

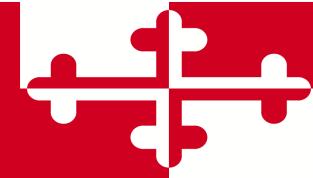


Creating a LEGO® model of CMS

Jeff
Temple,
Marguerite
Tonjes,
Jaime
Gomez



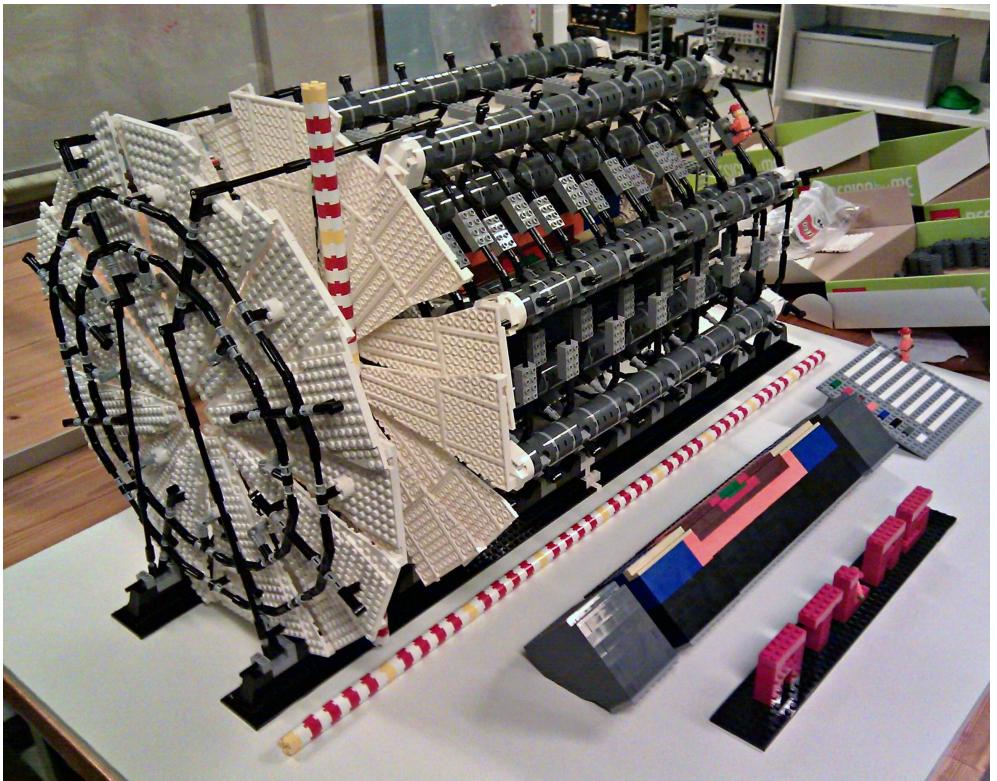
University of
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Depts. of
Physics/Nuclear
Chemistry



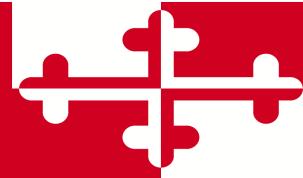


Why?

- 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!

