Recent progress on Accelerator R&D at PITZ

Frank Stephan for the PITZ team

Content:

- Operation of gun 4.2:
  - Current PITZ RF gun setup and operating experience
  - Measurements: **emittance**, coupler kick, RF stability
- New Developments at PITZ:
  - TDS commissioning, 3D ellipsoidal laser pulses, Gun5, THz studies, (plasma acceleration)
- Summary + outlook

PITZ: Collaboration for developing high brightness photo injectors and applications

Founding partners of PITZ:

- DESY, HH&Z (leading institute)
- HZB (BESSY): magnets, vacuum
- MBI (**S. Eisebitt**): cathode laser
- TU Darmstadt (TEMF, T. Weiland, **H. DeGersem**): simulations

Other national partners:

- Hamburg university:
  - most PhD students;
  - HGF-Vernetzungsfond;
  - generation of short pulses
  - plasma experiments
- HZDR:
  - BMBF-PC-laser-project between MBI, DESY and HZDR, unitl ~2009;
  - ~ regular exchange;
  - collaboration between HZB, HZDR, MBI and DESY in SC-gun-cluster

International partners in the **PITZ Collaboration**:

- STFC Daresbury (S. Smith, B.Militsyn): phase space tomography
- INR Troitsk (L. Kravchuk): CDS, TDS, Gun5
- INRNE Sofia (D. Tonev, G. Asova): EMSY + personnel
- LAL Orsay (A. Stocchi): HEDA1 + HEDA2
- Thailand Center of Excellence in Physics (T. Vilaithong, Ch. Thongbai): personnel
- **IAP Nizhny Novgorod** + **JINR Dubna**: 3D elliptical laser pulses, THz radiation

Other international partners:

- INFN Milano (C.Pagani): photo cathodes
- INFN Frascati + Uni Roma (L. Palumbo, M. Ferrario): TDS and E-meter pre-studies
- YERPHI Yerevan (V. Nikoghosyan): personnel

Operation of gun 4.2:
Current PITZ RF-Gun Setup and Dedicated Tasks

reminder

> Highest priority at PITZ currently:

Participate in the solution of the remaining problems of the RF gun for XFEL (RF windows, RF spring, stability and long term reliability)

- e.g. conditioning and operation of RF guns

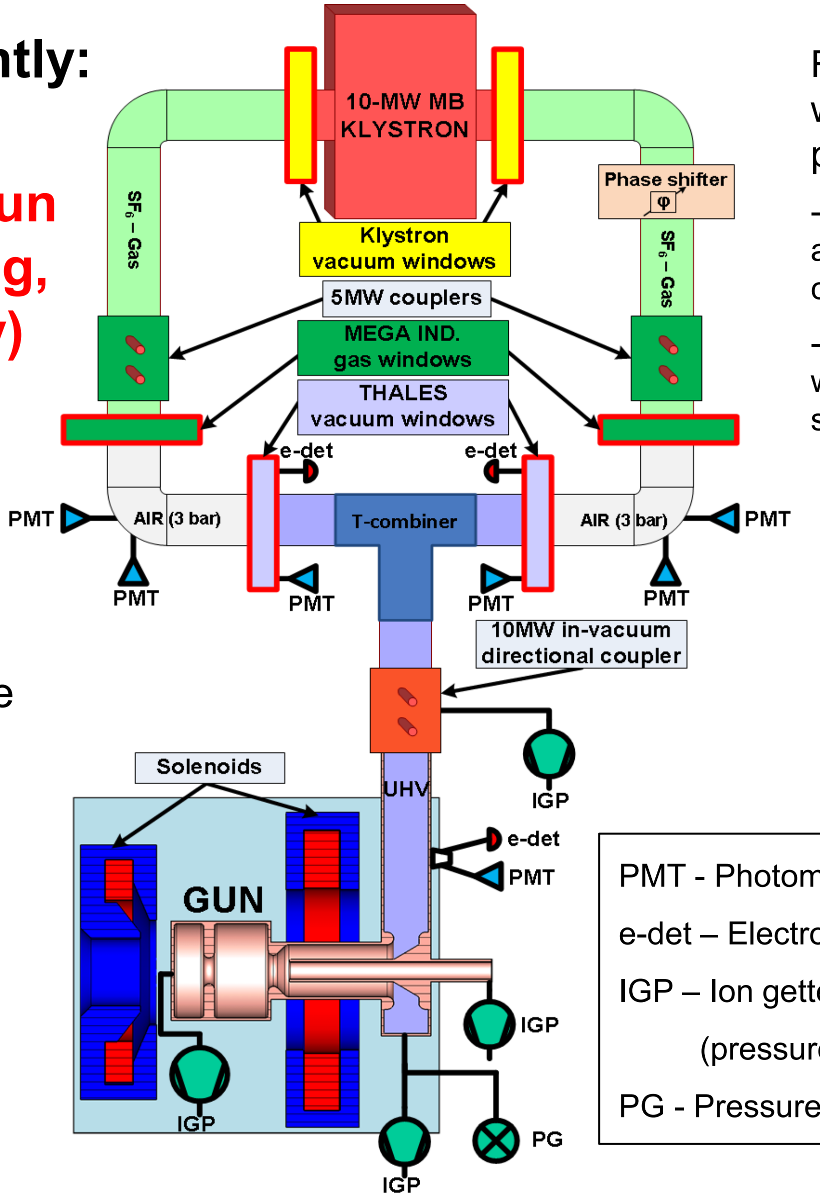
→ **Currently check the principle of operation with 2 RF windows**

→ Are current Thales windows appropriate (light signals, pure Ti coating) ?

→ Can current 10MW in-vacuum coupler be used reliably ?

→ Does configuration with 2 vacuum windows and 2 gas windows work ?

→ Check long term breakdown rate at high average power ?



RF vacuum windows position:

- adapted to available RF components

- compatible with XFEL setup

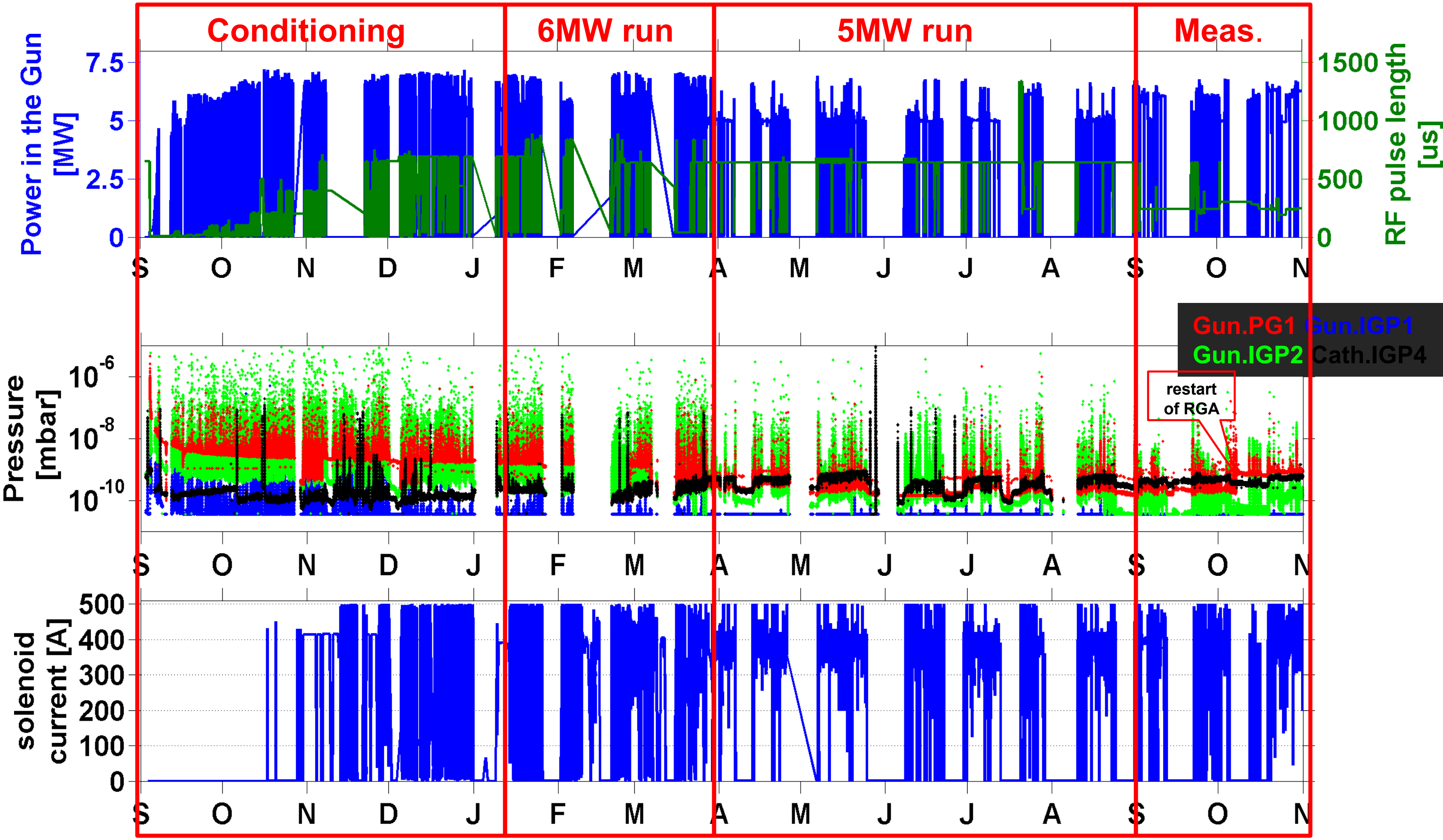
PMT - Photomultiplier tube

e-det – Electron detector

IGP – Ion getter pump (pressure reading)

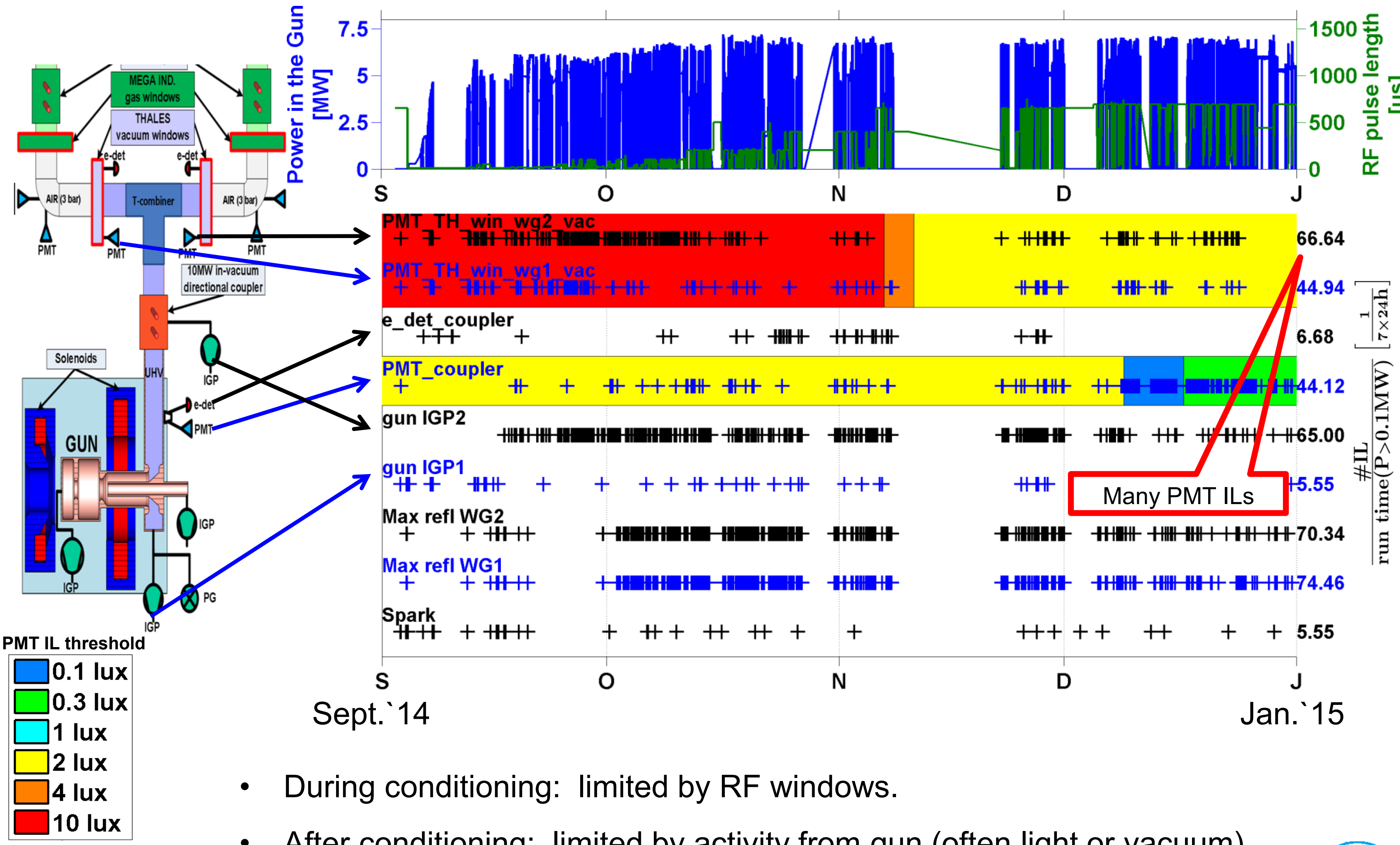
PG - Pressure gauge

Conditioning and operation history from 03.09.2014 to 01.11.2015



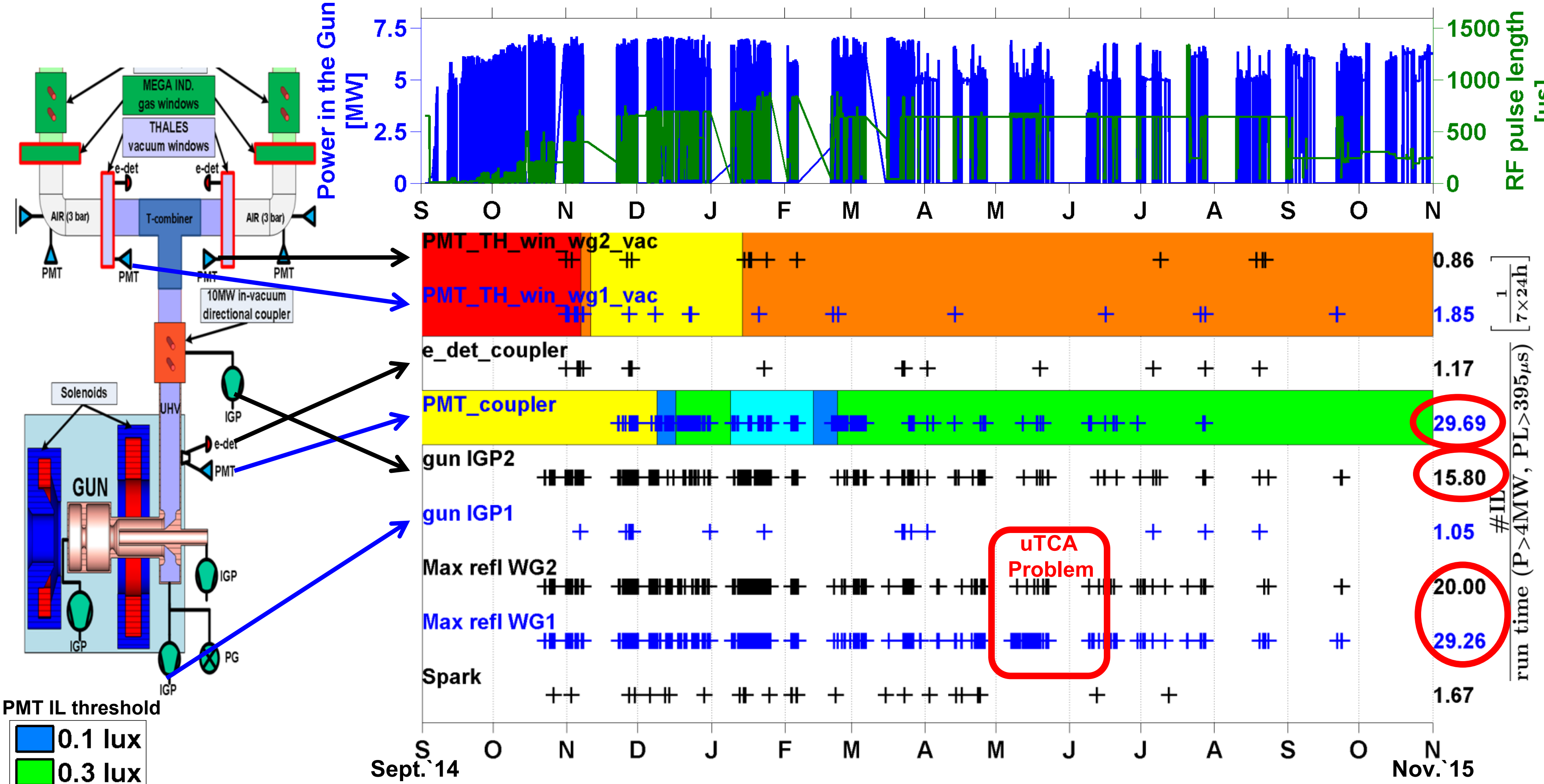
→ Gun **vacuum continuously improving** with time → finally: the best ever.

History and relevant interlocks during Gun 4.2 Conditioning



- During conditioning: limited by RF windows.
- After conditioning: limited by activity from gun (often light or vacuum)

Full history and relevant ILs for gun 4.2 (Pgun>4MW, PL>395us)



PMT IL threshold

- 🟦 0.1 lux
- 🟩 0.3 lux
- 🟦 1 lux
- 🟨 2 lux
- 🟧 4 lux
- 🟥 10 lux

- Most of the PMT ILs at the windows happened at low power
- **After conditioning: no problems with RF windows anymore !** (all remaining interlocks at RF windows were due to problems in the gun, other sub-systems or wrong operation due to operators)
- After conditioning: limited by activity from gun (often light or vacuum, even below intl. threshold)
  → goal of 1 interlock per week not yet reached due to OLD gun !

