SIDDHARTA Technical Note IR - 8

Towards the definition of the SIDDHARTA setup

Monte Carlo simulations for 3 selected setup configurations

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Content

1. Introduction

After a period of "brainstorming" related to the SIDDHARTA setup, we arrived in the period when decisions have to be taken concerning the geometry of the setup.

The idea behind this choice is to optimize the setup taking into account few – sometimes contradictory – features:

- try to optimize the S/B ratio;
- use at best the number of SDDs available: 200 cm^2, in cells of 6 units (3 x 2);
- make use of the experience gained in DEAR: shielding, degrader etc.;
- cope with a pipe with a diameter of 9 (10?) cm – the DEAR pipe if not a new one.

Monte Carlo simulations were already done [1,2], but in hypotheses which are not realistic anymore (as for example a smaller diameter pipe, when a toroid around the pipe could be foreseen).

Recently, in occasion of the SIDDHARTA Collaboration meeting of 22 April 2005, realistic Monte Carlo simulations were done taking into account the previously declared features.

In the present Note, the results of the simulations done in Frascati are discussed. They refer to three selected configurations. These three configurations are:

- one DEAR-like setup, above the pipe, reproducing the DEAR setup, but using a larger number of active area SDD detectors – reason of the choice: we know how to deal with this configuration;

- two DEAR-like setups, smaller diameter than the first solution, placed for example one above and the other below the pipe, using almost all number of 200 SDD detectors – reason of the choice: this configuration reproduces twice a configuration which is known to us and should give more signal than the first one, and an overall greater flexibility;

- one piece of a toroidal target – using at best the numbers of SDDs – reason of this choice: should optimize the signal.

All these geometries were reproduced in Monte Carlo simulations and the signal, coming from a generation of a certain, always the same, number of ϕ-particles, derived. In these simulations the relative number of X rays of 6.3 keV (kaonic hydrogen) arriving in the SDDs, in the hypothesis of an yield of 100% and considering a simplified geometry in which no absorption in the target walls was considered for each geometry, was derived. The goal was to compare these three setups from the point of view of the signal; some comments are done in this Note for what concerns background (so possibility of shielding) and other features related to the setup.

The Note contains a Section 2 describing the results of the DEAR-like setup; Section 3 deals with the setup containing 2 DEAR-like targets, while Section 4 the toroidal-portion target. In Section 5 Summary and Conclusions are presented.

2. DEAR-like setup

The DEAR-like setup, consisting of a cylindrical target placed above the pipe, was considered firstly. The target is placed at 8 cm from the IP (Interaction Point), its height is 15 cm and the diameter 15 cm as well, giving a volume of 2650 cm^3. The SDDs are placed around the target, at 0.5 cm distance, in three raws divided in 10 sectors each. So, the total number of SDDs used is: 10 x 3 x 6 = 180 cm^2.

In Fig. 1 and Fig. 2 the setup as schematically reproduced in the Monte Carlo, is shown.

