ACCELERATOR COMPUTING INFRASTRUCTURE & CONTROLS R&D

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WORK TO CARRY OUT

	`	2011	2012	2013	2014	2015	2016	2017
WP7	**Computing & Controls**							
	• *Infrastructure design, test & development*							
	• *Controls library*							
	• *Frontend & drivers*							
	• *Users interface*							
	• *High Level Software*							
	• *Accelerator code vs controls interface*							
	• *Logbook & trouble ticket*							
	• *Identification & Security*							
	• *Web tools, data access, and experiment data correlation*							
	• *Electronic Management Data System*							
	• *Project Management Data System*							
	• *Remote Control Room*							
	• *Accelerator infrastructure subsystems interface*							

DELIVERABLES

Work package number	7	Start date or starting event:	2010			
Work package title	Computing & Controls					
Participant	LNF	ROMA2	LAL			
Person-months per participant:	4	1.5	1			

Objectives: design, develop and maintenance of a computing infrastructure and a controls system for the superB project.

Description of work: SuperB Accelerator requires a large amount of computing tools, essentially dedicated to tree different purpose: implementation and maintenance of documentation and project management; beam simulation and controls; data monitors, presentation and correlation with the experiment. In the mean time those tools requires identification, security, accessibility for large and international community. Last but not list could be an opportunity to develop new concepts in accelerators controls and constitute a new computing infrastructure

D7.1) Computing infrastructure: design, develop and maintain a computing infrastructure with the following purpose: implementation and maintenance of an Electronics Management Data System (EMDS) dedicated to the storing and presentation of all (accelerators & experiment) project documents, cads, etc; implementation and maintenance of a Project Management Data System (PDS), for the accelerator and experiment, in order to efficiently allocate and monitors efforts and costs; develop a common infrastructure and tools with the experiment in order to share and correlate data; implementation and maintenance of accelerator simulation code FARM server sand services; implementation and maintenance of server and service needed for the beam controls.

D7.2) Software infrastructure, Control Systems: design, develop and maintain a control system for the accelerator device providing the possibility to integrate very fast data acquisition, interface with experiment data, electronic logbook, trouble ticket, high level software, simulation code interface. The work to be done can be divided in: design and implementation of the controls system libraries; development and implementation of the drivers, and interface with accelerators device; development and implementation of the user interface and high level accelerators software; development and implementation accelerator infrastructure interface to monitor and controls subsystems device like PLC, field bus, etc (electrical, fluid, etc installations); design and develop accelerator simulation code interface and controls systems in order to permit an easy and standardized data flow; implementation and development of an accelerator logbook and trouble ticketing system in order to monitors, store and allows statistics on accelerator devices and subsystems; design and develop web tools for public and private data presentation and correlation, online analysis, and monitoring.

D7.3) Users infrastructure, remote Control Room: D1 and D2 concourse to constitute the users infrastructure, where hardware and software tools are available for controlling, monitors accelerator's data and handle the SuperB project. All the above structure (hardware and software) requires a safe identification of participants to the projects and the study and implementation of collaborating tools for the large international community. In the mean time the implementation and maintenance of a Remote Control Room is needed in order to permit large collaboration and participation of the international SuperB accelerator community.

- design, develop and maintain the **computing infrastructure**
- design, develop and maintain the **software infrastructure** and **Controls System**
- design, develop and maintain the **user interface, identification** and **security** and **remote control room**

ACCELERATOR FARM

- is under installation a computer **FARM** dedicated to accelerators simulation & calculation code
- 5/16 slot rack equipped with blede 2 processor Intel Xeon X5660, 64 bit esa-core,2,80 GHz, 48 GB RAM, FiberChannel, GigabitEthernet dual.
  - simulation and calculation code: HFSS, GdFidL, MatLab, Mathematica, OPERA, ORCAD, inventor, FLUKA, GEANT, MCNPX, ANSYS
  - Controls R&D: Labview, memcache, mongoDB, etc
- hardware has been installed in April 2011. FARM configuration under the LNF computing infrastructure is going on. First test, software installation and configuration are also started. The FARM is foreseen be ready for users in June.

