Investigation of Beam Current and Position Monitoring Systems

Dito Shergelashvili
4th Year Bachelor Student, GTU
Advisors : Akaki Gigineishvili (GTU), Helmut Soltner (FZJ)

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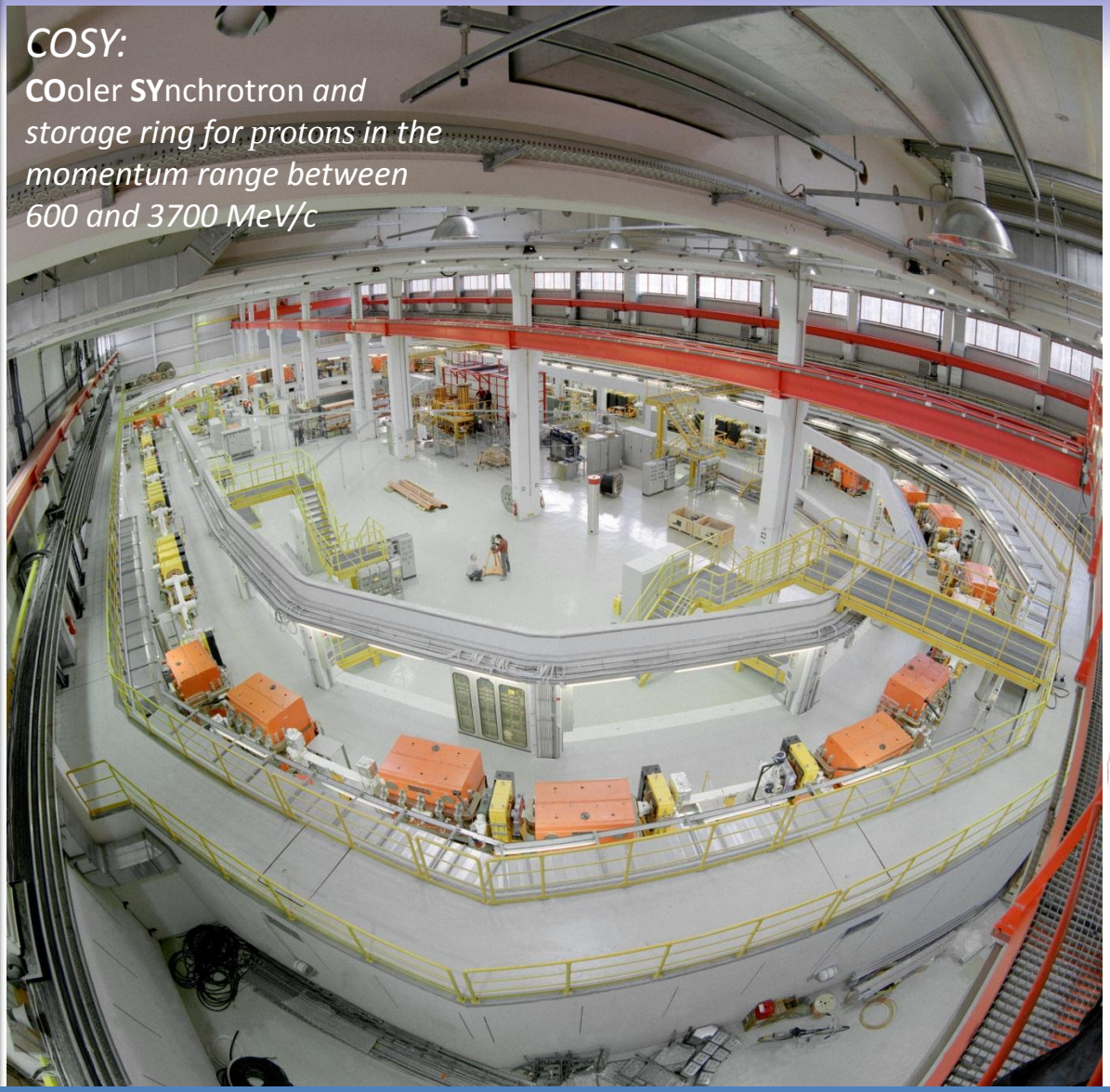
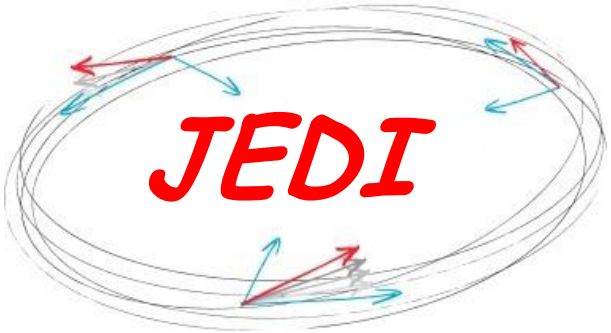