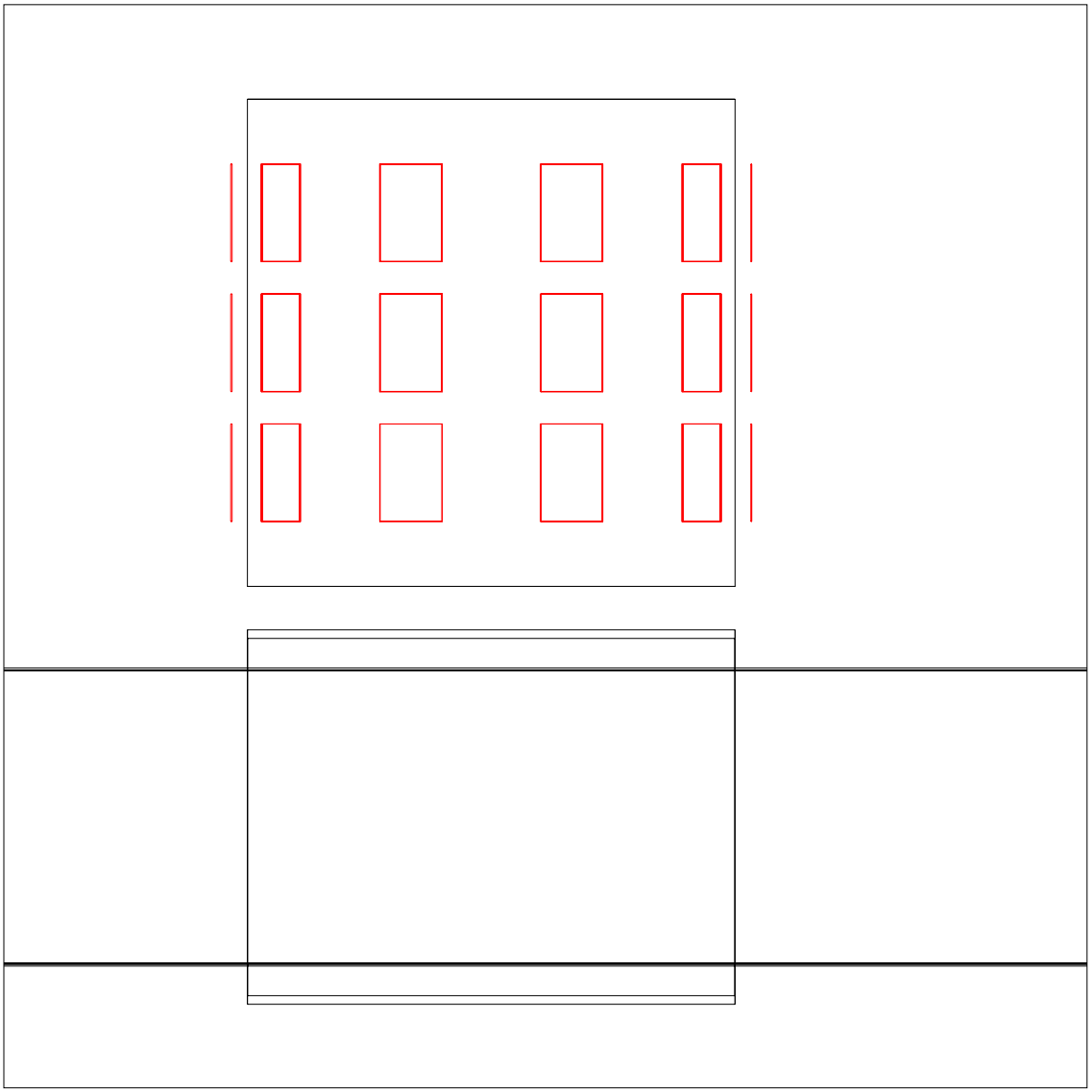

Fig. 1: Side-view of the DEAR-like setup (180 cm^2 SDDs) – Monte Carlo simulation

