

Future accelerators for High Energy Physics

Gionata Mondiale Donne nella Scienza
February 17th, 2022

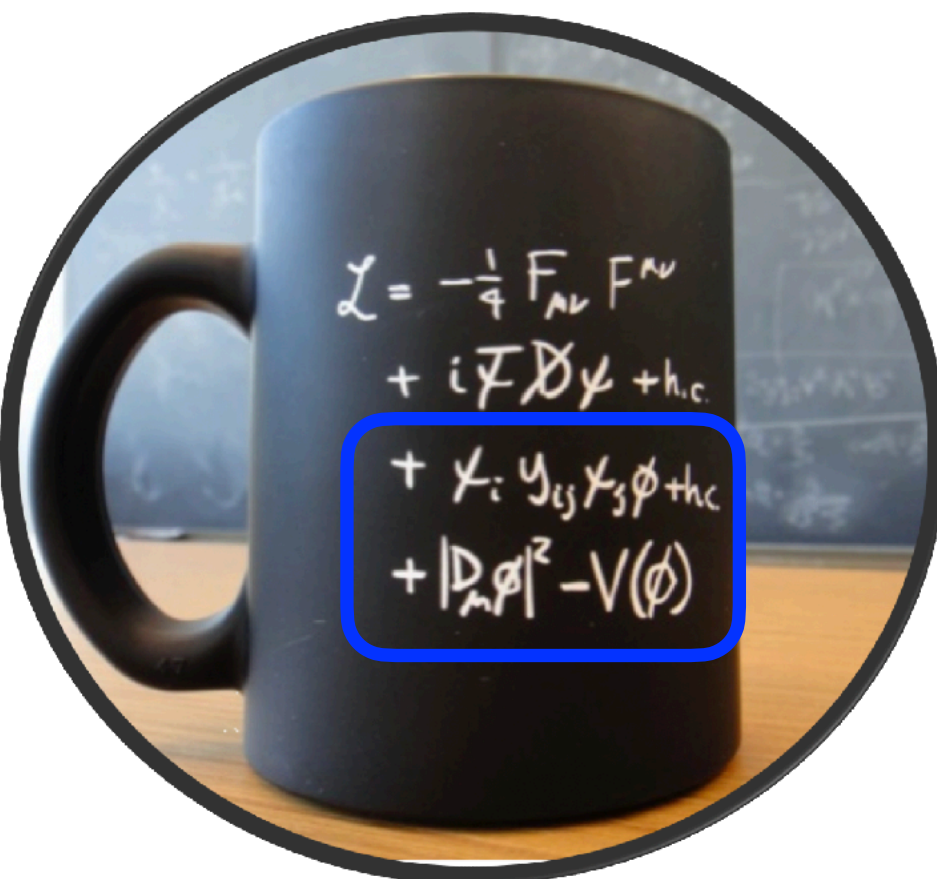
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Particle Physics Today

