LHC Controls Project

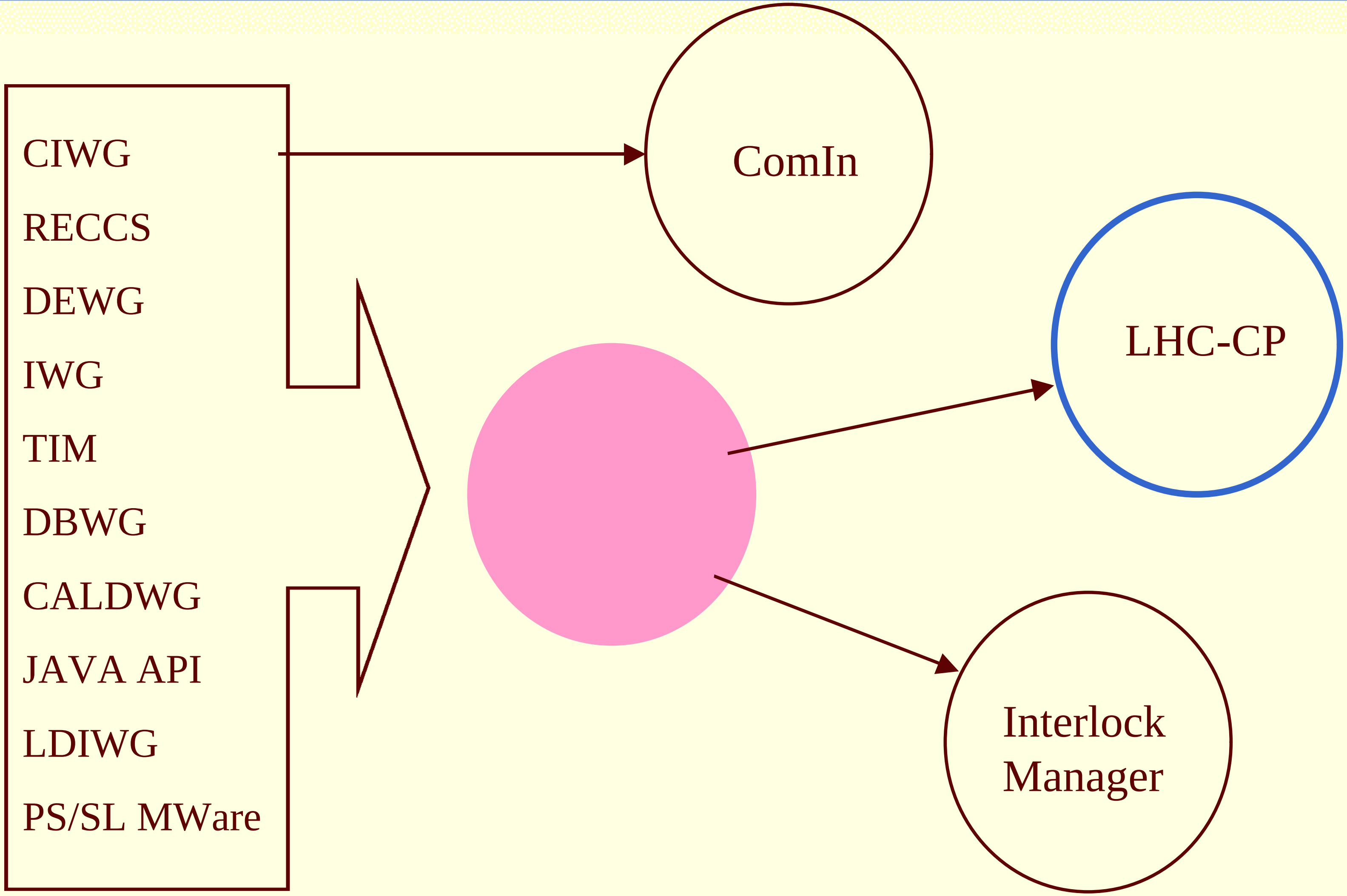
Summary of the 2nd LHC-CP Workshop

R. J. Lauckner

Outline

- Project Launch and Mandate
- People Involved and Activities
- Workshop Programme
- Controls Progress and the Issues
- Conclusions

Launch


CIWG
RECCS
DEWG
IWG
TIM
DBWG
CALDWG
JAVA API
LDIWG
PS/SL MWare
ComIn
LHC-CP
Interlock Manager

Mandate

LHC Commissioning Committee

LHC-CP

SPS and LHC Technical Committee

LHC Technical Coordination Committee

Mandate

- Efficient Use of Resources
- Consistent Technical Choices
- Meet Operational Requirements

Activities

- Requirements Analysis
- Architecture
- Services e.g. alarms, data management
- Guidelines
- Planning

People

Groups and Link People from SL

AP	Elena Wildner - Accelerator Physics, Database
BI	Jean-Jacques Gras - Monitors, Collimators
BT	Etienne Carlier - Kickers, Dumps
CO	Alastair Bland - Controls Infrastructure
HRF	Edmond Ciapala - RF, Damper ...
MR	Ronny Billen - Data Management
MS	Giusepi Mugnai - Warm Magnets
OP	Mike Lamont - Operations and Software
PO	Quentin King - Converters, Feedback

People

Groups and Link People from LHC

ACR	Philippe Gayet - Controls and Cryogenics
ECR	Marco Pezzetti - Cryogenics
IAS	Jacky Brahy - SCADA, PLC, Fieldbus
ICP	Felix Rodriguez Mateus - Quench Protection
MMS	Rob Wolf - Cryomagnets
MTA	Louis Walckiers - Magnet errors, multipole factory
VAC	Richard Gavaggio - Vacuum

People

Groups and Link People from other Divisions

EST/ISS	Pedro Martel - Production Data
PS/CO	Frank Di Maio - Injectors
ST	Peter Sollander - Technical Infrastructure, Alarms

People

Other Players

Rüdiger Schmidt - Machine Protection, Guru Work
Axel Daneels - Planning
Nicole Boimond - Administrative Support

Core Team

Philippe Gayet, Mike Lamont, Robin Lauckner,
Mark Vanden Eynden

Working Groups and Projects

LHC-CP

- LAWG ▶ use case, architecture
  - Real Time WG ▶ beam control, feedback
- Alarms ▶ general alarm service
- Components ▶ industrial system architecture
- *Database Committee*
- *Post Mortem*

} *Coming soon*

Future Front Ends ▶ backplane, architecture

Controls Middleware ▶ distributed control

Timing Working Group ▶ Fast / slow timing and timestamps

Programme

Thursday 5th April, 2001

Morning Session

Chair: M. Vanden Eynden

• 08:45	Welcome	*Ph. Lebrun*
• 08:50	Aims of Workshop	*R. Lauckner*
• 09:00	Progress with the Middleware	*A. Risso*
• 09:30	Alarm Sub-Project	*F. Calderini*
• 10:00	LAWG Sub-Project	*M. Lamont*
• 10:30	*Coffee*	
• 10:50	String 2 Controls	*R. Saban*
• 11:20	Project Planning	*A. Daneels*
• 11:50	LHC Timing System and Time Stamping	*G. Beetham*

Programme

Thursday 5th April, 2001

Afternoon Sessions (14:00 – 17:00)

• 14:00	Databases	40-R-C10	R.Billen
• 14:00	Architecture	40-SS-C01	P.Charrue
• 14:00	Hardware Sharing	40-R-B10	E.Ciapala

Programme

Friday 6th April, 2001

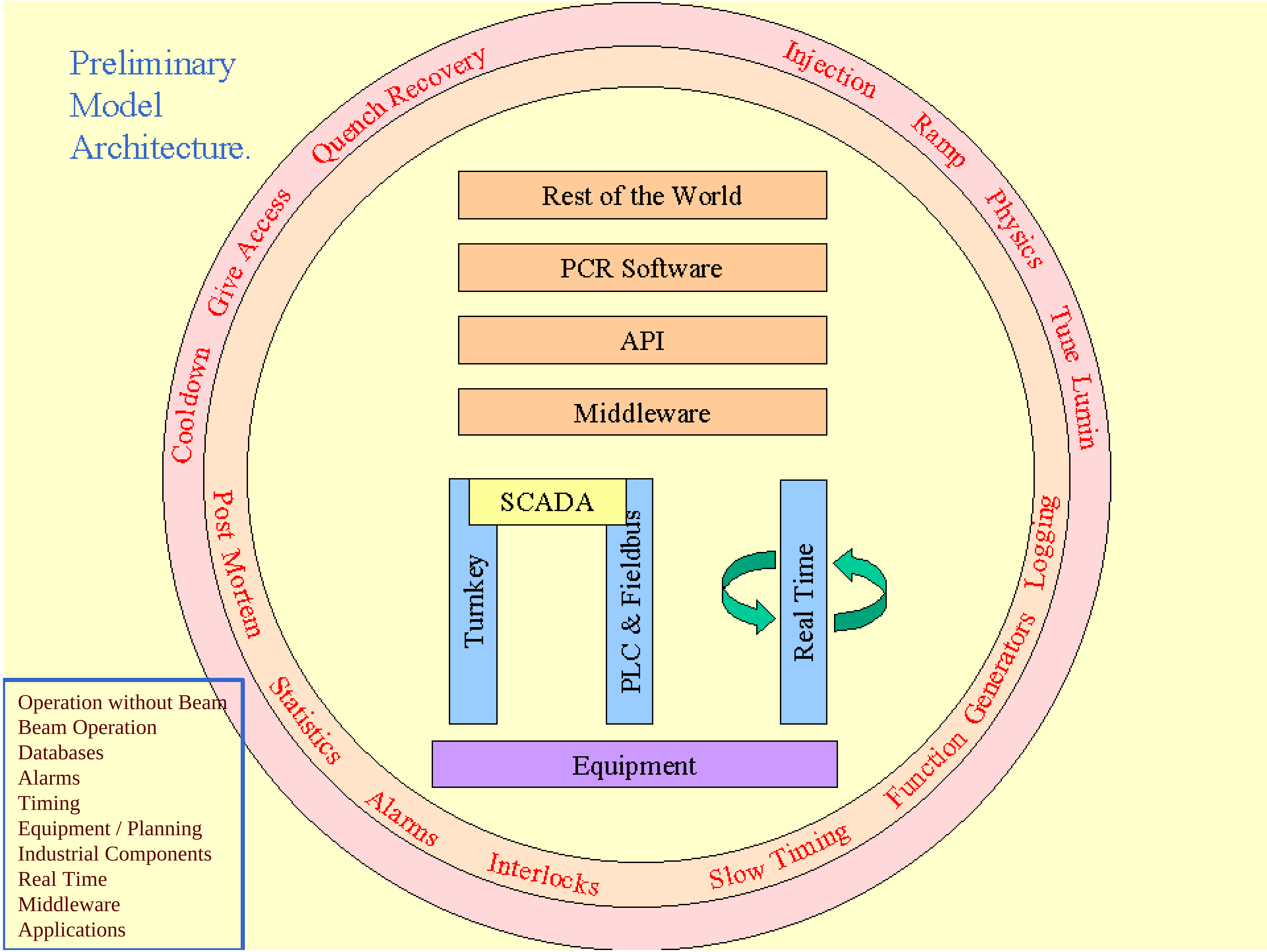
Morning Session

Chair: Ph. Gayet

- **09:00 Report from CERN Fieldbus WG G. Baribaud**
- **09:30 Report from CERN SCADA WG W. Salter**
- **10:00 Report from Database Session R. Billen**

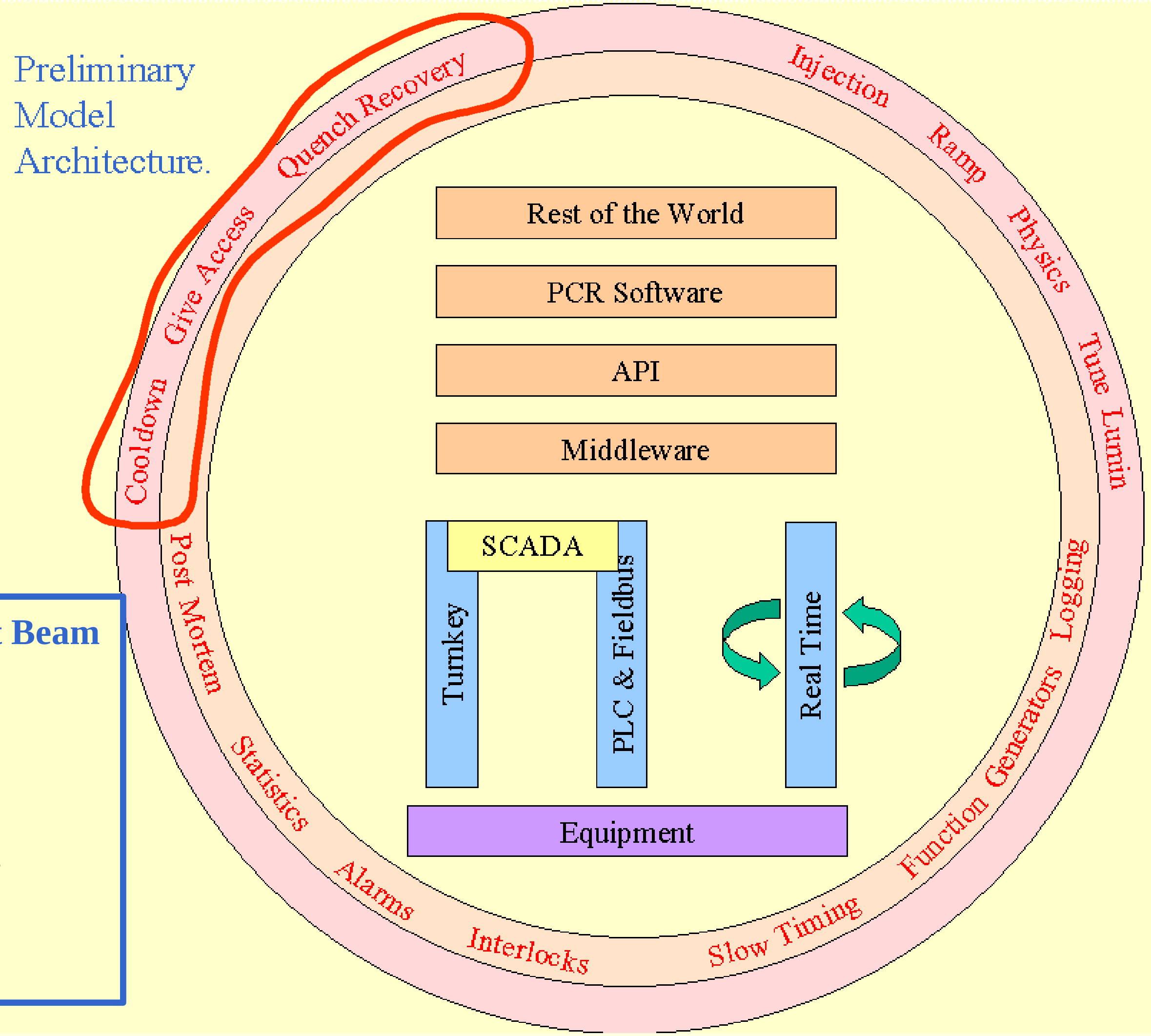
- **10:30 Coffee**

- **11:00 Report from Hardware Sharing Session E. Ciapala**
- **11:30 Report from Architecture Session P. Charrue**
- **12:00 Conclusions R. Lauckner**
-



