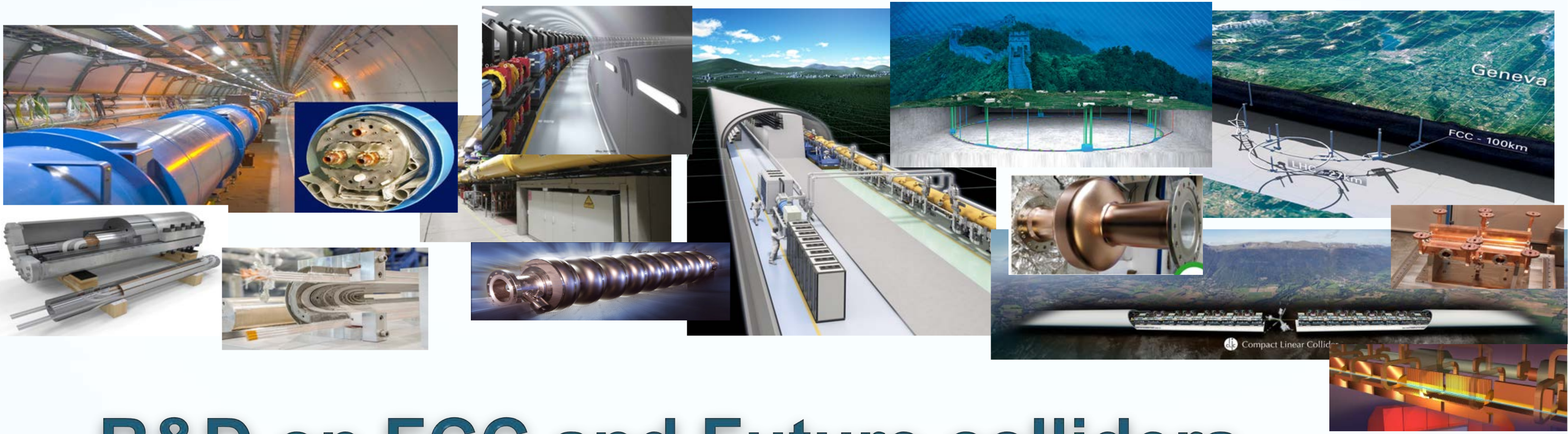


R&D on FCC and Future colliders at IN2P3

FCC-NPC

Institut national de physique nucléaire et de physique des particules

cnrs

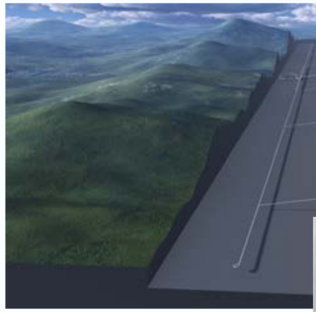
LAPP

IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

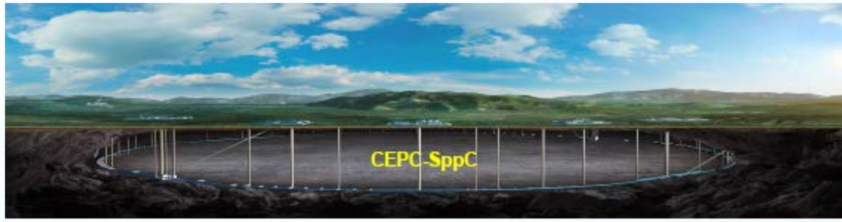
A. Faus-Golfe on behalf FCC-NPC team

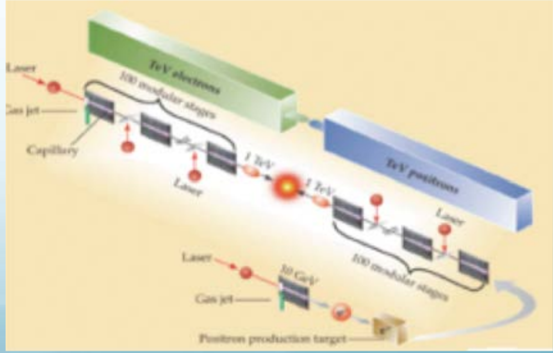
Outline

- **Introduction: HEP colliders**
  - Context
  - State of the Art and Scientific Issues
  - (IN2P3 contribution)
- **The FCC-NPC project**
  - Objectives and WPs
  - Timeline
- **Team, Resources and Budget**
- **Equipment Needs / Use Platforms-Infrastructures**
- **Genesis, Perspectives and Records**
- **SWOT analysis**







Present and Future Large Accelerator projects

In operation
In construction
Under study

An uncompleted view …

International Large Scale Projects

EPPSU

2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050 2052 2054 2056

LHC
ATF2
Super KEKB
XFEL
…

ESS
SC linac

ATF3

HL-LHC
11T Nb_3Tn

FAIR

LBNF

CepC.
High current
Z-pole

LHCeC
ERL

EIC

ILC
1.3GHz SC
nano-beam/stabilization

CLIC
12 GHz
nano-beam/stabilization

FCCee
High current
Z-pole

FCChh
16T Nb_3Tn/NbTn

FCCeh
ERL

HE-LHC (HL-LHC)
16T Nb_3Tn/NbTn

SppC

FCChh (FCCee)
16T Nb_3Tn/NbTn

$\mu^+\mu^-$

Present and Future Large Accelerator projects

In operation
In construction
Under study

An uncompleted view …

What will be next collider ?

International Large Scale Projects

EPPSU
FCC/CLIC, ILC ?

2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 20… 2056

LHC
ATF2
Super KEKB
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…

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FCChh
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16T Nb_3Tn/NbTn

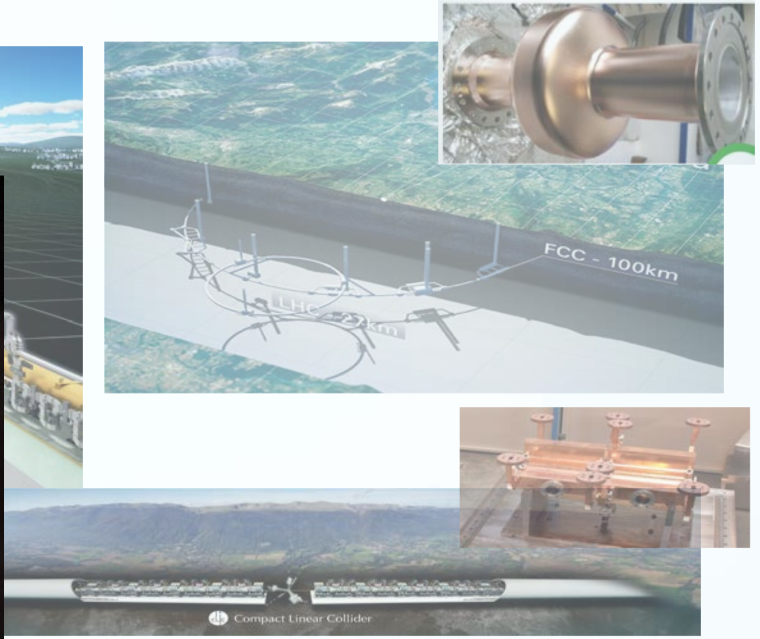
SppC

…**h (FCCee)**
16T … b_3Tn/NbTn
$\mu^+\mu^-$

Present and Future Large Accelerator projects

In operation
In construction
Under study

An uncompleted view …



International Large Scale Pr

EPPSU
FCC/CLIC, ILC ?

2018 2020 2022 2024 2026 20 … 2048 2050 2052 2054 2056

LHC
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Super KEKB
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…

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HL-LHC
11T Nb_3Tn

FAIR

ATF3

L

FCChh (FCCee)
16T Nb_3Tn/NbTn

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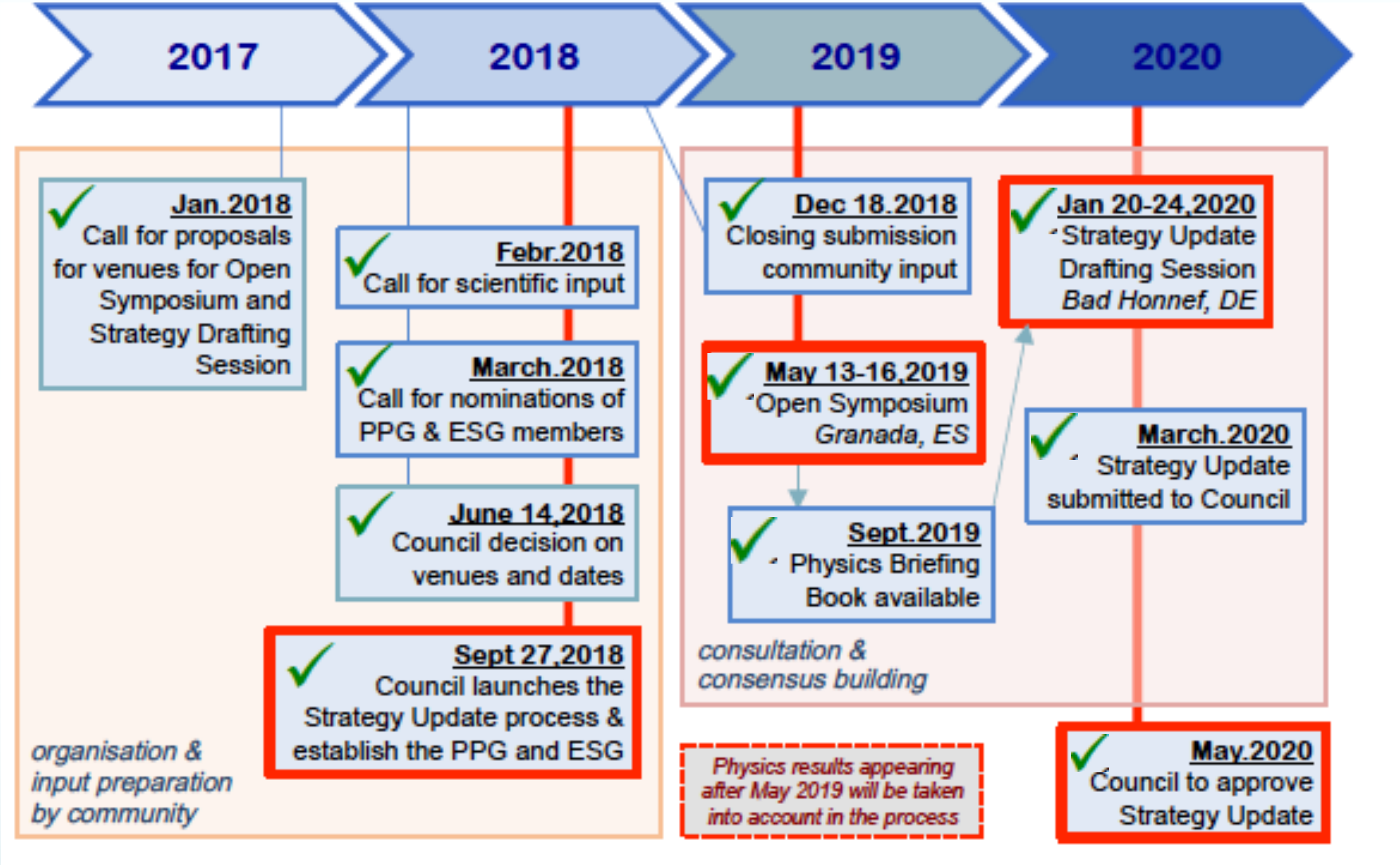
A complex choice

EIC

nano-beam/stabilization

Context: EPPSU 2020 process update



Context: EPPSU 2020 process update

20 strategy statements have been unanimously adopted by the European Strategy Group (ESG) in January 2020:

European Strategy Update

2020 Strategy Statements

Guide through the statements

2 statements on **Major developments from the 2013 Strategy**
a) Maintain focus on successful completion of HL-LHC upgrade
b) Maintain support for long-baseline ν experiments in Japan and US and the Neutrino Platform

3 statements on **General considerations for the 2020 update**
a) Preserve the leading role of CERN for success of European PP community
b) Strengthen the European PP ecosystem of research centres
c) Acknowledge the global nature of PP research

2 statements on **High-priority future initiatives**
a) **Higgs factory as the highest-priority next collider and investigation of the technical and financial feasibility of a future hadron collider at CERN**
b) **Vigorous R&D on innovative accelerator technologies – through roadmap**

4 statements on **Other essential scientific activities**
a) **Support for high-impact, financially viable, experimental initiatives world-wide**
b) Acknowledge the essential role of theory
c) Support for instrumentation R&D – through roadmap
d) Support for computing and software infrastructure

2 statements on **Synergies with neighbouring fields**
a) Nuclear physics – cooperation with NuPECC
b) Astroparticle – cooperation with APPEC

3 statements on **Organisational issues**
a) Framework for projects in and out of Europe
b) Strengthen relations with European Commission
c) Play active role in supporting Open Science

4 statements on **Environmental and societal impact**
a) **Mitigate environmental impact of particle physics**
b) Invest in next generation of researchers
c) Support knowledge and technology transfer
d) Spread cultural heritage: public engagement, education and communication

Letters for itemizing the statements are introduced for identification, do not imply prioritization

Note: H. Abramowizc ESG January 2020.

