Integrated Luminosity simulation with respect to ground motion

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Outline

- Introduction
- Dynamic imperfections due to ground motion
  - pulse to pulse
  - long term
- Conclusions

Ground motion

Main dynamic cause for luminosity loss

Slowly drifting element positions

Short time scales (< 10-60 s)

- A. Seryi models (see figure)

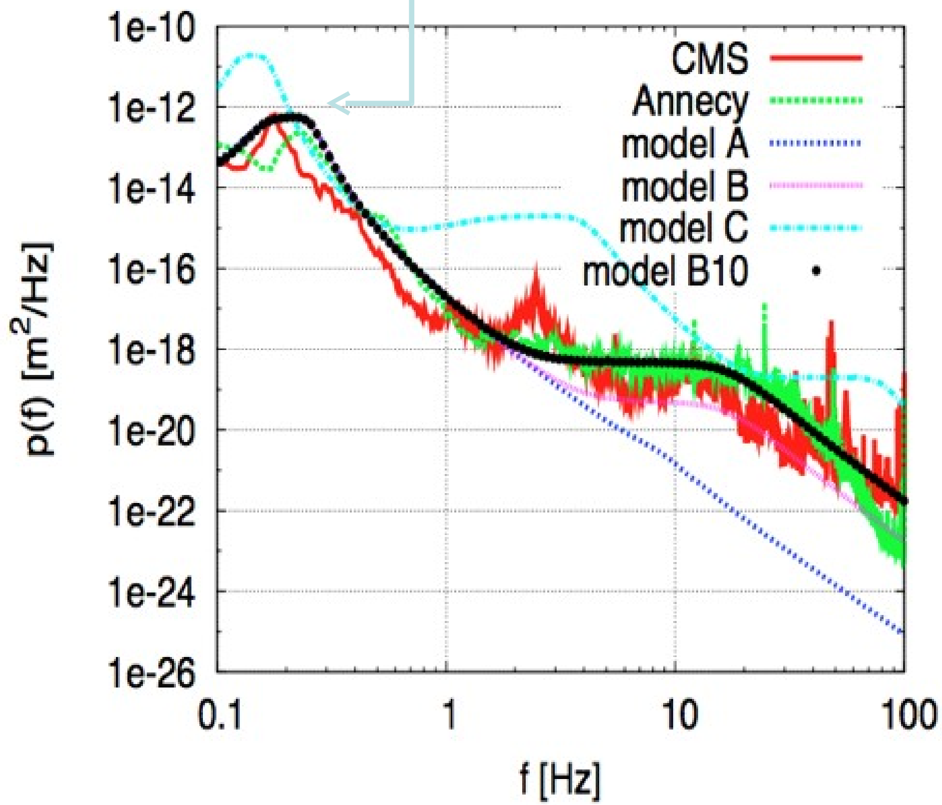
Long time scales

- ATL law:
- $<(\Delta y)2> = A*t*L$

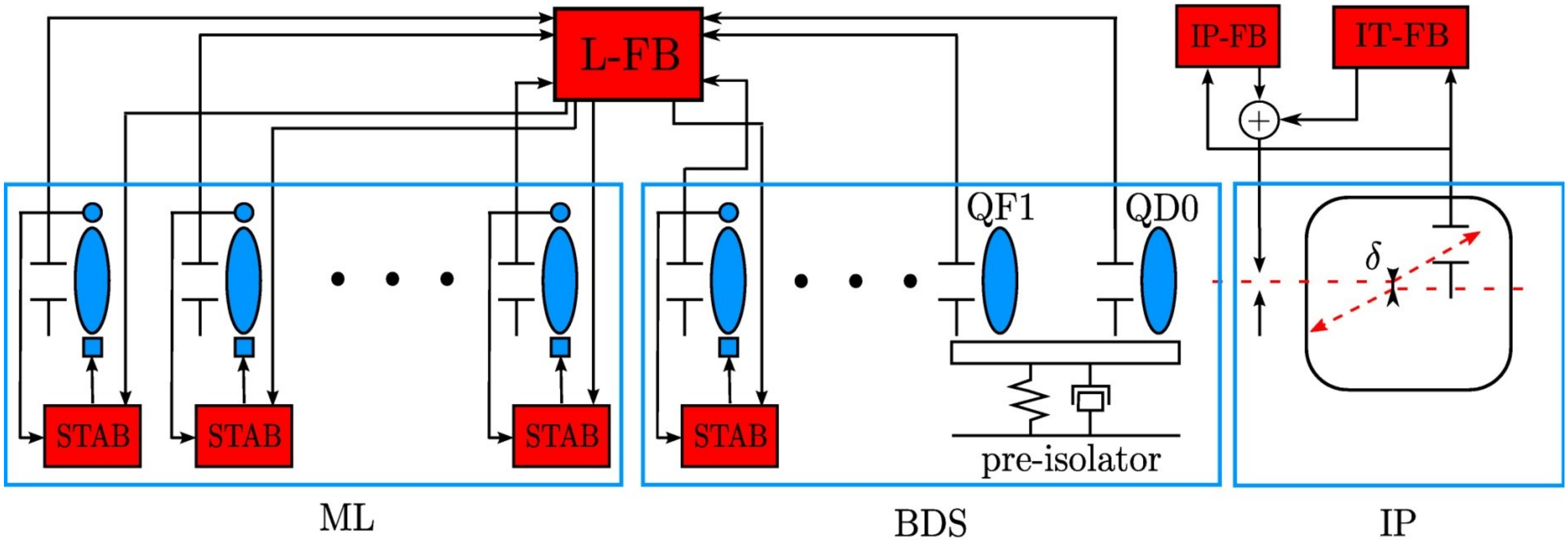
Value of A is highly dependent on site and measurements

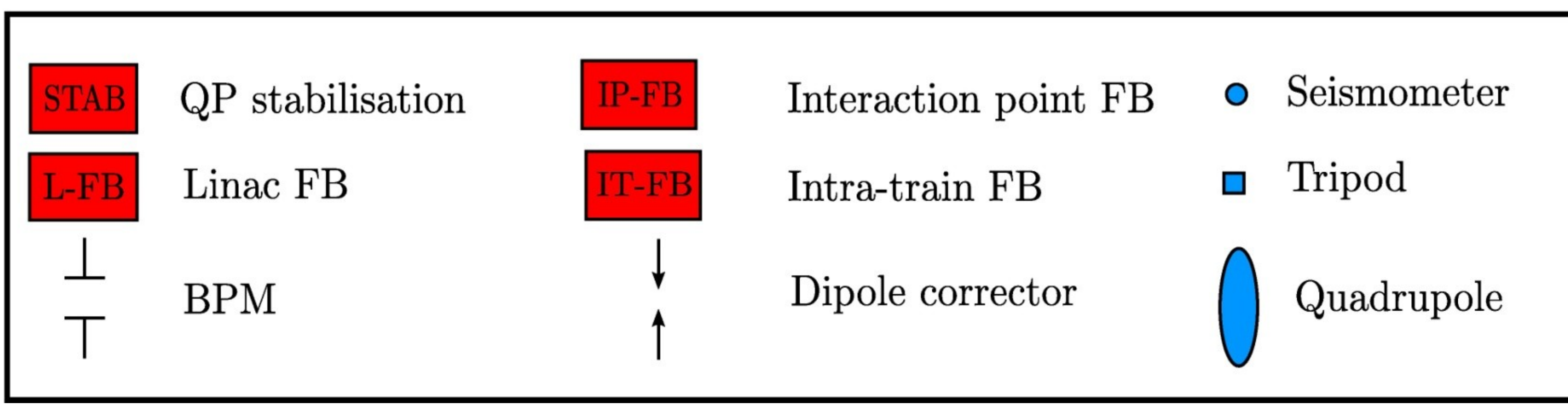
Here value for LEP tunnel is taken, but this value varies up to factor 5.

