Scintillator ECAL:
reconstruction & optimisation

Hit digitisation ← covered in Oskar's talk yesterday

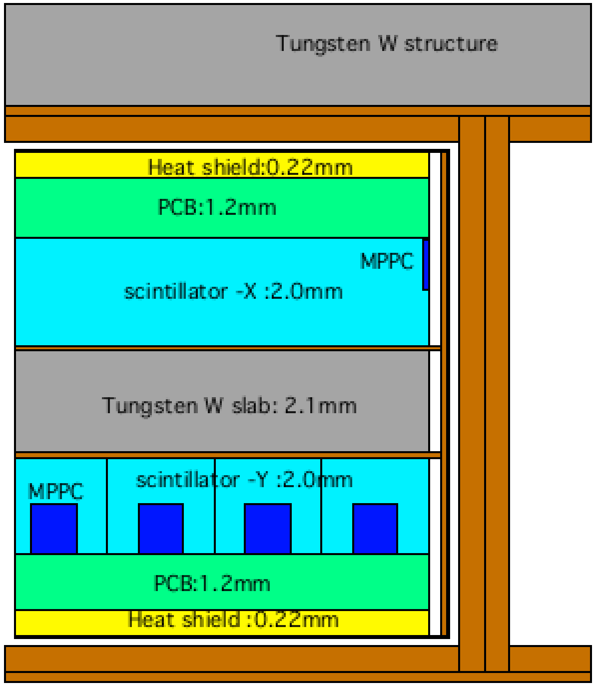
Strip Splitting Algorithm

Optimisation

Daniel Jeans (U.Tokyo) on behalf of
Kotera, Takeshita et al @ Shinshu
Ootani et al @ U. Tokyo

ILD Soft & Opt workshop, DESY, Feb 2016

ScECAL: layers of scintillator strips, individually read by SiPM
orthogonal orientation in adjacent layers

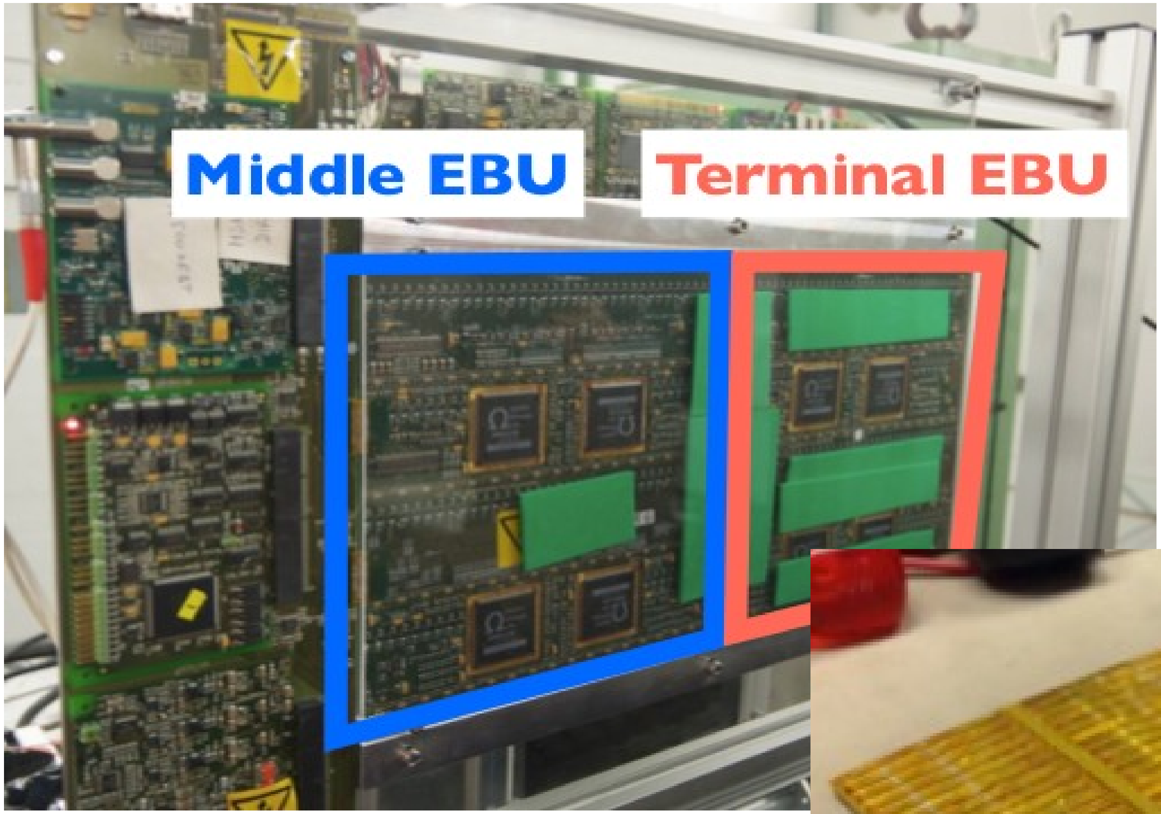


compared to square cells of same width,
strip-based readout (e.g. of ECAL)

