THE FEEDBACK ON NANOSECOND TIMESCALES (FONT) PROJECT: OPTIMISING THE LINEAR COLLIDER LUMINOSITY

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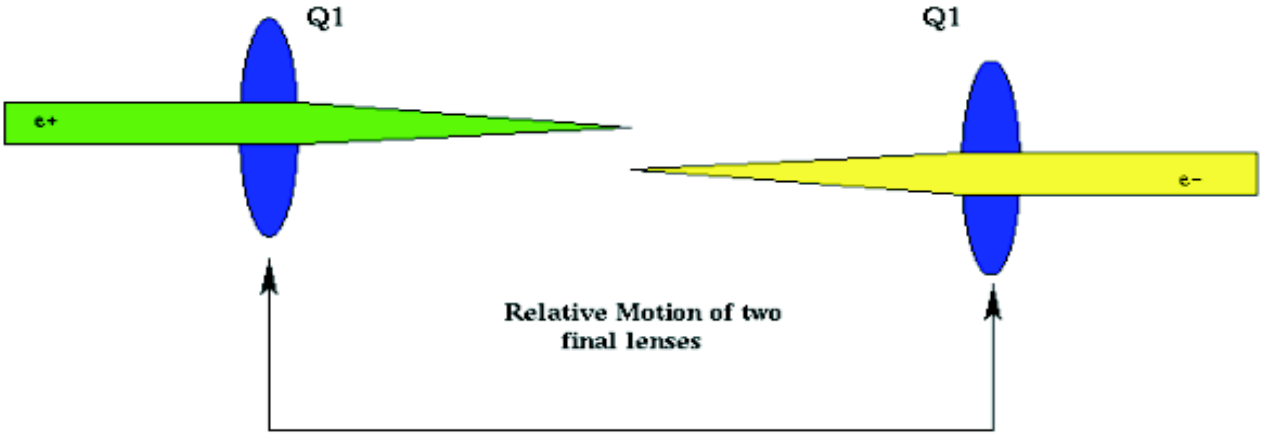
THE LC LUMINOSITY CHALLENGE

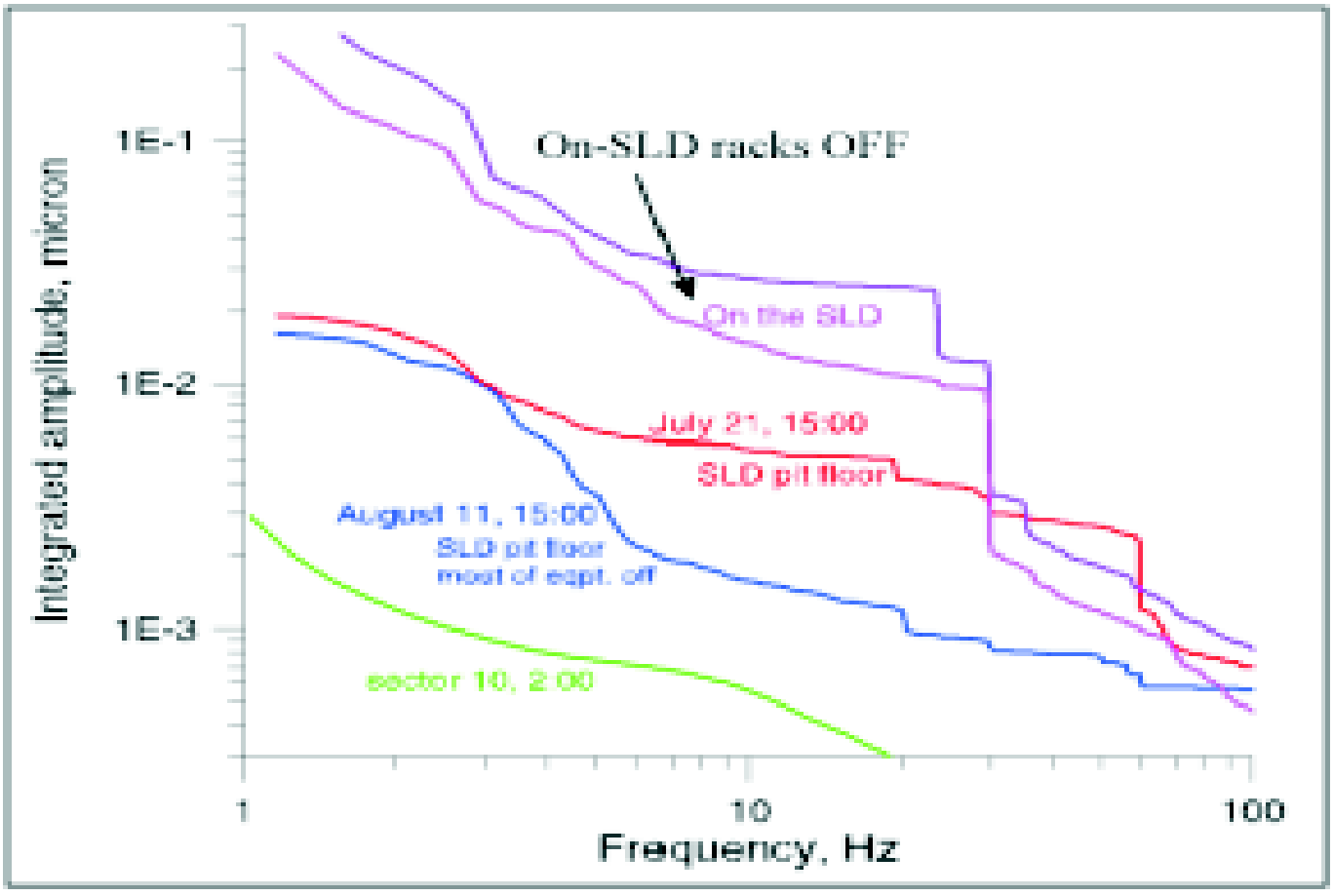
Machine	E (GeV)	$\mathcal{L}$ ($/cm^2/s$)	x size (nm)	y size (nm)
SLC	**100**	10^{30}	**1400**	**600**
TESLA	**500**	3×10^{34}	**500**	**5**
N/JLC	**500**	2×10^{34}	**300**	**5**
CLIC	**3000**	10^{35}	**40**	**1**

