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Luminosity performance with optimised feedback signals

- Cradle-to-grave simulation – track bunch through linac/BDS and do angle and IP position feedback
- Feedback by gain optimisation and simultaneously using BPM and luminosity signals
- Maximise integrated luminosity and investigate feedback stability

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Feedback simulation software

- Octave (free matlab clone) models feedback and serves as main program
- Linac and BDS modelled using Placet
    - ILC2006e lattice
    - Assume perfect linac with 40% emittance growth and apply ground motion to BDS
- Can run in 'full' or 'fast' (G-P run replaced with 2D interpolated spline fit to beam-beam curves) modes

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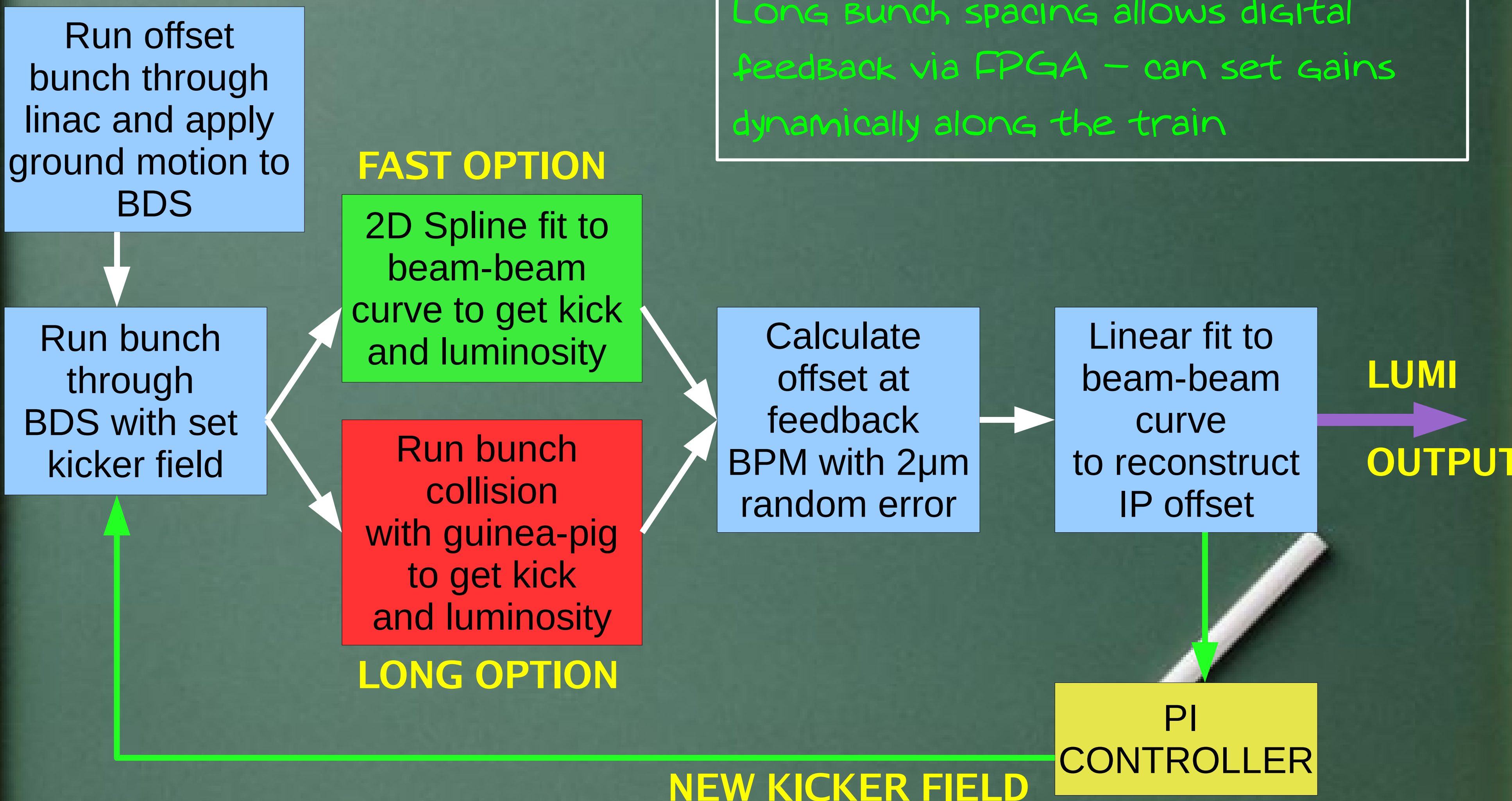
IP position feedback algorithm

