CLIC detector study and status of the CDR process

Lucie Linssen

- Introduction
- CLIC_SiD detector geometry and simulation model for the CDR
- Preparations for the CDR
- Outstanding issues
- Outlook

http://lcd.web.cern.ch/LCD/

Many thanks to Christian Grefe, Hubert Gerwig and others

Other CLIC-related talks

Further CLIC-related talks at this workshop:

Peter Speckmayer:

- Software development and performance studies of CLIC-SiD

Norman Graf + Jeremy McCormick:

- Software framework + SLiCPandora

Tim Barklow:

- Generation of physics and beam-background events + Physics benchmarks for CLIC

Phil Burrows:

- CLIC MDI

Harry Weerts

- ILC/CLIC SiD synergies, R&D plans

CLIC_SiD overview

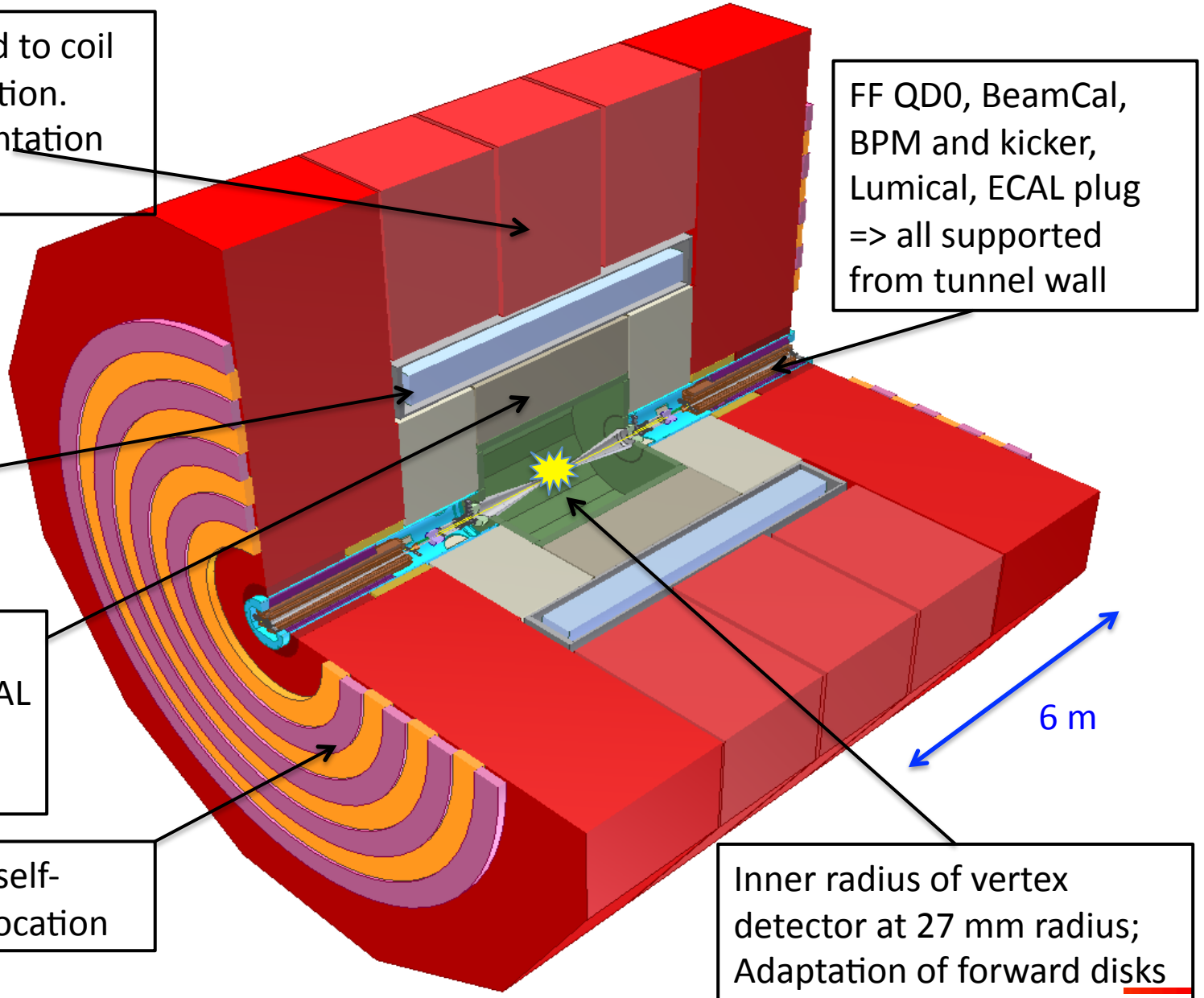
Size of yoke adapted to coil radius + field saturation. New yoke instrumentation layout

FF QD0, BeamCal, BPM and kicker, Lumical, ECAL plug => all supported from tunnel wall

B-field 5T, inner bore radius 2740 mm

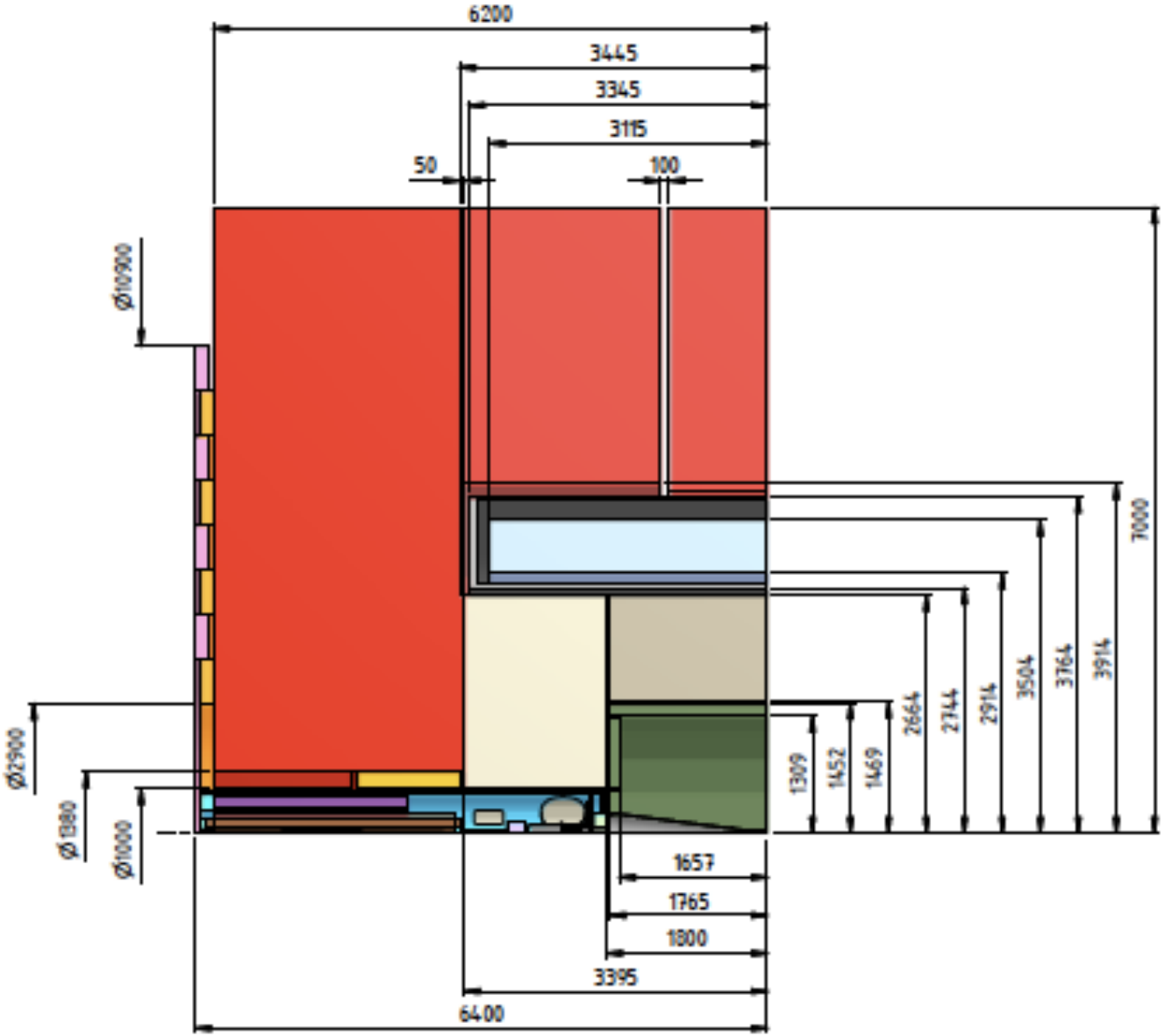
Si/W ECAL and tungsten-based HCAL barrel, steel-based HCAL endcap

These rings are for self-shielding at the IP location



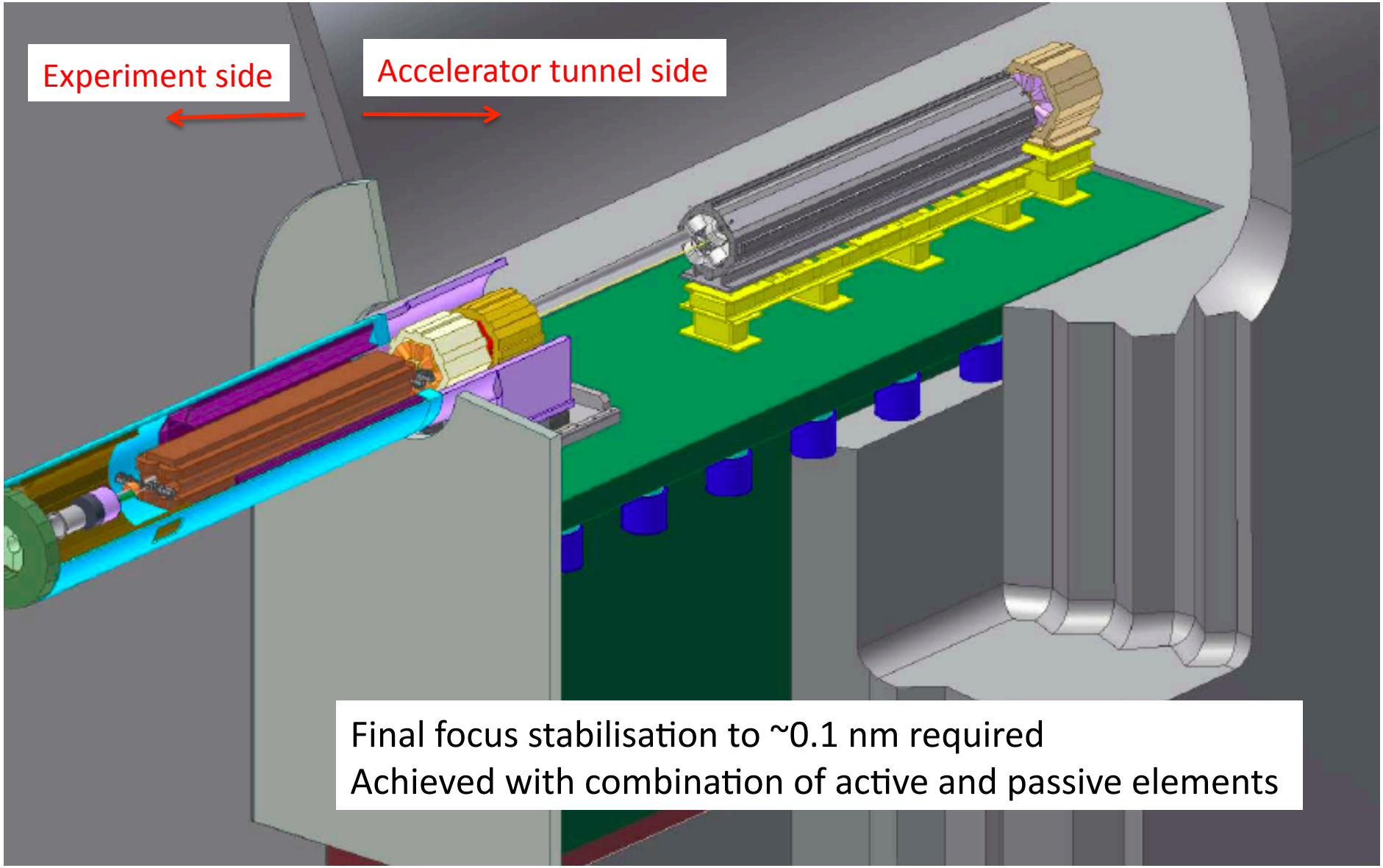
Inner radius of vertex detector at 27 mm radius; Adaptation of forward disks

