Update on CLIC_ILD detector studies

necessarily incomplete, but
attempting to give you a “glimpse”

presented by K. Elsener (CERN),
for the CLIC detector study team

ALCPG Eugene, 22 March 2011

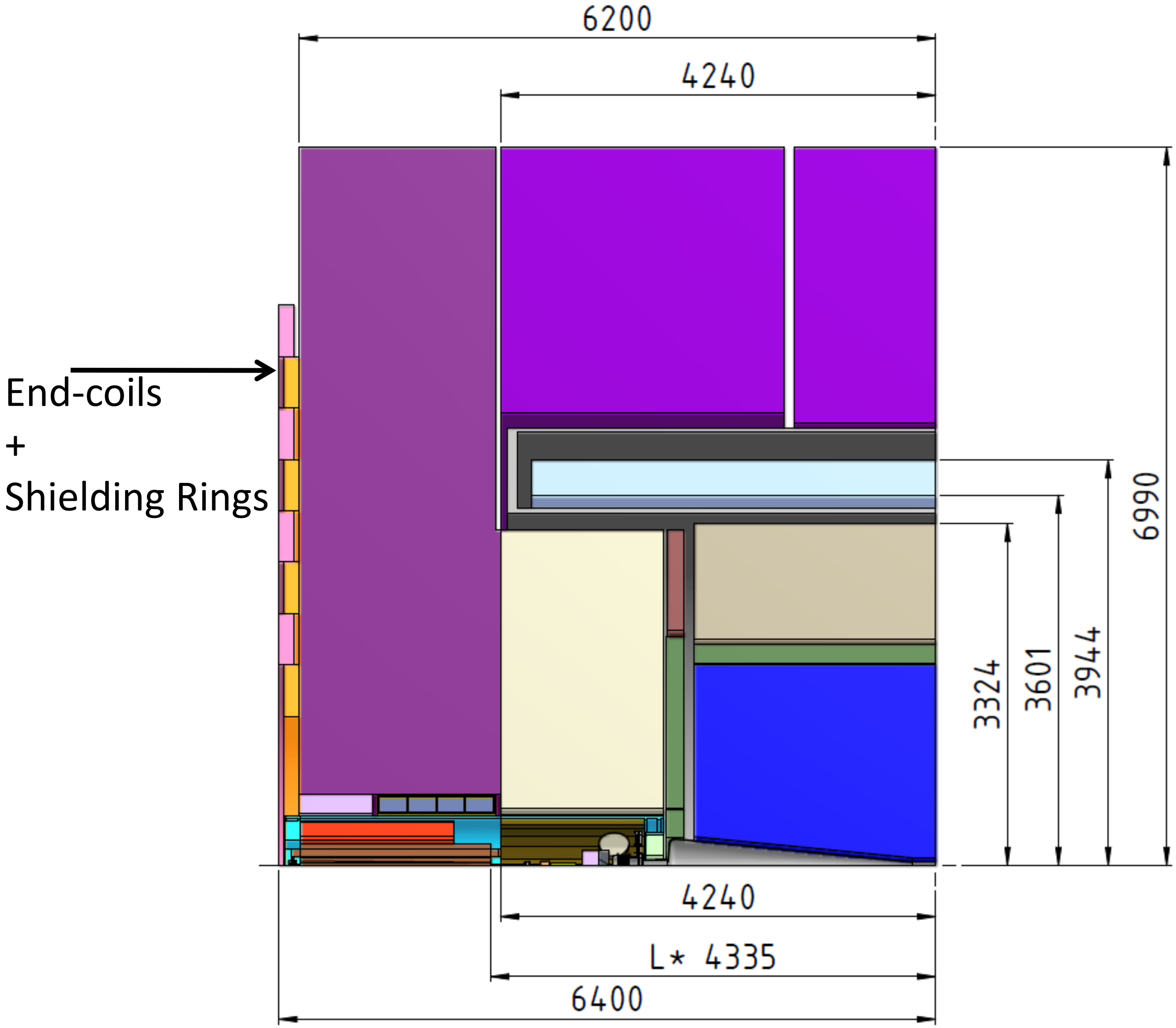
Note:

There are many individual contributions by ILD colleagues to the CLIC detector study – we are very grateful for this.

Thank you very much !

1) CLIC detectors for CDR: CLIC_SiD and CLIC_ILD
2) Modifications of ILD for CLIC
3) Overview of work in progress
4) A few recent examples
5) CLIC CDR and schedule
6) Outlook and ILD DBD

1) CLIC detectors: CLIC_ILD



2) Modifications of ILD for CLIC

(The main points)

Detector as short as possible in z, no opening on the IP

B-Field 4 Tesla, no anti-DiD

QD0 and forward elements:

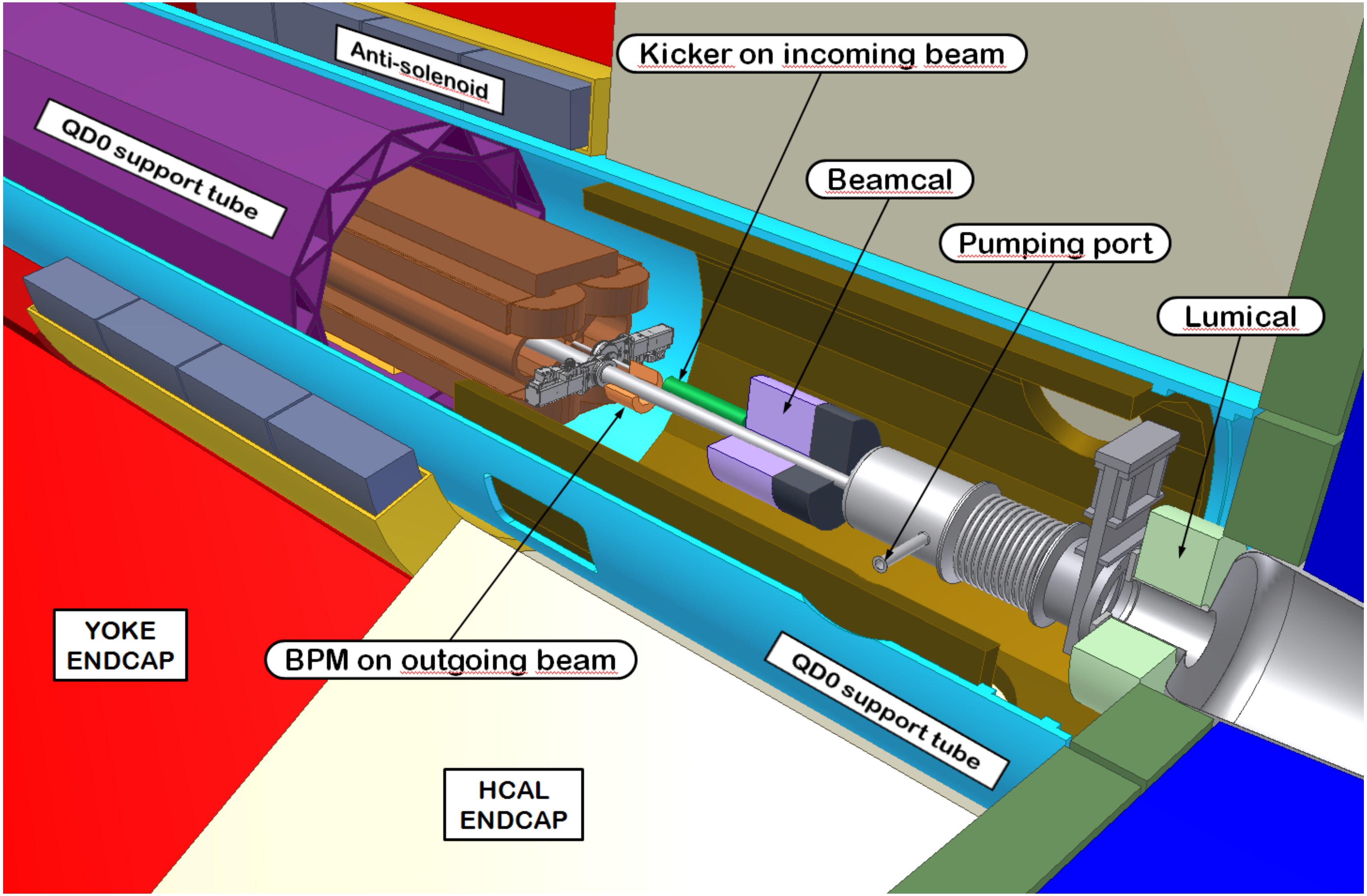
no LHCAL, LumiCal “outside” ECAL end-cap; double-support tube from tunnel; Antisolenoid; result: forward HCAL acceptance (R=0.5m), and muon acceptance

