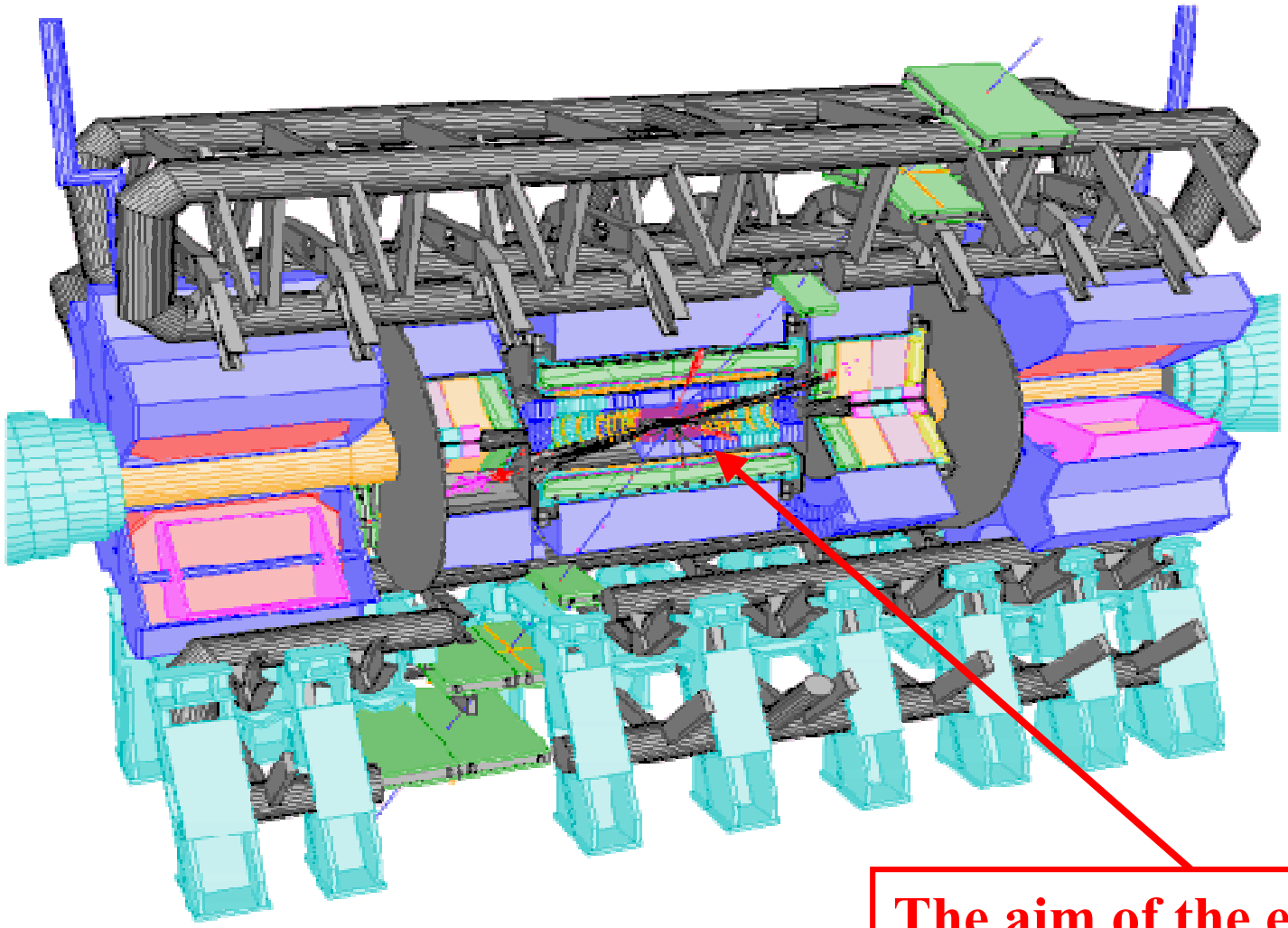
The users...



SL-OP

Mike Lamont

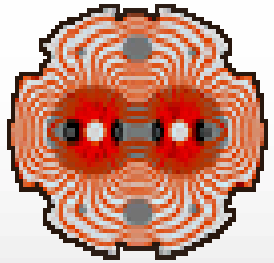
- Inject, accelerate & collide two high intensity proton beams
- With very minimal beam loss
- Maximise the delivered luminosity.

To do this...

