NLC - The Next Linear Collider Project

Update on NLC stability studies, NLC group contribution to TRC

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LCD group meeting
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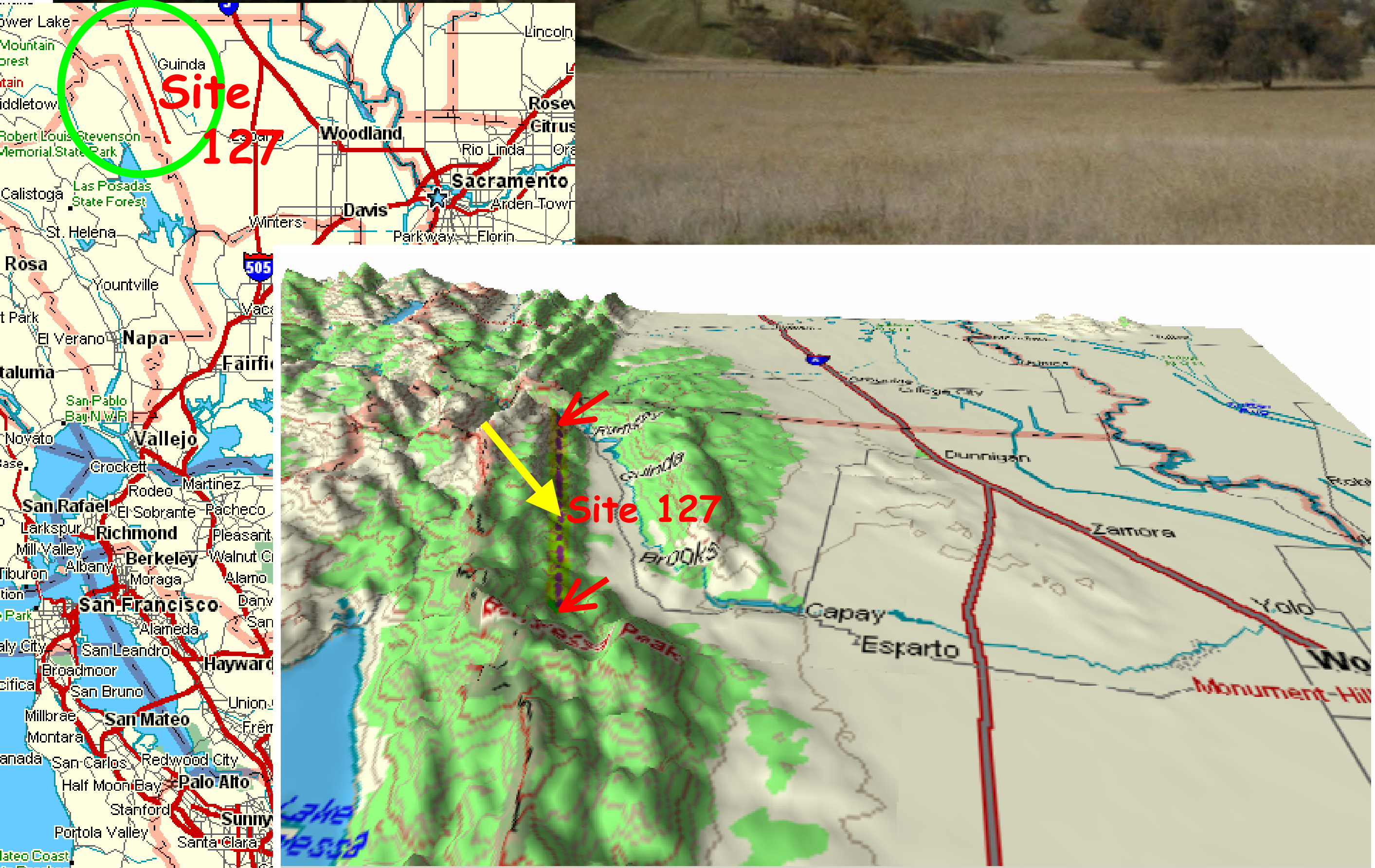
Topics that we will discuss today

- Update on stability of NLC sites study
- NLC Linac stability study
  - And issues of SC linac stability
- TRC study on performance of LC designs with static and dynamic errors (ground motion)
  - And issues of TESLA extraction line in realistic conditions
- TRC Collimation task force
- Briefly: slow motion studies and IP stabilization

Stability of NLC sites

- So far considered many representative sites (sites 127, 145, 135, 90, etc. in CA, and several in IL)
- Primary criteria: availability, stability, geology, power and water
- Both cut and cover and deep tunnel options were studied
- Current distributed RF system configuration encourages more detailed consideration of deep-tunnel sites
- Deep tunnel site 127 was investigated in details, now site 90 is under study

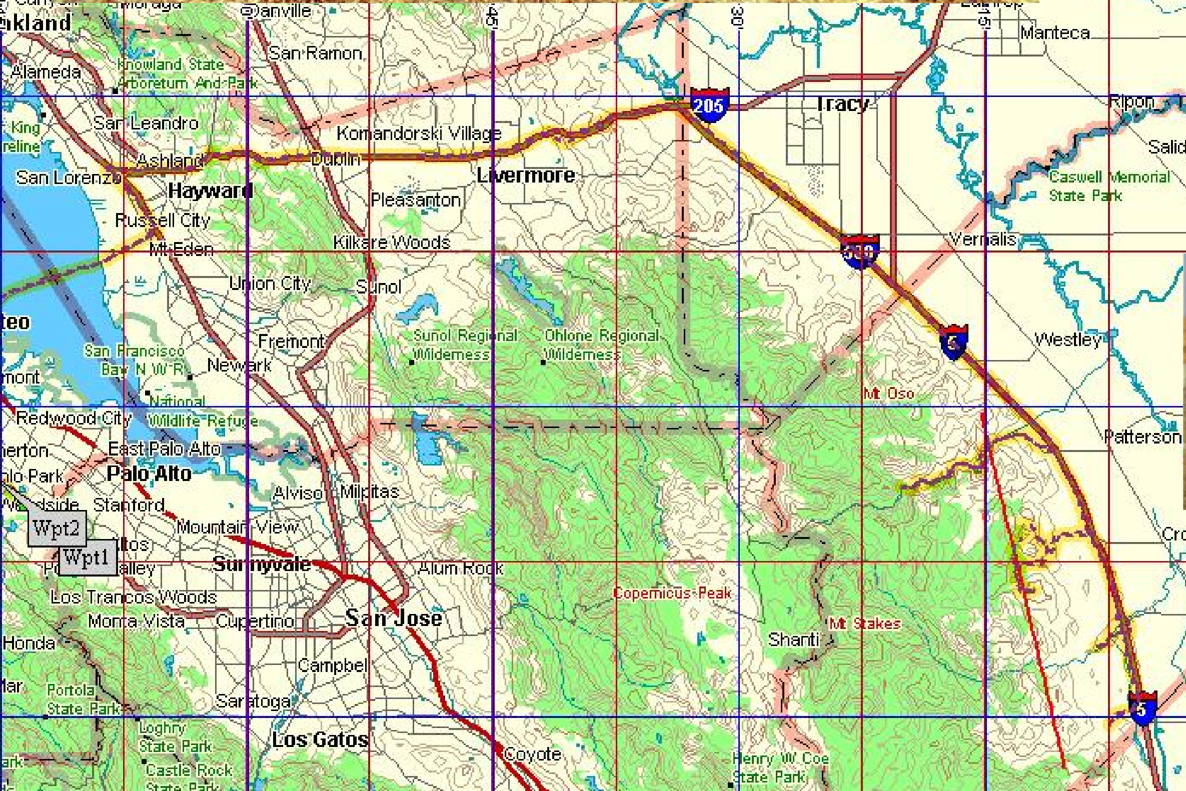
NLC representative sites in CA



Site 127 – Deep tunnel

Site 135- Cut & cover

NLC representative site 90



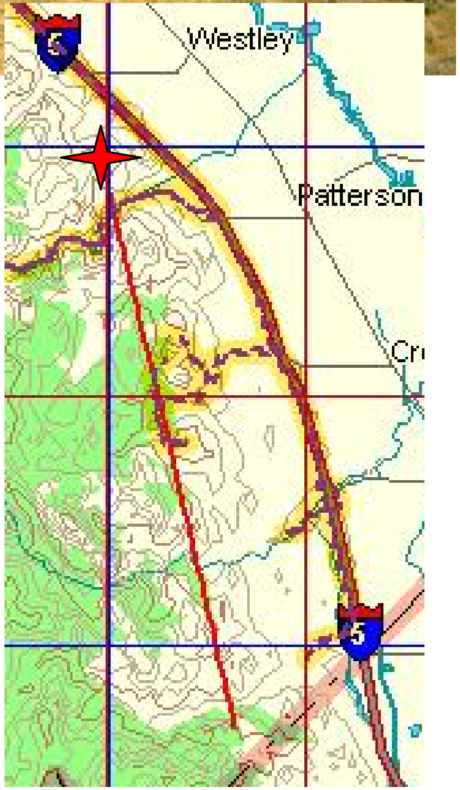
Site 90 –
Deep tunnel

Ground motion study at site 90

Measurements were done at a location most close to highway 5 (3 miles away)

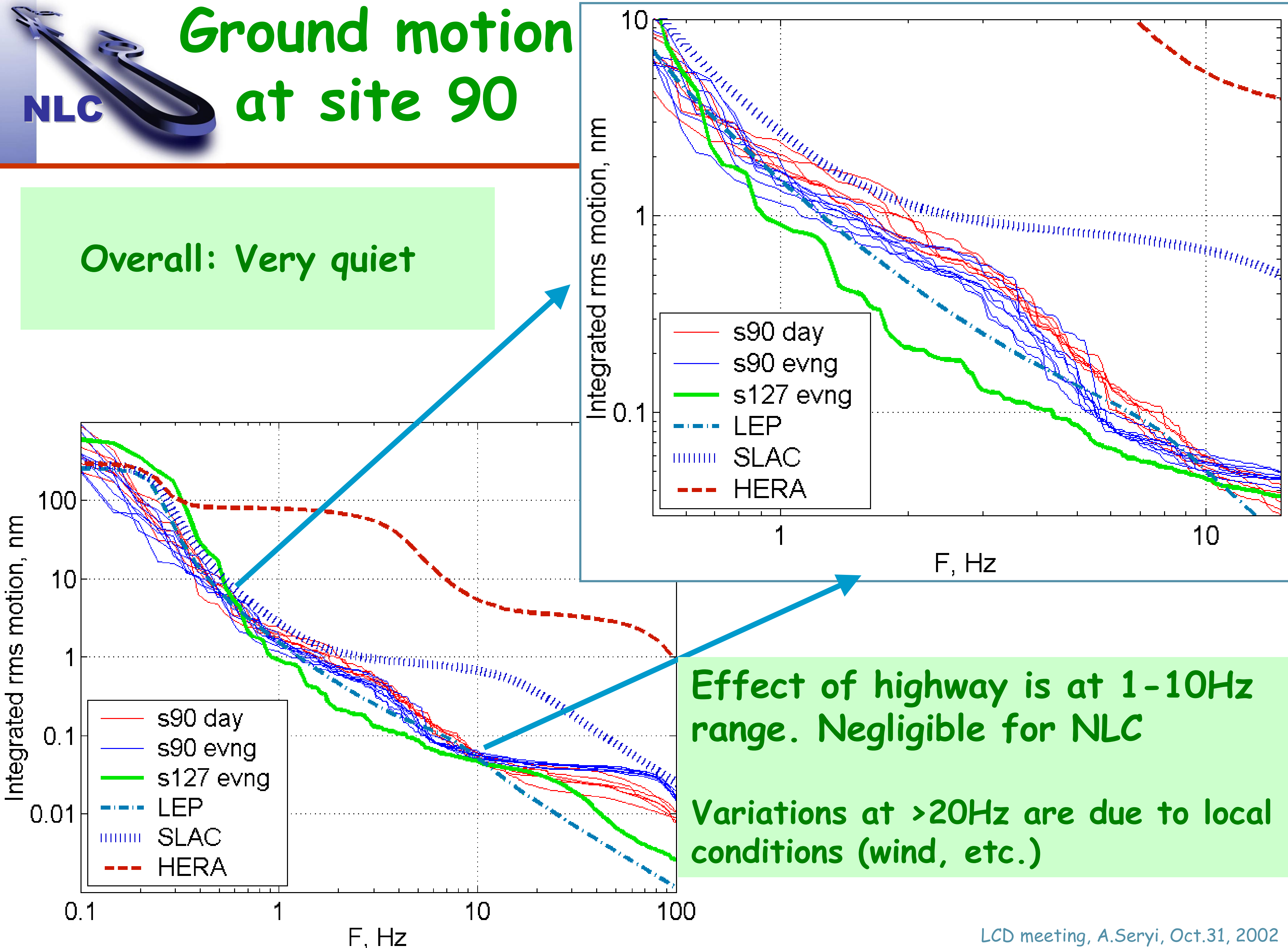
(235’ from local road)

Measurements were performed on surface.



Ground motion at site 90

Overall: Very quiet



Effect of highway is at 1-10Hz range. Negligible for NLC

Variations at >20Hz are due to local conditions (wind, etc.)