$\Rightarrow$ **Next-generation machines need nm-scale vertical beam sizes**

GROUND MOTION

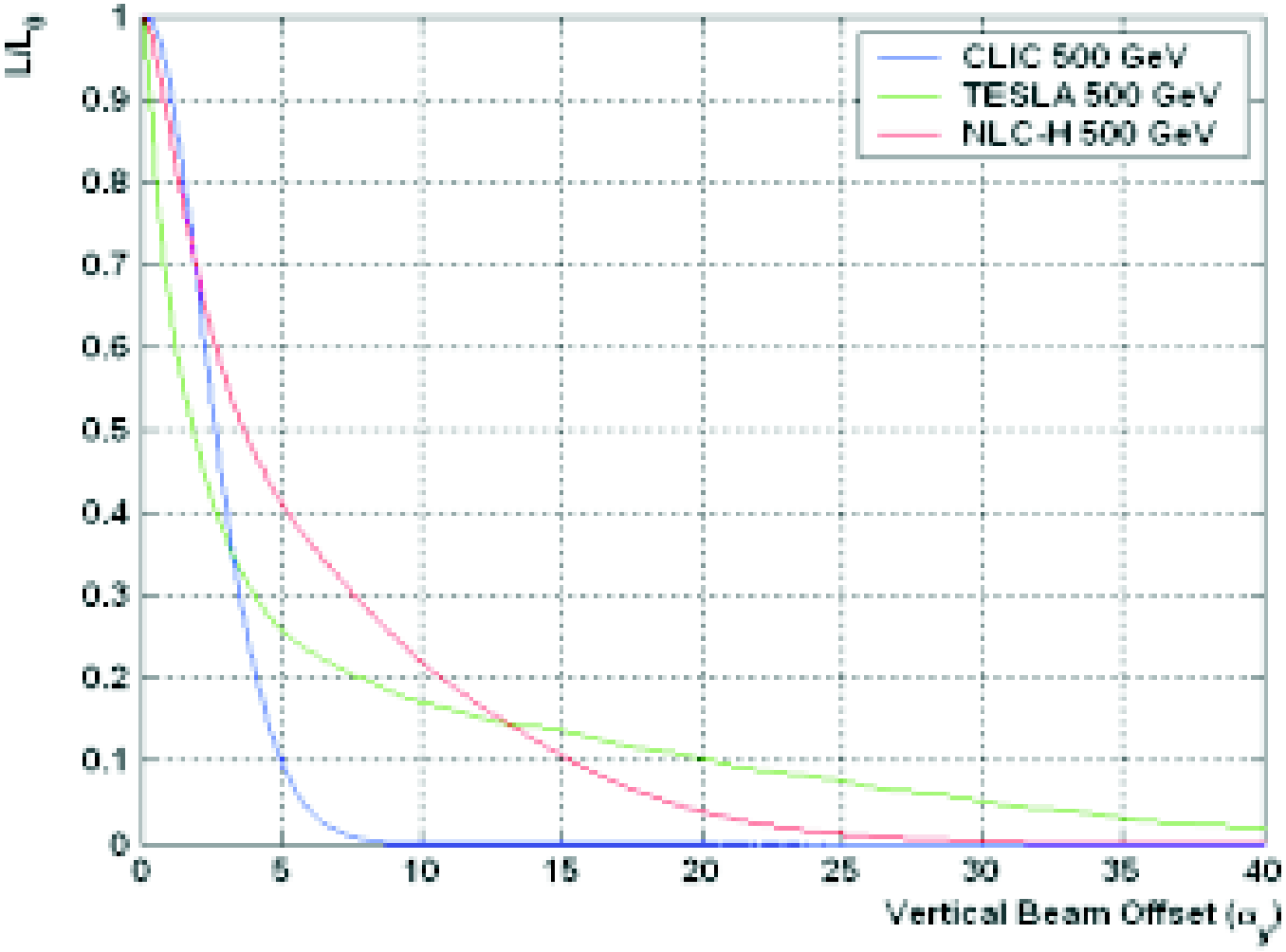


SLC ground motion data:



LUMINOSITY LOSS
DUE TO BEAM OFFSET

Oxford 'GUINEA PIG' simulations:



FAST IP FEEDBACK

- **Useful $\Rightarrow$ intra-train**

- **Bunch separation Δt:**

Machine	Δt (ns)	# bunches
TESLA	337	2820
NLC	1.4	190
CLIC	0.67	154

$\Rightarrow$ Feedback On Nanosecond Timescales (FONT)

