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Fixed-Target Charm at the Fermilab Tevatron

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1. INTRODUCTION

Fixed-target charm at the Fermilab Tevatron? Didn't we do that for over twenty years ending a decade ago? Why revisit that strategy?

Yes, we did have a very successful fixed-target charm program at Fermilab. Not only did it provide high precision measurements (some of which remain the most precise even today), but it also advanced flavor physics thinking in a way that still underlies many current analyses. It also demonstrated the utility of precision vertexing for heavy flavor physics, paving the way for the incorporation of silicon tracking systems in all the latest experiments. The fixed-target charm program ended when the technologies used were more-or-less played out, and attention turned to the opportunities at colliders, both at e+e- and hadron machines. The reason to bring a fixed-target charm experiment up now is a combination of the availability of technology well beyond what was available at the end of the previous program, and because it may be the most cost-effective way forward in this area. We will address these new opportunities below. In the recent "Roadmap for US High-Energy Physics" written by the Particle Physics Project Prioritization Panel (P5), future operation of the Tevatron was not considered. However, there exists a plan to keep the Tevatron cold after completion of the Collider program such that it could easily be operated again should sufficiently compelling physics opportunities arise. We believe one such opportunity is in charm physics, where mixing has recently been observed, but current sensitivity to CP violation (CPV) is limited. A fixed-target charm experiment at the Tevatron has the potential to greatly improve upon the sensitivity to mixing and CPV achieved by the B factories. Such an experiment could be the only way forward. A fixed-target charm experiment at the Tevatron could also be cost effective, as the Tevatron would not need to be run in collider mode, and also the beam energy could be reduced and still remain far above threshold. The goal in this paper is to present the physics case for such a charm experiment. We note that the most sensitive measurements of mixing and CPV rely on measuring decay-time distributions. For this type of measurement, a fixed-target experiment has an advantage over an e^+e^- B factory experiment due to the fact that the mean decay length is notably larger than the vertex resolution.

A Fermilab Tevatron fixed-target experiment could produce very large samples of D^* mesons that decay via $D^{*+} \to D^0\pi^+$, $D^0 \to K^+\pi^-$ [1]. The decay time distribution of the "wrong-sign" $D^0 \to K^+\pi^-$ decay is sensitive to D^0-$\overline{D}^0$ mixing parameters x and y. Additionally, comparing the D^0 decay time distribution to that for $\overline{D}^0$ allows one to measure or constrain the CP-violating (CPV) parameters $|q/p|$ and $\mathrm{Arg}(q/p) \equiv \phi$. This method has been used previously by Fermilab experiments E791 [2] and E831 [3] to search for D^0-$\overline{D}^0$ mixing. However, those experiments ran in the 1990's and reconstructed only a few hundred flavor-tagged $D^0 \to K^+\pi^-$ decays. Technological advances in vertexing detectors and electronics made since E791 and E831 ran now make a much improved fixed-target experiment possible. We estimate the expected sensitivity of such an experiment, and compare it to that of the B factory experiments Belle and Babar. Those experiments have reconstructed several thousand signal decays and, using these samples along with those for $D^0 \to K^+K^-/\pi^+\pi^-$, have made the first observation of D^0-$\overline{D}^0$ mixing [4,5]. The CDF experiment has also measured D^0-$\overline{D}^0$ mixing using $D^0 \to K^+\pi^-$ decays [6]. Although the background is much higher than at an e^+e^- experiment, the number of reconstructed signal decays is larger, and the statistical errors on the mixing parameters are similar to those of Babar.

Although we focus on measuring $x, y, |q/p|$, and ϕ, a much broader charm physics program is possible at a Tevatron experiment. We also briefly present some of these other opportunities.

2. EXPECTED SIGNAL YIELD

We estimate the signal yield expected by scaling from two previous fixed-target experiments, E791 at Fermilab and *HERA-B* at DESY. These experiments had center-of-mass energies and detector geometries similar to those that a new charm experiment at the Tevatron would have.