NLC stability

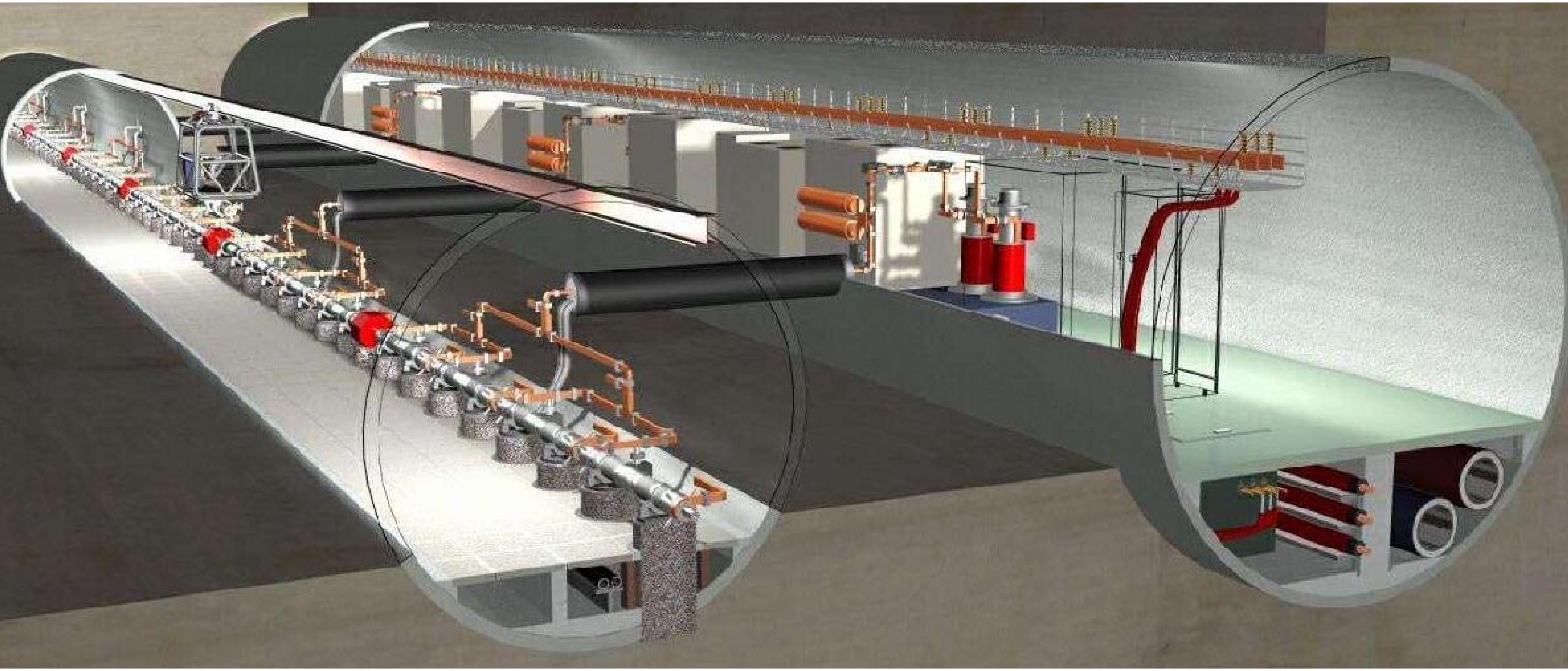
- Stable site
- Proper handling of equipment noise
  - External noise, outside of the tunnel
  - In-tunnel noise (e.g. from utility tunnel)
  - On-girder noise (e.g. from cooling water)

Focused on this

- Example of on-girder noise: vibration due to cooling water of RF structures
- Stability of the main linac with thousands of components may be more essential than FD, even though FD tolerances are tighter

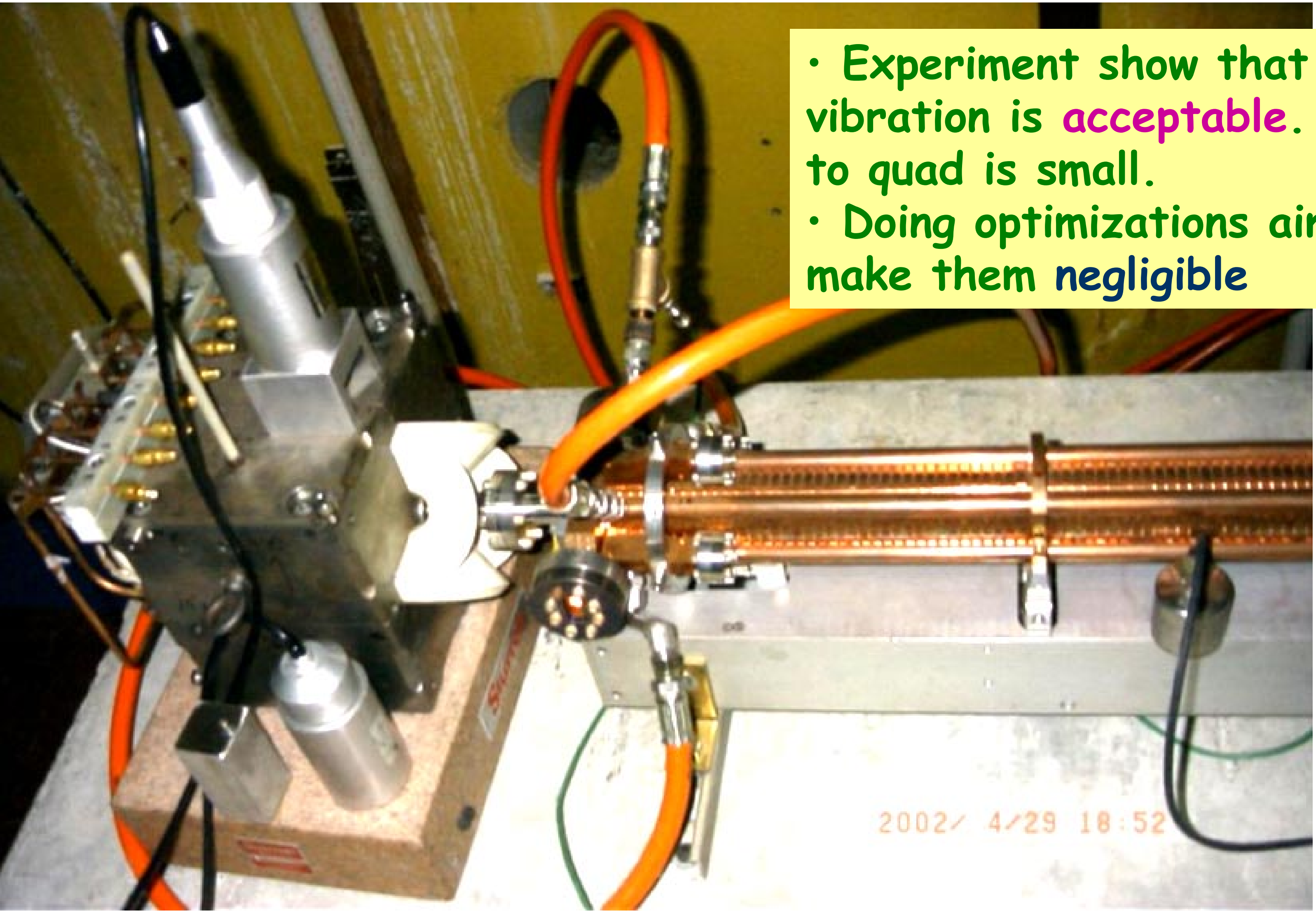
Important feature of warm LCs: quads can have separate supports

- Quads on separate supports are connected to rock
- Vibration coupling from RF structure to quad can be made very small
- This helps to achieve vibration stability requirement for linac quads



Artistic view of JLC-C [Shigeru Takeda, IWAA 99]

Vibration of RF structure due to cooling and vibration coupling to quadrupoles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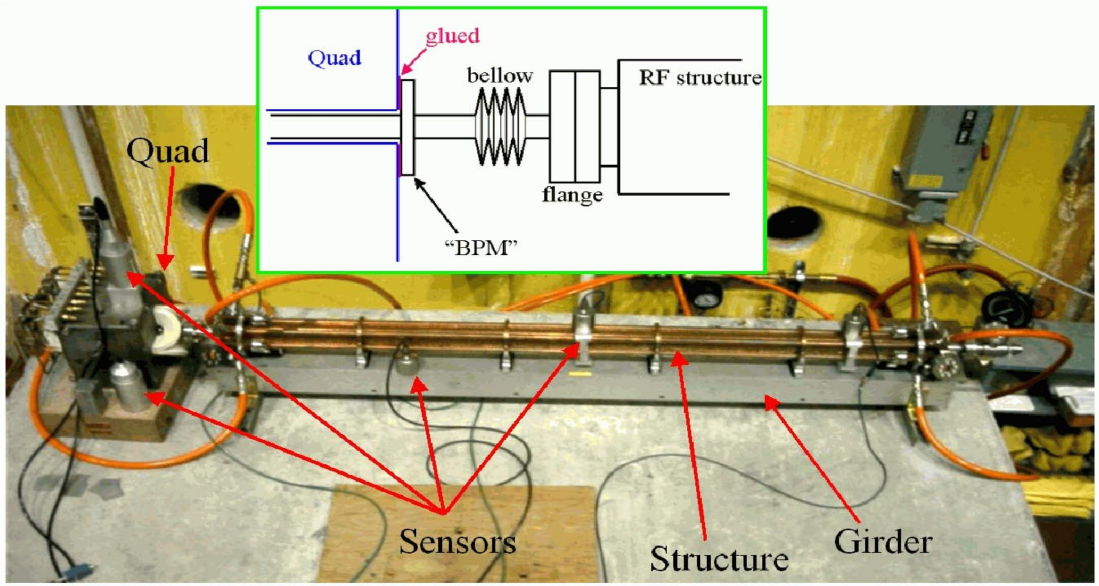
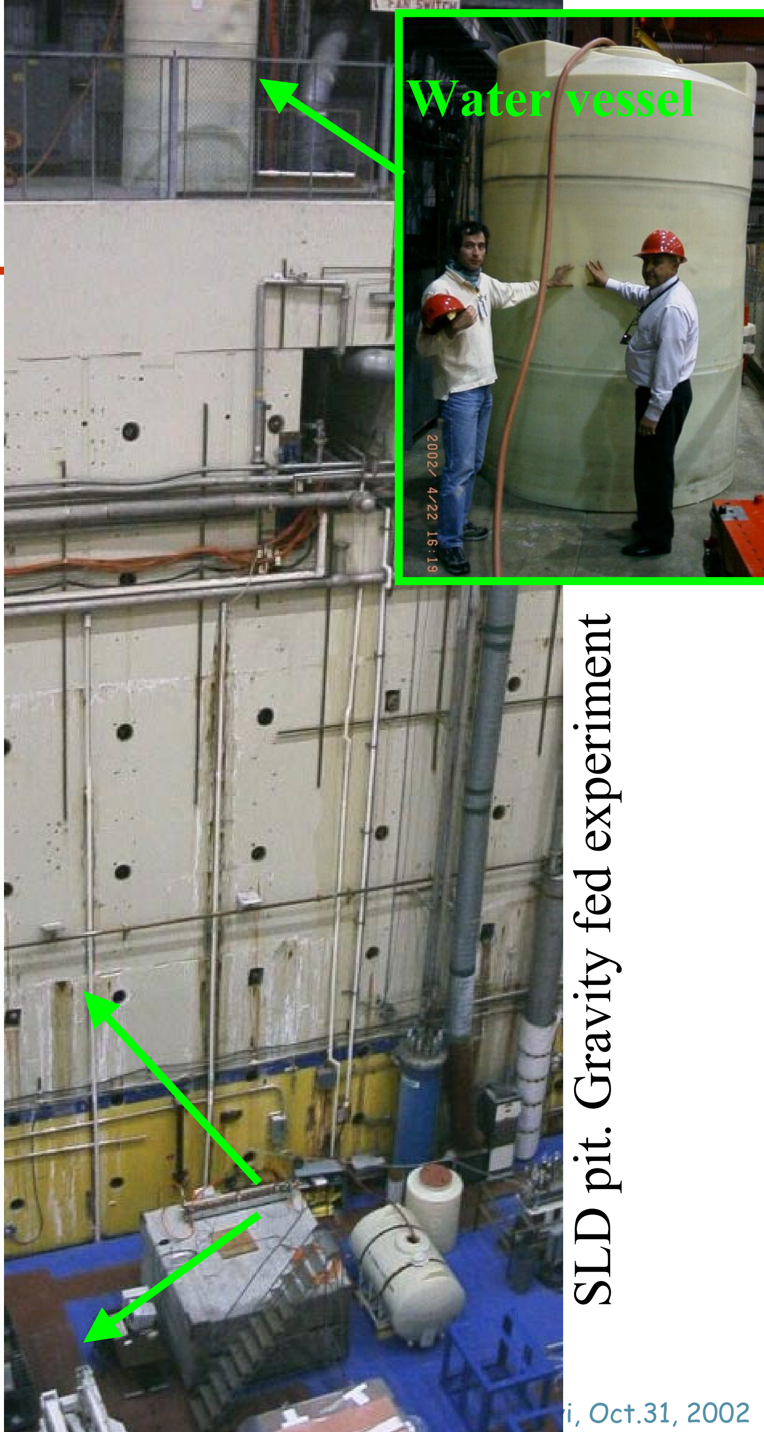
- Experiment show that additional vibration is acceptable. Coupling to quad is small.
- Doing optimizations aimed to make them negligible

Vibration setup in SLD

- Study vibration of the Structure - girder due to internal turbulence using gravity-fed water

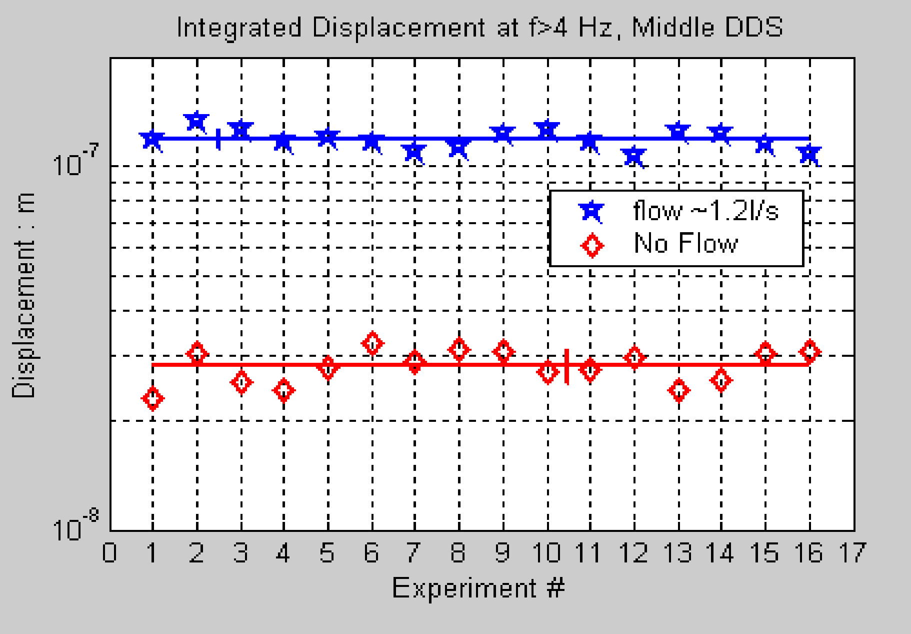
- Study vibration transmission to quadrupole in a structure-quad assembly

