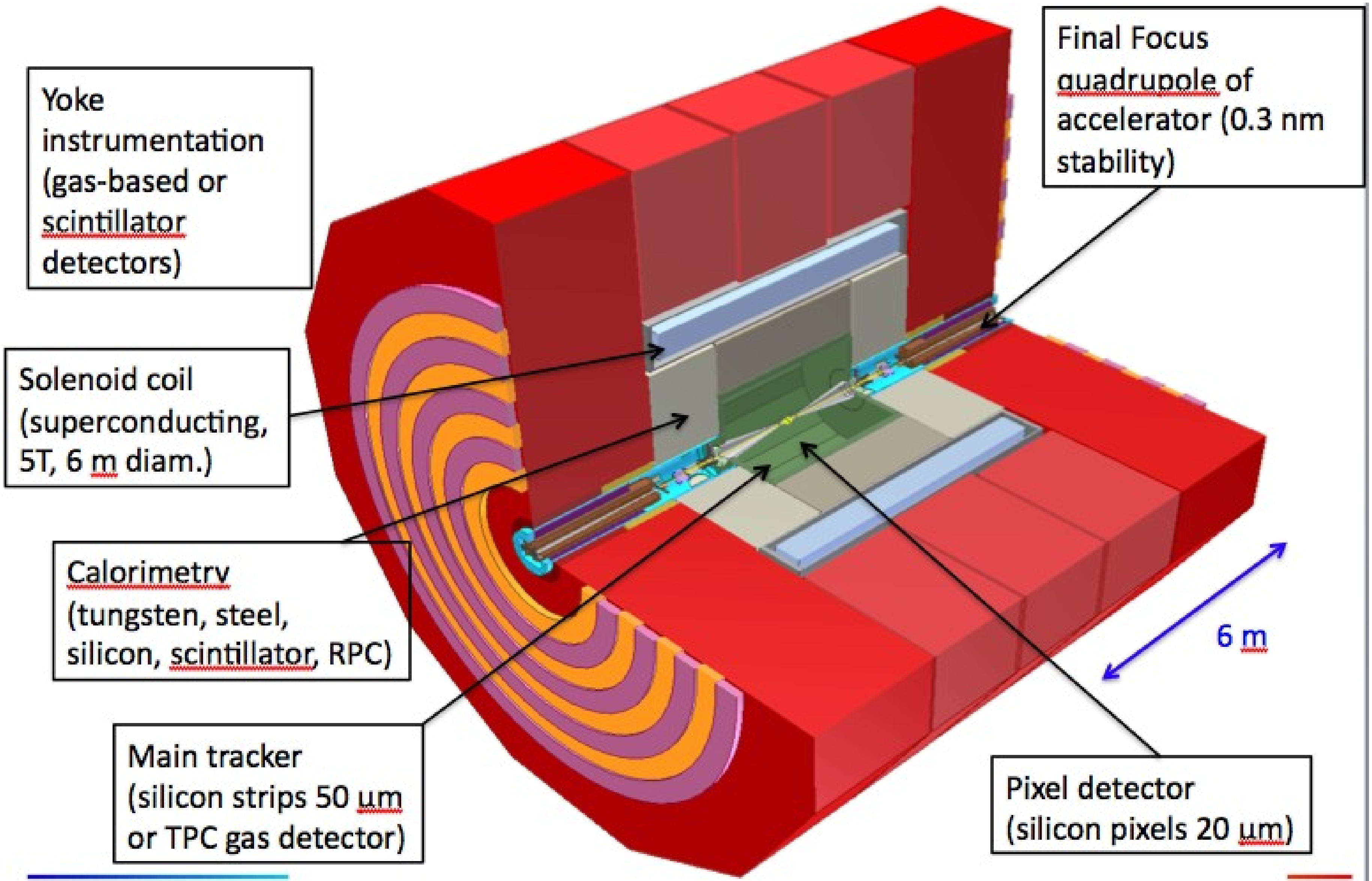
For Marcel Demarteau's R&D talk at ALCWG11

This is a collection of slides.
It is about CLIC-specific detector R&D
and also about
some R&D that CERN is doing for the linear collider (e.g. SAltro16, Timepix2)

Lucie, March 10th 2011

Detector concepts for CLIC



CLIC machine parameters

Parameter	Value
Center-of-mass energy $\sqrt{s}$	3 TeV
Instantaneous peak luminosity	5.9×10^{34} cm^{-2} s^{-1}
Integrated luminosity per year	500 fb^{-1}
Beam crossing angle	20 mrad
Train length	156 ns
$N_{bunches}$ / train	312 (every 0.5 ns)
Train repetition rate	50 Hz
IP size x/y/z	45 nm / 1 nm / 40 µm
# $\gamma\gamma \rightarrow$ hadrons / bx	3.2
# incoherent electron pairs / bx	3×10^5

