Plans for LHC Instrumentation at LBNL

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and many others

Outline

- Progress and status
    1. 40 MHz demonstration completed
    2. Electronics and signal processing
    3. CERN system integration planning
- Short and long term plans
    - FY06 and beyond
- Budget
- Conclusions

FY05 accomplishments

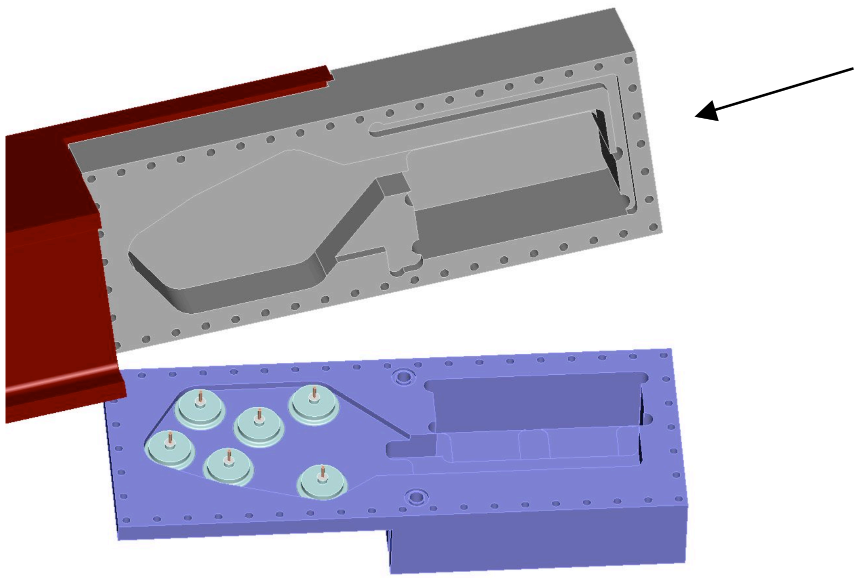
- Successful design review - 4/11/05
- 40 MHZ demonstration completed
- Final electronics design and integration underway
- Integration planning at CERN
- Plans for a test in RHIC

40 MHz Demonstration

- Tested the lumi detector at one of the hard x-ray beamlines at the ALS
  – X-ray to ion pair production very hard to calculate
  – White light configuration ~70-80 keV x-rays
- Chamber modification needed
- Tested proof of principle in August
- Complete set of data taken in September
- Required dedicated machine time to fill the ring with a 40 MHz bunch pattern
  – Pattern used allowed for a gap to measure single bunch response
  – Also tested without gap to see ‘continuous’ beam
- Enrico Bravin (CERN) at Berkeley during the experiments
  – Allowed for much more integration efforts

Experimental Setup

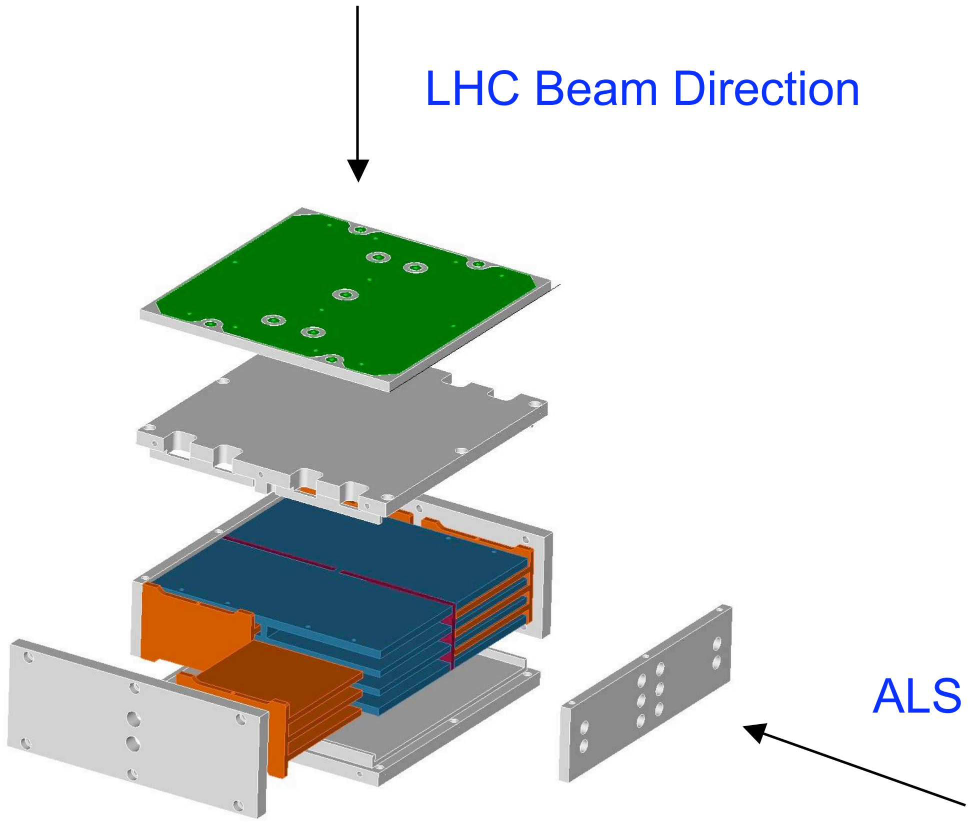
- Built a dedicated part of the case in Aluminum
  - Very thin (10 mils) wall exposed to the beam
  - Had to add Cu foil to prevent saturation of the electronics



