CLIC physics/detector CDR status and short-term goals;

Future plans for CLIC physics/ detector studies

Lucie Linssen

CDR status and short-term plans

The CLIC CDR, frozen version for the Review:
https://edms.cern.ch/document/1160419

The Review will take place October 18-20 in Manchester

The CDR will be published before the end of 2011.
During the ~6-8 weeks between the Review and the final publishing the CDR will be complemented with, for example:

** Inclusion of comments by the Review committee.
** New insights of a staged energy approach for CLIC, taking LHC results into account.
** CLIC physics potential with polarised beams (additional section to chapter 1)
** Determination of the luminosity spectrum through measurement of bhabha scattering.
** ……

The CLIC physics&detector CDR will be presented to the CERN Scientific Policy Committee in December 2011

CLIC CDR review

http://indico.cern.ch/conferenceDisplay.py?confId=146521

Name
Stefan Soldner-Rembold (chair)
Philip Bambade
Giovanni Batignani
Brigitte Bloch
Daniel Elvira
Philippe Farthouat
Paul Grannis
Marian Ivanov
Richard Nickerson
Arnulf Quadt
Rob Roser
Nobu Toge
Yifang Wang
Pipa Wells
Hitoshi Yamamoto

Review committee members

- October 18+19
  - Series of presentations
- October 20
  - Committee meeting + closeout

The committee will report to Steinar Stapnes

The report of the review will be made public

Continuation of CDR work in 2012

There will be some continuation of CLIC CDR work in 2012

Summary document for accelerator, physics and detectors

Will comprise:

summary of Vol. 1&2 on accelerator and physics/detector
staged energy approach for CLIC
value estimate
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And also: preparation for the update of the European Strategy for Particle Physics
Including a common LC document (see LCWS11 session 28/9 @ 18 hrs)

After the CDR….

Medium-term activities, covering a ~5-year period
(see chapter 13 of the CDR)

In a nutshell:

- Detector simulation studies and physics studies
    - Further detector optimisation
    - Extend the CLIC physics studies to CM energies below 3 TeV
    - Gradually explore physics with a machine built in stages
- Software development (common between ILC and CLIC)
- LC detector R&D (many common activities between ILC and CLIC)
- CLIC-specific detector R&D

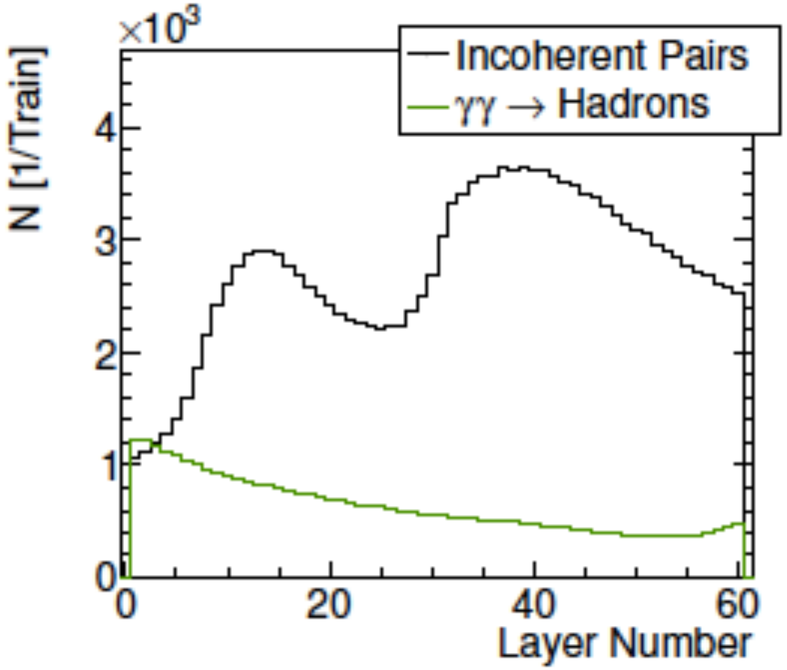
The next slides are extracted directly from the CDR document
…. a rather long list of activities