Conical part of vacuum pipe becomes “mask” (4 mm steel)
reduce BG from incoh. pairs; VTX radius out to 30 mm

HCAL deeper (7.5 lambda)
barrel: Tungsten instead of Steel

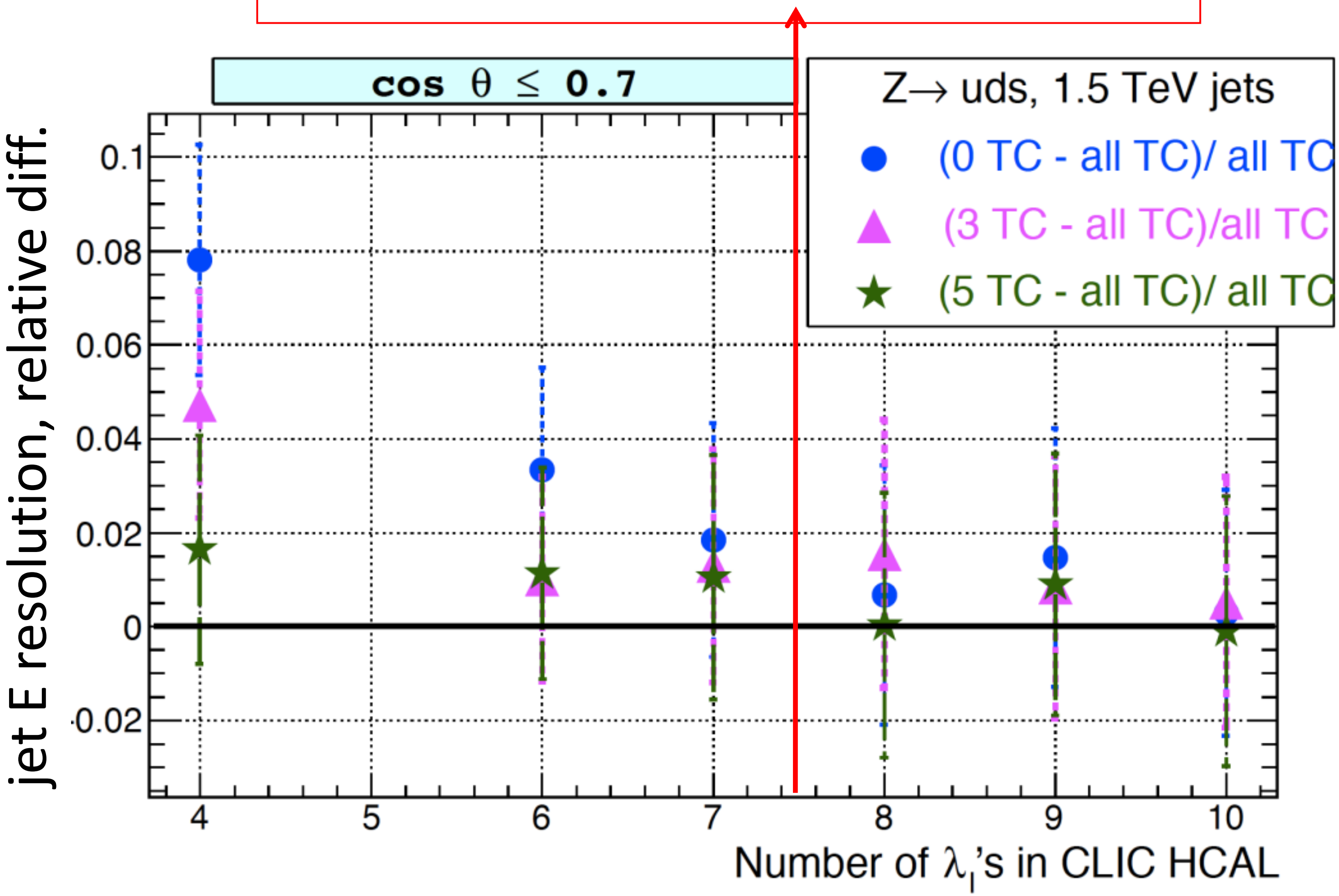
Muon System: optimised, 3x3 detector layers in yoke,
first 3 layers close to coil (tailcatcher)

Geometry for simulations frozen in Nov. 2010


Anti-solenoid
QD0 support tube
Kicker on incoming beam
Beamcal
Pumping port
Lumical
YOKE ENDCAP
BPM on outgoing beam
QD0 support tube
HCAL ENDCAP

HCAL and Muon System – Tail Catcher

HCAL design: 7.5 λ, ECAL: 1.0 λ



(A. Lucaci-Timore, using "old" Pandora, October 2010)

HCAL and Muon System

Active layers:

- RPC (digital) or scintillators (analog)
- Granularity: 3 x 3 cm^2 sensor size.

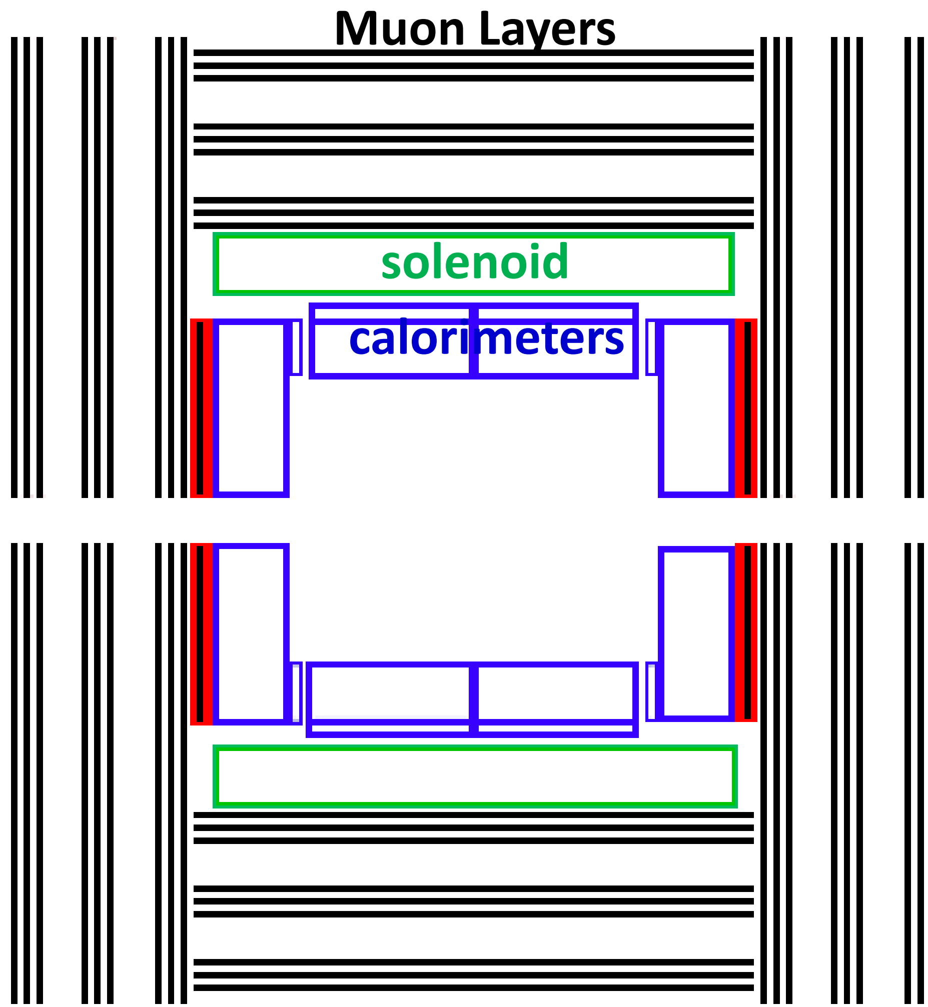
3x3 layered system:

- Tail-catching with three layers starting directly after solenoid.

(More layers do not improve jet energy resolutions).

- Outer 2x3 layers allow two large yoke masses in the barrel – must carry the longitudinal forces pulling the endcaps inward.