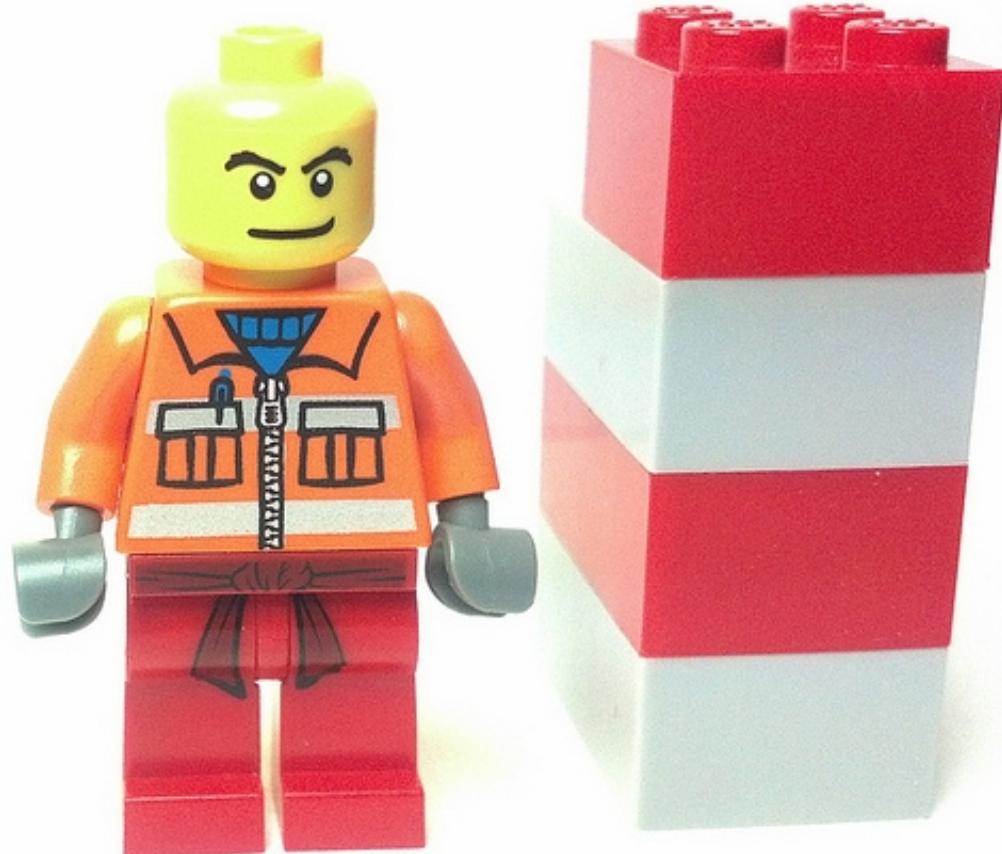




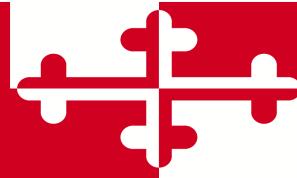
LEGO® dimensions

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



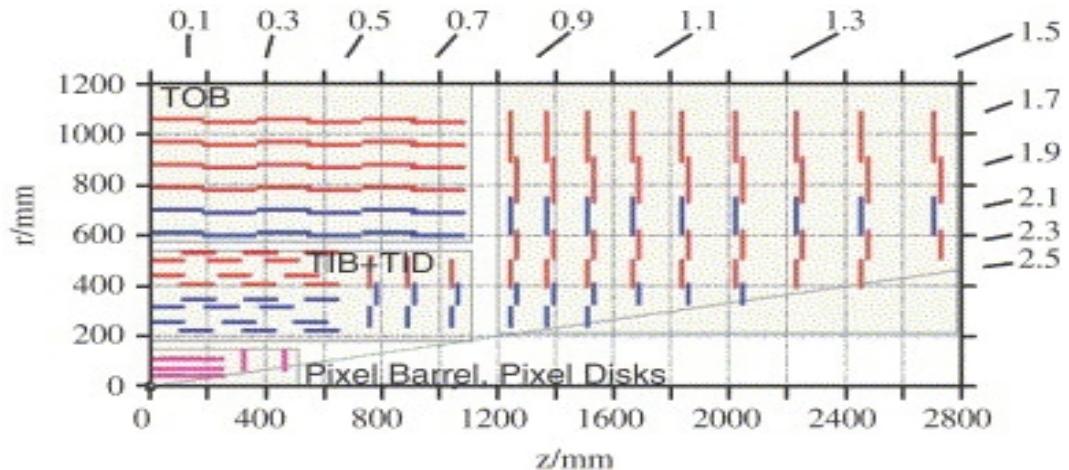
Standard Minifig is
4 bricks (1.84 m) tall



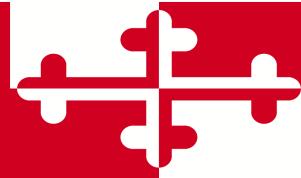


CMS Silicon Tracker

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

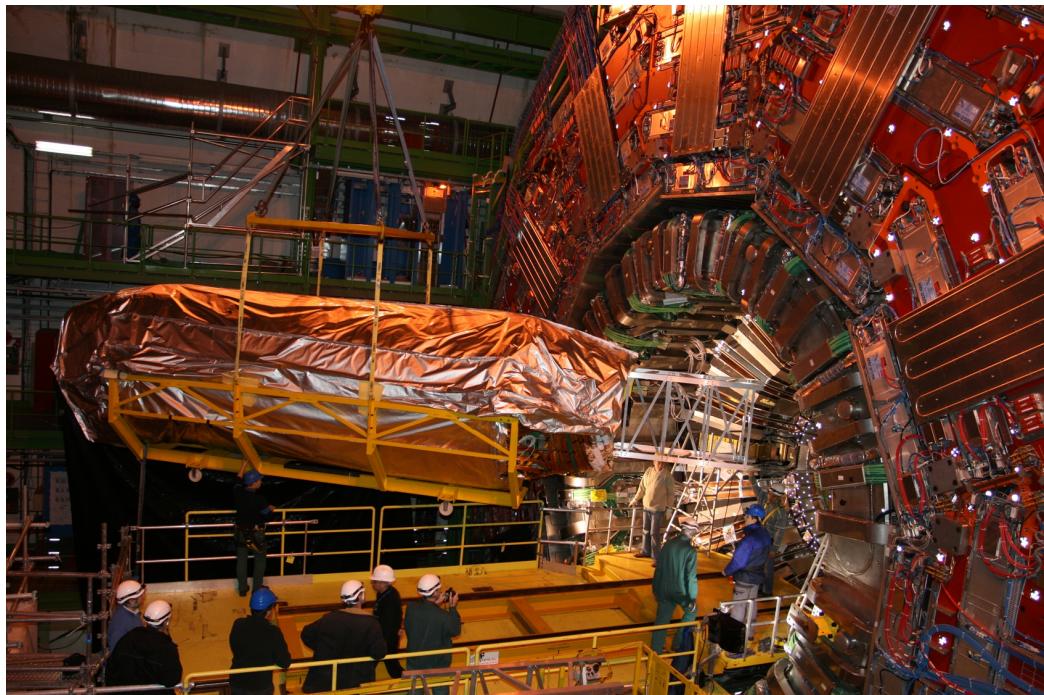


- Tracker Inner Barrel & Tracker Inner Disk (TIB/TID): $r < 0.5$ m, $z < 1.2$ m
- Tracker Outer Barrel (TOB): extends to $r = 1.2$ m
- Tracker End Cap (TEC): extends to $|z| = 2.8$ m
- **Pixel tracker outer radius is 10.2 cm; too small to have a LEGO® counterpart**





CMS Silicon Tracker Images

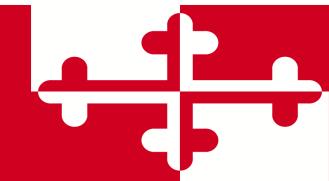
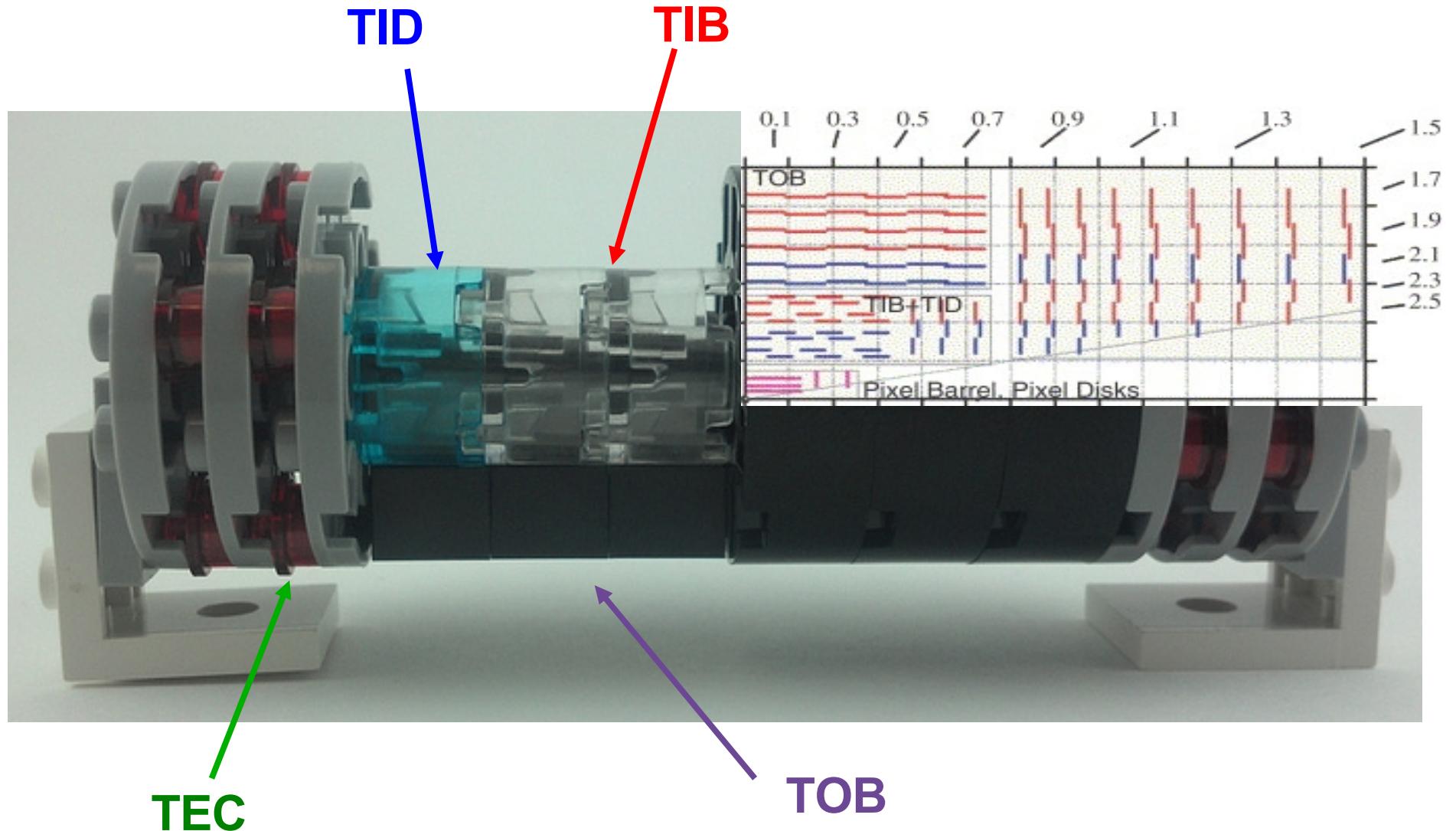


