# CLEX Module results and CALIFES experiments

W. Farabolini on behalf of the CTF3 team

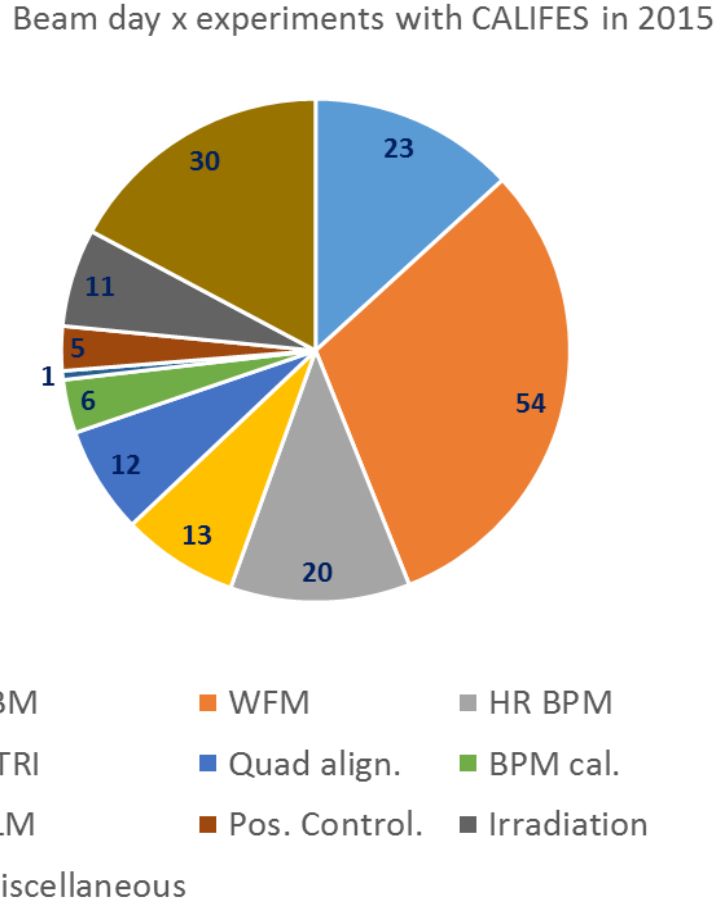
# Experiments with CALIFES in 2015

- Test Beam Module : 23 days W. Farabolini & Drive Beam Team
- Wake Field Monitors : 54 days R. Lillestol et al. **Wed 20/1 at 9:10**
- High Resolution Cavity BPMs : 20 days J. Towler **Tue 19/1 at 11:20**
- Interferometric OTR : 13 days R. Kieffer **Mon 18/1 at 16:55**
- Beam alignment in Quadrupoles : 12 days N. Aftab, S. Javeed **Mon 18/1 at 16:15**
- Califes Cavity BPMs calibration : 6 days N. Aftab, S. Javeed **Mon 18/1 at 16:15**
- Beam Loss Monitor: 1 day M. Kastriotou **Mon 18/1 at 16:35**
- Girders positions control : 5 days V. Rude, M. Duquenne
- Irradiation Test Bench : 11 days R. Alia et al. **Tue 19/1 at 16:55**
- Strip Line BPMs A. Benot Morell **Wed 20/1 at 10:10**
- Miscellaneous : 30 days
  (beam preparation, development, studies non referenced in the log-book…)

Total: **175 days** (users x days)

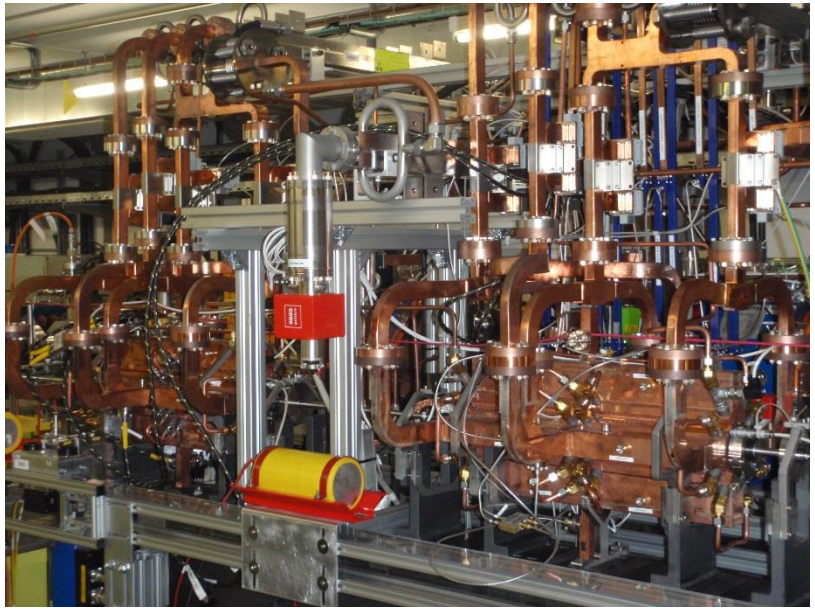
Klystron MKS30 for PHIN : 5 weeks

Very high beam reliability (almost no non-programmed unavailable day)



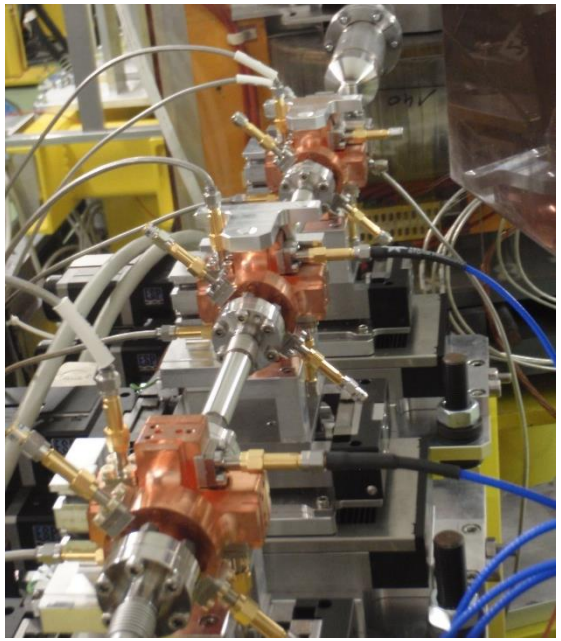
# Shutdown Periods and New Installations

17 Dec. 2014 – 9 Mar. 2015

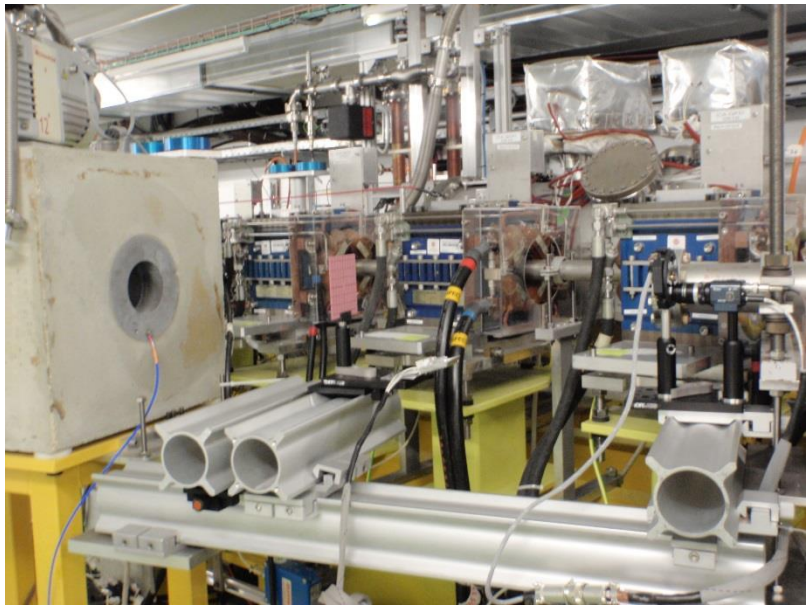


Second Super-structure on the TBM

- Survey of the whole line
- In situ RF measures with network analyser
- RF power chain calibrations (20)



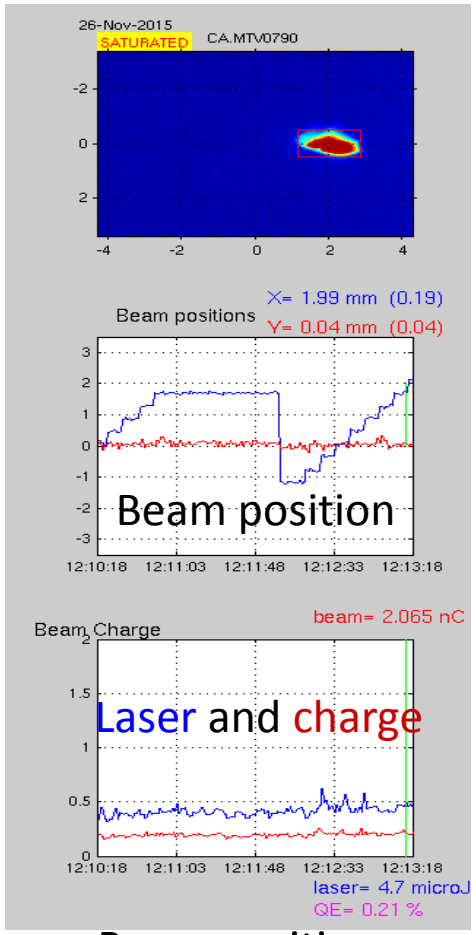
3 High Resolution Cavity BPMs on motorized stages (J. Towler M. Wendt)



