CALIFES and Two-Beam Module Status

W. Farabolini

on behalf of all the CALIFES beam users

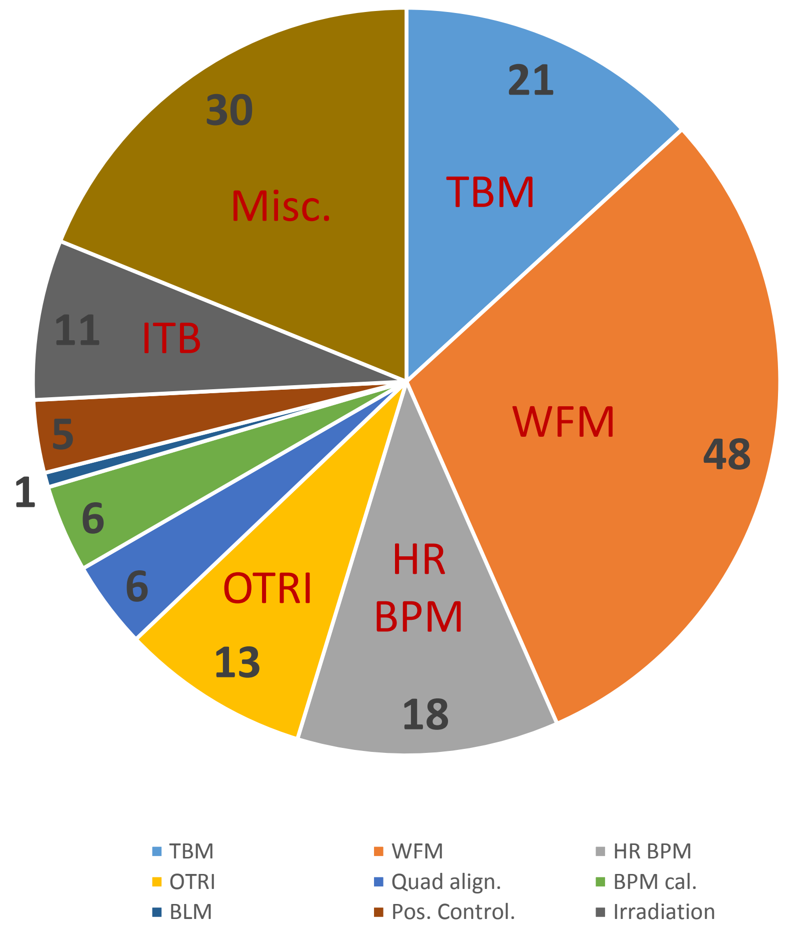
Studies repartition with CALIFES and TBM

Test Beam Module :	21 days	W. Farabolini
Wake Field Monitors :	48 days	R. Lillestol et al.
High Resolution Cavity BPMs :	18 days	J. Towler
Interferometric OTR :	13 days	R. Kieffer
Beam alignment in Quadrupoles :	6 days	N. Aftab, S. Javeed
Califes Cavity BPMs calibration :	6 days	N. Aftab, S. Javeed
Beam Loss Monitor:	1 day	M. Kastriotou
Girders positions control :	5 days	V. Rude, M. Duquenne
Irradiation Test Bench :	11 days	R. Alia et al.
Strip Line BPMs		A. Morell

Miscellaneous : 30 days
(beam preparation, development, studies non referenced in the log-book…)

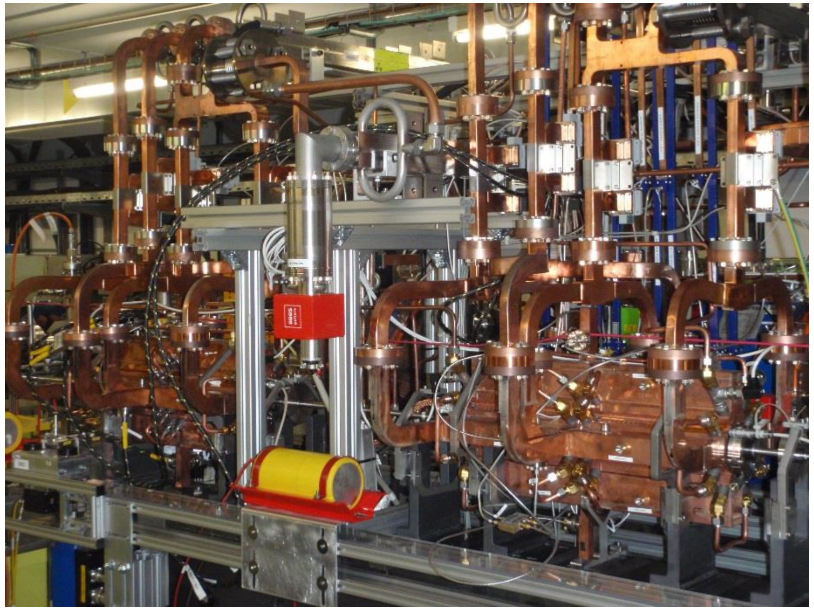
Total: 159 days (users x days)

Klystron MKS30 for PHIN : 5 weeks



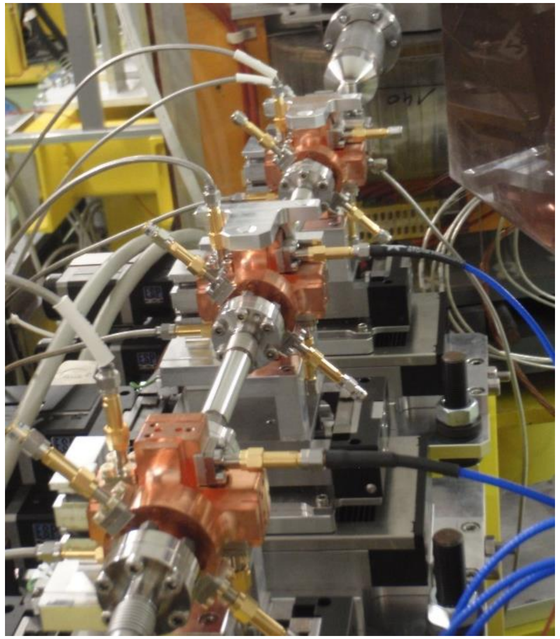
Shutdown Periods and New Installations

17 Dec. 2014 –
9 Mar. 2015

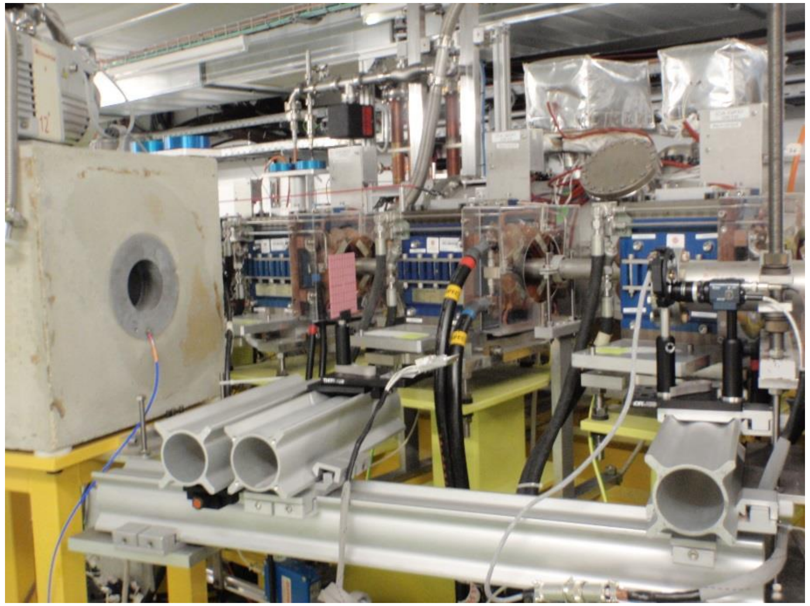


Second Super-structure on the TBM

- ➢ Survey of the whole line
- ➢ In situ RF measure with network analyser
- ➢ RF power chain calibrations



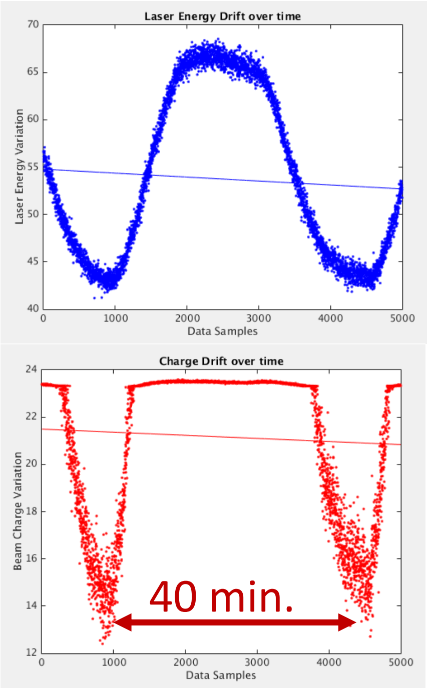
3 High Resolution Cavity BPMs on motorized stages



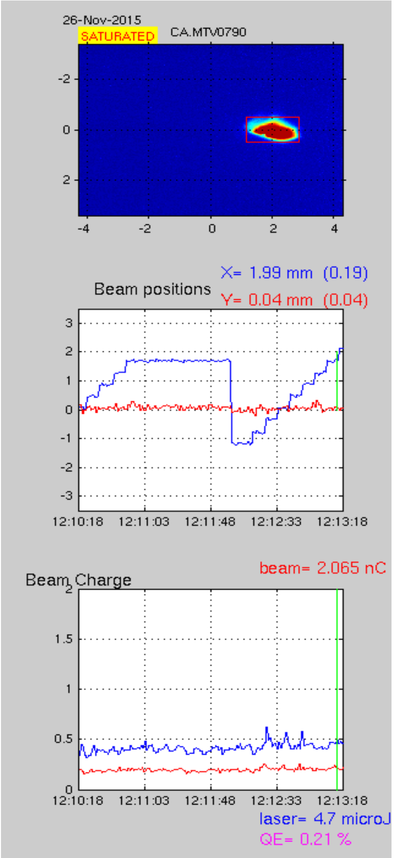
Irradiation Test Bench (E. Del Busto)

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

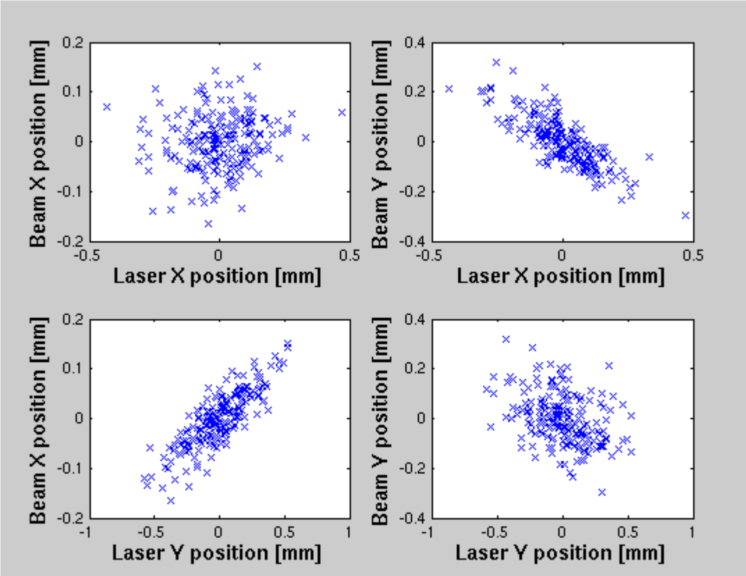
Some Laser stability concerns



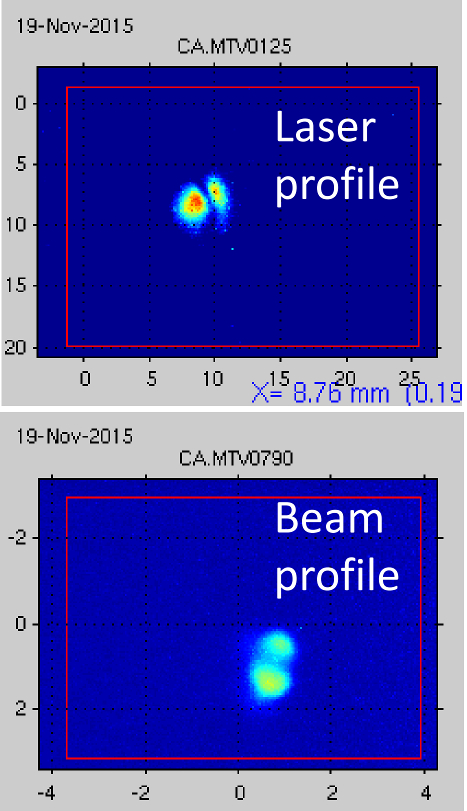
Laser Power and
Beam Charge drift



Beam position
and charge jitter



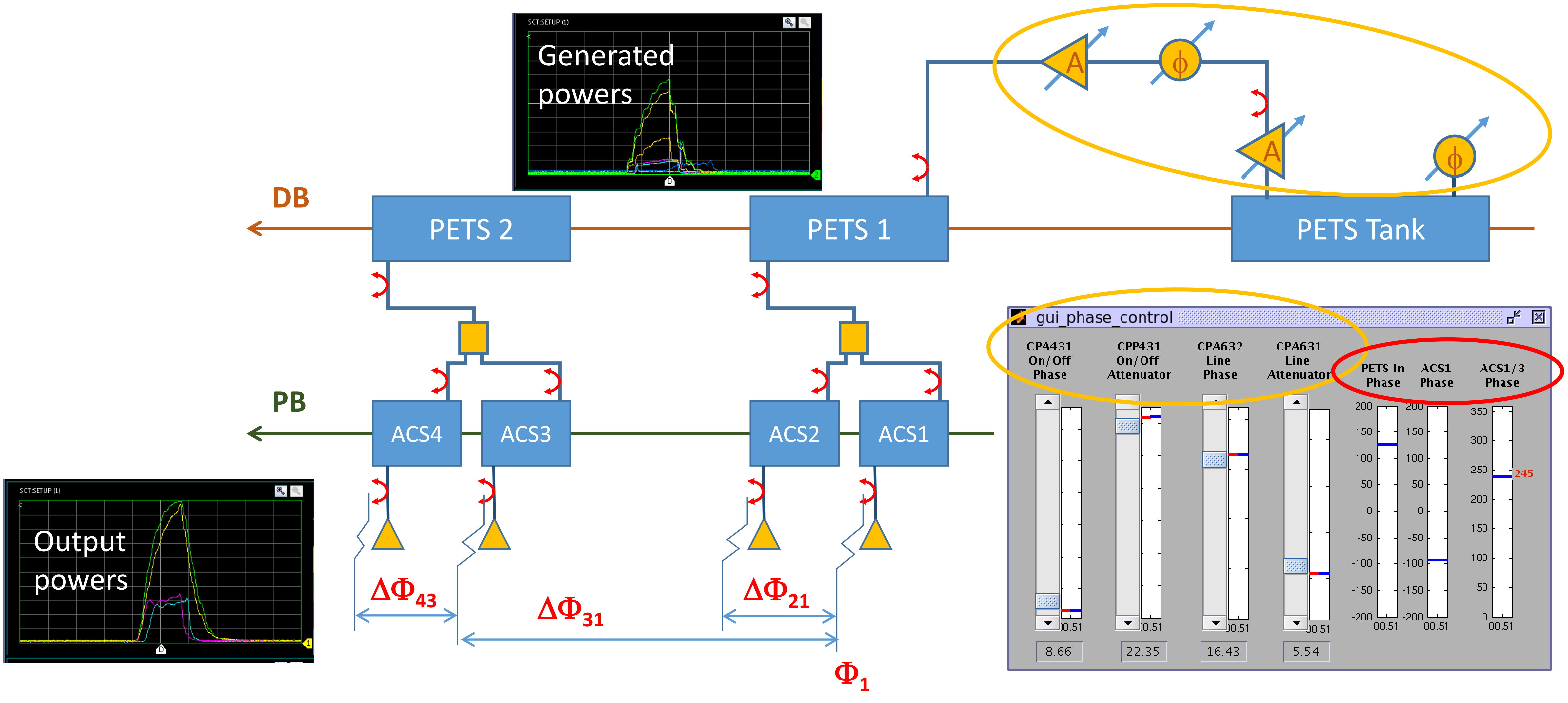
Laser/Beam position correlations



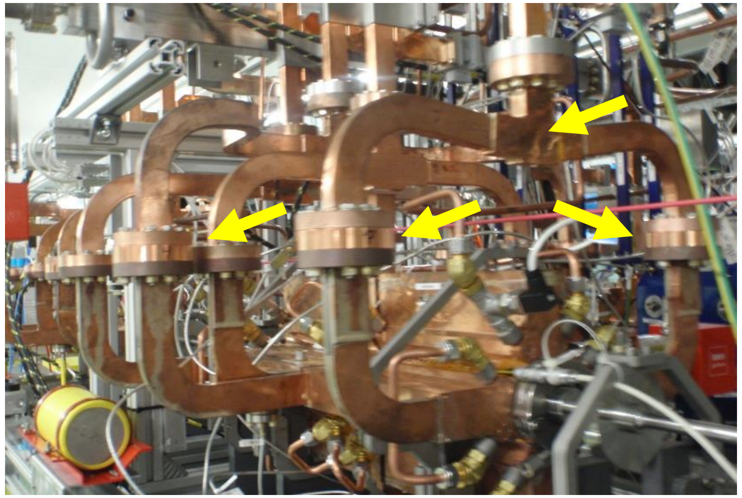
Double head Laser
and Beam shape

- Maintenance of the Laser Lab. Air conditioning system this week (measured temperature fluctuation: 5 deg C)
- Some problems with laser synchronisation and phase jump (LLRF team knows how to fix)