CONTROLS **SUPERB** R&D

- we would like to follow today **software trends** dominated by web technologies and services where *large database* are used and very high *throughput* is needed on the largest and robust available data bus: *ethernet*

- be free to implement **any kind of devices** reducing the hardware dependence and development time

- exploit the availability of many **programable cpu embedded devices**

- be able **controls** and where needed **acquire** data with performance limited only by hardware availability

→ move from polling to pushing based system
introducing new different feature to be exploited

IDEA...

- design a system where use the knowhow and tools coming from large amount data handling like in google, facebook, etc that means **no relational DB** where store live and history data with very high performance.

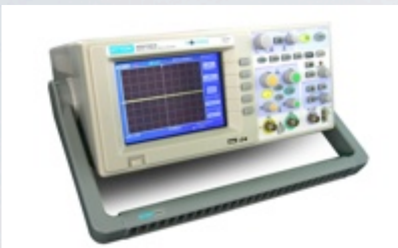
- all devices are completely independent and auto-configuring directly (semantics and syntax) in a **metadata server** allowing easy and fast data retrievement

- development on any different software and hardware platform

- to produce a **Control System Library** permitting to reduce the development needs only to the core part connected to the specific hardware device

EMBEDDED / CONTROLLED DEVICES

CPU embedded devices



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CPU controlled devices

PCs, arduino, rabbit, etc any controller over eth.

...

complex IO controllers
PLC, DAQ (VME, PXI, etc)

...

DATA CATEGORIES AND THROUGHPUTS

- data can be divided essentially in three different type:
  - **slow data** (a few bytes @ Hz)
    - eg: magnets, vacuum, temperature, etc
  - **fast data** (Kbytes of bytes @ kHz)
    - eg: BPM, beam lost monitor, luminosity monitor, synchronized bump, etc

continuos data

- **very fast data** (Mbytes @ GHz)
  - eg: BPM single pass, scope, RF, etc

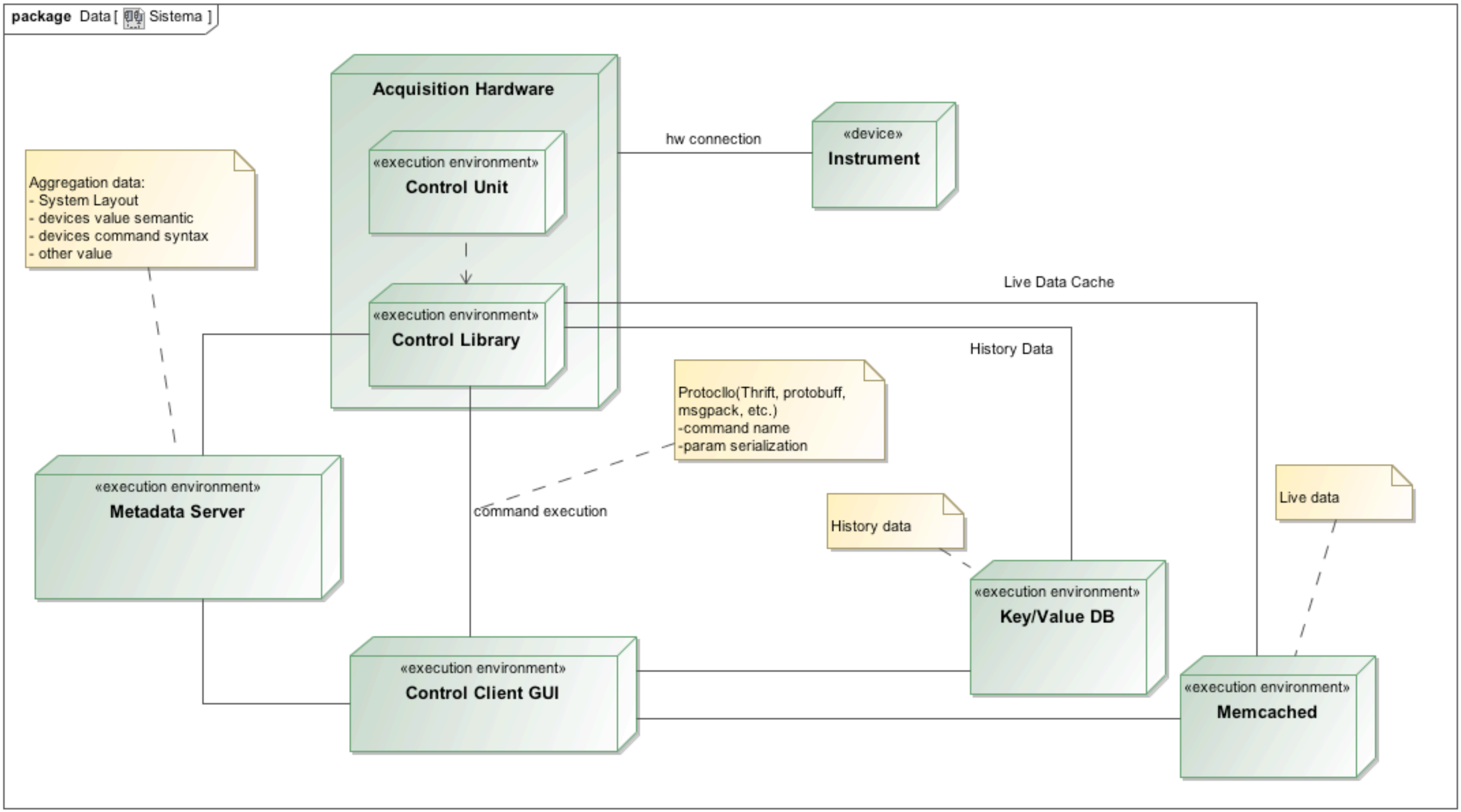
data bursted, limited by hardware and software dead time

