CMS RPC Preliminary Results for Aging Studies at new CERN GIF++ facility

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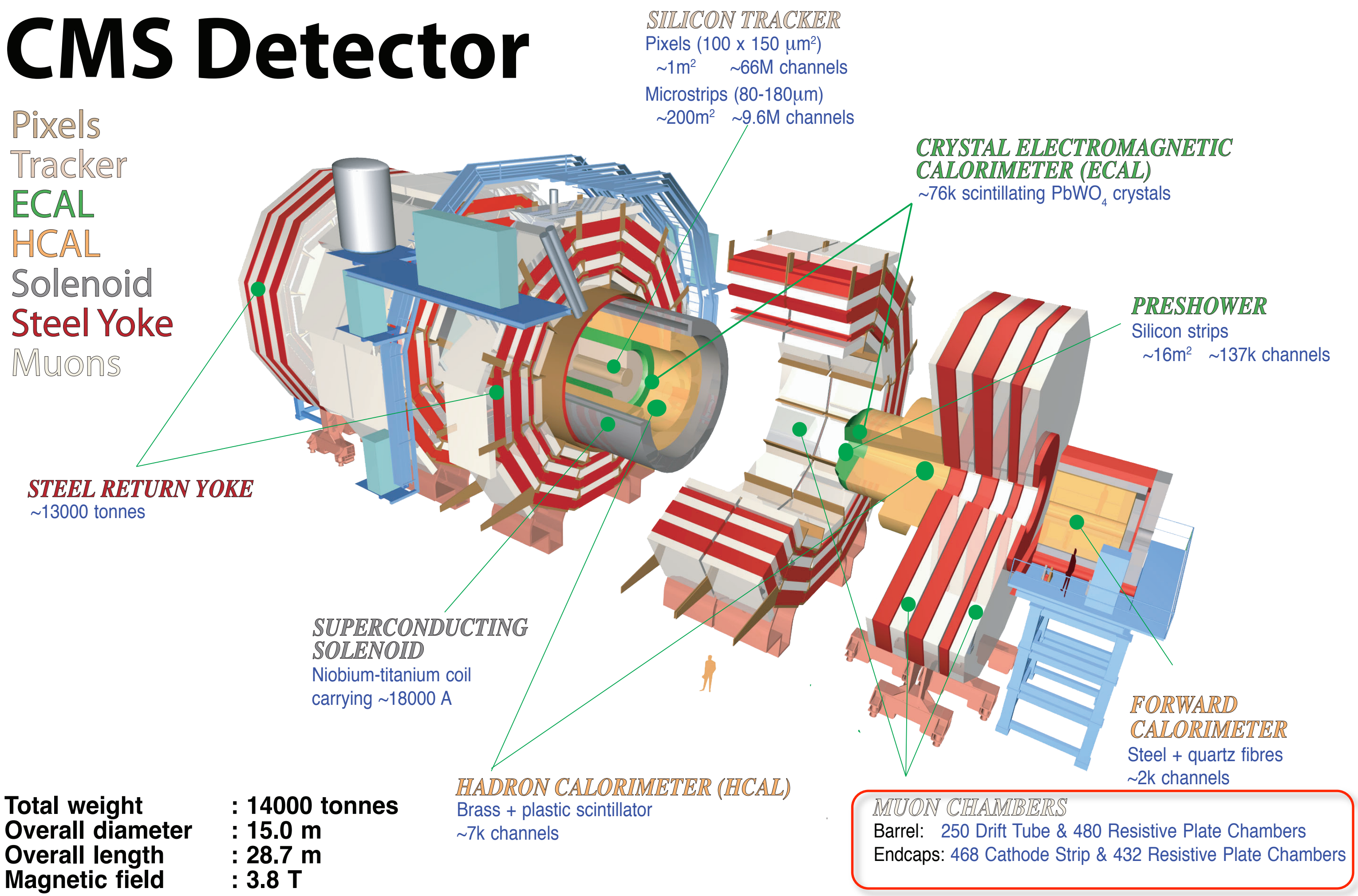
on behalf of CMS RPC Collaboration.

XIII ON RESISTIVE PLATE CHAMBERS AND RELATED DETECTORS 2016
Ghent University , Belgium / Feb 22 - 26

Talk Overview

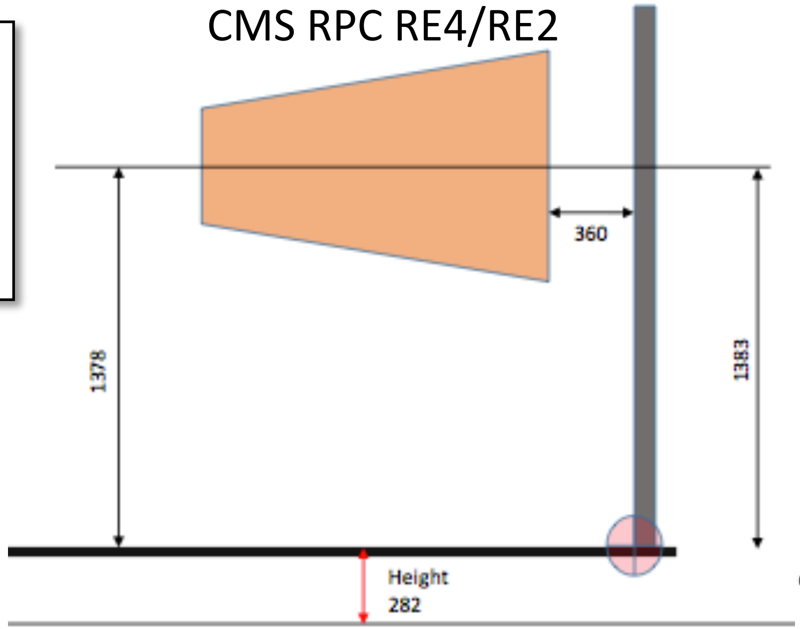
- We use four CMS RPC (Endcap) chamber for the aging study.
- Detectors have been installed at new CERN GIF++ Facility (2015)
  - ➢ We first establish our reference point measuring their performance, current, rates, etc.
  - ➢ We comission all our tools for Test Beam and Long Term Monitoring
  - ➢ We have started our aging study: currently with an extra RPC Test chamber.