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a) Mitigate environmental impact of particle physics
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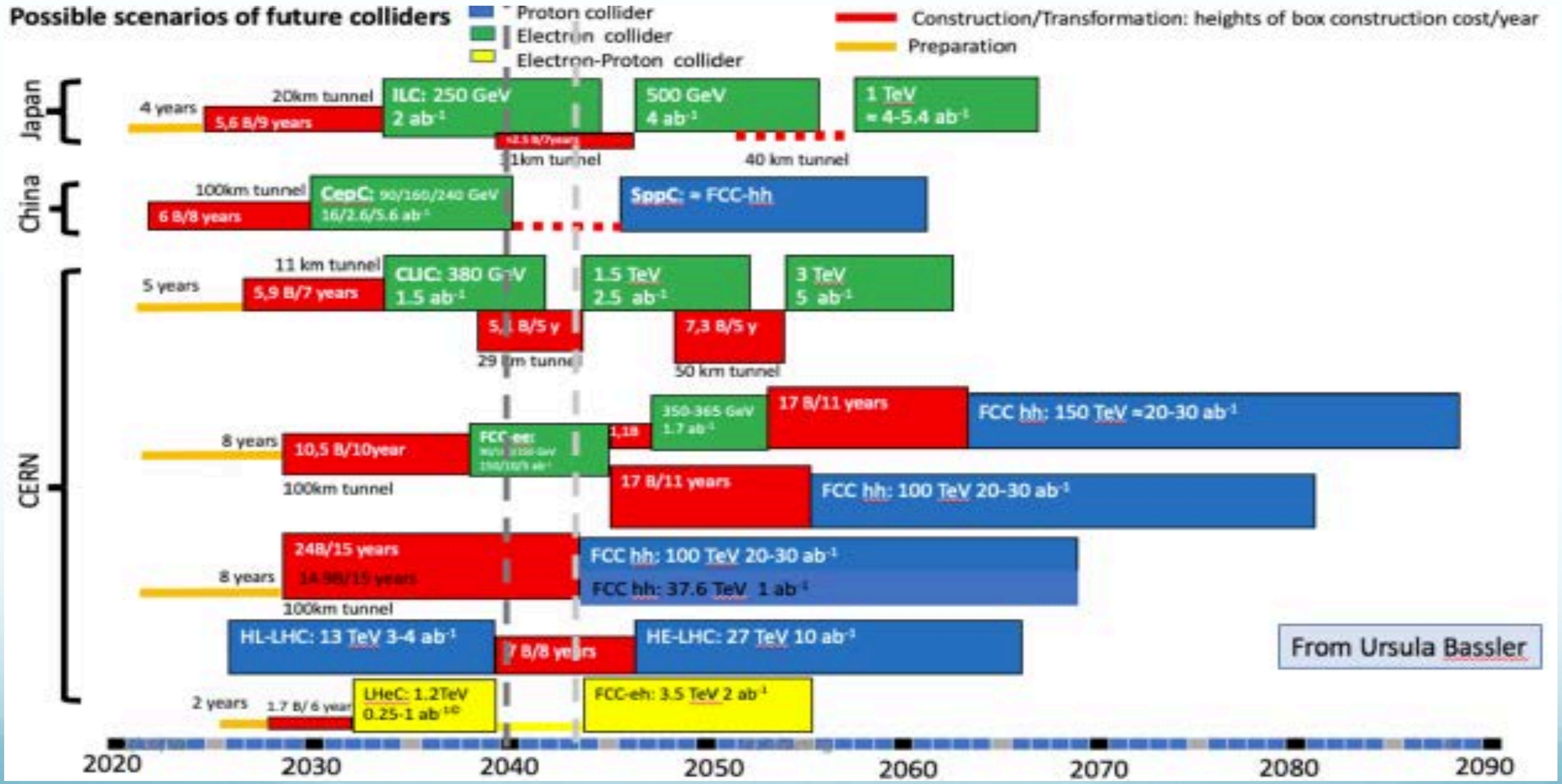
Letters for itemizing the statements are introduced for identification, do not imply prioritization

High-priority future initiative:
Prepare a **Higgs factory**, **followed by a future hadron collider** with sensitivity to energy scales an order of magnitude higher than those of the LHC, while **addressing** the associated environmental and **technical challenges**

Note: H. Abramowizc ESG January 2020.

Context: EPPSU 2020 process update

Map of possible future facilities



Context: EPPSU 2020 process update

Map of possible future facilities

HEP is Global, planning facilities is not independent. High level of cooperation and collaboration are needed.

Context: EPPSU 2020 process update

Technology View on Relative Timelines

Timeline	~ 5	~ 10	~ 15	~ 20	~ 25	~ 30	~ 35
Lepton Colliders – Linear and Circular:							
SRF-LC/CC	Proto/pre-series	Construction		Operation		Upgrade	
NRF–LC	Proto/pre-series	Construction		Operation		Upgrade	
Hadron Collier – Circular :							
14~16T Nb_3Sn	Short-model R&D		Prototype/Pre-series			Construction	
12~14T Nb_3Sn	Short-model R&D	Proto/Pre-series		Construction		Operation	
9~12T Nb_3Sn	Model/Proto/Pre-series	Construction		Operation			Upgrade
6~8T NbTi	Proto/Pre-series	Construction		Operation		Upgrade	

Note: LHC experience: NbTi, 10 T R&D started in 1980's and 8.3 T Production started in late 1990's, after ~ 15 years

A. Yamamoto Granada Symposium 2019.

Context: FCC - Next Particle Collider

A rich R&D program is driving the developing and building of these new facilities. A strong cooperation between national institutes, CERN and others global laboratories or collaborations is vital for the progress of the field and also for preserving the expertise.

In this context the main goal of the FCC-NPC project is to ensure an appropriate contribution to this vibrant and diverse R&D program focusing in where we have already demonstrated our know-how and expertise:

IN2P3

- **Nanobeams handling**
- **Nanobeam stabilization and positioning techniques**
- **Luminosity monitoring**
- **High-intensity e+ sources**
- **e+e- polarimetry**
- **Dynamics vacuum and material studies**

Scientific issues: Nanobeam size handling

$$L = f_{coll} \frac{N_b^2}{4\pi\sqrt{\epsilon_x \beta_x^* \epsilon_y \beta_y^*}}$$

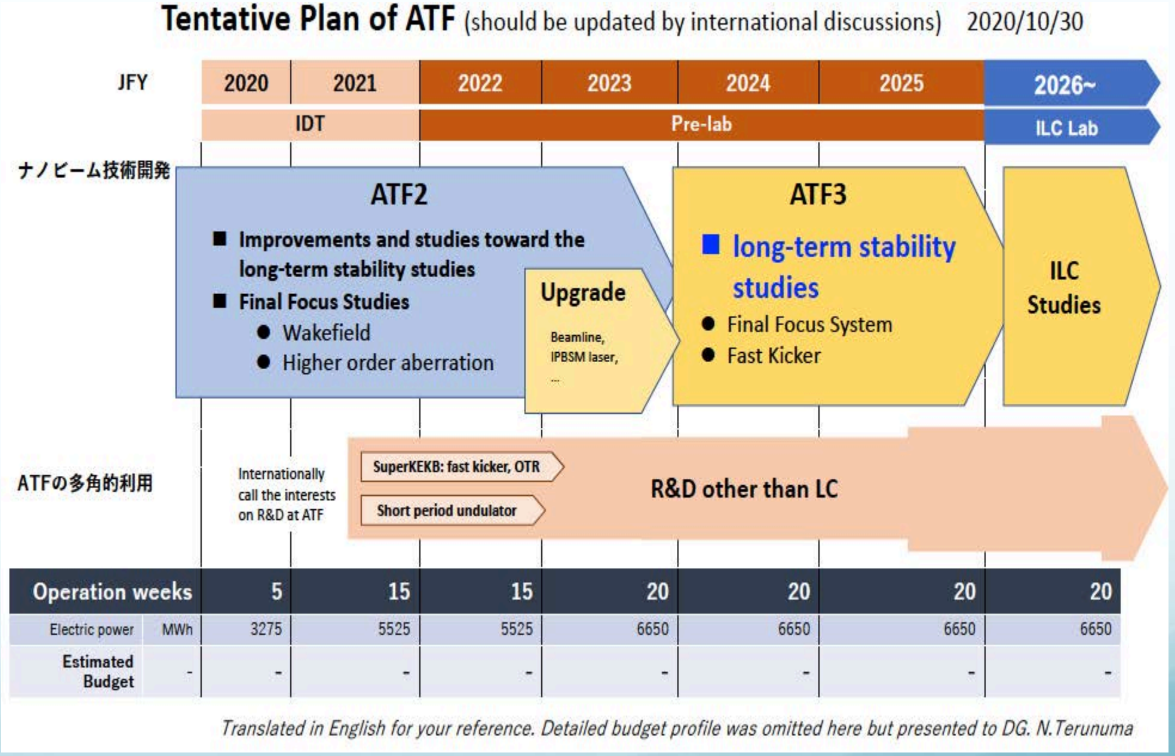
Very **high peak luminosity** needs **nanometre transverse IP beam sizes** (FCC-ee 30-70 nm, ILC 3-8 nm, CLIC 1-3 nm).
To **demagnify** the beams, complex **IR** and **FFS** are designed.

➢ ILC/CLIC scaled FFS: ATF/ATF2 ATF3

ATF/ATF2 FFS has verified the **minimal technical feasibility** of ILC-FFS, to **maximize** the **luminosity potential of ILC** a further investigation of:

- Intensity dependence effects on the IP size
- Optical aberrations specially with smaller β_x^*, design optics (β_x^* x β_y^*)
- Smaller sizes ultra-low β^* (CLIC)

will be pursued in a follow-on upgraded facility **"ATF3"** (ILC-IDT framed).



Scientific issues: Nanobeam size handling

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(FCC-ee 30-70 nm, ILC 3-8 nm, CLIC 1-3 nm).
To **demagnify** the beams, complex **IR** and **FFS** are designed.