DATA LOAD ESTIMATION

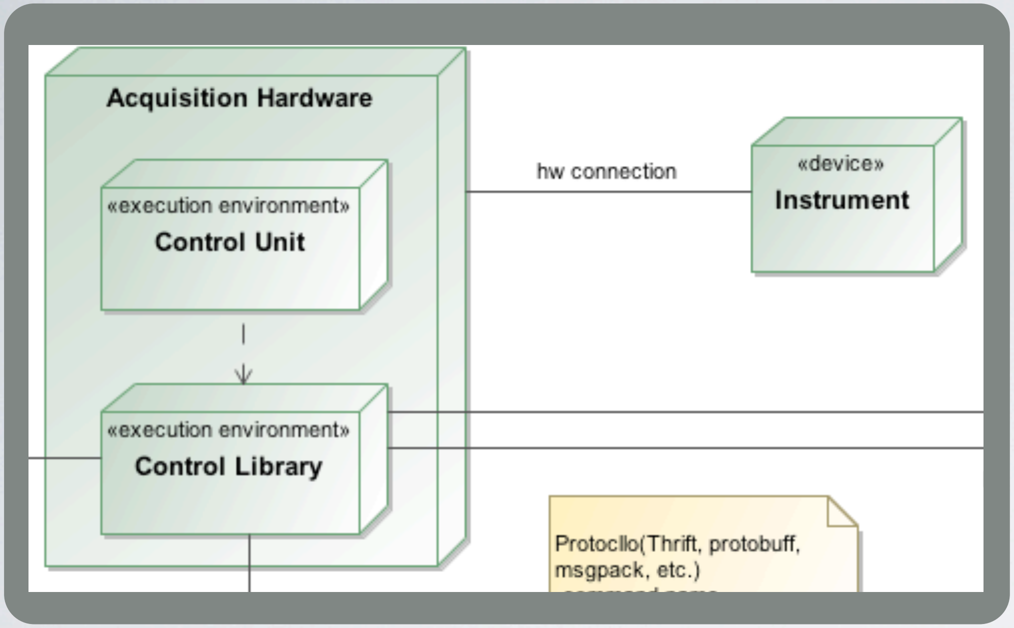
Elments	#@DAFNE	Data size [byte]	Frequency [Hz]	Throughput [Kb/s]	Frequancy S [Hz]
power supply	500	96	10	480	0.5
beam position monitors	80	32	50	128	50
BPM turn by turn	80	20000	2	3200	0
flags and screens	20	2000000	10	400000	0
sycrotron light monitors	3	2000000	30	180000	30
luminosity monitors	1	1000	1000	1000	1000
temperature monitors	100	32	1	3.2	1
beam loss monitors	50	32	50	80	1
current monitors	20	32	50	32	1
vacuum moniotrs	100	32	10	32	0.1
cryogenic system	1	1000	5	5	
RF system	3	1000	50	150	
injection system	1	1000	50	50	
scopes	10	10000	50	5000	
spectrum analyzer	2	10000	50	1000	
timing system	1	1000	50	50	
feedback system	6	10000	50	3000	
cleaning electrods, wire etc	20	64	1	1.28	
scrapers, slits, etc	20	64	1	1.28	
plc, termostick, flxmeter	2000	32	1	64	
Total [Mb/s]				594.28	1.08

