# 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)**

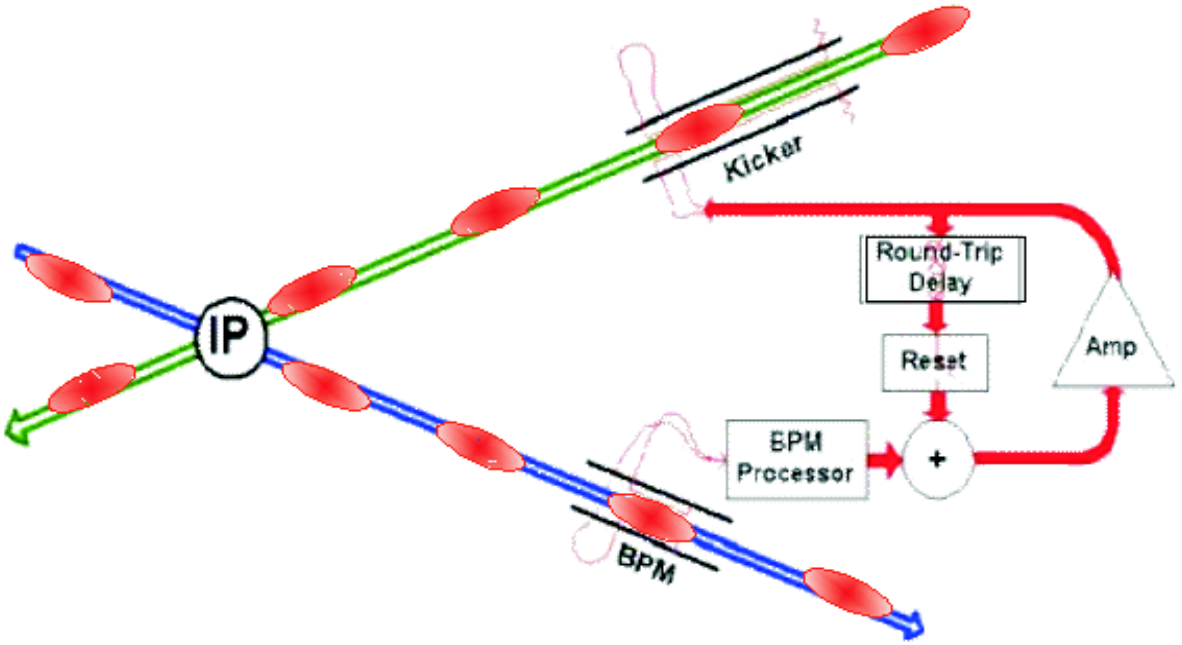
- **SLAC:**

  **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:**

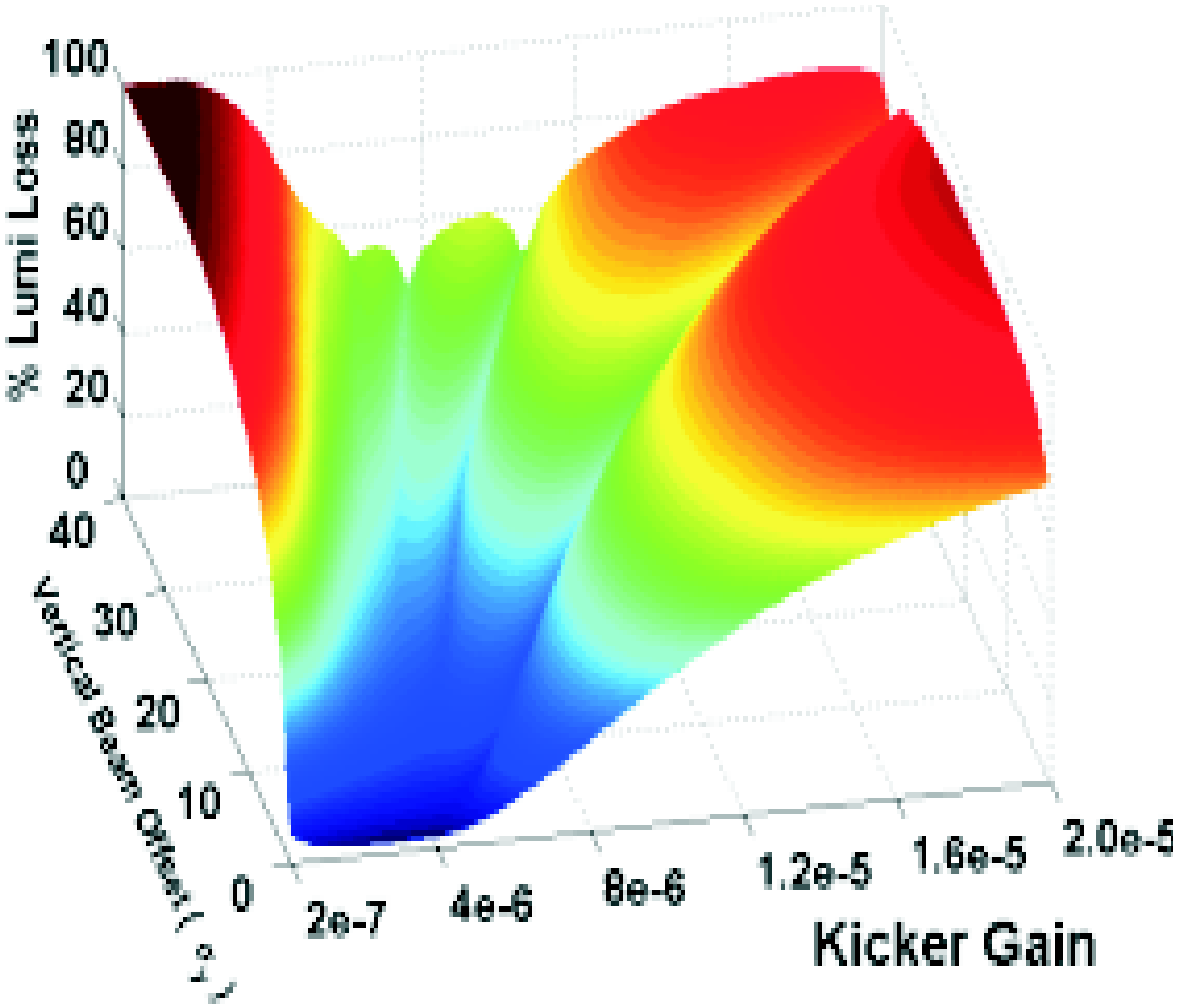
- **Beam position monitor (BPM)**
- **Signal processor**
- **Fast driver amplifier**
- **E.M. kicker**
- **Fast FB circuit**

