Feedback on Nanosecond Timescale (FONT)

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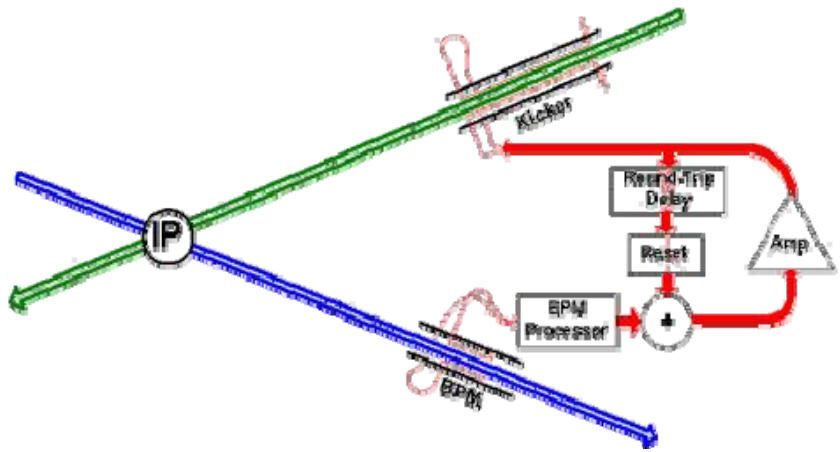
18th January 2007

Oxford (P. Burrows, C. Perry, G. Christian, T. Hartin, H. Dabiri Khah, C. Clarke, C. Swinson, B. Constance)
Daresbury (A. Kalinin)
SLAC (Mike Woods, Ray Arnold, Steve Smith)
KEK

FONT at the ILC

- The FONT group are involved in accelerator R+D for International Linear Collider.

- Purpose: To design and build prototype for intra-train feedback and feedforward, for example at IP of ILC.
- Need to demonstrate it is possible to deliver position correcting kick in ILC

