LAUC Status & Issues

S. Peggs

Overview

Proposed Contributions

- Beam Separation Dipoles
- Feedboxes
- Magnet System Engineering
- Collimators
- Laser Profile Monitors
- Linac4 Low Level RF

Summary

Aymar's "mission need" letter to Orbach, Jan 08

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Dr. Raymond L. Orbach
Under Secretary for Science
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC, 20585
USA

Your reference:
Our reference: DG-2008-016-O

Geneva, 14th January 2008

Dear Dr. Orbach:

Following the CERN "white paper initiatives" and the European Steering Group for R&D (ESGARD) recommendations for the LHC Interaction Region (IR) upgrade, the CERN Council has approved a 240 MCHF program to improve the current accelerator infrastructure. This is the first step in a comprehensive plan to increase the LHC performance beyond the nominal design luminosity of 10^{34} cm^{-2} sec^{-1}. The goal of this first initiative is to overcome currently known performance limitations in the LHC, opening the possibility for an ultimate performance with a peak luminosity of 2-3 10^{34} cm^{-2}s^{-1} by 2013. In a second initiative, an upgrade program aiming at a tenfold increase of the nominal LHC performance will follow, with an earliest implementation by 2017. These significant improvements in luminosity are guaranteed to enhance the Physics performance of the LHC, both by expanding the experimental reach of the ATLAS and CMS detectors, and by speeding up the attainment of results.

To succeed, the first initiative requires assistance from non-member states, and last summer I solicited support for accelerator development and resources from outside of CERN. The need for U.S. contributions to this initial effort is clear, since the U.S. labs possess a toolbox of unique skills that can be exploited to ensure that the ultimate luminosities can be achieved. Preliminary discussions have already taken place between U.S. and CERN representatives, examining potential contributions such as interaction region magnets and collimators – both of which are essential components in the first initiative.

We are eager to work with you to create a well-defined, realistic proposal, fully supported by CERN management and by the U.S. Department of Energy, for the delivery of U.S. contributions to the first initiative.

Yours sincerely,

Cordially

Robert Aymar

"… overcome currently known performance limitations … for … a peak luminosity of 2-3 10^{34}cm^{-2}s^{-1} by 2013."

"The need for U.S. contributions to this initial effort is clear, since the U.S. labs possess a toolbox of unique skills …"

Heuer's P5 “closing mandate”

General Remarks -3-

Collaboration in network of HEP laboratories/institutes
in Europe, Americas, Asia

Mandatory to have accelerator laboratories in all regions
as partners in accelerator development / construction /
commissiong / exploitation

Planning and execution of HEP projects today
need global partnership

Use the exciting times ahead to establish such a partnership

Garoby at "Beam07"

Conclusion

- The pace of work is good and will accelerate in the near future.
- We have to strengthen our links with the community and establish new collaborations.

We need You !

R.G. – 2/10/2007 LHC injectors' upgrade plan 22

Overview

SLHC-IRP1 Project

Goal for LHC Interaction Region Upgrade – Phase 1:

> "Enable focusing of the beams to $\beta^*=0.25$ m in IP1 and IP5, with reliable operation of the LHC at a luminosity of 2×10^{34} $cm^{-2}s^{-1}$, for the 2013 physics run."

Scope:

1. Replace the inner triplet quads with wider aperture quads (Nb-Ti) cooled to 1.9 K.
2. Upgrade the D1 beam separation dipoles, TAS beam absorbers etc to be compatible with the larger aperture.
3. Modify other magnets (eg D2-Q4) & introduce other equipment in the IR to the extent of available resources.
4. Maintain unchanged the of the cryogenic system cooling capacity & other main infrastructure elements.

SLHC-IRP1

Conceptual Design Report	mid 2008
Technical Design Report	mid 2009
Model quadrupole	end 2009
Pre-series quadrupole	2010
String test	2012
Installation	shutdown 2013

Work is coordinated by Ranko Ostojic, who states (Apr 08):

“CERN considers that other major items, in particular D1 dipoles, should be included as part of U.S. Contribution.”

“In addition, the existing U.S. Expertise in the domain of cryogenics, powering and quench protection should be used to the best for Phase-1 upgrade.”

Linac4 Project

In parallel to SLHC-IRP1, CERN is beginning to upgrade its injection chain.

Construction of the 160 MeV normal conducting H- Linac4 started in January 2008, to be completed in 2012.

