DORIS Energy Topics

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Olympus Collaboration Meeting
DESY, February 17th 2012

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Some basics …

- Sum of all horizontal kicks is 2π:

$$\frac{e}{p}\oint B_y\, ds = 2\pi$$

- Circumference of the central beam orbit is given by the RF-frequency (independ of energy!) :

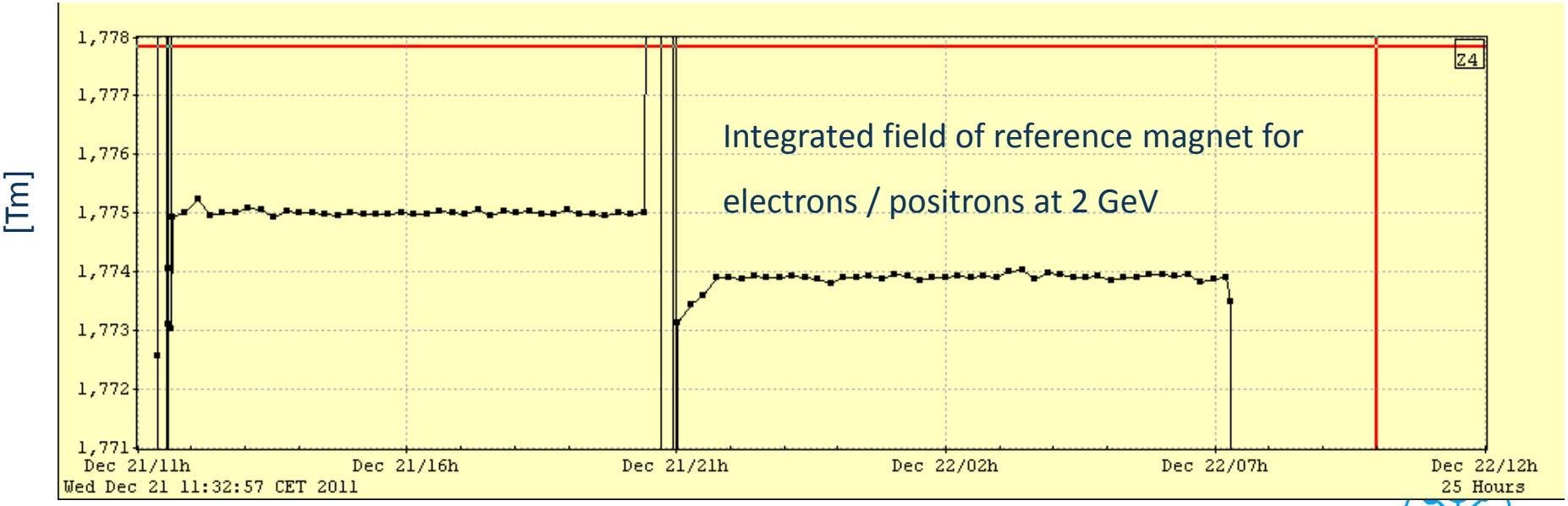
$$L = h\lambda = 482\,\frac{c}{f_{RF}} = 289.19\ \mathrm{m}$$

- The circumference is correlated with the beam energy over the momentum compaction factor α which depends on the optic:

$$\frac{\Delta L}{L} = \alpha\,\frac{\Delta p}{p}$$

Contributions to the beam energy (Dipole)