(Preferred over a geometry of six layers at equal distances, which resulted in similar efficiencies.)



(Erik van der Kraaij, using Pandora)

3) Overview of work in progress

Understanding backgrounds:

$\gamma\gamma$ – hadrons, muons
incoherent pairs
muons from BDS

Preparation of Software Tools – finding , fixing “issues”…

overlay of background from multiple BX
timing

Benchmark Processes (***done in CLIC_ILD***):

squark, sleptons, charginos+ neutralinos,
light and ***heavy Higgs*** at 3 TeV c.m.; ***ttbar*** at 500 GeV c.m.
-> studies under way (several mini-WG, reports to WG6)
finding issues while software tools are being improved

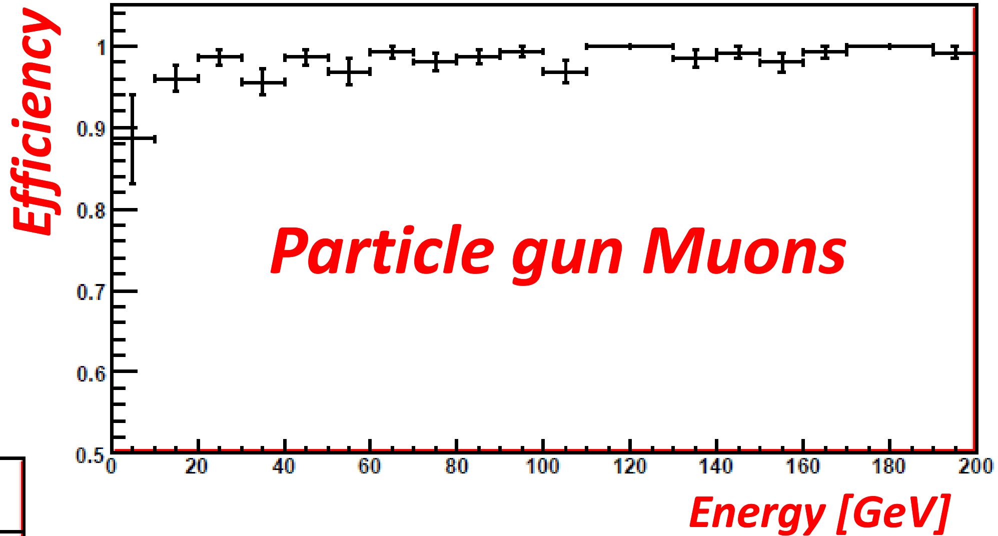
4) A few recent examples

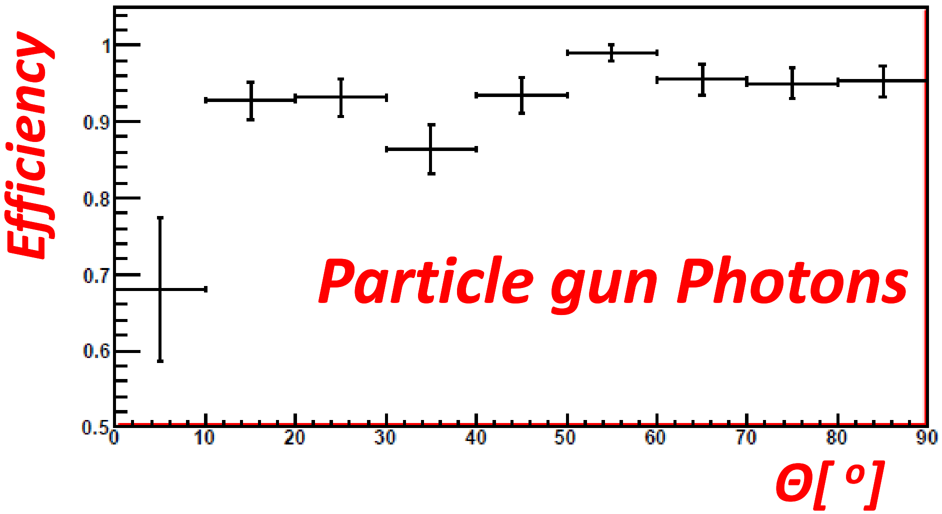
See the CDR preparation working group WG6,
eg. last meeting on 16 March 2011

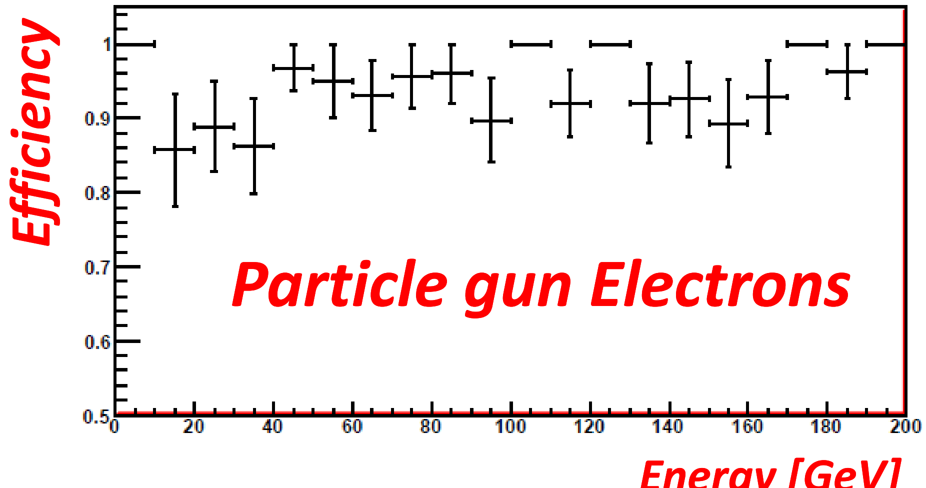
https://indico.cern.ch/conferenceDisplay.py?confId=129506

Particle ID Efficiency

- Take collections of MCParticles
  and PFOs of same PDG
- Match them on basis of Energy
  and position.
- Now used for both ILD and SiD and all particle types