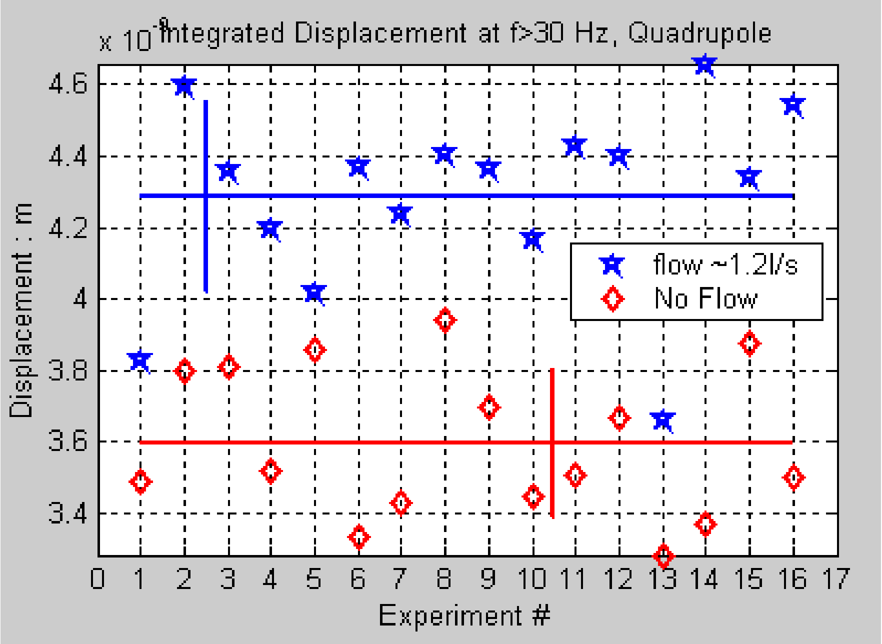




SLD pit. Gravity fed experiment

RF structure to Quad vibration coupling in gravity fed case





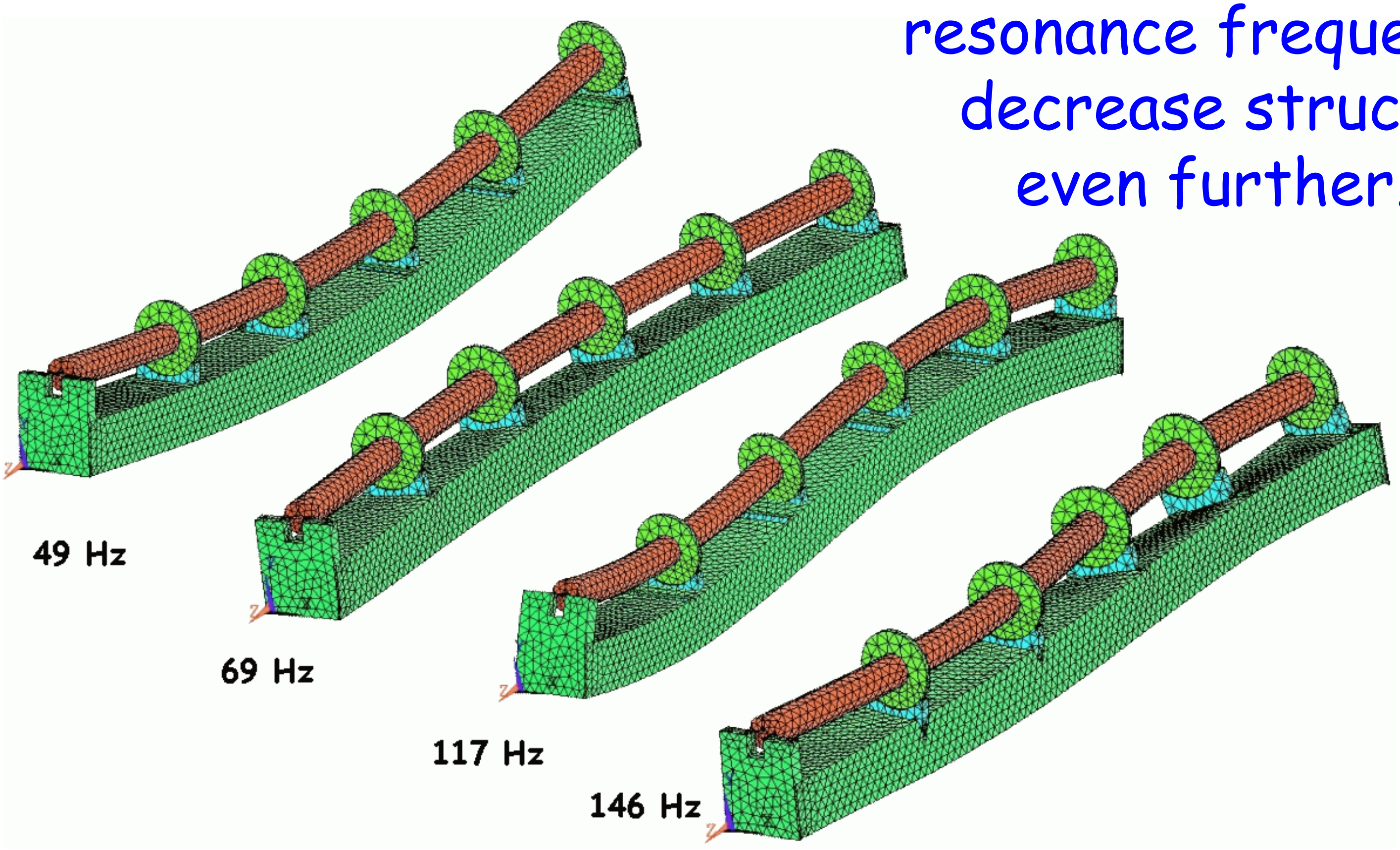
110nm of RF structure vibration cause 2.4nm of quadrupole vibration which is below 10nm tolerance

Also observed 350nm of RF structure vibration if cooled with NLCTA water, mostly due to pressure fluctuations in the incoming water (external turbulence). Even this case is tolerable.

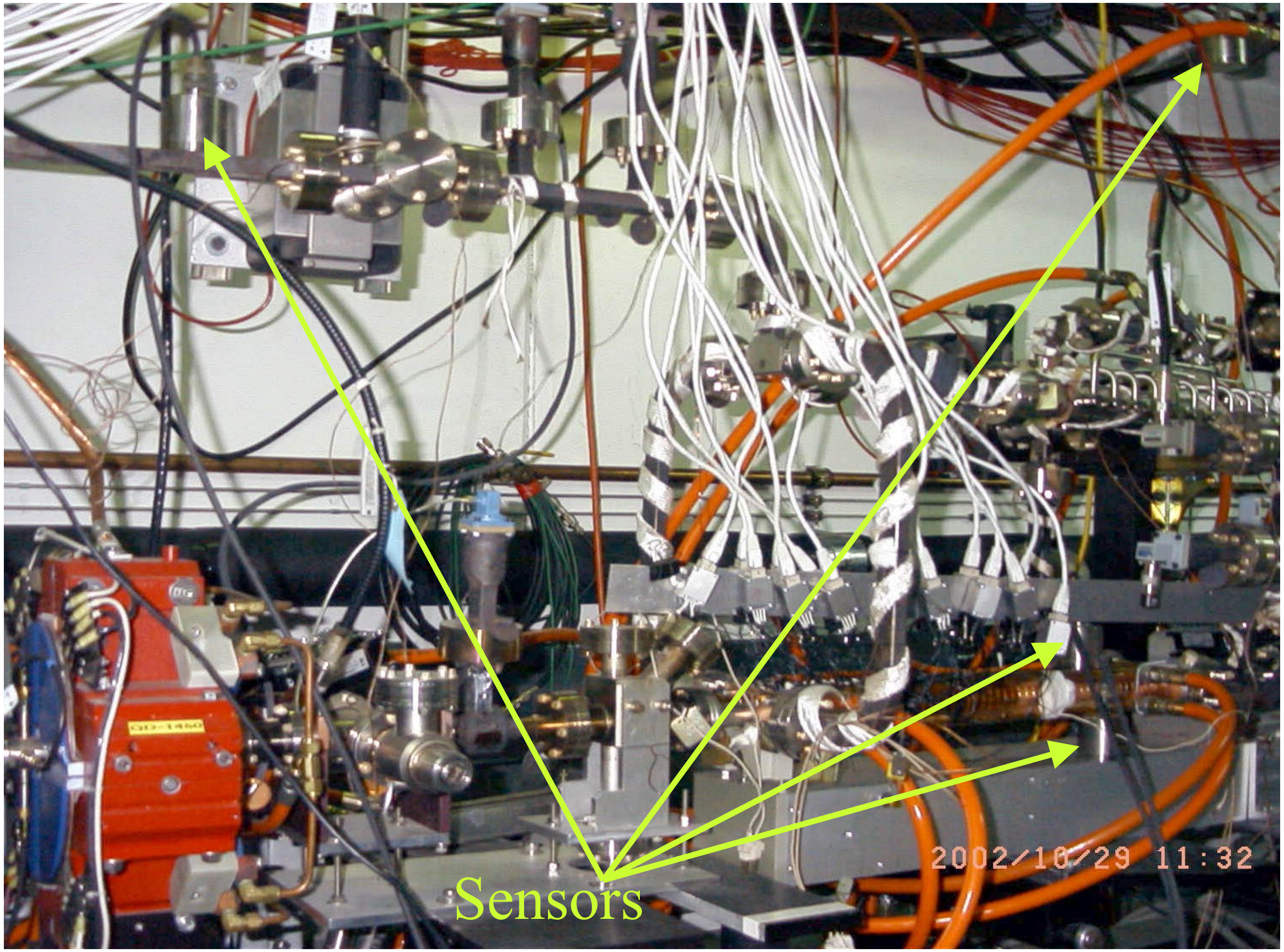
Optimization of girder-structure design. ANSYS modeling.

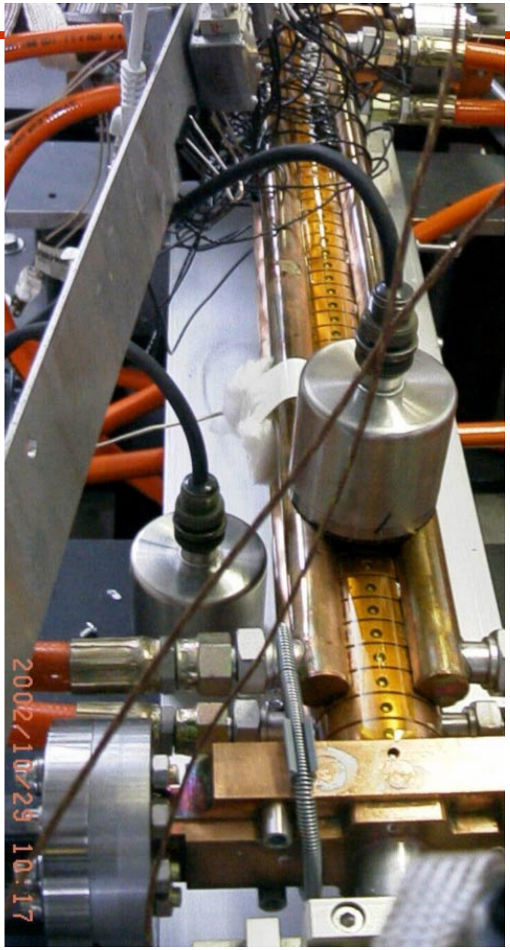
Modeled lowest resonance frequencies match measurements quite well.

Modeling show how to increase resonance frequency and thus decrease structure vibration even further.

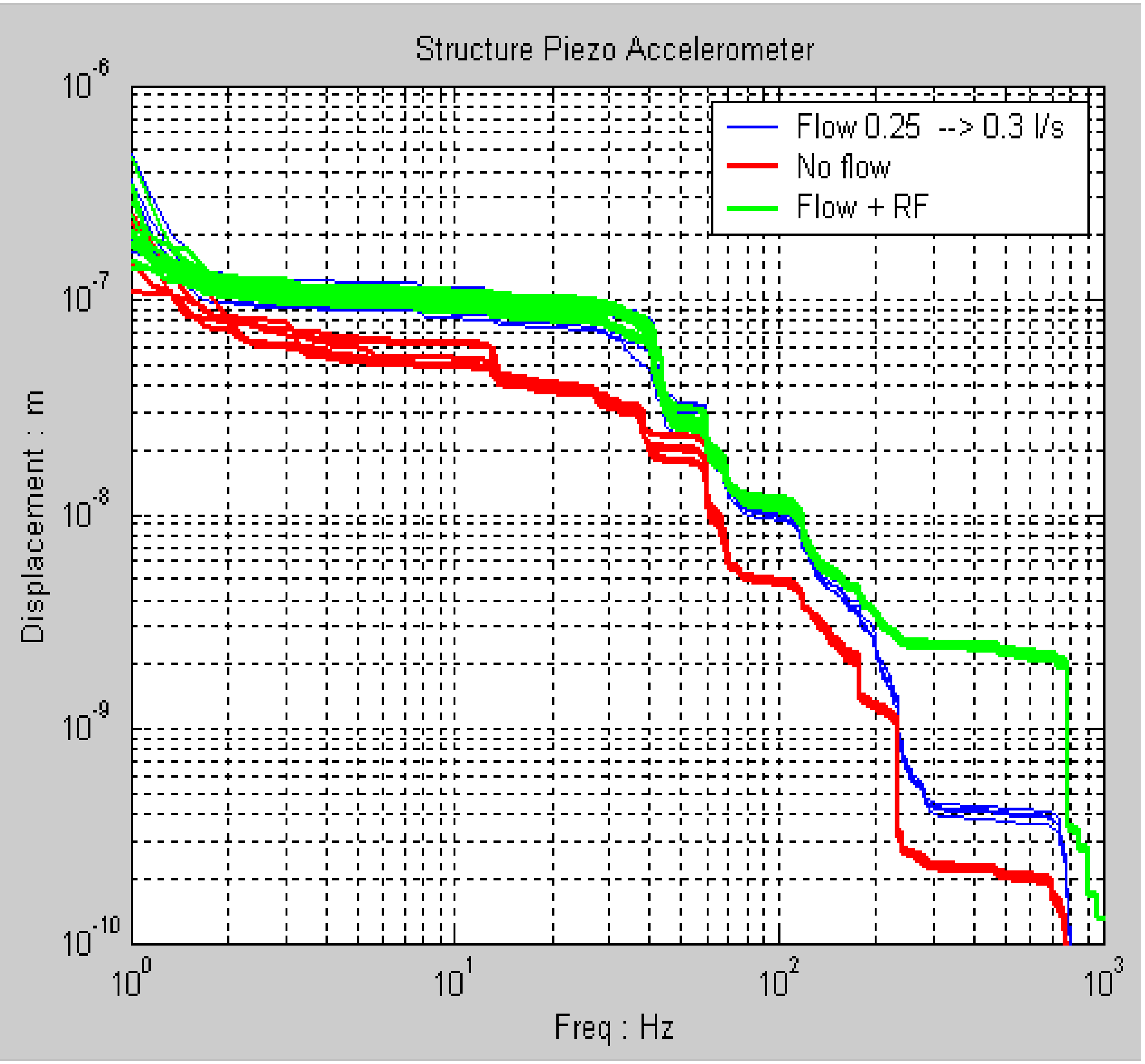


Water + RF pulse induced vibration in H60VG3 RF structure in NLCTA





Water + RF pulse induced vibration in H60VG3 RF structure in NLCTA

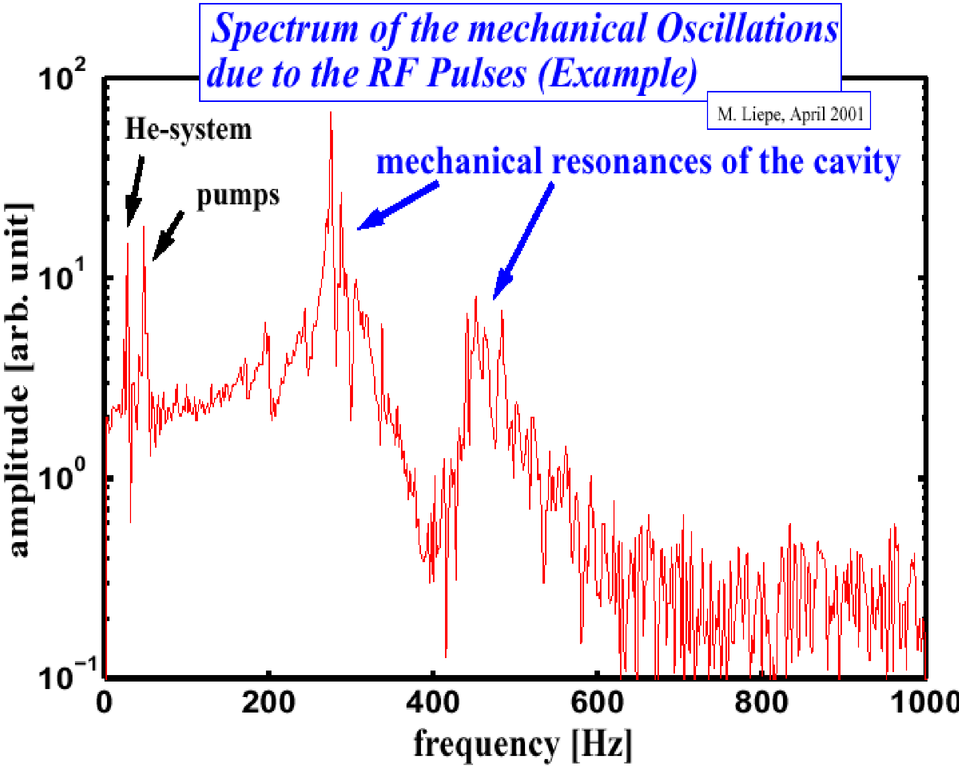


Additional vibration of accelerating structure due to RF pulse is only several nm, i.e. negligible

