

Development tasks, Schedules and Budgets

Impacts of FY14 funding reductions, future year reductions

J.D. Fox¹

LARP Ecloud Contributors:

J. Cesaratto¹, J. Dusatko¹, J. D. Fox¹, J. Olsen¹, M. Pivi¹, K. Pollock¹, C. Rivetta¹, O. Turgut¹
 G. Arduini², H. Bartosik², N. Gazis², W. Hofle², G. Iadarola², G. Kotzian², K. Li², E.
 Montesinos², G. Riddone², G. Rumolo², B. Salvant², U. Wehrle², C. Zanini²
 S. De Santis³, H. Qian³
 D. Alesini⁴, A. Drago⁴, S. Gallo⁴, F. Marcellini⁴, M. Zobov⁴
 M.Tobiyama⁵

¹Accelerator Research Department, SLAC

²BE-ABP-ICE Groups, CERN

³Lawrence Berkeley Laboratory

⁴LNF-INFN

⁵KEK

CERN HL Plan, Feedback is needed after LS2

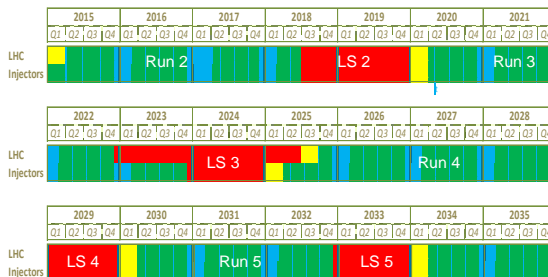
LHC schedule beyond LS1

Only EYETS (19 weeks) (no Linac4 connection during Run2)

LS2 starting in 2018 (July) 18 months + 3months BC (Beam Commissioning)

LS3 LHC: starting in 2023 => 30 months + 3 BC

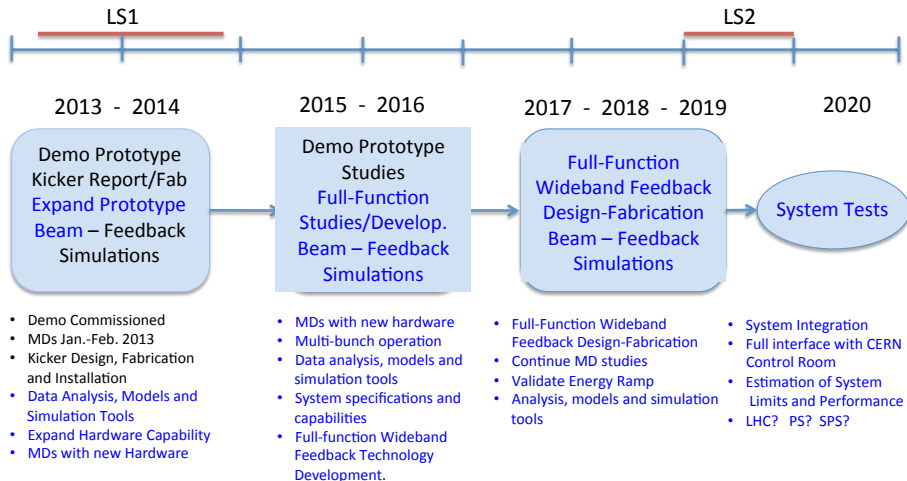
injectors: in 2024 => 13 months + 3 BC



LHC schedule approved by CERN management and LHC experiments spokespersons and technical coordinators
Monday 2nd December 2013

- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- Essential Feedback goal - be ready at end of LS2 with full-function system ready to commission
- Wideband Feedback is different from other LARP projects - it is needed after LS2

Research and Technology Timeline



- Essential goal - be ready at end of LS2 with full-function system ready for SPS Tests
- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- We must use the demo system, MD time post LS1 to validate control ideas, validate kicker and technical approach. Full Function is only 1 design iteration away from Demo System

Near Term Research and Technology Plans

- Existing 1 bunch Demo System
 - FY13 - FY14 Expand processing capabilities, add synchronization, other features (SLAC)
 - FY14 - FY15 Fabrication of wideband Transverse Kicker proof of principle prototype (CERN), upgrade Demo gateware (SLAC)
 - FY15 - FY16 Tests of 1 bunch upgraded demo with wideband kicker
- How is the "Full-Function Prototype" different from the "Demo System"? From a "Production System"?
 - Demo System -initial capabilities to explore single bunch dynamics, explore control algorithms,limited bandwidth kicker
 - Upgraded Demo System - enhanced capability, to be used with proof of principle wideband kicker, validate control capabilities
 - "Full-function" capability to control full ring, energy ramp, injection flexibility, operational interface
 - "Production System" - final operational hardware, with necessary upgrades and modifications learned from running "Full-Function"

Ecloud/TMCI Wideband Feedback "Full-Function Prototype"

- Full-Function Prototype completed in FY19 for test in FY20 (Full HL SPS currents and modes)
 - "Full-Function" - capability to control full ring at high intensity
 - "Full-Function" - synchronization during energy ramping
 - Integration of system control/beam diagnostics for operation
- System capability to control full SPS ring at HL upgraded intensity
 - Beam line pickups/kickers
 - Beam motion receiver, processing electronics
 - 4 - 8 Gs/sec DSP for intra-bunch feedback
 - System Timing, Synchronization Clocks/Oscillators
 - GHz bandwidth Kicker(s), Power Amplifiers
 - Operator interfaces, control/monitoring software
 - Beam diagnostic software, configuration software
 - Accelerator Dynamics models, Stability tools
- Areas of SLAC/CERN contributions
 - SLAC - Feedback signal processing and control software, diagnostic software
 - CERN - tunnel based vacuum Components (kickers) and cable plant
 - Opportunity for collaborative engineering team, shared operational expertise

