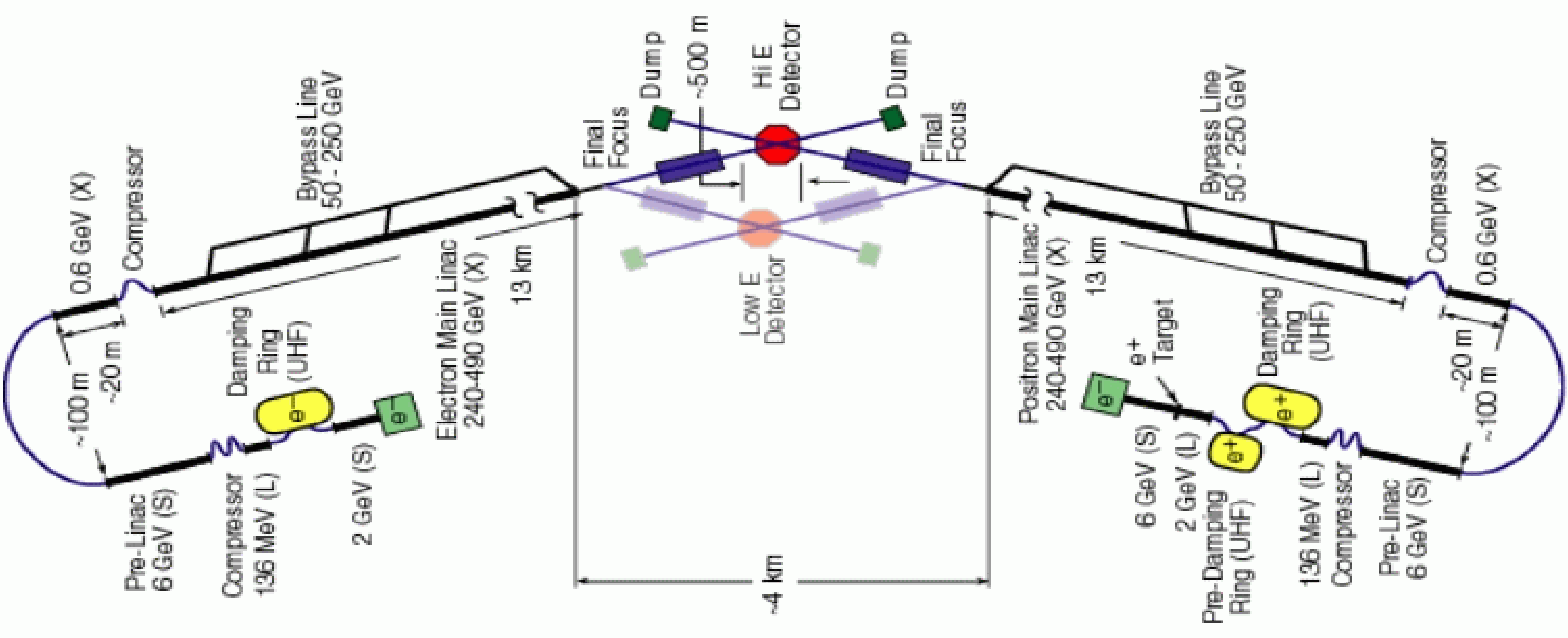
Two Beamline Ground Motion Simulation for NLC



LCD group meeting
May 28, 2002

Andrei Seryi for the

NLC Accelerator Physics Group

Goal:

Create a tool which will allow simulation of realistic behavior of LC and then learn to use beam based alignment, tuning, etc.

The team:

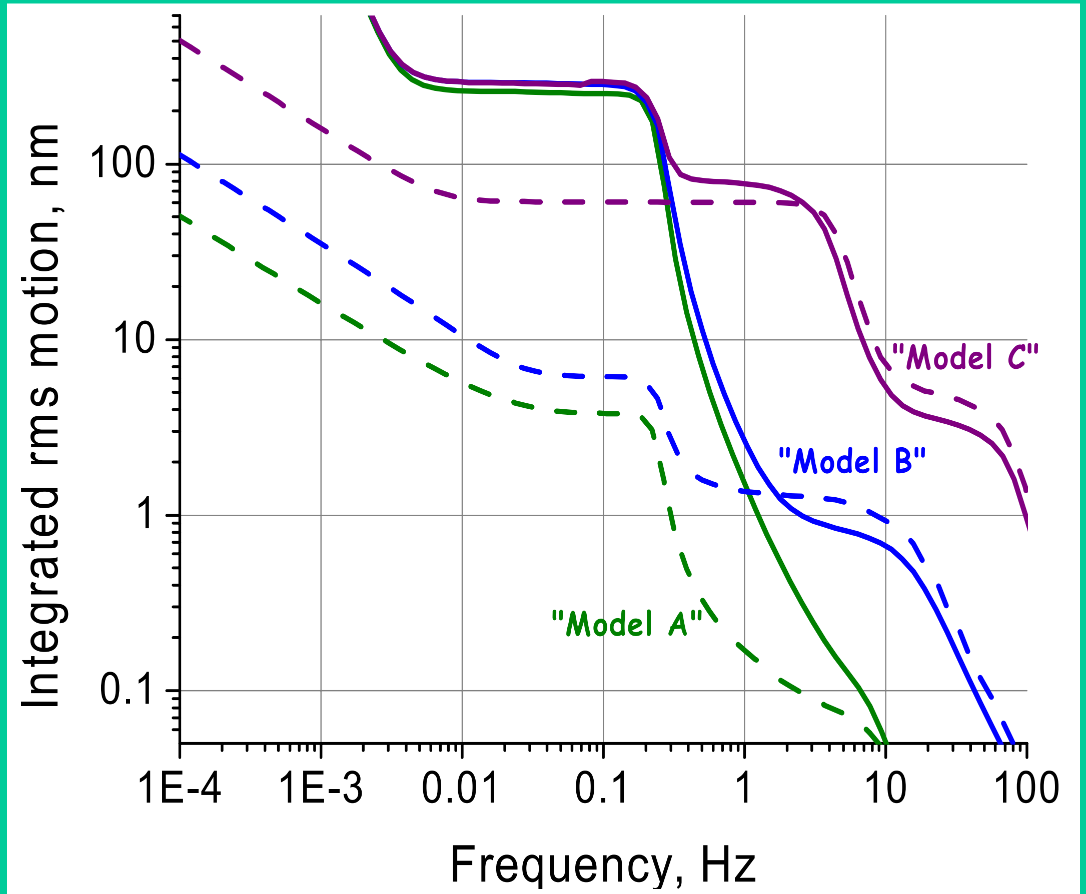
K. Bane, L. Hendrickson, Y. Nosochkov, T. Raubenheimer, A. Seryi, G. Stupakov, P. Tenenbaum, A. Wolski, M. Woodley

In this talk:

Focus on simulations of dynamics effects like ground motion and feedbacks

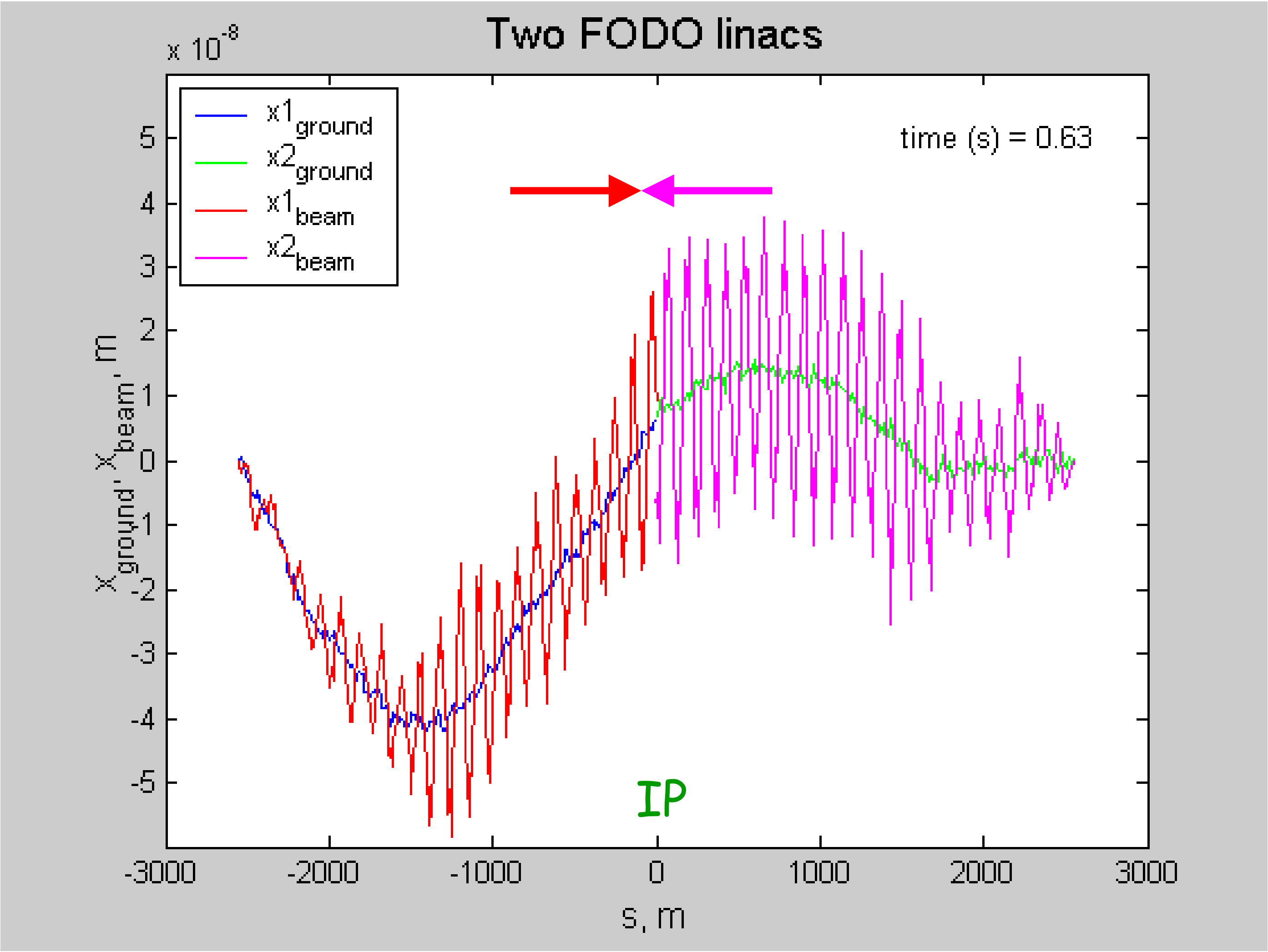
Ground motion models

- Based on data, build modeling P(ω,k) spectrum of ground motion which includes:
  - Elastic waves
  - Slow ATL motion
  - Systematic motion
  - Technical noises at specific locations, e.g. FD)



