Summary of working group on

# Main and Drive Beam Dynamics

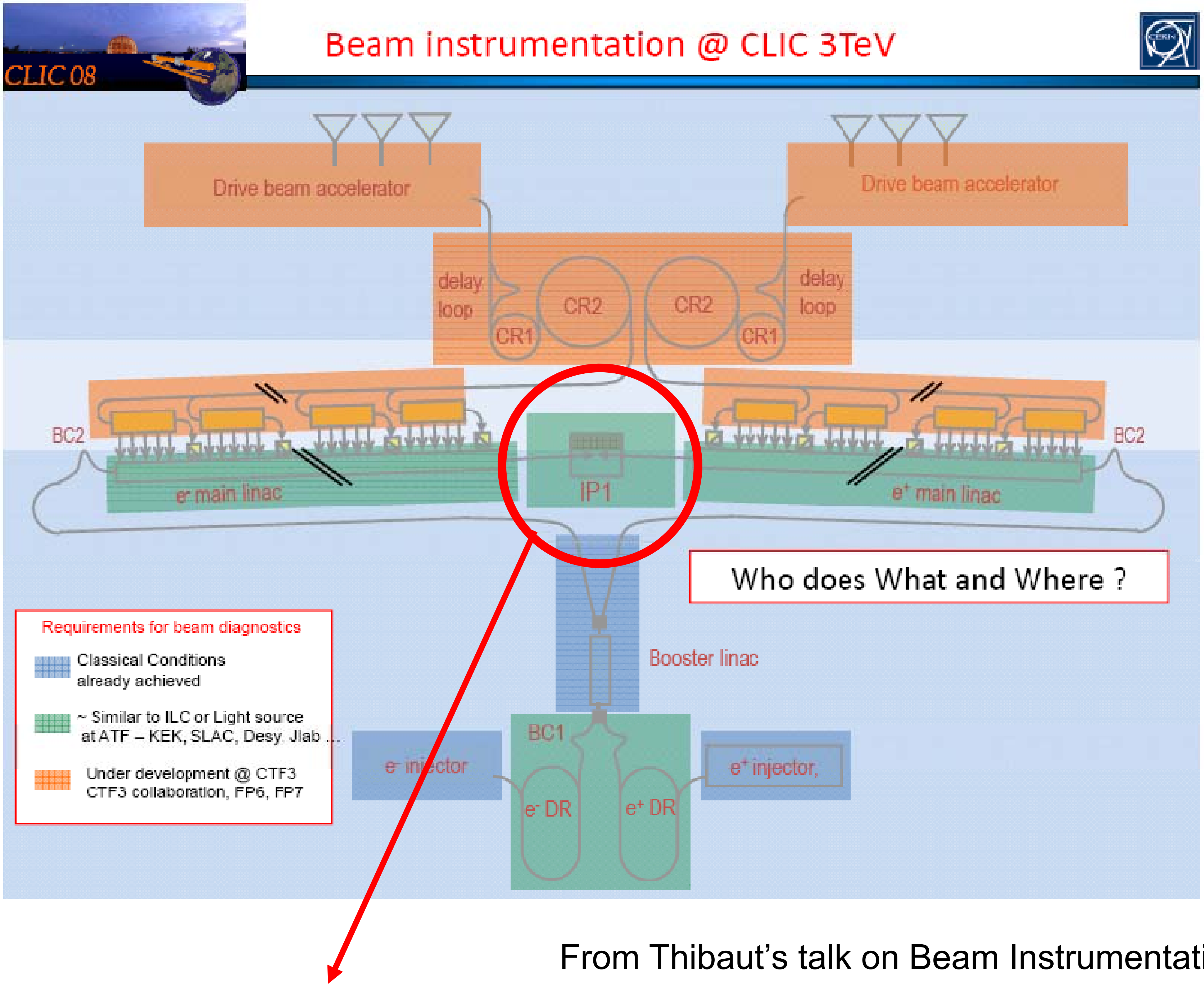
Conveners: C.Biscari, D. Schulte
INFN-LNF, CERN

CLIC08 workshop – 17-10-08

| day | Working groups | |
|---|---|---|
| 15 | BD + Instrumentation + rf structures | 8:30-10:00 |
| 15 | BD + Instrumentation | 10:00-12:30 |
| 15 | BD | 14:00-16:00 |
| 15 | BD + RF structures | 16:00-18:00 |
| | | |
| 16 | BD + Technical issues | 8:30-10:00 |
| 16 | BD | 10:00-12:30 |
| 16 | BD + Test Facilities + BDS and Machine detector interface | 14:00-16:00 |
| 16 | BD | 16:00-18:00 |

3 ‘alone’ sessions + 5 common sessions

# Beam instrumentation @ CLIC 3TeV




From Thibaut's talk on Beam Instrumentation

# IP parameters -> tolerances

Daniel Schult - CERN

Acceptable wakefield levels from beam dynamics studies have been used already in the structure design stage  (E.g. bookshelfing is a concern)

## Alignment procedure

based on

- Accurate pre-alignment of beam line components (O(10μm))
- Beam-based alignment using BPMs with good resolution (100nm) to measure bunches of different lengths
- Alignment of accelerating structure to the beam using wakemonitors (about 140000, 5um accuracy)

Tuning knobs using luminosity simulation/beam size measurement with resolution of 2 percent

Feedback of instrumentation experts important

# Luminosity stability

Quadrupole stabilisation (O(1nm) above 1Hz)
Feedback using BPMs resolving 10% of beam size (i.e. 50nm resolution)

Our concern is robustness of feedback

# Phase and current stability

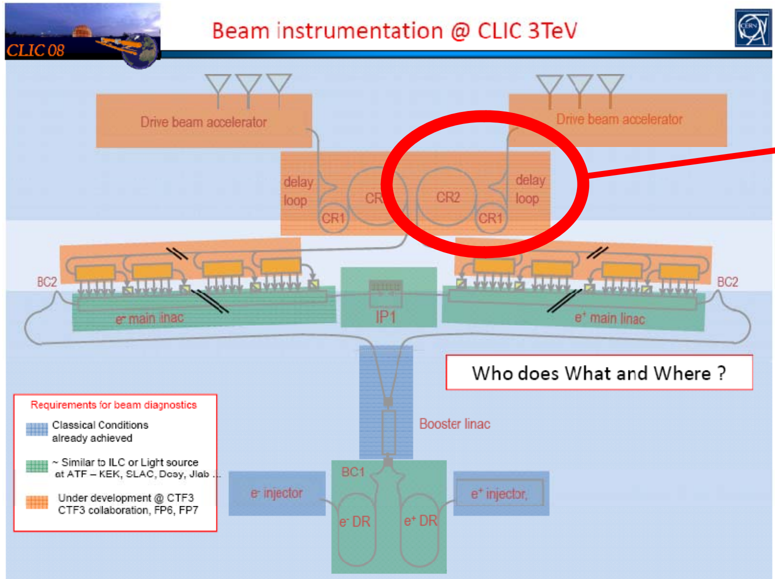
Drive beam amplitude and phase jitter lead to main beam energy jitter at BDS and consequently luminosity loss

