Instrumentation and Controls ‘Global Group 2’ Summary

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Charge:

- identify requirements, interpret as needed and try to assess with respect to the state of the art.
  - ‘Agree’ on instrumentation requirements and techniques working with the area subsystem groups;
- develop control system requirements.

- This has been done before (TRC etc) but now:
  - have definition and quickening pace,
  - catching up to do
  - Need to provide strong 'feedback'.

- begin to summarize the systems and think about costs.

List of ‘Decision Needed’ items:

3 out of 41 ‘decisions’ involve GG2 (more to come)

- Tunnel electronics
  - To what degree is this cost effective?
- *Linac BPM’s* …
  - What sort of pickup?
  - Higher Order Mode ‘HOM’ (accelerator cavity) BPM’s
- (also: should there be linac diagnostic sections…)

Definitions:

- *Instrument*
  - a measuring device for determining the present value of a quantity under observation

- *Diagnostic*
  - the art of investigation of the cause or nature of a condition, situation, or problem

- Which best describes the role of beam monitors?
  - How to converge on requirements?

Cost

- 5 to 10% of total for various accelerator projects
  - 4% controls / 2% instrumentation in Monday's presentation
  - ~500 M$
  - Instrumentation costs usually dominated by beam position monitoring
- Because Controls & Instrumentation will be subject to *continuous* attention (read effort):
  - Best performance / cost is metric not total cost
- Pace of technology:
  - 'High Availability' standards: (Advanced Telecom Computing Architecture)
  - Since Snowmass 2001

Strategy of the sessions

- Two kinds of session:
  - integrated with WG:
    - Damping Ring and Beam Delivery
  - Dedicated GG2 sessions
    - Linac BPMs (5)
    - Laser-based profile monitors
    - Feedback
    - Controls

- Rather tenuous link to WG's → to be fixed next week?

Draft instrumentation table

Sections for:
Intensity
Position
Profile (x/y & z)
Special

~ 60% crude information available

Monitors for intensity and transverse beam position

ILC component	Required resolution / precision	Required risetime	Technology	units needed	Cost estimate/unit	Information from	Remarks	R &D requirements
Injector								
Damping ring	10 μm / 100 μm		Button ?			Tesla TDR		
Damping ring	1 μm / ?					Tesla TDR	For wiggler sections	
Linac	10 μm / 100 μm		Cavity ? re-entrant ?	736		M. Wendt GG2 talk		
Linac	1%			4			Precision intensity	
Beam delivery	5 μm / 100 μm					Tesla TDR		
Beam delivery	1 μm / 100 μm					Tesla TDR	feedback	
Beam delivery							spectrometer 1 plane	

Beam Position Monitoring

- Snowmass 2005 discussions so far:
  - Linac (quad ~few hundred, Cavity or HOM), Beam Delivery Energy spectrometer
- Key issues:
  - Resolution
  - Stability (calibration)
  - x ←→ y coupling
  - Monopole suppression
  - Dynamic range (intensity and position)
  - Multi-bunch behaviour
  - Cleaning (for cryomodule application)
  - Impedance / Aperture --
  - Gain stability (esp. for rotated pickups)
  - System performance

Beam Position Monitoring

- LINAC example:
  1. Requirement from WG1 (LET) → 1 um resolution
     - Based on modeled tuning
  2. Requirement from GG2 → σ_x/3 , σ_y/3 (300 nm at the end of the linac)
     - Based on use of BPM as a diagnostic to identify sources of instability and as a predictor of collision overlap etc
     - Critical SLC experience with the use of beam monitors to 'predict' luminosity

