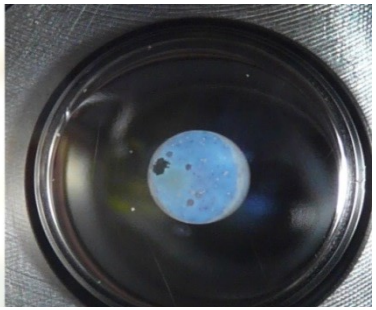
# PITZ Run coordination meeting.

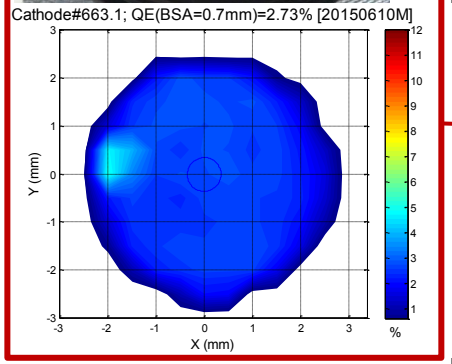
M. Krasilnikov
15.10.2015

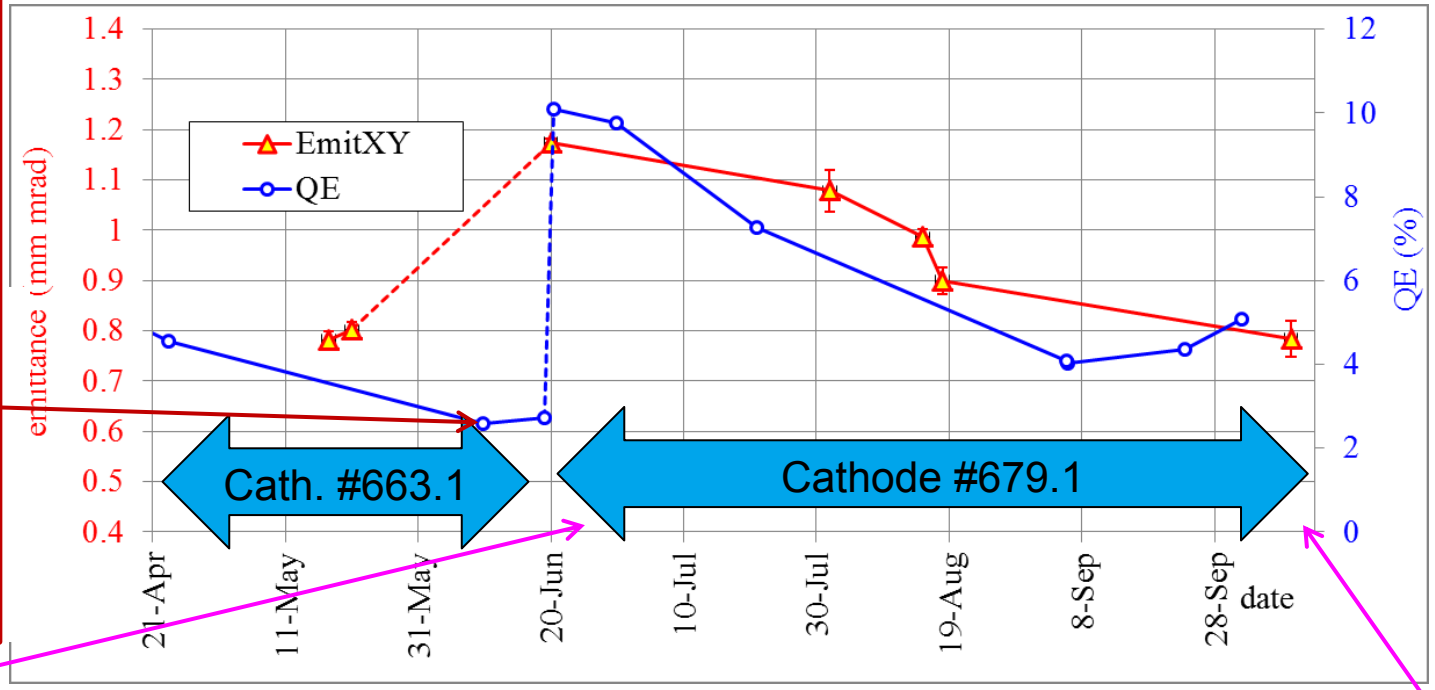
HELMHOLTZ GEMEINSCHAFT

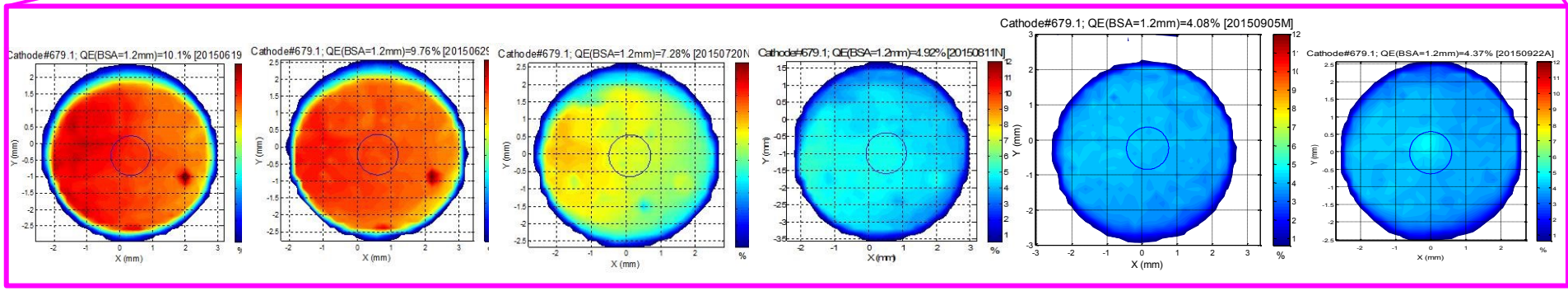
DESY

# 500 pC measured emittance and cathode QE at PITZ in 2015





# Technical shifts

T1 = Works on RF (uTCA) → (W. Koehler + HH-experts):
- T1a – check
- T1b – main works (RF experts)
- T1c – stability measurements

T2 = Dark current for DCM1 → (F. Tonisch)

T3 = E-beam for LOW.ICT1, HIGH2.ICT? → (F. Tonisch)

T4 = Preparation for TDS; max bunch charge (LT=90%) for 5MWg+MMMG for various BSA=0.2 mm → 3.5 mm → (H. Huck)

T5 = Acoustic sensor tests (6MW x 650us) → (M. Pohl)

T6 = …

| to do: | Technical Shifts (~0900-1700) | | | | | | |
|---|---|---|---|---|---|---|---|
| Week 42 | Mon Oct-12 | Tue Oct-13 | Wed Oct-14 | Thu Oct-15 | Fri Oct-16 | Sat Oct-17 | Sun Oct-18 |
| Morn. 7:00 to 15:30 | Renier | Renier | Rublack | Rublack | Vashchenko | | |
| | **T1a, T1c** | **T2, T3, T5** | **T3, T4, T5** | | **T1b, T1c** | | |
