Demands and Possibilities of e^-e^- Interactions at the ILC

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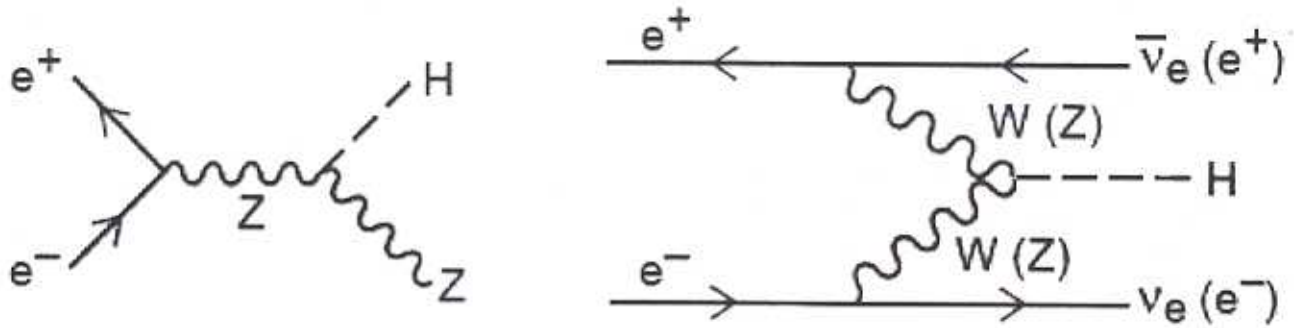
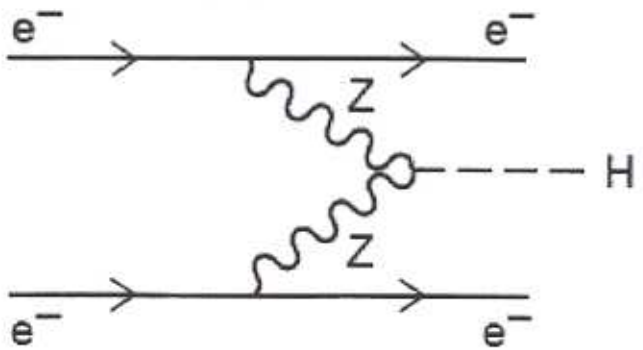
A Study of the Higgs Sector

The standard production process of the neutral Higgs boson is by e+e- annihilation into a virtual Z boson, followed by "Higgsstrahlung".



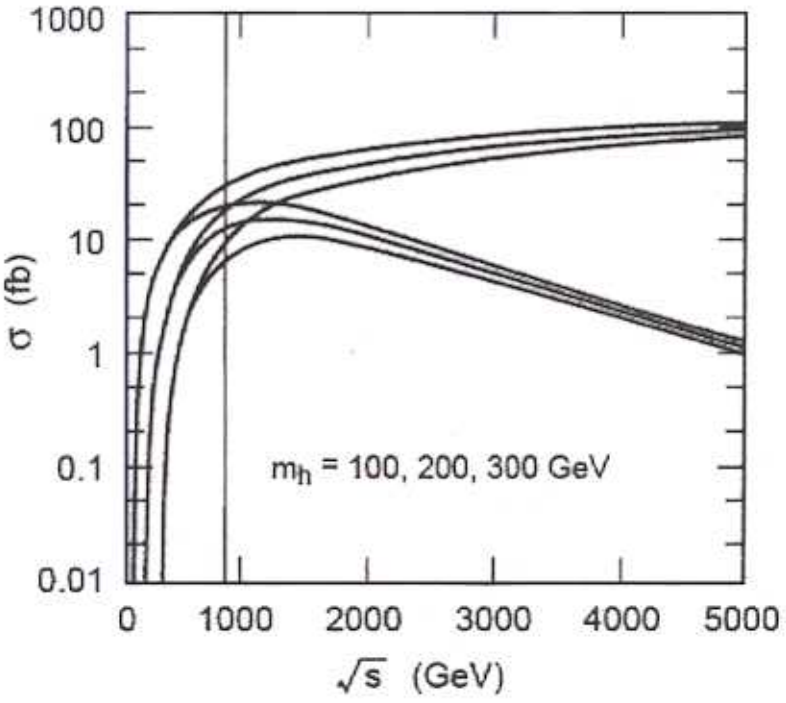
Alternatively e^+ and e^- emit virtual W's or Z's that fuse into an H^0, where the kinematics are not fully measurable because of the emitted neutrinos.