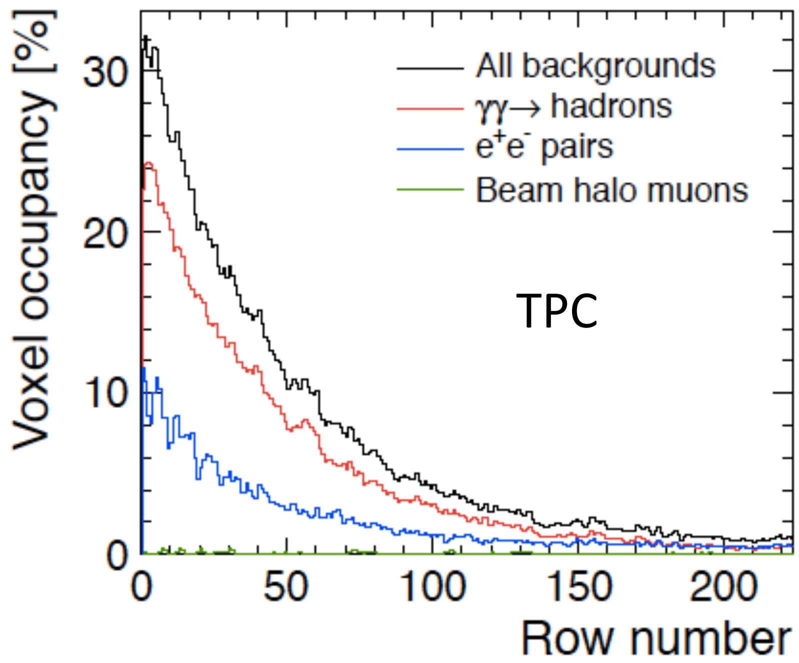
general ILC + CLIC

CLIC-specific

Detector simulation studies

Examples of high occupancy regions requiring further study at 3 TeV





High occupancy due to incoherent pairs in the high-z regions of the HCAL end cap. This points to inadequate shielding from the very forward calorimetry region

High occupancies in the TPC, mostly due to yy=>hadrons. One may consider pixelised readout for the TPC in this region or suppress the inner pad rows.

Detector simulation studies

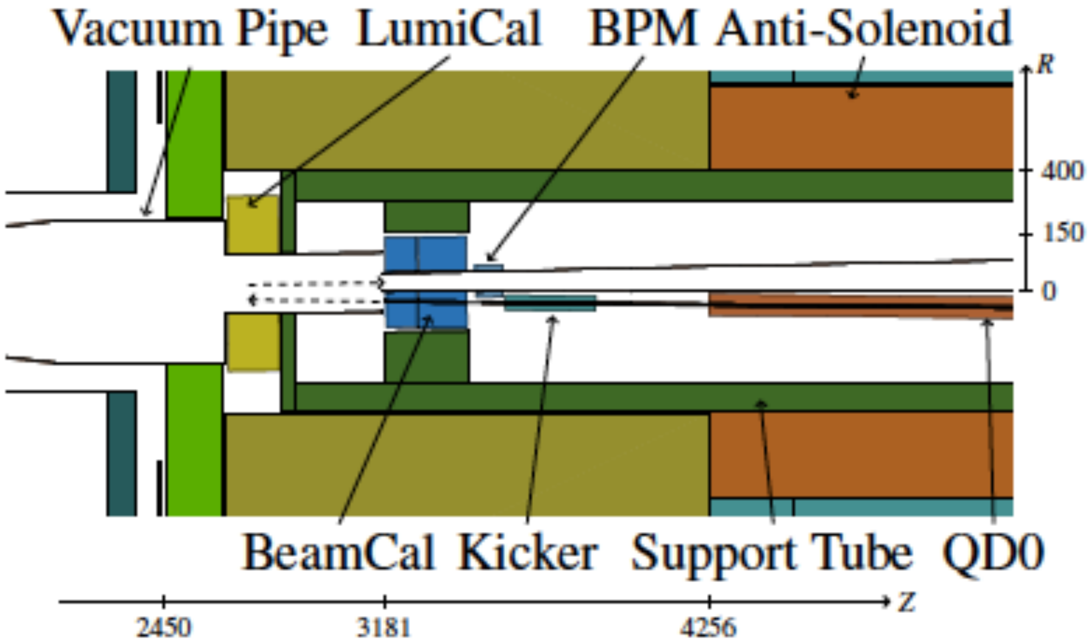


Figure 6: Very forward region of the CLIC_ILD_CDR detector model.