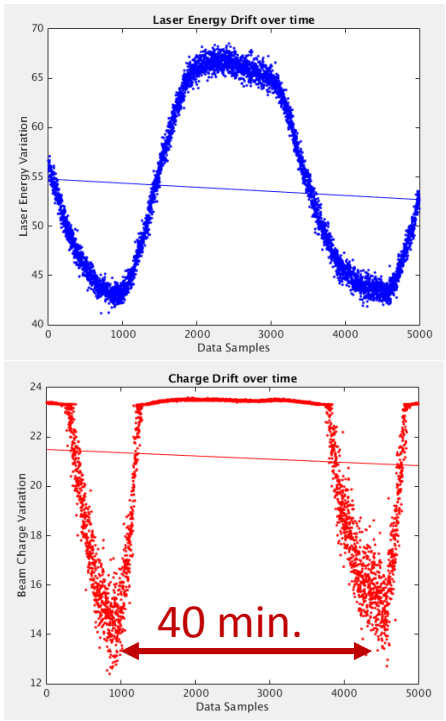
Irradiation Test Bench (E. Del Busto)

- Rare days of beam unavailability (Laser Pulse Picker power supply, Klystron focalisation coil power supply)
- Nearly no klystron trips (19 411 working hours)

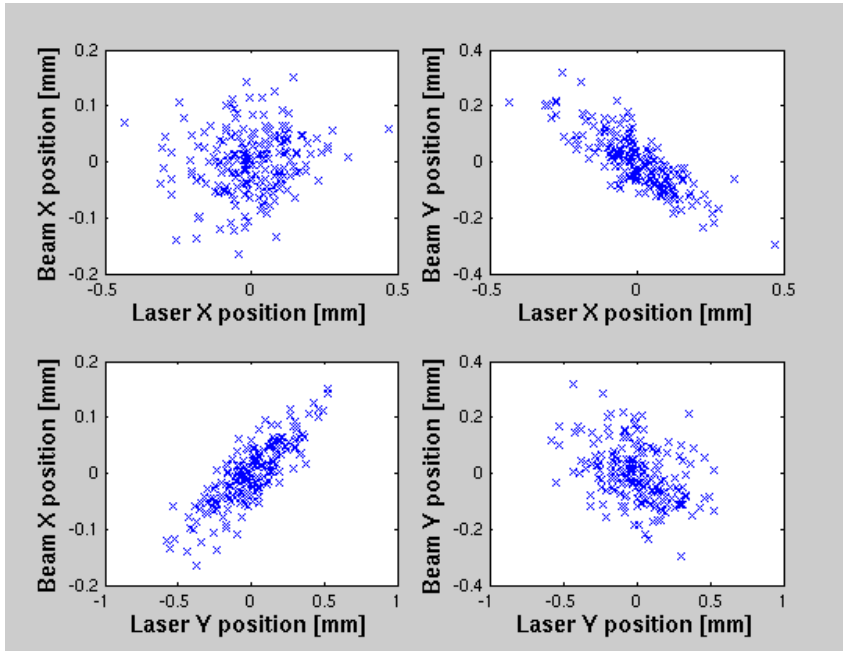
# Some Laser stability concerns




Beam position and charge jitter

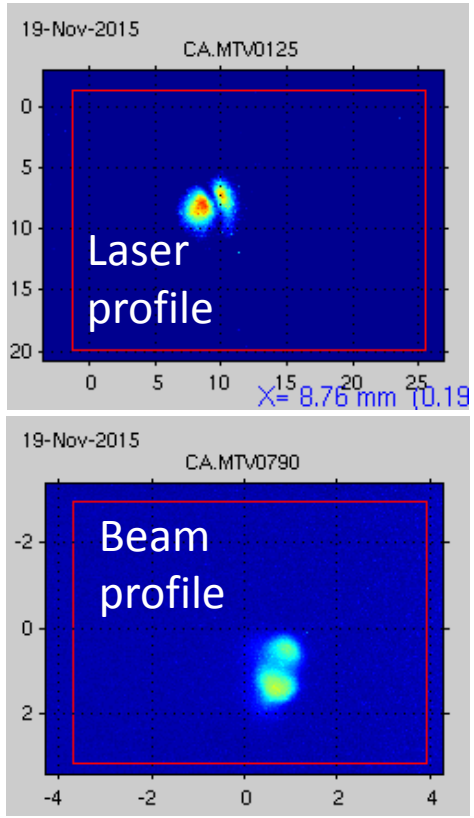



Laser Power and Beam Charge drift




Laser/Beam position correlations

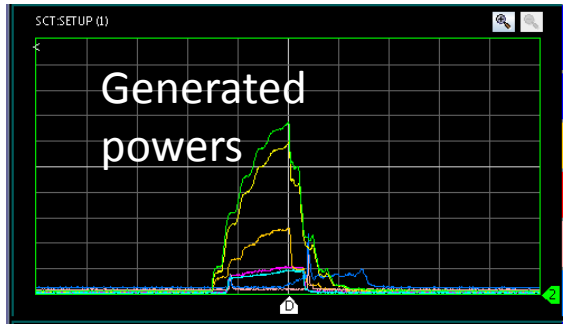
F. Friebel, Tue 19/1 at 15:20




Double heads shape for Laser and Beam

- Laser Lab. Air conditioning system replaced
- Some problems with laser synchronisation and phase jump (LLRF team knows how to fix)

