LARP Accelerator Systems: Status & Plans

Vladimir Shiltsev (Fermilab)

Content

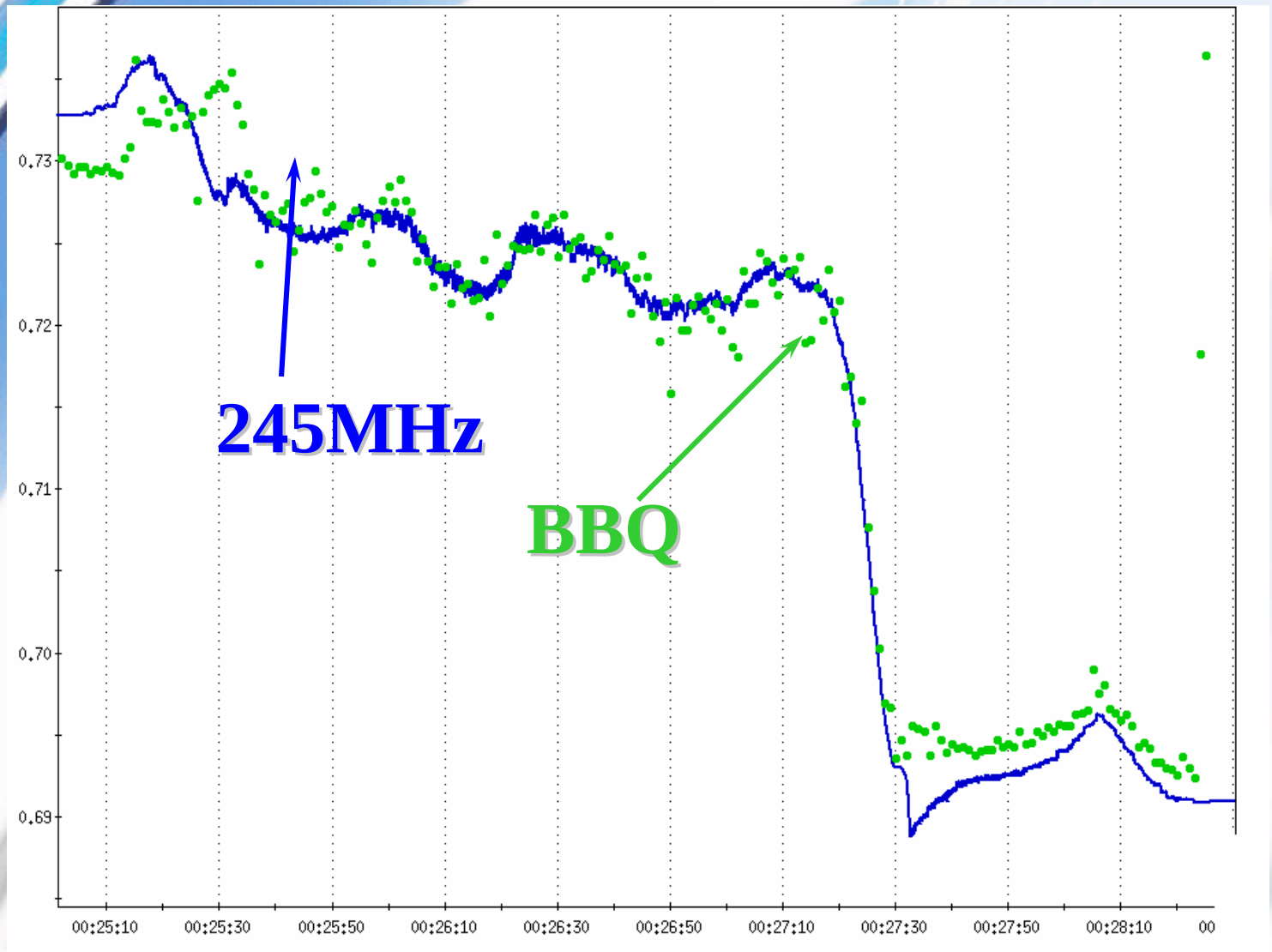
- Instrumentation Tasks:
  - Tune Feedback
  - Luminometer
  - New things: Schottky, ZDC, Head-Tail Q'
- LHC Collimation R&D
  - Rotating Phase II collimators
  - Other activities
- Beam Physics:
  - E-cloud & beam-beam simulations, IR upgrade
  - Long-range B-B compensation experiment
  - New proposal: dB/B with beam screen
- Machine commissioning:
  - CTF report, HardwCommiss and BeamCommiss
  - Effective communication : LHC@US etc

Tune Feedback Review (Apr)

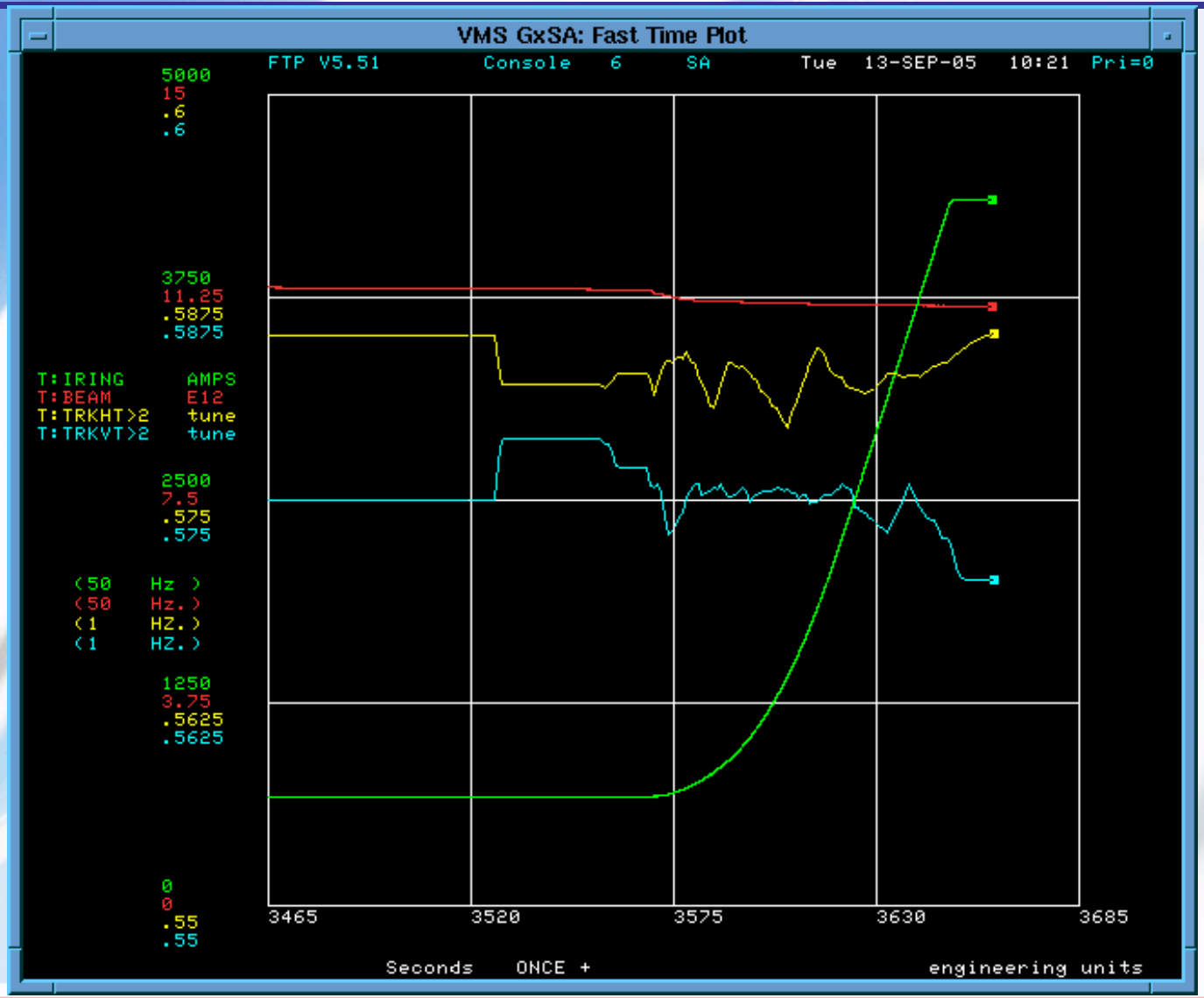
these overcome present RHIC obstacles

- demonstrated potential to satisfy LHC tune feedback requirements
- established the rapport that enables a successful collaboration
- 3D (Direct Diode Detection) provides a vast improvement over previous attempts
- proposed coupling compensation is very clever, needs testing
- **60Hz problem needs to be clearly defined by measurements in RHIC**
- modeling of coupled loops (tune, chrom, coupling, orbit feedback, RF,...) is needed
- a fully operational system should be implemented at RHIC