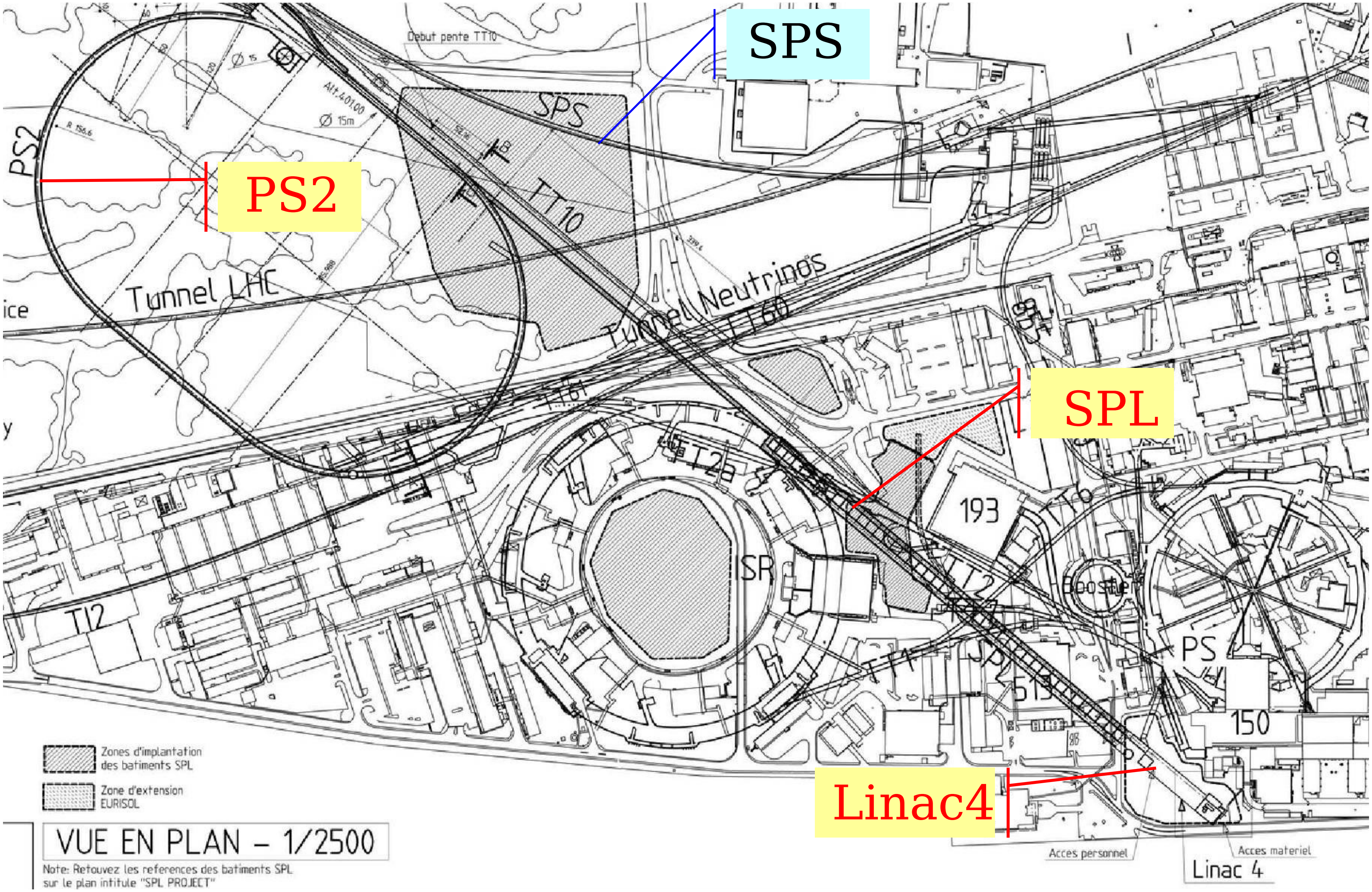
Linac4 will double the brightness & intensity of the output beam, moving towards higher luminosity in the LHC

(Opens the door to future injector upgrades, eg 4 GeV Superconducting Proton Linac [SPL] & 50 GeV [PS2].)

SLHC-IRP1+Linac4 provide the 2013 run with a luminosity reach 2 or 3 times greater than the nominal 10^{34} $cm^{-2}s^{-1}$.

