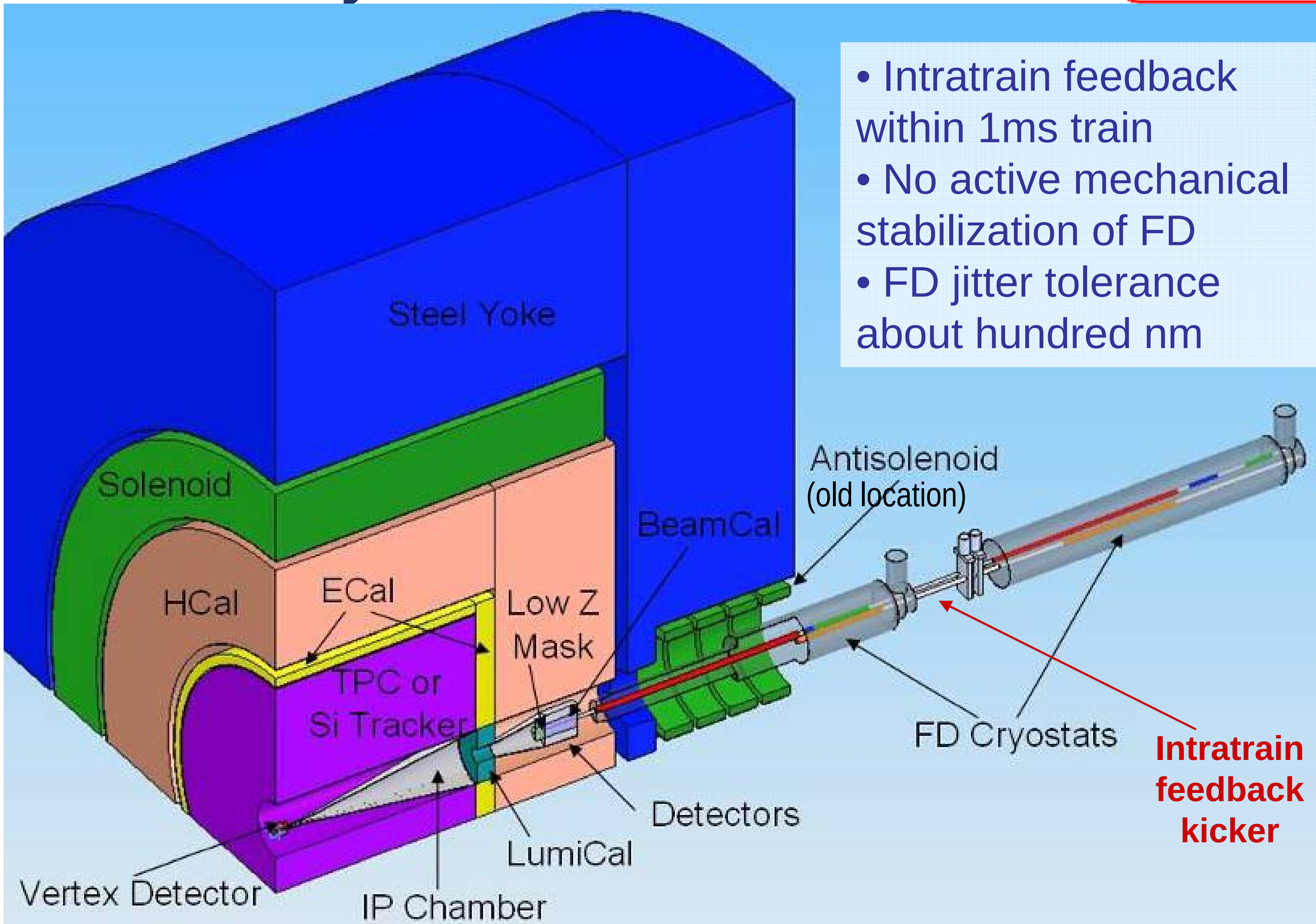
Near IR FF design including FD and longer L* issues

Andrei Seryi (SLAC)

October 16, 2008

CLIC 08 Workshop

ILC IR configuration & stability

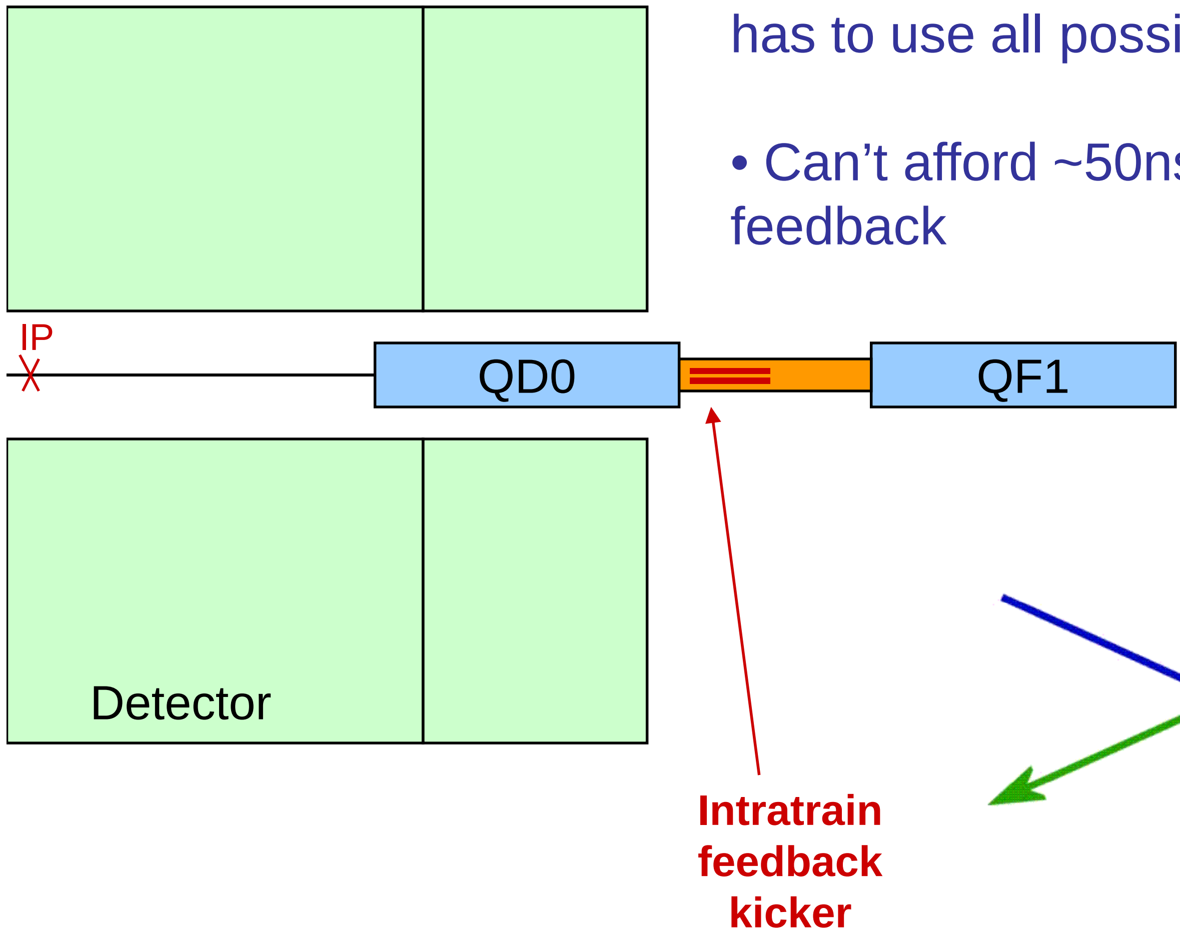


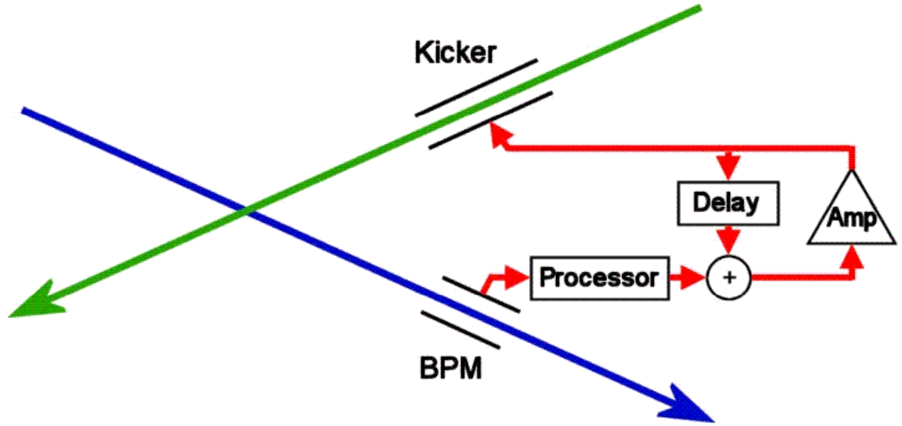
- Intratrain feedback within 1ms train
- No active mechanical stabilization of FD
- FD jitter tolerance about hundred nm