Gun-4.2 History

DESY, Hamburg site

2006 – built, dry ice cleaned

16.12.2009 ➔ FLASH

January 2010 – May 2012 – operation at FLASH (1200 GJ)

Dismounted → severe damage of the cathode spring area

Autumn 2012 → Gun backplane was re-machined to install contact stripe cathode spring (new design)
5.12.2012 dry ice cleaned

Optical inspection Gun4.2 – June 2012

- Damage on cupper part close to the spring

2006

2007

2008

2009

2010

2012

2014

2015

DESY, Zeuthen site

24.8.2007 ➔ PITZ tunnel
12.12.2007-13.02.2008 – conditioning at CTS

➔ PITZ linac
From 20.05.2008 – re-start at PITZ-1.7

09.06.2008 stop → bad vacuum: water-to-vacuum leak from T-combiner

10.07.2008-19.10.2009 – operation at PITZ-1.7 with 60MV/m at cathode

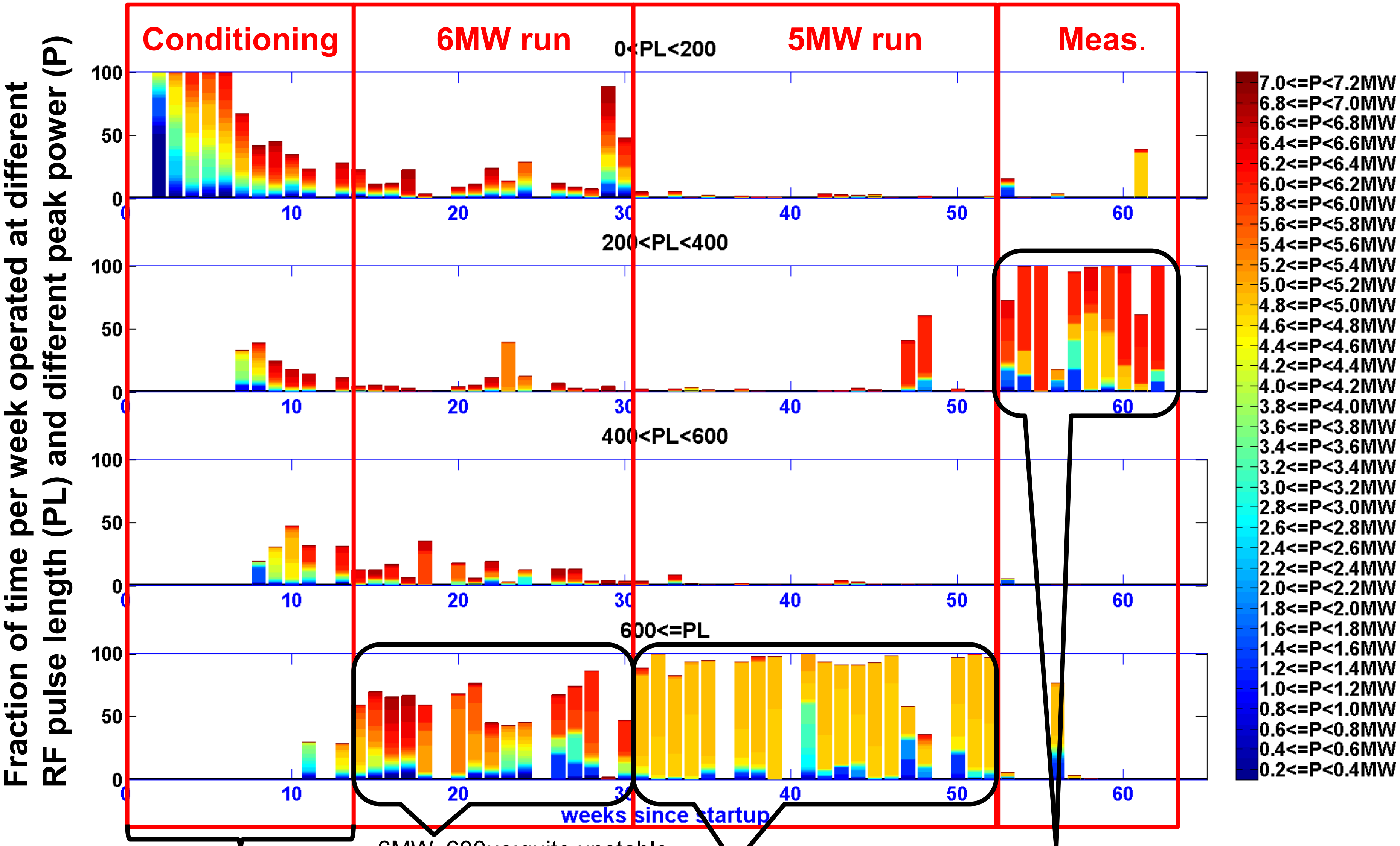
15.8.2012 ➔ PITZ for disassembling

May 2014 ➔ PITZ, mounted (vac. Lab) with 2 Thales windows (#1, #3) + 10 MW coupler + T-combiner
21.072014 ➔ PITZ tunnel
03.09.2014 – 31.12.2014 – conditioning at PITZ-2.0

01.01.2015 - 2.11.2015 – operation at PITZ-2.0 (393 GJ)

Power and pulse length usage over the full run of gun 4.2

(all data with >100kW in the gun are taken into account)



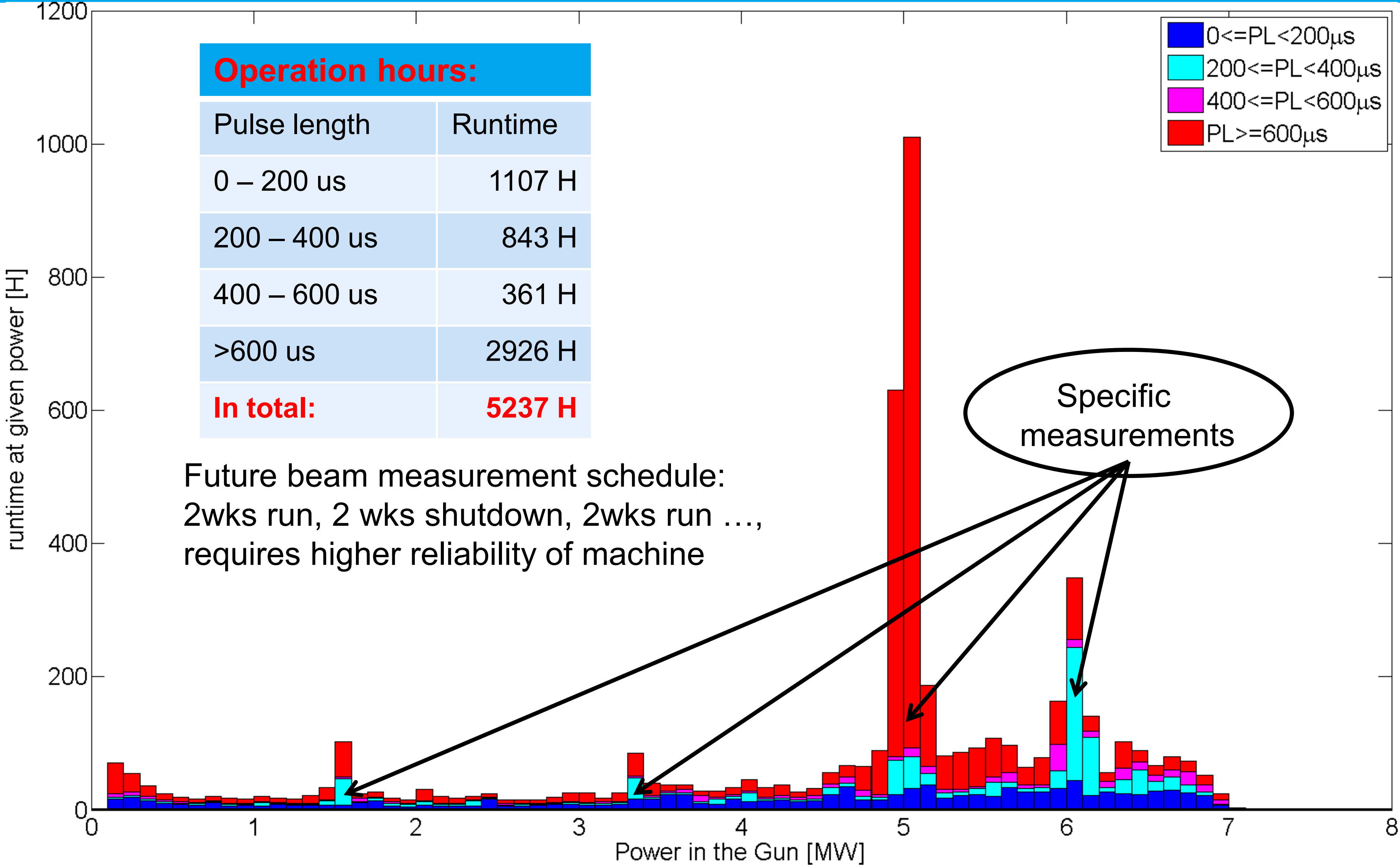
~3 months
(as usual)

- 6MW, 600µs:quite unstable
- slow recovery after vacuum trip → short pulses

- **5MW, 600µs: quite stable !**

- **6MW, 200µs: also quite stable !**

Run time at given Power



Operation hours:	
Pulse length	Runtime
0 – 200 us	1107 H
200 – 400 us	843 H
400 – 600 us	361 H
>600 us	2926 H
In total:	**5237 H**

Future beam measurement schedule:
2wks run, 2 wks shutdown, 2wks run …,
requires higher reliability of machine

Specific measurements

Total deposited energy: 393GJ

[Average peak power: 4.68MW, average RF pulse length: 444us]

Summary of RF operation results in 2014-2015

2 x Thales RF window solution at PITZ:

- **It works!**
- Venting → conditioning status of RF windows lost → needs re-conditioning
- **After** ~2-3 month of **conditioning** limited by RF windows ➔ **no problems anymore with windows !**

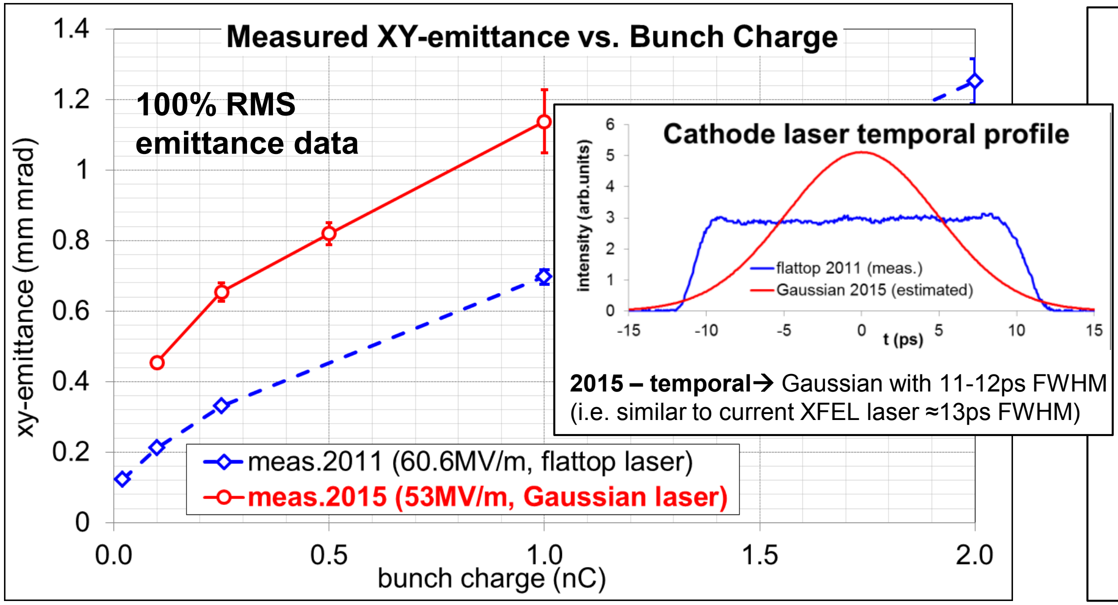
➔ **2 Thales RF windows works**, BUT due to the lively history (9 years) of **gun-4.2, this cavity cannot support full specifications** (1 week w/o IL at 6MW, 600us, 10Hz).

➔ Still, reliable **measurements** at reduced RF parameters are **possible**.

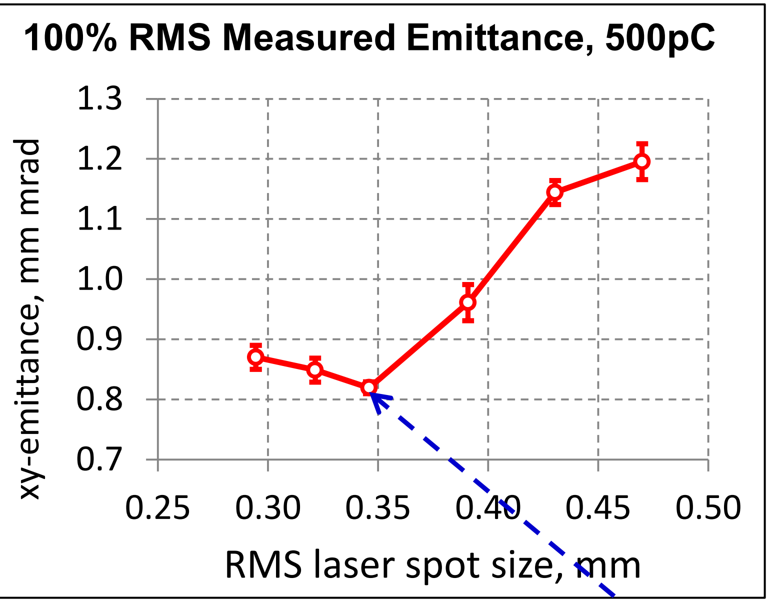
Beam measurements:

testing the beam quality for the XFEL startup conditions

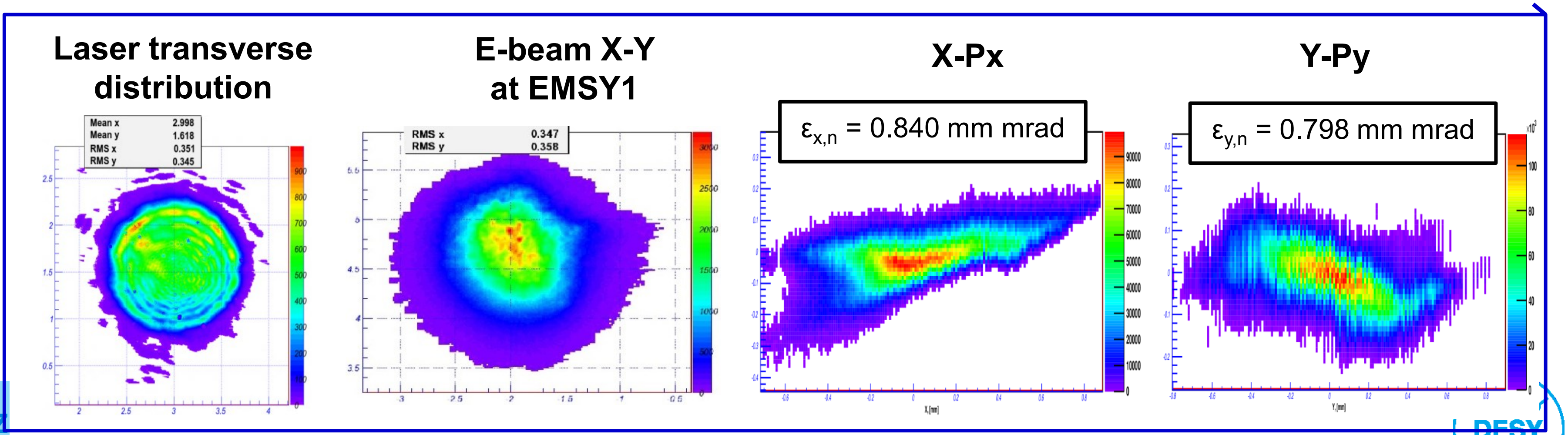
Emittance measurements in 2015: Gun at 53 MV/m, Cathode laser → temporal Gaussian



2015 – temporal→ Gaussian with 11-12ps FWHM (i.e. similar to current XFEL laser ≈13ps FWHM)



Requirement for XFEL (injector) commissioning: 1 mm mrad at 500pC → **fulfilled !**



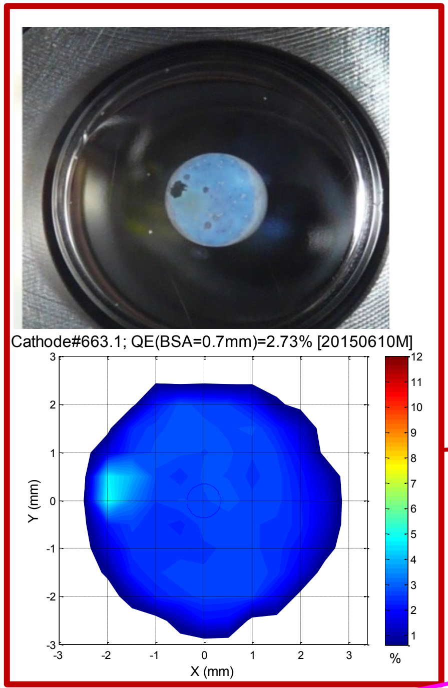
$\varepsilon_{x,n}$ = 0.840 mm mrad

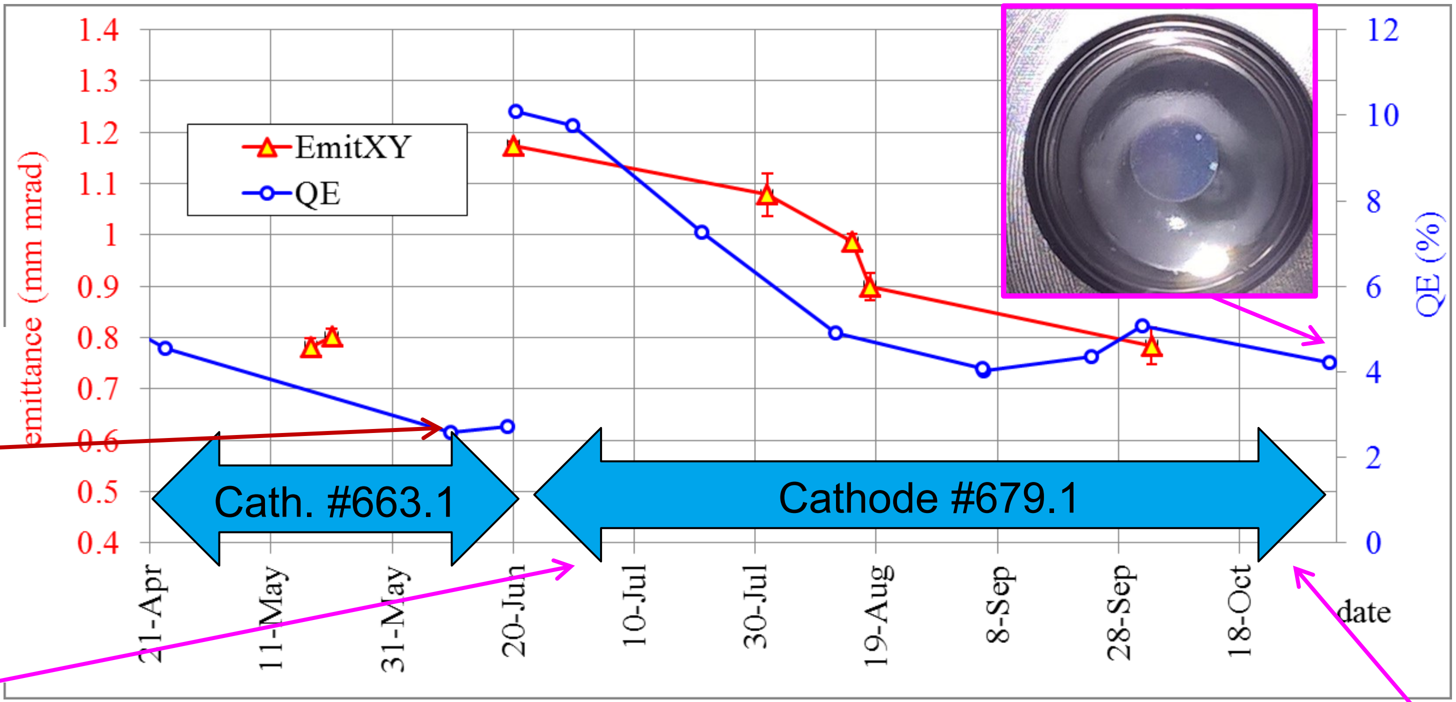
$\varepsilon_{y,n}$ = 0.798 mm mrad

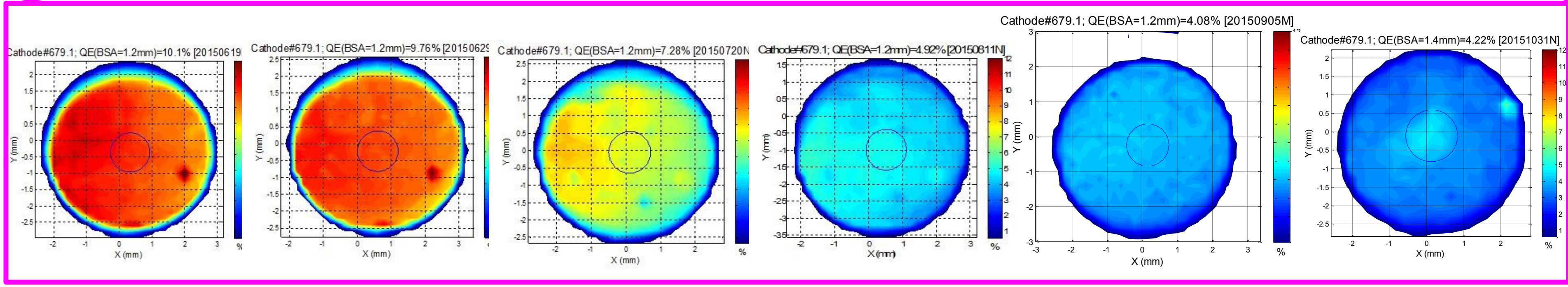
Beam measurements, continued:

Emittance and cathode QE

500 pC measured emittance and cathode QE at PITZ in 2015







➔ There seems to be a correlation between beam quality and cathode QE.