Vibration due to cooling water on 0.6m H60VG3 is ~3 times smaller than for 1.8m DDS (with NLCTA water)

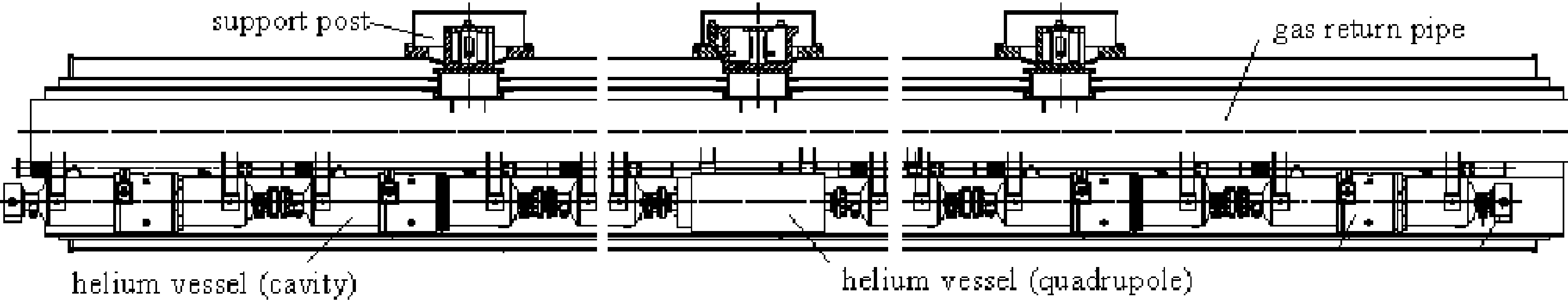
Quad stability in TESLA linac

- Vibration stability requirement for SC linac are much looser than in warm LC
- Issue: common support (helium return pipe), which may be "a shaky ground"
- Noises: from RF pulse (Lorenz force); mechanical coupling to pumps, etc.
- Vibration coupling to quads need to be appropriately minimized by the design



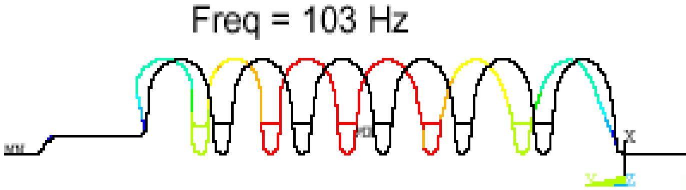
Spectrum of the mechanical Oscillations due to the RF Pulses (Example)

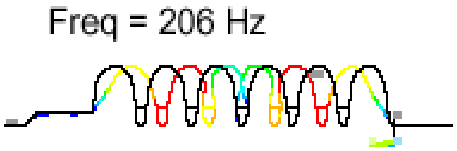
M. Liepe, April 2001

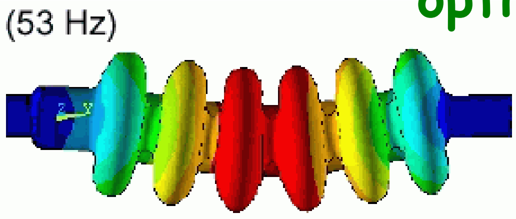


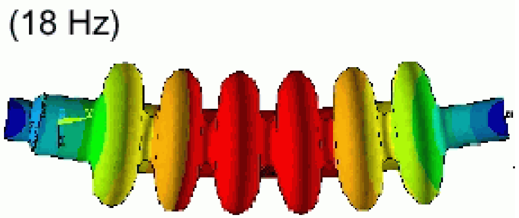
Optimization of quad stability in SC linac

- There are a lot of experience with analysis and successful optimization of vibration properties of RF structures
  - To make it stiffer, optimize positions of supports, etc., so that to decrease detuning by RF pulse
- Similar techniques could be extended to optimize design to minimize quad vibration







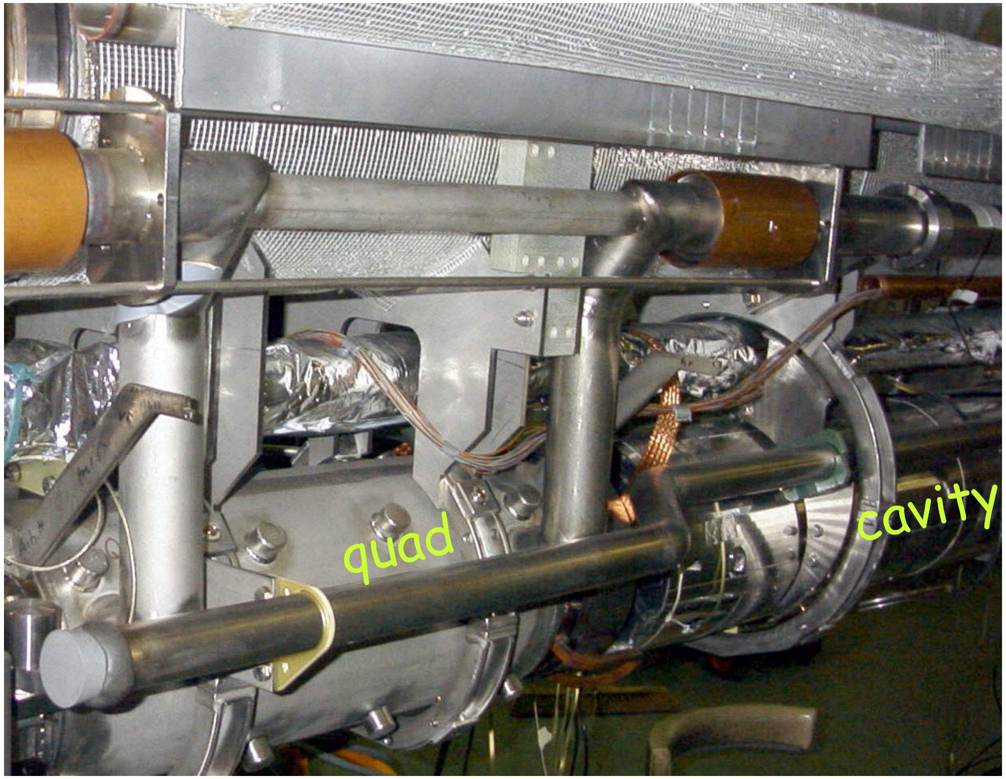


Example: Vibration modes of different SC cavities (for SNS) and their optimization [Carlo Pagani, Danilo Barni,SCPL 2000]

Linac quad vibration study at TTF

TTF cryomodules, since ~1995, were equipped with vibration sensors

Vibration studies are currently being carried out at TTF



These studies will allow evaluating linac quad vibration in comparison with tolerances and in comparison with expected ground motion.

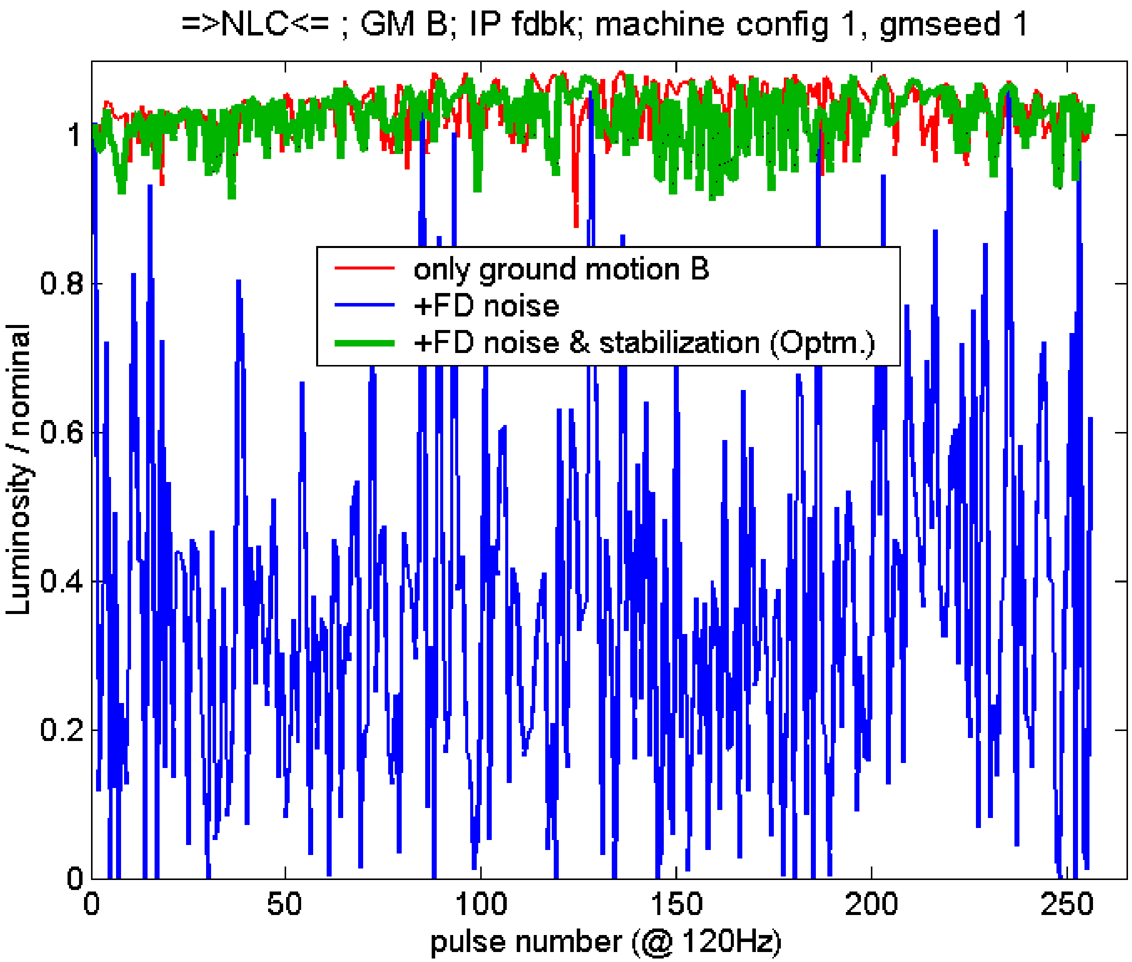
Performance of TESLA, JLC/NLC and CLIC in terms of ground motion

- Comparative studies within/for TRC
  - Apply ground motion (A,B,C) + FD noise to all machines
  - Apply proper IP feedback, fast IP feedback, FD stabilization
  - Find performance (delivered luminosity)
  - Use non-ideal machines for these studies (essential especially for realistic calculations of beam-beam)
    - I.e. machines with errors which has been corrected
      to about nominal initial luminosity
  - Study extraction of non-ideal jittering beam (especially essential for 0 crossing angle machines)
  - Etc.

In Dynamic studies with ground motion, >400 cases were studied, with >100K pulses and ~1/2 year total CPU time

NLC with and without FD stabilization, example

- Assume pessimistic, SLD-like FD vibration
- Then luminosity drops significantly (to ~1/3)
- If FD is actively stabilized or corrected, luminosity is restored



DR=>IP<=DR simulations in application to TESLA extraction

- TESLA disrupted (charged & neutral) beams share the same beamline with incoming beam within several 100 m from the IP
- Beam losses on beamline components need to be minimized
- In particular, excessive power deposition from beamstrahlung photons need to be avoided
- Integrated DR=>IP<=DR simulations allowed estimating the photon loads in realistic conditions

- For more details: "Beamstrahlung Photon Load on the TESLA Extraction Septum Blade", LCC-Note-104

TESLA extraction

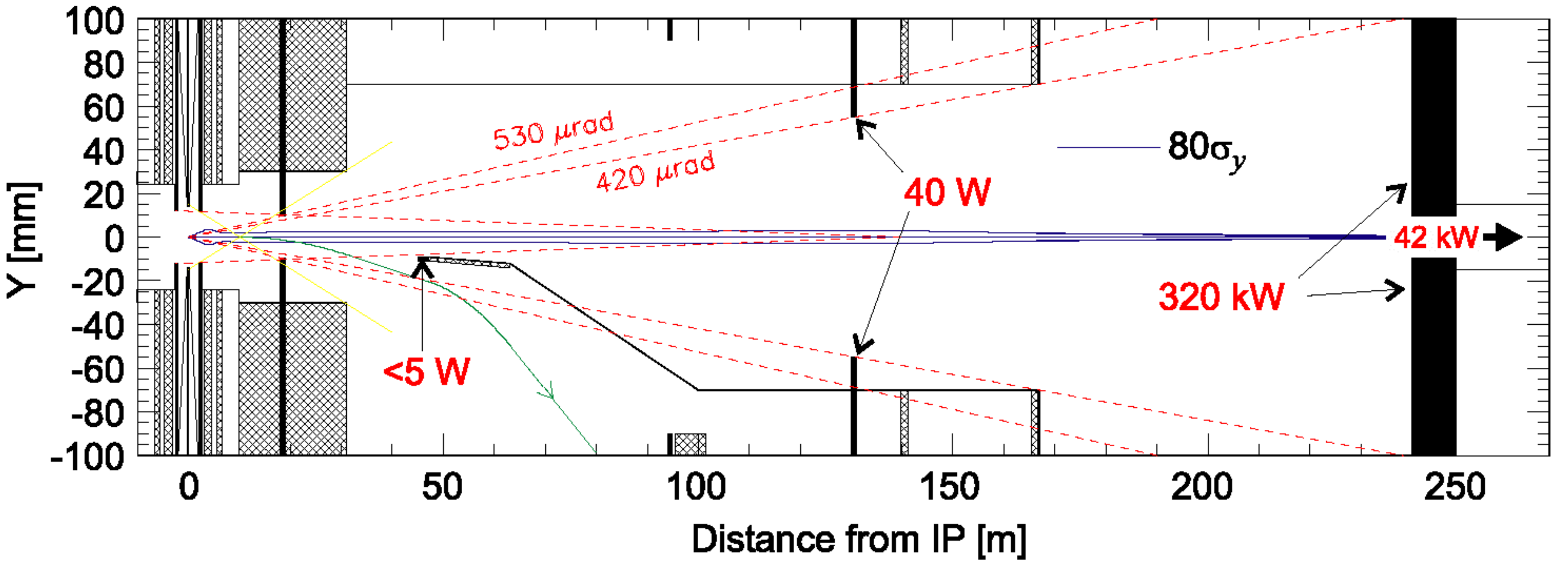
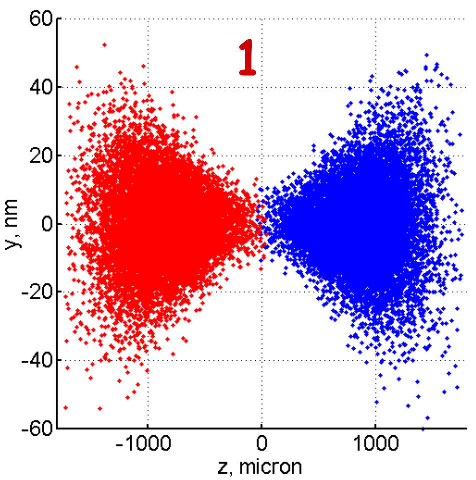
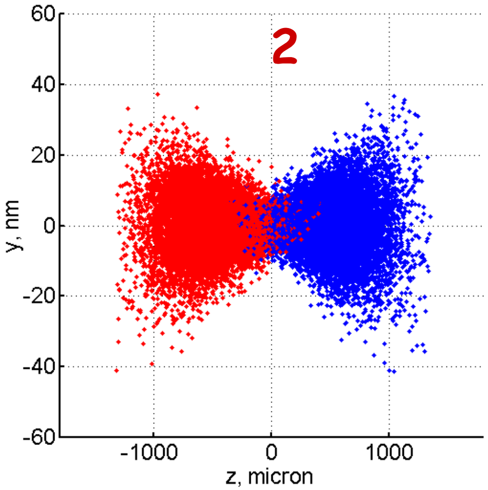