Long bunch spacing allows digital feedback via FPGA – can set gains dynamically along the train



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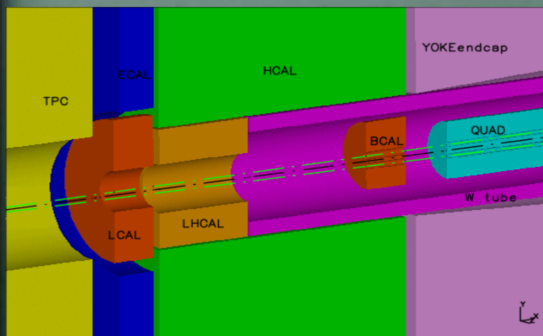
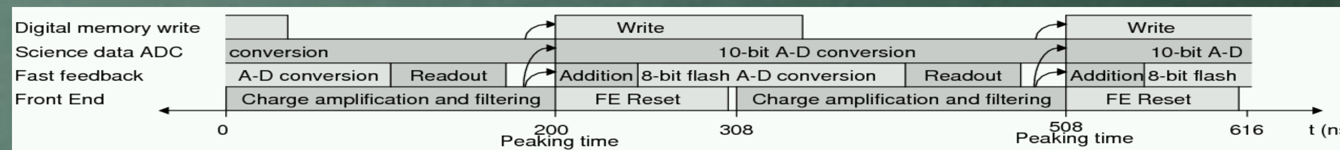
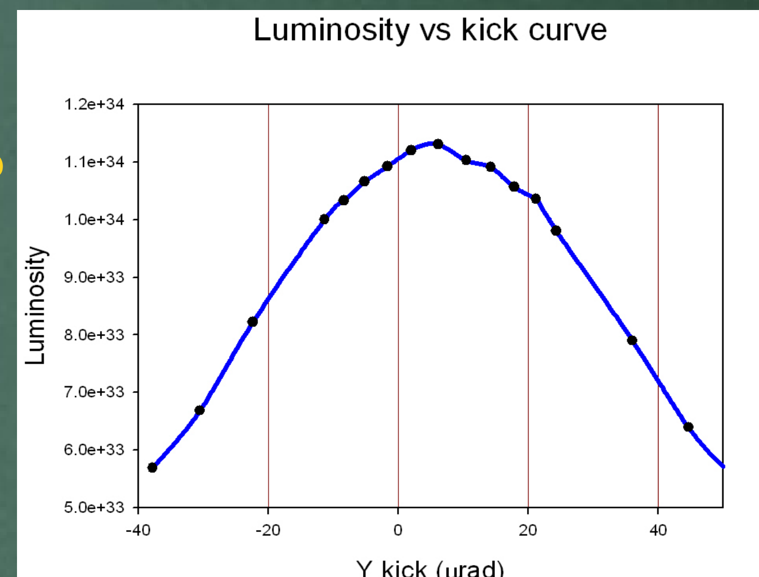
Luminosity signal and feedback

