# Needs

- shorter injection / extraction sector can be realized with a high field septum magnet
- for high energy or space-limited accelerators
  - Future Circular Collider (FCC) at CERN
  - SIS300 at FAIR, GSI
  - medical accelerators
- conventional septum magnets
  - iron dominated (C-shape yoke) magnet
  - magnetic field strength is limited about 2 T
- novel truncated cosine-theta design (TCT)
  - enables magnetic field above 2 T
  - right-left asymmetric coil structure
  - cylindrical iron yoke surrounding the coil

# Model

- target: FCC extraction septum
  - 4 T in the aperture
  - geometry contraints
  - flat Rutherford cable
  - 9 conductors/block - 5 blocks - 5.5 kA
  - 4 right-left asymmetric saddle coils
  - 1 race track coil
  - no shield in septum
- simulation results
  - lateral field distribution
  - longitudinal field distribution

# Theory

\[
\begin{align*}
B_y &= \mu_0 j_0 \left( \frac{1}{R_1} + \frac{R_y}{R_y^2} \right) \\
&= \mu_0 j_0 \left( \frac{1}{R_2} + \frac{R_y}{R_y^2} \right)
\end{align*}
\]

\[ j_i = \frac{j_0}{2} \left( \frac{1}{R_1} + \frac{R_y}{R_y^2} \right) \]

- right side
  - cosine-theta current
- left side
  - shielding current on y axis
  - current density proportional to the field strength
- Analytical calculation: five line currents per pole

# Next steps

- coil end design optimization
  - asymmetric saddle coil
  - necessity of a shield
- realistic design
  - take existing cable design (e.g. LHC cables)
  - enough margin to quench
  - aperture size with a beam pipe
  - magnet length
- mechanical engineering design
  - support structure
  - winding: block-to-block cable transition
- cryogenic design
  - quench protection

# Summary

- TCT design is suitable for high field, space-saving septum magnets.
- Both FAIR at GSI and FCC at CERN requires about 4 T extraction septum magnets.
- Design studies will be continued in collaboration between CERN and GSI.
- Applications for medical accelerators will be investigated.
- The complex coil winding with a direct winding machine may be feasible.
- Furthermore, a conceptual design study for normal conducting magnets is an interesting topic.
- TCT would be an alternative of the conventional design, may have advantage under certain conditions.