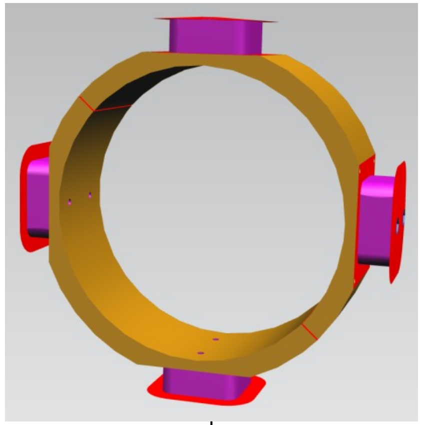
Analysis of 4 Gun Quadrupoles Behavior. Step 1.

Motivation: based on the collected data make proposal of GunQuads tuning procedure(s) that will be tested during the PITZ run period 15-18.04.2019

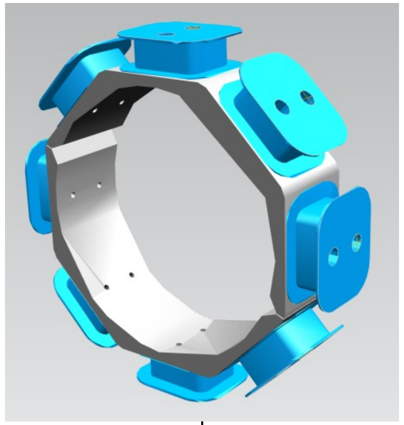
Igor Isaev
PPS
Zeuthen, 11.04.2019

Gun Quadrupoles Setup at PITZ

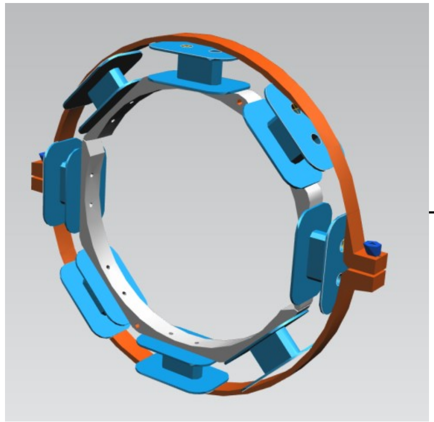
Design 1: GQ1

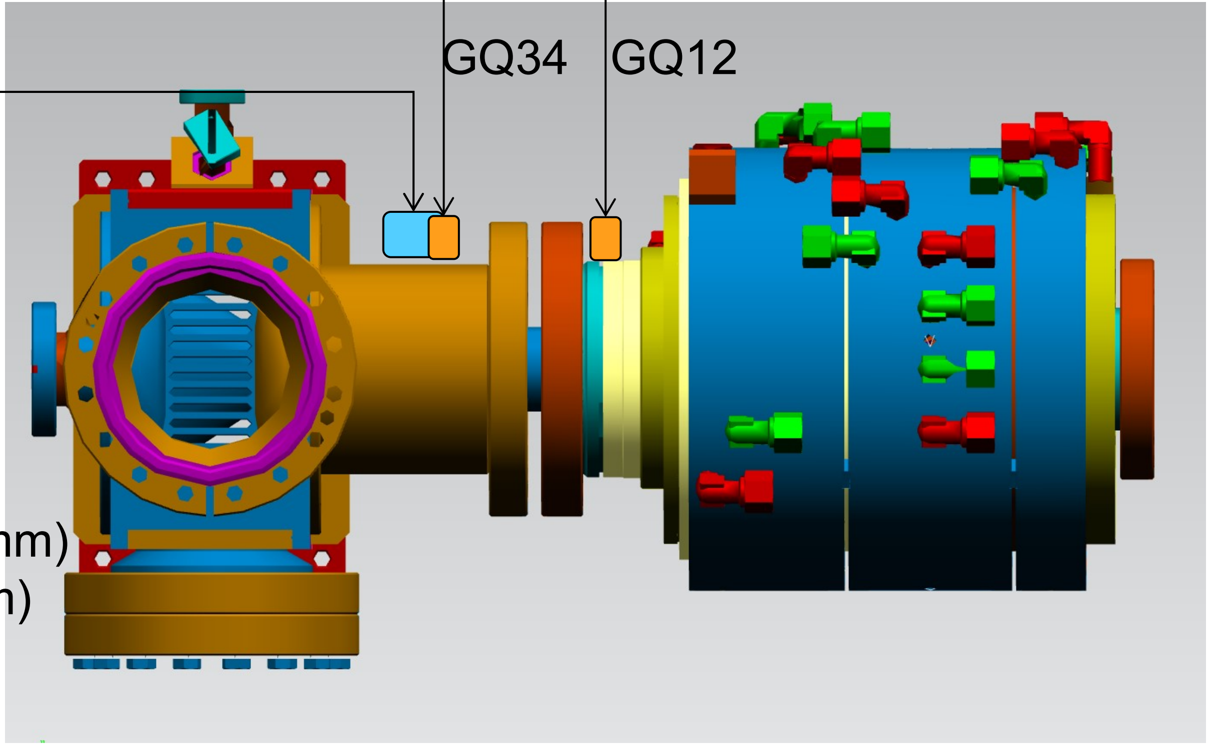


Design 2: GQ1,2



Design 3: GQ1,2,3,4





Parameters of the 3rd design:

- Combination of a normal and a skew quads:
  - GQ1 and GQ3 are Normal quads
  - GQ2 and GQ4 are Skew quads
- Aluminum frame
- Non-magnetic screws
- GQ12 Zposition = 233mm (solenoid begin 208.5mm)
- GQ34 Zposition = 315mm (solenoid end 343.5mm)

Data collection: experiments

For the data collection there were performed detailed <u>GunQuad scans</u>:

- GQ1 vs GQ2
- GQ3 vs GQ4
- GQ1+GQ2 as rotational quadrupole
  vs
  GQ1+GQ2 as rotational quadrupole

at the following parameters:

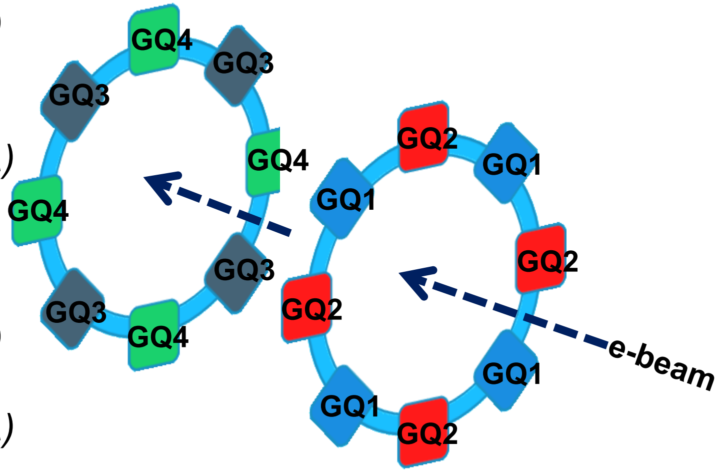
- Ibucking = 0A
- Booster: OFF

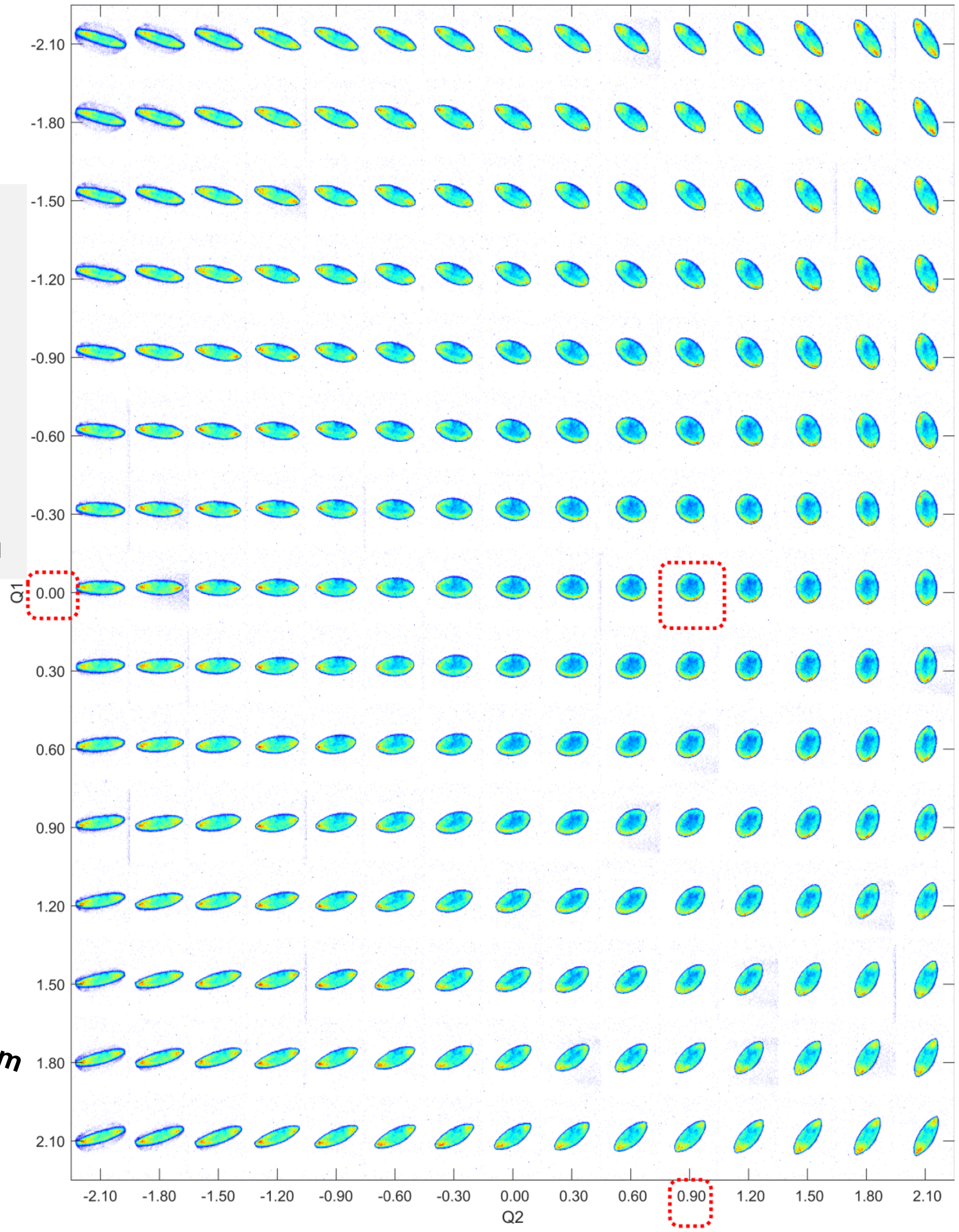
- Gun power **5.8MW**
  - Normal solenoid polarity
    - *Low.Scr3 (Imain=360A)*
    - *High1.Scr1 (Imain=336A)*
  - Opposite solenoid polarity
    - *Low.Scr3 (Imain=-360A)*
    - *High1.Scr1 (Imain=-336A)*

- Gun power **4.5MW**
  - Normal solenoid polarity
    - *High1.Scr1 (Imain=299A)*
  - Opposite solenoid polarity
    - *High1.Scr1 (Imain=-299A)*

Example:

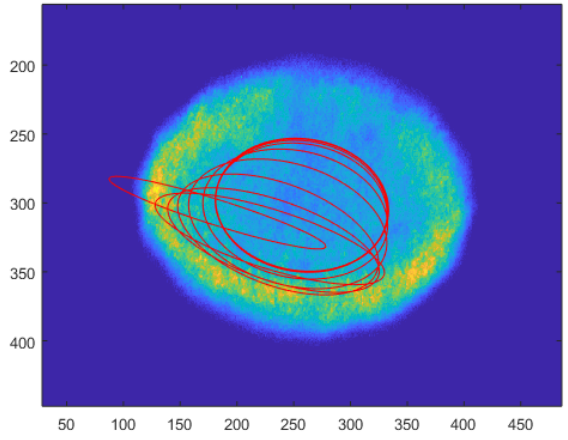
- Quad Scan GQ1 vs GQ2
- Gun power: 4.5MW
- Imain = 299A
- Ibucking = 0A
- High1.Scr1
- Normal Solenoid Polarity
- Name: G45H1S1_GQ12_Norm