FY2014 Development path - Research Areas

- During LS1 shutdown interval
- Expand Demo system
 - Low-noise transverse coordinate receivers, orbit offset and pickup techniques
 - Wideband Kicker Prototype for SPS Installation LS1 (CERN fabrication)
 - Upgrade Master Oscillator, Timing system to synchronize to the SPS RF system,
 - Expand firmware, design multi-bunch control
- Evaluate wideband RF Amplifiers, purchase 2 if funded
- Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness
- Continued simulation and modelling effort, compare MD results with simulations, explore new controllers

FY2015/2017 Research , Technology path, M&S

- MD measurements with wideband DEMO system (SPS beam time and analysis)
 - Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness
 - Continued simulation and modelling effort, compare MD results with simulations, explore new controllers
 - Evaluate options for Kickers (wideband? dual band?) and upgrade tunnel High-Power wideband RF amplifiers for SPS operation
- Technology Development and system estimation for Full-function system
 - Wideband 20 - 1000 MHz RF power amplifiers, with acceptable phase response
 - RF Support for SPS tests
 - Low-noise transverse coordinate receivers, orbit offset/dynamic range improvements, pickups
 - Expand Master Oscillator, Timing system for Energy ramp control
- High-speed DSP Platform consistent with 4 -8 GS/sec sampling rates for full SPS implementation
 - lab evaluation and firmware development
 - estimation of possible bandwidths, technology options for deliverable

FY2018/2019 Technology development path, M&S Plans

- FY2017 Continued Demo System Dynamics R&D
 - characterization of wideband kickers, pickups for final system specification
 - Control methods, evaluation of optimal control over full machine parameters
- FY2018/2019 Development of Full-function Prototype(LS2 2019)
 - Beam Motion receiver
 - Dynamic range preservation (orbit offset) processor
 - Front-end delay, timing and synchronization methods
 - SPS Timing System operational interface
 - FPGA Main processing logic motherboard(s)
 - Front End A/D System (4-8 GS/s, possibly $\Delta\Sigma$)
 - Back End D/A System (4-8 GS/s rate)
 - Back End low level distribution, band split, fanout and timing
 - Back End Power Amplifiers
 - High-Power couplers, monitoring and diagnostic mux systems
 - User interface processor and firmware for operations
 - Lab hardware, engineering model components (future critical spares)

FY2020 Research and System Test Plans

- Post LS2 - SPS Full-function Wideband Feedback Prototype Tests and Development
 - MD measurements, analysis
 - Publication of research results (Grad student thesis)
 - Adaptation of Demo system for PS test/use
 - Specification of LHC system, LHC system proposal
- Test and MD effort is joint SLAC/CERN activity, allows CERN to develop operational expertise, investment in implementation technology
- (Possible transfer of Demo system to PS for development and MD studies)

Manpower and Skills Overview

● Necessary Skills and Capabilities

- Accelerator modelling and dynamics
- MD measurements and data analysis
- Control theory and techniques
- Wideband RF (pickups, kickers, beam motion receivers)
- GS/s Digital signal processing
- Project management and planning

● Manpower

- SLAC based - signal processing, optimal control contributions
 - Staff Physicists and Engineers
 - Toohig Fellow and/or Postdoctoral Research Associate
 - Graduate Students
- CERN based
 - MD coordination
 - HeadTail Simulation codes and Ecloud studies
 - Potential firmware contribution
- Pickup, Kicker Structures and Tunnel cable plant
 - CERN funded, CERN managed
 - Design report with SLAC/LBL/LNF authors
 - CERN to fabricate prototype kickers under LIU HL program

Manpower - Research vs. Full-Function System Development

- Rationale by skill set, numbers and year 13-14, 15-17,18-20
- Balance between research/education component (grad students, Fellow) vs. Simulation/dynamics effort , Engineering skills required
- Possible coordination with CERN Engineering and Accelerator Physics skills
 - DSP firmware (SLAC and CERN)
 - Pickup and Kicker implementation (CERN,LBL and LNF)
 - Front end, Receiver (SLAC)
 - Master Oscillator, Timing system (SLAC and CERN)
 - Back end, Power stages (SLAC and CERN)
 - Diagnostic and beam motion analysis techniques (SLAC, CERN and LNF)
 - Nonlinear Beam and Feedback Simulations (CERN and SLAC)

