ILC ⇄ European XFEL

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XFEL Project - brief overview

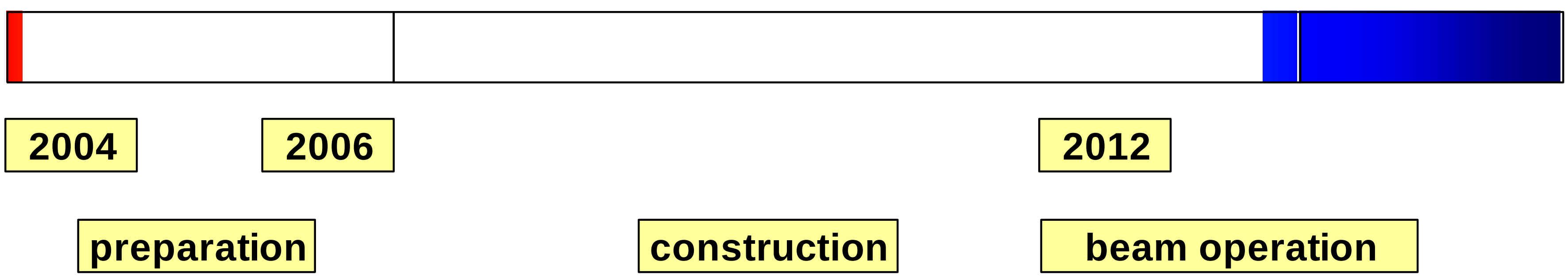
- 4^{th} generation SR user facility with SASE-FEL concept in the 1 – 64 Angstroem (→ 0.5Å) wavelength (1^{st} harmonic) and 100fs (→ < 1fs) pulse length regime

- In 1^{st} stage 3 SASE & 2 spontaneous undulator beam lines, 10 experimental stations

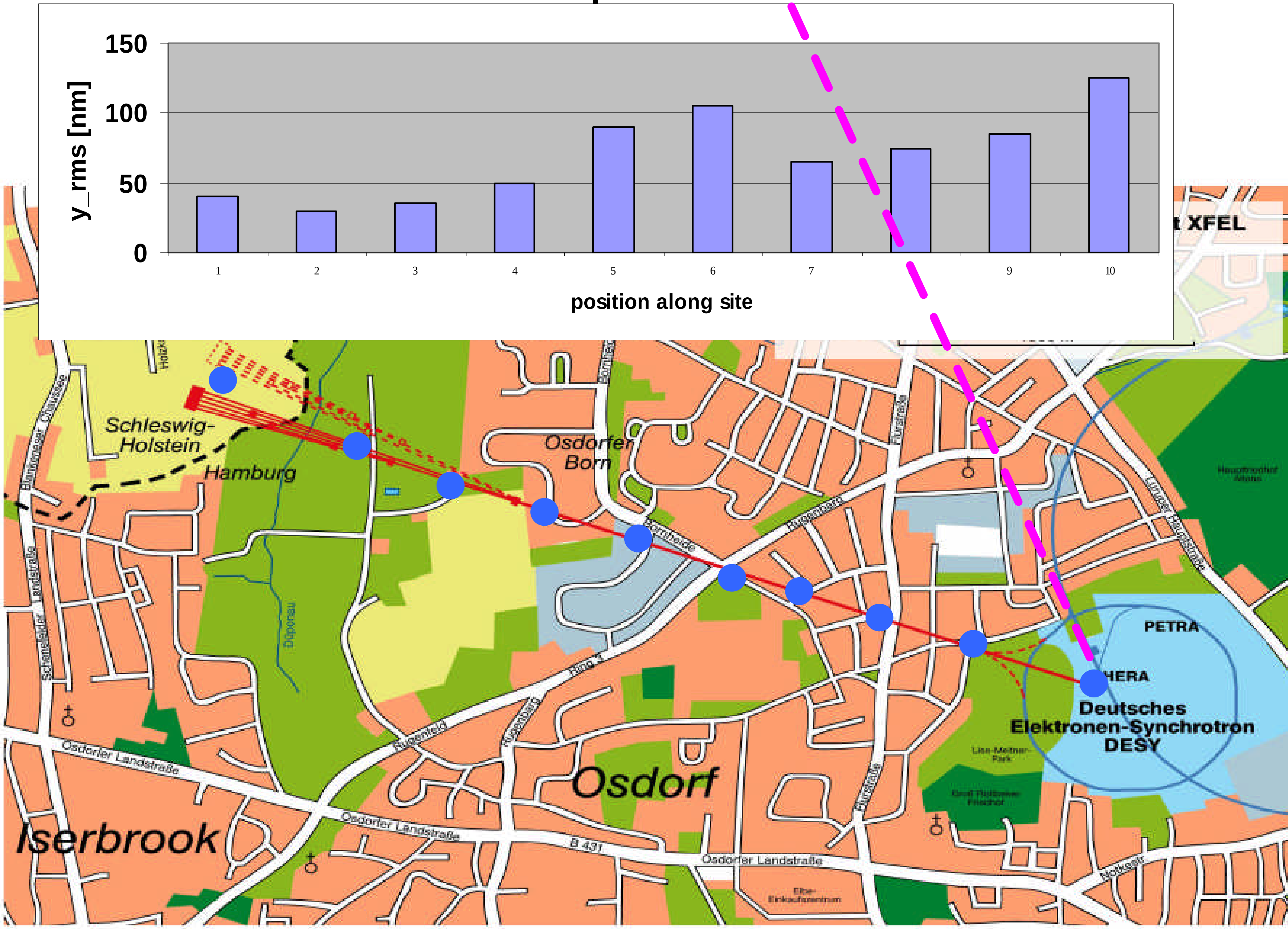
- Driver: 1.5km linac in TESLA technology, 20GeV beam energy @ 23MV/m gradient

