European activities

Recent progress:
A subset of the technical activities of the full ILC preparation phase programme have been identified as critical. Moving forward with these is being supported by the MEXT (ministry) providing increased funding.
European ILC studies, distributed on five main activity areas, is foreseen to concentrate (for the accelerator part) on these technical activities :

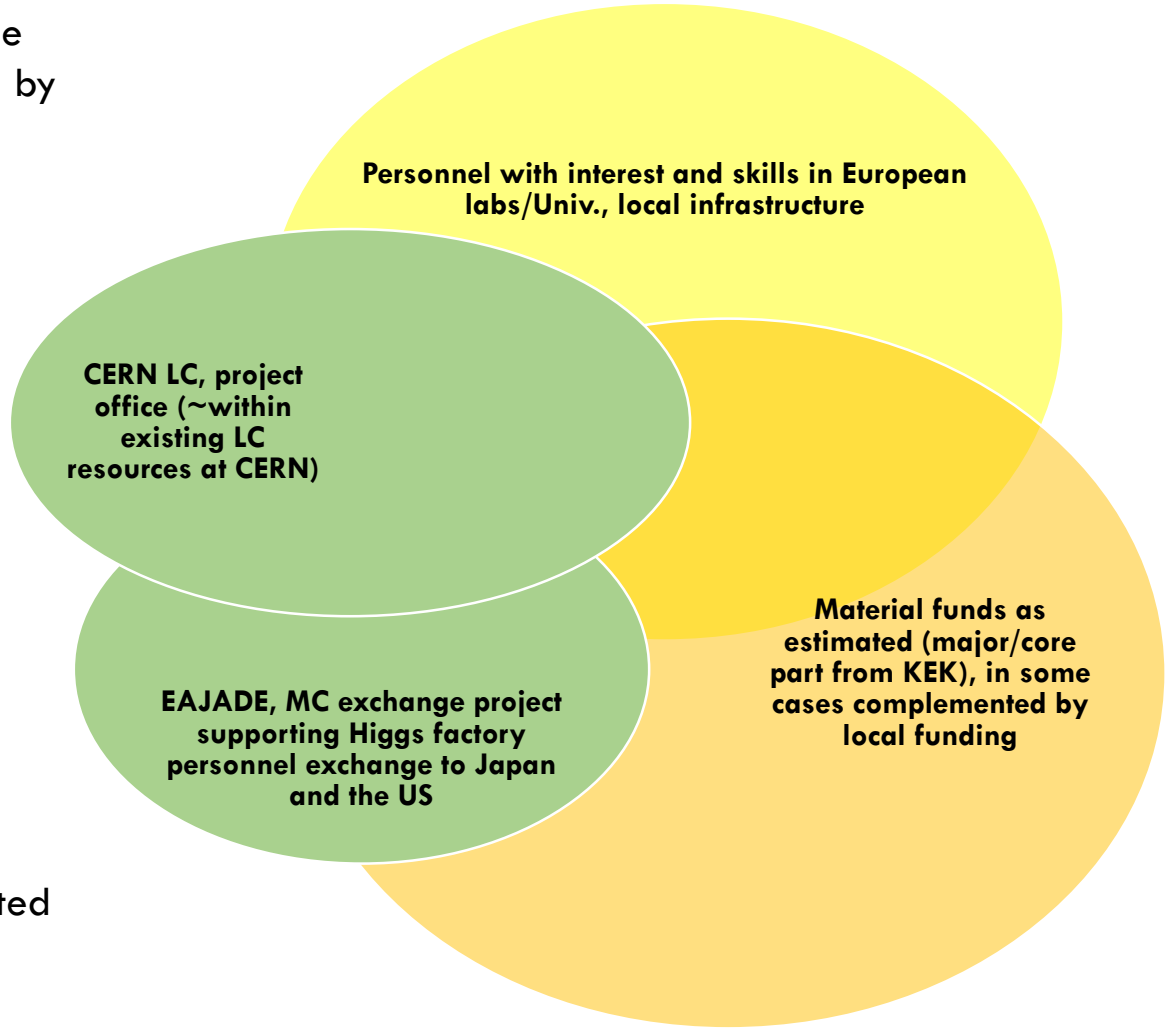
A1 with three SC RF related tasks
- SRF: Cavities, Module, Crab-cavities

A2 Sources
- Concentrate on undulator positron scheme – fast pulses magnet, consult on conventual one (used by CLIC and FCC-ee)

A3 Damping Ring including kickers
- Low Emittance Ring community, and also kicker work in CLIC and FCC

A4 ATF activities for final focus and nanobeams
- Many European groups active in ATF, more support for its operation expected using the fresh funding

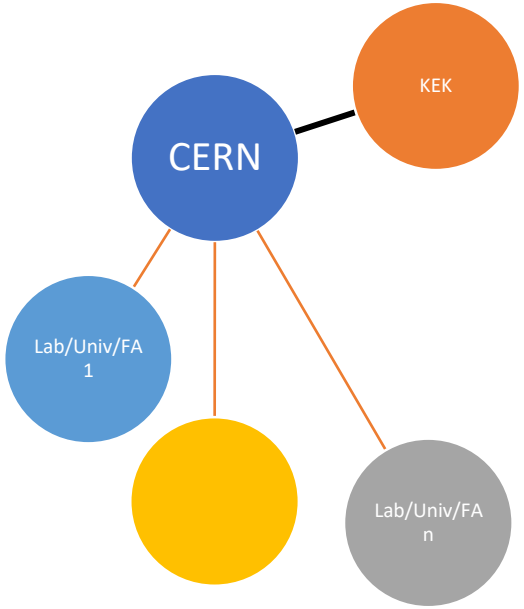
A5 Implementation including Project Office
- Dump, CE, Cryo, Sustainability, MDI, others (many of these are continuations of on-going collaborative activities)