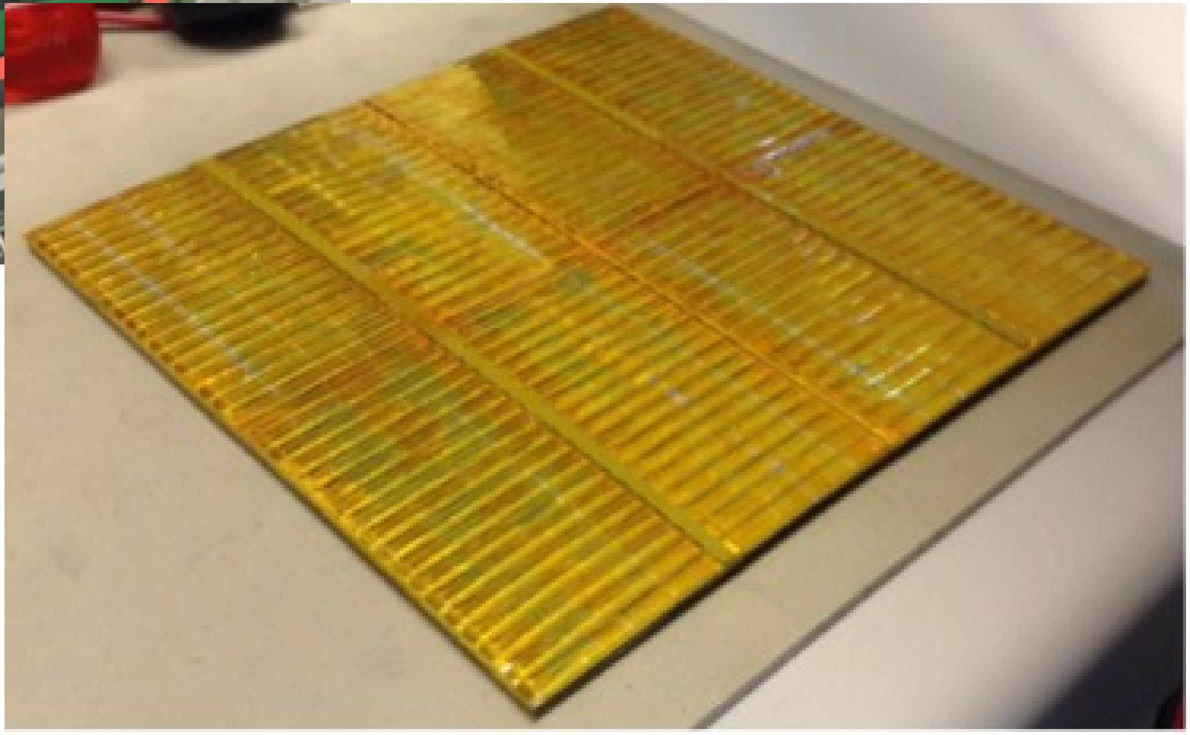
→ reduced number of readout channels,
and therefore complexity and cost

→ requires additional reconstruction step
to resolve hit position, with some remaining ambiguities

Sensitive layer prototypes



Ecal Base Unit
18x18cm^2,
144 channels



Strip-Splitting Algorithm (SSA)

