# Collimator wakefield kicks

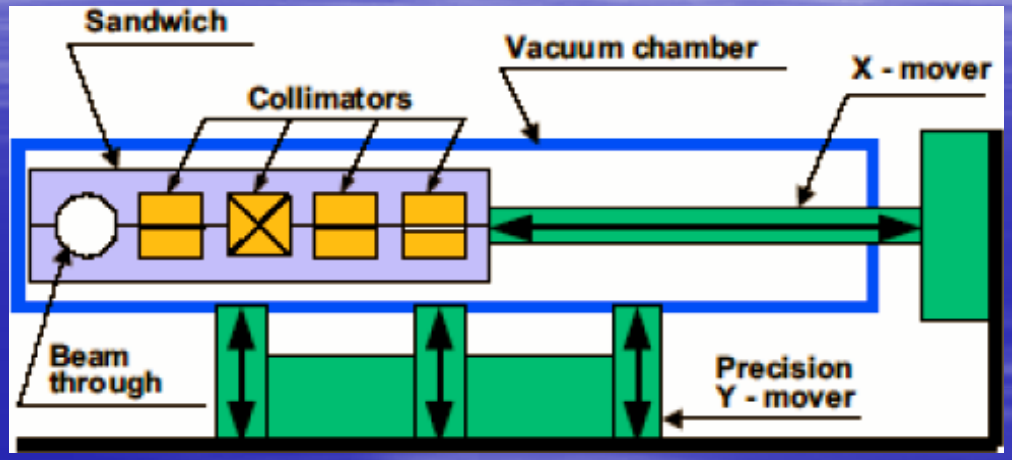
SLAC, RAL, CCLRC

# Motivation of Measurement

- Collimators near ILC IR will cause wakefields
  - Amplify incoming jitter.
  - Dilute emittance.
- Previous studies have shown the complexity of analytical calculations, even in simple cases.
- Goal is to measure the transverse kick for a range of collimator specs, and compare with simulations.
  - Try to improve agreement to ~10%.

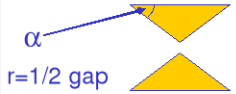
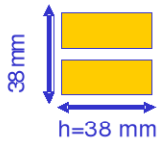
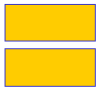
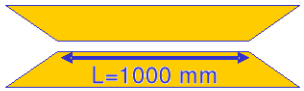
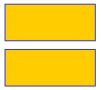
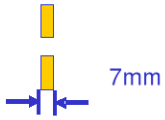
# Experimental Setup

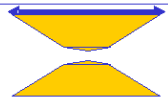
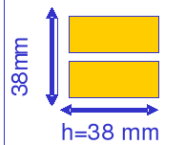
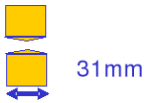
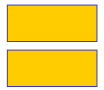
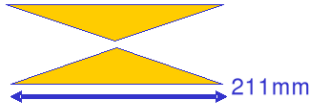
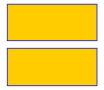
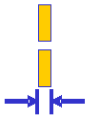
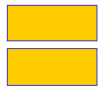
| | |
|---|---|
| **Beam Energy** | **28.5 GeV** |
| **Charge** | **~1.5e10** |
| **Bunch Length** | **0.3 – 1 mm** |
| ***x* Size** | **~1 mm** |
| ***y* Size** | **~100 um** |




- Apparatus installed in ESA that allows remote selection of one of four collimators, or an empty slot.
- Y-mover allows precision movement in 3D (y, z, dy/dz).
  - Micron-level read-back accuracy.
  - Hold beam still with position feedbacks, and move collimator.
- Four upstream, and six downstream BPMs
  - Reconstruct incoming and outgoing trajectory.
  - Deduce collimator induced kick.

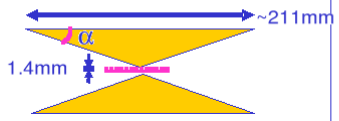
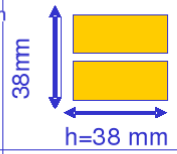
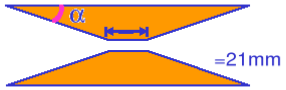
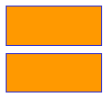
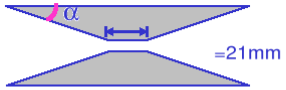
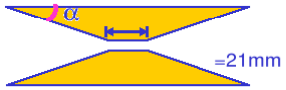
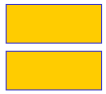
# Collimators (Run 1)