Require about 0.1deg phase and 7*10-4 gradient stability

Need to be able to measure this

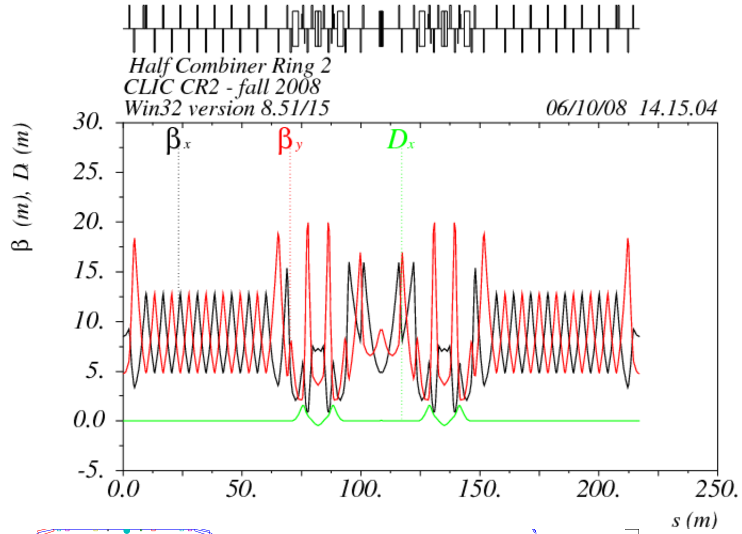
A number of effects can make drive beam jitter

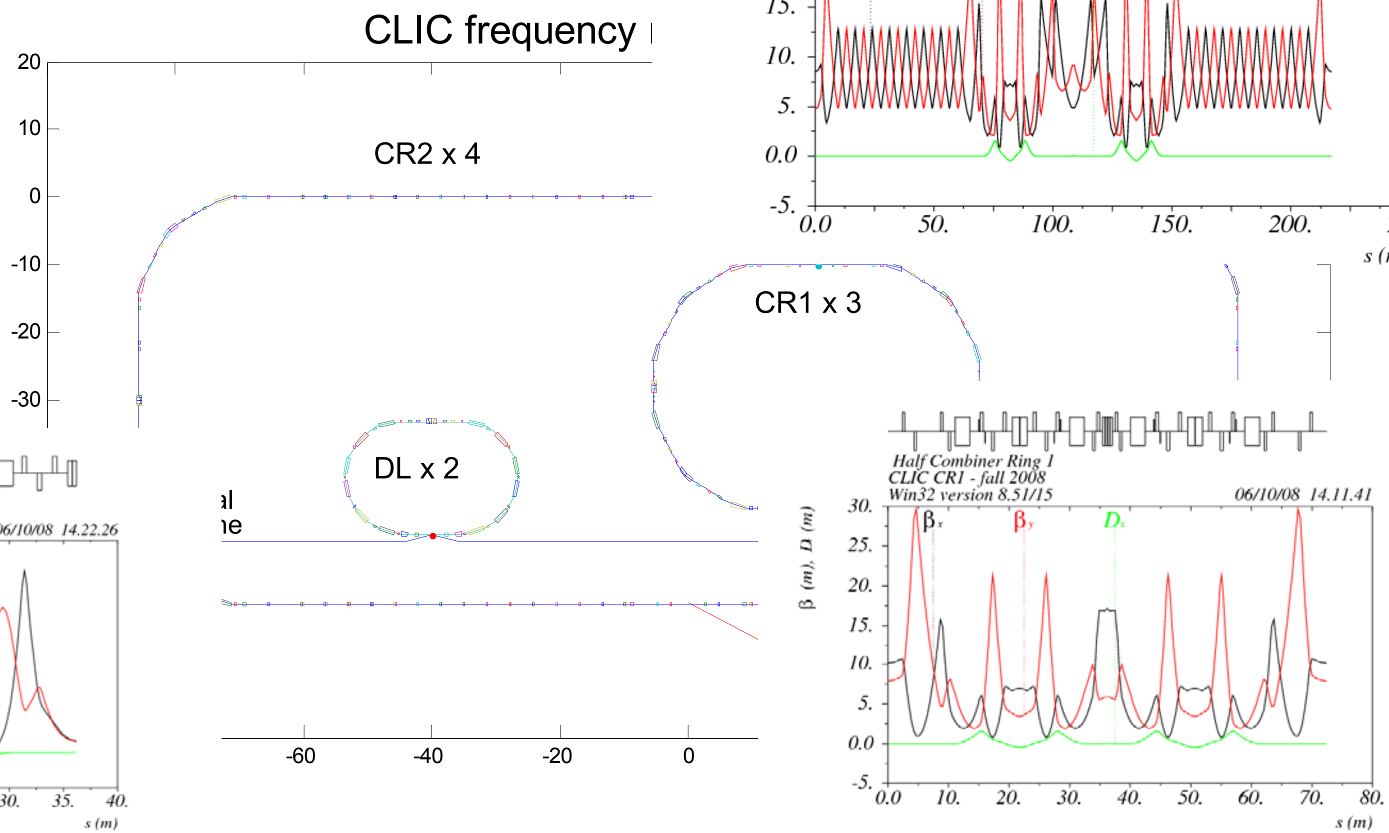
Need careful system design

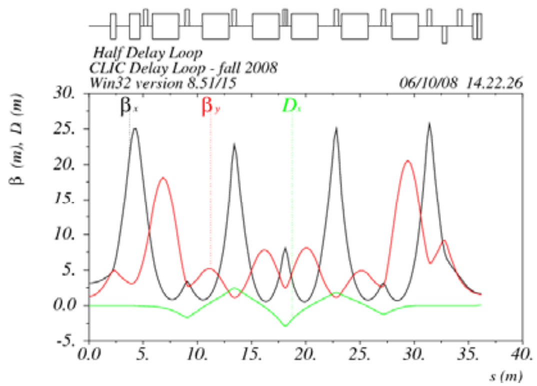



# DRIVE BEAM Frequency multiplication

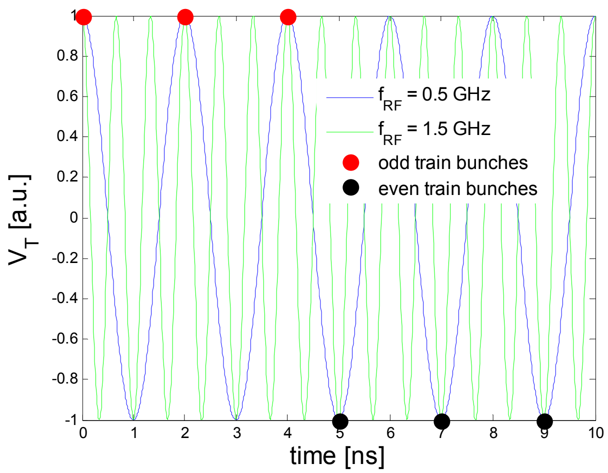
D.Alesini, C. Biscari, A. Ghigo, F. Marcellini
INFN-LNF contribution