basic algorithm

in MarlinReco/Clustering/hybridEcalSplitter/

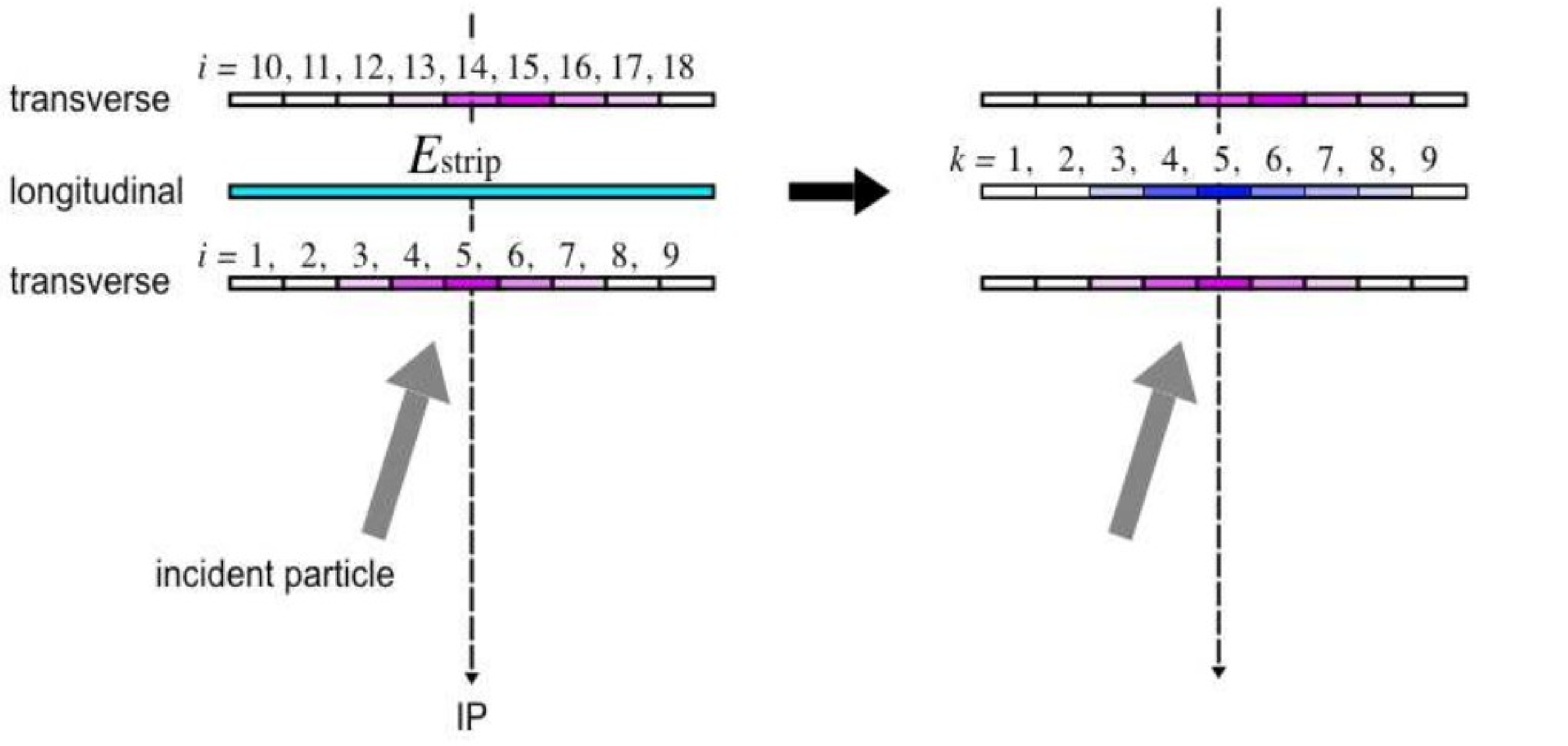
strip-tile geometry

arXiv:1405.4456

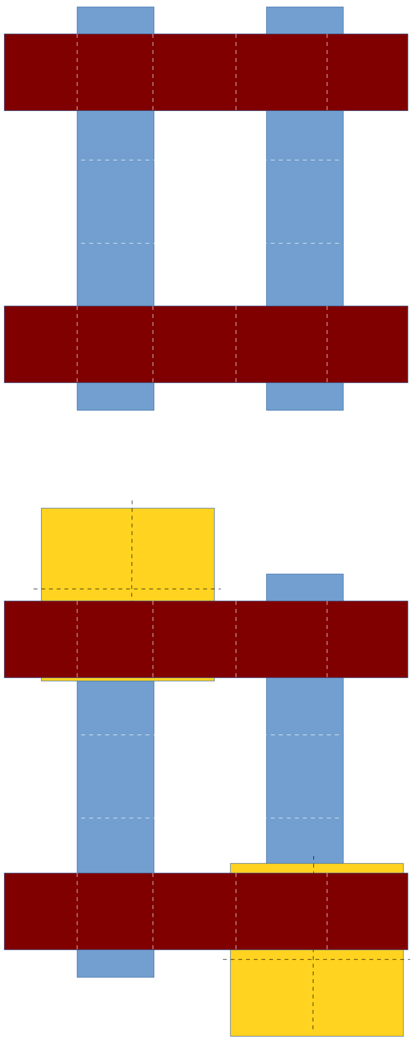
NIM A789 (2015) 158-164

In reconstruction step,
each strip is split into approximately square "virtual cells"

energy recorded in strip is distributed among virtual cells
according to energy in strips of adjacent (orthogonal) layers



SSA'



combine strip layers with square tiles

e.g. 5x45 – 10x10 – 45x5 mm²

resolve ambiguities inherent in
strip reconstruction

two-stage SSA reconstruction

1. strips used to split tiles into virtual cells
2. use these split tiles to split the strips

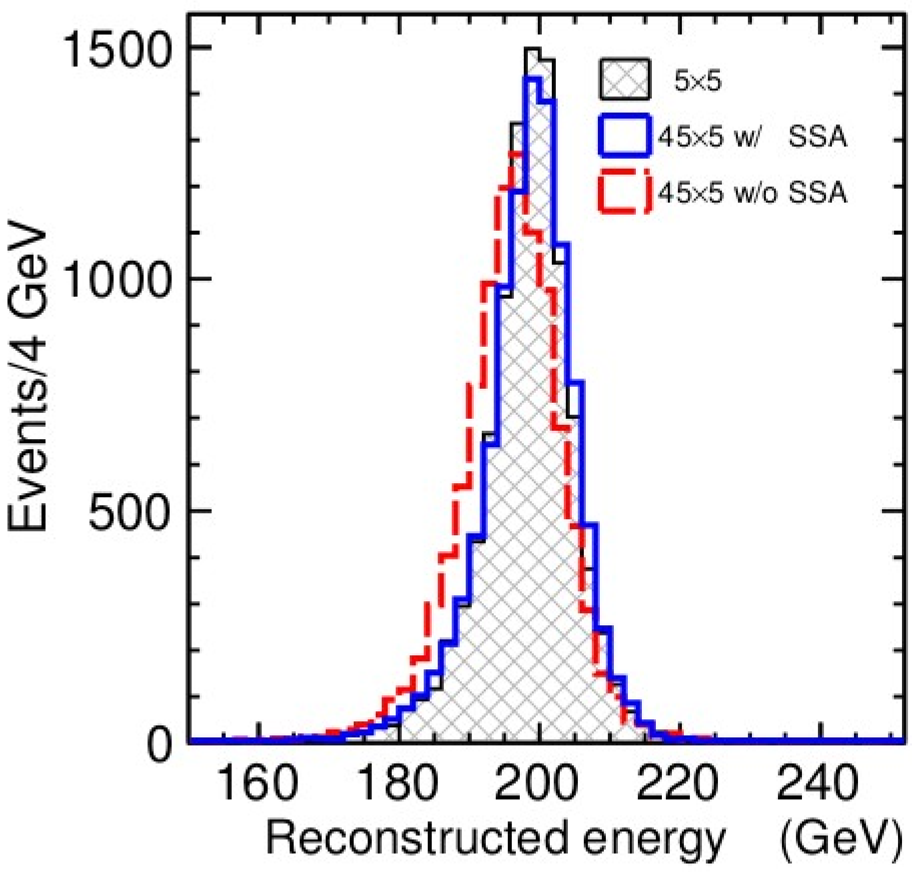
The virtual hits from SSA are then passed to standard PandoraPFA