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



PLL TT on Tevatron Ramp



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Tune Feedback Milestones

Apr 05 -	Preliminary Design Review - completed
Jun 05 -	finalize prototype architecture - need 60Hz balancing at RHIC
Nov 05 -	**prototype (4 planes) ready for RHIC beam**
Feb 06 -	send 2 planes to CERN for SPS testing
Apr 06 -	Final Design Review
May 06 -	SPS testing, initial Controls integration (FESA)
Jun 06 -	finalize architecture
Nov 06 -	final system (4 planes) ready for RHIC beam
Feb 07 -	deliver final system to CERN, system integration and testing

Summer'07 - system commissioning with beam

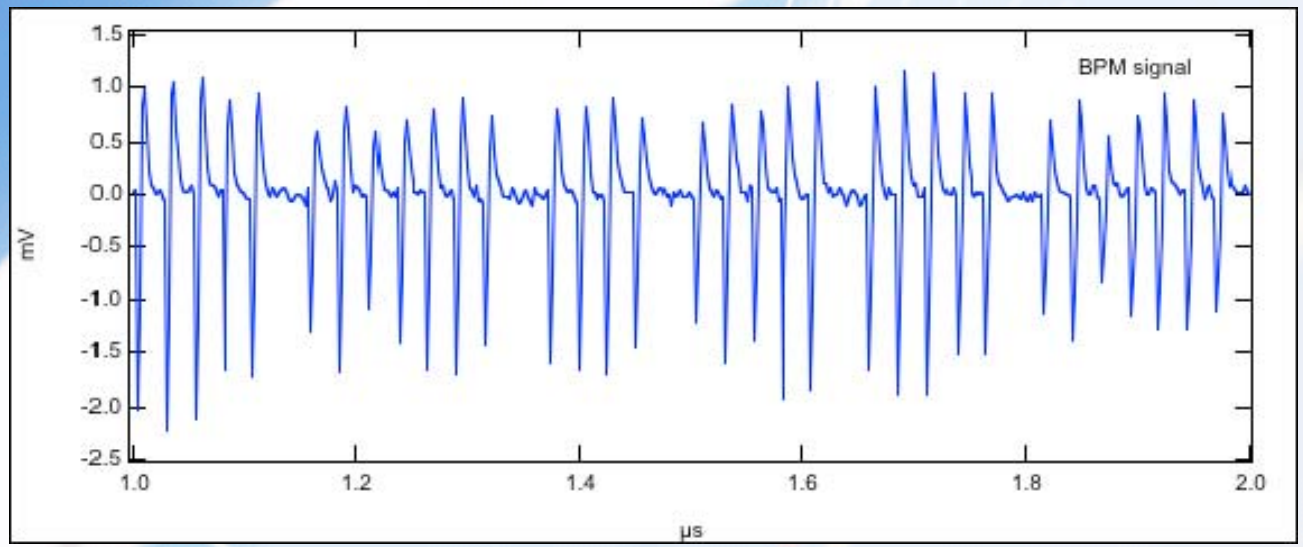
Luminosity Monitor

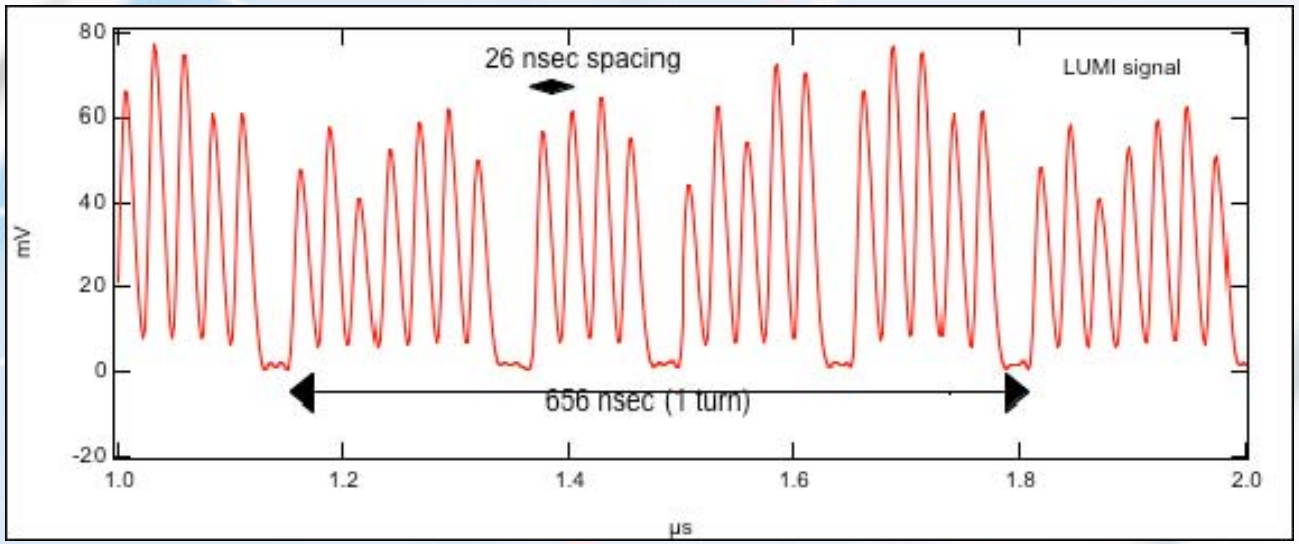
- LBNL to deliver
  - 4 ion chambers with electronics
  - DAQ with programming
  - Installation support
  - Hardware commissioning

- CERN to provide
  - Local installation
  - Control system integration
  - VME64 infrastructure

Agreement being defined in a system integration document part of the LHC document control system