EAJADE: Information at LINK

European Organisation of programme

- CERN plays coordinating role
- KEK contribution to the material cost is essential
- Main contract for flow of funds between CERN and KEK*
  - CERN-KEK ILC IDT agreement already extended by 2 years
  - Amendments/modifications would be needed for ITN, most practical is new Agreement (next slide)
- Subsequent contracts* – similar to what is done for other studies for future colliders – between CERN and European Labs in the cases where money flow is needed (limited number)
- Establish a distributed Project Office, administratively anchored to CERN, to follow up the work.
- Aim to involve CERN personnel, fellows, PJAS within the current LC resource planning at CERN (in many cases using long term collaborative links and common studies between CLIC and ILC)

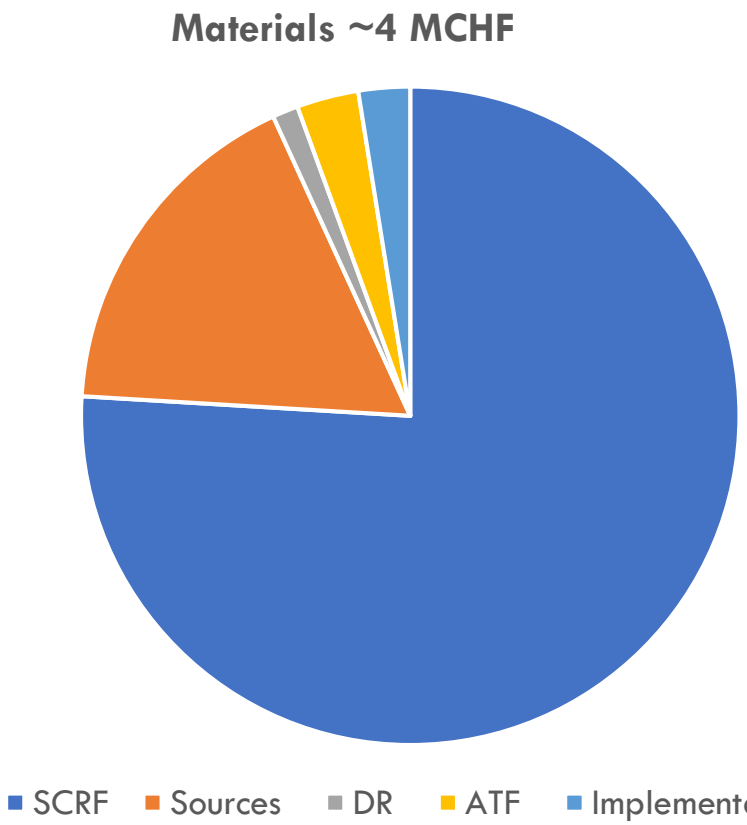


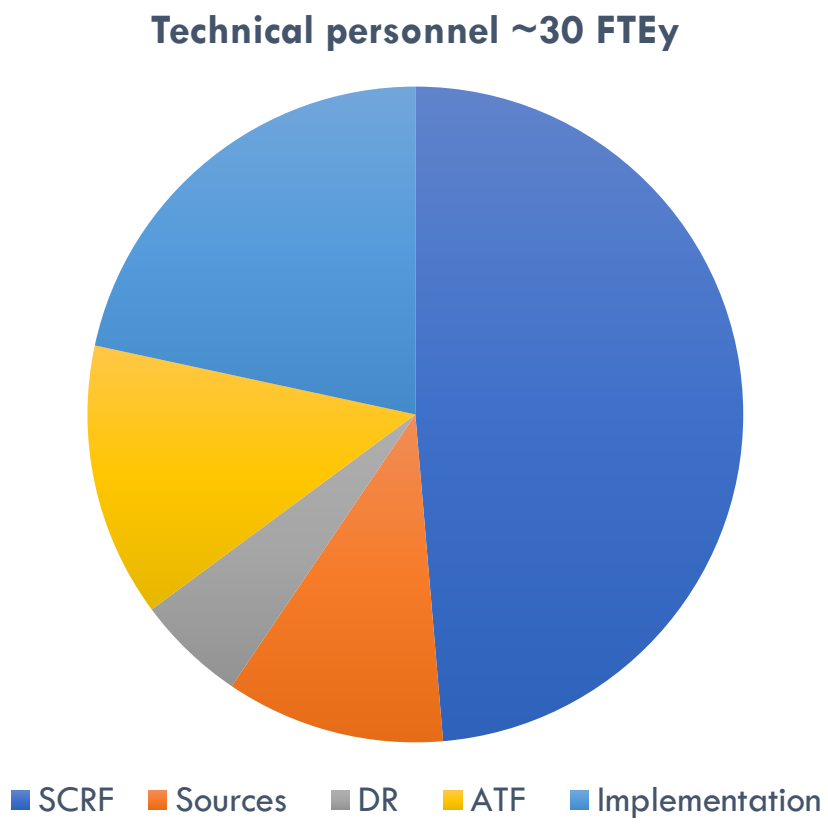
*Additional collaboration agreements between KEK and FA/countries might be very beneficially, where these activities are recognised directly

Resource estimate (core)

Estimated material funds 4 MCHF over 4 years

Top-down estimate of technical personnel purely for ITN deliverables ~30 FTY year





This rests of basis of technical expertise, infrastructure and technology in the European labs/Universities/Industries which are not included in this resource overview, plus the scientific community, including students, involved in ILC related studies.