just an exercise...

SYSTEM DATA FLOW



FRONT END



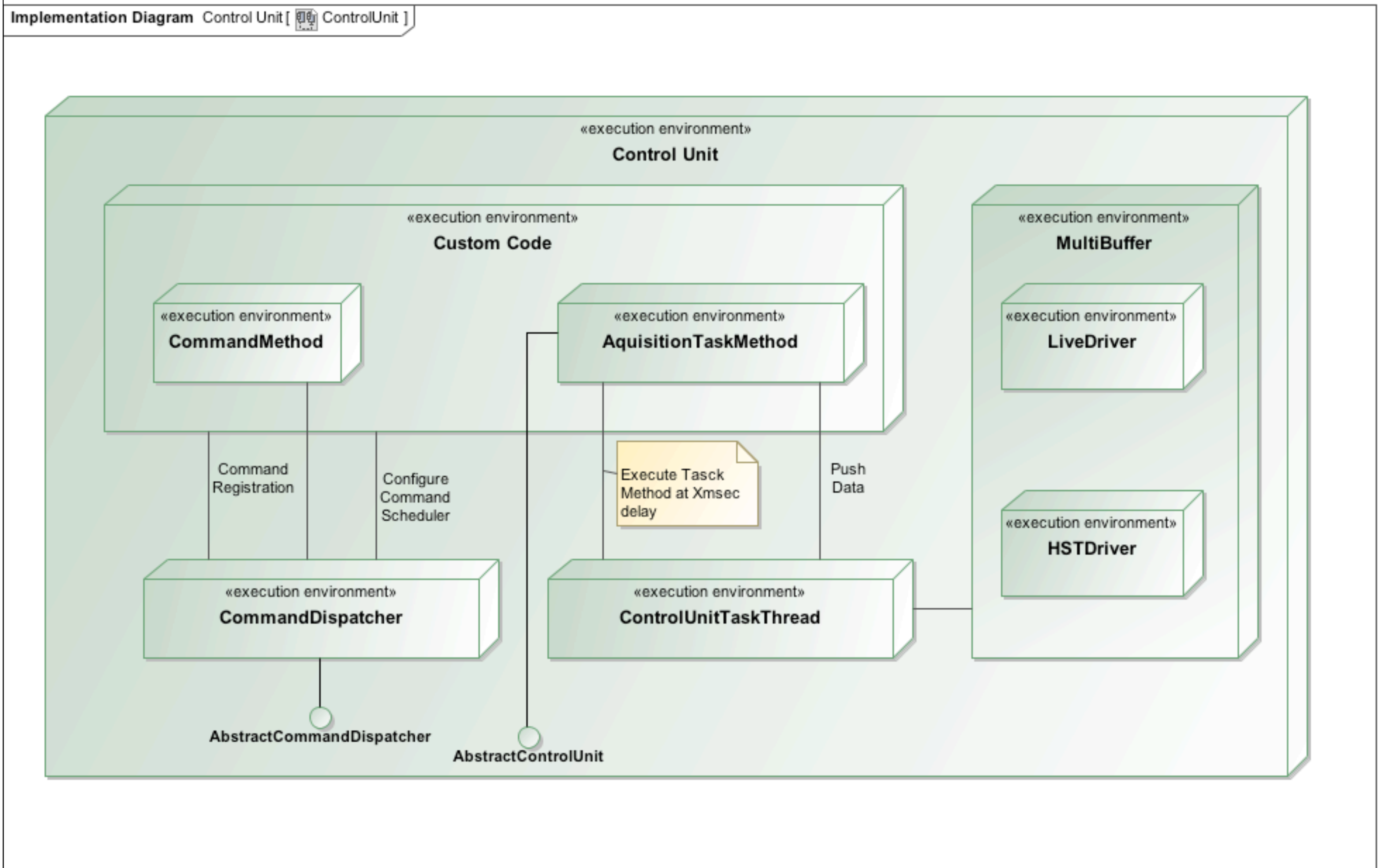
- **CPU embedded devices**
- **CPU controlled devices**
- **Complex IO controllers PLC, DAQ (VME, PXI, etc)**

