BEAM DYNAMICS AND DIAGNOSTICS FOR THE HIGH ENERGY BEAM TRANSPORT LINE OF MINERVA PROJECT AT SCK-CEN

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IPAC19

Origins of the project : MYRRHA 600 MeV, a sub-critical nuclear reactor driven by an ADS [1]

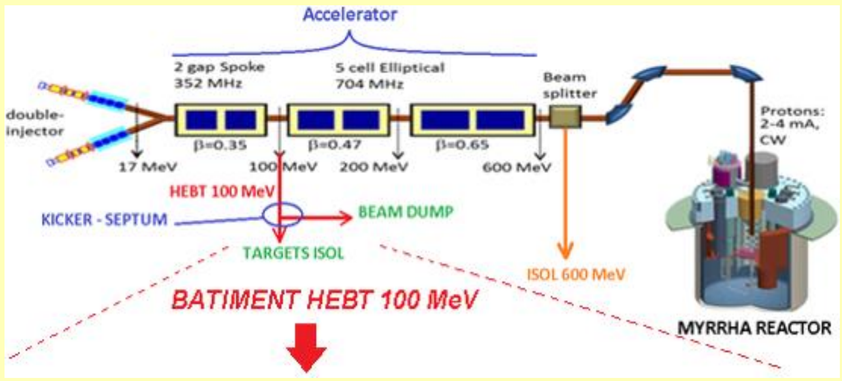
Greate reliability of the whole accelerator LINAC-type , less breakdown as possible in order to:

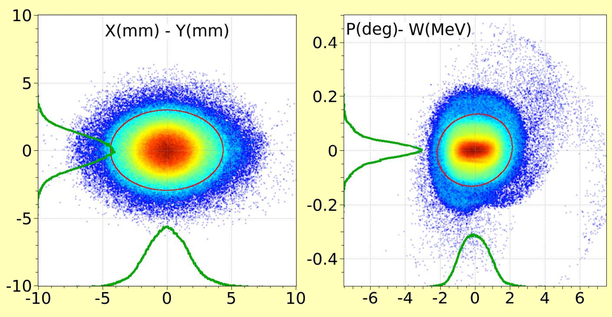
- Avoid thermal stress in the reactor, additional time to restart the reactor which needs 3 days.
- Reduce the Long-life isotopes in nuclear waste, study nuclear transmutation and produce medical isotopes.
- Achieve the MYRRHA goal for the limit of acceptable stops of 40 trips/year

Need to build a 100 MeV-proton MYRRHA demonstrator to evaluate its reliability: The MINERVA project [2]

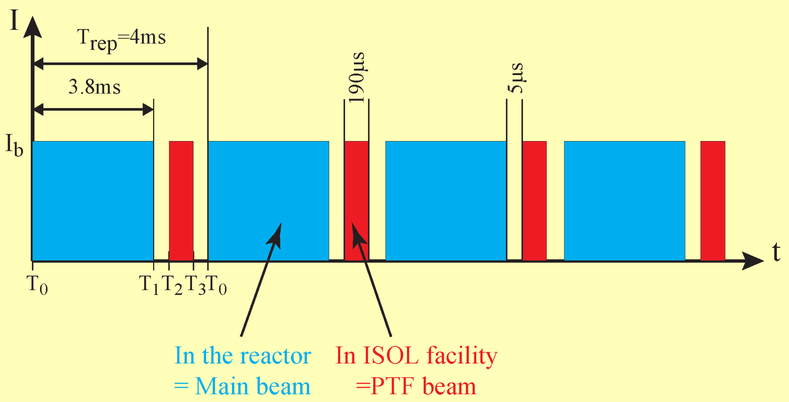
Beam characteristics of the 100 MeV demonstrator:

- E = 100 MeV
- I_{beam} = 4 mA
- 176 MHz repetition rate
- Pulse repetition at 250 Hz
- RMS normalized transverse emittance up to 0,245 π.mm.mrad

