Plans for LHC Instrumentation at LBNL

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and many others

Outline

- Progress and status
  - –Electronics progress and plans
  - –Mechanical packaging
  - –High speed testing
  - –Radiation hardness
- Short and long term plans
  - –Before and after
- Cost considerations
- Conclusions

Progress and Status

Four main areas of activity:

1. Final electronics design and integration
2. Packaging & hardware design
3. High Speed (40 MHz) test studies
4. Rad hardness studies

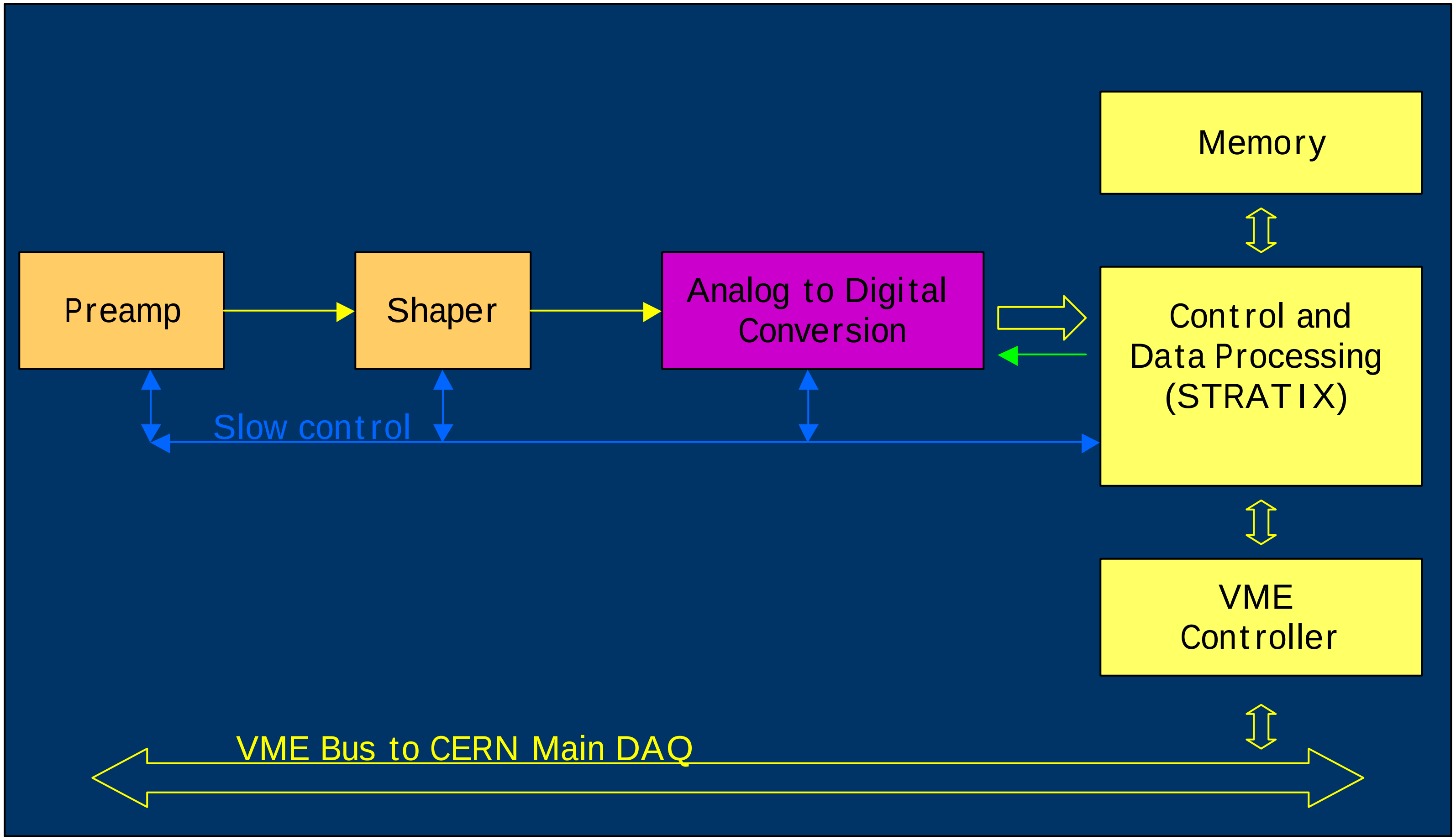
1. Electronics design and integration (J.-F. Bêche)

Ongoing development of new shaper electronics

Development of final electronics package

Development of proof-of-principle deconvolution routines

Block diagram



Pulse Shaping Electronics

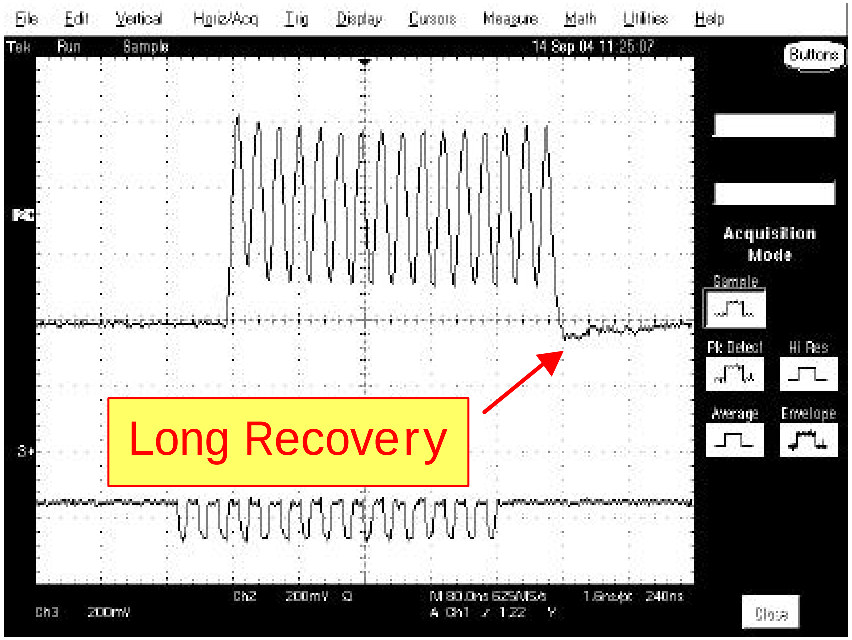
Pulse shaping electronics necessary to limit the noise bandwidth.

Pulse shaping is also necessary to reduce the width of the pulse to accommodate the 40MHz repetition rate.

Two main issues encountered with the shaper provided by Pavia:

- Stability - Several adjustable parts
- Baseline recovery (Pole-Zero cancellation)
  - Second pole of the preamplifier not compensated, creating either an undershoot or an overshoot when the signal returns to the baseline.

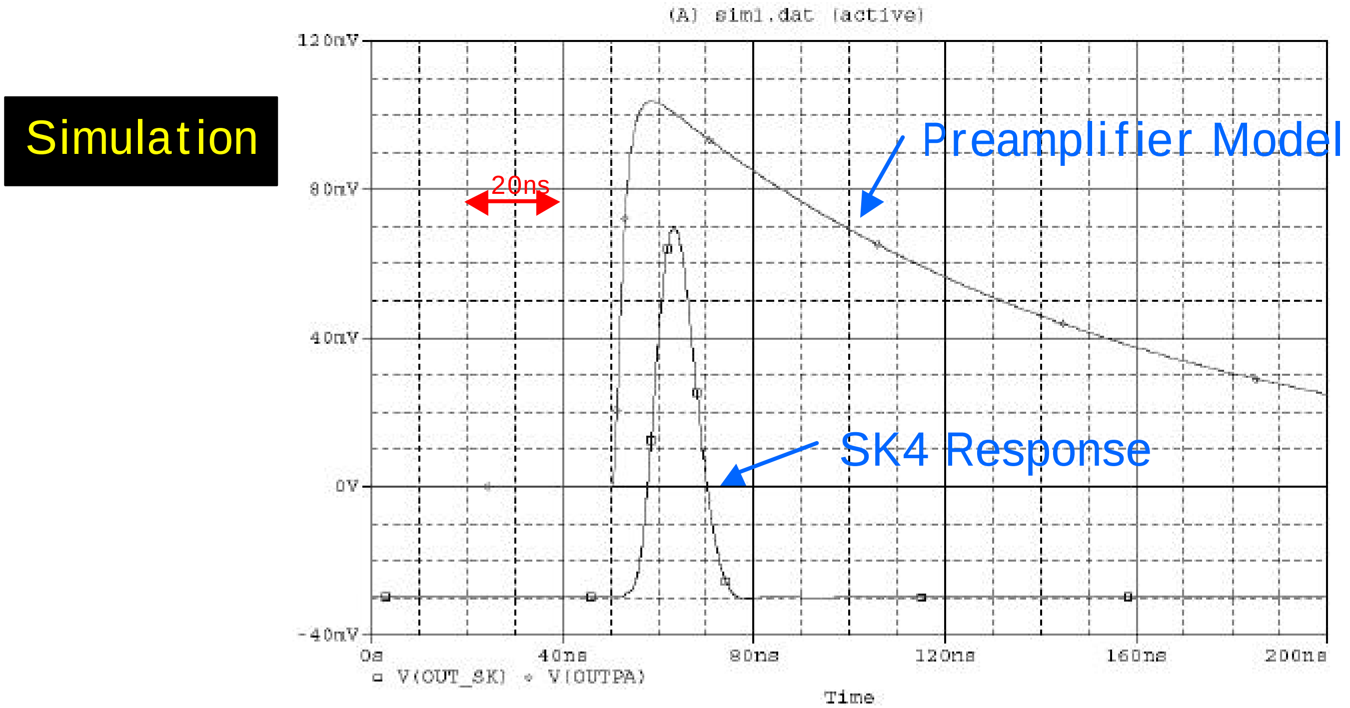
Pole-Zero Cancellation: Response to a burst (Cd=82pF)