The **Control Unit** (*CU*) is the user software (*driver*) to be interfaced with the **Control Library** (CUCL) a multi task process that provides:

- to handle input (*command*) and output (*readout*) data;
- to initialize and configure data flow (type, frequency, etc)

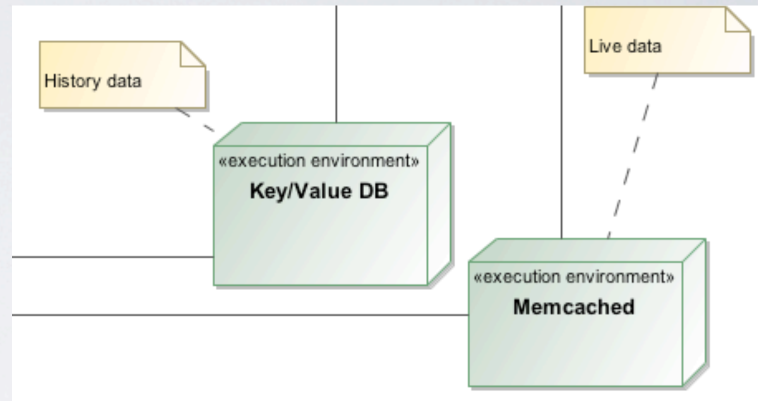
the **front end** gets device configurations from the **meta data server** where in mean time it auto-configure all data semantics and syntax

CONTROL UNIT DATA FLOW



LIVE CACHE AND HISTORY DB

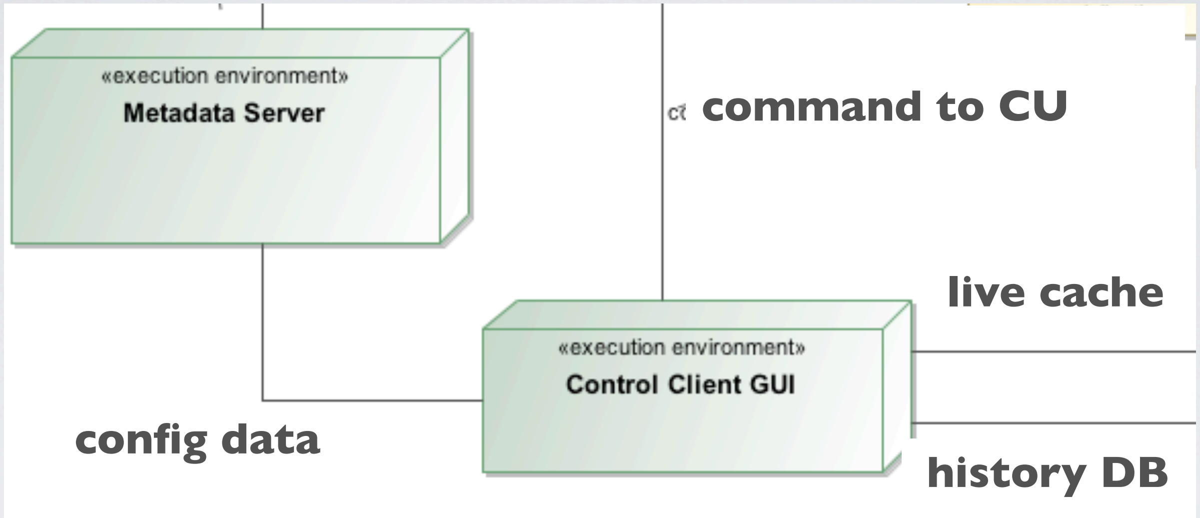
Data acquired by CU (*cu clock*) are updated in two **no relational DB** (*key/value*):