# RF DEFLECTORS (0.5, 1., 3. GHz)




**Delay Loop:**

$f = f_{linac}/2\ (2n+1)$, n=0,1,2,…

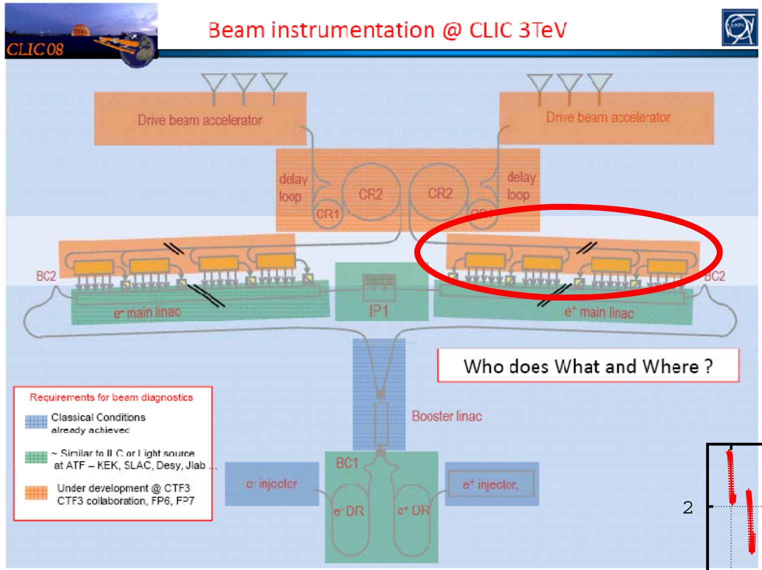
f = 0.5 GHz, 1.5 GHz, 2.5 GHz,…

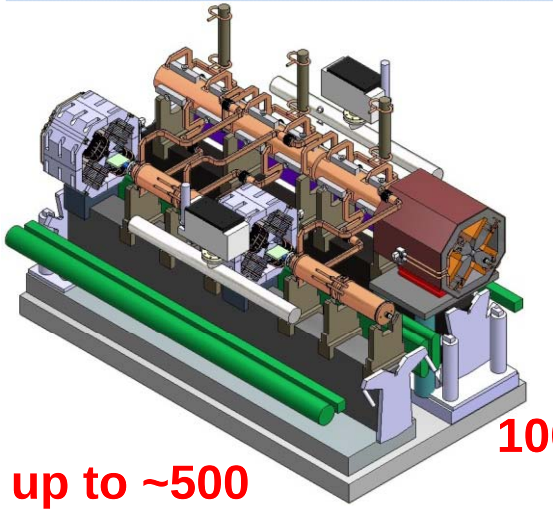
## RF deflectors possible parameters

| | freq [GHz] | | # of cells | cell radius [mm] | total lenght [mm] | | $Q_0$ [x 1000] | β | $Q_L$ [x 1000] | filling time [μs] | | single cell dissipated $PWR_{av}$ [kW] | Klystron $PWR_{peak}$ [MW] | $R_{shunt}$ [MΩ] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DL** | **1.5** | | **4** | **122** | **400** | | **29** | **1** | **14.5** | **3.1** | | **39** | **21** | **3.43** |
| | | | | | | | | | | | | | | |
| **CR1** | **2** | | **4** | **91** | **300** | | **25** | **1** | **12.5** | **2.0** | | **45** | **24** | **2.96** |
| **CR2** | **3** | | **6** | **61** | **300** | | **20** | **1** | **10** | **1.1** | | **24** | **20** | **3.6** |

# DECELERATOR LINAC

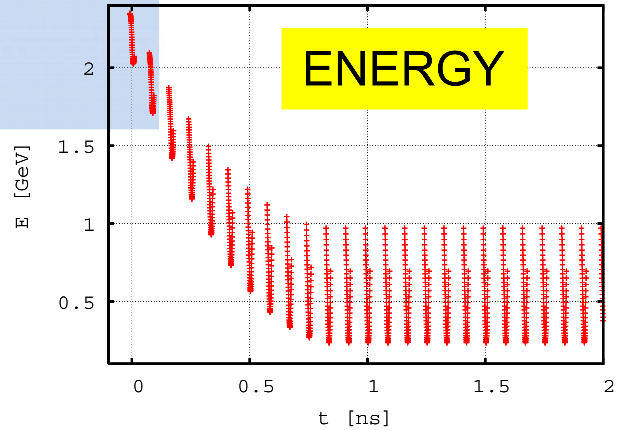
ERIK ADLI – CERN, Univers. OSLO

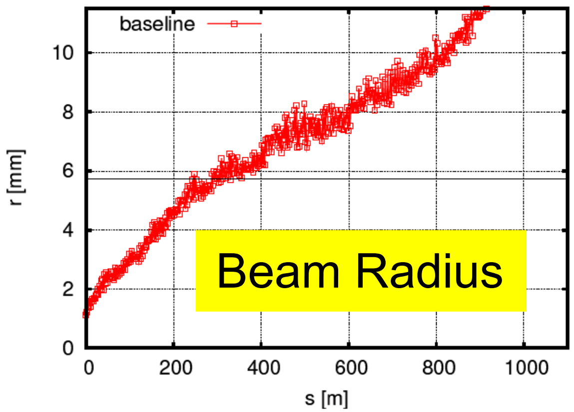


**up to ~500 modules / sector**

**100 A, 2.4GeV**




Longitudinal and transverse
Beam dynamics, including wakes

Alignment requirements (**rc < 1 mm** )

Seems feasible for all misalignment types, except quad offset

$\Rightarrow$ **Beam-Based Alignment of quads necessary**

# Input for Beam Diagnostics and Instrumentation

**BPM**

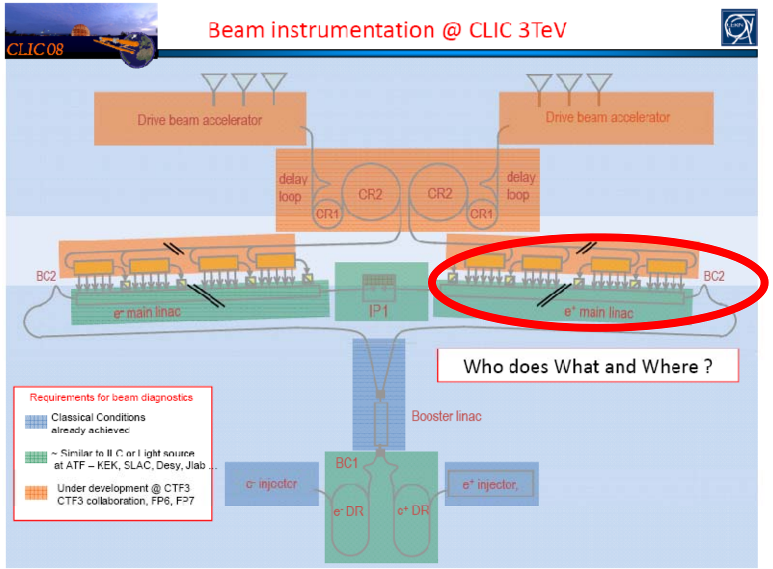
**BPM accuracy: ~ 20 um** (incl. static misalignment)
**BPM diff. meas: 2 um** ( <-> precision of ~ 1 um ?)
**Time resolution: ~ 20 ns** (fraction of tp)

