TESLA Meeting : Frascati May 26-28, 2003

http://www.lnf.infn.it/conference/tesla2003/programme.htm

Monday, May 26: Plenary Session

13:45 *Welcome, P. Raimondi*

14:00 *Status and Plans for TESLA, A. Wagner*

14:30 *Activities and Priorities for TESLA, C. Pagani*

15:00 *X-FEL Project - Overview and Recent Development, R. Brinkmann*

15:30 *Status of US LC Review, G. Dugan*

16:30 *Lab Reports: Saclay Laboratory Report, C. Magne*

Fermilab Report, K. Desler

LNF Laboratory Report, S. Guiducci

TEMF, TU Darmstadt Lab Report, W. Müller

INFN-Milano LASA Laboratory Report, D. Sertore

Tuesday, May 27

Group 1: Accelerator Physics and Design

1. *What Did We Learn From TTF1?, P. Castro - DESY*
2. *PITZ Gun Tests, F. Stephan - DESY*
3. *What is Needed to Improve the Beam Quality?, K. Flöttmann - DESY*
4. *Bunch Compressor: What are Critical Issues?, T. Limberg - DESY*
5. *Slice Beam Properties: How Do We Obtain Information on a Beam Profile?, O. Grimm - DESY*
6. *Stability/Reliability of the XFEL, B. Faatz - DESY*

7. *CEBAF Energy Recovery Experiment, M. Tiefenback - Jefferson Lab*
8. *Energy Recovery Options for the XFEL Linac, J. Sekutowicz – DESY/JLAB*
9. *Towards a High Brightness SC-RF Photo-Injector, M. Ferrario - INFN-LNF*

Tuesday, May 27

Group 1: Accelerator Physics and Design

10. *Helical Undulator for e+ Polarized, D. Angal-Kalinin - Daresbury Lab*
11. *TESLA Damping Ring: Injection/Extraction Schemes with RF Deflectors, D. Alesini - INFN-LNF*
12. *TESLA Damping Ring: RF Deflectors Design, F. Marcellini - INFN-LNF*
13. *Measurement of Beam Position in TTF Cavities Through HOM Power, O. Napoly - CEA-Saclay*
14. *Scattering Parameter Calculations for 2x7 Superstructure, U. Van Rienen - Universität Rostock*

Wednesday, May 28

15. *Start-to-End Simulations fo the TESLA LC, N. Walker – DESY*
16. *New TESLA Final Focus and Power loss at the Extraction Septum, O. Napoly - CEA-Saclay*

Tuesday, May 27

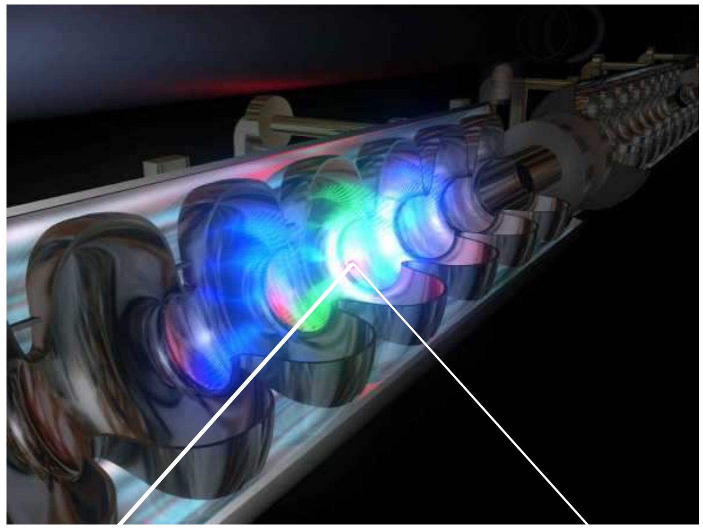
Group 2 Linac Technology

1. *Working Group Linac Technology Introduction: L. Lilje - DESY, D. Barni - INFN-Milano LASA*
2. *DESY EP Single Cell Cavity sent to Cornell: Various Treatments and Results ; 550 RRR Russian Nb Single Cell Cavity High Gradients Results with Thermometry, H. Padamsee - Cornell*
3. *High Gradients in TESLA Nine-cell Cavities, L. Lilje - DESY*
4. *Design for Accelerator Reliability, P. Pierini - INFN-Milano LASA*
5. *Cold BPM for TTF2, C. Magne - CEA-Saclay*
6. *Overview Technical Issues Related to Superconducting Accelerating Modules, L. Lilje - DESY*
7. *Cryomodule Design and Assy. Tuner Issue, D. Barni - INFN-Milano LASA*

Discussion on Linac Technical issues

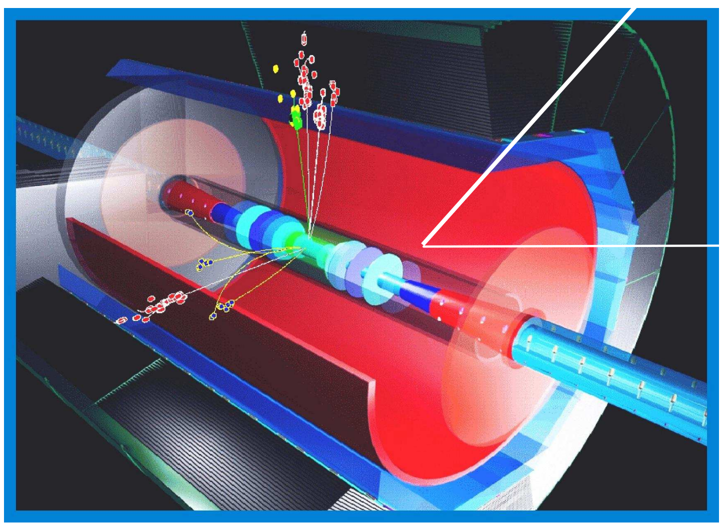
TESLA Collaboration Meeting at INFN-LNF

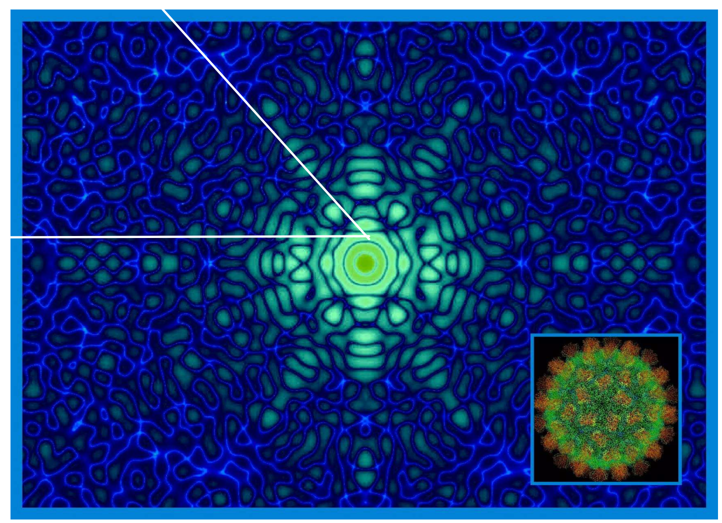
Albrecht Wagner, Frascati, 26 May 2003



Status and Plans for TESLA:

X-FEL and LC





Government Decision on X-FEL

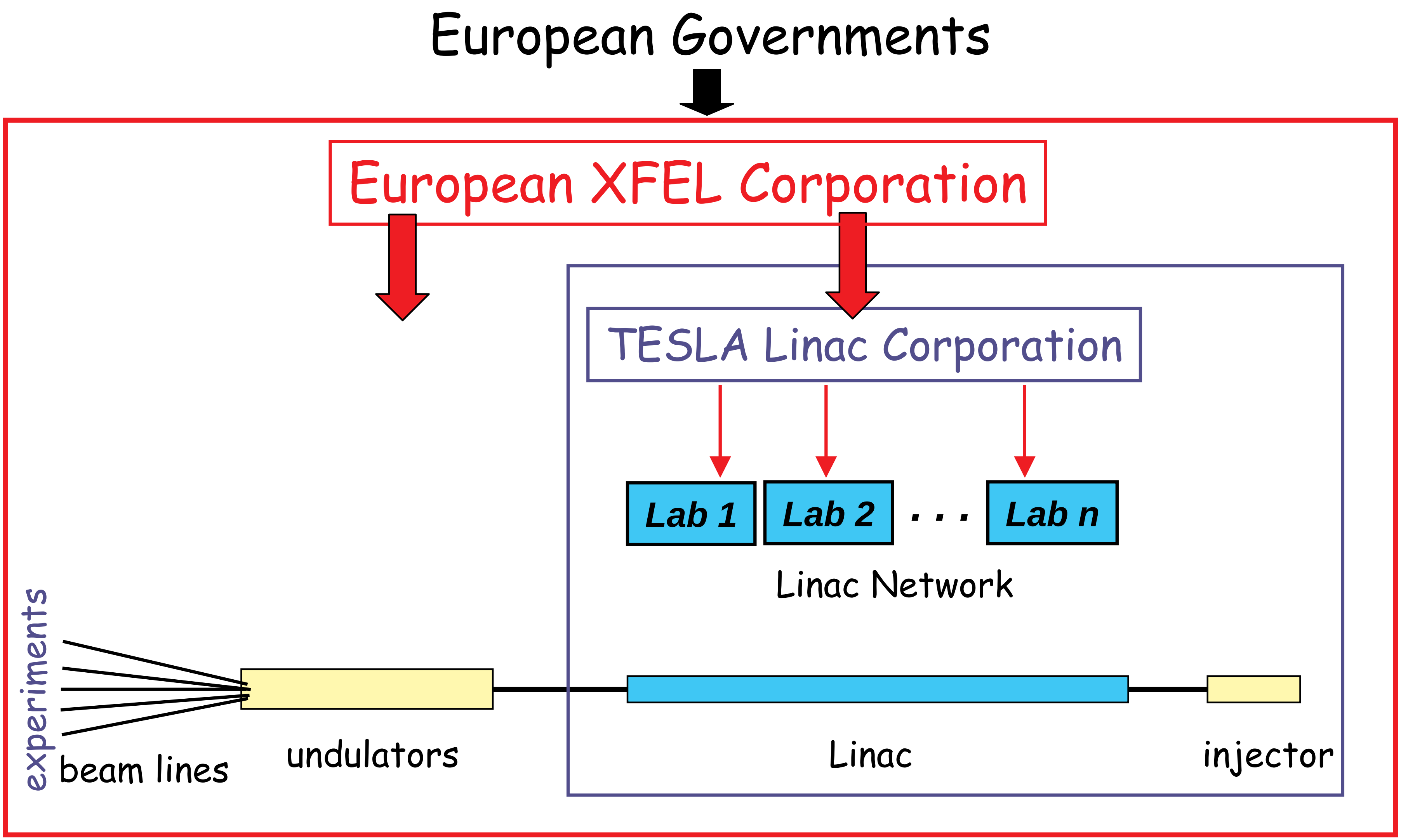
The decisions of the German Ministry for Education and Research concerning TESLA was published on 5 February 2003:

DESY in Hamburg will receive the X-FEL

Germany is prepared to carry half of the 673 MEuro investment cost.

Discussions on European cooperation will proceed expeditiously, so that in about two years a construction decision can be taken.

