TB 20th ATF2 Collaboration meeting

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15/03/2017

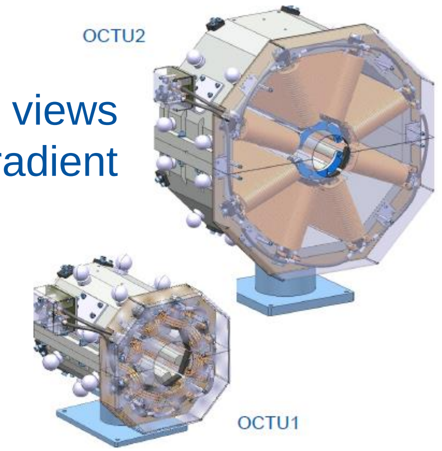
Outline

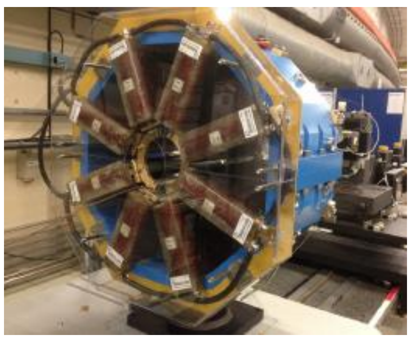
- ATF2 Studies
  - Procurement, measurement and installation of 2 octupoles for ATF2
  - Experience with half β_y* in ATF2
  - Analysis of the beam halo collimation system measurements
  - Simulation and measurement of beam halo at ATF (YAG/OTR)
  - BDSIM simulation studies of the background measured at ATF2 in dependence on the vertical beam halo collimator
- Goal 2
  - Status of IPBPM performance and resolution studies
  - Beam stabilization at the IP using the upstream FONT system
  - IP BPM movers calibration
  - Proposed Changes to IP-BPMs
  - Stray field measurements
  - PLACET Simulations of Intensity-dependent effects at ATF2
- Goal 1
  - Motivation
  - Results

Procurement, measurement and installation of 2 octupoles for ATF2

The CERN procurement of 2 Octupoles for further exploration of nanometre beam size beam dynamic was agreed in 2014 after a proposal presented at the CERN Midterm Collaboration meeting. This would have been part of the hardware CERN contributions for the prosecution of the ATF program.

The designs converged to the following detailed 3D views and parameter set. The final required integrated gradient were: 212 and 2046 T/m^2

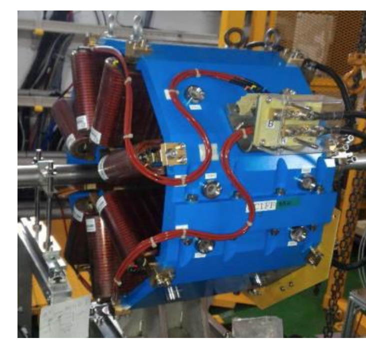




The 2 magnets were assembled in June-July 2016 and tested at CERN in August.

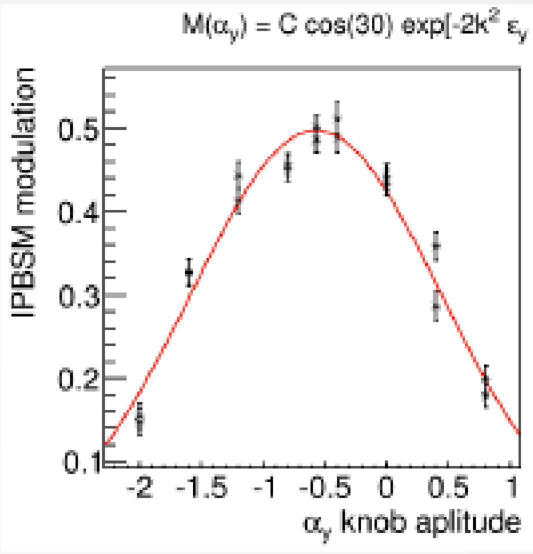
The magnets were sent to ATF in August. The magnets were finally installed in ATF on the 9-11 Nov. 2016.

