TLEP6 Summary

Accelerator // session

J. Wenninger / F. Zimmerman

Presentations

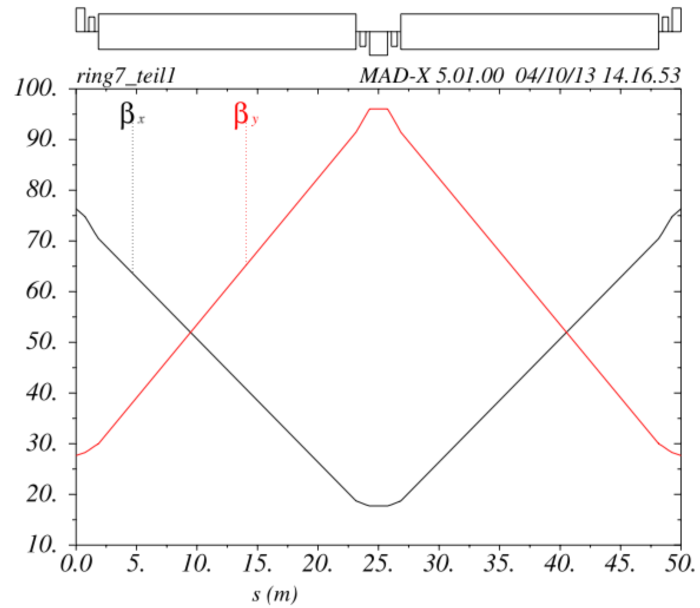
- TLEP Optics version 1 (9) – B. Holzer
- Chromatic Correction for TLEP Interaction Region – H. Garcia Morales
- Scaling & Assumptions for MDI, Collimation & Shielding – M. Boscolo
- Polarization Wigglers for TLEP and Lessons from LEP – J. Jowett
- FLUKA Status and Plan – L. Lari
- Update on TLEP Vacuum Design – R. Kersevan
- Another look at IP parameters and luminosity of TLEP – A. Bogomyagkov
- CEPC Accelerator Study – H. Geng
- CEPC Machine Optimization and Final Focus Design – D. Wang

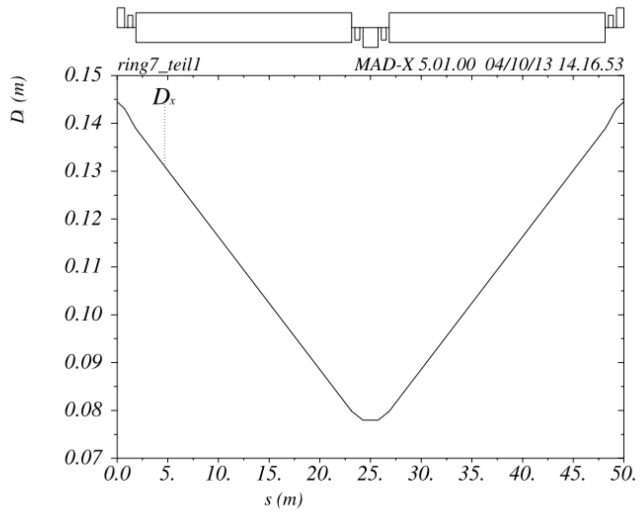
With input from A. Blondel & S. White's presentations @ plenary

B. Holzer

- Lattice for 175 GeV.
- FODO with cell length 50 m
  - 90°/60° LEP-like phase
  - Dipole 2 x (2 x11)

- Other cell structures will be evaluated in the near future.



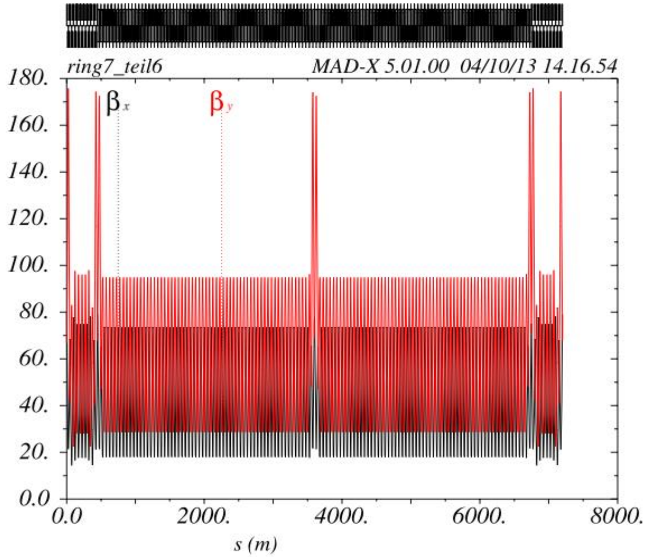


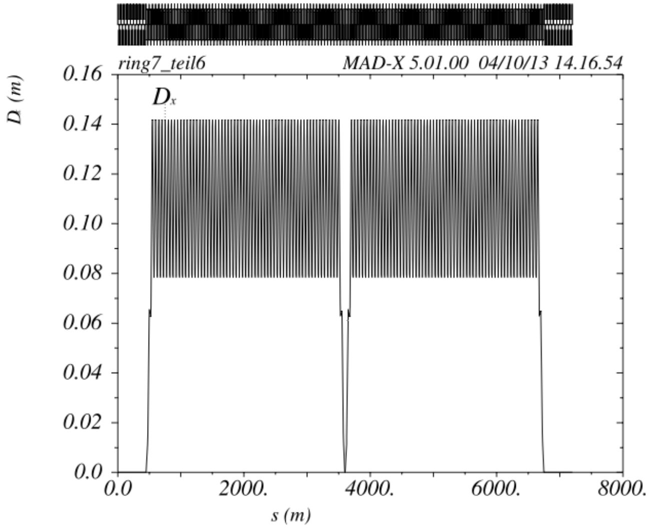
Lattice optics

B. Holzer

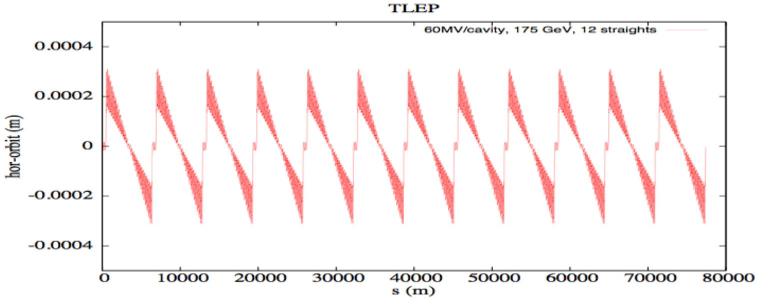
- Modular arc & long straight sections (SS).
  - IR can be easily inserted.
  - So far 12 long and 12 short SS.
    - 12 LSS = 8 RF & 4 RF + low beta (IP).

