Interaction Regions: Nonlinear

Fulvia Pilat

motivation: **correction of nonlinear fields (beam control, luminosity)** → β squeeze, crossing angle

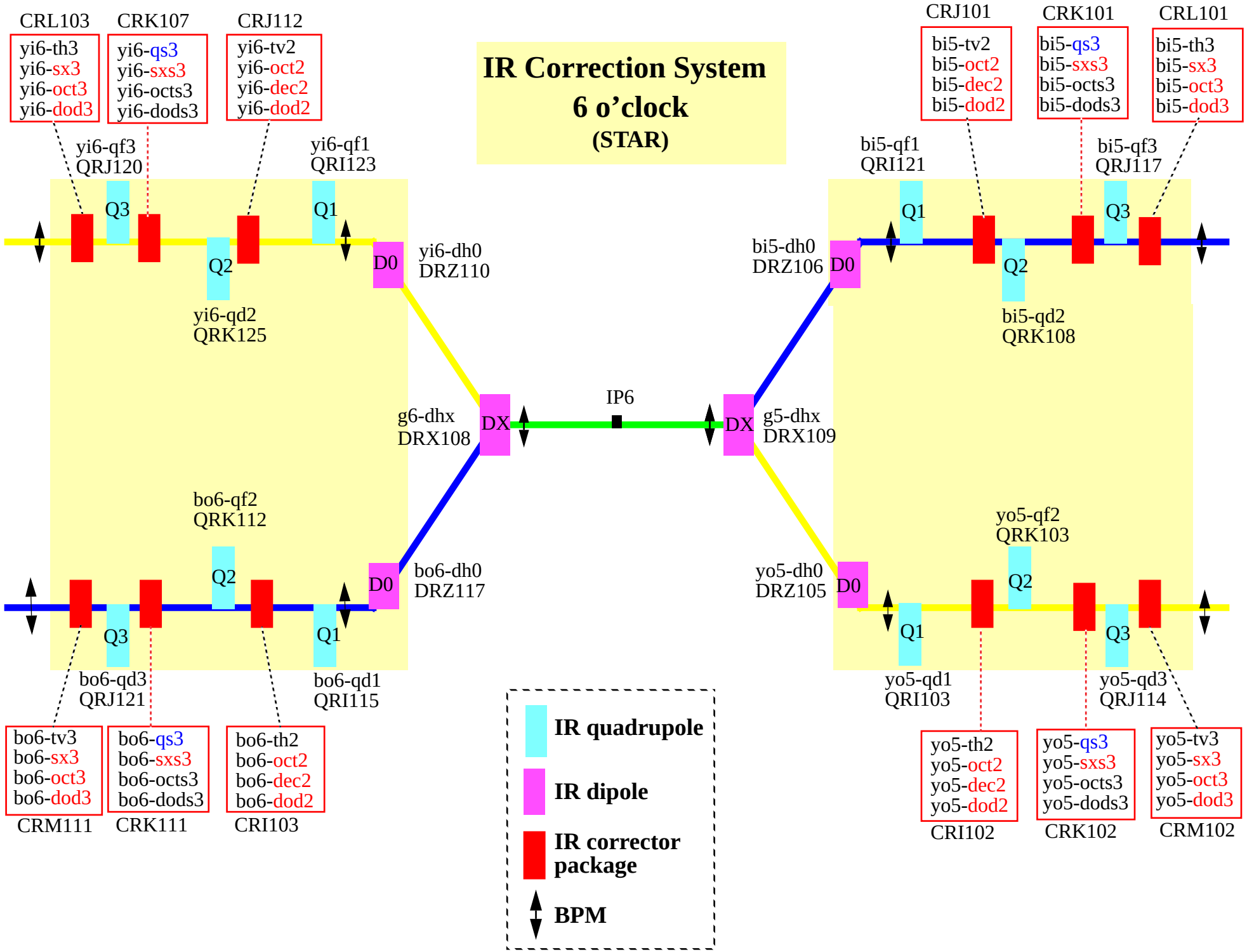
summary:

IR nonlinear **correction system**

IR nonlinear **correction methods**

IR bumps: preliminary **analysis** and **results**

Towards **Run 2001** **analysis**, plan for **beam studies**


IR Correction System
6 o'clock
(STAR)
CRL103
yi6-th3
yi6-sx3
yi6-oct3
yi6-dod3
CRK107
yi6-qs3
yi6-sxs3
yi6-octs3
yi6-dods3
CRJ112
yi6-tv2
yi6-oct2
yi6-dec2
yi6-dod2
yi6-qf3
QRJ120
yi6-qf1
QRI123
Q3
Q1
Q2
D0
yi6-dh0
DRZ110
yi6-qd2
QRK125
g6-dhx
DRX108
DX
IP6
DX
g5-dhx
DRX109
bi5-dh0
DRZ106
D0
CRJ101
bi5-tv2
bi5-oct2
bi5-dec2
bi5-dod2
CRK101
bi5-qs3
bi5-sxs3
bi5-octs3
bi5-dods3
CRL101
bi5-th3
bi5-sx3
bi5-oct3
bi5-dod3
bi5-qf1
QRI121
bi5-qf3
QRJ117
Q1
Q3
Q2
bi5-qd2
QRK108
bo6-qf2
QRK112
Q2
D0
bo6-dh0
DRZ117
Q3
Q1
bo6-qd3
QRJ121
bo6-qd1
QRI115
yo5-dh0
DRZ105
D0
yo5-qf2
QRK103
Q2
Q1
Q3
yo5-qd1
QRI103
yo5-qd3
QRJ114
bo6-tv3
bo6-sx3
bo6-oct3
bo6-dod3
CRM111
bo6-qs3
bo6-sxs3
bo6-octs3
bo6-dods3
CRK111
bo6-th2
bo6-oct2
bo6-dec2
bo6-dod2
CRI103
yo5-th2
yo5-oct2
yo5-dec2
yo5-dod2
CRI102
yo5-qs3
yo5-sxs3
yo5-octs3
yo5-dods3
CRK102
yo5-tv3
yo5-sx3
yo5-oct3
yo5-dod3
CRM102
IR quadrupole
IR dipole
IR corrector package
BPM

IR nonlinear correction methods

IR linear: IR bumps, action-angle, "local decoupling"

IR nonlinear:

dead-reckoning: **action-kick minimization** (Wei)
off-line **"IR filter"** (Tepikian)
order-by-order prescription, **assumes errors known** (5000 A)

semi-operational: **beam based** + **some off-line analysis**

IR bumps:
(Koutchouk)
analysis
package

measure and fit **observables vs. bump amplitude**:

rms orbit	(BPM's, linear, sextupole)
tunes	(Tune Meter, sextupole, octupole))
detuning	(Schottky, octupole, dodecapole?)
linear map (betas)	(AC dipole)

frequency analysis: **"better FFT"** detect and correct nonlinear **sidebands**
(Schmidt)
SUSSIX

IR bumps: method

analyze observables as a function of (horizontal / vertical) bump amplitude

multipole order n — off-axis --> **feed-down** on order m m<n

feed-down on dipole — $x_{rms} \approx b_{n-1(n)} \cdot \Delta x^{n-1}$ $y_{rms} \approx a_{n-1(n)} \cdot \Delta x^{n-1}$

rms orbit effect — **linear**...**sextupole** / **octupole** 1 μm BPM resolution (stability)

feed-down on quadrupole — $\Delta Q_{x(y)} \approx b_{n-1(n)} \cdot \Delta x^{n-2}$ $\Delta Q_{x(y)} \approx a_{n-1(n)} \cdot \Delta y^{n-2}$

tune shift effect — **sextupole**, **octupole**, **decapole?**

resolution for sextupole — $\Delta Q \approx \frac{1}{2\pi}\beta(Kl)b_{23} \cdot \frac{\Delta x}{R^2}$ $\Delta Q \approx 70 b_{23}$ at Δx=2cm

if ΔQ~0.001 then $\Delta b_{2,3}$ ~ 0.15 units

"background" — tune shift from rms orbit in lattice sextupoles
simulation with ideal lattice: ΔQ~0.0004

IR bumps: analysis and results

experimental data

IR bump	IP6 HOR	IP6 VER	IP8 HOR	IP8 VER	IP2 HOR	IP2 VER
Yellow	yo5	yo5	yi7	yi7	yo1	---
	yi6	yi6	yo8	---	yi2	yi2
Blue	bi5	---	bo7	---	bi1	bi1
	bo6	---	bi8	---	bo2	bo2

preliminary results:

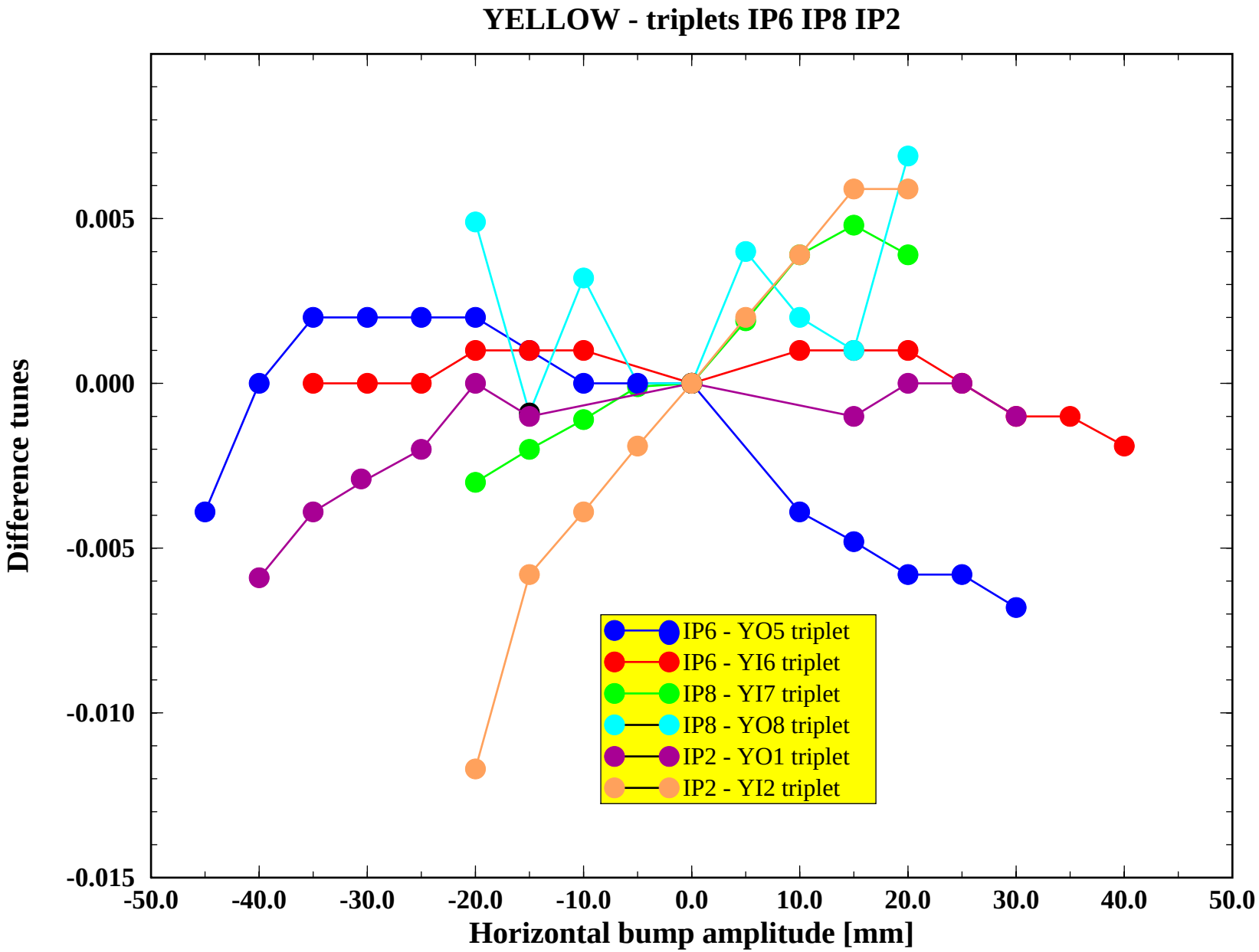
plots of tune shift vs. bump amplitude for all (measured) IR's