| Late 15:00 to 23:30 | | | | | | | |
| Night 23:00 to 7:30 | | | | | | | |

# Measurement program

1. **Emit500** = Emittance measurements for 500 pC, long Gaussian cathode laser pulse and 60MV/m? (GV, MK) → trajectory + stability?
2. **PITHz** – (BP) ?
   1. **PITHz4nC** = emittance for 4nC and BSA=3.0mm?
   2. **PITHzShortB**
3. **Foil4Plasma** = Experiments with foils in HIGH1.Scr2,4 (MG)
4. **TDS** = TDS studies: gun + booster at MMMG; Scan: bunch length vs (BSA, charge) – (HH, MK)
   1. **TDS – long**
   2. **TDS – short** (BSA=2; 3mm, first $Q/\sigma_t$→ max(LT), then min(Xyrms@EMSY2) )
5. **Emis** =Repeat some emission studies (esp., 1.5MW is not understood) – (MK, but from 26.10.2015)
6. **GunTests** – YR
   1. Fast gun recovery tests? (+O.Hensler) – 29.10M + 30.10A 2x2hurs
   2. Acoustic sensor tests (6MW x 650us – provoke gun IL) – (+Mario)
7. **CoupKick** = Remaining coupler kick studies – (IgI)
   1. Test solenoid movement (e-beam focused at LOW screens vs. solenoid angles) - (+MK)
8. **QE** = QE-map and QE?