A1: SRF Cavities and Cryomodule design

(Global Industrial Production Readiness)

- Research with single-cell cavities to establish the best production process
  - Advanced Nb sheet production method
  - Advanced surface treatment recipe
- Globally common design compatible with High Pressure Gas Safety (HPGS) regulation
- 24 nine-cell cavities are to be developed for industrial-production readiness
  - 8 cavities (4 / batch) in each region
  - Production process optimized in each region encouraged
- RF performance/success yield to be examined (at least including 2nd pass)
  - 3rd pass to be examined if effective

Production process

	# of cavities to be produced		
	Americas	Europe	JP/Asia
single-cell	2	2	2
nine-cell	8	8	8 (+ 12)

Material/Sub-component

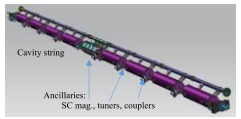
QA of Material/Sub-C

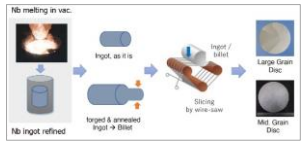
Cavity Production

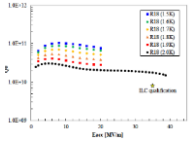
Surface Process

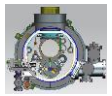
Vertical Test = Cavity RF Test

- Unify cryomodule (CM) design with ancillaries, based on globally common drawings and data-base, and
- Establish globally compatible safety design base to be approved by HPGS regulations individually authorized in each region, most likely referring ASME guidelines.









Group involved on European side in discussions of the programme:
CEA, INFN Milano primarily
Also potentially: IJCLab, DESY, STFC/Daresbury+Lancaster, CERN, Uppsala, ...
CIEMAT (for SC magnet)

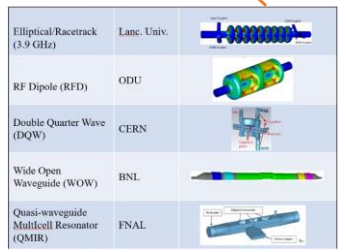
SCRF (Grad, Q) is a priority for most future high energy accelerators, and also beyond HEP

A1: Crab Cavity Development with down-selection

:
- RF property simulation to optimize cavity design
- Pre-down-selection to choose two primary candidates
- Development and evaluation of two prototype cavities
- Demonstration of synchronized operation with two prototypes
- Down-selection to choose final cavity design
- Cryomodule design based on final cavity design

Item	Recent specification (after TDR)
Beam energy	125 GeV (e-)
Crossing angle	14 mrad
Installation site	14 m from IP
RF repetition rate	5 Hz
Bunch train length	727 μsec
Bunch spacing	554 nsec
Operational temperature	2.0 K (?)
Cavity frequency	1.3/2.6/3.9 GHz
Total kick voltage	1.845/0.923/0.615 MV
Relative RF phase jitter	0.069 deg rms (49 fs rms)

two beamline distance
14.049m x 0.014rad = 197mm



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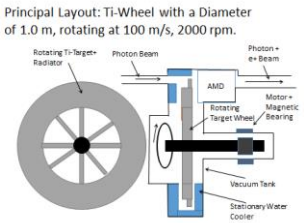
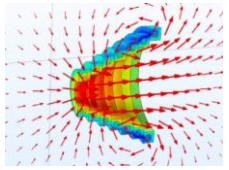
Links to general studies of crab cavity solutions:
(among others for HL-LHC, EIC and Elettra2.0)

A2: Positron Source - Rotating Target and Focusing System for Undulator Scheme

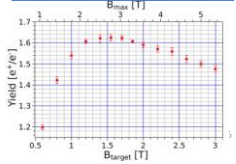
- Target specification
  - Titanium alloy, 7mm thick (0.2 X_0), diameter 1m
  - Rotating at 2000 rpm (≙ ~33 Hz) in vacuum
  - Photon power ~60 kW, deposited power in target about 2 kW, efficient power/e+
  - Radiation cooling
  - Magnetic bearings, widely used for Fermi choppers (ESS etc.), vacuum pumps and fast rotating masses
- R&D to be done as WP-prime
  - Detailed simulations in close contact with OMD design on-going
  - Design finalization, laboratory test of mock-up design (in the first 2 years)
  - Magnetic bearings: technical specifications done, ready for feasibility study, engineering design, test (in the remaining years)

- A priority item for the undulator scheme is the magnetic focusing system (OMD) right after the target
- The mature candidate is a pulsed solenoid (PS)
- R&D items to be done as WP-prime
  - Detailed simulations (almost finished)
  - Ready for engineering design for a prototype PS
  - Field measurements with 1kA (pulsed and DC) and with 50kA both in a single pulse mode and finally in a 5ms pulsed mode at 5 Hz
  - Prototype of plasma lens as OMD (funded study on-going), example for application of new technology for the ILC
- Undulators are very popular photon sources, possible synergies





Yield versus field on the target

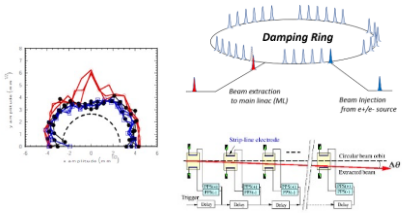


Group involved on European side in discussions of the programme:
Univ. of Hamburg, CERN, DESY, HZ Dresden-Rossendorf, SKF Jülich and possibly ESS-Bilbao.
For polarized positrons, providing physics advantages, linking also to FEL/undulators studies.