# 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**



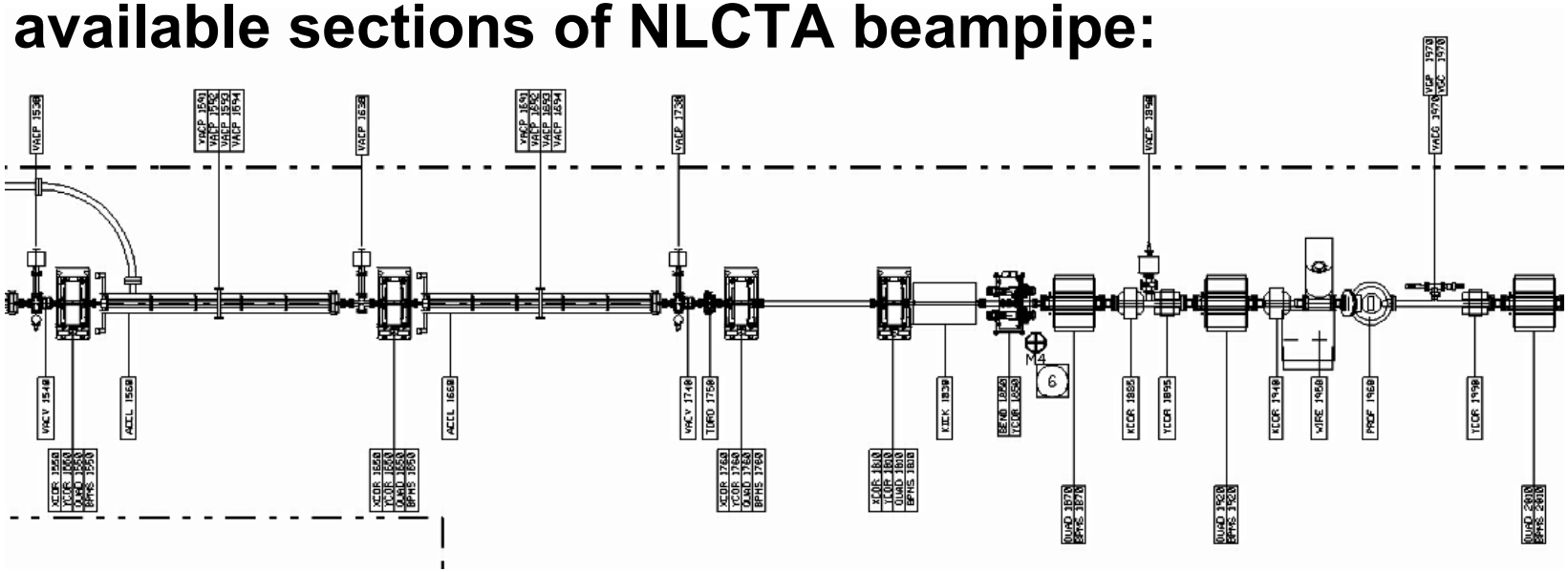
# FONT at NLCTA

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

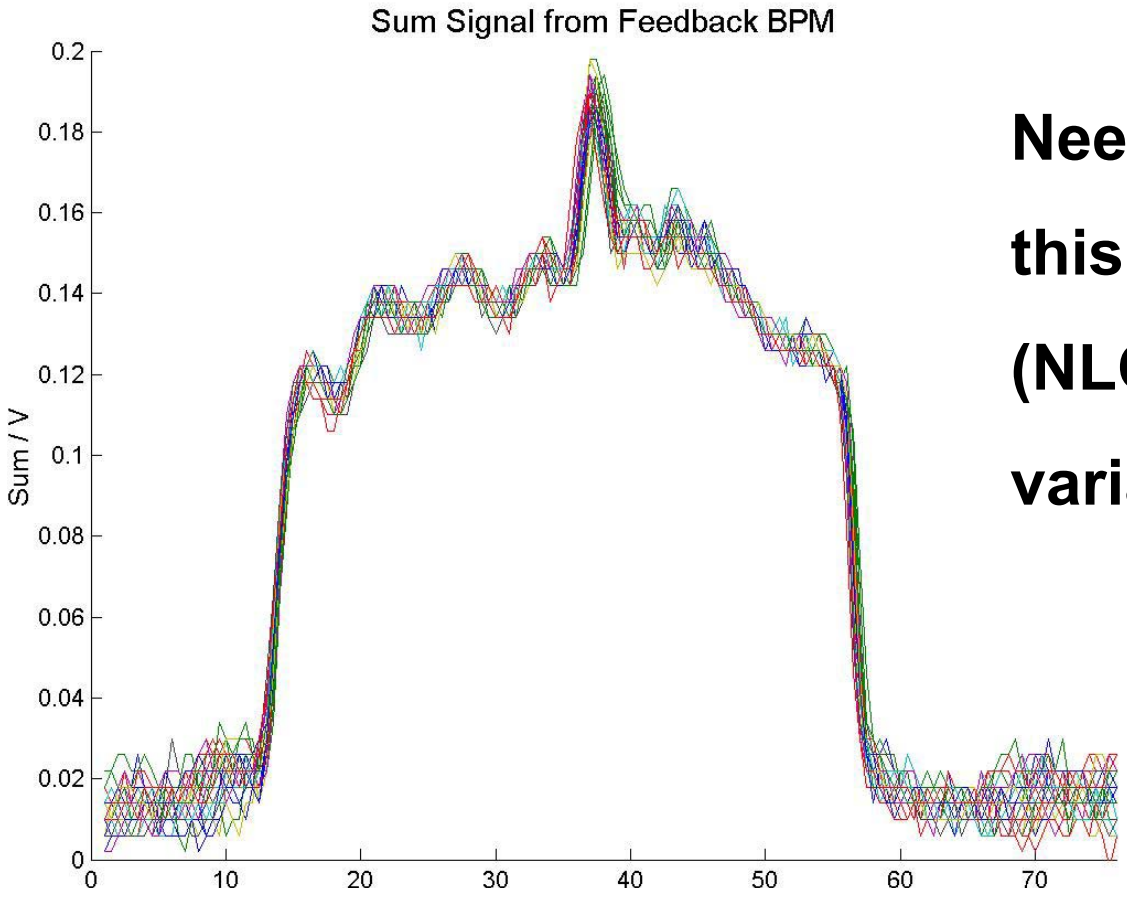
significant charge variation (50%) along train

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

2 available sections of NLCTA beampipe:



