



RADIATION DAMAGE IN OPTICAL FIBERS AND ATTENUATION OF THE HF SIGNAL

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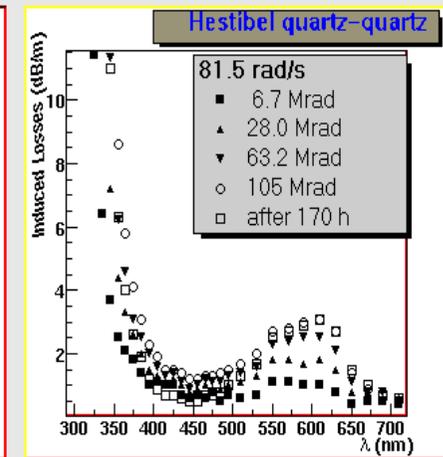
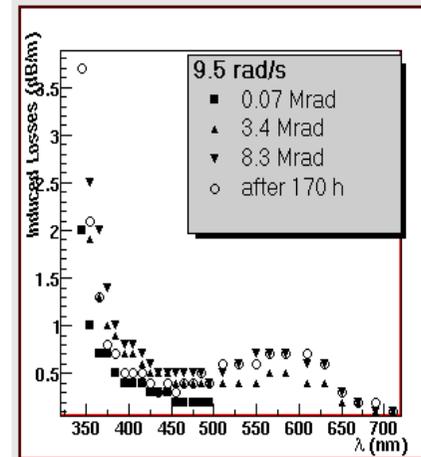
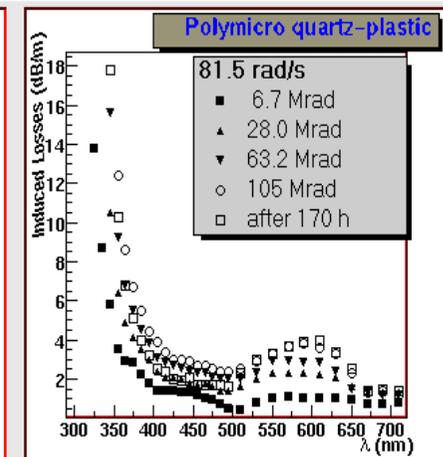
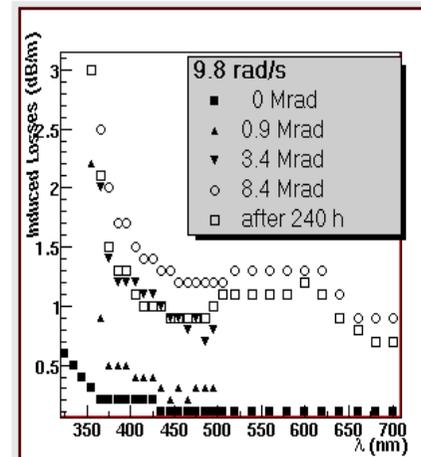


Summary of Measurements

Samples irradiated in Snezhinsk

- Co^{60} γ -source
- Two modes of irradiation
 - 0-10 Mrad @ dose rate ~ 10 rad/sec
 - 0-100 Mrad @ dose rate ~ 80 rad/sec

Sample	Dose rate rad/sec	Max dose rad
PolymicroQP	9.8	$8.4 \cdot 10^6$
Polymicro QP	81.5	$1.05 \cdot 10^8$
Hestibel QQ	9.5	$8.26 \cdot 10^6$
Hestibel QQ	81.5	$1.05 \cdot 10^8$
Infos QQ	9.6	$8.5 \cdot 10^6$
Infos QQ	9.5	$8.26 \cdot 10^6$
Infos QQ	82.0	$1.08 \cdot 10^8$
PolymicroQQ	9.6	$8.5 \cdot 10^6$
Polymicro QQ	82.0	$1.08 \cdot 10^8$





Data Representation

Data were combined as dose dependencies for each λ used in measurements, and then fitted to a power law including as many points as possible (*in some cases low and high rate data were incompatible*)

