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Transverse Feedback System (LHC Damper)

Outline of Presentation

- Functional Specification and purpose of system
- Overview of System ("PBS") and its components
- Progress overview and WBS in EVM
- Status of collaboration with JINR, Dubna (kickers and power amplifiers)
- Status of high power equipment and integration (tunnel)
- Test area and interlocks and industrial controls
- Low-Level System and software
- Planning, hardware baseline, EDMS, MTF, CtC

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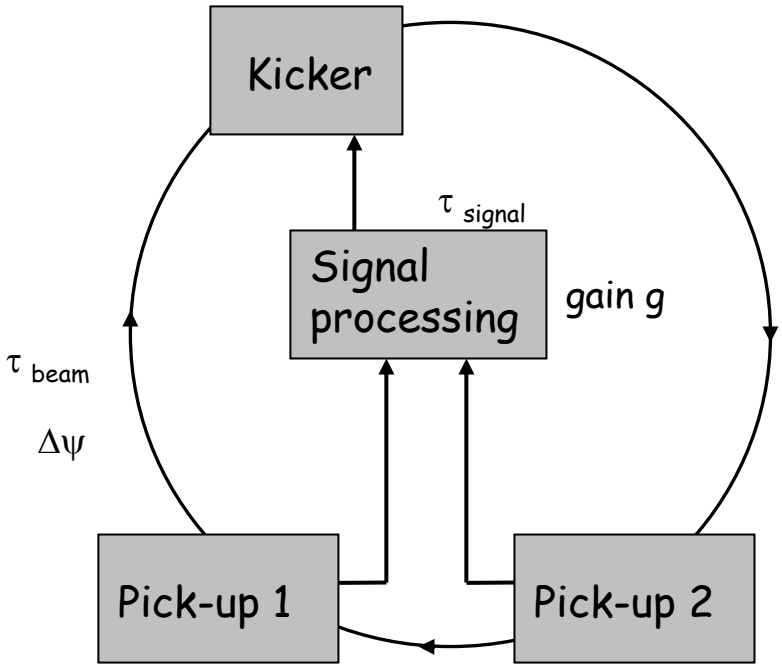
Transverse feedback



Need real-time digital signal processing

Match delays:

$\tau_{signal} = \tau_{beam} + MT_0$

T0 : beam revolution time

M=1: very common -> "One -Turn-Delay" feedback

- damping: of transverse injection oscillations
- feedback: curing transverse coupled bunch instabilities
- excitation: of transverse oscillations for beam measurements & other applications

Transverse Feedback ("LHC Damper")

Example SPS (CNGS type beam, 1 batch, 10^{13} protons):

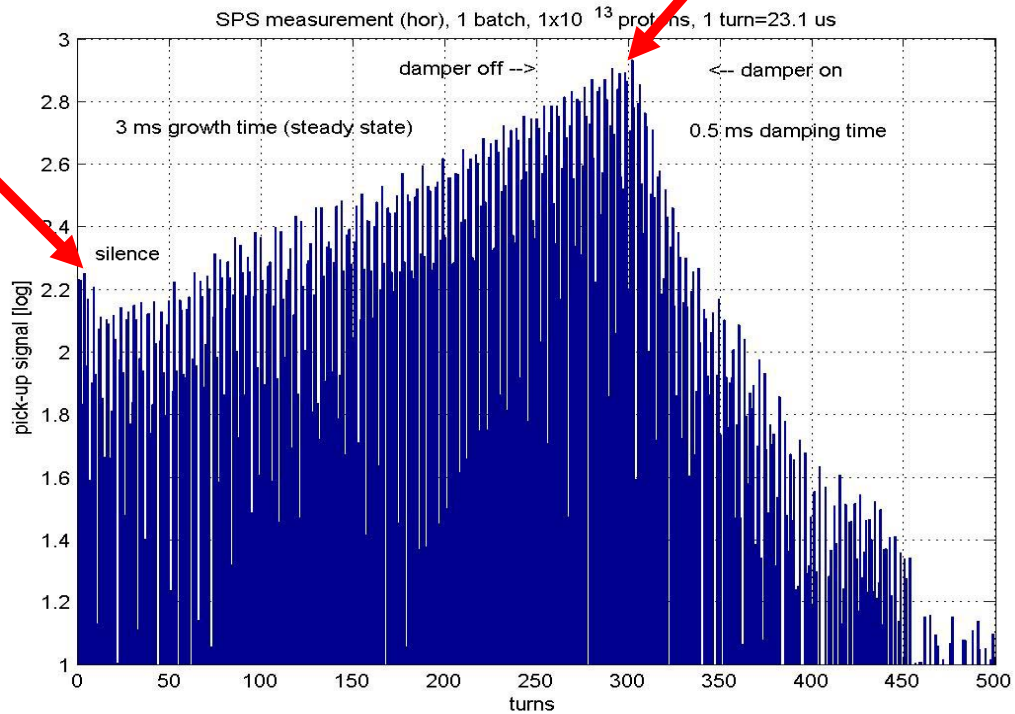
3 ms growth rate

0.5 ms damping time

50 + turns relative silence at injection

damper being switched on 7 ms (300 turns) after injection

injection with damper off



Status of Performance specification (1) (LHC Design Report)

Beam parameters and requirements for nominal intensity:

Injection beam momentum	450 GeV/c
Static injection errors	2 mm (at β_{max}=183 m)
ripple (up to 1 MHz)	2 mm (at β_{max}=183 m)
resistive wall growth time	18.5 ms
assumed de-coherence time	68 ms
tolerable emittance growth	2.5 %
Overall damping time	4.1 ms (46 turns)
bunch spacing	25 ns
minimum gap between batches	995 ns
lowest betatron frequency	> 2 kHz
highest frequency to damp	20 MHz

For more details see design report

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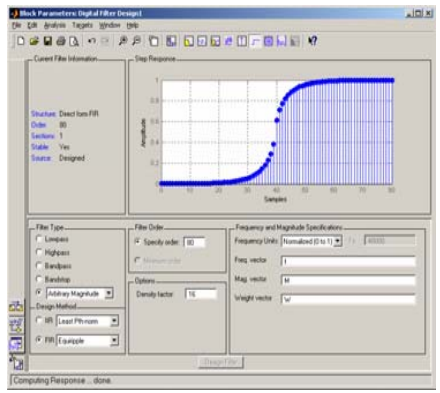
Performance specification (2)