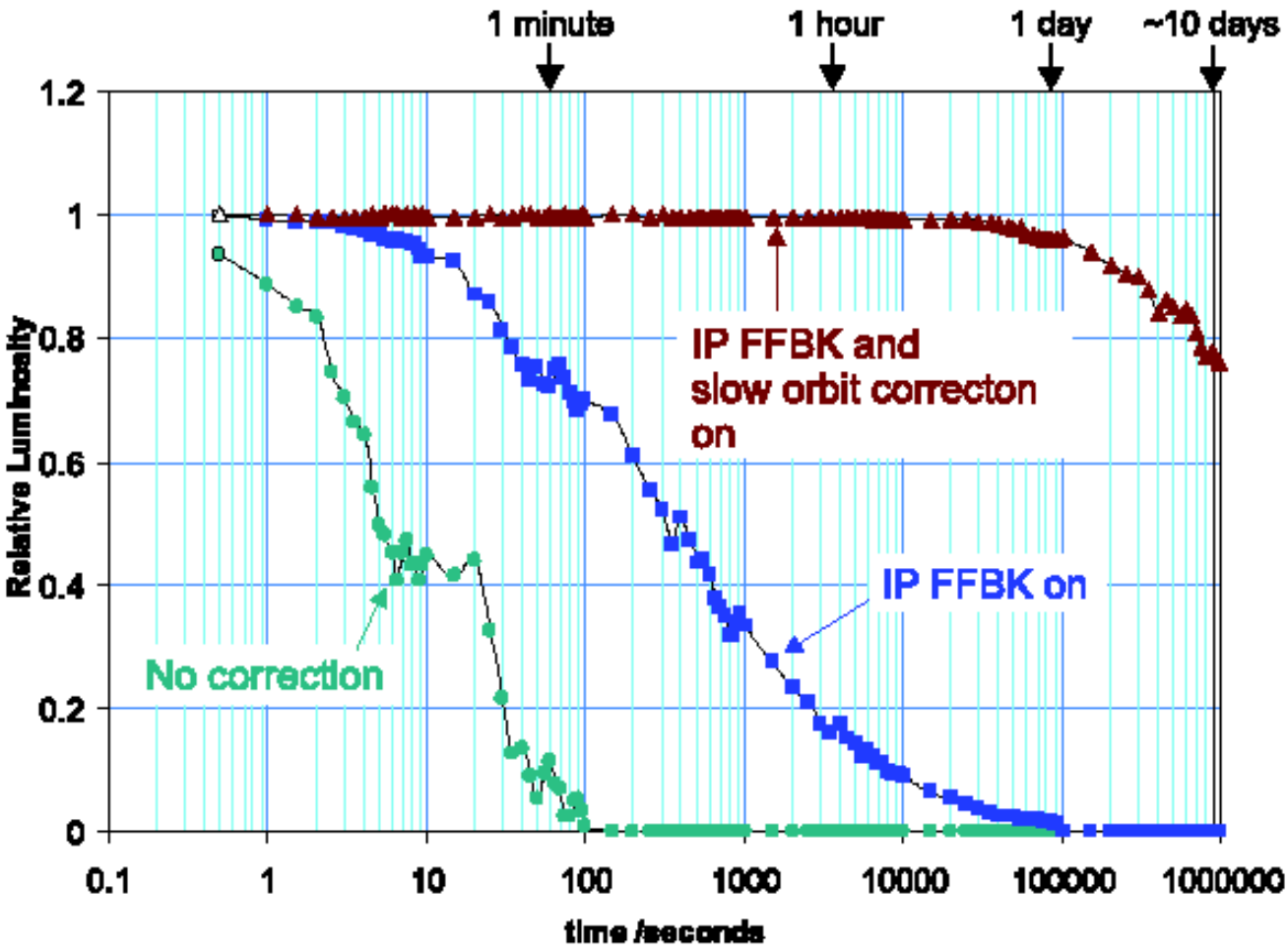
- **1ns $\equiv$ 1 foot**

$\Rightarrow$ compact system very close to IP

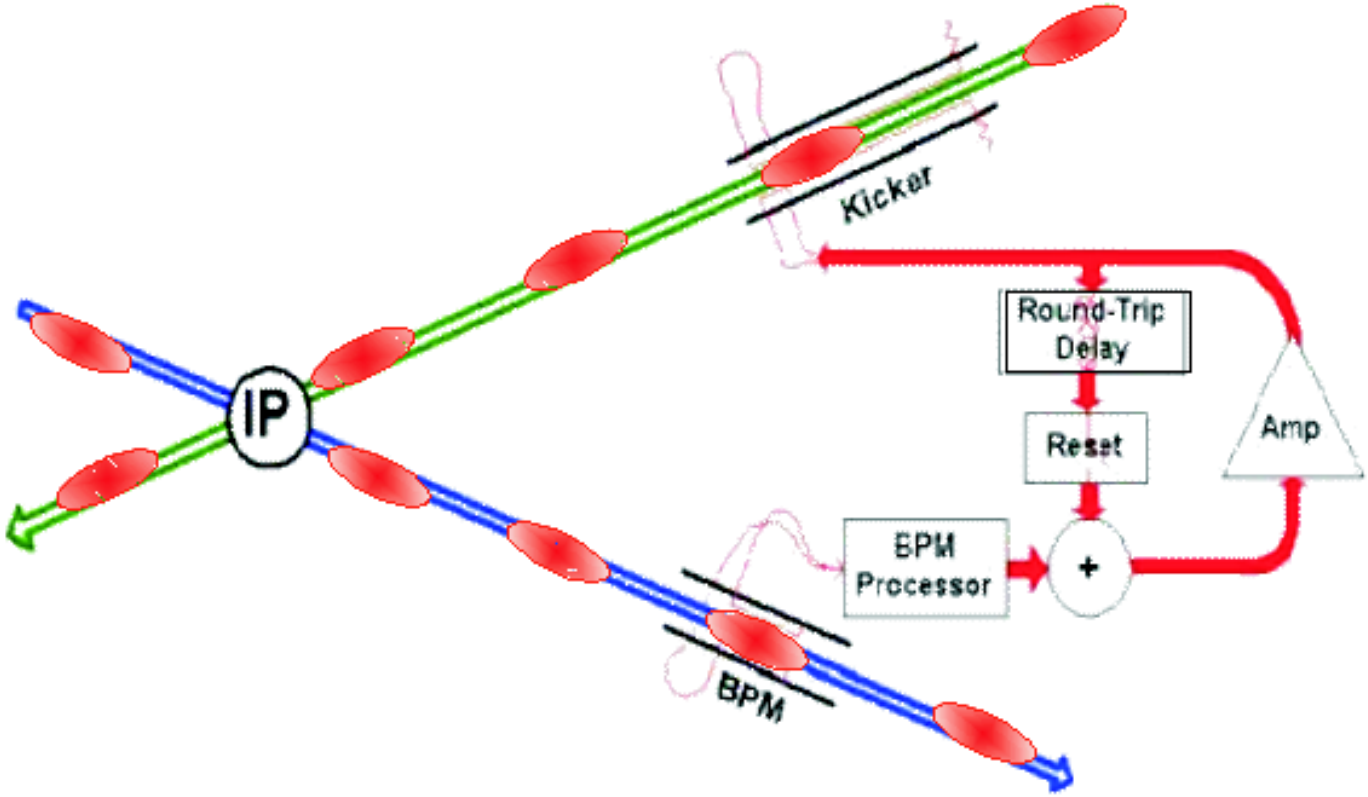
analogue electronics (J/NLC, CLIC)

EFFECT OF FEEDBACK ON LUMI

TESLA case (N. Walker/A. Wolski):



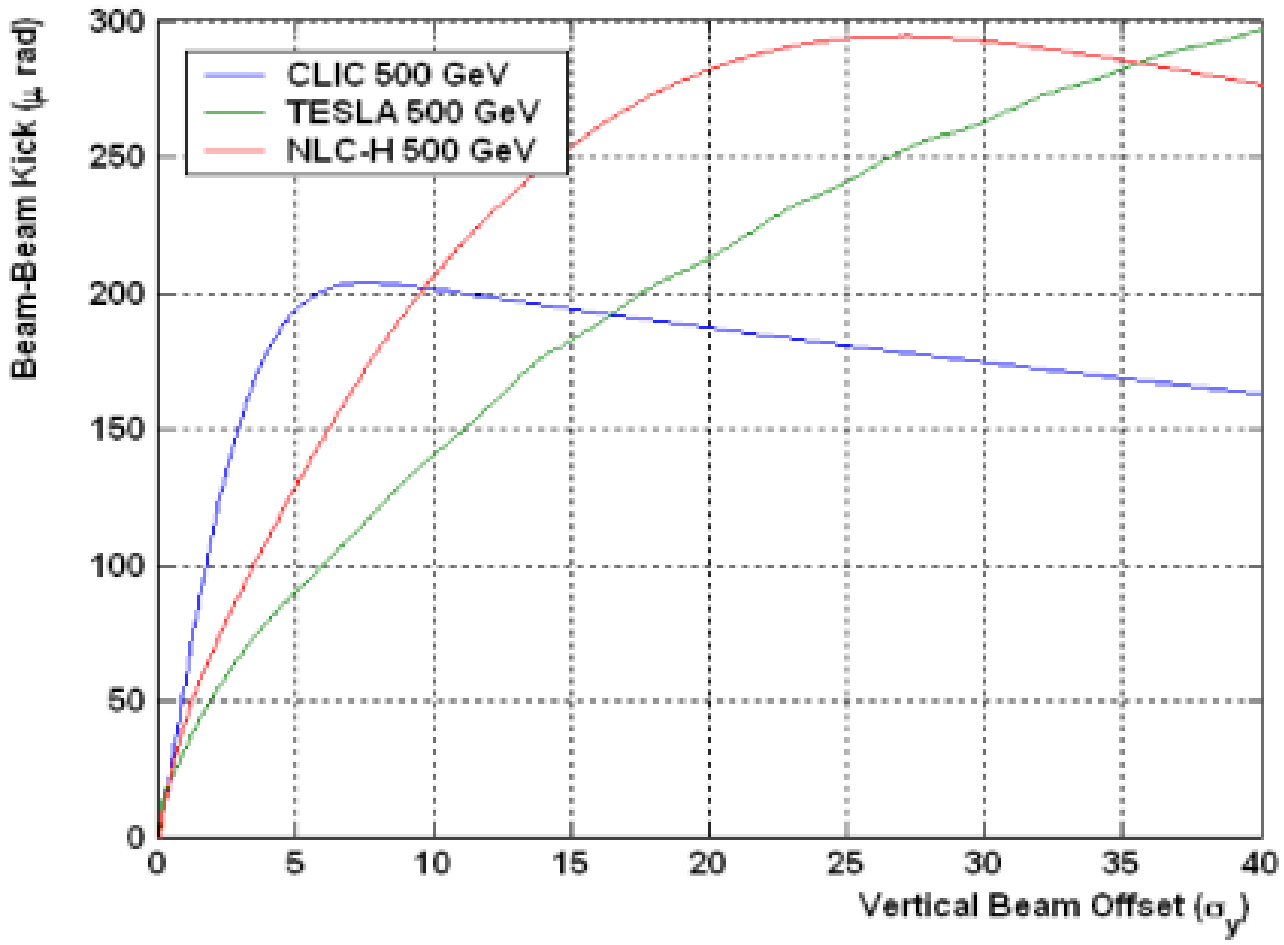
CONCEPTUAL FONT LAYOUT: IR WITH CROSSING ANGLE (JLC, NLC, CLIC)



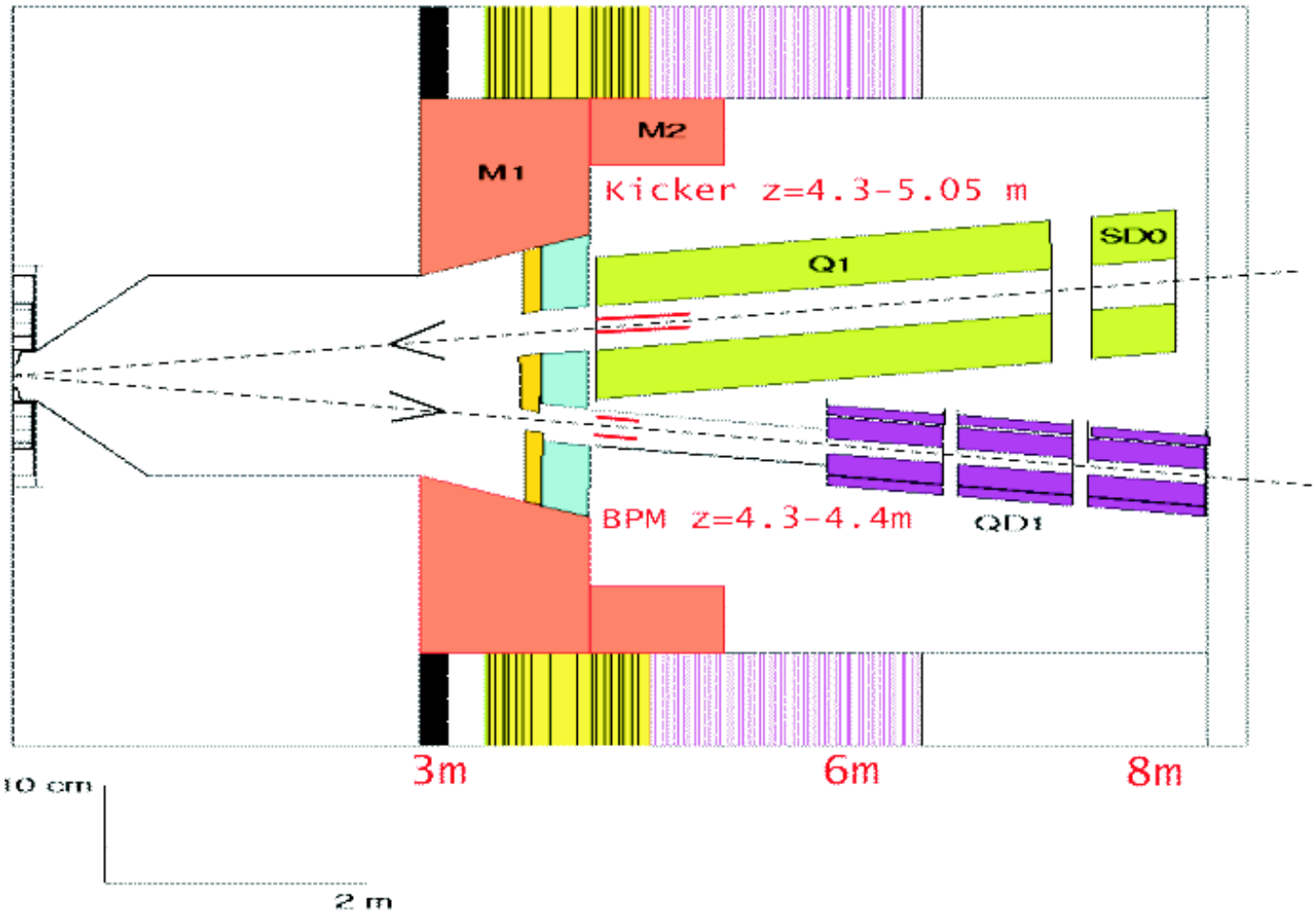
(M. Breidenbach, G. Haller, S. Smith)

