HF RADDAM Status

(Radiation Damage Monitoring System)

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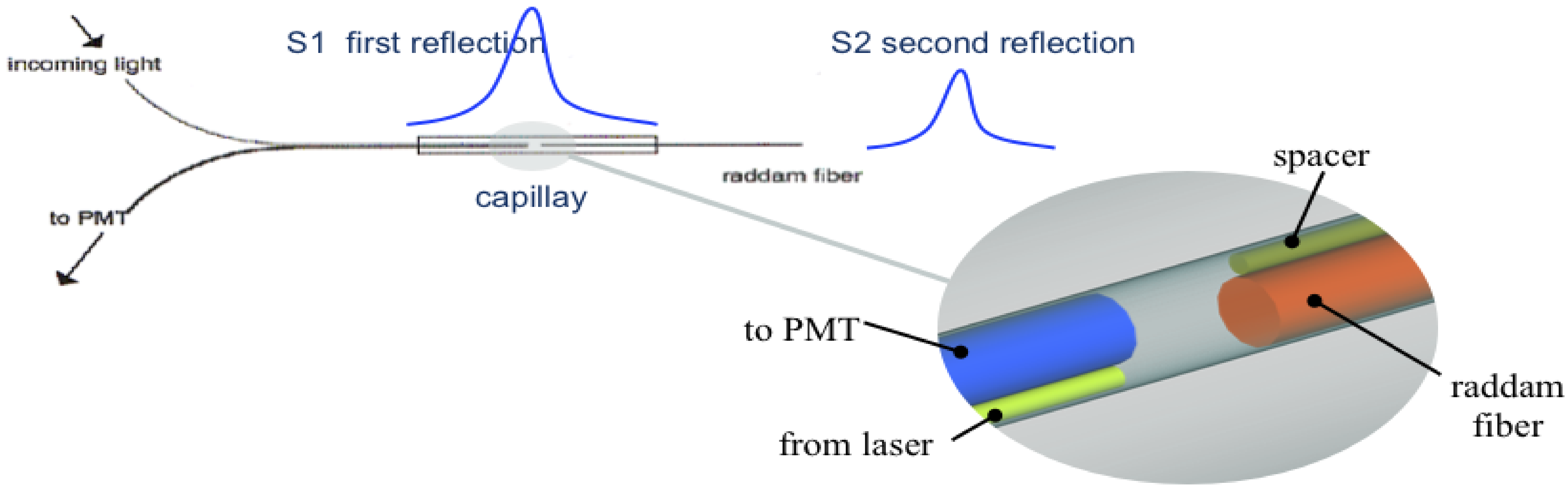
Environment for Fibers

- HF detectors will experience very high radiation levels (100 Mrad at $\eta=5$ with 500 fb^{-1})

- After ~10 years of operation the fibers will loose their light attenuation by half.

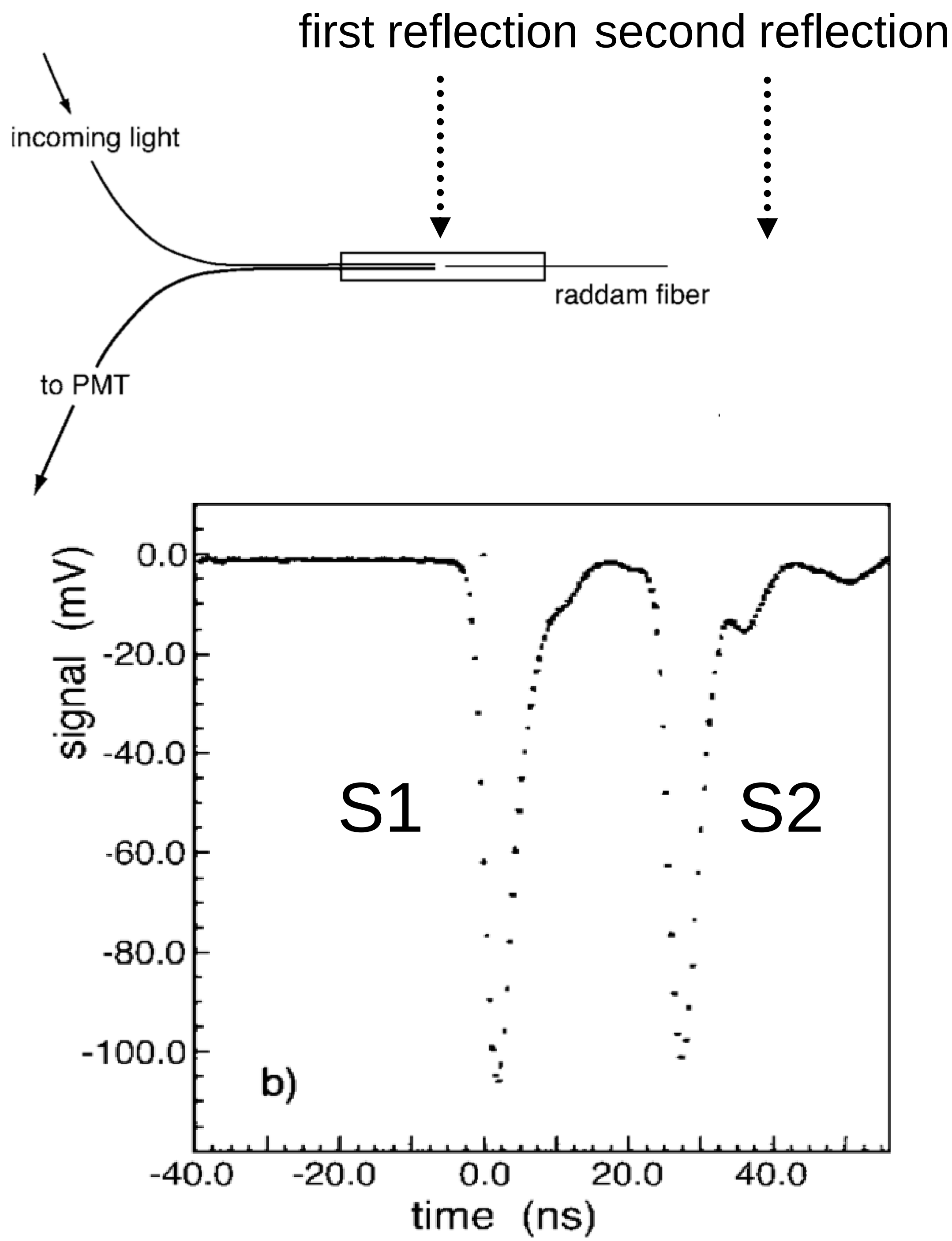
- The degradation will occur gradually and a monitoring tool is necessary.

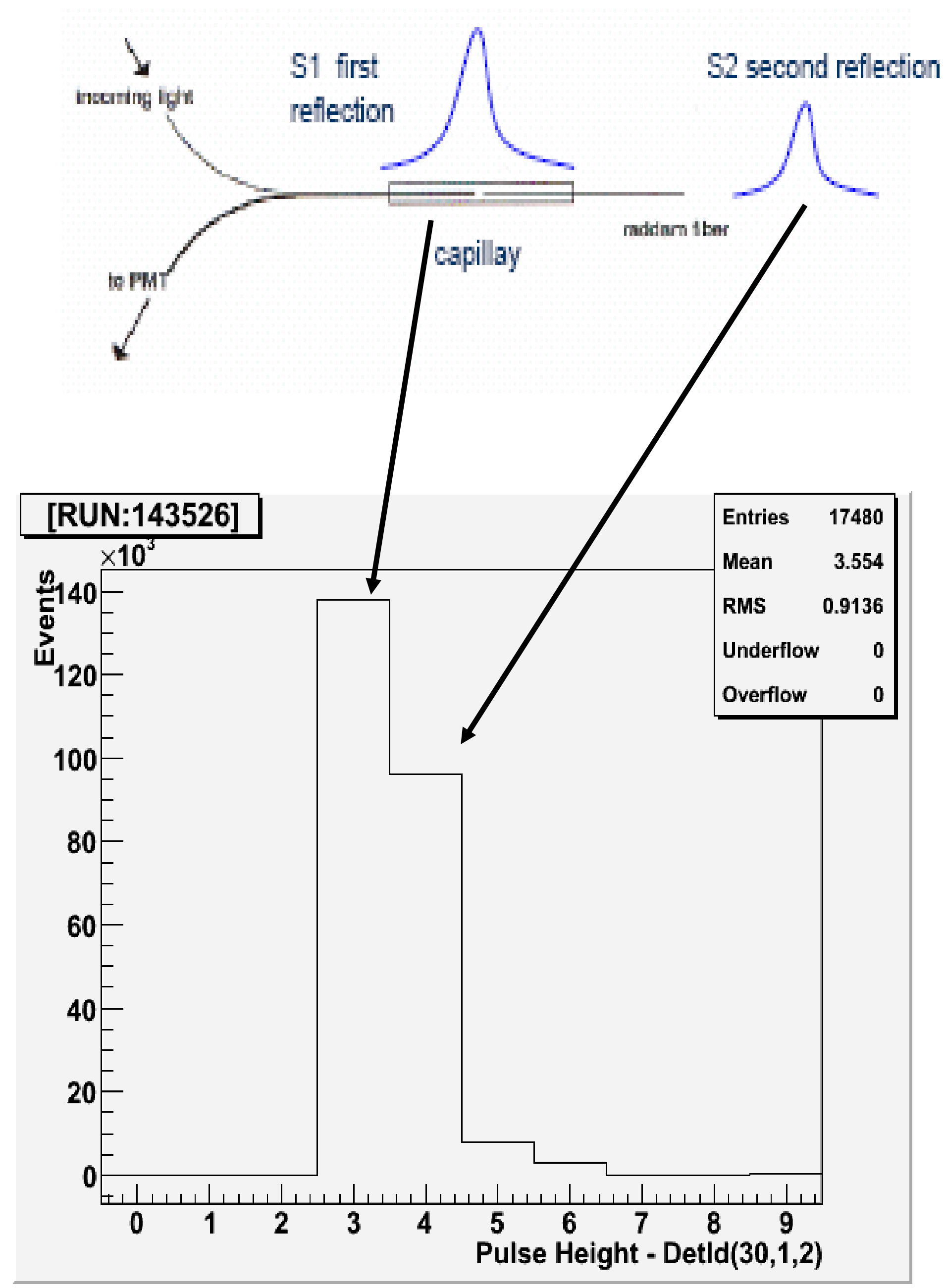
RADDAM principle [3]