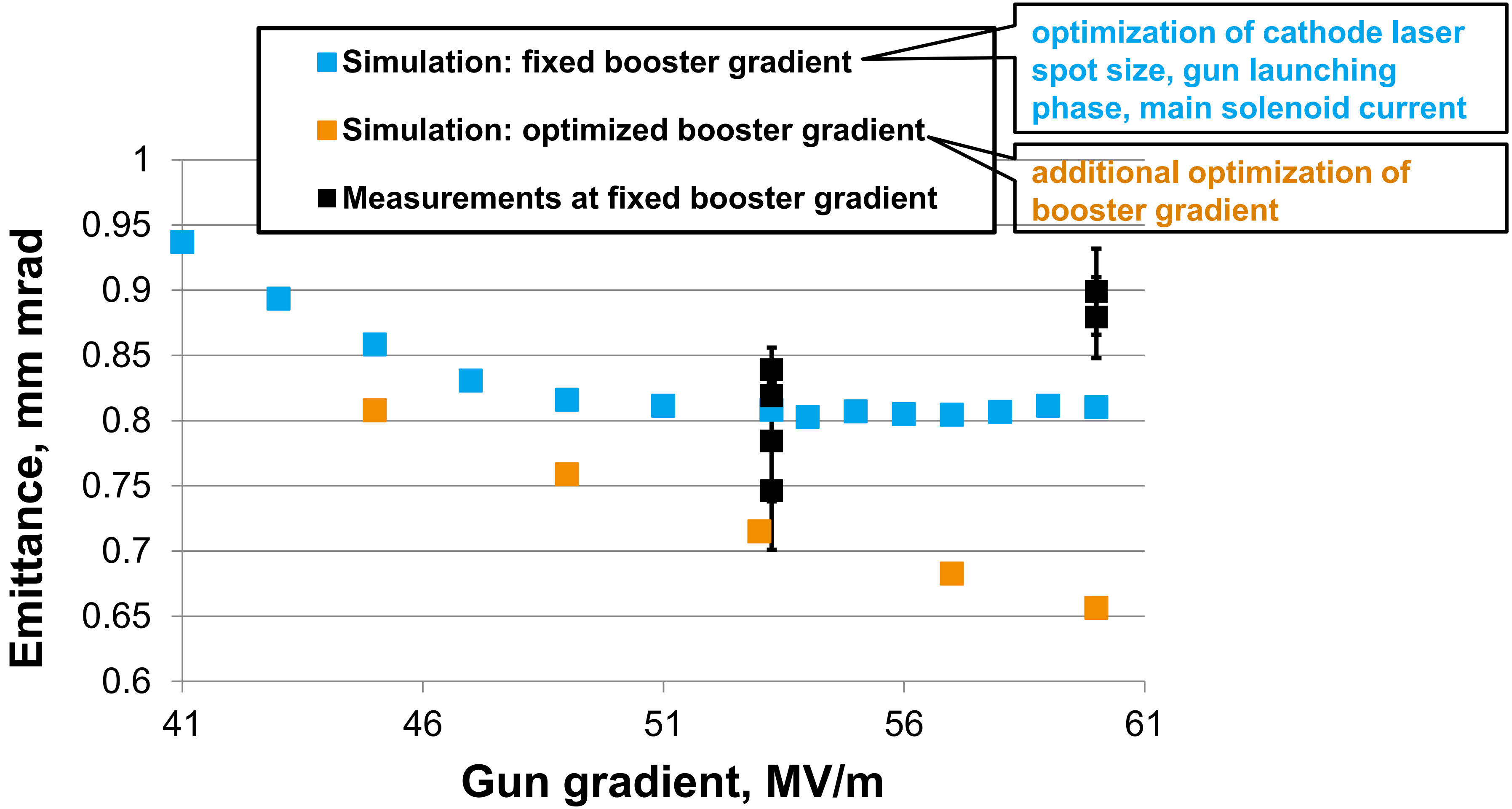
Beam measurements, continued:

Emittance vs cathode gradient

Measurements and Simulations

PROJECTED Emittance for different gun gradients

500 pC, 11.5 ps FWHM Gaussian laser

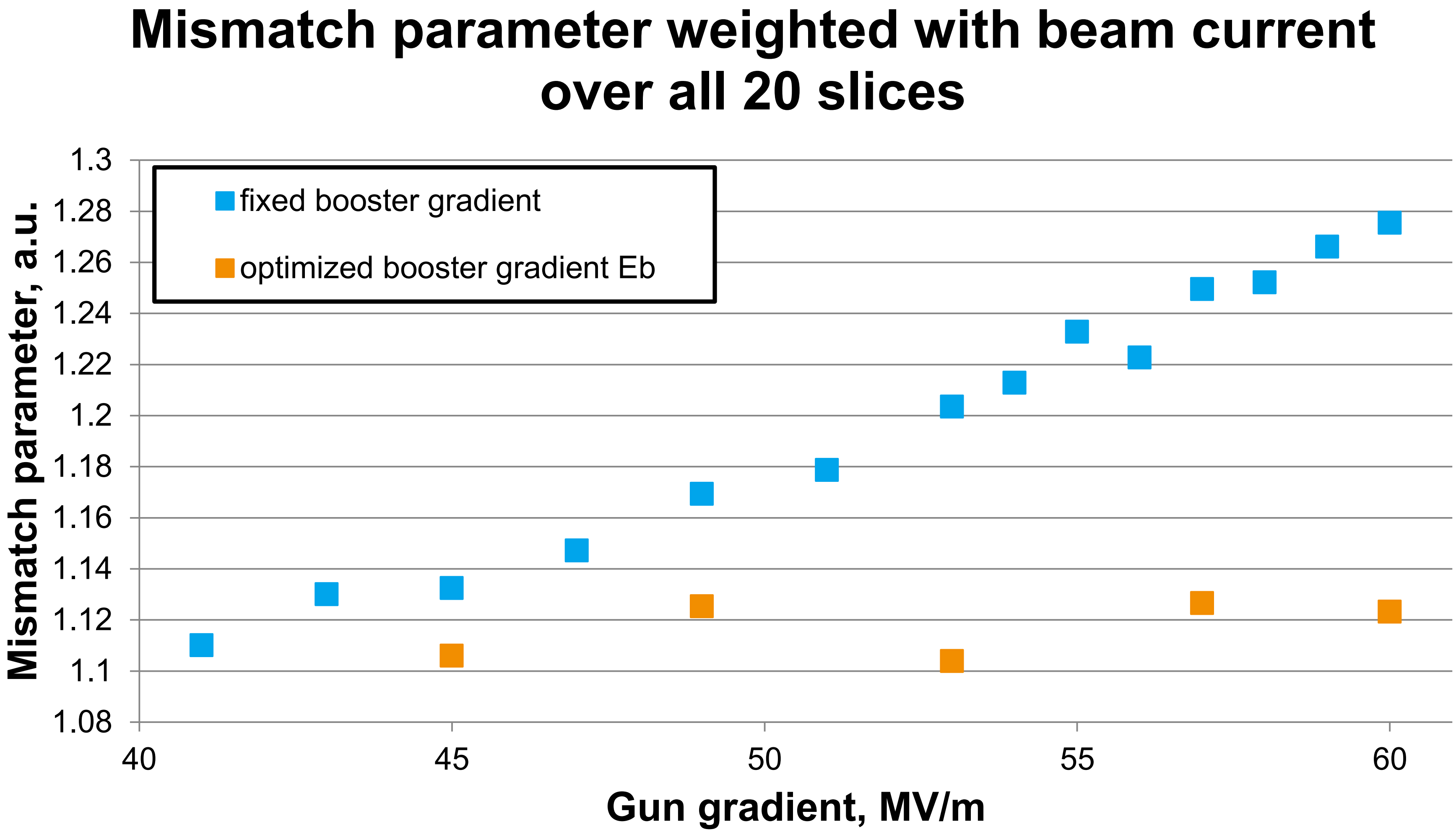


optimization of cathode laser spot size, gun launching phase, main solenoid current

additional optimization of booster gradient

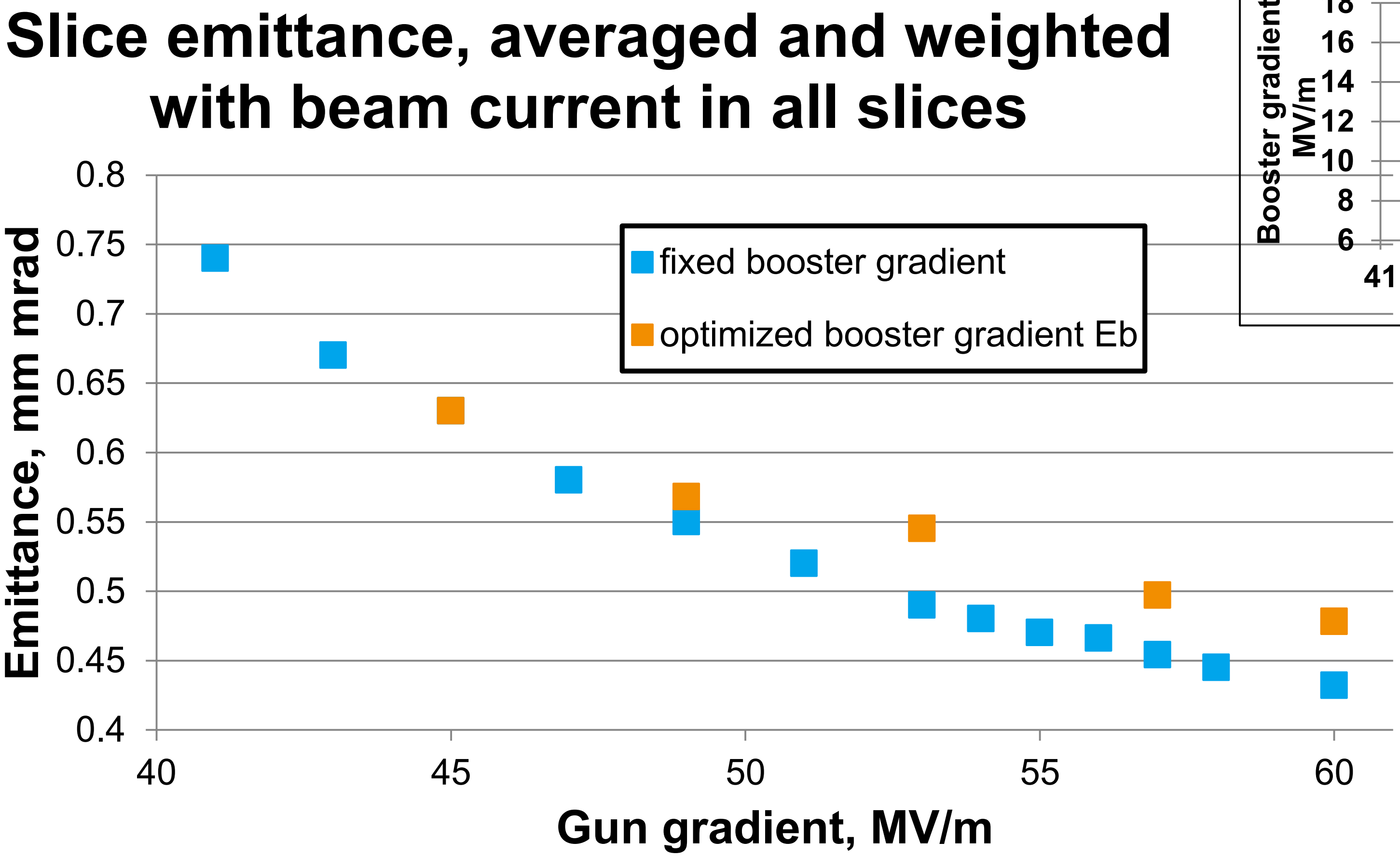
Statistical error bars are shown.

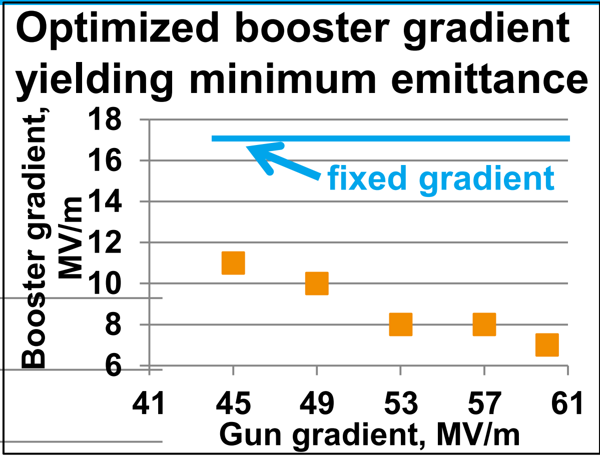
Mismatch parameter vs. gun gradient



→ As expected: for fixed booster gradient the slices are not well matched !

SLICE emittance vs. gun gradient





- **Higher booster gradient improves** weighted average of **slice emittance**
- **Mismatch effect stronger** than slice emittance improvement **for proj. emit.**

Beam measurements, continued:

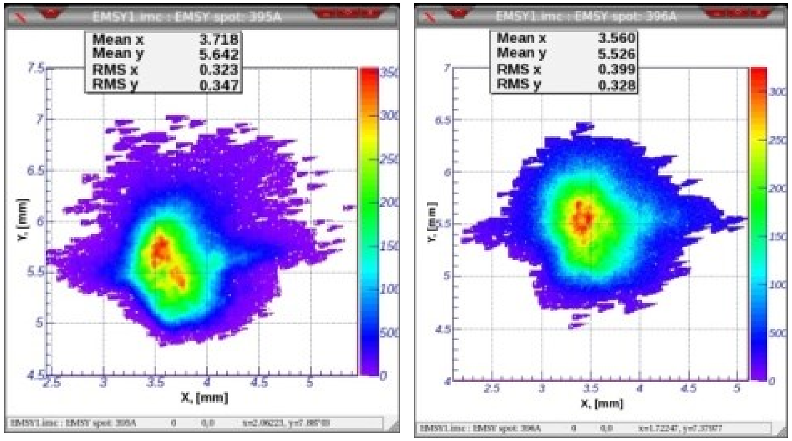
Investigations on electron beam imperfections:

(- photoemission studies)

(- electron beam imaging)

- electron beam asymmetry investigations

electron beam x-y asymmetry (tails)


EMSY1.imc : EMSY spot: 395A

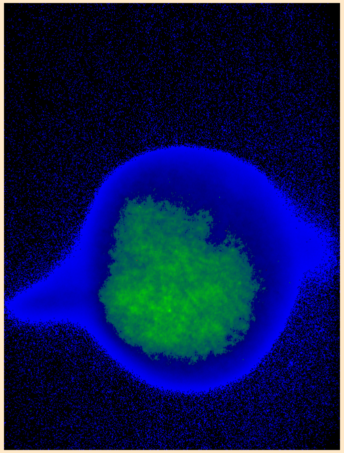
Mean x	3.718
Mean y	5.642
RMS x	0.323
RMS y	0.347

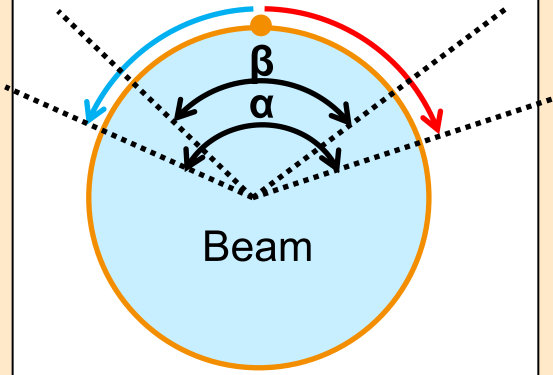
EMSY1.imc : EMSY spot: 396A

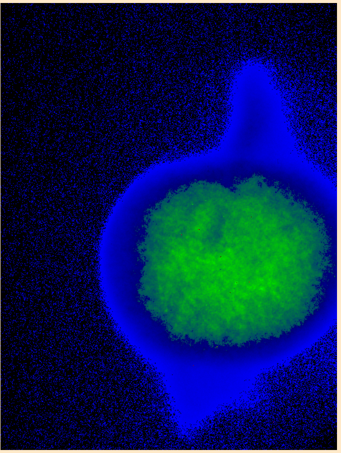
Mean x	3.560
Mean y	5.526
RMS x	0.399
RMS y	0.328