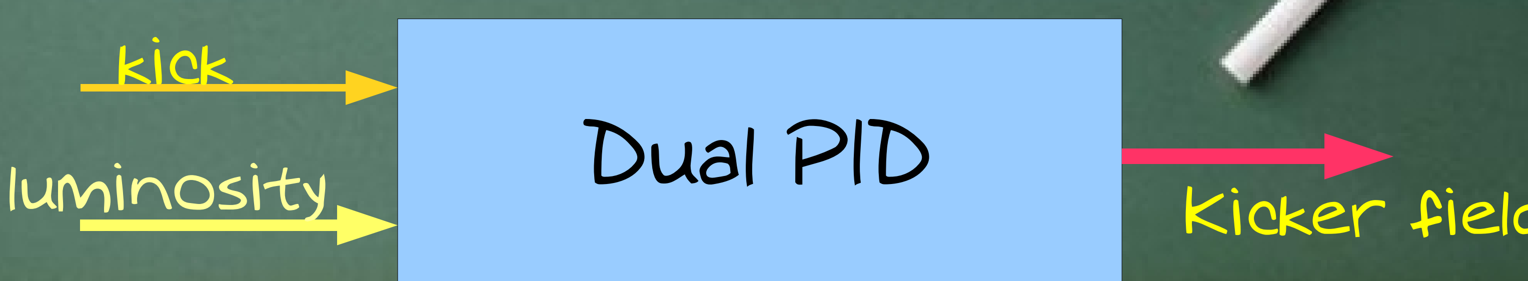




Lumi signal available within 3 bunches



- Two input signals – Y kick and lumi
- Luminosity is max when lumi-kick gradient zero
- So try to minimise gradient using PID controller and use output as set point for the position feedback
- Feedback on differential signal difficult so constrain max gradient
- Turn off after 20 bunches and let position fb do the rest



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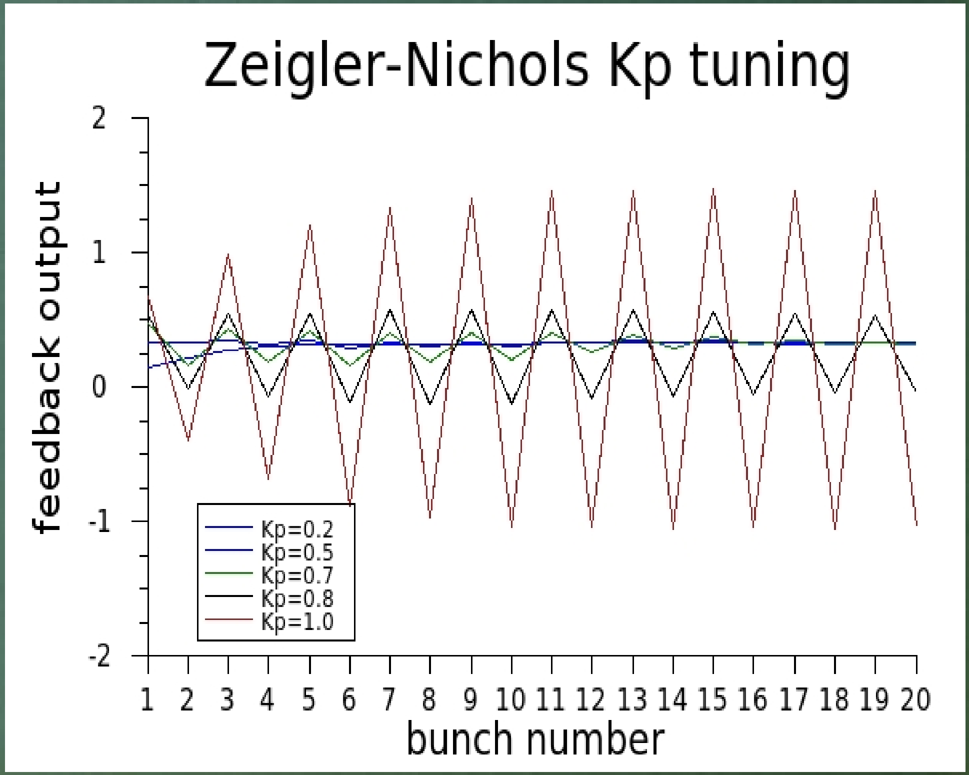
PI Controller & tuning