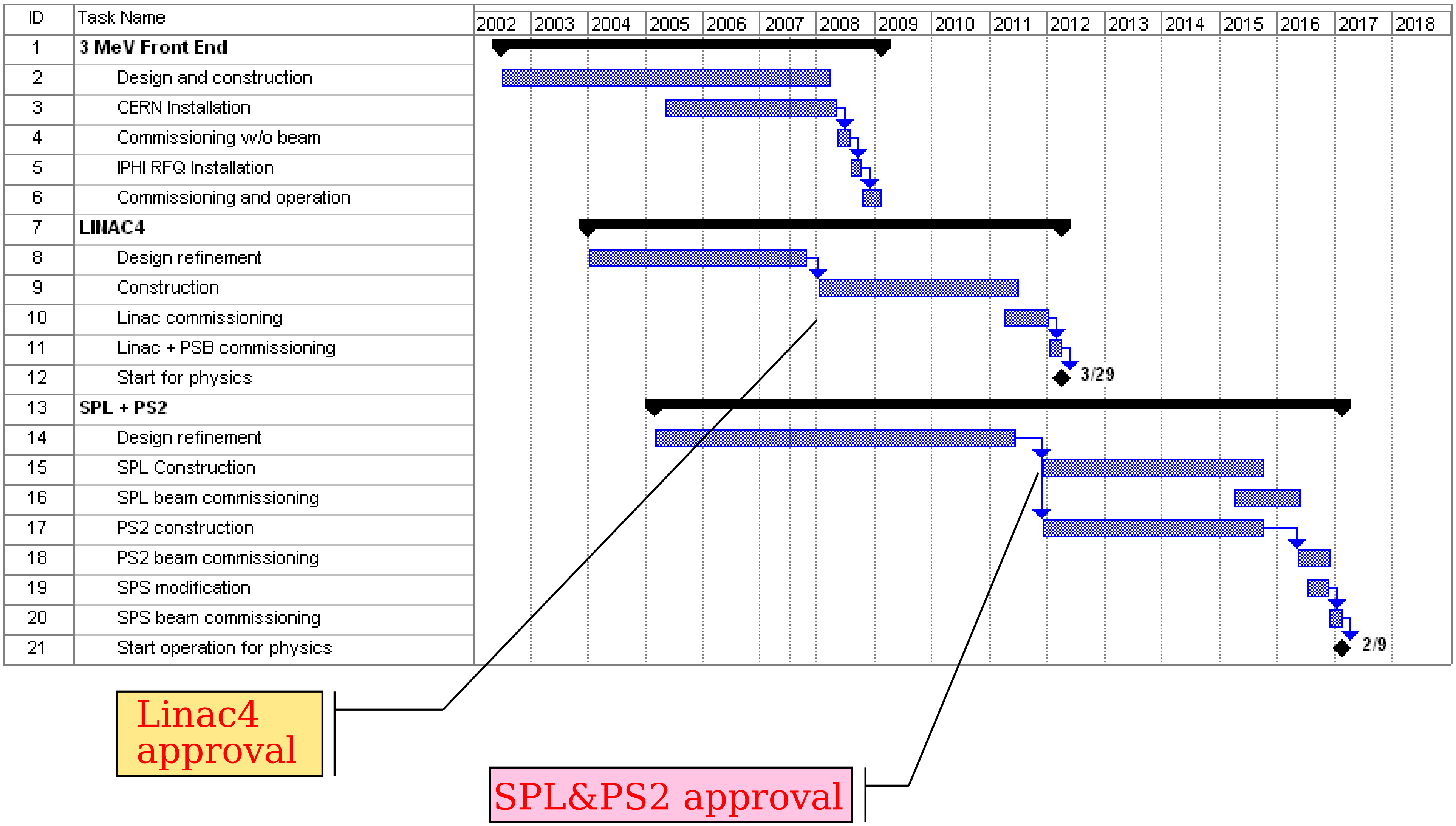
Work is co-ordinated by Maurizio Vretenar.

New Injectors



Injector schedule

Linac4 is in construction, PS2 is in R&D



LAUC integration with CERN

Continued participation in IR upgrades provides U.S. labs with unique technical challenges, and a means to increase the luminosity in an important and visible manner.

Major contributions to SLHC-IRP1 (& minor to Linac4) exploit unique resources & “competitive advantages”.

All LAUC contributions will be completed for the 2013 run.

CERN plans to release a fully integrated Technical Design Report (TDR) for SLHC-IRP1 in summer of 2009.

Crucial assumption: LAUC will be ready to achieve CD-2 in summer 2009, synchronized with the release and review of the CERN TDR. [Consultants please comment.]

Only then will solid LAUC project costs, schedules and scopes be confidently defined and agreed by all parties.

Top down

Total cost will not exceed $30M.

Initial construction funding in FY10, final in FY13.

Maximum funding rate will not exceed $10M/year

FY09 expenditure (by LARP) is necessary to achieve CD-2 in summer 2009.

Coarse & preliminary bottom up

	FY09	FY10	FY11	FY12	FY13	Totals
	[$M]	[$M]	[$M]	[$M]	[$M]	[$M]
Beam Separation Dipoles	0.6	3.3	5.4	5.4	0.0	14.7
Cryogenic Feedboxes	0.6	2.9	2.9	2.9	0.0	9.3
Magnet Systems Engineering	0.6	0.5	0.3	0.3	0.0	1.7
Collimators		0.4	0.8	0.8	0.0	2.0
Laser Profile Monitors	0.1	0.3	0.5	0.4	0.0	1.3
Linac4 Low Level RF	0.2	0.2	0.4	0.4	0.0	1.2
Anual Totals						
LARP (“LAUC Planning”)	2.1					2.1
LAUC		7.6	10.3	10.2	0.0	28.1

All six topics will have completed crucial R&D by FY10.

This excludes exciting long term topics – crab cavs, e-lenses, Nb3Sn quads – with great potential.

Their R&D will (typically) be performed in LARP.

Cost ranges

Critical Decision CD-1 is an approval of the selection of project activities, and the cost ranges associated with them:

"While a range of costs, schedule, and performance bound the solution/alternative, there is no committed or approved baseline until the design matures – when estimate and schedules can be defined with an acceptable degree of certainty."