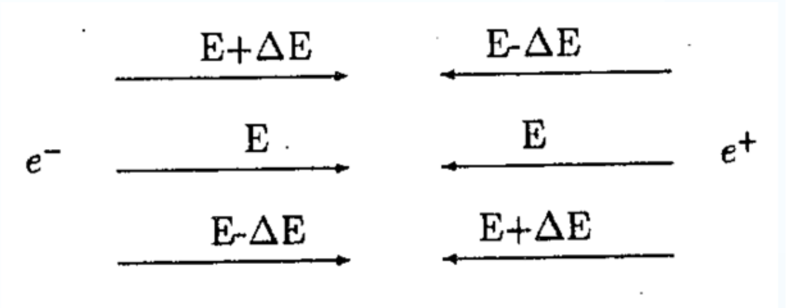
➢ FCCee IR studies: Monochromatization issues

In some “special” IR configurations as **monochomatization** the **energy spread** could be **reduced** to **maximize** the **sensitivity** of certain **physics channels**. Further studies on:

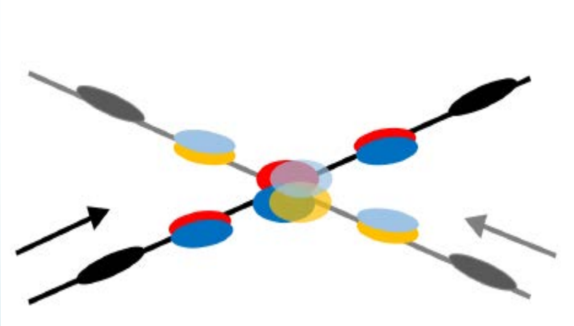
- Parameters including beamsstrahlung (increased ε_x) and crossing angle (crab cavities)
- Optics design to generate antisymmetric D_x^*

are needed to probe the feasibility of this kind of IR schemes.

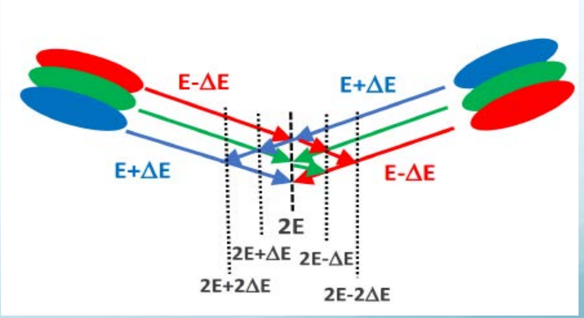
$$w = 2E_0 + 0(\varepsilon)^2$$



With crab crossing



Without crab crossing and integrated resonance scan



Different colours schematically indicate bunch portions with slightly different energies.

FCC-NPC Project: Objectives

- **WP2: Nanobeam size handling**

- **Objective 1: ATF3 ILC-CLIC FFS** facility **test optics design**, **long term stability operation** and tuning and **high-order aberration studies** in order to maximize the potential luminosity of ILC.

- **Objective 2**: Parametric study of a **monochromatic scheme** to maximize the sensitivity to the Yukawa coupling in **FCCee**, including beamsstrahlung and crossing angle effects between others and IR optics design implementation and integration of such scheme without luminosity degradation.

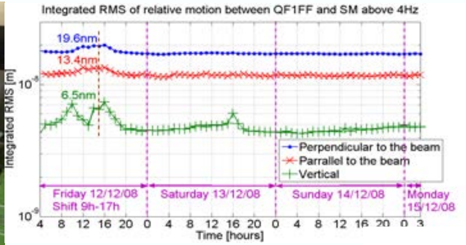
Scientific issues: Nanobeam stabilization and Positioning

Vibration mitigation and **misalignments control** are crucial to obtain **high luminosity** (CLIC FFS magnet specification displacements 0.2 nm at 4Hz).
With thousand of magnets**, dynamic positioning approach** by girder is the most effective approach.

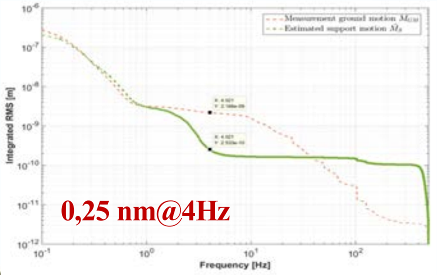
➢ Nanobeam stabilization

Ground Motion (GM), **structural vibrations effects** and **elements position inaccuracies has an impact on** beam brightness and position stability at the IP. R&D to mitigate this effect on:

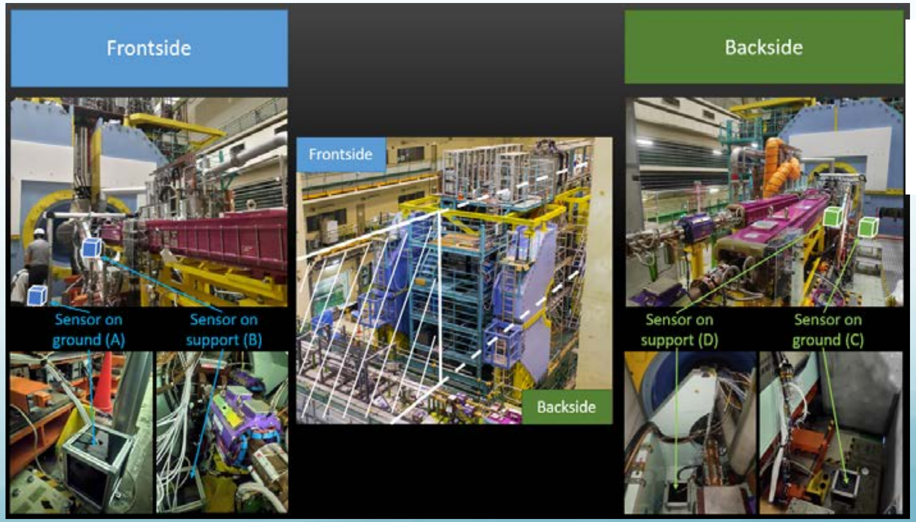
- **Coherence motion**, reducing the relative motions between the elements (main experiments strategy-low cost)
- **Active control**: reducing the absolute motion (high-cost)
- **Vibration monitoring** to evaluate the seismic and cultural noise (luminosity correlation...)



Coherence study at ATF2



Active control study for CLIC



4 seismic sensors (2 each side) BELLE II

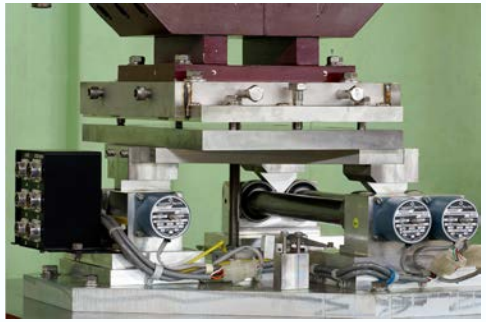
Scientific issues: Nanobeam stabilization and Positioning

Vibration mitigation and **misalignments control** are crucial to obtain **high luminosity**
(CLIC FFS magnet specification displacements 0.2 nm at 4Hz).
With thousand of magnets**, dynamic positioning approach** by girder is the most effective approach.

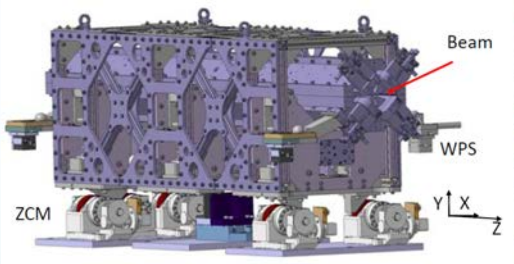
➢ Positioning techniques

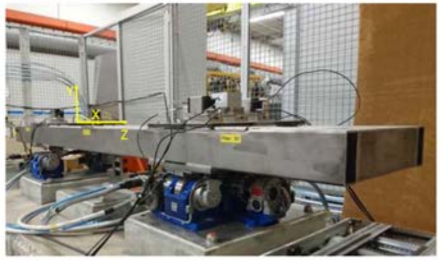
Positioning strategy based on the management of the girder position, with elements already aligned, is in the state of the art (ESRF, SLS, CepC)**.** R&D to extend the application is needed:

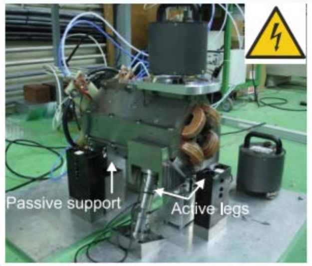
- **Actuators** (cam movers on components, control systems, nano-positioning systems)
- **Sensors**: Hydrostatic Leveling System, Wire Positioning Systems or differential sensors.



Camshaft driving motors at ATF2







Pre-alignment beam off: cam-mover alignment system positioning with WPS feedback system

Active-positioning

FCC-NPC Project: Objectives

- **WP3: Nanobeam Stabilization and Positioning techniques**

- **Objective 3:** Definition of **FCCee** MDI setup and strategy which respect the **vibration specifications**. These last ones have to be estimated with optics simulations and the acquired expertise on the **ATF/ATF2, CLIC** and **SuperKEKB experiment**.
- **Objective 4:** Develop the most adapted **positioning system** for **FCCee** girders to reduce misalignments during beam operation.

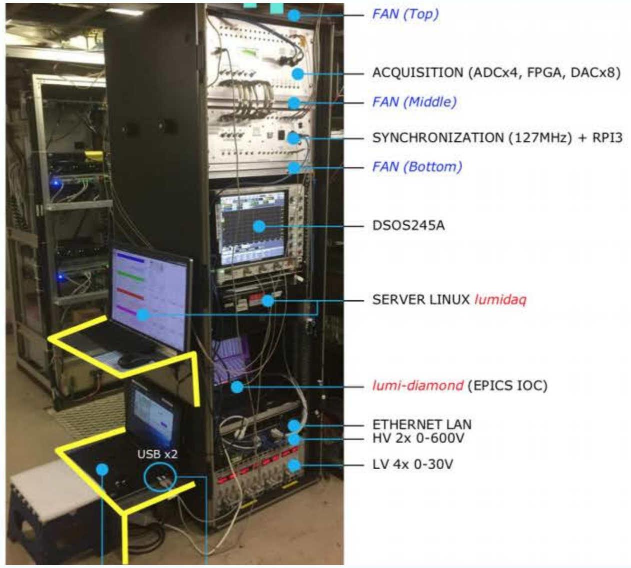
Scientific issues: Luminosity Monitoring

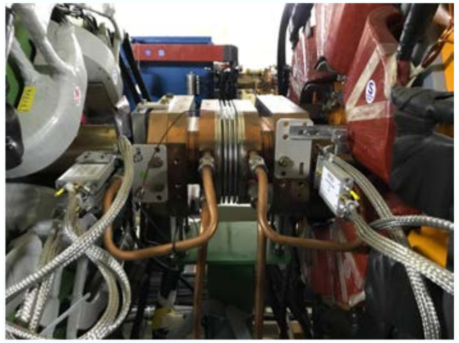
High luminosity implies the **dynamic correction** of **residual beam offsets** and **aberrations**, **fast luminosity measurement** are an essential tool.