Overview cont'd

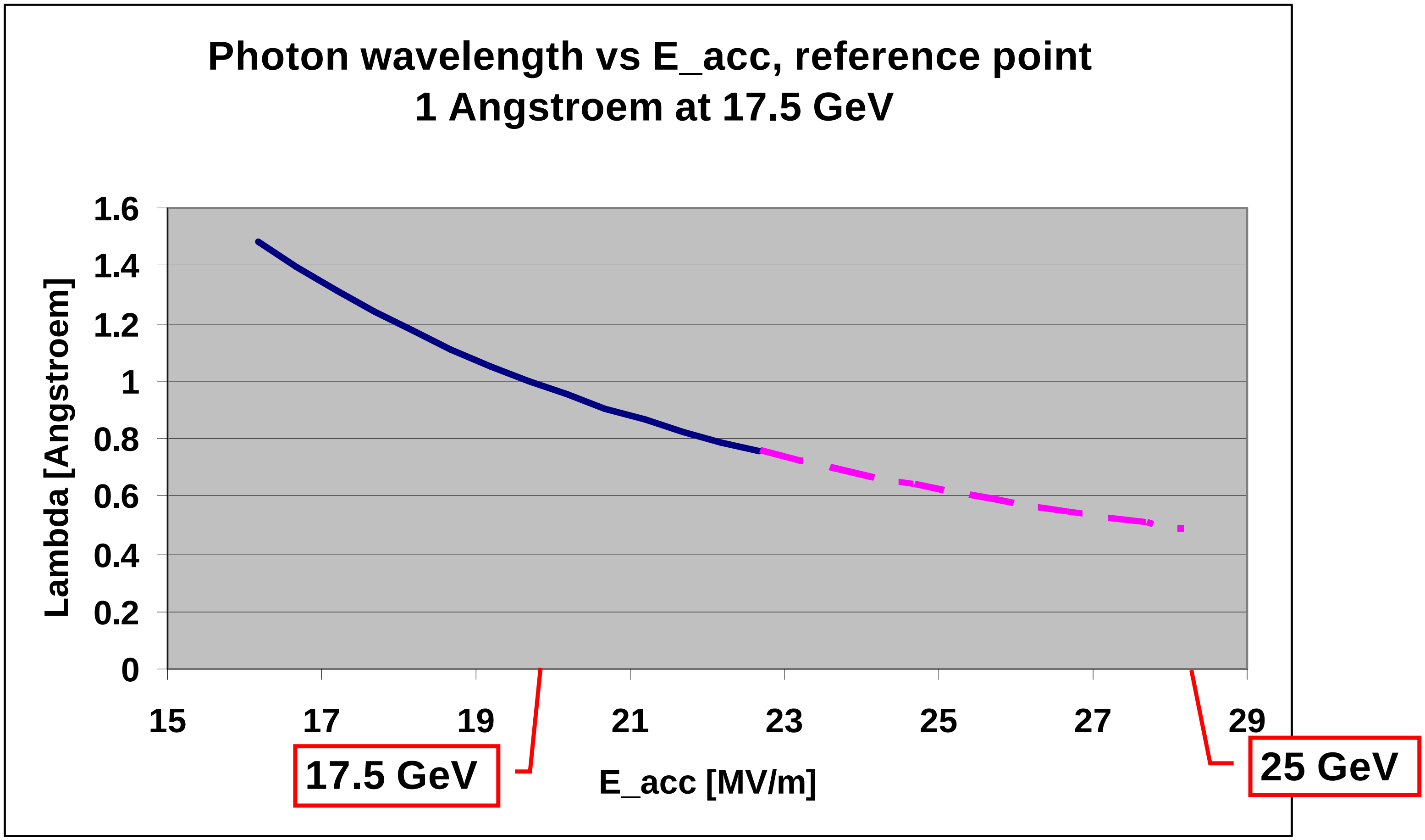
- German government Feb. 2003: go-ahead for XFEL as European project, incl. funding 50% of total 684 M€ (year 2000) project cost, + contribution from Länder HH & Schleswig-Holstein, ~ 40% European Partners
- Project organisation at Europ. Level (scientific/technical & administrative/financial) ongoing, completed in 2005
  (Sep. 2004: 9 Europ. Countries decided to sign MoU for project preparation phase)