ε_x = 1.6 nm

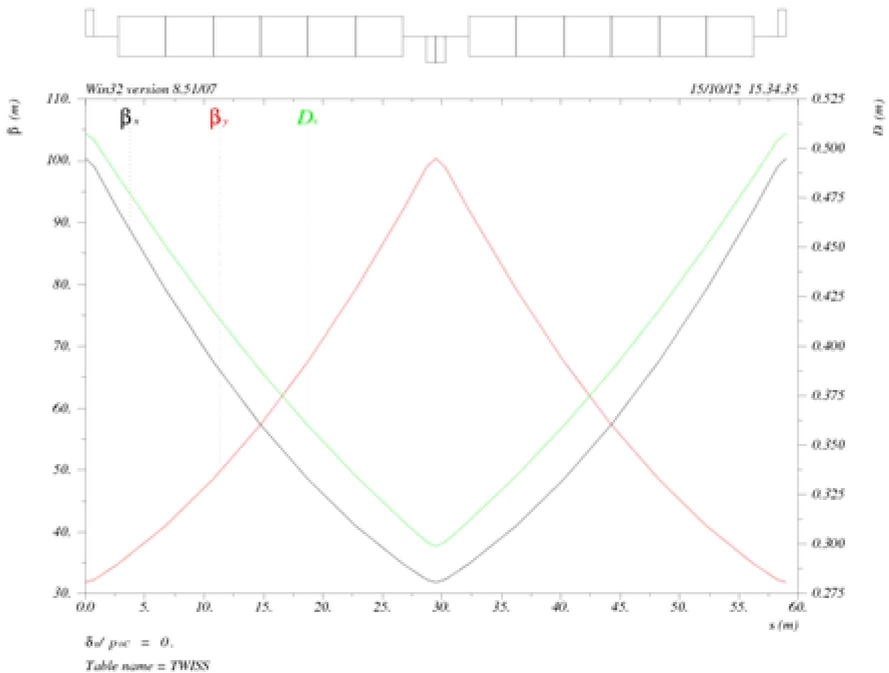




79.9 km long

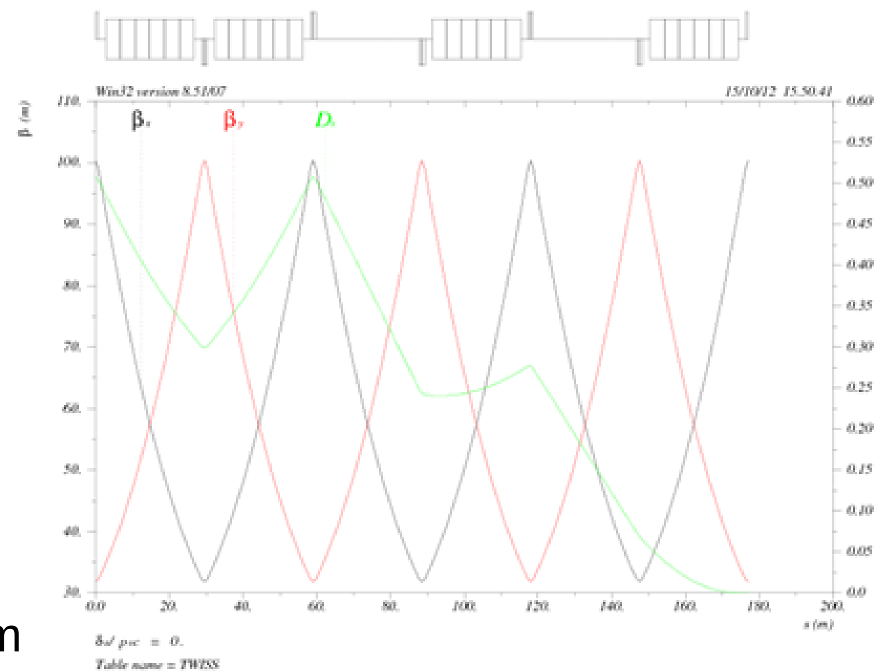


CEPC Lattice



Dou Wang

Dispersion suppressor

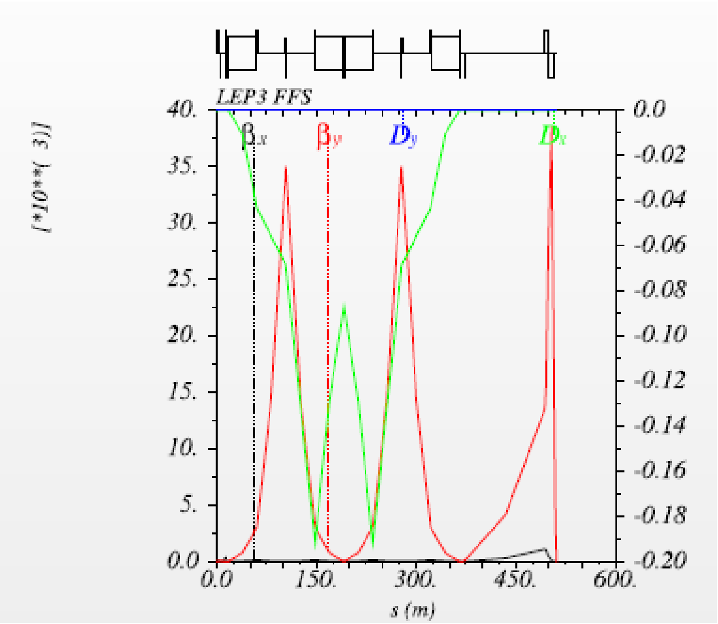


- 60° FODO cells in arc
- 16-fold symmetry
- SC cavities and other cryogenic system are inserted in 14 linear sections.

❑ Very similar to current TLEP arc

IR / Final Focus System (FFS)

- FFS with local chromaticity correction for the vertical plane.
  - *Using horizontal dispersion and normal sextupoles.*
  - *No local horizontal correction required – β_y* 1m versus β_y* 1mm.*



FFS parameters

- $L_{\mathrm{FFS}} = 511\,\mathrm{m}$
- $L^* = 3.5\,\mathrm{m}$
- $L_{\mathrm{QD0}} = 7.90\mathrm{m}$
- $k_{\mathrm{QD0}} = -0.034262\mathrm{m}^{-2}$

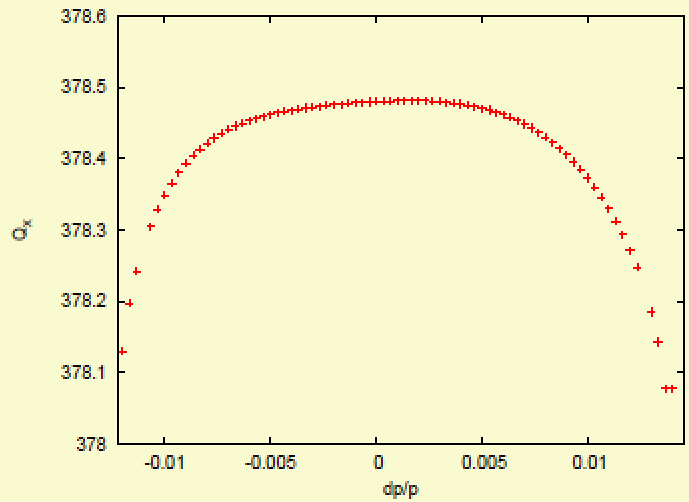
- Strong requirement of momentum aperture of +- 2%.
  - *Beamstrahlung lifetime.*

H. Garcia

Momentum acceptance

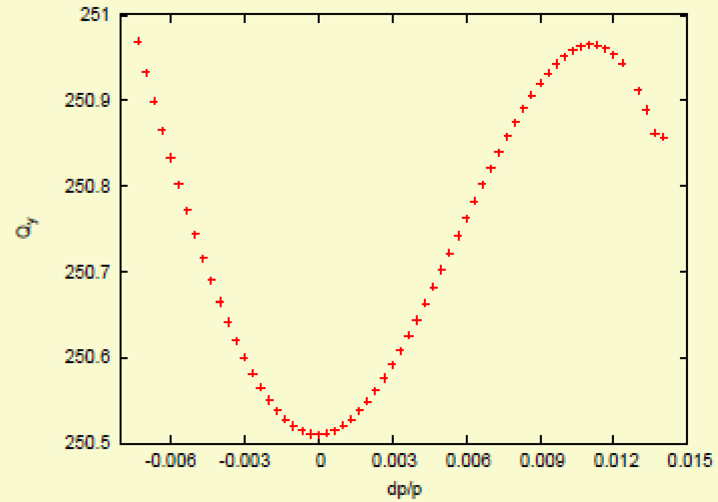
- Stability region not yet large enough : ≤ 1%.

$Q_x = 378.48$



- Relatively small plateau for $dp/p = \pm 1\%$.