Internship 2013, IKP

Objective :

- *Improving BCT and BPM is one of the most important task for **J**ülich **E**lectric **D**ipole moment **I**nvestigations (JEDI*) at COSY*
- *The future research requires thousand times better resolution than existing*



* http://www.collaborations.fz-juelich.de/ikp/jedi/

Investigate of Beam Current Transformers (BCT)

Simulation for BCT

Coil Type: toroid
Windings: n=40
Diameter: $a=60*10^{-3}$
Windings diameter: $ra=5*10^{-3}$
Current : I=1amp
Constant:: $\mu_0 = 4 * \text{pi} * 10^{-7}$

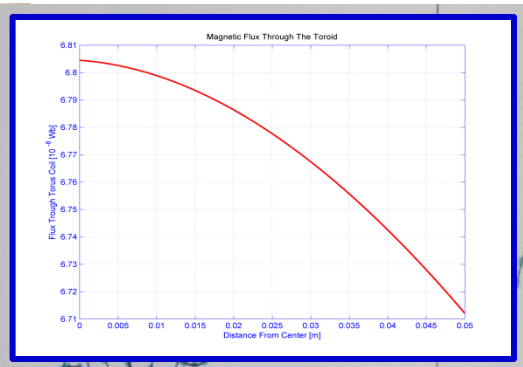
$$\text{r(n,φ)} = \begin{pmatrix} \cos(\varphi) & -sin(\varphi) & 0 \\ sin(\varphi) & cos(\varphi) & 0 \\ 0 & 0 & 1 \end{pmatrix} * \begin{pmatrix} a + ra * \cos(n * \varphi) \\ 0 \\ ra * \sin(n * \varphi) \end{pmatrix} \quad ex = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad ey = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \quad ez = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

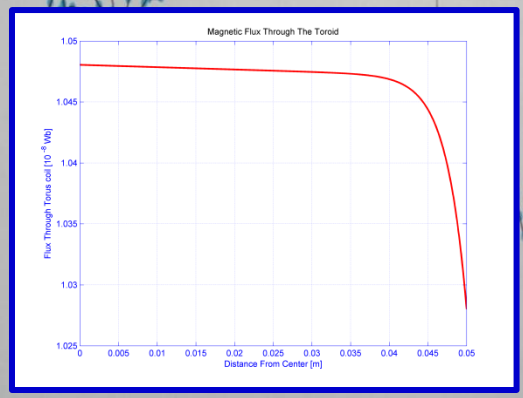
$$\text{r(n,φ)} \rightarrow \begin{bmatrix} \cos(\varphi) * \left(\frac{cos(40*\varphi)}{200} + \frac{3}{50}\right) \\ \sin(\varphi) * \left(\frac{cos(40*\varphi)}{200} + \frac{3}{50}\right) \\ \frac{\sin(40*\varphi)}{200} \end{bmatrix} \quad dr(n,\varphi) = \frac{d}{d\varphi}\, \text{r}(n,\varphi) \quad dr(n,\varphi) * ez \rightarrow \frac{cos(40*\varphi)}{5}$$

$$D(\varphi) = \begin{pmatrix} \cos(\varphi) & -sin(\varphi) & 0 \\ sin(\varphi) & cos(\varphi) & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \text{Az}(rr, xs) = \frac{1}{2\pi} * \text{I} * \ln\left[\sqrt{(rr - xs * ex)(rr - xs * ex)}\right]$$

$$\phi(xs) = \mu_0 * \int_0^{2\pi} Az(r(n,\varphi), xs) * \left(\frac{cos(40 * \varphi)}{5}\right) d\varphi$$

$$d\phi_k = \phi\left[(a - 2 * ra) * \frac{k}{100}\right] \quad K = 1,2,3 \ldots 100;$$