Further:

"Early in the project, the cost estimates support the recommended alternative and acquisition strategy. The estimates during this early phase of a project contain considerable uncertainty"

What *is* the CD schedule?

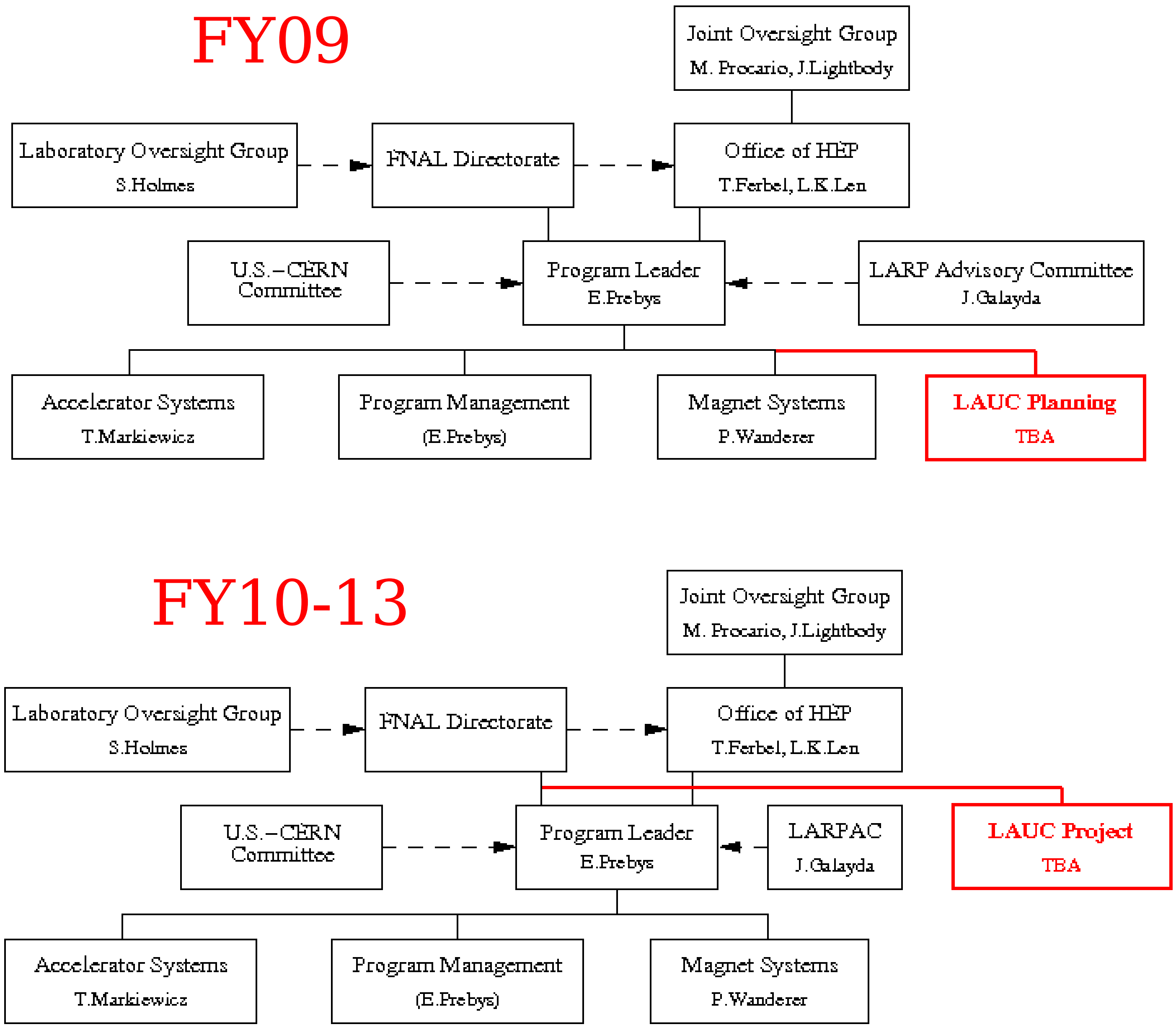
In Feb 25 we postulated:

CD-0	Approve Mission Need	Q2 FY08
CD-1	Approve Alternative and Cost Range	Q4 FY08
CD-2	Approve Performance Baseline	Q2 FY09
CD-3	Approve Start of Construction	Q2 FY10
CD-4	Approve Start of Operations	Q4 FY16

This vision must (obviously) slide.

Must not miss the CERN TDR in summer 2009.

Co-organization (synergy) with LARP



FY09:
"LAUC Planning" in parallel to Acc Sys, Mag Sys & Prog Mgmt.

FY10-13:
LAUC on a par with LARP.

Different sub-structure, shared superstructure

Beam Separation Dipoles

Why superconducting D1s?