Preliminary
Model
Architecture.
Injection
Ramp
Physics
Tune
Lumin
Logging
Function Generators
Slow Timing
Interlocks
Alarms
Statistics
Post Mortem
Cooldown
Give Access
Quench Recovery
Rest of the World
PCR Software
API
Middleware
SCADA
Turnkey
PLC & Fieldbus
Real Time
Equipment
Operation without Beam
Beam Operation
Databases
Alarms
Timing
Equipment / Planning
Industrial Components
Real Time
Middleware
Applications

Operation without Beam



Operation without Beam
- Beam Operation
- Databases
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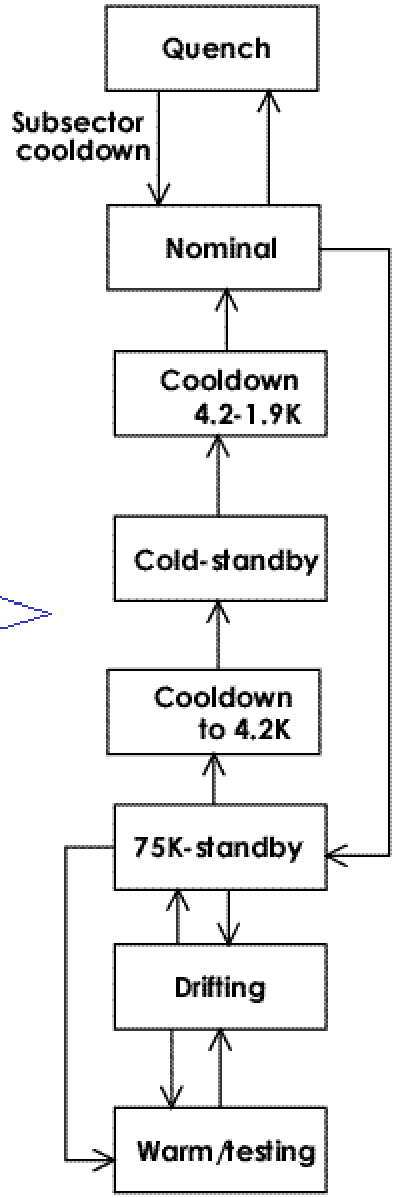
Responsibilities - CCR

- Drive cryogenics system:
- Cool down - standard sequence
- Green light for powering
- Quench recovery
- Green light for powering after quench
- On-line monitoring
- Monitoring vacuum
- Warm up



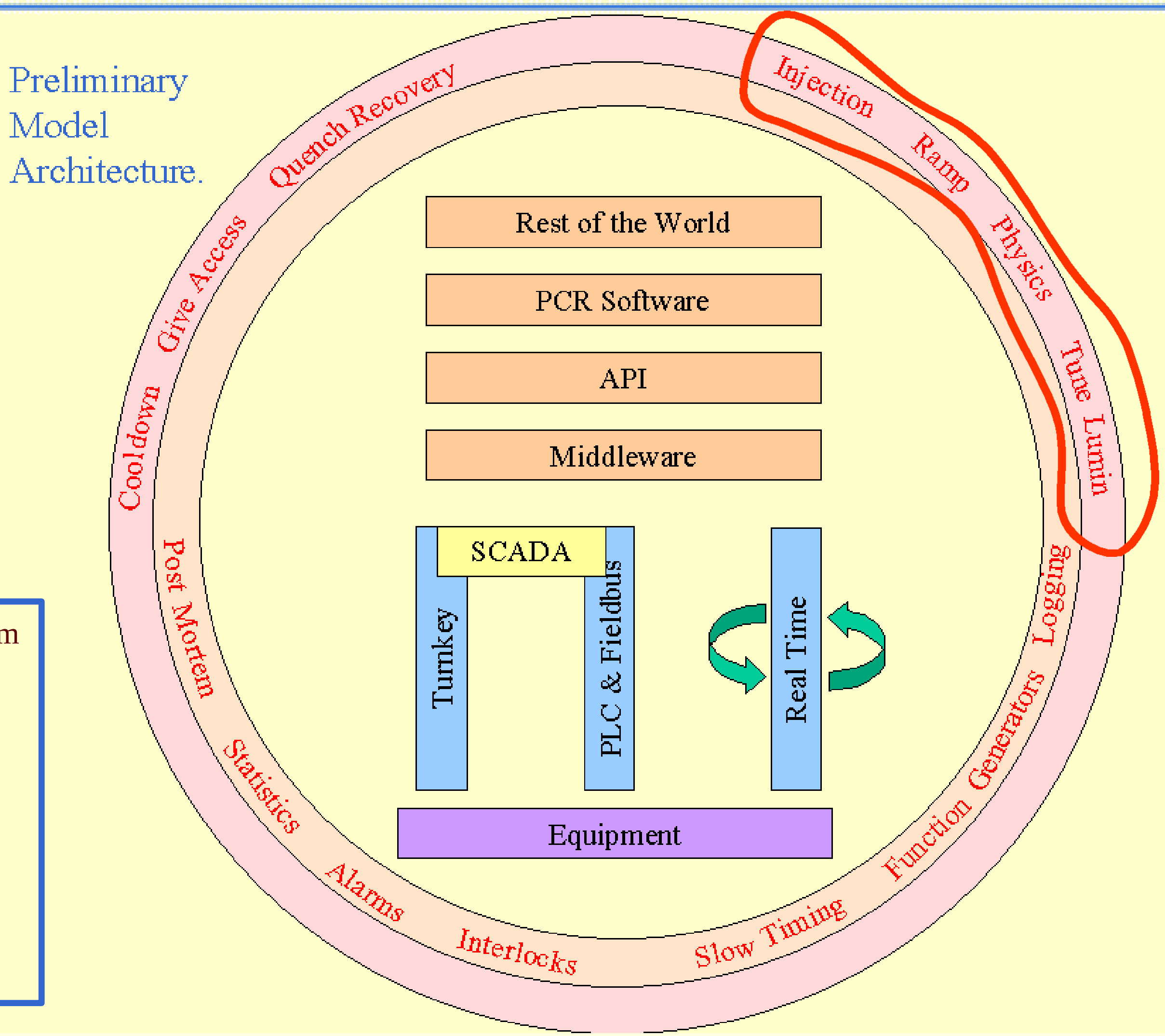
Responsibilities -TCR

- Monitors and operates 24 hours a day, 365 days a year the entire technical infrastructure of CERN comprising
  - the electrical distribution network and energy consumption management
  - heating, cooling, ventilation and air conditioning equipment
  - safety installations, any other infrastructure equipment
  - control systems
- Calls for breakdown and stand-by services
- Troubleshooting coordination:
  - CERN specialist, subcontractors
  - TCR on - site interventions

Issues

- ***Control Room Location is not important for LHC-CP***
- ***Control Room Responsibilities are important as they define the scope of the project and the interfaces***

Beam Operation



Operation without Beam
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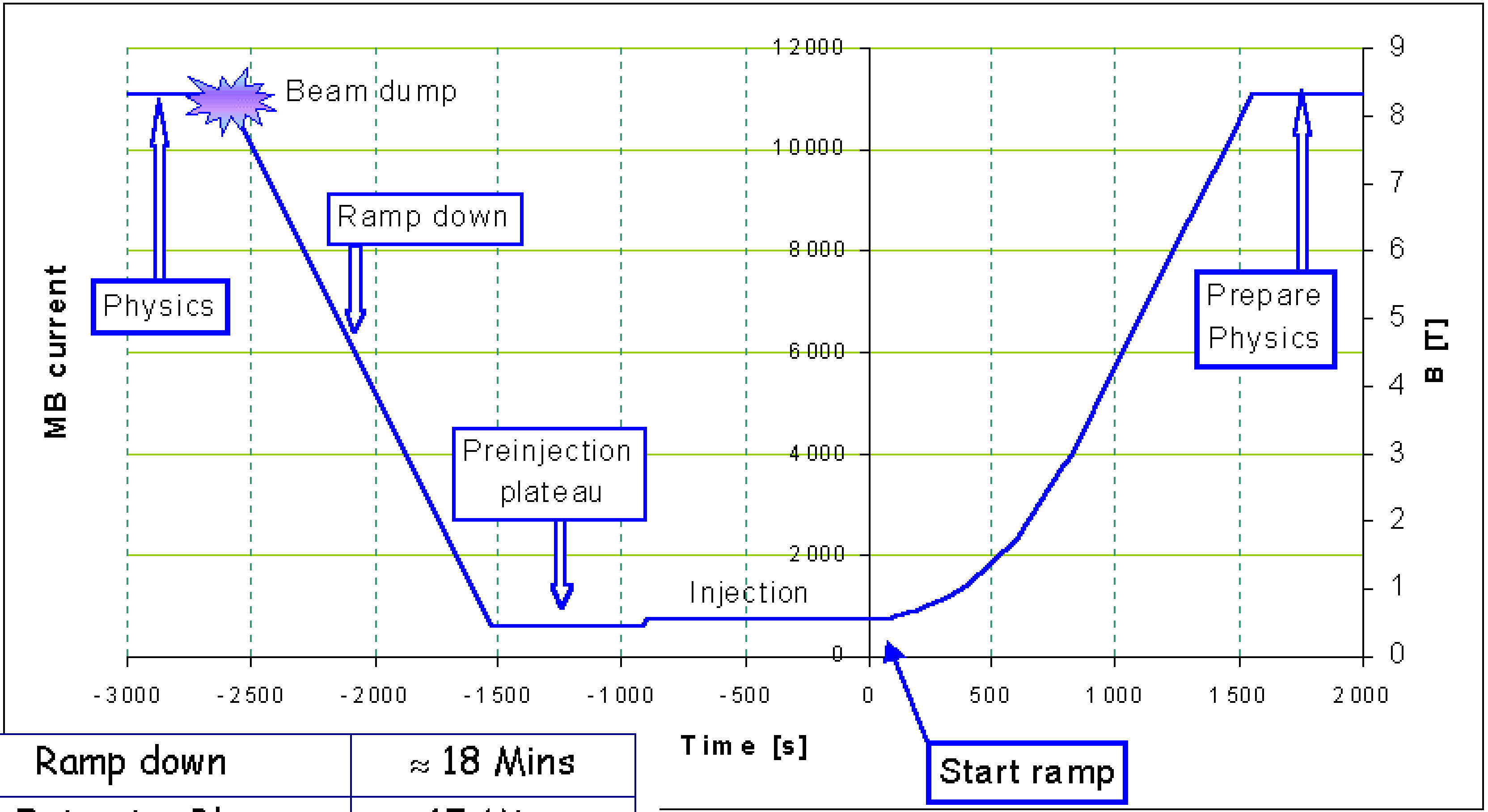
Baseline cycle

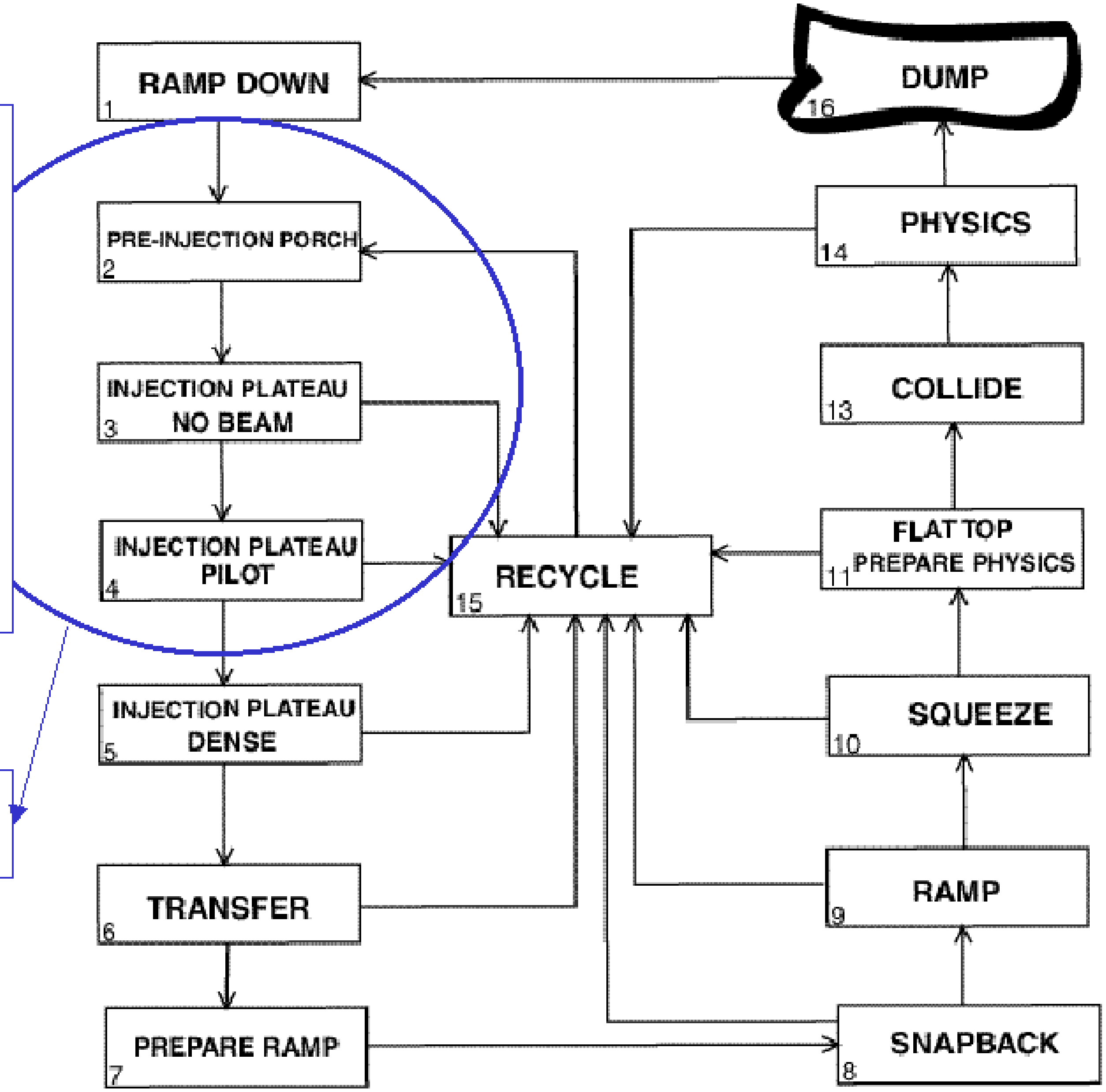


Ramp down	≈ 18 Mins
Pre-Injection Plateau	15 Mins
Injection	≈ 15 Mins
Ramp	≈ 28 Mins
Squeeze	< 5 Mins
Prepare Physics	≈ 10 Mins
Physics	10 - 20 Hrs

In the normal operations the LHC will perform a standard cycle which will be more-or-less set in stone.

The baseline cycle can be broken down into states which we can then Use Case our way through wrt to equipment, instrumentation and the control system.

Have a look at these in a bit more detail...



