

LARP

2011 USLARP/CERN meeting

Eric Prebys, Fermilab
Director, US LHC Accelerator Research Program
(LARP)

○ Part 1 (E. Prebys)

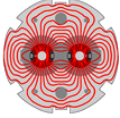
- Our impressions from Chamonix
 - Discussion
- Key activities and topics
 - Discussion following each item
- State of the HL-LHC and injector projects and relationship to LARP

○ Part 2 (G. Sabbi)

- LARP Magnet Program and integration into HL-LHC plan

I would like this meeting to be used primarily for discussion, so we'll keep formal presentations to a minimum.

First of all, thanks for the letter...



LARP

Letter to Dennis Kovar, Head Office of DOE
Office of High Energy Physics, 17-August-2010

Dear Dennis, ←

We are writing to express our support for the US LHC Accelerator Research Program (LARP) and to clarify the relevance and priority of some of the activities within this program with respect to the current CERN upgrade plans.

First and foremost, we are relying primarily on LARP to establish Nb₃Sn as a viable technology for use in the high luminosity upgrade of the LHC (HL-LHC), currently scheduled to be implemented in 2020 or 2021. LARP's Nb₃Sn program has had some impressive achievements over the last few years, but there are still several key demonstrations which are needed to provide the confidence necessary to proceed with the design and production of the focusing quadrupoles to be used in the LHC. LARP is working closely with CERN to establish a set of milestones which must be met, and it is vital that LARP have sufficient resources to meet these milestones.

In addition to the magnet program, two LARP activities which are closely linked to the CERN schedule are the crab cavity effort and the rotatable collimator development. Following the 9th crab cavity workshop in the fall

(...)

Prof. Rolf Heuer
Director-General

Dr. Steve Myers
Director for Accelerators

Some Key Results From Chamonix (wrt LARP)



- Energy=3.5+3.5
 - Most anticipated decision, but no real effect on LARP
- Schedule
 - As expected, the LHC will run through 2012
 - How does this affect LARP long term plans?
- Collimation
 - The current collimation system is working much better than expected
 - What are the implications for the LARP collimation program (more about this shortly)?
- E-Cloud
 - The SPS feedback system was discussed and the LARP effort specifically mentioned.
 - What future does this have?
 - What are you counting on from LARP?

Key Chamonix Results (cont'd)



○ Crabs

- Not really discussed much
- We're still assuming they're the base line option?

○ HL-LHC

- Will the ultimate luminosity of the initial configuration alter plans and goals for the HL-LHC upgrade?

○ Magnets

- Not really discussed
- How likely is the 150 mm aperture mentioned in Stephan's talk?

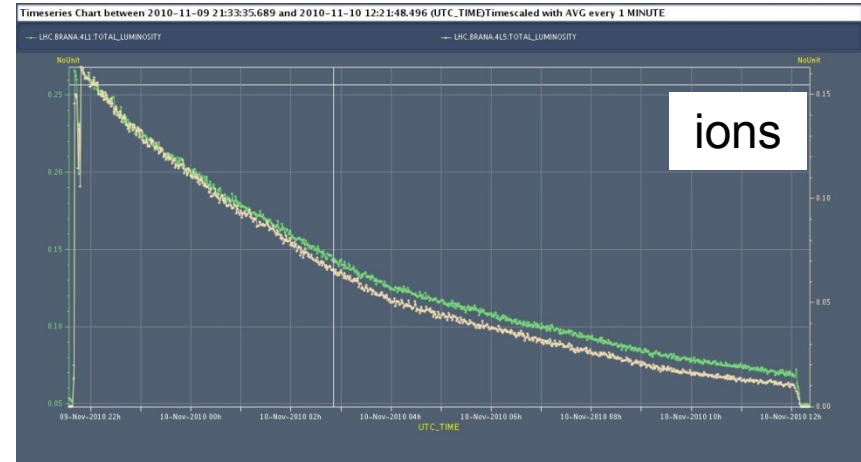
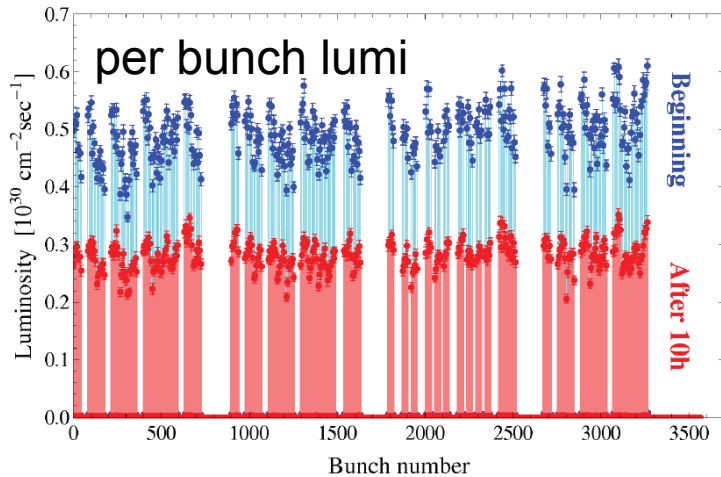
○ PSB/RCS Options