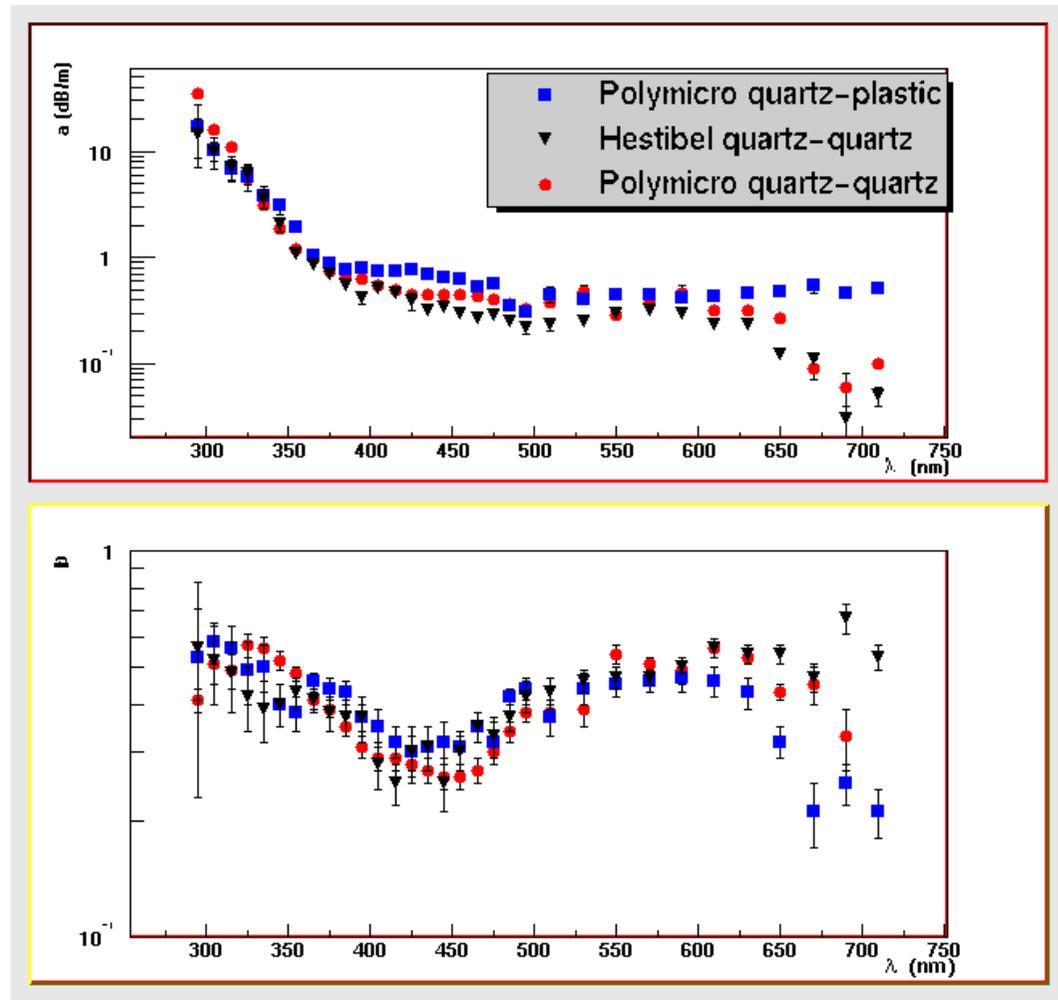
$$A(\lambda) = a(\lambda) \cdot D^{b(\lambda)}$$

A attenuation (in dB/m)

D Dose (in Mrad)

- $a(\lambda)$ attenuation spectrum @ 1Mrad
- $b(\lambda)$ attenuation rate for different fibers

Dependencies are smooth and values of $a(\lambda)$ and $b(\lambda)$ can be interpolated