Equipment performance specification:

choice:	electrostatic kickers ("base-band")
aperture	52 mm
kickers per beam and plane	4
length per kicker	1.5 m
nominal voltage up to 1 MHz at β=100m	+/- 7.5 kV
kick per turn at 450 GeV/c	2 μrad
rise-time 10-90%, DV= +/- 7.5 kV	350 ns
rise-time 1-99%, DV= +/- 7.5 kV	720 ns
must provide sufficient gain from	1 kHz to 20 MHz



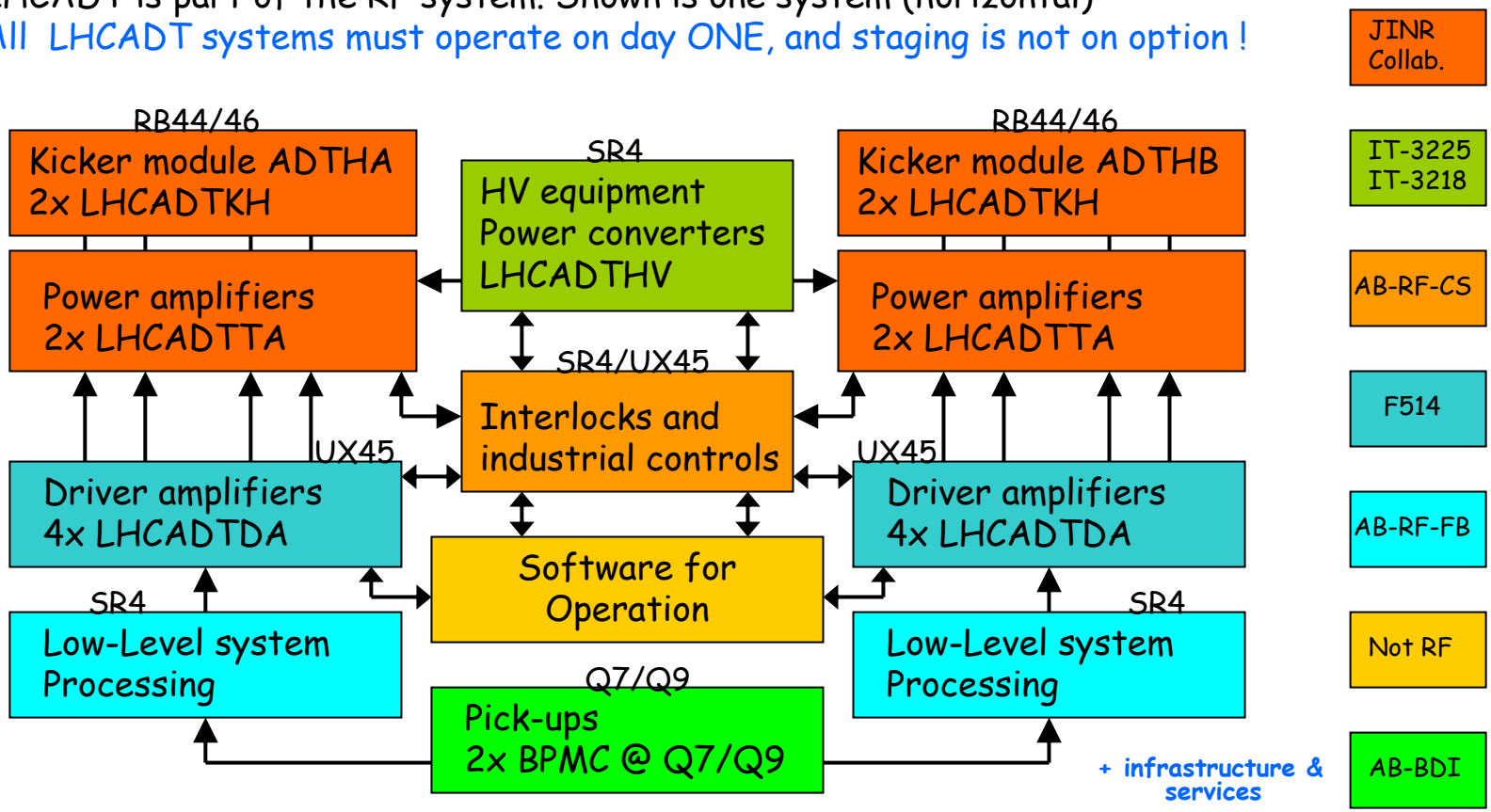
rise time fast enough for gap of 38 missing bunches

noise must be less than quantization noise due to 10 bit / 2σ

Performance specification frozen
-> but studies continue to evaluate and optimize bunch-to-bunch damping

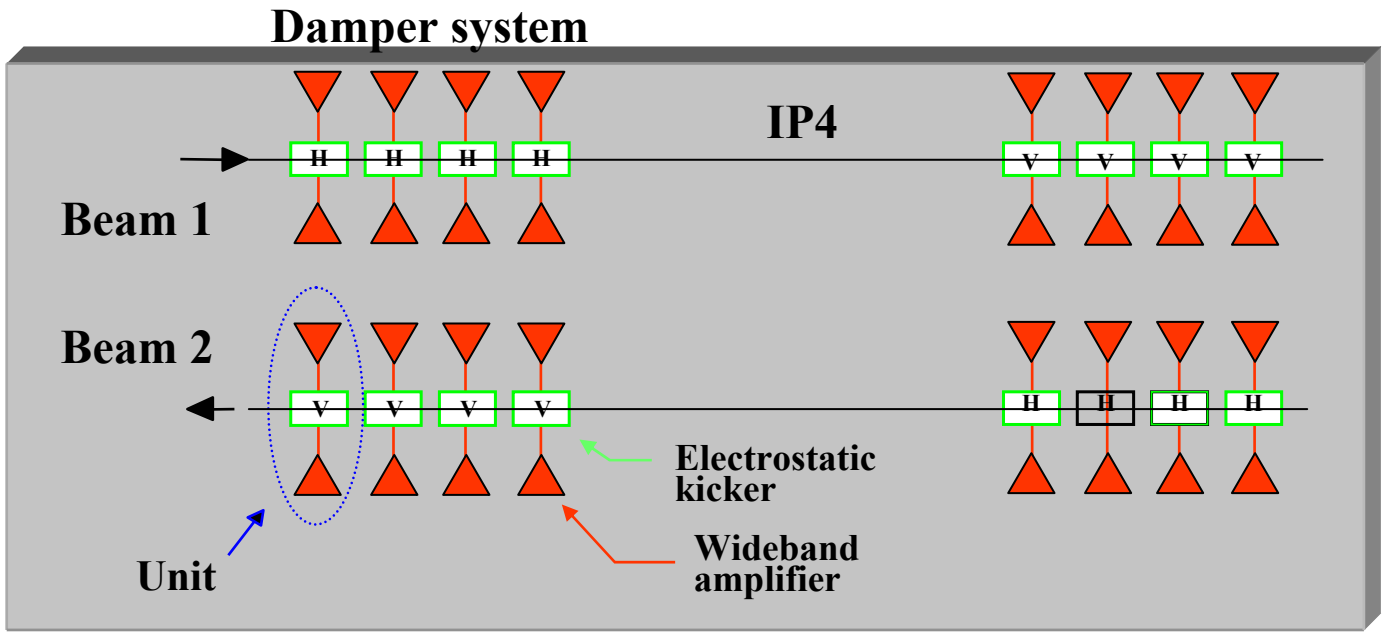
Overview of LHCADT system components and responsibilities ("PBS")

