



Lumi scans with wakefields in Merlin



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LET Beam Dynamics Workshop at SLAC

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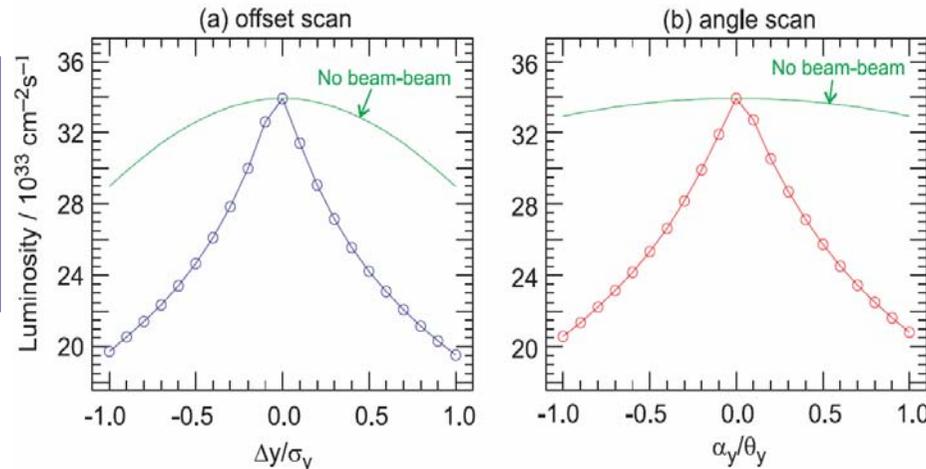


Offset and angle scan from TESLA TDR



Luminosity drops fast with small change of offset and/or angle

Results from
beam-beam
simulation with
GUINEA-PIG
from TESLA TDR



TESLA parameters:

$$\sigma_y = 5 \text{ nm} , \theta_y = 12 \text{ } \mu\text{rad}$$

How is the luminosity change for the ILC?

Now check with **beams generated by MERLIN:**

- effect of wakefields (w/o and with quadrupole errors)
- influence of HOM and RF couplers (with wakefields)



MERLIN beam parameters



Merlin beam:

10^4 or 10^5 particles \rightarrow 5k or 50k per beam:

• generated with **ILC2006c** lattice file:

$$\sigma_x \approx 600 \text{ nm}$$

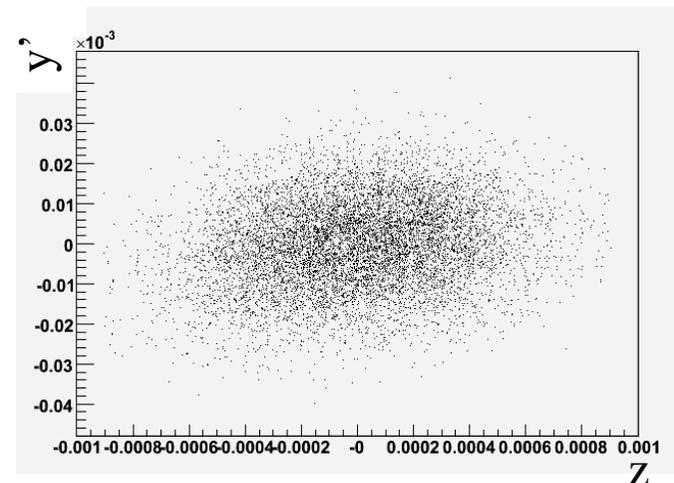
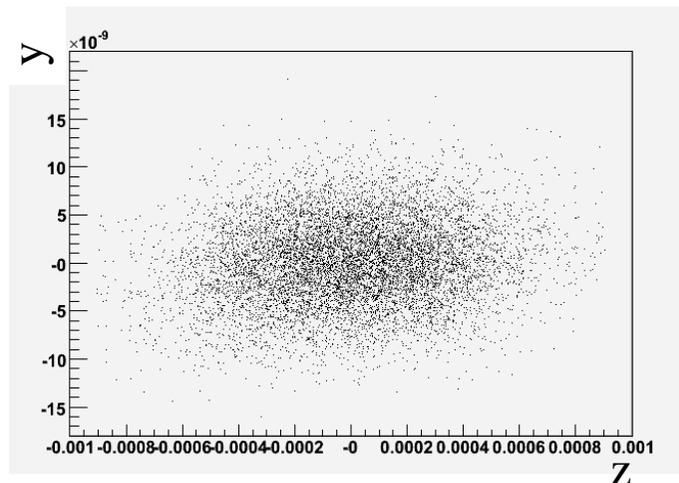
$$\sigma_x = 4.1 \text{ nm (nom RDR @ IR: 5.7nm)}$$

$$\gamma\epsilon_x = 8 \text{ mm}\cdot\text{mrad (nom RDR @ IR : 10 mm}\cdot\text{mrad)}$$

$$\gamma\epsilon_y = 0.02 \text{ mm}\cdot\text{mrad (nom RDR @ IR : 0.04 mm}\cdot\text{mrad)}$$

no undulators, with BDS

} higher lumi
than in RDR
($\sim 3 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$)

