Beta-function measurements at SIS18

V.Chetvertkova, G.Franchetti, R.Singh

Contents

- History of β function measurements at SIS18
- MD experiment: July 2016
  - Motivation
  - Method
  - Measurements
  - Simulations
  - Results
- Cryring

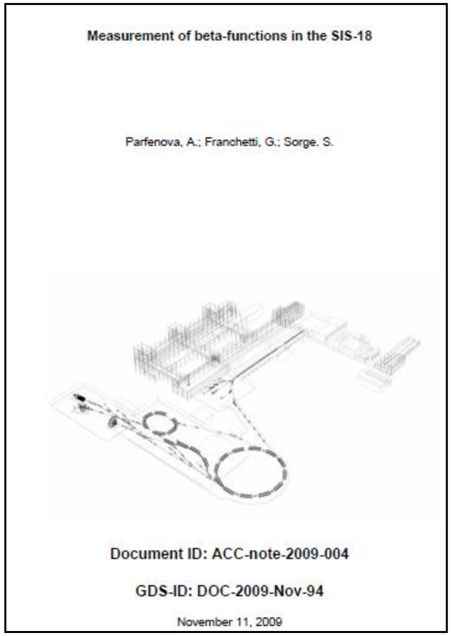
History of β-function measurements at SIS18

- **Measurements of beta-functions in the SIS18**
  A. Parfenova, G. Franchetti, and S. Sorge
  ACC-note-2009-004
  - tune response to a change in the closed orbit and a change in gradient of a sextupole magnet

$$\beta_{x,y\bar{l}} = \pm \frac{4\pi}{\Delta K_{2\bar{l}}} \frac{\Delta Q_{x,y}}{\Delta x_{CO\,\bar{l}}} = \pm \frac{4\pi}{\Delta K_{2\bar{l}}} \frac{{}_{x,y}Q^{x}_{\bar{t}}}{M^{x}_{\bar{l}\bar{t}}}$$

  - tune response to a change in gradient of a quadrupole magnet

$$\Delta Q \approx \sum_{q} \frac{\beta_{sq} \Delta k\, l}{4\pi}$$


Measurement of beta-functions in the SIS-18

Parfenova, A.; Franchetti, G.; Sorge. S.

Document ID: ACC-note-2009-004

GDS-ID: DOC-2009-Nov-94

November 11, 2009

July 2016: beam time at SIS18

Motivation:

- Measure relative β functions
- Test the procedure
- Gain experience

Method:

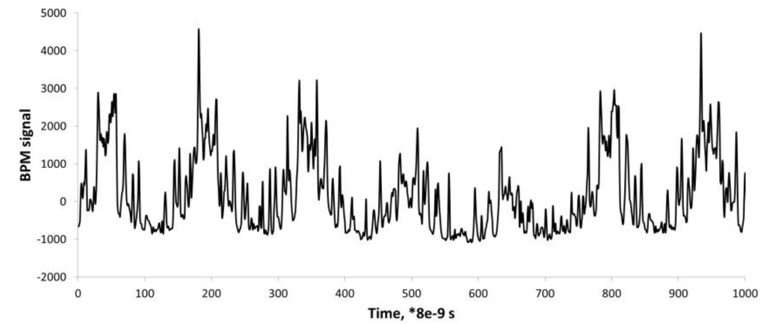
- Changing the strengths of the corrector quadrupoles, measuring the tune change
- Using a transverse kicker to excite the beam, measuring the phase advance
- Taking BPM data at 125MHz rate
- Reconstructing relative β functions