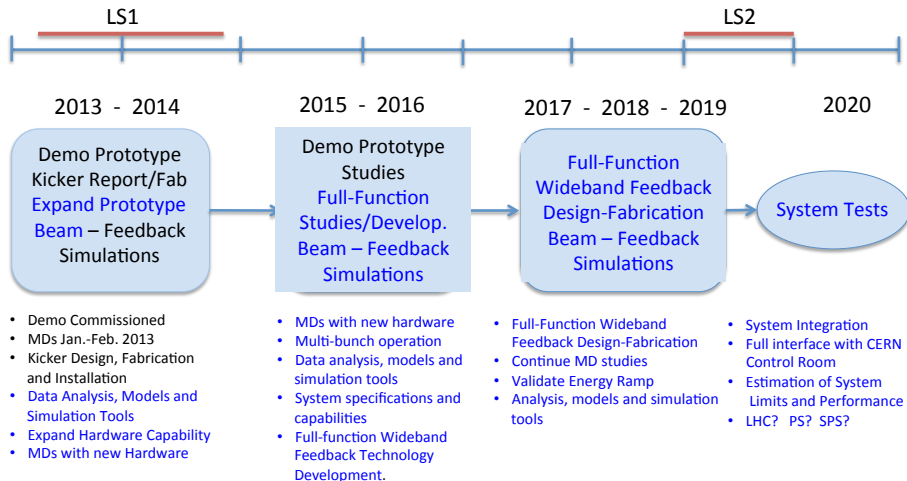
Development budget 2014 -2016

	FTE	FY12 BASE	FY12 BASE w/ Overhead	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Total w/o Contingency	Contingency %	Total incl. Contingency
M&E Evaluation				2.70%	5.47%	8.32%	11.24%	14.24%	17.32%	20.49%	21.74%	27.08%	30.11%			
Lab Evaluation				9.80%	2.82%	5.39%	8.02%	10.72%	13.46%	16.33%	19.24%	22.16%	25.27%			
DEVELOPMENT/EXPANSION OF DEMONSTRATION PROCESSING SYSTEM																
M&E		\$247,500	\$378,675	\$20,540	\$300,601	\$585,033								\$472,155		\$626,535
Synchronization function for energy ramp		\$25,000	\$38,250	\$0	\$40,342	\$41,432								\$81,775	33%	\$108,951
Receiver channel development, prototype		\$25,000	\$38,250	\$0	\$40,342	\$41,432								\$81,775	33%	\$108,951
High bandwidth locker power amplifiers, splitters/combiners		\$75,000	\$114,750	\$0	\$60,135	\$62,148								\$122,282	33%	\$162,527
Test laboratory equipment (e.g., high power loads, FPGA software, signal processing DAQ card)		\$22,500	\$34,425	\$0	\$36,360	\$37,365								\$73,725	33%	\$97,450
Wideband detector locker prototype		\$100,000	\$153,000	\$20,540	\$129,057	\$0								\$149,597	33%	\$198,005
LABOR		\$658,000	\$1,250,260	\$1,260,262	\$1,286,454	\$0								\$2,545,657		\$3,398,657
Staff Scientist, 1 FTE	1.7	\$268,600	\$510,340	\$514,423	\$524,732									\$1,039,154	0%	\$1,039,154
Staff Engineer, 0.7 FTE	0.7	\$102,900	\$195,510	\$197,074	\$201,623									\$398,007	0%	\$398,007
Toolbox Fellow (potential 1 FTE)	0.0	\$0	\$0	\$0	\$0	\$0								\$0	0%	\$0
Graduate Student, 2 FTE (50% LARP)	2.0	\$50,000	\$95,000	\$95,760	\$97,679									\$193,439	0%	\$193,439
Staff Scientist, 0.3 FTE	0.3	\$47,400	\$90,660	\$90,760	\$92,600									\$183,360	0%	\$183,360
Staff Engineer, 0.3 FTE	0.3	\$44,100	\$83,760	\$84,460	\$86,135									\$176,615	0%	\$176,615
SLAC Fellow/Postdoc (potential 1 FTE)	0.0	\$0	\$0	\$0	\$0	\$0								\$0	0%	\$0
Graduate Student, 2 FTE (50% SLAC)	2.0	\$50,000	\$95,000	\$95,760	\$97,679									\$193,439	0%	\$193,439
Fellow/Postdoc/Staff, 1 FTE	1.0	\$50,000	\$98,000	\$103,944	\$105,000									\$206,944	0%	\$206,944
DESIGN STUDIES OF FULL-FUNCTION PROTOTYPE, SIMULATIONS, MDN with 1 bunch Demo																
M&E		\$575,000	\$287,750	\$0	\$0	\$565,730	\$127,648							\$260,178		\$388,725
High power amplifier low level calibration		\$15,000	\$47,250	\$0	\$0	\$13,725	\$25,450							\$39,175	33%	\$51,961
High power amplifier high level calibration		\$10,000	\$30,250	\$0	\$0	\$9,150	\$17,975							\$26,125	33%	\$34,500
High capacity processing channel development, and FPGA platform for development		\$30,000	\$90,250	\$0	\$0	\$26,850	\$52,225							\$75,375	33%	\$100,500
LABOR		\$793,750	\$1,485,325	\$0	\$0	\$1,565,384	\$1,609,448							\$3,180,832		\$3,803,788
Staff Scientist, 2 FTE	2.0	\$316,000	\$600,400	\$602,760	\$608,552									\$1,211,314	20%	\$1,517,576
Staff Engineer, 1 FTE	1.0	\$147,000	\$279,300	\$281,224	\$284,224	\$281,700								\$563,424	20%	\$715,267
Toolbox Fellow (potential 1 FTE)	0.0	\$0	\$0	\$0	\$0	\$0								\$0	0%	\$0
Graduate Student, 2 FTE (50% LARP)	2.0	\$50,000	\$95,000	\$95,760	\$97,679									\$193,439	0%	\$193,439
Staff Scientist, 0.3 FTE	0.3	\$47,400	\$90,660	\$90,760	\$92,600									\$183,360	0%	\$183,360
Staff Engineer, 0.3 FTE	0.3	\$44,100	\$83,760	\$84,460	\$86,135									\$176,615	0%	\$176,615
SLAC Fellow/Postdoc (potential 1 FTE)	0.0	\$0	\$0	\$0	\$0	\$0								\$0	0%	\$0
Graduate Student, 2 FTE (50% SLAC)	2.0	\$50,000	\$95,000	\$95,760	\$97,679									\$193,439	0%	\$193,439
Fellow/Postdoc/Staff, 1 FTE	1.0	\$142,500	\$270,750	\$272,943	\$276,922	\$282,454								\$557,808	20%	\$693,965
TRAVEL		\$42,500	\$65,025	\$65,545	\$66,859	\$68,795	\$105,360							\$340,559		\$405,559
Subtotal LARP		\$1,177,000	\$2,146,575	\$872,802	\$1,031,401	\$1,275,045	\$1,285,879							\$4,465,216		\$6,852,535
Subtotal SLAC - CERN		\$245,110	\$471,060	\$471,060	\$471,060	\$471,060	\$471,060							\$1,856,460		\$2,302,770
Subtotal LARP+CCO (potential with others)		\$182,080	\$315,080	\$315,080	\$315,080	\$315,080	\$315,080							\$1,255,760		\$1,620,140
Subtotal CERN		\$337,500	\$604,250	\$202,484	\$134,085	\$285,343	\$292,464							\$1,094,977		\$1,392,018
Total LARP+SLAC (green + blue)				\$1,143,803	\$1,344,230	\$1,527,889	\$1,544,592							\$5,562,874		\$8,024,464
Total LARP+SLAC+CERN (green + blue + orange + green dot)				\$1,146,287	\$1,658,935	\$1,876,922	\$1,837,456							\$6,821,140		\$9,656,985

