

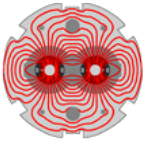
LARP

US LHC Accelerator Research Program

bnl - fnal- lbnl - slac

LARP Accelerator Systems: R&D Plan Overview

Vladimir Shiltsev (Fermilab)



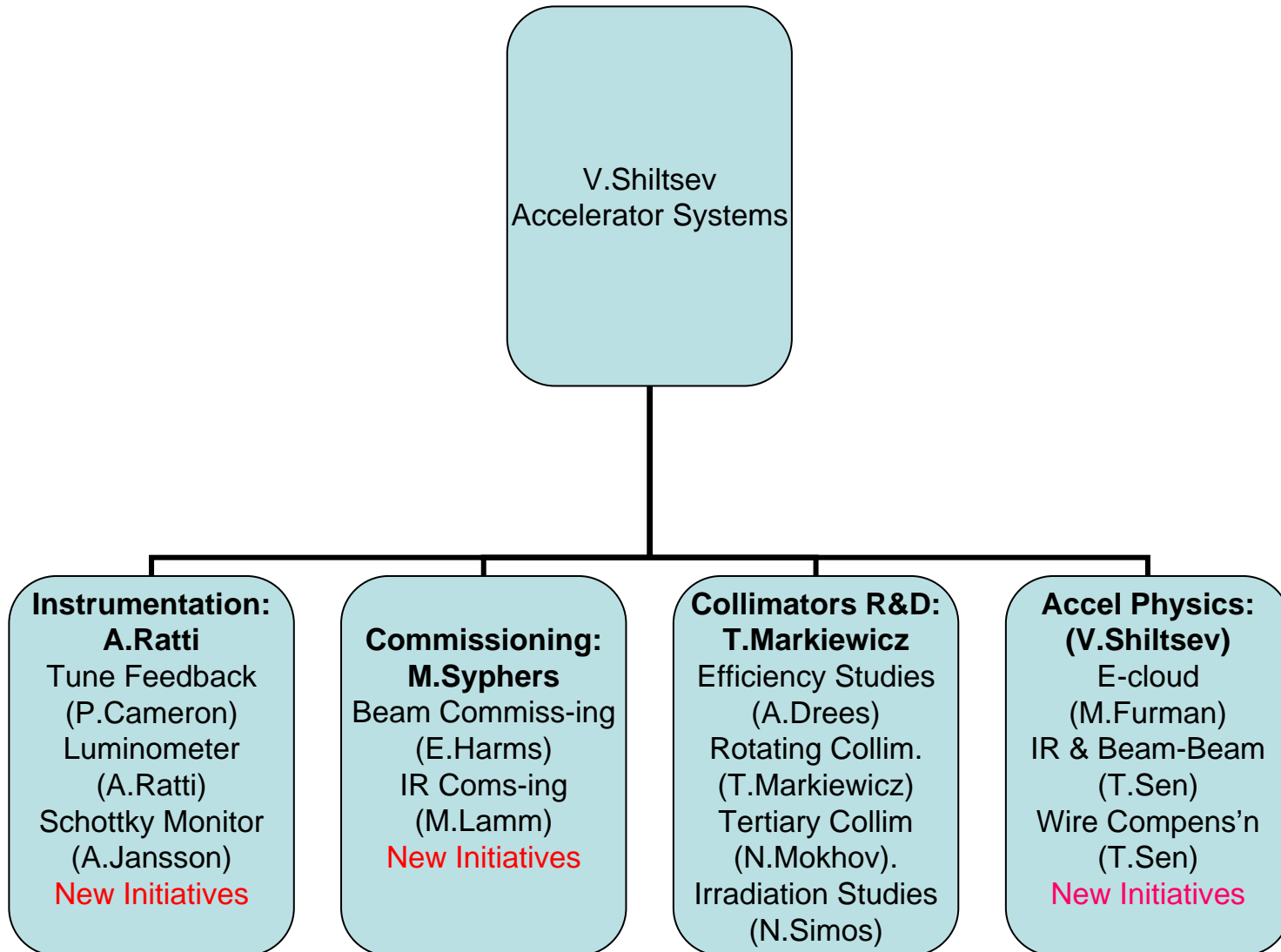
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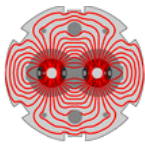
Content

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 - IR Workshop
 - LARP mini-meeting
- June 05 Review ScoreCard
- R&D Plan:
 - Instrumentation
 - Commissioning
 - Collimation
 - Accelerator Physics



Accelerator Systems Org Chart





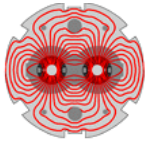
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FY06 Accelerator Systems Budget

v2b Accelerator Systems labor/MSTC breakdown

Blue: new WBS numbers

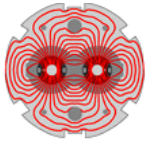
Sept 22, 2005			FY2006				
WBS			BNL	FNAL	LBNL	SLAC	Total
1	Accelerator Systems	Shiltsev	855	1150	1255	700	3960
1.1	Instrumentation	Ratti	345	250	935	0	1530
1.1.1.1	Tune feedback	Cameron	300	25			325
	Labor						
	MSTC						
1.1.1.2	Luminometer	Ratti	25		935		960
	Labor						
	MSTC						
1.1.1.3	Schottky monitor	Jansson	20	225			245
	Labor						
	MSTC						
1.2	Commissioning	Syphers	230	620	90	0	940
1.2.1.1	Beam Commissioning	Harms	150	250	0		400
	Labor						
	MSTC						
1.2.1.2	Interaction Region Commissioning	Lamm	80	370	90		540
	Labor						
	MSTC						
1.3	Collimation	Markiewicz	100	50	0	700	850
1.3.1.1	Cleaning efficiency studies	Drees	50				50
	Labor						
	MSTC						
1.3.2.1	Rotating Collimator R&D	Markiewicz		20		700	720
	Labor						
	MSTC						
1.3.2.2	Tertiary collimator study	Mokhov		30			30
	Labor						
	MSTC						
1.3.2.3	Irradiation studies	Simos	50	0			50
	Labor						
	MSTC						
1.4	Accelerator Physics	Shiltsev	180	230	230		640
1.4.1.1	Electron Cloud	Furman	50	0	150		200
	Labor						
	MSTC						
1.4.1.2	Interaction Regions & Beam-Beam	Sen	0	180	80		260
	Labor						
	MSTC						
1.4.1.3	Beam-Beam wires	Sen	130	50			180
	Labor						
	MSTC						



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June'05 DoE Review: Scorecard

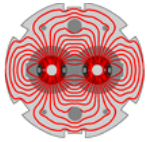
Recommendation – Accelerator Systems	Response/Action Plan
AS1: It also seems that it would be sensible to move the commissioning of hardware supplied under the LHC Accelerator Construction Project, which is mainly magnet-related, from accelerator physics to the superconducting- magnet branch of the program.	While the “Interaction Region Commissioning” of hardware supplied under the LHC Accelerator Construction Project could legitimately be located under Magnet R&D, nonetheless it is our considered opinion that it is best co-located under Accelerator Systems with the larger related activities of Beam Commissioning and Hardware Commissioning.
AS2: There was a sense, however, that the instrumentation activities might be squeezed out by excessive demands from other parts of the LARP program (magnets and/or commissioning). LARP management must guard against this happening, as these devices form an entry for the U.S. team into the arena of beam commissioning.	In order to avoid such a development, any budget adjustments which might influence financial support of the instrumentation tasks will be done after consultations and agreements with the LARP Program Leader and (if necessary) with appropriate LARP Magnets Task Leaders, as described the LARP Research Program Management Plan.
AS3: Plans for beam commissioning are being developed, but rather slowly, and still appear to be somewhat vague. In response to a request, the committee was given an indication of tasks in which U.S. participants might become involved. This list appeared to have been prepared without sufficient discussion with CERN. If the U.S. is to have a significant role in LHC commissioning, management must “stake a claim”, otherwise, the impact of U.S. participation in the commissioning will prove quite minimal. Considerably more attention should be given to this aspect of the LARP program, or the U.S. will miss the opportunity to play an important role in commissioning.	Discussions with CERN have resulted in a prioritized list of tasks for which LARP personnel are most likely to become involved in commissioning; recent planning of efforts have concentrated on IR and Hardware Commissioning. Following the Commissioning Task Force recommendation, the LHC “Commissioning” activity has been separated from “Accelerator Physics”. This activity includes IR, hardware, and beam commissioning. Recently, the Fermilab Director has agreed to support 4-7 additional people for LHC hardware commissioning, and LBNL has agreed at the level of 2-3 personnel. Some number of LARP personnel have been identified. To help facilitate future long-term trips to CERN, a Commissioning Oversight Team, with members from all 4 LARP laboratories, has been formed.



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June'05 DoE Review: Scorecard

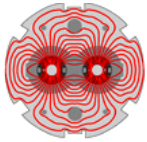
Recommendation – Accelerator Systems	Response/Action Plan
AS4: To prevent any miscommunication and eventual recrimination, it is therefore recommended that written documents, indicating the hardware to be delivered, and dates of delivery, be prepared and signed by both LARP and LHC managements.	The CERN Engineering Data Management Service (EDMS) – a special documentation format accepted for quality assurance at CERN – is used to define commitments, deliverables and dates of delivery of the hardware built by LARP. We are in the middle of corresponding discussions with CERN counterparts, for example as the potential inclusion of additional luminosity monitor modules is being negotiated. This is described in the Research Program Management Plan.



LARP

1.1 R&D on LHC Instrumentation

- L2 Leader: Alex Ratti (LBNL)
- FY06 budget 1,530 k\$
- Goals:
 - Build specialized instrumentation and diagnostics beyond the usual set. All of the instruments in the initial suite (ready in 2007) will be strong tools for efficient commissioning of the LHC, also they push the state-of-the-art, and in some cases the work helps our own machines. Instrumentation projects developed under LARP will be in operational use during LHC luminosity operation.
- L3 tasks:
 - Luminometer
 - Tune feedback
 - Schottky
 - New Initiatives



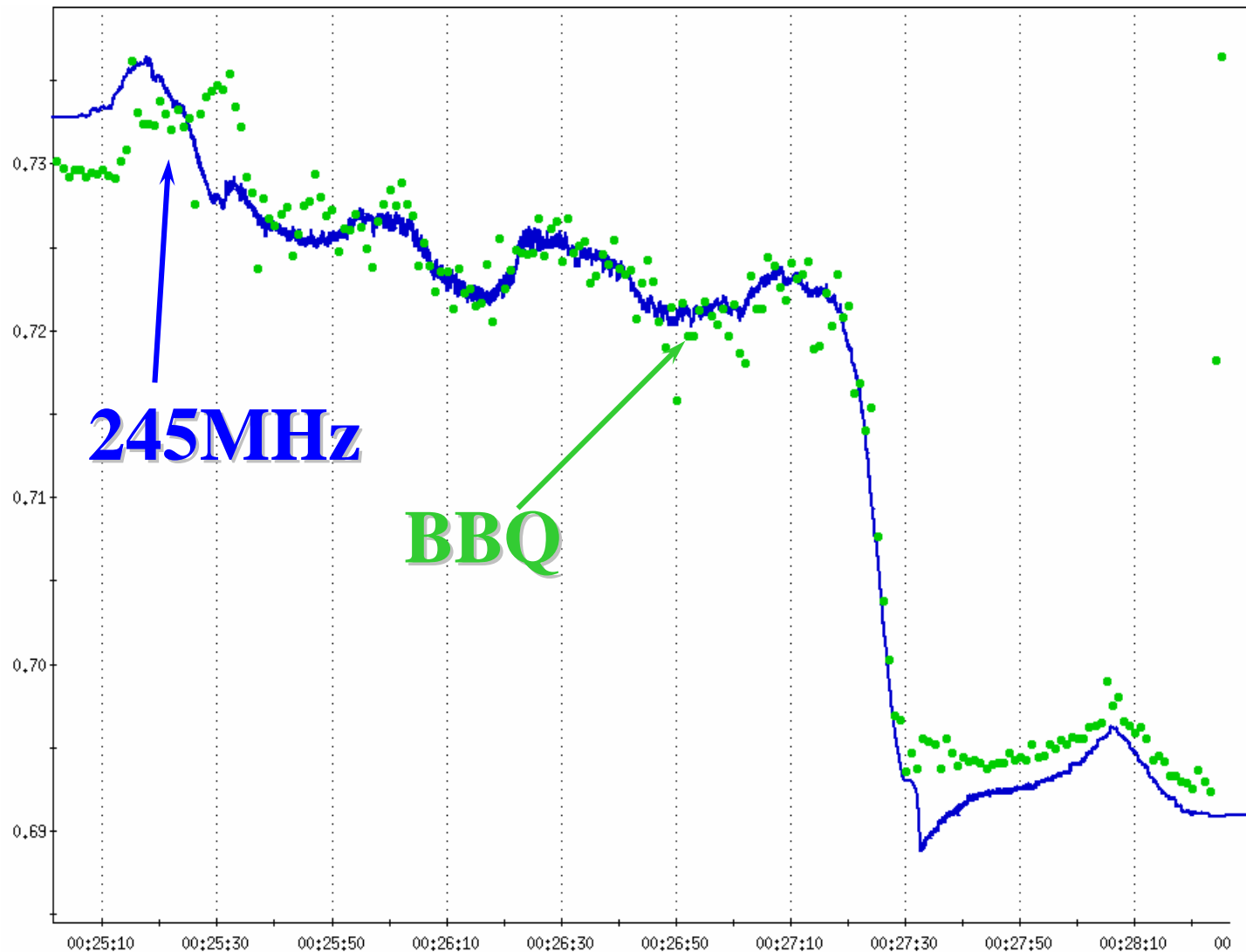
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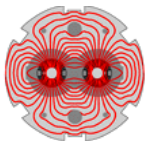
1.1.1 Tune Feedback

- L3 Leader: Peter Cameron (BNL)
- FY06 budget 323 k\$
- Goals:
 - Tune, chromaticity and coupling feedback instruments and software are being developed for the LHC to help deal with dynamic effects, particularly during injection and at the beginning of the ramp. Desired accuracy $\sim 0.001(2)$ for Q and C , $\sim 1-2$ in Q' . The Phase Locked Loop (PLL) method is to shake the beam and observe the BTF \rightarrow calc Q and use it in a FB to regulate a quad current and Q
 - Encouraging results with PLL tune feedback system were obtained in RHIC and Tevatron in 2005, many problems addressed and solved. (slides)
 - More details in A.Ratti talk



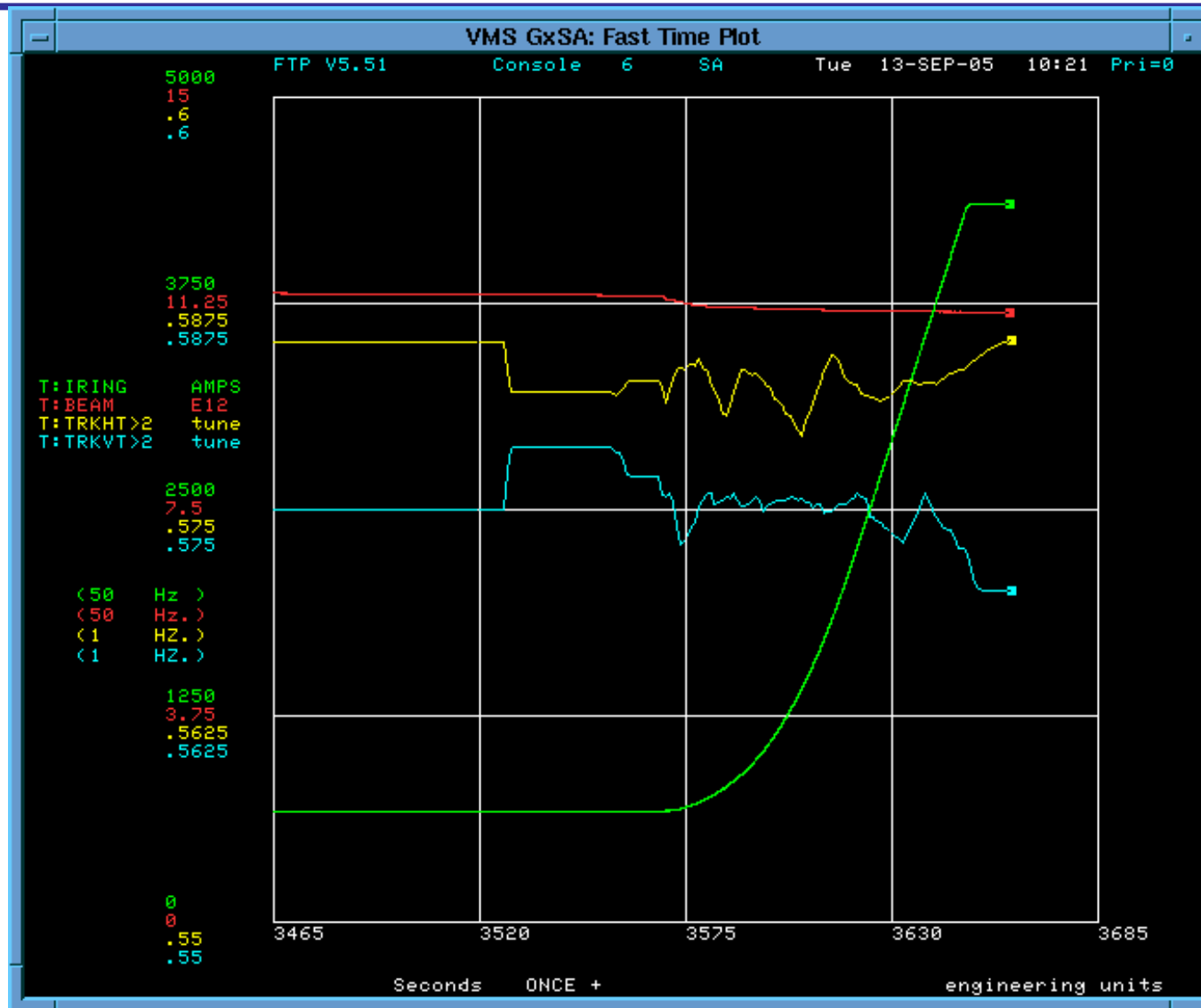
Good news: 3D tracks RHIC ramp (despite 60 Hz lines)