2.1. Scaling from *HERA-B*

HERA-B took data with various trigger configurations. One configuration used a minimum bias trigger, and from this data set the experiment reconstructed 61.3 ± 13 D^*-tagged "right-sign" $D^0 \to K^-\pi^+$ decays in 182×10^6 hadronic interactions [7]. This yield was obtained after all selection requirements were applied. Multiplying this rate by the ratio of doubly-Cabibbo-suppressed to Cabibbo-favored decays $R_D \equiv \Gamma(D^0 \to K^+\pi^-)/\Gamma(D^0 \to K^-\pi^+) = 0.380\%$ [8] gives a rate of reconstructed, tagged $D^0 \to K^+\pi^-$ decays per hadronic interaction of 1.3×10^{-9}. To estimate the sample size a Tevatron experiment would reconstruct, we assume the experiment could achieve a similar fractional rate. If the experiment ran at an interaction rate of 7 MHz (which was achieved by *HERA-B* using a two-track trigger configuration), and took data for 1.4×10^7 live seconds per year, then it would nominally reconstruct (7 MHz)$(1.4 \times 10^7)(1.3 \times 10^{-9})(0.5) = 64000$ flavor-tagged $D^0 \to K^+\pi^-$ decays per year, or 192000 decays in three years of running. Here we have assumed a trigger efficiency of 50% relative to that of *HERA-B*, as the trigger would need to be more restrictive than the minimum bias configuration of *HERA-B*.

2.2. Scaling from E791

Fermilab E791 was a charm hadroproduction experiment that took data during the 1991-1992 fixed-target run. The experiment ran with a modest transverse-energy threshold trigger, and it reconstructed 35 D^*-tagged $D^0 \to K^+\pi^-$ decays in 5×10^{10} hadronic interactions [2]. This corresponds to a rate of 7×10^{-10} reconstructed decays per hadronic interaction. Assuming a future Tevatron experiment achieves this fractional rate, one estimates a signal yield of (7 MHz)$(1.4 \times 10^7)(7 \times 10^{-10}) = 69000$ per year, or 207000 in three years. This value is similar to that obtained by scaling from *HERA-B*. We have assumed the same trigger + reconstruction efficiency as that of E791. We note that E791 had an inactive region in the middle of the tracking stations where the π^- beam passed through, and a future Tevatron experiment could avoid this acceptance loss. We do not include any improvement for this in our projection.

3. COMPARISON WITH THE B FACTORIES

We compare these yields with those that will be attained by the B factory experiments after they have analyzed all their data. The Belle experiment reconstructed 4024 D^*-tagged $D^0 \to K^+\pi^-$ decays in 400 fb^{-1} of data [9], and it is expected to record a total of 1000 fb^{-1} when it completes running. This integrated luminosity corresponds to 10060 signal events.

The Babar experiment reconstructed 4030 tagged $D^0 \to K^+\pi^-$ decays in 384 fb^{-1} of data [4], and the experiment recorded a total of 484 fb^{-1} when it completed running in early 2008. Thus the total Babar data set corresponds to 5080 signal events. Adding this to the estimated final yield from Belle gives a total of 15100 $D^0 \to K^+\pi^-$ decays. This is less than 8% of the yield estimated for a Tevatron experiment in three years of running.

The KEK-B accelerator where Belle runs is scheduled to be upgraded to a "Super-B" factory running at a luminosity of $\sim 8 \times 10^{35}$ cm^{-2} s^{-1} [10]. There is also a proposal to construct a Super-B factory in Italy near the I.N.F.N. Frascati laboratory [11]. An experiment at either of these facilities would reconstruct very large samples of $D^{*+} \to D^0\pi^+$, $D^0 \to K^+\pi^-$ decays, and in fact the resulting sensitivity to x'^2 and y' may be dominated by systematic uncertainties. This merits further study. We note that the systematic errors obtained at a future Tevatron experiment are expected to be smaller than those at an e^+e^- collider experiment, due to the superior vertex resolution and π/K identification possible with a forward-geometry detector.

4. COMPARISON WITH HADRON COLLIDERS

The LHCb experiment has a forward geometry and is expected to reconstruct $D^{*+} \to D^0\pi^+$, $D^0 \to K^+\pi^-$ decays in which the D^* originates from a B decay. The resulting sensitivity to mixing parameters x'^2 and y' has been studied in Ref. [12]. This study assumes a $b\bar{b}$ cross section of 500 μb and estimates several unknown trigger and reconstruction efficiencies. It concludes that approximately 58000 signal decays would be reconstructed in 2 fb^{-1} of data, which corresponds to one year of running. This yield is similar to that estimated for a Tevatron experiment. However, LHCb's trigger is efficient only for D mesons having high p_T, *i.e.*, those produced from B decays. This introduces two complications:

1. Some fraction of prompt $\overline{D}^0 \to K^+\pi^-$ decays will be mis-reconstructed or undergo multiple scattering and, after being paired with a random soft pion, will end up in the $D^0 \to K^+\pi^-$ sample (fitted for x'^2 and y'). As the production rate of prompt D's is two orders of magnitude larger than that of B's, this component may be non-negligible, and thus would need to be well-understood when fitting.