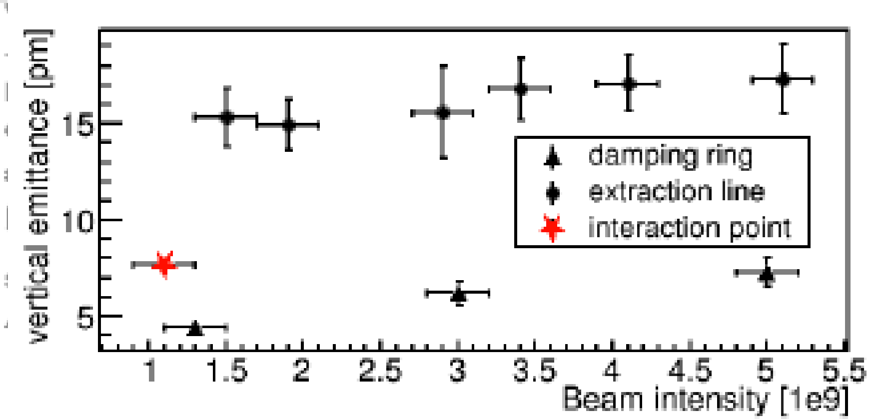
Installation is now completed. Both magnets are mounted on micrometric tables. First electrical checks at installation were done with a temporary power supply all tests were positive.



Experience with half β_y^* in ATF2

- Half β_y^* optics were precisely set using a new method of emittance measurement at the IP.
- Beam sizes larger than expected were measured for half β_y^* optics.
- The realistic (nominal) errors applied in the simulations do not reproduce the measured beam sizes,
- The simulation results get closer to the measured beam sizes for the following set of errors (w/o orbit correction): misalign. x1.5, mults x5, misalign. x1.5, mults x3.
- The orbit correction included in the simulations highly improves the simulation results.
- Possible reasons for observing larger beam sizes than expected:
  - Insufficient orbit control and sensitivity to machine drifts;
  - Contribution of wakefields combined with the beam orbit jitter;
  - Larger and/or additional multipolar fields (QF1FF, crosstalk, …);
  - Larger alignment errors;
  - Instrumentation errors.
- Results are published in Phys. Rev. Accel. Beams 19, 101001 (2016).





Analysis of the beam halo collimation system measurements

- A **retractable vertical collimation system** was installed in ATF2 in March 2016 and the functionality and efficiency in reducing the **background photons in the Post-IP has been** measured successfully.

- The **reduction of photons** generated in the **BDUMP** was modeled using **BDSIM** (Genat4) as a function of the vertical collimation system half aperture **showing good consistency with measurements.**

- **The collimator WF impact** has been completely studied by means of analytic models, numeric simulations and measurements. A **10% agreement on the benchmarking between CST PS** simulations and measurements has been measured which gives us the possibility to understand the impact of such a system improving the accuracy of past measurements. **This is crucial for FLCs since** the ATF2 vertical collimation system was inspired **on a first mechanical design of the ILC spoilers.**

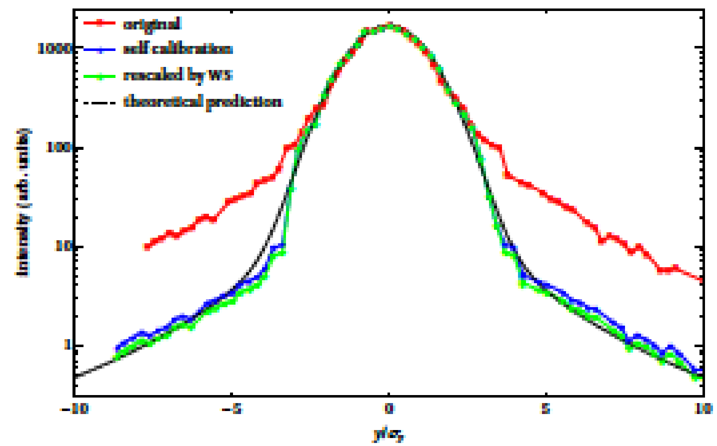
- These WF measurements give **confidence on the CST PS simulations**, the wake potential calculated can be introduced in tracking codes. The **scaling to the ILC** bunch length of the **CST PS simulations for ATF2 has to be made.**

TBP has been removed before 2017 February run and now the collimator is the only way to reduce background in the IPBSM. It is working efficiently!!!!

