400 MHz RF System: Power

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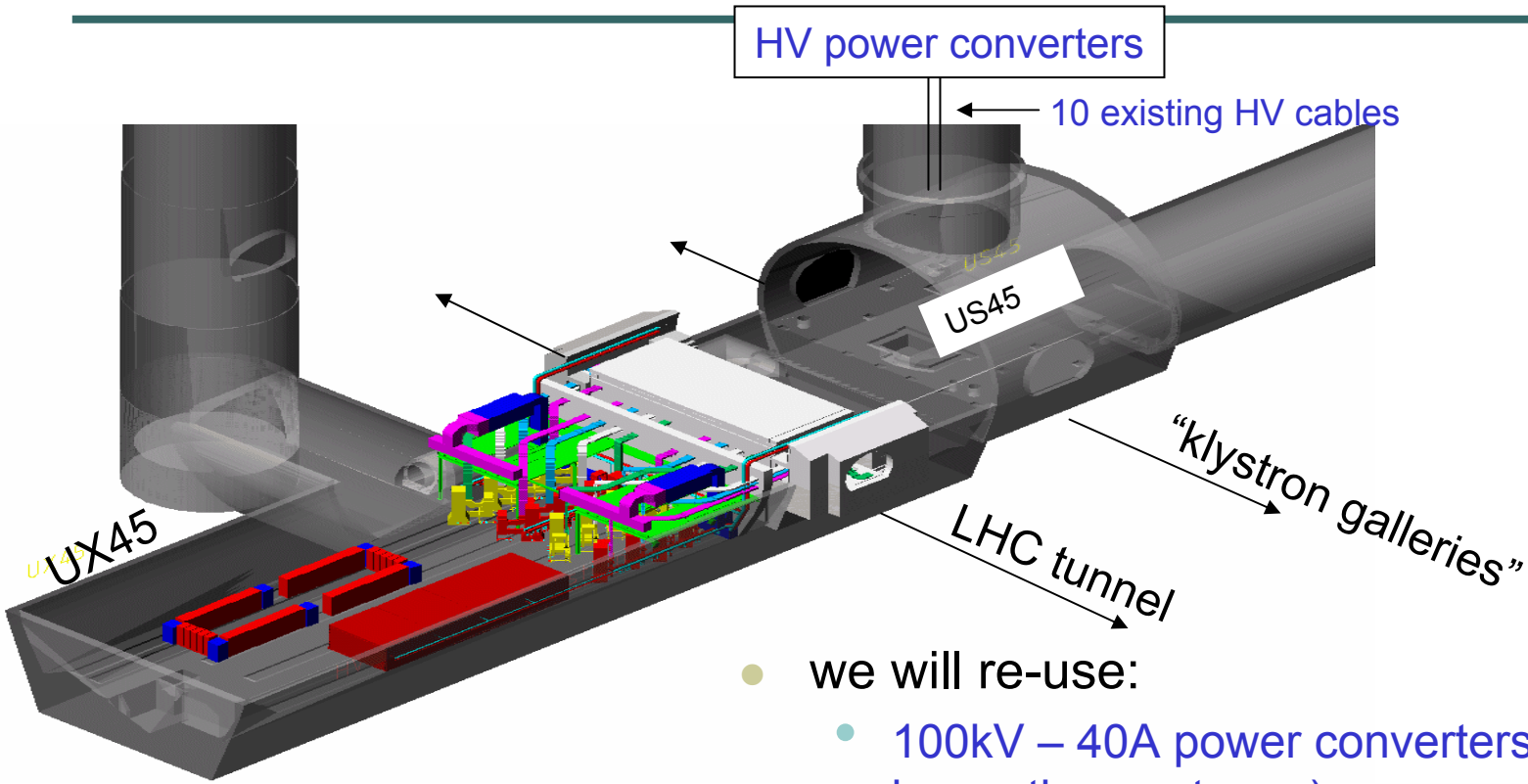
summary

- ..along the power line...
  - from the surface to UX45
  - HV bunkers & their equipment
  - klystrons, circulators
  - wave guide system

...status, integration,difficulties,...