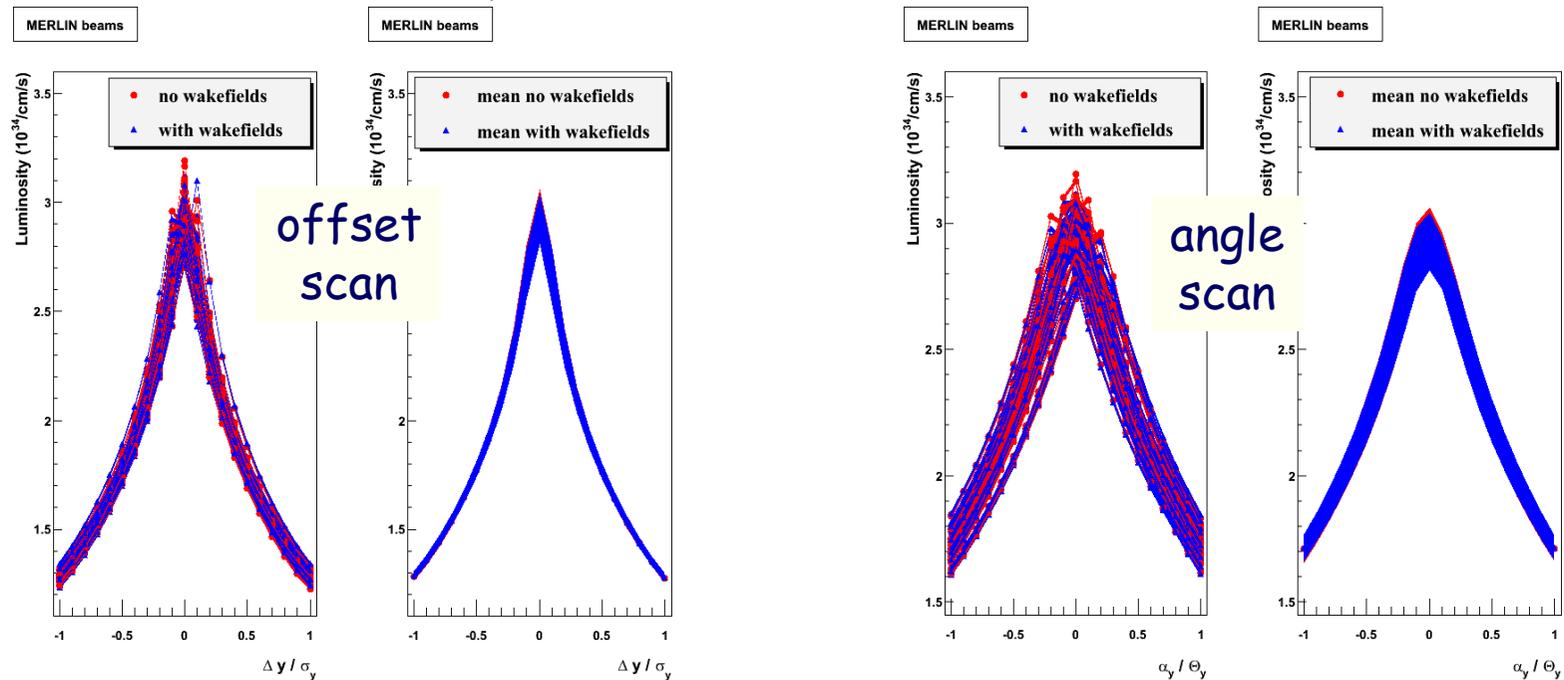




Offset & angle scans: no quadrupole error



Ideal machine, only influence of **longitudinal** wakefields
2 x 50 beams (different random numbers)



Essentially no difference visible between the two samples
← longitudinal wakefield has no negative influence on lumi