A Model for a European X-FEL Laboratory



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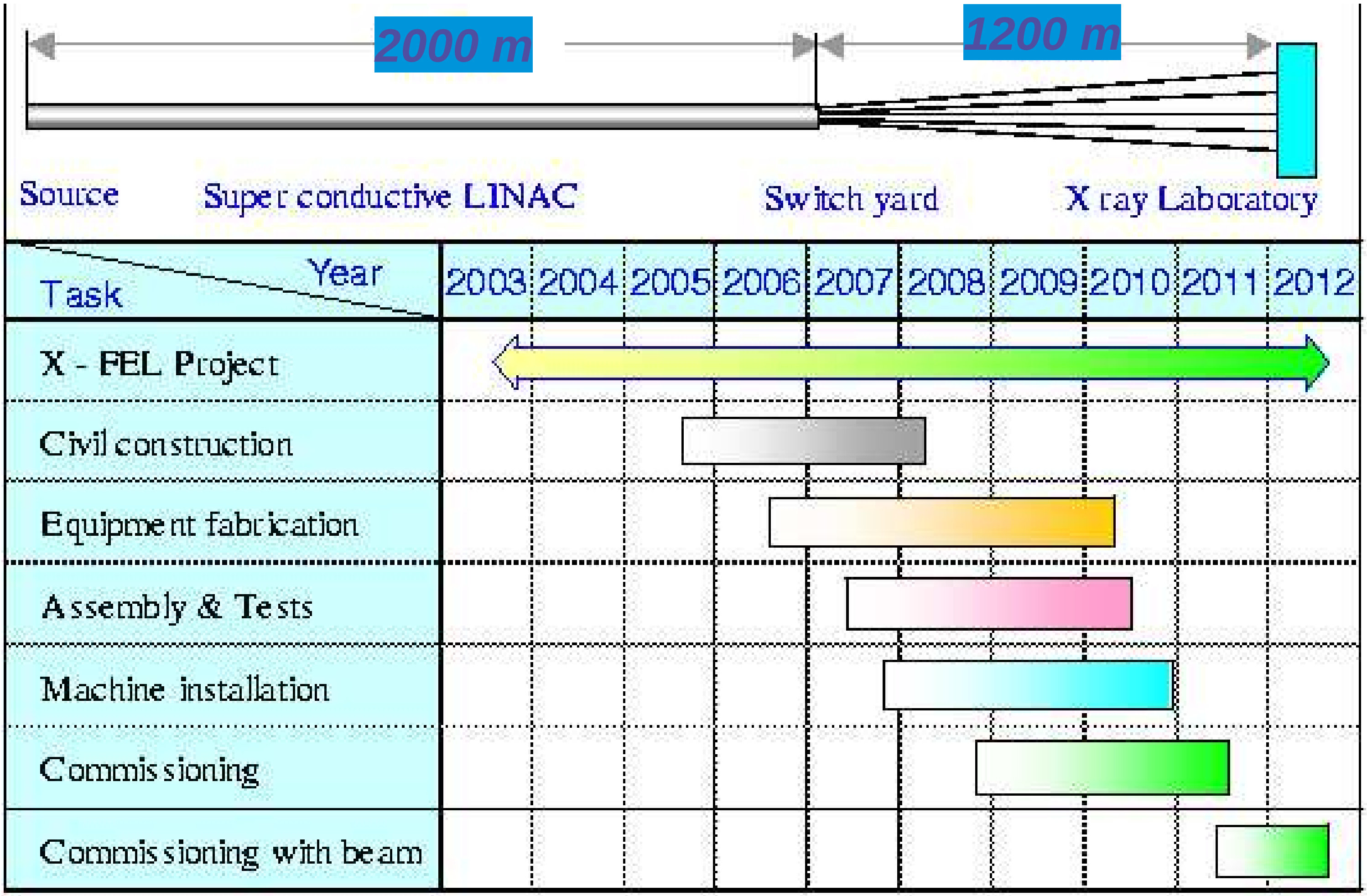
European XFEL Laboratory

time schedule



start in 2005 • • • • • • • • • • • • • • • complet in 2011

Albrecht Wagner

Government Decision on LC

Today no German site for the TESLA linear collider will be put forward.

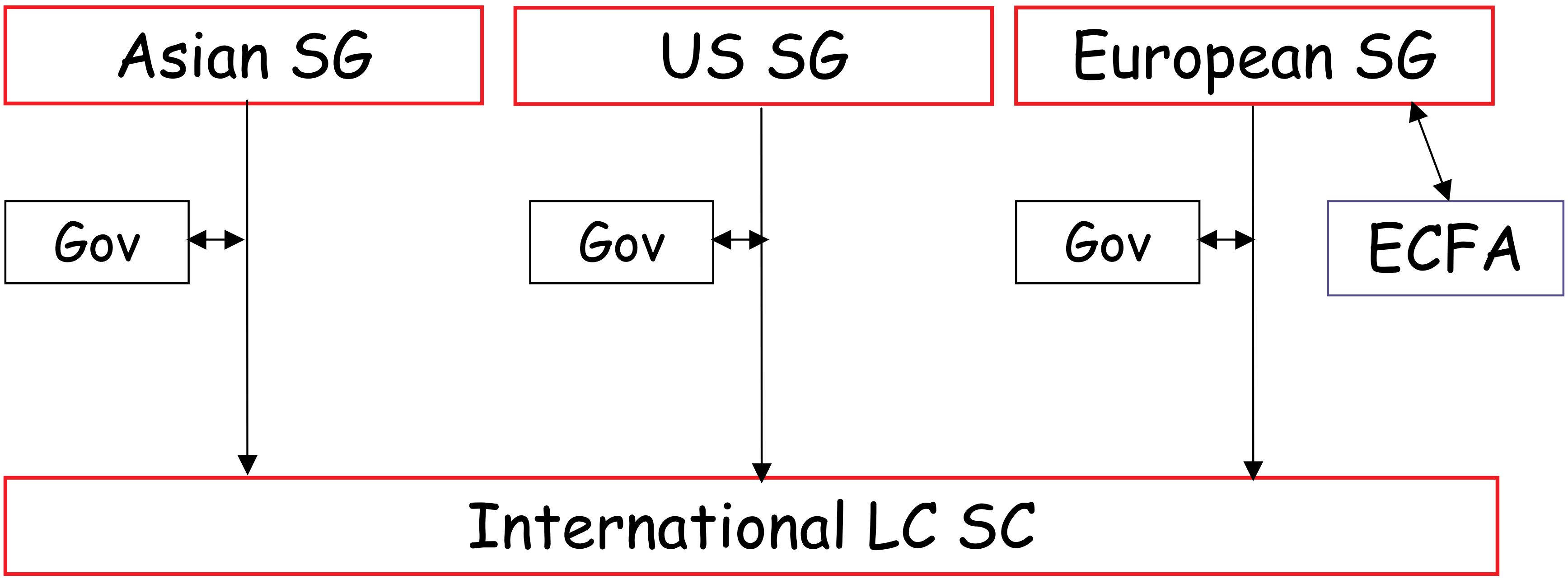
This decision is connected to plans to operate this project within a world-wide collaboration

DESY will continue its research work on TESLA in the existing international framework, to facilitate German participation in a future global project

Albrecht Wagner

LC Steering Groups

ICFA initiative for an international co-ordination:



First proposed Feb. 2002 (J. Dorfan), very active since Aug. 2002

TESLA and the Technology Choice

If the chosen technology is ‚cold', a major synergy will exist between the work on the X-FEL and the LC:

- SC technology, mass production, reliability, all RF issues (klystrons, LLRF, RF distribution and components ..)
- Fast orbit feed back
- Damping ring kicker system (X-FEL beam distribution)
- Beam diagnostics
- ….

If the chosen technology is 'warm', a major rethinking is necessary. In this case the role of DESY (and possibly some of the TESLA partners?) will be less pronounced, due to the commitment to the X-FEL.

Albrecht Wagner

Next Steps

X-FEL

Continuation of the R&D work for the X-FEL accelerator

....

....

Linear Collider

Continuation of the high gradient programme (construction, optimisation and tests of cavities with 35 MV/m)

....

CW Energy Recovery Linac for Next Generation of XFELs

General Thoughts based on TESLA XFEL-TDR

J. Sekutowicz

TJNAF:	*A. Bogacz*
INFN:	*M. Ferrario, L. Serafini*
DESY:	*D. Proch, S. Simrock*
BNL:	*I. Ben-Zvi*
LANL:	*P. Colestock*
UCLA:	*J. B. Rosenzweig*

TESLA_TTF Meeting

Frascati, May 26-28, 2003

Motivation

XFEL pulsed linac, present layout:

E_{max} = 20 GeV

L = 1.4 km

78 Cryomodules each housing 12 sc cavities

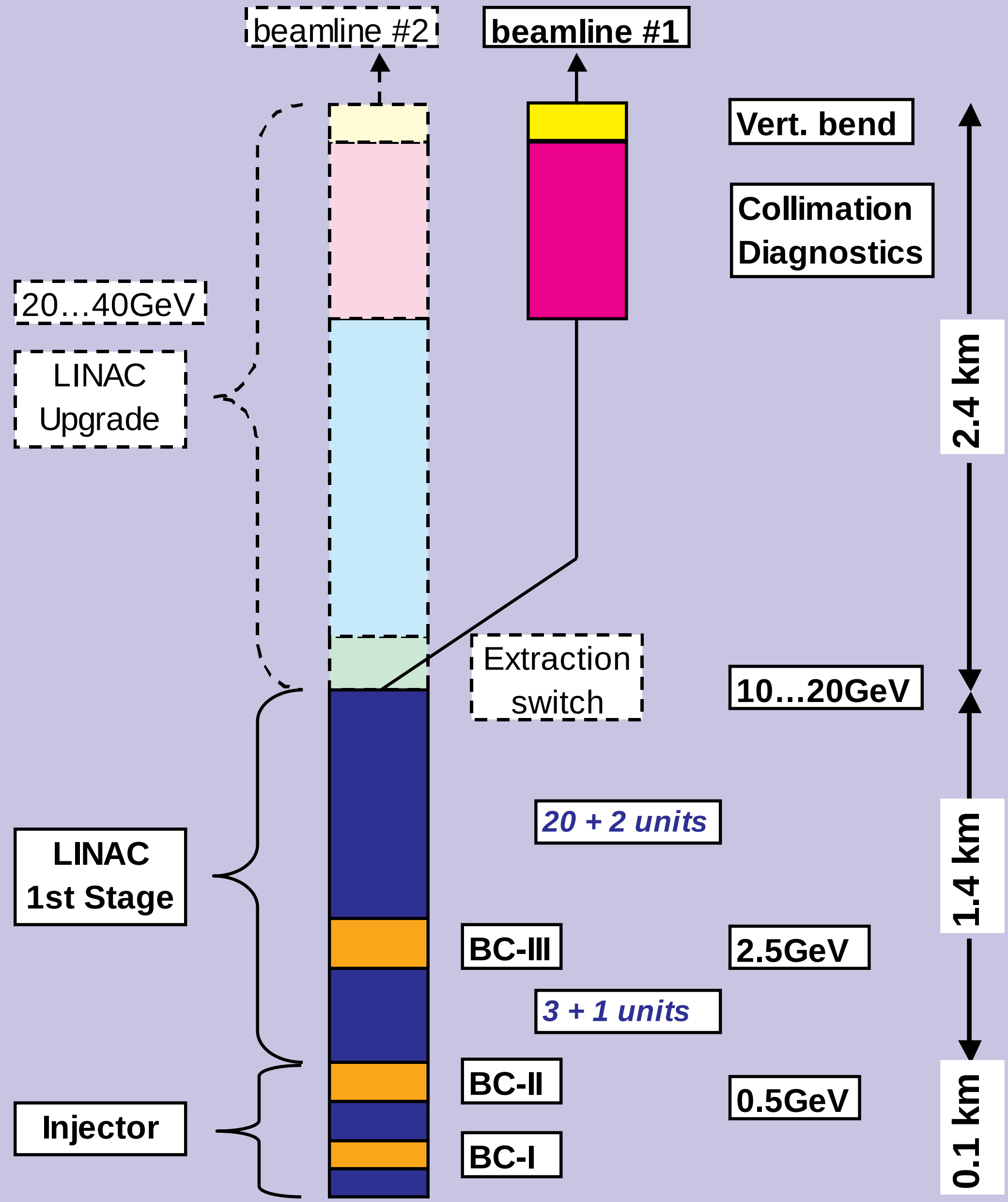
936 cavities at E_{acc} = 23.5 MV/m

Cryoplant 1.2 kW at 2 K (safety margin ~50%)