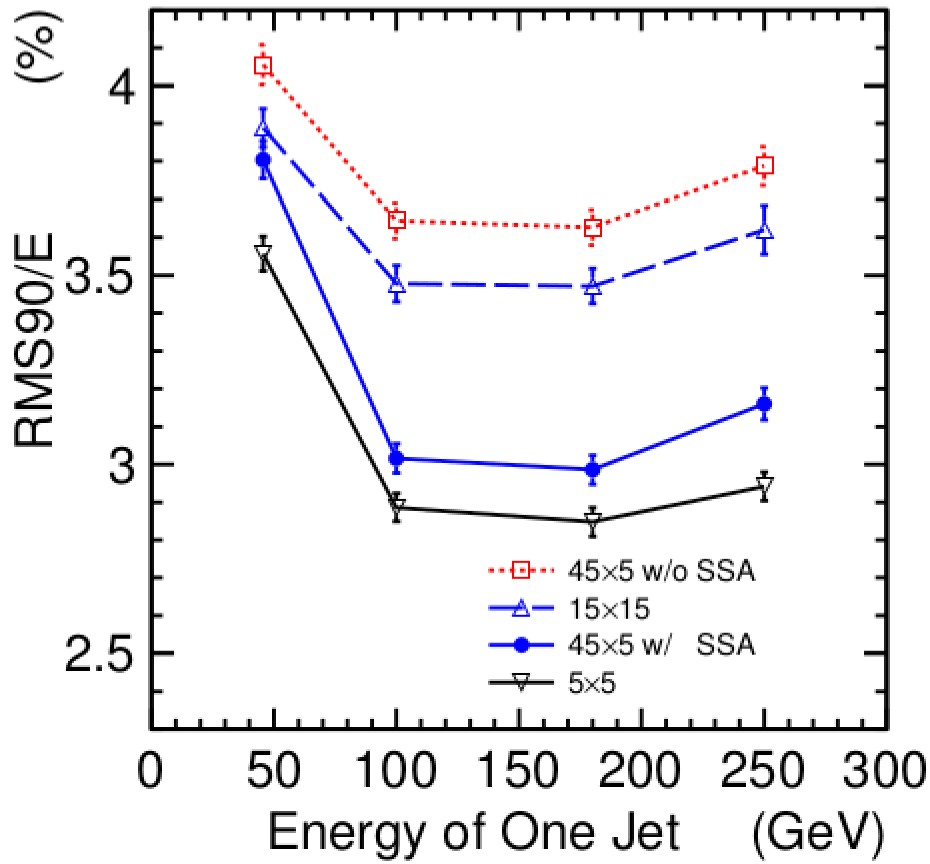
usual Pandora calibration using single particles

Following pages show results with DBD-era reconstruction software

SSA performance on $e^+e^- \rightarrow qq$ events

DBD-sized detector, 45x5 mm2 strips, SSA + PandoraPFA (DBD-era)

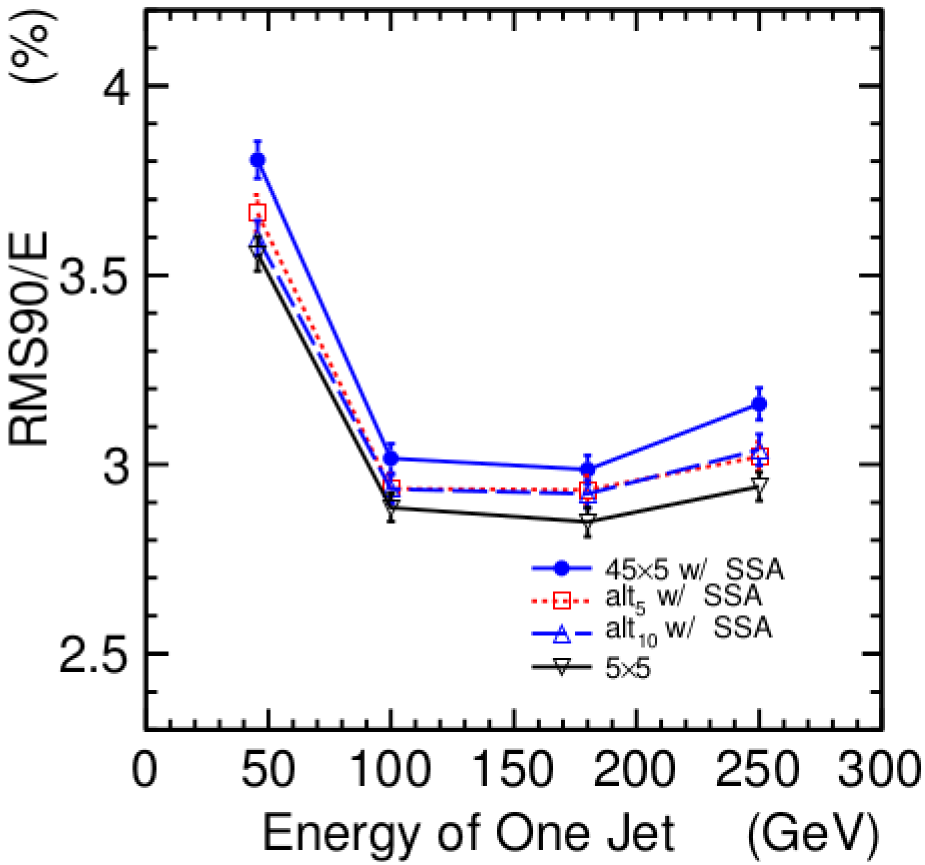




SSA works! 45x5mm^2 strips:

- much better performance than same area 15x15mm^2 tiles
- approaches performance of 5x5mm^2 tiles

Intermediate tile layers, with SSA' algorithm



5x45 mm^2 strips

strips + tiles (5x5mm^2, 10x10mm^2)

5x5 mm^2 tiles

Intermediate tile layers further improve performance

Optimisation

Readout scheme

SiPM pixels

Scintillator thickness

Strip length

sampling scheme
- number of layers
- energy resolution
- pattern recognition

detector radius

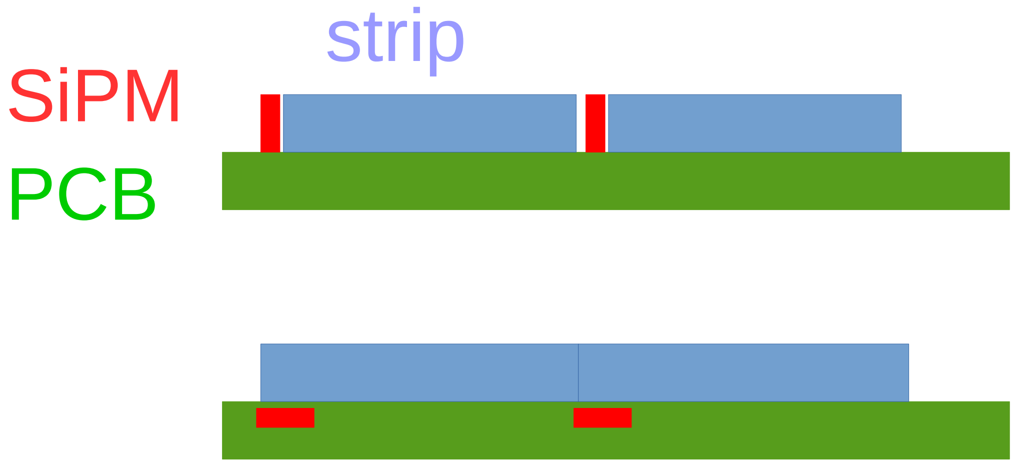
} no dedicated studies for ScECAL

strip readout

more robust integration has SiPM integrated into readout PCB

allows “bottom readout” of scintillator light
   reduces dead area

   (at moment small dead volume corresponding to the SiPM package is implemented in the Mokka simulation)