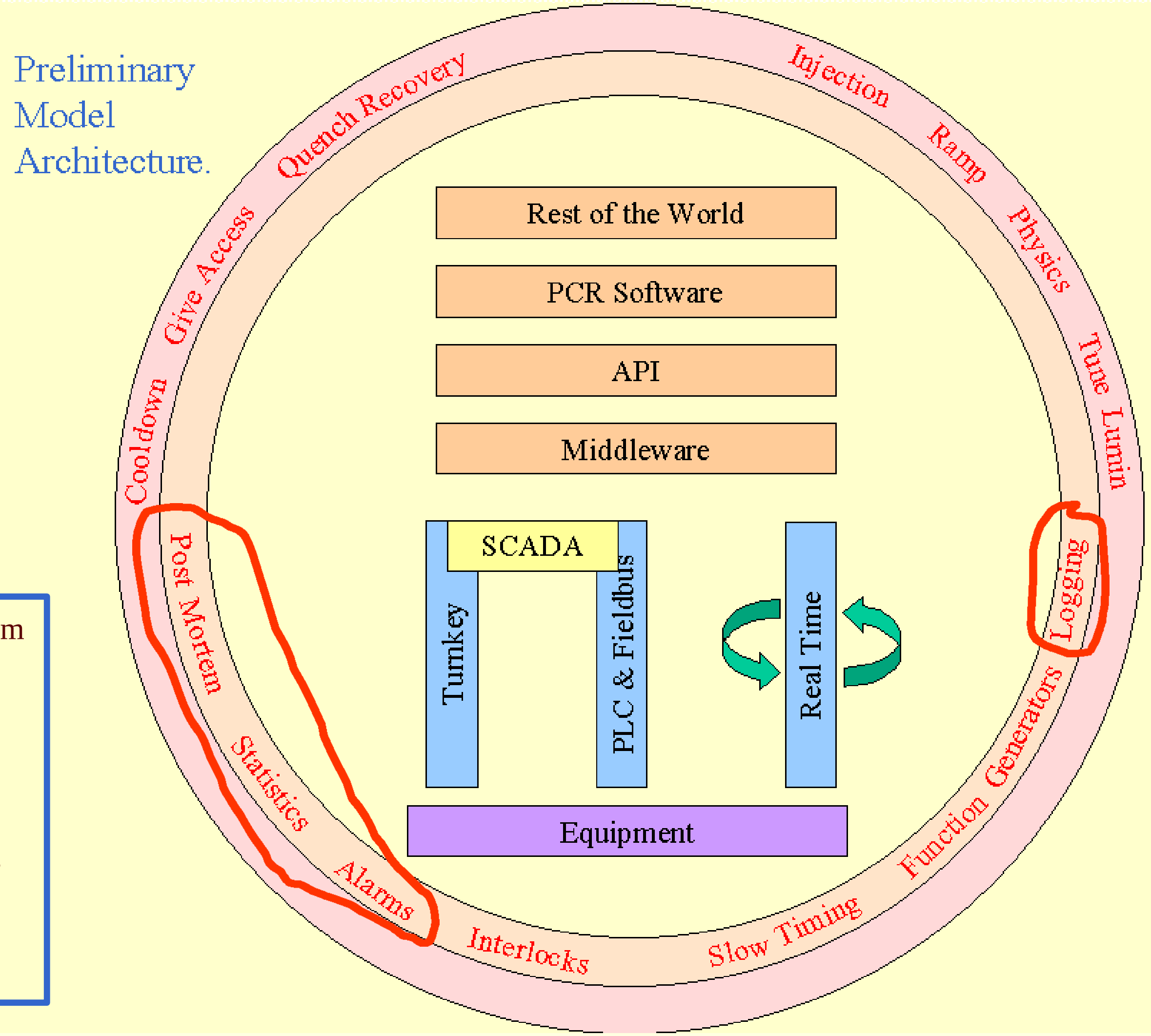
Pre-injection plateau

- Ramp down to ~ 600 A. Check that power converters have performed cycle down properly.
- Collimators out - check
- TDI to parking - check
- Kickers to standby
- Dumps - active - check
- Check kicker timing and BST.
- RF: 200 MHz, 400 MHz & transverse dampers:
  - → Set RF frequency to injection level, → Set the gain of the phase loop amplifier → Set the gain and time constant of the synchronization loop amplifier, → Close the phase loop around the VCO, → Switch the RF DRIVE ON, → Switch the phase loop to the cavity sum signal, → Reset the revolution frequency generator following reset of TTC
- Check: interlock system operational
- Check: magnet protection system
- Check: beam and power abort system operational.

Issues

- ***Use Case: key activity involving Operations, Machine Physics and Controls Teams***
- ***Need to complete first pass Use Case - should cover all PCR activities***
- ***Information must be published, it will***
  - ***impact on the planning work***
  - ***be fed into the software development process***

Databases



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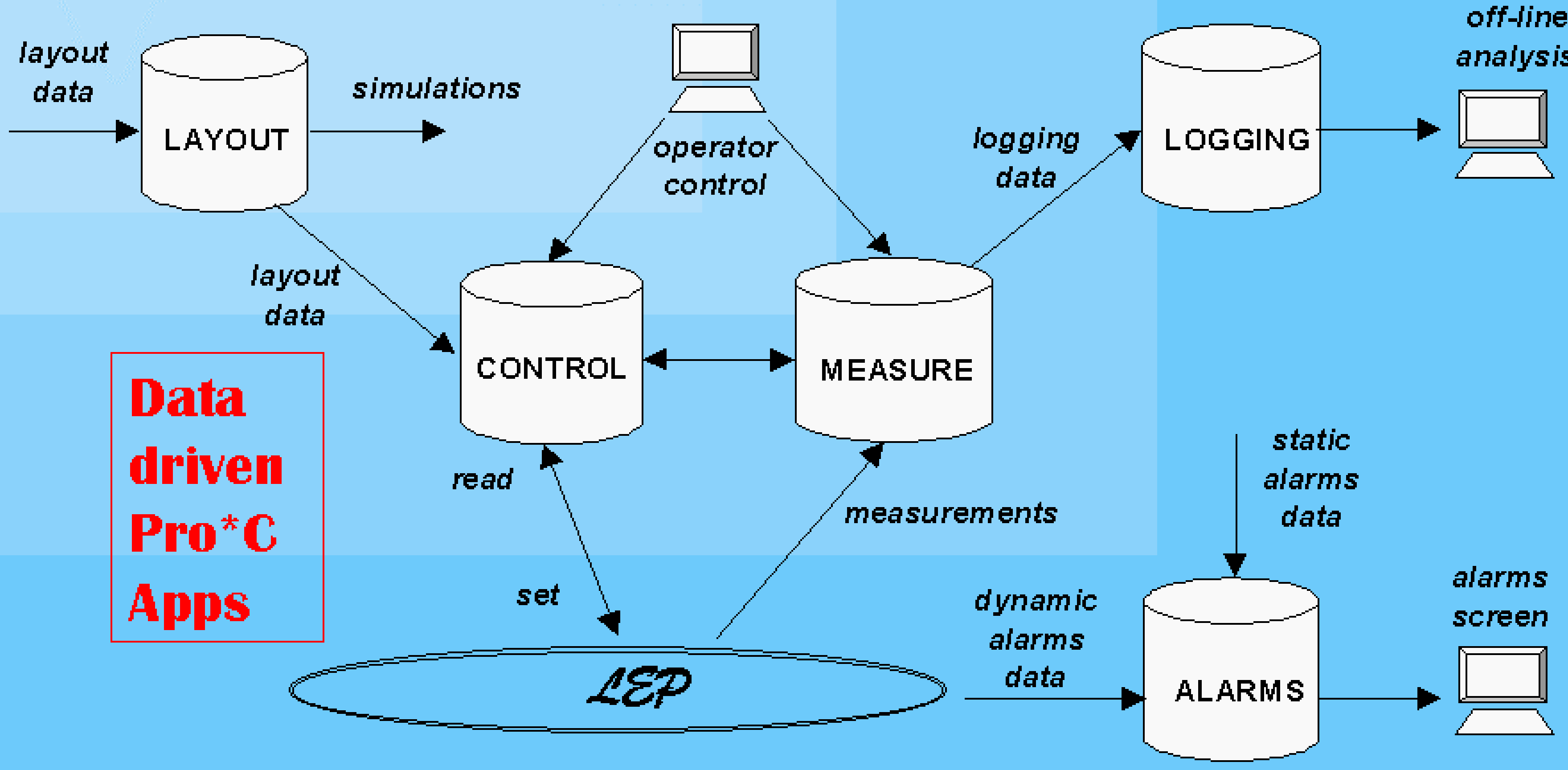
LEP operational Databases



Data driven Pro*C Apps

Conclusion

- A policy has been formulated by the project.

  ☞ **Code de la route...**

- The tools are coming into place (EDMS, MTF, ...) and the formats are (mostly) under control.

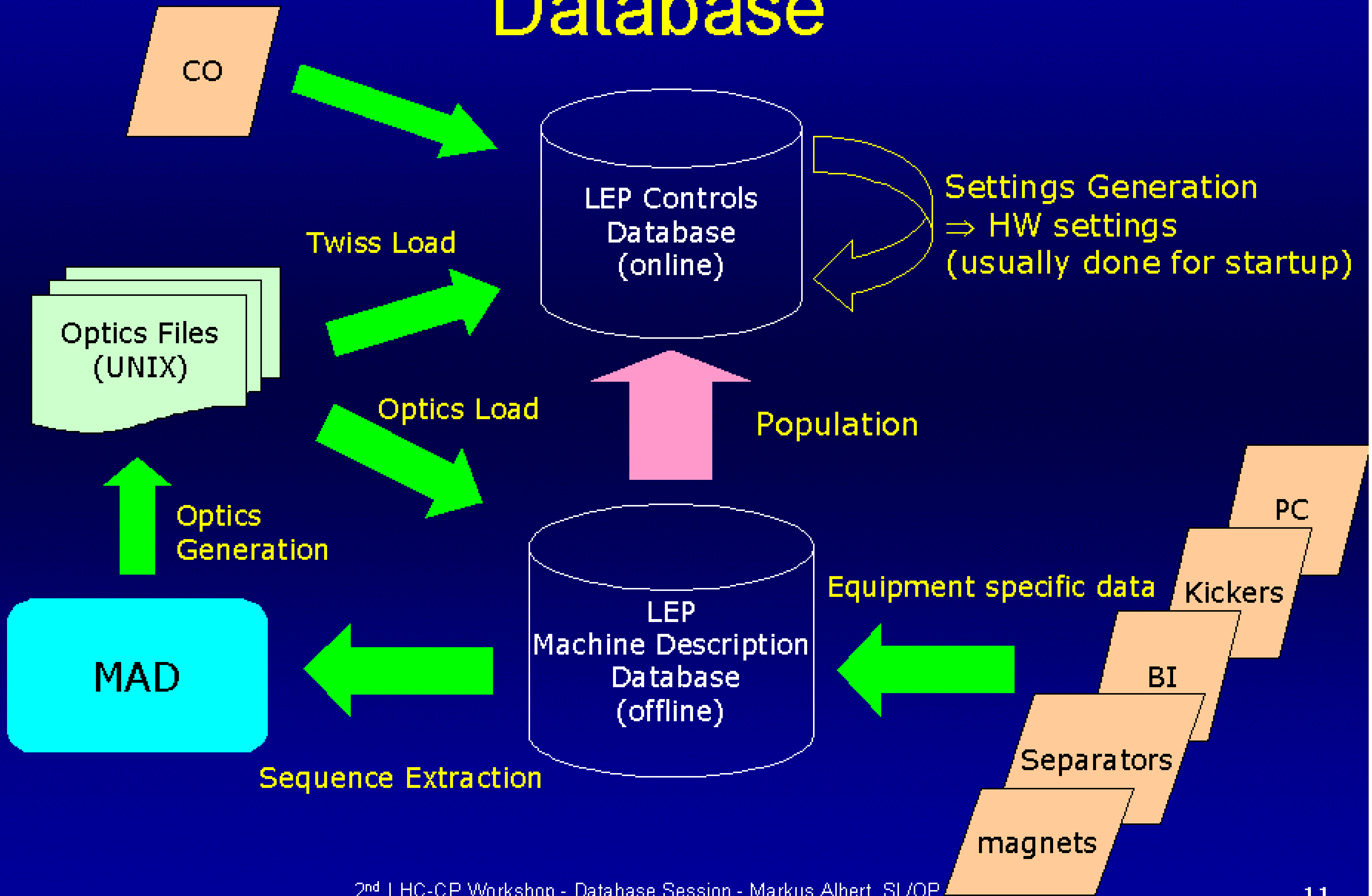
  ☞ **Please no .pdf files!**

- Now the project engineers have to be convinced to actually use these tools (private vs common). Your (LHC Controls Project's) needs must be conveyed to them....

- There is a need to start discussion on what data should be in the "LHC database" and who will manage it...

  ☞ **LHC-CP needs to tell Thomas what data is needed, he'll take care of the upstream data.**

Population of the LEP Controls Database



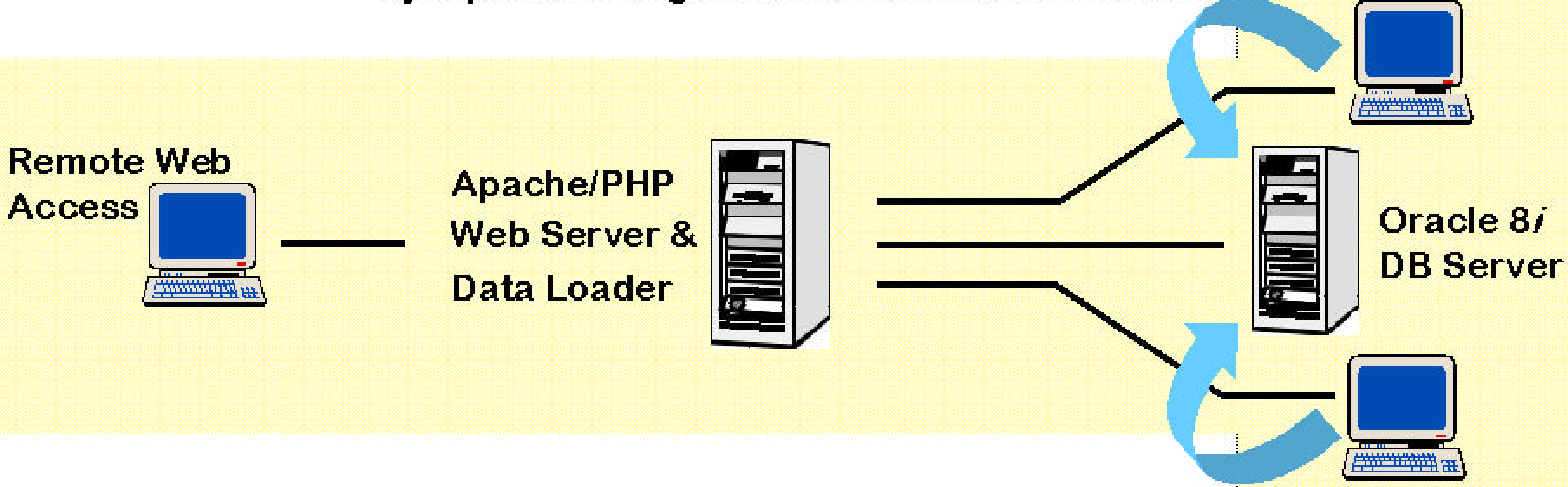
String 2

Database Services

strict

STRING2 INSTRUMENTATION AND CONFIGURATION TOOL

- Instrumentation repository
- Grouping signals into classes prior to assigning triggers and configuration parameters
- DAQ configuration file generation
- Synoptic drawings to ease information retrieval