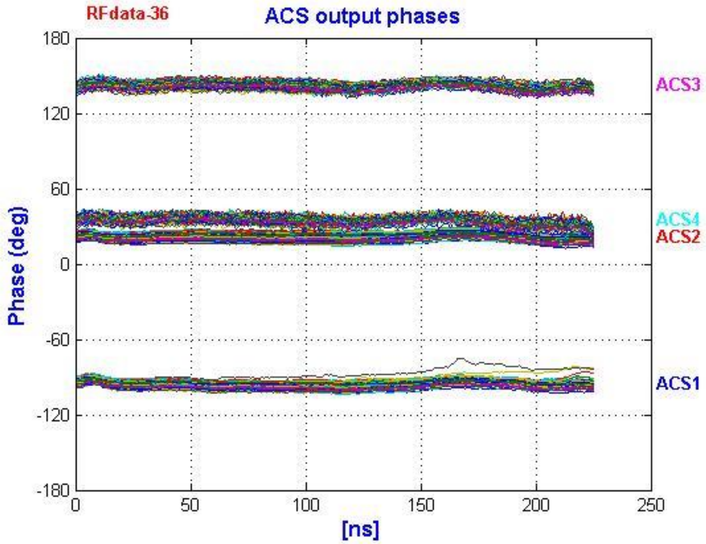
Test Beam Module (TBM) control



Principle of the Phase check



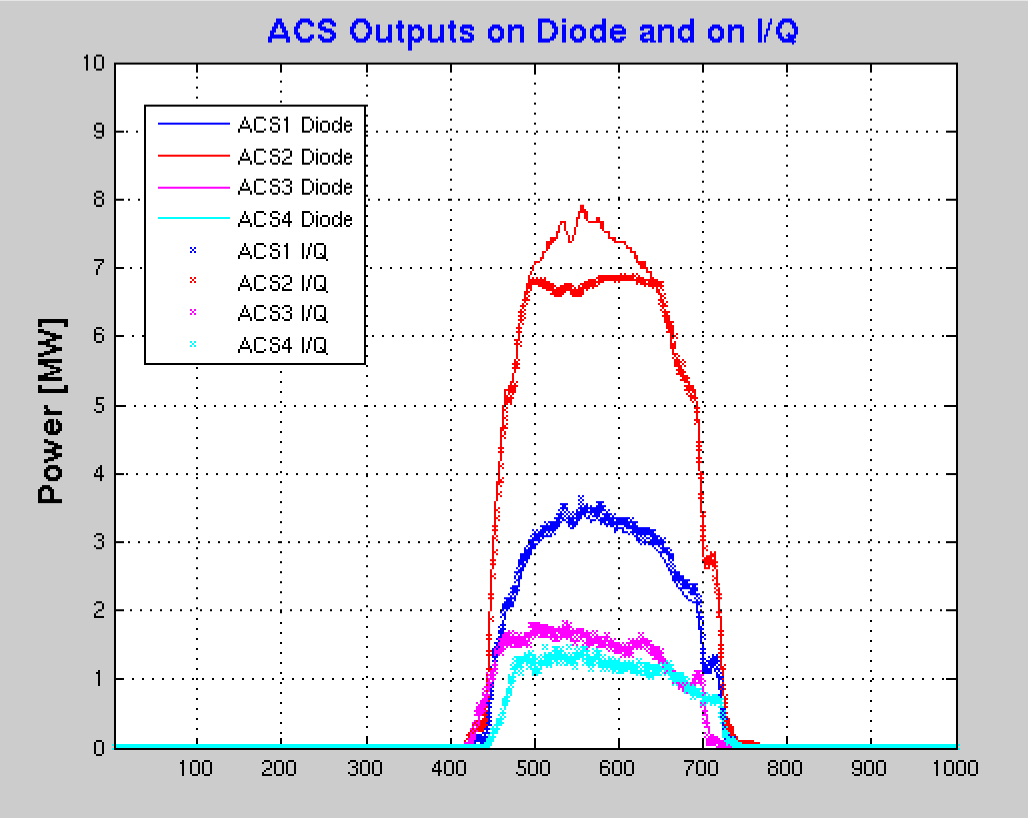
RF distribution with WG spacers

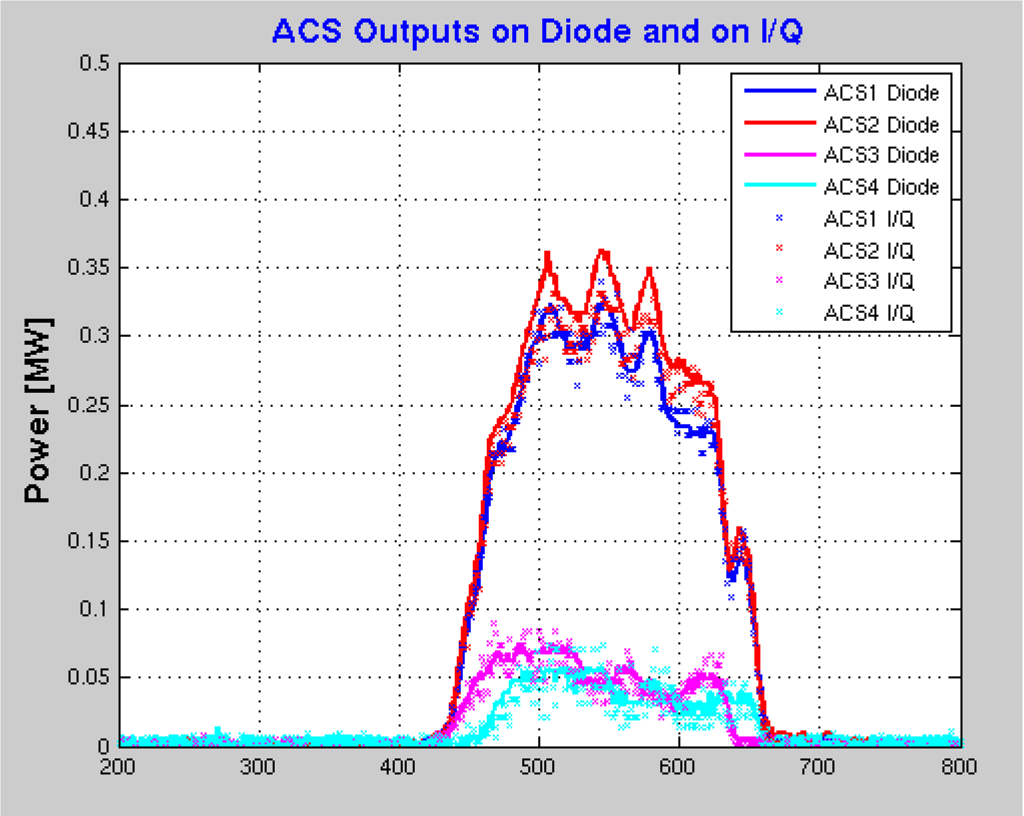


Output phases from structures

PB	DB	Correct if:	Phase error without recirculation	Phase error with recirculation	
$\Delta\Phi_{21}$ 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
Φ_1 PB	Φ_1 DB	At 180º	0 º	0 º	CALIFES phase control

Power measures problem



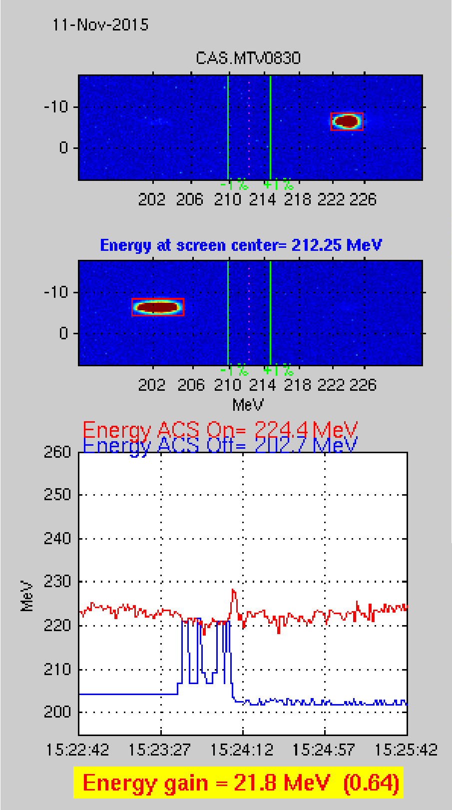


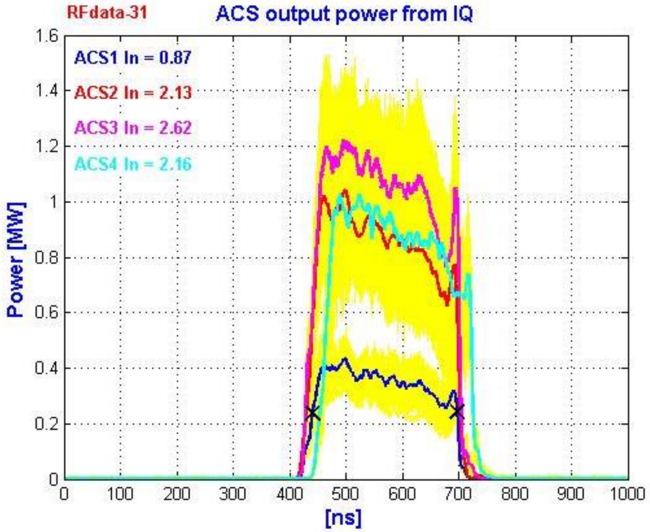
Very good agreement between Diodes and I/Q power
But a strong discrepancy between ACS1 and ACS2

This discrepancy was not present up to the 27 April
but with lower power (non linearity ?)

Energy gain performance

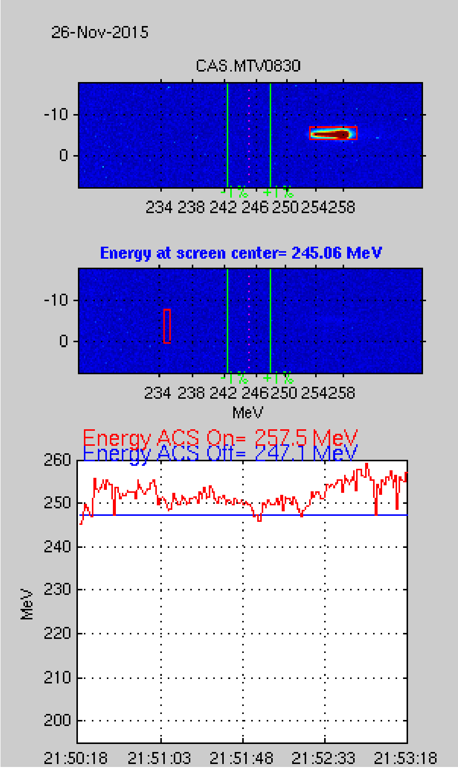
Without Priming



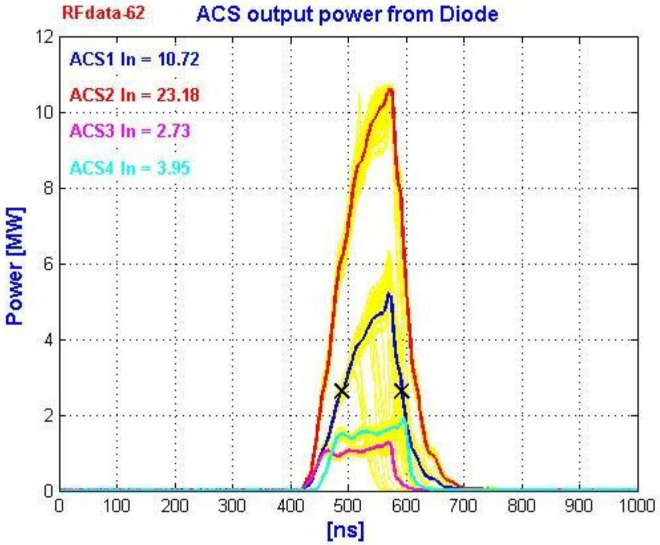


$$E_{gain} = coef^* \; ((ACS4_{in})^{.5} + (ACS3_{in})^{.5} + (ACS2_{in})^{.5} + (2.65 * ACS1_{in})^{.5}) = 21.6 \text{ MeV}$$

With Priming



Energy gain = 55 MeV



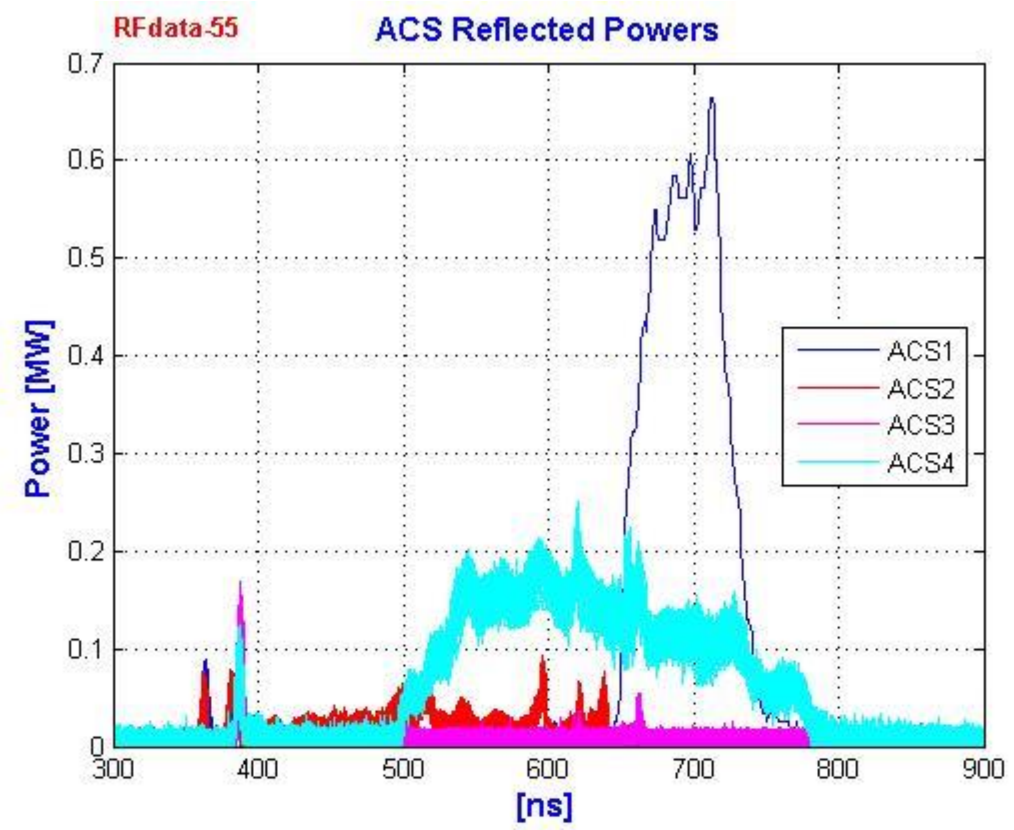
$$E_{gain} = 7.1 + 5.9 + 17.2 + 19.0 = 49.2 \text{ MeV}$$

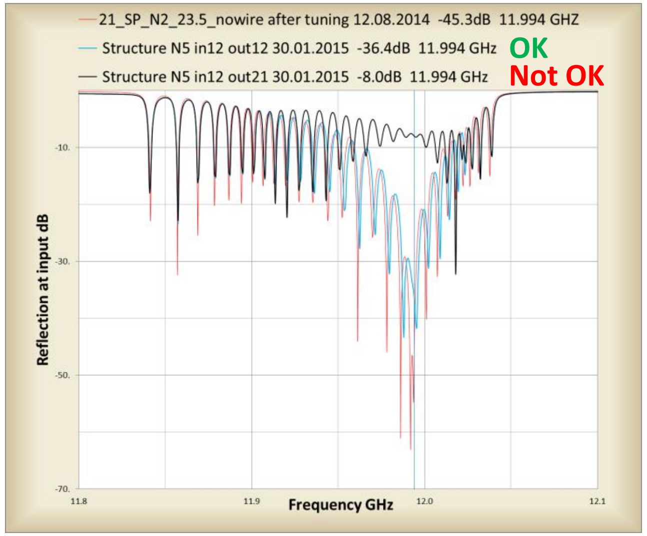
Power In / Power Out = 2.44 (S_{12} = 0.64)