Example of integrated spectra of absolute (solid lines) and relative motion for 50m separation obtained from the models

P(ω,k) is then used to generate x(t,s) and beams GO



Example of Mat-LIAR modeling

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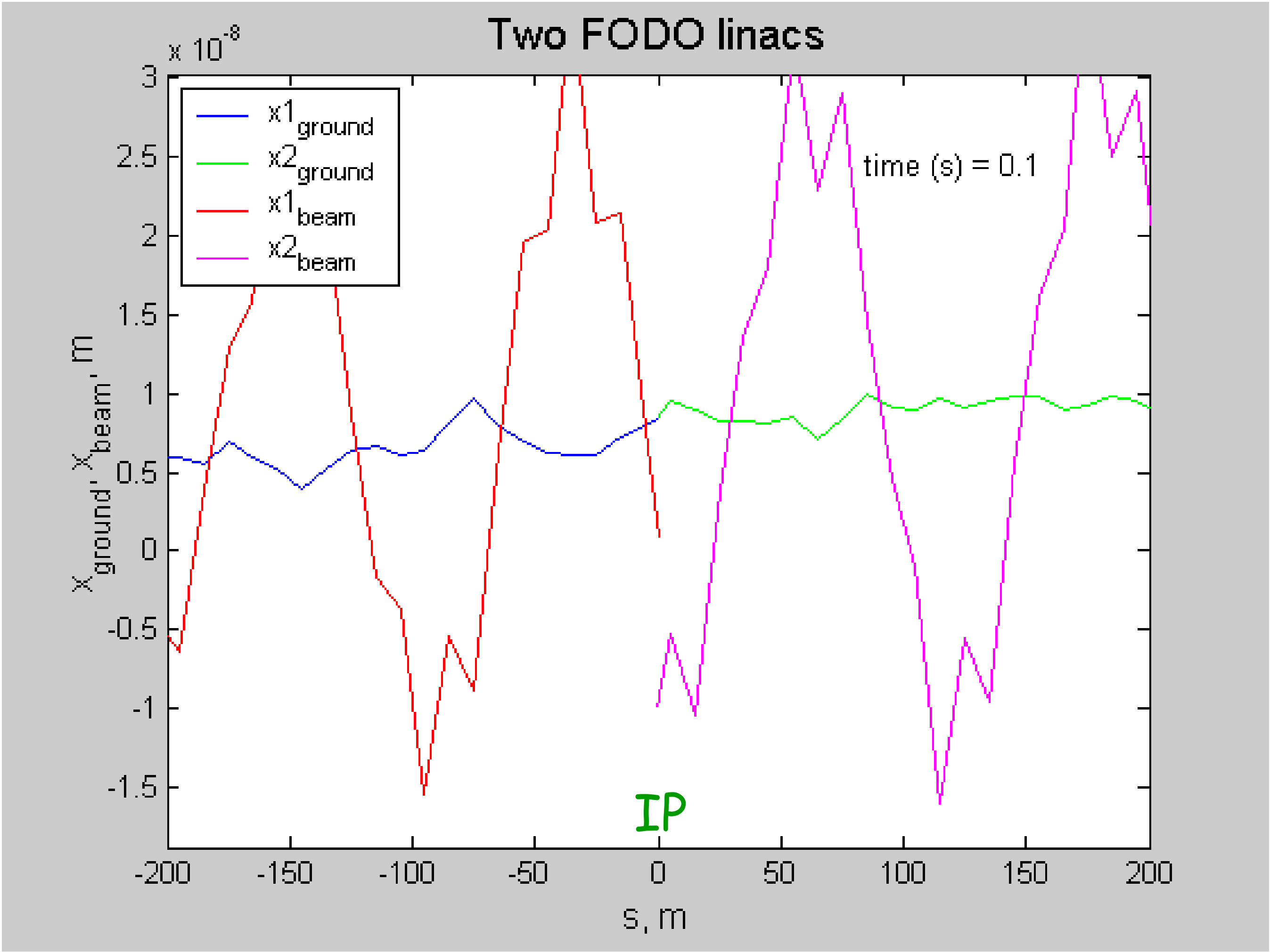
Important that correlation between e+ and e- beamlines is preserved



Note that ground is continuous, but beams have separation at the IP

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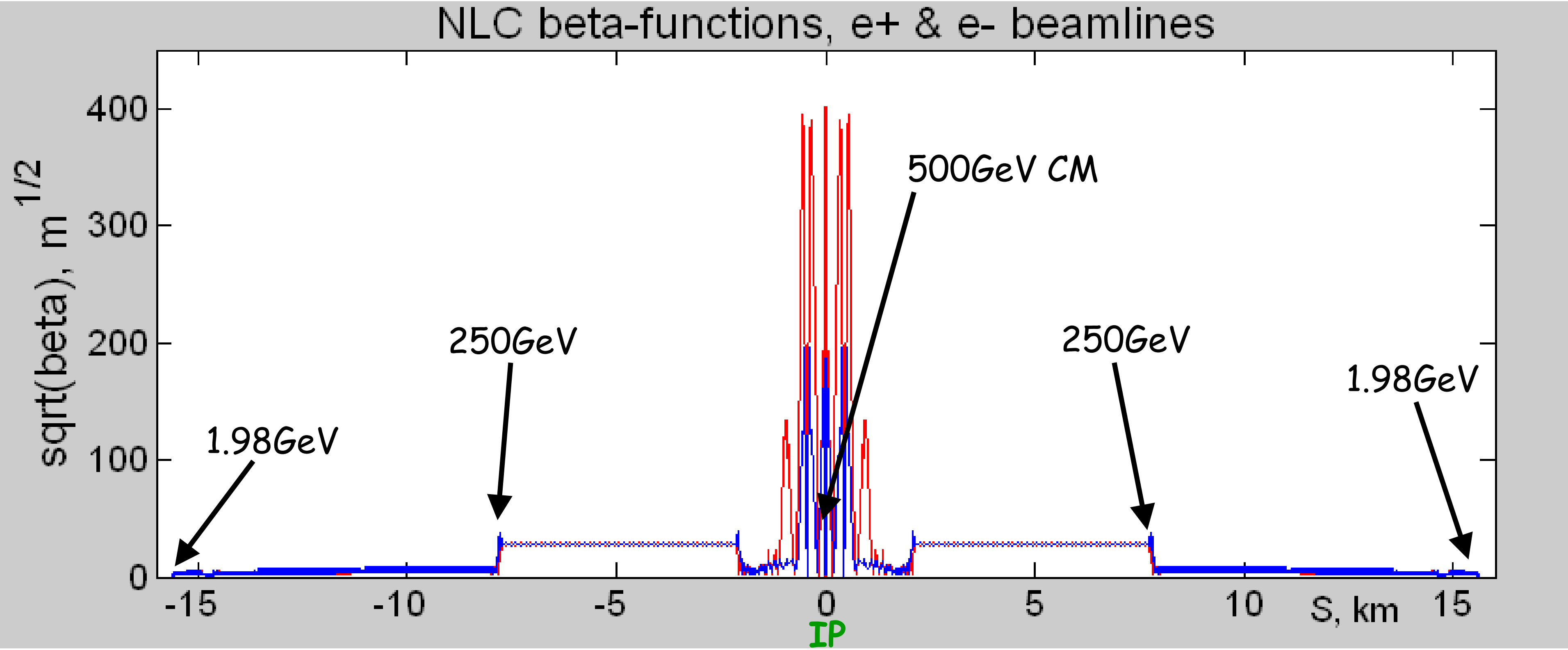
Simulations of complete NLC
DR => IP <= DR



Included: ground motion
SLC style IP feedback
RF structure misalignments
Beam-beam effects …

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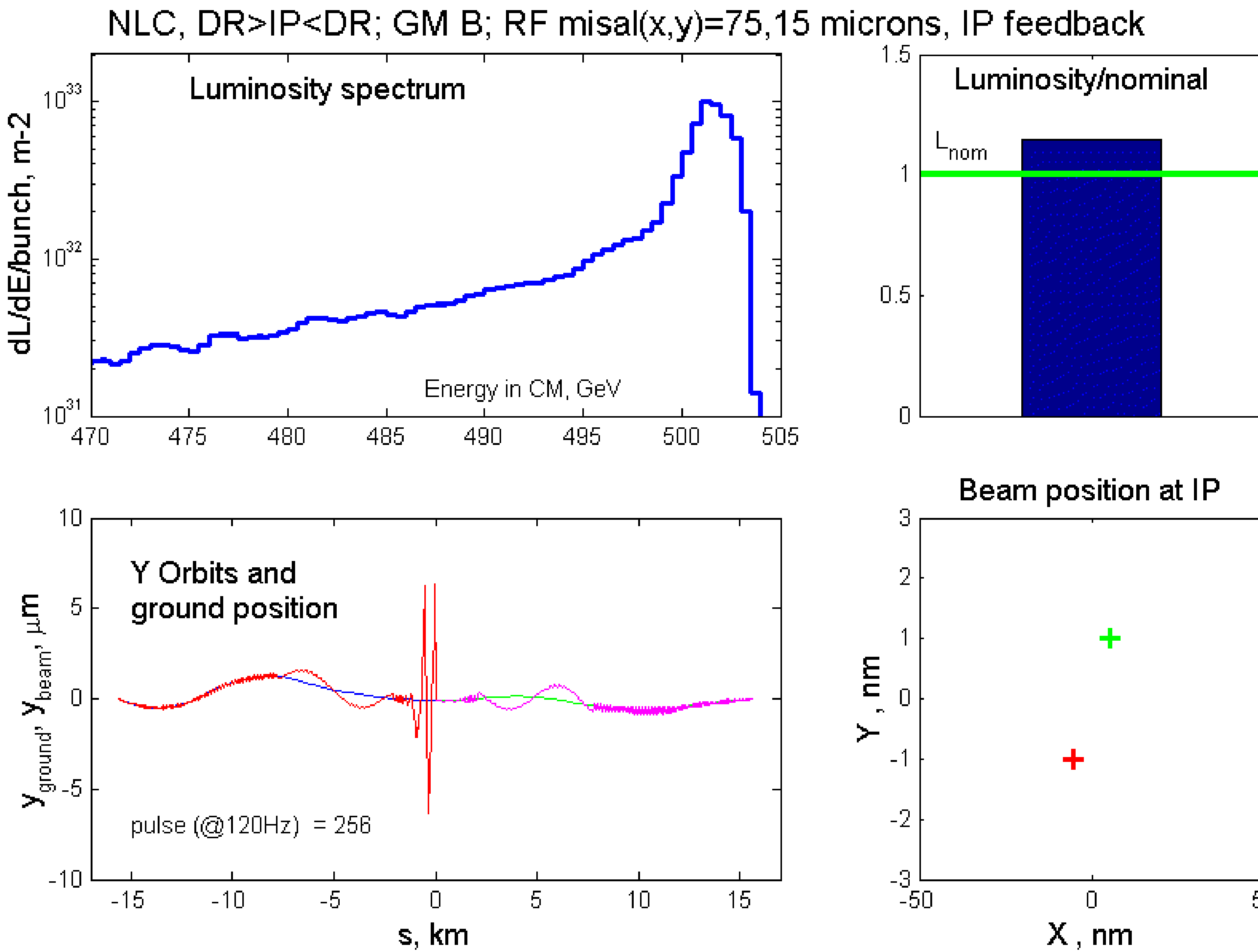
Intermediate ground motion