R. Brinkmann

Schematic layout of XFEL accelerator

(TDR supplement 2002)



Total length matched with LC site layout (cryo station and central area)

R. Brinkmann (April 11 and Frascati Meeting)

Proposed modifications in recent discussions:

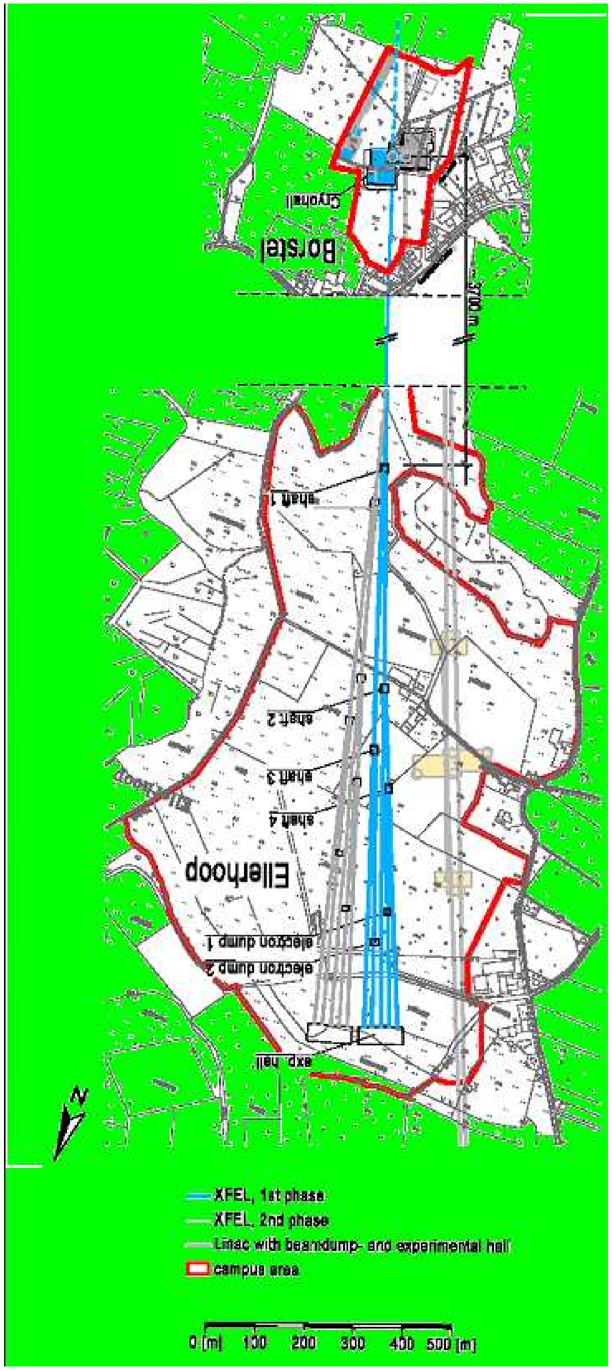
- Shortening of the accelerator tunnel to ~2km

  (Injector + linac + collimation/diagnostic etc.)

- XFEL site layout not necessarily linked to LC site (except: don't ***exclude*** LC construction at foreseen Hamburg/S.H. site); possibility of User Facility near DESY under study

- **TTF-like modules with 8 cavities per module; 4 or 6 of modules per Klystron ?**

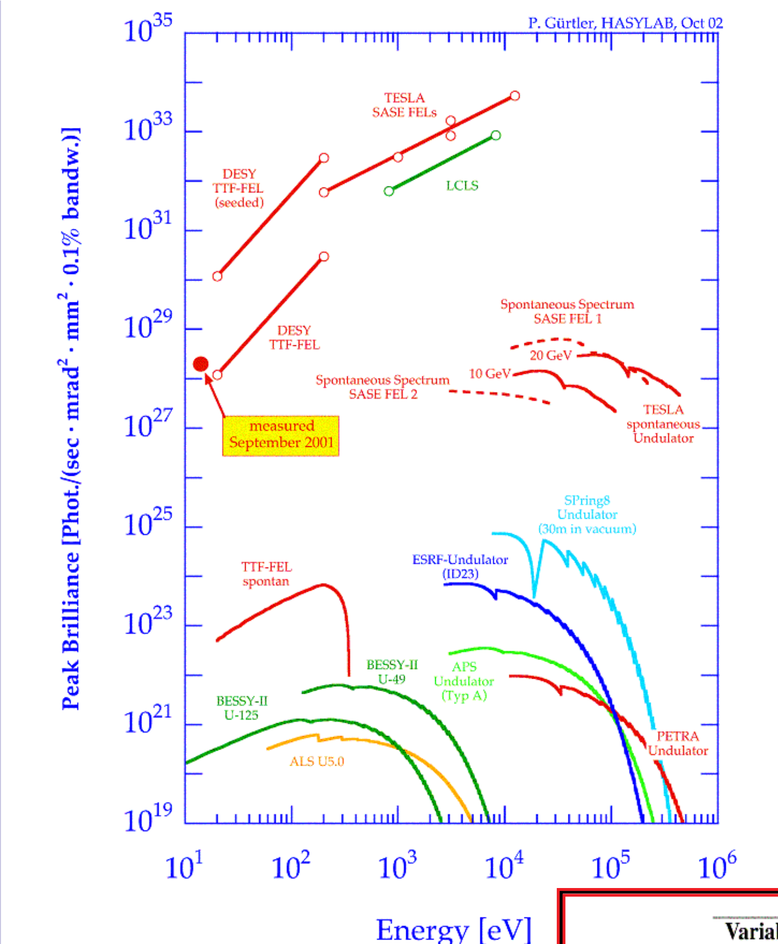
R. Brinkmann

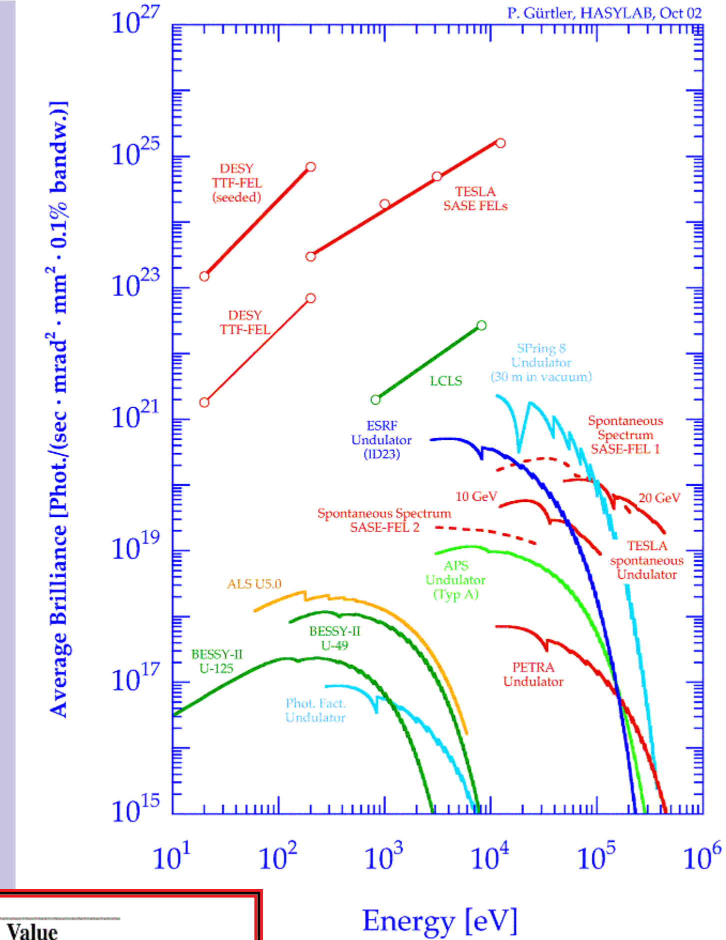


DESY will work out a site proposal for the XFEL

Not yet decided:

green field vs. near-DESY



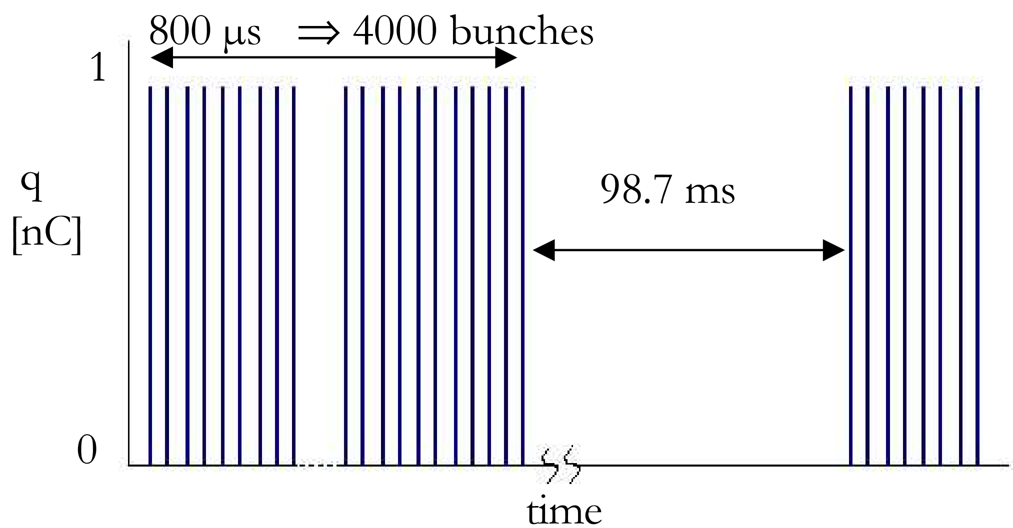


Variable	Unit	Value		
electron energy range	GeV		10-20	
electron bunch length (rms)	fs		80	
electron bunch charge	nC		1	
normalized emittance	mrad mm		1.4	
uncorrelated energy spread (rms)	MeV		2.5	
photon pulse length (FWHM)	fs		100	
photon energy	keV	0.2	3.0	12.4
wavelength	nm	6.4	0.4	0.1
number of photons per bunch	$\times 10^{12}$	430	20	1.2
peak brilliance	$\times 10^{33}$	0.06	1.7	5.4
peak power	GW	135	100	24

Table 1: *Performance goals for the electron beam (top) and FEL radiation (bottom) at the TESLA XFEL. Peak brilliance is given in common units of photons / (sec·mrad^2·mm^2·0.1 % bandwidth).*

What do we buy for this money ?

up to 40000 @ 1 nC bunches /s at 20 GeV



	Unit	Value
Final energy	GeV	10...**15**...20
Injection energy	GeV	0.5
Accelerating gradient*) E_{acc}	MV/m	10...**17**...23.5
Total length (incl. BC-III)	m	1380
Active length	m	859.4
Modules	#	78
Cavities	#	936
Klystrons	#	26
Bunch charge Q_b	nC	1
Bunch spacing Δt_b	ns	200
Bunch train length (max.)	μs	800
Repetition rate	Hz	10
Average beam power	kW	600
AC power (RF and cryogenics)	MW	3.5

* In the first linac section, the gradient is fixed at 18 MV/m for a constant beam energy of 2.5 GeV in the bunch compressor III.