Quadrupole error

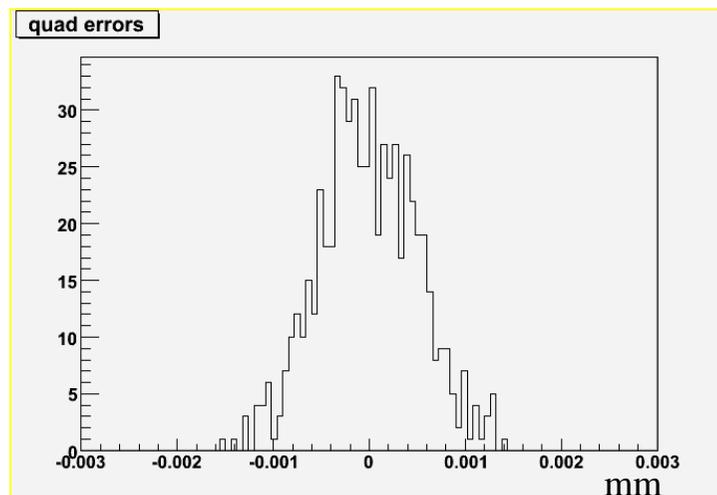


Ideal machine: only longitudinal wakefields visible

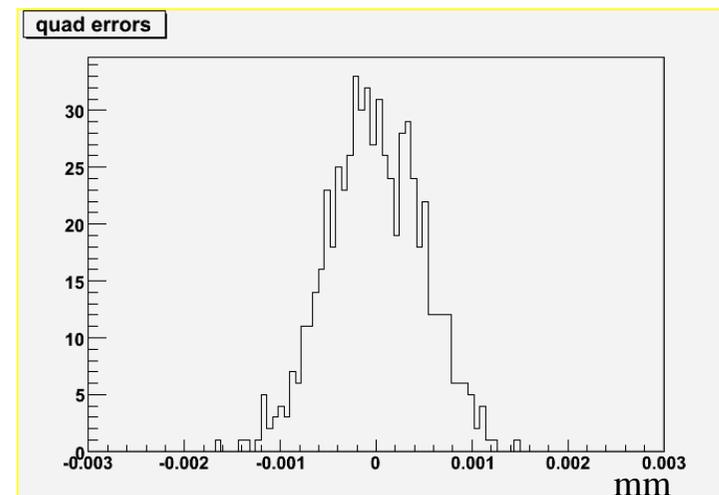
First test: to see the effect of vertical wakefields we need to be off-axis in vertical direction

☛ introduce quadrupole errors with $\sigma = 500 \mu\text{m}$

Run in 50 different configurations of quadrupole errors and with 1-2-1 steering



Examples for
2 different
quad error
configurations

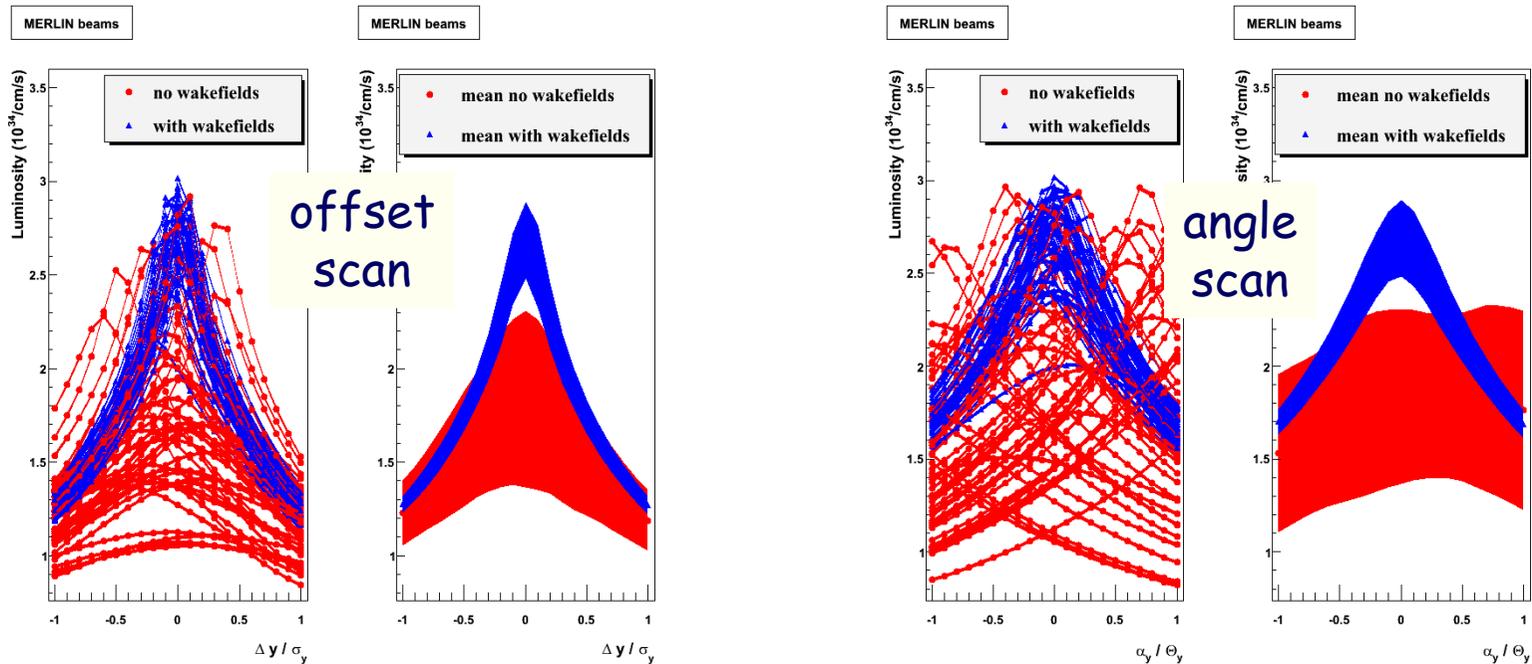




Offset & angle scans: with quadrupole errors



2 x 50 beams (different random numbers)
and quadrupole errors ($\sigma_y = 500 \mu\text{m}$)