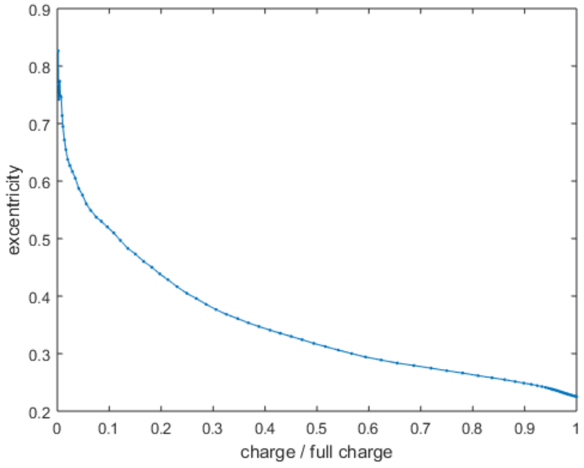




Data Analysis: roundness calculation.

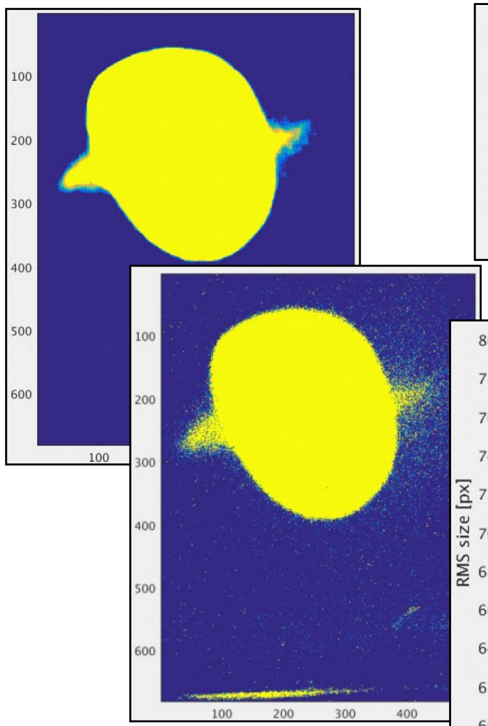
Ellipse fitting algorithm



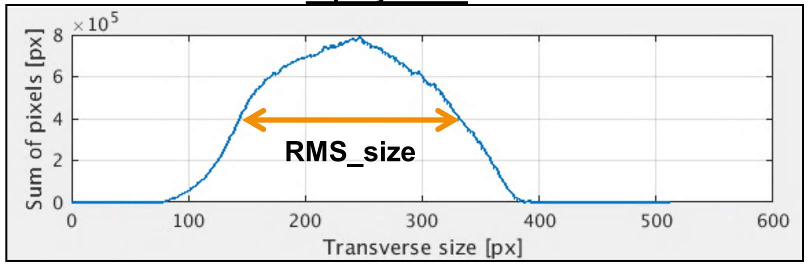


Direct algorithm

1. Rotating the original image (imrotate)
2. Getting projection (projection = sum(imc,1))
3. Calculating RMS size of the projection
   - mu = sum(x*y)/sum(y)
   - RMS_size = sqrt(sum((x-mu)^2 *y) /sum(y))
4. Calculating roundness for original image as integral value of RMSvsAngle array



X projection



RMS sizes vs rotation angle

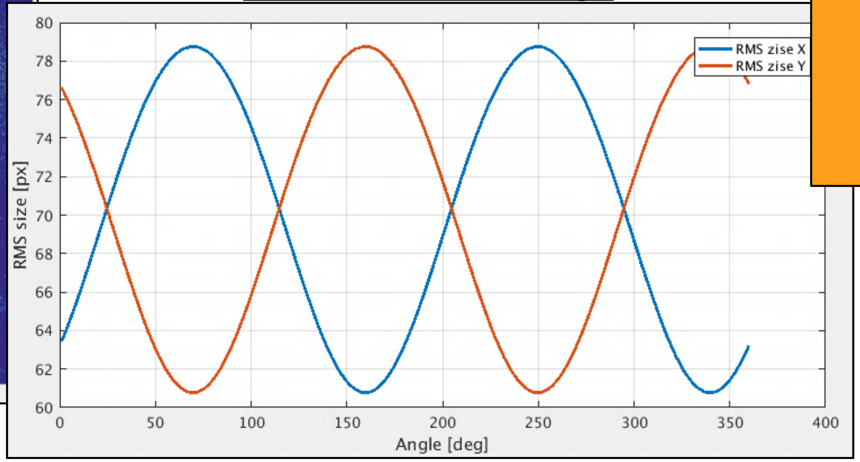
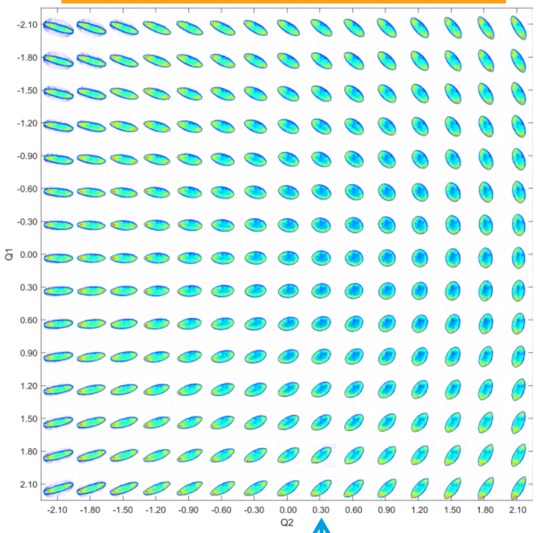
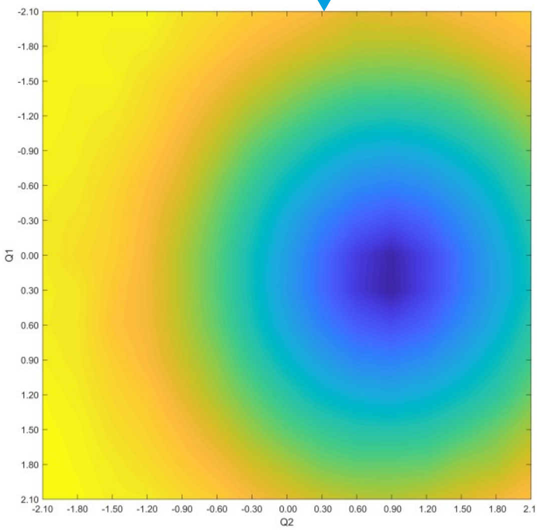