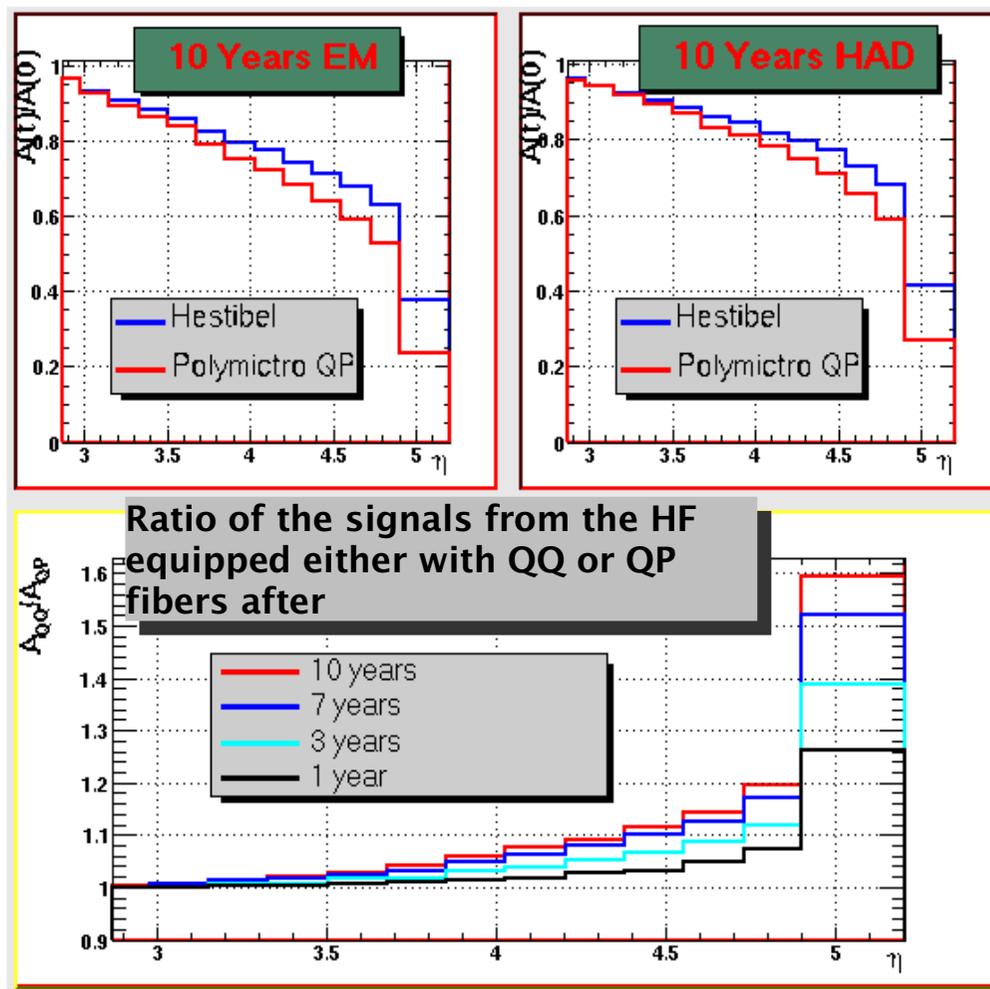
Quartz-Quartz vs Quartz-Plastic

- >2K of Minimum Bias events $\sim 400\text{K}$ p.e
- CMSIM 125
- HF response with the shower library

Signal was then attenuated with parameters for **Hestibel quartz-quartz** and **Polymicro quartz-plastic** fibers

For the central towers ~ 60 to $\sim 75\%$ of the signal is lost after 10 years of operation

The quartz-quartz fibers are needed for the central tower(s?). The difference is rather insignificant for the rest of the HF.