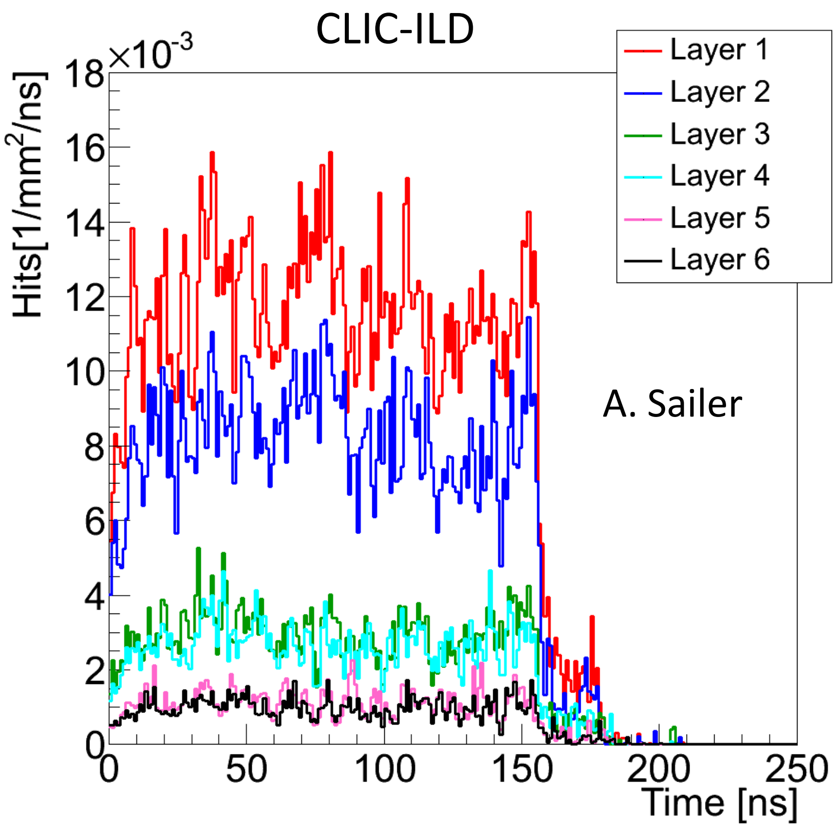
Vertex detector

Beam-Beam backgrounds

- Background occupancies in vertex region dominated by incoherent electron pairs produced from the interaction of real or virtual photons with an electron from the incoming beam
- 20 mrad crossing angle leads to large amount of back-scattered particles, suppressed in latest design by optimization of absorbers and forward geometry

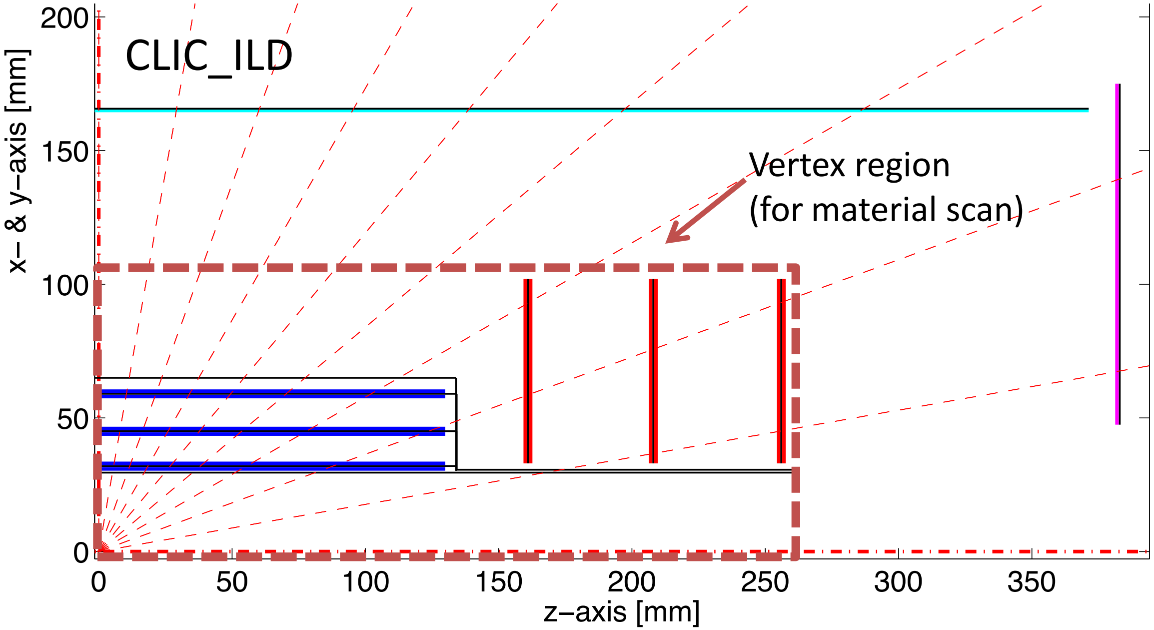
- In CLIC_ILD innermost barrel layer (R=30 mm):
  - ~1.5 hits / mm^2 / 156 ns train
- assuming 20 x 20 um^2 pixels, cluster size of 5, safety factor of x5:
  - ~1.5% occupancy / pixel / 156 ns train
- $\gamma\gamma \rightarrow$hadrons: ~5-10x smaller rates
- CLIC-SiD: similar background rates