Micro-seismic peak



Counter-measures



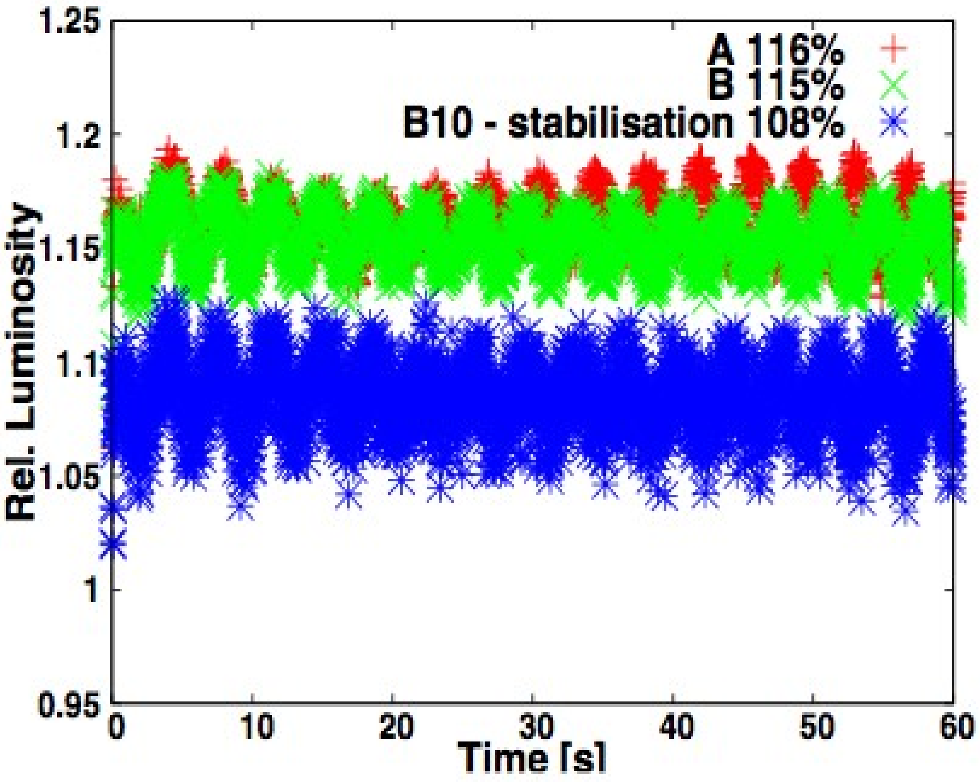


Taken from J. Pfingstner

Pulse to pulse motion

- Presented on Tuesday
- Model A:
  no stab. needed
- Model B:
  needs FD stab.
- Model B10 or worse:
  needs quad stab.