- What is the path to a decision?
- Where can LARP help?

Instrumentation

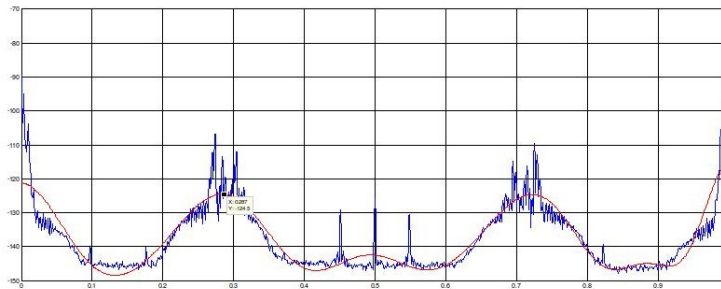
◉ Luminosity monitor

- Primary tool for fast luminosity measurements and VDM's



◉ Schottky Detector

- Can now be used for bunch by bunch tune measurements



- Improved support for remote access to data

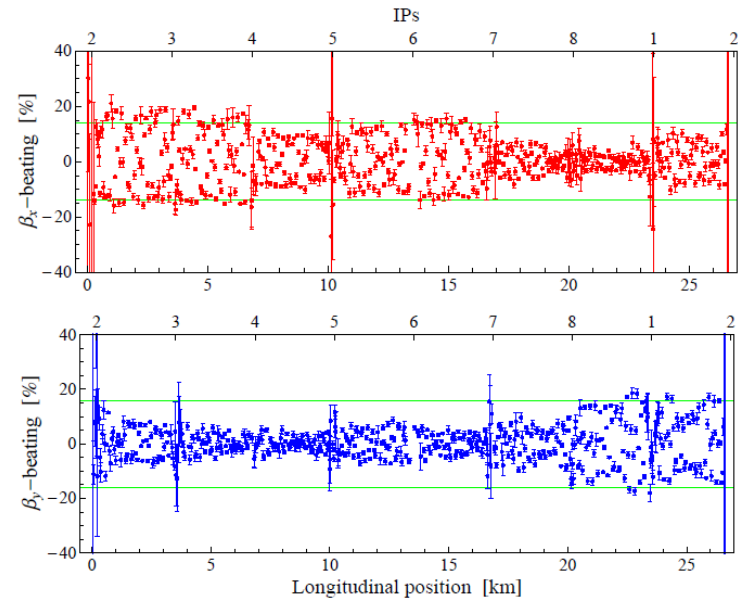
Instrumentation (cont'd)

AC Dipole

- Continues to be the primary tool for high field optics measurements

SLM

- Saw ion bunches
- Focal problem identified and fixed, which should eliminate inconsistency between SLM and flying wire.

