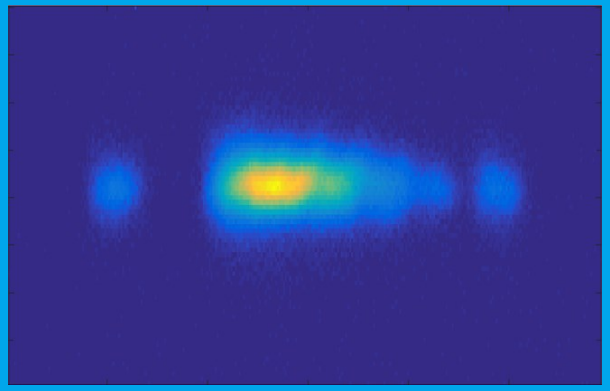
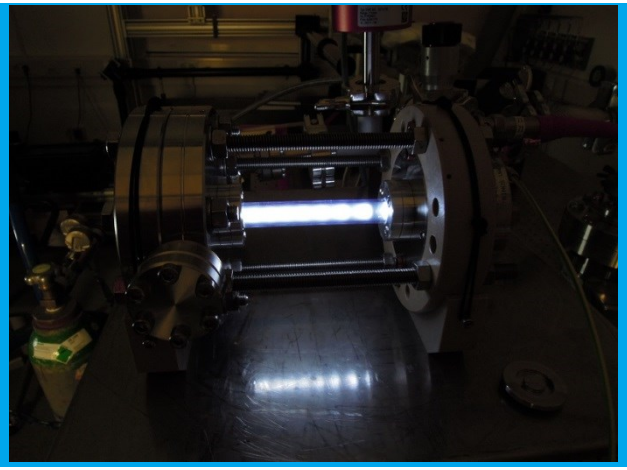
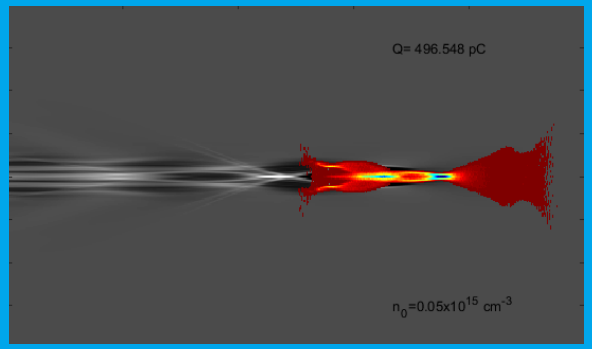
Status of HTR and gas discharge PWFA experiments.







Gregor Loisch

PITZ Physics Seminar

Zeuthen, 10.01.2017

HELMHOLTZ ASSOCIATION

DESY

Outline

1. Introduction
2. Results first experiments
3. Results second experiments
4. SMI in gas discharge plasma
5. Review of technical problems last run
6. Next run

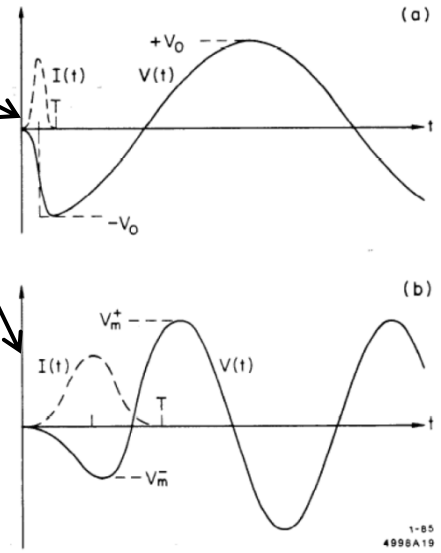
High transformer ratios

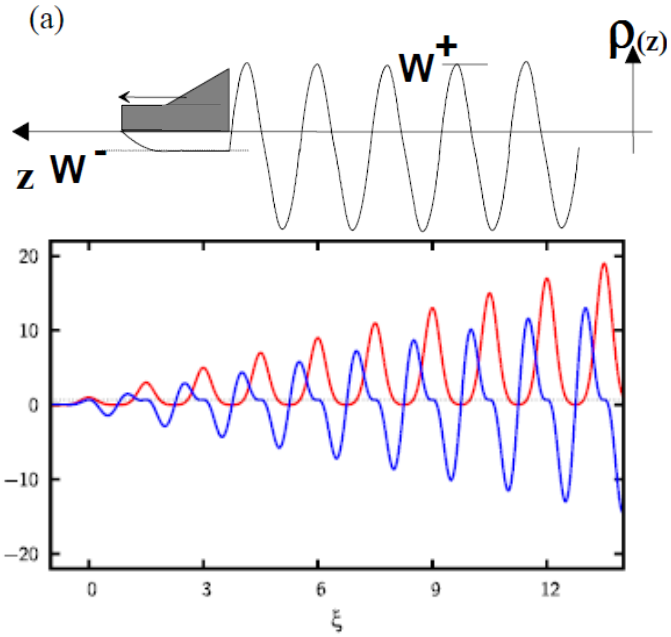
Collinear wakefield acceleration (linear theory):

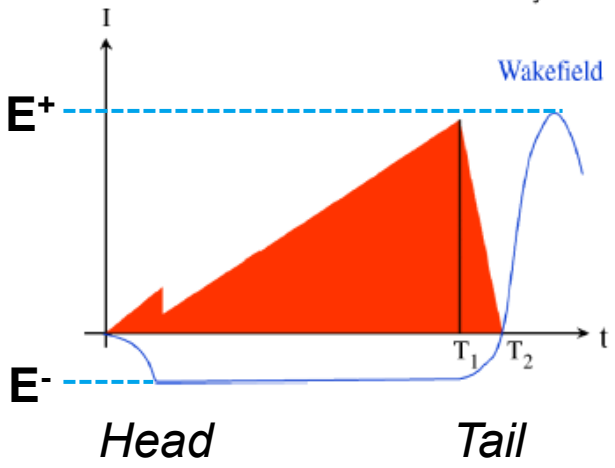
Fundamental theorem of beamloading: $E_{acc}/E_{dec} < 2$

→ Only true for symm. Bunches

→ Various proposed bunch shapes



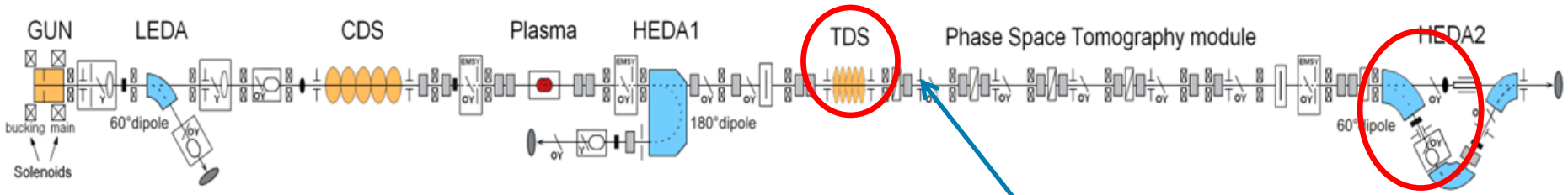




HTR:

$E^+/E^- > 2$

Experiments – Measurement method



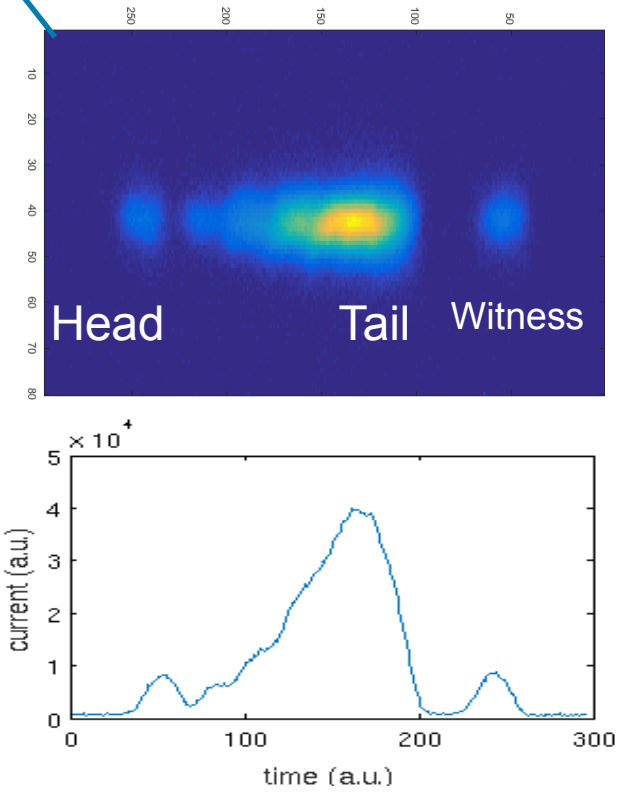
Time resolved energy measurement (slice energy)