CLIC IR discussion…

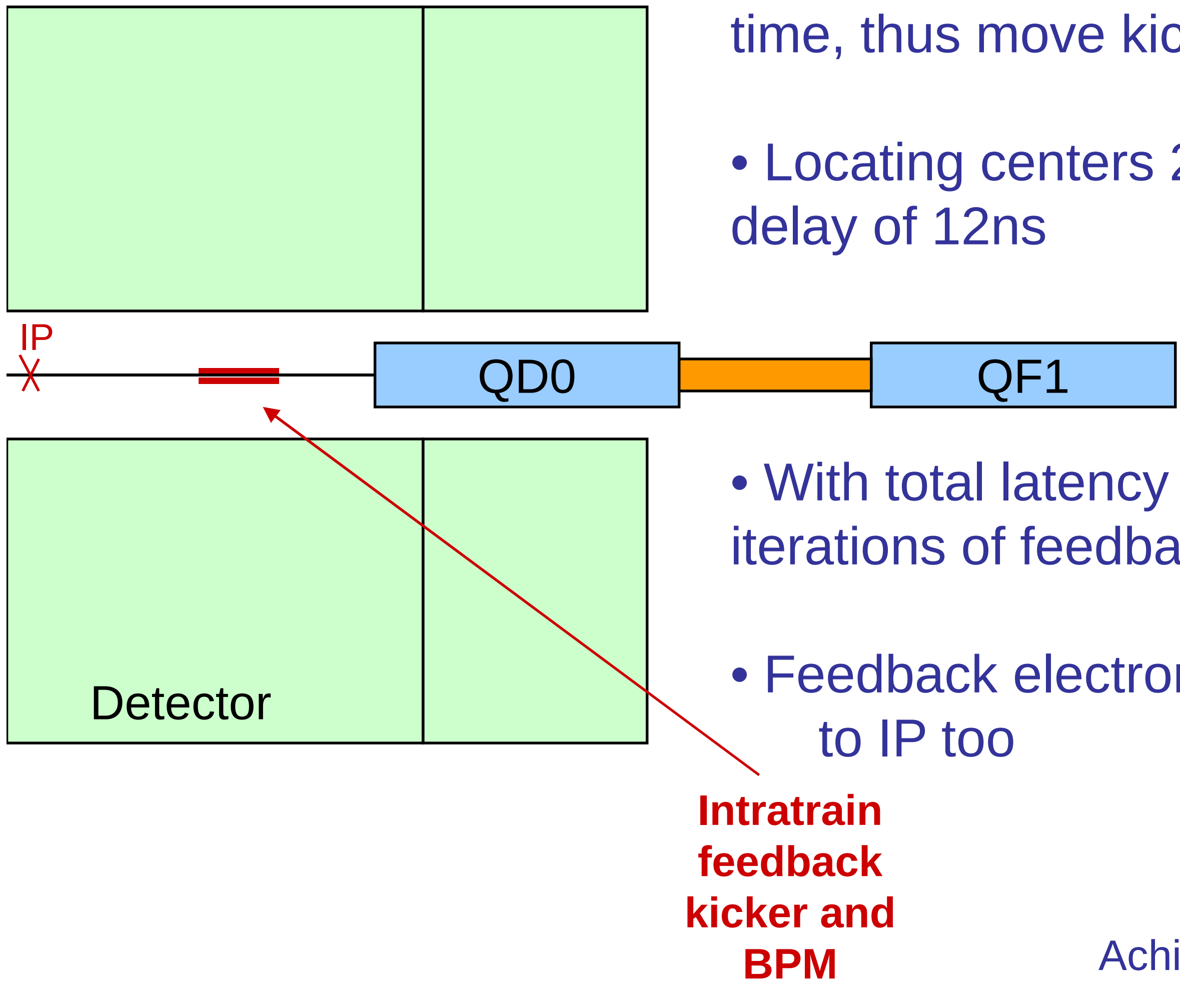
• In CLIC, with 1nm beam size, and 150ns train, has to use all possible options to provide stability

• Can't afford ~50ns trip-around time of intra-train feedback





CLIC IR discussion…



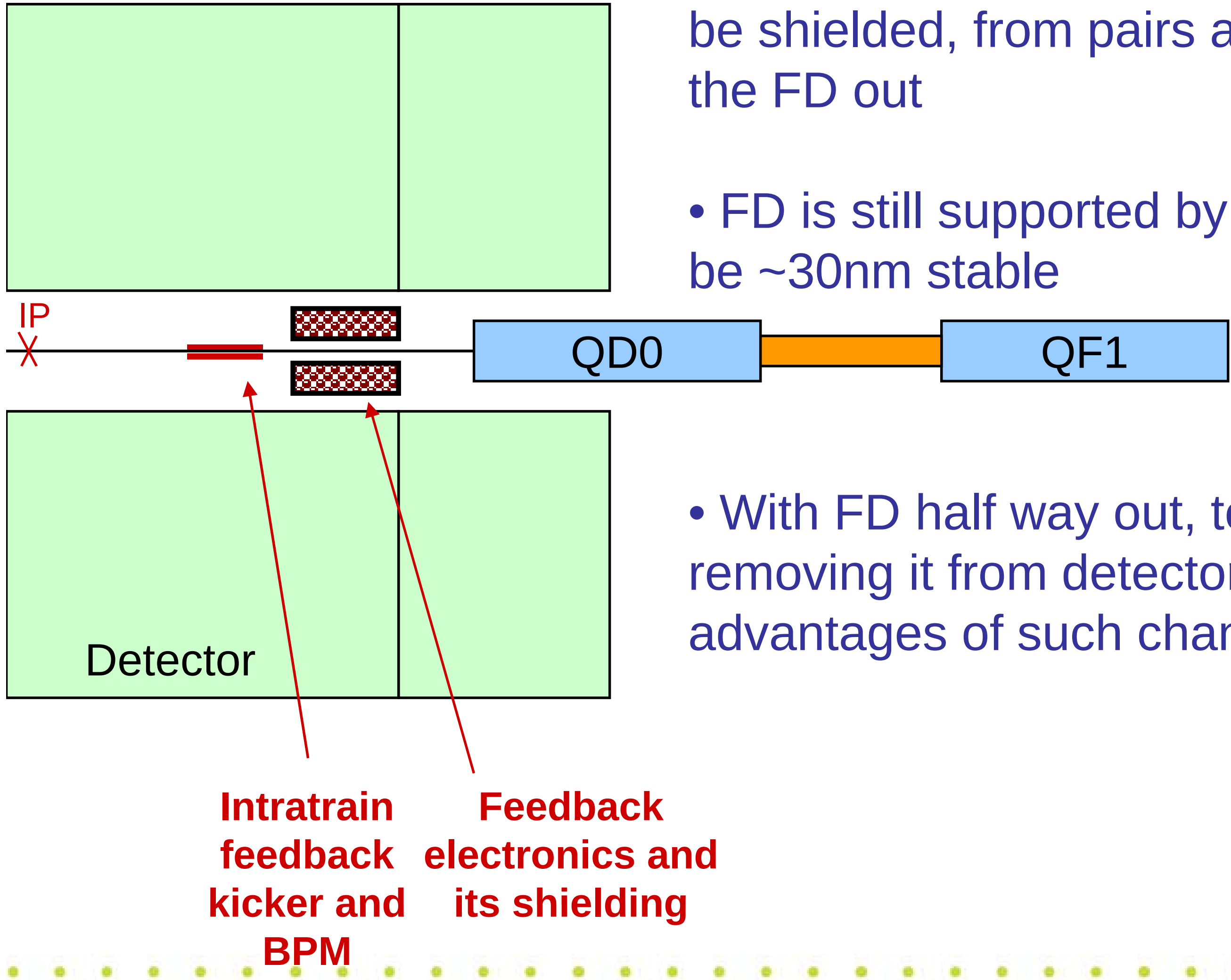
- First MUST-DO is to minimize the trip-around time, thus move kicker and BPM closer to IP
- Locating centers 2m from IP give irreducible delay of 12ns
- With total latency of ~25ns, can already have ~6 iterations of feedback
- Feedback electronics may need to be closer to IP too

Achieved latency of FONT3 analog electronics ~13ns (P.Burrows et al).

