

Summary of Exotic Collider Concepts Group

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Abstract

We present a summary of the discussions in the Exotic Collider Concepts Group. Most of the discussions were centered around the status and open problems for muon-muon and gamma-gamma colliders. In addition the group discussed some general problems and new results of accelerator physics.

1. Introduction

The discussion on Exotic Collider Concepts started with a general review and introduction presented in the plenary session by S. Chattopadhyay. This introductory talk was followed by a series of presentations and discussions within the group itself, and, in some cases, jointly with other groups.

Most of the discussion on exotic colliders was centered on new lepton-lepton and lepton-photon colliders, and on some aspects of particle beam physics of general interest. The present status and development of $\gamma - \gamma$, $e - \gamma$, and $\mu - \mu$ colliders was presented by R. Palmer and by A. Sessler. In addition there were more contributions on $e - \gamma$ colliders by D. Cline and P. Chen, on Beam Cooling in Focusing Channels by Z. Huang, P. Chen and R. Ruth, on a Graviton Factory by P. Chen, on a Plasma Based Collider, by J. Rosenzweig, on Acceleration and Cooling in Crystals by A. Bogacz, on the Oide's Limit by J. Irwin, and on Beam Conditioning by D. Whittum.

2. Muon and gamma colliders

The recent work and status of the $\mu - \mu$ collider was presented by R. Palmer. He discussed an approach to this collider based on the use of available technology, avoiding as far as possible new ideas and techniques like the Optical Stochastic Cooling, magnets with fields larger than 10 T, and very large accelerating fields. These new ideas and technologies could improve the collider performance or reduce its cost, but would also need a dedicated R&D program to show that they work as expected.

The collider is aimed at an energy of 2+2 TeV with a correspondingly large luminosity of $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ or greater. Muons are produced from a high repetition rate proton accelerator, which could be a new machine like Kaon, or an upgraded AGS, with an intensity of about 10^{14} protons per second. The muons are accelerated in a multifrequency linear accelerator and then stored in a storage ring. To obtain the large luminosity needed at an energy of 2+2 TeV, it is essential to increase the beam phase space density from the low value at the source to the large value needed at the interaction point. The method proposed is based on ionization cooling and coupling of the three degrees of freedom, to obtain the required emittances. An experimental program to check the most critical elements, like ionization cooling and the final phase space density obtainable, was also discussed, and considered important to establish the feasibility of this collider.

The $\gamma - \gamma$ and $e - \gamma$ colliders were presented by A. Sessler. These colliders can be seen as an extension of $e^+ - e^-$ colliders, adding to their physics capability at a modest cost. The $\gamma - \gamma$ and $e - \gamma$ colliders are based on the same accelerator system used for a $e^+ - e^-$ collider. The electrons and positrons are accelerated in a linac to the final energy, and interact with a powerful laser beam, just before they reach the interaction point, to produce gammas by Compton backscattering. The gammas then collide producing a luminosity similar to that obtainable in the electron-positron collider. The electrons and positrons are swept away from the interaction region using a magnetic field, or using an angle between the electron and positron beams. The design of the interaction region and the distance of the electron-gamma conversion points from the interaction point are critical elements for this type of collider. The luminosity of a $\gamma - \gamma$ collider can be of the same order or larger than that of the $e^+ - e^-$ collider on which it would be based. To reach this luminosity one needs lasers with a power in the terawatt range, pulse length of a few picosecond, repetition rate of a few hundred Hz, and a wavelength of 1 to 10 μm . Such lasers could be based on systems like the Chirped Pulse

Amplification Terawatt lasers recently developed, or Free Electron Lasers. The requirements and the present availability of the lasers was also discussed.

The possibility of modifying the SLC into an $e - \gamma$ collider, using a plasma lens to increase the $e - \gamma$ luminosity, was discussed by D. Cline and P. Chen, emphasizing that this could be an important step in developing this type of colliders.

3. Other topics

Some very interesting accelerator physics papers were presented in this group.

A paper by Z. Huang, P. Chen and R. Ruth discussed beam cooling in a focusing channel as a result of synchrotron radiation emission. The authors show that in a uniform focusing channel the normalized emittance is damped to the ultimate limit, the electron Compton wavelength. This result is very interesting because it shows for the first time the theoretical possibility of reaching the quantum mechanical limit for the emittance.

P. Chen discussed a laboratory based Graviton Factory, with the possibility of producing and detecting gravitons through the resonant photon-graviton interaction. Gravitons would be produced by a powerful electromagnetic radiation beam, propagating through a large static magnetic field. The number of gravitons produced in this process is proportional to the square of the magnetic field intensity, the square of the interaction length, and the input laser power. The detection is done through the inverse process, propagating the gravitons through the same magnetic field to produce again photons of the same frequency of the original photons. Chen discussed possible ways to reduce the required power to a practical value, although we are still far from the possibility of a real laboratory based experiment.

The possibility of using a plasma wakefield accelerator in the blow out regime to produce an accelerator capable of accelerating a beam to high energy while preserving its emittance, to produce a high luminosity collider, was discussed by J. Rosenzweig. He stressed the similarity between acceleration in this regime, and acceleration in a conventional metallic wall accelerator, and the fact that one should be able to obtain in this system linear focusing forces. This is an interesting theoretical possibility, which can be used to orient the R&D work on new accelerators.

Acceleration and cooling in a crystal was discussed by A. Bogacz, and its application to a $\mu - \mu$ collider was discussed by D. Cline. The acceleration can be obtained through an Inverse FEL mechanism, modulating the crystal structure

with an acoustic wave, and using a laser in the micrometer wavelength region as a driver.

The two last paper discussed in the group were on Oide's limit and on beam conditioning. Oide's limit was rediscussed by J. Irwin in a 2-dimensional approximation, and the beam conditioning was discussed by D. Whittum. This idea was developed initially to improve an FEL performance, but is also a good example of beam manipulation to optimize some beam parameters relevant to one particular application.