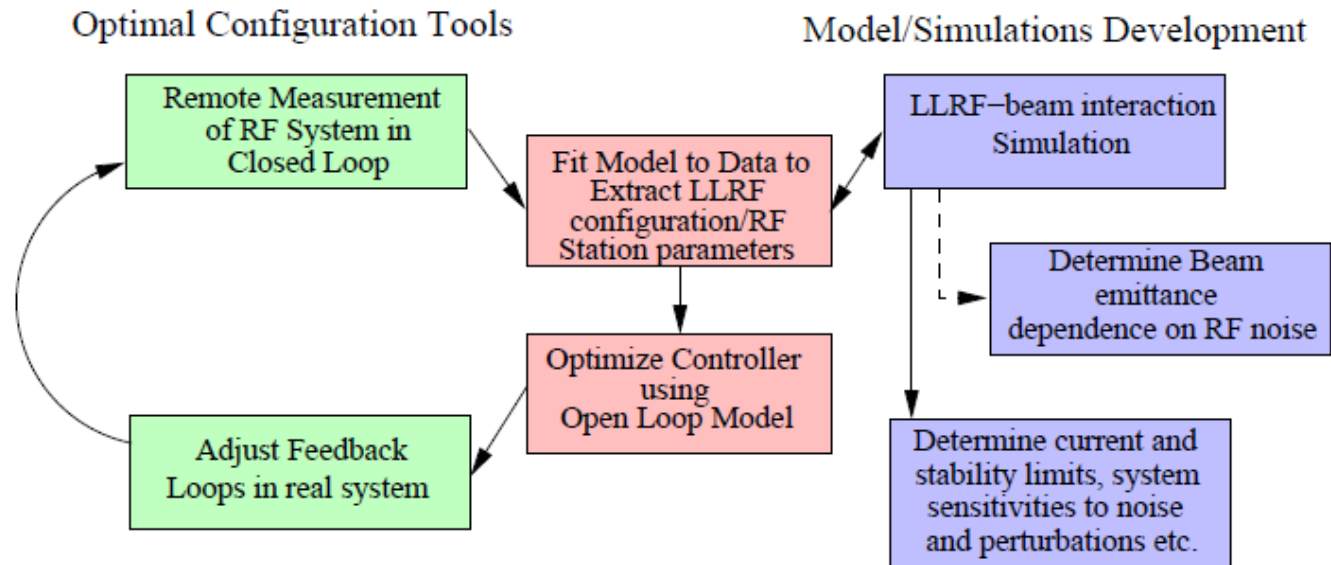


Instrumentation (sort of)

LLRF Tools

- Leverage RF tools and techniques developed at PEP-II

Work to date fits into two **related** activities:



- Configuration tools used extensively during LHC RF commissioning and operation.

Discussion: Instrumentation

- Handoff and support?
 - Our impression is that everything is either handed off or in the process of being handed off.
 - Is there anything more we need to do on our end?
- Are there additional instrumentation topics where we could contribute?
 - Noting that we've already passed on the PSB IPM's

LARP Long Term Visitor Activity



- This year, LARP supported four long term visitors:
 - Uli Wienands (SLAC)
 - PS2 close out
 - LARP PSB coordination
 - UA9 work
 - Chandra Bhatt(FNAL)
 - Long bunch studies for LPA option
 - Rama Calaga (former Toohig Fellow)
 - Commissioning
 - Crab Cavities
 - Eliana Gianfelice-Wendt
 - Gap cleaning studies
- In addition, former long term visitor Alan Fisher has continued to make contributions to the SLM system.

◉ Continuing Fellows

- Dariusz Bocian (FNAL)
 - ◉ Working on modeling of the Nb₃Sn magnets
 - ◉ Extended for third year
- Ryoichi Miyamoto (BNL)
 - ◉ AC Dipole and Lumi monitor
 - ◉ Extended for third year
- Riccardo DiMaria
 - ◉ Left Toohig Fellowship to become CERN Fellow