- YAG screen for high charge driver

→ *maximum loss in driver*

- (small) LYSO for low charge witness

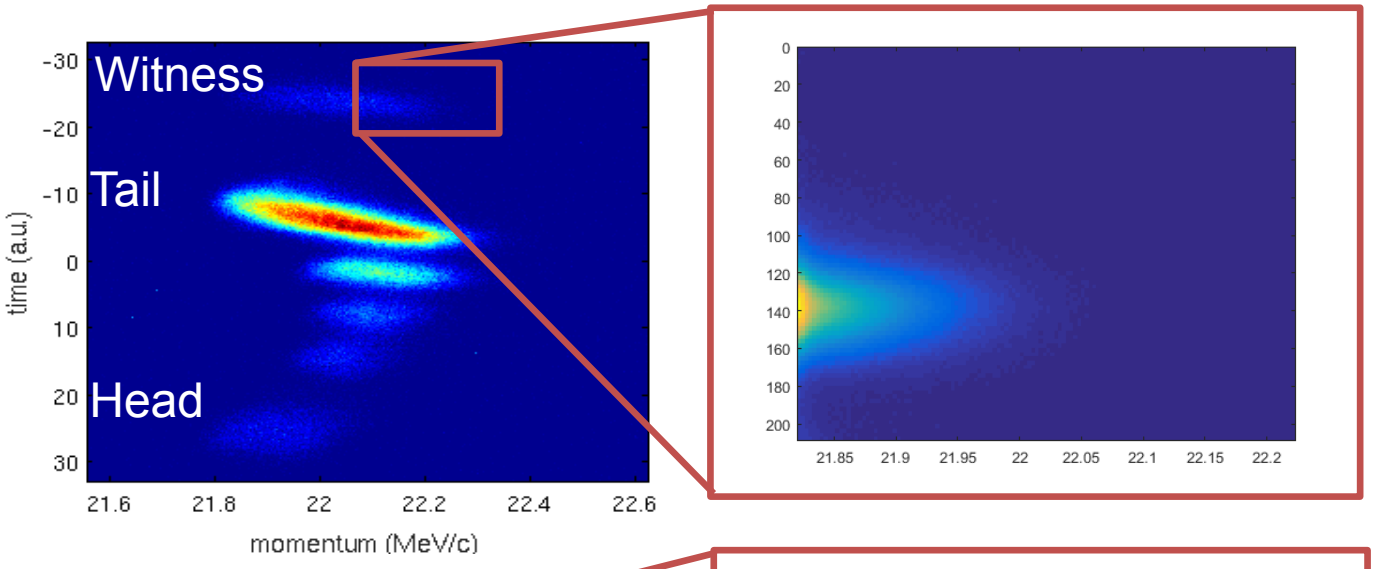
→ *Increase of maximum energy of witness*



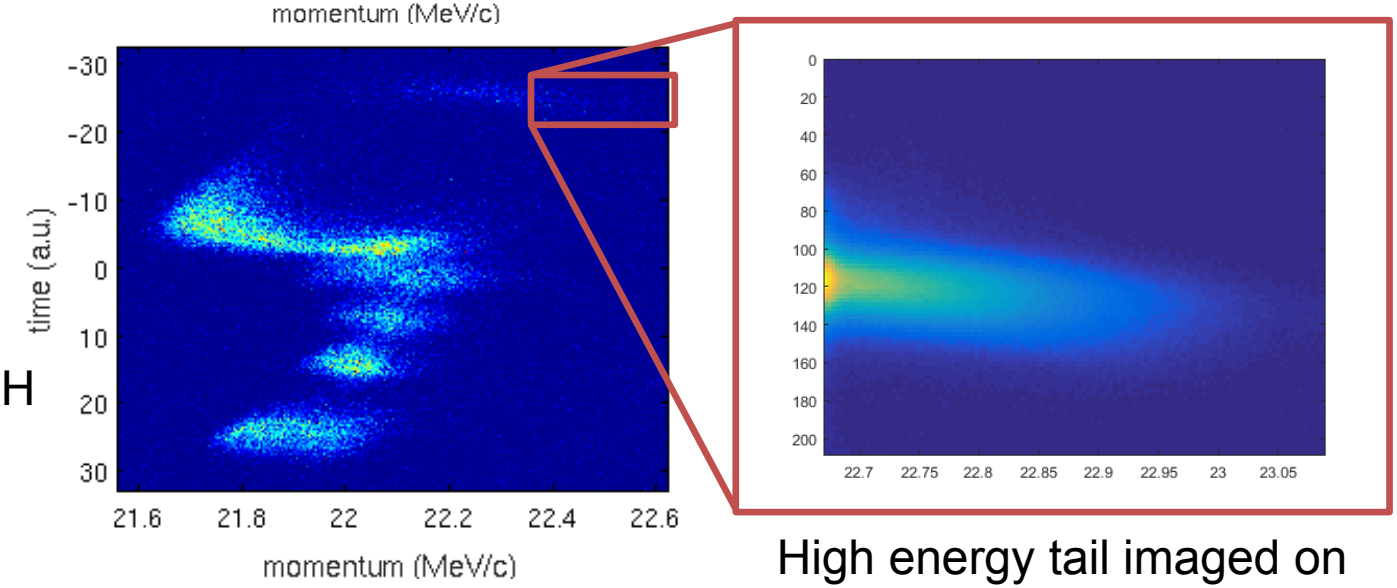
Measured electron beam profile

Experimental results – first run

Streaked beam in dispersive section, NO plasma

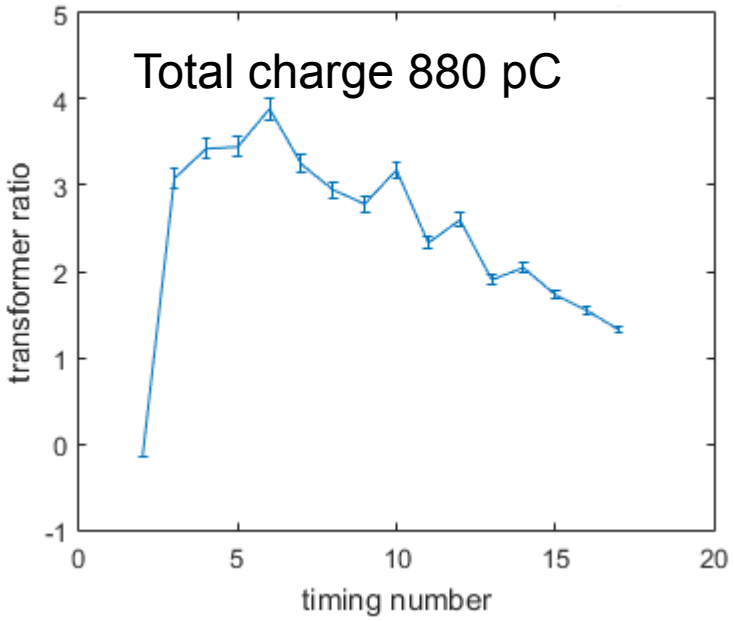


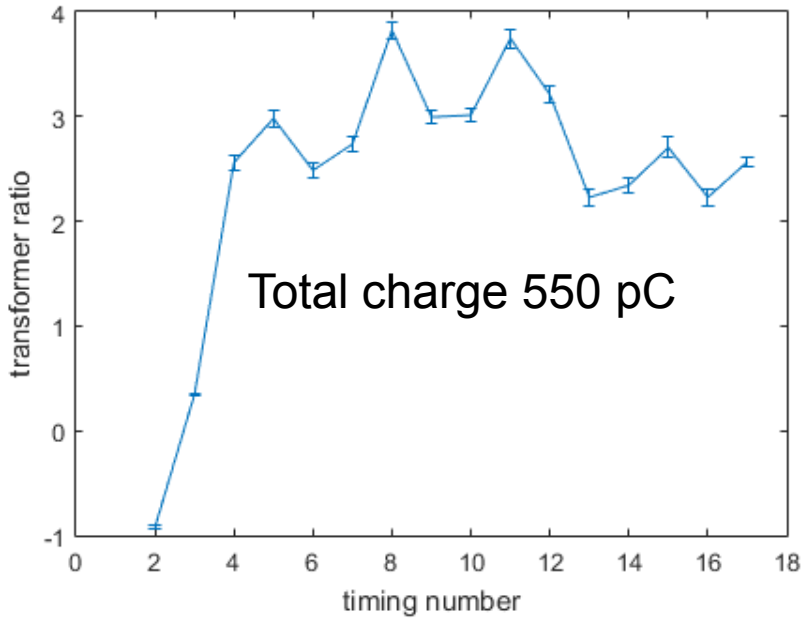
Streaked beam in dispersive section, WITH plasma