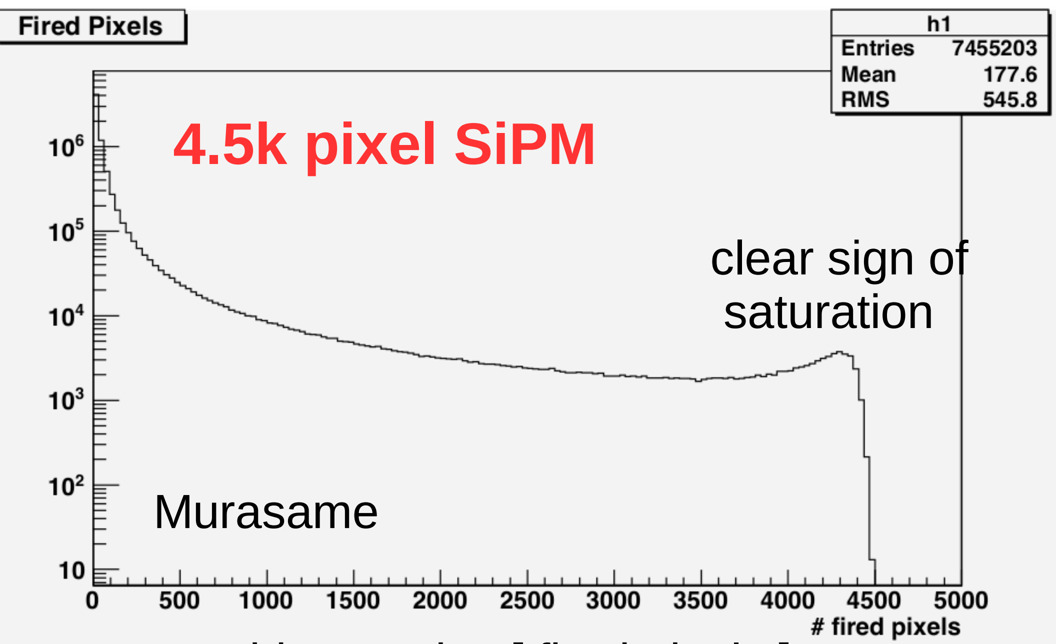
Required number of SiPM pixels

SiPM has intrinsically limited range, determined by number of pixels

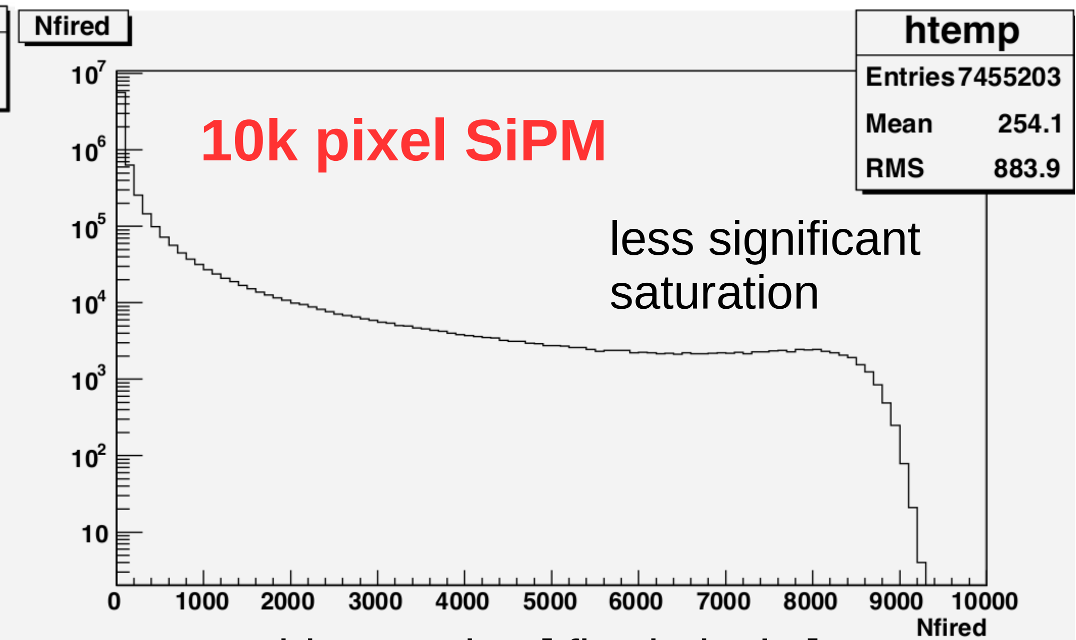
- minimum number of pixels / MIP to ensure reasonable efficiency → choose 10
- together with number of SiPM pixels, this defines dynamic range

test in showers produced by 250 GeV electrons (highest energy EM objects @ ILC)

- → highest energy single strip energies
- → determined total number of pixels for SiPM