1st *Simulation result:*

- μ_0 is inside the integral
- No stability
- Simulation error

2nd *Simulation result:*

- μ_0 is out of the integral
- keeps stability at 80% of radius from center
- low number of windings causes decreasing flux near the coil
- **such stability is totally satisfactory for beam current monitoring**

Investigate of Beam Current Transformers (BCT)

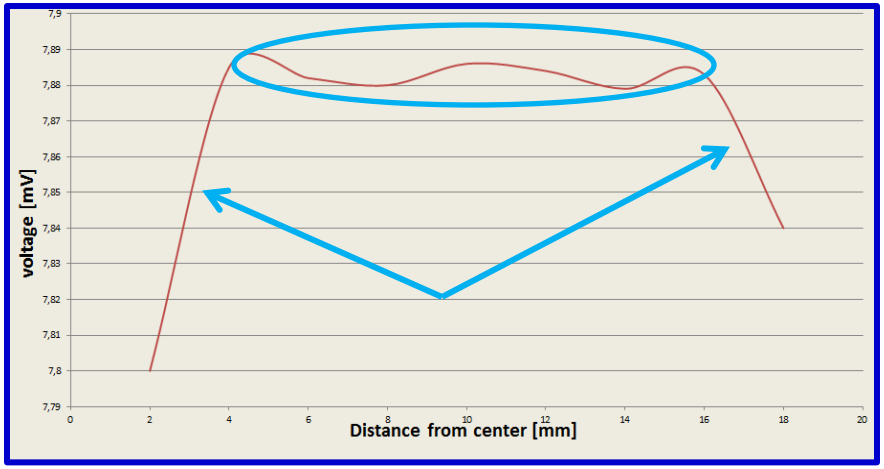
Experiment on BCT

Coil:

- Diameter 20 mm
- 30 windings
- Resonates at 1 MHz
- “Beam” current is 0,016mA
- Two wire

Lock-in Amplifier SR844:

- 25 kHz to 200 MHz frequency range
- 80 dB dynamic reserve
- Auto-gain, -phase, -reserve and –offset
- Two 16-bit DACs and ADCs
- Internal or external reference

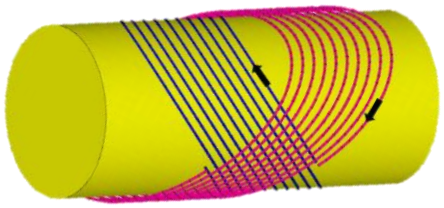


Experimental result:

- Magnetic flux stability inside the torus
- Low voltage at start and end points was caused by uneven distribution of copper wire.

Investigate of Beam Current Transformers (BCT)