CLIC_SiD Numbers



Hubert Gerwig,
Nicolas Siegrist

Final focus stabilization

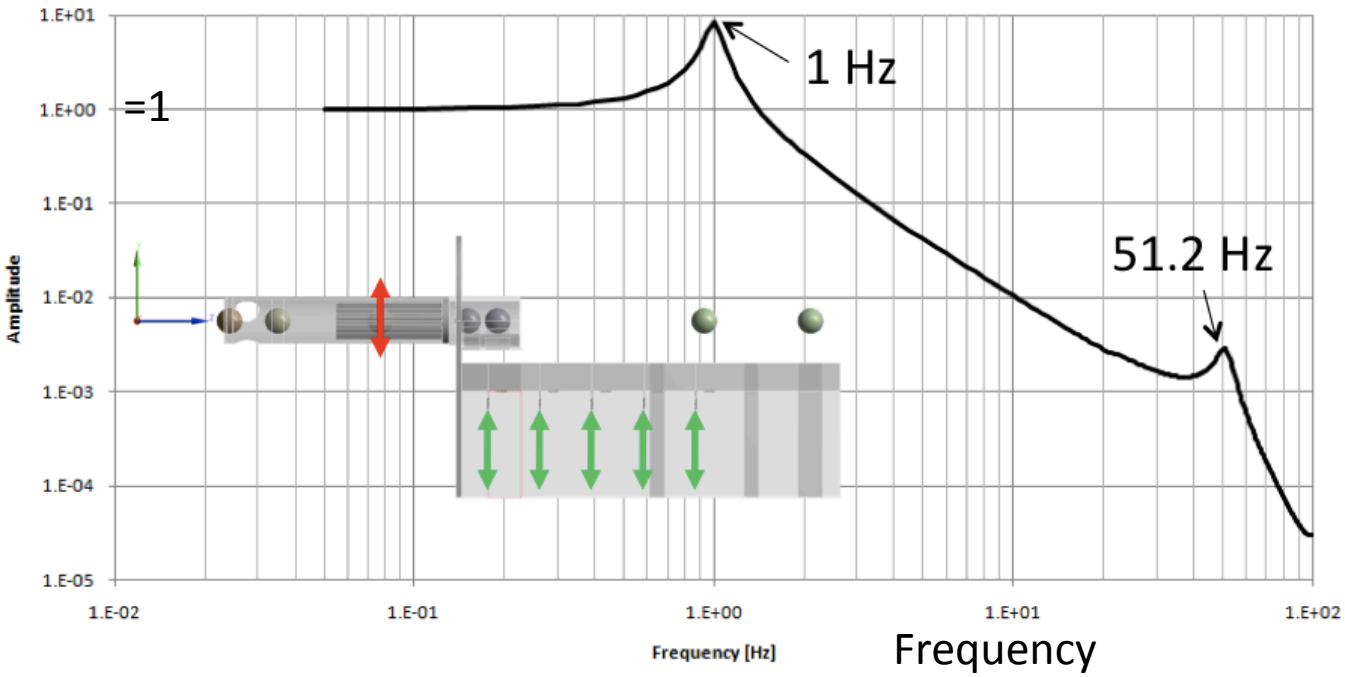


Final focus stabilisation to ~0.1 nm required
Achieved with combination of active and passive elements

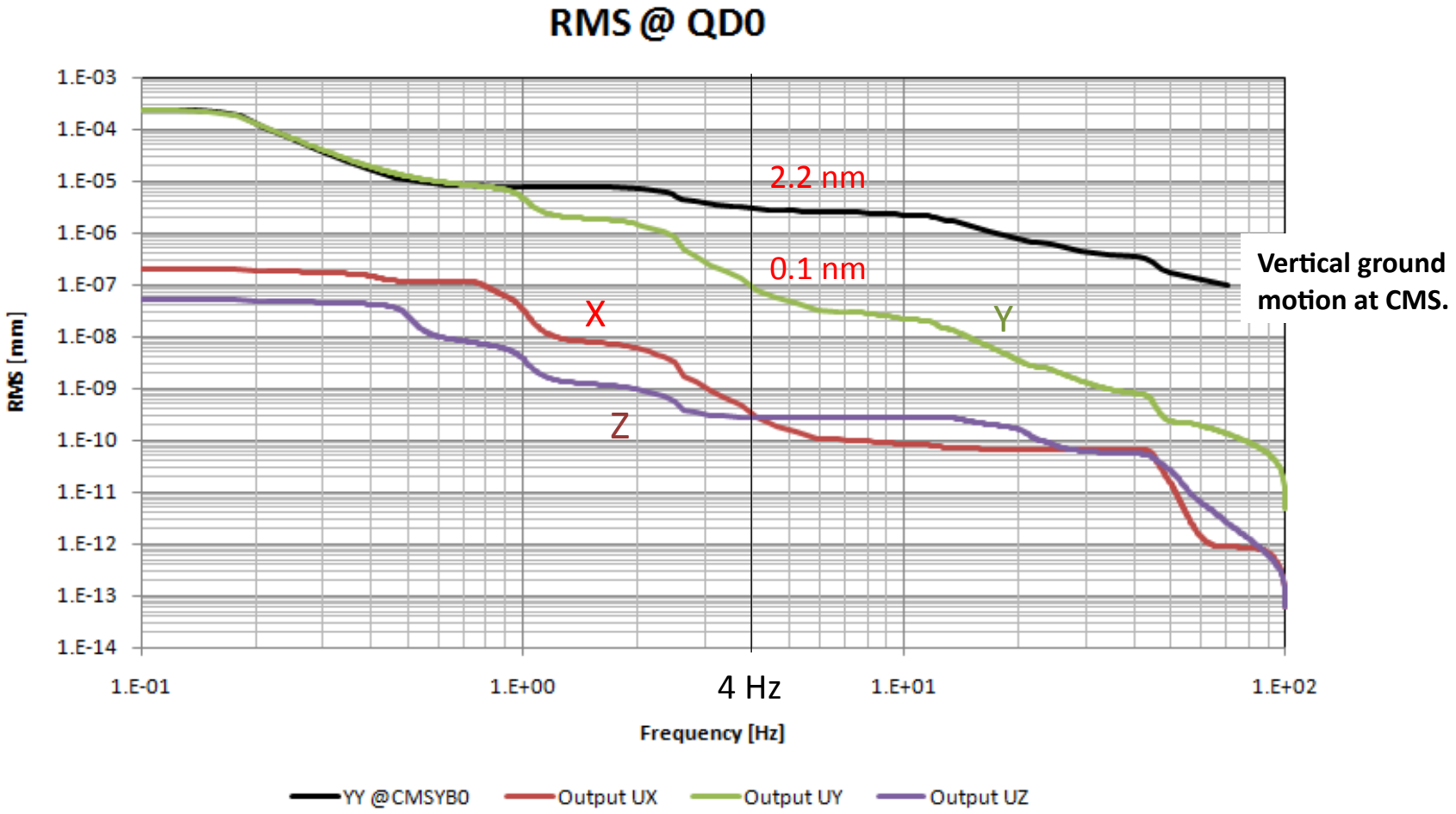
QD0 stabilization

- Pre-isolator:
  - Low dynamic stiffness + large mass (50-100 ton) => Acts as a low-pass filter
- Active stabilizator
  - Piezo-based active stabilizators
- Beam-based stabilization
  - Beam-Position Monitor + Kicker