2. To obtain the D^* vertex position (*i.e.*, the origin point of the D^0), the experiment must reconstruct a $B \to D^*X$ vertex, and the efficiency for this is not known. Monte Carlo studies indicate it is 51% [12], but there is uncertainty in this value.

The LHCb study found that, for $N_{K^+\pi^-} = 232500$, a signal-to-background ratio (S/B) of 0.40, and a decay time resolution (σ_t) of 75 ps, the statistical errors obtained for x'^2 and y' were 6.4×10^{-5} and 0.87×10^{-3}, respectively. These values are less than half of those that we estimate can be attained by the B factories by scaling current errors by $\sqrt{N_{K^+\pi^-}}$: $\delta x'^2 \approx 14 \times 10^{-5}$ and $\delta y' \approx 2.2 \times 10^{-3}$. As the signal yield, S/B, and σ_t of a future Tevatron experiment are similar to those for LHCb, we expect that similar errors for x'^2 and y' can be attained.

The CDF measurement of charm mixing [6]has 12700 $D^{*+} \to D^0\pi^+$, $D^0 \to K^+\pi^-$ decays from 1.5 fb^{-1} of integrated luminosity. This could increase by about a factor of five by the end of Run II at the Tevatron collider.

To compare to these estimates, we have done a "toy" Monte Carlo (MC) study to estimate the sensitivity of a Tevatron experiment. The results obtained are similar to those of LHCb: for $N_{K^+\pi^-} = 200000$, $S/B = 0.40$, $\sigma_t = 75$ ps, and a minimum decay time cut of $0.5 \times \tau_D$ (to reduce combinatorial background), we find $\delta x'^2 = 5.8 \times 10^{-5}$ and $\delta y' = 1.0 \times 10^{-3}$. These errors are the RMS's of the distributions of residuals obtained from fitting an ensemble of 200 experiments. A typical fit is shown in Fig. 1.

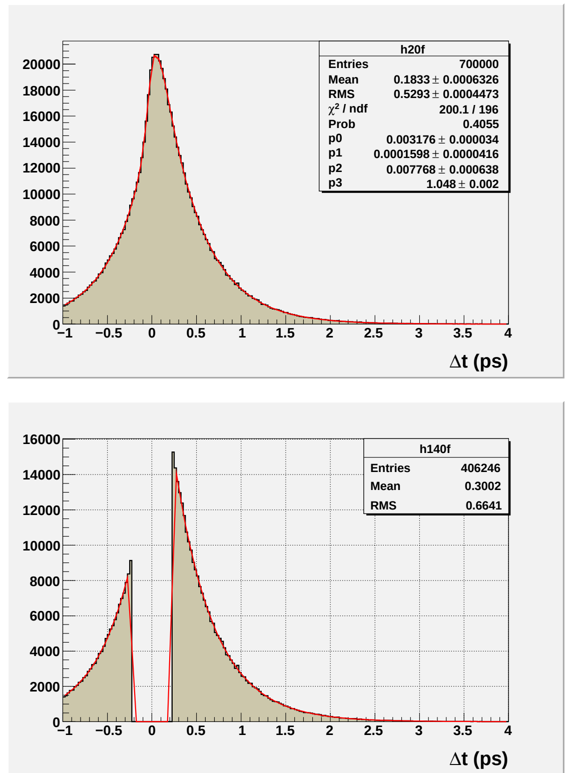

Figure 1. Monte Carlo $D^0 \to K^+\pi^-$ decay time distributions (top) without and (bottom) with a minimum decay time cut. Superimposed is the result of a fit. The ratio of signal to background after the $t_{\rm min}$ $(=\tau_D/2)$ cut is 0.40, and the decay time resolution σ_t is 75 fs.