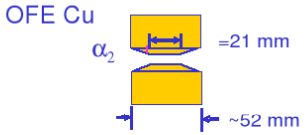
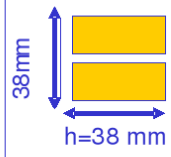
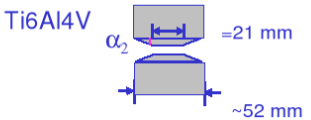
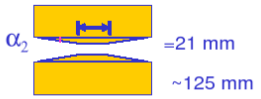
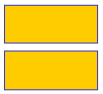
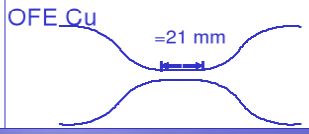
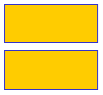
| Collim. # | Side view | Beam view | Revised 4-May-2006 |
|---|---|---|---|
| 1 |  |  | α=324mrad<br>r=2.0mm |
| 2 |  |  | α=324mrad<br>r=1.4mm |
| 3 |  |  | α=324mrad<br>r=1.4mm |
| 4 |  |  | α=π/2rad<br>r=4.0mm |

| Collim.# | Side view | Beam view | Revised 4-May-2006 |
|---|---|---|---|
| 8 |  |  | $r_1$ =4.0mm<br>$r_2$ =1.4mm<br>$\alpha_1$=289mrad<br>$\alpha_2$=166mrad |
| 7 |  |  | $\alpha_1$=π/2 rad<br>$\alpha_2$=166mrad<br>$r_1$=4.0mm<br>$r_2$=1.4mm |
| 6 |  |  | α=166mrad<br>r=1.4mm |
| 5 |  |  | α=π/2rad<br>r=1.4mm |

- Collimator #1 is identical to one from a previous test by P.T.
- Analytical prediction for #7 and #8 is identical, but 3D simulation hints at differences.
- #3 will have a much larger resistive component than the others.
- This set explores a wide range of taper angles.

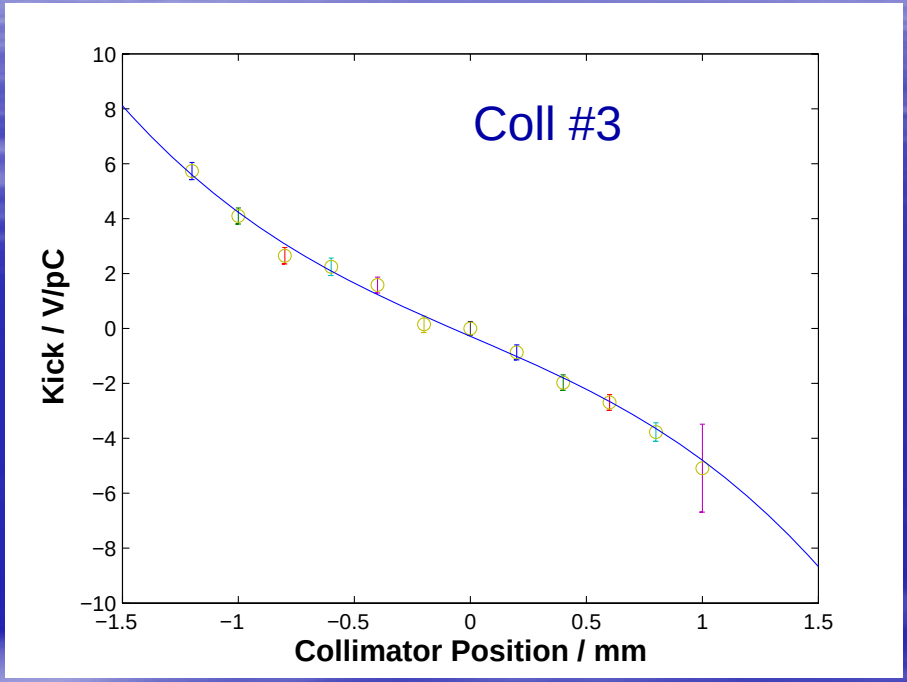
# Collimators (Run 2)

