

# CERN – NEW PARTICLE ACCELERATOR



## Particle accelerator projects, ILC, CLIC, FCC, CERN, Geneva, Switzerland

For future particle accelerator facilities a study was conducted on international level. It comprises the concept, to accelerate electrons, positrons as well as protons to very high energies in the range of terra electron volts and to bring them to collision.

### Scope

#### ILC (International Linear Collider)

- Energies for FCC-ee (Lepton) collisions up to 0.5 TeV

- Linear accelerator tunnel

#### CLIC (Compact Linear Int. Collider)

- Energies for FCC-ee (Lepton) collisions of up to 5 TeV

- Linear access tunnel

#### FCC (Future Circular Collider)

- Energies of up to 100 TeV for FCC-hh (Hadron) collisions

- Collisions of up to 60 TeV FCC-he / 0.35 TeV FCC-ee

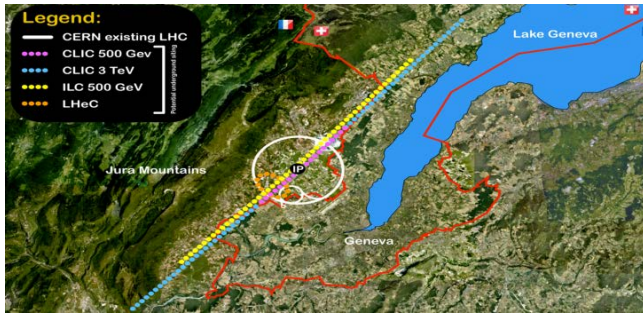
- Ring shaped accelerator tunnel

### Challenges

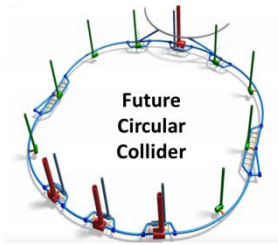
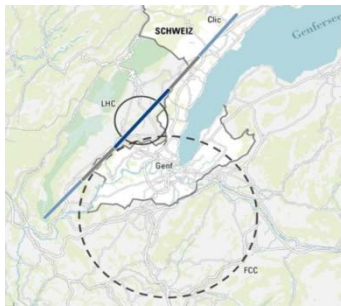
- Extreme precision of tunnel position required
- Highest requirements for tunnel segment sealing

### Amberg Services

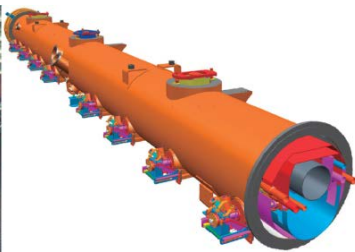
- Project management for feasibility studies and cost estimates for construction works
- Initial designs and risk analysis, esp. for geology and shaft construction



- CLIC und ILC linear accelerator with LHC



- FCC ring shaped accelerator, 80 – 100 km long



- Cryogen Module as main accelerator component

## AMBERG FACTS

### Contracted Value Amberg

Amberg total	300'000 CHF
ILC total	180'000 CHF
CLIC total	30'000 CHF
FCC total	90'000 CHF

### Project Phases & Duration

#### ILC

Design report & cost estimates	2006 – 2007
Various amendments	2007 – 2012

#### CLIC

design report & cost estimates	2006 – 2007
Various amendments	2007 – 2014

#### FCC

risk analysis, heading method, logistics, shaft construction & cost estimates	2014 – 2016
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### Project details

#### ILC, linear accelerator

- Tunnel, length approx. 30 km, diameter 5.6 m, single-shell lining
- 16 access shafts
- 1 experimental cavern
- 2 beam diversion tunnels

#### CLIC, linear accelerator

- Tunnel, length approx. 48 km, diameter 5.6 m, single-shell lining
- 12 access shafts
- 5 experimental caverns
- 2 beam diversion tunnels

#### FCC, ring shaped accelerator

- Tunnel approx. 80 – 100 km long, single-shell lining
- 16 access shafts, depth up to 300 m
- Various access caverns

## KUNDENFAKTEN

### Overall Cost

Estimated construction cost	
ILC	1.2 – 1.5 bio. CHF
CLIC	1.4 – 1.7 bio. CHF
FCC	not defined yet

### Overview Project

- Particle accelerator of superlative with energies in the multi digit terra volt region
- 2 linear accelerators ILC and CLIC for collisions with electrons and their anti-particles positrons (FCC-ee) by accelerator tunnel 30 and 48 km long, various shafts an experimental caverns
- 1 ring shaped accelerator tunnel 80 – 100 km long for collisions with hadrons (FCC-hh), hadrons-leptons (FCC-he) and Leptons (FCC-ee), various shafts and experimental caverns
- The accelerators serve for the physical investigation of the building parts of the elementary particles, which are generated by collisions with very high energy

### Geology

- Moraine and molasse rock, partly heterogeneous and water bearing
- Jura formation partially with karst and strong water ingresses