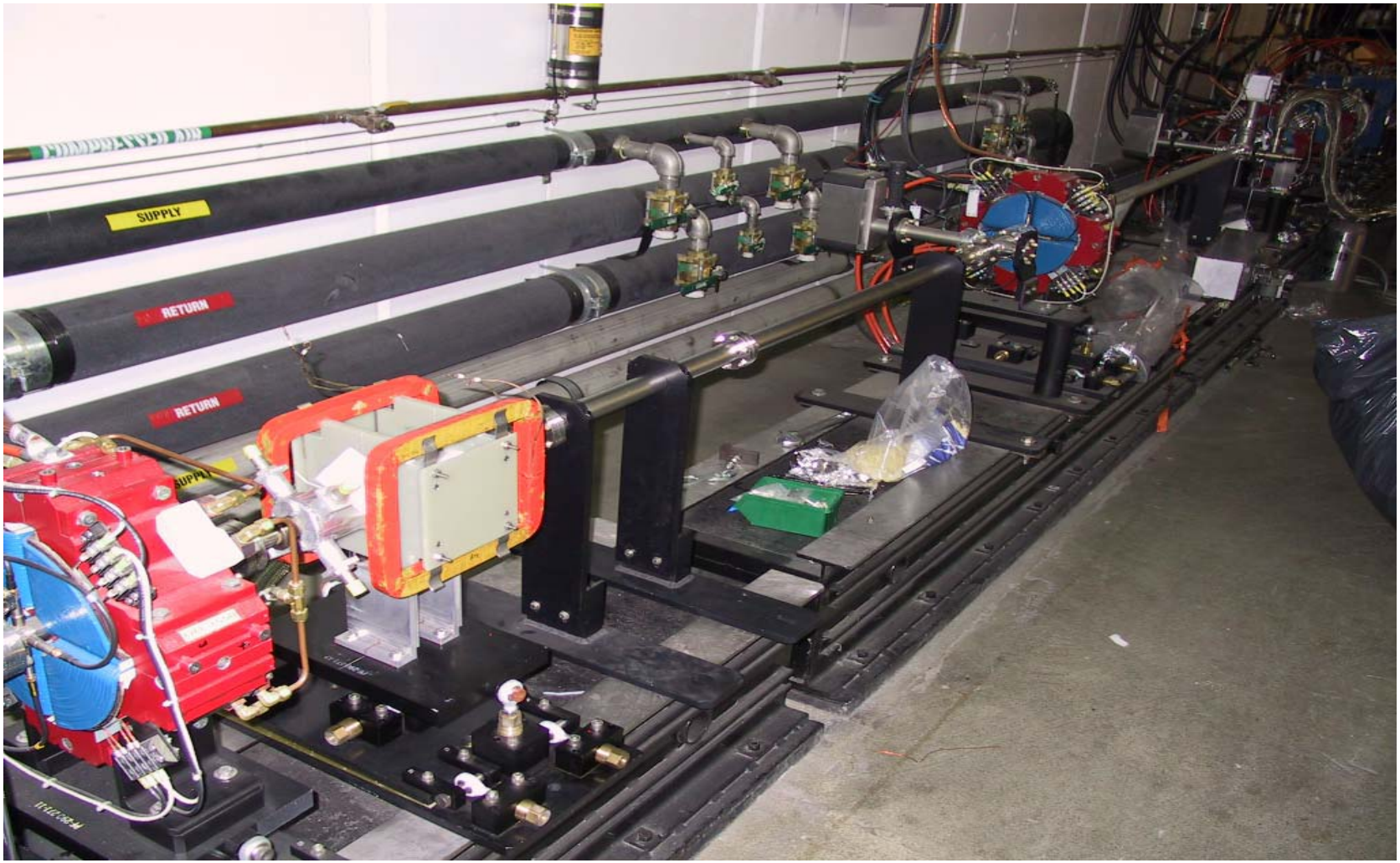
# NLCTA charge variation along train



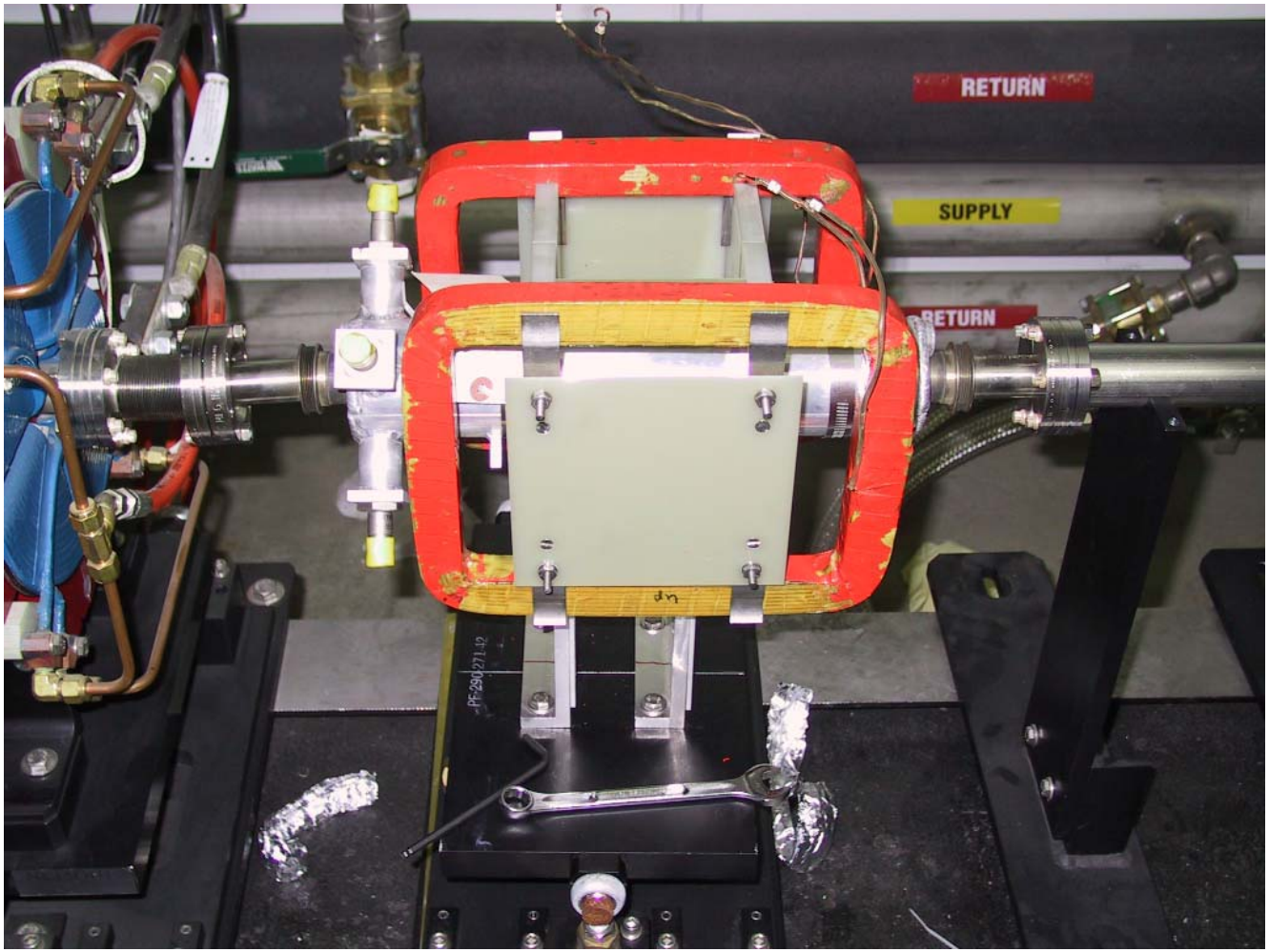

170ns long train

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

# FONT1 at NLCTA: beamline

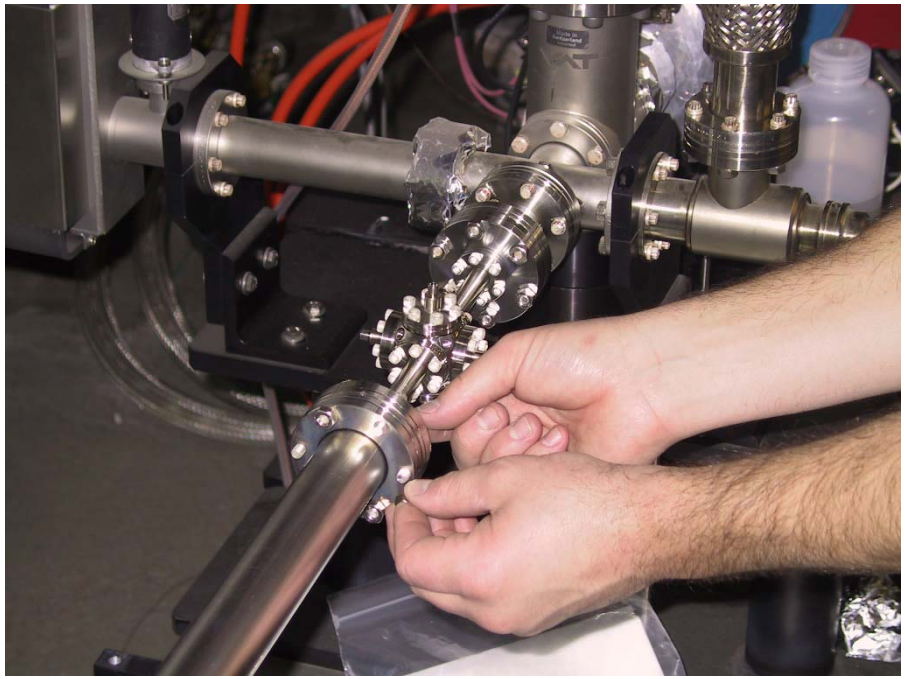


# FONT1 at NLCTA: magnets

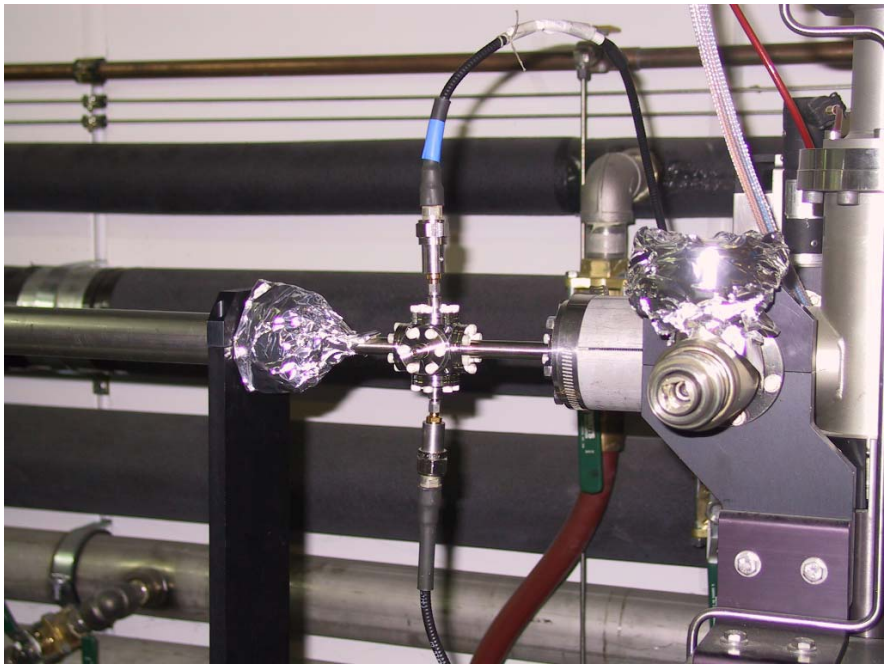



**SLC dipole and post-damping ring kicker**

# FONT1 at NLCTA: BPM

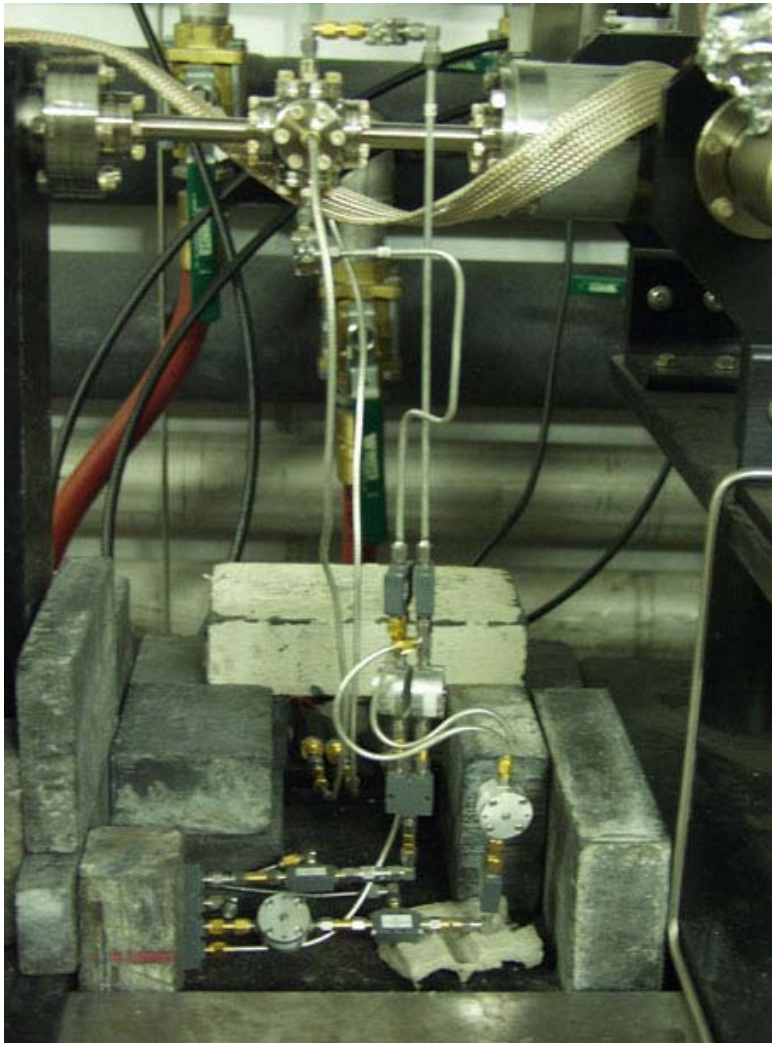


**New button type BPM for X-band bunch structure**



**Initial readout w. diode detectors**

# FONT1 at NLCTA: BPM processor



**Read each y pickoff signal:**

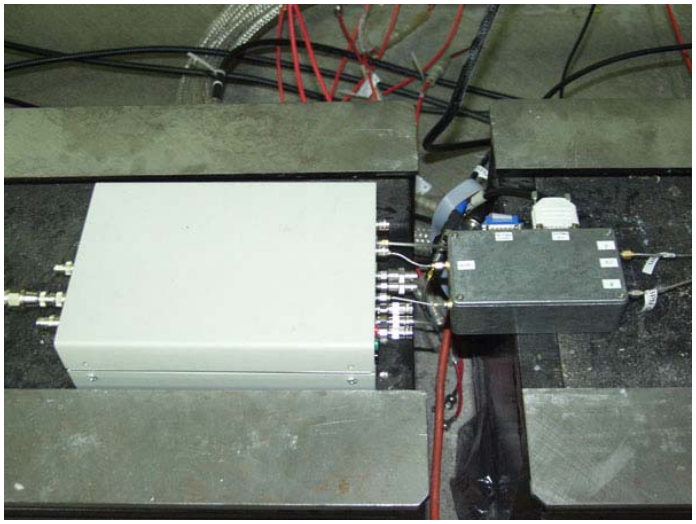
**Formed sum and difference, mixed down from X-band to baseband.**

**Charge normalisation:**

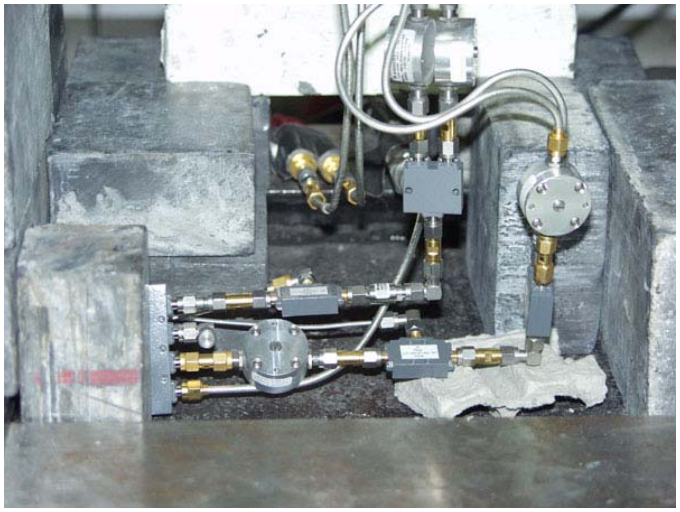
**1/sum performed w. AWG (slow) with real-time first-order correction**