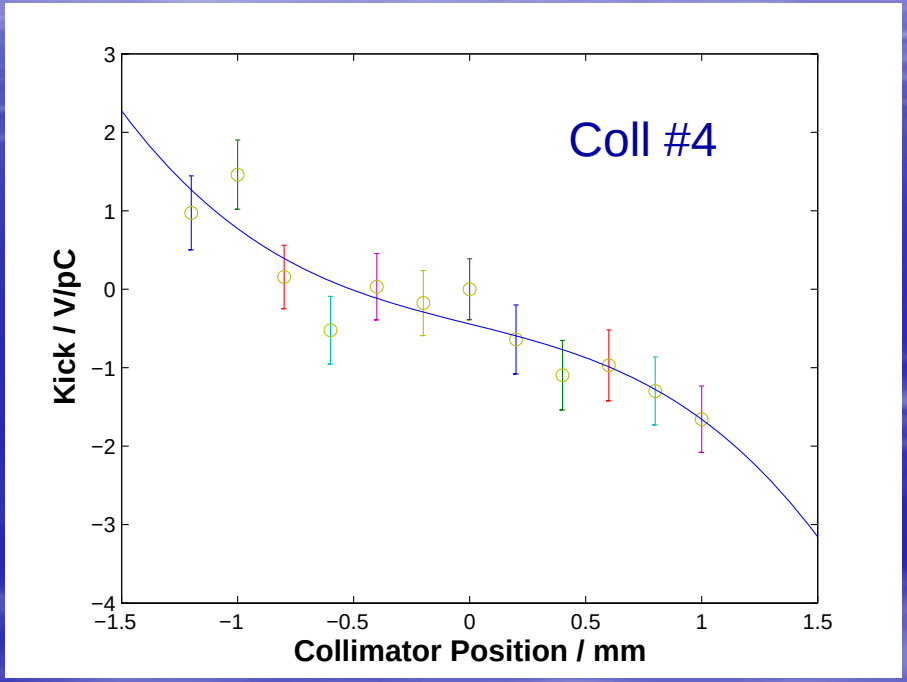
| Collim.# | Side view | Beam view | Revised 27-Nov-2006 |
|---|---|---|---|
| 6 |  |  | α=166mrad<br>r=1.4mm<br>(1/2 gap) |
| 10 |  |  | α=166mrad<br>r =1.4mm |
| 11 |  |  | α=166mrad<br>r =1.4mm |
| 12 |  |  | α=166mrad<br>r=1.4mm |

| Collim.# | Side view | Beam view | Revised 27-Nov-2006 |
|---|---|---|---|
| 13 |  |  | α1=π/2 rad<br>α2=166mrad<br>r1=4.0mm<br>r2=1.4mm |
| 14 |  |  | α1=π/2 rad<br>α2=166mrad<br>r1=4.0mm<br>r2=1.4mm |
| 15 |  |  | α1=π/2 rad<br>α2=50mrad<br>r1=4.0mm<br>r2=1.4mm |
| 16 |  |  | non-linear taper<br>r=1.4mm |

- Collimator #6 identical to #6 from Run 1.
- This set investigates the effect of material and surface finish on the kick.
- #16 tested a smooth impedance change.

# Data Analysis




- Record ~300 pulses at each collimator position.
- Fit incoming and outgoing trajectories
  - Weighted by the resolution of the BPMs
- Calculate kick angle from these fits.
- Fit to 3$^{rd}$ order polynomial
  - Set coefficient of 2$^{nd}$ order term to zero.
  - Kick factor deduced from linear term.

# Results and Conclusions

Predictions made for 0.5 mm bunch length.

3D modelling does **not** include resistive effects.

| Coll. | Measured Kick Factor / V/pC/mm (Linear Fit) | Measured Kick Factor / V/pC/mm (Linear & Cubic Fit) | Analytic Prediction Kick Factor V/pC/mm | 3-D Modeling Prediction Kick Factor V/pC/mm |
|---|---|---|---|---|
| 1 | $1.4 \pm 0.1$ (1.0) | $1.2 \pm 0.3$ (1.0) | 2.27 | $1.63 \pm 0.37$ |
| 2 | $1.4 \pm 0.1$ (1.3) | $1.2 \pm 0.3$ (1.4) | 4.63 | $2.88 \pm 0.84$ |
| 3 | $4.4 \pm 0.1$ (1.5) | $3.7 \pm 0.3$ (0.8) | 5.25 | $5.81 \pm 0.94$ |
| 4 | $0.9 \pm 0.2$ (0.8) | $0.5 \pm 0.4$ (0.8) | 0.56 | 0.8 |
| 5 | $3.7 \pm 0.1$ (7.9) | $4.9 \pm 0.2$ (2.6) | 4.59 | 6.8 |
| 6 | $0.9 \pm 0.1$ (0.9) | $0.9 \pm 0.3$ (1.0) | 4.65 | $2.12 \pm 1.14$ |
| 7 | $1.7 \pm 0.1$ (0.7) | $2.2 \pm 0.3$ (0.5) | 4.59 | $2.87 \pm 0.53$ |
| 8 | $1.7 \pm 0.3$ (2.0) | $1.7 \pm 0.3$ (2.2) | 4.59 | $2.39 \pm 0.89$ |
| 13 | | $4.1 \pm 0.4$ (0.8) | | $3.57 \pm 0.98$ |
| 14 | | $2.6 \pm 0.4$ (1.0) | | $3.57 \pm 0.98$ |
| 15 | | $2.0 \pm 0.3$ (1.8) | | $2.51 \pm 1.16$ |
| 16 | | $1.3 \pm 0.3$ (1.0) | | $2.35 \pm 1.50$ |

- Good agreement with PT's previous measurement of #1.
- Analysis not yet complete on all collimators.
- Some anomalies,
  - Why do #1 and #2 have the same measured kick factor?
  - Why is the measurement for #14 lower than #13?