



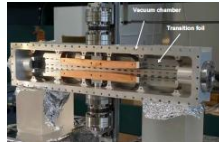
ATF2 Final Focus Test Beamline

ATF2 final focus test beamline
Nanometer beam development

- Final focus System R&D
- Intra-train ultra-fast beam feedback



Low-emittance beam R&D



Transition kit



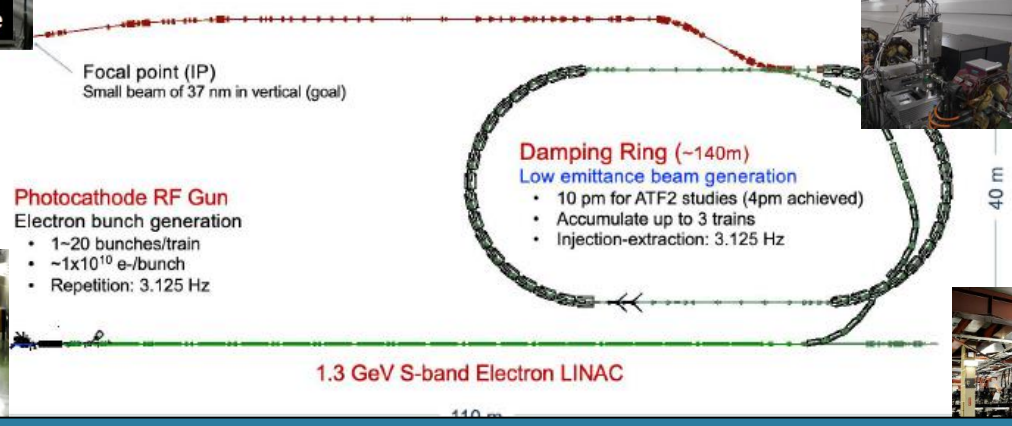
Photocathode RF Gun
Electron bunch generation

- 1~20 bunches/train
- $\sim 1 \times 10^{10}$ e-/bunch
- Repetition: 3.125 Hz

Damping Ring (~140m)
Low emittance beam generation

- 10 μ m for ATF2 studies (4 μ m achieved)
- Accumulate up to 3 trains
- Injection-extraction: 3.125 Hz

Focal point (IP)
 Small beam of 37 nm in vertical (goal)



1.3 GeV S-band Electron LINAC

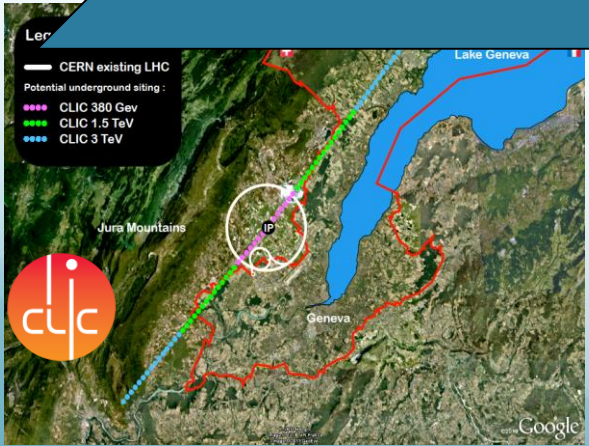


1.3 GeV S-band LINAC

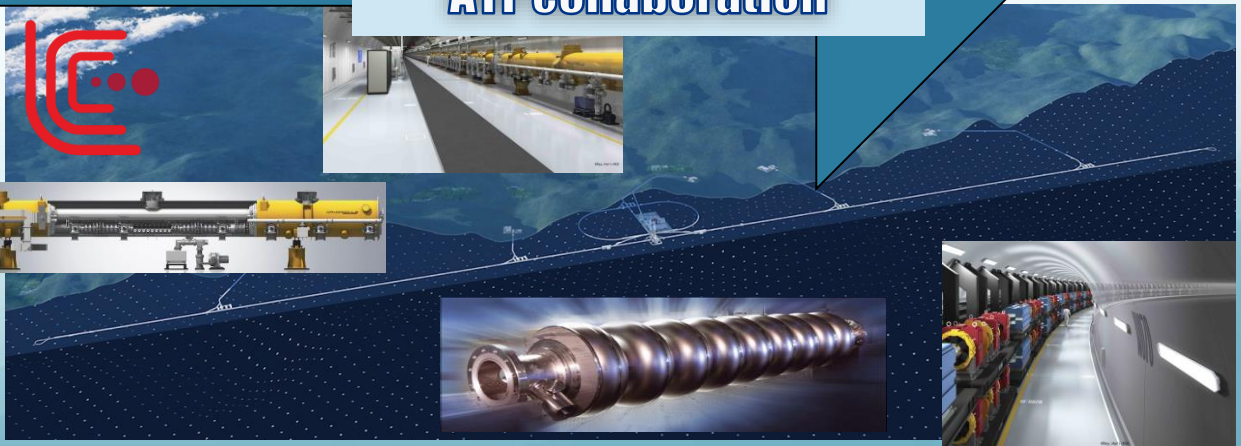


Status and Future programme for LC studies at ATF2-3

A. Faus-Golfe on behalf ATF collaboration

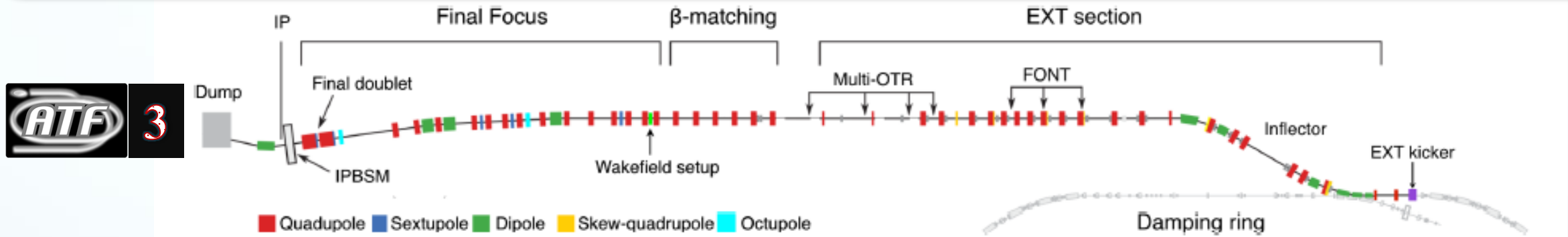


20,500 NCRF
 12 GHz
 (L~25 cm)

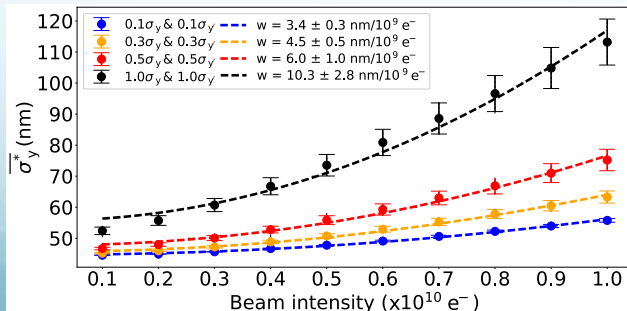


ATF3 objectives and collaboration:

Based on the achievements of the ATF2 no showstopper for ILC has been found, **ATF3** plan is to pursue the necessary R&D to **maximize** the **luminosity potential of ILC**. In particular the assessment of the **ILC FFS system design** from the point of view of the beam dynamics aspects and the technological/hardware choices and the **long-term stability operation issues**.