| to do: | Measurements | | | | | | |
|---|---|---|---|---|---|---|---|
| Week 43 | Mon Oct-19 | Tue Oct-20 | Wed Oct-21 | Thu Oct-22 | Fri Oct-23 | Sat Oct-24 | Sun Oct-25 |
| Morn. 7:00 to 15:30 | Gross Isaev | Gross Isaev | Gross Isaev | Foil4Plasma Gross Lishilin | Gross Lishilin | | Rublack Lishilin |
| Late 15:00 to 23:30 | Renier Kalantaryan | | Renier Kalantaryan | | | Huck Gross | Huck Gross |
| Night 23:00 to 7:30 | Good Melkumyan | Good Melkumyan | | | | Good Isaev | |

Emit500

CoupKick / Emit500

TDS - long

| to do: | Measurements | | | | | | |
|---|---|---|---|---|---|---|---|
| Week 44 | Mon Oct-26 | Tue Oct-27 | Wed Oct-28 | Thu Oct-29 | Fri Oct-30 | Sat Oct-31 | Sun Nov-01 |
| Morn. 7:00 to 15:30 | Krasilnikov Rublack | CoupKick (solAngle) Krasilnikov Rublack | | GunTests Melkumyan | Krasilnikov | Krasilnikov Melkumyan | |
| Late 15:00 to 23:30 | Boonpornpras Lishilin | | Boonpornpras Lishilin | short Rublack Huck | | | |
| Night 23:00 to 7:30 | | Vashchenko Pathak | Vashchenko Pathak QE | PITHz ShortB Boonpornpras Pathak | GunTests Boonpornpras Pathak | | Boonpornpras Pathak |

PITHz4nC

Emit?

TDS – short Emit - short

Emis

# Emittance measurement program (GV)

Possible reasons:

- Not optimized beam trajectory for 6.3 MW: beam trajectory was optimized to be steering free through the booster but it not necessary should provide the smallest emittance. Proposal: scale magnets currents according to the relation of beam momenta, try other trajectories for 500 pC
- Amplification of beam distortions (asymmetries) has larger impact on beam quality for higher gun gradients than gained emittance reduction. Proposal: as charge density plays a role try to compare emittance for different beam charges: 100 pC, 250 pC, 1 nC

Additionally → short Gaussian cathode laser pulses:

- Optimize emittance for 250 and 100 pC?

Timeline:

- 3 shifts for the 1st point
- 30 shifts for the 2nd point

# PITHz = E-beam studies for THz option (PB)

**PITHz4nC = Preliminary Beam optimization for SASE FEL**

**Objective:**
**4 nC** beam optimization and transport

**Initial setting**
- Long Gaussian laser pulse length: **~12 ps** FWHM
- Gun: **6 MW** in the cavity, **200 us** RF pulse duration
- Booster: **3 MW** in the cavity, **200 us** RF pulse duration

**Procedure**
**Optimization of machine parameters**
1. Adjust BSA=3.0mm
2. Find laser transmission to produce bunch charge of **4 nC** (LOW.FC2+attenuator, HIGH1.ICT1) at gun+booster=MMMG phases
3. LEDA scan, set to MMMG phase
4. HEDA1 scan, set to MMMG phase
5. Optimize $I_{main}$ for minimum transverse emittance by measuring emittance vs. $I_{main}$ using EMSY1

