Event rates in PANDA:

After discussion with A. Lehrach the following estimates have been put together. This is based on the information in the target TDR

Assumptions:

1. $2x10^7$ pbar/s accumulated
2. Target density $4x10^{15}$
3. Max. number of pbar allowed in HESR 10^{11}
4. at the end of a cycle the remaining pbars remain in HESR, and the new ones are topped up
5. The instantaneous Lumi during the cycle can be modified in three ways: variation of the target density(probably only for the cluster target), the focus of HESR can be varied, the mean position of the beam can be slowly moved to vary the beam-target overlap. According to Andreas these should allow the instantaneous Lumi to be kept constant to ~10% during the cycle.

Based on these assumptions and the info in the HESR chapter of the target TDR we get the following estimates:

Cycle time (= beam prep + measurement + return to injection conditions) with the maximum cycle averaged lumi

1.5 GeV/c τ_{cy}=5000 s τ_{prep}=120 s $L_{cy} = 0.5x10^{32}$

15 GeV/c τ_{cy}=2500 s τ_{prep}=290 s $L_{cy} = 1.6x10^{32}$

It seems strange that the higher momentum has a shorter cycle time since the beam lifetime is longer at 15 GeV/c, but this is a simple consequence of the 10^{11} limit in HESR. At 1.5 GeV/c we have such a short lifetime we are limited by the accumulation rate, so it is better to accumulate longer. At 15 GeV/c there are many pbars left at the end of the cycle so we don't have to add so many, and it is advantageous to fill more frequently.

The values of L_{cy} above are averaged over the full cycle, we are however interested in the instantaneous Lumi during the measuring phase of the cycle. This must be higher to have the quoted cycle averaged lumi.

$L_{meas} = L_{cy} \times \tau_{cy} / \tau_{exp}$ $\qquad$ $\tau_{exp} = \tau_{cy} - \tau_{prep}$

1.5 GeV/c $L_{cy} = 0.5x10^{32}$ $\qquad$ $L_{exp} = 0.5x10^{32}$

15 GeV/c $L_{cy} = 1.6x10^{32}$ $\qquad$ $L_{exp} = 1.8x10^{32}$

Based on assumption 5 up above, the value of L_{exp} corresponds to the time averaged and (to ~10% accuracy) the instantaneous rate in PANDA during the full cycle.

These luminosities correspond to the following average rates in the detector:

1.5 GeV/c $L_{exp} = 0.5x10^{32}$ σ_{had} = 100 mbarn $R_{exp} = 0.5x10^{7}$ /s

15 GeV/c $L_{exp} = 1.8x10^{32}$ σ_{had} = 51 mbarn $R_{exp} = 1.0x10^{7}$ /s

There are 4 sources mentioned that use up the pbars, here I take only the hadronic interactions in the target since the other losses will be distributed around HESR (not necessarily uniformly). At the lowest momentum there will be in addition some single Coulomb scattering into PANDA. This will however be a small contribution compared to the total rates, but may have a larger effect on the far forward detectors in the Forward Spectrometer.

There are several issues that have to be added to this discussion:

1) This estimate is the average lumi during the measurement. If we use the barrier – bucket system, then 10% of the HESR will be empty, so the average instantaneous lumi (and thus rate) for the measurement must be 10% higher.
2) These are average rates, but since we have a CW interaction we will not have a constant time between events, instead the distribution will be approximately an exponential. This is a fluctuation on the time scale of single events, and will affect the pile-up/occupancy of (some of) the detectors, but should not affect the average data rate in the FEE that has to be transported further.
3) This estimate assumes that the target is homogeneous in time, which is OK for the cluster-jet target. The cluster jet target currently reaches $1x10^{15}$ and not the $4x10^{15}$ assumed above. If we are to achieve the maximum rates above with this target, then either the target density must be increased further, or the 10^{11} limit in HESR must be increased, or a combination of both. The number of stored pbars can go higher, either by increasing the cooling power or to a limited extent accepting a poorer longitudinal momentum resolution. This is an argument to have the e-cooler running together with the stochastic cooling.
4) The nominal target density ($4x10^{15}$) is claimed to be achievable for the pellet target. The current status indicates that there will be a big factor between the peak and average target-beam overlap density. Thus the detector rates (on the ~ 10 μs scale) will increase by that factor. I think we should turn the argument around and say that the specifications of the pellet target should be smaller than the ratio of the maximum rate accepted by the detectors to the average rates presented above. If we say the detectors can handle $2x10^{7}$/s and take the highest average rate above ($1x10^{7}$ for 15 GeV/c), then the target must have less than a factor 2 (peak/average) beam/target overlap-density fluctuations.

SUMMARY

Given the assumptions and caveats discussed above, I think it is reasonable to specify $2x10^{7}$/s as the reaction rate that the detectors must be able to handle. Of course it might be important to multiply this by a generic “safety factor”.