"Give the Monkeys Windows"

Operating challenges

- **Super-conducting magnets**
  - multipoles, snap-back, persistent currents, key beam parameters affected.
  - high energy, high intensity beams, extremely low tolerance to beam loss, quench protection collimation mandatory at all times
- **Machine design**
  - 2 rings, 8 sectors, bits of the ring in common, cross-talk between the rings, small mechanical aperture, large energy swing ⇒ large range in magnets and power converters.
- **Beam dynamics**
  - Wide range of optics Beta* 18 m to 0.5 m
  - Dynamic aperture, crossing angle, beam-beam effects
  - Intra-beam scattering, synchrotron radiation, image currents, intra-beam scattering, instabilities, electron cloud, PACMAN bunches, ghost bunches.
  - Coupling, dispersion, beta beating … very tight orbit tolerances - stability for collimation… Tight tolerances on main beam parameters, E, Q, Q'



What do OP want?

- **Integrated measurements & control.** Threading, trajectory oscillations, steering, orbit from pilots , adjustment of TDI and collimators, matching, screens, measurement of optics parameters. Closed orbit of both rings, global & local correction etc. etc. Signals such as BCT, lifetimes, beam loss, luminosity, beam sizes. Measurements of tune & chromaticity. Measurements from the reference magnets
- **Control** Set and ramp: RF, power converters, kickers, dumps, collimators, etc.
- **Feedback** to provide stability of machine parameters, Track Q, Q', b5, energy during injection plateau.
- **Feed-forward** of magnet measurements and experience
- **Tools** Correlations, scans, Coupling between control and
  e.g. synchronised acquisitions. Tr fixed di
- **Data management** control of rar tings, history, rollback
- **Logging & post-mortem analys** ost-MD analysis and statistics
- **Diagnostics & cross-system co**
- **On-line optics model**
- **Timing & synchronization**

In your dreams buster

Beam Instrumentation

- Major system, intimately involved in all aspects of running the LHC with beam
- Integral part of the beam based control system, totally essential for the exploitation and protection of the LHC.
- Should have a defining role in the choice of any control system architecture