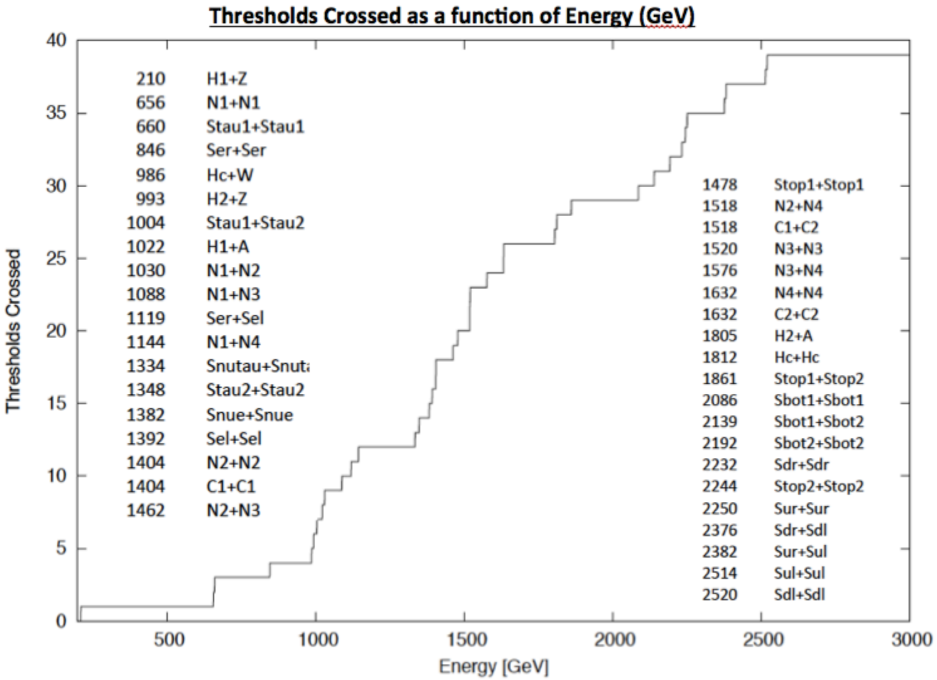
The QD0 and its stability requirements at CLIC have a significant impact on the detector layout and acceptance in the forward region. More study is needed to quantify the impact on the physics and to make a balance between pros and cons of having QD0 inside the detector.

