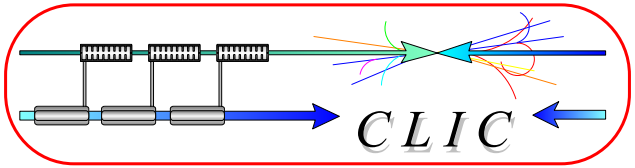
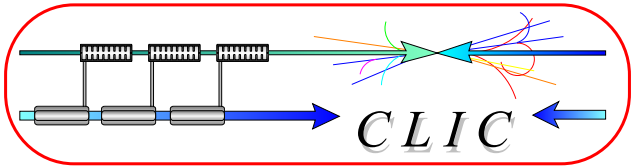


CLIC Detector Synergies with SiD R&D

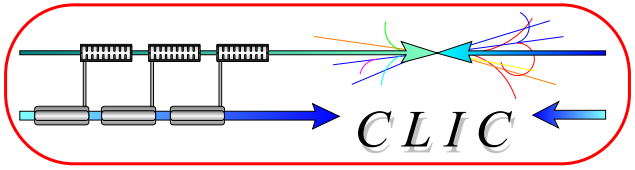
Konrad Elsener

for the LCD@CERN team



Outline

- LCD project at CERN
- CLIC and ILC
- recent work in LCD@CERN (examples)
  - Magnet
  - Hadron calorimeter
  - Vertex detector
  - LumiCal
  - from CLIC000 to CLIC01_SiD (27 Feb. 2009)
- future R&D at CERN
- further synergies with SiD R&D



References:

CERN Linear Collider Detector project http://lcd.web.cern.ch/LCD/
CLIC Study http://clic-study.web.cern.ch/CLIC-Study/

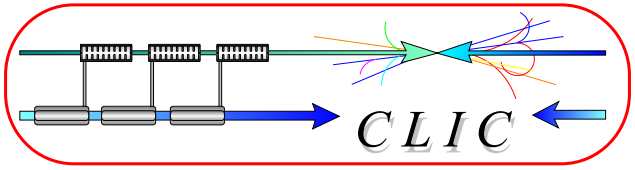
2004 Report on CLIC Multi-TeV Physics
http://documents.cern.ch/cgi-bin/setlink?base=cernrep&categ=Yellow_Report&id=2004-005

Talk Jean-Pierre Delahaye at ILC'08
http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=33&sessionId=9&confId=2628

Talk Lucie Linssen at LCWS'08
http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=148&sessionId=23&confId=2628

Talks Alain Hervé + Christian Grefe at LAPP Annecy Dec 2008
http://indico.cern.ch/materialDisplay.py?contribId=10&sessionId=1&materialId=slides&confId=46062
http://indico.cern.ch/materialDisplay.py?contribId=7&sessionId=0&materialId=slides&confId=46062

Talk Daniel Schulte at CERN Jan 2009
http://indico.cern.ch/getFile.py/access?contribId=7&resId=1&materialId=slides&confId=47141



LCD @ CERN

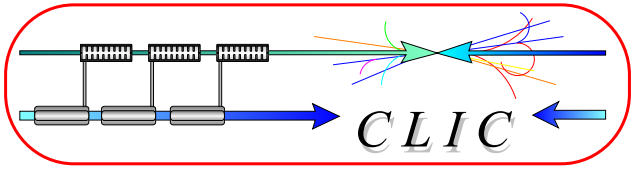
Linear Collider Detector Project at CERN

Who are we ?

Lucie Linssen (project leader)
Dieter Schlatter
Konrad Elsener
Peter Speckmayer (Fellow)
Christian Grefe (Doct)
Andre Sailer (Doct)
+ part time help from CERN staff
+ visitors

in close collaboration with LAPP Annecy
Jean-Jacques Blaising
Jan Blaha (Doct)

ETH Zurich
Alain Hervé



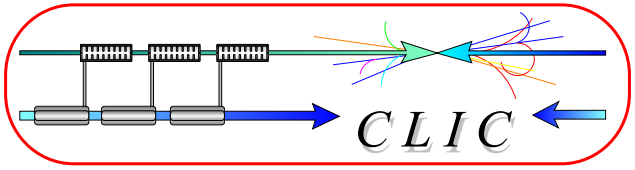
Linear Collider Detector Project at CERN

What is our goal ?

We are working towards a linear collider detector which will operate in an energy range (CM) from 500 GeV to 3 TeV

working together with the ILC concepts (SiD, ILD, 4th) and with detector Collaborations (LC-TPC, EUDET, FCAL, CALICE).

In a concerted effort with the individual concepts, we would like to work towards describing the possible changes or upgrades to the ILC concepts to make them compatible with multi-TeV energies and CLIC beam conditions.



LCD @ CERN

We gratefully acknowledge SiD support

Examples:

Setting up SiD software tools for CLIC simulations
(-> CLIC000 detector “in general” looks like SiD)

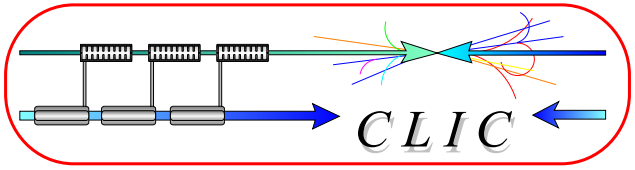
3 TeV jets and calibrations

+ much other help from our “SiD consultants”:
Marcel Stanitzki, Jan Strube

Norman Graf, Steve Wagner, Ron Cassell

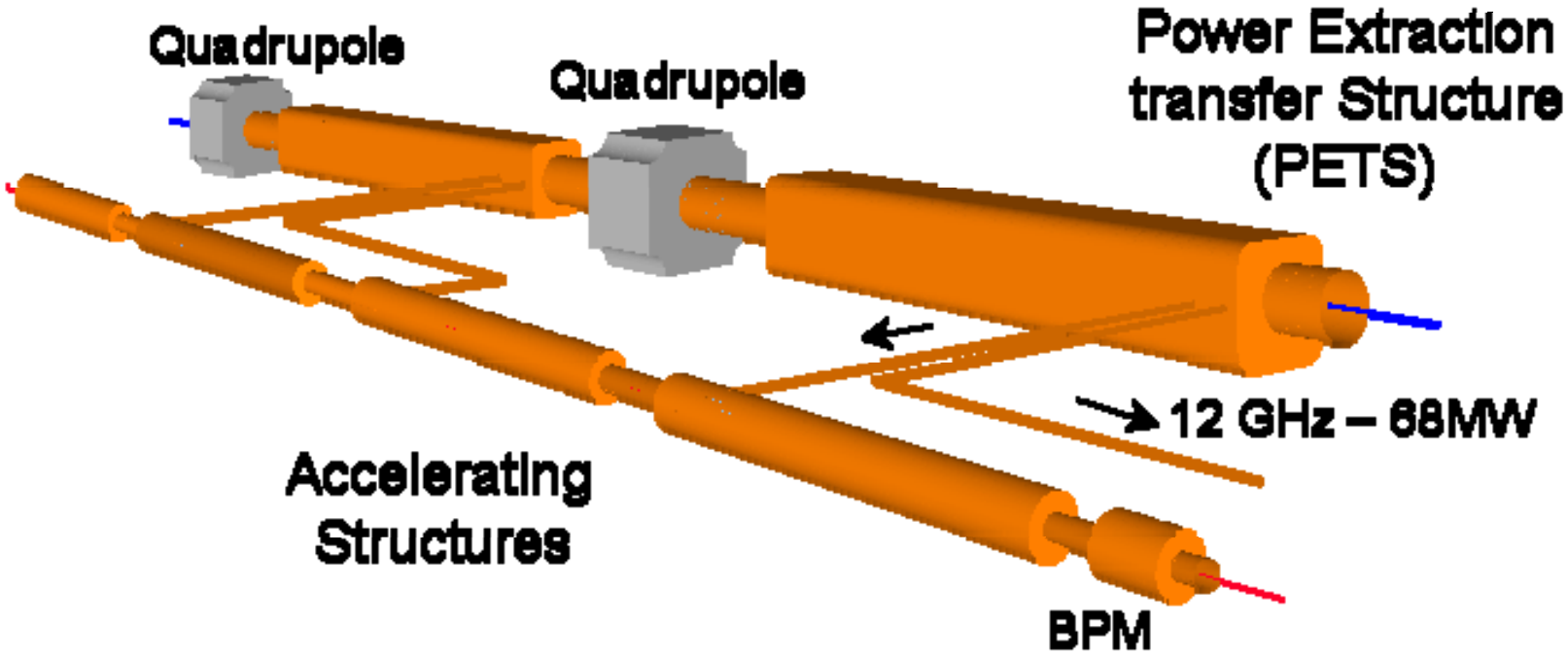
Matt Charles

...



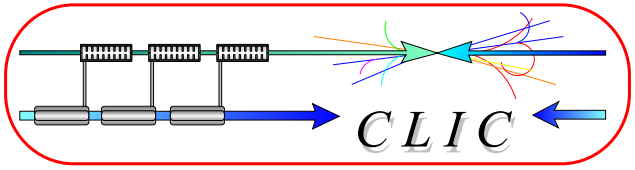
CLIC scheme

Drive beam – 100 A, 240 ns
from 2.4 GeV to 240 MeV



Main beam – 1.2 A, 156 ns
from 9 GeV to 1.5 TeV

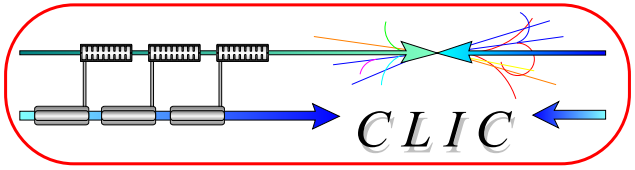
CLIC timeline: CDR in 2010, TDR in 2015



CLIC at 3 TeV and 500 GeV

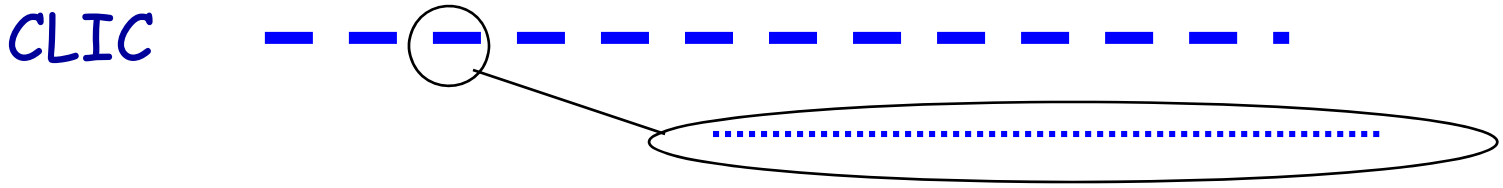
Crossing Angle 20 mrad

Center-of-mass energy	CLIC 500 GeV	CLIC 3 TeV
Total (Peak 1%) luminosity	2.3 (1.4)·10^{34}	5.9 (2.0)·10^{34}
Repetition rate (Hz)	50	
Loaded accel. gradient MV/m	80	100
Main linac RF frequency GHz	12	
Bunch charge [10^9]	6.8	3.72
Bunch separation (ns)	0.5	
Beam pulse duration (ns)	177	156
Beam power/beam (MWatts)	4.9	14
Hor./vert. IP beam size (nm)	202 / 2.3	40 / 1.0
Hadronic events/crossing at IP	0.19	2.7
Coherent pairs at IP	100	3.8 10^8
BDS length (km)	1.87	2.75
Total site length km	13.0	48.3
Total power consumption MW	129.4	415



CLIC and ILC
CLIC time structure

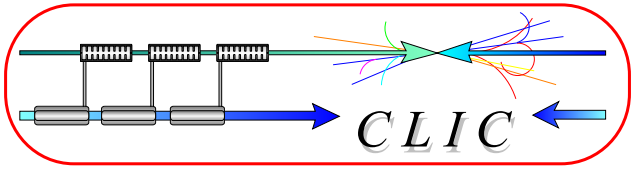
Train repetition rate 50 Hz



CLIC:	1 train = 312 bunches	0.5 ns apart	50 Hz
ILC:	1 train = 2820 bunches	337 ns apart	5 Hz

Consequences for CLIC detector:

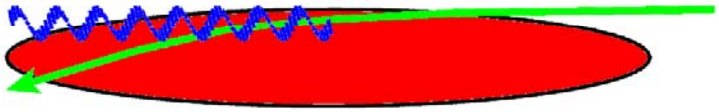
- Assess need for detection layers with time-stamping
  - Innermost tracker layer with sub-ns resolution
  - Additional time-stamping layers for photons and for neutrons (if needed)
- Readout electronics will be different from ILC
- Power pulsing at 50 Hz, instead of 5 Hz



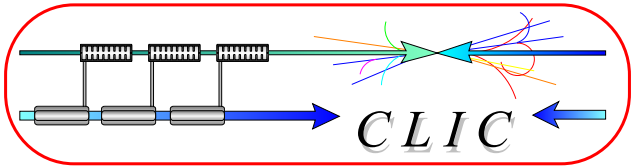
CLIC and ILC
Beam-induced background

Background sources: CLIC and ILC similar

Due to the higher beam energy and small bunch sizes they are significantly more severe at CLIC.