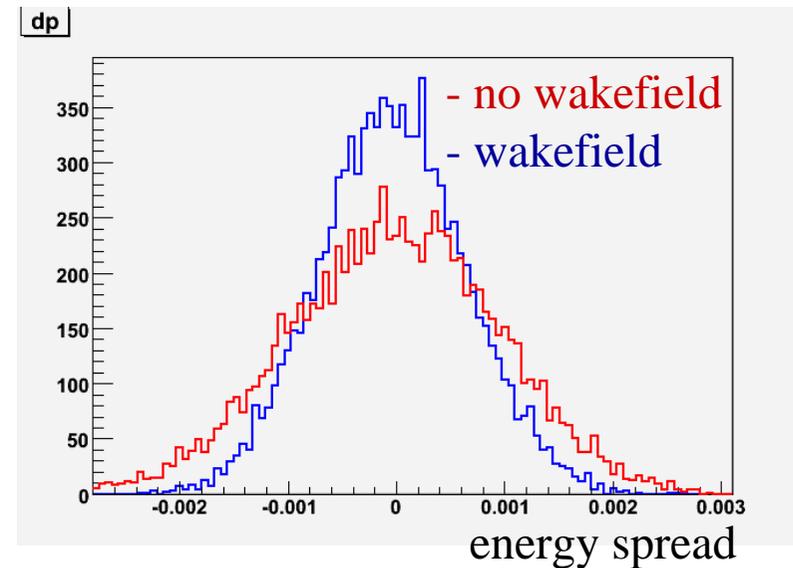
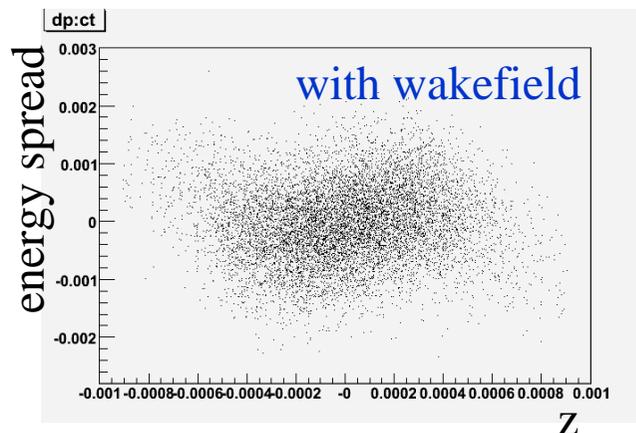
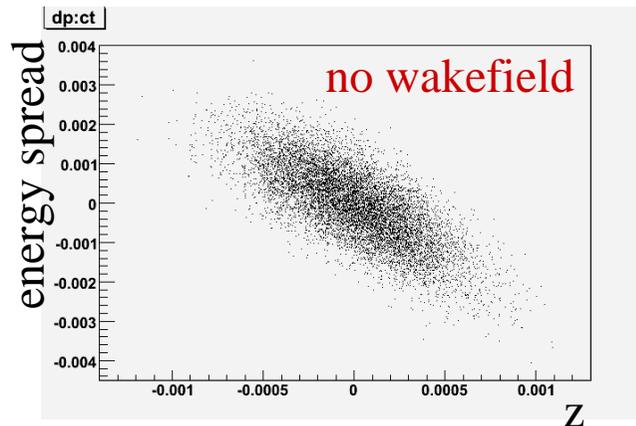
- Wakefield sample looks better than non-wakefield sample
- Stronger effect on beam angle than on offset



Difference wakefield/ no-wakefield sample



Wakefields cause the energy spread to be smaller



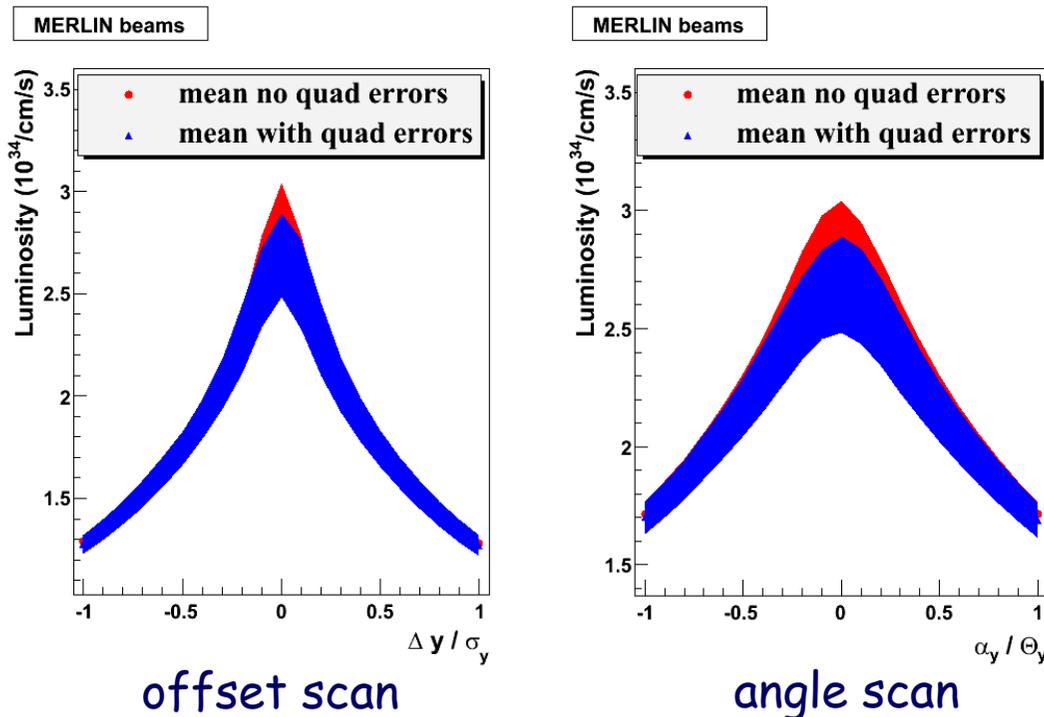
(because the RF angle (5.3°) is tuned to be optimal with wakefields)