Averaged over 20 seeds



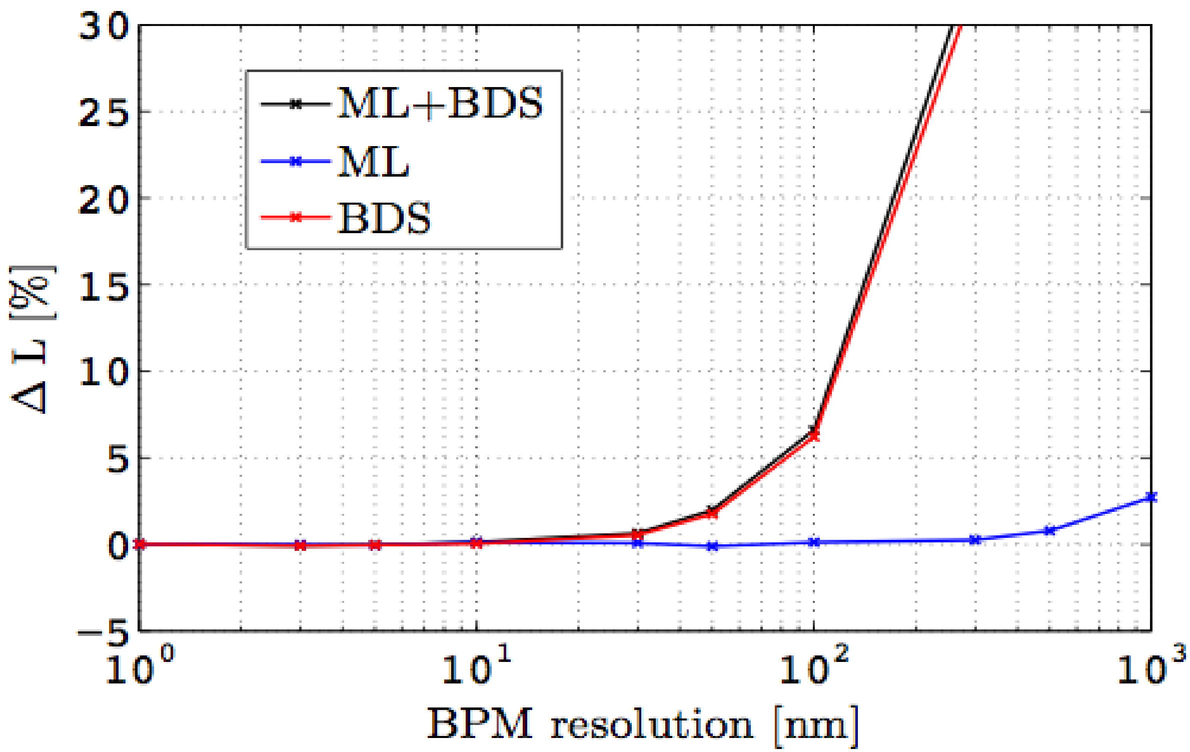
BPM resolution

Impact of BPM resolution

No ground motion, only BPM errors

Required BPM resolution in BDS 50 nm (baseline) for a few % loss

Improved result due to noise-robust beam based feedback

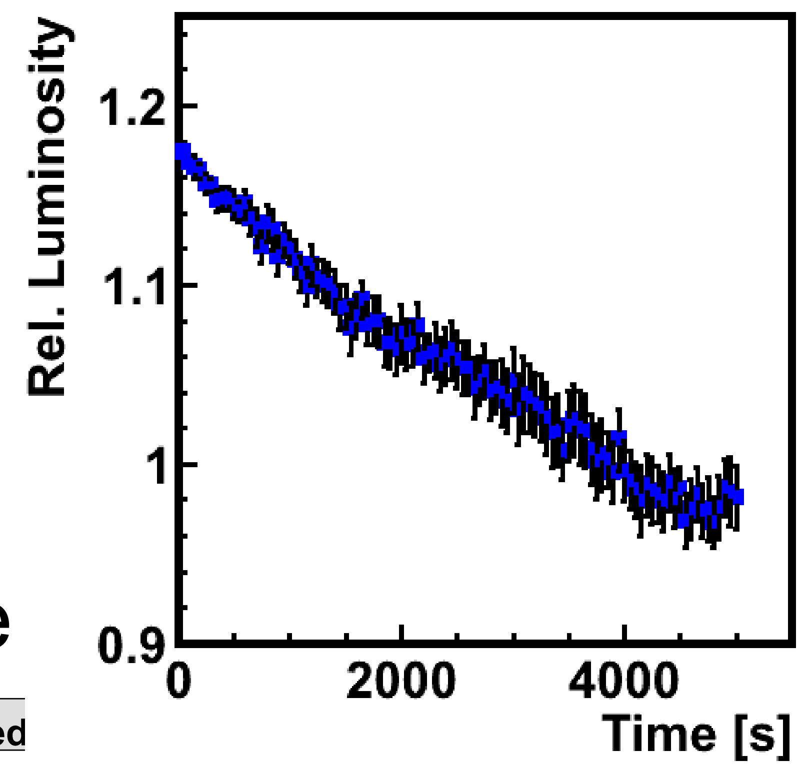


Long term

- Let's assume we have aligned/tuned CLIC to reach the nominal machine
- How to stay maintain luminosity for long time scales? (> 1 hour)
  - The beamline is a living object
- And how to simulate this?
  - simulation: 2 * 1 train ML+BDS + collision: ~1 minute
  - 1 hour beamtime = 180.000 train collisions = 100 days simulation time

ATL: ML + BDS

- Start with nominal beamlines (ML+BDS):
  - Apply 50s of ATL motion to the beam
  - Apply Beam Based Feedback for 80 iterations (and no dynamic imperfections), in reality 25.000 iterations
- Pessimistic case, but not possible to track each pulse
- After about half an hour: 5-10% lumi loss
- Lumi loss not (primarily) caused by emittance growth
- Degradation of the beam shape