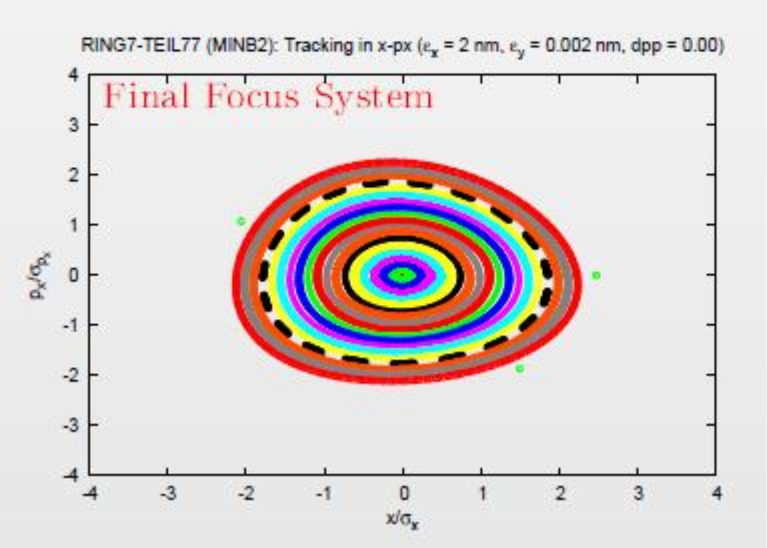
$Q_y = 250.51$



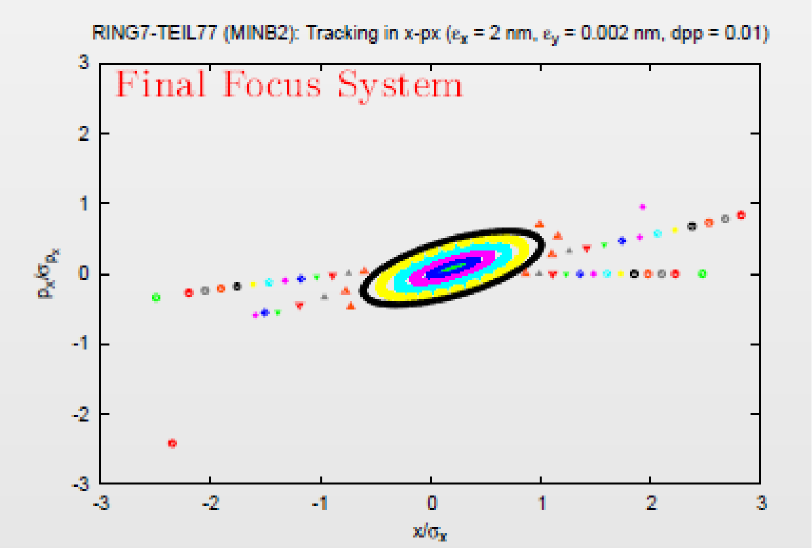
- Some third order contributions remain.
- Almost $dp/p = \pm 1\%$ stability.

Dynamic aperture

- H plane, dp/p = 0



- H plane, dp/p = 1%



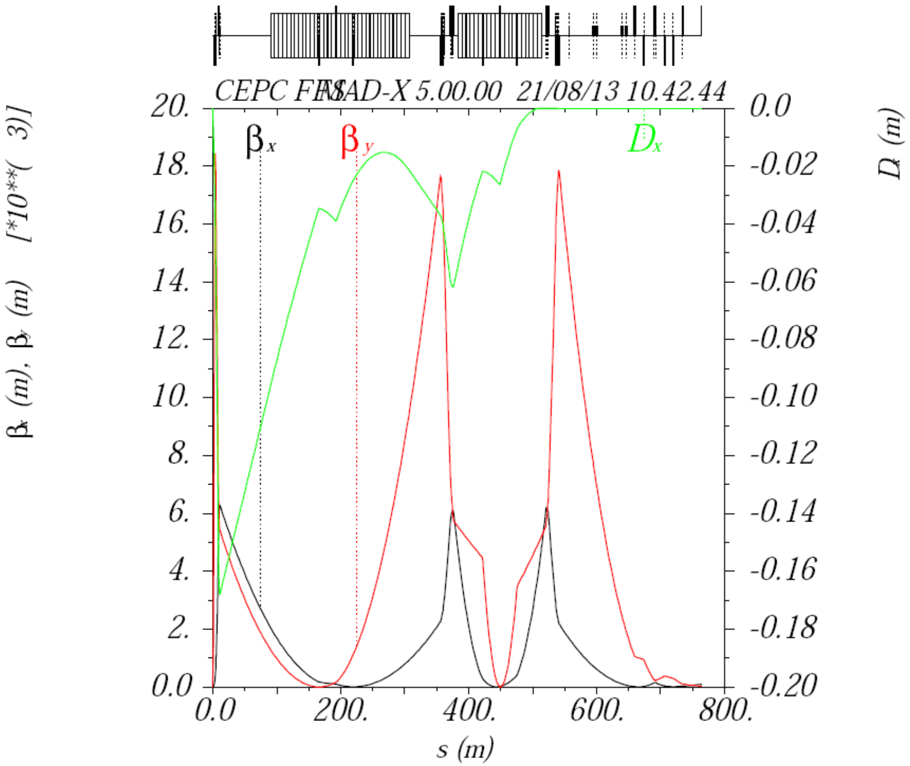
- Possible cures:
  - *Add horizontal local chromaticity correction.*
  - *Match arc cell sextupole phase-advance.*
  - *Match IP phase advances.*
  - *…*

Critical area where more work is needed

CEPC IR

- Local chromaticity correction schemes.
- Local compact FFS design with L* = 1.5m.
- Local non-compact design.
  - *Vertical β* of 1 mm and 0.35 mm.*

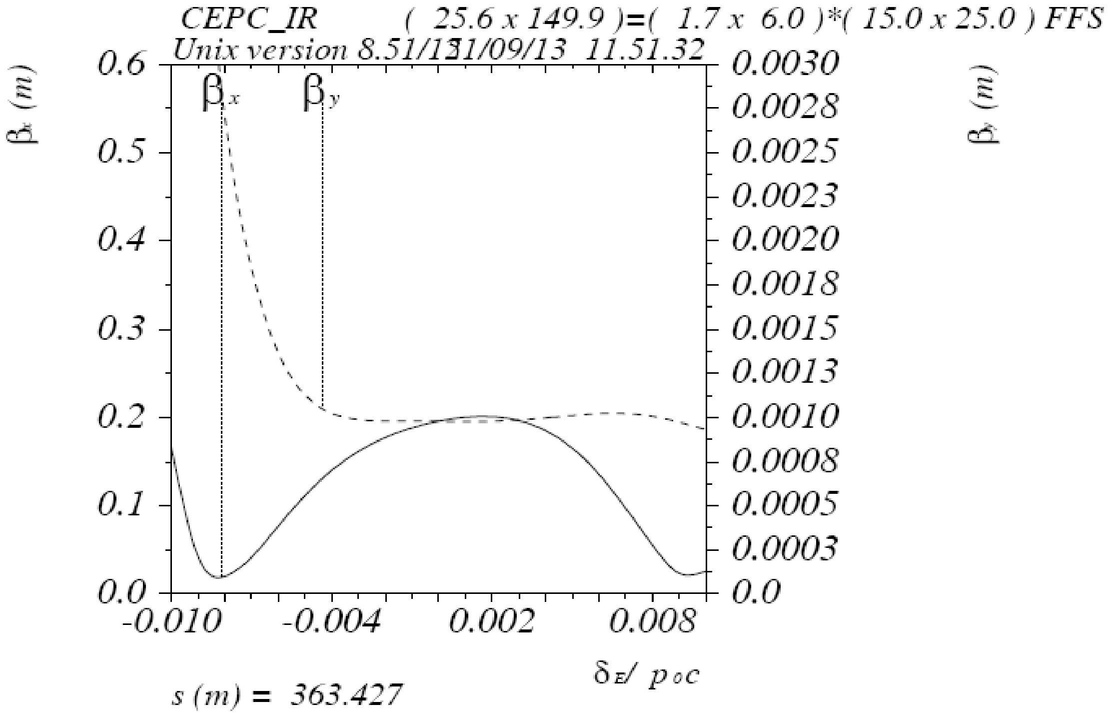
⟺ Sextupole arrangement



Dou Wang

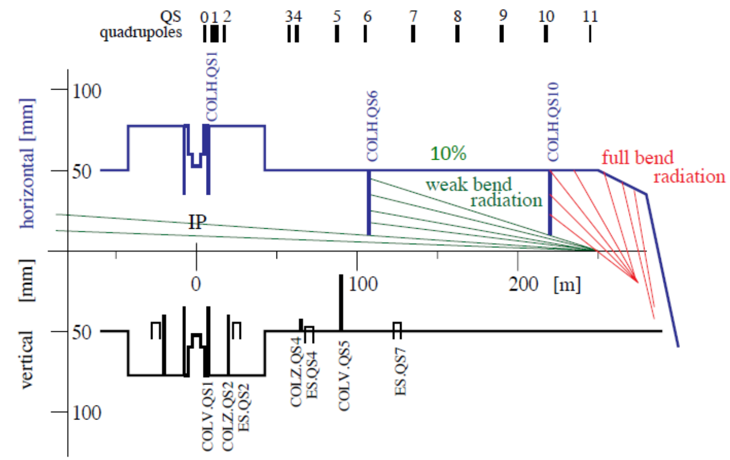
Acceptance

- No dynamic aperture was shown, only IP optics versus dp/p



- Clearly lot's of synergies between CEPC and TLEP IR !