July 2016: beam time at SIS18

Measurements: Carbon C3+ beam

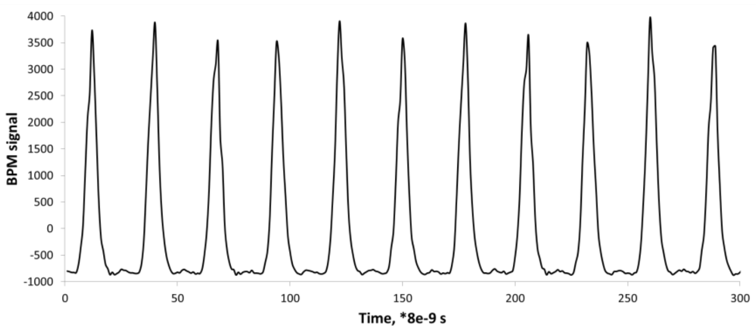
Several options considered

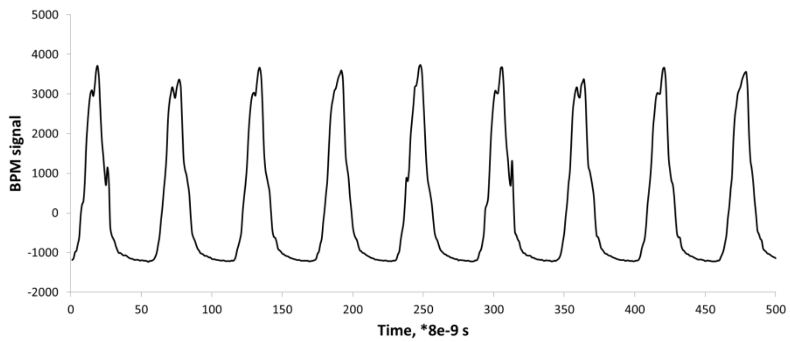
- Measurements at injection
  - **6.8 MeV/u, bunch quality is low**



Example of the BPM signal at ~7 MeV/u

- Measurements at flat top
  - **300 MeV**
  - **50 MeV**





Examples of the BPM signals at extraction

v. chetvertkova @gsi.de

Measurements: Carbon C3+ beam

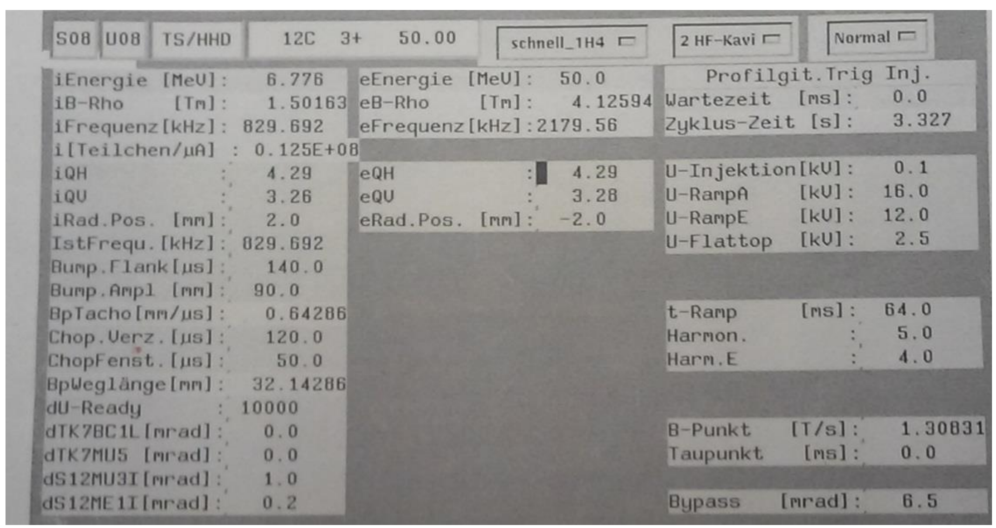
- 50 MeV/u
- Trim value Frev:
  eFrequenz/h=435.912 kHz
- Measured Frev=436.71 kHz

Trim values tunes:

- Qx = 4.29
- Qy = 3.28

Measured fractional tunes:

- Qx = 0.3
- Qy = 0.29



v. chetvertkova @gsi.de

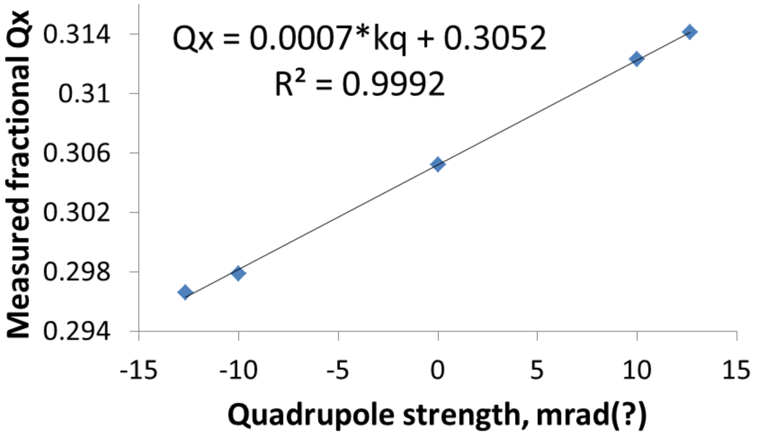
July 2016: beam time at SIS18

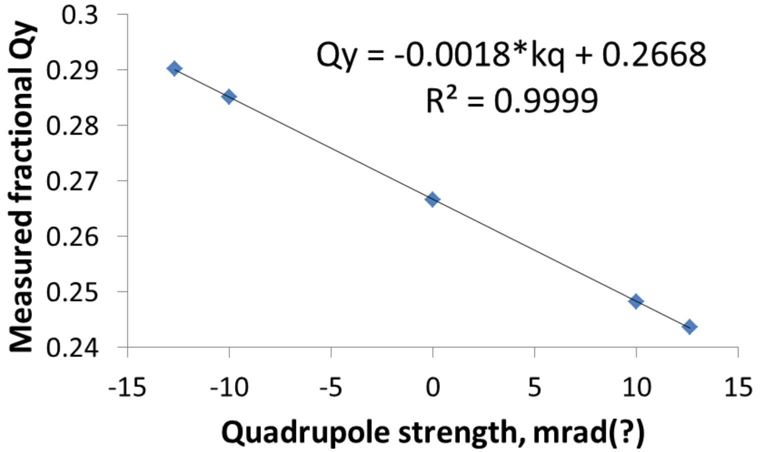
Measurements:

Tune changes when a quadrupole corrector is switched on:

Quadrupole corrector	Inverted* strength value, mrad	Qx	Qy
Q4	12.5	0.315	0.243
Q4	-12.5	0.296	0.289
Q8	12.5	0.315	0.243
Q8	-12.5	0.294	0.289
Q10	12.5	0.315	0.243
Q10	-12.5	0.296	0.291

* Inverted strength values are used here for further comparison with MADX, since MADX and MIRKO use opposite sign conventions

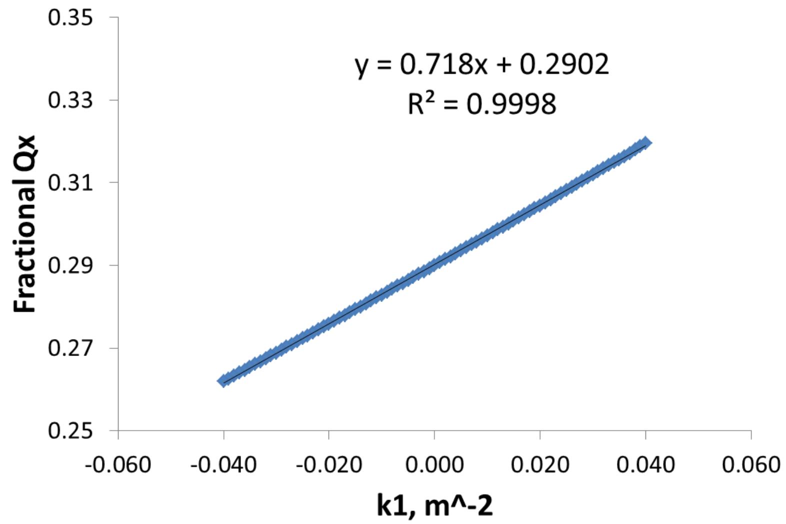


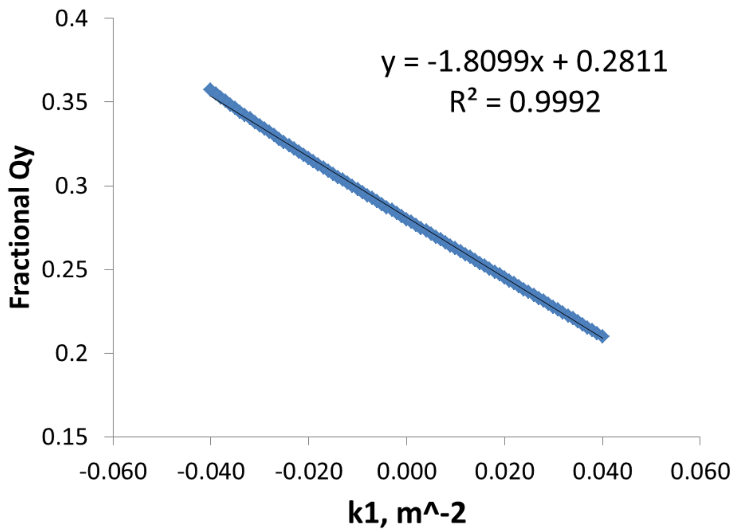


v. chetvertkova @gsi.de

MADX simulations:

– Tune values vs quadrupole corrector strength





July 2016: beam time at SIS18

- **Some theory:**

$$\beta = \frac{4\pi \, \Delta Q}{\Delta K} \qquad \nu = \int_{s_0}^{s} \frac{1}{\beta} d\tau + \nu_0$$

–Finding relative β functions

$$\frac{\beta_2}{\beta_1} = \frac{(x_{21} Cos(2\pi Q) + x_{22})^2 + x_{21}{}^2}{(x_{11} Cos(2\pi Q) + x_{12})^2 + x_{11}{}^2}$$

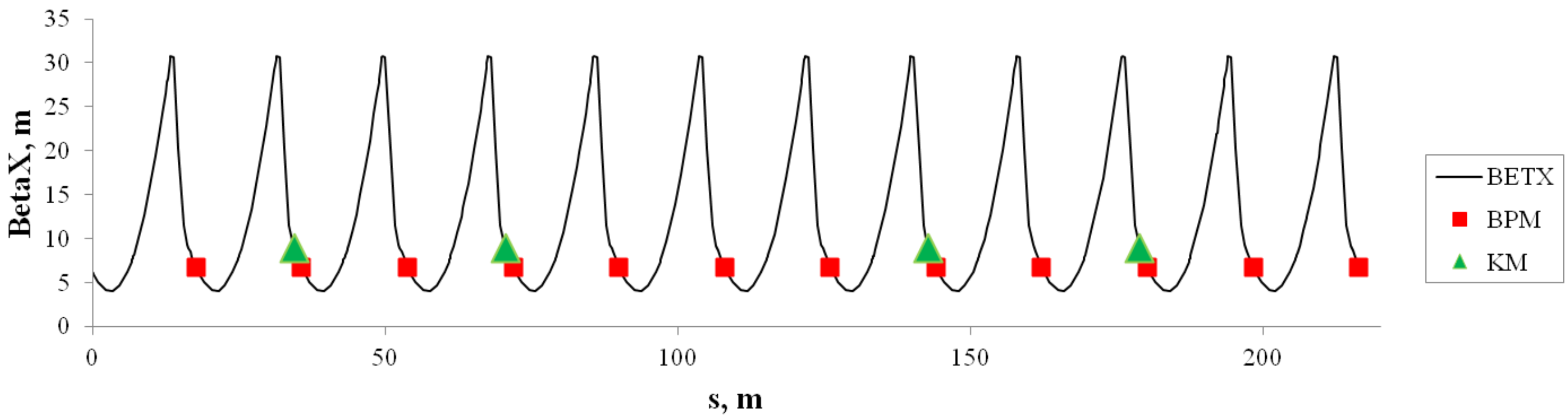
–Finding phase advance

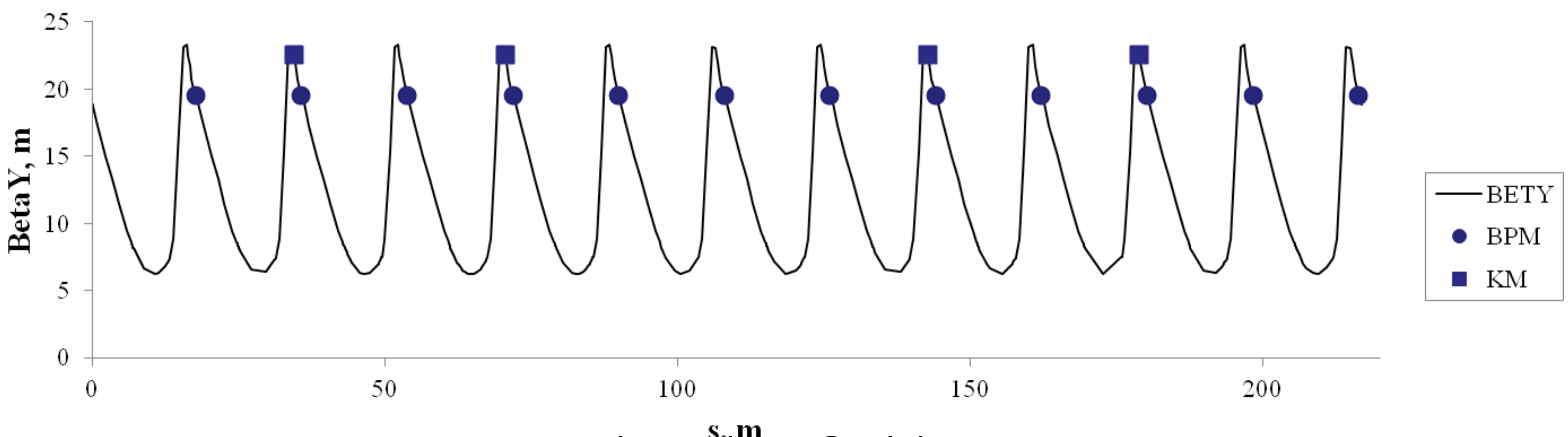
$$< x_n Cos(2\pi Q + \phi) > = \frac{\sqrt{\varepsilon\beta}}{2} Cos\, \mu$$