For Bunch n

$$F_{kick}(n)=F_{kick}(n-1)+(K_p+K_i).P_{off}(n)-K_p.P_{off}(n-1)$$

Tune Kp and Ki using Zeigler-Nichols method

- Set $K_i=0$ and increase K_p until ($K_p=K_c$) where output starts to oscillate with period P_c
- Then $K_p=0.45\ K_c$ and $K_i=1.2K_p/P_c$



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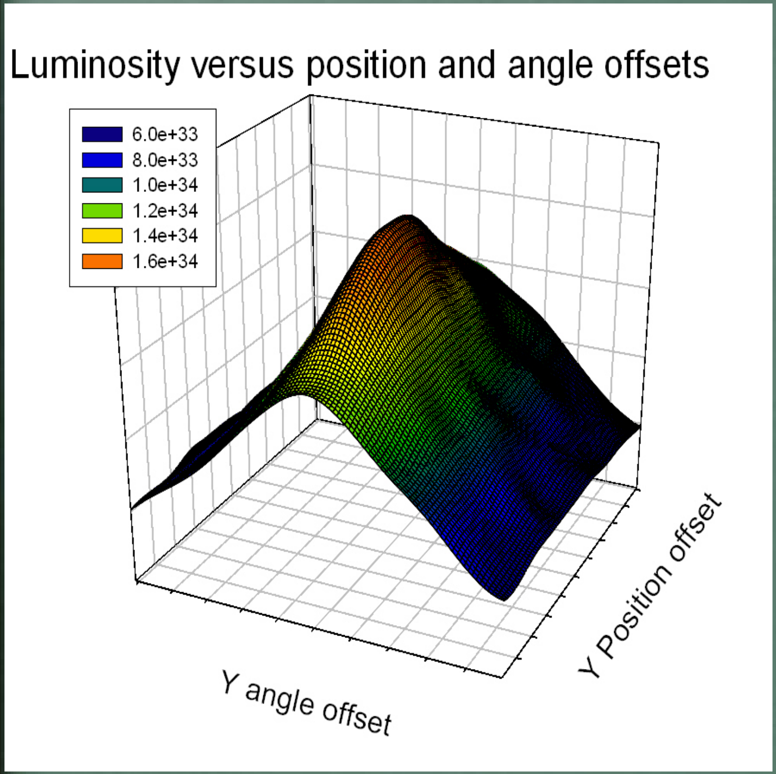
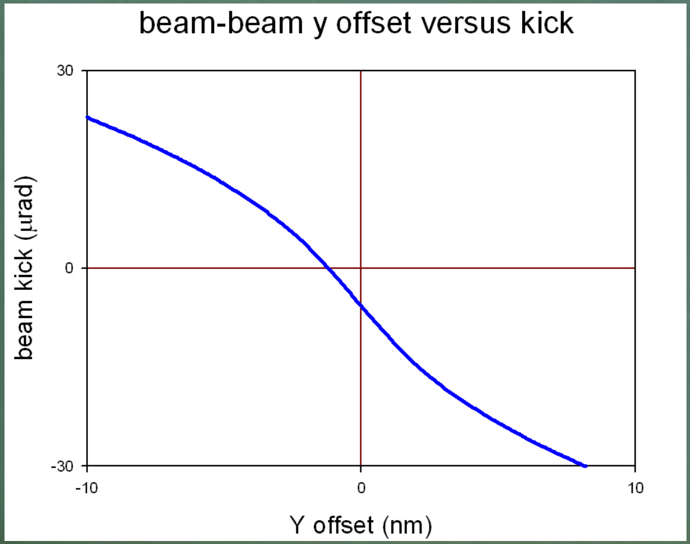
Beam-Beam curve