sextupole

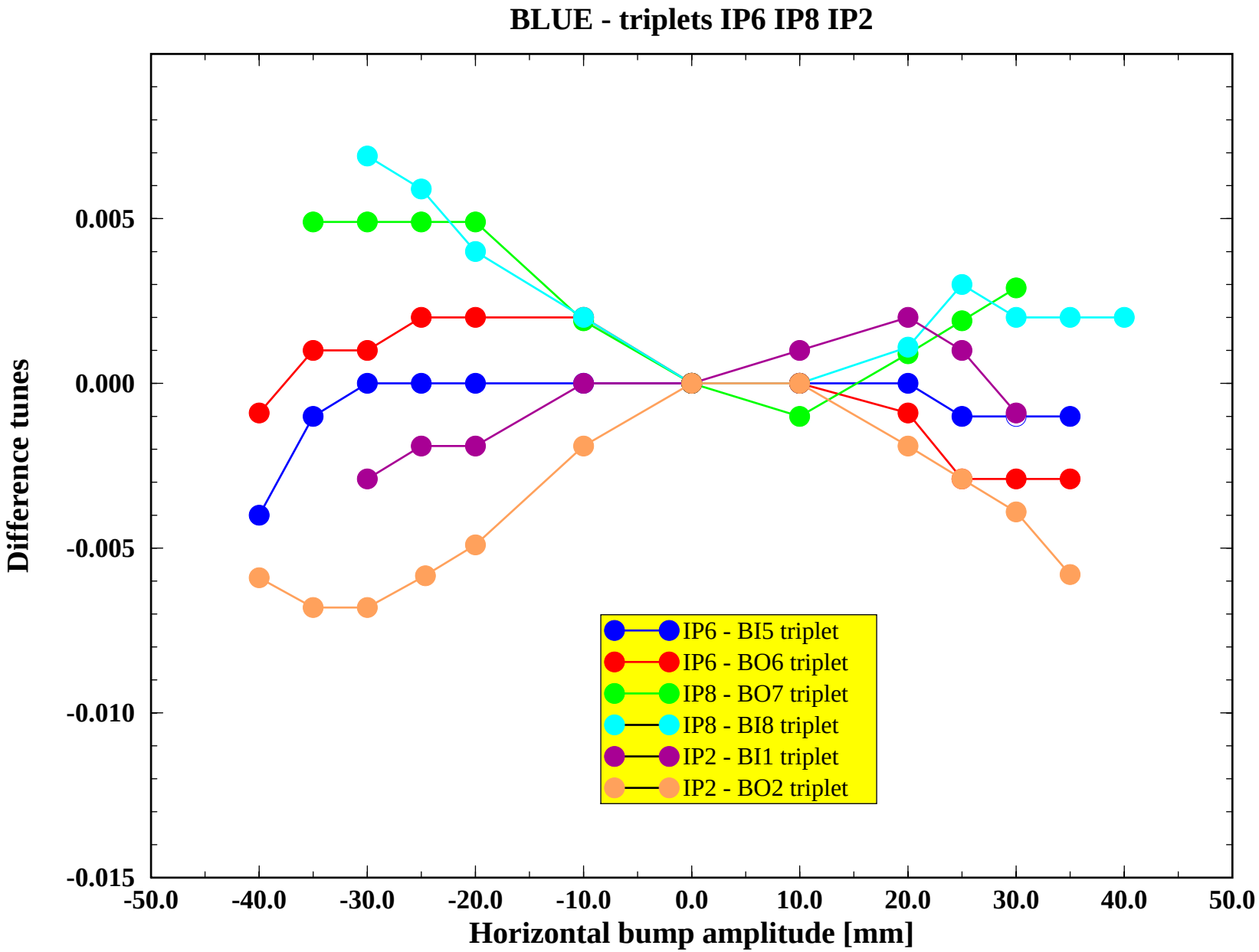
$$\Delta Q = \frac{\beta}{4\pi} kL\Delta x$$

IR	triplet	sextupole (K2L)
IP2	YI2	0.0164
IP8	YI7	0.0134
IP2	BI1	0.0042

Horizontal tune vs. horizontal bump



Horizontal tune vs. horizontal bump



IR studies: Plans for Run 2001

Analysis Run 2000 data

- systematic analysis of tune data - **prediction** for sextupole correction
- compare with RHIC **model**
- "disentangle" **normal and skew feed-down** effects (JPK, work in progress):

  multipoles: direct tune shift, indirect through coupling

  sum and **difference tunes**

$$Q_{sum} = Q_{x0} + Q_{y0} + \Delta Q_x + \Delta Q_y$$

$$Q_{diff} = \sqrt{(Q_x - Q_y)^2 + |c|^2}$$

Plans for Run 2001 beam studies

INJECTION

correct orbit, **IR coupling**, **machine coupling**
try **sextupole correction** in selected IRs
data for **frequency analysis**

COLLISION

correct orbit, **IR coupling**, **machine coupling**
nonlinear IR bump analysis at collision (data)
correction **sextupole (octupole)** in selected IRs
data for **frequency analysis**
nonlinearity vs. beta star (**beta squeeze**)