LM 40 MHz ALS X-ray test



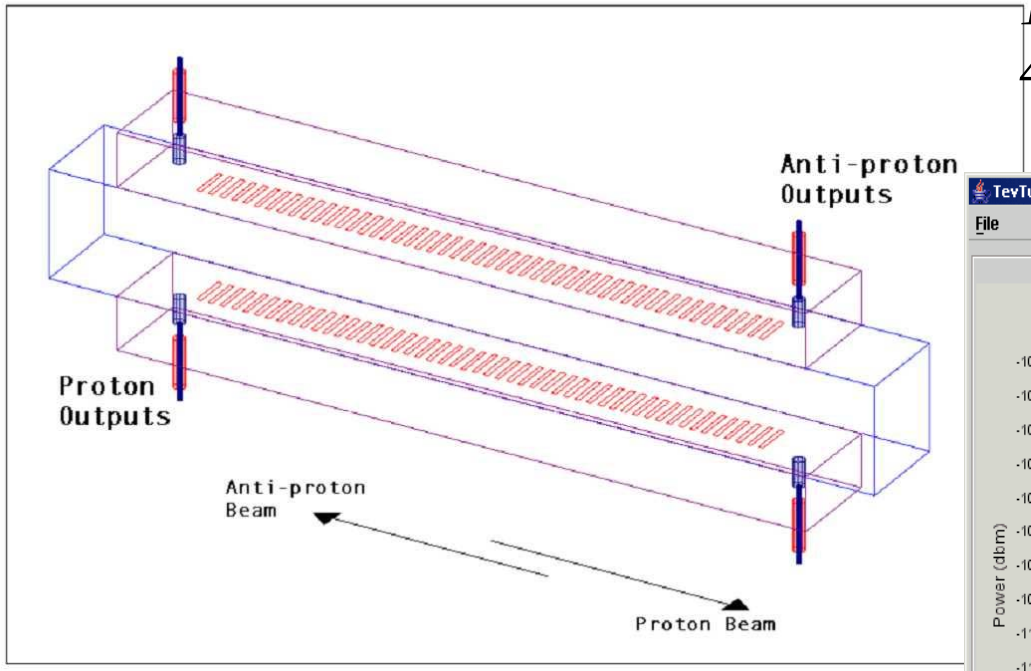


LM: Milestones

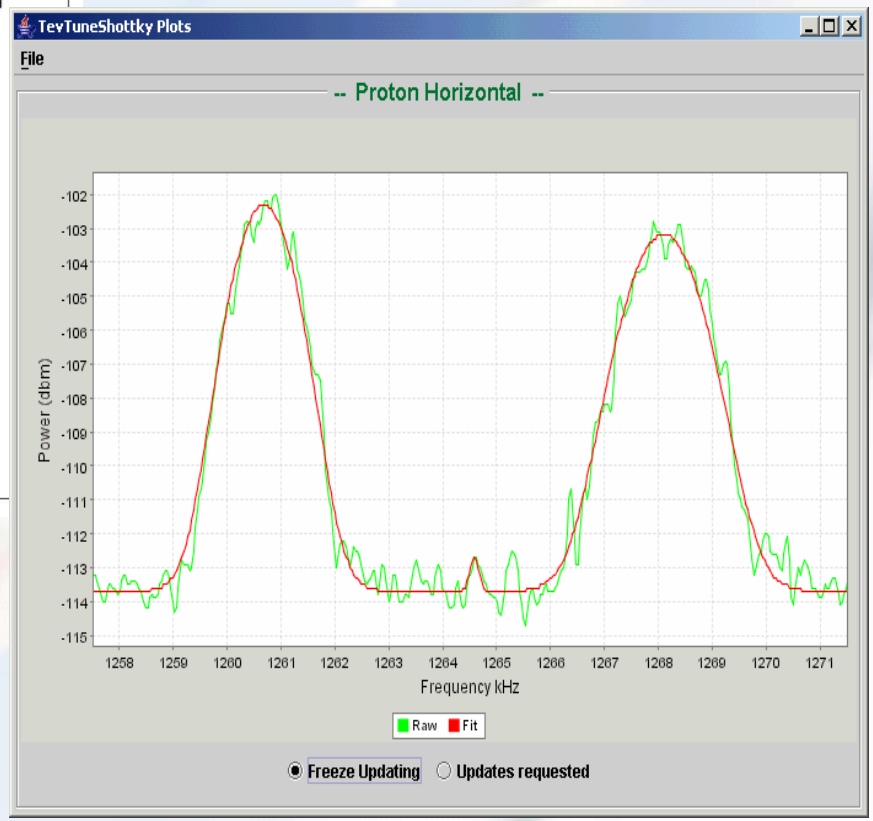
- **FY05**
  - Complete conceptual design of FE electronics
  - Complete/formalize system integration document
  - Complete high speed tests; 40MHz @ ALS
- **FY06**
  - Design and build first unit of DAQ system
  - Final design of complete first unit
  - Test prototype at RHIC
- **FY07**
  - Build all units
  - Install and HW commission all units

Schottky - Technical approach

Slotted Waveguide Pickup

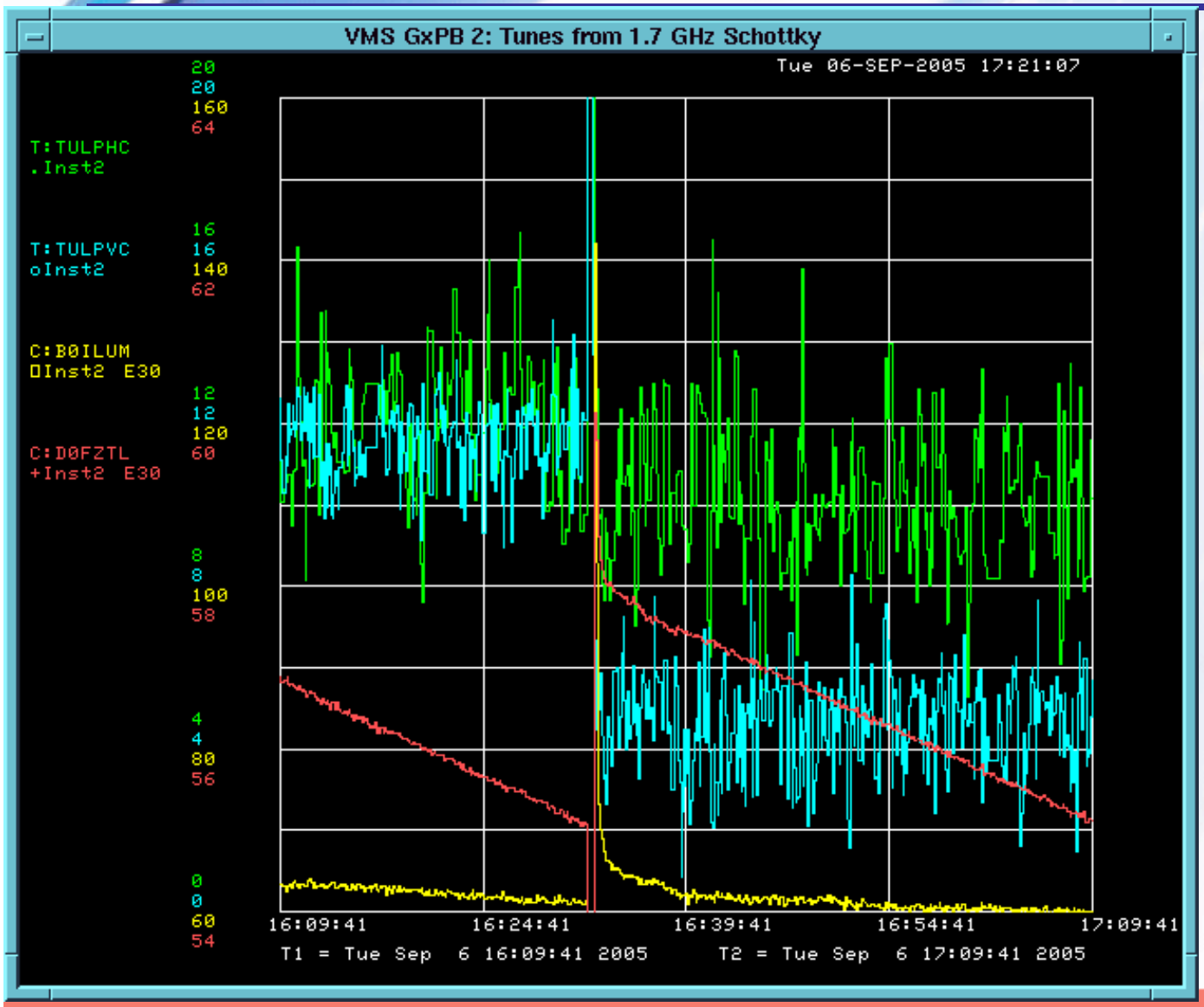


1.7 GHz 75 mm aperture at Tev
4.7 GHz 60 mm proposed for LHC



Reports: *bunch-by-bunch, p,a*
- *tunes*
- *chromaticities*
- *emittances*
- *momentum spread*