Detailed resource-loaded schedule developed to meet SPS startup November 2014 and MD efforts in FY14 and FY15. Presented in Discussion Time

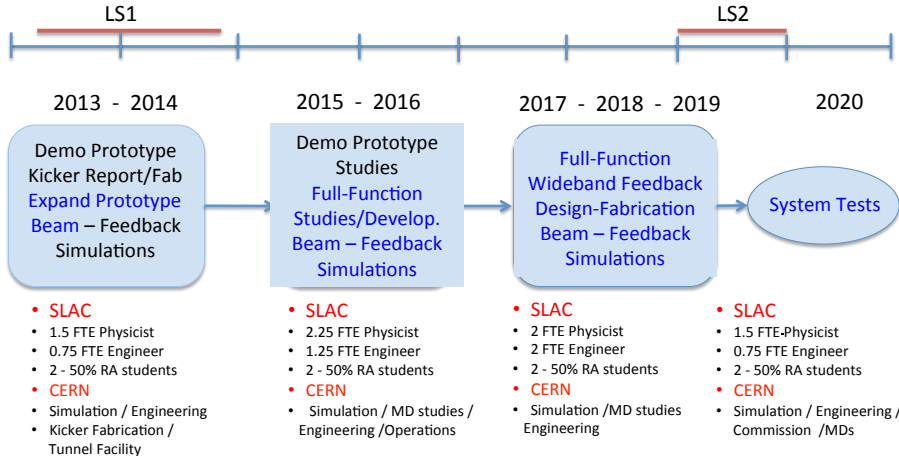
		FULL FUNCTION DELIVERABLE - HIGH BANDWIDTH INTRA-BUNCH INSTABILITY FEEDBACK SYSTEMS Full function deliverable available for test after LS2													
		Revision #1.3 J. Cesaratto, I. Fox, C. Rivetta, based on 1 full function deliverable and "supplied" SLAC labor rates													
		Revision Date: 06/06/2012													
		Brief Scope Description and Assumptions													
		S1		S3		LS2				LS3					
		FY12 BAGE	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Total w/o Contingency	Contingency %	Total incl. Contingency
BMS Location			2.70%	5.47%	8.32%	11.24%	14.24%	17.32%	20.49%	23.74%	27.08%	30.51%			
Labor Location			0.80%	2.82%	5.19%	8.02%	10.72%	13.49%	16.33%	19.24%	22.18%	25.27%			
DEVELOPMENT/EXPANSION OF DEMONSTRATION PROCESSING SYSTEM															
BMS		\$100,000	\$0	\$62,738	\$64,160								\$106,895		\$161,633
Synchronization function for energy ramp		\$25,000	\$0	\$26,168									\$26,168	33%	\$34,917
Receiver channel development, prototype		\$25,000	\$0	\$26,168									\$26,168	33%	\$34,917
High bandwidth receiver active region (100MHz/100MHz)		\$25,000	\$0	\$26,168									\$26,168	33%	\$34,917
Standard offline kicker prototype		\$61,500	\$64,160	\$65,919									\$130,100	33%	\$173,071
LABOR		\$975,000	\$982,800	\$1,002,495									\$1,985,295		\$1,985,295
Staff Scientist, 2 FTE		\$600,000	\$604,800	\$616,920									\$1,221,720	0%	\$1,221,720
Staff Engineer, 2 FTE		\$280,000	\$282,240	\$287,850									\$570,180	0%	\$570,180
Postdoc/Principal, 1 FTE		\$180,000	\$181,440	\$185,070									\$366,510	0%	\$366,510
Graduate Student, 2 FTE (50% cost split with SLAC)		\$95,000	\$95,760	\$97,679									\$193,439	0%	\$193,439
DESIGN STUDIES OF FULL-FUNCTION PROTOTYPE, SIMULATIONS, MDs with 1 bunch Demo															
BMS		\$175,000		\$108,120	\$81,430								\$191,750		\$214,065
High level analysis for MD simulations		\$75,000		\$47,240	\$36,500								\$81,430	33%	\$107,061
High level analysis for MD simulations (100MHz/100MHz)		\$75,000		\$47,240	\$36,500								\$81,430	33%	\$107,061
High capacity processing channel development, 2nd FPGA platform for development		\$25,000		\$0	\$81,430								\$81,430	33%	\$110,545
LABOR		\$1,120,000		\$1,180,168	\$1,209,824								\$2,390,192		\$2,390,192
Staff Scientist, 2.25 FTE		\$675,000		\$711,183	\$729,115								\$1,440,318	20%	\$1,728,021
Staff Engineer, 1.25 FTE		\$375,000		\$388,800	\$395,070								\$774,935	20%	\$930,121
Postdoc/Principal, 1.5 FTE		\$270,000		\$284,550	\$293,654								\$576,207	20%	\$693,448
Graduate Student, 2 FTE		\$95,000		\$100,121	\$102,039								\$202,740	20%	\$243,281
DESIGN AND FABRICATION OF A FULL-FUNCTION DELIVERABLE WITH CONTROL INTERFACE															
BMS (cost per system, based on one system)		\$718,000				\$391,272	\$159,141						\$950,413		\$1,355,620
Front end hybrid and beam motion monitor		\$50,000				\$57,120	\$0						\$57,120	50%	\$85,680
Kick-off and dynamic range preservation processor		\$30,000				\$34,272	\$0						\$34,272	50%	\$51,408
Front end variable delay and timing alignment		\$20,000				\$0	\$23,464						\$23,464	50%	\$35,196
Timing and synchronization system for interface to accelerator		\$20,000				\$11,454	\$11,712						\$23,166	50%	\$34,740
FPGA signal processing channel (logic processing functional)		\$100,000				\$0	\$117,320						\$117,320	50%	\$175,960
Front end A/D system for 4 GS/s rate		\$20,000				\$0	\$23,464						\$23,464	50%	\$35,196
Back end A/D system for 4 GS/s operation		\$20,000				\$0	\$23,464						\$23,464	50%	\$35,196