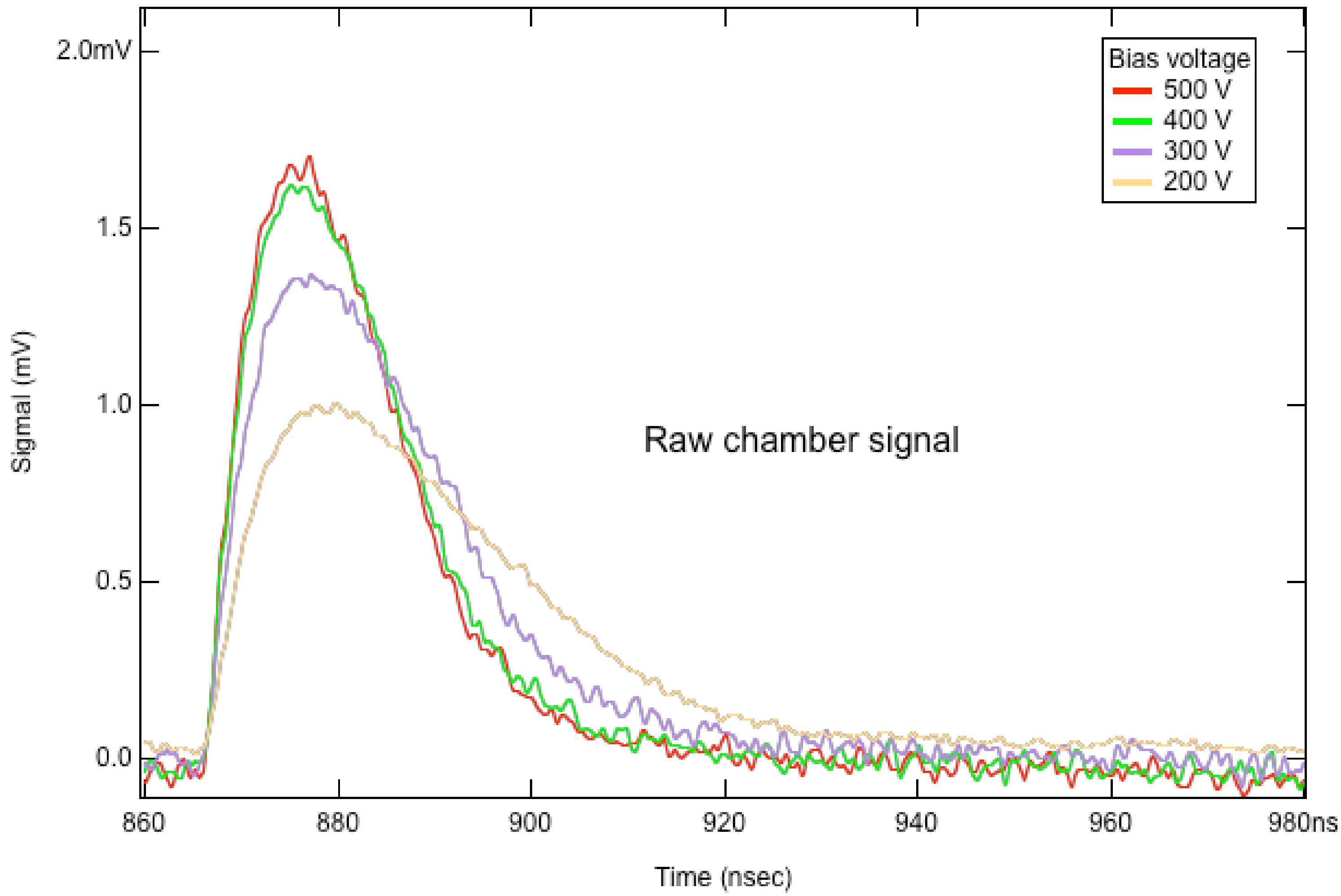
New Al housing w. thin wall

Experimental Setup

Beam hit the chamber from the side to allow for minimal attenuation

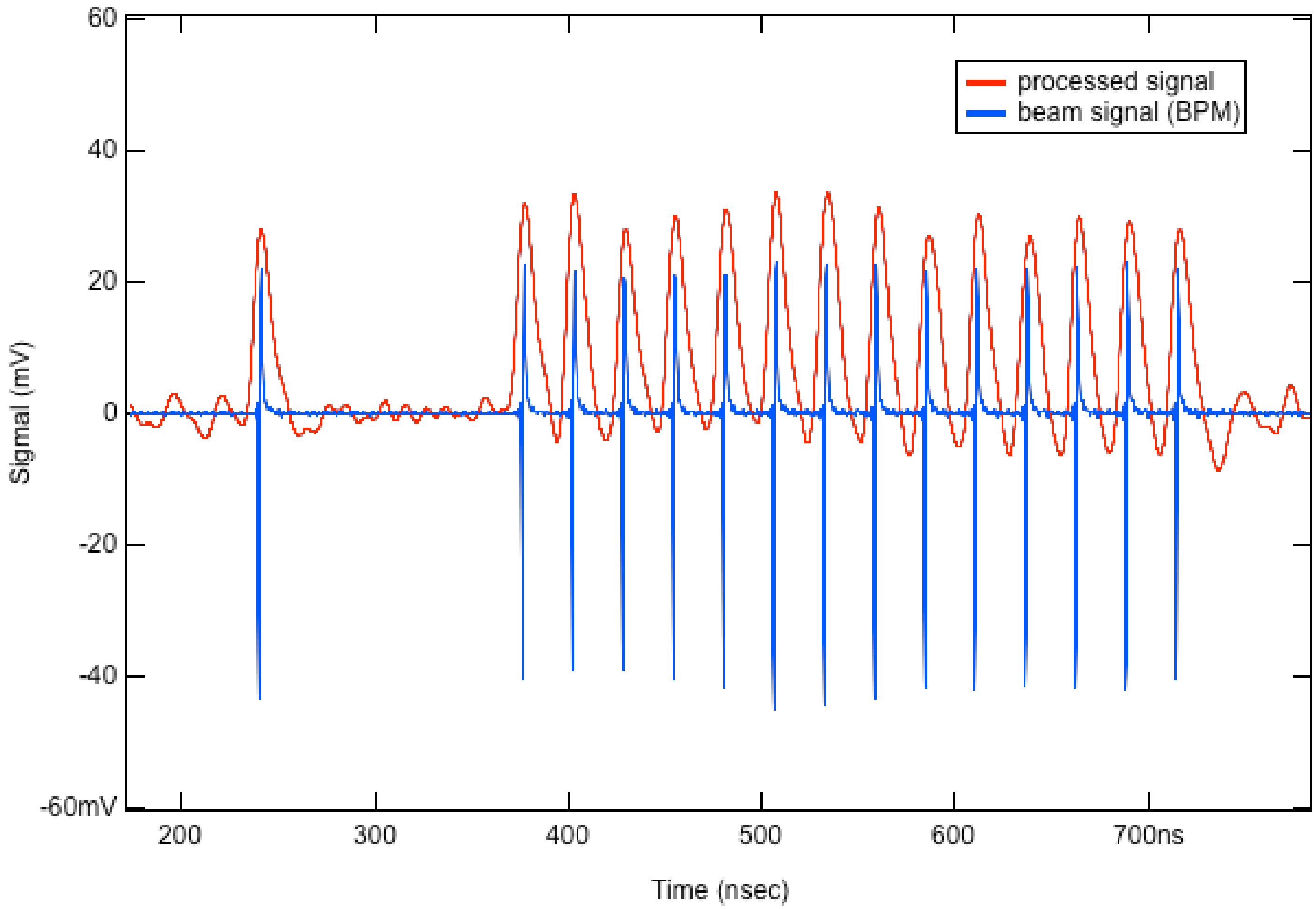


Raw Chamber Signal



20 ns/div

With Signal Processing



40 MHz Demonstration - Results

- Data recorded for multiple cases
  - V scans
  - Intensity scans (50 mA -> few mA)
  - Multiple turns will give statistics
- Data analysis starting