Loss monitors
sensitivity: 80 pC on one detector
Spatial intervals of detectors:
order of some 10's of meter

Challenge: separate drive beam losses and main beam losses (main difference: E)

**Sector dump: energy measurement**

Transverse profile monitors
Phase space monitors

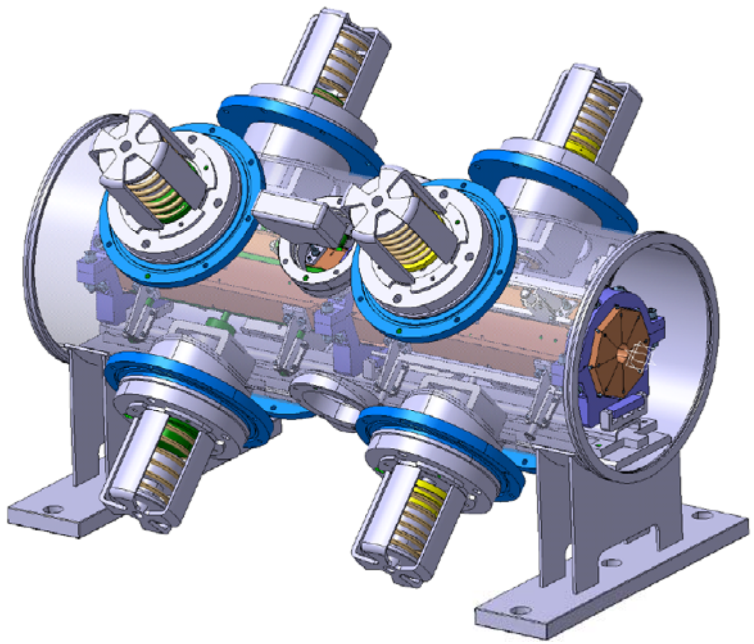



# PETS structures ON-OFF

Igor Syratchev & Alessandro Cappelletti
CERN

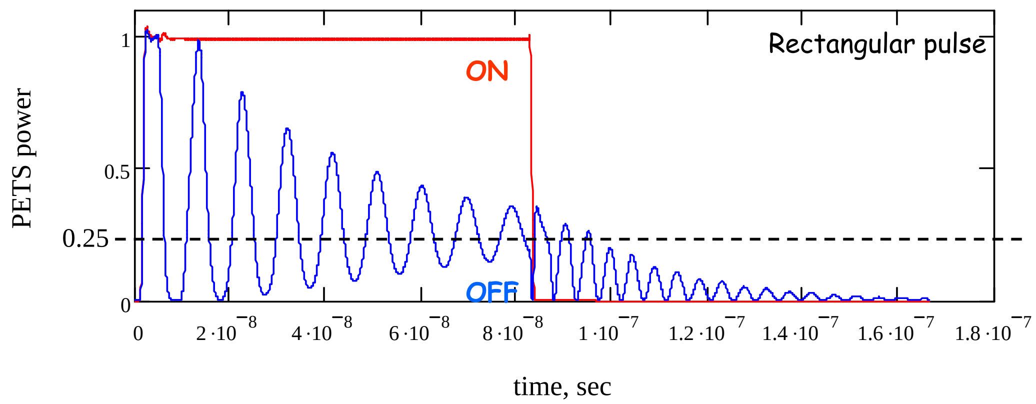
PETS breakdown during operation
Design breakdown trip rate
< 3x10-7/pulse/meter

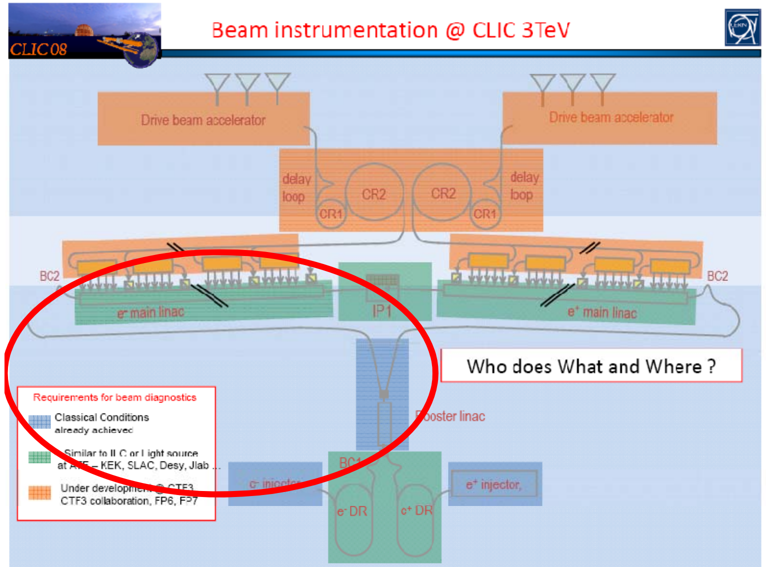
In order to maintain the operation efficiency we want to do the switching OFF very fast – between the pulses (20 msec).