Back end time based distribution, based with fanout and timing distribution channel		\$40,000				\$0	\$46,928						\$46,928	50%	\$70,392
Pickup pickup front-end, 4 channels, 100 MHz		\$180,000				\$0	\$217,240						\$217,240	20%	\$277,880
Back-end power amplifiers, 4 channels, 100 MHz		\$130,000				\$10,176	\$0		\$185,780	60%			\$214,740		\$214,740
Pickup pickup front-end, 4 channels, 100 MHz		\$130,000				\$10,176	\$0		\$185,780	60%			\$214,740		\$214,740
Pickup pickup front-end, 4 channels, 100 MHz		\$130,000				\$10,176	\$0		\$185,780	60%			\$214,740		\$214,740
Low interface processor and firmware for operator		\$90,000				\$19,892	\$30,531		\$40,523				\$50,935	20%	\$60,935
Control plane development for operator		\$35,000				\$36,130	\$30,530		\$41,675	60%			\$50,005	50%	\$75,005
OPTIONAL ITEMS (cost per system, based on one system)		\$270,000				\$131,410	\$346,094		\$460,534				\$938,038		\$938,038
Control cables, high and low power		\$25,000				\$29,130	\$0		\$33,130	50%			\$41,665		\$41,665
Tunnel racks, cooling, and power distribution, monitoring		\$20,000				\$0	\$23,464						\$23,464	50%	\$35,196
Pickup structure (including feedthroughs and vacuum structure)		\$75,000				\$85,680	\$0		\$95,880	50%			\$119,820	50%	\$179,820
Low band kicker assemblies (including feedthroughs, 2 each and vacuum structure)		\$250,000				\$258,480	\$0		\$266,960	50%			\$333,480	20%	\$403,480
High band kicker assemblies (including feedthroughs, 2 each and vacuum structure)		\$250,000				\$0	\$293,300						\$293,300	50%	\$439,950
LABOR		\$1,255,000		\$1,389,534	\$1,424,300		\$678,292		\$1,692,127				\$5,568,979		\$5,568,979
Staff Scientist, 2 FTE		\$600,000		\$616,920	\$633,840		\$274,880		\$704,880	40%			\$2,116,240		\$2,116,240
SLAC Staff Engineer, 2 FTE		\$280,000		\$287,850	\$295,540		\$124,291		\$339,809	40%			\$986,890		\$986,890
CERN Staff Engineer		\$280,000		\$310,054	\$317,772		\$162,862		\$399,600	40%			\$1,106,910		\$1,106,910
Postdoc/Principal, 1.5 FTE		\$270,000		\$298,944	\$306,421		\$161,761		\$370,994	40%			\$1,140,655		\$1,140,655
Graduate Student, 2 FTE		\$95,000		\$100,184	\$102,810		\$52,554		\$123,513	40%			\$342,018		\$342,018
TRAVEL (by year with escalation (labor rates) and overhead)		\$42,556	\$45,345	\$66,224	\$67,514	\$68,434	\$73,474	\$74,521	\$78,190				\$692,131		\$692,131
Total for 1 delivered full-function system, as CERN contribution															
		\$1,293,756		\$1,777,878	\$1,894,717	\$1,653,342	\$2,777,002	\$2,988,056	\$1,926,748				\$11,207,207		\$11,207,207
Total for 1 delivered system to the SPEJ, as CERN contribution															
		\$1,048,180	\$1,121,654	\$1,430,364	\$1,363,680	\$1,854,482	\$2,018,361		\$954,498				\$5,768,803		\$12,275,065
LABOR RATES: (including benefits and 5.5% indirect)															
Staff Scientist		\$300,000													
Staff Engineer		\$280,000													
Postdoc		\$180,000													
Graduate Student (50% SLAC, 50% SLAC AID support)		\$95,000													
NOTES:															
Green highlighted in green correspond to potential CERN contribution															
Green highlighted in green correspond to LABR contribution															
Contingency categories listed in proposal document, % rate are averaged over assigned line items															
Travel costs escalated with labor rate. What is travel escalation rate?															
CERN costs estimated using typical US Lab costs.															
Total, CERN contribution assumes CERN provides for the OPTIONAL ITEMS (e.g., vacuum, kickers, pickups, cabling, etc.)															
CERN Fellow/Postdoc (E.g., K. U) works on a mix of simulation and hardware development															