- Many issue at the machine-exp interface:
  - *Optimization of detector acceptance,*
  - *Solenoids and their compensation,*
  - *Background conditions (SR, beam-gas, bhabha…)*
  - *….*



LEP IR

- The tools are available, but we need to work on some IR design first (linked to the number and arrangement of rings):
  - *L*,*
  - *Crossing angles,*
  - *Number of beam pipes…*

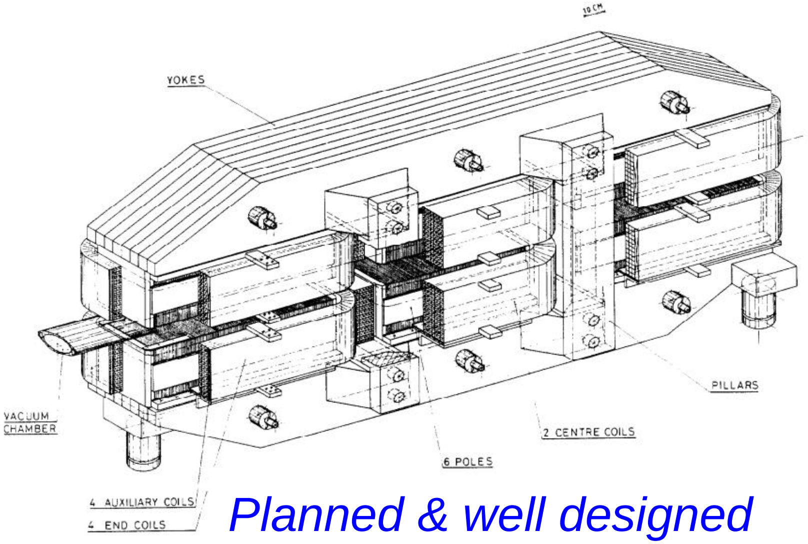
M. Boscolo

Wigglers & polarization

- From LEP

The nice guys

emittance & damping control



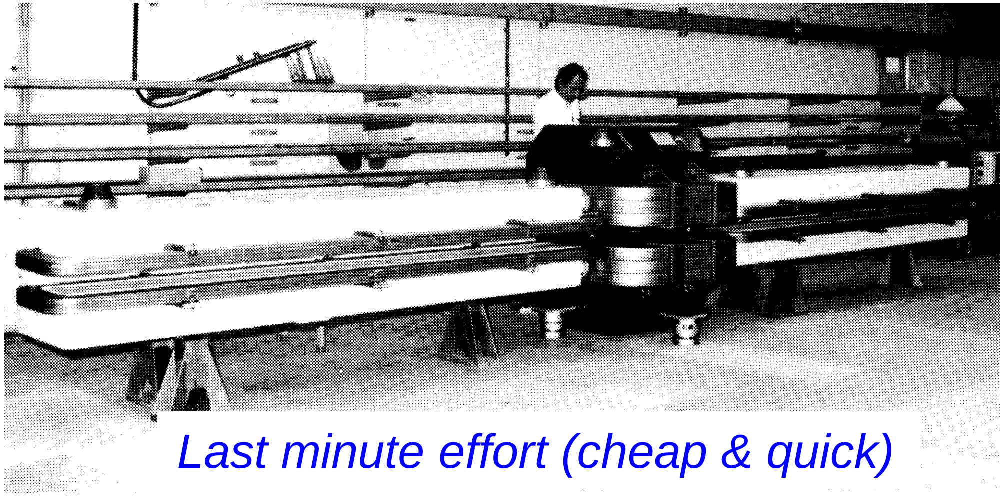
Planned & well designed

Fig. 3 Proposed LEP wiggler magnet

The bad guys

~~polarization~~ & damping control

essential for LEP2 !!



Last minute effort (cheap & quick)

J. Jowett

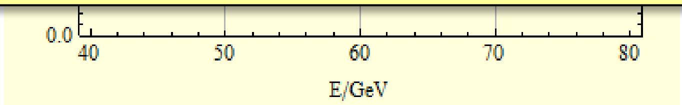
Wiggler & polarization

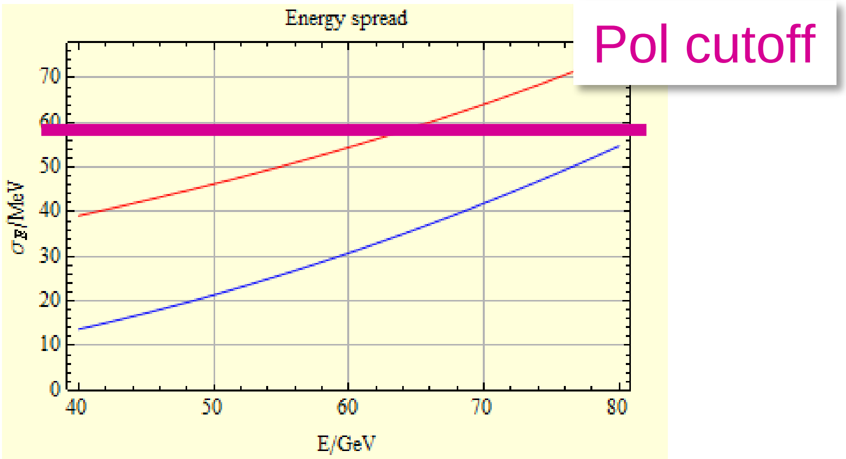
- Interest in wigglers: reduce polarization time τ from 150 hours.
  - *Balance between τ gain and energy spread that kills polarization → from LEP limit at ~ 60ish MeV.*

See also A. Blondel:

- Possible compromise for reduction of τ to ~12 h → ~1 h for 10%-ish P.

- 20% of the total power loss from the wigglers !





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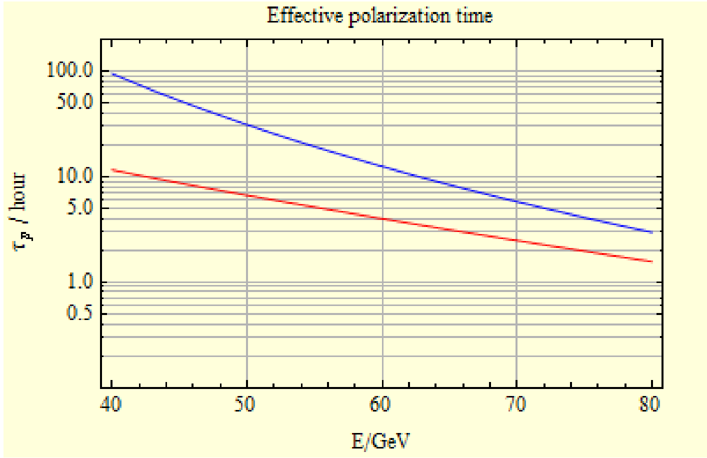
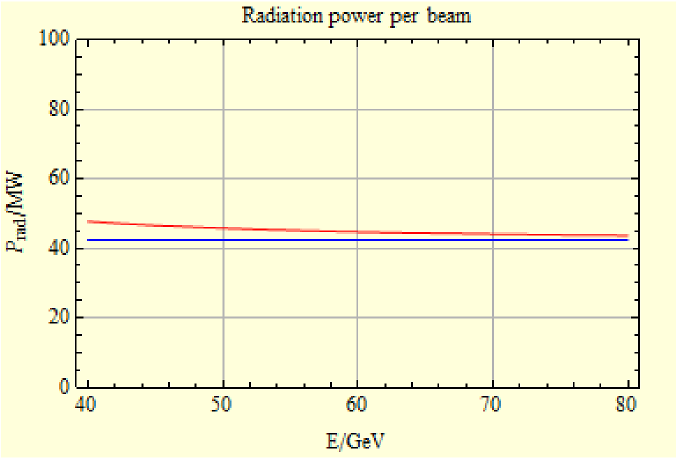




TLEP $HZ^0W^-W^+t\bar{t}$

- Another analysis of the beamstrahlung lifetime:

A. Bogomyagkov

V.I.Telnov

$$\tau_{bs} = \frac{10}{f_0}\frac{4\sqrt{\pi}}{3}\sqrt{\frac{\eta}{\alpha r_e}}\exp\left(\frac{2}{3}\frac{\eta\alpha}{r_e\gamma^2}\times\frac{\gamma\sigma_x\sigma_s}{2r_eN_p}\right)\frac{2}{\sigma_s\gamma^2}\left(\frac{\gamma\sigma_x\sigma_s}{2r_eN_p}\right)^{3/2} \quad (8)$$