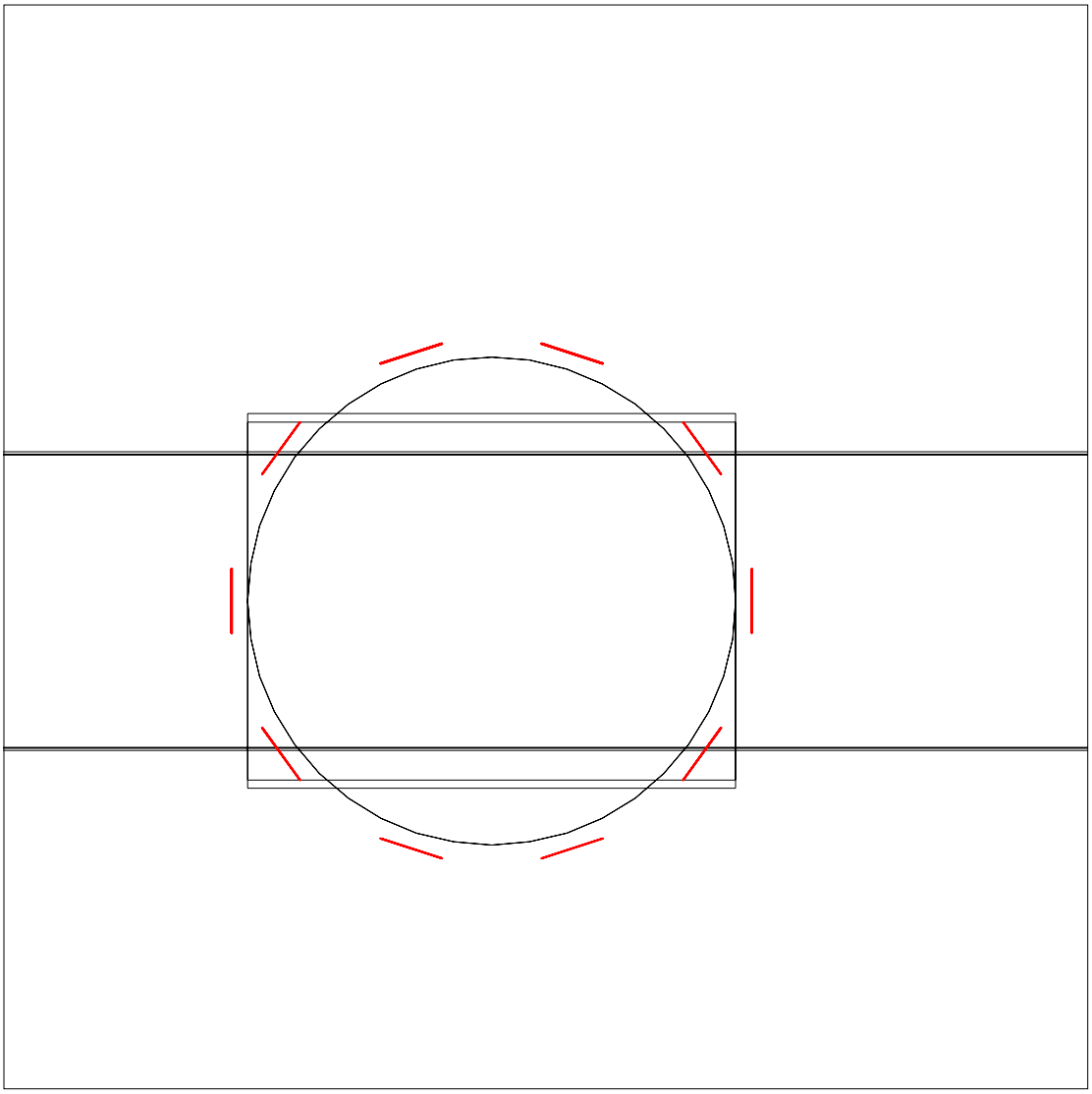

Fig. 2: Top-view of the DEAR-like setup (180 cm^2 SDDs) – Monte Carlo simulation.

The hydrogen density inside target was 2.1 g/l.

A number of 100,000 ϕs were generated. The results of this simulation were:

- **a number of K- stopped inside the hydrogen target (with optimized degrader) of 3240;**
- **a number of X rays of 6.3 keV at CCDs of 543.**

3. Two DEAR-like setup

A version of the DEAR-like setup is obtained by placing two DEAR-like setups, with smaller diameters, in order to optimize the number of kaons stopped inside, the other above and one below the pipe..

Two targets were then placed at 8 cm from the IP; the height of each target is 10 cm, the diameter 10.4 cm, with a total volume of 1700 cm^3. The SDDs are placed around the target, at 0.5 cm distance, in two raws divided in 8 sectors each. So, the total number of SDDs used is: 2 x 8 x 2 x 6 = 192 cm^2.

In Fig. 1 and Fig. 2 the setup corresponding to one out of the two targets, as schematically reproduced in the Monte Carlo, is shown.