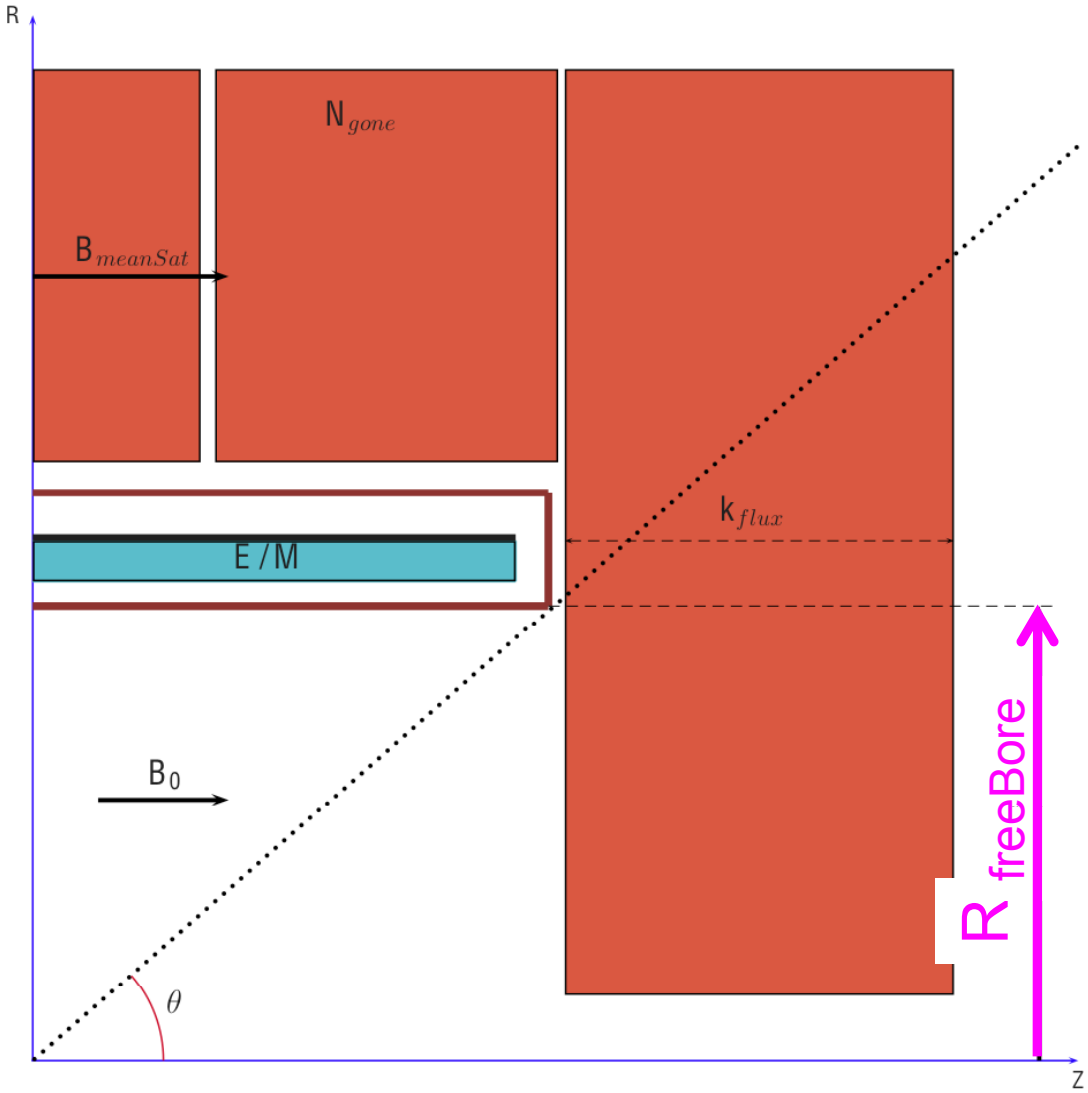


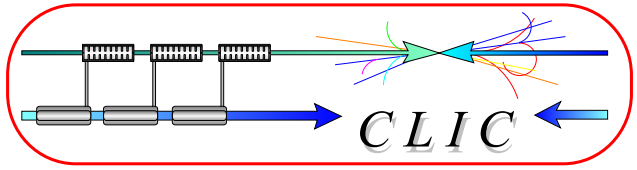
- CLIC 3TeV beamstrahlung ΔE/E = 29% (10×ILC_{value})
  - **Coherent pairs (3.8×10^8 per bunch crossing)** <= disappear in beam pipe
  - Incoherent pairs (3.0×10^5 per bunch crossing) <= suppressed by strong B-field
  - γγ interactions => hadrons
- Muon background from upstream linac
  - More difficult to stop due to higher CLIC energy (active muon shield)
- Synchrotron radiation
- Beam tails from the linac
- Backscattered particles from the spent beam (neutrons)



Recent work in LCD@CERN

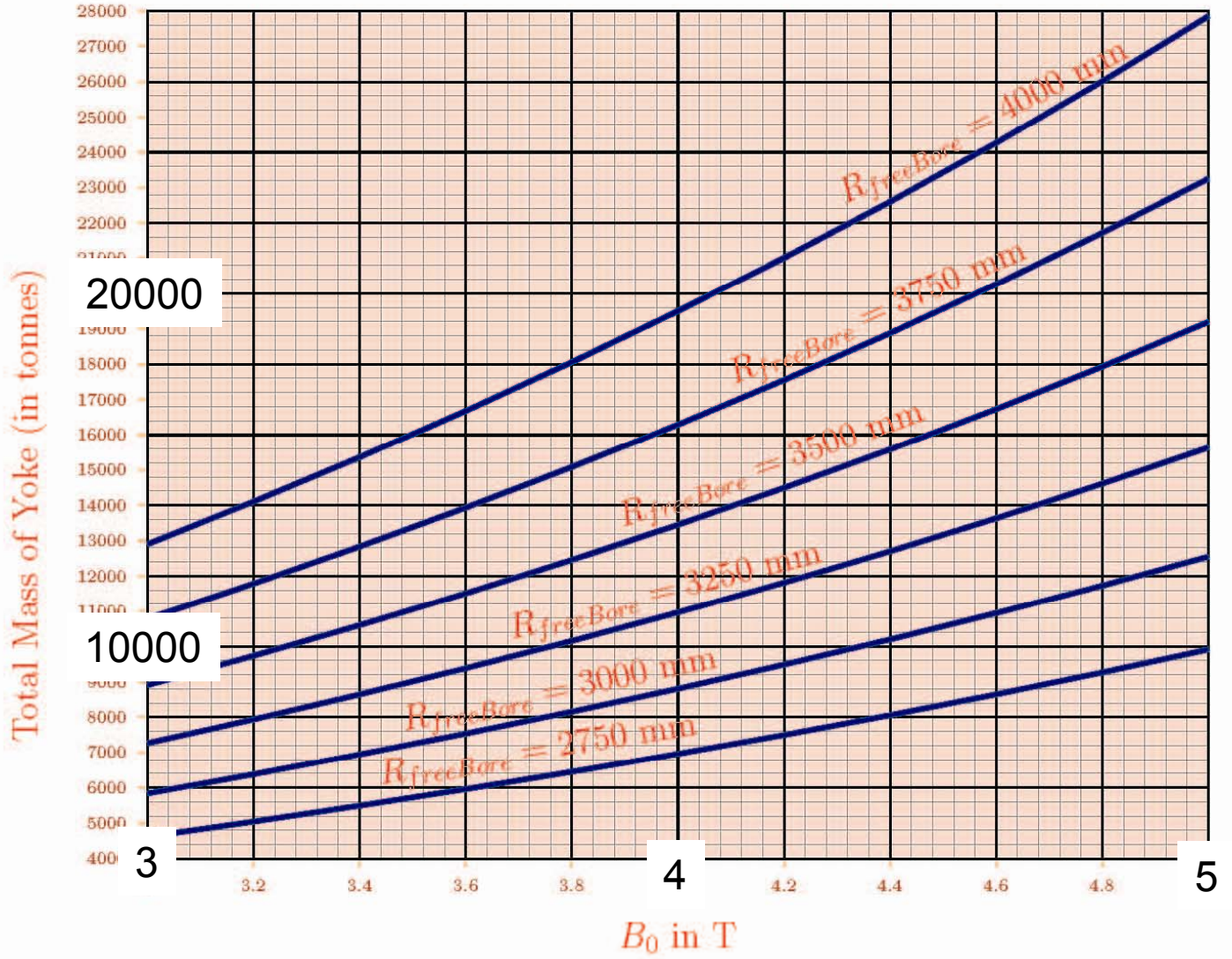
Magnet Coil and Yoke
Parametric Model by Alain Hervé





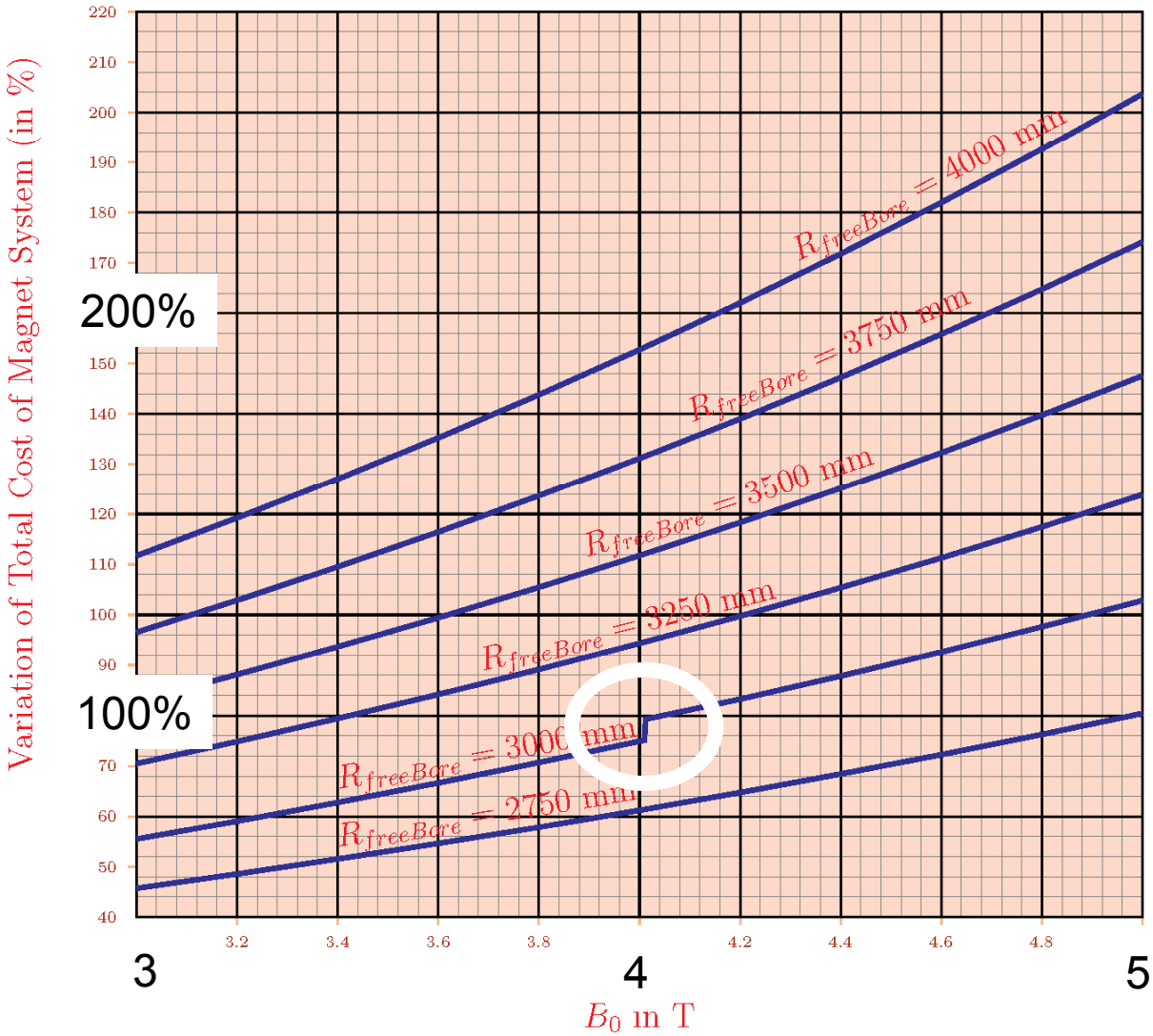
Mass of Yoke in tons

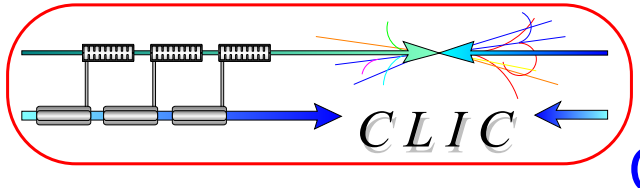
courtesy Alain Hervé



Total Cost of Magnet System

courtesy Alain Hervé



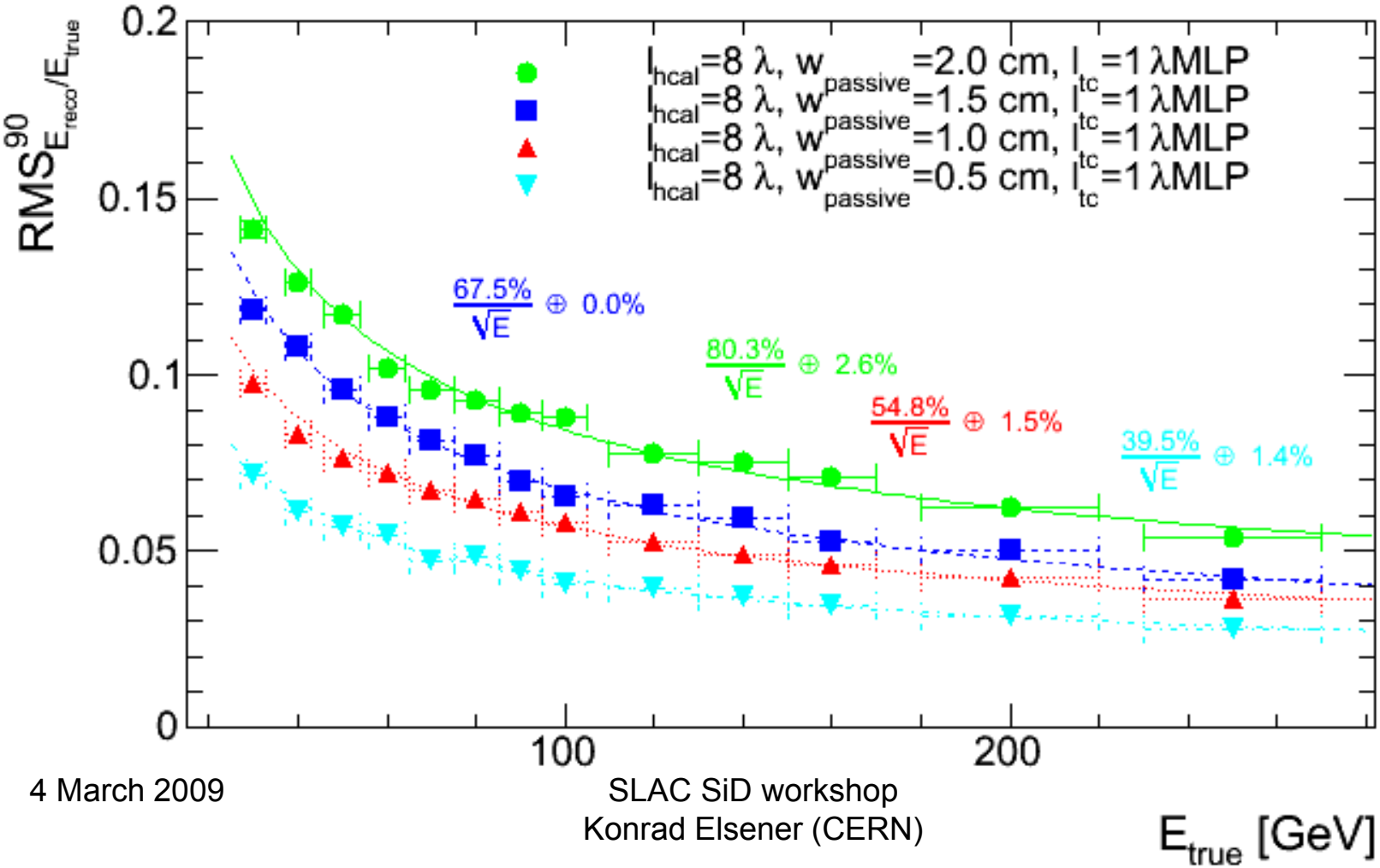


Hadron Calorimeter

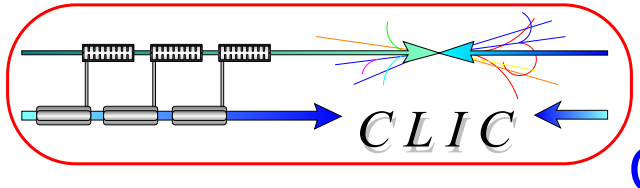
Courtesy Peter Speckmayer, Christian Grefe