New XFEL site: independent from LC site

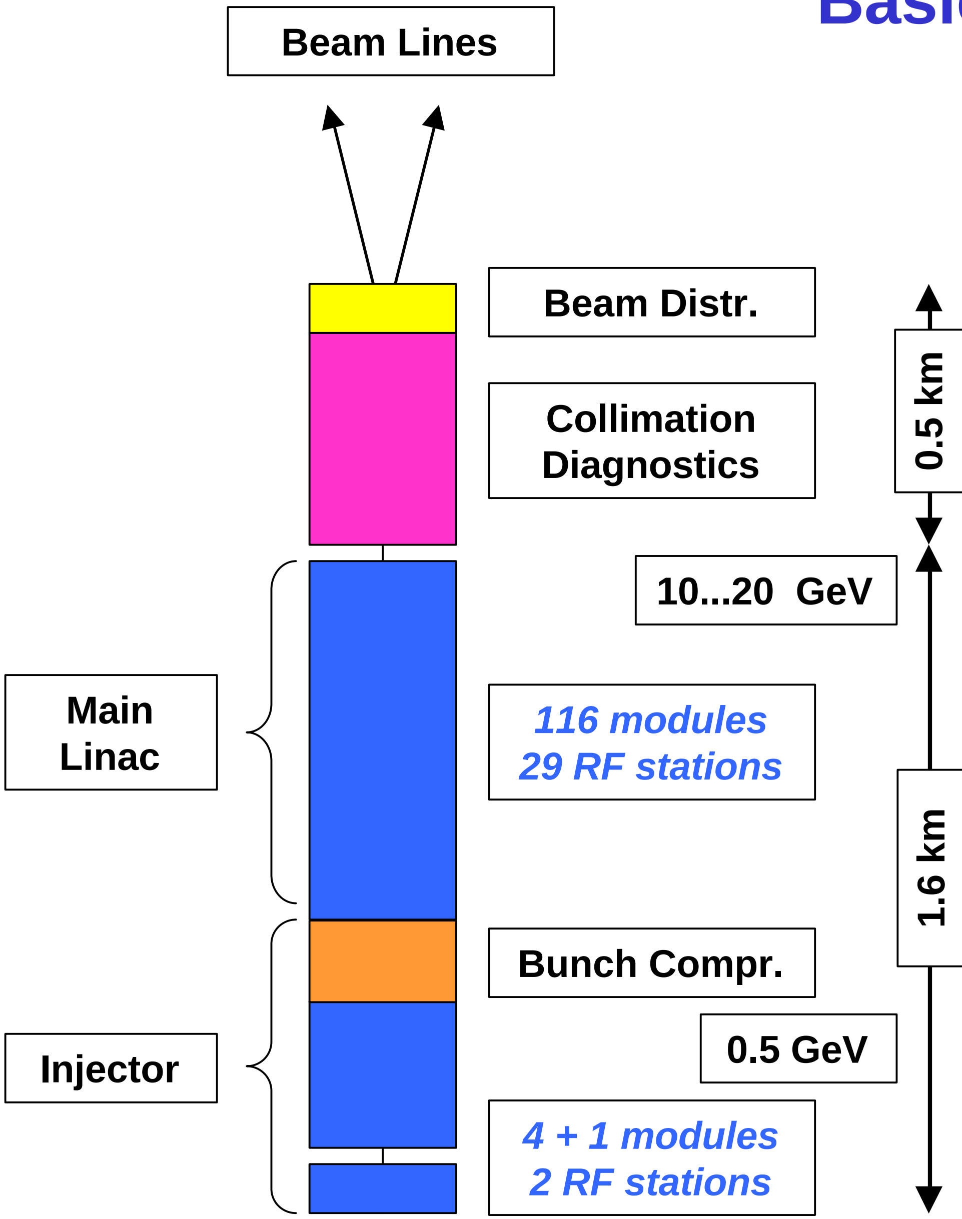


Photon wavelength vs. acc gradient

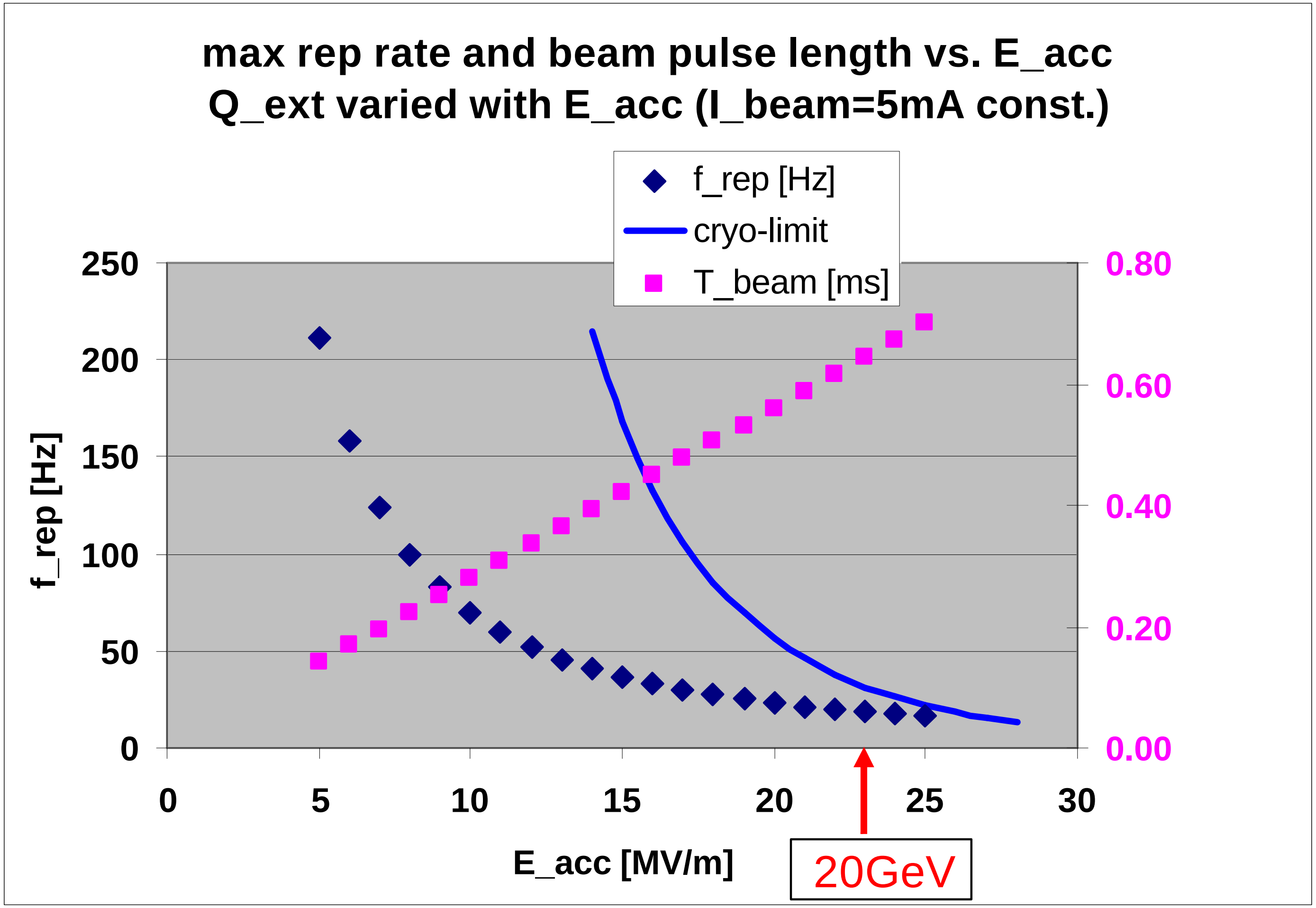


→ **25 GeV is reasonable upper limit for layout of beam line magnets**

Basic Accelerator Layout



Main linac	
Beam energy	20 GeV
acc gradient	22.9 MV/m
Bunch spacing	200 ns
beam current	5 mA
power→beam p. klystron	3.8 MW
incl. 10% + 15% overhead	4.8 MW
matched Q_{ext}	$4.6 \cdot 10^6$
RF pulse	1.37 ms
Beam pulse	0.65 ms
# bunches p. pulse	3250
Rep. rate	10 Hz
Av. Beam power	650 kW



Cryogenic plant equal to one of the six TESLA-500 LC plants →

Cryogenic limit for CW operation is E_{acc} = 7...8MV/m (6…7 GeV), **if $Q_0=2\times10^{10}$**