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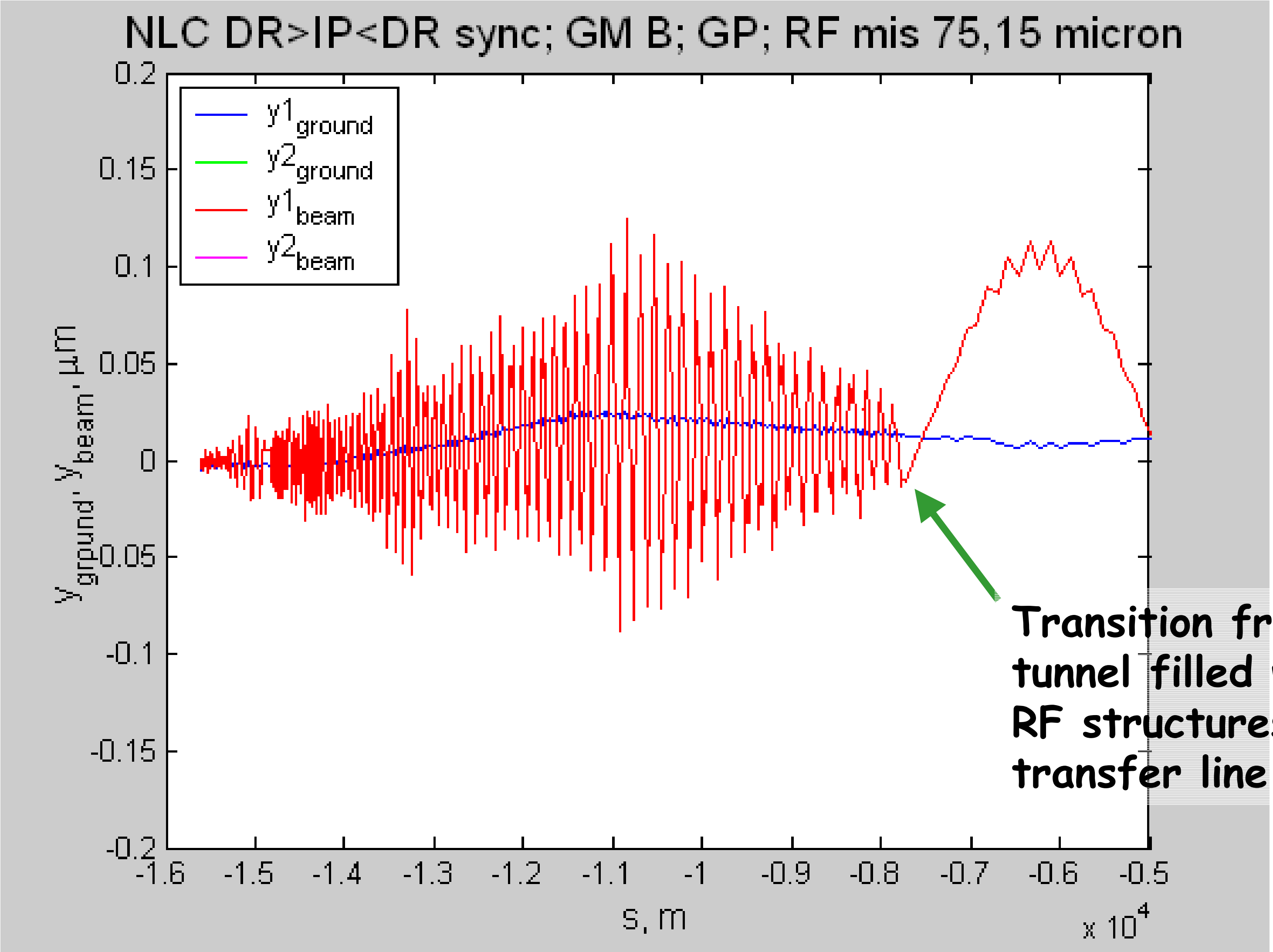
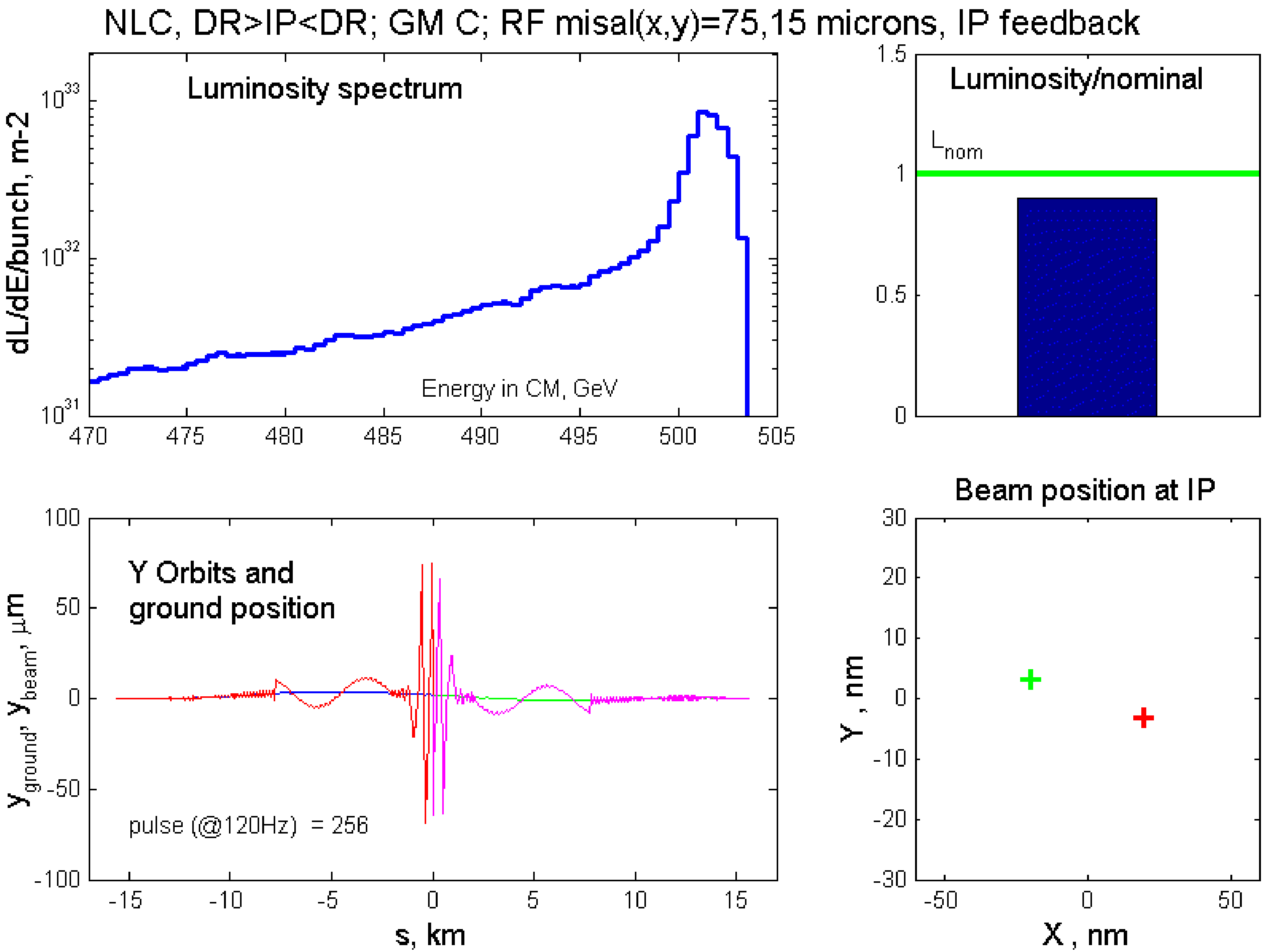
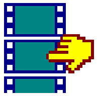
Zoom into beginning of e- linac …