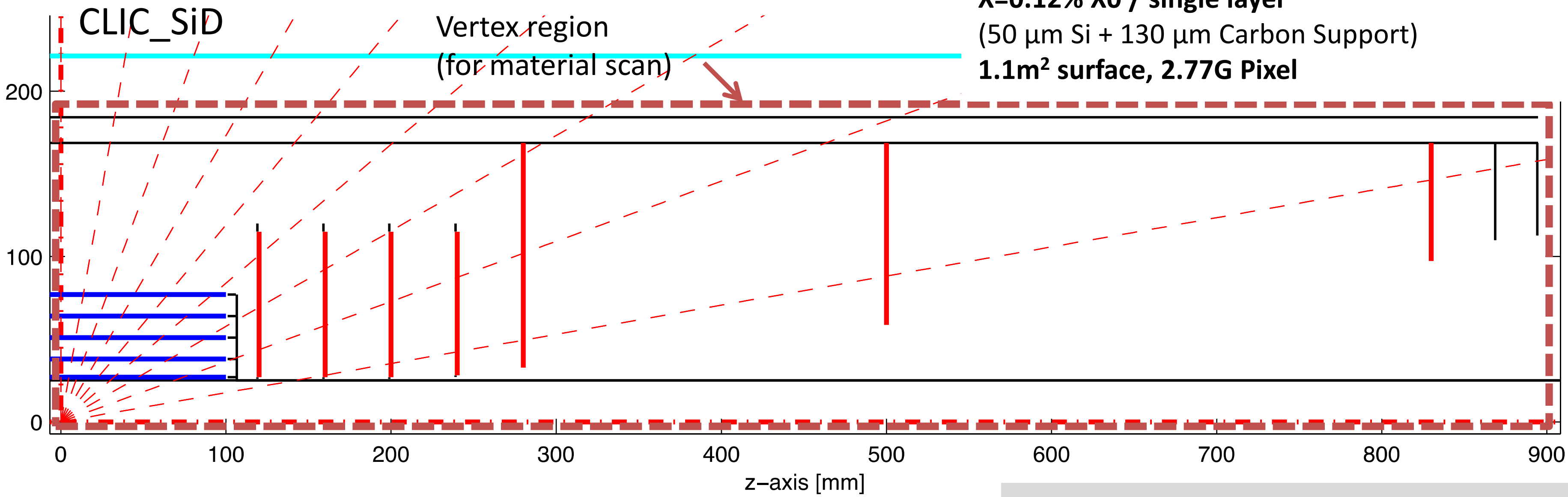
→ Multiple hits per bunch train can occur
→ Sufficient to readout only once per train
→ Time stamp with 5-10 ns required