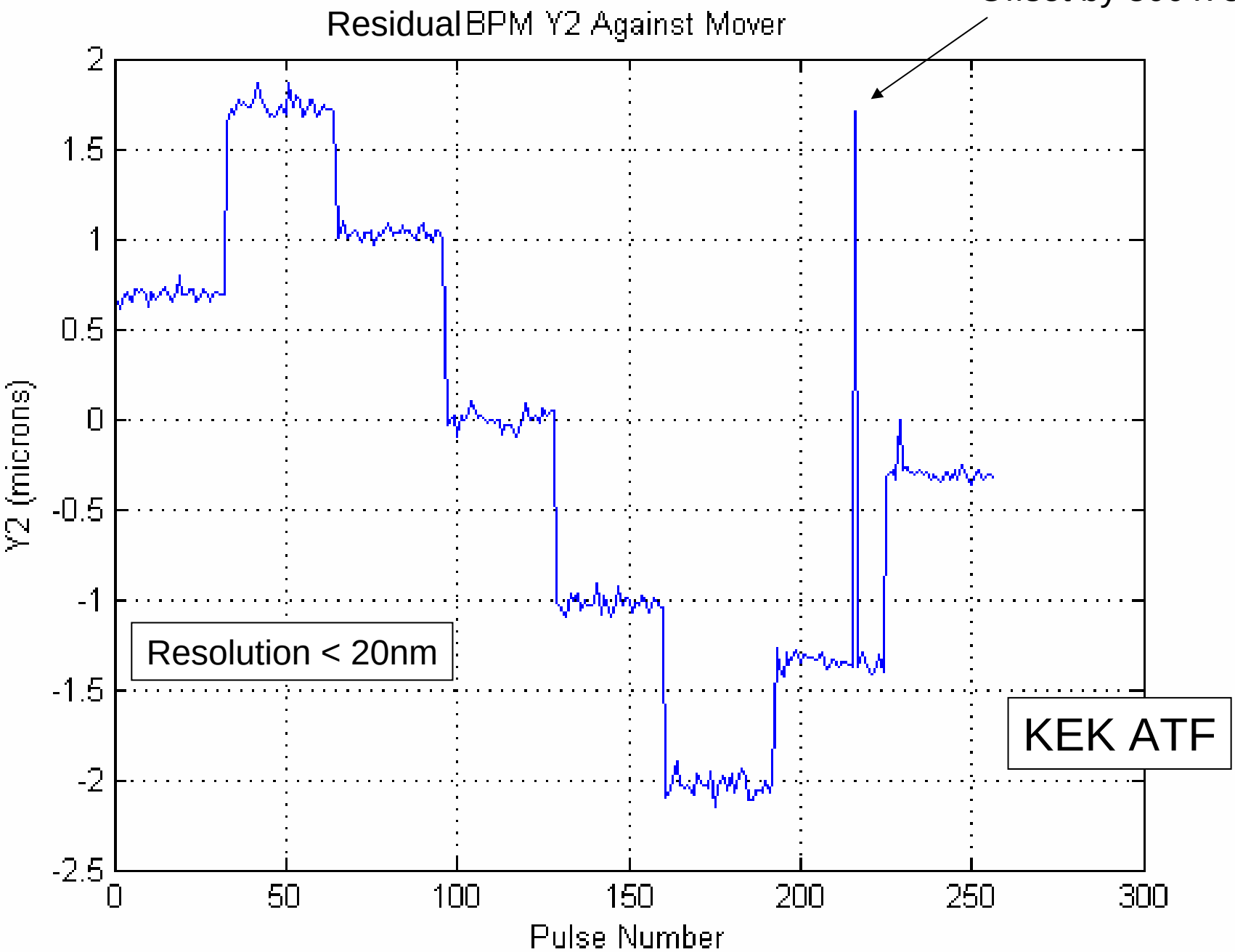
- *"Must be able to measure position with resolution less than beam size"*
- *GG2 recommendation: Require 300 nm resolution*