CLIC IR discussion…

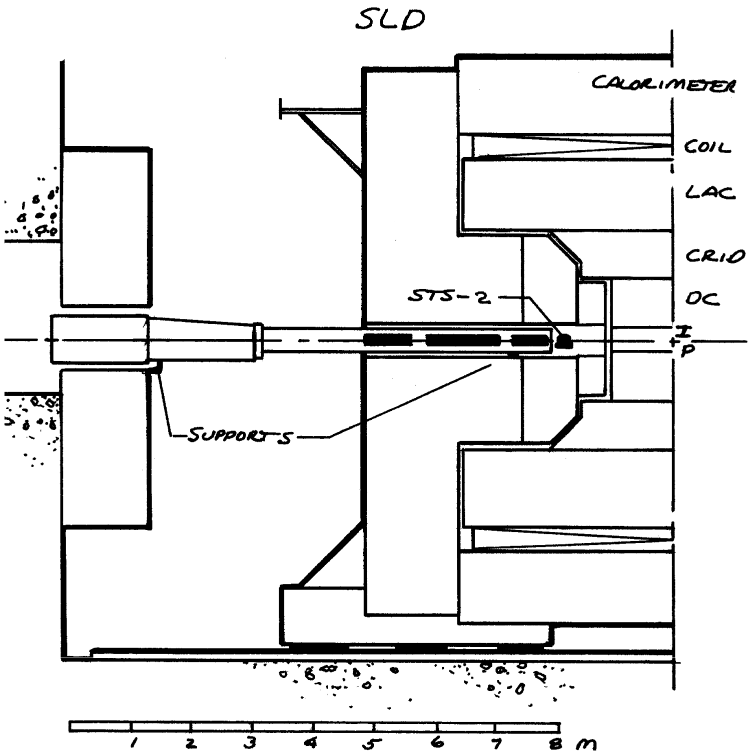
- Placing feedback electronics (perhaps need to be shielded, from pairs and radiation) may push the FD out

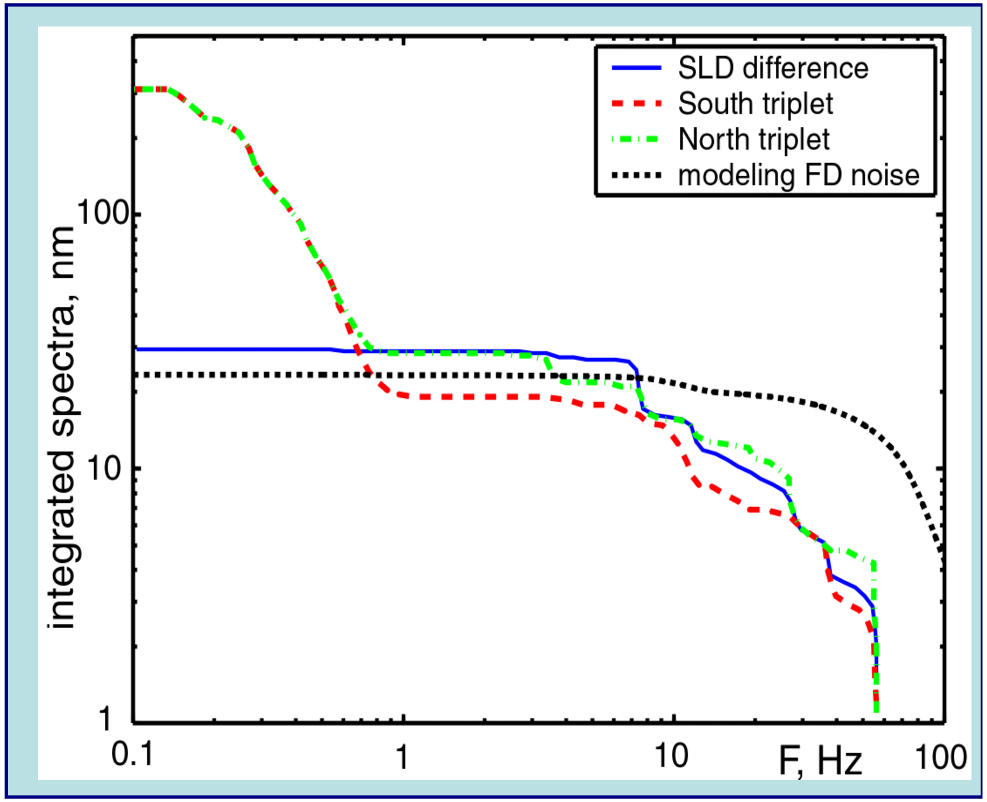
- FD is still supported by detector which is likely to be ~30nm stable



- With FD half way out, tempting to consider removing it from detector entirely, and exploring advantages of such change

Detector is a noisy ground



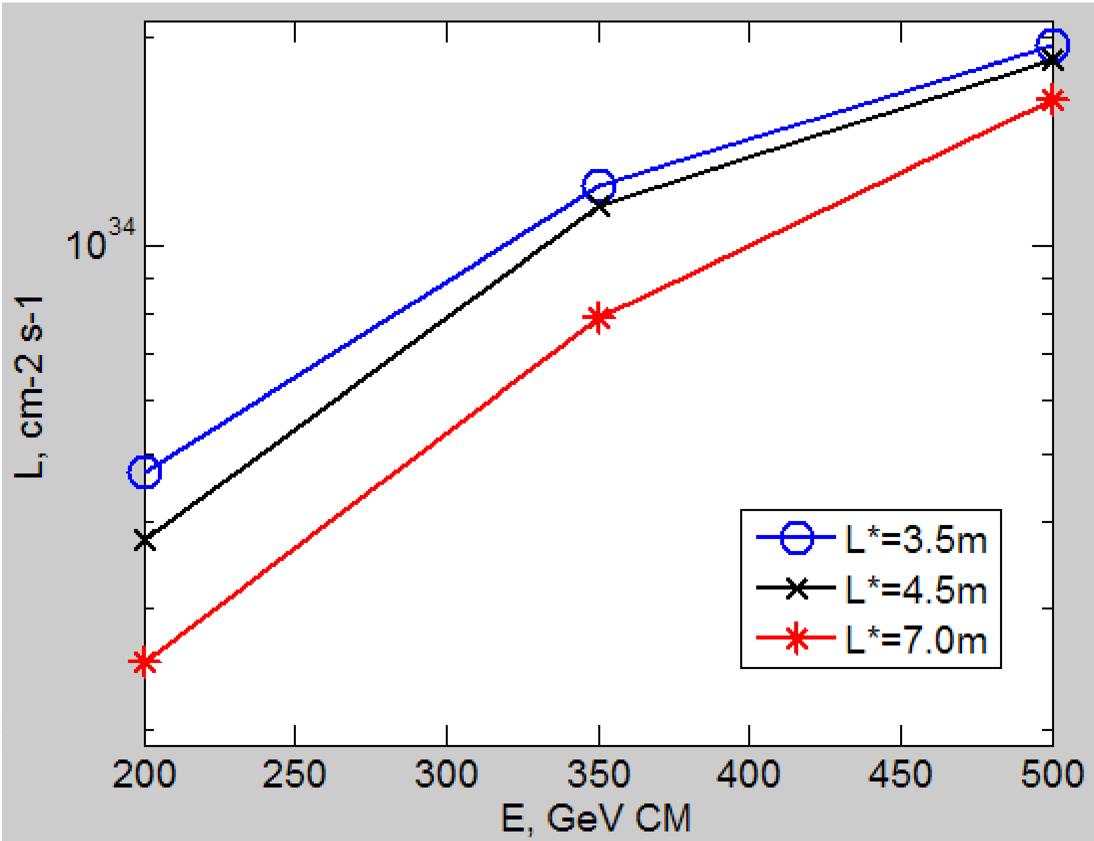


Measured ~30nm relative motion between South and North final triplets of SLC final focus. The CLIC or ILC detector may be designed to be more quiet. However present state of detector engineering does not allow relying on that.