FFS Knobs

- Last 5 Sextupoles of Final Focus (SF6, SF5, SD4, SF1, SD0)
  - Changing their x and y position changes the beam shape.
  - Two sets of orthogonal knobs
    - Orthogonal: “not necessary to retune”
    - 10 knobs, x-y separated, based on SVD, produced by E. Marin with MAPCLASS
    - 10 knobs, x-y mixed, based on SVD, not directly corresponding to traditional beam parameters, produced by A. Latina
  - Here A. Latina's knobs are used

Knobs Calculation

$$\Sigma = \begin{pmatrix} \sigma_{xx} & \sigma_{xx'} & \sigma_{xy} & \sigma_{xy'} & \sigma_{xz} & \sigma_{x\delta} \\ \sigma_{x'x} & \sigma_{x'^2} & \sigma_{x'y} & \sigma_{x'y'} & \sigma_{x'z} & \sigma_{x'\delta} \\ \sigma_{yx} & \sigma_{yx'} & \sigma_{y^2} & \sigma_{yy'} & \sigma_{yz} & \sigma_{y\delta} \\ \sigma_{y'x} & \sigma_{y'x'} & \sigma_{y'y} & \sigma_{y'^2} & \sigma_{y'z} & \sigma_{y'\delta} \\ \sigma_{zx} & \sigma_{zx'} & \sigma_{zy} & \sigma_{zy'} & \sigma_{z^2} & \sigma_{z\delta} \\ \sigma_{\delta x} & \sigma_{\delta x'} & \sigma_{\delta y} & \sigma_{\delta y'} & \sigma_{\delta z'} & \sigma_{\delta^2} \end{pmatrix}$$

$$Sigma = \frac{\Sigma}{\Sigma_0}$$

$$K = \left.\overbrace{\begin{pmatrix} \sigma_{xx} & \sigma_{xx'} & \sigma_{xy} & \sigma_{xy'} & \sigma_{xz} & \sigma_{x\delta} & \cdots & \sigma_{\delta^2} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \sigma_{xx} & \sigma_{xx'} & \sigma_{xy} & \sigma_{xy'} & \sigma_{xz} & \sigma_{x\delta} & \cdots & \sigma_{\delta^2} \end{pmatrix}}^{\text{21 columns}}\right\}\text{10 rows}$$

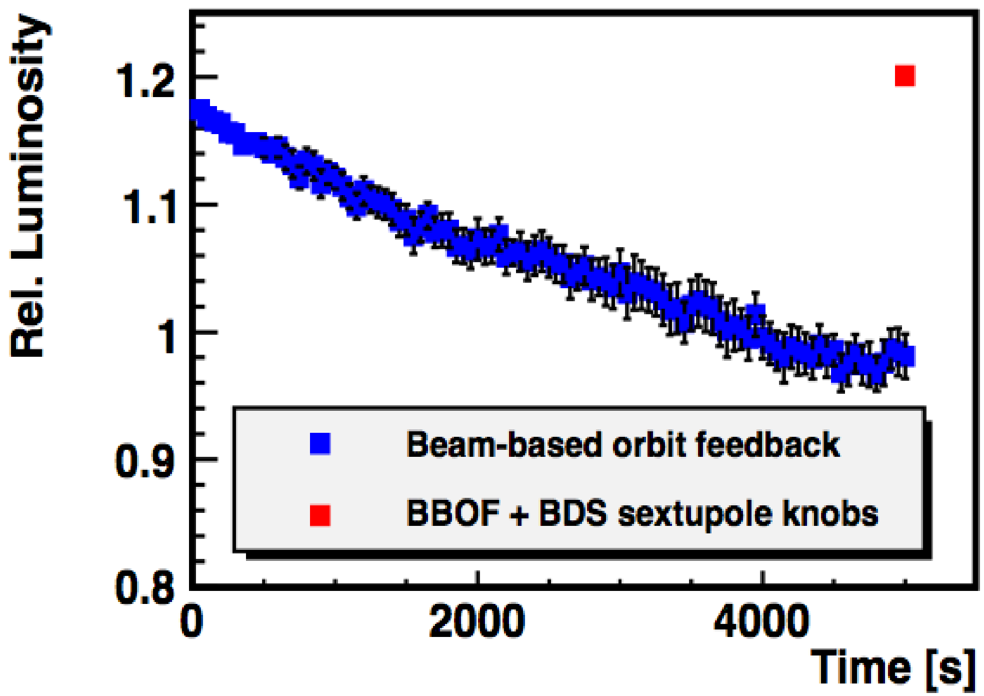
$$knob = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \end{pmatrix}$$