stride

STRING2 DATA EXTRACTOR

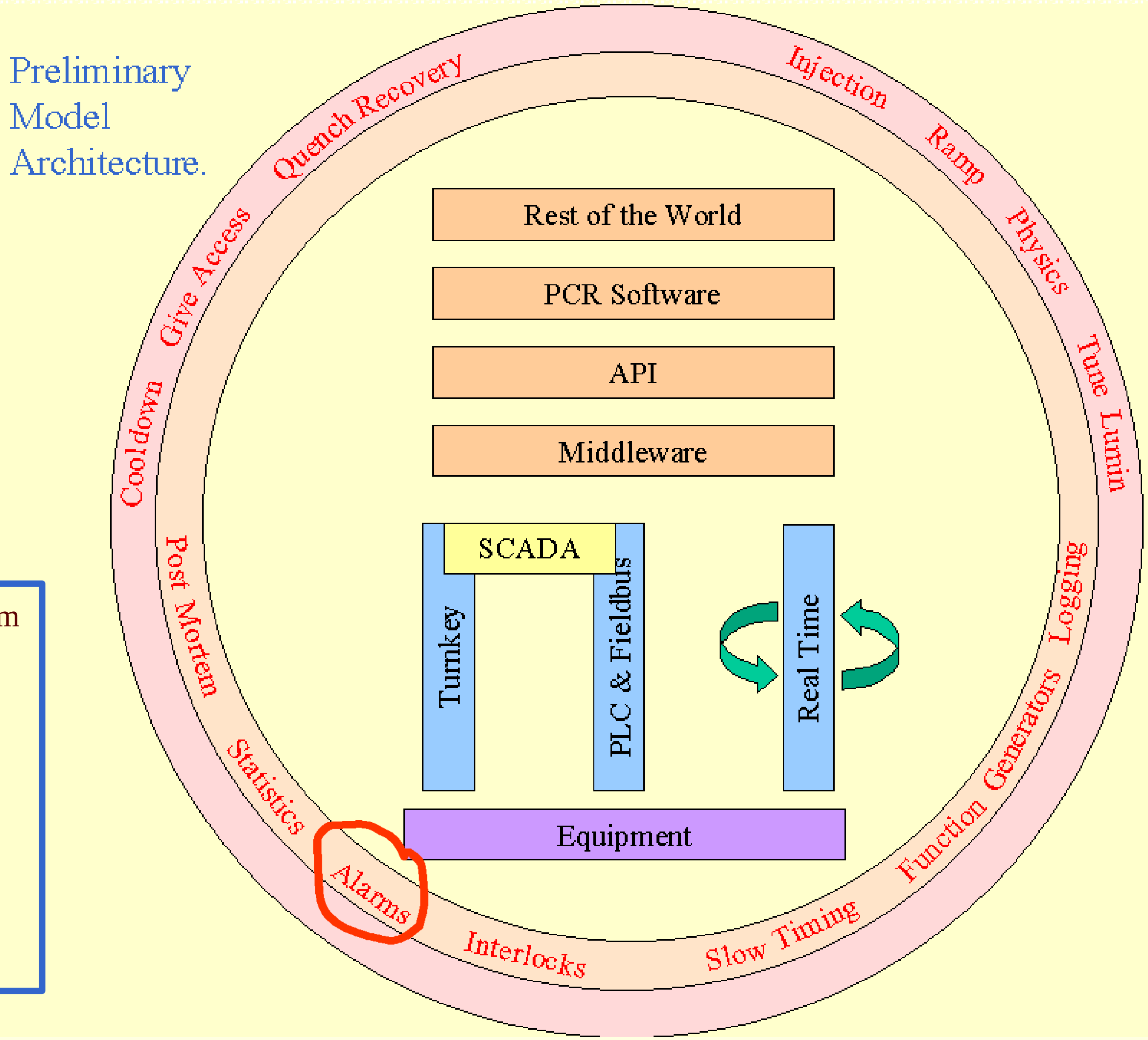
- Fast and versatile data extractor
- Common interface to DAQ and SCADA data
- Historical configuration browser
- Not an analysis tool, but simple visualization capabilities provided

Courtesy T.Ladzinski, M.Peryt

Issues

- ***Need a Database Forum for this community***
- ***LHC-CP must tell LHC builders what they need***
- ***First LHC Control Databases should be ready early 2003 for QRL systems: cryogenics, vacuum, alarms, TCR***

Alarms



Operation without Beam
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Overview

- What
  - An *alarm/warning* is something wrong, abnormal, a problem with the *process*
  - The *process* is anything which could affect the well being of the LHC complex be it either : hardware, software or environment
  - Since we consider problems both at the alarm level and at the warning level, we refer to them as *Fault States* (FS)

Overview

- Where
  - LHC Control Centre(s) and specialists will require FS information from any part of the CERN site:
    - Radio Frequency, Power Converters, Magnets
    - Beam monitoring
    - Beam transfer
    - Vacuum
    - Cryogenic
    - Cooling & Ventilation
    - Electricity
    - Safety System
    - Experiments
    - Control SW
    - Environment

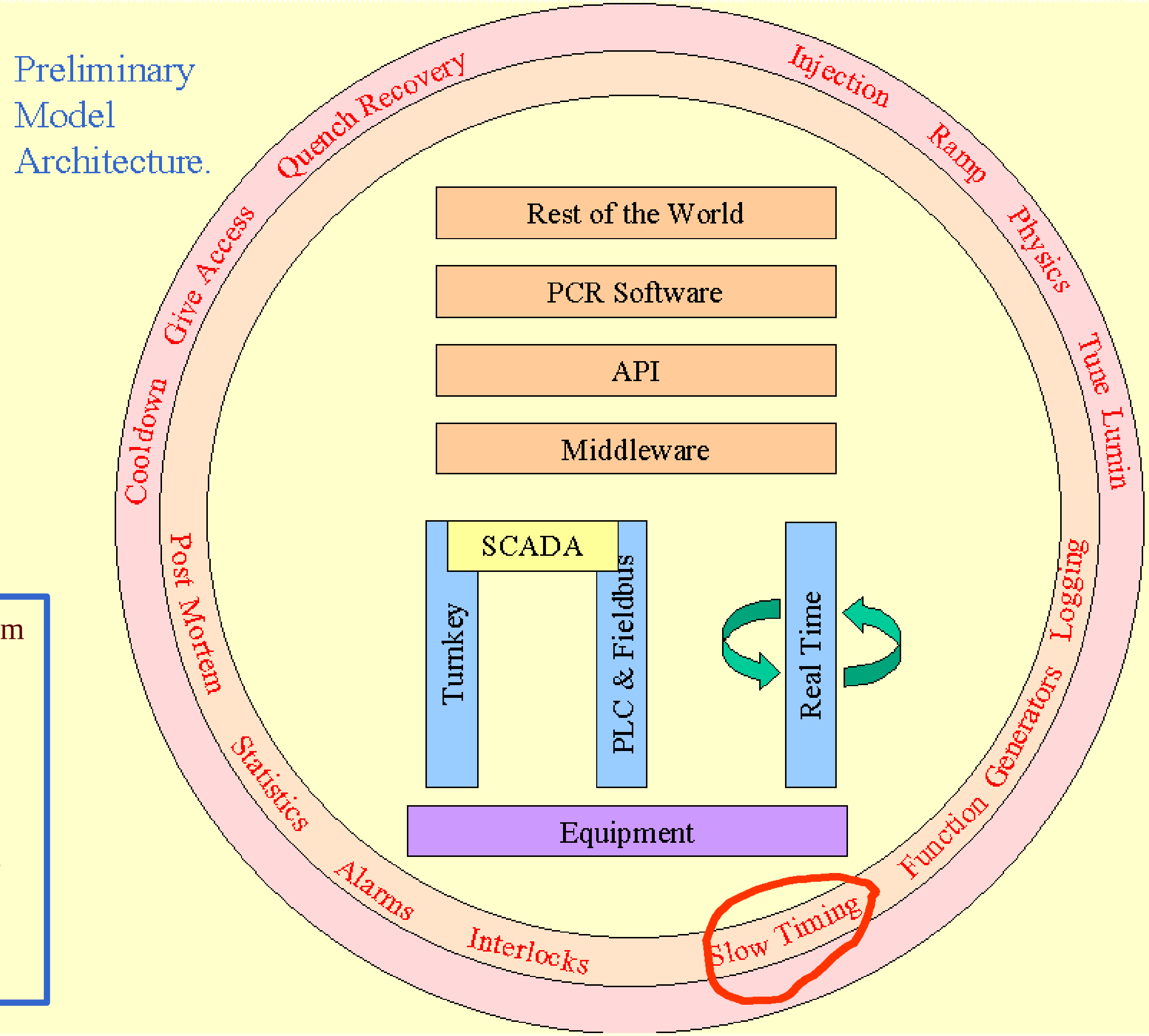
Objectives for 2001

- User requirements
  - 'Alarm Service Survey' in preparation
  - UR gathering and analysis by Q2 2001
  - UR document by Q3 2001
- Technology investigation
  - Two possible solutions:
    - Use an industrial system
    - Use open technologies
  - Decision by Q4 2001
- Functional and architectural specification
  - Depending on the adopted solution
  - Carried on in parallel with technology investigation
  - Preliminary functional and architectural spec by Q4 2001/Q1 2002

Issues

- ***PCR will need alarms from across CERN***
- ***Choice of technology an important decision for this year***
- ***Alarm project will not detect the alarm conditions or generate the alarms***
- ***Closely coupled to TCR and JCOP***

Timing



- Operation without Beam
- Beam Operation
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- **Timing**
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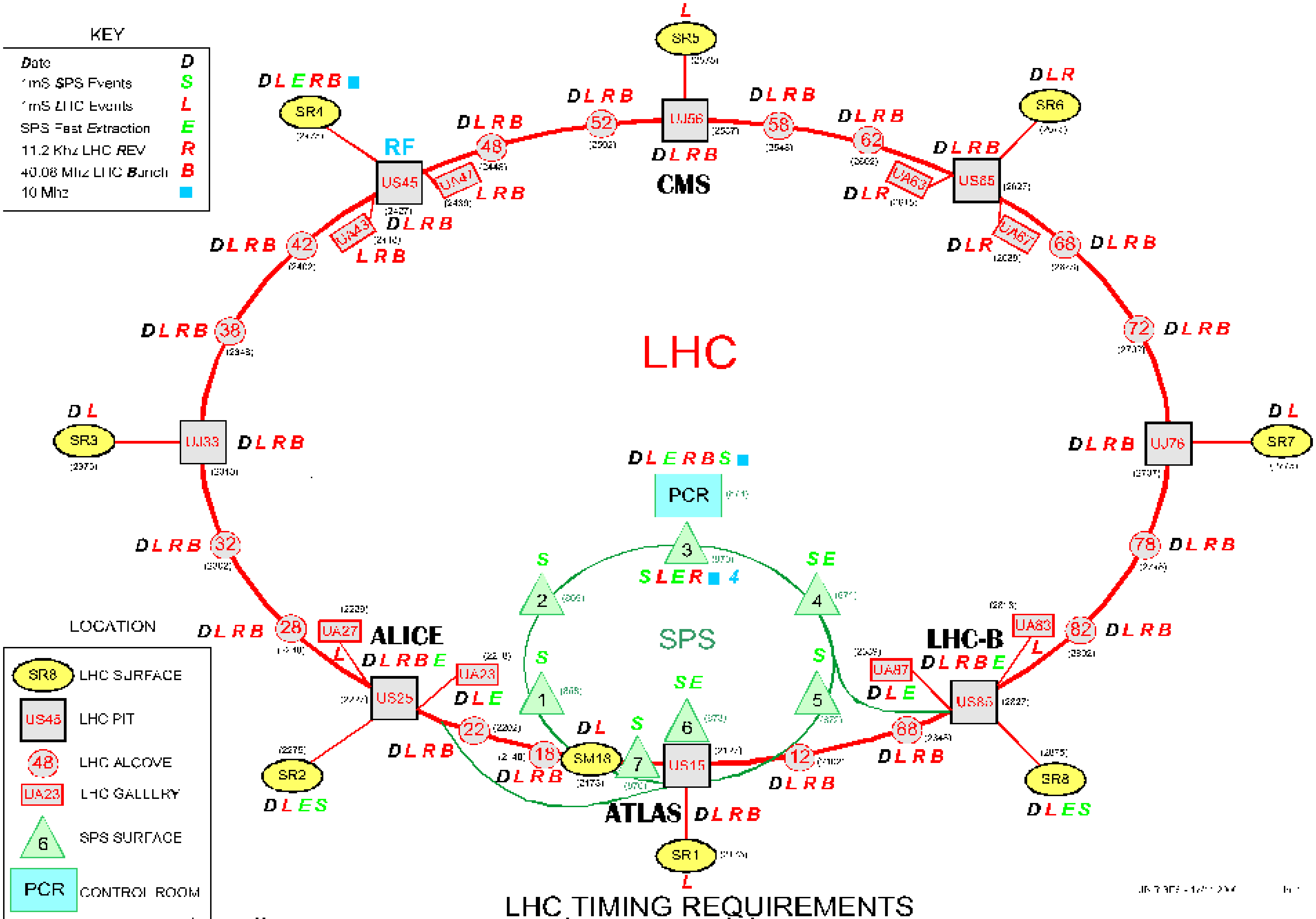
What do the users want?

- 1) 40MHz LHC bunch frequency, BA3 RF via PCR.
- 2) 11.7 kHz LHC rev. frequency, BA3 RF via PCR.
- 3) Beam Synchronous Timing, PCR.
- 4) SPS fast extraction pre-pulses, BA3 RF via PCR.
- 5) LHC fast injection pre-pulses, SR4 via PCR.
- 6) SPS slow timing, SPS MTG in PCR.
- 7) LHC slow timing, LHC MTG in PCR.
- 8) Timing receivers.
- 9) Time of day and events.



LHC TIMING REQUIREMENTS

SPS Events, a reminder

Reserved	Event	Cycle Type	Cycle Type
SPS	Extraction	Proton	1
SPS	Transition	Proton	2

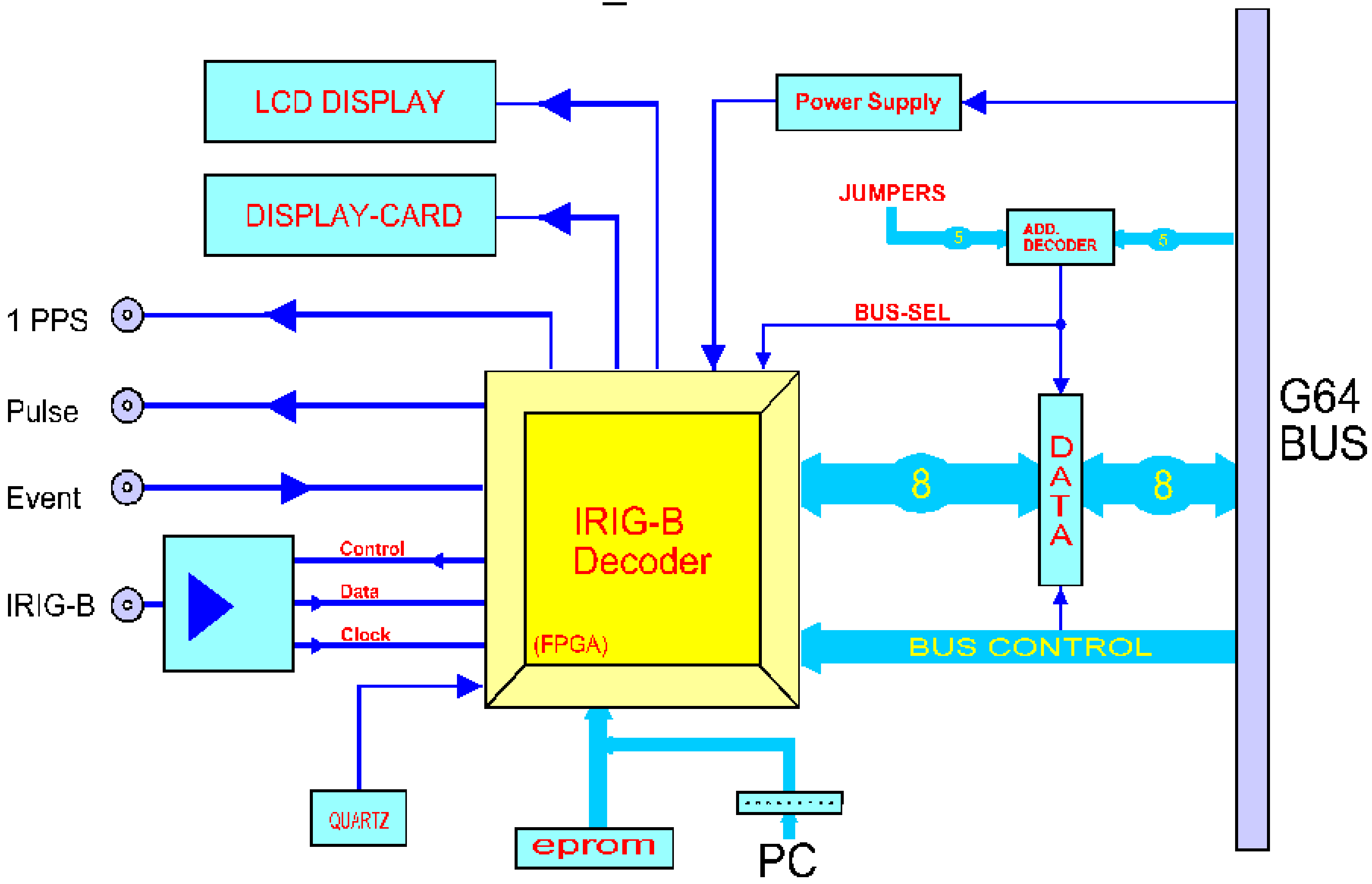
LHC Events, a proposal

Ring	Event	Mode	Batch
Ring 1	Set Bunch Clock	Filling	3
Ring 2	Dump	Adjusting	-
LHC	Start Ramp	Ramping	-
LHC	Post Mortem	Physics	-

And what about?