◉ New Fellows

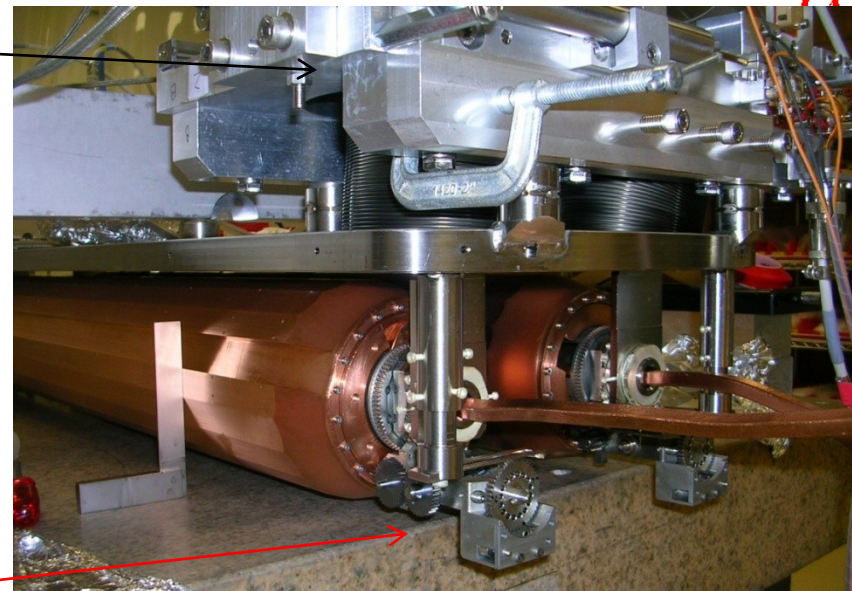
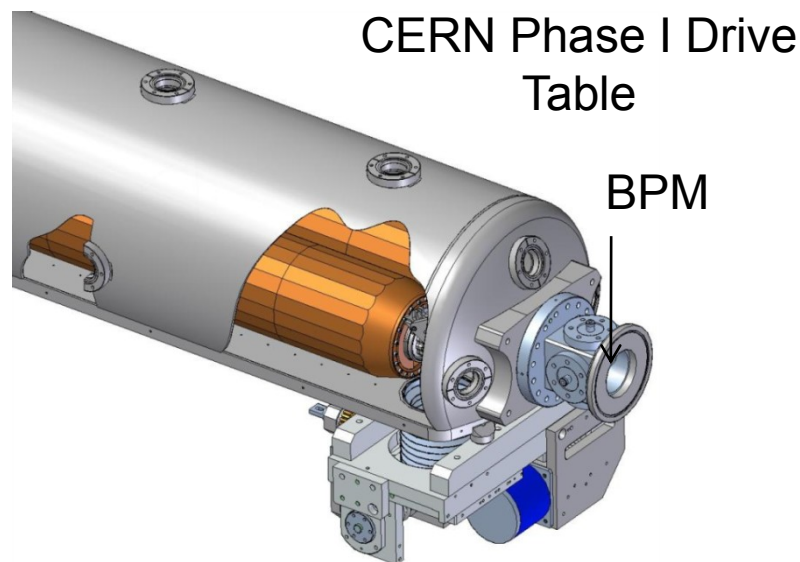
- Simon White (BNL)
 - ◉ luminosity measurement, electron lenses
- Themis Mastoridis (SLAC)
 - ◉ LLRF and high bandwidth SPS damping system

Discussion: LARP Personnel



- ⦿ Are LARP visitors at CERN being used effectively?
- ⦿ Are there more activities were LARP personnel would be useful?

LARP Rotatable Collimator Prototype



Rotation Drive

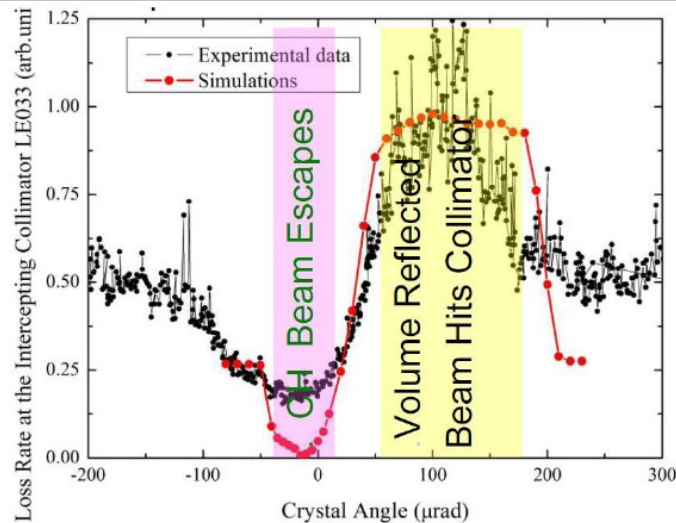
- Jaws, supports, rotation drives, vacuum tank, BPM assembly ready & tested
- Installation & functional tests of RF foils joining jaws to beam-line in progress
- Next Steps:
 - Remount jaws so that future rotations twist the cooling tubes as per design; retest rotation.
 - Weld on vacuum tank cover, evacuate, retest; vacuum bakeout, RGA scan at 10^{-9} torr, retest.
 - Ship, retest & fiducialize at CERN, install in SPS
 - Anticipate shipment to CERN in early March
- Details of destructive tests in HiRadMat Facility under discussion
- Whether/how to proceed to partner with CERN for production versions needs guidance

Crystal Collimation: UA9(CERN) and T980(FNAL)