CERN LIUWG points out that superconducting D1s have advantages over normal conducting (as now) & superferric:

- aperture can be made as large as the quadrupoles.
- longer slot length available for correctors.
- estimated cost is lower

RHIC DX magnets are available (almost) off the shelf:

“unfair competetive advantage”

Why DX?

DX 180 mm NbTi dipoles have operated trouble-free in RHIC for almost 10 years.

Small modifications would be made to the cold mass design (yokes & ends: see P. Wanderer presentation).

LAUC proposes to build 10 cold masses, assembled into 4 cryostats (plus one spare) at BNL.

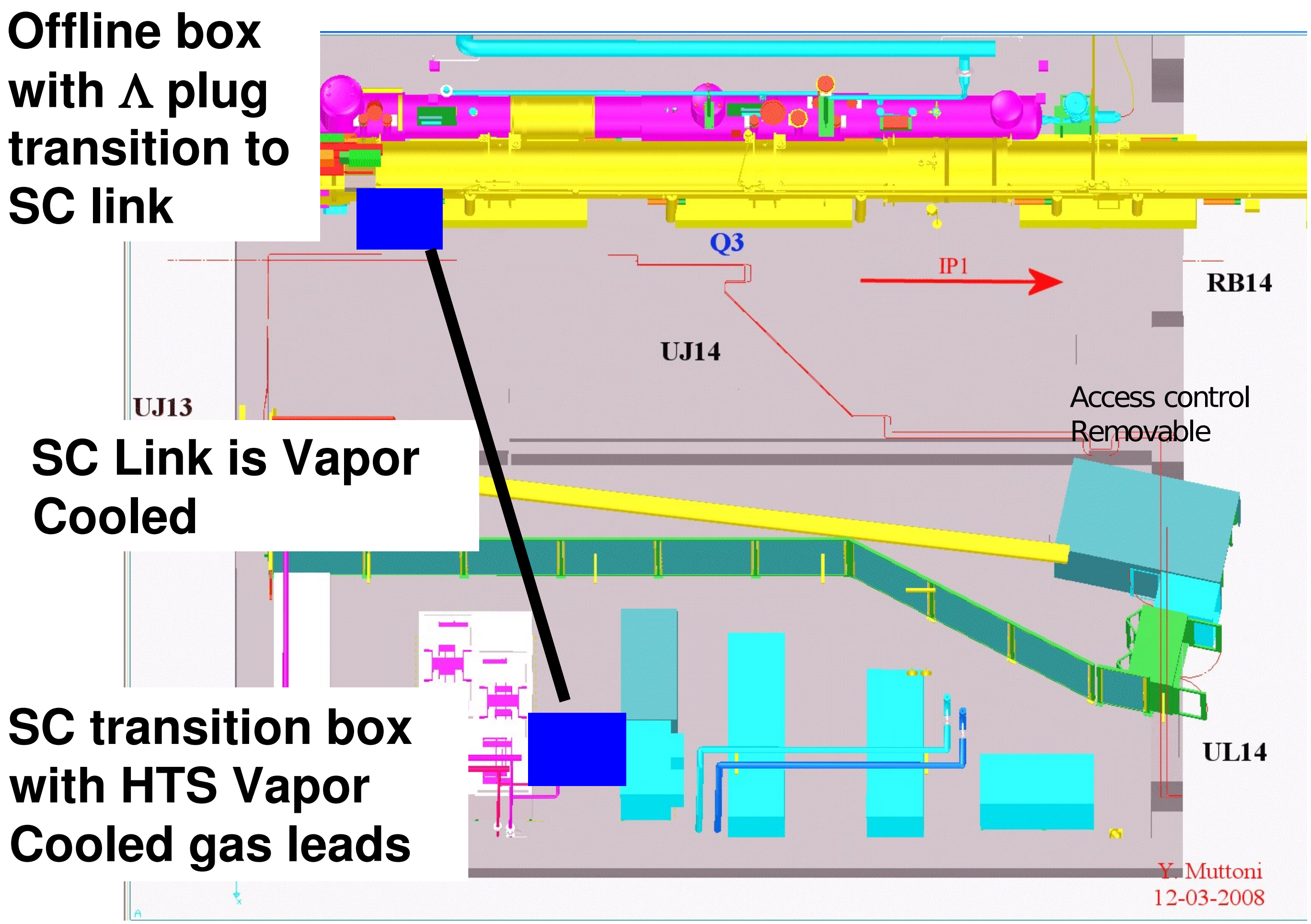
Option: deliver un-cryostatted cold masses.

Feedboxes
&
Magnet System Engineering

Cryogenic power distribution feedboxes

LAUC would build 4 feedboxes & the corresponding DC current links, using recent advances in materials to minimize costs & maximize cooling efficiency.

Current links made with HTS or MgB_2 conductors will bridge the HTS power lead box to the magnet cryostats.



Feedboxes

The U.S. is in a uniquely strong position because we designed & built the existing feedboxes, & specified & tested the existing HTS leads.

LARP supported a leading U.S. role in the hardware commissioning of both the CERN and U.S. supplied feedboxes.