The preferable mode of Higgs boson production in e^-e^- interactions, where the final-state electrons define the Higgs mass fully, is



The ZZ fusion cross-section saturates above the threshold region, so that it becomes proportional to m_Z^2; it does not depend much on the scalar mass as long as that is well below the center-of-mass energy at which the measurement is being performed.

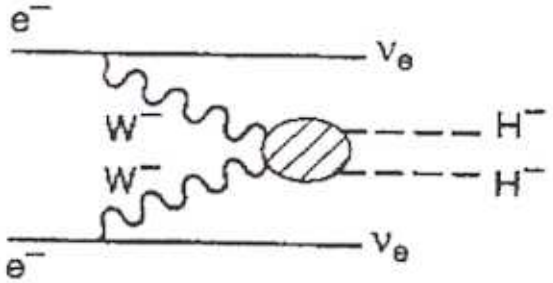
Once the detector imposes an angular cut (say, a 5° cone in the forward and backward directions), the cross-section becomes geometric and decreases as 1/s, as illustrated below - but it remains roughly independent of the scalar mass.



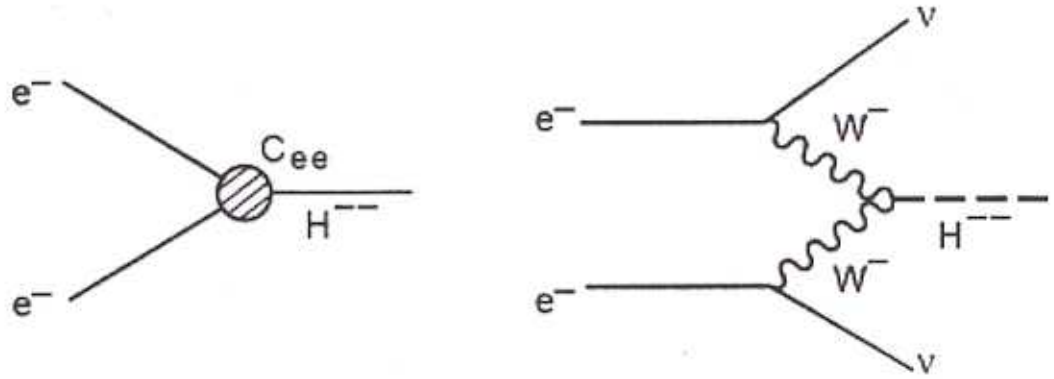
Extended Higgs Sector

Having established that e^-e^- is the (in| state of choice for basic Higgs studies at the ILC, let us also look at the extended Higgs phenomena that comprise singly and doubly charged scalars, H^- and H^{--}.

Here, we see that the tree-level realization of a singly charged H^- can be well studied in the e^-e^- input channel by the WW fusion process.



We then also have easy access to the production process of doubly charged Higgs bosons in the e^-e^- channel, either with an unknown direct coupling c_{ee} or via the W^-W^- fusion graph, adding some spice to the process under investigation.



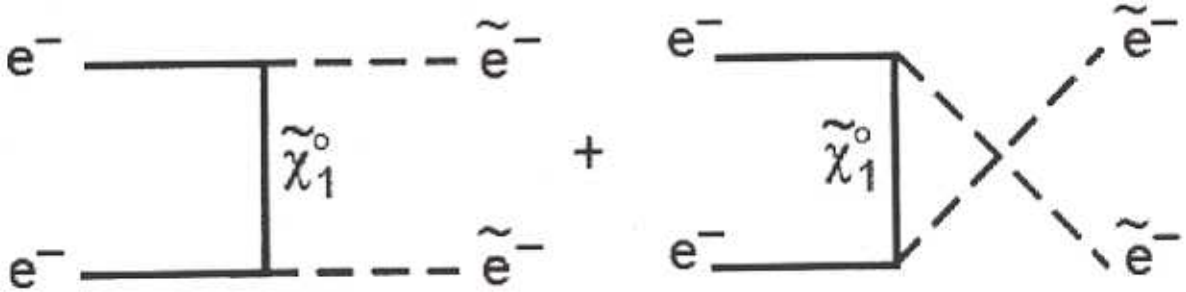
Again, none of these processes would be accessible were it not for the optimally defined e^-e^- initial state.