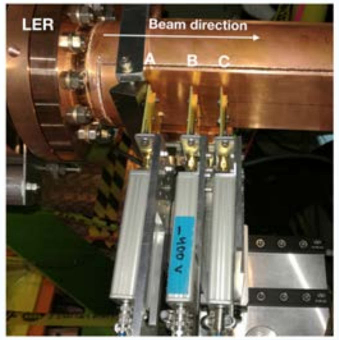
➢ Fast luminosity monitoring

Sufficiently **fast luminosity** or related **observables** as input to:

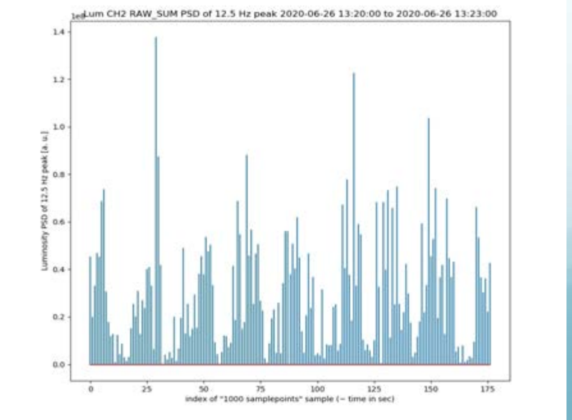
- **Feedback systems** which **stabilize** the **colliding beams** and **minimise** their **residual** horizontal and vertical **offsets.**
- **Aberration correction** tuning procedure due to imperfections in the field quality and alignment of magnets.
- **Luminosity optimization**, including mechanical vibration near the detector area







Power Spectral Density component at 12.5 Hz reconstructed during 3 minute scan: injections are visible lasting 10 seconds every 20 seconds !



FCC-NPC Project: Objectives

- WP4: Luminosity monitoring

- **Objective 5**: Conducting dedicated **experiments** at the **SuperKEKB** colliders, aiming at maximising its performance, including for specific tests and validations of concepts and methods being developed in the context of future colliders such as **FCCee**, in particular with respect to **luminosity optimisation** using LumiBelle2, study and **mitigation** of effects from **mechanical vibration near the IP**.

Scientific issues: High-Intensity e^+ sources

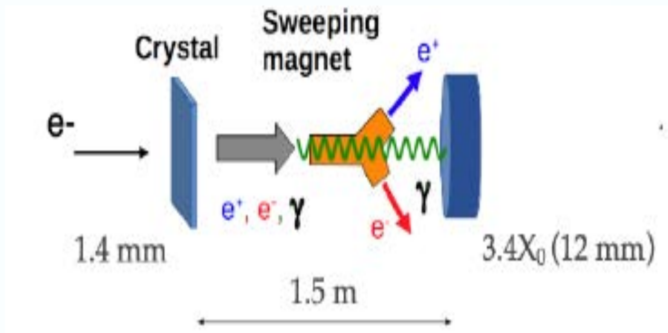
High-beam intensity and **low emittance e^+** are necessary to achieve high-luminosity
(ILC/CLIC 10^{16} e^+/second, FCCee 2.1×10^{10} e^+/bunch for 0.5 e^+/e^- yield)

➢ Novel types of e^+ sources

R&D beyond existing lepton injector technology :

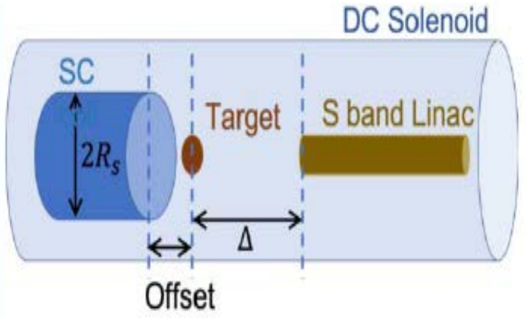
- **Novel types of e^+ source** based on the hybrid scheme (channeling in crystals) with new granular targets.
- **e^+ capture system** based on **SC solenoid** as the matching device for the capture system
- Use of the **Artificial Intelligence** (AI) for global **optimisation** of the e^+ injector parameters

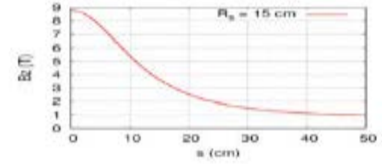
Hybrid target



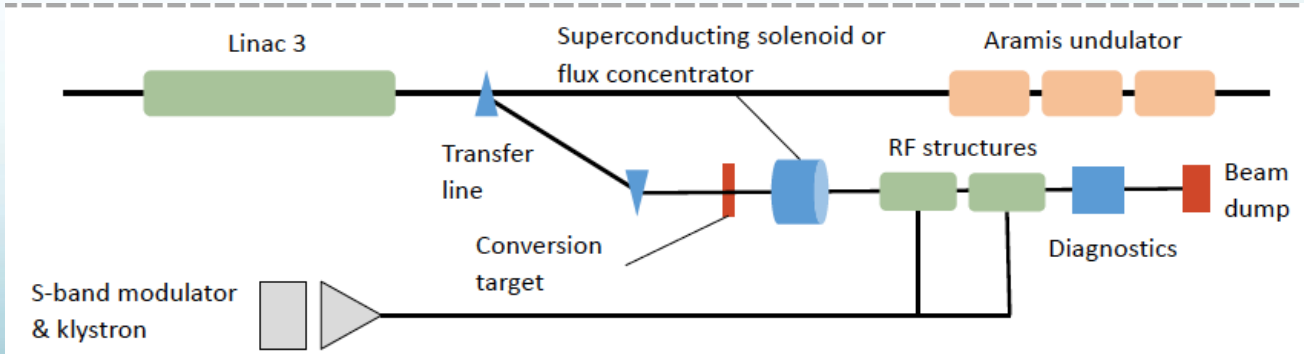
Hybrid target

AMD based on SC solenoid





e+ production test in SwisFEL



FCC-NPC Project: Objectives

- **WP5**: High-Intensity e^+ Sources

- **Objective 6:** Approach the **e^+ production** rate **10^{15}-10^{16} e^+/second** requested by the future collider projects, by means of novel types of e^+ sources based on **hybrid scheme** with **new granular targets** and positron **capture systems** based on **SC solenoids**.

Scientific issues: e^+e^- Polarimetry

To **optimize** the **collision** of polarized beams, **rapid measurements of polarization** are a key ingredient. (ILC per-mil level precision)

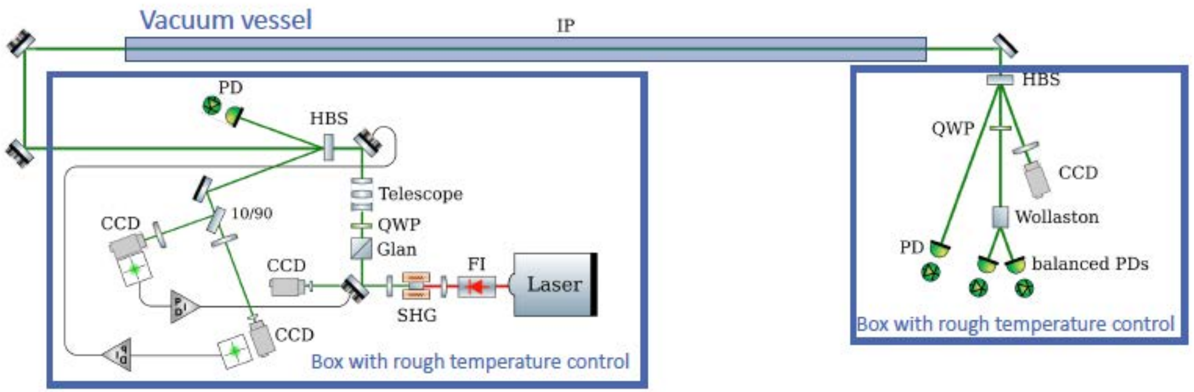
➢ Compton polarimetry

R&D on:

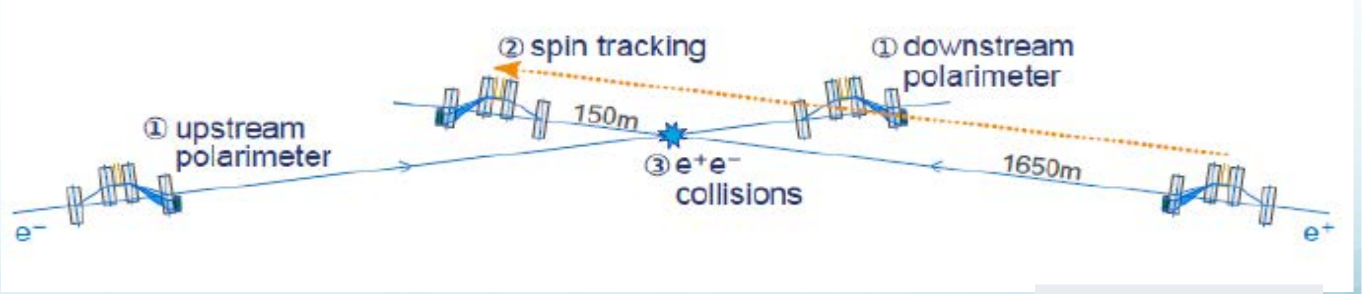
- Design of the **laser systems** in terms of the real time monitoring of the laser-beam polarization that enters as an unavoidable systematic uncertainty on longitudinal polarization
- Feasibility study of **per-mil level** precision

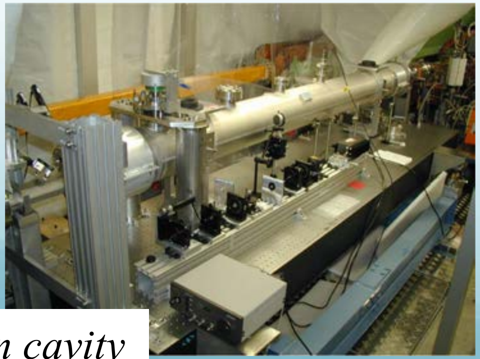
5W green laser at 250MHz

Laser beam injection line



Compton polarimeter + Spin tracking + e^+e^- collision data





HERA polarization cavity

Upstream Laser design: 30µJ/pulse in red for continuous ellipsometry at 1.8 MHz, 100W in red 50W in green

Downstream Laser design: 100mJ at 2KHz

FCC-NPC Project: Objectives

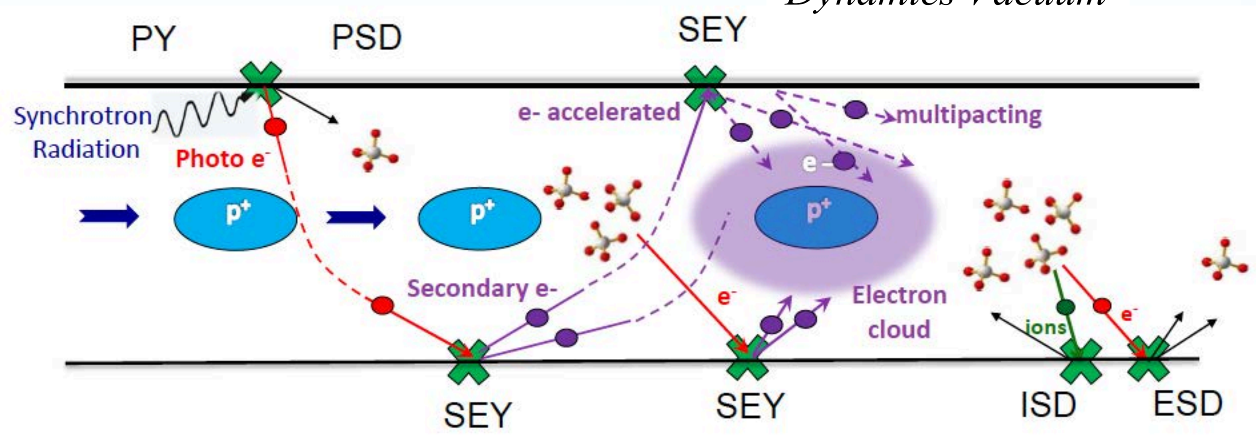
- **WP6: e^+e^- polarimetry**

- **Objective 7:** Design and optimization of **laser systems** for the **Compton polarimeters**, including the implementation and the laser beam transport for **SuperKEKB** and **ILC**. In particular for the ILC to obtain the required one **per-mille precision** on the determination of the **laser polarization** in the accelerator, in a reliable and reproducible way, which otherwise may become a limiting systematic uncertainty.