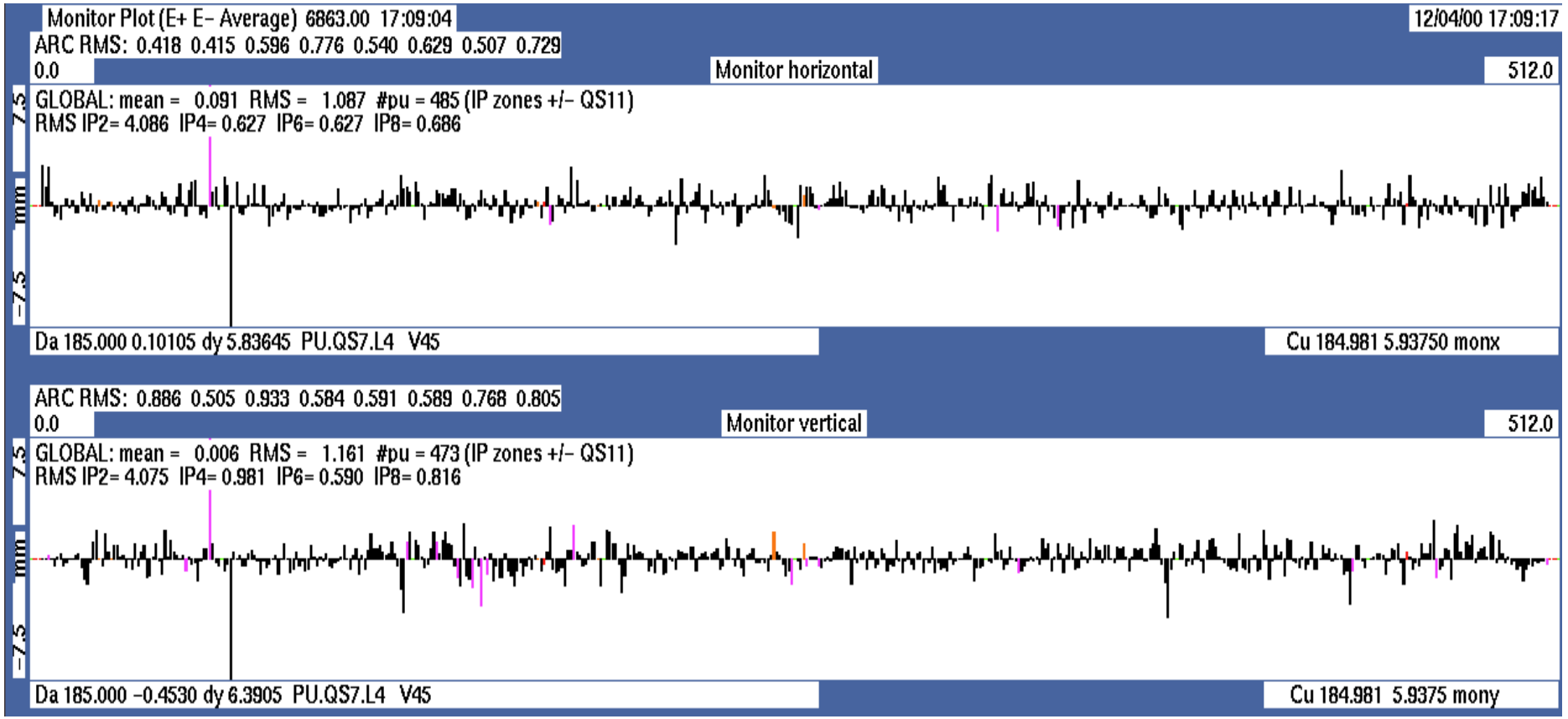
SL-BI

Hermann Schmickler

- Two classes of instrumentation: global & local
- The global systems e.g. orbit and beam loss will provide the main control challenges:-
  - Orbit: 10 Hz RT connection to PCR
  - BLMs: 100 Hz RT connection to PCR
- Local systems such as tune & chromaticity will be involved in RT feedback
- Proposed Architecture
  - VME
  - World FIP for RT
  - Ethernet for off-line retrieval & Post-mortem
- *Some talk of being involved in high-level development*

LEP Orbit

Maximum sampling frequency 0.067 Hz



LHC Orbit

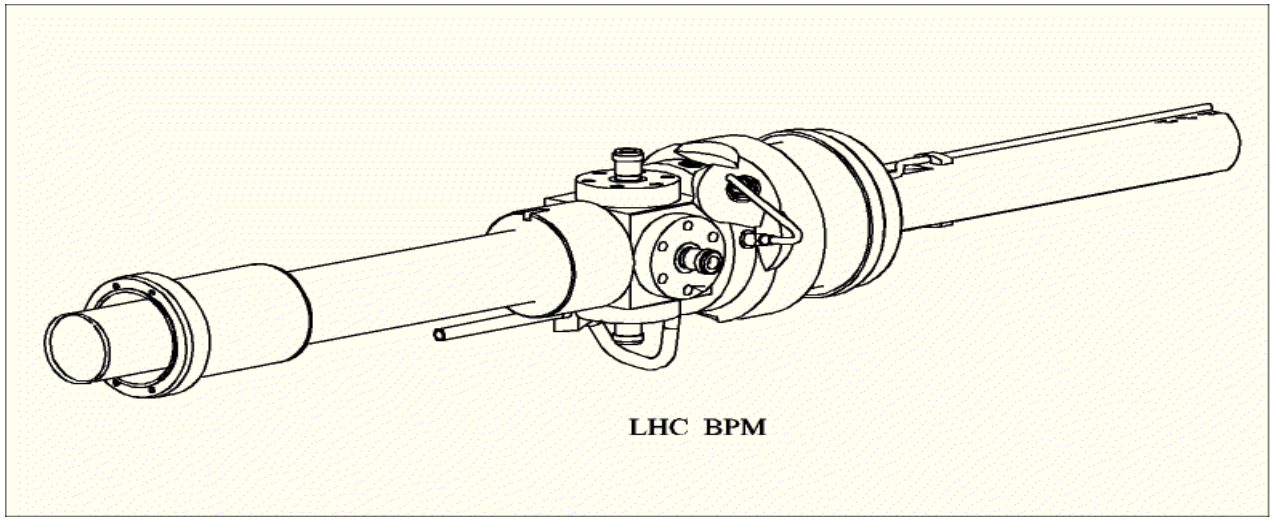
Proposed sampling frequency 10 Hz

SL-BI - Controls Issues

- Choice of front-end in tunnel (VME/processor?). Tight schedule for testing and use in TI8/TI2. Being investigated by SL-CO
- Choice of RT operating system
- Interconnections
- Radiation
- Connection to beam dump system?
- RT-control