SPS	Start TI2 Mugef	Proton	1

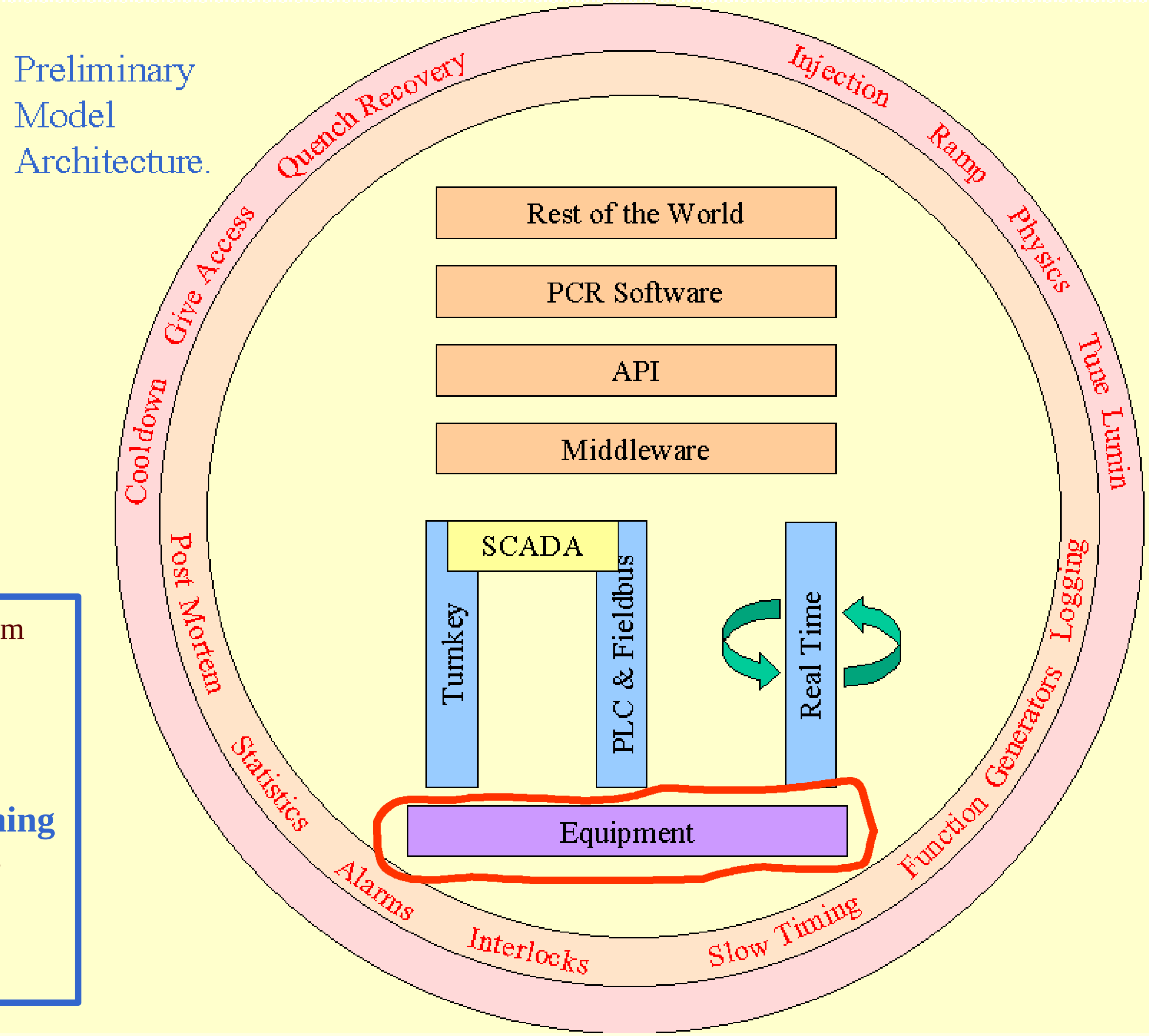
G64_IRIG-B


LCD DISPLAY
DISPLAY-CARD
Power Supply
JUMPERS
5
ADD. DECODER
5
BUS-SEL
1 PPS
Pulse
Event
IRIG-B
Control
Data
Clock
IRIG-B Decoder
(FPGA)
8
DATA
8
G64 BUS
BUS CONTROL
QUARTZ
eprom
PC

Issues

- ***A classic slow timing service will do the job***
- ***Time stamping of comparable importance to events***
- ***Hardware interfaces, software interfaces and event semantics must be defined this year***
- ***Ignoring possible existence of a "real time" network***

Equipment



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Preliminary

Phase	Systems to install (incl. Controls)	Details
FIRST BEAM (Feb. 2006) / SECTOR TEST (Apr. 2004) / QRL Commissionin	General Services	Main power & Electrical distribution
		Personnel Safety system (access control, gas & fire detection, …)
		Cooling & Ventilation
	Equipment in Control Rooms	TCR
		CRYO
	Cryogenics	
	Vacuum	
SECTOR TEST (Apr. 2004)	General Services	Machine (Equipment) Protection (Interlocks, Abort system)
	Harmonic Factory	
	Magnet	Ref magnet measurment
		Current control system
	Beam Observation	Beam Position Monitors
		Beam Current TF
		Profile
		Losses
		anything else ?
	Beam Synchronous Timing (BST)	
	Kickers	MKI8 Injection Kicker Ring 2
	Beam Dumping Systems	TDI8-TCDD8 Injection Dump/Collimator Ring 2
	Powering	Powersupplies, busbars, …
	Transfer lines	TI8
FIRST BEAM (Feb. 2006)	Transfer lines	TI2
	Magnet (Protection System)	Quench Detection
	RF	LHCACS (200 MHz)
		LHCACN (400 MHz)
		LHCADT (Transv. Damper)
		Timing
	Beam Observation	Chromaticity
		Tune
		anything else ?
	Collimators	
	Kickers	MKI2 Injection Kicker Ring 1
	Beam Dumping Systems	MKD/MKB (R1 & R2)
		TDI2-TCDD2 Injection Dump/Collimator Ring 1
	Etc, … Etc,…	

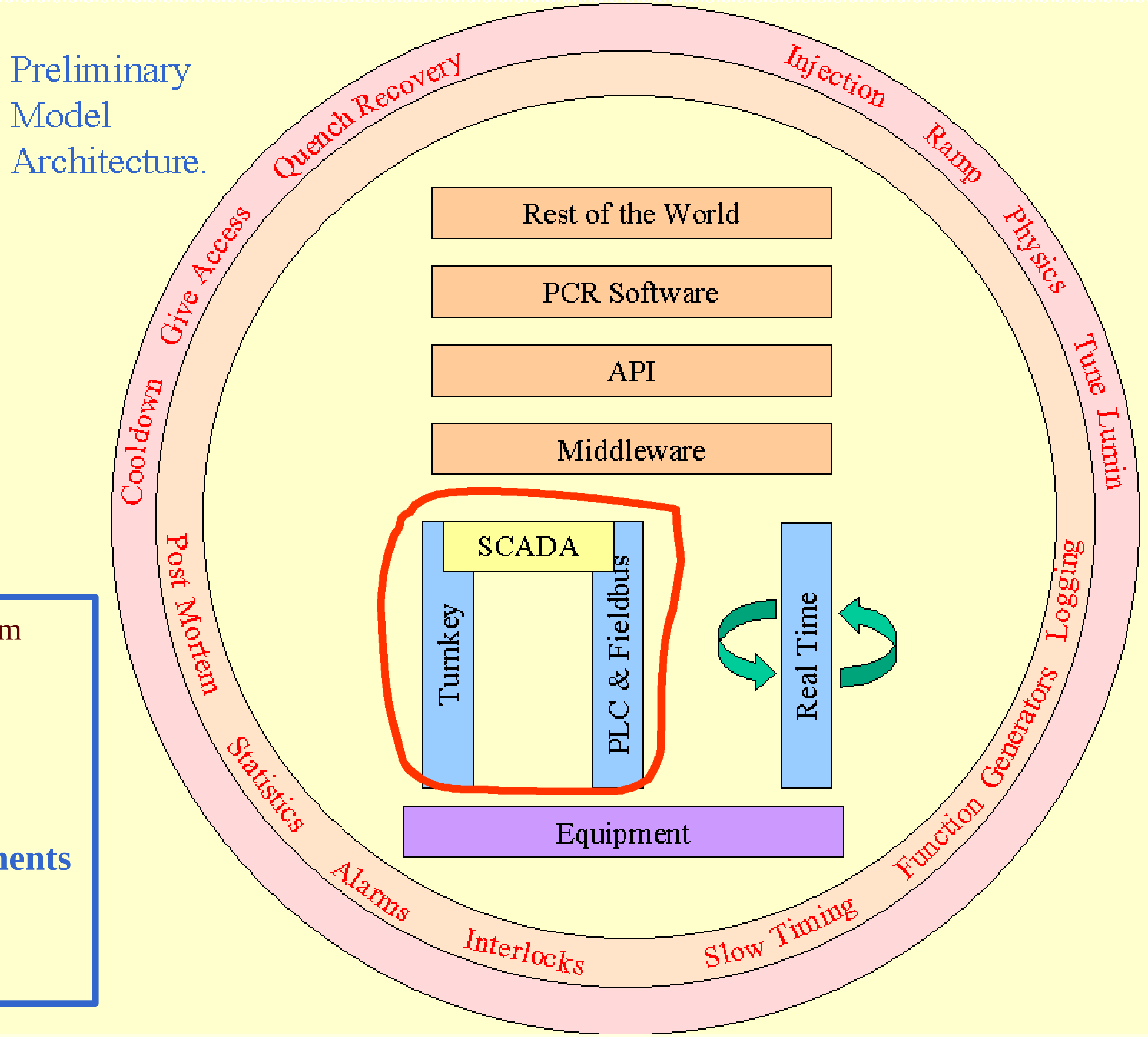
Preliminary

	Components		Client			Link-Person	
	Subsystem	**Sub-Sub-System**	**QRL**	**Sector Test**	**First Beam**	**Name**	**Group**
Control System	SCADA		Y	Y	Y	Ph.Gayet	LHC/
	Timing	Time Stamping	Y	Y	Y	G.Beetham	SL/ CO
		Slow Timing		Y	Y		
	Communication	Ethernet	Y	Y	Y	P. Anderssen	IT/ CS
		Video	?	Y	Y		
		Radio LAN	Y	Y	Y		
		Intercom	Y	Y	Y		
		Telephone	Y	Y	Y		
	Fieldbusses		Y	Y	Y	Ph.Gayet	LHC/ IAS
	PLC		Y	Y	Y		
	Servers		Y	Y	Y	P.Charrue	SL/ CO
	Databases (incl. Logging & Archives)	Addresses	Y	Y	Y	R.Billen	SL/ MR
		Alarm	Y	Y	Y		
		Calibration	Y	Y	Y		
		Measurement	Y	Y	Y		
		Logging	Y	Y	Y		
		Settings	?	Y	Y		
		Layout	?	Y	Y		
		Optics		Y	Y		
	Alarm System		Y	Y	Y	M.Tyrrell	SL/ CO
	Control Rooms	Specialised	Y	Y	Y	Ph.Gayet	LHC/
		TCR	Y	Y	Y	P.Ninin	ST/ MO
		PCR		Y	Y	P.Charrue	SL/ CO
	Middleware	Client - Server API	?	Y	Y	K.Kostro	SL/ CO
		LDIWG	?	Y	Y	R.Lauckner	SL/ DI
	Post Mortem	Transient Recorders		Y	Y	R.Lauckner	SL/ DI
		Diagnostics		Y	Y		
		On-Line Help		Y	Y		
		Documentation		Y	Y		
	Digital Controllers (Fct. Generators)			Y	Y	Q.King	SL/ PO
	Analog Signals			Y	Y	R.Lauckner	SL/ DI
	Front-Ends	(Gateways, VME, ...)		Y	Y	P.Ribeiro	SL/ CO
	PCR Application S/ W			Y	Y	M.Lamont	SL/ OP
	RT Feedback			?	Y		

Issues

- ***Planning of QRL Reception Tests is useful to establish planning method***
- ***Looking at QRL has revealed early needs for time stamping, database and alarm services***
- ***Need to tackle the Sector Test***