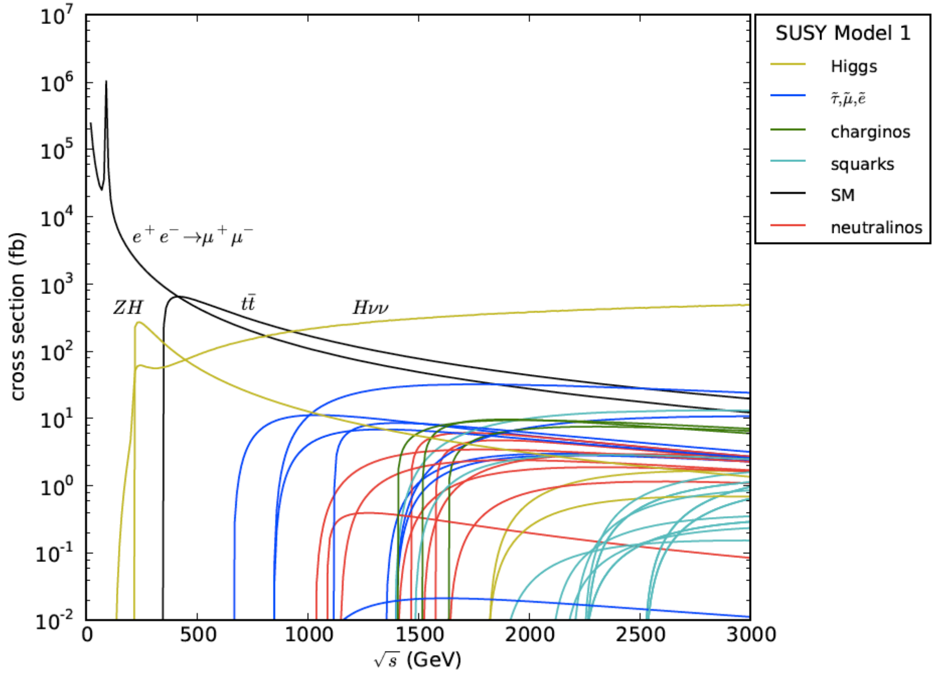
Detector simulation studies

Simulation Studies and Detector Optimisation

- Origin and mitigation of high occupancies in low-angle region of endcap calorimetry;
- Location of QD0 inside or outside the detector and impact on the physics;
- Origin and mitigation of high TPC occupancies;
- Occupancies in inner tracking regions and related technology choices;
- Detector optimisation and background suppression at intermediate centre-of-mass energies;
- Simulation studies in support of detector development and beam tests;
- Implementation of the response of various detector readout technologies in the full-detector simulations.

Physics at CLIC





Use a single SUSY model as an example to study how a LC built and operated in energy stages could explore new physics, including the gradual accumulation of knowledge on e.g. EW symmetry breaking, DM relic abundance, GUT scale unification
(see James Wells presentation, LCWS11 27/9 plenary, 19 hrs)

Physics at CLIC

Physics at CLIC

- Monitor the developments at the LHC and report on their implications for the physics potential of CLIC; <= preferable in broad LC context
- Investigate the physics opportunities and challenges of a staged approach to reaching the highest energy of the CLIC machine;
- Investigate the relative merits of electron polarisation versus electron and positron combined polarisation;
- → Study a supersymmetric benchmark model point in full detail to determine all the masses and mixings that can be measured, and investigate how well these measurements can lead us to answers to fundamental questions such as the verification of supersymmetry, the origin and mediation of supersymmetry breaking, the relic abundance of the lightest neutralino, and the compatibility of the model to various approaches to explaining the baryon asymmetry of the universe. <= could be done in collaboration with a similar study for ILC

Software development

For the CDR used:

- Mokka/Marlin framework
- SLIC / org.lcsim framework

Quite some overhead to work with two frameworks (each having their advantages and drawbacks)

Fortunately, for the CDR, we also made use of common tools:

LCIO
Event generation (WHIZARD + PYTHIA)
ILCDIRAC grid production
PandoraPFA / SLICPandora fo particle flow analysis
LCFI for flavour tagging

In a next phase:

- Further improvement of simulation tools => <u>continuation of trend to have common tools</u>

Software development

Software development

- Roadmap towards common software tools for both experiments;
- Improved and well-maintained tracking codes;
- Improved software tools for geometry descriptions;
- More advanced reconstruction methods, making use of the granularity in space and time.