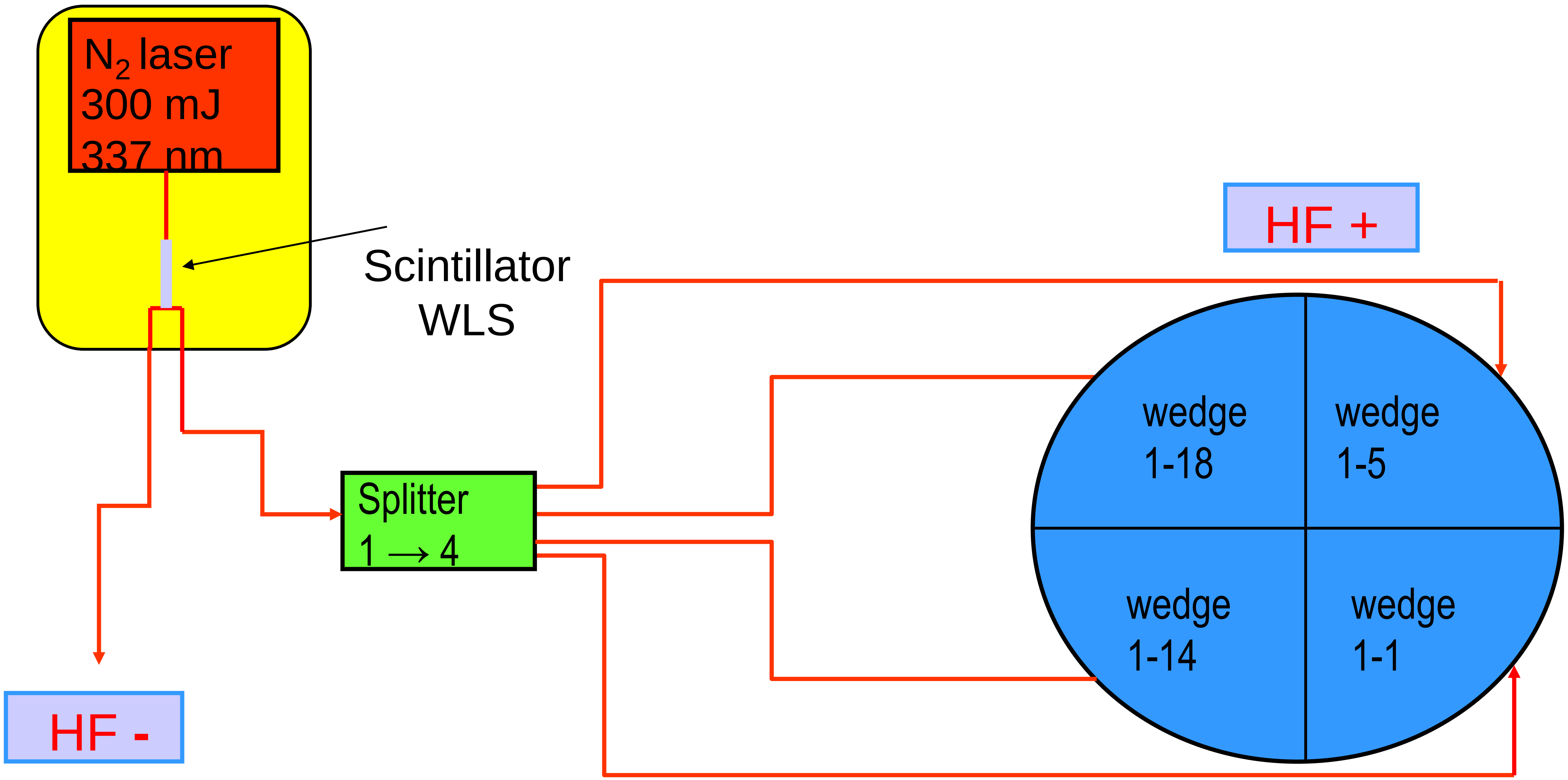
- Inject light through a capillary tube in a 2.5 m long fiber (two ends polished). For HF this length corresponds to a regular fiber length read by PMT.
- Reflection occurs at the two ends, signal S1 at the entrance and S2 at the far end. S2 coming 25 ns later.
- The ratio R = S1 /S2 is related to the fiber transparency , and its value depends on the accumulated dose and post irradiation time t for recovery.
- The fibers in HF are grouped in towers. Raddam fibers are equipped in 7 eta towers of 8 HF wedges.
- HF detected light (fibers+ PMT) has a spectrum centred at 450 nm