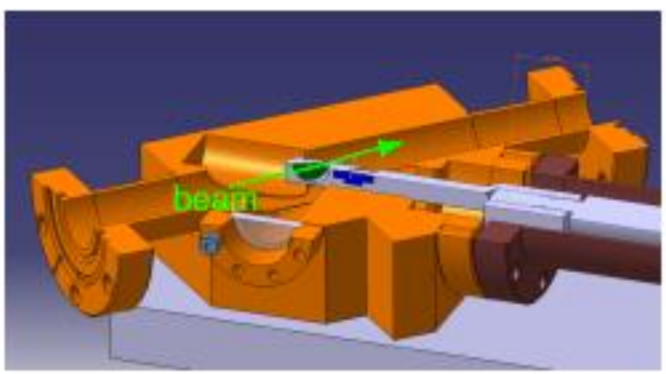
Simulation and Measurement of Beam Halo at ATF2

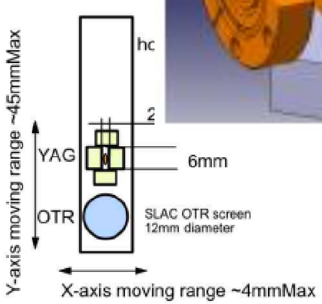
BGS: Beam Gas Scattering

- Simulation of BGS halo in damping ring indicate
  - Equilibrium halo distribution is mainly determined by BGS events within last 2τ
  - Good agreements are observed between simulation and theoretic estimation of beam halo
  - Simulation and theory both predict much less halo in $\vec{x}$ than $\vec{y}$
- With rescaling of DS data, vertical beam halo (vacuum dependence) are observed and consistent with theoretical prediction
- For halo study at dispersion-free region, upgrading of OTR/YAG screens monitor is underway (plan to install in May)
- Meanwhile, simulation of tail/halo from IBS (in SAD) is going on



Beam profile after rescaling is comparable with estimation, while both of them agree well with halo predicted by BGS theory/simulation!





Schedule of upgrading of OTR/YAG screen monitor

- Fabrication and software development
  @ KEK
  1) April 1st week, mover hardware complete
  2) Aprile 1st -3nd week, controller check and software check
  @ LAL
  1) April 2nd week
  fabrication of chamber (main body, screen holder) and custom flanges,
  2) April 3nd-4nd week, chamber cleaning, welding and vacuum test
  3) May 1st week, delivery chamber to KEK
- Installation and calibration
  May 2nd-3nd week, install to beam line, system check and calibration

BDSIM simulation model of ATF2 & Background Studies for the Vertical Collimator System

Plans for further BDSIM simulations in collaboration with RHUL:

- Reviewing the BDSIM geometry model of ATF2
- More accurate Aperture Model of ATF2
- Put together all new component models for a more accurate ATF geometry model
- Improve the Vertical Collimator model
- Introduce beam bumps in simulation to study effect of beam orbit changes on background level at the RHUL cherenkov detector and the IP
- Change vacuum pressure in the simulation to also compare these data taken

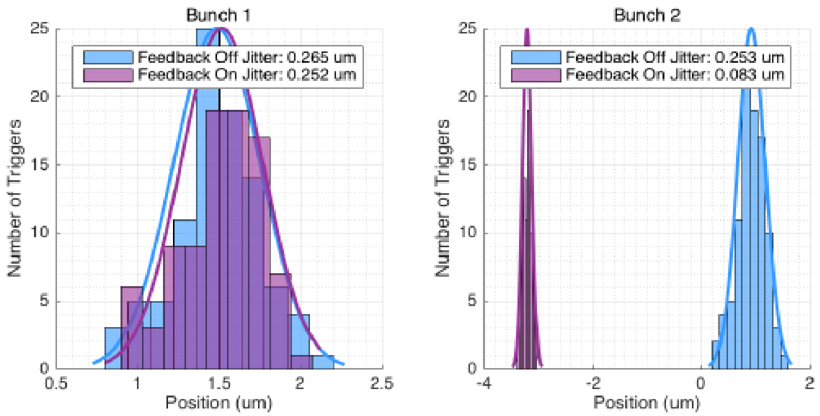
Status of IPBPM performance & resolution studies

Operational Challenges

- Sample timing jumps – under investigation
- Unwanted parasitic signal source still unknown – currently soothed using BPFs.
- Delay cable set-up in IP region is not optimised for best timing. Optimise for next operation.
- Need to take care with signal levels to avoid non-linear calibrations and saturation effects.

New Results

- Latest resolution results suggest a useable geometric resolution of ~70 nm (60 nm with integration). This result is reduced to 20/30 nm using multi-parameter fits.
  X information appears to do very little to improve the result.
- New two-BPM IP feedback mode has been used to stabilise the beam at the IP to **83 nm** with **10dB** attenuation at a charge of 0.85×10^{10}.