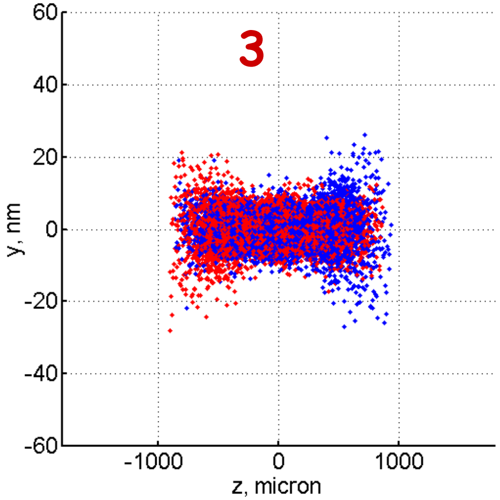
Figure 7.6.4: *Vertical layout of the final transformer region. The beamstrahlung power levels on the collimators are for the* $E_{cm} = 500\, GeV$ *machine.*

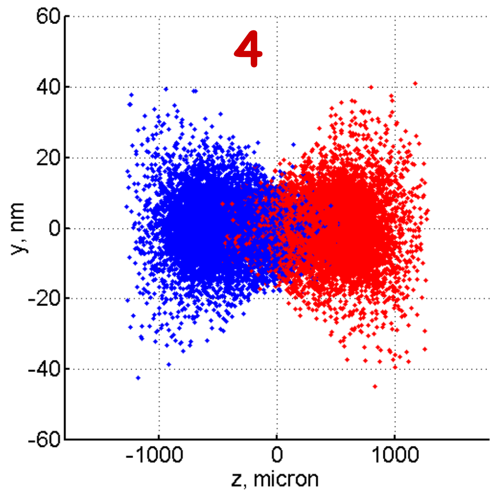
Picture from TDR. The power levels correspond to the ideal Gaussian beams with nominal parameters.

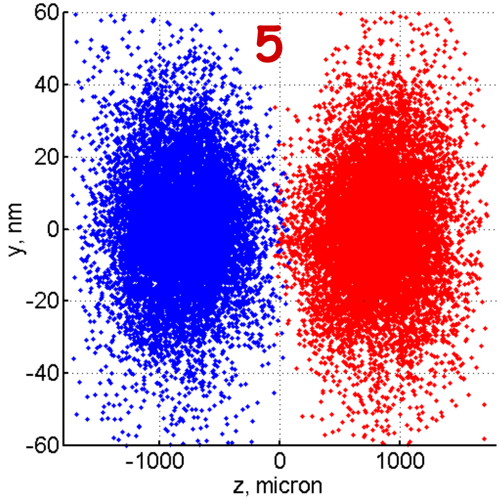
Collision of ideal Gaussian beams with Tesla parameters





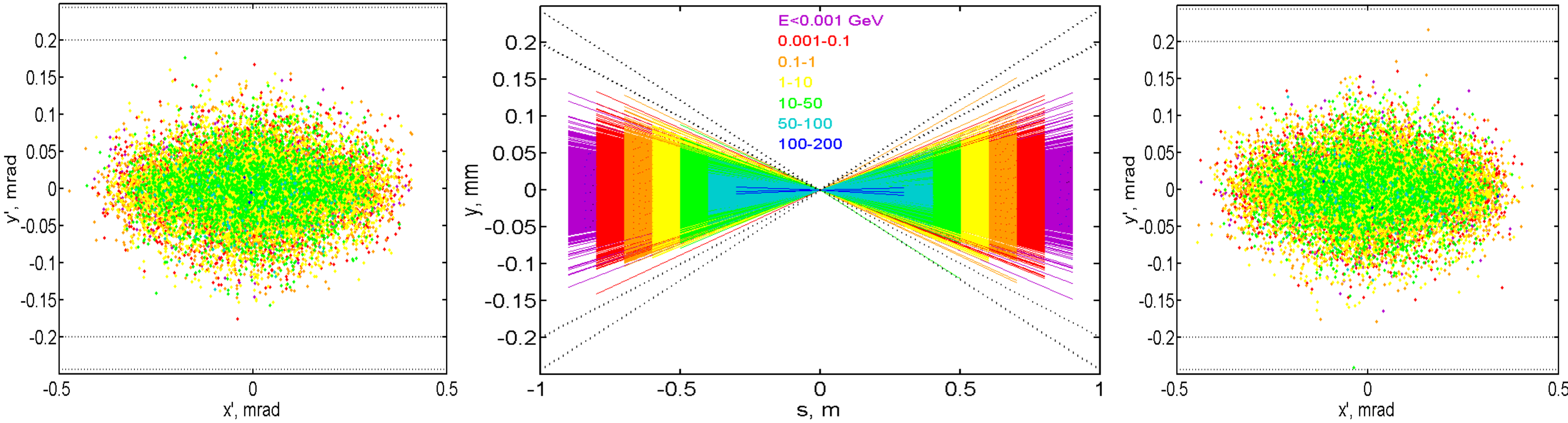


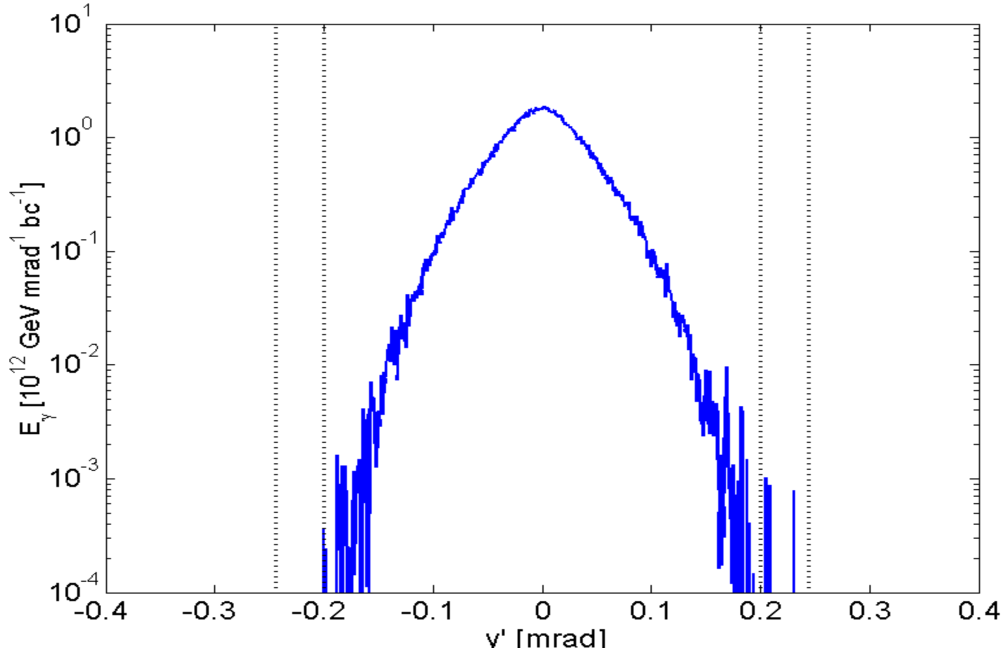




In spite of large disruption parameter the beam-beam instability is practically suppressed due to ideally symmetrical beams

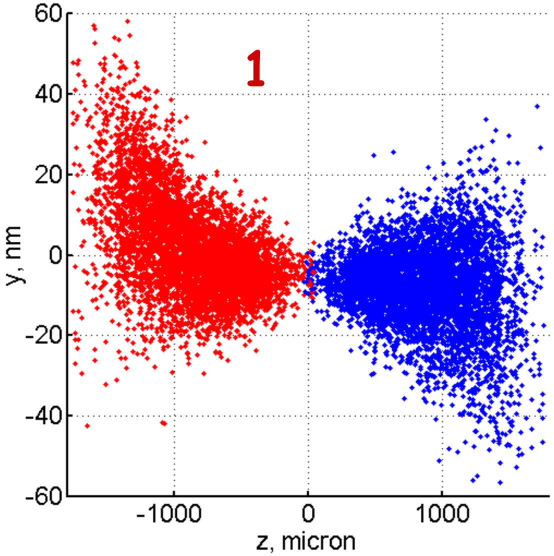
Photons from ideal Gaussian beams with Tesla parameters

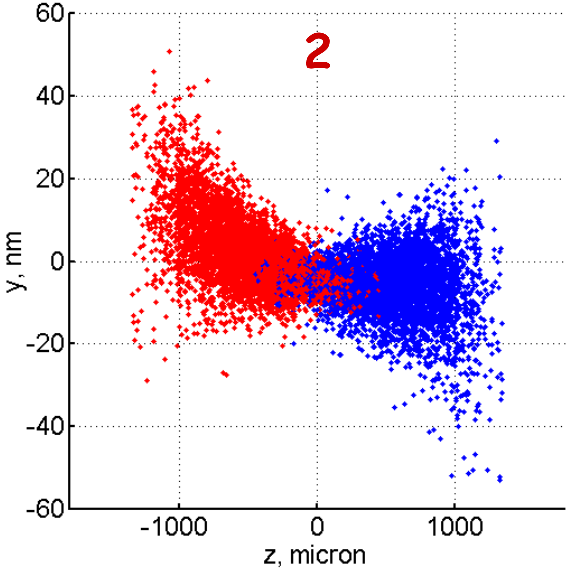


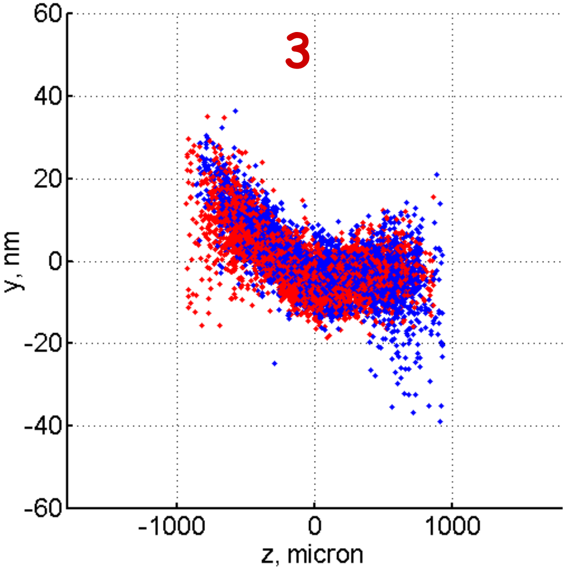


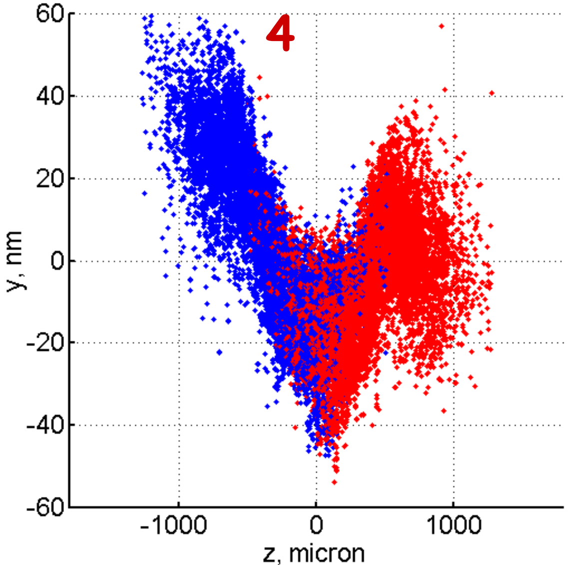
For ideal beams both the total photon power (~360kW) and photon load on septum blade (~3.5W) are in agreement with TDR

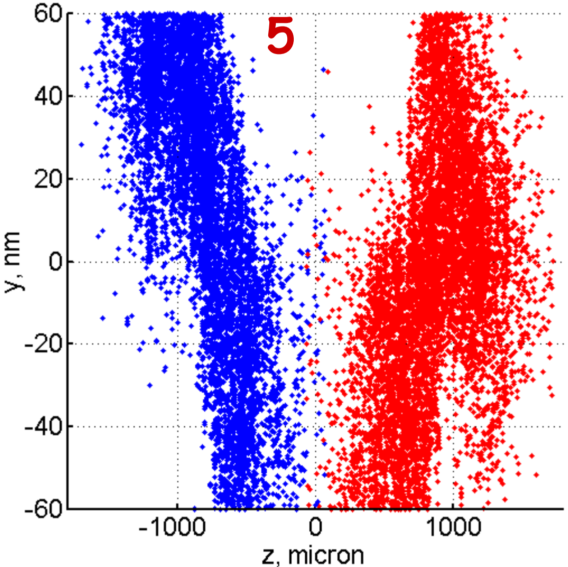
Example of collision of un-ideal (realistic) Tesla beams