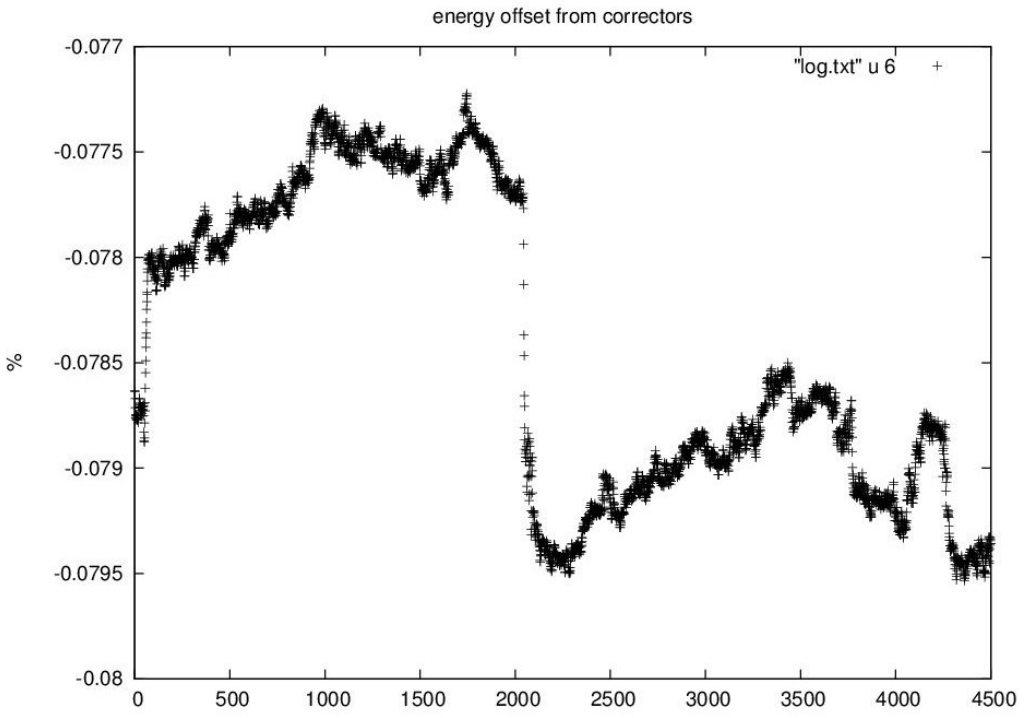
1. Magnetic field of the bending dipoles which is defined by the measured excitation curve and the applied current
2. The current is measured with 2 independend DCCTs
3. Careful cycling of the magnets is needed for reproducibility
4. A continuous measurement of the field integral of the reference magnet is installed for verification



Contributions to the beam energy (Correction coils)

- The horizontal correctors can change the energy by up to 5% in total
- The effect of a kick θ can be calculated with the help of the dispersion function D at the position of the kick:

$$\frac{\Delta E}{E} = -\frac{1}{\alpha}\frac{D_x \theta}{L}$$



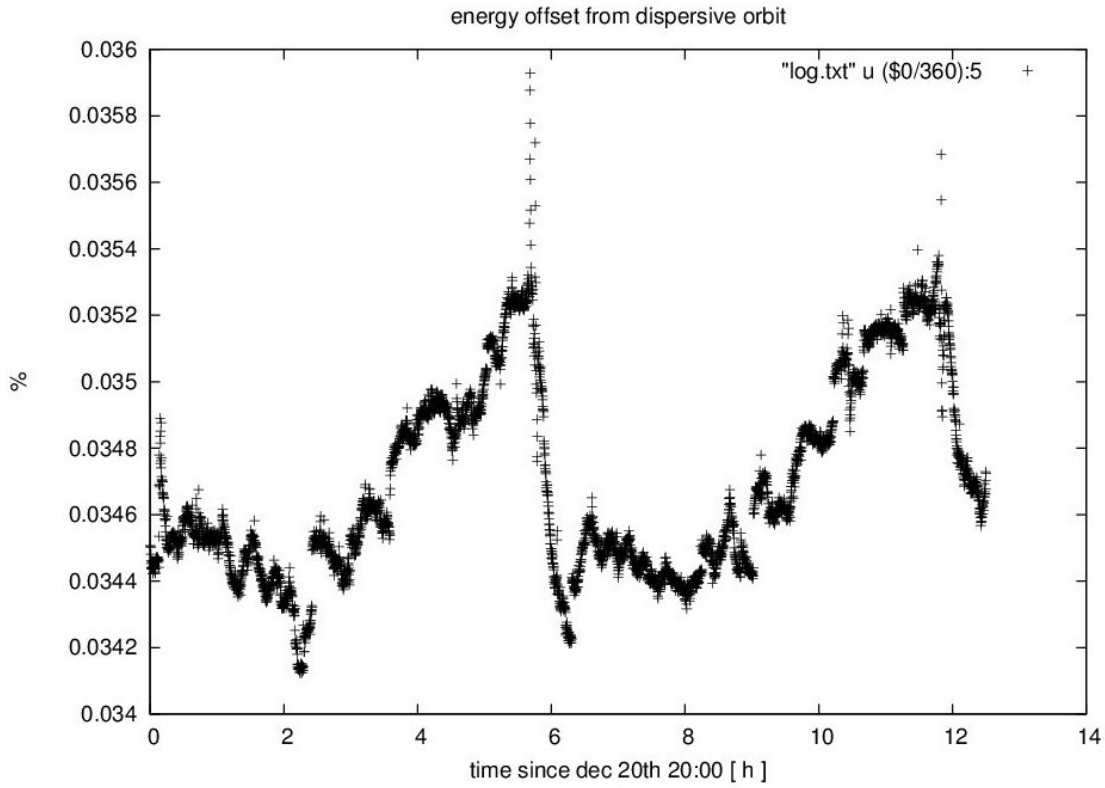
Effect of correctors calculated over 12 hours during a 4.5 GeV run :
2 x E-5

Contributions from the orbit

- If the ring shrinks in circumference the circumference of the orbit is nevertheless fixed by the RF. Therefore the beam position monitors tell us that the beam is travelling on an orbit on the outside of the nominal orbit.
- In this case the beam passes with some offset through the quadrupoles and gets an additional kick.
- The energy shift can be estimated by using the BPMs:

$$\frac{\Delta E}{E} = \sum_i \Delta x_i D_i \Big/ \sum_i {D_i}^2$$

Effect of orbit lengthing calculated over 12 hours during a 4.5 GeV run : 1 x E-5



Contributions from stray fields

1. Fast (< 1 hour) and slow (> days) variations will be cancelled by polarity switching or averaging
2. Day / night variations might be correlated with particle type or magnet switching
3. Constant stray fields which depend on the polarity (PS. Cables etc.) might shift the energy – but have the same effect on both particle types
4. Important are constant stray fields which have the opposite effect on e- and e+! We measured these fields around the ring with a hall probe when all power supplies were off to get an estimation of this effect.
5. Additional stray fields might depend on the fields from the PETRA power supplies if they are not compensated!

First estimation of stray field effect:

- Mean vertical stray field : $B_y \approx 30\ \mu T$
- About half of the ring is shielded by iron magnets
- Total deflection by stray fields :

$$\alpha = 4.5\ \cdot 10^{-6}\,\frac{1}{m} \cdot 150\ m = 6.75\ \cdot 10^{-4}\ rad$$

- Relative energy shift :

$$\frac{\Delta E}{E} = \frac{\alpha}{2\pi} = 1.1 \cdot 10^{-4}$$

More precise estimation will follow…

Energy server

- For convenience the different energy contributions are collected and calculated by an energy server which is accessible over tine:

  - Device Context : DORIS
  - Device Server : DOENGY
  - Properties :

1. EDipole : beam energy in GeV calculated from Dipole current (Soll)
2. dEDipoleImS : relative energy change (dE/E) due to dipole current error
3. EDipoleRefMagnet : beam energy in GeV calculated from Reference Magnet maesurement
4. dECorrector : relative energy change (dE/E) due to corrector kicks
5. dEOrbit : relative energy change (dE/E) due to dispersive orbit
6. dEStray : relative energy change (dE/E) due to stray fields (estimation)