Lattice studies for COSY and AD rings

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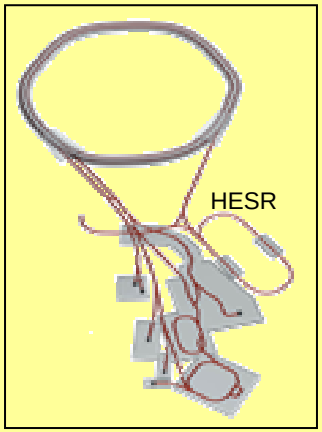
Outline

- Introduction
- CELL Geometry
- Low β calculations
- COSY & AD Rings
- Summary & Conclusion

QCD Physics at FAIR (CDR): unpolarized Antiprotons in HESR



PAX → Polarized Antiprotons

Central PAX Physics Case:

Transversity distribution of the nucleon in Drell-Yan:
→ FAIR as successor of DIS physics

- last leading-twist missing piece of the QCD description of the partonic structure of the nucleon
- **observation of $h_1^q(x,Q^2)$ of the proton for valence quarks** (A_{TT} in Drell-Yan >0.2)
  - **transversely polarized proton beam or target (✓)**
  - **transversely polarized antiproton beam (×)**

Central issue

Polarize antiprotons

Method: **Spin-Filtering** of antiprotons by multiple passage through an internal polarized gas target

CELL Geometry Calculations

$$\beta_{x,y}(s)=\beta_{x,y}(0)+\frac{s_{x,y}^2}{\beta_{x,y}^2(0)}$$

$$R_{x,y}(s)=\sqrt{\varepsilon_{x,y}\times\beta_{x,y}(s)}$$

$$\varepsilon_{x,y}\cdot\beta_{x,y}^2(0)-R_{x,y}^2(s)\cdot\beta_{x,y}(0)+\varepsilon_{x,y}\cdot s_{x,y}^2=0$$

$$R_{x,y}^4(s)-4\varepsilon_{x,y}^2 s_{x,y}^2\geq 0 \;\Rightarrow\; R_{x,y}(s)\geq\sqrt{2\varepsilon_{x,y}s_{x,y}}$$

Discriminant is Zero

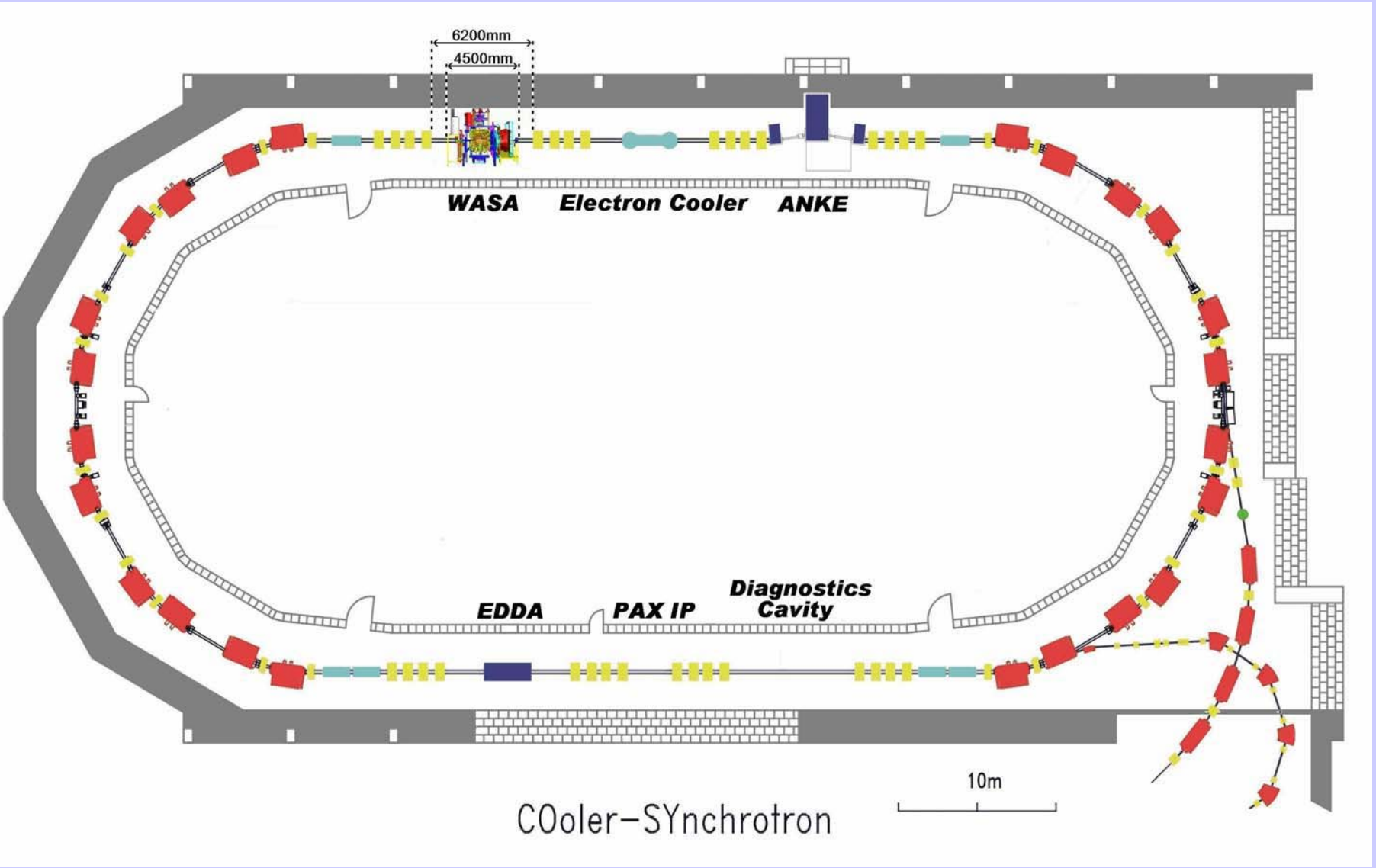
$$\beta_{x,y}(0)=\frac{R_{x,y}^2(s)}{2\varepsilon_{x,y}}=\frac{2\varepsilon_{x,y}s_{x,y}}{2\varepsilon_{x,y}}=s_{x,y}$$