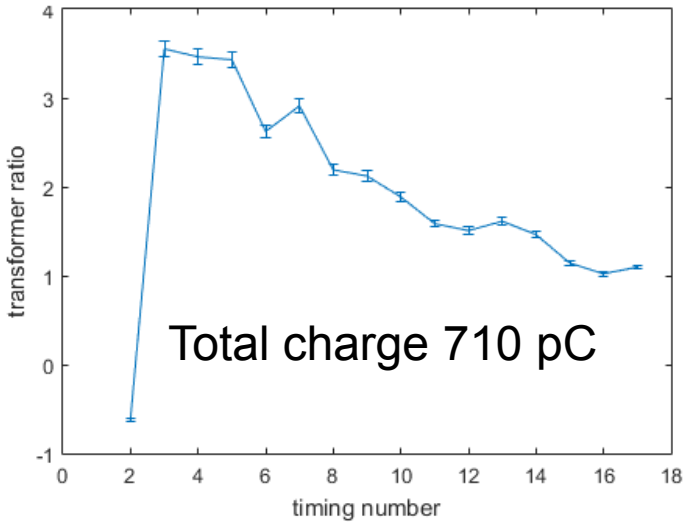


High energy tail imaged on LYSO screen

Experiments – Measurement results







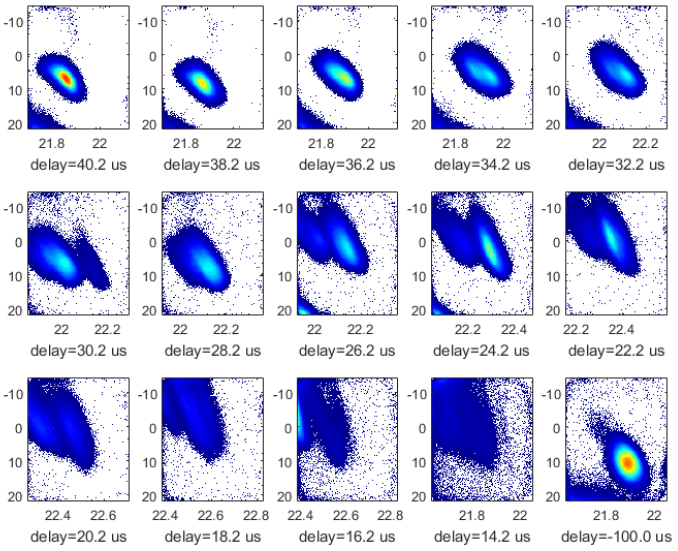
- Different other measurements
- also observed negative/low TRs (reasonable…)
- Problem with all measurements:
  - LYSO too small
  - Focusing of witness not investigated (early failure of plasma cell; vertical focus looks good, to be checked)

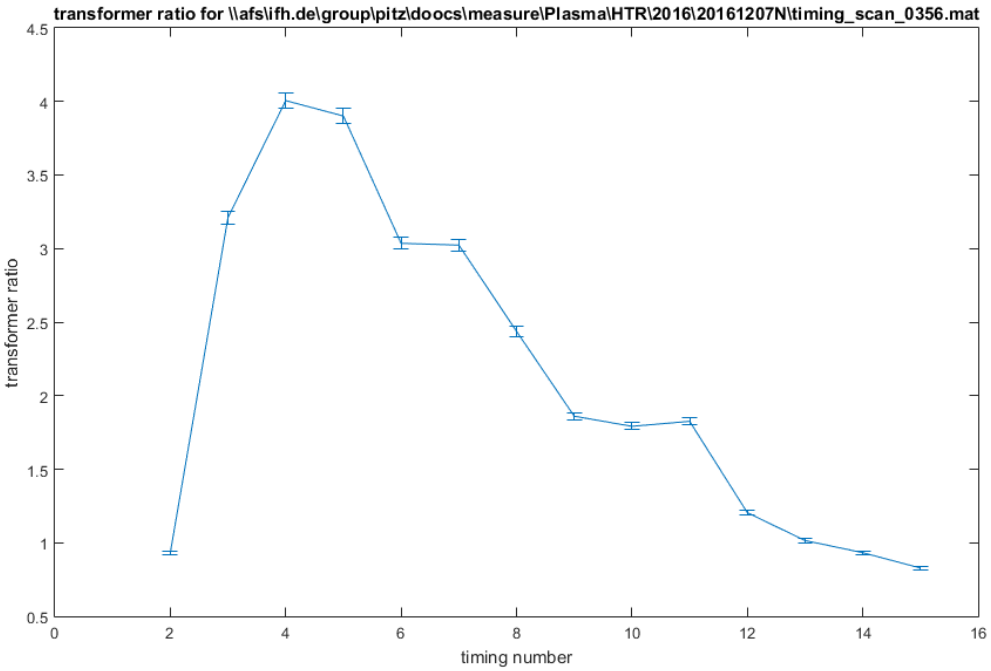
Experimental results – second run

- Much less measurements due to short time
- Also promising results (using same method as last time)

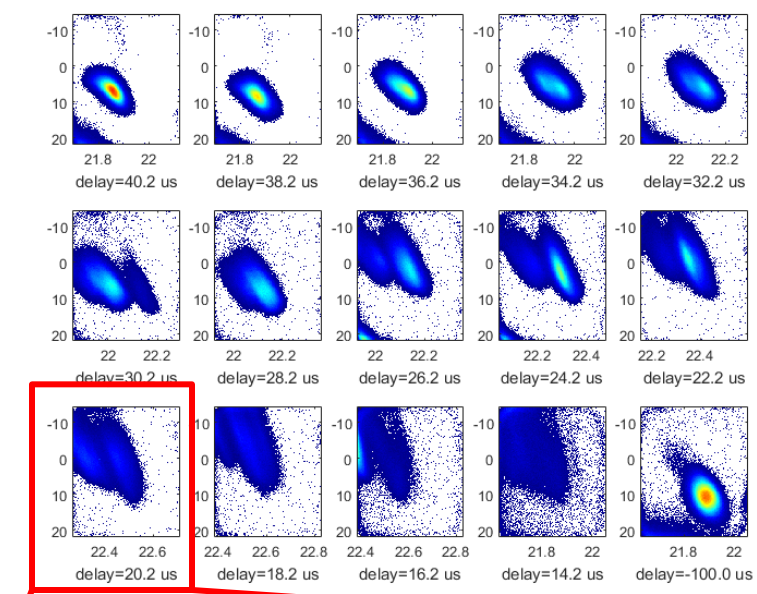
- Mean energy gain of witness also available → lower TR (~2.7) (reasonable..)

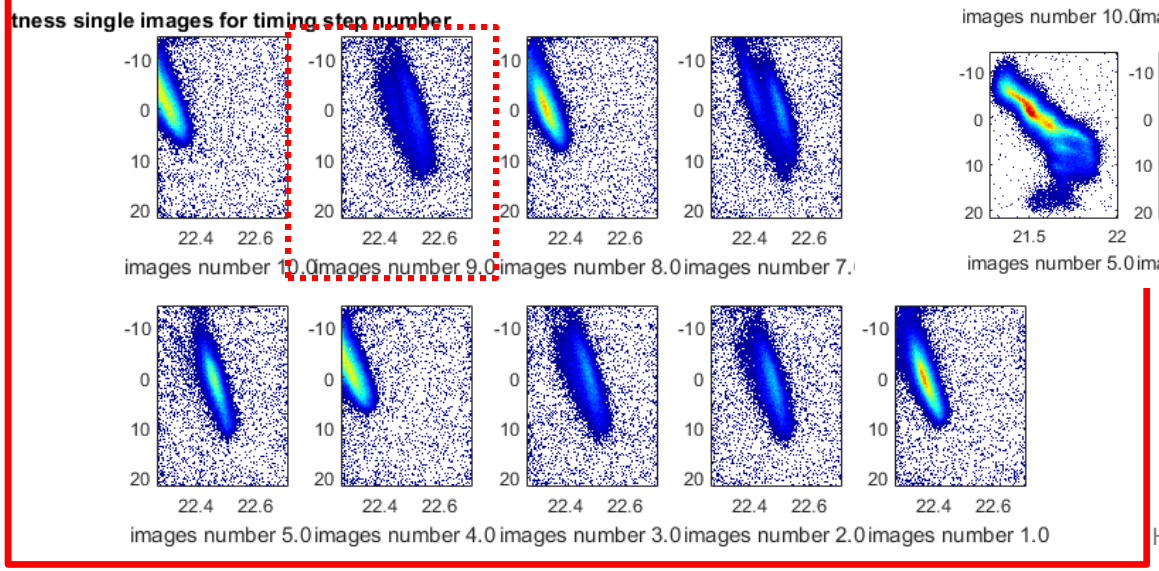
- Problem: discharge not stable during measurements