E-beam transverse tails investigations

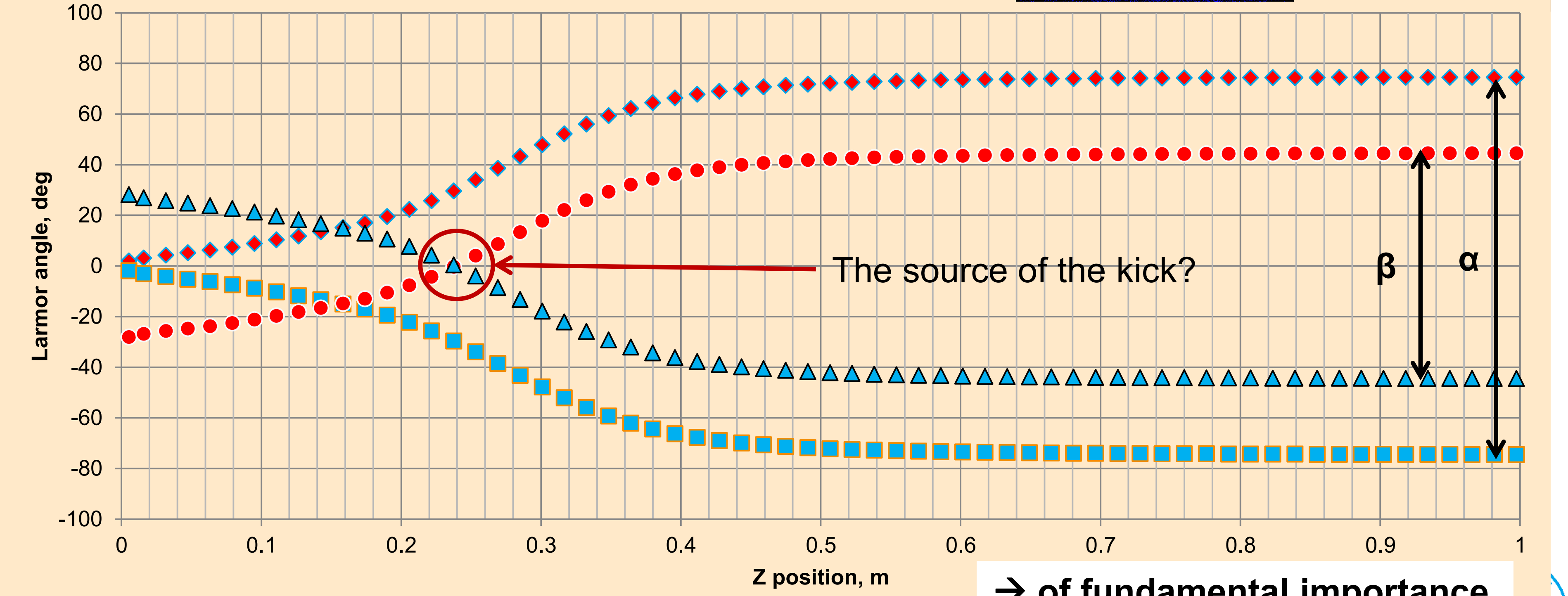
E-beam at HIGH1.Scr1, Imain=**+**360 A, **Normal polarity,** Ibucking=0A, No booster





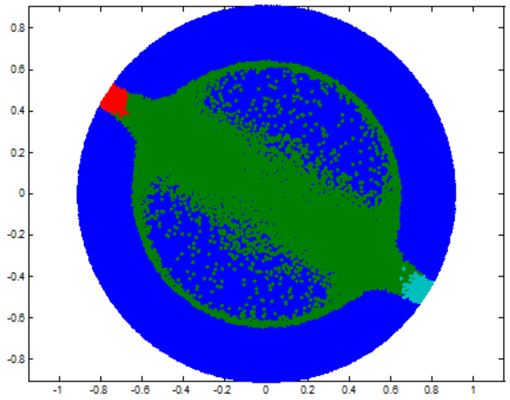
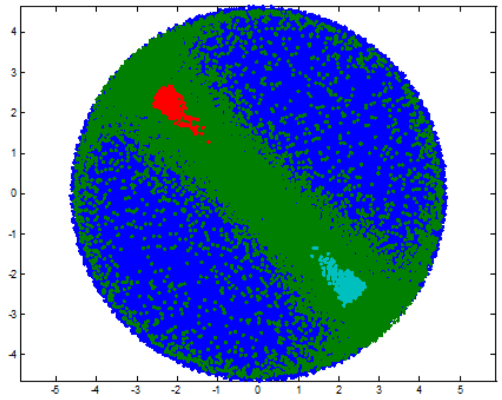
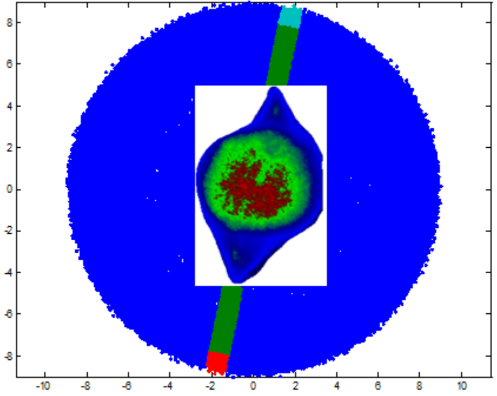
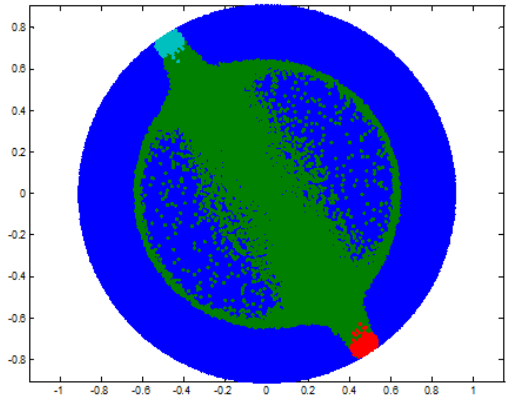
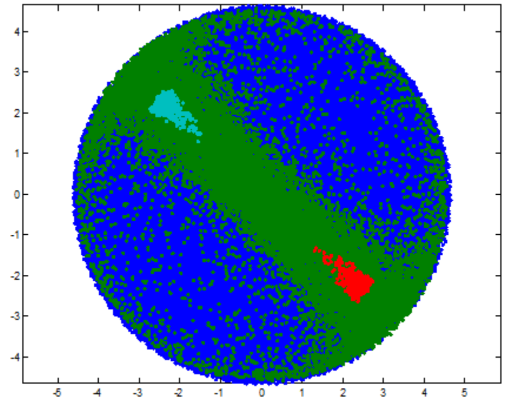
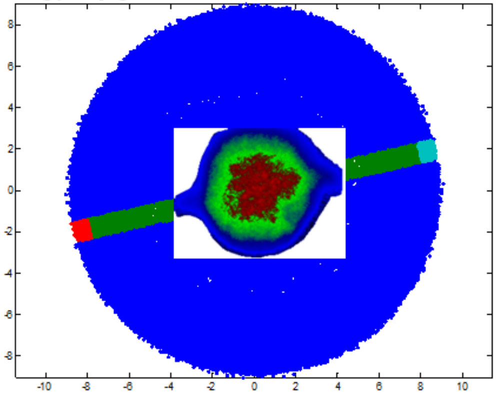


E-beam at HIGH1.Scr1 Imain=**-**360 A, **Opposite polarity,** Ibucking=0A, No booster



→ **of fundamental importance for FLASH + XFEL**

Tails: “tracking back” towards cathode ($SolB_{max}$~>360A^{exp})

	Cathode	Z=0.18m	EMSY
MaxB(1)= - 0.208692T			α=78° 
MaxB(1)= + 0.208692T			α=13° 

- **45° Kick at z=~0.2m**
- Halo particles at the cathode → edge particles at EMSY

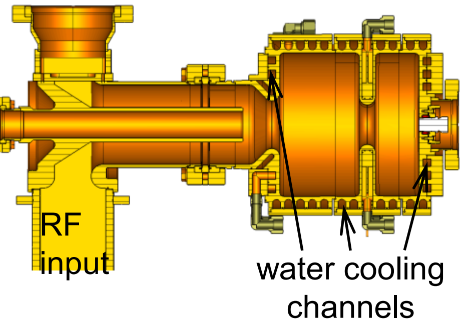
Gun RF stability

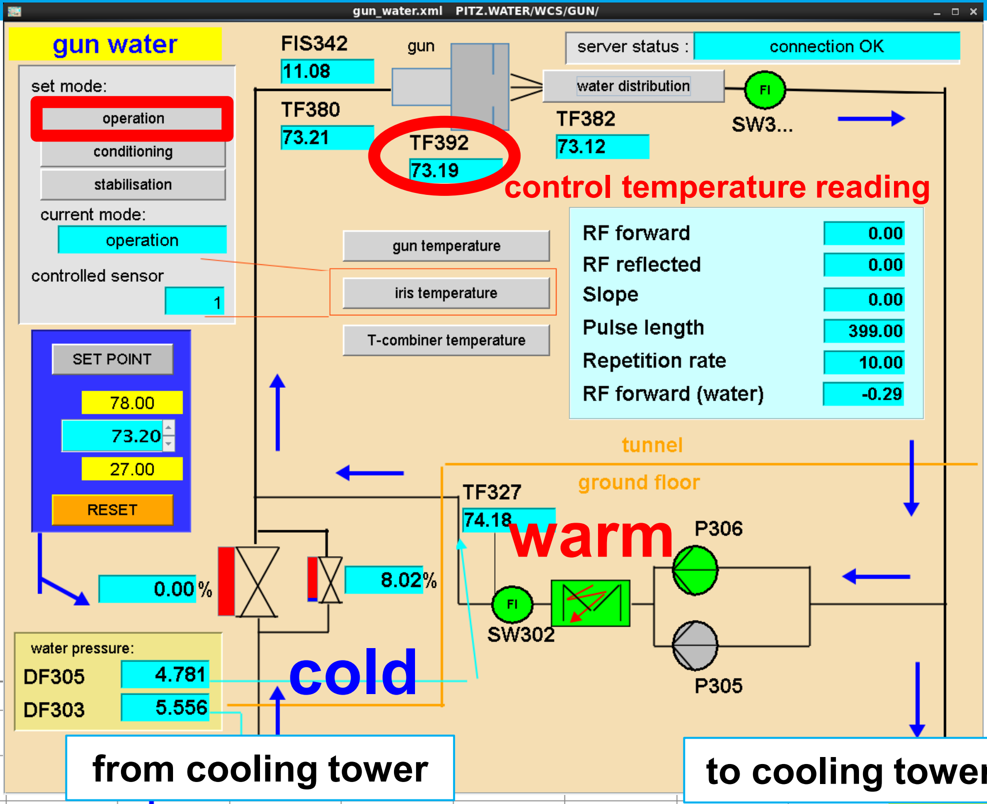
and corresponding upgrade of

- Gun temperature regulation
- LLRF control

The gun water cooling system (WCS) – operation mode

≤**50 kW** average power in copper block of ~23x23x23 cm³ to be controlled to **0.01 °C**.





gun_water.xml PITZ.WATER/WCS/GUN/

gun water

set mode:

operation

conditioning

stabilisation

current mode: operation

controlled sensor: 1

SET POINT

78.00

73.20

27.00

RESET

0.00 %

8.02 %

water pressure:

DF305 4.781

DF303 5.556

FIS342 11.08

TF380 73.21

TF392 73.19

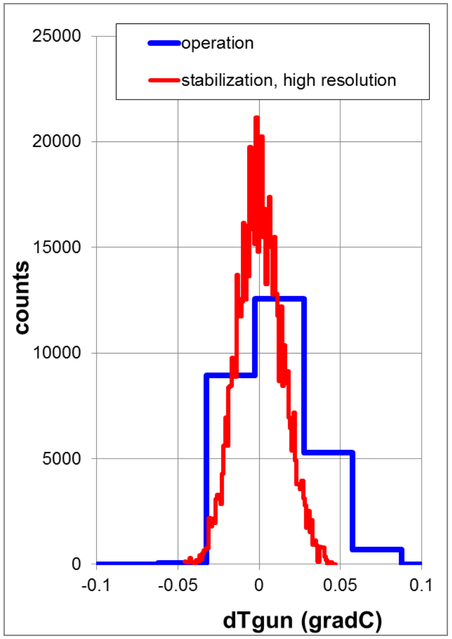
TF382 73.12

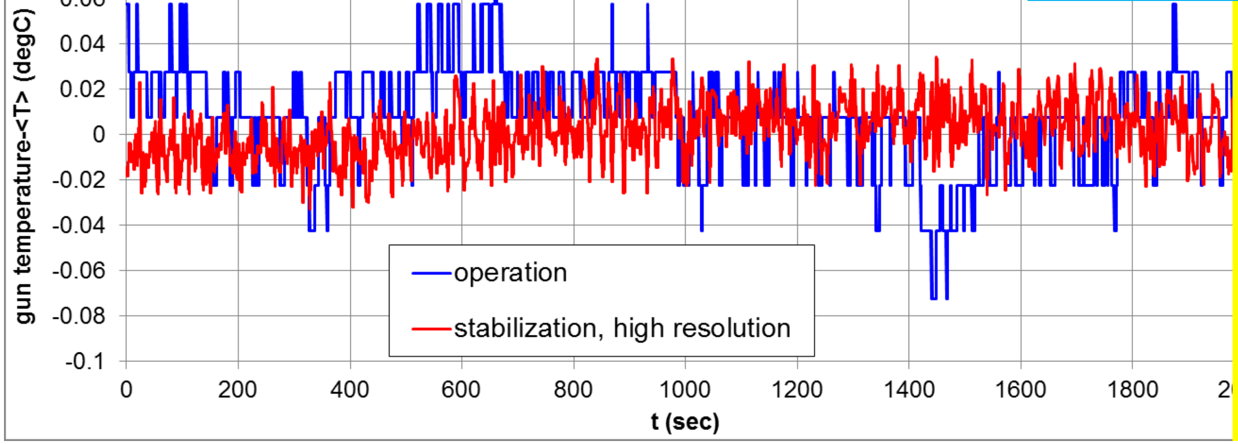
TF327 74.18

server status : connection OK

control temperature reading

RF forward	0.00
RF reflected	0.00
Slope	0.00
Pulse length	399.00
Repetition rate	10.00
RF forward (water)	-0.29





Gun WCS:

- 2 run modes
- T-readout resolution

Temperature sensor	Controller	Resolution °C
Pt100 class A	Siemens: 16bit RTD 6ES7331-7PF01-0AB0	0.025
Pt100 class AA	National InstrumentsNI 9217 RTD NIcRIO-9030	0.0001

The gun water cooling system (WCS) – stabilization mode

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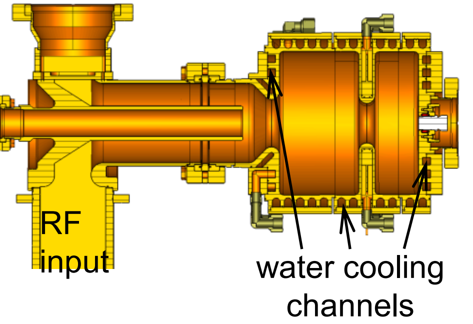
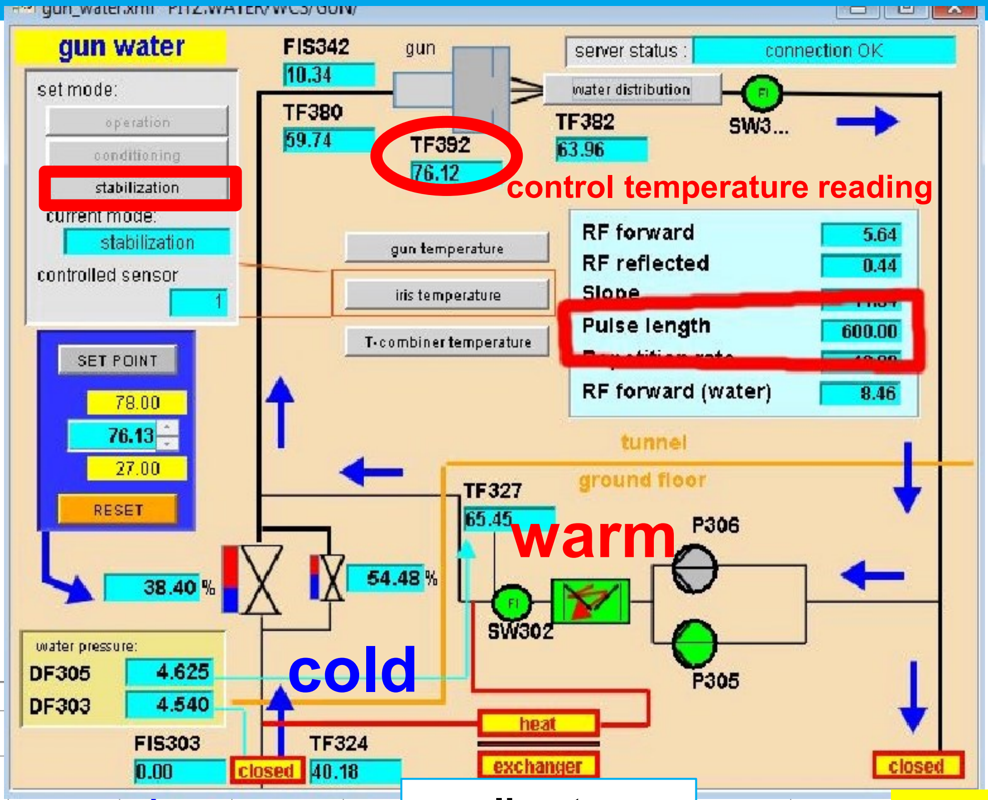



gun_water.xml PITZ.WATER/WCS/GUN/

gun water

set mode:
operation
conditioning
stabilization

current mode: stabilization

controlled sensor: 1

server status: connection OK

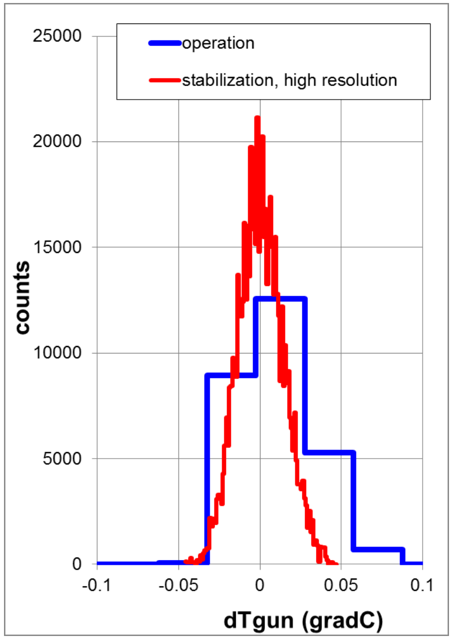
FIS342 10.34
TF380 59.74
TF392 76.12
TF382 63.96
TF327 65.45
TF324 40.18
FIS303 0.00 closed