Selectron Pair Production

Next, let us briefly point out some fascinating features that permit us to resolve questions on supersymmetric masses exclusively via fully defined e^-e^- ⟨in| states.

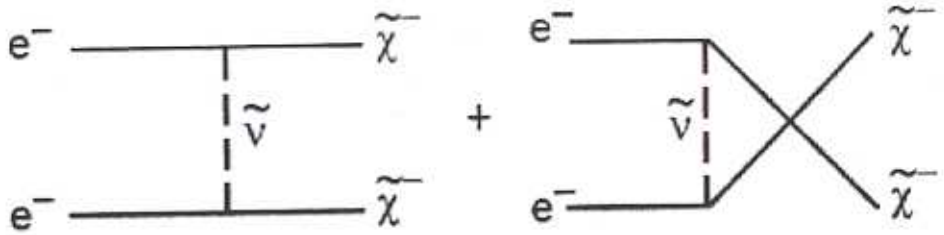
It may well be that unquestionable SUSY signals will be seen by the LHC well before ILC turn-on, but a detailed definition that permits interpretation of any such phenomenon will be impossible until fully defined input channels can be determined; there, again, help from the e^-e^- collider option is unavoidable in several contexts.

Selectron pair production via neutralino exchange has a purity of signal that is completely inaccessible to e^+e^- interactions.

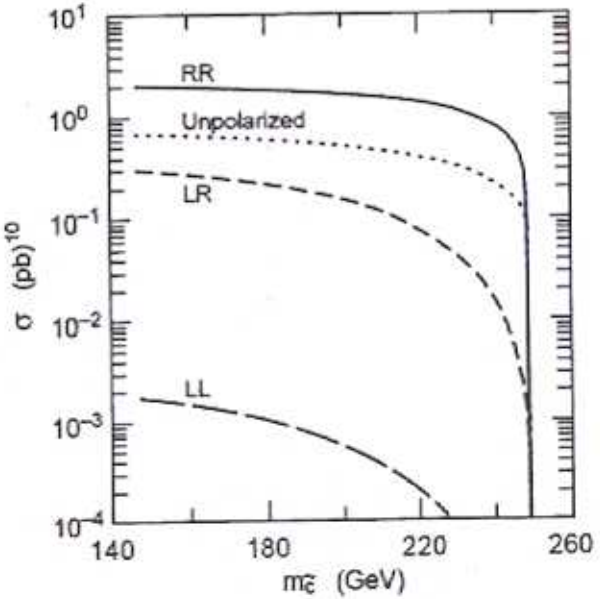


Quite obviously, this type of SUSY investigations will take over once we have ILC energies to study these novel states of matter.

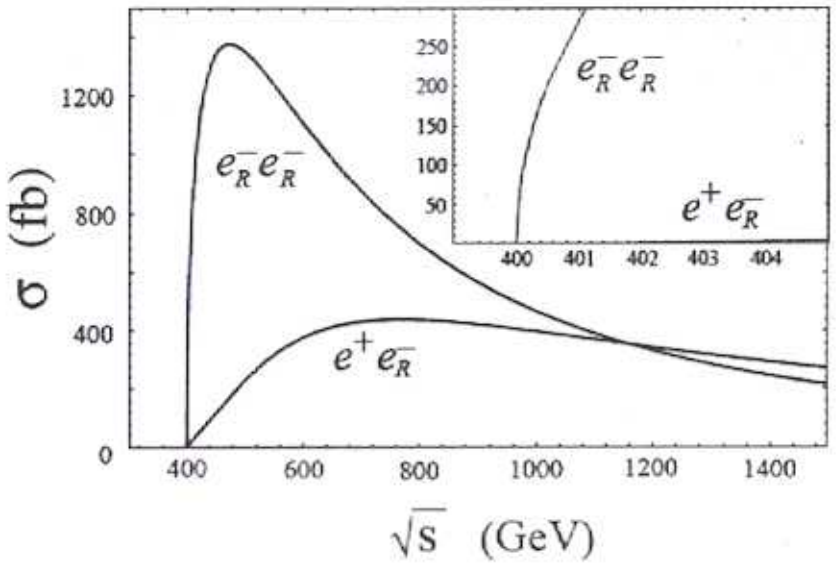
Similarly, we can study the graphs for chargino pair production via sneutrino exchange.



We can demonstrate the tremendous advantage of initiating this interaction with highly polarized e^- beams, by displaying the great differences between RR, LR, and LL polarized electrons



Jonathan Feng did an excellent study of mass determination of such supersymmetric states by means of threshold studies, as shown below.