System Engineering

LARP

Unique human resources are available at U.S. labs to participate in Magnet System Engineering, just as they were for the initial inner triplet implementation.

We can immediately contribute to complete system design efforts: cryogenics, power distribution, energy deposition, accelerator physics, quench protection.

The effect of the inner triplets on the luminosity is strong and complex, so it is necessary to understand the integrated system, including alignment, I&C, et cetera.

This involvement will exploit U.S. capabilities at the same time as developing them at the cutting edge.

A complete understanding of system issues will allow us to better prepare for future upgrades in follow-on construction projects.

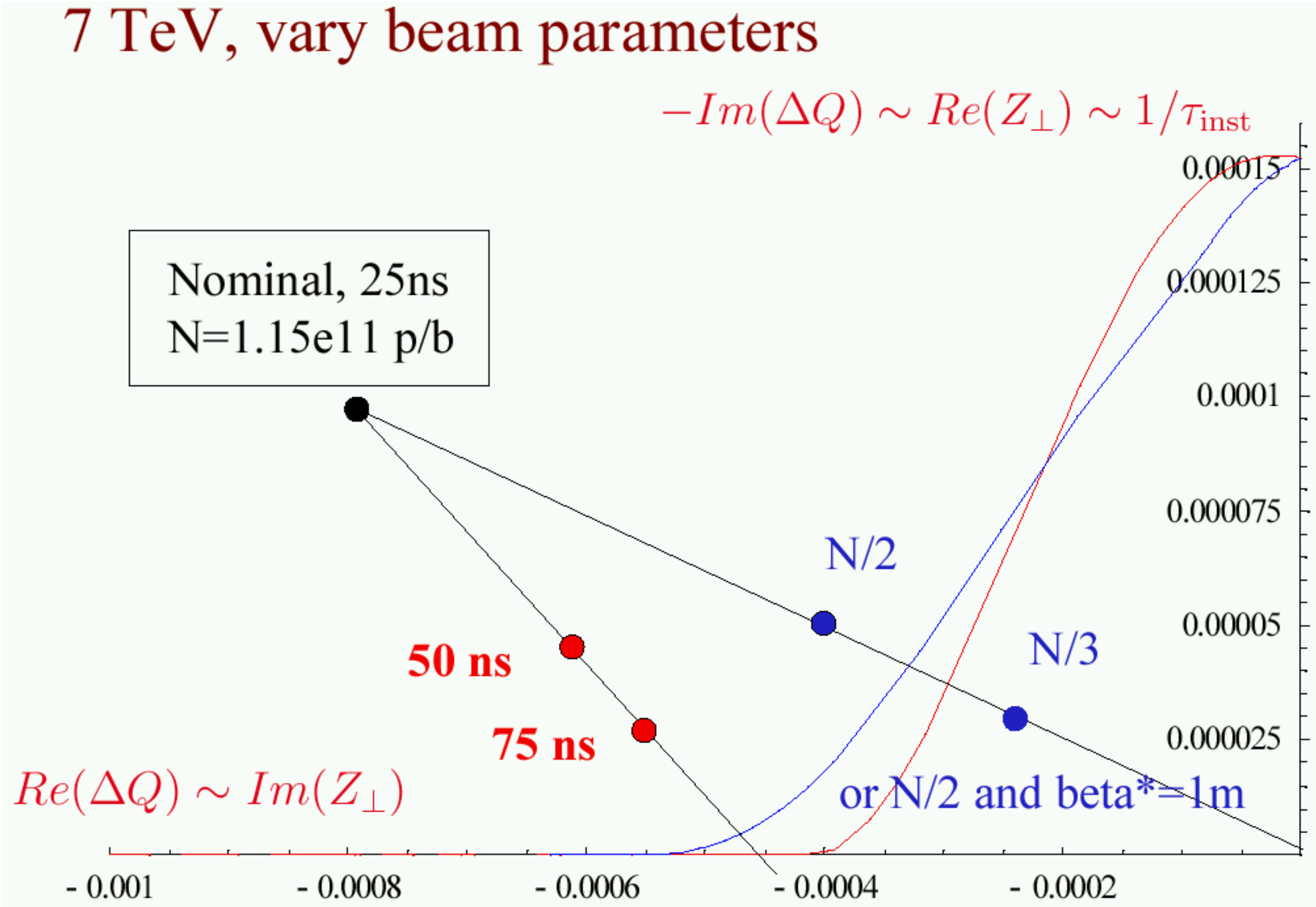
Collimators

“Overcome performance limitations”

One issue that is expected to challenge the LHC collimator system is the need to reduce the beam impedance.

Eg, larger inner triplet quad aperture enables wider collimator jaws, allowing reduced beam impedance even with an increased number of collimators.

More beam, more luminosity.
(More flexibility.)



Rotatable Collimators

The "Rotatable Collimator" (RC) design developed in LARP could play an important role in impedance reduction.