- **live-cache** (*live clock*)
- **history** (*history clock*)

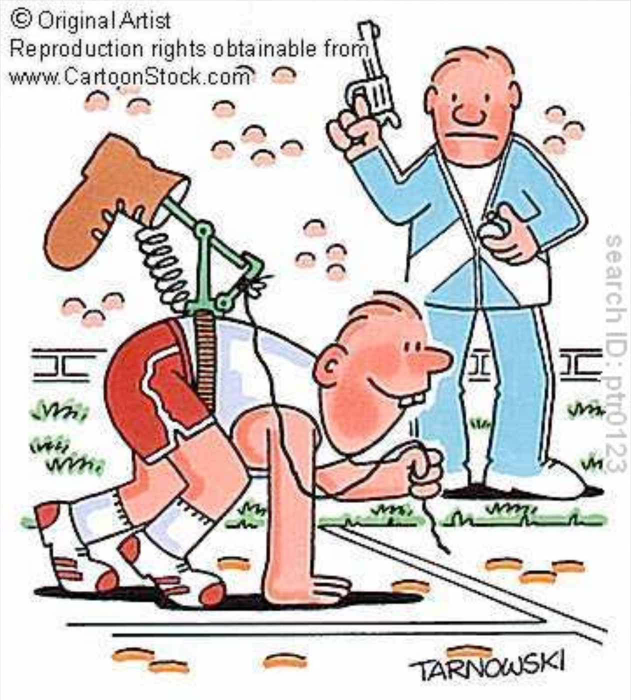
for bought the solutions, candidates under tests are two free open-source software: **MongoDB** - from "humongous" - is a scalable, high-performance, open source, document-oriented database & **Memcached** a free & open source, high-performance, distributed memory object caching system

USER INTERFACE TOOLKIT



The **User Interface Toolkit** (UITK) retrieves all configuration information to access data and control devices from the **Metadata Server** previously updated by front end; The Graphic User Interface provides the live and archived data representation and correlation