Comparison of wakefield samples w/ and w/o quad errors



To extract the effect of quad errors with wakefields on lumi compare wakefield samples with and without quad errors:



$$L_{\text{no QE}} = (2.9 \pm 0.1) \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$
$$L_{\text{QE}} = (2.7 \pm 0.2) \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$

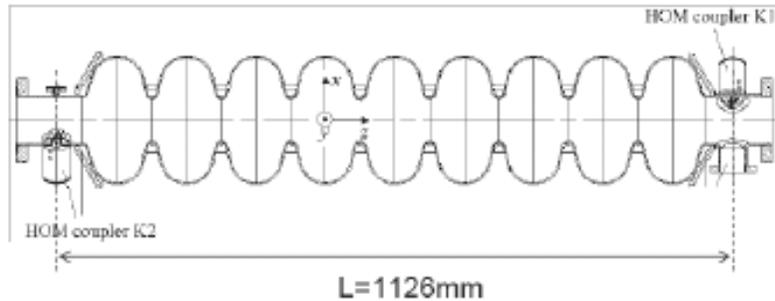
- Loss due to vertical wakefields with only quad errors: ~9%
- Angle and offset scans don't help
- need more studies with realistic errors introduced in cavities, BPMs,...



Reminder: HOM and RF couplers

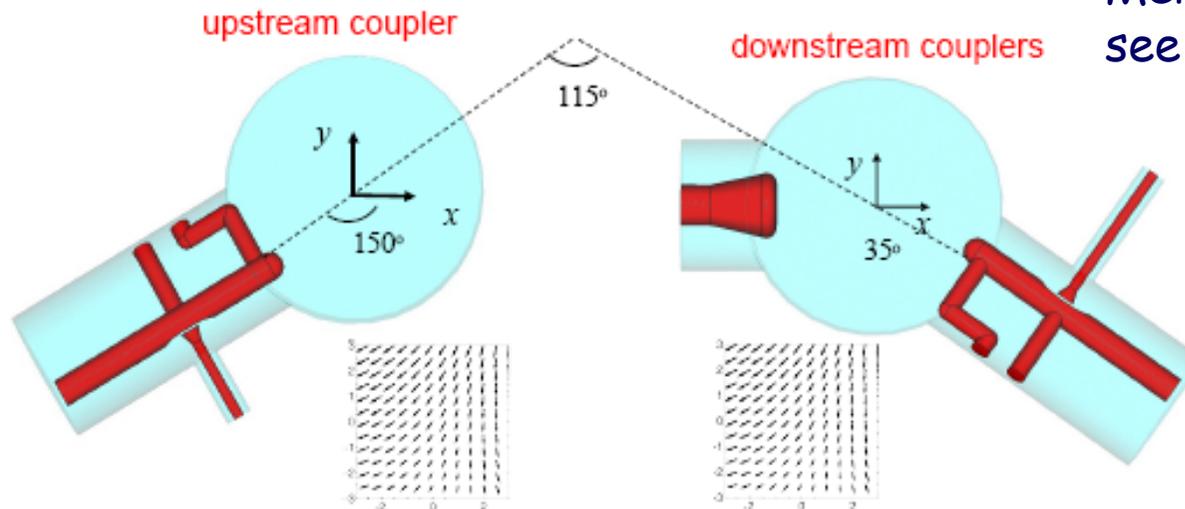


Resonator TESLA TEST Facility



Thanks to:
Igor Zagorodnov
and Martin Dohlus
(see talk DESY, ILC
meeting. 4 May 2007)