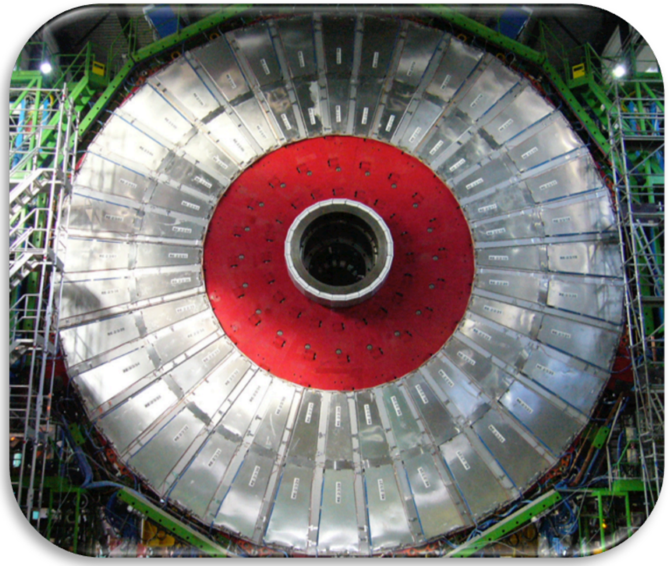


CMS Endcap and Barrel RPC*

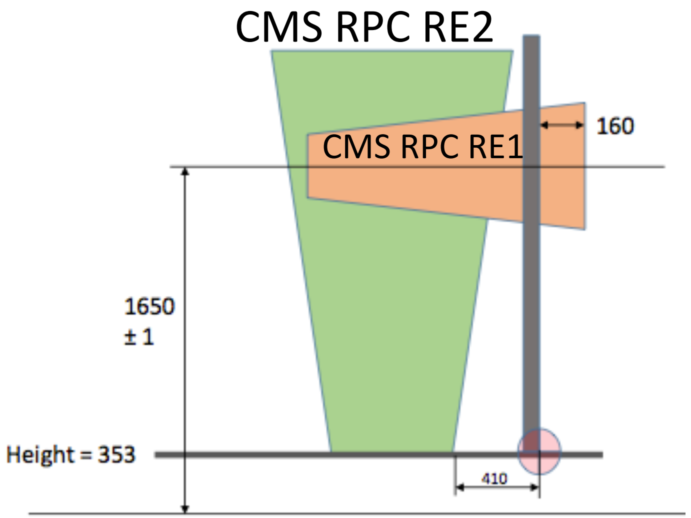
Detectors are mounted in two Trolleys:

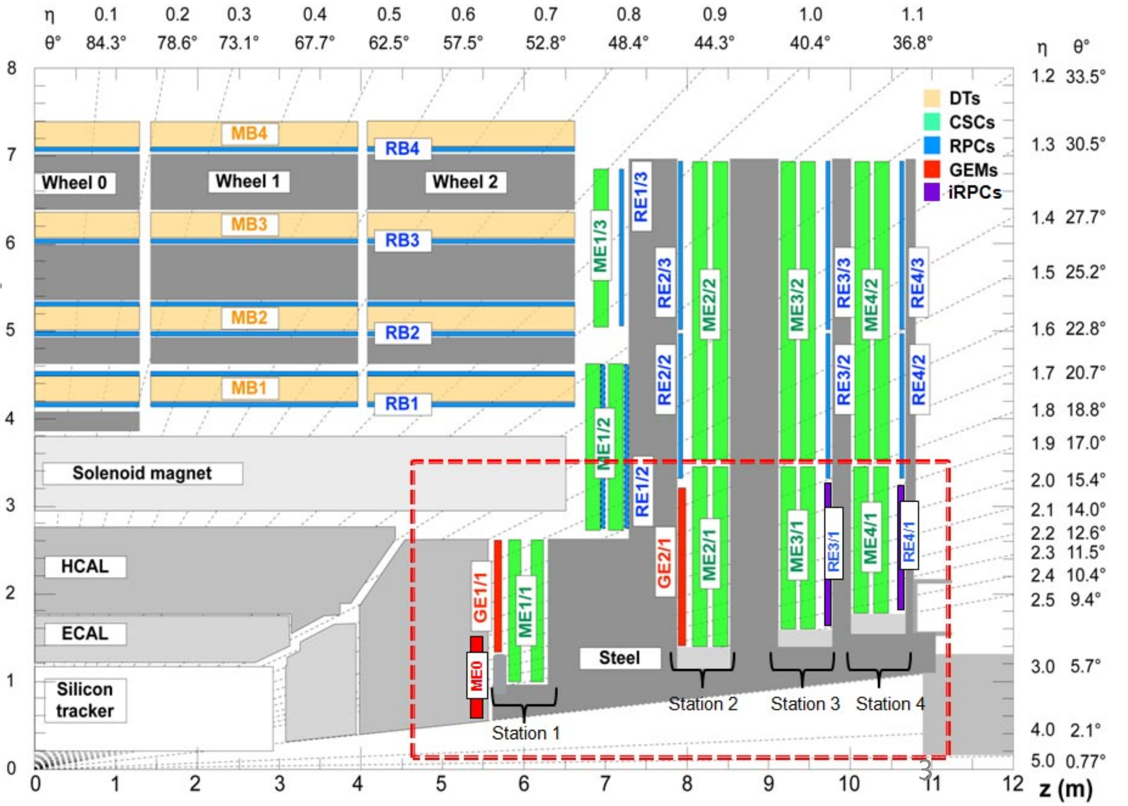
Trolley-1:
- 2 CMS RPC RE2 Chambers
- 2 CMS RPC RE4 Chambers
- 6 Gaps





Trolley-3:
- 1 CMS RPC RE2 “Spare” Chamber
- 2 RE1 iRPC KODEL (RE1)

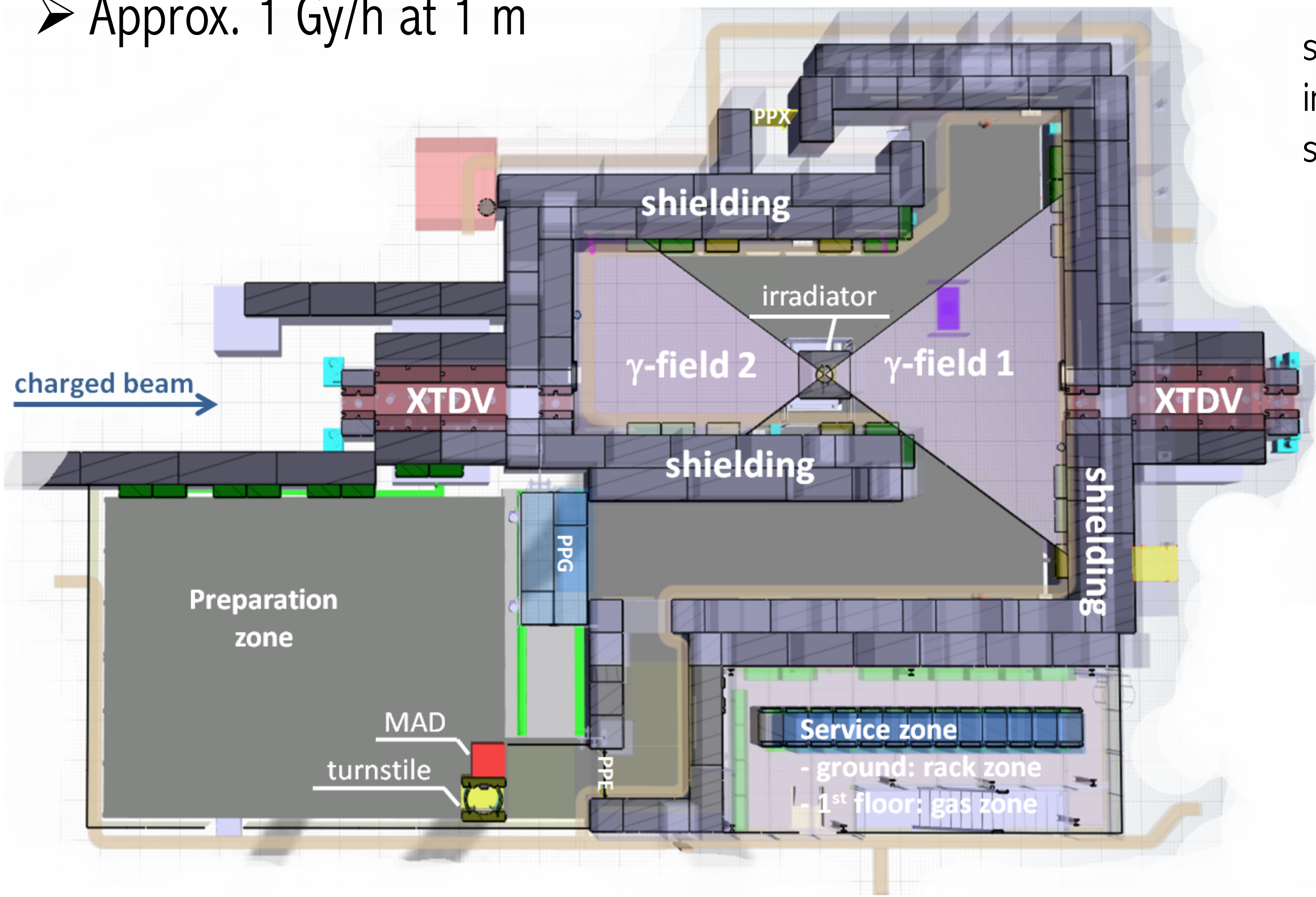




* Monday talk by Isabel Pedraza

New CERN Gamma Irradiation Facility (GIF++)