A. Sailer

CLIC vertex detector region



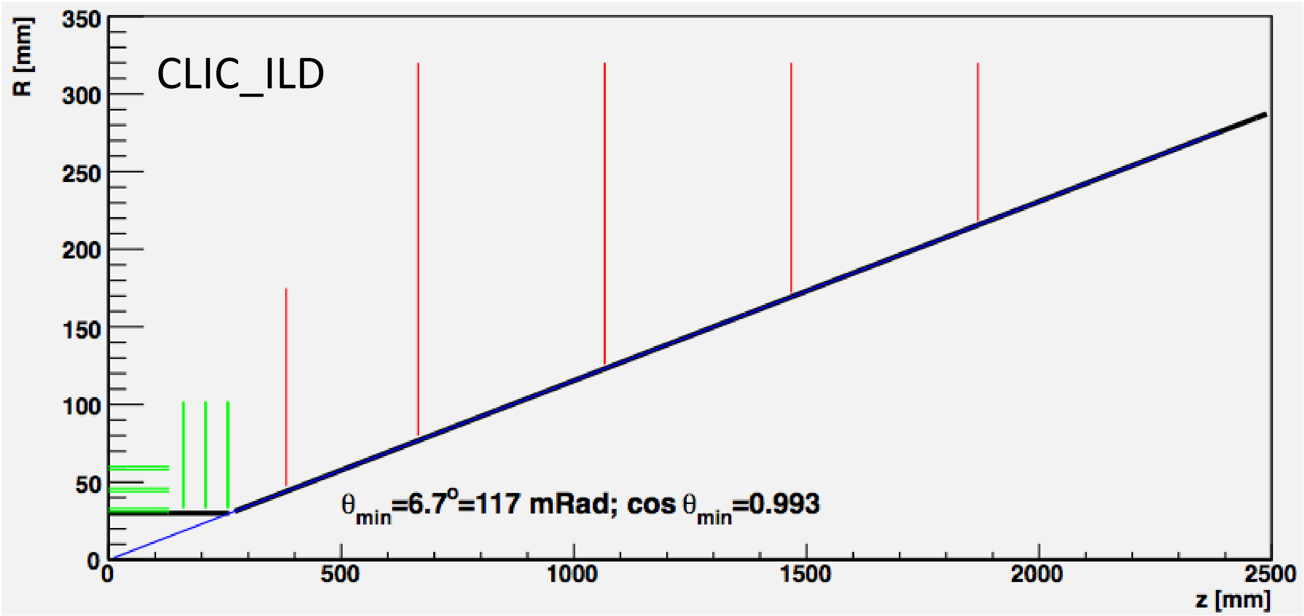


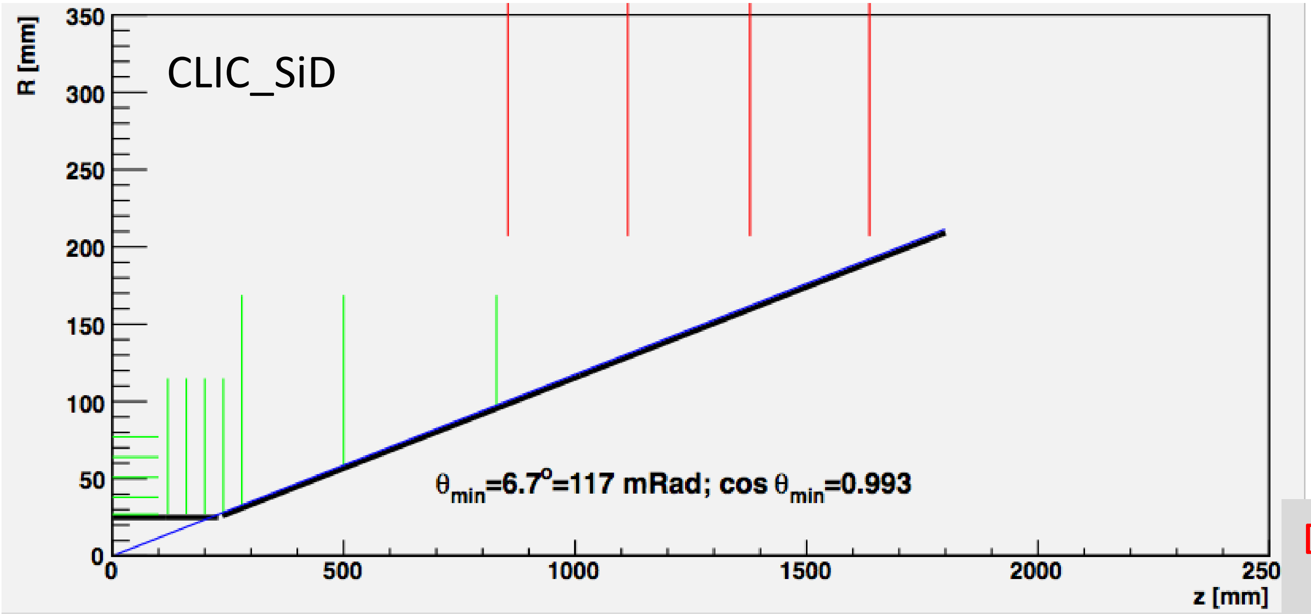
CLIC_ILD
0.6 mm Be beampipe at R=30 mm
3 double layers of pixel cylinders
3 double layers of pixel disks
20 µm pixels, analog readout, σ_{sp}=2.8 µm
X=0.18% X0 / double layer
(2 x 50 µm Si + 134 µm Carbon Support)
0.74m^2 surface, 1.84G Pixel

CLIC_SiD
0.5 mm Be beampipe at R_i=25 mm
5 single layers of barrel pixel cylinders
7 single layers of forward pixel disks
20 µm pixels, binary (analog) r/o,
σ_{sp}=5.8 µm (3 µm)
X=0.12% X0 / single layer
(50 µm Si + 130 µm Carbon Support)
1.1m^2 surface, 2.77G Pixel