Tungsten – Scintillator calorimeter

Conventional Calorimetry, resolution for **6,7,8,9 -> 40 λ**



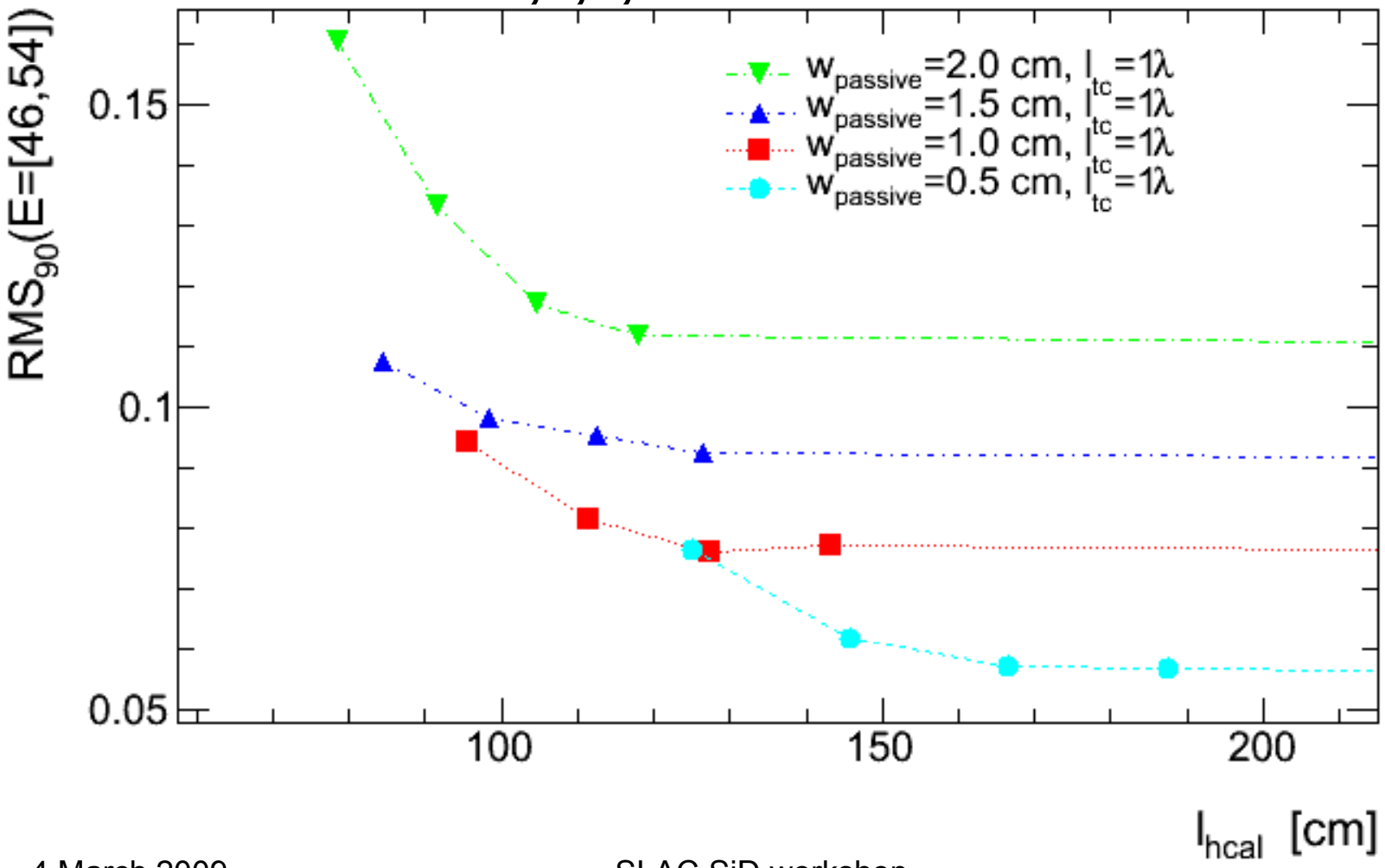
VERY PRELIMINARY



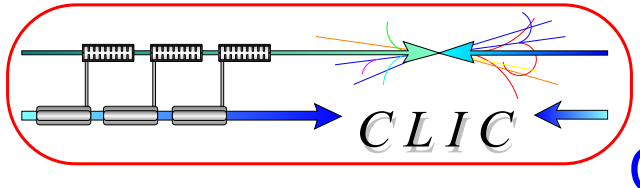
Hadron Calorimeter

Courtesy Peter Speckmayer, Christian Grefe

50 GeV **6,7,8,9 -> 40 λ**



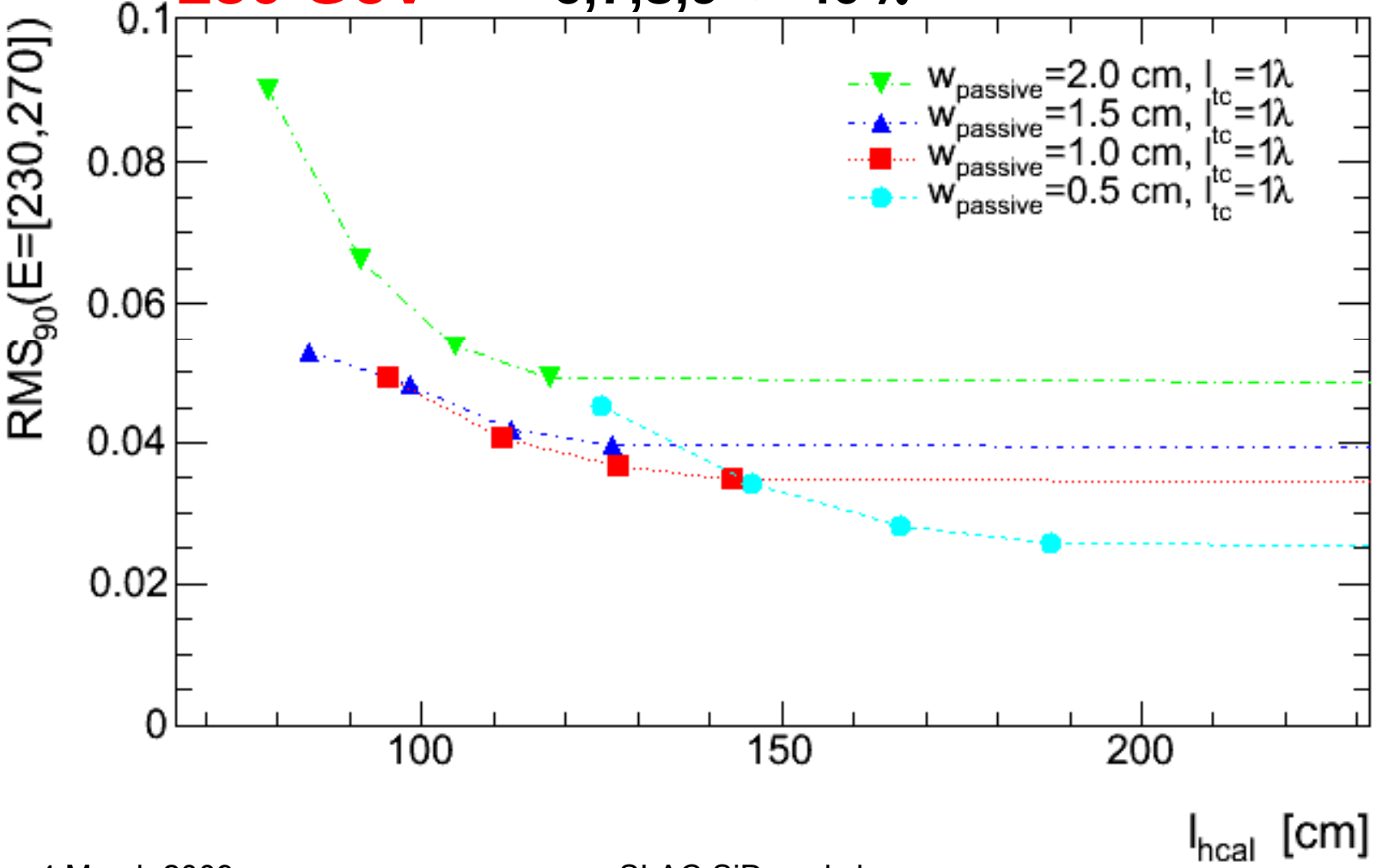
VERY PRELIMINARY



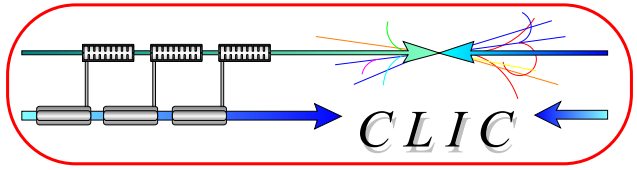
Hadron Calorimeter

Courtesy Peter Speckmayer, Christian Grefe

250 GeV **6,7,8,9 -> 40 λ**

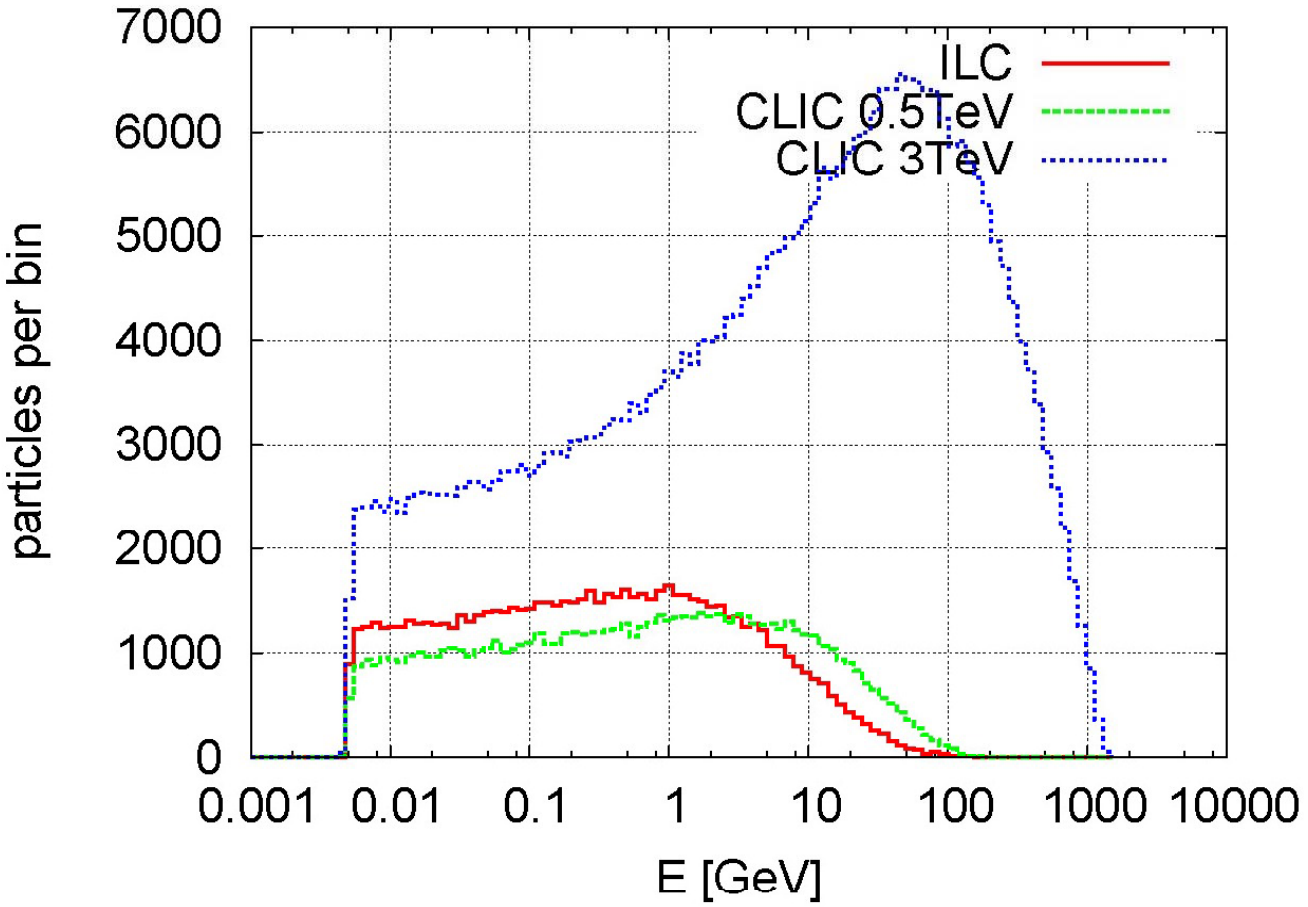


VERY PRELIMINARY

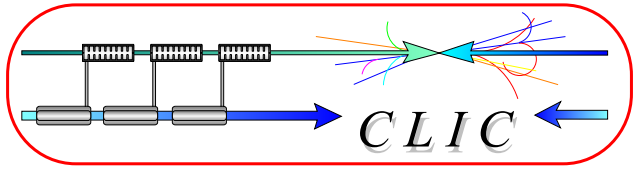


Vertex Detector

Production of incoherent pairs (courtesy Daniel Schulte)