Ours

$$\tau_{bs} = \frac{1}{f_0}\frac{4\sqrt{\pi}}{3}\sqrt{\frac{\eta}{\alpha r_e}}\exp\left(\frac{2}{3}\frac{\eta\alpha}{r_e\gamma^2}\times\frac{\gamma\sigma_x\sigma_s}{\sqrt{2}r_eN_p}\right)\frac{\sqrt{2}}{\sqrt{\pi}\sigma_s\gamma^2}\left(\frac{\gamma\sigma_x\sigma_s}{\sqrt{2}r_eN_p}\right)^{3/2} \quad (9)$$

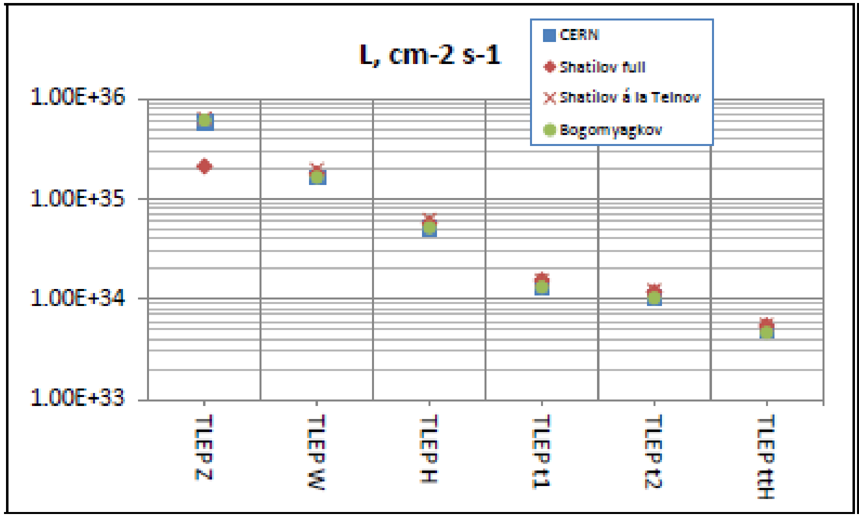
Starting point

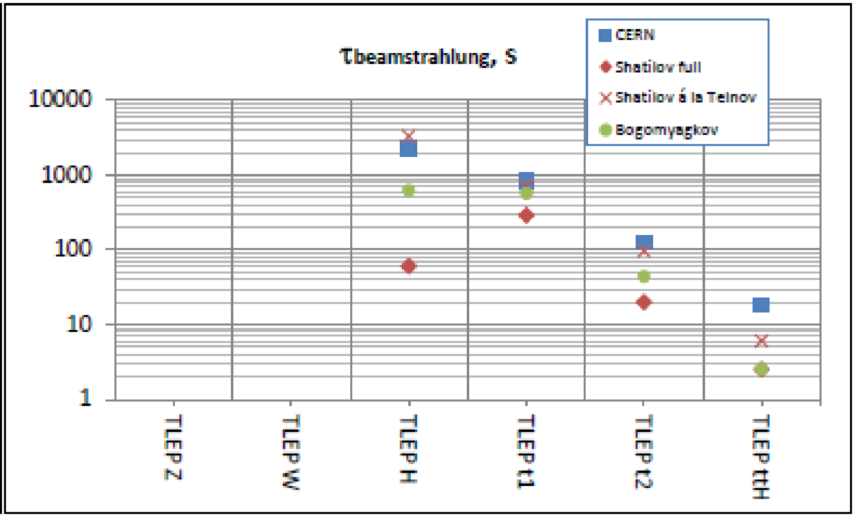
	Z	W	H	t		ttH, ZHH
E_{beam}, Gev	45	80	120	175		250
Current[mA]	1440	154	29.8	6.7		1.6
$N_{bunches}$	7500	3200	167	160	20	10
$N_{particles}[10^{11}]$	4.0	1.0	3.7	0.88	7.0	3.3
$\varepsilon_x[nm]/\varepsilon_y[pm]$	29.2/60	3.3/17	7.5/15	2/2	16/16	4/4
$\beta^*_x[m]/\beta^*_y[mm]$	0.5/1	0.2/1	0.5/1	1/1		1/1
$\sigma_s[mm]$	2.93	1.98	2.11	0.77	1.95	1.81
F_{hg} hourglass	0.61	0.71	0.69	0.90	0.71	0.73
$L/IP[10^{32}cm^{-2}s^{-1}]$	5860	1640	508	132	104	48
ξ_x/IP	0.068	0.086	0.094	0.057		0.075
ξ_y/IP	0.068	0.086	0.094	0.057		0.075
τ_L, s	5940	2280	1440	1260	1560	780
$\tau_{bs}(\eta = 2\%)[s]$	$> 10^{25}$	$> 10^6$	2280	840	126	18
$P_{SR}[MW]$	50	50	50	50	50	50

Luminosity & beamstrahlung

Tools:

- Computer simulation with Lifetrac [D.Shatilov] modified to include full spectrum of beamstrahlung, quasi strong-strong model.
- Analytical: more accurate calculation than by V.I.Telnov, quasi strong-strong model, radiation integrals.





Luminosity : good agreement, except for TLEPZ → lower beam-beam tune shift limit found – blow-up.

In agreement with LEP Z, $\xi \sim 0.035$

Lifetimes are lower…

Consistent with S. White's results !

Luminosity optimization

TLEP
$HZ^0W^-W^+t\bar{t}$

- Boost of TLEPZ lumi by crab waist,
- Optimization of BS lifetimes

To be considered for updated parameters !

Blue – value decreased, red – value increased.

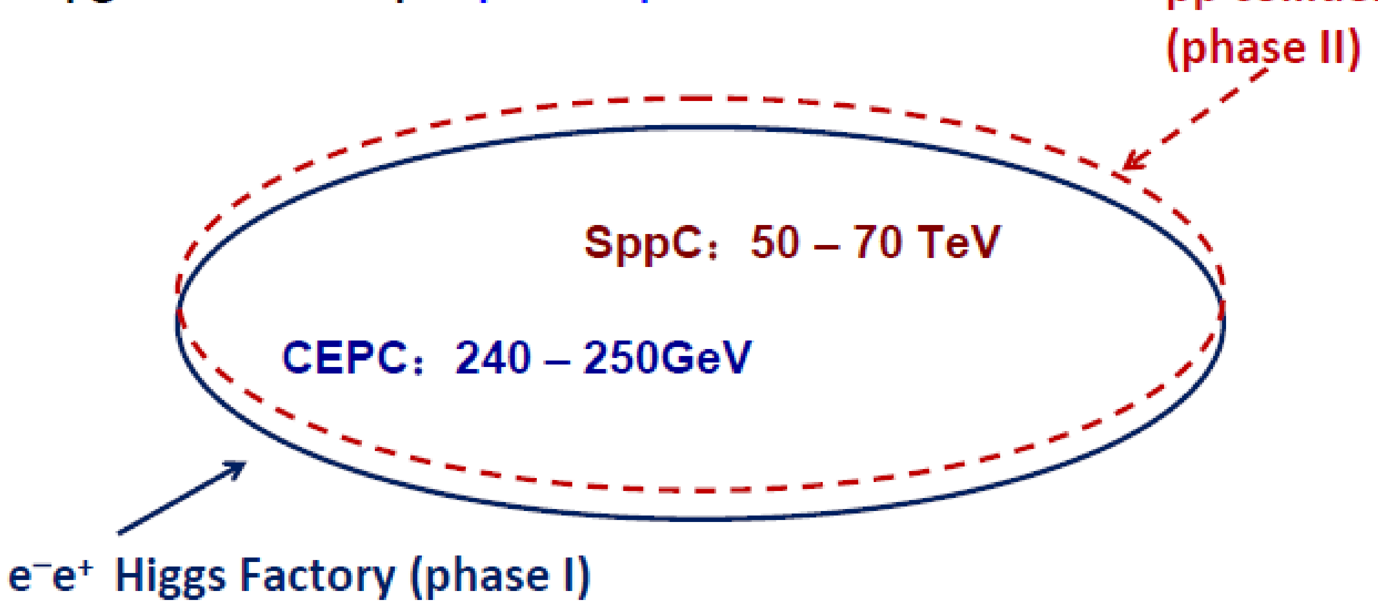
	Z	W	H	t	ttH, ZHH
2θ, mrad	70	0	0	0	0
Current[mA]	973	163	29	6.6	1.6
$N_{bunches}$	7500	8500	1200	120	24
$N_{particles}[10^{11}]$	2.7	0.4	0.5	1.15	1.4
$\varepsilon_x[nm]/\varepsilon_y[pm]$	0.14/0.7	1.3/2.6	1/2	2.1/4.25	4.3/8.68
$\beta^*_x[m]/\beta^*_y[mm]$	0.5/0.8	0.5/1	0.5/1	0.5/1	0.5/1
$\sigma_s[mm]$	6.3	1	1.3	1.8	2.2
F_{hg} hourglass	0.98	0.86	0.8	0.73	0.69
$L/IP[10^{32}cm^{-2}s^{-1}]$	24216	2093	577	130	17
ξ_x/IP	0.014	0.0857	0.095	0.07	0.029
ξ_y/IP	0.208	0.0859	0.095	0.07	0.029
τ_L, s	1479	2874	1840	1877	3426
$\tau_{bs}(\eta = 2\%)[s]$	$>10^6$	$>10^{13}$	$>10^7$	3009	3667
$P_{SR}[MW]$	36	50	50	50	50

