Feedback on Nanosecond Timescales (FONT): FONT2 December 2003 run results

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- People
- FONT1 (2002)
- FONT2 (2003/4)
- Future FONT plans

FONT Group

- **Queen Mary:**

  Philip Burrows (faculty), Glen White (RA), Tony Hartin (prog.)
  Stephen Molloy, Shah Hussain (grad. students)

- **Daresbury Laboratory:**

  Alexander Kalinine, Roy Barlow (elec. eng.), Mike Dufau (des.)

  Susan Smith, Rob Smith, Mike Dykes, Mike Poole

- **Oxford:**

  Colin Perry (elec. eng.) + technicians

  Gerald Myatt (retd. faculty) Simon Jolly, Gavin Nesom (grad students emeritii)

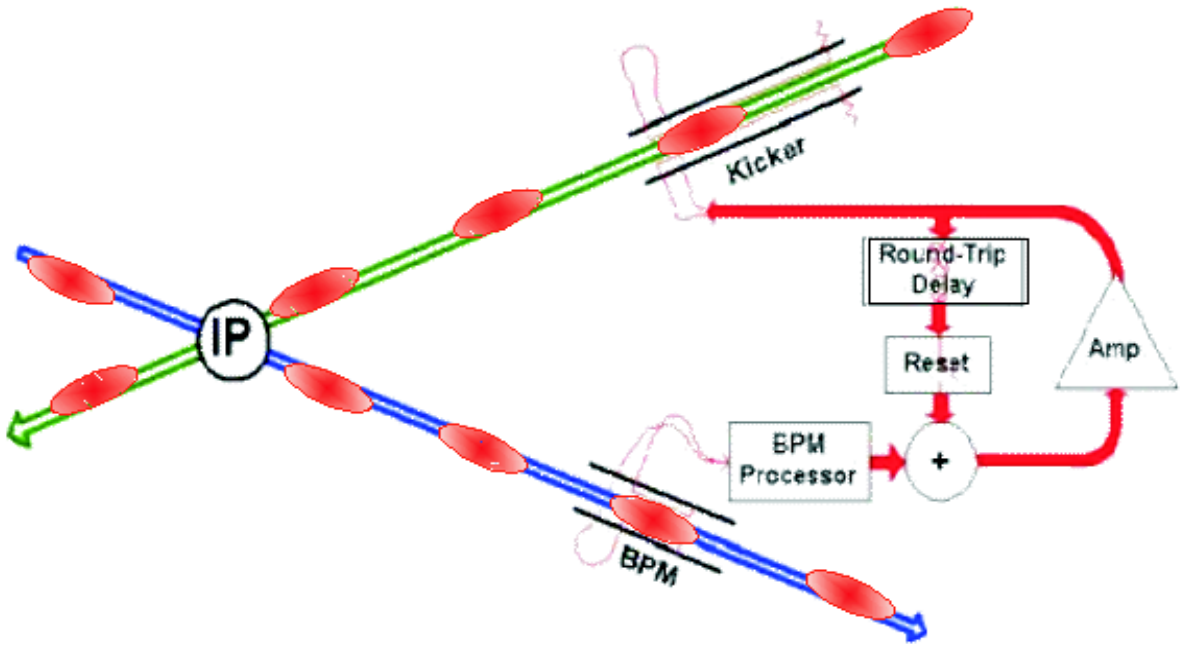
- **SLAC:**

  Joe Frisch, Tom Markiewicz, Marc Ross

  Chris Adolphsen, Keith Jobe, Doug McCormick, Janice Nelson, Tonee Smith, Mark Woodley + technical support

Beam-based Feedback (FONT)

Intra-train beam feedback is last line of defence against ground motion



Key components:

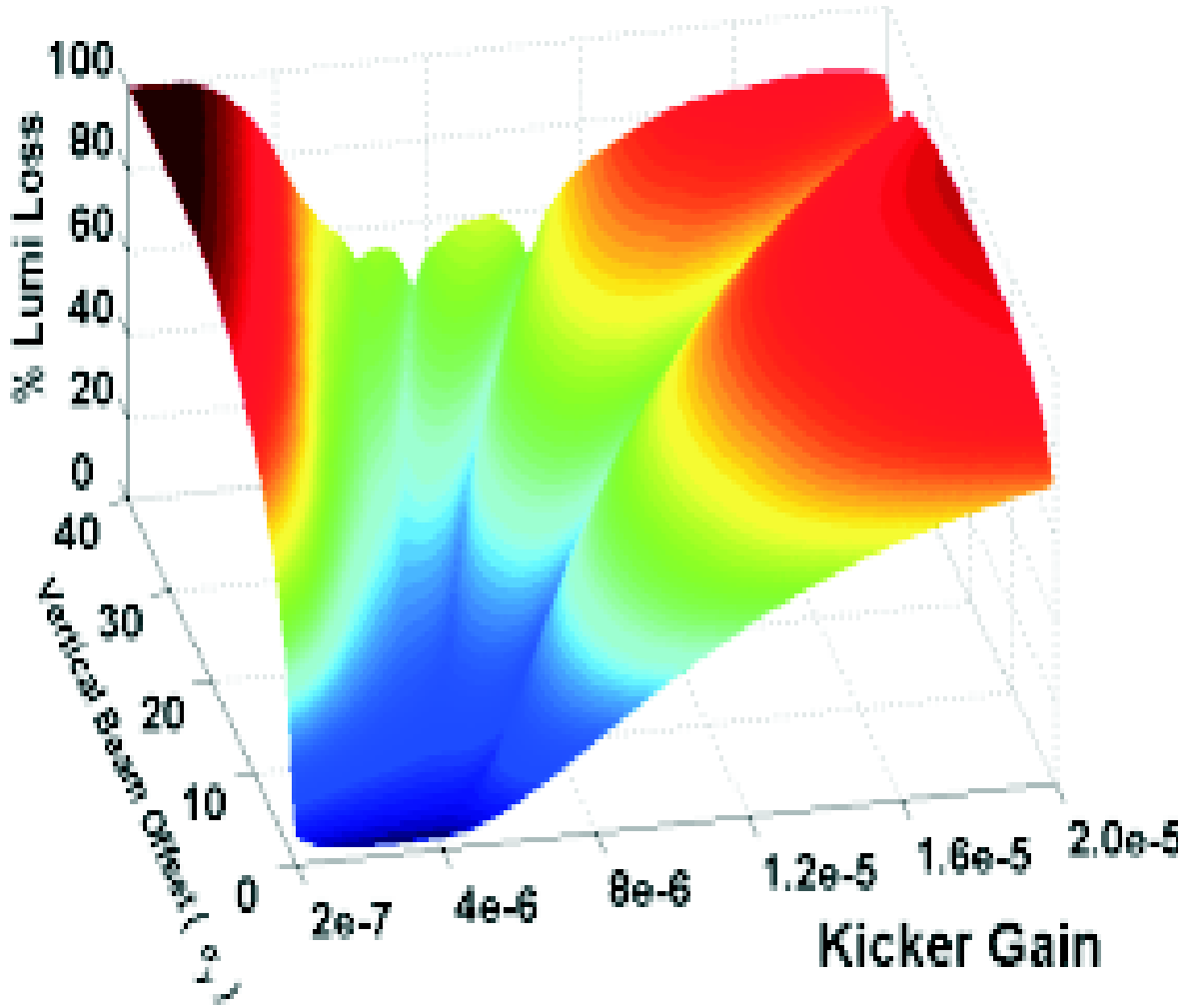
- **Beam position monitor (BPM)**
- **Signal processor**
- **Fast driver amplifier**
- **E.M. kicker**
- **Fast FB circuit**

FONT Luminosity Recovery (NLC 'H')

For small offsets (< 5 sigma), and appropriate gain:

system can recover > 80% of design luminosity

Much easier (and required) at TESLA: 2820 bunches X 337 ns

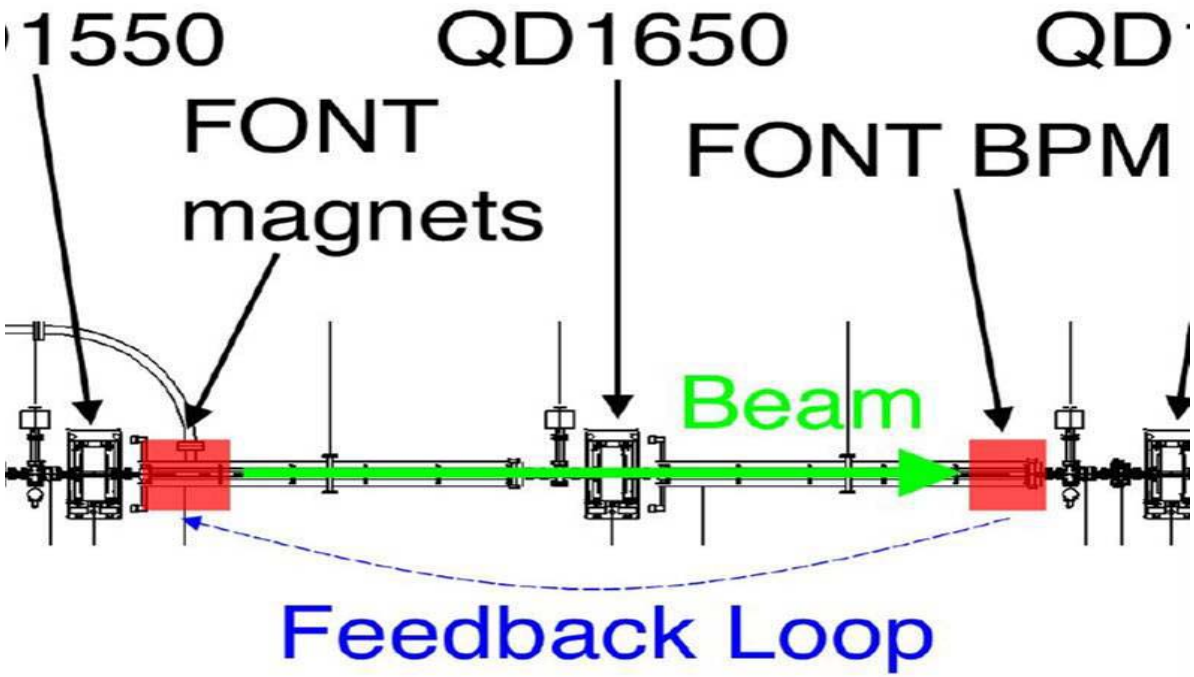


FONT at NLCTA

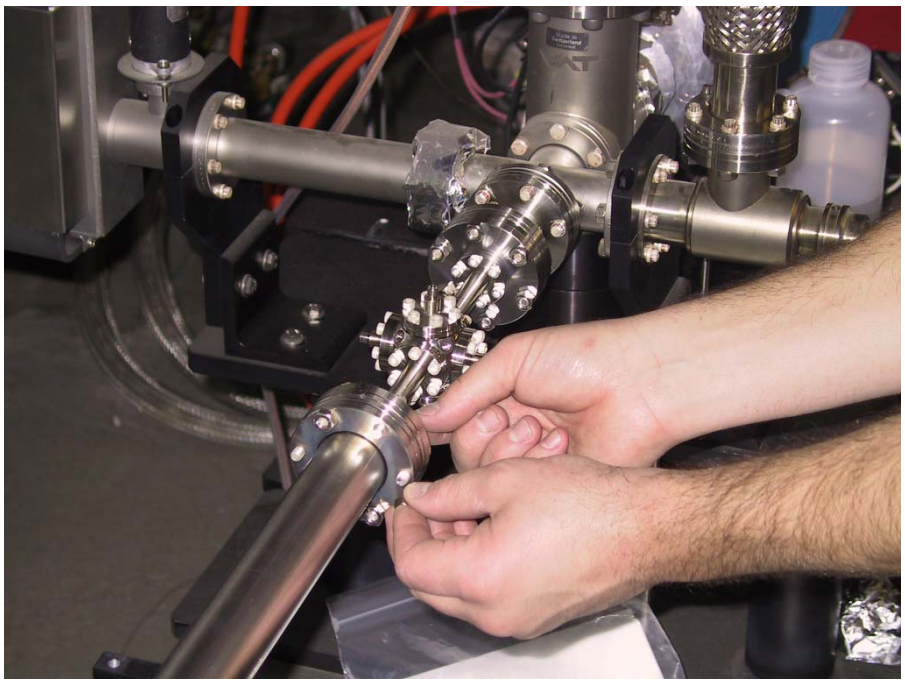
170ns long train, bunched at X-band (87ps)

significant charge variation (50%) along train

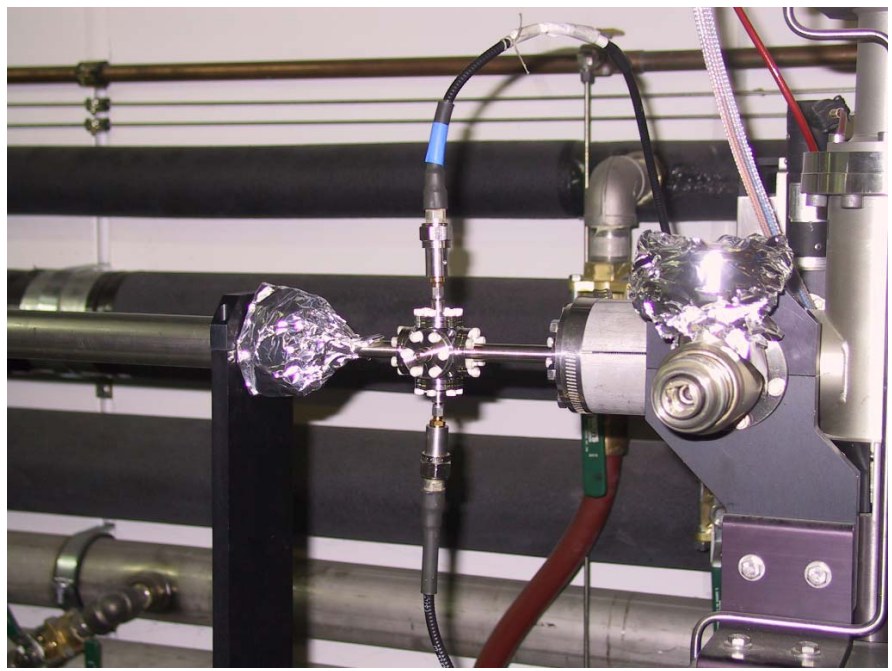
large beam (1mm), train-train jitter O(100 microns)



FONT1 at NLCTA: BPM

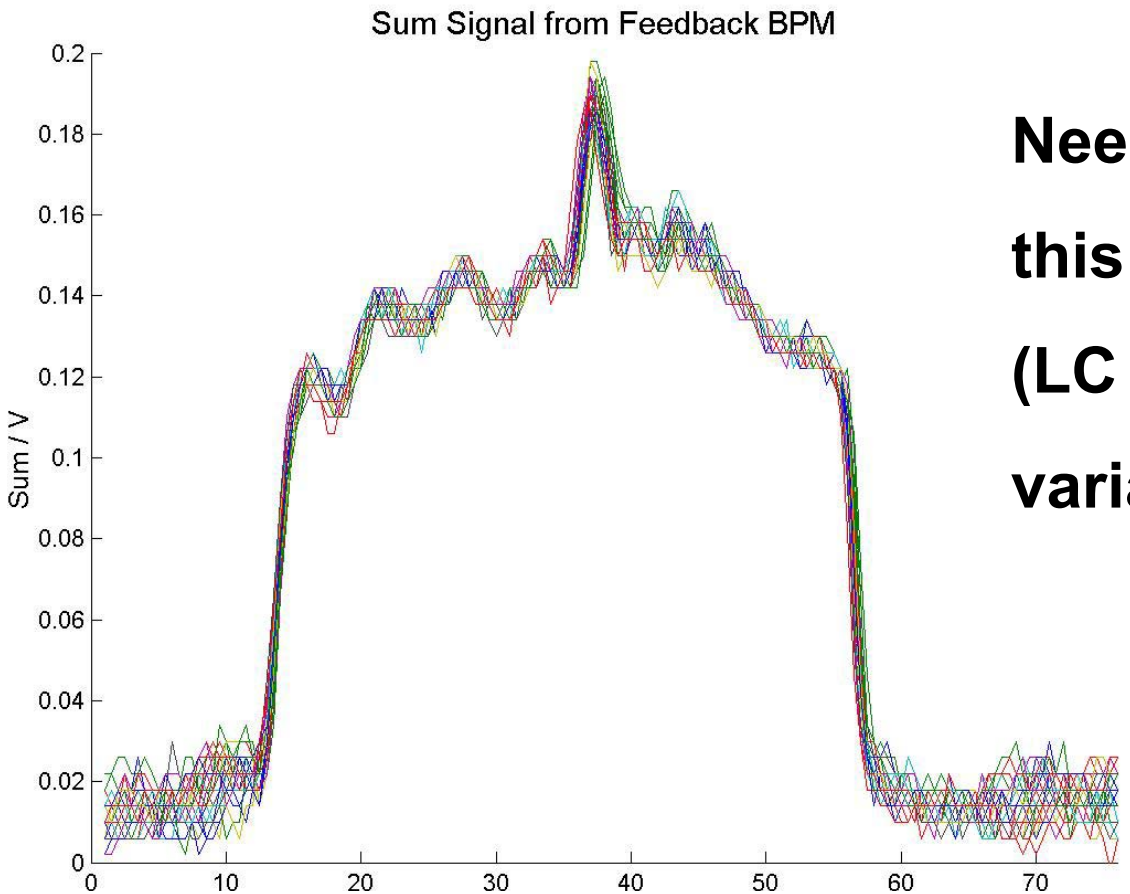


New button type BPM for X-band bunch structure



Initial readout w. diode detectors

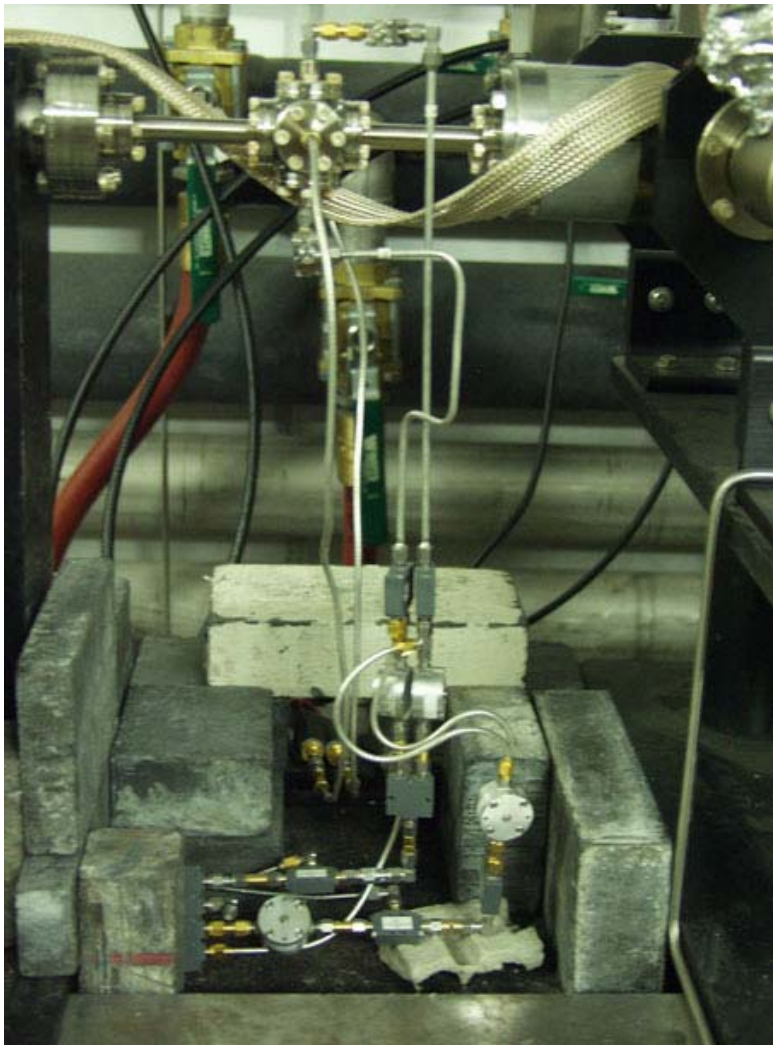
NLCTA charge variation along train



170ns long train

Need to deconvolve this from BPM signal (LC design charge variation << 1%)