5. GLOBAL FIT FOR CPV PARAMETERS

If we assume the $\delta x'^2$ and $\delta y'$ errors obtained in our toy MC study (which are close to the values obtained in the LHCb study), we can estimate the resulting sensitivity to CPV parameters $|q/p|$ and ϕ. The first parameter characterizes CPV in the mixing of D^0 and $\overline{D}^0$ mesons, while the second parameter is a phase that characterizes CPV resulting from interference between an amplitude with mixing and a direct decay amplitude. In the Standard Model, $|q/p|$ and ϕ are essentially 1 and 0, respectively; a measurable deviation from these values would indicate new physics.

To calculate the sensitivity to $|q/p|$ and ϕ, we do a global fit of eight underlying parameters to 28 measured observables. The fitted parameters are x and y, strong phases $\delta_{K\pi}$ and $\delta_{K\pi\pi}$, R_D, and CPV parameters A_D, $|q/p|$ and ϕ. Our fit is analogous to that done by the Heavy Flavor Averaging Group (HFAG) [13]. The only difference is that we reduce the errors for x'^2 and y' according to our toy MC study, and we also reduce the error for y_{CP} by a similar fraction. This latter parameter is measured by fitting the decay time distribution of $D^0 \to K^+K^-/\pi^+\pi^-$ decays, which would also be triggered on and reconstructed by a Tevatron charm experiment.

The results of the fit are plotted in Fig. 2b. The figure shows two-dimensional likelihood contours for $|q/p|$ and ϕ; for comparison, the analogous HFAG plot is shown in Fig. 2a. One sees that a future Tevatron experiment would yield a very substantial improvement.

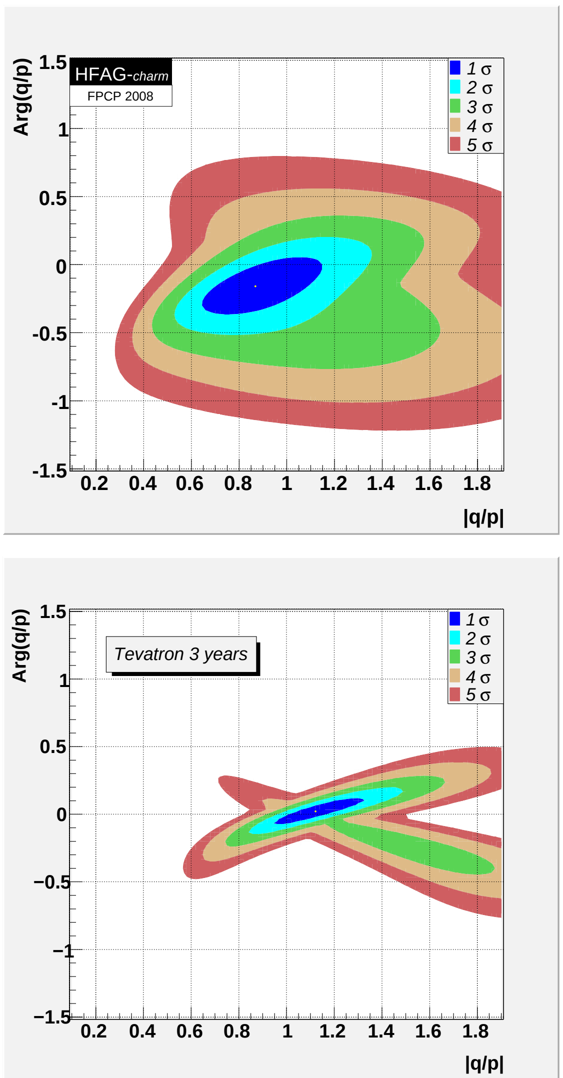

Figure 2. $|q/p|$ versus ϕ likelihood contours resulting from a global fit to measured observables (see text). Top: data after FPCP 2008, from the Heavy Flavor Averaging Group [13]. Bottom: after three years of running of a Tevatron charm experiment.

6. OTHER PHYSICS

6.1. Lifetimes and lifetime differences

6.2. Direct CPV searches

6.3. Rare and forbidden charm decays

6.4. Spectroscopy via Dalitz-plot analyses

A very high statistics charm experiment can hope to unravel many mysteries related to resonances in the 1-2 GeV region. This is because charm hadron masses are in the 2 GeV range and $\pi\pi$, $K\pi$ and KK resonances often dominate charm particle decays. For instance, one can aspire to improve many aspects of our understanding outlined below. There is much to be learned also from the decays of the $J/\psi, \psi(2S)$, and even the η_c, which could also be produced at some level in any such experiment.

