List of questions on AFP LoI
CERN 16-1-2009

Ilias Efthymiopoulos, Per Grafstrom, Nigel Hessey, Tom Le Compte, Heinz Pernegger, Mike Tyndel and Antonio Zoccoli

1) General

a) Schedule
   - Provide a project roadmap for the design, construction and installation of the system. In particular, since the installation of the cryostats involves warming up of two LHC sectors a possible date/year for that should be indicated. Cross check the compatibility of the installation schedule (cryostats, detectors, services) with the LHC one. The likely access times to install/commission/maintain should be clearly indicated.

b) Physics
   - apart from the determination of the Higgs quantum numbers motivate and discuss in detail other physics cases if you consider them comparable in importance to the Higgs case.
   - Provide study on the physics goals as a function of the time resolution, alignment and backgrounds. What happens if they are worse by a factor 1.5-2 with respect the design values?

c) Collimation
   - Describe the compatibility of the project with the machine layout, in particular with collimators (present, but also future/reserved locations). Discuss background rates expected from the near collimators.

d) Timing and timing detectors
   - The achievable timing resolution is obviously a very critical issue in your proposal. It would be interesting to see possible physics performance for different scenarios of the final timing resolution
   - The final resolution will depend on the time spread in the radiator, photon detection device, the electronics and the reference timing. Please discuss where you see the biggest difficulties. We have seen a recent paper (*NIM A: Volume 595, Issue 1, 21 September 2008, Pages 270-273*J. Vav'ra et al,) where a single detector resolution of 7 ps was obtained with a laser diode as input but then going to a test beam only 23 ps was achieved as a single detector efficiency.
   - Concerning the reference timing we have not understood all details and it would be nice to understand better how stability of the order of 5 ps or better can be achieved in absolute timing.
   - There is a very critical issue related both to the life time and the maximum rate of the proposed photon detector (MCP-PMT). Please develop your latest understanding on this issue.
   - We also ask the question how serious it is that the GASTOF version can not detect multiple protons? Also related to multiple protons (mainly at 220 meter) ,we wonder if this will not generate a combinatorial back ground.?

e) Trigger
   - The L1 trigger bandwidth taken at 10^{33} will be about 30%. Is there a bandwidth issue - either for L1 or the HLT - at large luminosities?

- Discuss the system with particular emphasis on latency

f) Silicon Detector
  - It is not clear that it is possible to get a trigger signal from the FE13 pixel chip (get in touch with Kevin Einsweiler <k_einsweiler@lbl.gov>). If this functionality is not available with the needed timing properties, the chip must be redesigned. Which will be the production time scale in this case?
  - Provide the fluency through the detector as a function of the position. This will be useful to estimate the radiation damage to sensors and chips.
  - Provide some information the robustness and redundancy of the system. Since the access will not be possible, what will happen if some pieces will break?

g) Alignment
  - discuss the alignment procedure and the precision which can be achieved
  - How will be affected the physics case, if the alignment precision will be a factor 1.5 worse than the design one?

h) Costs & Overview
  - Discuss roughly the total cost of the all the parts of the system
  - provide an overview on the manpower allocation and on the responsibilities on the different part of the project

2) Machine

- Collimators: there are very recent discussions to put cryogenic collimators at 420 meter. How will this interfere? Quite an issue to understand more about. Check if the detector position is compatible with the new collimators which perhaps will be installed after the first shut-down of LHC. Moreover it would be useful to investigate how the detector at 420m can perform if they will be placed behind the collimators, with the background generated.
- Collimators: there are collimators very close to the 220 meter station, just in front. How does this affect the measurement? What happens if they are too closed??
- Is the AFP schedule compatible with the ATLAS upgrade project?
- Investigate the bake-out issues. How do the sensors and alignment system components survive? If no bake-out is foreseen, would the vacuum be acceptable?
- the costs/manpower estimate of the two cryostats at 420m needs to be better explained
- Investigate the location of the electronics in the allocated space. Is the space in the tunnel/alcoves available/reserved?
- Discuss the expected levels and radiation hardness issues for the proximity electronics/services.
- A more detailed access scenario to the detector would help:
  a. what is time needed to replace a super layer/blade in case it stops working; time for opto replacement if necessary?
  b. what is foreseen as regular maintenance (at station level; service systems near detector in tunnel, cooling, etc.)?

3) Physics

- the physics case of using this device to measure the quantum numbers of a Higgs candidate is quite strong. However, the case for many of the other measurements is much weaker and we would not recommend that they be highlighted in a TDR. Backgrounds in many of the proposed channels are quite large, and a compelling case would have to be made that they can be handled.