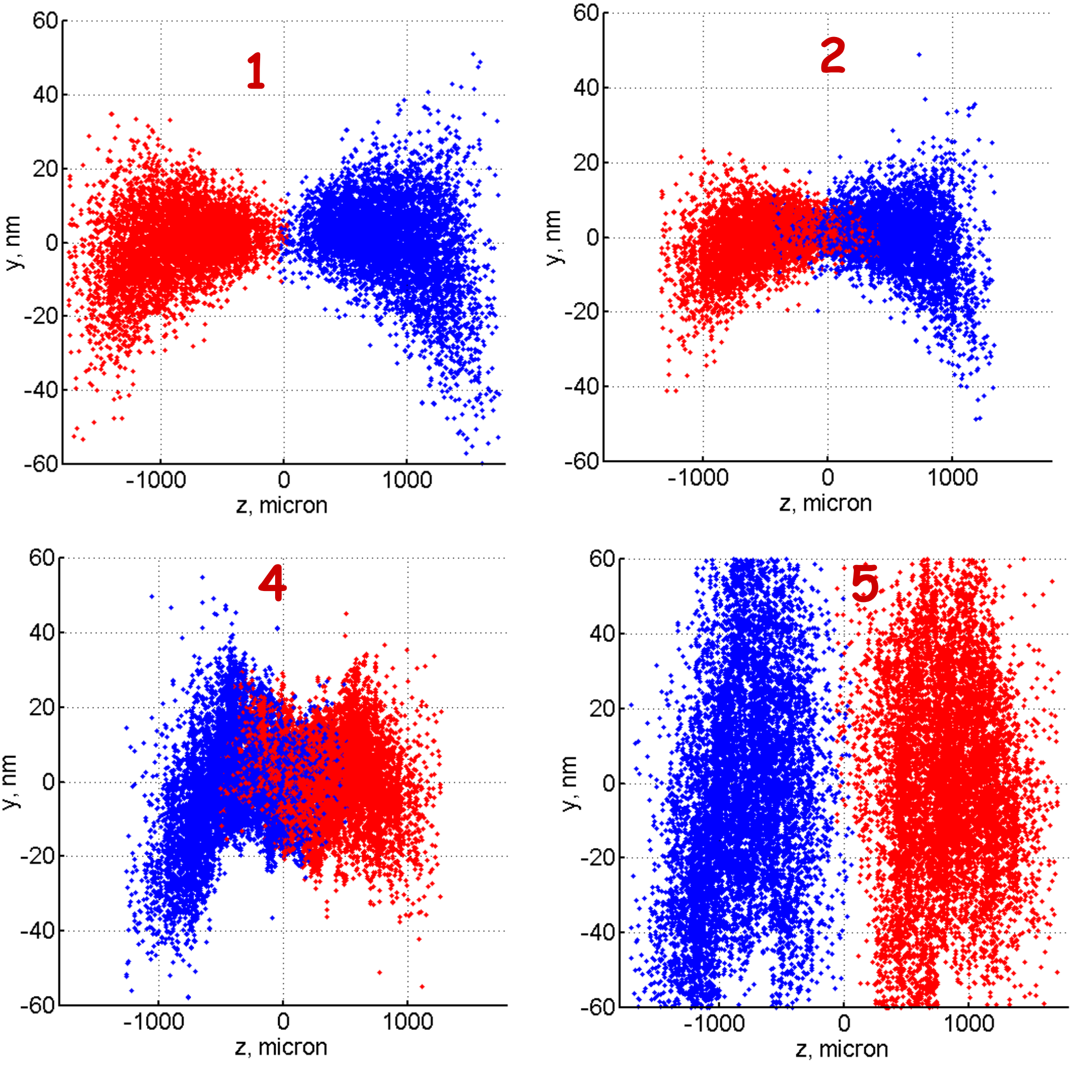






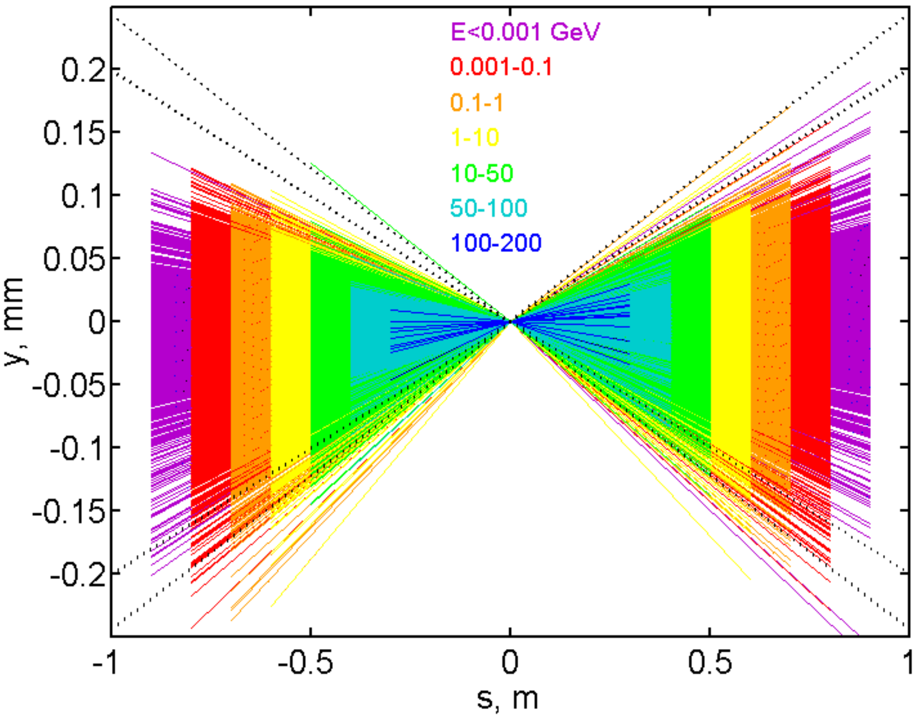
In spite of beam-beam instability, luminosity for this collision is equal to the nominal, but outgoing angles increase

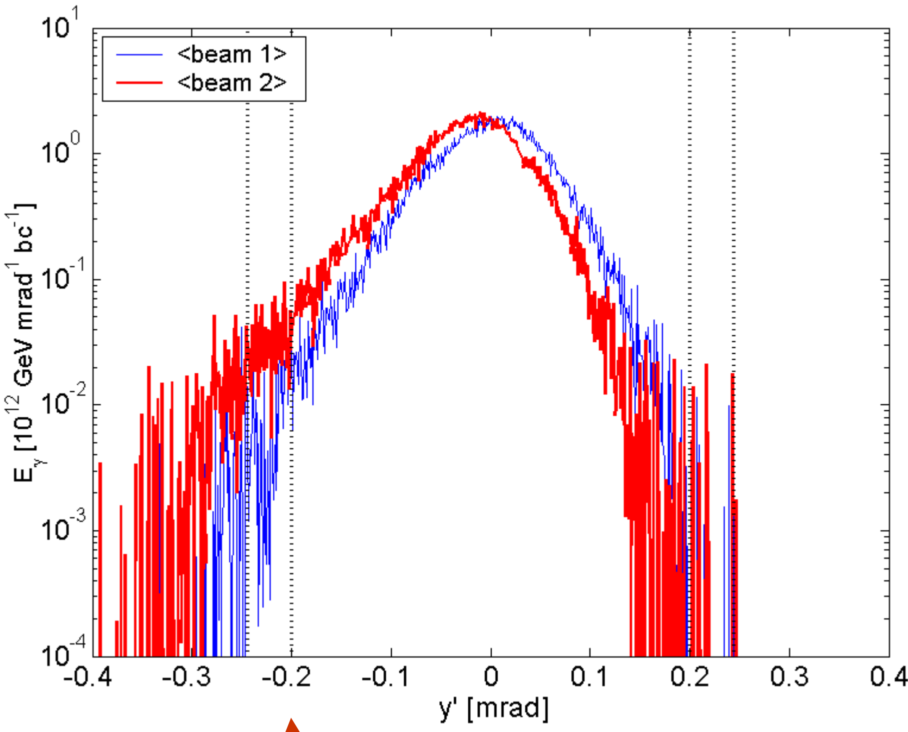
Another example of collision of un-ideal (realistic) Tesla beams



In spite of beam-beam instability, luminosity for this collision is also equal to the nominal, but outgoing angles increase

Photons from collision of un-ideal (realistic) Tesla beams

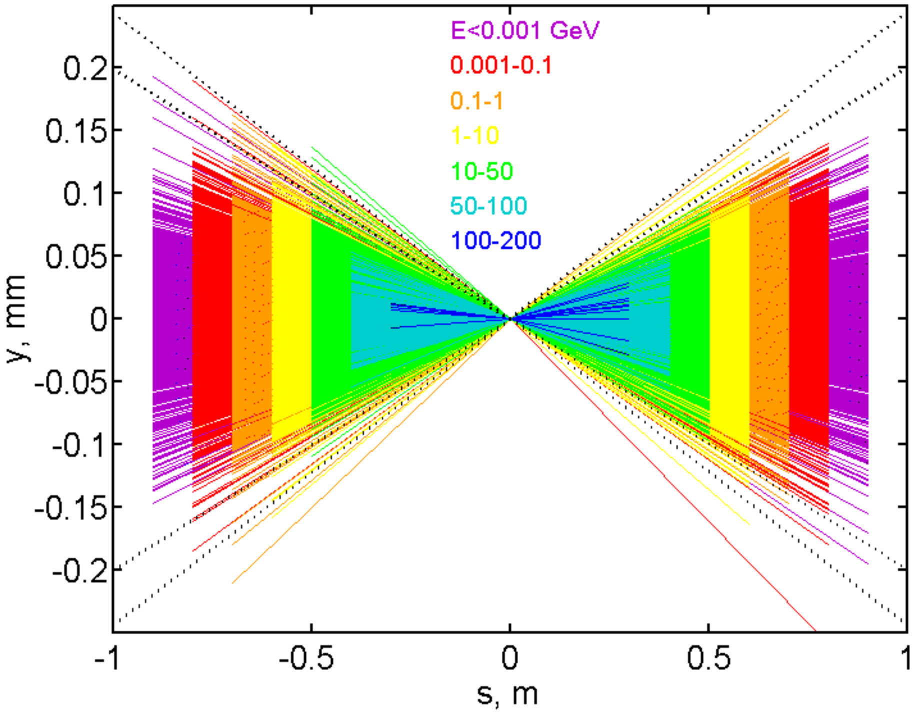


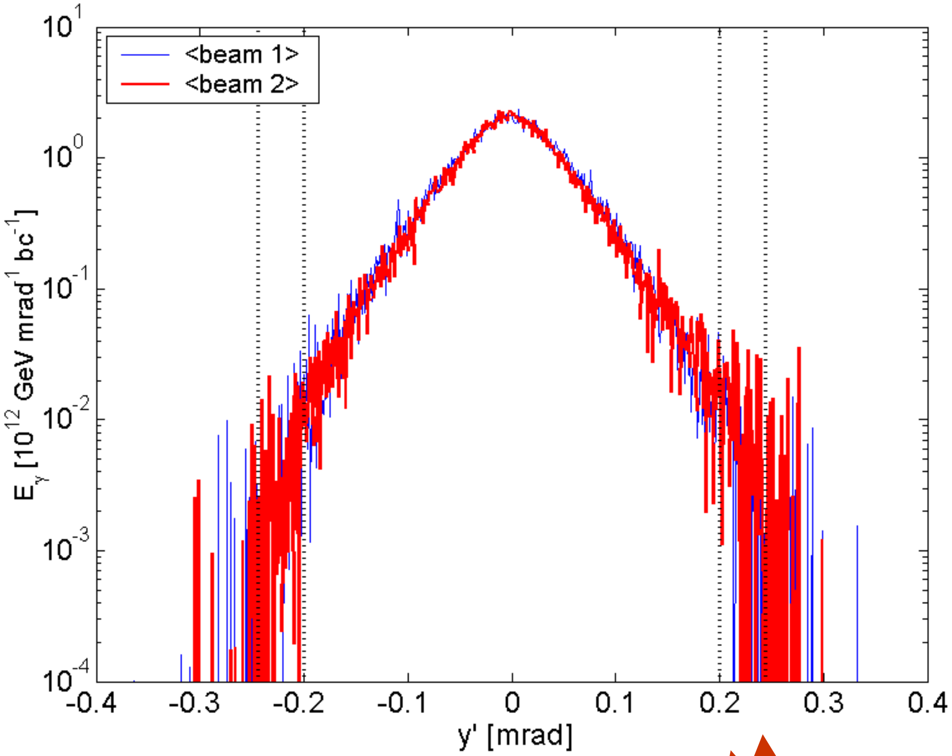


~3kW on septum

For realistic beams, photon load on the septum reach kW level. Total power also increase

Photons from collision of un-ideal (realistic) Tesla beams, another example





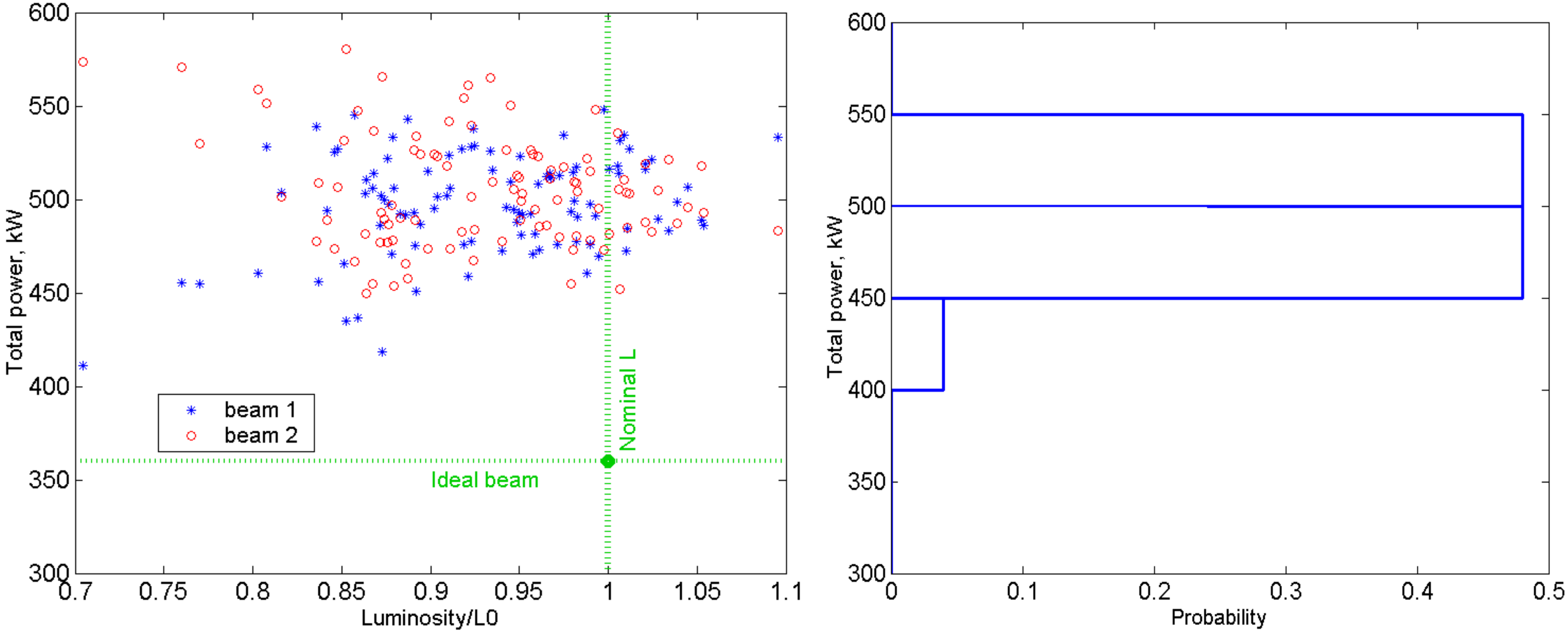
~0.5kW on septum

For realistic beams, photon load on the septum reach kW level. Total power also increase