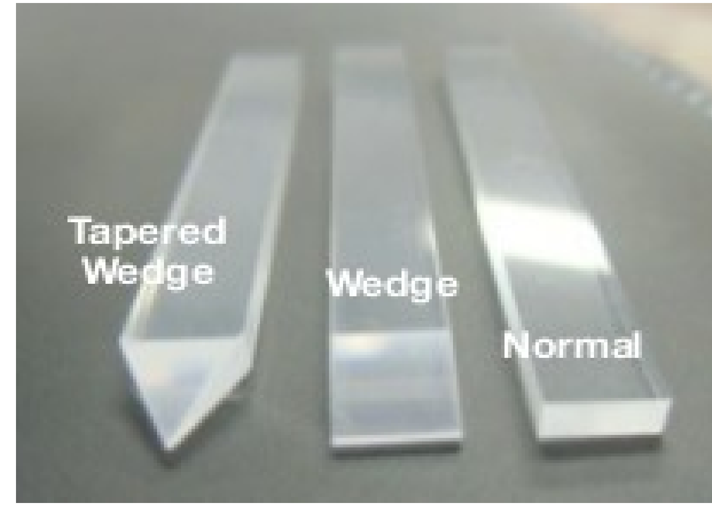
hit energies [fired pixels]



hit energies [fired pixels]

1x1 mm^2 10k pixel MPPCs available, but difficult to operate with current readout ASIC

Scintillator thickness and shape

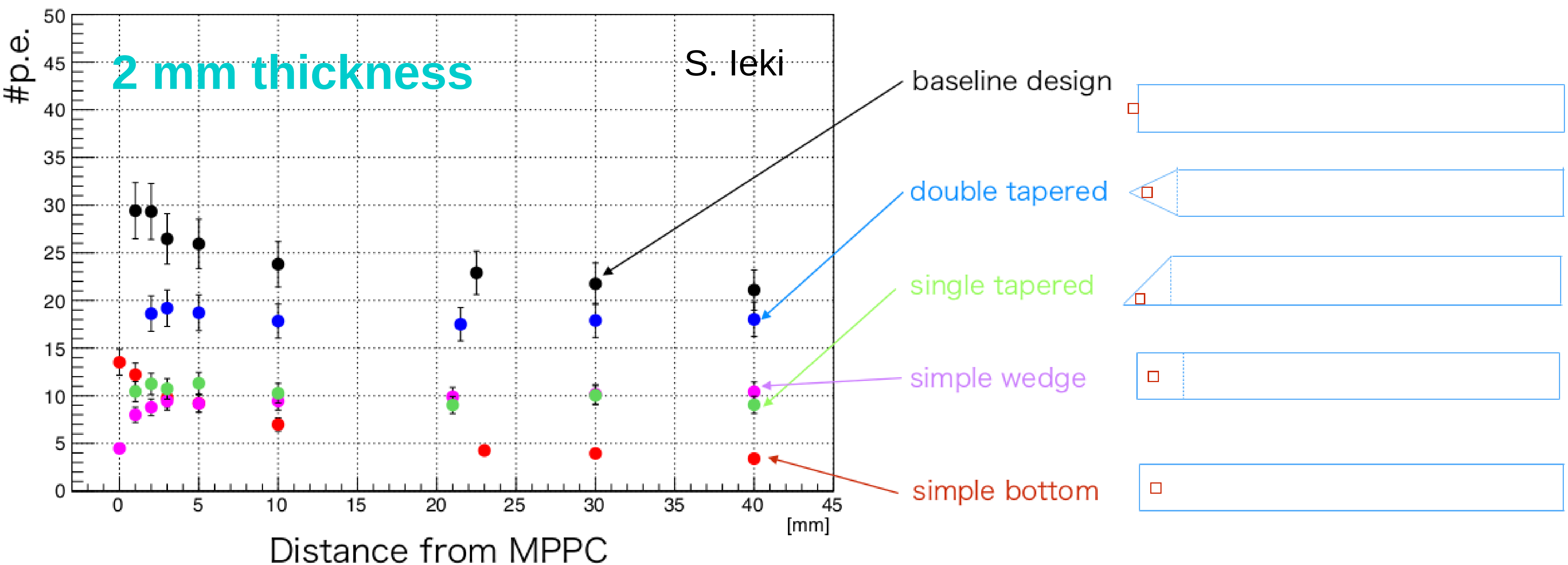


Thinner → more compact ECAL

Thicker → better photon energy resolution

Thickness determines #pixels / MIP
(about 10 is needed: >10 → reduced dynamic range
<10 → reduced MIP efficiency)

