Science & Technology Facilities Council
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BASROC CONFORM

Preparations for EMMA Commissioning

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THPD028

ABSTRACT

The preparations for commissioning EMMA - the Electron Model of Many Applications - are summarised in this paper.

EMMA is a 10 to 20 MeV electron ring designed to test our understanding of beam dynamics in a relativistic linear non-scaling fixed field alternating gradient accelerator (FFAG).

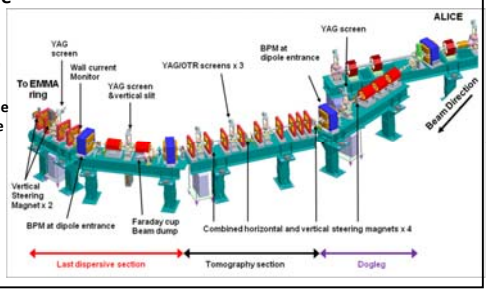
EMMA will be the world's first non-scaling FFAG and this poster reports some of the progress made in preparation for beam commissioning later this year.

EMMA Injection Line

The injector for EMMA, is an existing machine, Accelerators and Lasers In Combined Experiments (ALICE).

ALICE will deliver single bunches of charge 16 to 32 pC and energy 10 to 20 MeV at a rate of 1 to 20 Hz.

The EMMA injection line ends with a 70° septum for injection into the EMMA ring itself followed by two kickers to direct the beam onto the correct, energy dependent, trajectory.



Also see MOPEC046, Modelling of the EMMA NS-FFAG Injection Line using GPT, THPD030, Characterisation and Optimisation of the ALICE Accelerator as an Injector for the EMMA NS-FFAG and THPD029, Setting the Beam onto the Reference Orbit in Non-Scaling FFAG Accelerators.

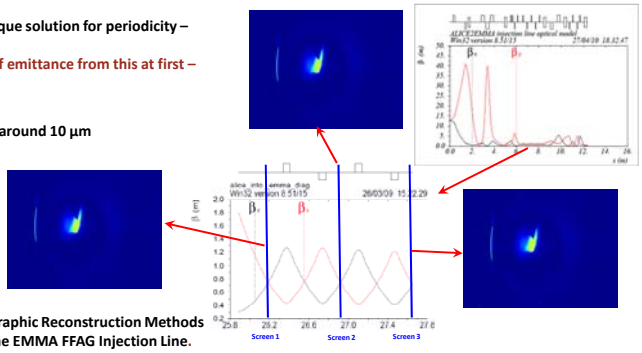
Tomography

All three screens set up identically (D = 0).
→ Twiss parameters fully determined (unique solution for periodicity – maybe not quite 60°)
Can derive very approximate knowledge of emittance from this at first – should be improved later

15 MeV & 40 pC
ε_N not measured in injector but should be around 10 µm

Images are:
- Very noisy
- Not Gaussian
- Saturated (→ full width ≈ 4σ)

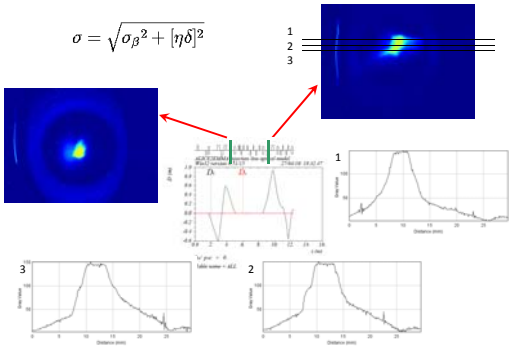
Rough estimate based on the above gives ε_N ~ 40 µm in both planes



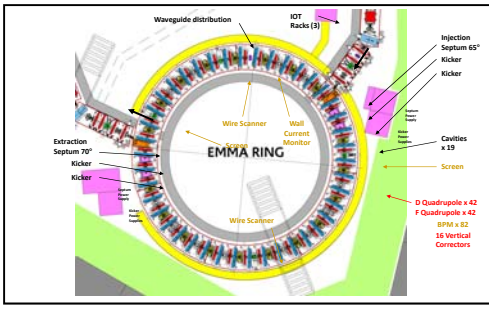
Also see THPD031 Development of Tomographic Reconstruction Methods for Studies of Transverse Phase Space in the EMMA FFAG Injection Line.