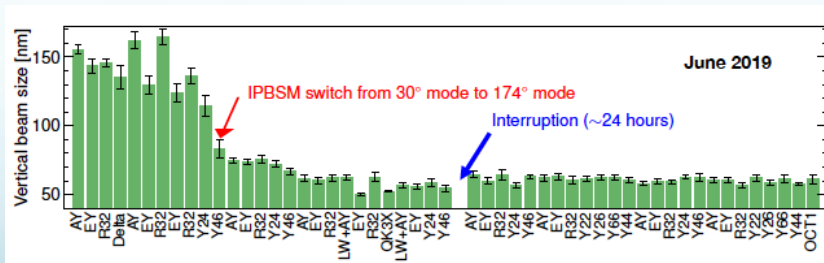


Long Term stability



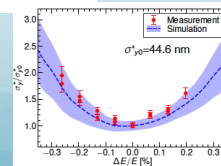
Intensity dependence studies

High-order aberrations



Ultra-low β^* studies

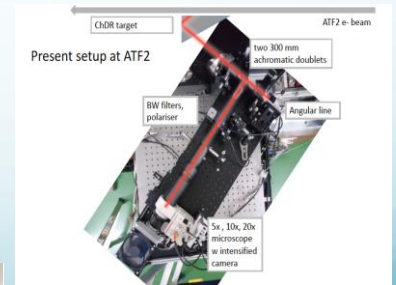
Energy bandwidth



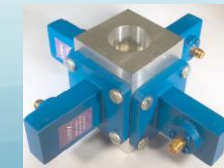
Instrumentation R&D



Collimator



Incoherent Diffraction Cherenkov Radiation Monitor



Waveguide BPM

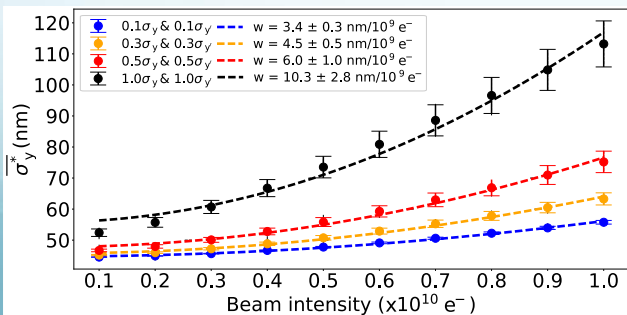
ILC – IDT WP15 System Design of ILC FFS

Time critical WPs relevant for ATF

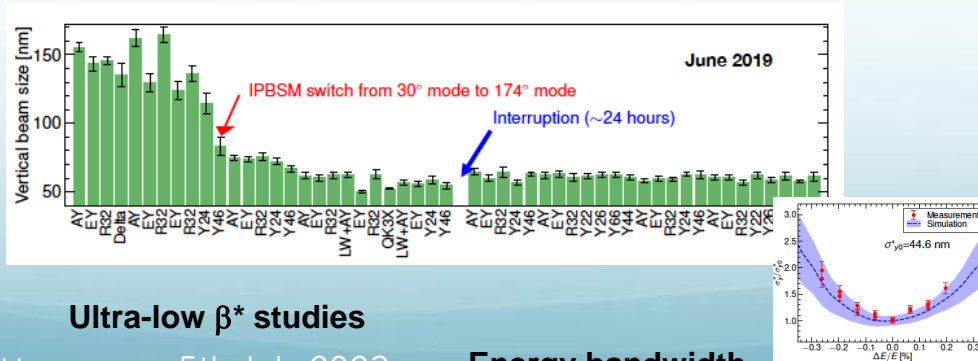
WP15 Tasks : Maximize Luminosity potential of ILC

T1: ILC-FFS system design	T1.1: Hardware optimization
	T1.2: Realistic beam line driven / IP design
T2: ILC-FFS beam tests	T2.1: Long-Term stability
	T2.2: High-order aberrations
	T2.3: R&D complementary studies

Long Term stability

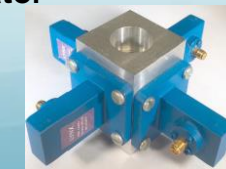


High-order aberrations

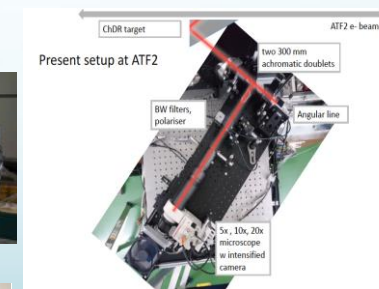


Instrumentation R&D

Collimator



Waveguide BPM



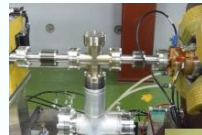
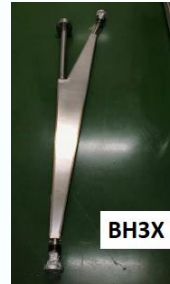
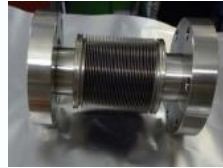
Incoherent Diffraction Cherenkov Radiation Monitor

T1.1: ATF2-3 Hardware upgrades



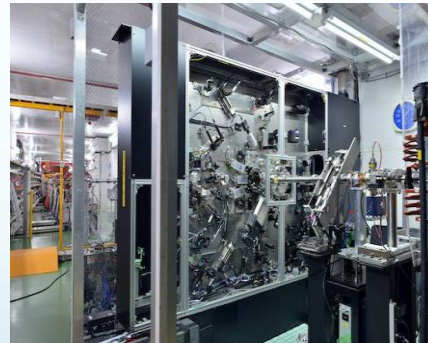
➤ Vacuum Chambers (ID beam 24 mm):