Image Roundness = 0.7716
Filtered image Roundness = 0.7747

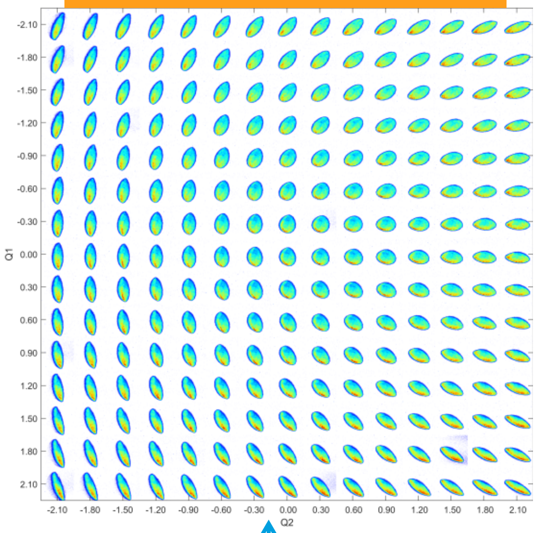
Data Analysis: results

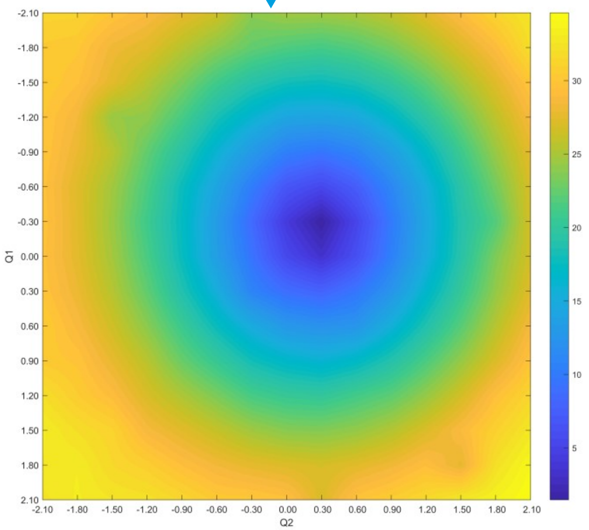
G45H1S1_GQ12_Norm





G45H1S1_GQ12_Opps

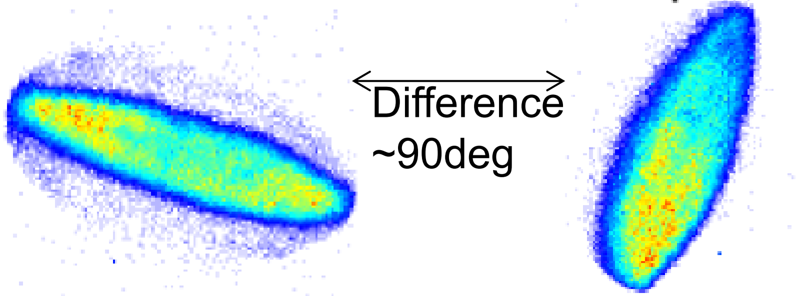


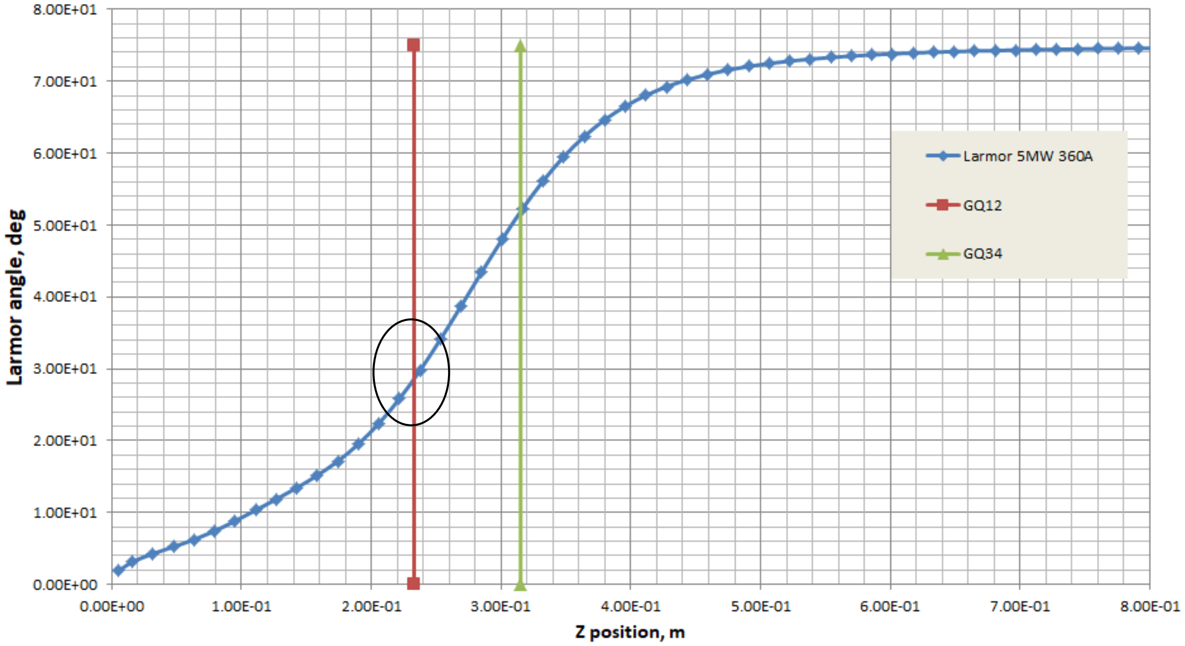