Merlin implementation:
see talk of Dirk Krücker

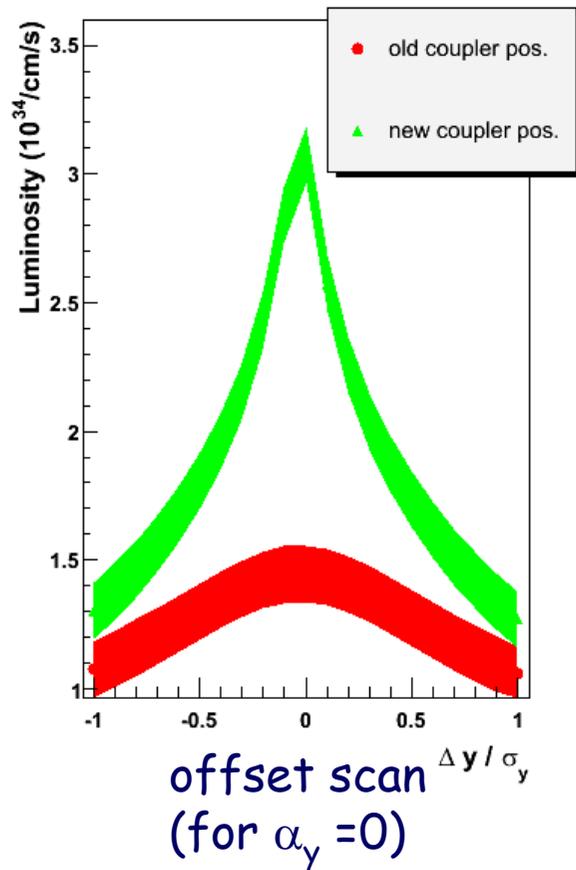




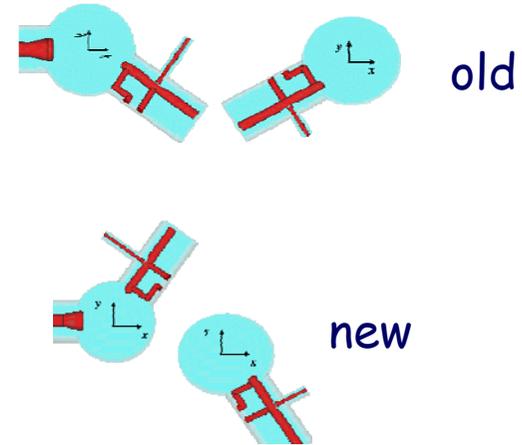
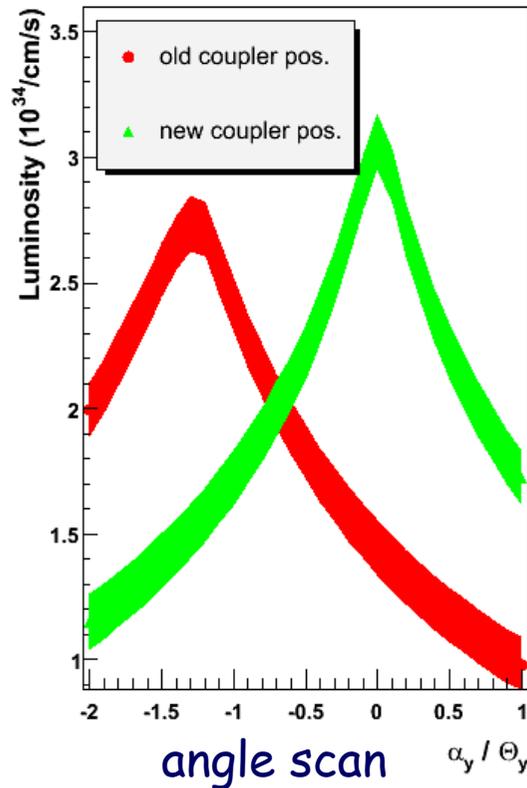
Offset & angle scan: comparison of old/new HOM coupler position



MERLIN beams



MERLIN beams



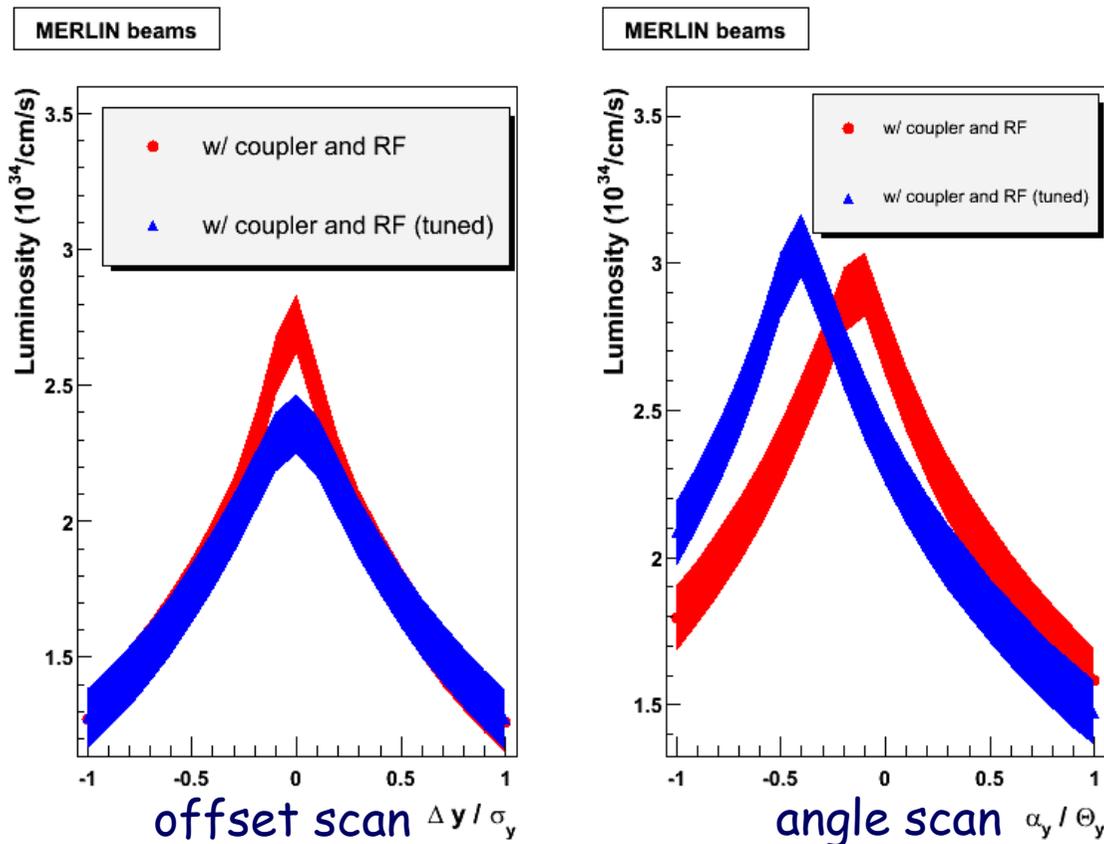
Old coupler position needs stronger tuning in angle
After angle tuning loose ~12% in lumi with old coupler pos.