Insertion into CMS



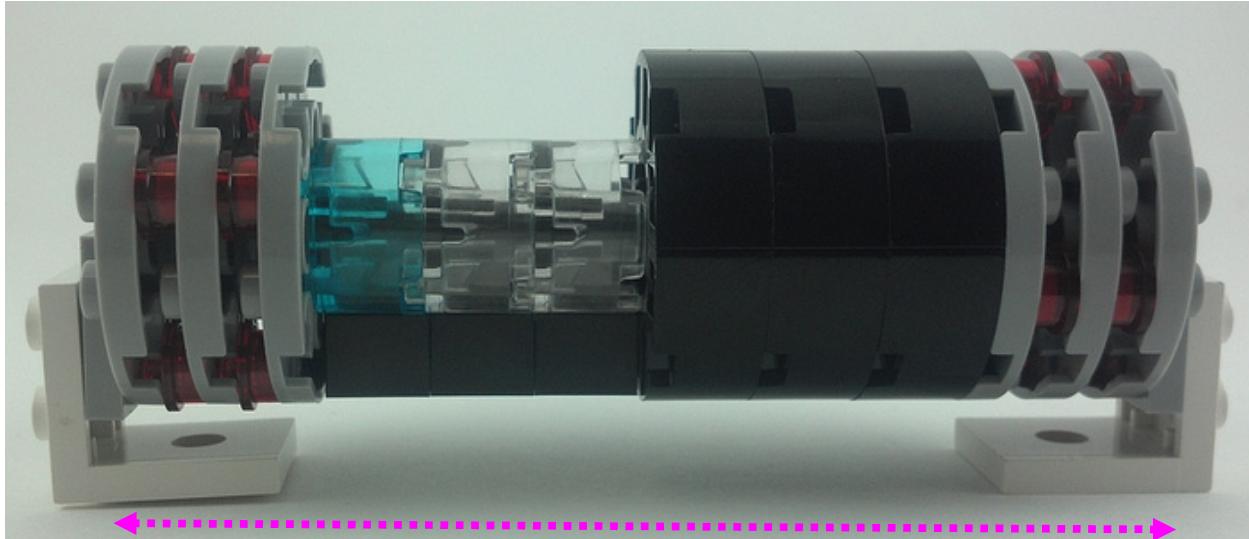
View of Tracker End Cap

CMS Silicon Tracker: LEGO® Model





CMS Silicon Tracker: Comparing Dimensions



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)

Diameter: 4 studs
(1.5 meters)

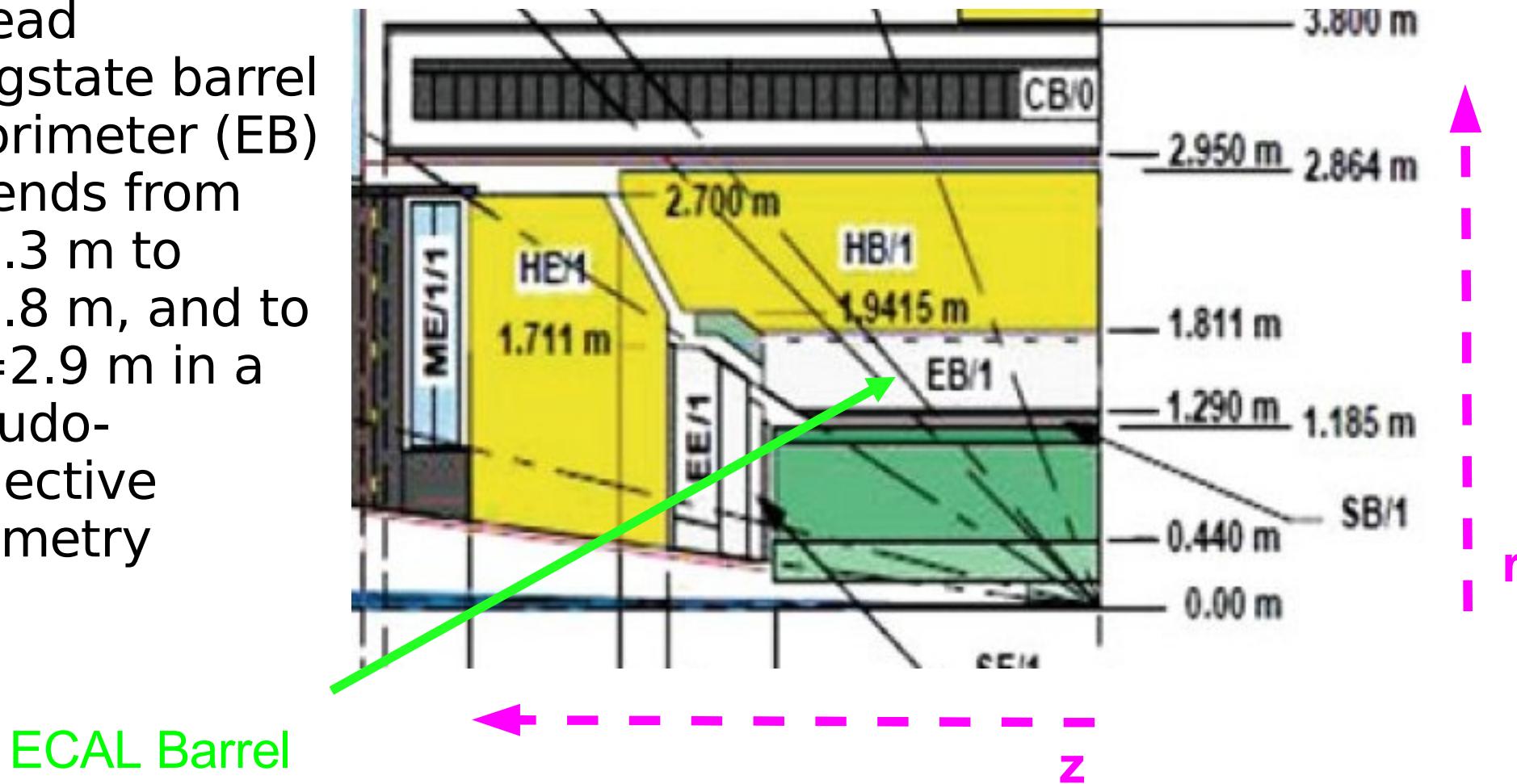
A bit smaller than the actual tracker, but we're limited by availability of round LEGO® pieces