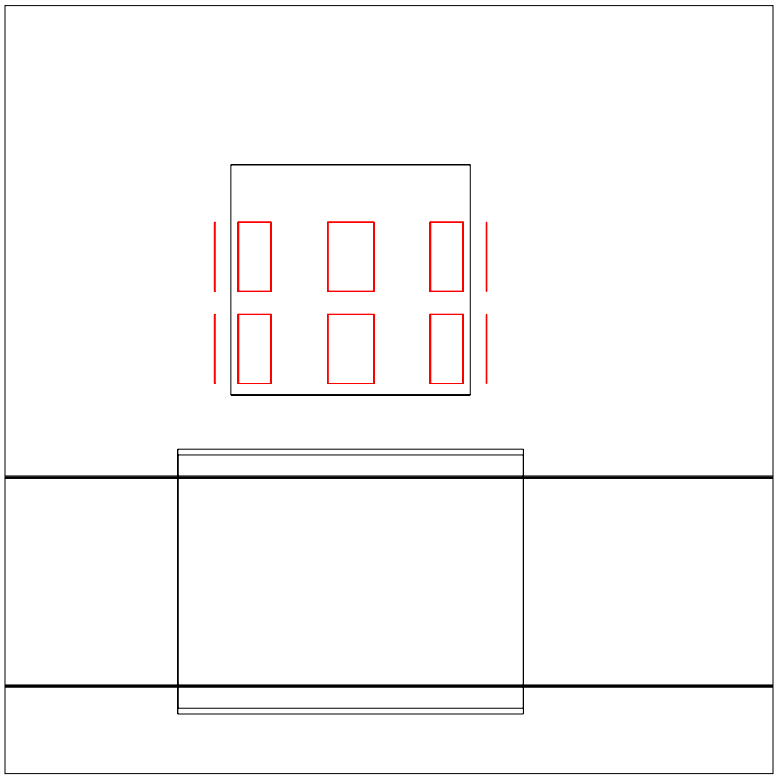

Fig. 3: Side-view of one of the two DEAR-like setup (192 cm^2 SDDs in total) – Monte Carlo simulation

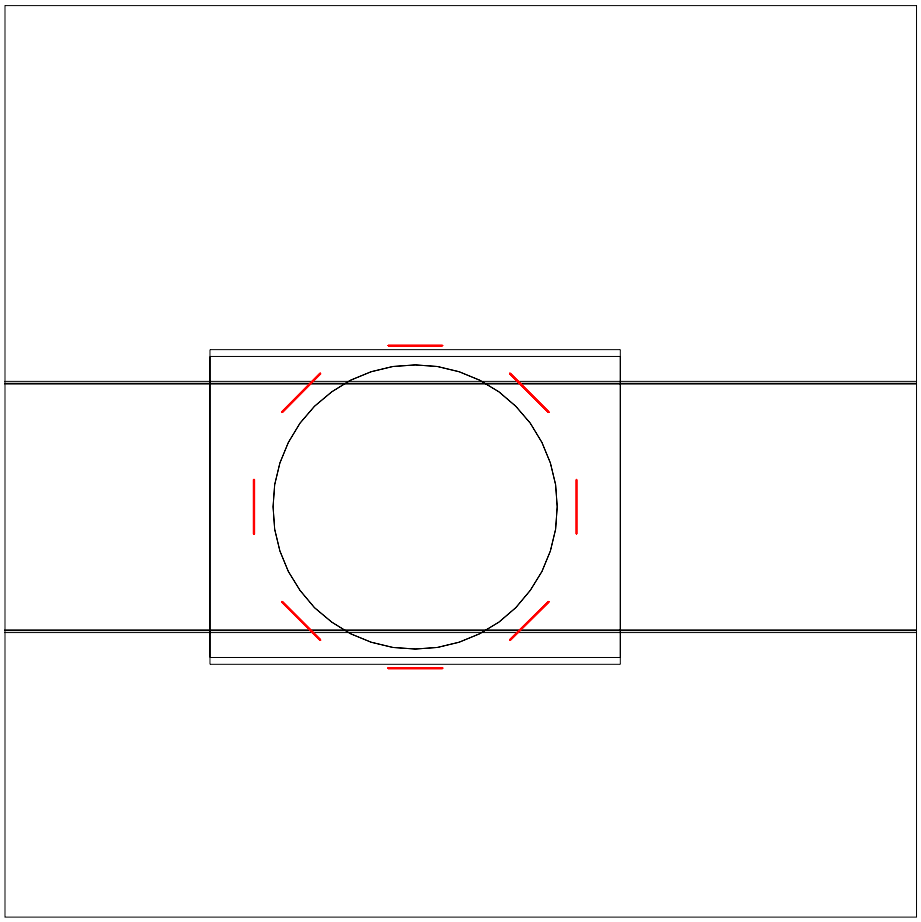

Fig. 4: Top-view of the one of the two DEAR-like setup (192 cm^2 SDDs in total) – Monte Carlo simulation

The hydrogen density inside target was 2.1 g/l.