Luminosity dependence on L* for ILC

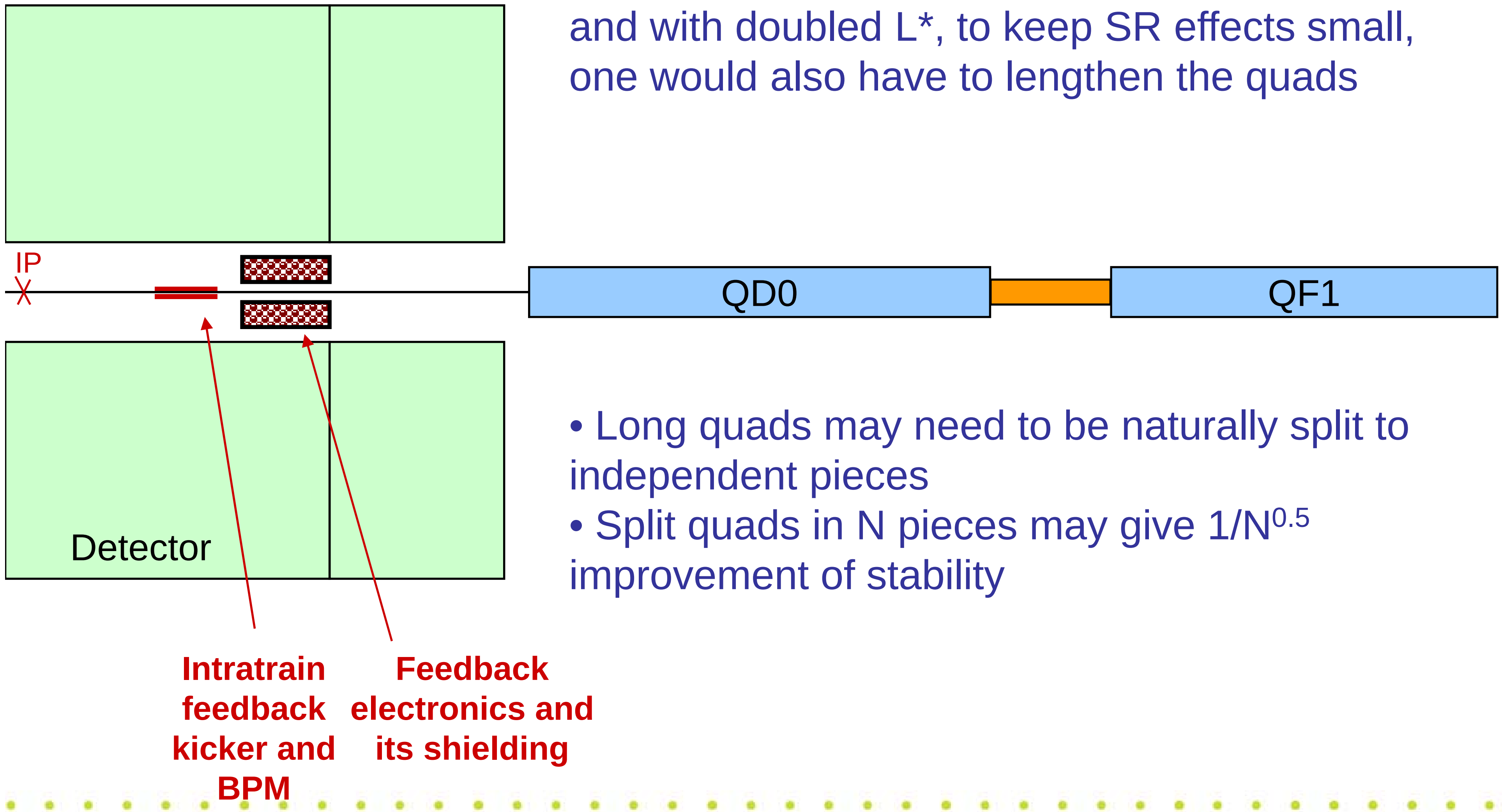
- For nominal energy, in some range of parameters and geometries the loss of luminosity is slower than linear with L*
  - Due to possibility to open extraction apertures and not to tighten the collimation depth
  - Based on a model that include assumptions about beam jitter, collimation wakes, etc.
  - Specific studies for CLIC parameters need to be done

- Tentative dependence of luminosity on L* for ILC parameters
  - **Reduced by ~5-10% for L* 3.5m => 4.5m**
  - **Reduced ~factor of two for 3.5m=> 7.0m at min energy and ~25% at max energy**



CLIC IR discussion…

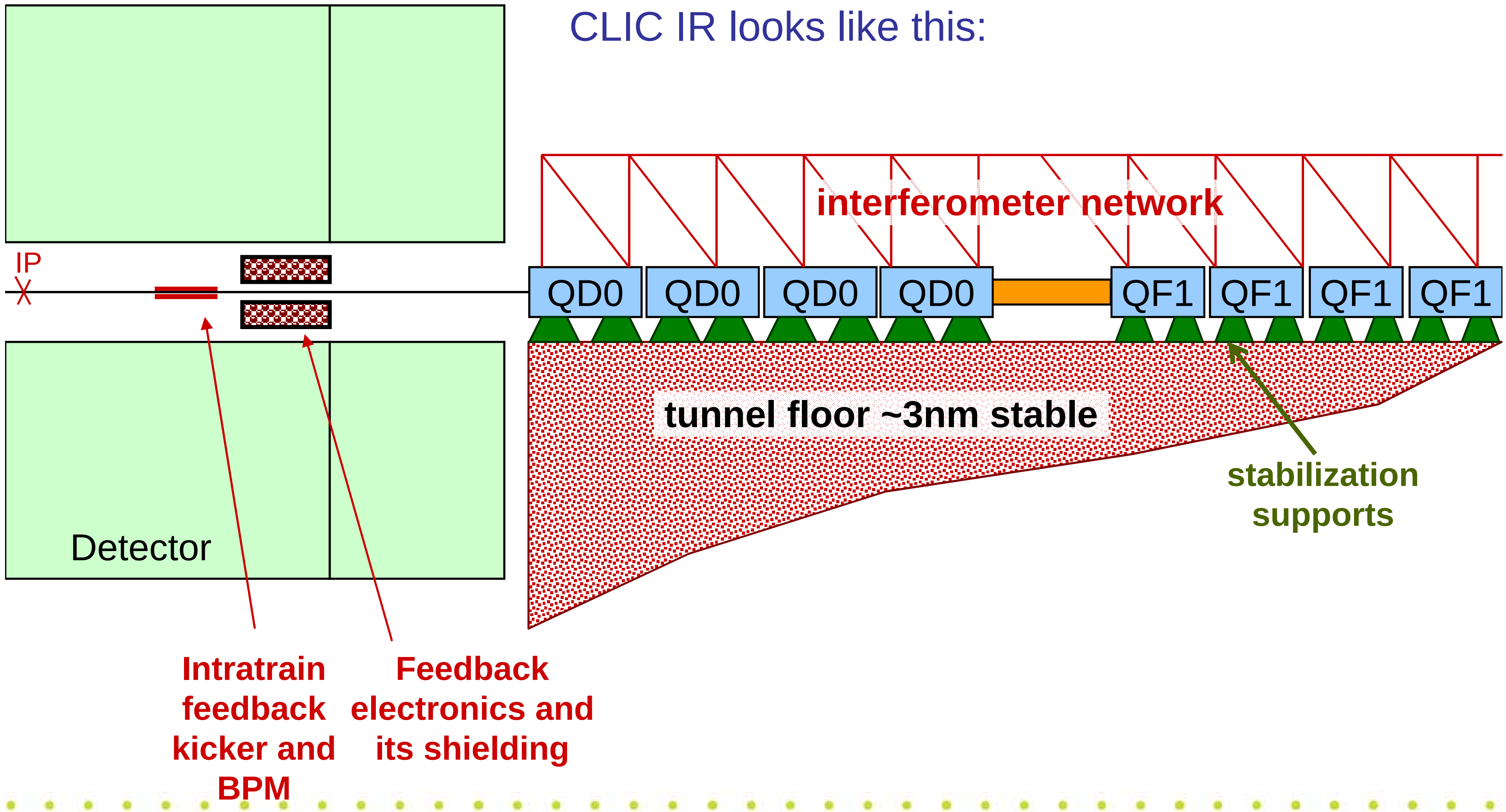
- At high energy, the SR in FD is very important, and with doubled L*, to keep SR effects small, one would also have to lengthen the quads



- Long quads may need to be naturally split to independent pieces
- Split quads in N pieces may give $1/N^{0.5}$ improvement of stability