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

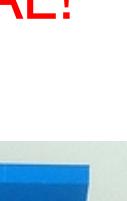




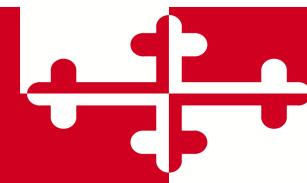
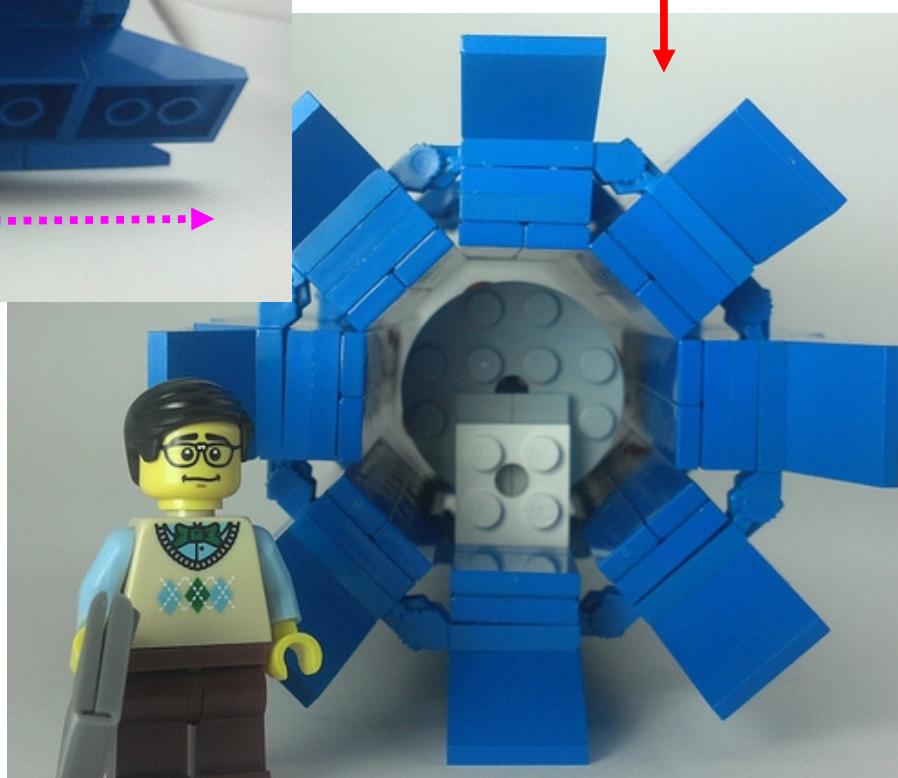
LEGO® ECAL



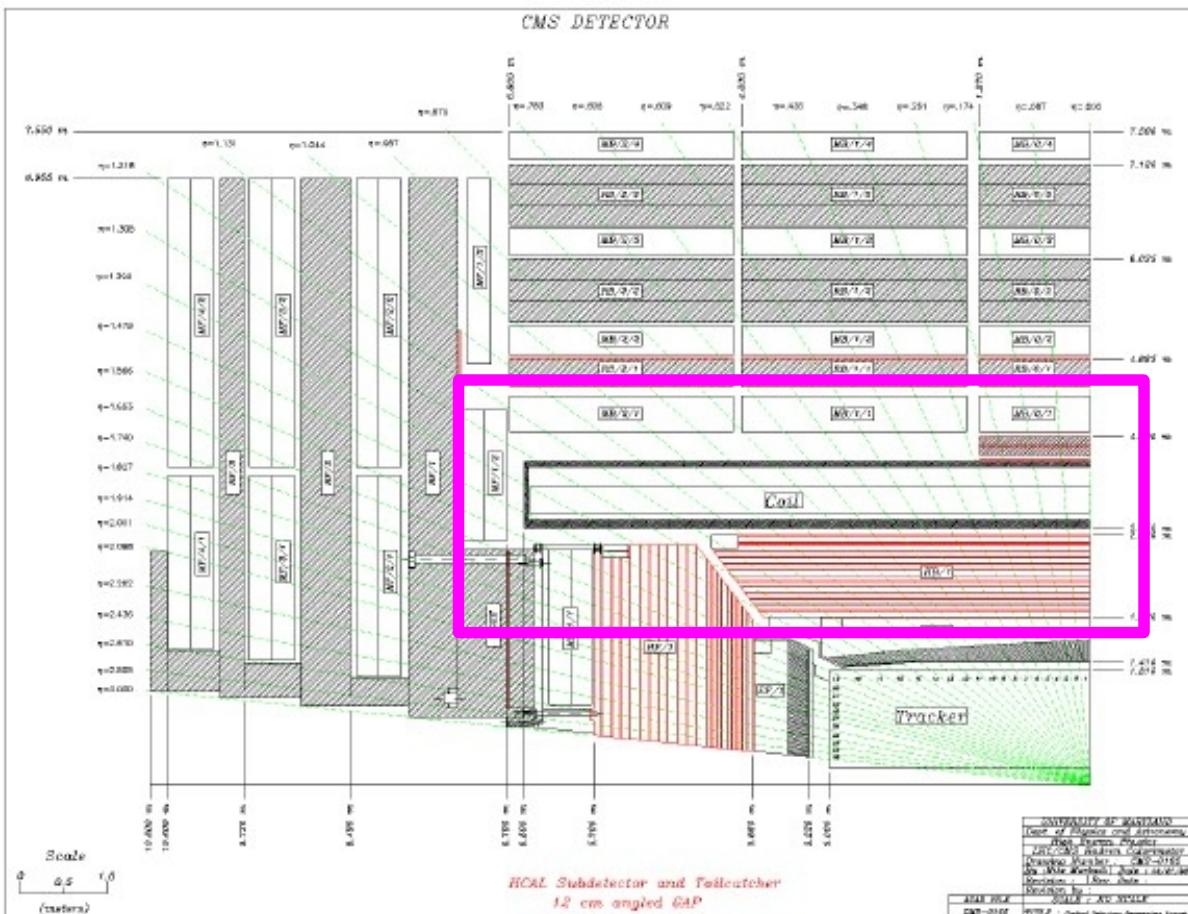
Tracker fits
snugly within
ECAL!



