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# Investigation of the Hardware Functions of the URAGAN Muon Hodoscope Using Mathematical Modeling


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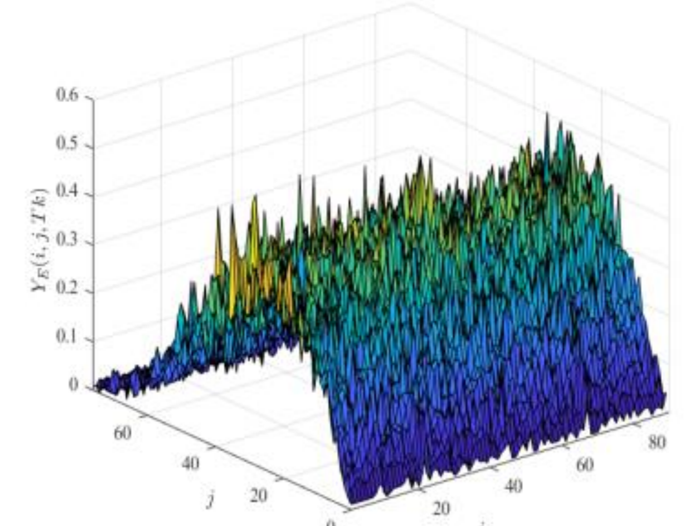
## URAGAN muon hodoscope (MH) observations and hardware function (HF) for MH



Example of 3D MH-observations

MH-observations $Y(i,j,Tk), i = 1,\dots,N_1, j = 1,\dots,N_2, k = 1,2,\dots$

Input MH-function $Y_0(i,j,Tk)$

$Y(i,j,Tk) = A(i,j)Y_0(i,j,Tk)$, $A(i,j)$ – hardware function (HF)

$Y^\circ(i,j,Tk) = \frac{Y_0^\circ(i,j,Tk)}{A^\circ(i,j)}$, $Y_0^\circ(i,j,Tk) \Rightarrow ?$, $A^\circ(i,j) \Rightarrow ?$

## Problem definition for HF study of MH URAGAN

HF $\Rightarrow a_{0,ij}$, input MH-function hypothesis $\Rightarrow c_0 + \delta Y_0(i,j,Tk), Y_0(i,j,Tk), k = 1,2,\dots,k_f$

$S_0(a,c_0,Y) = \sum_{k=1}^{k_{f_1}} \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} (Y(i,j,Tk) - a_{0,ij}c_0)^2, a_{0,ij}c_0 = a_{ij}, S_0(a,Y) = \sum_{k=1}^{k_{f_1}} \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} (Y(i,j,Tk) - a_{ij})^2 \Rightarrow a_{N,ij}^\circ$

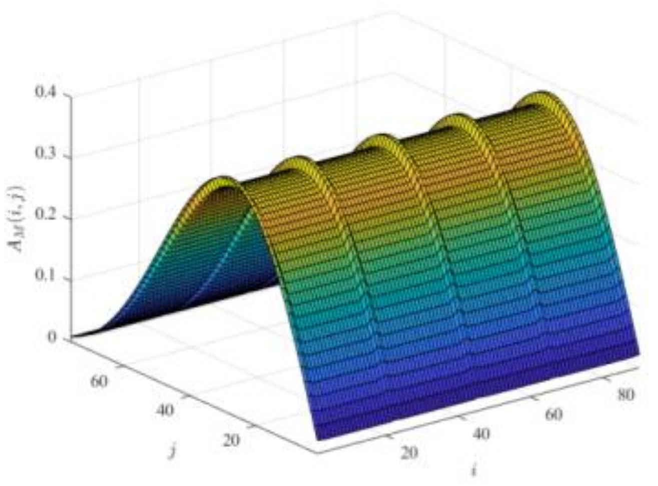
$A_N^\circ(i,j)$ – normalized HF evaluation, $\frac{\partial S_0(a,Y)}{\partial a_{ij}} = 0 \Rightarrow a_{N,ij}^\circ = \frac{1}{k_f}\sum_{k=1}^{k_f} Y(i,j,Tk)$

$\delta Y_N^\circ(i,j,Tk) = \frac{Y(i,j,Tk) - A_N^\circ(i,j)}{A_N^\circ(i,j)}$ – evaluation of normalized input MH-function variation

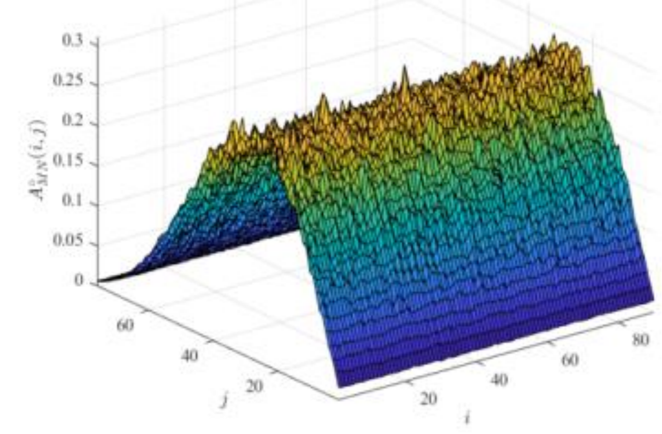
$\mu(i,j) = 1 - \delta\mu$ – model Forbush decrease, $\delta Y_N^\circ(i,j,Tk,\delta\mu)$ – variation with decrease