CLIC IR configuration

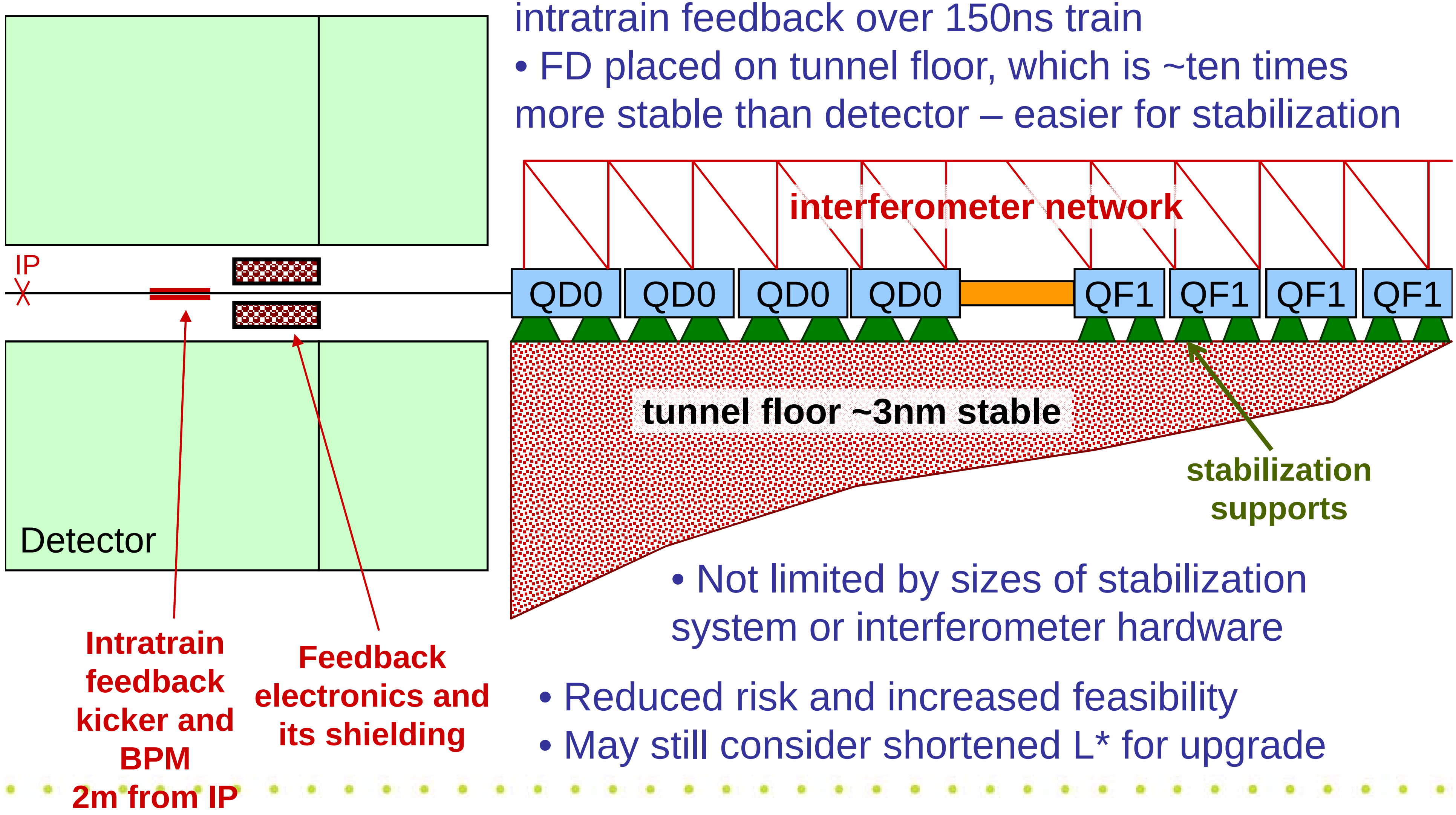
- After all these steps, the changed concept of CLIC IR looks like this:



New CLIC IR – advantages

• Reduced feedback latency – several iteration of intratrain feedback over 150ns train

• FD placed on tunnel floor, which is ~ten times more stable than detector – easier for stabilization



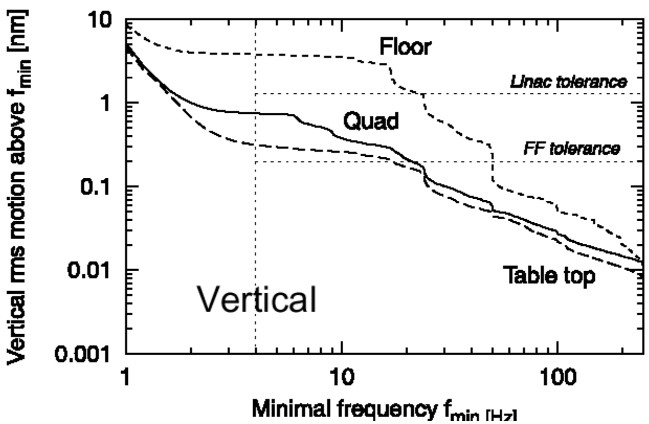
• Not limited by sizes of stabilization system or interferometer hardware

• Reduced risk and increased feasibility

• May still consider shortened L* for upgrade

What is achieved / Sizes of hardware

Quadrupole vibration:



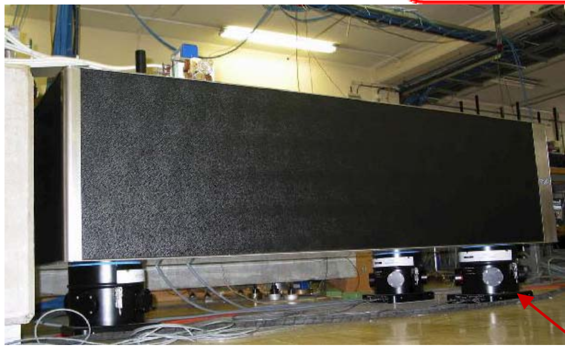
On magnet top:

X: (0.4 ± 0.1) nm

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

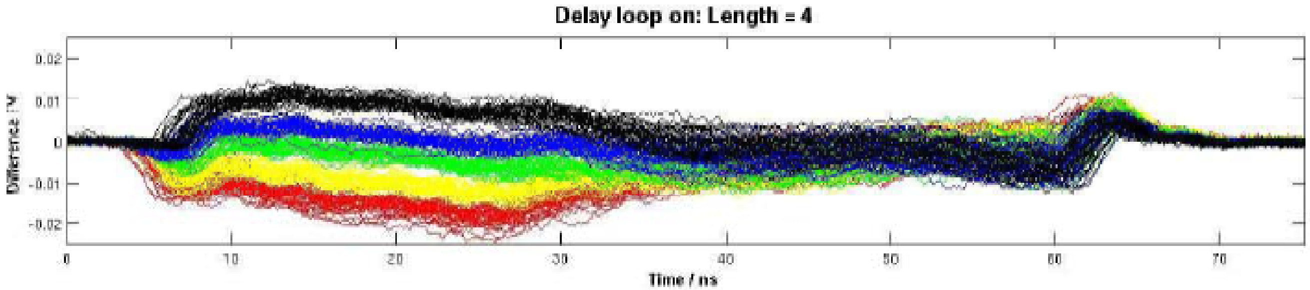
Z: (3.2 ± 0.4) nm

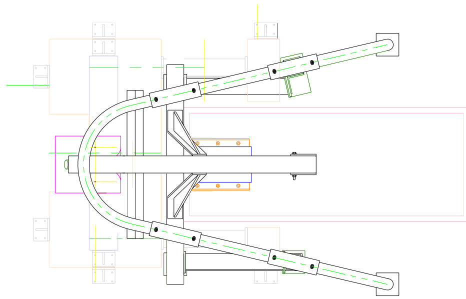
without cooling water.



~0.3m

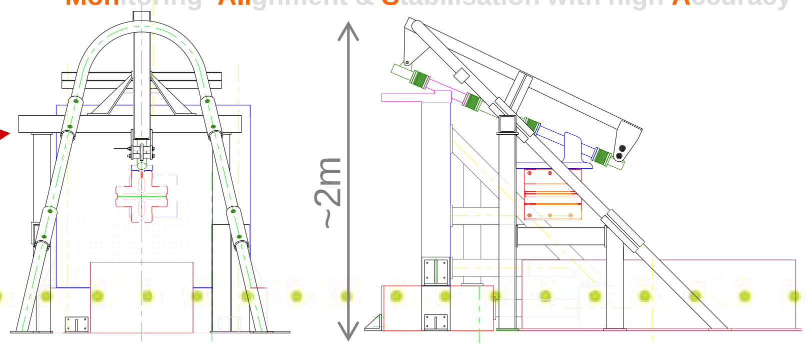
R.Assmann et al, Stabilization with STACIS give ~10 reduction of tunnel floor vibration