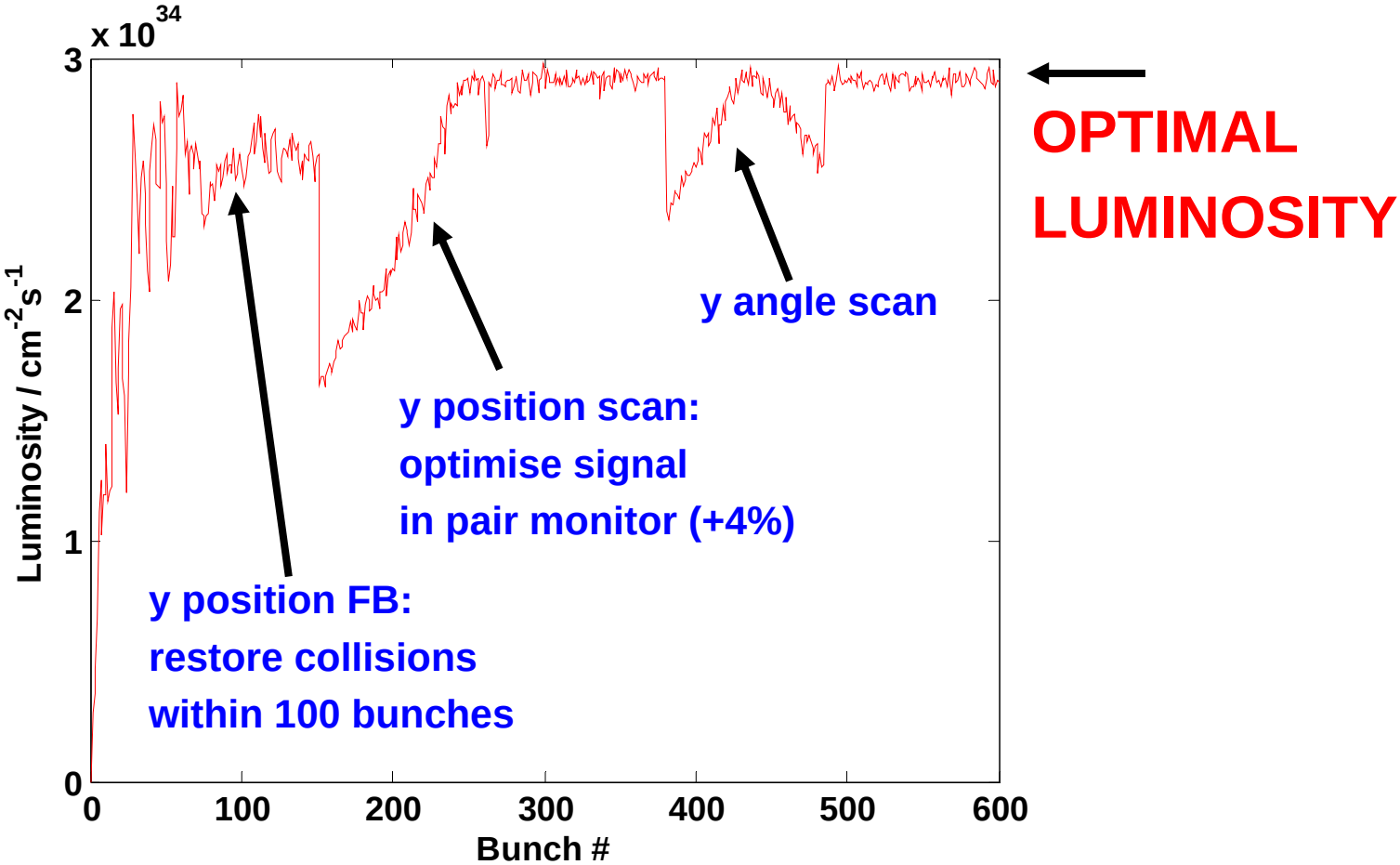


Demonstrate feedback prototype works (ATF, KEK)

Demonstrate feedback prototype works in ILC background conditions (ESA, SLAC)

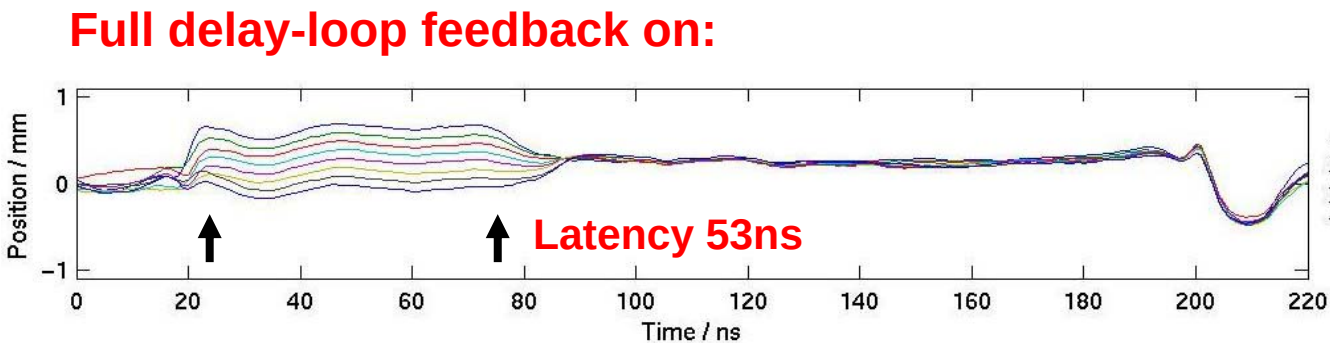
FONT at the ILC 2

- Feedback will restore luminosity at the IP.