Beam Position Monitoring - Pickup Technology

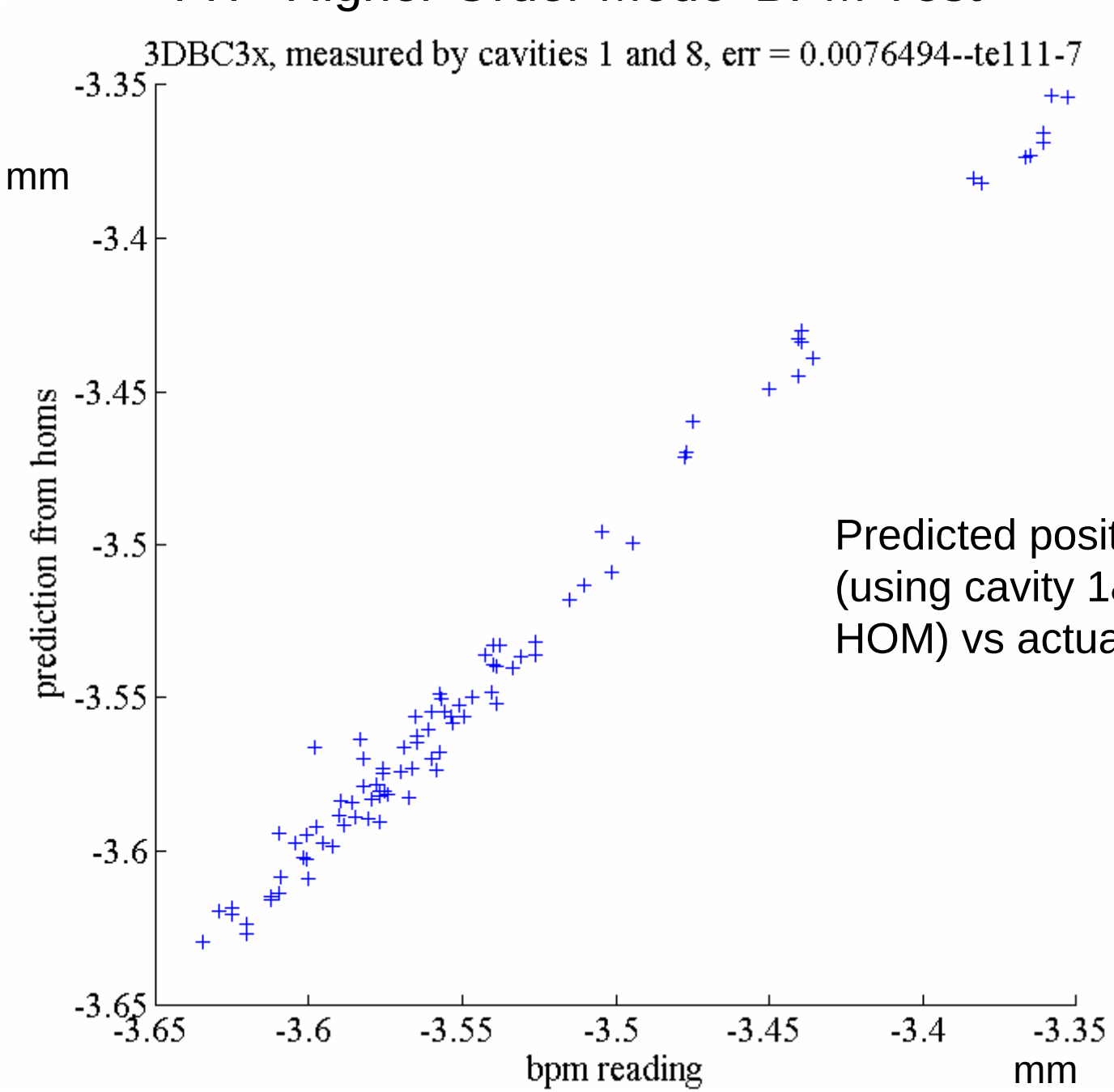
- Cavity BPM's have demonstrated best resolution – by far
  - 15 nm single bunch (6e9) or 2e-6 *r* for C-band ;
  - This result is understood; better can be done
- Re-entrant cavities – tests underway
  - < 1 um, short response decay
- Striplines / buttons – worldwide experience
  - ~ 1 um for 25 mm diameter
  - Calibration: 'difference of large signals'
- SCRF Cavity - HOM's – 1700 MHz dipole
  - 3 um resolution at TTF

- BCD → Cavities for LET (BC to BD), buttons for DR

ATF Cavity BPM test: Move BPM in 1 um Steps



TTF ‘Higher Order Mode’ BPM Test



Predicted position (using cavity 1&8 HOM) vs actual

BPM RD plan:

- Is this a ‘done deal’?
- ***No***
  - Cavity BPM system tests → *ATF2* 25 each with 100 nm expected
    - All modern (large) machines use buttons/striplines
    - Performance budget understood for large scale systems
      - (a common problem is validation of BPM readings…PEPII, TeV)
  - Quad/slotted cavity cold test (*SLAC-ESA*)
  - HOM tests (*TTF*)
  - Re-entrant cavity tests (*TTF/Saclay*)
  - Cleaning – follows Nb progress…
- High resolution BPM’s useful for testing mechanical/electrical subsystems (ATF2)