Transition from tunnel filled with RF structures to transfer line

Noisy ground motion





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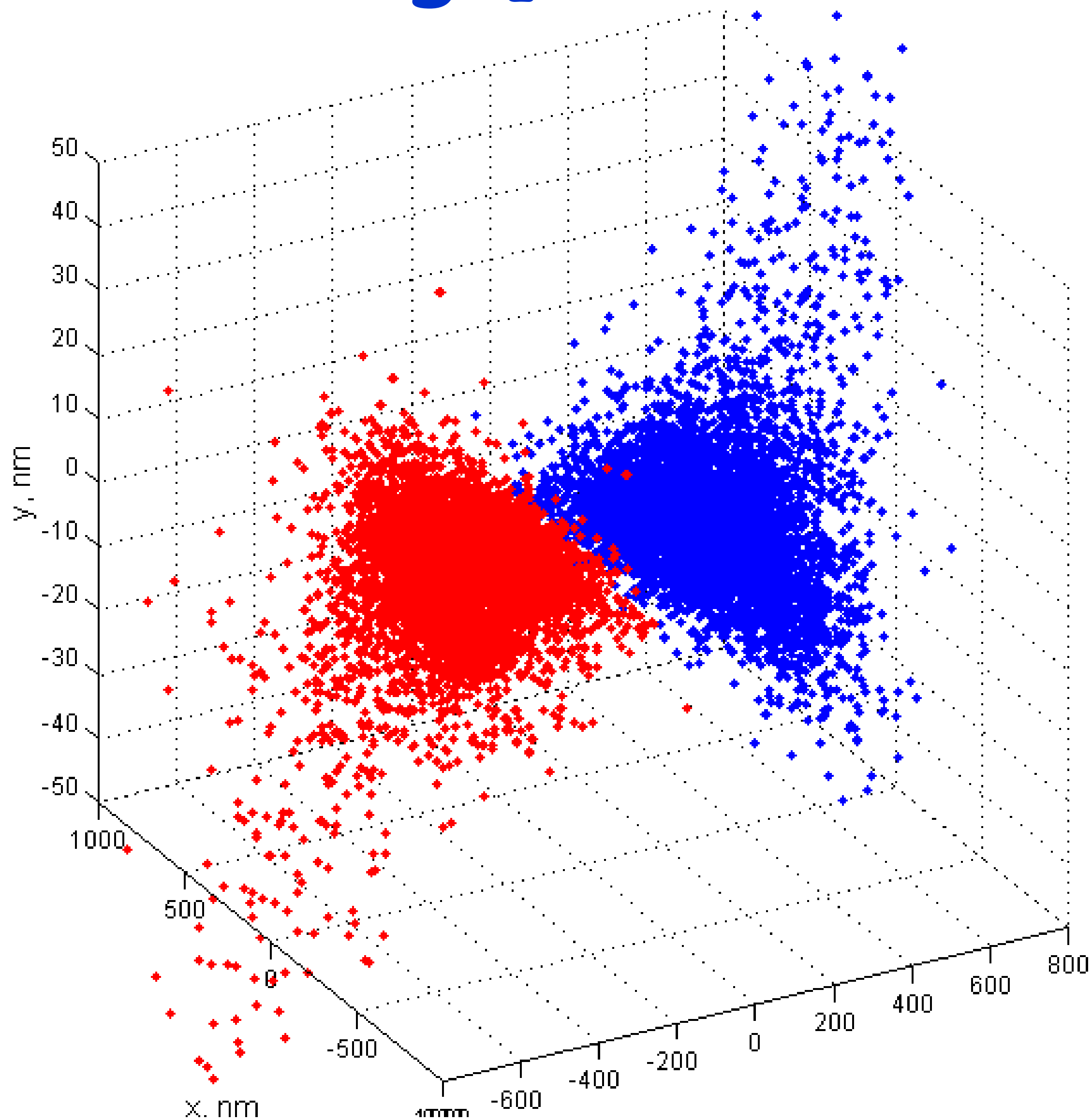
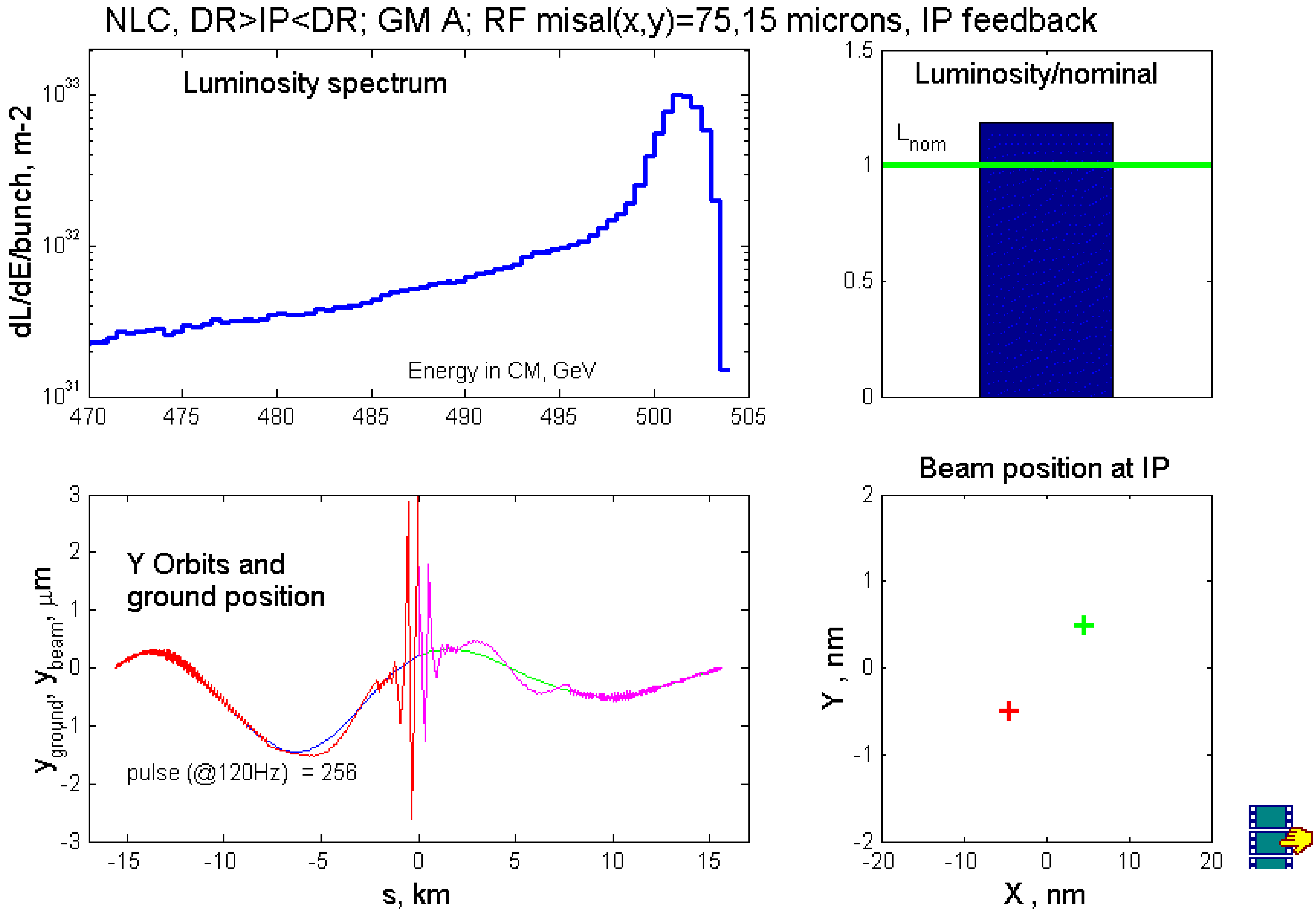
Beam-beam collisions calculated by Guinea-Pig [Daniel Schulte]



Quiet ground motion



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IP beam-beam feedback

Colliding with offset e+ and e- beams deflect each other

Deflection is measured by BPMs

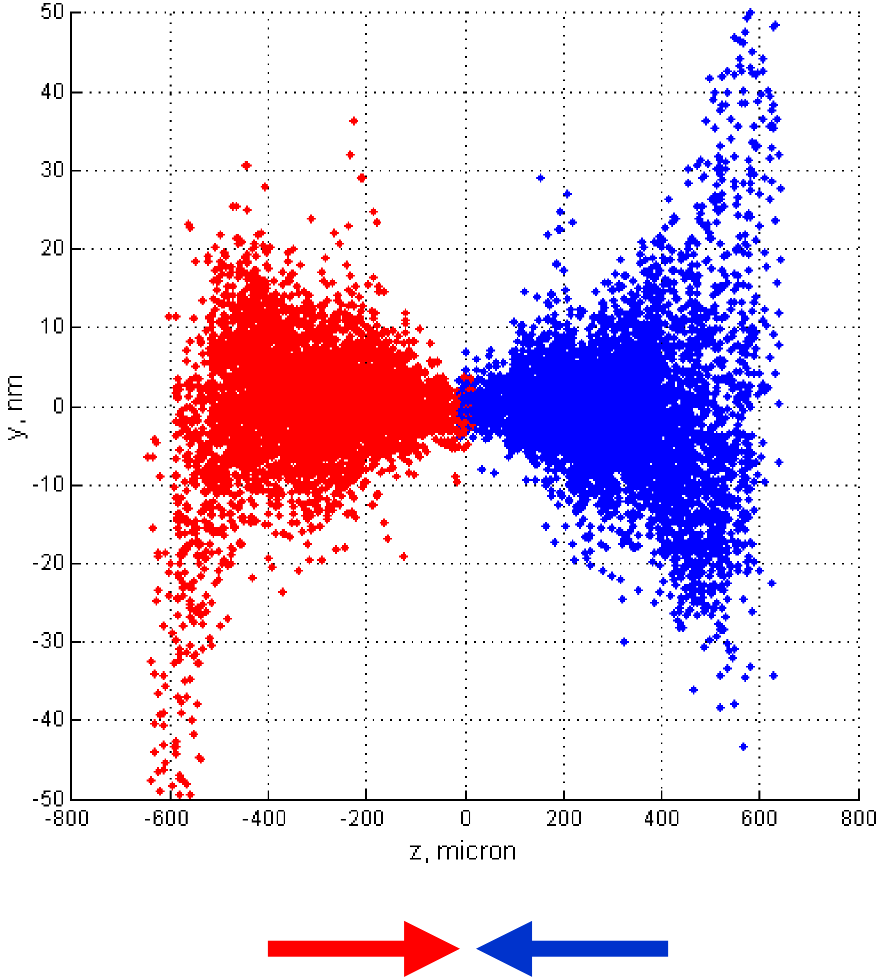
Feedback correct next pulses to zero deflection
(it uses state space, Kalman filters, etc. to do it optimally)