Schottky Monitor in Tev → LHC



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

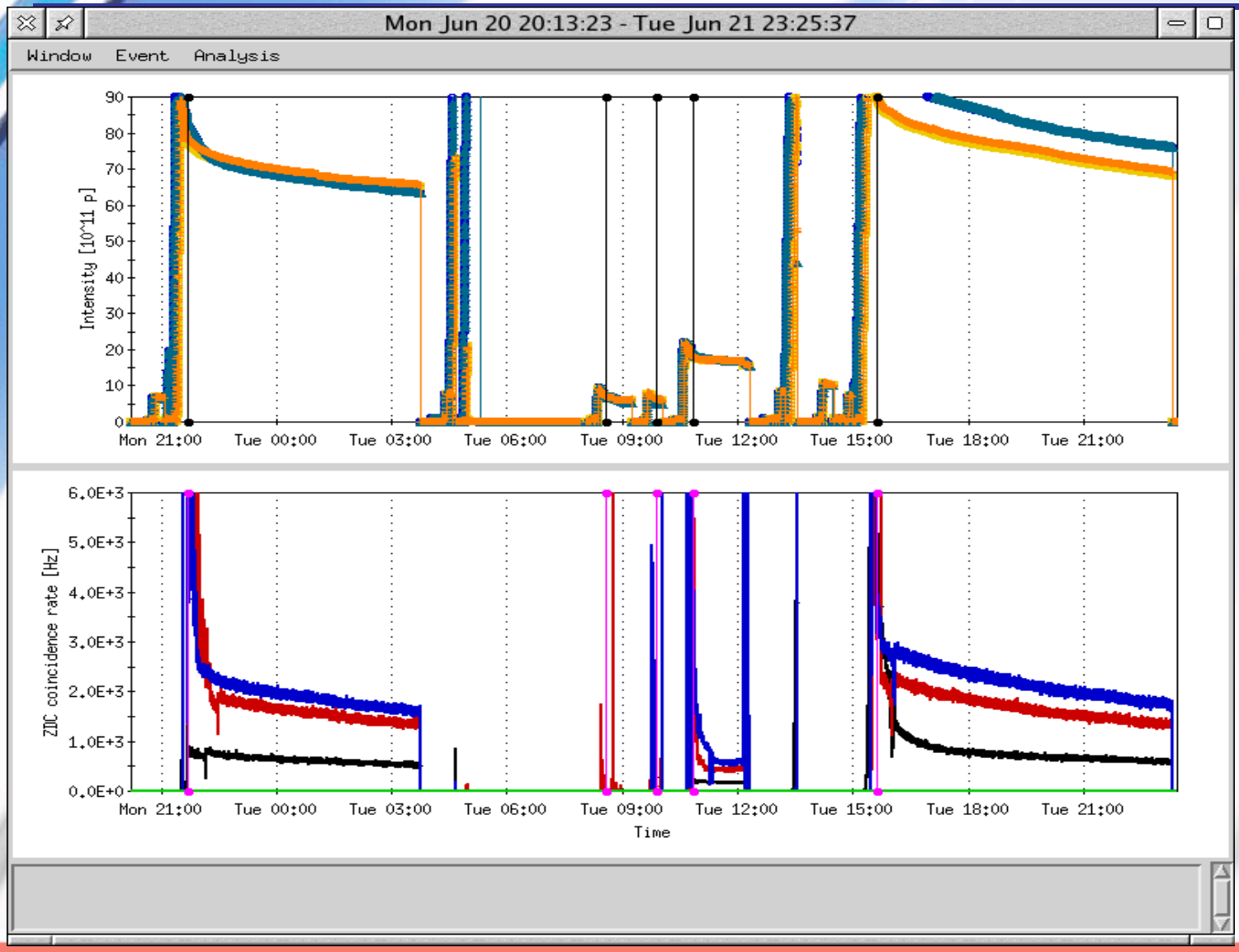
4.7GHz to be built by CERN

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

New Initiatives: ZDC

- Works at RHIC IPs; be built for ATLAS
- 65k$ asked to make it avail for LHC
- ZDC offers:
  - Linearity from 10^28 to 10^33
  - Low background
  - Will help to understand & calibrate LM
  - Longitudinal “z-” distribution of luminosity possible with advanced 50 ps electronics (not what LBL LM has now tau=10ns)

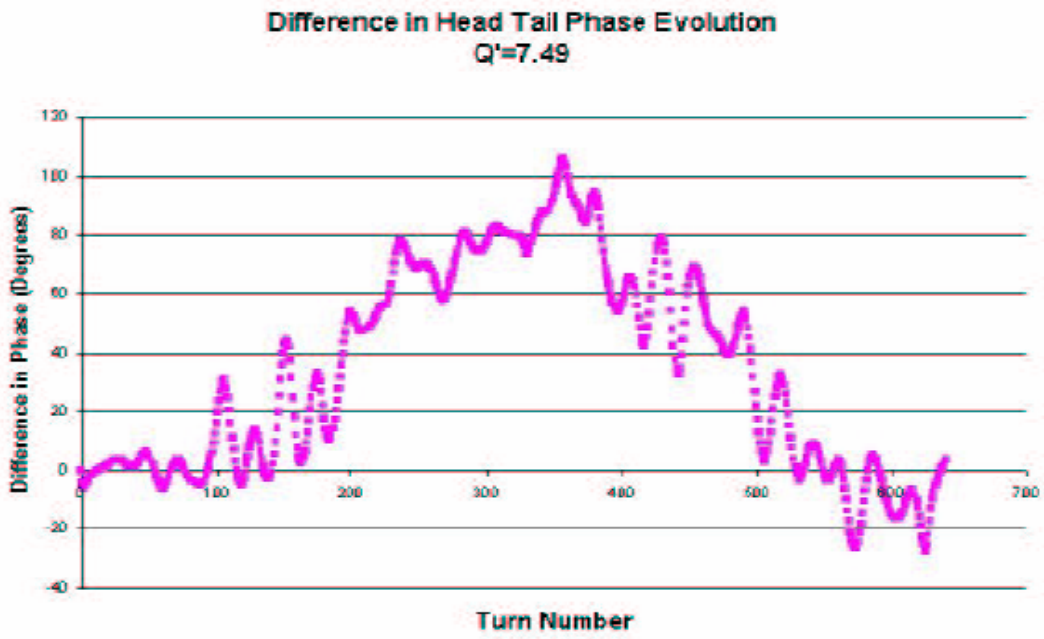
ZDC in RHIC



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

New Initiatives: Head-Tail Q'

- Modern scopes allow to detect motion of 5cm slices of 10-50 cm long bunch



- Head-tail phase difference ~Q'
- In routine use for injection tuneup Tev
  - +- 0.5 unit, very fast, reliable;also computes tunes, coupling, checks optics
  - V.Ranjbar is here to discuss LHC case

Collimators R&D: 4 Tasks

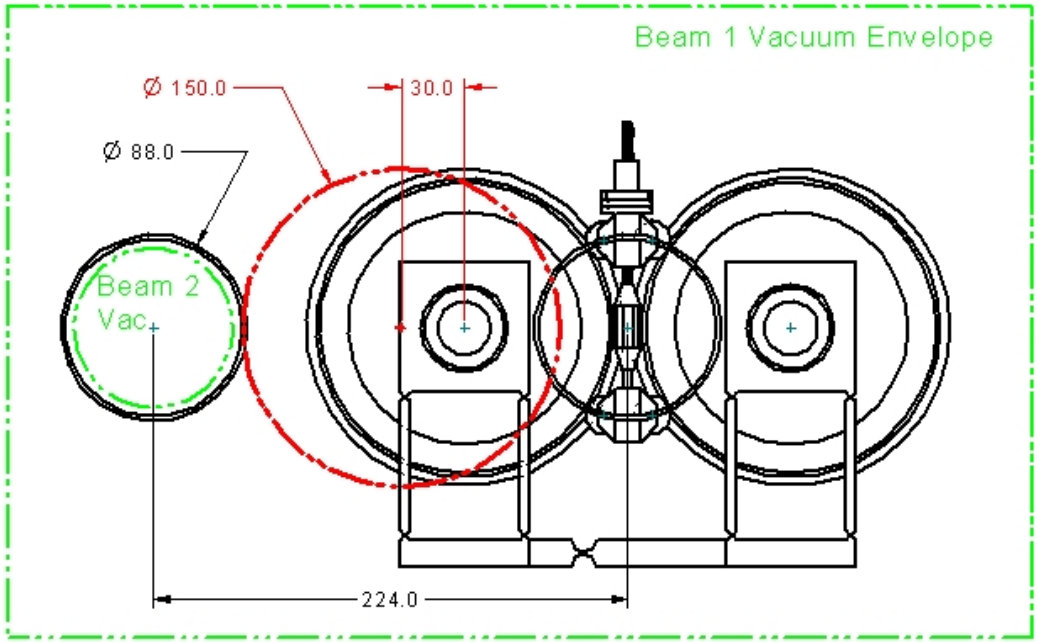
- Use RHIC data to benchmark the code used to predict the cleaning efficiency of the LHC collimation system
  Responsible: Angelika Drees, BNL [Task #2]

