Update on BC Alignment

A.Latina

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- **Case 1** : BC1 used to align BC2
- **Case 2** : alignment of the BC at once

⇒ Misalignment model: "COLD"

σ_{quad}	=	300 μm	quadrupole position error
$\sigma_{\text{quad roll}}$	=	300 μrad	quadrupole roll error
σ_{cav}	=	300 μm	cavity position error
$\sigma_{\text{cav angle}}$	=	300 μrad	cavity angle error
$\sigma_{\text{sbend angle}}$	=	300 μrad	sbend angle error
σ_{bpm}	=	300 μm	bpm position error

⇒ BPM resolution : $\sigma_{\text{bpm res}} = 1$ μm

⇒ Wakefields of the cavities are taken into account

CASE 1: BC1 used to align BC2

- A perfectly aligned BC1 is used to generate the test beams for DFS in BC2
  - an offset of few degrees in the RF phase of the BC1 accelerating structures, leads to an energy difference at the entrance of BC2
  - bunch energy as a function of the RF phase offset

$$\begin{aligned}
\Delta\phi = +2^o &\Rightarrow \text{99.5908\%}\ E_0 \\
\Delta\phi = +5^o &\Rightarrow \text{98.9878\%}\ E_0 \\
\Delta\phi = +10^o &\Rightarrow \text{98.0158\%}\ E_0
\end{aligned}$$

$$\begin{aligned}
\Delta\phi = -2^o &\Rightarrow \text{100.414\%}\ E_0 \\
\Delta\phi = -5^o &\Rightarrow \text{101.045\%}\ E_0 \\
\Delta\phi = -10^o &\Rightarrow \text{102.114\%}\ E_0
\end{aligned}$$

$\Rightarrow \phi_0 \ = \ 110$ deg

$\Rightarrow$ $\text{E}_0 \ \simeq \ 4.79$ GeV

CASE 1: alignment strategy

1. 1-to-1 correction
2. Dispersion Free Steering using two test beams, $\pm\Delta\phi$
3. Dispersion bumps optimizations

   - using two *artificial* dispersion bumps (entrance, exit)

   - using the skew quadrupoles in BC2

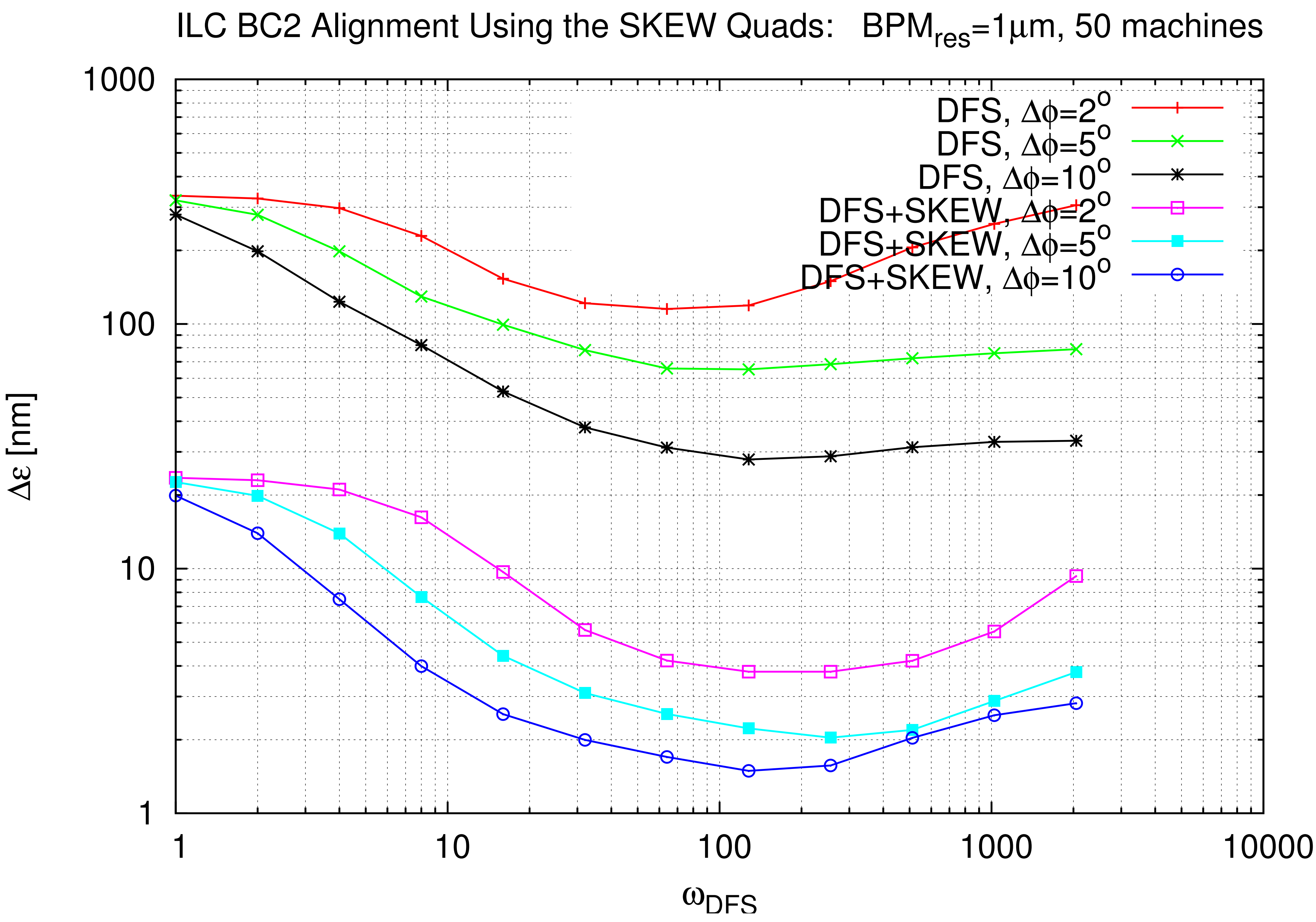
$\Rightarrow$ Final emittance growth after DFS and DISPERSION BUMPS (2x) optimization