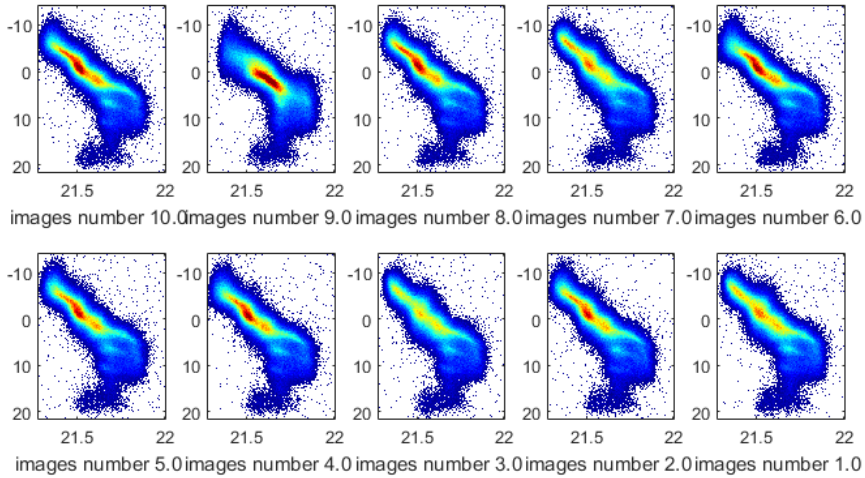
Experimental results – second run



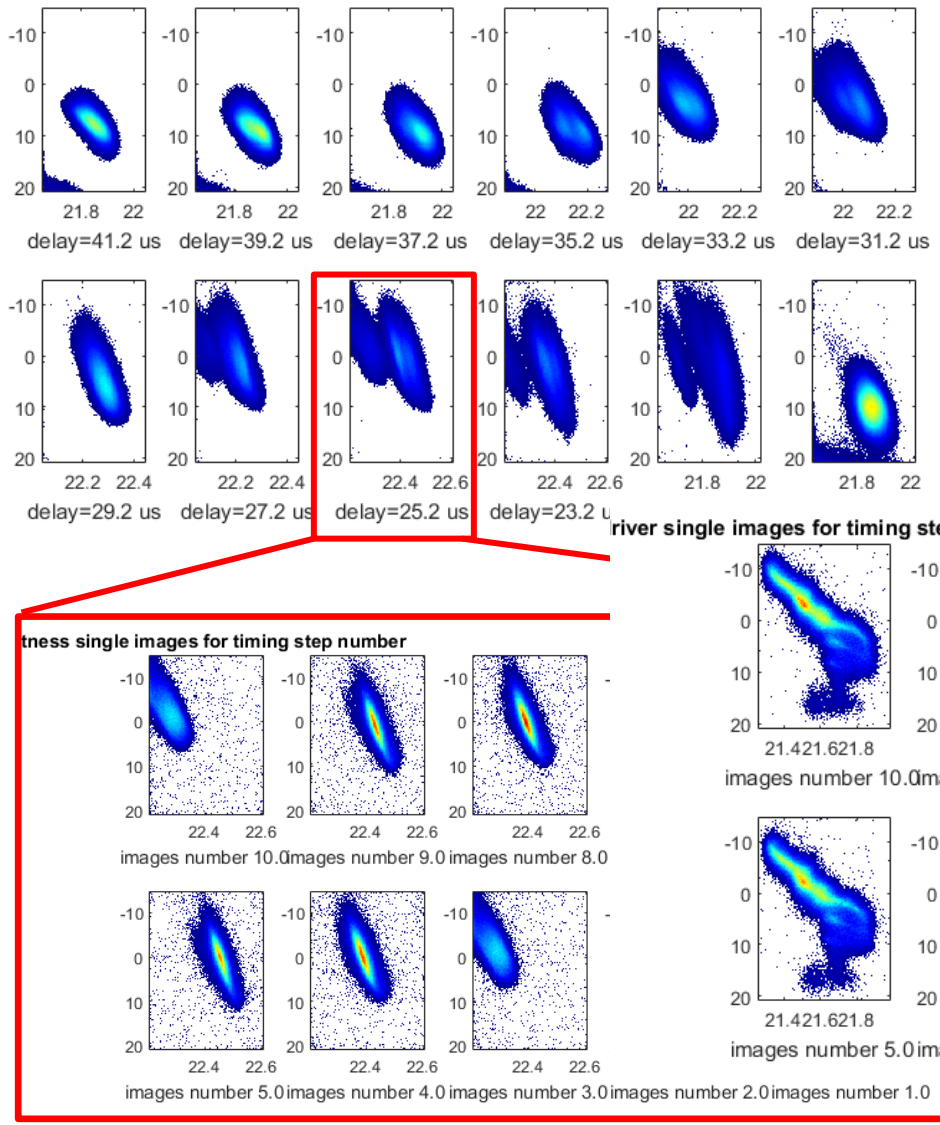


- Witness and driver jitter slightly
  → Taking single witness yields
  TR of max. energy: 4
  TR of mean energy: 2.8

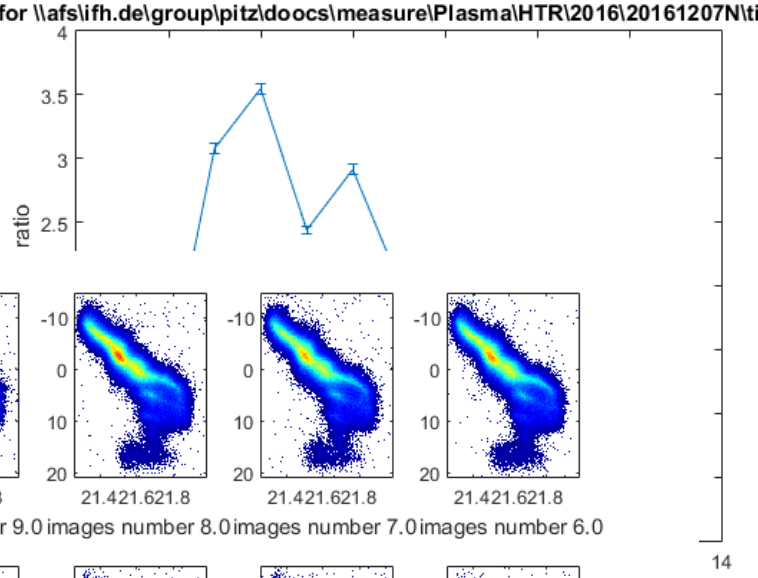
- Problem: driver also jitters → comparing to average…?



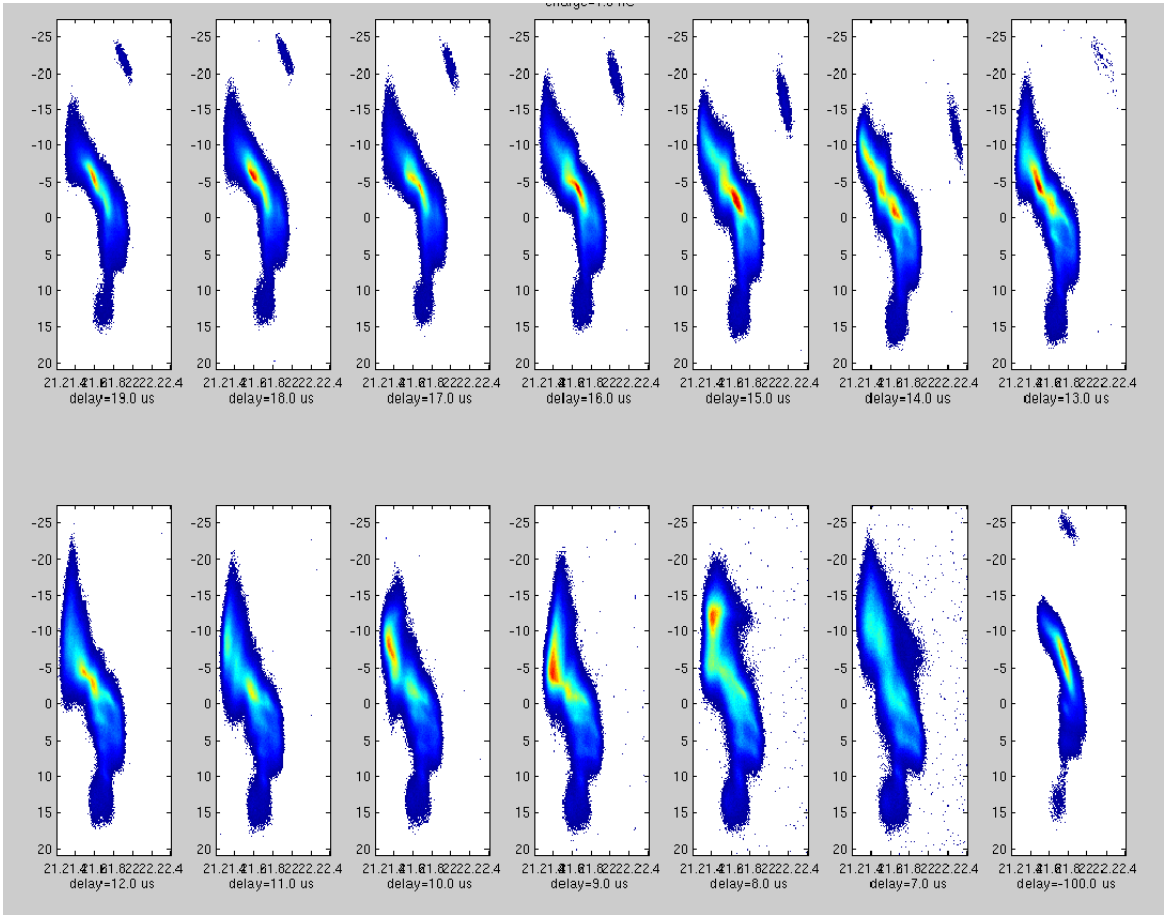
Experimental results – second run – second best



- Similar results for second best measmnt.:
  TR of max. energy: 3.55
  TR of mean energy: 2.38
  (but Driver seems stable!!)