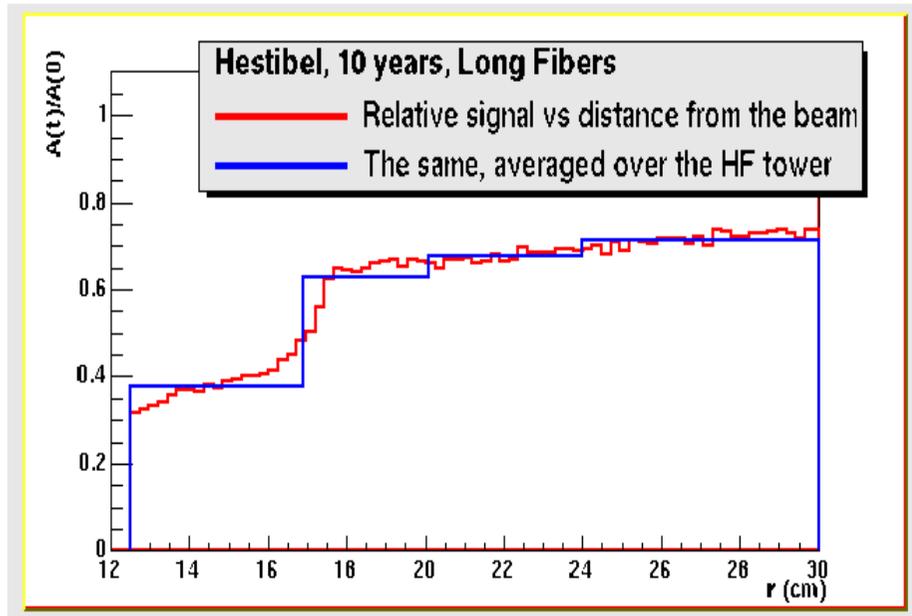


Attenuation within towers

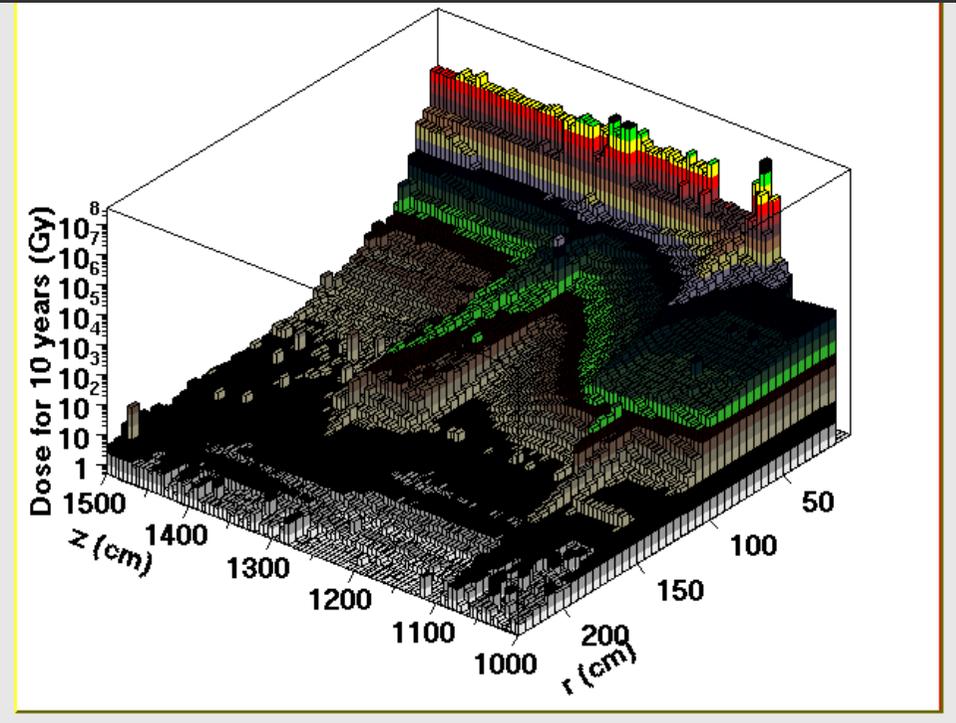
Big difference in attenuation between 1st and 2nd towers \Rightarrow radial dependence within the tower.

Reasons:

- Radial dependence of the absorbed dose
- Beam pipe shape (for the 2nd tower)



Dose map in the HF area (note a log scale on Z)