Beam stabilisation at the IP using the upstream FONT system

- Stripline BPM system hardware upgraded for improved resolution: ~150 nm
- K2-P3 single-loop feedback
  - Beam jitter stabilised to < 300 nm at P3
  - With extra jitter: factor 60 jitter reduction
- Coupled-loop upstream feedback
  - Beam stabilised: 460 nm at P2, 270 nm at P3
  - Factor 3 reduction in jitter at MFB1FF and IPC
  - Propagating data to IP waist: nm-level stability

ATF2 IP-BPM - piezo movers calibration (2016.10.04 – 2016.10.13)

1. Lateral PI mover has a slightly limited stroke (max disp. 252 to 268 mm), but works continuously.
2. XY couplings not as expected, especially for PI (large positive and negative "drop").
3. Vertical calibrations

   With linear fit, PI movers tripod system meet the "expected" specs (rel. accuracy ~ 1/1000 of stroke), but not the Cedrat one (~ 1/1000 , far from no less than 1/700).

   Some leads for Cedrat movers (but useful for PI):

   a) Eliminate the systematic error to improve accuracy by using 2 cubic polynomial fits (one for up, one for down) instead a single cst (gain). → rel. acc. ~$8x10^{-4}$/1.1 to $1.7x10^{-4}$ (PI/Cedrat).

   b) Work within a short range (2V) around mid-stroke → rel. acc. ~10^{-3} for both movers

   c) Avoid scanning at max voltage (keep a 0.5V at end of range, even 0.6V for Cedrat).

4. Vertical stability (worse case SD) at 3.3 nm (PI) and 7.4 nm (Cedrat).
   Stability expected to be better when BPMs disp. system installed in the chamber at IP (than done on a table on the ground).
5. Campaign of measurements done too quickly in Oct. 2016.
   More data should have been gathered (→ statistical study, warm up effect analysis).
   New campaign of measurements to be done ?

Proposed Changes to IP-BPMs

Objectives

The present BPMs have a shorter decay time than necessary

- we are concerned at most with 2 bunch operation, ~280ns between bunches
- feeback performance depends only on measuring the first
- the second is needed to observe the performance, but can have more elaborate off-line processing

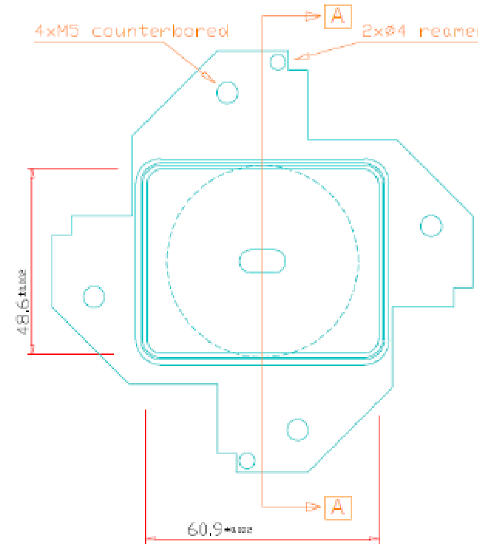
Short decay times always present problems with getting the best resolution

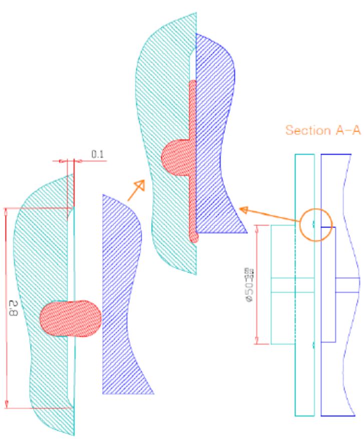
We have reliable figures for the resolution attainable with the present electronics at 30ns decay time

- it seems preferable to try operating in a similar region
- this ***may*** permit improved resolution

The present BPMs could be adapted to give this, without risking permanent harm to them

Conventional vacuum-brazed copper BPMs would be much nicer, but they would be a major and lengthy project





Schedule

Aim was:

- expect to be done for May running
- an easy option to restore the BPMs unchanged if we were late

Tight but reasonable. But any complications from alignment issues etc make it impractical

It might be ok were it acceptable to miss May, and install for June in the event of problems.

- the present BPM C only would be available in May
- unaltered, if old C is to be modified; otherwise, with probably with the spacers added

The same would apply if the intent was to install for June.

The natural solution would be to make the changes over the summer

- adequate time for preparation and a longer period for the work.

But from our perspective does not mesh well with the needs of our students.