LHCADT is part of the RF system. Shown is one system (horizontal)
All LHCADT systems must operate on day ONE, and staging is not on option !



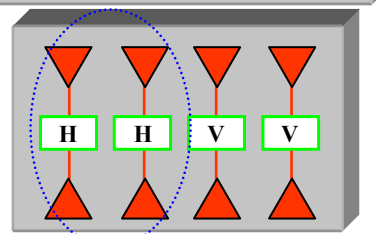
Shown is one "system". There are four independent systems, one per plane (H/V) and beam.

The LHC Transverse Damping System (high power part)



- 20 electrostatic kickers
- 40 wideband amplifiers, i.e. 40 tetrodes (20 amplifier cases)

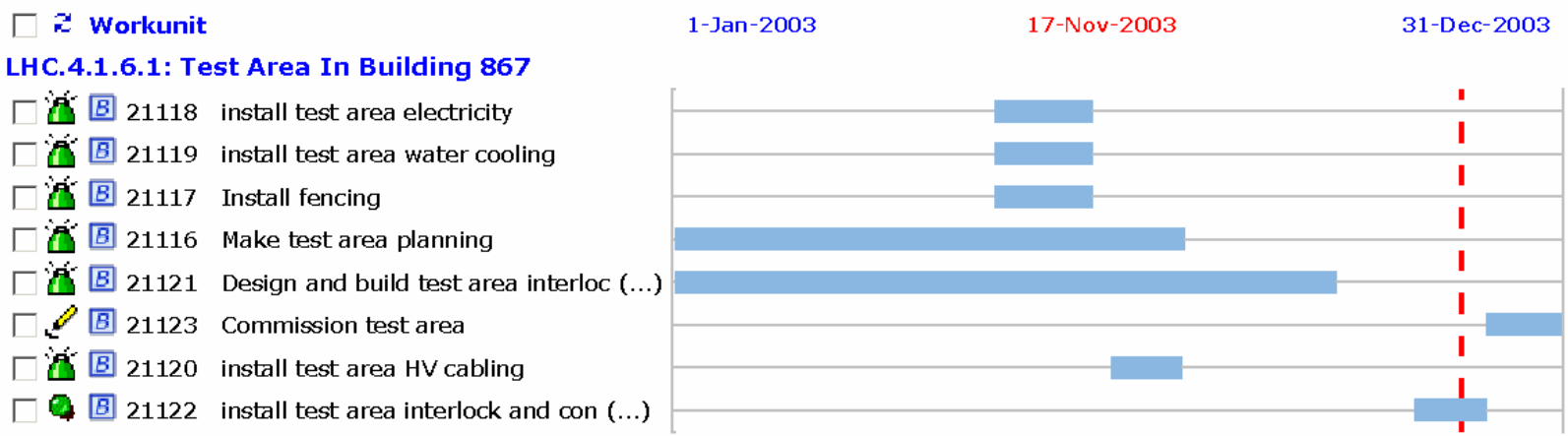
+ Spare units



Progress Overview ("WBS") as in EVM

4.1.6.1 Preparation of test area in building 867:
work has not started yet, currently not on critical path
need to be tackled in 2004
-> work for ST division needs definition and coordination

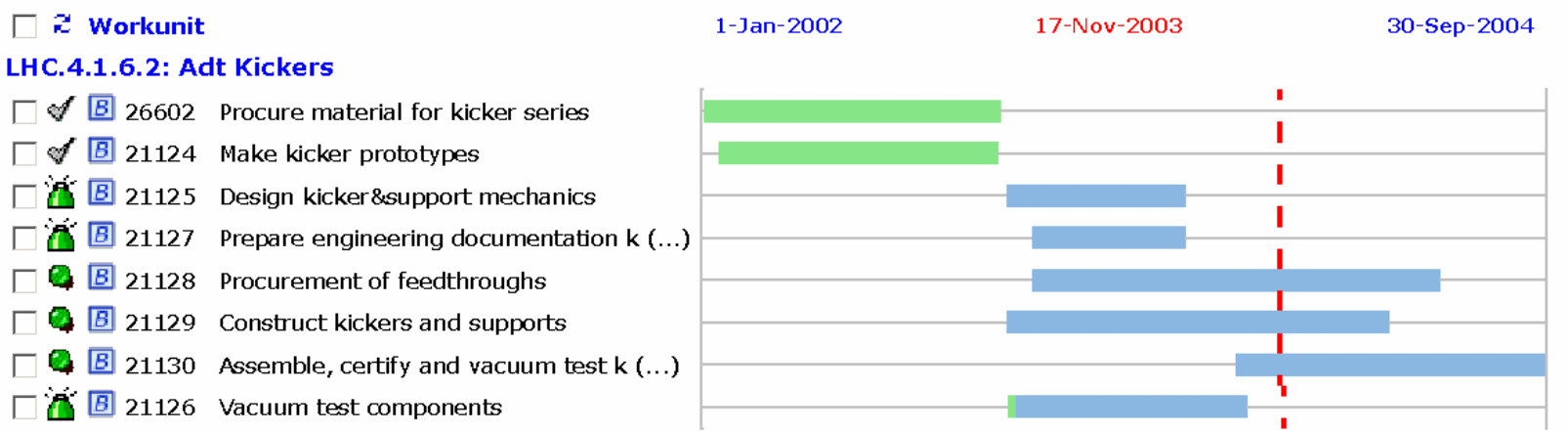
Very important sub-project as we plan to fully test the power system before installation (including interlocks & industrials controls)



