Review of the LEP Injector complex

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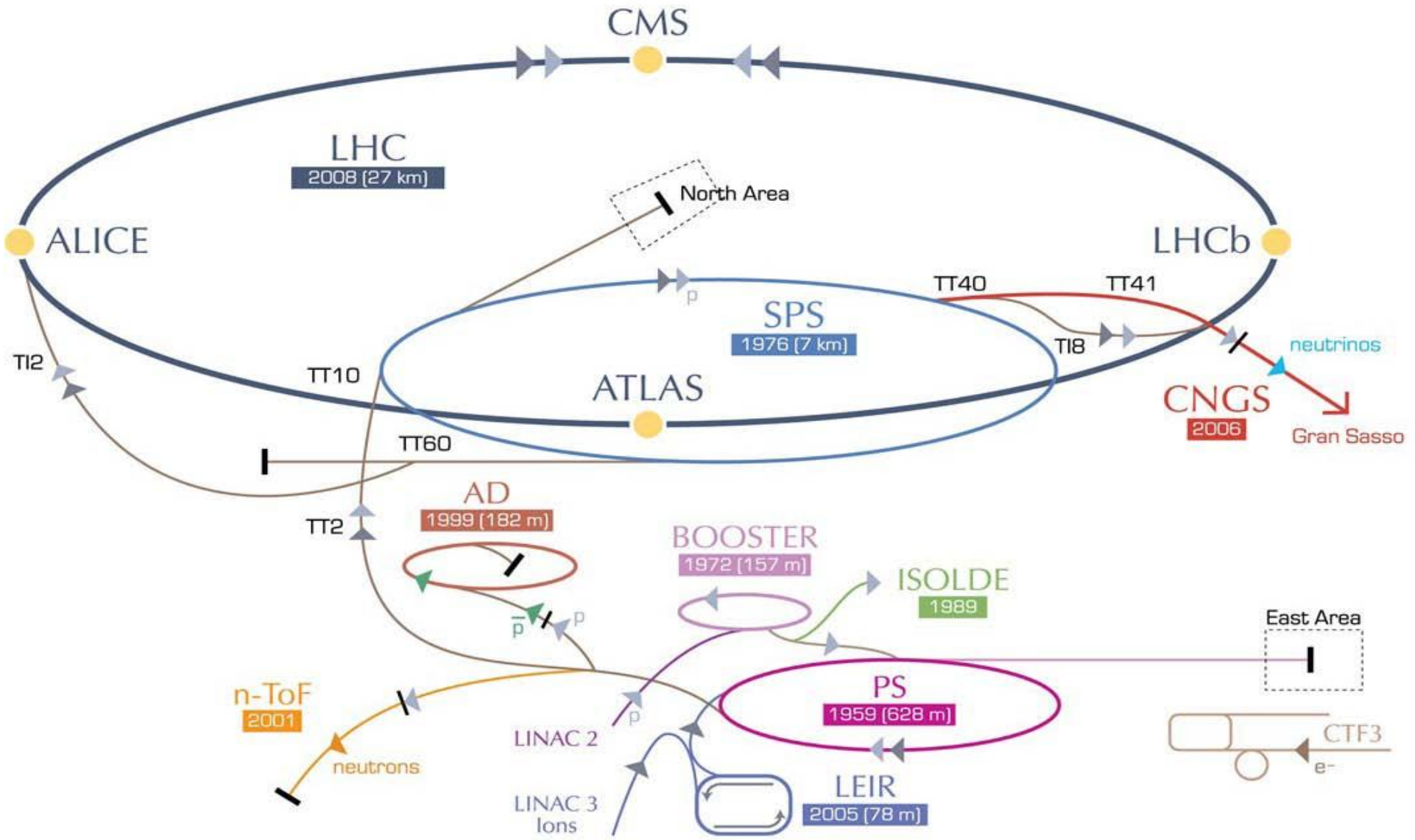
The CERN accelerators today



CERN power consumption in 2011

CERN's total annual electricity consumption is 1TWh or 1,000,000 MWh:

40 to 45% is for the LHC (including 12 to 14% for cryogenics and 7 to 9% for cooling and ventilation)

10 to 12% is for the LHC experiments (ATLAS, CMS, ALICE and LHCb)

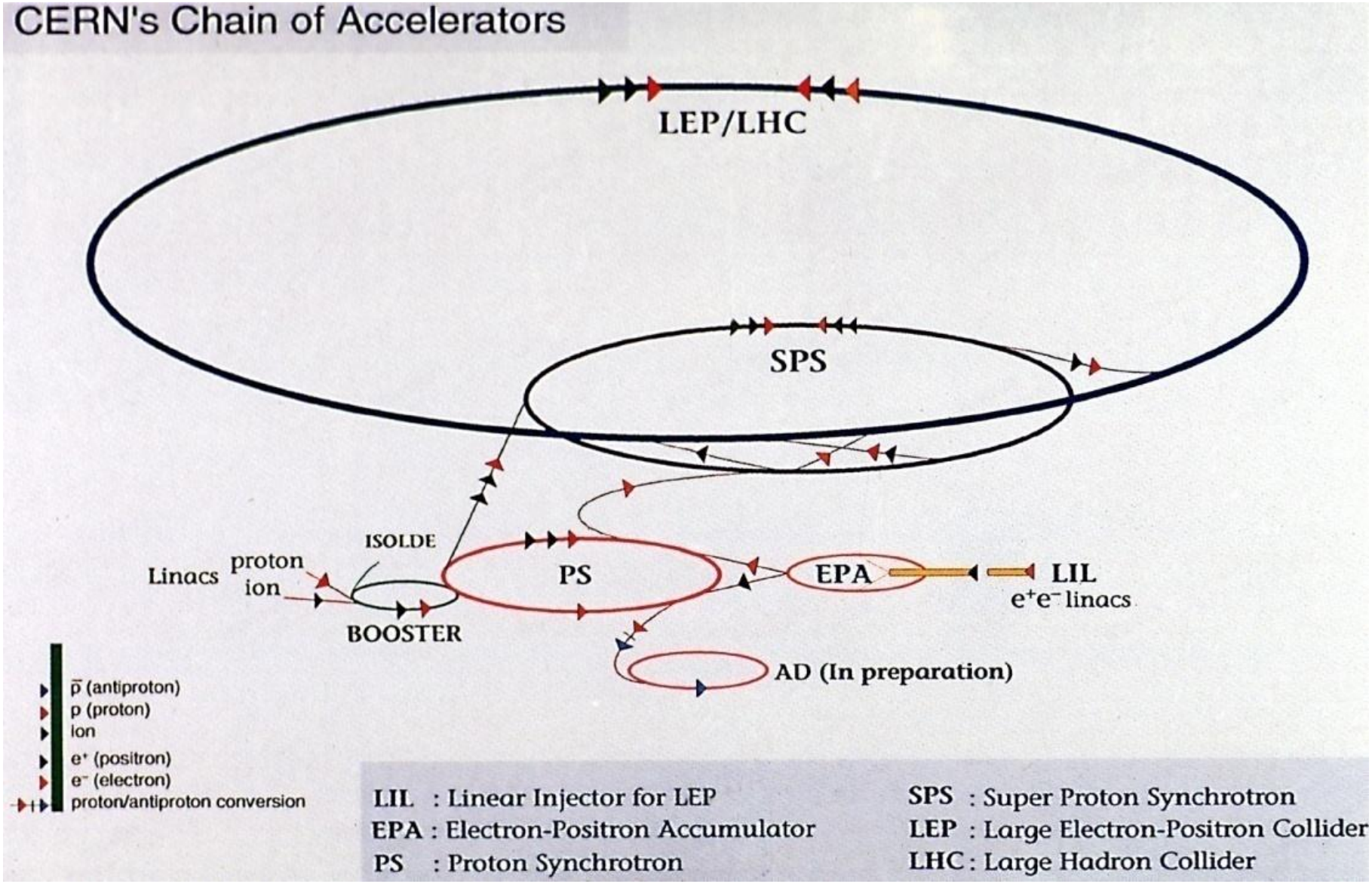
28 to 32% is for the SPS (including 6 to 7% for the North Area experiments)

2 to 3% is for the PS + Booster + Linac

5 to 6% is for the Computer Centre (B513)

7 to 9% is for offices and restaurants, etc.