FONT1 at NLCTA: BPM processor

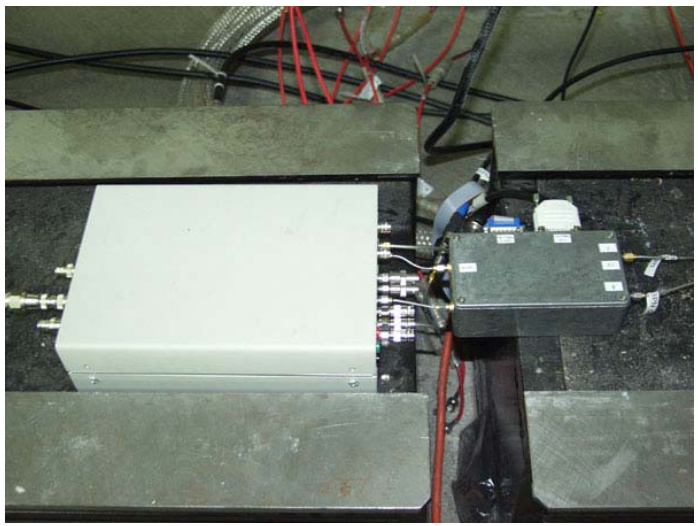


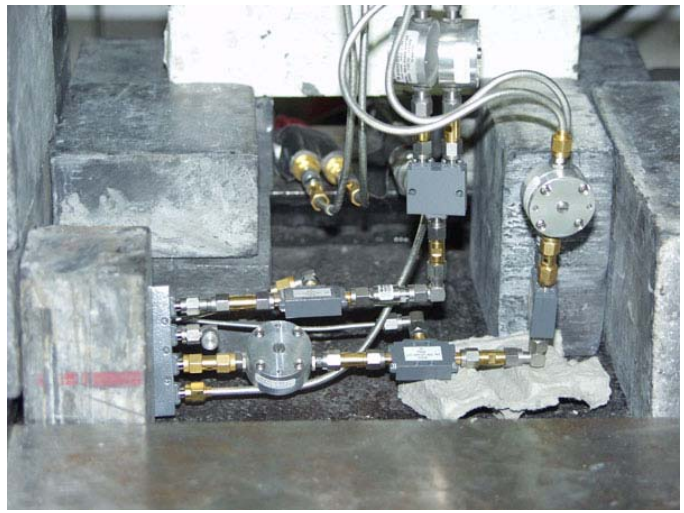
Read each y pickoff signal: Formed sum and difference, mixed down from X-band to baseband.

Charge normalisation: 1/sum performed w. AWG (slow) with real-time first-order correction

FONT1 at NLCTA: charge normalisation/feedback

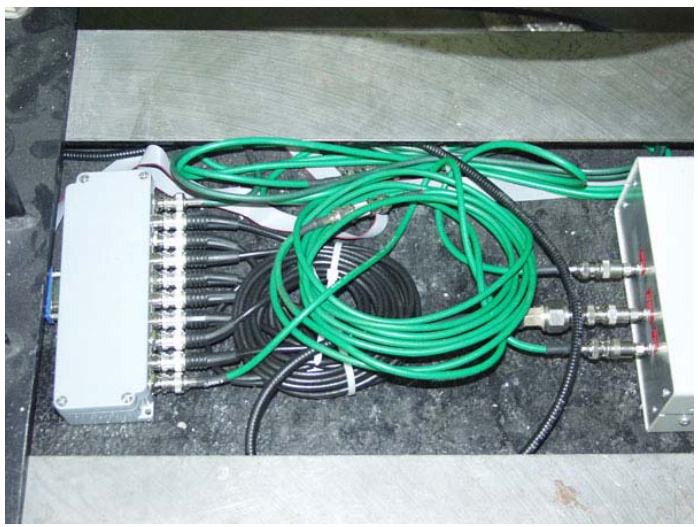
2

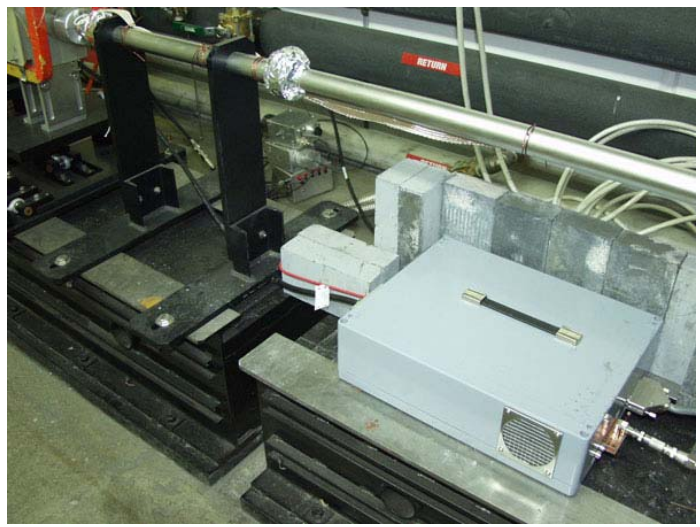




1

3





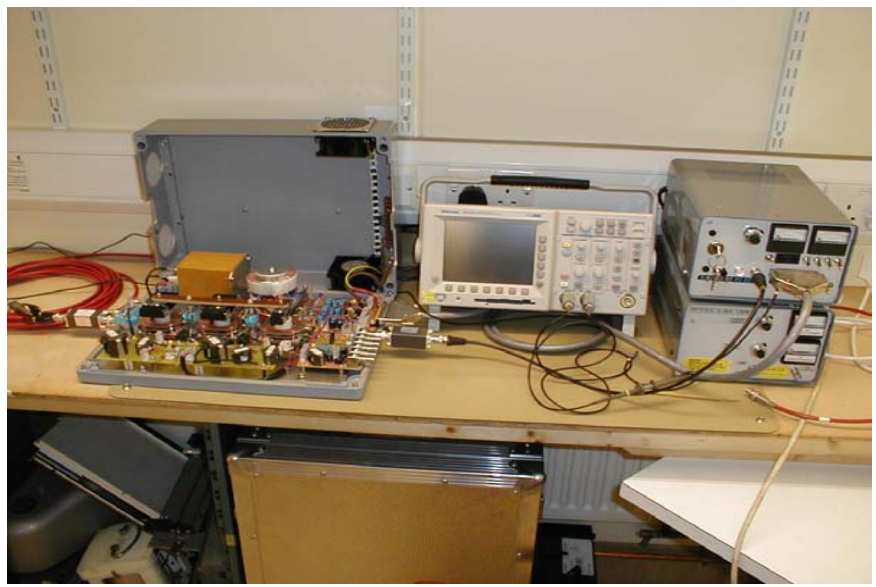
4

FONT1 at NLCTA: kicker driver amplifier

3kW amplifier:

3 planar triode tubes;