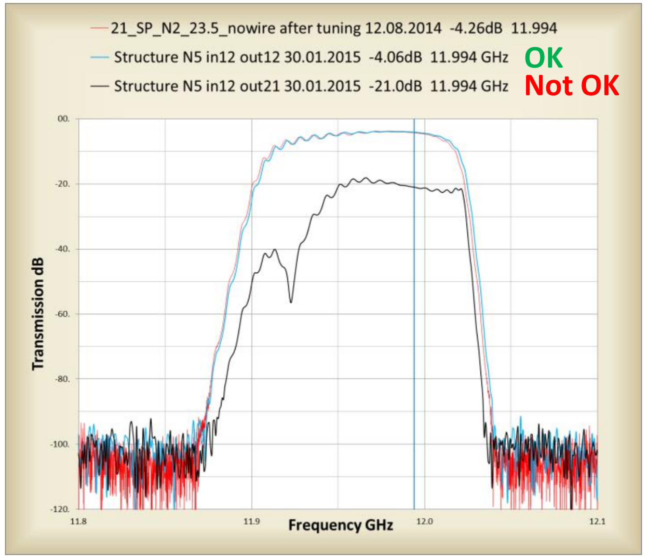
E_{gain} [MeV] = 100/sqrt(42.6)*0.23 * sqrt(P_{In} [MW])

= coef * sqrt(P_{In} [MW])

Reflected Power from structures







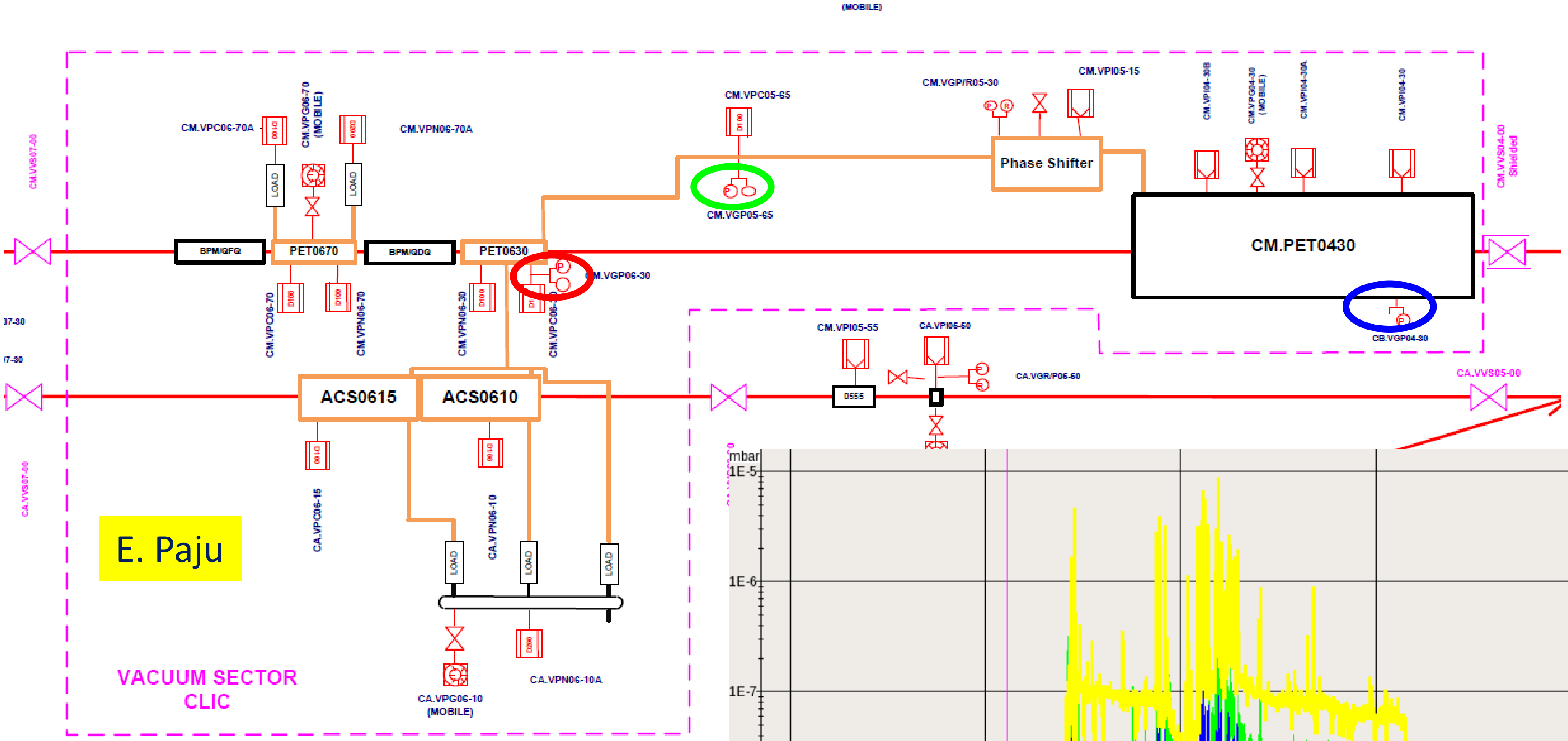
Two-Beam Module in CLEX RF measurements of the SAS N3-N4

Andrey Olyunin
Dmitry Gudkov

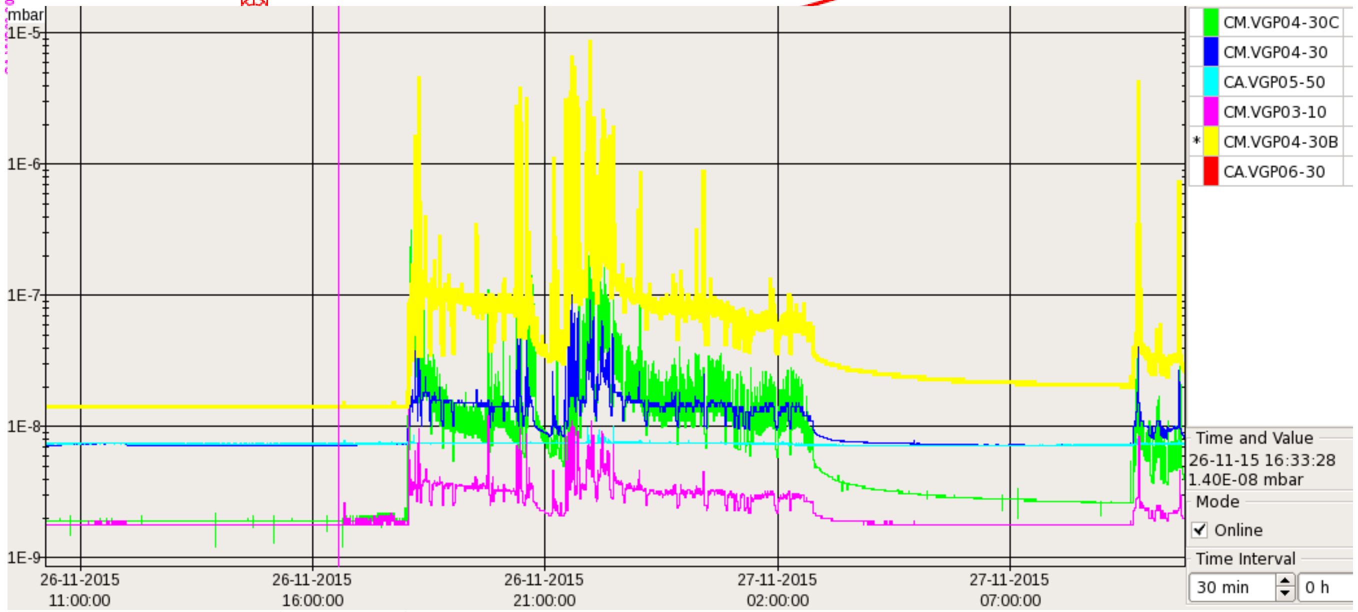
Problem already known from the installation

- 180 superposed RF pulses (1 BD in ACS1)
- Some reflected power by ACS4 after 110 ns (last cells)

Vacuum activity during RF conditioning

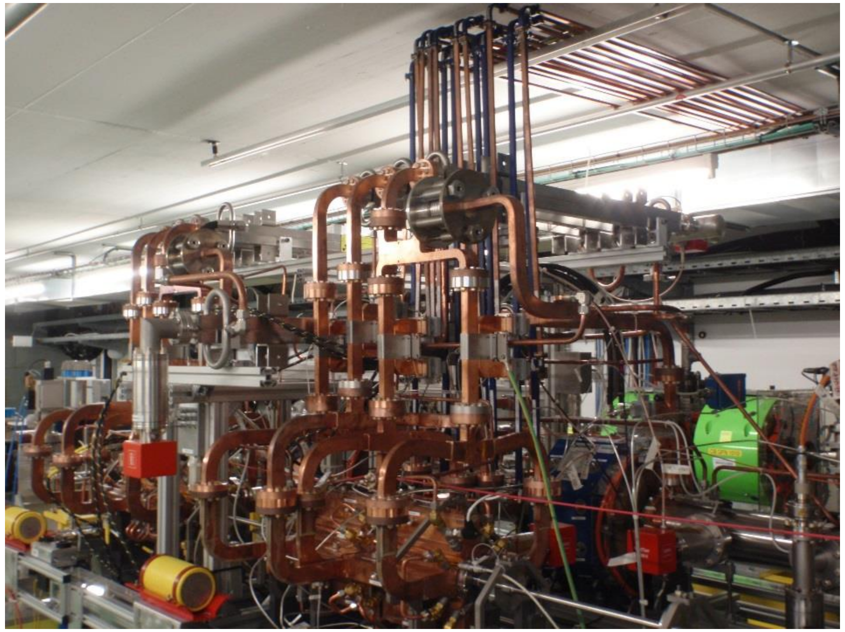


E. Paju

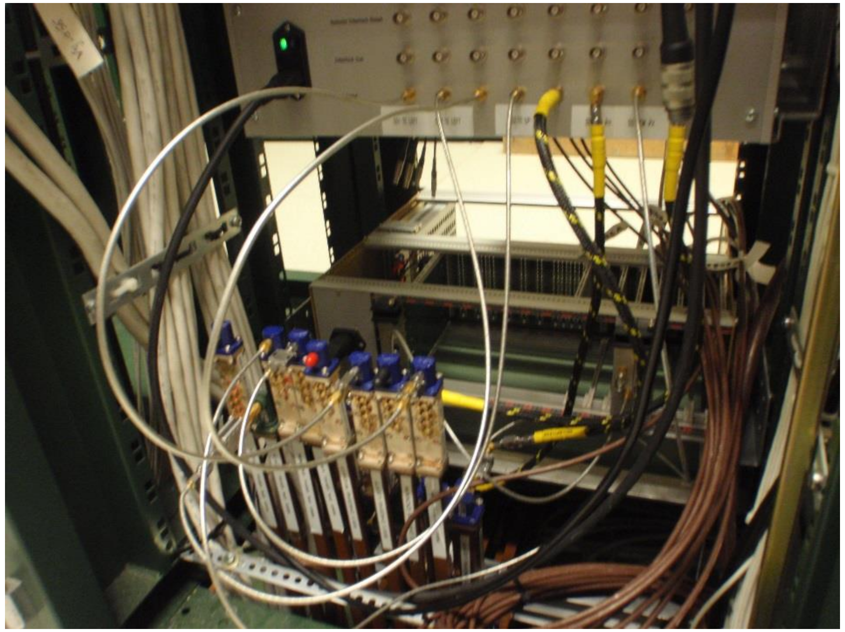


Vacuum scheme to be actualized

Wake Fields Monitors



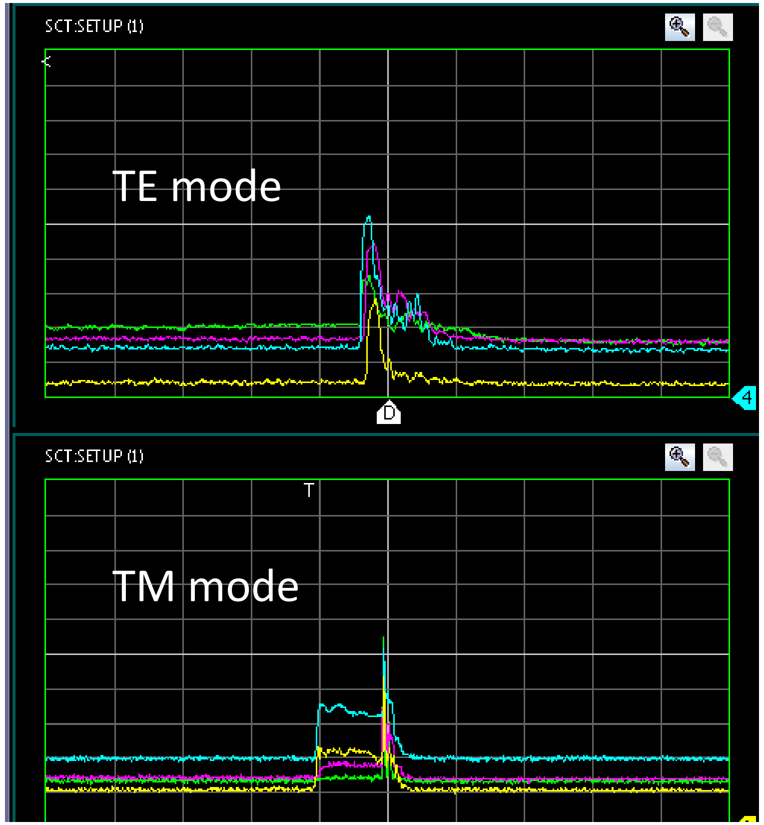
Connection by waveguide to the gallery

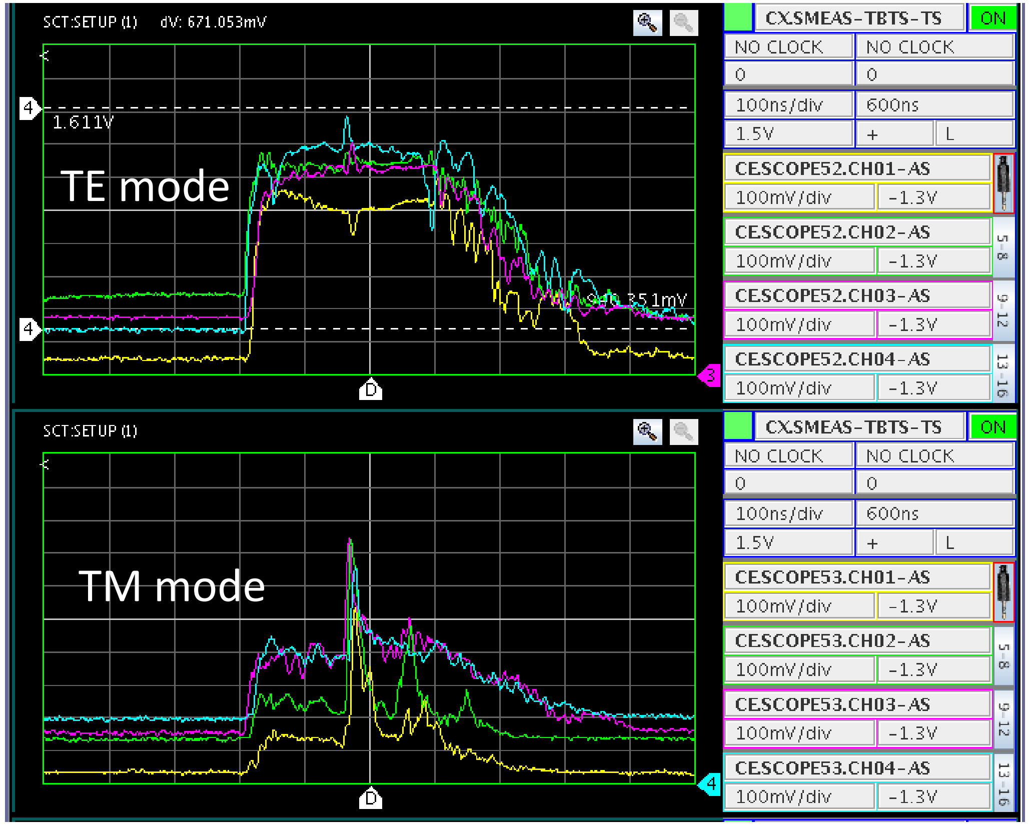


waveguide filters and log-detector crate

- The present installation (16 waveguides + filters) has been developed for the previous TD24.
- The location of the WFM pick-up have changed (2^{nd} cell instead of central cell)
- The TE-like and TM-like frequencies are now different (27.3 GHz instead of 24 GHz, and 16.5 GHz instead of 18 GHz)
- Some problems with the log-detector crates (too low bandwidth -> short the final amplifier)