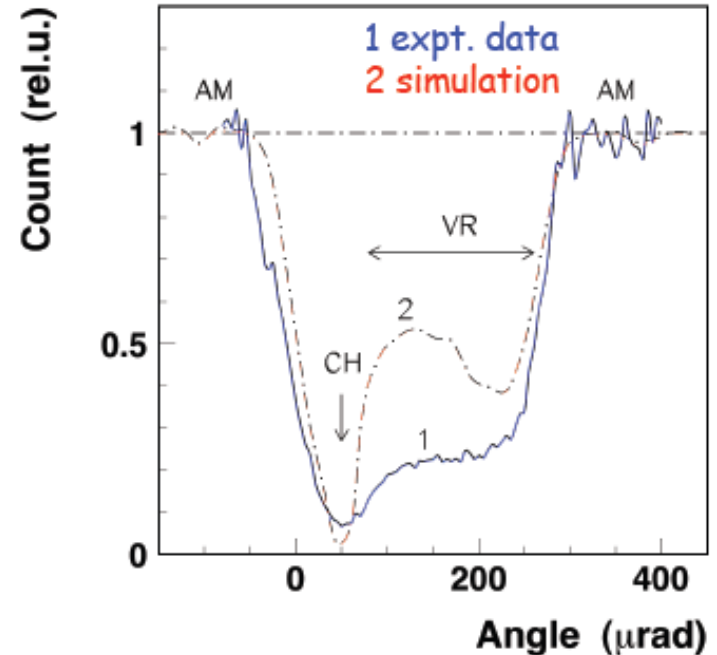


- Both experiments saw improved configuration in 2010
 - UA9: improved goniometers and instrumentation installed over winter shutdown
 - T980: New crystals and instrumentation
- Very impressive channeling data from both experiments

Losses on E03 Collimator: Monte-Carlo vs Data



T980

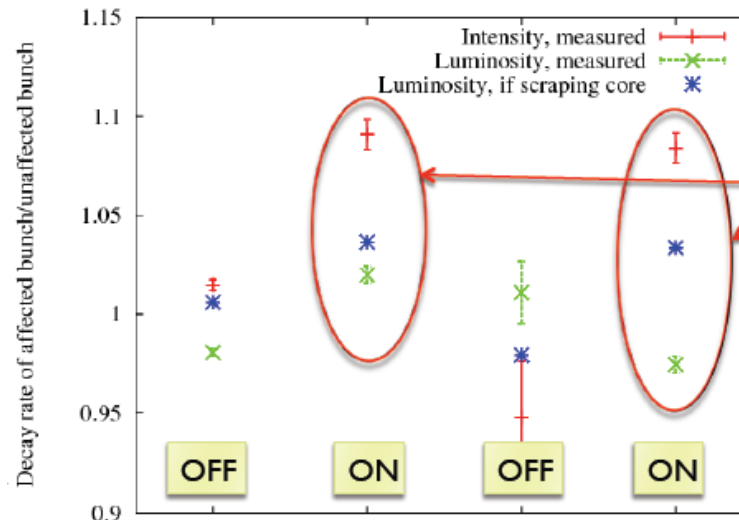
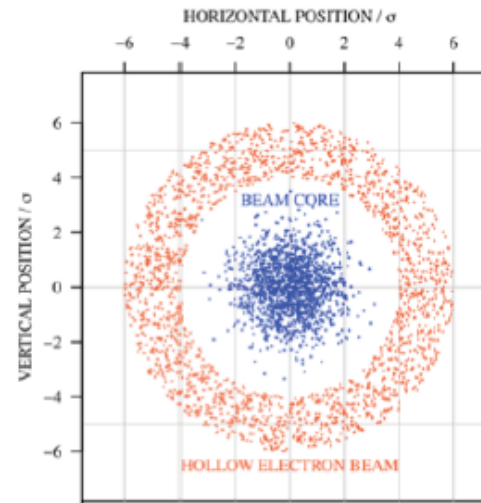
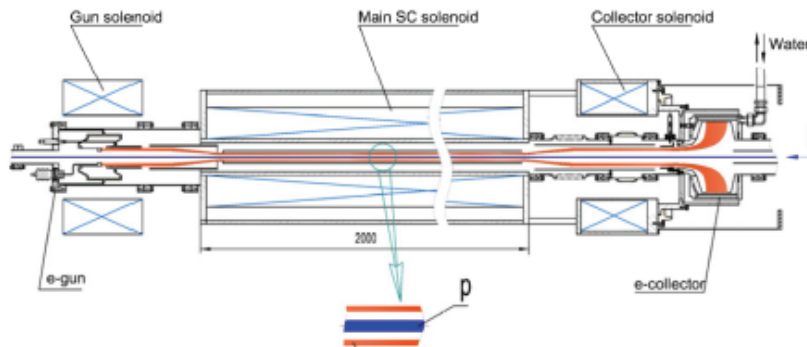


UA9

Hollow Electron Beam Collimation



- ▶ Use magnetically confined hollow electron beams as scrapers for high energy circulating hadron beams to remove halo particles leaving the core unperturbed
- ▶ Motivation: Presently, no viable collimation solution for LHC beams at full intensity below 5 sigma.