Ideal case

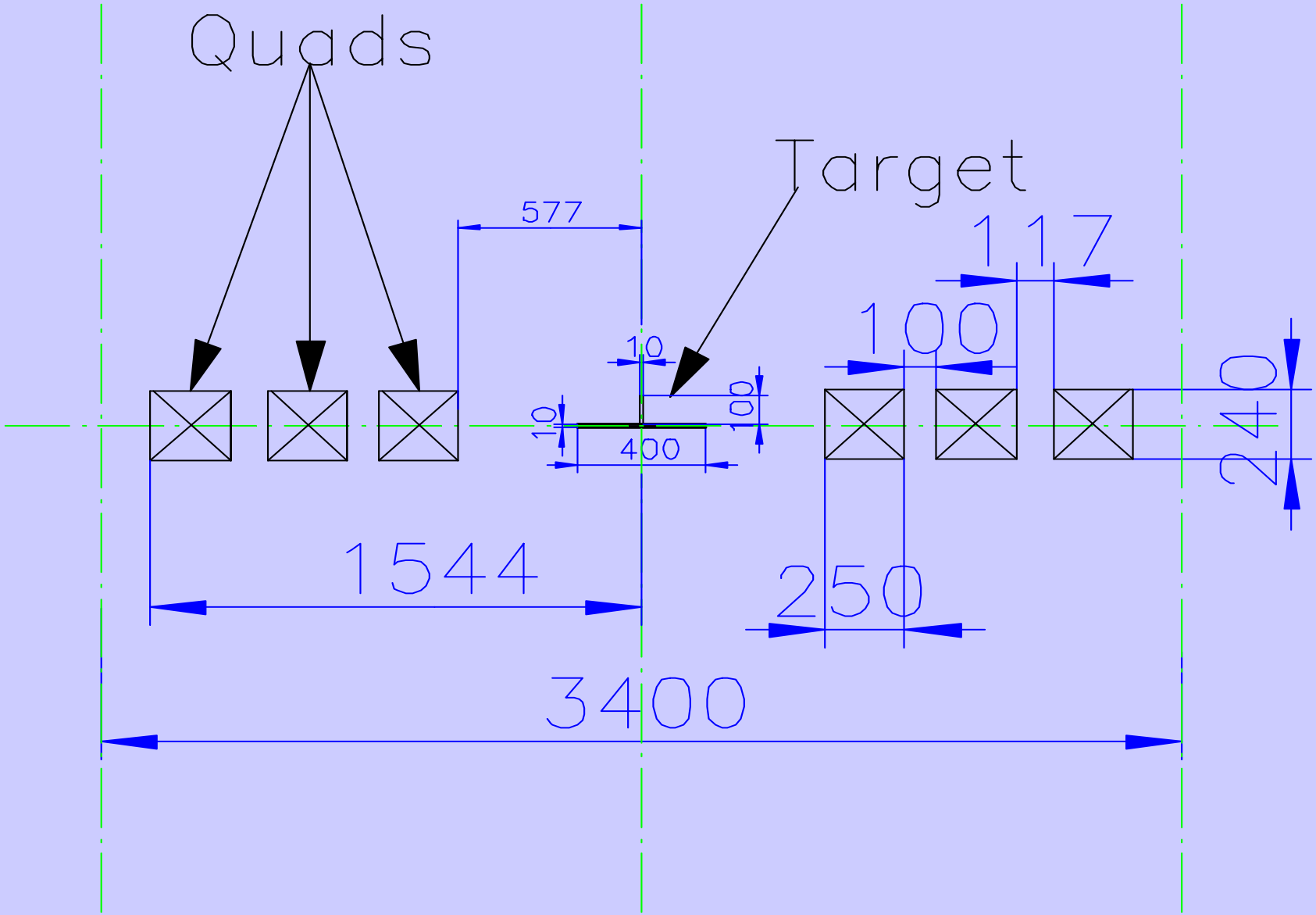
Discriminant is more than Zero

$$\beta_{x,y}(0)=\frac{R_{x,y}^2(s)\pm\sqrt{R_{x,y}^4(s)-4\varepsilon_{x,y}^2 s_{x,y}^2}}{2\varepsilon_{x,y}}$$

