Purpose of the Alignement Investigation Device (AID) of the AIDA project

M. Winter – IPHC-Strasbourg

***Abstract*—This document describes briefly the goals of the AID apparatus, equipped with PLUME reference ladders**

1 - Introduction

The AID is supposed to allow exploring some aspects of double-sided ladders expected to turn into added values. These studies start by preparing tools exploiting and combining (correlating) the double impact delivered by each traversing particle. The next steps consist in studying the alignment and the track extrapolation power of the concept. The existence of 4 hits per detector layer in the ladder overlaps will be a central subject of investigation.

The material required should come close to the list provided hereafter:

- 1 pair of ladders mounted in a first box, featuring a phi orientation difference of $2{\cdot}\pi/12$ rad (box-in)
- 1 pair of ladders mounted in a second box, featuring a phi orientation difference of $2{\cdot}\pi/24$ rad (box-out)
- a third box is needed, identical to one of the above, preferably to the second one (to be checked)
- the overlap area of neighbouring ladders should be variable by sliding one of the two ladders of each pair in order to modulate the area typically from about 100 m to 1 mm. The sliding may rely on 3 fixed positions, such as 0.1/0.3/1 mm or 0.1/0.3/0.5 mm or 0.2/0.4/0.6 mm.
- the pair of ladders equipping one box should be movable by precisely known shifts or rotations using micrometric mouvement stages mounted at the ladder ends
- a high precision "transparent" beam telescope
- a very thin ($<<$ 1 mm), low Z, target (or 2 targets with different Z values)
- 1 box with a pair of FSBB chips would be interesting as well
- external ladders (DEPFET, NA63, NA61, etc) could be easily integrated in the system

To make full sense, the project requires accurate (= predictive) Monte-Carlo, allowing to predict how the results obtained with the AID would evolve with modified geometries closer to those of specific applications.

2 - Understanding double-sided ladders

Before going to the kernel of the project, the potential of ultra-light and precise double-sided ladders needs to be evaluated. This means:

- study the correlation of hits generated by traversing particles
- evaluate the single point accuracy when combining both impacts as a function of the particles'angle of incidence
- investigate added value in terms of tolerable occupancy (?)
- accompany the study with GEANT-4 Monte-Carlo simulations, expected to allow predicting performance variations as a function of geometrical and material parameters (ladder width, material budget, single point resolution, ...) to derive an optimised and feasible ladder design.

The material required is at least one double-sided ladder orientable w.r.t. the beam line, mounted in a box.

3 - Alignment:

The ladders are supposed to be traversed by the beam particles. Two steps of the alignment should be investigated:

- the alignment of each ladder with its (slightly overlapping) neighbouring ladder inside the same station
- the alignment of one detector station w.r.t. to its neighbouring ones.

a) Alignment of ladders belonging to the same station:

The study is feasible with 2 overlapping ladders and may be achieved with the DESY beams since the impacts combined are very close to each other.

Two values of the (ϕ) angle between the ladders may be considered: $\pi/6$ and $\pi/12$, which are representative values for the inner and outer layers of a vertex detector. Both types of ladder configurations are thus desirable, but compromises consisting in using one type of arrangement only may be made without dramatic impact.

At the SPS, the track reconstructed in several stations may be used, which would strengthen the combination of hits in the overlapping areas.

The ladder overlap may be studied using a point spread function approach addressing the shadow of one active area edge of the sensors on one side on the active area of the sensors on the other side of the ladder. The same remark applies to the ladder overlaps.

The study should allow evaluating the potential of the approach as a function of the overlapping aera and statistics, and should end up with a concrete value of the residual uncertainty on the alignment.

b) Alignment of consecutive stations:

The study would naturaly require 3 stations (i.e. boxes), 2 of them being used as reference to reconstruct the track, the third station being moved to make the alignment studies.

The study seems to require high energy beams, i.e. at the CERN-SPS, which faces limitations due to the SPS shutdown

until October 2014. Simulations may indicate what can be achieved with the electron beams at DESY.

4 - Track extrapolation:

Two types of extrapolation are to be studied:

- the extrapolation to neighbouring detectors, and thus the track matching
- the extrapolation to the beam interaction region, and thus the reconstruction of vertices

a) Track matching

The study consists in using 2 stations as reference and in extrapolating to the third station. If a third station is not available, it may be compromised with a beam telescope.

The question of the beam characteristics, i.e. SPS or DESY, should be cleared out with the help of simulations.

b) Impact parameter reconstruction

The study consist in reconstructing interaction vertecies of beam particles traversing a thin target.

The interaction may be Rutherford-like (eN $\longrightarrow$ e'N') with the electron kink being identified by comparing the outgoing electron trajectory to the one measured with the beam telescope installed upstream of the target.

It will possible to estimate the added value of combining impact positions on both ladder faces, and the impact of the alignment precision on the vertex position accuracy should be evaluated.