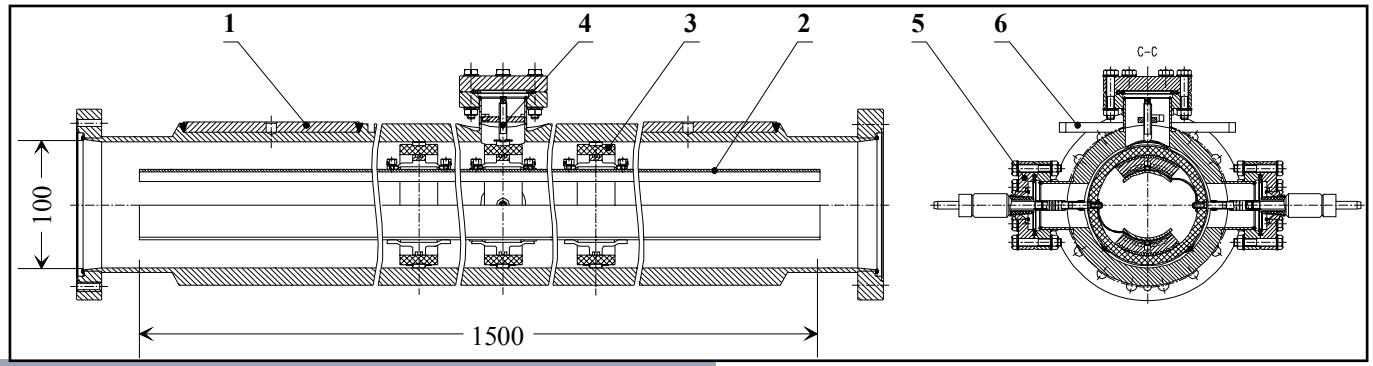
Progress Overview ("WBS") as in EVM

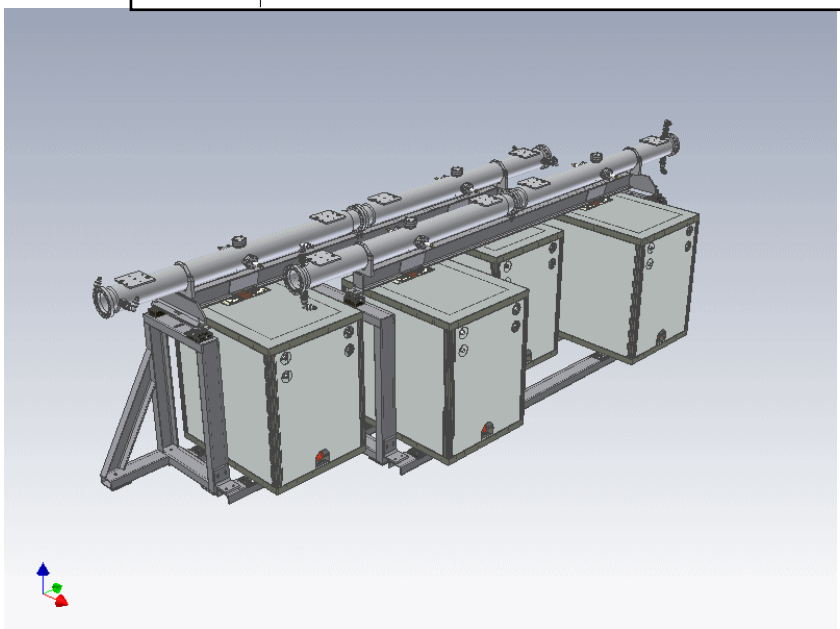
4.1.6.2 ADT kickers (JINR-CERN collaboration agreement signed in 1997)

design done, drawings in CDD, prototype tested
material for all series shipped to JINR
first two kicker tanks rejected by LHC-VAC due to welding quality issues
project is on critical path and needs full support both at CERN and JINR



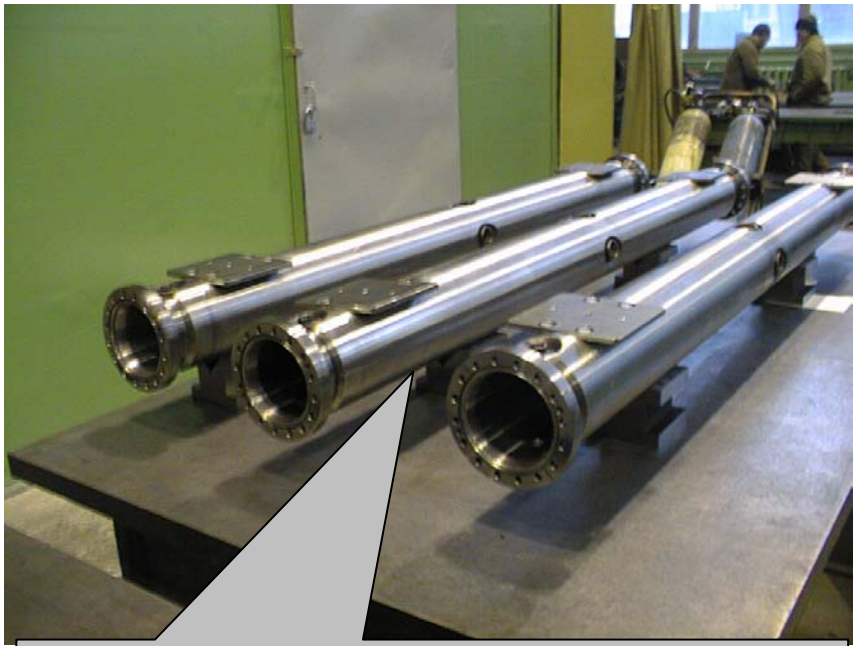
Status of kicker design





- Kicker design documented in CDD, moving from design phase to manufacturing, all raw material has been delivered from CERN in JINR
- Some design issues remain to be clarified and documented (support structure and inter-connection from amplifier to kicker, installation procedure)

Status of kicker fabrication



3 vacuum tanks were manufactured at the "Raduga" Plant (Dubna) in cooperation with Izhevsk in 2002.