Scientific issues: Dynamics Vacuum and Material studies

One of the main **potential limitation** in all future colliders is the **dynamic pressure**. Specifications of **vacuum systems** and vacuum studies, including **materials** are of paramount importance.

Dynamics Vacuum

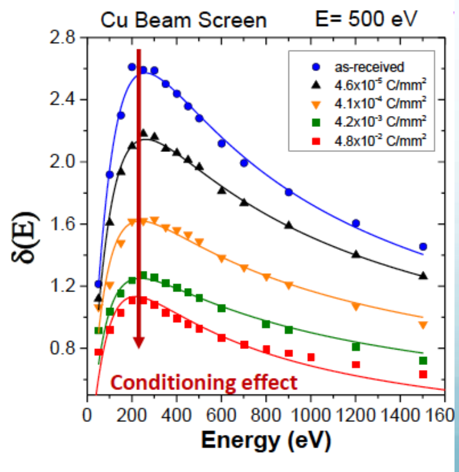


- **Dynamics Vacuum and New Materials**

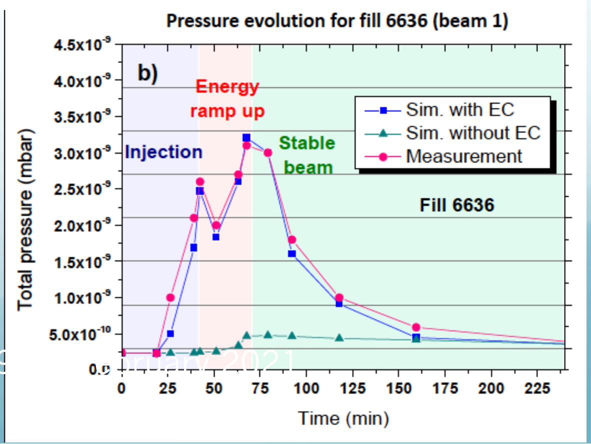
R&D on:

- Measurement of the **Secondary Emission Yield** (SEY) a fundamental parameter for multipacting
- **Ion Stimulated Desorption** (ISD) in particular the different yields of production
- **Dynamic pressure simulation** code development (DYVACS)

SEY measurements



LHC measurements versus DYVACs simulations



FCC-NPC Project: Objectives

- **WP7: Dynamic Vacuum and Material studies**

- **Objective 8**: Contribute to understanding the **global dynamic pressure phenomena** related to **stimulated desorption**, charged particle creation and charged **particle cloud build-up** in next generation of particle collider. Furthermore special attention will be paid to the materials **properties** studies, including **innovative materials** (high electrical conductivity, high radiation resistance, high mechanical strength, low desorption yield, low SEY with a fast conditioning, weak magnetic permeability and, if possible, with a pumping action).

The Project: in a nutshell

FCC - Next Particle Collider

Institut national de physique nucléaire et de physique des particules

Coordinator:
A. FAUS-GOLFE

2021

Parameters

Resp: A. FAUS-GOLFE
L. BRUNETTI
P. BAMBADE
I.CHAIKOVSKA
A.MARTENS
B.MERCIER

ILC-ATF2
CLIC
SuperKEKB
FCC

MP-IN2P3

Nanobeams

Resp: A. FAUS-GOLFE
A. PASTUSCHENKO (PhD)
V. CILENTO (PhD)

ILC-ATF2
CLIC
FCCee

MP-IN2P3
FJPPL

Stabilisation

Resp: L. BRUNETTI
G. BALIK
B. AIMARD
A. DOMINJON
IR PHYSICS
NEW POSTDOC

ILC-ATF2
SuperKEKb
FCCee

MP-IN2P3
FJPPL
FCC-IS

Luminosity

Resp: P. BAMBADE
S. WALLON

SuperKEKB

MP-IN2P3
FJPPL

Positrons

Resp: I. CHAIKOVSKA
A. FAUS-GOLFE
S. WALLON
V. KUBYTSKY
H. GULER
B. BAI (PhD)
NEW POSTDOC
NEW PhD

FCCee
SuoerKEKB
ILC
Muon coliders

MP-IN2P3
FJPPL
IFAST
MoU FCC

Polarimetry

Resp: A. MARTENS
F. ZOMER
Y. PEINAUD

ILC
FCCee
SuperKEkB

MP-IN2P3
FJPPL

Vacuum

Resp: B. MERCIER
G. SATTONNAY
F. LETELLIER
E. MISTRETTA
IR PHYSICS
S. BILGEN (Postdoc)

FCC

MP-IN2P3
MoU FCC

The Project: WPs and Tasks

FCC-NPC WPs and Tasks	2021		2022		2023		2024	
	S1	S2	S1	S2	S1	S2	S1	S2
WP1: Performances, Parameters and Synergies for FC								
T1.1: Meetings, Review, Perspectives	■	■	■	■	■	■	■	■
T1.2: Calls, Requests Funding, MoUs, Documentation	■	■	■	■	■	■	■	■
WP2: Nanobeam size handling								
T2.1: ATF3 ILC-FFS assessment system design			■	■	■	■		
T2.2: ATF3 ILC-FFS oriented beam experiments						■	■	■
T2.3: Monochrom parametric study for FCCee	■	■						
T2.4: FCCee monochrome optics implementation			■	■	■	■	■	■
WP3: Nanobeam stabilization and Monitoring								
T3.1: Ground motion/Mech. Vibrations SuperKEKB	■	■	■	■	■	■	■	■
T3.2: FCCee global vibration mitigation strategy	■	■	■	■	■	■	■	■
T3.3: Dynamic Positioning system studies	■	■						
T3.4: Design of positioning experimental set-up			■	■	■	■	■	■

FCC-NPC WPs and Tasks	2021		2022		2023		2024	
	S1	S2	S1	S2	S1	S2	S1	S2
WP4: Luminosity Monitoring								
T4.1: Operation, Maintenance of LumiBELLE2	■	■	■	■	■	■	■	■
T4.2: Online/Offline analysis of LumiBELLE2 data	■	■	■	■	■	■	■	■
T4.3: Specifications of luminosity monitoring for FCCeee			■	■	■	■	■	■
WP5: High-Intensity e+ sources								
T5.1: Simulation of e^+ target and capture system	■	■	■	■	■	■		
T5.2: Experimental test and data analysis			■	■	■	■	■	■
T5.3: Advance optimization for e^+ injector			■	■	■	■	■	■
WP6: e+e- Polarimetry								
T6.1: Compton polarimeter for SuperKEKB	■	■	■	■	■			
T6.2: Feasibility study of per-mil polarization precision			■	■	■	■	■	■
WP7: Dynamic Vacuum and Material studies								
T7.1: SEY measurements (OFE Cu, NEG alloys, amorph C...)	■	■	■	■	■	■	■	■
T7.2: ISD – CERN qualification set-up			■	■	■	■		
T7.3: VPS – CERN setup measurements				■	■	■	■	■
T7.4: DYVACS code developments	■	■	■	■	■	■	■	■

Team, Resources and budget I

FCC-NPC – 11.05 FTEs			
Team members	**Lab**	**FTE/year**	**Tasks & Expertise**
WP1: Performances, Parameters and Synergies for FC – 0.1 FTEs			
A.Faus-Golfe	IJClab	0.1	Coordination, Collider performances, Synergies
WPs leaders	IJClab / LAPP		
WP2: Nanobeam size handling - 2.2 FTEs			
A.Faus-Golfe	IJClab	0.2	Optics design, Beam dynamics, Beam experiments
A.Pastushenko (PhD)	IJClab / CERN	1.0 (end Oct 2021)	Optics design, Beam dynamics, Beam experiments
V. Cilento (PhD)	IJClab / CERN	1.0 (end Oct 2021)	Optics design, Beam dynamics, Beam experiments
WP3: Nanobeam stabilization and Monitoring - 3.3 FTEs			
L. Brunetti	LAPP	0.5	Control science
G. Balik	LAPP	0.5	Control science
B. Aimard	LAPP	0.2	Mechanical engineer
A.Dominjon	LAPP	0.1	Instrumentation
IR Physicist	LAPP	1.0	Beam dynamics, Beam diagnostics
Postdoc3.1 IN2P3	LAPP	1.0	Beam dynamics, Beam diagnostics

Team, Resources and budget II

FCC-NPC – 11.05 FTEs			
Team members	**Lab**	**FTE/year**	**Tasks & Expertise**
WP4: Luminosity Monitoring – 0.5 FTEs			
P. Bambade	IJClab	0.2 (+ 0.3 Belle2)	Beam experiments and analysis
S. Wallon	IJClab	0.3	Mechanics, Beam experiments and analysis
WP5: High-Intensity e+ sources – 2.8			
I.**Chaikovska**	IJClab	0.4	Beam dynamics, Beam experiments
A.Faus-Golfe	IJClab	0.1	Optics design, Beam dynamics
S. Wallon	IJClab	0.2	Thermo-mechanics
V. Kubytsky	IJClab	0.05	Machine Learning
H. Guler	IJClab	0.05	Machine Learning
B.Bai (PhD)	IJClab / IHEP	1.0 (end Oct 2021)	Optics design, Beam dynamics
Postdoc5.1 FCC MoU	IJClab	1.0 (start May 2021)	Beam dynamics, Beam experiments
PhD5.1 IN2P3	IJClab	1.0 (start Oct 2021)	Beam dynamics, Beam experiments

Team, Resources and budget III

FCC-NPC – 11.05 FTEs			
Team members	**Lab**	**FTE/year**	**Tasks & Expertise**
WP6: e+e- Polarimetry – 0.45 FTEs			
A.Martens	IJClab	0.2	Design, Performances
F. Zomer	IJClab	0.1	Design, Performances
Y. Peinaud	IJClab	0.15	Mechanics, Integration
WP7: Dynamic Vacuum and Material studies – 1.7 FTEs			
B.Mercier	IJClab	0.4	Vacuum, Materials, Beam experiments
G.Sattonnay	IJClab	0.3	Vacuum, Materials, Beam experiments
F. Letellier	IJClab	0.1	Vacuum
E. Mistretta	IJClab	0.1	Vacuum
IR Physicist	IJClab	0.8 (start Dec 2021)	Vacuum, Materials, Beam experiments
S. Bilgen (Postdoc lab)	IJClab	0.8 (end Dec 2021)	Vacuum, Materials, Beam experiments

Team, Resources and budget IV

2020							
FCC-NPC R&D	**WP1: Parameters & Synergies**	**WP2: Nanobeam size handling**	**WP3: Nanobeam stabilization & Positioning system**	**WP4: Luminosity monitoring**	**WP5: High-Intensity e+**	**WP6: e+e- Polarimetry**	**WP7: Vacuum & Materials**
LABS	IJClab - LAPP	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
FUNDING	Material and Travelling: 64.5 (k€)						
MP-IN2P3	7 (4 Covid19)		30 (6 Cov19)	12 (2 Cov19)	19 (2 Cov19)		4
FJPPL		2	Cov19		Cov19	Cov19	
MoUs							2.5
	3	2	24	10	17		8.5
	Personnel: 3 PhDs 2 Postdocs						
MP-IN2P3					1 Postdoc (end Oct 2020)		
Lab. funds			1 Postdoc (end Oct 2020)				
CSC-UPSay					1 PhD (end Oct 2021)		
CERN-PhD		2 PhD (end Oct 2021)					