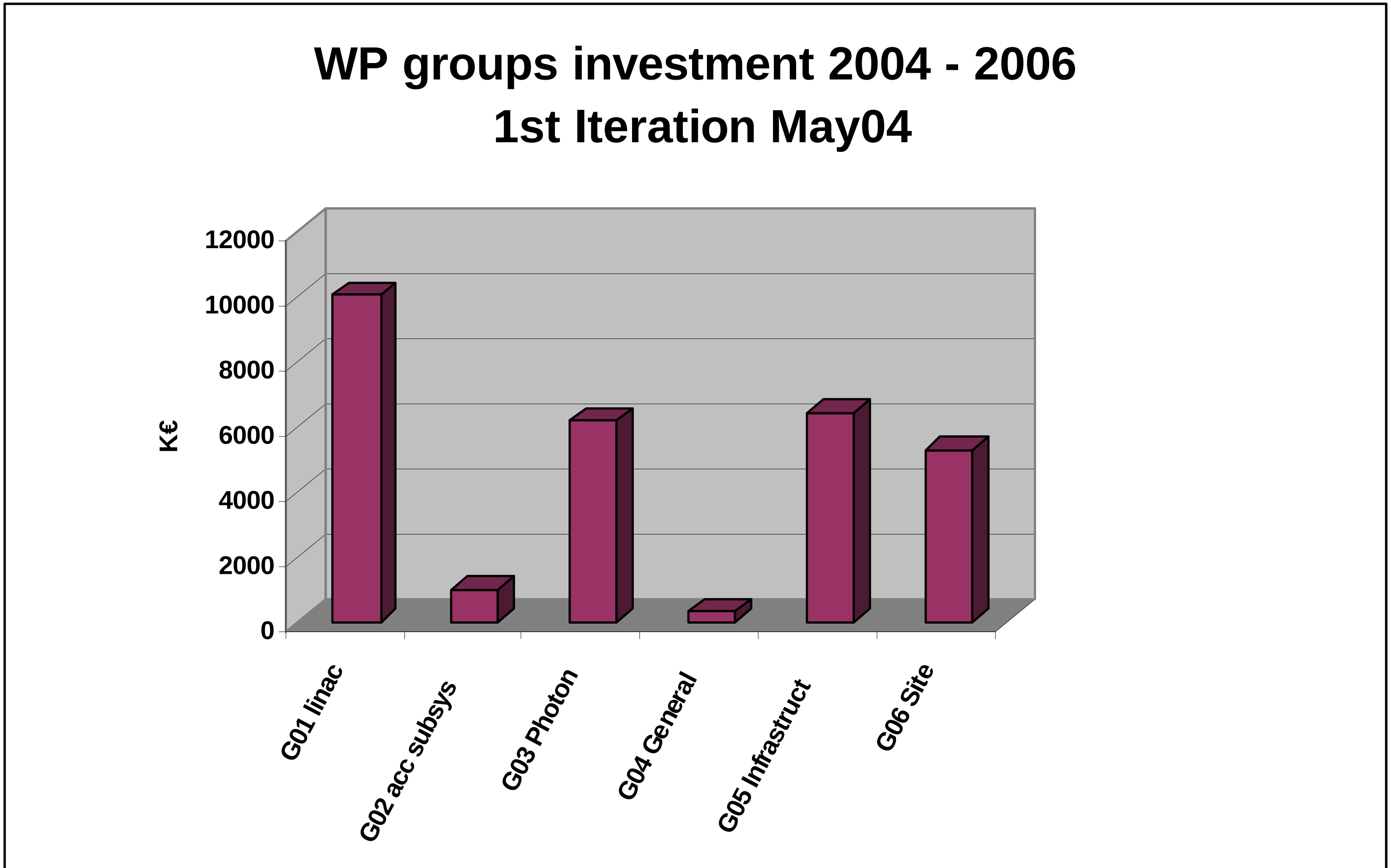
Linac technology

- Will build 120 accelerator modules (~ 1000 cavities) and ~35 RF stations in industry – requires ***everything*** also needed for the the LC, except:
  - **17m (12 cav's) instead of 12m (8 cav's) modules *(marginal gain in fill factor)***