7.5 A, 350V o/p



Allows us to move 65 MeV beam by +- 1 mm

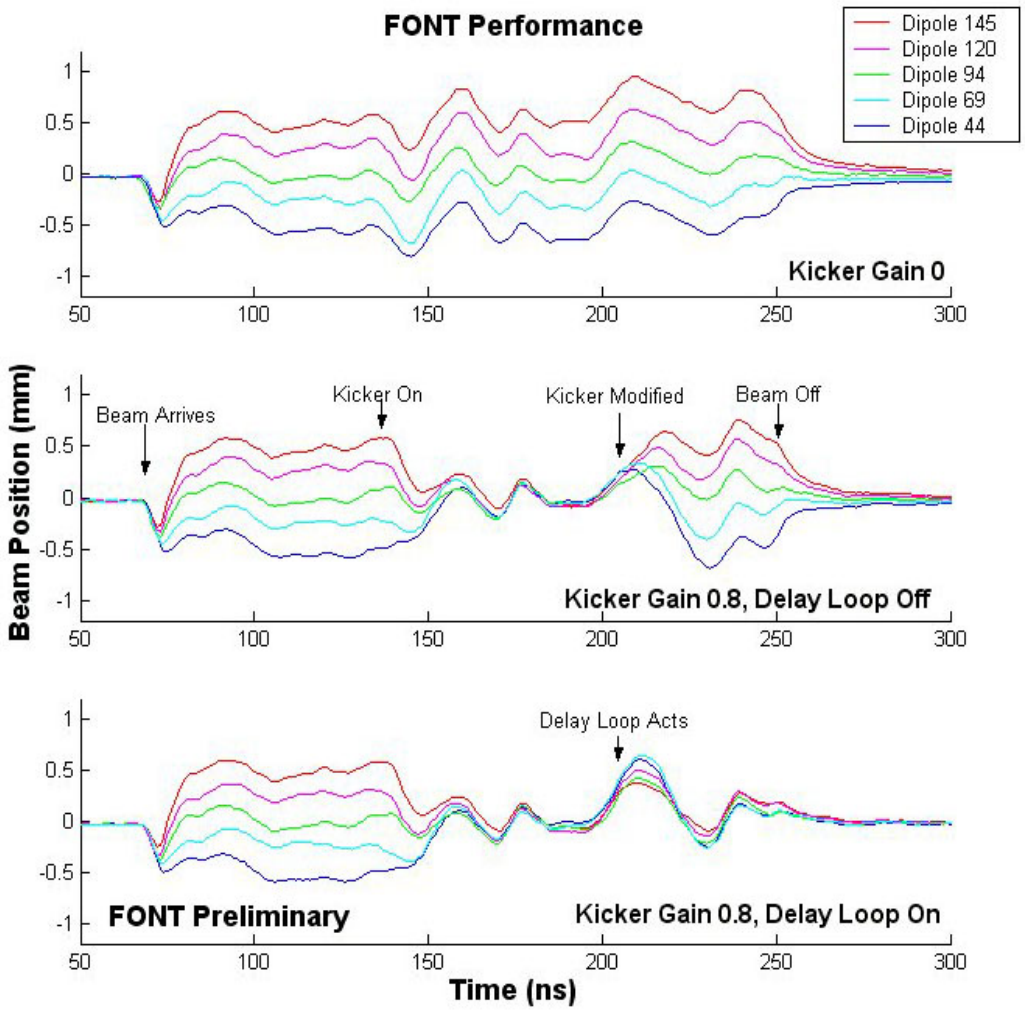
FONT1 at NLCTA: expected latency

- Time of flight kicker – BPM: 14ns
- Signal return time BPM – kicker: 18ns

  Irreducible latency: 32ns
- BPM cables + processor: 5ns
- Preamplifier: 5ns
- Charge normalisation/FB circuit: 11ns
- Amplifier: 10ns
- Kicker fill time: 2ns

  Electronics latency: 33ns
- Total latency expected: 65ns

FONT1 at NLCTA: results



10/1 position correction of

65 MeV e- beam

achieved

latency of 67 ns

system tested in feed forward and feedback modes

FONT2 at NLCTA: outline

Goals of improved FONT2 setup:

- **Additional 2 BPMs:** independent position monitoring
- **Second kicker added:** allows solid state amplifiers
- **Shorter distance between kickers and FB BPM:**
  irreducible latency now c. 16 ns
- **Improved BPM processor:**
  real-time charge normalisation using log amps (slow)
- **Expect total latency c. 53 ns:**
  allows 170/53 = 3.2 passes through system
- **Added 'beam flattener'** to remove static beam profile
- **Automated DAQ including digitisers and dipole control**

FONT2 at NLCTA: expected latency

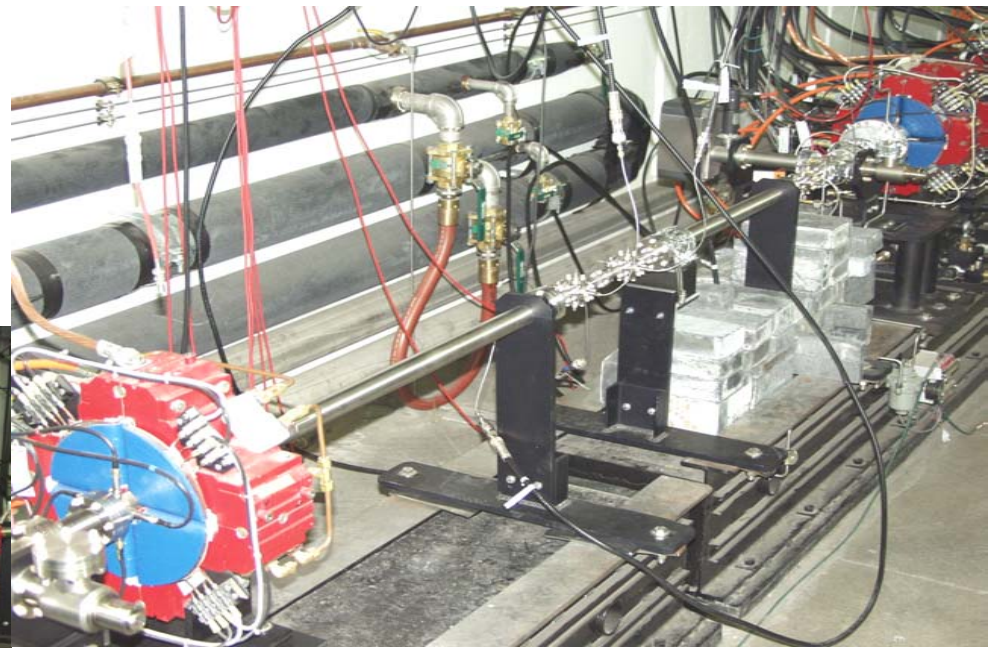
- Time of flight kicker – BPM: 6ns
- Signal return time BPM – kicker: 10ns

  Irreducible latency: 16ns
- BPM processor: 18ns
- FB circuit: 4ns
- Amplifier: 12ns
- Kicker fill time: 3ns

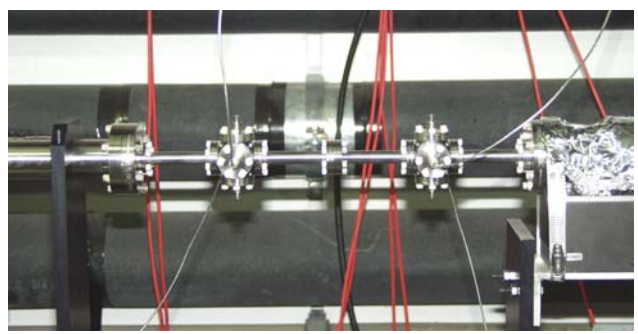
  Electronics latency: 37ns
- Total latency expected: 53ns