6.4.1. Model-independent scattering amplitudes

Investigators such as Dunwoodie, Meadows *et al.* have pioneered the approach of not parameterizing the scattering amplitude but, instead, obtaining amplitudes and phases as a function of energy directly from the data. This gets around many of the problems that plague the various parameterizations. On the other hand, it is not easy to obtain convergent fits to data when a complex amplitude is desired in fine steps of mass. Current results with this technique are in good agreement with the simple isobar model. The true benefits will accrue when differences are well established. It should be noted that the idea that intermediate resonances necessarily exist is not universally accepted. Indeed, such doubts motivated Dunwoodie to advocate that we measure scattering amplitudes directly without any assumptions about resonances, and compare with results in other related processes. Higher statistics than currently available will be required.

6.4.2. Improvement in descriptions of the resonances

So far we have mostly used a Breit-Wigner functional form to describe resonances, with some modifications for barrier penetration factors etc. However, there is no well-established theory which prescribes a precise form for the propagator for wide resonances. Hence, deviations from the simple forms are to be expected, particularly for describing broad resonances with high statistics. This is already evident in Dalitz fits to, for example, the $D^0 \to K^0_S\pi\pi$. Another example is that Gounaris and Sakurai provided a formula for the case of the well-known wide resonance $\rho(770)$ [14]. Experimentally, one can try to examine scattering amplitudes [15] and one does not find clear Breit-Wigner-shaped peaks. This further delineates the need for high-statistics studies of scattering.

A related issue is that of parameterization via Breit-Wigner peaks or via the K-matrix and P-vector formalisms [16–18]. The K-matrix method is well motivated, but does it (a) provide a better description of data than a simple sum of resonances and (b) is it merely a different parameterization since there are hidden assumptions in this approach? A well-known success is the Flatte formula for coupled channel descriptions of the $f_0(980)$. This description is being tested (at least) by BaBar analysis of $D_s \to \pi\pi\pi$ data at the moment.

Another example of uncertainties in physics descriptions lies in the issue of whether the Zemach formalism or the helicity formalism correctly describes decays [19,20].

Barrier penetration factors modify the resonant propagators. Their derivation is based on simple quantum mechanical models of mesons [21,22]. There is no reason to expect these expressions to be rigidly true. Indeed, we must search for better descriptions both empirically as well as theoretically, especially when there are higher mass excitations in the same amplitude (*e.g.*, the P-wave extracted from K pi scattering).

6.4.3. Improvements in masses and widths of well-established resonances

It is well known that the parameters (and parameterization) of the f0(980) are not well established. Indeed, as a simple scan of the particle data table of light, unflavored mesons will establish, beyond a mass of around 1 GeV, one or more of the mass, width and major branching fractions of most resonances are not well known. This is also true for strange mesons apart from the $K^*(892)$: the $K^*_2(1430)$, the $K^*_3(1780)$ and the $K^*_4(2045)$. Note however that mass and width values must be in context, *i.e.*, may not be identical in all processes, (*e.g.*, there could be effects due to thresholds or to cross-channel interference in Dalitz-plot analyses.

Note that there is also the possibility of learning about light meson systems from charm baryon decay. For example, in Ziegler's thesis study of $\Lambda_c \to \Lambda K^+ \overline{K}^0$ [23], she showed that the Dalitz plot is well-described in terms of a_0 and $\Xi(1690)$ amplitudes only. It would be interesting to look at the $\Lambda_c \to \Lambda\eta\pi^+$ Dalitz plot in order to relate the a_0 to $K^+\overline{K}^0$ and $\eta\pi^+$ amplitudes, assuming that one can obtain adequate statistics on both Λ_c decay modes.

6.4.4. Sorting out poorly established resonances

As stated in the PDF reviews of low mass resonances [24,25], scalar resonances have large widths; there are many in a short mass interval; and there is "competition" from glueballs and multiquark states. In addition there is the experimental problem of distinguishing these from "non-resonant components" in Dalitz analyses.