A3: Damping Ring optimization and injection/extraction

- The ILC damping ring (DR) is required to satisfy the low emittance and the large dynamic aperture simultaneously.
- The ILC DR will be further improved by incorporating the findings of the latest light source design. Increasing the dynamic aperture is also important in the design of DR.
- By quantitatively evaluating the effect of fringe field to the dynamic aperture of magnets in ILC DR, the method for evaluating fringe field to the dynamic aperture in accelerator design will be established and the design of ILC DR will be optimized.

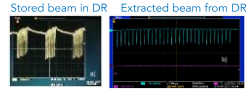
ILC fast injection/extraction system



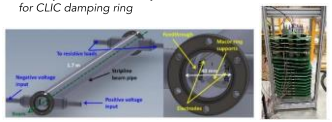
- A fast kicker system using a semiconductor pulse power supply with nanosecond response was confirmed as proof of principle at KEK's ATF about 10 years ago.
- Semiconductor technology has been evolving, and it is now possible to advance nanosecond response beam injection/excitation systems using the recent semiconductor technology.
- The technical evaluation of the fast kicker power supply using the recent semiconductor technologies.
- The evaluation of fast pulsed power supply technology will contribute not only to the fast kicker system but also to the performance and reliability of nanosecond-scale beam control technology and its application to a wide range of accelerator systems.

Beam extraction test at KEK ATF

Stored beam in DR Extracted beam from DR



Beam injection/extraction system for CLIC damping ring



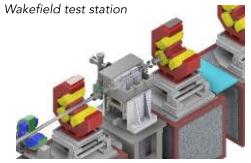
Many group can find this interesting and have capabilities to do it, there is a large and well organised low emittance ring community in Europe – and many also experience with similar studies for CLIC and FCC-ee

A4: ATF3 programme (final focus, nanobeams)

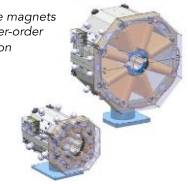
- ATF2 beamline is the only existing test accelerator in the world to test the final focus system (FFS) of linear colliders.
- The following 3 research topics are important topics to be pursued at the ATF.
  - wakefield mitigation
  - correction of higher-order aberration
  - training for ILC beam tuning
- The technical research at ATF2 beamline has proceeded, and should continue to be based on the ATF international collaboration, or its extension (welcome to new collaborators).

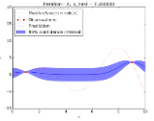
ATF2 beamline

Wakefield test station



Octupole magnets for higher-order aberration





Maximum search algorithms to be applied to beam tuning (Machine Learning)

Very relevant studies for any linac and Higgs factory closely related to low emittances and nano beams, e.g. alignment, stabilisation, instrumentation, beam-dynamics, etc.

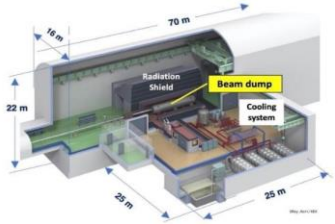
- Strong European leadership with several group from **France, UK, Spain, Germany and also CERN, also extensively used for PhD training**
- A future ATF3 programme has been defined and reviewed internationally, supported also by MC researcher exchange programmes as EJADE and EAJADE (LINK)

A5: Implementation studies

- Project Office to follow this effort, admin base CERN but can/should be distributed
  - Linking to EAJADE and communication efforts, and the KEK-CERN offices

- Continue existing collaborative efforts on CE and Cryo (CERN, DESY, KEK)
- Common studies CLIC/ILC on sustainability issue (ongoing), e.g. power, energy and running models, CO2 (sustainability is also an EAJADE WP).
  - the four activities above are all addressing optimisation of lum. to power, and/or power consumption directly for ILC
  - will also connect to green ILC studies in Tohoku within EAJADE (e.g. facility integration in local environment and infrastructure, carbon emission goals, power availability and sources)
- Connecting to ILC physics and detector developments, in particular MDI (also a focus of EAJADE)

- One of the ITN studies also belong to this activity:
  - Finalize the engineering design of the main beam dump system
    - Vortex water flow in the dump vessel
    - Cooling water circulation and heat exchange
    - Remote exchange of the beam window
    - Countermeasure for failures / safety system



Involved: CERN, EAJADE community, ESS Bilbao for dumps. Many of these topics are related to exploiting communalities between EXFEL, HL-LHC or CLIC and ILC

Recent updates - I

Overall concept in more practical terms:

- Implemented the ITN activity in Europe is that CERN act as a “hub", receives core funding from KEK and distribute activities and funds to European partners.
- We therefore need an agreement which allow transfer of funds from KEK to CERN, covering up to 4 MCHF over 4-5 years (i.e. extendable up to this level), with flexibility in the amounts to be transferred and for the time-profile (i.e - amounts and exact use (deliverables) of the funding received are specified in the actual invoices generated along the way).
- I would expect that we in 2023 could receive XXXX CHF.
- A key goal of an agreement is to move step by step up to the maximum years and funds mentioned above, so that Europe, CERN and KEK can be confident at every step that we deliver as expected for the right amounts. And that we also can adjust and/or stop in a controlled way.

