# LHC-RF Spares Policy

T. Linnecar for the RF team

Collation of detailed information contributed by:

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# RF Systems

- **400 MHz System – ACS**
  - SC cavity modules
  - High power RF
- **Transverse Damping System – ADT**
  - Kickers
  - Amplifiers
- **Wideband Monitors - APWL**
- **Slow Controls and Interlocks**
- **Beam control – ALL**

→ **Operation and maintenance policy**
→ **Critical items**
→ **Identification/cost missing spares**

| Risk: | |
|---|---|
| High | **H** |
| Medium | **M** |
| Low | **L** |
| Very Low | **VL** |

Missing:
(xkCHF)

"Consequences of RF system failures during LHC beam commissioning"

Chamonix XIV, p138

2 main conclusions: →

1) Loss of power to up to two cavities can be accommodated when beam is present provided intensity per bunch is < ½ nominal for 25 ns beam and < nominal for 75 ns beam.
2) Beam intensities up to ½ nominal can be injected into a machine with up to 4 cavities (1 cryogenic module) inactive

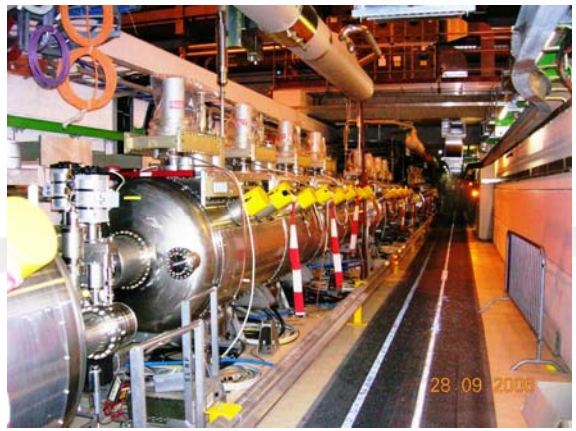
Corollary:

- Each installed cavity must have a complete perfectly working chain for intensities > ½ nominal

# A) 400 MHz system - ACS - modules

- SC cavity modules: 4 modules, 2 per beam, each module 4 cavities – 1 complete spare module available beginning 2008
  - Loss of 1 module requiring removal from ring **M**
    - replace with spare – 2 to 4 weeks , or
    - work with 1+2 modules, replacing missing module with vacuum pipes, 2 weeks to make
  - Loss of 2 modules **L**
    - replace 1 with spare, other with vacuum pipes, or
    - if on different beams work with 1+1 modules, replacing vacuum pipes
  - Loss of 3 modules **VL**
    - replace 1 with spare, others with vacuum pipes and work with 1+1 modules
- Consequence of working with one module, 4 cavities, per beam

  – lower luminosity and beam lifetime in coast, (at significantly lower intensities than nominal could work with lower emittance and push voltage on cavities).



- ACS module repair – note: clean-room work etc. in SM18
  - 1 complete spare cavity unit exists – SM18 (tests) **L**
  - Contamination of cavities in module **M**
    - Manufacture 2 more cavities – produces spares but more importantly

    Transfer of expertise on coating, rinsing ,cleaning of SC cavities in case of contamination etc.

    (NB experience in LEP where cavity was contaminated and had to be removed and treated)

    Cost over three years – **250kCHF**

- Power couplers **M**
  - end 2007 total 25 complete couplers → 20 installed on five modules, 5 spare
  - end 2008 plus 8 complete couplers → 16 spare couplers for 16 operational (in ctc)
  - Repair on surface (SM18)
  - time to replace faulty coupler (clean room) 1 week plus ~ 4 weeks coupler and cavity conditioning