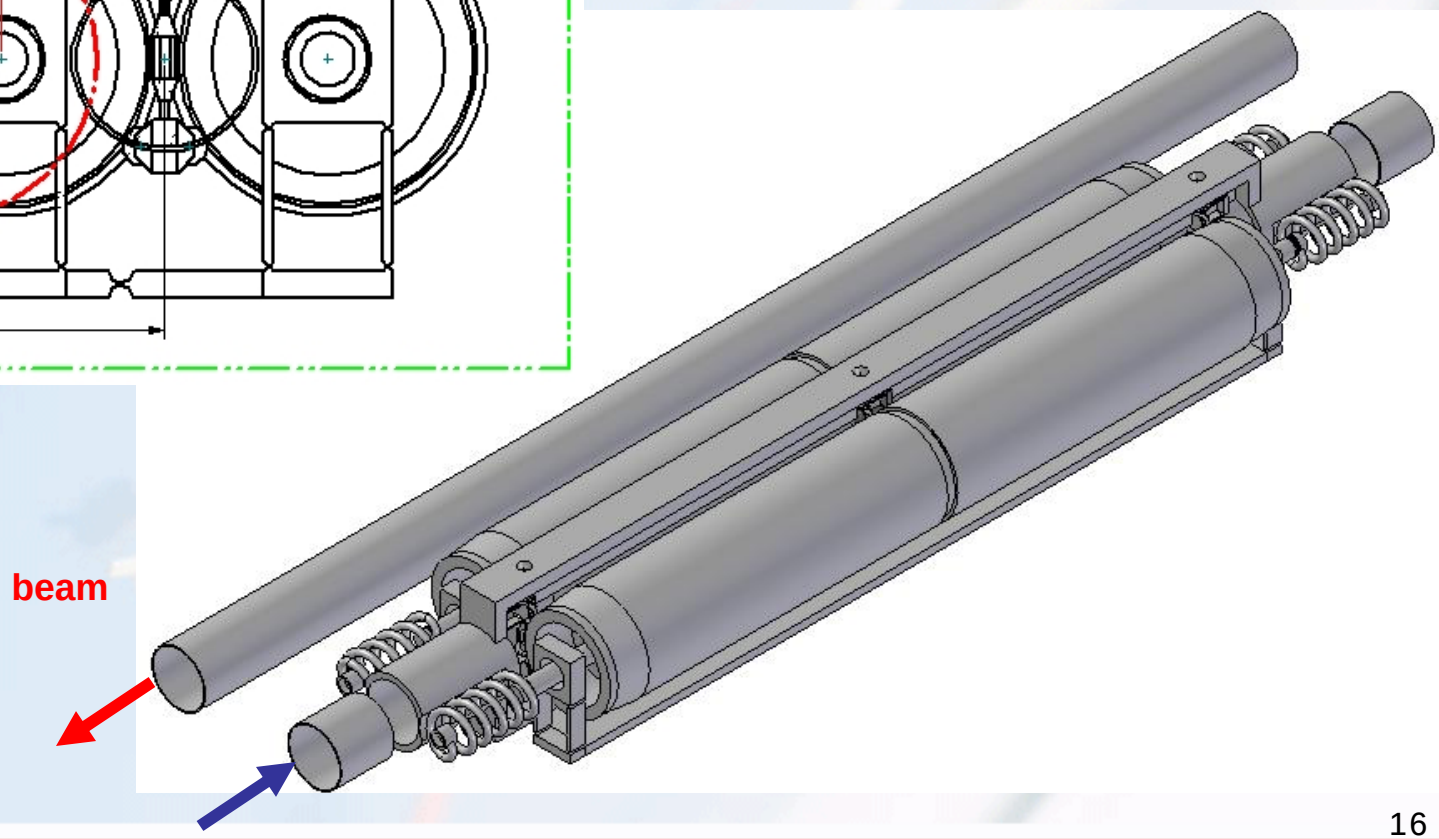
- Understand and improve the design of the tertiary collimators that protect the LHC final focusing magnets and experiments
  Responsible: Nikolai Mokhov, FNAL [Task #3]

- Study, design, prototype and test "Phase II" collimators that can be dropped into 32 reserved lattice locations required for L=1e34
  Responsible: Tom Markiewicz, SLAC [Task #1]

- Use the facilities and expertise available at BNL and FNAL to irradiate and then measure the properties of the materials that will be used for phase 1 and phase 2 collimator jaws
  Responsable: Nick Simos, BNL [Task #4]

Phase II Collimators





Collimators R&D: Milestones

- FY 2004: Introduction to project
- FY 2005: Phase II CDR and set up of a collimator lab at SLAC
- FY 2006: Design, construction & testing of **RC1**
- FY 2007: Design, construction & no-beam testing of **RC2**
- FY 2008: Ship, Install, Beam Tests of RC2 in LHC May-Oct 2008 run
- FY 2009: Final drawing package for CERN
- FY 2010: Await production & installation by CERN
- FY 2011: Commissioning support

RC1 = Mechanical Prototype; RC2: Beam Test Prototype

Collimators R&D: Status/Issues

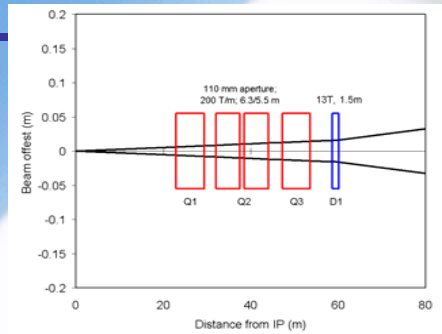
- Adequate software in place and MANY studies have been done
- No conceptual design yet to start building prototype (expected in October)
- Most challenging is 1st secondary downstream of primary in 450kW-10 sec scenario – expands beyond 25 um flatness
- Helpful visit of CERN team (Ralph&Co) to SLAC → steps toward a mechanical prototype
- RHIC 100 GeV p-loss map to be compared with debugged SixTrack
- Tertiary analysis awaits input from CERN (coming)
- Irradiation studies at BNL 200 MeV linac on high gears, analysis to come

Accelerator Physics Activities

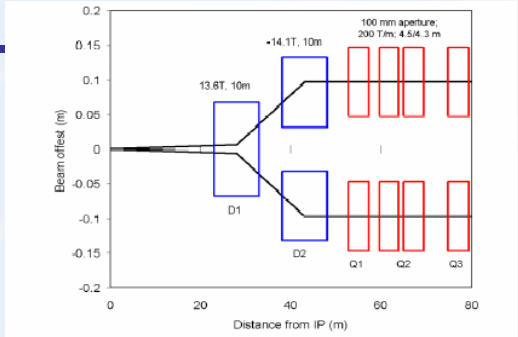
- E-cloud:
  - Some progress toward understanding SPS e-cloud data; POSINST code development in progress (better agreement with CERN models);
  - new 3D code (with Voy) shows e-cloud buildup movie; expect valuable input from RHIC'06 run where CERN ecloud detectors to be installed
- IR designs under development (see slide)
  - Matched optics for both the quadrupole first and dipole first designs were developed for β^* ~0.25m. Maximum quadrupole gradients of 200 T/m suffice
  - possibility of doublet focusing with the dipole first design
  - presented at Arcidosso
- Beam-beam simulations – progress not obvious:
  - Beam-beam 3D code numerical noise effects
  - Need to explain experimental data from Tev and RHIC separation studies
  - Whole activity needs to be re-energized
  - ..especially important for wire compensation→
- Active work on BeamBeamWire test at RHIC:
  - Be installed in 2006 → experiments
  - Have to make sure that Wire plans fit RHIC plans

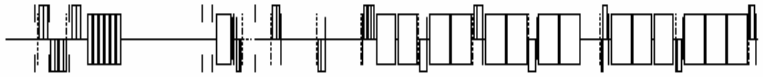
IR Designs for the Upgrade with Triplets