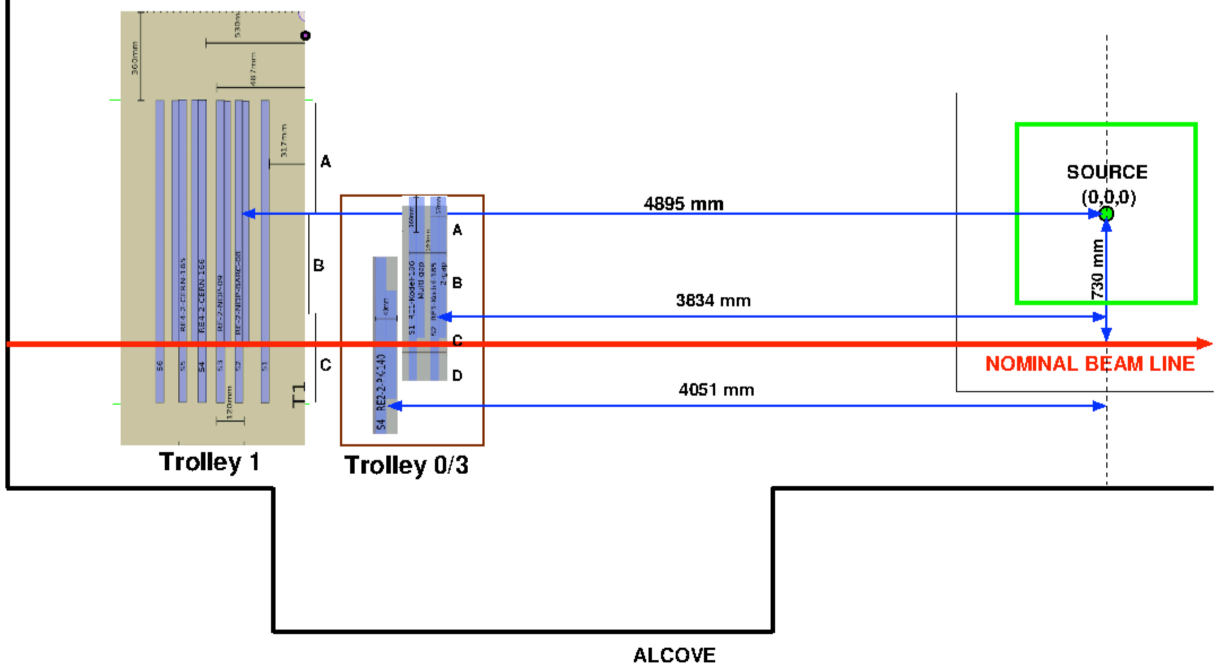
- 13.9 TBq ^{137}Cs
- Approx. 1 Gy/h at 1 m



Upstream area of the GIF++ Facility showing the ^{137}CS Gamma Irradiator and a dotted red line to show the beam line. Trolley-1 RPC Chambers are in the picture, and only part of the upstream section (gamma γ -2 field) is been shown.

GIF++ Simulated and Measured Background Rates

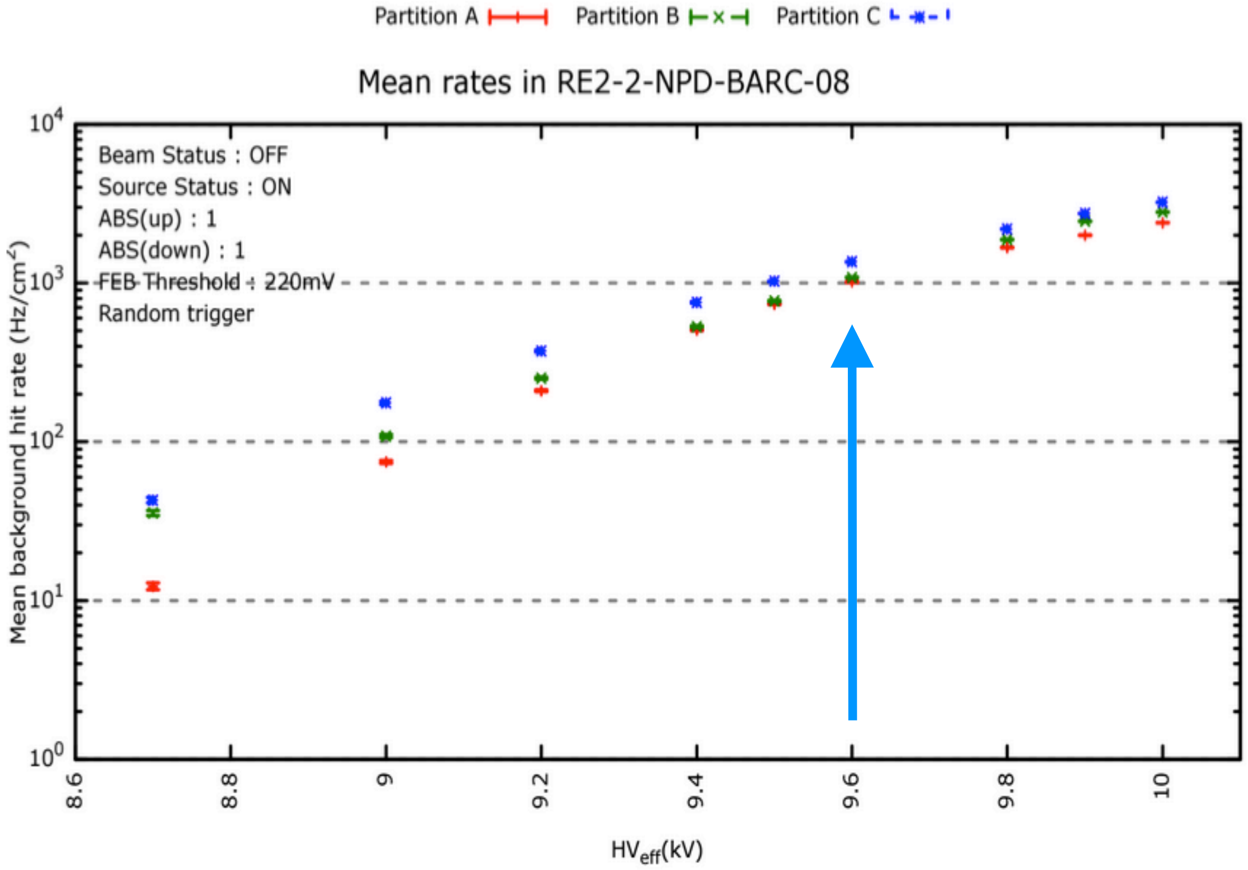
Trolley-1 & Trolley-3 Test Beam October 2015



