Second Review of Backgrounds in HERA II

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Committee Membership

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Principal Charges

- Do H1 and ZEUS understand their backgrounds quantitatively?
- Have solutions to the background problems been identified?
- Are preparations adequate for applying these solutions during the March 2003 shutdown?
- What measures should be taken to clarify any remaining questions?

General Observations of the Committee

- The HERA crew and the collider experiments are to be congratulated on the further progress in understanding the problems unique to HERA II.
- The two collider experiments can still tolerate only a fraction of the HERA II design luminosity because of bacground rates in their main drift chambers
- The understanding of these backgrounds has been substantially refined since the October meeting.
- As before, these backgrounds can be resolved into distinct categories:
  - Double-scattered synchrotron radiation, which is quite well understood, with measures for reduction in the final design stages
  - Lepton beam-gas scattering, which is also quite well understood, but for which measures for only limited reduction have been identified and designed
  - Proton beam-gas scattering, which is the most serious problem, but is requiring continuing strong efforts to understand completely.
- The beam-gas backgrounds have continued to decrease with continued HERA beam operation, due to vacuum improvements
- The ZEUS collaboration has relaxed their nominal tolerance level for drift chamber current by a factor of 3, and will reduce their gas gain by a factor of 2, for a total increase in background tolerance of a factor of 6.
- With the new ZEUS tolerance level, both collider experiments require a further vacuum improvement of about a factor of 3 in order to tolerate full design luminosity after all planned improvements are implemented in the 2003 shutdown

Synchrotron Radiation Background

- Continued simulation work by ZEUS indicates that SR backgrounds will be 1.7 times worse for e^- beam
- Extensive changes to all 3 ZEUS masks that should reduce their SR background by a factor of 7 are in the final design stage
- One H1 mask is also being redesigned
- The changes will reduce not only SR background, but also HOM heating and secondary 'target' thicknesses for beam-gas scattering
- Concerns remain about the expected poor cooling contact of certain masks, which will still suffer from some HOM heating, but the only solutions for this would require a much longer shutdown
- The back-scattered flux from Abs4 will be reduced by a factor of 1.7 by adding a multi-layer coat on it.
- The technical difficulties of the multi-layer coat now appear to be under control
- After all planned changes, the remaining SR background is expected to account for $\sim 20\%(5\%)$ of the drift chamber budget of H1 (ZEUS)

Positron Beam-gas Background

- Bremsstrahlung on upstream gas $\Rightarrow$ energy-degraded positrons hit IR masks and detector

- Mask showering will be reduced $\sim 50\%$ by installing much thinner masks

- Pumps may be added to the 5 m unpumped section in the South GA magnet, for a reduction factor of 1.5 in the total e-gas rate, most importantly to reduce the ZEUS silicon tracker dose

- Remaining e^+ beam-gas background is expected to account for $\sim 10\%(25\%)$ of the total drift chamber budgets of H1 (ZEUS)

Proton Beam-gas Background

- Proton beam-gas background is still worse than in HERA I
- It's clearly associated with dynamic vacuum degradation by e^+ beam
- Simulations by both H1 and ZEUS indicate more than half of the relevant primary interactions occur in the $0 < z < -3$ m range, with the rest distributed further upstream according to the varying vacuum conditions
- Beam-gas Bremsstrahlung rates observed in the lumi detectors confirm that the pressures inside the detectors are correspondingly higher now than in 2000.
- Simulations with non-hydrogenous gas (e.g. CO) explain the track multiplicity data better, both for HERA I and HERA II
- The experience of November shows that operating the Semi-cryo surfaces of the GO/GG magnets in the IRs at higher temperature worsens both the vacuum and the backgrounds
- Only very limited opportunities for augmenting the pumping systems have been identified
- Huge pressure increases (factor of 100) are observed in the IRs while the beam is at 12 GeV injection energy, where HOM heating is known to be much more intense
- These pressure excursions at 12 GeV were absent in HERA I
- The vacuum near the GI magnets that are excited with high power densities degrades slowly during the fills, indicating thermal desorption from warming of the beam pipe
- It now seems possible that much of the present vacuum conditioning progress may be due to thermal baking rather than SR scrubbing
- Assuming a further effective vacuum improvement of a factor of 3, the p-gas backgrounds are expected to account for $\sim 45\%(70\%)$ of the drift chamber current budget of H1 (ZEUS)

Recommendations . . .

- The committee endorses the planned modifications to the H1 and ZEUS IR's, with only one tentative reservation:
  - The need for the additional pumps to the south-left GA magnet should be confirmed by further TSP heating tests in that vicinity
  - The very different simulated sensitivities of the two detectors to this region should be re-examined to ensure that they are understood
  - The possibility of gaining much of the same benefit by only baking that beam pipe *in situ* should be investigated
- There is no compelling reason to delay the major portion of the March shutdown in order to gain further understanding of the background problems
- The committee endorses the main priorities for HERA operation in the limited time before the March shutdown
  - Demonstration of the capability of HERA to operate a 50 mA e^+ beam at full energy
  - Demonstration of the capability of HERA to deliver a luminosity of $4 \cdot 10^{31}$ /(cm^2 s)
  - Demonstration that the North and South rotators can be operated with beam
- Attempting to demonstrate beam polarisation with all rotators and detector solenoids on is given lower priority by the Committee, as there does not remain sufficient time to fully diagnose any problem so serious that it would require modifications in a shutdown

Further Recommendations

- A few additional vacuum tests are considered important to clarify the most uncertain aspects of the present understanding
  - Another attempt to bake at 12 GeV with cryo-surfaces as warm as possible, and more frequent pump regeneration, to indicate if thermal vacuum conditioning must take a larger role in the future
  - Both experiments should re-measure p-gas background with the positron beam at 12 GeV, in an effort to identify the gas sources
  - Further TSP heating tests at both $z \sim +30$ m with only e^+ beam and $z = -$(3.6–60) m with only proton beam to clarify present disagreements with predicted sensitivities
- The committee strongly encourages serious consideration of two further shutdown projects to improve the IR vacuum:
  - Reduction of the cooling water temperature for the GI magnets
  - Preparations for a hot nitrogen flush of the entire IR pipe *in situ* at the end of the shutdown
- Significant engineering projects (such as the C5 modifications in H1/ZEUS) should be systematically reviewed by an internal committee to ensure that all aspects (mechanical, vacuum, RF, etc...) have been taken into account in a coherent fashion.
- The committee also suggests improvements in instrumentation:
  - At least in the case of H1, there is a need for a more robust and reliable radiation-monitoring and beam-abort system that continues to function at any radiation level
  - Both experiments should consider diversifying their beam-abort logic to include a prompt response to very severe radiation spikes
  - More redundancy in the temperature and vacuum sensors, as well as a fast-sampling capability thereof, would reduce the uncertainties now clouding our understanding of the causes of beam-gas background