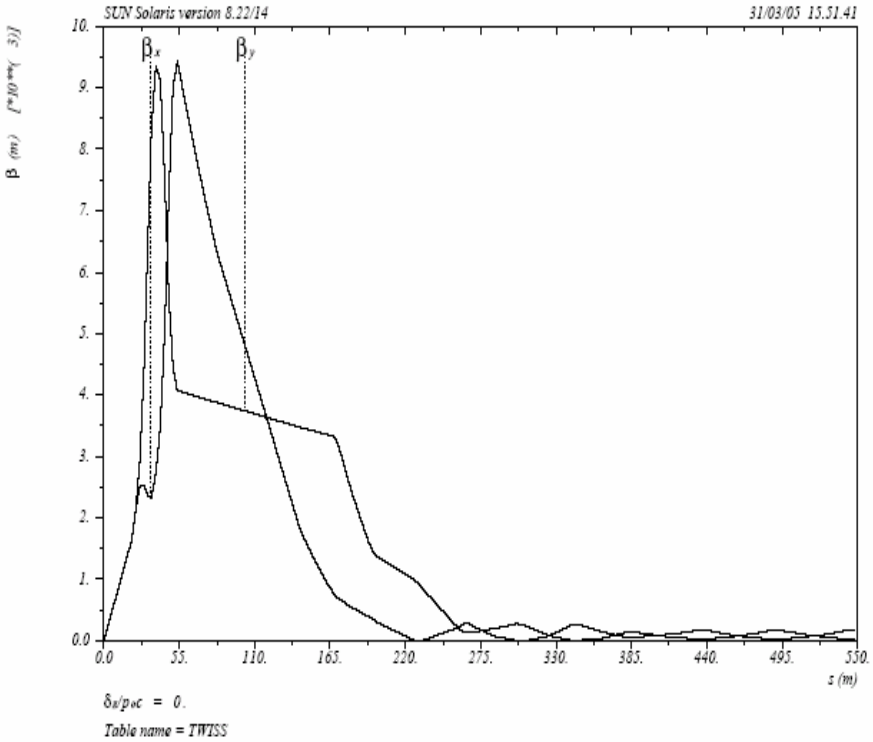
Quadrupoles first

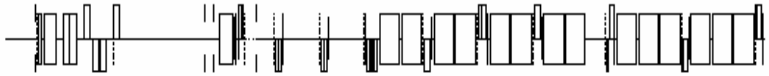


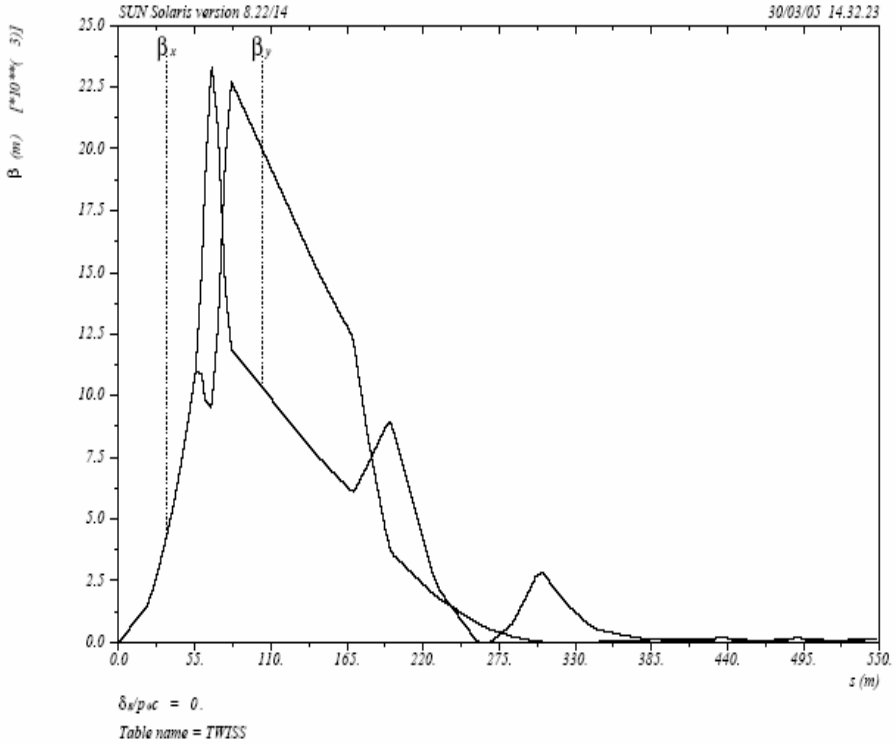
Dipoles first



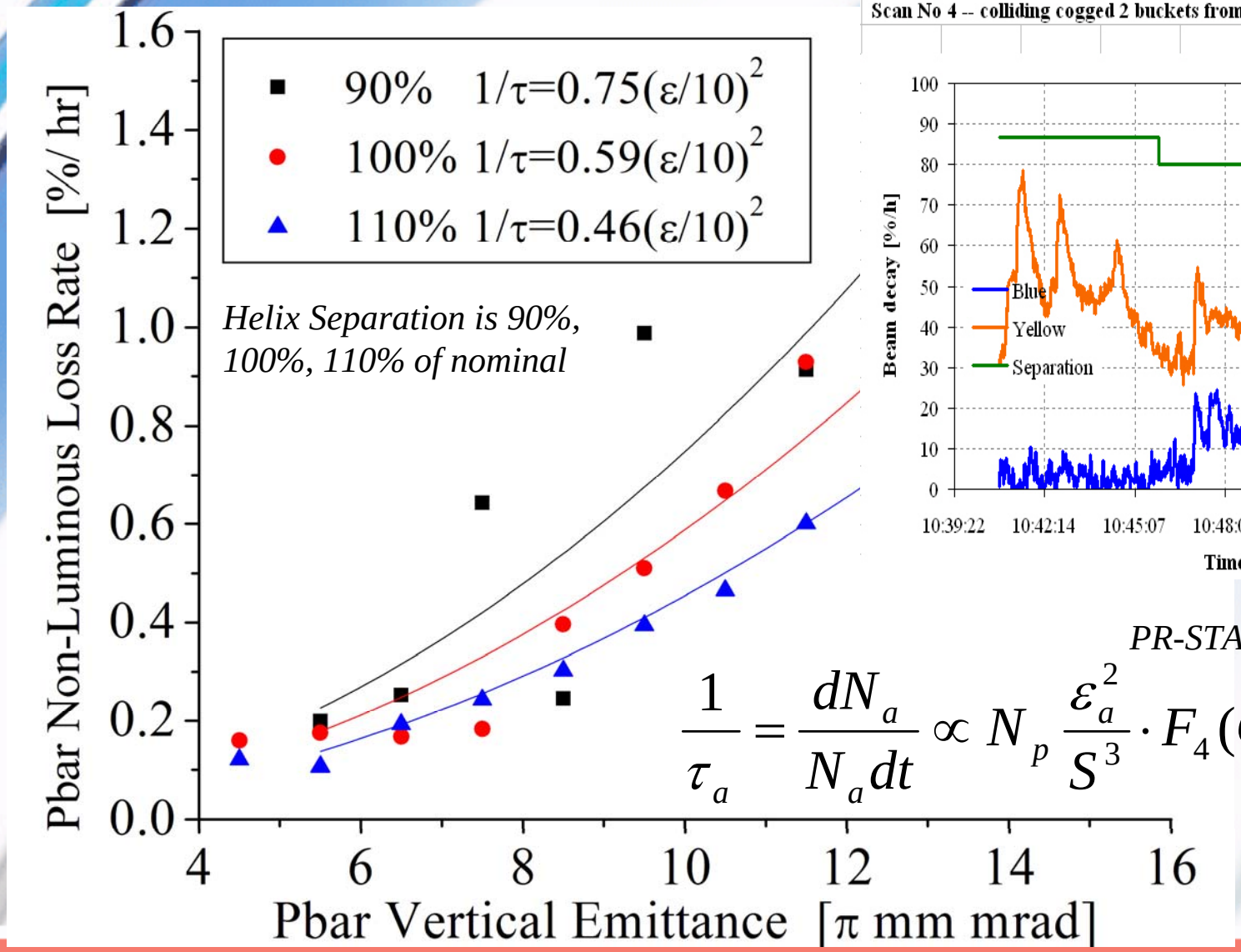


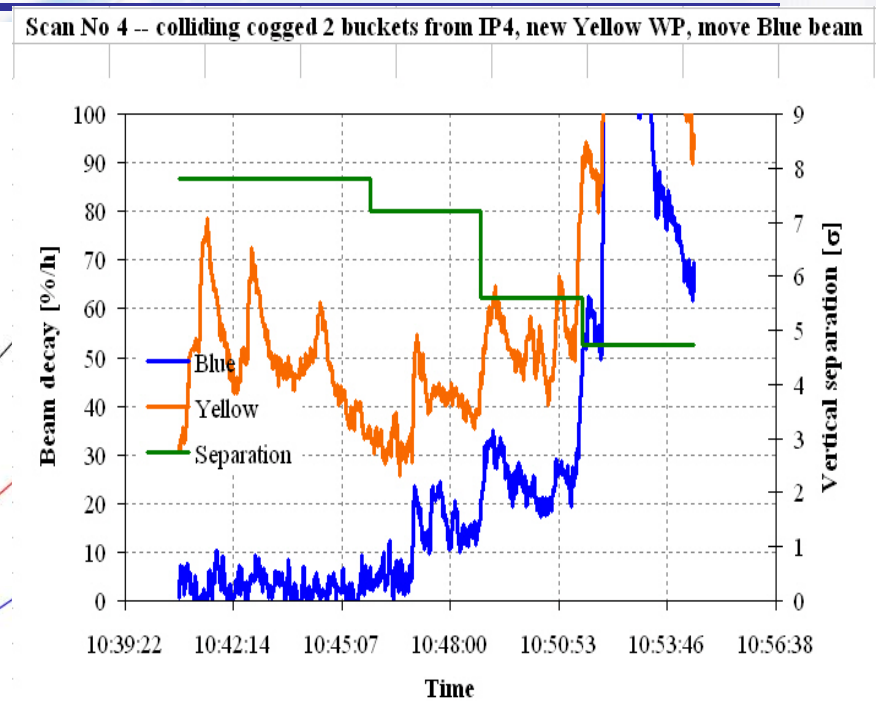






Tevatron Pbar Lifetime vs Separation



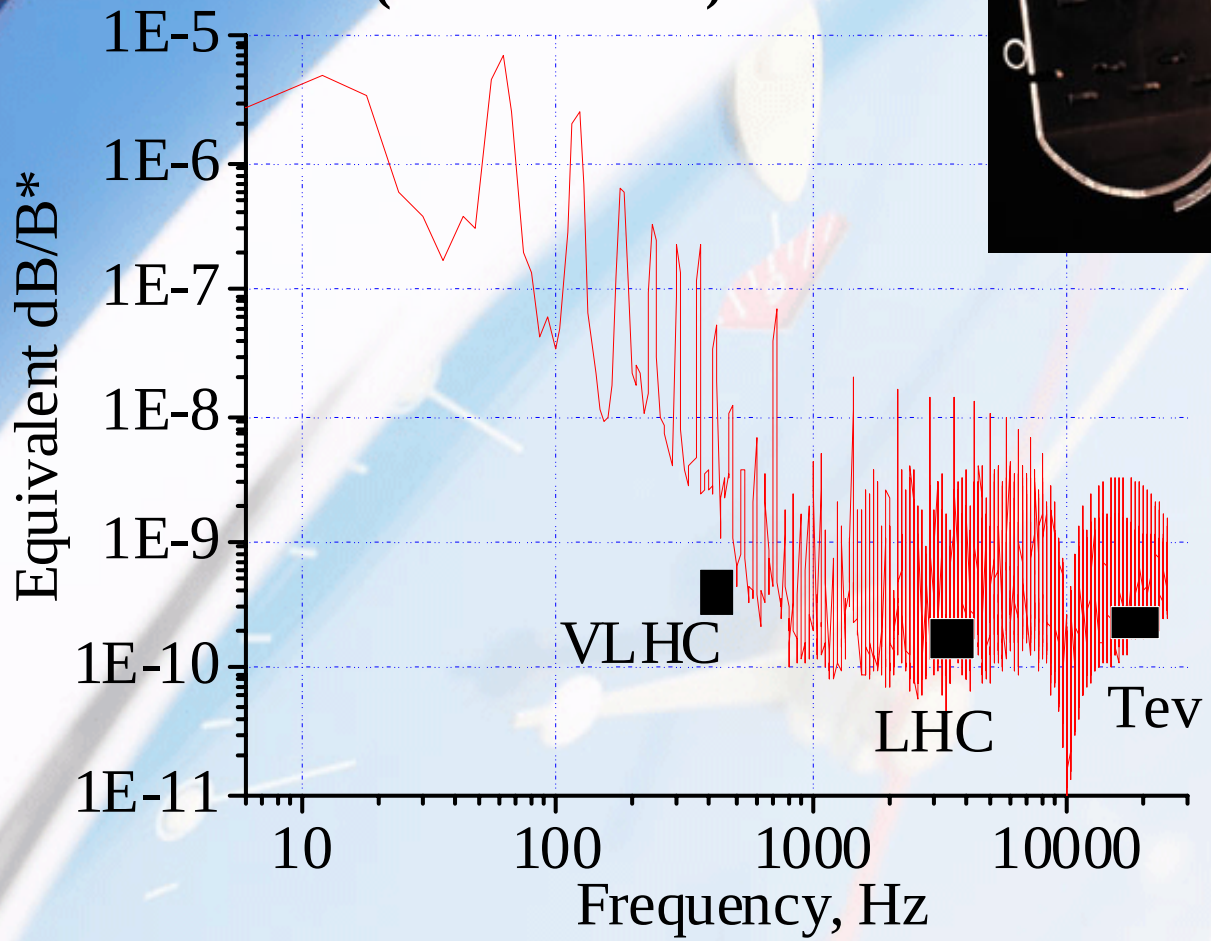


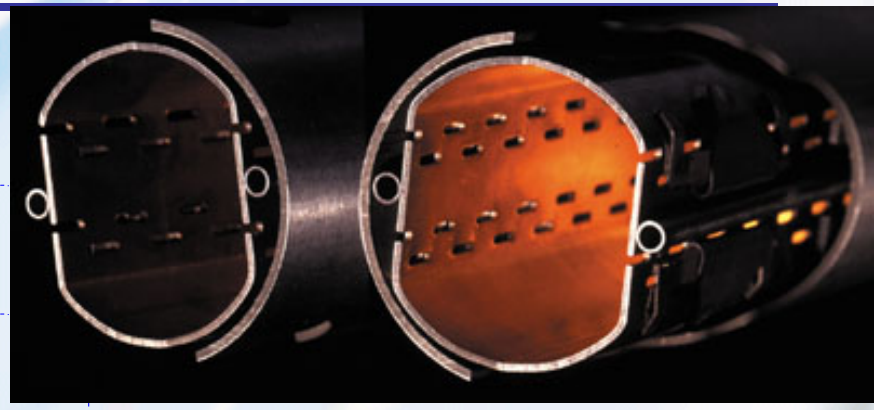
PR-STAB (2005)

$$\frac{1}{\tau_a} = \frac{dN_a}{N_a dt} \propto N_p \frac{\varepsilon_a^2}{S^3} \cdot F_4(Q_{x,y}, Q', M, \varepsilon_L)$$

Dipole Field Fluctuations with Screen

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





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

Can be measured at CERN MMF and in Tev

Commisioning: 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 last week

Benefits to the US HEP

- overall benefit if the LHC turns on rapidly and successfully:
  - support of the US investment in the LHC
  - secure future accelerator based HEP projects in the US
- the information and experience gained will be available for:
  - the LHC upgrades
  - the ILC (e.g., on large 2K systems) and other future machines
  - (possibly) for operating colliders, e.g. RHIC
- opportunities to
  - train younger staff
  - advance international cooperation
  - conduct forefront accelerator physics R&D

Issues Considered

- Funding:
  - Beam/Deliverables Commissioning – by LARP
  - Installation/Additional Hardware – not identified yet
- Schedule/Uncertainties
  - HC in FY'06-07 + "tail", BC in FY'08 and beyond
  - DG letter on HC → DoE response → ? (practical steps) ?
  - US side uncertainty – RHIC&TeV operations, ILC efforts
- Available Human Resources:
  - CTF members approached management of corresponding labs and explained/discussed the issue
  - estimated # of Eng and Phys possibly available for long (½ to 1 yr) and short (few weeks – few mos) commitment; got blessing from management to count on them
  - have preliminary lists of names

CTF Summary Table

Available Res's	Low-Est	Optmistic
Hardware Comm	6 FTE	11.5 FTE
Beam Commiss.		
long-term visits	8 FTE	19 FTE
short-term visitors	22	

- Need an acceptable working proposal to organize US participation in HC
- Estimates include ~3 non-existant people to be hired from LARP funds
- There are very preliminary lists of names for HC & BC

… e.g. like that one:

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 M.Lamont format (presented in Danford in Apr'05)