Noise problem from the Drive Beam



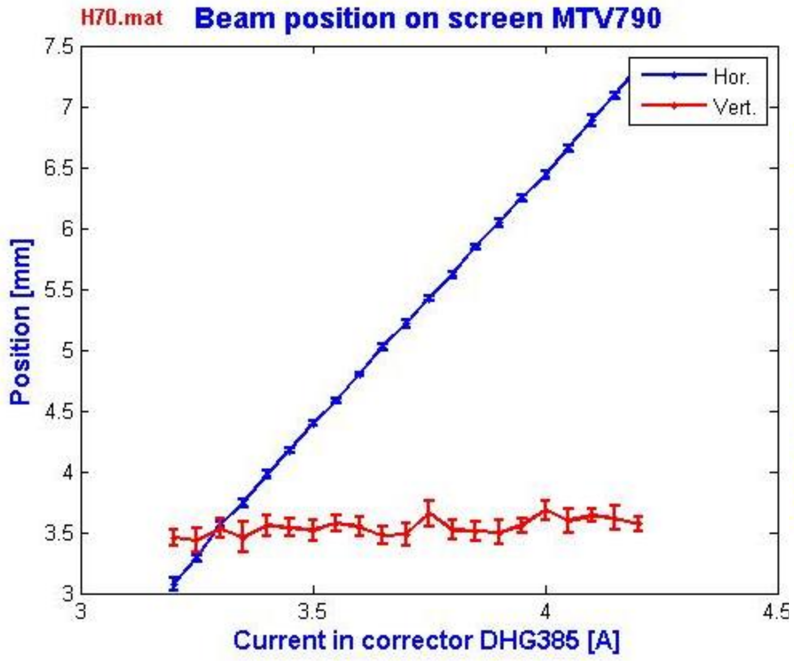


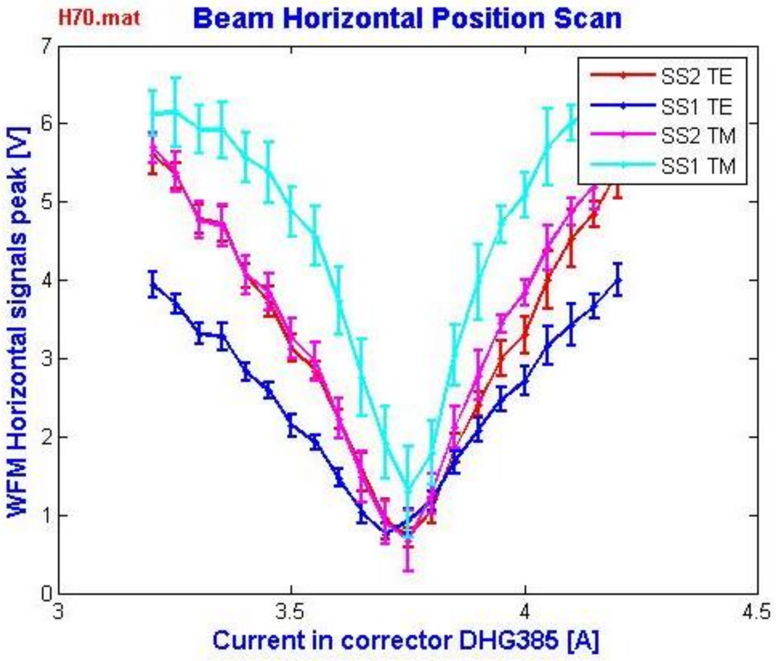
Noise in TM mode when DB is in TBL
Now solved by better grounding

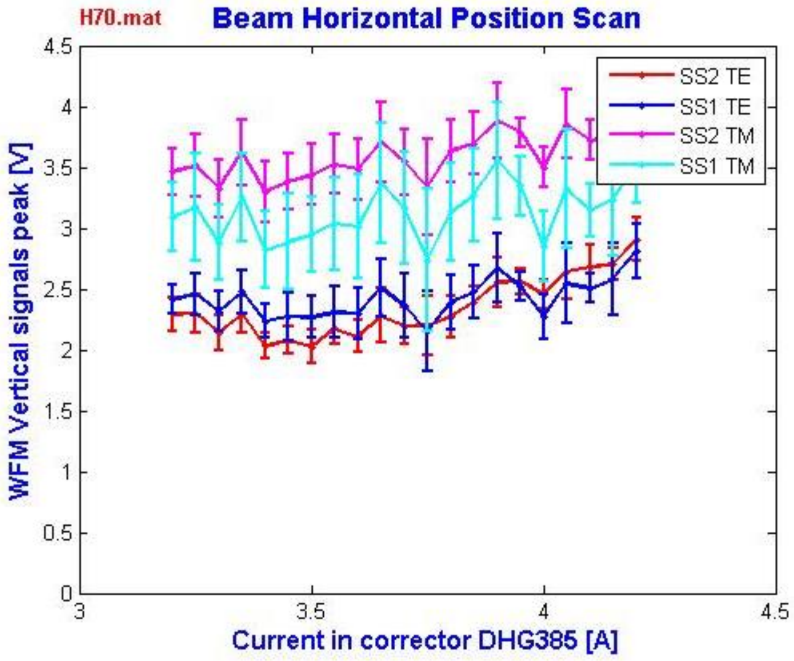
Noise in TM and TE modes when DB is in TBM
Due to DB current or RF Power ? Still under investigation

Necessity to have a clear picture of the useful bandwidth

Beam Horizontal position scan data







- Regular Horizontal beam scan
- Vertical beam jitter

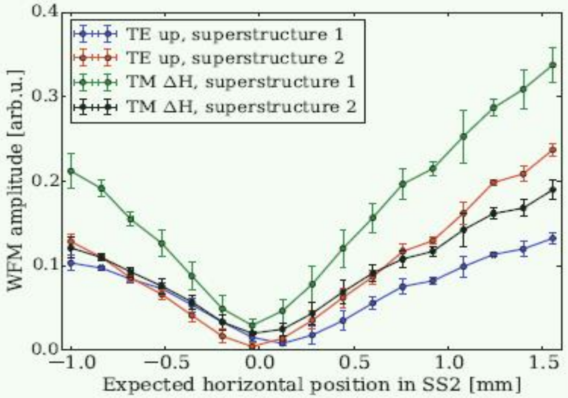
- Consistent Horizontal WFM signals
- Good structure alignment

- Vertical beam jitter visible on WFM signals

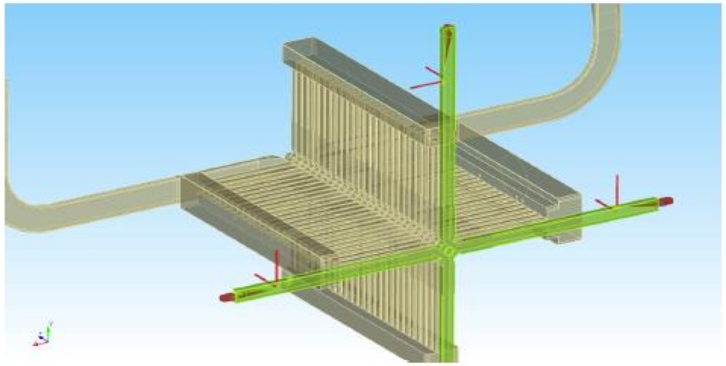
WFM resolution

R. Lillestol

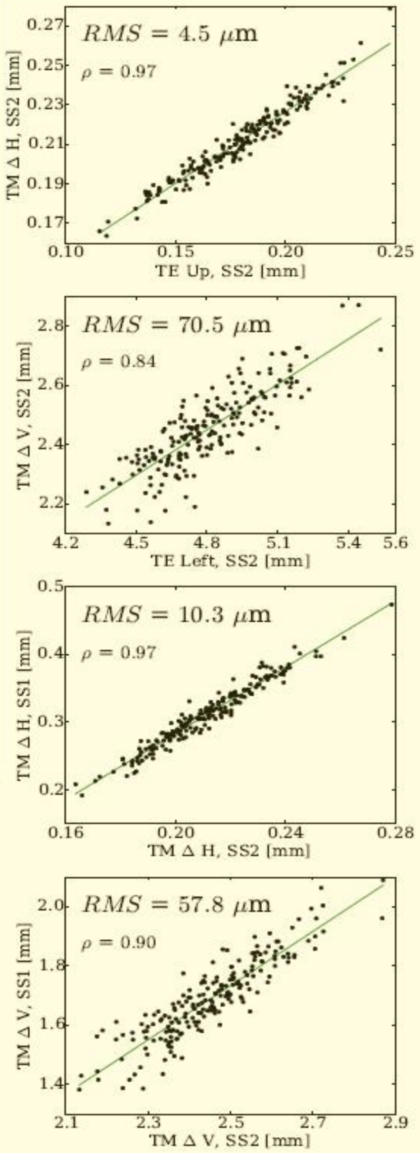
- **WFMs**: Accurate determination of the beam position in accelerating structures
- 4 HOM waveguides used for measuring dipole modes
- A TE-like mode at ∼27 GHz and a TM-like mode at ∼17 GHz are measured (on different sides of the waveguides)



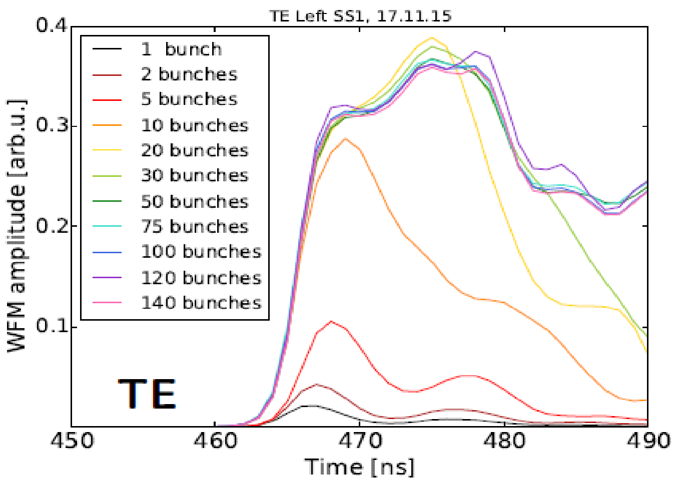
Scan: Good agreement of structure centers between signals, after online module alignment

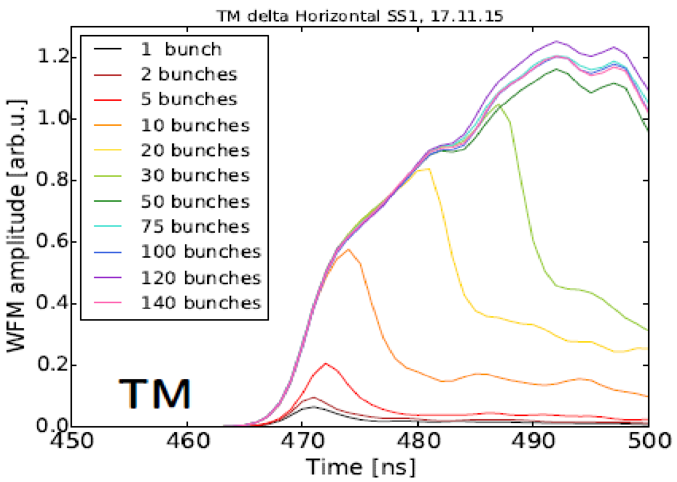


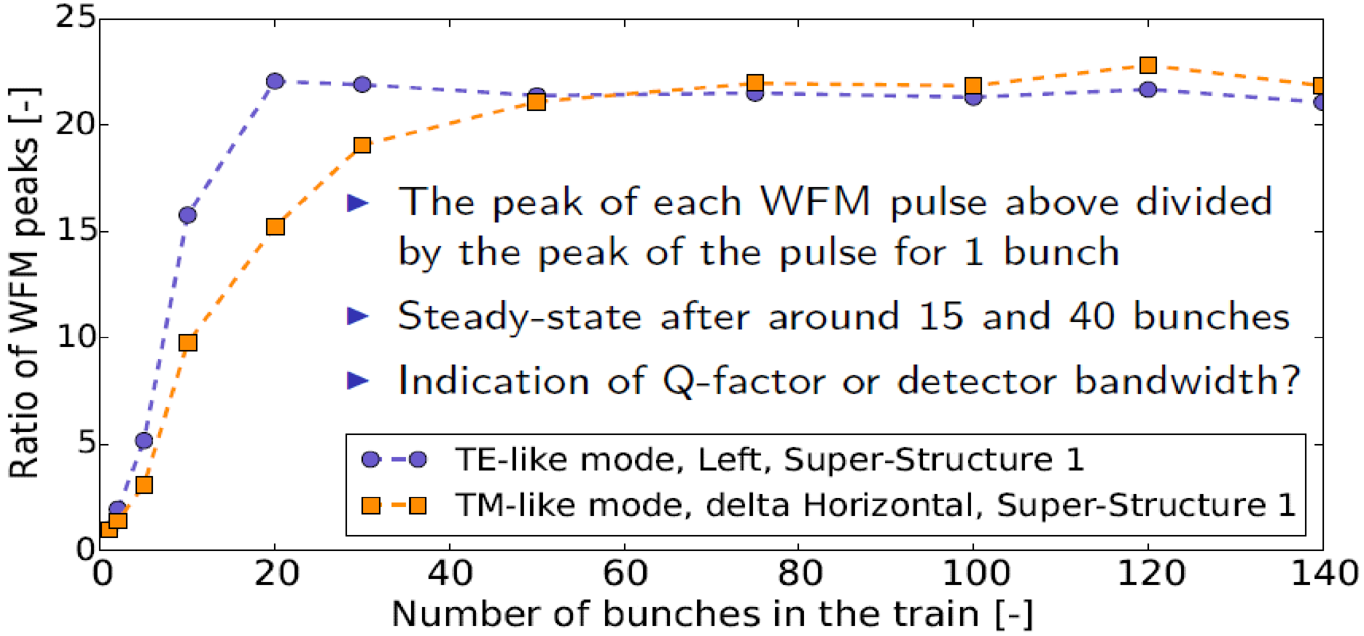
Resolution estimates near the structure center when the beam is kept still for many pulses
→ However, large discrepancies between channels (to be followed up)



Evolution of the WFM pulse shapes with number of bunches in train

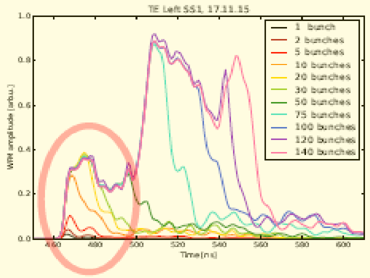




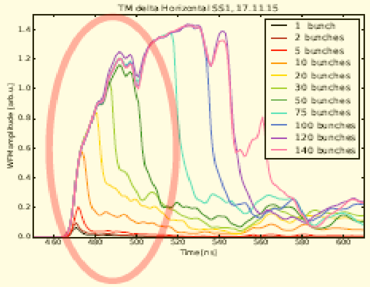


Note: The pulses on the left are actually longer than the real WFM signals.