Photon loads on septum in un-ideal TESLA machine

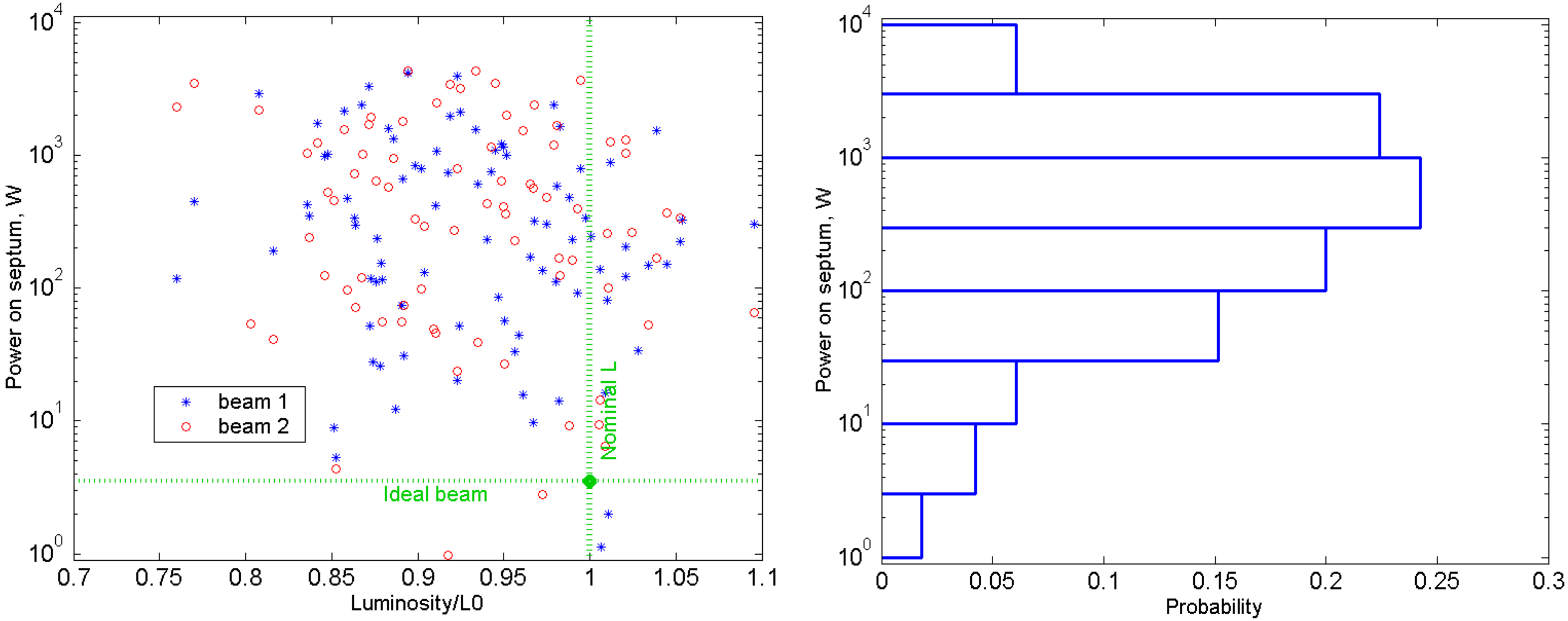
- Assume that certain misalignment errors are applied to TESLA linac, perform one-to-one correction
- Errors are chosen in such a way that this simplified procedure result in ~nominal initial luminosity
- Assume ideal IP intra-train feedback
- 100 un-ideal machines generated, photon load evaluated for each
- To some machines, ground motion is applied for 256 pulses (at 5 Hz), assuming intra-train feedback with maximization of luminosity within the train

Total photon power for 100 un-ideal TESLA machines



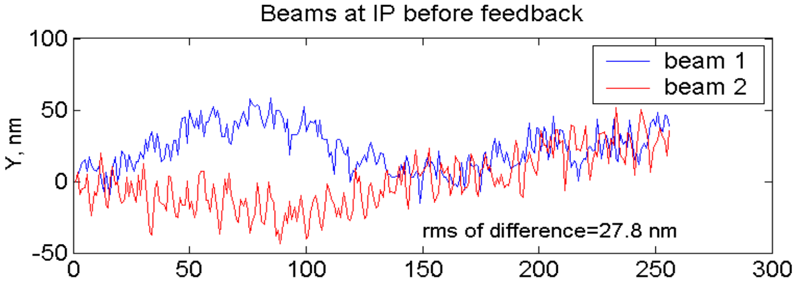
For realistic beams, total photon power is ~500kW instead of 360kW for ideal beams

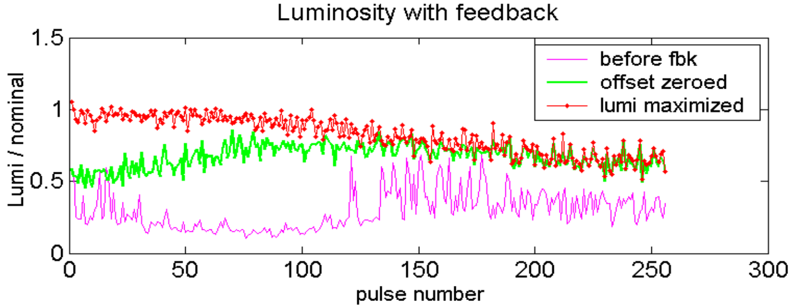
Photon power on septum blade for 100 un-ideal TESLA machines

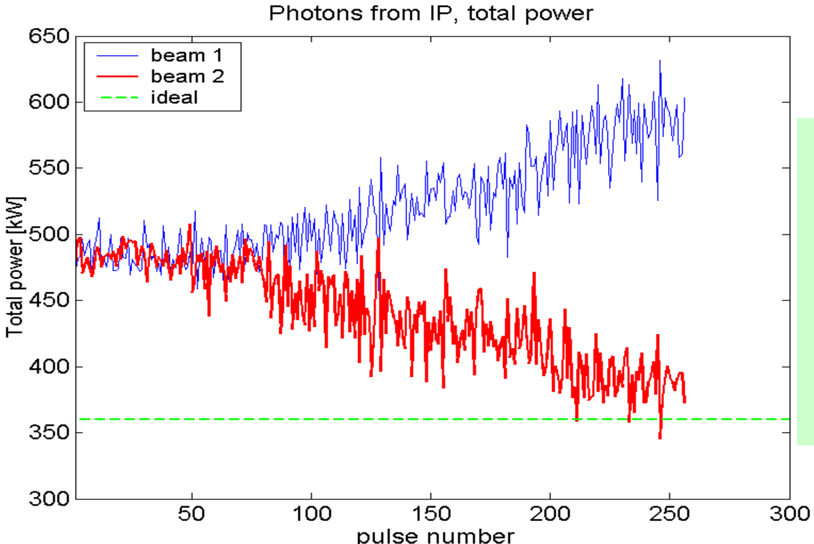


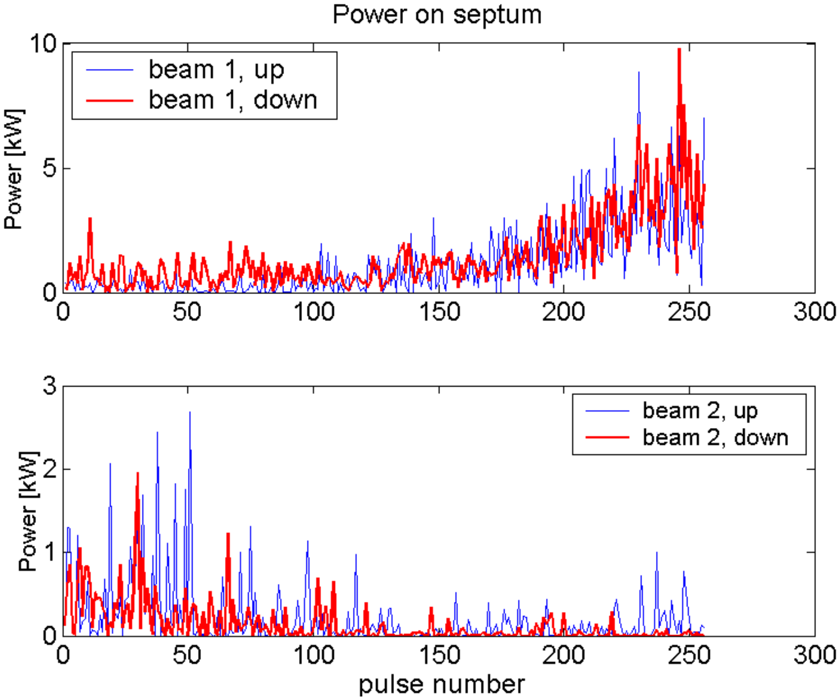
- For realistic beams, photon power on septum can reach several kW still with nominal luminosity
- Photon power on septum is larger than 1kW in 30% cases
- Only less than 3% cases agree with TDR

Example of photon loads in TESLA with ground motion C


Beams at IP before feedback


Luminosity with feedback


Photons from IP, total power


Power on septum

Large fluctuation of photon loads, <>~0.5kW with L~100% => 4kW @70%

Beginning of train (before feedback) => ~10 times higher instantaneous photon loads

Further studies needed w.r.to TESLA photon loads

- Evaluate impact of high photon loads on septum (or its masks) survivability and background
- Develop mitigation measures (for example introduction of horizontal crossing angle)

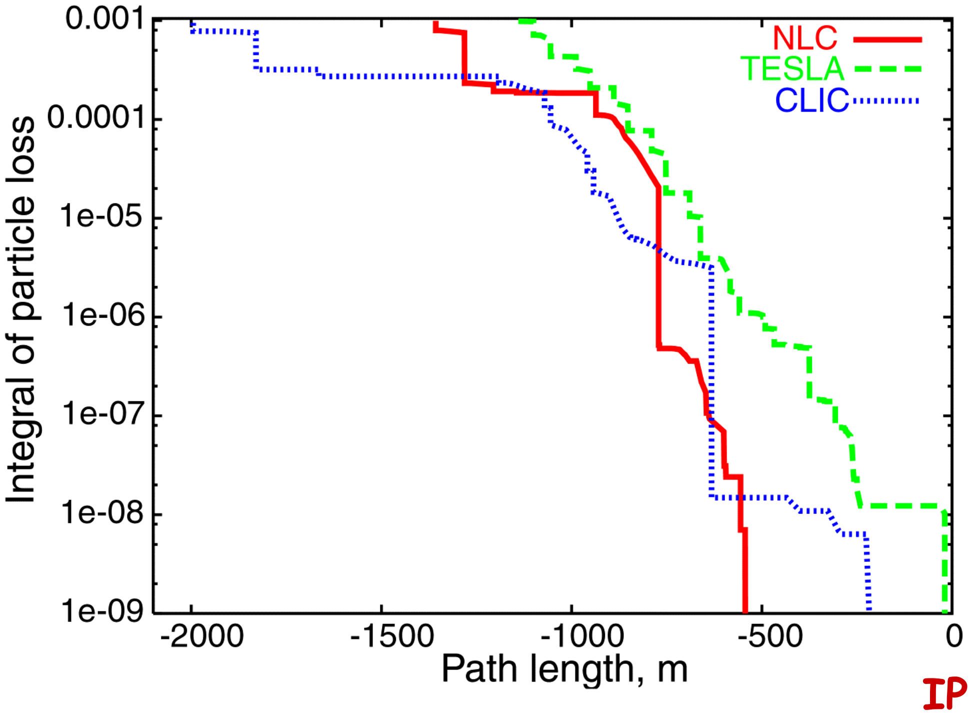
Collimation studies for TRC

- TRC (and beyond) Collimation Task Force

N. Mokhov, A. Drozhdin, et al.	FNAL
D.Schulte, F.Zimmermann	CERN
G. Blair	Univ. of London
W. Kozanecki, O.Napoly	Saclay
N. Walker	DESY
	SLAC team

  - Comparative studies of BDS performance in terms of
    - Losses of primary beam, losses of halo
    - Background in the detector (primary and secondary particles, SR photons, muons, etc.)
  - Use FNAL tools (STRUCT, MARS) for simulations of all systems (TESLA, NLC, CLIC)
    - Use other tools (Geant 3, Geant 4, Turtle, Eggs, etc.) for cross checks

Collimation system performance



A. Drozhdin, et. al., "Comparison of the TESLA, NLC and CLIC Collimation-System Performance", in preparation.

Collimation-system performance assuming an incident fractional halo of 1e-3

Fractional loss of charged-halo particles, integrated upstream from IP

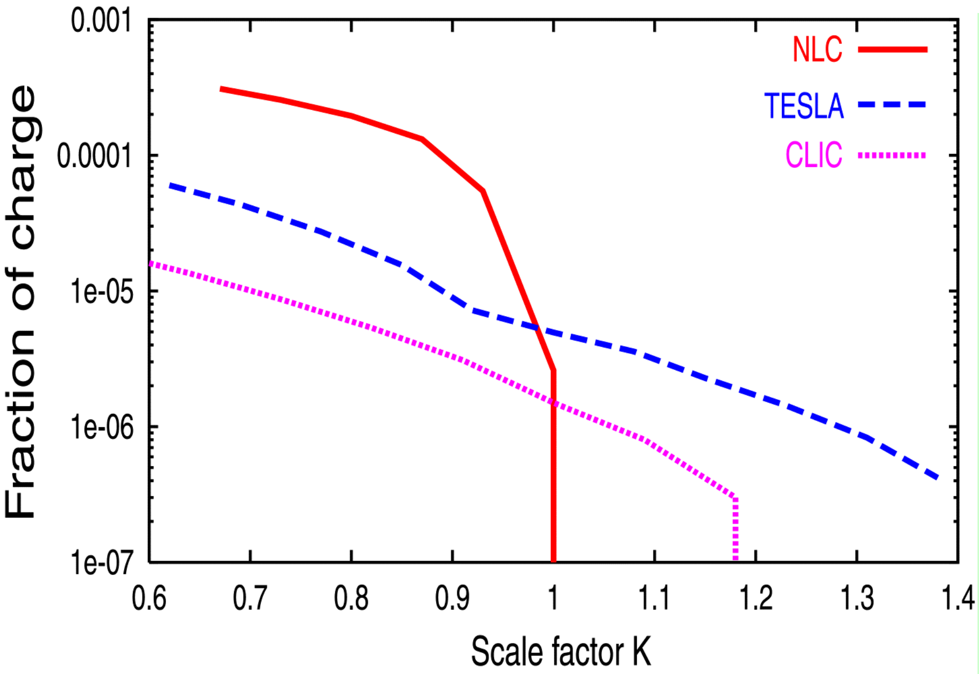
This losses are relevant for estimation of (muon, etc.) background in the detector

As designed, losses are expected to vanish after the upstream edge of the secondary-collimation system, which is about –(550-580)m in NLC and TESLA

Only NLC design performs as expected

Example of Coll.TF results

Collimation system performance



Collimation-system performance assuming an incident fractional halo of 1e-3

Fraction of charged-halo particles outside the safe rectangular aperture in FD which defines intended collimation depth

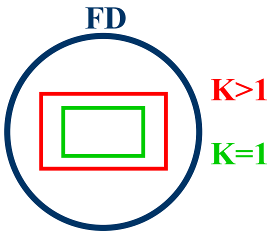
This characteristics are relevant for estimation of detector background produced by the synchrotron radiation in FD

As designed, particles are expected to be absent outside scale K=1

Only NLC design performs as expected

A. Drozhdin, et. al., "Comparison of the TESLA, NLC and CLIC Collimation-System Performance", in preparation.

Example of Coll.TF results

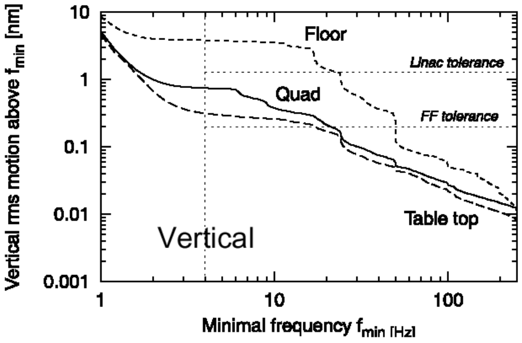


Collimation status and further plans of Collimation Task force

- At least one design is almost satisfactory already
- Need to continue optimization of collimation design and study
- In particular, need to continue with evaluation of muons, etc., and with effect of static and dynamic errors on losses and background
- Mini workshop at SLAC in December, HALO-03 in May 2003

CLIC stability study

Quadrupole vibration:



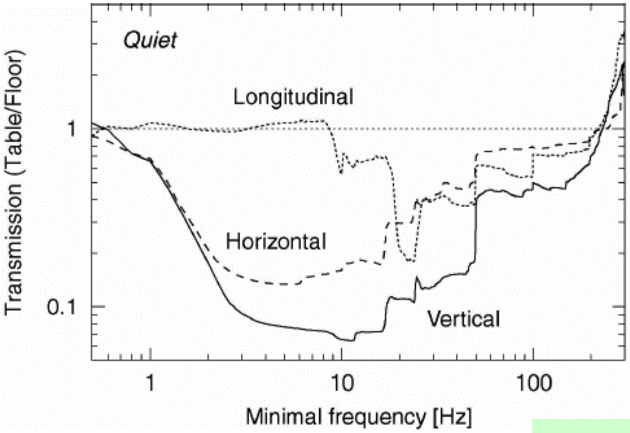
On magnet top:

X: (0.4 ± 0.1) nm

Y: (0.9 ± 0.1) nm
(0.3 nm on table top)

Z: (3.2 ± 0.4) nm

without cooling water.