- Luminosity dependent on offset AND angle
- Yoff-kick curve doesn't go through zero – initial feedbacks are incorrect
- Need fB in offset AND angle



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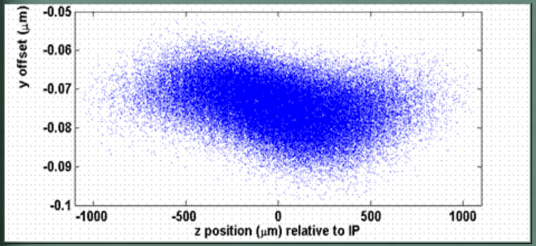
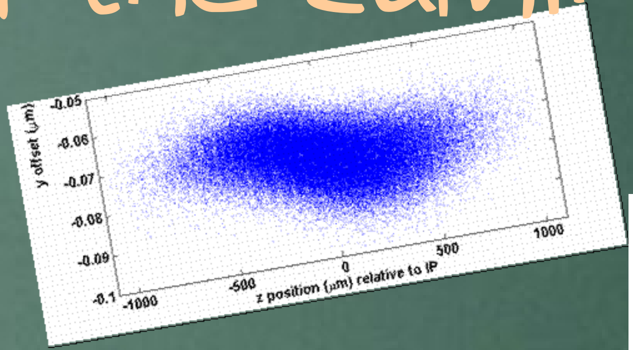
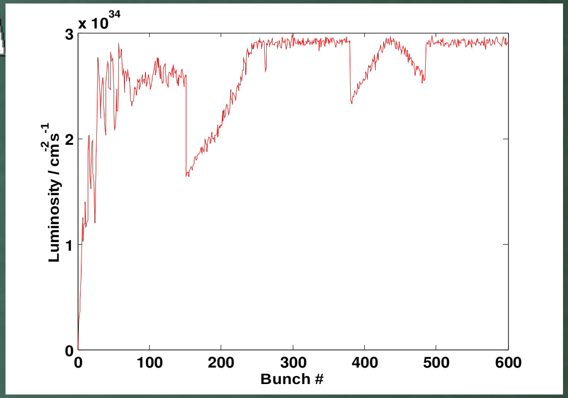
Optimising the Luminosity