BEAM-BEAM INTERACTION: INPUT TO THE FB SYSTEM

Oxford 'GUINEA PIG' simulations:



FEEDBACK SYSTEM COMPONENTS IN NLC IR LAYOUT



Component placement critical:

Minimise system latency

Minimise e^+e^- flux @ BPM

Minimise back-splash into VXD + tracker

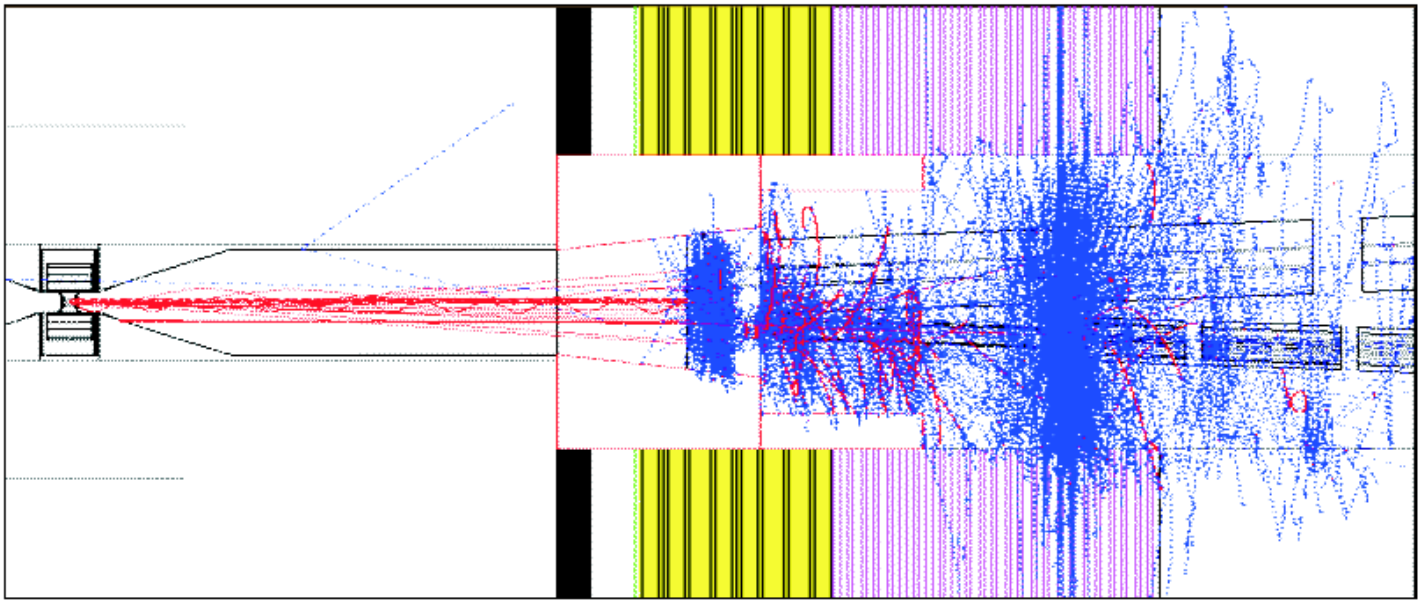
IR BACKGROUNDS

50,000 e^+e^- per bunch crossing

EM showers ⇒ backsplash in detector

Photoproduction of neutrons

Oxford simulation: 20 e^+e^- pairs (!):



No significant increase of:

VXD or tracker hits

neutron flux

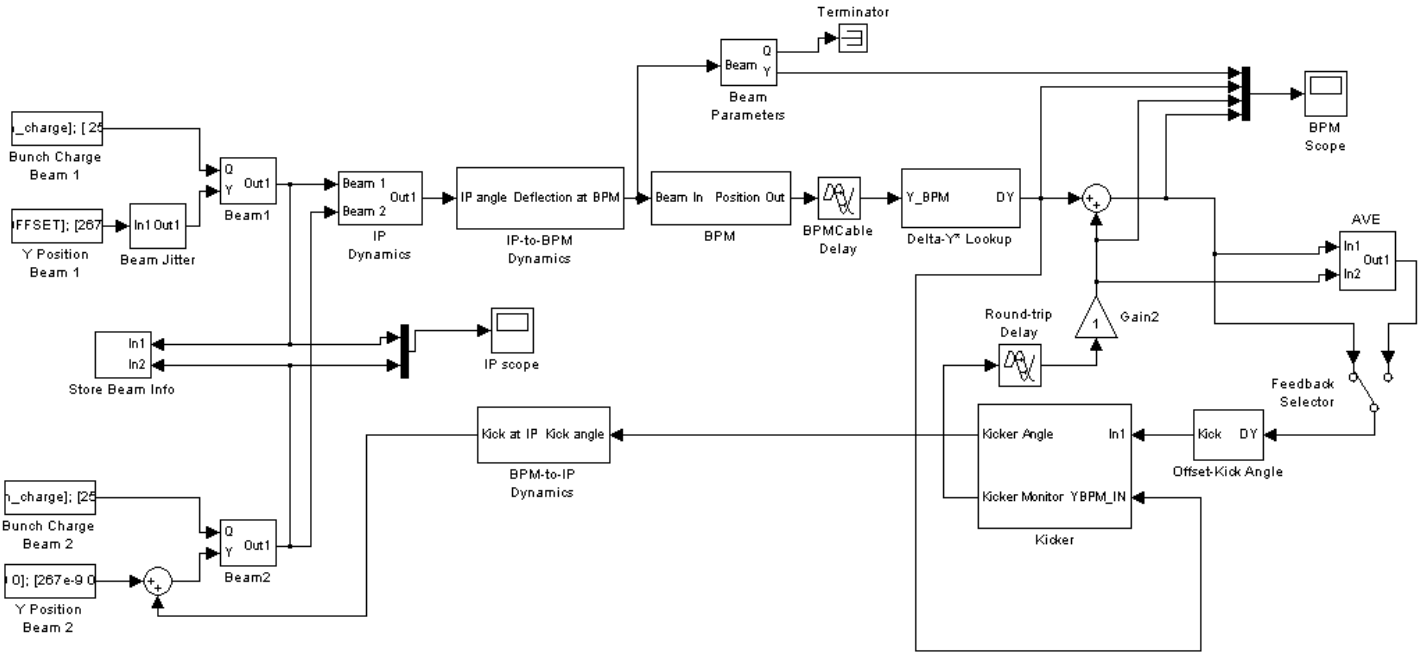
due to FB system components

SIMULATIONS

Set up powerful simulation infrastructure:

- **Linac beam transport: PLACET/LIAR**
- **Beam del system xport: MERLIN/LIAR**
- **Beam-beam dynamics/EM backgrounds: GUINEA PIG**
- **Feedback model: SIMULINK/MATLAB**
- **IR material/knock-on EM backgrounds: GEANT**
- **neutron backgrounds: FLUKA**

FEEDBACK MODEL

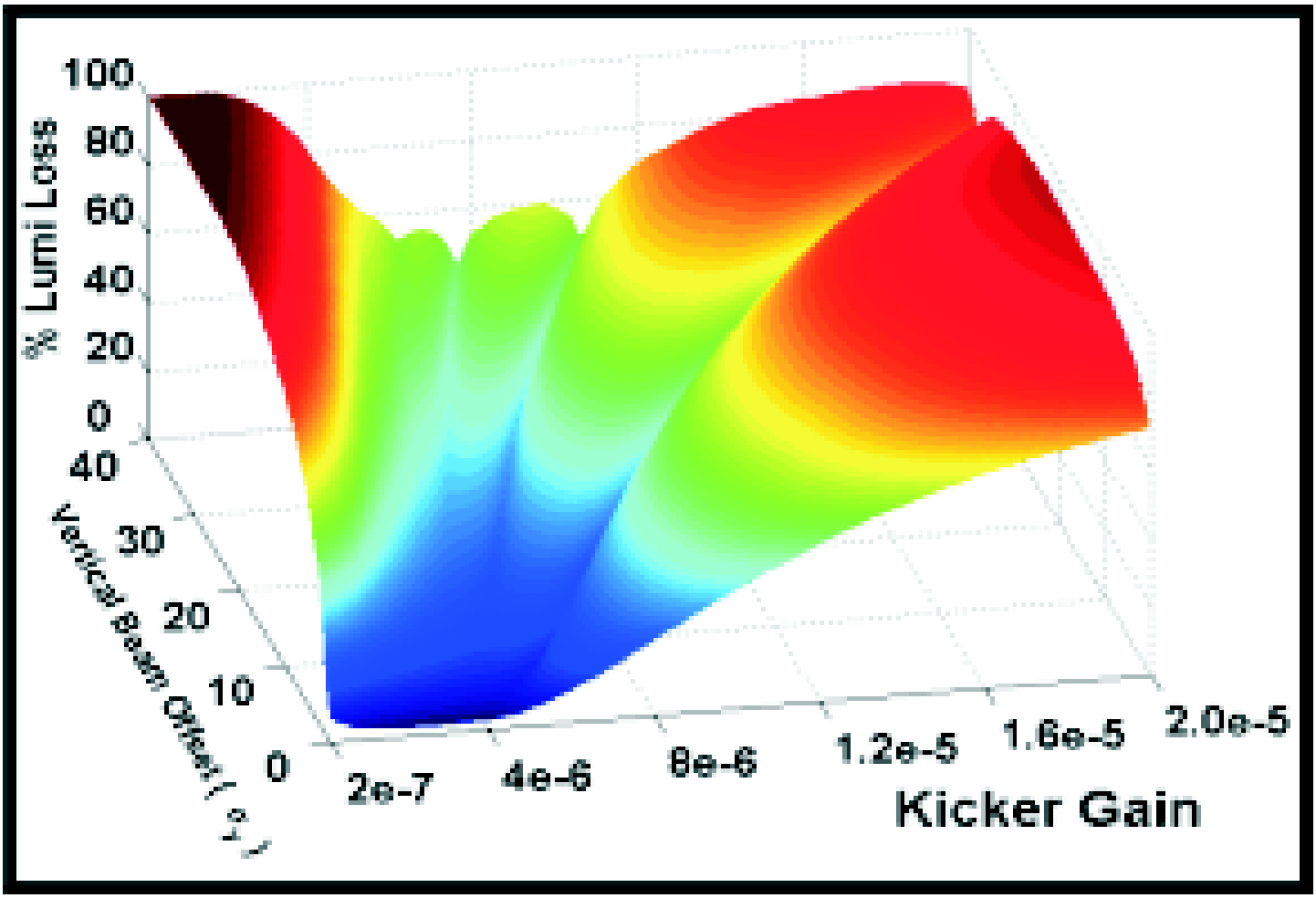


Includes:

- Signal propagation delays
- BPM parameters + response time
- Kicker parameters + response time

SYSTEM PERFORMANCE:

THE OFFSET-GAIN PLANE



Choice of gain 'delicate':

- ⇒ **feed-forward from linac?**
- ⇒ **adaptive algorithms?**
- ⇒ **robust algorithms**

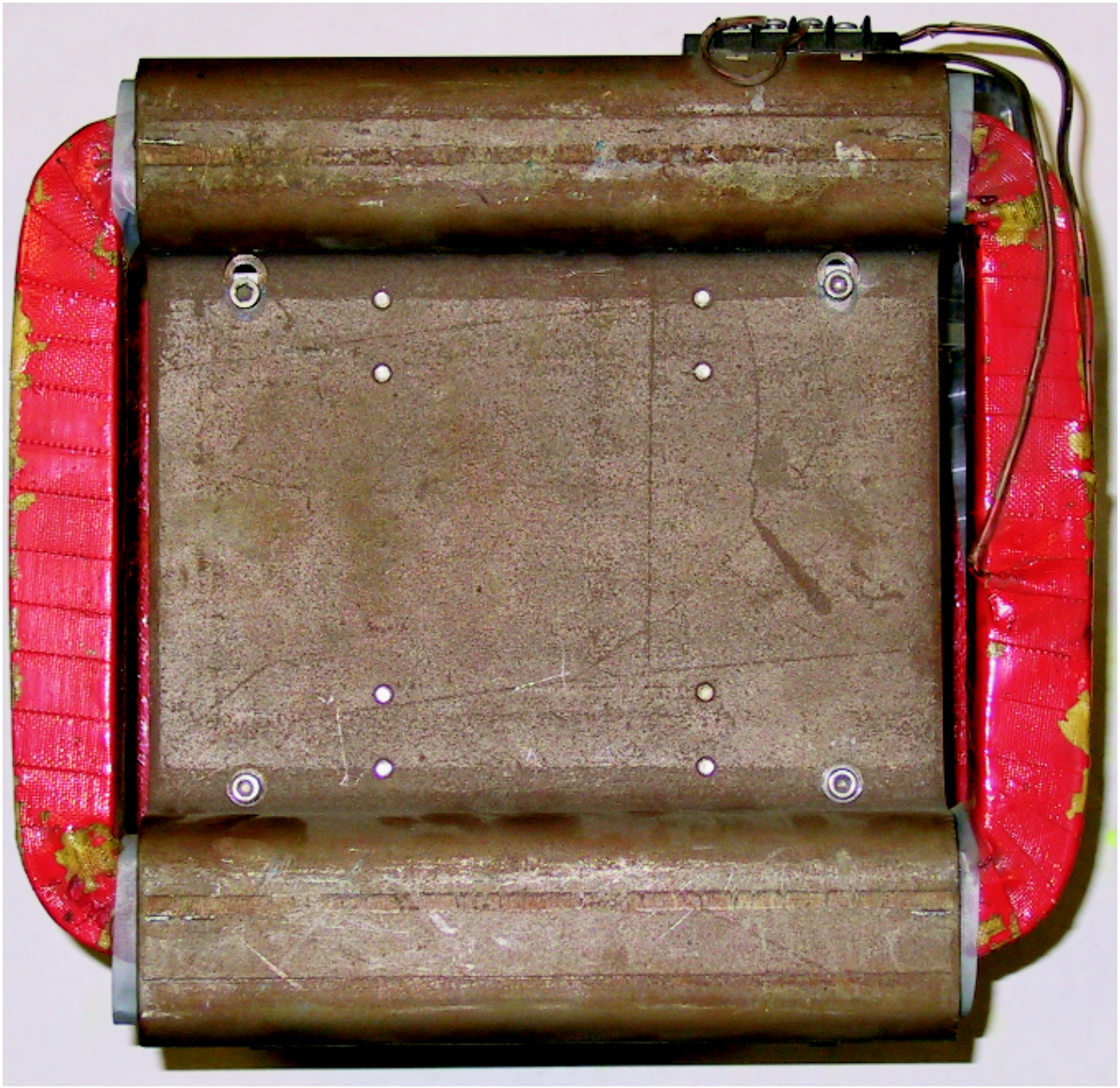
FONT EXPERIMENT OVERVIEW

- 'Simulate' NLC/JLC/CLIC beam using NLCTA 150ns bunchtrain
- 'Simulate' ground motion with dipole magnet
- Measure offset of leading bunches in fast X-band BPM
- Feedback correction to upstream kicker
- Kick trailing bunches towards nominal
- Check with downstream BPM
- Adjust kicker correction + repeat
- Aim to close loop within 30 ns