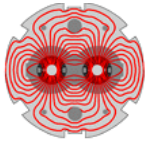


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PLL TT on Tevatron Ramp



#4386



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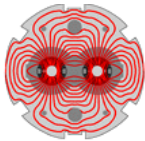
Tune Feedback Overall Plan

- **FY2006:**

- Q1: make prototype PLL (4 planes) ready for RHIC beam
- Q2: deliver 2 planes to CERN for SPS testing
- Q3: Final Design Review, SPS testing, initial Controls integration (FESA)
- Q4: finalize architecture

- **FY2007:**

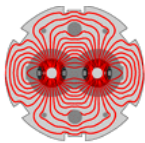
- Q1: make final system (4 planes) ready for RHIC beam
- Q2: deliver final system to CERN, system integration and testing
- Q3: system commissioning with beam



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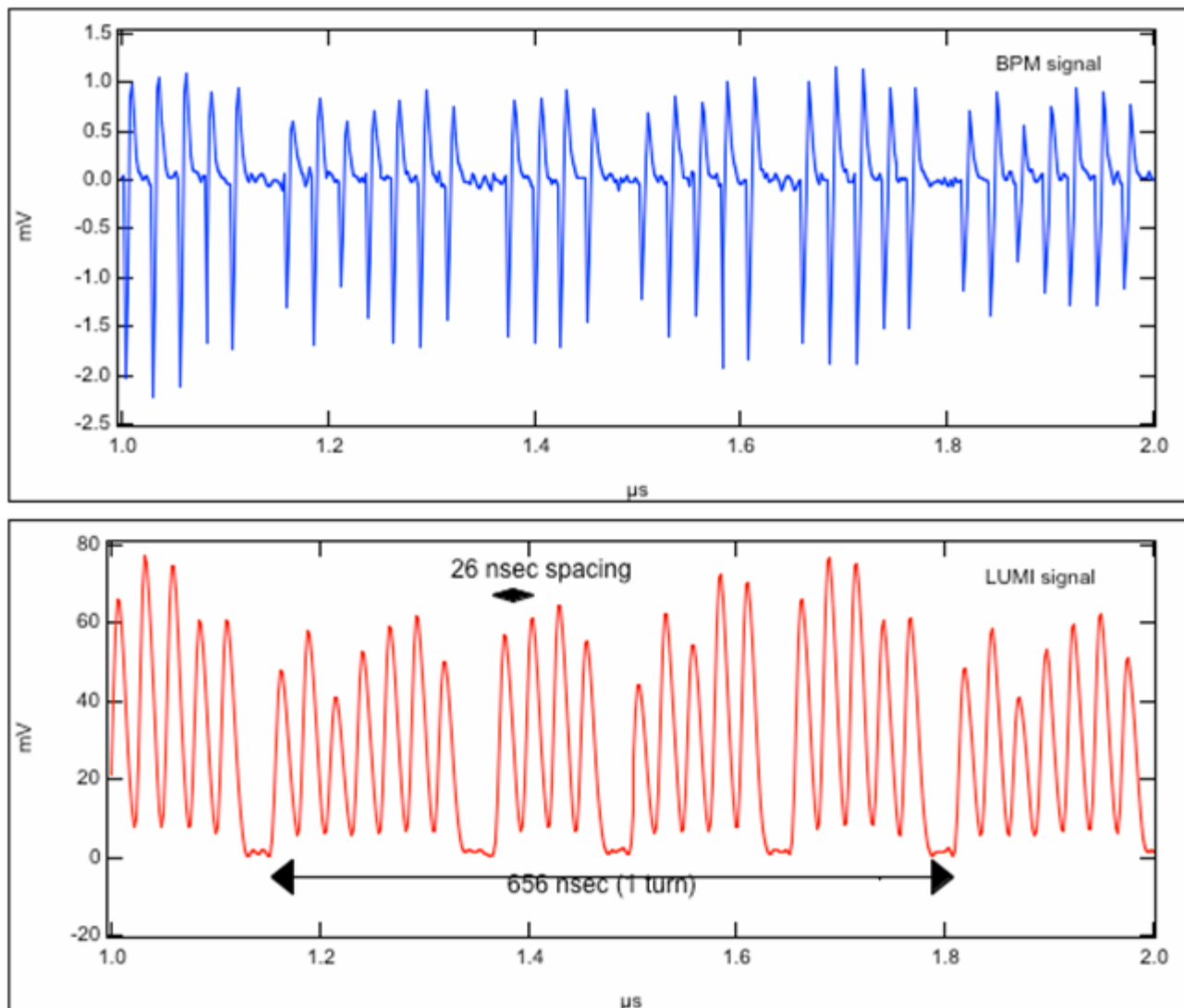
1.1.2 Luminometer

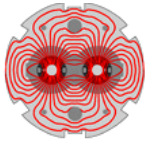
- L3 Leader: Alexander Ratti (LBL)
- FY06 budget 960 k\$
- Goals:
 - LARP will deliver 4 ionization gas luminosity monitors to the LHC, to go on either side of IP1 (ATLAS) and IP5 (CMS). Flowing gas is needed to ensure that fresh medium is used to prevent radiation damage effects. Experimenters are petitioning LHC management to "purchase" 2 or 4 of similar monitors for use at IP2 and/or IP8. In 2005 the LBL group completed and formalized the system integration document, describing the installation plan at CERN.
 - A test of the prototype luminosity monitor at the ALS (LBL) X-ray beam line was very successful and demonstrated 40 MHz capability of the monitor, and completed the feasibility studies planned for the device. (slides)
 - More in A.Ratti talk



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LM 40 MHz ALS X-ray test

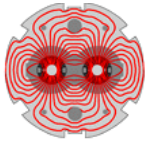




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Luminometer Overall Plan

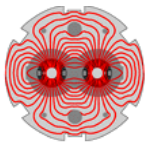
- **FY2006:**
 - Design and build first unit of DAQ system
 - Final design of complete first unit
 - Test prototype at RHIC
- **FY2007:**
 - Build all units
 - Install and commission all units at CERN



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1.1.3 Schottky Monitors

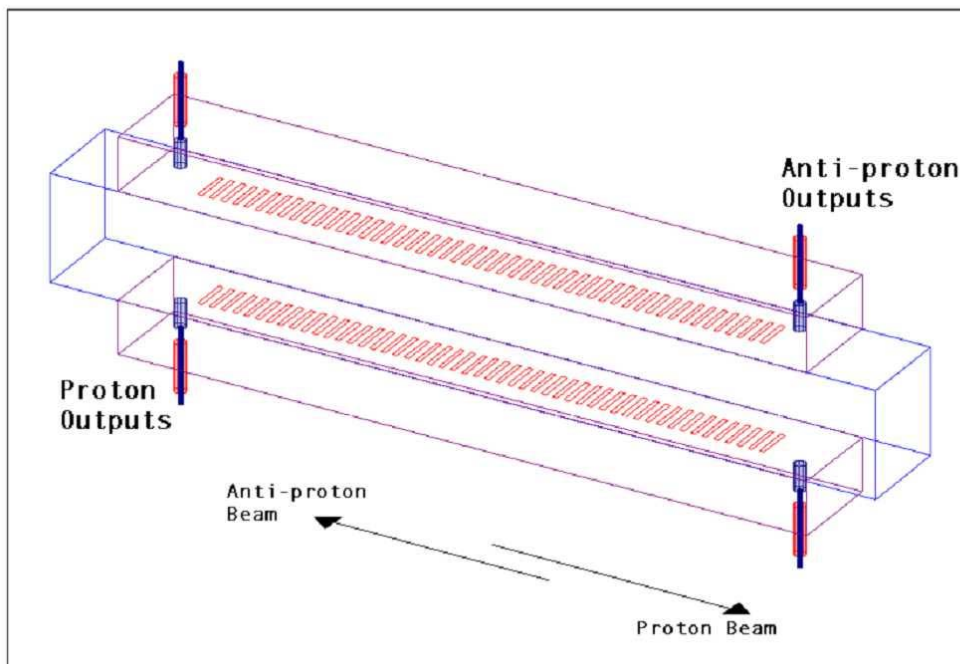
- L3 Leader: Andreas Jansson (FNAL)
- FY06 budget 245 k\$
- Goals:
 - 4.7 GHz Schottky monitors will continuously and non-destructively measure the LHC beam sizes, tunes, and distributions on bunch-by-bunch basis. Under that task, LARP will deliver: a complete design and analysis, a drawing package, the analog signal processing electronics, analysis software, installation and hardware commissioning support at CERN. CERN will provide manufacturing and local installation, DAQ system and controls system integration.
 - Great performance in Tevatron and Recycler (slides)



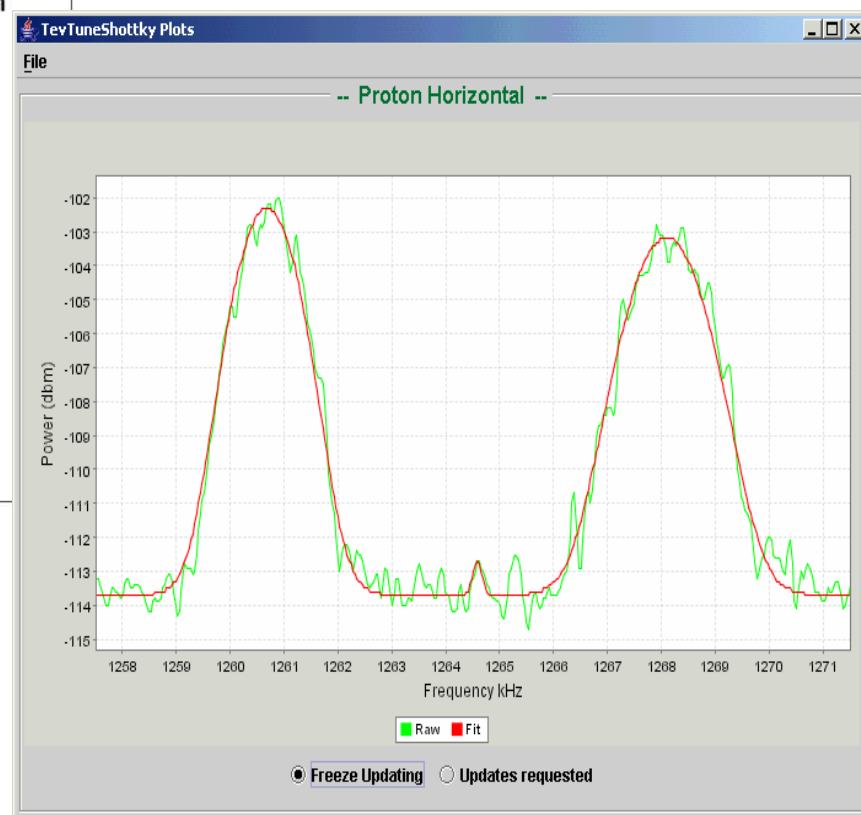
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Schottky - Technical approach

Slotted Waveguide Pickup

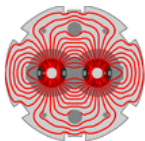


1.7 GHz 75 mm aperture at Tev
4.7 GHz 60 mm proposed for LHC



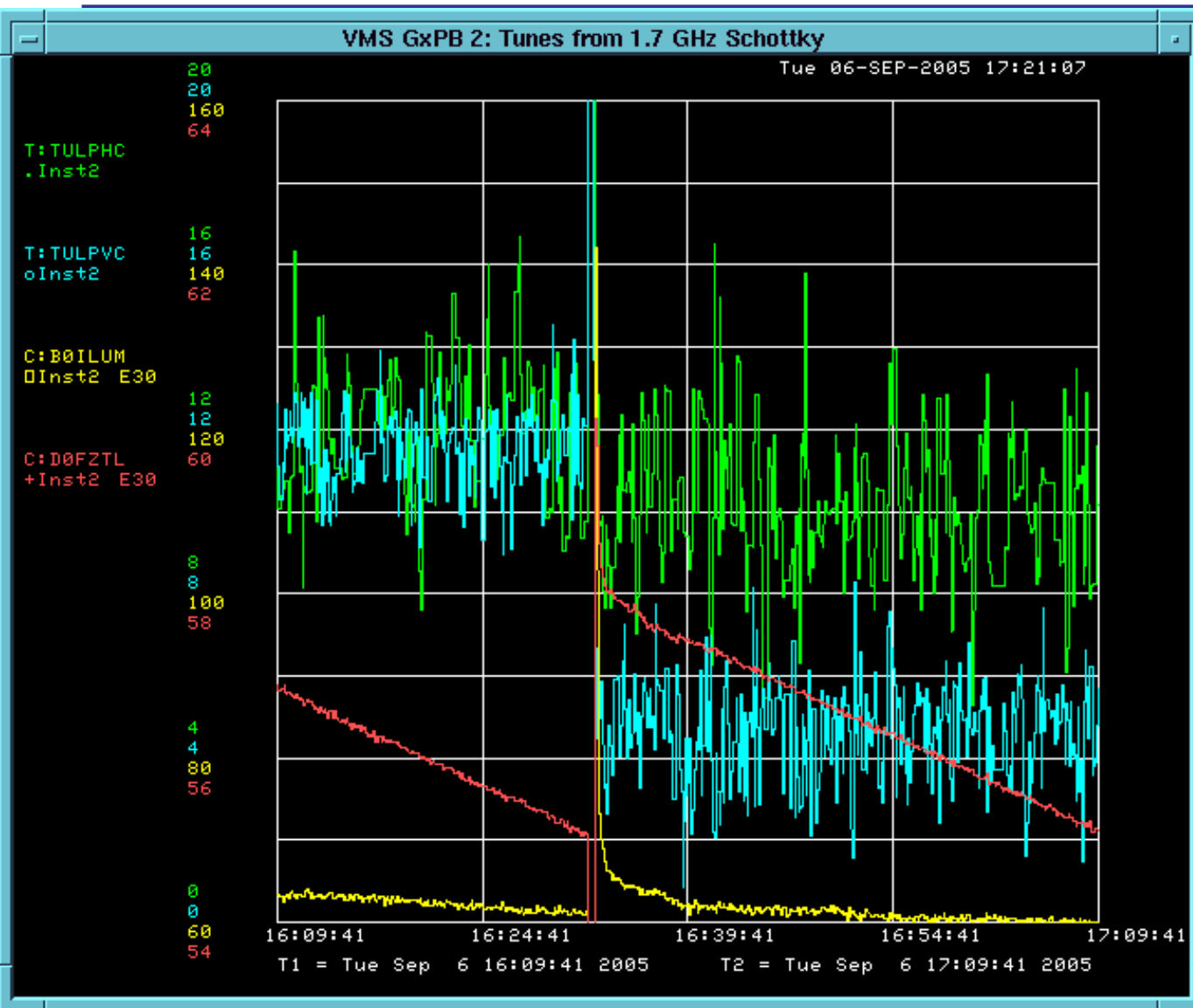
Reports:

bunch-by-bunch, p,a
tunes
chromaticities
emittances
momentum spread



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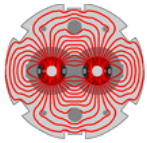
Schottky Monitor in Tev → LHC



← Store 4371; optics correction during store, 1.7 GHz Schottky shows significant chromaticity change