2021							
FCC-NPC R&D	**WP1: Parameters & Synergies**	**WP2: Nanobeam size handling**	**WP3: Nanobeam stabilization & Positioning system**	**WP4: Luminosity monitoring**	**WP5: High-Intensity e+**	**WP6: e+e- Polarimetry**	**WP7: Vacuum & Materials**
LABS	IJClab-LAPP	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
FUNDING	Material and Travelling: 46 + EU + R (k€)						
MP-IN2P3	6	3	12	7	12	3	3
FJPPL		R	R		R	R	
FCPPL		R					
EU projects			FCC_IS		I_FAST		
MoUs							
	6	3	12	7	12	3	3
	Personnel: 4 PhDs 3 Postdocs						
MP-IN2P3			1 Postdoc (start Jan 2021)		1 PhD (start Oct 2021)		
Lab. fund							1 Postdoc (start Jan 2021)
MoUs					1 Postdoc (start Feb 2021)		
CSC-UPSay					1 PhD (end Oct 2021)		
CERN-PhD		2 PhD (end Oct 2021)					

Team, Resources and budget IV

2022							
FCC-NPC R&D	WP1: Parameters & Synergies	WP2: Nanobeam size handling	WP3: Nanobeam stabilization & Positioning system	WP4: Luminosity monitoring	WP5: High-Intensity e+	WP6: e+e- Polarimetry	WP7: Vacuum & Materials
LABS	IJClab-LAPP	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
TOTAL (k€)							
Material (k€)							
115			30		30	35	30
Travelling (k€)							
70	5	10	15	10	15	10	5
185		10	45	10	45	45	35
Personnel							
4 PhD		1			1	1	1
3 Postdoc			1	1	1		

Equipment needs, Use of Platforms/Infrastructures

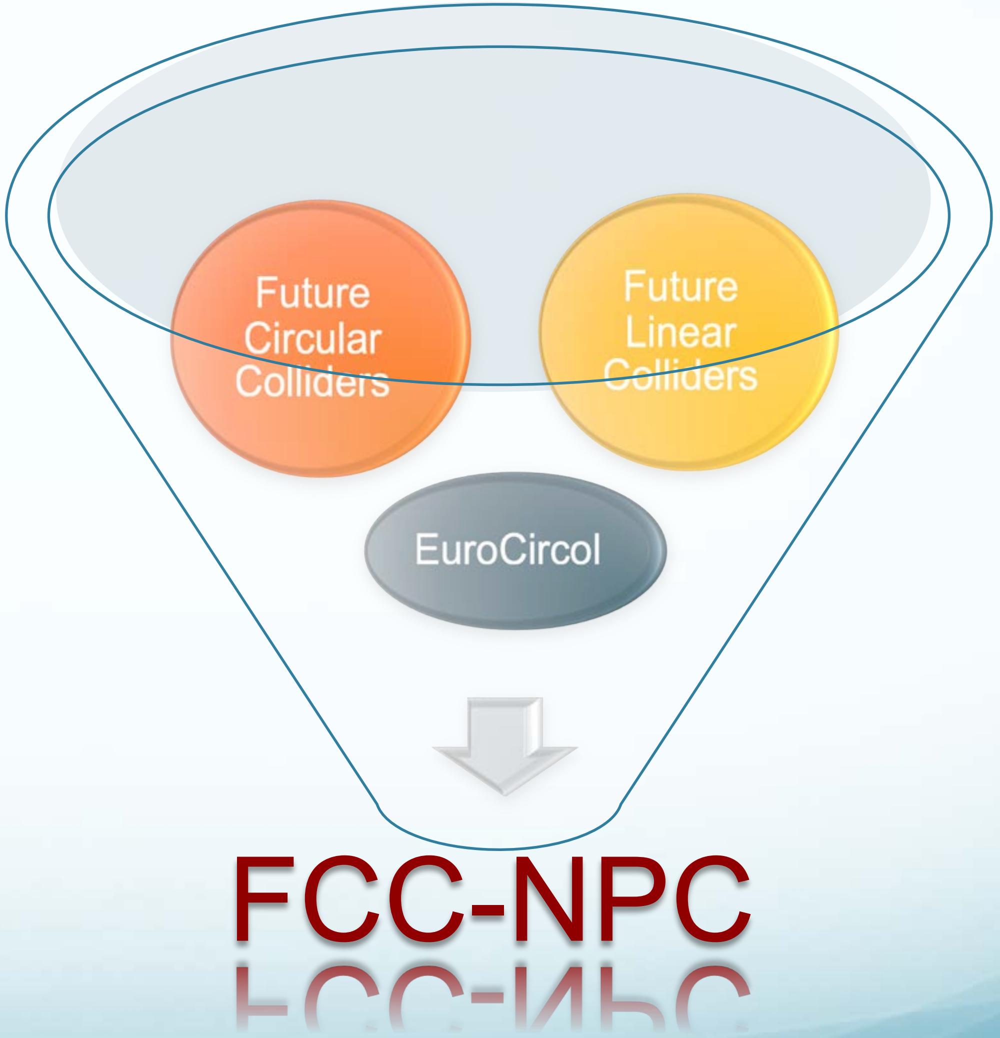
Platforms & Infrastructures							
FCC-NPC R&D	WP1: Parameters & Synergies	WP2: Nanobeam size handling	WP3: Nanobeam stabilization & Positioning system	WP4: Luminosity monitoring	WP5: High-Intensity e+	WP6: e+e- Polarimetry	WP7: Vacuum & Materials
LABS	IJClab-LAPP	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
EQUIPMENTS							
Mechanical Ws			X	X	X	X	X
Electronics Lab.			X	X	X		
Optical rooms						X	
Vac & Surfaces							X
Andromede							X
Vibrations			X				
ATF2/ATF3		X	X				
SuperKEKB			X	X	X	X	
LHC							X
MAMI					X		

Genesis, Perspectives and Records

- The **FCC-NPC project integrates, harmonize and synergize** the IN2P3 **R&D accelerator activities** related with **current and future colliders** at **IJClab** and **LAPP** (run as a “project”).

- In the **medium and long term** the ambition of the project is:
  - **Consolidate** the **R&D** areas
  - **Identify** the **approaches** with **greatest potential.**

All of this in **alignment** with the **IN2P3 strategy** and having in view the next **EPPSU strategy update.**



Genesis, Perspectives and Records

Achievements 2019-2020

- **CDR published January 2019 https://fcc-cdr.web.cern.ch/**
- **European Strategy Update Document 2019**
- **Prospectives IN2P3 20-20-2030 (G707)**
- **Conferences and Workshops 2019-2020:**
  - FCC 2019 week (2talks) https://indico.cern.ch/event/727555/timetable/
  - FCPPL Annual workshop 24-27 April 2019 (talk, organizer) https://indico.ihep.ac.cn/event/9587/
  - TYL-FJPPL Annual workshop 2019 8-10 May http://nuclear.korea.ac.kr/indico/conferenceTimeTable.py?confId=395#20190508
  - FCC-ee MDI workshop 9-20 September 2019. https://indico.cern.ch/event/839155/timetable/#20190909
  - FCC-ee Injector kick-off meeting, 2 October 2019, https://indico.lal.in2p3.fr/event/5829/
  - FCC-ee positron source studies and planned beam test at PSI, LAL, 17 October 2019
  - LCWS2019, 28 October-1 Nov (talk)
  - FCC France (talks organizer) 14-15 November 2019
  - CepC 2019 18-20 November 2019 https://indico.ihep.ac.cn/event/9960/timetable/
  - Mini-Workshop: Accelerator - Machine Detector Interface for Future Colliders, Hong-Kong 16-17 Janvier 2020 http://iasprogram.ust.hk/hep/2020/workshop_accelerator.php
  - Review ATF2 at KEK, 29 septembre https://agenda.linearcollider.org/event/8626/
  - Mini-CLIC workshop 2020 30 septembre- 1 octobre https://indico.cern.ch/event/952778/overview
  - Kickoff meeting FCC IS 9-13 novembre 2020
  - CepC 2020 18-20 November 2020
  - FCC France January 2021

Genesis, Perspectives and Records

- **Invited collaborators:**
  - P. Martyshkin Flux concentrator for positron source (October 2019) (P2I grant research stay)

- **Experimental campaigns**

CERN

- Measurement of ions in the VPS (Vacuum Sector Pilot) of the LHC (2019) (MoU CERN-IN2P3) (S. Bilgen)

KEK

- Restart of the positron injector for the phase 3 commissioning of superKeKB (February 2019) (FJPPL-positrons, FCC) (I. Chaivskoska, Y. Han)
- Participation in the Lumibelle2 and stabilization at SuperKekB (2019-2020) (P. Bambade)
- Participate in the ATF2 winter run (February 2020) (A. Faus-Golfe, A. Pastushenko)

- **New funding proposals:**

Funded

- H2020-INFRADEV-01-2019-2020 Frontier Circular Collider Innovation Study (FCC IS)
- CHART Swiss Research Foundation (tasks identified for LAL for positron sources tested in SwissFEL new line)
- H2020-INFRAINNOV-04-2020 RIA, “Innovation Fostering in Accelerator Science and Technology (I_FAST) 2021-2025

In preparation

- ILC-International Development Team (ILC-IDT) WG2 Accelerators: “Technical preparation for ILC-prelab”, 2022-2025 (Appendix 1).
- China Scholarship Council and UPSay PhD program “ Implementation of a monochromatic scheme for the direct s-channel Higgs production at FCC-ee”, 2020.
- FJPPL and FCPPL 2021-2022

Genesis, Perspectives and Records

Publications 2019-2020

- FCC CDR https://fcc-cdr.web.cern.ch/
- R. Bruce, A. Abramov, A. Bertarelli, M.I. Besana, F. Carra, F. Cerutti, A. Faus-Golfe, M. Fiascaris, G. Gobbi, A. Krainer, A. Lechner, A. Mereghetti, D. Mirarchi, J. Molson, M. Pasquali, S. Redaelli, D. Schulte, M. Serluca, E. Skordis, M. Varasteh, 'Collimation system studies for the FCC-hh', IPAC2019.
- I. Chaikovska et al. "Positron Source for FCC-ee", IPAC2019.
- M. Serluca, A. Dominjon, B. Aimard, G. Balik, L. Brunetti, B. Caron, A. Jeremie, G. Lamanna, 'Vibration Mitigation Methods to Optimize Colliders Performance', Poster Les Journees Accelerateurs 2019.
- M. Antonelli et al. "Positron driven muon source for a muon collider", arXiv preprint arXiv:1905.05747 (2019).
- P. Bambade, A. Faus-Golfe (Orsay, LAL) et al., "The International Linear Collider. A European Perspective", Jan 28, 2019. 11 pp. e-Print: arXiv:1901.0982.
- Philip Bambade, Tim Barklow, Ties Behnke, Mikael Berggren, James Brau, Dmitri Denisov, Angeles Faus-Golfe, Keisuke Fujii, Juan Fuster, Frank Gaede, Paul Grannis, Christophe Grojean, Andrew Hutton, Benno List, Jenny List, Shinichiro Michizono, Akiya Miyamoto, Olivier Napoly, Michael Peskin, Roman Poschl, Frank Simon, Jan Strube, Junping Tian, Maksym Titov, Marcel Vos, Andrew White, Graham Wilson, Akira Yamamoto, Hitoshi Yamamoto, Kaoru Yokoya, "The International Linear Collider: A Global Project", LAL/RT 19-001, IFIC/19-10, FERMILAB-FN-1067, KEK Preprint 2018-92, JLAB-PHY-19-2854, arxiv 1903.01629
- P. Korysko, A. Faus Golfe, A. Latina, K. Kubo, T. Okugi, N. Terunuma, "Intensity dependence effects at ATF2-KEK", IPAC19.
- D. Banon Caballero, W. Wuensch, K. Szypula, N. Catalan Lasheras, B. Gimeno, A. Faus Golfe, "Combined Fied Emission and Multipactor simulation in High-Gradient RF Accelerating structures", IPAC19.
- D. Banon Caballero , V. Sanchez, M. Boronat, N. Catalan-Lasheras, A. Vnuchenko, J.Paszkiewicz, V. del Pozo Romano, S. Pitman, M. Widorski, W. Wuensch, W.L. Millar, M.Volpi, T.G. Lucas, B.Gimeno, A. Faus-Golfe, "Dark Current Analysis at CERN's X-Band Facility", IPAC19.
- A. Vnuchenko, D. Esperante Pereira, B. Gimeno Martinez, S. Benedetti, N. Catalan Lasheras, M. Garlasch, A. Grudiev, G. McMonagle, S. Pitman, I. Syratchev , M. Timmins, R. Wegner , B. Woolley, and W. Wuensch, A. Faus Golfe, "High-gradient testing of an S-band, normal-conducting low phase velocity accelerating structure", Physical Review Accelerators and Beams 23, 084801 (2020)