A number of 100,000 ϕs were generated. The results of this simulation were:

- **a number of K- stopped inside the hydrogen target (with optimized degrader) of 3540;**
- **a number of X rays of 6.3 keV at CCDs of 612.**

4. Toroidal-portion setup

In order to optimize the number of X rays arriving to the SDDs, a version of the toroidal setup, firstly put forward when we worked under the hypothesis of a smaller pipe diameter, consisting in a portion of a toroid above the pipe, was considered. The distance of the target from IP is 8 cm, the angle subentended by the toroidal sector of 150^0 , the target height 7.5 cm, for a volume of 2611 cm^3. The SDDs are placed on the two sides perpendicular to the beam-pipe, one raw of 6 x 6 SDDs in each side, and above the target, in two layers of 9 SDDs cells each. The SDDs are at 0.5 mm from the target. The total number of SDDs is: 2 x 6 x 6 + 2 x 9 x 6 = 180 cm^2.

In Fig. 5 and Fig. 6 the setup corresponding to this setup, as schematically reproduced in the Monte Carlo, is shown.

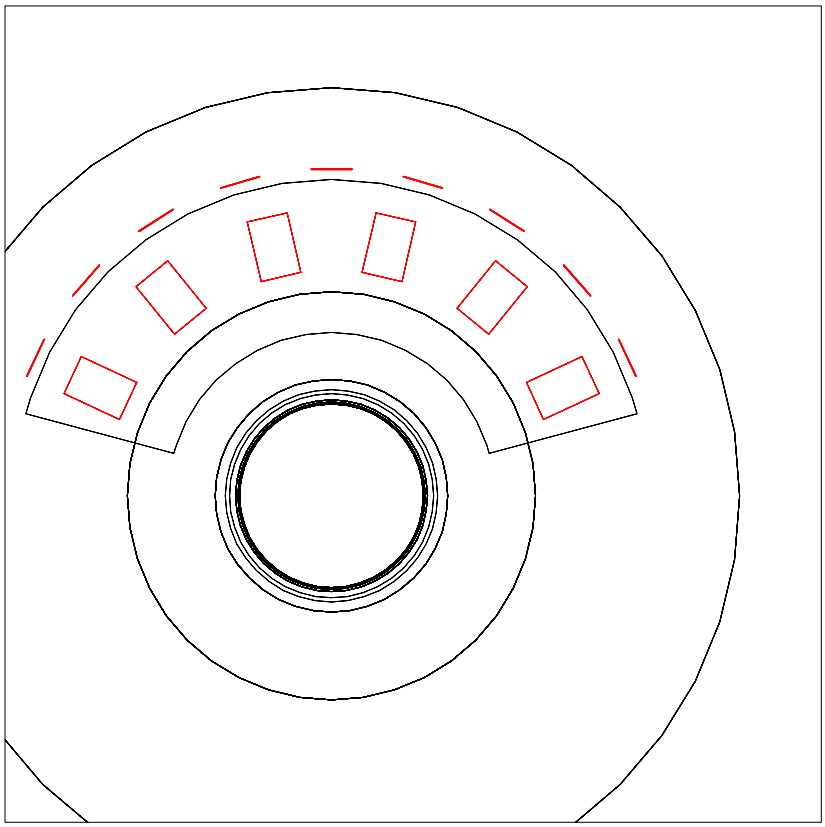

Fig. 5: Front-view of the toroidal-piece setup (180 cm^2 SDDs in total) – Monte Carlo simulation