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

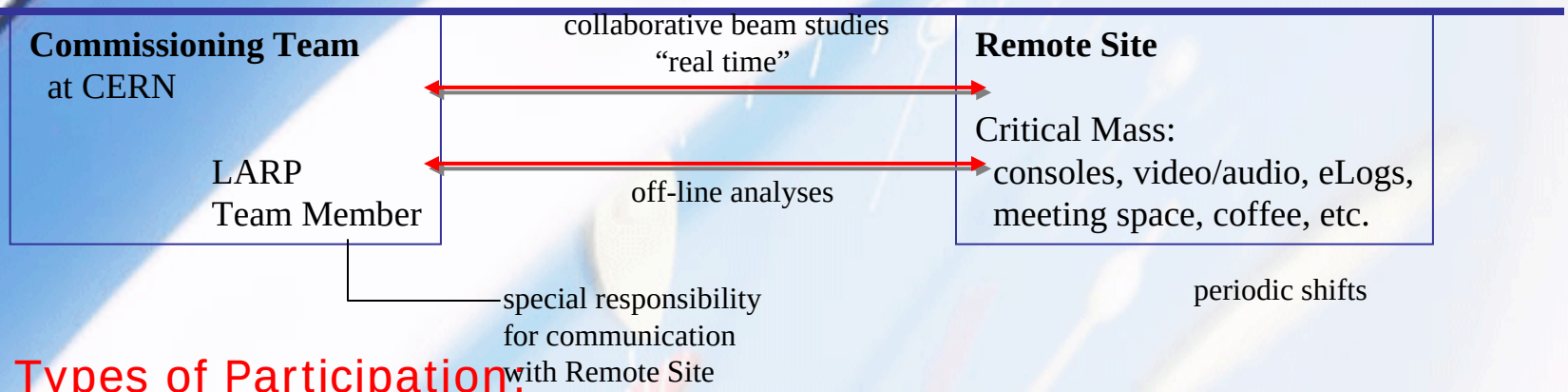
CTF Recommendations

- 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

CTF Recommendations

- Involvement of junior staff is important:
  - Definetely, 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

Motivation for Communication Center



Four Types of Participation:

1) Deliverables

   person builds something, visits to install, debug, etc., then leaves; may need remote access

2) On-site Commissioning

   person has moved to CERN (for ~1 year, say) and works daily with LHC group

3) 1-on-1 Contacts

   person works with a particular person or group located at CERN, with occasional trips to CERN to participate in a study, etc.

4) Remote Participation

   person is part of a group at Remote Site, participating daily for shorter time periods

   - "Training" can be performed at the Remote Site; periodic, shorter trips to CERN working with the "On-site" commissioners; people can continue to work remotely upon return

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 <u>develop remote "operations" center at FNAL.</u>
- Important step in the development of future "global" machines like the ILC..."

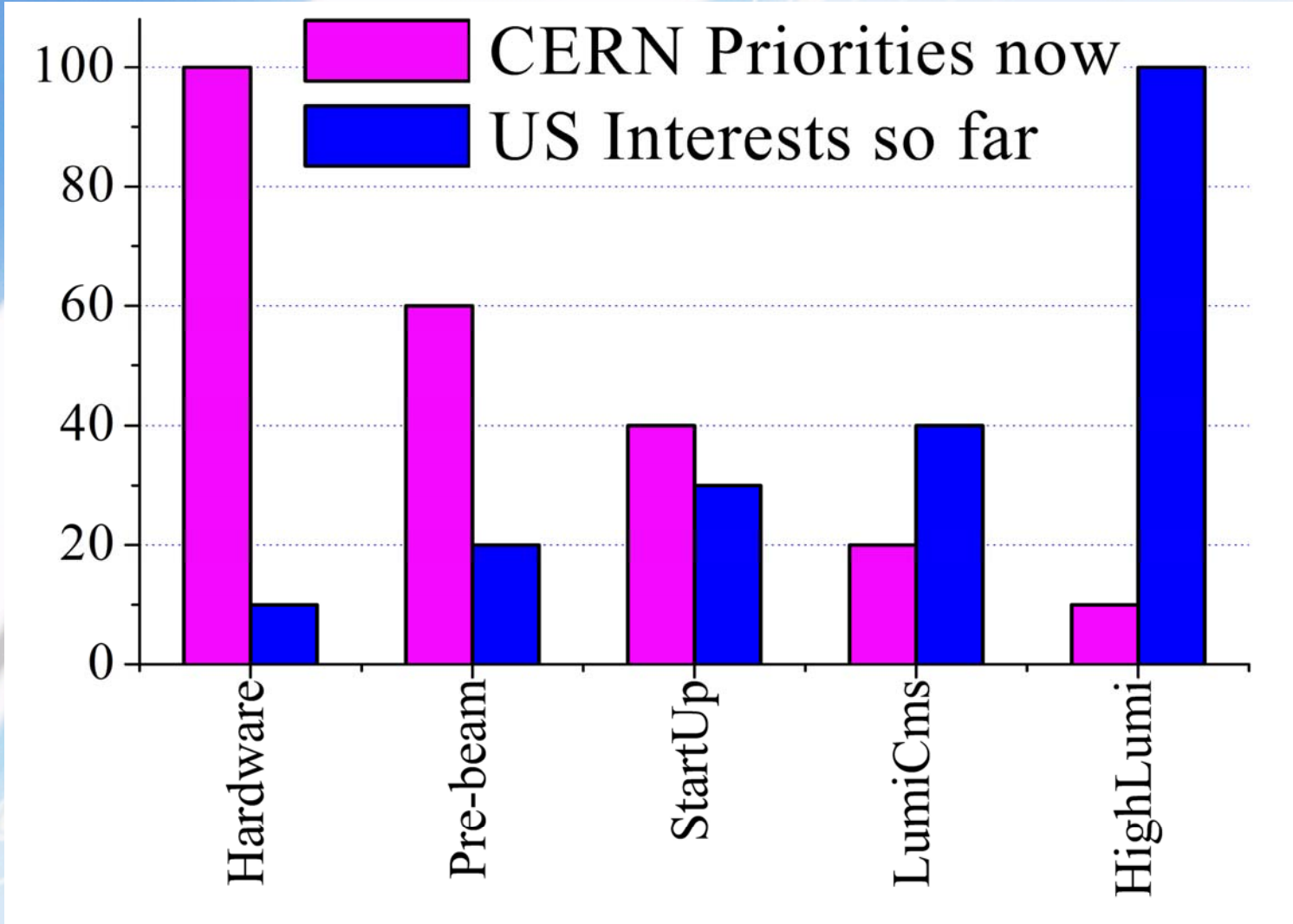
Is that better than laptop PC connection?

- Shift activities are best performed from a place that has a 24/7 video/audio link to the CERN. For CMS it is expected that we will be involved in data- quality monitoring shifts. I don't know if this makes sense for LHC.
- If CERN needs to contact an experiment, this could be handled through LHC@FNAL (ie. locating the expert).
- If you are working on your laptop, and you need to talk to someone at the CCC, it is unlikely that you would be able to simply call the CCC. However, calling LHC@FNAL which is expected to have an open communications channel to the CCC could be the way to get your questions answered.
- LHC@FNAL is expected to have up-to-date hardware and software for remote operations. You may have it on your laptop as well, but you would have to make an effort to keep the software up-to-date.
- Capabilities at LHC@FNAL are expected to include multiple, large, high-quality monitors with on-demand video and audio conferencing.
- LHC@FNAL may end up being a "trusted site" with access to information that will not be permitted from a laptop. This is not definite, but it's a possibility. We are considering an area that would be secured by a card-entry system so that qualified people can get in to access restricted information.

Some Comments

- CERN should support it because it make an effective use of external help of visitors in machine commissioning:
  - Faster help on already delivered hardware
  - You invest your time and knowledge in smb, why not get more out of him/her by involving in post-visit of in-between visits analysis (access to logbooks, dataloggers, SDA, post-mortem data, etc)
  - I dreamed about such a thing after visits of CERN, SLAC and BNL physicists to help to boost Run II performance
- LHC@FNAL is probably bad-chosen name , it should be LHC@US as it will served in that fashion anyway
- We plan to take an active part in that activity to make sure it takes into account accelerator needs

Living Abroad Issues

- Longer Term Visit Issues
  - 6 to 12 months
  - Move family/schools
  - Travel/Relocation expenses
  - Salary adjustment to cost of living
  - Insurance
  - Extra money from CERN ("Project Associate"=5kCHF/mos HC)
  - Taxation
- The visits should look attractive in order to bring more people
- We explored some of these issues:
  - Memo from FNAL HR
  - First look into taxation issues
  - Studied and agreed with US-CMS guidances
  - Another memo on issues for Green Card holders
  - Discussion with B.Chrisman on fast(er) foreign travel approval

LHC Commissioning