- It seems obvious that both the 220 and 420 stations would be useful. Provide more information on the trigger scheme for the 220 station. Discuss as well the level2 trigger scheme for the 420 station.
- A general question concerning the method of using the timing to get rid of pile up background. Say that we are running at 10^34 and have 25 interactions per bunch crossing. Is there not a huge combinatorial background of 2 protons having the same time difference as the signal protons?

4) Performances and time scale

- how is it possible to have an integrated luminosity of 100 fb-1 with the present LHC schedule? The integrated luminosity per year is nowadays assumed to be 6 fb-1 for a 10^33 year and 60 fb-1 for a 10^34 year. How does this fit into the run plans?
- Is there a compatibility issue for high statistics and low rate? Prepare 2 or 3 different with different luminosity and ramp-up scenarios, to verify that the measurements are possible.
- Timing: the explanation of the 35ps resolution (one detector had a time resolution of 32 ps and the other 13 ps) is not very convincing (and 13 ps per detector gets us 17 ps for two). It would be important to prove that it is possible to achieve a time resolution of 10-20 ps with a set-up similar to the final one (detector, electronics, cables etc.).
- We know from ALFA that the timing for L1 latency is extremely tight also at 220 meter. Each nanosecond has to be documented to see if one is in time for L1.
- What happens to plots like the one at page 8, fig 1.2 if the predicted signal is may be a factor two lower and the background a factor 2 higher? In other words, what are the errors on the predicted cross sections and on the predicted background. Also what happens to the h-WW channel if the 3 events for 30 fb-1 becomes 1 event?
- The statement on page 14 that lepton pair production is a perfect candidate for absolute LHC luminosity measurement is not correct. The rate is too low.
- The missing mass resolution depends on the beam energy spread. 0.77 GeV is quoted. Sounds very accurate. What do we know about this number? What happens if this number is greater by a factor 3 *or* is this impossible from the point of view of LHC?

5) Silicon detector

- The alignment procedure of the detector is not clear.
- The alignment of the 220 station is not easy as being discussed (page 33) especially if the elastic scattering cross section at large t is too low. How critical is this to the missing mass resolution using the 220 meter station?
- What happens if the angular resolution will 1.5 μrad instead of 1 μrad?
- The installation schedule (89 days) must by accurately scrutinized. If the duration will be longer, this could create problems
- The 1% X0 appears to be really a strong requirement for the angular resolution (given that fig 5.8 shows that the 1.0urad resolution is just barely reached under optimal conditions). A detailed breakdown of the X0 would help
- It is difficult to understand how close to the beam the detectors will be and how and when this is decided. Anyway it would help to know the detector positions also in term of sigmas.
- Section 5.4.4 briefly mentions the station at 220m, but a real layout of this station (blade level) is really needed to understand chip/sensor arrangement, electronic readout and assembly.

- In general it would be good to obtain more information on the expected radiation levels, (including uncertainties) and to look at activation levels for all the detectors. For example the placement of the electronics in alcoves can be dangerous.
- Silicon tracker : plots for the life-time integrated number of protons and neutrons/mm2 as function of radius for the 420(220) stations are really needed. This will have the obvious influence on.
    - Up to which radius is the ATLAS Pixel FEI3 a valid option. Is it compatible with the goal to go to 5mm? Is the to be expected non-uniformity after irradiation within a chip an issue (signal, FE settings,…)?
    - Sensor leakage current and power dissipation: is it possible to cool the edges closest to the beam reliably? What is the leakage current vs radius?
    - What is the distribution of full depletion vs radius on sensors?
- Silicon tracker, thermal issues, there are some competing conditions/requirements:
  (a) 1% X0/X radiation length of the station without cooling pipe below chip ;
  (b) high radiation damage-> large power dissipation in the sensor;
  (c) max 2C temperature difference between hottest and coldest point of detectors (p60).
    - Can you really achieve the temperature uniformity without cooling pipe under sensor/chip after full irradiation? Really would like to see a FEA simulation of the temperature distribution across the 420 and, in particular, the 220m stations for the present layout.
    - What's the margin against thermal runaway at the sensor edges for the 220m and 420m stations?
    - What's the requirements on thermal interfaces (cooling pipe - blade-chip-sensor)
    - What's the highest temperature on stations during beam pipe bake-out? Can the the cooling system bring the temperature down to a reasonable level during bake-out or are thermal screens needed? p60 maintenance scenario 10 to 40C: how many days at which temperature (anti-annealing of sensors)?
- Silicon tracker: describe the backup solution for the 3D chip
- Construction: it is clear that there are some uncertainties in the schedule at the moment. Still a rough breakdown of the construction schedule would help to understand:
  (a) the required delivery date of components
  (b) the time needed for assembly and testing of stations
  (c) integration and system implementation in ATLAS.