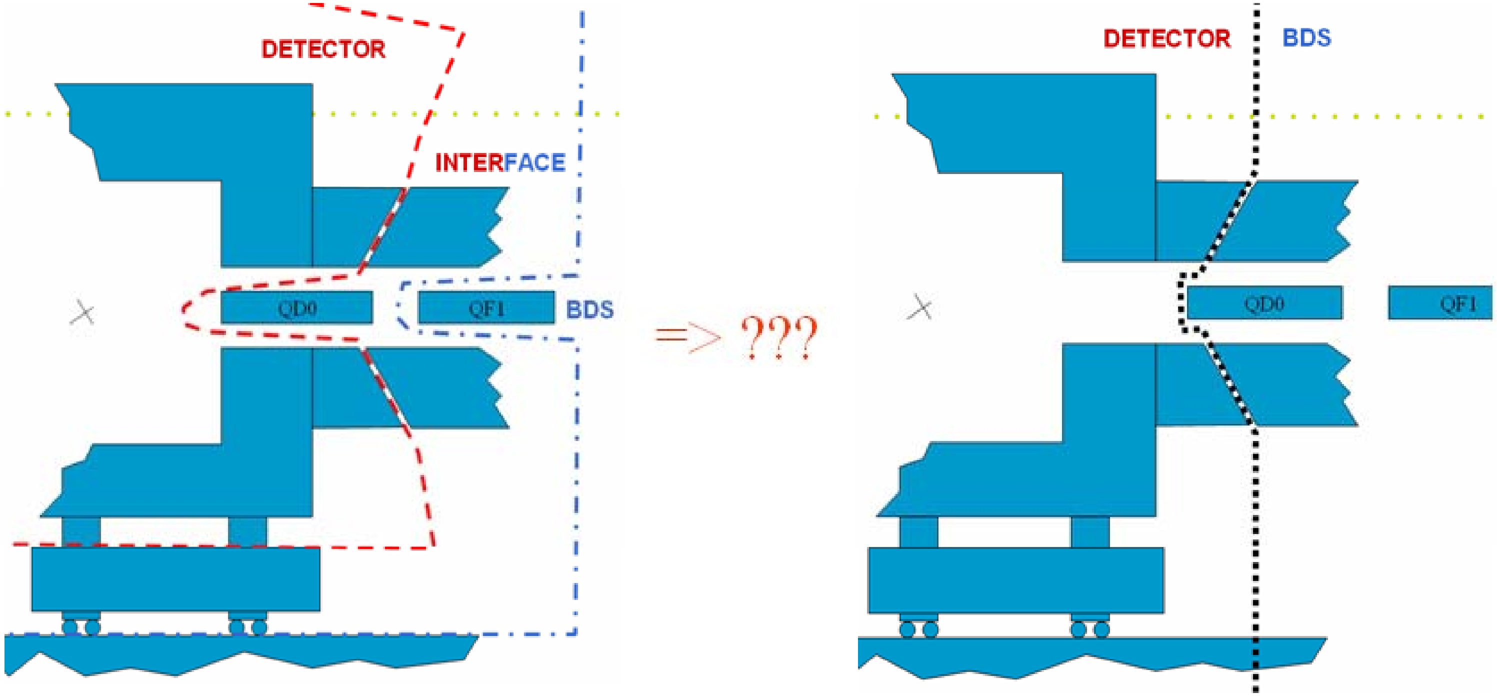
P.Burrows et al, FONT3 demonstrated latency of 23ns, including 10ns of irreducible time-of flight

Monitoring **Ali**gnment & **S**tabilisation with high **A**ccuracy



D.Urner et al, MONALISA interferometer system for ATF2 final doublet: space availability matters

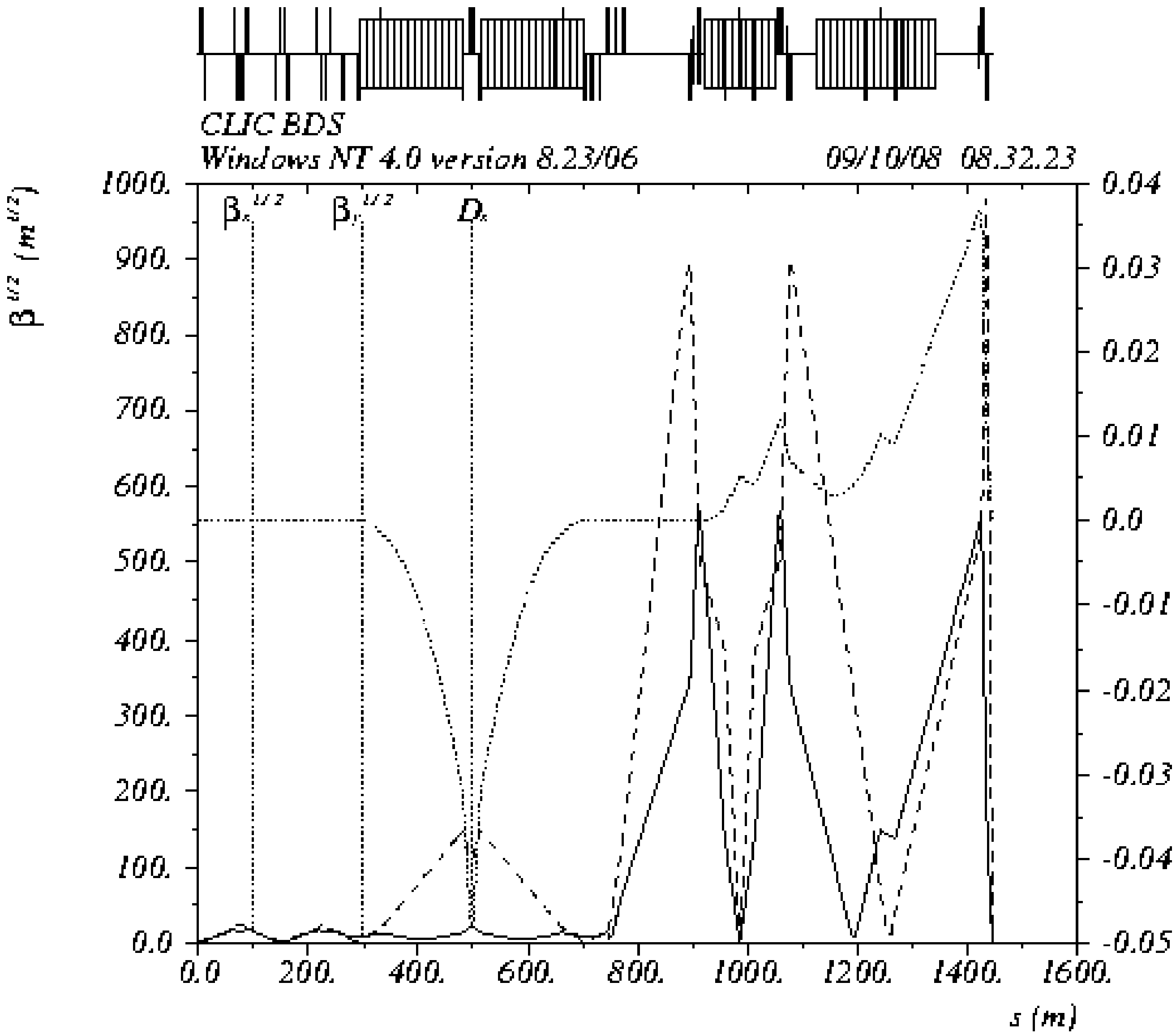
Simplified IR



- Longer L*, long enough to have QD0 outside of detector, separating M/D more cleanly and simplifying push-pull
  - Some impact on luminosity is unavoidable; Rvx may need to be increased
- If a longer L* design will be found viable, a question will be
  - whether to consider it as a permanent solution
  - if a Luminosity upgrade, by shortening the L*, would be considered later, after operational experience will be gained with a simpler system