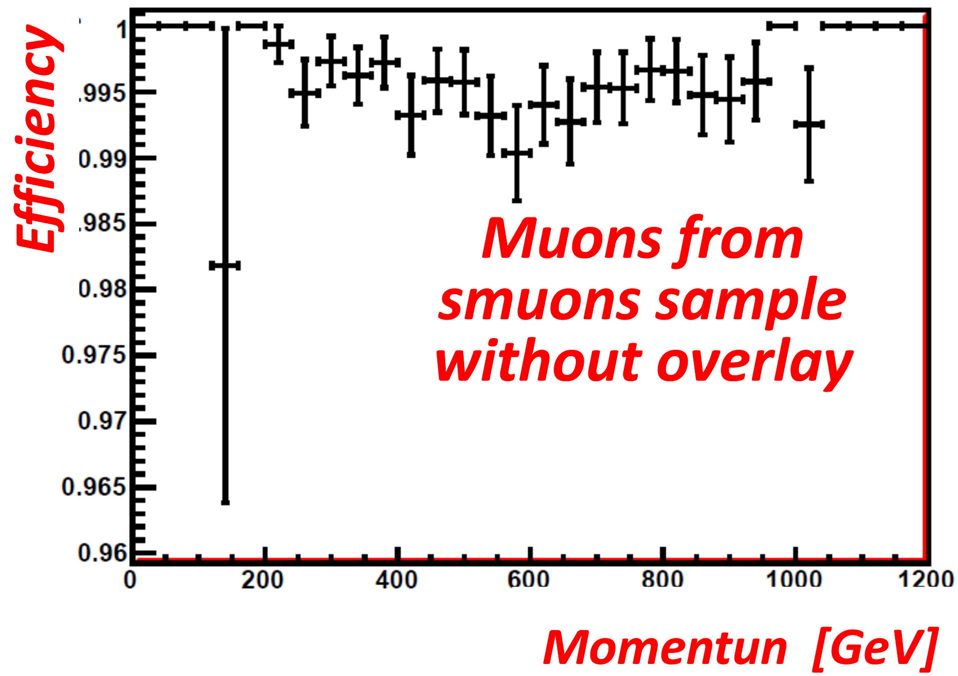


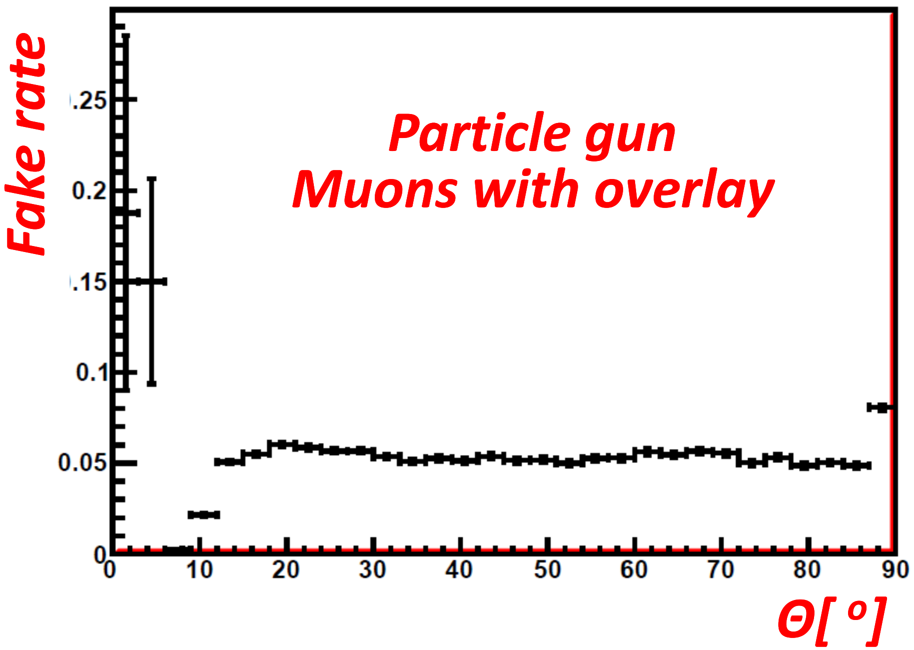


(J. Nardulli, using latest CLIC_ILD_CDR software)

Tracking Efficiency

- Take collections of MCParticles and tracks
- Match them: the % of hits of a track, that belong to the MCParticle we want to match it to, has to be > 75%

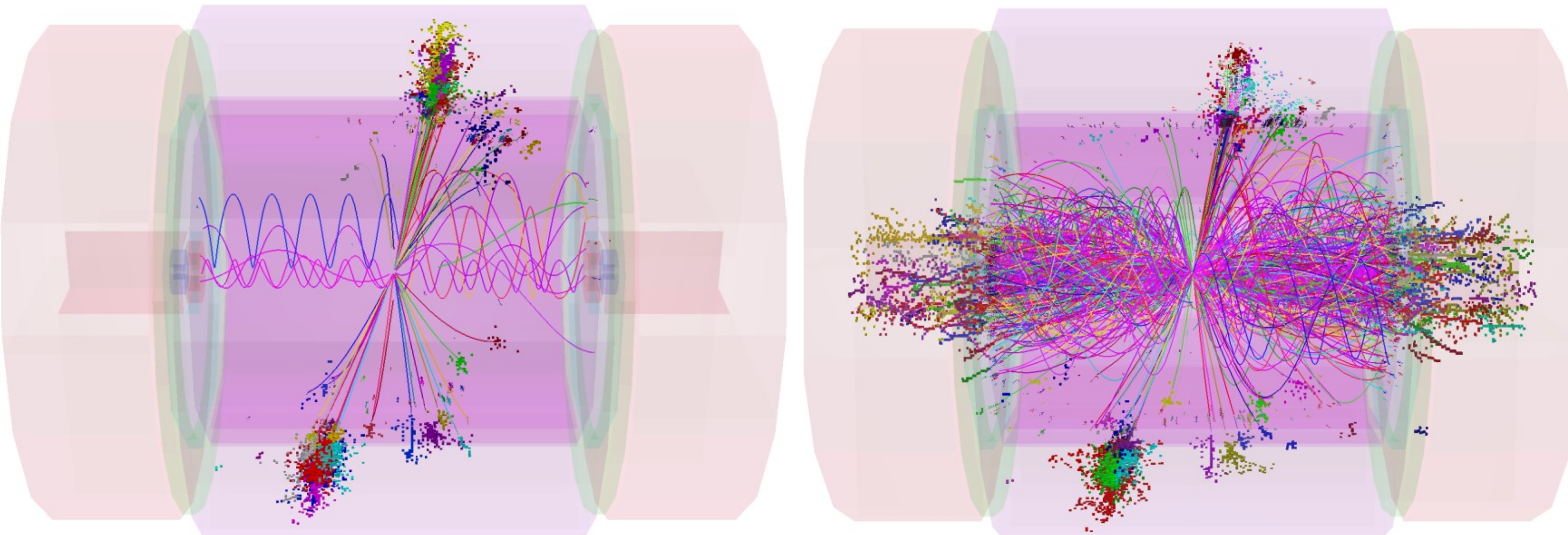




(J. Nardulli, using latest CLIC_ILD_CDR software)

Overlay Reconstruction

- ★ Can now routinely process events with overlay !
  - few minutes per event
  - overlay **60 BXs gamma gamma -> hadrons** (limited by fortran PatRec)
    - believe to be a good approximation
    - accounts for almost all calorimeter background
    - + TPC PatRec is feasible (see ALICE reconstruction)
- ★ Compare overlay/non-overlay processing for 1 TeV Z event



1.4 TeV of background (reconstructed particles) !

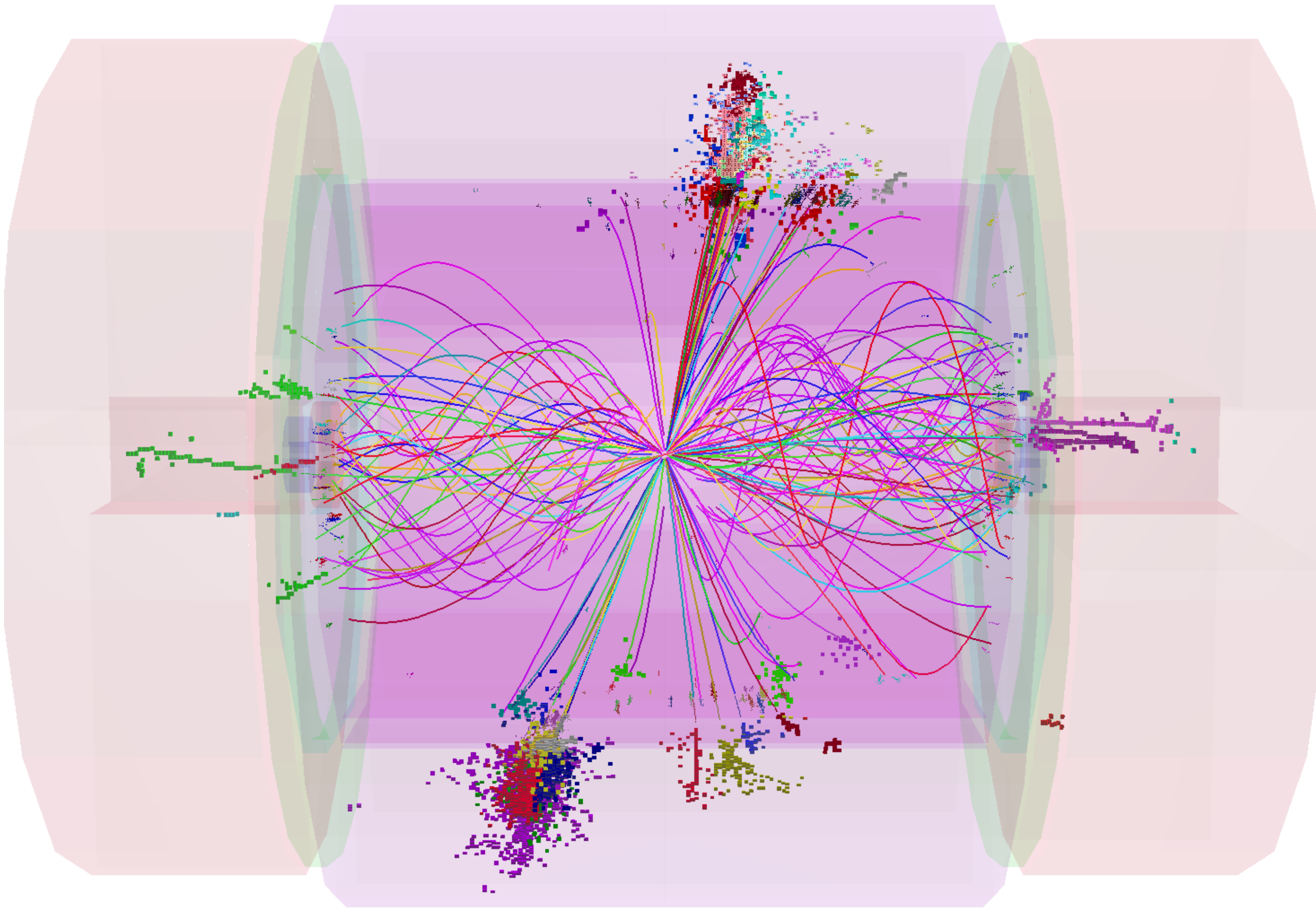
PFO-based Timing Cuts

★ For each PFO type define two levels of timing cuts (tight, loose)