- Already shown
  - No space charge saturation effects
  - Minimal pileup
    - Greatly simplifies deconvolution

- Excellent experience for the operation of an integrated device
  - Will keep the BTS setup in place

Electronics Development

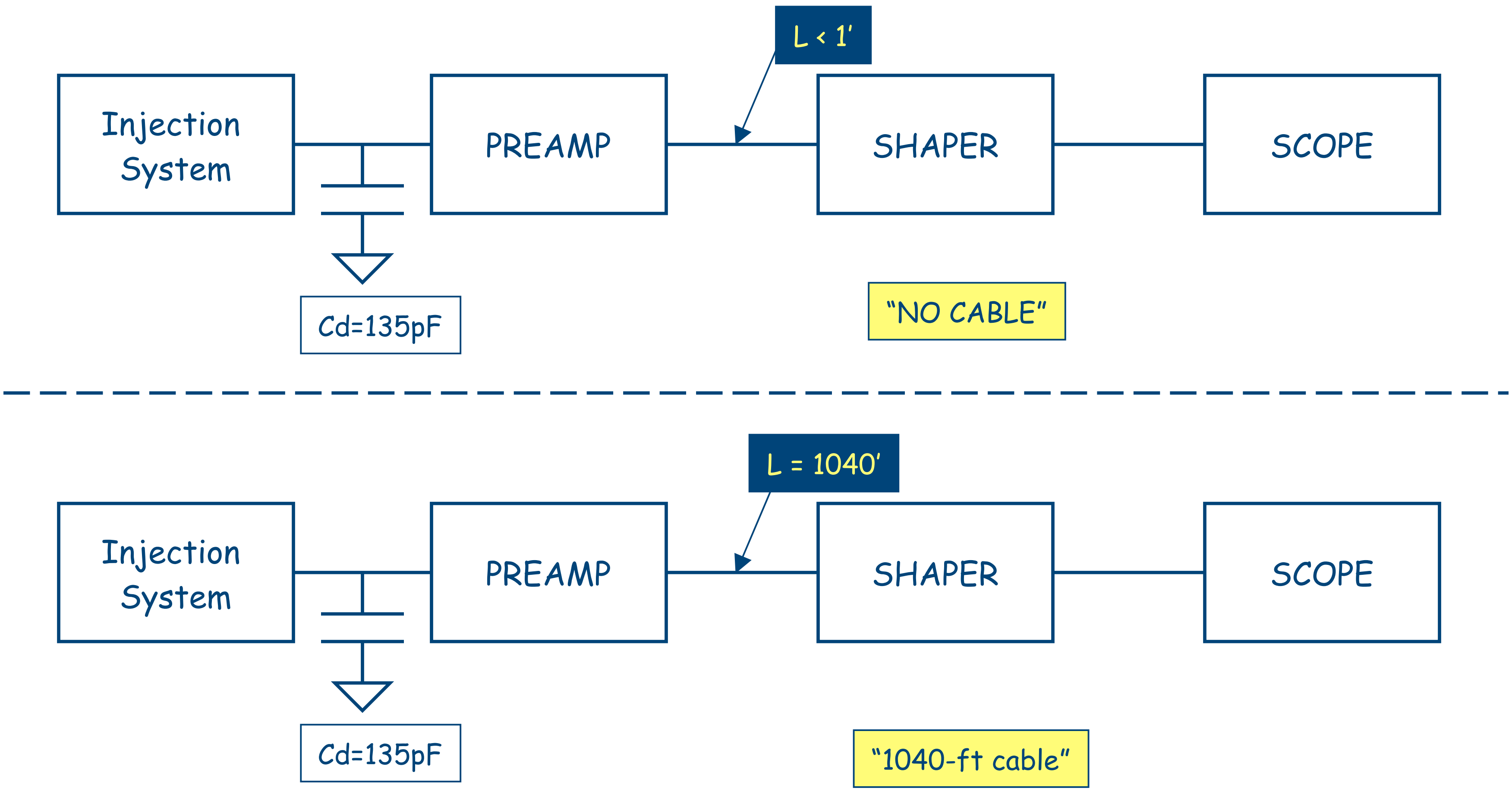
Current Activities

- Shaping Amplifier
- Preamplifier
- Power Supplies and Regulation

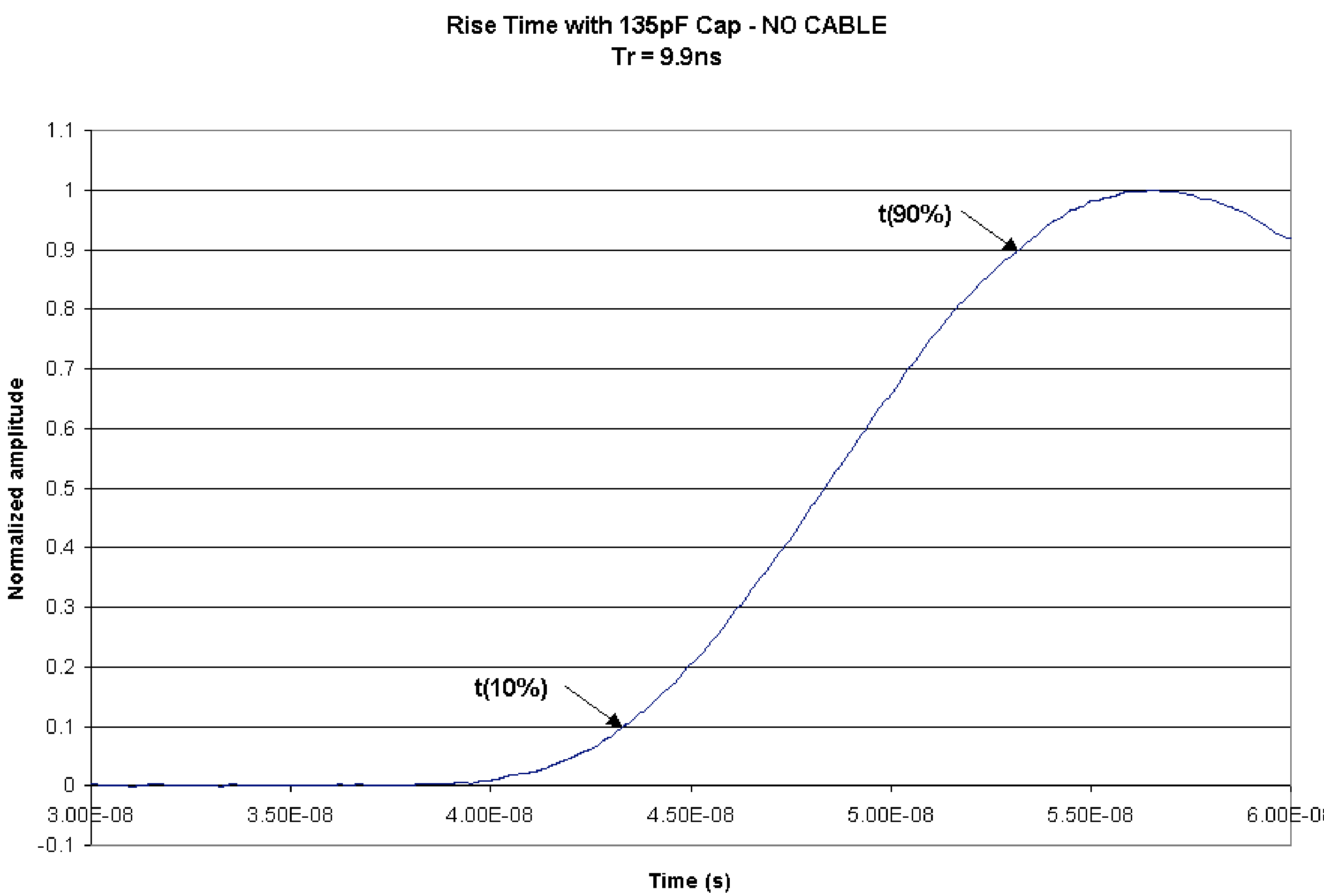
FY2006 Activities

- Mezzanine Development
- HV distribution board (to be mounted with the quadrants)
- Mechanical integration (Front-end)
- Integration and test of the signal complete channel (preamplifier, shaper and digitizer)