- Bellows shielding
- Clamp Flanges (ATF-DR type)
- Cavity BPM tapering (ID 20 mm)
- Stripline BPMs
- Dipole chamber (box type replaced by simple pipe)
- Septum chambers (A, B, C)
- FONT stripline kicker
- Pumping port chamber (ID 24 mm)



➤ IP-BSM Laser:

- Nd:YAG laser replacement choice, new laser parameters
- Start LTL, FF-IP simulation study
- Start laser stability study (energy, pointing, mode, and fringe pattern)
- e-beam arrival and timing jitter



IPBSM (nanometer beam size monitor)

➤ FD vibration girder

- Girder for all the final elements coupled with a global positioning system

➤ CBPMs:

- Re-installation of all CBPMs (current #24, all #32)
- Add separate fast small movers for centering and position calibration, including mechanical study, specs (~10kg load and um resolution, prioritize high-β regions)
- Electronics: analogue electronics reliable but spares needed
- Digitizers: 20-year old model, higher resolution ADCs would increase the dynamic range.

➤ New Magnets

- FD: QD0, QF1, SD0, SD1
- Skew sextupoles including movers
- Septum C (standard dipole)
- ZVOX vertical corrector (between septum B and C)



➤ IP-BPMs

- Re-design towards sub-10 nm, wide dynamic range and linearity (new electronics/digitizers)

➤ Multi-OTR system

- Focusing motor, Filter actuator, CDD cameras
- XPS with oriented motor

➤ FONT IP feedback

- Font kicker to improve wakefields

T1.1: ATF2-3 Hardware upgrades



➤ Vacuum Chambers (ID beam 24 mm):

- Bellows shielding
- Clamp Flanges (ATF-DR type)
- Cavity BPM tapering (ID 20 mm)
- Stripline BPMs
- Dipole chamber (pipe)
- Septum chamber
- FONT stripline
- Pumping port chamber



➤ CBPMs:

- Re-installation of all CBPMs (current #24, all #32)
- Add separate **fast small movers** for centering and position calibration, including mechanical study, specs (size high- β regions) available but spares

Major hardware ATF issues were identified in the ATF2 review. ATF2 beam line upgrade will be done in the framework of the new R&D MEXT grant starting in April 2023 and continue for 5 years. Priority has been established, starting with IP-BSM, magnets and beam pipes.

➤ IP-BSM Laser

- Nd:YAG laser re-**choice**, new laser parameters
- Start LTL, FF-IP simulation study
- Start laser stability study (energy, pointing, mode, and fringe pattern)
- e-beam arrival and timing jitter



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- Girder for **all the final elements coupled** with a global positioning system

resolution ADCs



- ZVOX vertical corrector (between septum B and C)

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- Re-design towards sub-10 nm, wide dynamic range and linearity (new electronics/digitizers)

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- XPS with oriented motor

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- Font kicker to improve wakefields

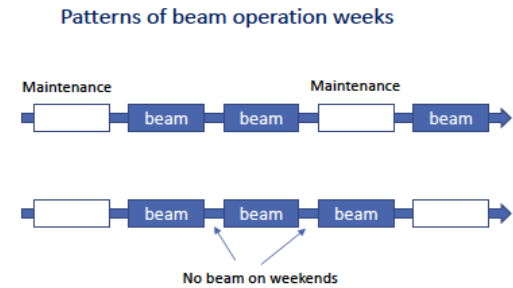
T2: ATF3 operational plan FY2023

- The **grant for ILC related R&D** will begin early **FY2023** and will continue for **5-years**. For ATF, this grant will support the equipment for ATF2 upgrade and workers contracting. However, it should not pay for the electricity operation of ATF.
- Based on the current electricity budget estimation, the operation of ATF will be about **10 weeks** in **FY2023**.
- The electricity cost is high and more than double that of previous years. We expect it will continue for a first half of FY2023.
- Plan for a 10-week beam operation by the end of December 2023, **depending** on the **supplementary budget** (as in FY2022) or cost of electricity is eased in some extent we **will plan for January 2024**

Beam Operation weeks

It will be same as before because of the manpower

Patterns of beam operation weeks



Series of a few beam-weeks and a maintenance week

Beam week

- 24 hours continuous beam operation from Monday afternoon to Friday evening.

No beam on weekend

- due to the **manpower** (staff responsible for safety,...)
- Weekends are used to prepare for next week studies.

Maintenance week

- for the preparatory work of R&D,
- installation and improvement of devices for the coming beam studies.

Holiday

Candidate of the beam weeks

No room to operate in Summer

	April					May					June				
Sun	2	9	16	23	30	7	14	21	28	4	11	18	25		
Mon	3	10	17	24	1	8	14	21	28	5	12	19	26		
Tue	4	11	18	25	2	9	15	22	29	6	13	20	27		
Wed	5	12	19	26	3	10	16	23	30	7	14	21	28		
Thu	6	13	20	27	4	11	17	24	31	8	15	22	29		
Fri	7	14	21	28	5	12	18	25	1	9	16	23	30		
Sat	1	8	15	22	6	13	19	26	2	10	17	24			

	July					August					September				
Sun	2	9	16	23	30	6	13	20	27	3	10	17	24		
Mon	3	10	17	24	31	7	14	21	28	4	11	18	25		
Tue	4	11	18	25	1	8	15	22	29	5	12	19	26		
Wed	5	12	19	26	2	9	16	23	30	6	13	20	27		
Thu	6	13	20	27	3	10	17	24	31	7	14	21	28		
Fri	7	14	21	28	4	11	18	25	1	8	15	22	29		
Sat	1	8	15	22	6	13	19	26	2	9	16	23	30		

	October					November					December				
Sun	1	8	15	22	29	5	12	19	26	3	10	17	24		
Mon	2	9	16	23	30	6	13	20	27	4	11	18	25		
Tue	3	10	17	24	31	7	14	21	28	5	12	19	26		
Wed	4	11	18	25	1	8	15	22	29	6	13	20	27		
Thu	5	12	19	26	2	9	16	23	30	7	14	21	28		
Fri	6	13	20	27	3	10	17	24	1	8	15	22	29		
Sat	7	14	21	28	4	11	18	25	2	9	16	23	30		

	January					February					March				
Sun	7	14	21	28	4	11	18	25	3	10	17	24	31		
Mon	1	8	15	22	29	5	12	19	26	4	11	18	25		
Tue	2	9	16	23	30	6	13	20	27	5	12	19	26		
Wed	3	10	17	24	31	7	14	21	28	6	13	20	27		
Thu	4	11	18	25	1	8	15	22	29	7	14	21	28		
Fri	5	12	19	26	2	9	16	23	1	8	15	22	29		
Sat	6	13	20	27	3	10	17	24	2	9	16	23	30		