Table 3.6.1: *Overview of main parameters for the first stage XFEL linac.*

The questions are:

can we buy much more in the future after pulsed XFEL ?

is there a major change in the technology needed ?

An alternative possible future layout of the linac driving XFEL

Technical assumptions, towards cw operation :

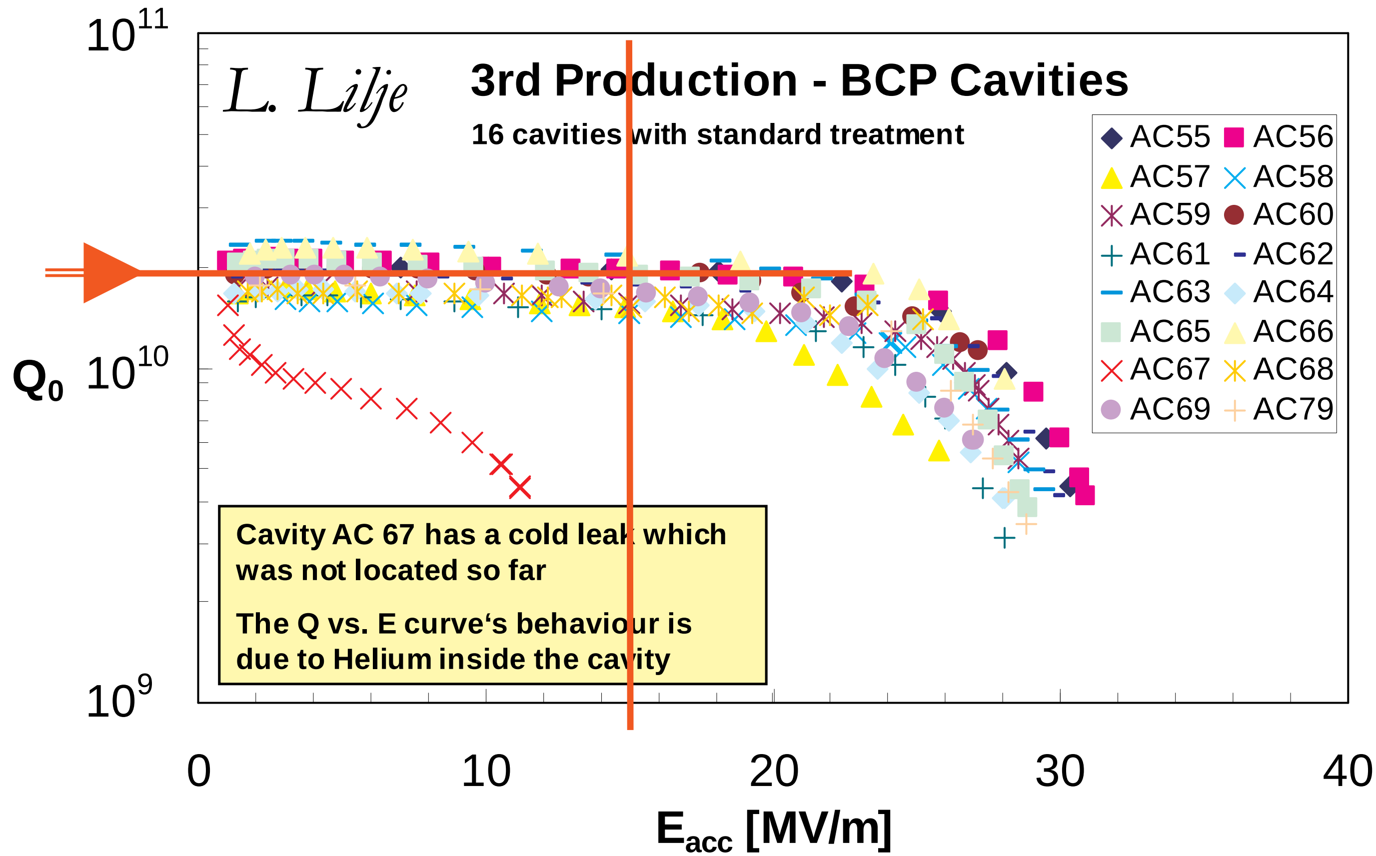
I. 1284 cavities @ Qo ~ 2E10 @ Eacc ≤ 15 MV/m

II. 4÷6 kW @ 2K cryoplant

III. energy recovery

Are these assumptions very challenging ?

- *cavities :*



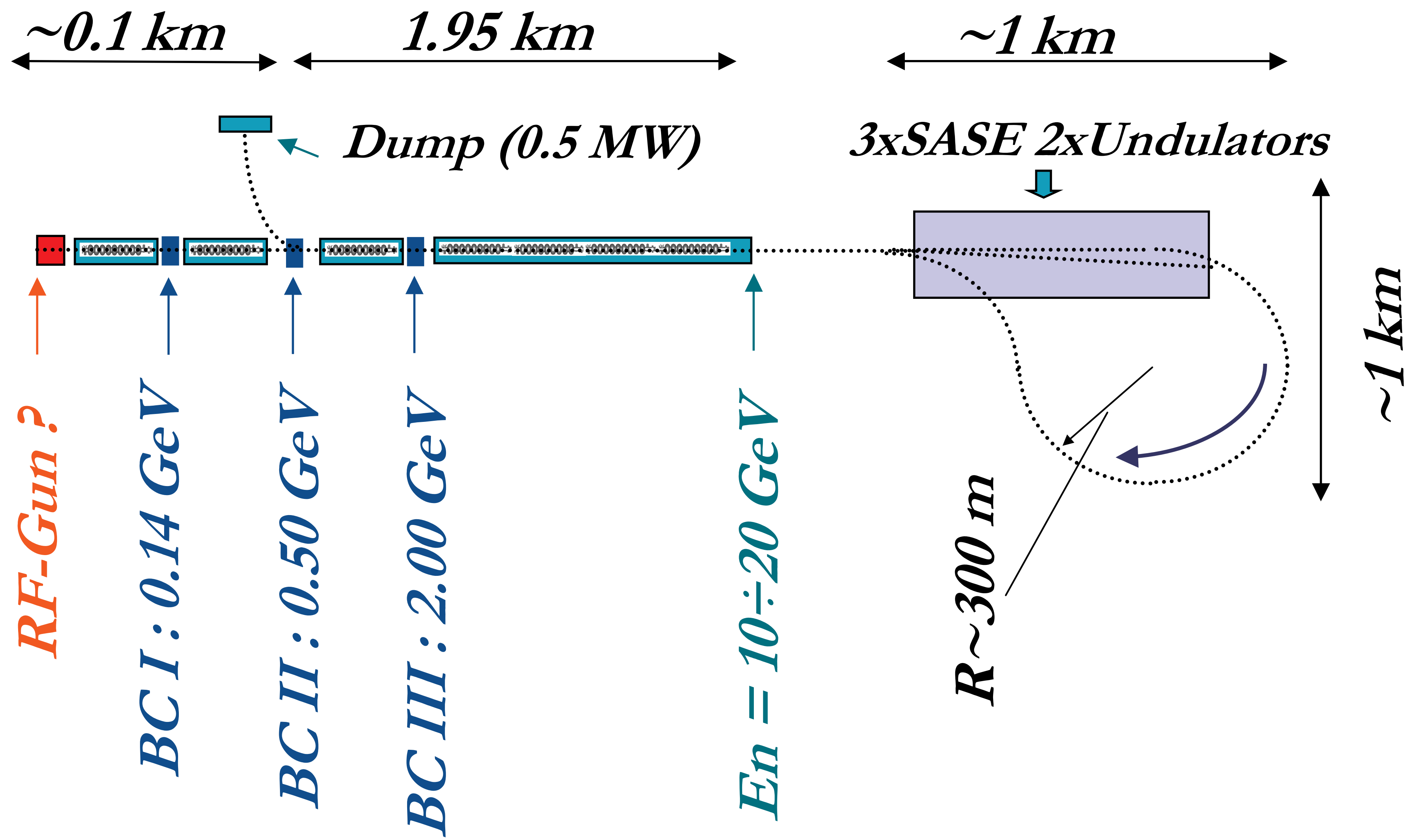
- *cryoplant = ~45÷55 M€*

- *energy recovery 95 %:*

  we have good chance after experiment at CEBAF :

  1 GeV⇒ 20 MeV (98 %) with 320 sc cavities

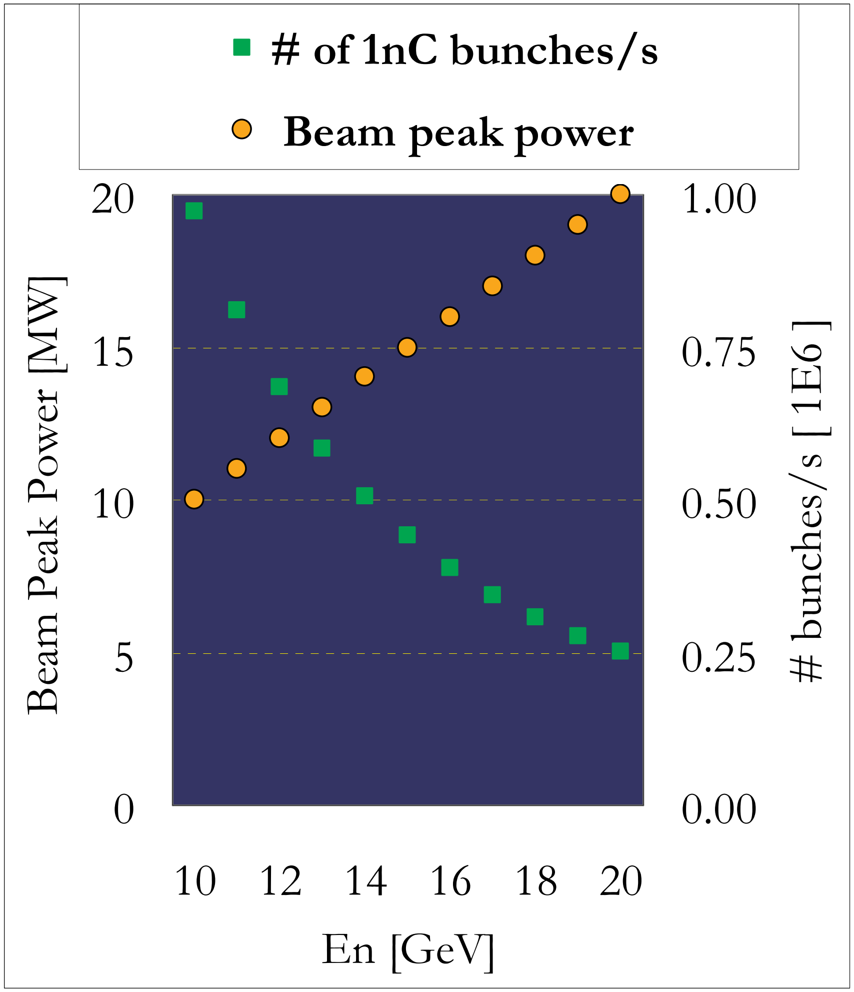
Possible layout can be very similar to the present pulsed linac