- installation planning
- conclusions

from the surface to the tunnel

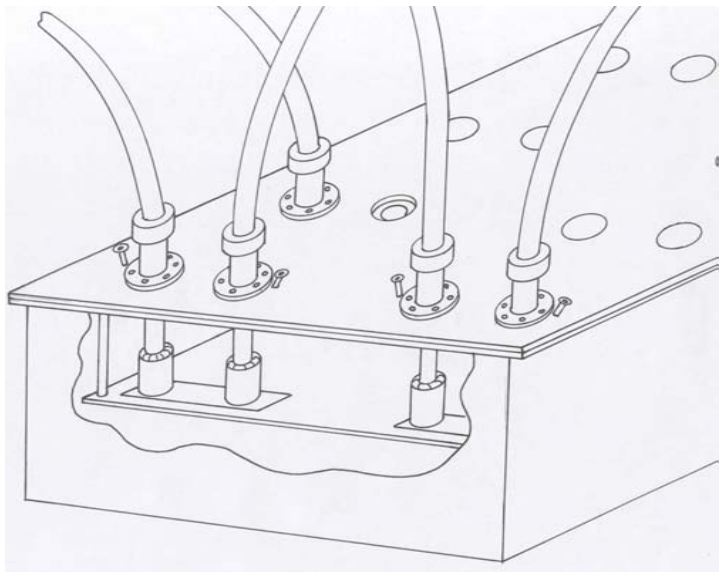


- we will re-use:
  - 100kV – 40A power converters (visual inspection next year)
  - high voltage cables
- HV junction boxes needed in US 45

HV junction boxes

- why?:
  - the idea is to avoid pulling new cables from the surface ➔ HV bunkers (UX45)
  - elegant, simple & cheap solution, based on modified LEP RF oil tanks
  - US45 ➔ UX45 (HV bunkers): 10 new cables to be pulled

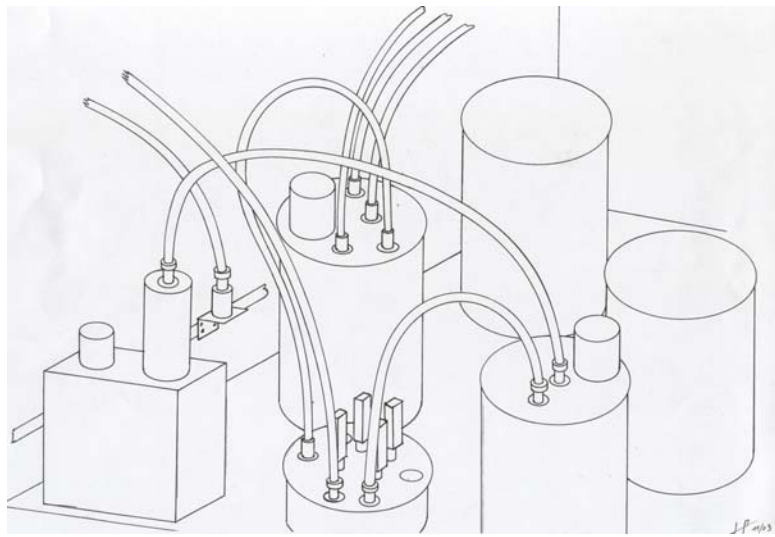
- status:
  - ✓ integration of junction boxes
  - getting TIS approval (under discussion)
  - new HV cables to be integrated



HV bunkers (UX45)

- HV bunkers
  - 4 HV bunkers to be built (end 2004)
    - 1one HV bunker per HV power supply (4 klystrons per p.s.)
  - equipment in modified LEP RF HV oil tanks
    - 4 modulators, 1 fast protection system, 1 HV commutator, 2 smoothing capacitors