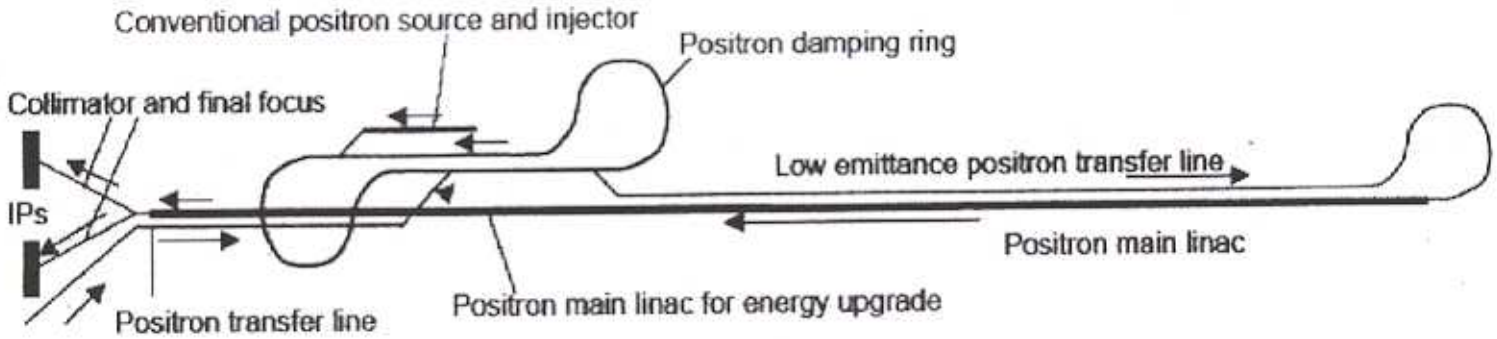
This figure gives definitive proof for the tremendous superiority of the e^-e^- initial state for the determination of supersymmetric masses.

He also discussed the importance of the e^-e^- initial state for precision studies of selectron gauge couplings which, in turn, permit definitive proof that the selectron is the SUSY partner of the electron.

Compatibility of e^-e^- with e^+e^- Modes of Operation

e^-e^- operation of the IR is readily compatible with the large-angle option, because the two beams are transported in separate magnets.

e^- operation of the "positron" linac is readily obtained by reversal of all bending magnets, and use of the anticipated auxiliary conventional electron/positron injector.