Simulated gamma flux for Test Beam

ABS	Currents (gamma/s/cm2)			
Upstream	RPC RE2 T1S1 C	RPC RE2 T1S2 C	RPC RE4 T1S3 C	RPC RE4 T1S4 C
1	2676640	2601130	2542030	2474900
4.6	685087	664449	649858	632179
6.8	498670	485277	475458	462415
10	362690	351383	342958	334457

Downstream ABS 46420

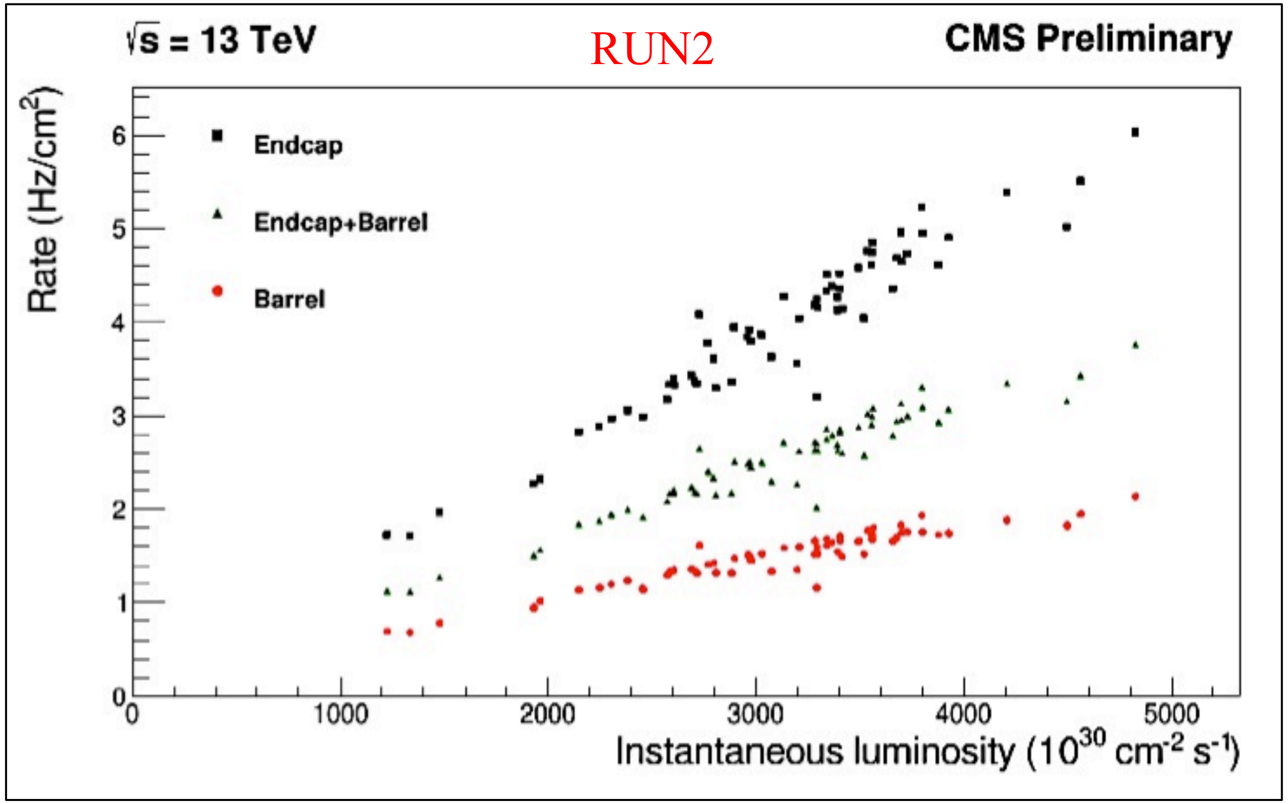


Measured Background Rate at maximum ABS 1:
0.6 - 1.2 kHz/cm^2 at HV working point

CMS RPC Expected Background Rate

Using: RUN1 (@ 8TeV) and RUN 2 (@13TeV) data we can estimate the maximum expected background rate at HL-LHC (@ lumi of 5 x 10^{34} cm^{-2} s^{-1} at 14 TeV)

safety factor = 3 (included)	C M S	
Maximum Background Flux	BARREL ~ 300 Hz/cm^2	ENDCAP ~ 600 Hz/cm^2



* See posters by Mariana Shopova, Mehar Ali Sha about performance of RPC

CMS RPC Irradiation Expected Time

HL-LHC :

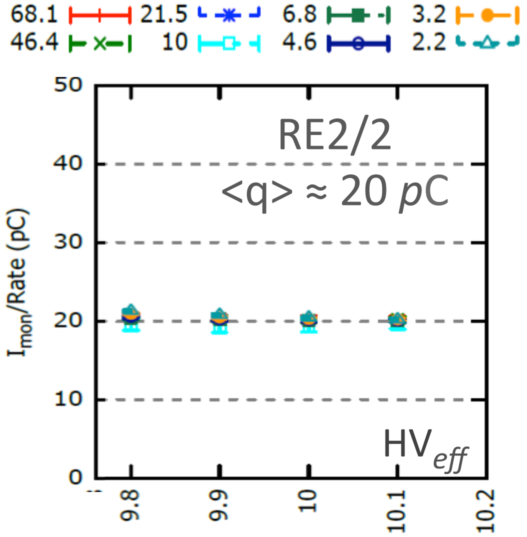
- Integrated Luminosity of 3000 fb^{-1}
- Instantaneous Luminosity 5 x 10^{34} cm^{-2} s^{-1}

$T_{eff} = 6 \times 10^7$ s

$$\text{HL-LHC.Int.Charge } (C/cm^2) = \langle q \rangle \times T_{eff} \times \Phi_{exp}$$

Integrated Charge (C/cm^2)

safety factor = 3 (included)	C M S	
Int. Charge (C/cm^2) @ 3000 fb^{-1}	BARREL ~ 0.5	ENDCAP ~ 1



Current/Rate (pC) Meassure at GIF++

Maximum Background Flux (Hz/cm^2)

safety factor = 3 (included)	C M S	
Maximum Background Flux	**BARREL** ~ 300 Hz/cm^2	**ENDCAP** ~ 600 Hz/cm^2