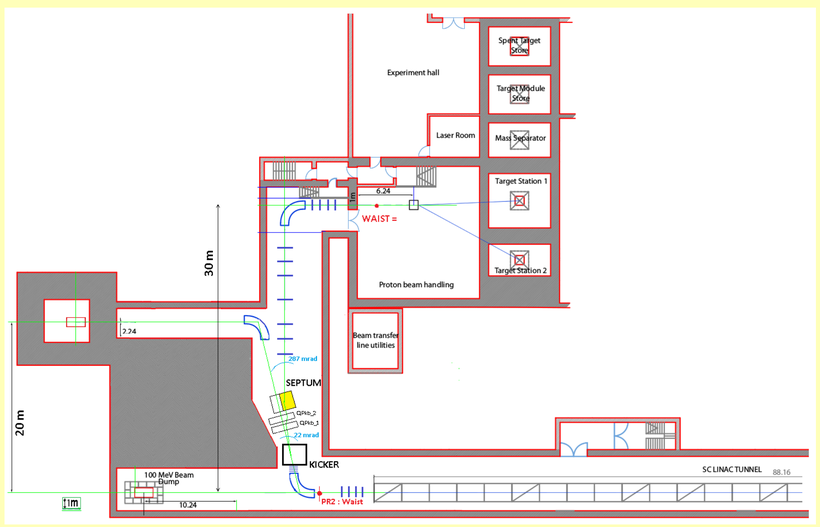




Output LINAC - Input HEBT Beam caracteristics

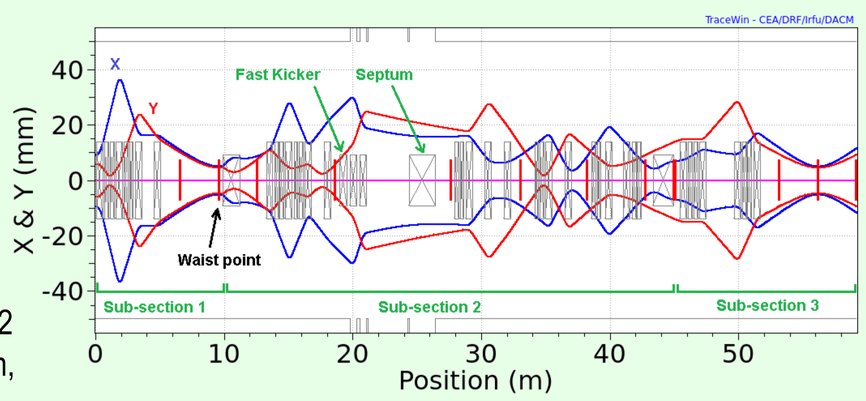


Beam Time Structure requirements for MINERVA in nominal operating mode

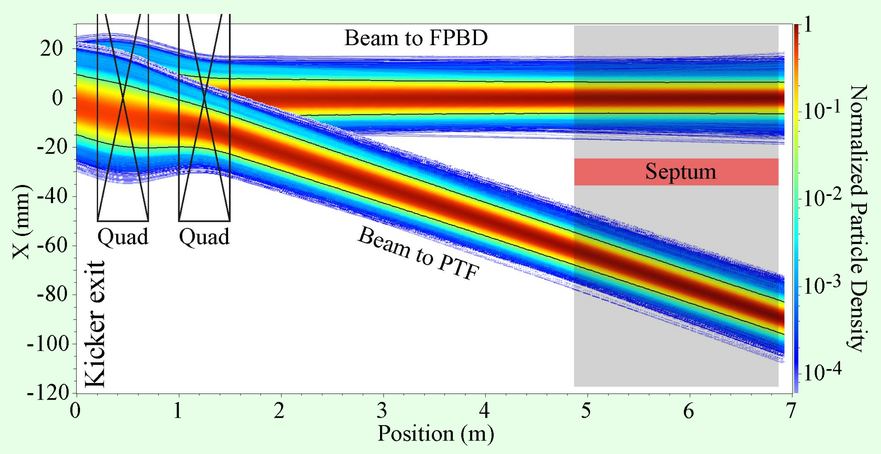


Beam dynamic for the 100 MeV HEBT

- Kicker – Septum [6] [7] [8]
  - Fast switching magnet (kicker) with a separator magnet (septum). Magnetic design specifications.
  - Beam extraction to the PTF line for ISOL [3].
- Beam dynamic simulations with TRACEWIN [5]
  - Beam dynamic with the kicker-septum module. 2 quadrupoles between the kicker and the septum, keeping a focusing effect.
  - Keep beam requirements in the line. Preventing errors on the beam and magnetic elements. Looking for a strong dynamic from unstabilities.



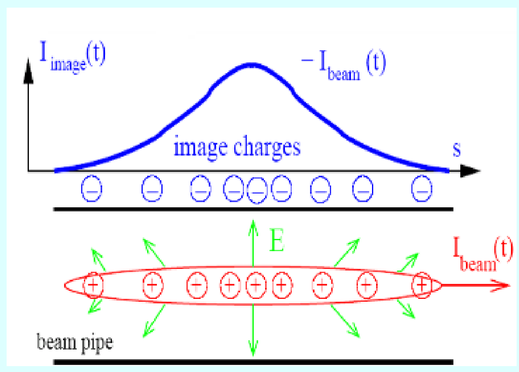
6 RMS beam envelopes along the PTF line from the LINAC exit



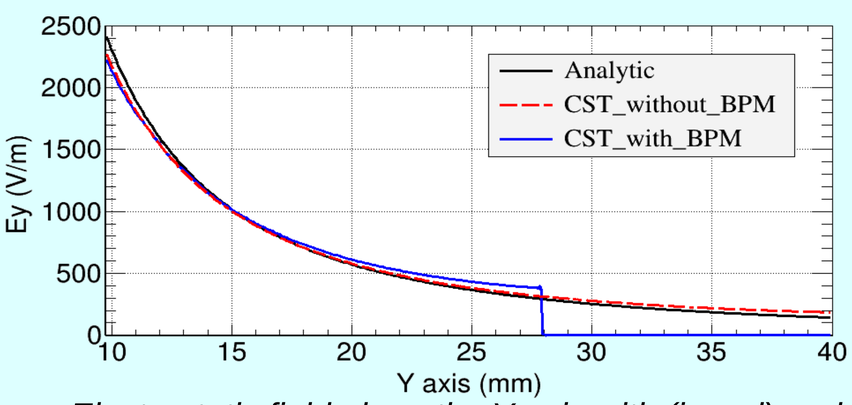
Horizontal beam density from the exit of the kicker up to the septum