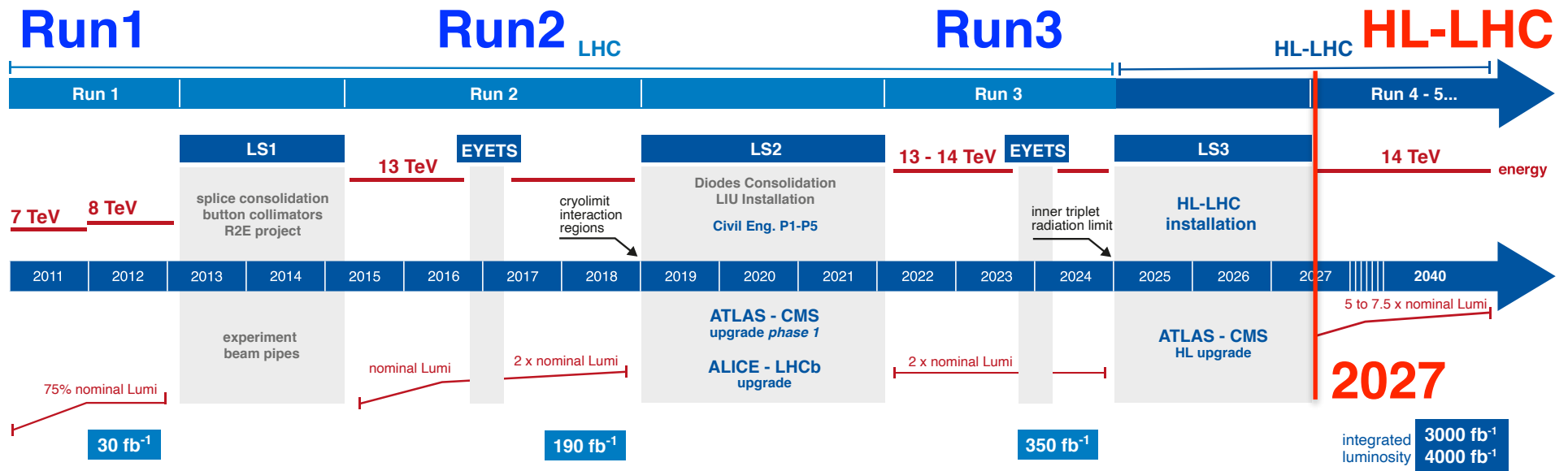

$$\begin{aligned}\mathcal{L} = & -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} \\ & + i\bar{\psi} \not{D} \psi + \text{h.c.} \\ & + \bar{\chi}_i Y_{ij} \chi_j \phi + \text{h.c.} \\ & + |D_\mu \phi|^2 - V(\phi)\end{aligned}$$

- The Standard Model of Electroweak Interactions:
 - Enormous success in describing matter at the smallest scales
- Describing \neq understanding
- Although there is no lack of novel theoretical ideas, there are **no clear indications where new physics is hiding**

pp Collider HL-LHC@CERN

HL-LHC

Increase the number of collisions to increase the statistics of events
High Intensity



New Physics ?

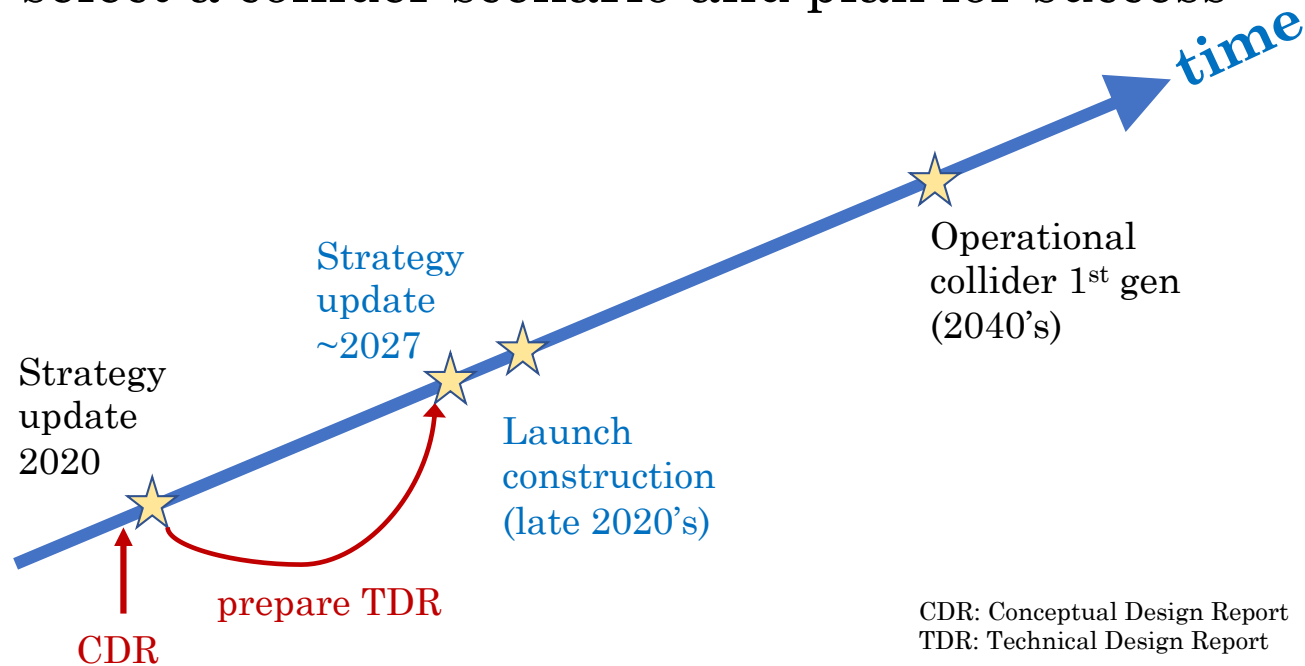
Indirect searches for
the imprint of New
Physics at lower
energies
Precision frontier
e⁺e⁻ collider