Asymmetric beam shape orientations

GQ1 = -2.1A GQ2 = 0A

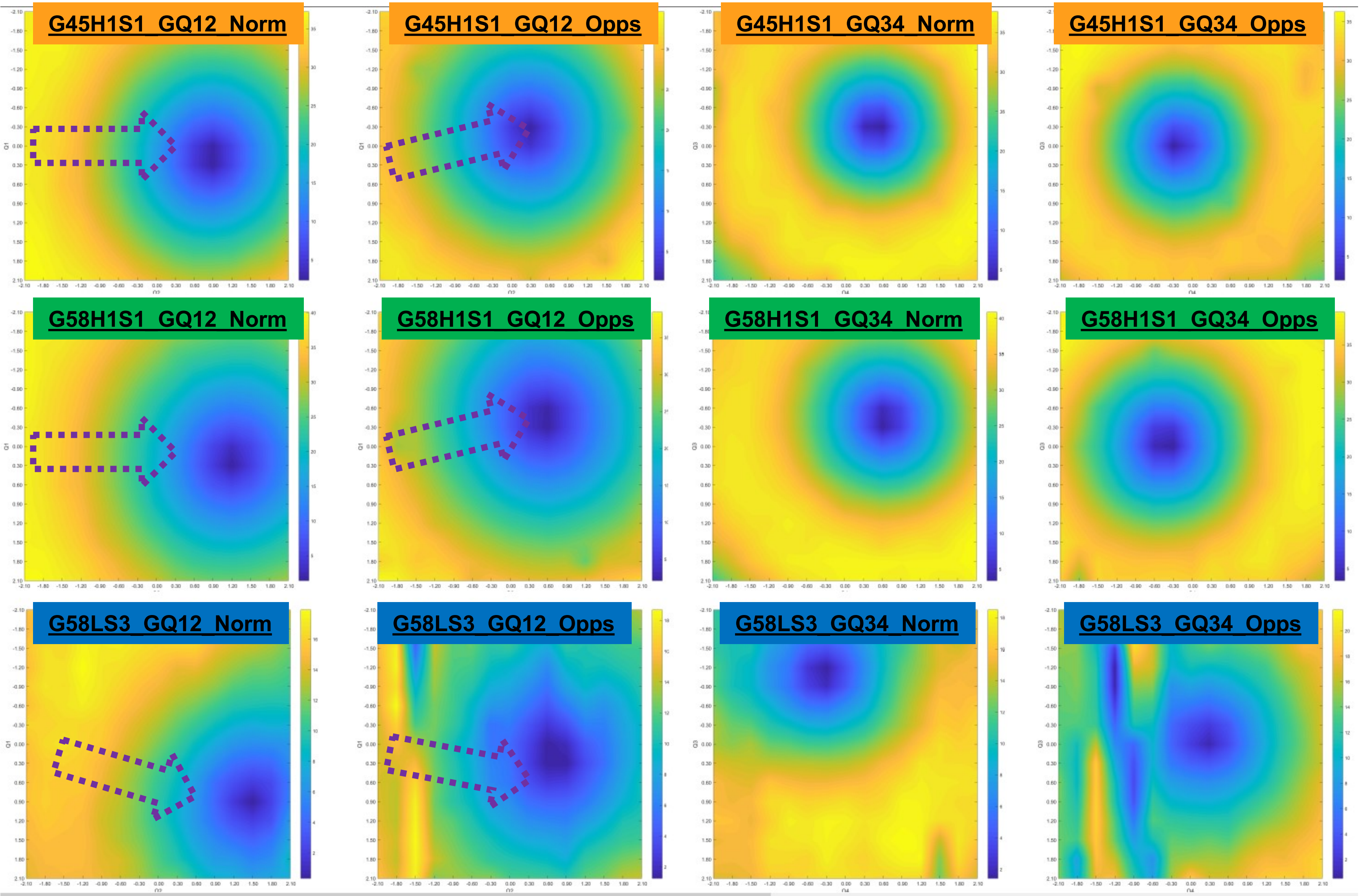
G45H1S1_GQ12_Norm **G45H1S1_GQ12_Opps**





Larmor angle at GQ12 is 28.6deg
Final Larmor angle is 74.87deg
$\Rightarrow$ difference is 46.27deg
x2 (Normal and Opposite polaroties) => 92.54deg