Radiation Damage Monitoring Fiber



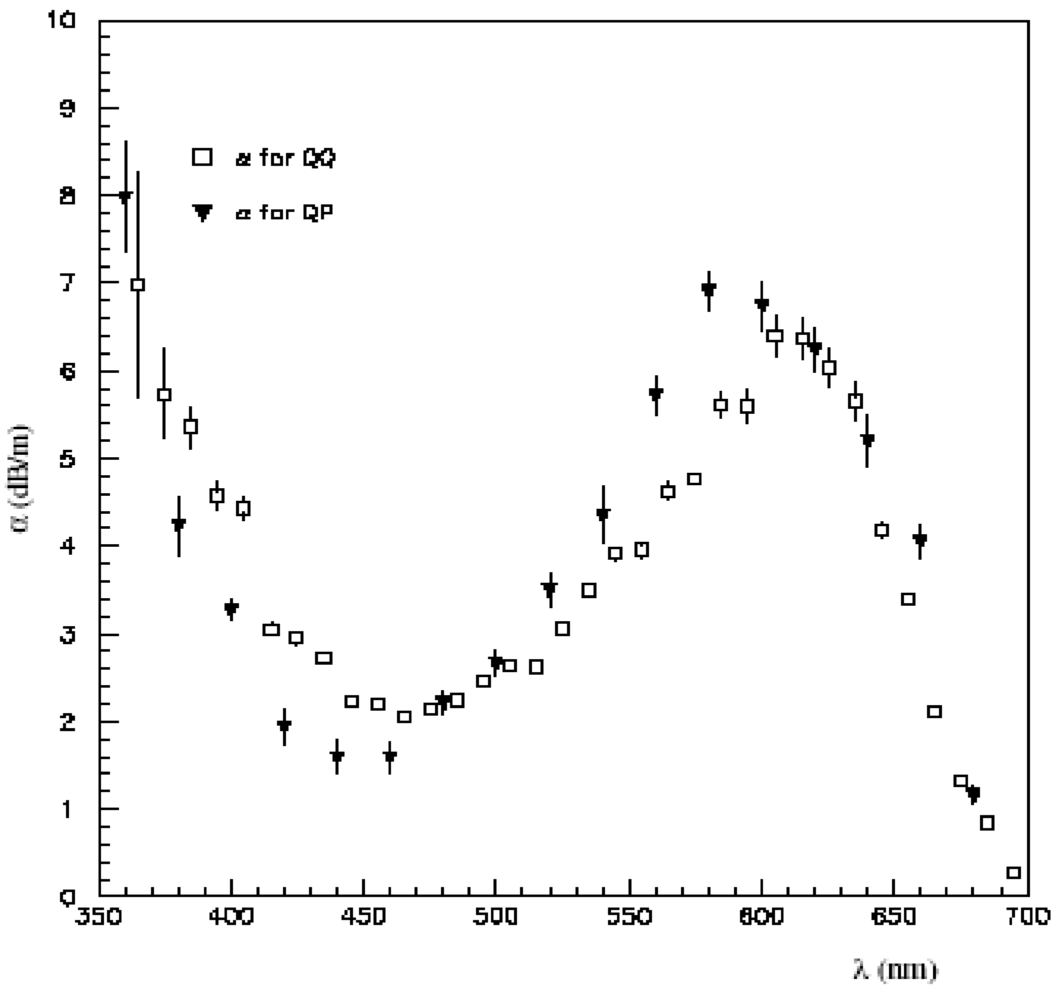


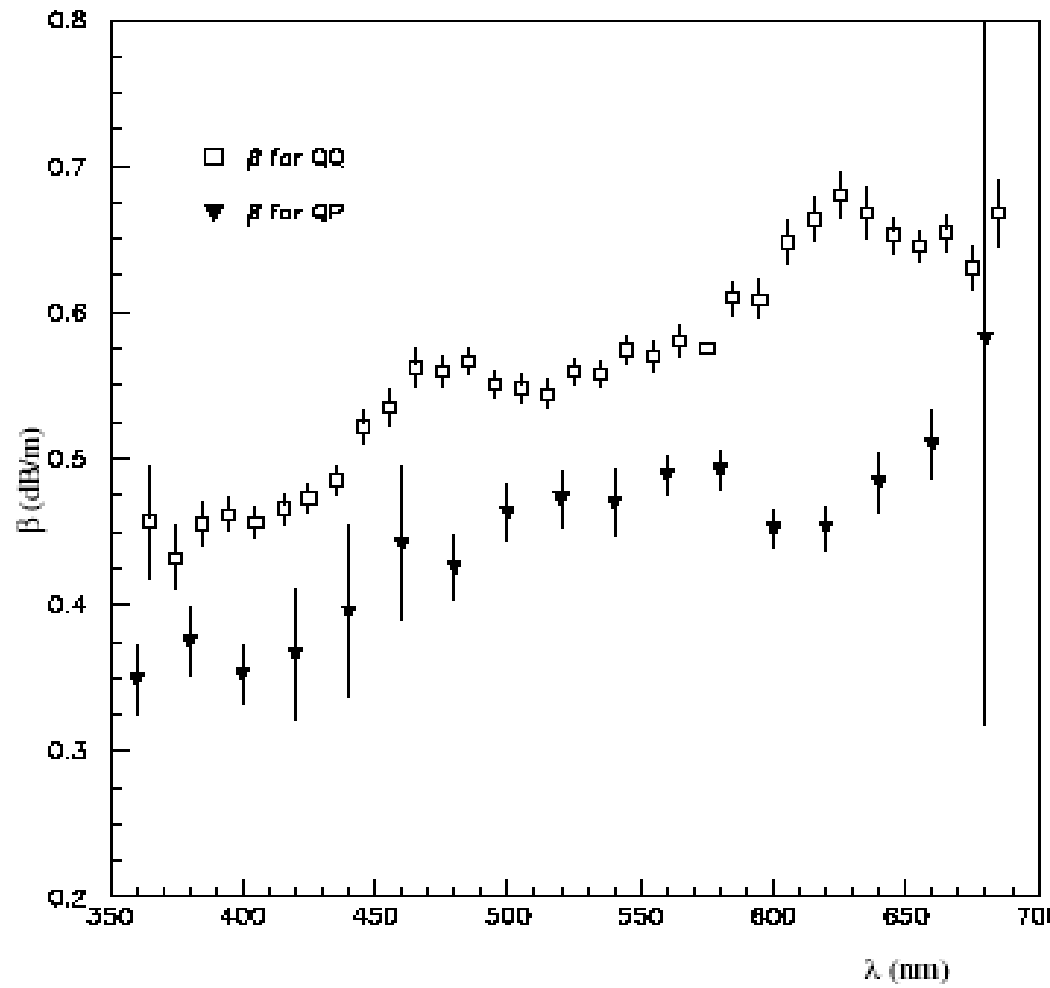
HF Raddam device



The device use a pulsed nitrogen laser (337 nm) and it is wavelength shifted into the blue region (440 nm) by a 2 cm long scintillating fiber positioned in a feed-through connector. This light is then distributed into fibers in four wedges per HF. Within a wedge, 7 towers (spanning all rapidity regions) are instrumented with these sample fibers. Each fiber is readout by the PMT that serves that particular tower.[6]

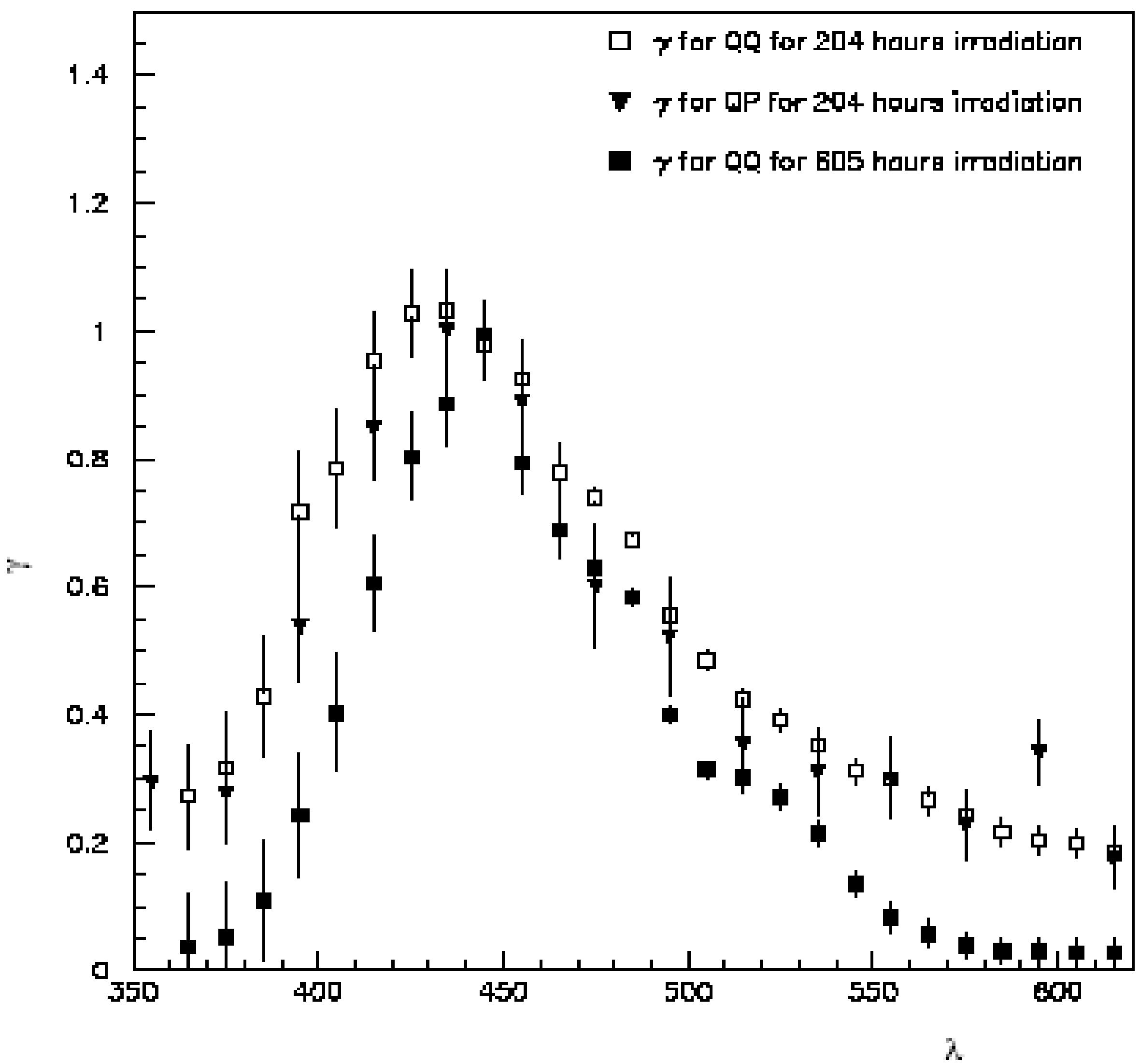
Radiation damage in irradiated quartz fibre [1][2]

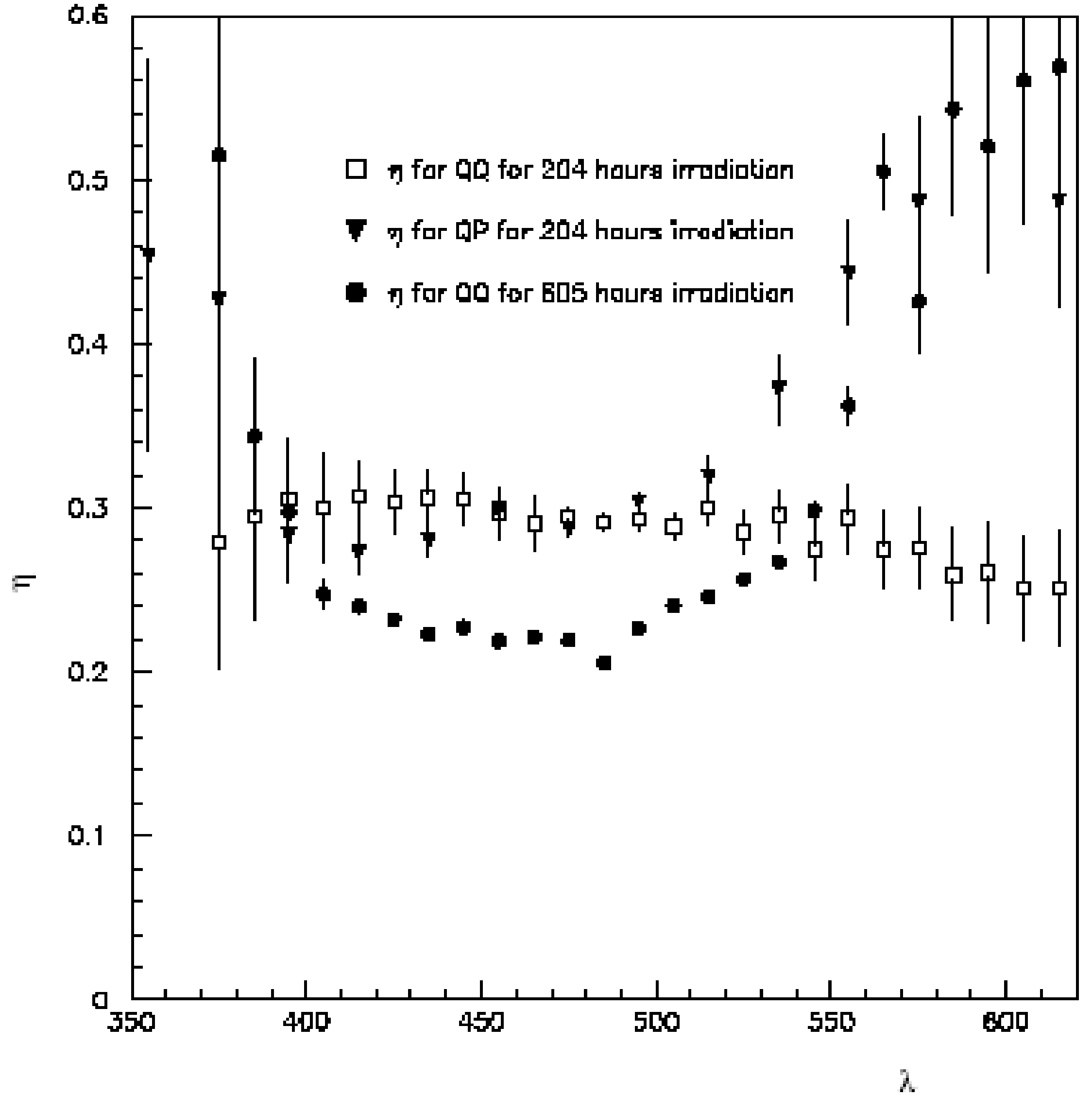




α and β parameters versus λ for qq and qp fibres corresponding to the fit of irradiation data up to 1.25 Grad.

Damage Recovery parameters [1][2]





Recovery parameters γ and η versus λ for qq and qp fibres versus wavelength, after 205 and 605 h of irradiation.