  - **Shortened inter-cavity spacing & superstructure *(fill factor/cost advantage not well balanced with extra R&D effort)***
  - **RF stations de-rated in peak power – not in average power! *(higher rep rate/duty cycle desirable by users)***

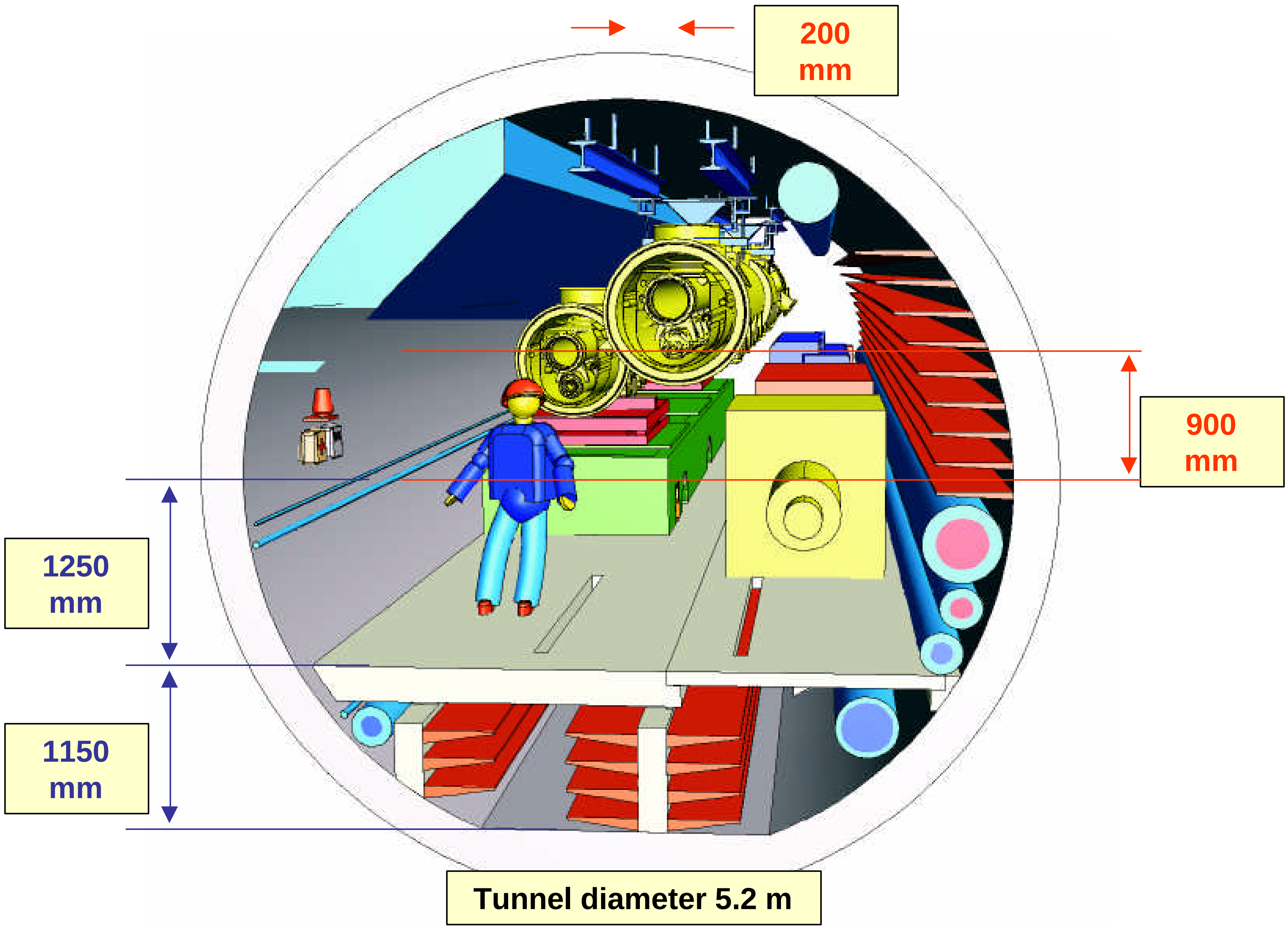
Examples for ongoing work (not exhaustive):