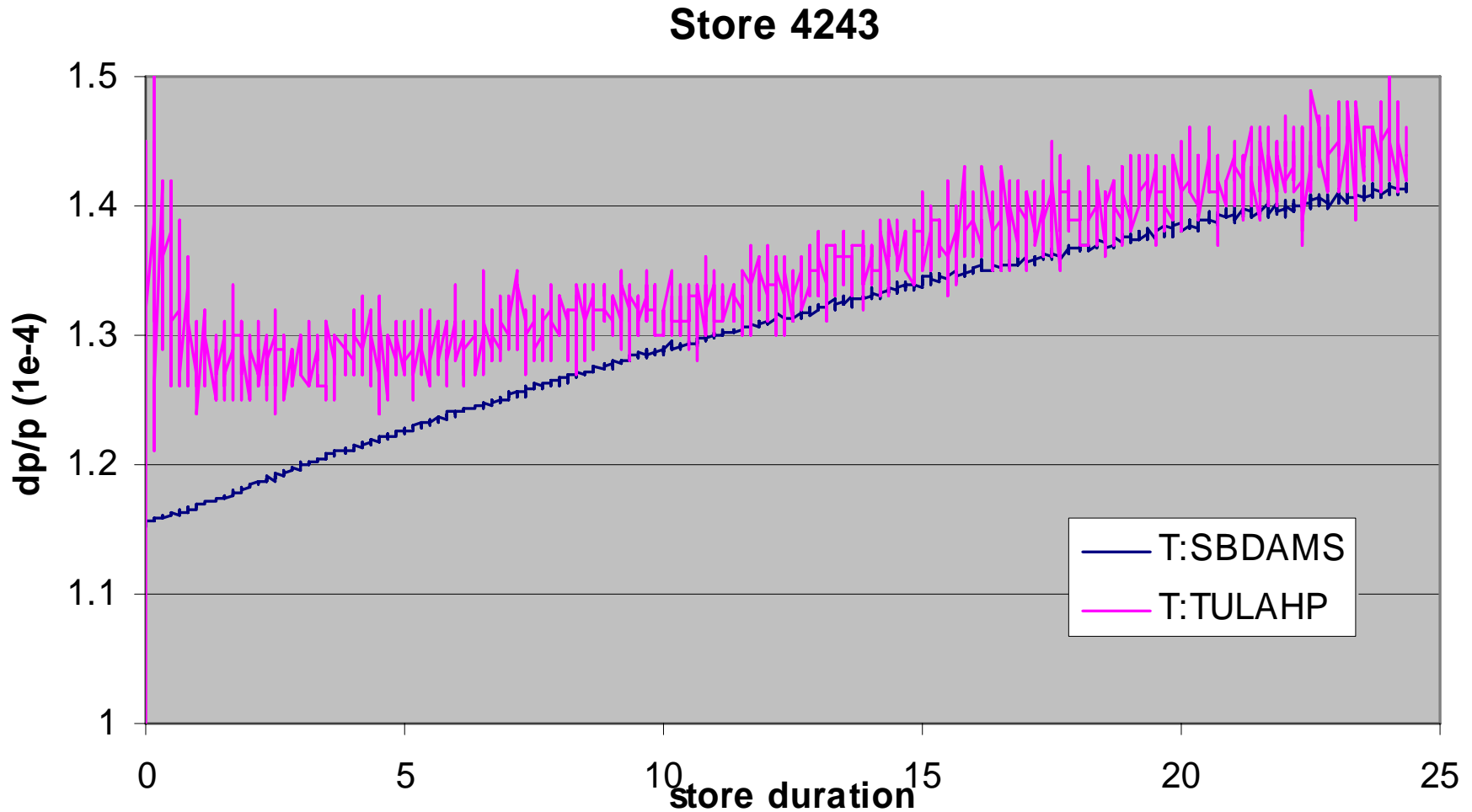
4.7GHz to be built by CERN

R.Pasquinelli & A.Jannsson of FNAL to design it, and take part in integration, analysis software development and commissioning



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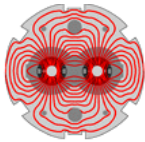
Recent Observation: BB tune spread





Schottky Monitors Overall Plan

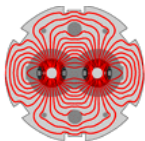
- **FY2006:**
 - S/N study of low intensity bunches in Tevatron
 - Design pick-up structure, study PLL DAB board for DAQ
 - complete an “integration document”, signed off by both parties, and entered into CERN EDMS
 - Design and build front-end electronicsQ1
 - Joint LARP and CERN review of the proposed design
- **FY2007:**
 - Adapt Fermilab analysis software
 - Hardware commissioning at CERN without beam
- **FY2008:**
 - Hardware commissioning at CERN with beam
- **FY2009:**
 - Beam studies of chromaticity measurements, ramp effects



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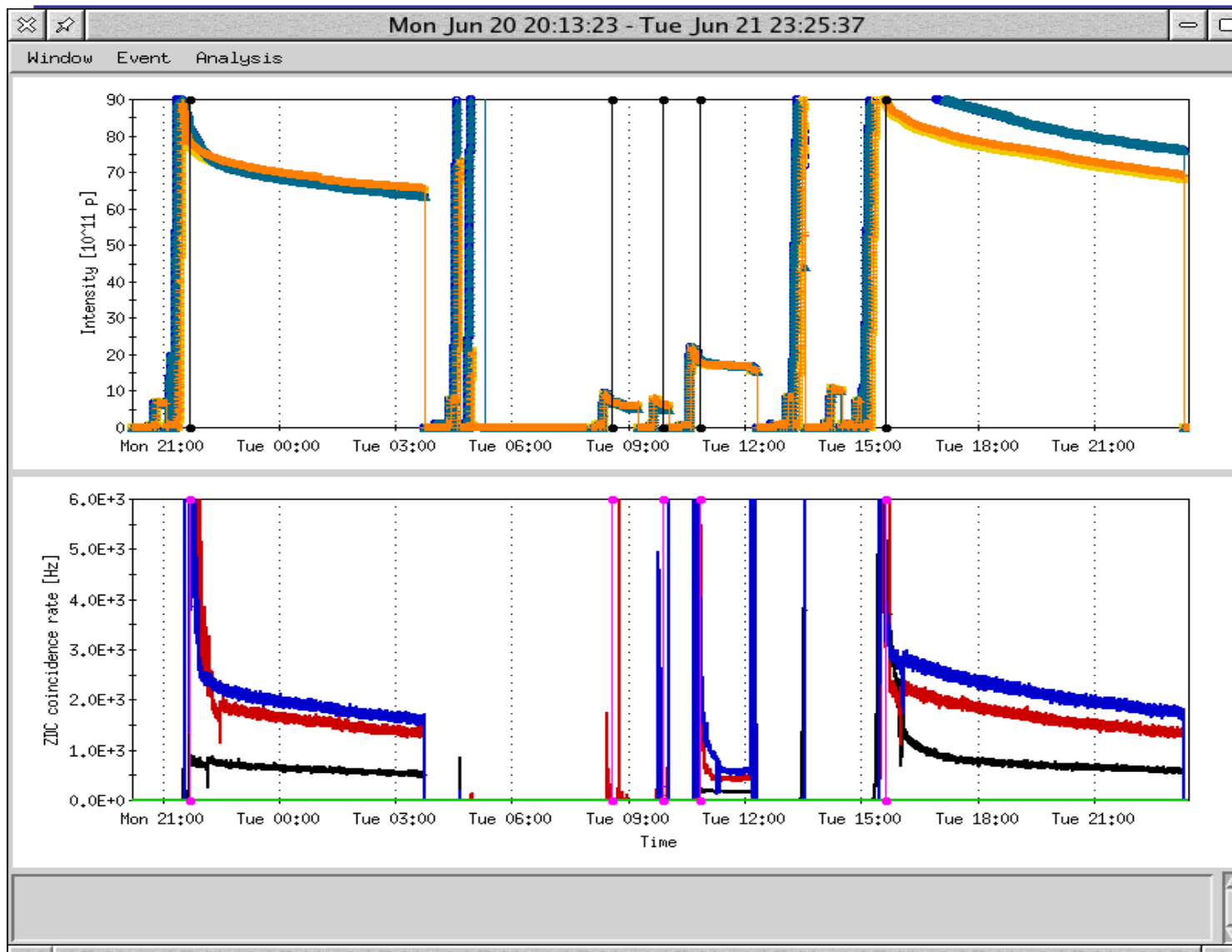
New Instrumentation Initiatives

- L3 Leader: Alexander Ratti (LBL)
- FY06 budget 0 k\$
- Goals:
 - Those are not part of the current work scope but possibly will be very useful for the LHC, and for which the U.S. laboratories can supply expertise. Some of these systems can be productively developed using the Tevatron or RHIC and be useful in improving the performance of both the LHC and our domestic accelerators. This work is a continuation beyond the initial suite of instruments, and it is estimated as a level of effort in later years.
 - ZDC, Head-Tail, SyncLiteFiber, AC Dipole (slides)



LARP

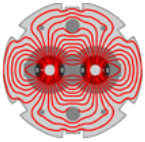
ZDC in RHIC



←p-p store (June 21, 2005)
Independence on background need to be checked

S.White is activity activity leader (BNL)

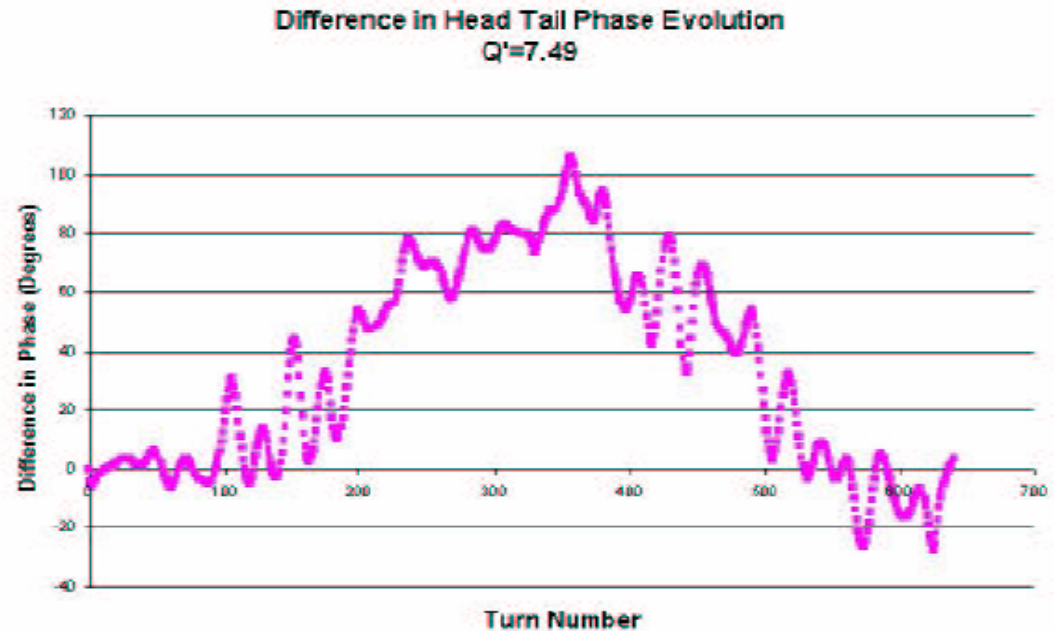
Decisive meeting Nov 9, 2005 at BNL

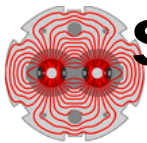


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Head-Tail Q' Monitor

- Modern scopes motion of 5cm slices of 10-50 cm long bunch
- HT dPhase \sim Q'
- In routine use for injection tuneup Tev
 - ± 0.5 unit, very fast, reliable; also computes tunes, coupling, checks optics
 - V.Ranjbar is leading this activity for LARP



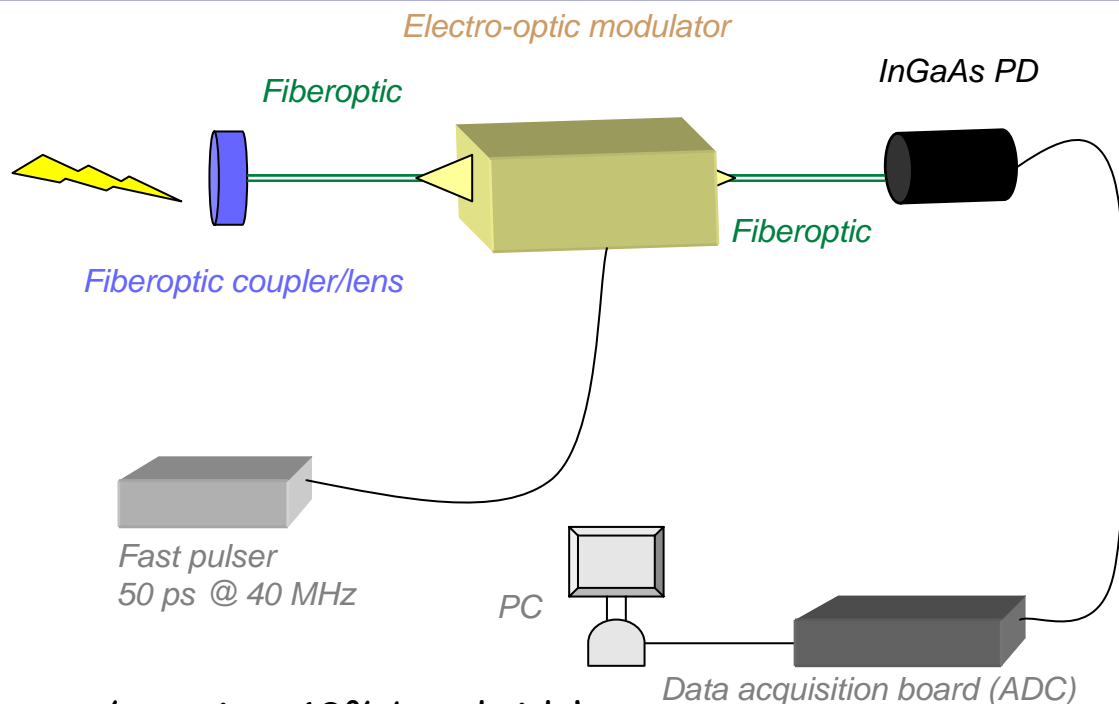


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SyncLite Fiber: ghost bunches measurement (DeSantis, Byrd, Zolotorev)

LHC Requirements

- Time resolution:
 50 ps
- Max integration time:
 10 s
- Sensitivity:
 $5 \cdot 10^5 \text{ p}$



$5 \cdot 10^5$ protons emit ~ 30 photons/turn in a 10% bandwidth.

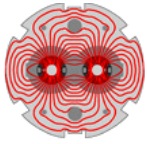
The electro-optic modulator/fast pulser combination can map the entire LHC ring, with the required resolution, every 500 orbits.

In the allowed integration time, every single 50 ps-long region is sampled 200 times.

A 70% QE photodiode would accumulate >4000 counts.

We can estimate a total of -6/8 dB from the coupling into the optical fiber and the various insertion losses.

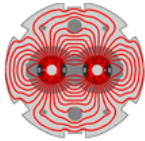
Main noise sources are the modulator extinction ratio ($\sim 3 \cdot 10^{-3}$) and the photodiode dark current ($\sim \text{nA}$)



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AC Dipole

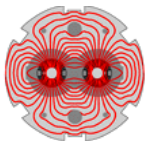
- Tevatron is building one for Run II upgrades → LHC?
 - A.Jansson in collab with BNL and UT



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1.2 LHC Commissioning

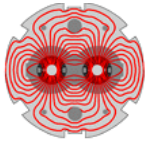
- **L2 Leader:** Michael Syphers (FNAL)
- **FY06 budget** 1,140 k\$
- **Goals:**
 - There is an overall benefit to the U.S. high-energy physics program if the LHC turns on rapidly and successfully. Our experimental physics groups have invested heavily in the LHC project, and the science produced there thus represents a return on the U.S. investment. A healthy and strong HEP activity at LHC will surely be necessary to secure future accelerator-based HEP projects in the U.S. The information gained during the commissioning will be available in a timely manner and will have maximum positive effect on U.S. plans for LHC
- **L3 tasks:**
 - Beam Commissioning
 - Hardware Commissioning
 - Toohig Fellowship
 - New Initiatives



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1.2.1 Beam Commissioning

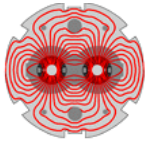
- L3 Leader: Elvin Harms (FNAL)
- FY06 budget 400 k\$
- Goals:
 - The Beam Commissioning task consists of :
 - *Commissioning of LARP Deliverables:* This includes the commissioning and exploitation of beam instrumentation developed with LARP funds, such as luminometers, tune feedback, and phase 2 collimators.
 - *Generic Beam Commissioning:* This includes participation in beam startup, various beam studies, and exploitation of beam instrumentation other than that developed with LARP funds. Some 30 topics for possible U.S. contributions were listed by CERN Beam Commissioning leaders and presented at the LARP collaboration meetings in 2005.
 - The LHC is scheduled to have first beam in 2007. The beam commissioning activity will begin **~a year before** that, in order to prepare and be sure that our scientists are fully integrated with the team at CERN. The LHC will be a very difficult machine to operate, and it is expected to take several years for it to approach its design performance - we expect commissioning work to extend **for about two years after** first beam. By that time, the LHC should be nearing peak luminosity, and the effort will segue into analysis and fundamental accelerator physics, using the LHC as an experimental instrument.



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Beam Commissioning Overall Plan

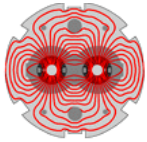
- **FY2006:**
 - First visits for commissioning of LARP deliverables organized and started;
 - Long term plan (LTP) of general beam commissioning formulated, reviewed and approved
 - LARP presence for the SPS start up
- **FY 2007:**
 - first year of full involvement of LARP in the LHC beam commissioning
- **FY2008-2009:**
 - the commissioning effort continues according to the LTP/N study of low intensity bunches in Tevatron
 - See M.Syphers talk for more details



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1.2.2 IR & Hardware Commissioning

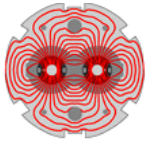
- L3 Leader: Michael Lamm (FNAL)
- FY06 budget 540 k\$
- Goals:
 - The IR & HC task consists of :
 - *Interaction Region Commissioning*: This relatively modest and well defined Task refers to non-beam commissioning of hardware built in the U.S.-LHC Construction Program, such as interaction region magnets, and feed boxes. LARP will support 2-3 1-year long visits for that purpose in FY06-07. The names are identified, the visits are scheduled.
 - *Hardware Commissioning*: U.S. lab directorates will support 6-9 FTEs for additional hardware commissioning assistance to CERN, and LARP is a natural vehicle through which this activity will be organized.
 - The entire IR and Hardware commissioning effort will take place in FY'06 and FY'07 – until the end of the LHC installation and machine commissioning.