Damage and recovery of irradiated quartz fibres [1][2]

Radiation damage (Decrease of signal)

$I(\lambda,D)/I(\lambda,0) = \exp[-A(\lambda,D).L/4.343] \rightarrow S1/S2$

Optical attenuation is defined as

$A(\lambda,D) = \alpha(\lambda)\ [D/D_s]^{\beta(\lambda)}$

where
D: Accumulated dose
D_0: Reference dose
$\alpha(\lambda)$ and $\beta(\lambda)$: Characteristic parameters which define radiation hardness of a given fiber (must be found empirically).
A in dB/m, D in Mrad, L in m

Recovery (Increase of transm. signal)

$$\frac{I_D(\lambda,t)}{I(\lambda,D)} = \exp\left[A(\lambda,D)(L/4.343)\left(\frac{\gamma t^n}{t_{irr}^n + \gamma t^n}\right)\right]$$

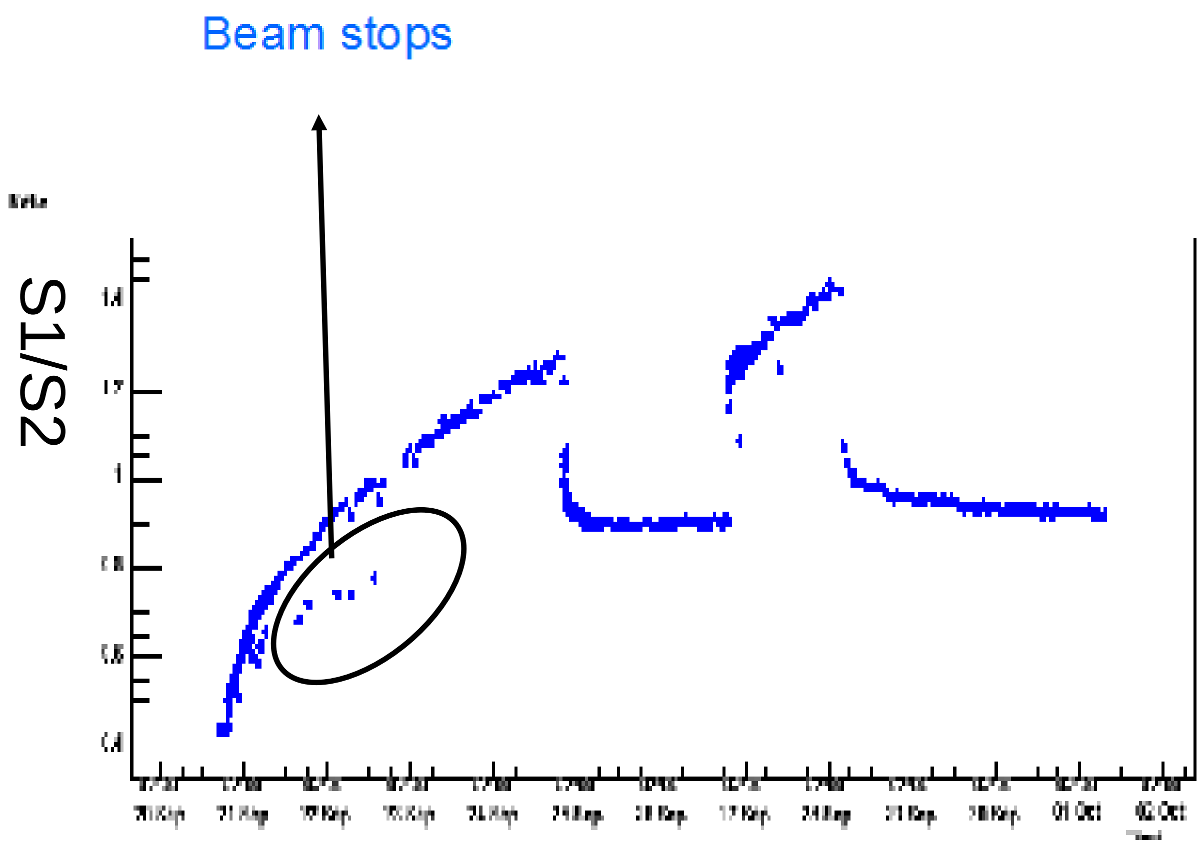
Estimate of radiation damage and recovery versus dose in HF quartz fibers

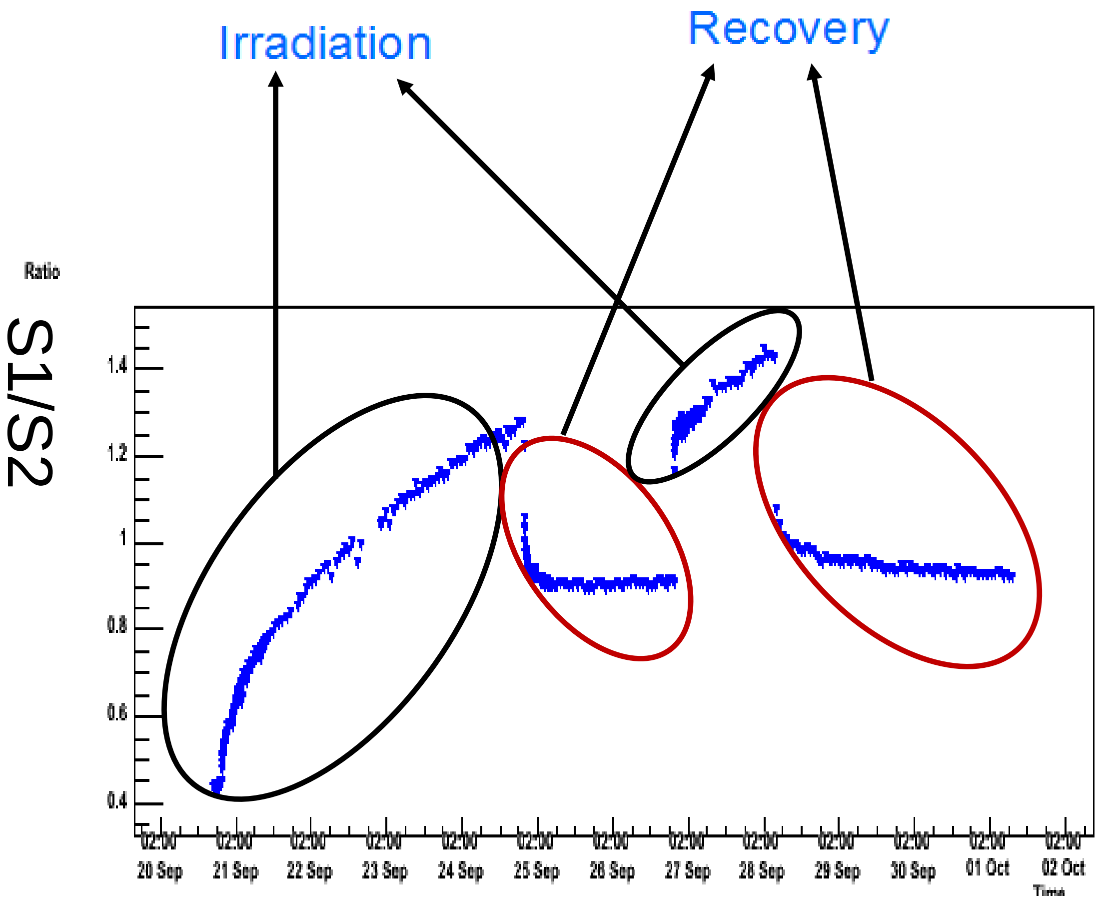
t_{irr} (days)	1	2	3	5	10	20	50	100	150	200	2000
Dose *(Mrad)*	***0.5***	***1.0***	***1.5***	***2.5***	***5.0***	***10***	***25***	***50***	***75***	***100***	***1000***
A (dB/m)	**0.156**	**0.211**	**0.252**	**0.316**	**0.428**	**0.581**	**0.869**	**1.179**	**1.410**	**1.600**	**2.754**
Signal loss *(%)*	***5.7***	***7.7***	***9.1***	***11.3***	***15.0***	***19.8***	***28.0***	***36.1***	***41.5***	***45.6***	***65.0***
Increase aft.**1h** *(%)*	***1.7***	***1.9***	***2.1***	***2.3***	***2.7***	***3.0***	***3.6***	***4.0***	***4.3***	***4.5***	***4.1***
Increase aft.**8h** (%)	2.5	3.0	3.3	3.8	4.4	5.1	6.2	7.1	7.7	8.1	7.4
Increase aft.**1d** (%)	3.0	3.7	4.1	4.7	5.6	6.6	8.1	9.0	9.8	10.9	10.2
Increase af.**10d**(%)	***4.0***	***5.1***	***5.8***	***6.8***	***8.5***	***10.4***	***13.4***	***16.1***	***17.9***	***19.2***	***19.4***

This table shows the increase of 450 nm signal at different dose and post d.t. time t (dose rate 0.5 Mrad/day)

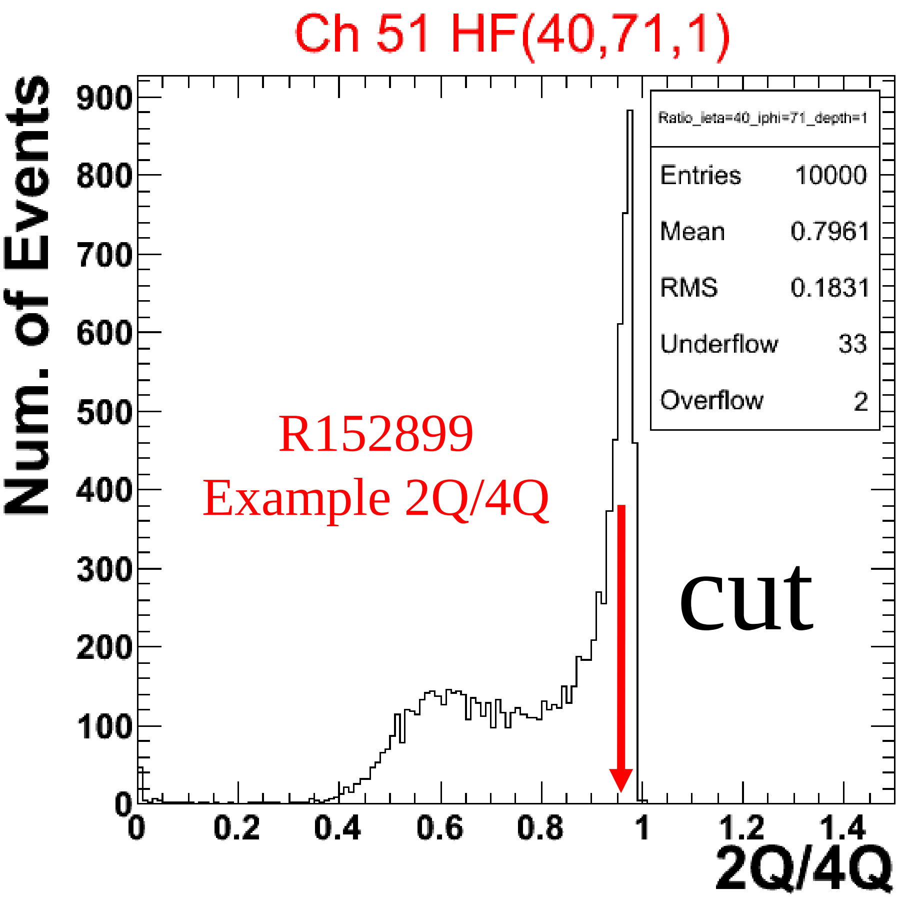
Irradiation test history [3]