# FONT1 at NLCTA: charge normalisation/feedback

2



1



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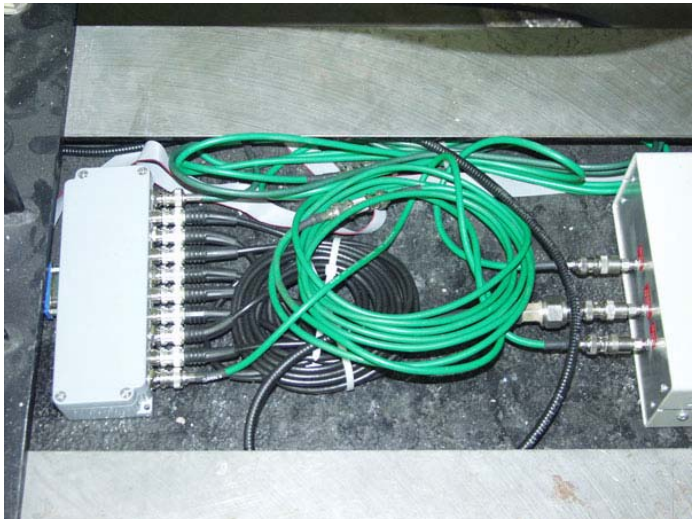

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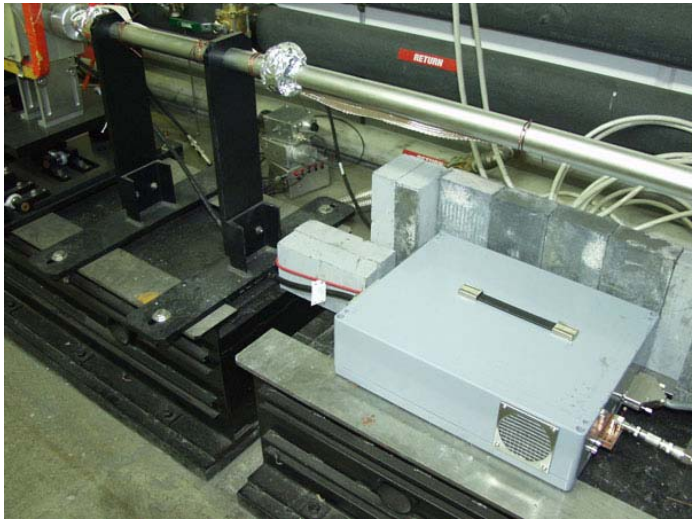
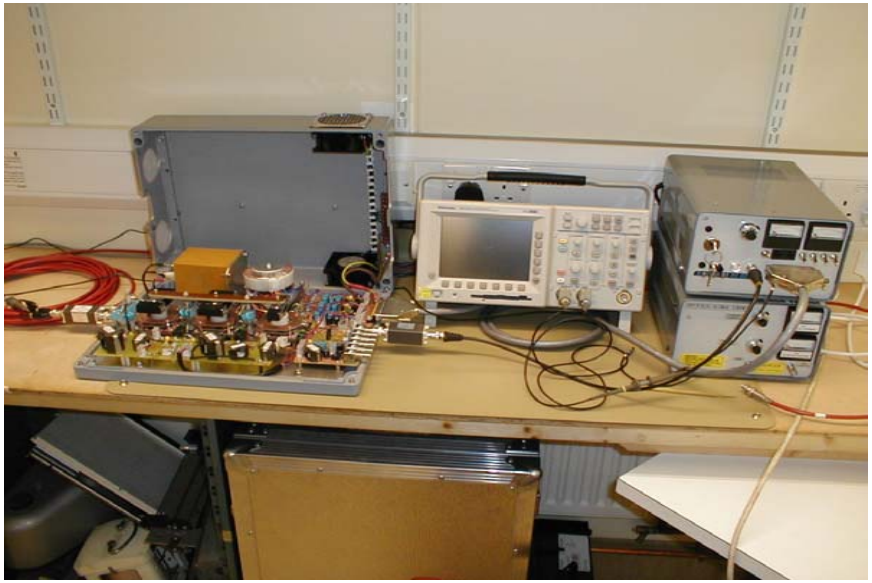


# FONT1 at NLCTA: kicker driver amplifier

**3kW amplifier:**

**3 planar triode tubes;**

**7.5 A, 350V o/p**



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

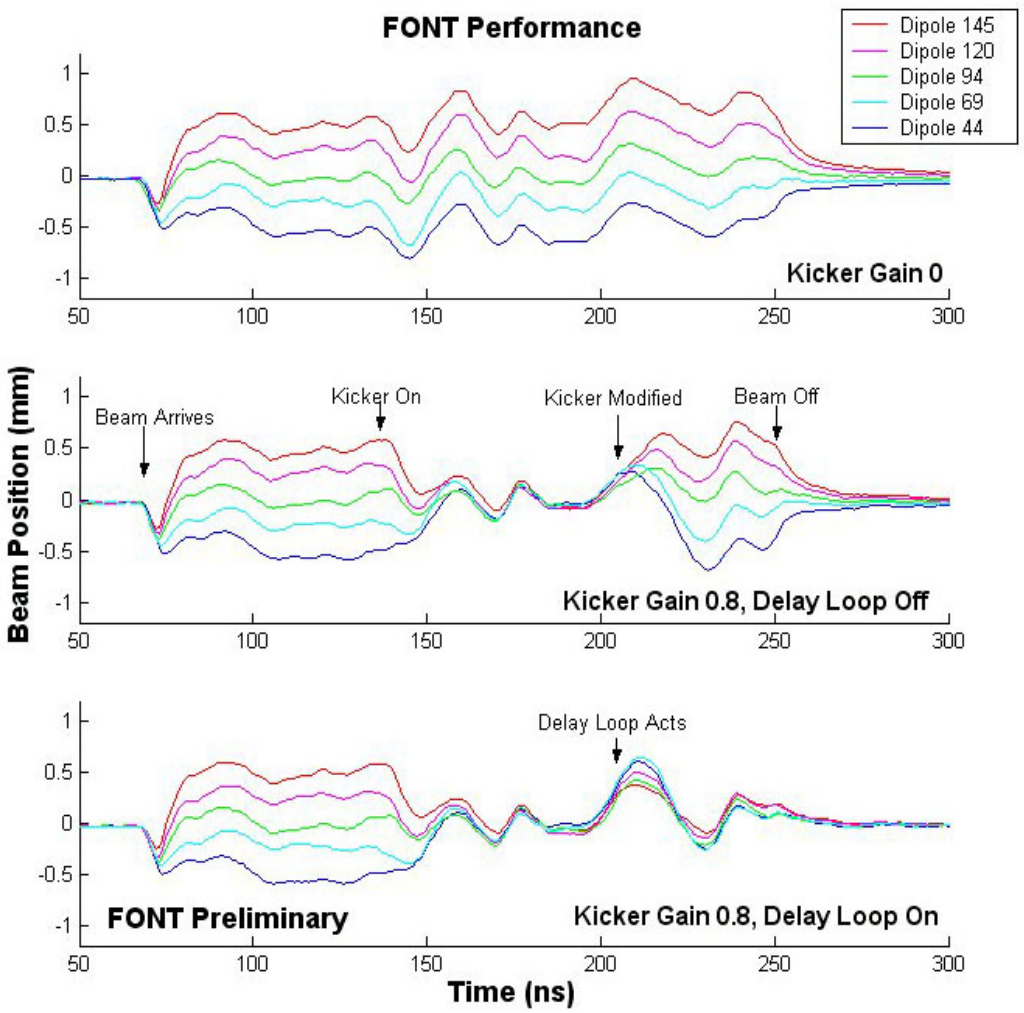
# FONT1 at NLCTA: expected latency

- 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

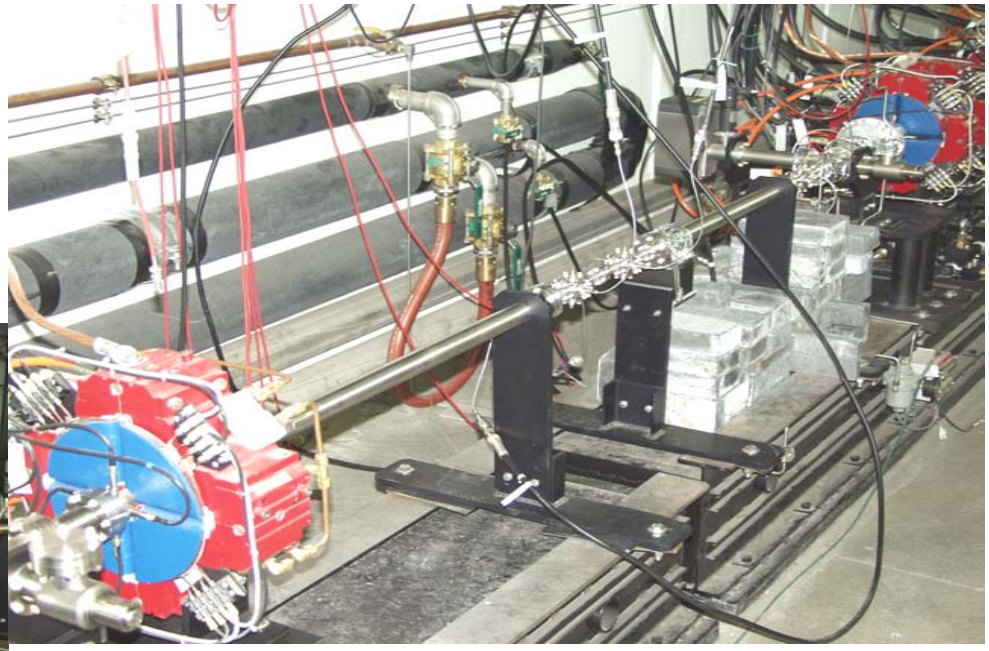
- Time of flight kicker – BPM: 6ns
- Signal return time BPM – kicker: 10ns

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

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

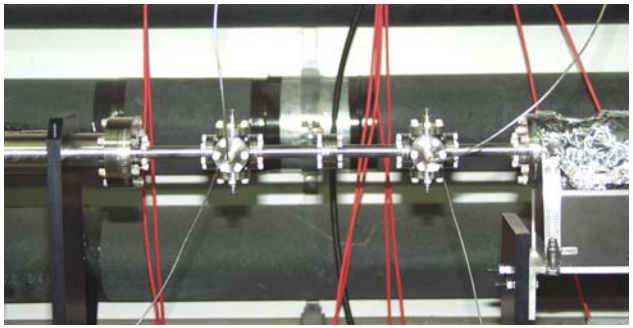
# FONT2 at NLCTA: new beamline configuration