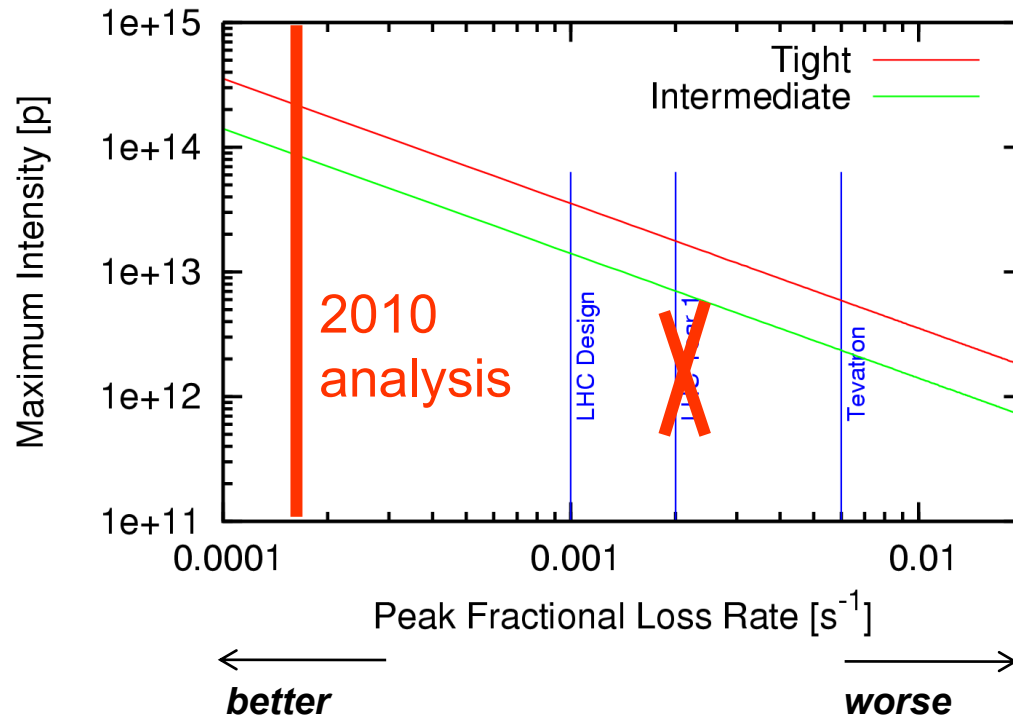
Scraping halo !
Effect is well reproducible

Each point is based on 30-45 min observation

Note: LHC Collimation Performance*



- Beam loss *much* lower than anticipated



- No intensity limit at 3.5 TeV
- Intensity 30% of nominal at 7 TeV

*from Ralph Assmann's Chamonix talk

Collimation Discussion



- How does the unexpectedly good performance of the collimation system affect long term plans for collimation in general and the LARP rotatable collimators in particular?
- Is there still interest in hollow electron beam or crystal collimation?

LHC LLRF and Longitudinal Beam Dynamics: Results

LLRF Optimization tools

- The LLRF configuration tools have been used by the CERN BE-RF group to remotely commission the LLRF feedback loops of the RF stations during start up in both November 09 / February 10.
 - Tools reduced commissioning from 1.5 days/station to 1.5 hours/station.
 - Model based configuration adds consistency and reliability. CERN BE-RF group have repeatedly expressed their support and enthusiasm for this collaboration.
 - Finish commissioning of 1-turn delay filter in all the RF stations.

RF Noise Effect on Beam Diffusion Studies

- Developed theoretical formalism relating the equilibrium bunch length with beam dynamics, accelerating voltage noise, and RF system configurations.
- Conducted measurements that confirmed our formalism and models, identified performance-limiting components, and set an allowable noise threshold for acceptable lifetime.