### Contact person

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## CHALLENGES



ILC – schematic view

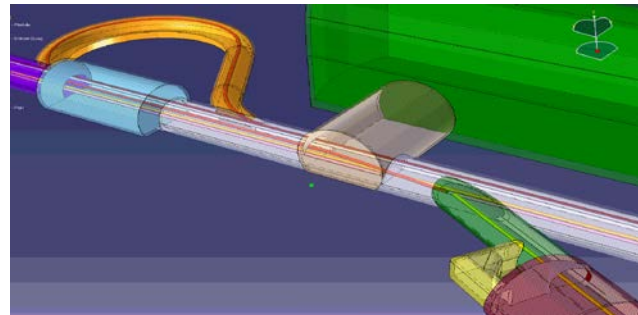
### Complex interrelated system of subsurface constructions for supply and acceleration of electrons/positrons (ILC, CLIC) and protons (FCC)

- The big challenge was the realization of the ideas and related boundary conditions from nuclear physics in an interrelated system of subsurface buildings, which can be built at reasonable cost

#### Special requirements:

- Groundwater saturated moraine and formation water from karst of the Jura foothills in the south.
- Measures to keep interruptions in operation at a minimum in order to ensure a continuous investigation of the particle collisions at the detector sites
- Provision of a considerable number of annex buildings such as particle beam stoppers /energy centrals etc. accessed from the accelerator tunnel under construction
- Accelerator tunnel „laser straight“

## ENGINEERING APPROACH



CLIC – UTRC cavern, drive beam loop & beam dump

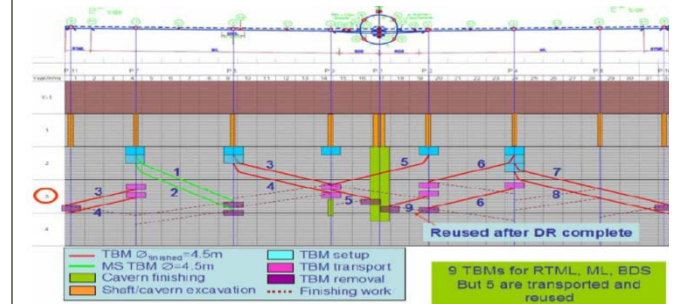
### Deep shafts, big caverns and long machine driven headings with a considerable number of annex-buildings like caverns, turning loops etc.

- All building elements were designed after the ideas and conditions of the later users with consideration of the local geological conditions and assessed in respect to their interconnection with the adjacent elements and their counter action to each other

#### Special requirements:

- Suitable construction methods for sealing of more than 50 m deep construction pits for building of the shafts in the water saturated moraine
- Approximate determination of sealing thickness for compensation of surface loads for pair wise located detector caverns (more than 30 m wide and 40 m high)
- Optimization of requirements for tunnel construction (tunnel boring and reinforcement) for the construction of the many annex buildings

## TECHNICAL SOLUTIONS



ILC – work program for subsurface constructions

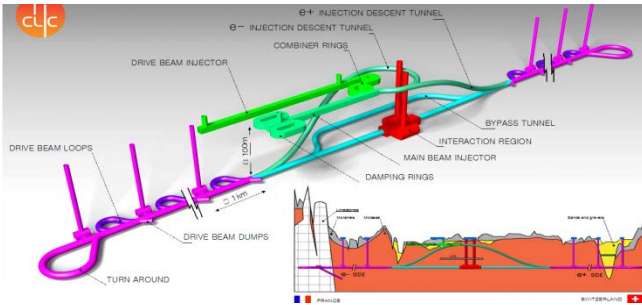
### Integration of all subsurface and surface buildings under consideration of constructional, temporal, economical as well as ecological aspects

- For the establishment of a cost estimate and the construction program all elements of the accelerator were integrated in such a way, that a realistic building process is feasible without encountering reciprocal restrictions

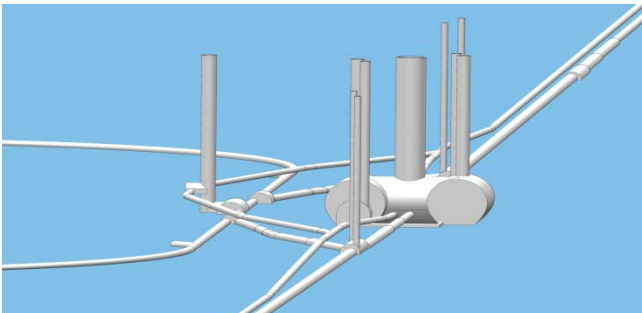
#### Special requirements:

- Planning of the building process under consideration of „flexible“ boundary conditions as a result of the latest results from the ongoing scientific investigations
- Suitable shaft dimensions and installations to fulfil the logistic tasks for the construction operation and for the necessary installation of the accelerator equipment
- Side gallery in Jura formation for accomplishment of high formation water ingress in karstic areas