The BI challenge

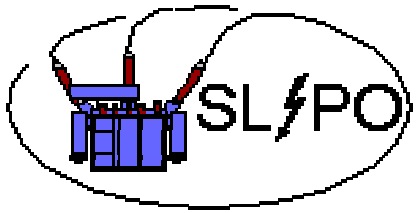
- **The LHC controls infrastructure (hardware and software) will have to be available in April 2004 for the commissioning of the TI8 line…**



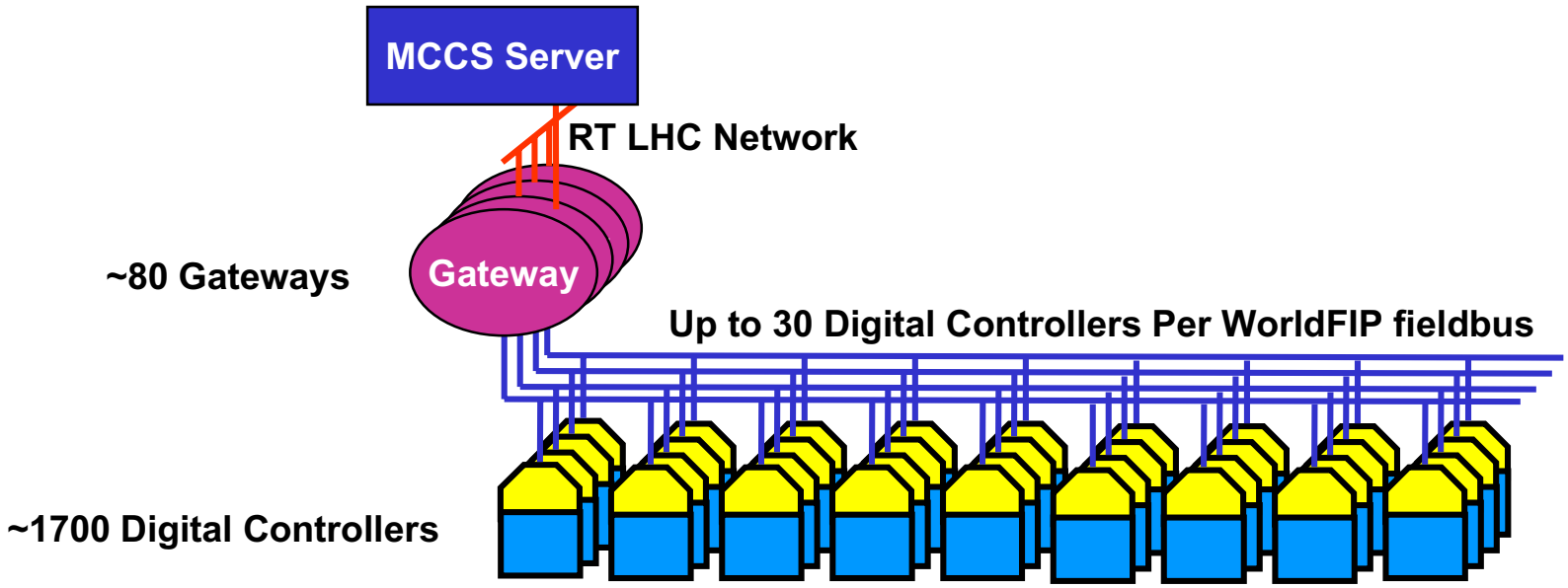
Power Converters

Quentin King

- Major system - all magnets - set, ramp, trim etc. etc. Offering RT control at 100 Hz (whether you need it or not!)
- Digital controllers:- CERN design, manufactured by industry. Prototypes for String II.
- Gateways:- standard SL-CO - Power PC running LynxOS
- Fieldbus: WorldFIP from CEGELEC
- Timing: via an IRIG-B receiver card