Industrial Components



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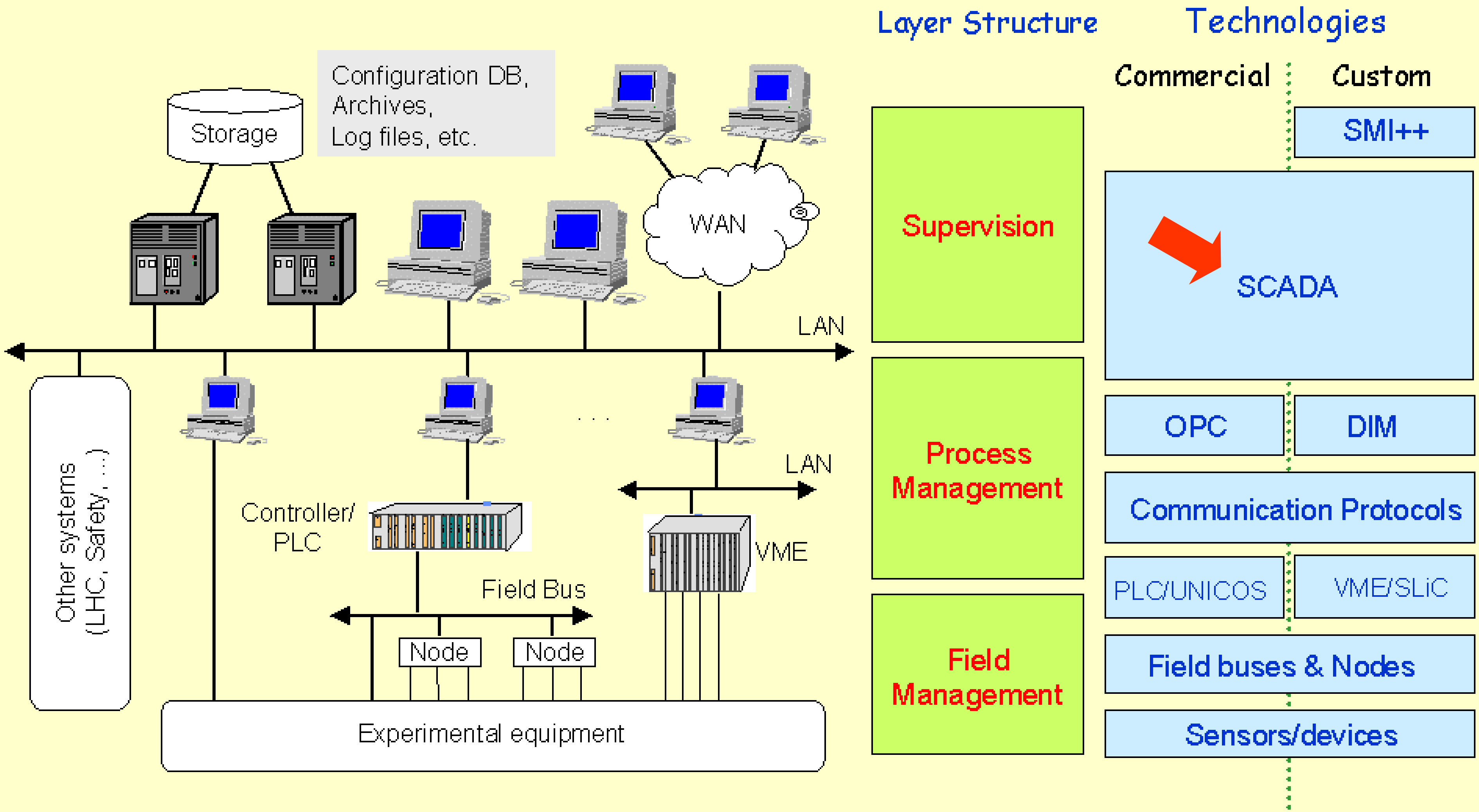
Controls Technologies (JCOP)



Based on an original idea from LHCb

Status of PVSS at CERN

- Controls Board
  - Diversity of SCADA systems at CERN
- SCADA Working Group
  - Survey usage of SCADA
  - Recommendation
- JCOP
  - Evaluation of SCADA systems
  - Tender and selection of PVSS
- Controls Board
  - SCADA Recommendation
- SCADA Working Group
  - Implementation report

The first proposal

- Analysis of CERN requirements
- Review of industry activities
- Mature products
- Workshops at CERN
- Proposed CERN standard

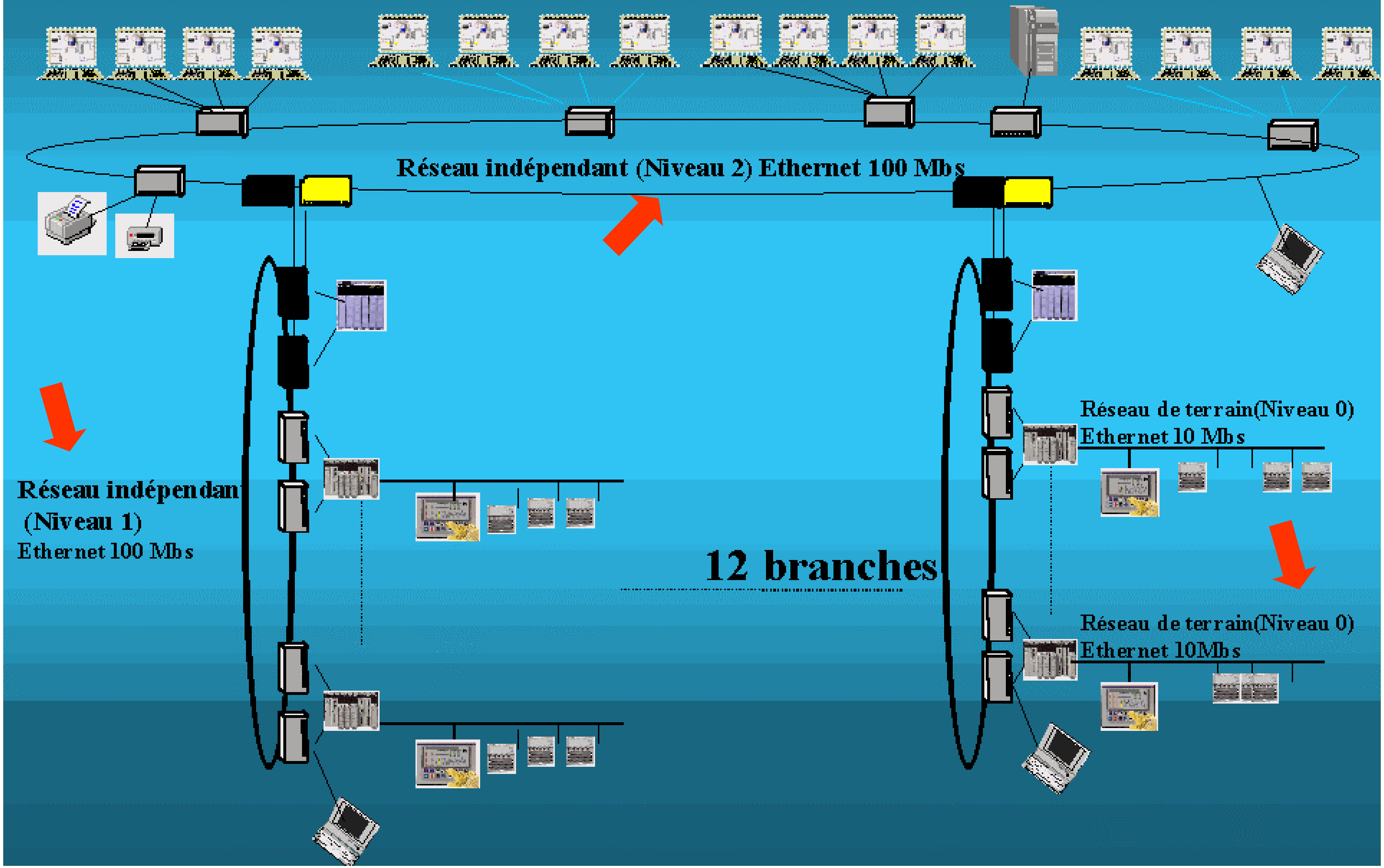
CAN, Profibus and WorldFIP
and CERNwide support scheme

- Endorsed by CERN management

Emergence of Ethernet

- Emergence of Ethernet in the fieldbus domain : fieldnetwork
- A fast progressing event
- Determinism can be ensured under specified conditions
- PLC interface : Market is leading to TCP/IP for communications
- Coupling with other fieldbuses
- Transparency for PLC configuration tools
- Industrial components: industrial standards, redundancy
- At CERN:LHC cryogenics, cooling and ventilation
  - Potential exists
  - Must be thoroughly investigated for standard

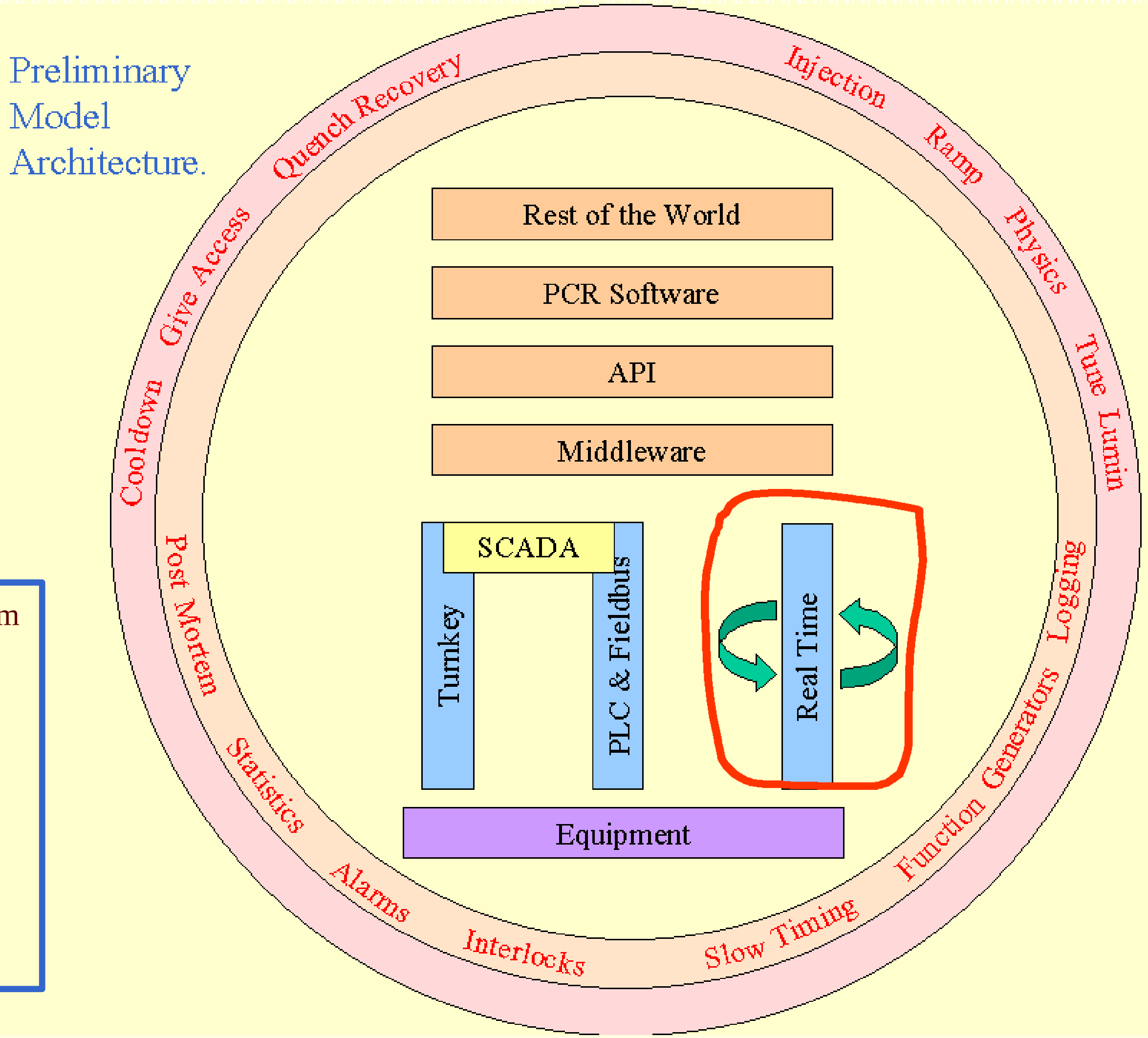
Example of architecture (1)



Issues

- ***Support requirements for SCADA, PLC and Fieldbus must be detailed and put into place across the project***
- ***SL also need same support for SPS***
- ***Opportunities for common choices beyond Controls Board recommendations***
- ***Integration with classical controls still not clear - SCADA in PCR? horizontal communications at Front End? ...***

Real Time



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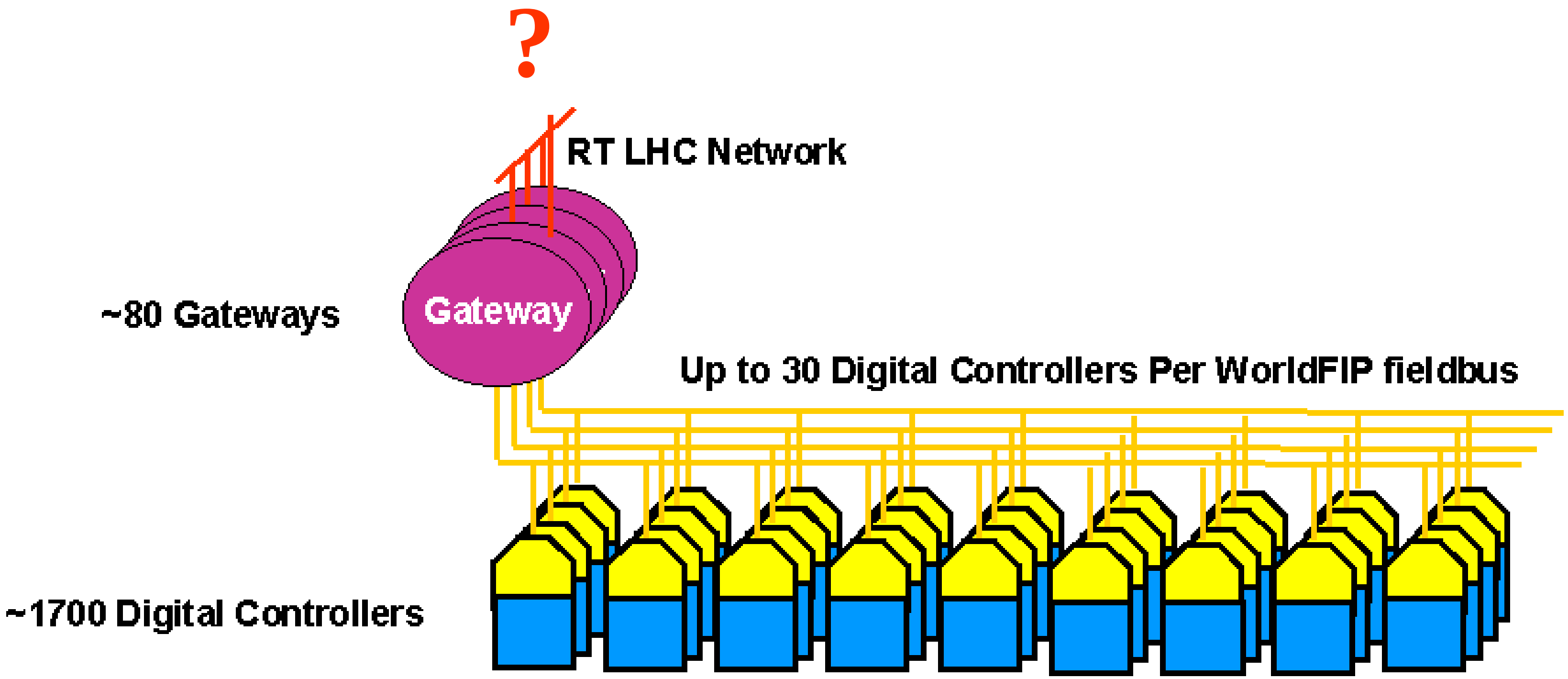
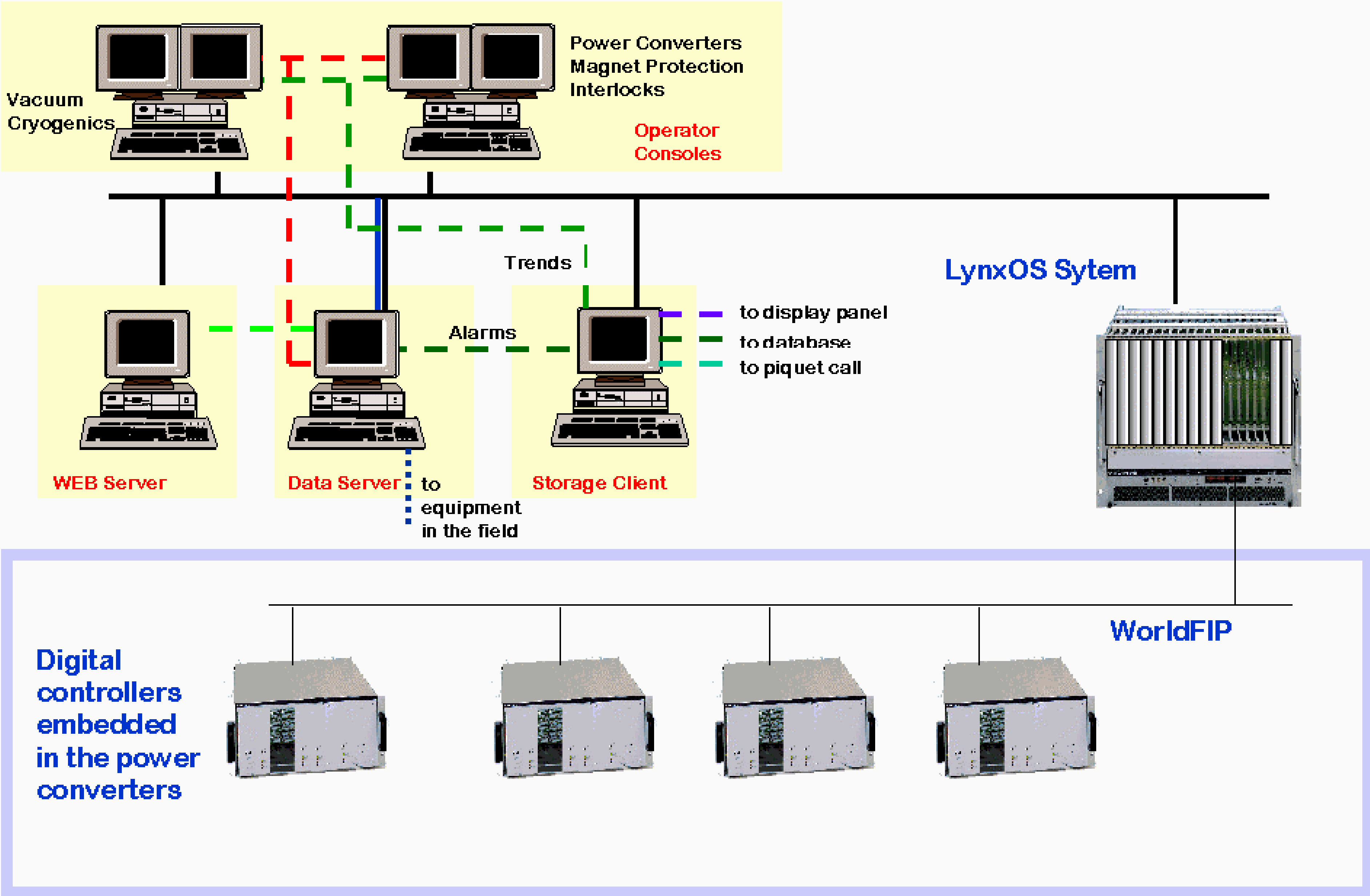
SL/PO architecture