- status
  - ✓integration
  - ✓TIS approval
  - to be built end of 2004



HV bunker equipment

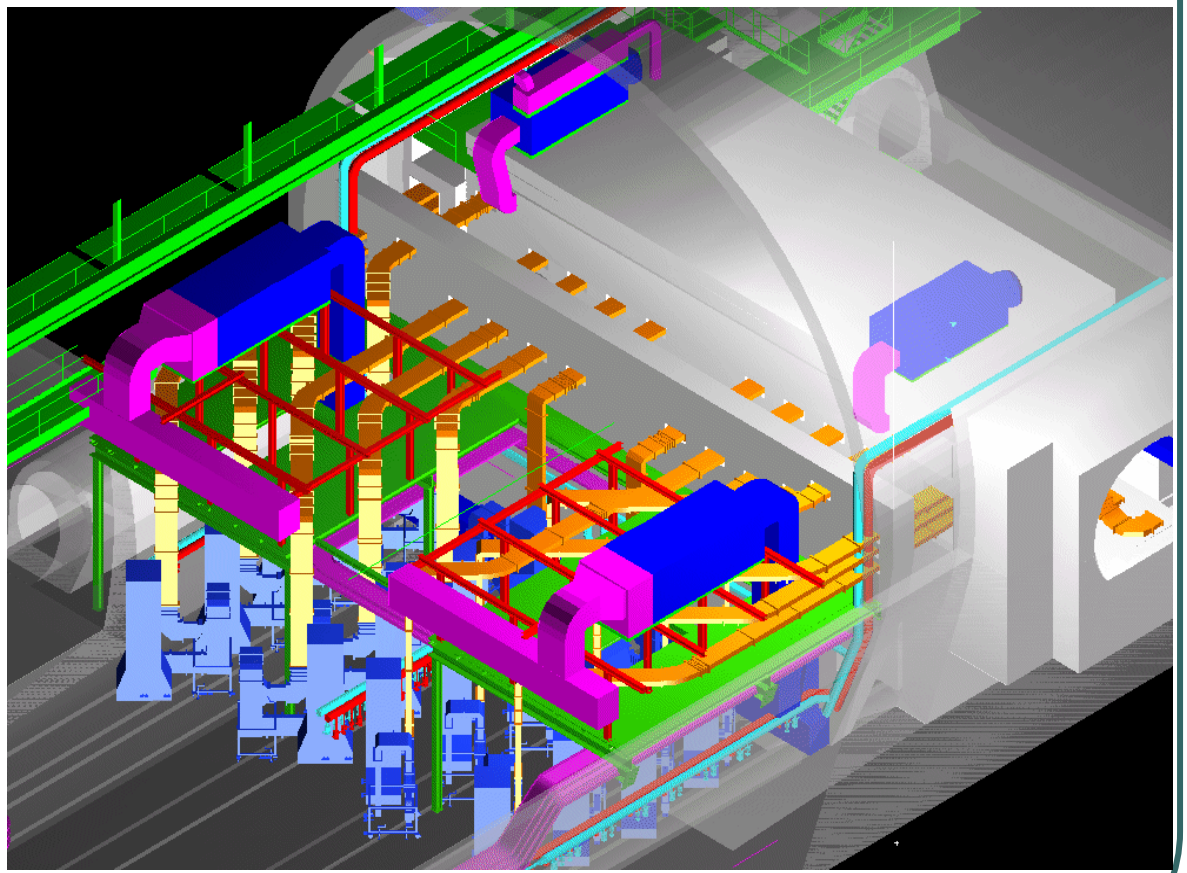
- what can not be seen at a first glance:
  - new equipment in the oil tanks!
  - efforts were made to improve performance, reliability & diagnostic:
    - remote controlled HV commutator
    - klystron modulators: new optical fiber system for tetrode control
    - crowbar: new fast spike detection system
  - silicon oil instead of mineral oil:
    - less safety constraints (no expensive fire protection systems)
    - less maintenance work

HV bunker equipment – status

- prototypes:
  - all prototype built, tested and validated in klystron test stand
  - specific tests to be made in SM18 test stand with klystrons in parallel
- “series” production:
  - HV equipment developed & built at CERN
    - production has started
  - ordering of sensitive/expensive components:
    - 9 tetrodes to be ordered next year
    - 3 thyratrons to come in 2004-2005
    - all fully equipped HV cables at CERN at the end of 2003