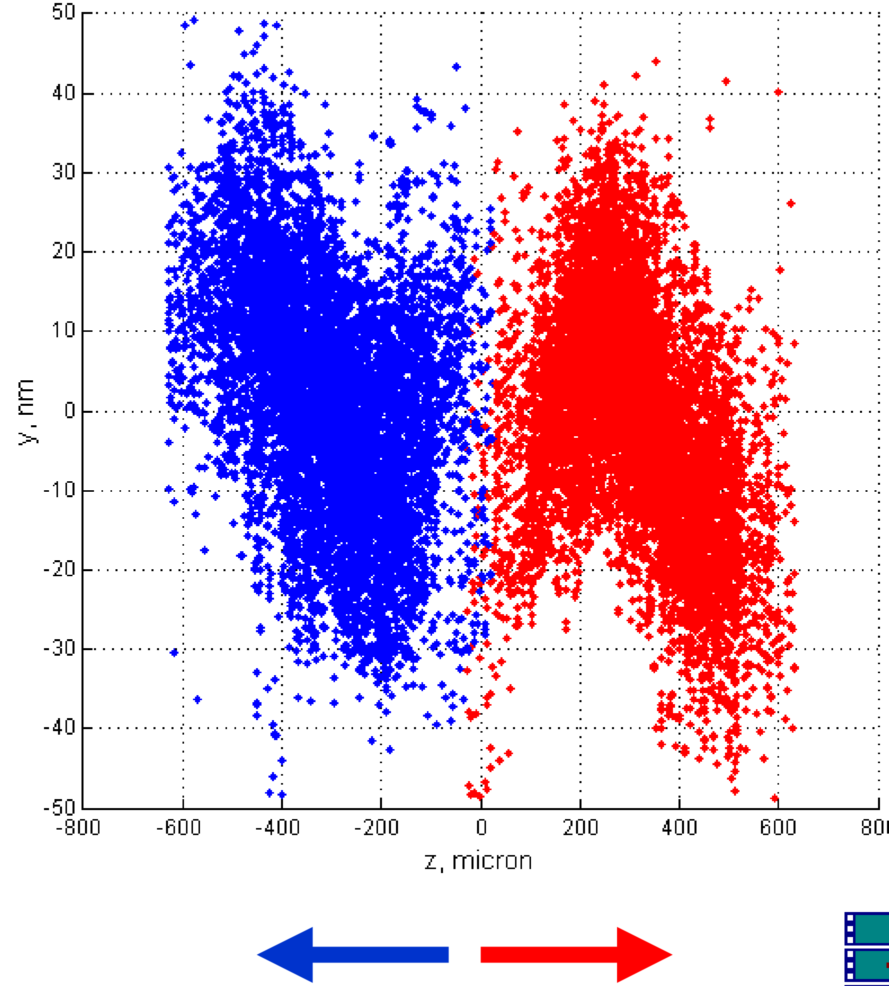
The previous page shows that feedback needs to keep nonzero offset to minimize deflection

reason: asymmetry of incoming beams

(RF structures misalignments=> wakes=> emittance growth)

Pulse #100, Z-Y





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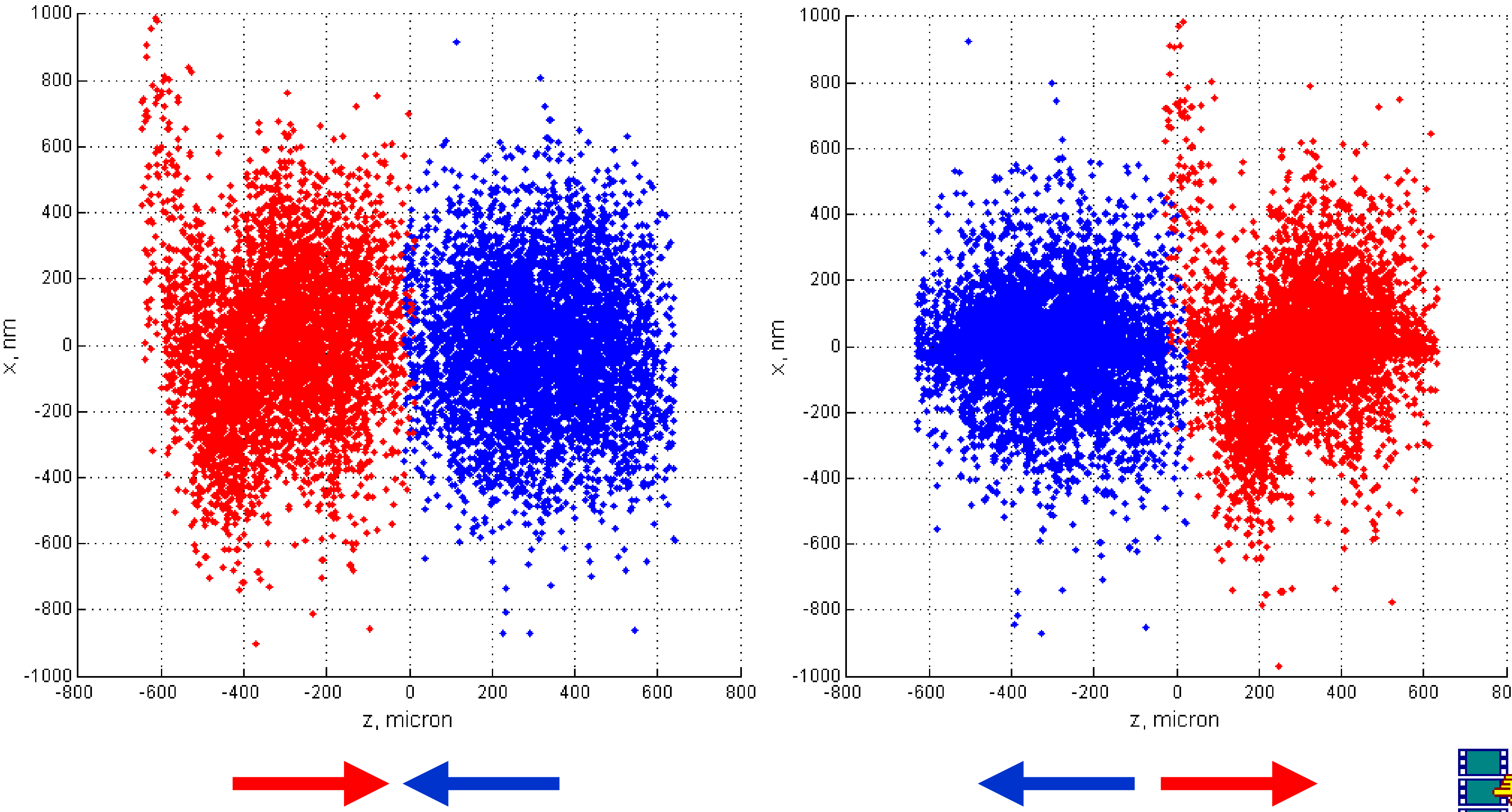
Pulse #100, Z-X


x, nm
z, micron
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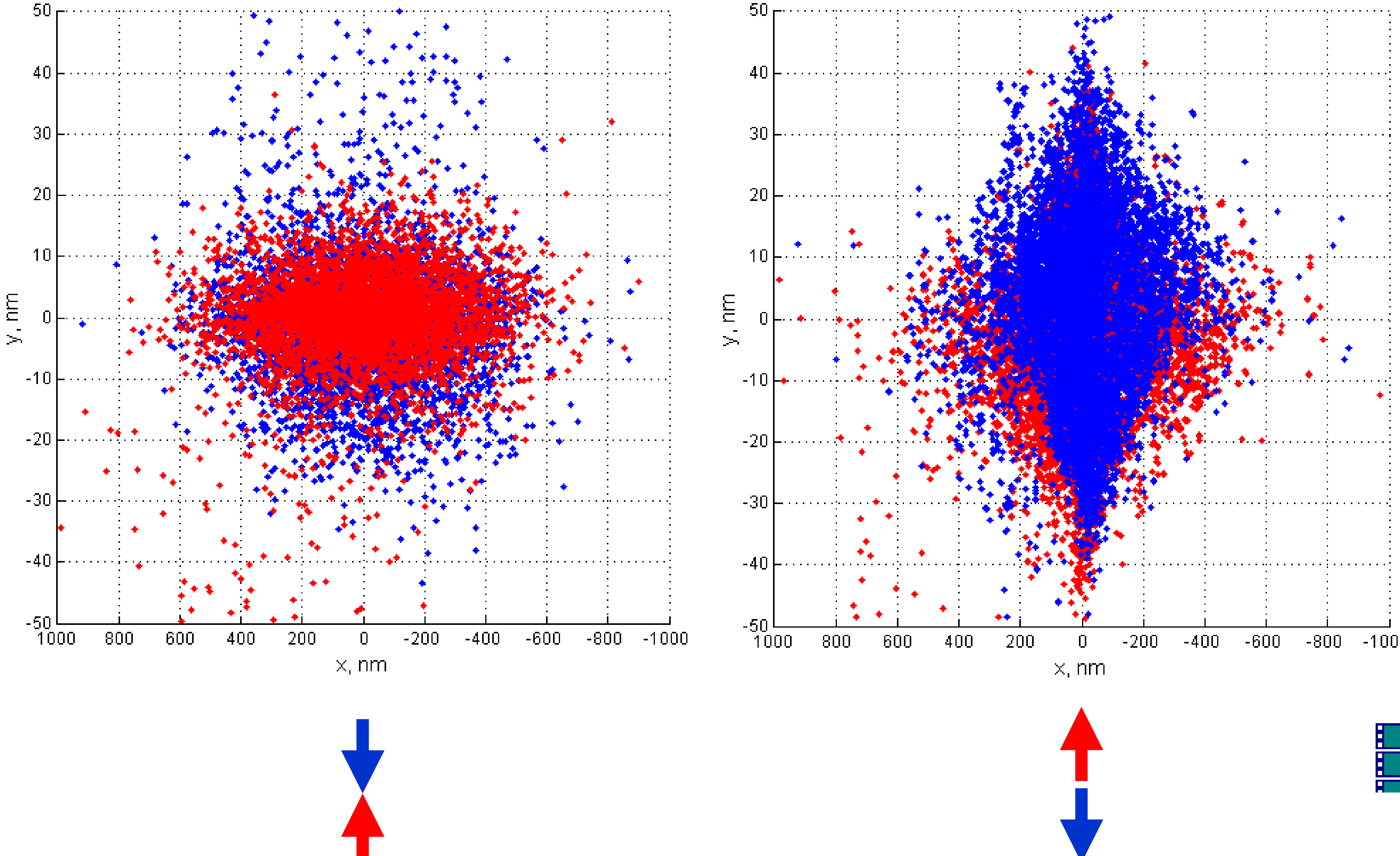
Pulse #100, X-Y