Experimental results – HTR



- Witness beam was kicked vertically
- To be understood
- On PST.Scr1 no significant offset could be seen
- Energy difference too small for velocity bunching

Experimental results – HTR

- High transformer ratios measured for several parameters

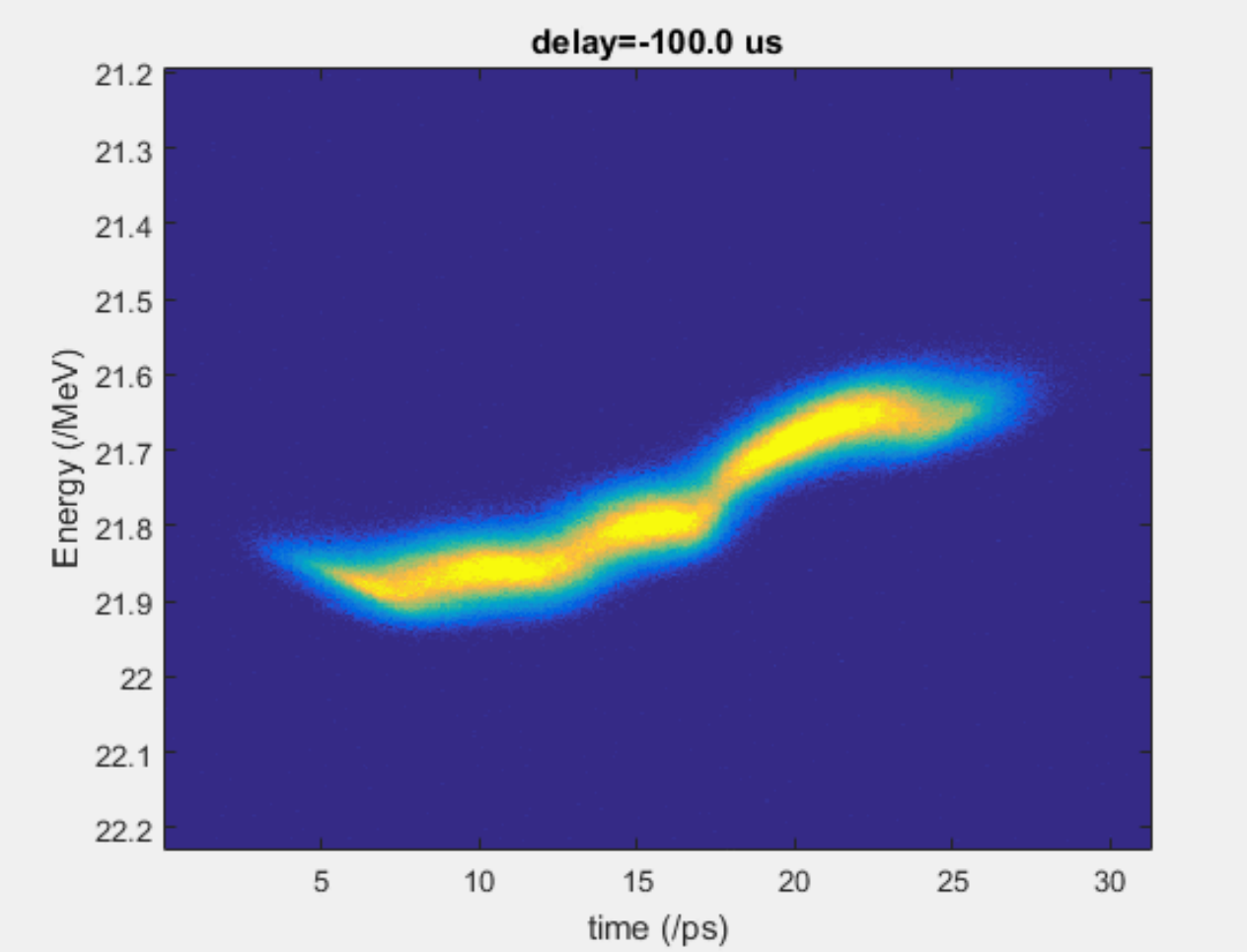
- Main issues: → no full witness beam on screen (necessary?)
  → Jittering plasma (no an issue for one medium TR case)

- Former issue of energy measurement inaccuracies quantified:
  - 100 keV energy error = 8 mm beam offset
  - Or 5 mrad (more than one steerer going from min. to max. ..)
  - Will be checked for in next measurements
  - Witness kicks to be investigated (maybe off axis in plasma cell or asymmetric current path of plasma..)

Experimental results – second run

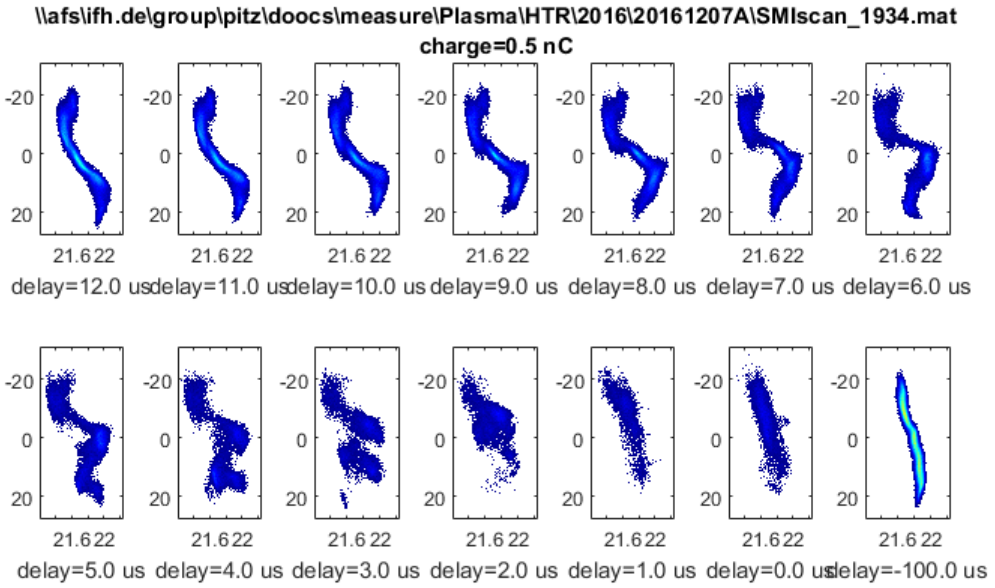
Self modulation in a gas discharge plasma

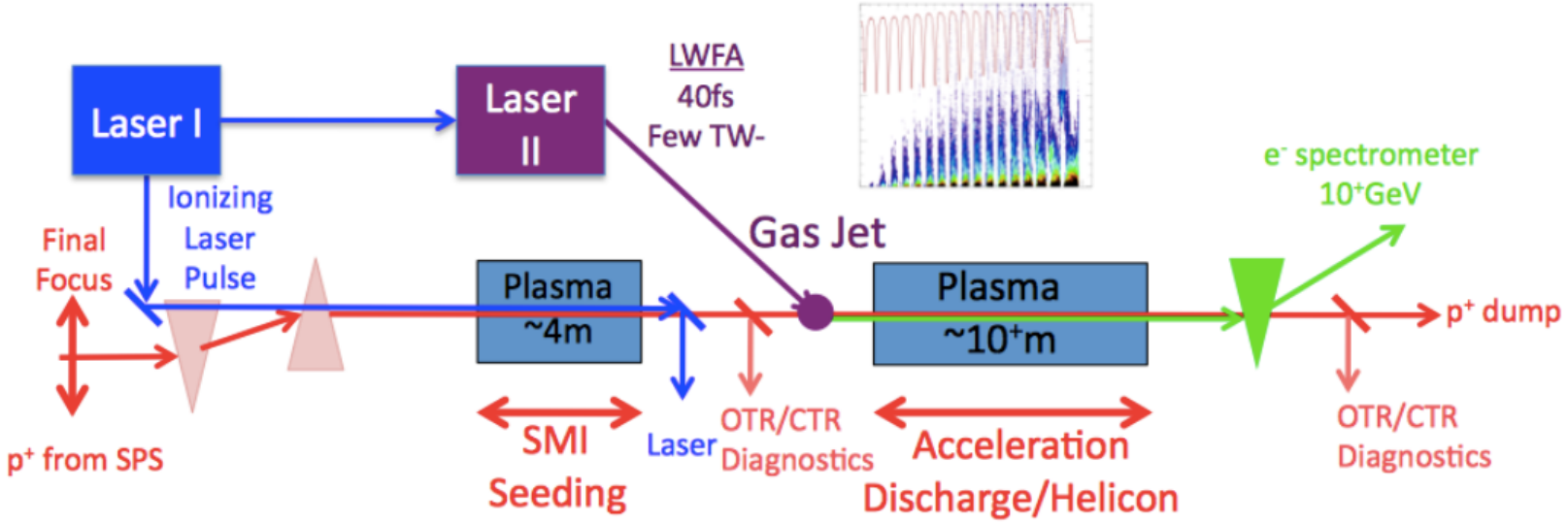
→ measured!
→ Higher densities than Li-cell
→ Less signal (~400 pC, longer plasma)



Experimental results – second run

- Will be used as a benchmark density measurement for spectroscopy
- Potentially important results for AWAKE run II (characterization of gas discharge cell in relevant density regime)