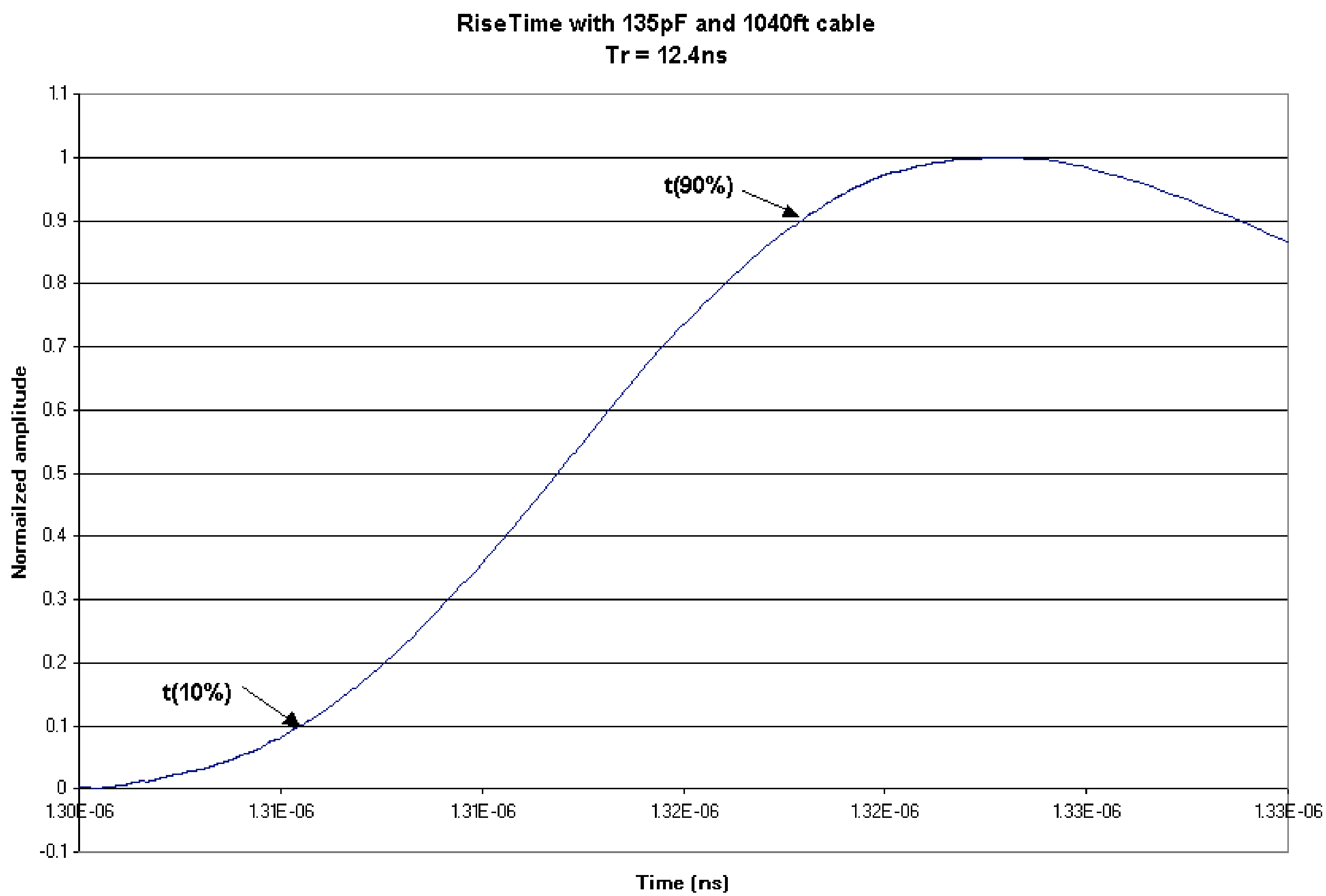
Measurement Setups



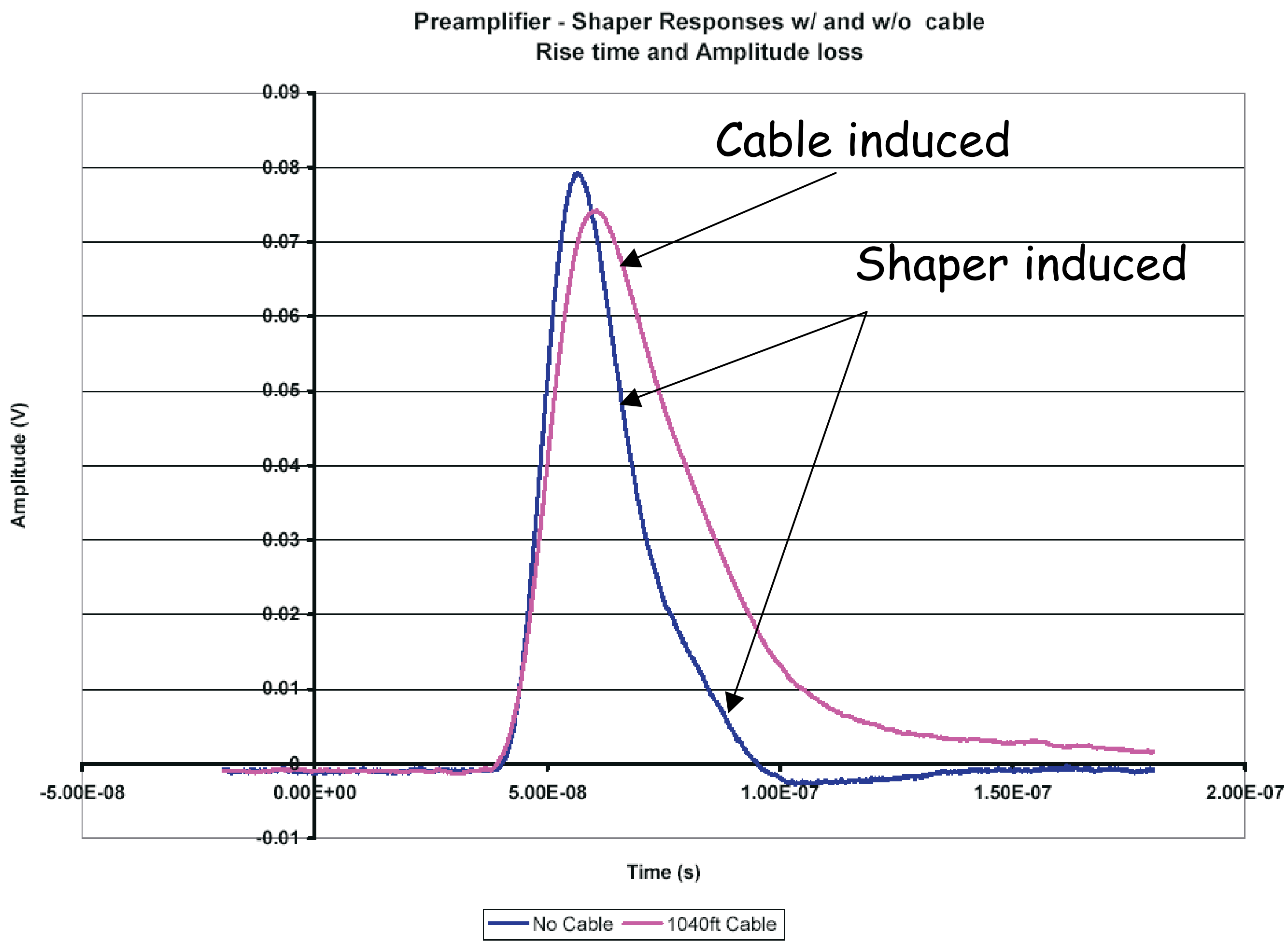
Cd=135pF – Short Cable



Cd=135pF – 1040' Cable

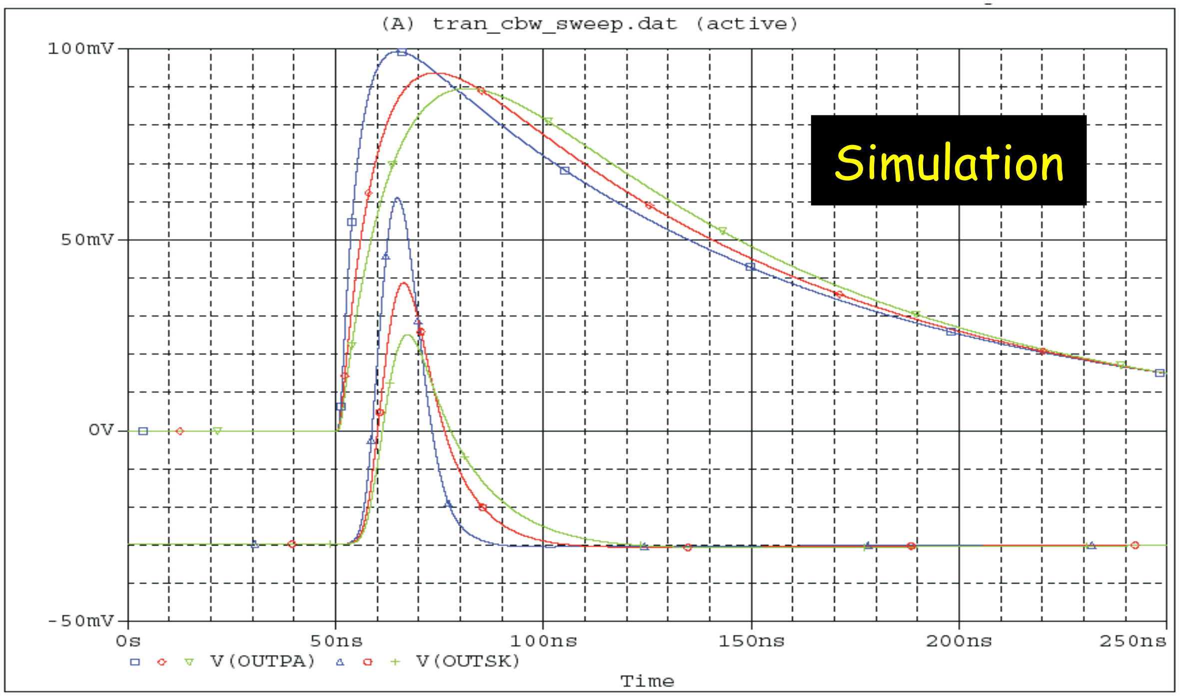


Comparison



Preamplifier - Shaper Responses w/ and w/o cable
Rise time and Amplitude loss
Cable induced
Shaper induced
Amplitude (V)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-5.00E-08
0.00E+00
5.00E-08
1.00E-07
1.50E-07
2.00E-07
Time (s)
No Cable
1040ft Cable

Shaper Output Signal versus Rise of its input(simulated)