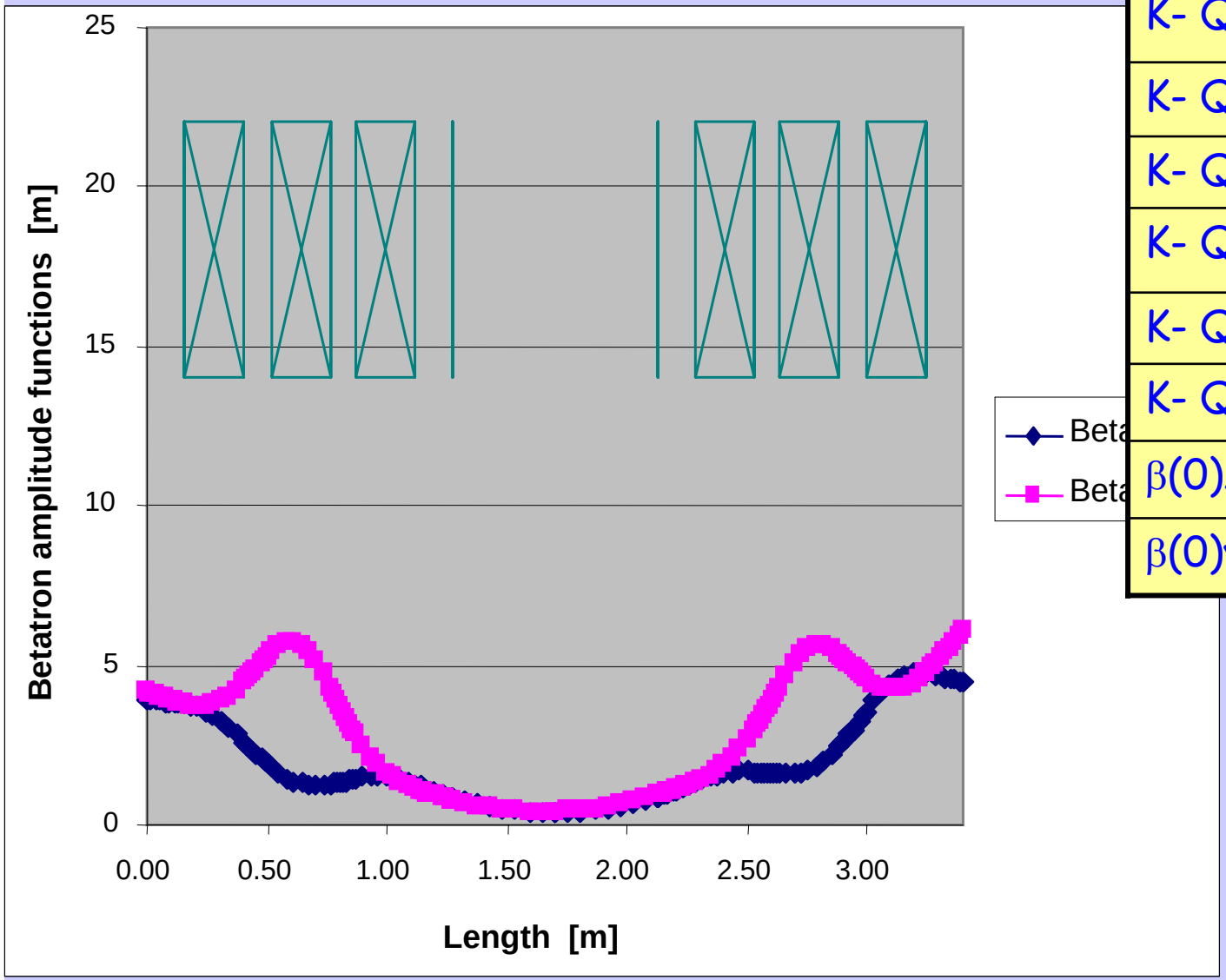
COoler SYnchrotron - COSY



Target Point 1 @ COSY



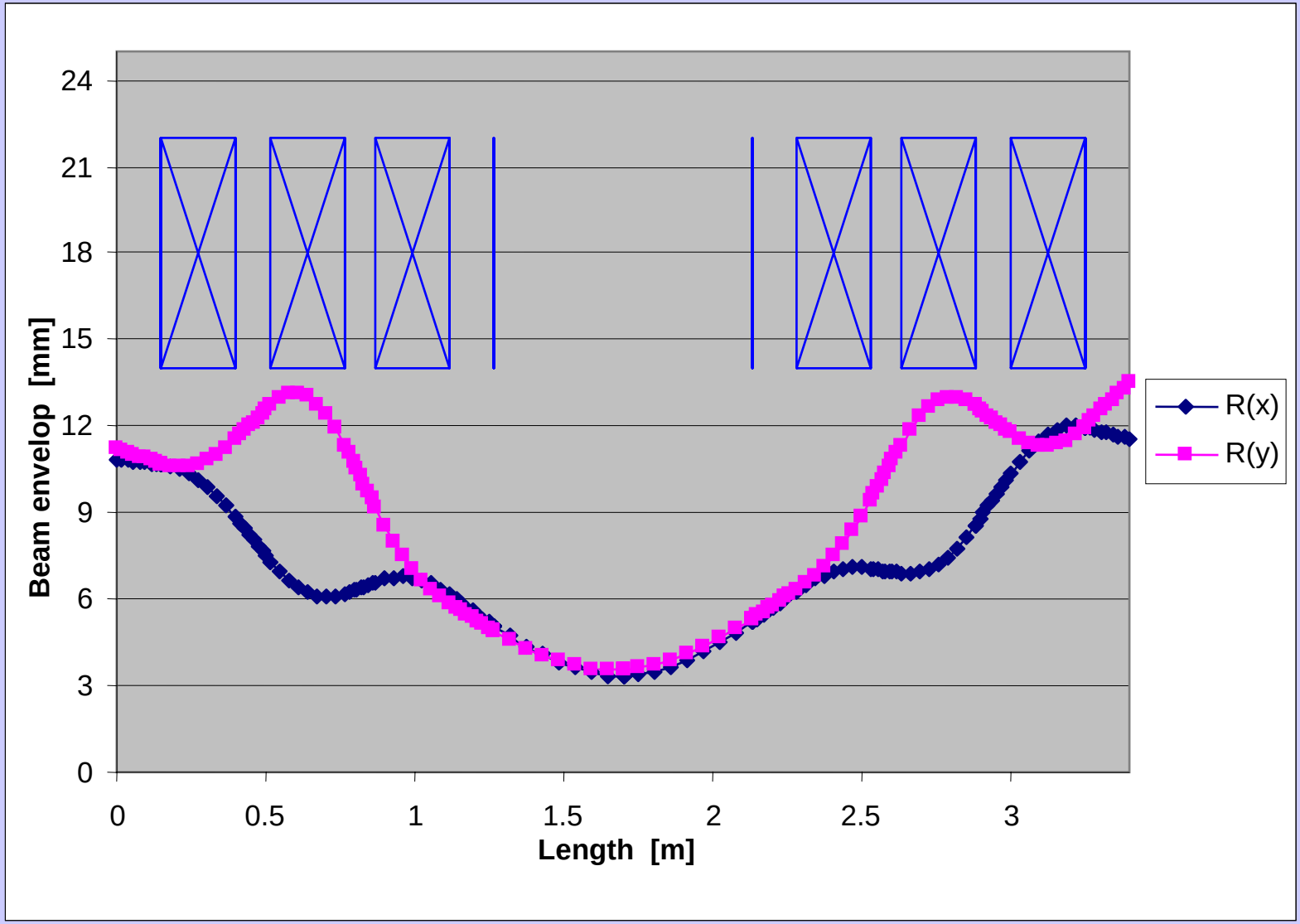
COSY TP1 3Quads: Beta Function



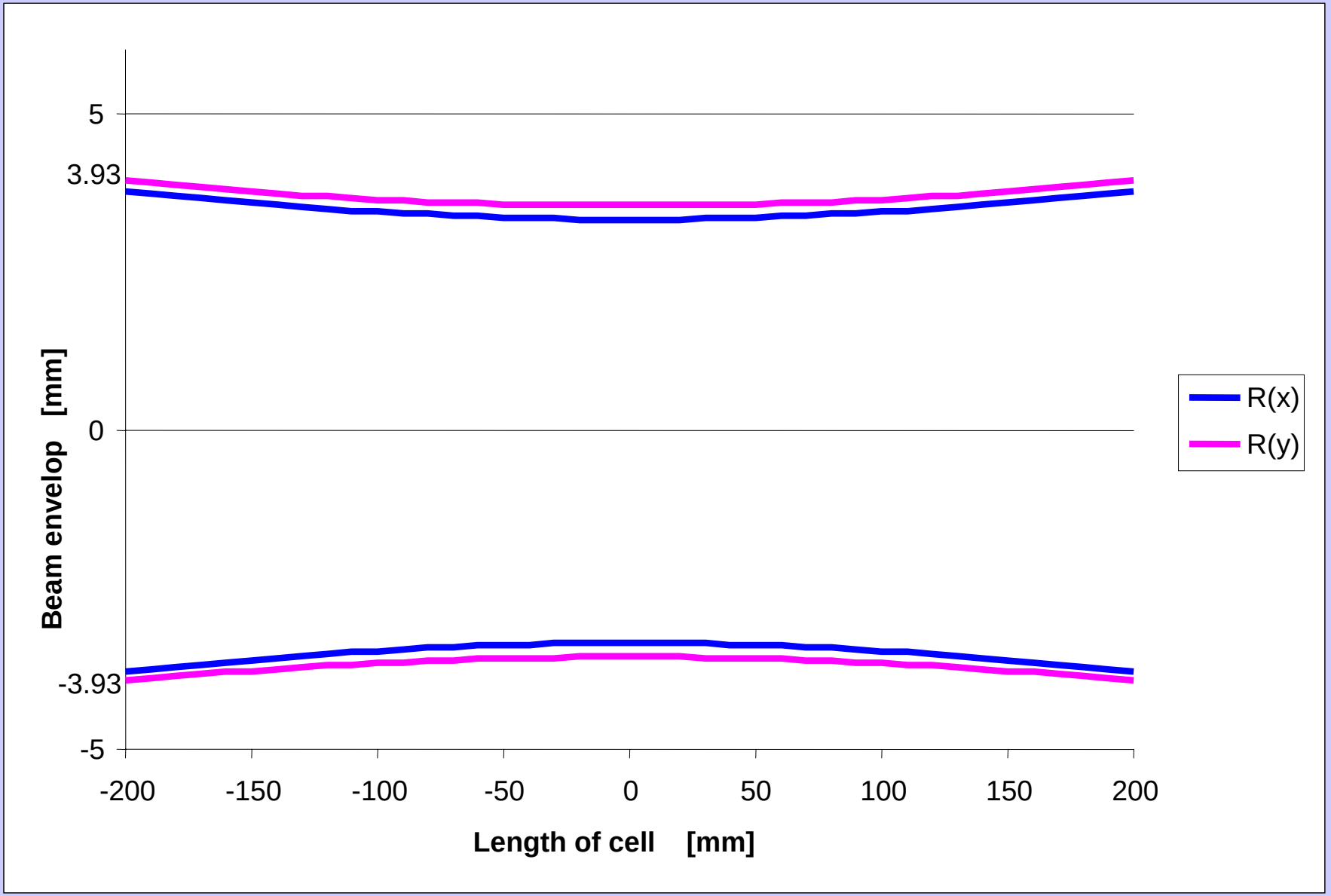
K- Quad 3	4.914 m^{-2}
K- Quad 2	-9.939 m^{-2}
K- Quad 1	7.566 m^{-2}
K- Quad 1	5.823 m^{-2}
K- Quad 2	-8.617 m^{-2}
K- Quad 3	6.283 m^{-2}
$\beta(0)x$	0.37m
$\beta(0)y$	0.42m