$$T_{irr} = \frac{T_{eff}}{AF} =$$

AF = Acceleration Factor

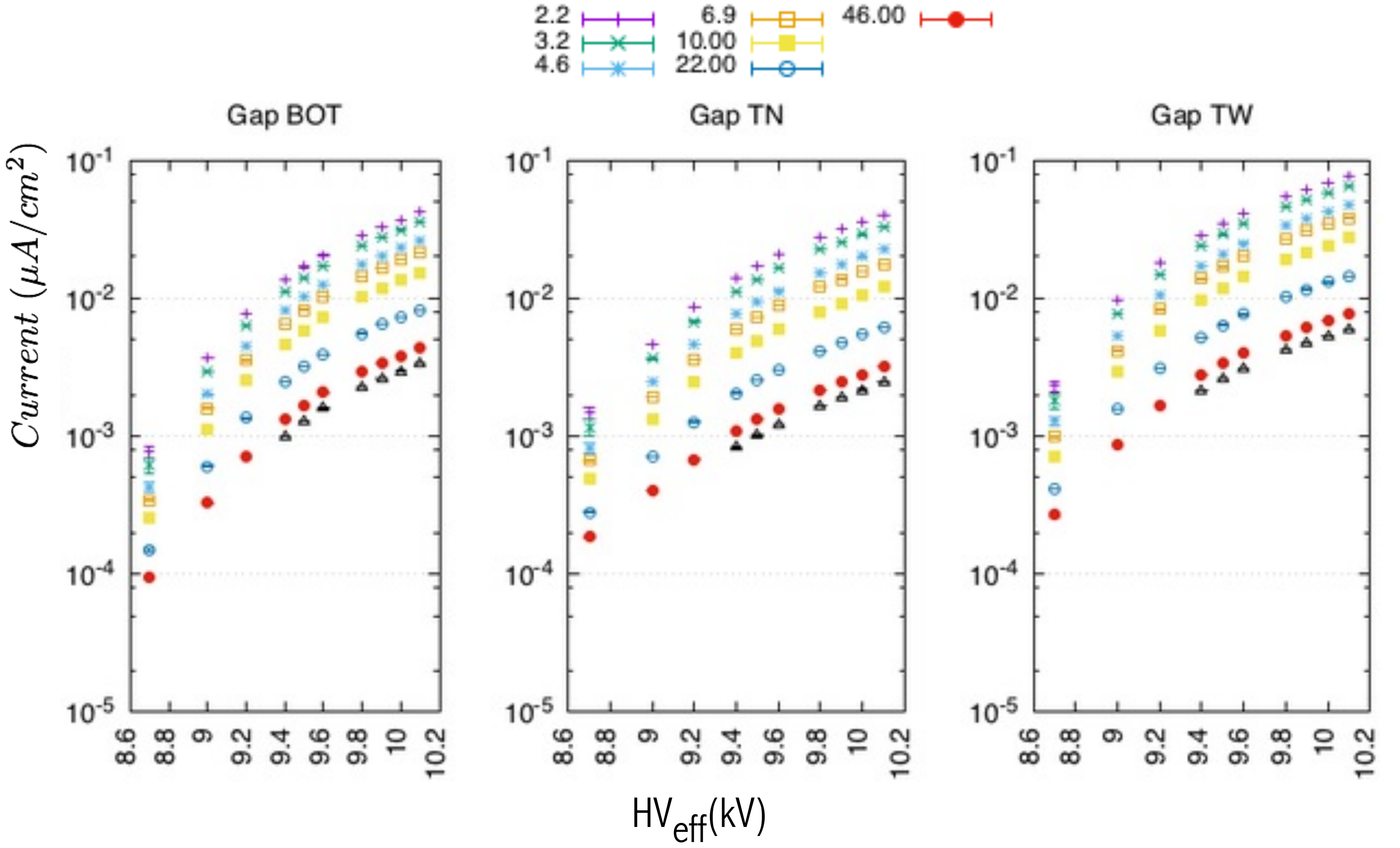
T_{irr} ~ 17 months (with AF=2)

Using GIF++ Overall efficiency of 70%

Current for CMS RPC RE2 (HV)

Trolley-1 (CMS RPC RE2) Current/cm^2 vs HV$_{eff}$(kV) for different attenuators

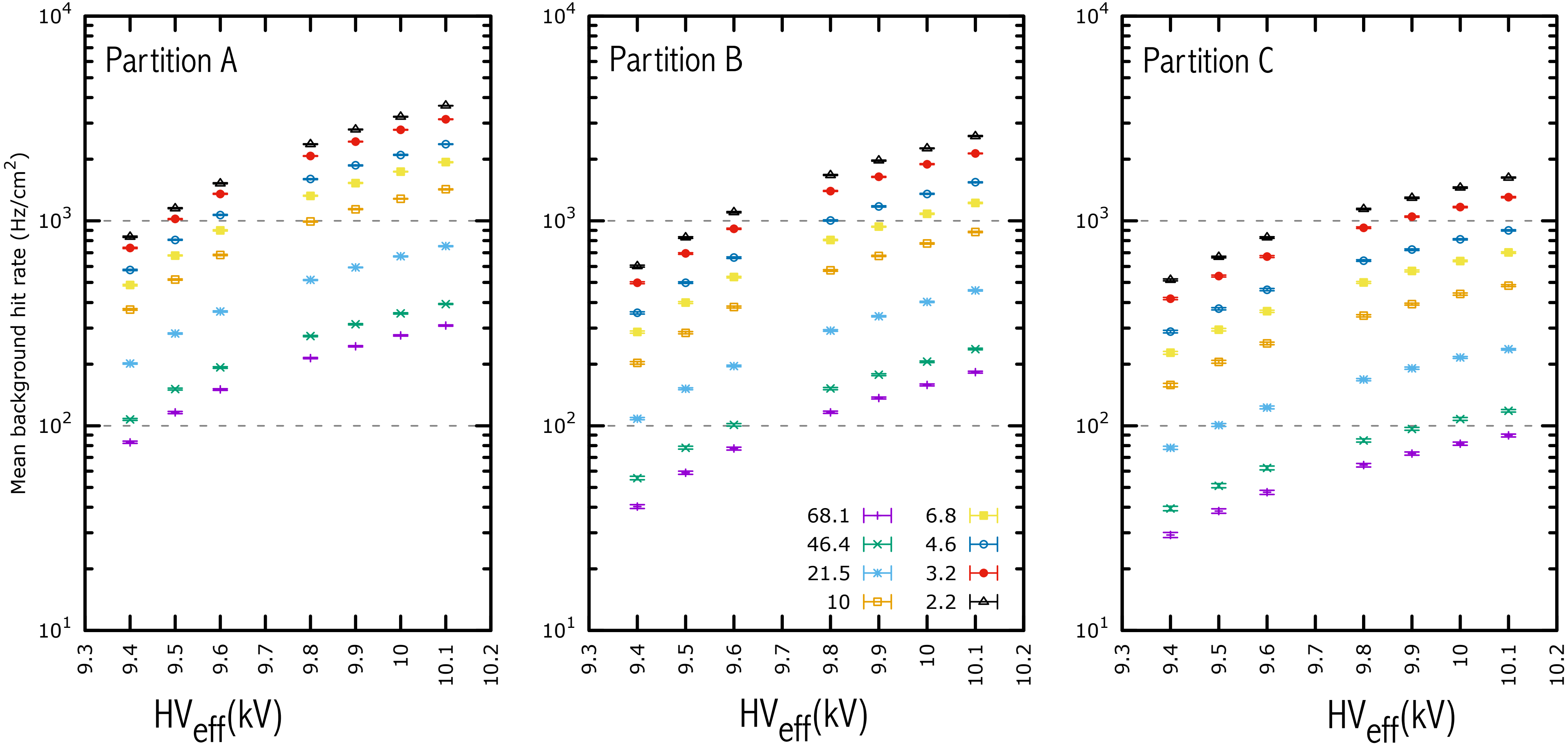
We have an example of the current vs HV$_{eff}$ for different attenuator factors