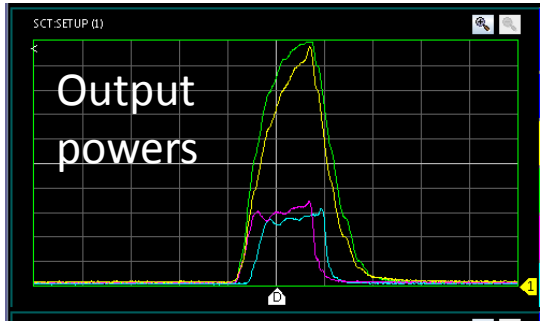
# Test Beam Module (TBM) control



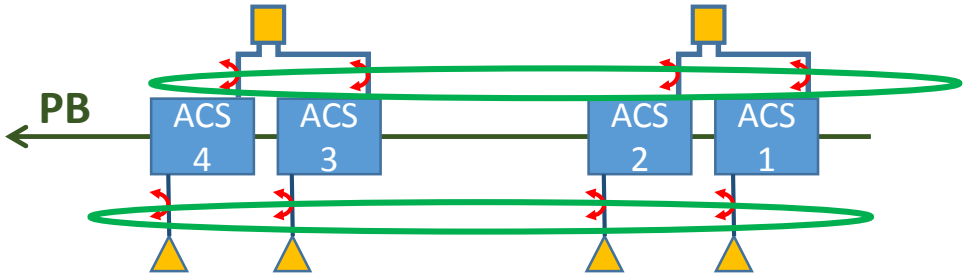




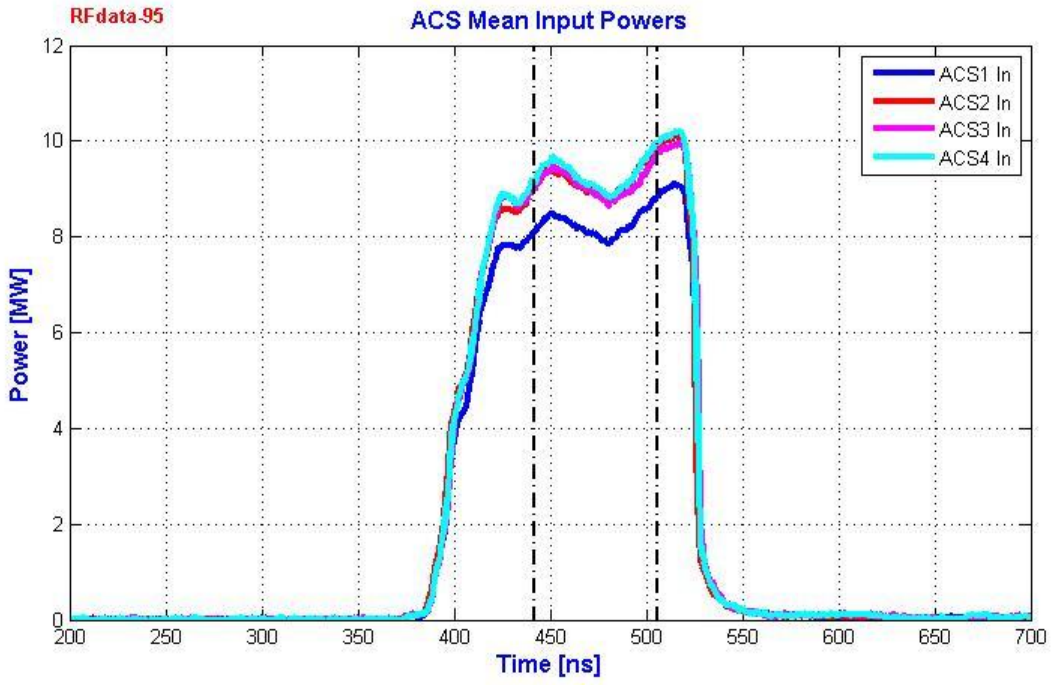


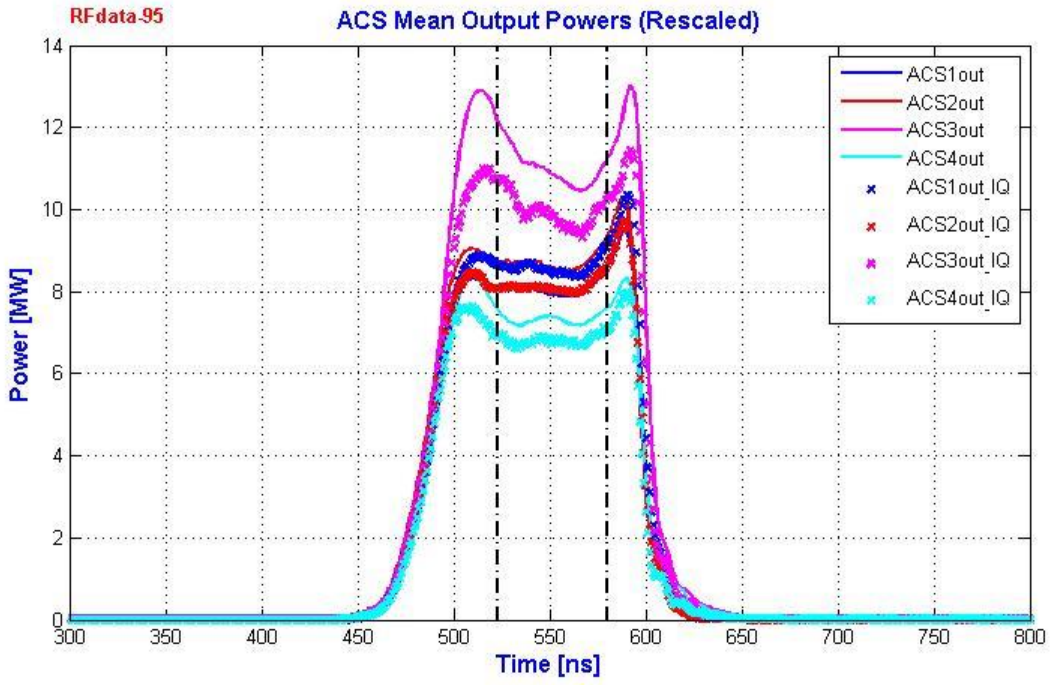



# TBM powered by DB – no RF priming




Power In / Power Out = 2.44 ($S_{12}$ = 0.64)

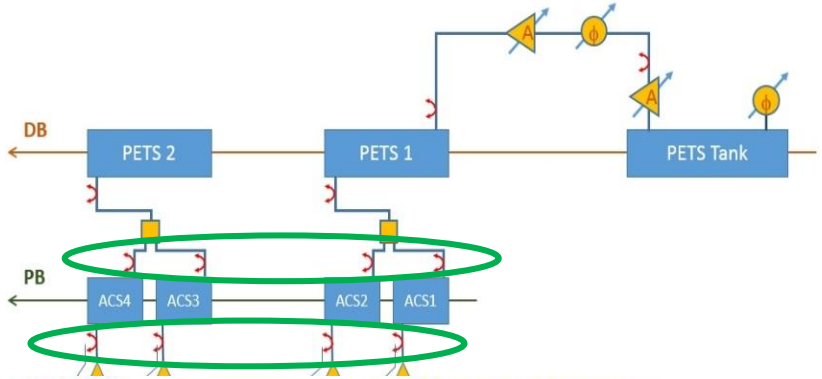


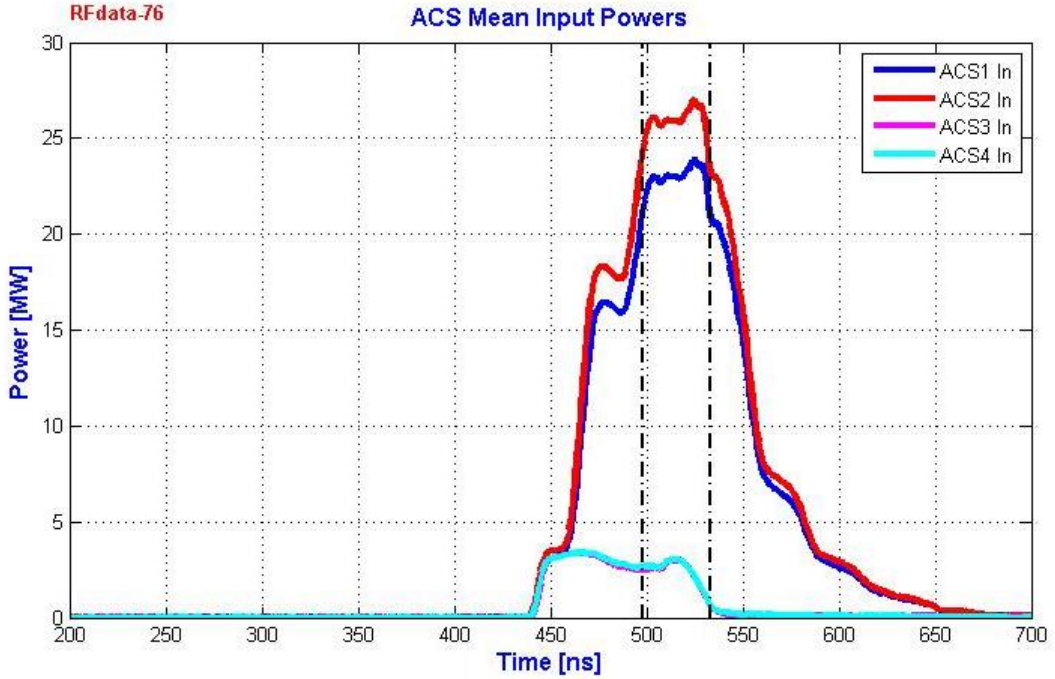



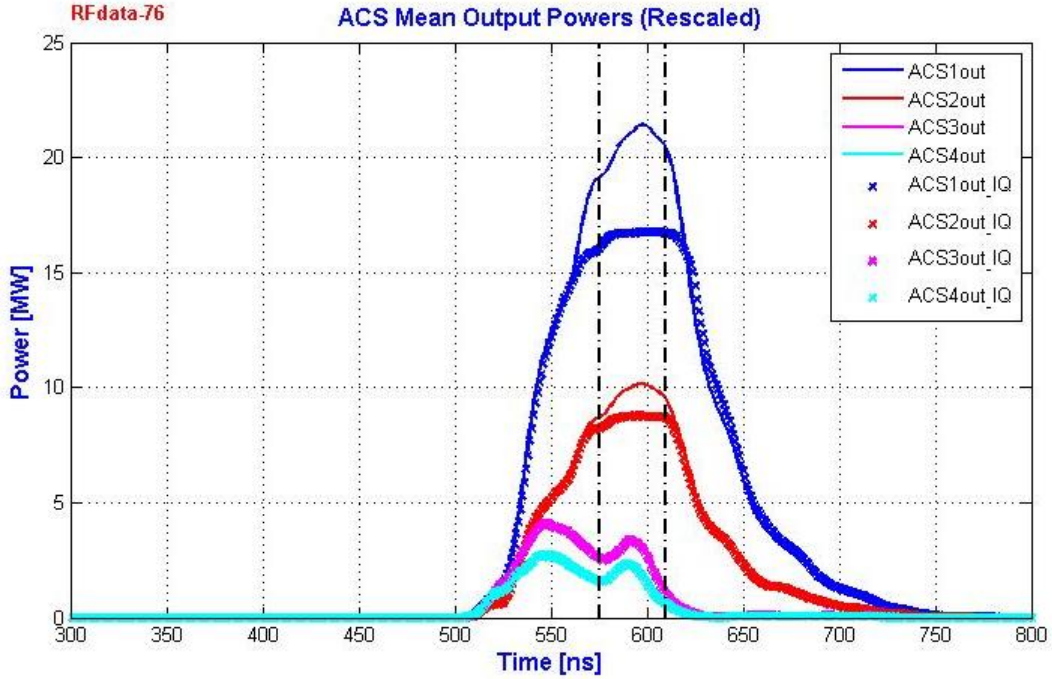

Consistent power measurements at the 4 ACS inputs (excepted ACS1). Drive beam 23 A

- Consistent power measurements at the ACS1 & 2 outputs
- Discrepancies for ACS3 & 4 outputs
- Rather consistent between Diode and IQ measures