Data Analysis: results GQ12 and GQ34 scans

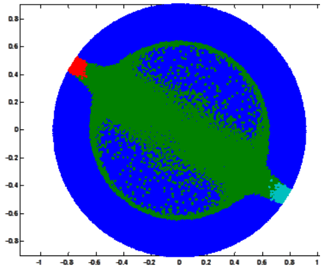
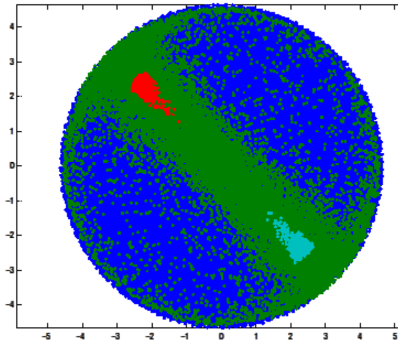
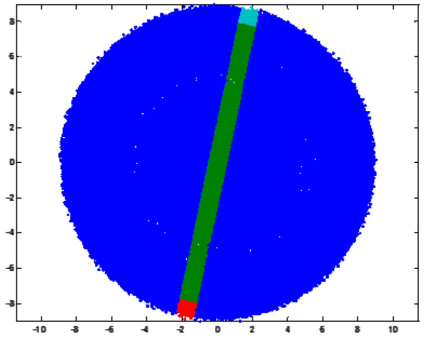
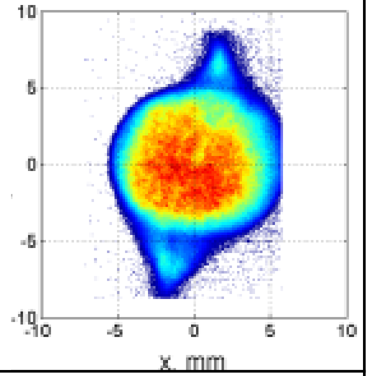
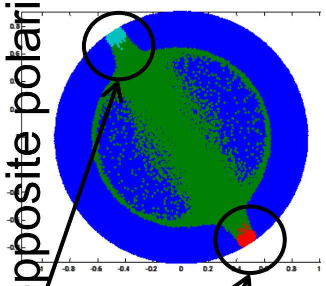
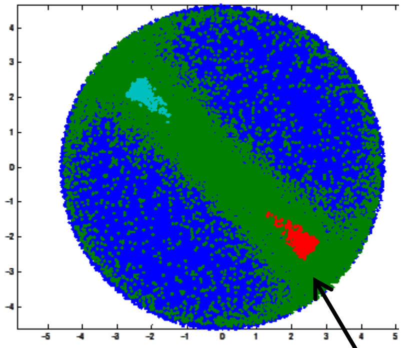
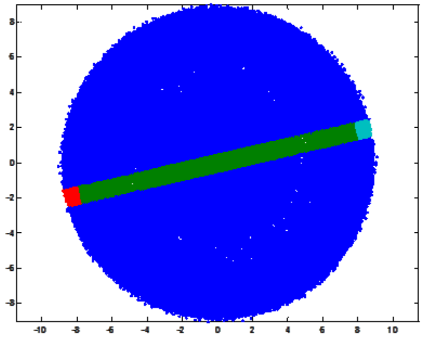
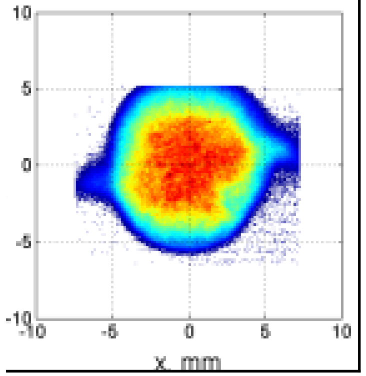


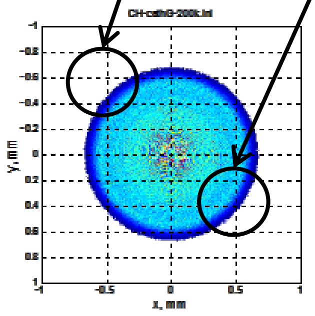
Currents Settings:
-2.1 : 0.3 : 2.1 [A]

Intermediate conclusions:

- as stronger solenoid as stronger GQ12 and GQ34 amplitude that should applied for compensation

Larmor experiment interpretation: “tracking back” towards cathode

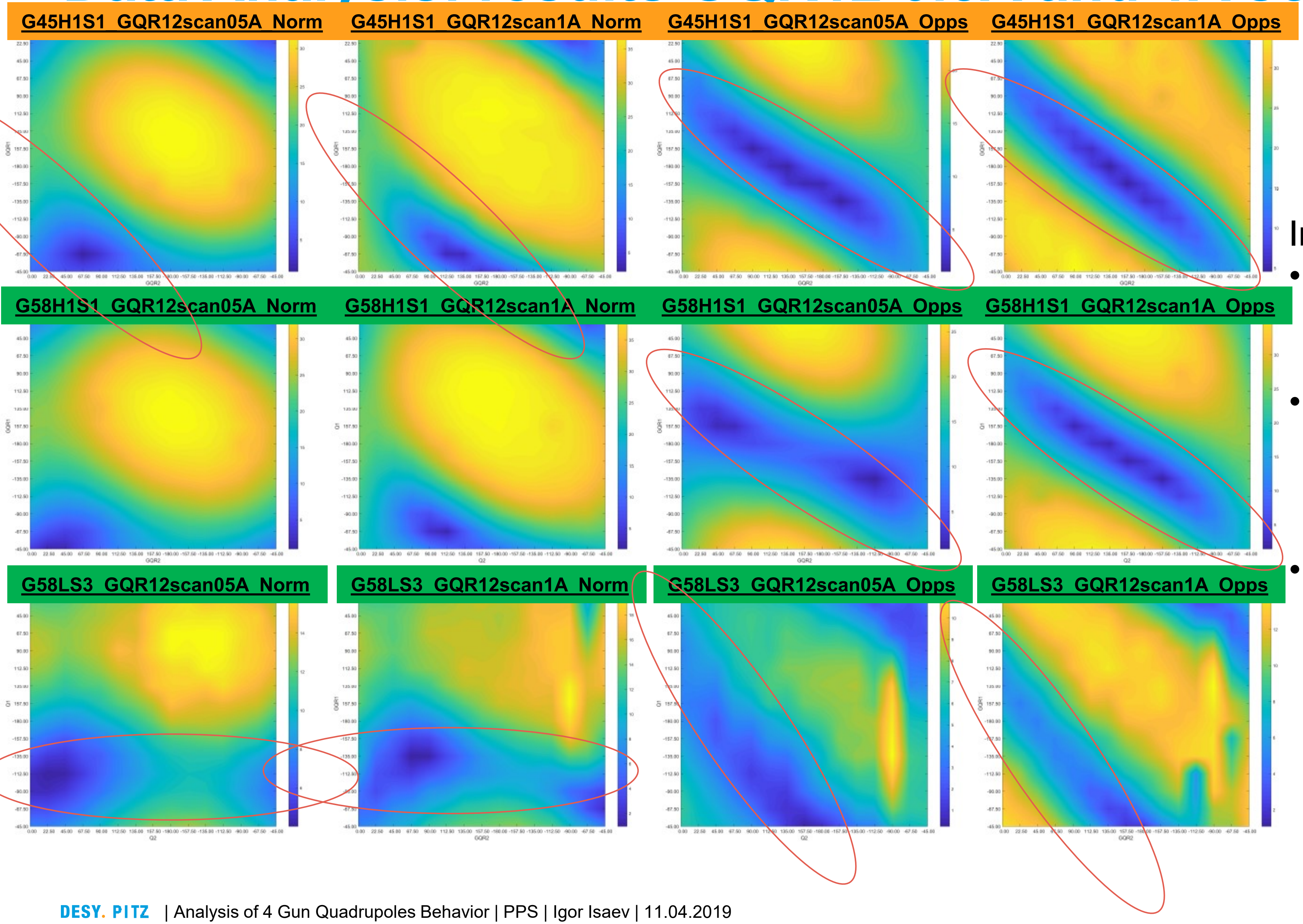
	Cathode	Z=0.18m	EMSY	
MaxB=+0.208692T (+361A) normal polarity				
MaxB=-0.208692T (-361A) opposite polarity				



The edge particles at EMSY coming from the halo particles at the cathode

45° Kick → skew quadrupole?
The kick at z=0.18m is oriented by 45°.
Could it be described by a skew quadrupole?

