AIDA PROPOSAL

SUBJECT:

Proposal for an ILC Vertex Detector Component

– Draft of Septembre 23rd, 2009 –

Author: Ingrid Gregor, Marc Winter
on behalf of a group of physicists from IPHC/Strasbourg,
Univ. Oxford, Univ. Bristol, DESY/Hamburg, Univ. Geneva

---

1 Introductory Remarks

The project AIDA offers an opportunity for the ILC vertex detector community to address system integration aspects which become major issues when thinking about a very high precision device. The question will be studied on how to keep the high resolution provided by thin and granular sensors all the way through their integration in a detector, accounting for cooling and power saving aspects.

System integration studies have in fact already been launched by a few European groups, which are developping ultra-light double-sided ladders, aiming a final prototype, validated in the laboratory, by 2012. The project, called Plume[1], is not restricted to a given pixel technology. Its deliverables (e.g. ladders) provide a typical example of what should be evaluated with the infrastructure developed within the AIDA project. Moreover, the know-how, the personnel and the tools involved in Plume could be made available and benefit to the whole AIDA community.

The present document tends to summarise expectations and plans European groups presently actively contributing to an ILC vertex detector. The components of the project are still vaguely defined. They will become more precise once the group of active contributors will be better defined. Some of them may actually come from non-ILC communities.

The organisation of the project follows guide lines which could be usefuly applied through the whole project. In particular, activities to be incorporated in a work package and trigger EU funding, should satisfy criteria such as the following:

- they should be restricted to system integration issues (i.e. no detector technologies' RD), for which they should aim at providing integrating and testing facilities;
- they should not already be launched and carry on independently of AIDA. Projects which will not crucially depend on EU funding but are needed because they are essential to it, may however be mentioned in the project description as external basic inputs to it;

[1]standing for Pixellised Ladder with Ultra-light Material Embedding.

- they may rely on a know-how and equipments of some specific participating institutes which use the project to make them available to the whole community as a service of general interest;
- infrastructures resulting from, and funded by, the project should be installed in international labs which can ensure that their operation and access will be maintained after the end of the project.

2 Ilc Vertex Detector Activities belonging to the Project

2.1 Questions addressed by the project and related infrastructures

The project should allow assessing individual vertex detector ladders and studying systems composed of several ladders. The main motivation for this objective is to find out how to avoid diluting the high precision of granular and thin pixel sensors with the material needed for their integration (electrical servicing, mechanical support, cooling) or with uncontrolable missalignments.

The infrastructure built within the project would include components associated to a test beam, complemented with others which do not require a particle beam. The project is expected to provide the framework of constructing the following infrastructures:

- **test beam related components:**
  a beam telescope (BT) with a large active area and a movable target allowing to generate interaction *vertices*;
- **off-beam components:**
  infrastructures allowing to test ladders under stress originating from temperature variations, cooling (air flow) or Lorentz forces (power pulsing).

2.1.1 Test beam related infrastructure

The infrastructure installed near a test beam needs to be adapted to the following generic activities:

- study the tracking and vertexing performances of a group of layers for various geometries, sensor technologies and ladder types (single-sided versus double-sided)
- evaluate the alignment capacities of a group of layers for various geometries and ladder types
- estimate the impact of the vertex detector characteristics on the global tracking and PFA, and compare to simulation results

Its central equipment is a beam telescope, which would be an extension of the device constructed within the EUDET project. It would differ from it by its much larger active area. The active surface envisaged is in the ordre of $\sim 4{\times}4$ to $6{\times}6$ cm^2. The BT would be composed of 2 movable arms, each composed of 3 planes, as for the EUDET BT.

The BT will allow performing directly some of the studies underlying the project and provide the necessary information on each beam particle to Devices Under Test (DUT) for their own studies.

It should in particular allow investigating alignment issues. Those are likely to be performed with DUTs. One of them could be part of the project deliverables. It could consist of an independent telescope composed of 2 planes, each made of two independent, mobile, half-planes. Half planes belonging to the same plane could be moved with respect to each other (translations and rotations) in a controled way, with a typical precision at the micron level. This would allow detailed studies of alignment procedures (hardware and software). This activity encompasses a sizeable programming component (simulation and reconstruction software, allowing for extensive alignment studies).

Alignment studies are also expected to be performed with a device generated by the PLUME collaboration, which may consist of a box containing 3 consecutive pairs of overlapping, double-sided ladders. It will be fabricated outside of the AIDA framework but will serve as an important tool for it. The device will be suited to alignment and vertexing (target) studies and will allow assessing the advantages of double-sided ladders as compared to single-sided ones.