# TBM powered by DB – with RF priming



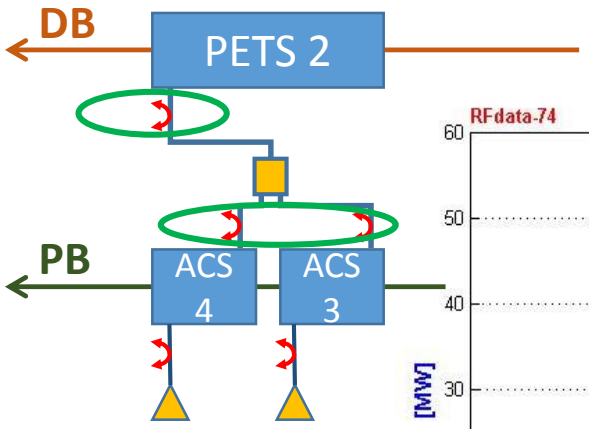



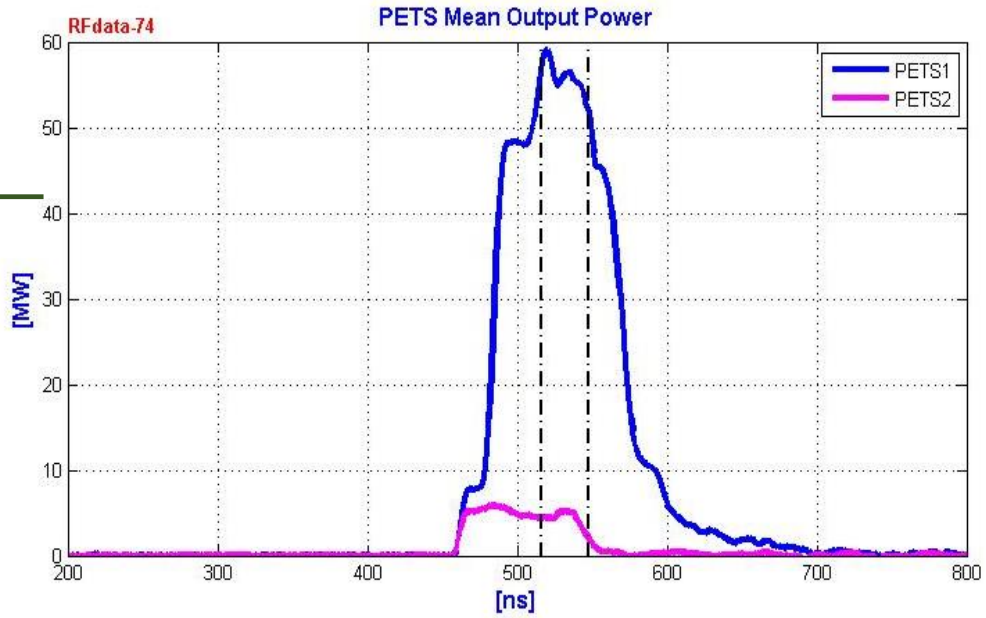



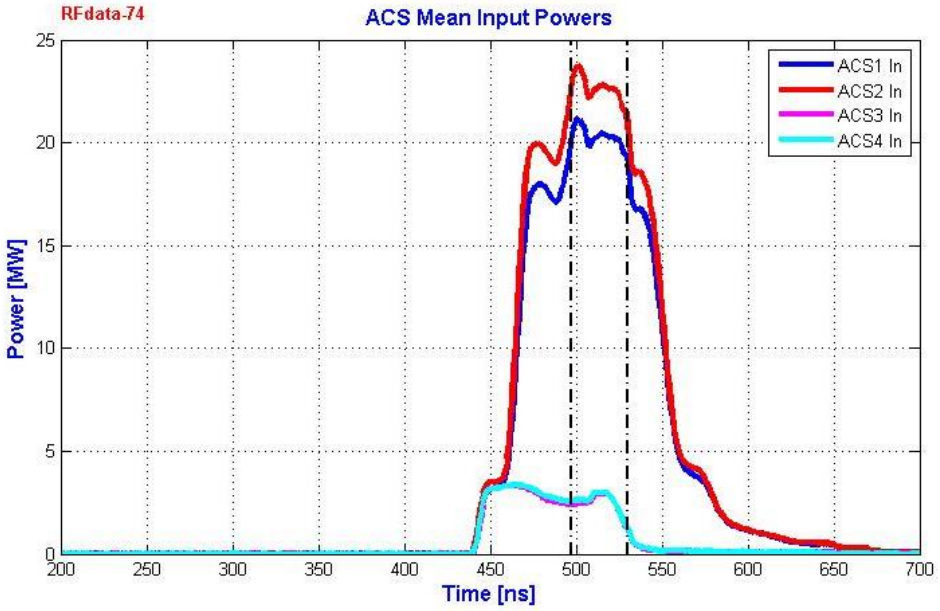

- Same consistency for ACS inputs power measurement
- High efficiency of the RF recirculation

Saturation of the IQ chain (no attenuator installed)

# Comparison with PETS output power



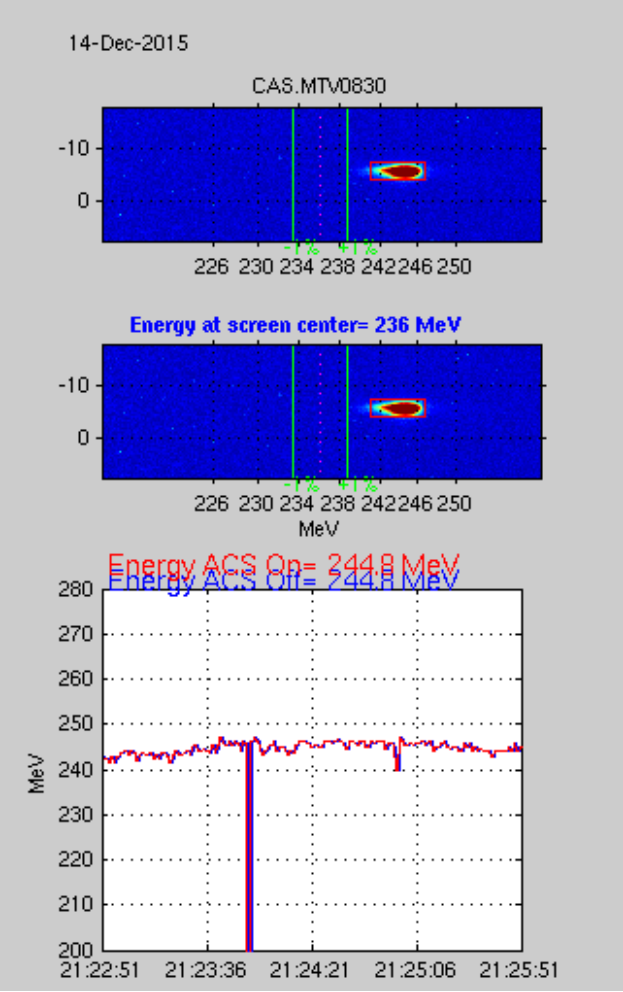




PETS 1: 55.6 MW PETS2: 4.7 MW

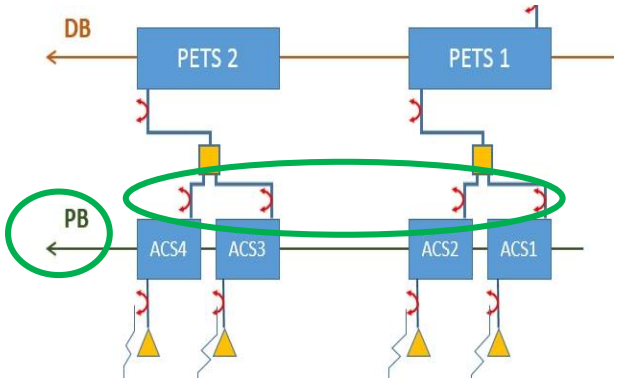
ACS1: 20.2 MW ACS2: 22.6 MW sum: 42.8 MW
ACS3: 2.7 MW ACS4 : 2.7 MW sum: 5.4 MW

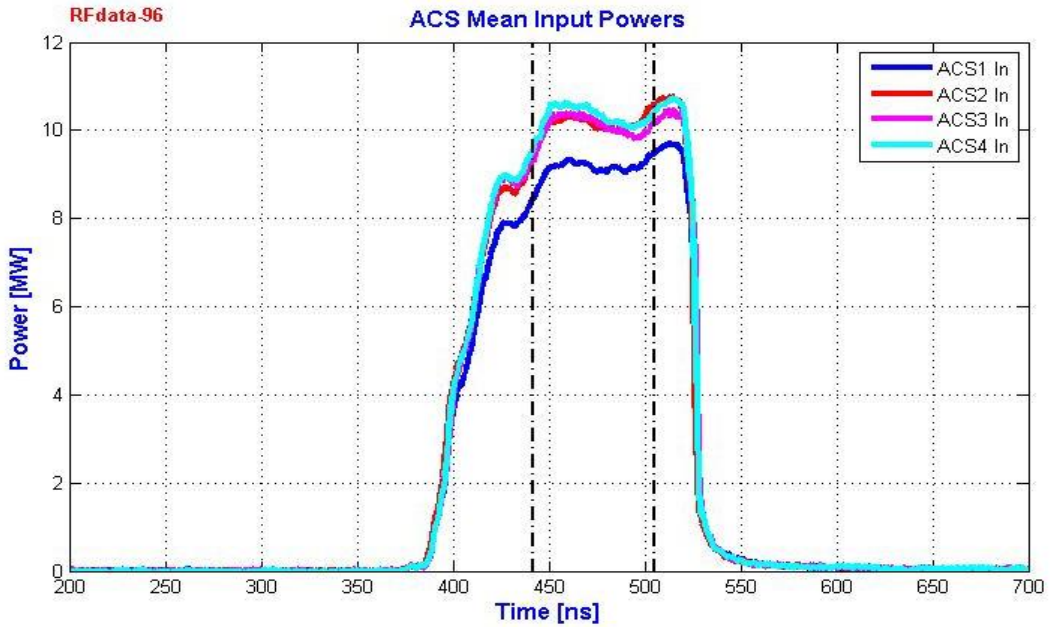
Not really consistent : 23 % power loss from PETS 1, even if we know that ACS1 power is under valuated

# Comparison with energy gain




TBM energy gain: **43 MeV**



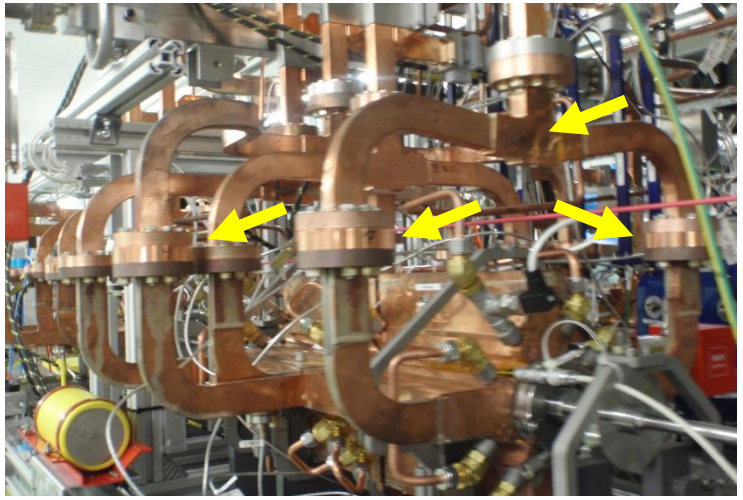

- Direct DB power production with 23 Amps – 140 ns
- Power input on each ACS: $P_{in}$ = 10.4 MW (ACS1 rescaled)