Main body of ECAL is
20 studs (7.7 m) long, with
angled pieces at ends to
suggest projective geometry



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 ~ 1 m thick in radius, 12.5 m long

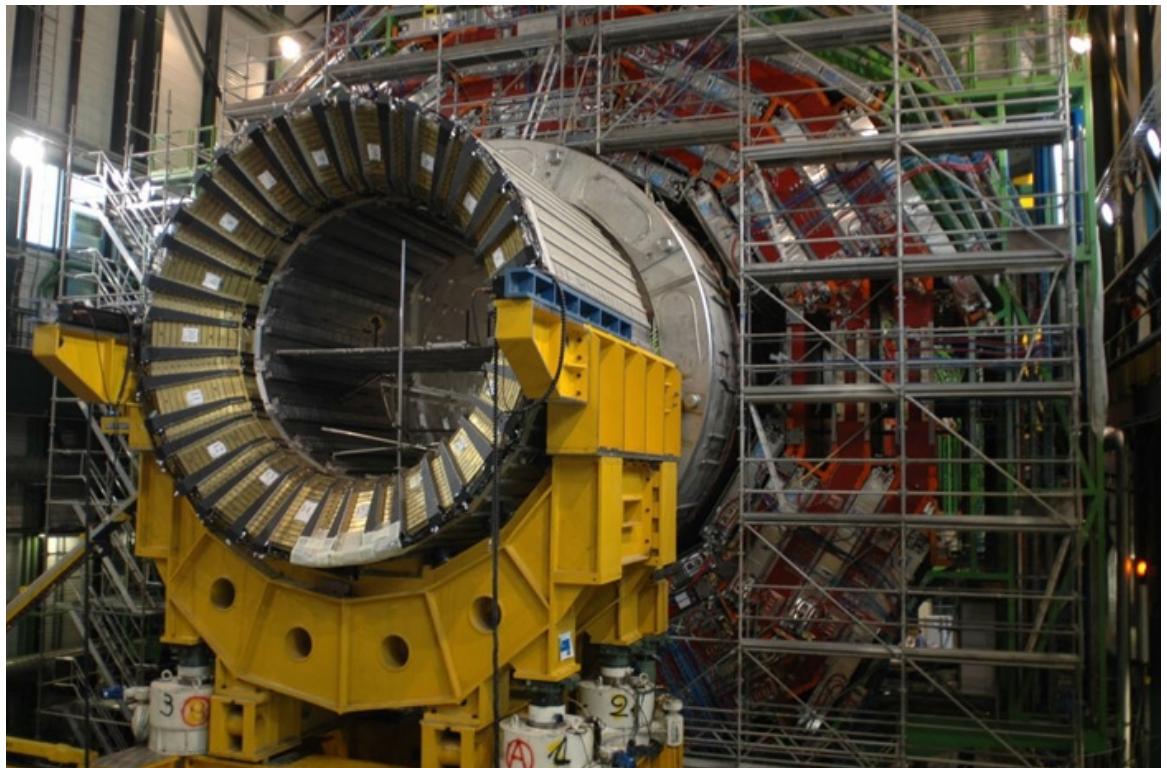
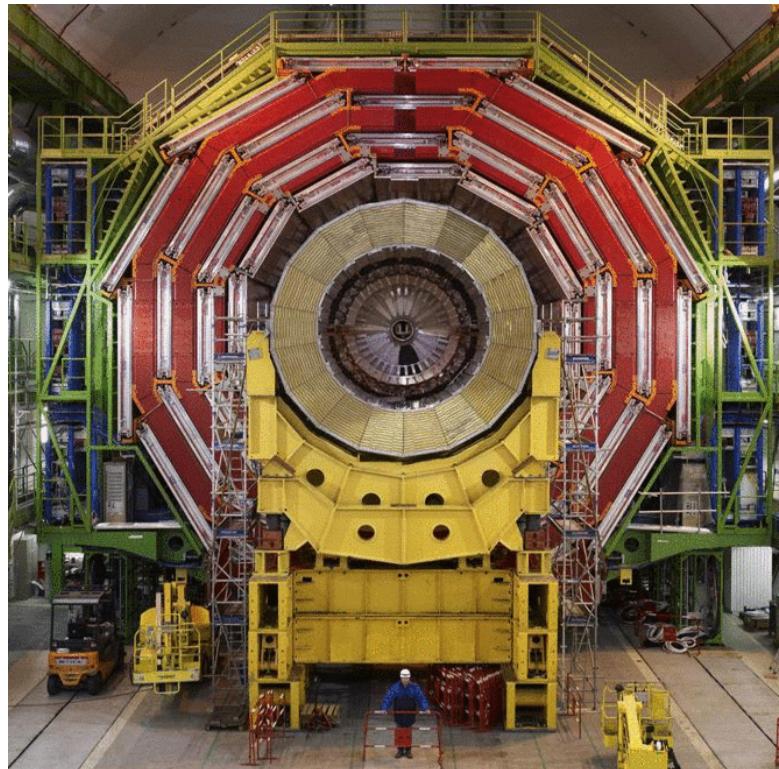