The LEP complex in 2000



A very brief history and some statistics

LIL = LEP Injector Linac: Designed by LAL – Orsay (Convention March 1982)

EPA = Electron Positron Accumulator

LPI = LEP Pre-Injector

LPI = LIL + EPA

First beam in LPI: 11th December 1985

First beam in LEP: 14th July 1989

Last beam in LEP: 2nd November 2000

LPI beam statistics

Time in hours	1998	1999	2000
Total time with beam	6260	6287	7032
Beam for PS/SPS/LEP	4902	6155	5544
Setting-up	504	336	290
SLF 42 + SLF 92	470	800	4992
LEA	1550	400	960
COLDEX on EPA	0	670	0
HSE	0	42	72

Power consumption of LEP complex

LEP = Large Electron Positron collider

- Power consumption (1998):

LPI (LIL + EPA) @ 0.5 GeV:	1 MW
PS @ 3.5 GeV:	12 MW
SPS	52 MW
LEP @ 100 GeV :	120 MW (in [1], 150 MW)
4 Detectors:	52 MW (Aleph, Delphi, L3, Opal)
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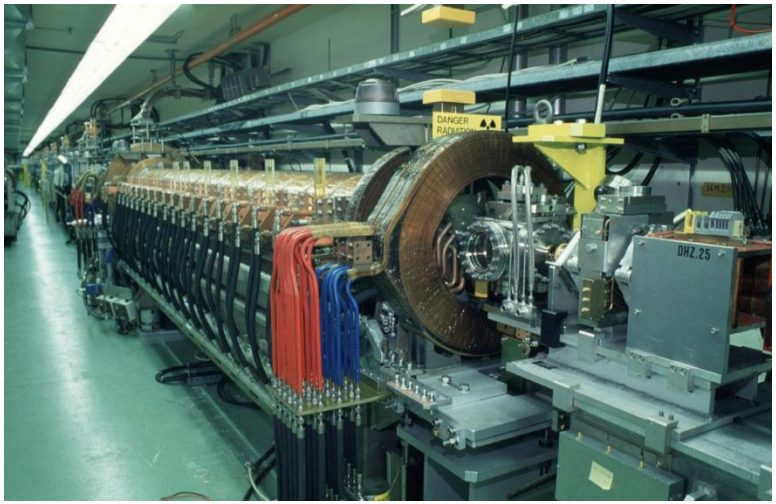
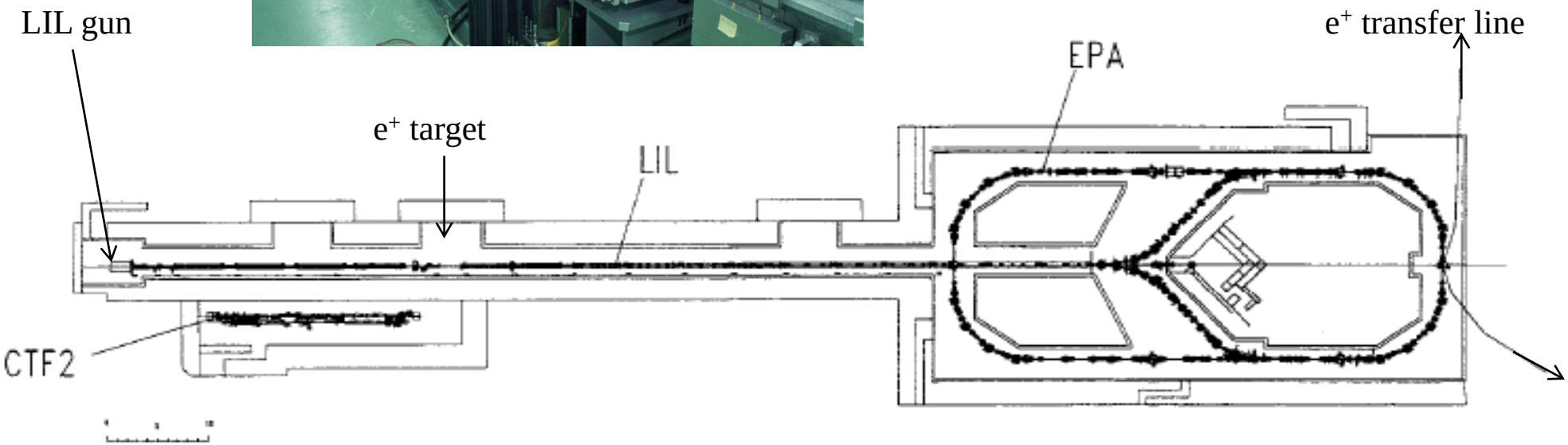
TOTAL :	237MW

