04/15/2008, draft 3
Hall D beam line Pair Ppectrometer
Technical description and specifications

Note: The General description currently contains no details on the mechanical design.

1. **Changeable photon converter**
2. **Dipole magnet and vacuum chamber**
3. **Two arm detection system**
4. **Electronics**
5. **Software**

1. Changeable photon converter

The aim of this device is to provide a necessary level of photons conversion efficiency, depending on the task and conditions and allowing in particular the regulation of random coincidences rate. The setting of the converters with various thicknesses in the range of 10^{-4}--$10^{-5}X_0$ should be driven remotely in the vacuum pipe.

2.Dipole magnet and vacuum chamber

A magnet of rectangular shape is assumed to be used. An expected performance includes the requirements of $\int \boldsymbol{Bdl} \geq$ 2.62 tesla-meter and magnetic poles width($2D_x$) in the analysis plane not less than 40-50cm. In the present calculations an assumptions are made as a follows: B_{max}=1.311tesla, effective length of the magnet L_{eff}=2m and D_x=25cm . ..
The vacuum chamber is an important part of the Pair Spectrometer. It is assumed to be 2m long, with trapezoidal structure in horizontal plane, made of stainless steel and allowing to guide the analyzed particles through the vacuum till the first layer of the PS detectors The width of the vacuum chamber at its exit is approximately 160cm and allows to accept and explore the minimal radius/maximal bending angle(α_{max}=2arctg(D_x/L_{ef}f) of the analyzing particles on the base L_1=2m away from the magnet.

3 Detection system

The goal to achieve the maximal acceptance at a good resolution(σ/E_γ~0.7%), rend their quires the moderate distance of PS hodoscopes from the analyzing magnet, that allows from the other hand to install the counters reasonable far from the beam line and provide their reliable radiation shielding. .
The detection system consists of 6 scintillation counter telescopes in the one arm and 10 telescopes in the other , composing together 6x10=60 not overlapping combinations of the measured photon energies at the fixed value of the magnetic field. The maximal measured energy is set to be a 12.4 GeV, slightly over of the electron beam energy to provide the absolute calibration tasks. The ratio(R) of the measured maximal to minimal photon's energies is set to $R=E_{max}/E_{min}$=1.908, allowing to cover the most part of the bremsstrahlung spectrum of 12GeV electrons by 3 magnetic field setting (i.e. from 1.73 to 3.3GeV, 3.35 to 6.4GeV and 6.5 to 12.4GeV).
At photon energy coverage from 6.5 to 12.4 GeV, the energy distribution between electron and positron arms is following:

- Fine Spacing Forward(FSF) hodoscope:
  Pmin=3.25GeV, δP=0.1GeV/c, Pmax=Pmin+9x δP Gev/c= 4.15GeV/c.
  Pmax/Pmin=1.277

- Wide Spacing Forward (WSF) hodoscope:
  Pmn=3.25GeV/c, δP=1GeV/c , Pmax=Pmin+ 5xδPGev/c=8.25GeV/c,
  Pmax/Pmin=2.538

The details of the counters location, corresponding trajectories and resolutions are presented in Table 1 and 2. The first layer of the detectors, the FSF(1-10) and WSF(1-5) hodoscopes are installed immediately after windows of vacuum chamber, made of maylar 50-100μm thick. The second layer of detectors, the backward FSB(1-4) and WSB(1-5) hodoscopes are shifted 100cm downstream from the first layer, forming 10 and 5 telescopes FS(10) and WS(5) The beam is directed along the z axe, magnetic field aligned along the Y one and counters are installed at fixed z-value in the xz-plane.The minimal measured energies in both arms are equal and correspond to a minimal radius of 827cm and the maximal bending angle $\alpha=14^{O}$.