FONT at ATF: Operation

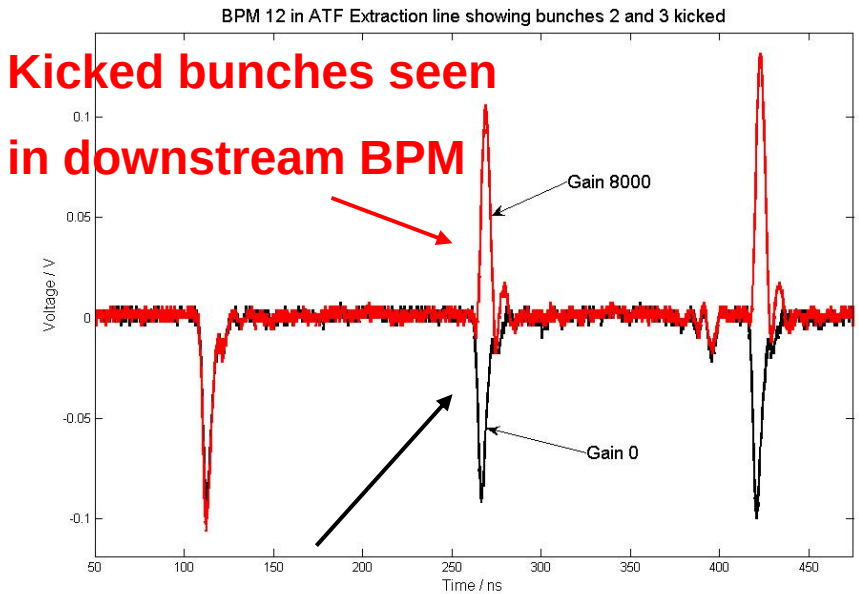
- FONT has previously demonstrated beam position correction in 53ns at NLCTA and 23ns at ATF using an analogue processor.



- Since cold technology decision, we have more time between bunches to digitise the analogue signal and use algorithms to correct position more effectively.
- The amplifier is custom built (TMD Technologies).
- We require ILC-like bunches and bunch-spacing. Plus three BPMs for calibration and watching the feedback at work.

FONT at ATF: Results

- Recently tested the digital processor and the amplifier.
- We had three bunches at 140-154ns bunch spacing.
- The beam position signal of one bunch was digitised and fed back through an amplifier to a kicker upstream.
- Downstream BPMs showed bunches 2 and 3 were successfully kicked.