2.1.2 Off-beam infrastructure

The other components of the working programme address the main studies summarised below:

- powering and grounding schemes for ladders
- the extraction of the power dissipated by ladders, layers or groups of layers
- the mechanical stability of layers with air flow
- the mechanical stability of layers with pulsed sensor powering, within a high magnetic field

The infrastructures needed to achieve these studies are typically the following ones:

- a power extraction facility (e.g. realistic cooling infrastructure) with diagnostic capabilities (e.g. cameras)
- a facility for mechanical study of new ladder concepts (including mechanical stress simulation software)
- a power cycling facility within magnetic field, including adequate power sources and diagnostic equipment

- know how in realising high-tech detector components (e.g. ultra-light ladders for various pixel technologies, as proposed by the PLUME collaboration))

2.2 Institutes interested in participating

At present, the institutions having expressed their interest for the project are:

- PLUME collaboration: Bristol University, DESY, Oxford University, IPHC/Strasbourg
- OTHERS: University Geneva, University of Warsaw
- POTENTIAL: Prag ?

A very rough estimate of the total manpower avaialble from these institutes is < 10 FTEs. This too little to achieve the complete set of activities described in the previous section. The software components are particularly poorly covered. More contributors would be very welcome. The manpower requested from EU may focus on this category of activities.

3 Costs and Deliverable Production Time Scale

3.1 Composition and Cost of Main Deliverables

There are two main instrumental deliverables, which demand manpower and funding: the beam telescope and the alignment investigation device.

3.1.1 Beam Telescope (BT)

The request to E.U. will be restricted to the material components of the BT. All the engineering time required to build it will be provided by the contributors.

A list, perhaps still slightly incomplete, of the main components of the device follows:

- 2 sensor mechanical supports (1 per arm) : 20 kE
- 1 DUT support (?) : 10 kE
- a global mechanical support holding both arms and (?) the DUT support: 10 kE
- 54 sensors (assuming 3×3 per plane) with spares, thinned to 50 μm: 30 kE
- 54 interface with spare (i.e. hybrid) boards : 10 kE
- between 15 and 18 DAQ boards + spare : 80 - 100 kE
- 1 trigger component and a timing unit : 15 kE
- cabling : 10 kE
- 1 or 2 PCs : 5 kE

- **Total cost:** $\lesssim$ 200 kE

The institutes will also ensure the availability of the telescope for the users' community.

It is assumed that the movable target will not generate a significant financial effort to be taken over by the project.

3.1.2 Alignment Investigation Device (AID)

Here again, the EU funding rest is restricted to the material components needed to build the device. No engineering time enters the request. The device can be seen as a sort of telescope made of 2 planes, each composed of 2 independent mobile half-planes. The components identified sa far are the following:

- 4 mobile and precise sensor mechanical supports (1 per half plane) with their steering system: 80 kE
- laser based (?) alignment system : 30 kE
- a global (precise) mechanical support holding the sensor supports : 10 kE
- 8 sensors (assuming 2×2 per plane) with spare : 5 kE
- 8 interface (i.e. hybrid) boards with spare : 5 kE
- 2 DAQ boards (1 per plane) with spare : 15 kE
- 1 PC and peripherals: 5 kE

- **Total cost:** $\gtrsim$ 150 kE

3.1.3 Others

Two other main expenditure lines are to be considered: the off-beam equipment and the additionnal manpower needed.

A - Off-beam equipment

The mechanical studies and power pulsing tests are expected to benefit in a large extent from existing equipment and infrastructures (e.g. high field magnet). There are still missing components, which are essentially the following ones:

- equipment for cooling studies (air flow source, diagnostic devices) : 30 kE
- equipment for mechanical studies (camera, sensors, etc.) : 40 kE
- part of power pulsing equipment (interface boards, DAQ, power sources, specific electronics) : 30 kE
- design and fabrication of a high precision box for alignment studies with a set of ladders (fabricated in PLUME project) : 50 kE

- **Total cost:** $\gtrsim$ 150 kE

B - Manpower

Though not yet clarified, it is assumed that tasks addressing hardware aspects will be almost fully covered by the manpower of the participating institutes. The objectives exposed in this document require also a sizeable software effort, concerning for instance:

- BT simulation and track reconstruction
- AID simulation and software for alignment studies
- CAD of ladder for mechanical studies (including power cycling)
- simulation of temperature distribution and power extraction with air flow

It seems that the institutes will not be able to provide most of the necessary manpower for all these tasks. At least one or two post-docs will be needed, which will also take a leading part to the commissionning of the devices fabricated within the project.

It is not yet clear whether the EU funding request will concern 2 post-docs or 1 post-doc and 2 PhD students. The financial support requested will, in both cases, amount to about 300 kE

3.2 Summary of EU funding request

Category of expenditure	BT	AID	Off-beam	Manpower	**TOTAL**
EU request	200 kE	150 kE	150 kE	300 kE	**800 kE**

The total funding request of this part of the work package on detector development is therefore in the ordre of 800,000 euros.

3.3 Time Scales

The BT should require $\lesssim$ 24 months to be designed and built. Its design could start before the project starts (1.01.11). One could therefore expect the telescope to be ready for use at the end of the third semestre (Summer 2012).

The AID requires presumably only 12 to 18 months. It is assumed that the same manpower will intervene for the BT and the AID. One may therefore consider that the AID will be completed and fully commissioned by the end of the 4th semestre (i.e. end of 2012).