Pre-isolator alone:
Response to
vertical excitation



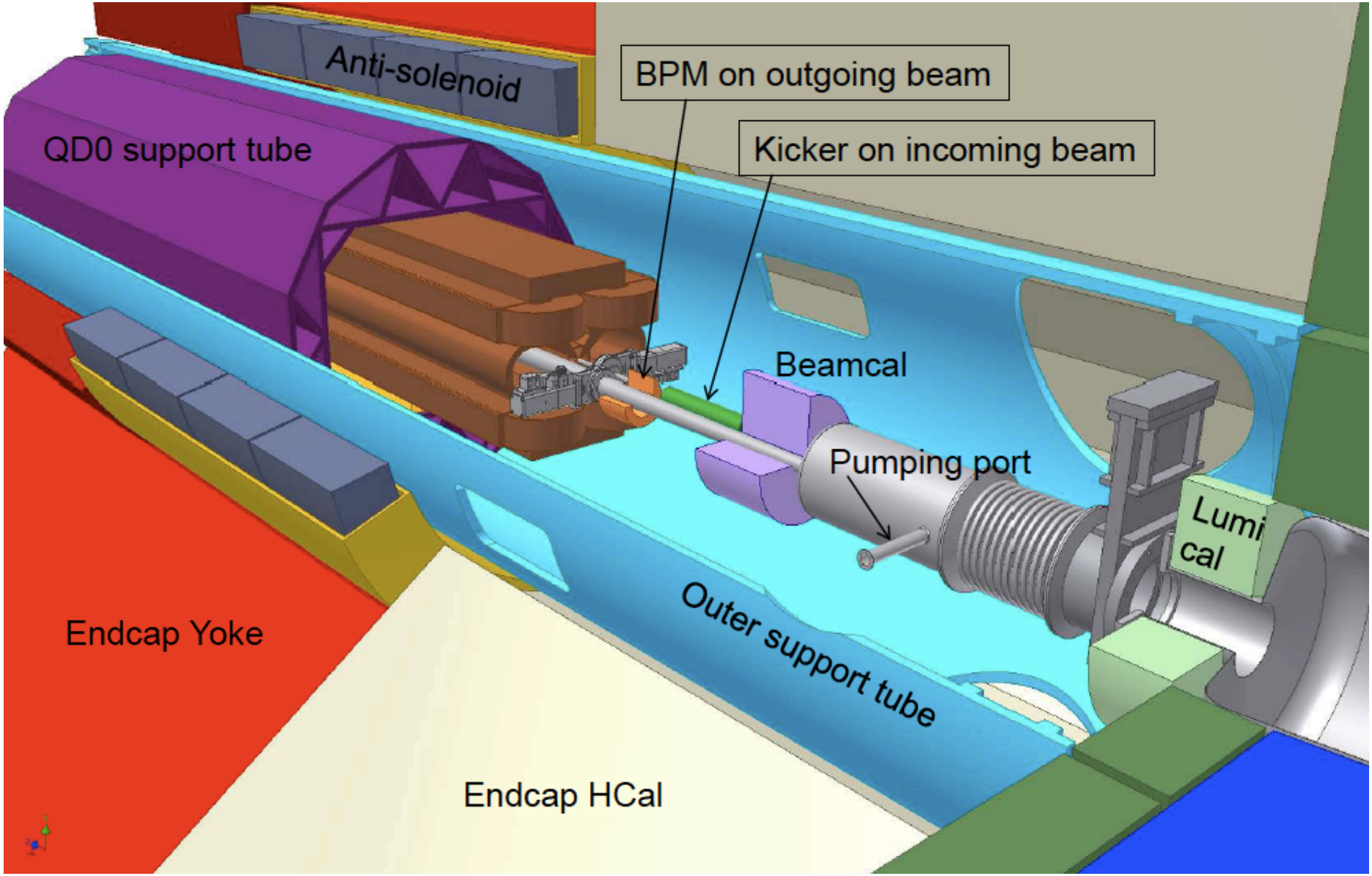
Response to vibration



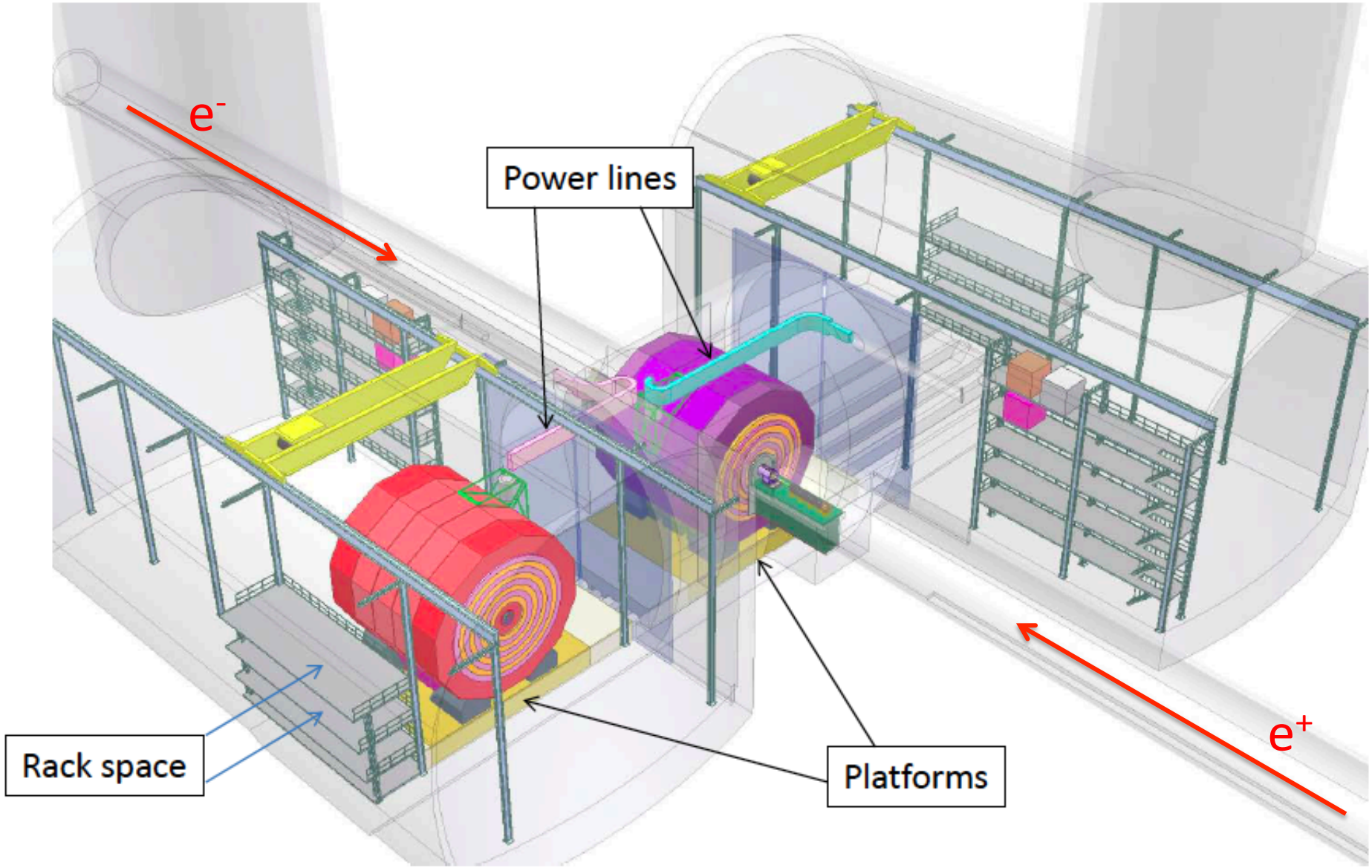
Vertical ground motion at CMS.

Reduction in r.m.s. displacements by a factor 20 above 4 Hz

Forward region layout

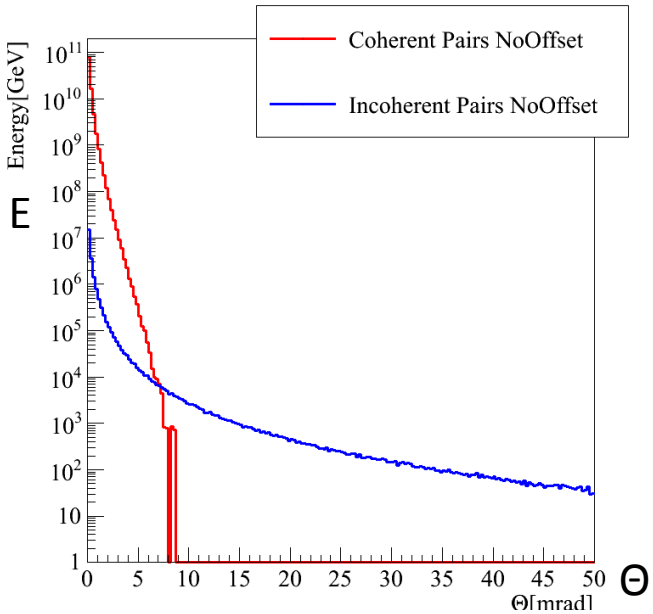


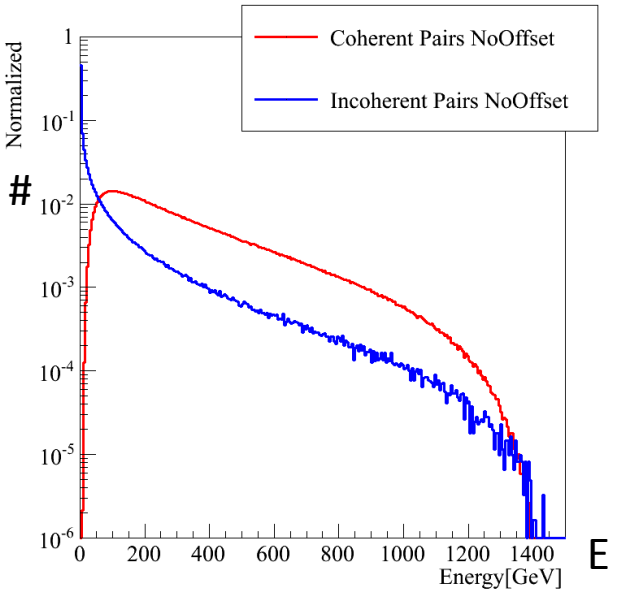
Two experiments in push-pull



Vertex Detector & Forward Region

- Crossing angle: 20 mrad (14 mrad @ ILC)
- Beam-beam interactions produce photons and e^+e^- pairs
  - coherent pairs with high energies and low angles (~10^8/BX)
  - incoherent pairs with high angles and low energies (~300k per BX)