The rise time and the width of the shaped pulse are a function of the rise time of the signal at the output of the preamplifier.

LARP

Detector Capacitance and Cable effects
Double Differentiation

BERKELEY LAB

The cable induced effects are similar to those induced by a larger detector capacitance.

Double differentiation is necessary to shorten the pulse

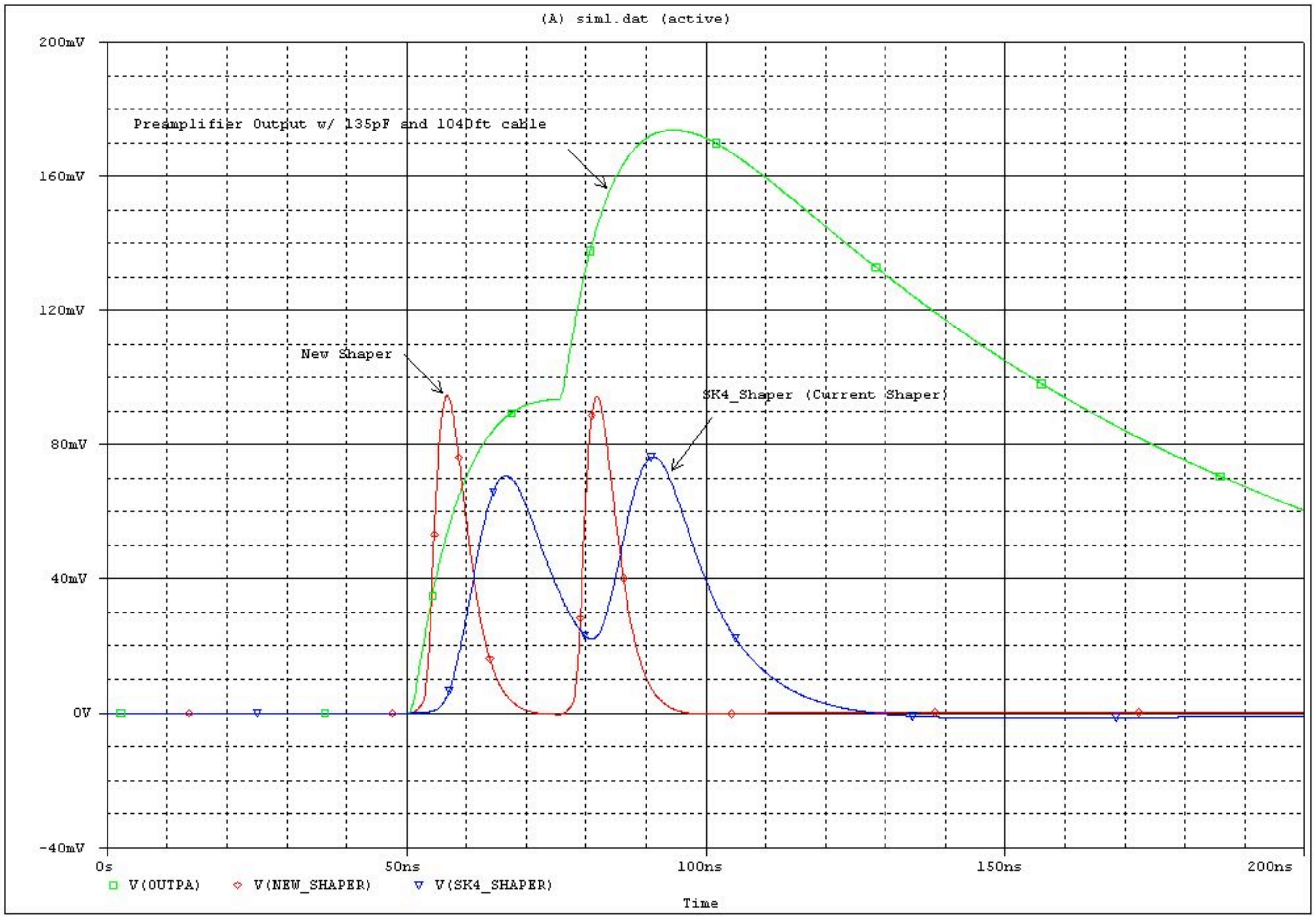
Current Shaper:

- Single Differentiation cuts off the long trailing edge of the preamplifier's output.
- Effect on the falling edge only !

New Shaper:

- Same differentiation as for the current shaper
- Additional stage to differentiate the leading edge of the preamplifier.
- New simulation model completed
- First version currently being tested

Simulation Results



Preamplifier

Moving towards the "production" version:

- Bias made thermally stable
- Breakdown issues
- All Caps are ceramic – Better radiation hardness than Electrolytic and Tantalum.
- Gain stage.