Other smaller items

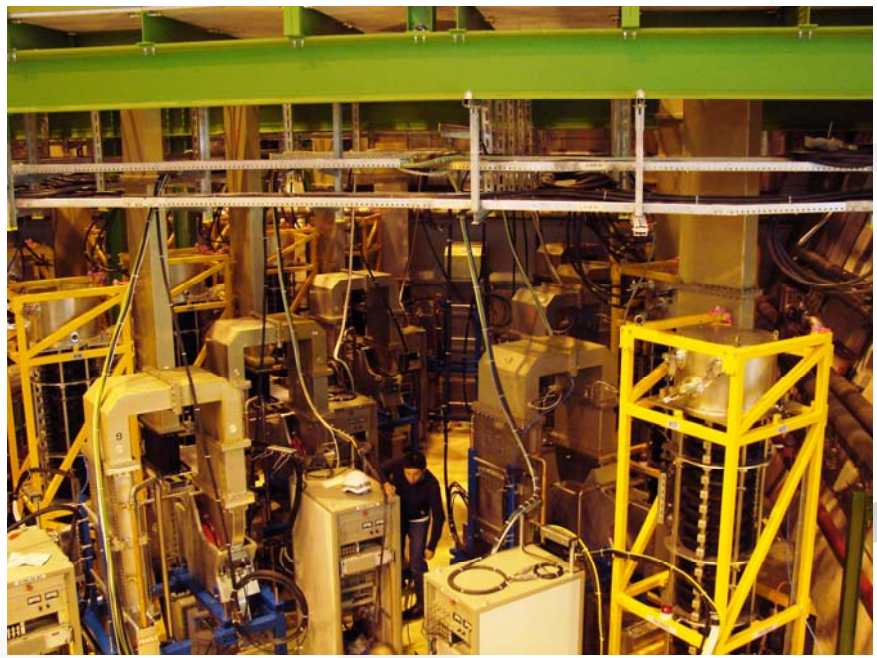
- HOMS – 7 pieces each types A and B — **L**
  - Replacement on surface (SM18)
- Tuner system – spare parts to be bought (20kCHF) — **M**
  - Repair in tunnel – 3 days
- Rupture disks – 5 spares – more to be bought (10kCHF) — **M**
  - Repair in tunnel – 1day plus cool-down, 1 week
- Other cryogenic items (3kCHF) — **H**
- Temperature measurement system (30kCHF) — **M**
- Penning gauge spares (main couplers) (12kCHF) — **H**

- **Have spare parts for all elements – need to increase number – 75kCHF**

# B) RF power - ACS– Large components

- Klystrons – recurrent replacement in the future– unknown lifetime **H**
  - 16 needed, 4 spares at CERN (1 used for coupler conditioning, 1 for tests in SM18)
  - Assume 30khrs lifetime: (if necessary change policy according to experience)
    - Order 2 in 2007, pay in 2008-2009 (440k€)(Thales cheapest)
    - 1 new klystron in 2010, 3 repairs 2008-2012 (220+x% k€ +340k€)
  - FC document for spares and repairs accepted (1 M€/5 years)
  - Replacement 1 day – spare in UX45

- Circulators and RF loads – 16 installed **H**
  - 2 spares of each exist (SM18, B112) - insufficient
  - FC document accepted for extra spares
  - 2 circulators + 2 ferrite disks + 2 loads to be ordered – 2008, 2009 (242kCHF)
  - Replacement 1 day – spare in UX45



- HV cables – surface to HV bunkers – 10 installed, 8 used **L**
  - 2 spares, to be tested
  - 2000m spare cable AB/PO
  - Replacement 1 week
- HV cables – HV bunkers to klystrons – 48 installed **L**
  - 3 spares (to be installed when necessary)
  - 2 spares to buy (30kCHF)
- Power converters – see talk of Freddy Bordry

## Other items where spares need completing

| Item | Sub-item | No. installed | Spares existing | Time to repair (days) | Spares to complete | Total Cost kCHF | Risk |
|---|---|---|---|---|---|---|---|
| Modulators | | 16 | 4 | 1 (spareUX45) | 0 | | **M** |
| | Tetrodes | | 15 | 1 | 0 | R(ecurrent) | **H** |
| Crowbar | | 4 | 4 | 1 | 0 | | **H** |
| | Thyratrons | | 2 | 1 | 2 | 100 (+R) | **M** |
| | Capacitors | | 2 | 1 | 2 | 30 | **M** |
| RF drivers (LEP) | | 16 | 1 + many parts | 0.5 | * | | **M** |
| Focus power supplies | | 16 | 2 | 0.5 | 2 | 30 | **H** |
| Arc detectors | Electronics/fibers | 80 | 10/20 | 0.5 | 10/50 | 10 | **H** |
| | | | | | | | |
| Other items to complete spares | Modulator components, DCCT, oil circulators, optical fibres,blowers, air pressure measurement etc. | | To be completed | | | 17+12+5+ 5+10+2+1 0+2+5+5+ 15+17 =105 | **M** |
| TOTAL (small items) | | | | | | 275kCHF | |