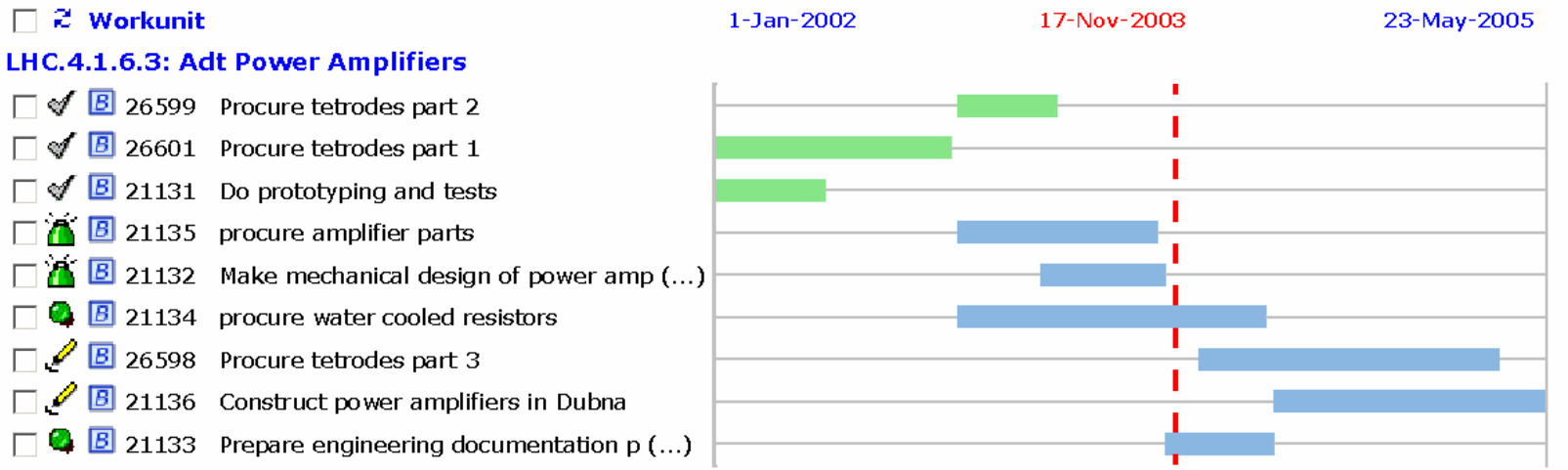
- The pre-production unit (2 vacuum tanks) was tested at CERN in 2003 and revealed welding quality issues that are being resolved (1 tank leaking, both tanks rejected by LHC-VAC)
- An alternative variant for production of vacuum tanks is discussed with Lesnoy (Minatom's plant)
- Feedthroughs for HOM couplers were recuperated from LEP RF spares, vacuum tested and conditioned for storage and future use for the LHC damper (CERN supplied item)
- Main Feedthroughs: Contract placed Delivery in 2004 (CERN supplied item)

Progress Overview ("WBS") as in EVM

4.1.6.3 ADT power amplifiers (JINR-CERN collaboration)

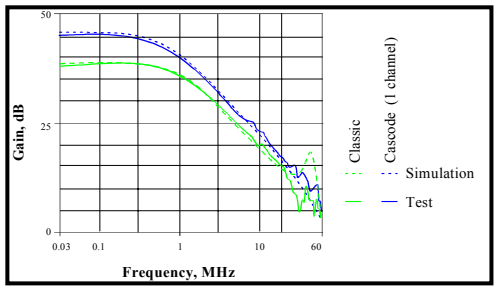
Prototype tested, design advanced but drawings not yet in CDD
Amplifier parts partially ordered and shipped to JINR

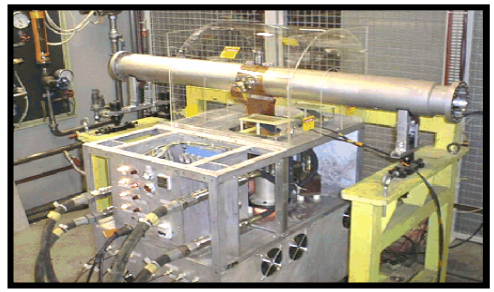
Requires more support from CERN to catch up with delay
Project is critical and needs full support, both at CERN and JINR



Status of power amplifier

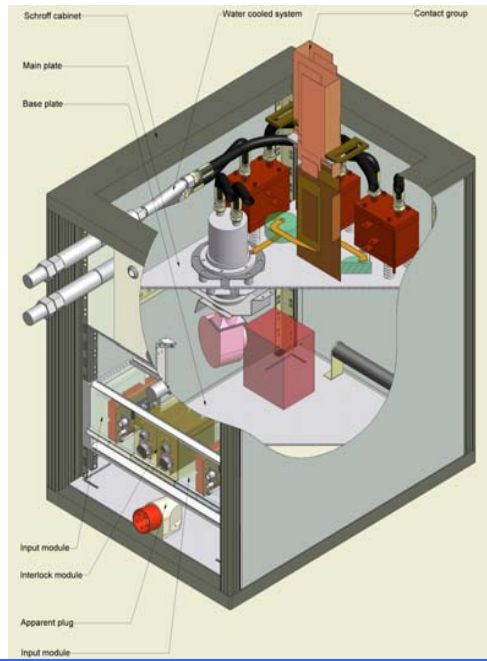
Prototype manufactured and tested in 2001