Default cuts: (timing cuts applied after TOF correction)

Cut	Photon	Neutral h	Charged
Max pT to apply loose cut	4.0 GeV	8.0 GeV	4.0 GeV
Loose timing cut	2.0 ns	2.5 GeV	3.0 ns
pT to apply tight cut	0.75 GeV	0.75 GeV	0.75 GeV
Tight cut	1.0 ns	1.5 ns	1.5 ns
Far forward $\cos\theta$	0.975	0.975	n/a
Far forward loose cut	2.0 ns	2.0 ns	
Far forward tight cut	1.0 ns	1.0 ns	
Track-only min pT			0.5 GeV
Track-only max time at ECAL			10 ns

SelectedPandoraNewPFAs



0.2 TeV of background

Symptom	Looking harder	Problem	Cure	Status
Events taking too much time	Too many particles in forward region. High energy photons showering in steel part of beam pipe Too many FTD hits/tracks	Nasty loops in Silicon/ TrackingCLIC	Iterative determination of "phi" segmentation	Fixed (MT)
Loss of efficiency for very high energetic muons	Very high energetic track disappears. No TPC hits stored Only neutrals are left	Hardcoded cut in Tracking/Fortran code at 1 TeV	Set cut at 2TeV	Fixed (SA)
Overlay timing	Memory leaks in overlay processor	3 separate leaks identified		Fixed (AS & JM& PS)
Memory leaks	Memory leaks in FullLDCTracking, VoFinder, TPCDigitization	Several leaks identified		Fixed (AS & JM)
Degradation of Pandora PFA performance	In forward region		Wrong capitalization of steeringparameter	Fixed (JM)
Low muon-ID efficiency in transition region	Hits in different layers not clustered together	Pseudolayer mapping issues	Look for hits in more layers	Fixed (JM & EK)
Different nr of TPC hits if processing X events or skipping X-1 events	Problem in random seed generator		Random seed made dependent on event nr	Fixed (SA)

5) CLIC CDR and schedule

-> European Strategy Update in 2012
LHC run prolongation to end 2012
-> recent re-scheduling and re-grouping of CDR volumes

Vol 1.: Accelerator
Vol 2.: Physics and Detectors
both ready end of summer 2011

Vol 3.: (formerly "executive summary")
is the key input to the European Strategy Update
as late as possible in 2012,
depends on detailed schedule of Eur.Strat.Update

6) Outlook and ILD DBD

-> still much work ahead for CDR (physics and detectors)

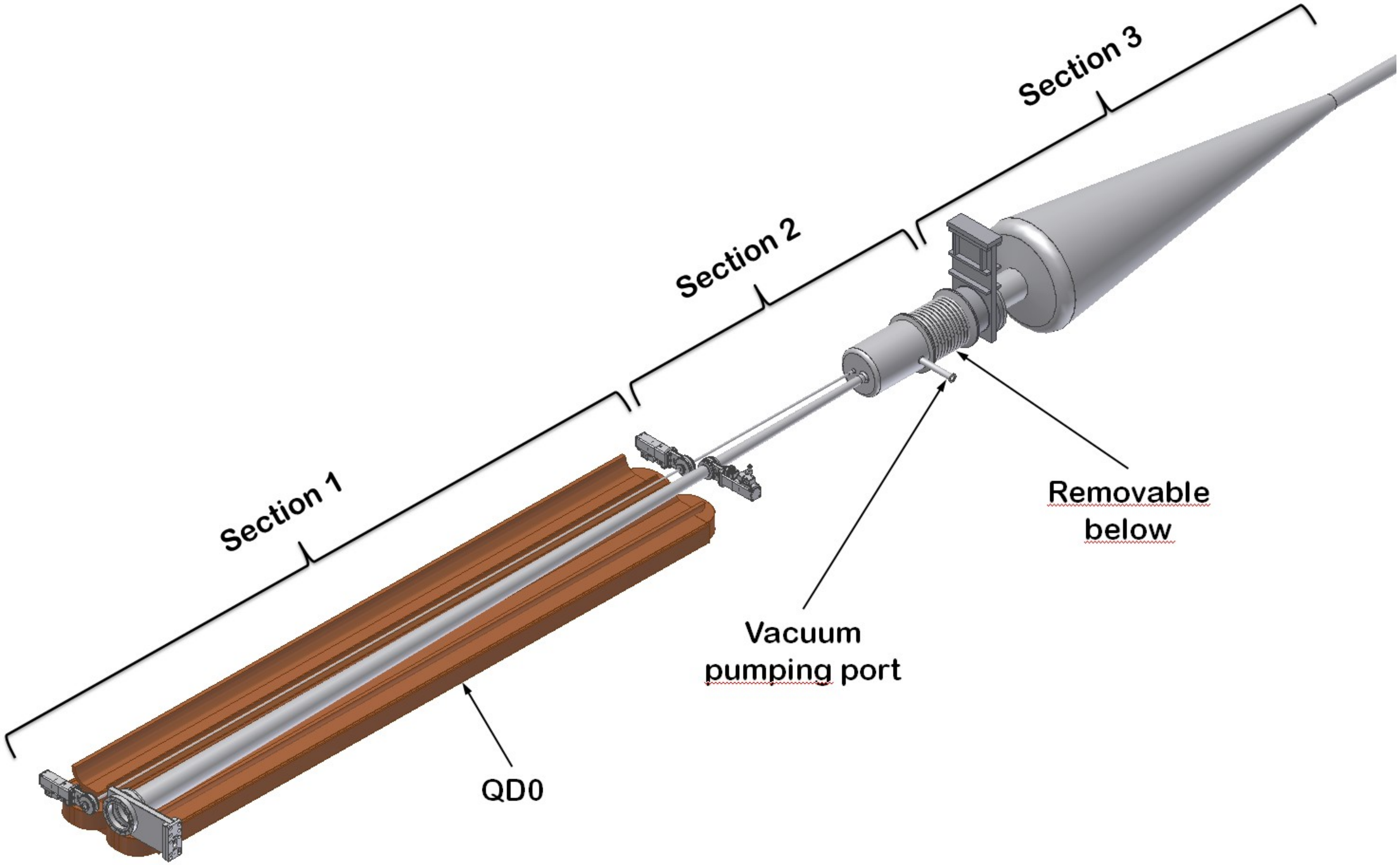
-> some additional work will be required for the European Strategy Update