Direct searches for
new heavy particles
→ Need colliders
with larger energies
Energy frontier
pp collider

We need powerful machines to explore the
unknown through the
precision and energy frontiers

Path to a New Collider @CERN

Typical path towards a new collider at CERN:
select a collider scenario and plan for success



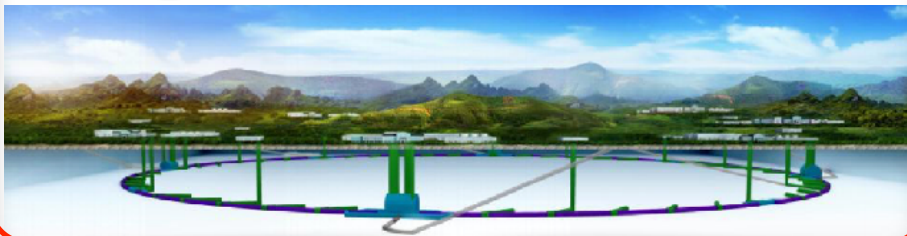
- Since HL-LHC will collect data until ~2040 and since big physics projects take ~20 years time to plan and build
→ **NOW** is the right time to start defining the future of HEP

e^+e^- collider options on the table

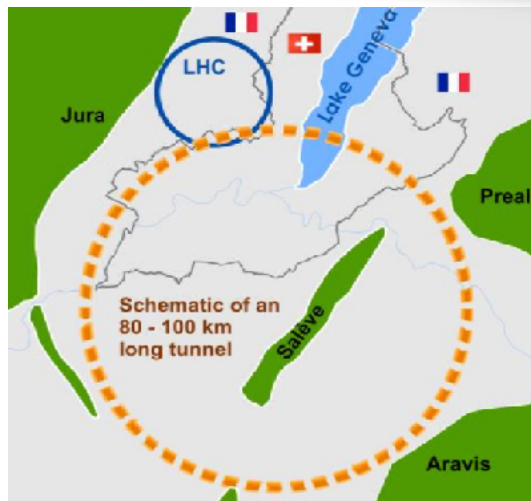
Circular



China



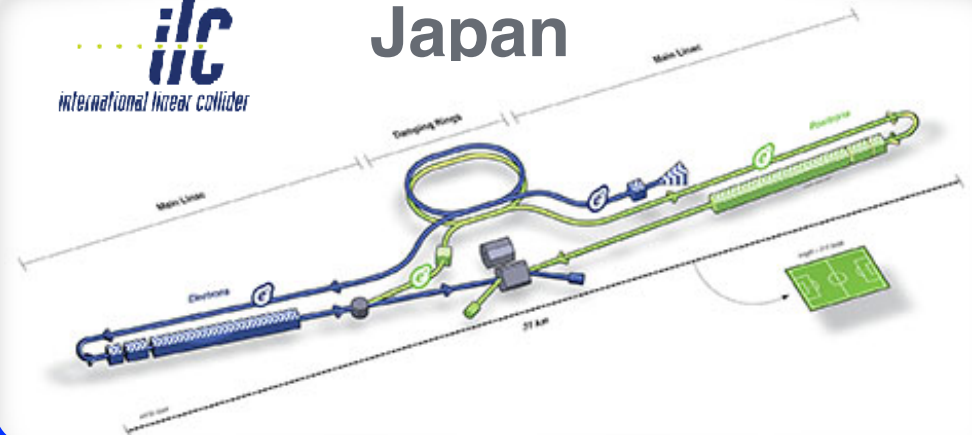
CERN



Linear



Japan

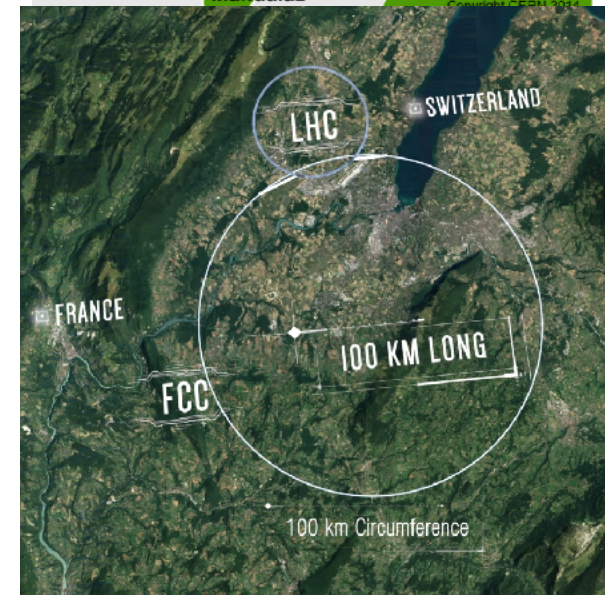
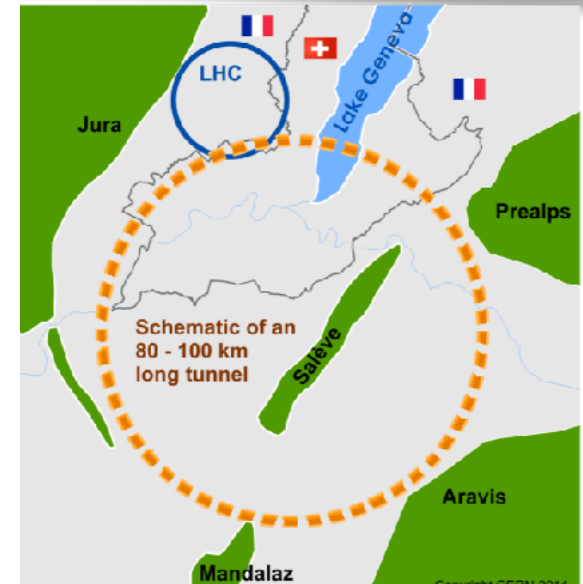


CERN



Future Circular Colliders @ CERN

- The Future Circular Collider (FCC) study is a design study for a post-LHC particle accelerator at CERN
- The collider will be installed in a tunnel with a circumference of 100 km and detectors installed at two (up to four) interaction points.
- The e^+e^- collider FCC-ee is considered as a first step towards a pp collider FCC-hh
- <https://fcc-cdr.web.cern.ch/>