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IR & HC Overall Plan

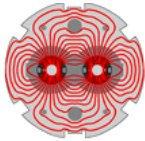
- **FY2006:**
 - general Hardware Commissioning to be organized in the first half of FY'06
 - Jan'06: Finish installation procedures for US deliverables
 - Feb'06: Provide installation oversight of US deliverables in first IR
 - Mar'06: first long-term commissioner at CERN
 - Jun'06: begin Commissioning 1st IR
- **FY 2007:**
 - CERN's planned end date for hardware commissioning
 - See M.Syphers talk for more details



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Toohig Fellowship

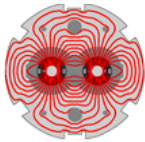
- Committee Chair: Peter Limon (FNAL)
- FY06 budget 200 k\$
- Goals:
 - It is critical that U.S. accelerator physicists and engineers make use of this relatively rare opportunity to train younger staff members on the LHC machine. In 2005, the LARP announced Toohig Fellowships - postdoctoral research positions in accelerator science for recent PhDs in physics or engineering.
 - 1st selected - Rama Calaga (Stony Brook)
- *Overall Plan:*
 - FY 2006-2010: up to 2 Toohig Fellows will be selected each year



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New Initiatives

- L3 Leader: Michael Syphers (FNAL)
- FY06 budget 0 k\$
- Goals:
 - LARP is currently considering participation in the CMS/LHC Remote Access Center at Fermilab – which will support several types of LARP activities :
 - Participate in LHC hardware & beam commissioning and operations
 - Monitor LHC accelerator components (e.g. systems built in the U.S.)
 - Analyze the monitoring data for LHC
 - Develop software for the LHC
 - Provide access to monitoring data and analysis results
 - Provide training and data-analysis facility for members of US/LARP
 - Provide a rapid response call center to get experts located in North America connected to CERN (data access, operational status, etc.)
 - The ability to participate in experiments remotely from the U.S. may greatly reduce the travel strain and cost of Accelerator Physics and LHC beam commissioning activities.
 - Eric Gootschalk (FNAL) is leading LHC@FNAL initiated by FNAL Director in April'05

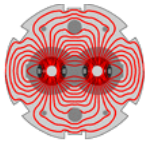


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What is that “Center” about?

... from preliminary ROC task force report
(E.Gottschalk):

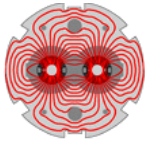
- **Communication hub**
 - Serving as a (reduced) extension of CCC and CMS CR
 - Serves the LHC community in entire North America
- **Provide hard- and software necessary for participation in LHC and CMS activities**
 - training prospective commissioners
- **Role in public relations**
 - Very visible at FNAL
 - Demonstrate how international projects may be carried out



LARP

Possible Layout: FNAL WH GF

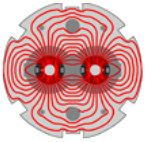




LARP

LHC@FNAL Overall Plan

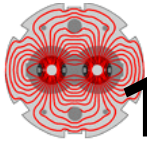
- **FY2006:**
 - we will take part in initial discussions on that subject within framework of the LHC@FNAL Task Force led by Eric Gottschalk (FNAL).



LARP

1.3 LHC Collimation R&D

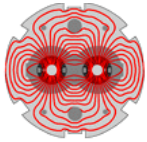
- L2 Leader: Tom Markiewicz (SLAC)
- FY06 budget 850 k\$
- Goals:
 - The LHC cleaning system must have exceptional efficiency to meet its design parameters, significantly beyond the state-of-the-art that is achieved in existing colliders. It is crucial for the success of the LHC that different paths are explored in order to optimize the design, hardware and operational procedures for the LHC collimation system. In view of the exceptional difficulty for the LHC it is essential to pursue parallel R&D studies in- and outside of CERN. The phased approach for the LHC collimation system will allow to test various proposals and to implement the best solutions in an already defined upgrade path to nominal performance. The LHC Collimator R&D will complement the work at CERN and will be performed in close
- L3 tasks:
 - Cleaning Efficiency Studies
 - Rotating Collimators R&D
 - Tertiary Collimators Studies
 - Material Irradiation Studies



1.3.1 Cleaning Efficiency Studies

LARP

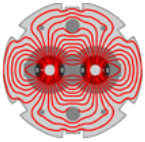
- L3 Leader: Angelika Drees (BNL)
- FY06 budget 50 k\$
- Goals:
 - The ultimate goal of this sub program is to bench mark code(s), in particular SIXTRACKwColl, in a variety of aspects with RHIC beams.
 - We plan to install and implement at BNL accelerator tracking code identical with the one used at CERN (K2, SIXTRACK with Collimators, i.e. SIXTRACKwColl) and perform simulations of collimation efficiencies and loss maps which will then be compared to simulation results from earlier studies done at RHIC with other codes (Teapot, K2, ACCSIM) and with data. Various data sets at two energies are available.
 - During the RHIC proton run collimator setup procedures should be implemented into the RHIC control system and tested with beam under real operating conditions.



LARP

Cleaning Efficiency Studies: Overall Plan

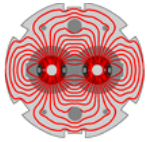
- **FY2006:**
 - debug the code
 - compare with other simulation and data, test setup procedures,
 - finish reports



LARP

1.3.2 Rotating Collimators

- L3 Leader: Tom Markiewicz (SLAC)
- FY06 budget 720 k\$
- Goals:
 - The ultimate goal is a successful design for low impedance, high efficiency LHC secondary collimators. The design will be validated with a sufficient but small (1-3) number of prototypes and beam tests. The design specifications and the prototypes are the primary deliverables. The time scale is set by the desirability of testing the prototypes with LHC beam in 2008/09. Then, CERN will decide whether or not to proceed with the rotating collimator design. If a decision is made to proceed, this sub-project will provide an engineering drawing package to CERN and will support the effort to commission the collimators once they are manufactured and installed by CERN.



LARP

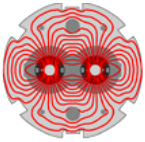
June 15-17 CERN/SLAC Collaboration Meeting

• Attendees

- CERN: Ralph Assmann (Project Leader, Tracking), Allesandro Bertarelli (Mechanical Eng.), Markus Brugger (Radiation Issues), Mario Santana (FLUKA)
- SLAC: Tom Markiewicz, Eric Doyle (ME), Lew Keller (FLUKA), Yunhai Cai (Tracking), Tor Raubenheimer
 - Radiation Physics Group: Alberto Fasso, Heinz Vincke

• Results

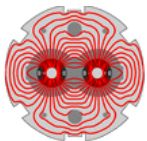
- Agreement on basic design of RC1 (1st rotatable prototype)
- Transfer of many of CERN mechanical CAD files
- Lists of
 - Further studies required
 - Outstanding Engineering Issues requiring more design work
 - Project Milestone List & Action Items List
- Test Installation of “New FLUKA”



Conceptual Design of RC1 (1 of 2)

LARP

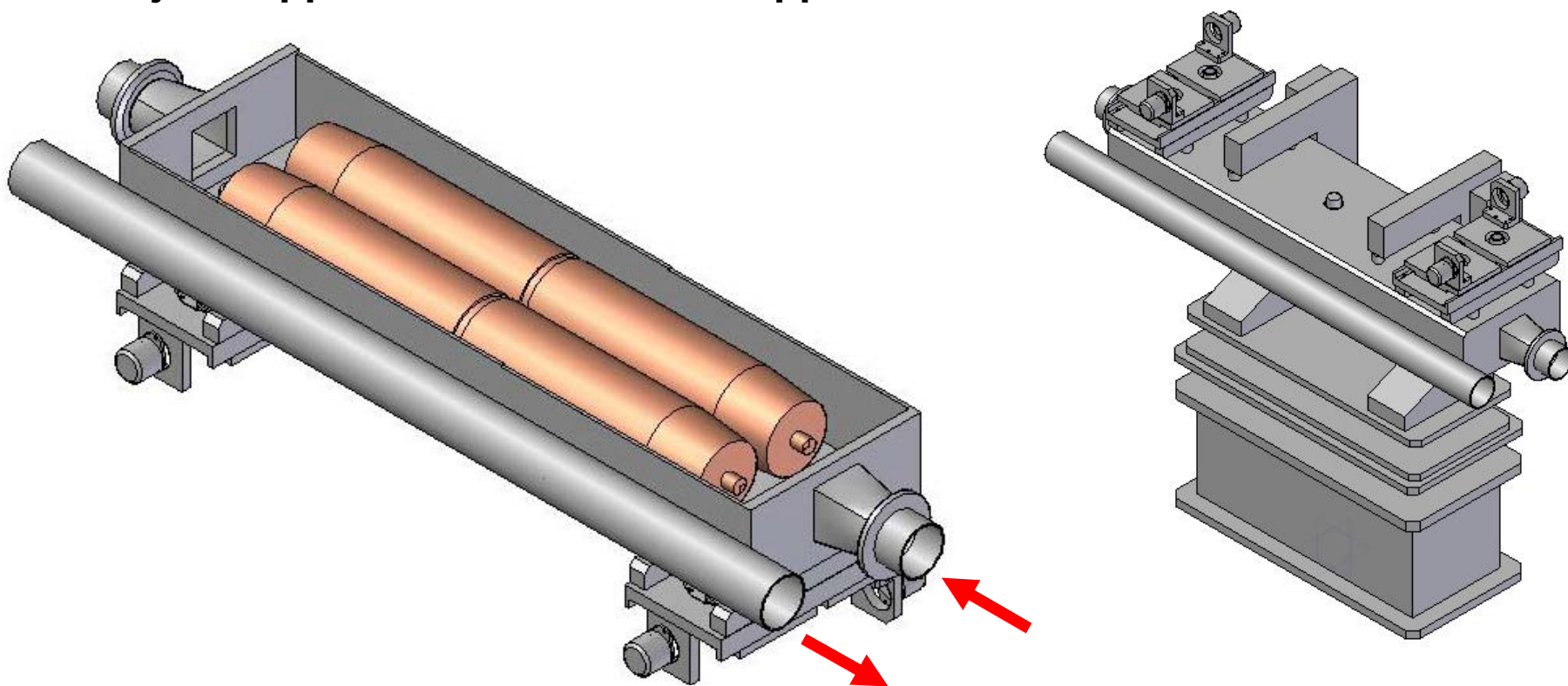
- **Mechanics must fit within CERN Phase I C-C envelope**
 - 224mm center-to-center with 88mm OD beampipes
 - 1480mm longitudinal flange-to-flange
 - 25mm adjustment/jaw (22.5mm relative to beam w/ ± 5 mm allowed beam center motion)
- **and use Phase I alignment and adjustment scheme**
 - Two 75cm Cu cylindrical jaws with 10cm tapered ends, 95cm overall length with axes connected to vertical mover shafts
 - 136mm OD with 9mm taper
 - Each jaw end independently moved in 10 μ m steps
 - Vacuum vessel sized to provide 8mm clearance to adjacent beam and allow gross/fine 0°, 45°, 90° positions
- **Relaxed mechanical deformation specifications**
 - <25 μ m INTO beam guaranteed by adjustable mechanical stop(s)
 - Ride on groove deep enough to not be damaged in accident case
 - Adjustable between ± 5 and ± 15 sigma (2-6mm) & centered on beam
 - <325 μ m (750 μ m) AWAY FROM beam @ 0.8E1p/s loss (4E11p/s)
 - Flexible support on adjustment

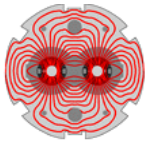


LARP

Proposed layout

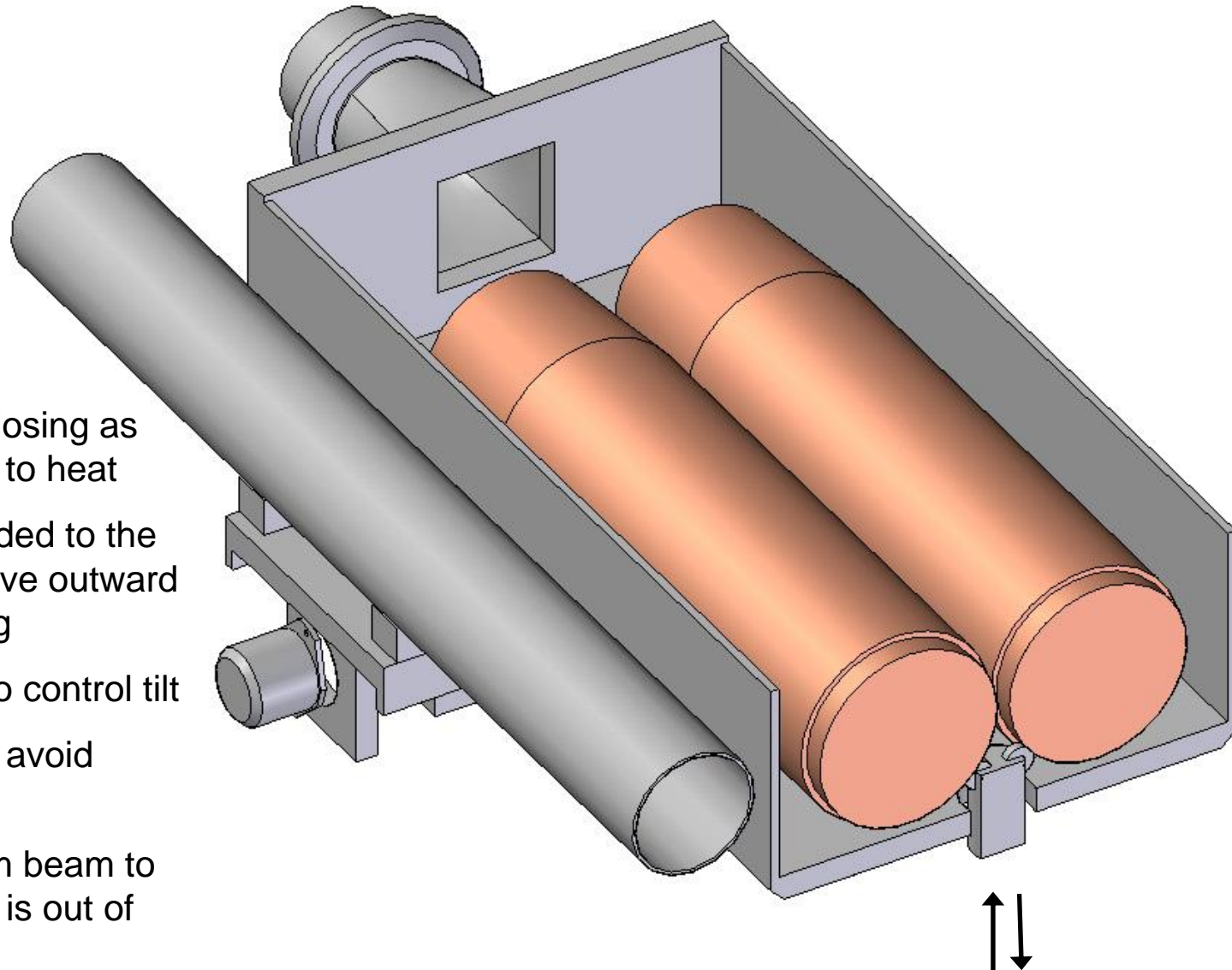
136mm diameter x 950mm long jaws, vacuum tank, jaw support mechanism and support base derived from CERN Phase I