**Beam Transport**
6. Set $I_{main}$ for the minimum emittance
7. Measure the temporal profile using **TDS**
8. Transport beam to and focus beam at High2.Scr2 (Quadrupole magnets downstream from the High1.Scr1 can be used.)
9. Print and save beam images from all screens (Low.Scr1…Low.Scr3, High1.Scr1 … High1.Scr5, PST.Scr1 … PST.Scr5, High2.Scr1 and High2.Scr2)
10. Measure momentum spread using HEDA2

**Option:** LPS tomography (D.Malyutin tool) using HEDA1 and HEDA2

# PITHz = E-beam studies for THz option (PB)

**PITHzShortB = Preliminary Beam optimization for CTR experiments**

**Objective:**
Studies of velocity bunching using the CDS booster for **100 pC** electron beam

**Initial setting**
Laser Gaussian pulse length: short **2.5 ps** FWHM
Gun: **6 MW** in the cavity, **200 us** RF pulse duration
Booster: **3 MW** in the cavity, **200 us** RF pulse duration

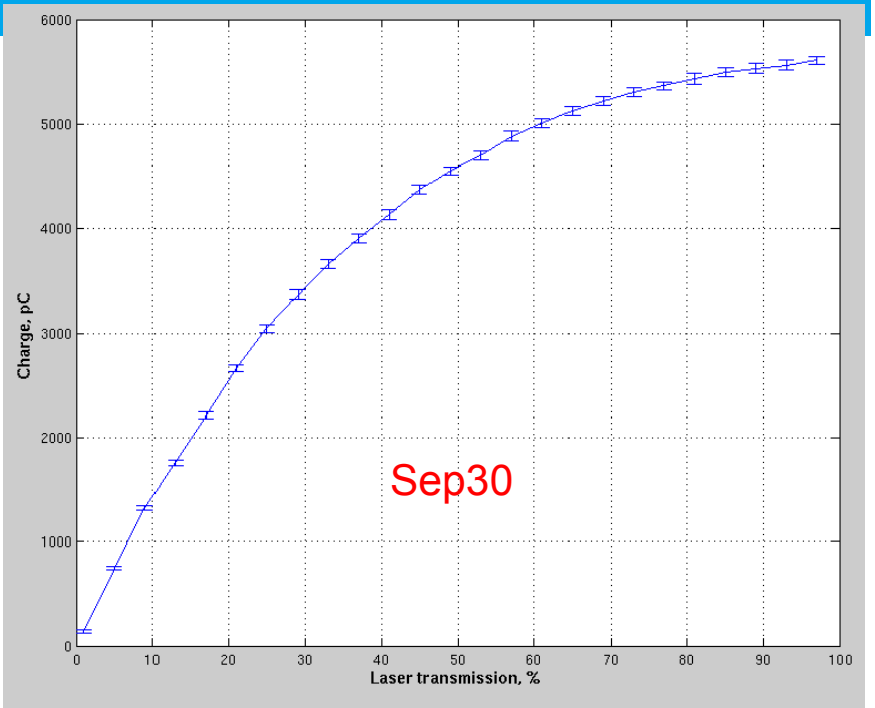
**Procedure**
1. Fix laser transmission at 50%
2. Adjust BSA, as small as possible, for bunch charge of 100 pC using Low.FC2 (gun+boo=MMMG)
3. LEDA Scan, set to MMMG phase
4. HEDA1 scan, set to MMMG phase
5. Transport beam to PST.Scr1
   - $I_{main}$ set for minimum beam size at PST.Scr1
   - Check charge at High1.ICT1
6. Measure bunch length VS booster phase using TDS (scan for the minimum bunch length)