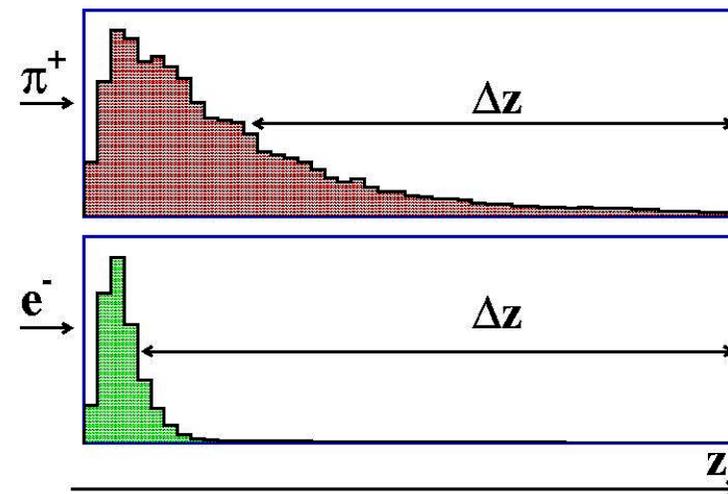
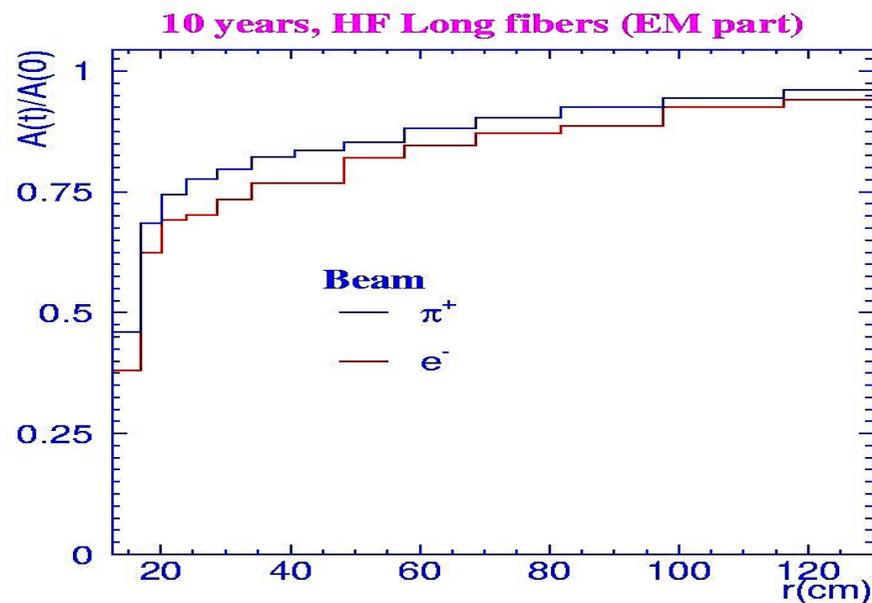
This leads to an extra systematic shift in η , calculated from the tower number.



Corrections for electromagnetic and hadronic showers

Different depth for electromagnetic and hadronic showers \Rightarrow different radiation damage corrections. This difference can serve as an estimate of the uncertainty introduced by the unknown (model dependent) composition of the jet.

- Electrons and pions; $\sim 200\text{K}$ events each
- CMSIM 121 (CMSIM 125 is underway)
- HF with the shower library
- Radiation damage parameterization for Hestibel quartz quartz fibers



There is the difference... But how big it is ?



Corrections for electromagnetic and hadronic showers(continued)

Let's denote as $E^{(\pi)}$ and $E^{(e)}$ the energy reconstructed with radiation damage corrections from pion and electron beams.