D. Dannheim, M. Vos, C. Grefe

Vertex detector layout, including beam pipe



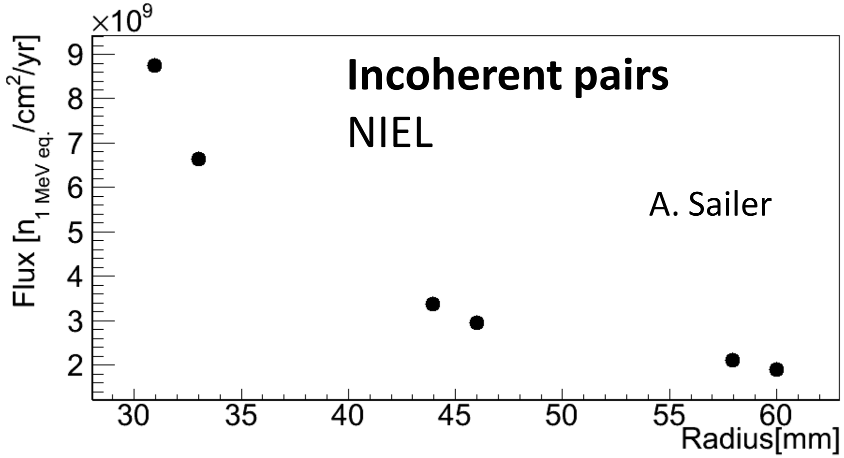


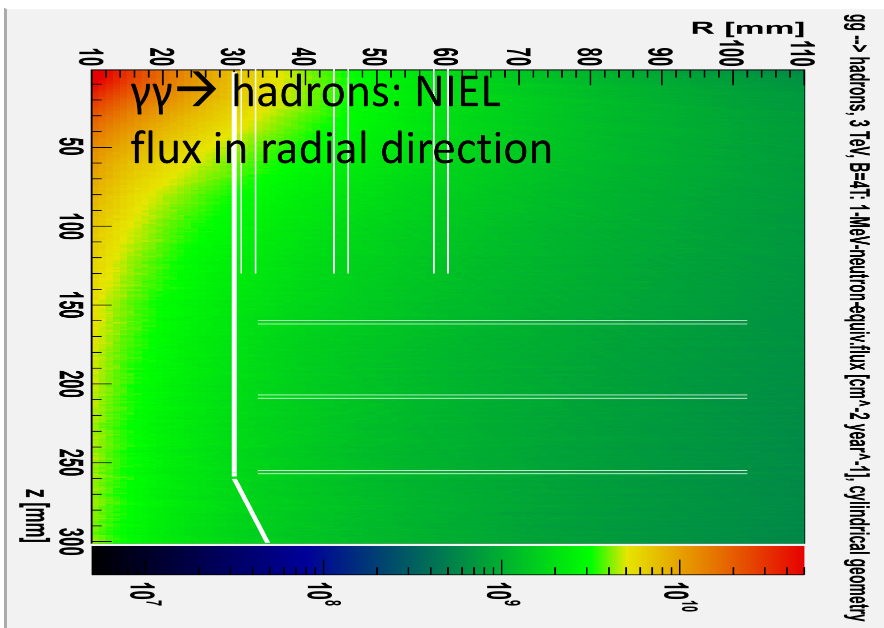
D. Dannheim, M. Vos, C. Grefe

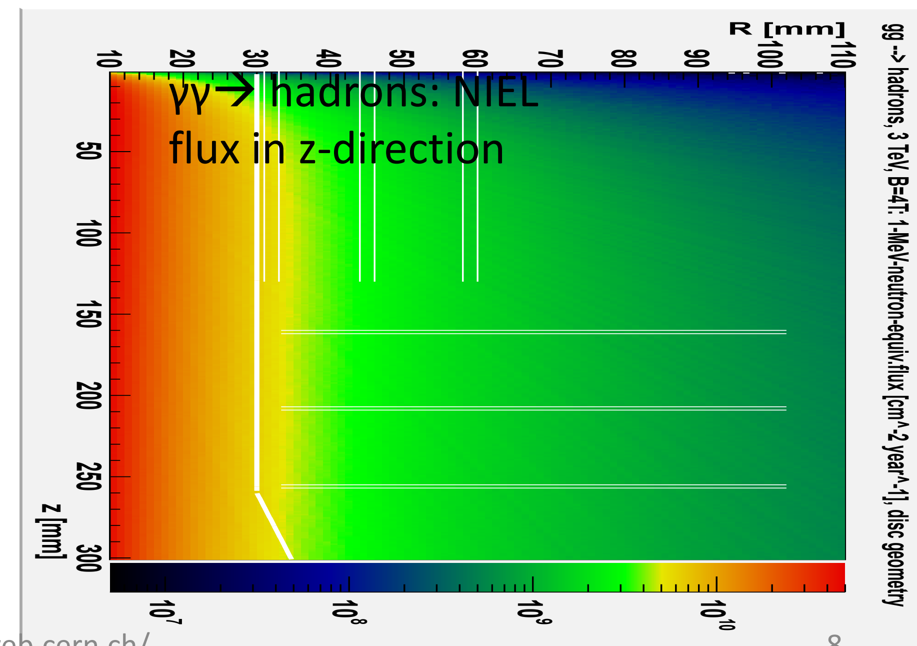
Radiation hardness requirements (CLIC-ILD)

A. Sailer, D. Dannheim

- Expect negligible radiation damage from primary interactions
- Background from beam-delivery system: backscattered neutrons + synchrotron radiation, not investigated in detail yet. Reducible by careful design of collimation system
- incoherent pairs:
  - NIEL: <~ 10^{10} n_{eq} / cm^2 / year
  - TID: <~ 80 Gy / year
- γγ → hadrons
  - NIEL: <~10^{10} n_{eq} / cm^2 / year
  - TID: <~5 Gy / year







Summary: vertex-detector parameters

Parameter	CLIC-ILD	CLIC-SiD
Magnetic field	4 T	5 T
Beam pipe (central region)	0.6 mm Beryllium, R=30 mm	0.5 mm Beryllium, R=25 mm
Barrel pixel layers	3 double layers 31 mm < R < 60 mm	5 single layers 27 mm < R < 77 mm
Forward pixel disks	3 double layers 160 mm < z < 257 mm	7 single layers 120 < z < 830 mm
Layer thickness	0.18% X0 / double layer	0.12% X0 / single layer
Pixel size	20 μm pitch, 50 μm silicon depth	
Total area	0.74 m^2	1.11 m^2
Total number of pixels	1.84G	2.77G
Readout	σ_{SP}~3 μm, trigger-less for 312 bx in 156 ns at 50 Hz	
projected IP resolution (90°)	$\sigma_{R\phi}=1.5\ \mu m \oplus 20\ \mu m\ GeV / p_T$	similar, t.b.c.
Power consumption target	< 100 mW/cm^2 (<0.4 μW/pixel) before power pulsing	
Background occupancy (ee)	~0.01 hits / mm^2 / ns (innermost layers)	
Time resolution	5-10 ns (for background rejection)	
Radiation (pairs+γγ→hadr.)	NIEL: ~10^{10} n_{eq} cm^{-2} y^{-1} ; TID: ~100 Gy y^{-1}	

R&D plans for CLIC vertex

- Requirements for CLIC vertex detector:
  - 5-10 ns timestamp
  - triggerless readout over full 156 ns train
  - 0.1%-0.2% X_0/layer
  - ~3 µm point resolution

- Possible roadmap:
  - need high-resistivity thin (~50 µm) sensor layer
  - need very thin readout layer (~50 µm)
  - ~20µm*20µm pixels
  - currently looking into hybrid solution
    - With advanced interconnect (or future 3D integration)
    - Possibly following Medipix3=>Timepix2=>Timepix3 (65nm)=>CLICpix road
    - Sensor and ASIC thinning
    - DC-DC power delivery + power pulsing

Do not forget to announce the power delivery and power pulsing workshop May 9+10, Orsay, France

http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=5010

Timepix2
(for pixelized TPC readout, and also as a step in the roadmap to a possible CLICpix)

Timepix2 ASIC development

- Follow-up on Timepix and Medipix3 chips
- Broad client community (HEP and non-HEP):
  - X-ray radiography, X-ray polarimetry, low energy electron microscopy
  - Radiation and beam monitors, dosimetry
  - 3D gas detectors, neutrons, fission products
  - Gas detector, Compton camera, gamma polarization camera, fast neutron camera, ion/MIP telescope, nuclear fission, astrophysics
  - Imaging in neutron activation analysis, gamma polarization imaging based on Compton effect
  - Neutrino physics
- Main Linear Collider application: pixelized TPC readout

- Technology IBM 130nm DM 3-2-3 or 4-1
- Design groups: NIKHEF, BONN, CERN
- PLL and on-pixel oscillator architecture test (MPW, spring 2011)
- Expected submission of full Timepix2 chip (early 2012)