TIMING

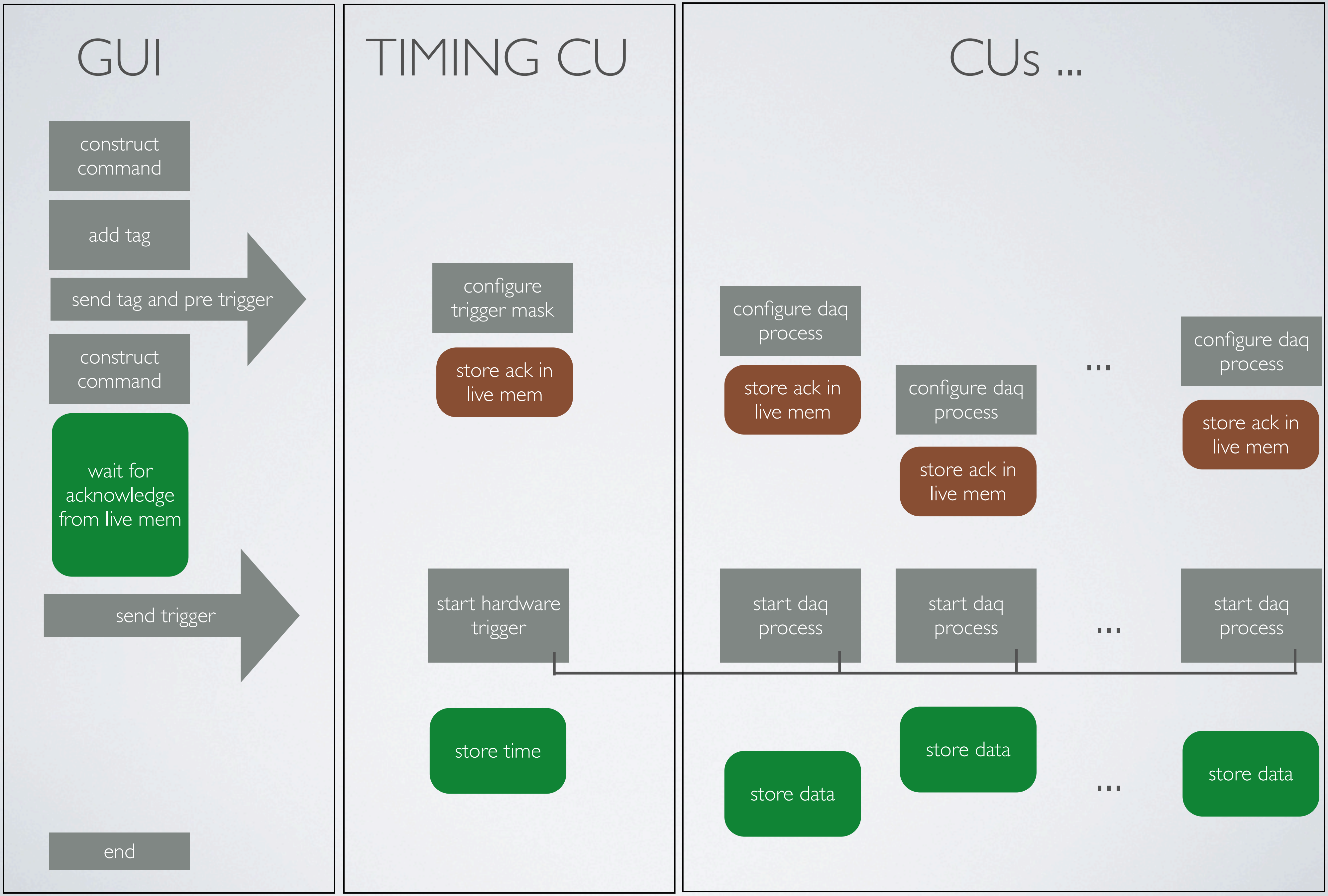


- **TAG** events data with **µs** precision
- **synchronize** (jitter) data with **ps** precision
- allows maximum **repetition rate** with a minimum dead time respect to accelerator event determinate by injection frequency **100 Hz**

HOW TO TIMING DATA

- any controller/device is **NTP/PTP synchronized**
- a timing system distribute and provide hardware trigger (TTL/NIM) to any different controller/device needs a timing accuracy greater then milliseconds
- **PRE TRIGGER** command mask configure controllers/devices to execute a specific task and pre configure the **timing controller** to dispatch a specific mask to the controllers/devices.
- any pre trigger mask is flagged with a specific **timing TAG**
- **TRIGGER** command to timing controller latch time stamp and send hardware trigger to controllers/devices
- data from controllers/devices and timing controller are **updated** with their own duty cycle in the live/history data

DAQ TIMING FLOW



CONCLUSION

- **Controls R&D**, based on this new concepts and on the knowhow of INFN accelerators personnel, **started** - see next talk - and we are open to match and integrate new and different idea
- Accelerators **computing infrastructure is under design**, and need to be soon interface with the experiment and integrated with diagnostics, timing and by further scientific hints
- We are working to **expand the community** of people interested in developing computing infrastructure, codes, controls and diagnostic, drivers, etc.

SPARE

RELATED TASKS

- **computing interface**
  - logbook & trouble ticket
  - data presenter & web tools
  - security
  - data server, processing, access
  - Electronic Management Data System
  - Project Management Data System
  - *Remote Control Room*

RELATED TASKS CONT.

- **Front end drivers and CU development**
- **User Interface**
- **High Level Software**
- **Accelerator Simulation codes**
- **Accelerator code interface vs control system**

RELATED TASKS CONT.

- **timing system**
  - custom or adapted choice (white rabbit or similar)?
  - requirements and/or R&D needed
  - coordination with diagnostics, controls system, experimental group
- **interface vs subsystems** (PLC, field bus, etc)

RELATED TASKS CONT.