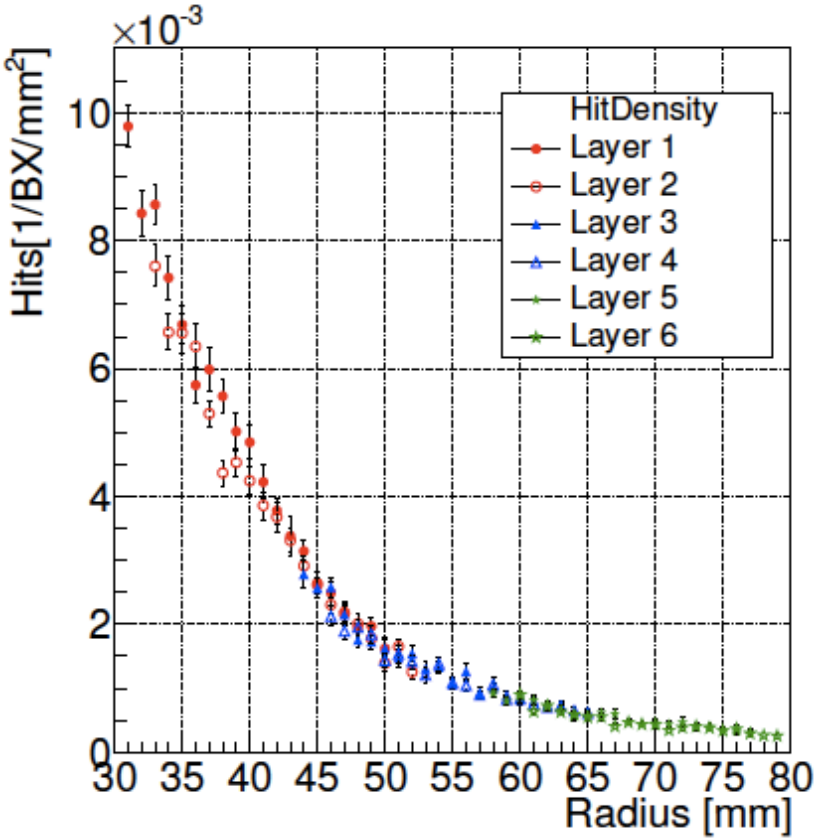




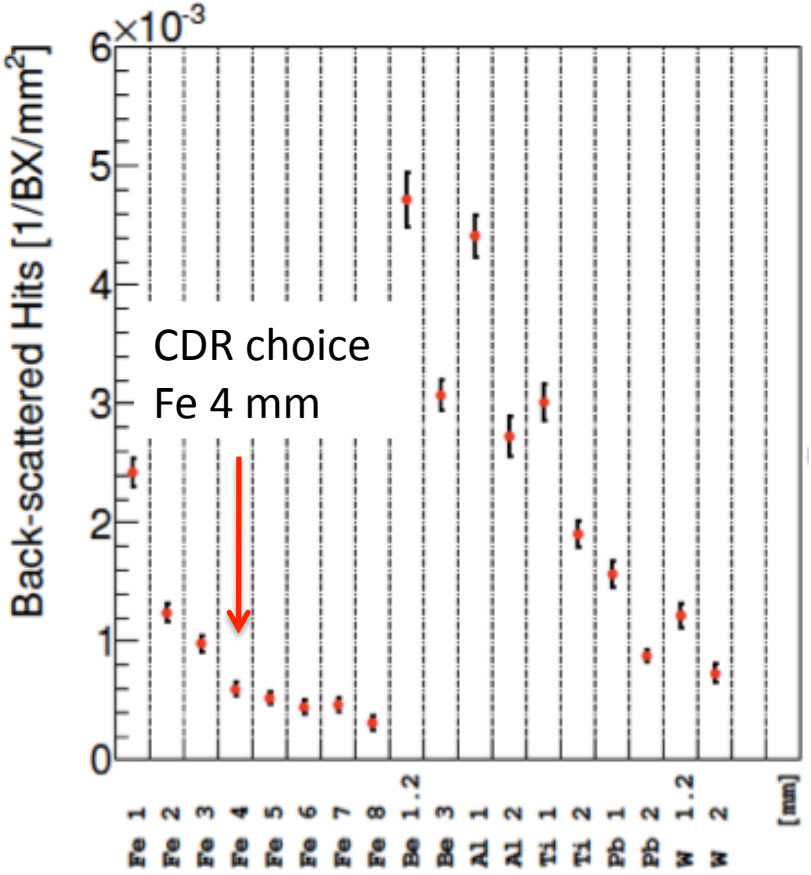
• Move beam pipe and first vertex layer to ~27 mm to reduce direct hits from pair background
• Increase outgoing beam pipe radius to 10 mrad (r_{min} BeamCal)
• Allow space for intra-train-feedback-system and kickers between BeamCal and QD0

André Sailer

Occupancy in vertex detector



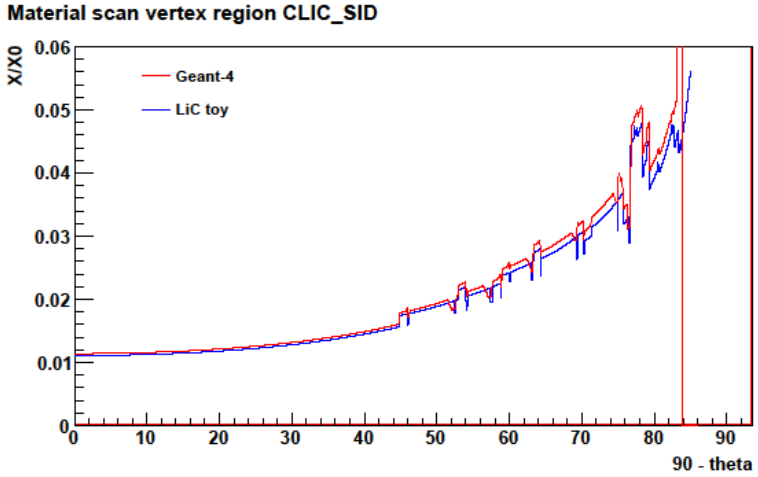
Hit density (1/(BX mm2) in the vertex detector as a function of the radius of the inner layer (CLIC_ILD study)



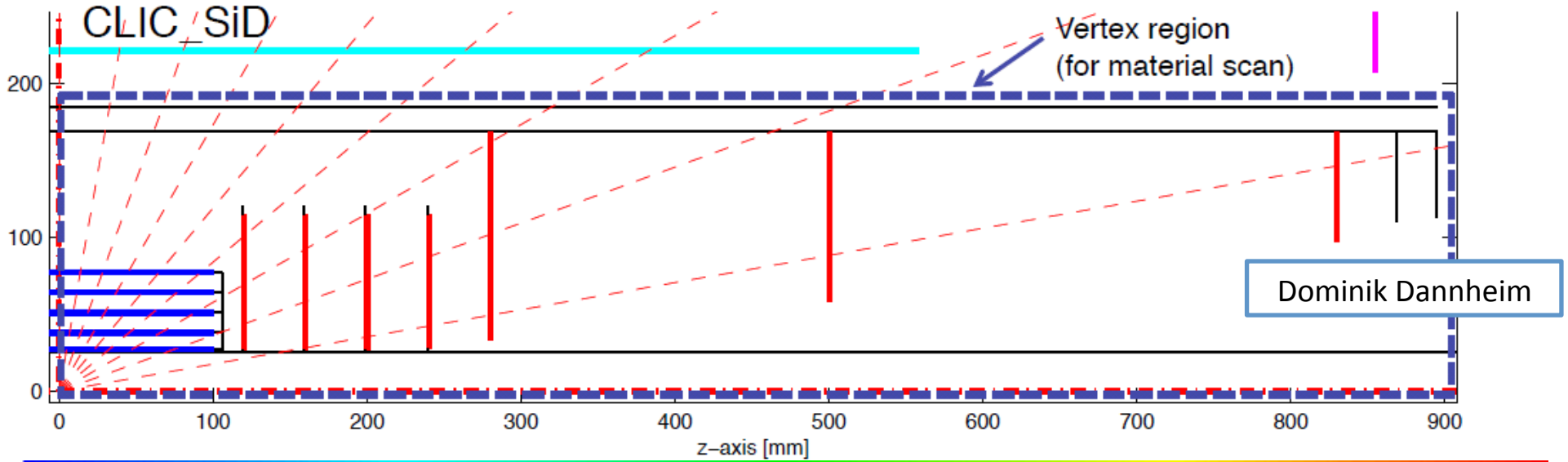
Back-scattered hits (1/(BX mm2) into the vertex detector (1st layer at 31 mm) as a function of material/ thickness of conical beam pipe (CLIC_ILD study)

André Sailer

CLIC_SiD Vertex Detector



- 0.5 mm Be beam pipe with r_{max} = 25 mm
- removed titanium coating inside beam pipe
- 5 pixel layers in barrel (z_{max} = 100 mm)
- 7 pixel disks in endcap and forward
- 20*20 µm² pixels with digital readout
- 50 µm Si thickness + 130µm Carbon support per double layer (0.12% X_0)
- Conical part of beam pipe in 4 mm steel to absorb back-scattering



CLIC_SiD Forward Region

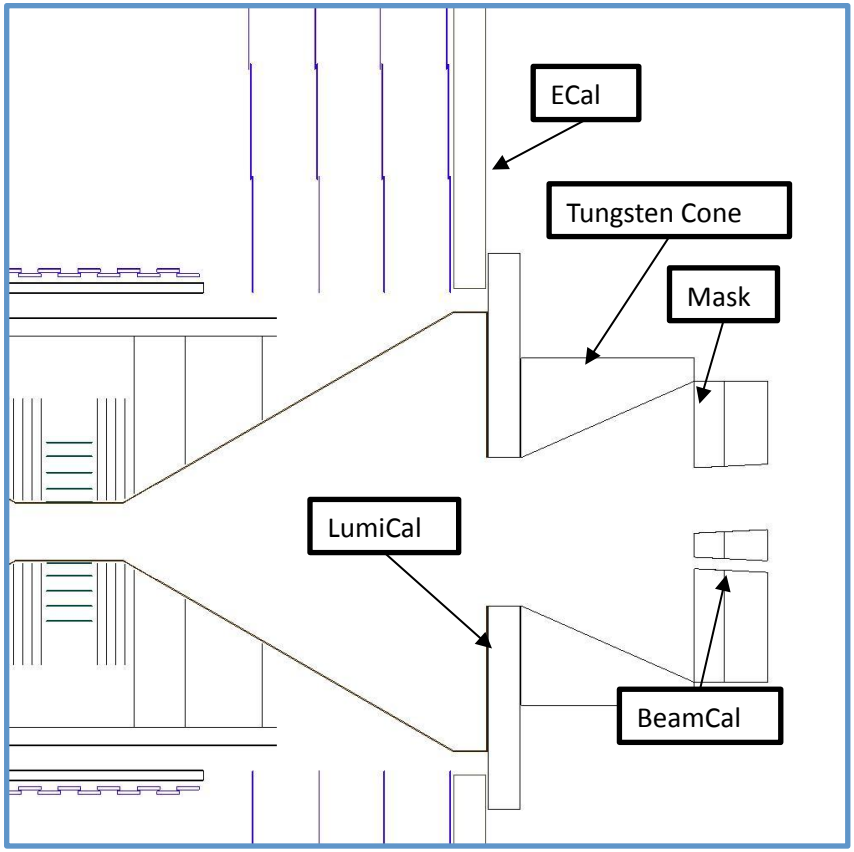
"almost" pointing beam pipe to avoid passing material in a shallow angle

LumiCal:

- implemented like ECal
- 20*2.7 mm + 10*5.4 mm layers tungsten
- 1 mm gap size (0.3 mm Si + Air, Copper Capton), 3.5*3.5 mm² readout
- moved LumiCal behind ECal to avoid gap

BeamCal:

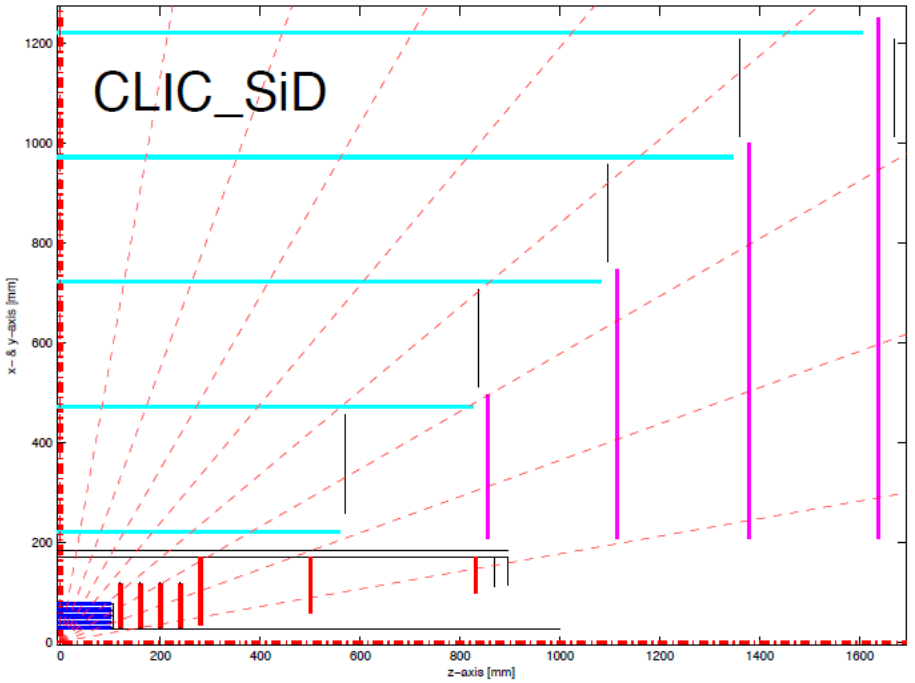
- 50*2.7 mm tungsten + 1mm gap size
- increase outgoing beam pipe opening to 10 mrad
- ~50 cm space for kicker and intra-train-feedback between BeamCal and QD0 (L*=3.5 m)