* Replacement programme needed - consolidation next 3 years

# C) Transverse damper - ADT

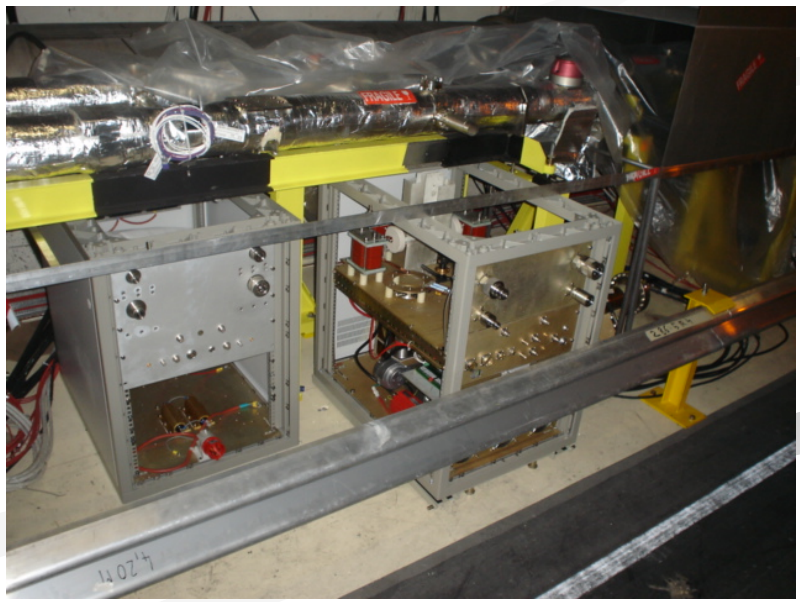
- 4 independent systems, one per plane and per ring. **L**

  Each system 2 modules of 2 kickers.

  (4 vertical modules and 4 horizontal modules)

  - 2 complete modules in reserve, 1 horizontal, 1 vertical -1 week to replace
  - Delicate parts:
    - Main feedthrough: 32 installed, 12 spares
    - HOM feedthrough: 32 installed, 12 spares

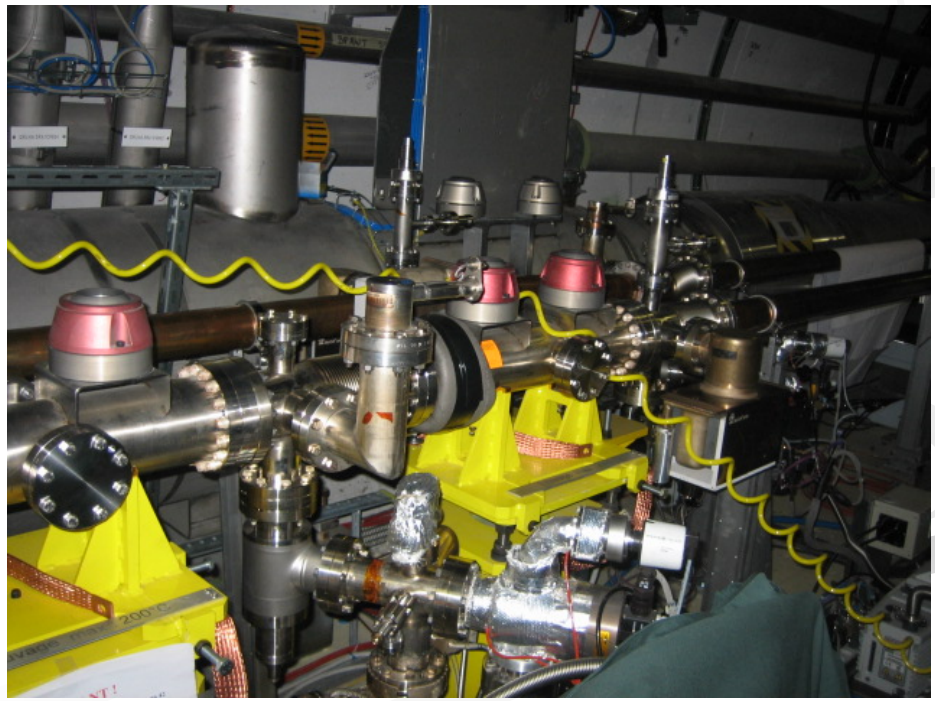
- Each individual kicker has its own amplifier unit with 2 tetrodes **M**
  - 16 units installed: 4 complete spares, < 0.5 day to change
  - Driver amplifiers: 8 spares
  - Delicate items with minimal spares: (97 kCHF)
    - High power resistors, HV capacitors, flexible hoses, Ug1 and Ug2 power supplies



# D) Wideband longitudinal monitors - APWL

- 6 monitors installed in LHC, 3 per beam. 3 spare **M**
  - Spare ferrites at 30% level
  - **Weak point** – vacuum feedthroughs – 48 installed, 8 spares **M**