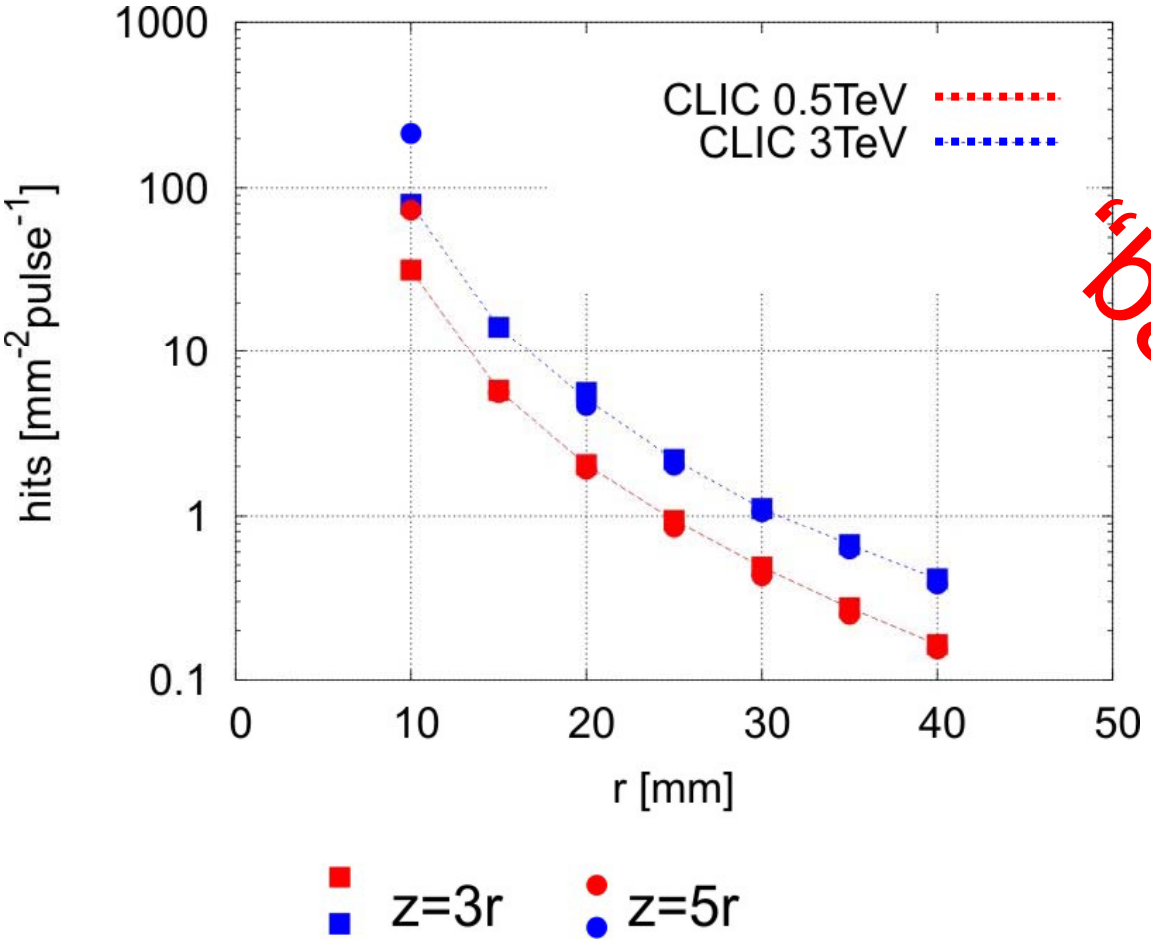
PRELIMINARY



Vertex Detector

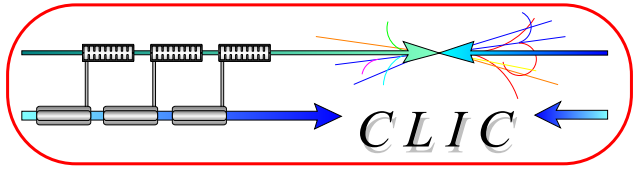
Vertex detector hits from incoherent pairs, B=5T, two angular coverages (courtesy Daniel Schulte)

312 BX



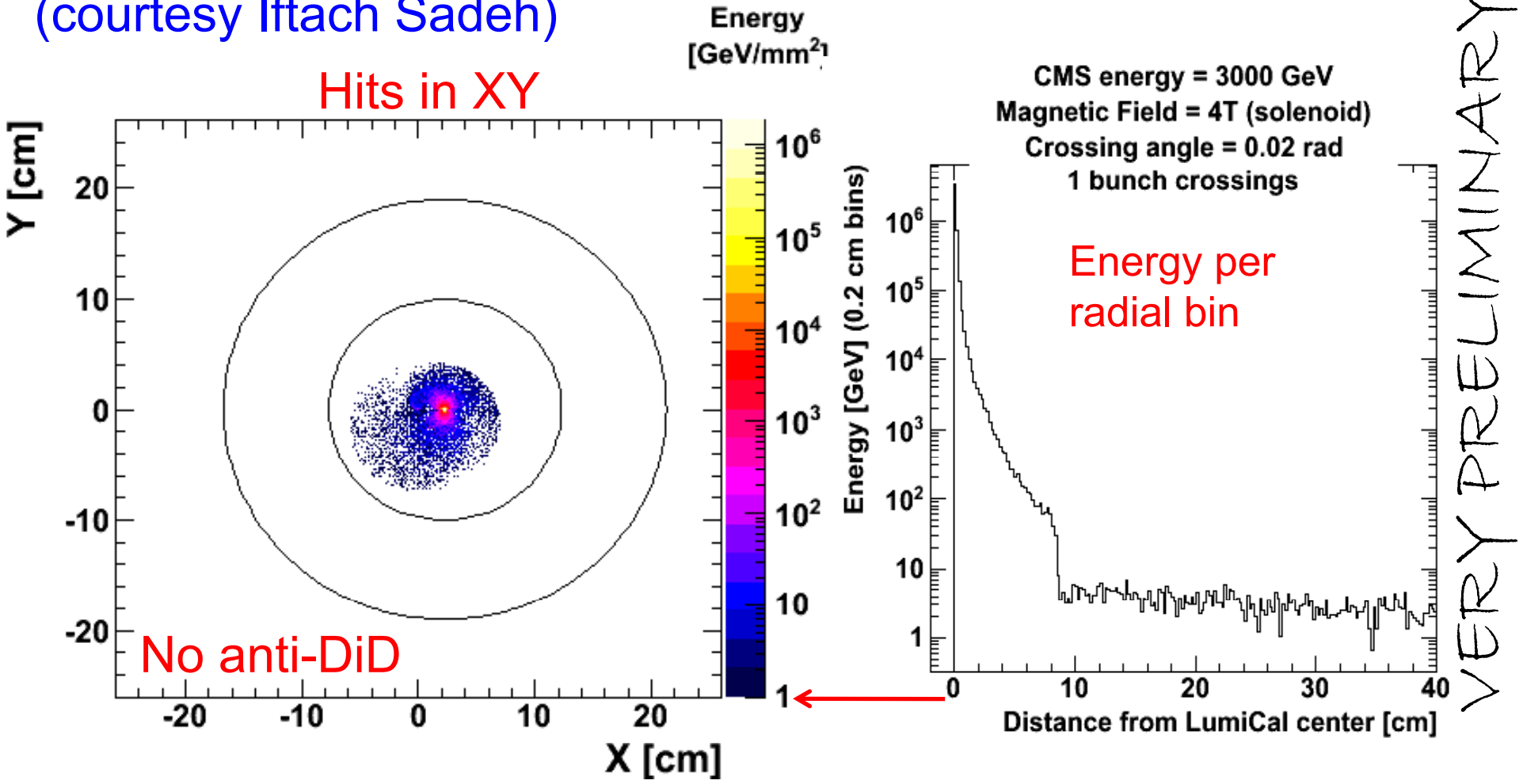
"barrel"

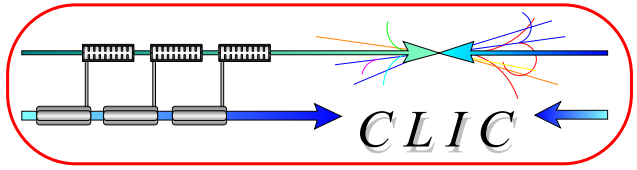
PRELIMINARY



LumiCal

Beamstrahlung Background on LumiCal at CLIC 3 TeV (courtesy Iftach Sadeh)

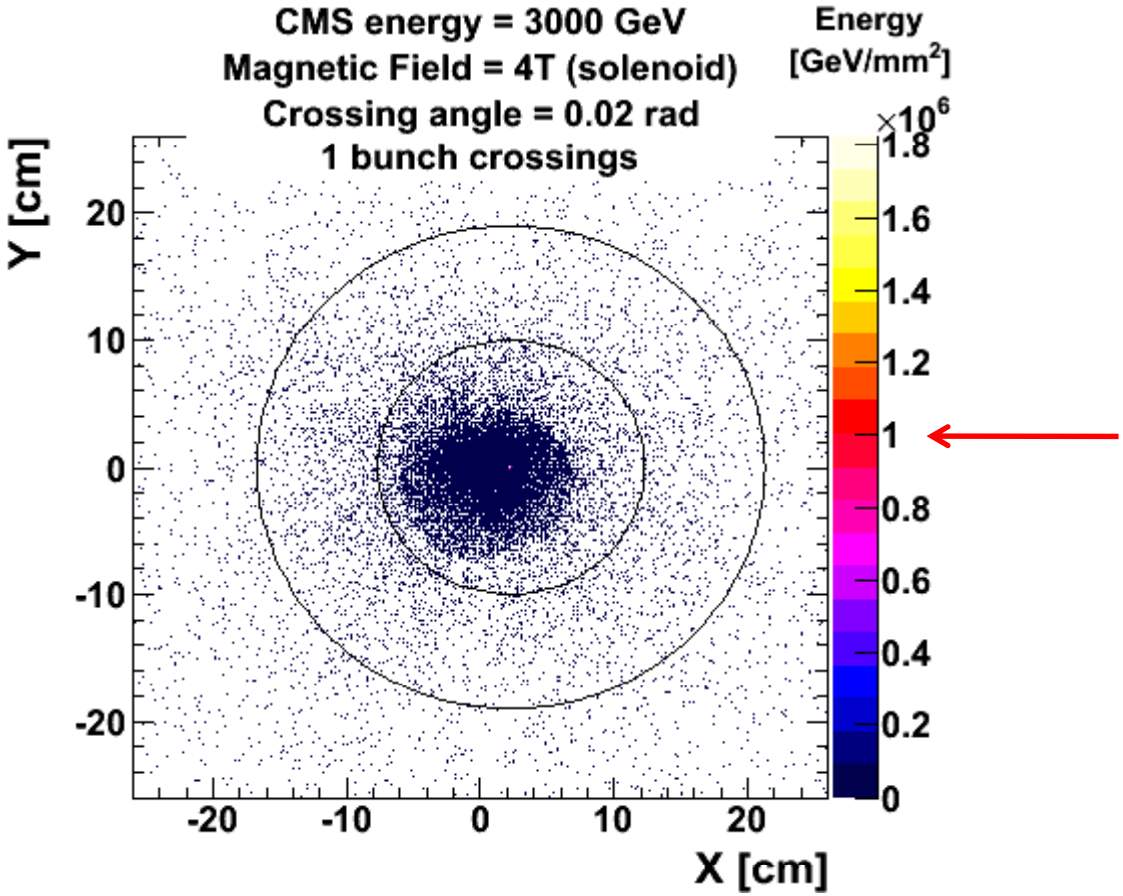




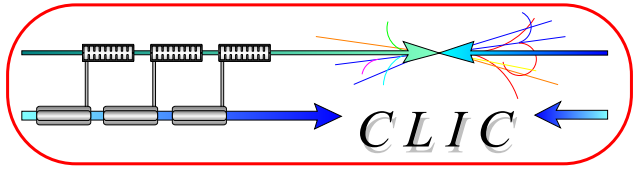
LumiCal

Beamstrahlung Background on LumiCal at CLIC 3 TeV (courtesy Iftach Sadeh)

Hits in XY
No anti-DiD

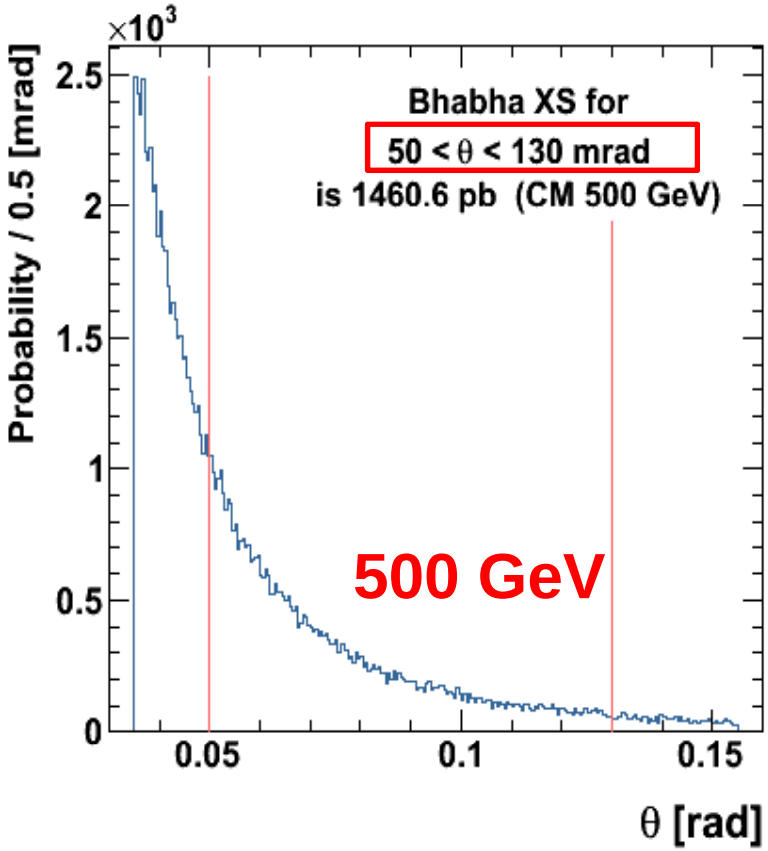


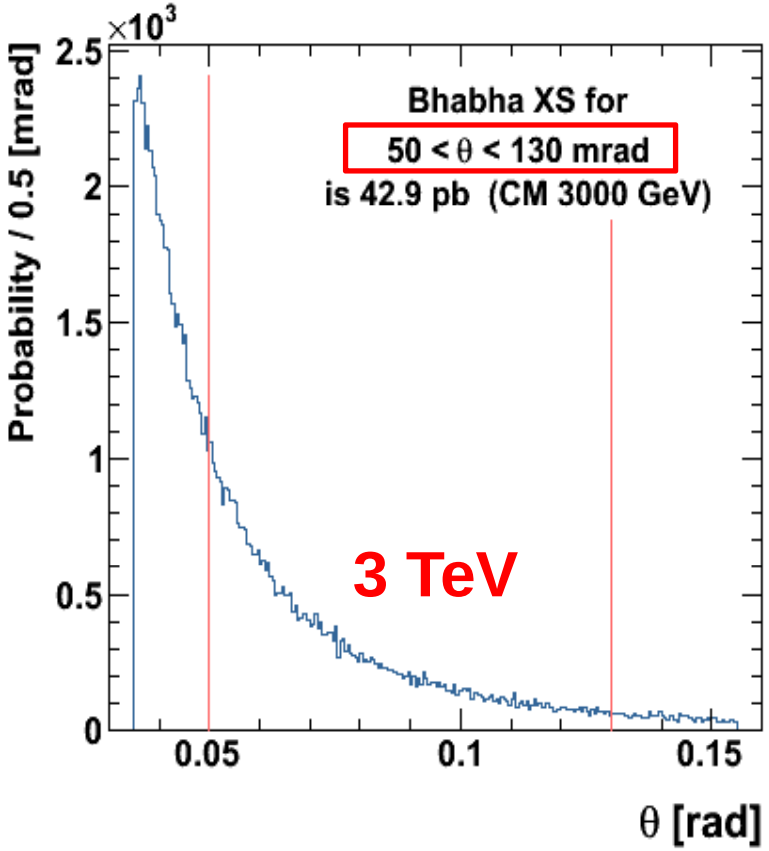
VERY PRELIMINARY



LumiCal

Bhabha events on LumiCal at CLIC 500 GeV and 3 TeV
for LumiCal radii 10 -> 35 cm (courtesy Iftach Sadeh)