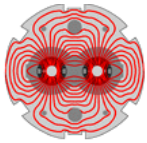


LARP

Adjustable gap-defining stop

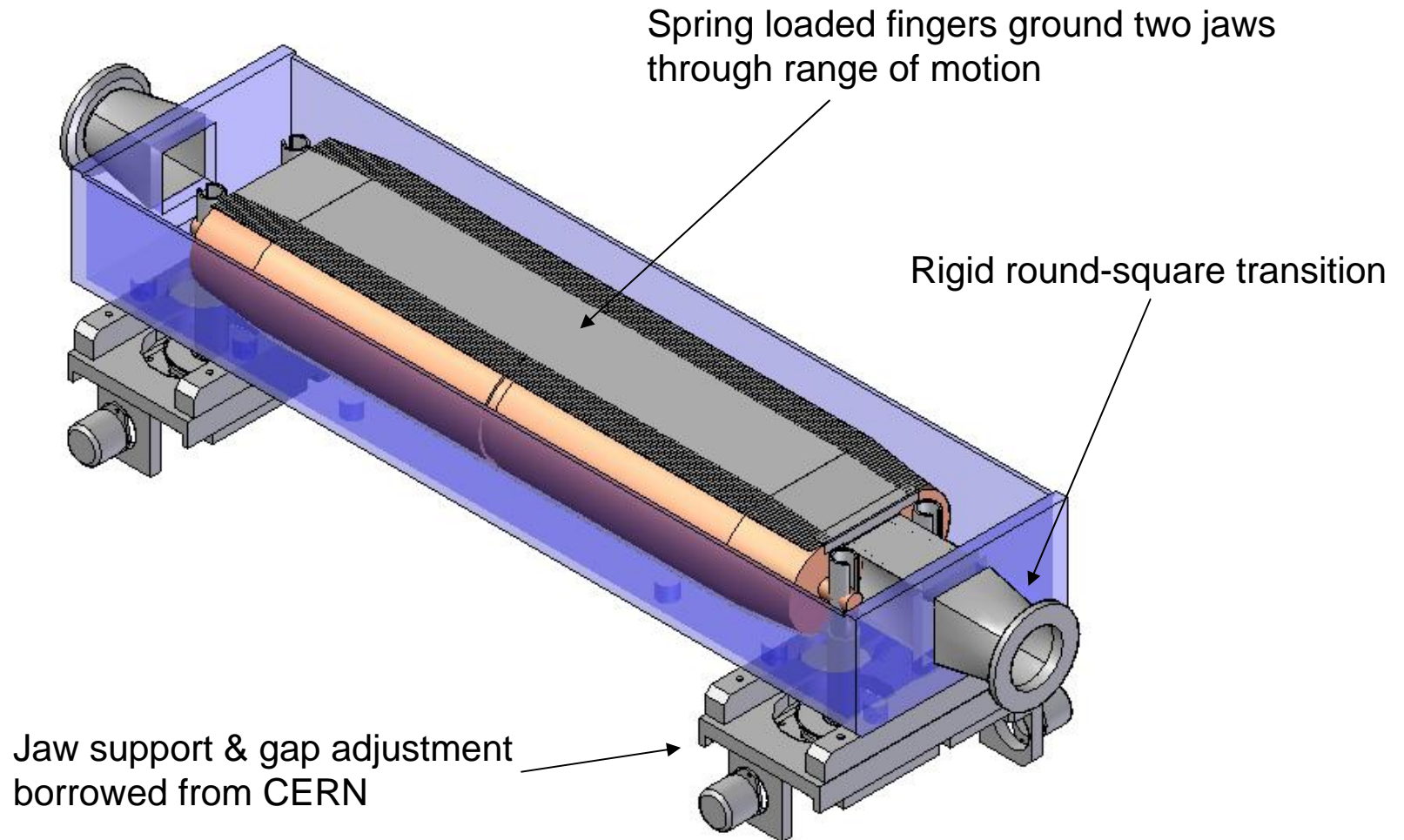


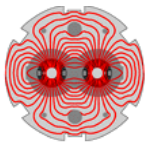
- Stop prevents gap closing as jaw bows inward due to heat
- Jaw ends spring-loaded to the table assembly ... move outward in response to bowing
- May use two stops to control tilt
- Slot deep enough to avoid damage in accident
- Stop far enough from beam to never be damaged & is out of way at injection



LARP

RF Contact Overview

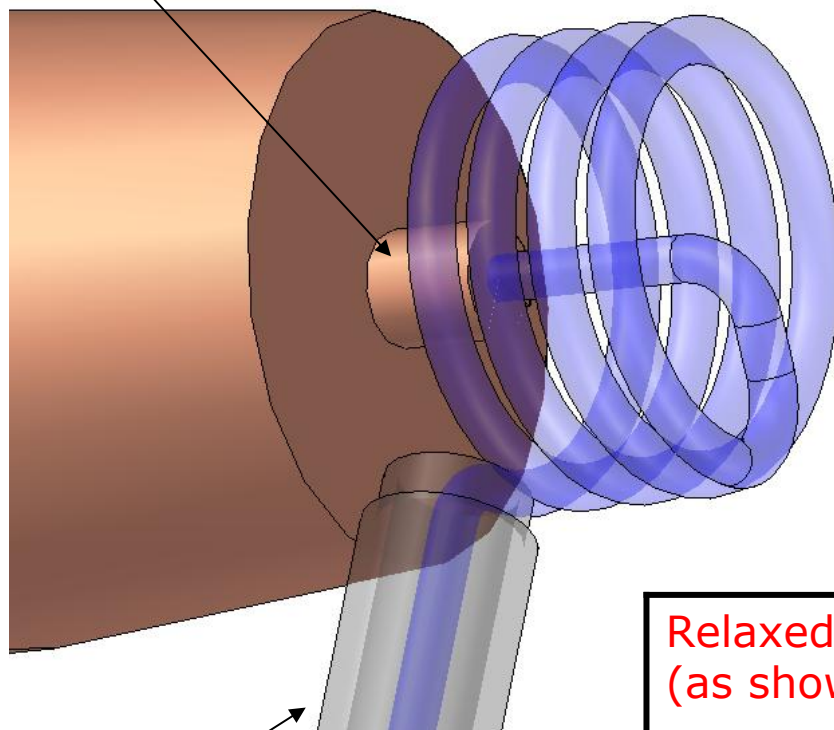




LARP

Detail of flex cooling supply tube

Stub-shaft (bearing not shown)



Support shaft

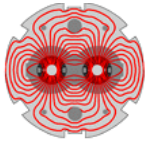
Contiguous with helical tube inside jaw.

Formed after assembly-brazing of jaw and installation of bearing on stub-shaft

Exits through support shaft per CERN design

Material: CuNi10Fe1, 10mm O.D., 8mm I.D.

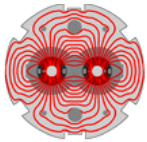
Relaxed (as shown)	# coils	4
	O.D.	111mm (4.4in)
full 360° rotation	# coils	5
	O.D.	91mm (3.6in)
	torque	9.1N-m (81in-lb)



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Rotating Collimators Overall Plan

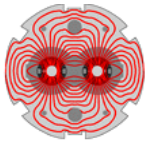
- **FY2006:**
 - Q1: Review of RC1 engineering design
 - Q2-3: construction of functional collimator RC1
 - Q4: tests of the first cylinder of RC1 at SLAC
- **FY 2007:**
 - tests of RC1 (two rounds)
 - design and construction of RC2
 - Non-Beam Tests of RC2
- **FY 2008:**
 - Ship, Install, Beam Tests of RC2 in LHC May-Oct 2008 run
- **FY 2009:**
 - RC2 beam tests
 - final drawing package for CERN
- **FY 2010-11:**
 - Await production & installation by CERN
 - Commissioning support



1.3.3 Tertiary Collimator Studies

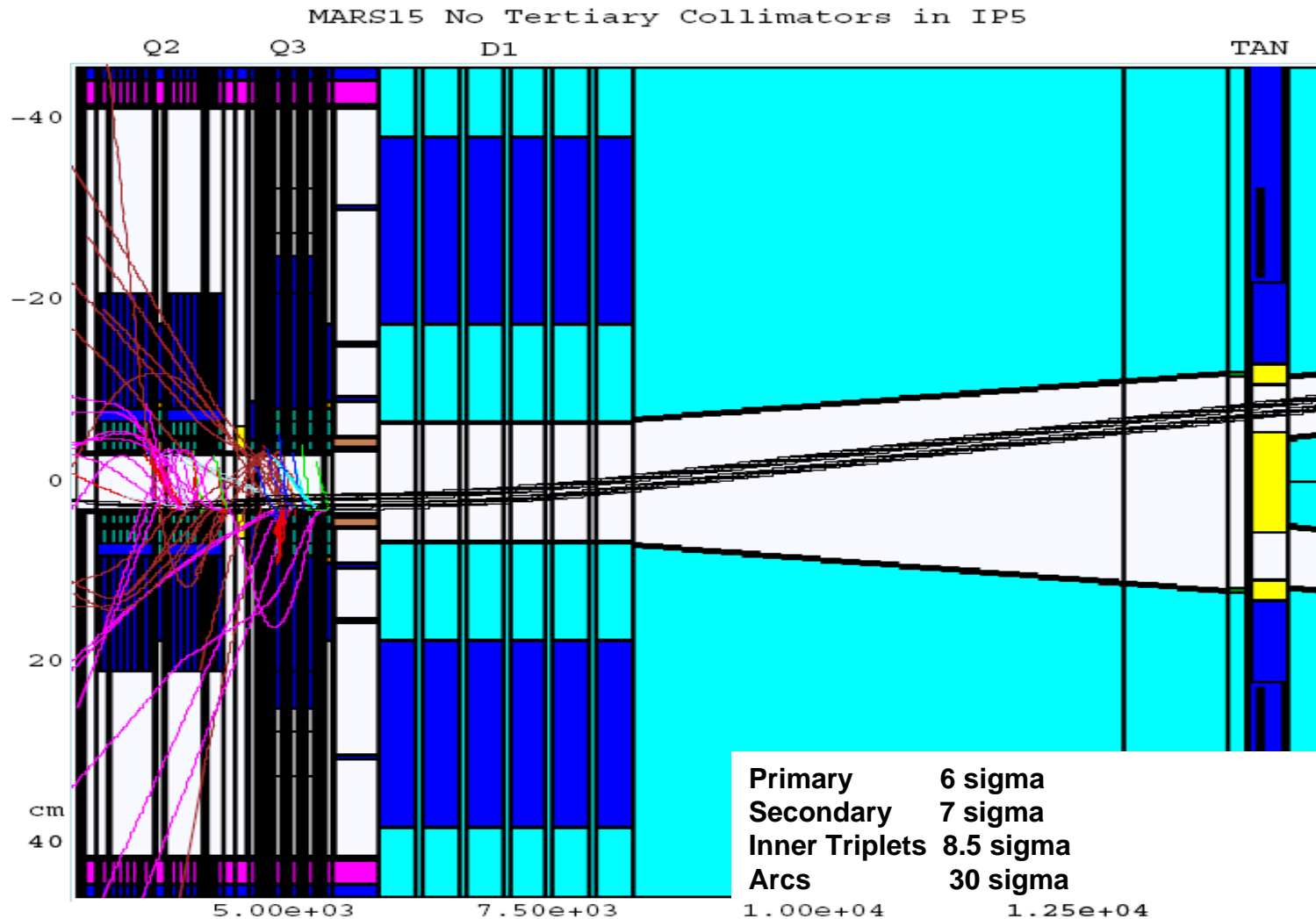
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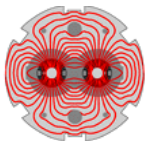
- L3 Leader: Nikolai Mokhov (FNAL)
- FY06 budget 30 k\$
- Goals:
 - Tertiary collimators in high-luminosity insertions are needed to protect of LBQuads and detectors. We will carry out full tracking – with the STRUCT code - of secondary halo particles up to the limiting apertures in the IP1 and IP5 insertions and farther to the CMS and ATLAS detector inner detectors followed by realistic energy deposition modeling with the MARS15 code with and without tertiary collimators.
 - Minimization of machine-related backgrounds and protection of the final focus and collider detector components at normal operation and accidental beam losses is to be added to the collimation system specifications. The ultimate goal is a successful design for high efficient robust tertiary collimators in all the LHC experimental insertions. The design specifications are the primary deliverables.



TERTIARY BEAM HALO LOSS

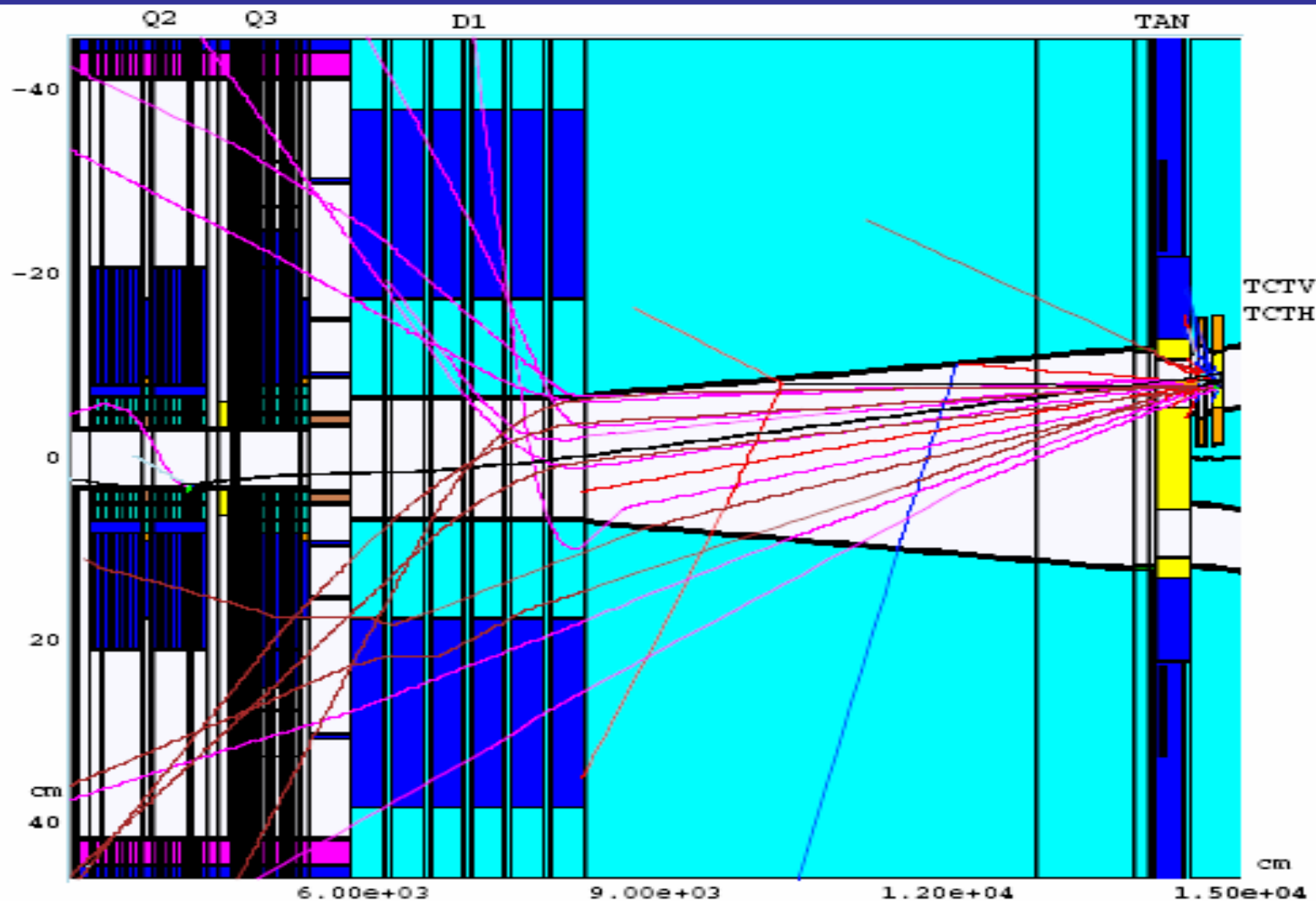
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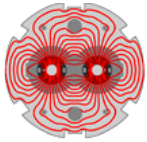


LARP

MODELING WITH TWO COPPER TCTs



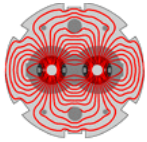
Particle tracks $E > 10$ GeV for a few 7-TeV protons on TCTs



LARP

Tertiary Collimators Overall Plan

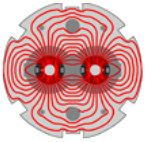
- **FY2006:**
 - Q1: Update the IP1 MARS model and perform test runs with beam loss files generated at CERN for betatron cleaning for BEAM1
 - Q2: Optimization studies of the tertiary collimator set in IP1
 - Q3: Update the IP5 MARS model and perform test runs with beam loss for betatron and momentum cleaning for BEAM2
 - Q4: Perform optimization studies of the tertiary collimator sets in IP1 and IP5 for betatron and momentum cleaning for BEAM1 and BEAM2
- **FY2007:**
 - extension to heavy-ion mode of operation
- **FY 2008-09:**
 - Studies towards luminosity upgrade
- **FY 2010-11:**
 - Engineering design and production
 - Commissioning



LARP

1.3.4 LHC Collimation R&D

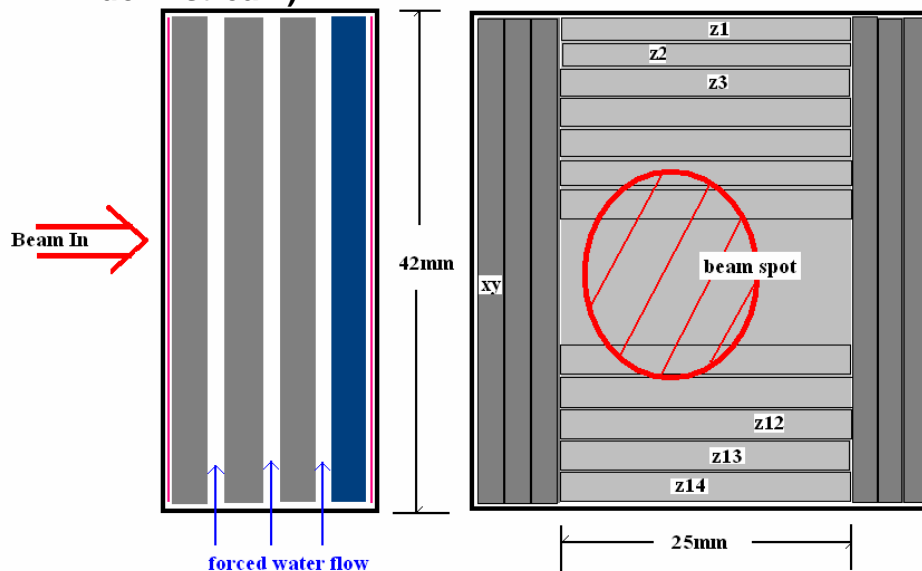
- L3 Leader: Nikolaos Simos (BNL)
- FY06 budget 50 k\$
- Goals:
 - To determine how prone LHC collimator materials are to changing physical and mechanical properties, important to the beam collimating function, with the onset of irradiation. Behavior of wide range of materials from low to high Z under irradiation and post-irradiation to be studied at BNL. The main phase of the irradiation study uses the 200 MeV beam of the BNL BLIP ($\sim 70\mu\text{A}$ average current). It is expected to induce approximately 0.25 dpa on the materials and will provide initial screening.
 - To address potential issues with materials considered for Phase 2 collimators, the effects of irradiation on the driving design parameters must be established early on and thus guide the final selection and the design. Specifically, materials that are being discussed are Cu, Be, Al, Inconel, W, Ti alloys and AlBeMet. Understanding of how irradiation primarily degrades thermal conductivity (as well as other physical and mechanical properties such as ductility, strength, fracture temperature, etc.) is of importance.