Rates Measured for CMS RPC RE2

Trolley-1 (CMS RPC RE2) Mean background hit rate during October Test Beam*

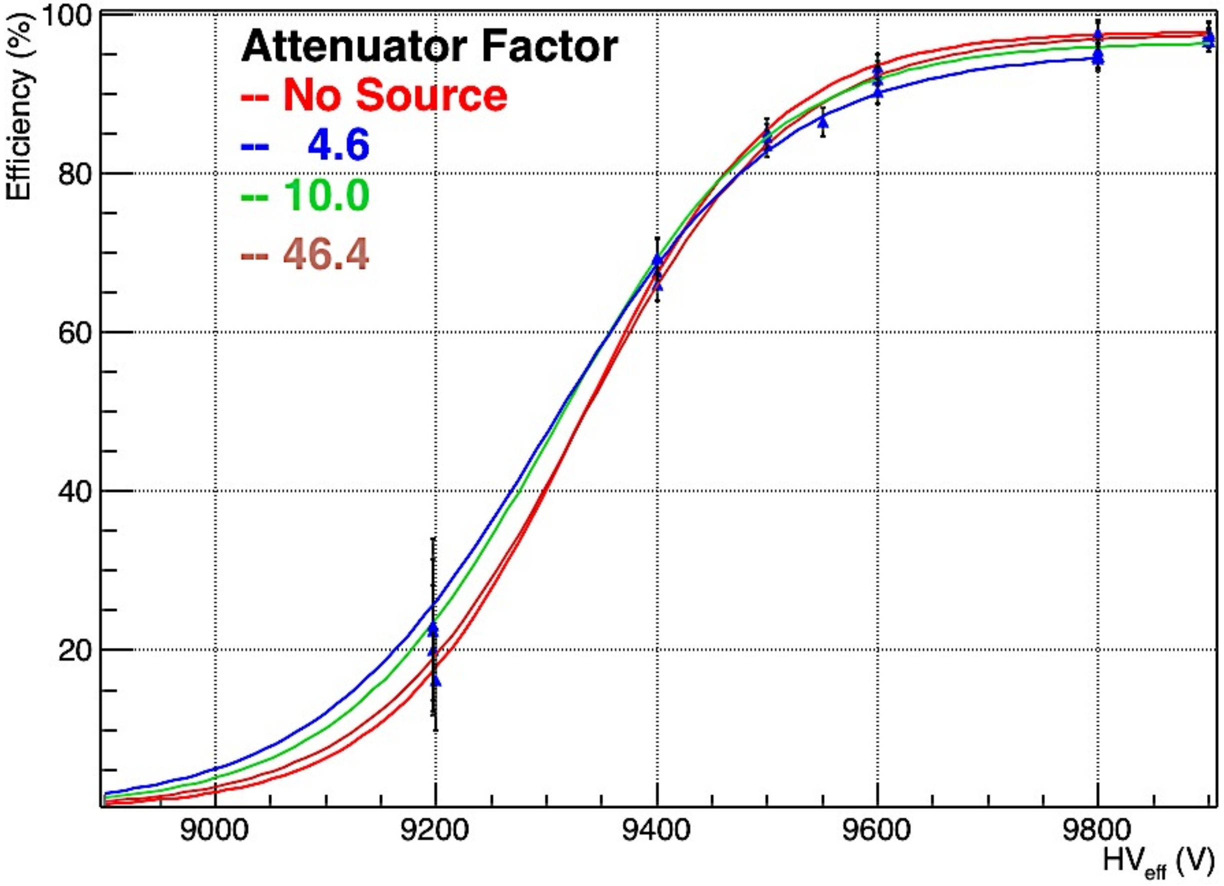
We have an example of the mean background hit rate vs HV_{eff} for different attenuator factors