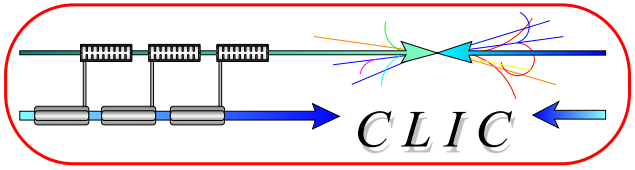


VERY PRELIMINARY

$\Delta N/N = 3.7 \times 10^{-5}$

(500 [1/fb] – 4 years)

$\Delta N/N = 2.2 \times 10^{-4}$



from CLIC000 to CLIC01_SiD
(meeting 27 February 2009)

NB. CLIC000 September 2008: very first attempt at 3TeV
based on SiD-01

Decision last Friday:

start by freezing B-field and coil $R_{freebore}$

5 T 2.90 m

define HCAL (barrel) passive and active layers

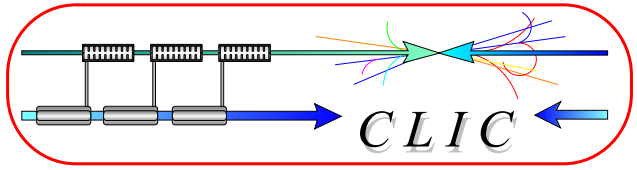
option 1 W, 1 cm Scint. 5 mm
+ G10 2.5 mm

-> **8.5** λ (+1 λ)

option 2 Fe 2 cm same

-> **6.5** λ (+1 λ)

later: study hybrids of W with Fe or xyz



from CLIC000 to CLIC01_SiD
(meeting 27 February 2009)

Decision last Friday:

leave ECAL unchanged (W-Si, SiD_01)

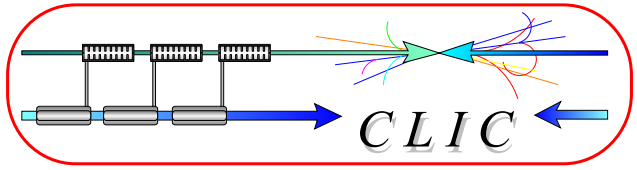
leave tracker R_{outer} unchanged (R ~ 125 cm)

leave tracker unchanged

change vertex innermost layer radius: R = 30 mm

-> adjust barrels and discs

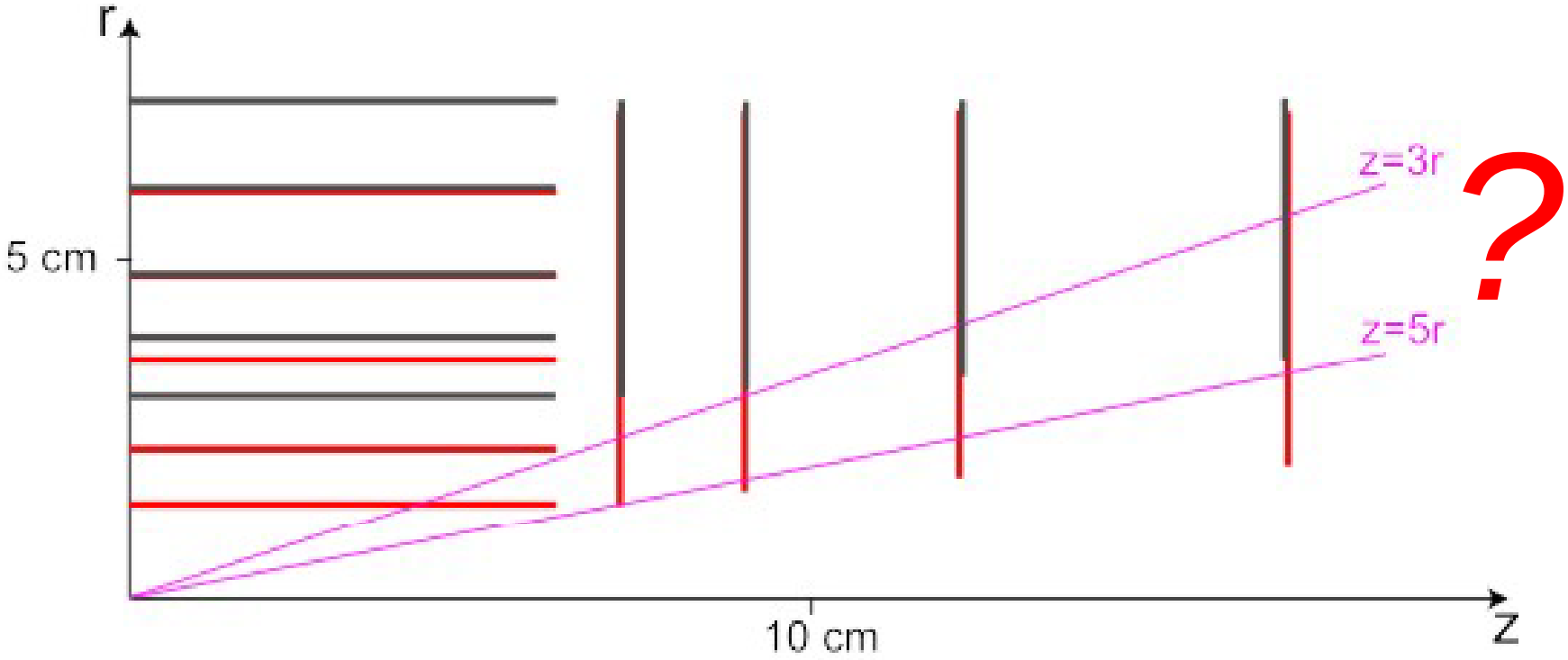
still too conservative ? to be checked



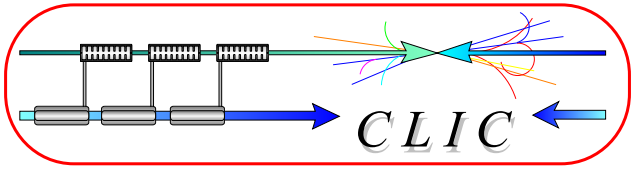
from CLIC000 to CLIC01_SiD
(meeting 27 February 2009)

vertex detector choices - short barrel

r = 30 mm



CLIC (5T) SiD (5T)



Future R&D topics at CERN

Preliminary list

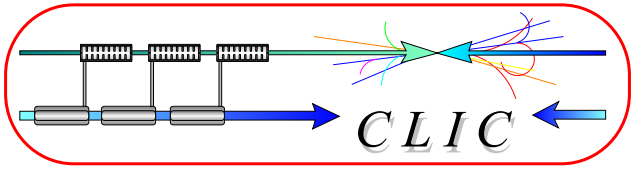
Time stamping
(reject background events from other bunch crossings
- 0.5 ns apart)

W or W-mix (Pb, Fe, ?) hadron calorimeter

Alternative to PFA calorimetry
(e.g. dual readout calorimetry)

Synergy of R&D (approved CERN) between LC and SLHC for on-detector powering and for integrated silicon pixel detectors

Mechanical engineering issues: Integration, heavy HCAL, coil, stability issues, vibration etc.



Future topics at CERN

Preliminary list

Aspect ratio / length of barrel

a) at 3 TeV important physics more forward/backward

increase tracker length ?

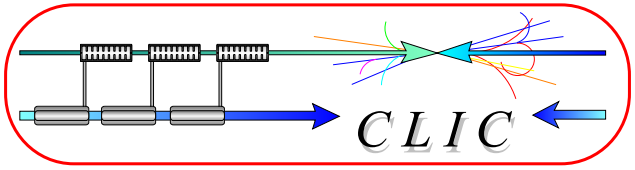
b) cf. discussion on field homogeneity at B = 5 T

Anti-DID or DID

Beam physics (luminosity) vs. LumiCal

BeamCal and “mask”

background onto BeamCal, backscattering into sub-detectors



further synergies with SiD

Preliminary list

taken from slides by Marcel Stanitzki, 17 Sept 2008

- HCAL choice of absorber and readout
- Performance at 1 TeV (-> 3TeV)
- Physics Performance

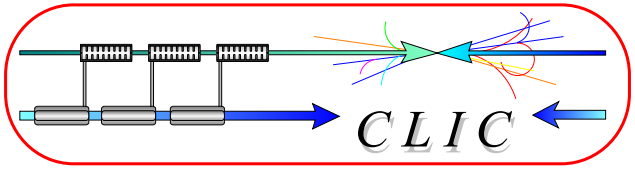
others

- B-field choice: 5T or lower ?

- Coil conductor R&D

(replace pure Al by Ni doped alloy, replace electron beam welding by less expensive technique, general optimisation...)

- continuation of infrastructure / engineering effort



further synergies with SiD

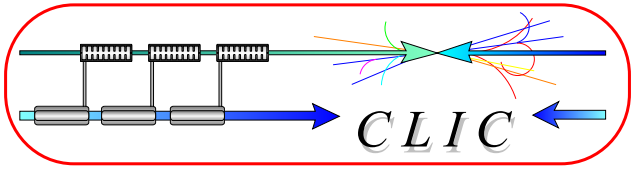
Preliminary list

- joint ILC-Concepts + LCD@CERN software workshop
  28/29 May 2009 at CERN

  contact: Dieter.Schlatter@cern.ch

  - further unification in the Linear Collider Detector software
    - detector description (geometry)
    - “data model” and file formats
    - standardize digitisation

- joint SiD - CLIC meeting to discuss a 0.5 – 3 TeV detector ?
  When ?



INVITATION

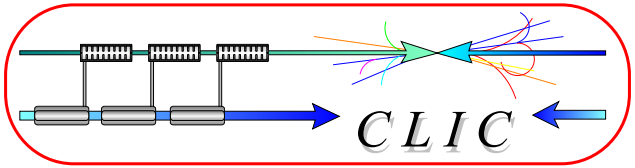
A) Visitors to LCD@CERN project are always welcome; short term or longer term possible (support exists)

B) Special type of Fellowship – COFUND

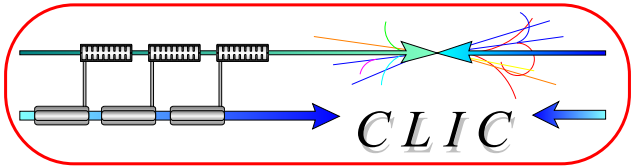
(Post-Doc, 3 years, applications from non-CERN-member states are welcome; applications exclusively in 2009)

selection: based on the research project presented

-> we will be happy to help draft a project

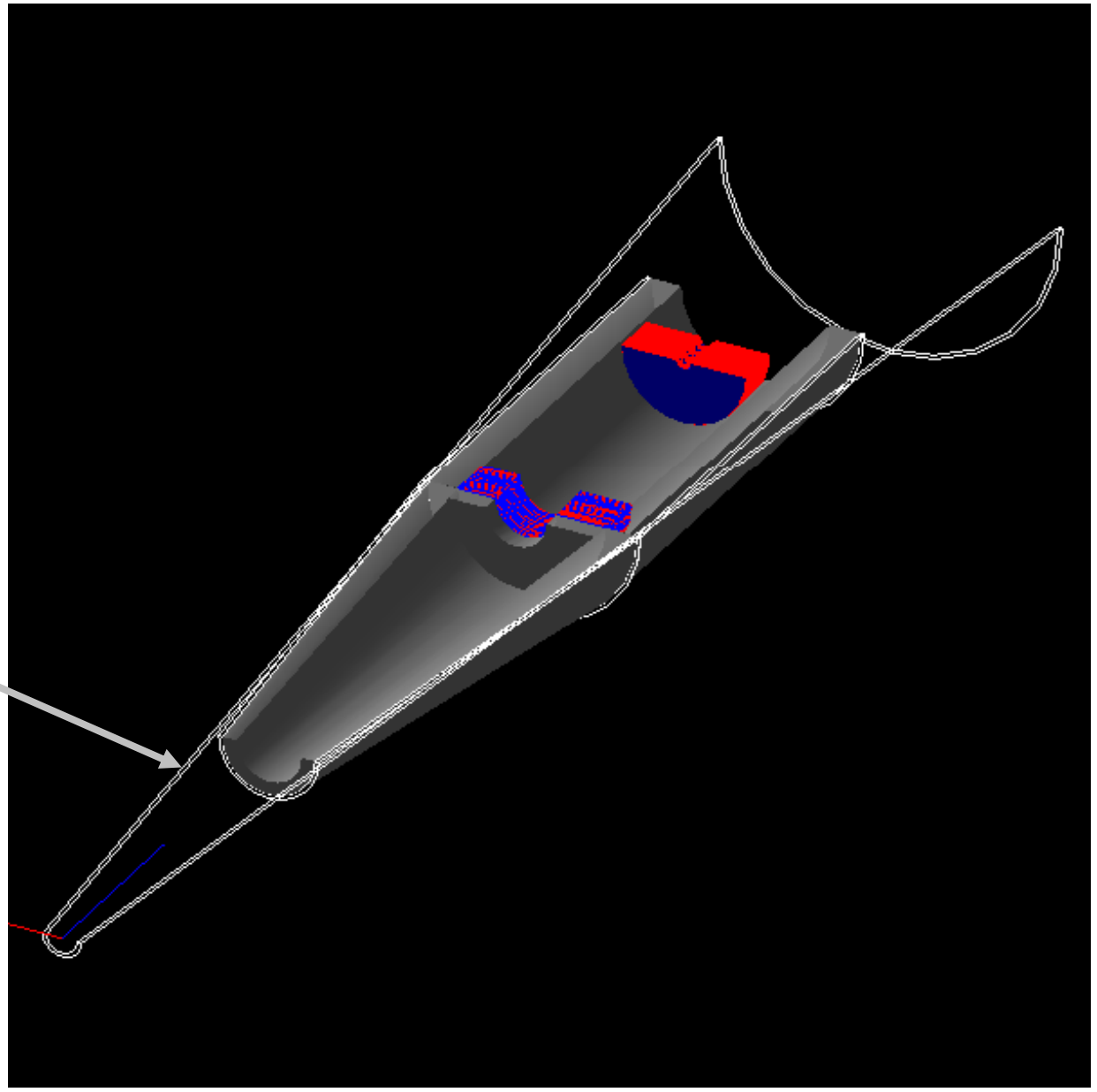


Thank you !