Tentative Plan for FY2023

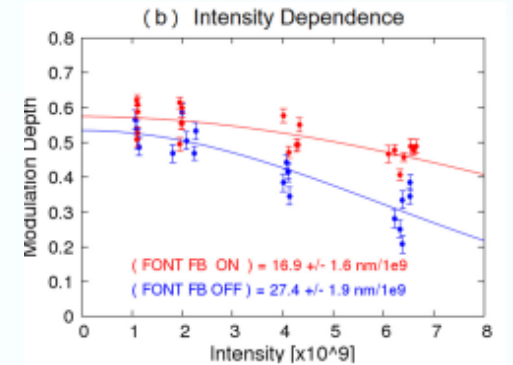
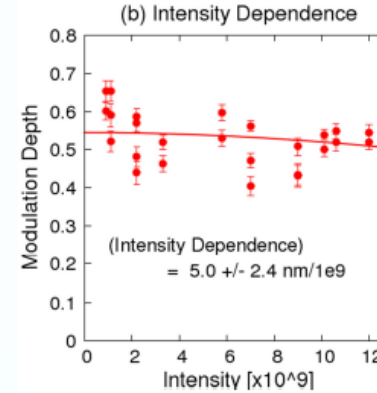
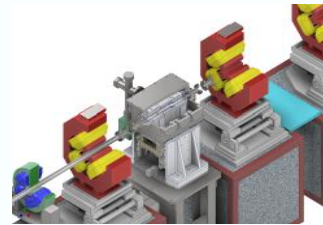
Depend on the electricity cost

T2: ATF2 recent experimental studies

without the participation of the overseas collaborators

➤ Wakefield mitigation (new wakefield test station)

- Static: mitigation by relocating the sources in lower β -positions
- Dynamic: FONT feedback



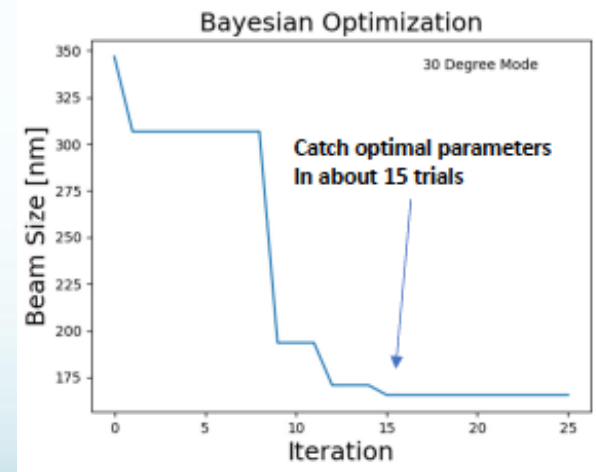
Static and dynamic wakefield sources compensation

➤ High-order aberration correction and mitigation

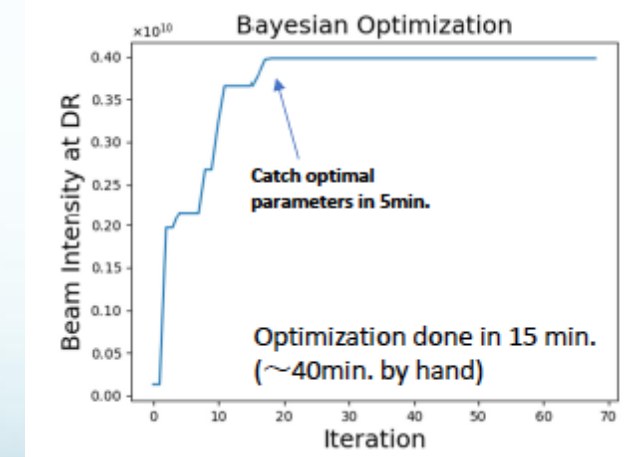
- Measurement of FF quads multipoles
- Impact of tilt scan
- Ultra low- β studies

➤ ILC beam tuning (ML)

- Automatic beam tuning
 - Minimize the tuning parameters
 - Simultaneous optimization
- Beam optimization
 - “Black-box”
 - Bayesian optimization



FF nano-beam tuning

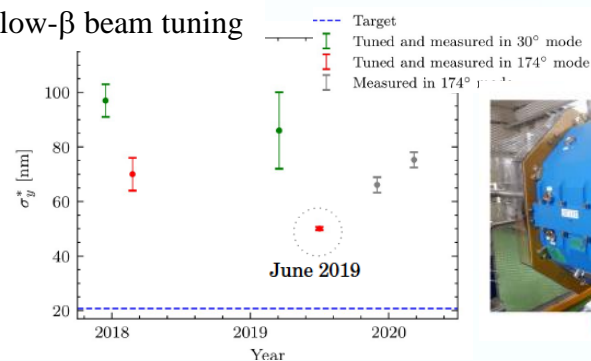


Linac transport to DR

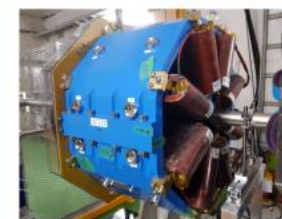
T2 : ATF3 overseas collaborations contributions

- Most of collaborators are willing to **participate** starting in **June 2023**. The ideal will be to arrive the week before in to check/familiarize with the ATF2 current situation (Database lattices with all the ATF2-3 upgrades)
- **Beam Instrumentation:** CERN team has participated in ChDR studies in June 2023.
- **Beam dynamics:** CERN, JAI CNRS team will participate in Fall 2023.
- Task force in “magnet movers”
- Task force for “software new Flight simulator
- Task force in “cavity BPMs”

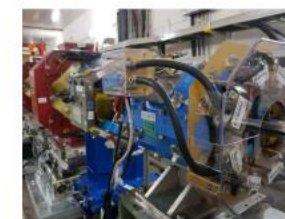
Ultra low- β beam tuning



Octupoles studies



OCT1FF



OCT2FF

WFS studies

Simulations:

Static errors:

- Misalignment of quadrupoles, sextupoles and BPMs of 100 μ m RMS.
- Strength error of quadrupoles and sextupoles of 0.1% RMS.
- Roll error for quadrupoles and sextupoles of 200 μ rad RMS.

Dynamic errors:

- Incoming pos. & ang. jitter of $1.0\sigma_x$ and $1.0\sigma_y$, respectively.