Concept discussed in meeting between CERN and KEK DGs in January, next - start to prepare new agreement

Presentation requested in the CERN SPC and Council 20.3 and 22.3

Recent updates – II

Activities:

- Discussion between CERN (Steinar), KEK (Akira, Shin), CEA (Enrico and IRFU management), INFN (Laura in contact with INFN management) on cavities: material, single cell cavities, testing, placing contracts ..
- Discussion between CERN and UoH about pulsed magnet
- ATF3 kick off 8-9.3
- Sustainability study submitted for tunnel (and IPAC presentation approved) – need to get back into dump, cryo etc. EAJADE kick off end March, project start 1.3.
- Also very active work on crab cavities but currently not “European specific”, also DR work to be planned

Contact points for WPs (Enrico, Laura. Peter, Gudi, DR to be decided, Angeles and Phil ATF2/3, Benno/Maxim for sustainability

Ideally identify main technical contact at CERN, and complement list above with 2-3 more names to take overall follow up responsibilities, including pursuing complementary funding and resources

CERN MTP text will reflect developments, CERN funds will accommodate some operational support

CERN – KEK office being refinances for 2023-24

Need also to report back to LDG

Goal	The International Linear Collider (ILC) studies are progressing lead by an International Development Team (IDT) where CERN participates. The CERN linear collider studies support this effort through combined activities with CLIC, co-operation with KEK for specific technology developments where CERN has expertise, and studies using ATF2 facility. The future of the ILC focussed part of linear collider activities will depend on the progress of the ILC project in Japan, building on the commonalities between CLIC and ILC, common R&D interests between CERN and KEK, and extensive European activities and capabilities related to ILC studies and technologies, inside and outside CERN.
Organisation	The International Linear Collider (ILC) studies are led by an International Development Team (IDT) where CERN participates. The CERN team also plays an important role in organising and facilitating European planning for the ILC preparation phase.
2023 targets	• Participate in relevant working groups for ILC and organize collaborative R&D efforts with KEK for ILC and CLIC; • Continue to play a coordinating and facilitating role for European planning and contributions to the ILC as the project evolves.

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(Global Industrial Production Readiness)

- Research with single-cell cavities to establish the best production process
  - Advanced Nb sheet production method
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- Globally common design compatible with High Pressure Gas Safety (HPGS) regulation
- 24 nine-cell cavities are to be developed for industrial-production readiness
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Production process

	# of cavities to be produced		
	Americas	Europe	JP/Asia
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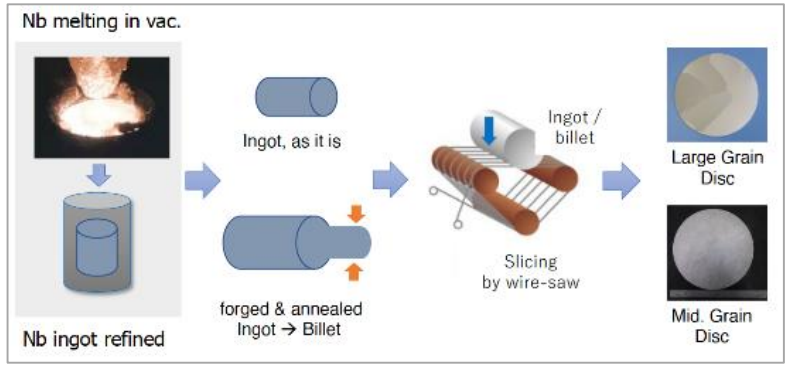