$$K = \frac{g}{B\rho}$$

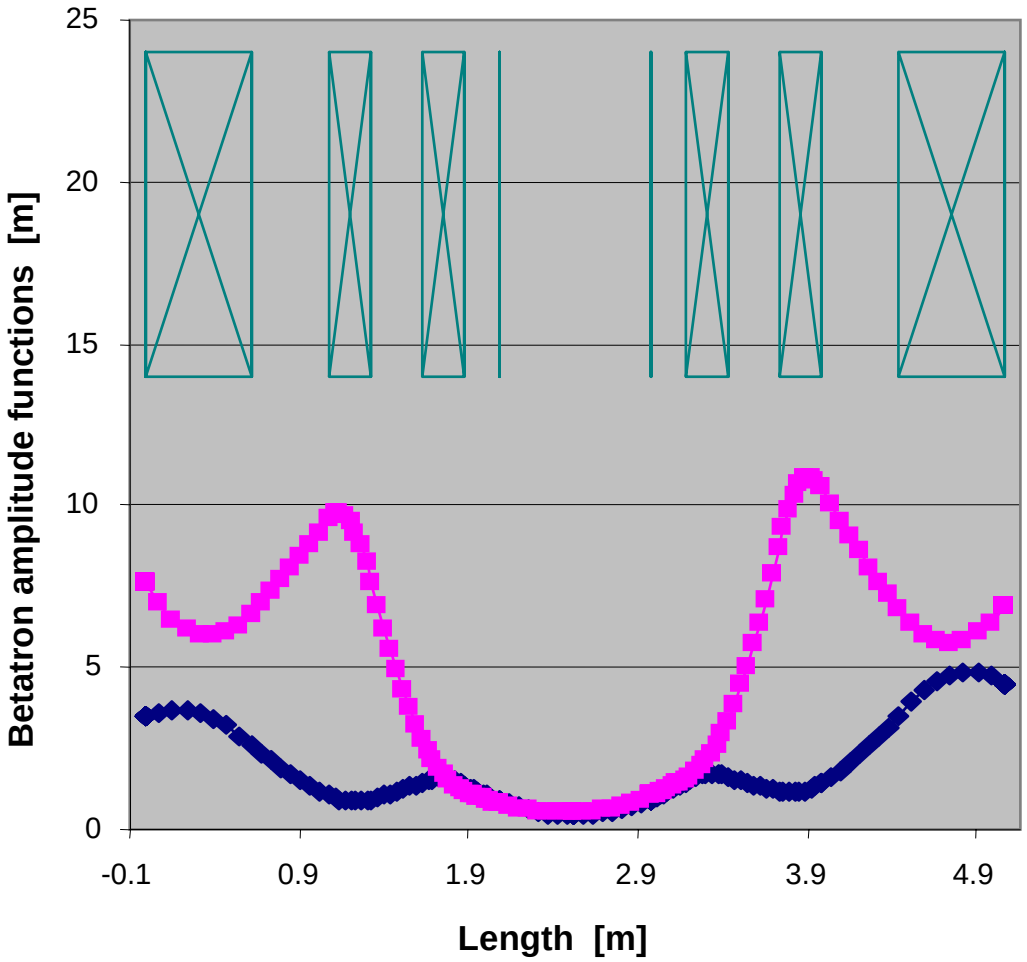
COSY TP1: Beam envelop



COSY TP1: Beam in the Cell



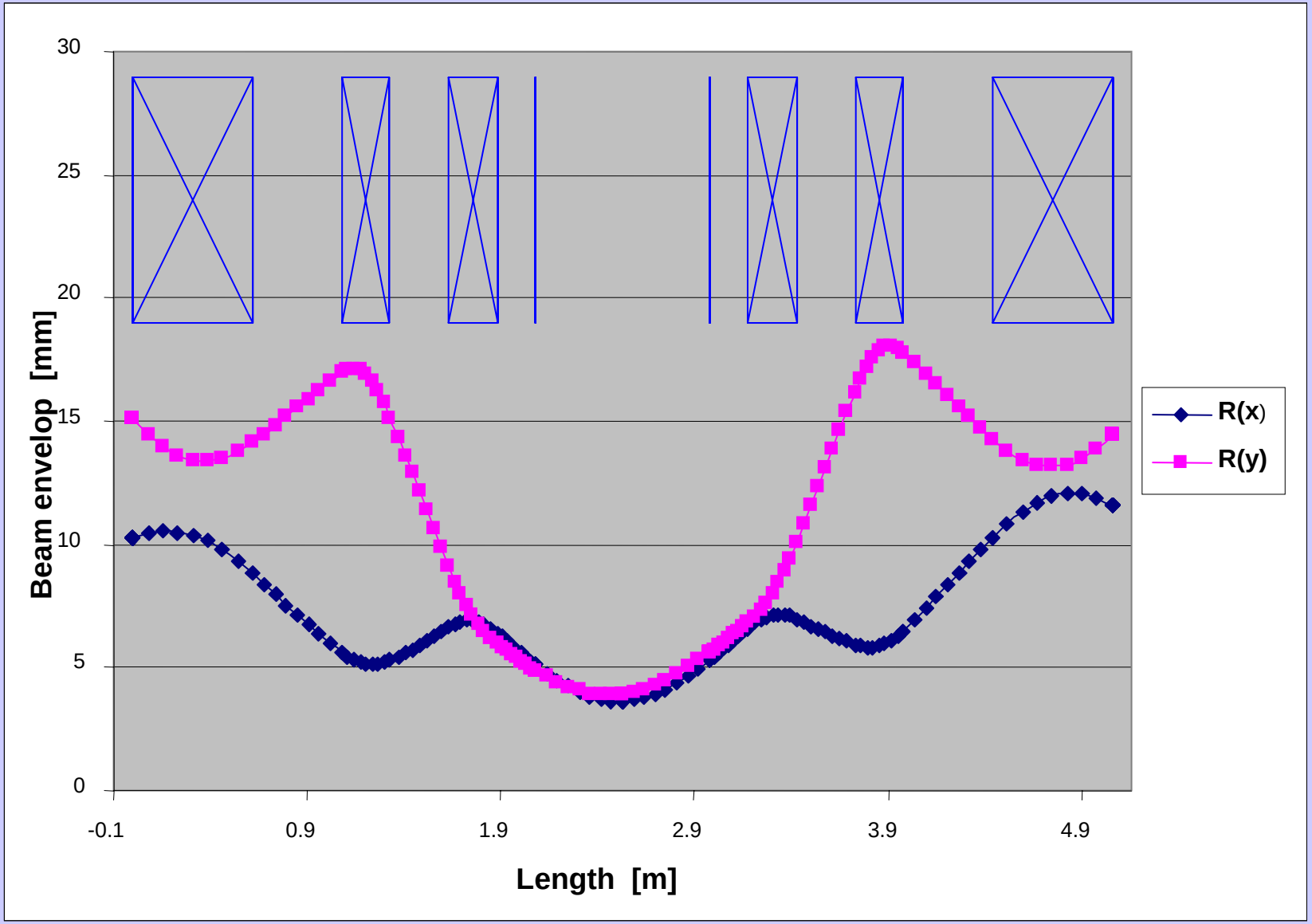
COSY TP1 2+1 Quads: Beta Function



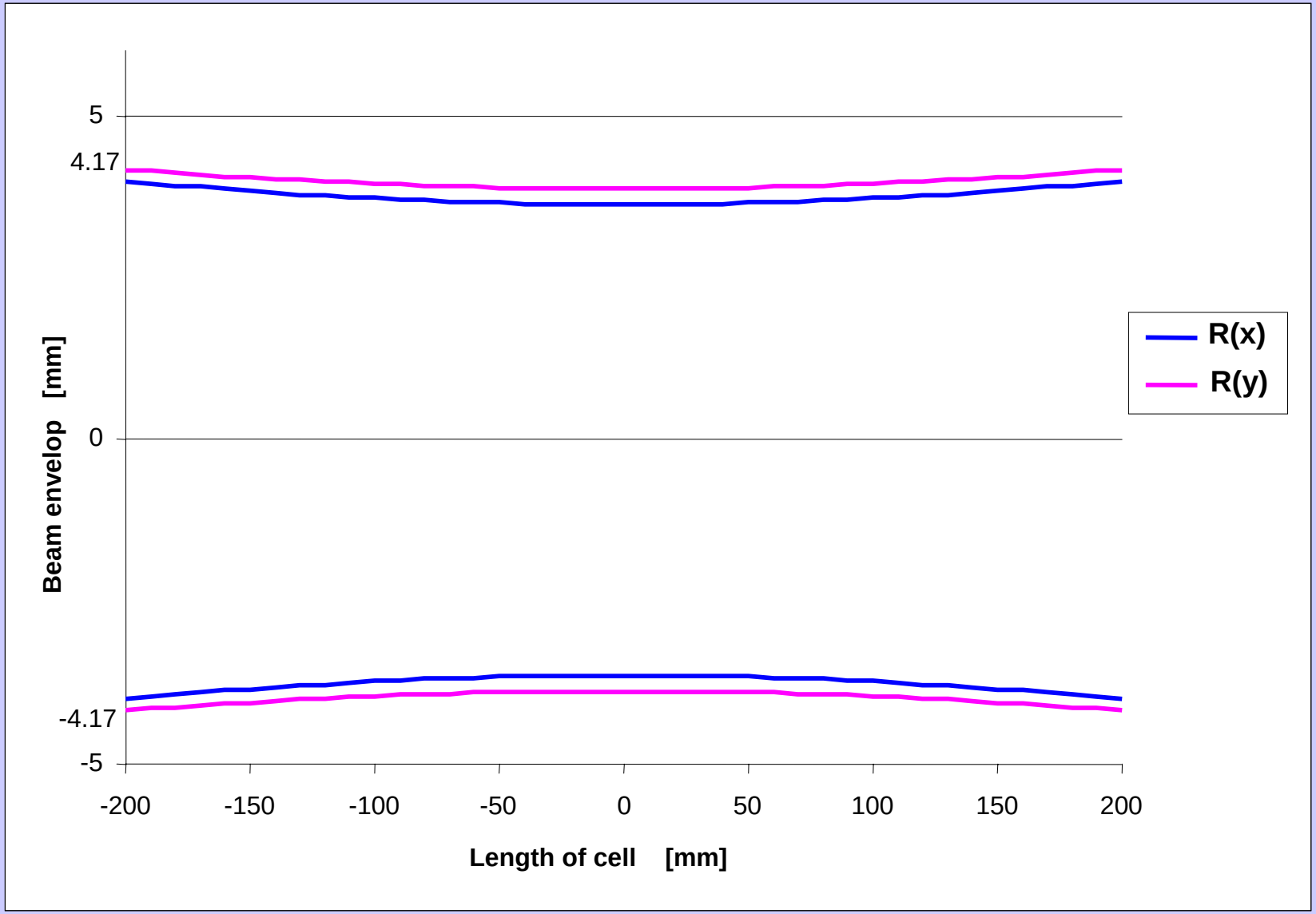
K- Quad 3	1.785 m^{-2}
K- Quad 2	-6.385 m^{-2}
K- Quad 1	7.472 m^{-2}
K- Quad 1	6.612 m^{-2}
K- Quad 2	-6.414 m^{-2}
K- Quad 3	1.829 m^{-2}
$\beta(0)x$	0.44m
$\beta(0)y$	0.50m