Strip can be shaped to act as light guide

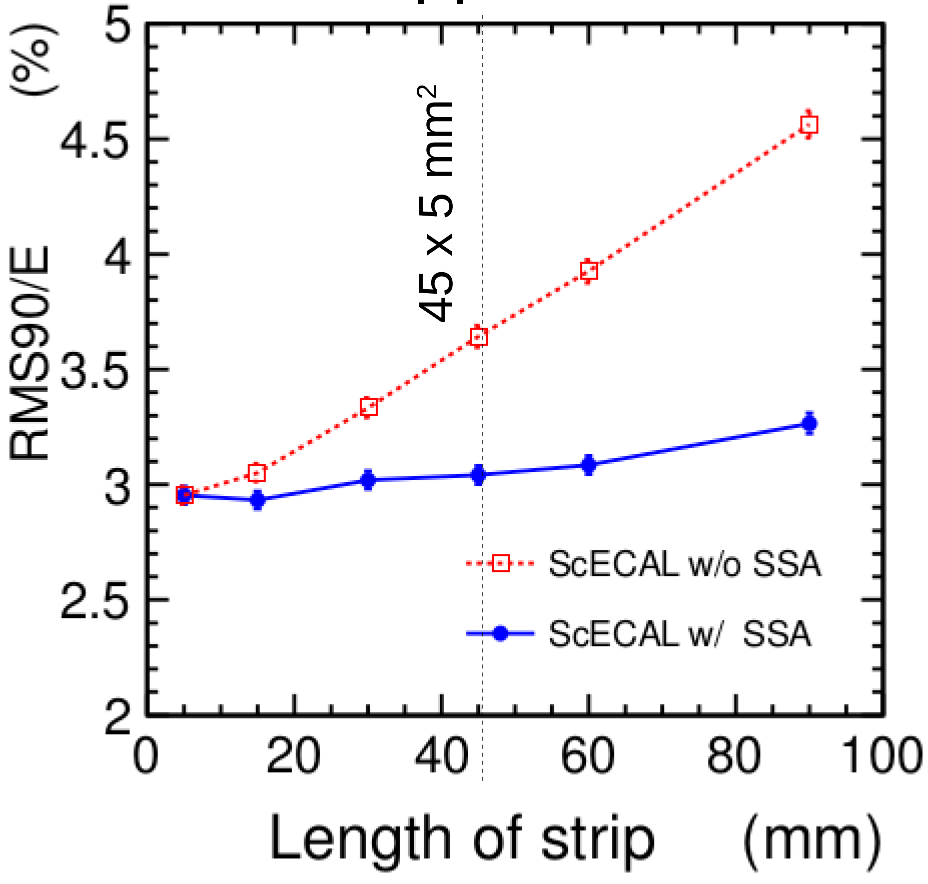


Strip length

(at constant width: 5mm chosen, motivated by SiECAL studies)

longer strips → less chanels → lower cost
→ more confusion, less uniform response

ee → qq @ 200 GeV



rather weak dependence on strip length

standard 45mm length is far from any “cliff”

Shorter strips should give more uniform response
(simulation of non-uniformity possible in Mokka/ILDCaloDigi)

Summary

- SSA can successfully reconstruct a strip based ECAL
  intermediate tile layers give further improvements
  JER rather close to pure tile-based geometry

- chosen 45mm strip length seems far from performance cliffs

- 2mm thick scintillator proven to be sufficient
  proposals to further reduce thickness:
  to be studied in more detail in prototypes

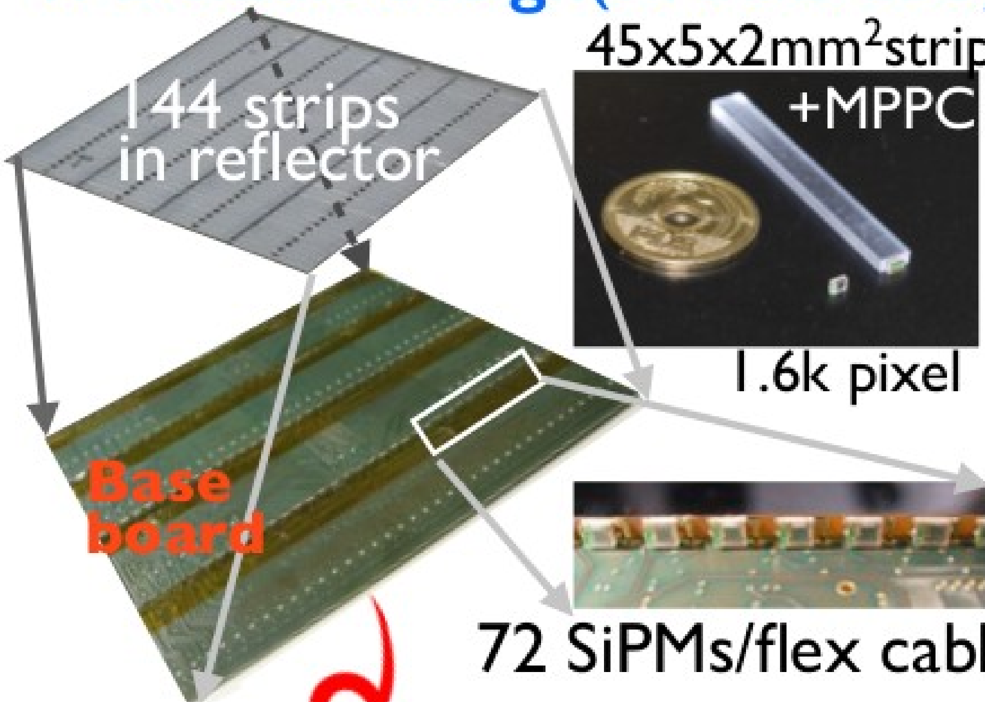
- “bottom readout” of scintillator:
  better mechanically, less uninstrumented surface
  wedge-based designs can give good uniformity

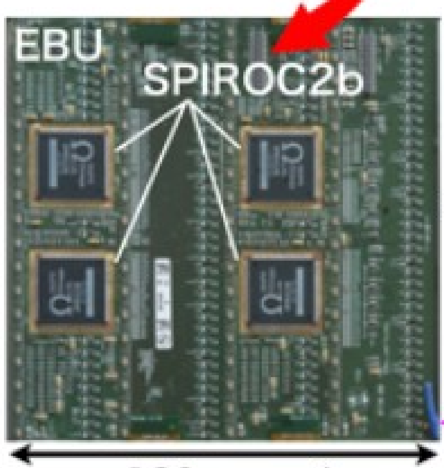
- 10k pixel SiPM avoids drastic saturation in high energy Bhabhas

backup

ScECAL technological prototype

1. Default design(on trans. EBU)





- Individually set bias, amplifier, threshold.
- Auto trigger.
- LEDs for gain monitor