Nominal TBM energy gain:

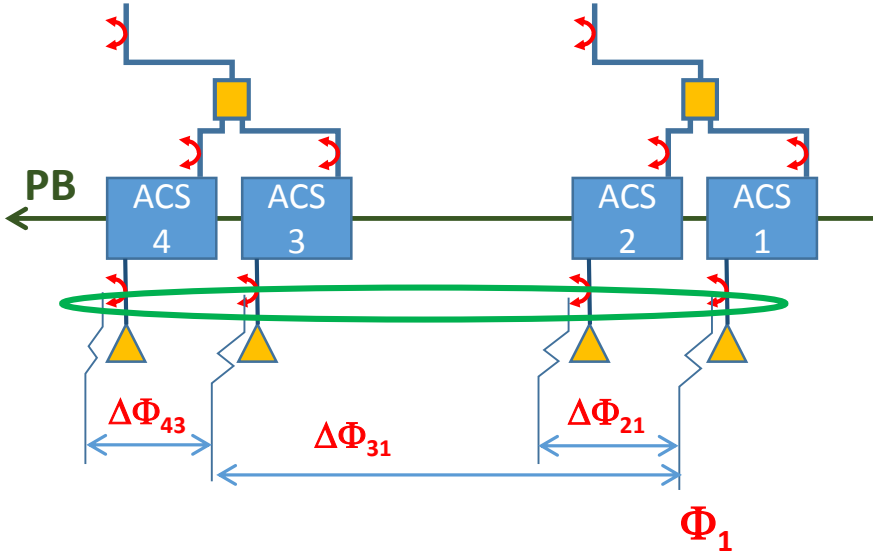
$$E_{gain} = \frac{100 \text{ x } 0.23 \text{ x } 4}{\sqrt{42.6}} \sqrt{P_{in}} = \mathbf{45.5\ MeV}$$

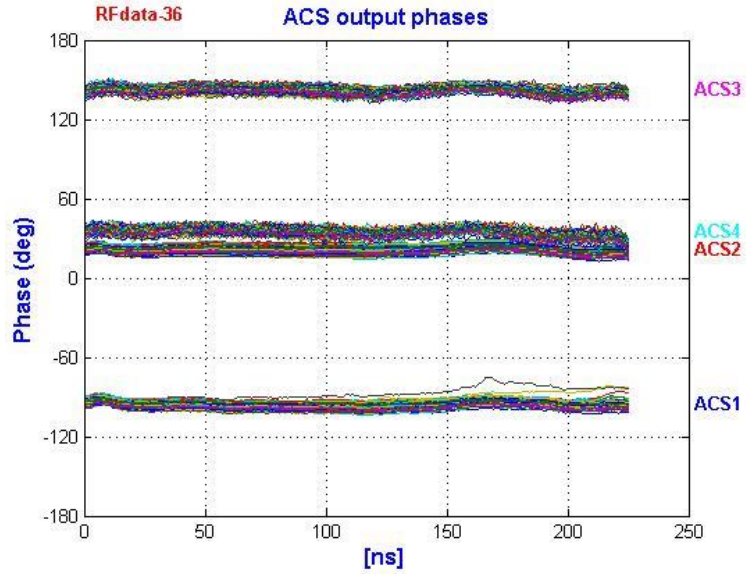
The discrepancy can be sought in the phase errors

# Phases between structures



RF distribution with WG spacers to correct phase distribution



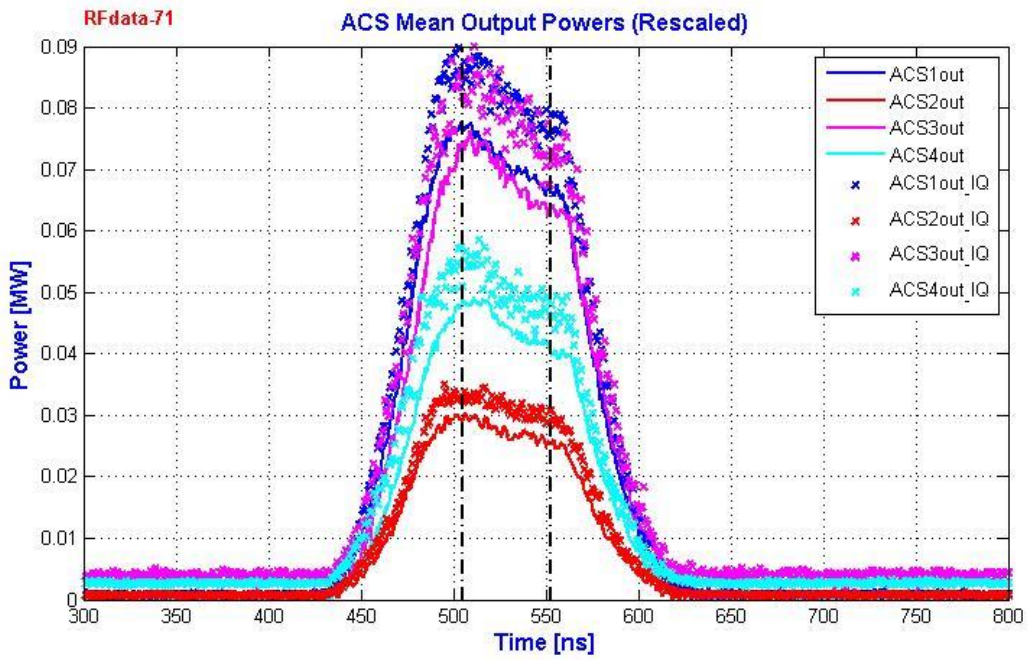




Output phases from structures

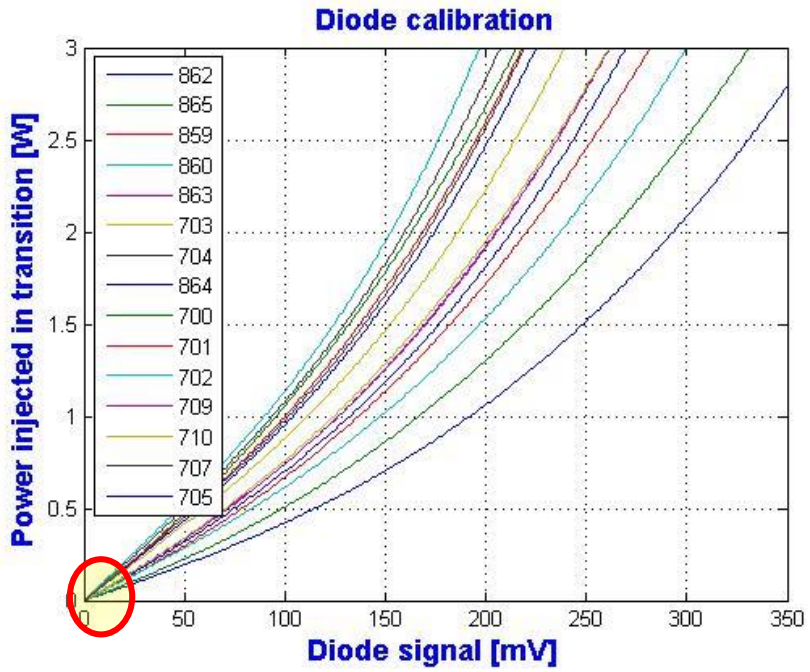
| PB generated power | DB generated power | Correct if: | Phase error without recirculation | Phase error with recirculation | Phase control |
|---|---|---|---|---|---|
| $\Delta\Phi_{21}$ PB | $\Delta\Phi_{21}$ DB | Equal | -6 º | -4 º | No control |
| $\Delta\Phi_{43}$ PB | $\Delta\Phi_{43}$ DB | Equal | -13 º | -12 º | No control |
| $\Delta\Phi_{31}$ PB | $\Delta\Phi_{31}$ DB | Equal | **-31 º** | -6 º | Priming control |
| $\Phi_1$ PB | $\Phi_1$ DB | At 180º | 0 º | 0 º | CALIFES phase control |

