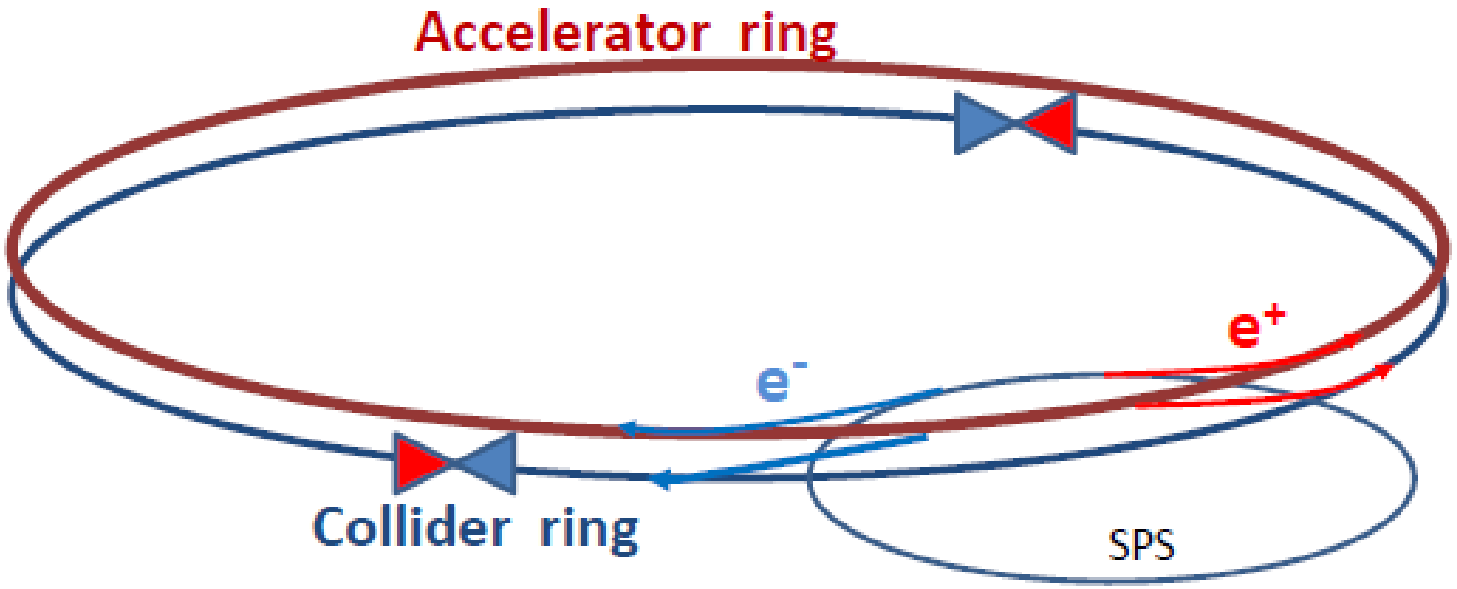
LEP3

A high Luminosity e^+e^- Collider in the LHC tunnel to study the Higgs Boson



Many thanks to Frank Zimmermann and Marco Zanetti for organizing this meeting !!!

Genesis

As the Higgs became cornered below 140 GeV/c^2 in Grenoble, the question was raised around the corridors 'what about a new e+e- colliding ring' ?

Raised the 'LEP3' at the EPS-HEP ECFA session in Grenoble (July 2011) and got such feedback:

Subject: LEP3
From: Klaus Desch <desch@physik.uni-bonn.de>
Date: 23.07.2011 18:21
To: Alain Blondel <alain.blondel@cern.ch>

Dear Alain,

back-of-the evelope: LEP2 could deliver ~1 pb-1/day at 208 GeV for 20 MW at the beam-beam-limit

Higgsfactory: needs ~500 fb-1 -> needs factor ~500 or so higher luminosity ->
power (naïve) 20 MW * 500 * 240^4 / 208^4
= prohibitive in LHC tunnel

Cheers,

the end?
or
the challenge?