FONT2 at NLCTA: new beamline configuration

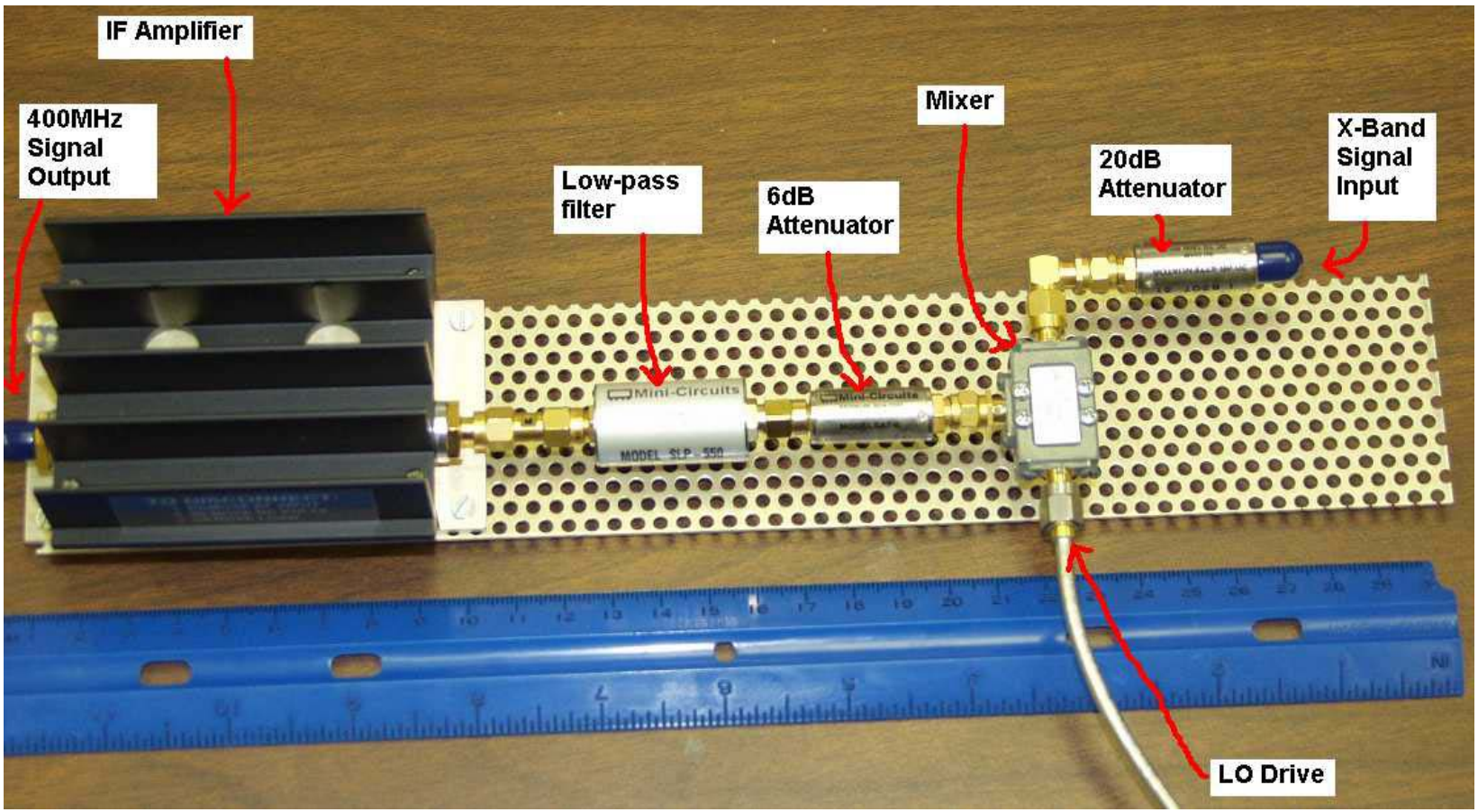
Dipole and kickers



New BPMs



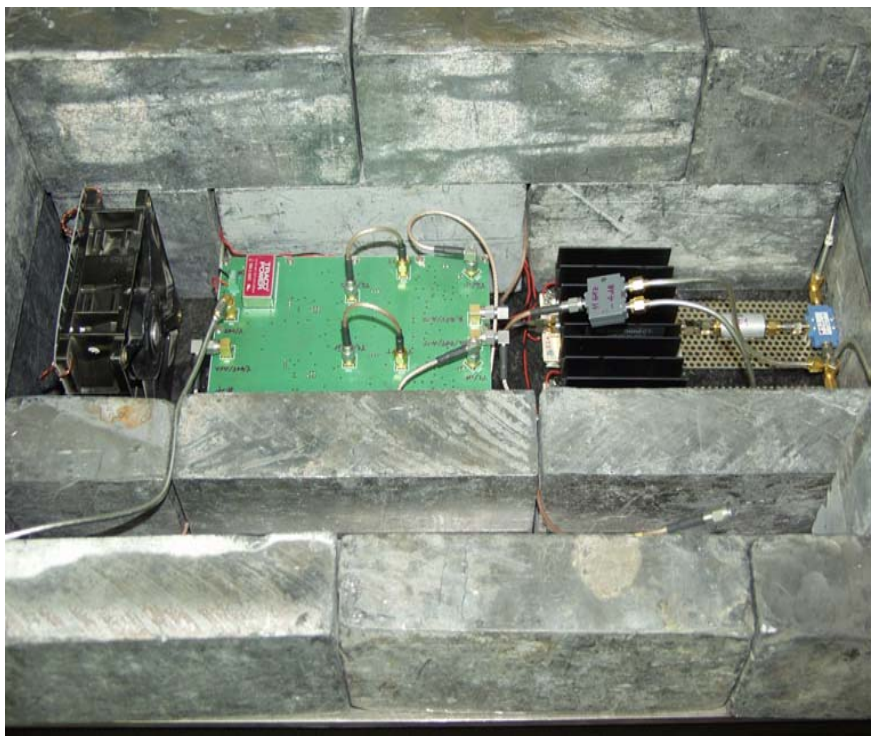
FONT2: new front-end IF processor



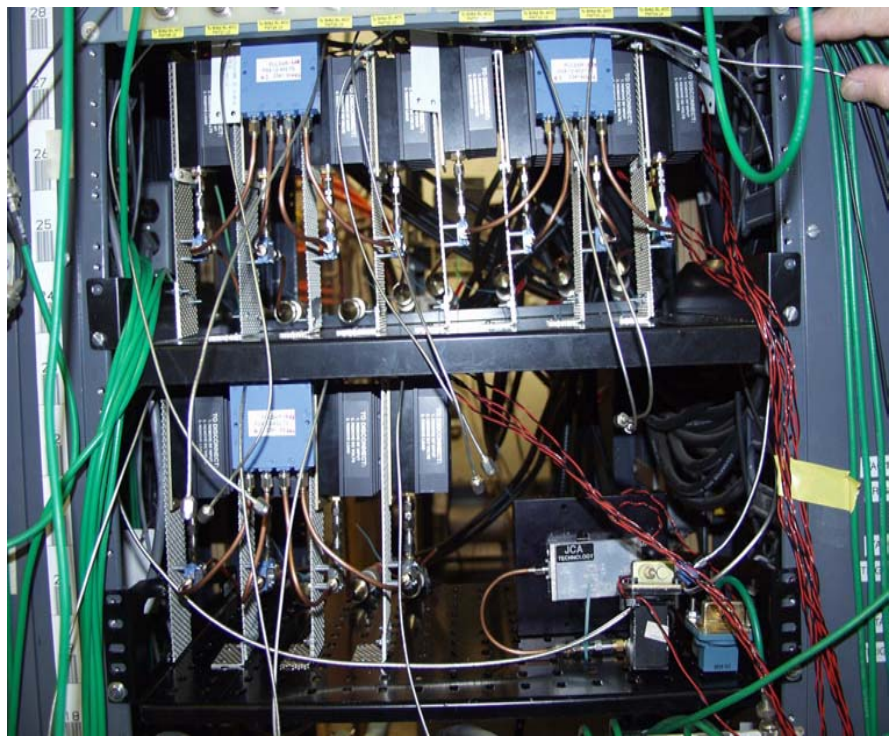
FONT2: new front-end IF processor

14 channels: 2y on beamline, 6y + 6x outside

2y on beamline:



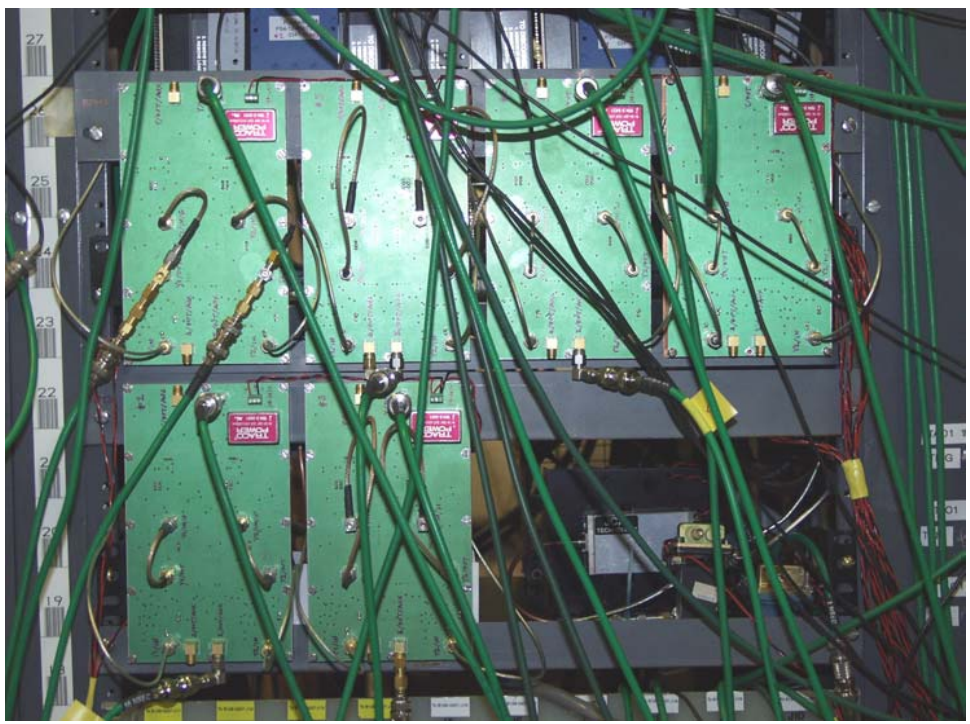
6y+6x outside tunnel:

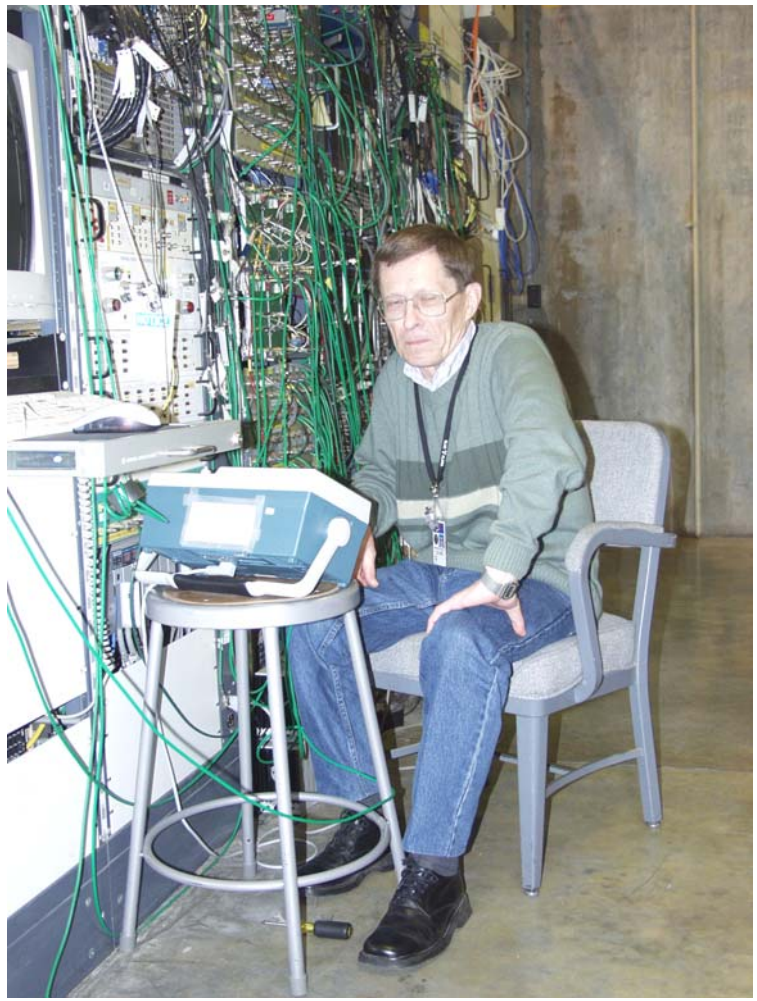


FONT2: synchronous demodulator PCBs

(y1-y2)/(y1+y2) w. log amps

6 boards outside tunnel:

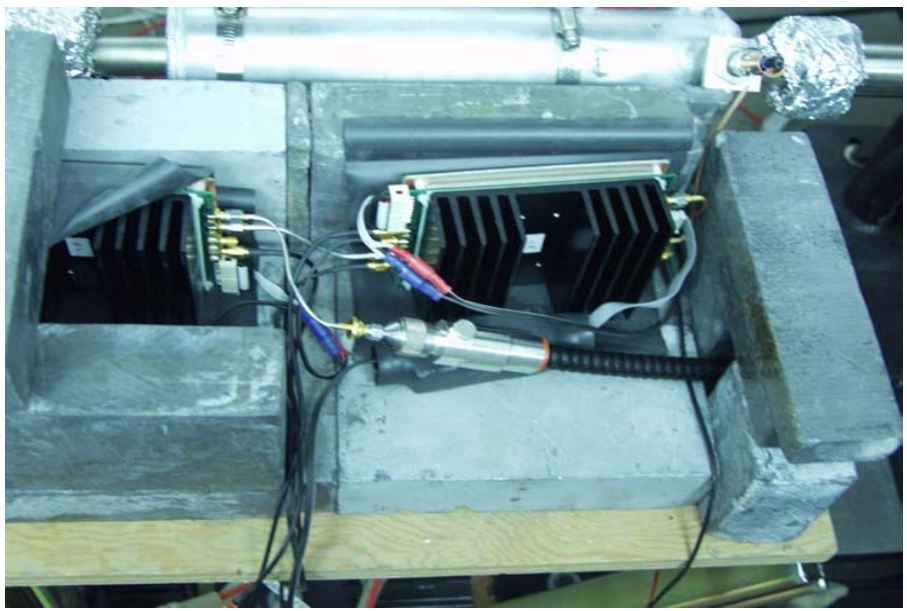




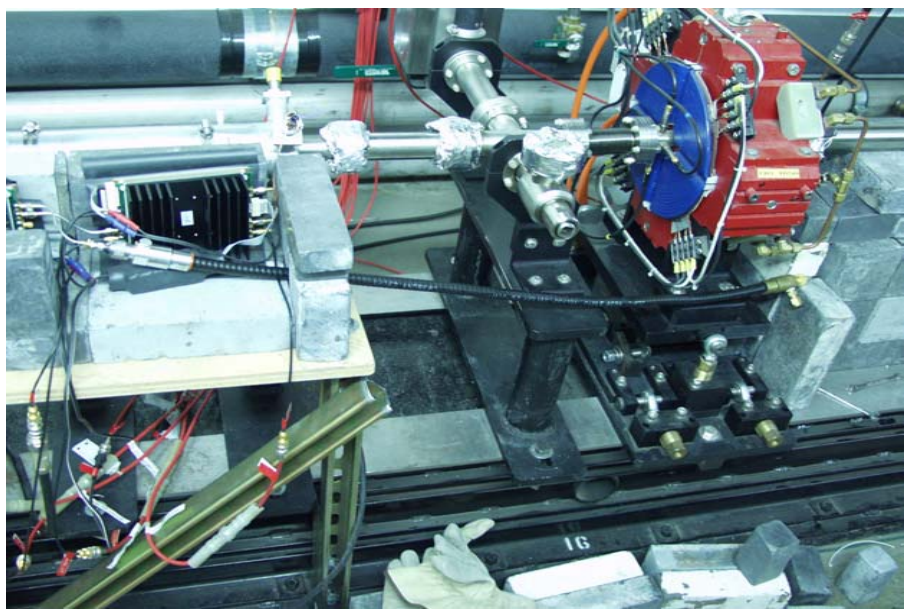
FONT2: new solid state amplifiers

Total drive same as last year

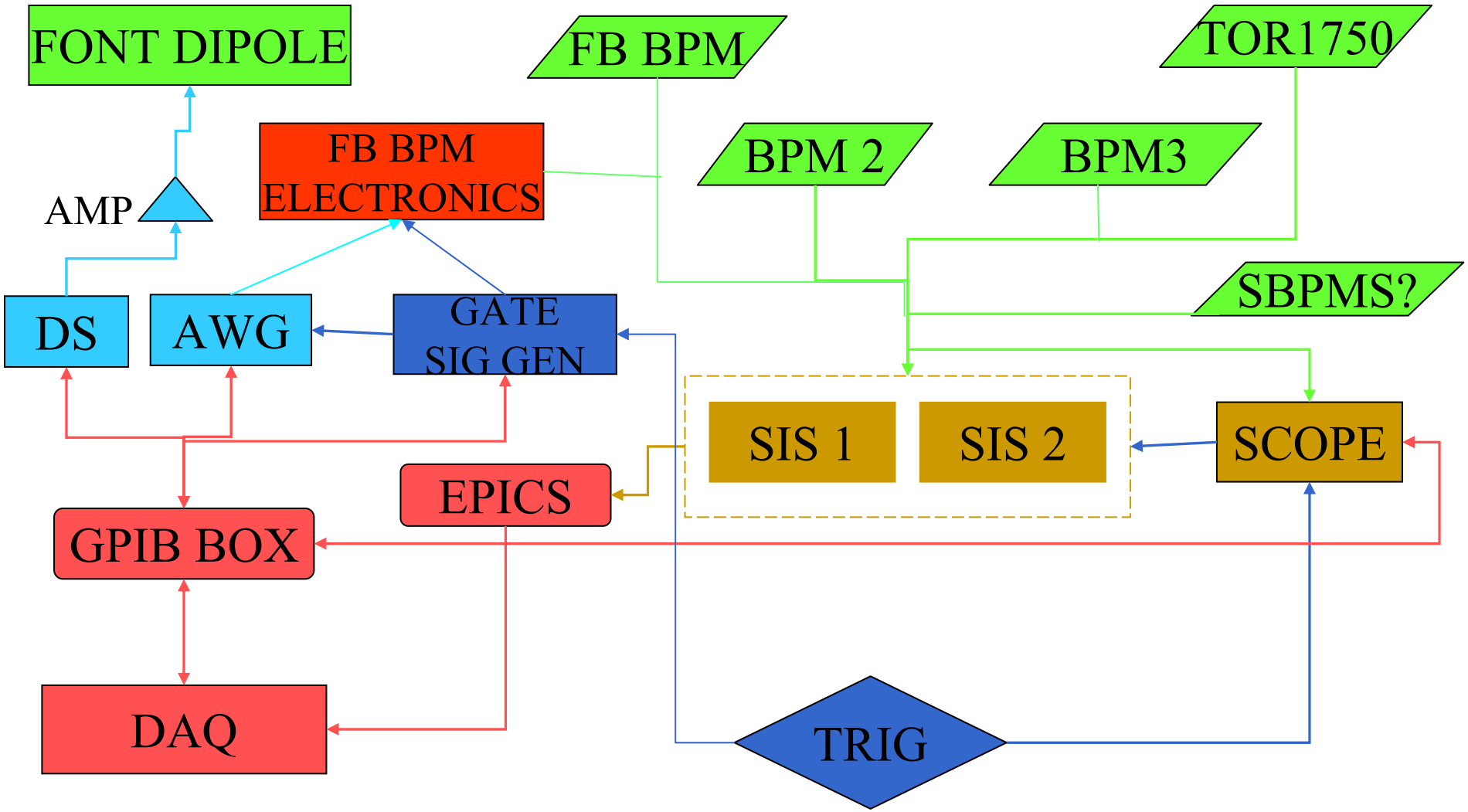
Amplifier pair w. shielding:



FB o/p signal into amp (0.9c):