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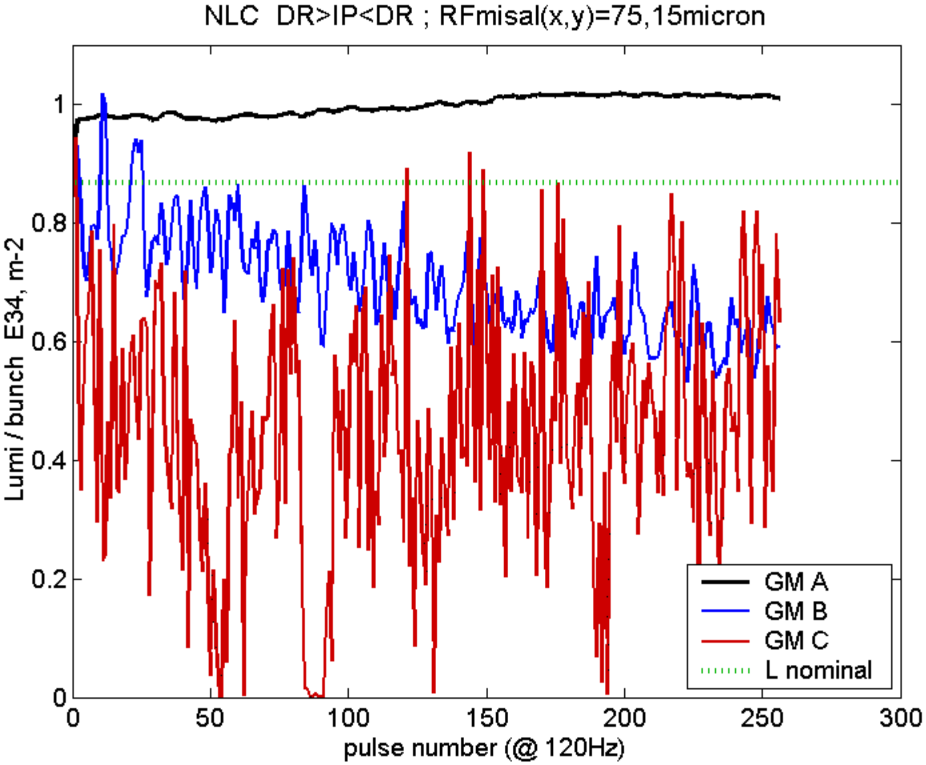
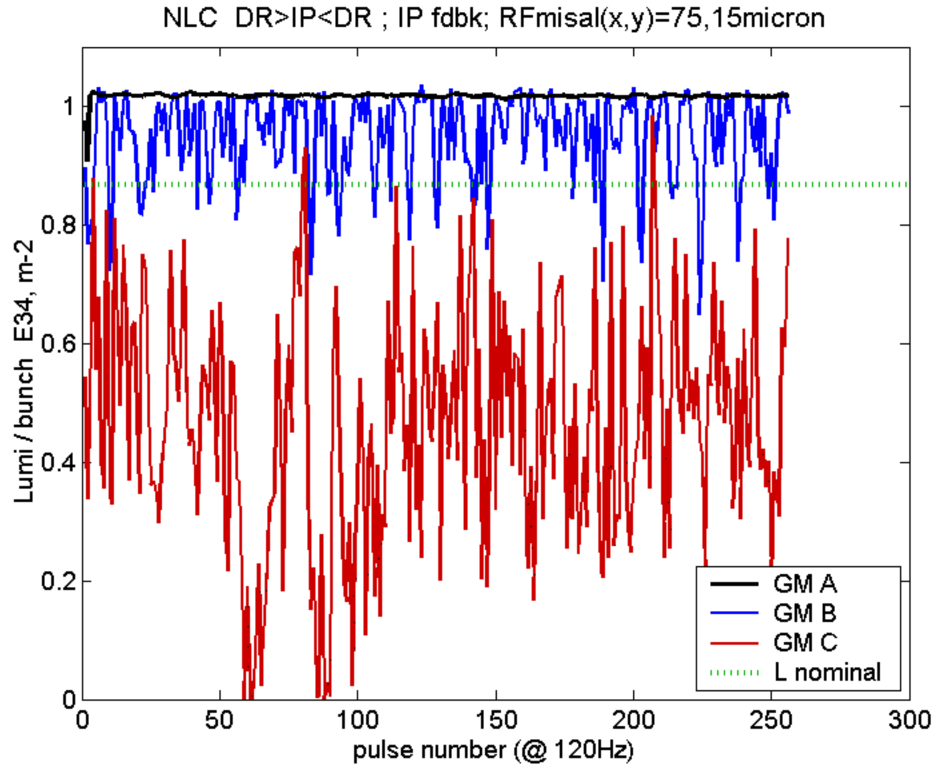
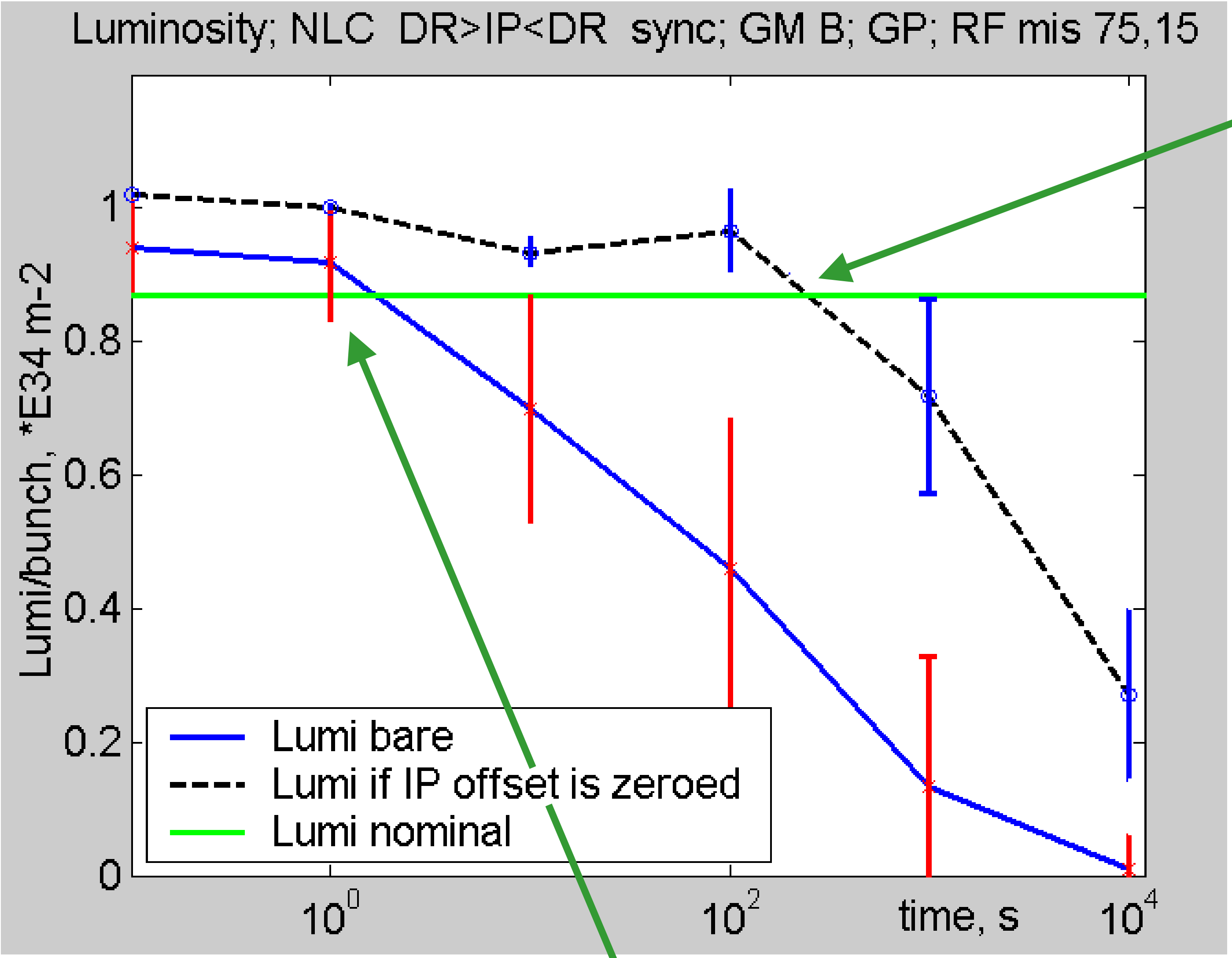
With and without IP feedback, summary





Example for one particular seed
(seed is the same for the left and right plots)

Effects of fast and slow motion



With only IP feedback, Lumi decays as orbit offsets at BDS magnets become too big.
Have ~10000 pulses to fix orbits (should be quite enough)

Lumi decays as IP beam offsets become too big. The IP feedback fixes it.