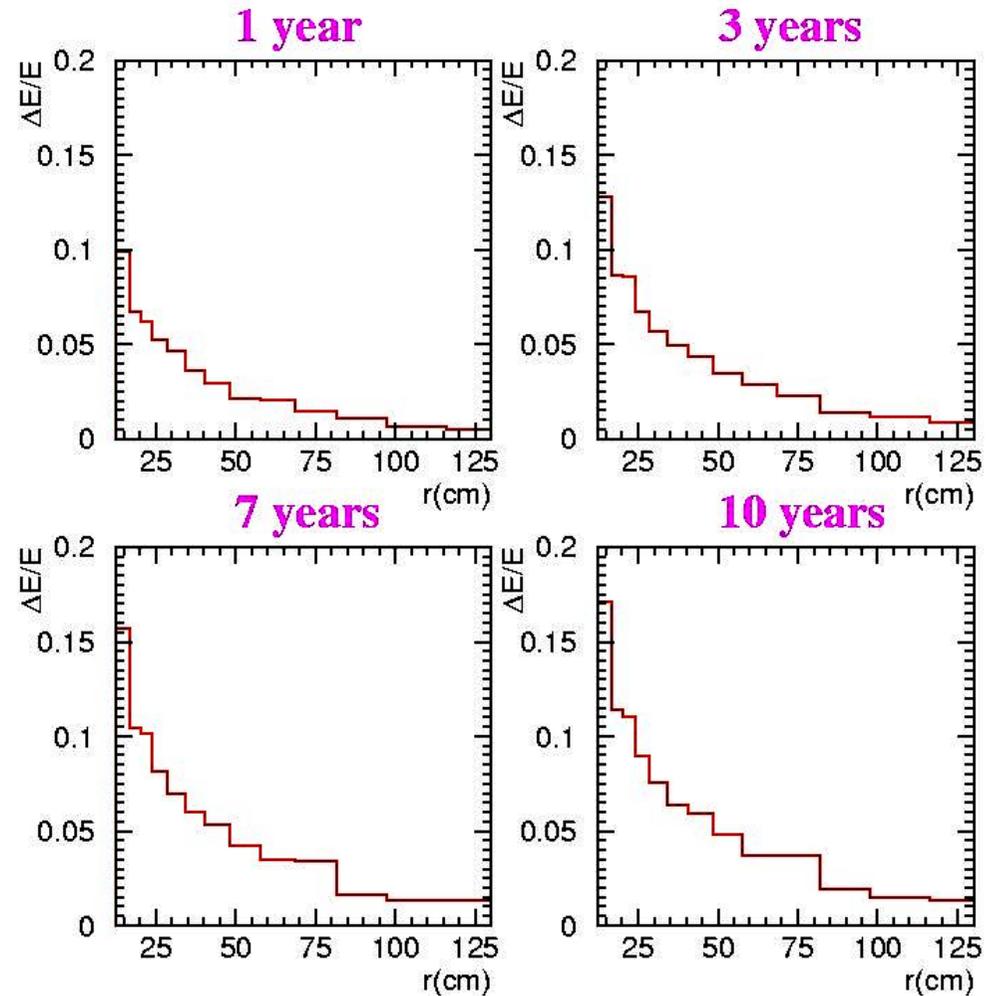
$$E^{(\pi)} = \frac{E_{measured}}{C^{(\pi)}} \quad E^{(e)} = \frac{E_{measured}}{C^{(e)}}$$

Then
$$\frac{\Delta E}{E} = \frac{E^{(e)} - E^{(\pi)}}{E^{(e)}} = \frac{C^{(\pi)} - C^{(e)}}{C^{(\pi)}}$$

will be upper estimate of uncertainty, introduced by the unknown composition of the jet.

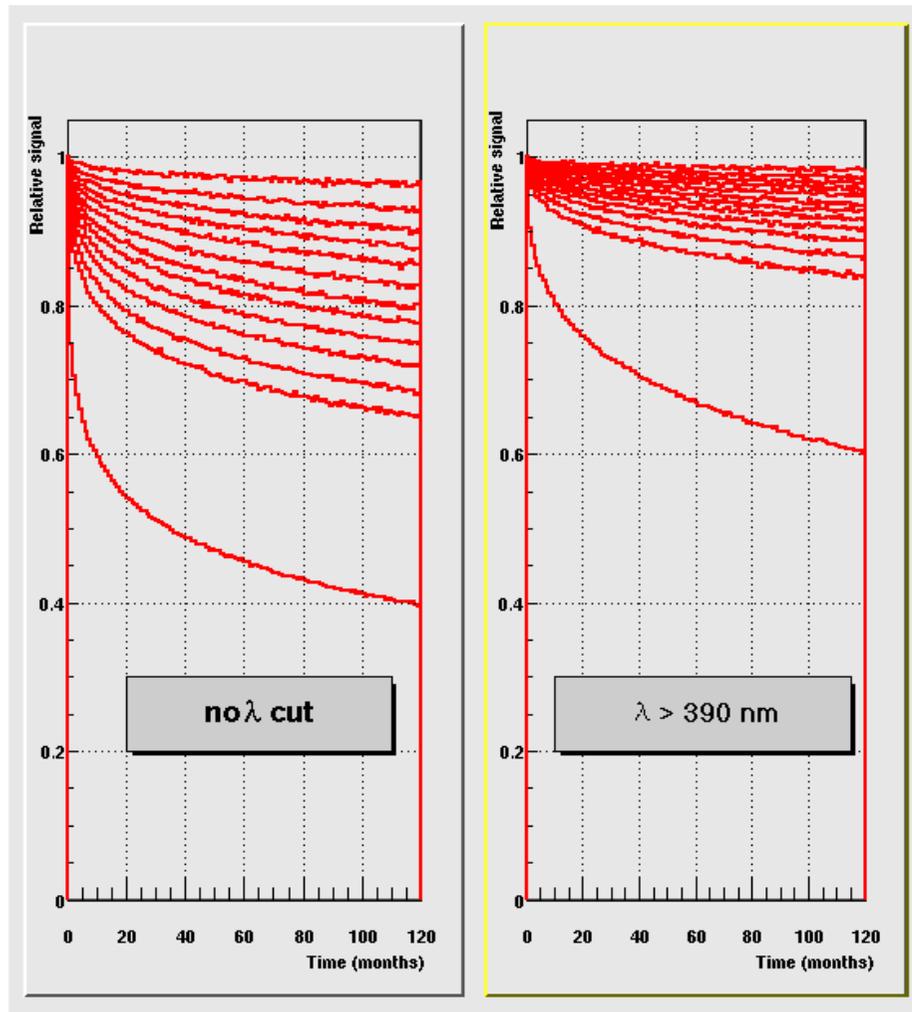
For towers > #3 ($\eta < 4.552$), this uncertainty does not exceed 10% for all time of the HF operation.