Different options uder consideration
New ideas and collaborations welcome

RF pulse envelopes at the PETS output






# ILC – N. Solyak + A. Latina

*Transport Beam* from DR to ML

*Match Geometry/Optics*

*Collimate Halo*

*Rotate Spin*

*Compress Bunch (6mm→0.3mm)*

*Preserve Emittance (analysis of all sources of degradation)*

*- Budget for Vert.norm. emittance < 4nm*

*Protect Machine*

*3 Tune-up / MPS abort dumps*

*Additional constraints:*

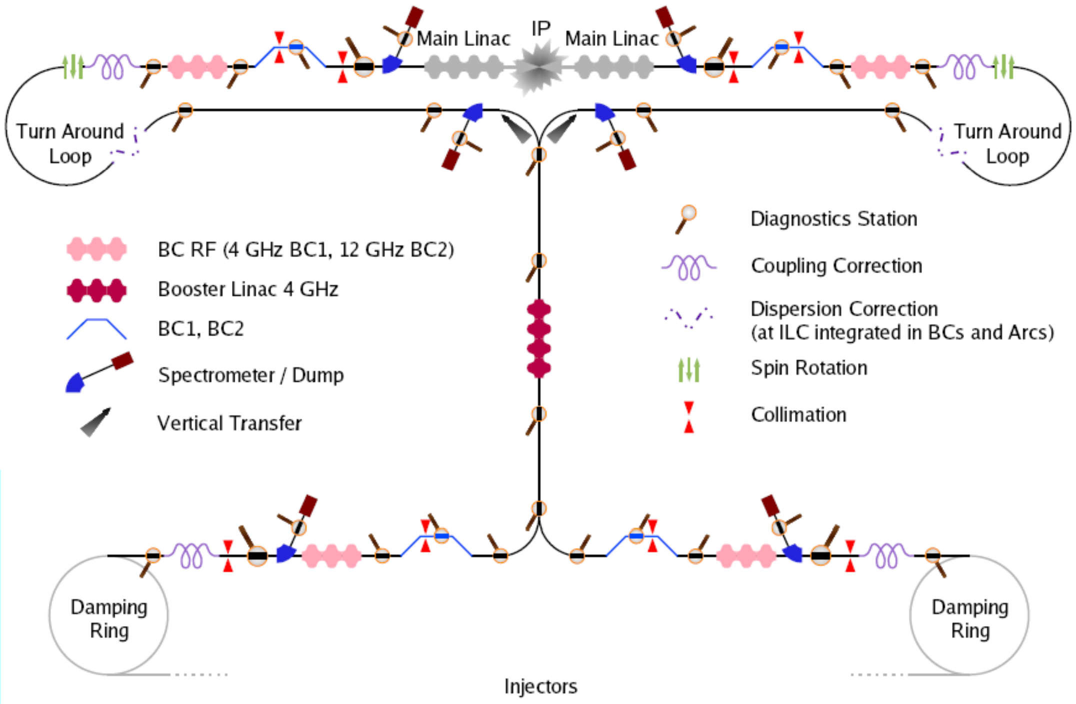
*Share the tunnel with e-/e+ injectors*

*Need to keep geometries synchronized*

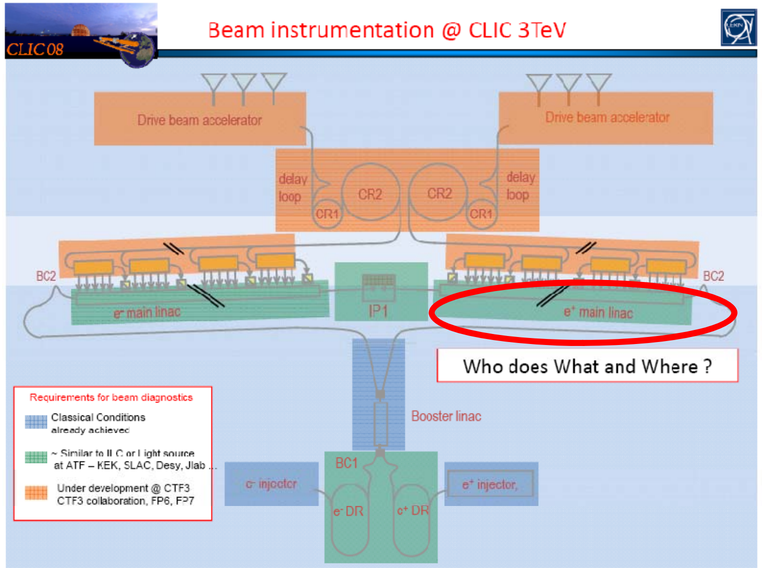
*Alignment procedure in progress*

+ cost breakdown

# Frank Stulle . RTML (Ring to Main Linac)




Different position of spin rotator
Bunch compressor
Wiggler against chicane



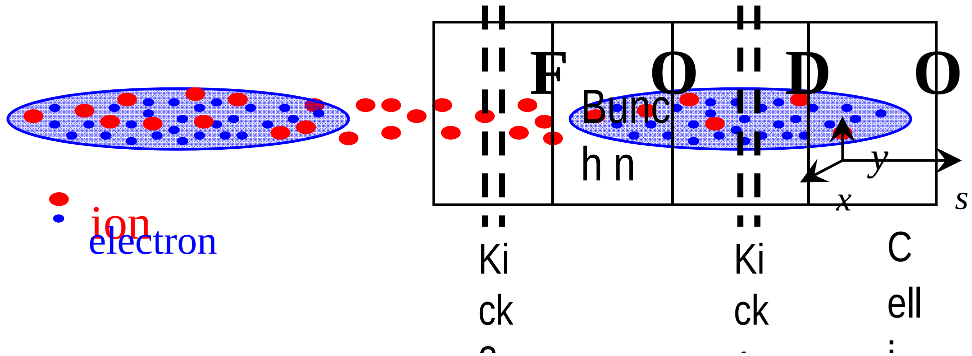

# MAIN LINAC Beam Dynamics Aspects

## Fast Ion Instability Studies

G. Rumolo and D. Schulte - CERN

Development of FASTION Code
Acceleration and damping of emittance included

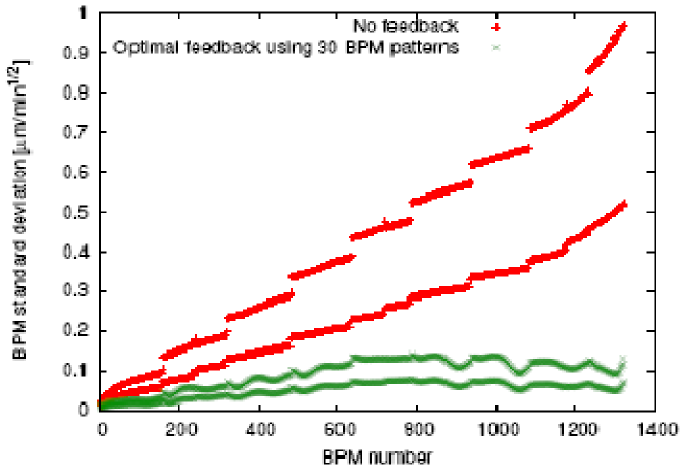
Trapping occurs at low energies
10 nTorr - Beam stable –
50nTorr - coherent oscillation + incoherent emittance growth




## Optimized Feedback systems

Peder Eliasson – Uppsala University

Taking into account ground motion
Response Matrix and SVD
By using a reduced # (30 instead of 1300) of monitors and correctors emittance growth under control