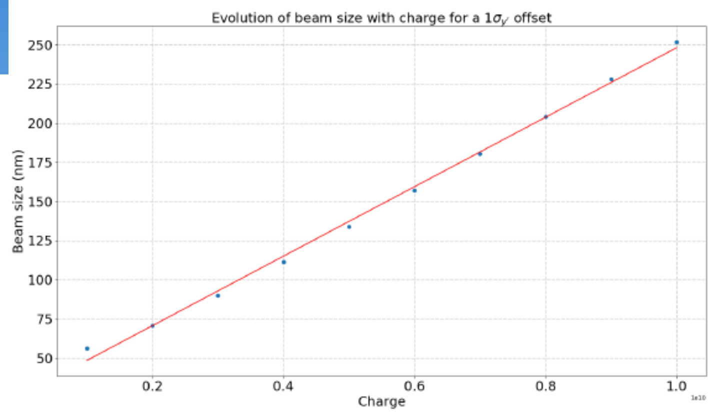
Stray Field Measurements

- CLIC-BDS is most sensitive to wavelength (≈7 km), 12% $\mathcal{L}_{\text{loss}}$ for 1 nT amplitude stray field variation without any countermeasure
- ATF2-FFS is most sensitive to wavelength (≈25 m), $\frac{\Delta\sigma_y^*}{\sigma_{y0}^*} \approx 0.8\%$ for 1 nT amplitude variation
- Natural and man-made magnetic field sources are well-above that tolerance at Earth's surface

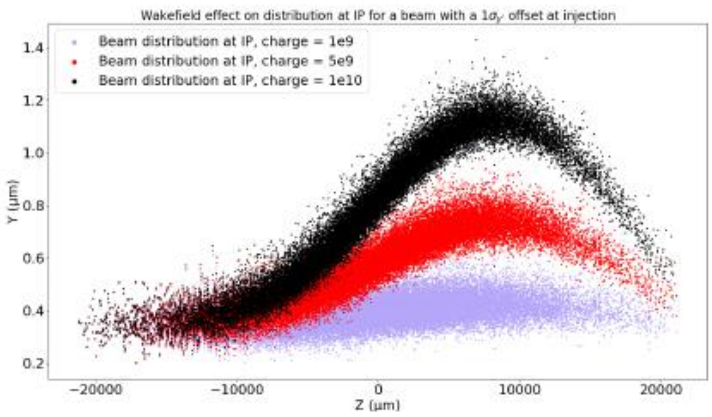
- Variations of $\geq \mu T$ are observed at CTF3 due to the PS cycle
- Variations of tens of nT are observed closed to the waveguides
  - Signal can be effectively shielded with a soft-μ material

- Acquire and/or develop additional sensors
- Developing strategies for mitigating intolerable $\vec{B}$ variations
  - Compensation schemes: active and/or passive
- Could the ATF2 facility be a potential location for testing such a compensation system?

PLACET Simulations of Intensity-dependent effects at ATF2



- Pursue the studies on the intensity-dependent effects
- Start comprehensive simulations of ATF2 using Placet
- Preparatory studies are presented here



- Integrate static and dynamics imperfections in the simulation, e.g.:
  - Incoming beam jitter
  - Misalignment of components
  - Diagnostics systematics
  - Stray fields
- Assess incoming beam jitter from experimental data
- Try to reproduce in simulation the measured intensity dependence plot
- Long term goal: explore potential strategies to mitigate these effects
- Extrapolate the results for CLIC and ILC

Small Beam Issues

- ***Nonlinear field***
- ***Energy bandwidth***

Beam size tuning results on 2016/02/05

- *The correction with skew sextupoles worked well (same scheme of ILC).*
- *IP beam sizes were evaluated by assuming the perfect laser fringe contrast.*

The IP vertical beam size at ATF2 low beta optics is sensitive to the fringe field of final doublet.

The fringe field may be corrected by using octupole magnets.

But, the fringe field of QF1FF is not correct for present ATF2 deck, which use the hard-edge model with long-coil measurement by SLAC.

Summary of energy bandwidth

When we apply the enough number of the iteration of knob tuning, the final sextupole setting after the beam size tuning is automatically optimized for the momentum spread of the beam ($\Delta p/p$=0.06-0.08%).

It suggested both for the simulation and the measurement.

Therefore, it is small impact for the initial sextupole setting.

The momentum bandwidth for 10x0.25 optics is tighter than those for 10x1 optics.