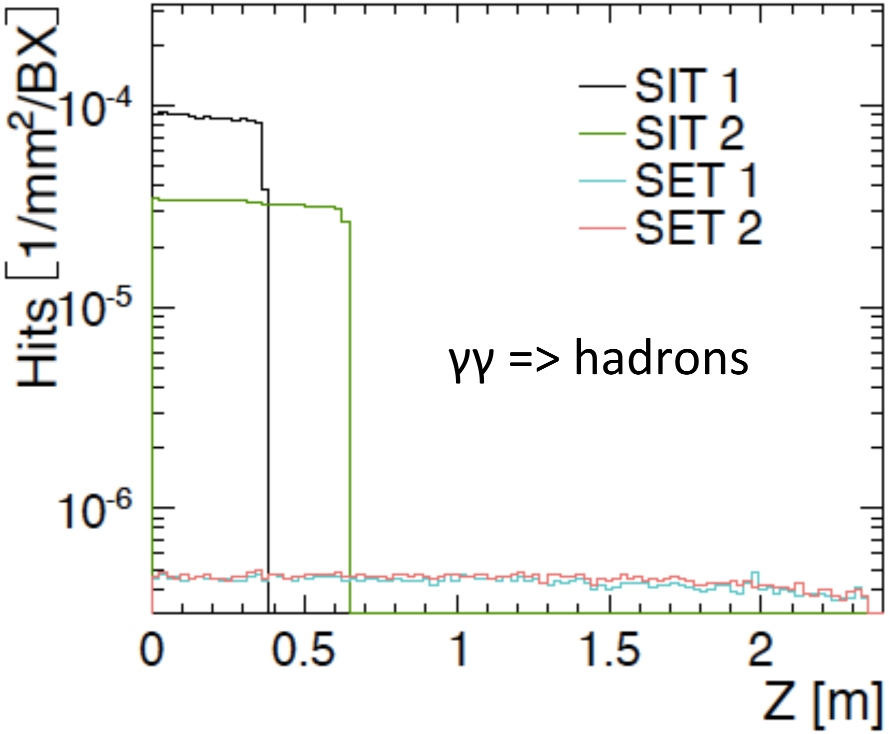
Vertex detector

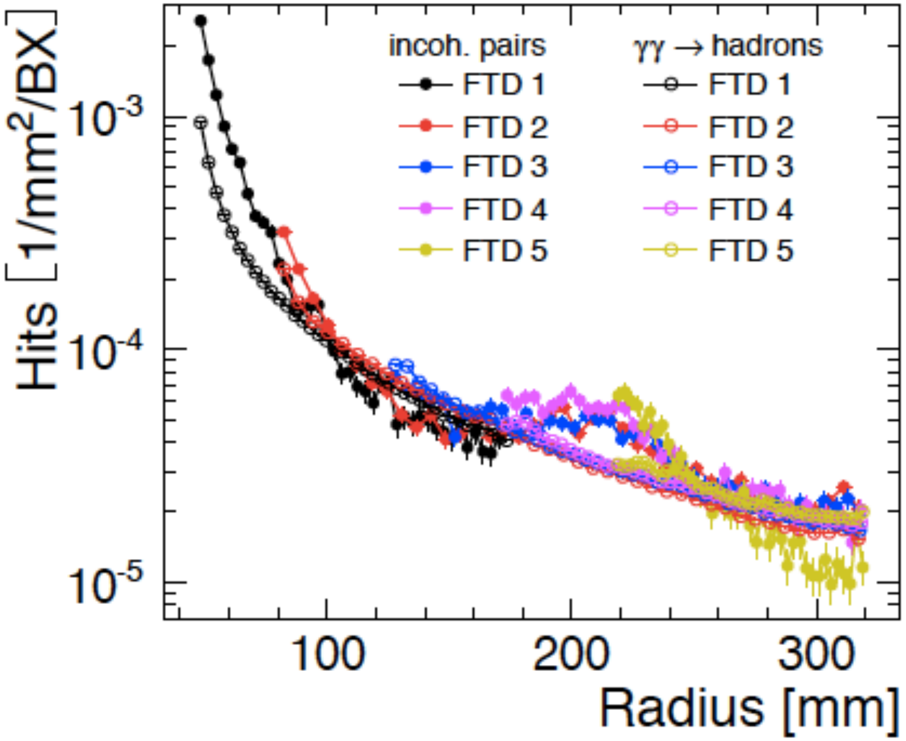
Vertex detector

- Developments towards a thin hybrid or integrated CMOS or multi-tier (SOI, 3D or other) pixel technology with small pixel sizes of O(20 μm) and a hit time resolution of O(5 ns);
- Development of high-density interconnect technologies towards maximum detector integration and seamless tiling;
- Thinning of wafers, ASICs or tiers and development of low-mass construction and services materials to reach O(0.2% X0) material per layer;
- Advanced power reduction, power delivery, power pulsing and cooling developments to reach O(0.2% X0) material per layer.

Silicon tracking

High occupancies per bunch train in inner strip tracking layers





~2.4 hits/strip per 156 ns bunch train in SIT1, including safety factor. Similar situation for inner layer of CLIC_SiD strip tracking

~2.9 hits/strip per 156 ns bunch train in FTD2, including safety factor.

Silicon tracking

Silicon tracking

- Study of technology choices to mitigate high occupancies in the inner tracking regions;
- Development and beam tests of low-mass silicon strip detectors with time stamping functionalities, low-power electronics, power pulsing, air cooling and low-mass supports.