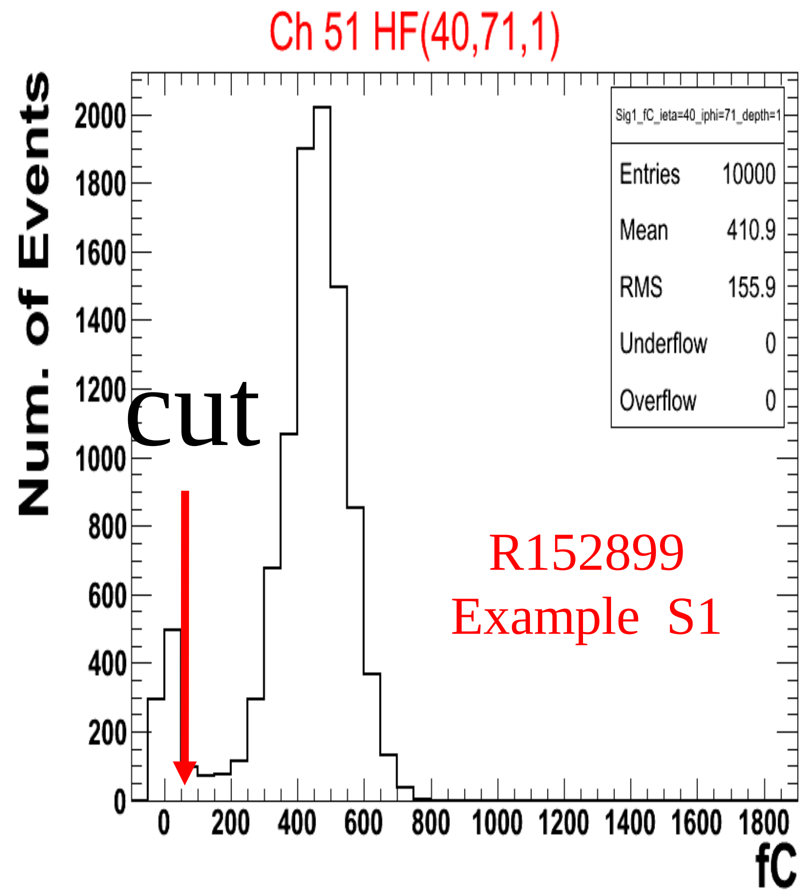
PS Irradiation at high dose rate 2.6 Mrad/hour, 250 Mrad in 4 days

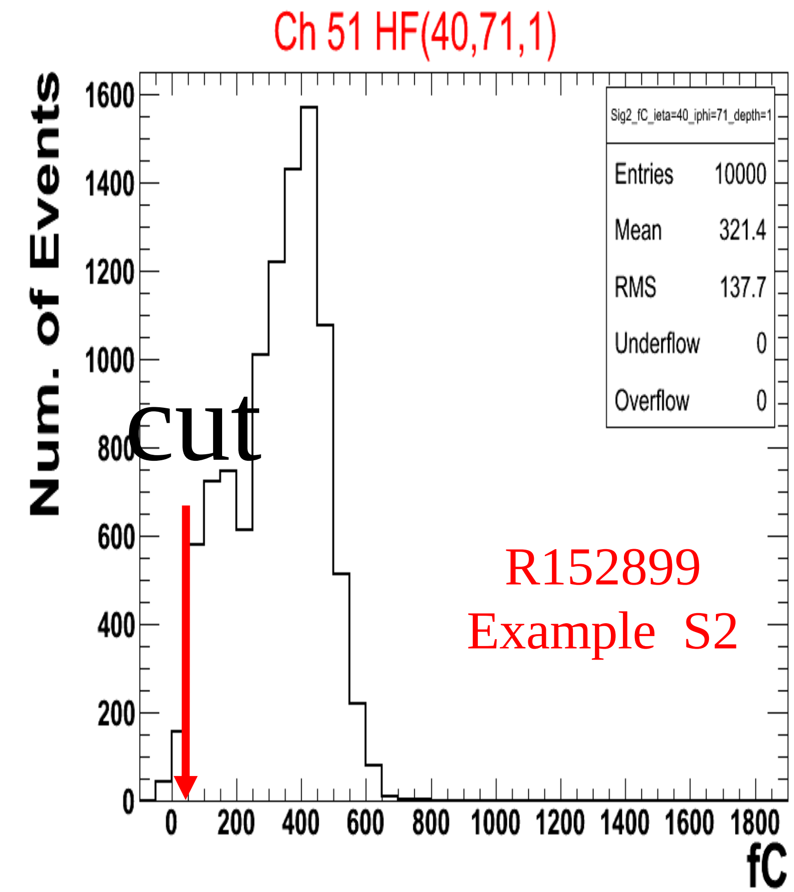


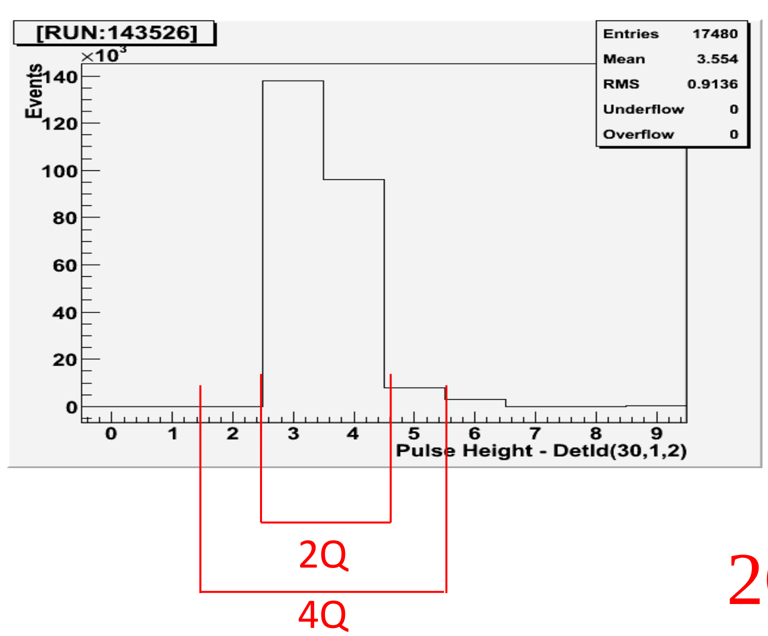


Event Selection









radTS : time slice id where S1 measured. radTS = 3 for HF(+), 4 for HF(-)

2Q : sum of the fC in radTs and radTS+1.

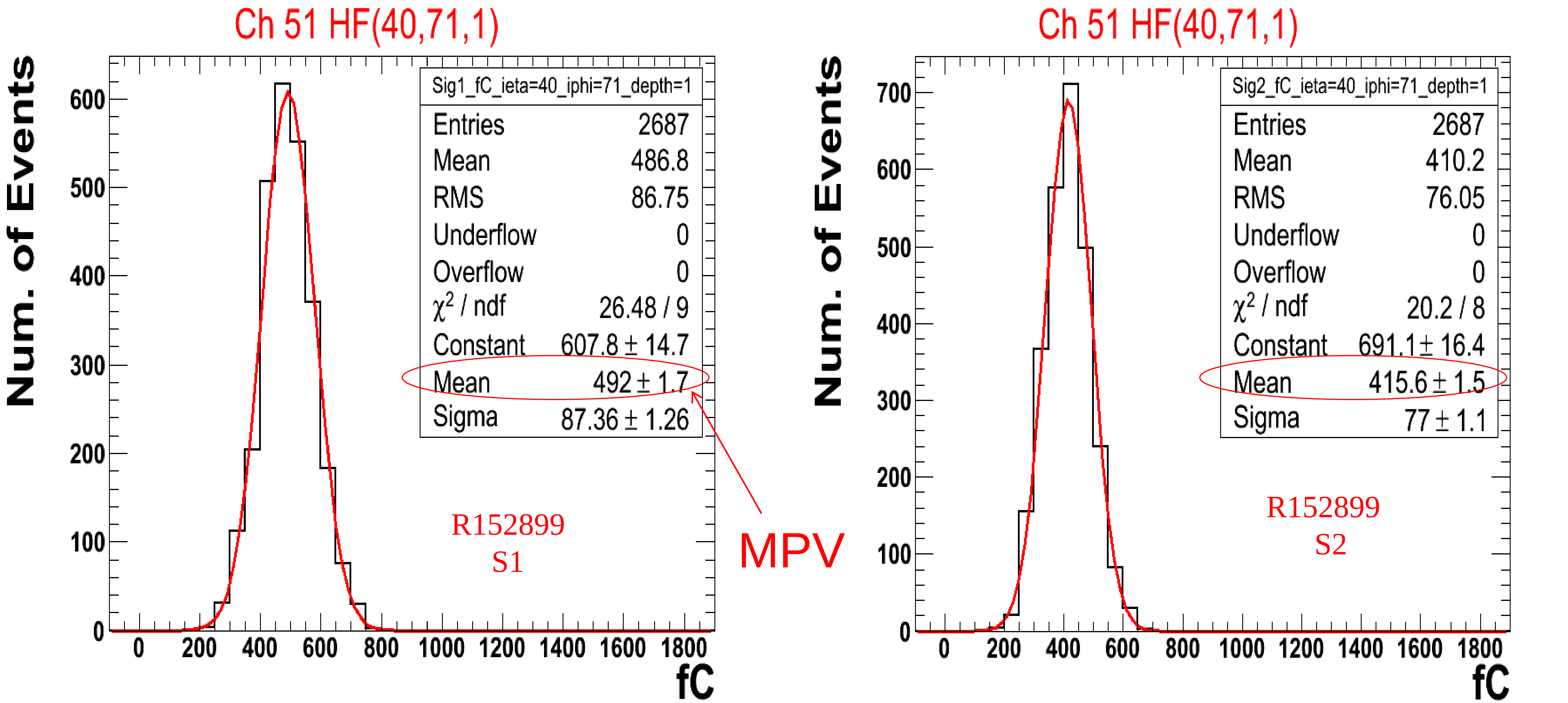
4Q : sum of the fC in radTs-1, radTS, radTS+1, and radTS+2.