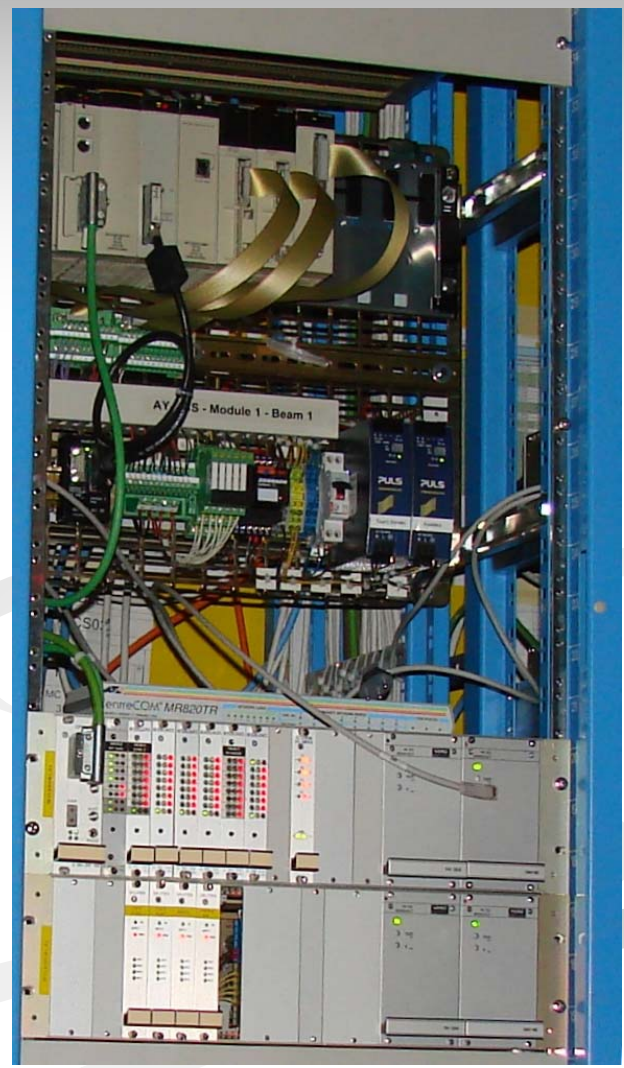
    New design required – very high priority (80 kCHF)



# E) Slow controls and interlocks

- PLC chassis **L**
  - ADT – 8 installed, 2 spares
  - ACS – 20 installed, 2 spares
  - 3 spares needed (10 kCHF)
- Interlock cards - 220 installed
  - 56 spares
- Fieldbus CPU - 40 installed
  - 6 spares – 5 to be acquired (10 kCHF)
- Other small items (10 kCHF)

- Good situation for spares: (30 kCHF) needed to complete



# F) Beam control - ALL

- VME crates, 50 installed **L**
  - 10 spares complete crates used in lab. for development.
  - Active parts
    - VME power supply: 50 installed, 15 spare
    - Backplane: 50 installed, 10 spare
- VME modules, ~ 300 installed **M**
  - For modules where 1 per cavity - 16 installed, 9 spares
  - For modules where 2 per cavity - 32 installed, 12 spares
- NIM crates, 10 installed **L**
  - 10 spares
- NIM modules, 50 installed **M**
  - 25% spares
- Special components **M**
  - FPGAs, ADC, DAC – availability typically 6 years

    Should build up minimum stock of these components (120 kCHF)

    (Maybe synergy with other groups)

# G) Personnel

- No spares

# Summary

- **No immediate danger but an effort must be made in 2008 – 2010 (Recurrent are/will be on operation budget)**

- Klystrons, circulators and loads – build up safe situation **900 kCHF**
  - Money needed in 2008 - 2009

- ACS system – SC modules and High Power (**M+H**)
  - Money needed in 2008 – 2010 380 kCHF
- ADT system – Amplifiers (**M+H**)
  - Money needed in 2008 – 2010 97 kCHF
- APWL system – Feedthroughs (**M+H**)
  - Money needed in 2008 80 kCHF
- ALL plus slow controls and interlocks (**M+H**)
  - Money needed in 2008 – 2010 150 kCHF

TOTAL (**M+H**) in 2008-2009 **707 kCHF**

- Also highly recommended 2008-2010
  - Manufacture of 2 400 MHz cavities **250 kCHF**

# Financing

- Klystrons, circulators and loads
  - The proposed LHC operations budget already includes 345kCHF for the regular acquisition of klystrons, circulators and loads. **But** latest prices indicate an increase of 50% for the klystrons and ~10% for the circulators, loads. **Consequently the sum allocated to the LHC operation budget for klystrons etc. should be increased to 450kCHF/year**.
- Other items
  - The 700kCHF for the other items can be funded from 3 years of operation budget.
- Spare cavities
  - The 250kCHF for the new cavity could be a project @ 80kCHF/year for three years.