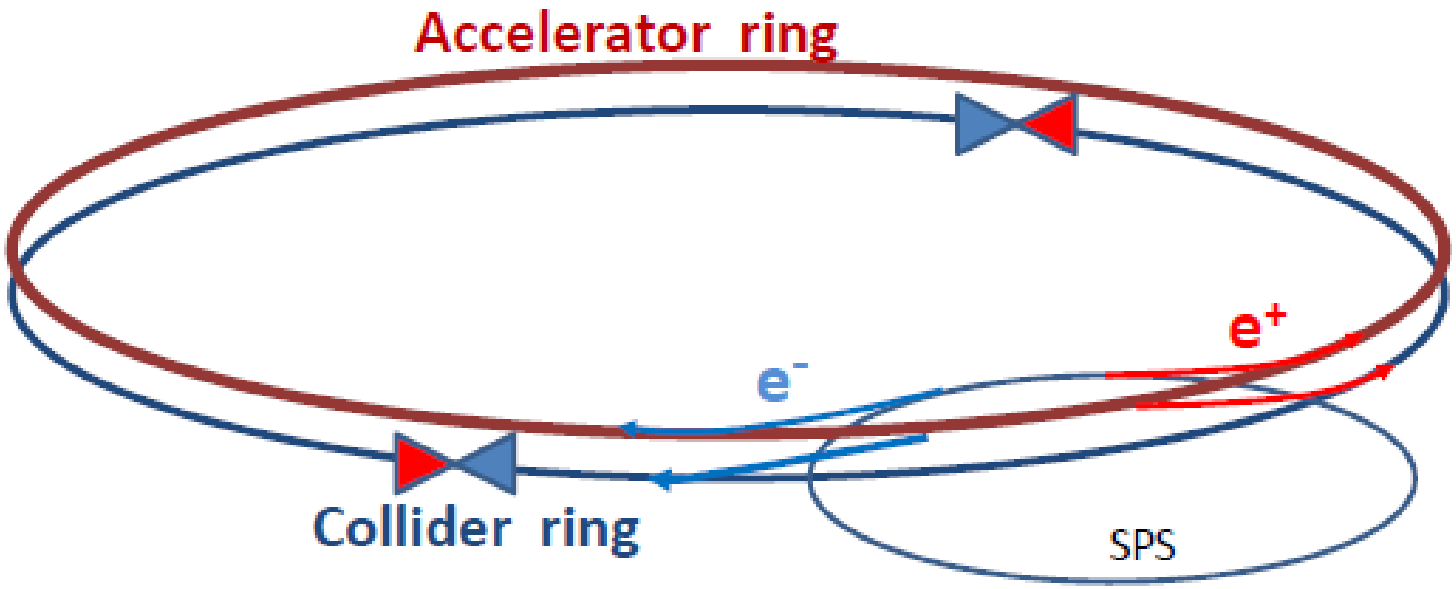
How can one increase over LEP 2 (average) luminosity by a factor 500 without exploding the power bill?

Answer is in the B-factory design: a very low vertical emittance ring with higher intrinsic luminosity

electrons and positrons have a much higher chance of interacting

➔ much shorter lifetime (few minutes)

➔ feed beam consituously with a ancillary accelerator



Extrapolating from LEP2

(remarkably scarce) litterature on last year of LEP2 says:
went up to 104.5 GeV per beam
beam lifetime was ~100 minutes, burned by interactions
beam power was 20MW (would be 45 MW at 120 GeV/beam)
β^* was 5cm and beam-beam tuneshift ξ^* was 0.12

➔ LEP2 was NOT at the beam beam limit

Excel spread sheet says:

with β^*= 2mm and reducing horizontal emittance you can get to ξ^* =0.15
and a life time of O(minute) (you need higher frequency RF → ILC !)

➔ instantaneous luminosity is 100 times higher ☺!
but this machine is unuseable unless … one refills all the time
➔ B factory – which I realized at the ICFA meeting in October 2011
refilling continuously gives you the other factor 5.

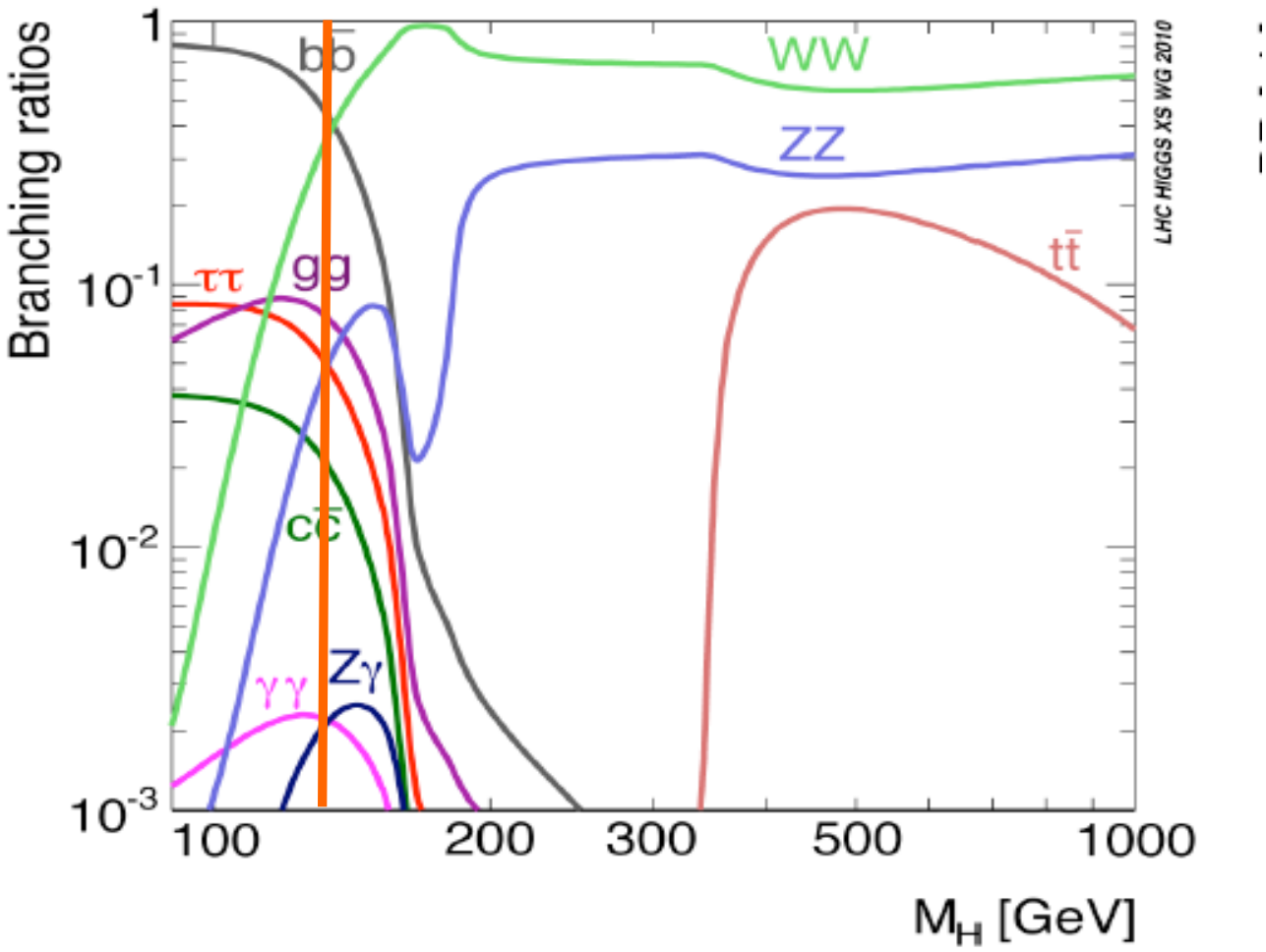
At that point I needed professional help; Franck Zimmermann
got all excited, and quickly confirmed (3 days!) that he could apply the LHeC optics to get the desired result! (see his presentation)