TE:



TM:



R. Lillestol

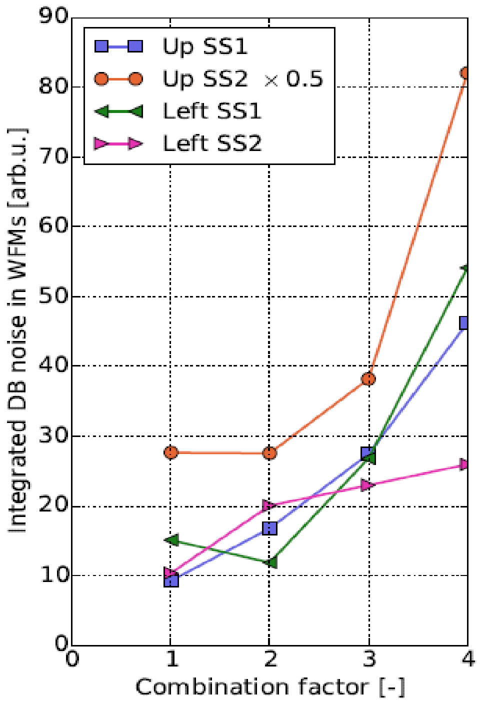
Impact of drive beam noise on the WFM TE signals

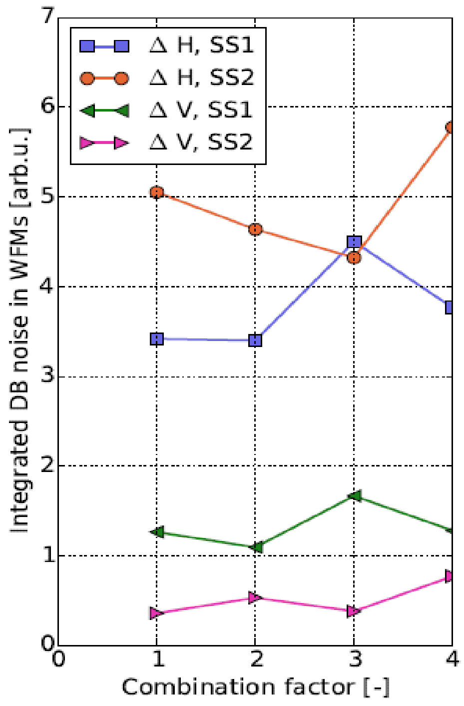
R. Lillestol

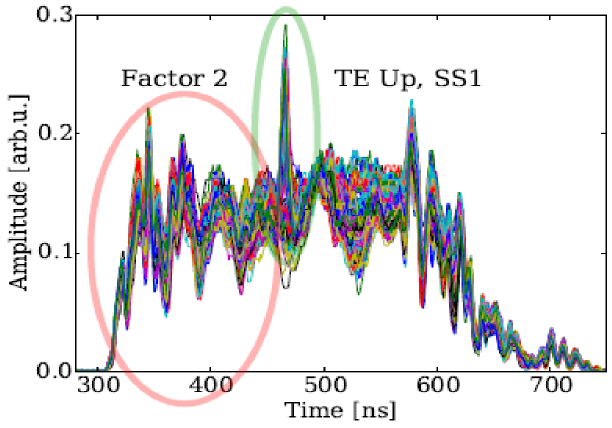
There is significant noise in WFM signals when the drive beam is used.

Improvements: Three noise sources identified and two resolved

1. **Califes noise**: RF noise from klystron
   - ✓ Better cables in the gallery
2. **Noise from DB in TBL** (only superstructure 2)
   - ✓ Structure 2 grounded properly
   - ✓ Avoid DB spectrometer dump (much more noise)
3. **Noise from TBTS**:
   - ✗ Noise source not fully understood, but expected to be injected from PETS to structure
   - ✗ Noise worse in horizontal plane and much worse for the TE-like mode







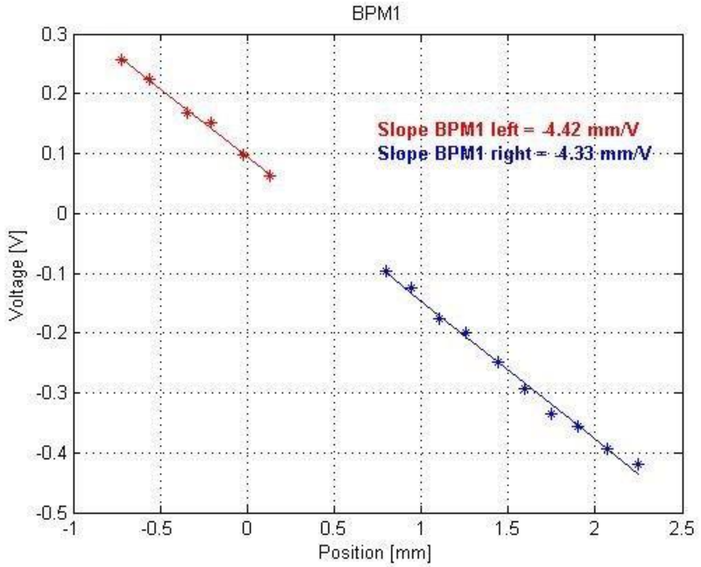
Future plans: Measure the signal and noise spectra in the gallery (complicated due to high frequency of 27 GHz)

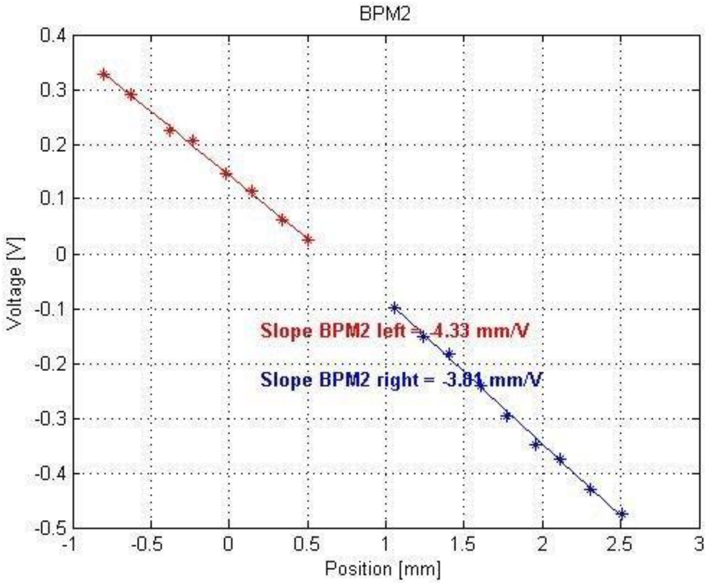
- Answers why the noise is so bad for TE modes
- Answers if noise can be further reduced also for TM modes using more suitable filters
- Gives indication of noise asymmetry between horizontal and vertical planes

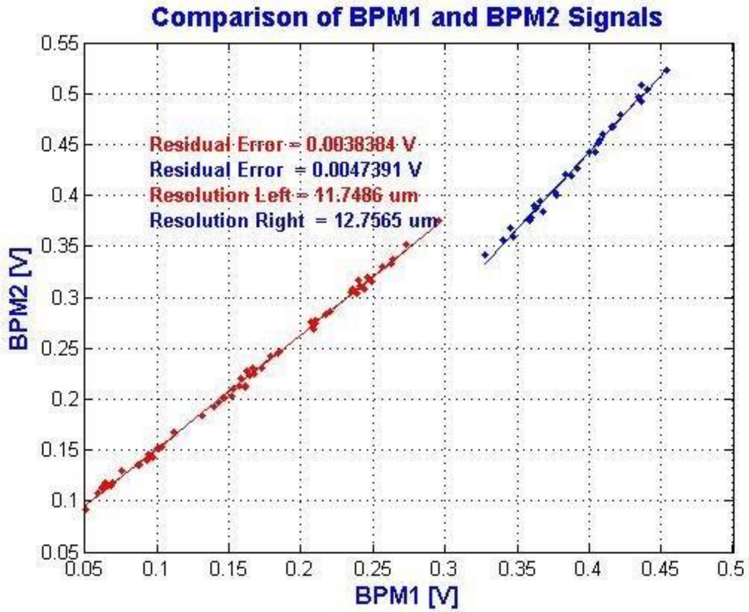
Correlation between Califes BPMs Signals

N. Aftab
S. Javeed

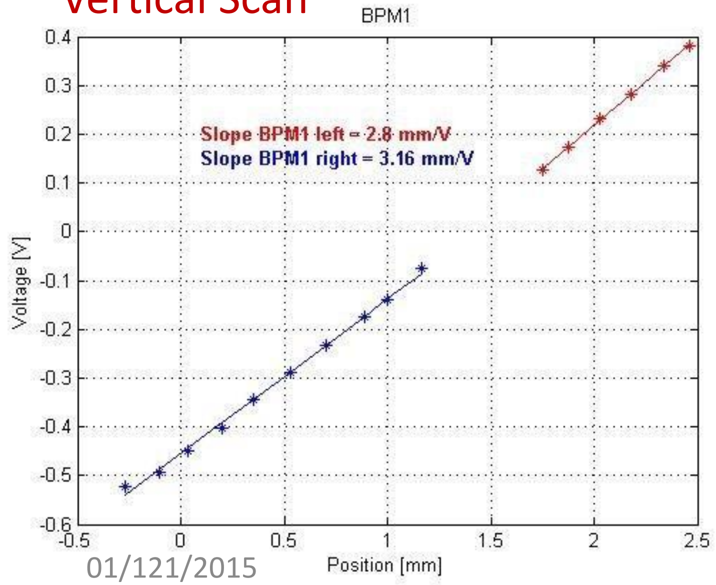
Horizontal Scan

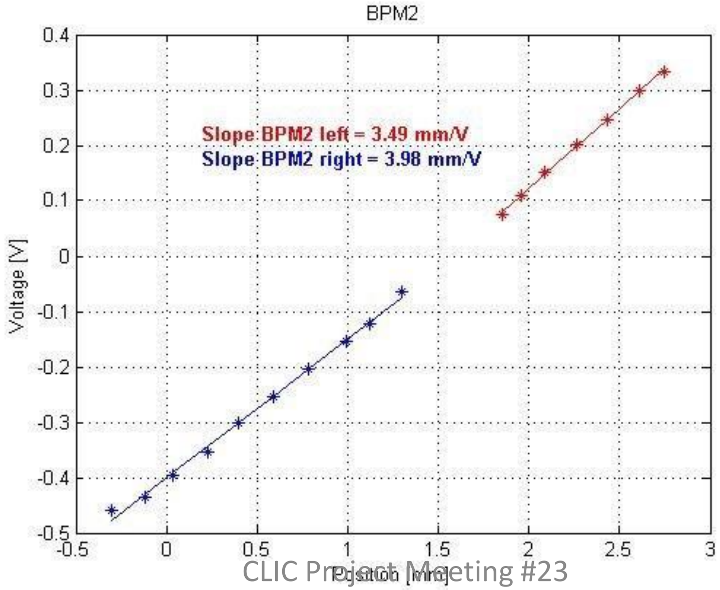


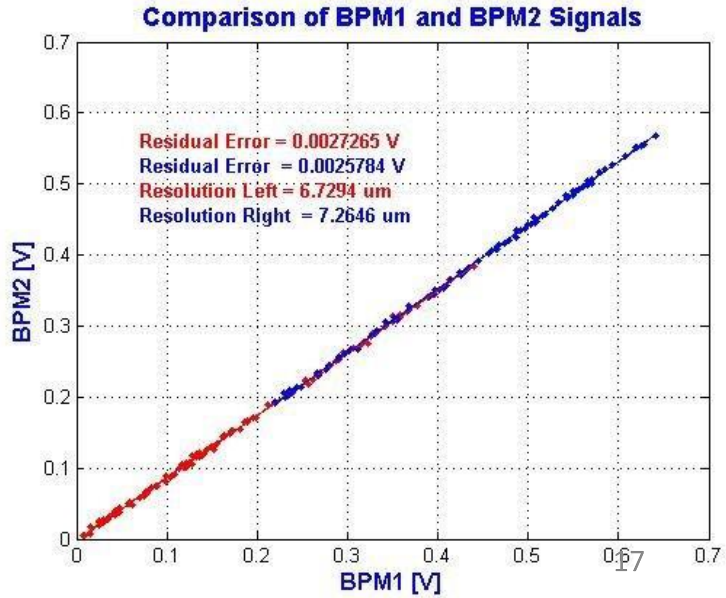




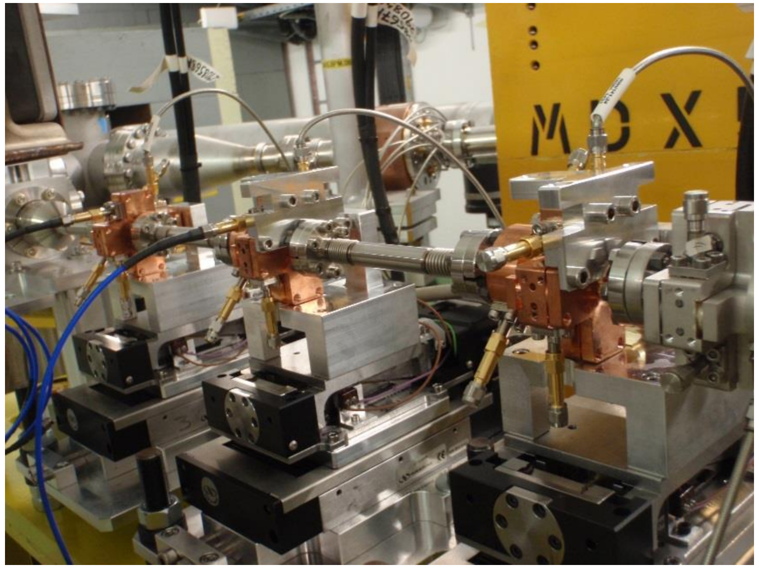
Vertical Scan







High Resolution Cavity BPMs

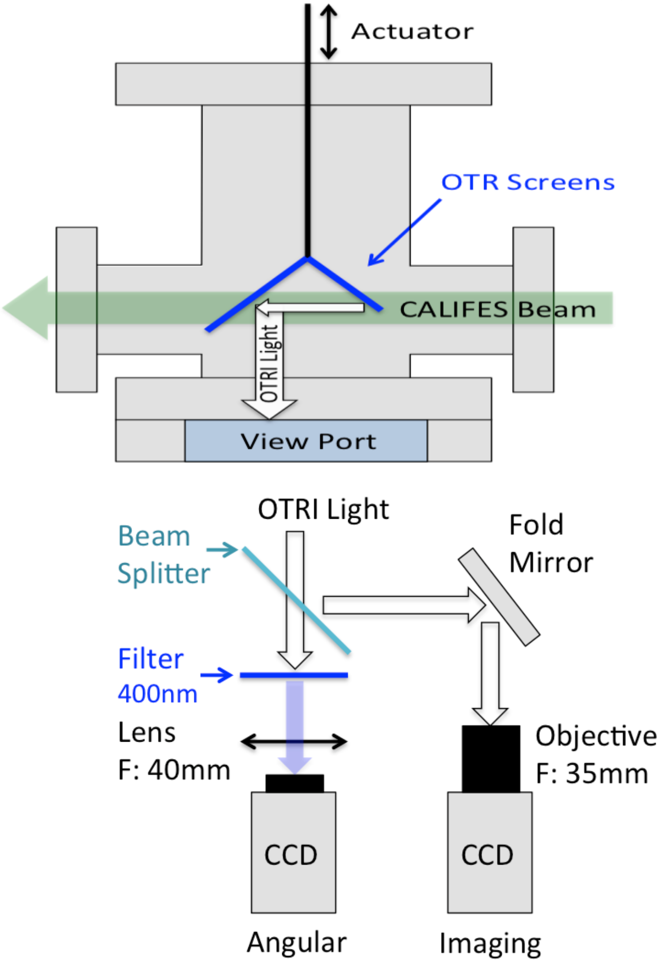


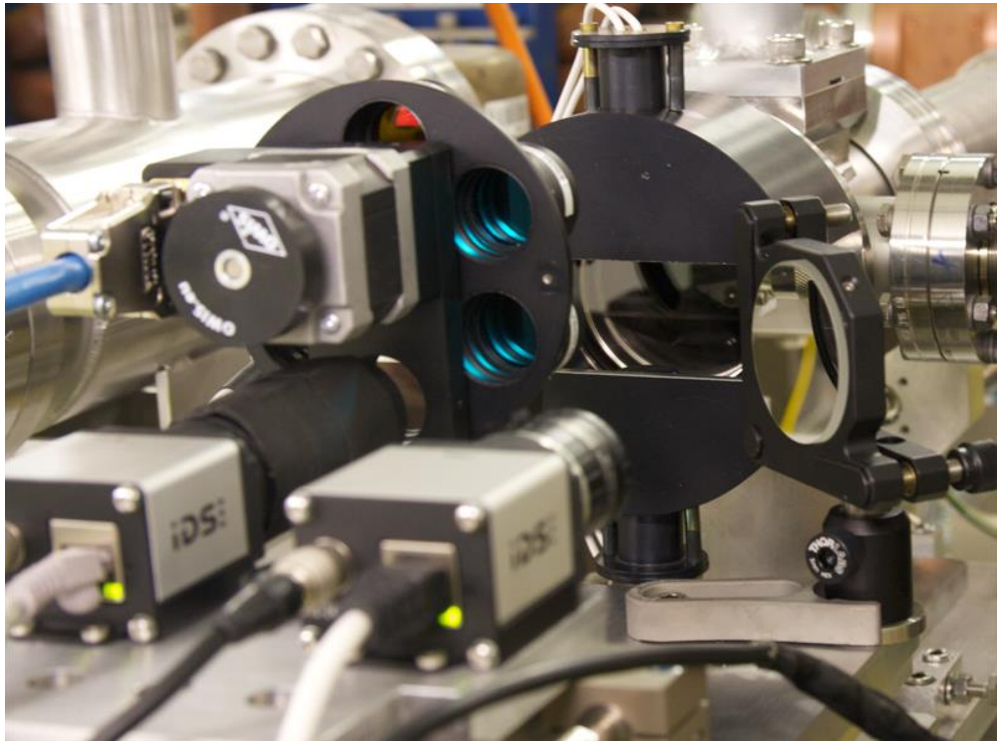
- BPMs are installed on vertical and horizontal stages:
  - ➢Perfect alignment on the beam line
  - ➢Calibration signal vs. position
- 3 Cavities for dipole mode + 1 for beam current measurement (normalisation)
  - ➢Beam jitter free measures
- Many data taken but still to be processed to derive the resolution
- The 3 down mixing electronics have been destroyed by the drive beam losses.
  - ➢Reparation on going and protective measures to be taken