Genesis, Perspectives and Records

- R. Yang, A. Pastushenko, A. Aryshev, M. Bergamaschi, V. Cilento, A. Faus-Golfe , M. Fukuda, P. Korysko, K. Kubo, S. Kuroda, T. Naito, T. Okugi, F. Plassard , N. Terunuma, R. Tomás, "Tuning the ultralow β* optics at the KEK Accelerator Test Facility 2", Physical Review Accelerators and Beams 23, 071003 (2020).
- P. Korysko, P. N. Burrows, A. Latina, A. Faus-Golfe, "Wakefield effects and mitigation techniques for nanobeam production at the KEK Accelerator Test Facility 2", Physical Review Accelerators and Beams 23, 121004 (2020).
- G. Sattonnay, V. Baglin, S. Bilgen, and B. Mercier, "DYVACS (DYnamic VACuum Simulation) Code: Calculation of Gas Density Profiles in Presence of Electron Cloud", IPAC19 Melbourne, May 2019, pp. 1244-1247. doi: 10.18429/JACoW-IPAC2019-TUPMP007.
- Lai, T. L., Jacquet, D., Ribaud, I., Eller, M. J., Verkhoturov, D., Schweikert, E. A., Tizei, L. H. G., Shao, F., Bilgen, S., Mercier, B., Sattonnay, G., & Della Negra, S. (2020). "Enhanced sputter and secondary ion yields using MeV gold nanoparticle beams delivered by the Andromede facility". Journal of Vacuum Science & Technology B, 38(4), 044008. https://doi.org/10.1116/6.0000173

PhDs since 2015

- Title: Striplines Kickers for CLIC Damping Ring, Student: C. Belver Aguilar, University: Valencia, Date: October 2015.
- Title: Development of Diamond Sensors for Beam Halo and Compton Spectrum Diagnostics after the Interaction Point of ATF2, Student: S. Liu, University: Paris-Sud, Orsay, Date: June 2015
- Title: Beam dynamics in the final focus section of the future linear collider, Student: O. Blanco, University: Paris-Sud, Orsay, Date: June 2015
- Title: BPM system for the Drive Beam of CTF3, Student: A. Benot Morell University: Politecnica de Valencia, Date: February 2016.
- Title: Fast Luminosity Monitoring Using Diamond Sensors for SuperKEKB, Student: D. El Khechen, University: Paris-Saclay, Orsay, Date: December 2016
- Title: Breakdown studies for high gradient RF warm technology in: CLIC and hadrontherapy linacs, Student: J. Giner Navarro, University: Valencia, Date: February 2017

Genesis, Perspectives and Records

- Title: Beam Halo Collimation and Induced Wakefield Studies for Future Linear Colliders: the ATF2 Case, Student: N. Fuster Martinez, University: Valencia, Date: July 2017.
- Title: Development of direct measurement techniques for the in-situ internal alignment of accelerating structures, Student: N. Galindo Muñoz, University: Politecnica de Valencia, Date: February 2018
- Title: Diagnostics and characterization of beam halo at the KEK Accelerator Test Facility, Student: R. Yang, University: Paris-Saclay, Orsay, Date: October 2018
- Title: Optics optimization of longer L* Beam Delivery System designs for CLIC and tuning of the ATF2 final focus system at ultra-low β* using octupoles, Student: F. Plassard, University: Paris-Saclay, Orsay, Date: July 2018
- Title: Fast luminosity monitoring and feedback using monocrystalline CVD diamond detectors at the SuperKEKB electron-positron collider in Japan, Student: C.G. Pang, University: Paris-Saclay, Orsay, Date: September 2019
- Title: High-Gradient issues in S-band RF Acceleration Structure for Hadrontherapy accelerators and Radio Frequency Quadrupoles, Student: A. Vnuchenko, University: Valencia, Date: June 2020.
- Title: Dynamic pressure in particle accelerators: Experimental measurements and simulation for the LHC, Student: S. Bilgen, University: UPSay, Date: December 2020.

Under Supervision

- Title: Simulations and Measurements of Vacuum discharge in High-Gradient RF Accelerators, Student: D. Bañon Caballero, University: Valencia, Starting Date: October 2017.
- Title: Optimization of the optics for the FFS of CLIC 380 GeV and experimental studies for ATF2, Student: A. Pastushenko, University: Paris-Saclay, Starting Date: October 2018.
- Title: Optics Design of a dual beam delivery system for lepton colliders and experimental measurements of the ATF2 ultra-low nanometer beam size, Student: V. Cilento, University: Paris-Saclay, Starting Date: October 2018.
- Title: Injector linac optimizations for FCCee and applications for PRAE, Student: B. Bowen, University: Paris-Saclay / University Chinese Academy of Sciences, Starting Date: October 2018.

SWOT self analysis

STRENGTHS	WEAKNESSES
• International, national and local projects - Participation in both the design and implementation of accelerator projects (LHC, ILC-CLIC, FCC, ...), with major responsibilities. - Existence of local accelerators and platforms in operation, under construction or at the proposal stage (ALTO, SUPRATECH, PHIL, Vacuum&Surfaces, IGLEX: ThomX and Andromede) - Excellent integration in expert teams of two state of the art projects currently in operation at KEK (ATF2 and SuperKEKB) **• Team** - Pioneering and multidisciplinary teams with broad expertise (Beam dynamics, Beam instrumentation, Mechanics, Material science…) - Global view of the field built up over years of involvement in international collaborations - Culture of engineer / researcher collaboration and project - Framed by the largest Accelerator Physics community in France. **• Teaching** - Training of doctoral students and Master 2: "Grands Instruments-PLATO" and NPAC -Possibility of internships and practical work **• Industrial relations** - Existence of links with manufacturers (Amplitude Systems, etc.)	**• Team** - Small teams, difficult to have impact, dispersion - Insufficiently coordinated and coherent approach by a set of skilled but diverse teams with little overlap in expertise or interests - Few recruitments, few permanent staff and posts at the University - Undersized technical groups to ensure international, national and local projects - Low mobility of some of the team members **• Teaching** - Low share of research professors - Few PhD theses for some of the team members - Very low number of HDRs in the accelerator field - Too restrictive conditions to obtain support for PhD students in comparison with competing teams abroad strongly limit our competitiveness internationally **• Technical resources** - Lack of available resources in electronics and online data acquisition systems (e.g. FPGA programming and online data handling) - Lack of appropriate / convenient local facilities for the testing / calibration of instrumentation, e.g. with suitable radioactive sources

SWOT self analysis

OPPORTUNITIES	THREATS
• **International, national and local projects** - Major contribution in several current and new global projects and European networks (EUCARD2, EuroCircol, EuPRAXIA, ARIES, AMICI, CompactLight, FCC_IS, I-FAST ...) and local platforms under construction - Strong links with major international labs (CERN, DESY, KEK, Fermilab, SLAC, IHEP….) - Development of transversal projects in the field of health and other applications - Strengthen ties with industrialists - Direct participation in currently the only operating state of the art high-energy electron-positron collider in the world, also serving as main test facility for accelerator concepts being developed for FCCee, CEPC, future tau-charm factories (and more generally also ILC). • **Major role** in **strengthening** existing collaborations, efficient pooling of resources and cooperation with others labs. • Promote **targeted projects** for concept studies and “high risk” technologies. • Very strong **pool** of brilliant **students** at UPSay	• **Teams** Reduction in human resources and loss of technical know-how in certain areas of expertise • Uncompetitive salaries compared to those in industry, and foreign research institutes and laboratories • **Projects** - Mismatch between short-term offers (3-5 years) and the actual duration of the projects. - Time spent responding to calls for tenders for insignificant returns - Managing contracts becomes more and more restrictive, complex and therefore time-consuming, requiring human resources of the project engineer type - Insufficient consideration of an appropriate balance between supporting local accelerator projects and R&D activities and direct involvement in major international projects

Thanks for your attention

Luminosity recipe: linear vs circular

$$L = f_c \frac{N_{e-} N_{e+}}{4\pi\sqrt{\beta_x^* \varepsilon_x}\sqrt{\beta_y^* \varepsilon_y}} = \frac{I_{e-} I_{e+}}{4\pi\sqrt{\beta_x^* \varepsilon_x}\sqrt{\beta_y^* \varepsilon_y} \cdot f_c \cdot e^2}$$

$$P_{SR} = V_{SRe-} I_{e-} + V_{SRe+} I_{e+}$$

The way to reduce SR power is to reduce beam currents in both electron and positron beam.
To keep luminosity high, one would need to reduce one, two or all in

$$\sqrt{\beta_x^* \beta_y^*} \cdot \sqrt{\varepsilon_x \varepsilon_y} \cdot f_c$$

Luminosity recipe: linear vs circular

- In **storage rings** additional limitations appear: **beam-beam tune shift** and IP chromaticity (small β_y^*) which favors **high beam currents**, **large emittance** and **high collision frequencies**

$$\xi_{x,y} = \frac{N\, r_0 \beta^*_{x,y}}{2\pi\gamma\, \sigma_{x,y}\,(\sigma_x + \sigma_y)} < 0.1 - 0.5$$

- In **linear** the relevant number is the **disruption parameter**

$$D_{x,y} = \frac{N_e}{\gamma_e} \frac{2r_e}{(\sigma_x + \sigma_y)\sigma_{x,y}} \sigma_z$$

- At **high-energies** the most dangerous effect **is beamstrahlung**: SR in strong EM field of opposing beam during collision. It can cause significant amount of energy loss, induce large energy spread and loss of the particles. Using very **flat beams** is the main way of mitigating this effect