CEPC

D. Wang & H. Geng

CEPC is

- an **C**ircular **E**lectron **P**ositron **C**ollider
- proposed to carry out high precision study on Higgs bosons
- to be upgraded to a super proton-proton collider



- So far no Z, W or tt option

CEPC

D. Wang & H. Geng

- Two presentations showed extensive scans of the parameter space to find an optimal starting point for the performance, RF requirements etc..
- First lattice options were presented (see before).
- Basic inputs:
  - *50 or 70 km ring,*
  - *120 GeV / beam,*
  - *50 MV / beam (but ½ power option also considered),*
  - *So far 1 IP,*
  - *So far single ring with Pretzel-like scheme for separation.*
    - *20-40 bunches.*

Many synergies between TLEP & CEPC!

70 km CEPC

L ~ (2-3.5) 10^{34} $cm^{-2}s^{-1}$

	Baseline design		Low power design	
Number of IPs	1	2	1	2
Energy (GeV)	120	120	120	120
Circumference (km)	70	70	70	70
SR loss/turn (GeV)	2.14		2.14	
N_e/bunch (10^{12})	0.87	1.23	0.44	0.61
Bunch number	39	28	39	28
Beam current (mA)	23.3	23.3	11.7	11.7
SR p[illegible]	[illegible]		25	
B_0 (T[illegible]	[illegible]7		0.047	
Bend[illegible]	[illegible]		8.56	
Mom[illegible]	[illegible]		4.7	
β_{IP} x/y (m)	[illegible]/0.001	0.79/0.001	0.1/0.0005	0.2/0.0005
Emittance x/y (nm)	9.5/0.094	9.5/0.19	9.5/0.047	9.5/0.094
Transverse σ_{IP} (um)	61.6/0.31	86.6/0.43	30.8/0.15	43.3/0.22
ξ_x/IP	0.175	0.245	0.087	0.123
ξ_y/IP	0.088	0.062	0.088	0.062
V_{RF} (GV)	5.8		5.8	
f_{RF} (MHz)	709		709	
σ_z (mm)	2.5		2.5	
Energy spread (%)	0.11		0.11	
Energy acceptance (%)	4.4		4.4	
γ_{BS} (10^{-4})	12.2	12.2	12.2	12.2
n_γ	0.58	0.58	0.58	0.58
δ_{BS} (10^{-4})	3.7	3.7	3.7	3.7
Life time due to beamstrahlung (minute)	30	30	30	30
F (hour glass)	0.65		0.47	
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	3.5	2.5	2.5	1.8
AC power for RF source/two beam (MW)	286		143	

TLEPH : ~ (2-4) x 5 10^{34} $cm^{-2}s^{-1}$

CEPC : ~ 3 10^{34} $cm^{-2}s^{-1}$

1 2 3 rings…

- Pretzel schemes are tricky, limited number of bunches..
- What about a 2 ring design with separate arcs and common long straight section (and common RF)?
- If no other separation scheme (except IP) is desired, and the length of the long straight section is L_s then:

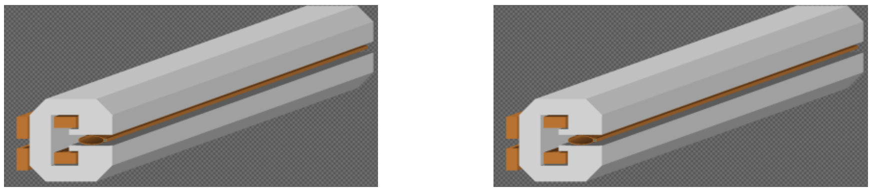
  The bunch spacing must be $\geq L_s$

  - *L_s = 500 m → max 160 bunches in a 80km TLEP.*
  - *~OK for TLEPH and TLEPt*
  - *Not ok for TLEPZ and TLEPW.*

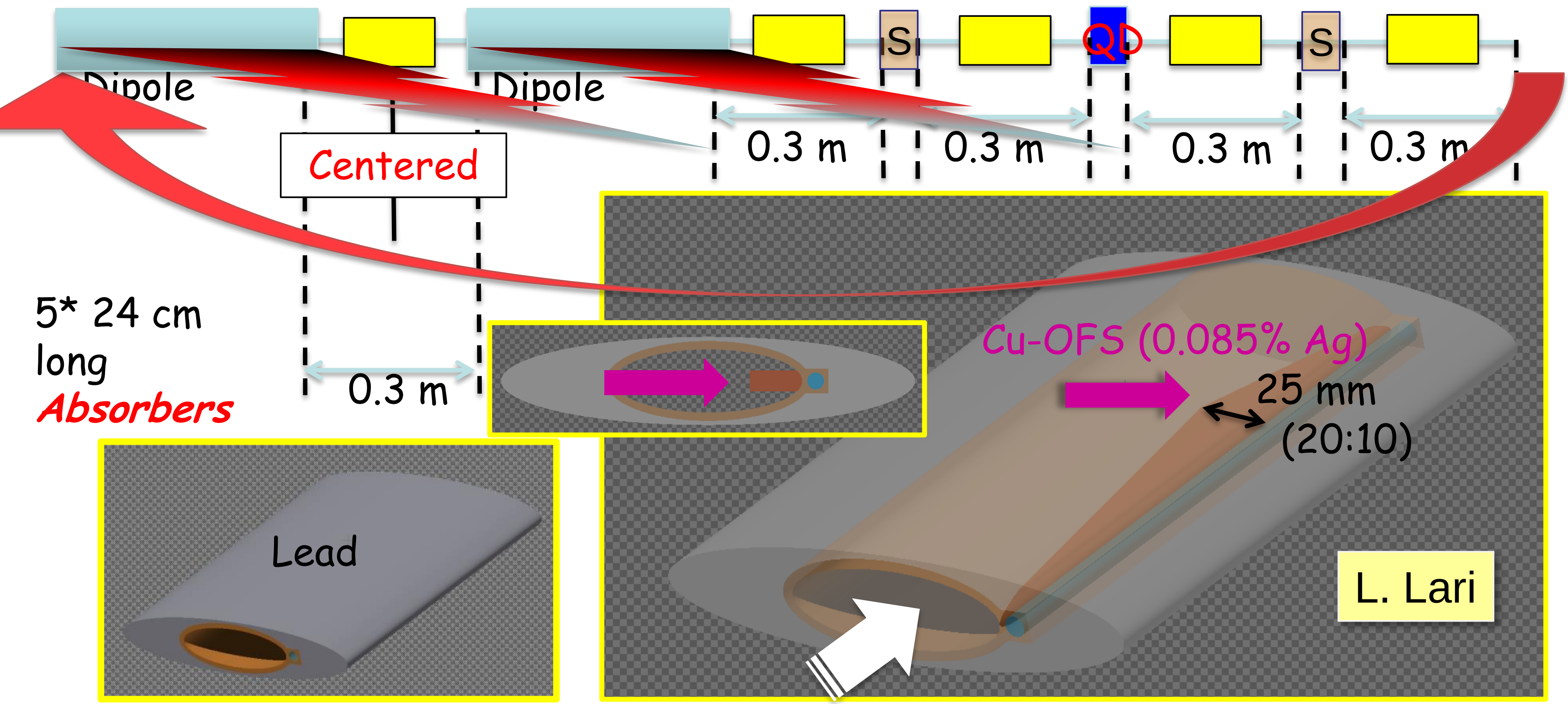
- The number of bunches of TLEPZ/W is so large that a complex local Pretzel schema (helical ?!) may be needed in each IR, with beam offset in cavities…

It is the TLEPZ/W options that are driving the need for 2 rings with separate RF systems !