TPC-based tracking

TPC-based tracking

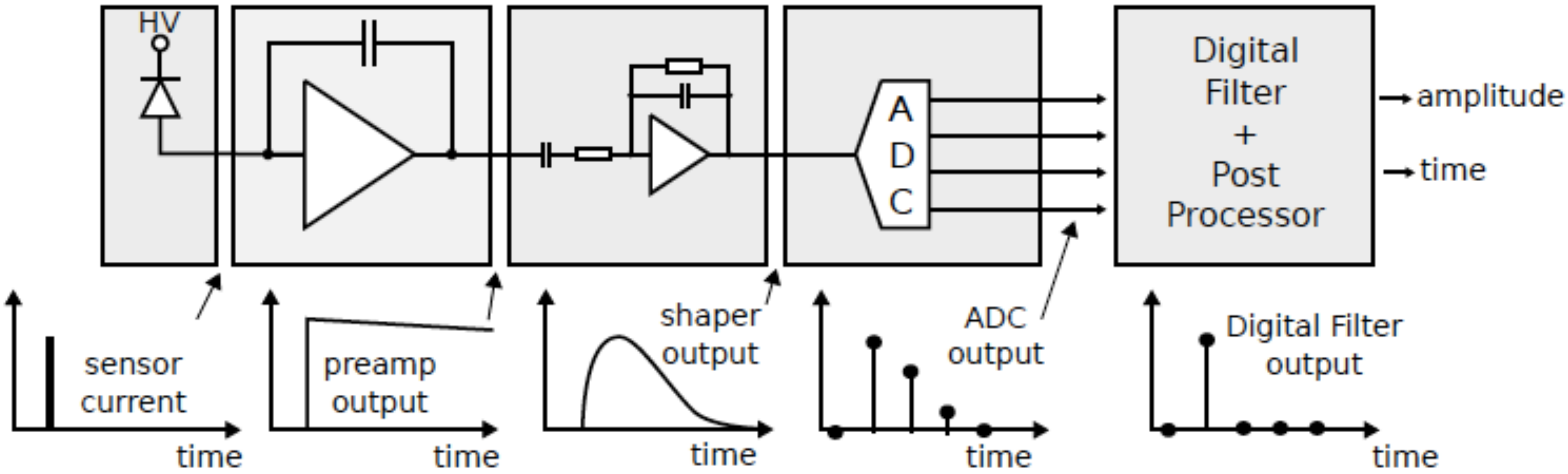
- Continued TPC prototype tests (GEM, Micromegas, pad, pixel, ion backflow);
- TPC endplate integration and cooling.

Calorimetry

Calorimetry

- Beam tests of fine-grained ECAL, HCAL and forward calorimeter modules based on different active and passive layers (including tungsten for HCAL) and accompanying validation of GEANT4 modelling;
- Engineering designs and technological prototypes of ECAL, HCAL and forward calorimetry;
- Electronics developments for calorimetry at CLIC, including power delivery and power pulsing tests at the system level.

Electronics and power delivery



Calorimeter electronics at 3 TeV requires:

- 12-14 bit pulseheight measurement
- ~1 ns time resolution for hits
- Up to 5 hits per 156 ns bunchtrain

Electronics and power delivery

Electronics and power delivery

- Qualification of deep sub-micron technologies for the integration of advanced functionalities in compact detector ASICs;
- Studies and prototyping of core front-end functionalities with low power consumption, in particular: pulse height and time measurements, in some cases (silicon tracking and calorimetry) combined with multi-hit functionality within the 156 ns bunch train, as well as on-chip power pulsing features;
- Power delivery and power pulsing at the system level, including system tests in a 4 to 5 T magnetic field;
- Interconnect technologies for front-end electronics and low-mass services.