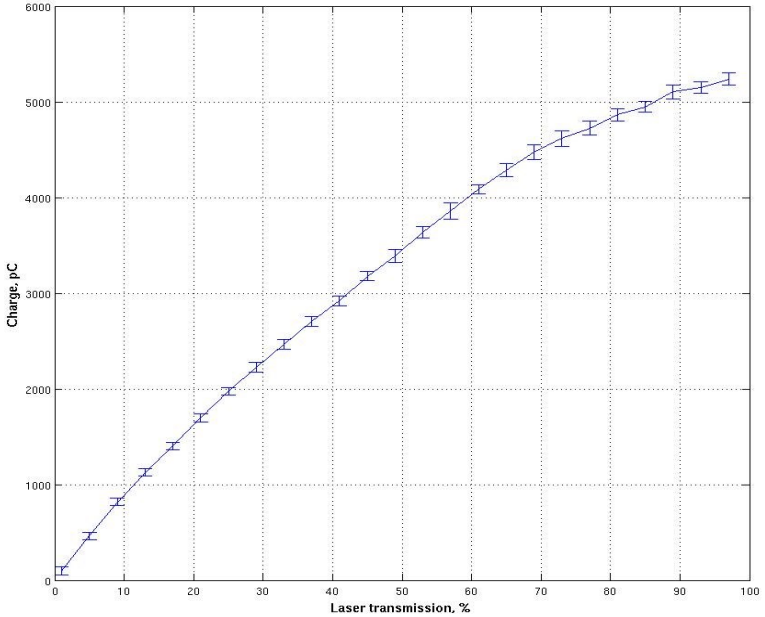
# TDS = TDS studies: bunch length vs (BSA, charge) (HH)

Photocathode laser: short / long Gaussian
gun + booster at MMMG;
Scan: bunch length vs (BSA, charge)

| | BSA=0.2mm | BSA=0.4mm | … | … | … | … | BSA=2.4mm | BSA=3.0mm |
|---|---|---|---|---|---|---|---|---|
| ?Q=20pC | | | | | | | | |
| Q=100pC | | | | | | | | |
| Q=250pC | | | | | | | | |
| Q=500pC | | | | | | | | |
| Q=750pC | | | | | | | | |
| Q=1nC | | | | | | | | |
| … step 0.25nC | | | | | | | | |
| Q=4nC | | | | | | | | |

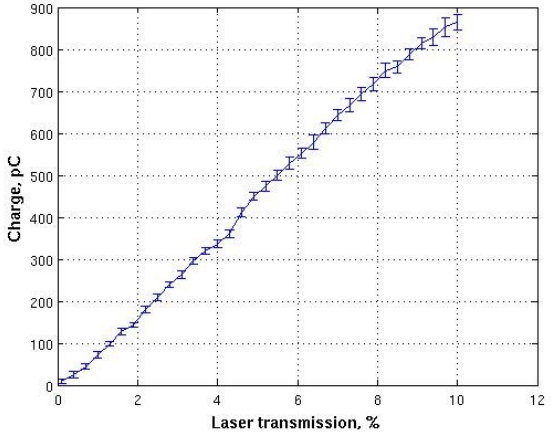
# Charge vs. Laser Transmission




Oct14

x-axis: 0-100% LT
Y-axis: 0-6 nC




(fine scan 0-800pC)