String 2

Controls for Power Converters



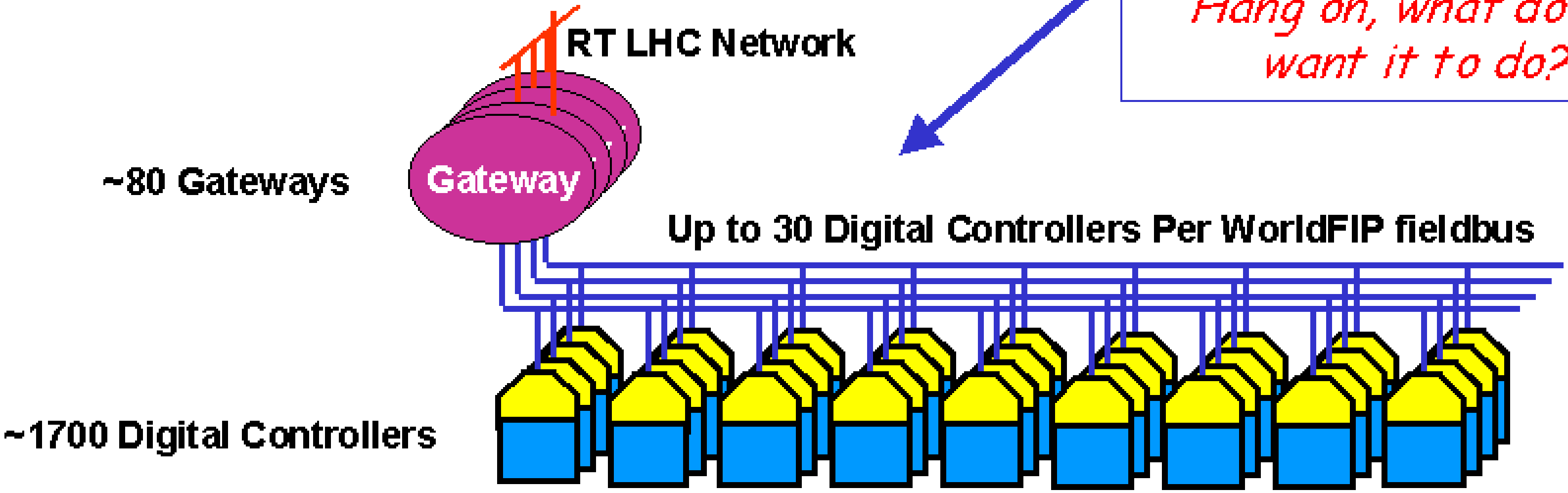
Courtesy R.Denz

2. Equipment - high level control

- Power Converters
  - asynchronous set (different methods),
  - synchronous set - millisecond timing
  - command-response,
  - functions (number of points, splines, download, deltas v. absolute)
  - slow timing,
  - post mortem, alarms,
  - real-time correction channel

Does this do what we want it to do?

Hang on, what do we want it to do?

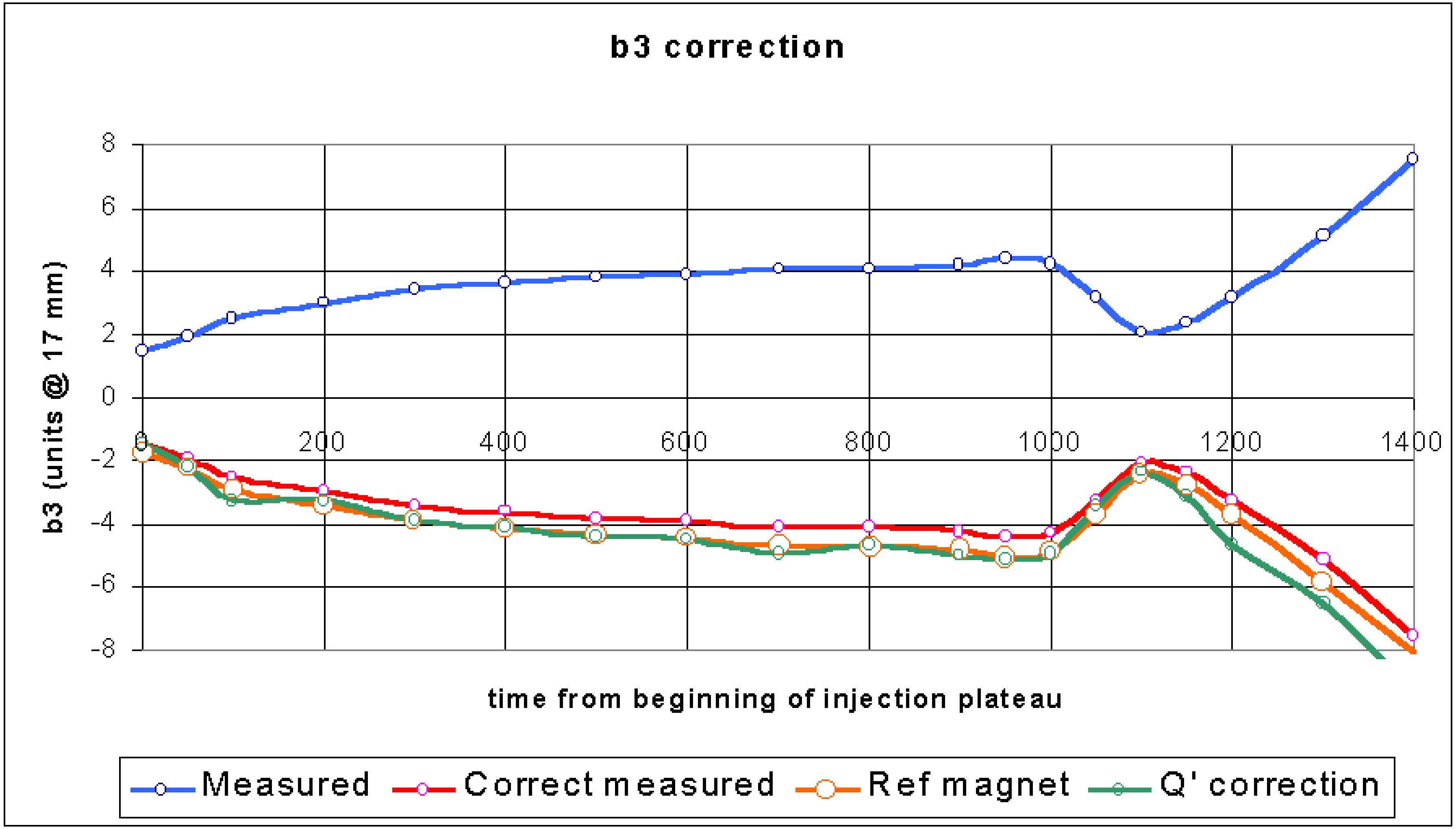


RT requirements II

		Acquisition	Actuators
Reference magnets	3 - 10 Hz		Trim quads, sextupoles…
Global orbit feedback	1 Hz	As below…	2*500
Chromaticity	1 Hz	Single instrument	Trim sextupoles
Tune feedback	10 Hz	Single instrument	Trim quad PC
Beam loss display + poss input to feedback system	10 Hz	250 crates 130 Kbytes/s	N/A
Real-time knobs	10 Hz	Real-time display	1 to 500
Global orbit acquisition	10 Hz	250 crates 200 Kbytes/s	N/A
Local orbit correction & acquisition	Max 100Hz	~10 PUs	~5 correctors

Response limited by PC/magnet

Multiple inputs - single output



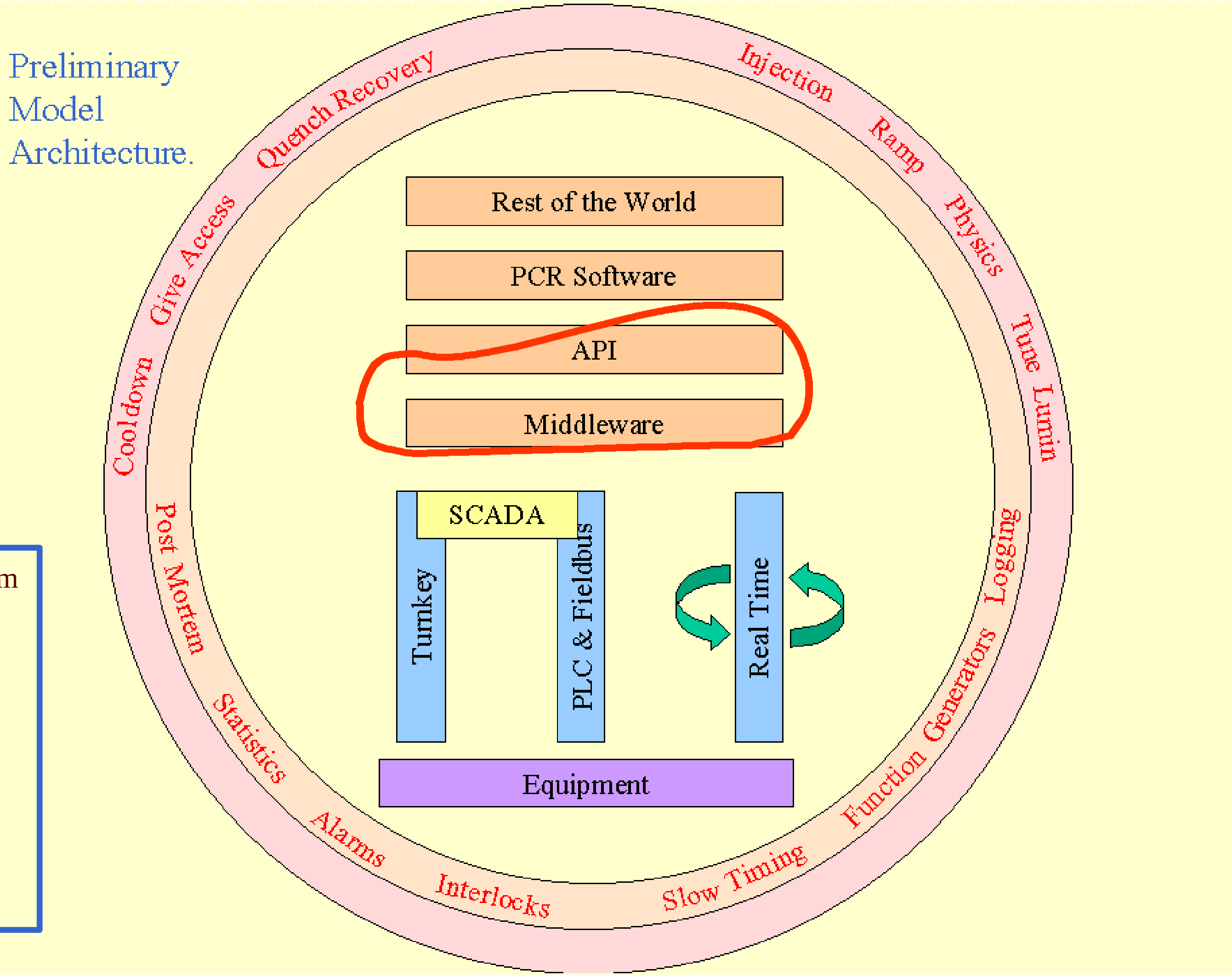
Essential challenge of many sub-systems hitting common actuators

Not to mention the problem of hysteresis loop crossing

Issues

- ***MISO means a coherent approach across systems***
- ***Good progress into defining feedback requirements, now need to apply digital theory control ('a field in its own right' - T. Himel, SLAC)***
- ***For industrial and custom front ends need a survey of all systems and proposed solutions***

Middleware



Operation without Beam
Beam Operation
Databases
Alarms
Timing
Equipment / Planning
Industrial Components
Real Time
Middleware
Applications

What is Middleware?