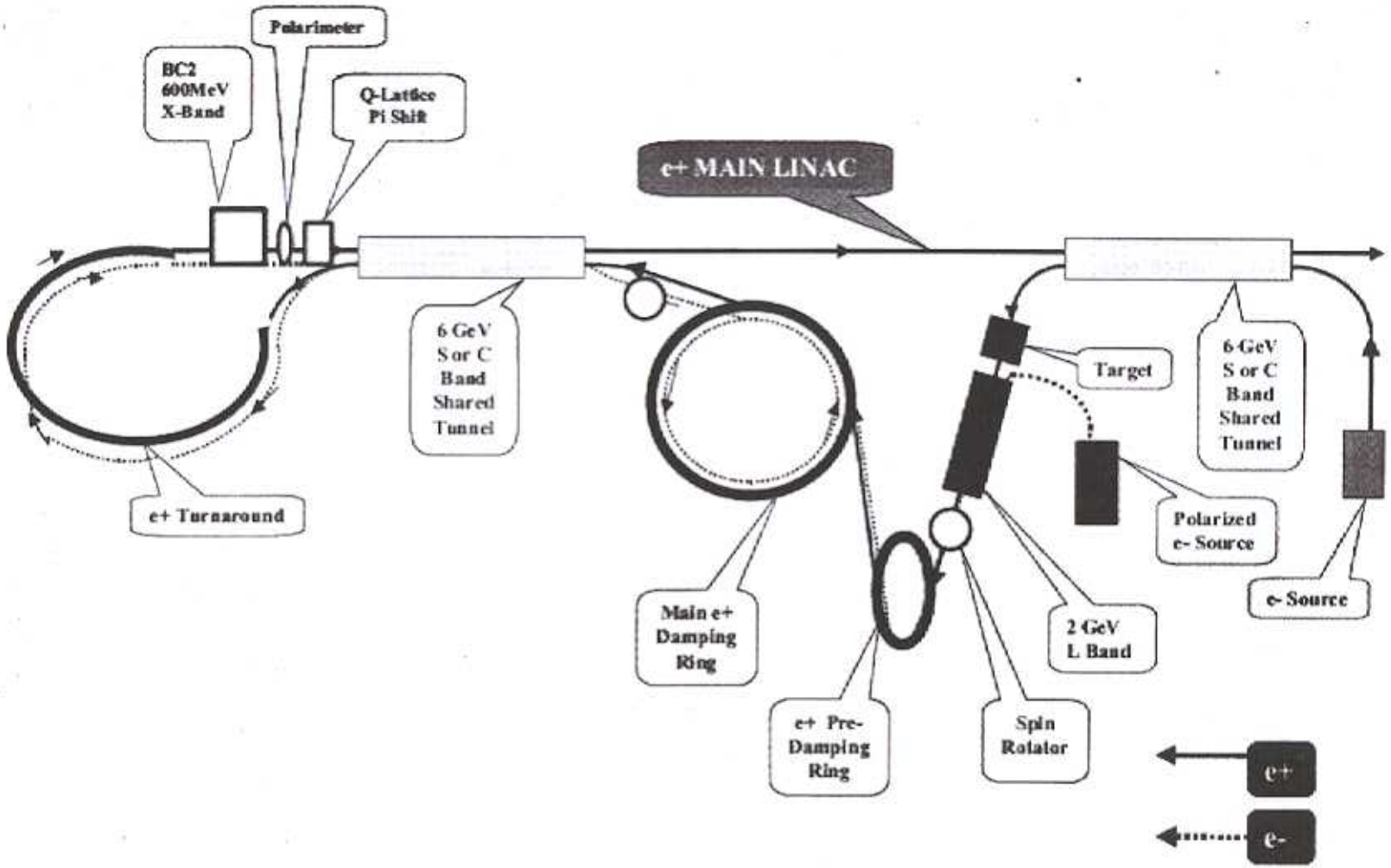
Summary

Studies of the Higgs sector and the access to SUSY phenomena provide examples of the tremendous advantage to be gained by well-defined and cleanly prepared e^-e^- interactions at the ILC.

The e^-e^- $\langle$in| state can be accessed in the same IR and with the same detector as used for studies of e^+e^- initial states.

e^- operation is readily possible in the positron arm of the ILC.

The benefits of e-e- operation of the ILC should be available from the beginning of the project.