J. Towler

Optical Transition Radiation Interference

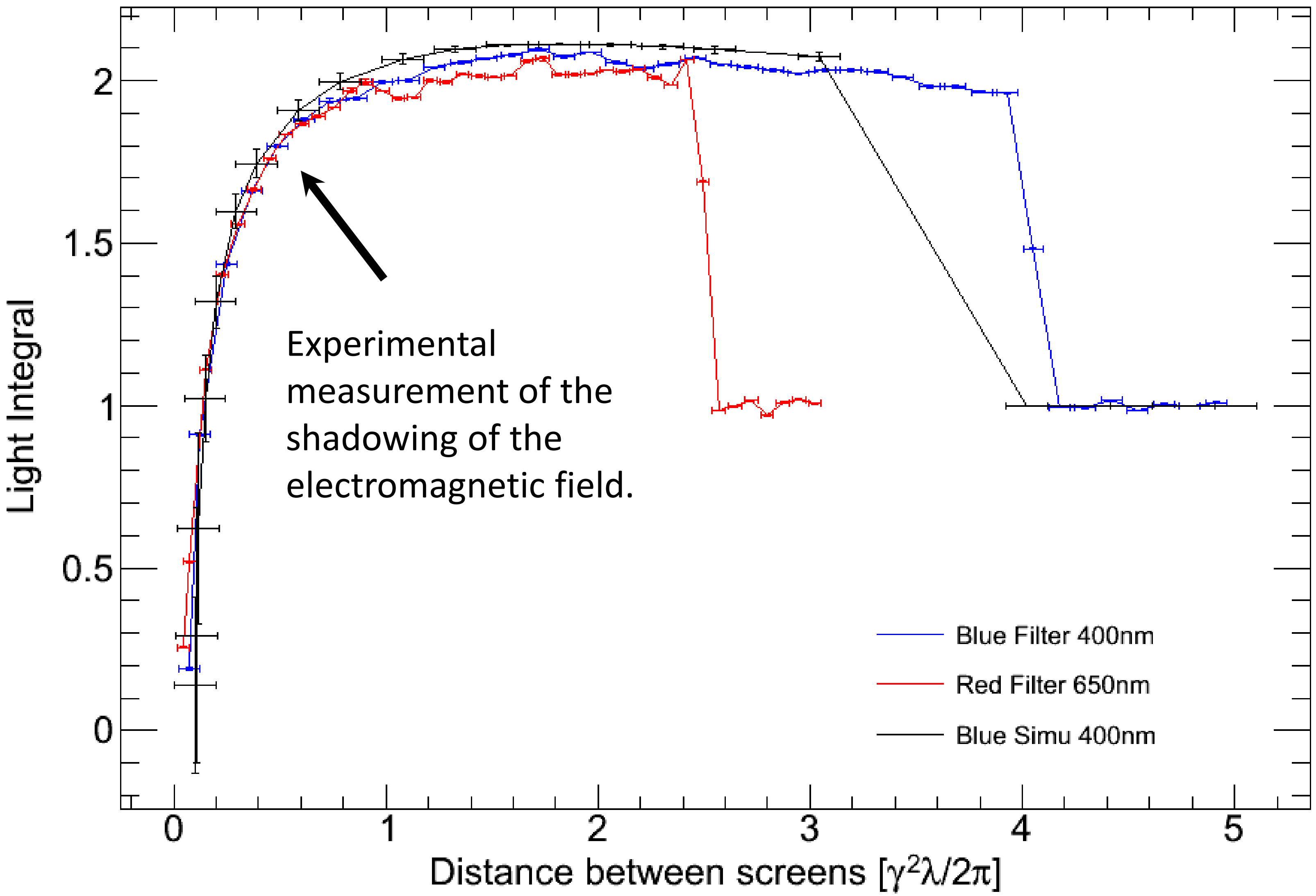
R. Kieffer





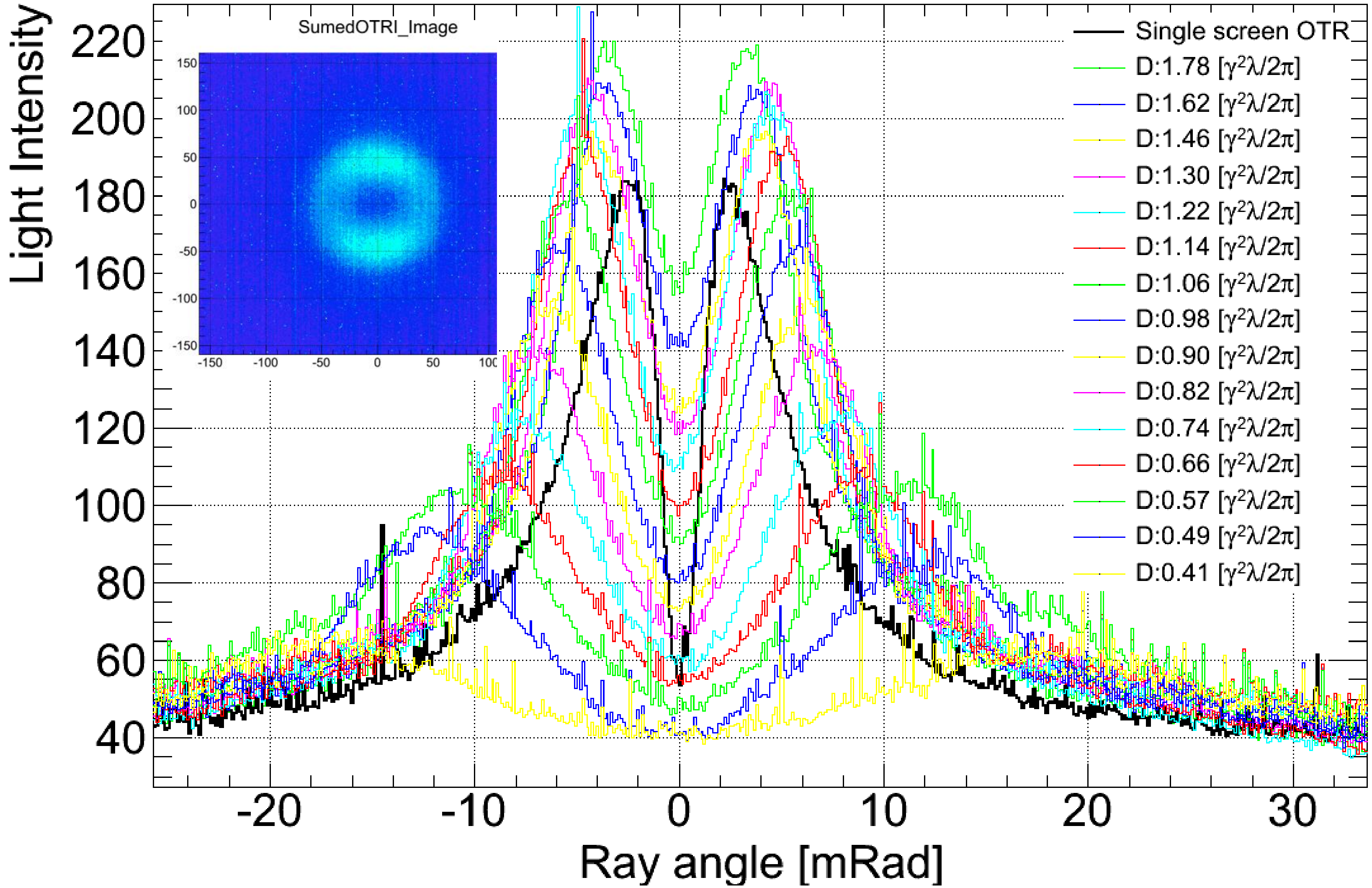
Optical Transition Radiation Interference

R. Kieffer



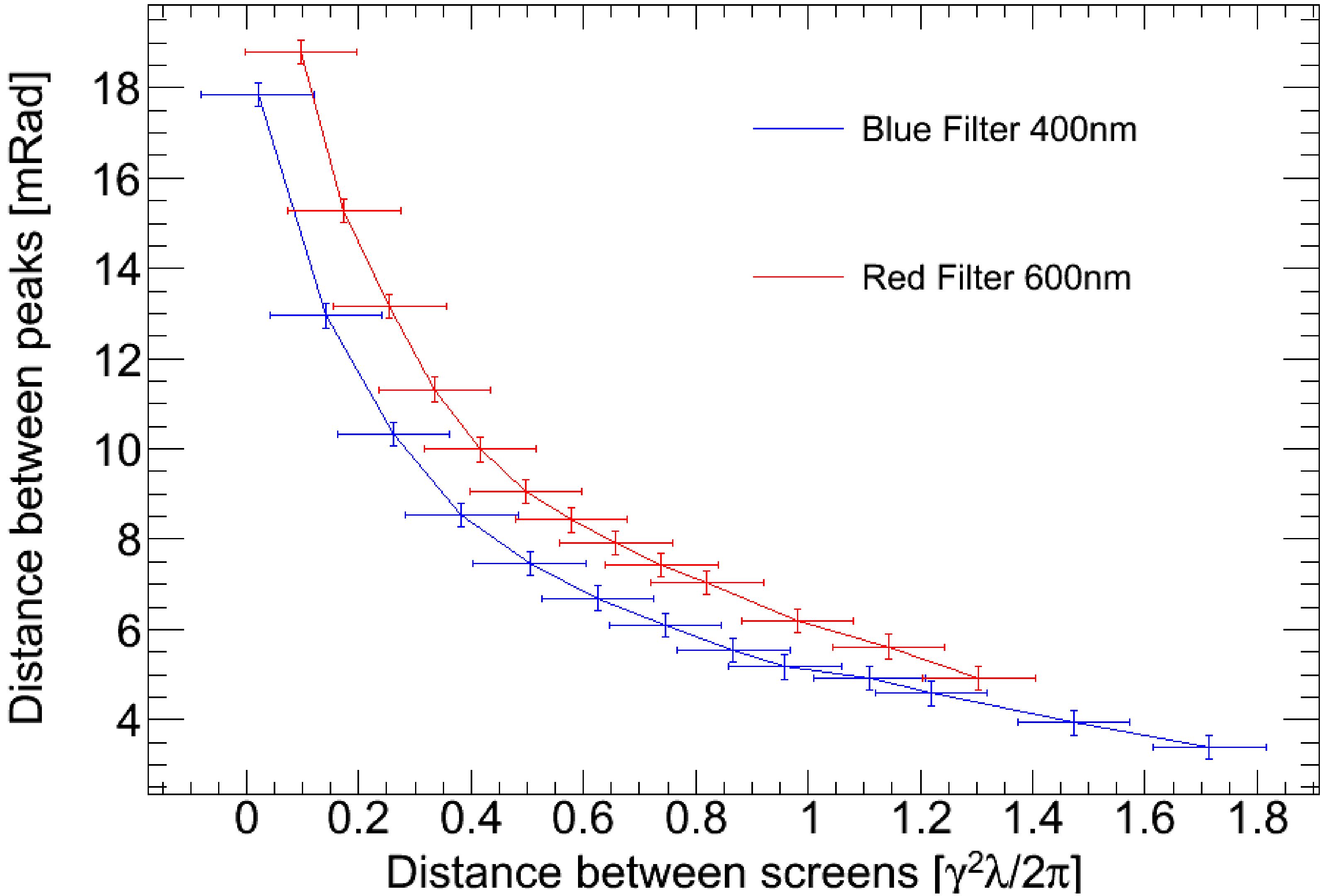
Angular observation 600-40nm Red Filter OTRI Vertical Polarization

R. Kieffer



Angular Distance Between peaks Vertical Polarization

R. Kieffer



CLIC Beam Loss Monitor studies with Califes

M. Kastriotou

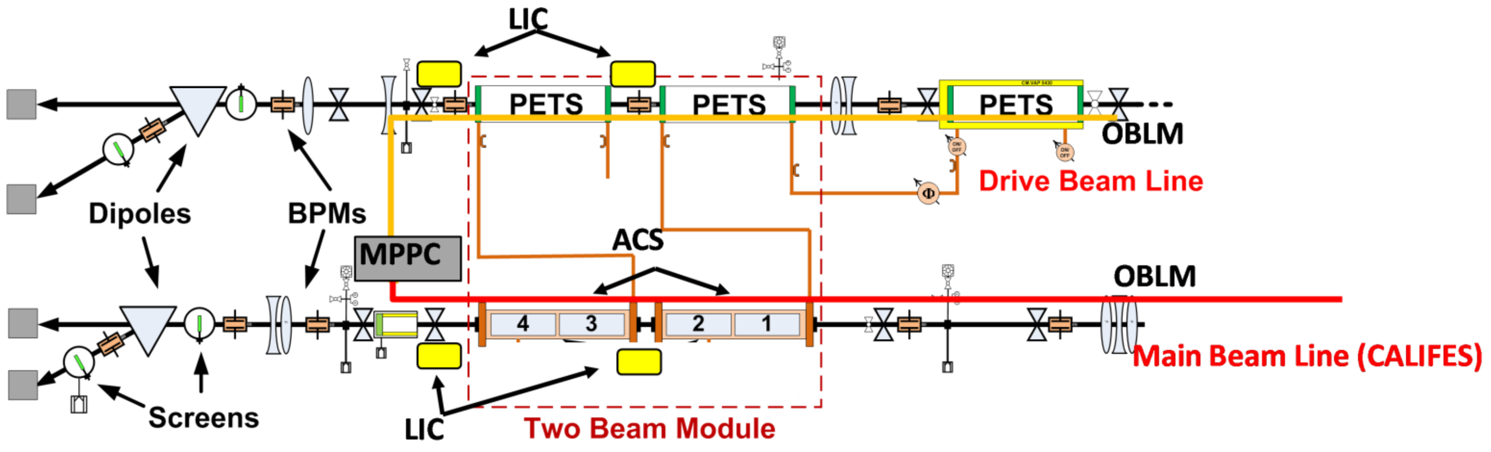
Measurements of BLM so-called "crosstalk" on the TBM

- "Crosstalk" : losses of one beam line detected by the BLMs protecting the other one → limitations in sensitivity of CLIC BLMs

Examined detectors:

- **Little Ionisation Chambers (LIC)**
- **Optical fibre BLMs (OBLM)** → Multi-Mode optical fibres coupled to photosensors (14400- pixel Multi Pixel Photon Counters)

MB	2 LICs 5 cm downstream of the AS	7 m long Ø365 μm SiO_2 optical fibre, 4 m upstream the TBM
DB	2 LICs 10 cm downstream of quads	5 m long Ø200 μm SiO_2 optical fibre, 2 m upstream the TBM

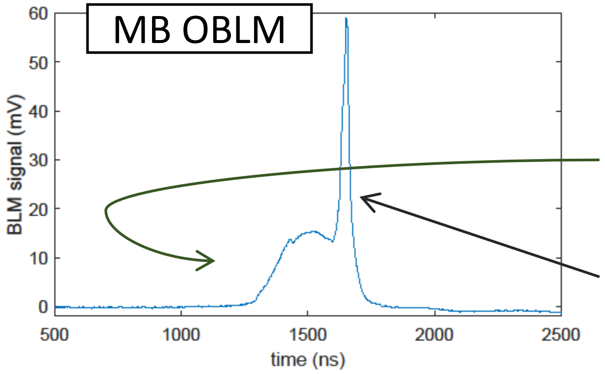


Measurements during Califes nominal operation

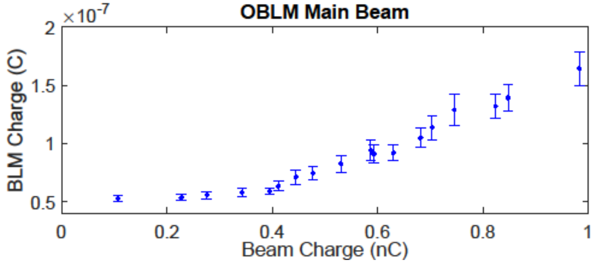
Sensitivity scan with 10-200 bunches, good beam transmission

M. Kastriotou

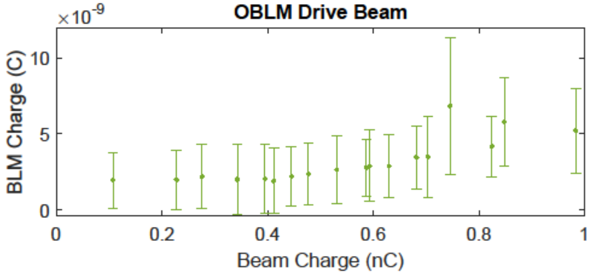
- LICs insensitive in Califes losses → Measurements with optical fibre BLMs
- Beam charge calculated from the BPMs.