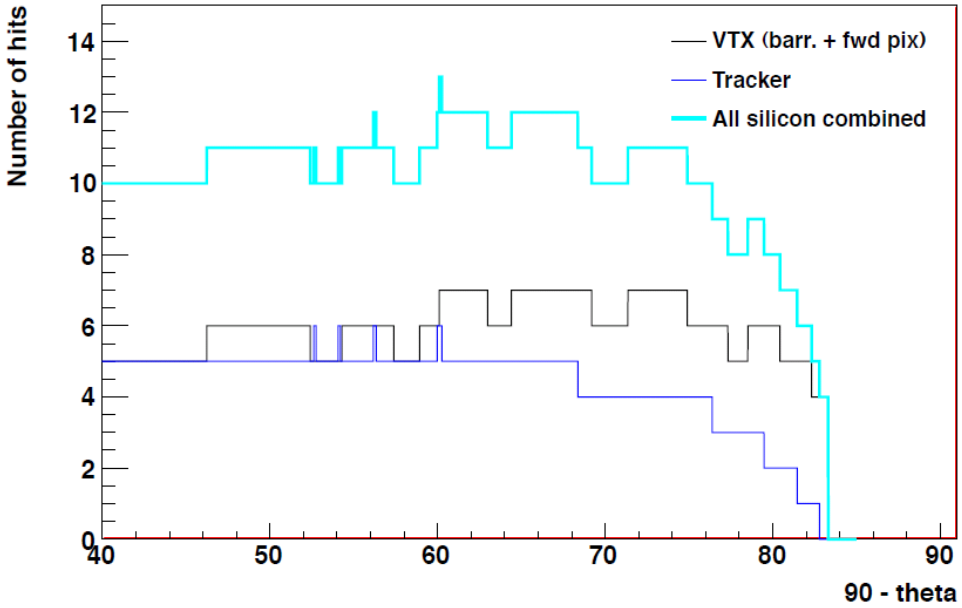
Christian Grefe

CLIC_SiD Tracker

- 5T solenoid field
- 5 barrel strip layers (10cm * 25µm with 50µm digital readout)
- 4 endcap stereo strip layers (10cm) * 25µm with 50µm digital readout)

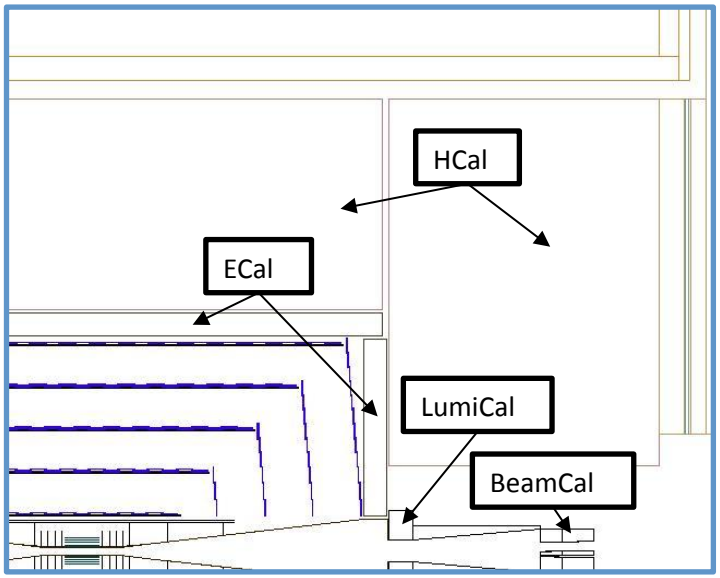


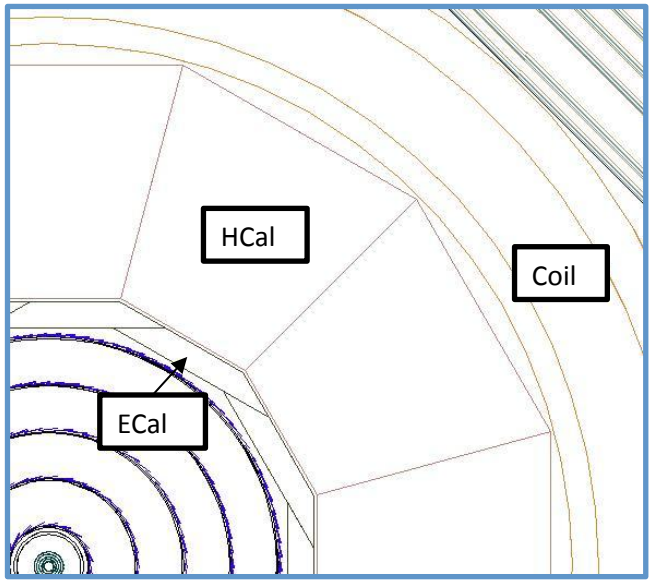
Number of hits in CLIC_SiD tracking detectors (LiC toy)



CLIC_SiD Calorimeters

- ECal (12 sides)
  - Absorbers:
    - 20*2.5 mm tungsten absorber layers
    - 10*5.0 mm tungsten absorber layers
  - Active:
    - 1.25 mm gap size (0.3 mm Si + Air, Copper Capton), 3.5*3.5 mm² readout
- HCal (12 sides, 7.5 Λ_i)
  - Barrel: 75*10 mm tungsten
  - Endcap: 60*20 mm steel
  - Active: 6.5 mm gap size (5 mm polystyrene + 1.5 mm air), 3*3 cm² cell size

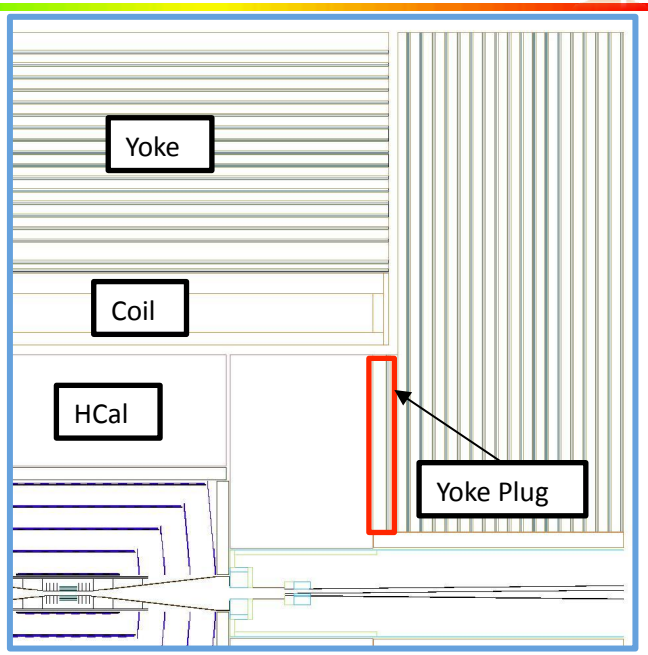


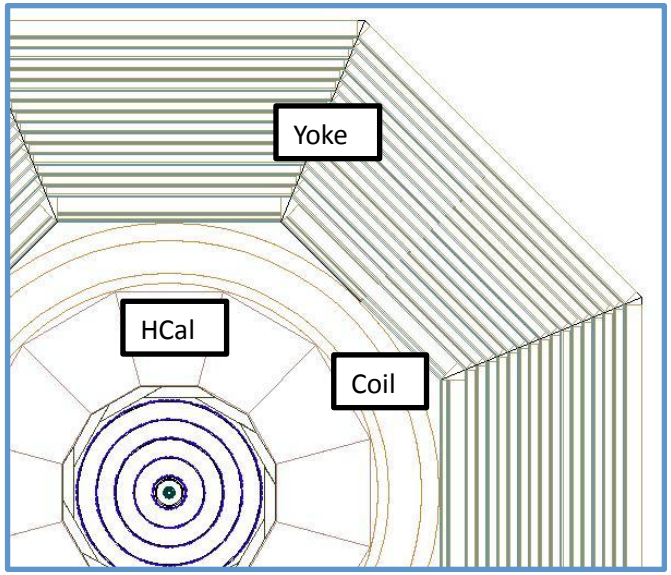


• Analog readout for the HCal was chosen as a baseline for CDR simulation model
• Alternative technologies will be investigated in dedicated studies and presented in the CDR

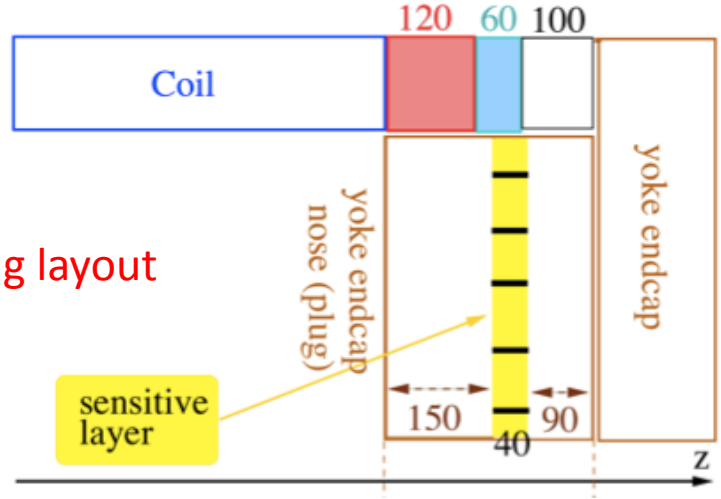
CLIC_SiD Muon System & Yoke

- Yoke (8 sides)
  - Absorber: 18*10 cm steel
  - Active: 4cm gap size (RPC 3*3 cm²)
  - Barrel: 20 cm steel layer after first active layer to take stresses
- Yoke Plug (12 sides)
  - Introduced in order to align start of yoke in the endcap with end of the conductor
  - instrumented with first muon chamber: 15 cm steel + 4 cm RPC + 9 cm steel





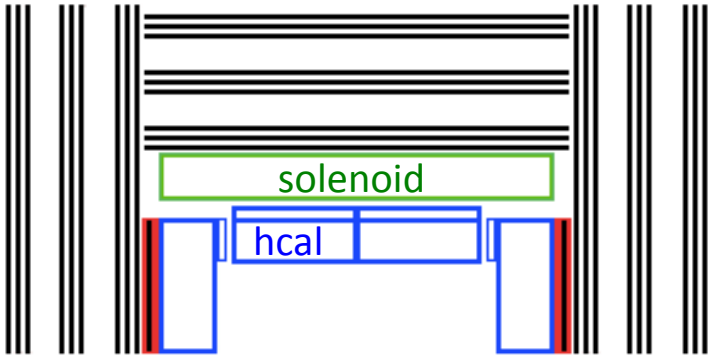
Yoke plug layout



Studies of yoke instrumentation

Choose active layers during digitization

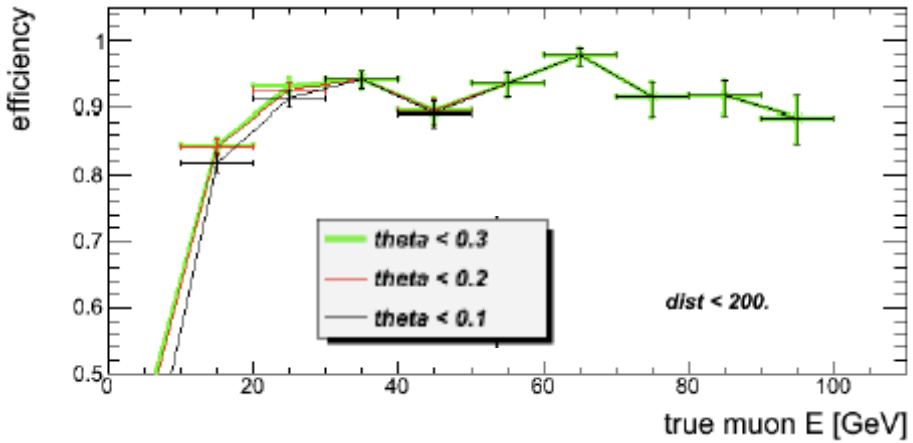
- First 3 layers are used as a tail catcher
- Simulations indicate that 2 * 3 layers in addition provide good Muon ID