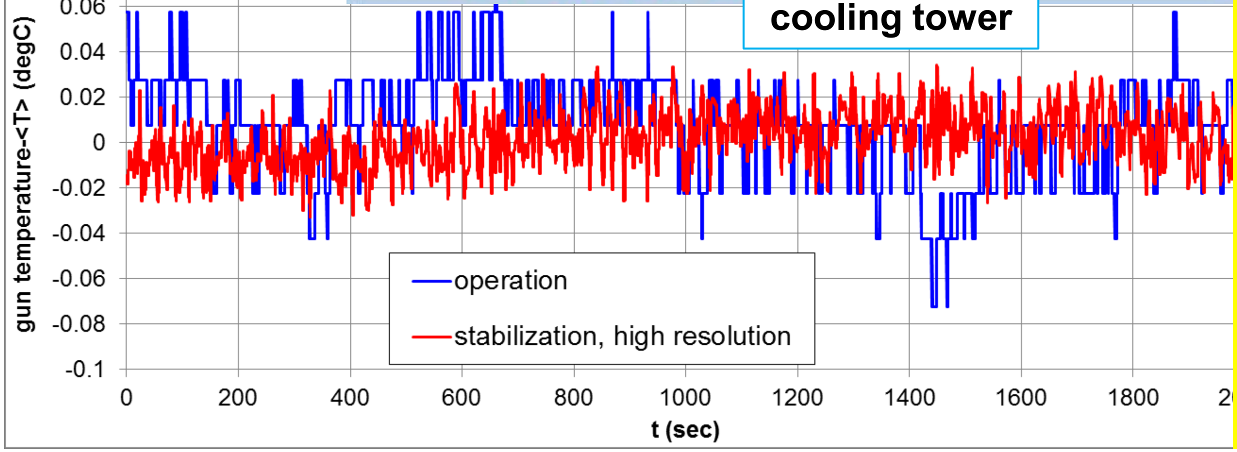
SET POINT
78.00
76.13
27.00
RESET

38.40 %
54.48 %

water pressure:
DF305 4.625
DF303 4.540

RF forward 5.64
RF reflected 0.44
Pulse length 600.00
RF forward (water) 8.46

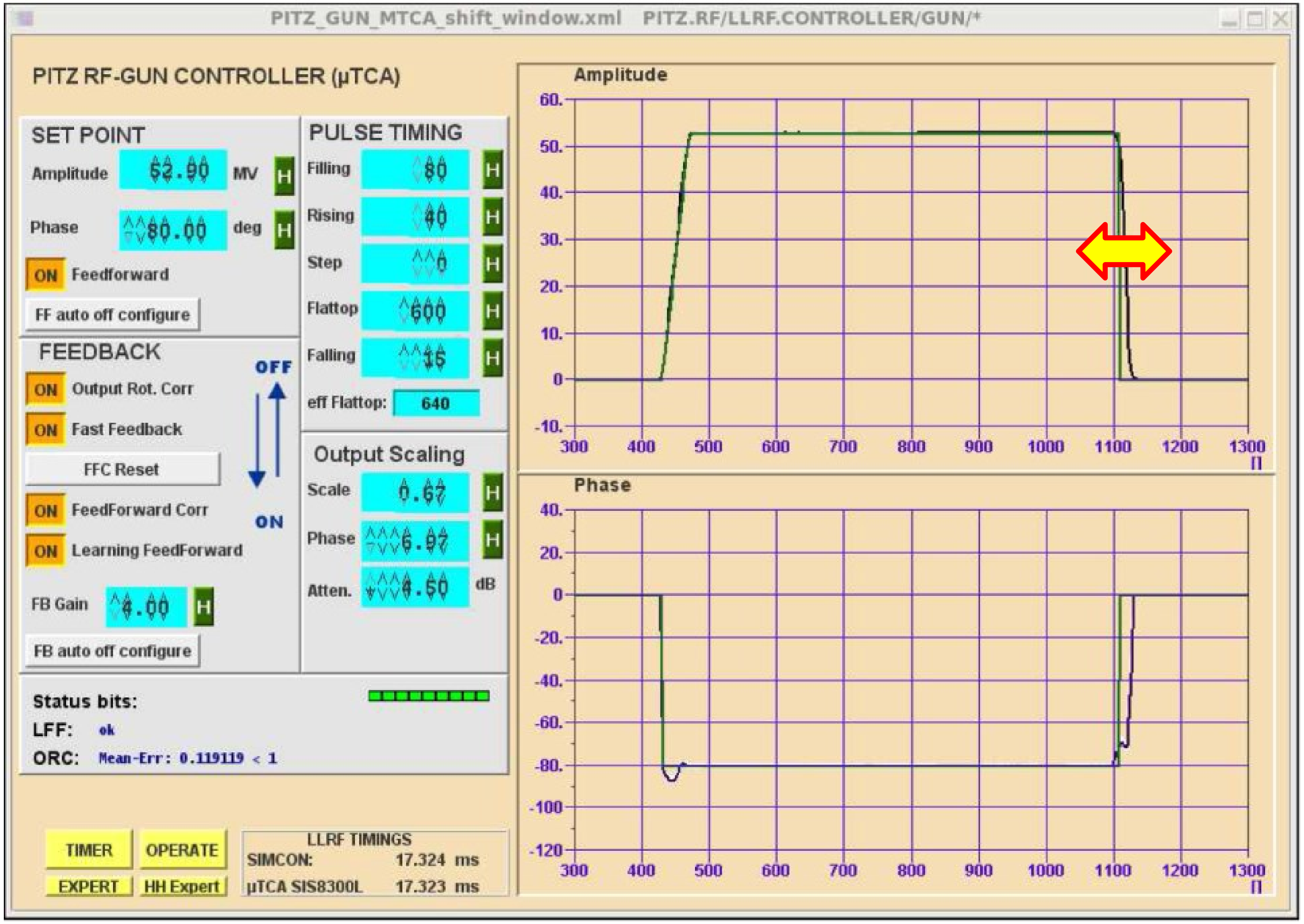




Gun WCS:
- 2 run modes
- T-readout resolution

Temperature sensor	Controller	Resolution °C
Pt100 class A	Siemens: 16bit RTD 6ES7331-7PF01-0AB0	0.025
Pt100 class AA	National InstrumentsNI 9217 RTD NIcRIO-9030	0.0001

Gun LLRF: since November 2014 µTCA system implemented



PITZ_GUN_MTCA_shift_window.xml PITZ.RF/LLRF.CONTROLLER/GUN/*

PITZ RF-GUN CONTROLLER (µTCA)

SET POINT

Amplitude 52.90 MV

Phase 80.00 deg

ON Feedforward

FEEDBACK

ON Output Rot. Corr

ON Fast Feedback

ON FeedForward Corr

ON Learning FeedForward

FB Gain 4.00

PULSE TIMING

Filling 80

Rising 40

Step 0

Flattop 600

Falling 16

eff Flattop: 640

Output Scaling

Scale 0.67

Phase 6.97

Atten. 4.60 dB

Status bits:

LFF: ok

ORC: Mean-Err: 0.119119 < 1

LLRF TIMINGS

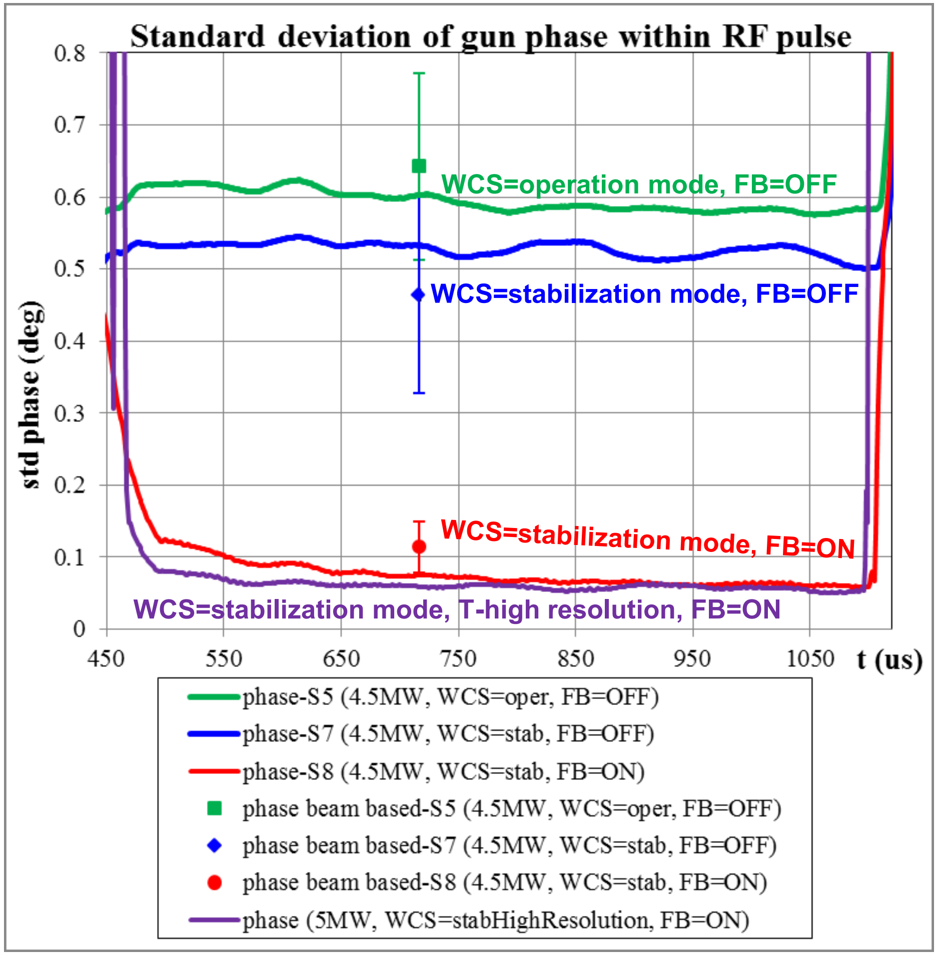
SIMCON: 17.324 ms

µTCA SIS8300L 17.323 ms

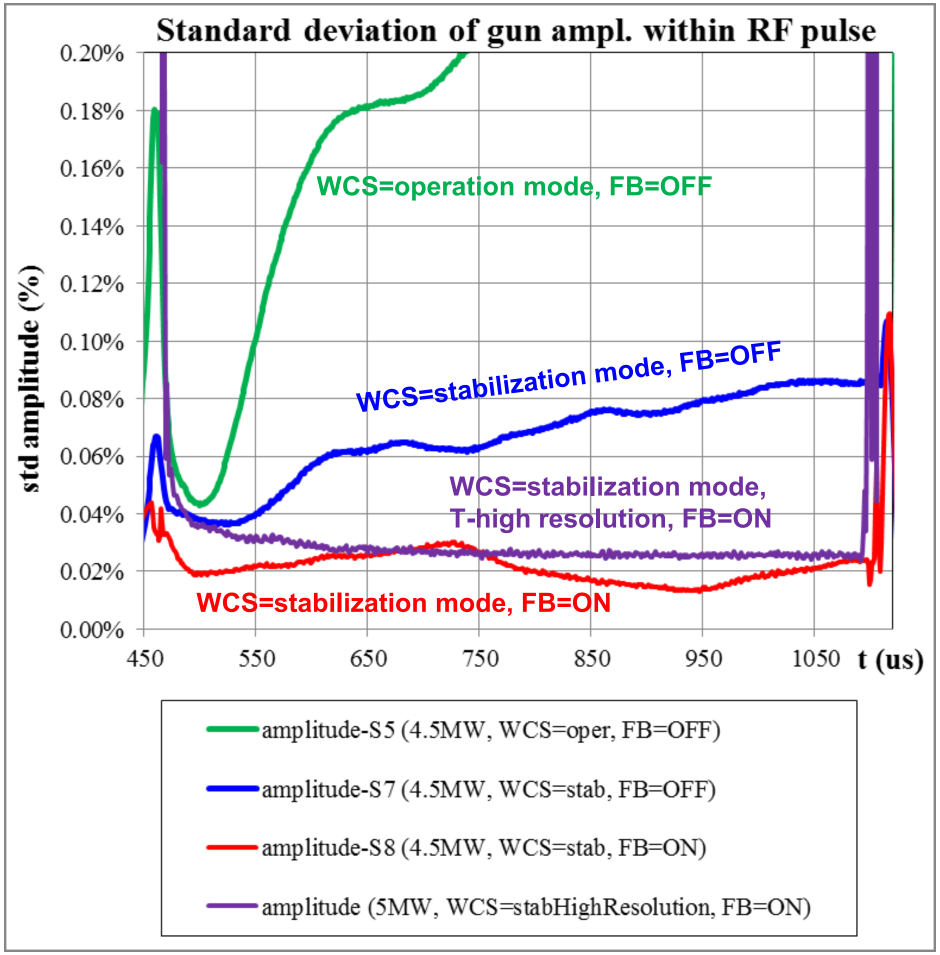
Also included meanwhile: Fine gun phase and amplitude stabilization using adaptive RF pulse length tuning

Gun RF stability at 4.5 (5.0) MW
650µs flat-top RF, 800 subsequent shots

Phase



Amplitude

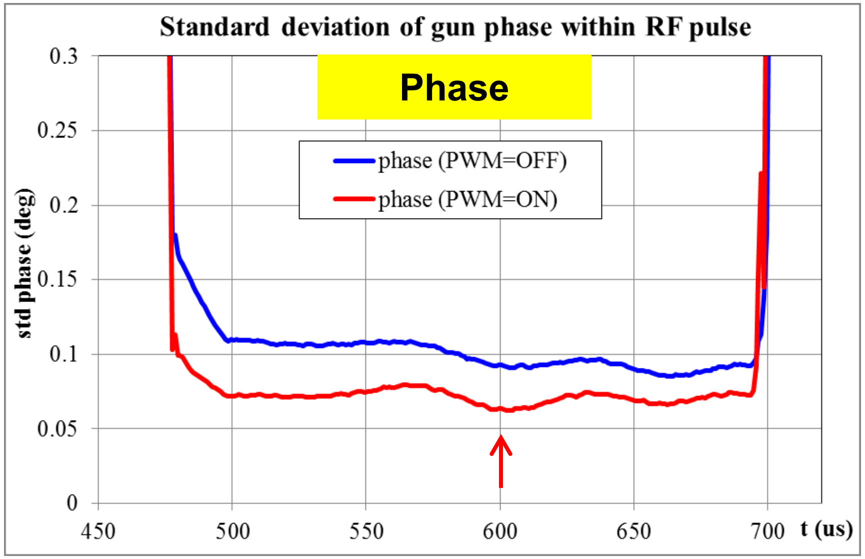


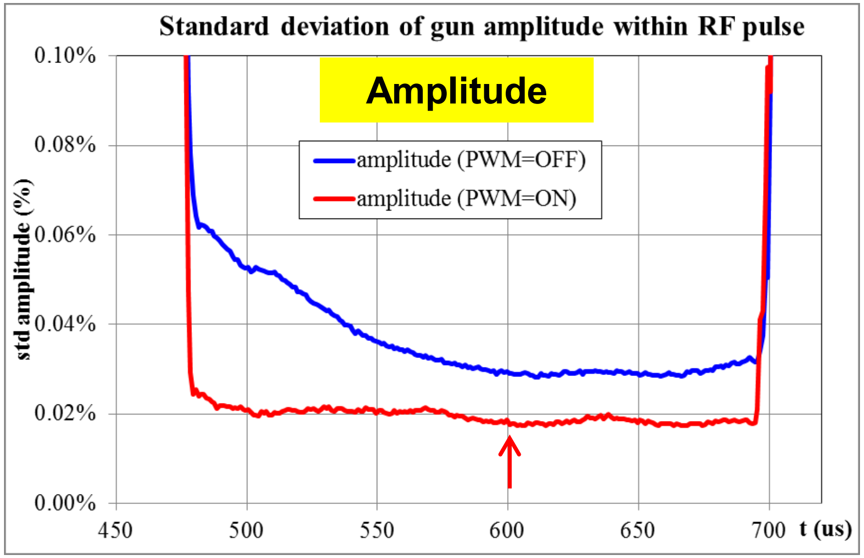
LLRF measurements are cross-checked with beam measurements !

Pulse Width Modulation (PWM)

Tests at PITZ:
- Pgun~6.35MW (60MV/m)
- ~200us RF pulse flattop
- WCS=stab, High Resolution
- FB gain=2.5

PWM	σ_T (°C)	σ_ϕ (deg)	σ_A (%)
OFF	0.0231	0.0926	0.0295
ON	0.006	**0.0633**	**0.0187**

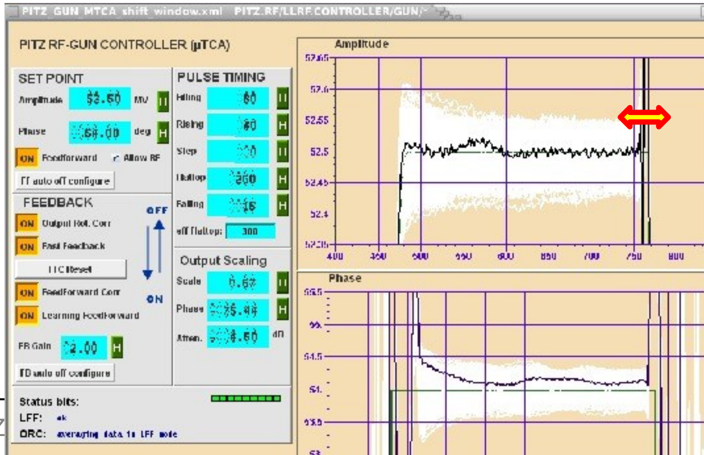




Comparable to FLASH operation results (400us) – **but still not according to specs:**

Phase jitter ≤ 0.01 degrees, Amplitude jitter ≤ 0.01 %

Possible reasons (investigations ongoing):
- Fine tuning of uTCA ?
- RF source instability (e.g. Modulator ?! → same problem at XFEL)



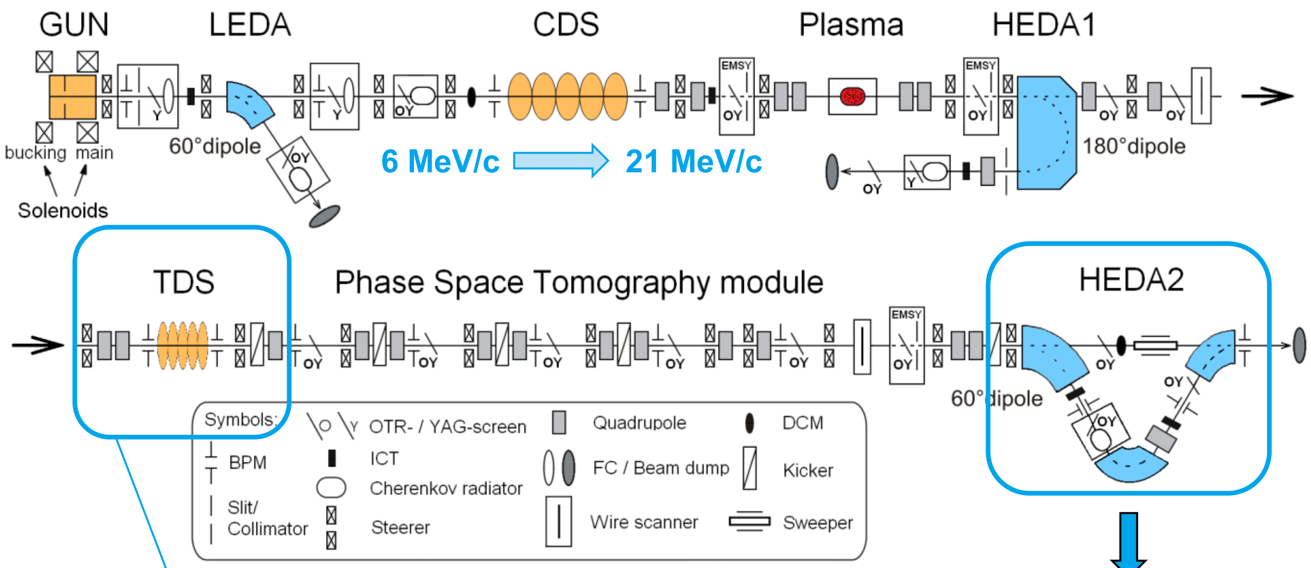
Amplitude 52.50 MV
Phase 64.00 deg
FB Gain 2.00
Filling 60
Rising 60
Flattop 200
Falling 16
eff flattop: 300
LFF: ok
ORC: averaging data in LFF mode