Beam Diagnostic - Beam Position Monitor (BPM)

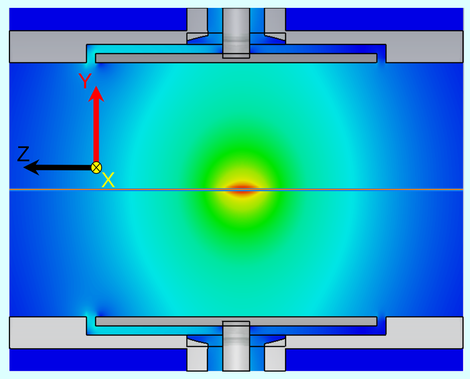
- BPM Button type principle [9]
  - E-field emitted from the proton bunch, inducing charges.
  - 4 electrodes, 2 for each transverse axis.
  - Transverse displacement => difference signal between the opposite plates.
  - Signal digitalized in a bandwidth defined by the acquisition chain.
- BPM studies for MINERVA
  - Calculations with CST Studio [10], Wakefield Solver.
  - Proton beam simulation through a BPM geometry selected for MYRRHA.
  - Study of E-field propagation and dependencies with beam characteristic and BPM geometry.
  - Aim: Parametric study on V_{out} depending with beam characteristics and BPM geometry.
  - The frequency components depends on the beam bunch's length beyond 500 MHz.
  - Along HEBT, σ_z bunch length from 1.85 mm up to 20 mm at the PTF. Using same BPM and calibration along the line, this results leads to focus the BPM measurements on frequencies below 500 MHz.



Scheme of induced charges on a metal plate by the charged beam

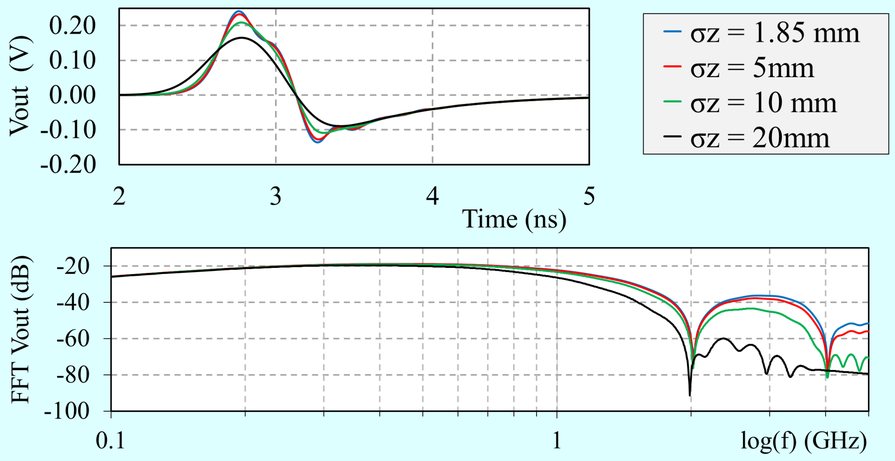


Electrostatic field along the Y axis with (in red) and without BPM (in green), and from analytic (in blue)



MYRRHA's BPM transversal cut in electrostatic field results of CST

Output voltage from an electrode of the MYRRHA's BPM, for a centred 100-MeV/4mA proton beam.



FFT of V_{out} in dB, showing frequency components

Perspectives:

- Due to future building modifications, HEBT beam optic has to be updated .
- Calculations on the simulated MYRRHA BPM has been achieved. Measurement on real beam (IPHI, SP2) to compare with the simulation results.

References:
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[2] MINERVA in MYRRHA Phase 1, MYRTE WP2, CERN, Switzerland, October 2018.
[3] H.R. Ravn and B.W. Allardyce, "On-Line Mass Separators", in Treatise on Heavy-Ion Science, Edt. D. A. Bromley, Plenum Press, New York, ISBN 0-306-42949-7, 1989
[4] https://cordis.europa.eu/project/rcn/196919/factsheet/en
[5] http://irfu.cea.fr/dacm/logiciels/index.php
[6] J. Borburgh and M. Crescenti, "Final Design, Special Magnets", CERN AB Division, Geneva, July 2003.
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[8] J. Borburgh, B. Balhan and M. Barnes, "Design and development of kickers and septa for medaustron", IPAC10 THPEB032, Japan, May 2010.
[9] Peter Forck, "Beam Position Monitor", GSI, CAS, Darmstadt, Germany, May 2008.
[10] https://www.cst.com/
[11] P-Y. Beauvais, "Status report on the saclay high-intensity proton injector project (IPHI)", EPAC, Austria, 2000.
[12] M.-G. Saint Laurent et al., SPIRAL PHASE-II, European RTT, Final report, ERBFMGECT980100, September 2001.