BPMOK MODEL APPLIED FOR THE BPM OPTIMIZATION FOR THE 100 MeV HEBT FOR THE MYRRHA PROJECT

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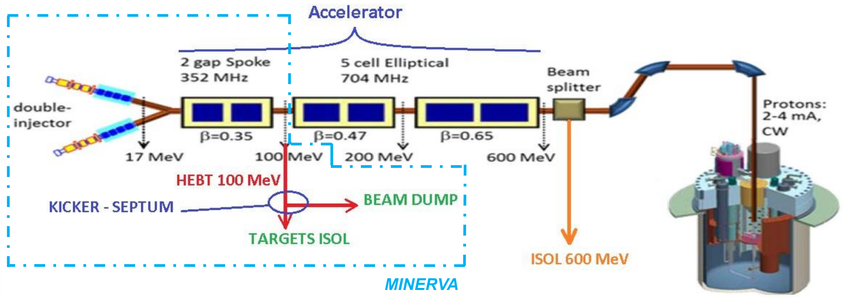
Origins of the project : MYRRHA (Multi purpose Hybrid Research reactor for High tech Applications) 600 MeV, a sub-critical nuclear reactor controlled by a LINAC [1]

Greate reliability of the whole accelerator LINAC-type :

- Avoid thermal stress in the reactor. Additional time to restart the reactor could need 3 days.
- The MYRRHA goal for the limit of acceptable stops (>3 s) of 40 trips/year.
- Transmutation of the Long-life isotopes in nuclear waste and producing Electricity with it.
- Radioisotope production for medical purpose in Europe.

Phase 1 (MINERVA [2]), 100 MeV-proton MYRRHA demonstrator to evaluate its reliability:

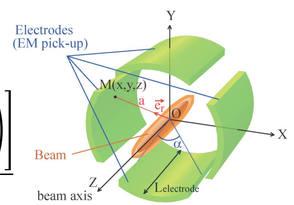
- Beam : I_{beam} = 4 mA, E= 100 MeV, Q=1, F_{acc} = 176 MHz (bunch repetition)



- HEBT beam dynamics has been calculated with TraceWin [3,7,9]

The model BPMOK [7] for BPM optimizations

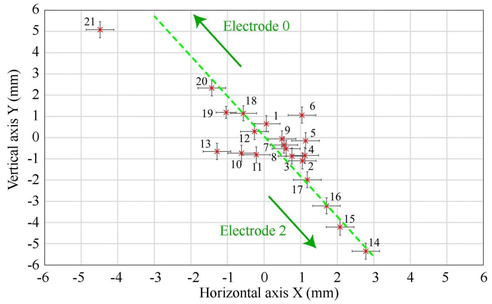
$$\begin{cases} E_r(M) = \dfrac{yqe}{4\pi\varepsilon_0}\sum_k \iiint f_k \dfrac{x(x-x_0)+y(y-y_0)}{a}\,dx_p dy_p dz_p \\ f_k = \dfrac{N\,(2\pi)^{-3/2}}{\sigma_x\sigma_y\sigma_z}\dfrac{\exp\left[-\frac{1}{2}\left(\left(\frac{x_p-x_0}{\sigma_x}\right)^2+\left(\frac{y_p-y_0}{\sigma_y}\right)^2+\left(\frac{z_p-z_0}{\sigma_z}\right)^2\right)\right]}{\left[(x-x_p)^2+(y-y_p)^2+(\gamma z-z_p+k\gamma L_{acc})^2\right]^{3/2}} \end{cases}$$



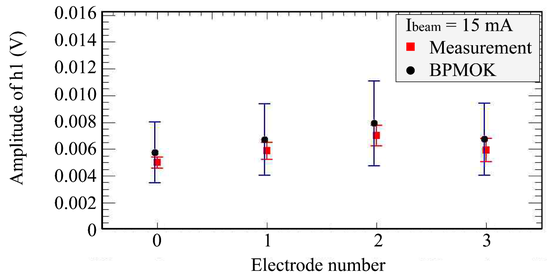
f_k represents the contribution of the E-Field particles inside a Gaussian beam (σ_x, σ_y, σ_z). (x_p , y_p , z_p) are the particles coordinates. (x_0 , y_0 , z_0) are the bunch center coordinates. γ is the Lorentz factor. L_{acc} is length between 2 bunches in the beam axis. k∈ $[-N_{bunch}; N_{bunch}]$ is the bunch position in the train of ($2N_{bunch}$+1) bunches. N is the number of particles in the bunch. a is the radius of the BPM.