Beam Profile Monitoring

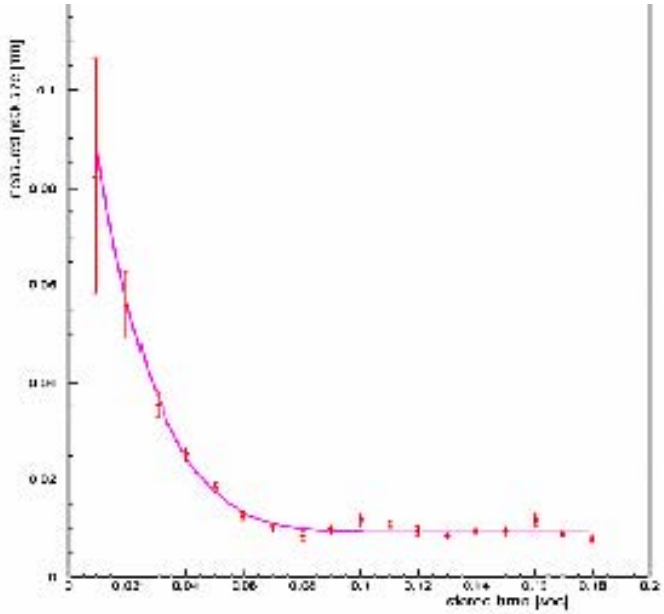
- Laser-based monitors for all ‘damped, full current’ bunch measurements
  - Secondary, traditional, devices used for tune-up.
- Complex set of issues including
  - Beamline integration (e.g. How to extract compton scattered beam)
  - Range of performance parameters
  - Laser physics … storage cavity, standard Q-switched, mode locked
  - F# 1 optics
- Active RD by UK, KEK, DESY, SLAC groups…

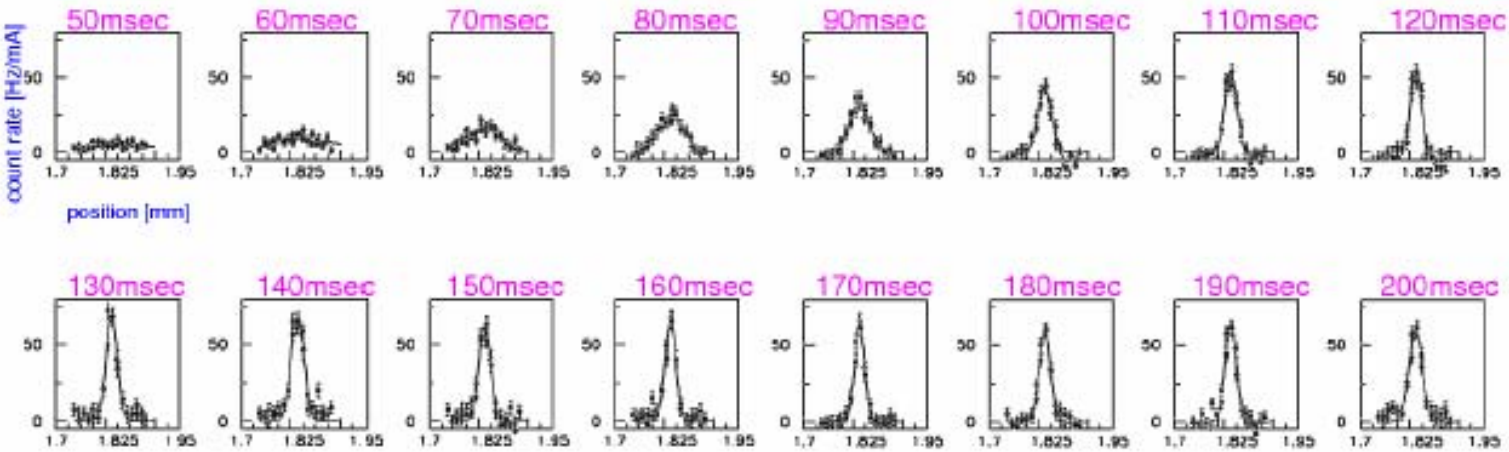
- Bunch length monitors based on FEL RD (deflecting ‘crab’ structures, optical techniques)

Measurement of the emittance damping

in the ATF damping ring using CW laserwire to measure ~5 um beams

- Repeat beam injection to the DR.
- Separately count up the signal according to the time after the injection.





Yosuke Honda

Controls

- Development of BCD strategy:
  - List ‘general’ requirements
  - Understand ‘parameterization’
  - Special requirements:
    - Remote access (international participation)
    - Machine protection
    - High Availability – contribution from APS,…
      - Using telecom industry standard
      - Development of a diagnostic layer to warn of pending failure
      - Redundancy strategy for electronic/power sub-systems
- ‘Cost-able’ in 2006
- Focus RD effort

Role of Feedback

- TDR reliance on IP deflection may have been too much (?)
  - BPMs must be able to predict effectiveness → bunch to bunch measurements with sub-sigma resolution
  - *IP deflection feedback will not work with large bunch to bunch variations ('large' relative to beam size)*
- Integrated Simulations – Linda Hendrickson show significant effects – not compensated by steering feedback
  - (SLC experience --- feedback never seems to work as well as in simulation)
  - Also seen in fast feedback tests (FONT-Burrows)

Beamsize growth effects, with feedback (Linda Hendrickson)

Single-beam studies of beamsize growth, with 5-hz feedback in LINAC and BDS.