- Qualification of 3 vendors (Eu., US and J) for 10 MW MBK production (2004 – 2005)
- Industrial studies & prototypes for horizontal klystron/tunnel installation (2005 – 2006)
- Involve industry in string & module assembly
- Industrial studies for RF coupler fabrication (procurement & tests of prototypes at LAL/Orsay)
- Improvement of tuner design incl. piezo (Coll. Saclay)
- Further experience with EP treatment, improve statistics for cavities with 800C/***not*** 1400C baking
- Build up module test stand (1st test candidate will be Module#6 with 35MV/m cavities) → end of 2005
- Develop & test cold BPMs (coll. Saclay)
- …..

Budget (preliminary) for XFEL project preparation 2004 - 2006



Layout with ***single*** linac tunnel



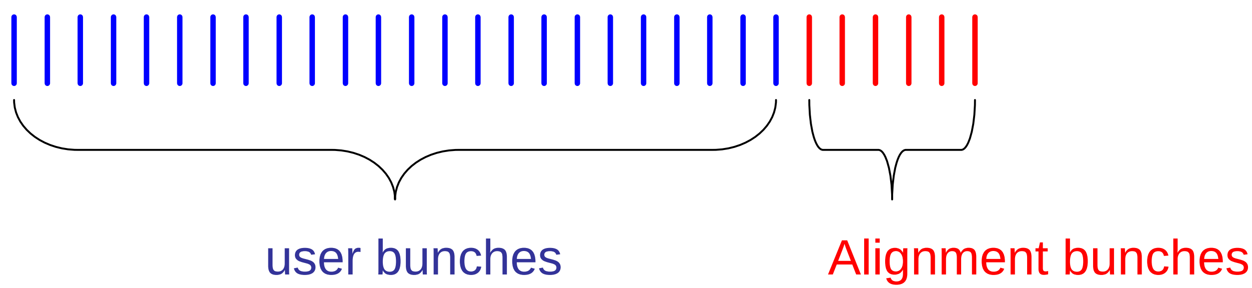
Beam dynamics

(assuming same alignment tolerances; comparison not exhaustive; rough scaling ±factor 2 for some of the XFEL parms)

Issue	parameter	TESLA LC	XFEL	comment
m.b. transverse wake	**peak orbit ampl.**	**1**σ	**0.2**σ **- 0.4**σ	**intra-train feed-forward!**
BC / Φ_{RF} **error**	Δ**E, time,** σ_z	**O(0.1°)**	**O(0.01°)**	
Synchronisation	Δ**t**	**<0.5ps**	**<0.05ps**	
1μ**m Orbit stab. BDS / undulator**	$\Delta\varepsilon/\varepsilon$ **/** Δ**y'**	**few %**	**0.1**σ**'**	**intra-train feedback!**
Energy jitter	Δ**E/E**	**O(10**$^{-4}$**)**	**(O10**$^{-4}$**)**	