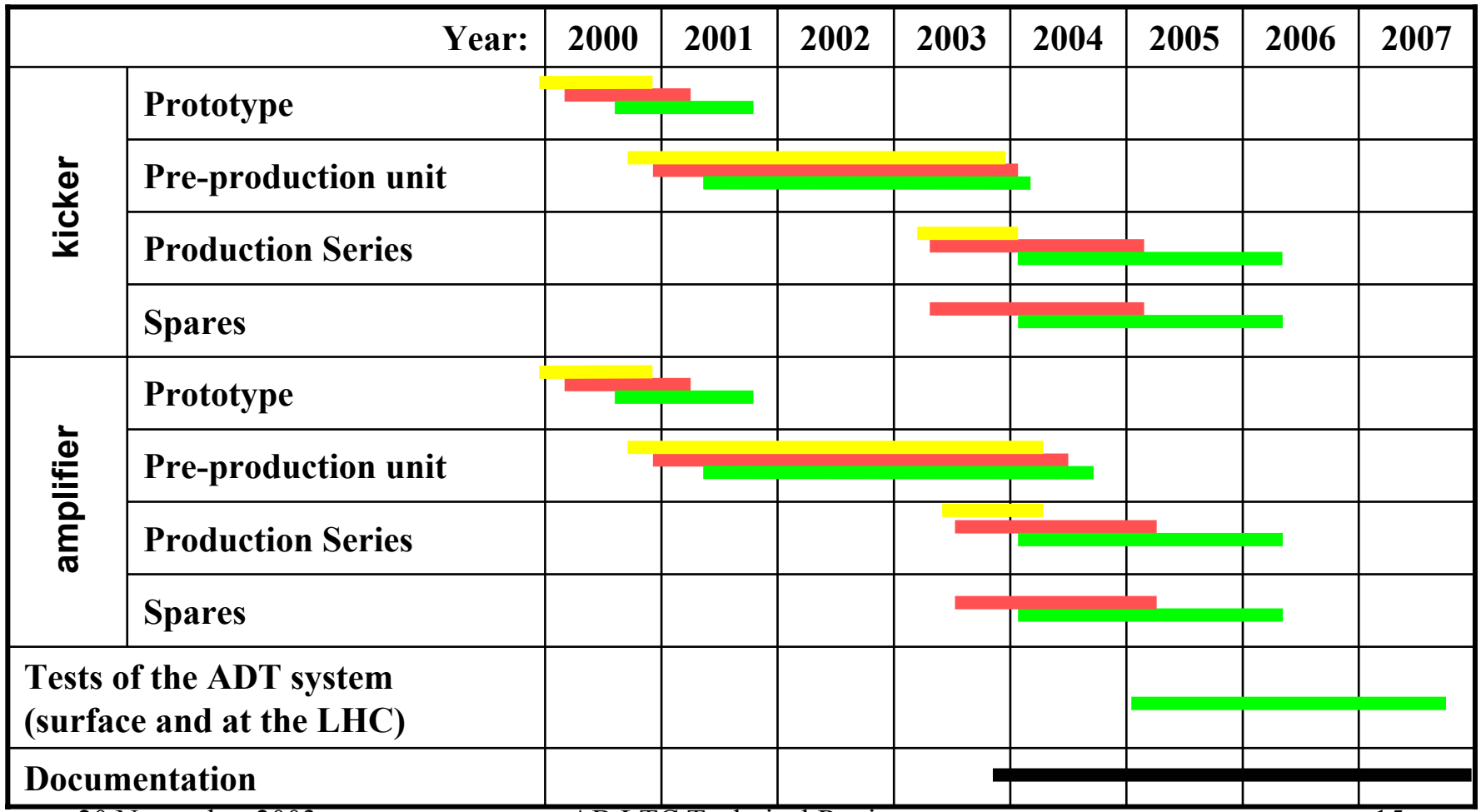
Production series design and manufacturing:

- list with specifications for the all components for the power amplifier was agreed between JINR and CERN
- the amplifier for the pre-production unit is being manufactured (will be completed in December 2003 if all components will be available)
- current bottleneck is CERN manpower available for ordering of components
- a large number of orders < 50 kCHF and some > 50 kCHF still need to be processed (specification, price enquiry …)



Transverse Feedback ("LHC Damper")

design construction installation & testing



LHC Construction and Installation

General Co-ordination Schedule at Point 4

CM		UPGRADE OF SERVICES					SIGNAL CABLE PULLING			KLYSTRONS		ACS & ADT						AB/RF TESTS			
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4		
2005												2006											

Progress Overview ("WBS") as in EVM

4.1.6.4 Driver amplifiers (contract F514/AB/LHC adjudicated in June 2003)
Good collaboration with SPL (G. Edwards),
company (Thales Communications Belgium) was slow in signing contrat
after receiving letter of intent, work started, now also signed

Progressing well and on schedule, prototype expected in January 2004
contractual delivery of 40 amplifiers in 4 batches up to January 2005
Aim: test two amplifiers in the SPS in 2004

Remark: time spent on EVM <-> CET adjustments could have been better used on solving other real problems

4.1.6.9 Procurement of high-voltage power converters (1x F contract, 1x <750kCHF)
Responsibility: AB-RF,
good collaboration with AB-PO group (J. Lahaye/G. Simonet) single MS done

IT-3225 Tender finished and supplier selected (joint RF/PO IT)
[Auxiliary power converters for tetrode amplifiers & LEIR]

IT-3218 Tender launched, adjudication foreseen in FC March 2004
[Power converter for Supply of Anode Voltage for tetrodes]
Offers will be received in January 2004, delivery during 2005

Progress Overview ("WBS") as in EVM

4.1.6.6 Interlocks and industrial controls (AB-RF-CS section)

intimately linked to the build-up of the test area in building 867
will be a high priority for 2004
conceptual design OK

needs implementation, detailed planning and procurement, …

4.1.6.8 Infrastructure Power (UX45/RB/SR4), Integration (V. Rodel)

Tunnel integration done (see following slides)
follow-up of services (water-cooling, electricity) under way

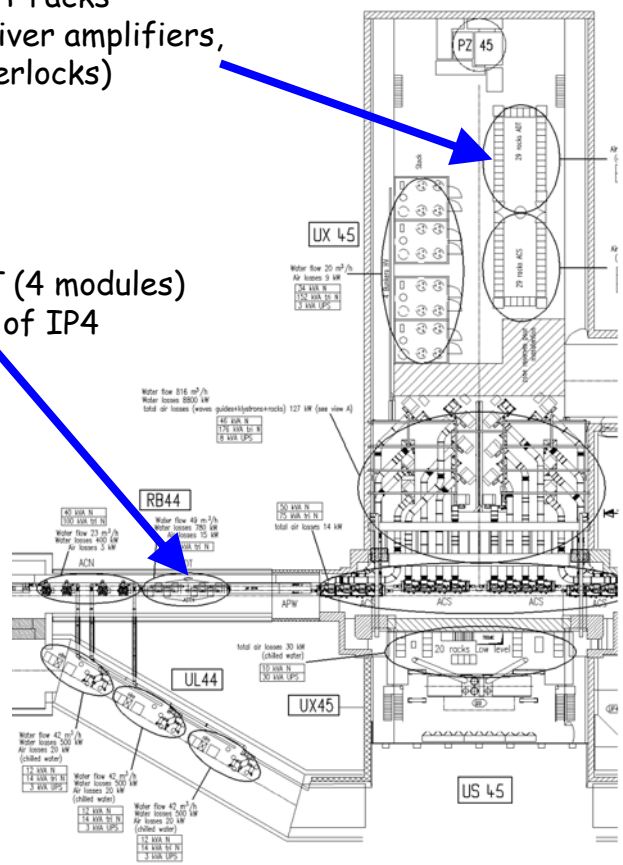
UX45 integration done by RF group
surface integration not yet done (SR4 building)

cable installation planned and requests submitted to ST division
cable ordering launched by ST (except for RF cables, 7/8")