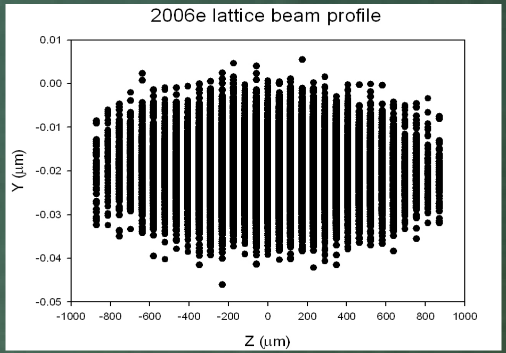




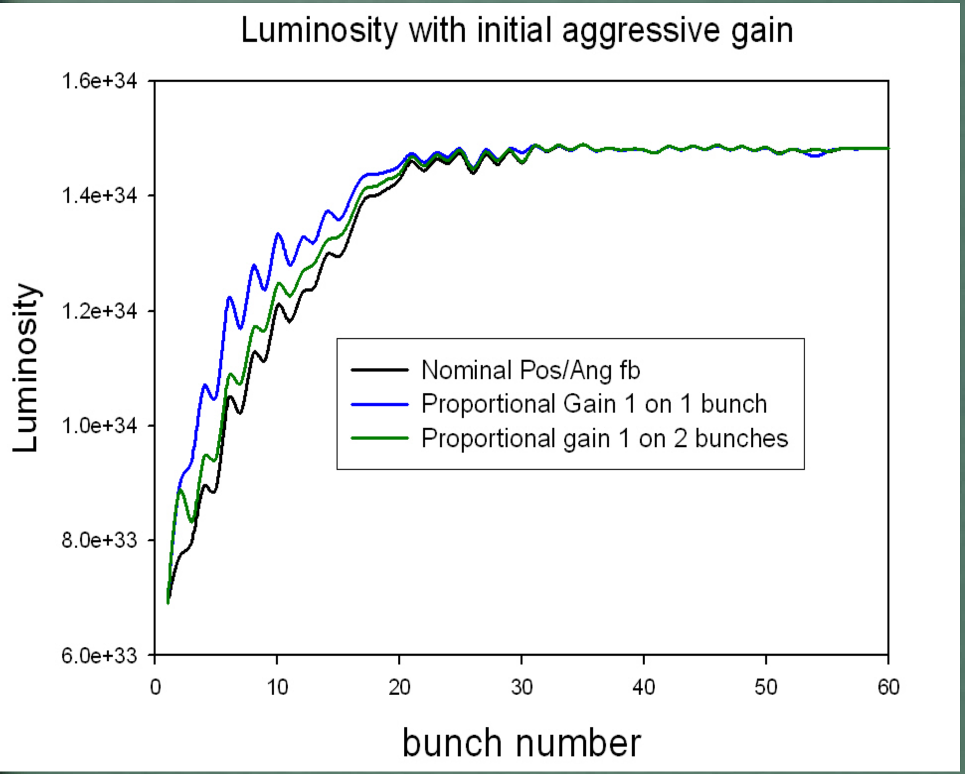


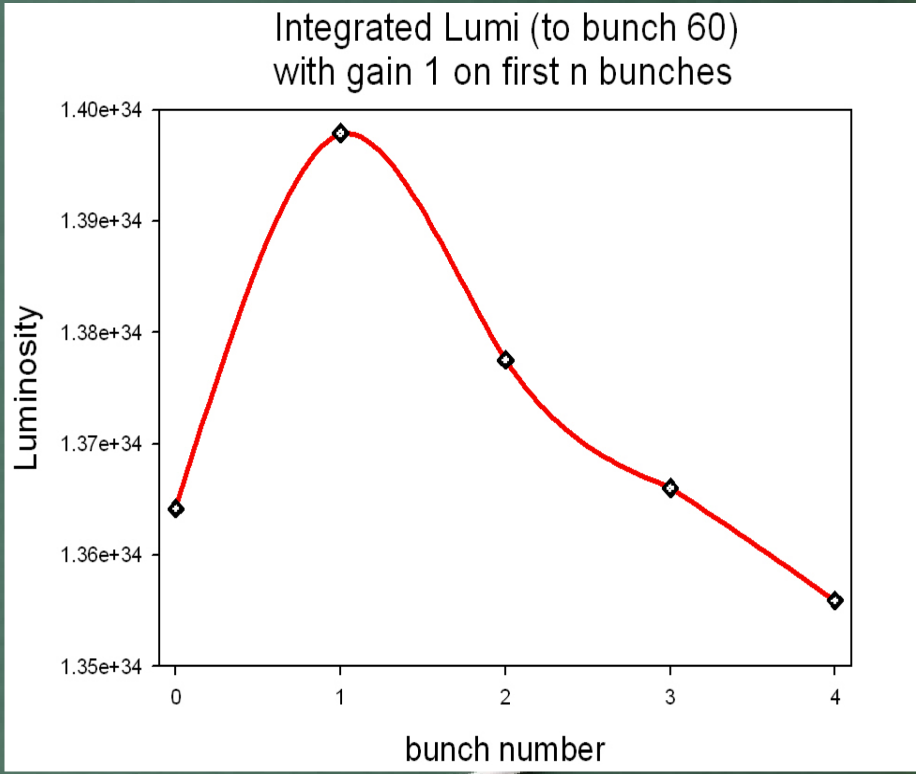
- 2005 lattice banana bunches - Correct angle and pos, then do lumi scan further down the train