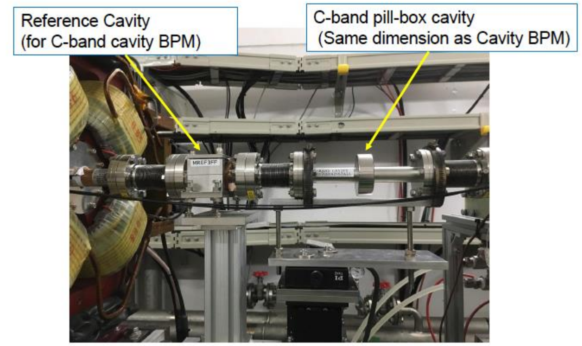
Therefore, the energy bandwidth for 10x0.25 optics is tighter than that for 10x1 optics.
But, the energy bandwidth will be optimized to the ATF2 energy spread of $\Delta p/p$=0.06-0.08%.
(not reached to the design energy bandwidth.)

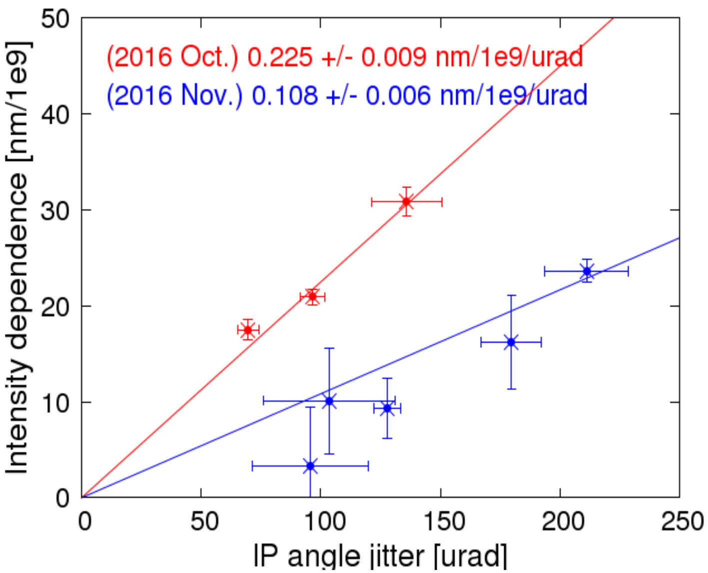
ATF2 Recent Wakefield (Beam size Intensity dependence) Studies

Wakefield: Sources of intensity dependence?

- Static Wakefield effect
  - Optimization position of wakefield source (BPM's reference cavity on mover) may cancel most wakefield of other misaligned sources.
  - May be some residual?

- Dynamic Wakefield effect
  - Cannot be cancelled by adjusting positions of wakefield sources.

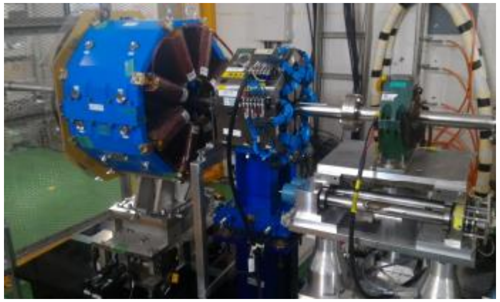


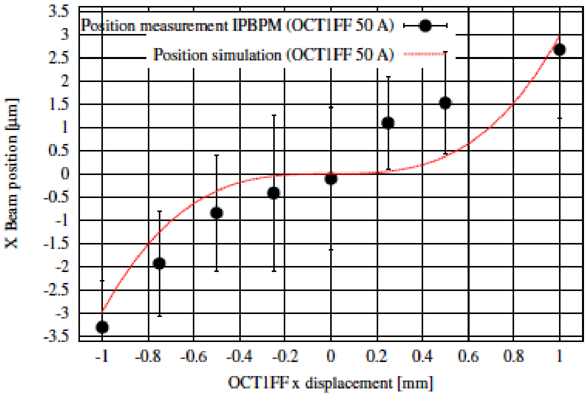


- Wakefield + angle jitter (angle at IP phase orbit jitter) is significant source of beam size intensity dependence
  - But cannot explain all dependence.
    - Factor 1.7 larger than calculation
    - Data selected by angle at IP not consistent with the "fully dynamic" explanation.
  - There may be residual static wakefield effect.
  - Or, maybe other effects than wakefield?
- Reduction of wakefield in November. Removal of cavity BPMs, etc.
  - Expected intensity dependence reduction factor about 1/2
  - Observed 1/3 ~ 1/2
- Studies with different types of wakefield sources on mover
  - Suggesting incomplete cancellation of wakefield by one wake source. (We had expected almost complete cancellation ?)
  - Need more data.
  - More experiments with different types of wake sources?