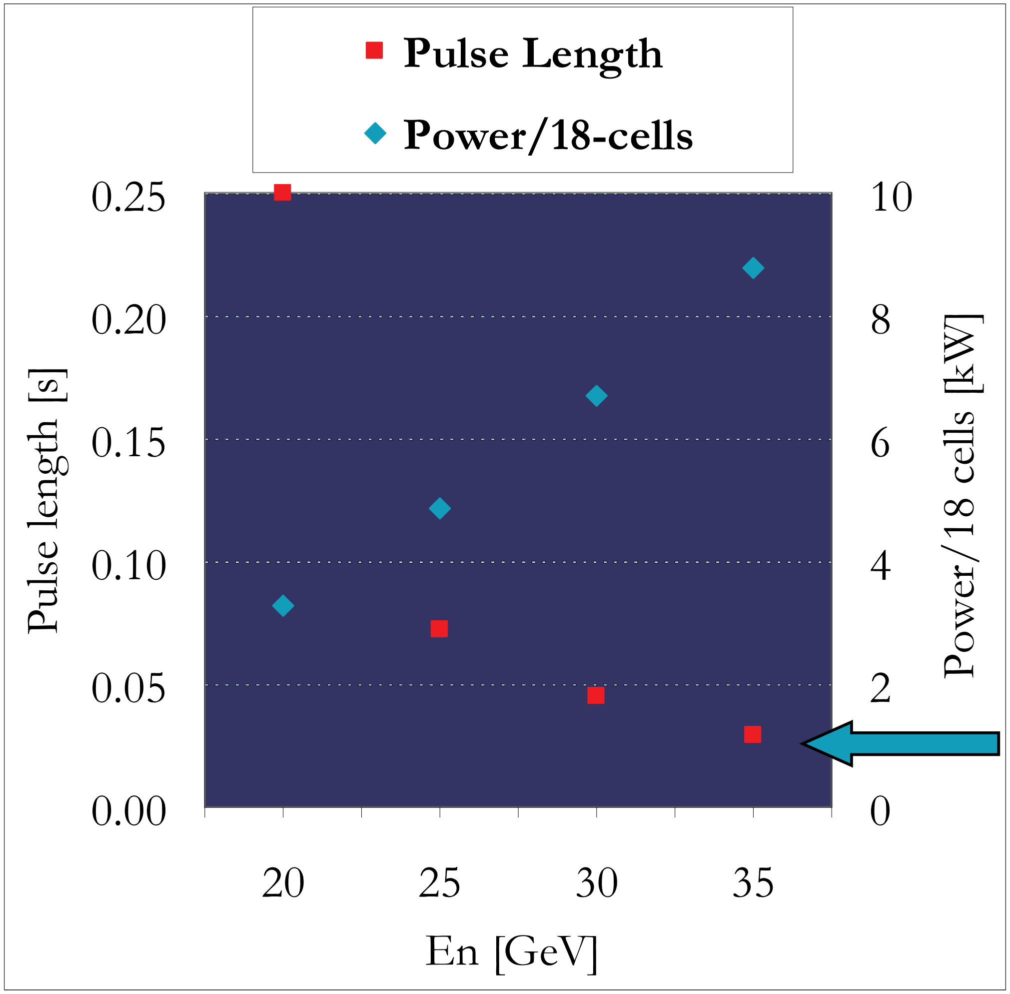
A very preliminary and not optimized list of parameters

Final energy	**[GeV]**	**10**	**20**
Eacc	[MV/m]	7.5	15
Qo	[1E10]	2	2
(R/Q) per subunit	[Ω]	985	985
Static losses per subunit at 2 K	[W]	0.12	0.12
Dynamic loss per subunit 2k	[W]	3.1	12.4
Total Loss at 2K per subunit	[W]	3.2	12.5
Duty Cycle	[%]	97	25
Pulse length	[ms]	972	250
Energy Recovery	[%]	95	95
Current	**[mA]**	**1**	**1**
Beam power/two subunits	[kW]	0.78	1.56
Matched Q no energy recover	[1E7]	0.8	1.6
Matched Qext_ energy recover	[1E7]	16	32
3 dB width for Qext_recovery	[Hz]	8	4
Optimum Qext to min. power for 6 Hz microphonics	[1E7]	5.9	7.3
Power factor resulting from 6 Hz microphonics	-	1.65	2.4
Total power: beam + microphonics/2 subunits	**[kW]**	**1.29**	**3.74**
3 dB width Qext minimizing RF-power	**[Hz]**	**22**	**18**
Total RF- power	**[kW]**	**825**	**2400**
Peak beam power before radiation	[MW]	10	20
Beam power at beam dump	**[MW]**	**0.50**	**0.25**

Example: 1 mA= 1 nC @ spacing 1 μs



Length of the pulse and power/FPC vs. En

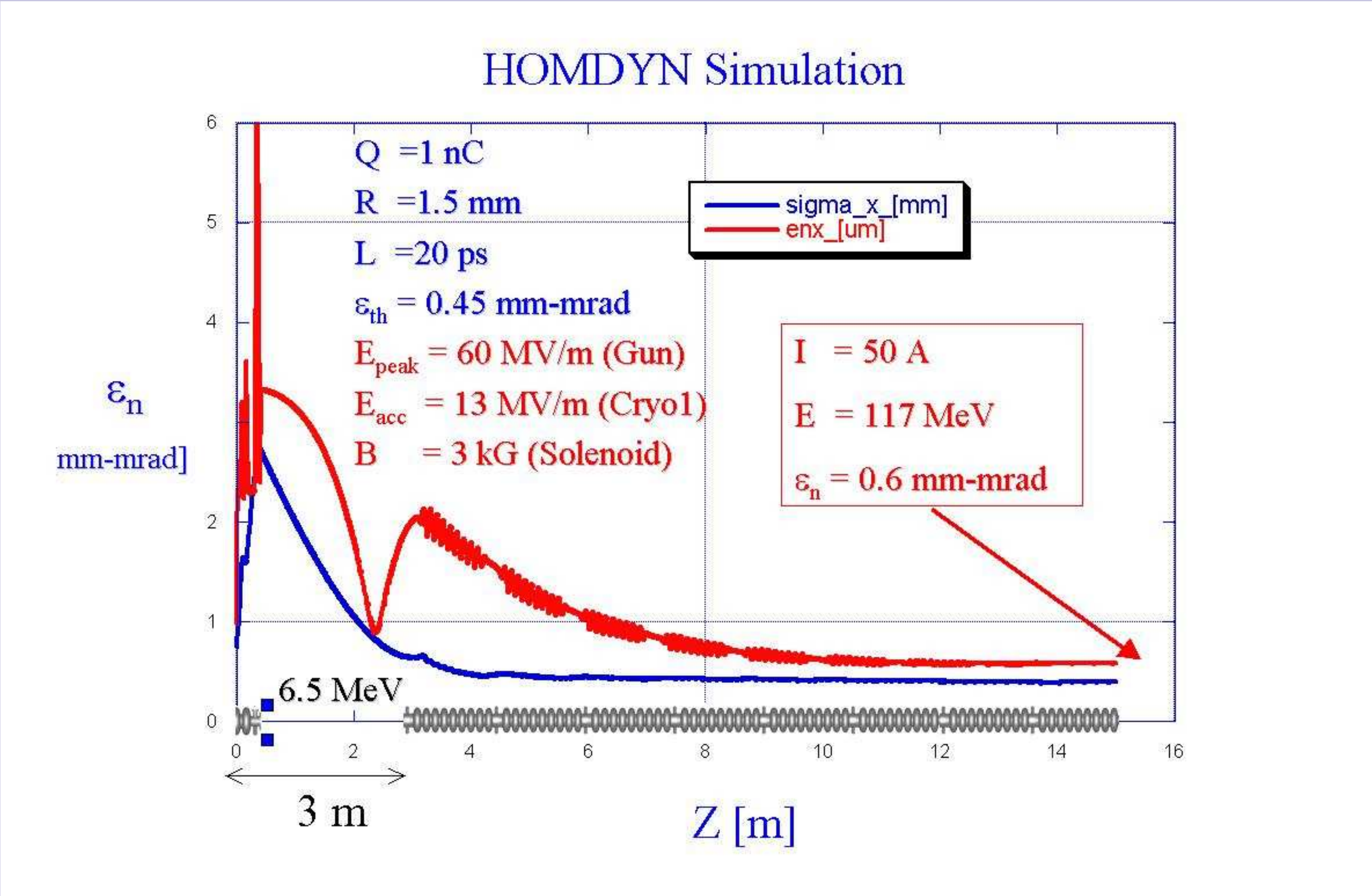


25 000 bunches/s

But this may require additional RF

How realistic is this layout ?

1. Injector (optics):



Injector (RF-gun):

DESIGN, CONSTRUCTION AND STATUS OF ALL NIOBIUM SUPERCONDUCTING PHOTOINJECTOR AT BNL

T. Srinivasan-Rao, I. Ben-Zvi, A. Burrill, G. Citver, A. Hershcovitz, D. Pate, A. Reuter, J. Scaduto, Q. Zhao, Y. Zhao, BNL, Upton, NY, USA

J. Delayen, P. Kneisel, TJNAF, Newport News, VA, USA

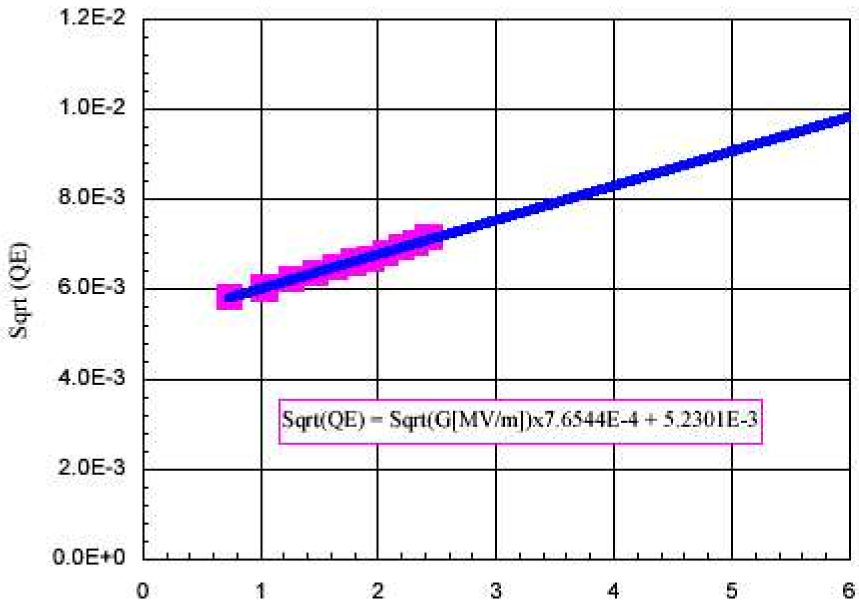
H. Bluem, M. Cole, A. Favale, J. Rathke, T. Schultheiss, Advanced Energy Systems, Medford, USA

Figure 4: Photograph of ½ cell Nb cavity

Ready for cold test: QE? Thermal Effects?