Status Tunnel and UX45 integration

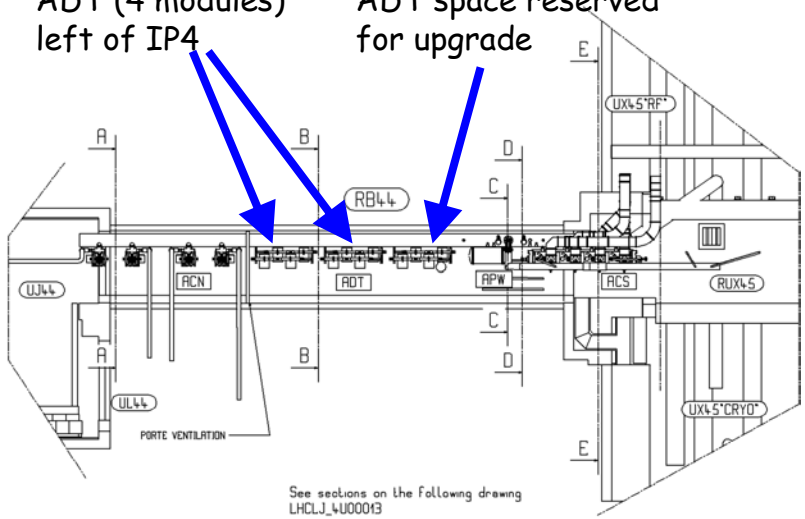
ADT racks
(driver amplifiers,
interlocks)

ADT (4 modules)
left of IP4



ADT (4 modules)
left of IP4

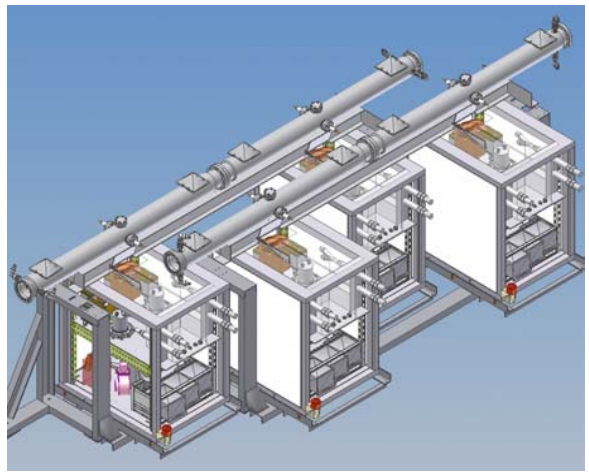
ADT space reserved
for upgrade



Infrastructure and integration ongoing
Integration in UX45 done by RF group !

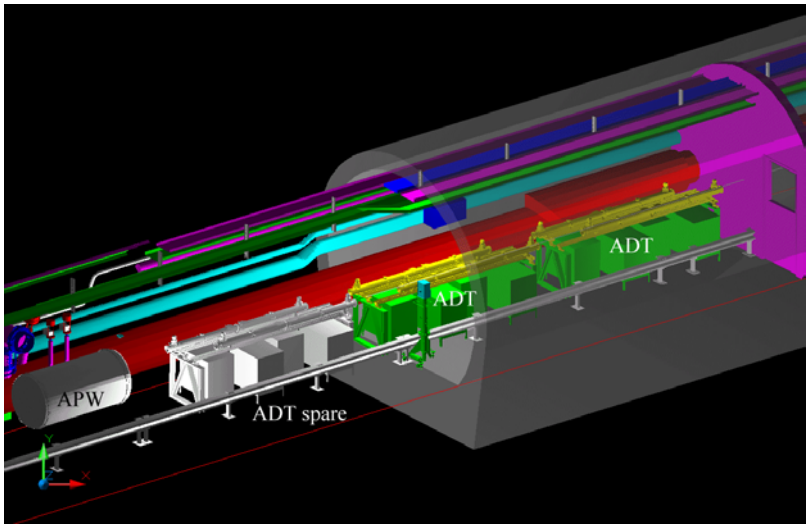
Status in tunnel (Summer 2003)

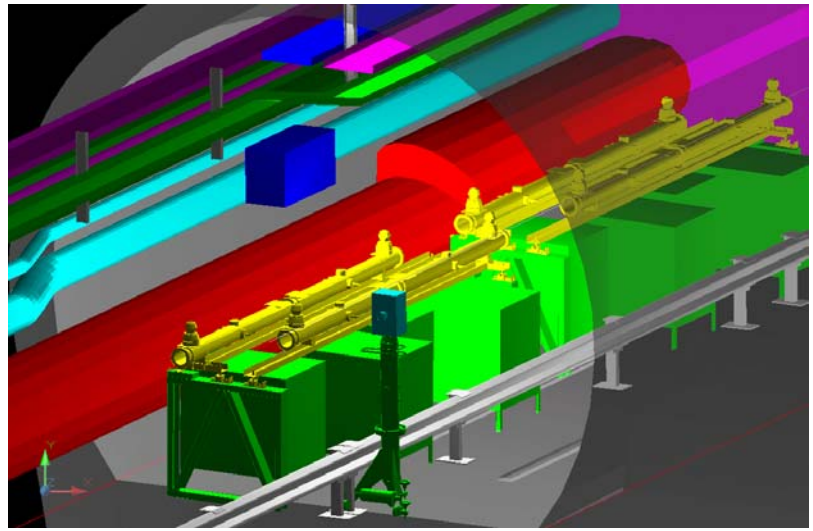
Situation in tunnel in Summer 2003, view from UX45 along LHC tunnel



Damper equipment (two modules with two kickers each per beam and their power amplifiers)