FONT2: new DAQ/control system



FONT2 run Nov/Dec 2003 + Jan 2004

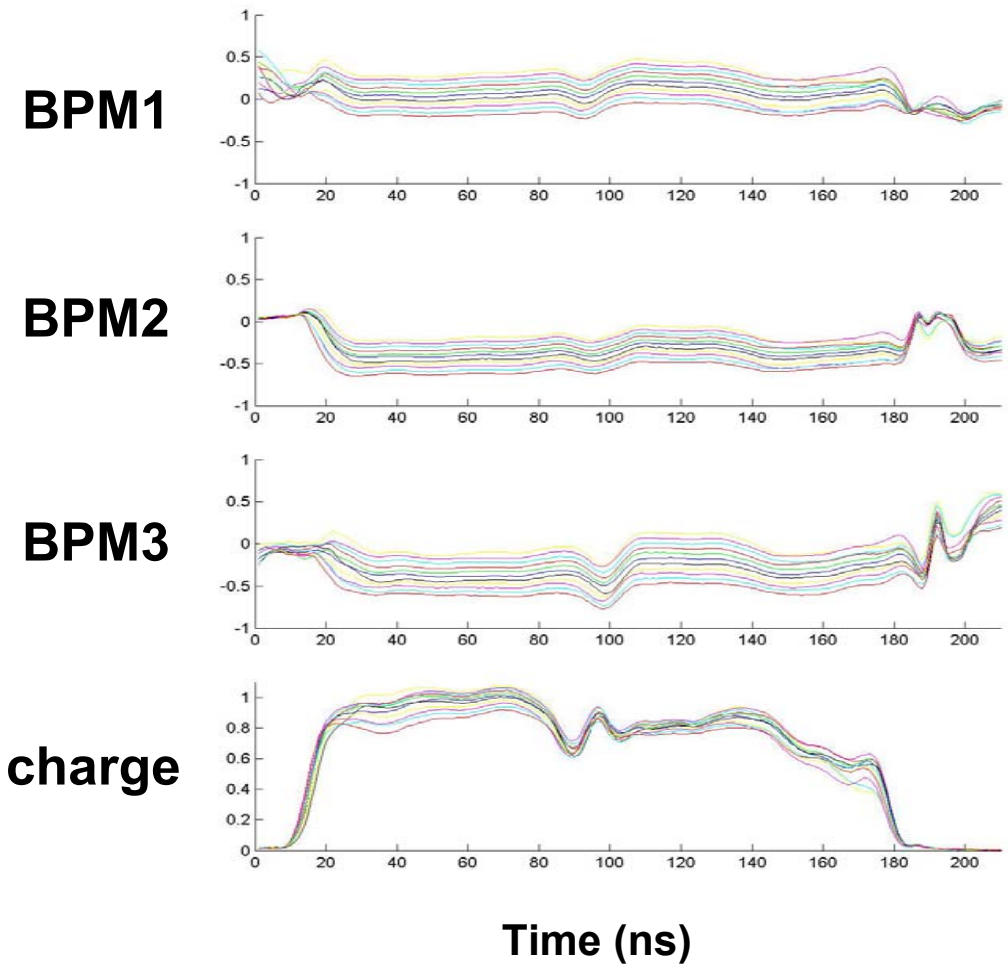
- Nov 7-9: commissioned system of 3 BPMs and new electronics
  resolution measured using 'triplets': c. 15 microns
- Opportunistic runs Nov 24 – Dec 13 (10 shifts)
  operating conditions difficult due to 8-pack + high-gradient structure tests
- Dec 3: commissioned new amplifiers, kicker, FB circuit + DAQ
  full system run in feed-forward and feedback modes
- Dec 9: commissioned beam flattener in standalone mode
- Dec 13: ran full system with beam flattener
- Jan 15 – 26: systematic parameter optimisation and quality data taking

FONT2: first results Nov 2003

Beam registered in all 3 BPMs w. dipole scans

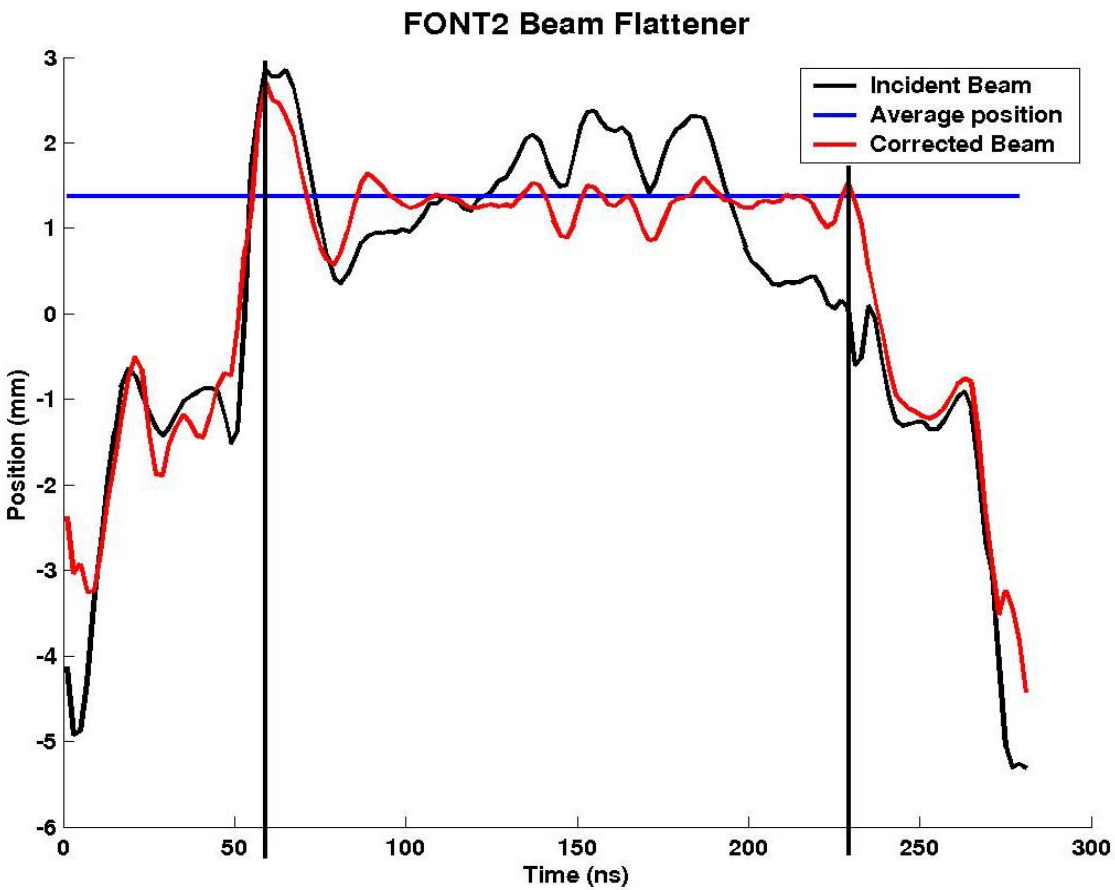
Resolution measured:

c. 15 microns



FONT2 initial results: beam flattener

Feedback off for illustration:



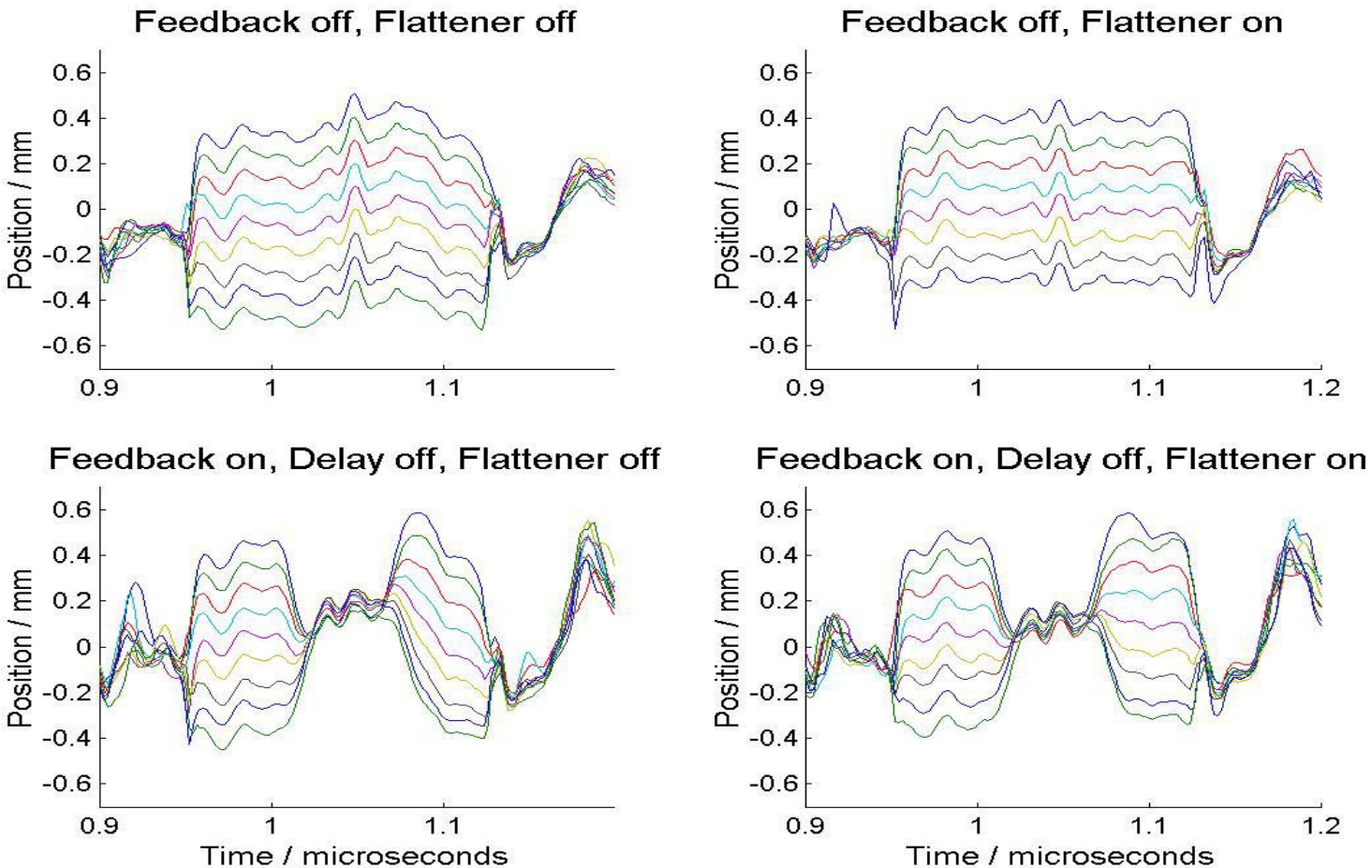
Flattener corrects to average beam position: removes 'static' structure

Performance bandwidth limited:

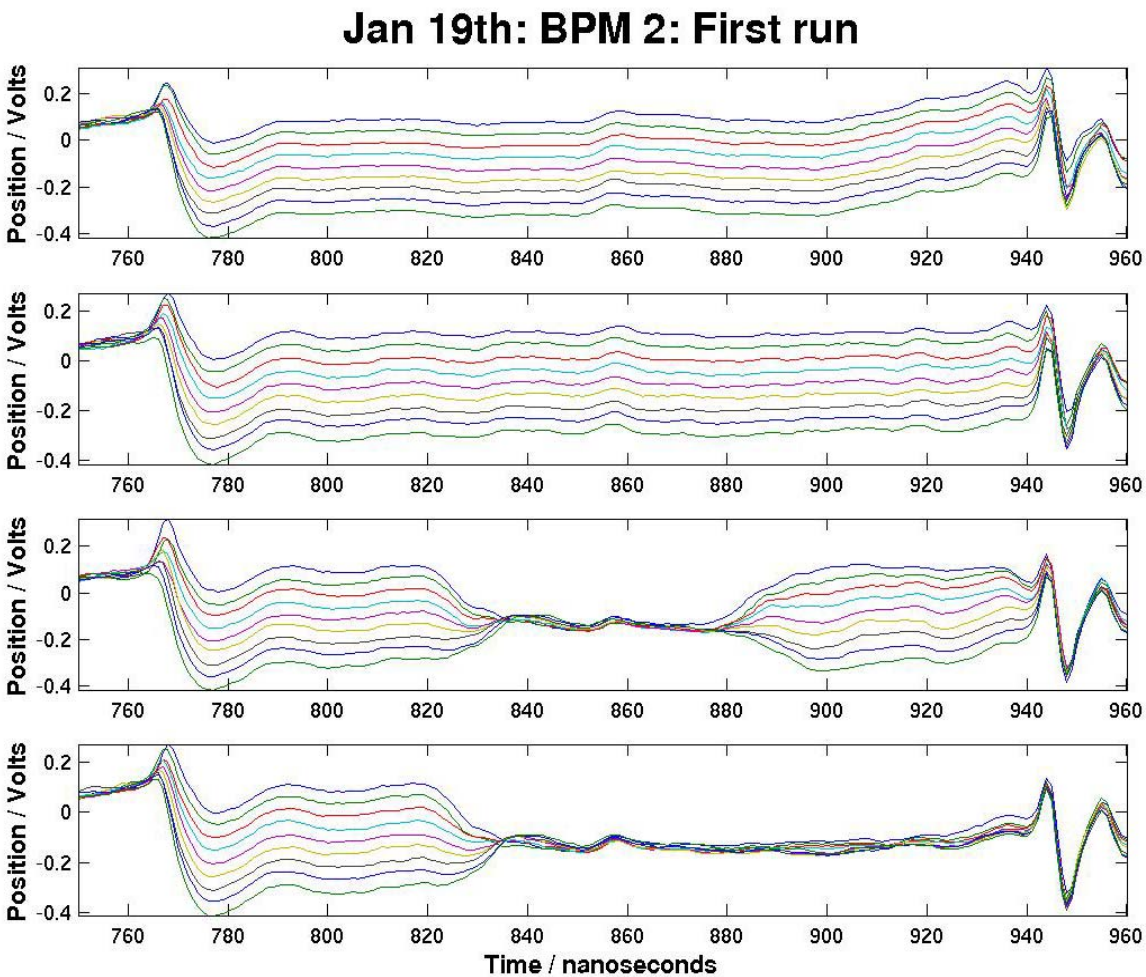
80 MHz (AWG)

30 MHz (amp)

FONT2 initial results: beam flattener



FONT2 initial results: feedback mode



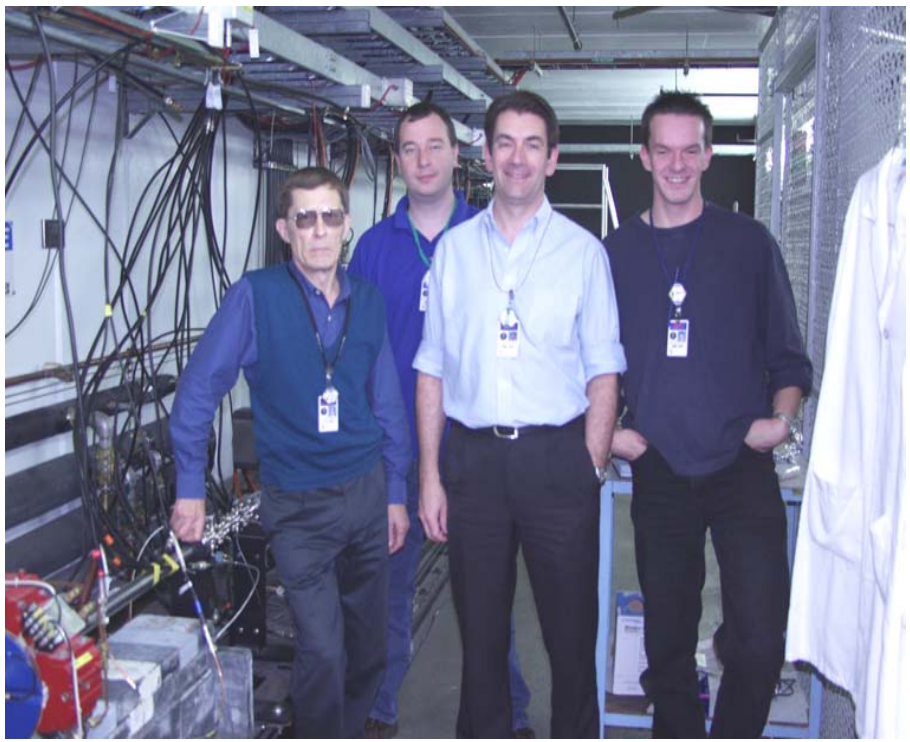
Beam starting positions

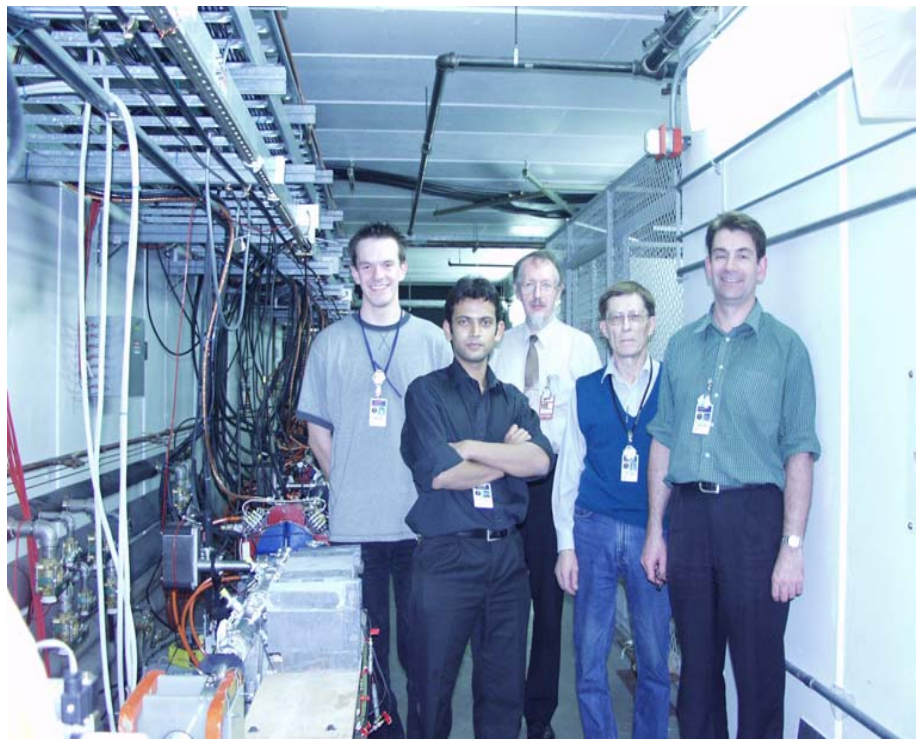
Beam flattener on

Feed forward on

Feedback on

FONT2 crew





Ideas for further development work

- **e+e- background studies in SLAC A-line**
- **World's smallest emittance e- beam is at KEK/ATF**
- **Scaling:**

  1 micron at ATF (1 GeV) ~ 1 nm at LC (1000 GeV)
- **Beam-based feedback at ATF could be scale model for LC**

Comparison of ATF with NLCTA

	NLCTA	ATF
Train length	170 ns	300 ns
Bunch spacing	0.08 ns	2.8 ns
Beam size (y)	500 mu	5 mu
Jitter (y)	100 mu	1 mu
Beam energy	65 MeV	1.3 GeV

ATF has 'right' bunch spacing and train length, and the beam is smaller and more stable than at NLCTA

-> much better place for fast feedback prototypes

Possible future developments for FONT at ATF

3 suggestions:

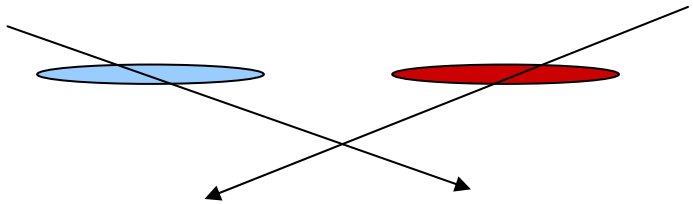
1. **Stabilisation of extracted bunchtrain at 1 micron level:**
   low-power (< 100W), high stability amplifier
   stripline BPM w. ~ 1 micron resolution
   these are exactly what are needed for the LC!

2. **Stabilisation of extracted bunchtrain at 100 nm level:**
   requires special BPM and signal processing
   useful for nanoBPM project

3. **Test of intra-train beam-beam scanning system:**
   high-stability ramped kicker drive amplifier
   very useful for LC

Development of Improved Feedbacks

- **Beam angle-jitter:**



correction best done near IP with RF crab cavity (needed anyway): system needs design + prototyping

- **Ideally, feedback on luminosity:**

bunch-by-bunch luminosity measurement would allow intra-train luminosity feedback