- **diagnostics**
  - requirements and R&D
  - custom, adapted and commercial choices
  - coordination with timing and controls system
- **feedback systems** (longitudinal/transversal/luminosity/orbit, etc)

RELATED TASKS CONT.

- **luminosity monitor**
- **radio frequency system**
- **injection system**
- **magnets & power supply**
- **vacuum system**
- **cooling system**
- **cryogenic system**

(Bold: computed values)		V12		V13		V14	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	cm^{-2} s^{-1}	1.00E+36		1.10E+36		1.11E+36	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18
Circumference	m	1258.4		1263.5		1159.5	
X-Angle (full)	mrad	66		60		60	
β_x @ IP	cm	2.6	3.2	2.6	3.2	2.6	3.2
β_y @ IP	cm	0.0253	0.0205	0.0253	0.0205	0.0253	0.0205
Coupling (full current)	%	0.25	0.25	0.25	0.25	0.25	0.25
Emittance x (without IBS)	nm	1.97	1.82	2.09	1.93	1.90	1.82
Emittance x (with IBS)	nm	2.07	2.37	2.19	2.51	2.00	2.37
Emittance y	pm	5.17	5.92	5.49	6.27	4.99	5.92
Bunch length (zero current)	mm	4.69	4.29	4.8	4.4	4.53	4.29
Bunch length (full current)	mm	5	5	5	5	5	5
Beam current	mA	1892	2447	1930	2470	1892	2447
Buckets distance	#	2		2		2	
Buckets distance	ns	4.20		4.20		4.20	
Ion gap	%	2		2		2	
RF frequency	Hz	4.76E+08		4.76E+08		4.76E+08	
Revolution frequency	Hz	2.38E+05		2.37E+05		2.59E+05	
Harmonic number	#	1998		2006		1841	
Number of bunches	#	978		982		901	
N. Particle/bunch	#	5.08E+10	6.56E+10	5.18E+10	6.63E+10	5.08E+10	6.57E+10
σ_x @ IP	microns	7.334	8.701	7.554	8.960	7.202	8.701
σ_y @ IP	microns	0.036	0.035	0.037	0.036	0.036	0.035
$\sigma_{x'}$ @ IP	microrad	282.1	271.9	290.5	280.0	277.0	271.9
$\sigma_{y'}$ @ IP	microrad	143.0	169.9	147.3	174.9	140.4	169.9
Piwinski angle	rad	22.50	18.96	19.86	16.74	20.83	17.24
σ_x effective	microns	165.22	165.29	150.24	150.31	150.22	150.30
Σ_x	microns	11.379		11.719		11.295	
Σ_y	microns	0.050		0.052		0.050	
Σ_x effective	microns	233.35		212.13		212.13	
Hourglass reduction factor		0.950		0.950		0.950	
Tune shift x		0.0021	0.0033	0.0026	0.0040	0.0026	0.0040
Tune shift y		0.0989	0.0955	0.1067	0.1041	0.1089	0.1070
Longitudinal damping time	msec	13.4	20.3	13.6	20.6	11.6	20.3
Energy Loss/turn	MeV	2.11	0.865	2.08	0.88	2.24	0.865
Momentum compaction		4.36E-04	4.05E-04	4.69E-04	4.35E-04	4.60E-04	4.05E-04
Energy spread (zero current)	dE/E	6.31E-04	6.68E-04	6.30E-04	6.68E-04	6.52E-04	6.68E-04
Energy spread (full current)	dE/E	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.64E-04	7.34E-04
CM energy spread	dE/E	5.00E-04		5.00E-04		5.11E-04	
Energy acceptance	dE/E	0.01	0.01	0.01	0.01	0.01	0.01
SR power loss	MW	3.99	2.12	4.01	2.17	4.24	2.12
Touschek lifetime	min	33	16	33	16	33	16
Luminosity lifetime	min	4.81	6.22	4.48	5.73	3.99	5.16
Total lifetime	min	4.20	4.48	3.94	4.22	3.56	3.90
RF Wall Plug Power (SR only)	MW	12.22		12.38		12.71	
Total RF Wall Plug Power	MW	17.08					