Preamplifier + Pavia Shaper version2

PZ Cancellation:
Development of a new Shaper

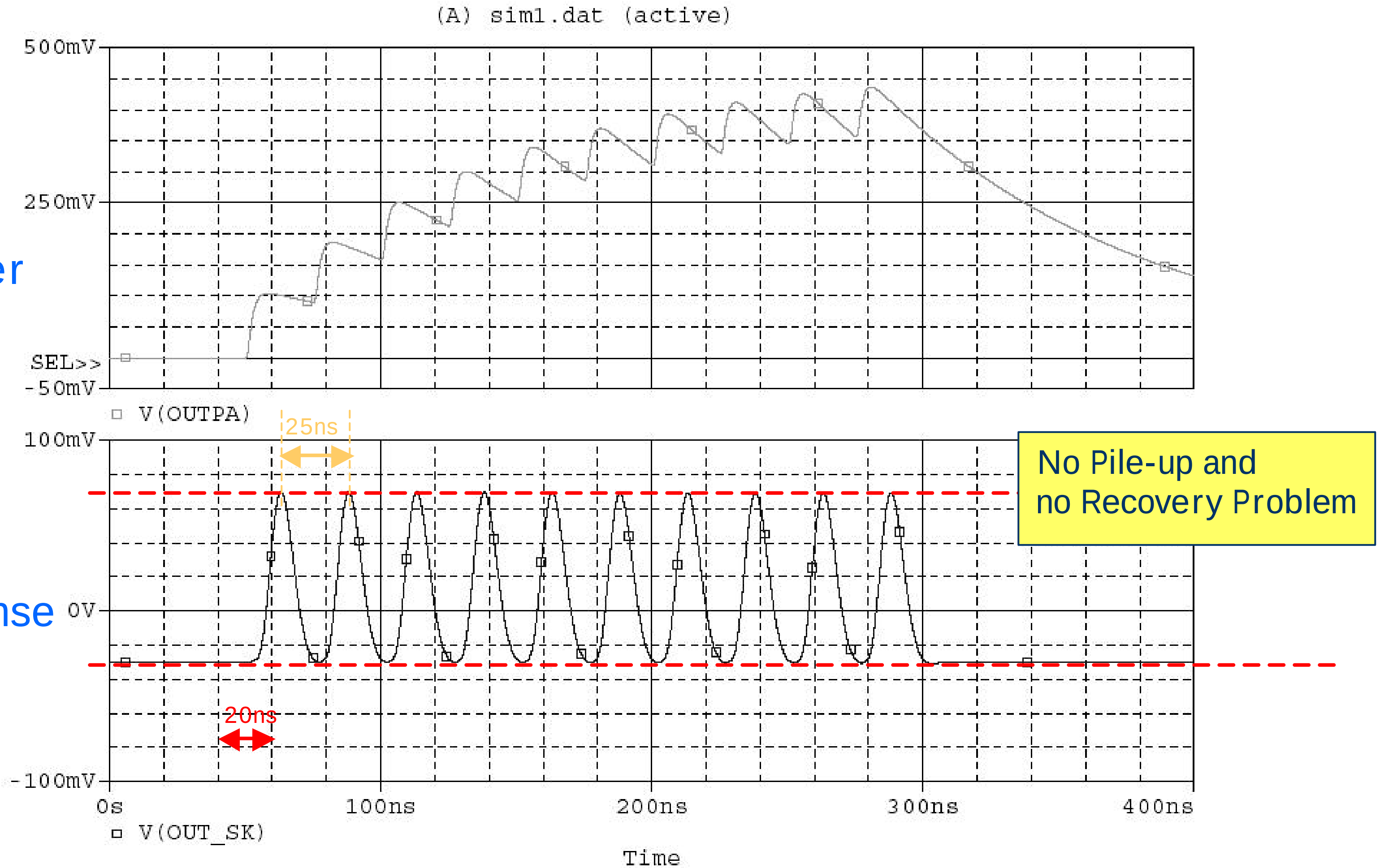
Classic pseudo-gaussian shaper with Peaking time of 8ns and PZ cancellation of the low-frequency pole of the preamplifier (feedback network).



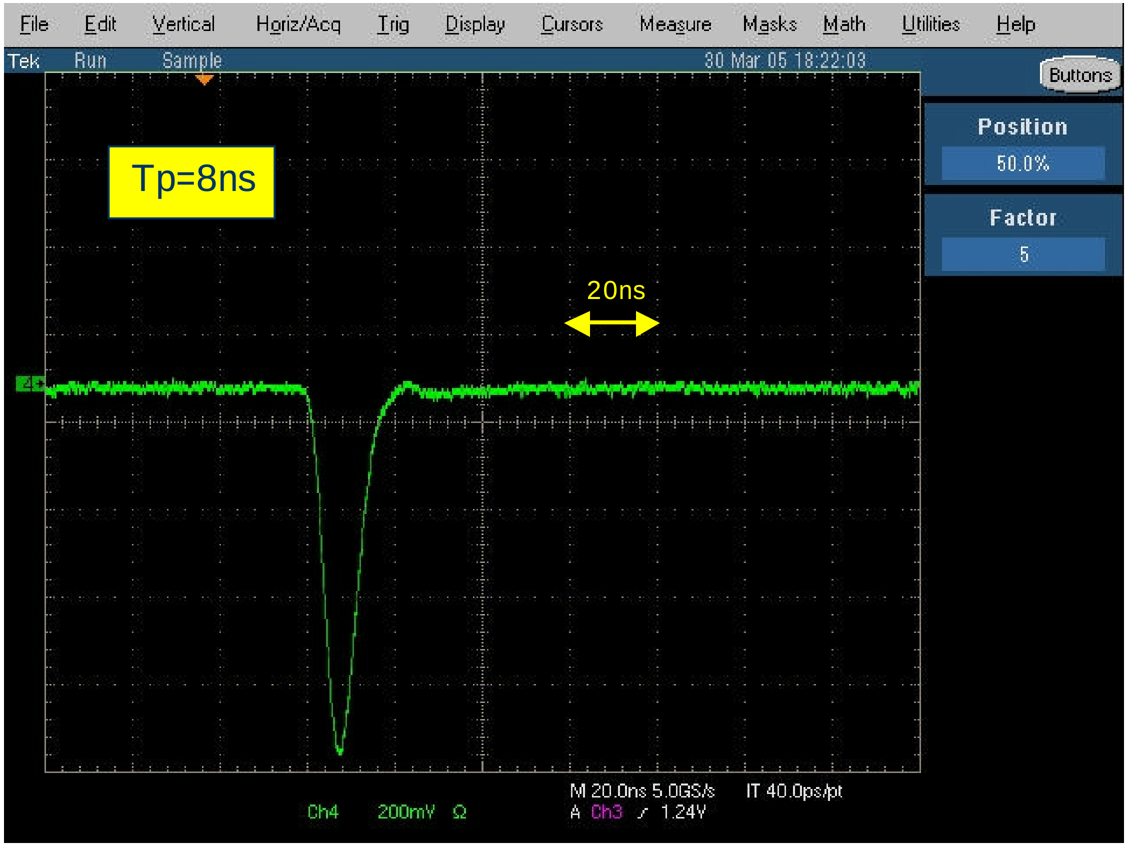
SK4: 40MHz Burst Response (simulated)

Preamplifier Model

SK4 Response With PZ adjusted

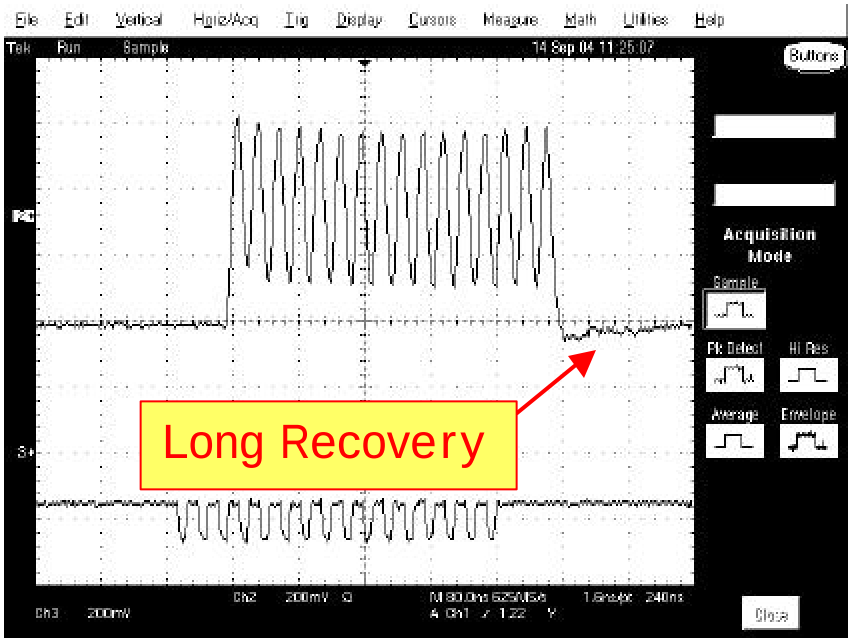


SK4 Shaper(*): Step Response (Measured)

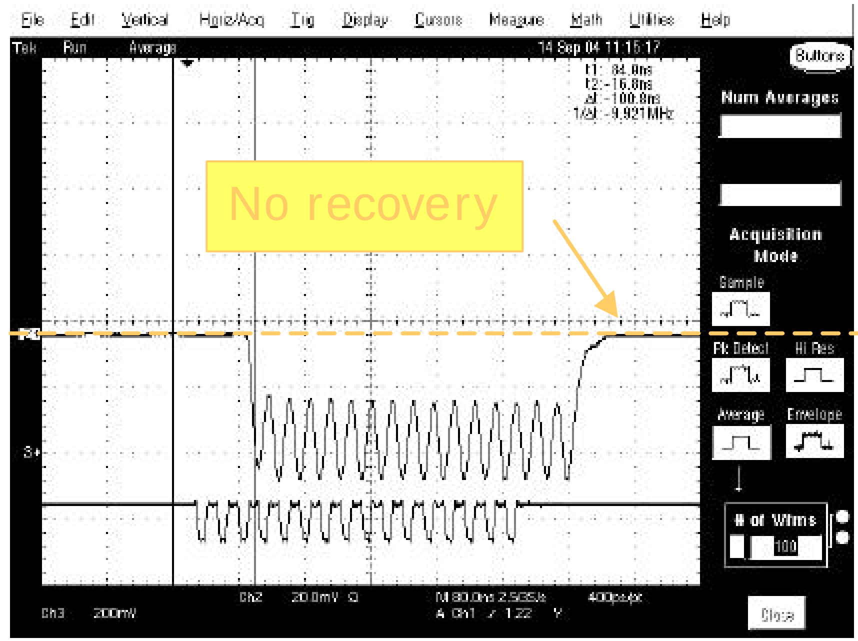


(*) In the board implementation, an inverting driver stage follows the shaping network (Gain and offset adjustment). The Amplifiers used in this are OPA695.