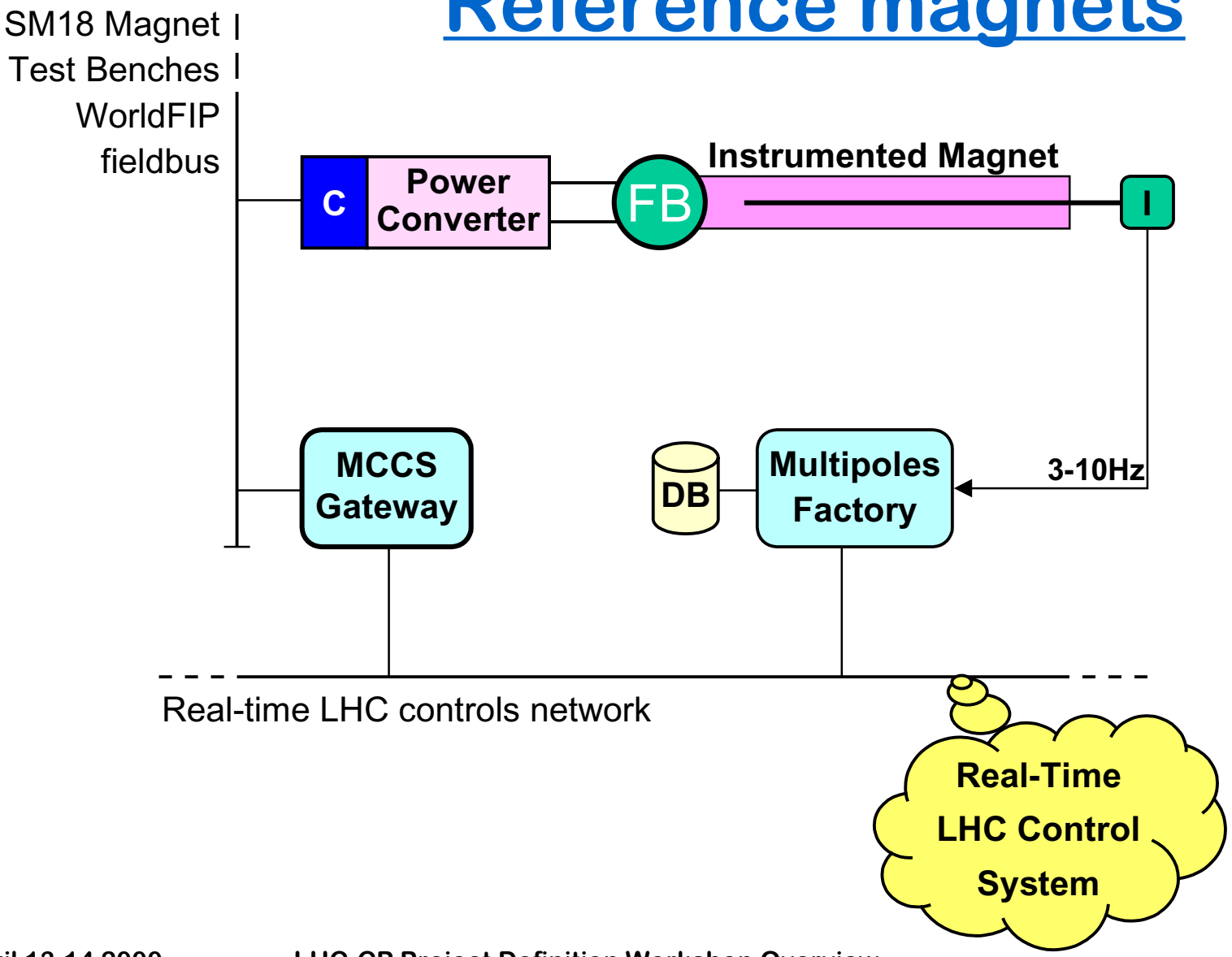
Magnet Current Control System (MCCS) Overview



Power converters - issues

- Event Timing
- Real Time Architecture
  - IP? ATM protocol? QOS?
- Real-time servers… integration into the rest of the control system. Middleware?
- Alarms, interlocks, logging, post-mortem

Reference magnets



Radio Frequency

Ed Ciapala, Andy Butterworth, Philippe Baudrenghien

- The “Low Level” RF control system needs to manage the synchronisation, frequency and phase of the cavities
- Schneider PLCs & FIP for things like power supplies & surveillance.
- Fast synchronization signals - SPS-LHC transfer.
- Mountain ranges, analog signals, time waveforms, high bandwidth remote acquisition
- Control of settings, functions…
- Fast feedback links…