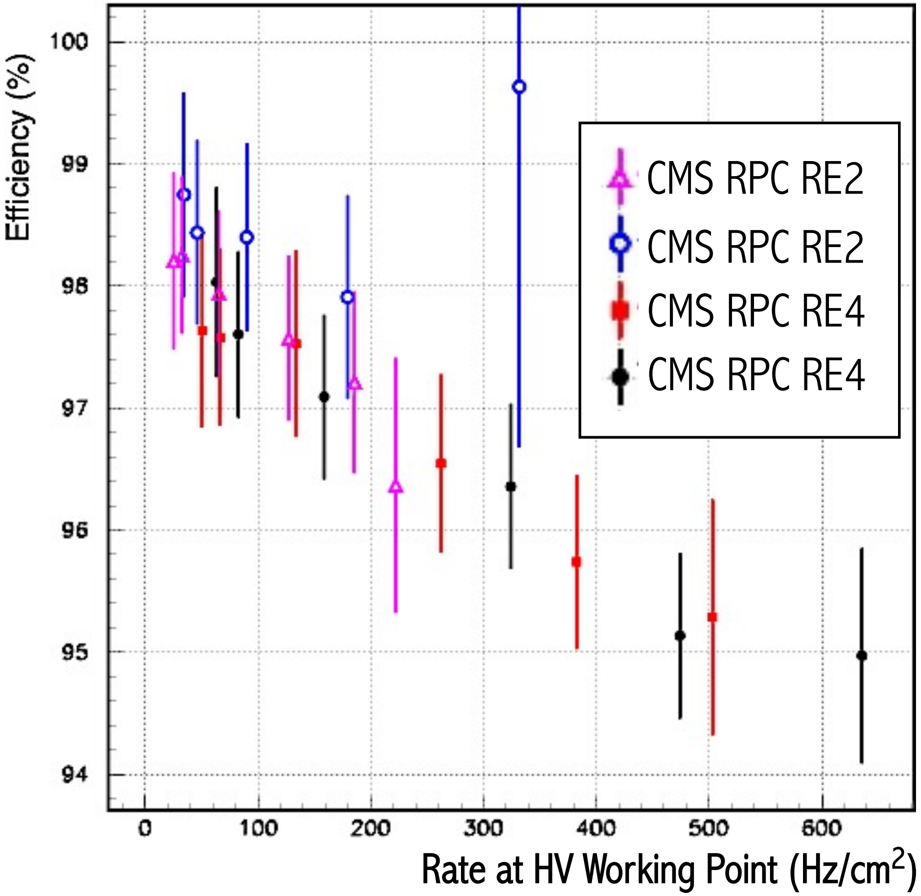
* Yesterday´s talk by Alexis Fagot

Efficiencies for CMS RPC RE2

Trolley-1 (CMS RPC RE2) Efficiencies* during October Test Beam



Example of Attenuator Scan in one RE2 during October Test Beam 2015



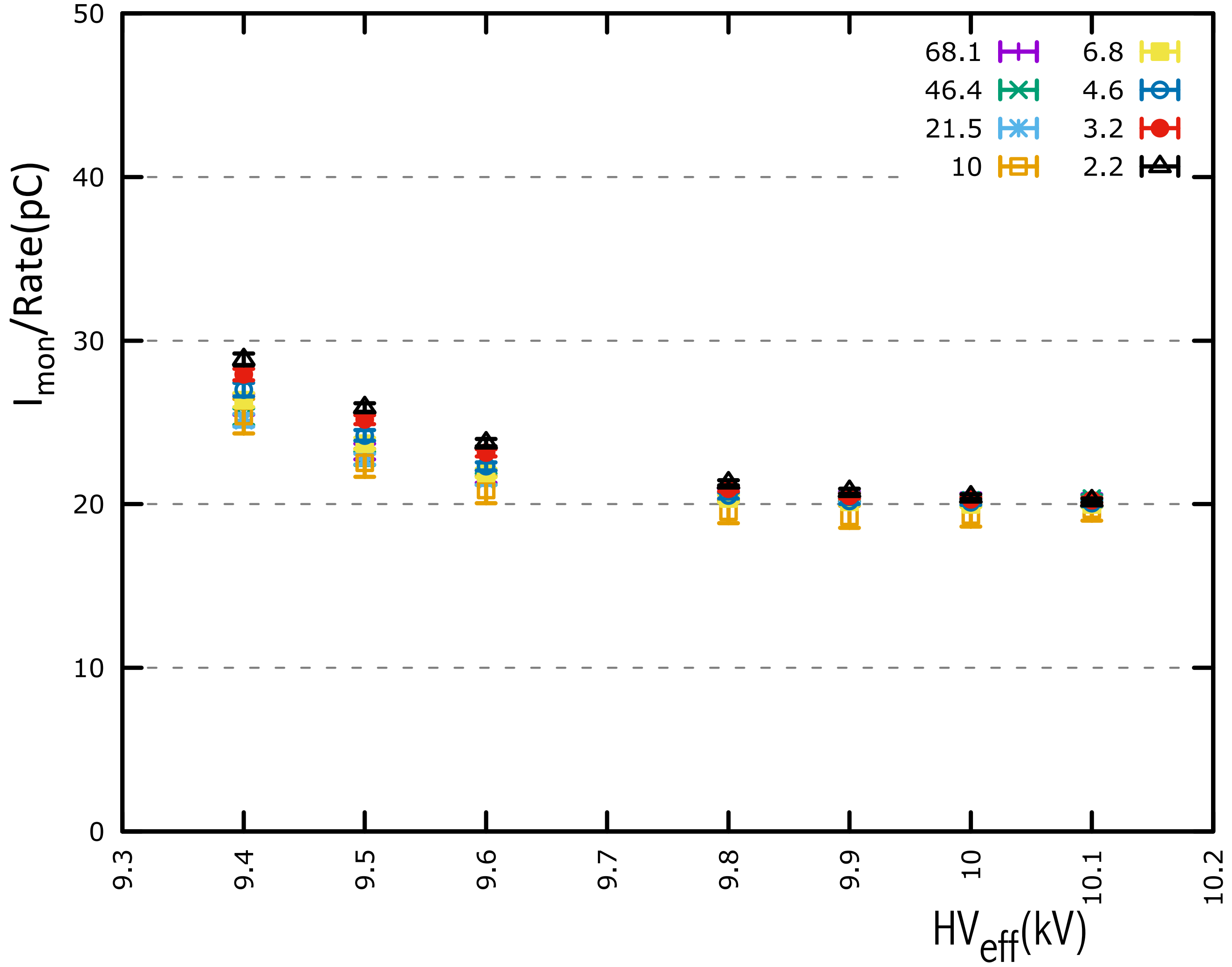
Eff_{max} vs Rate for all RE2 and RE4 aging chambers during October Test Beam 2015

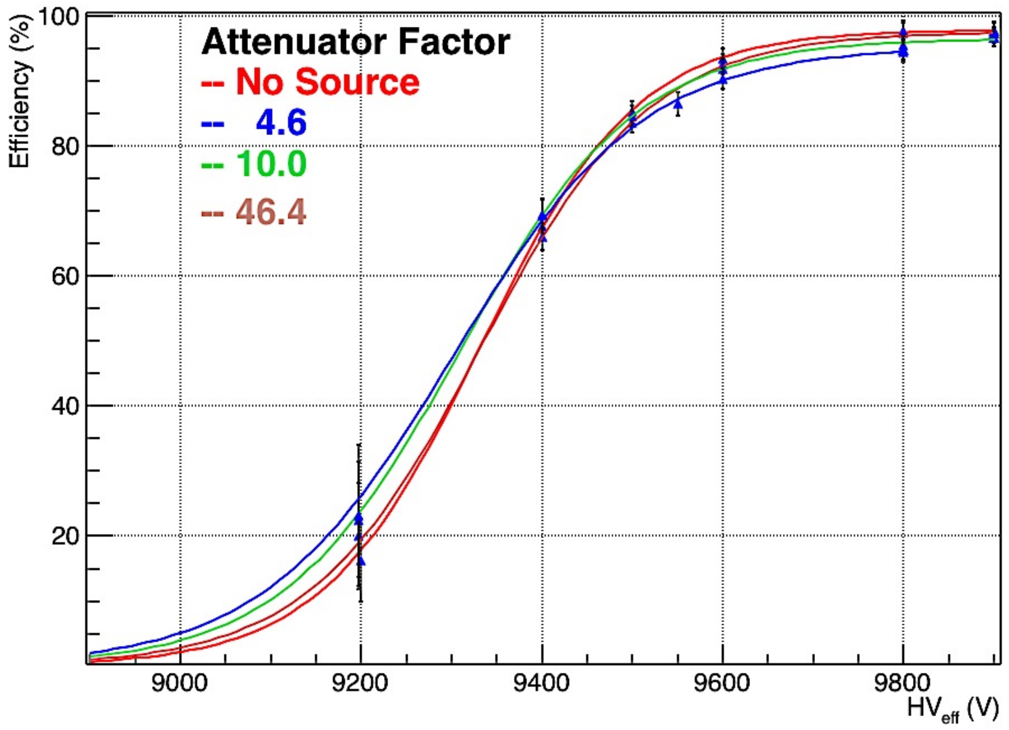
* See posters by Genoveva González about Efficiency studies

Carge Deposition at one CMS RPC RE2

Trolley-1 (CMS RPC RE2) Mean charge deposition per hit during October Test Beam

We have an example of the charge deposition t vs HV_{eff} for different attenuator factors