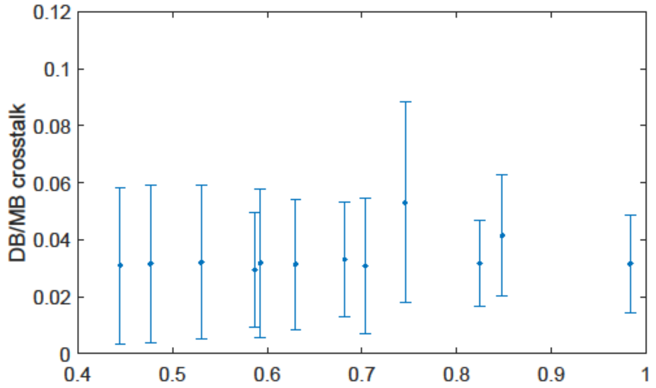
High sensitivity: detection of the electron gun dark current and Califes beam losses.



Califes beam losses measured by the MB OBLM



Califes beam losses measured by the DB OBLM



Crosstalk to DB BLMs calculated as

$$Crosstalk = \frac{Q_{DB}}{Q_{MB}}$$

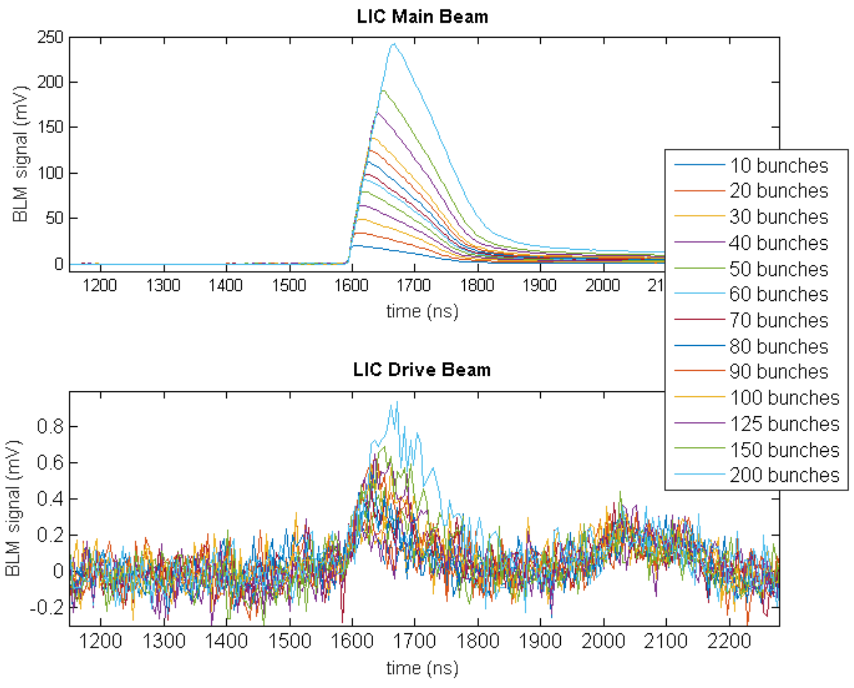
(Q: total detected charge)

and estimated **3.4%** of the signal measured by the MB BLMs.

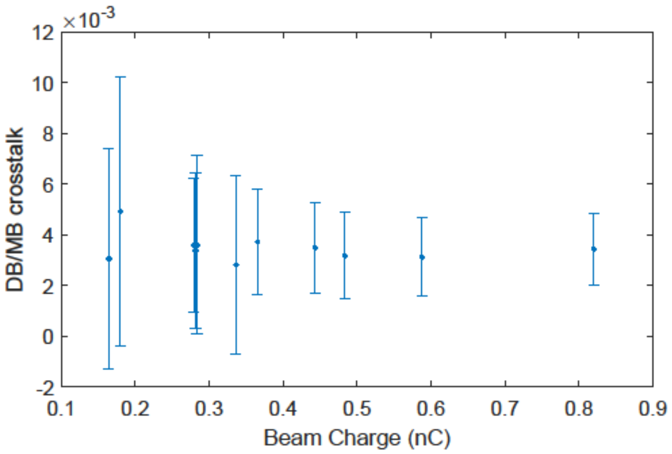
Measurements for a loss scenario (with LICs)

M. Kastriotou

- Insertion of OTR screen to the beam
- Optical fibre BLM photosensor saturation → <u>LICs used for measurements</u>



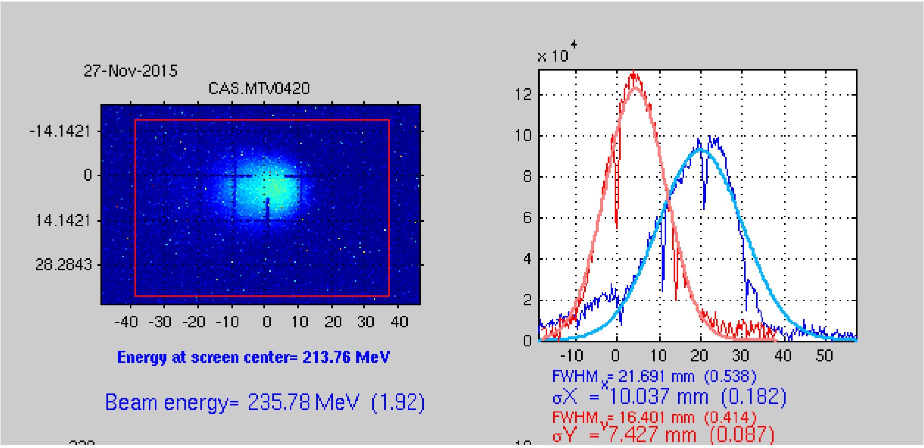
Crosstalk to DB estimated at **0.6%** of the signal measured from the MB BLMs.



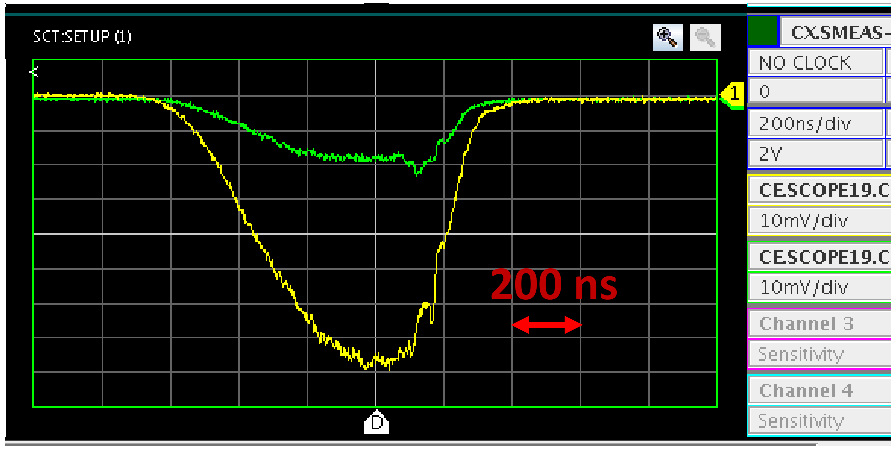
<u>Future steps at Califes:</u>

Repeat the measurements with different setups to avoid saturation

Beam for irradiation test bench



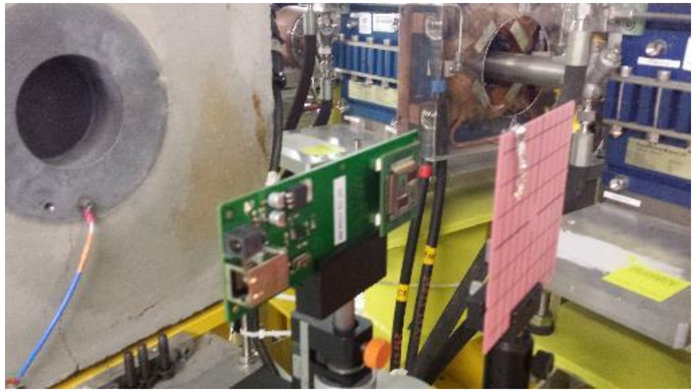
Beam transverse profile



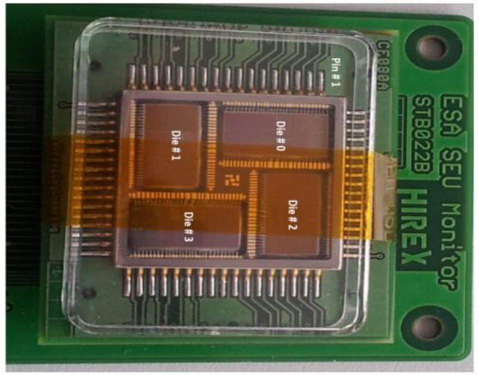
Dark current time profile

Dark current from gun is used for irradiation

- Stability, low bunch charge (< 0.2 pc), long train 600 ns FWHM: 1800 bunches, higher emittance
- Rep. rate 5 Hz, 0.3 nC per pulse, 16 x 21 mm^2 Gaussian size downstream to scattering screen



ESA Monitor



4 memory chips

General Context

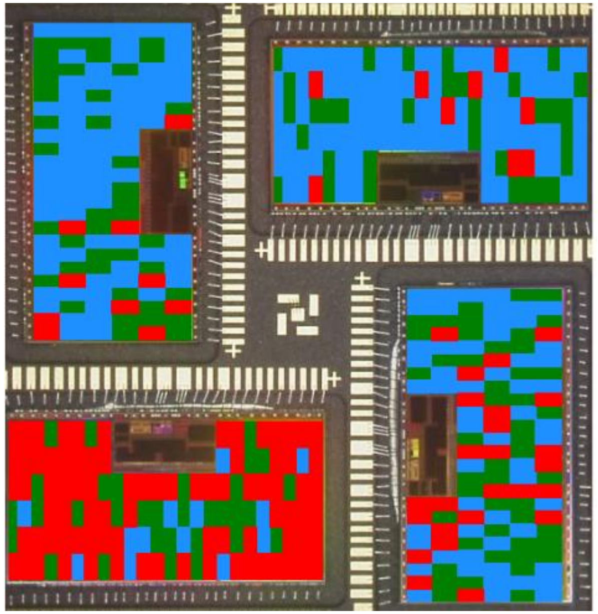
Rubén García Alía (EN/STI/EET)
Maris Tali (EN/STI/EET)
Markus Brugger (EN/STI/EET)
Salvatore Danzeca (EN/STI/ECE)
Matteo Brucoli (EN/STI/ECE)

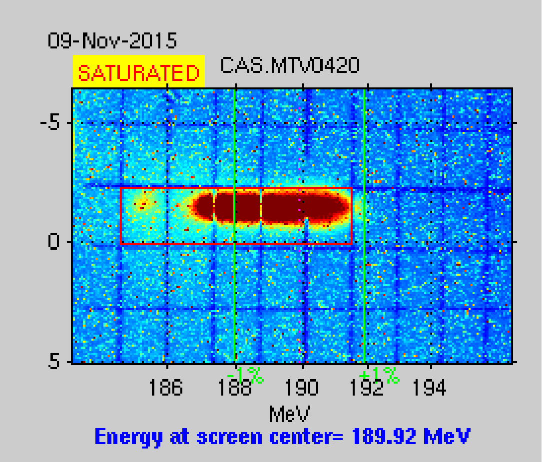
- The purpose of the 2015 R2E tests at CALIFES is that of **validating the beamline for radiation effect with high energy electrons**
- Main application: **ESA JUICE mission** to the Jovian system where high energy electrons are trapped in the magnetic field
- Other applications:
  - Earth electron belt (though lower energies apply)
  - High-energy accelerator environment (electrons present but typically dominated by hadrons)
- Main assets of CALIFES beamline for radiation tests:
  - **High energy** (important for Single Event Effects)
  - **High intensity** (important for total dose and displacement damage studies)

Electron induced SEUs

R. G. Alia

- 200 MeV electrons were found **capable of inducing SEUs** even in a relatively old technology (state-of-the-art electronics is expected to be much more sensitive)
- Error probability 4-5 orders of magnitude lower than for high energy protons and expected to be induce via electronuclear interactions
- Measured SEU probability in the order of magnitude of simulated results with FLUKA, but subject to a **large uncertainty** due to relatively small beam size and lack of dedicated dosimetry

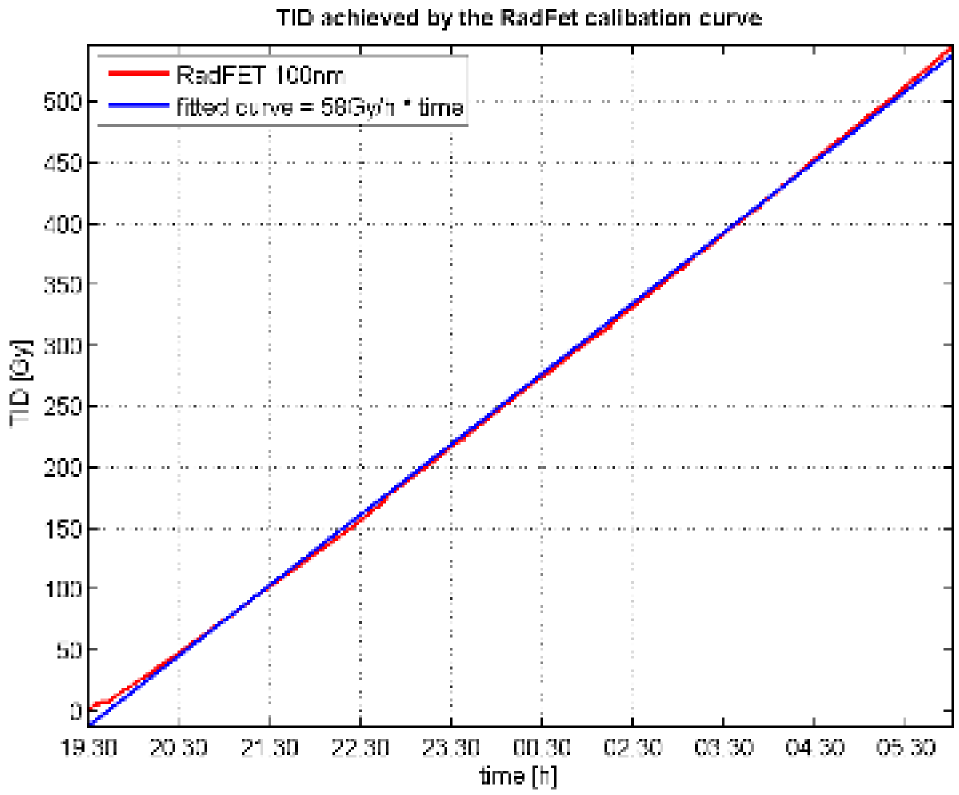




Dose Rate

R. G. Alia

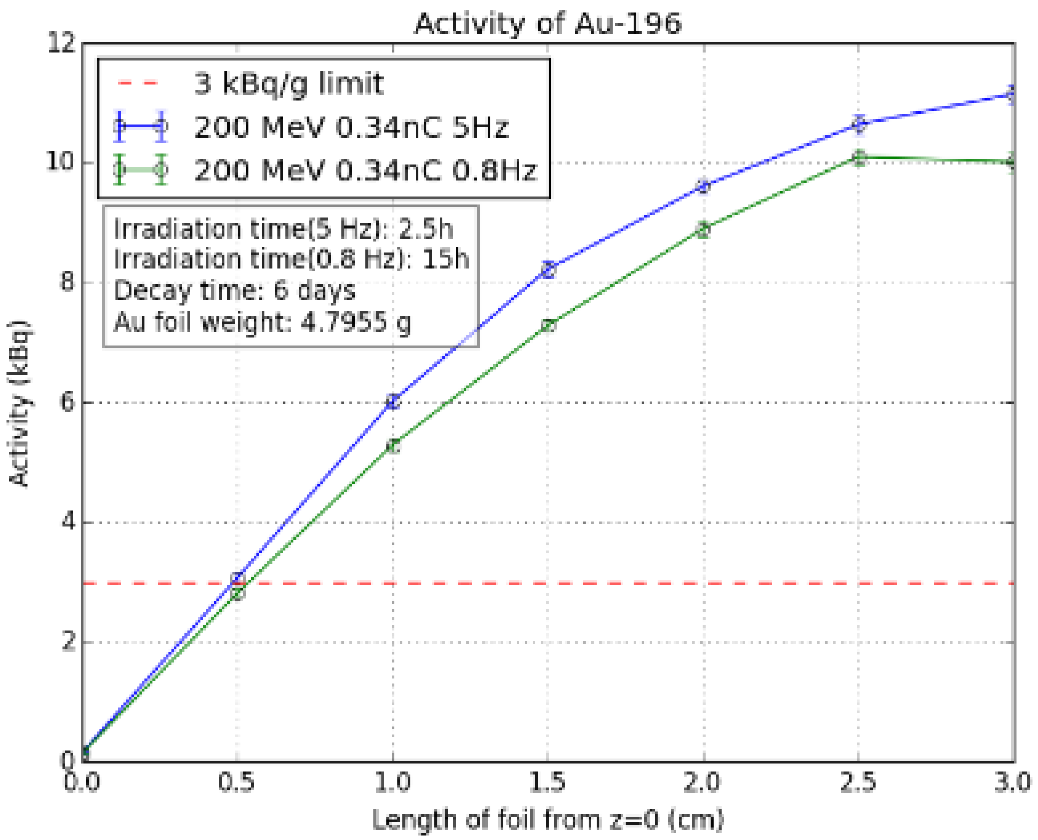
- The dose rate was measured using the RadFET detectors and showed a linear response with time for two different test frequencies
- An independent measurement of the **electron fluence at the DUT location** is needed in order to calibrate the detectors for 200 MeV electrons