MB events can be used at least as a first order radiation damage correction.





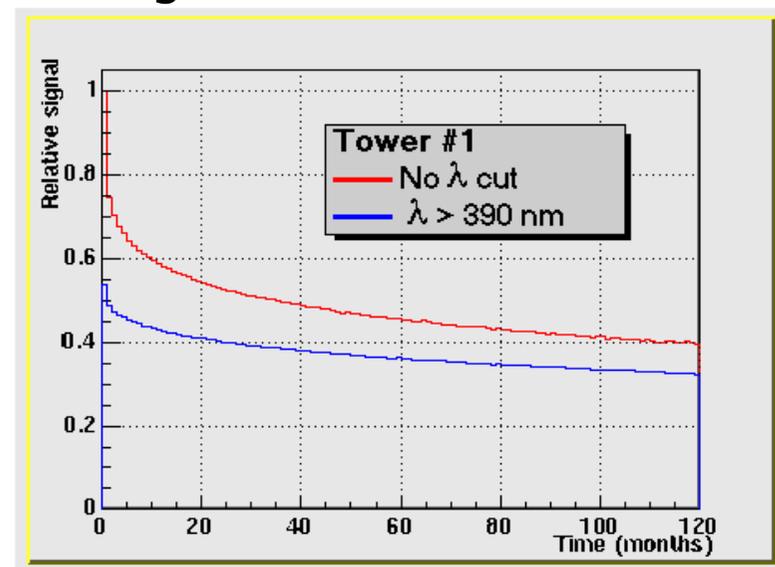
HF Signal vs Time of Operation



- Minimum bias events
- Attenuation parameters for Hestibel quartz quartz fibers

Tower #1 loses $\sim 25\%$ of its signal during the 1st month of operation.

Wavelength filter ($\lambda > 390$ nm) improves stability, but kills $\sim 30\%$ of the signal .





Conclusions

- The quartz quartz fibers show less radiation damage, compared to quartz plastic ones. Combination of quartz quartz (for innermost towers) and quartz plastic fibers is needed for the best performance of the HF.
- The minimum bias events can be used for monitoring of the HF performance and for calculation of the radiation damage corrections (at least of the first order corrections)
- Close monitoring/recalibration is most needed at the beginning of operation, when the HF signal changes faster.
- The wavelength filters can be used for innermost towers. The improvement in stability for other towers does not compensate $\sim 30\%$ losses in the HF signal.

UNCERTAINTIES

- ✓ The conclusions heavily depend on the results of irradiation measurements with γ source. Radiation damage from hadrons can be different.
- ✓ Higher radiation damage rate from hadrons can increase the difference between corrections for electrons and pions, as well as the dynamics of the behaviour of the HF signal with the time of operation.