$A_M(i,j,\alpha)$ – parametric HF model, $Y_M(i,j,Tk,\delta\mu) = A_M(i,j)Y_0(i,j,Tk)\mu(i,j)$ – model observations

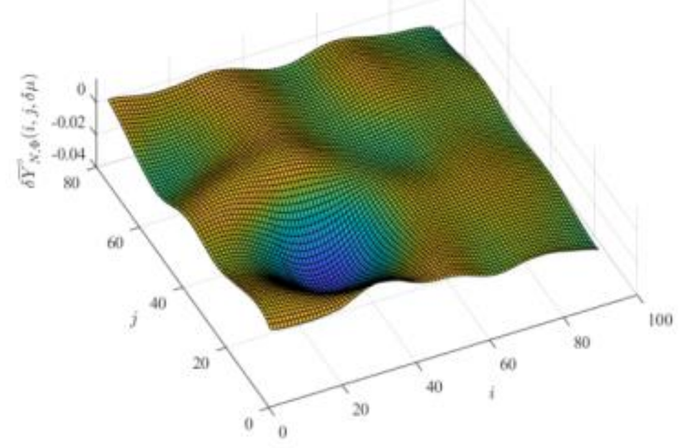
## HF study on model MH observations



3D HF-model $A_M(i,j,\alpha)$



3D-evaluation of normalized model HF $A_{M,N}^\circ(i,j)$



3D-evaluation of $\delta Y_N^\circ(i,j,Tk,\delta\mu)$ with model Forbush decrease $\delta\mu = 0.03$

## HF study on experimental MH observations

Recognition coefficient

$$\varepsilon(r,s) = 1, m_0^\circ - \sigma_0^\circ > m_{r,s}^\circ + \sigma_{r,s}^\circ$$

$$\varepsilon(r,s) = \frac{(m_{r,s}^\circ + \sigma_{r,s}^\circ) - (m_0^\circ - \sigma_0^\circ)}{(m_0^\circ + \sigma_0^\circ) - (m_{r,s}^\circ + \sigma_{r,s}^\circ)}, m_0^\circ - \sigma_0^\circ \le m_{r,s}^\circ + \sigma_{r,s}^\circ$$

$$\varepsilon(r) = \frac{1}{M}\sum_{s=1}^{M} \varepsilon(r,s)$$

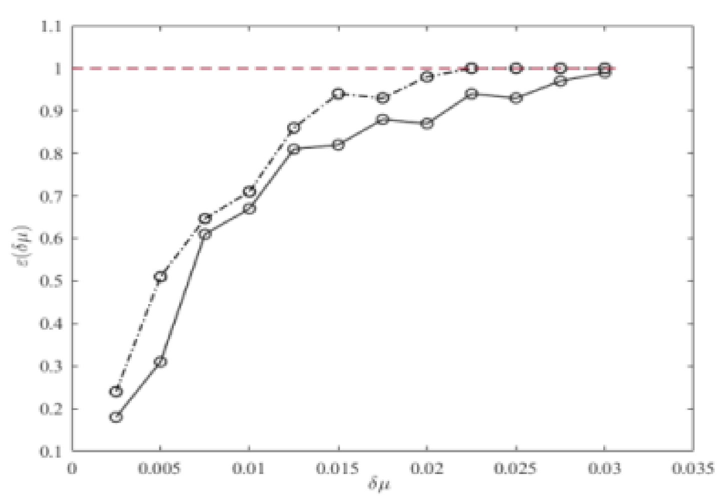
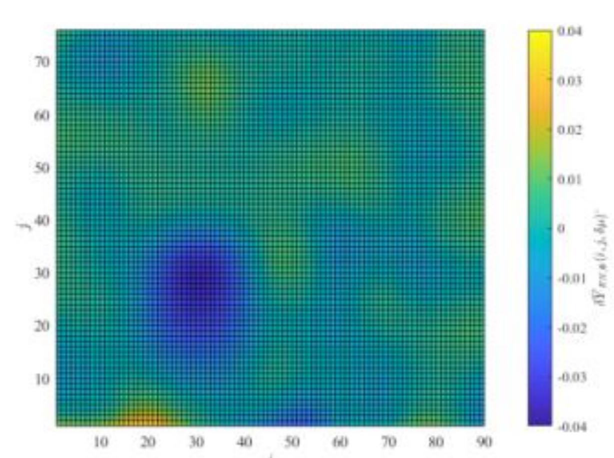


Diagram $\varepsilon(r), \varepsilon_0 = 0.9$

$\delta\mu_r = 0.0025r, r = 1,\dots,12$

$\delta\mu = 0.02 \div 0.03$



2D-evaluation of experimental $\delta Y_N^\circ(i,j,Tk,\delta\mu)$ with model Forbush decrease $\delta\mu = 0.03$

## Acknowledgements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