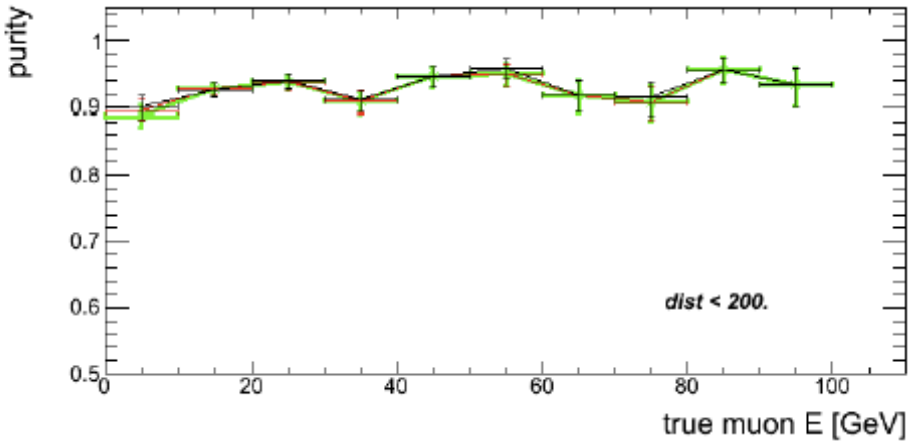


Muon ID processor being implemented in Pandora

Based on matching tracks with hits in the yoke instrumentation

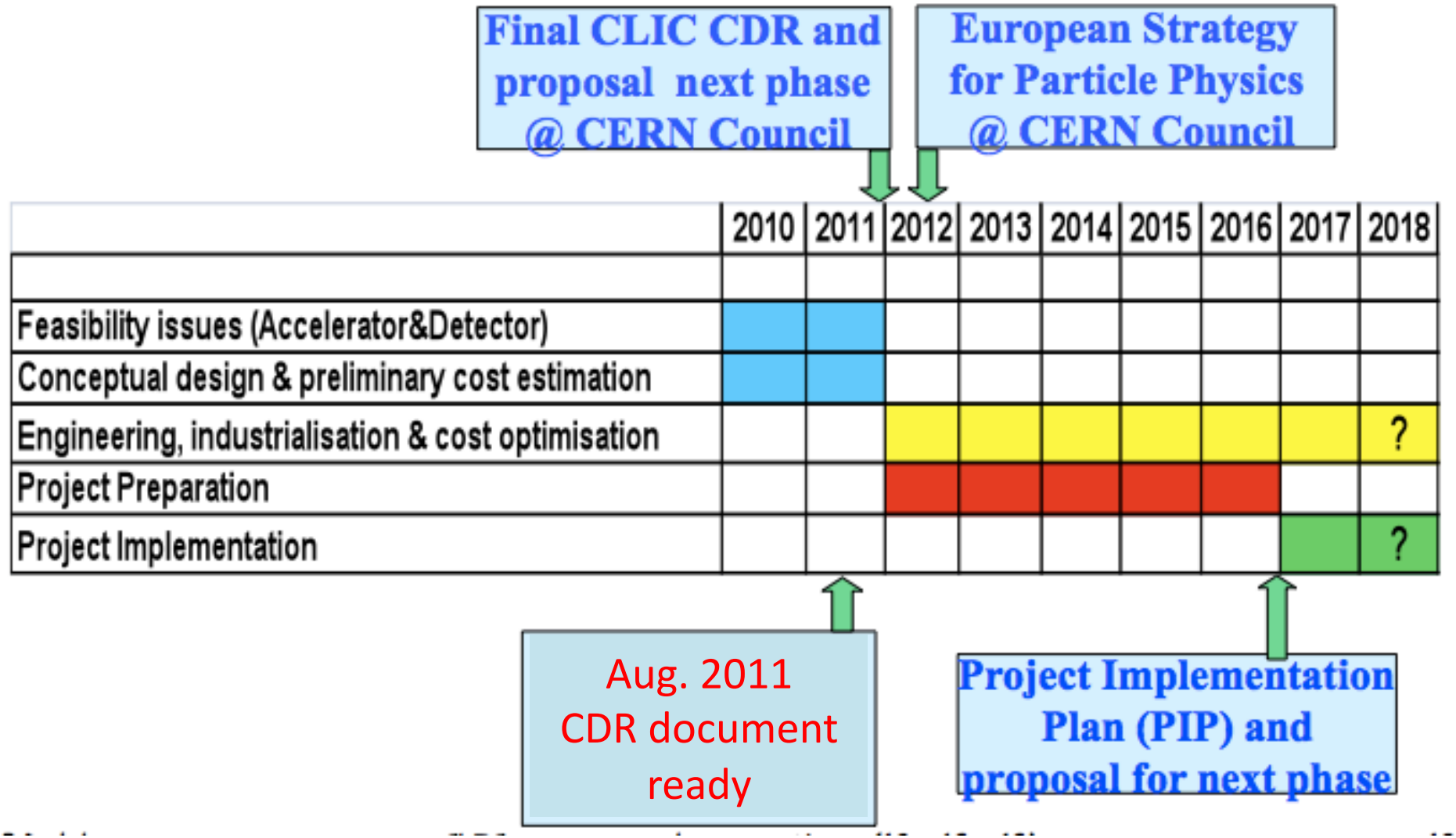
Efficiency — Muons in b-jets — Purity





Erik van der Kraaij

CLIC schedule



CLIC CDR document schedule

CDR deadlines:

- **Oral presentation** to CERN Scientific Policy Committee (SPC) => **June 20/21 2011**
  - Ask SPC to appoint a sub-committee for receiving the document
  - Allow some time for SPC comments before Dec-2011 CERN council meetings
- **Our deadline for the completed Vol 3 document: end-August 2011**

- Final presentation of printed version to CERN council in December 2011

The oral presentation in June 2011 puts additional constraints on the work plan:

- End-May 2011 => all essential input material for the CDR has to be available
- End-June 2011 => final deadline of individual chapters
- End-August 2011 => deadline for the finished Vol 3 document
- End-August 2011 => deadline for the finished Vol 1 document

Planning physics/detector CDR

Performance/benchmark simulations are the most critical part for the physics/detector CDR

Current time-line for readiness for mass production:

- ✓ 25/10/2010: Finalize geometry for CLIC_ILD and CLIC_SID
- ✓ 01/11/2010: Finalize Mokka and SLiC implementations of CLIC_ILD and CLIC_SID
- 01/11/2010: Complete implementations of Overlay processor => good progress
- 01/12/2010: Complete *validation reconstruction path for CLIC_ILD and CLIC_SID*
- 15/12/2010: Finalize reconstruction software and tag releases

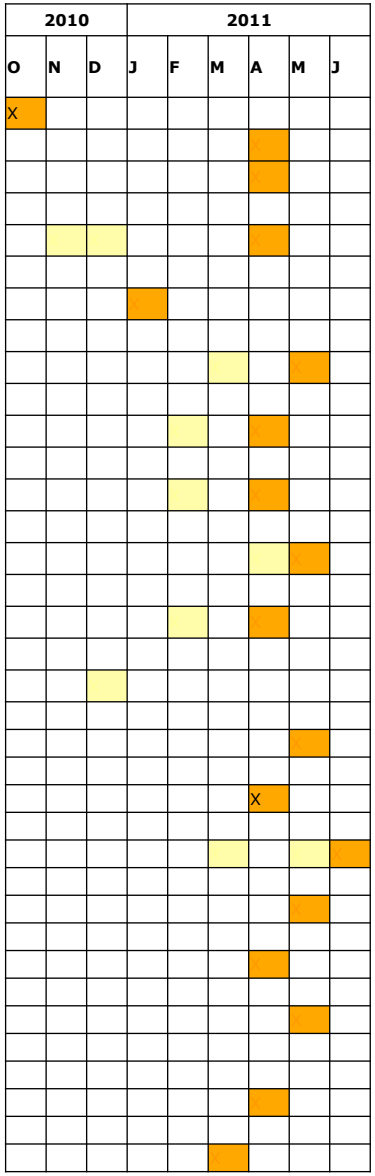
CDR editing:

Discussions have taken place will editors of of all chapters

We now have an almost complete "bullet CDR"

Physics/detector CDR editing

Chapter #	Title	Approx. page count	Submission deadline
1	Introduction	3	25-Oct-10
2	CLIC physics potential	15	30-Apr-11
3	CLIC experimental conditions and detector perf. requirements	20	30-Apr-11
4&5	CLIC detector concepts	14	31-Jan-11
6	CLIC vertex detectors	10	31-May-11
7	Tracking systems	15	30-Apr-11
8	Calorimetry	15	30-Apr-11
9	Superconducting solenoids and magnet systems	8	31-May-11
10	Muon systems at CLIC	4	30-Apr-11
11	Very forward calorimeters	8	31-Dec-10
12	Readout electronics and data acquisition	5	31-May-10
13	Interaction region and detector integration	15	30-Apr-11
14	Physics performance	20	30-Jun-11
15	Future plans and R&D prospects	3	15-May-11
16	Detector cost	3	30-Apr-11
17	Conclusion	1	31-May-11
Appendix A	Software packages	4	30-Apr-11
Deadline for input to the R&D plan			**31-Mar-11**



Outstanding issues

Recent progress on SiD tracking software for CLIC and on SLiCPandora.