- Evaluates the Electric field induced by the particles beam on the electrodes surfaces at the point *M(x, y, z)*.
- Calculates the number of induced image charges on the electrodes : $\vec{E}.\vec{e_r} = \sigma/\varepsilon_0$
  $Q_{im}(t) =< E_r > (t)\ \varepsilon_0\ L_{electrode}\ a\ \alpha$ ➔ $U(t) \propto I(t) = dQ_{im}(t)/dt$
  ➔ $\tilde{U}(\omega) = DFT[U(t)]$ ➔ harmonics : $h1 = \tilde{U}(F_{acc})$ $h2 = \tilde{U}(2F_{acc})$ . . .
- Aims to consider all beam cases and to reduce usual hypothesis [4,5] .
- Allows to realize fast parametric studies of the button type BPM.

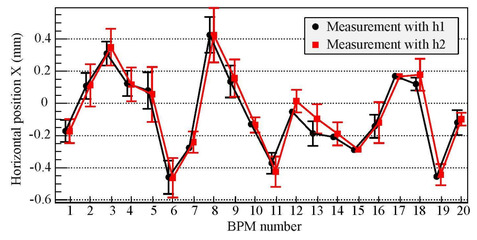
Experimental measurements at IPHI [8] and SPIRAL2 [10] facilities : validation of BPMOK [7]



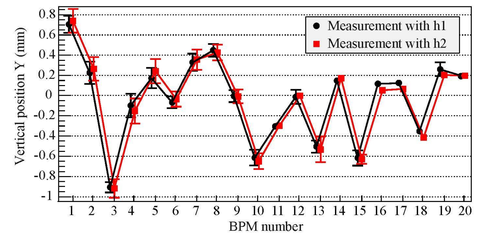
Beam positions of the IPHI measurements



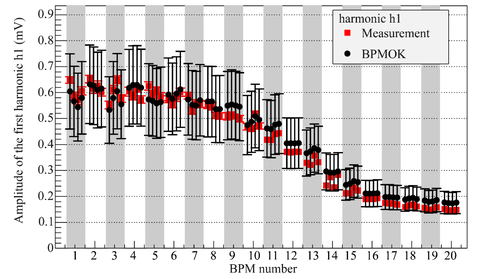
h1 of the 4 electrodes BPMOK vs Measurements for the BPM at IPHI

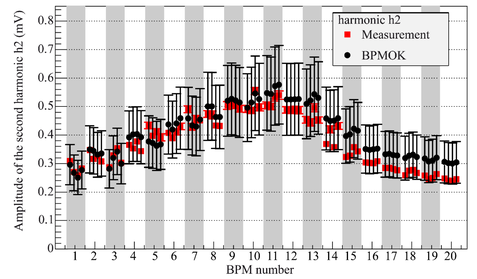


Horizontal beam positions measured by the 20 BPM of the LINAC of SPIRAL 2



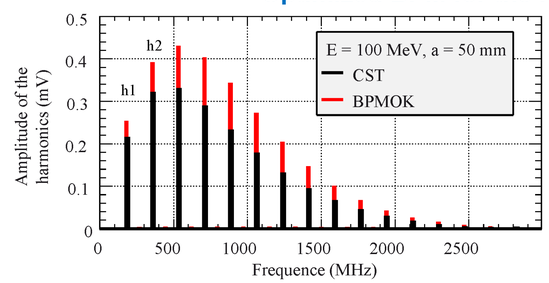
Vertical beam positions measured by the 20 BPM of the LINAC of SPIRAL 2





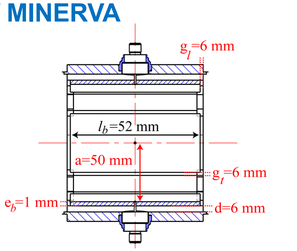
h1 & h2 results from measurement VS BPMOK for the 20 BPM of the SPIRAL2 LINAC with the centered beam

Optimized BPM for the HEBT of MINERVA

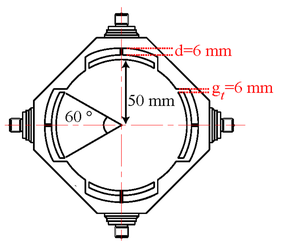


BPMOK vs CST [6] Wakefield solver simulation

- **Use the same acquisition electronics as the BPM built for the MINERVA LINAC [11,12], for input power from -47 dBm up to +9 dBm.**
- **Possibility to measure the beam ellipticity.**
- **Further studies with BPMOK will evaluate the possibility to measure the bunch length using the ratio h1/h2 [7].**



Longitudinal cut view of the BPM's scheme



Transversal cut view of the BPM's scheme

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