bunches OK)*
31/10/06	31/12/06	All “regular” collimators *Up to 40% of intensity but restricted β^* in IR2/8*
31/03/07	31/05/07	All “phase 1” collimators *Up to 40% of intensity with free β^* in IR2/IR8 and no restriction for injected batches*
30/04/07	30/06/07	Phase 3 ready for nominal luminosity *Up to 40% of intensity but allowing for nominal luminosity. Delayed installation.*
30/04/08	30/06/08	All “phase 1+3” spares available

Version 2: Minimal "Ready for Year 1" System

- Detailed performance estimates need to be done. Numbers based on past experience and qualitative considerations.
- A system to be ready for LHC first year operation would consist of the 60 most important collimators (out of 125 total collimators)
  - 8 TCP collimators (all installed of phase 1).
  - 24 TCS collimators (2/3 of installed).
  - 22 TCT collimators (3/4 of installed).
  - 4 TCLP collimators (all installed of phase 1).
  - 2 TCDI collimators (1/7 of installed).

  These collimators would allow to **run the LHC in 2007 (first year)** for 43 on 43 nominal bunches and without an expected limitation from the collimation system!
- Do such considerations make sense? What is the really required minimal system? Should we study and define a sub-system? Do we need all collimators in 2007? What are other critical collimators? …