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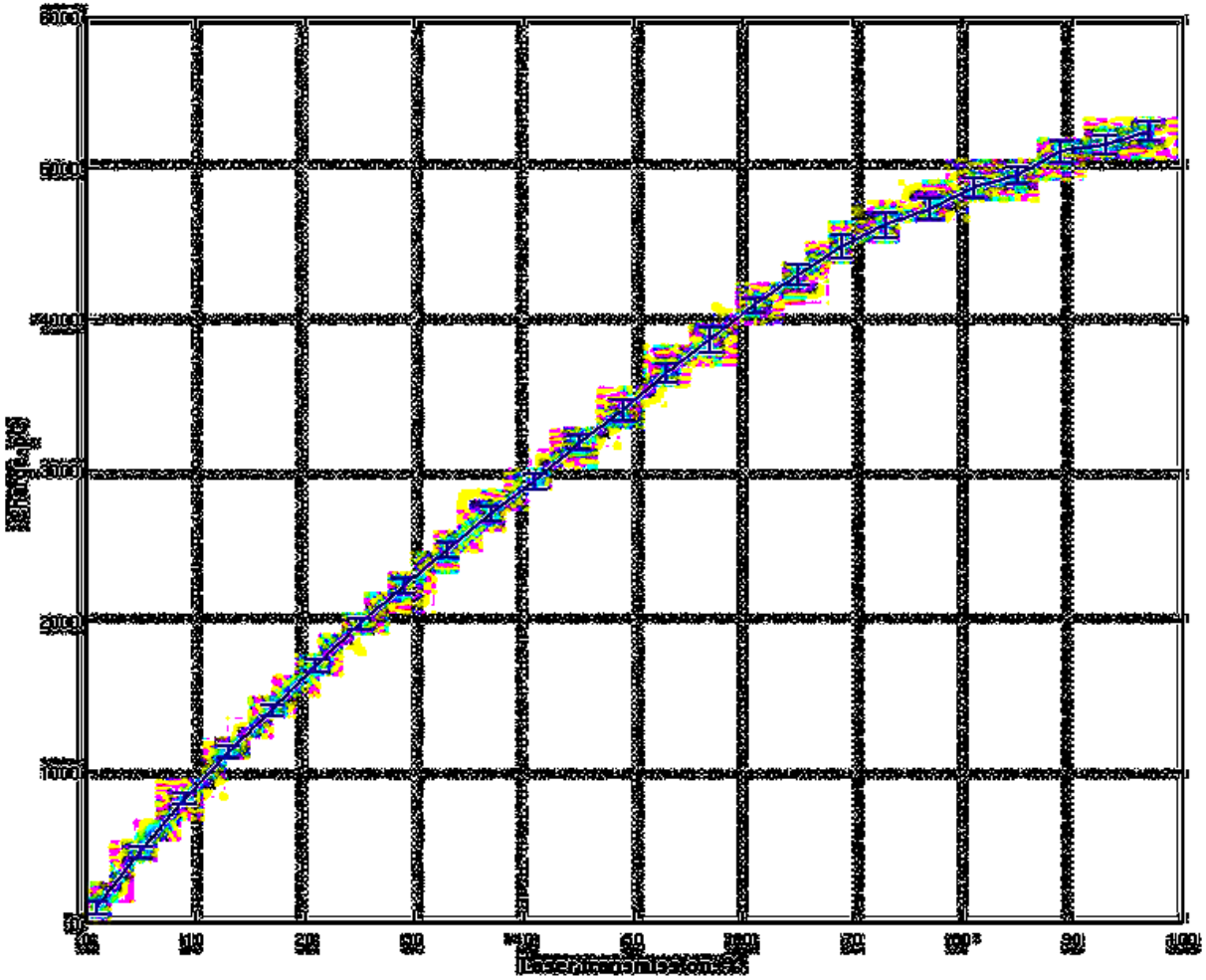