A list of issues in charm spectroscopy includes:

- Parameters for the well-established: $K_0^*(1430)$.
- The κ: Wide and close to $K\pi$ threshold; difficult to establish. Connections to theoretical work on poles of the T-matrix have not been firm.
- The $a_0(980)$: Being close to the $K\overline{K}$ threshold, it is difficult to establish this without a proper coupled-channel analysis. The broad structure at 1300 MeV: needs further confirmation in existence and isospin assignment.
- $\sigma(600)$: Hard to establish. Broad, must be "distorted by background as required by chiral symmetry", from "crossed channel exchanges" etc. The $\sigma(600)$ plays an important role as the "Higgs boson of strong interactions" in chiral symmetry-breaking models, and supposedly "generates" most of the proton and η' masses.
- $f_0(980)$: Overlaps strongly with the $\sigma(600)$, if such exists. (Leads to a dip in the $\pi\pi$ spectrum at the $K\overline{K}$ threshold.)
- $f_0(1500)$: Mass is fairly well-established, but not precisely so. Whether this resonance is mainly glue is an open question. Note however that the $f_0(1710)$, is seen in J/ψ radiative decay (indicating gg coupling) while the $f_0(1500)$ is not.
- Pseudoscalars: Is there only a single $\eta(1440)$ or are there also $\eta(1405)$ and $\eta(1475)$? The latter two are not firmly established. Similarly, one can ask whether the $\eta(1295)$ is an established resonance. Theorists have questioned the need for this large number of states. At the same time, classification schemes can accommodate these resonances. Do they have large gluonic content?
- 1^{++} isoscalars: Is the $f_1(1420)$ decaying to $K^*\overline{K}$ real? Similarly, an $f_1(1510)$ is reported, and again, this resonance needs to be firmly established.
- What are the masses, widths and couplings of all these resonances? Knowledge of the branching fractions and such coupling information will lead to clearing up of oddities in data analyses, such as which channels should show which resonances.
- Interpretation: Fitting the scalars into a nonet is a problem. The choice of the ninth member is ambiguous. Are they dominantly multiquark ($qq\bar{q}\bar{q}$) states? Are they glueballs? And how many of the masses and widths are predicted by lattice gauge calculations?

6.4.5. Spectroscopy via production (*e.g.*, double charm baryons)

Doubly-Charmed Baryons were discovered at Fermilab in forward hadroproduction with baryon beams. Several states are reported, each in several decay modes. However, there has been no confirmation of these states from non-baryon-baryon interactions. These states are a new and different window into QCD. Their spectroscopy, lifetimes, and decay schemes are all illuminating.

There are critical experimental issues for a 100-1000+ event experiment. These include:

- High energy baryon beams
- High rate beam and detector
- Excellent tracking, particularly in the vertex region
- Good downstream hyperon reconstruction efficiency for good charmed baryon reconstruction efficiency
- Excellent particle ID

6.4.6. Comparisons with other experiments:

- LHC
- Super B-Factories

7. OVERVIEW OF NEW TECHNOLOGIES

7.1. Silicon pixel detectors/vertexing

Silicon pixel detectors will play a crucial role in a new high-rate fixed-target charm experiment. Their contributions include pattern recognition in complex event topologies, radiation-hard high-rate capability so that primary beam can go through the detector without compromising performance, and excellent spatial resolution enabling the reconstruction of interaction and decay points from measured charged particle tracks.

Historically, silicon microstrip detectors played an important role in fixed-target charm experiments. When these high precision vertex detectors were introduced in the eighties, they revolutionized the study of heavy flavors. Besides offering high precision tracking and vertex information, they lead to the possibility of high statistics experiments, something that earlier generations of experiments, using bubble chambers or emulsions could not possibly accomplish. In 1985/1986, CCDs were used in a fixed-target charm experiment, the first application of pixel devices in high energy physics. Since then, silicon strip detectors have become major tracking elements in all collider experiments; for the Tevatron, LEP, B-factories, and now the LHC. CCDs were limited to only e+e- colliders because of their readout speed. On the other hand, the use of hybridized pixel detectors, in which readout chips were bump-bonded to silicon sensors, have been used in heavy ion experiments at CERN (WA97, NA62) and are now being employed as the vertex detector for ATLAS, CMS, and ALICE. With the development and experience gained over the last decade or so, the hybridized pixel detector technology has matured, and certainly can be an important tool for future fixed-target charm experiments.