The LPI in 2000





e^- parameters

Parameters	LIL	EPA
e^- energy [GeV]	0.2 to 0.7	
e^- bunch population	20 x10^9	
bunch length [ps]	15	
bunch interval [ns]	0.333	
beam pulse length [ns]	10	
Beam sizes [mm] (rms)	3	
Flux [e^-/s]	2 x10^{12}	
repetition rate [Hz]	100	0.83
Number of bunches		1 to 8
e^- bunch population		up to 4.5x10^{11}
average current [mA]		up to 170
tot. wall plug power[MW]	1	

e^+ parameters

Parameters	LIL	EPA
e^- energy [GeV]	0.200	
e^- bunch population [10^{10}]	0.5 to 20	
bunch length [ps]	15	
bunch interval [ns]	0.333	
beam pulse length [ns]	10 to 50	
Beam sizes [mm] (rms)	1	
repetition rate [Hz]	100	100
e^+ energy [GeV]		0.500
e^+ bunch population [10^{11}]		3
average current [mA]		11
Yield (e+/e-)		$7x10^{-3}$
Flux [e^+/s]		$7x10^{10}$

top-up injection: e^+ production

top-up interval << beam lifetime

→ average luminosity ≈ peak luminosity!

LEP3 needs about 4×10^{12} e^+ every few minutes, or of order 2×10^{10} e^+ per second

for comparison:

LEP injector complex delivered ~10^{11} e^+ per second (5x more than needed for LEP3!)

YES

F. Zimmermann FNAL talk 15th November 2012

e^+ rate possible improvements

$$dN^+ / dt = a \times y \times N^- \times E^- \times f$$

a = accumulation efficiency

y = e+/e- conversion efficiency (yield)

N^- = number of electrons in the primary beam

E^- = energy of the primary beam

f = linac repetition frequency

a = function of the damping time and also

improvements with magnetic energy compressor

N^- limited by the energy spread introduced by beam loading

Summary

The lepton production for LEP was a factor 3 above the requested performance for positron and a factor 5 for electron.

LPI availability for LEP operation: > 98 % over the last three years (1998,1999, 2000)

The LPI Control room on Thursday 2nd November 2000 at 7.30 a.m.

Some references

[1] G. Plass, “THE LEP PROJEC’I - STATUS AND PLAN”, IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, .4ugust 1983

[2] The LEP Injector Study Group, LEP Design report Vol. I, The LEP Injector Chain, CERN/PS/DL/83-31 (1983).

[3] S. Battisti et al., “The design of the LEP electron positron accumulator, 12th International Conference on high-energy accelerators”, Batavia, IL, USA, 1983.

[4] J.H.B. Madsen, “LEP Injector Linacs”, CERN/PS/89-56 (LP).

[5] C. Bourat, H. Braun, L. Rinolfi, “New optic of the LIL for e^+ production”, CERN/PS/94-18 (LP).