Accelerator R&D at PITZ in 2016, 2017, ff

Frank Stephan for the PITZ team

Content – main activities:

- testing the 2 RF window solution with full XFEL specs
- beam characterization + 3D ellipsoidal laser pulses: ultimate electron beam quality
- Gun5: the next generation of RF gun
- plasma acceleration experiments at PITZ
- tests towards CW RF guns

Remarks:

1) Scientific exchange with the corresponding people from MPY, XFEL and FLASH is by default planned for each of the research topics and therefore not additionally mentioned in the following slides.
2) Challenges for technical groups from previous slides are not repeated on subsequent slides.

HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

Testing the 2 RF window solution with full XFEL specs

- Scientific challenges, status, highlights:
  - PITZ has shown in 2015 that **2 Thales RF windows** can work reliably up to XFEL specs → **after conditioning time: no problem from Thales RF windows could be 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
- Current time planning:
  - **Gun4.6** (new, "watchband reloaded" cathode design) now being installed at PITZ is equipped with **2 DESY RF windows** → expected to run at XFEL specs during 2016
  - (If run is not stable due to RF windows → try with 2 Thales type windows → 2016 – 2017)
  - (If run not stable due to gun → try with Gun4.5 → end2016 – 2017)
  - If Gun4.6 runs reliably with 2 DESY RF windows (as expected) → test of Gun4.5 with 1 Thales window is possible in 2017
- Challenges for technical groups in M division:
  - MHF-sl: if needed: further dry-ice cleaning of components
  - MHF-p: if needed: RF simulations, further improvement of gun modulator (PITZ, XFEL)
  - MSK: latest installation of llrf hard- and software, further development of llrf regulation
  - MCS: joined development of unified, quick and safe start-up procedures

beam characterization + 3D ellipsoidal laser pulses: ultimate electron beam quality

> Scientific challenges, status, highlights:
  - Detailed electron beam characterization, incl. using TDS structure (projected, slice + thermal emittance, bunch length, long. phase space, origin of µ-bunching instability) using different operation parameters (cathode gradient, laser pulse shapes, bunch charges, photo cathodes) → e.g. measurement matrix: **emittance (laser shape, gradient)**
  - Further development of laser pulse shaping towards generating **3D ellipsoidal laser pulses** → close collaboration between FS-LA, IAP Nizhny Novgorod, PITZ → **ultimate beam quality** → should allow XFEL performance beyond current specs

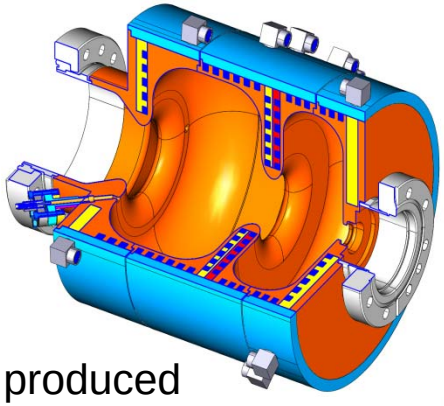
> Current time planning:
  - 2016: fully commission TDS system, start detailed beam characterization, first synchronized photoelectrons from IAP laser system
  - 2017 ff: continue detailed beam characterization, continuous upgrade and improvement of IAP laser system with corresponding beam characterizations to develop a laser system suitable for installation at an user facility

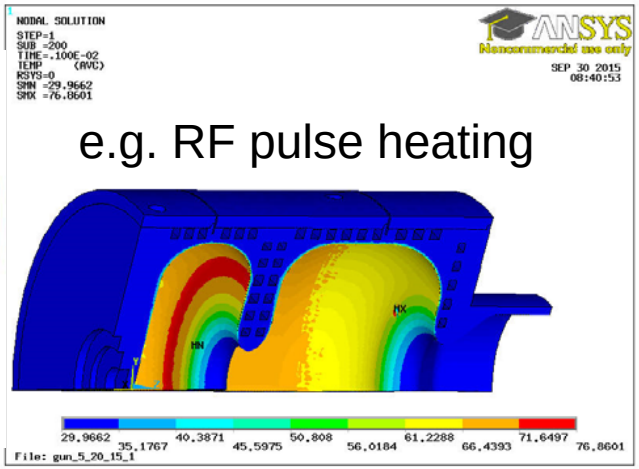
> Challenges for technical groups in M division:
  - MIN, MSK: know-how exchange / if needed support to fully commission TDS system
  - MSK: support installation of synchronization system for IAP laser
  - FS-LA: 2016: - help to repair OSS and to install laser diagnostics at MBI laser → stability
    - new oscillator for IAP laser (own development or commercial solution)

Gun5: the next generation of RF gun

- Scientific challenges, status, highlights:
  - **Gun5** has - **RF pickups** → should allow improved RF regulation, new RF feed technology
    - improved **cell/iris shape** → better RF efficiency, reduced DC in the cavity
    - improved **water cooling** → better heat removal → allows higher duty cycle (e.g. 25 Hz at XFEL, 800 µs at FLASH)

  → Gun5 should allow more stable and reliable operation !