LARP

LHC Phase I 2D carbon-carbon Irradiation Specimen at BNL BLIP Facility

117 MeV or 200 MeV BNL LiNAC Protons
(depending on the isotope production requirements downstream)



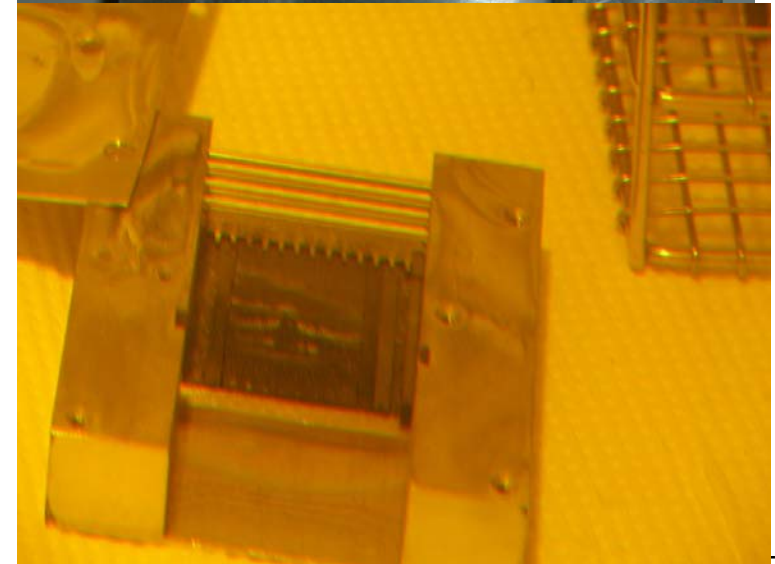
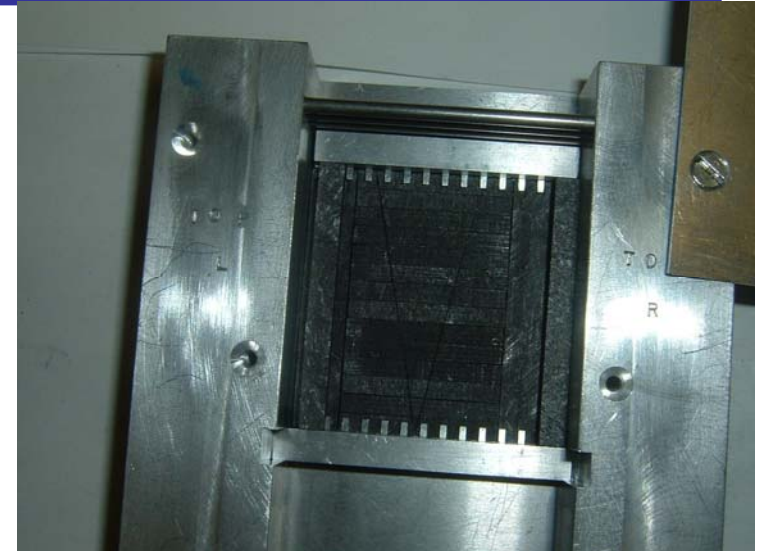
Preliminary Assessment:

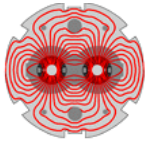
2D CC specimens normal to the planes of reinforcing fibers and close to the center of the beam (receiving high dose) experienced degradation. →
Less degradation was seen in the specimens along the reinforcement.

NOTE: Total dose received MUCH HIGHER than what LHC collimator jaws will see.

Status:

Phase I Carbon-Carbon irradiation completed
Sample activation measurements completed
Thermal Expansion of specimens started
PLANNING of FY06 Post-Irradiation and Follow-up
Irradiation Studies





LARP

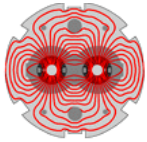
Materials Irrad. Studies Overall Plan

- **FY2006:**

- Dec'05: Complete post-irradiation measurements of carbon-carbon for Coefficient of Thermal Expansion (CTE) changes
- Jan'06: Complete analysis of irradiation data on CTE changes
- Feb'06: Complete experimental system upgrade for thermal diffusivity/conductivity measurements. Finalize Phase-II material irradiation matrix, irradiation layout
- Mar'06: Begin irradiation at the P-bar facility, FNAL

- **FY2007:**

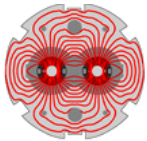
- Q1-2: Complete post-irradiation analysis for thermal diffusivity and resistivity of carbon-carbon composite
- Q3-4: Complete the LHC Carbon-Carbon Irradiation Assessment Report



LARP

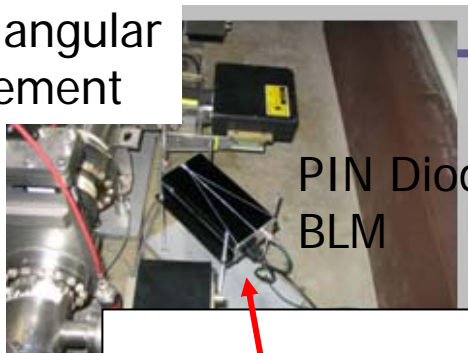
New Collimation Initiatives

- L3 Leader: N.Mokhov (FNAL)
- FY06 budget: 0 k\$
- Goals:
 - Successful demonstration of very efficient crystal channeling sparked interest to Bent CC for the LHC Phase II collimation system
 - Advantage of BCC is orders of magnitude gain in cleaning efficiency
- Plans are:
 - Perform further studies in Tev (FY06-07)
 - Understand the results
 - Take part in BCC system design studies



Tev Crystal Collimator

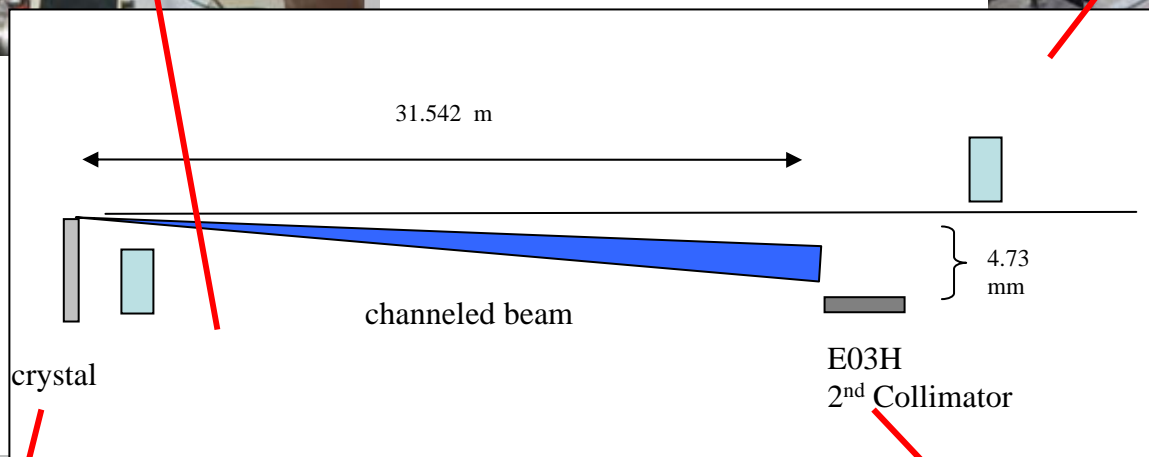
Laser – angular
measurement



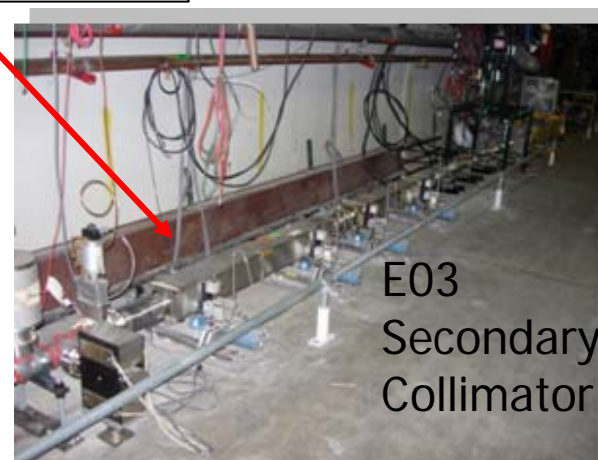
PIN Diode
BLM



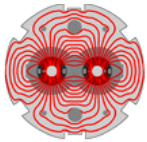
E0
Scintillator
Paddles



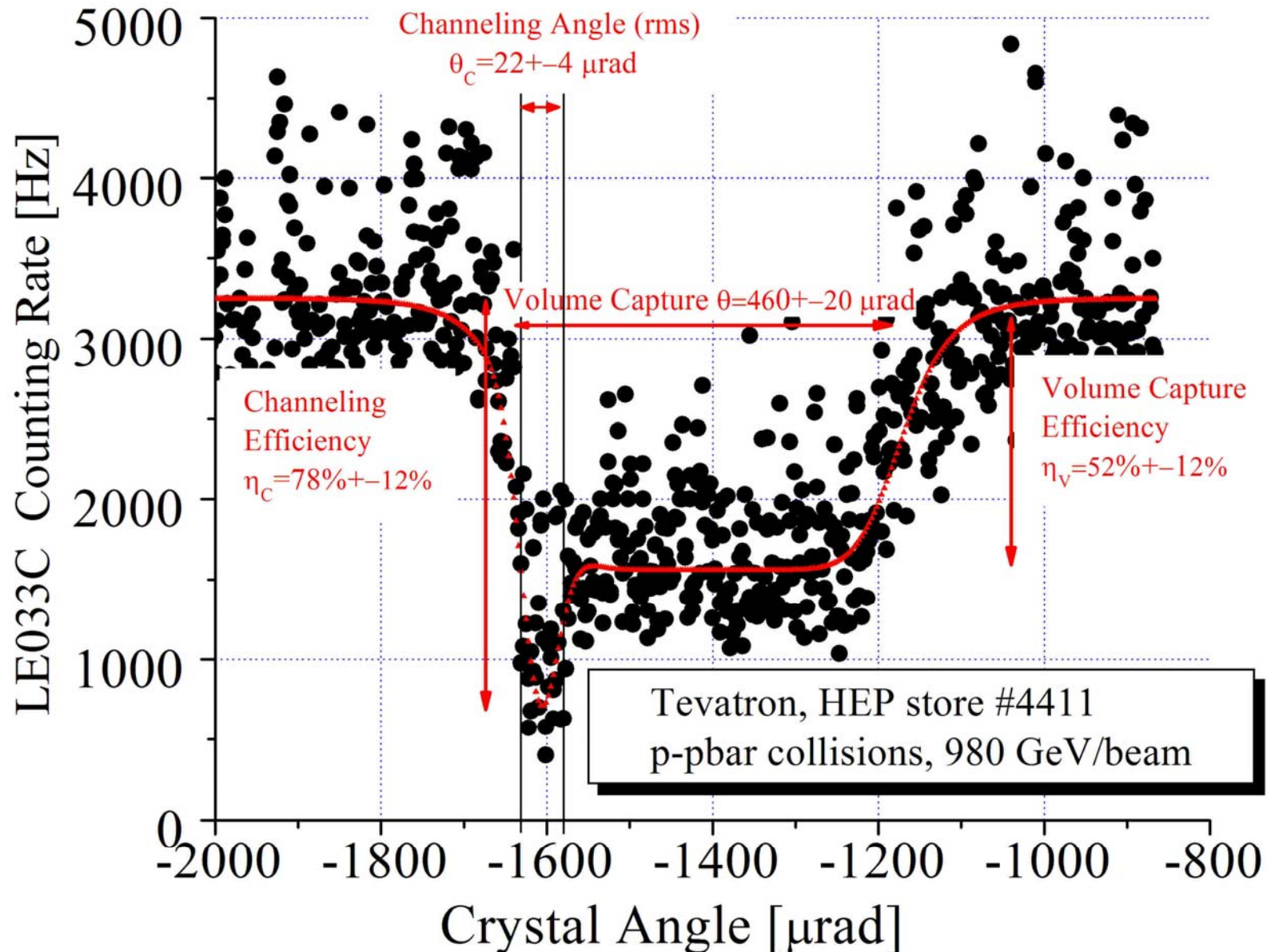
E0 Crystal
Collimator Assembly

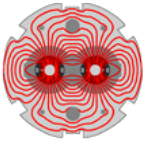


E03
Secondary
Collimator



1 TeV Channeling, Oct 5, 2005

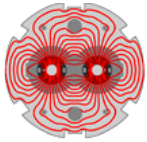




LARP

1.4 Accelerator Physics R&D

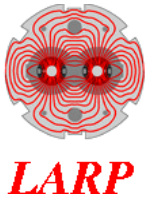
- L2 Leader: (Vladimir Shiltsev)
- FY06 budget 640 k\$
- Goals:
 - LHC, as a frontier machine, pushes the parameters to the limit where one can learn the most. Accelerator physics activities will require a mix of calculation, simulation and experimentation. Some of these activities can be done at home institutions in the U.S. Others will require presence at CERN because some experiments important for future colliders can be done only at the LHC, where the average and peak currents are high, and where synchrotron radiation is a significant effect. The results of these calculations, simulations and experiments will give us the knowledge to design and build with confidence the next generation hadron
- L3 tasks:
 - Electron Cloud Simulations
 - IR Upgrade Design
 - Wire Beam-Beam Compensation R&D
 - New Initiatives



LARP

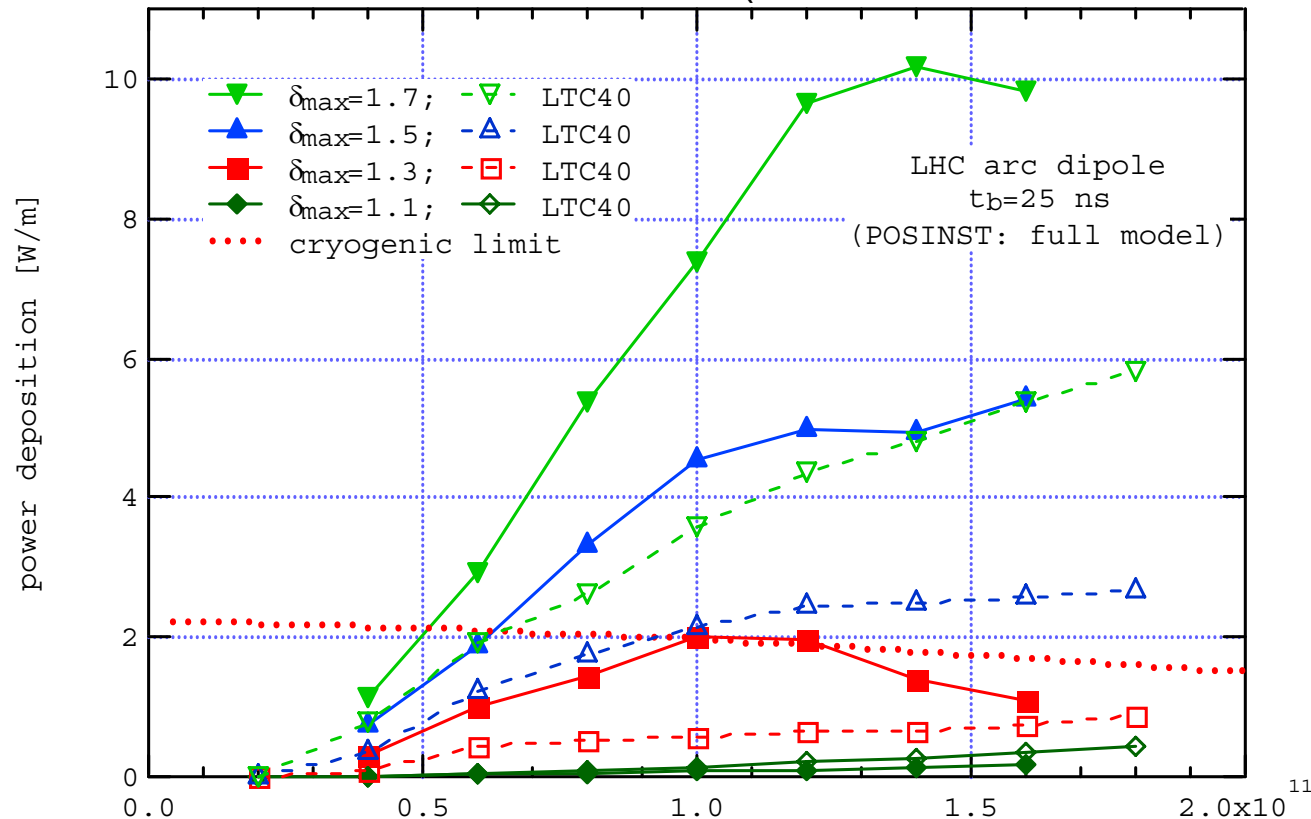
1.4.1 Electron Cloud Simulations

- L3 Leader: Miguel Furman (LBL)
- FY06 budget 640 k\$
- Goals:
 - The electron cloud effect is a significant problem in many of the current generation of high intensity electron-positron and hadron colliders. In the LHC, the electron cloud effect, if uncontrolled, is expected to cause excess power deposition on the cryogenic beam screen and an increase in beam emittance. Electron clouds have been detected in SPS, RHIC, and in the Tevatron. RHIC and the Tevatron are cryogenic test beds similar to the LHC. Measurements, simulations, and analytical work will contribute to a better understanding of the electron cloud effect. Conversely, the ongoing efforts at CERN to describe and model electron cloud effect will benefit current and future U.S. Collider performance.
 - Experimental data on electron cloud effects during recent SPS run had been acquired and they will be used for EC codes calibration. In addition, we intend to better understand the ECE in the cold sections of RHIC