Project Timeline



- Essential goal - be ready at end of LS2 with full-function system ready for SPS Tests
- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- We must use the demo system, MD time post LS1 to validate control ideas, validate kicker and technical approach. Full Function is only 1 design iteration away from Demo System

Manpower Timeline



- Essential goal - be ready at end of LS2 with full-function system ready for SPS Tests
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LARP June 13 Review - Budget Guidance and Planning towards 2020 Full Function System

- June 2013 LARP funding guidance (\$1.3M) used to plan and scale FY14,15,16 effort, with modest early use of FY17 project funds
- Expansion of 1 bunch Demo System
 - FY13 -14 Expand processing capabilities, add ramp synchronization, orbit offset dynamic range, other features (SLAC)
 - FY13 -14 Fabrication of wideband Transverse Kicker proof of principle prototype (CERN)
 - FY15 - 16 Beam Tests of 1 bunch demo with wideband kicker (both)
- LARP Project funding expected start in 2017
 - Design and development of full-function system
 - Requires joint LARP-CERN Resources to complete
 - Wideband Feedback plans presented at LARP Internal Review June 2013 (www.uslarp.org) -consistent with CERN schedule
 - If actual LARP funding is reduced below planning baseline, timeline and effort must be reassessed, de-scoped, delayed or canceled

Comments from LARP Reviewer's Report June 2013

Wideband feedback systems

The R&D has shown significant progress in the last year, with a successful testing of the single-bunch prototype in the SPS

There is reasonable confidence that an extension of the demonstrated approach will fulfill the requirements of damping high frequency instabilities in the SPS. The general approach can be extended to solving similar problems in the LHC and PS.

#1 Can the proposed project scope fit within the schedule and budget guidance given?

Presented schedule estimates are optimistic and have minimal headroom to react to additional budget pressures.

#2 Are the proposed cost, cost profiles and schedules reasonable?

To meet LS2 schedule for installation into the SPS, the engineering effort must clearly pivot from development mode to production mode by 2017.

We feel that proposed manpower allocations may be underestimated. To appropriately amortize the engineering work done in the research phase of the project (through 2016), there has to be continuity in engineering manpower.

#3 Are external risks (schedule, contributions) adequately considered?

To reduce external risk associated with the extent of CERN's commitment to make local expertise available to assist and participate in commissioning, a more formal statement from CERN is needed.

The project risks losing momentum if LS2 dates slide.

Comments from LARP reviewer's Report June 2013

#4 Is the technical plan proposed by each sub-project optimally developed? Are there additional technical risks that should be considered?

Kicker design is still in relatively early stage and several significant issues remain to be investigated and addressed, such as handling beam-induced power and ultra high vacuum requirements.

#5 Is the proposed management structure appropriate for the scope and scale of the project?

Not presented.

#6 Are there additional comments the Committee feels are relevant, regarding either individual tasks or the project as a whole?

We suggest exploring collaboration with RHIC, which has similar instabilities for which it is pursuing feedback damping.

Installation of a prototype wideband kicker in the SPS before the end of LS1 is critical.

- CERN Review (July 2013) - Impact of new SPS Q20 optics requires new controller design study and stability analysis. Additional work added to original scope of effort

Comments from CERN LIU-SPS Report July 2013



Report on the Review of the LIU-SPS High Bandwidth Transverse Damper System CERN - July 30th 2013

This is the final report of the review committee for the LIU-SPS High Bandwidth Transverse Damper System held at CERN on July 30th, 2013.

Implementing a system capable of combatting electron cloud instabilities could significantly increase the scrubbing efficiency in the SPS. In addition it would ensure that the quality of beams destined for the LHC can be preserved from injection to 450GeV, possibly also allowing the preparation of doublet bunches for scrubbing the LHC. **In view of this, the reviewers recommend that the second phase of this project, the construction and test of a multi-bunch high bandwidth transverse damper demonstrator, proceeds as quickly as possible, to allow a final decision on whether or not to build a fully functional system to be taken at the end of 2016.**

Question 8: Are there deliverables or studies which need advancing in time, for example before the LARP construction decision?

The short term aim is clearly to get a working multi-bunch high bandwidth demonstrator operational in the SPS, even if this is using a reduced power kicker, a pick-up which is not suitable for the damping of doublet bunches and an electronics which cannot handle a full LHC bunch train. The knowledge gained from this will be invaluable for defining the architecture of the final system.

The two critical parameters which remain to be defined are the kick strength required and the bandwidth of the final system. Simulations and beam studies should therefore be targeted to give this input as soon as possible, as this choice will impact both the kicker type and electronic architecture.

Impacts of FY2014 Funding Reductions

- Major events since June 2013 FNAL Review
 - CERN has slipped LS2 one year (post LS2 restart now 2020)
 - FY2014 LARP funding reduced by 1.1M\$
 - Feedback Project FY14 funds reduced substantially below guideline plans, with critical impacts on FY14 progress and planned FY15 tasks
 - LARP project funds expected 2017, now delayed
- LARP Management has requested re-scoped plans considering
 - Funding as requested (LARP June 2013 planning levels), with LARP base continuation in FY17
 - Funding at 90% levels (assign 12 - 16% cuts to June 2013 budget plans)
 - Funding at 80% levels (assign 35% cuts to June 2013 budget plans)
- Serious impacts to possible Feedback contributions to HL and LHC program