Polarity Reversal Model

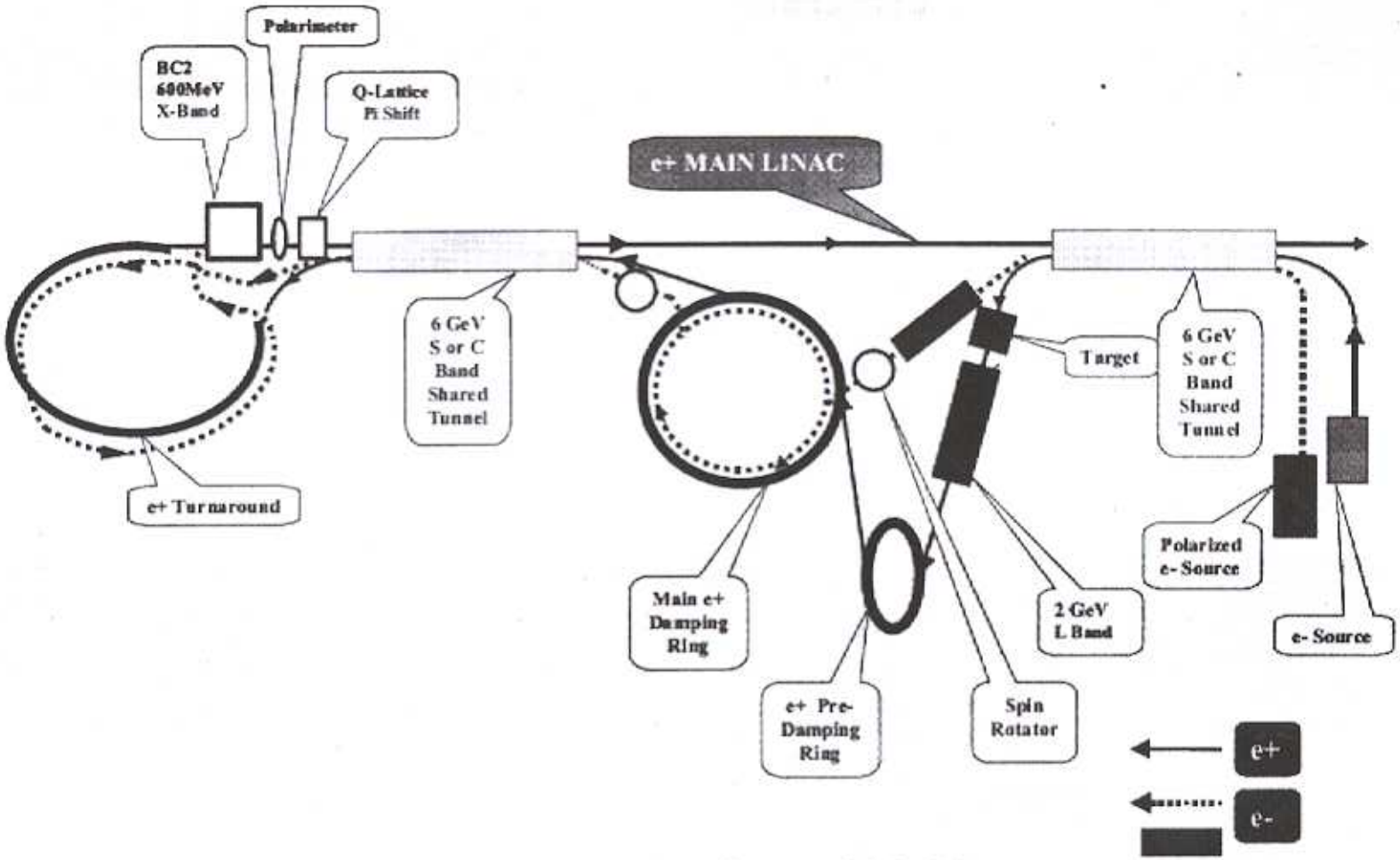


Fig. 2 Direction Reversal Model