Octupoles study for ultra-low β_y^* at ATF2

- New pair of octupoles were installed and are ready to be use for beam tuning
- The small position kick at the IP when octupoles are moved in horizontal and vertical plane make the Beam Based Alignment difficult to perform
- Thanks to the new progress made by the FONT group on the IPBPM resolution in February operation, BBA of OCT1FF in both plane and OCT2FF in horizontal plane should be possible in the next operations
- Over misalignment of the octupoles impact quite strongly the tuning performance but the impact can be reduce by applying octupole knobs
- Beam size reduction thanks to the octupoles will be visible with the IPBSM if the beam is already well tuned
- The demonstration of octupole efficiency can only be done if enough beam tuning time is allocated to low-β_y^* study





Small beam size monitoring using OTR and ODR at ATF2

OTR achievements

- Sub-micrometer beam size has been demonstrated
- Emittance measurement by the OTR PSF method are in good agreement with the measurements performed by conventional multi-otr system

OTR future development

- More systematic studies are required to fully understand the performance of the system and define the resolution limits and accuracy of the device
- A new intensified camera has been installed to increase the signal to noise ratio (one of the instrument limitation)

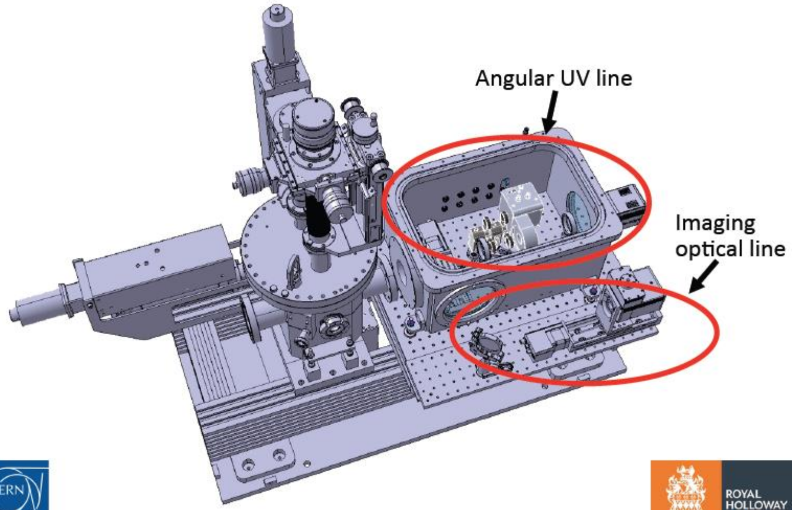
ODR achievements

- Possibility to use DR as an optical beam position monitor has been tested
- Sensitivity to beam size of tenth of micrometers has beam demonstrated
- Mask contribution to block synchrotron radiation has been observed

ODR future development

- More systematic studies are required to define the resolution limits and accuracy of the device
- Far-UV optical line designed to optimize sensitivity to small beam sizes, manufacturing of the UV tank is ongoing. It will be ready next week, foreseen to been installed in the May 2017

DR at ATF2 planned upgrade



UV optical line in a dedicated tank

The UV line needs to be built under Argon or Nitrogen atmosphere to avoid UV absorption by air. The pressure can be around atmosphere level (maybe 100mBar over-pressure)

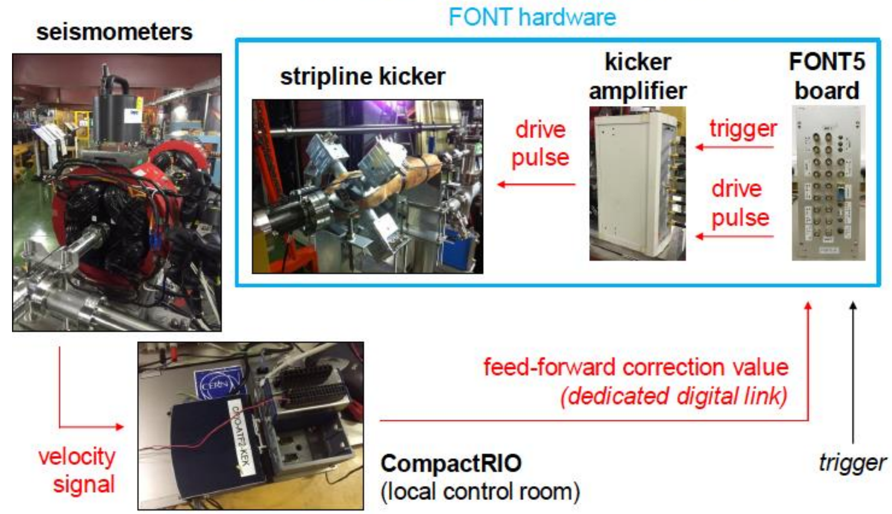
We are finishing the design of a tank to contain this UV optical line. It will be installed in the black box on the side of the ODR replacing the actual optical line we have inside.