Magnet and ancillary systems

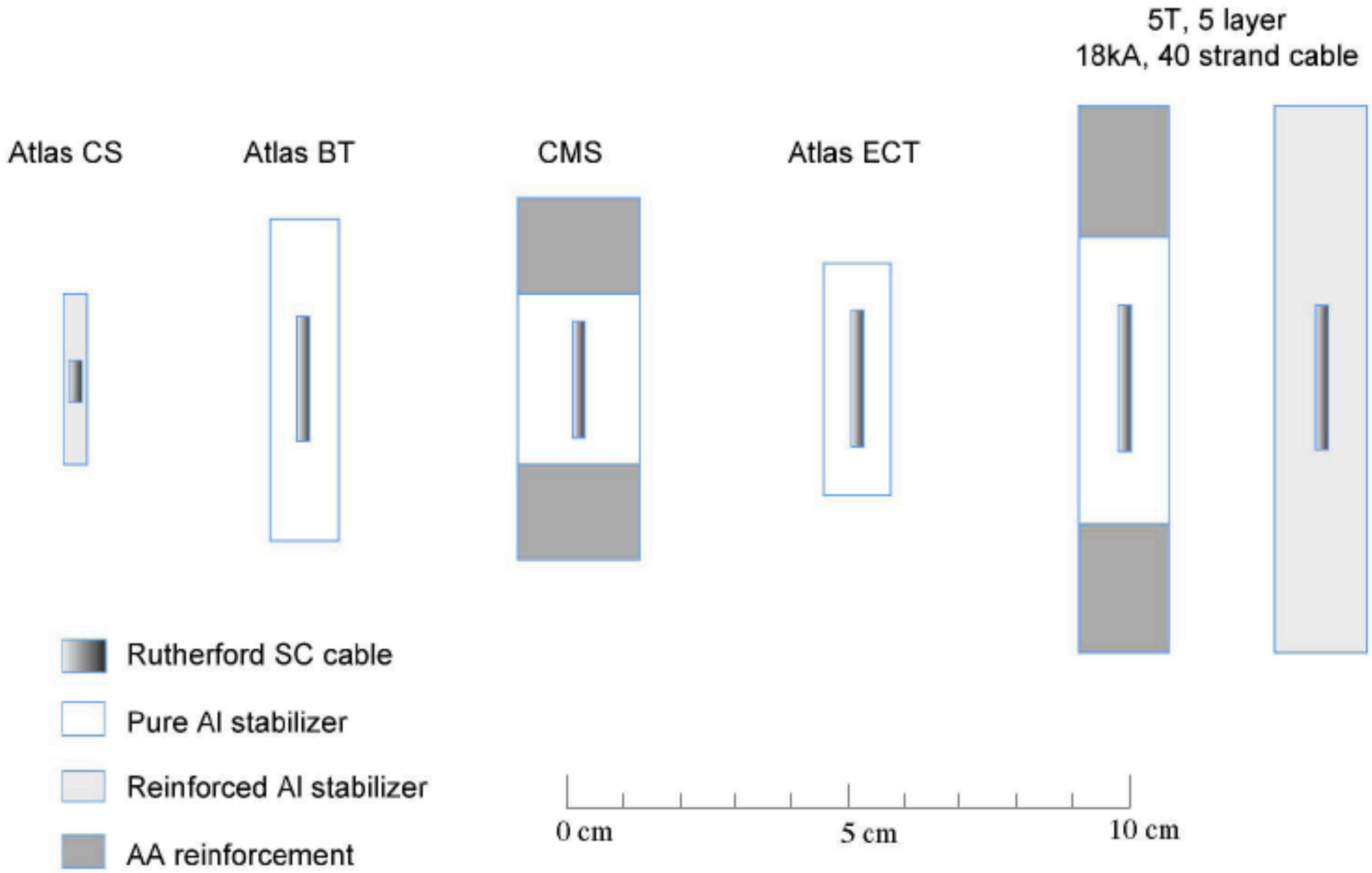


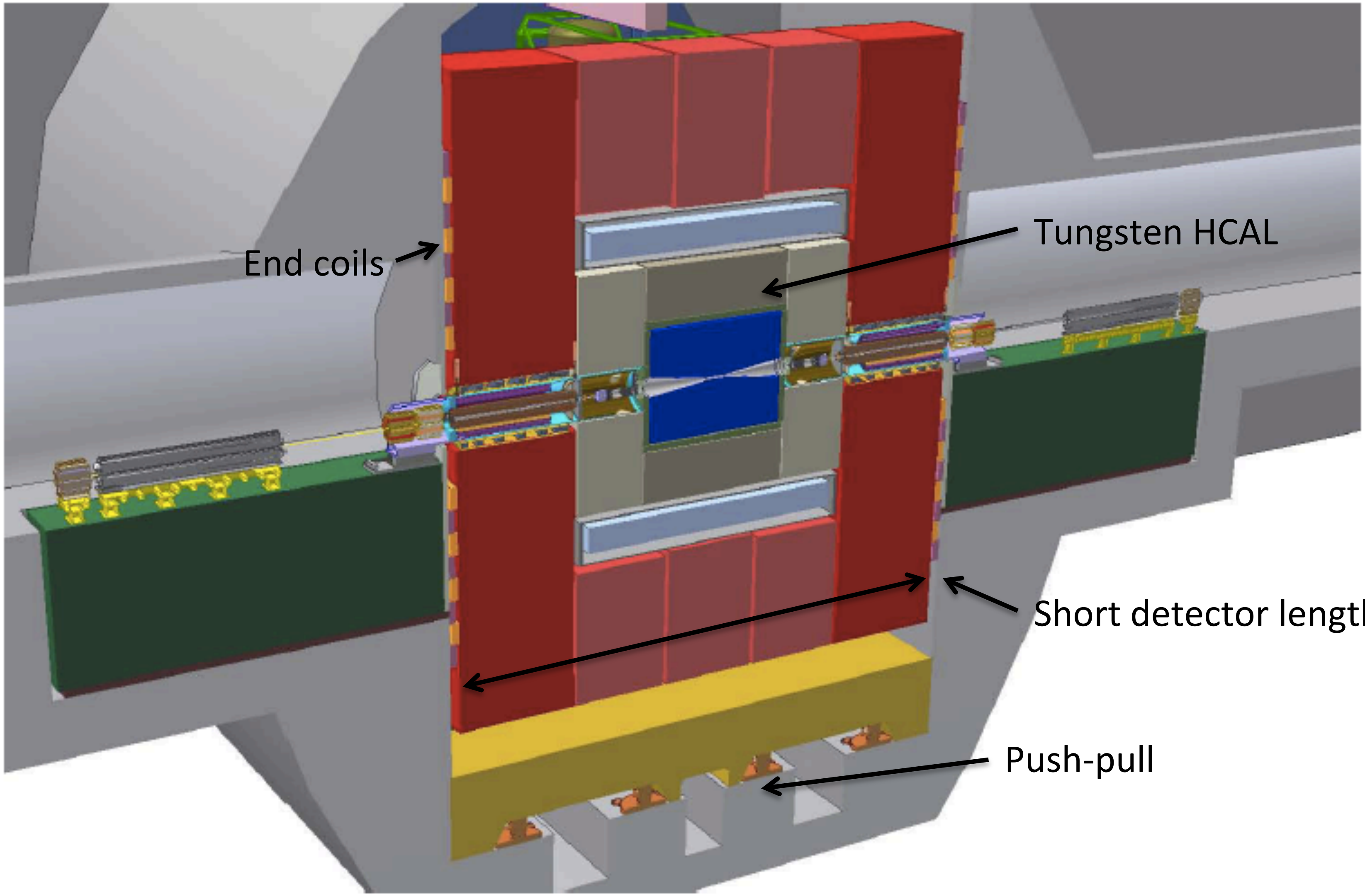
Fig. 7.3: Cross sections of Al stabilised and reinforced conductors previously used and the proposed two conductor options for the 5 T solenoid in the CLIC_SiD design.

Magnet and Ancillary Systems

Magnet and Ancillary Systems

- Extrusion tests and characterisation of a large re-inforced superconductor;
- Material studies and tests of new conductor re-inforcement materials;
- Winding technique for a large conductor;
- Flexible high-temperature power line;
- Prototyping of safety elements, e.g. a water-cooled dump resistor.

Engineering and Integration



Engineering and Integration

Engineering and Detector Integration

- Design and integration of the detector concepts in gradually increasing detail;
- Construction and joining techniques with tungsten;
- Engineering and layout studies for a short detector length including end-coils;
- Detector movements and push-pull operation;
- Alignment techniques and deformation measurements;
- Engineering and production techniques of a beryllium with steel beam pipe.

Outlook

Lots of challenging and interesting work ahead

A large fraction of work is common to ILC+CLIC
Looking forward to continued collaboration !

Challenging R&D projects with clear spin-off the other projects and fields

More details in the CLIC physics/detector CDR
https://edms.cern.ch/document/1160419

Please give your support to the physics case of a future linear collider by signing up for the CDR here:
https://indico.cern.ch/conferenceDisplay.py?confId=136364
Does not imply any formal commitment.