**Dipole and kickers**

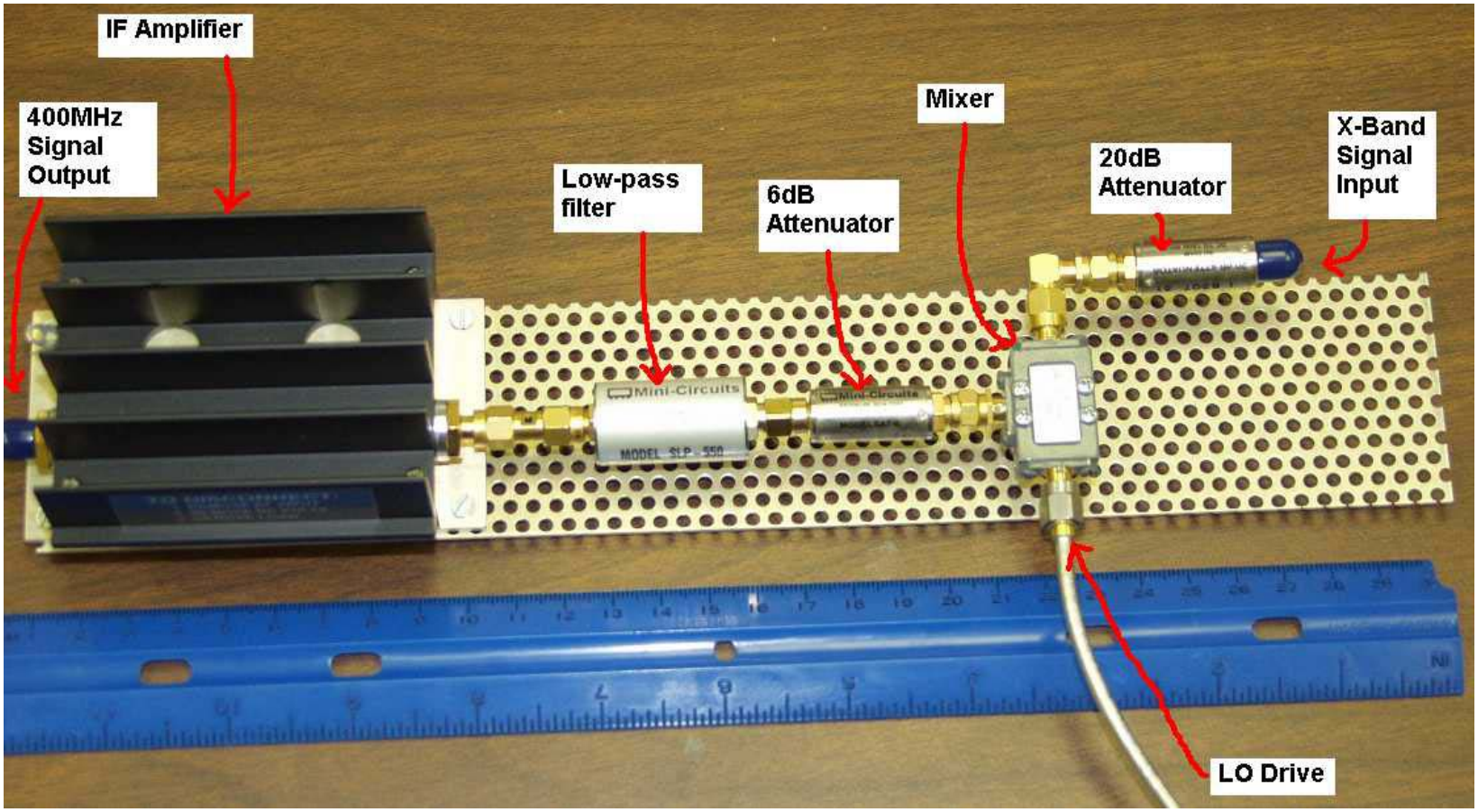


**New**

**BPMs**



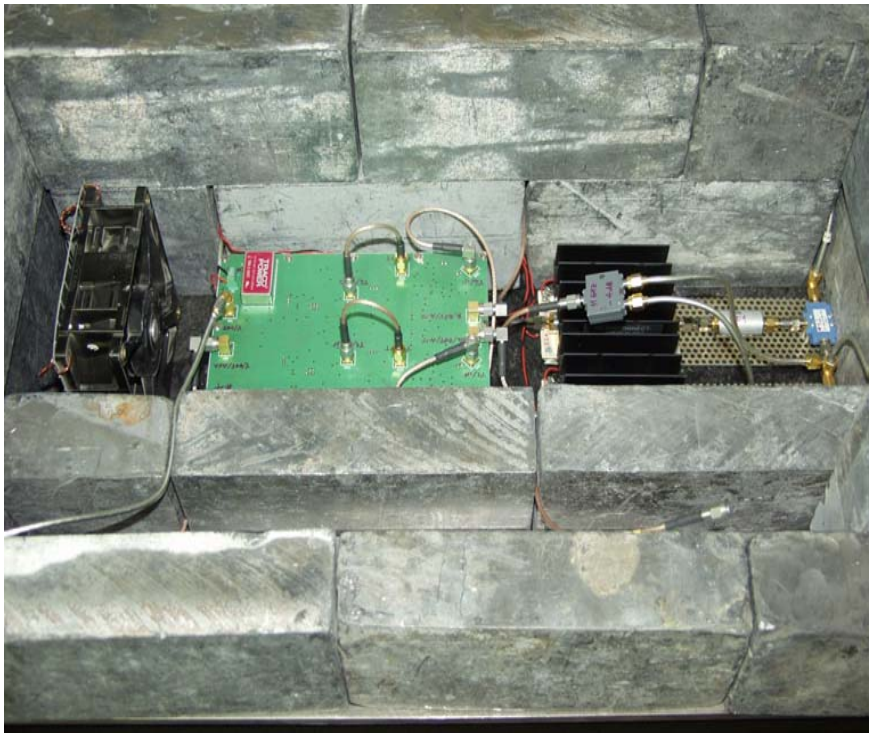
# FONT2: new front-end IF processor



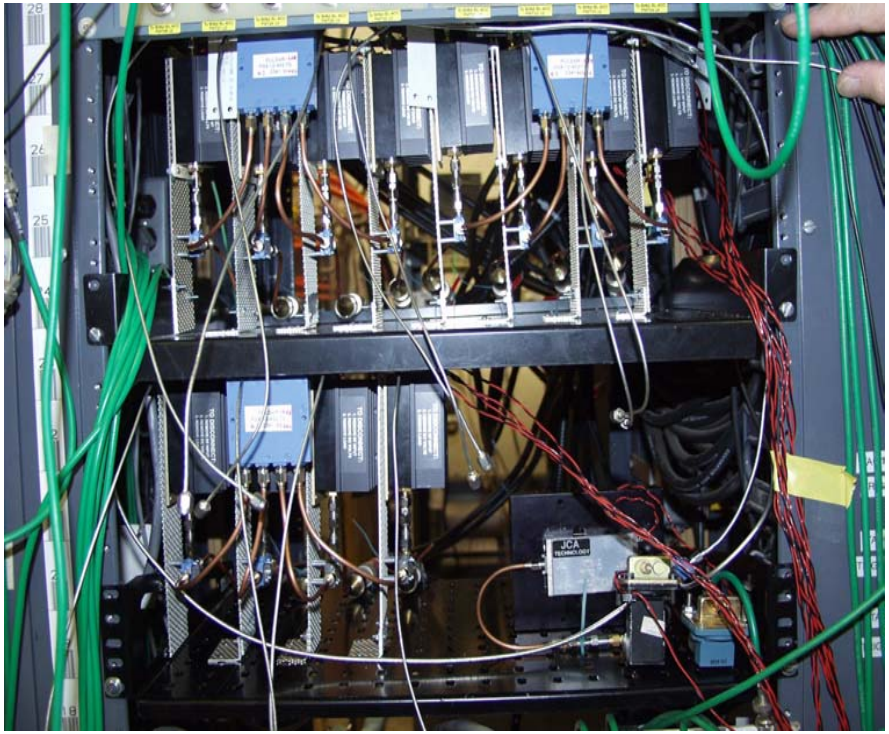
# FONT2: new front-end IF processor

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

**2y on beamline:**



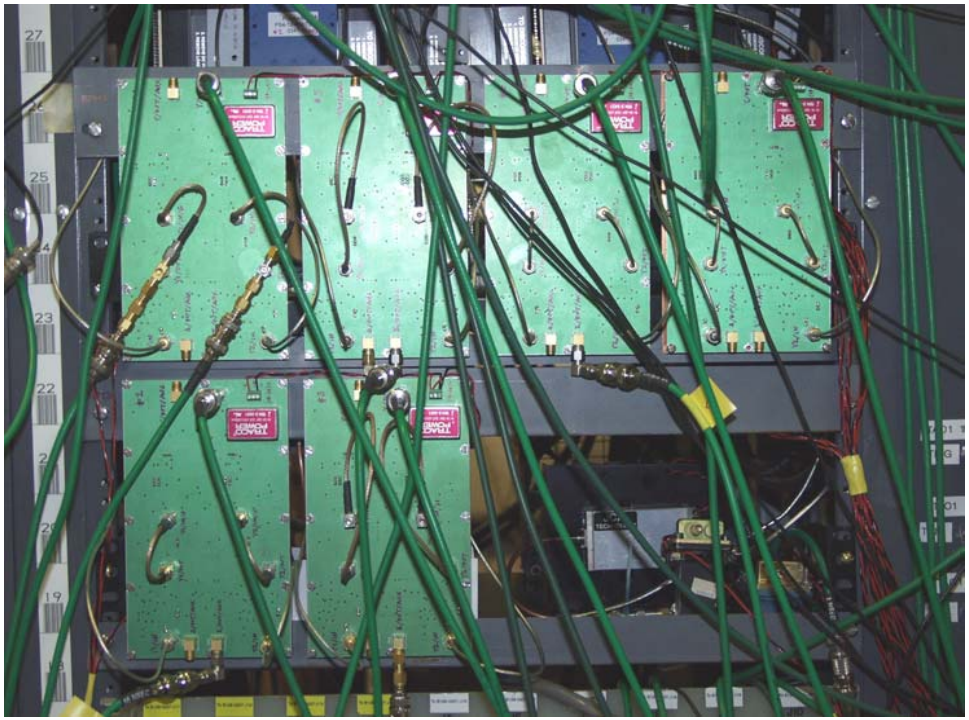