Kick from RF field + coupler wakefields



RF kick: quite strong, but 1-2-1 steering works here:



blue curve is with linear tuning
in waist, dispersion, coupling
(see talk of Dirk Krücker)

$$L_{\text{no RF}} = (2.9 \pm 0.1) \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$
$$L_{\text{RF, tuned}} = (3.0 \pm 0.1) \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$

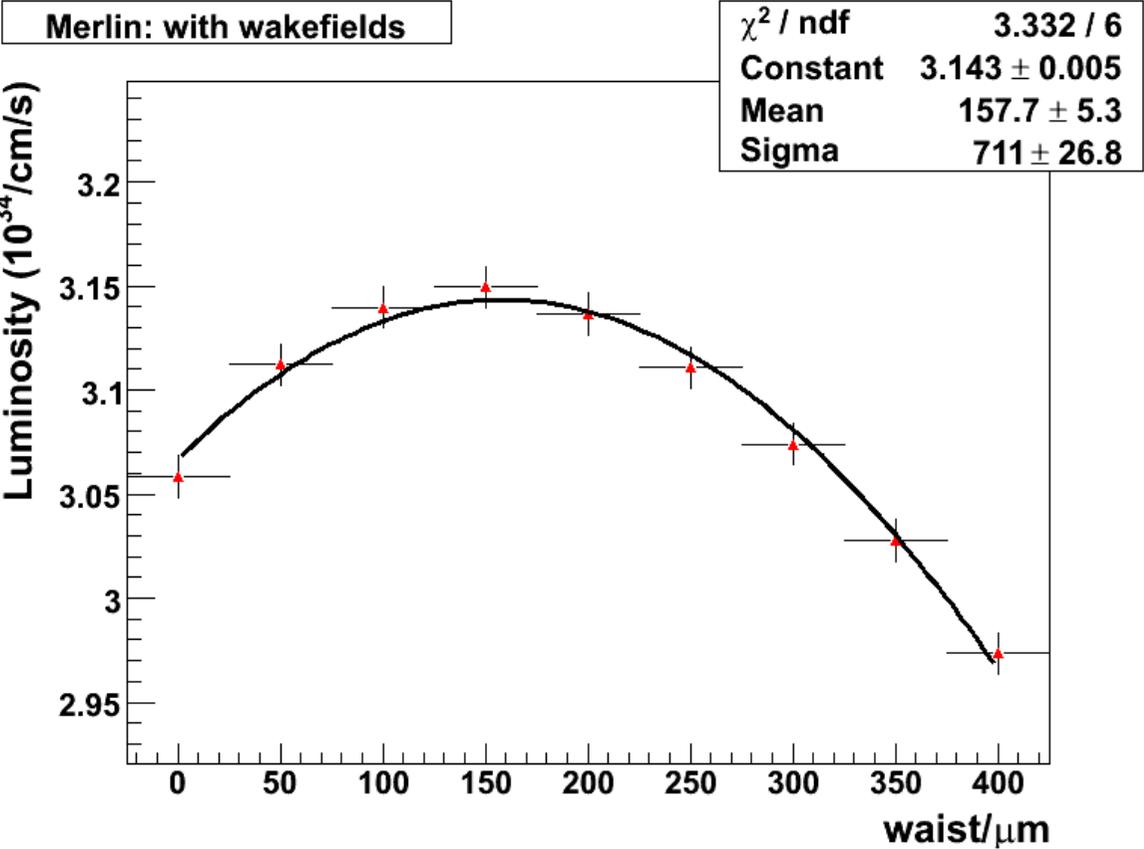
consistent within error
effects of RF and
coupler kicks can be
tuned away



Waist scan with MERLIN beam



Waist scan for beam with RF and coupler kicks for best angle ($\alpha_y/\theta_y = -0.4$)



Waist tuning:
gain 3% of lumi



Conclusions and Outlook



- Longitudinal wakefields have no negative influence on lumi
- No lumi gain due to offset/angle scans with vertical quad misalignment and wakefields
- New coupler geometry better than old one (gain ~12% of lumi)
- Influence of RF kick can be tuned away (at least if the rest of the accelerator is ideal...), linear tuning helps here
- Waist scan: gain ~3% of lumi with optimal waist

To Do:

- Use more realistic accelerator errors and alignment to check influence of vertical wakefields and RF kicks (errors on cavities, BPMs,...)