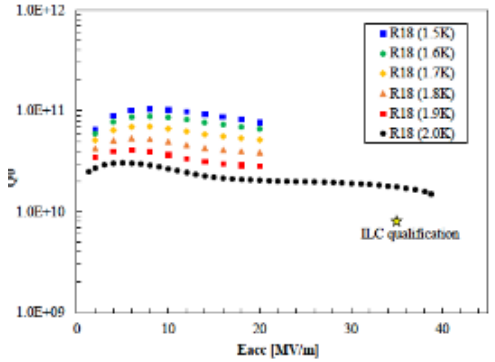

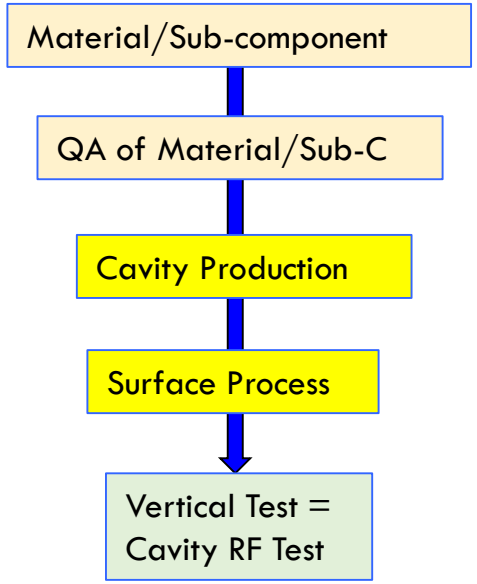

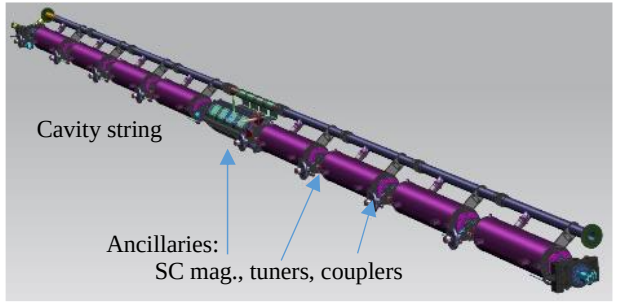

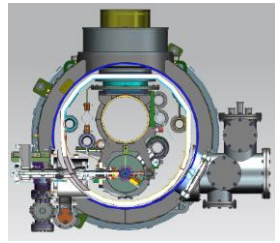

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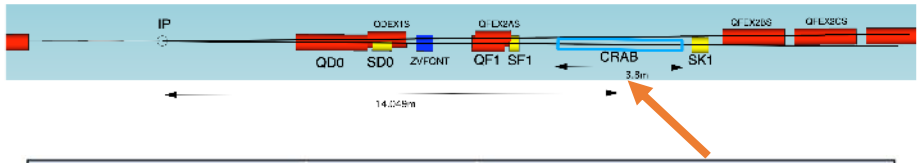
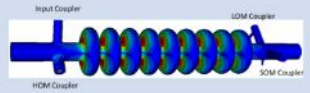
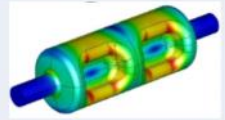
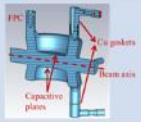
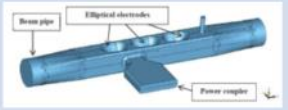


Elliptical/Racetrack (3.9 GHz)	Lanc. Univ.	
RF Dipole (RFD)	ODU	
Double Quarter Wave (DQW)	CERN	
Wide Open Waveguide (WOW)	BNL	
Quasi-waveguide MultIcell Resonator (QMIR)	FNAL	

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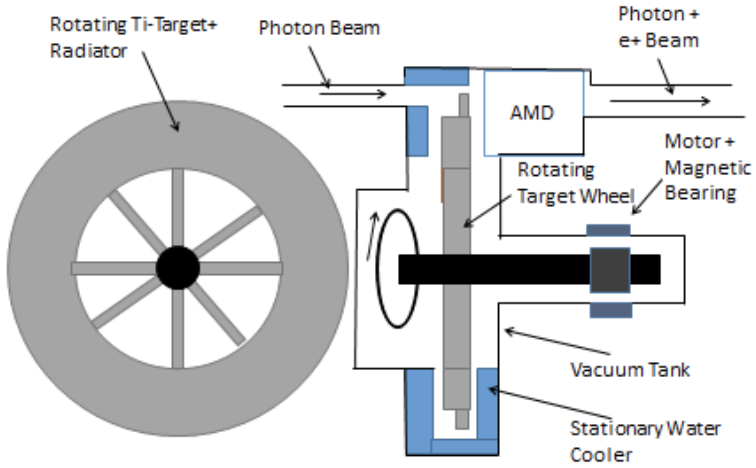
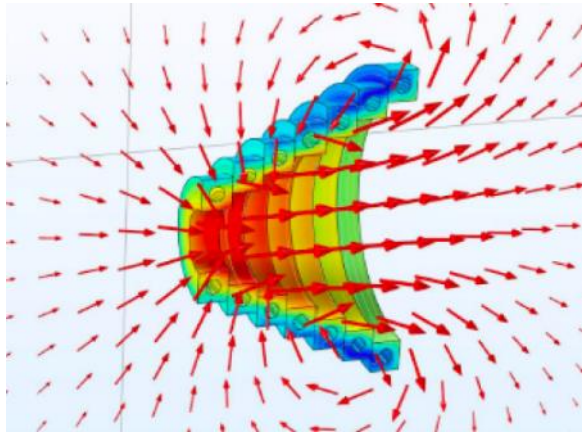
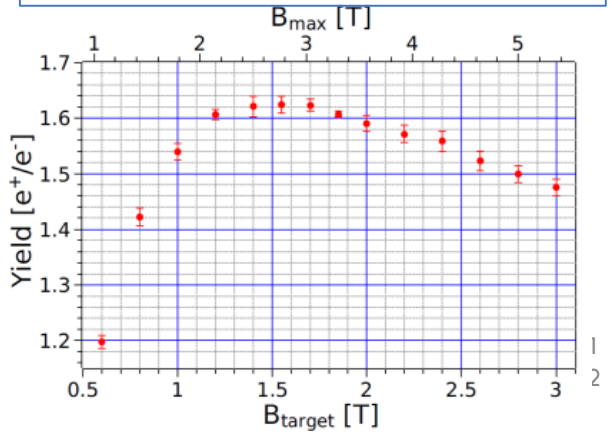
  - Detailed simulations (almost finished)
  - Ready for engineering design for a prototype PS
  - Field measurements with 1kA (pulsed and DC) and with 50kA both in a single pulse mode and finally in a 5ms pulsed mode at 5 Hz
  - Prototype of plasma lens as OMD (funded study on-going), example for application of new technology for the ILC
- Undulators are very popular photon sources, possible synergies

Principal Layout: Ti-Wheel with a Diameter of 1.0 m, rotating at 100 m/s, 2000 rpm.