M. Ferrario

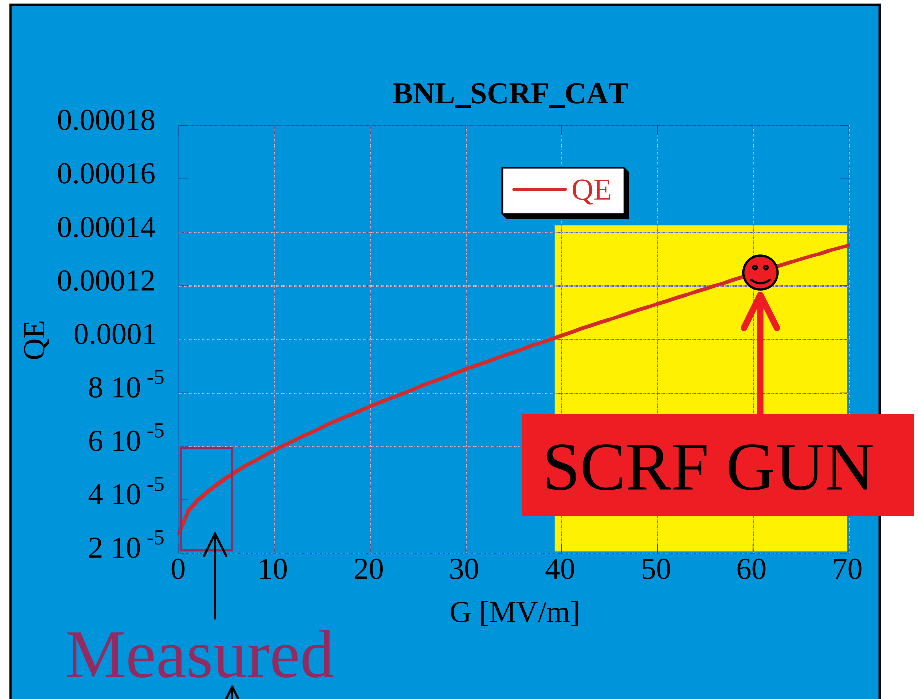
Measurements at room T on a dedicated DC system



$$\eta = K\left(h\nu - \phi_o + \sqrt{e/4\pi\varepsilon_o}\sqrt{E_s}\right)^2$$

$\eta = QuantumEfficiency$
$h\nu = PhotonEnergy$
$\phi_o = ElectronWorkFunction$
$K = Const.$
$E_s = AppliedElectricField$

Extrapolation to Higher Field



Limited by the available voltage

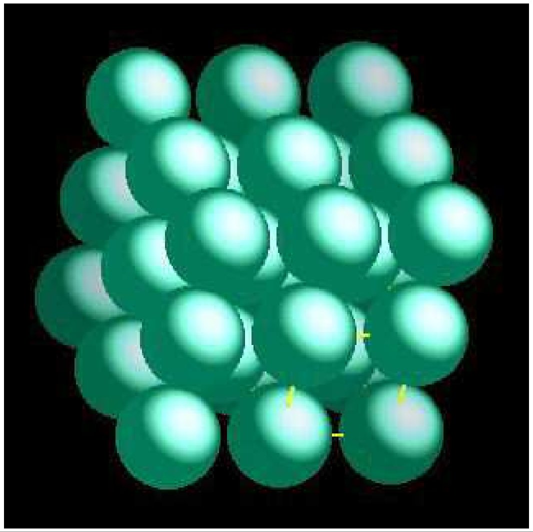
What should we look at to improve QE ? :

- Photon energy use at BNL is 4.66 eV (λ=266 nm)
  Work Function for Nb is : 4.0÷4.9 eV

- Is Nb the best superconductor for the photoemission ?

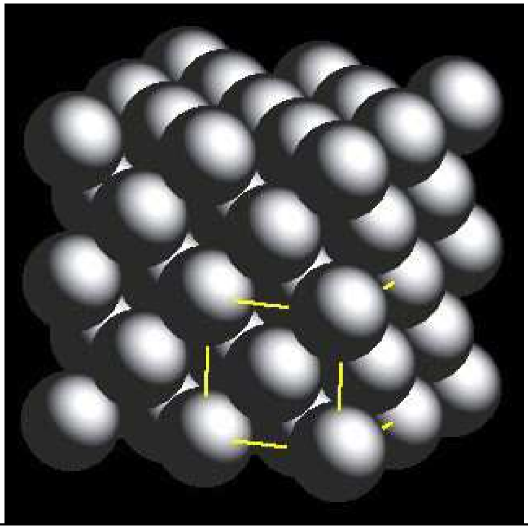
Cs (WF=2 .1 eV)

a /pm	*b* /pm	*c* /pm
614	614	614
α / °	β / °	γ / °
90	90	90



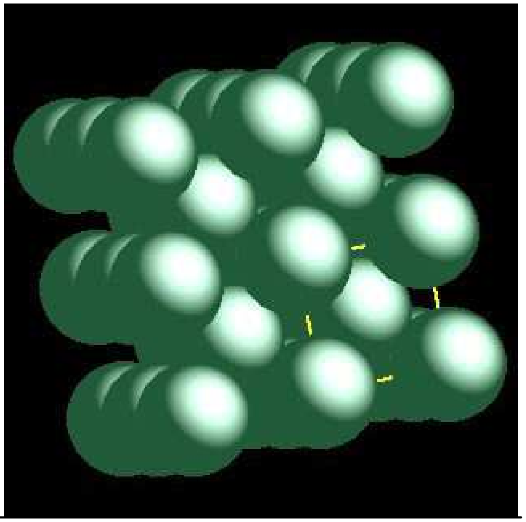
Pb (WF= 4.2 eV)

a /pm	*b* /pm	*c* /pm
495	495	495
α / °	β / °	γ / °
90	90	90



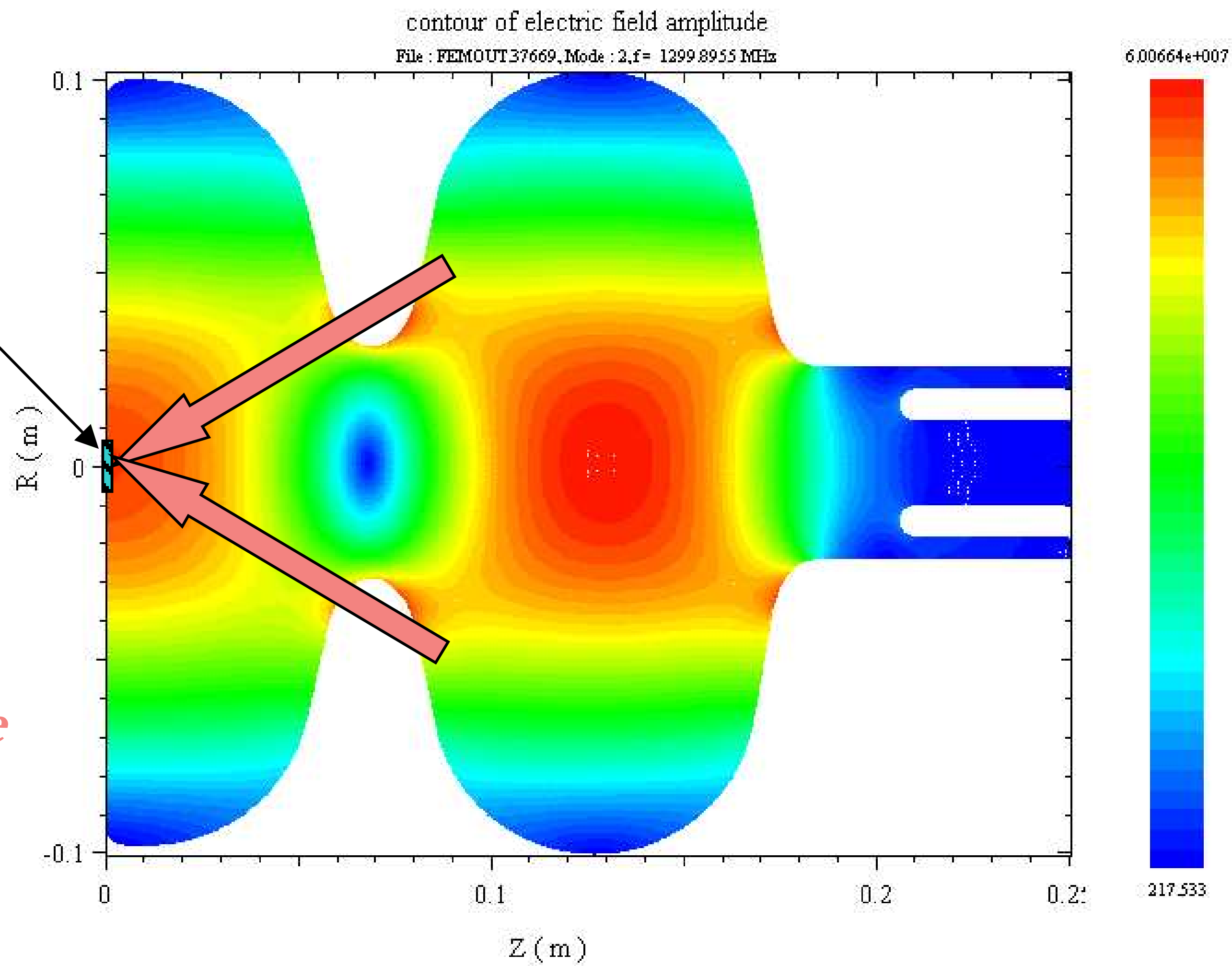
Nb (WF= 4.9 eV)

a /pm	*b* /pm	*c* /pm
330	330	330
α / °	β / °	γ / °
90	90	90



If Pb is the better photo-emitter

What technique can be used to place Pb at the Nb surface ?

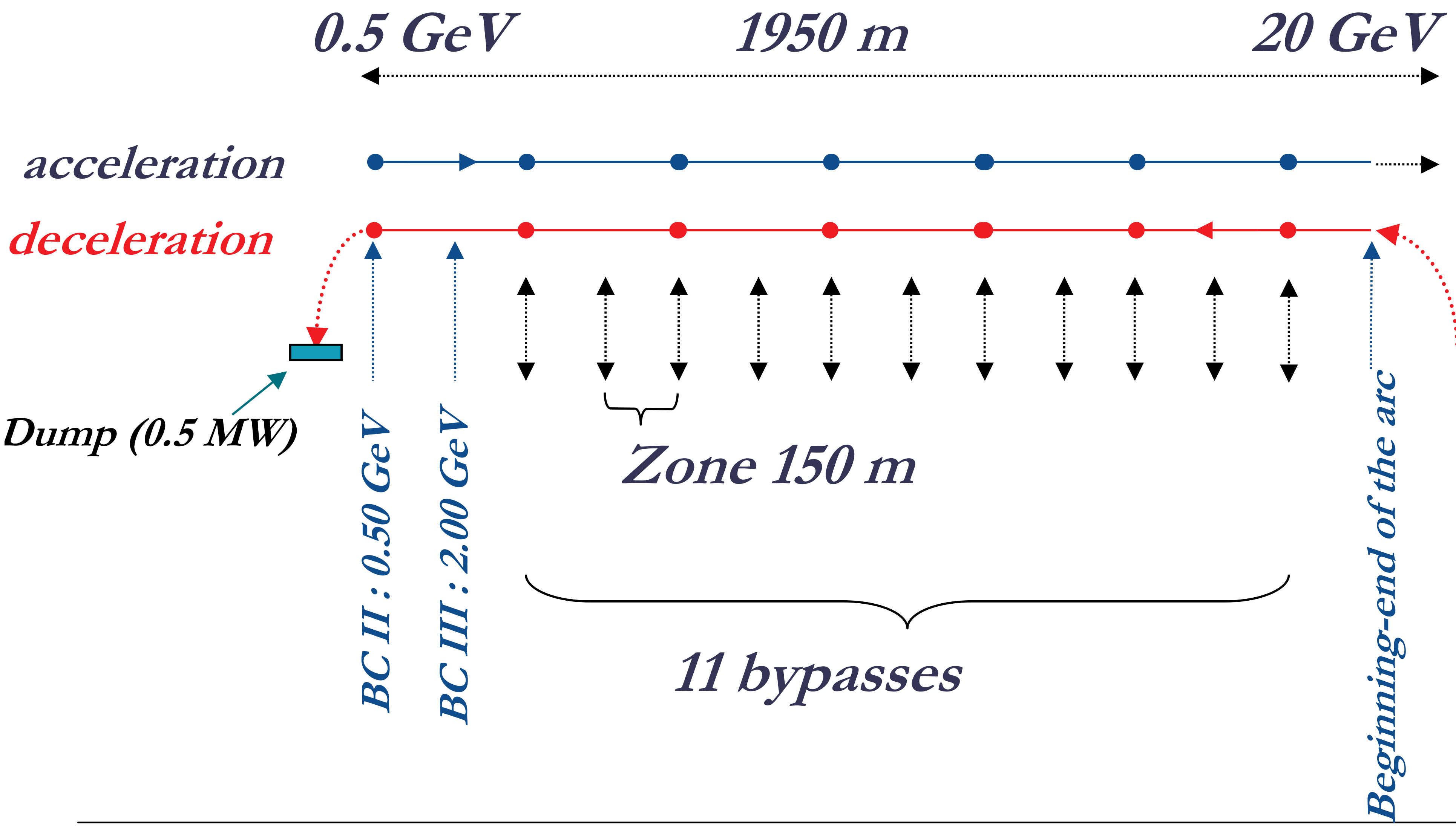


Is it better to illuminate cathode with one laser beam or two beams ?