DIPOLE OFFSET MAGNET

Reclaimed SLC 'type-4' linac corrector

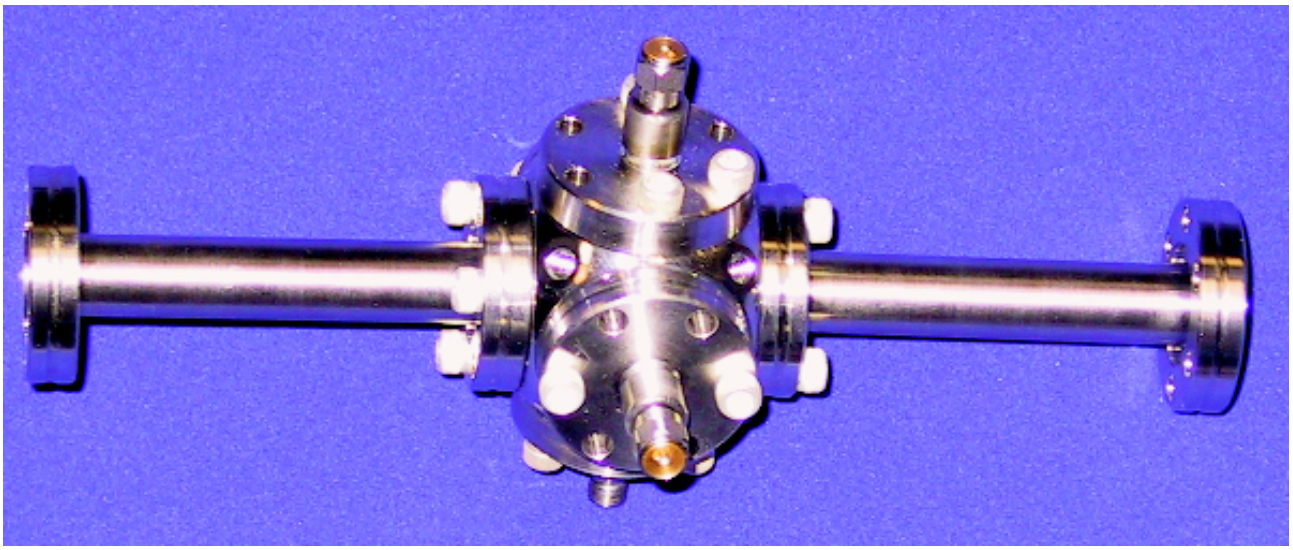
6A peak current $\rightarrow$ 5 mm @ BPM



NEW FAST BEAM POSITION MONITOR

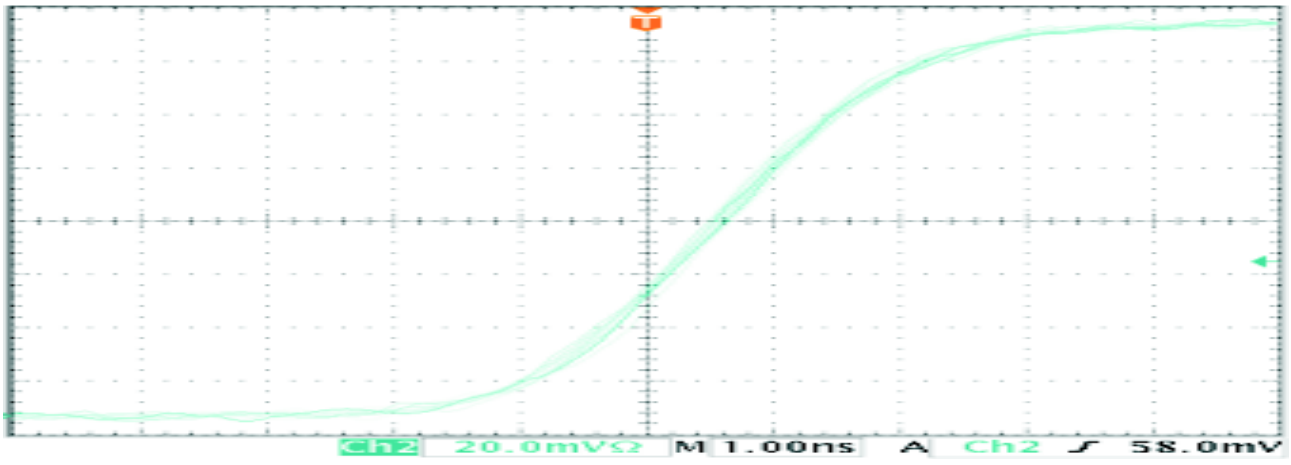
Built new X-band 'button' BPM:

resolution $\sim$ 10 μm



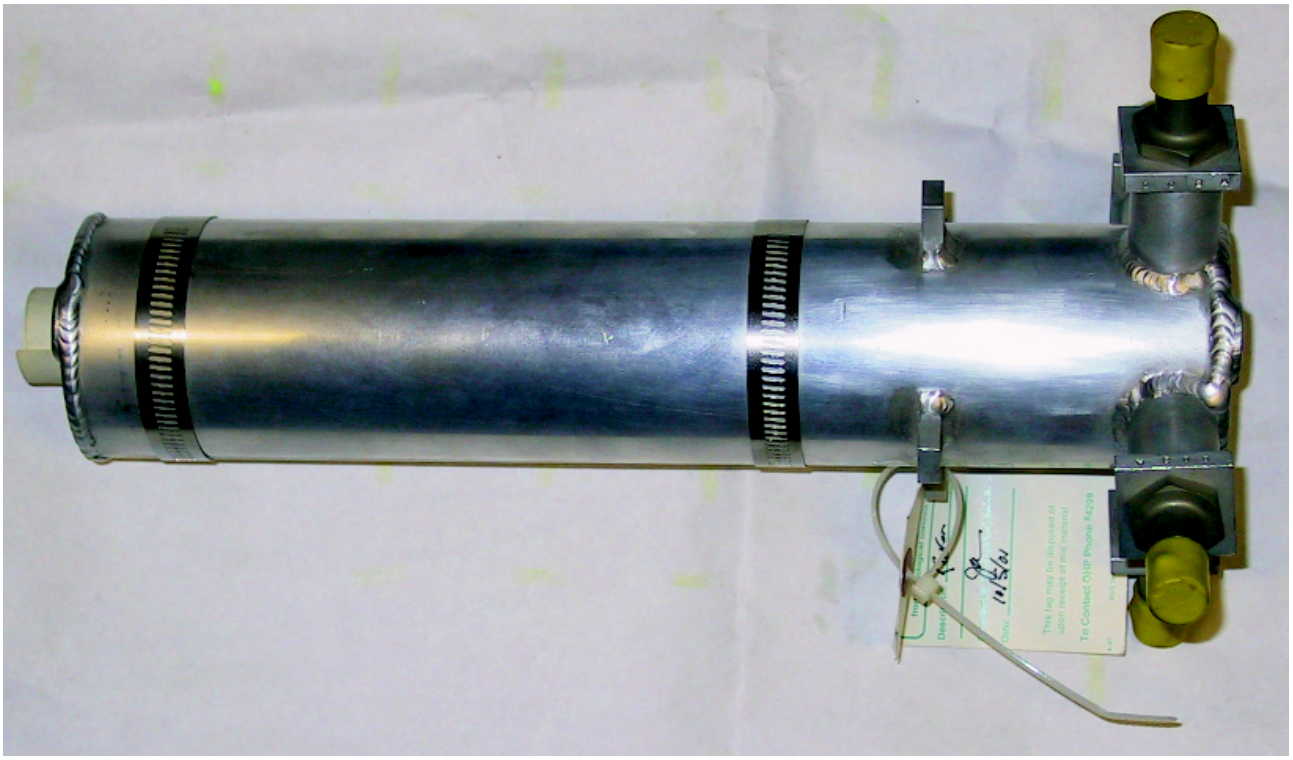
Built prototype BPM processor circuit:

risetime $\sim$ 3 ns



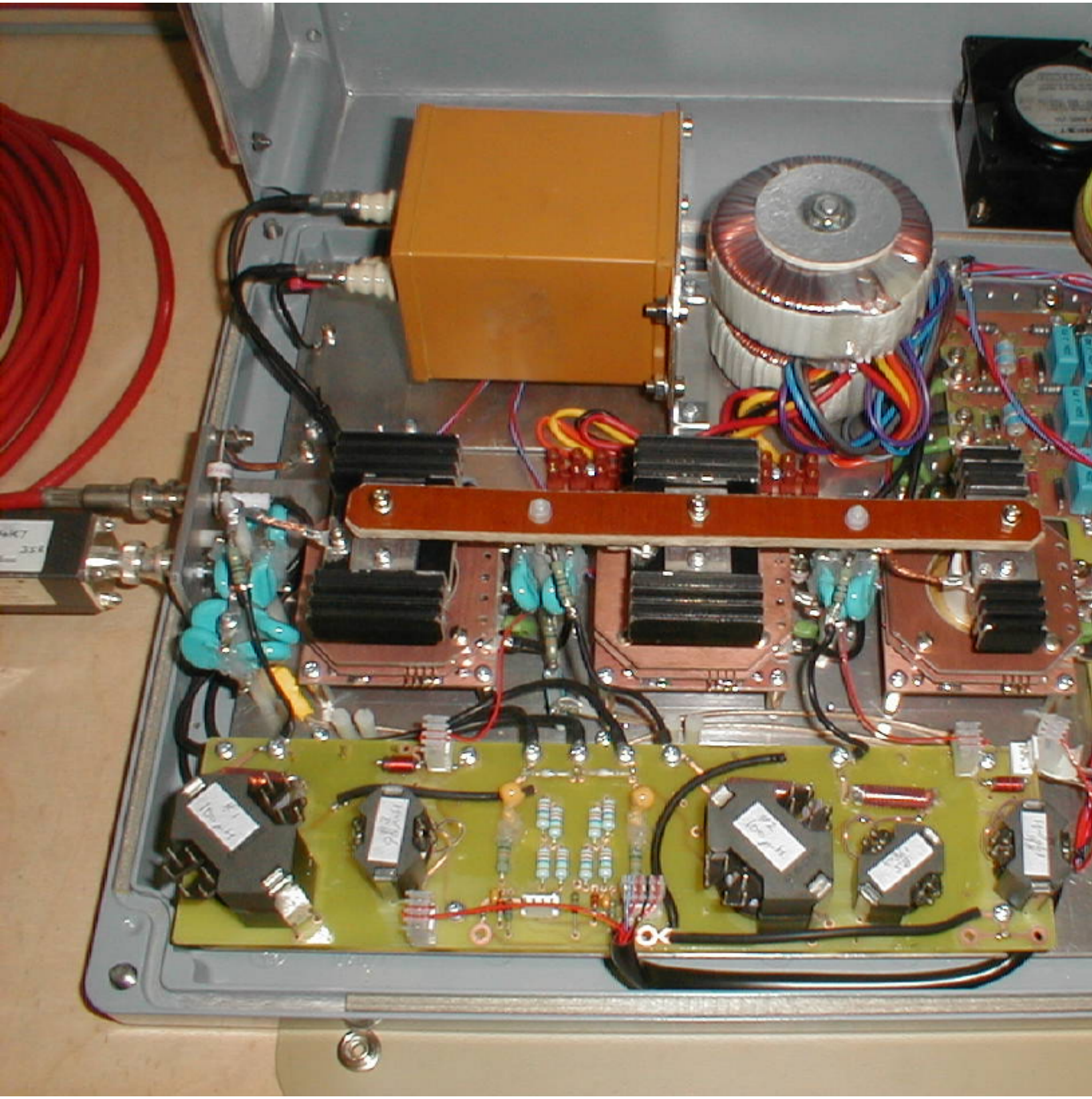
FAST KICKER

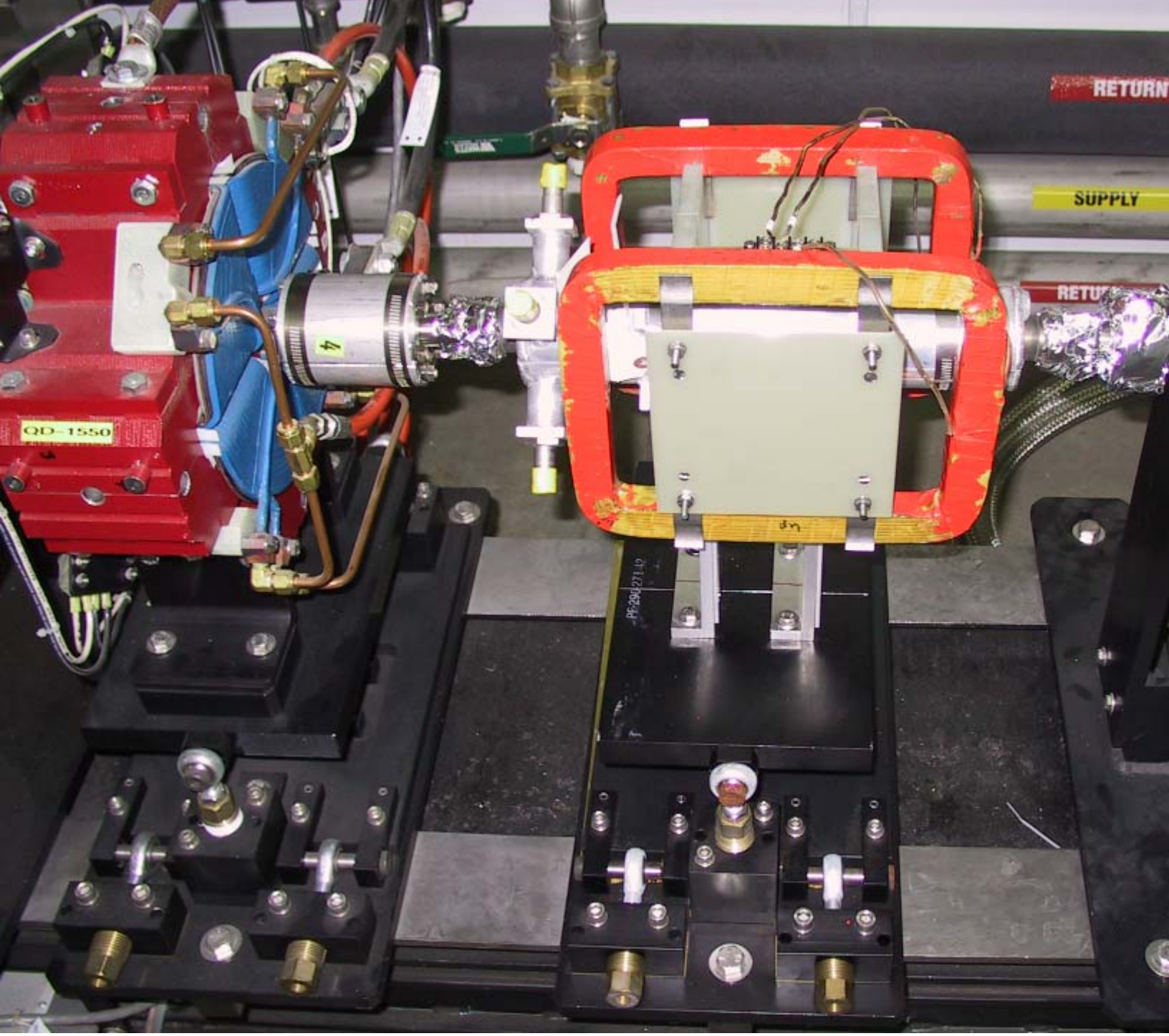
Reclaimed SLC kicker:

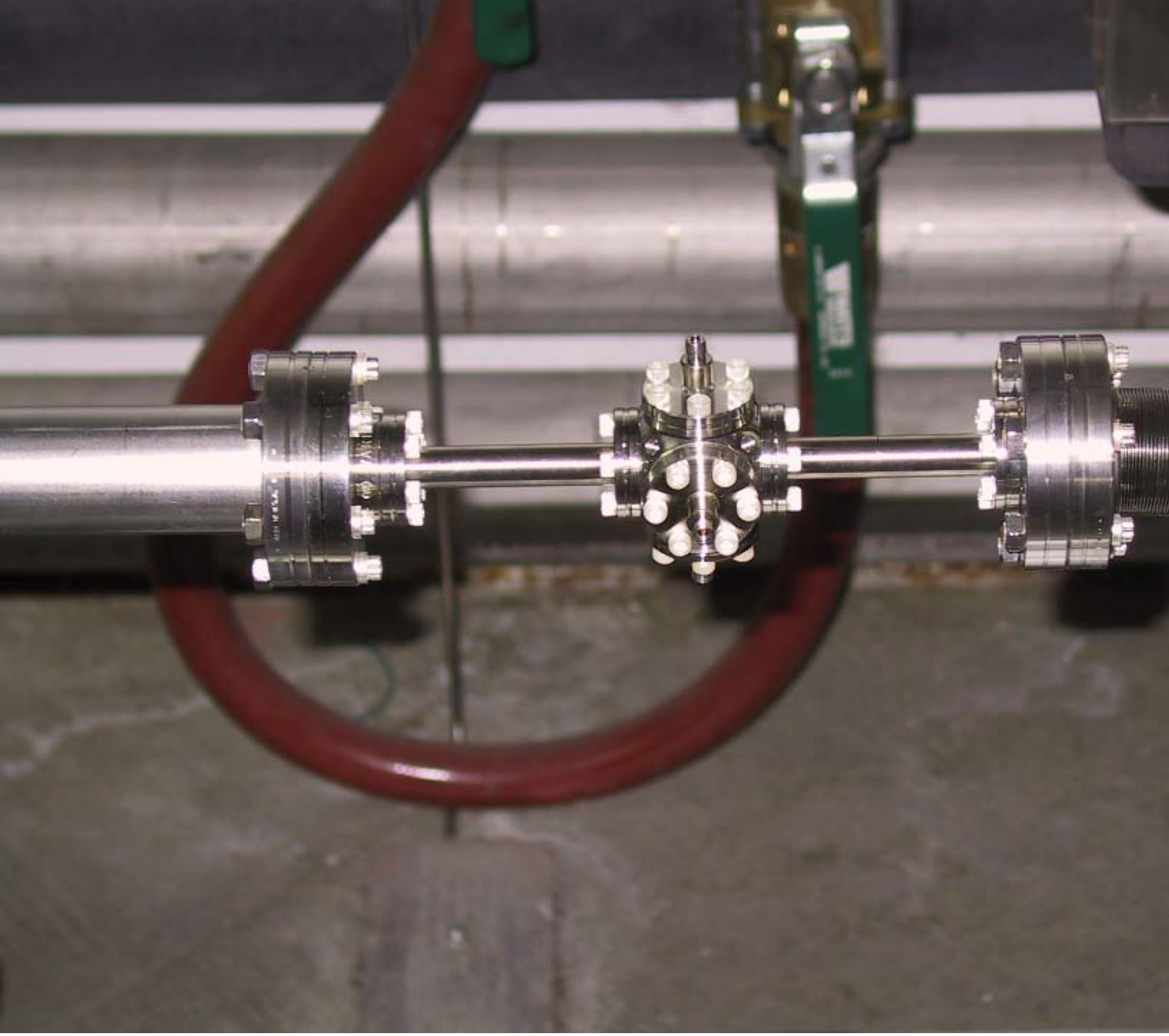


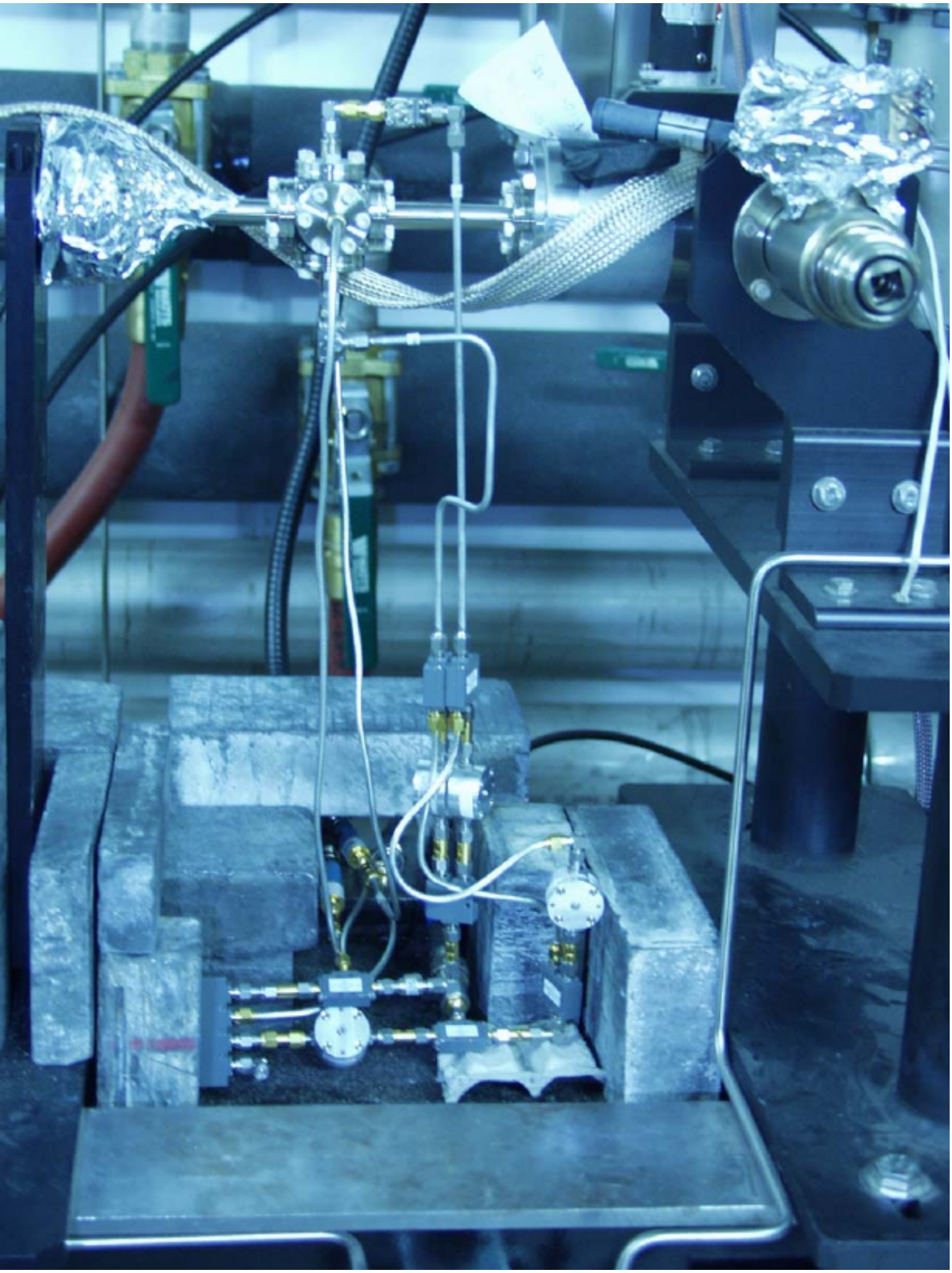
Designed and built kicker driver amplifier:

- 3-stage tube amplifier
- Y690 planar triode tubes
- Power $\leq$ 5 kW




RETURN
SUPPLY
QD-1550





AIMS OF FONT1

To correct a deliberately-introduced beam offset on a timescale of 10 ns

Phase 1:

Offset fixed: study gain, timing

Phase 2:

Change offset: study response

Phase 3:

Randomise offset pulse-by-pulse: pray!

Hope to demonstrate this by Feb. 2003

FONT COLLABORATORS

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