Pixel detectors offer excellent three-dimensional information, which leads to much better pattern recognition, avoiding ambiguities and ghost tracks. Its advantage over the two-dimensional information provided by the silicon strip detectors have been demonstrated by both the fixed-target experiments at CERN and also at SLD. With a pixel size of 50 microns by 400 microns, test beam results achieved a resolution of better than 2 microns. The detector noise is about 100 electrons or less. This means such a detector would give a signal-to-noise of better than 200:1. These detectors are also very quiet, and the spurious hits, as observed during the commissioning phase of the LHC experiments, are of order of 10^{-5}. Furthermore, such devices can be self-triggered. All the readout chips used in the LHC experiments have the feature of being data-driven, which means that the chip generates a fast signal when a hit is registered above threshold. ALICE has used this information, and has taken a lot of cosmic ray and first beam data using a pixel-detector trigger.

Pixel detectors, because of their fine segmentation, can also handle very high rate, and handle high radiation dosage. It has all the excellent features that are required in a next generation of charm experiments.

Since 1998, Fermilab has been active in the pixel R&D effort. This has led to the development of the FPIX series of pixel readout chips for the BTeV experiment. When BTeV was cancelled, a group from Los Alamos picked up the design and used the chip, sensor, interconnect, and a lot of the mechanical design to build a couple of forward muon stations for the PHENIX experiment. With small modification, such a design could be well suited for a new charm experiment at the Tevatron.

7.2. Triggering on decay vertices, impact parameters

7.3. RICH detectors, π/K separation

The physics goals of a fixed-target charm experiment requires good charged particle identification to observe various decay modes of interest. At the Tevatron fixed-target energies, one must be able to separate pions, kaons, and protons with high efficiency over a range of momentum from several GeV up to hundreds of GeV. This can be accomplished by using a Ring Imaging Cherenkov detector (RICH).

¿From the early days of the OMEGA experiment, over the years, RICH detectors have been built and operated in different environments. They were used in fixed-target experiments at Fermilab (e.g., E665, E706, E789, E781), in *HERA-B* at DESY, as well as in e^+e^- collider experiments (DELPHI and SLD). Currently, a RICH detector is used in a hadron collider experiment (LHCb).

The detector performance and cost is determined, to a large extent, by the choice of the photo-detector. In the early days, experiments used gas detectors based on photo-ionizing gas such as TMAE or TEA. Operationally, this has not been easy. On the other hand, the new rounds of experiments tend to use commercial detectors such as PMT (SELEX), MAPMT (HERA-B) and HPD (LHCb) which offer stability, ease of operation, and maintenance at a moderate cost.

We can take the SELEX RICH as an example. The RICH vessel is 10.22 m long, 93 inches in diameter and filled with neon at atmospheric pressure. At the end of the vessel, an array of 16 hexagonal mirrors are mounted on a low-mass panel to form a sphere of 19.8 m in radius. Each mirror is 10 mm thick, made out of low-expansion glass. For the photo-detector, SELEX used 2848 0.5-inch photomultipler tubes arranged in an array of 89 by 32. Over a running period of 15 months, the detector operated very stably. The ring radius resolution was measured to be 1.56 mm and, on average, 13.6 photons were observed for a $\beta = 1$ particle.

7.4. Micro gas tracking detectors, *e.g.*, GEM

8. SUMMARY

In summary, we note the following and conclude:

- D^0-$\overline{D}^0$ mixing is now established, and attention has turned to the question of whether there is CPV in this system.

- Technical advances in detectors and electronics made since the last Fermilab fixed-target experiments ran would make a new experiment much more sensitive to mixing and CPV effects. Silicon strips and pixels for vertexing are well-developed, and detached-vertex-based trigger concepts and prototypes exist (*e.g.*, *HERA-B*, CDF, BTeV, LHCb).

- Such an experiment would have substantially better sensitivity to mixing and CPV than all Belle and Babar data together will provide. The Tevatron data should have less background than LHCb data. Systematic uncertainties may also be less than those of any Super-B Factory experiments and LHCb.

- The Tevatron and requisite beamlines are essentially available.

- Such an experiment could help untangle whatever signals for new physics appear at the Tevatron or LHC.

Recently, a working group has formed to study the physics potential of a charm experiment at the Tevatron in more detail. Information about this working group and its results can be obtained at `http://www.nevis.columbia.edu/twiki/bin/view/FutureTev/WebHome`.

In brief, we write this chapter to keep the possibility of a fixed-target charm experiment at the Tevatron a viable option for Fermilab (and the US HEP program), to be decided upon once there is a clearer picture of available funding, manpower, and feasibility of the current roadmap.

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