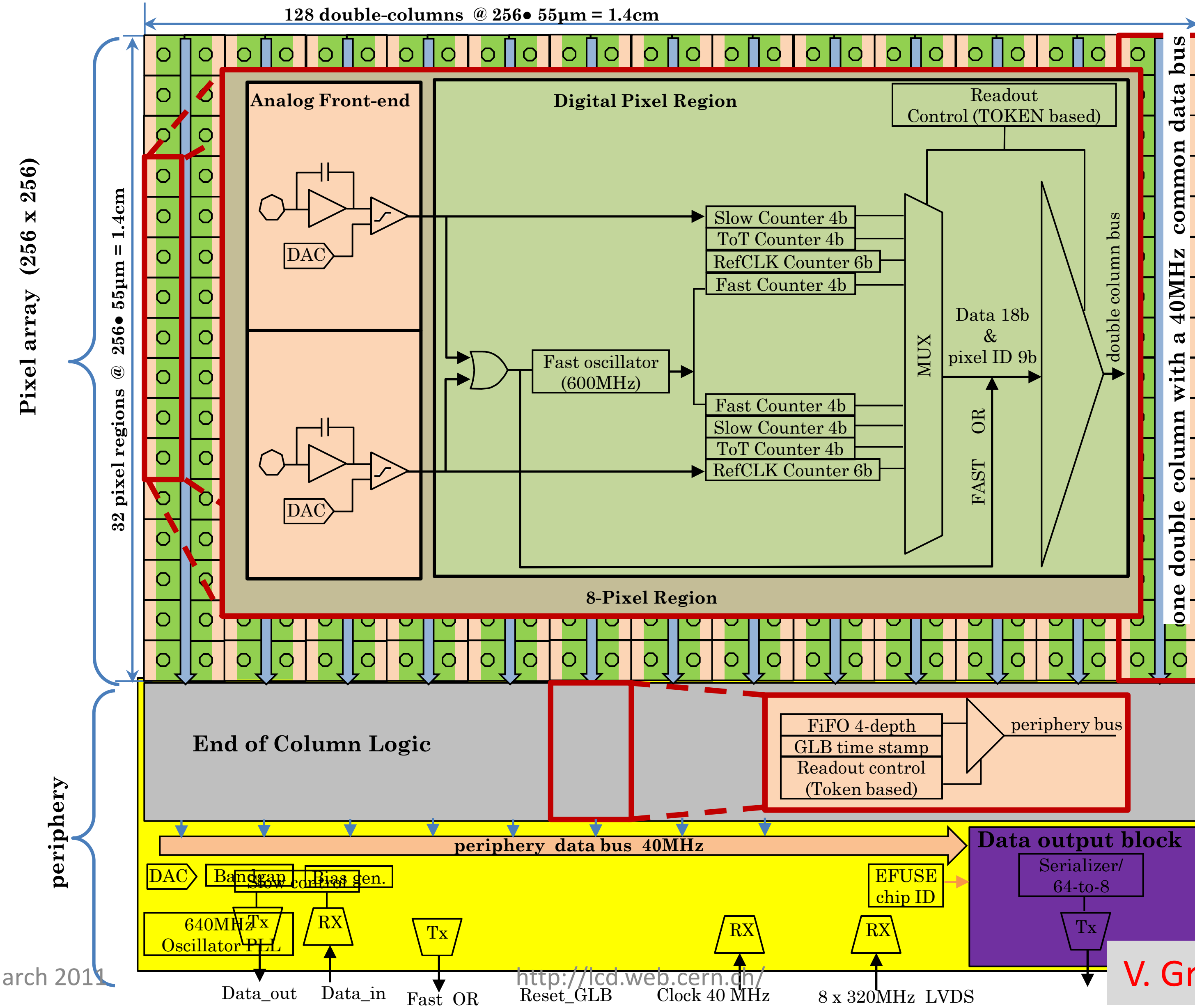
X. Llopart-Cudie, CERN

Timepix2 Main requirements

- Matrix layout: 256x256 pixels (Pixel size 55x55 µm)
- Low noise and low minimum detectable charge:
  - < 75 e- ENC
  - < 500 e- minimum threshold
- Time stamp and TOT recorded simultaneously
  - 4 bits Fast time-stamp
    - resolution ~1.5ns (if using on-pixel oscillator running at 640MHz)
    - Dynamic range 25ns
  - 10-12 bits Slow time-stamp
    - Resolution 25ns (@40MHz)
    - Dynamic range 25.6 µs (10 bit) to 102.4 µs (12 bit)
  - 8-10 bit Energy Measurement (TOT)
    - Standard Resolution 25ns (@40MHz)
    - Energy Dynamic range from 6.4 µs to 25.6 µs (@40MHz)
- Bipolar input with leakage current compensation
  - e- and h+ collection, input capacitance <<50 fF
- Sparse Readout