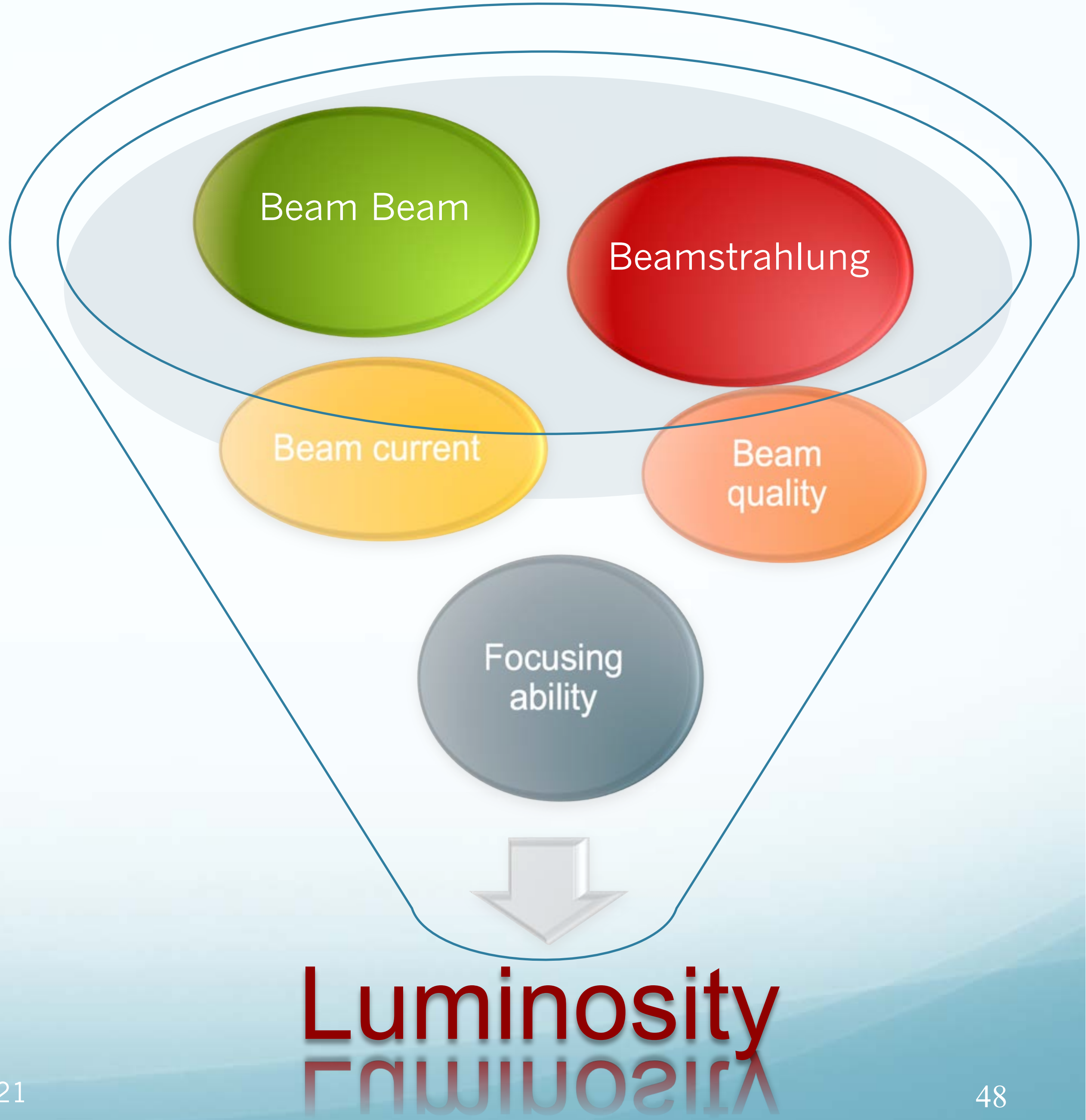
$$\langle \Delta\gamma \rangle = \frac{4}{9}\sqrt{\frac{\pi}{3}} N^2 \frac{r_e^3}{\sigma_x^2 \sigma_z} \gamma^2$$

$$for\ \sigma_x >> \sigma_y$$

Luminosity recipe

Luminosity cannot be fully demonstrated before project implementation:

- Luminosity is a feature of the facility not the individual technologies
- Relying in experience, theory and simulations
- Foresee margins

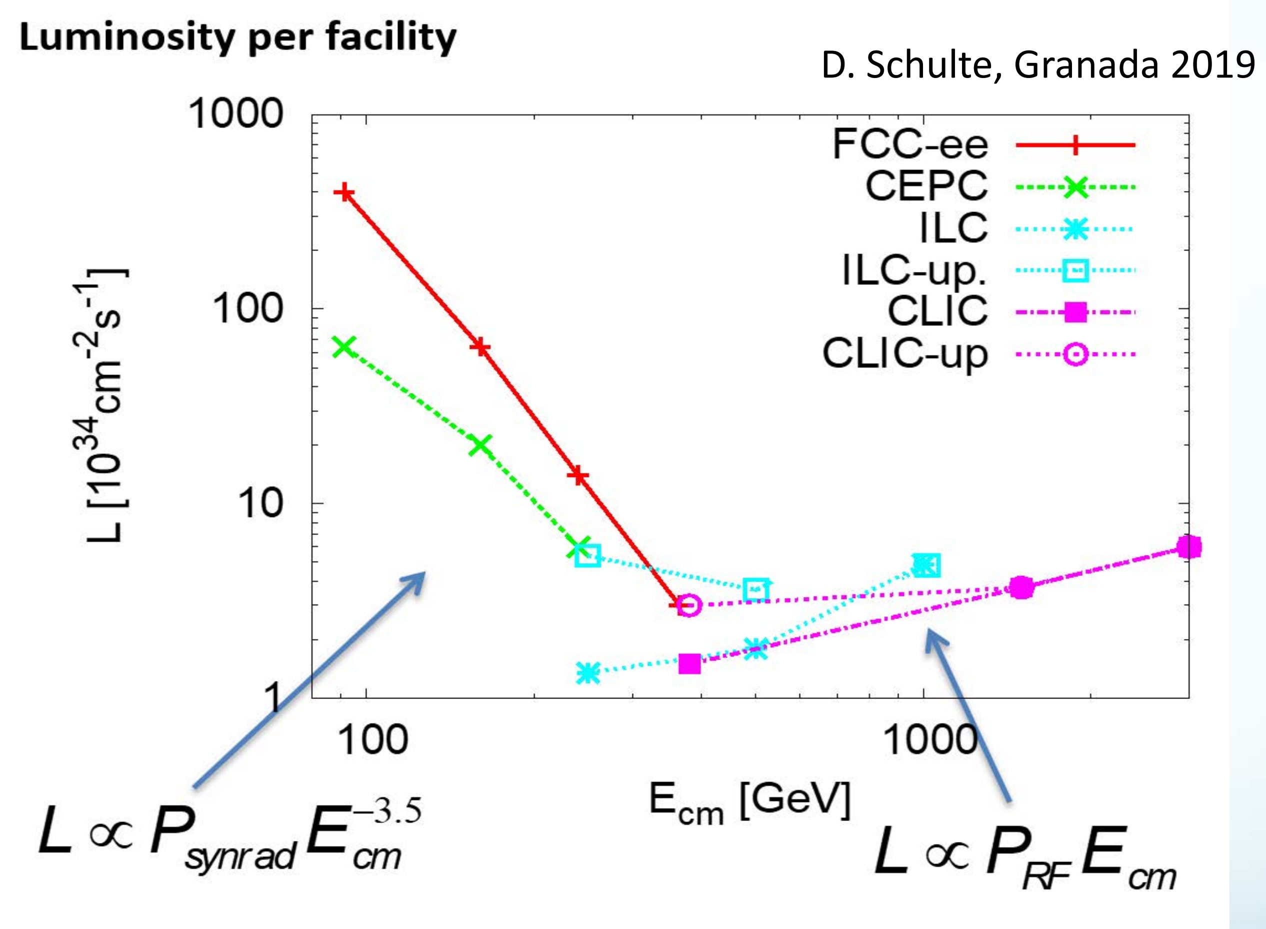


Luminosity recipe: the "dreamt" Luminosity

Energy dependence:

At **low energies circular** colliders surpass
- Reduction at high energy due to SR

At **high energies linear** colliders excel
- Luminosity per beam power roughly constant



Note: The typical higgs factory energies are close to the cross over in luminosity
Linear collider have polarised beams (80% e^-, ILC also 30% e^+) and beamstrahlung

ILC-IDT: the ICFA mandate

ICFA
ILC International Development Team
August 20, 2020

https://icfa.fnal.gov/wp-content/uploads/ICFA_IDT_Structure.pdf

At its 86th meeting held on August 2, 2020, ICFA approved the formation of the International Linear Collider International Development Team (ILC-IDT, referred to here as the Team) with a mandate to make preparations for the ILC Pre-Lab in Japan, which is the next step in the ILC project.

The Team has commenced its work and is expected to complete its mandate by the end of 2021.

Structure and function of the ILC-IDT

The Team is hosted by KEK and consists of the Executive Board (EB) and three Working Groups (WG1, WG2 and WG3).

The EB comprises:

- a Chair;
- a member from each of the three regions contributing to the ILC effort (Americas, Asia-Pacific and Europe); and
- three ex-officio members (KEK liaison officer and Chairs of WG2 and WG3, whereas WG1 is chaired by the EB Chair).

The EB members are appointed by ICFA. The EB has the overall responsibility for the Pre-Lab preparation.

The EB and WG1 will carry out the key tasks of developing the function and organisational structure for the Pre-Lab. They will support the preparation of Memoranda of Understanding among the national laboratories and other interested parties for the operation of the Pre-Lab and will support discussions at the national authority level.

WG1 membership is established by the EB, includes the EB members and is chaired by the EB Chair.

WG2 conducts the ILC accelerator and facility work.

WG3 carries out the ILC physics and detector activities.

The members of WG2 and WG3 will be appointed by the EB.

MICHIZONO) 2

ILC-IDT: the Executive Board

IDT-WG2 organization

IDT EB

IDT WG2
Shin Michizono (Chair)
Benno List (Deputy)

Tuesday (bi-weekly)

Charges of Sub-groups

- Discuss and coordinate the topics for
  - technical preparation (remaining topics) at Pre-lab
  - preparation for mass production at Pre-lab
  - possible schedule at Pre-lab
  - international sharing candidates of these activities
  - final technical design and documentation (EDR)
- Report to the IDT-WG2

In order to avoid the regular conflict with SRF and DR/BDS/Dump subgroup, I would like to propose to move DR/BDS/Dump from Tuesday to Wednesday.

SRF

Tuesday (bi-weekly)

Yasuchika Yamamoto	***KEK***
Sergey Belomestnykh	FNAL
Nuria Catalan	CERN
Enrico Cenni	CEA
Dimitri Delikaris	CERN
Rongli Geng	JLAB
Hitoshi Hayano	KEK
Bob Laxdal	Triumf
Matthias Liepe	Cornell
Peter McIntosh	STFC
Laura Monaco	INFN Milano
Olivier Napoly	CEA
Sam Posen	FNAL
Robert Rimmer	JLAB
Marc C. Ross	SLAC
Luis Garcia Tabares	CIEMAT
Kensei Umemori	KEK
Hans Weise	DESY
Akira Yamamoto	KEK

DR/BDS/Dump

Tuesday -> Wednesday? (bi-weekly)

Toshiyuki Okugi	***KEK***
Karsten Buesser	DESY
Philip Burrows	U. Oxford
Angeles Faus-Golfe	LAL
Kiyoshi Kubo	KEK
Andrea Latina	CERN
Jenny List	DESY
Thomas Markiewicz	SLAC
Brett Parker	BNL
Ivan Podadera	CIEMAT
David L. Rubin	Cornell
Nikolay Solyak	FNAL
Nobuhiro Terunuma	KEK
Glen White	SLAC
Kaoru Yokoya	KEK
Mikhail Zobov	INFN LNF

CRAB

Dump

Nobuhiro Terunuma	***KEK***
Toshiyuki Okugi	KEK

Chris Densham(STFC)
Marco Calviani (CERN)
Yu Morikawa (KEK)
Fernadno Sordo (ESS Bilbao)
Peter Sievers (CERN)

Sources

Monday (bi-weekly)

Kaoru Yokoya	***KEK***
Jim Clarke	STFC
Steffen Doebert	CERN
Joe Grames	JLAB
Hitoshi Hayano	KEK
Masao Kuriki	U. Hiroshima
Benno List	DESY
Gudrid Moortgat-Pick	U. Hamburg

Peter Sievers (CERN)
Sabine Riemann (DESY)

Civil engineering

Nobuhiro Terunuma	***KEK***
John Andrew Osborne	CERN
Tomoyuki Sanuki	U. Tohoku

IDT-WG2 meeting (Feb.2,2021) 2

Exercice de prospective nationale
en physique nucléaire, physique
des particules et astroparticules
Développements technologiques et applications associés

cnrs
Institut National
de Physique Nucléaire
et de Physique des Particules

Accelerators and related Instrumentation:

Next Particle Collider

9-10 February 2021

CSI IN2P3

Séminaire thématique

Photo : Christophe Barué - GANIL