cos(15.5º) x 45.5 = 43.8 MeV

# RF Power generated with the Probe beam

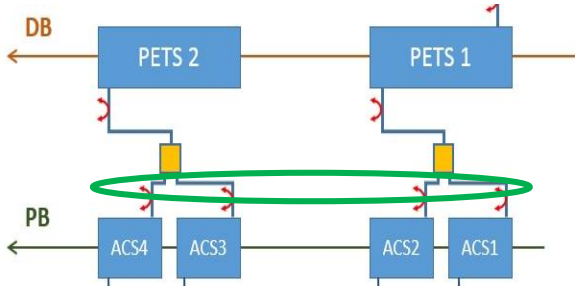


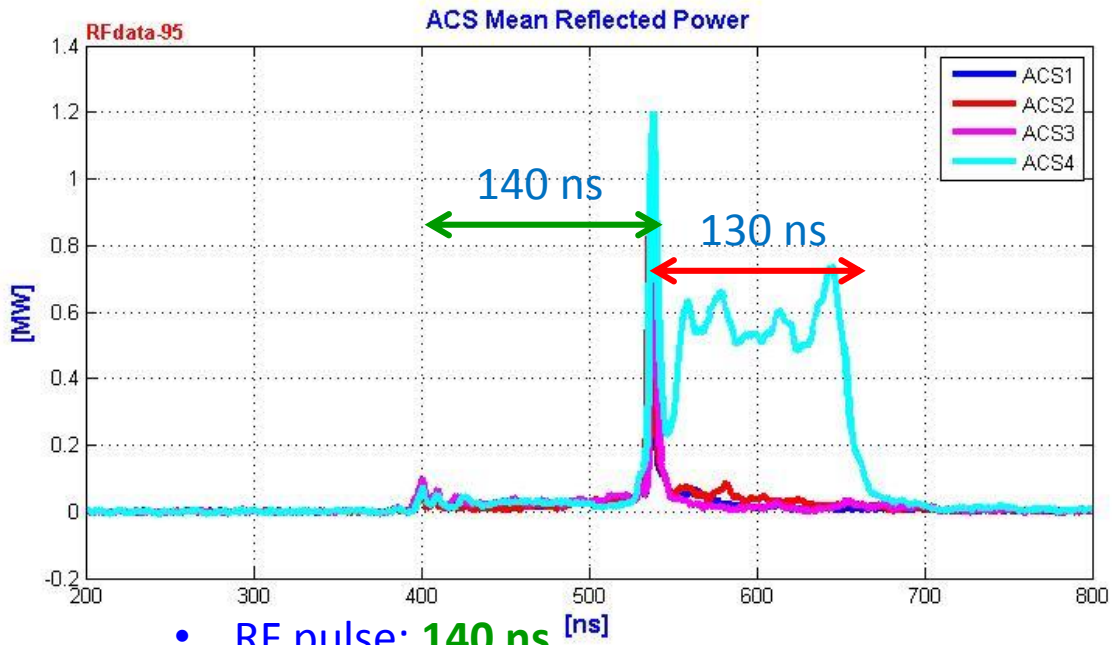

- Much lower power (< 100 kW)
- Power calibration not adapted but still possible to extract a phase



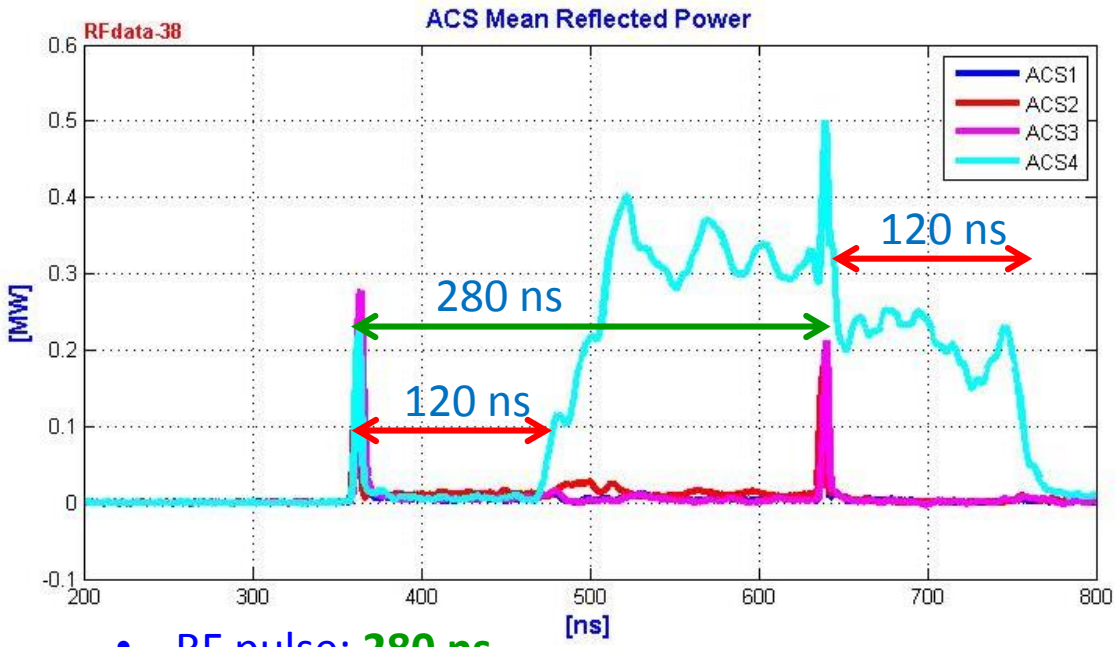

Diode calibration for all RF lines injecting power after the 60 dB coupler

# Structures reflected power



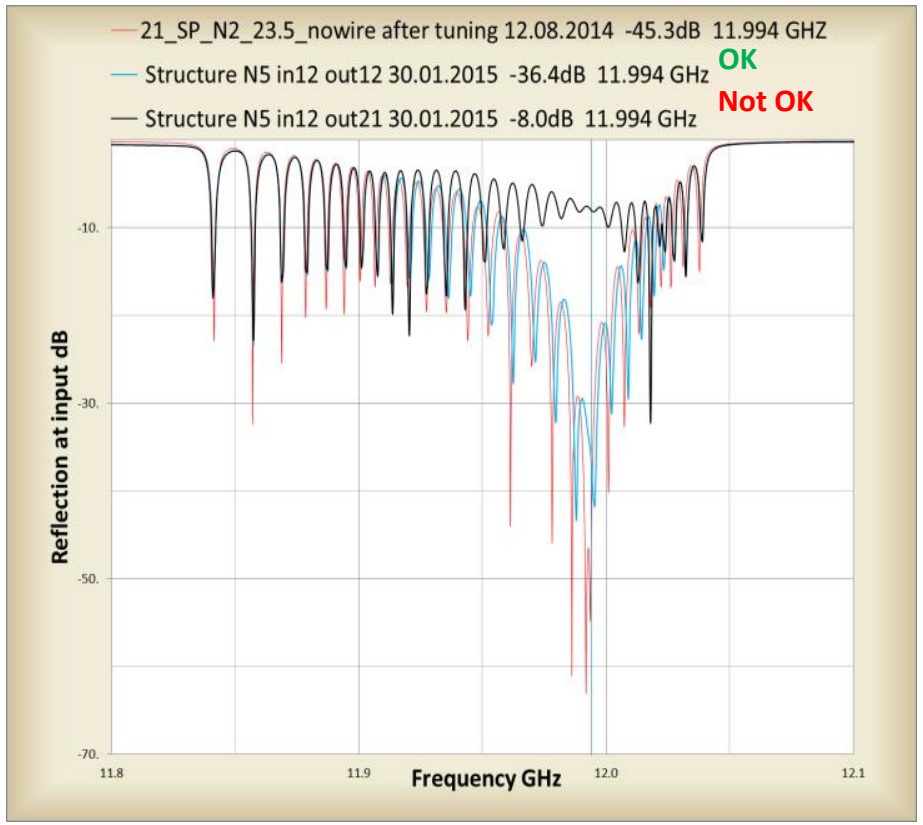

- RF pulse: **140 ns**
- ACS4 Reflected Power during 130 ns



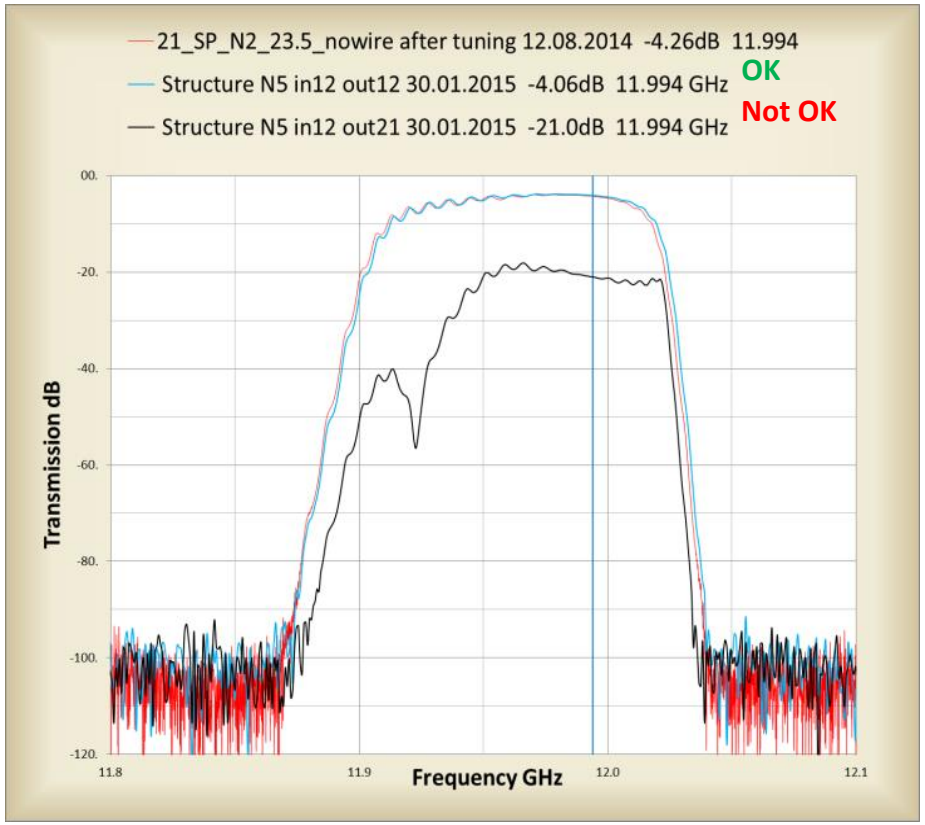

- RF pulse: **280 ns**
- ACS4 Reflected Power appears after 120 ns and lasts 120 ns after the end of the RF pulse

- ACS filling time: 65 ns
- ACS4 reflection default close to the end the structure (output port ?)