Measurements:

Done on 03/02/2016
(Intensity_fringe_160203_193347)

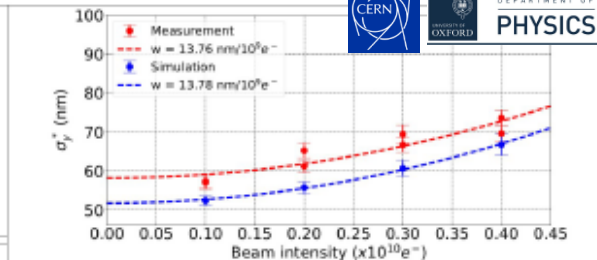
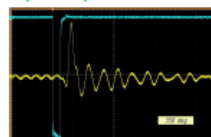


Figure: Comparison between measurements and simulations of the vertical beam size at the IP (σ_y^*) vs. the beam intensity and the intensity-dependent parameter w .

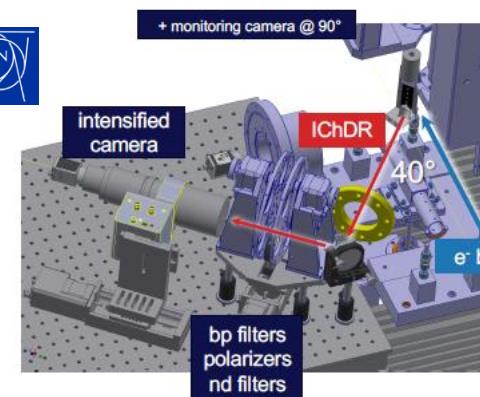


Cavity BPM in an ATF2 quadrupole

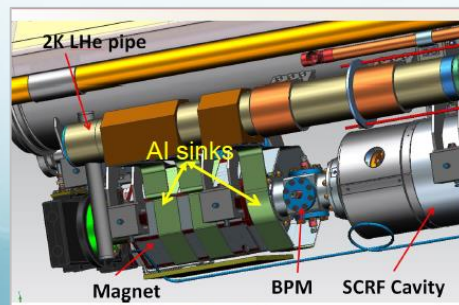
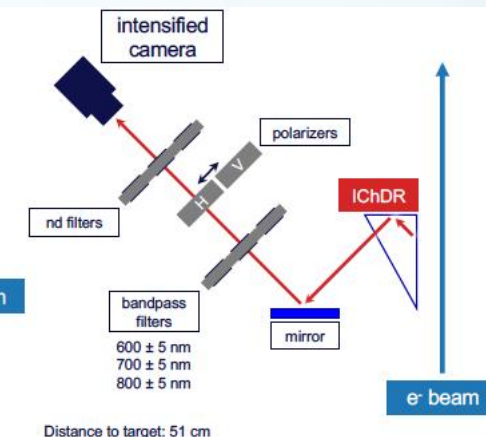


Injected pulse after downconversion in CBPM electronics

CBPMs electronic upgrade



Incoherent ChDR



Cold CBPMs for ILC main linac

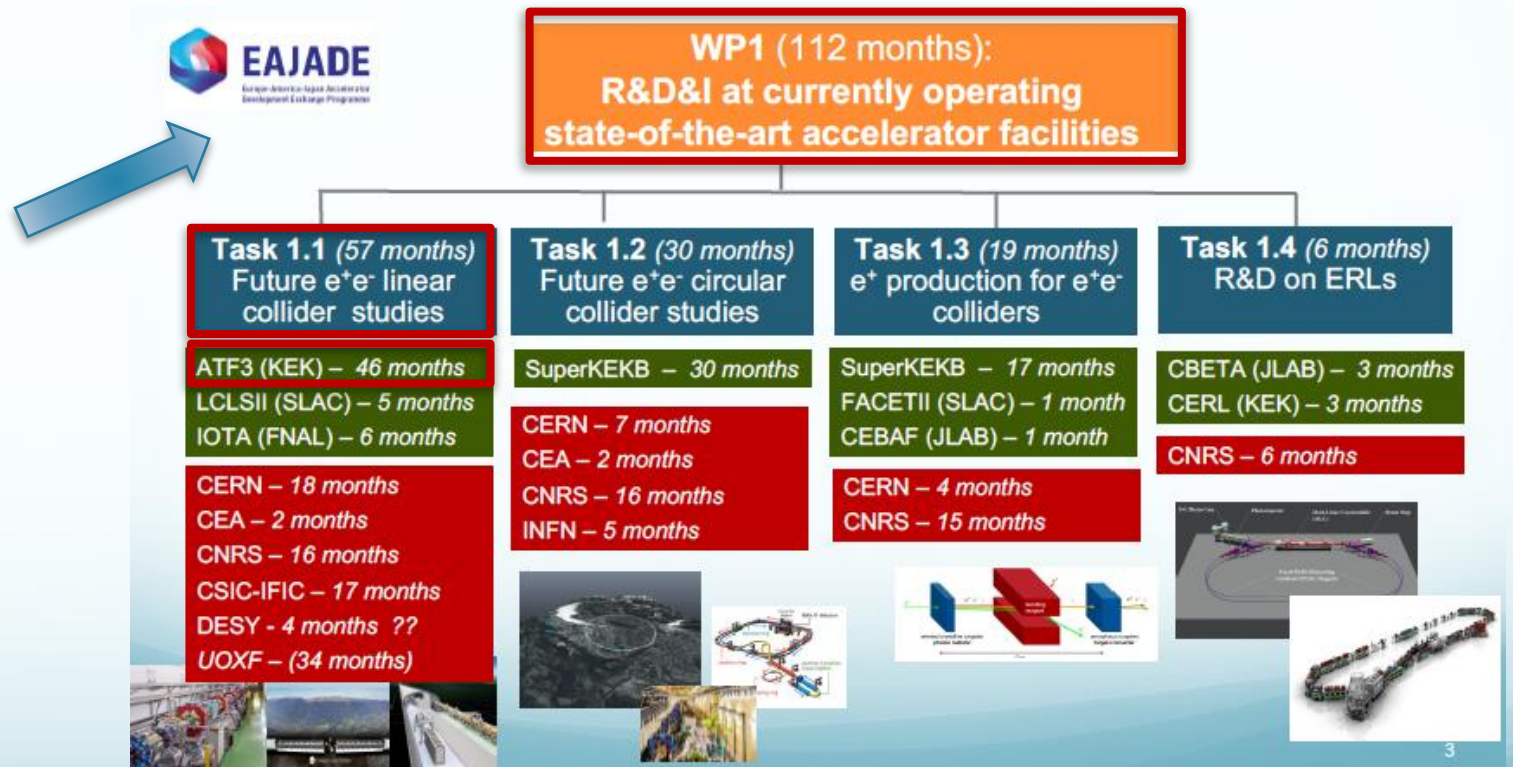
ATF3 in EAJADE project



EAJADE (Europe–America–Japan Accelerator Development and Exchange programme) focused in Higgs Factories, with participation of **major EU** (CERN, INFN, CEA, DESY, CNRS, CSIC, UOXF), **Japan** (KEK, Tokyo Univ., Tohoku Univ.) **USA** (BNL, FNAL, SLAC, JLAB, LBNL, Cornell Univ.) and **Canada** (VISPA) labs. **(2023-2027)**