FLUKA model

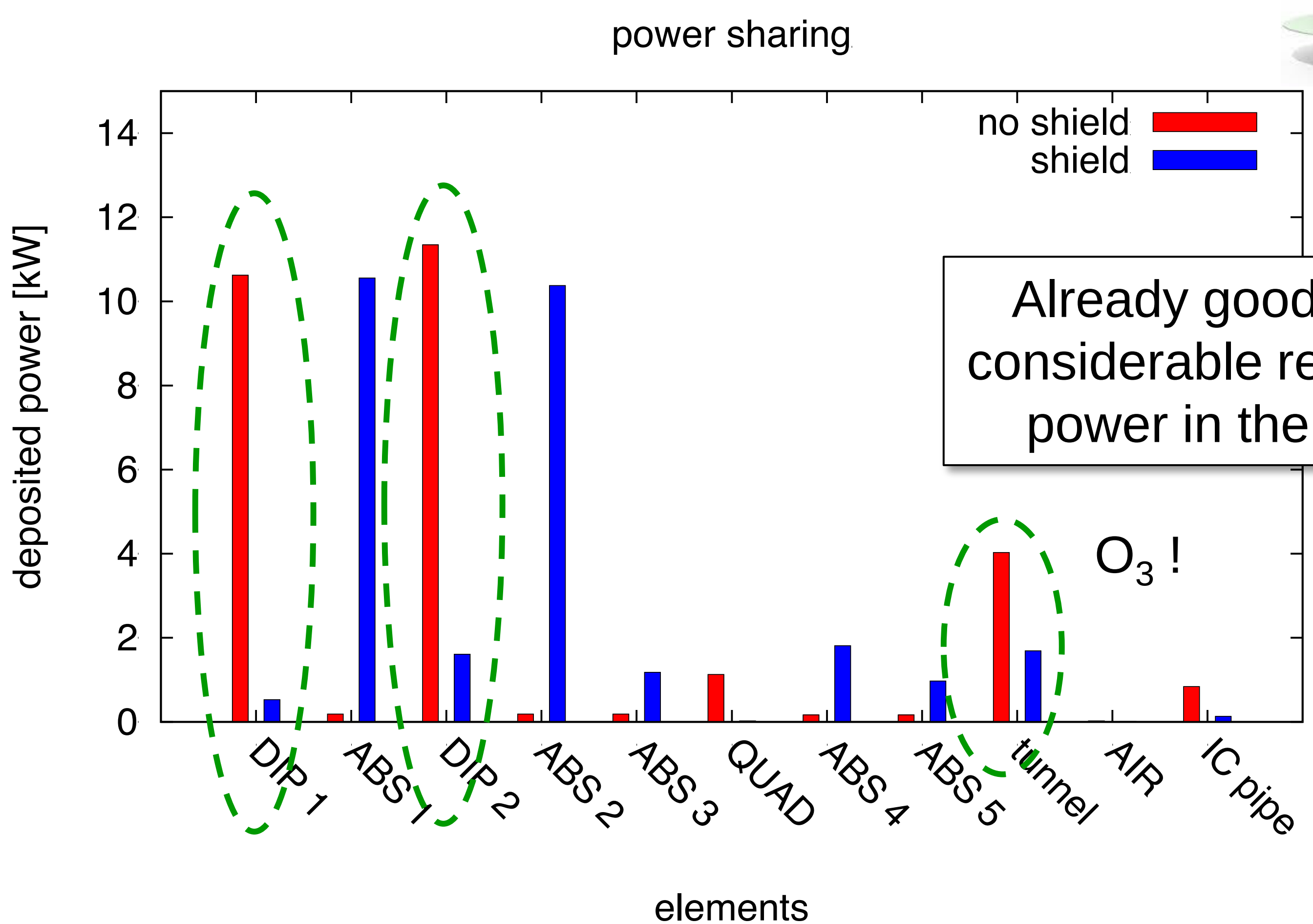


- Model of 11 m dipole + chamber + absorbers (0.3 m space).



FLUKA results

All results take into account a Beam current = 10 [mA]



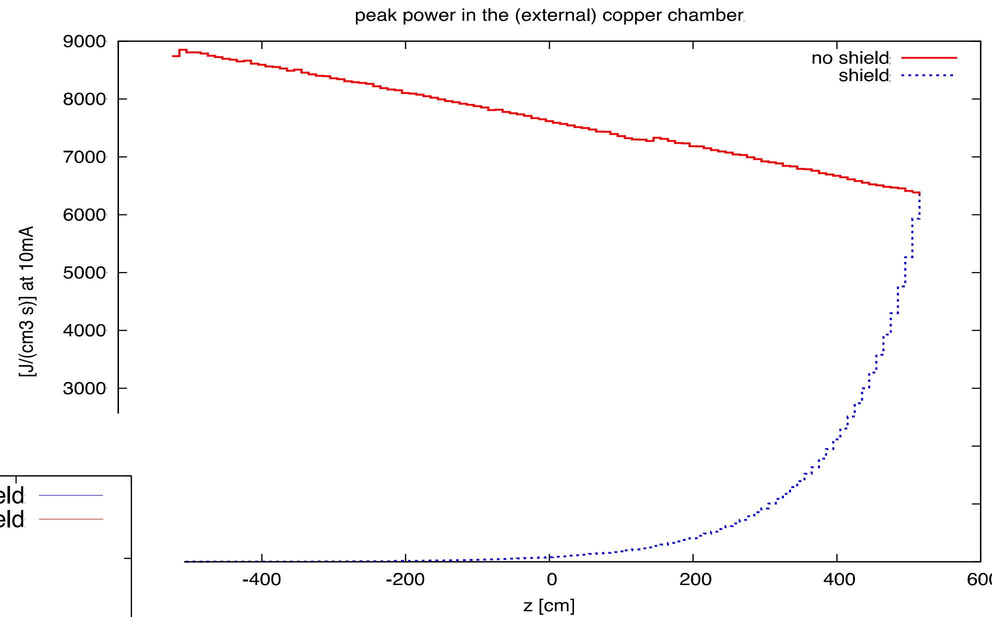
Already good result – considerable reduction of power in the dipoles

O_3 !