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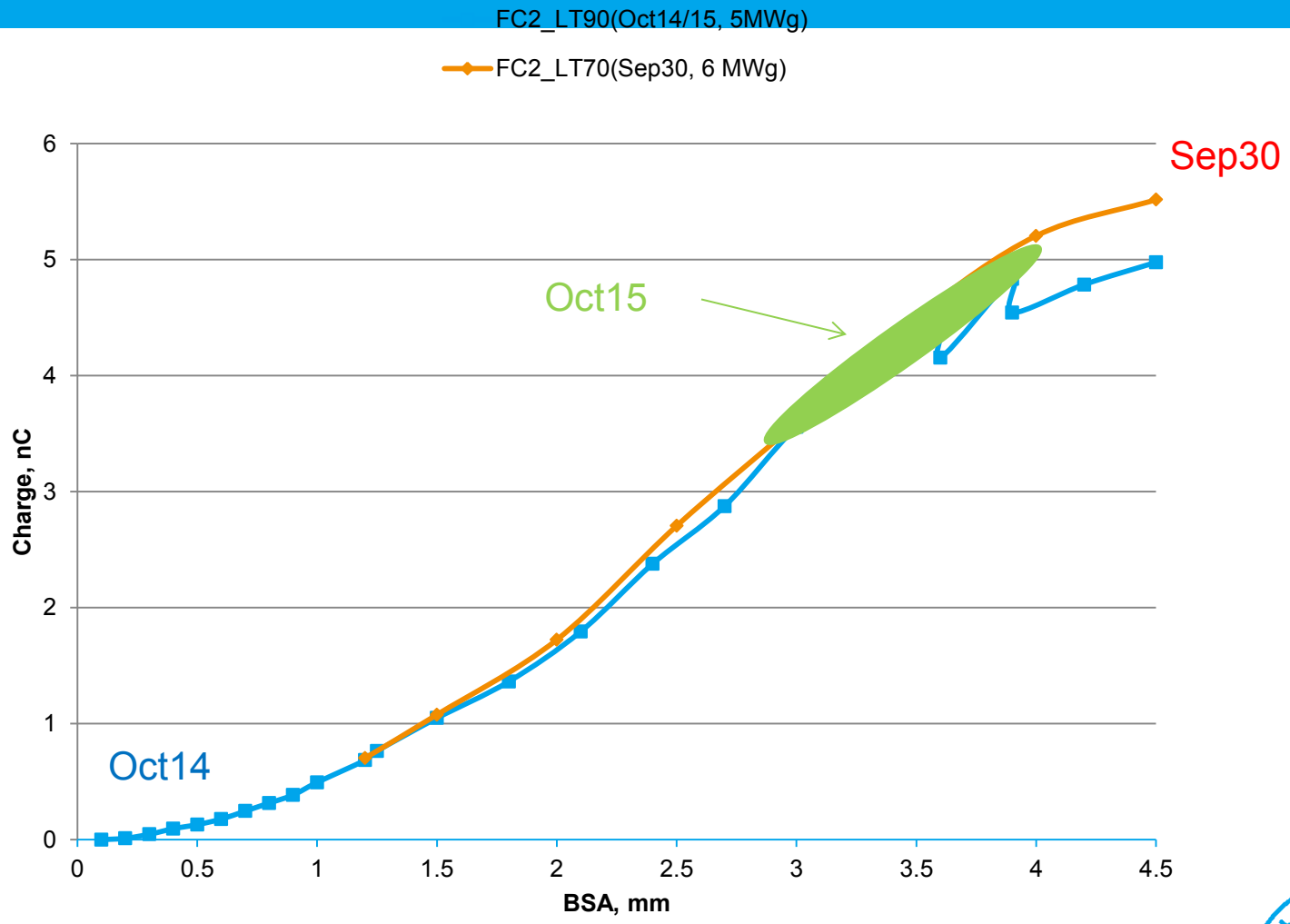
# Charge vs BSA

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# TDS = TDS studies – (HH)

Photocathode laser: short / long Gaussian
Gun (5MWg) + booster (3MWb) at MMMG;

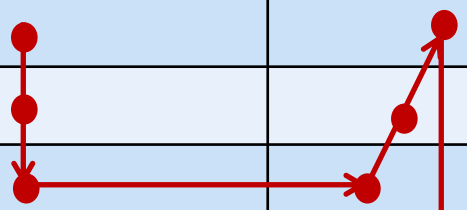
1. BSA/charge matrix → Scan: bunch length vs (BSA, charge) see Table

2. Charge scan until 4 nC (250 pC steps), to reproduce previous results that don't fit well to simulations, and also because we weren't able to go so high before. To verify that measurements are not impaired by phase, for each charge do booster-MMMG and MMMG +/-5 deg. Occasionally check that we are still at gun-MMMG.

3. Set up HEDA2 for highest possible resolutions, then take some pictures for different booster phases.

# Emission re-measurements (MK)

- Too low range of the pulse energy for short Gaussian pulses (diode pumps?)
- Probably solenoid was not adjusted for 1.5MW
- Automatic Phi0 – fitting procedure was applied only at the end of measurements
- Energy meter for short pulses → inconsistency around the range transition

| Pgun | Phase w.r.t. Phi0 | BSA=0.8mm | BSA=1.8mm |
|---|---|---|---|
| 6 MW | 90 deg |  | |
| | 49 deg | | |
| | 30 deg | | |
| 3.375 MW | 90 deg | | |
| | 42 deg | | |
| 1.5 MW | 90 deg | | |