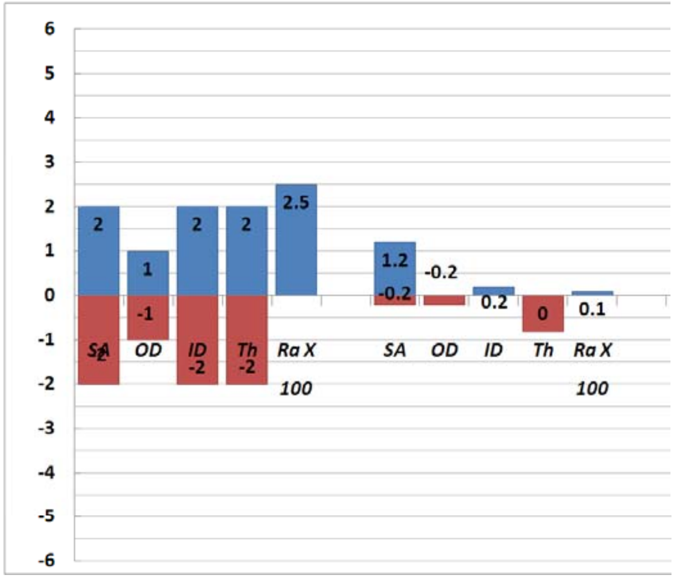
# Tolerances of the structures
# Riccardo Zennaro - CERN

4 kinds of tolerances:

- *Machining (Δx, Δy, Δz)*
- *Assembly (Δx, Δy, Δz)*
- *Alignment (Δx, Δy, Δz)*
- *Operation [Cooling] (ΔT (t) water in, ΔT (z))*

4 kinds of problems:

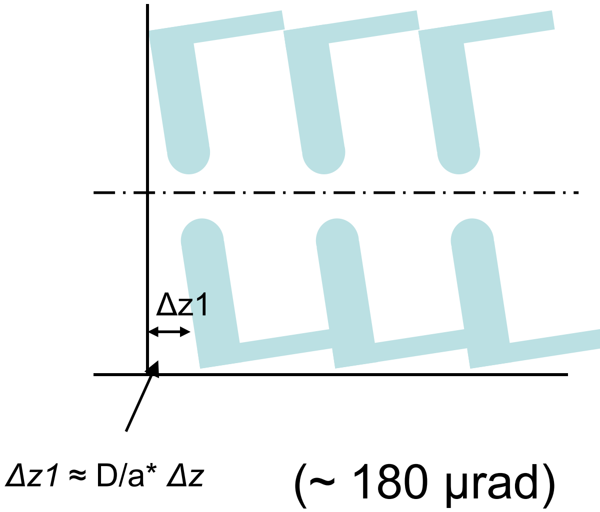
- *Beam induced transverse kick (wakefield)*
- *RF induced transverse kick*
- *RF matching (reflected power)*
- *Phase error*




RF mismatching, phasing errors and bookshelf are critical for structure tolerances

Bookshelf for structures in disks requires equivalent tolerances (~ 180 μrad)

Variation of the cooling water temperature could generate beam energy variations; feedback system ?



# Alignment and stabilization

## STRATEGY OF CLIC ALIGNMENT

Hélène MAINAUD DURANT Thomas TOUZE :

- Mechanical pre-alignment
  → Within +/- 0.1 mm (1σ)
- Implementation of active pre-alignment
  → Girders and quadrupoles within ± 10 μm (3σ)

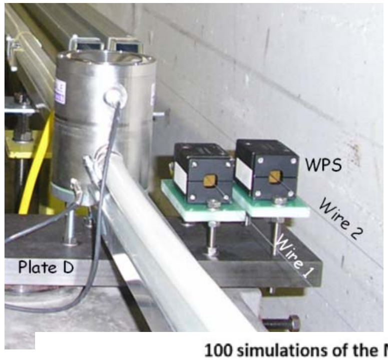
10 times smaller than LHC

- Implementation of beam based alignment
  → Active positioning to the micron level
- Implementation of beam based feedbacks
  → Stability to the nanometer level

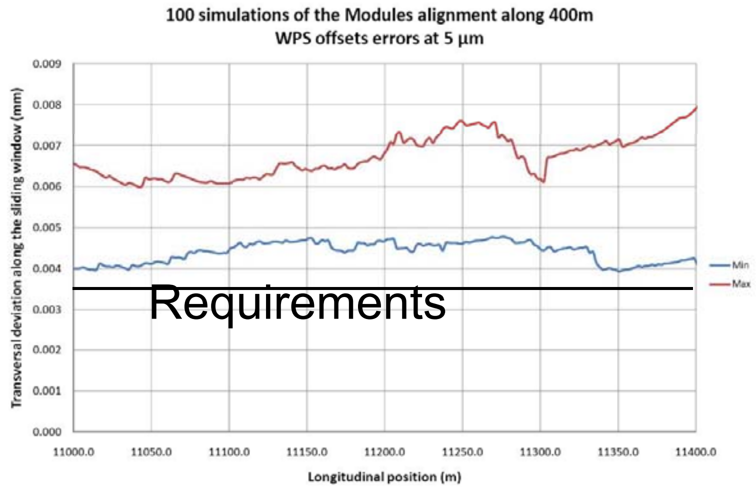
CTF2 experience (± 5 μm ) CLIC Simulations

Two references under study:
a stretched wire
a laser beam under vacuum
Using 'proximity' and 'propagati
networks along the 20 km