Selection criteria:

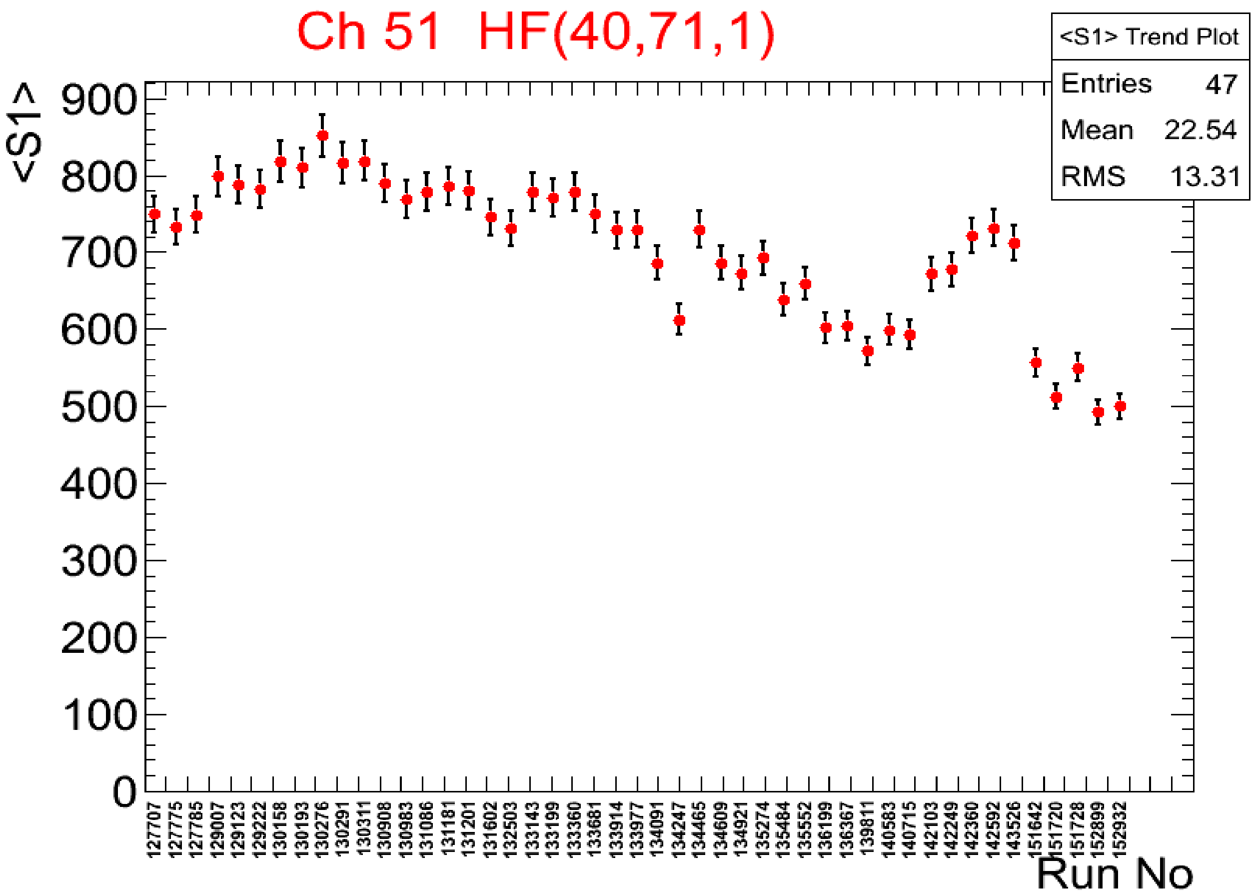
2Q/4Q > 0.95 & Q[radTS] > 50 fC & Q[radTS+1] > 50 fC

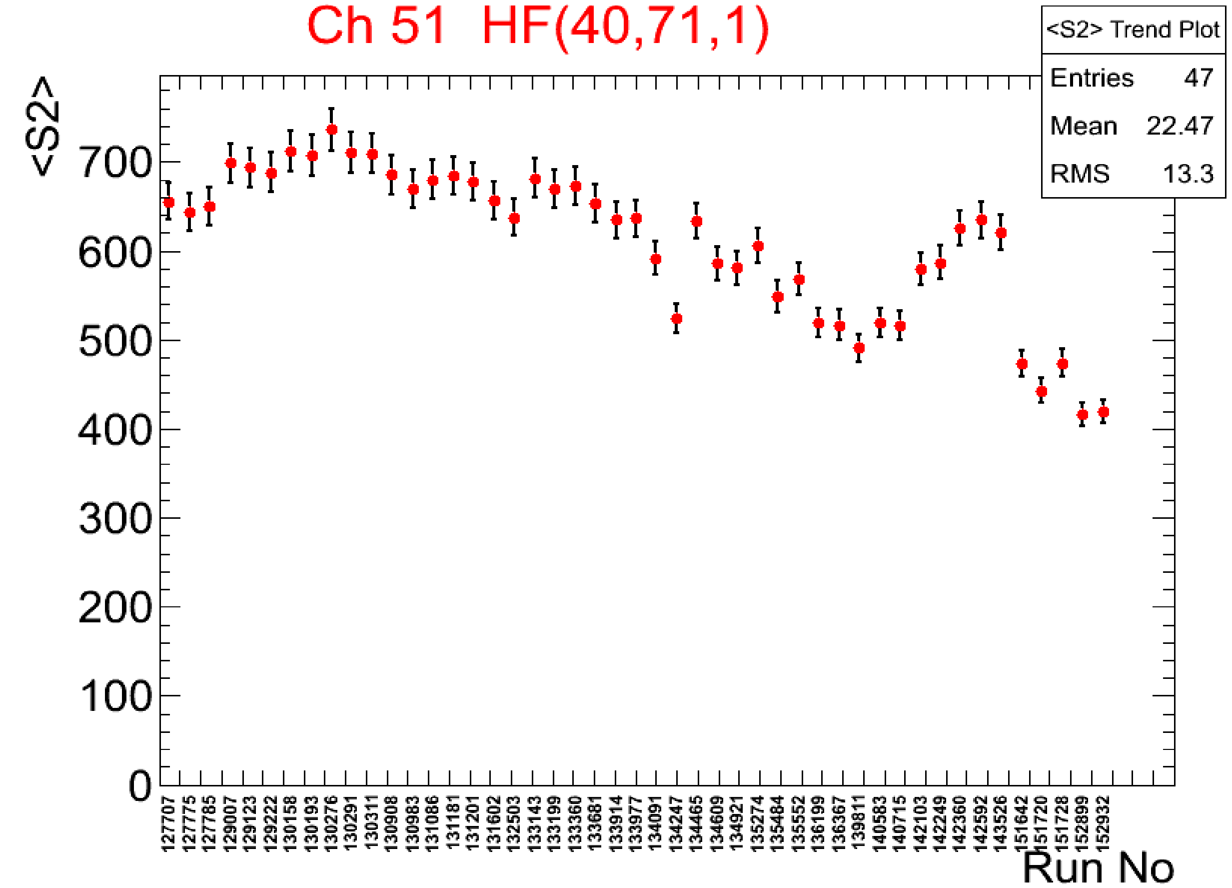
(50 fC requirement is used after pedestal subtraction)

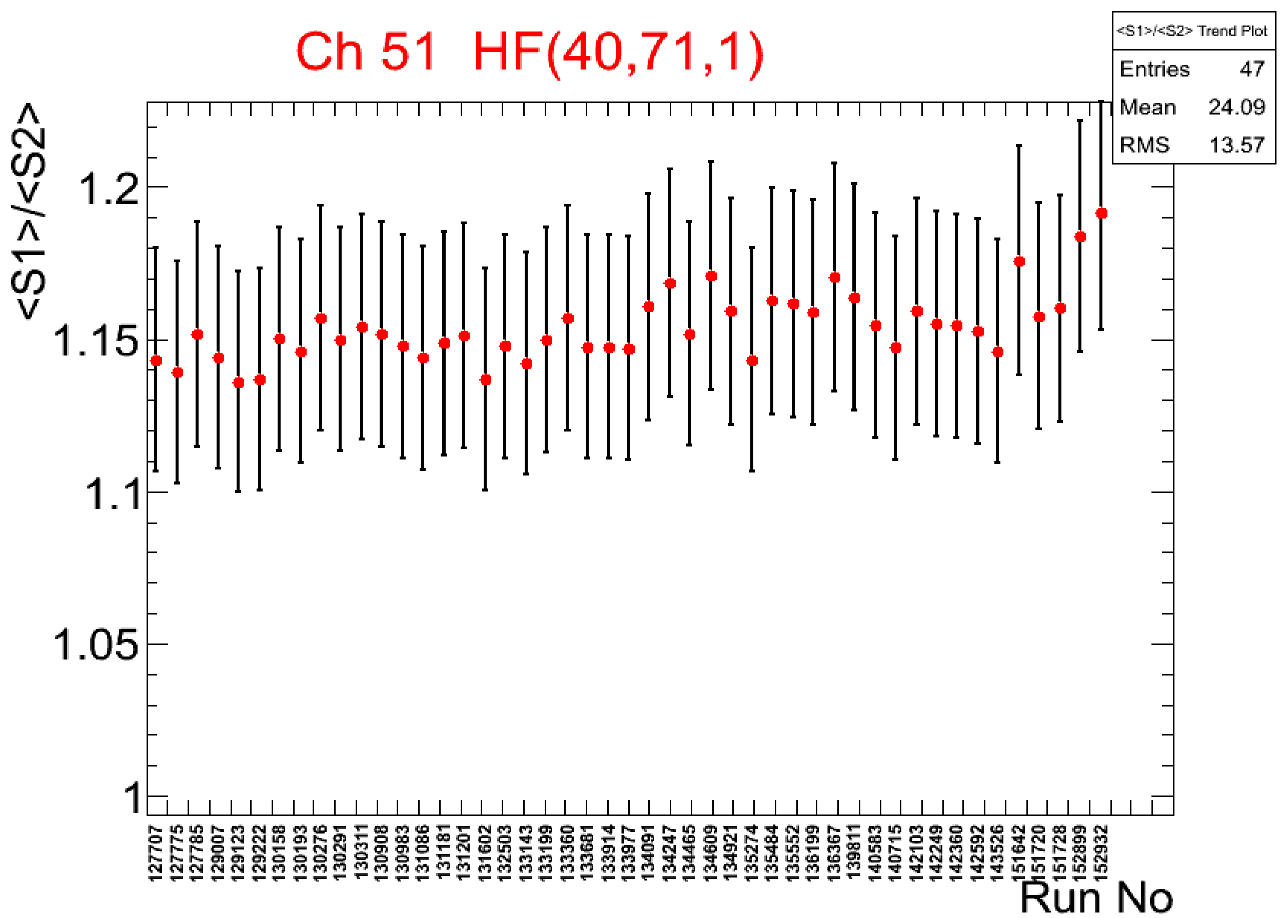
On average ~20-30% of the total events remain.