New Developments at PITZ:

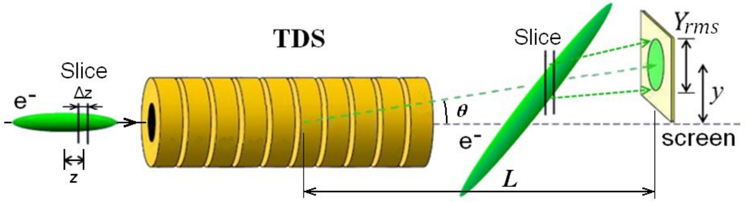
- Transverse Deflecting System (TDS)
- Laser system generating 3D ellipsoidal laser pulses
- Gun 5: the next generation of RF guns
- Case study: IR/THz from PITZ-like setup
- (First results from plasma acceleration experiments)

New developments at PITZ: Transverse Deflecting System (TDS)

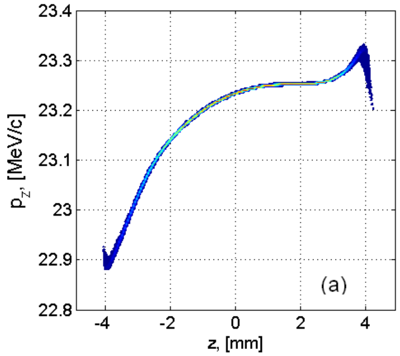
allows high time resolution measurements



horizontal spectrometer dipole



deflecting cavity: **bunch length** mapped to vertical axis



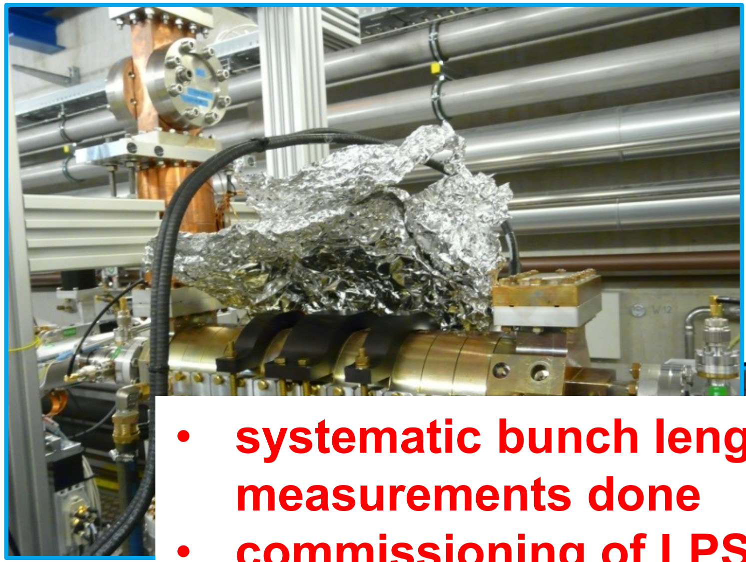
direct image of **longitudinal phasespace (LPS)**

also:
slice emittance measurement!

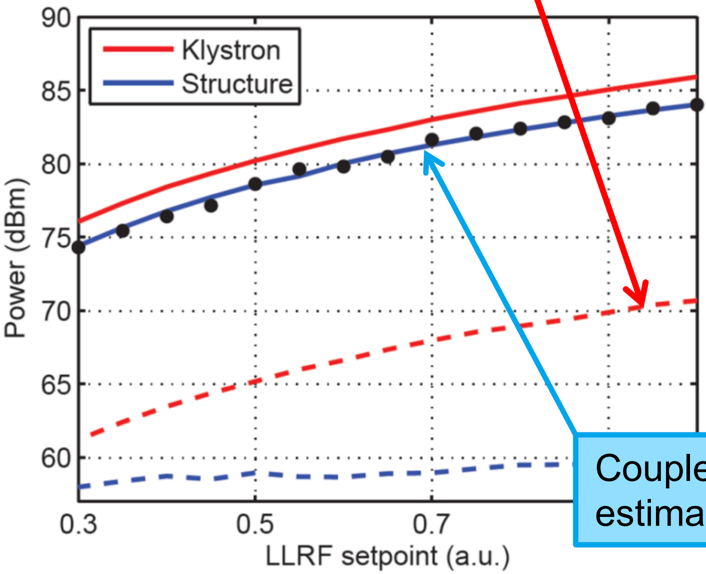
Deflecting Structure - Commissioning

- Prototype for the E-XFEL injector
- Designed & manufactured by *Institute for Nuclear Research* (INR, Troitsk, Russia)
- Traveling wave structure, like LOLA

- May 2015: on-site acceptance test of modulator
- **July 2015: first RF in structure!**
  - Structure conditioned up to ~500 kW (~25% of design value)
  - Reflection at klystron coupler precludes higher power.
  - **Reflection of whole WG system under investigation…**



- **systematic bunch length measurements done**
- **commissioning of LPS + slice emittance ongoing**



Coupler readings in good agreement with power estimation from e-deflection (black dots)!

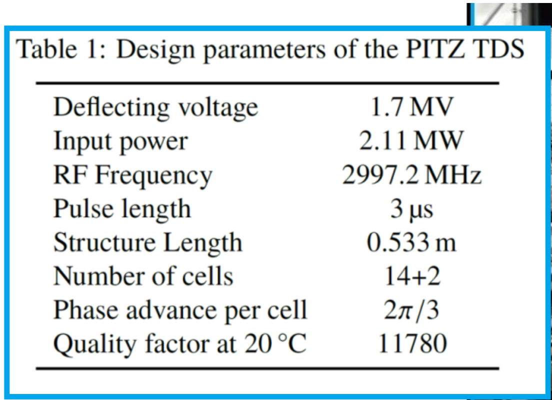
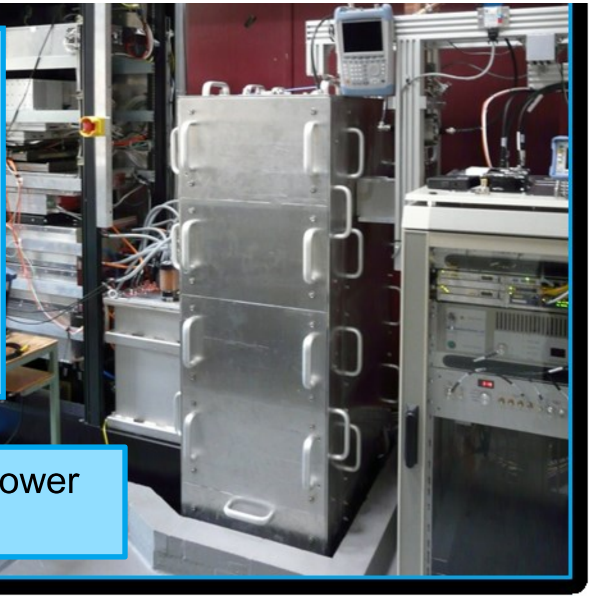
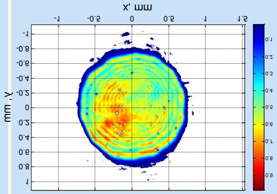
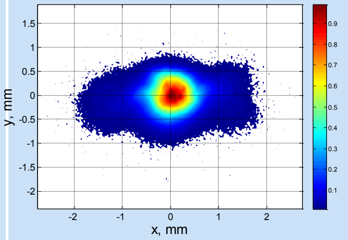
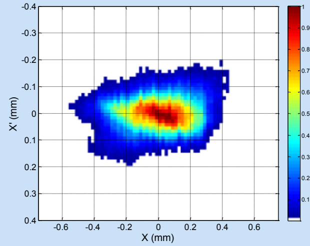
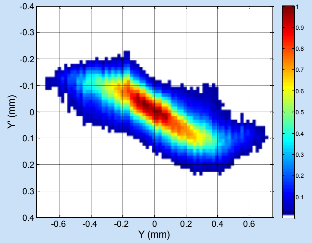
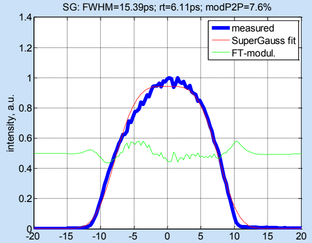
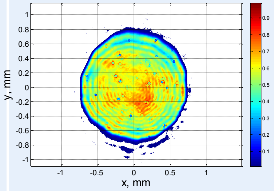
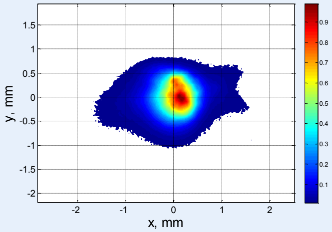
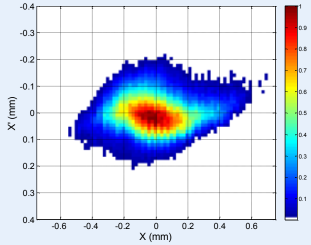
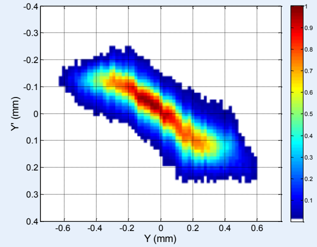
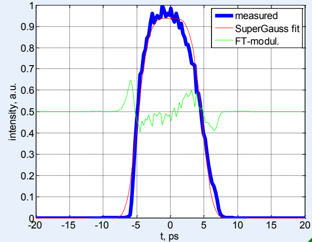


Table 1: Design parameters of the PITZ TDS

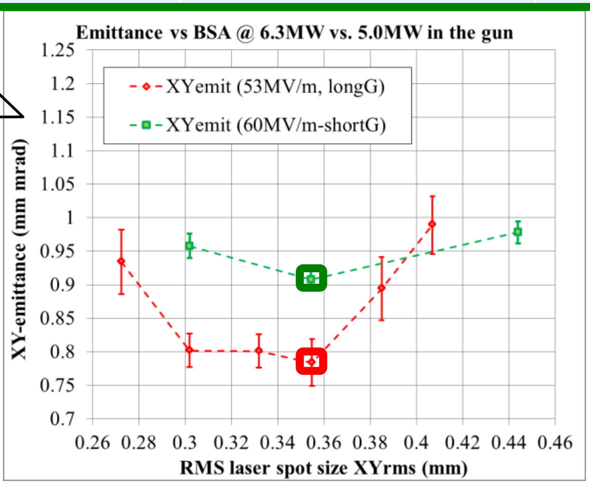
Deflecting voltage	1.7 MV
Input power	2.11 MW
RF Frequency	2997.2 MHz
Pulse length	3 μs
Structure Length	0.533 m
Number of cells	14+2
Phase advance per cell	$2\pi/3$
Quality factor at 20 °C	11780

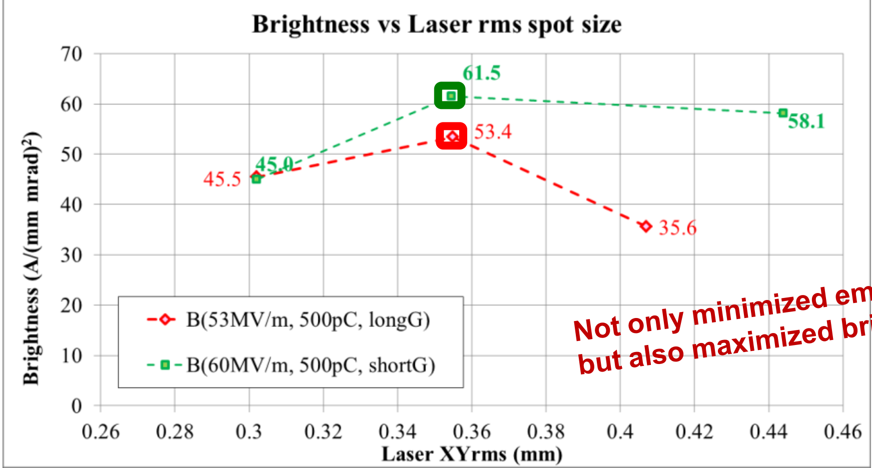


Measured emittance+brightness in 2015: 500pC; Gaussian laser pulses

Cathode laser temporal	VC2 (laser)	E-beam at EMSY1	X-PX	Y-PY	E-beam temporal profile (TDS)
Long Gaussian ~11.5ps FWHM 53MV/m					
Short Gaussian ~2-2.5ps FWHM 60MV/m					

Various photo cathode pulse length, various gun gradients

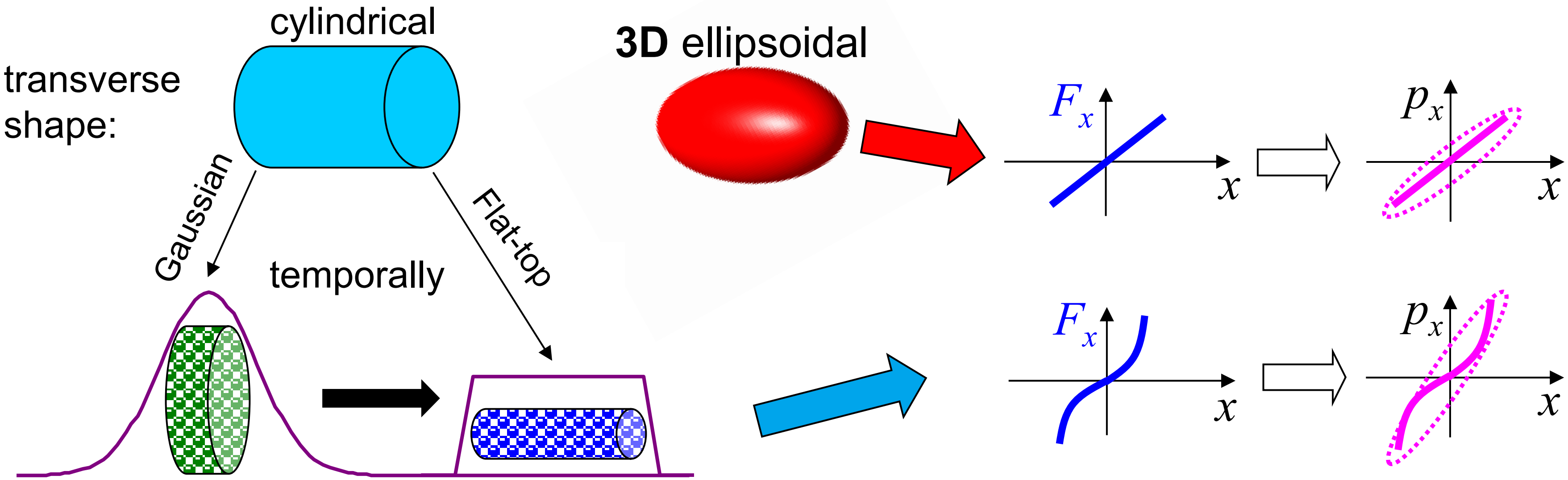


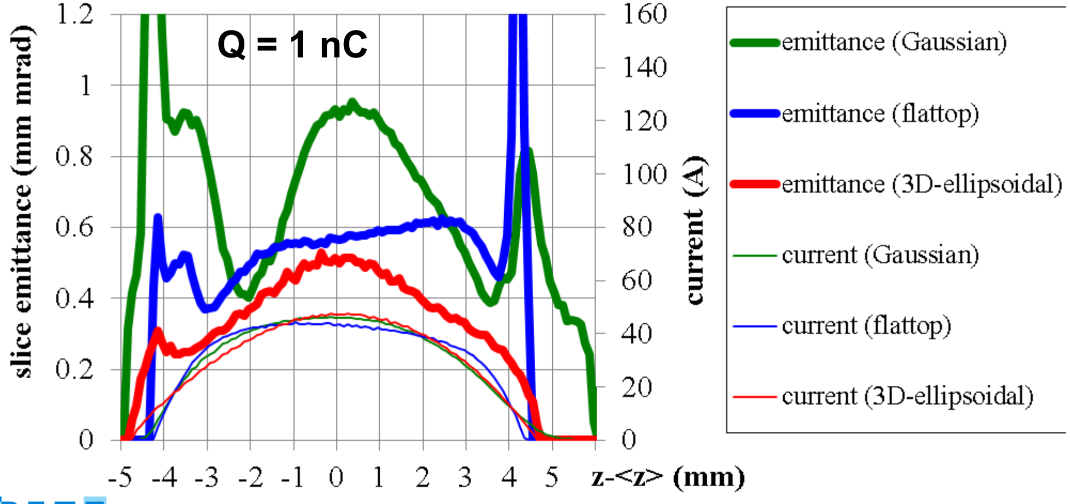


Not only minimized emittance, but also maximized brightness

New developments at PITZ: Cathode laser pulse shaping → towards 3D ellipsoid

Main idea: minimize the impact of the space charge on the transverse emittance.