## TT1 TEST FACILITY

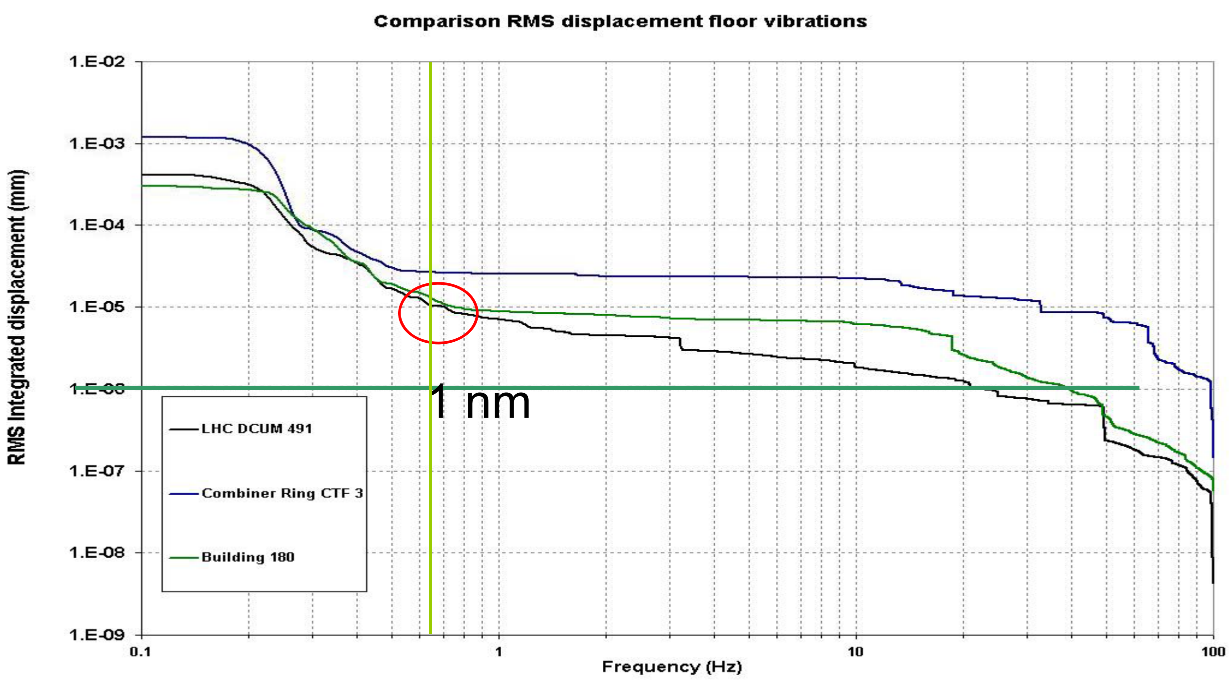



Test wires
Humidity effects
Sensors



# ground motion analysis at CERN

K.Artoos, M. Guinchard

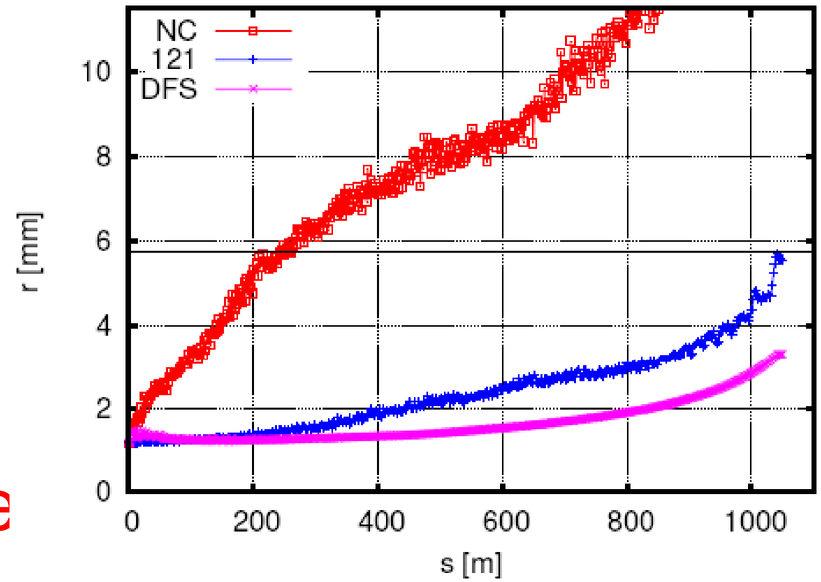



CLIC requirements
1-2 nm

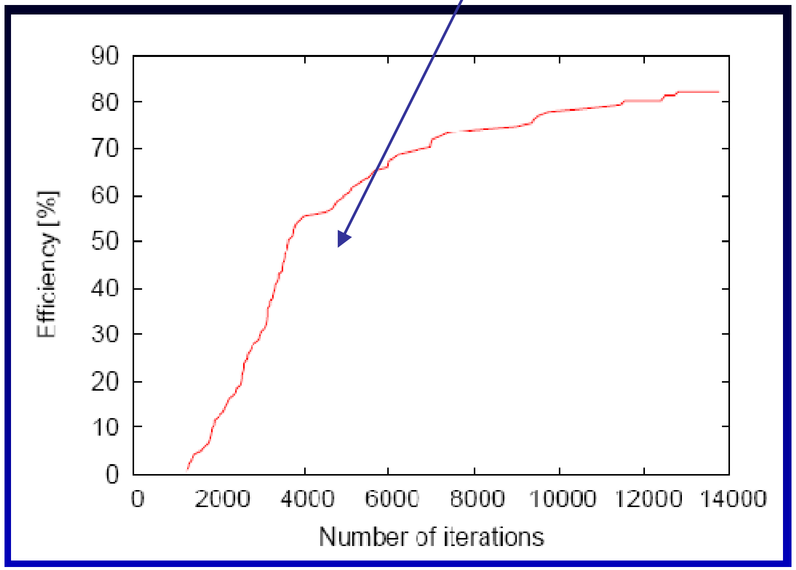
- Ground vibration level between 1 and 10 nm "average integrated RMS" at 1 Hz seems possible.

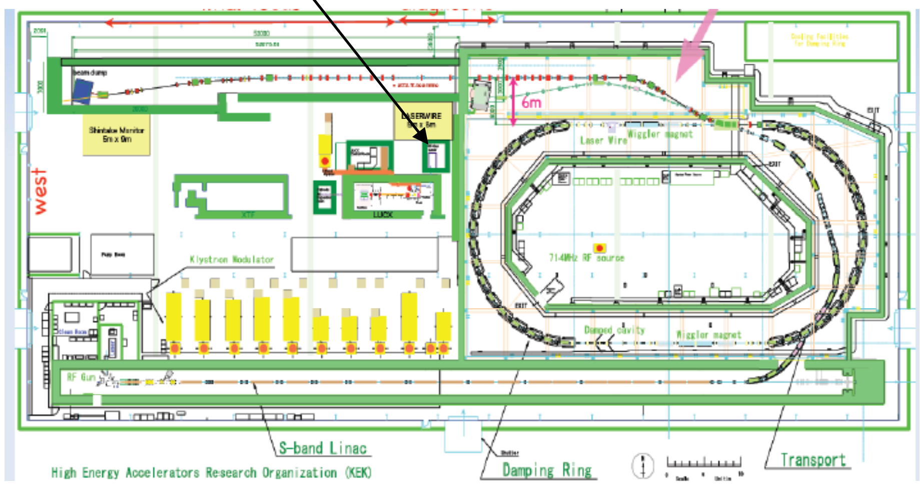
- It is possible to measure (averaged) nanometre displacements with seismometers but some characterisation of devices and analysis methods is still needed.