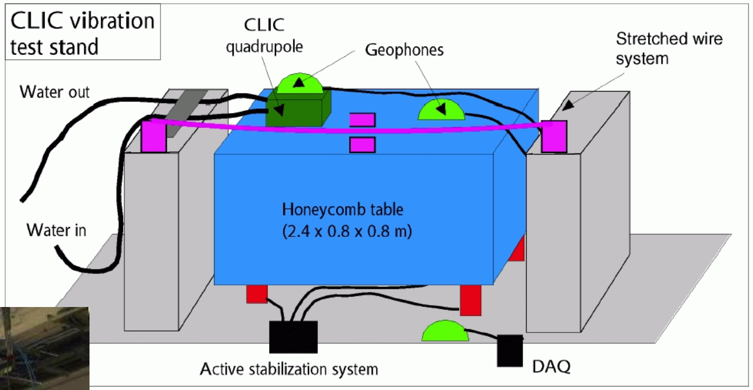


R.Assmann et al.
Nanobeam 2002

With nominal flow of cooling water:

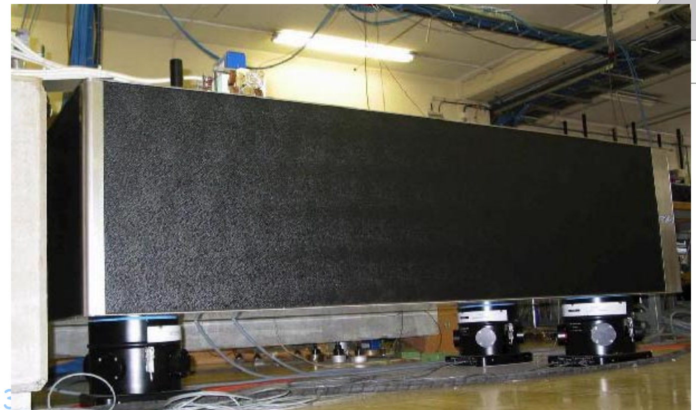
Y: (1.3 ± 0.2) nm

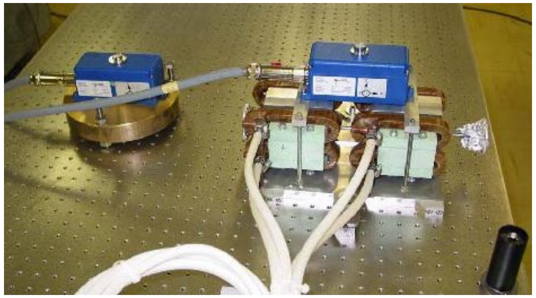
Tight vertical linac tolerance demonstrated!



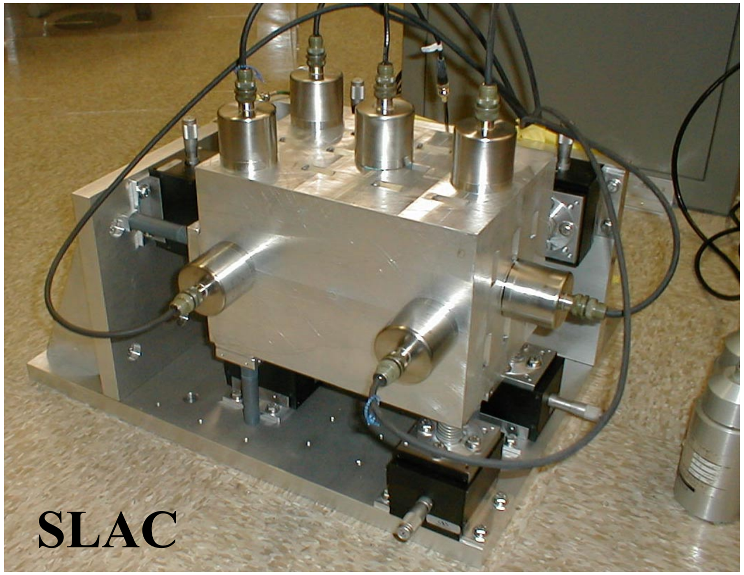
Using commercial STAICIS 2000 (TMC) achieved 1nm stability of a CLIC quadrupole

Nonmagnetic sensors, detector friendly design would be needed in real system

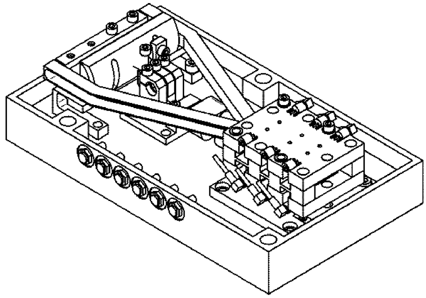


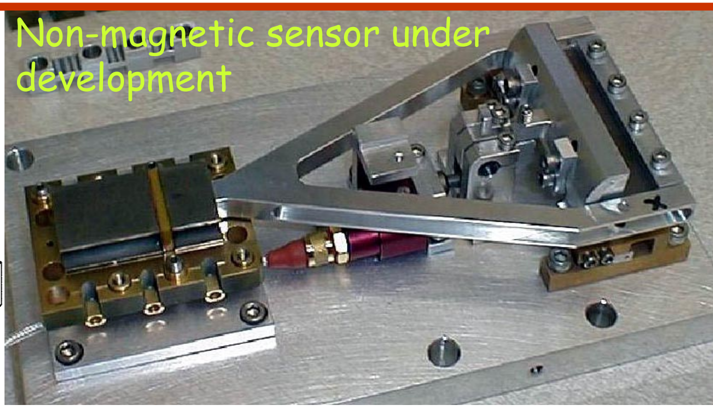


R&D on mechanical stabilization with inertial and optical sensing

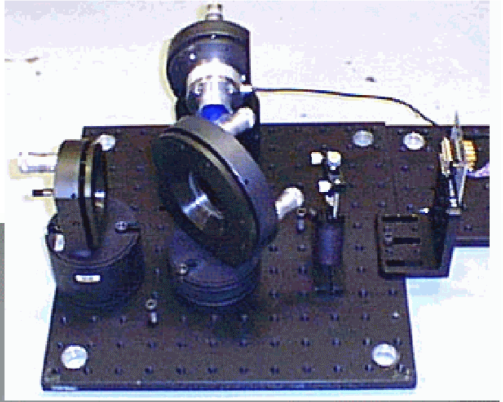


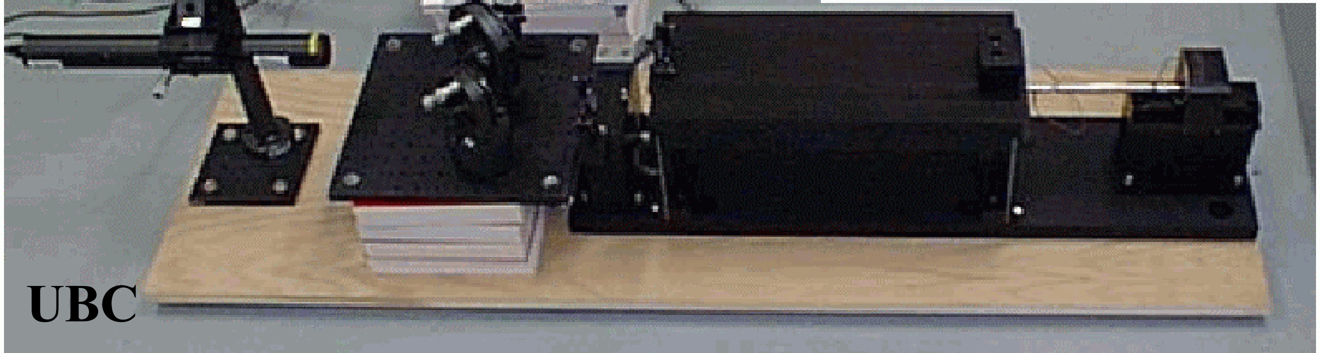
SLAC





Non-magnetic sensor under development





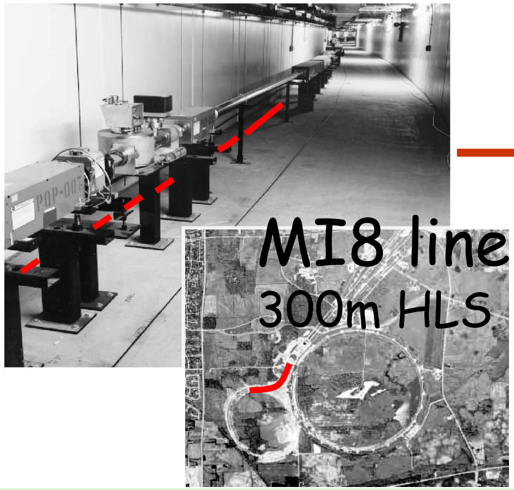
UBC

Joe Frisch, et al.
Tom Mattison, et al.

Cultural effects on slow motion

MI8 results

V.Shiltsev et al.

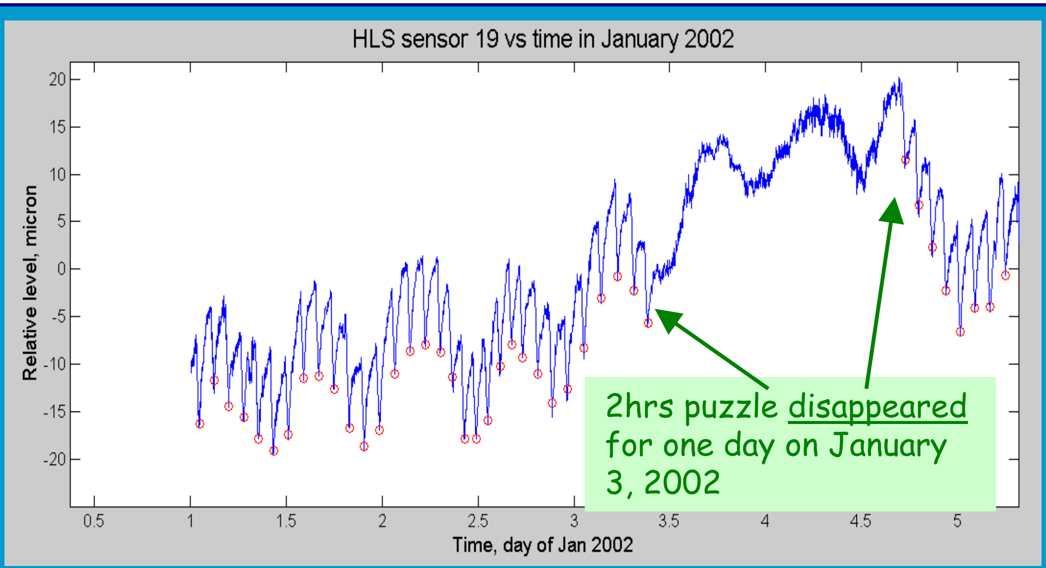


- Major component to relative motion at MI8 is given by "2hour puzzle" – 10 μm motion occurring near one of the end of the system

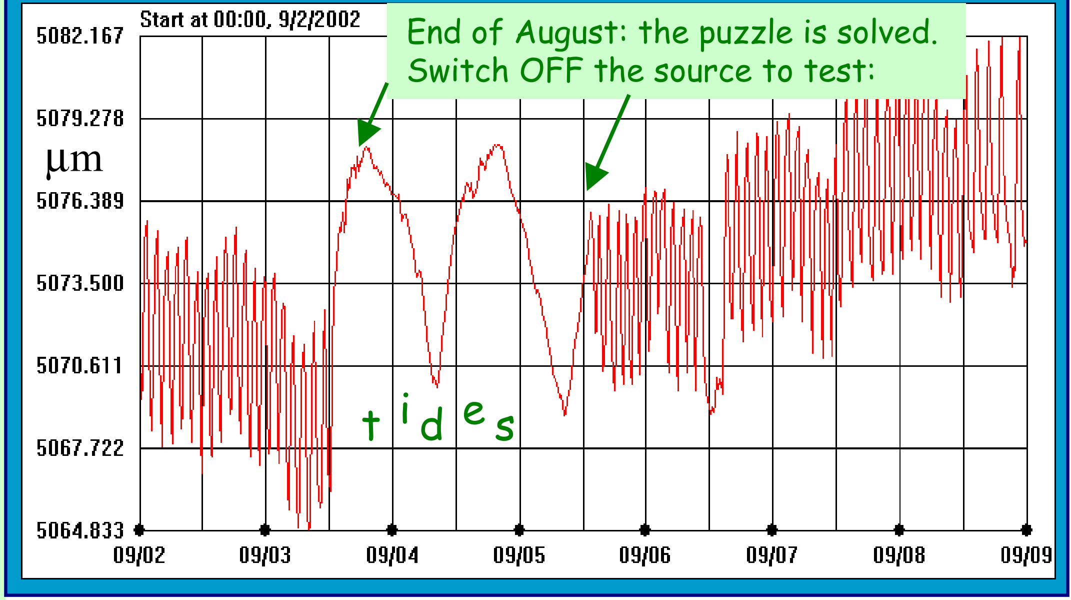
- Caused by domestic water well 219ft deep and several hundred feet away

- Large amplitude, rather short period, bad correlation – potentially quite nasty for collider

- May be relevant for shallow tunnel in sedimentary geology



2hrs puzzle disappeared for one day on January 3, 2002



End of August: the puzzle is solved. Switch OFF the source to test:

Summary

- You have been updated on
  - NLC site studies
  - NLC linac stability studies
  - Issues with SC linac stability
  - Issues with extraction in SC design
  - Collimation task force
  - Very briefly on stabilization and slow motion studies
- Only a small fraction of the work contributed by NLC group to TRC was presented to you today
- More to come…