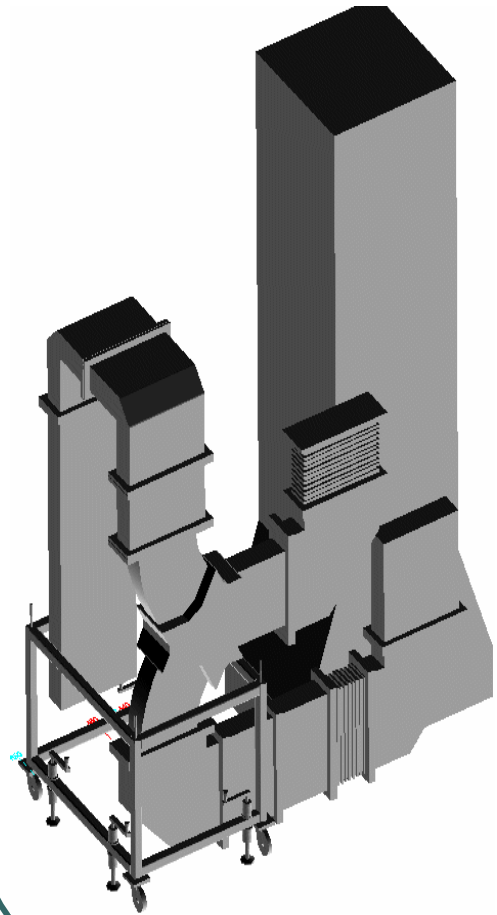
UX45 – RF power zone

- integration done by RF group:
  - shielding wall
  - platforms
  - HV bunkers
  - electronic racks
  - water cooling distribution
  - HV earthing system
  - control system
  - wave guides, incl. wave guide supports
  - ventilation
  - cabling: cable trays, RF cables, HV cables, etc



❖ very crowded area!!! still lots of problems to be solved...

klystron, circulator & load chassis



- independent & compact:
  - klystron (vertical)
  - circulator & load (modified LEP circ)
- “plug & play” chassis:
  - fully cabled and equipped, including:
    - control system
    - air/water cooling equipment, ionic pump PS, ...
  - only few connection with the external world
    - most of tests (and work!) done prior to installation
    - less installation work
    - higher reliability
    - “easier” replacement in case of problem
- tested in B112 & SM18 tests stand

the LHC klystrons

- 330kW CW klystrons:
  - built by Thales
    - 20 klystrons ordered (2001)
    - 6 klystrons already tested and accepted at CERN
    - delivery schedule: 1 klystron / 2 months
      - all klystrons at CERN – Summer 2005
- Critical parameters:
  - ✓ short group delay < 150ns
    - crucial for control loops
  - ✓ klystron cavity 1, 2 and 4 frequencies must be the same for all klystron
    - very important for low level system (high gain loops)
- Klystron equipment:
  - ionic pump, focus p.s., RF drivers, water cooling syst.:
    - modified LEP equipment (big savings)
    - old equipment: gradual replacement program to be implemented
  - power meters, arc detectors, etc
    - new design to improve reliability

circulators and loads

- 330kW ferrite junction circulators and loads
  - manufacturer: AFT (Germany)
  - 18 circulators and loads ordered
    - prototype tested and accepted at CERN
    - next delivery: November 2003
      - few months late compare to schedule due to a modification of load design (water leak inside WG after shockwave)
      - next load will be intensively tested
      - investigating protections against shockwaves in water cooling system
    - all circ & load at CERN mid-2004
- preparation of chassis ongoing (at CERN)