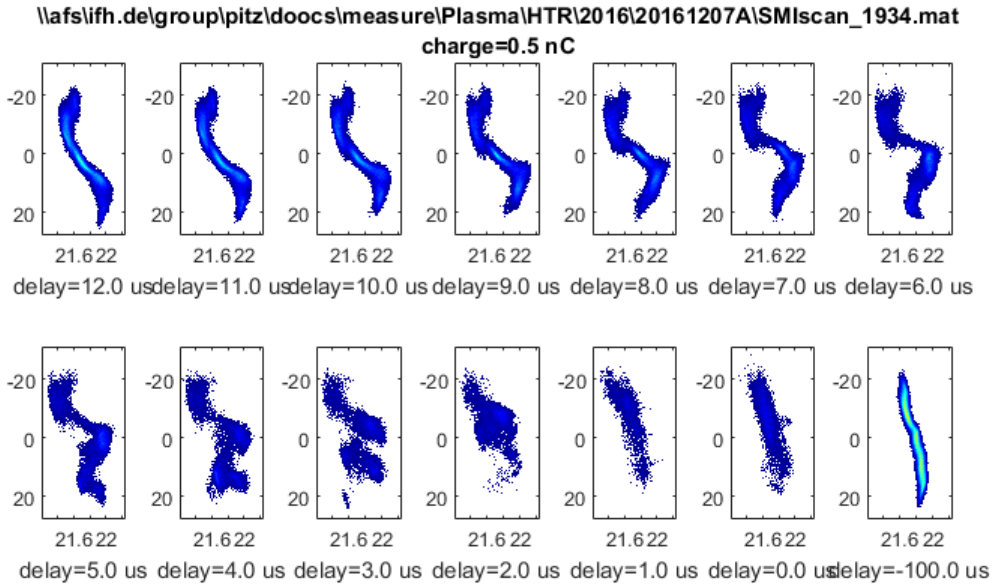


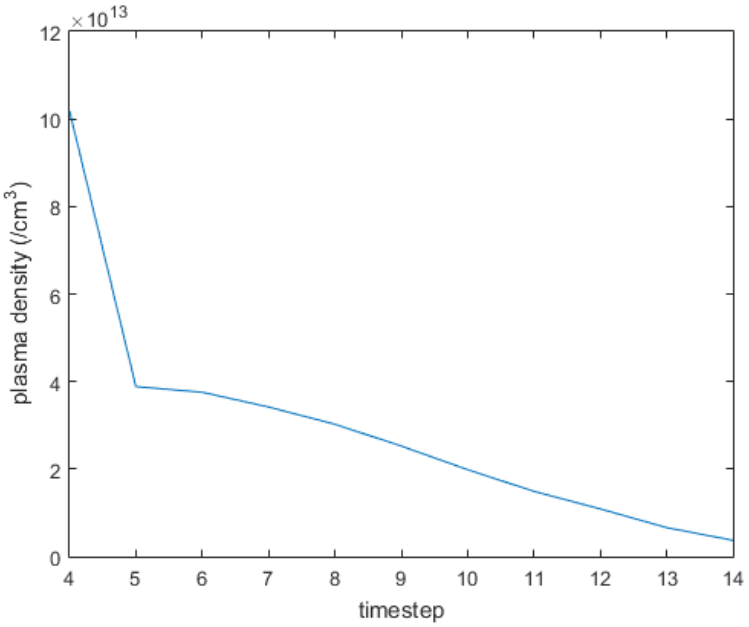
Experimental results – second run

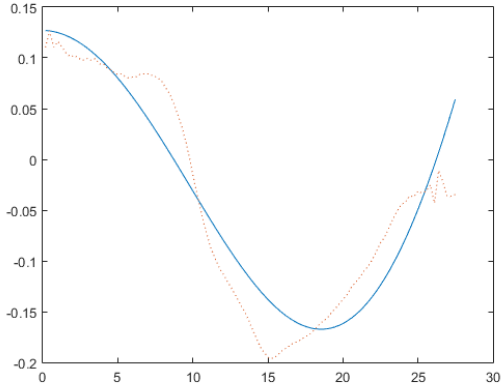
- Energy modulation fitted with formula:
  $\Delta E = a^* x^* \sin(\omega^* x + b) + c$

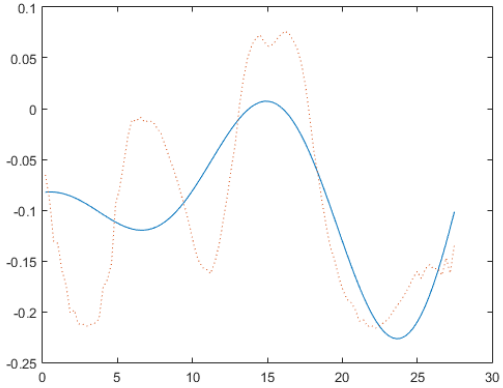
→ Density can be measured using this method

- Results not yet too accurate (better fitting formula sought…)