$$< x_n Sin(2\pi Q + \phi) > = - \frac{\sqrt{\varepsilon\beta}}{2} Sin\, \mu$$

July 2016: beam time at SIS18

- **MADX simulations:**
  - β functions without perturbations

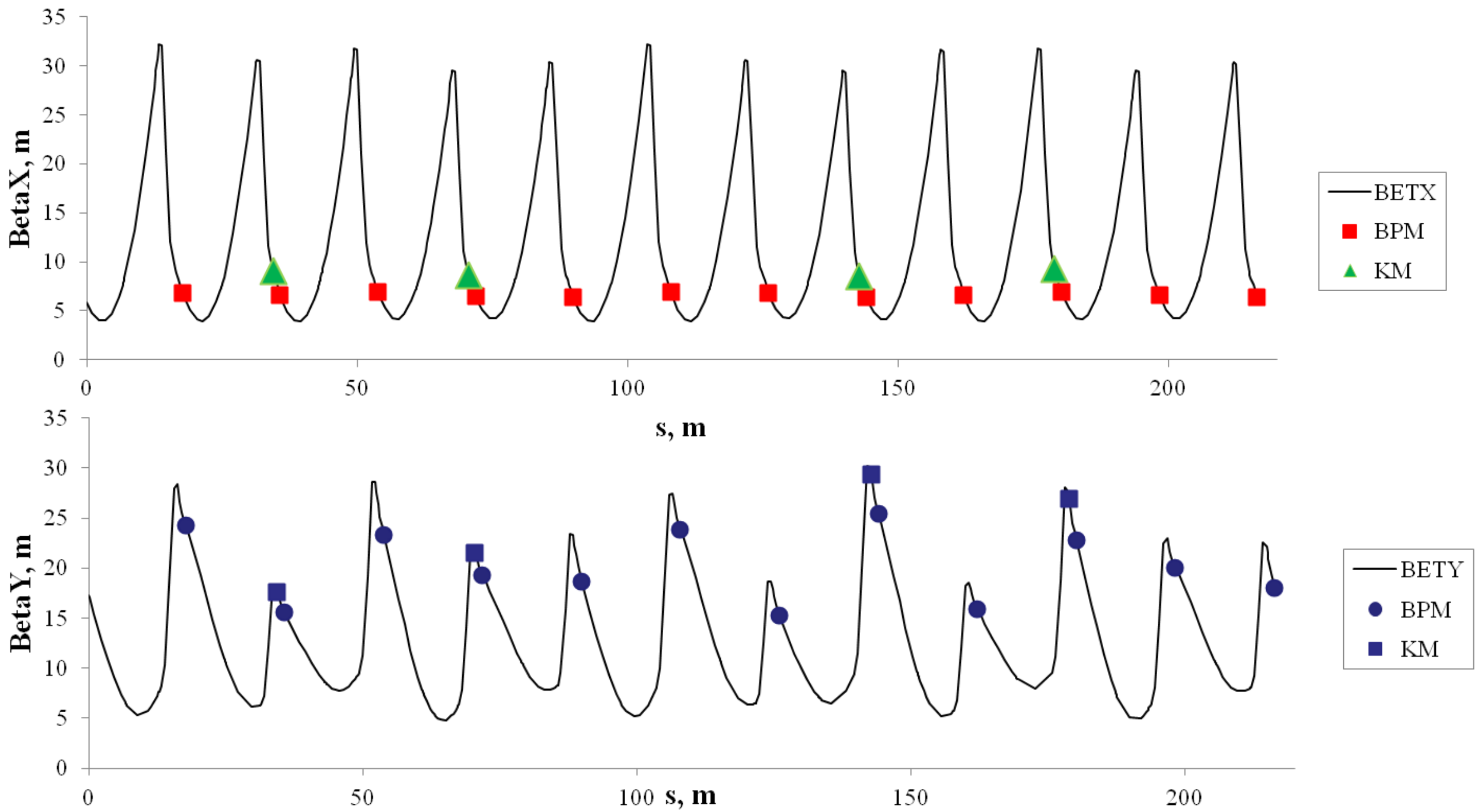




v. chetvertkova @gsi.de

July 2016: beam time at SIS18

- **Simulations:**
  - β functions when quad corrector GS02KM with k1=0.03*k1(QF) is on



v. chetvertkova @gsi.de

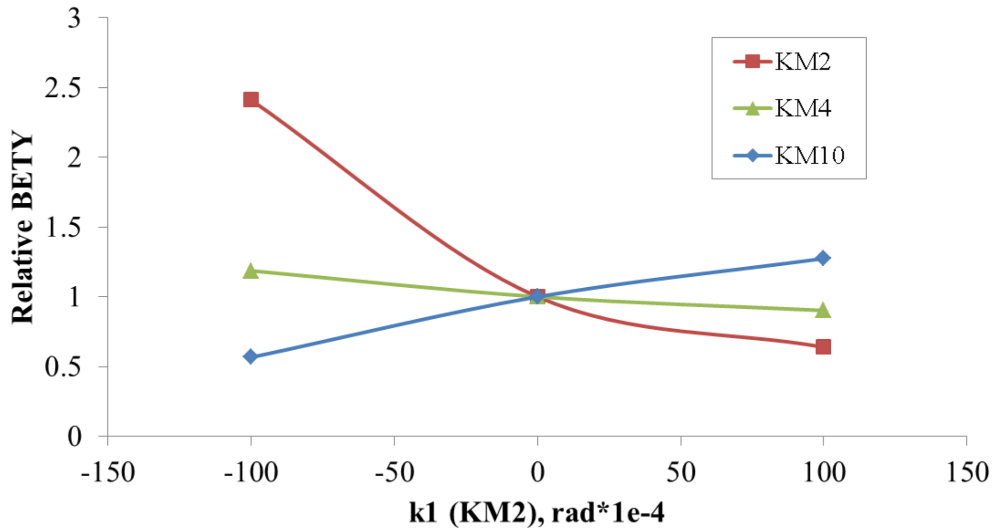
July 2016: beam time at SIS18

- **Simulations:**
  - Relative vertical β functions at BPMs, when corrector is on at k1=3e-2 m^{-2}

	KM2		KM4		KM10	
K1,rad	0.01	-0.01	0.01	-0.01	0.01	-0.01
BPM1	1.000	1.000	1.000	1.000	1.000	1.000
BPM2	0.639	2.411	0.902	1.187	1.275	0.566
BPM3	0.961	1.153	1.215	0.591	0.817	1.289
BPM4	0.794	1.802	0.776	1.426	1.359	0.433
BPM5	0.769	1.901	1.167	0.682	0.849	1.238
BPM6	0.981	1.076	0.965	1.066	1.218	0.656
BPM7	0.629	2.450	0.935	1.124	1.070	0.889
BPM8	1.046	0.822	1.191	0.636	0.965	1.055
BPM9	0.653	2.354	0.764	1.449	1.300	0.526
BPM10	0.937	1.248	1.270	0.486	0.830	1.268
BPM11	0.823	1.691	0.794	1.392	1.249	0.607
BPM12	0.742	2.006	1.138	0.738	1.033	0.948