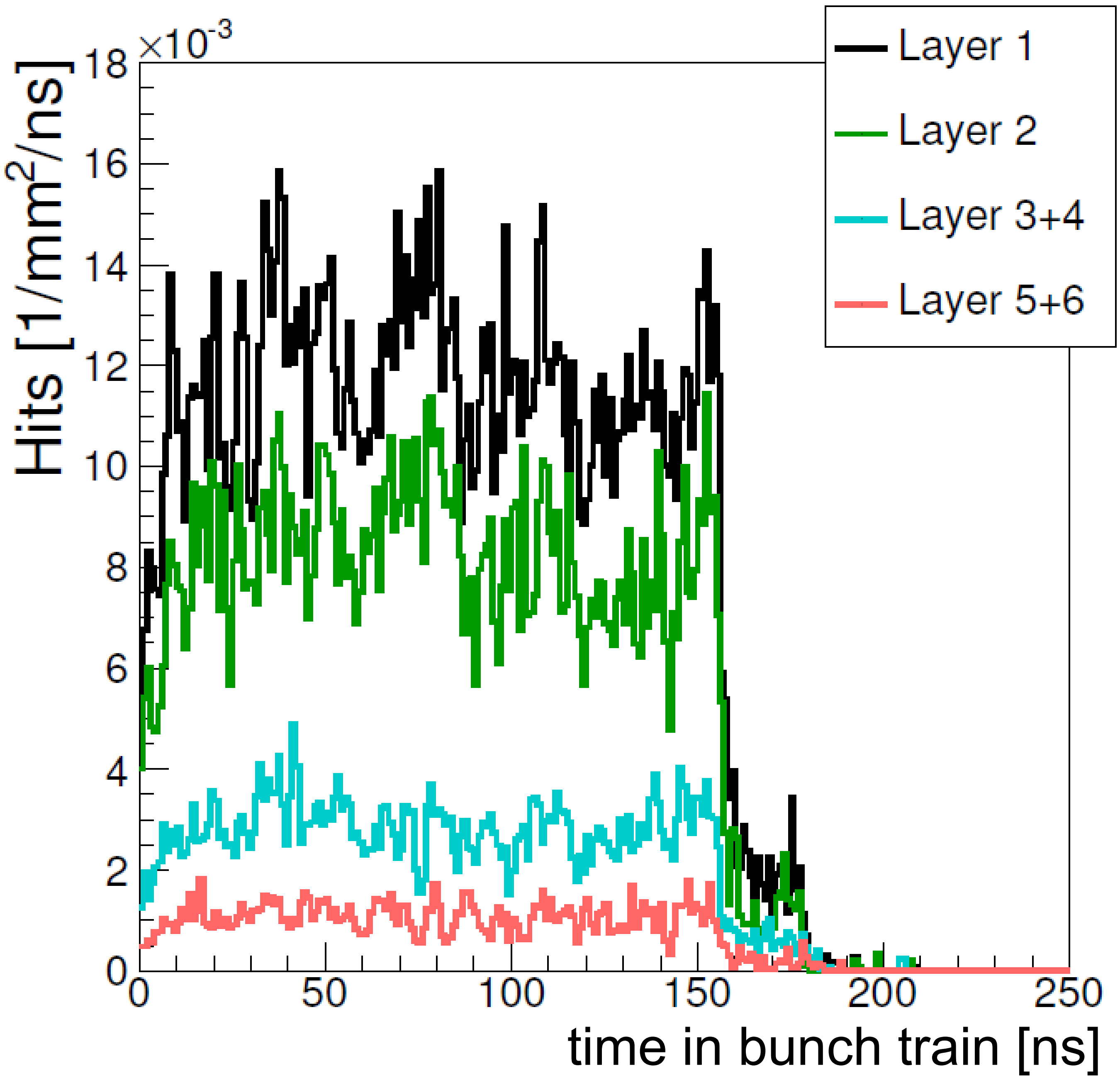
-> the CERN LCD group has submitted a list of possible contributions to the ILD_DBD, this list is now with the ILD management board for discussion and feedback to LCD

Disclaimer:
In 2011, the LCD project has come under increasing budgetary pressure at CERN; we hope 2012 will not bring additional surprises

SPARES

Vacuum Layout: Update




Hits [1/mm²/ns]
×10⁻³
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
time in bunch train [ns]
Layer 1
Layer 2
Layer 3+4
Layer 5+6

CLIC detector – muon system design

Active layers:

•RPC (digital) or scintillators (analog)

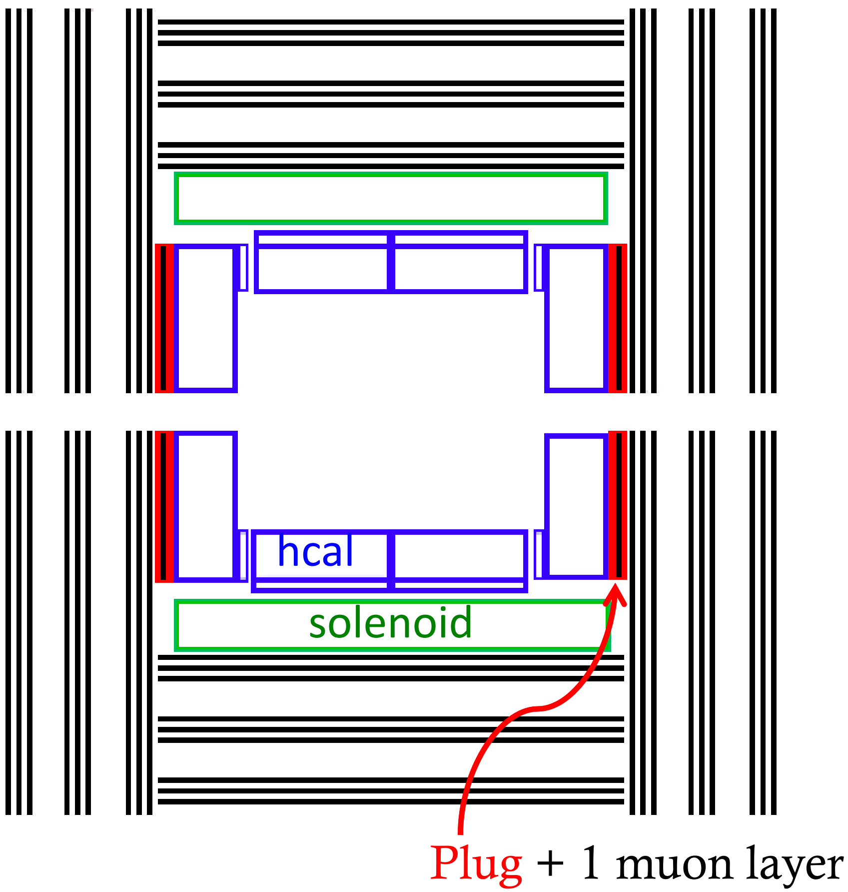
•Granularity: 3 x 3 cm^2 sensor size.

A 3x3 layered system for:

•Tail-catching with three layers starting directly after solenoid. More layers do not improve jet energy resolutions.

•The outer 2x3 layers give way to two large yoke masses in the barrel. These are to carry the longitudinal forces pulling the endcaps inward.

Preferred over a geometry of six layers at equal distances, which resulted in similar efficiencies.

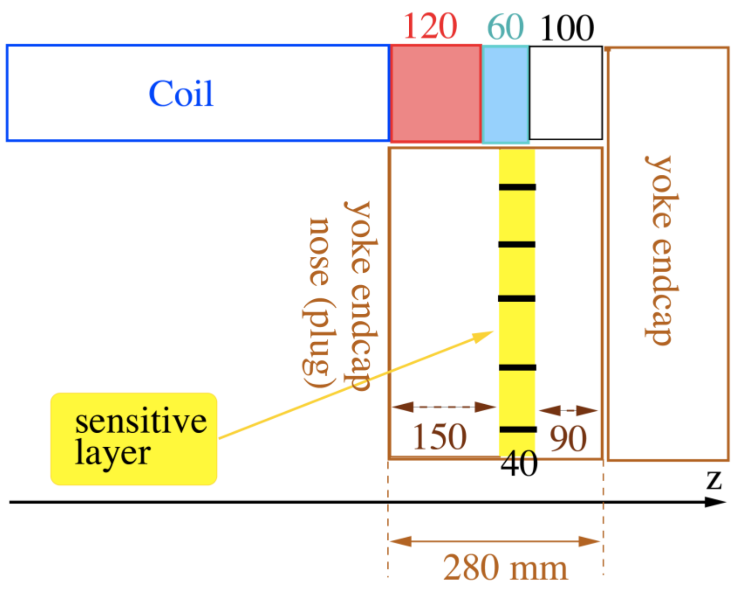


➢ Each endcap includes a plug, with a 10^{th} layer. This is to have the magnetized yoke start immediately where the coil ends, improving B-field uniformity.