Spare Slides

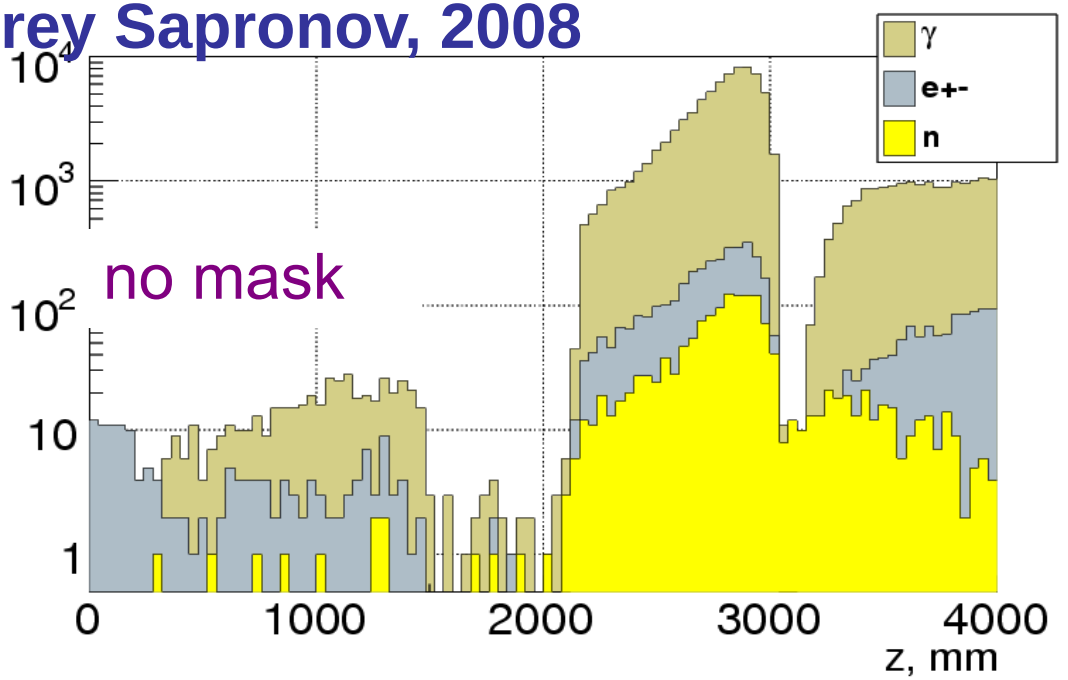
recent work for CLIC – Andrey Sapronov, 2008
(inspired by 2004 CLIC report and work on ILC)

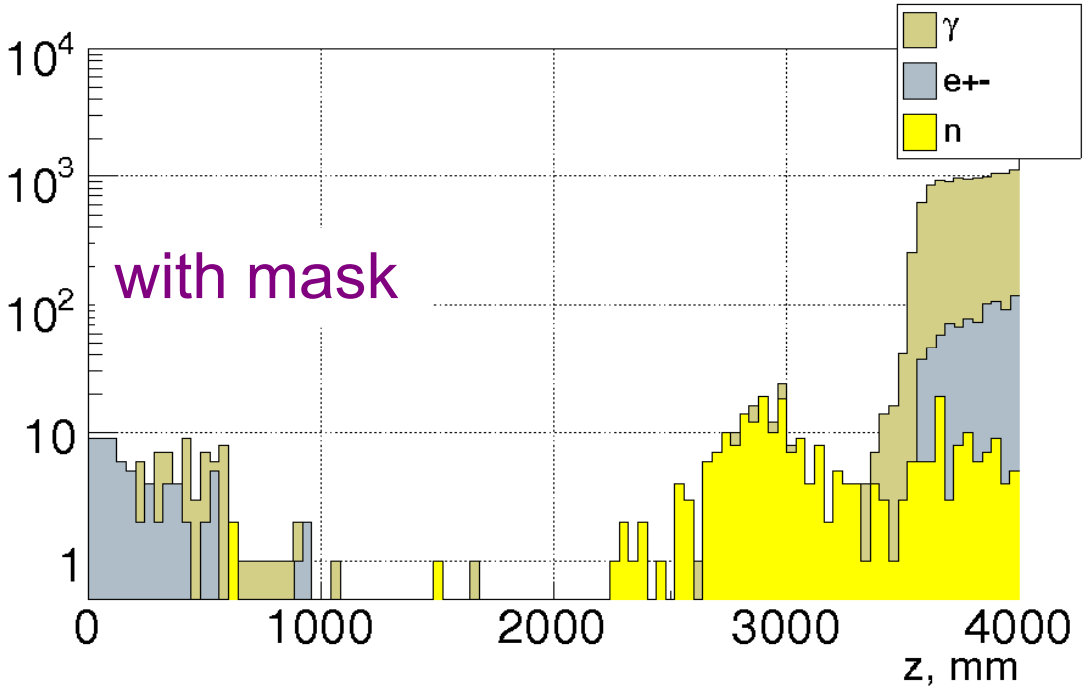


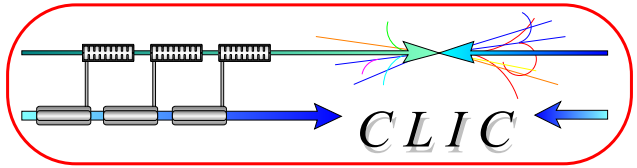
"dummy volume"
to count background
particles

recent work for CLIC – Andrey Sapronov, 2008

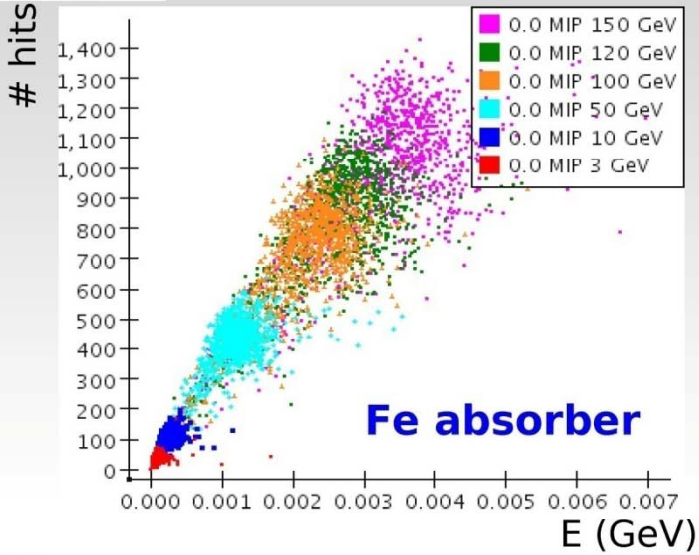
Preliminary background studies:
mask effectiveness,
spatial distribution of background hits in the dummy volume:

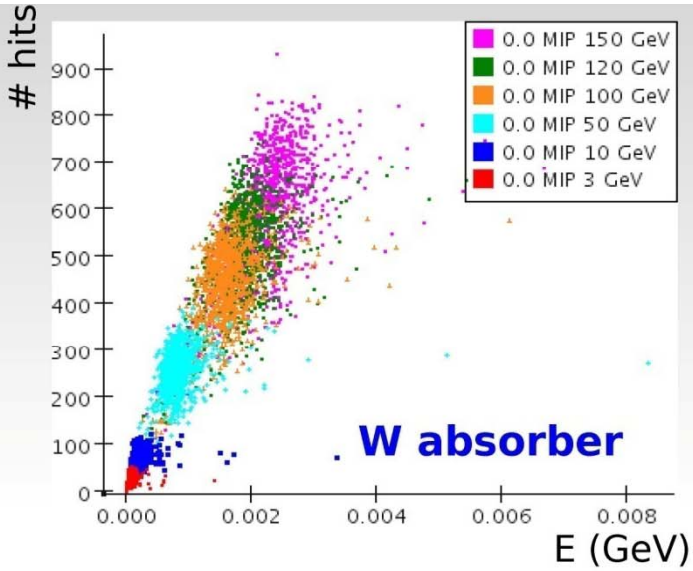


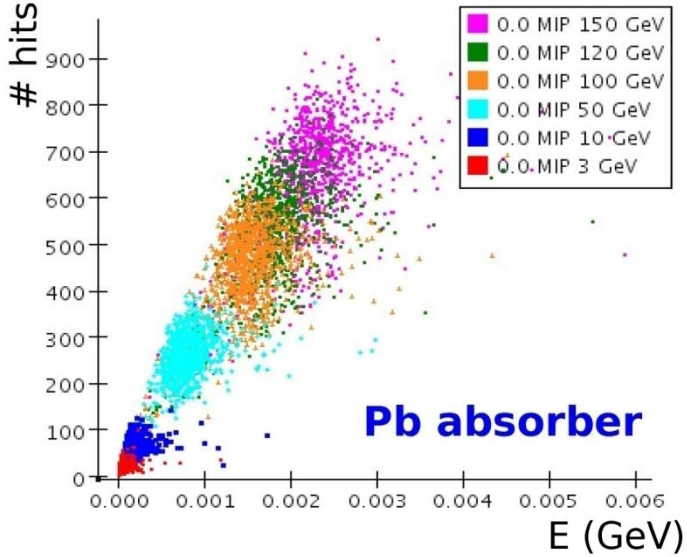




Hadron Calorimeter



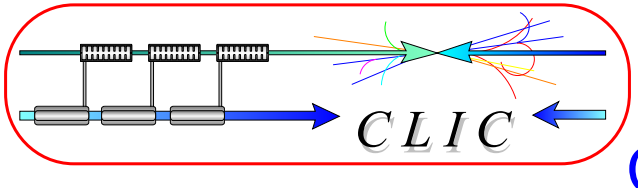




Digital readout (Threshold = 0 MIP) vs energy deposited per pad for different absorber materials: Fe, Pb, and W in an energy range from 3 to 150 GeV

Courtesy Jan Blaha (LAPP)

VERY PRELIMINARY

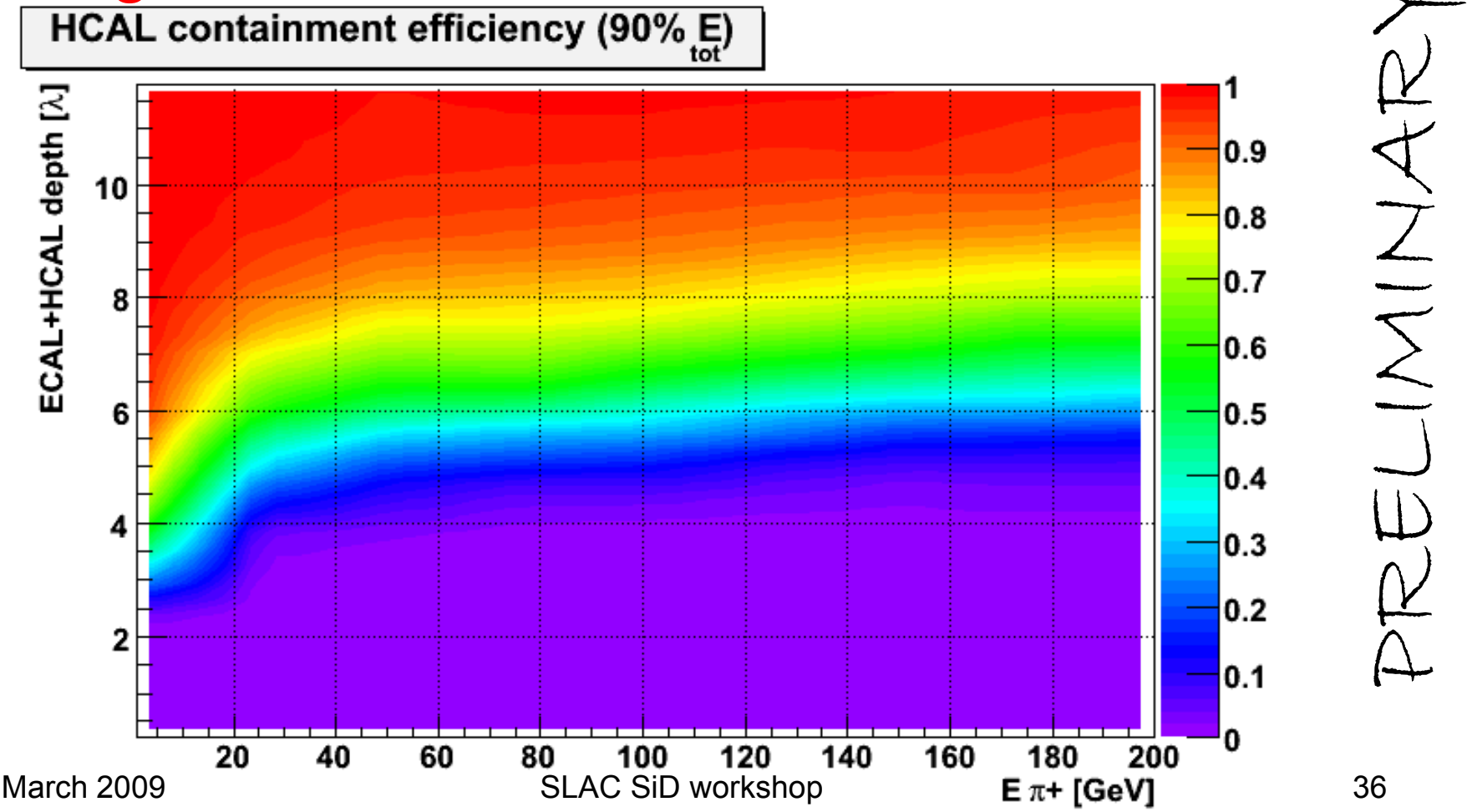


Hadron Calorimeter

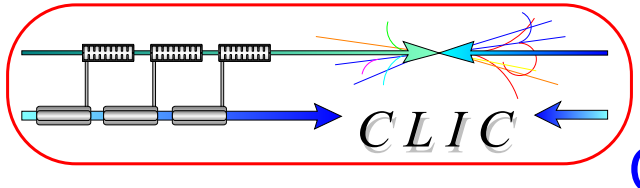
Courtesy Peter Speckmayer, Christian Grefe