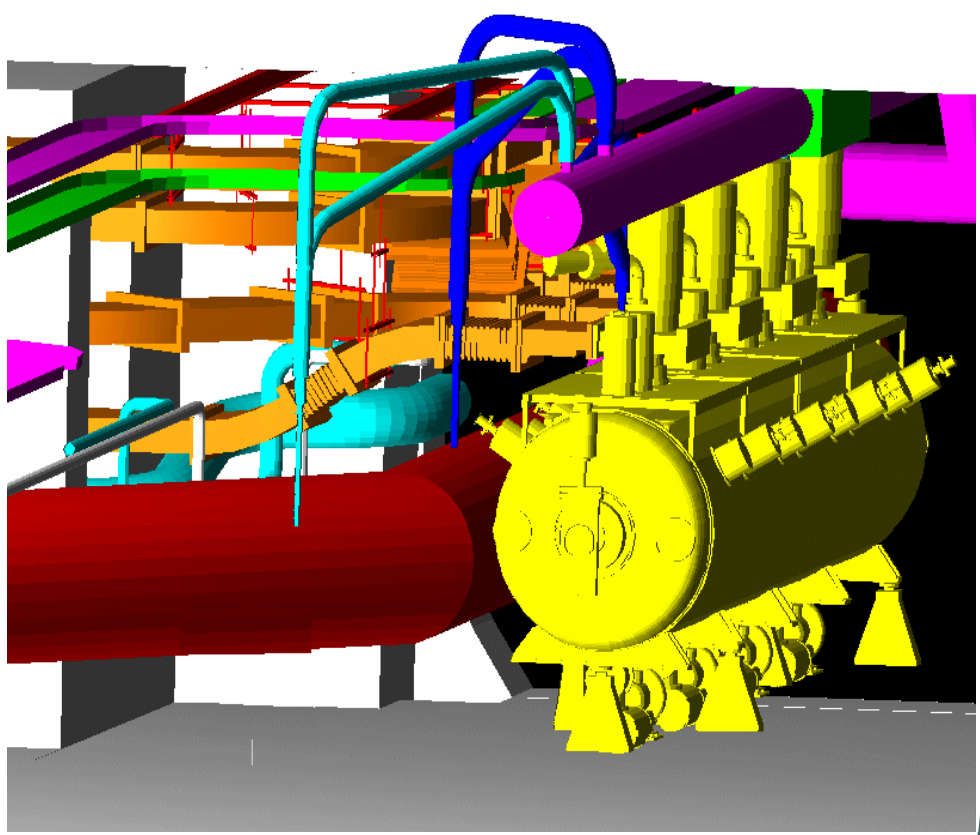
power control system

- The LHC RF control systems is based on Programmable Logic Controllers (PLC) with remote i/o:
  - distributed as close as possible to the signal sources
    - minimize the number & length of cables - less installation work
    - improve the signal quality – higher reliability
    - integration of controls part difficult (klystron & cavity)

      ➔ fine tuning of integration needed
  - big efforts made to improve reliability & diagnostic: new interlock system, ...
  - first versions of PLC & RF specialist software are used in the test stands

wave guide system

- 1 klystron per cavity:
  - re-use LEP half height wave guide
    - storage is an issue!
  - efforts made to minimize the number of bends, avoid chicanes,..., susceptible to trap higher order modes (risk of arcing)
  - critical areas above “external” modules where installation will be extremely difficult
    - to be checked out very carefully



installation planning in UX45

- civil engineering: ➔ second half 2004
  - shielding wall
  - platform
  - HV bunkers
- RF services: ➔ March – October 2005
  - electronic racks
  - water cooling distribution
  - klystron & HV bunker earthing system
  - ventilation
  - cabling: cable trays, RF cables, HV cables, etc
- RF equipment: ➔ October 2005 – March 2006 !!!
  - HV bunker equipment
  - klystrons, circulators
  - waveguides
  - control system

conclusions (1)

- technical work is going ok
  - no major problem with HV equipment
    - specific tests still to be done in SM18
  - 6/20 klystrons tested & accepted at CERN
    - delivery schedule: 1klystron every 2 months
  - first circulator & load tested & accepted
    - spring 2004: all 16 circulators & load at CERN
  - control system
    - intensive tests in SM18
- integration in UX45
  - civil engineering
    - ✓ shielding wall, HV bunkers
    - platforms to be designed & integrated

conclusions (2)

- cabling
  - HV cabling, RF & control cabling:
    - integration in progress, cable trays defined
    - new HV cables to be integrated (US45-UX45)
- water cooling
  - fairly well advanced: some details to be discussed with ST/CV
    - re using LEP RF equipment – large savings
- waveguide system
  - UX45: well defined
  - big difficulties near the “external” modules!!!