Pole-Zero Cancellation:
Response to a burst (Cd=82pF)



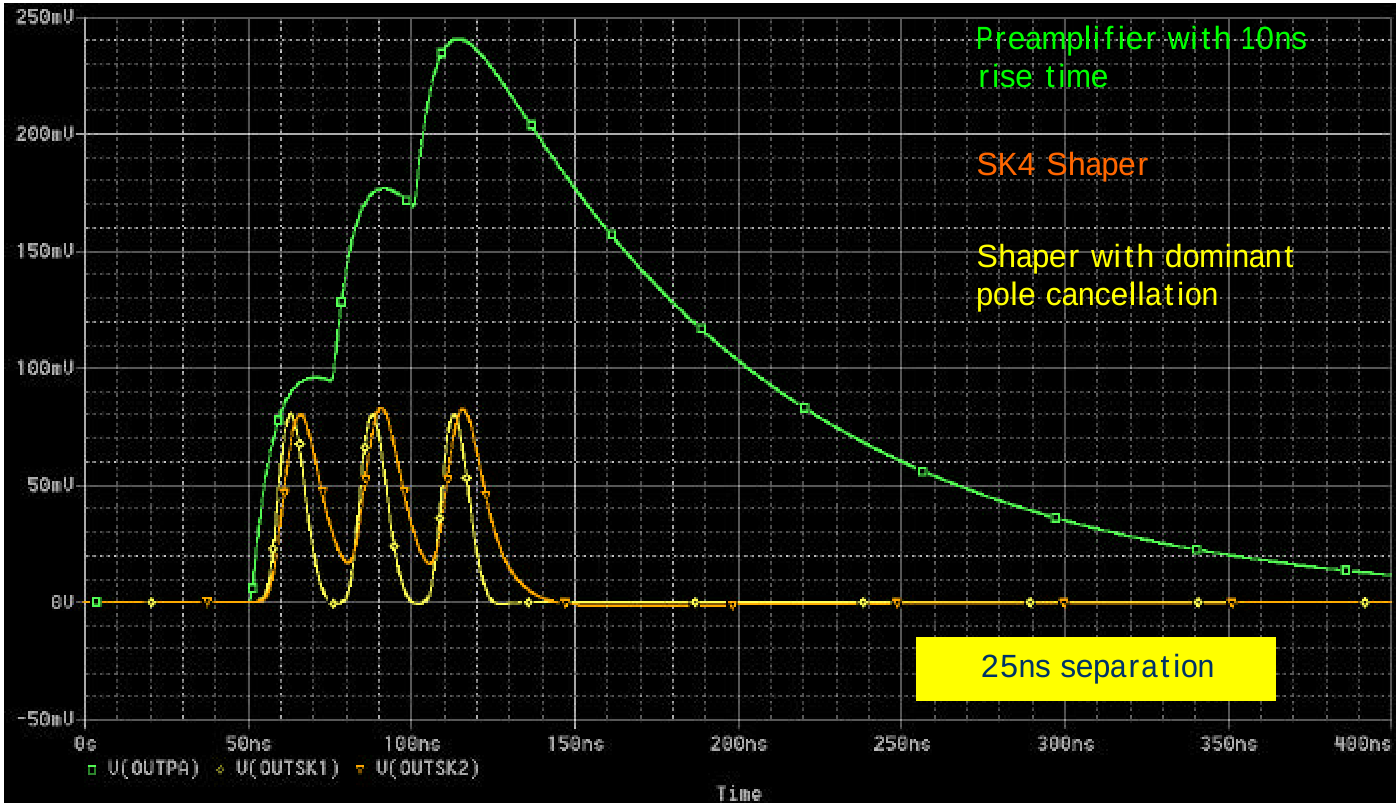
Preamplifier + Pavia Shaper version2



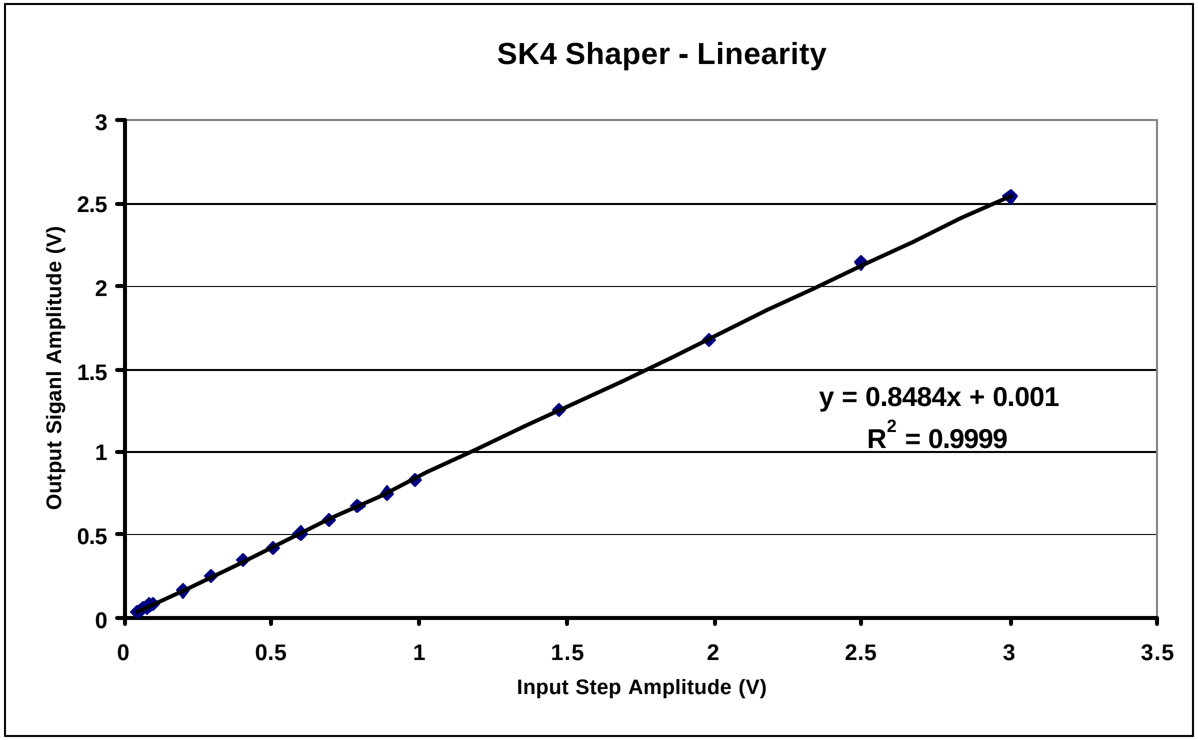
Preamplifier + SK4 Shaper

Pole-Zero Cancellation: Cancellation of the CDxRin Pole

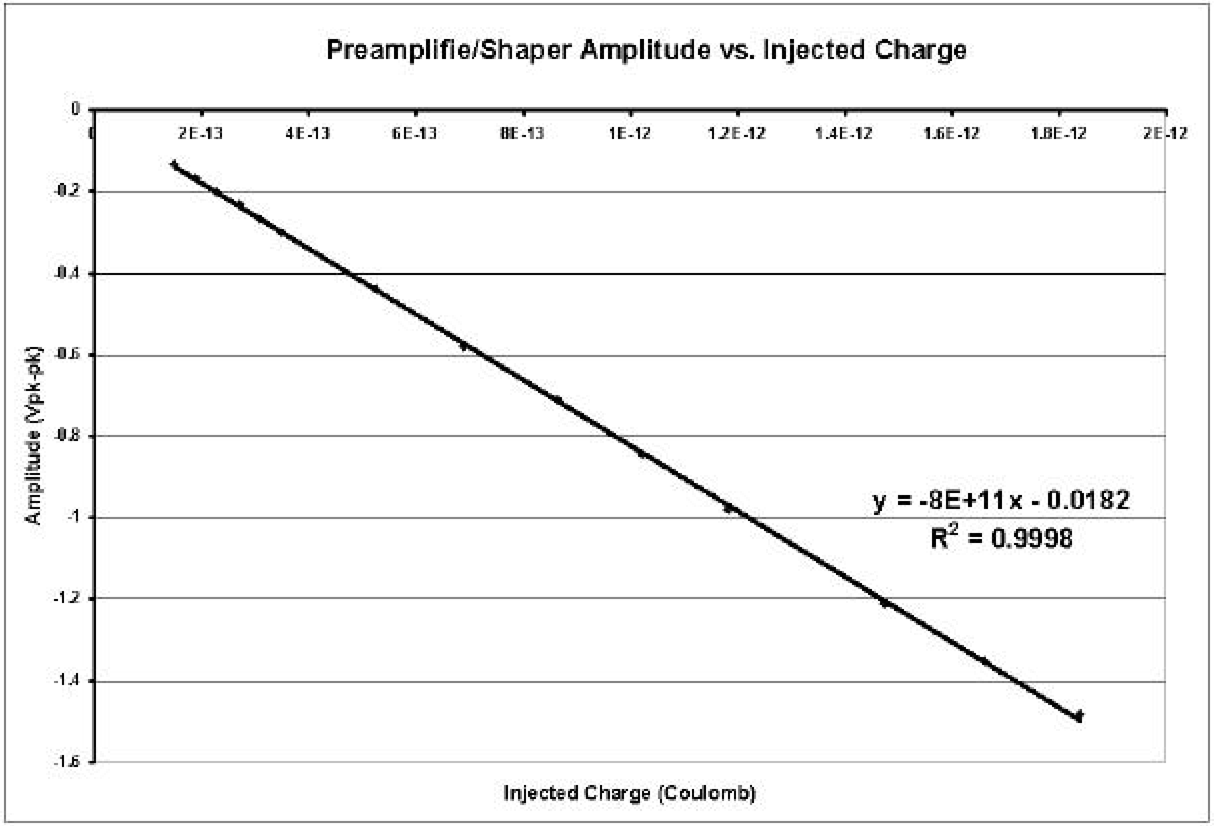
Study of shaper with the cancellation of the $C_D x R_{in}$ pole is underway.