$$\Delta\phi = \pm 10^o \;\Rightarrow\; \text{1.7 nm}$$

$\Rightarrow$ Final emittance growth after DFS and SKEW quad optimization

$$\begin{aligned} \Delta\phi &= \pm 2^o \;\Rightarrow\; \text{3.7 nm} \\ \Delta\phi &= \pm 5^o \;\Rightarrow\; \text{2.0 nm} \\ \Delta\phi &= \pm 10^o \;\Rightarrow\; \text{1.5 nm} \end{aligned}$$

All results are average of 50 machines



ILC BC2 Alignment Using the SKEW Quads: BPM$_{res}$=1μm, 50 machines
DFS, Δφ=2°
DFS, Δφ=5°
DFS, Δφ=10°
DFS+SKEW, Δφ=2°
DFS+SKEW, Δφ=5°
DFS+SKEW, Δφ=10°
Δε [nm]
ω$_{DFS}$
1000
100
10
1
1
10
100
1000
10000

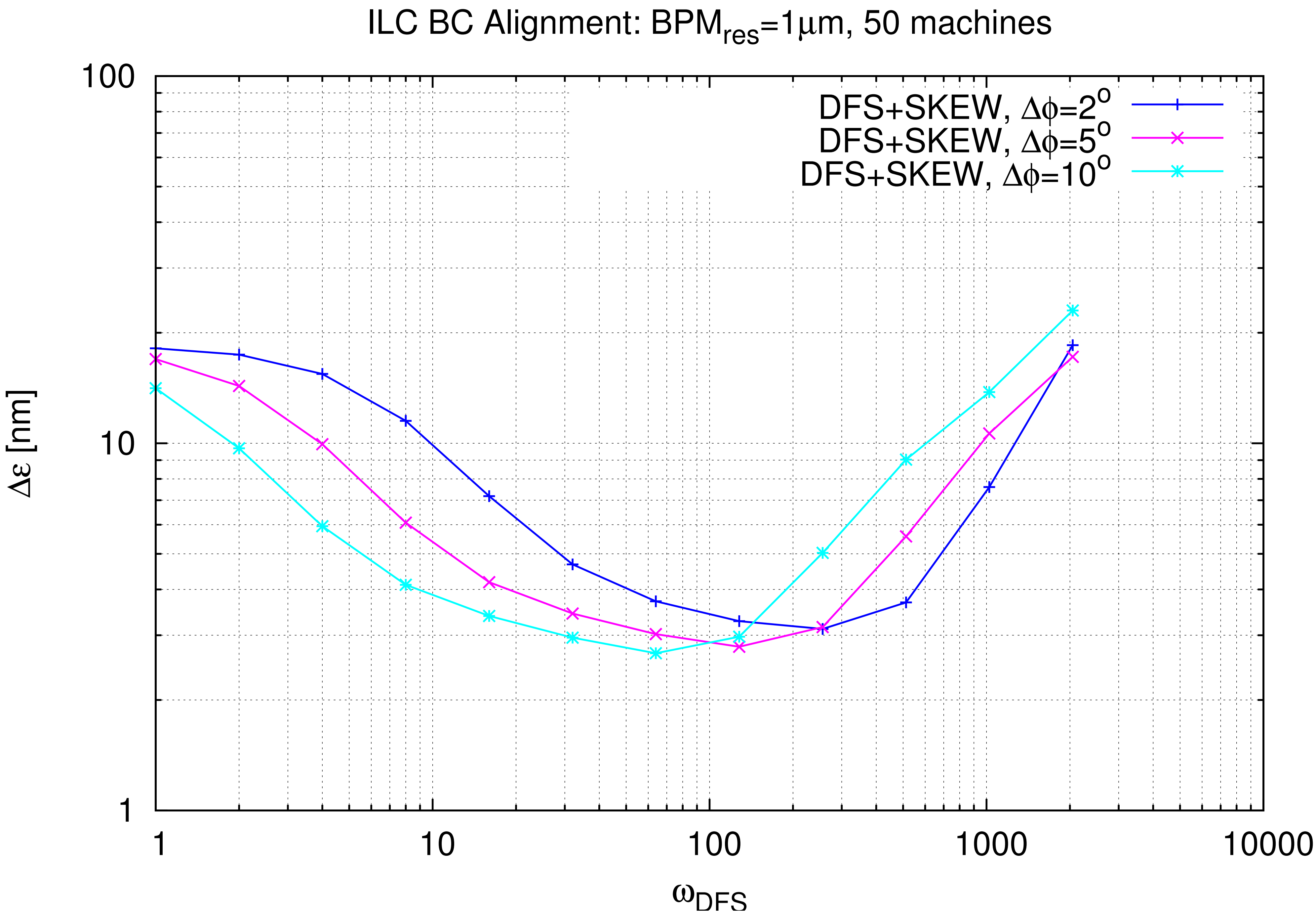
CASE 2: alignment of BC1 and BC2 at once

- the BC is aligned at once : the phase offset is applied to all cavities
- ...using DFS and SKEW quad optimization
  - the RF phase of all accelerating structures is offset by few degrees
    - $\Rightarrow$ thus the bunches gain different acceleration $\Rightarrow$ this can be exploited by DFS
    - $\Rightarrow$ the energy difference grows along the BC (efficacy of DFS grows along the lattice)
  - all 4 pairs of SKEW quadrupoles are used for dispersion reduction

