04/08/2008, draft 2
Hall D Pair Spectrometer
Tentative design, exploring the features of PRIMAX project's pair spectrometer's magnet.

The PS magnet used in PRIMAX project has an effective BL=1.5T*m, at effective length Leff ≈ 0.8m, maximal field Bmax≈1.9T, and maximal bending angle ~34^o. The PS detectors In PRIMAX were build to be identical in both arms (two plane of scintillator hodoscopes, 16 telescopes in each arm), allowing to cover 31 points in the photon energy range from 1.3 to 4Gev. This info still needs in confirmation as it is based on the non-complete geometry description in Lumi monitoring in PRIMAX and NIM A572(2007)654 paper devoted to a measurements with MicroStrip device.

Anyhow one may do some evaluations of applicability of PRIMAX bending magnet for Hall D purpose with this level of knowledge.

The specific conditions for Hall D for the use of PRIMAX magnet

- BL=1.5T*m is not enough for noticeable trajectories bending in the vicinity of end point 12GeV, even at symmetrical setting, such as 6+6GeV/c in each arm(appr. 4degree). The length of magnet(0.8m) and of existing vacuum chamber(0.53m out of magnet) are from the other hand too short to go far enough from the beam pipe in the transversal plane aimed to achieve a reasonable size of detectors in the transversal plane and installation of radiation shield.
- Need in good sampling of CB peak (≥10points/GeV) in the range of energy 6-to 9GeV, having simultaneously a maximal energy acceptance. This requires to build-up a non symmetric configuration of PS arms, including fine sampled, small acceptance hodoscope in one arm and wide spaced and high acceptance hodoscopes in the second.

Proposed design of hodoscopes sizes and location implies:

- **An existence of a long vacuum chamber extended at least 2m out of magnet**
- **Non-alternative selection of highest energy 6.125GeV/c in both arms of PS.**
- **Fine sampling(70-100MeV) of CB energy spectrum measurements**
- **Coverage of full CB spectrum(by 2-3 magnet's current setting**

The Wide Spacing Forward (WSF) hodoscope arm consists of 5 plastic scintillator telescopes covering electron energy range from 6.125 to 2.125 GeV/c, with step of 1 GeV/c at Bmax=1.9T. The second arm, the Fine Spacing Forward (FSF) hodoscope consists of 10 plastic scintillation strips and covers positron energy range from 6.125 to 5.225GeV /c with energy step app. 0.1GeV/c. The strips are 3.5mm wide, readout through the fiber light guides by multi-anode PMT or SIM PMT similar to one proposed in the tagger microscope design. This subject is considered below. The ratio of the measured maximal to minimal photon energy($E_\gamma^{max}/E_\gamma^{min}$) at one current setting is 1.6667 and allows to cover a photon energy range from 2.35 to 12.25GeV by two measurements, having in each 50 not overlapping energy points. The FSF and WSF arms data are presented in Tables1,2 below.
The choice of resolution in WSF arm is guided by wish to have the photon energy resolution the same as in the FSF arm, app. σ/E_γ=0.45%:

Table1
The FSFH - arm., P_{max}= 6.125.GeV/c and P_{min}= 5.225.GeV/c at B=1.9T

Counters of FSF hodoscope	P(GeV/c)	<R>(m)	<α> (deg)	<x>(cm)	Δx(cm)	(σ/P)(%)
FSF1	5.225	9.17	5.01	21.03	0.36	0.45
FSF10	6.125	10.75	4.27	17.91	0.34	0.45

The 10 telescopes of FS arm are formed by single counter SF located 100cm downstream of FSF hodoscope and having x=27.59 and width Δx=5 cm. The 10 strip FSFH configuration may be easily transformed to 15 strips one with strips width 2.3mm each.

Table 2
The WSFH - arm., P_{max}= 6.125.GeV/c and P_{min}= 2.125.GeV/c at B=1.9T

Counters of WSFHhodoscope	P(GeV/c)	<R>(m)	<α> (deg)	<x>(cm)	Δx(cm)	(σ/P)(%)
WSF1	2.125	3.73	12.38	51.58	0.81	1.1
WSF2	3.125	5.48	8.39	35.36	0.74	. 1.0
WSF3	4.125	7.24	6.34	26.65	0.68	0.9
WSF4	5.125	8,99	5.11	21.45	0.63	0.83
WSF5	6.125	10.75	4.21	17.91	0.58	0.8

The counters and readout means

Dealing with plastic scintillating strips or square fiber pieces, creates the problems with the use the fiber light guides. In the case of tagger microscope, the 2cm long piece of 2mm thick green scintillating fiber (BCF-20) is exposed in parallel to a tagging electrons trajectories. This configuration allows app. 4MeV ionization energy input, generating app. 1600 photons. This number is then reduced, convoluting with fiber's angular acceptance(app. 0.06) and efficiency of the green sensitive photocathode (0.22-0.30), leading to a final maximal number of app.30 ph.el's registered by SiM PMT. In the case of FSF strips, they should have the thickness enough to rich the similar efficiency, that means the need in the strip thickness ≥1cm, achievable for example by 3 pieces of 3mm thick square fibers exposed perpendicularly to the PS trajectories. Those pieces are glued to the long clean fiber or alternatively, single green fiber is used to behave as a radiator and carry light till PMT.

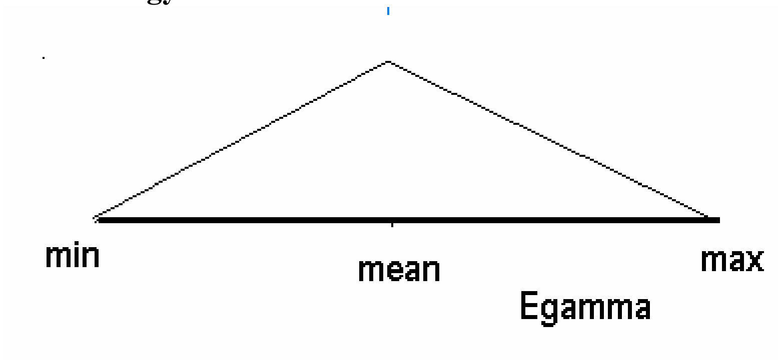
From the other hand there might be some improvement/optimization in PMT and scintillator choice. For example at YERPHI was synthesized and tested a fast green scintillator PS+1% 4V3HF(see NIM A 423(1997)27-31) having a rising time app. 0.2nsec. I cannot compare it with BCF-20 proposed for tagger, but seems it worth to be done. The SiM PMT's need in good thermo- and bias- stabilization, while for small number of channels the use of PMT with green extended photocathode is preferable as I believe.

The backward layer hodoscopes as well as electronics and expected software are not presented in this design, while are described in the second one made for B*L=2.622T*m that is done regardless to the availability of PrimEx magnet. In this sense there is no qualitative difference between these two designs.

Alternative Design

Version 2

As an alternative way it's possible to use two identical hodoscopes of 30 micro-strips each , covering an energy range from 6.25 to 3.25 GeV/c in both arms. This configuration, may be easily evaluated using Table 1 and 2, and allow to measure the photon spectrum in 2*30-1=59 energy points, while 30*30=900 combinations fills non-homogenously the measured energy acceptance in the form of triangle with maximal weight w=30 at the mean energy and the minimal one w=1 in two ends of energy range.



However this option, if partly attractive, creates the problems of too redundant electronics and readout consumption…So one need to understand in details the electronics organization, including the timing.