After event selection S1 and S2 distribution are fitted with gaussian fit.

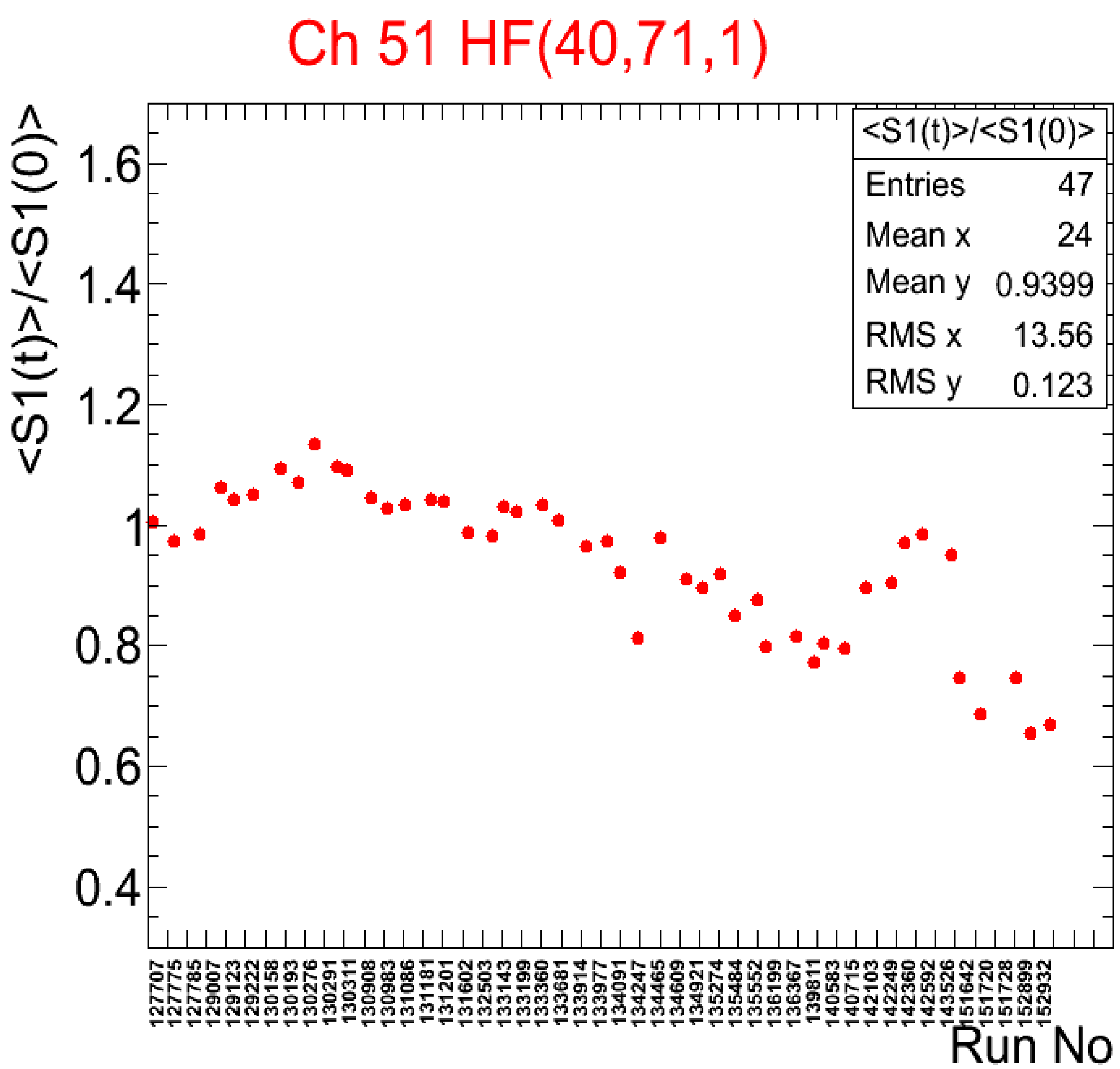




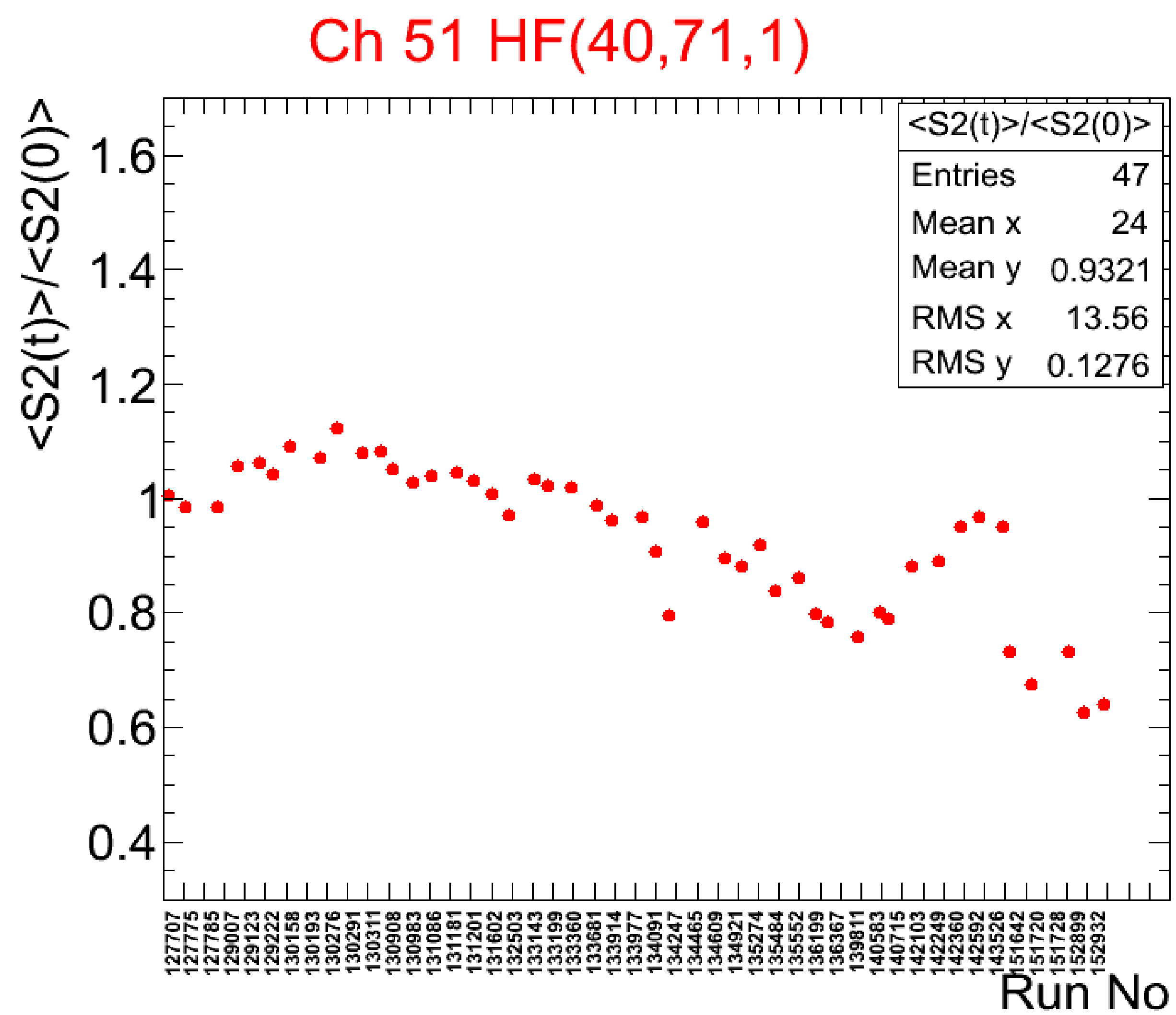


We considered the following error sources:
2% QIE quantization error
- (i.e. effect of binning)[4]
- 2.5% QIE-to-QIE spread [5].

The resulted error estimation is 3.2%.