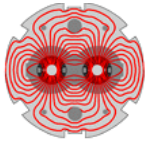


LHC arc dipole power deposition bunch spacing: $t_b = 25$ ns

Aver. power deposition vs. bunch intensity for a given peak value of the SEY (POSINST and ECLOUD codes)



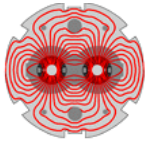
* "LTC40": LHC Tech. Committee. Mtg #40, April 2005 (CERN simulations, F. Zimmermann)



LARP

E-Cloud Studies Overall Plan

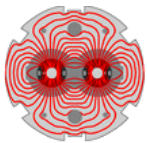
- **FY2006:**
 - Complete the analysis of June 2004 SPS run. Additional SPS studies including bunchlength dependence
 - Finish LHC heat-load estimate and POSINST-ECLOUD benchmarking
 - Define optimal LHC conditioning scenario and fill pattern during first two years of beam operations
- **FY2007:**
 - Perform 3D simulations bunch trains, beam instability for LHC arcs
 - Report on applicability of Iriso-Peggs maps to LHC
 - Report on e-cloud simulations for RHIC detectors, predict BBB tune shift
- **FY2008:**
 - Report on e-cloud simulations for LHC IR4 “pilot diagnostic bench”



LARP

1.4.2 IR Design and Beam-Beam Simulations

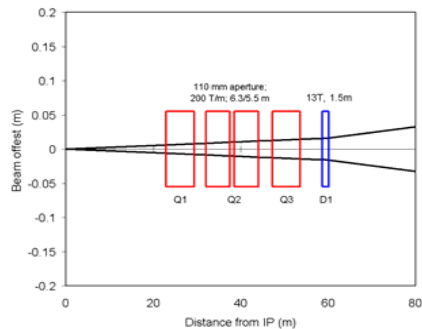
- L3 Leader: Tanaji Sen (FNAL)
- FY06 budget 260 k\$
- Goals:
 - All LHC upgrade scenarios require integrated analysis and development by accelerator physicists and magnet builders, in both the U.S. and in Europe, and the development of the Interaction Region optics is central to this integration. For example, the "dipole first" and "dipole last" scenarios depend on whether the beam is split into two beam pipes before or after the quadrupole triplet. Accelerator Physicists in LARP will work closely with magnet designers to generate an upgraded IR design.



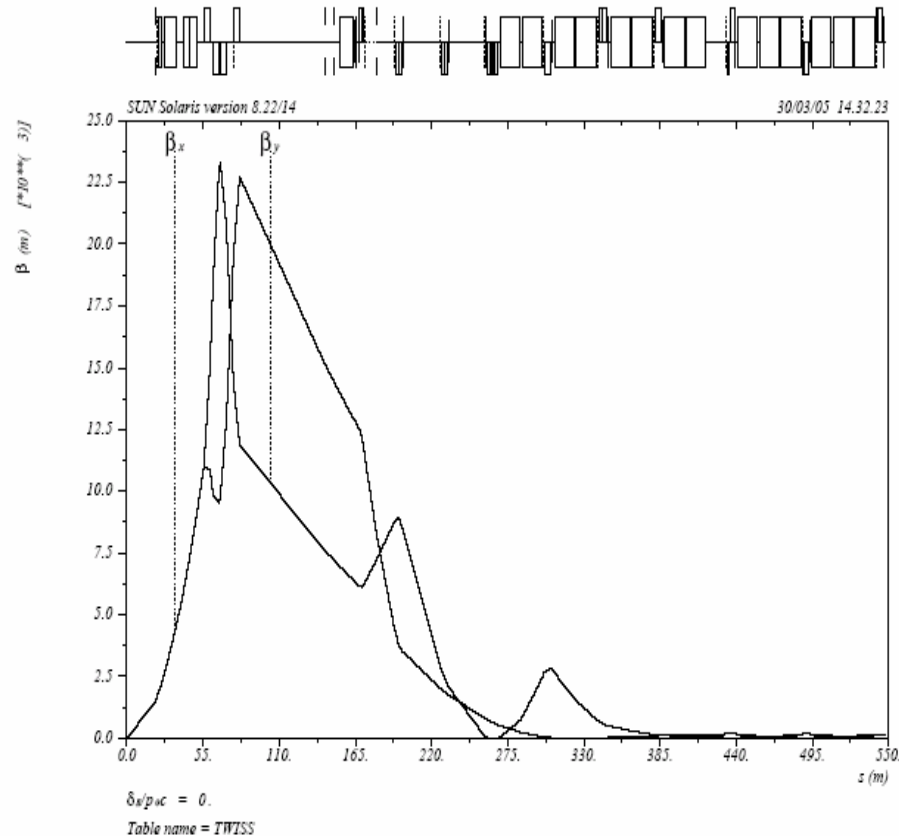
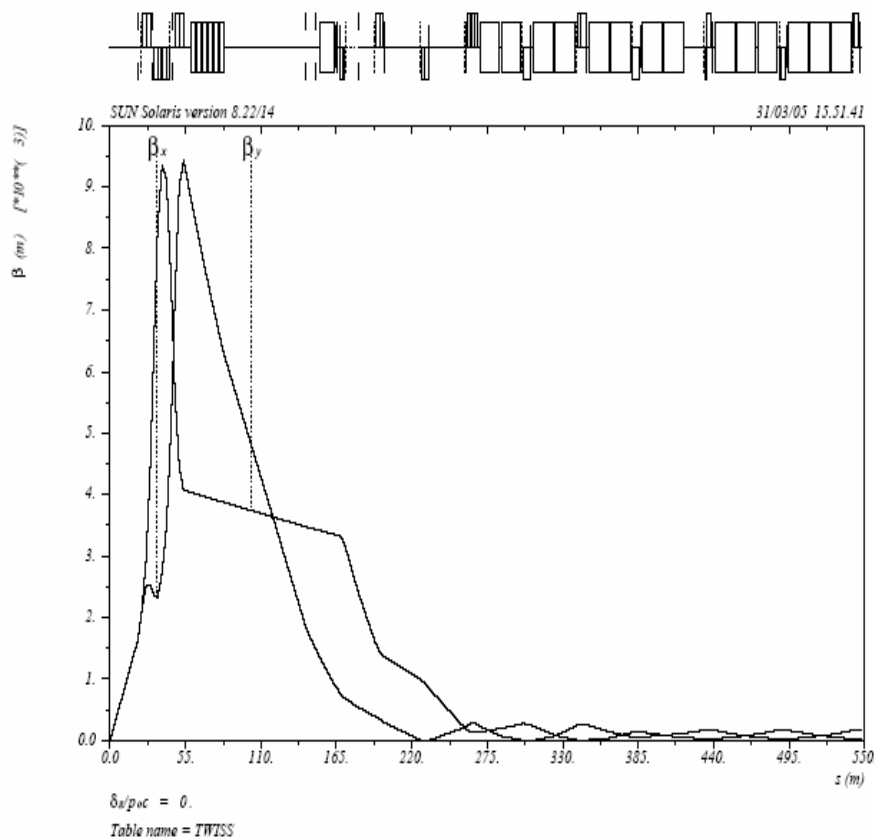
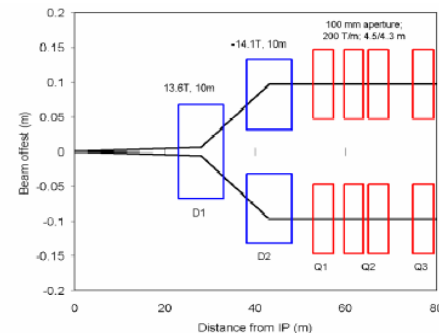
LARP

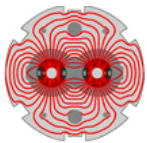
IR Designs for the Upgrade with Triplets

Quadrupoles first



Dipoles first





LARP

Physics: Long Range @ RHIC

SPS : $\tau \sim d^5$

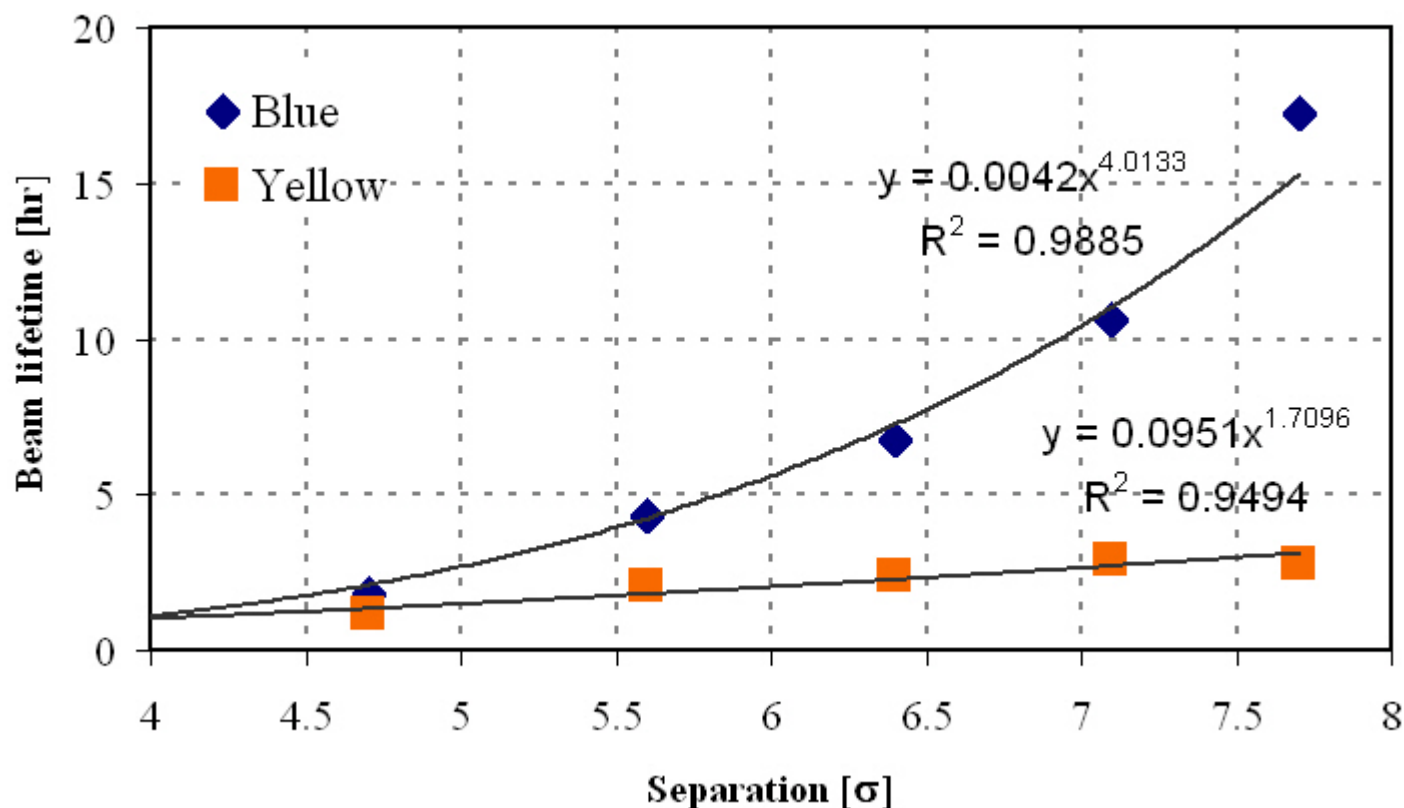
[measured 11/09/04]

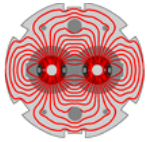
Tevatron: $\tau \sim d^3$

[measured in HEP stores, TEL]

RHIC : $\tau \sim d^4$ or d^2

[measured 04/28/05, scan 4]

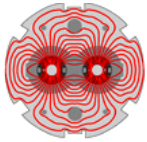




LARP

IR and Beam-Beam Overall Plan

- **FY2006:**
 - Design concepts for the IR upgrade will be explored in greater detail.
 - Develop matched designs that can be used from injection to collision.
 - Develop non-linear correction schemes for both Dipole-first (DF) and Quadrupole-first (QF) designs
 - Energy deposition and magnet protection considerations for both designs
 - Study interference of TOTEM and ZDCs with IR systems
 - Benchmark codes against Tevatron and RHIC beam-beam observations and CERN's fast-multipole code
- **FY2007:**
 - Application of BEAMBEAM3D to halo formation, luminosity monitor (swept beams).
 - Explore in simulations long-term emittance growth and working point dependencies
- **FY2008:**
 - Plans to be determined after obtaining previous years results.



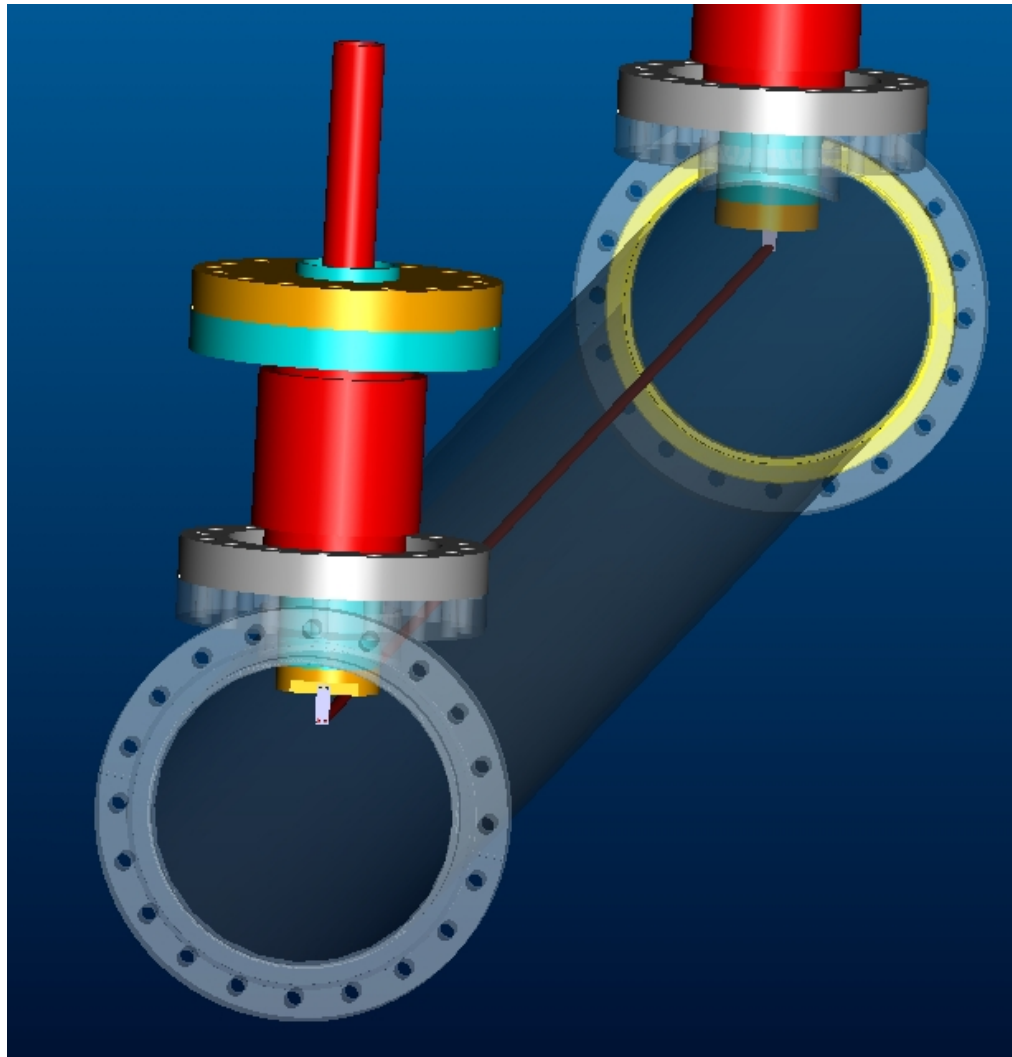
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1.4.3 Wire Beam-Beam Compensation

- L3 Leader: Tanaji Sen (FNAL)
- FY06 budget 180 k\$
- Goals:
 - It was recently proposed to compensate LHC long-range interaction effects by placing several current carrying wires in vicinity of the beams close to main IPs. Beam experiments with wires in SPS showed that one wire can compensate detrimental effects caused by another wire. LARP is supporting an experimental test of the wire compensation at RHIC which provides unique environment to study experimentally long-range beam-beam akin to LHC operation. The experiment assumes installation of a wire compensator on a movable stand in one of the RHIC rings.