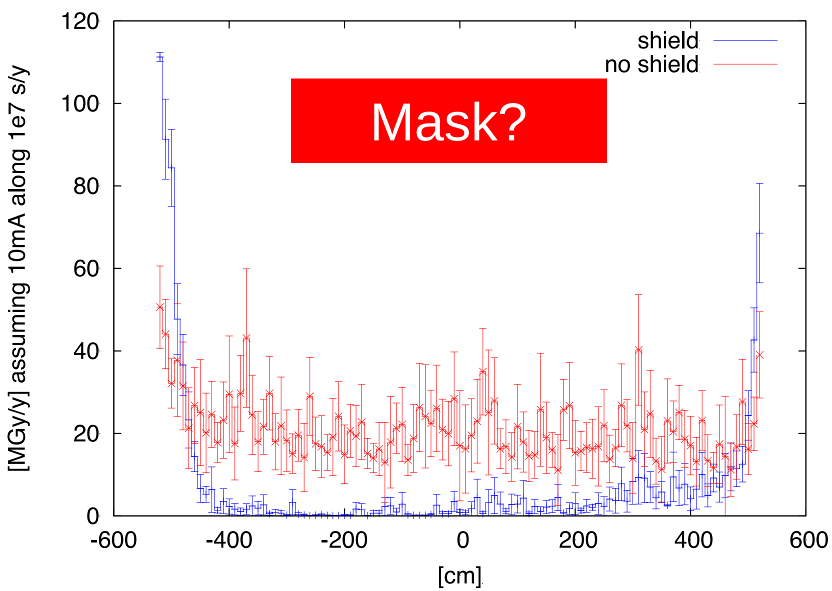
Input for the next iteration

L. Lari

Peak power density in the dipole beam-pipe



Radiation to the coils



>> input for second iteration on dipole length & absorber

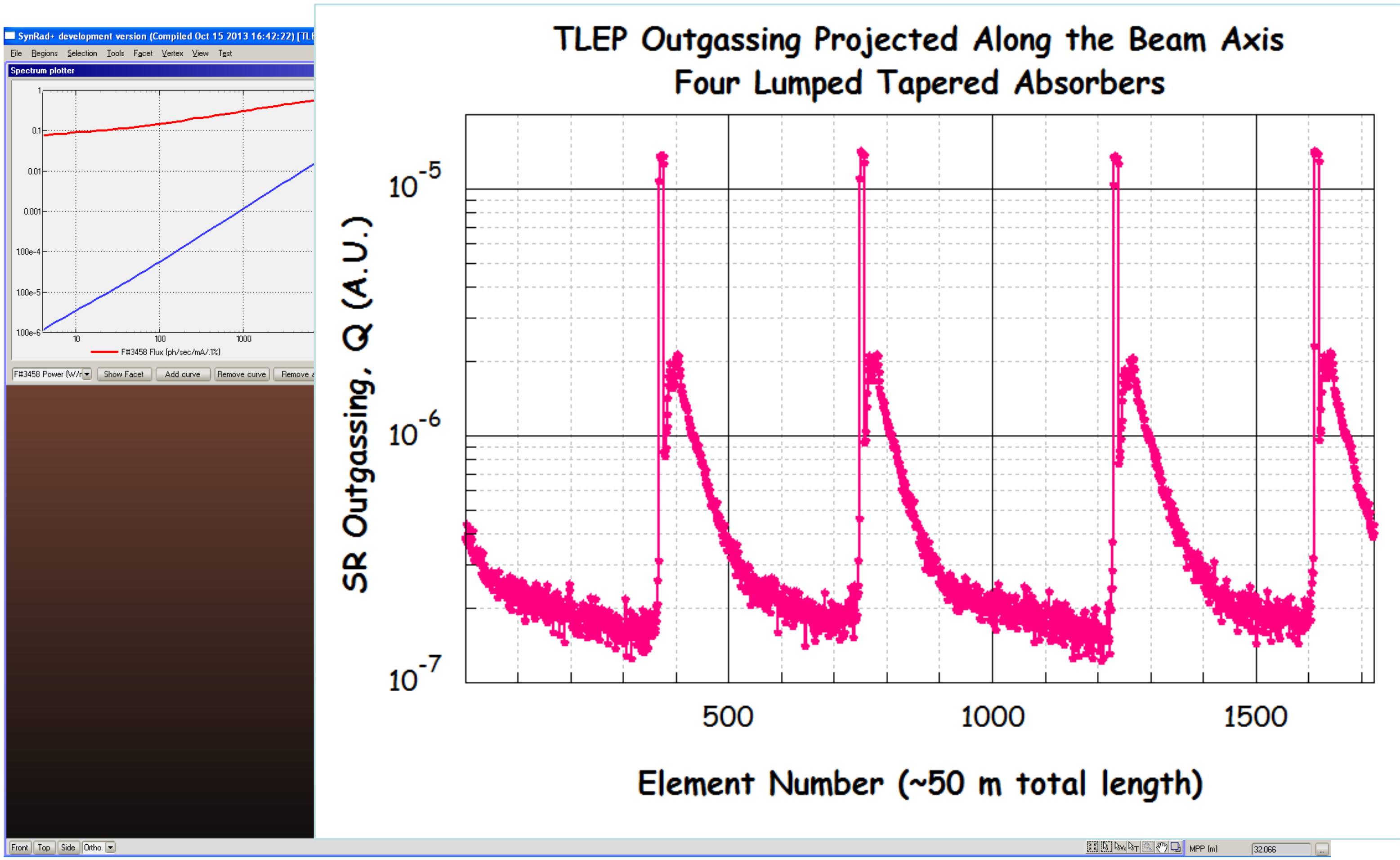
Vacuum system

	LEP2	TLEP-t	TLEP-h	TLEP-z	ESRF
Energy (GeV)	104	175	120	45.5	6
Current (mA)	4	5.4	24	1,180	200
Radius (m)	3096	9569.5	9569.5	9569.5	23.4
E_{crit} (eV)	805,862	1,242E+6	4.005E+5	21,833	20,504
Total Power (MW)	13.37	46.82	46.00	46.75	0.98
Linear Flux Dens. (ph/s/m)	1.73E+16	**1.27E+16**	3.86E+16	7.22E+17	6.60E+18
Linear Power Dens. (W/m)	687.3	778.6	765.1	777.5	6,684.0 (on BM) [~44,000 on crotch abs]

R. Kersevan

Vacuum simulation

- Monte-Carlo simulation with real curved geometry.
  - *Absorbers at end of every dipole*

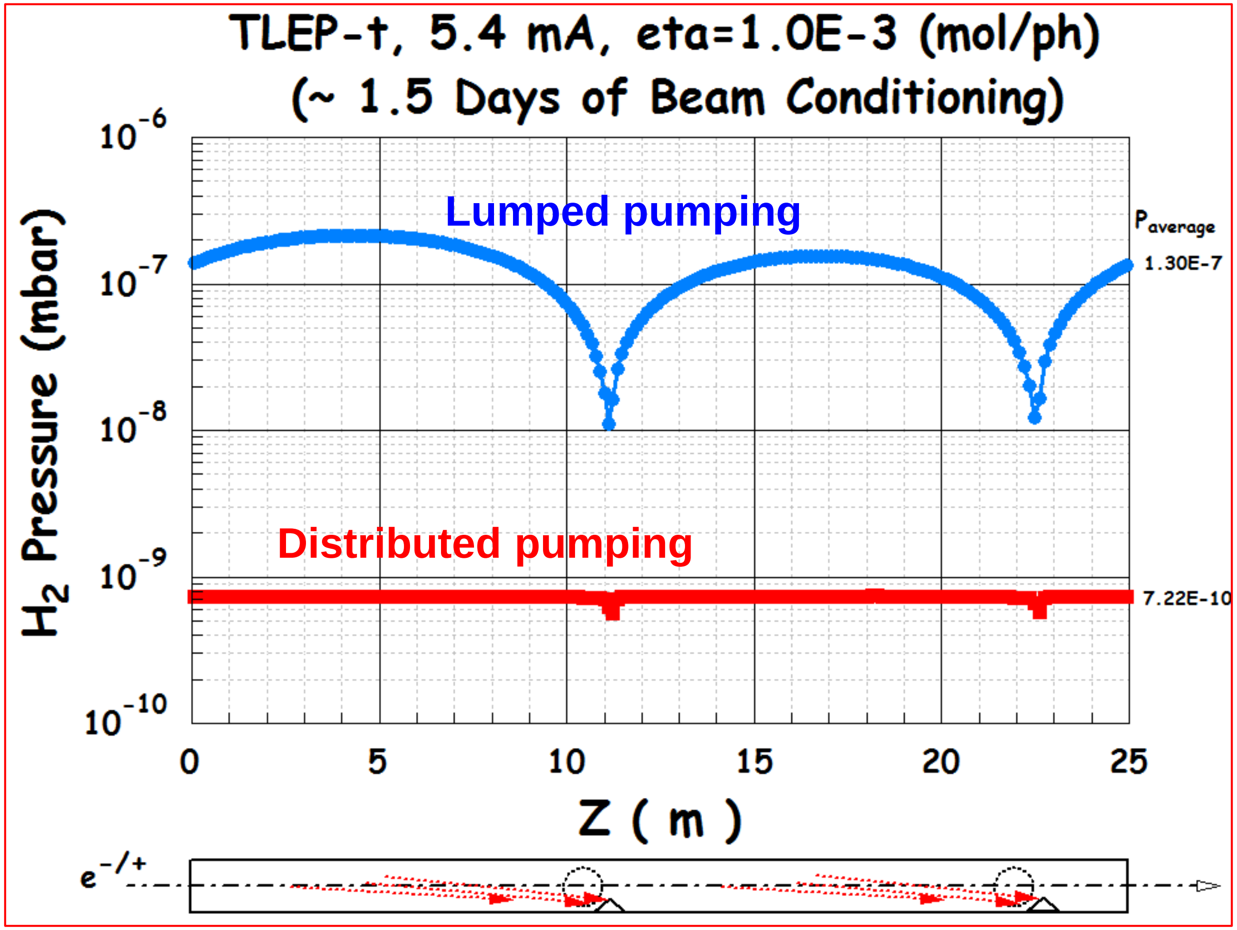


Vacuum

- From vacuum point of view strong interest for lumped absorbers.
  - *One absorber / 11 mm → ~9 kW of power.*

- Clear advantage of distributed NEG system.
- Looking good !
- Conditioning times to be checked !

R. Kersevan



What's next (1)

- Update parameters for February FCC kick-off with latest input.
- Deliver a first version of a lattice with first order IR including place holders for photon absorbers, BPMs, orbit correctors…. This will allow various studies to start:
  - *Study vertical emittance with errors (is it credible?),*
  - *Polarization with errors,*
  - *Etc*
- FFS with improved dynamic aperture.
- IR / ring recombination schemes.
- Injector chain !!!!

Thanks to all the speakers for the excellent presentations !