Predictions of stability limits

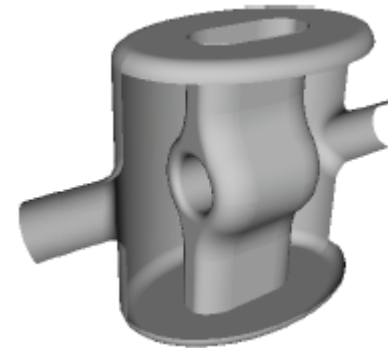
- Estimated longitudinal stability margin for 2011 operations.
- Impact of future LLRF configurations on RF noise levels is being investigated.

- Study feedback/Ecloud/TMCI dynamics via simulations, machine measurements
 - Validate simplified beam dynamics model, feedback models against WARP, head-tail and MD measurements. Estimates of tune shifts, growth rates, and bandwidths
 - Estimates of Ecloud/TMCI dynamics with feedback control
 - Use simplified beam dynamics model with feedback model, incorporate kicker limitations
 - Study control algorithms, limits of control
 - Lab effort -development 4 GS/sec. excitation system for SPS
 - Implement excitation system synchronous with the SPS ring to drive individual bunches - Tool to identify the bunch dynamics.
 - 5 100Watt 1 GHz amplifiers purchased for SPS MD, plans for excitation measurements with existing kicker
 - Explore 4 Gs/sec. 'small prototype-several bunch' functional feedback channel for 2011 fab and MD use
 - SPS GHz bandwidth kicker design report in progress (SLAC-LBL), report will recommend implementation plan for kicker fab, installation during 2012-2013 shutdown
- Discussion: how important does CERN think this effort is (potentially large \$\$)?

- As agreed, LARP has submitted material for the PS2 white paper covering
 - E-cloud
 - Impedance
 - Space Charge
- We have begun to transfer this expertise to the PSB energy upgrade effort
 - Because of budgetary constraints, other suggested contributions, such as IPM's, had to be canceled.
- Discussion: How much LARP presence is expected in the PSB effort?
 - Currently very little has been budgeted

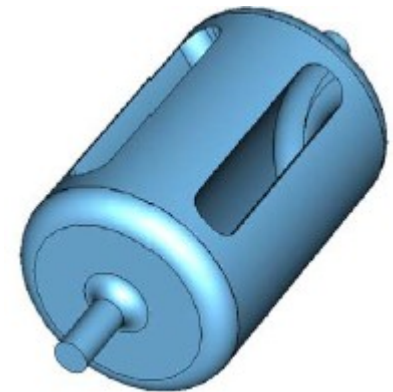
○ Important decisions at CC10

- KEK crab cavity test in SPS canceled
 - Still feel a test of some sort in SPS is required, but should be better thought out and more closely aligned with ultimate goals.
- Adopt 400 MHz, compact, local scheme as base line unless proven unworkable.
- Appear to be 3-4 potentially workable designs.
 - LARP has supported SLAC and Jlab. May support new BNL concept.
- Complete conceptual design of 800 MHz elliptical as a backup.



○ Discussion points

- How is CERN proceeding with the long term plan?
- What will LARP's role be?