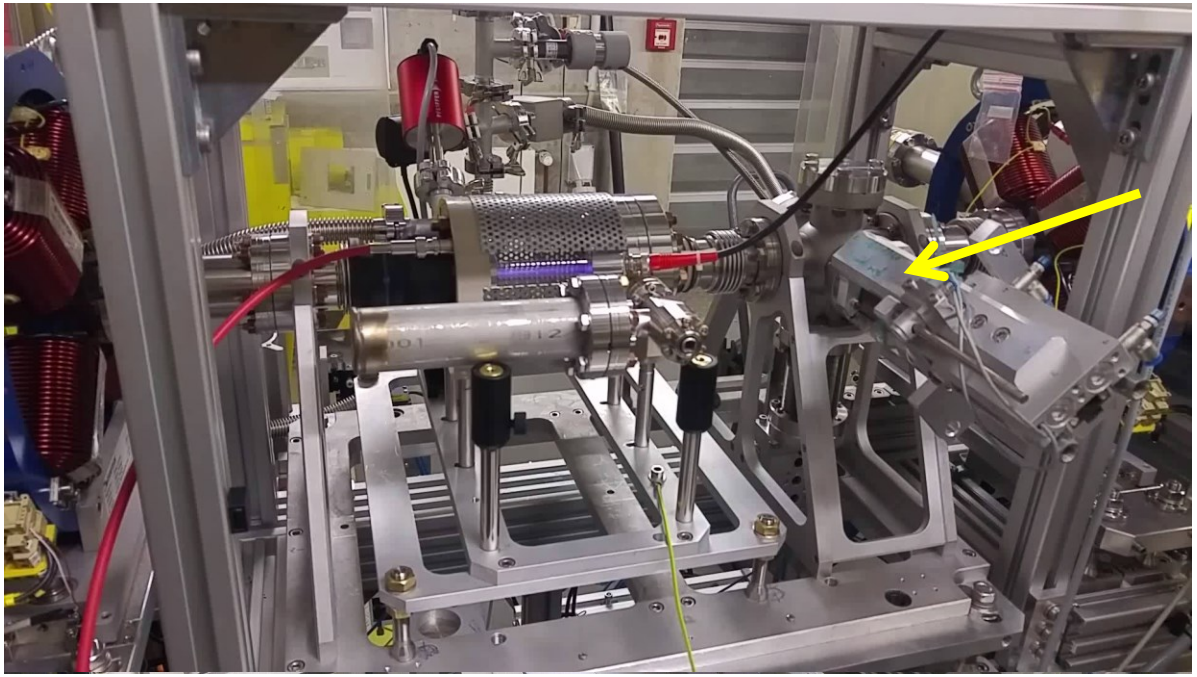






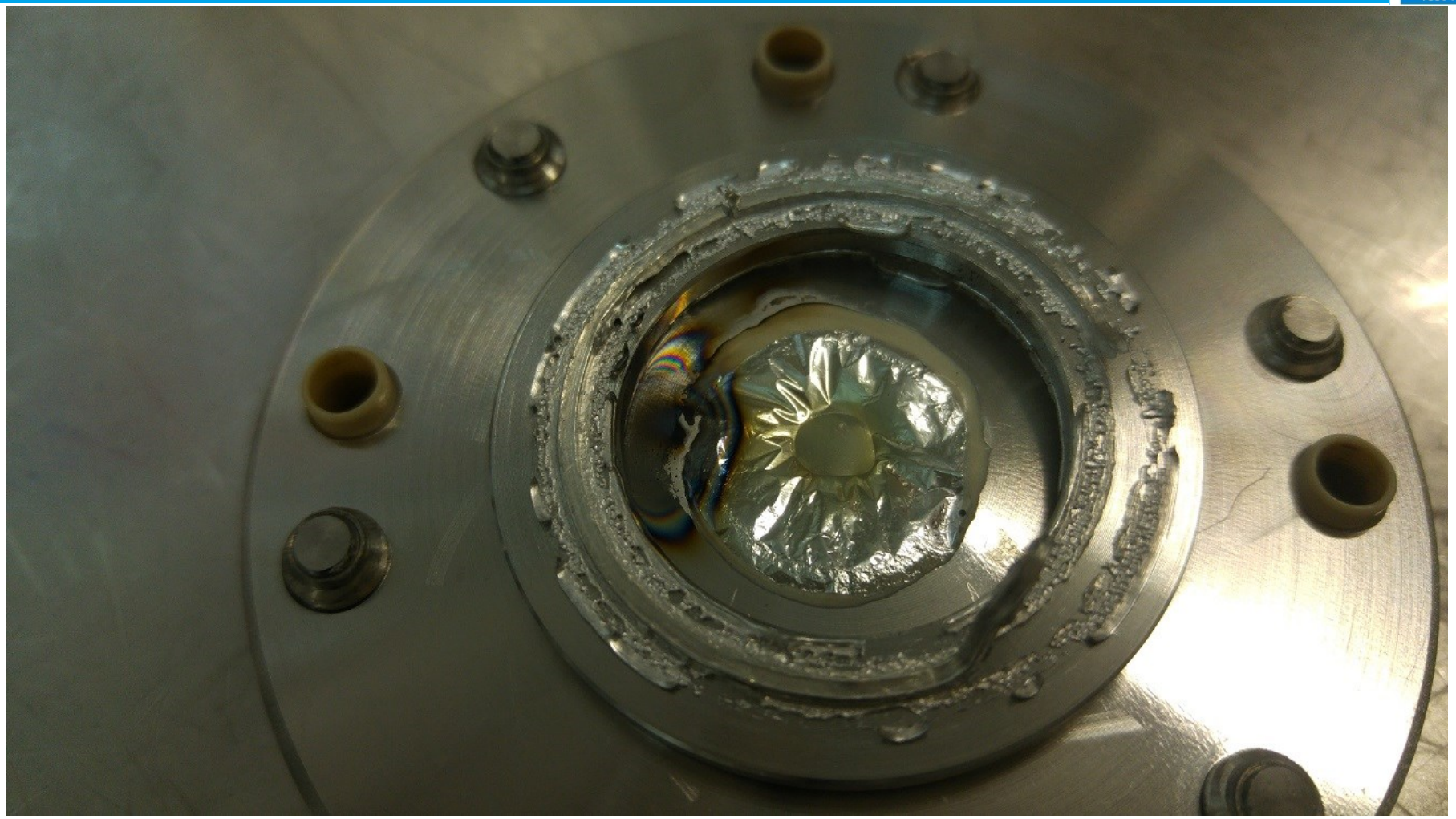


Discharge plasma cell – technical issues

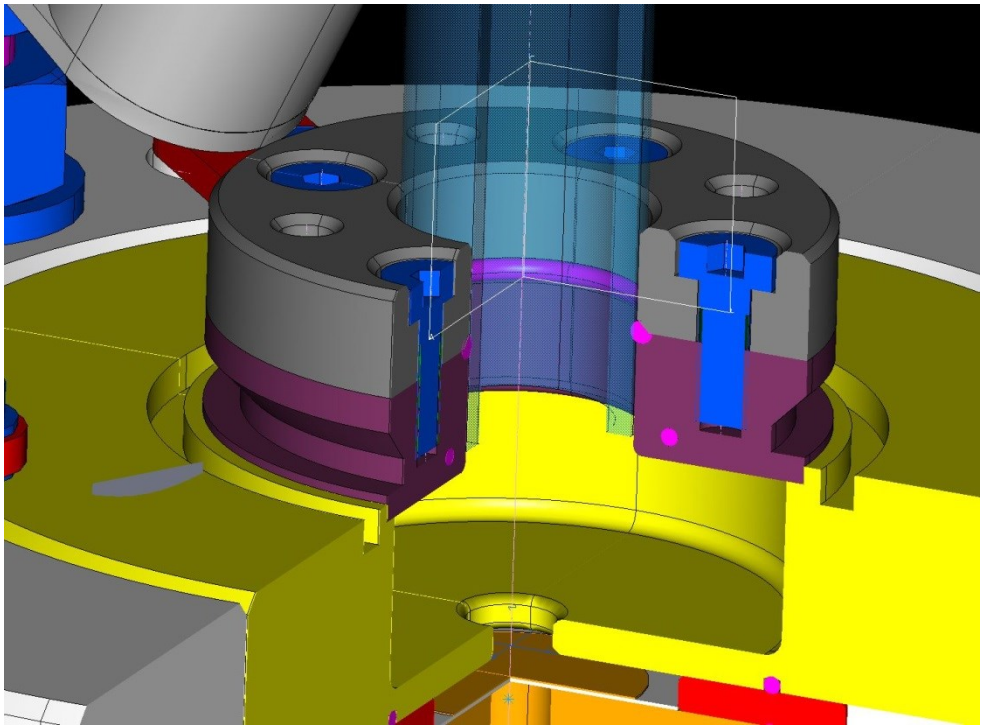


- Discharge plasma cell
  - 10 cm plasma length + screen station (→SMI experiments/focusing..)
  - Max. density ~x 10^{15}cm^{-3}
- Remote control of witness bunch delay (→ timing scans/field reconstruction)
- Aborted after ~ 20 h → what happened?

Discharge plasma cell – technical issues



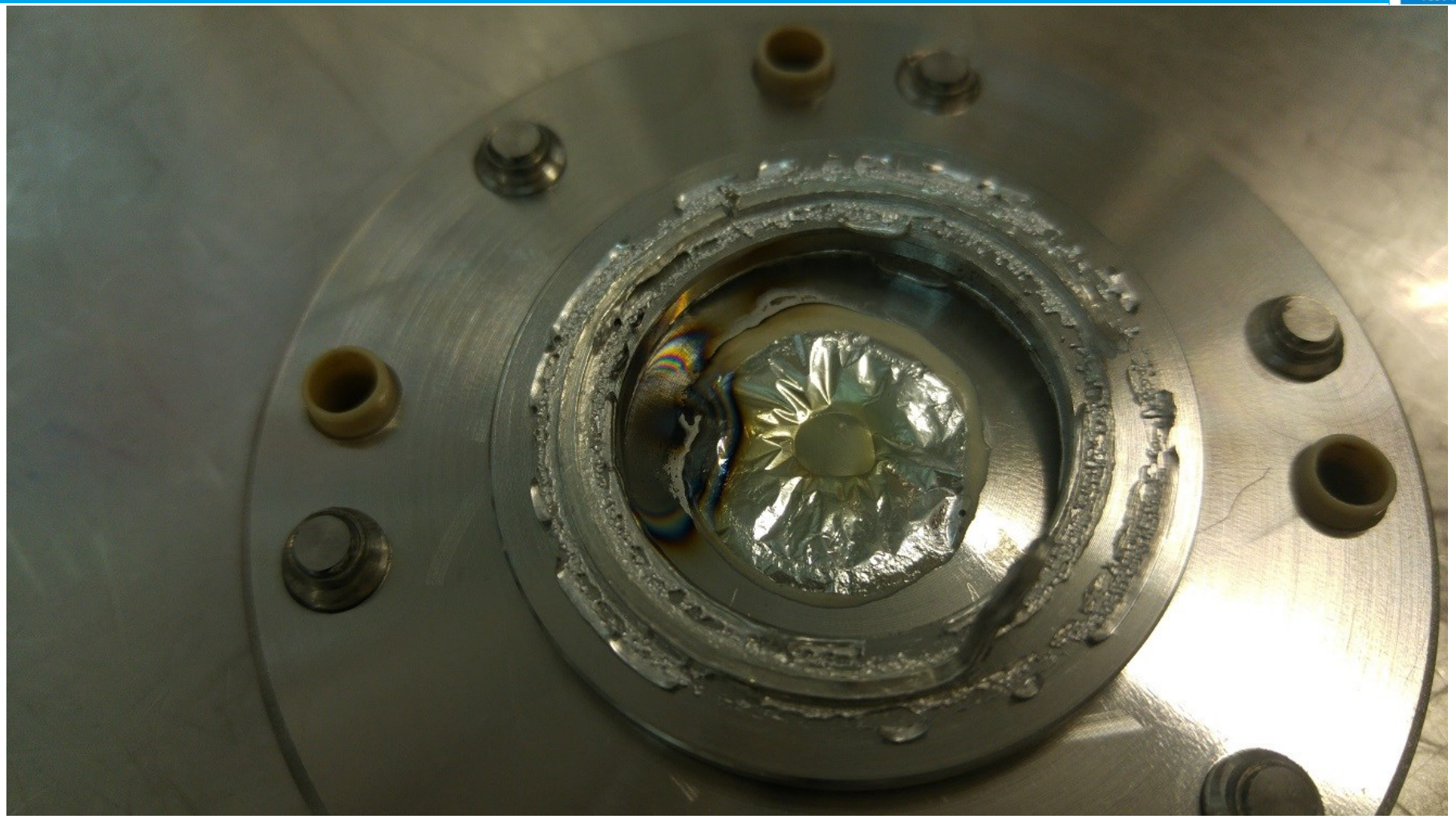
Discharge plasma cell – technical issues



- Increased breakdown voltage/ change of gas mixture issue
  - Reproduction not possible
  - Thermal leak?
  - Irreversible process involving foil glue (beam induced…?)

- Leaky foil issue
  - Discharge on left arm of Paschen curve (→ backside of cathode)
  - Due to damage of components an insulator was exchanged with a conductor → potential on foil flange

Discharge plasma cell – technical issues



Issues are under final investigation and will be resolved soon

- Increased gas pressure (→ right arm of Paschen curve)
- New cathode (→ longest way inside of flange)
- Hopefully no beam induced problem…

Prospects of next experimental run

- More (most? ☺) stable plasma cell
- Improved experimental conditions
  - (big) LYSO screens in Disp3.Scr1/High2.Scr2
  - Remote control of HV
  - Full remote control of witness delay line
  - Better alignment of witness delay line (stable charge when moving…)

- Better experimental understanding
  - Measure good parameters on both sides of TDS RF
  - Watch out for witness kicks and investigate
  - Improved measurement tools

→ Final measurement of high transformer ratios and beam based density diagnostics!?
→ Additional SMI programme
→ Additional PWFA programme

Thank you very much
for your attention!