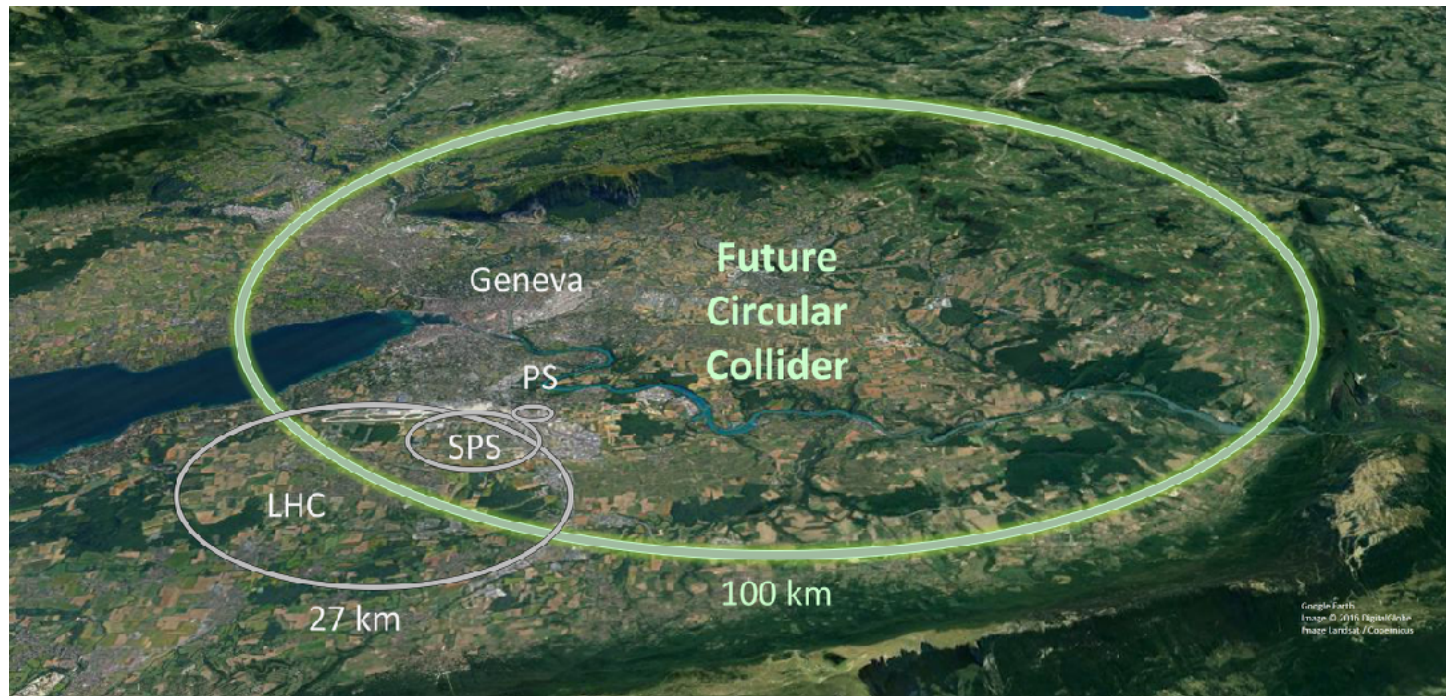
Future Circular Colliders @ CERN

- **FCC-ee - Precision frontier**

- Possible running scenario of FCC-ee @ $\sqrt{s} = 90 \rightarrow 365$ GeV

- **FCC-hh - Energy frontier**

- The pp-collider FCC-hh @ $\sqrt{s} = 100$ TeV will possibly follow in a second phase



Detectors for Future Lepton Colliders

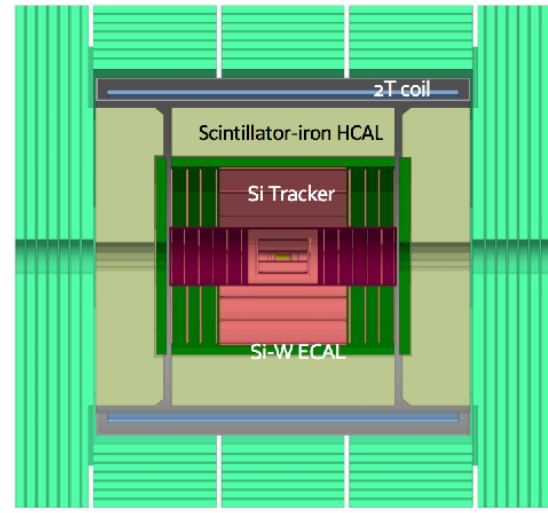
- Two complementary detector designs are being studied
 - The “CLIC-Like Detector” (**CLD**) developed for **FCC-ee**:
 - Consolidated option based on the detector design developed for CLIC
 - Proven concept, understood performance

INFN-BO

- The “**International Detector for Electron-positron Accelerators**” (**IDEA**)
 - Specifically developed for **FCC-ee/CepC**
 - Innovative and cost-effective design

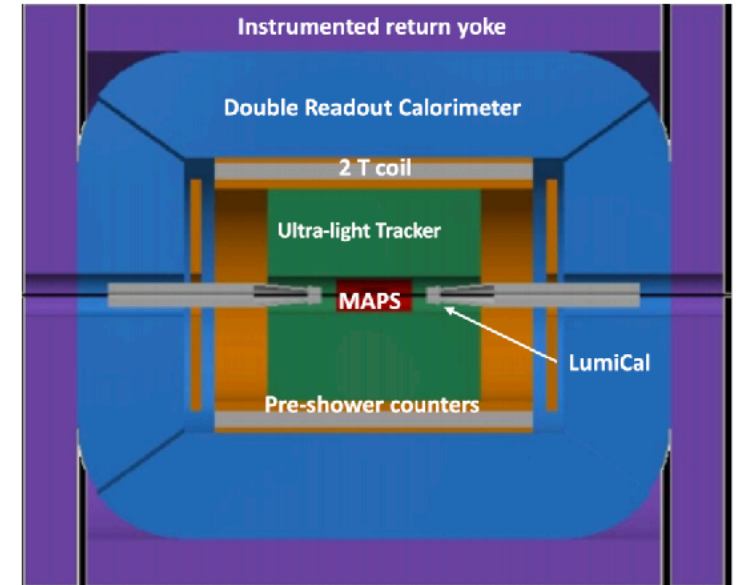
Detectors for Future Lepton Colliders

CLD



- 2 T solenoid
- All silicon vertex detector and tracker
- High granularity calorimeter system
- Muon detector with RPCs

