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PHYSICS WITH SMALL HIGH RESOLUTION BUBBLE CHAMBERS

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At this conference, Heinrich Leutz [1] shows how it is possible to design and build a small bubble chamber which offers a spatial resolution of $\sim 50 \mu\text{m}$ and a sensitivity of several events per microbarn within a few days of run.

It is now known that the lifetime of most charmed particles is such ($\sim 10^{-13}$ s) that it is necessary to reach spatial resolutions of $\sim 5 \mu\text{m}$ to observe directly their decays when produced at SPS energies. Paul Lecoq [2] shows how bubble chambers equipped with holographic optics can reach such a resolution.

I shall, myself, briefly review some ideas to use these detectors in particle physics.

Let me first remind that, whereas in classical optics, the resolution is related to the depth of field by the relation

$$R = 1.22 \sqrt{D\lambda}$$

which, with $\lambda = 550 \text{ nm}$, limits D to 12 mm for $R = 50 \mu\text{m}$, no such relation exists between R and D with holography. This means that holography does not only allow to reach resolutions R of 5 to 10 μm , in principle it also provides a way to reach larger sensitivities since larger beam fluxes can be used, each incident particle having little effect on the quality of the holograms of its neighbours as long as they are separated by distances larger than R .

Therefore, it is possible to consider resolutions of ~ 5 to $10 \mu\text{m}$ with 200 to 300 incident particles per hologram, spread over a gate of $\sim 100 \mu\text{s}$ if a hydrogen bubble chamber is used. With a duty cycle of the order of 5×10^{-3} , this corresponds to beam intensities of the order of 3×10^6 particles/s (instead of $\sim 2 \times 10^4$ particles/s for LEBC).

Within this frame, several proposals have been made to use high resolution bubble chambers at SPS.

The idea of using high resolution small hydrogen bubble chambers to observe the charmed particles was first proposed by Colin Fisher [3] in 1977. Two experiments have already been runned, using LEBC, a lexan bubble chamber equipped with classical optics [1]. The first experiment, known as NA13, has provided information on the production cross section of D in $340 \text{ GeV/c } \pi^+ p$ collisions [4]. A second experiment, NA16, is in progress. It is a repetition of NA13, with ~ 10 times the statistics of NA13, the bubble chamber being complemented with the spectrometer and gamma detectors of EHS [5]. The spectrometer gives a momentum resolution of $\sim 2\%$ with a good acceptance, allowing effective mass measurements, i.e. some separation between charm candidates and strange particles which appeared to be the main source of background in NA13. The gamma detectors allow the reconstruction of the π^0 's for a large fraction of the charm decay candidates.

A natural extension of this experiment is to run a holographic hydrogen bubble chamber (HOLEBC) in front of the complete EHS spectrometer, including gamma detectors and particle identification (SAD, ISIS, FC, TRD) [6]. A prototype experiment [7] could yield about 10^5 holograms, i.e. 50 to 100 charmed particle pairs with a good sensitivity over the full lifetime range.

The choice of the EHS spectrometer is guided by the capability of this spectrometer to reconstruct with high precision ($\Delta p/p \sim 1\%$) multiparticle events, offering an almost complete downstream analysis. EHS gamma detectors (lead glass walls) provide information on π^0 's with an accuracy of $\sim 3\%$. It is expected that ISIS would provide identification from 3 to 60 GeV/c .

One of the obvious limitations of such a proposal is the absence of an efficient on-line trigger and therefore the poor ratio : number of observed charmed decays over the number of holograms ($\sim 10^{-3}$). It is well known that an efficient "charm trigger" has still to be invented. With the above test experiment, one could gain some experience with high resolution drift chambers [8] to tag the events containing charged D mesons, but the resolution and two track

separation of these detectors still seem marginal to be used as efficient on-line triggers. An attempt to remedy this evil has been proposed by Stefan Tavernier, Erik Johansson and collaborators, [9].