- Middleware is the **software** between the application programs and the operating system and base networking

- It is the ***SLASH*** in the term ***Client / Server***

CMW Capabilities (1/2)

DEVICE-PROPERTY Model

- HW and SW entities are represented as **Devices**
- Devices have **Properties**
  - Composed of elements of **Simple Data Type** like Integer, …, Double, String and **Arrays** of them
- Properties can be **Set-Get**
  - Blocking (synch) & non blocking (asynch)
- Properties can be **Monitored**
  - Publish/Subscribe on value change and on cycle event

CMW Capabilities (2/2)

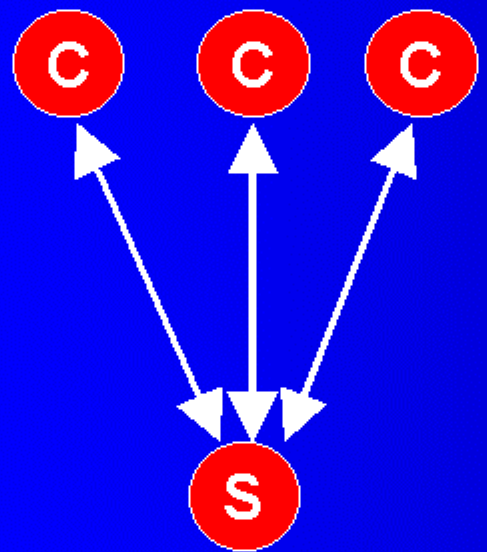
TOPIC Model

- Based on the **Publish** & **Subscribe** communication paradigm
  - Used when multiple application need to receive the same message
  - Conceptually similar to the Newsgroup
- Communication is **Asynchronous**
- Well adapted to **Loosely Coupled** systems

Chosen Technology

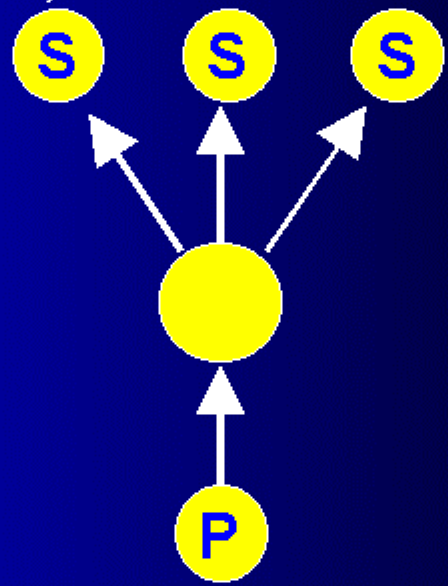
CORBA

- Establishes Client / Server relationship between objects
- OMG Standard



Message Oriented MW

- Implements the Publish / Subscribe communication paradigm
- Java Message Service (JMS) API

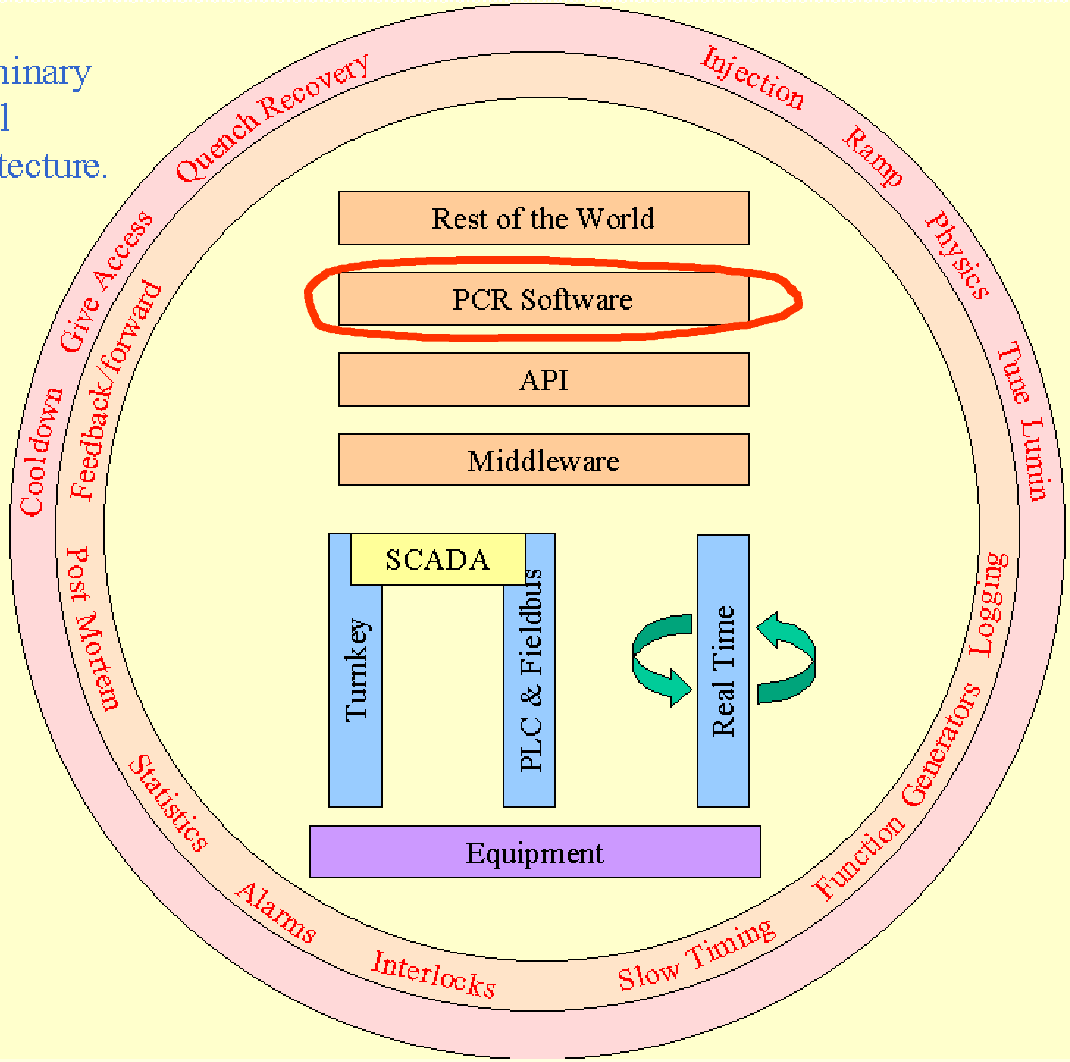


Issues

- ***CMW is ready to deploy***
- ***LHC-CP must study proposed services and provide feedback***
- ***Pressure from SL-CO to align with SPS 2001***
- ***JCOP pushing to re-start LDIWG*** .

Applications

Preliminary
Model
Architecture.



Operation without Beam
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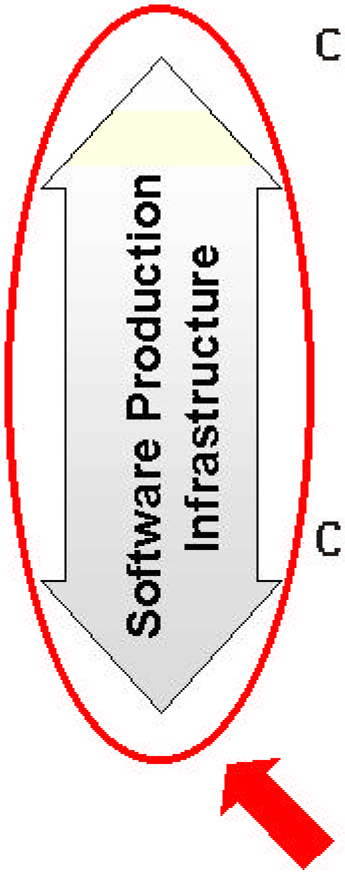
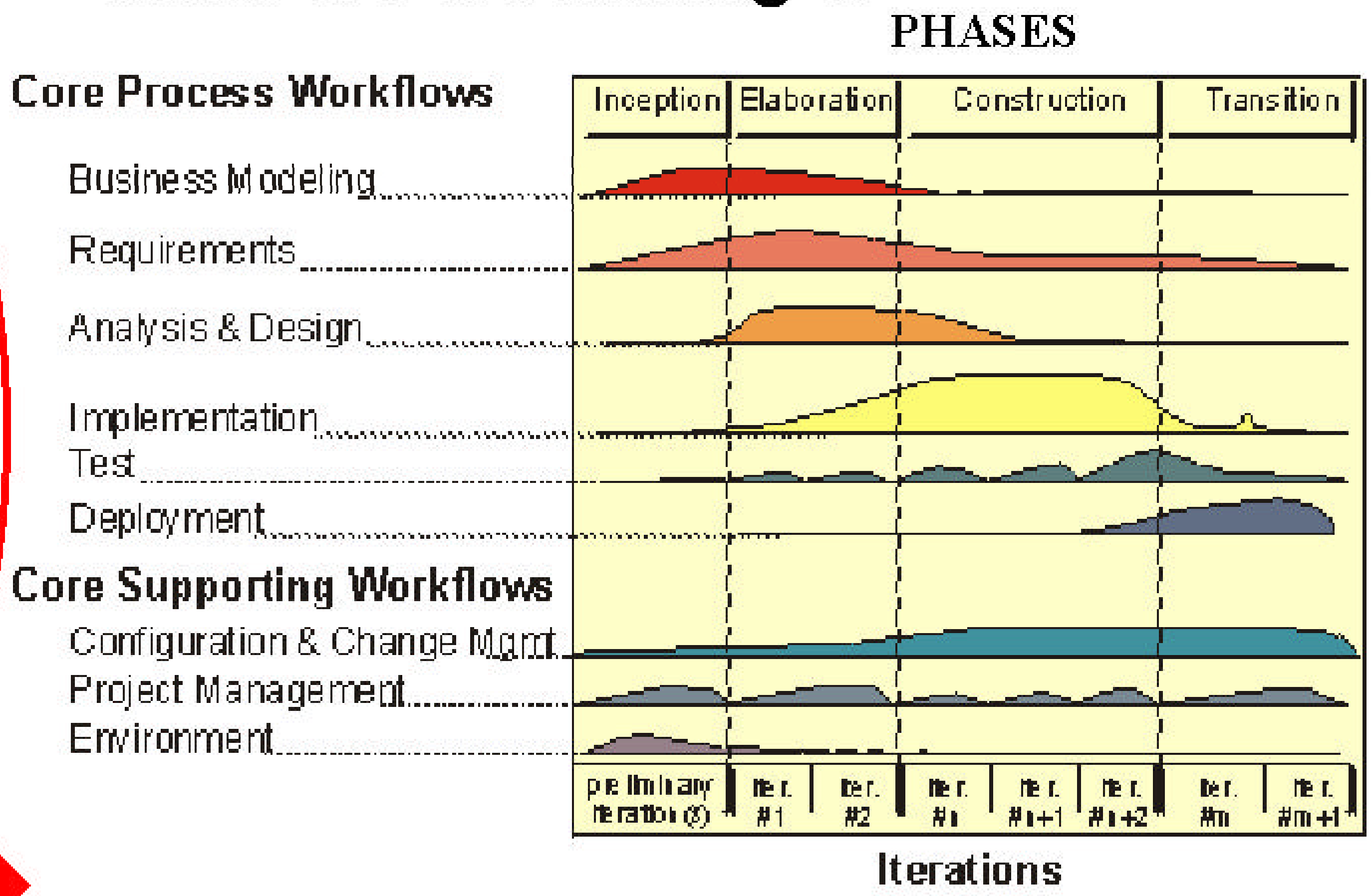
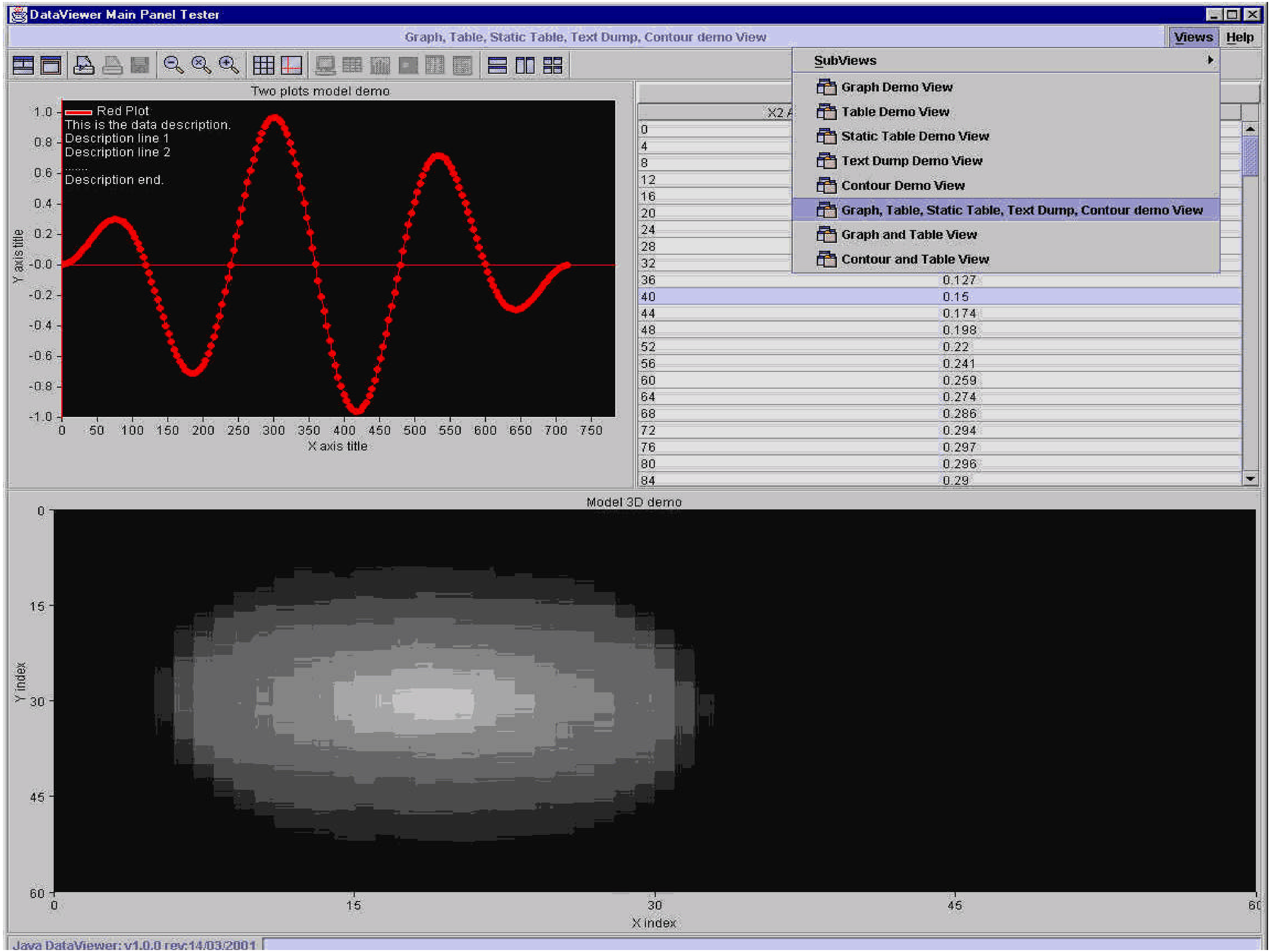
The Software Production Process

What are we talking about ?





FOCUS OF THIS TALK


DataViewer Main Panel Tester
Graph, Table, Static Table, Text Dump, Contour demo View
Views
Help
SubViews
Graph Demo View
Table Demo View
Static Table Demo View
Text Dump Demo View
Contour Demo View
Graph, Table, Static Table, Text Dump, Contour demo View
Graph and Table View
Contour and Table View
Two plots model demo
Red Plot
This is the data description.
Description line 1
Description line 2
Description end.
Y axis title
X axis title
Model 3D demo
Y index
X index
Java DataViewer: v1.0.0 rev:14/03/2001

Issues

- *LHC will use modern software environment*
- *Is there a requirement for a scripting language: TCL/TK, Perl, Python ?*
- *Is software testing an issue?*
- *SCADA is not the appropriate tool for complex accelerator modelling and parameter management*

Conclusions

LHC-CP has

- set up a framework for communication across the 5 divisions involved: workshops, project meetings, core team
- created sub-projects for technical work and connected to existing working groups on Middleware, Timing, Front Ends
- made good progress on the goals set at the 1st Workshop (April 2000)

Conclusions

- Top level use case and analysis is confirmed as the obvious best way to proceed on solid ground
- Parallel initiatives into other areas are proving useful and this will be expanded into database, post mortem …
- We need to get behind the hardware sharing and the planning initiatives!

Conclusions

- Technology requirements are not an issue
- Technology evolution presents challenges - use standards where possible
- The LHC-CP approach is the right way to go - it would feel better if we were going faster
- The 3rd LHC-CP Workshop will be in April 200~~1~~2