Demonstration of active orbit feedforward based on ground motion in ATF2

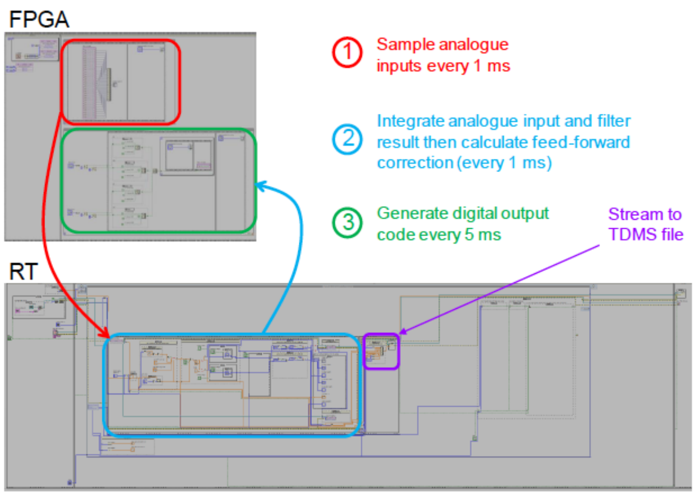
Latest results

- From owl shift on 24 February 2017
- Seismometers placed on first four quads
- Several studies performed:
  - K1 gain scan, QD2X, 23-26 Hz filter
  - K1 gain scan, QF1X, 23-26 Hz filter
  - K2 gain scan, QD2X, 4-100 Hz filter
  - And many runs with feed-forward off

Feed-forward hardware



Feed-forward software



- Beam dependence on quad motion stable within 10% on 8 hour timescale
- QD2X correlation superior but decent performance achieved using QF1X
- Kickers highly decoupled (by design)
  - K1 corrects at BPM39, K2 corrects at BPM20
- Wide-band filter → wide-band correction

Exploring long L^* option at ATF2

CLIC IR design converge toward the **long L^* for the FFS :**

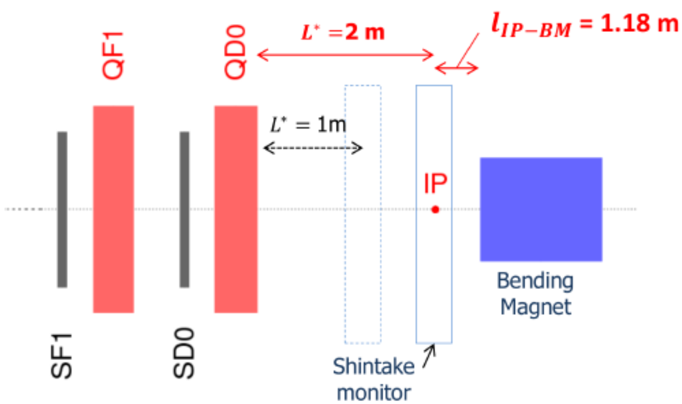
Announced changes to the detector model

- The detector team has decided to concentrate for the time being on a **single** detector with all-silicon tracking.

No more push-pull

- A number of **parameters have been** frozen to allow consistent studies on detector optimisation and performance.
- For the forward region design they concentrate now on the long L* solution with **QD0 in the tunnel**, i.e. outside the detector. The exact value of L* has been defined as 6 m.

This has major implications for MDI



- Long L^* option is in very early stage and present result should not be taken as definitive performances
- This configuration is very challenging from technical and optics design point of view
- It can be very interesting to have experimental proof of feasibility for the long in the long term plan of ATF2 :
  - Chromaticity correction
  - tuning
  - IP beam stabilization to nanometer level
  - Ground motion feedforward impact for longer L*

Ongoing PhDs

	Instiutution	Expected Final year	Subject
M Patecki	CERN-U. Warsaw	Mai 2017	ultra lowb*
N. Fuster Martinez	IFIC	June 2017	collimation
M. Bergamaschi	CERN-RHUL	October 2017	OTR-ODR
F. Plassard	CERN-UpSud	January 2018	octupoles / long l*
T. Bromwich	JAI	March 2018	FONT5 IPBPMs
A. Schuetz	DESY	March 2018	backgrounds
R. Yang	UpSud	September 2018	Halo formation
P. Korysko	JAI	October 2019	wakefields

Thank you for participating in the 20th ATF2 Project meeting and make possible this fruitful collaboration