Gold activation measurement

R. G. Alia

- ^{196}Au activity can be correlated with the electron fluence through FLUKA simulations
- Test will yield an **independent measurement of the electron intensity at the DUT location** which can then be correlated to the beam current value measured upstream
- Useful as a cross-check but not practical as long term solution



Conclusions

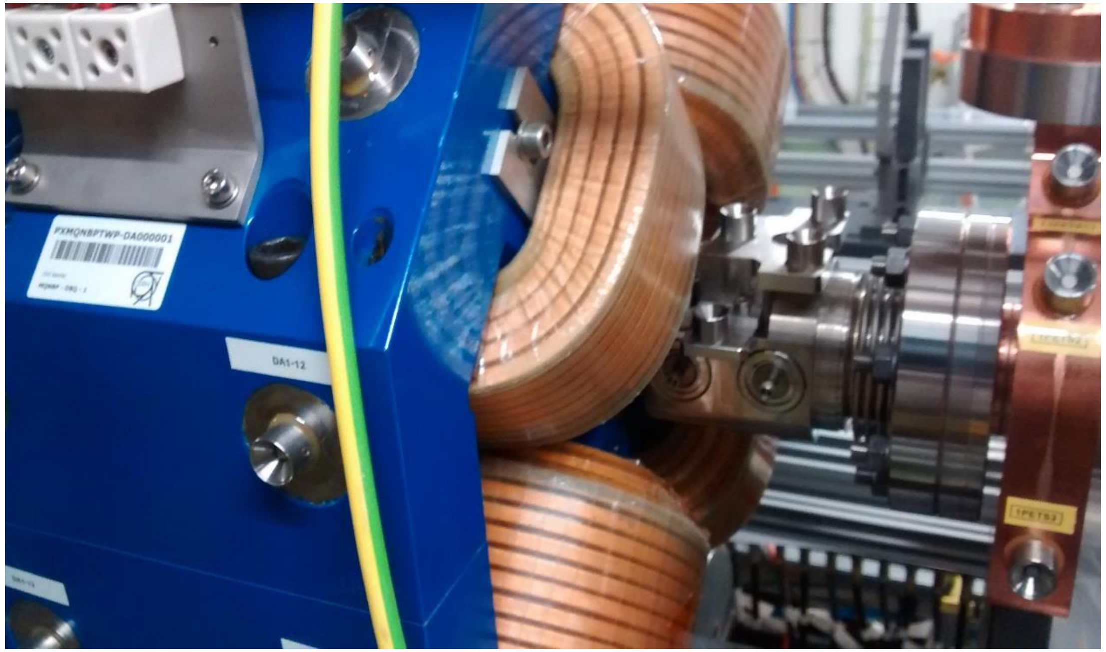
R. G. Alia

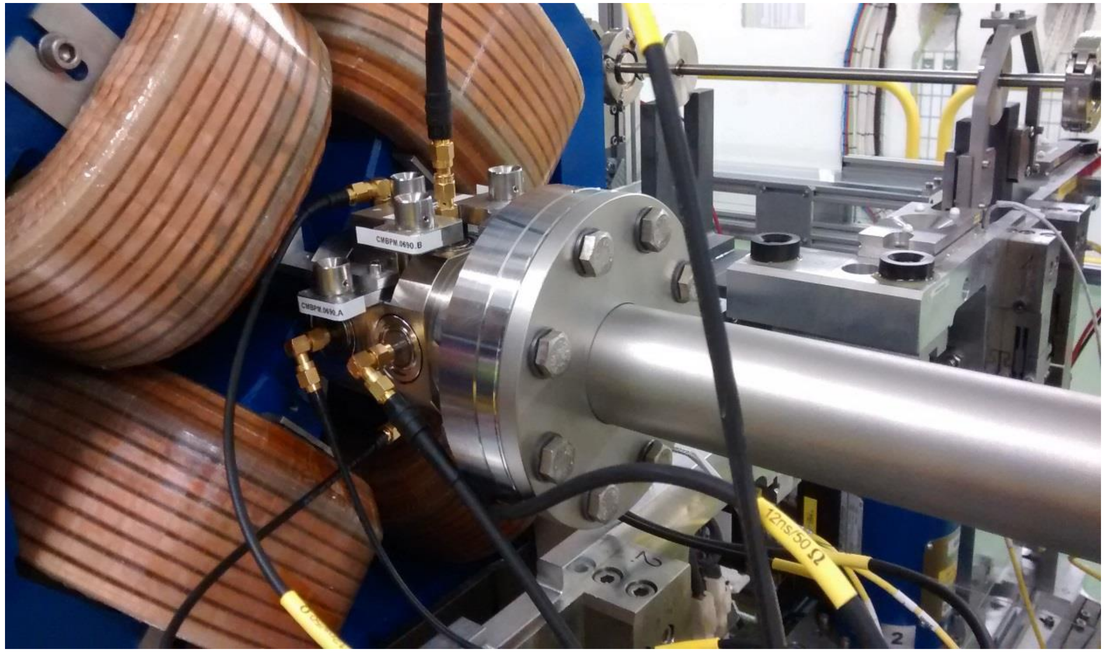
- Promising first SEU and TID results confirm CALIFES' **potential for radiation effects testing**
- Strong interest by ESA who would (if possible) like to perform measurements in 2016 for three identified nanoscale transistor technologies and through a subcontractor
- However, several key points need to be addressed before the facility can be operational for standard radiation effects testing:
  - **Beam size** would need to be increased to (ideally) **5 x 5 cm^2** with a homogeneity of ~20%
  - A **dedicated dosimetry system** would need to be installed in the DUT position (example: pencil shape ionization chamber placed instead of the DUT and calibrated against a linear beam intensity indicator permanently available – e.g. beam current monitor)

Terminated Stripline BPM for CLIC TBM

A. B. Morell

- Two units installed: CM.BPL0645, CM.BPL0685

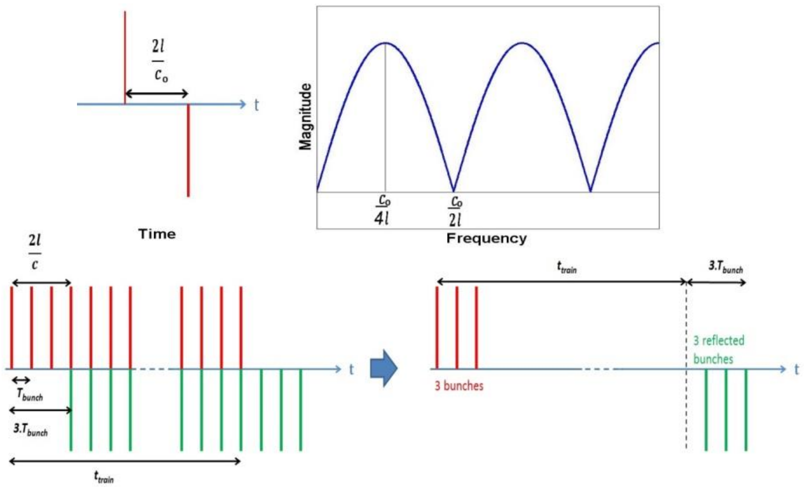




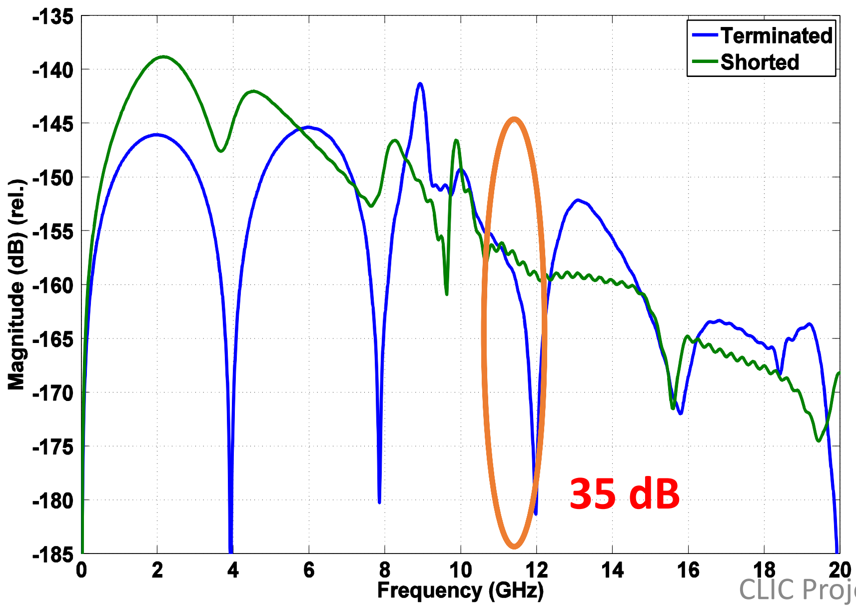
- New FESA class developed for BPM control and data acquisition (TBM and TBL): CLEXBPM.

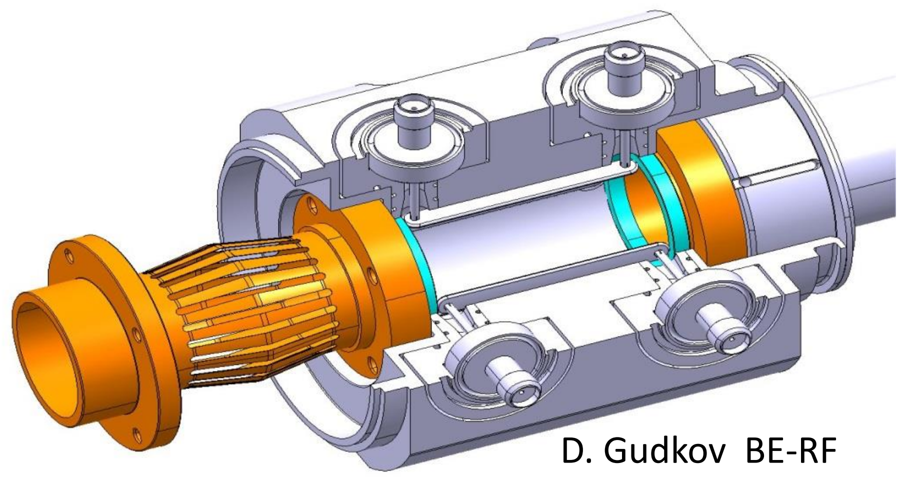
Terminated Stripline BPM for CLIC TBM

A. B. Morell



Parameter	Shorted BPM	Terminated BPM
Stripline length	25 mm	37.5 mm
Angular coverage	12.5% (45°)	5.55% (20°)
Electrode thickness	3.1 mm	1 mm
Outer radius	17 mm	13.54 mm
Ch. Impedance	37 Ω	50 Ω
Duct aperture	23 mm	23 mm
Resolution	2 µm	**2 µm**
Accuracy	20 µm	20 µm
Time Resolution	10 ns	10 ns





D. Gudkov BE-RF

Beam tests for 2015/2016

A. B. Morell

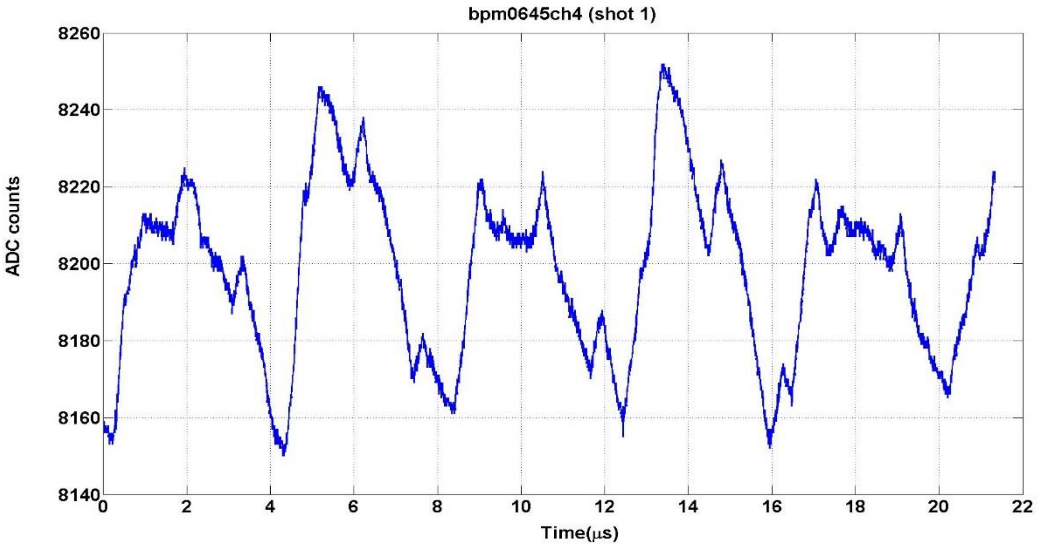
- Linearity/Sensitivity → Beam scan in H, V planes for two cases:
  - Low PETS power
  - Highest possible PETS power (max. achieved ~ 60 MW)

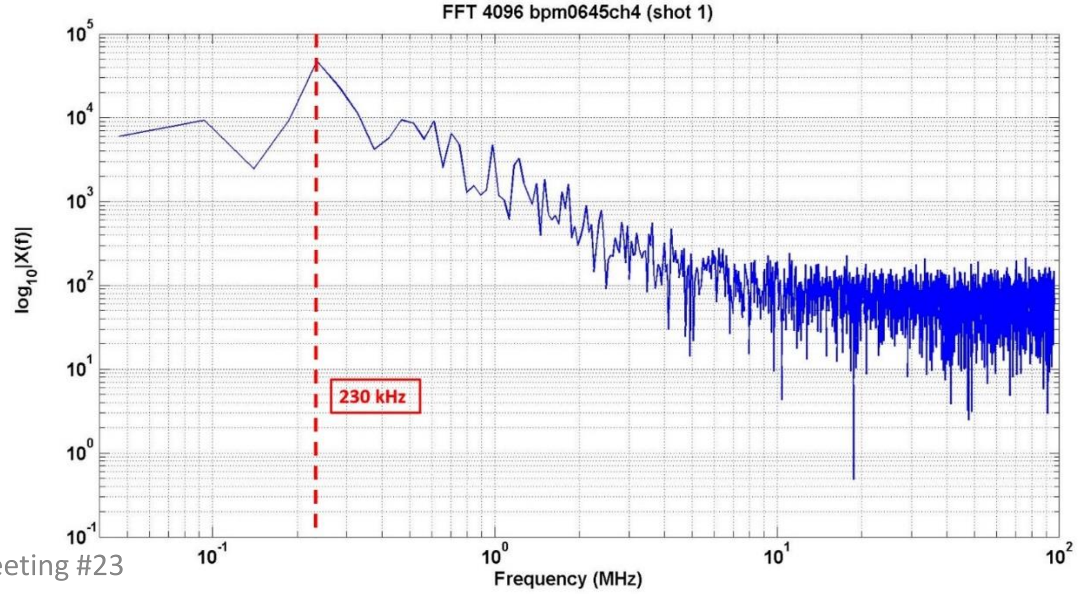
- Resolution → Synchronous acquisition of as many consecutive shots as possible for SVD analysis.

Noise issues

A. B. Morell

- Unwanted noise observed in the absence of beam / CAL inputs → up to ~100 ADC counts <-> ~25mV → Unacceptable
- Not present when cabling is removed
- Uncorrelated component → Ground loop
- Correlated component → ~230 kHz interference (switched power supply?)
- Mitigation strategies being currently tested:
  - Transformers
  - Inductive common mode chokes
  - Capacitive DC blocks





Conclusions

- A large user's community is conducting many challenging experiments in the CTF3/CLEX facility using the CALIFES beam and also the Drive beam.
- Despite the limited human resources we have been able to provide to most of them reliable beams and support all along the year.
- We are still keen to receive new experimental proposals.
- Many thanks to all the users who have provided me with many (too many ?) slides. Sorry for the cut.