Experiment on BCT

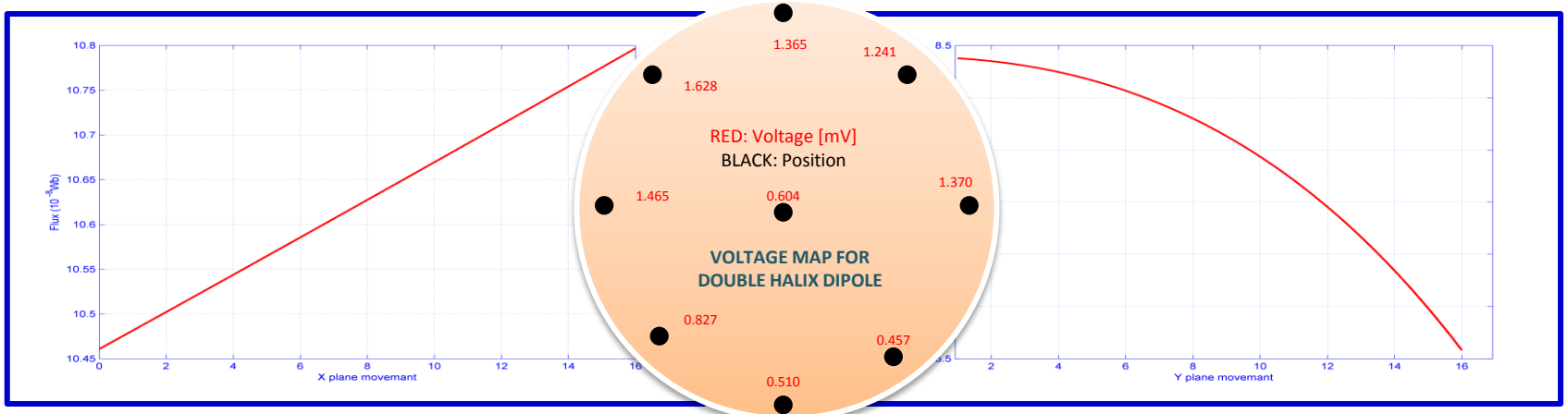


Double helix dipole:

- Made in FZJ (ZEA)
- Plastic material
- 50 windings
- Wire crossing angle: 90°
- Wire angle against the tube: 45°
- Only 2 connector

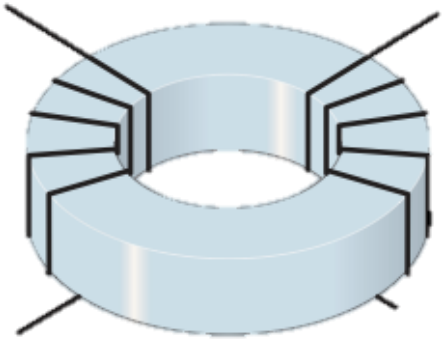
Conclusion and Outlook:

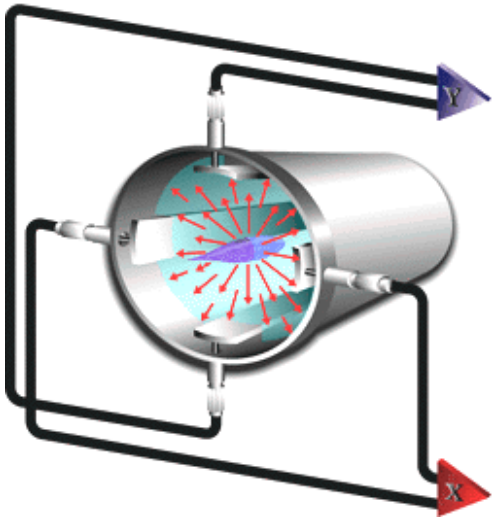
- Double helix dipole is not suitable for beam current monitoring
- Toroid which resonates at the beam frequency is satisfactory as BCT



Investigate of Beam Position Monitoring Systems*(BPM)*

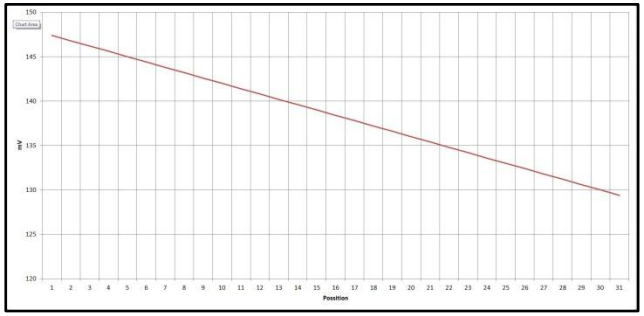
BPM coil and principles





1D BPM coil

- Toroid
- Two identical coil
- 180^0 between the couple coils
- Opposite direction of windings
- Two wire connections
- One dimension information



2D BPM coil

- Toroid
- Diameter with 30 mm
- Four identical coils
- 180^0 between the coupled coils
- 90^0 between the neighbor coils
- Opposite direction of windings
- Four wire connections
- Two dimension information
- **0,6nV difference per 10nm**

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