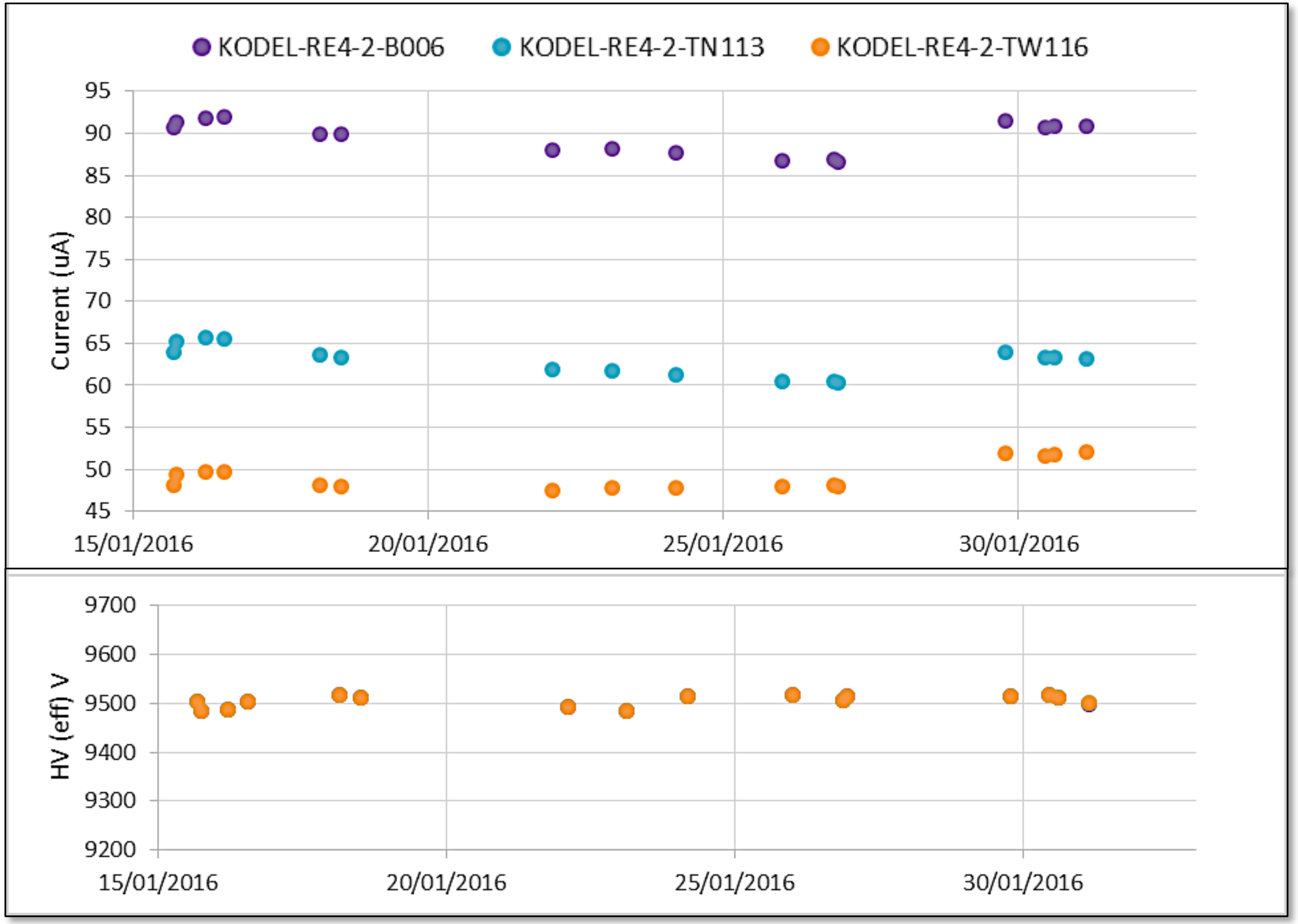




Example of Attenuator Scan in one RE2 during October Test Beam 2015

Aging: Example of Monitoring Tools

Stability of the currents of an old RE4/2 chamber using a Kodel-RE4 spare Gap as reference

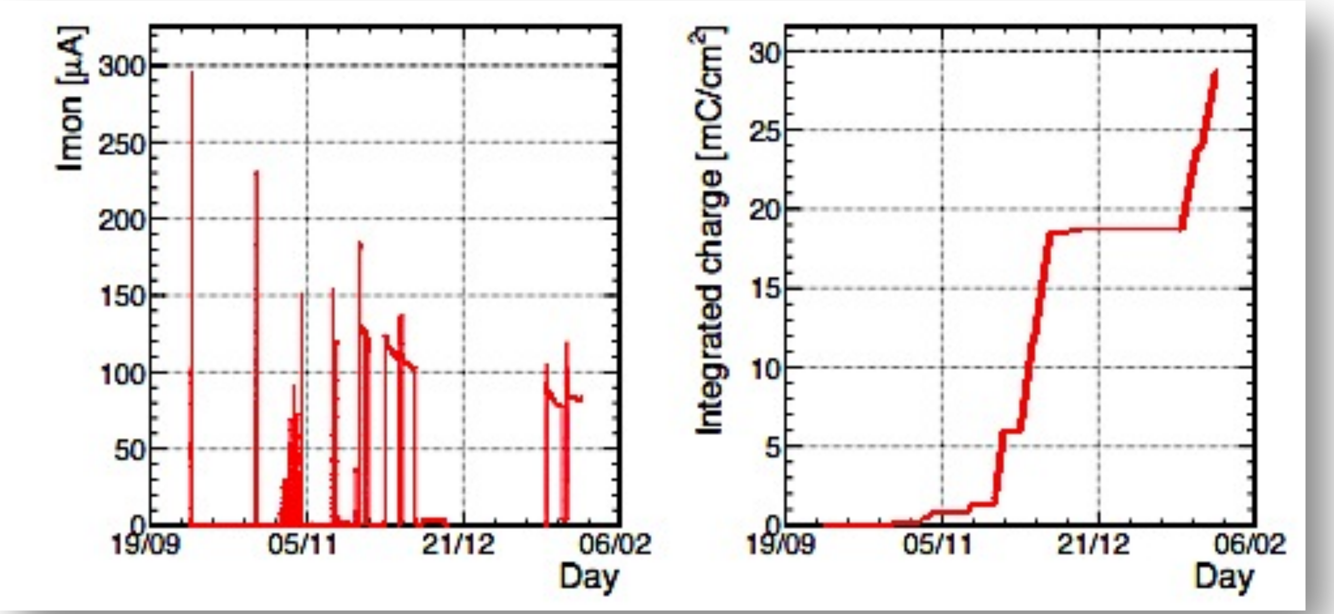


On November 2015, we started the long term irradiation test on an “old spare chamber” in order to validate our protocols.

Example of Calculating Integrated Charged

The integrated charge $Q_{int}(t)$ (in mC/cm^2) is calculated as follows:

- Perform discrete integration of $Q_{int}(t) = \int_{t_o}^{t} I_{mon}(t')dt'$ using the trapezoidal rule
- Neglect points with CAEN HV status $\neq 1$ and Source status $\neq 1$
- Division by the area of the gap (in cm^2)



Results representative gap:

- ✓ Area: 6432 cm^2
- ✓ Monitoring time: 87 days
- ✓ HV status = 1: 52%
- ✓ Source on : 60%

On November 2015, we started the long term irradiation test on an "old spare chamber" in order to validate our protocols.

Conclusions

RPC Consolidation aging test:

- Completed the characterization of the two RE2 and two RE4 CMS RPC chambers.
- Completed the commissioning of all tools needed to control* and monitor the system.
- Started, since November, an aging test on a spare chamber.

We will begin soon the irradiation of two chambers.

The other two will be used as reference (off almost all the time).

iRPC aging test:

- Ready to start the aging test on the iRPC prototypes. The test will begin as soon as we have a prototype in agreement with all CMS requirements.
- Assuming, an AF of 3, plan is to be able to certify for 10 years of HL-LHC the iRPC in about 1.5 years of irradiation time at GIF++.

* See posters by Muhammad Gul about DCS in GIF++

Backup

FEB – radiation tests

Radiation tolerance:

- FEBs have been tested up to a neutron fluence of 10^{12} neutrons/cm^2, corresponding to 3000 fb^{-1} in the region of |eta| < 1.6

- Most of the front-end electronics is analog, so SEUs would just increase the spurious noise rate by a negligible quantity

During the GIF++ irradiation test, the FEB* will stay always on.
Plan to integrate a value of gamma fluence and dose corresponding to 3 time the expected ones.

* The front end Electronics trheshold is set to 220mV and the reference pressure and temperature for high voltage correction are P_o=965 mbar and T_0 = 293.15 K

Aging studies summary

Detector life-time could depend by:

1. The integrated charge
2. The long-term operation of RPCs with a **fluoride-rich** gas
3. The material and component degradation

We will spot aging effects, by recording

1. **Current and rate (twice per week) at fixed working point in presence of background.**
2. **Detector performance** (efficiency, cluster size..): plan to test the chambers with muon beam (when possible, about once every 2 months). **First characterization done in Oct. 15.**
3. Bulk **resistivity: plan to do every 2 months** (with Argon).
4. Intrinsic noise and bulk dark current: plan to measure I vs HV and rate vs HV with source closed **(once per week).**
5. Gas leak and pollution: plan to measure the leak and HF production once per **2 months**

The behavior of the irradiated chambers will be compared with a non irradiated one.

Efficiency Sigmoid Fit

The fitted efficiency $\langle\epsilon\rangle$ curve is given by a sigmoidal function of HV_{eff} using the following parameters

- ϵ_{max} : asymptotic efficiency,
- $HV_{50\%}$: $\frac{\epsilon_{max}}{2}$ inflection point,
- $\lambda \propto$ slope at inflection point.

$$\langle\epsilon\rangle = \frac{\epsilon_{max}}{1+e^{-\lambda(HV_{eff}-HV_{50\%})}}$$

Adjusting those parameters, the working point of the chamber is

$$HV_{WP} = HV_{knee} + 150 \text{ V}$$

HV_{knee} : HV_{eff} value at $\langle\epsilon\rangle = 0.95 \cdot \epsilon_{max}$