July 2016: beam time at SIS18

- **Simulations:**
  - Relative vertical β functions at BPM2

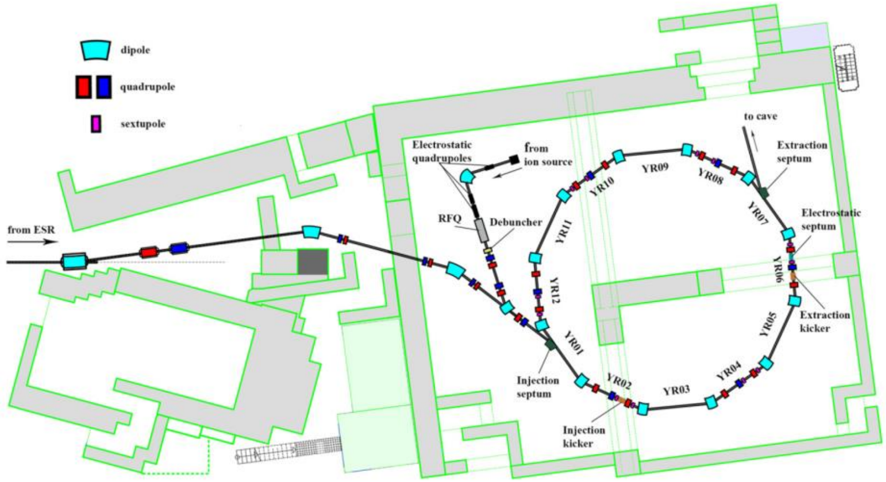


July 2016: beam time at SIS18

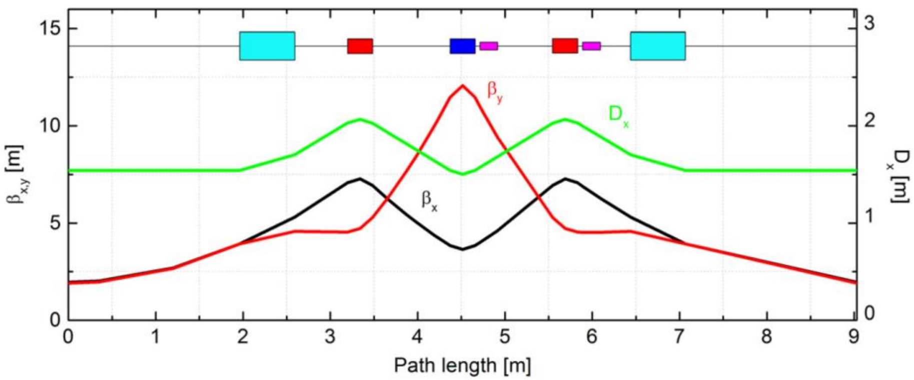
- **Preliminary results:**

	No perturbation		KM2	
BPM #	VERT	HOR	VERT	HOR
1	0.900592	0.861871	0.939785	0.918178
2	0.896227	0.967903	0.933133	1.008001
3	1.030901	0.963856	1.067163	1.018319
4	0.945044	0.98343	1.064039	1.101758
5	0.960413	0.930327	1.062991	1.05658
6	0.98567	0.911373	1.025001	0.95907
7	NA	NA	NA	NA
8	0.898251	0.949253	0.924489	0.998922
9	0.921067	0.993399	0.959565	1.038919
10	0.903527	0.936977	0.943956	0.977361
11	0.904338	0.94624	0.941217	0.997457
12	0.926496	0.96956	0.962524	1.009891

CRYRING



CRYRING@ESR layout



Lattice functions of CRYRING. Light blue - dipoles, blue/red - horizontally defocusing/focusing quadrupoles, purple - sextupoles

Parameters of CRYRING@ESR

Ring circumference	54.178 m
Magnetic rigidity	0.054–1.44 Tm
Max. injection energy of protons	30 MeV
Injection	fast and multi-turn
Injection energy from RFQ	300 keV u^{-1}
Extraction	fast and slow

<u>Status on 17 Nov 2016</u>:
- Ion source fixed
- Beam makes ~1.3 turns

v. chetvertkova @gsi.de