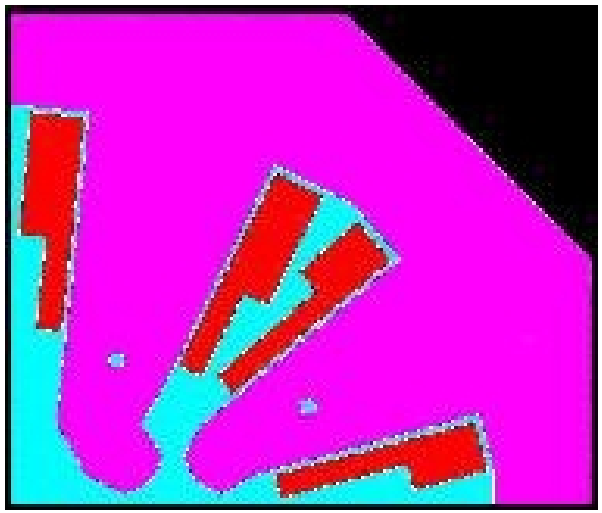
RF issues

- Synchronization (bunch to bunch) & ms.
- Complexity of configuring a large FIP system. Support.
- Alarms
- Logging & Post-mortem
- Ability to trigger beam dump
- All measurement and control programs must be available in klystron galleries IP4, SR4, PCR & BA3 FC.

SL-MS Warm magnets

Gijs de Rijk

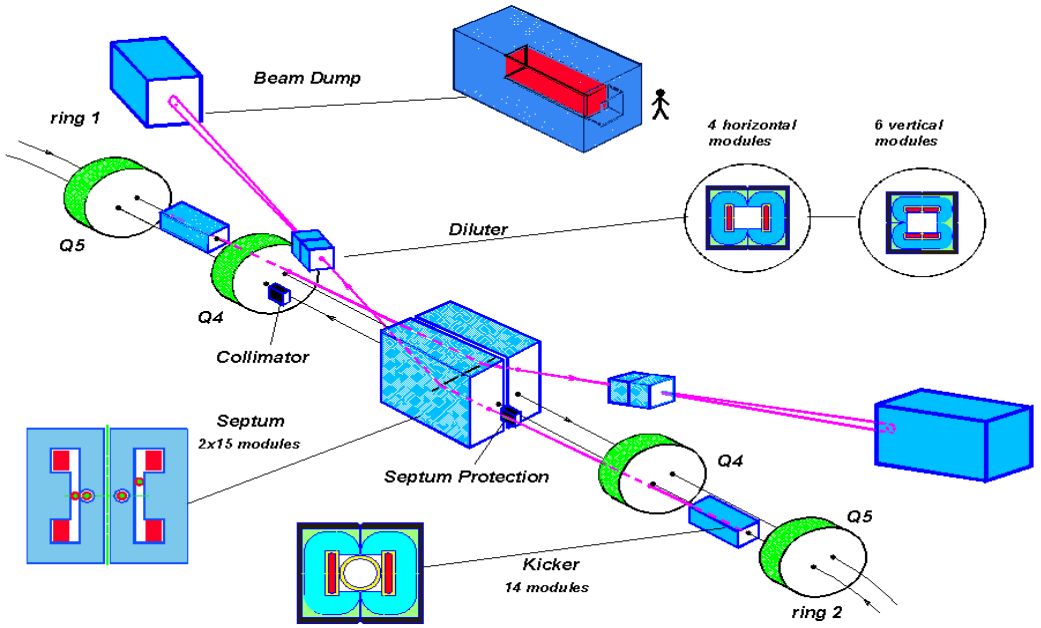
- Control as given by power converters
- Will use Siemens PLCs & Profibus for surveillance
- Reliability important for protection. (If a magnet fails the beam must dumped, injection prevented.)
- Interlocks
- Alarms



Beam Transfer

Etienne Carlier

- Kickers, Collimators, Beam Dump
- PLCs for slow controls
- VME/fieldbus for fast acquisition
- VXE, waveform acquisition, NAOS...