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MARYLAND



HCAL/Solenoid images

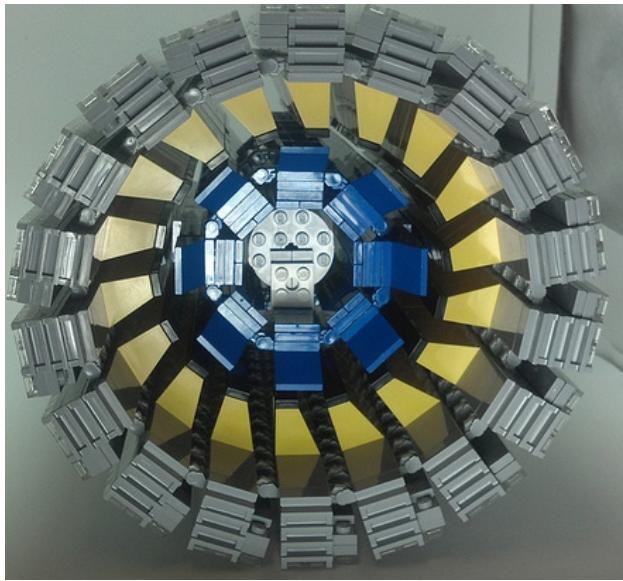
*below: HCAL barrel
(without solenoid) inside the
muon rings*



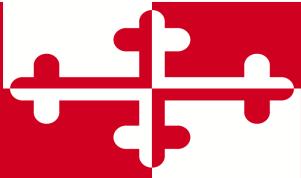
above: HCAL being inserted into solenoid



Lego® HCAL/Solenoid:



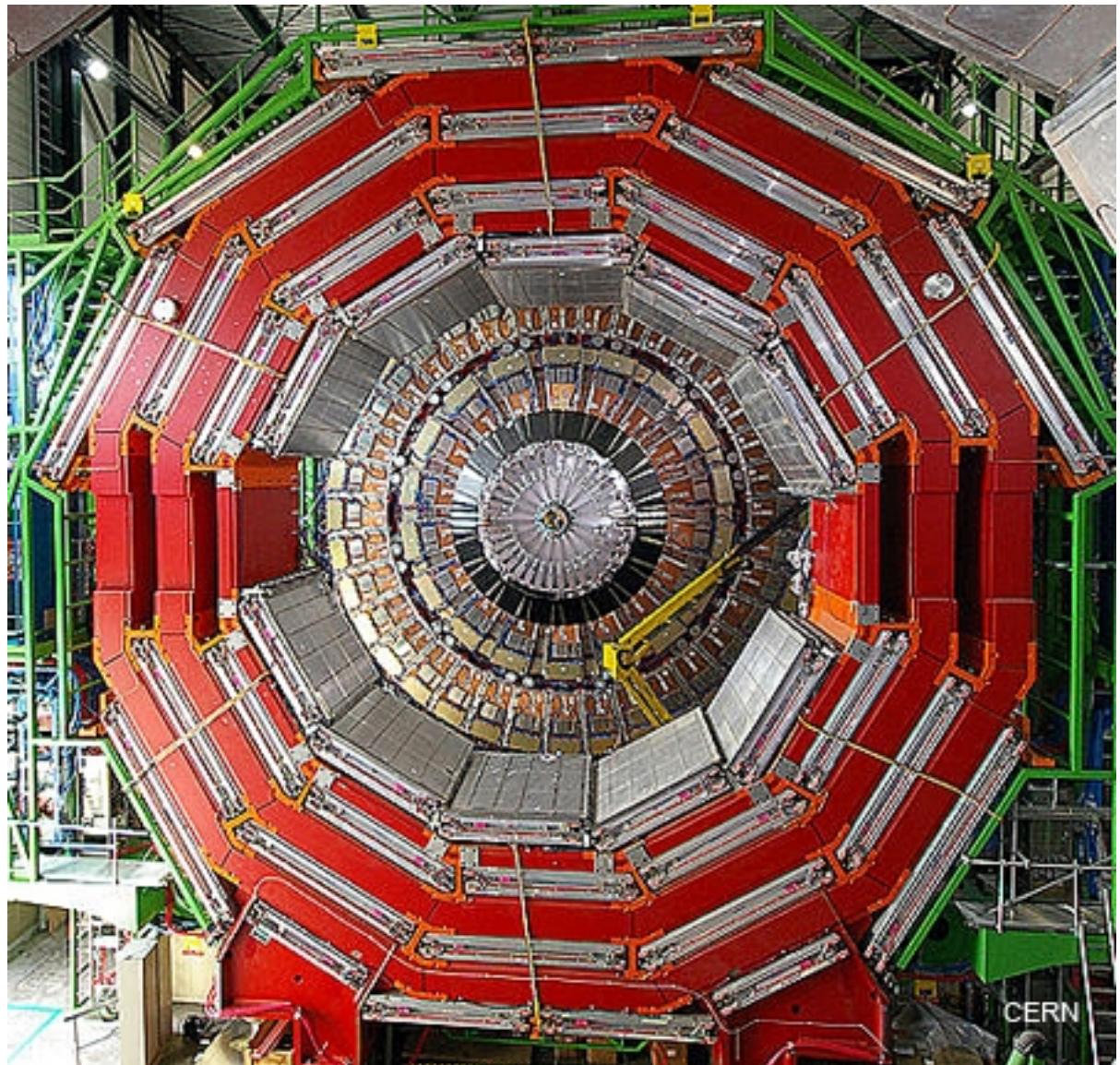
- Solenoid (grey) is 34 studs (13.1 m) long
- HCAL (yellow) is 24 studs (9.2 m) long
- Solenoid diameter: ~16 bricks (7.4 m)
- Transparent studs on outer layer of solenoid represent HO (Hcal Outer detector)