- 2007 lattice shows reduced banana and nothing gained from doing lumi optimisation further down the train



Pos/Ang fb Luminosity improvement with Z-N and agressive gains on initial bunches





- Max lumi gain with aggressive feedback on 1st bunch only

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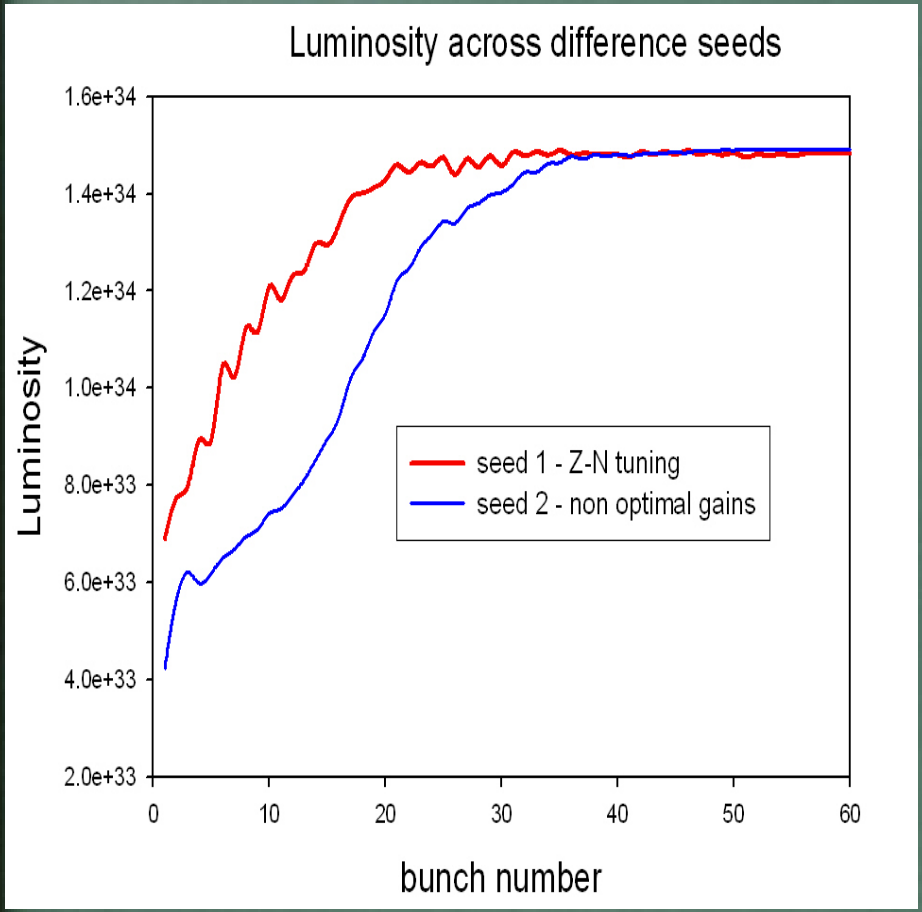
Gain tuning across random seeds



- Need to optimise gain statistically across seeds, but..
- On average there will be non-optimal gain and the luminosity suffers at start of train
- Try to improve lumi using luminosity signal