IDEA



- Thin and light 2 T solenoid coil inside calorimeter system
 - Silicon vertex detector
 - Short drift, ultra light wire chamber
 - **Dual Readout calorimeter**
 - **MPGD-based muon detector**

INFN-BO

Future Circular Colliders: CepC/SppC@China

- Circular colliders projects in China with many possible sites that meet the construction conditions
- Qinghuandao (秦皇岛) with great geological conditions and strong support from the local municipal government could be the potential site
- **Circular electron Positron Collider (CepC)**
 - The first phase will construct a circular electron-positron collider in a tunnel with a circumference of 50-70 km
 - Could start operations in the early 2030s
 - ~10 years operation in total
- **Super proton proton Collider (SppC)**
 - Could follow in the late 2040s



Qinghuandao site



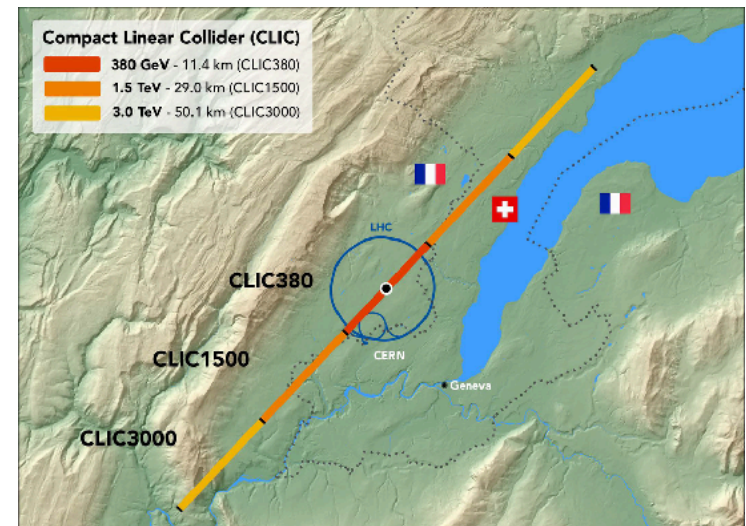
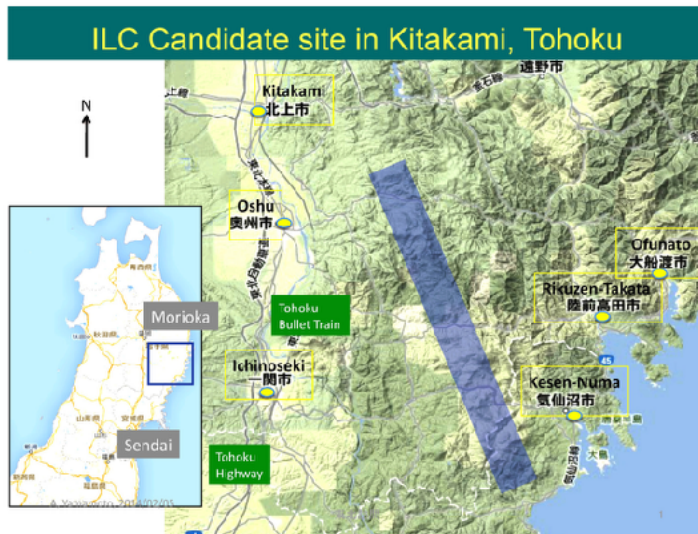
Linear Colliders: ILC, CLIC

- **ILC** (International Linear Collider) @Japan:

- $\sqrt{s} = 250$ GeV, upgradable to 500 GeV and possibly to 1 TeV

- **CLIC** (Compact Linear Collider) @CERN:

- $\sqrt{s} = 380$ GeV, upgradable to 1.5 TeV and possibly to 3 TeV
- CERN's interest decreasing with the internal competition of FCC



Involvement of DIFA/INFN Bologna

We are already very active
on different fronts

**FCC physics
performance studies**

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**CepC and FCC-ee
IDEA detector R&D**

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“Back” to the Future

- Several future colliders are proposed
 - Circular lepton colliders: **FCC-ee** and **CepC**
 - pp colliders: **FCC-hh** and **SppC**
- Circular lepton colliders can later be replaced by very high energy pp colliders → The sequential implementation of a **lepton** and a **hadron** collider maximises the physics reach
- Attractive scenarios of staging and implementation cover more than 50 years of exploratory physics

Don't miss the DeLorean to get off to a flying start

BACK TO THE FUTURE