We have here more questions than answers

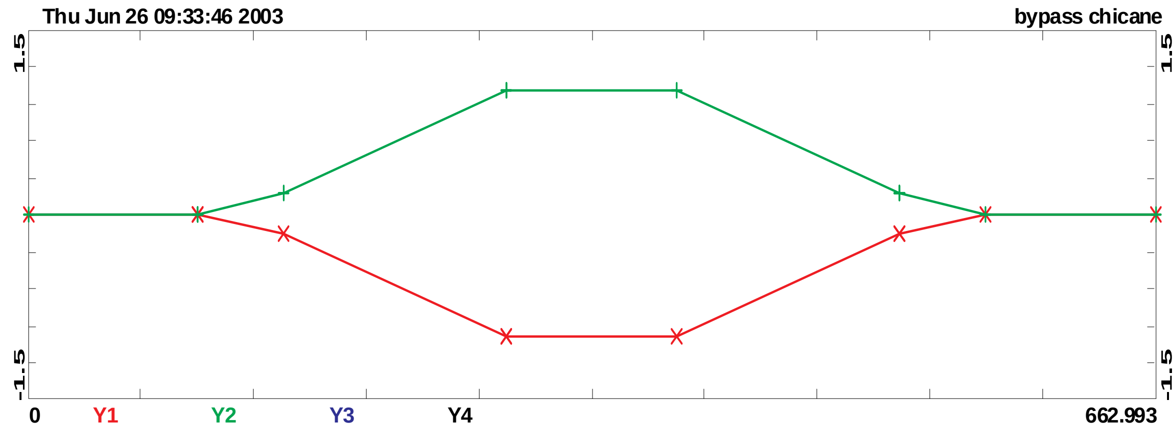
Cont. "How realistic is this layout ? "

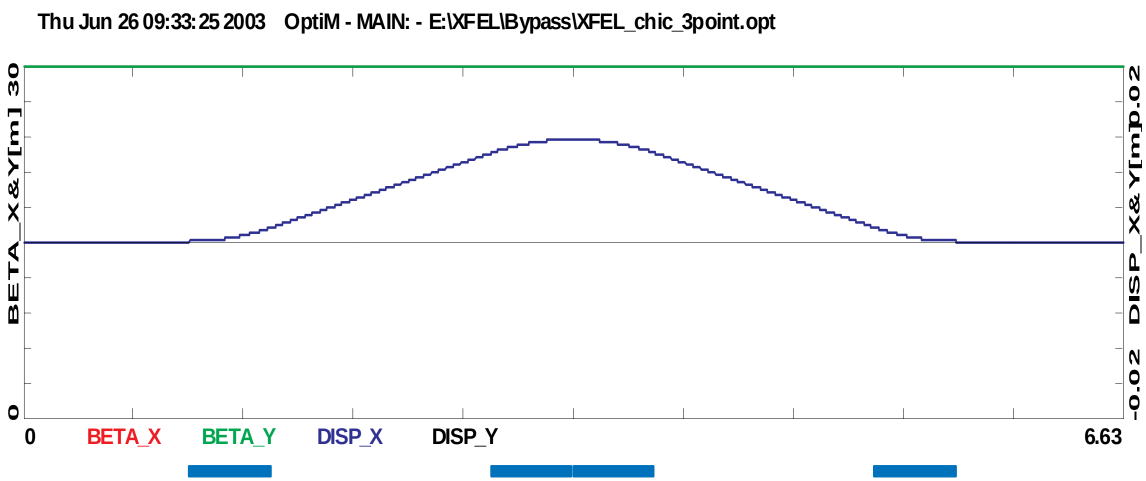
There is no beam-beam interaction !!!!!



A. Bogacz

Bypass chicane





Energy: 18 GeV

Beams separation: 2×10 mm

Chicane length: 463 cm

Dipole magnet:

L = 50 cm

θ_{bend} = 0.366 deg

ρ = 78 m

B = 7.7 kG

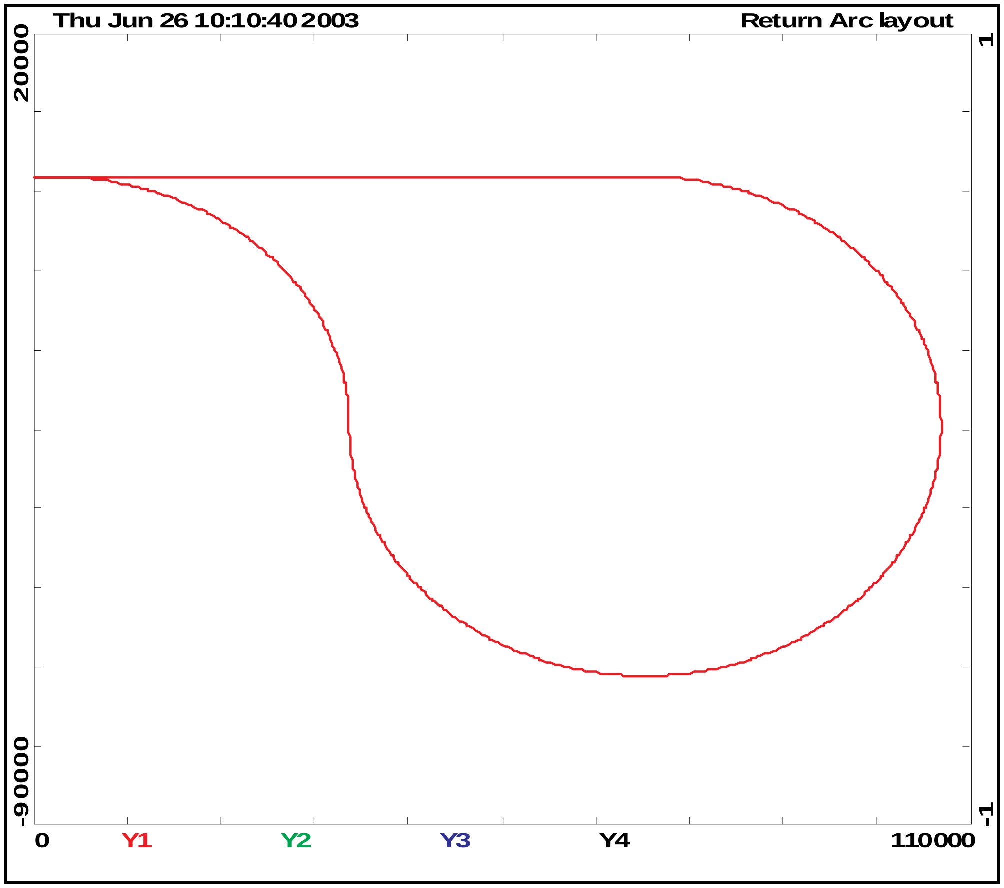
SR losses: 482 keV

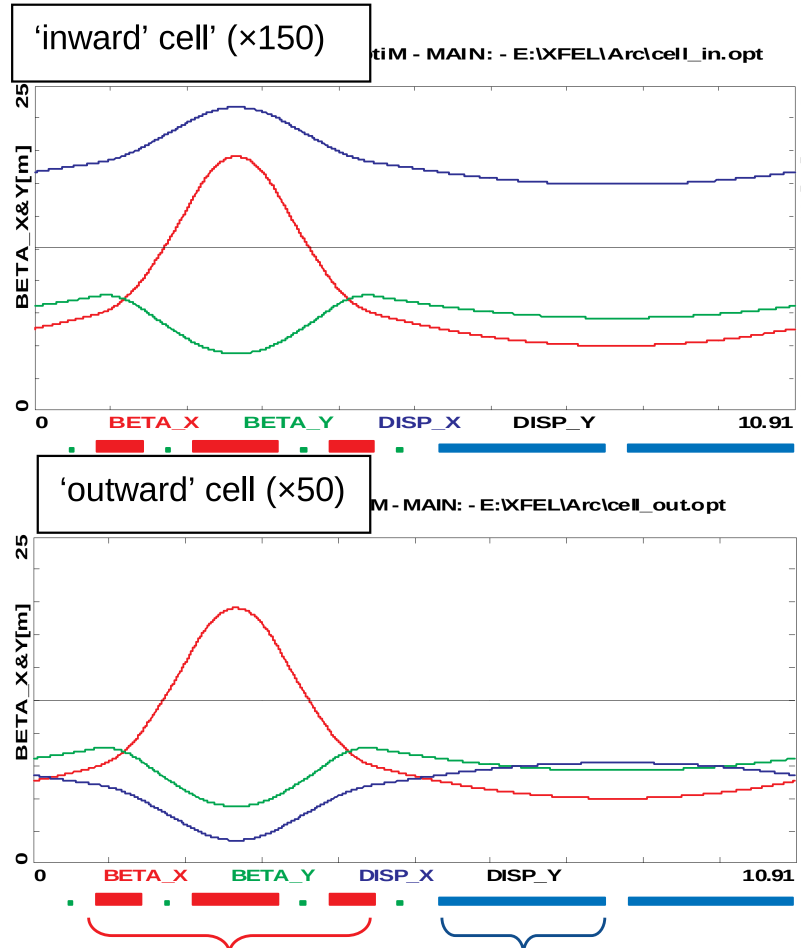
D_{max} = 1 cm

M_{56} = -0.13 mm

A. Bogacz

"Teardrop" Return Arc





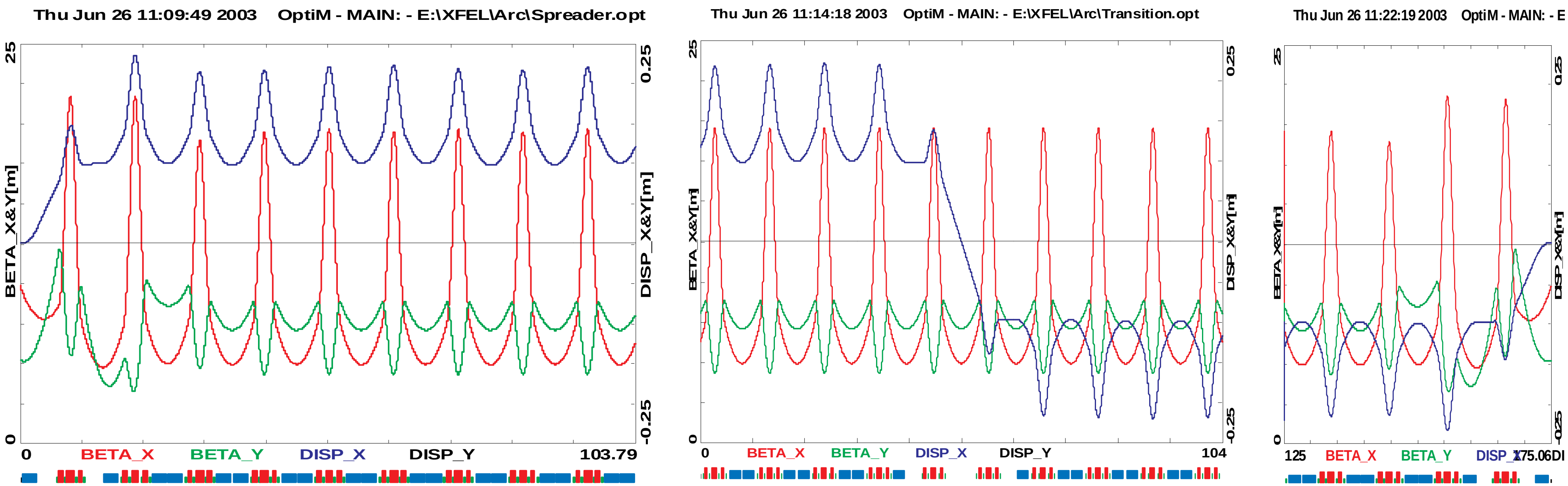
Total Length: 2929 m
D_{max} = 22 cm
D_{dip} = 10 cm
M_{56} = 64 cm
SR losses: 93 MeV (0.45%)