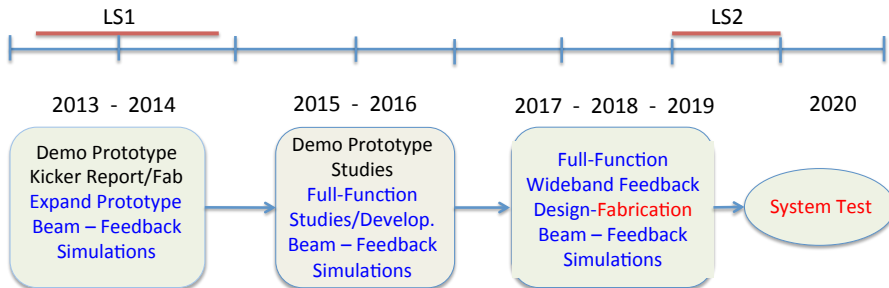
LARP Review FY2014 Goals- FY14 35% cuts applied

- Black - done within FY14 reductions, Blue -partially accomplished, Red -dropped
- Expand Demo system
 - Expand firmware, design multi-bunch control, code orbit offset/dynamic range improvements
 - Low-noise transverse coordinate receivers,orbit offset and pickup techniques
 - Wideband Kicker splitters, power amp improvements and studies
 - Expand Master Oscillator, Timing system to synchronization to SPS RF, Energy ramp control
 - Wideband Kicker Prototype,tunnel engineering for SPS Installation LS1 (CERN supported)
- Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness
- Continued simulation and modeling effort, compare MD results with simulations, explore new controllers for Q20 optics
- Development of matlab tools for system timing/phasing alignment (repeatable operating point)

FY2015/2016 Goals - with 35% cuts

- Black - can be done within FY14 reductions, Blue -partially accomplished, Red -dropped
- MD measurements with wideband DEMO system (SPS beam time and analysis)
 - Multi-bunch control studies with existing amplifiers
 - Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness, interaction with existing feedback
 - Continued simulation and modeling effort, compare MD results with simulations, explore new controllers
 - Evaluate Kicker performance, options (wideband? dual band?) Estimate useful required power for full-function
- Technology Development and estimation for kicker systems
 - Wideband 20 - 1000 MHz RF power amplifiers, with acceptable phase response
 - RF monitoring, control for SPS tests
- High-speed DSP Platform consistent with 4 -8 GS/sec sampling rates for full SPS implementation
 - lab evaluation and firmware development
 - estimation of possible bandwidths, architectures and technology options for deliverable

Research and Technology Timeline 35% cuts



- Demo Commissioned
- MDs Jan.-Feb. 2013
- Kicker Design, Fabrication and Installation
- Data Analysis, Models and Simulation Tools
- Expand Hardware Capability
- MDs with new Hardware

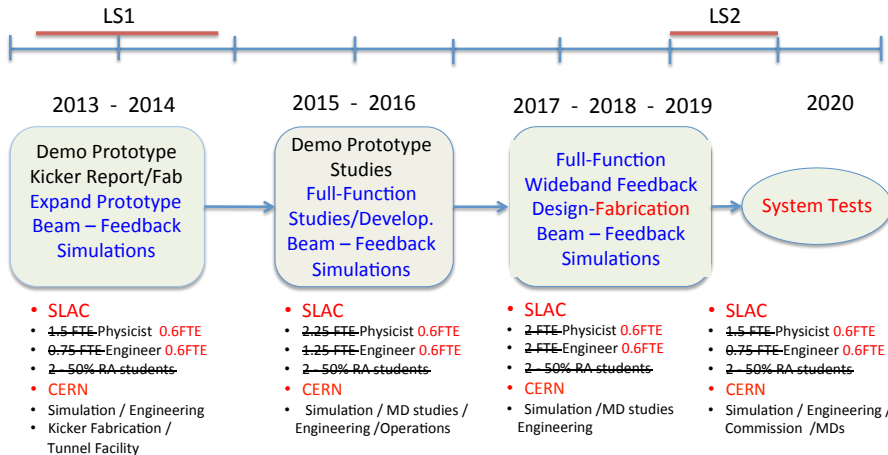
- MDs with new hardware
- Multi-bunch operation
- Data analysis, models and simulation tools
- System specifications and capabilities
- Full-function Wideband Feedback Technology Development.

- Full-Function Wideband Feedback Design-Fabrication
- Continue MD studies
- Validate Energy Ramp
- Analysis, models and simulation tools

- System Integration
- Full interface with CERN Control Room
- Estimation of System Limits and Performance
- LHC? PS? SPS?

- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- Impact - There is simply no functioning prototype in place post-LS2 to control HL upgraded currents. Many additional years needed to complete system

Manpower Timeline - 35% reduction



- Toohig Fellows can participate/lead in MD studies and analysis
- Graduate students can participate/lead in control analysis, lab tests, and matlab tool development
- Fellows and Students cannot replace experienced engineering staff

Manpower - Research vs. Deliverable System Development

- June 2013 LARP Reviewers - concern about lean manpower and tight schedule
- Staff Plan evolves to reflect changing tasks over years
- Balance between research/education component (grad students, Fellow) vs. Simulation/dynamics effort, Engineering skills required
- Plan requires experienced engineering staff, continuity is essential
- 2018 transition from R&D to system engineering required to meet LS2 startup
- Fellows and Students cannot replace experienced engineering staff

FY15, FY16 goals - with 12 - 16% cuts

- First priority - items dropped in FY14 cuts (Timing/Synch for energy ramp, Orbit offset compensation, matlab tools)
- Second - augment FY15 MD measurements with wideband DEMO system (SPS beam time and analysis)
 - Travel funds necessary to do SPS measurements
 - Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness, interaction with existing feedback
 - Evaluate Kicker performance, options (wideband? dual band?) Estimate useful required power for full-function
- Third - FY16 High-speed DSP Platform consistent with 4 -8 GS/sec sampling rates for full SPS implementation
 - Partial lab evaluation and de-scoped firmware development
 - Estimation of possible bandwidths, architecture options for deliverable
- Assume Transfer to CERN funding- All aspects for kicker systems
 - Wideband 20 - 1000 MHz RF power amplifiers, with acceptable phase response
 - RF monitoring, control for SPS tests
- Impact - still not ready to develop full-function system in 2018, delays full-function system by 2 - 3 years, misses LS2 SPS startup