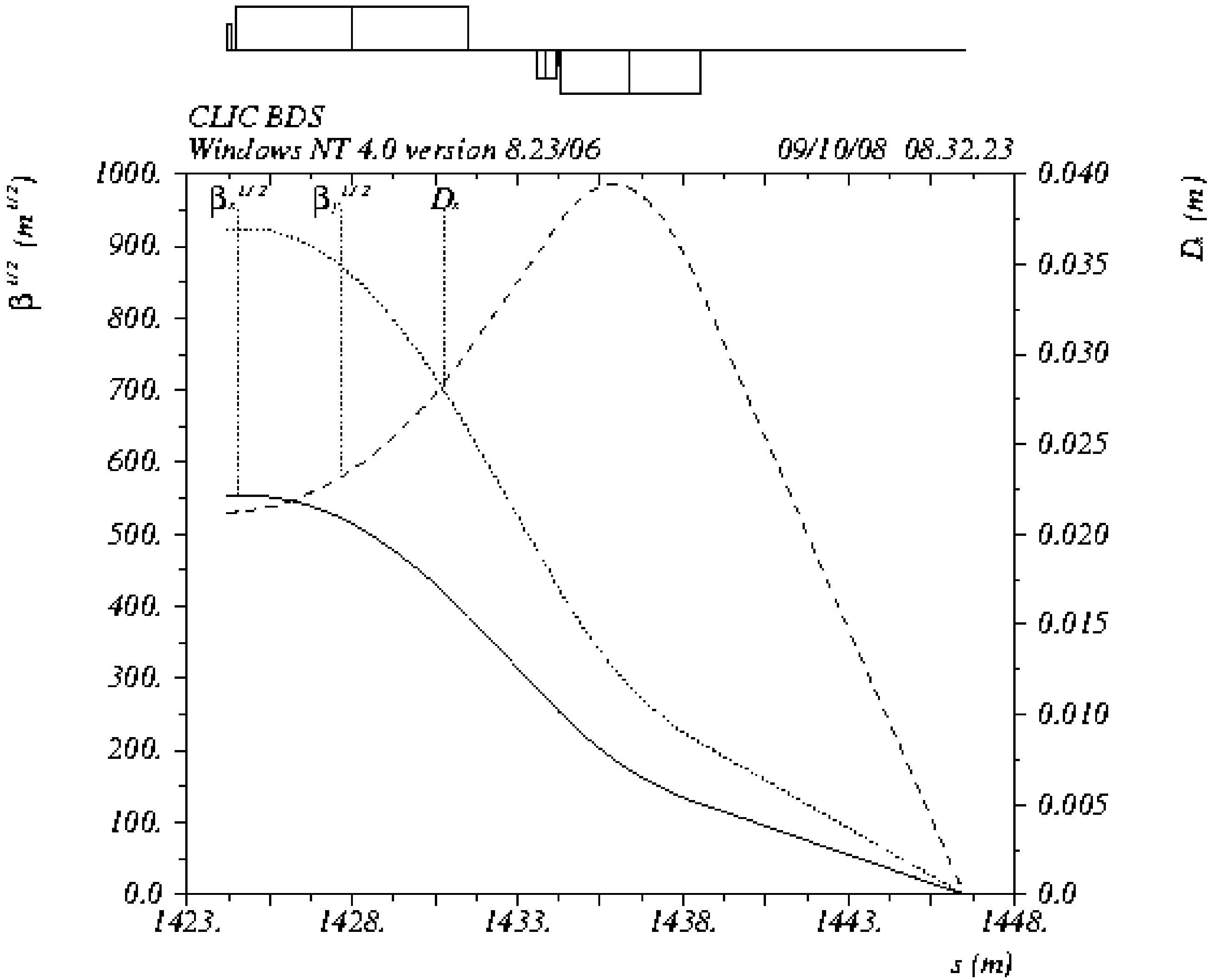
FF design for L*=8m

- To support the long L* idea, started to look at BDS design with L*=8m for CLIC beam and E=3TeV CM
- Start from NLC BDS
  - **reduce and optimize dispersion**
  - **lengthen and optimize FD**
  - **retune the optics to cancel aberrations**
    - (BDS length or location of elements was not changed in comparison with initial NLC BDS)
    - (Did not optimize or evaluate collimation system survivability)
- Design look promising
  - **(after just ~week of efforts)**
  - **Luminosity somewhat lower that nominal (~80%)**
  - **Further optimization may bring “double L* BDS” close to nominal performance**



Designed for 3TeV CM,
IP emittances = (660/20) nm
IP betas = (6.9/0.068) mm

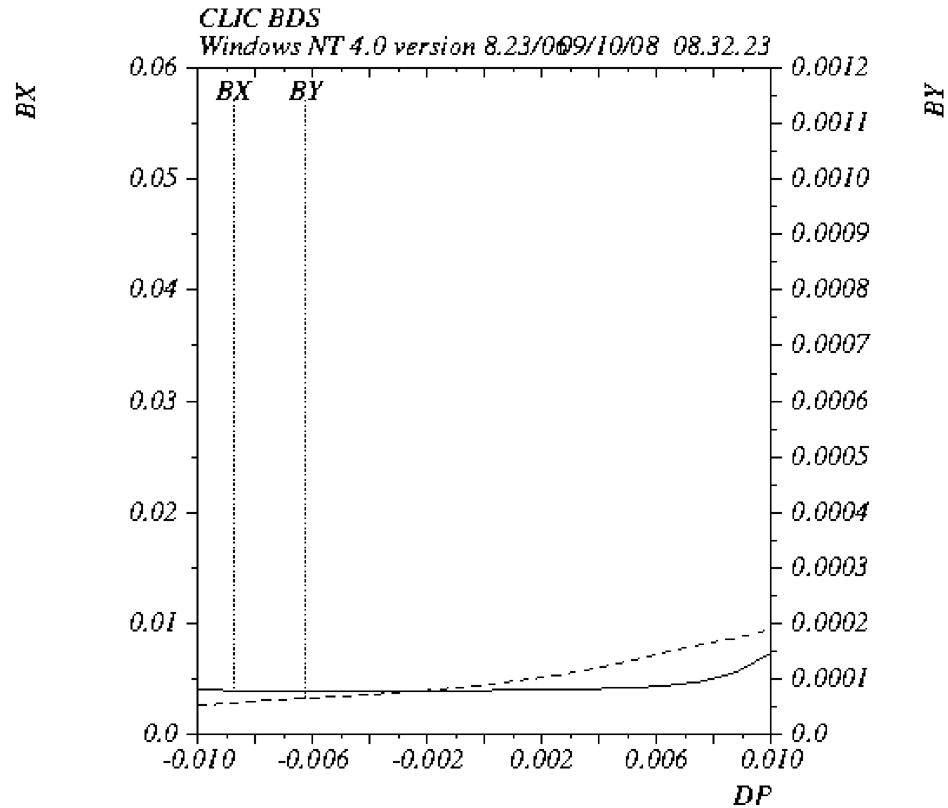
L*=8m version: CLIC_LSTAR17.mad



Final doublet at 3TeV CM:
QD0: 213 T/m
QF1: 72 T/m

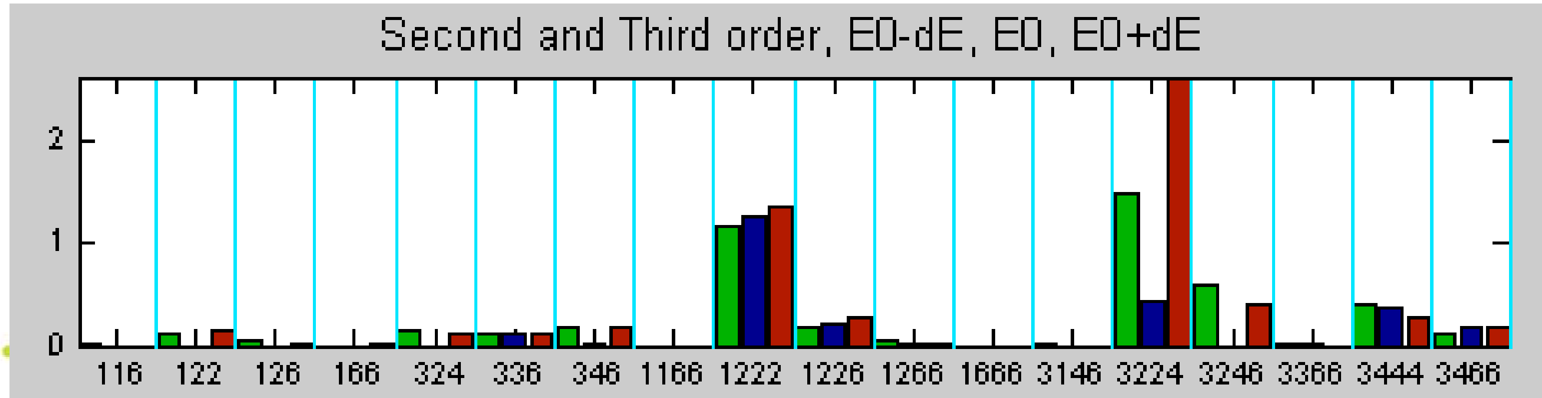
(Sextupoles need to be lengthened and reoptimized)

L*=8m version: CLIC_LSTAR17.mad



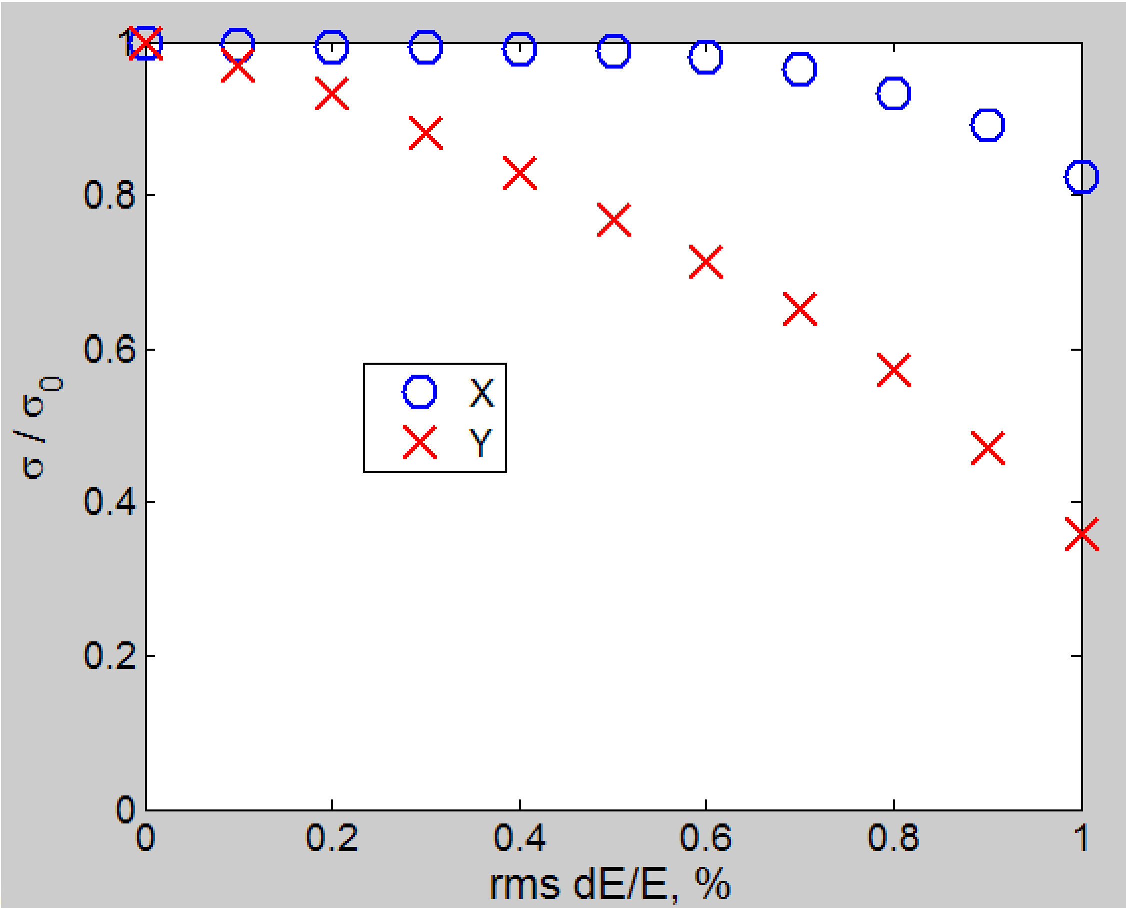
Energy bandwidth (MAD)