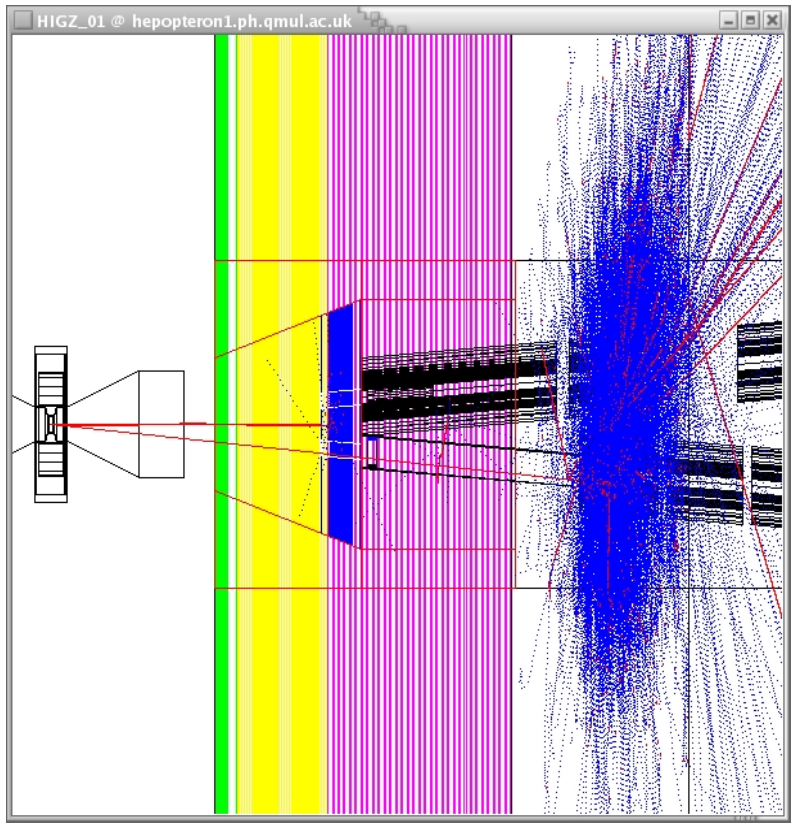


FONT at ATF and ATF2: Future

- Continue with current plans to close the feedback loop in March/April 2007.
- Develop better resolution processors (currently 5μm, require 1μm) with striplines, if possible. If not, cavities.
- Correct for x,x',y,y' using 4 BPMs and kickers (2008).
- Demonstrate feedback works with long ILC train of 20-60 bunches (2009).
- Implement feedback algorithms.
- Integrate feed-forward from the ring to the extraction line.
- In the future, the FONT system will be used for stabilisation in y at the ATF2 Interaction Point.

FONT at ESA: The ILC Environment

- The BPM sits in an area where there are lots of low energy particles.
- Simulations by Tony Hartin (Oxford) show high fluxes of charged particles (up to 10^5)
  - Are simulations correct down to low energies?



- Charges being added or removed from the BPM causes errors (1pm per charge – Steve Smith).
- FONT requires resolution on the micron level.

FONT at ESA: Module

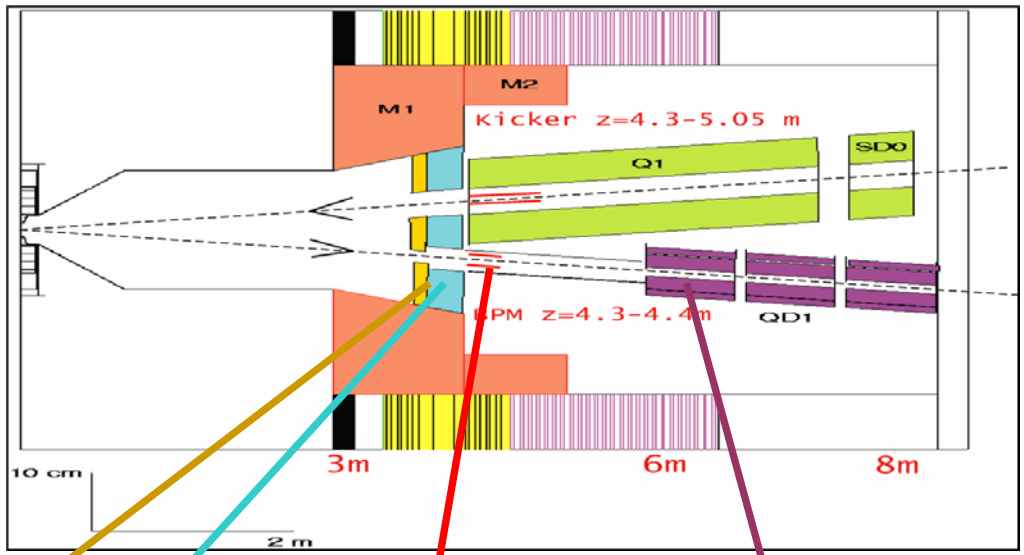
- Recreate the environment around the BPM
  - (Match the particles entering the region)
  - Match the materials in the region
- Constructed at Daresbury.