SK4 Shaper Linearity



Preamplifier-SK4 Shaper Linearity



Front-End Electronics Summary

Preamplifier:

A non-proper termination produces a bump on the trailing edge of the amplifier, which in turn produces distortion on the tail of the signal of the shaper.

Shaper:

The SK4 shaper performs better in term of Pole Zero cancellation than the previous version

Study is underway to include one more differentiation stage to cancel the $C_D x R_{in}$ pole.

Front End Electronics Summary (2)

Preamplifier/Shaper:

The laboratory tests are conclusive regarding the performance.

Beam experiments have taught us that the PZ adjustment should be performed under the real experimental conditions.

This drives the decision to integrate the shaper with the DAQ board, away from the tunnel.

Front-End Electronics
Current and Future Work

Complete the characterization of the electronics with the new shapers and with the chamber at the ALS.

Preamplifier:

- Separation of the Preamplifier and the Shaper – Test and Evaluation of performance
- Redesign of biasing network on the board to conform with the cabling available at CERN.

Shaper:

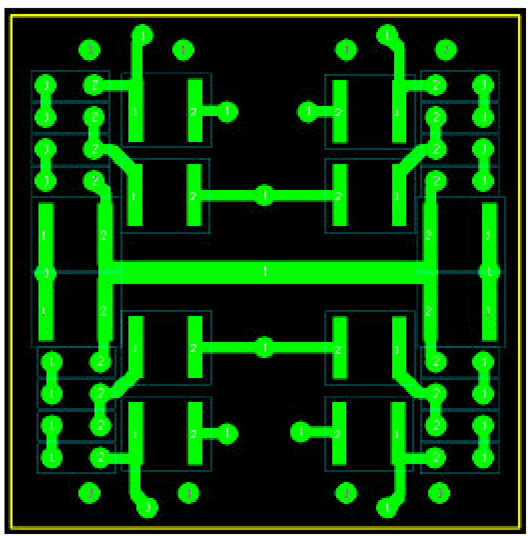
- SK4 shaper:
  - Complete Characterization with preamplifier with beam signal
- Cancellation of the dominant pole:
  - Complete study and simulations
  - Build and test prototype.

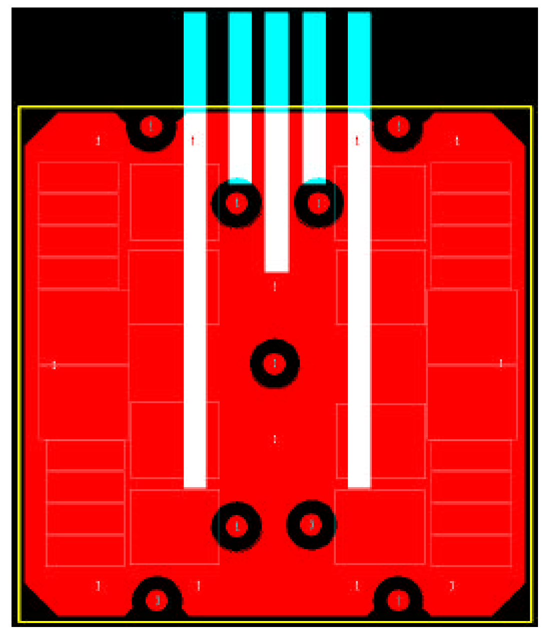
Front-End Electronics
Current and Future Work (2)

High Voltage Distribution Board:

Work is underway to finalize the design of the DC distribution board in the chamber (described later). A new layout to:

- Allow better connections of the stiff rad-hard cables
- Add a resistor in series with the Ground connection of the SHV to provide isolation.