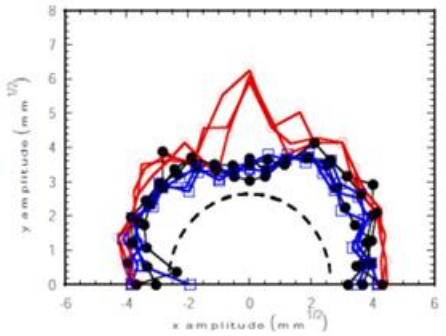
Yield versus field on the target



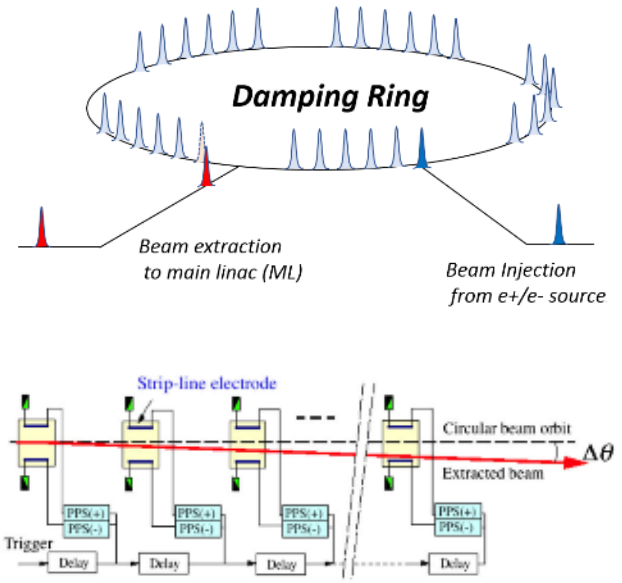
Group involved on European side in discussions of the programme:
Univ. of Hamburg, CERN, DESY, HZ Dresden-Rossendorf, SKF Jülich and possibly ESS-Bilbao.
For polarized positrons, providing physics advantages, linking also to FEL/undulators studies.

A3: Damping Ring optimization and injection/extraction

- The ILC damping ring (DR) is required to satisfy the low emittance and the large dynamic aperture simultaneously.
- The ILC DR will be further improved by incorporating the findings of the latest light source design. Increasing the dynamic aperture is also important in the design of DR.
- By quantitatively evaluating the effect of fringe field to the dynamic aperture of magnets in ILC DR, the method for evaluating fringe field to the dynamic aperture in accelerator design will be established and the design of ILC DR will be optimized.



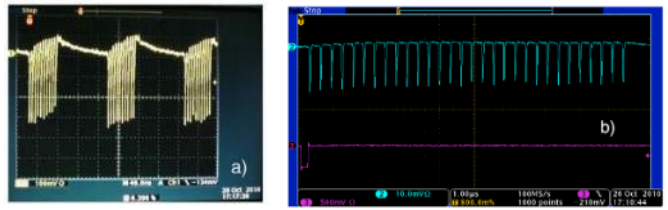
ILC fast injection/extraction system



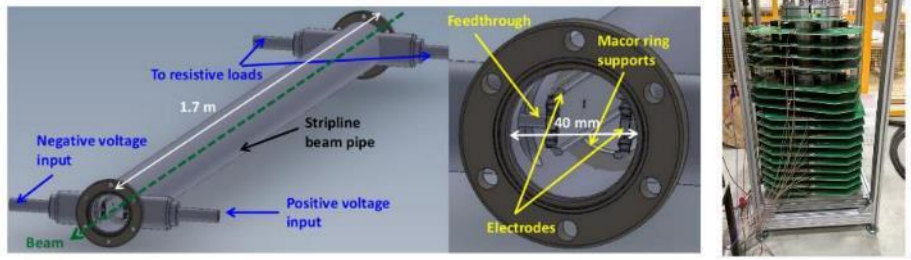
- A fast kicker system using a semiconductor pulse power supply with nanosecond response was confirmed as proof of principle at KEK's ATF about 10 years ago.
- Semiconductor technology has been evolving, and it is now possible to advance nanosecond response beam injection/excitation systems using the recent semiconductor technology.
- The technical evaluation of the fast kicker power supply using the recent semiconductor technologies.
- The evaluation of fast pulsed power supply technology will contribute not only to the fast kicker system but also to the performance and reliability of nanosecond-scale beam control technology and its application to a wide range of accelerator systems.

Beam extraction test at KEK ATF

Stored beam in DR **Extracted beam from DR**



Beam injection/extraction system for CLIC damping ring

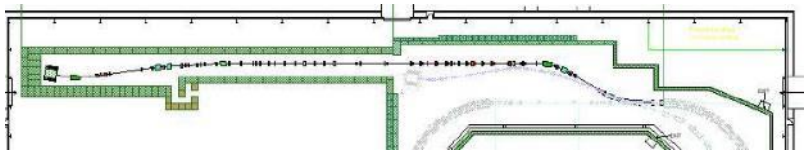


Many group can find this interesting and have capabilities to do it, there is a large and well organised low emittance ring community in Europe – and many also experience with similar studies for CLIC and FCC-ee.