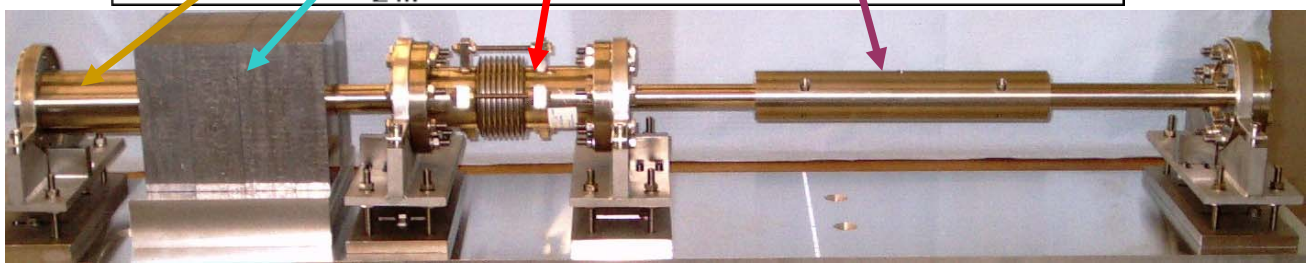
Low Z Mask

Beam Cal

Stripline BPM

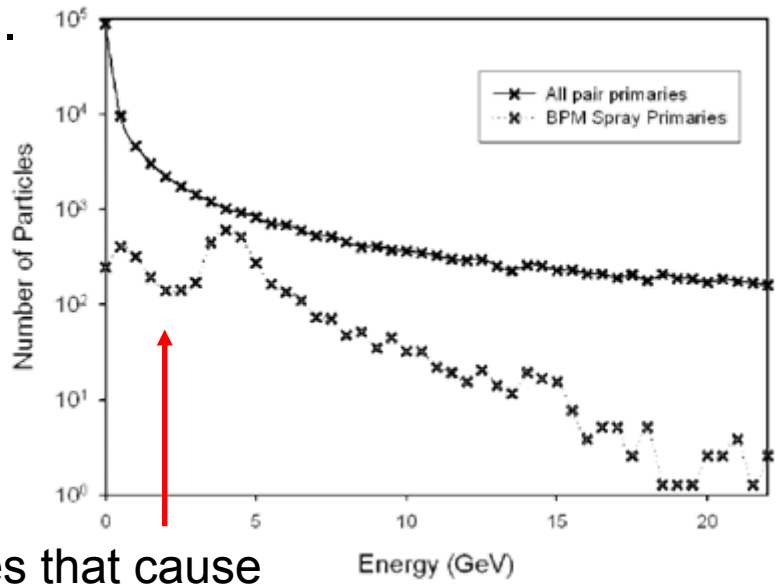
QD1 Pole face





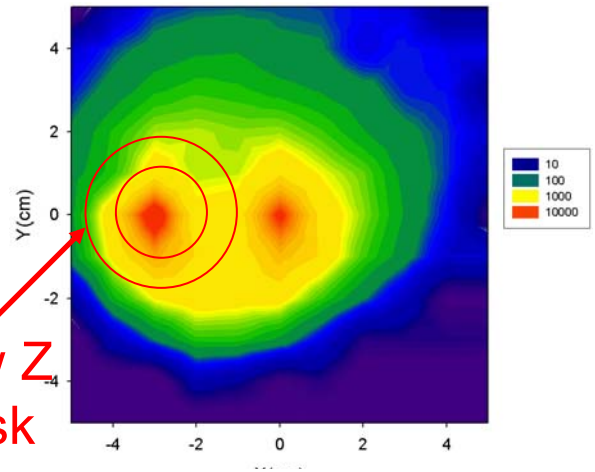
FONT at ESA: Requirements

- ILC conditions impossible to replicate but we can identify the parts that matter- energies and fluxes of particles that cause hits on BPM striplines.
- We require electrons and positrons of average 4 GeV impacting front face of module as well as the original electron beam.



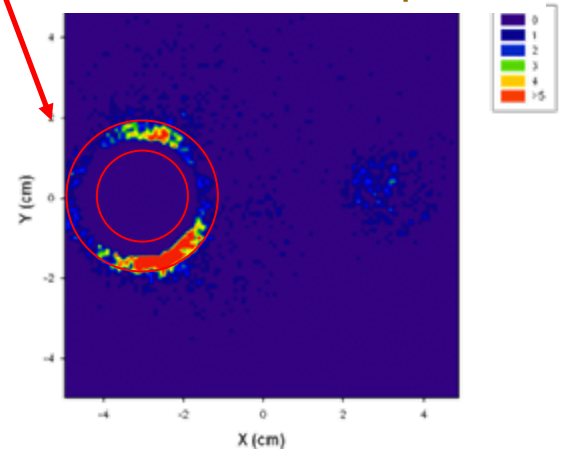
The charges that cause hits on the striplines peak around 4 GeV