Let's see towards the end of this SiD workshop where we stand with:

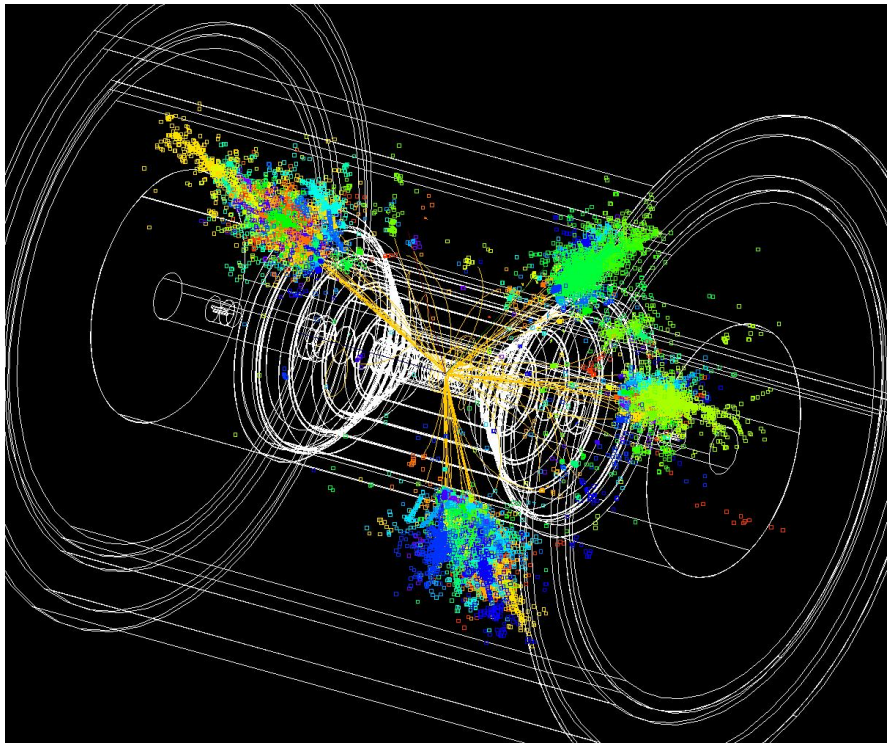
- SiD tracking performance for the CDR
- SLiCPandora and related assessment of jet performance and particle ID

Other subjects:

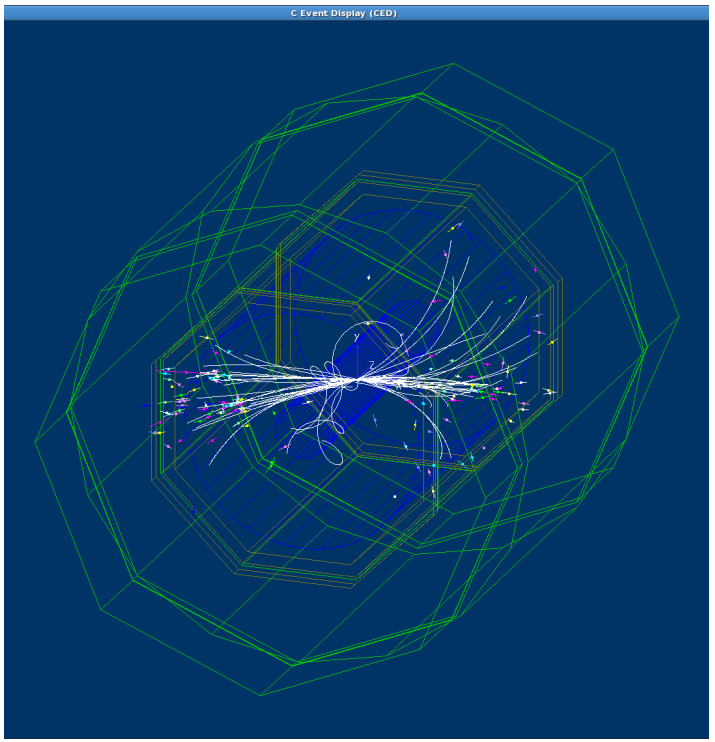
- Outstanding implementation of ~3 µm vertex hit resolution for CLIC-SiD
- Outstanding tracking issues (fundamental algorithm fixes instead of "patches")
- Flavour tagging: common LCFI for LoI's of SiD and ILD => difficult to maintain common flavour tagging for ILD DBD (Japanese groups), SiD DBD (?) and CLIC CDR (CDR time-line too early). Risk of divergence.
- Implementation of yoke plug in the reconstruction
- LCIO simulation driver for digital HCAL (although too late for CDR mass production, shall be done asap)

The CLIC physics/detector studies would not have been possible with your large ILC effort !

Thank you for your collaboration and continuous support !



CLIC_SiD



CLIC_ILD

SPARE SLIDES

CERN LCD group and ILC DBD

The CERN LCD group plans to participate in ILC DBD efforts (SiD and ILD) after the CLIC CDR

- Fair sharing of efforts between ILD and SiD
- Preference for common issues SiD/ILD/CLIC
- **The more similar the software frameworks get, the better for all of us.**

We currently see participation in the domains of:

- Adaptations of ILD and SiD for the 1 TeV case
- Benchmark studies
- DBD editing

CERN LCD resource level for dedicated DBD work still to be defined

CERN LCD is currently preparing a hardware R&D program (tungsten HCAL, CLIC vertex detector technology, solenoid R&D, QD0 stability tests, power pulsing

- Opportunities for collaboration with ILC in these areas

Authorship of the CDR

CDR Authorship

The CLIC CDR will be based on vast amounts of work, previously carried out by the ILC physics/detector communities.

We plan to provide **broad opportunity to sign the CLIC CDR**.

Signing the CDR is a recognition for work in the **past** (on ILC or CLIC) and/or a firm intention to contribute in the **future**.

Due to the fact that "the CLIC CDR" comprises both the accelerator and the detectors, the author list will be a **common author list**

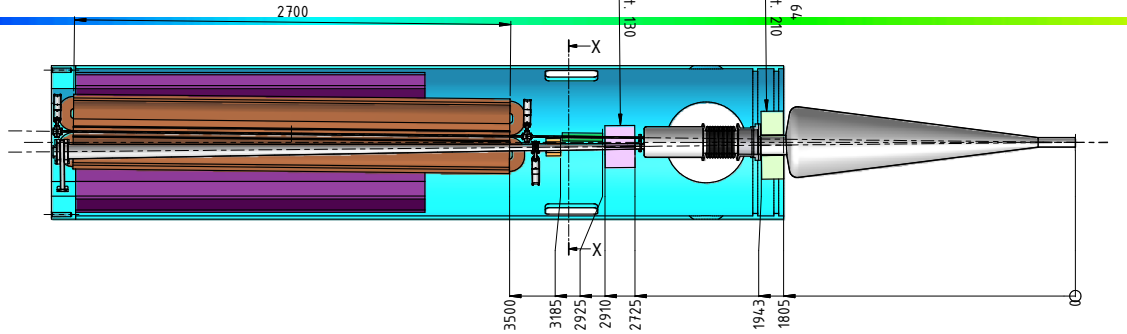
We will set up a web-based inscription for this (e.g. like for ILD and SiD LoI's).
Timing: ~May 2011

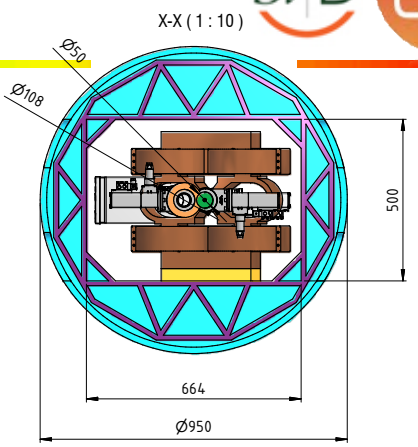
Permanent evolution of CLIC MDI

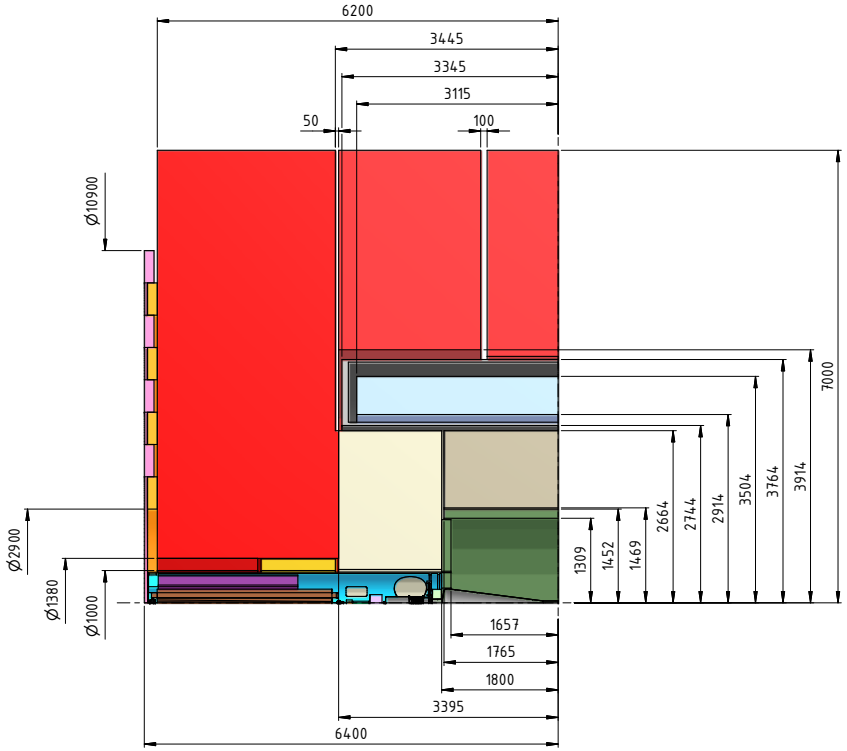
Parameter drawing for 2 detectors	2 experimental caverns connected via a transfer tunnel	Interface BDS/IP extremely short no pac-man but ring chicane with only linear movement	Each detector on a platform
All FF magnets on a pre-isolator exchangeable via experimental cavern	A two-in-one support tube with eigen-frequencies tuned on function and purpose	A sectorisation of the vacuum that allows pre-pumping, no bake-out, pumping port	Stabilisation directly under QD0 Pre-alignment on pre-isolator in the tunnel
Sectorisation for IP, sliding doors separate data taking & maintenance area	Longer experiment adapts via end coils to shorter experiment	Lumical, Kicker Beamcal, BPM and vacuum valves fully integrated	Survey gallery and emergency escape tunnel integrated in cavern design