Data Analysis: results GQR12 0.5A and 1A scans



Agnles Settings:
0 : 22.5 : 180 [deg]
-180 : 22.5 : 0 [deg]

Intermediate conclusions:

- GQR Amplitude does not significantly change map distribution
- There is always dependence GQR1 vs GQR2 angle for values valley **<- this must be characterized**
- This dependence can be utilized for the tuning

Proposals for Gun Quadrupoles tuning

The main tool for the Tuning is the Gun Optimizer created by Gregor Loisch

A. Set round beam at H1S1 by G2 only, and afterwards tune GQ34 at the same screen
B. Set round beam at H1S1 by G12, and afterwards tune GQ34 at the same screen
C. Set round beam at H1S1 by G12, and afterwards tune GQ34 at different screen
D. (?) Iteratively Adjust GQ12 at H1S1, then tune GQ34 at H1S2 and repeat
E. Use GQ1234 tuning and initial point take from dependence GQR1 vs GQR2

Preferable constraints :

- The GQ settings must be limited to 0.6A
- Do not use Low.Scr3 -> too small images

BACKUP slides

Gun powe	4.5MW				
Screen	High1.Scr1				
Imain	299A				
Ibucking	0A				
Solenoid	Normal		Opposite		Units
Quad	A	B	A	B	
GQ12	0	0.9	0	0.3	A
GQ34	-0.3	0.3	-0.3	-0.3	A
GQ34			0	-0.3	A
GQR 0.5A	-67.5	67.5	180	135	deg
GQR 1A	0	-135	180	135	deg
GQR 1A	0	-112.5			deg
GQR 1A	22.5	-90			deg
GQR 1A	-67.5	135			deg

Gun powe	5.8MW				
Screen	High1.Scr1				
Imain	336A				
Ibucking	0A				
Solenoid	Normal		Opposite		Units
Quad	A	B	A	B	
GQ12	0	1.2	-0.3	0.6	A
GQ34	-0.6	0.6	-0.3	-0.6	A
GQ34			-0.3	-0.3	A
GQ34			0	-0.6	A
GQ34			0	-0.3	A
GQR 0.5A	0	-22.5	-157.5	180	deg
GQR 0.5A	-45	45			deg
GQR 0.5A	-22.5	-22.5			deg
GQR 1A	-67.5	90	180	112.5	deg
GQR 1A	-67.5	112.5			deg
GQR 1A	0	-90			deg

Gun powe	5.8MW				
Screen	Low.Scr3				
Imain	360A				
Ibucking	0A				
Solenoid	Normal		Opposite		Units
Quad	A	B	A	B	
GQ12	0.3	0.6	0.6	0.9	A
GQ34	-0.6	-0.3	0	0.6	A
GQR 0.5A	-135	112.5	0	22.5	deg
GQR 0.5A			0	0	deg
GQR 0.5A			22.5	45	deg
GQR 1A	-135	157.5	45	-67.5	deg
GQR 1A			-45	135	deg

Decomposition for constant and sweep parts vs normal and opposite polarities

Const-Sweep Quads <- for normal and opposite polarities

x1+x2=A1 y1+y2=B1

x1-x2=A2 y1-y2=B2

x1=A1/2+A2/2

x2=A1-x1

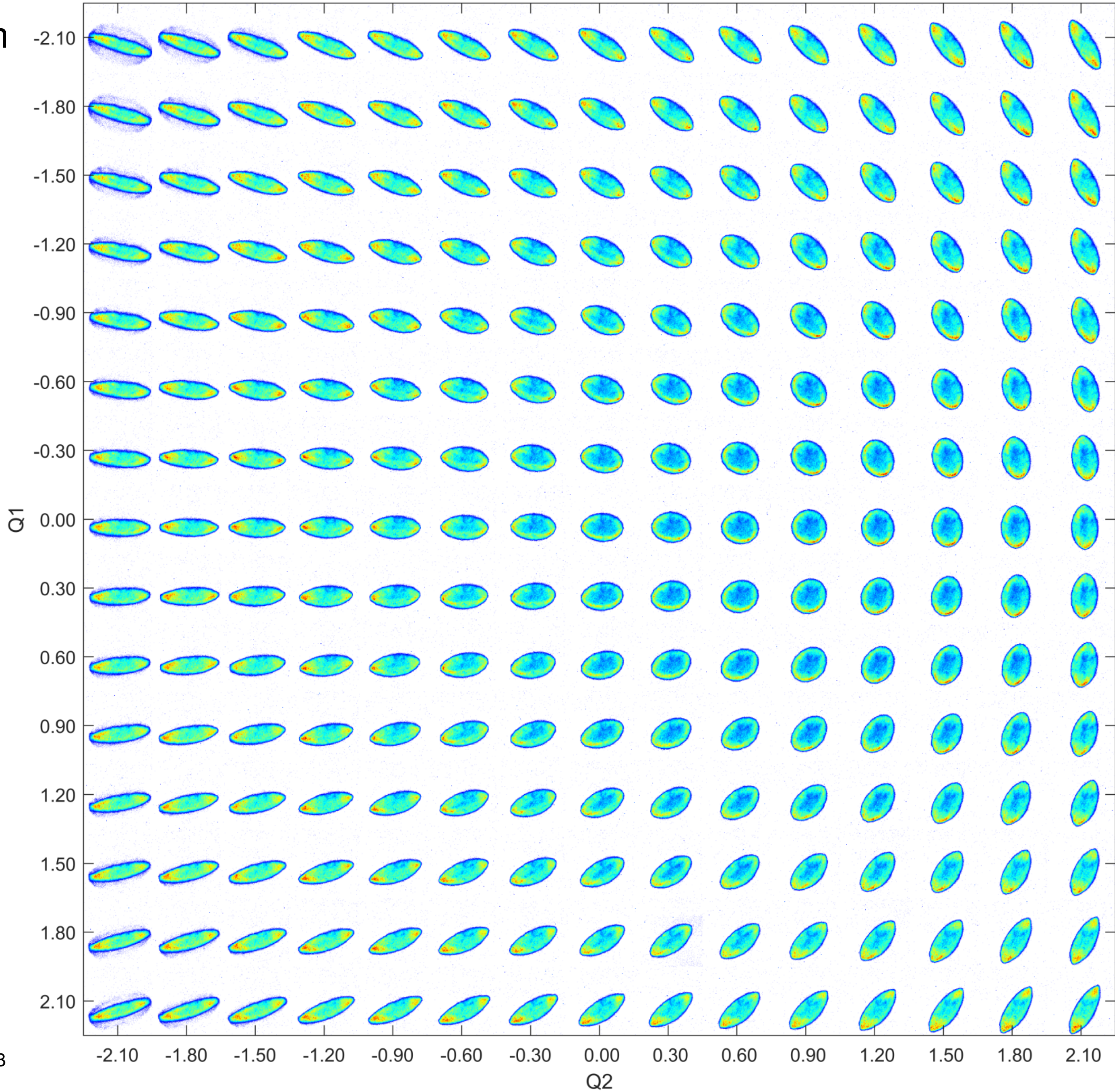
	GQ12			GQ34	
	QA	QB		QA	QB
const	0	0.6	const	-0.15	0
sweep	0	0.3	sweep	-0.15	0.3