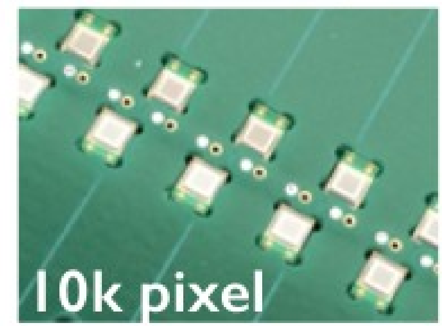
transverse EBU

2. Bottom readout

non dead volume from MPPC

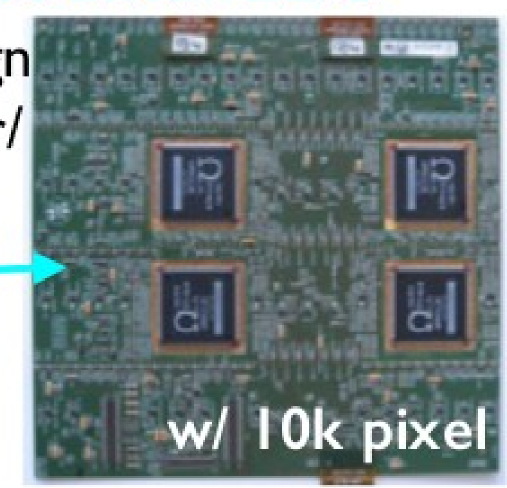
Bottom readout design by Tokyo group

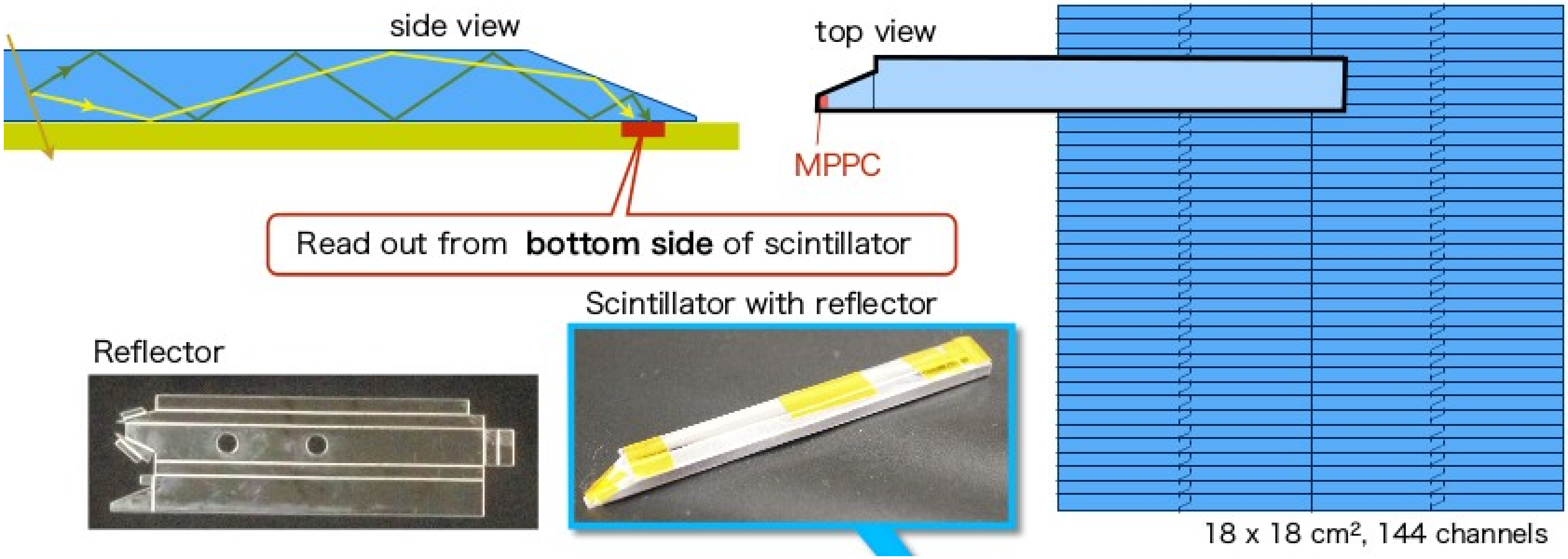
MPPCs embedded into a board

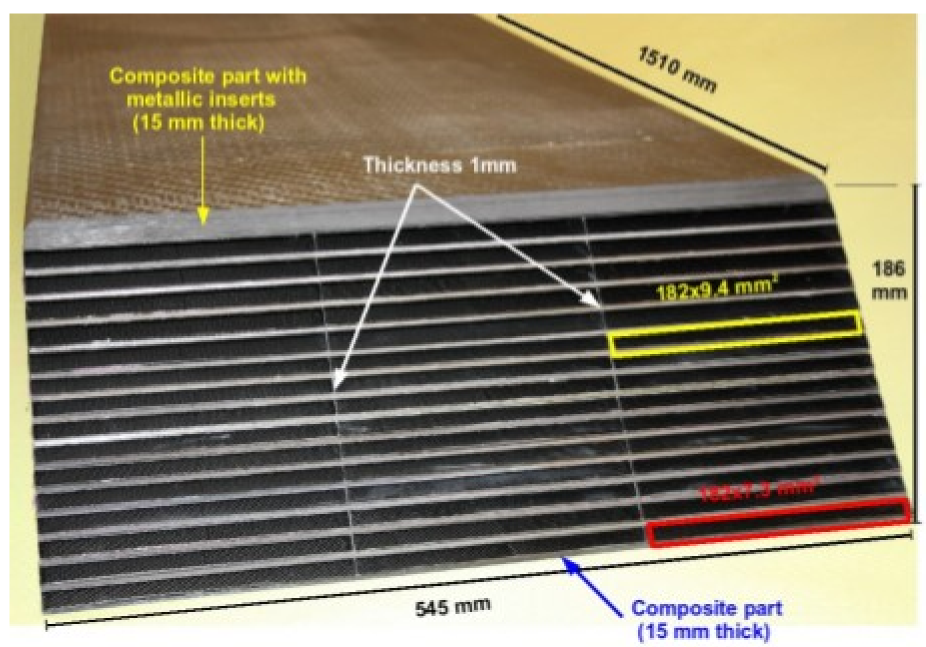


3. longitudinal EBU

Default design of scintillator/ MPPC




side view
top view
MPPC
Read out from **bottom side** of scintillator
Scintillator with reflector
Reflector
18 x 18 cm², 144 channels


Composite part with
metallic inserts
(15 mm thick)
1510 mm
Thickness 1mm
186
mm
182x9.4 mm²
545 mm
Composite part
(15 mm thick)

LLR