Intra-train beam stabilisation

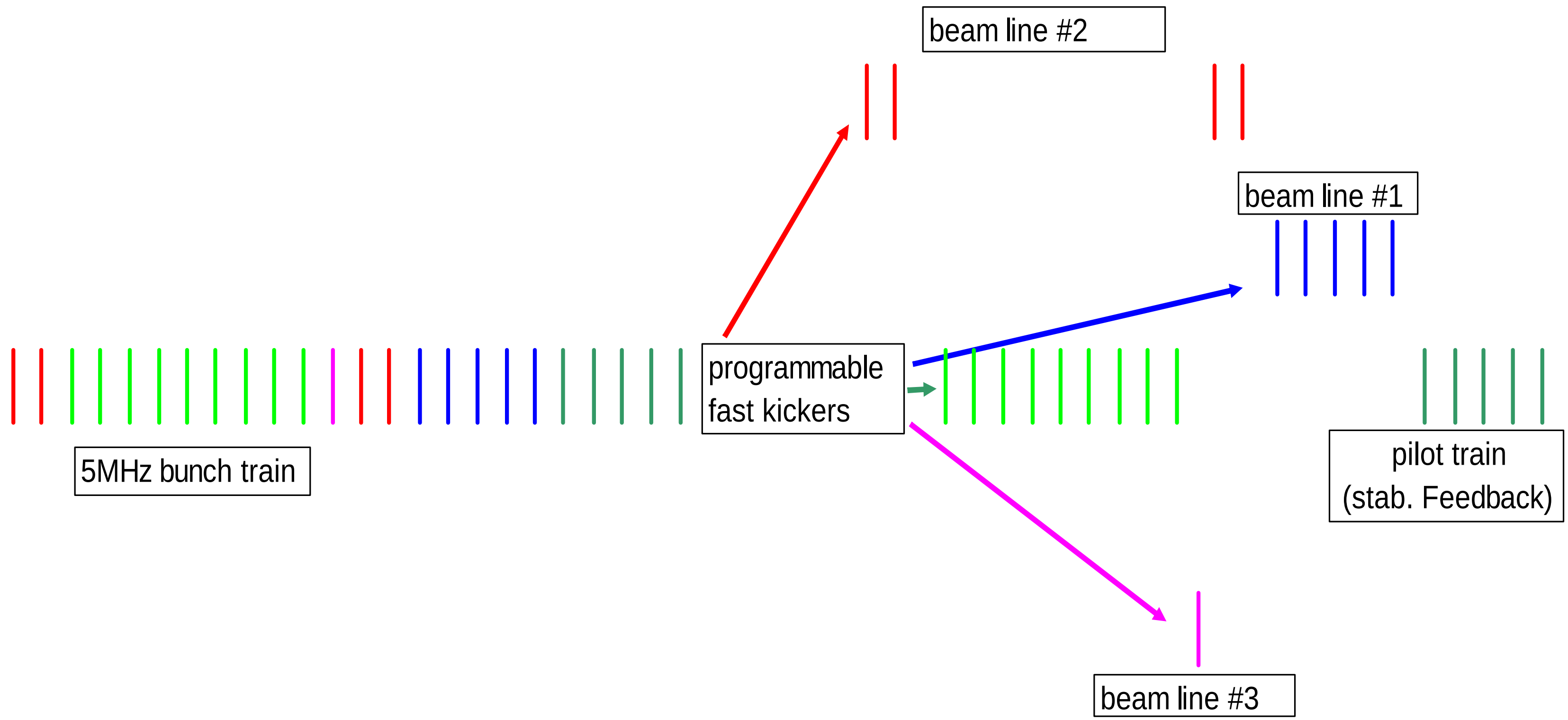
- From ground vibration: jitter ~ 0.1σ at end of linac
  - Can be enhanced during "single events" e.g. heavy traffic, and by quad support eigenmodes
  - Other effects: stray fields, HOMs, …
- → feedback system between linac and distribution to undulators



Also active stabilisation of energy and possibly other beam parameters

Different users – different time structures

- Generation of bunch train patterns:
  - At the source → varying transient effects in the entire accelerator (handled e.g. by the LLRF system)
  - At the beam delivery/distribution system → more challenging kicker devices → **similar to damping rings kickers!**



Conclusions

- Major components of the XFEL facility are the same as or very similar to the ones needed for the s.c. Linear Collider
- The benefits of the XFEL project for a later LC project regarding accelerator design, industrialisation, fabrication and testing of components, operational aspects (controls, reliability, MPS, …) are obvious
- New developments for the ILC may also be beneficial for the XFEL!