This proposal discusses the provision of 5 RCs – 4 plus one spare – as part of a broader "Phase-II Collimator" program.

The strawman proposal may need alteration before CD-2, depending (for example) on

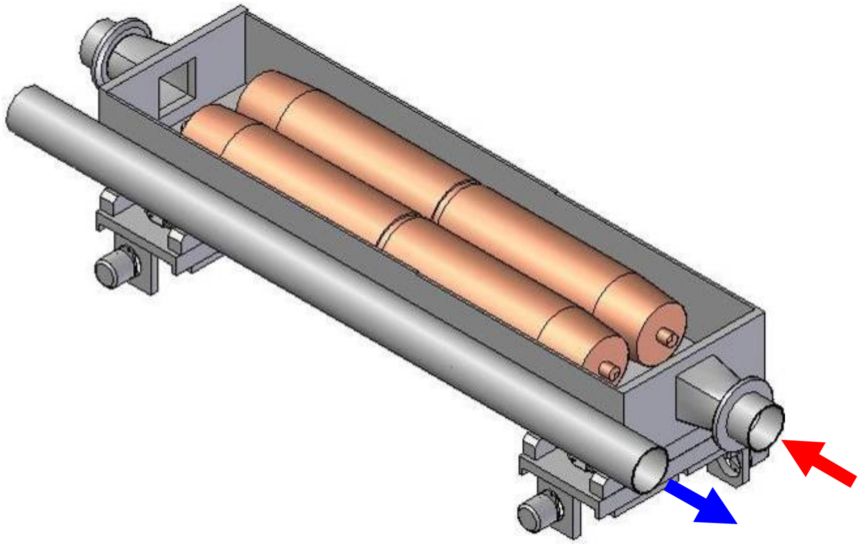
- real experience with beam
- the broader "Phase-II Collimator" plan

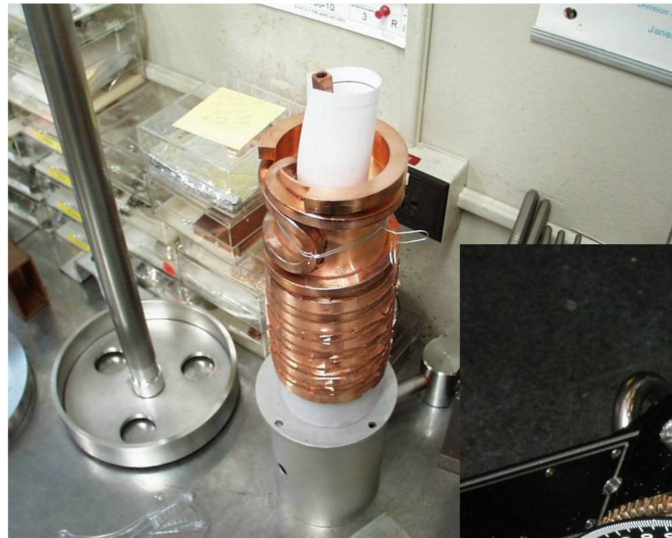
In all scenarios – however many RCs – the LAUC effort would work in a tight collaboration with the CERN groups.

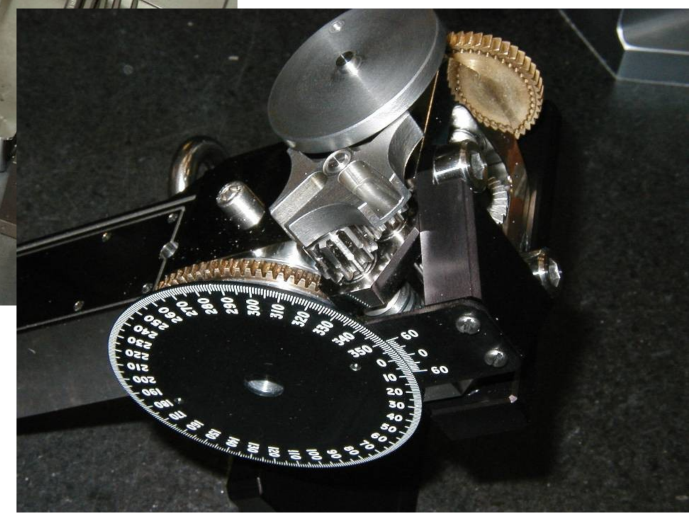
The "Phase-II Collimator" program overlaps the SLHC-IRP1 project.

(Assmann plans a collimation review in August or fall 08 – AFTER the June CDR – we should join if possible.)

R&D







LAUC inclusion assumes that an RC prototype is validated in beam tests in mid-2009 at CERN.

Good example of LARP-LAUC synergy.

Other (non-LAUC) collimation issues

Off-momentum particles scrape at “missing dipole” locations in dispersion suppressors.

Solutions?: Cold collimator "catchers". Or install warm-to-cold transitions ….

Collimator set up time. 48 hours/ring, once per month.

Solutions?: (retro-fit?) pick ups at each end of each jaw.

Diffusive kick in primary collimator too small.