Quadrupole triplet (×200)
L_F = 125 cm
G_F =3 kGauss/cm
L_D = 68 cm
G_D = -3 kGauss/cm

Dipole magnet (×400)
L = 240 cm
θ_{bend} = 0.9 deg
ρ = 153 m
B = 4.4 kGauss

A. Bogacz

“Teardrop” Return Arc Optics



- *achromatic*
- *uniform periodic focusing (π/2 phase advance per cell)*
- *adjustable momentum compaction (M_{56})*

Cont. “How realistic is this layout ? “

Cryostats

Two types of cryostat are under consideration:

- TTF-like, 12 m : housing 8 cavities, space=3λ/2: OK
- TESLA-like, 17 m : housing 12 cavities, space≠ n·λ/2: not OK

We believe that cryostat for ER linac should be optimized

For ER linacs power transferred to a sc cavity is small, we can lower capital costs keeping number of FPC low.

⇩

Cavities can have many cells

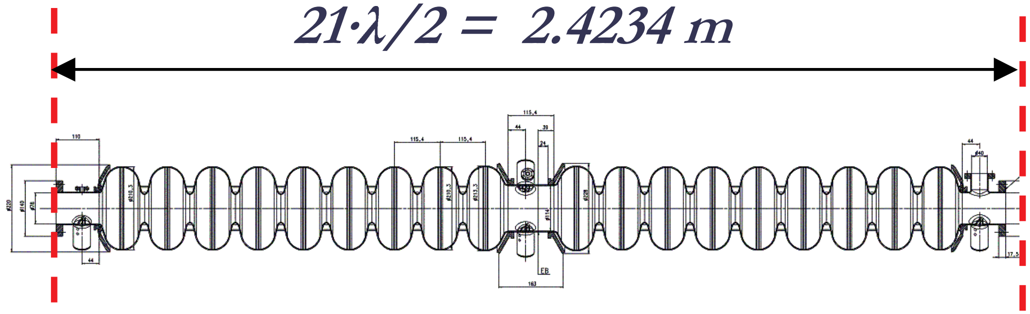
2x7-cell or 2x9-cell SSTs seem to be an attractive option

Building blocks

SST+sc bellows

at 15 MV/m: 31.25 MeV

$21 \cdot \lambda/2 = 2.4234$ m

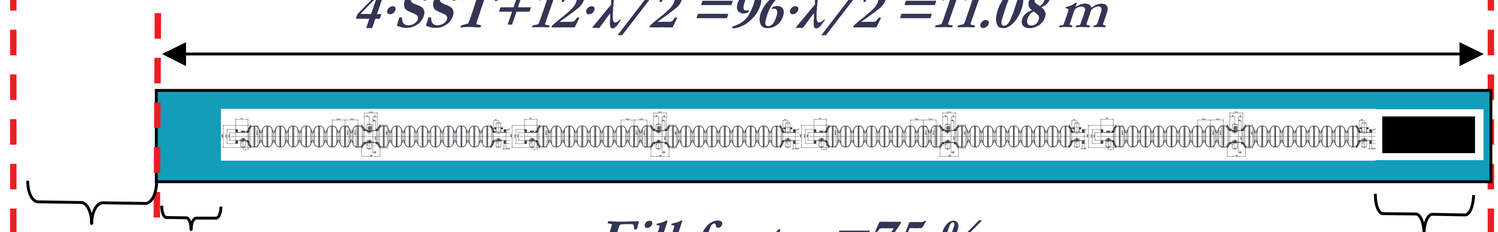


12.002 m

Cryostat

125 MeV

$4 \cdot SST + 12 \cdot \lambda/2 = 96 \cdot \lambda/2 = 11.08$ m

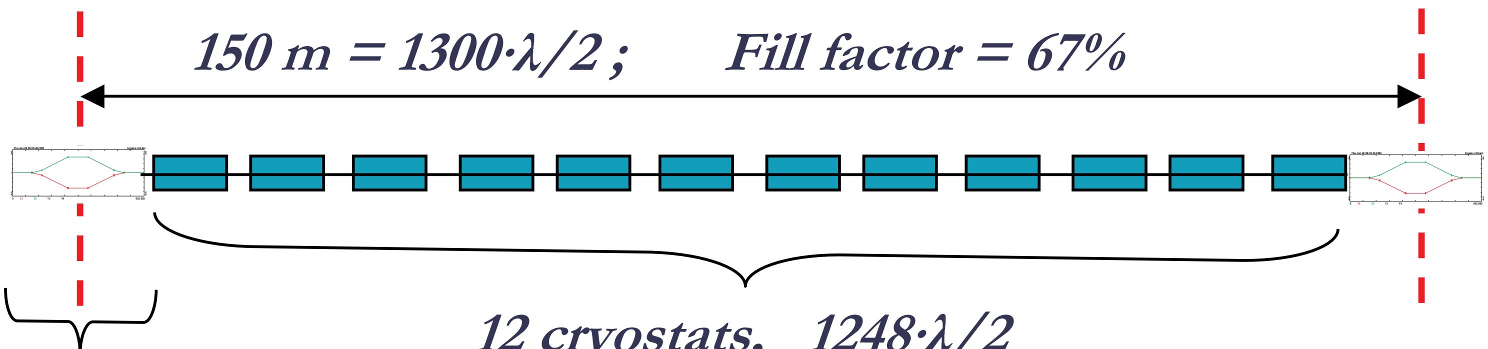


$8 \cdot \lambda/2$ $4 \cdot \lambda/2$ Fill factor=75 % $8 \cdot \lambda/2$

Zone between 2 bypasses

1.5 GeV

150 m = $1300 \cdot \lambda/2$; Fill factor = 67%



12 cryostats, $1248 \cdot \lambda/2$

Bypass, $52 \cdot \lambda/2$

How much does the RF cost ?

We have here practically 2 solutions:

Solid state amplifiers ~ 5 kW/FPC ⇒ 6 M€ (Simrock)

16 kW klystrons (CEBAF 12 GeV upgrade) ⇒ 16 M€

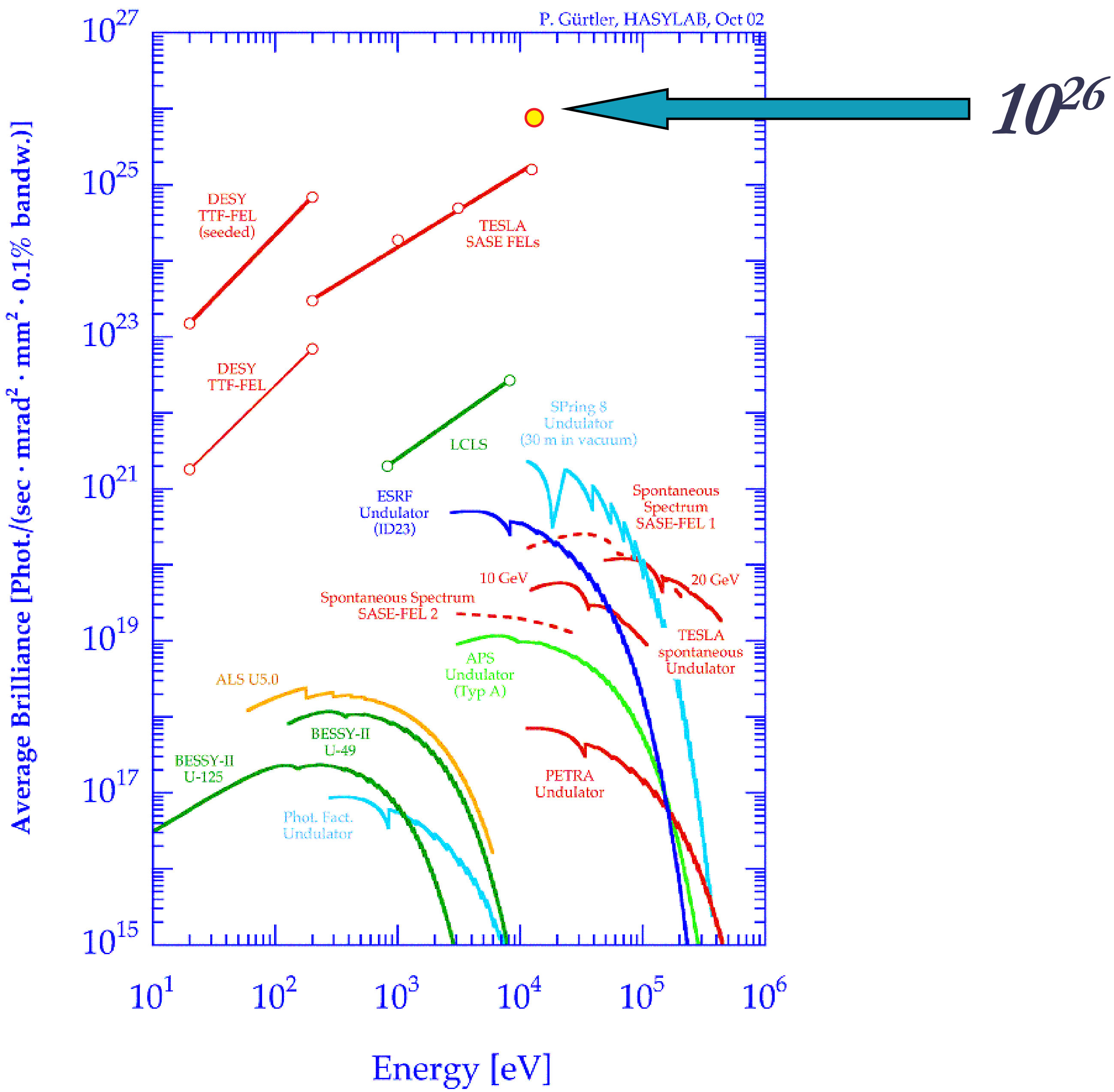
Summary

Needed R&D :

- *cw RF gun*
- *suppression of microphonics*
- *more experience with the energy recovery*

Total AC power for Cryoplant + RF < 10 MW

But we will have :   6 x more bunches /s



P. Gürtler, HASYLAB, Oct 02
10^{26}
Average Brilliance [Phot./(sec · mrad² · mm² · 0.1% bandw.)]
Energy [eV]
DESY TTF-FEL (seeded)
TESLA SASE FELs
DESY TTF-FEL
LCLS
SPring 8 Undulator (30 m in vacuum)
ESRF Undulator (ID23)
Spontaneous Spectrum SASE-FEL 1
10 GeV
20 GeV
Spontaneous Spectrum SASE-FEL 2
TESLA spontaneous Undulator
APS Undulator (Typ A)
ALS U5.0
BESSY-II U-49
BESSY-II U-125
PETRA Undulator
Phot. Fact. Undulator