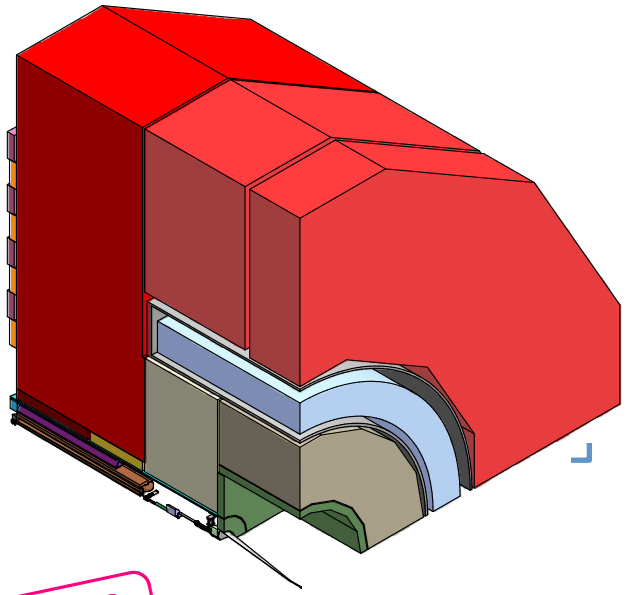
Hubert Gerwig

CLIC_SiD Numbers









DRAFT FOR DISCUSSION

CLIC_SiD for CDR

ECHELLE SCALE 1:50 1:20

DES/DRA. N. Siegrist 29.09.2010

CONTROLLED

RELEASED

APPROVED

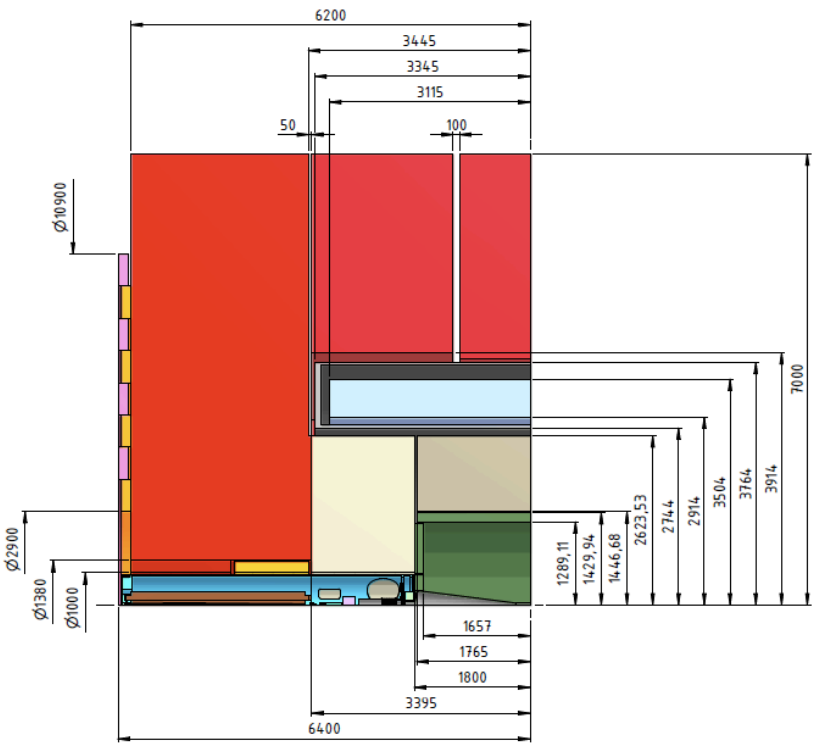
NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION

SIZE A2

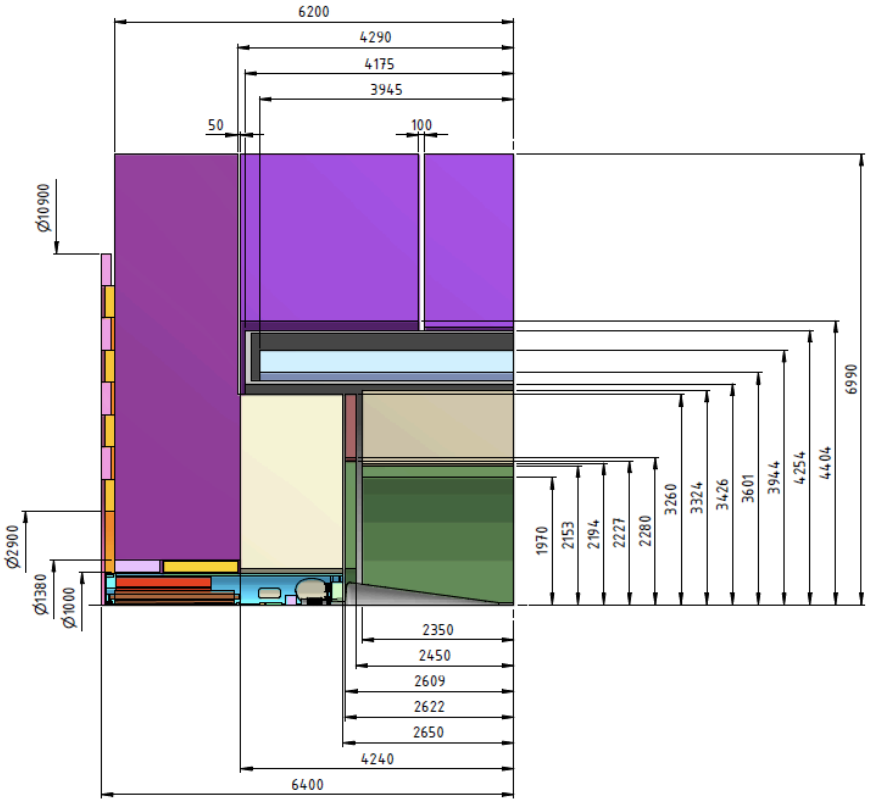
See also at: *https://twiki.cern.ch/twiki/bin/view/CLIC/ClicCDRNumbers*

CLIC_SiD and CLIC_ILD

CLIC_SiD [5T]

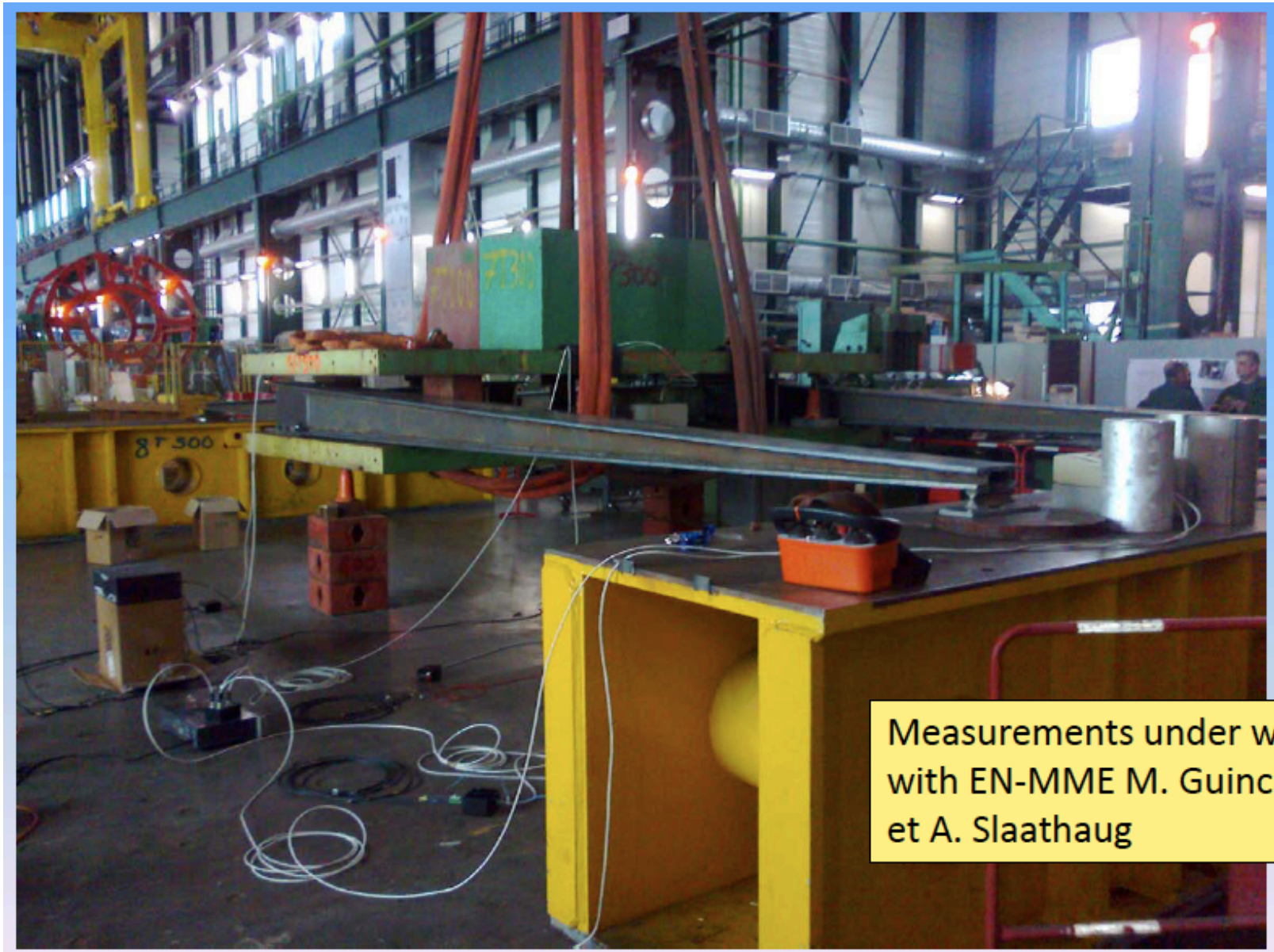


CLIC_ILD [4T]



CLIC_SiD & CLIC_ILD COMPARATIVE LAYOUT	ECHELLE SCALE 1:50	DES/DRA.	N. Siegrist 19.10.2010
		CONTROLLED	
		RELEASED	
		APPROVED	
NON VALABLE POUR EXECUTION NOT VALID FOR EXECUTION	DAC	SIZE A2	IND.

Pre-isolator prototype



Linear Collider main parameters

Technology	ILC	CLIC	
Centre-of-mass energy (GeV)	500	500	3000
Total (Peak 1%) luminosity (10^{34})	2.0(1.5)	2.3(1.4)	5.9(2.0)
Total site length (km)	31	13.0	48.3
Loaded accel. gradient (MV/m)	31.5	80	100
Main linac RF frequency (GHz)	1.3 (Super Cond.)	12 (Normal Conducting)	
Beam power/beam (MW)	20	4.9	14
Bunch charge (10^9 e+/-)	20	6.8	3.72
Bunch separation (ns)	176	0.5	
Beam pulse duration (ns)	1000	177	156
Repetition rate (Hz)	5	50	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	10/40	4.8/25	0.66/20
Hor./vert. IP beam size (nm)	640/5.7	202 / 2.3	40 / 1
Hadronic events/crossing at IP	0.12	0.19	2.7
Coherent pairs at IP	10	100	$3.8\ 10^8$
Wall plug to beam transfer eff	9.4%	7.5%	6.8%
Total power consumption (MW)	216	129.4	415

World-wide CLIC&CTF3 Collaboration

http://clic-meeting.web.cern.ch/clic-meeting/CTF3_Coordination_Mtg/Table_MoU.htm

CLIC multi-lateral collaboration
41 Institutes from 21 countries

ACAS (Australia)
Aarhus University (Denmark)
Ankara University (Turkey)
Argonne National Laboratory (USA)
Athens University (Greece)
BINP (Russia)
CERN
CIEMAT (Spain)
Cockcroft Institute (UK)
ETHZurich (Switzerland)
FNAL (USA)
Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
IHEP (China)
INFN / LNF (Italy)
Instituto de Fisica Corpuscular (Spain)
IRFU / Saclay (France)
Jefferson Lab (USA)
John Adams Institute/Oxford (UK)
John Adams Institute/RHUL (UK)
JINR (Russia)
Karlsruhe University (Germany)
KEK (Japan)
LAL / Orsay (France)
LAPP / ESIA (France)
NIKHEF/Amsterdam (Netherland)
NCP (Pakistan)
North-West. Univ. Illinois (USA)
Patras University (Greece)
Polytech. University of Catalonia (Spain)
PSI (Switzerland)
RAL (UK)
RRCAT / Indore (India)
SLAC (USA)
Thrace University (Greece)
Tsinghua University (China)
University of Oslo (Norway)
Uppsala University (Sweden)
UCSC SCIPP (USA)

CLIC – overall layout 3 TeV