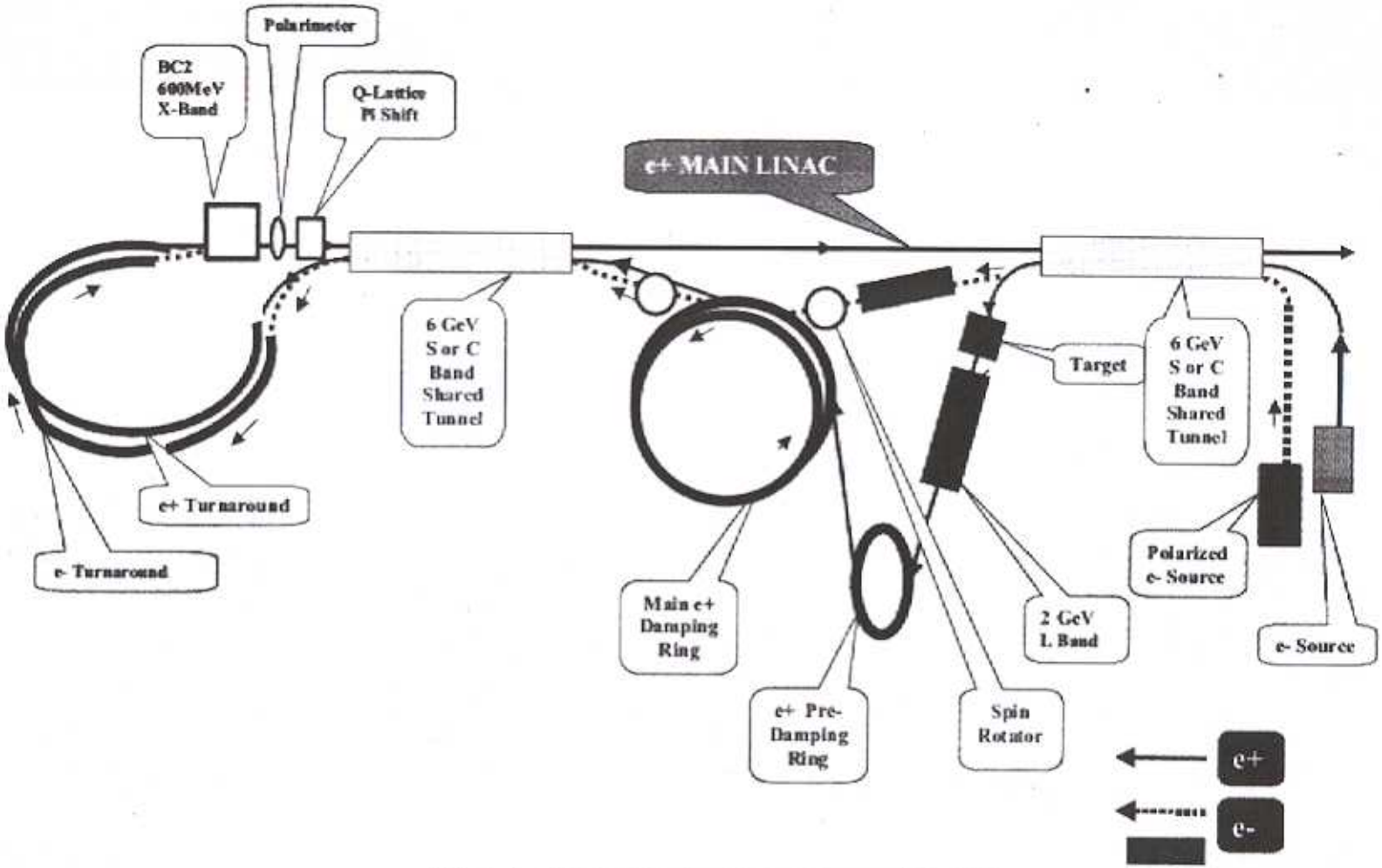
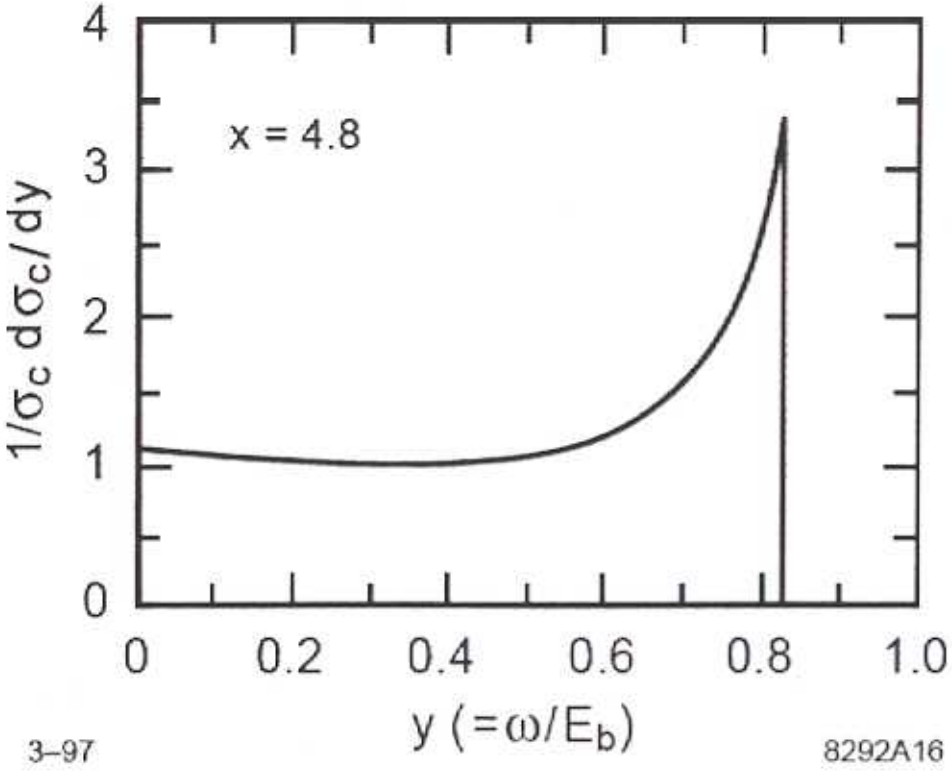