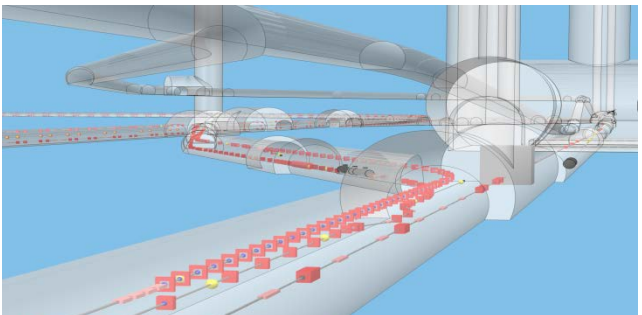
# CHALLENGES



CLIC – schematic view and geological situation

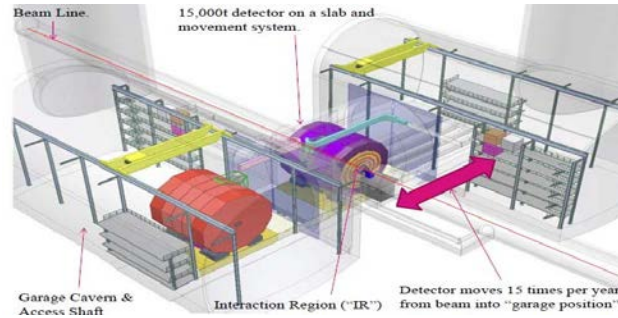


ILC – 3D-view of area around detector cavern

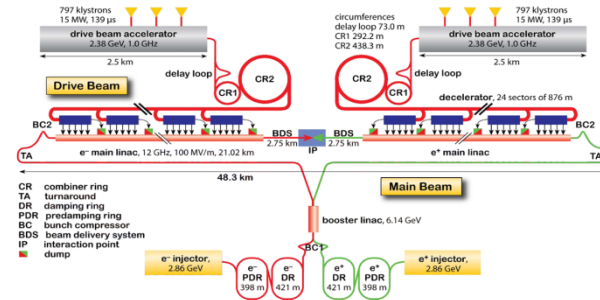


Electron / positron feeding into the main tunnel

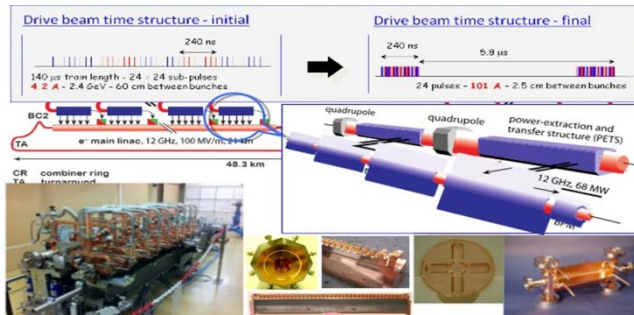
# ENGINEERING APPROACH



Scheme of cavern with interaction areas

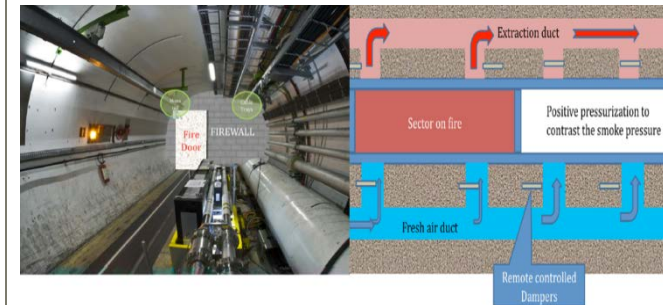


CLIC – Scheme for 3 TeV extension

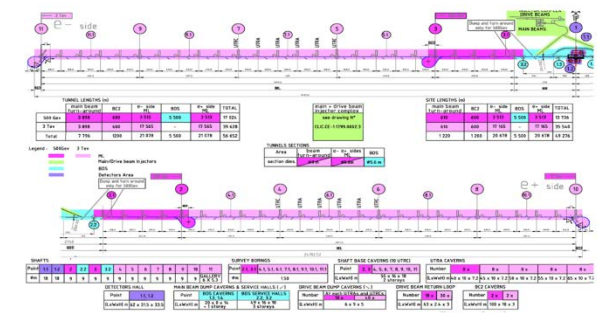


Scheme / Installations for particle accelerator

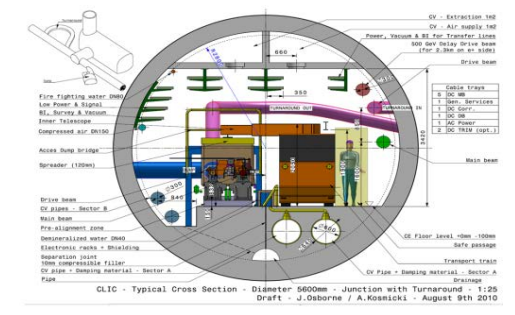
# TECHNICAL SOLUTION



Concept for fire prevention



CLIC Scheme of the entire building complex



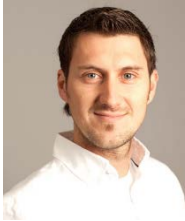
CLIC – typical cross-section after installation

## AMBERG KEY PERSONAL



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