**6y+6x outside tunnel:**

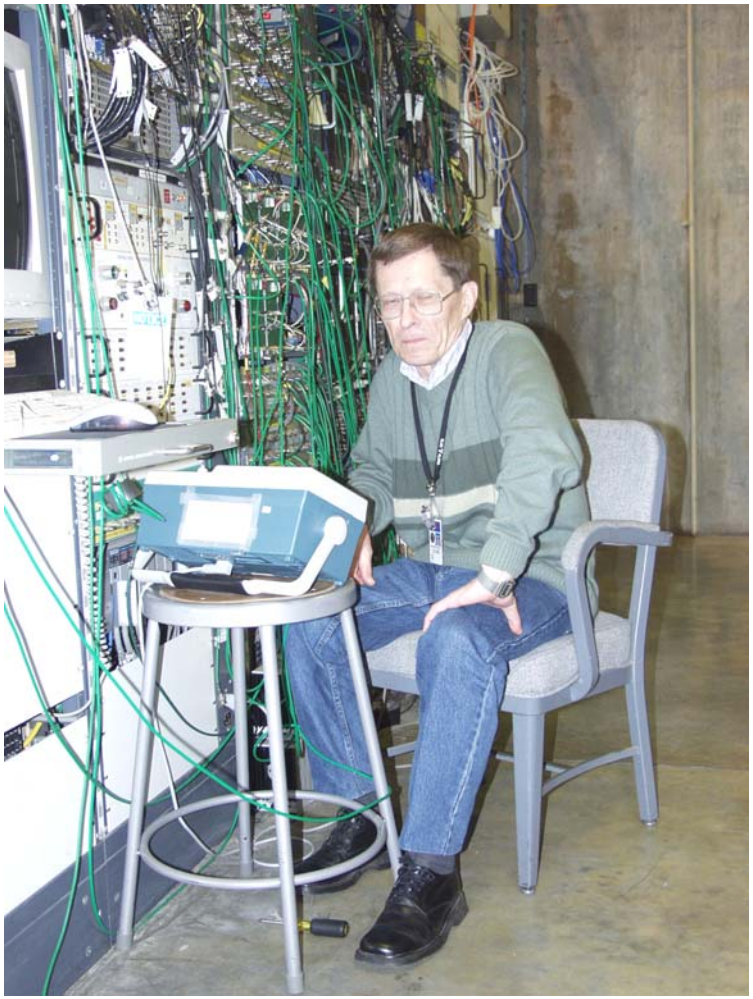


# FONT2: synchronous demodulator PCBs

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

**6 boards outside tunnel:**

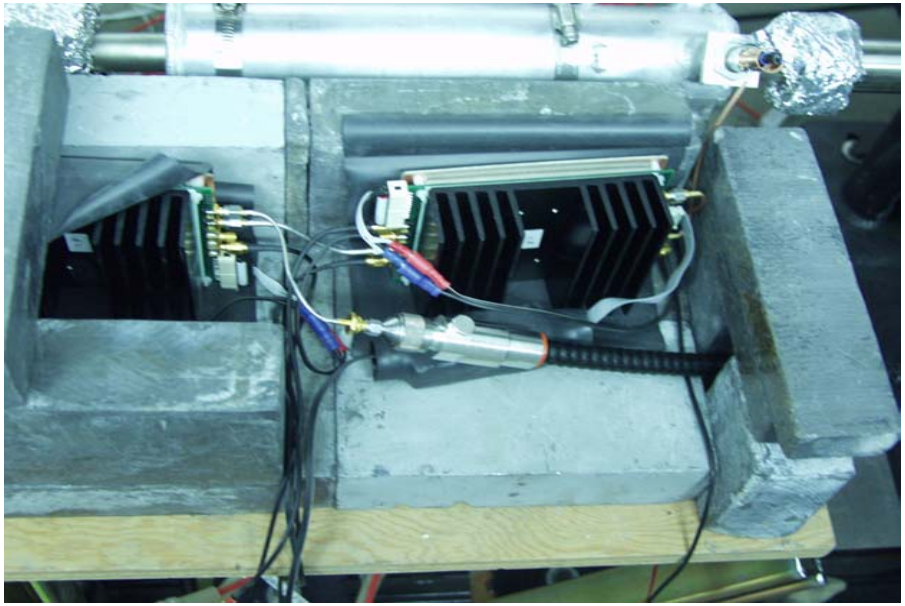




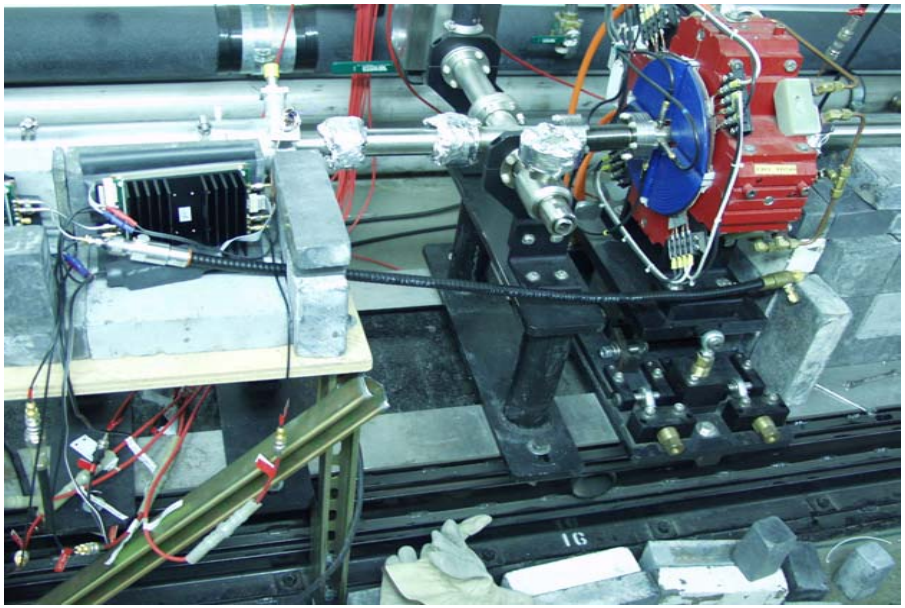
# FONT2: new solid state amplifiers

## Total drive same as last year

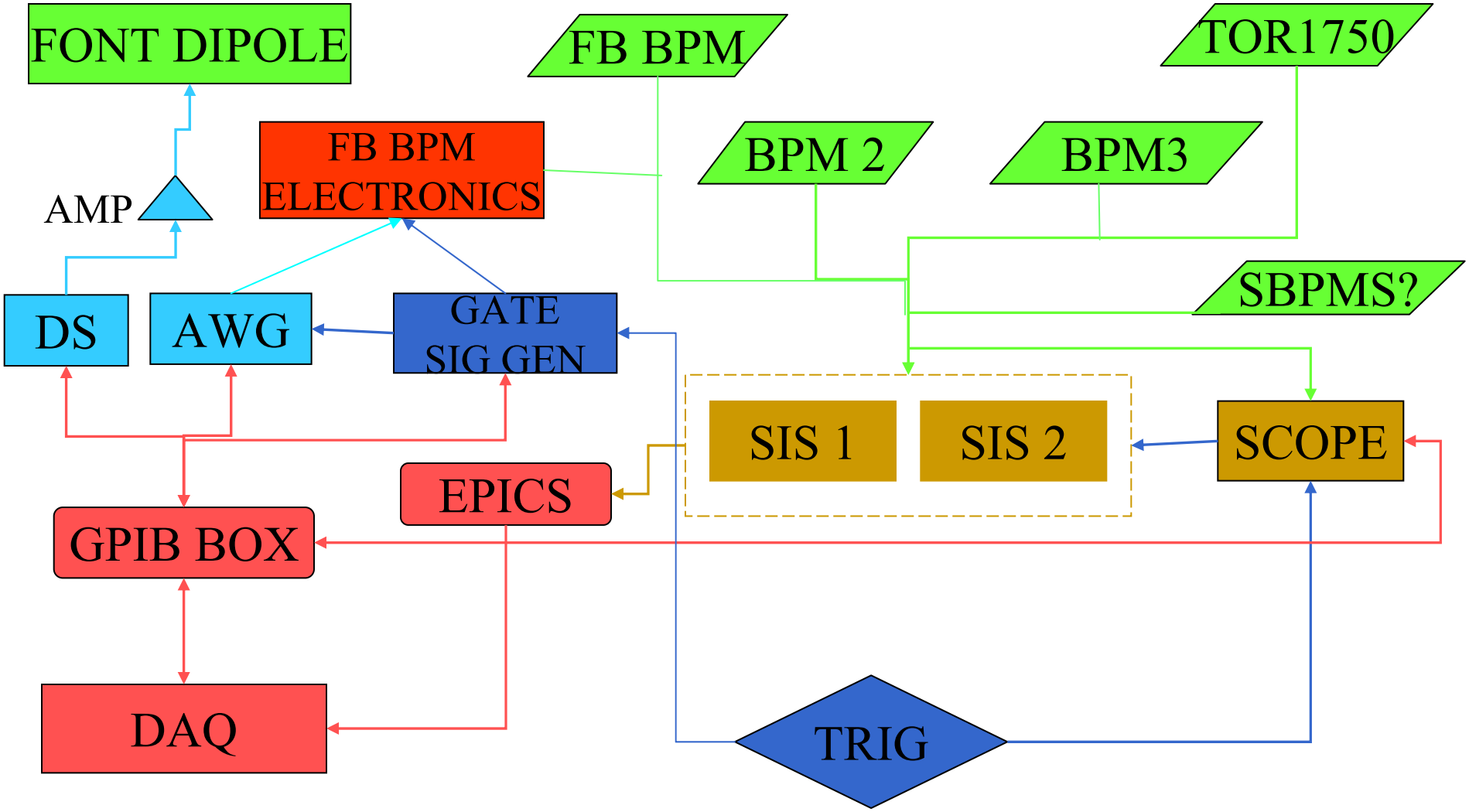
### Amplifier pair w. shielding:



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



# FONT2: new DAQ/control system



# FONT2 run Nov/Dec 2003

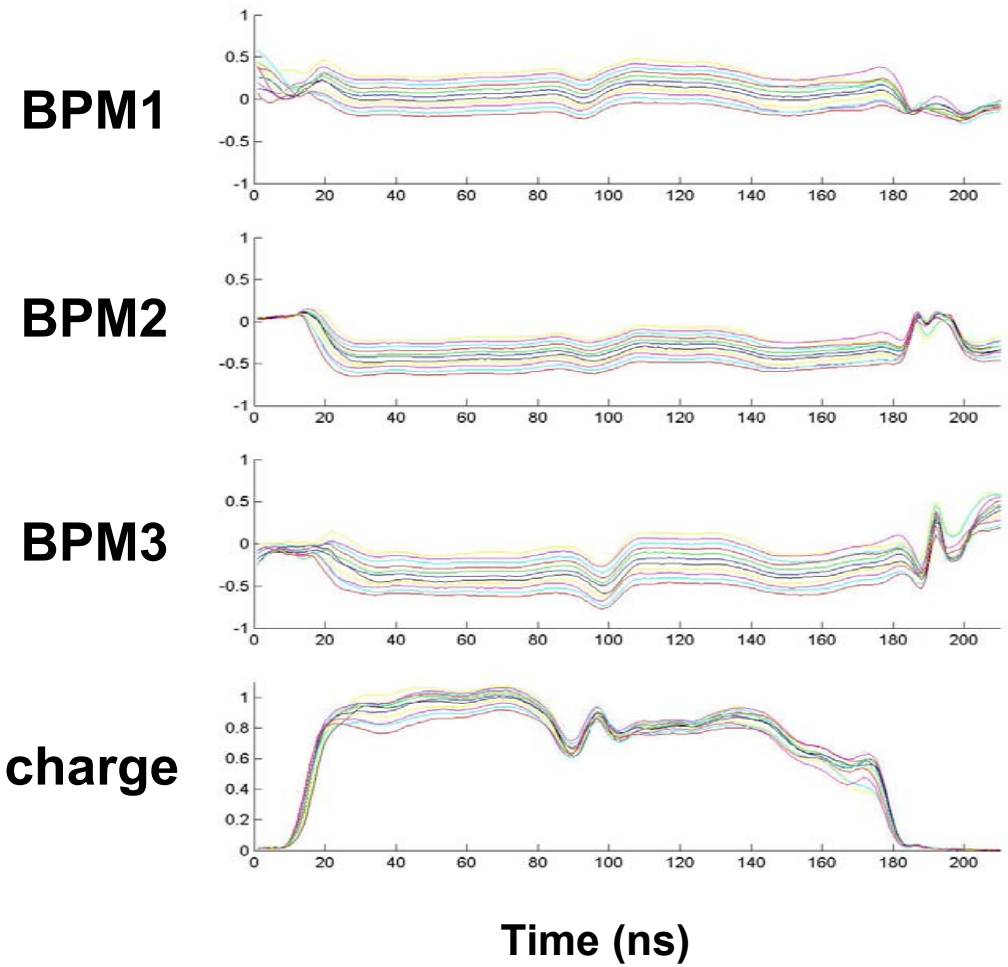
- Nov 7-9: commissioned system of 3 BPMs and new electronics
  resolution measured using 'triplets': c. 15 microns
- Opportunistic runs Nov 24 – Dec 13 (10 shifts)
  operating conditions difficult due to 8-pack + high-gradient structure tests
- Dec 3: commissioned new amplifiers, kicker, FB circuit + 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