Table 1 – Work Package (WP) List

Work package no.	Work package title	Activity type	Number of person-months involved per secondment	Lead beneficiary	Start month	End month
1	R&D&I at currently operating state-of-the-art facilities	Research, training	143	CNRS	1	48
2	State-of-the-art high-gradient, high-efficiency, reduced-cost radio-frequency structures and power sources	Research, training	68	INFN	1	48
3	Special technologies, devices and systems performance	Research, training	74	CERN	1	48
4	Sustainable technologies for scientific facilities	Research, Training	12	CEA	1	48
5	Investigation of potential early applications of novel and advanced technologies for colliders	Research, training	52	DESY	1	48
6	Management, dissemination, training, knowledge transfer, and communication	Management, training, dissemination, communication	4	DESY	1	48



17th ICB ATF/ATF2 in LCWS2023, SLAC

Last ICB meeting: 16th MEETING OF THE ATF/ATF2 INTERNATIONAL COLLABORATION BOARD: October 30th 2019, LCWS19, Sendai.

MINUTES OF 17th MEETING OF THE ATF/ATF2 INTERNATIONAL COLLABORATION BOARD: May 17th 2023, LCWS23, SLAC.

Present: P.N. Burrows (Oxford, Chair), B. Foster (DESY), A. Faus-Golfe (IJCLab, TB Chair), A. Latina (CERN), S. Michizono (KEK, IDT WG2), T. Okugi (KEK), S. Stapnes (CERN), N. Terunuma (KEK, ATF spokesperson), G. White (SLAC).

Remote: J. Gao (IHEP).

The International Collaboration Board (ICB) of the ATF/ATF2 Project held its 17th meeting on May 17th, 2023, during the LCWS23 at SLAC. Several ATF progress-report presentations were made at the Workshop; the full agenda and presentations can be found at: <https://indico.slac.stanford.edu/event/7467/timetable/>

ATF status and operations:

N. Terunuma summarised beamtime in recent years. In JFY20 beam was largely off; 12 (11) weeks of operations were delivered in JFY21 (JFY22) respectively, although overseas collaborators were unable to participate due to Covid19 travel restrictions. In JFY23 10 weeks are scheduled for 2023, with a strong possibility of an additional 5 weeks before April 2024. The electricity cost of operations is now significantly higher (roughly a factor two) than in 2019. A number of improvements to the beamline have been made in recent years, including an upgrade to the IPBSM laser and beam transport system. Further planned improvements include a new QD0 and 4 new skew sextupoles (2023) and other magnet renewals (2024). New beampipe sections and shielded bellows (to reduce wakefields) are in design. This substantial set of upgrades motivates a next phase of the facility, 'ATF3', approved by KEK, which will form a key element of the ILC Technology Network (ITN) with a funding line planned for 5 years starting JFY23. MEXT is expected to review ATF3 regularly during this 5-year period.

The ICB thanked KEK for supporting ATF3 and agreed to extend the Collaboration scope so as to include ATF3.

The ICB agreed to extend the period of validity of the Collaboration MoU until either: the day that it declares officially the dissolution of the ATF/ATF2/ATF3 Collaboration, or: a future MoU that replaces the current one is signed.

T. Okugi summarised the planned KEK contributions to the ITN work packages 14' (DR), 15' (ATF3) and 17' (dumps).

There followed an informal discussion of possible overseas contributions to ATF3 via the ITN. European and US institutes are certainly interested in contributing subject to availability and agreement of resources. The EAJADE project will allow direct support for the respective European collaborators to travel to KEK for ATF3 activities. ATF operations meetings will resume shortly to enable coordination of beamtime requests and hardware activities.

The ICB agreed to consider applications from new member institutes that wish to participate in ATF3 activities.

Philip Burrows 18/5/23
Chair, ATF/ATF2/ATF3 ICB

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- The ICB agreed to **extend the period of validity of the Collaboration MoU** until either: the day that it declares officially the dissolution of the ATF/ATF2/ATF3 Collaboration, or: a future MoU that replaces the current one is signed.
- The ICB agreed to **consider applications from new member institutes** that wish to participate in **ATF3 activities.**



ATF2 final focus test beamline

ITN-EU contribution to WP15 is starting...