# Network analyser measure during installation




ACS4 Reflection



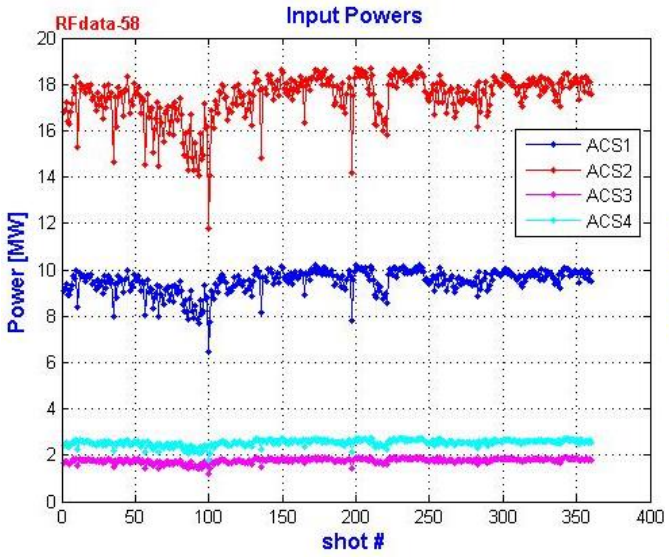

ACS4 Transmission

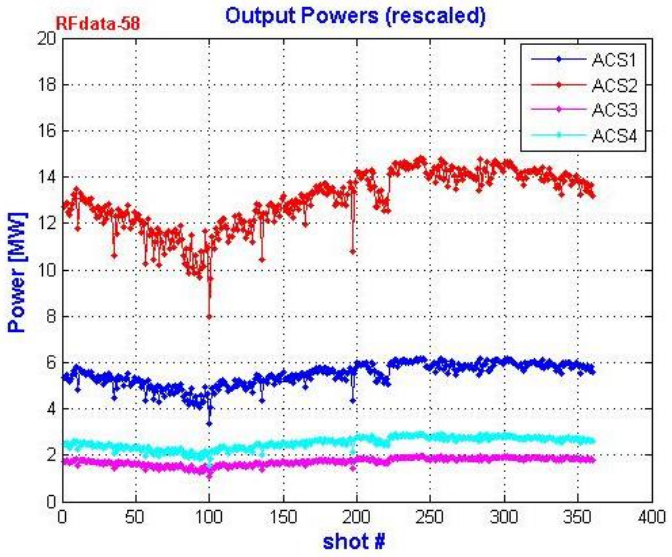
**Two-Beam Module in CLEX**
**RF measurements of the SAS N3-N4**

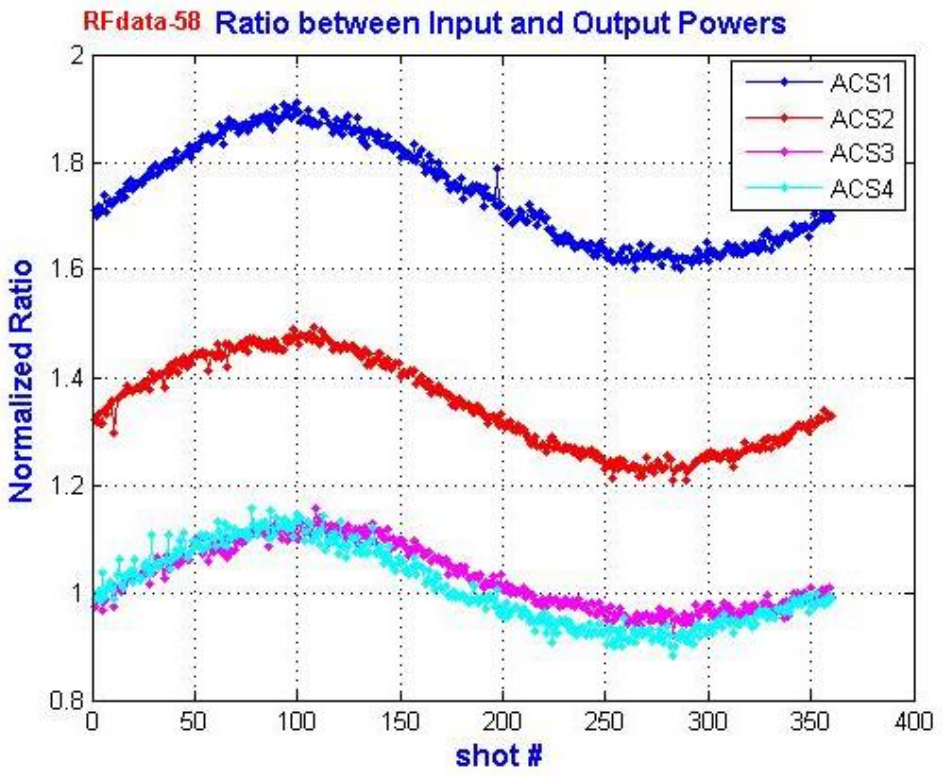
Andrey Olyunin
Dmitry Gudkov

- This problem was revealed after the structure installation
- Default of transmission partly explained the ACS3/ACS4 outputs power discrepancy

# Probe beam phase scan



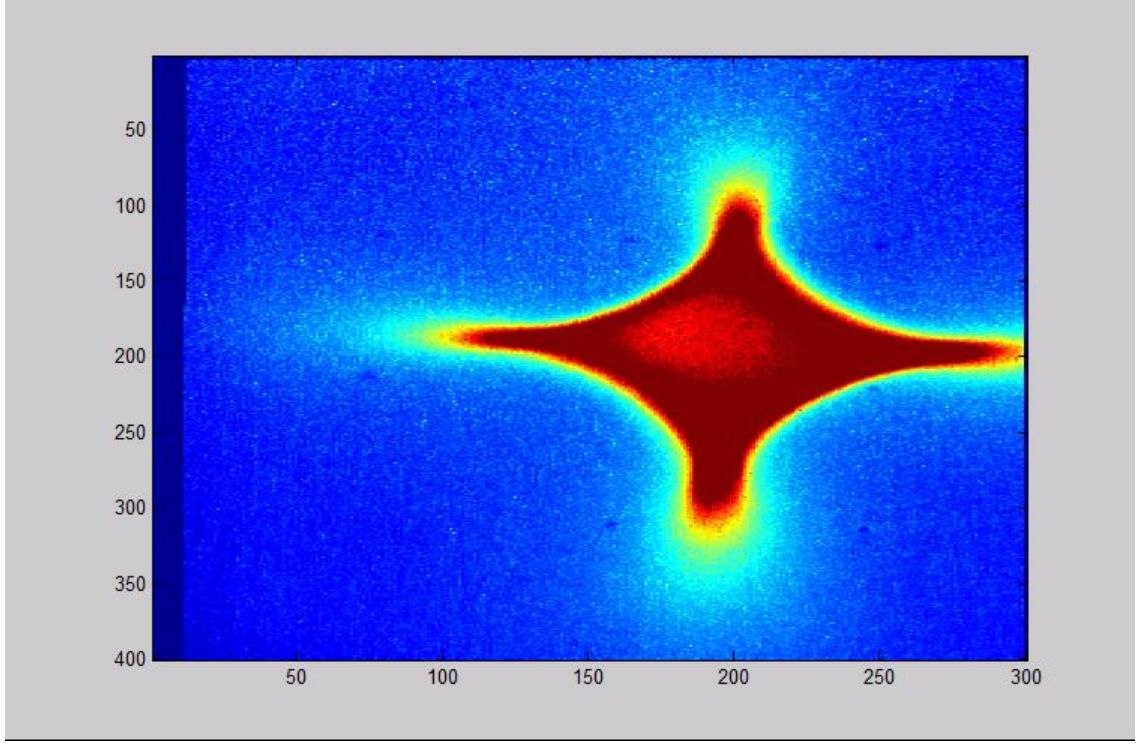



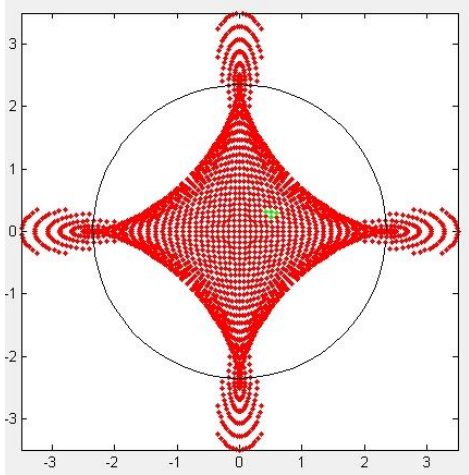



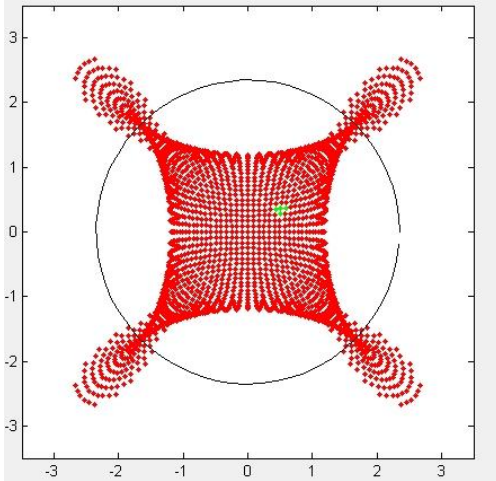

- Probe beam phase vs. Drive beam phase changed by 1 degree at every shot
- Power generated by drive shows fluctuation (especially with priming)

Input/Output ratio clearly shows the beam loading.