Table 1. Parameters of PS-40 registration system: Counters' location, trajectories, widths in the analyzing plane, resolutions.

e^+ - arm

Counters of FSF hodoscope	P(GeV/c)	R(cm)	<α> (deg)	<x>(cm)	Δx(cm) at (δP/P)=0.7% / 0.55%
FSF1	3.25	827.0	14	74.4	1.82/1.43
FSF2	3.35	852.4	13.58	72.1	1.76/1.38
FSF3	3.45	877.9	13.18	70.0	1.71/1.34
FSF4	3.55	903.3	12.80	67.9	1.65/1.30
FSF5	3.65	928.8	12.45	65.9	1.61/1.27
FSF6	3.75	954.2	12.11	64.2	1.57/1.23
FSF7	3.85	979.6	11.79	62.7	1.53/1.20
FSF8	3.95	1005. 1	11.49	61.0	1.49/1.27
FSF9	4.05	1030.5	11.20	59.4	1.45/1.14
FSF10	4.15	1056.0	10.93	57.9	1.41/1.11

Second layer of FS arm:Fine Spacing Backward hodoscope

Counters of FSB hodoscope	x(cm)	Δx(cm)	Comments
FSB1	96.5	9.7	covers FSF1-FSF3
FSB2	88.5	7.7	FSF4-FSF6
FSB3	82.4	4.4	FSF7-FSF8
FSB4	77.8	4.0	FSF9-FSF10

e^- arm. The widths of counters are adopted to a photon energy resolution of 0.7%, that is equal to a FSF arm resolution

Counters of WSF hodocope	P(GeV/c)	R(cm)	α (deg)	x(cm)	Δx(cm) at $(\delta E/E_\gamma)$=0.7%/ $(\delta E/E_\gamma)$=0.55%
WSF1	3.25	827.0	14.00	74.4	2.88/2.26

WSF2	4.25.	1080.6	10.67	56.4	2.63/2.07
WSF3	5.25	1334.9	8.62	45.4	2.47/1.94
WSF4	6.25	1589.1	7.23	38.1	2.35/1.85
WSF5	7.25	1843.4	6.22	32.7	2.26/1.78
WSF6	8.25	2097.6	5.47	28.8	2.19/1.72

Second layer of WSF arm, Wide Spacing Backward hodoscope

Counters of WSB hodoscope	x(cm)	Δx_R(cm)	Comments
WSB1	99.3	4.5	
WSB2	75.2	4.5	
WSB3	60.6	4.0	
WSB4	50.8	3.5	
WSB5	43.5	3.5	
WSB6	38.4	3.5	

Note, the resolution ($\delta E/E_\gamma$)=0.55%/ provides app. two standard deviations between the neighbor energy points.

The counters
As is seen from Table 1 there is clean possibility to use the blue plastic scintillators as the counters radiator, viewed through the light guides(probably curved for FSF hodoscope) by fast, blue sensitive, 1'' PMT's. The radiator thickness of the forward hodoscopes might be chosen app. 0.5cm, while for the backward one might reach 1-2cm.

4. Electronics

There is in total 26 counters in FSF(10),FSB(4),WSF(6),WSB(6) hodoscopes.
The following structure of electronics logic is Proposed::
Disctiminators: 10 channels of CFD for FSF hodoscope and 16 channels of fixed threshold discriminators for other hodoscopes. Four channels of FSB arm discriminators should have a 3 signal outputs.

Fast twofold coincidences: 16 channels
The signals of 16 telescopes FS(10) and WS(6) are defined through the fast coincidences inside of PS arms: FSF(i)xFSB(i)=FS(i) and WSF(j)xWSB(j).=WS(i). The care should be done in preventing the fast timing loss of FSF channels by means of respective choice of width of FSB and WSB signals and their positioning..

Fast strobe coincidences: 6 modules of 10 channels at least each.
The signals of six WS(i) telescopes strobe the signals of ten FS(j) telescopes, forming a 6x10=60 signals. These modules can have the fast OR output to be used for the trigger logic and the programmable readout. Again it is important to keep the timing of FSF(i) signals unaffected after strobe coincidences.

TDC's: 6 modules of 10 channel TDC's with common START and separate STOP's..
Allows to measure the timing between the START (tagger or RF) and the fast PS signals(SF).

Each of 10 TDC modules may initiate an interruption of measurements , Inhibit crate and data readout.
If the strobe coincidences have the readout and the fast OR output, they may be used for interruption of higher priority, allowing to register the photons, having no coincidences with tagger,

Auxillary modules: Delay lines, Fan-outs, Mixers et al
Should be defined after finalization of the electronics logic.. .

5.Software

The software for PS-40 should consist of :
- offline programs, allowing to set the thresholds and delay times
- offline program for measurements of PS efficiency using incoherent bremmstrahlung spectra
- offline program for magnet current setting, measurement and adjustment of CB peak position, driven by tuning of diamond crystal orientation.
- online program for measurements and monitoring of CB spectra.
- offline program for PS data analysis and CB polarization calculation.