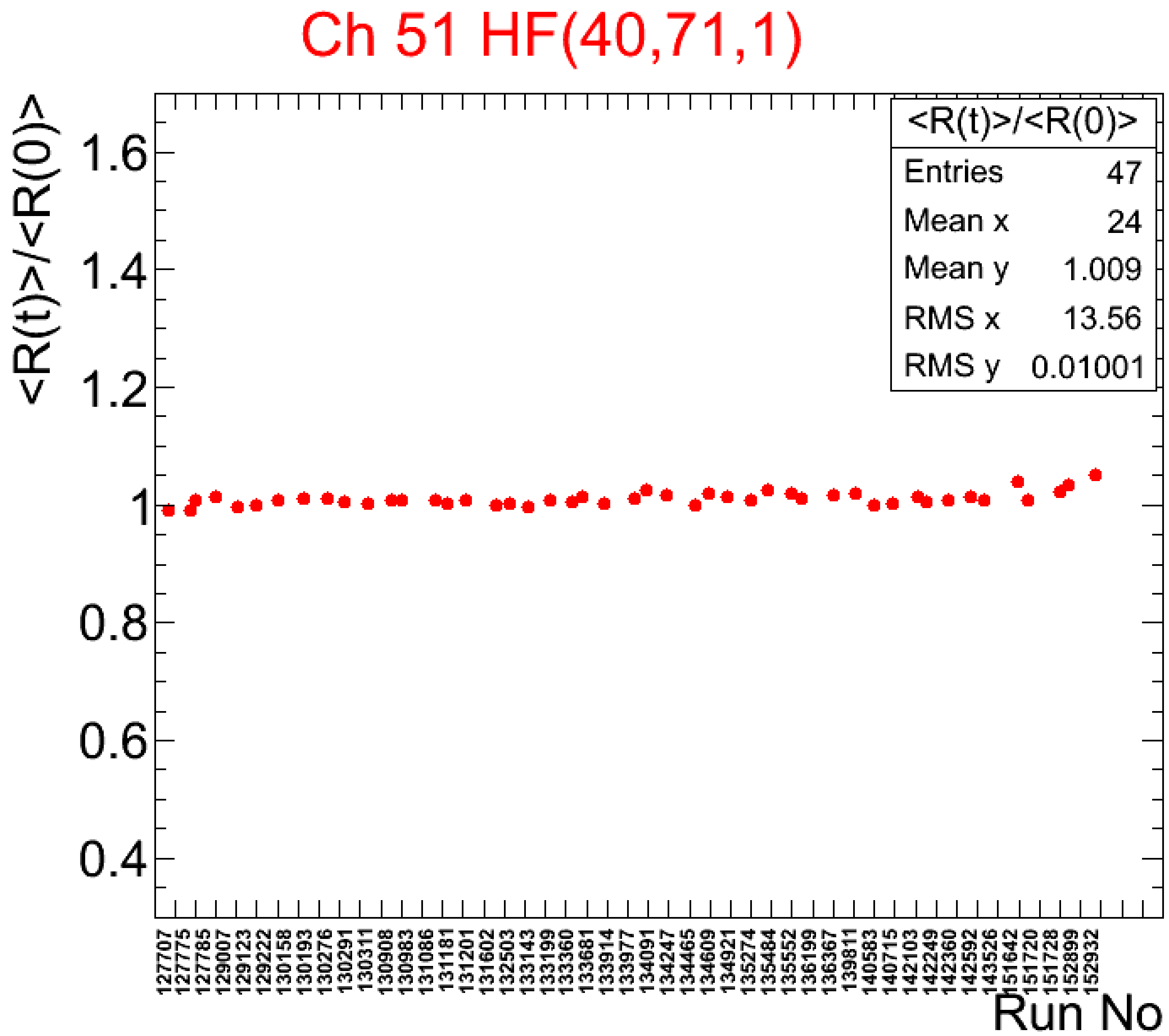
2010 Runs



2010 Runs

<S1(t)>/<S1(0)>
Monitoring of laser light intensity

<S2(t)>/<S2(0)>
Laser light intensity + Raddam effect



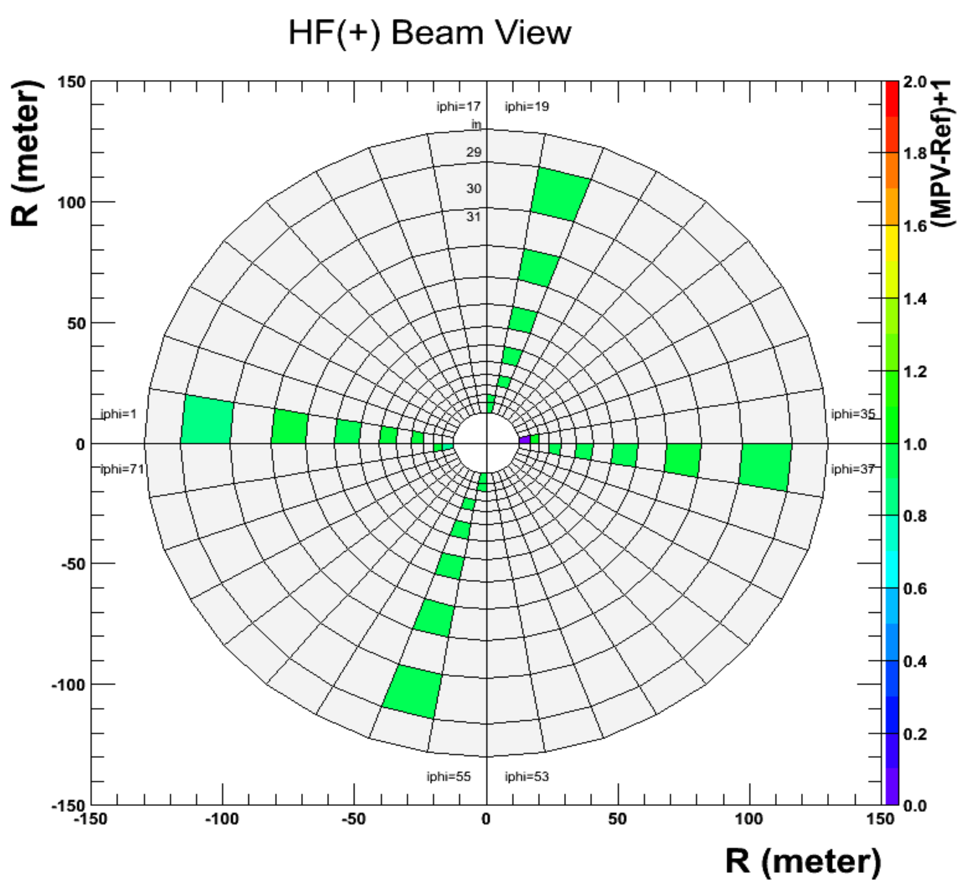
$$R(t)/R(0) = [(<S1(t)>/<S2(t)>)/(<S1(0)>/<S2(0)>)]$$

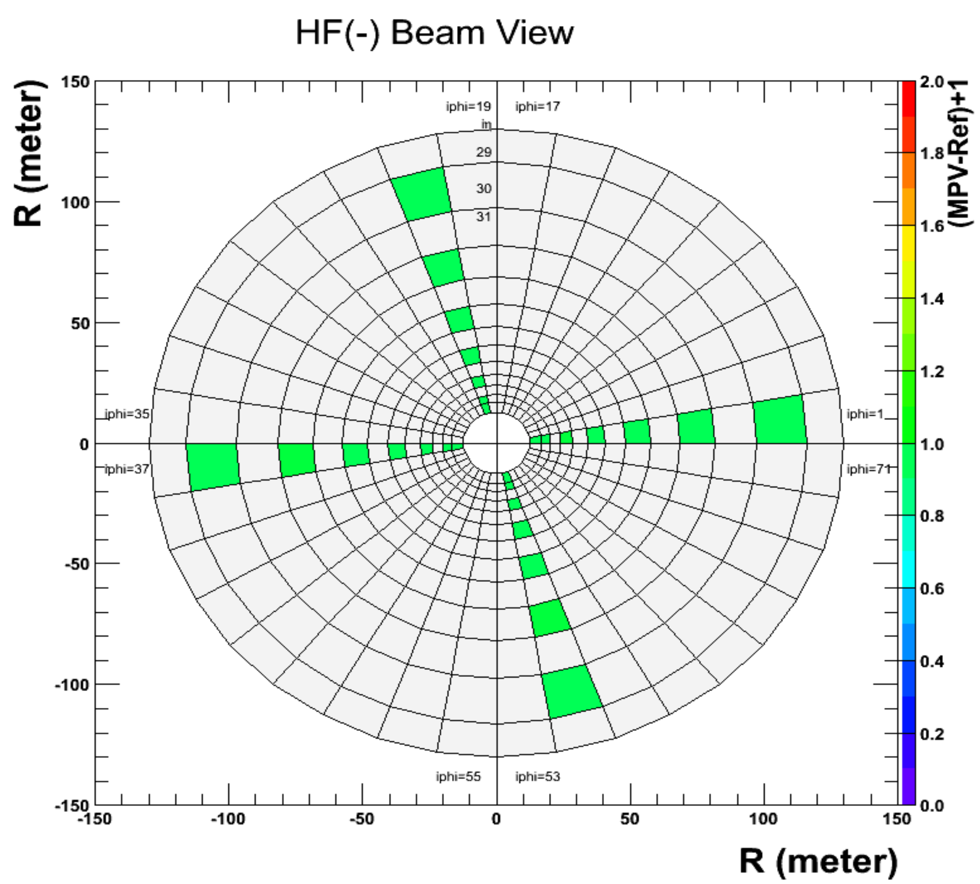
Nomalized Raddam effect

DQM Update

Plan to update on DetDiag Raddam offline analyzer :

- Implement for each channel and Run S1, S2 distributions and S1/S2
- Update plot view for short-term problems lasers, PMT, QIE and timing.
- Provide a stand-alone ROOT macro for trend analysis based on DQM outputs.





WHAT COULD BE IMPROVED

- A good laser with more precise timing and less aging presently we select only 20-30 % of data
- Install spares of long fibers going from laser shifter to HF**±**
- Replace SMA connectors by ST ones at the level of laser bench (radial positioning of fibers)
- Improved event selection.
- Produced one example DQM plot, will work on updating DetDiag for RADDAM runs.
- Final goal is to provide a simple ROOT macro for trend analysis based on DQM outputs.

Conclusion

- Raddam device is working in 55 channels /56

- We have reliable analysis of Raddam data to be installed in DQM

- Can be used to monitor:
  - ❑Radiation damage of fibers,
  - ❑Laser intensity
  - ❑Stability of electronics, quality of timing in 55 channels

References

[1] I.Dumanoglu et al. NIM A 490 (2002) 444-455

[2] K. Cankocak et al., CMS note 2007/03 submitted to NIM A. 585(2008) 20-27

[3]http://indico.cern.ch/getFile.py/access?contribId=7&resId=1&materialId=slides&confId=38625

[4] http://lss.fnal.gov/archive/2010/pub/fermilab-pub-10-210-ppd.pdf

[5] https://twiki.cern.ch/twiki/bin/viewauth/CMS/ChargeInjector

[6] CMSNOTE 2006-044