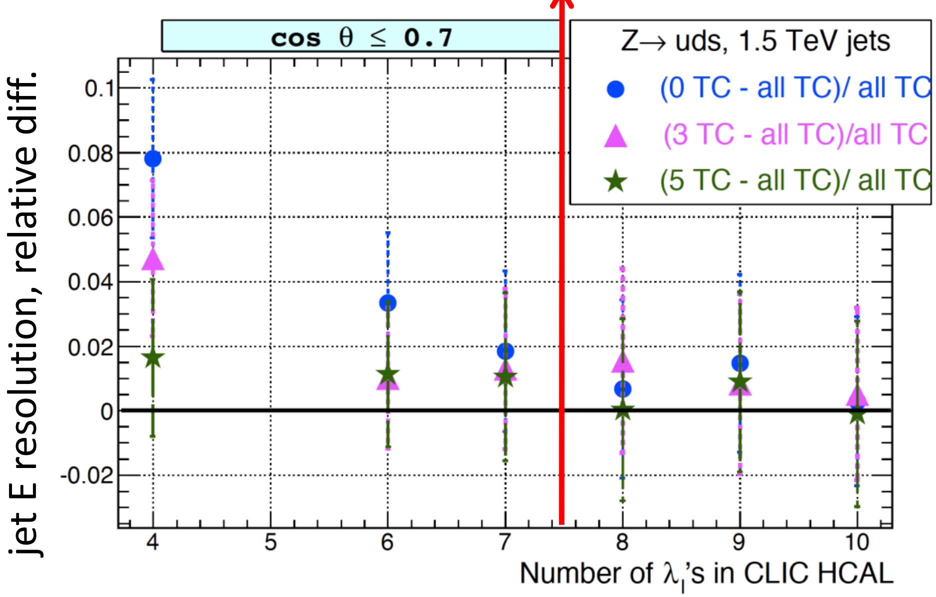
CLIC detector - tailcatcher

Engineering: need yoke endcap aligned to coil

➢Avoid 28 cm of steel before first sensitive layer: insert 1 layer after 15 cm.



HCAL design: 7.5 λ, ECAL: 1.0 λ



Jet energy resolution studied with different HCAL- and tailcatching depths

➢ In endcap and barrel start yoke instrumentation with three sensitive layers.

CLIC detector – angular coverage

For muon ID & pattern recognition

2x three layers beyond tail-catcher

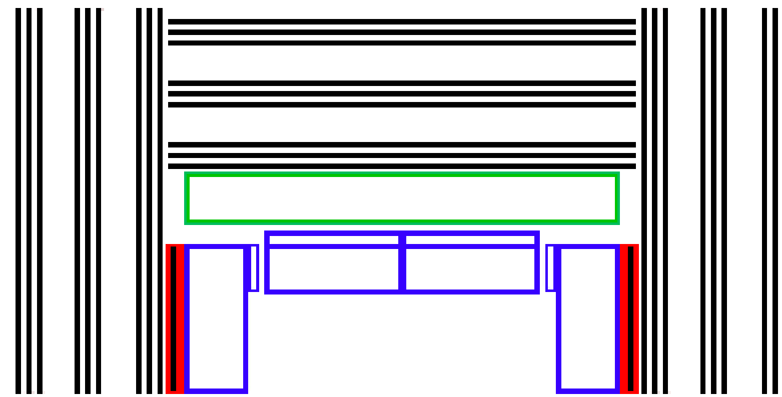
➢Yoke barrel: 9 sensitive layers

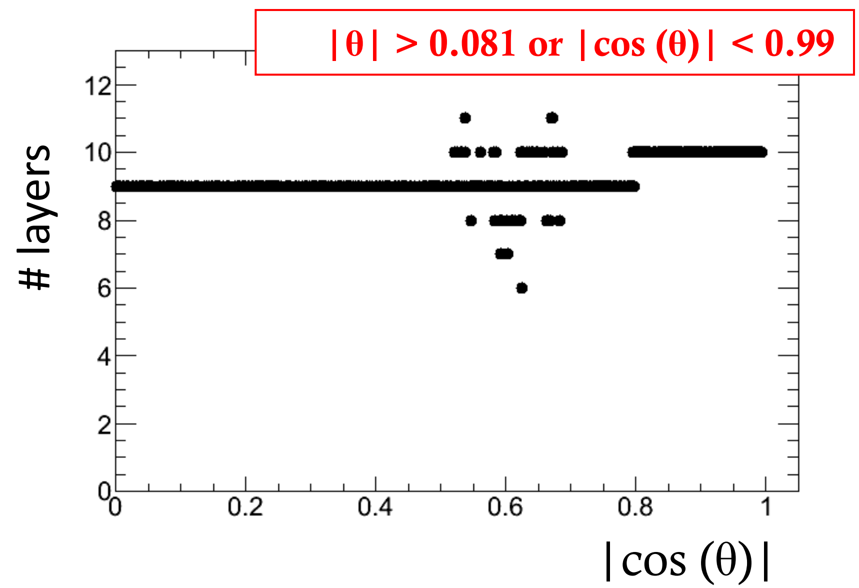
Starting with active layer directly after solenoid

➢Yoke endcap: 10 sensitive layers

Including single plug layer

In the transition region from barrel to endcap (0.5 < | cos(θ) | < 0.8) the muon passes sometimes less, sometimes more than 9 layers.





Definitions

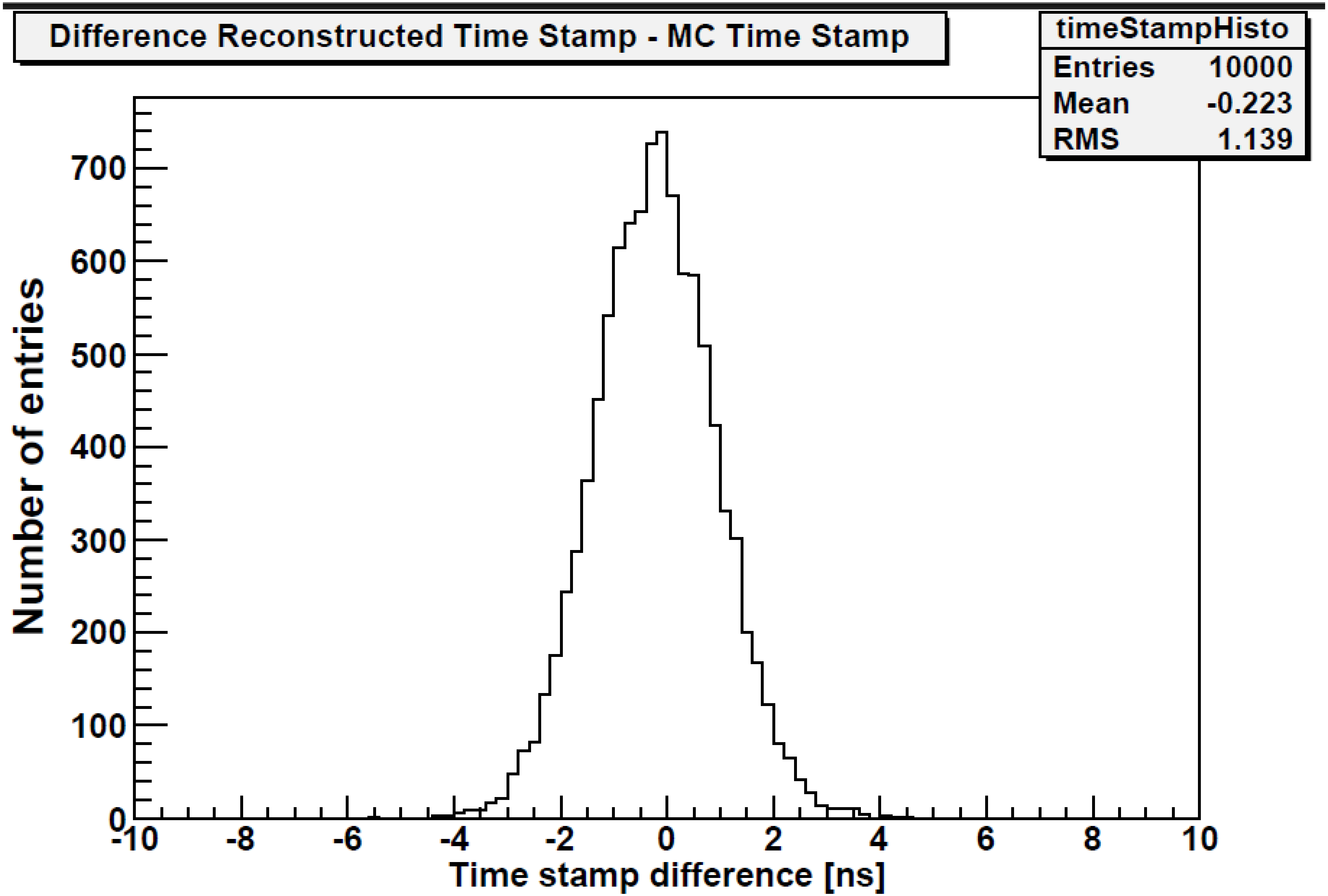
Efficiency:

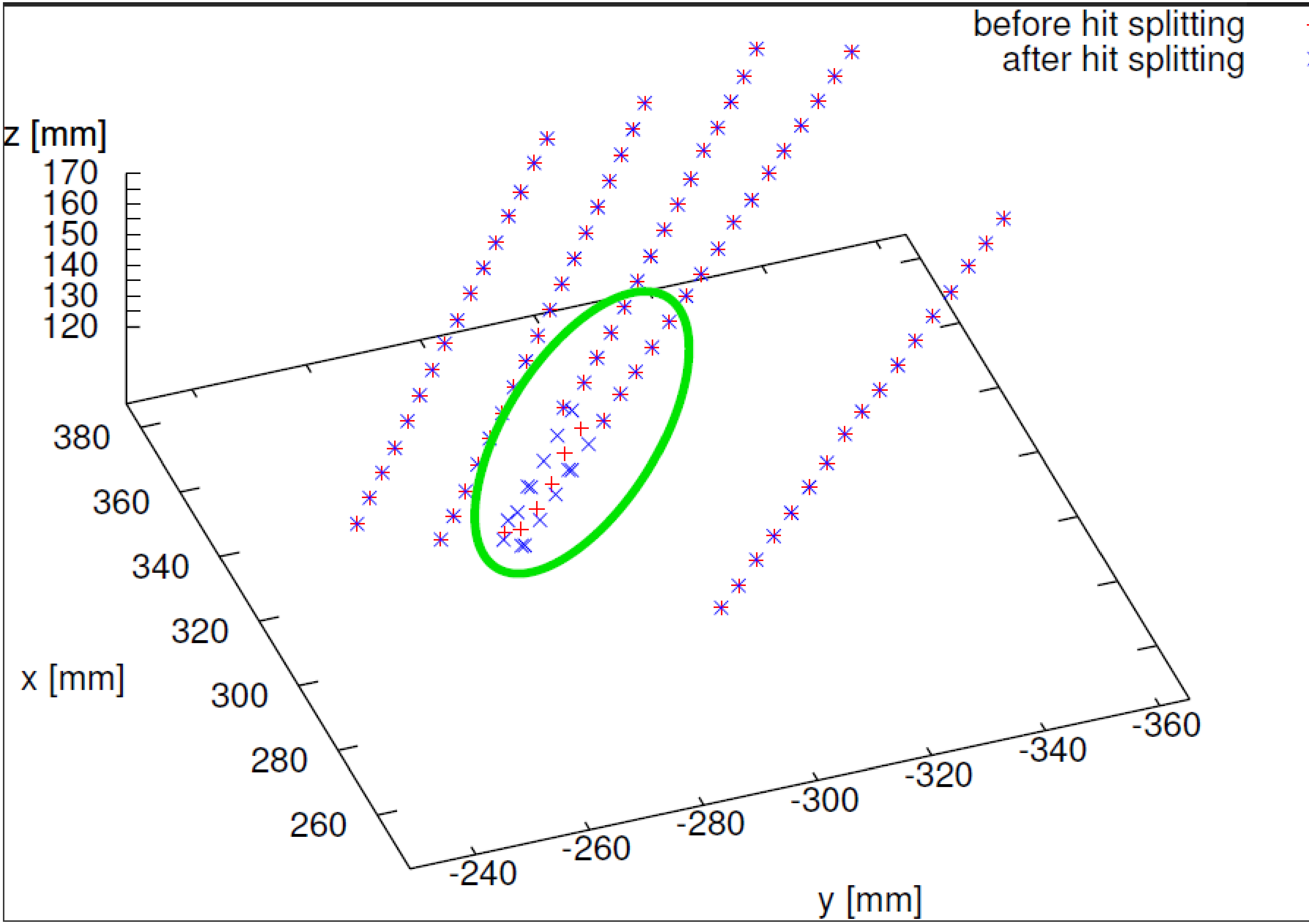
→matched MCParticles/findable MCParticles

Purity:

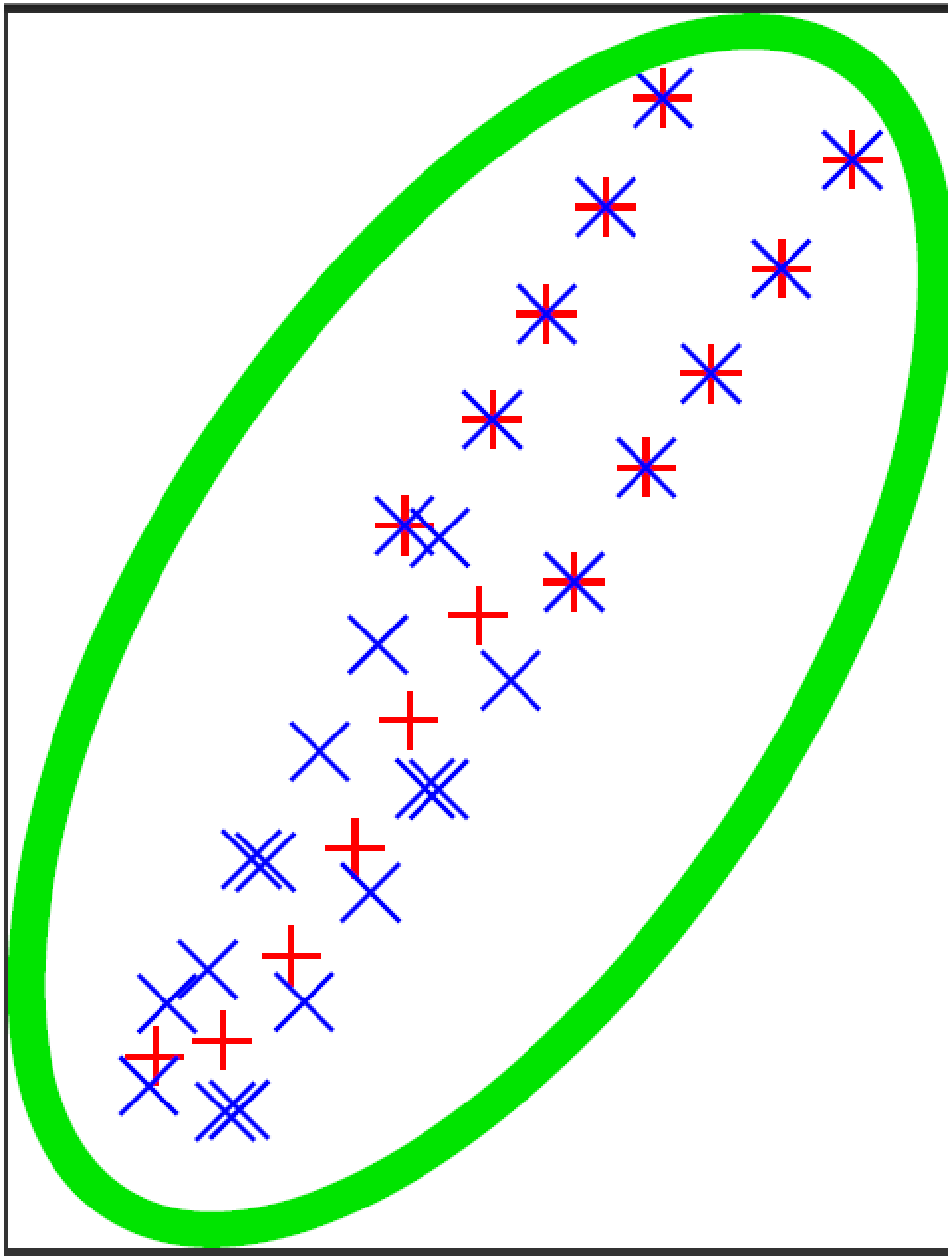
→Matched PFOs/findable PFOs

→These definitions are per MCParticle → see plots
and per Event → see numbers


Difference Reconstructed Time Stamp - MC Time Stamp
timeStampHisto
Entries 10000
Mean -0.223
RMS 1.139
Number of entries
0
100
200
300
400
500
600
700
-10
-8
-6
-4
-2
0
2
4
6
8
10
Time stamp difference [ns]



before hit splitting
after hit splitting
z [mm]
170
160
150
140
130
120
380
360
340
320
300
280
260
x [mm]
-240
-260
-280
-300
-320
-340
-360
y [mm]



Beam Halo Muons