Creating a LEGO® model of CMS

Jeff Temple,
Marguerite Tonjes,
Jaime Gomez

University of Maryland
Depts. of Physics/Nuclear Chemistry
Why?

- Inspired by ATLAS model built by Sascha Mehlhase at the Neils Bohr Institute (http://sascha.mehlhase.info/physics.php)
- Why let ATLAS have all the cool toys?

  Anything ATLAS can do, CMS can do ... better
  ... later
  ... with more mass in a smaller volume!
LEGO® dimensions

Scale model to LEGO® “minifig” dimensions

- Roughly a 1:48 scale
- 1 LEGO® brick = 0.461 m high
- 1 LEGO® stud = 0.382 m wide

Standard Minifig is 4 bricks (1.84 m) tall
CMS Silicon Tracker

• ~5.6 m long (z)
• diameter ~ 2.4 m
• Comprises:

  • Tracker Inner Barrel & Tracker Inner Disk (TIB/TID): r<0.5 m, z < 1.2 m
  • Tracker Outer Barrel (TOB): extends to r=1.2 m
  • Tracker End Cap (TEC): extends to |z|=2.8 m

• Pixel tracker outer radius is 10.2 cm; too small to have a LEGO® counterpart
CMS Silicon Tracker Images

Insertion into CMS

View of Tracker End Cap
CMS Silicon Tracker: LEGO® Model

- TID
- TIB
- TEC
- TOB
CMS Silicon Tracker: Comparing Dimensions

Diameter: 4 studs (1.5 meters)
A bit smaller than the actual tracker, but we're limited by availability of round LEGO® pieces

Length: 9.3 bricks (4.3 meters)
- Also smaller than actual tracker, but proportionally consistent with radius
- Tracker holding apparatus extends overall length to 10.6 bricks (4.9 m)
Electromagnetic Calorimeter (ECAL)

• A Lead Tungstate barrel calorimeter (EB) extends from $r=1.3$ m to $r=1.8$ m, and to $|z|=2.9$ m in a pseudo-projective geometry.
Main body of ECAL is 20 studs (7.7 m) long, with angled pieces at ends to suggest projective geometry.

Tracker fits snugly within ECAL!
CMS Hadron Calorimeter (HCAL) and Solenoid

- HCAL barrel is a brass-scintillator sampling calorimeter
  - made up of 18 20-degree wedges within solenoid coil
    - Each wedge ranges from \( r=2 \) m to \( r=3 \) m
- HCAL barrel is 9 m long
- Solenoid is \( \sim 1 \) m thick in radius, 12.5 m long
HCAL/Solenoid images

below: HCAL barrel (without solenoid) inside the muon rings

above: HCAL being inserted into solenoid
Lego® HCAL/Solenoid:

- Solenoid (grey) is 34 studs (13.1 m) long
- HCAL (yellow) is 24 studs (9.2 m) long
- Solenoid diameter: ~16 bricks (7.4 m)
- Transparent studs on outer layer of solenoid represent HO (Hcal Outer detector)
CMS Muon Rings

- 5 Muon rings
- Each ring contains 4 layers of drift tubes (DTs) and resistive plate chambers (RPCs) interspersed within magnet return yoke
- 12 different phi positions (30-degree segmentation) in each ring
- Central ring (ring 0) contains an additional “tail-catcher” inner layer
LEGO® Muon Rings

• Solenoid and inner detectors sitting on (disassembled) muon rings.

• Center muon ring has additional red “tail-catcher” layer
CMS Barrel Detector

- Hinged muon rings surround solenoid
- Spacer pieces on solenoid maintain muon ring shape
- Green outer plates provide support, match CMS support structure*

* CMS support structure set not included
CMS Endcaps

- Endcaps contain:
  - Preshower detector
  - ECAL endcap
  - HCAL endcap
  - Muon endcaps
    - 4 layers of muon chambers
LEGO® Endcaps

muon chambers

Endcap Calorimeters
LEGO® HF and CASTOR

- HF and CASTOR provide forward calorimetry information
- Sit behind last muon station

HF:
- quartz fibers extend a distance of 1.65m
- light guides to PMTs from 1.65 to 3.47 m
- concrete shielding around HF, plug behind HF

CASTOR:
- 0.6m wide, 1.6m long, behind HF
LEGO® HF

Top left: Side view
Top right: Front view
Bottom right: Back view
(with plug installed)
CASTOR (schematic)

CASTOR (Lego scale)
Final HF+ (including shielding and support stand) behind muon endcap
LEGO® HF- and CASTOR

CASTOR
Completed Detector
Mini CMS model

- 1:200 scale

- Solenoid
- Muon ring
- Muon Endcap
- HF
Logos
Final Specs

- Total pieces: ~ 14,000
- Total cost: ~ $2300.00
  - (mini-CMS model, CMS logo, and CERN logo each cost between $50-$100)
- Total person-hours: Hmm... more than there should've been, probably.
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• shop.lego.com for its “pick a brick” service

• Many sellers at bricklink.com
Side-by-side comparison
List of BrickLink Suppliers

4 Fun Bricks & More
ACE: Blacktron Surplus LLC
Alaska Brick Movers
BAY AREA BRICKWERKES!
Bay Area Brick Yard
Bombcar Heavy Bricks
Brick Ideas
Brock's Bricks
Builder's Universe - Sale!
Cincinnati Bricks, LLC
CreativeFury
Dad's AFOL Supplies
Dumbo's Mother
Grandma's Attic
Japhy's Bricks
Joes Brick Depot

Johnny's Bricks
Missing Brick
Plastic Bricks Direct
Play Well USA
Queen Creek Bricks
Rens Brick Room
Spyder's Brick Stores
Tanner's Bricks
TOLEDO Bricks, LLC
The Brick Layers
TheBrickGuys
Toy Brick Brigade
ToyBurg
ViroColor Productions
We-Like-It Bricks & Studs