Backup slides





Tuning the beam



- In reality: tune the beam to have the mean of the beam centered around 0 in the interaction point.
- ⇒ Do it also in MERLIN (but no change in shape)
- ☛ see talk of Dirk Krücker for details

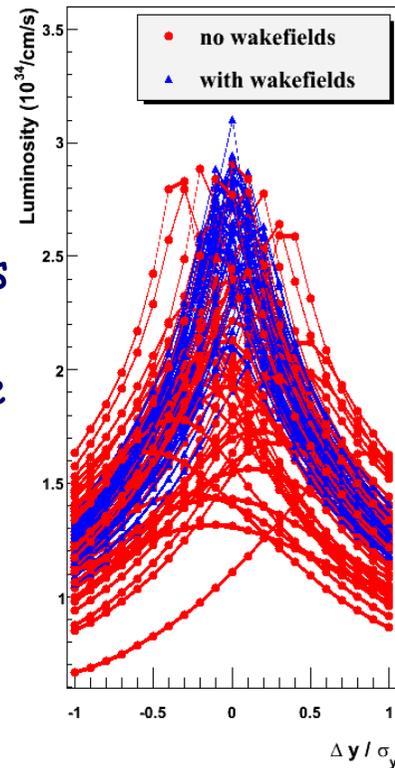


Offset scan (ILC2006c): quadrupole error and tuned

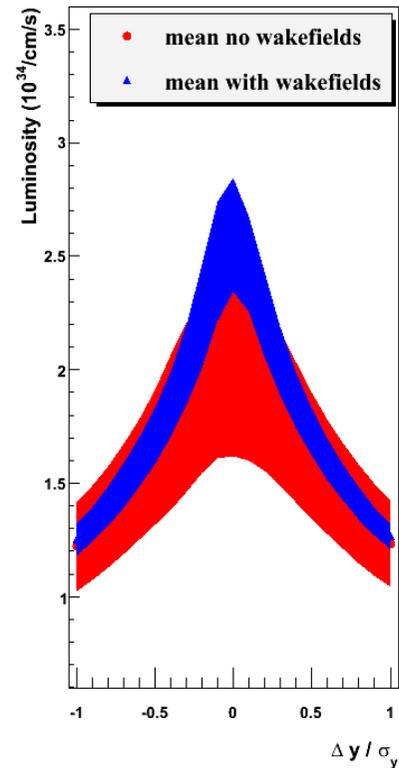


2 x 50 beams
with different
quadrupole errors
($\sigma_y = 500 \mu\text{m}$)
tuned to have the
mean centered
around 0

MERLIN beams



MERLIN beams



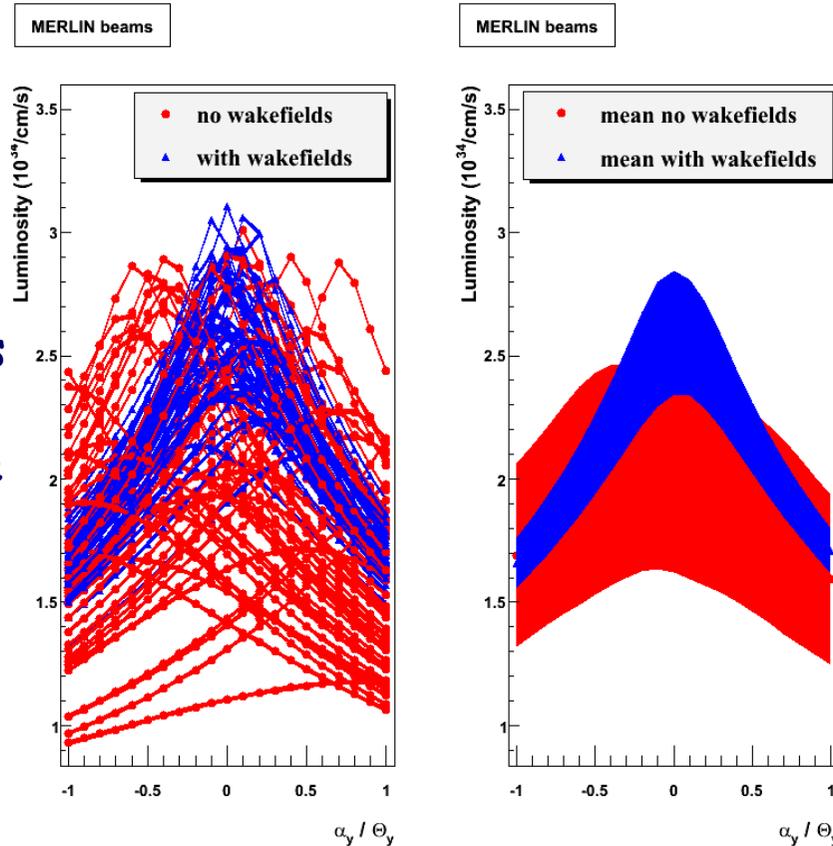
Looks similar to
untuned sample,
slightly better for
the no wakefield
case



Angle scan (ILC2006c): quadrupole error and tuned



2 x 50 beams
with different
quadrupole errors
($\sigma_y = 500 \mu\text{m}$)
tuned to have the
mean centered
around 0



Looks similar to
untuned sample,
slightly better for
the no wakefield
case

Looks similar to untuned sample.