Breakdown Issues (Solutions evaluated on this version)

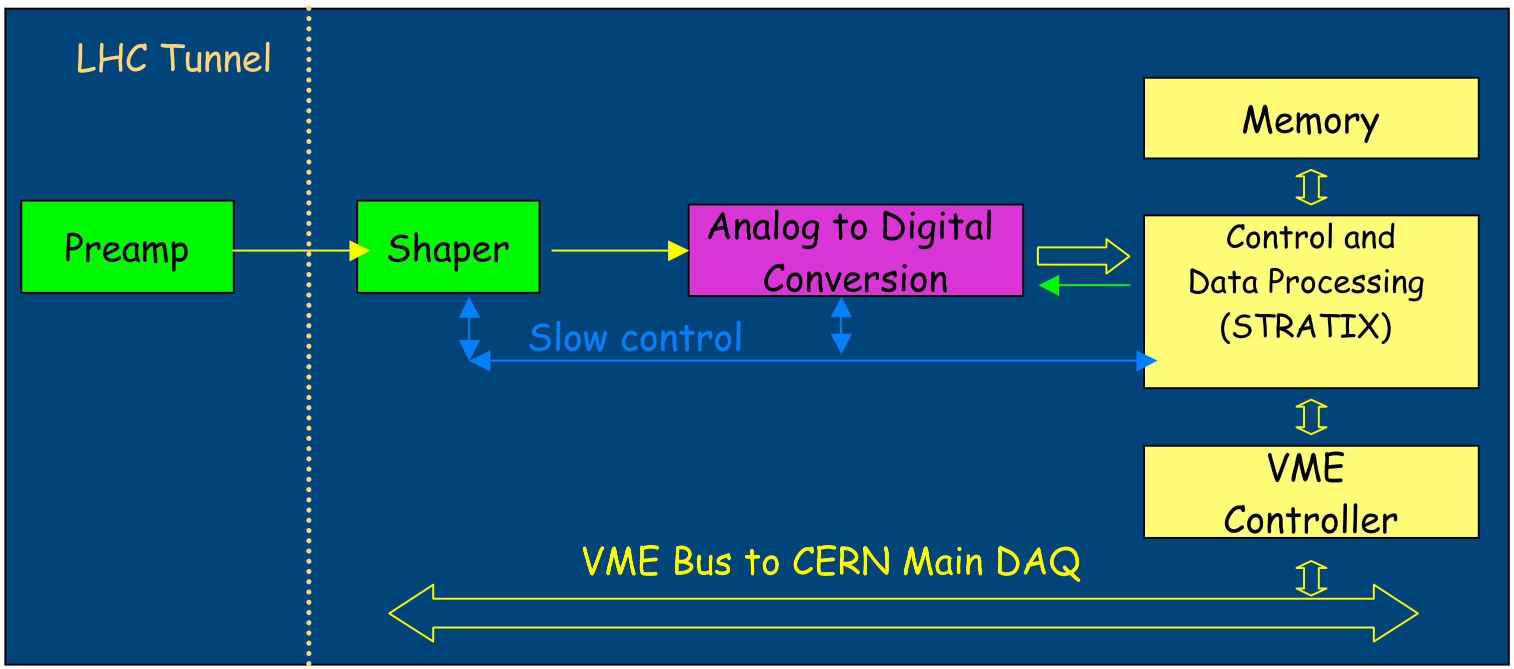
- Reverse breakdown protection:
  - Current amplifier has a diode that might be too slow.
  - Fast Schottky and diode-connected BJT instead.
- Forward breakdown when the chamber electrical field quenches (ion build-up?)
  - Fast Schottky and diode-connected BJT with offset for turn-on condition.
- Franco suggested also to include and to try a Resistor in series, inside the loop.

Preamplifier (Continued)

- Space-qualified Ceramic caps are radiation tolerant up to 20krad-100krad
  - No data available beyond these levels!
- Bias decoupling capacitors are not an issue (still caps).
- Signal capacitors are the issue:
  - Preamplifier: Gain and **Matching** are linked to cap values
    - Structure with matching not cap dependent ?
  - Shaper: Cap values determine the shape of the signal
    - Separation of preamplifier and shaper – Shaper in the counting room !
- Breakdown issue linked to input on the Base of the BJT.
- Design Study with Common-Base amplifier

Electronics Activities for FY06

- Power supplies (regulators) and mechanical enclosure for front-end
- Mezzanine board development
- Integration and tests of the signal processing electronics channel
  – Preamplifier + Shaper + Digitizer (Mezzanine)
- Design of the HV distribution board for the new detector



Integration planning at CERN

- Complete system description
- Met with all relevant parties at CERN
- Draft being circulated
- Finalize next week at CERN
- Start EDMS process

CERN
CH-1211 Geneva 23
Switzerland

the **Large Hadron Collider** project

LHC Project Document No.
LHC-
CERN Div./Group or Supplier/Contractor Document No.
-
EDMS Document No.
-

Date: 1999-09-22

Technical Specification

LHC LUMINOSITY MONITOR

Abstract

The LHC luminosity monitors are gas ionization chambers that sample energy deposition in the forward TAN neutral particle absorbers. These luminosity monitors are primarily sensitive to high energy neutrons produced near zero degrees by pp collisions at the IPs. The neutrons interact in the TAN absorbers to produce hadronic-electromagnetic showers that deposit energy by ionization. The luminosity monitors are placed near the maximum of shower energy deposition in the TAN absorbers. Since the flux of neutrons and shower energy deposition are proportional to luminosity, the signal strength measured by the ionization chambers provides a measurement of relative luminosity. The ionization chambers and associated electronics have been designed to measure luminosity with 40MHz, or bunch-by-bunch, resolution. The ionization chambers are segmented into quadrants to allow measurement of beam-beam crossing angle. Small modulation of the transverse position of one beam at the IP allows measurement of beam-beam separation at the IP. The measurement of beam-beam separation can then be used in a slow feedback loop to reduce the beam separation to zero and maintain the LHC in optimum luminosity.

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Technical Specification - ToC

LHC Project Document No.
LHC-

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The case for IP2 and IP8

LHC users have expressed written interest in having luminosity measurement capabilities at IP2 and IP8. These devices are viewed as machine items.

LARP is only providing 4 monitors which will be installed in IP1 and IP5

Installation and planning for using identical devices at 2 and 8 is very different:

- these IPs don’t have TANs and will require a dedicated housing
- the supporting electronics is housed in areas not accessible during beam runs

LARP can provide more devices to CERN, which would be cost effective if funded (by CERN) during the production of the 4 items funded by LARP

Plans for a test in RHIC

- Install in IR 10
  - Former experiment, now empty
  - Compare with known ZDCs
- Will require dedicated collisions
- Multiple reasons to prefer Au-Au collisions
  - More neutron yield
  - Better neutron energy
  - Dedicated collisions have less effect on lifetime than in p-p mode

RHIC Experiment Setup

Table 1: Ionization chamber details

Quadrant area,mm2	1600
Gap between plates,mm	1.0
No. of gaps in parallel	6
Gas	Ar+6%N2
Gas pressure,atmos abs	6
Ioniz pairs/mip-mm	58.32
E/p, V/mm-atm	200
Gap voltage, V	1200
Electron drift velocity,mm/microsec	45.0
Amplifier/Shaper gain, microV/e-	0.16
rms noise,mV	1.24

RHIC Experiment Setup (cont.)