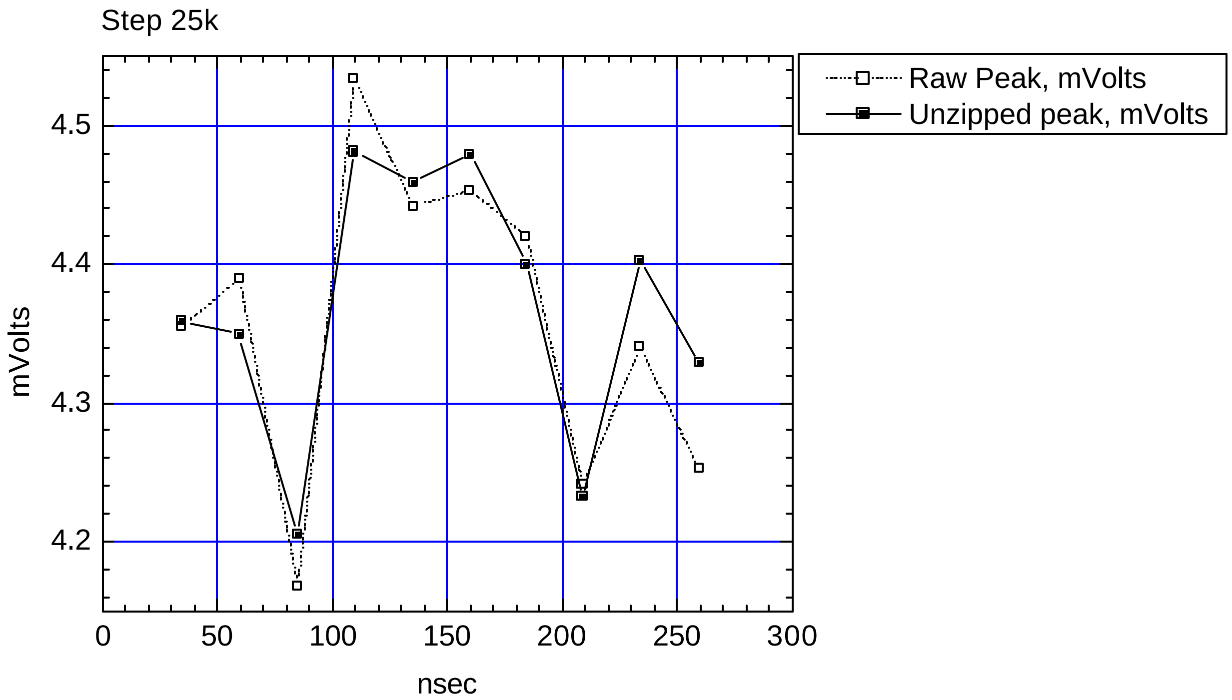


Deconvolution Studies

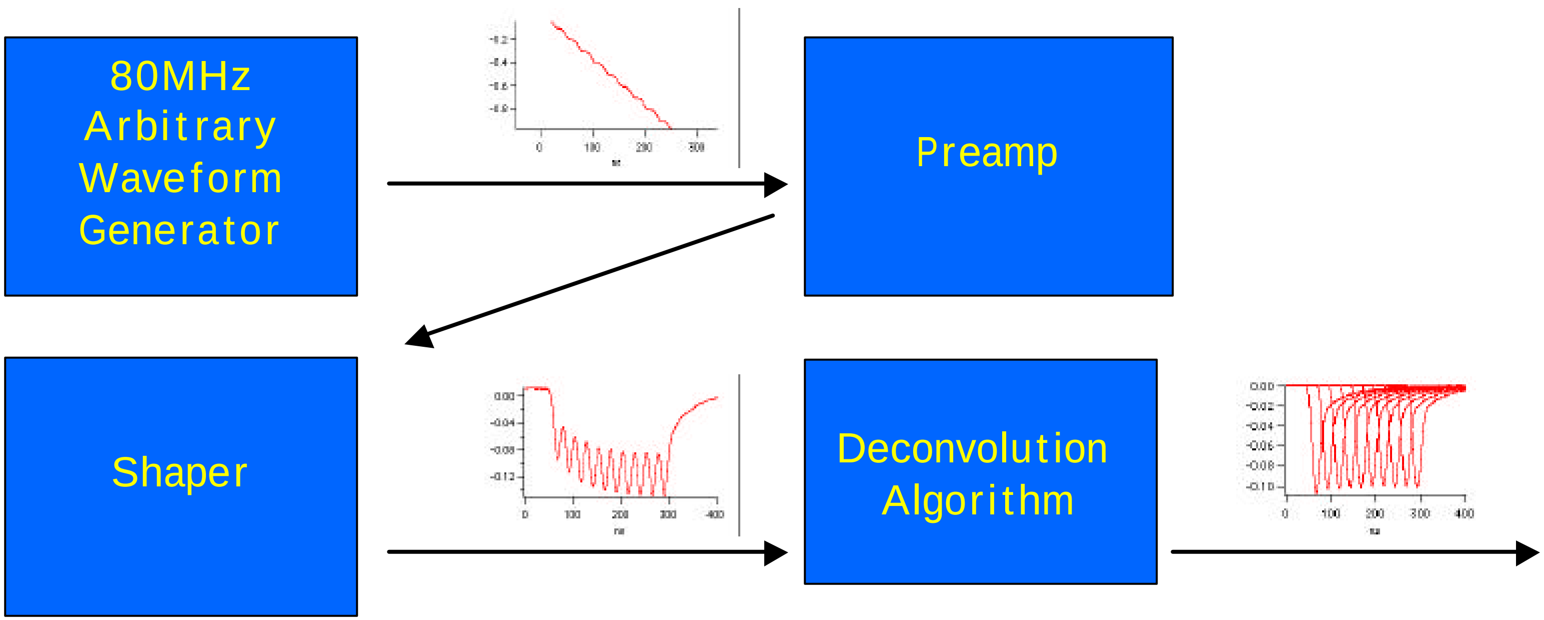
Work in progress

Described in detail at the upcoming review

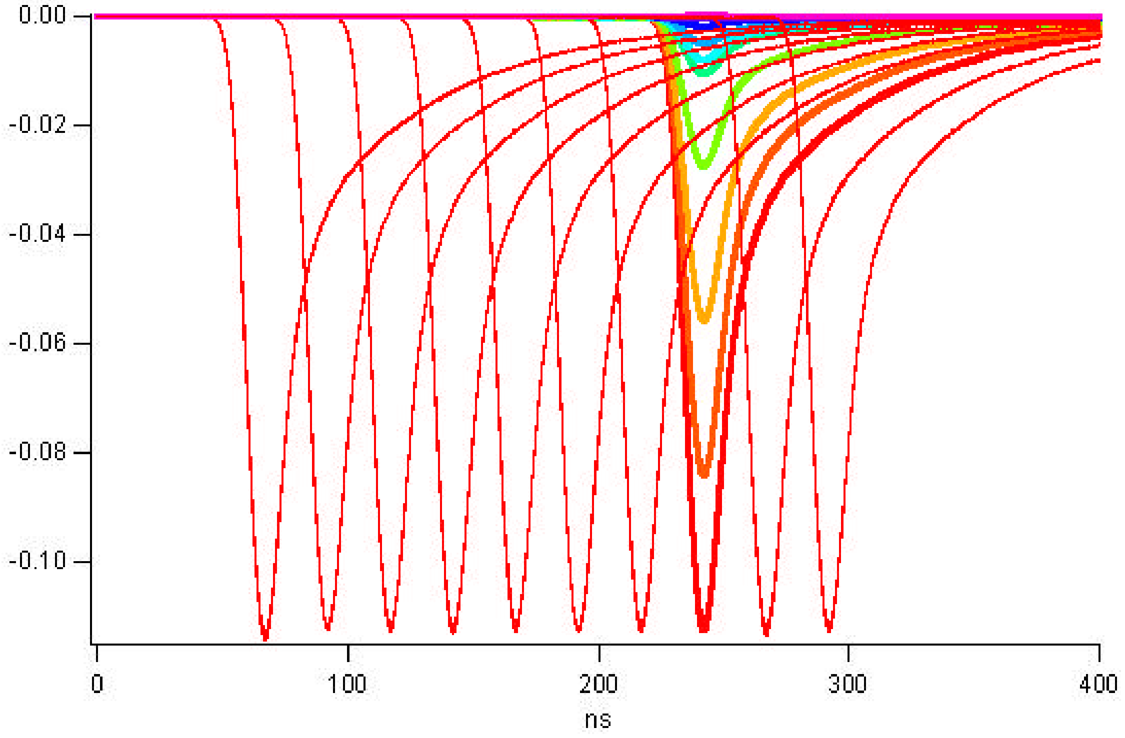
Encouraging early results



Test Setup


80MHz Arbitrary Waveform Generator
Preamp
Shaper
Deconvolution Algorithm

Reconstructed waveforms

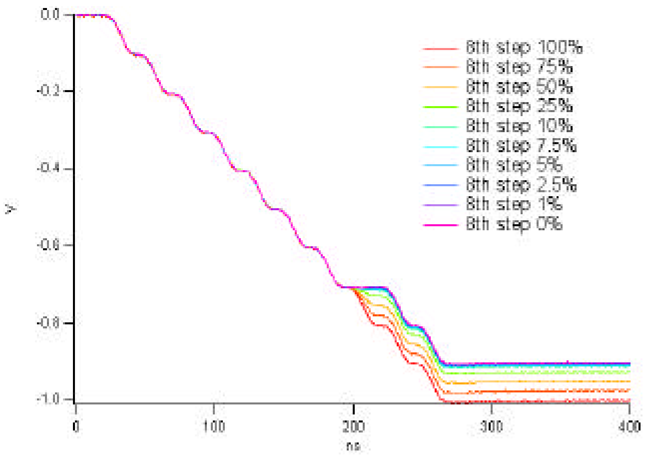


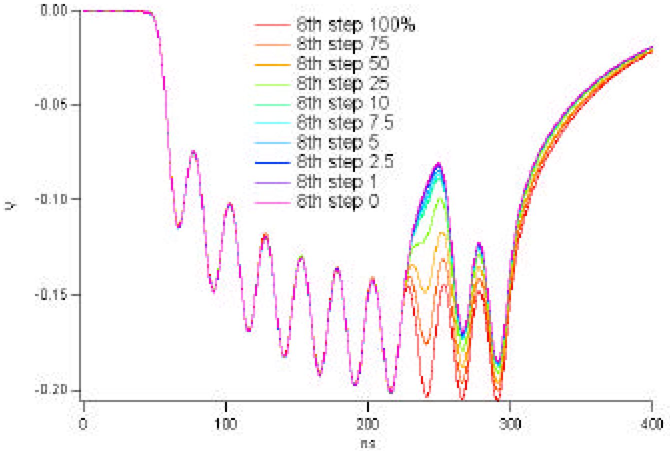
Testing Methodology

Vary the height of one of the steps produced by the waveform generator.

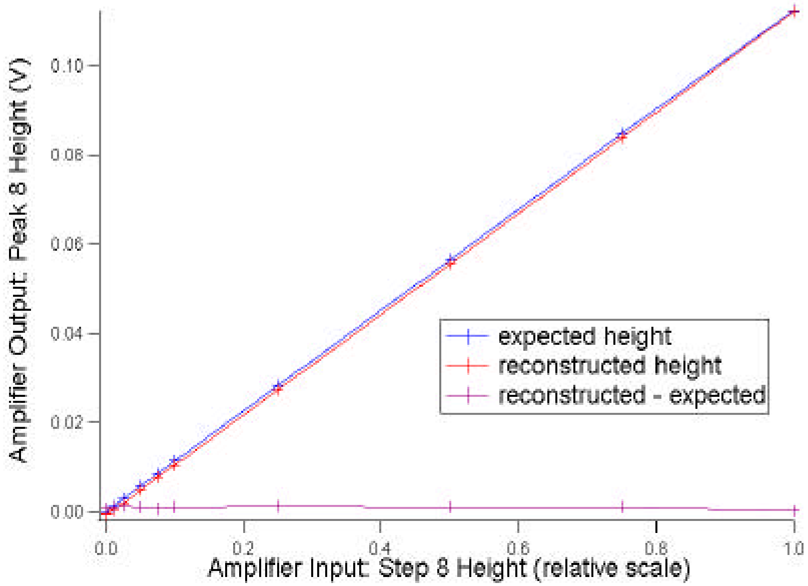
This varies the true height of the resulting pulse in proportion to the height of the step.

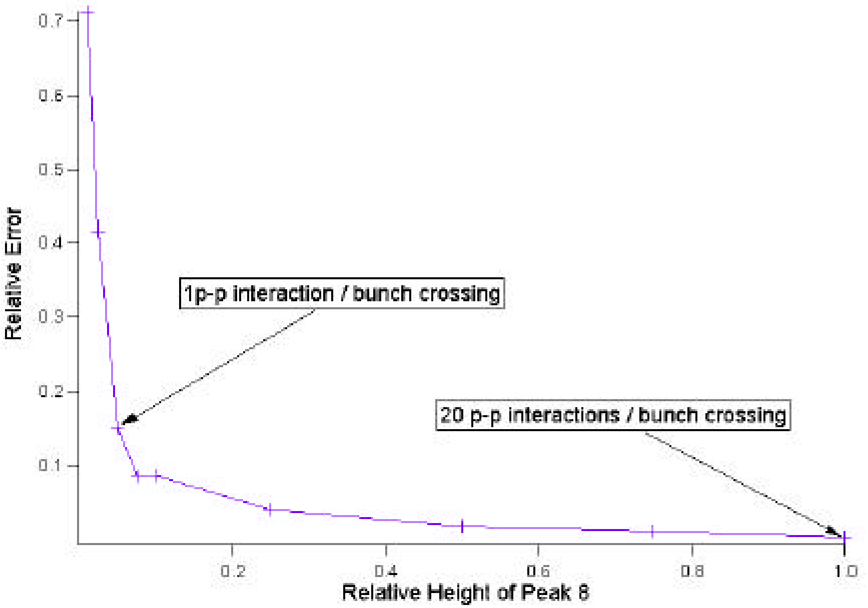
Given the "piled-up" waveform, what is the Dynamic Range over which the algorithm can accurately reproduce the height?





Deconvolution Errors





The current method uses the arbitrary waveform generator to the limits of its capabilities.

The alternative solution is to use a true deconvolution algorithm using Fourier transform.

2. Packaging and hardware design

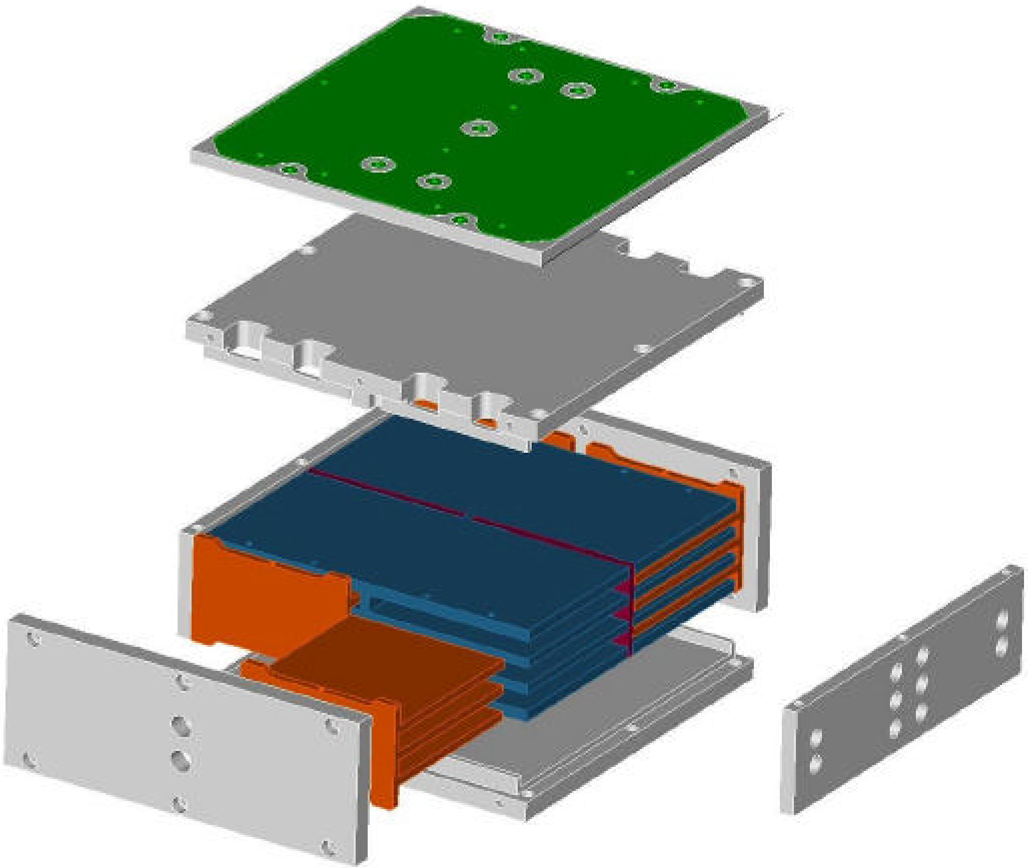
Mechanical package is being finalized

One major weaknesses of the existing prototype is the power distribution network,