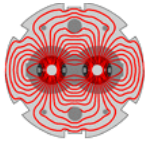


RHIC BBLR design – Sketch



Main features:

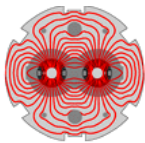
- elliptic copper bar ($a/b = 59\%$)
- air cooled heat sinks
- on vertically movable stand (60mm movement)



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Wire Beam-Beam Compensation Overall Plan

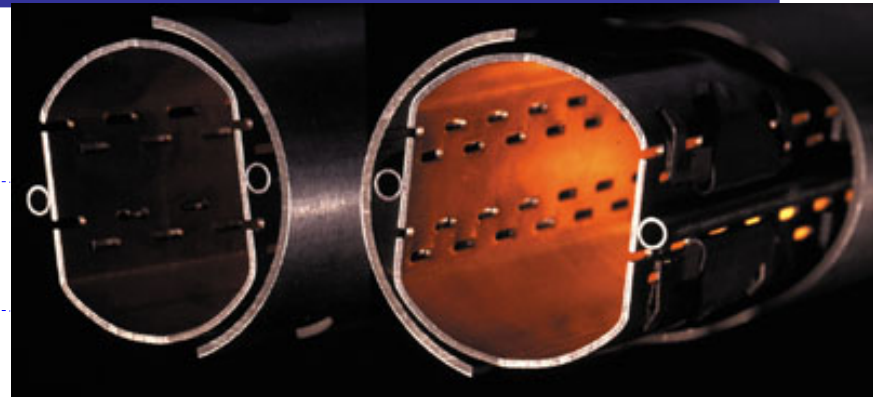
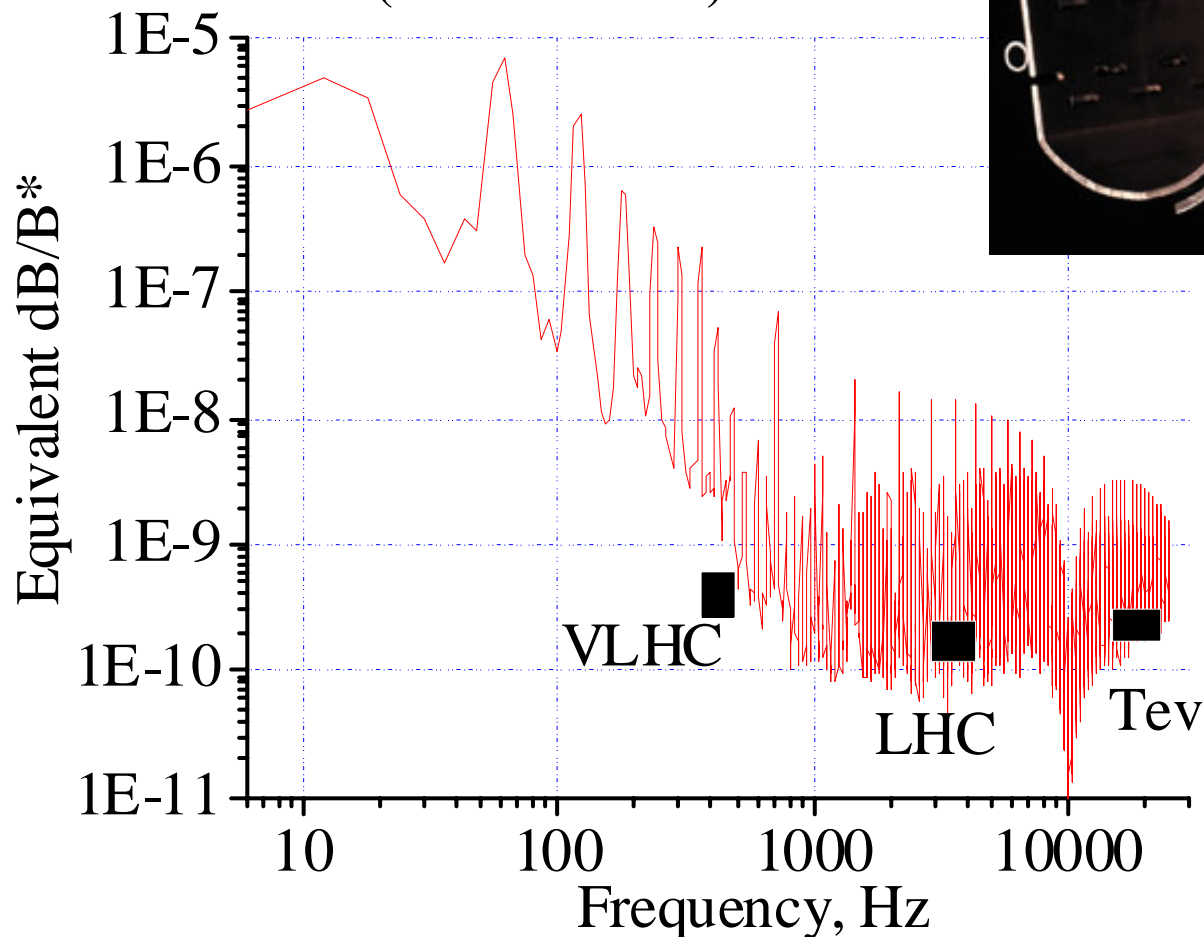
- **FY2006:**
 - Design and construct a wire compensator
 - Install wire compensator in RHIC in summer 2006, downstream of Q3 in IR6
 - Perform theoretical studies to test the compensation and robustness
- **FY2007:**
 - Study the wire compensation in RHIC with 1 proton bunch in each beam and nominal conditions at flat top and 1 parasitic interaction.
 - Beam studies to test tolerances on: beam-wire separation compared to beam-beam separation, wire current accuracy and current ripple
- **FY2008:**
 - Decide on scope of work for the LHC wire compensation



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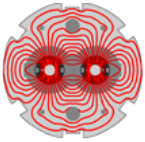
New Initiatives: dB/B Fluctuations

Tevatron Stand-Alone Dipole measurements (Proc. PAC'01)



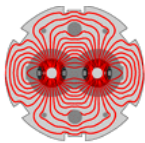
LHC screen: light and feels
feels 20 K He flow
turbulence;
B-flux is constant at 3kHz
3kHz
→ dB/B ~ dR/R → need
dR < 1A to blow horizontal
horizontal emittance

Can be measured at CERN
CERN MMF and in Tev



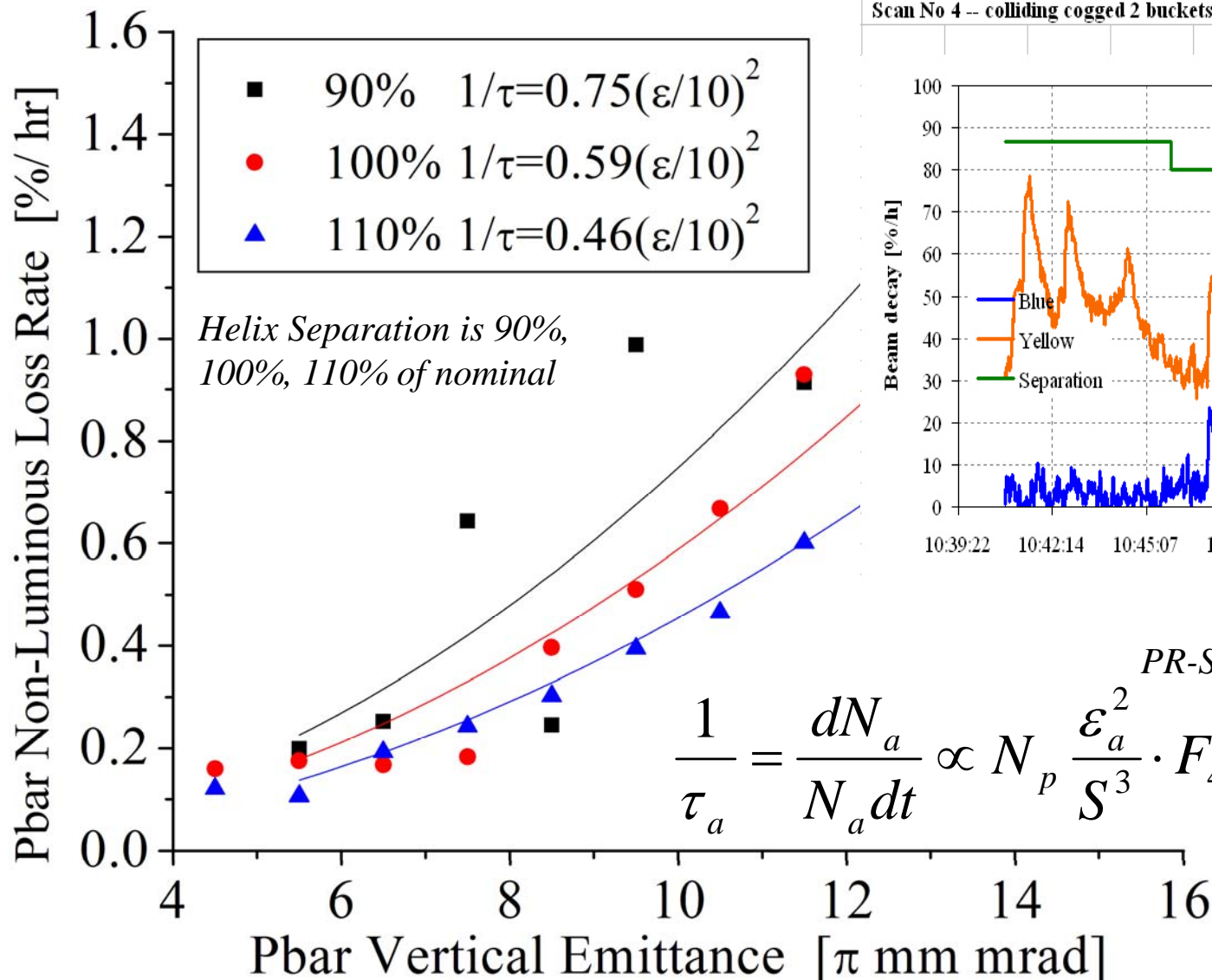
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- The end
 - Backup slides

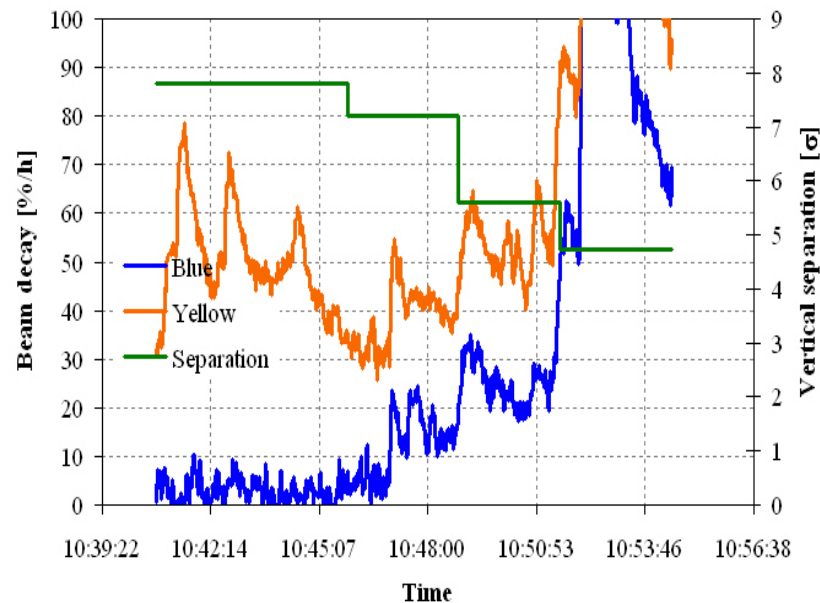


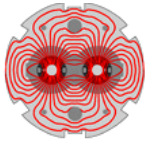
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Tevatron Pbar Lifetime vs Separation



Scan No 4 -- colliding clogged 2 buckets from IP4, new Yellow WP, move Blue beam





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Commissioning: CTF Report

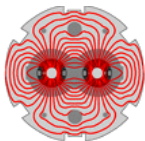
U.S. LHC Accelerator Research Program

LHC Commissioning Task Force Report

M. Lamm, V. Shiltsev (Fermilab), G. Ganetis, W. Fischer (BNL),
A. McInturff, M. Zisman (LBNL), T. Raubenheimer (SLAC)

August 2005

- **addresses:**
 - Resources missing
 - MC organization within LARP
 - Benefits to US
 - Possibilities at 4 labs
 - Funding Issues
 - Living Abroad
- **Recommendations**
- **CTF Report**
 - finished in July
 - to Steve Peggs in Aug
 - released in Sep'05



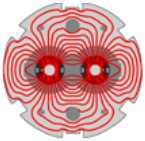
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BC Common Interest Topics

Task		Level of interest (1 = highest)	Person 1	Person 2	Person 3
Control system					
Applications software		1	x	x	x
Accelerator Technical services					
	TI operations				
	Electrical supply				
	Cooling & Ventilation				
Vacuum					
Cryogenics		2	x		
Access					
Cold magnets		2	x	x	
Warm magnets					
Magnet circuits and power converters		2			
Power Interlock System (PIC)					
Quench Protection and Energy Extraction (QPS)		2	x		
SPS extraction, transfer, injection and first turn		2	x	x	
Multi turn losses and BIS dependability					
Protection devices other than collimators		2	x		
Collimation system and Halo cleaning		1	x		
Clean Beam Extraction					
Radio protection		3			
Beam instrumentation					
	Screens				
	BCTs				
	BPM, trajectory & orbit correction				
	BLM				
	PLL for Q, Q', coupling	1	x		
	Profile monitors		x		
	Schottky	1	x	x	
	Luminosity monitors	1	x		
Vacuum conditions during operation and electron cloud			x	x	
Reference magnet system					
RF systems and longitudinal beam dynamics					
Transverse feedback		2	x	x	
Experimental solenoids and compensations					
Experimental equipment (Roman pots, velo)					
Beam in the injectors		2	x		
Ion beam in the injectors			x	x	
Orbit feedback system		1	x		
Filling efficiency and flat bottom conditions		1	x		
Ramp and squeeze losses and overall quality		1	x	x	
Machine protection system		1	x	x	
Optics		2	x	x	x
Mechanical aperture			x		
Machine Impedance and collective instabilities		2	x		
Dynamic aperture		2	x		
Lattice corrector settings		3	x	x	x
Triplet corrector settings		3	x	x	
Lifetimes		3	x	x	
Separation schemes		2			
Crossing angle schemes		2			
Collisions and luminosity steering		1	x	x	
Experimental conditions		3			
Ions					

← Following R.Bailey and and M.Lamont format (presented in Danford in Apr'05)

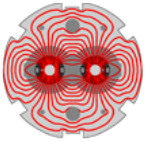
So far only for FNAL people → to be continued continued for other labs



CTF Recommendations

LARP

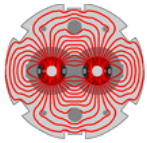
- We endorse the idea that LARP can be effectively used for organization of US involvement in the LHC commissioning. We recommend to form a Machine Commissioning L2 Task (MCT) within LARP for that purpose:
 - the MCT to include hardware(HC – if funding resolved) and beam commissioning (BC)
 - the MCT leader(s) to approach individuals in the US labs. The CTF members can help (e.g. Zisman at LBL)
- Participation in LHC hardware commissioning desirable but
 - a formal Request Letter is needed from CERN followed by the US response - done
 - funding and Scheduling HC to be addressed ASAP
 - urgency to organize HC to become effective in FY'06



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CTF Recommendations

- **Involvement of junior staff is important:**
 - Definitely, in Beam Commissioning
 - May be less practical for HC
 - We recommend “pairing” with more experienced people
 - Short term visits to collaborate/supervise younger staff to be supported by LARP
 - Remote Access Room in the US can be useful
 - Full support for the Toohig Fellowship program
 - needs to be launched in 2005
 - many issues not addressed yet
- **To be further explored:**
 - how to combine commissioning of LARP deliverables with participation in “generic” beam commissioning
 - balance between short and long-term visits



LARP

from P.Oddone P5 talk 09/12/05

"...LHC: delivering on the promise

- US LHC Accelerator R&D Program = LARP:
Fermilab + LBNL + BNL + SLAC
 - Commissioning: bring huge FNAL experience to LHC
 - Technology for upgrades: once again, luminosity will be key
- FNAL will have presence at CERN but also develop remote "operations" center at FNAL.
- Important step in the development of future "global" machines like the ILC..."