In their proposal, the vertex detector is a small rapid cycling heavy liquid, holographic bubble chamber followed by a muon filter. The trigger consists of a multiplicity selection and of a muon selection. Scintillation counters upstream and downstream of the bubble chamber are used to select one incident particle and a downstream multiplicity of at least three. The muon detector consists of 4 m of iron. Three hodoscopes placed after 2.1, 2.7 and 3.6 m of iron define the muon trigger. This filter is followed by six sections of iron followed each by a proportional chamber. The information from these chambers, together with the information from the scintillators is used to guide, off-line, the scanning of the holograms. The trigger efficiency from events with charmed particles leading to, at least, one muon, should be $\sim 60\%$ and the charm enrichment factor achieved on the holograms should be ~ 20 .

Assuming 25 Hz for the bubble chamber filled with C_3F_8 (interaction length of 180 cm for π 's), with 150 particles for a gate of 30 μ sec ($I = 5 \times 10^6$ part./sec), a run of ~ 10 days would provide ~ 1000 charm pairs distributed on ~ 40000 holograms. Running with incident $\pi^\pm$, $K^\pm$, $p^\pm$ at 100, 200, 350 GeV/c, one could learn how charm production cross sections depend on incident beam particle and energy.

The possibility of introducing a relative efficient on-line trigger and to conserve the advantages of a good downstream spectrometer, gamma detectors and particle identification, may be accessible for photoproduction of charmed particles. The set-up would be basically very similar to P154 [7], the camera and laser used for the formation of holograms being triggered for photos with $E > E_0$ ($E_0 \sim 50$ GeV/c), and using a hodoscope for the detection of hadronic photoproduction. It has been shown by E. Kistenev, S. Reucroft, L. Ventura and G. Zumerle [10] that a beam of $\sim 10^7$ photons with energy $E > 2$ MeV over a flat top of 2 sec would provide a high energy ($E > 10$ GeV) hadronic photoproduction every SPS flat top. The holograms would contain, in addition, ~ 10 conversions, but it should be easier to deal with this background with holographic techniques than with classical optics. A run of 10 days would produce $\sim 5 \times 10^4$ holograms, $\sim 1\%$ of them containing a charm pair. In principle, the resolution obtained with the holographic technique could be brought to one or two microns, in which case, search for beauty may not be excluded.

One of the limitations of EHS is due to the low beam intensities which can be tolerated by ISIS and the spectrometer. In order to take full advantage of the increase in sensitivities offered by the holographic technique, it is attractive to design experiments making use of neutral beams.

One possibility could be a neutral beam made by charge exchange of $K^- \rightarrow K_L^0$. If a tagged K_L^0 beam can be set up at sufficiently high energy and intensity, a rich field of physics could be opened (F-meson, τ lepton...): It may also be possible to investigate nucleon-antinucleon annihilations, using an antineutron beam obtained from a $\bar{p}$ beam by charge exchange. This possibility would become very attractive if a 400 GeV/c $\bar{p}$ beam is extracted from the SPS.

Murat Boratav [11] studied the possibility of running a heavy liquid holographic bubble chamber in a 300 GeV hyperon beam. The idea is very attractive since it could give access to the direct observation of charmed hyperons like the S and A (DSC) with a Σ^- beam and the T (SSC) with a Ξ^- beam. At 300 GeV/c, the cross section for production of A may be of the order of $10 \mu\text{b}$ and the hyperon beam could contain $\sim 20\%$ of Σ^- . A run of ~ 20 days would provide 80000 holograms with ~ 400 S and A directly observed.

Let me end up this list of suggestions with a much simpler proposal, i.e., to measure the lifetime of the π^0 's. One could observe directly the line of path of a π^0 produced by charge-exchange, starting with a 300 GeV/c π^- beam. The mean path would be $60 \mu\text{m}$, and an accurate lifetime could be determined, using the decay $\pi^0 \rightarrow e^+ e^- \gamma$.

This brief summary shows the potential interest of high resolution, high sensitivity experiments which could be performed with small holographic bubble chambers.

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