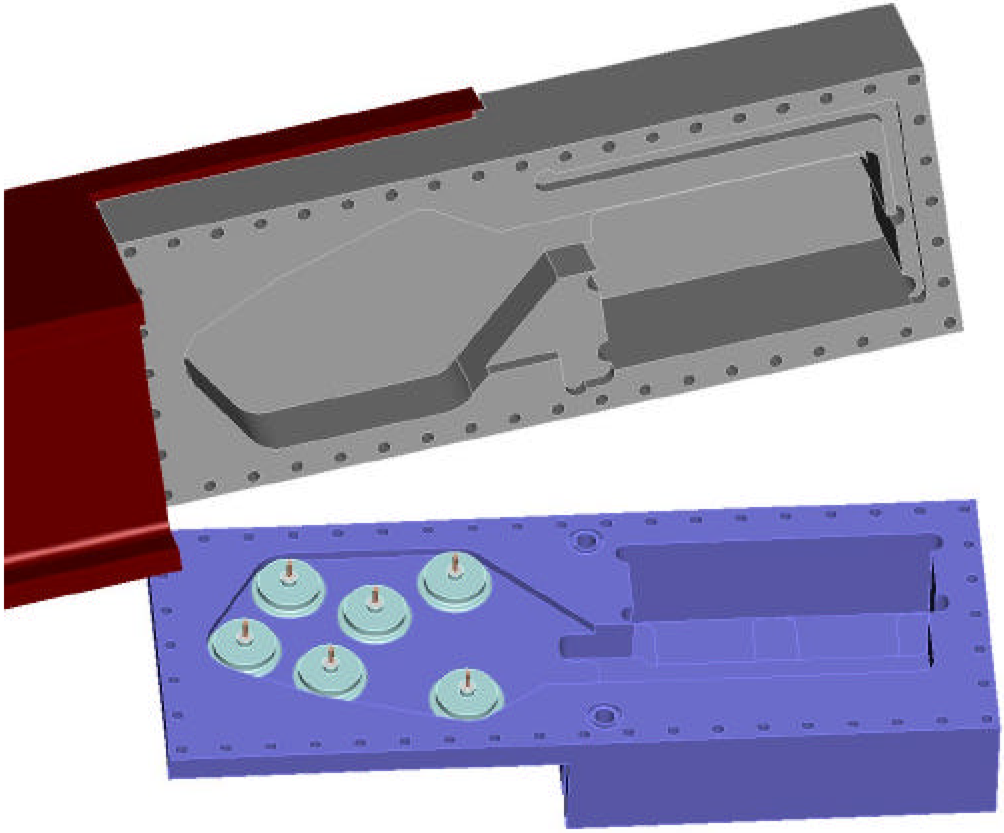
- Now being replaced by a ceramic PC board
- Components installed towards the inside (ceramic)
- Cables will run on the outside (chamber wall)

Also addressing many minor nuisances of the fabrication and assembly process

Chamber Exploded View



Chamber assembly



3. The saga of the 40 MHz test

- Started looking at FNAL booster
  - Not feasible for beam dump limitations and beam availability
- Beam Scraping at ALS
  - Source was not controllable, so the test was simple, but gave only qualitative (good) results
- Jlab FEL setup
  - suitable bunch pattern, but the background was too high
    - Complicated experimental setup
- Can test at an ALS beamline using 20 keV x-rays
  - Feasibility study by JB

Test at ALS beamline

Use an x-ray beamline (20 keV), we can expose one quadrant to very well controlled beam

Needs a thin wall chamber, running at 1 ATM pressure

Run the ALS at 40 MHz (actually 39 or 41MHz) in a dedicated machine physics run

Feasibility study completed by JB, results due at the review next week

Making arrangements to have this approved as an experiment

4. Rad Hardness tests

As we were struggling to figure out a meaningful test of the materials, we contacted Brian Wirth, professor of nuclear engineering at the UC Berkeley, specializing in modeling of materials radiation damage

The outcome is that there is little value added by making a test.

Test conditions are drastically different from LHC conditions
- Shower vs. neutrons
- Flux strength

A failure would not necessarily imply failure in the LHC and vice versa - Only exception is if the device fails right away.

Interested in a collaboration modeling the problem - to be defined

LUMI Long Term Plans

- FY04 - done
  - Continue performance tests
    - Complete 40 MHz test and optimization - Beam test still under development!
  - 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 - test at FNAL/RHIC?
  - Radiation damage assessment
- FY06
  - Fabrication of 4-8 units + spares - Total quantity TBD - First unit in FY06
  - Fabrication of auxiliary hardware (install and remove gear)
  - 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

FY05 Activities

LUMI

- Electronics
  - Bench tests of hi rep rate response
  - Beam test at BTS test to validate single pulse response
  - High rep rate beam test (if available)
  - Finalize FE electronics design
  - Design FE electronics integration in the tunnel
  - Continue integration with CERN (TRIUMF) DAQ
- Mechanical
  - Design of deliverable system + TAN integration
- Radiation hardness test - see above
- Design review to be scheduled - Apr 11, 2005
- Complete system integration document

Blue - from previous meeting

Red - update/comment

Plans for FY06

Build and deliver one complete unit to CERN in Spring of 2006 as requested by CERN. This includes:

- a chamber, mating TAN bar, gas handling system, tunnel electronics package, installation and integration support at CERN

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

Budget Summary

Cost guidelines from FY04 task sheets

Device/FY In FY04 $1,000s	04	05/act	06	07
LUMI	203	450/395	950	811

These numbers are pending LUMI review on April 11.