# FONT2: first results Nov 2003

**Beam registered in all 3 BPMs w. dipole scans**

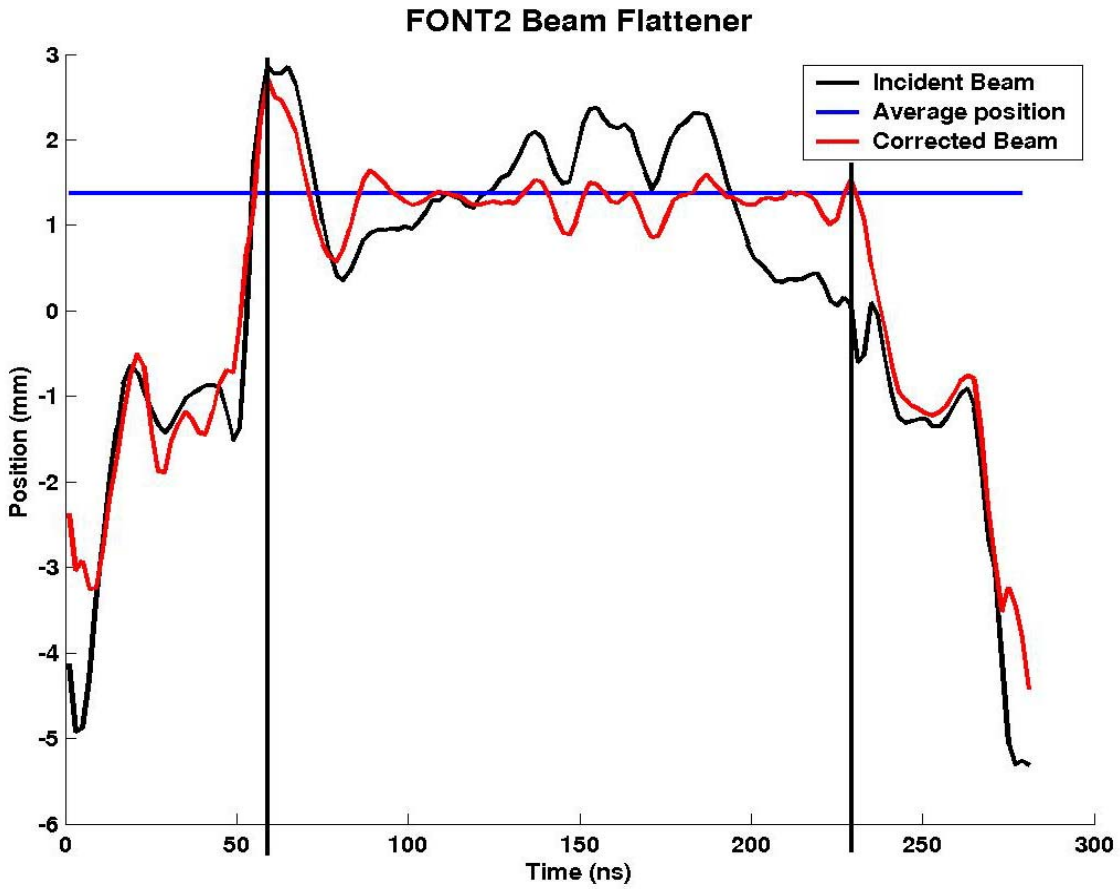
**Resolution measured:**

**c. 15 microns**



# FONT2 initial results: beam flattener

**Feedback off for illustration:**



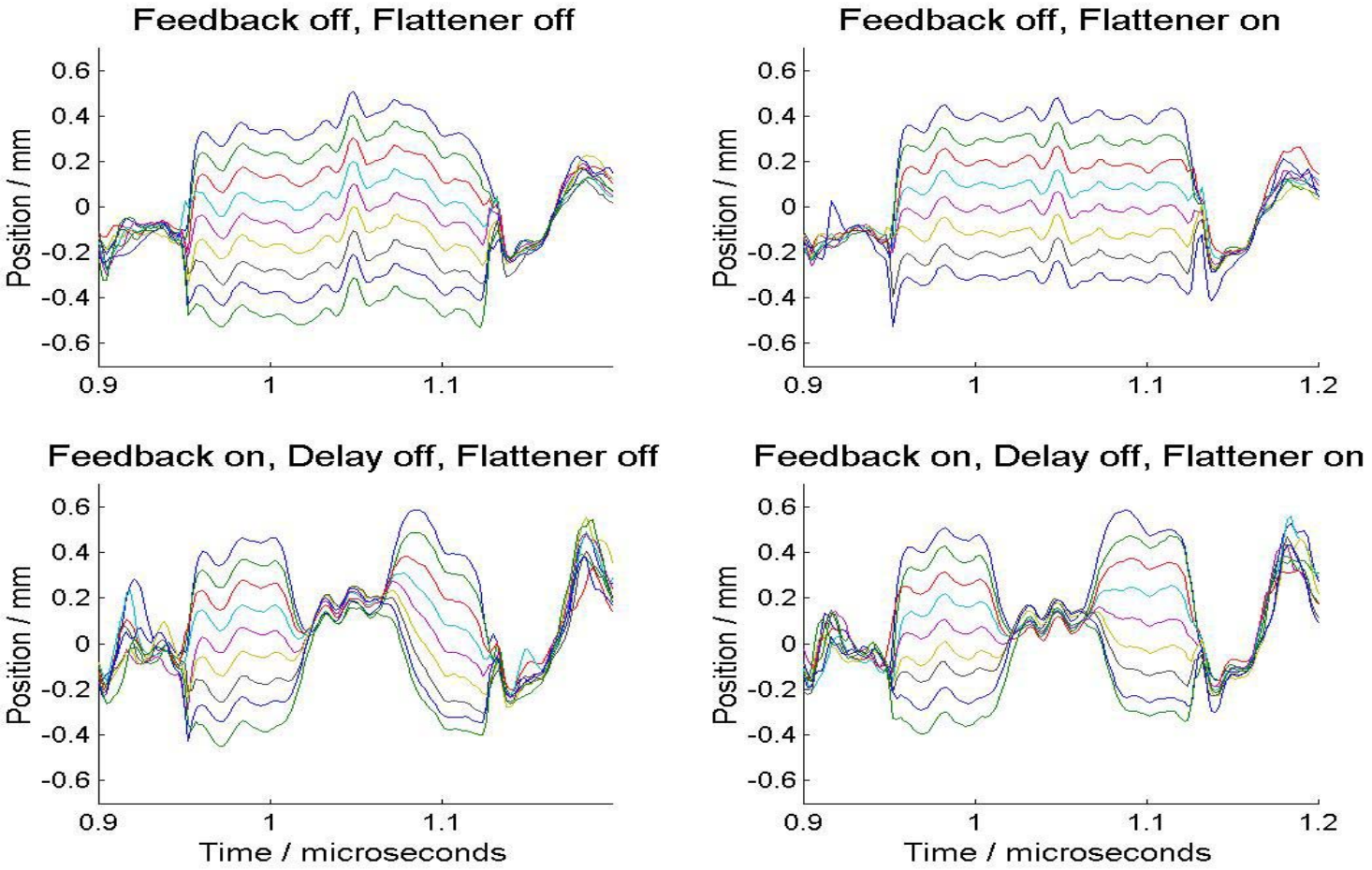

**Flattener corrects to average beam position: removes 'static' structure**

**Performance bandwidth limited:**

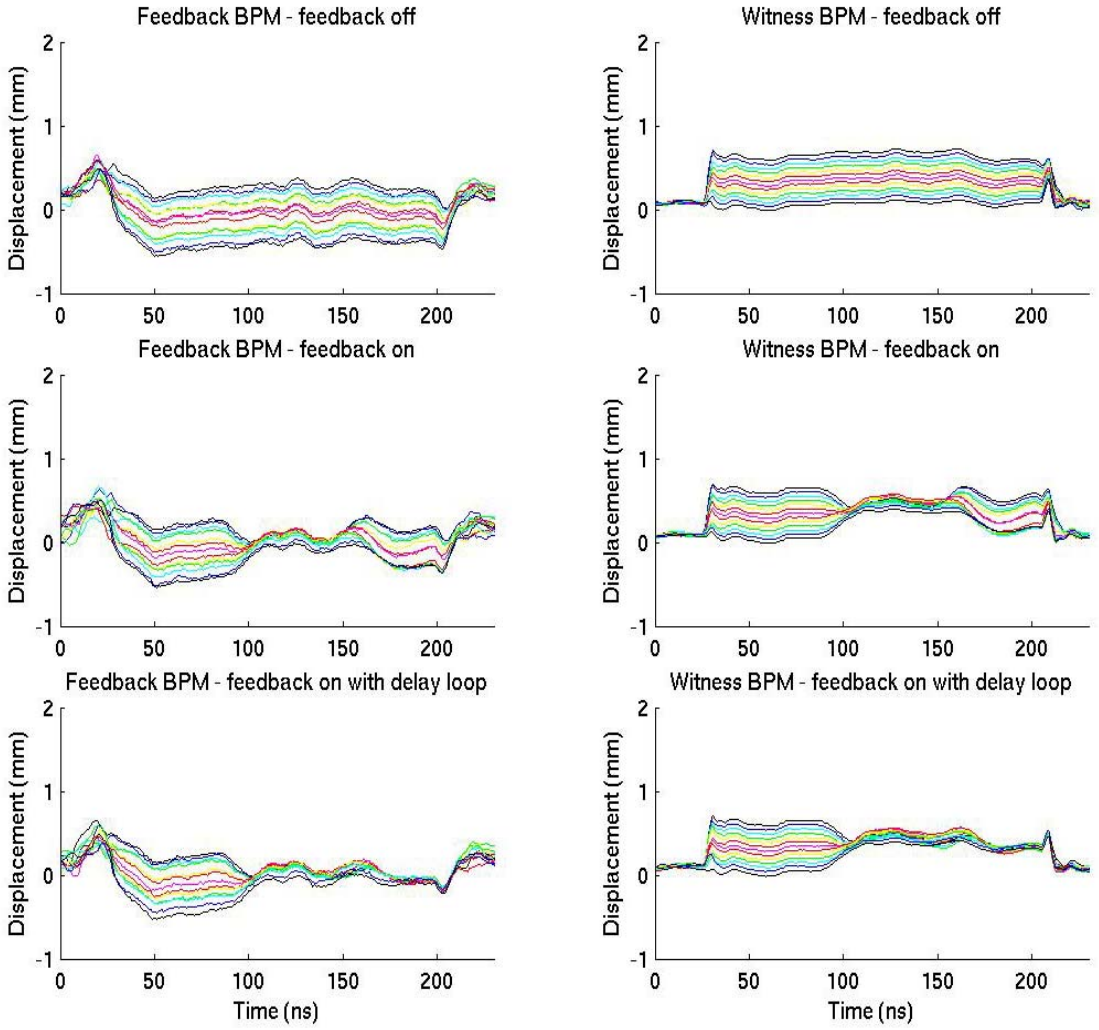
**80 MHz (AWG)**

**30 MHz (amp)**

# FONT2 initial results: beam flattener



# FONT2 initial results: feedback mode

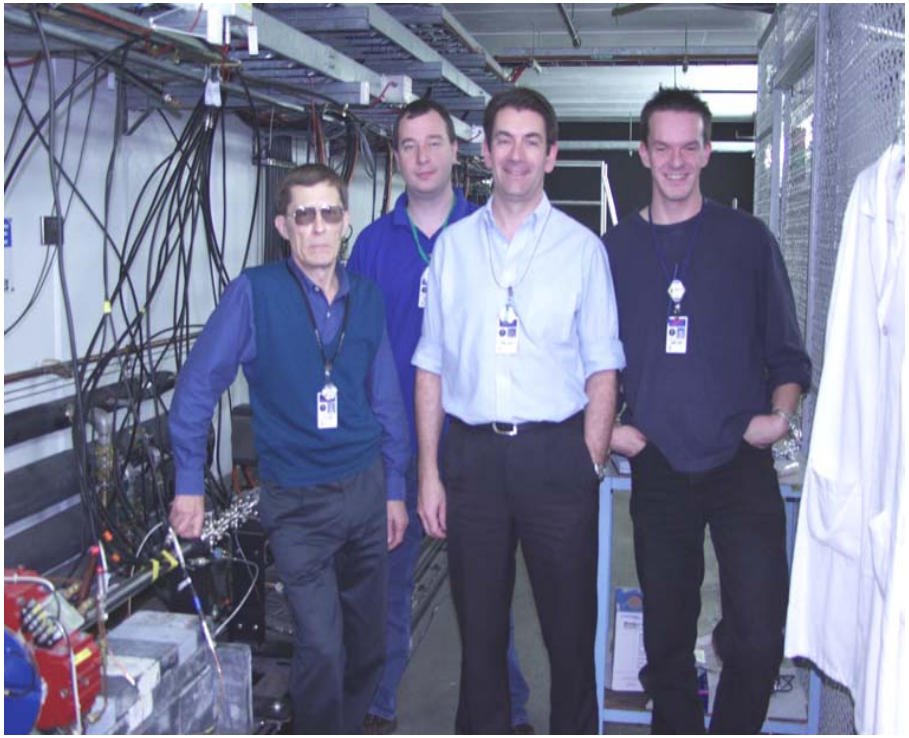


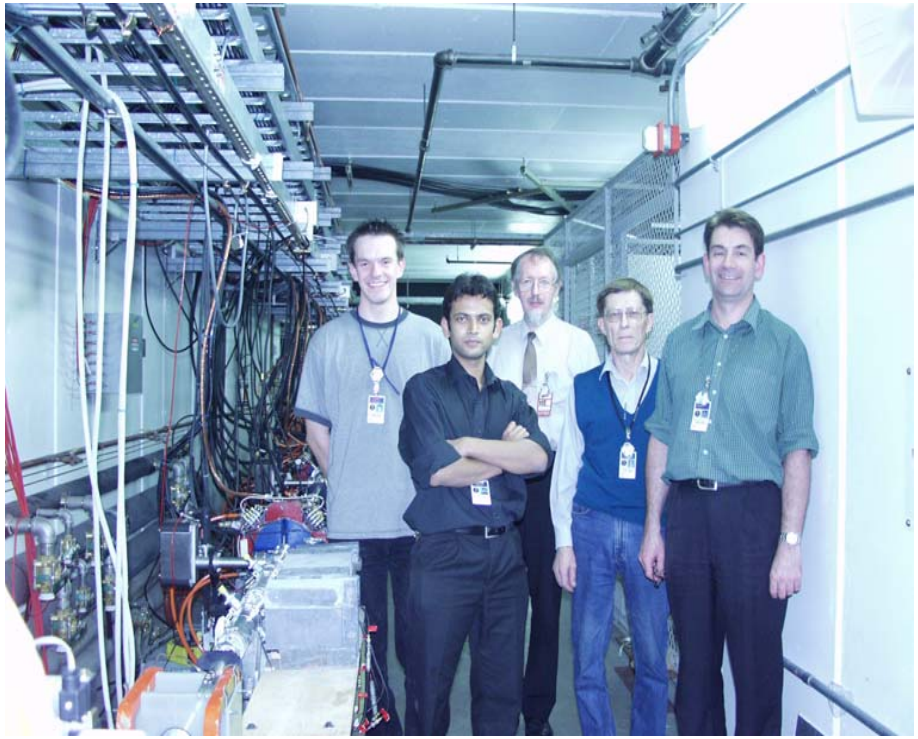

**New witness BPMs commissioned**

**System works in FF + FB modes**

**More data to analyse: stay tuned…**

# 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:**

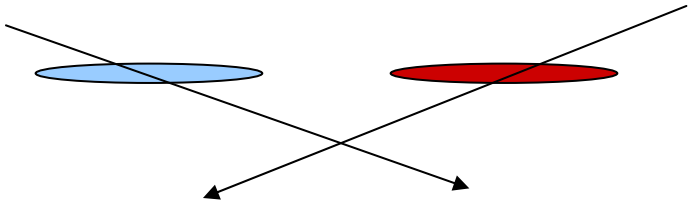
1. **Stabilisation of extracted bunchtrain at 1 micron level:**
   **low-power (< 100W), high stability amplifier**
   **stripline BPM w. ~ 1 micron resolution**
   **these are exactly what are needed for the LC!**

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**