# Alignment studies



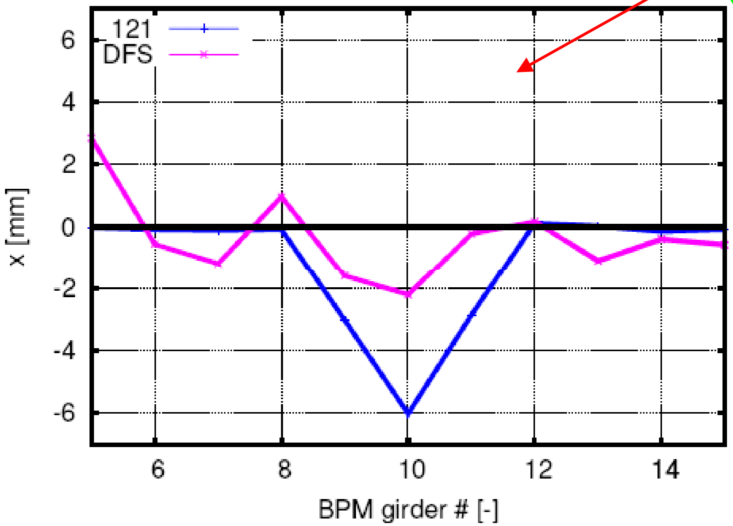

- Erik ADLI – BBA in the Dece
- Rogelio Tomas – DFS in ATF2 anc CLIC
- Glen White – BBA in ATF2 and ILC



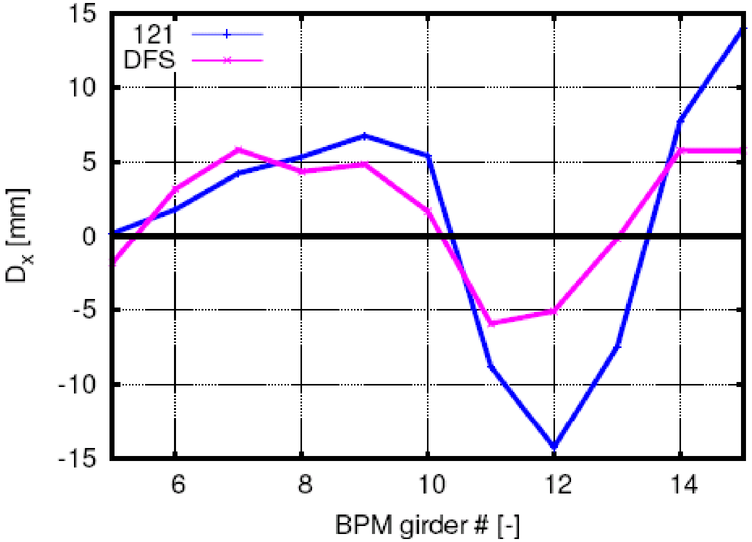



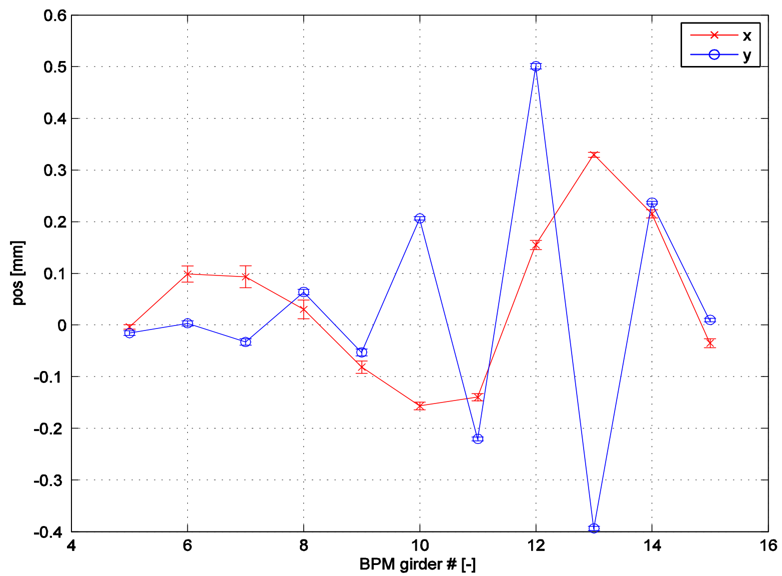
# CTF3

# Eric Adli – BBA and DFS in ctf3 linac




- **Model-based steering :**
- **Converges after ~4 iterations (compared to 2 for machine responses)**
  - **10-20 s per iteration**
- **Defect corrector in the vertical (G14): shows the global LS solution found by SVD (for 10 correctors and 11 BPMs)**

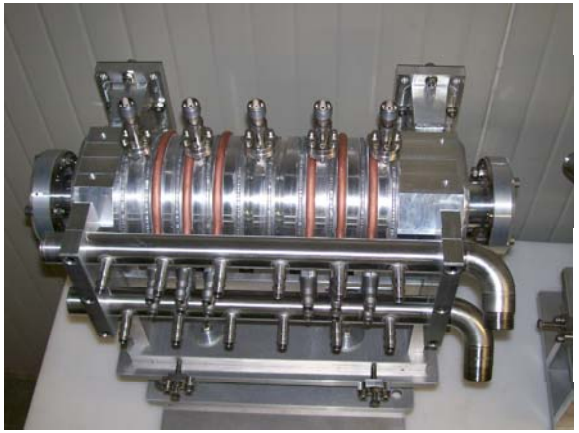


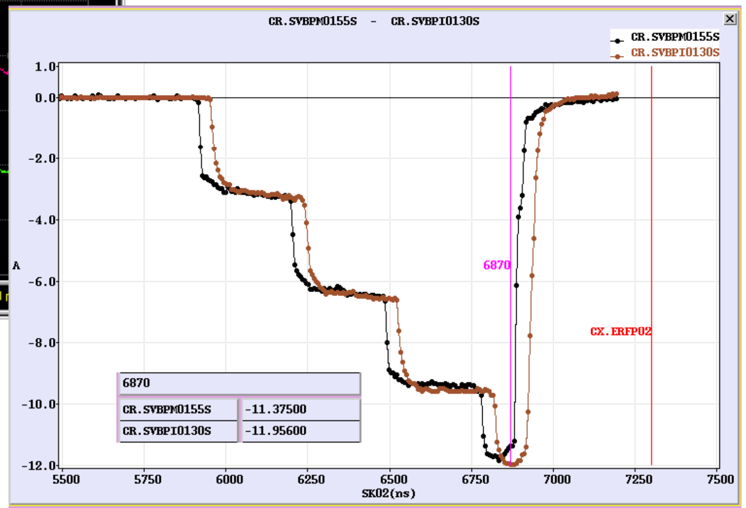



D.Alesini - LNF INFN

# Beam dynamics analysis of vertical instability and of its suppression in CTF3 combiner ring


Modification of rf deflector design by shifting and absorbing vertical mode frequency



# ILC-CLIC collaboration on BD issues

- Some discussion of common work programme
  - Problem on ILC side due to funding
  - Some transition on CLIC side with people leaving and arriving

- RTML discussions were very useful
  - ILC considers bunch compressor chicane like in CLIC
  - CLIC will investigate if ILC like wiggler based scheme is necessary to meet tolerances
  - Different position of spin rotator
  - Improvements of ILC RTML performance studies/beam based alignment still possible, work started for CLIC
  - Time varying stray fields in long transfer lines is critical problem for both projects, even if level is somewhat different
    - Common effort to get data/perform measurements
- Continuation of code benchmarking programme
  - Depends on resources

# conclusions

- List of missing studies – triggerd by Bernard Jeanneret

- Call for more collaborators
- Planned Periodic webex meetings in view of CDR preparation