Will be finalized shortly after that, as requested

Conclusions

We 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

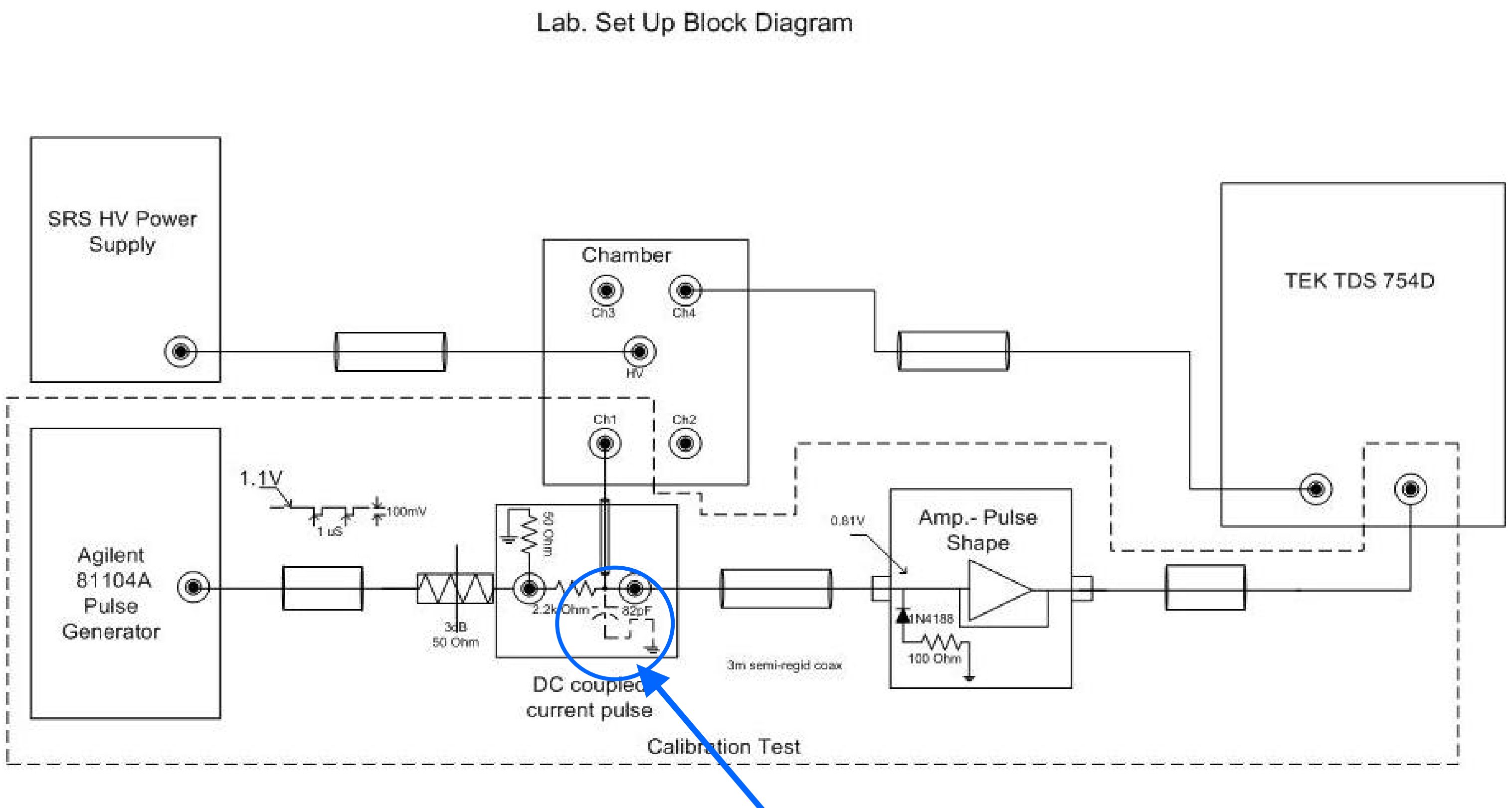
Budget from 2002 LARP meeting

Activity	Year	FY03	FY04	FY05	FY06	FY07	FY08	Total
Luminosity monitor	FTEs	1.09	1.12	2.10	6.04	4.86	4.32	19.53
LBNL	Labor	156.2	159.9	321.3	806.3	592.9	524.8	2561.4
	Matls	83.0	43.3	199.7	687.9	218.8	41.6	1274.3
	Total	239.2	203.1	521.0	1494.3	811.6	566.4	3835.6
Longitudinal profile meas.	FTEs	0.43	0.25	0.80	3.59	5.04	4.11	14.22
LBNL	Labor	65.1	30.0	122.8	434.7	579.8	457.2	1689.5
	Matls	0.0	33.9	0.0	262.0	659.6	72.0	1027.6
	Total	65.1	63.9	122.8	696.7	1239.4	529.2	2717.0
Bunch by bunch closed orbit	FTEs	0.00	0.00	0.00	0.00	0.25	0.50	0.75
LBNL	Labor	0.0	0.0	0.0	0.0	62.5	125.0	187.5
	Matls	0.0	0.0	0.0	0.0	6.0	12.0	18.0
	Total	0.0	0.0	0.0	0.0	68.5	137.0	205.5
Phase locked loops	FTEs	0.30	0.30	0.30	0.30	0.30	0.00	1.50
BNL	Labor	78.0	78.0	78.0	78.0	78.0	0.0	390.0
	Matls	20.0	20.0	20.0	20.0	20.0	0.0	100.0
	Total	98.0	98.0	98.0	98.0	98.0	0.0	490.0
Electron lens	FTEs	0.00	0.00	0.00	0.00	0.25	0.50	0.75
FANL	Labor	0.0	0.0	0.0	0.0	62.5	125.0	187.5
	Matls	0.0	0.0	0.0	0.0	6.0	12.0	18.0
	Total	0.0	0.0	0.0	0.0	68.5	137.0	205.5
Feedback systems	FTEs	0.00	0.00	0.00	0.00	0.25	0.50	0.75
FNAL	Labor	0.0	0.0	0.0	0.0	62.5	125.0	187.5
	Matls	0.0	0.0	0.0	0.0	6.0	12.0	18.0
	Total	0.0	0.0	0.0	0.0	68.5	137.0	205.5
Total	FTEs	1.82	1.66	3.20	9.93	10.95	9.92	37.50
	Labor	299.3	267.8	522.1	1319.0	1438.2	1357.0	5203.4
	Matls	103.0	97.2	219.7	970.0	916.3	149.6	2455.8
	Total	402.2	365.0	741.8	2289.0	2354.5	1506.6	7659.2

Budget from 2003 Lehman review

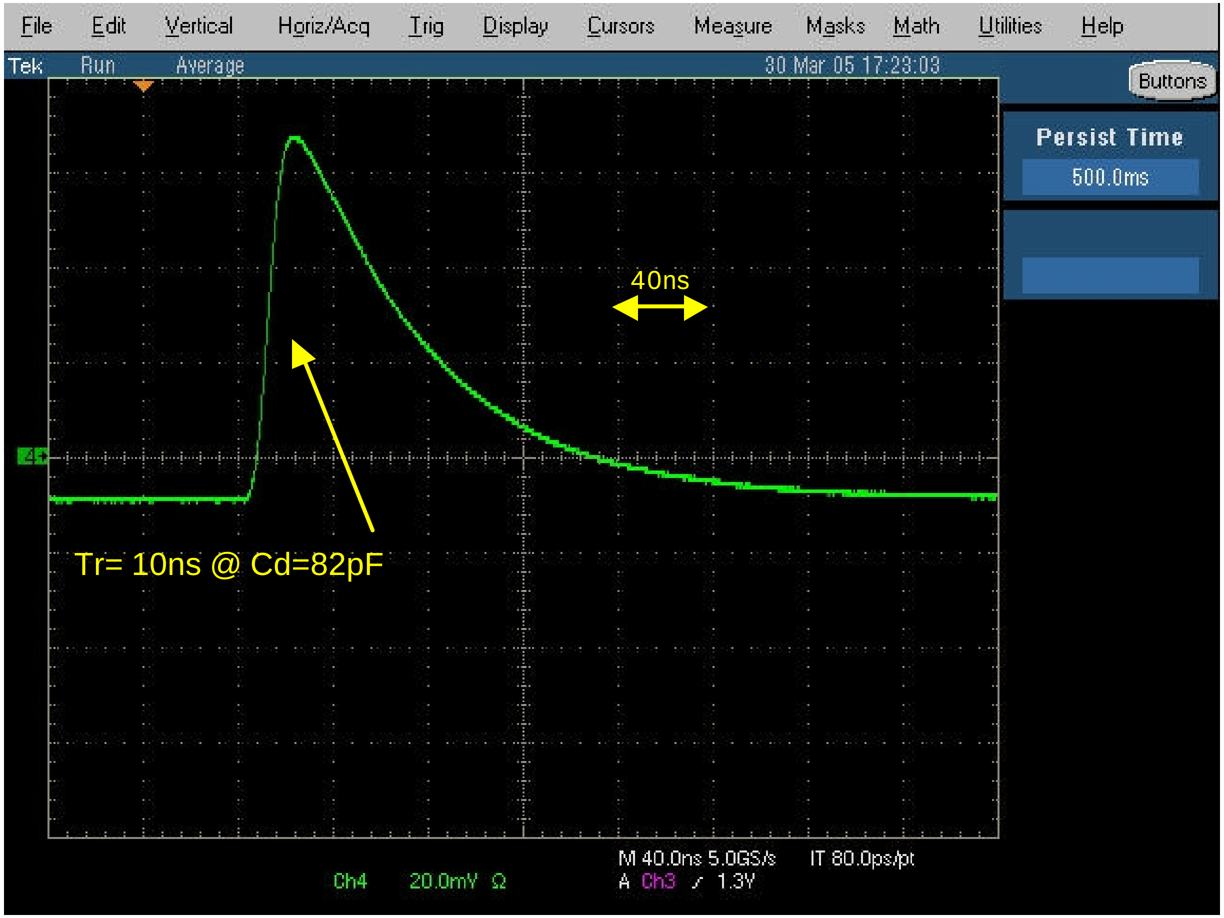
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Preamplifier + SK4 Shaper: Laboratory Setup

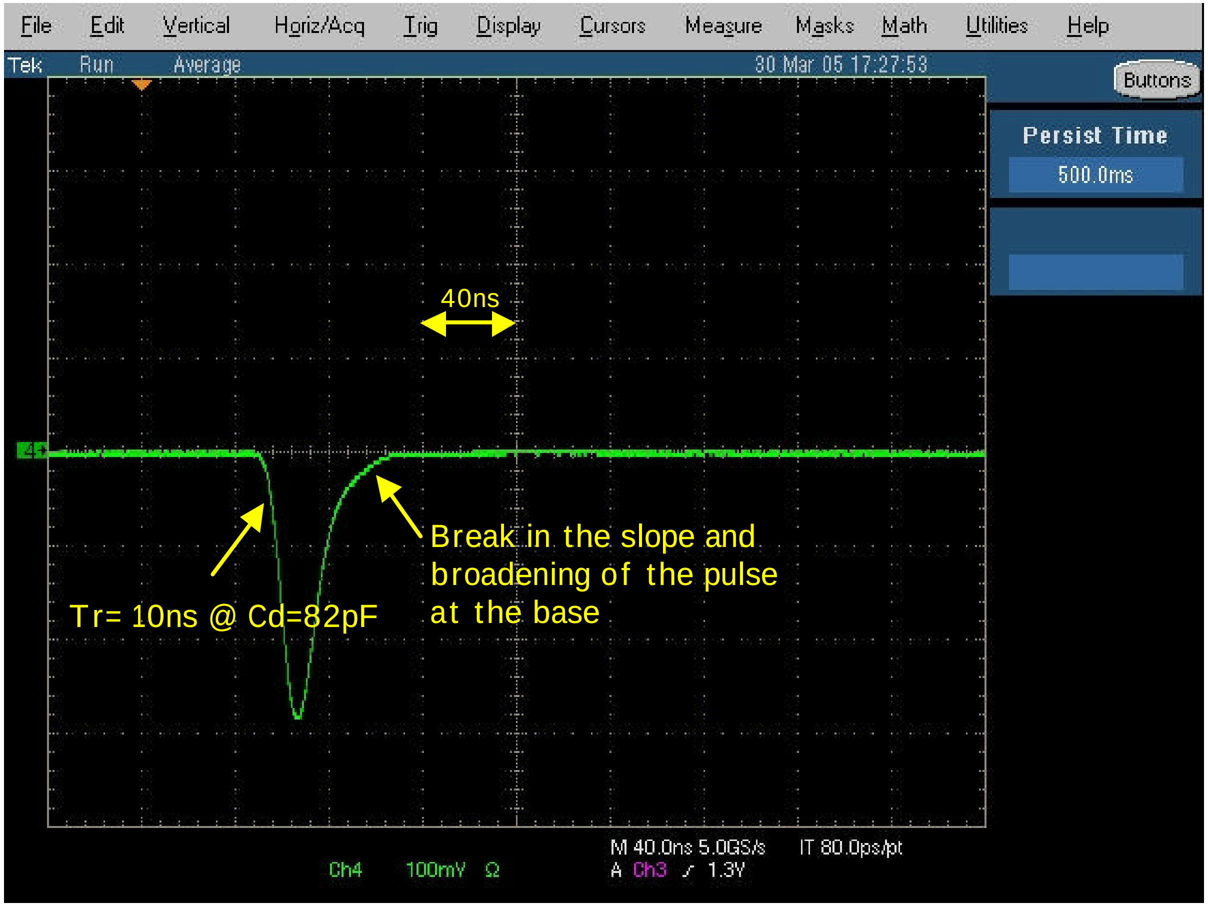


C_D = 82pF (Equivalent to Chamber)