Simulations of slow effects are only possible with simplifications…

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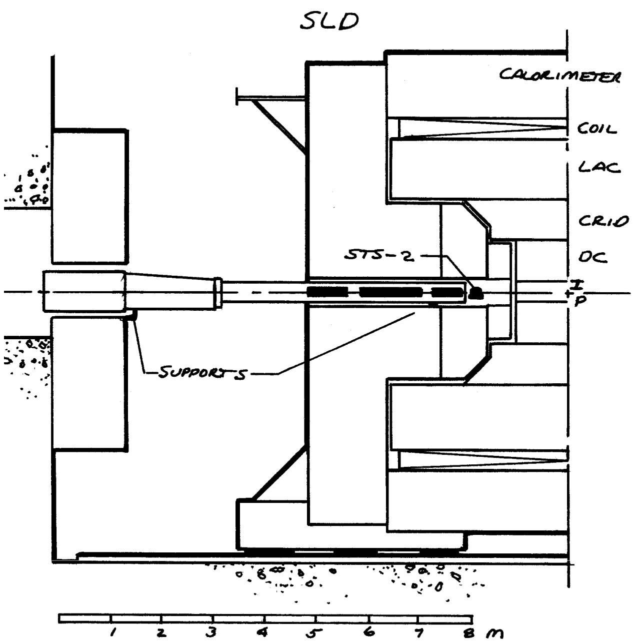
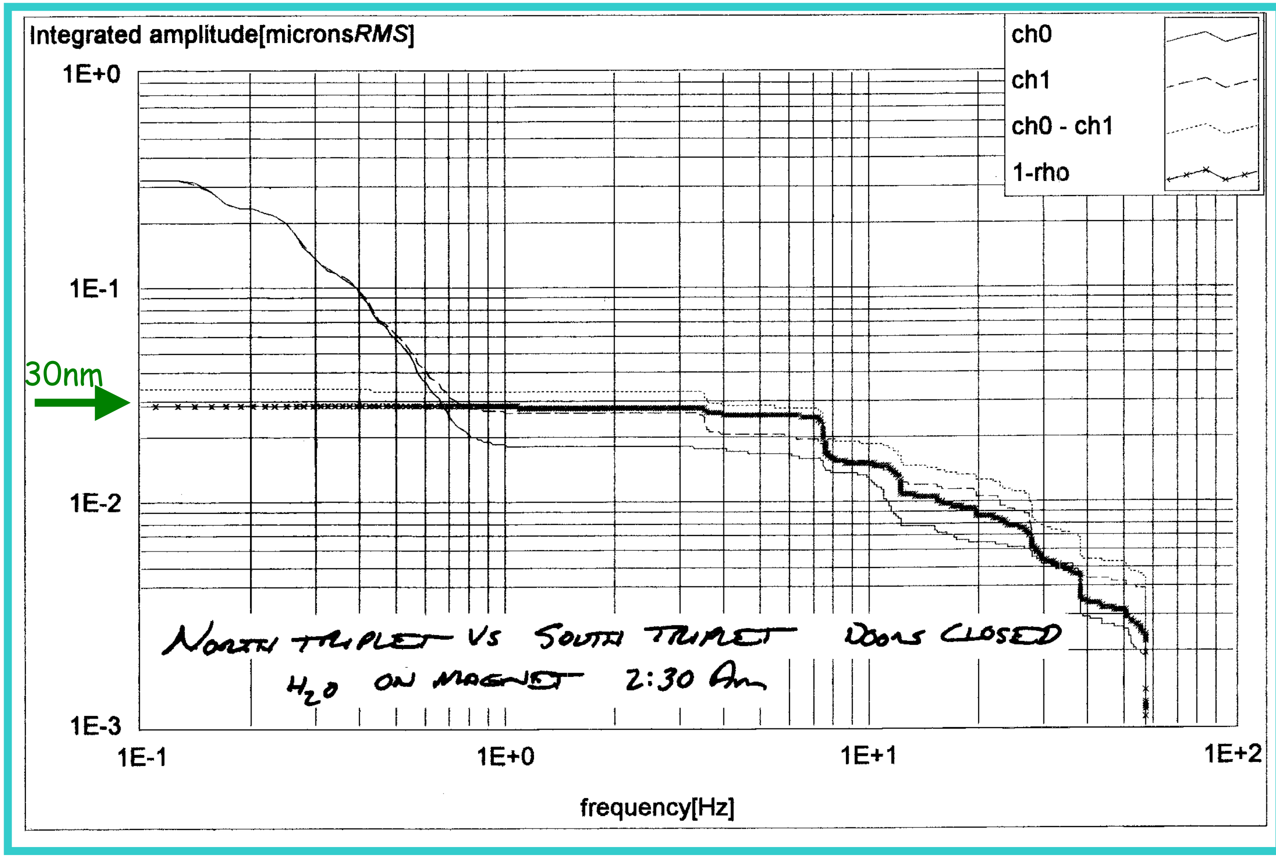
Cultural noise at detector

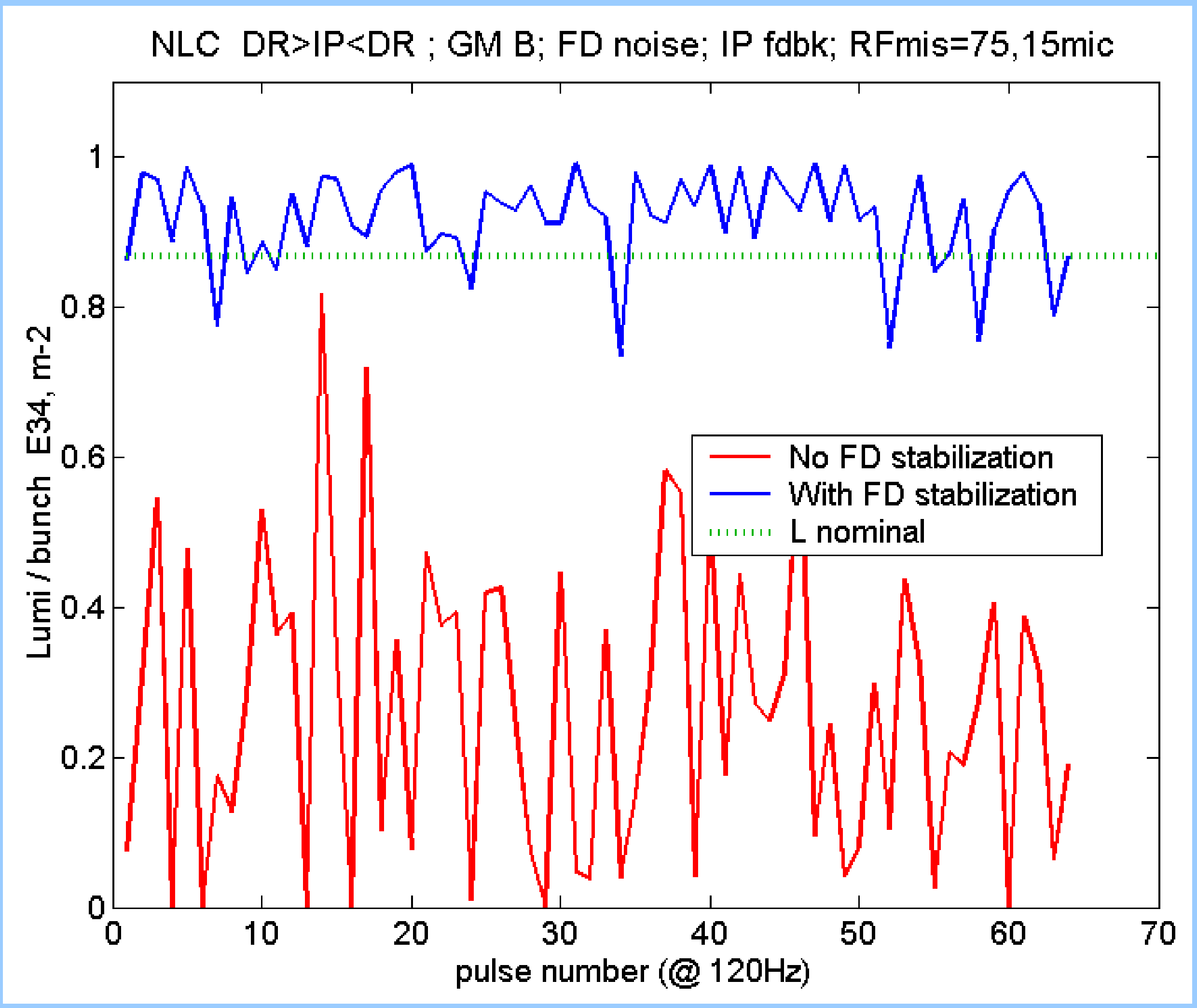
1995 SLD measurements [Gordon Bowden]





- Measured ~30nm relative motion between South and North final triplets
  - Magnetic field was OFF (magnetic field ON could have increases detector rigidity)
  - North triplet (Ch1) noisier – this side of the building is closer to ventilation and compressor stations
  - Resonances (3.5Hz, 7Hz) are likely to be resonances of detector structure
- More quiet detector possible, but at what cost and how much more quiet ?

Modeling detector vibration and FD stabilization…



NLC with ground motion B, IP feedback and additional SLD-like detector noise (~20nm at each FD). Stabilization represented by an idealized transfer function.