Table 3: Collider parameters	LHC(p-p)	LHC(p-p)	RHIC(p-p)	RHIC(Au-Au) All events	RHIC(Au-Au) Inelastic events
Luminosity, cm-2sec-1	1.0E+34	1.0E+32	1.0E+31	2.00E+26	2.00E+26
Beam energy, TeV	7.0	7.0	0.1	19.7	19.7
Filled bunches	2808	2808	116	116	116
Lumi/bunch pair, cm-2sec-1	3.6E+30	3.6E+28	8.6E+28	1.7E+24	1.7E+24
No. bunch spaces	3564	3564	116	116	116
Bunch separation, nsec	25	25	110	110	110
Rev freq, kHz	11.2455	11.2455	78.2	78.2	78.2
Inelastic + Coul diss xsection, mb	80	80	44	57000	7000
Interactions/bunch xing	25.3	0.25	4.9E-02	1.3E-03	1.5E-04
Effective neutron multiplicity/int	0.5	0.5	5.5E-02	3.2E+00	15
Effective neutron prod xsection, mb	40.0	40.0	2.4	180000	105000
Neutrons/bunch xing	12.7	0.13	2.6E-03	4.0E-03	2.3E-03
Mean neutron energy, TeV	1.5	1.5	0.03	0.1	0.1
Mean mips/bunch xing(1 quad)	6.8E+03	6.8E+01	2.8E-02	1.4E-01	8.3E-02
No ioniz e-/bunch xing	2.4E+06	2.4E+04	9.9E+00	5.0E+01	2.9E+01
Mean pulse height/bunch xing, mV	**3.8E+02**	**3.8E+00**	**1.6E-03**	**7.9E-03**	**4.6E-03**
Mean mips/neutron	5.4E+02	5.4E+02	1.1E+01	3.6E+01	3.6E+01
Flux ioniz e-/neutron	1.9E+05	1.9E+05	3.7E+03	1.2E+04	1.2E+04
Mean pulse height/neutron,mV	3.0E+01	3.0E+01	6.0E-01	2.0E+00	2.0E+00
Interactions/sec	8.0E+08	8.0E+06	4.4E+05	1.1E+04	1.40E+03
Det eff	3.5E-01	3.5E-01	4.7E-02	7.2E-01	1.0E+00
Events/sec	2.8E+08	2.8E+06	2.0E+04	8.2E+03	1.4E+03
Events/bunch xing	8.9E+00	8.9E-02	2.3E-03	9.0E-04	1.5E-04
Mean energy/neutron, TeV	1.5	1.5	0.03	0.1	0.1
Neutron mult/det event	1	1	1	3.2	15
Mean energy/event, TeV	1.5	1.5	0.03	0.32	1.5
Mean mips/event	7.7E+02	7.7E+02	1.3E+01	1.6E+02	5.4E+02
No ioniz electrons/event	2.7E+05	2.7E+05	4.4E+03	5.5E+04	1.9E+05
Mean pulse height/event, mV	**4.3E+01**	**4.3E+01**	**7.0E-01**	**8.8E+00**	**3.0E+01**

RHIC Experiment - Next Steps

- Make a formal request as a RHIC AP experiment
  - Separate from the request of testing LHC ZDC prototype
  - Discussed at RHIC AP experiment workshop -> Nov. 9-10

- Ship chamber to BNL in October
- Use existing electronics
  - With scopes and manual processing
  - Test the LHC DAQ system when it becomes available
    - DAB-IV board
    - Mezzanine card

Rad Hardness

In finalizing the design of the chamber and its electronics, we are selecting its components

We plan to research previous knowledge on radiation damage of materials and use best practices to minimize risk

We are still in contact with Brian Wirth, professor of nuclear engineering at the UC Berkeley, specializing in modeling of materials radiation damage, who is interested in this problem. A collaboration is not yet defined.

While there is likely moderate value added by making a test, a quick failure would help identify weak components. Would like to take advantage of other tests planned within the LARP program.

LUMI Long Term Plans
(as of 2004)

- FY04 - done
  - Continue performance tests
    - Complete 40 MHz test and optimization
    - Start production engineering study
- FY 05 - ongoing
  - Complete mechanical fabrication details
  - Integrate test stand with standard CERN DAQ system
  - Integration into TAN
  - Continue performance tests and electronics integration
  - Radiation damage assessment - discussed at Danford's 04 meeting
- FY06
  - Fabrication of 4-8 units + spares - Only first unit in FY06
  - Fabrication of auxiliary hardware
  - Device tests, electronics integration and performance qualification
  - Deliver first unit to CERN
- FY07
  - Fabricate balance of units and auxiliary hardware
  - Transfer to CERN
  - Installation support
  - Commissioning support
- FY08
  - Post-commissioning and pre-operations support

Plans for FY06 (revised)

Build one complete unit. This includes:

a chamber, mating TAN bar, gas handling system, tunnel electronics package

Complete DAQ chain w. mezzanine boards and acquisition firmware integrated in CERN VME system

no luminosity specific firmware/software

Complete documentation of chamber production and electronic processing system

Test existing prototype in RHIC (if feasible)

Budget Summary

Cost guidelines from task sheets:

FY	04	05	06	07
Requested	203	450	1187	811
Received		395	935	1063??

in $k

Conclusions

(mostly same as in 4/05)

We accomplished our major goals for FY05 and are on track to deliver what we promised in the past. In FY06 we maintain our overall plan

Funding-to-date continues to be marginally adequate

- supplemented by LBNL institutional support
  - both money and people

Year-by-year funding cycle at DoE contributes to risk

- As LHC commissioning approaches and project deliverables become due, we need a contingency plan

LBNL is committed to deliver and support Lumi and other devices through LHC commissioning and initial operations

- With support from the LARP AP and commissioning group