X. Llopart-Cudie, CERN

Timepix2 Top Level Schematic



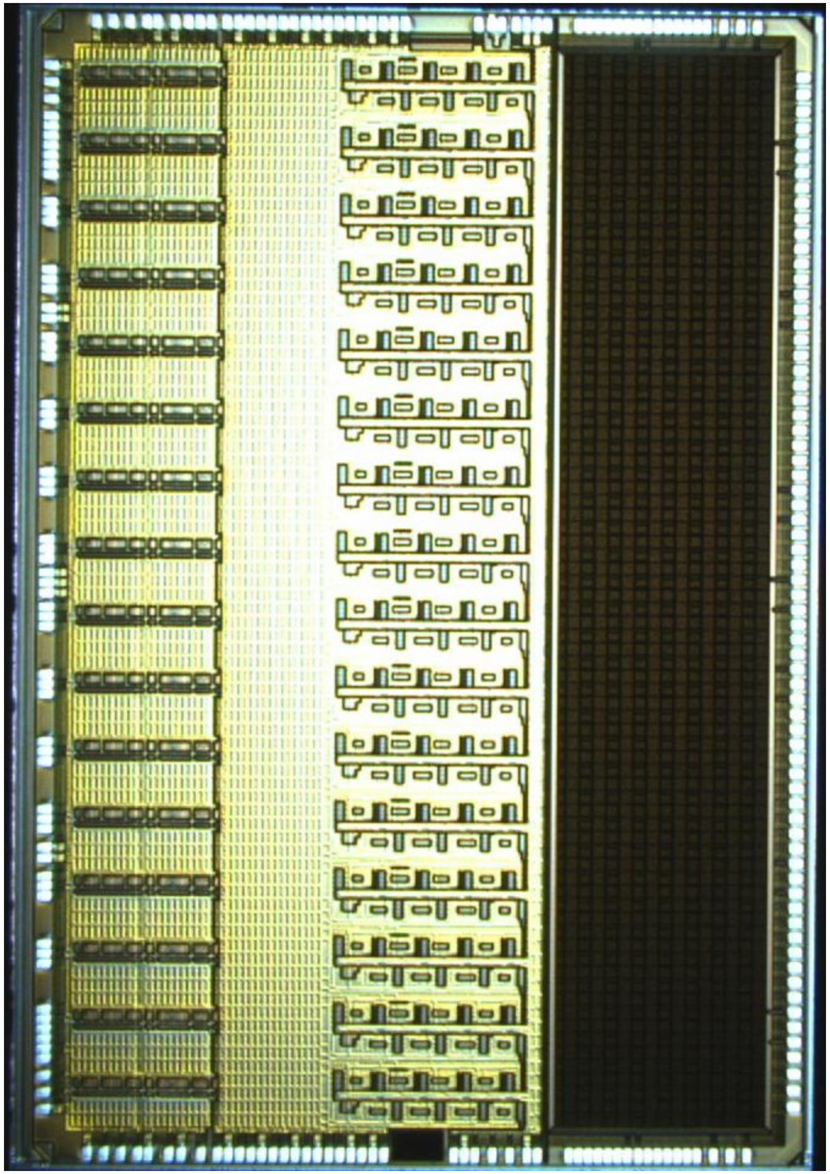
V. Gromov, Nikhef

SAltro16
(for TPC pad readout)

We have just received Saltro16 back from the foundry. So it is not yet tested.
I presume that you are also receiving slides from the from the LC-TPC collaboration.
These may contain material of the GEM test in the TPC, where the amplifier stage of S-Altro is already in use.

The Saltro 16

P. Aspell, M. de Gaspari, H. Franca,
E. Garcia, L. Musa, CERN



A 16 channel front-end chip including DSP functions for the readout of gaseous detectors such as MWPC, GEM, Micromegas.

Submitted in IBM 130nm CMOS technology, Q3 2010.

Received back from the foundry Q1, 2011, currently under test.

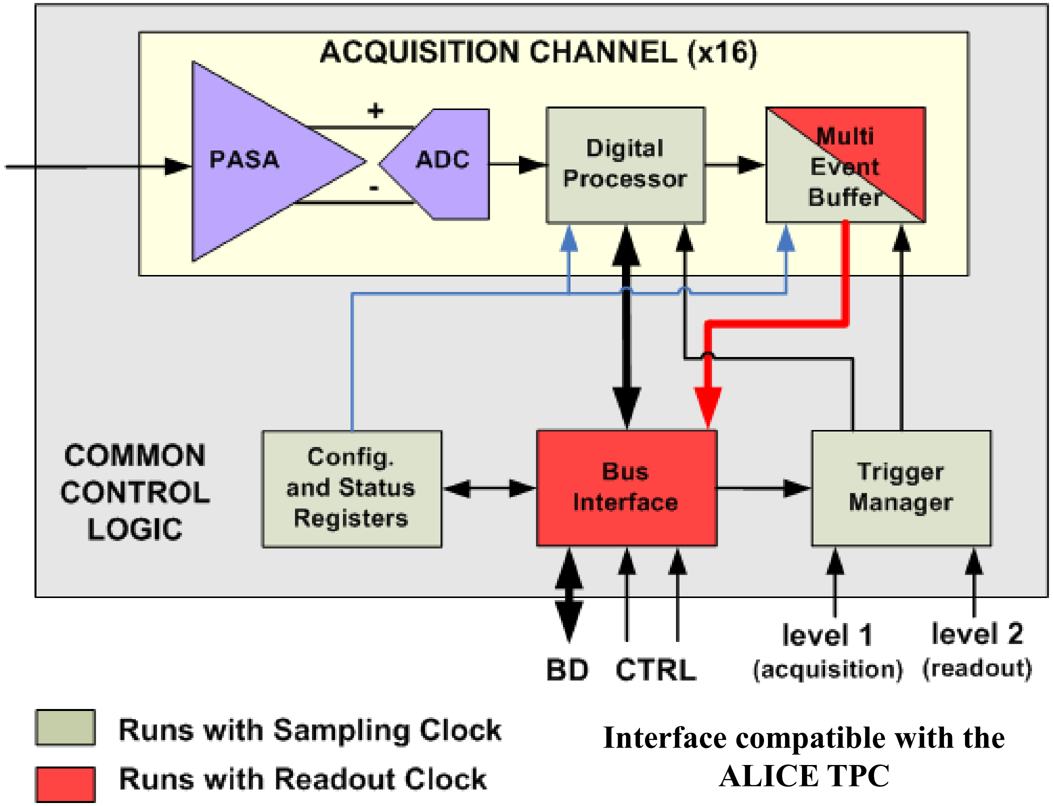
Size: 5750um x 8560um, 49.22mm^2

The Saltro 16 architecture.