# 1. Scattering measurement of 0.9μm foil at High1.Scr4 (MG)

- **Goal:** measurement of scattering angles for plasma cell electron window
- **Results:** Saved images of High1.Scr4 and High1.Scr5 (or possibly a PST screen) using YAG screens

- Laser: long Gaussian - 0.5mm BSA
- Gun: 6MW in the gun; pulse length: >200us; on-crest
- Booster: 3MW in the booster; pulse length: 200us; on-crest
- Bunch charge: 100pC

- Time estimate: 0.5 shifts

# 1. Scattering measurement of 0.9μm foil at High1.Scr4 (MG)

- **Goal:** Investigation of electron beam focusing onto plasma position
- **Results:** Magnet settings; saved images of Low.Scr1 to High1.Scr3 using YAG screens

- Laser: long Gaussian - 0.5mm BSA
- Gun: 6MW in the gun (+ option: 5MWg); pulse length: >200us; on-crest
- Booster: 3MW in the booster; pulse length: 200us; on-crest
- Bunch charge: 100pC; 50pC; 500pC

- Time estimate: 1.5 shifts

# Coupler kick: additional studies (Igl)

**Experiment 1. Solenoid tile test**
**Goals:**
Reference setup (e.g. 21.06.2015M): BSA=1.2mm, 5MWg, GunPhase=MMMG, 500pC, the Booster off, solenoid → focusing at LOW.Scr 2 and 3. Bucking solenoid is off.
Scan the solenoid tilt angle and take pictures at LOW.Scr 2 and 3.

**Plan of measurement:**
Set BSA 1.2 mm
Charge 500pC
Gun->5MW power, MMMG phase
Focus the beam at low.Src3
Adjust the solenoid current to find the 'cross'-like beam structure
Charge the main solenoid tilt angle and document the changes of the beam transverse shape
Move solenoid to the initial position(!!!!).

**Required experts:**
Mikhail Krasilnikov
Michael Winde

**Experiment 2. Beam acceleration w/o forward RF power**
**Goals:**
Reference setup (e.g. 21.06.2015M): BSA=1.2mm, 5MWg, GunPhase=MMMG, 500pC, the Booster off, solenoid → focusing at HIGH1.Scr1 + 7A in order to see the beam ears. Bucking solenoid is off.
Change laser timing in order to place the beam at the 2$^{nd}$ horn of the reflected power. And observe the beam shape change.

**Plan of measurement:**
Set BSA 1.2 mm
Charge 500pC
Gun->5MW power, MMMG phase
Focus the beam at HIGH1.Scr1 + 7A. Find the Beam ears.
Change the laser timing settings to place the beam at the end of the pulse. Where already no forward RF but still reflected (2$^{nd}$ horn at the reflected power)
Play with the gun and booster RF phases to find the beam the the sreen.
Take pictures to the beam at the screen.
Restore the timing settings.

# Coupler kick: additional studies (Igl, MK)

- Idea: try to use rf pulse location “w/o forward” (but still rf power in the cavity)
- Measurements:
  1. BSA=1.2mm → VC2
  2. Pgun=5MW, adjust the rf pulse length to ~1$^{st}$ pulse start+10us (e.g. using dark current and charge at FC)
  3. Tune gun temperature (stabilization?)
  4. FB→OFF
  5. Beam at LEDA → MMMG phase
  6. Q(MMMG)=500pC (LOW.FC2, check Imain for a good focusing at LOW.Scr2)
  7. Measure Q as a function of rf pulse length → determine range
  8. Beam at LEDA as a function of the rf pulse length for the obtained range. ?Adjust SPA to keep the same <PZ> (possible MMMG phase readjustment?) ➔ table (Trf, SPA, SPPhase). !??FB??
  9. Beam at HIGH1.Scr1 (no booster, Imain=361A?) – to see transverse tails. Apply the table, for each setup (rf pulse length Trf) save the image at HIGH1.Scr1