Very well known collaborators



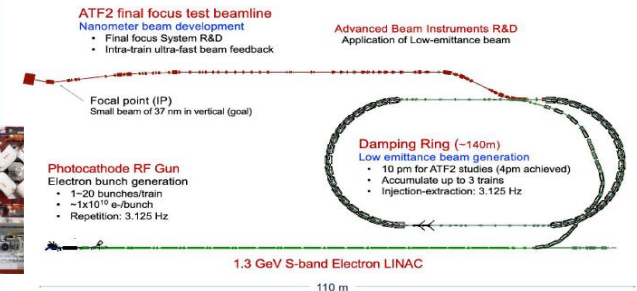
IIC- CLIC- FCCee



New possible collaborators... synergies to be founded

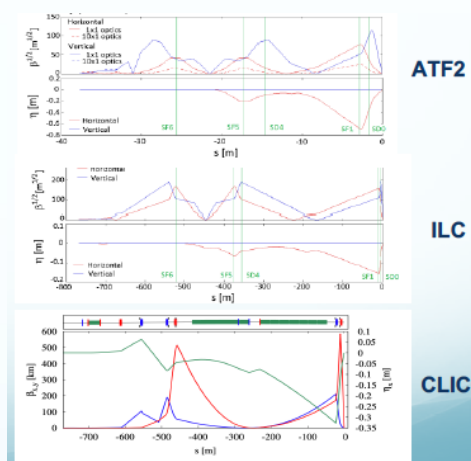
ATF2 goals and achievements

ATF2 is a unique test facility to develop nanobeam technologies for LCs



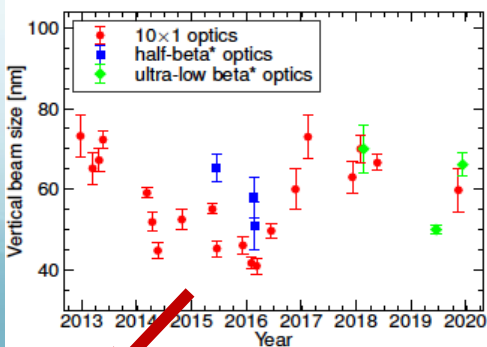
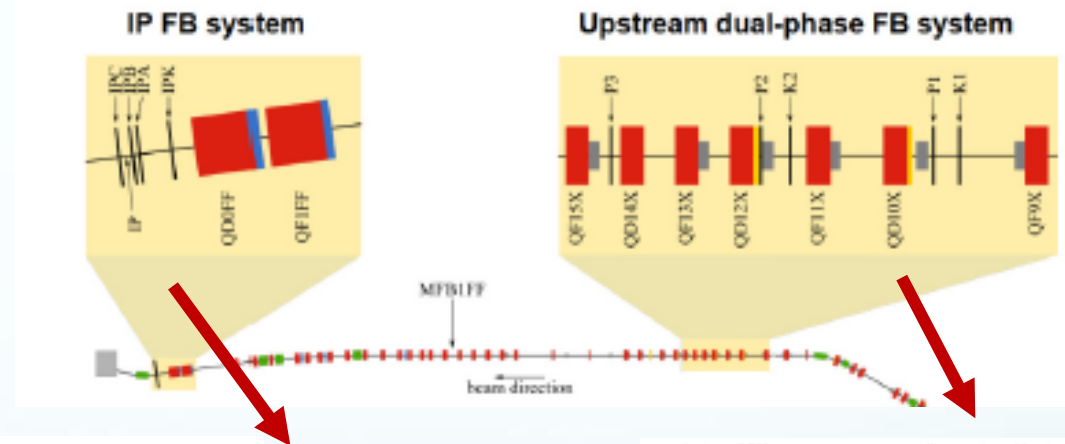
Goal 1: Establish the ILC FFS methodology with similar optics and compatible beamline tolerances

	Units	ATF2	ILC	CLIC
E_{cm}	[GeV]	1.3	250	380
\mathcal{L}	[10^{34} cm $^{-2}$ s $^{-1}$]		1.35	1.5
f_{rep}	[Hz]	3.12	5	50
$n_{bunches}$	1	1 - 20	1312	352
N_e	[10^{10}]	1.0	2.0	0.52
σ_b	[μ m]	7000	300	70
Δt_b	[ns]	154	554	0.5
$\gamma\epsilon_x / \gamma\epsilon_y$	[nm]	5000 / 30	5000 / 35	950 / 30
σ_x^* / σ_y^*	[nm]	9000 / 37	516 / 7.7	149 / 2.9
IP Stabilization	σ_y^*	< 0.05	< 0.2	< 0.08
L^*	[m]	1	4.1	6
β_x^* / β_y^*	[mm]	40 / 0.1	13 / 0.41	8 / 0.1



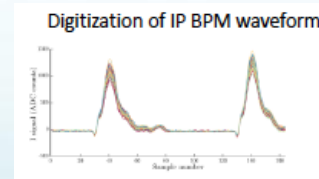
Goal 2: Develop a few nm position stabilization for ILC collisions

FONT5 system

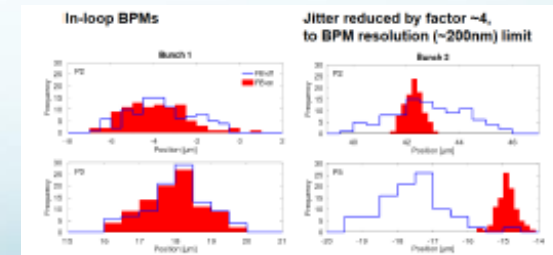


Small beam sizes were obtained with beam intensities of 0.5-1.5 10^9 e-/bunch (10^{10} design value) and reduced aberration optics ($10\beta_x^* \times \beta_y^*$)

smallest beam size ~41 nm (2016)



Bunch	Position jitter (nm)	
	Feedback off	Feedback on
1	106 \pm 16	106 \pm 16
2	96 \pm 10	41 \pm 4



IP beam position has been stabilized up to the BPM resolution for both upstream and IP. FB latency 133 ns (366 ns target value) and IP position jitter from 106 to 41 nm (2018)

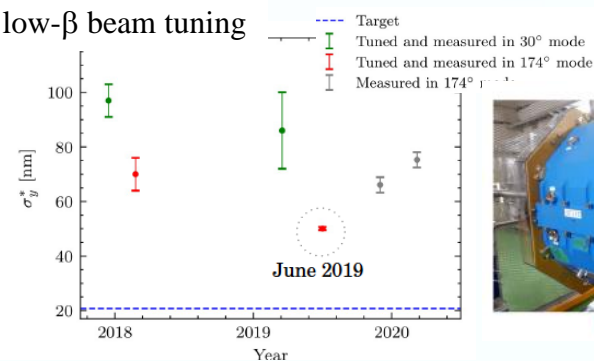
ATF3 overseas collaborations contributions

- Most of collaborators are willing to **participate** starting in **June 2023**. The ideal will be to arrive the week before in to check/familiarize with the ATF2 current situation.

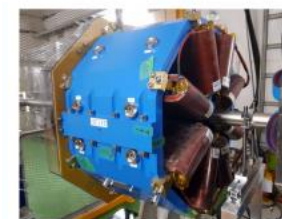
- **Beam dynamics:** CERN team will be interested not in specific beam time in June 2023 but just familiarize with the current ATF3.
 - Ultra-low studies (long L*...)
 - Optics optimization and simulation (wakefield mitigation)
 - Beam time in Nov-December 2023

- **Beam Instrumentation:** ChDR checks and will be interested in some beam time starting in June 2023

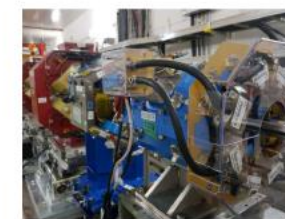
Ultra low- β beam tuning



Octupoles studies



OCT1FF



OCT2FF

WFS studies

Simulations:

Static errors:

- Misalignment of quadrupoles, sextupoles and BPMs of 100 μ m RMS.
- Strength error of quadrupoles and sextupoles of 0.1% RMS.
- Roll error for quadrupoles and sextupoles of 200 μ rad RMS.

Dynamic errors:

- Incoming pos. & ang. jitter of $1.0\sigma_x$ and $1.0\sigma_y$, respectively.