All charges at the ILC



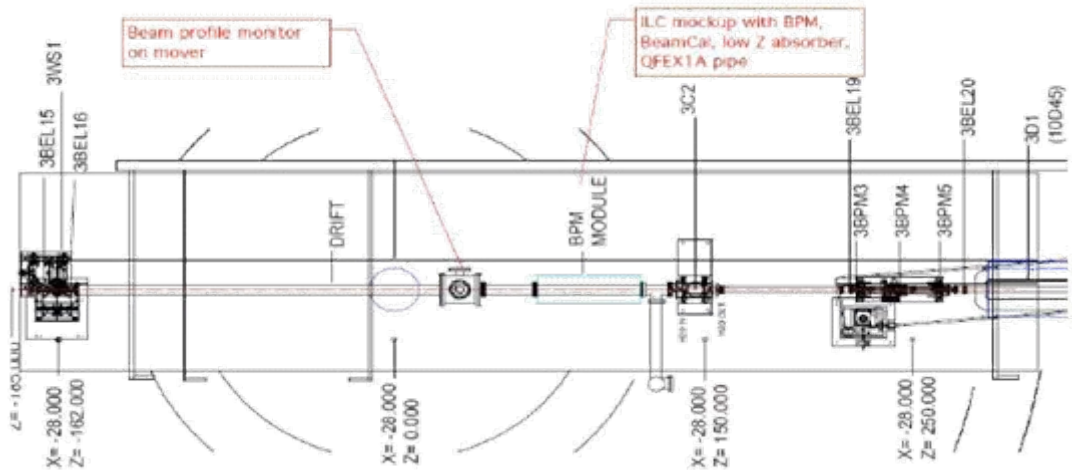
Low Z Mask

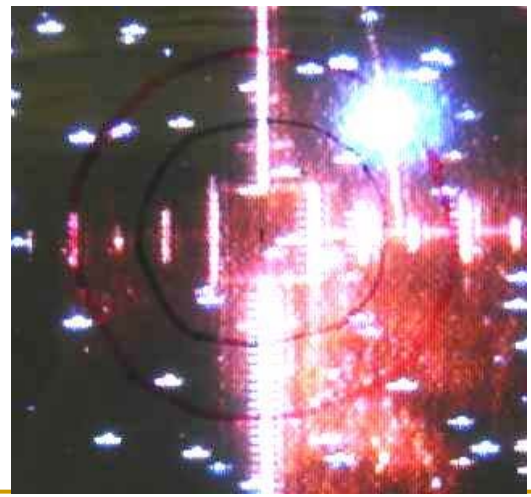
Charges that go on to cause hits on striplines



FONT at ESA: Method 1

- Used optics to increase size of the 28.5 GeV electron beam at ESA.
- CCD camera to aid positioning beam spot on the front face of the module.
- A Low Flux Toroid monitored current down to 10^6 electrons.
- Although we had higher fluxes than ILC backgrounds, we assumed we could scale the results accordingly.
- The beam did not illuminate the whole mask. We assumed we could superimpose results from different locations.