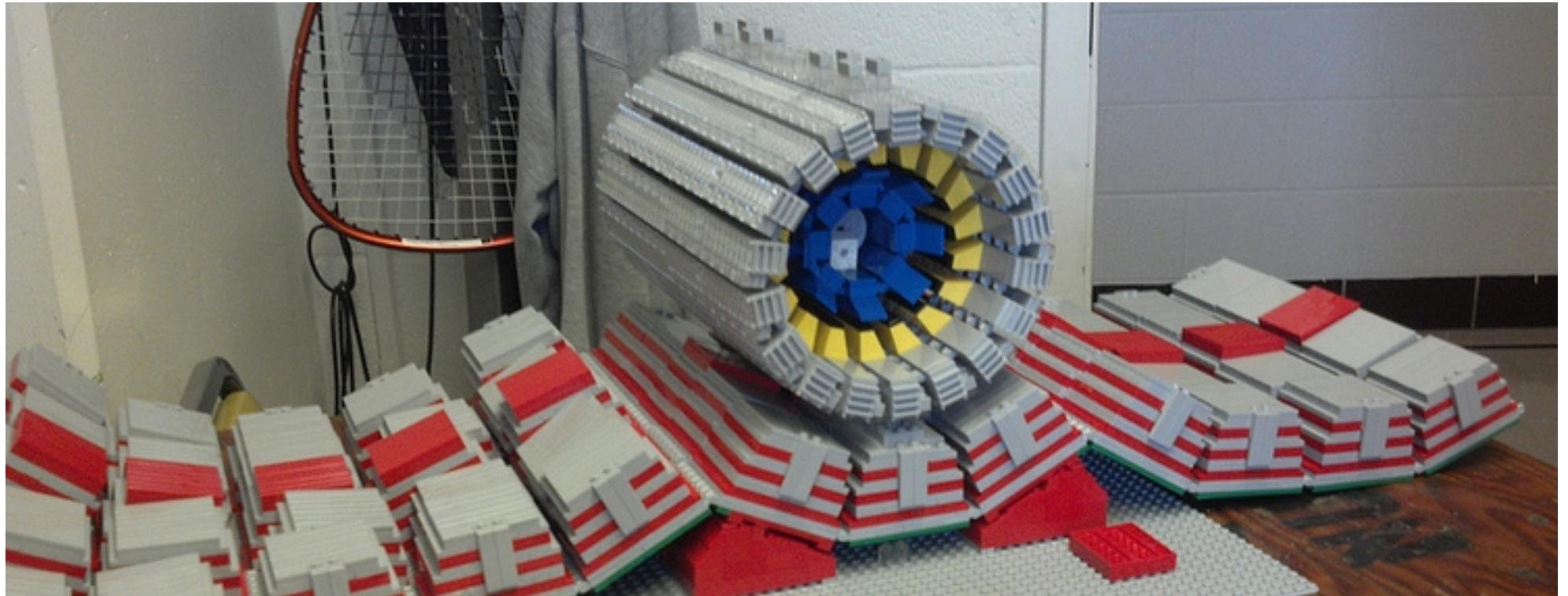
CMS Muon Rings

- 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

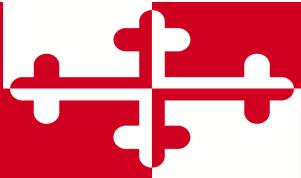




LEGO® Muon Rings

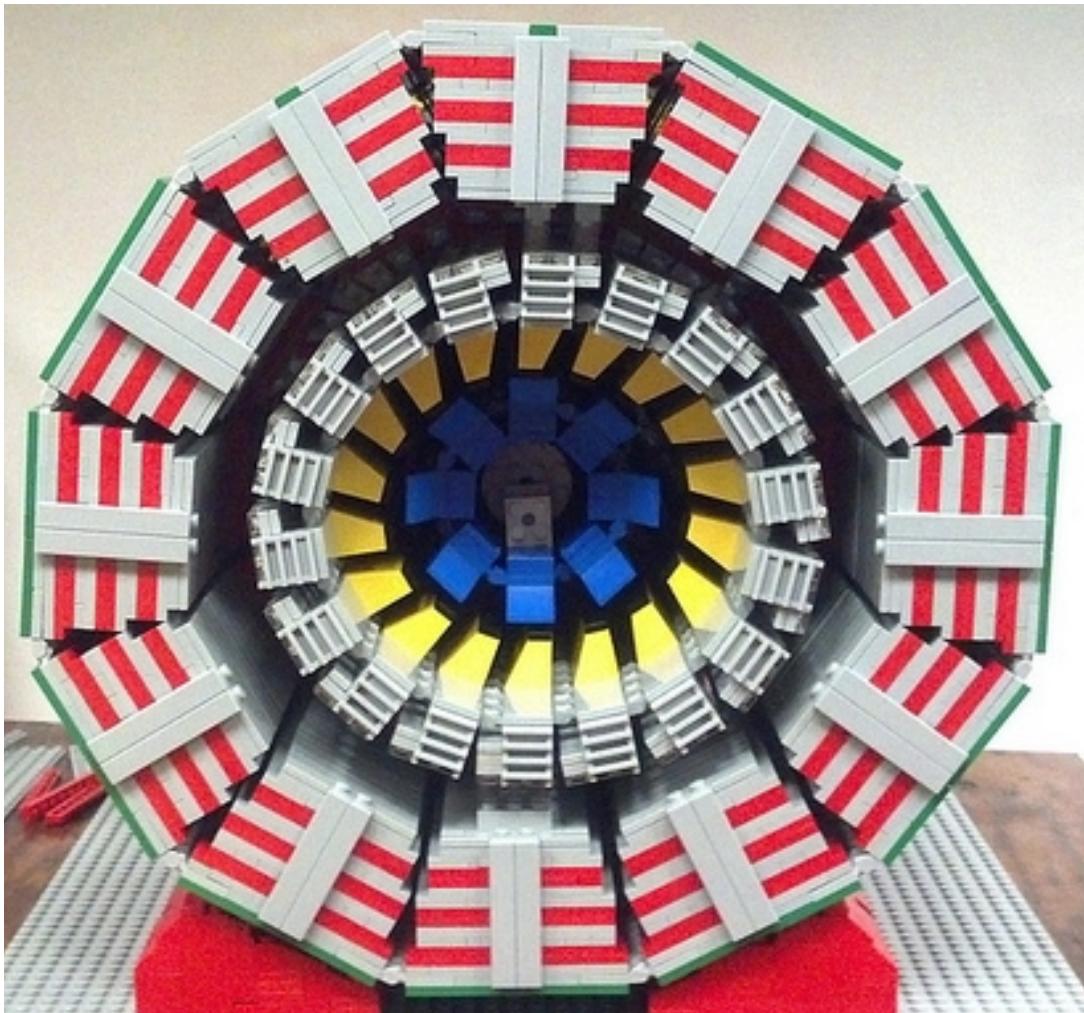


- Solenoid and inner detectors sitting on (disassembled) muon rings.
- Center muon ring has additional red “tail-catcher” layer