Risks and Mitigation

- Successful 1 bunch Demo and initial MD effort is excellent start to show ability to meet schedule requirements and technical competence
- External Technical Reviews - June and July 2013 validate approach and plan towards LS2 full-function system
- Technical Risks - Uncertainty in required bandwidth, control methods for non-linear system, complexity/type of control algorithm, necessary system power, etc.
 - Mitigations in reconfigurable FPGA algorithm, scalable power stages, possibility of adding extra kickers or multiple kicker technologies.
 - Confidence from post LS-1 multi-bunch tests, decision point before fab of full-function deliverable
- MD program, extensive simulation and modeling effort help estimate high-current operational dynamics from SPS studies pre-LS2

Methods to Increase Risk

- Demonstrated risk - underfunding of necessary FY13-14 effort
 - example, FY13 budget plan, underfunding of actual FY13 year
 - limitation of engineering contribution to 12.5% FTE
 - Guarantees project is understaffed in FY14, loses important time this year to work on critical system capabilities (energy ramp, multi-bunch capability, etc.) necessary for post LS1 MD program. M&S funds limited
 - FY14 amplifier evaluation/purchase pushed back into FY15 due to budget limits
 - No new wideband amplifiers in place to drive new kickers
 - Lack of manpower assignment authority means risk of loss of critical signal processing engineer, loss of continuity of project progress (SLAC management priority isn't LARP)
- Mismatch of LARP funding profile with HL-LHC schedule, CERN anticipation of feedback for use post LS2
- Reductions of spending below LARP June 2013 budget plan reduce possible development of all required system features, provide less functional system with incomplete capabilities. Doesn't meet HL upgrade requirements.

Summary and Discussions

- "Full Function Prototype" as end point - original plan was to make PS, SPS and LHC production systems after full-function
- roughly 30% extra M&S costs to make 3 actual production systems based on operational experience from Full-Function prototype
 - manpower is extremely lean for combined research and engineering effort
 - research aspect, Ph.D. students and new control ideas are inexpensive but not luxuries to be cut out to save \$
 - System design is reconfigurable, allowing future improvements
 - CERN interest in multiple systems for the PS, SPS and LHC
 - CERN interest in development of accelerator diagnostics as function within feedback channel
 - Operational software, operator integration within CERN environment is potentially beyond scope of this prototype
- Discussions with Reviewers
 - Project funding is 80% salaries, overheads - technical component is 13 - 20%
 - Realistic plans for FY 13, 14 - necessary timing and synchronization functions
 - importance of original FY13 and FY14 planning, including amplifier evaluations
 - Critical and vital installation of wideband kicker into SPS at end of LS1
 - Importance of MD program in FY15, modeling effort to verify control algorithms and system features

Review Structure

- Overview, Review Responses, Technology and Recent Progress
- Control Techniques, Machine simulations, MD analysis and Options for next steps
- Plans, schedules, budgets and HL Impacts
- We are here
- Discussion with Reviewers
- (Optional) Technology Development - Progress and plans
- (Optional) MD results, analysis methods and MD plans
- Continued Discussion with Reviewers

Acknowledgements and Thanks

- We cannot adequately acknowledge the critical help from everyone who made the winter 2012 feedback Demo MDs possible. We are grateful for the collaboration and generous help.
- Thanks to CERN, SLAC, and LARP for support

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Wideband Feedback - Implementation in LHC

- Architecture being developed is **reconfigurable!**
- Processing unit implementation in LHC similar to SPS:

	SPS	LHC
RF frequency (MHz)	200	400
f_{rev} (kHz)	43.4	11.1
# bunches/beam	288	2808
# samples/bunch	16	16
# filter taps/sample	16	16
Multi-Accum (GMac/s)	3.2	8

- LHC needs more multiply-accumulation operation resources because of # of bunches, but reduced f_{rev} allows longer computation time (assuming diagonal control).
 - LHC signal processing can be expanded from SPS architecture with more FPGA resources
 - Similar architecture can accommodate needs of both SPS and LHC.
- Still need kicker of appropriate bandwidth with acceptable impedance for LHC. Learn from SPS experience.

Labor Cost Methodology

- Labor costs based on SLAC overhead and numbers from representative typical rates
- Mix of Student/fellow contributions, Lab Staff (physicist/engineer) contributions
- 50% grad student support, 50% assumed support from SLAC ARD GARD funds
- Would benefit from availability of Toohig Fellow (but as extra manpower)
- Does not include any LBL, LNF or CERN manpower as a LARP cost
- Costs include escalation and contingency per DOE model

Technology and System Development Cost Methodology

- Catalog prices for purchased items (eg power amplifiers, delay lines)
- Consistency with project technology development costs to date (fab of Demo and Excite systems)
- System capabilities estimated based on best knowledge from simulations, MD results and experience
- Plan for deliverable system, engineering model will become spare for operations
- Costs include escalation and contingency per DOE model

Other costs carried in budget

- Travel for MD measurements, conferences, accelerator schools
- Lab equipment (e.g. test/measurement necessary for design/evaluation, prototype hardware evaluations, MD instrumentation, software for E&M design and FPGA design) - TBD amounts, partial split with GARD funds