16 channels,

Each channel comprising :
Low-noise programmable pre-amplifier and shaper,
ADC,
Digital Signal Processor.

Max sampling frequency: 40MHz
Max readout frequency: 80MHz



Interface compatible with the ALICE TPC

PASA	ADC	Digital Signal Processor
Single-ended to differential	10bit	Baseline correction 1: removes systematic offsets
Pos/neg polarity	40MHz max freq	Digital shaper: removes the long ion tail
Shaping time 30-120ns	Power adjustable to the freq	Baseline correction 2: removes low-freq baseline shifts
Gain 12-27mV/fC		Zero Suppression
Power pulsing feature included.	Possibility of power pulsing via external bias control.	External clock control for power pulsing

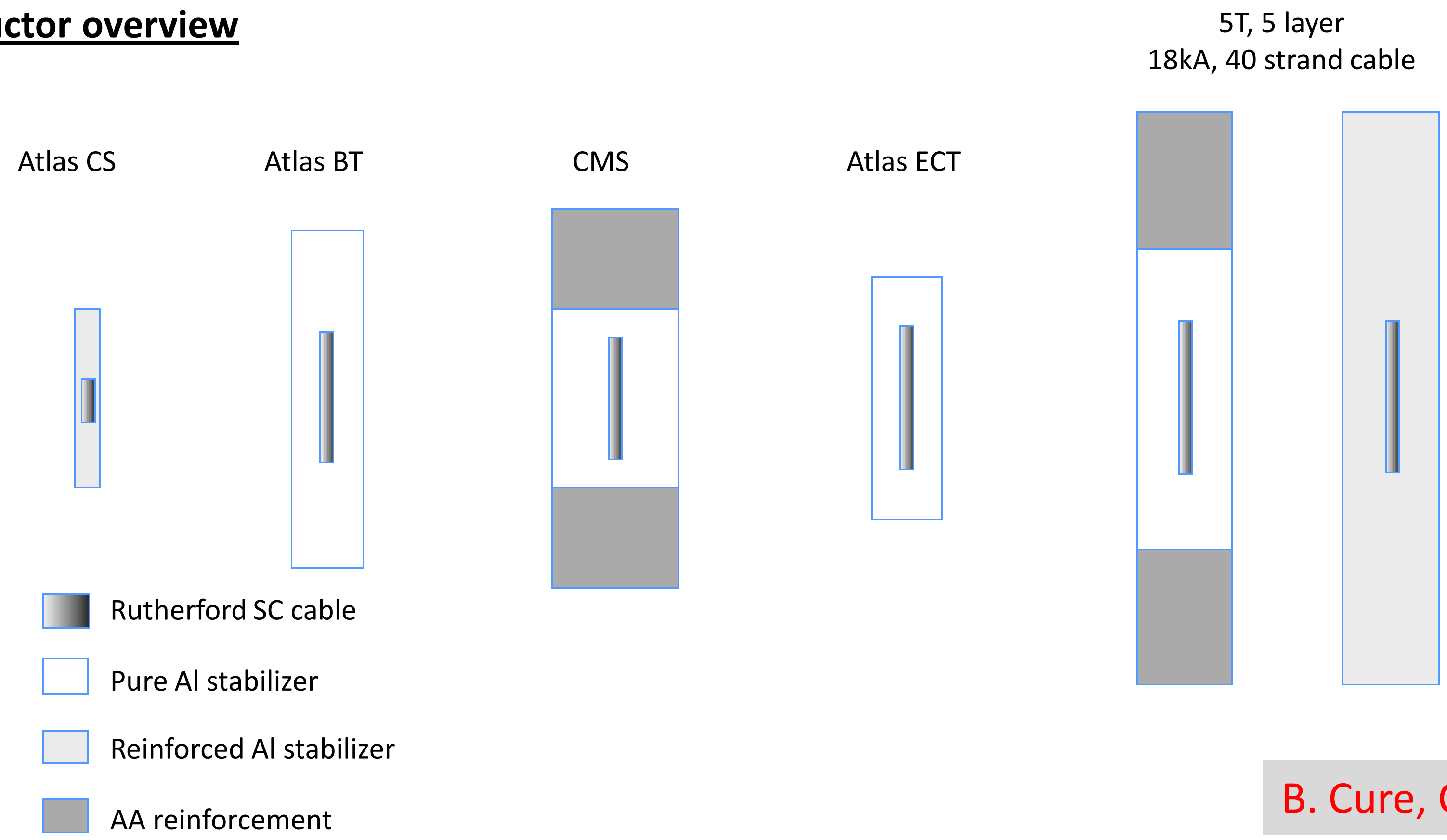
Superconducting solenoid

R&D on reinforced superconducting cable for main solenoid

Material studies and magnet calculations are ongoing in several labs.

Using experience from ATLAS and CMS magnet systems, an R&D effort has started on the superconducting cable for the main solenoid.

Conductor overview



B. Cure, CERN

Update:
SC conductor R&D
– main detector magnet

Coextrusion “Rutherford cable”
With structural Al stabiliser (Al-0.1wt%Ni)

Preparations under way
(in collaboration CERN+KEK)

Collaboration with industry

-> first tests foreseen
second half of 2011

Co-extrusion press at Nexans

B. Cure, A. Gaddi, Y. Makida, A. Yamamoto