LEP3 is exciting!

It provides an economical (or even feasible) solution

-- to study the X(125) with high precision
-- and to perform many precision measurements on H, W, Z

The machine is not 'easy' but should be reasonably 'safe' from the point of view of achieving the performance



125 GeV is really a good place to be:

$\bar{b}b$, WW, gg, $\tau\tau$, ZZ, $\bar{c}c$ are all above a few % and $\gamma\gamma$ is ~maximal

Questions: I PHYSICS

Suppose LEP3 concept works, … and that X(125) really exists.

A can LHC study X(125) and answer enough questions
or do we need a complementary machine?

shopping list:
branching ratios, invisible width
mass, width, spin-parity
3-H and 4-H self couplings
……

I have some doubts about the red ones…

B is LEP3 is really the complementary machine one needs?

C are the LHC detectors OK or do we want new ones?

D can they accommodate low beta insertions and luminosity monitors?

Questions: II ACCELERATOR

Among the many questions that should be addressed in more detail:
1) a comparison of cost and performance for the proposed double ring separating the accelerator and collider and for a single combined ring;
2) a total of about 15 GV of RF acceleration is needed : 9 GV for the storage ring and 6 GV for the accelerator - it will be necessary to determine the optimum RF gradient as a compromise between cryopower and space requirement, and the optimum RF frequency with regard to impedance, RF efficiency and bunch length [in this paper we consider the use of high-frequency ILC-type cavities];
3) the LHeC lattice has reduced the effective bending radius compared with LEP while one would rather like to increase it instead;
4) the performance may perhaps be further improved by using even smaller value of β_{*y} and e.g. the technique of crab waste-crossing[15];
6) the performance at 91.2 E_{cm} (the Z peak), possibly with polarized beams

7) the co-habitation of such a double machine with the LHC would require careful examination of the layout of both machines - for the single LHeC ring no show-stopper has been found [7];

9) the ramping speed of the accelerator ring;
10) the positron source;
11) the limit on the single bunch charge;
12) the top-up scheme, e.g. injecting new bunches at full intensity or refilling those already colliding;

and

13) the alternative possibility of building a new larger tunnel and storage ring(s) with twice the LEP/LHC circumference, which we call DLEP. Possible DLEP parameters are listed in Table 2, alongside those for LEP3. Naturally, in the long-distant future a DLEP tunnel could also house a proton collider ring with a beam energy about four times higher than the LHC (assuming two times stronger magnets). Rings with a circumference of 30.6 km and 50 km were proposed during the LEP design in 1979 and 1976, respectively, requiring part of the tunnel to be located in the rocks of the Jura, at a depth of 860 m under the crest [16]. The circumference of DLEP should be optimized in order to avoid Hirata-Keil resonances [17] in case the machine is later used for lepton-hadron collisions with the LHC.

Goal of meeting:

I- first acquaintance

II- what are the most burning questions?
do we have the answers?

III- organize towards regular 'collaboration' as felt necessary
(steering group, regular meetings etc…)

IV- delineate a plan of work for a 'design study'
-- what kind of manopower is needed

V- prepare statement for European Strategy