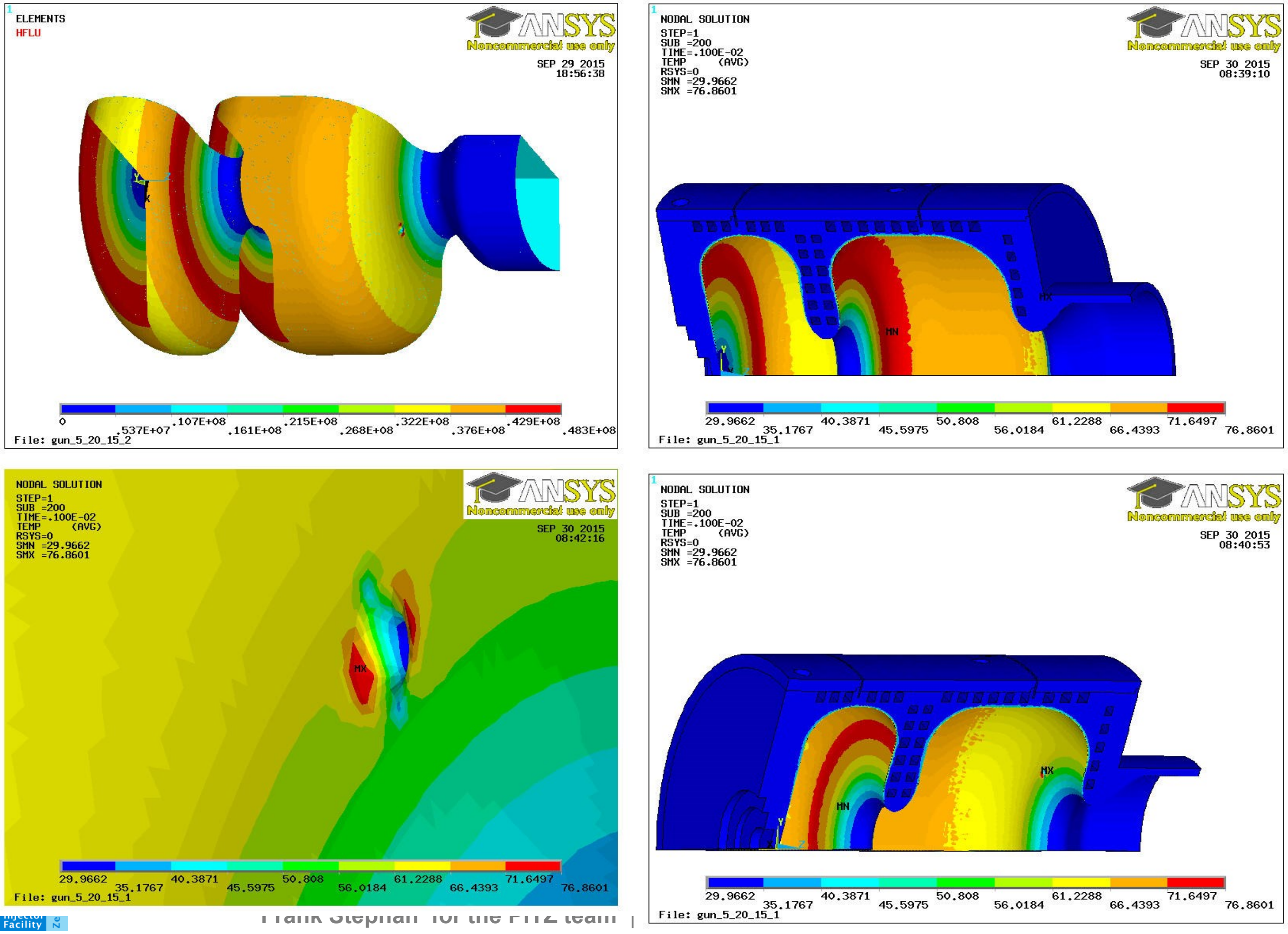
Potential of 3D ellips. for all FELs:

- ➢ **30-50% lower av. slice emittance**
- ➢ **Better longitudinal compression**
- ➢ Reduced beam halo
- ➢ Less sensitivity to machine settings
- ➔ **German-Russian collaboration:**
- • **IAP (Nizhny Novgorod) built laser**
- • 2014/2015: installed at PITZ
- • **2016: generate synchronized beam → characterization**

New developments at PITZ: Gun5 - the next generation of RF guns

- Gun5 has improved - RF pickups → RF stability
  - cell/iris shape
  - water cooling

  } → operating stability/ reliability
- Example: RF pulse heating



- physical design almost finished (INR + (DESY))

- all questions from previous Gun5 review answered

- design report is sent around

- final review of Gun5 with Hamburg colleagues in March

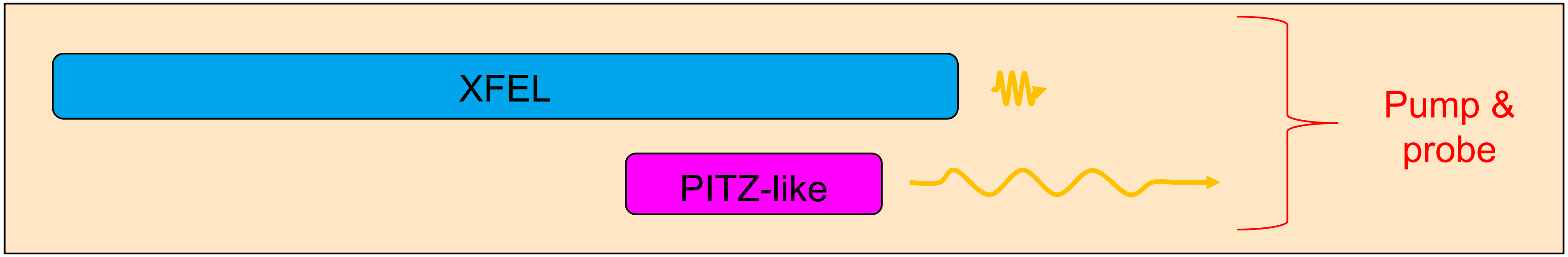
New developments at PITZ: Why studying a THz source at PITZ?

- Combination of **tunable IR/THz** and X-ray pulses in **pump and probe experiments** at the European XFEL facility finds **wide applications**
- Requirements: spectral and temporal characteristics, peak power, polarization, precise synchronization
  → no universal solution from traditional techniques up to now !

⇨ **TUNABLE IR/THZ SOURCE FOR PUMP PROBE EXPERIMENTS AT THE EUROPEAN XFEL**

E.A. Schneidmiller, M.V. Yurkov, DESY, Hamburg, Germany
M. Krasilnikov, F. Stephan, DESY, Zeuthen, Germany

Contribution to FEL 2012,
Nara, Japan, August 2012

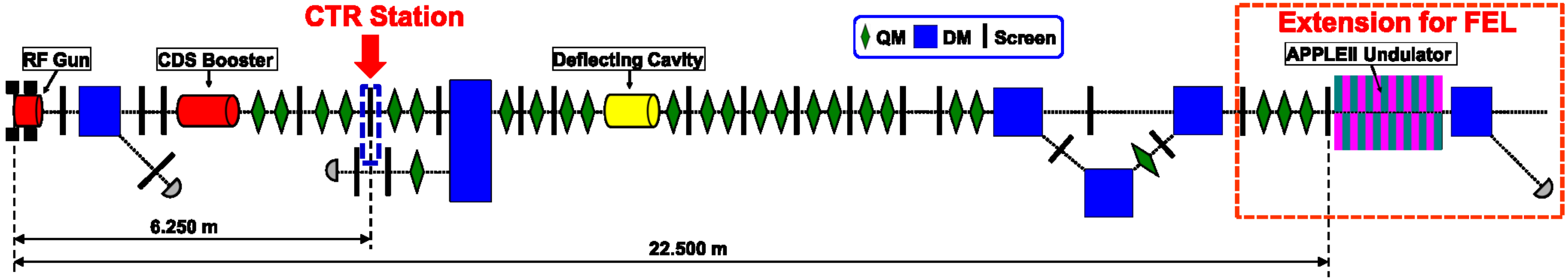


- PITZ-like setup:
  - can produce required IR/THz radiation
  - **identical pulse train pattern** as XFEL
  - could be installed **close to XFEL experimental end stations**

  [→ additionally: allows pump-probe experiments with **low-energy ultra-short** electron bunches (Q ≤ pC)]

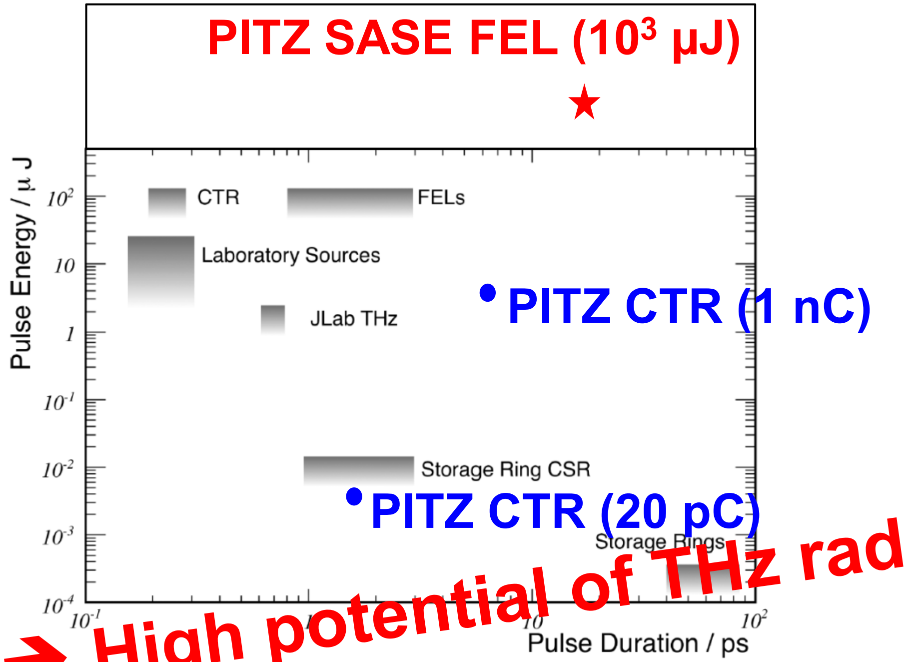
➔ PITZ can serve as prototype for such a development.

Simulations of the IR/THz Options at PITZ (High-gain FEL and CTR)

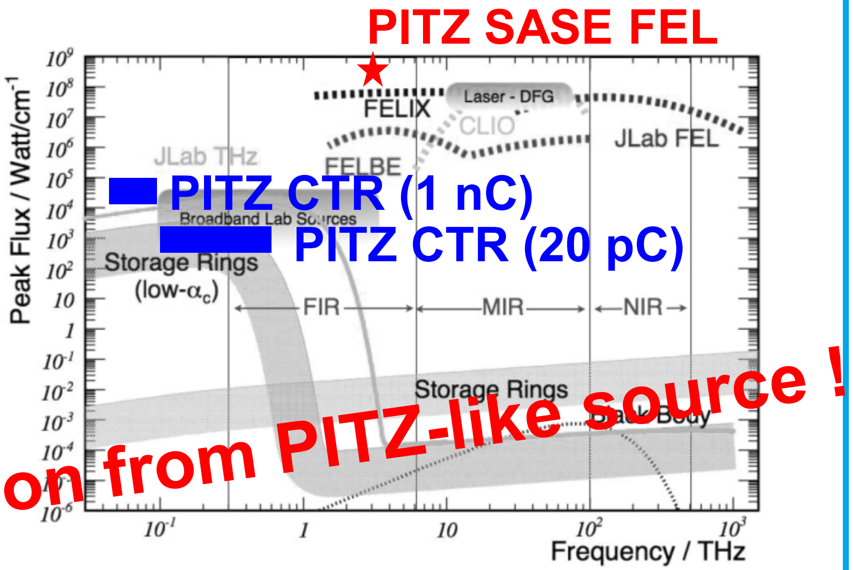


Comparison to the other IR/THz sources (the radiation from PITZ sources are just estimations):

Pulse energy VS FWHM of the generating bunch for the various sources



Spectral peak power density VS frequency



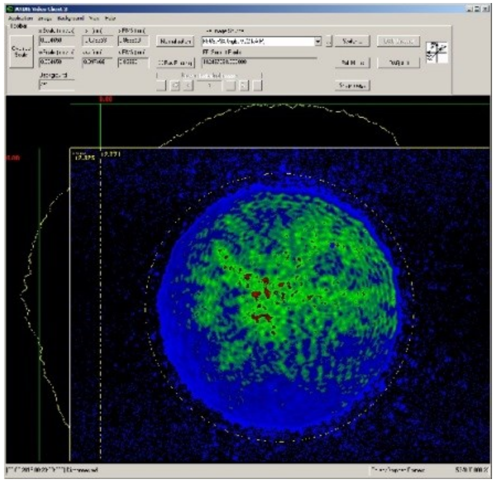
→ High potential of THz radiation from PITZ-like source !

Reference: Anke-Susanne Müller, Rev. Accl. Sci. Tech., 03, 165 (2010)

PITHz(4nC): First results (29.09N-30.09M)

Laser with long Gaussian pulse

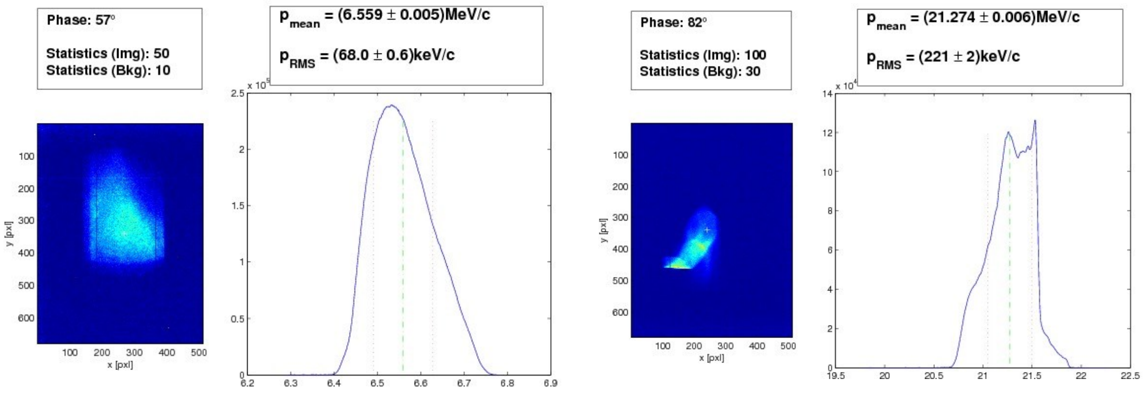
Laser profile at virtual cathode (BSA = 3.5 mm)



Projections of beam momentum at MMMG phases

After the gun

After the booster



Phase: 57°

Statistics (Img): 50
Statistics (Bkg): 10

p_{mean} = (6.559 ± 0.005)MeV/c

p_{RMS} = (68.0 ± 0.6)keV/c

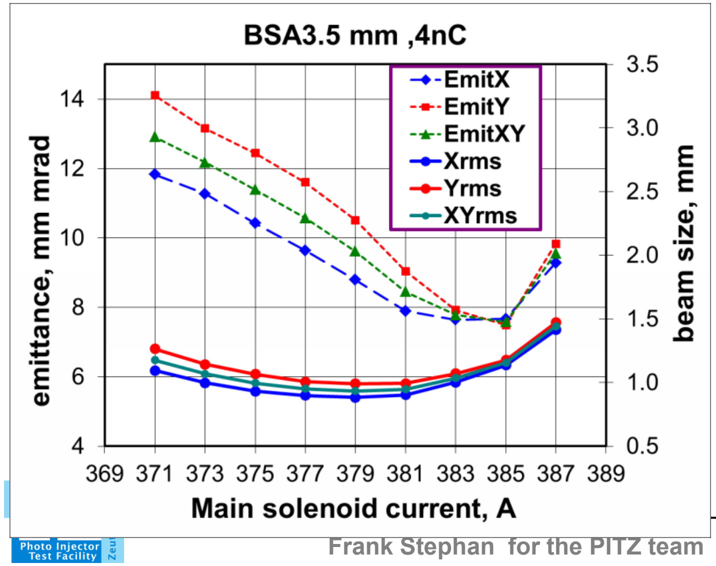
Phase: 82°

Statistics (Img): 100
Statistics (Bkg): 30

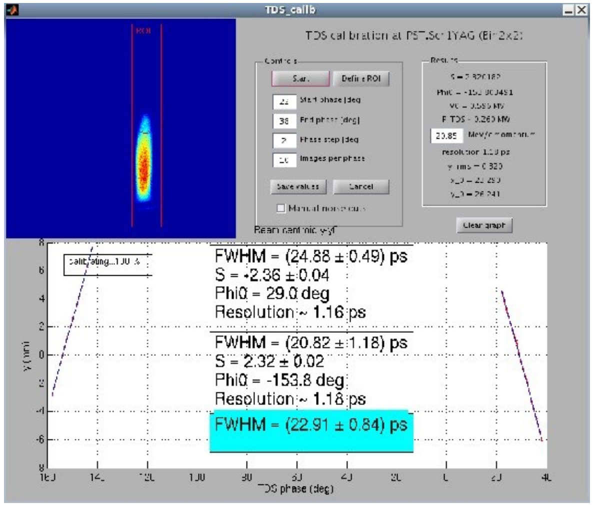
p_{mean} = (21.274 ± 0.006)MeV/c

p_{RMS} = (221 ± 2)keV/c

Emittance measurement



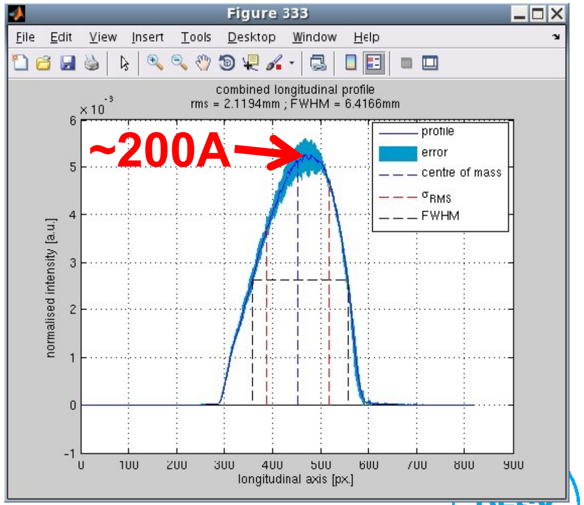
Longitudinal profile measurement



FWHM = (24.88 ± 0.49) ps
S = -2.36 ± 0.04
Phi0 = 29.0 deg
Resolution ~ 1.16 ps

FWHM = (20.82 ± 1.18) ps
S = 2.32 ± 0.02
Phi0 = -153.8 deg
Resolution ~ 1.18 ps

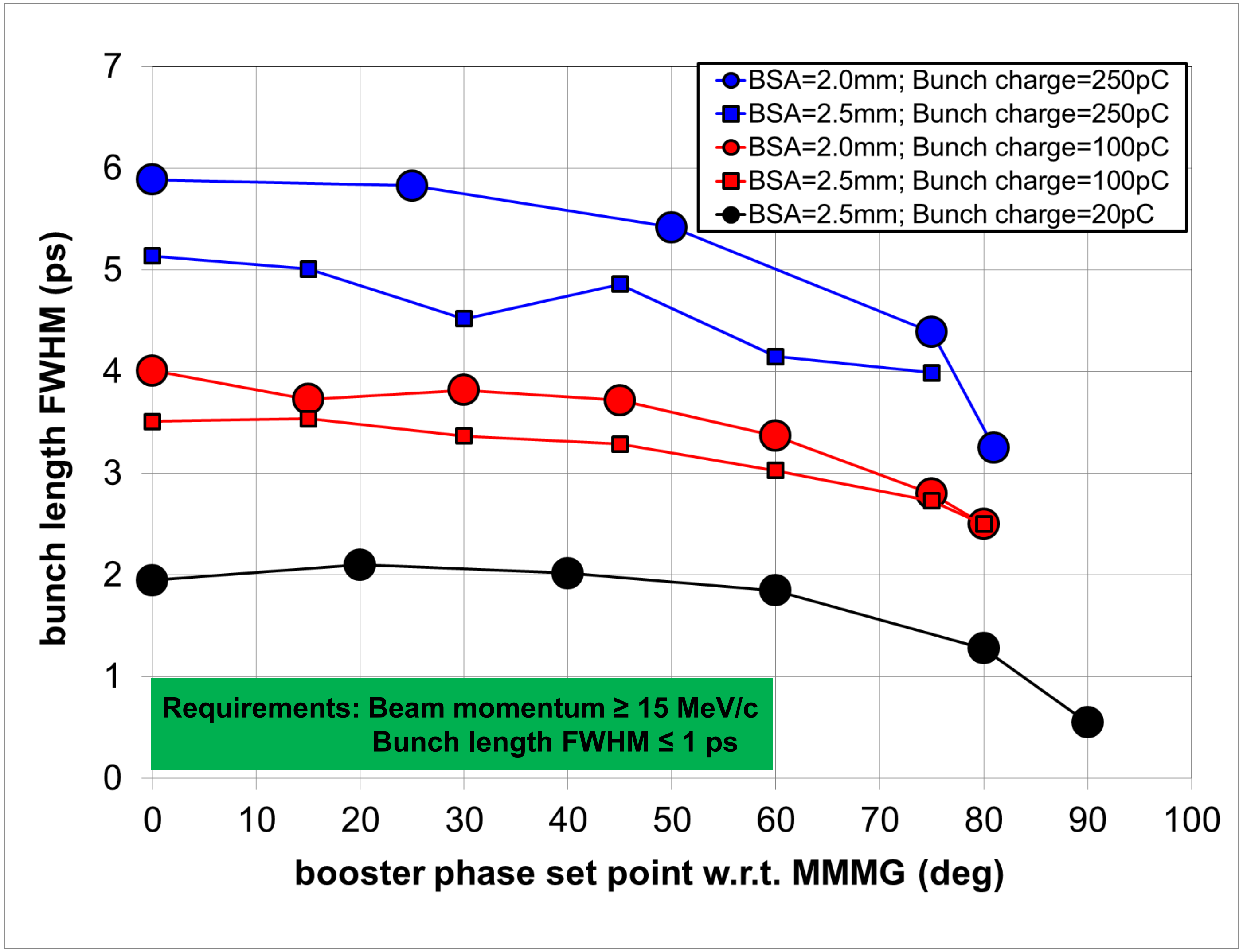
FWHM = (22.91 ± 0.84) ps



~200A

Laser with short Gaussian pulse

PITHz(Short Bunch): Velocity bunching (30.10M-31.10N)



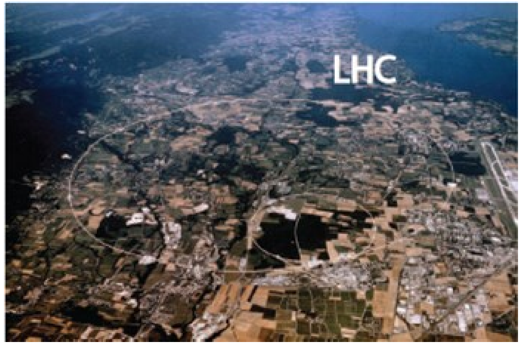
➔ Already promising, larger BSA to be tested. HEDA2 to be studied !