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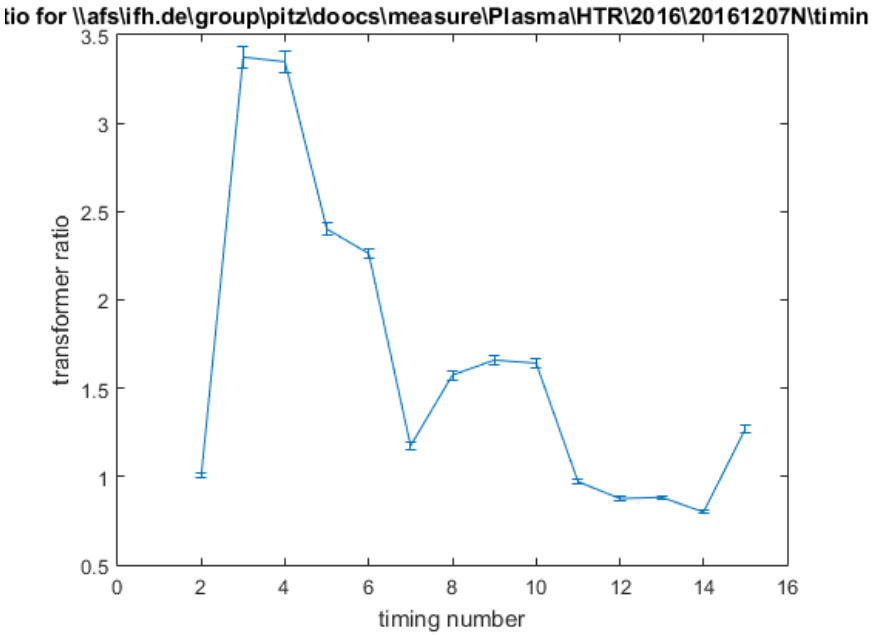
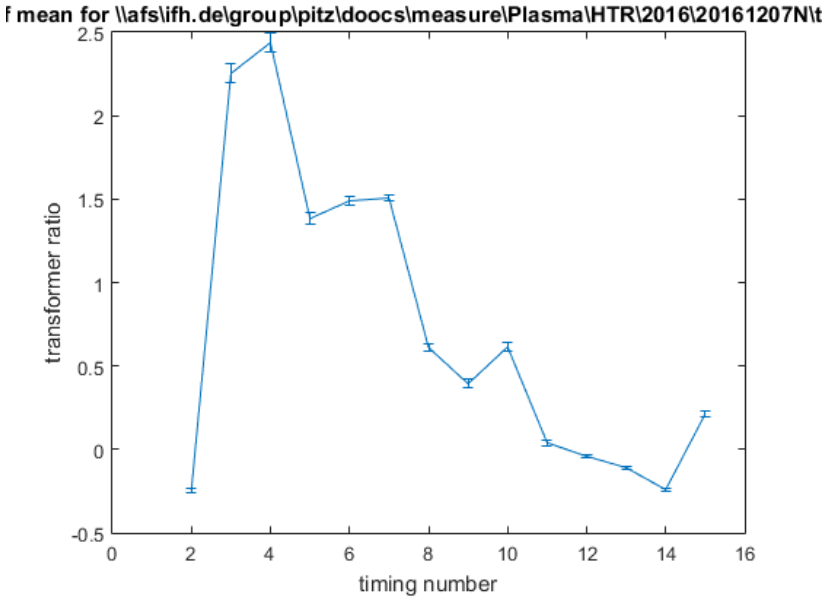
Experimental results – second run – third best

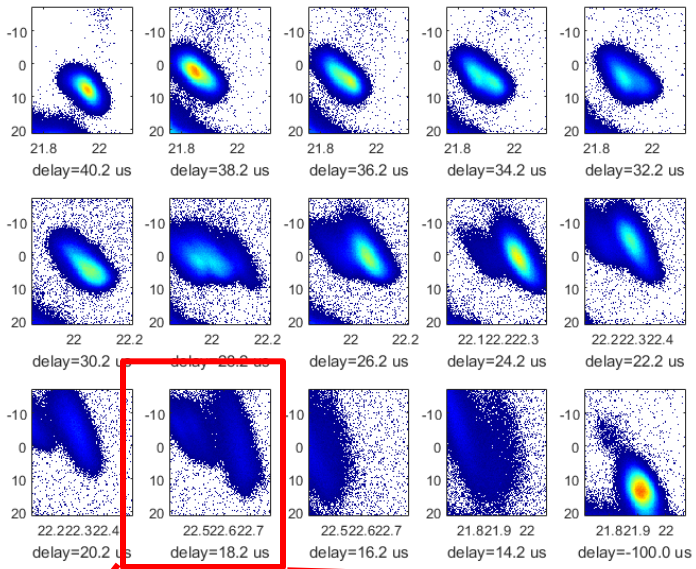


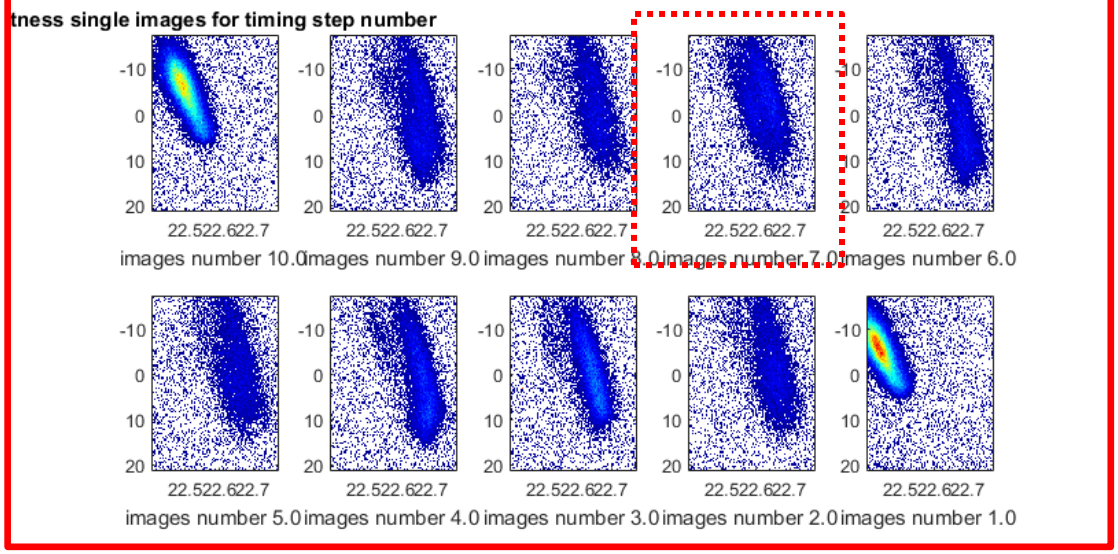


- Witness and driver jitter slightly
  → Taking single witness yields
  TR of max. energy: 3.3
  TR of mean energy: 2.5

- Problem: jittered as well → average driver

Experimental results – second run – third best



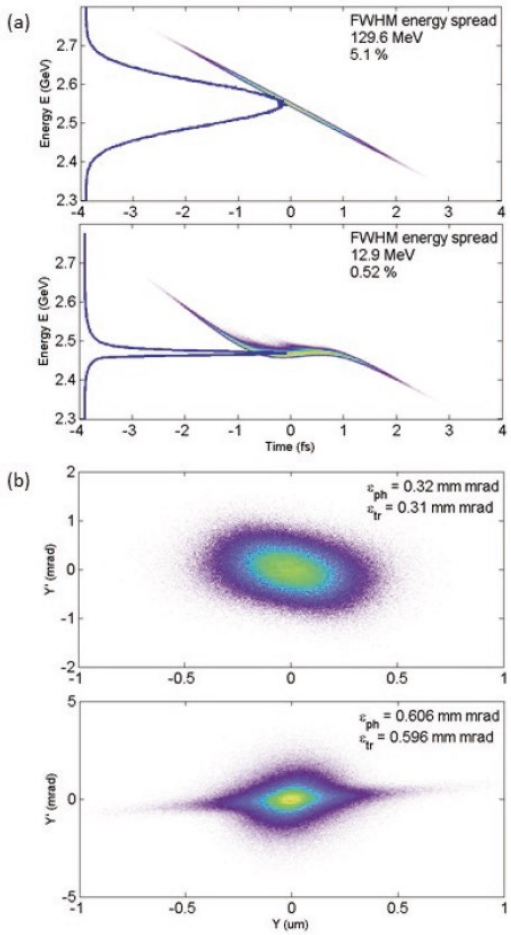


- Witness and driver jitter slightly
  → Taking single witness yields
  TR of max. energy: 3.3
  TR of mean energy: 2.5

- Problem: jittered as well → average driver

Other possible PWFA experiments

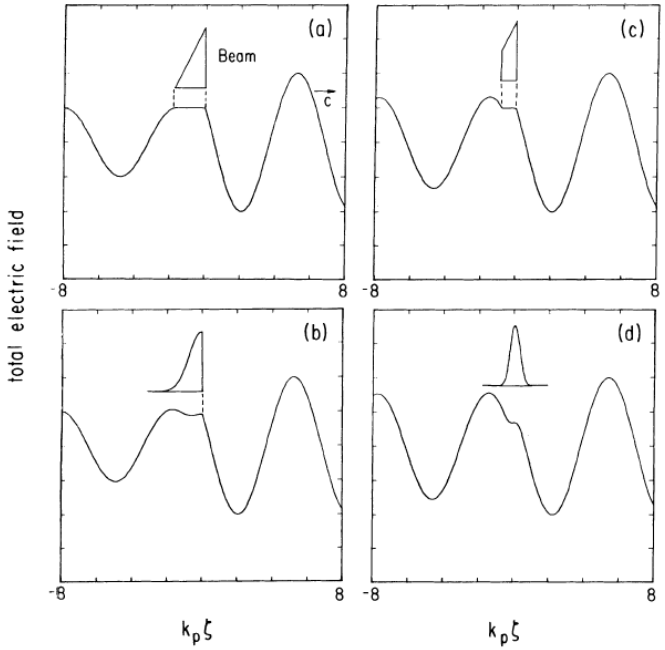
Dechirping of PWFA accelerated bunches in a plasma



- Proposed for FLASHForward
- Reduction of E-spread for min. chromaticity
- Not investigated thus far
- Easy to measure with PITZ

DESY Accelerators Ann. Rep. 2014

Energy spread reduction using shaped witness bunches



- For lower energy spread of acc. bunches
- Not investigated
- Possible with PITZ pulse shaper
- Simulations needed