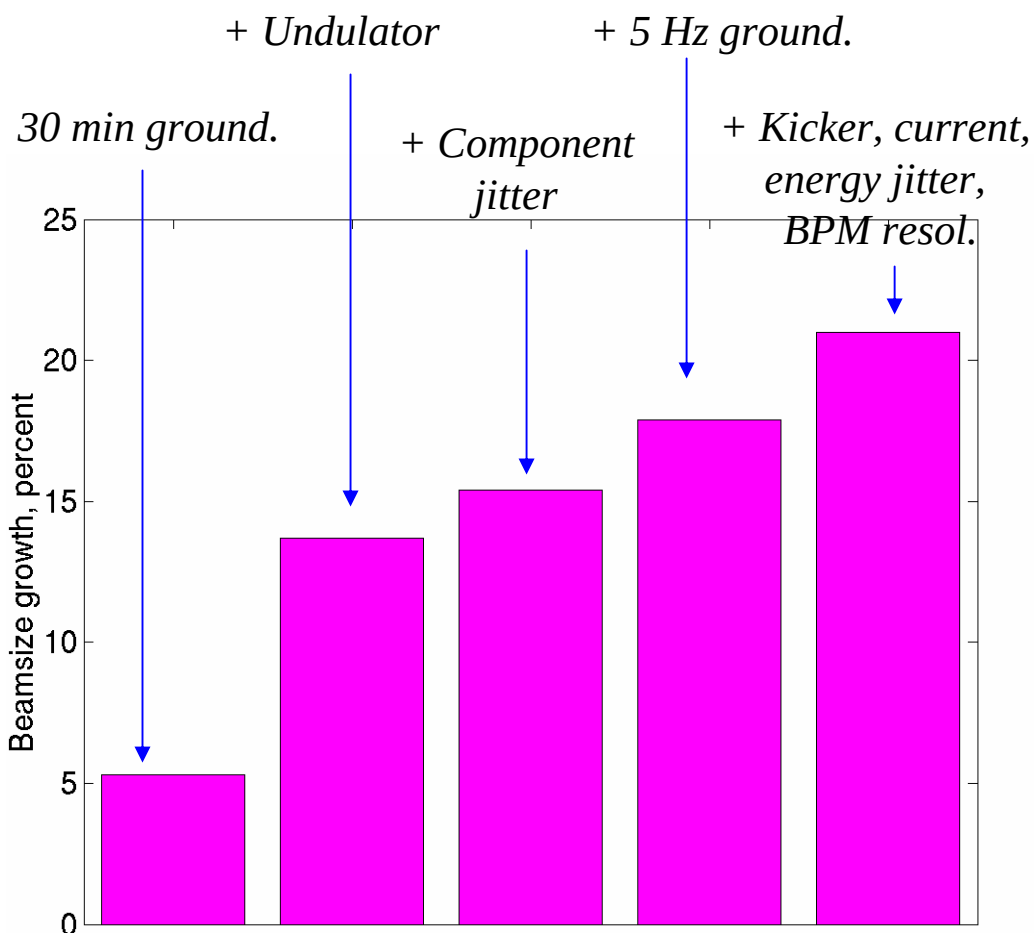
Perfect initially, add 30 minutes "KEK" ground motion", let feedback converge
-> 5% beamsize growth (380% without feedback).

Increase energy spread for undulator (.15% end of linac; this effect needs more study!)
-> 14%.

Add component jitter (25 nm BDS, 50 nm linac) -> 15%.

Add 5-Hz "KEK" ground motion -> 18%.

Add kicker jitter (.1 sigma), current jitter (5%), energy (.5% uncorrelated amplitude on each klys, 2 degrees uncorrelated phase on each klys, 0.5 degrees correlated phase on all klystrons, BPM resolution .1 um. -> 21%



Conclusions and Recommendations - Instrumentation

- Draft table (with ~1 iteration) → next week
  - Requirements based on use of instrumentation for *DIAGNOSTIC and Beam Tuning* purposes
  - Anticipate real difficulties with:
    - Beam Delivery BPM/profile monitors
    - Beam phase monitors (0.03 degrees → 65 fs)
    - Instrumentation integration
    - Feedback integration

Instrumentation RD & role of international collaboration

- KEK ATF will remain the only ‘small beam’ test facility for some time
- Instrumentation RD is well suited for University (i.e. small and / or independent) groups and students
  - Easy to do something interesting → from start to finish
- Lunch seminar next Thursday
- Revitalization of the 2002 RD list