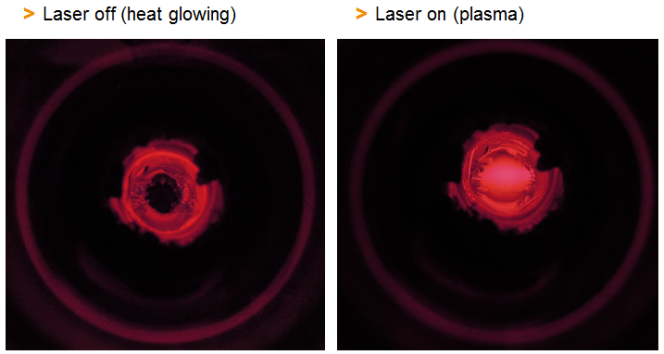




- Current time planning:
  - spring 2016: physics design of producible cavity ready
  - rest of 2016: produce construction drawings, start test production
  - until autumn 2017: Gun5 should be produced
  - end 2017 / start 2018: start gun conditioning and test of improved RF regulation at PITZ

- Challenges for technical groups in M division:
  - MVS: give feedback on production technology, from late 2016 on start test production and later on final production of Gun5 (in cooperation with Hansa Press ?!)
  - MSK: from late 2017 on strong support on and test of LLRF regulation on gun pickup

Plasma acceleration experiments at PITZ



- Scientific challenges, status, highlights:
  - Several pre-experiments: beam focusing, scattering by thin window foils, gas density measurements
  - **First plasma in cross-shaped plasma cell worldwide**, **BUT** no Self Modulation Instability (SMI) observed yet ! (SMI – needed for AWAKE experiment at CERN: p bunch → e bunch)
  - Reasons understood: too low plasma density (coarse mesh, poor ArF laser transport), too low beam density (thick windows, long. laser shape) → **all problems solvable !** (8k€)
- Current time planning:
  - spring/summer 2016: repeat self modulations experiments with improved setup
  - summer/autumn 2016: first experiments on generating high transformer ratios (efficient acceleration with beam driven PWFA)
  - 2017+: first experiments on lab astro physics if PITZ proves to be suitable in simulations
- Challenges for technical groups in M division:
  - MVS: until late 2016 provide one special Mo cathode to test DC production needed for lab astro physics experiments

tests towards CW RF guns for XFEL / FLASH

Not yet decided if such a development will take place

Emission, therm. emittance, beam quality @ reduc. grad.	Test cathodes emitting at green wavelength	Development and Test of a 216 MHz NC CW RF gun
> Scientific challenges, status, highlights:		
Independent from the final type of CW gun (NC or SC):		
▪ max. emission gradient for any CW gun (NC or SC) is expected to be lower than for current PITZ gun	▪ can significantly reduce the requirements on the photo cathode laser system (power, damage, shaping)	▪ follows baseline solution for LCLSII ▪ based on APEX design from Berkeley (186 MHz) ▪ changed frequency to fit DESY synchronization
> Current time planning:		
▪ 2017ff: study emission, thermal emittance, optimal achievable beam quality **at CW gradients** with PITZ gun and different laser shapes (incl. flat-top, 3D ellips.)	▪ maybe 2016+: production of “green cathodes” at LASA ? ▪ maybe 2017+ tests @PITZ: DC, emission and thermal emittance at CW gradients	▪ 2017f: start preparatory work ▪ design, built and condition RF gun and its RF system ▪ 2019(or later): install in PITZ, system test, characterization
> Challenges for technical groups in M division:		
▪ MPY, FS-LA: close exchange on experiment planning and results	▪ MVS: if interested and time allows join the development ▪ FS-LA: close exchange on experiment planning and results	▪ RF gun + RF system design in close cooperation with MVS, MIN, MHF-p, MHF-e, MKK, …