Fig. 3 Independent Systems Model



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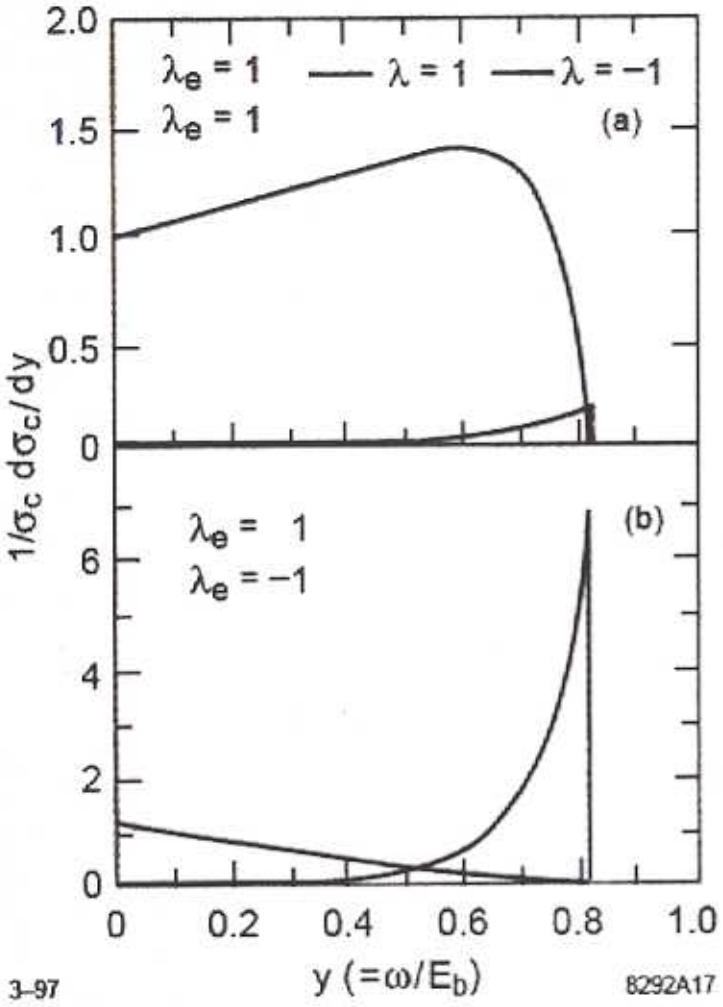
2.0
1.5
1.0
0.5
0
$\lambda_e = 1$ — $\lambda = 1$ — $\lambda = -1$
$\lambda_e = 1$
(a)
$\lambda_e = 1$
$\lambda_e = -1$
(b)
6
4
2
0
0
0.2
0.4
0.6
0.8
1.0
$1/\sigma_c\ d\sigma_c/dy$
$y\ (=\omega/E_b)$
3-97
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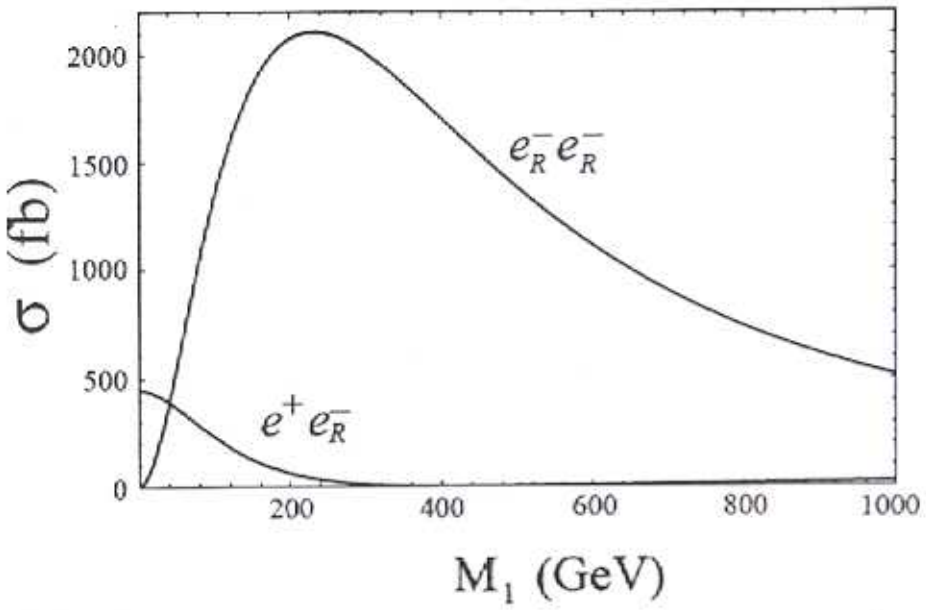
2000
1500
1000
500
0
σ (fb)
$e_R^- e_R^-$
$e^+ e_R^-$
200
400
600
800
1000
M_1 (GeV)