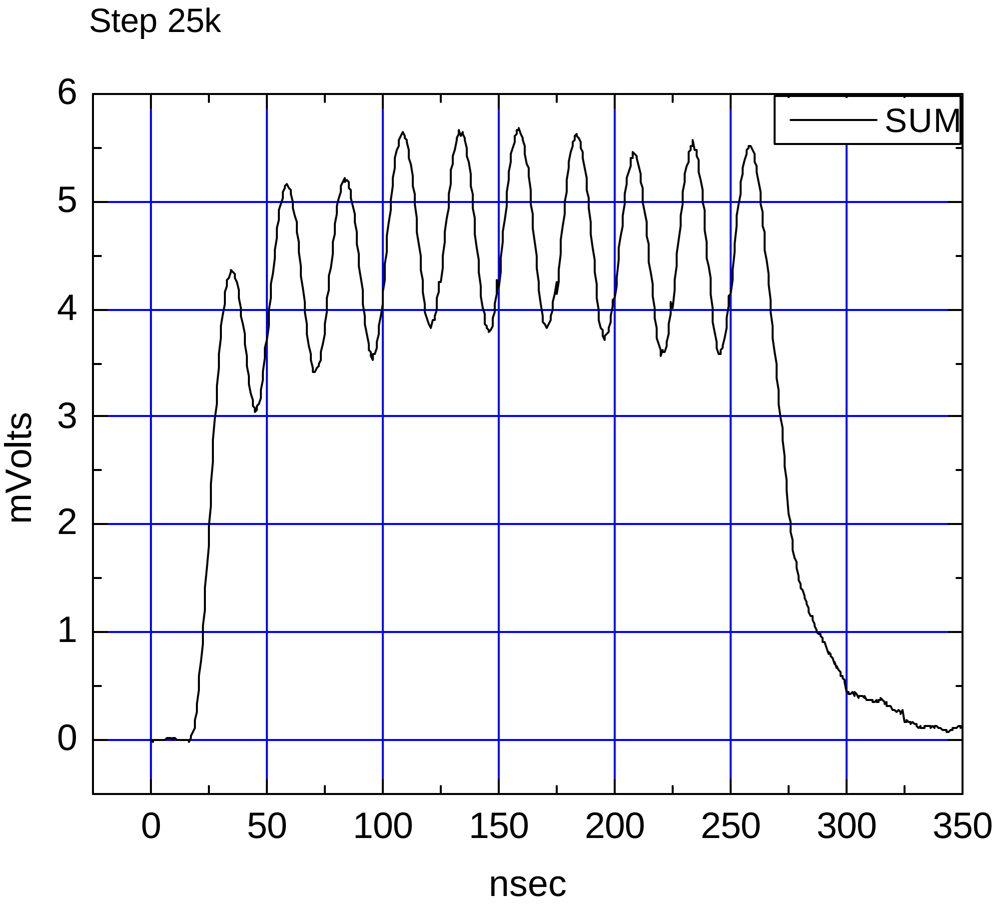
Preamplifier Signal with Cd=82pF (Avg=32)



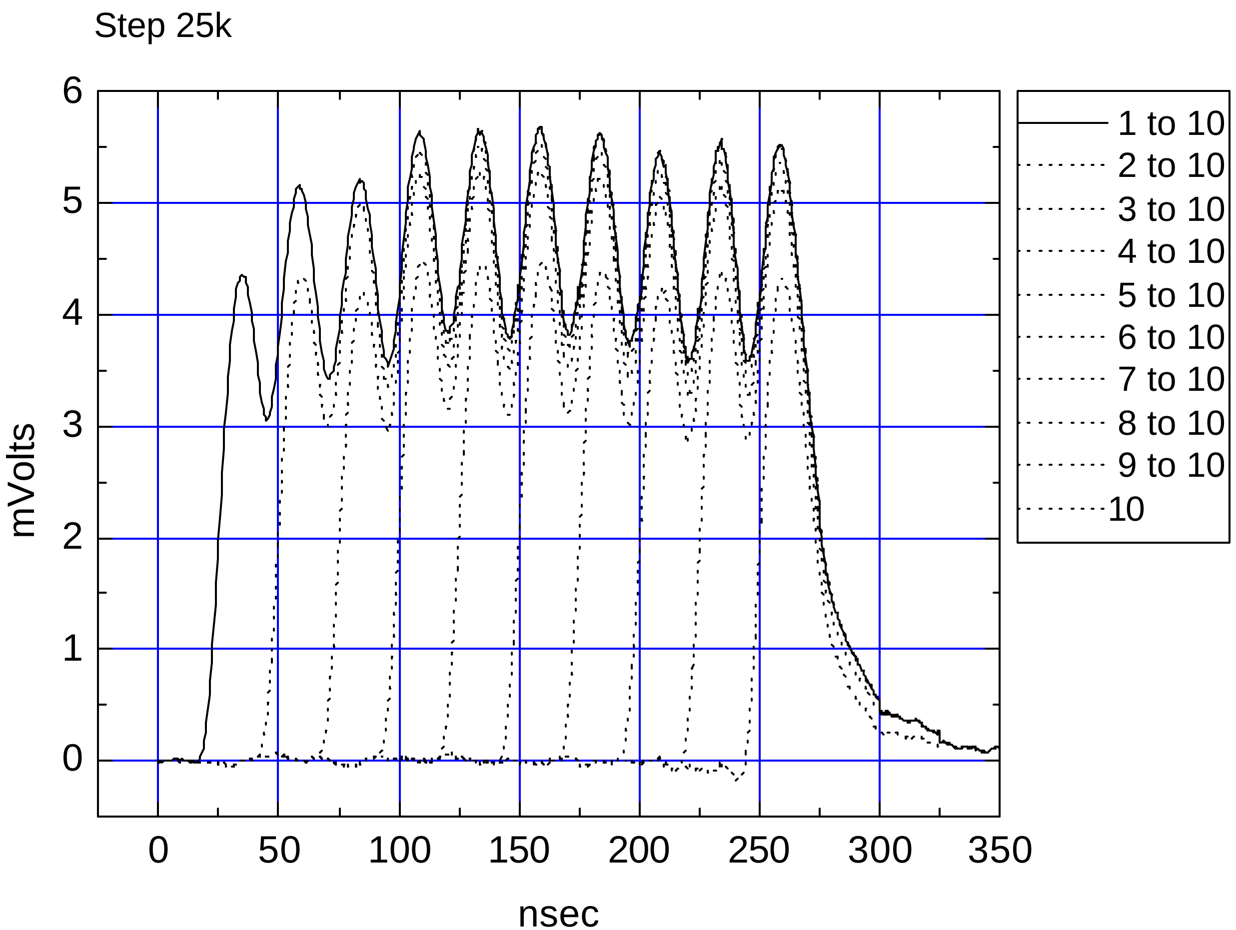
Preamplifier + SK4 Shaper with Cd = 82pF (Avg=32)



Ten pulse summation, pulses successively delayed by 25ns



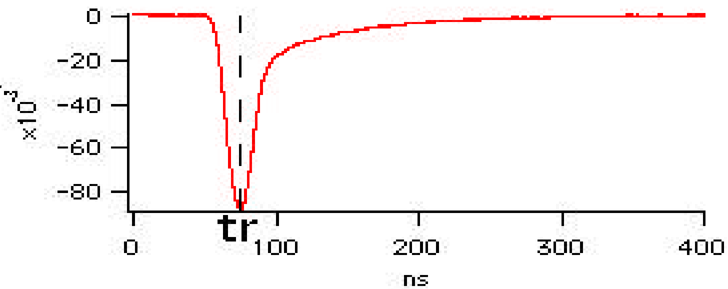
Successively fit and subtract the leading pulse



Deconvolution Algorithm Input

R(t), the response to a single pulse

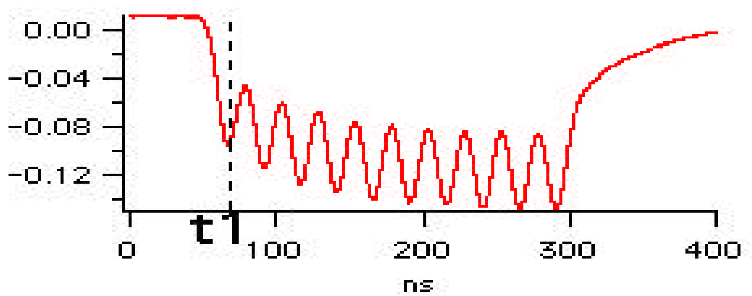
P(t), “Piled-up” pulse train r



t_r, time of peak in R(t)

t_1, time of 1st peak in

?t, true time between



Deconvolution Algorithm

Shift reference waveform by t_1 - t_r.

Lines up reference peak with 1st "piled-up" peak

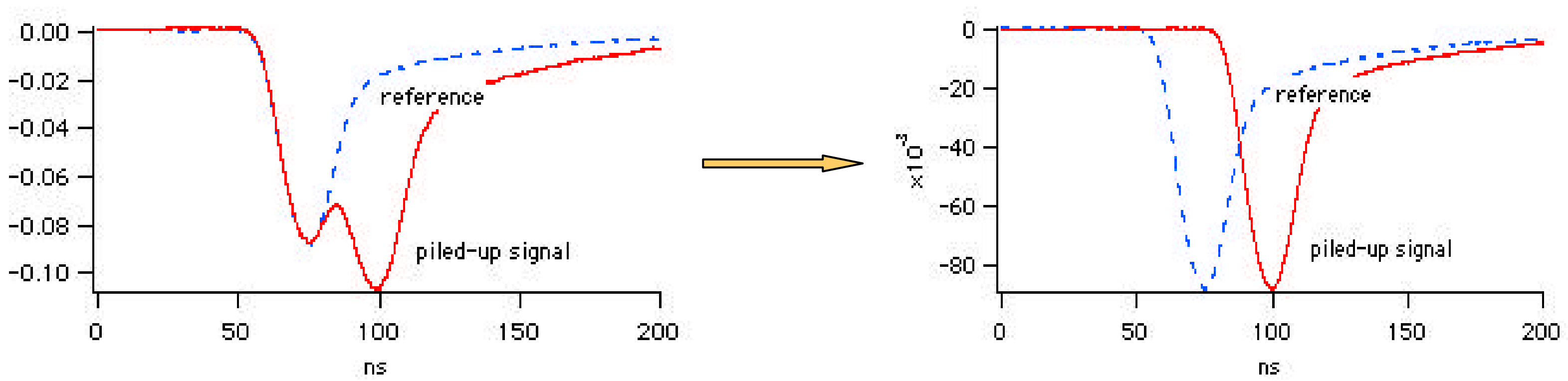
P(t_1) is the true height of the 1st remaining pulse.

Record P(t_1) for output

Subtract (R(t) * P(t_1) / R(t_1)) from P(t)

S

If



Synchronous overlay of ten 2.4k event waveforms and the 24k mean waveform