Measurements:

Done on 03/02/2016
(Intensity_fringe_160203_193347)

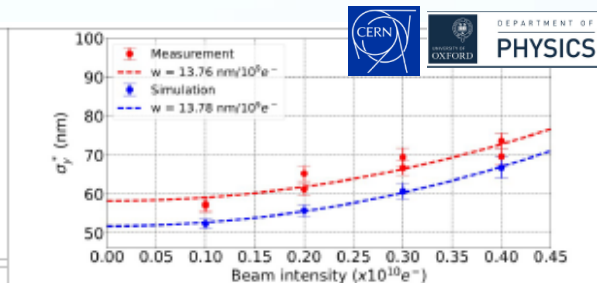
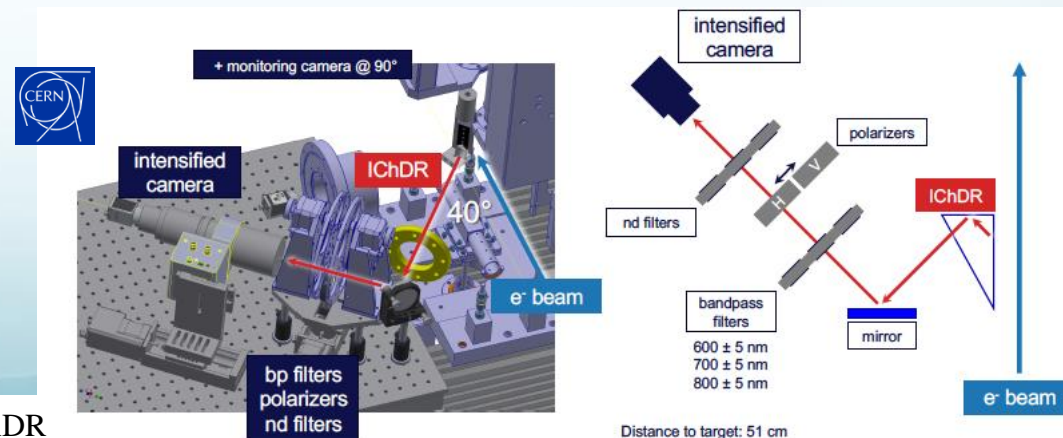
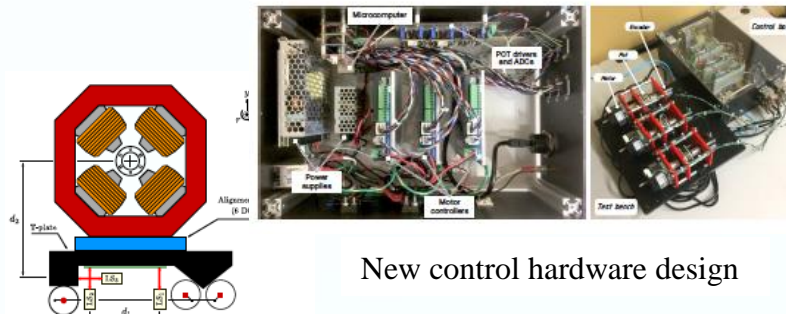


Figure: Comparison between measurements and simulations of the vertical beam size at the IP (σ_y^*) vs. the beam intensity and the intensity-dependent parameter w .

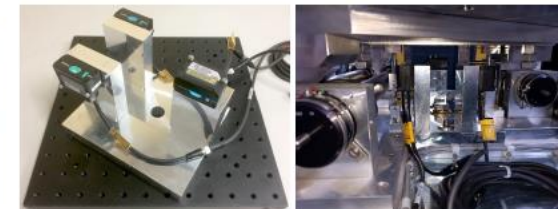


ATF3 overseas collaborations contributions

- Database lattices with all the ATF2-3 upgrades
- Task force in “**magnet movers**”: dedicated meetings will be organized to discuss the proposed upgrades (A. Aryshev, K. Kruchinin, S. Mazzone, A. Schloegelhofer, L. Brunetti, P. Karataev, A. Lyapin)
- Task force for “**software new Flight simulator**”: dedicated meetings will be organized to discuss the proposed upgrades. Agreed in one first tool and first implementation. (A. Aryshev, K. Kruchinin, A. Latina, P. Korysko, A. Aksoy, A. Pastushenko, R. Tomas, E. Manosperti,)
- Task force in “**cavity BPMs**”: dedicated meetings will be organized to discuss the proposed upgrades (A. Aryshev, K. Kruchinin, K. Popov, A. Lyapin, N. Fuster)




New control hardware design



New calibration bracket

 ATF3 hardware “policies”, proposal

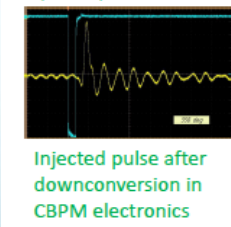
- Connection-wise
 - Serial
 - UART (RS 232,485,422,USB)
 - TCP/IP
 - MODBUS
 - Avoid firewire, wifi, Bluetooth etc
- Bus-wise
 - VME, CAMAC
 - Avoid PCI, PXI, etc
- Towards unification
 - Thorlabs, not Newport
 - Stepping motor controller magmover type
- Cameras
 - Genicam/GiGe

 Flight Simulator upgrade proposal

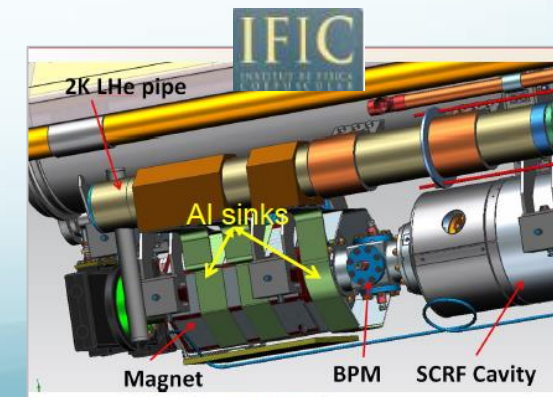
- Based on the proposed policies
- Create a set of tools instead of integrated system
- Dispersion measurement and correction
 - EXT+FF, DR ??
 - Need df ramp – ATF LLRF and timing (separate topic)
- Emittance measurement
 - EXT – mOTR
 - DR - XSR ??
- BBA
 - EXT + FF
 - LINAC - ??
 - BT - ??
- Coupling measurement and correction
 - EXT + FF
- Matching ??
- Standardization ?? Only EXT and FF ??



Cavity BPM in an ATF2 quadrupole



CBPMs electronic upgrade



Cold CBPMs for ILC main linac