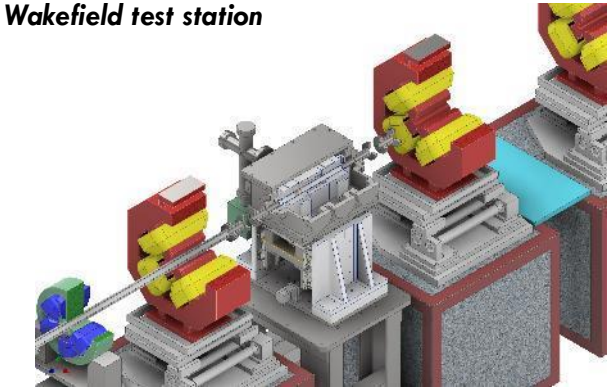
A4: ATF3 programme (final focus, nanobeams)

- ATF2 beamline is the only existing test accelerator in the world to test the final focus system (FFS) of linear colliders.
- The following 3 research topics are important topics to be pursued at the ATF.
  - wakefield mitigation
  - correction of higher-order aberration
  - training for ILC beam tuning
- The technical research at ATF2 beamline has proceeded, and should continue to be based on the ATF international collaboration, or its extension (welcome to new collaborators).

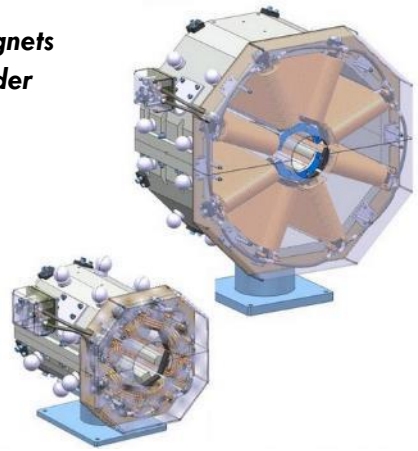
ATF2 beamline

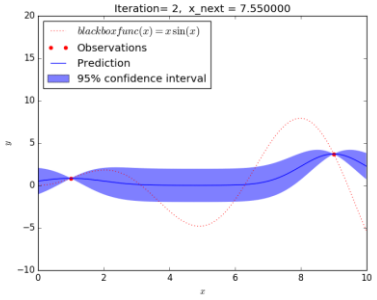


Wakefield test station



Octupole magnets for higher-order aberration





Maximum search algorithms to be applied to beam tuning (Machine Learning)

Very relevant studies for any linac and Higgs factory closely related to low emittances and nano beams, e.g. alignment, stabilisation, instrumentation, beam-dynamics, etc.

- Strong European leadership with several group from **France, UK, Spain, Germany and also CERN, also extensively used for PhD training**
- A future ATF3 programme has been defined and reviewed internationally, supported also by MC researcher exchange programmes as EJADE and EAJADE (LINK)

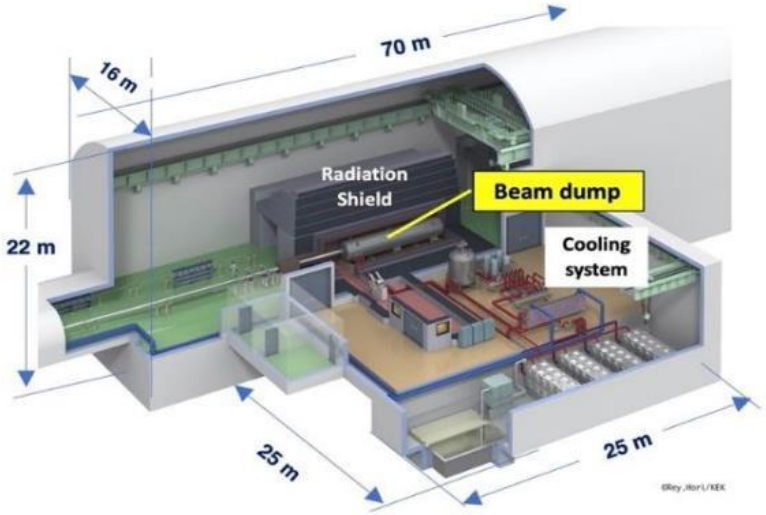
A5: Implementation studies

- Project Office to follow this effort, admin base CERN but can/should be distributed
  - Linking to EAJADE and communication efforts, and the KEK-CERN offices

- Continue existing collaborative efforts on CE and Cryo (CERN, DESY, KEK)
- Common studies CLIC/ILC on sustainability issue (ongoing), e.g. power, energy and running models, CO2 (sustainability is also an EAJADE WP).
  - the four activities above are all addressing optimisation of lum. to power, and/or power consumption directly for ILC
  - will also connect to green ILC studies in Tohoku within EAJADE (e.g. facility integration in local environment and infrastructure, carbon emission goals, power availability and sources)
- Connecting to ILC physics and detector developments, in particular MDI (also a focus of EAJADE)

- One of the ITN studies also belong to this activity:

  - Finalize the engineering design of the main beam dump system
    - Vortex water flow in the dump vessel
    - Cooling water circulation and heat exchange
    - Remote exchange of the beam window
    - Countermeasure for failures / safety system



Involved: CERN, EAJADE community, ESS Bilbao for dumps. Many of these topics are related to exploiting communalities between EXFEL, HL-LHC or CLIC and ILC