$$K = \frac{g}{B\rho}$$

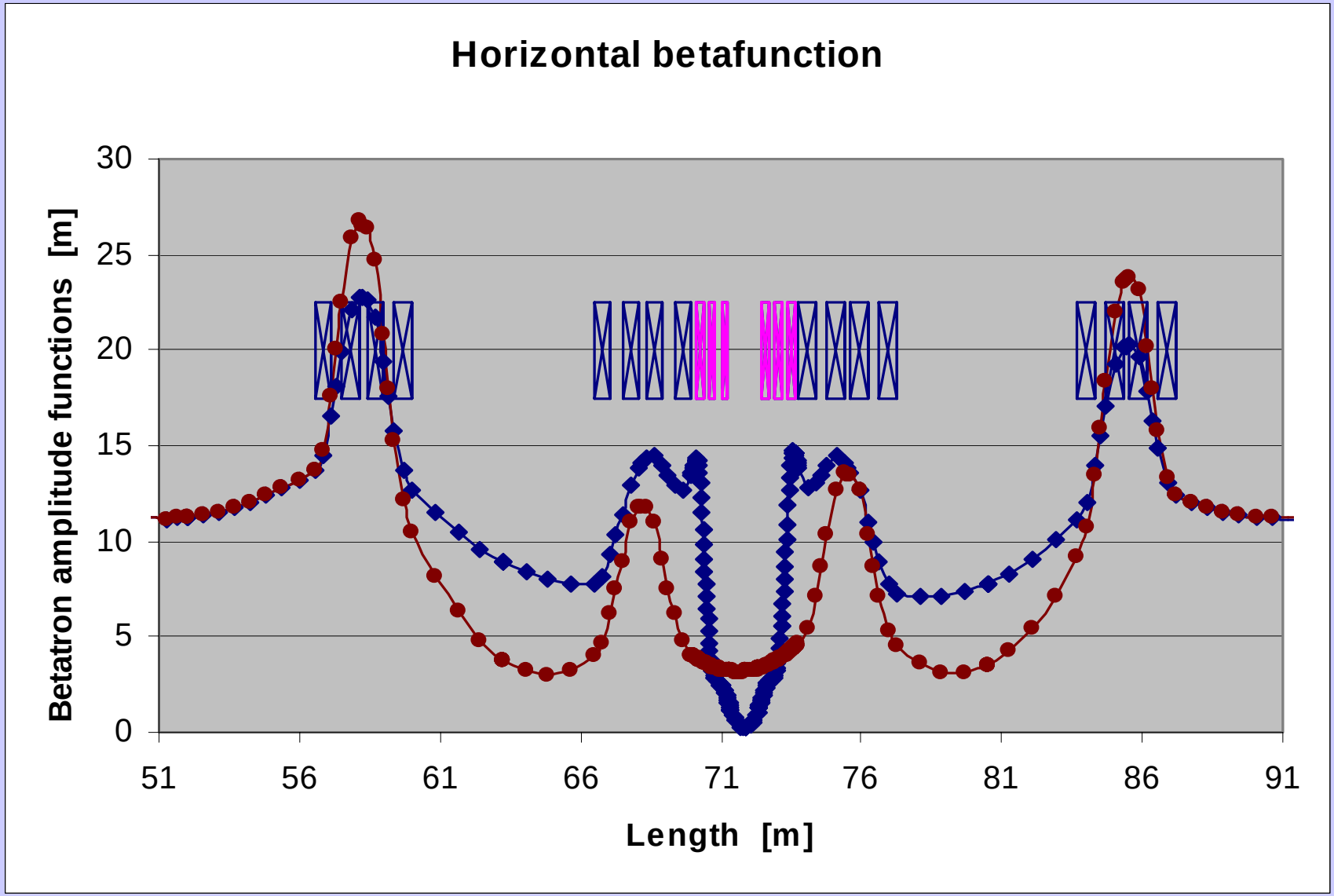
COSY TP1: Beam envelop



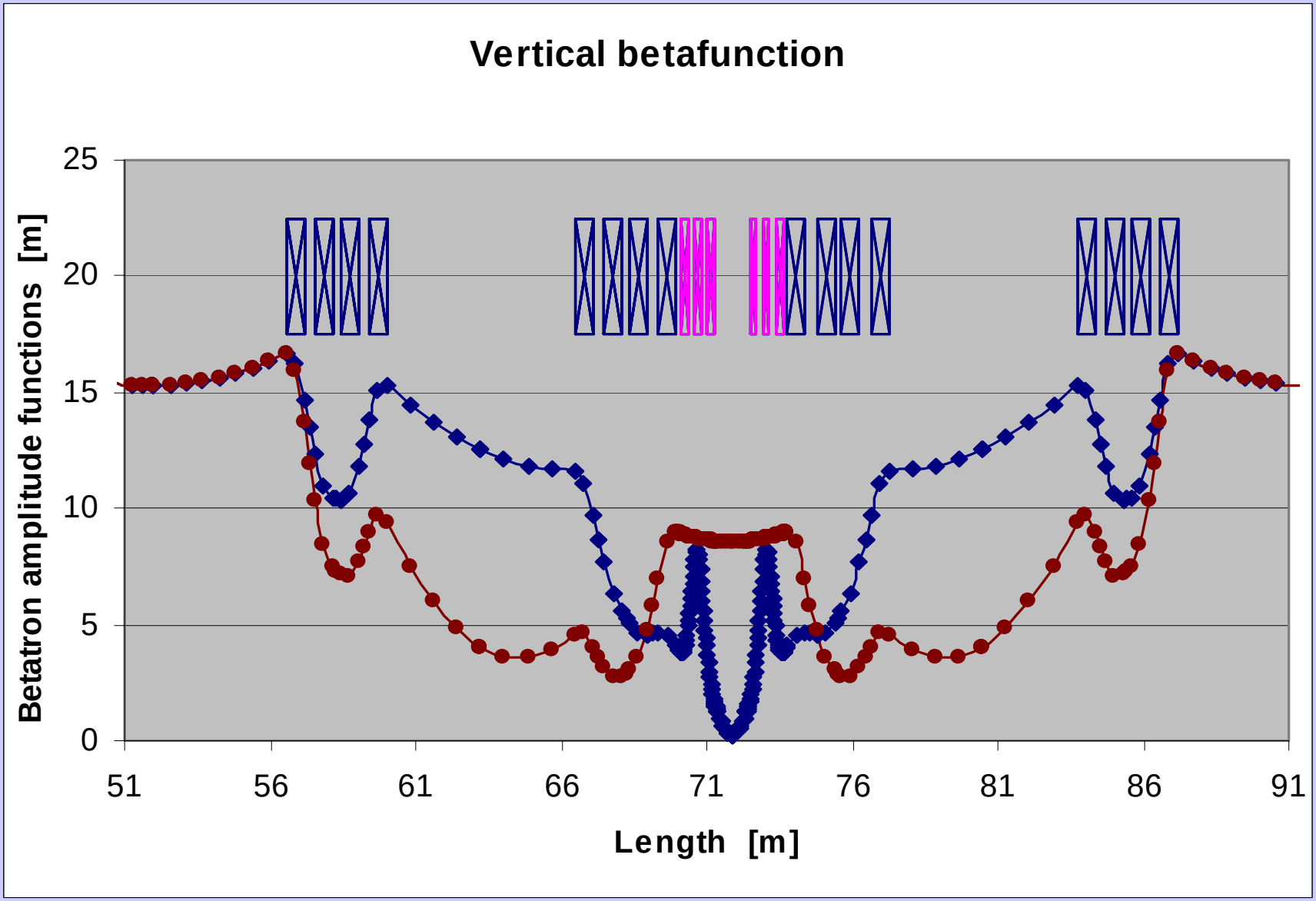
COSY TP1: Beam in the Cell



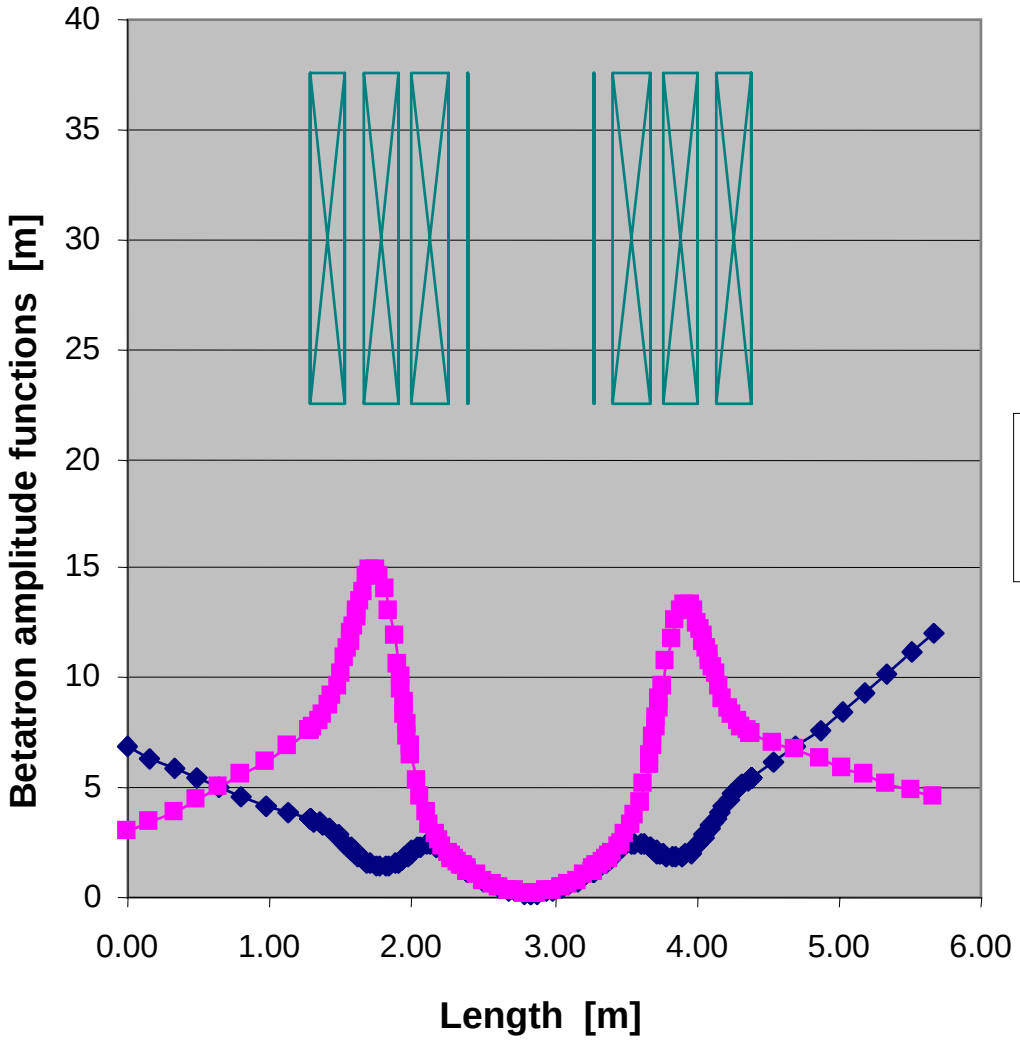
COSY with Low Beta section



COSY with Low Beta section



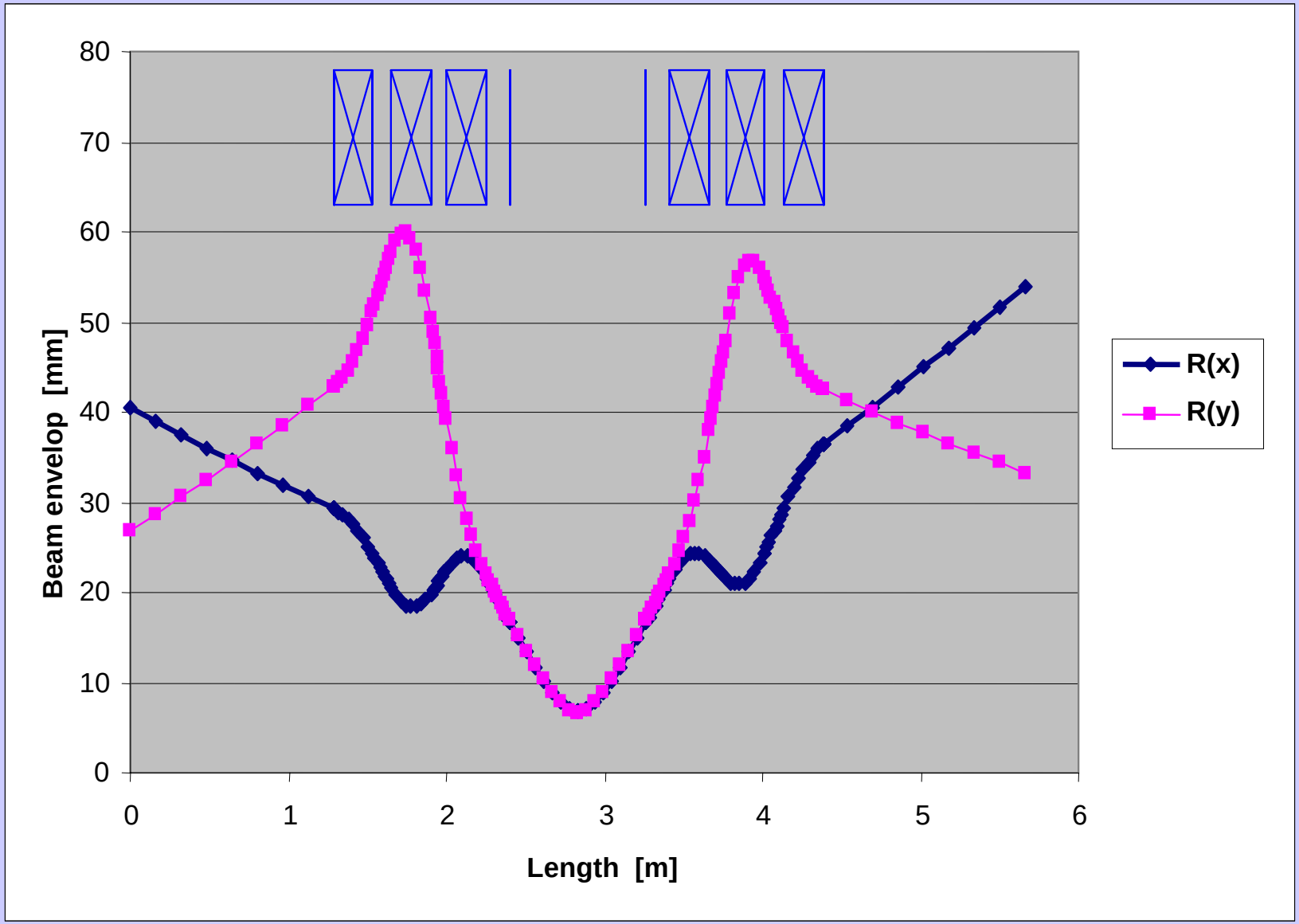
AD Low Beta section



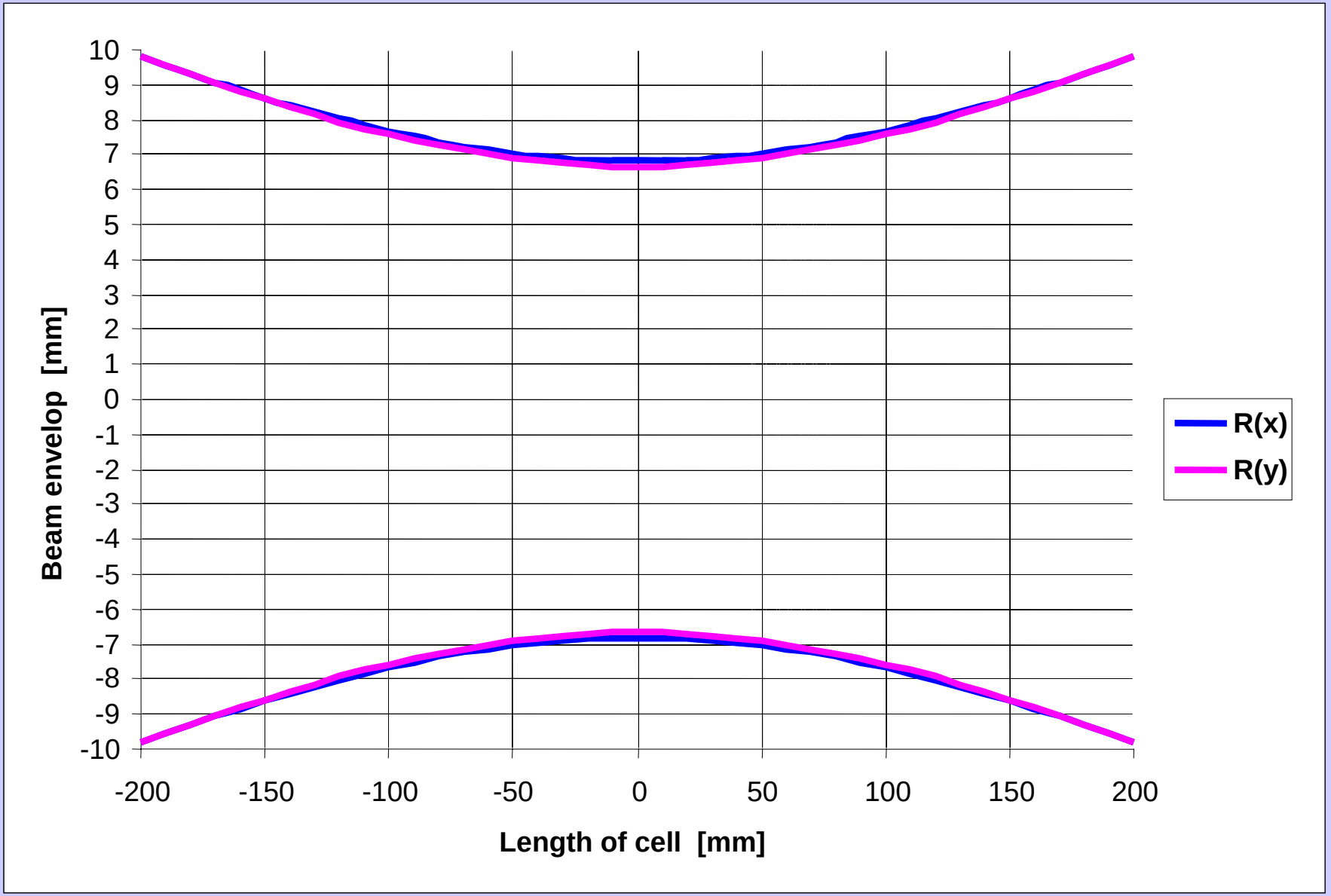
K- Quad 3	3.663 m^{-2}
K- Quad 2	-11.593 m^{-2}
K- Quad 1	10.491 m^{-2}
K- Quad 1	9.060 m^{-2}
K- Quad 2	-10.822 m^{-2}
K- Quad 3	3.514 m^{-2}
$\beta(0)x$	0.193m
$\beta(0)y$	0.186m

$$K = \frac{g}{B\rho}$$

AD Low Beta section



AD Low Beta section



Summary & Conclusion

At COSY, the machine acceptance fits through a 10 mm wide storage cell.

In the case if, Low Beta section with 3 quadrupoles doesn't work, second version of Low Beta section will be used.

The new superconducting quadrupole magnets do not affect the telescopic setup of the COSY straight section.

At the AD during injection, the cell has to be opened by about 2 cm.

We need realistic field calculations to recalculate our results with MAD.