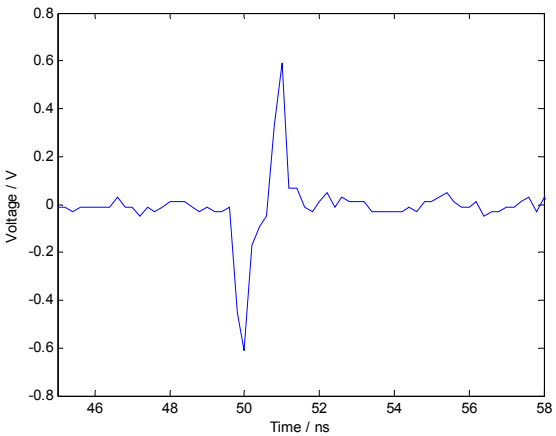




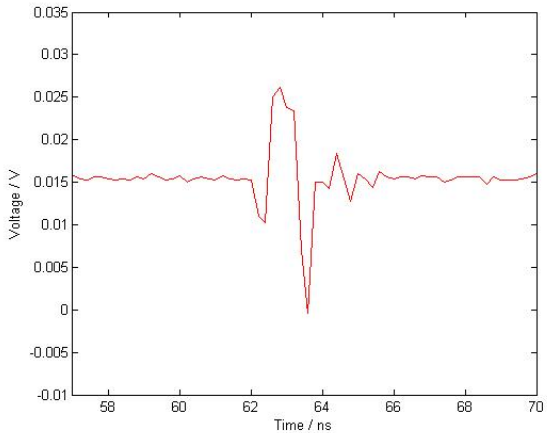
FONT at ESA: Method 1 Results

- Despite energy disparity, GEANT simulations suggest the charges hitting the strips are similar to those at ILC.
- Signals with the beam on the Low Z mask were different from BPM stripline signal- suggestive of secondary emission.

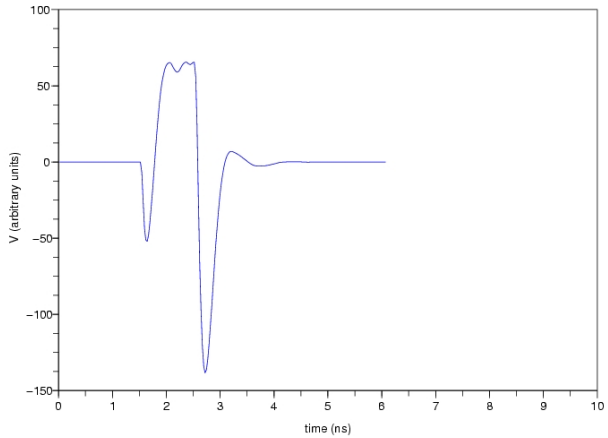
Typical stripline signal



Real Data from ESA



Simulation (T. Hartin)

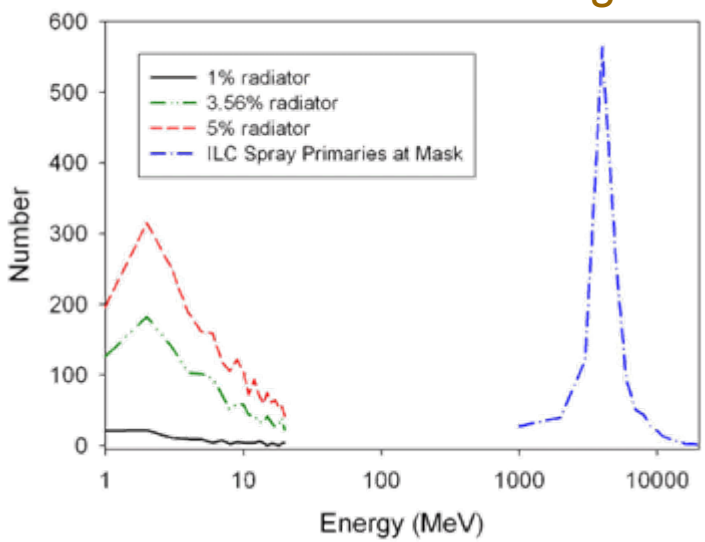


- Simulating these results in GEANT has had some success but is problematic as secondary emission is a few eV and the cutoff in GEANT is 100eV.
- The signals caused by secondary emission were not large enough to cause problems for the operation of the stripline BPM.