# Beam shape during phase scan

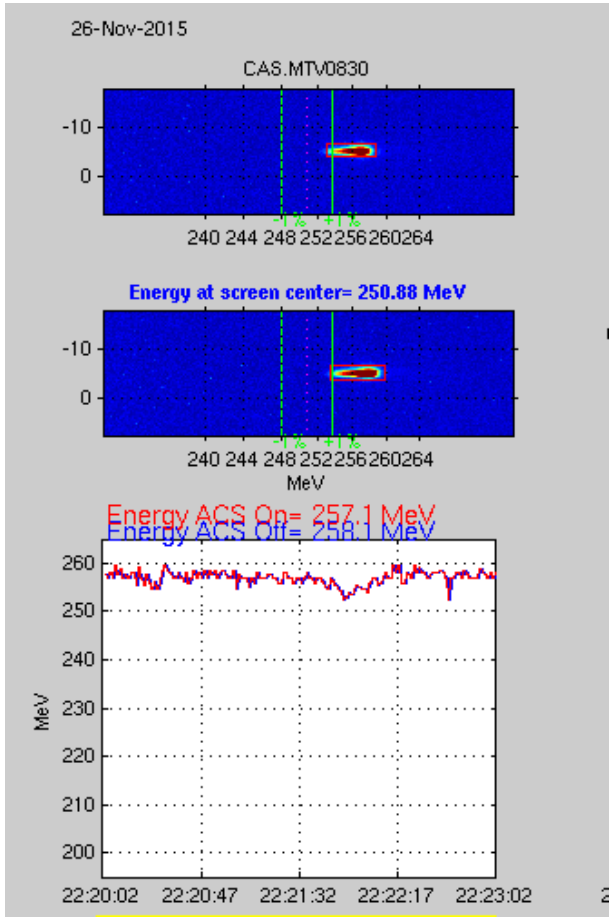


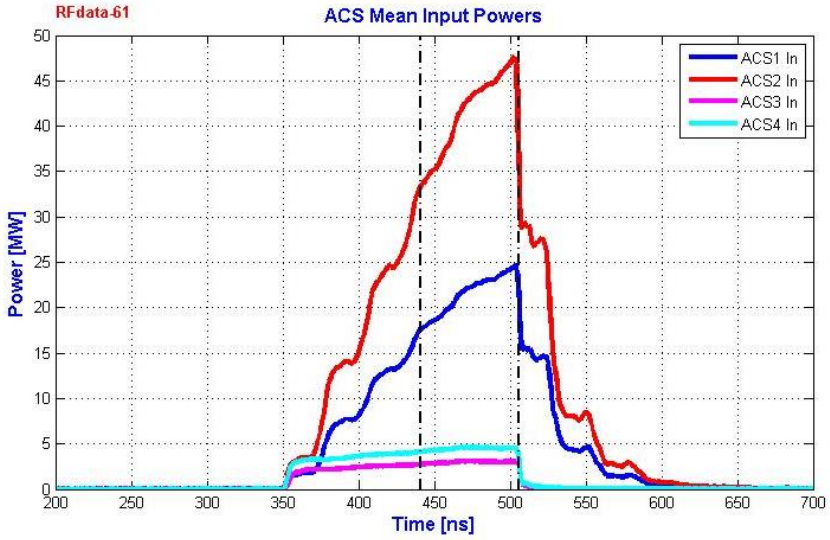




Simulations with 2 different phases

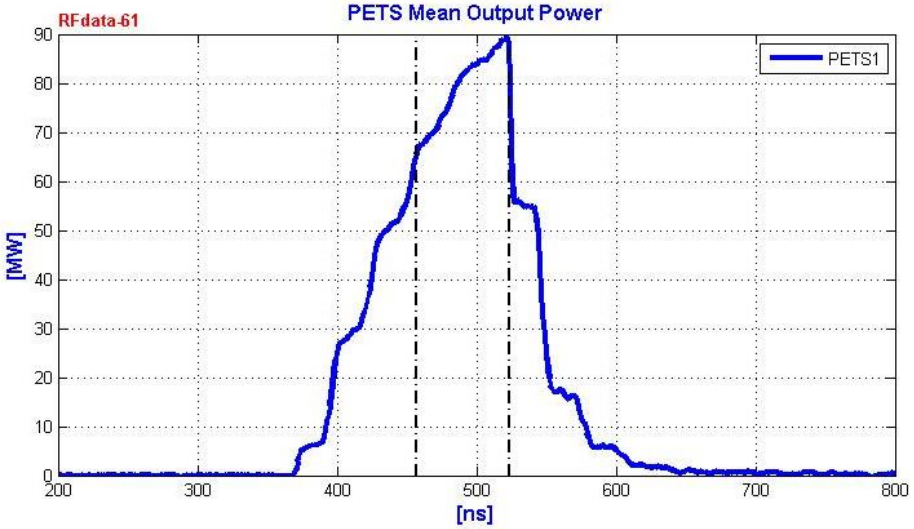
# Highest energy gain obtained (so far)




TBM energy gain: **58 MeV**



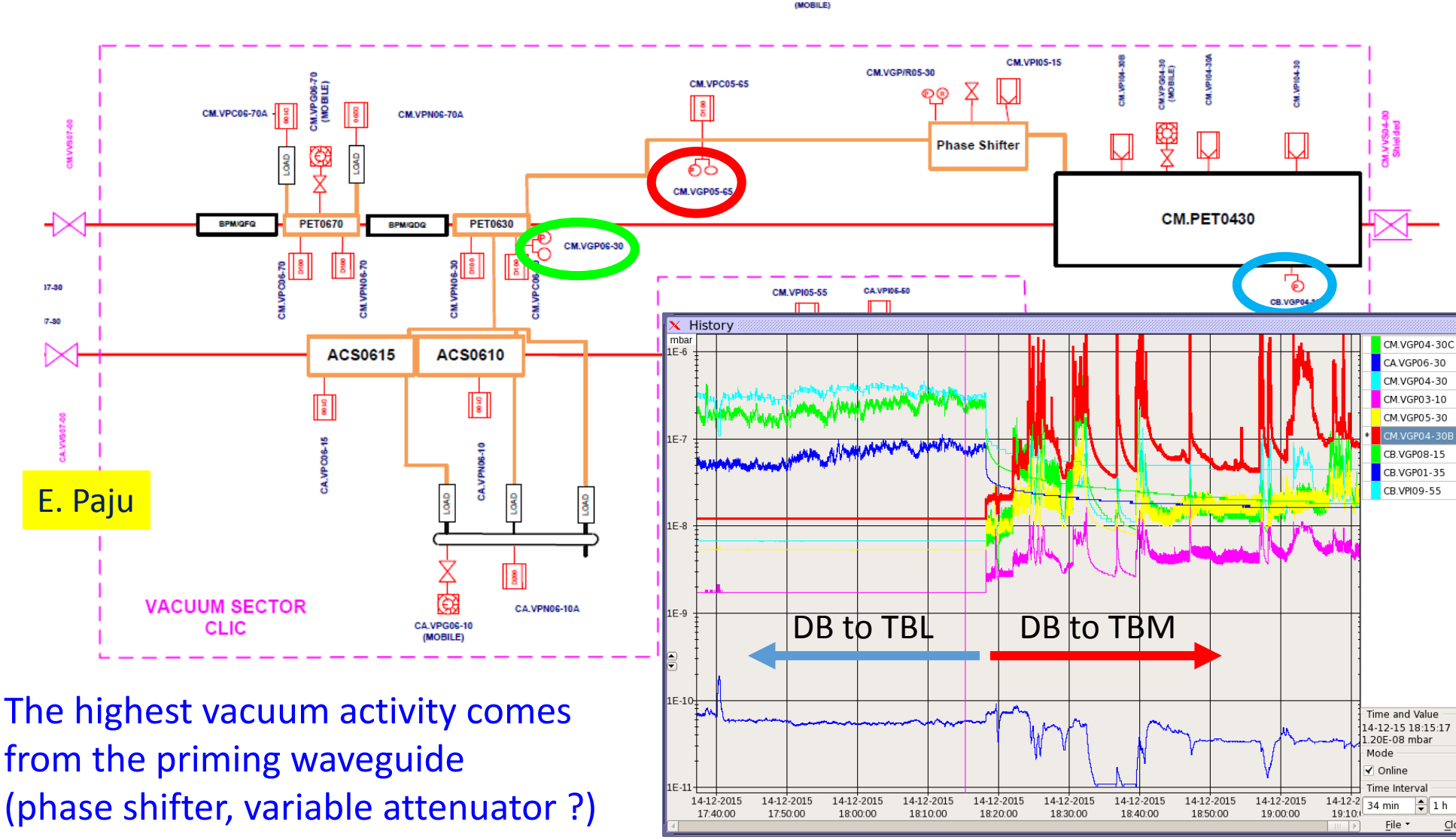

ACS2 input: **45 MW**




PETS 1 output: **85 MW**

With DB 15 A (factor 4), pulse length 140 ns
Limited by BD

# Vacuum activity during RF tests




The highest vacuum activity comes from the priming waveguide (phase shifter, variable attenuator ?)

# Conclusion

- The CALIFES beam has bean extensively used for many experiments
- Concerning TBM tests and considering the complexity of the RF scheme more studies and DB time are necessary this year
  - Improve the structures conditioning
  - Improve some RF calibrations
  - Validate the module performances
  - Study the beam quality after acceleration by the TBM
  - Test all the subsystem in integrated conditions (WFMs, girder alignment, BLM…)

Thank you for your attention