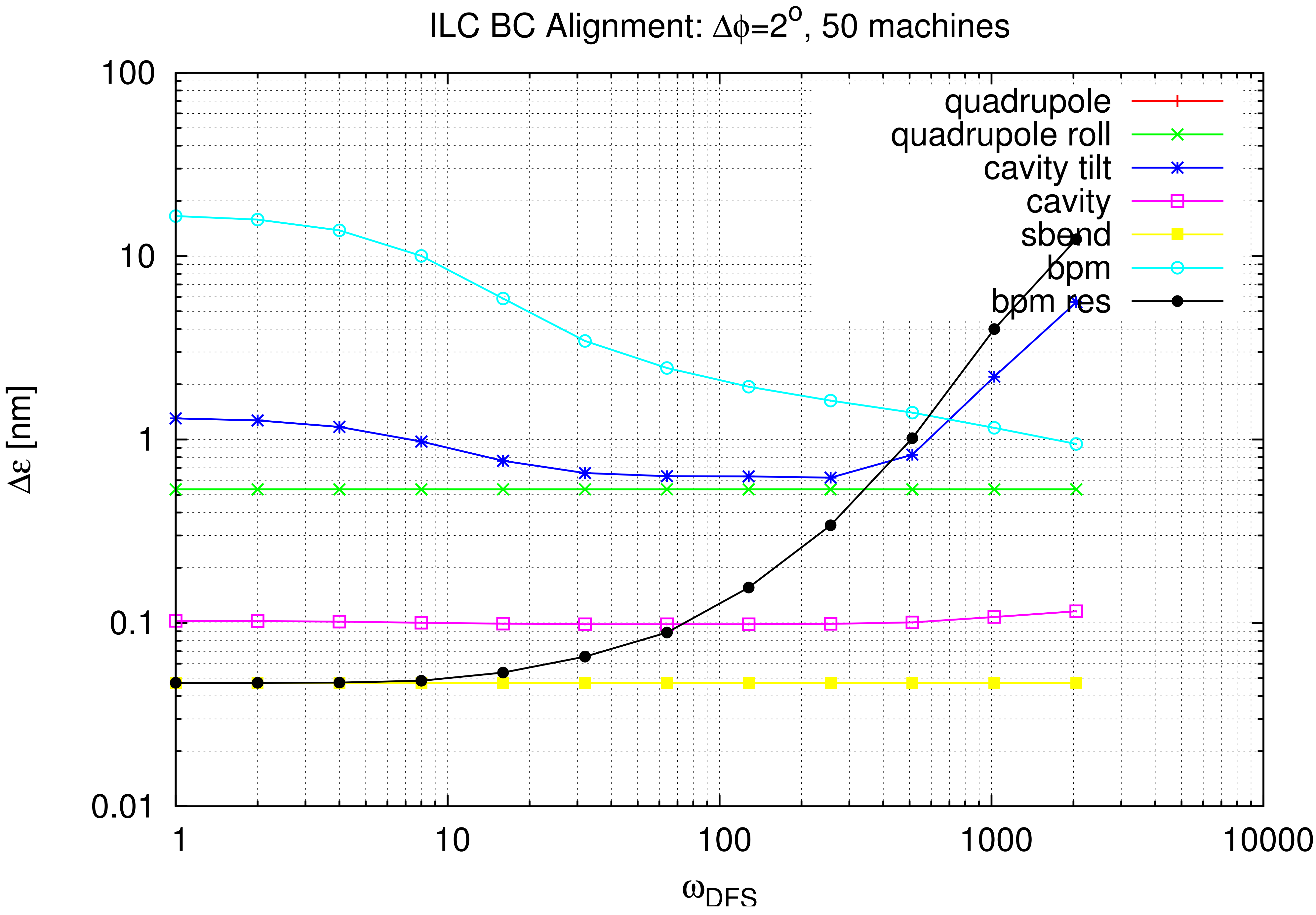
$\Rightarrow$ Final emittance growth after DFS and SKEW quad optimization

$$\begin{array}{lcl} \Delta\phi = \pm 2^o & \Rightarrow & \text{3.12 nm} \\ \Delta\phi = \pm 5^o & \Rightarrow & \text{2.79 nm} \\ \Delta\phi = \pm 10^o & \Rightarrow & \text{2.68 nm} \end{array}$$

All results are average of 50 machines



ILC BC Alignment: BPM$_{res}$=1μm, 50 machines
DFS+SKEW, Δφ=2°
DFS+SKEW, Δφ=5°
DFS+SKEW, Δφ=10°
Δε [nm]
ω_{DFS}
100
10
1
1
10
100
1000
10000



ILC BC Alignment: Δφ=2°, 50 machines
Δε [nm]
ω_DFS
100
10
1
0.1
0.01
1
10
100
1000
10000
quadrupole
quadrupole roll
cavity tilt
cavity
sbend
bpm
bpm res

Conclusions

- all misalignment were taken into account, and wakefields of the cavities as well
- we used a *pessimistic* scenario :
  - we assumed "COLD" misalignments for all elements, whereas the majority of them are in the "WARM" areas (150 μm misalignment instead of 300)
  - our BPMs were not "attached" to the QUADRUPOLEs

- Best final emittance growth is :
  - 1.5 nm, after aligning the BC2 using the BC1 (assuming a perfect BC1)
  - 2.68 nm, after aligning the whole BC