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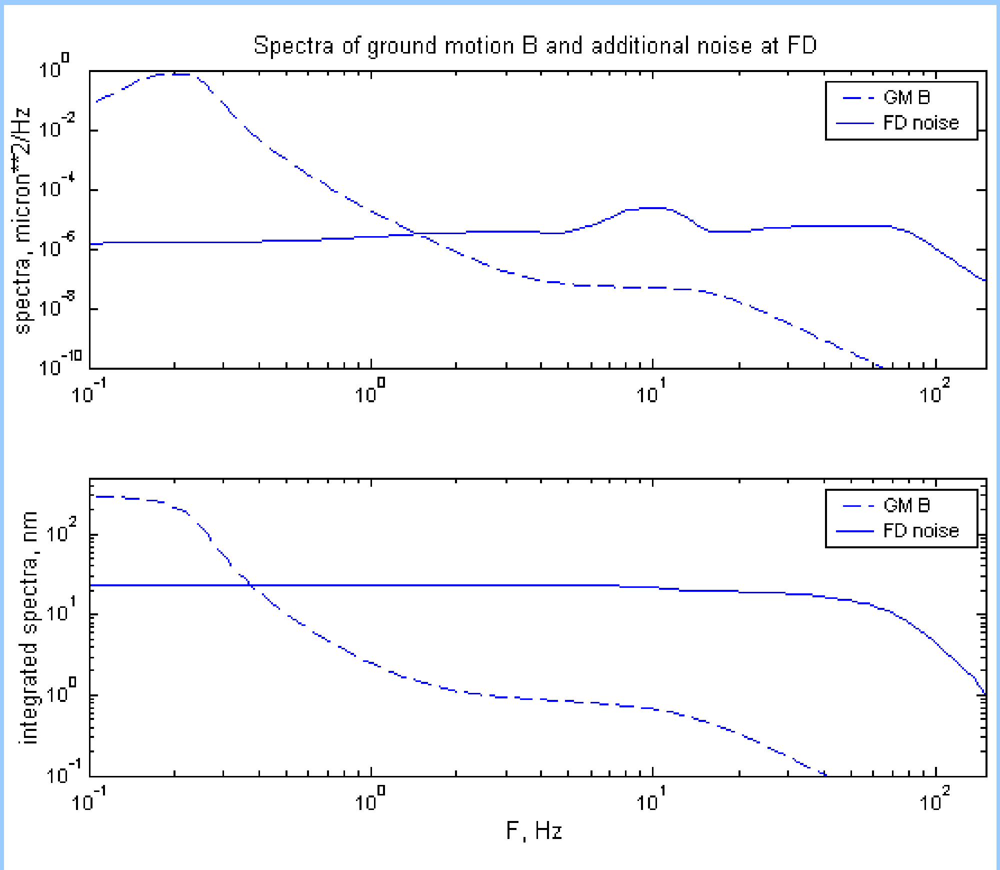
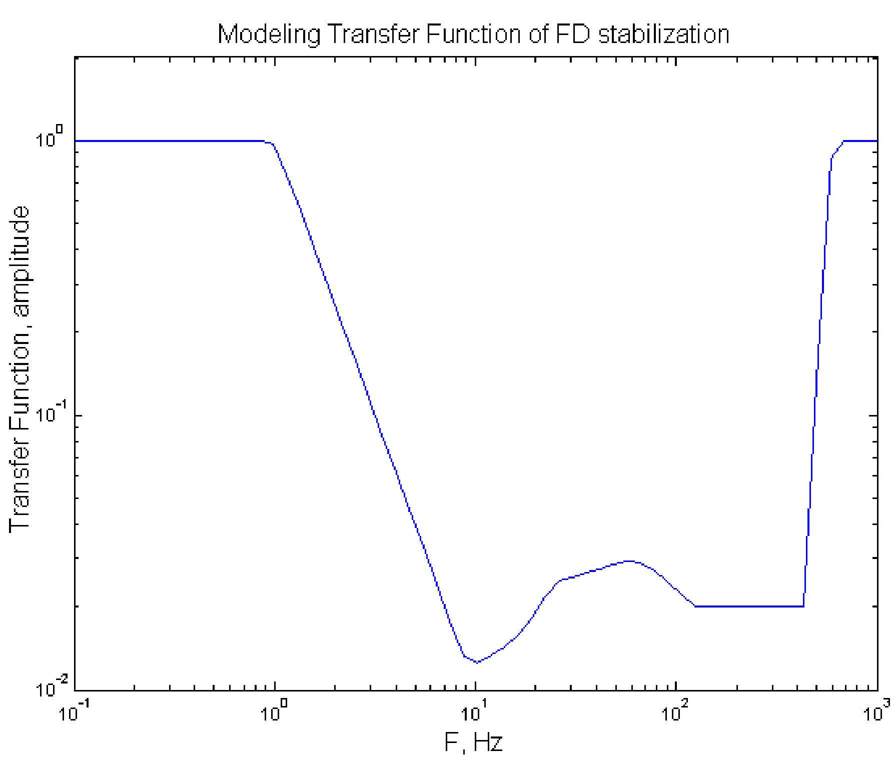
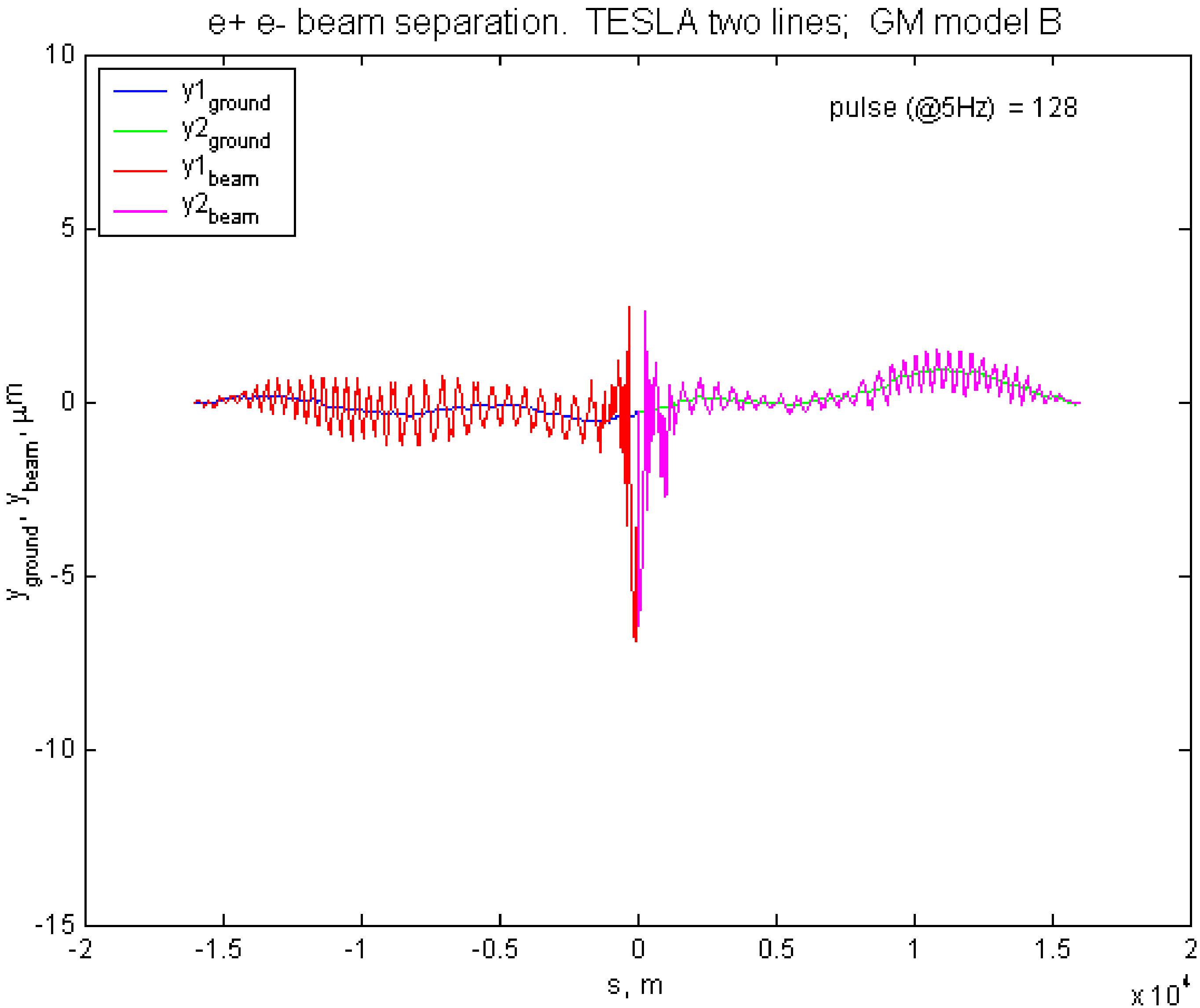
Details of the modeling of FD stabilization...





For TRC we do similar studies with TESLA and CLIC …



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Virtual NLC ?

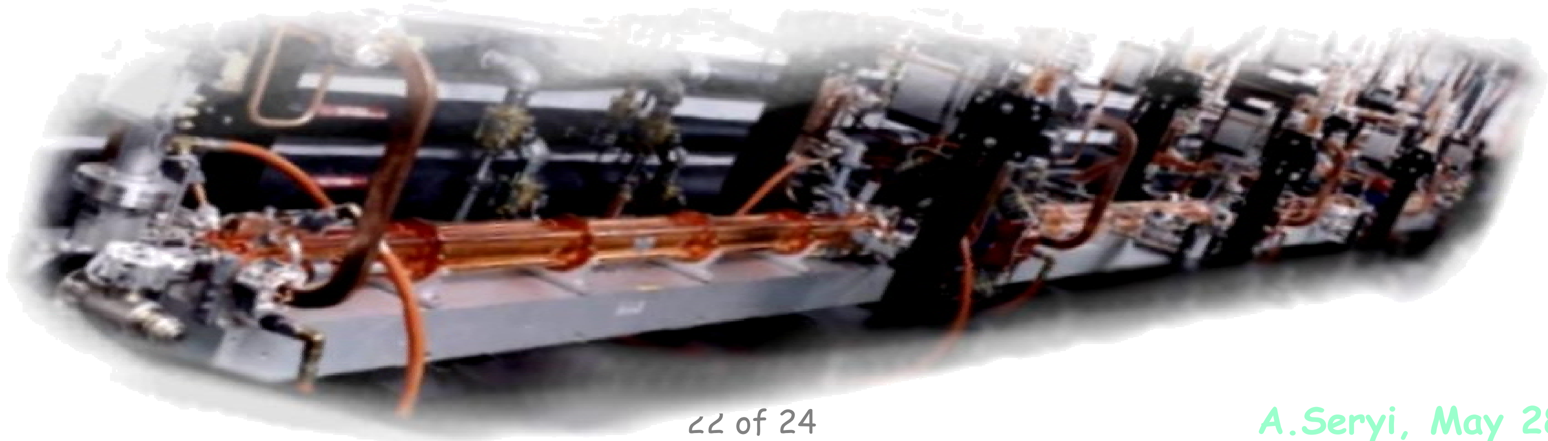
1 bunch, 500 pulses takes 10 hours on 2GHz PC

Real time calculations (120Hz, 192 bunch/train) will require:

300000 of 11.4GHz ideally parallel processors

If each of them is 1cm long, they will span over 3km

Easier to build real NLC



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Simulations of complete NLC
DR => IP <= DR

Good news :

No big surprises yet - everything works as expected

But we just started. For example, need to learn how to tune the machine with jittering luminosity…

And of course, simulations do not substitute developing hardware, taking more measurements, verifying models, etc.

For more details, see

http://www-project.slac.stanford.edu/lc/local/AccelPhysics/GroundMotion/

http://www.slac.stanford.edu/accel/nlc/local/AccelPhysics/codes/liar/web/liar.htm

http://www.slac.stanford.edu/~seryi

This talk is posted at

http://www.slac.stanford.edu/~seryi/LCD_May28_2002/