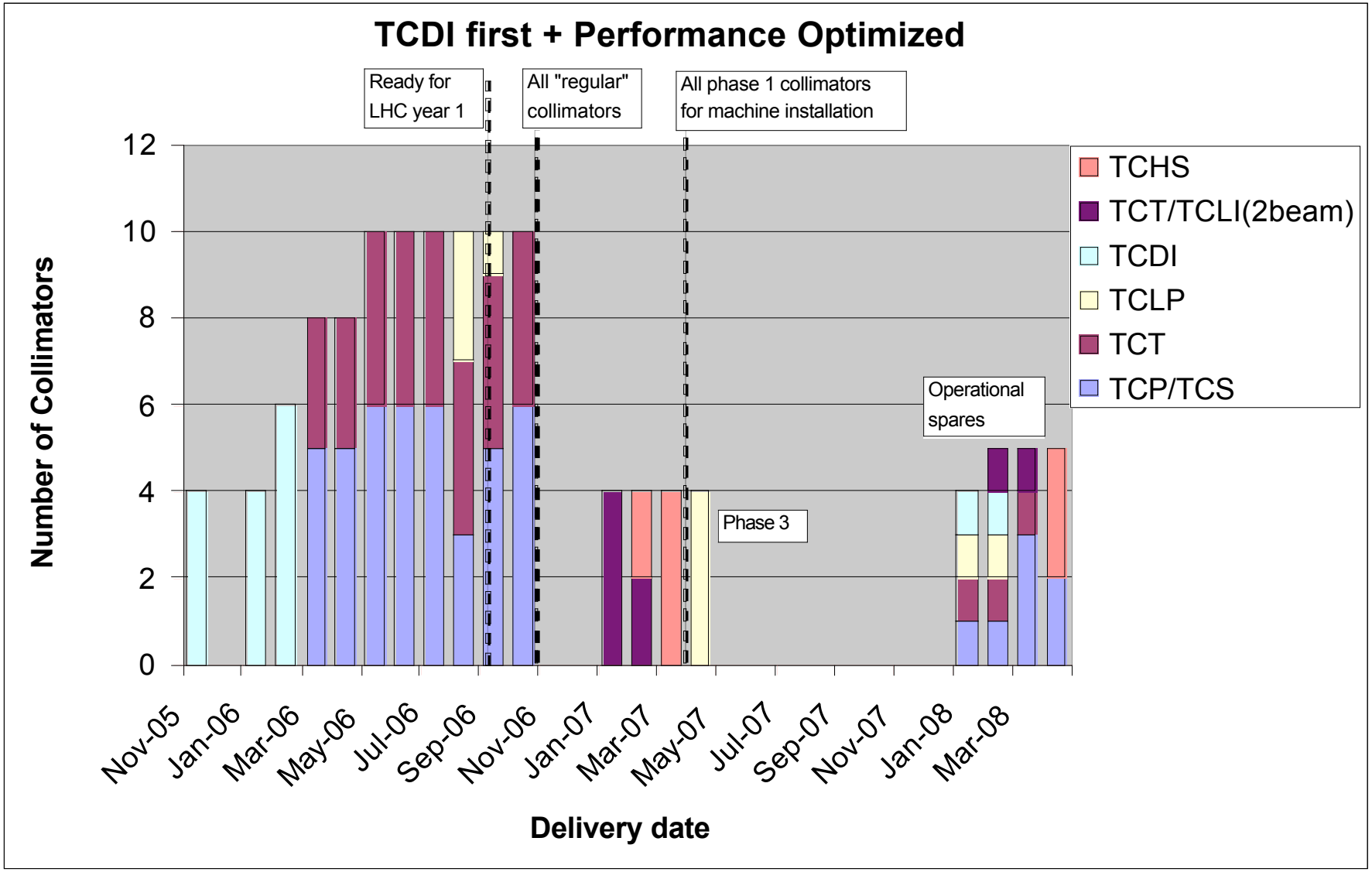
Version 2: Performance Optimized



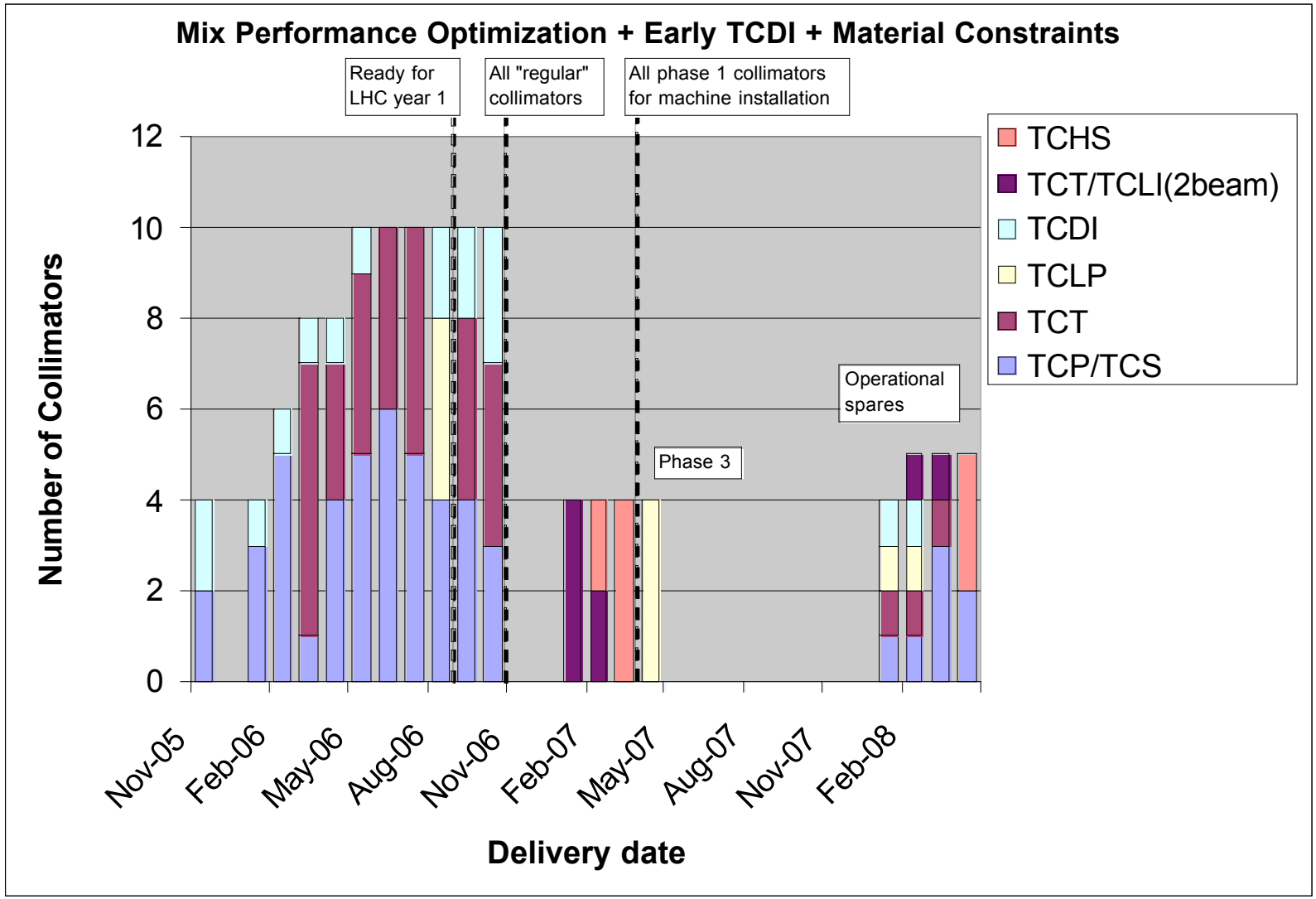
Important Dates for Version 2

Date all delivered	Date all ready for installation	Status
(below is contract, company schedule: + 1 month)		
31/07/06	**30/09/06**	Ready for LHC year 1 *Up to 3% of intensity (43 bunches OK)*
31/10/06	31/12/06	All “regular” collimators *Up to 40% of intensity but restricted β^* in IR2/8*
31/03/07	31/05/07	All “phase 1” collimators *Up to 40% of intensity with free β^* in IR2/IR8 and no restriction for injected batches*
30/04/07	30/06/07	Phase 3 ready for nominal luminosity *Up to 40% of intensity but allowing for nominal luminosity. Delayed installation.*
30/04/08	30/06/08	All “phase 1+3” spares available

Version 3: TCDI First + Performance Optimized Later



Version 4: Some Mixture



General Remarks on Production

- We need to foresee production of up to 3-4 collimator types in parallel.
- We cannot finish one type before doing the next type (spares at the end).
- Installation-ready for **minimal "first year system" for the LHC** with contractual dates, ingnoring for the moment delayed schedule from producer:
  - Installation priority: 31.12.2006 (version 1: last delivery 30.10.2006)
  - Performance priority: **30.09.2006** (version 2: last delivery 31.07.2006)
  - TCDI first: 30.11.2006 (version 3: last delivery 30.09.2006)
  - Mix: 31.10.2006 (version 4: last delivery 31.08.2005)

  Note: Dates assume contractual peak production of 10 collimators/month in Summer 2006!
  Successful sample production assumed for 31.07.05 (has not started yet)!