	GQ12			GQ34	
	QA	QB		QA	QB
const	-0.15	0.9	const	-0.3	0.15
sweep	0.15	0.3	sweep	-0.3	0.45

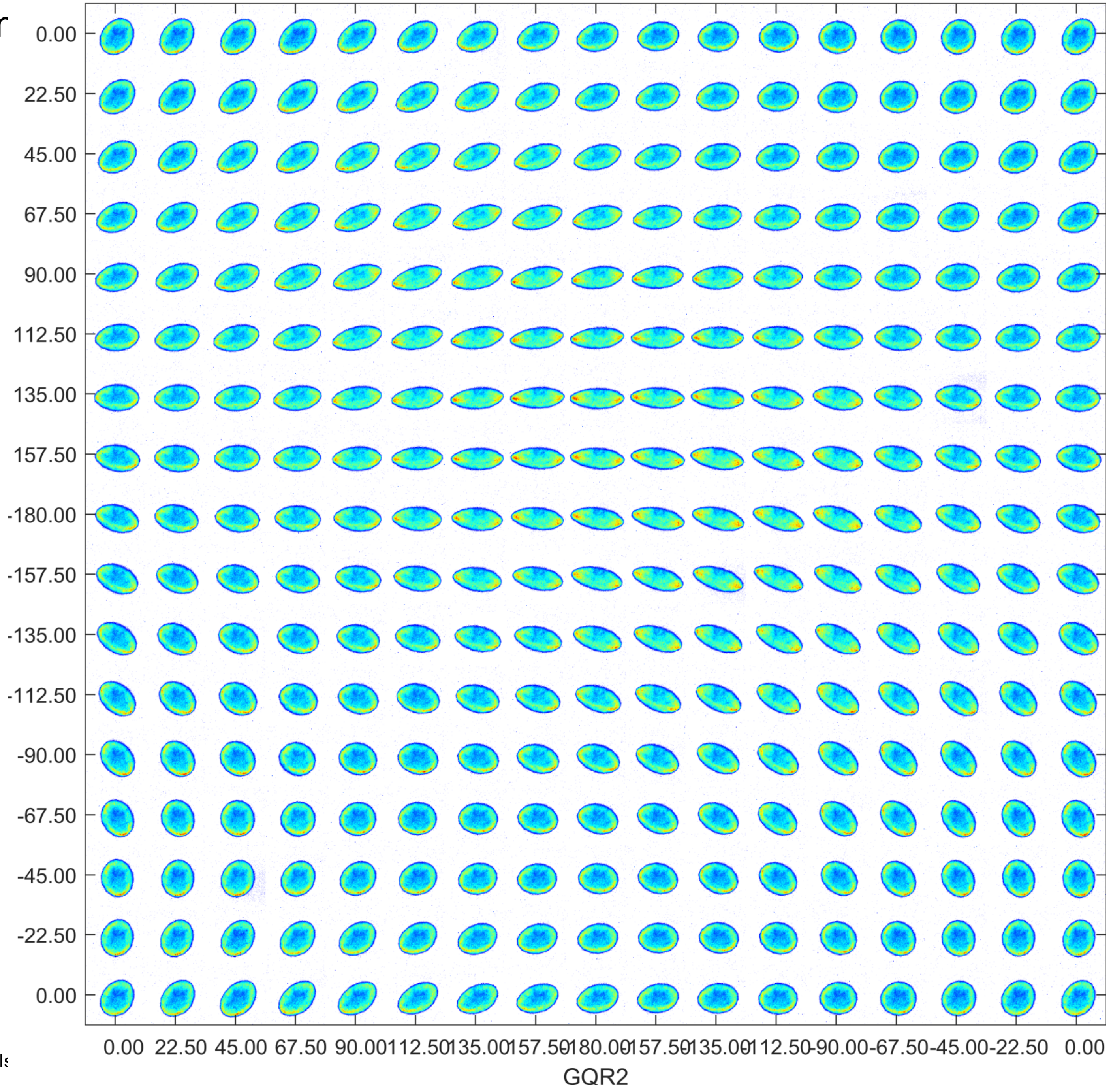
	GQ12			GQ34	
	QA	QB		QA	QB
const	0.45	0.75	const	-0.3	0.15
sweep	-0.15	-0.15	sweep	-0.3	-0.45

DI

G45H1S1_GQ12_Norm



G45H1S1_GQR12scan05A_Norm



G58LS3_GQ12_Norm