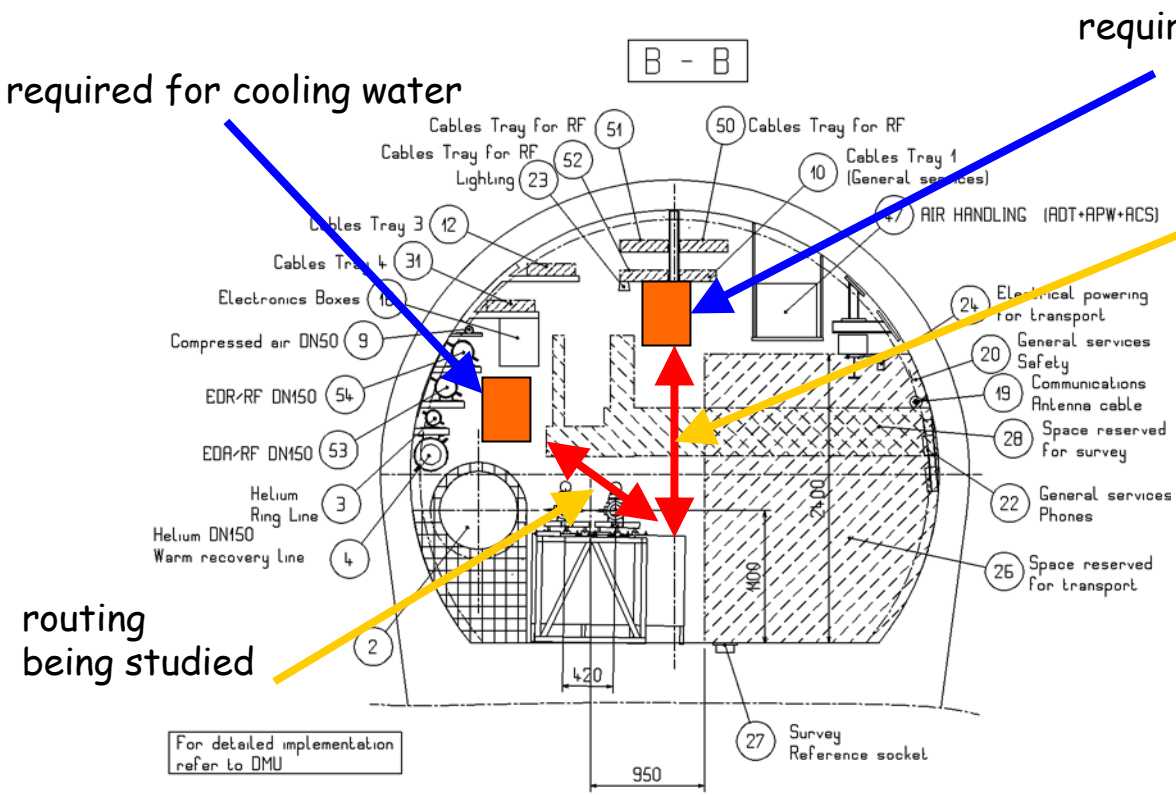
Status: Tunnel integration RB44 / RB46





Integration Studies in tunnel RB44 / RB46
(done in Autumn 2003, some follow-up for
services and cable routing)

Status Tunnel and UX45 integration



Cross-section of tunnel (RB44 / RB46)

3D integration done but

additional volumes required for:

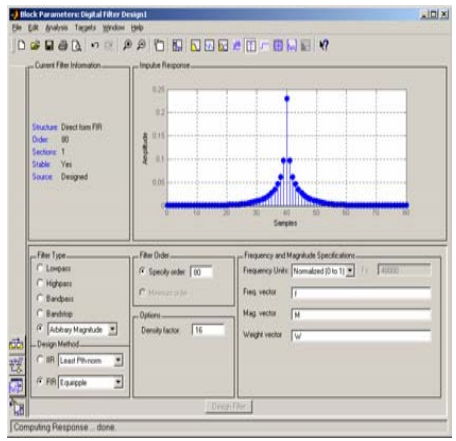
- water-cooling
- patch panels and cable routing

These issues are being followed-up with high priority

Progress Overview ("WBS")

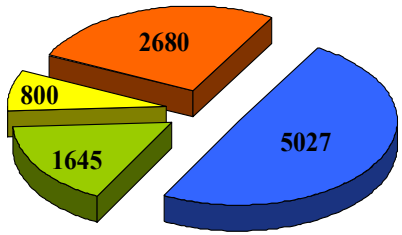
4.1.6.10 ADT Low-level electronics

- System will be based on experience gained with SPS Damper
- 12 or 14 bit digitization @ 80 MHZ (or higher)
- FPGA logic for implementing most functions (notch filter, fine delay adjustment, betatron phase adjustment by two pick-ups or Hilbert filter and single pick-up use
- System specification was planned for this year, but is delayed (not critical)
- Design work will have to start in 2004 and will peak in 2005 (present focus is on power system and large contracts, resources !)
- Job of low level signal processing is to optimize drive signal taking into account requirements of application (damping, beam measurements) and given pulse response of the power system
- Use standard applications for control (function generators, timing etc.)



CtC and progress with contracting

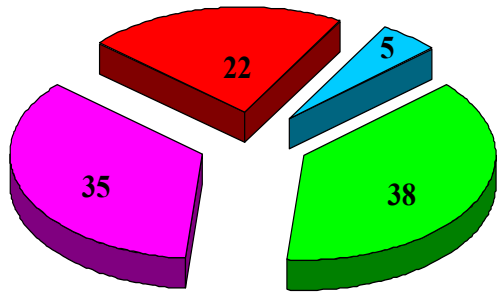
CtC LHCADT: 10.152 MCHF (March 2003)



kCHF

- AB-RF-FB owned workunits (excluding JINR Project)
- Cabling & and Infrastructure
- CERN share of JINR/CERN project
- JINR/Russia share of JINR/CERN Project

Contracting progress (%)



%

- paid (includes down payments & material for JINR)
- contracted (includes JINR/Russia share)
- tenders under way (includes bulk part of cables)
- pending detailed specifications

22 % pending includes labor intensive low-level electronics !

Documentation (HW baseline, EDSM, CDD, EVM, MTF)

- HW baseline -> system included, structure defined, specifications in
- EDMS used for storage of specifications for orders/contracts
- CFU for follow-up of large contracts and orders (two F contracts)
- EVM: all work units defined and followed-up (refinement as we proceed ?!)
- Detailed information spread out on file servers, web pages, will need effort to migrate information into EDMS
- Use of MTF needs to be studied -> will need effort in 2004 (power amplifiers & kickers)

Conclusions

- All System components are identified and budgeted for in CtC and EVM, overall within CtC estimate (8 MCHF + 2.680 MCHF JINR)

- Development and Design of kicker and power amplifier is done in collaboration with the JINR in Dubna and is well advanced. Successful timely production requires full support of this project by the JINR management and a clear statement by CERN about priorities. Welding quality issues are being resolved. This project is critical and we are approaching the point of zero margin in the planning.

- Integration in tunnel (RB44, RB46) OK, details of electrical supply and cooling water supply to be clarified and designed in collaboration with ST division, some gray areas in infrastructure interfaces

- Project on track, but other projects and pressures make it difficult to focus effort on LHC machine as foreseen in manpower plan