Fraction of events with at least 90% containment in the calorimeter

single π+



PRELIMINARY

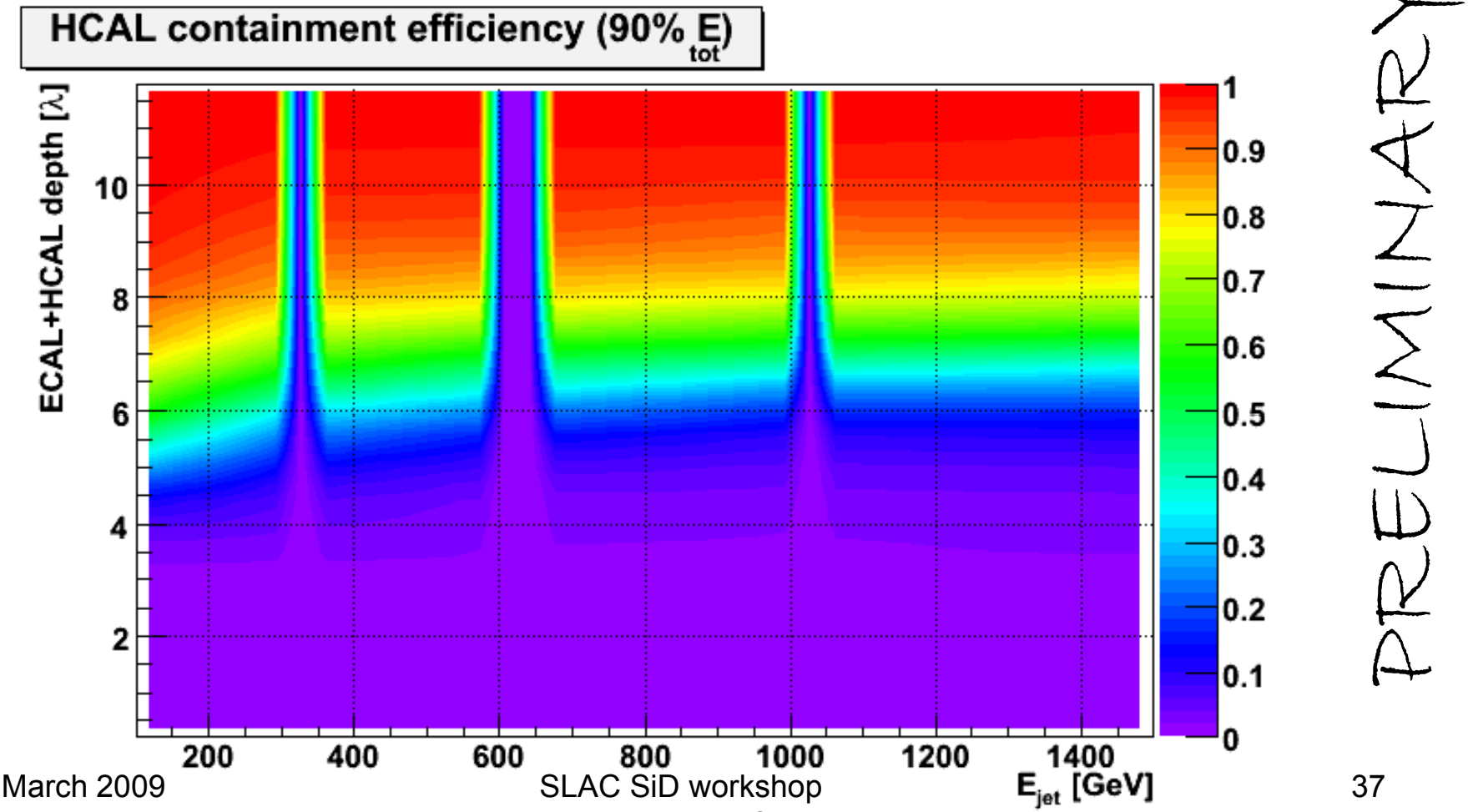


Hadron Calorimeter

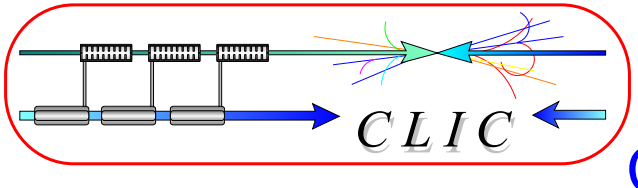
Courtesy Peter Speckmayer, Christian Grefe

Fraction of events with at least 90% containment in the calorimeter

u jets



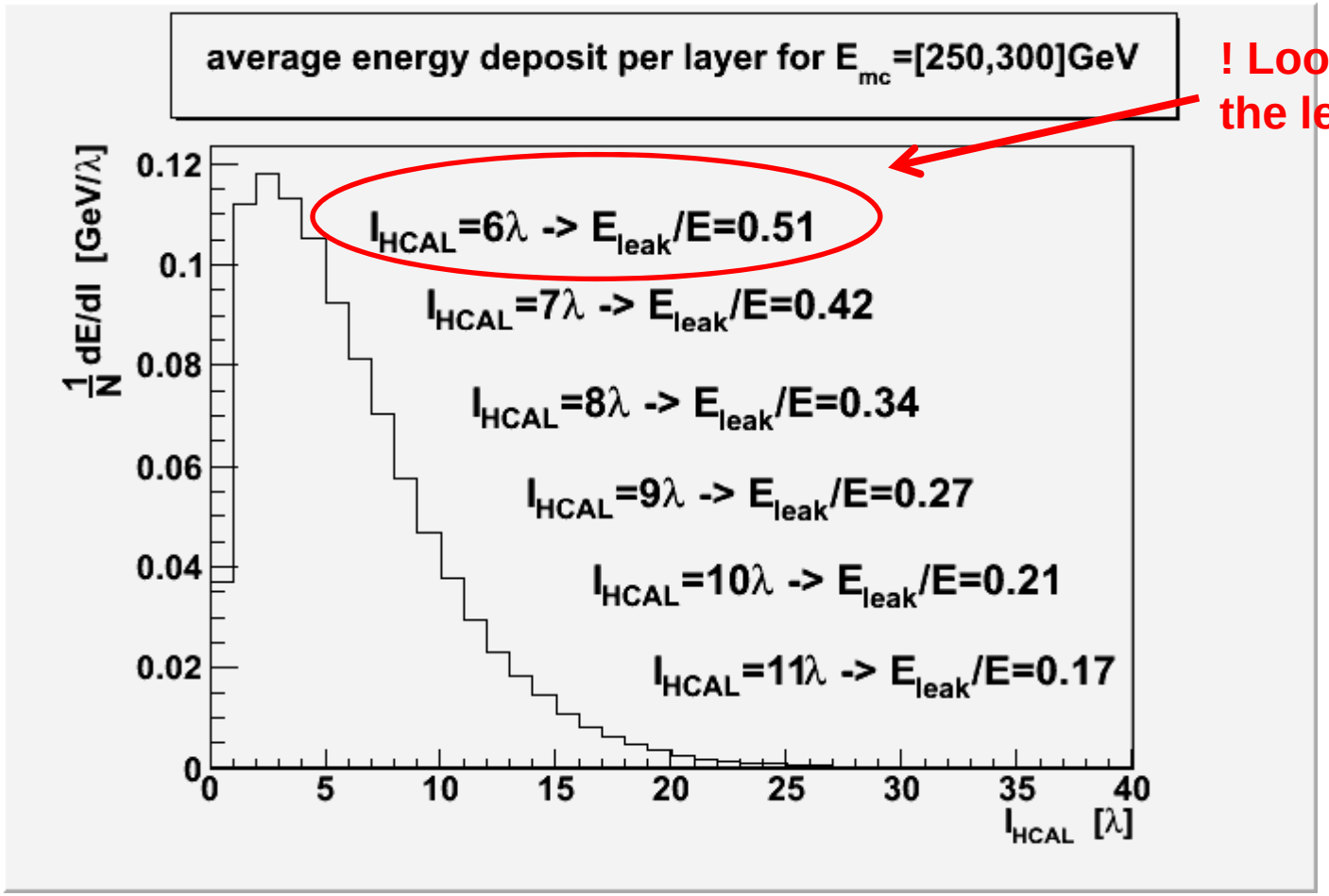
PRELIMINARY



Hadron Calorimeter

Courtesy Peter Speckmayer, Christian Grefe

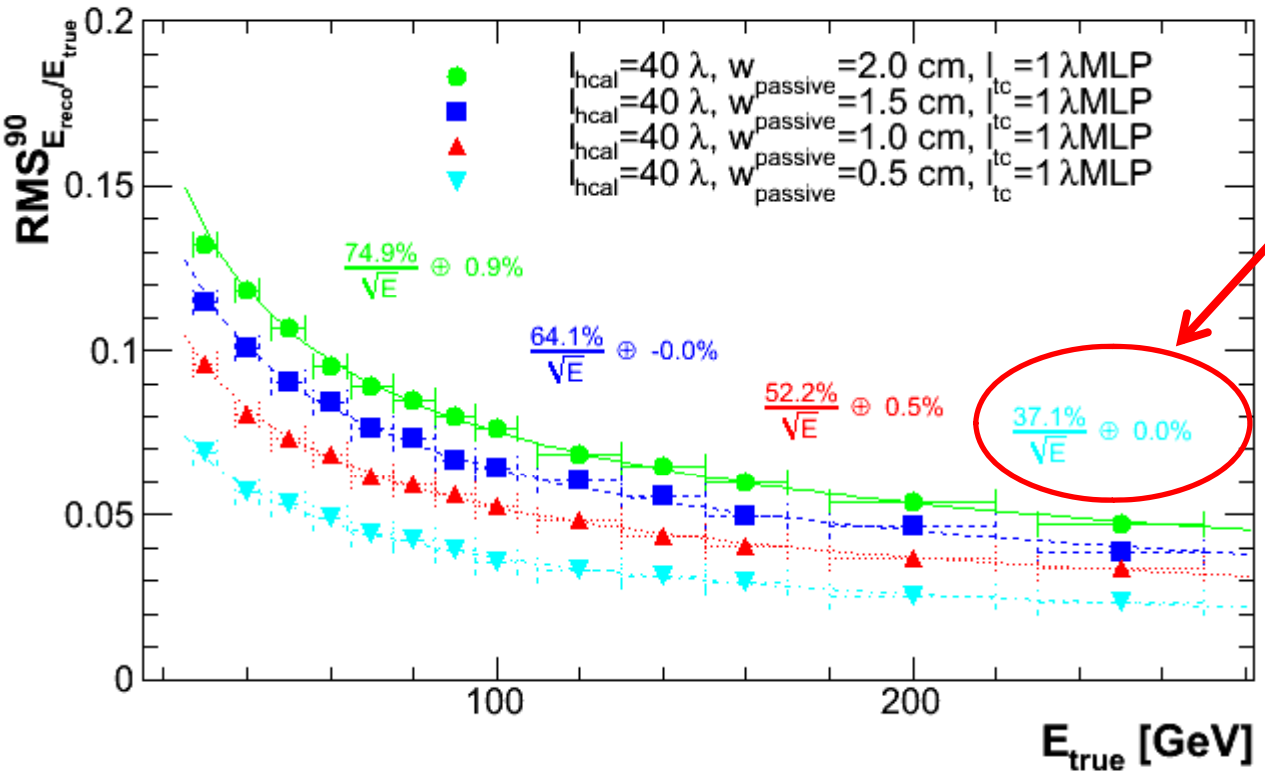
Average leakage (E=[250,300]GeV)



Hadron Calorimeter

Courtesy Peter Speckmayer, Christian Grefe

(conventional calorimetry) energy resolution (“infinite” HCAL)