$$U^T\,S\,V = \mathrm{svd}(Sigma)$$

- K has 21 columns (from *Sigma*) and 10 rows (each degree of freedom, (x,y) position x 5 sextupoles)
- The knobs are the columns of the matrix V

ATL + FFS Knobs

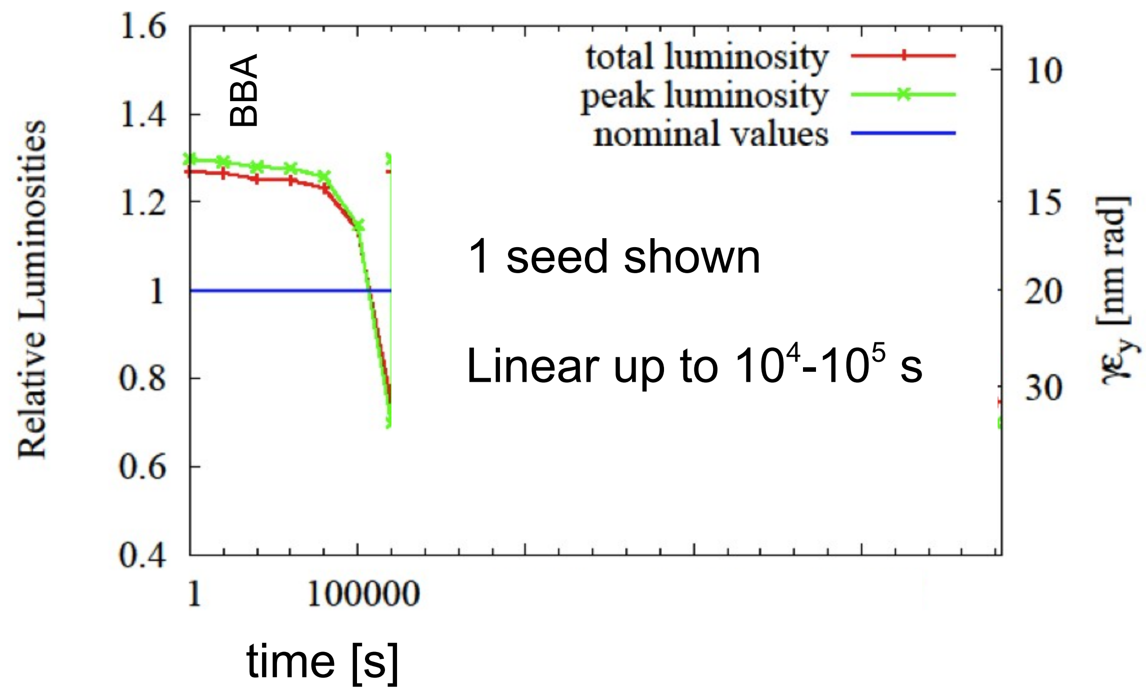
- Apply FFS Knobs after ATL simulation



- B. Dalena CLIC meeting:
  - Knob tuning O(250) luminosity measurements
  - < 1s for each luminosity measurement:
    see B. Dalena's presentation in this session

ATL simulation: Main Linac

- Study done by B. Dalena
  1. Perfect BDS
  2. Static misalign. ML
  3. BBA
  4. ATL motion
  5. 1-1 correction
  6. IP correction



- After 10^5 s (=1 day) about 5-10% lumi loss
- Luminosity loss due to emittance growth

IPAC10 paper
Also studied in PAC09 paper

Conclusions / Outlook

- Ground motion simulations have been presented
  - Pulse to pulse simulations look to be in good shape
  - After about an hour additional BDS tuning to be performed
  - After about a day additional ML tuning to be performed
- In practice tuning-information would be gathered continuously
  - to be studied