Major remaining aberrations are $U_{xx'x'x'}$ and $W_{yx'x'y'\delta}$
So far they limit achievable IP beam size



- Evaluation: (with several codes)
- **Transport**: aberrations
- **Turtle**: tracking (without SR effects)
- **Dimad**: tracking
  - **without SR**
  - **with SR in bends**
  - **with SR in bends and all other magnets**
  - **(looking at Dimad tracking, optimize FD length and the value of dispersion in FF and in Collimation)**
- Guinea-pig beam-beam taking Dimad tracked beam with all SR included

- Evaluation:
- Dimad: tracking with SR in all magnets, versus rms energy spread:



Y-bandwidth affected by remaining aberration of 4th order $W_{yx'x'y'\delta}$

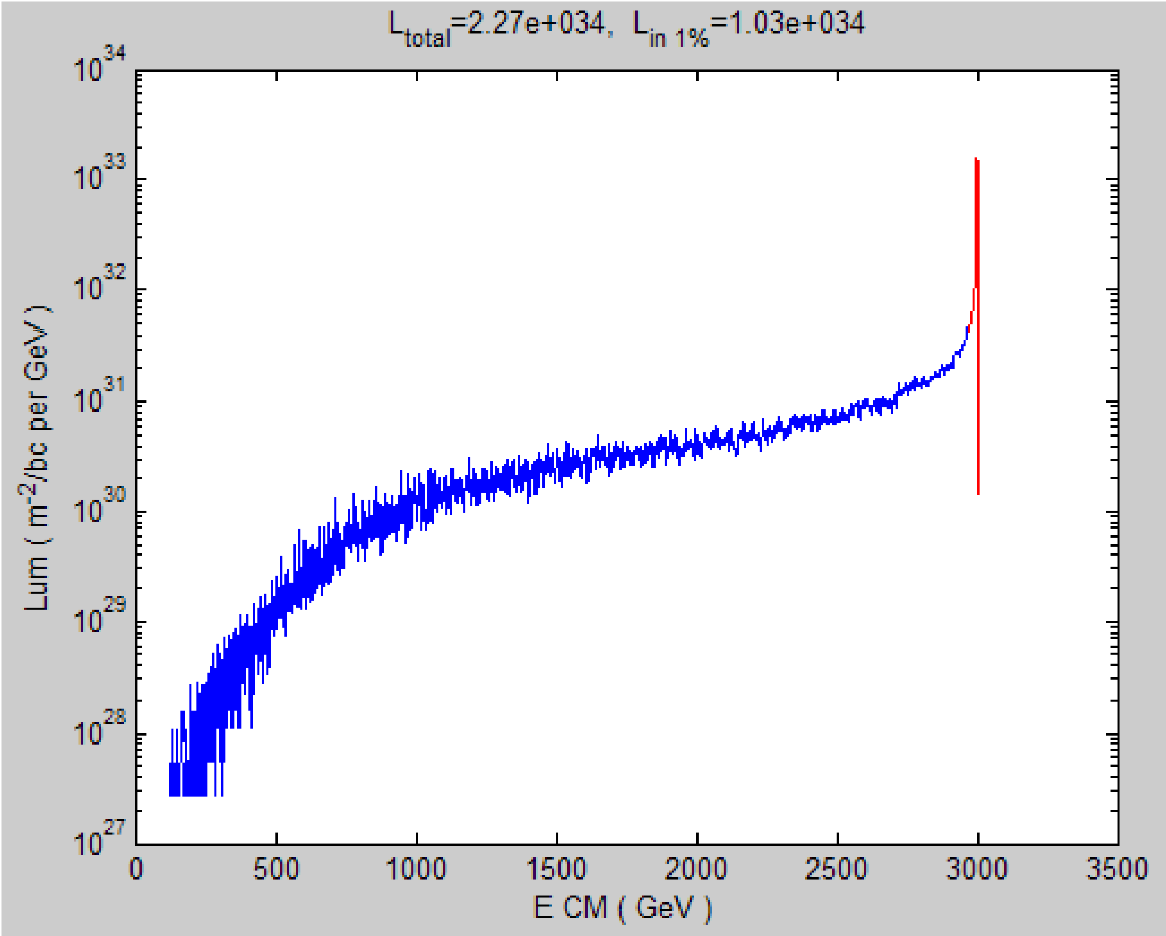
Can be further improved

- Evaluation (continued):
- Track (with all SR), GP, and study Luminosity and L(in 1%) versus IP beta-function
- So far achieved:
  - **L(1%)= 1.35e34 $cm^{-2}s^{-1}$ for nominal (6.9/.068) IP β**
  - **L(1%)= 1.60e34 $cm^{-2}s^{-1}$ for (13/.1) IP betas**
    - or 80% of nominal luminosity in 1% peak

en sge bex bey sx0 sy0 Tsx Tsy Tsx*Tsy D0sx D0sy D2sx D2sy D4sx D4sy
BTD:1500 3.5 0.0069 6.8e-005 0.039388 0.00068067 0.075213 0.001446 0.00010876 0.07781 0.001218 0.08794 0.001479 0.08746 0.001739
Dimd, G-P: sxy=6.713e-005 Ltot=2.9588e+034 L(in 1%)=1.3561e+034
BTD:1500 3.5 0.013 0.0001 0.054064 0.00082543 0.069853 0.001216 8.4941e-005 0.06958 0.00109 0.07642 0.001303 0.07647 0.001478
Dimd, G-P: sxy=5.6072e-005 Ltot=3.5424e+034 L(in 1%)=1.6018e+034

Use Luminosity equivalent spot size both from Turtle and Dimad

L*=8m version: CLIC_LSTAR17.mad



GP spectrum, Dimad tracking with SR. (13/0.1)mm IP betas.
(Lumi shown is per bunch crossing)

L*=8m version: CLIC_LSTAR17.mad

- Evaluation (continued):
- For IP betas of (13/0.1mm):

linear IP sizes, x y : 54.06 0.825 nm
with aberrations (dE/E=0.35%) : 69.58 1.090 nm (128.7 132.1%) (+^2: 81 86%)
with SR in bends only : 76.42 1.303 nm (141.4 157.8%) (+^2: 58 86%)
with SR in all magnets : 76.47 1.478 nm (141.4 179.1%) (+^2: 0 85%)

- => contributions to Y size at IP from
  - **aberrations**
  - **SR in bends (producing dE/E and ε)**
  - **SR in Final Doublet**
- are about equal

» (+^2 == added in quadratures)

L*=8m and Collimation

- The present BDS with L*=3.5m has Final Doublet with aperture radius r~4mm

- The new BDS with L*=8m will have FD (SC) with aperture r~10mm (still smaller that Rvx)
  - **=> collimation depth will not be more tight.**
  - **good.**

Summary

- BDS with L*=8m may be feasible for CLIC, even for 3TeV CM
  - **Luminosity (in 1%peak) is ~80% of nominal 2E34**
  - **Further optimization possible**
    - (but also errors in BDS need to be included)
- Advantages of doubled L*
  - **The FD stability may be claimed to be feasible <u>now</u>, with present technology that was already demonstrated**
    - (FD magnetic center stability is a separate issue ~independent on L*, and needs to be verified in any case)
  - **(Compare: CLIC FD stability requirements for L*=3.5m are <u>extremely challenging</u>)**
  - **Plus, much simpler MDI, easier FD design, no need for antisolenoid, etc**