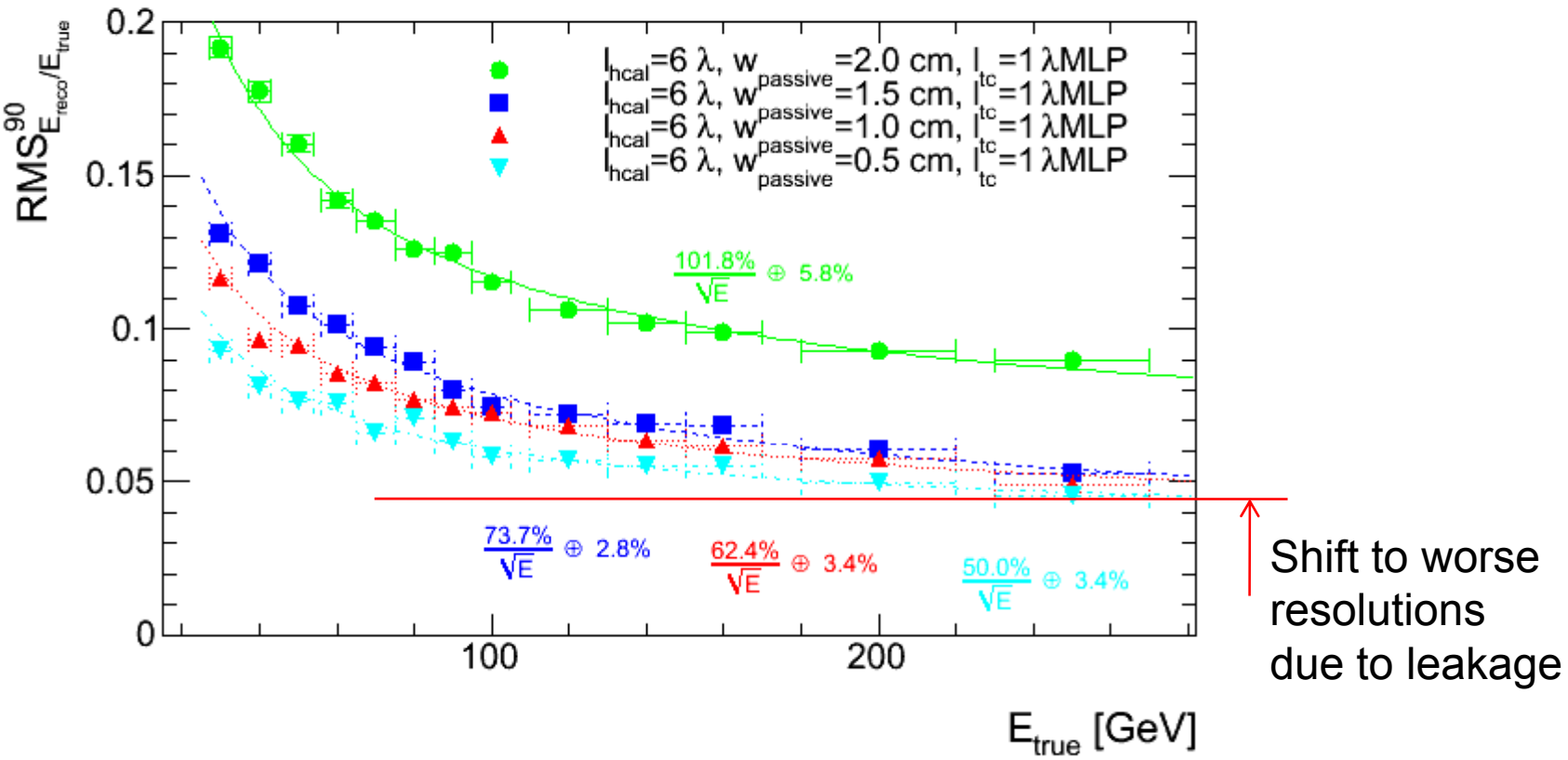


No noise,
Perfect read-out,
Infinite HCAL
(in reality, this
will be worse)

Hadron Calorimeter

Courtesy Peter Speckmayer, Christian Grefe

(conventional calorimetry) energy resolution ("6 lambda" HCAL)



Shift to worse resolutions due to leakage

LC TPC Large Prototype Beam Test at DESY
LC TPC Collaboration with EUDET Facility

Pixel beam telescope (EUDET)

Si strip detector (EUDET/SiLC)

Magnet: PCMAG (LC TPC/KEK,CERN)

Field cage & All Mechanics (EUDET: DESY)

Endplate (LC TPC/Cornell)

Gas system (EUDET:DESY)

Different MPGD Detector Modules (LC TPC: Asian group, Saclay & Carleton, NIKEHF, Bonn etc)

Test beam (DESY)

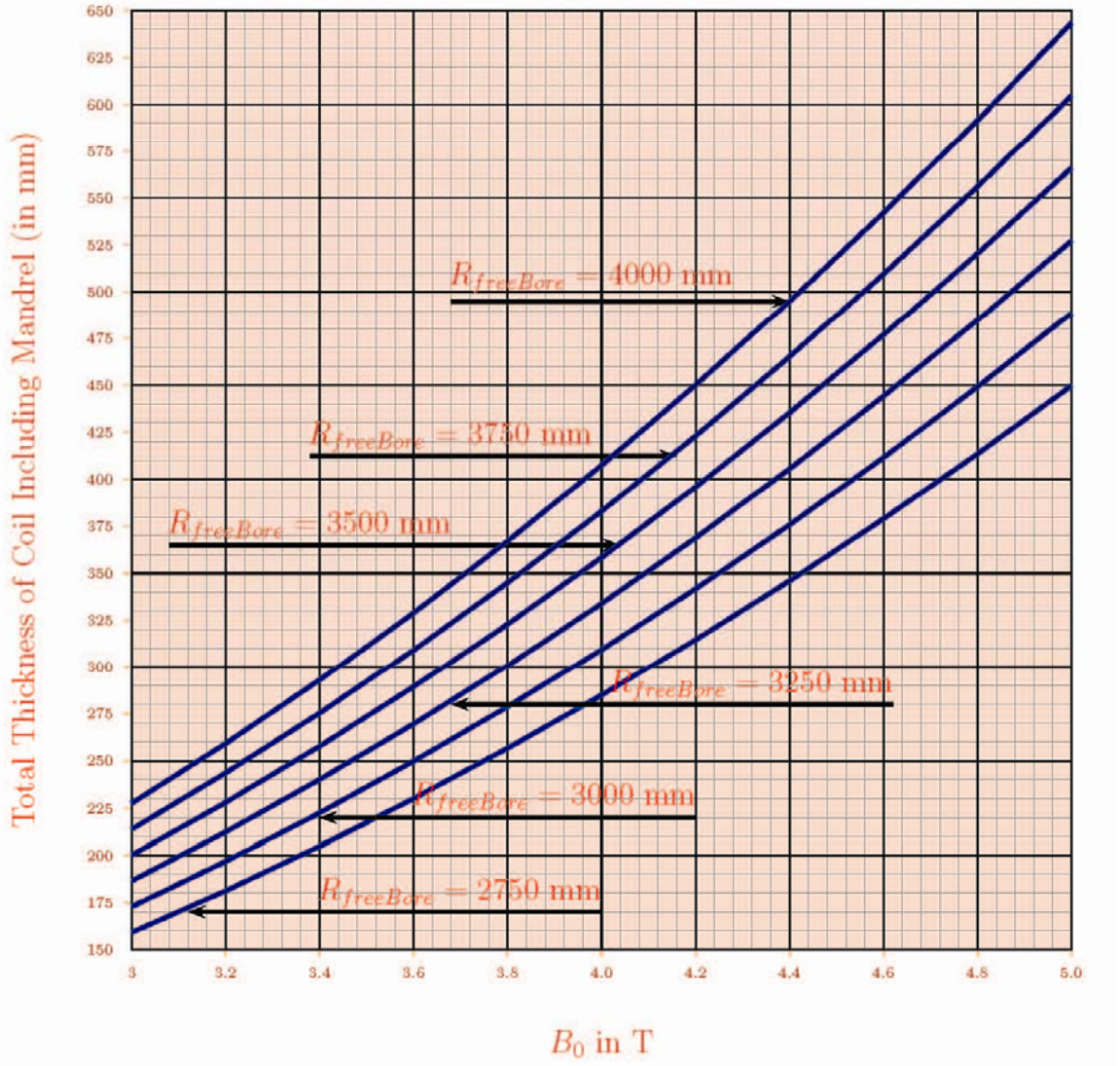
DAQ & Monitoring (EUDET)

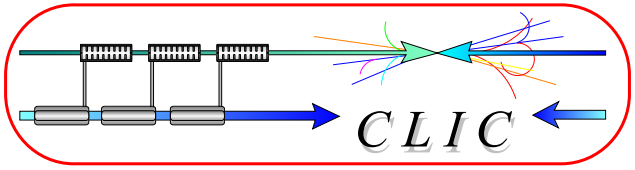
Cosmic trigger (LC TPC/KEK, Saclay)

Two types of Readout electronics (EUDET:CERN, Lund & LC TPC; CDC group, Saclay)

Software development (EUDET & LC TPC)

Thickness of Winding (in mm)





Conclusions-II

Alain Hervé, ILD Workshop, Seoul 17 February 2009,
4365-ILD-T-Coil-Developments.ppt

There is a starting R&D effort at CERN for the conductor:

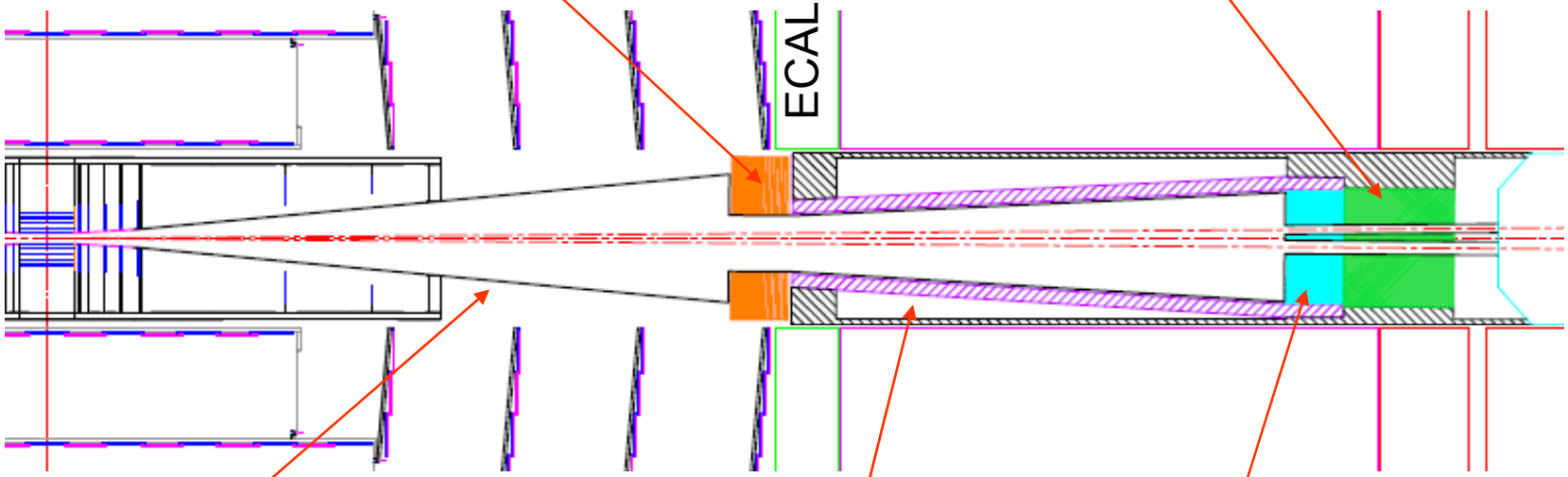
- To review and optimize the conductor geometry.
- To replace pure aluminum by a Ni doped alloy, as used in the ATLAS central solenoid (Yamamoto et al.), and produce a demonstration length.
- To replace the electron beam welding by a less expensive process.

It would thus be judicious for ILD to join this R&D effort.

SiD Forward Region

LumiCal
20 layers of 2.5 mm W +
10 layers of 5.0 mm W

BeamCal
50 layers of 2.5 mm W

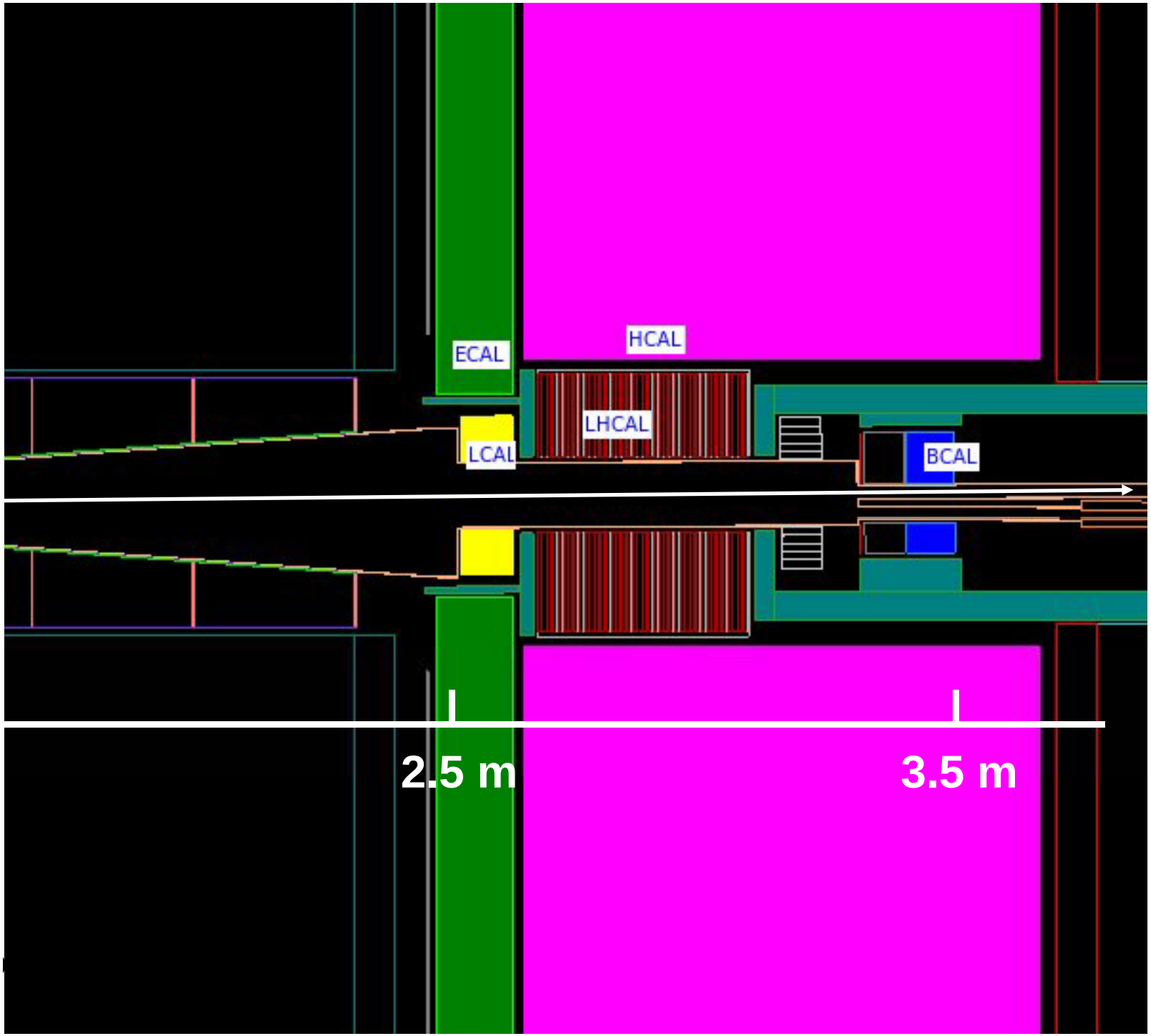


Beampipe
+/- 94 mrad (detector)
+101 mrad, -87mrad (ext. line)

3cm-thick Tungsten Mask

13cm-thick BoratedPoly

Centered on the outgoing beam line


ECAL
HCAL
LHCAL
LCAL
BCAL
2.5 m
3.5 m