Steps towards a Decision

- June 1st: Input from the installation side.
- June 6th: Visit to company.
- June 10th: Visit of company at CERN.
- June 13th: CWG on possible priorities.
- June 15th: New proposal for production schedule from company.
- June 21st: Decision on first 10 collimators to avoid further delays.
- June 29th: LTC???
- July 4th: ABMB
- July 6th: Announcement of collimator production & installation plans.

➔ Comments on process are welcome!

Questions for Brainstorming

- **Significant risks from collimator production exist!**
  - We rely on a single company without any margin in the production schedule!
  - We are already discussing bypassing of some quality assurance steps and delays before the production has started!
  - We can imagine strong future pressure to skip time-consuming quality checks and calibration procedures!
  - Strong risk to end up with sub-optimal collimators in the LHC (need 3 times better than Tevatron already for 43 on 43 nominal bunches)!
- **How to best address this risk?**
  - Define sub-system for first year? Minimize risk for performance?
  - Delay less important collimators? Acceptable? What are these?
  - Accept installation delays (plug-in of later collimators): cost of temporary pipes (2kCHF/pipe), second installations, break of vacuum for installing delayed collimators, …
  - Insist on all collimators for 2007 and, if required, put additional money (if budget available)?
  - …
- Your input will have an impact on what collimators will be there in 2007! Feedback required from members of CWG, LHCOP, MPWG, …