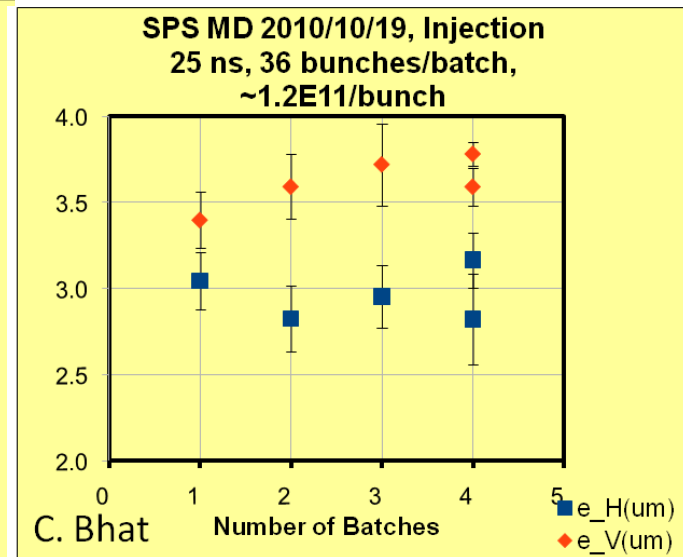
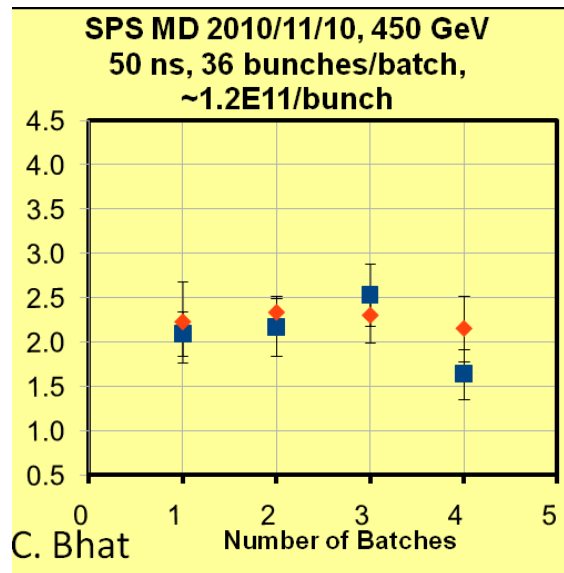
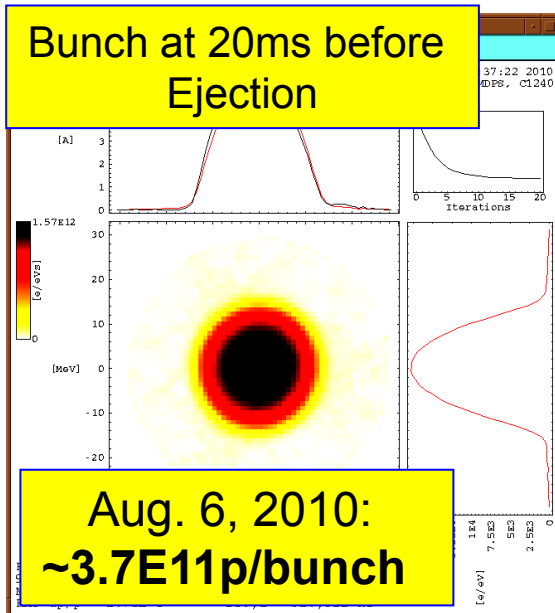
Large Bunch Studies for LPA Solution (C. Bhatt)



- Have come up with a new set of flat bunch (LPAS) parameters in view of the re-stated SLHC L_{peak} goal ($\geq 5 \times 10^{34} \text{cm}^{-2} \text{sec}^{-1}$) & estimated bb tune shift (< 0.02) from LHC data

	Previous Parameters	New Parameters
# of Bunches	1404 (50 ns spacing)	1404 (50 ns spacing)
ppb(xE11)	4.90E+11	3E11-3.5E11
LE(4 σ) (RMSBL(cm))	2.5 eVs (11.8 cm)	2 eVs (9 cm)
$\mathcal{E}(\sigma)$ (μm)	3.75	3-3.75
β^* (m)	0.25	0.35-0.42

- Performed studies of large bunches in the PS, as well as emittance growth studies for various bunch spacings



Discussion: Accelerator Physics



- Accelerator physics is one of the areas where LARP can make significant contributions to the LHC
 - This is because much of the scientific effort comes “for free” from the labs (although this is getting a bit tougher)
- Is it CERN’s impression that we are using our resources as effectively as we can?
 - Electron cloud?
 - Beam beam?
- Are there other areas where we can assist?
 - Collimation?
 - Crab cavity issues besides cavity design?

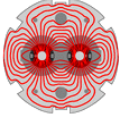
HL-LHC Design Effort



- LARP has joined with CERN and EuCARD for the design study for the high luminosity upgrade of the LHC.
- The proposal was submitted in November, 2010.
- Where do we go from here?
 - Major milestones?
 - Any follow up LARP involvement (beyond what's been committed to)?
 - Any strategy for engaging US resources beyond LARP?
 - There's clearly significantly more interest in the US than LARP can support.

Conclusion and Acknowledgements

- We feel that LARP has made and continues to make valuable contributions to the LHC.
- We want to work with CERN to use our (limited) resources as effectively as possible in the future.
- We greatly appreciate the support and recognition that we've gotten from CERN
 - It doesn't go unnoticed when LARP is mentioned in a CERN talk.
- We also want to acknowledge the significant resources that have been provided by the labs outside of direct LARP funding.
- I want to thank the following people who provided significant material for this talk:
 - Tom Markiewicz, Rama Calaga, John Fox, Chandra Bhatt, Sasha Valishev, Uli Wienands, Nikolai Mokhov, Alex Ratti, Alan Fisher, Ryoichi Miyamoto, *et al*



ANY OTHER BUSINESS??