LAOLA@PITZ: Self Modulation → Background

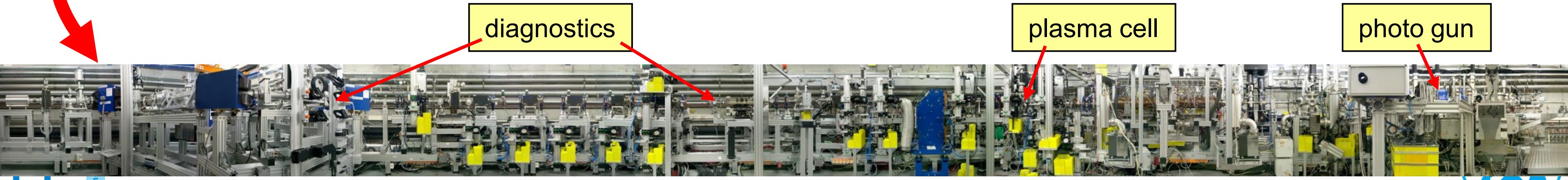
- Background: proton driven PWFA experiment at CERN (AWAKE collaboration) plans to utilize beam-plasma instability for **self modulation**
  - Use high energy proton beam to drive wake and convert the **proton beam** energy into **electron beam** energy in a **single** stage
  - Problem:

$$E_{z,max} = 240(MV\ m^{-1})\left(\frac{N}{4x10^{10}}\right)\left(\frac{0.6}{\sigma_z(mm)}\right)^{2}$$

Caldwell et al., Nature Physics (2009)

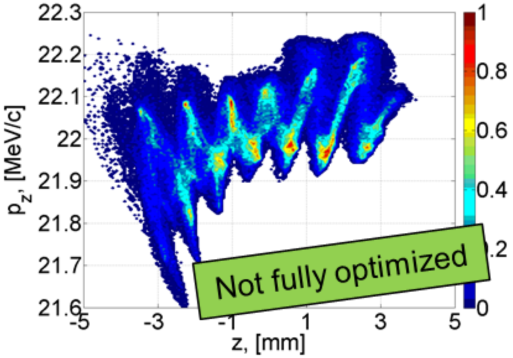


    - High accelerating gradient requires **short** bunches $\sigma_z < 100\ \mu m$
    - Existing proton machines produce **long** bunches $\sigma_z \approx 10$ cm
  - Solution: use beam-plasma instability to **modulate the beam at the plasma wavelength**, driving strong plasma waves for acceleration
  - But: so far simulations only (no direct experimental evidence)
- Goal: detect and characterize **self modulation of electron beams** in PITZ beam line to gain critical insights into **relevant physics** (dephasing, hose instability etc.)



Plasma cell experiments: basic essentials

- Proof of concept: start to end simulation of planned experiment at PITZ shows measurable effect

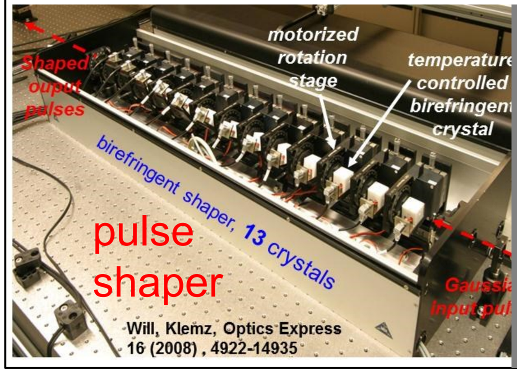


Longitudinal Phase-space studies
Simulations: Martin Khojoyan / Dmitriy Malyutin

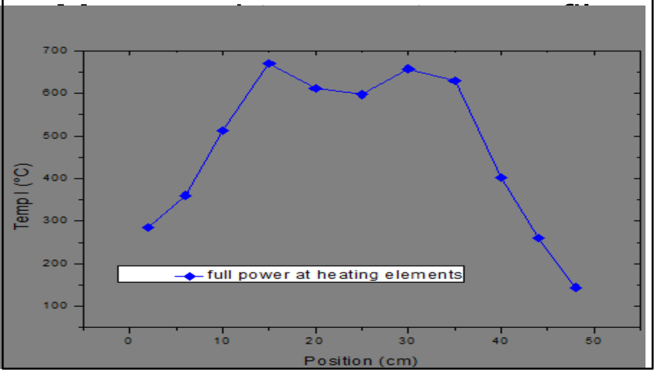
Expected phase space shows measurable signature

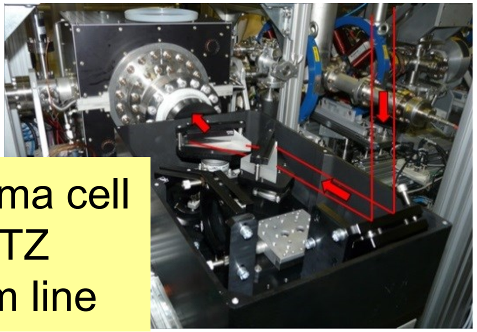
Good visibility: $\lambda_p \approx 1\text{mm} \rightarrow$ Plasma density 10^{15} cm^{-3}

- Key devices for experiment
  - Photoinjector laser, developed and built by Max-Born Institute Berlin includes pulse shaper
  - Well developed diagnostics
  - Plasma cell (Lithium vapor heat pipe oven)
  - ArF Ionization laser



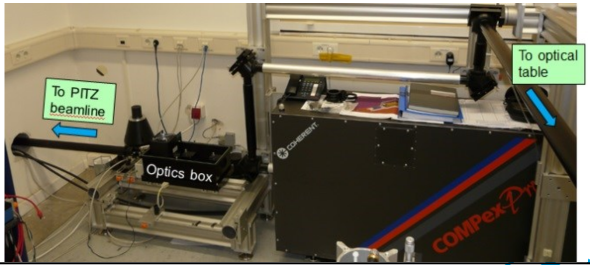
Will, Klemz, Optics Express 16 (2008) , 4922-14935





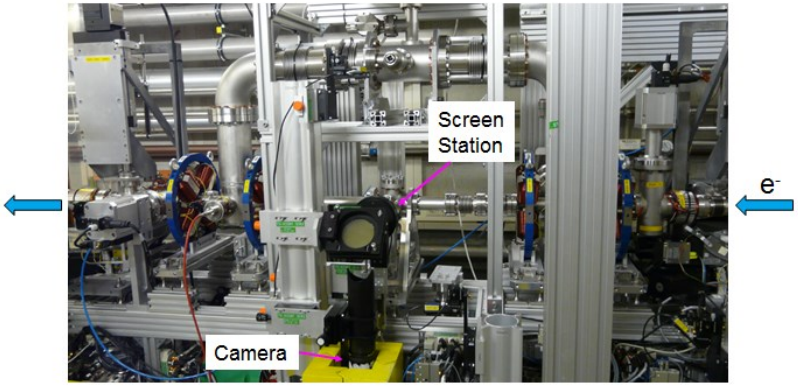
Plasma cell in PITZ beam line

Ionization laser: λ=193nm

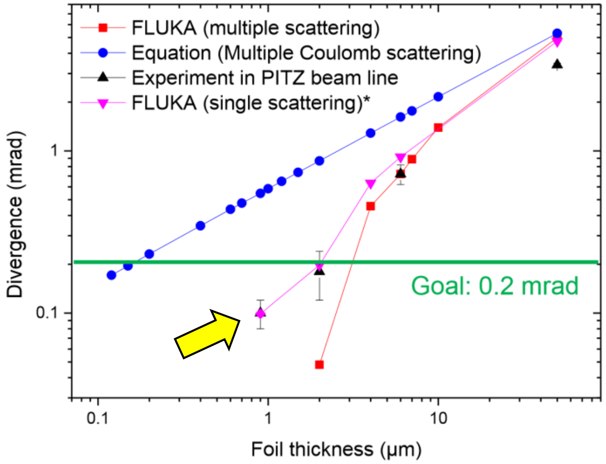


Plasma cell experiments: experimental results up to now

Focusing into plasma cell position: <100μm rms

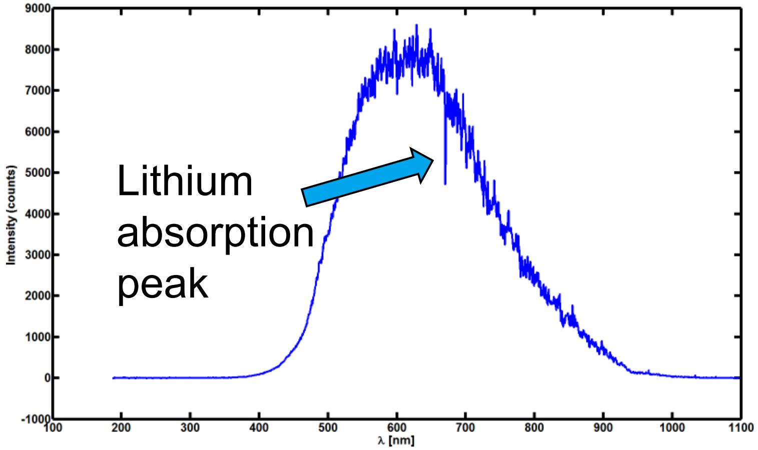


Measured scattering of thin foils (e- windows)



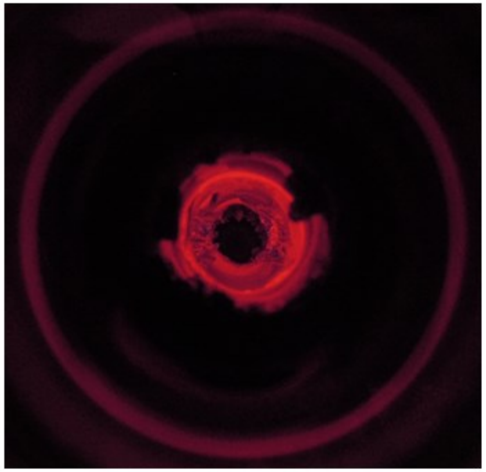
Goal: 0.2 mrad

Measured Li vapor density: ≈10^{14} cm^{-3}

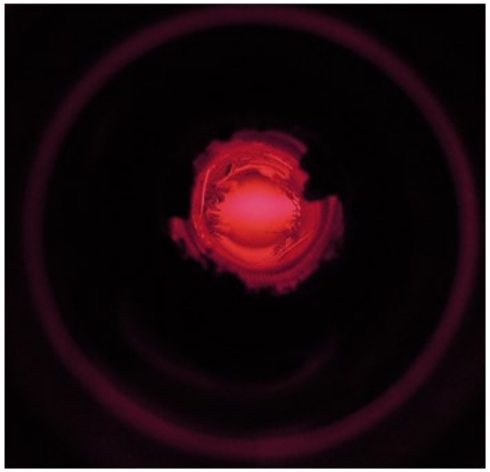


Lithium absorption peak

> Laser off (heat glowing)



> Laser on (plasma)



→ **First plasma is cross-shaped plasma cell worldwide, but no SMI observed yet !**

Plasma cell experiments: next steps

Problems	Solutions
Heating wires overpowered	Stronger heater / better heat insulation
Lithium accumulation in cooling zones	• Finer mesh → better lithium transport • Longer side arms
Only 10% laser pulse energy delivered to plasma cell	• Better optics (e.g. cylinder lenses; antireflection coating) • Increase efficiency of nitrogen beamline generation
Electron windows increase achievable focus size	Thinner electron window foils

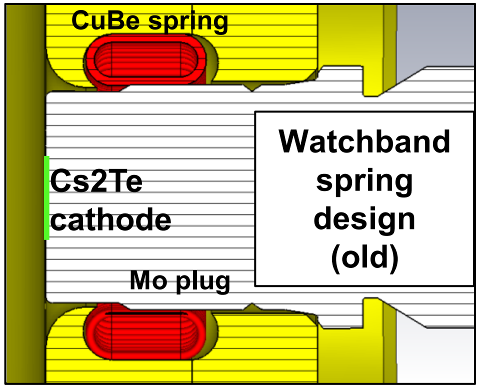
> **Continue plasma experiments in spring 2016 with improved hardware** (estimated costs for upgrade only ~8 k€)

Summary

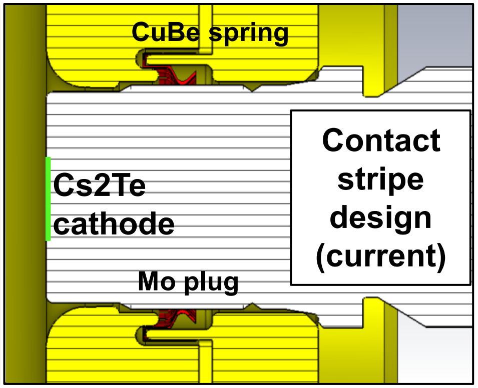
- PITZ has shown that **2 Thales RF windows** can **work** reliably up to XFEL specs
  → **after conditioning time: no problems from Thales RF windows were found**
  BUT: Gun4.2 (9 years old) could NOT reliably support XFEL specs. Therefore, run at XFEL specs was only 3 month with many interlocks from the gun, afterwards run at 5MW, 650µs, 10Hz was quite stable
- **Beam quality for XFEL start-up conditions demonstrated,**
  emittance vs QE and vs cathode gradient was studied
- Origin of beam asymmetries traced back to coupler nose / solenoid
- Progress in improving **stability of gun** (temperature stabilization, LLRF upgrade)
  → **specs not reached yet → modulator (?) → important for XFEL gun**
- Transverse deflecting system for **high time resolution measurements** and **3D ellipsoidal laser pules** in commissioning.
- Gun5 physical design almost finished.
- **Tunable IR/THz source** based on PITZ setup promises **unique capabilities** for pump-probe experiments at **European XFEL**
  - Design of the system and experimental pre-checks are ongoing
- First **plasma experiments** performed at PITZ → no self-modulation observed yet, but **clear path to successful experiments visible**

Outlook for 2016

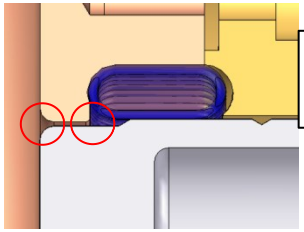
- The next gun setup is in preparation
  - **Gun 4.6** with "**watchband-reloaded**" design of cathode spring is baked and installed (should be even more robust than latest contract strip design which seems to work without problems)
  - two conditioned **DESY-type vacuum RF windows** are available for the 2-window setup (as in 2011)
  - T-Combiner with optimized design for placing RF windows is installed
  - Gun conditioning should start this week
  - expected conditioning time ~3 months



Watchband spring design (old)

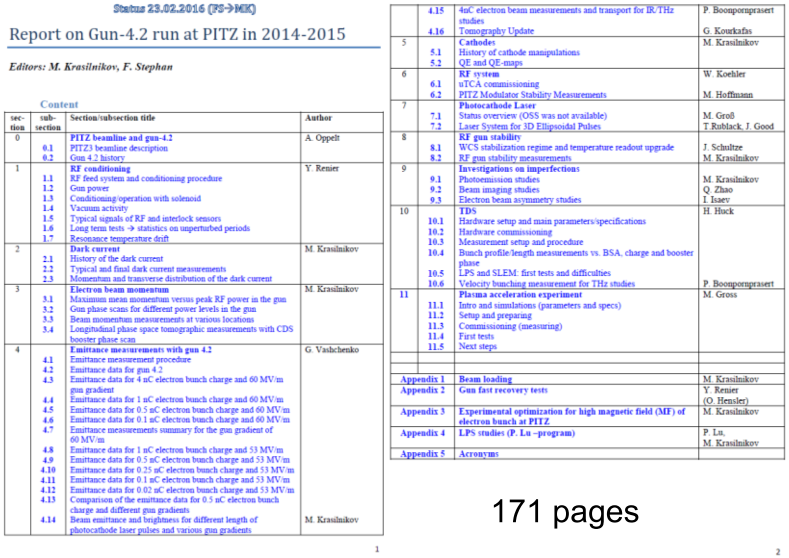


Contact stripe design (current)



"Watchband reloaded" spring design (looks promising)

- PITZ **water cooling system** is planned **to be upgraded** in March – May, **Gun conditioning** should be possible **in parallel** with short interruptions.
- **Gun5** review meeting in HH in March 2016 ?!
- **Run** period (expected with **650µs, 6.5 MW, 10 Hz**) will allow to continue **beam measurements** and commissioning of **TDS**, **3D laser** and upgraded **plasma cell**.



Status 23.02.2016 (FS→MK)

Report on Gun-4.2 run at PITZ in 2014-2015

Editors: M. Krasilnikov, F. Stephan

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	0.1	PITZ3 beamline description	
	0.2	Gun 4.2 history	
1		**RF conditioning**	Y. Renier
	1.1	RF feed system and conditioning procedure	
	1.2	Gun power	
	1.3	Conditioning/operation with solenoid	
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Thank you for your attention !