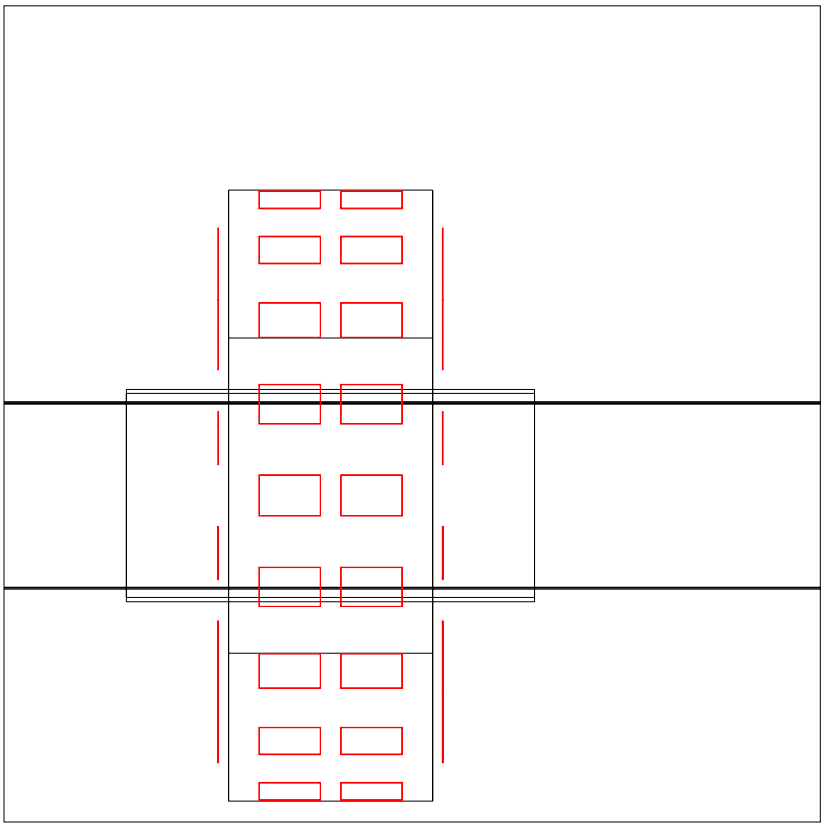

Fig. 6: Top-view of the toroidal-piece setup (180 cm^2 SDDs in total) – Monte Carlo simulation.

The hydrogen density inside target was 2.1 g/l.

A number of 100,000 ϕs were generated. The results of this simulation were:

- **a number of K- stopped inside the hydrogen target (with optimized degrader) of 5409;**
- **a number of X rays of 6.3 keV at CCDs of 779.**

5. Summary and conclusions

Three different versions of the setup were considered in a Monte Carlo simulation for the SIDDHARTA experiment. The geometries are realistic, based on what was learned from DEAR and/or constraints given by the geometry (pipe). The selected geometries are: a simple DEAR-like setup; two DEAR-like setup; portion of a toroid, and are described in the previous Sections.

100,000 ϕs were generated for each one of the geometries. The number of kaons stopped inside the target and of the X rays of 6.3 keV registred by the SDDs (in the hypothesis of a 100% yield and no absorption inside target window) were recorded for each geometry, the summary of the results being shown in Table 1.

Table 1: Summary of the Monte Carlo results.

Setup	Kaons stopped	X rays at SDDs	Volume
Toroidal 180cm^2	5409	779	2611 cm^3
DEAR-like 180 cm^2	3240	543	2650 cm^3
2 DEAR-like 192 cm^2	3540	612	1700 cm^3

From Table 1 it results that:

- the **toroidal geometry** gives **a signal 1.4 times better than DEAR-like** and 1.3 times better than two DEAR-like geometries;
- the **DEAR-like** and the **two DEAR-like** geometries are, **from the signal point of view**, rather **equivalent** (the gain in having two targets is less than 10% for an equivalent number of SDDs).

Comments:

- **the toroidal setup** is more difficult to be built and there are **shielding problems**: i.e. shielding might not be as efficient as in DEAR, because the geometry does not allow it; eventually this solution, even if giving a higher signal, might be biased by higher background too. Moreover, there are SDDs in this geometry looking into the IP – we have no experience with this kind of arrangement. For these reasons, this solution is not the best one;
- the two DEAR like solutions from the signal point of view are equivalent. The two target ones might give us more flexibility (for example the use of two different gases inside the targets). The mechanics (supports, shielding) of two targets is more difficult and costs are higher. The two targets does not leave free the option of having a trigger which uses two scintillator on one side of the pipe, in case that the use of only two of them (back-to-back) might not distinguish kaons well enough.

In conclusion, the choice might be done between the two DEAR-like setups, after an evaluation of all features and elements: costs; mechanics; trigger, real advantage to have two targets instead of one.

Acknowledgements:

We acknowledge the support of the European Community-Research Infrastructure Activity under the FP6 "Structuring the European research Area" programme (HadronPhysics Contract No. RII-CT-2004-506078).

Bibliography:

[1] Catalina Curceanu (Petrascu), **Preliminary Monte Carlo simulation of the SIDDHARTA (Silicon Drift Detector for Hadronic Atom Research by Timing Application) setup and performances**, SIDDHARTA Technical Note-IR-3, 25 August, 2003

[2] Catalina Curceanu (Petrascu), **Preliminary Monte Carlo simulation of the SIDDHARTA (Silicon Drift Detector for Hadronic Atom Research by Timing Application) toroidal setup**, SIDDHARTA Technical Note-IR-4, 24 November, 2003.