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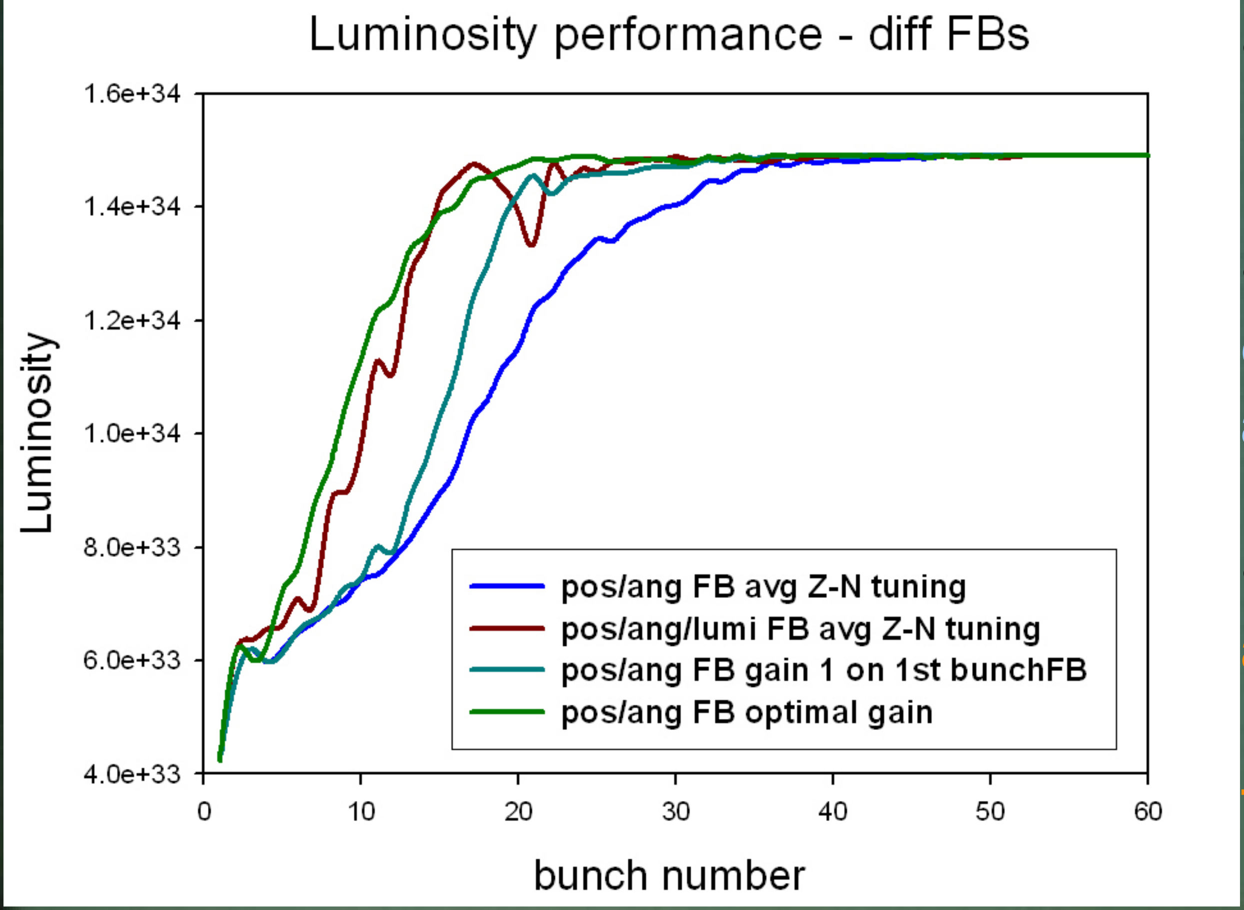
Luminosity – random seed

1. nominal Position/Angle feedback only, converges slowly
2. Aggressive Gain on 1st bunch leads to improvement
3. optimising gain and adding lumi feedback provide the best lumi gain, but..



- **Lumi signal feedback is unstable**
- **would be best to optimise the gain adaptively train-to train**
- **will look for a way to adaptively set gain on pos/ang feedbacks using the luminosity signal from bunch 3 in the train**

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Conclusions

- Zeigler-Nichols gives "safe" gains – reliable but slow
- Optimal gains probably vary widely train-to-train – aggressive gain on 1st bunch only gives integrated lumi improvement
- Feedback using lumi signal gives better integrated lumi improvement, but unreliabel differential signal
- Look at using lumi signal to set position/angle fB gains adaptively