Energy Spread Measurements

$$\sigma = \sqrt{\sigma_\beta{}^2 + [\eta\delta]^2}$$



- Assume the two quads before YAG not massively out from nominal ...
- D ≈ 0.7 m
- $\beta_x \leq 2$ m
- Should be able to almost ignore contribution from σ_β
- Energy spread (x) consistently around 105 keV (rms) or less
- Need better set-up
- Need better pictures
- No optimisation done so far with the linac phases
- Results are quite promising and should only get better ... ☺



EPICS Interface

Development of high level software is one of the keys to successful commissioning.

All the hardware and diagnostics are connected to EPICS and virtually no signals are available otherwise.

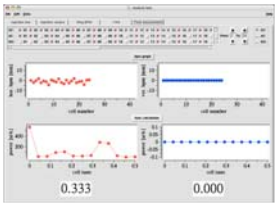
A virtual accelerator has been constructed in parallel to the real machine.

A sequence of algorithms for the high-level software are being tested using the virtual accelerator.

This example reads BPM signals of the first 24 cells in order to calculate the cell tune.

Also see THPD024 Recent Developments On The EMMA On-line Commissioning Software.

The same software will be used for the real machine just by changing the prefix of process variables.



RF Systems Commissioning

19 identical normal conducting copper cavities in the EMMA ring.
1.6 ms pulse of RF at between 1.2960 and 1.3015 GHz at 1 to 20 Hz.

The RF sub-systems on EMMA are presently being installed and commissioned.

Unique RF waveguide distribution system to divide and cascade the RF power clockwise and anti-clockwise around the ring. Low-power acceptance test completed.

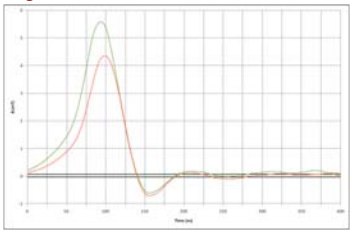
Single high-power RF amplifier with a 90 kW IOT supplied and installed by CPI. Acceptance tests successful.

The amplitude and phase control of the RF system, along with the synchronization to the 1.3 GHz RF system of ALICE, its injector is provided a LLRF system that has been delivered and installed, with commissioning tests planned for June 2010.

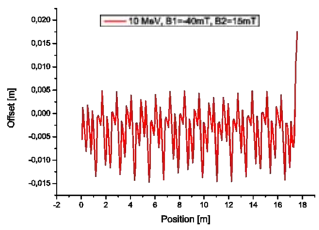
Also see THPEB056, Commissioning of the RF System for EMMA at Daresbury Laboratory and TUPEA058, The EMMA LLRF System and its Synchronization with ALICE.

Kicker Ringing

Both injection and extraction systems consist of a septum magnet and two kicker magnets.
During acceleration the beam passes many times through the kicker - it is desirable that there is no injection kicker field present during the successive passes.
The initial injection design:
Single turn injection, orbit period approximately 55 nanoseconds.
Kicker magnetic field of less than one percent after one turn (55 nanoseconds).
This has proved difficult to achieve - it is still about 10% of the peak value after the second pass of the beam through the kicker.



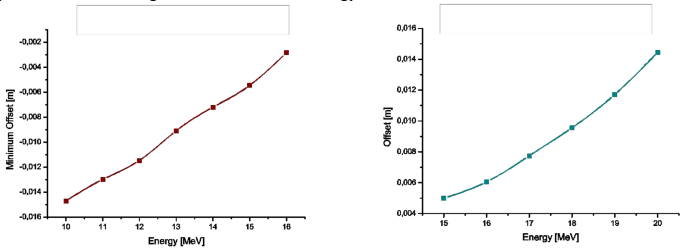
Magnetic field vs. time for two different excitation voltages. ±1% limits shown in black.



Closed orbit of first turn with ringing field in kicker.

One-turn injection simulation is performed directly by tracing backwards the injection orbit of a reference particle from a point on the reference trajectory after the second kicker to the septum magnet.
The worst case simulation is of a 10% ringing field at 10 MeV, at higher energies it gets progressively.

This can be seen by looking at the minimum (left) and the maximum (right) deviations of the trajectory with respect to the EMMA design orbit as a function of energy.



Multi-turn injection in a NS-FFAG accelerator is also possible.
Initially inject on to an orbit close to the equilibrium one, such that the residual kicker magnetic places the particles on the true equilibrium orbit during the second turn.
The only restriction of this scheme is the requirement that the trajectory excursion should remain well inside the physical aperture of the machine.

The modelling of the two-turn injection involves two passes of the beam through the kicker fields. During the first pass they are set to their peak value and are fired at the correct time, while during the second pass their amplitude is reduced to 10% of their peak and the polarity is reversed.

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COLLABORATION

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