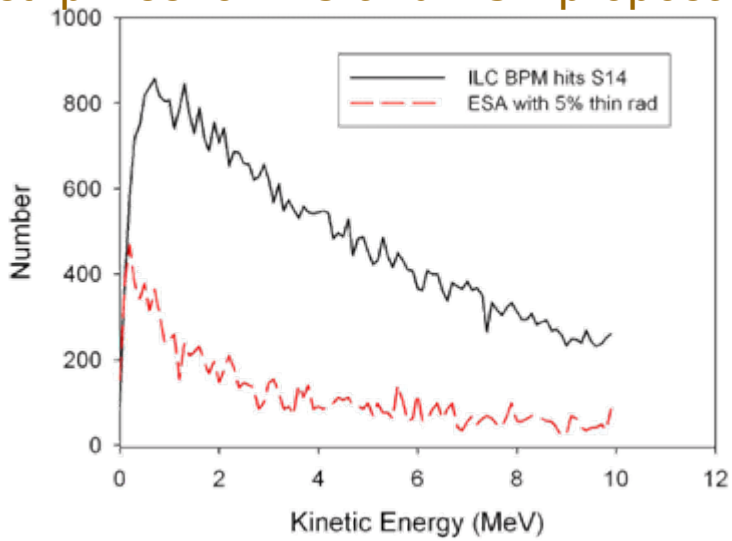
FONT at ESA: Method 2

- Planning for March, we intend to deliver both electrons and positrons as a halo around the main electron beam using thin radiators just upstream of module.
- The energies of charges hitting the module do not match.
  - GEANT simulations show this does not affect the energy distribution of what hits the striplines.
- Can make numbers match.

Energy spectra from Aluminium Radiators and ILC charges



Energy spectra of charges hitting BPM striplines for ILC and ESA proposal

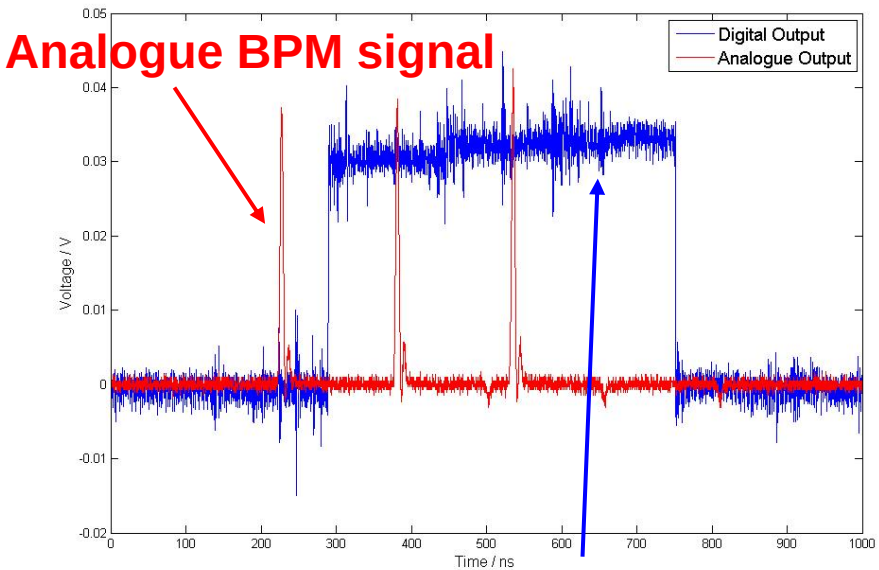


FONT: Summary

- Work is ongoing at ATF and ATF2 (KEK).
  - For feedback, FONT can use any energy above 10 MeV.
  - ILC bunch charge.
  - ILC bunch spacing.
  - ILC bunch train length.
  - Low bunch to bunch jitter.
- Work at ESA (SLAC) will continue in 2007.
  - Ability to simulate IR backgrounds.
  - Other beamline elements can be tested there.

FONT Digital Set-up

Stripline → Analogue Processor → Digital Processor → Amplifier → Upstream Kicker



Digitised BPM signal

FONT at ESA: Method 3 (no plans to use this method)

- To match energies and fluxes, we propose Be target in BSY.
- We can select only 4 GeV electrons.
- We can fill the entire beampipe with electrons so illuminating the whole front face of the module. Collimators and optics control the shape.
- We can change fluxes to match ILC backgrounds or to make them a factor of ten worse.
- We only have spray- no primary beam to measure.