Solution?: crystal collimator primary.

Laser Profile Monitors
&
Linac4 Low Level RF

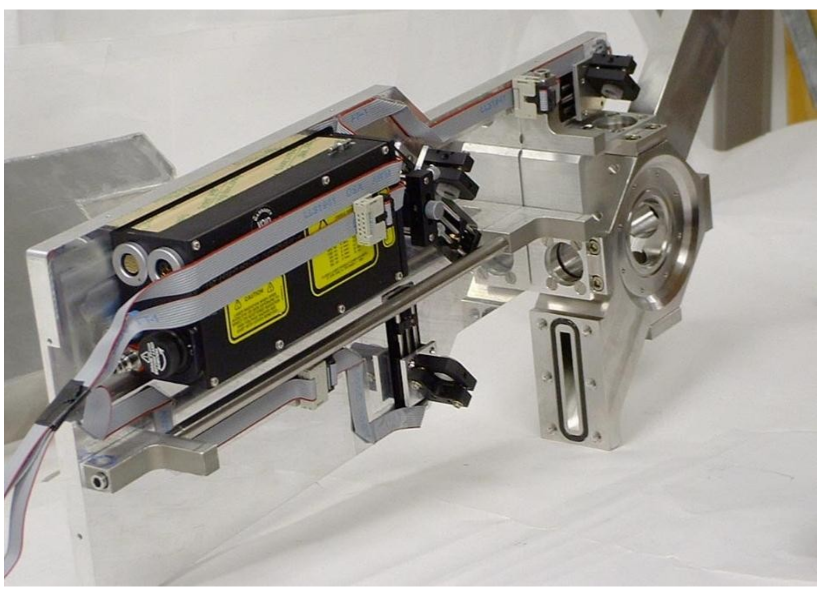
Laser Profile Monitors

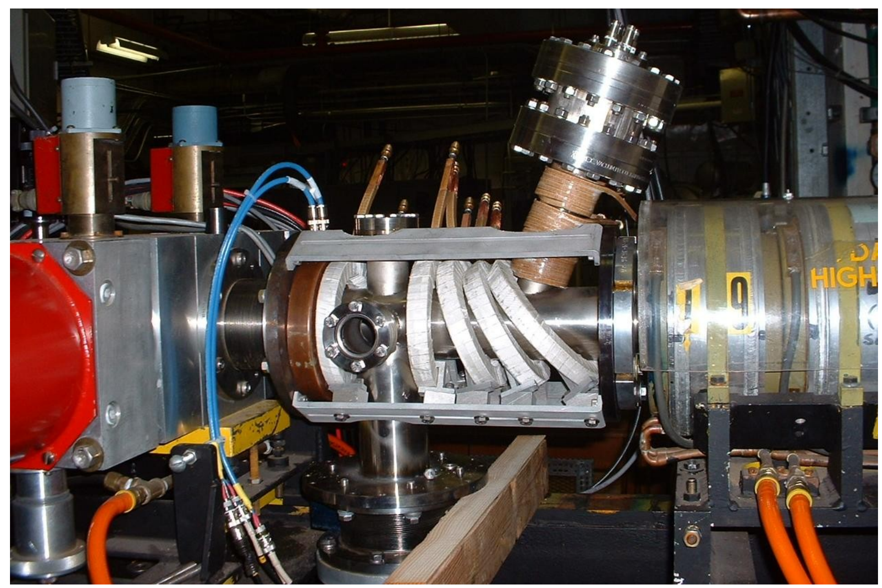
LPMs enable non-destructive observation of H- beams, with no risk to the vacuum system in accident scenarios.

They are fast in action – full profiles in Linac4 will be measured within a single linac pulse.

LAUC proposes to deliver 3 stations, for installation in the transfer line downstream of Linac4.

Builds on the recent innovative success, as in the SNS, and also as tested at BNL for potential use at FNAL.





Linac4 LLRF

The Linac4 Low Level RF (LLRF) contribution provides the firmware that implements the feedback loops of cavity and beam control in the single FPGA that would also perform all the required networking and data transfer tasks.

It is based on the innovative and unique core firmware that is presently operating the SNS linac LLRF.

CERN would remain responsible to design and build the hardware and controls interfaces, in a close collaboration with the US. participants.

Future extension into SPS & SPL?

Summary

Summary

1) LARP & LAUC are separate, with co-ordinated strategies.

2) LAUC MUST keep pace with CERN TDR in summer 2009, achieving CD-2.

3) LARP support is necessary in FY09 for LAUC Planning.

4) Top down: Less than $30M total from FY10 to FY13, at less than $10M/year.

5) Bottom up: what estimates require in FY09 for LAUC Planning – $2.1M – is more than what LARP readily “offers” in 2 FY09 scenarios: $M(0.9,1.0) out of $M(12,13).

6) What IS the CD schedule?

Hand gestures

"You won't have Nixon to kick around anymore, because, gentlemen, this is my last press conference."

Richard M. Nixon