Beam Transfer - issues

- Synchronized acquisition of measurements
- Timing & synchronization
- Very,Very reliable external data required
  - energy, position of abort gap, revolution frequency
- INTERLOCKS
- Integration - middleware

SL-CO Timing (TIWG)

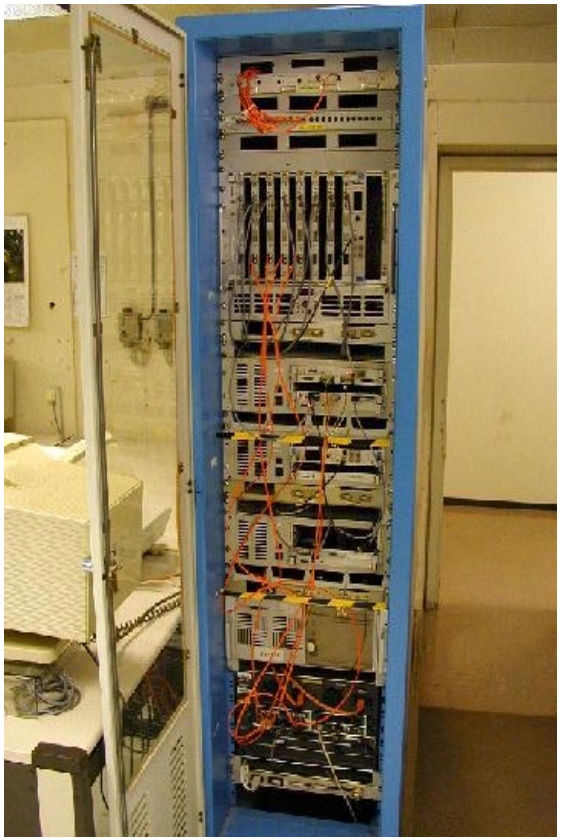
Michel Jonker was talking to Gary Beetham

- Slow timing - distribution of absolute time for timestamping…
  - GPS using IRIG-B in to octants and alcoves.
  - Possibly over worldFIP (Schneider)
- Slow timing - events
  - TG8 into pits,
  - Timing event distribution to the equipment in tunnels.
- "Beam Synchronous Timing is the responsibility of BI" (bunch to bunch synchronization of beam related actions)
- Fast timing (bunch and revolution frequencies - RF & kicker timing)

SL-CO-FE - Real Time

Michel Jonker was talking to Pedro Ribeiro & Thijs Wijnands

- Appears to be a clear need for RT control.
- Investigating RT architectures
  - Front-ends, Networks
  - Prototype
    - WorldFIP, FIP running LynxOS, ATM
    - SPS as test-bed
- What are the requirements?
- “Clear decisions & guidelines are needed..”



SL-CO - infrastructure (NM & WS)

Michel Jonker was talking to Pal Anderssen

- Communications & Interface WG
- Requirements collected
- Technical proposal to be released in July
- Industrial solutions - no in house products
  - fibre optics (also for RT)
  - IP/Ethernet
  - Gigabit Ethernet backbone
- Network architecture designed in house
- Technology lifetime is an issue

SL-CO Alarms

Michel Jonker was talking to Mark Tyrrell

- Alarm section mandated to provide Alarm system for LHC controls
- Integration of safety systems, SCADA (some of which have their own systems…)
- Currently working on design for CERN wide Alarm system - proposal soon.

Middleware

- Communication glue, software bus…
- Mandate for middleware for PS/SL as part of the convergence project for existing accelerators.
- Requirements
- Technology
- Next big milestone: operational version of running by December for use in EA and PS.
- Command-response & subscription
- (Looking at CORBA and MOM…)
- Anticipate interfacing to industrial system via OPC
- Data exchange issues are also being addressed by LDIWG.

Beam handling

- Beam Instrumentation
- Power converters
- Reference Magnets
- Beam Transfer
- Radio Frequency
- Resistive Magnets
- Operations
- Accelerator Physics
- *Controls (Alarms, Front Ends, Timing, Work Stations, Network Management, Applications)*
- *Working Groups (CIWG, DEWG, LDIWG, TIMWG, Middleware)*

Conclusions I

- Design of elements and their low-level control is well advanced.
- Similarly for the key beam instrumentation systems
- Equipment groups are waiting for:
  - the technical infrastructure that they will plug into (some decisions are already being taken)
  - the software & protocols that will link them to the high level
- Universally they need:
  - to connect to (an) interlock system
  - to connect to an alarm system
  - the use of a logging system, to feed into a post-mortem system
- Timing is, of course, important both for event, and absolute time, distribution. Some questions remain to be answered.

Conclusion II

- The requirements of the high-level system are for the large part numerable but have yet to be formally specified. Whether or not these requirements be met by the proposed solutions need to be verified.
- A novel aspect of the high-level requirements detailed so far is the need for real-time control. However the requirements of a real-time architecture have yet to be fully specified.
- Radiation is a major concern.
- Maintenance & support of any technical solution chosen is a concern.