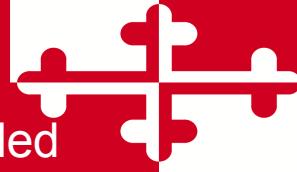




CMS Barrel Detector



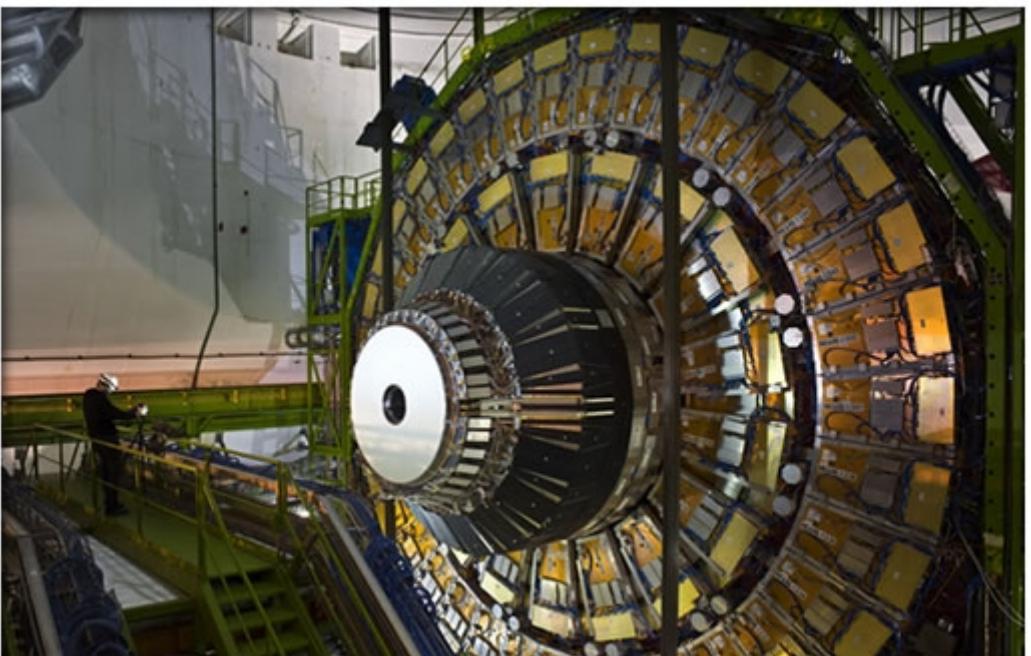
- Hinged muon rings surround solenoid
- Spacer pieces on solenoid maintain muon ring shape
- Green outer plates provide support, match CMS support structure*





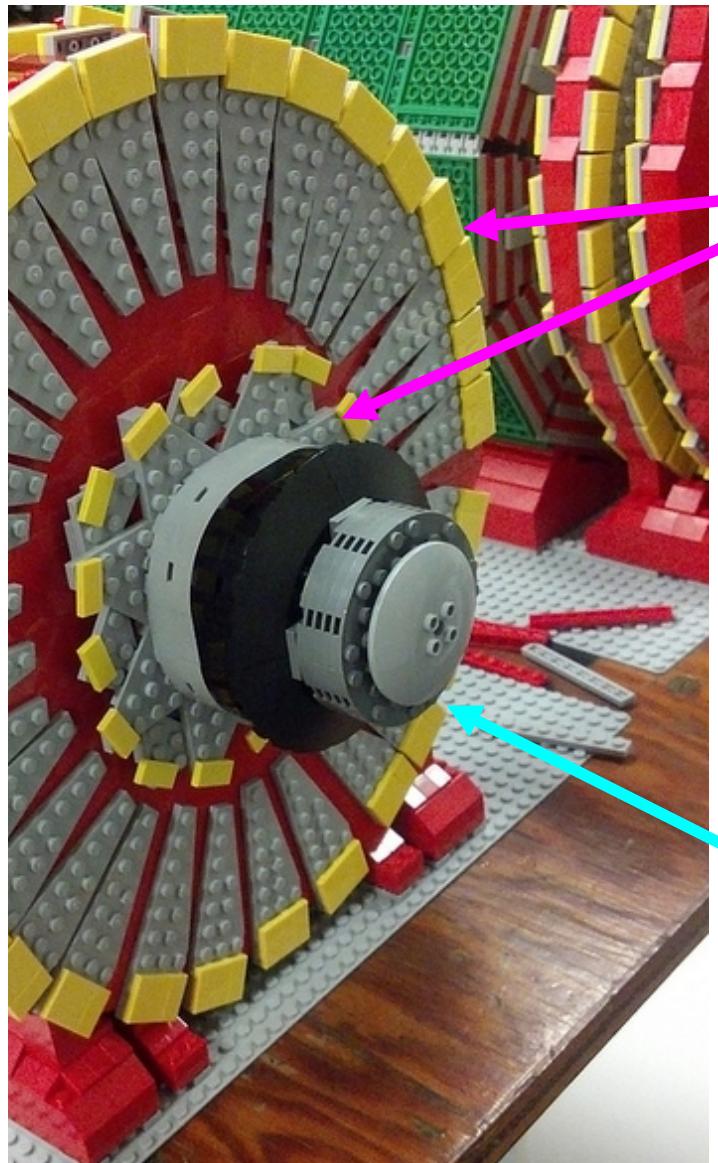
CMS Endcaps

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

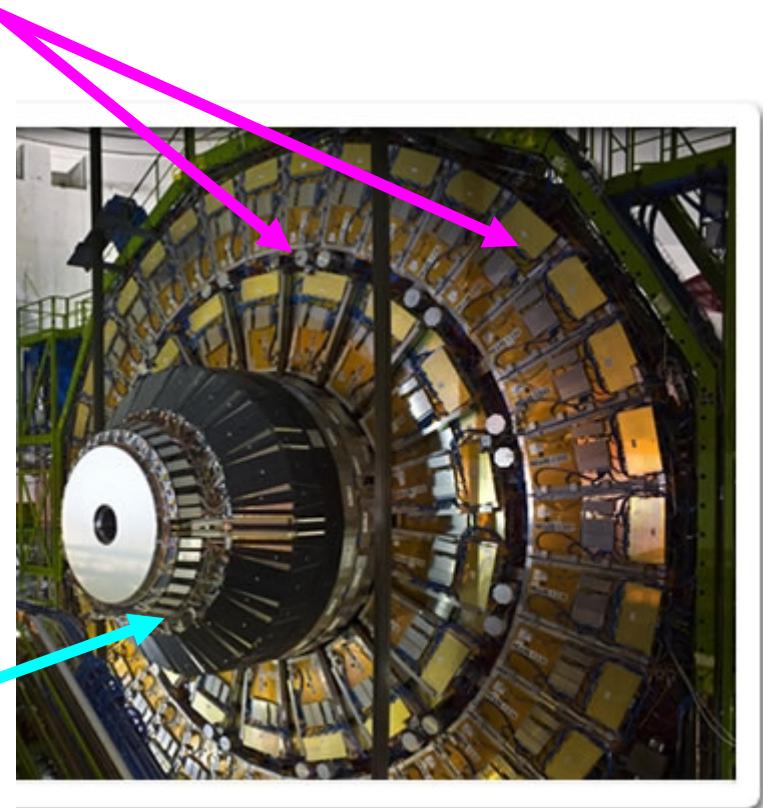




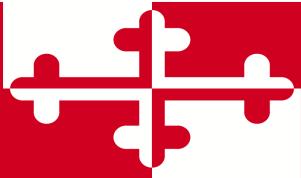
LEGO® Endcaps



muon chambers



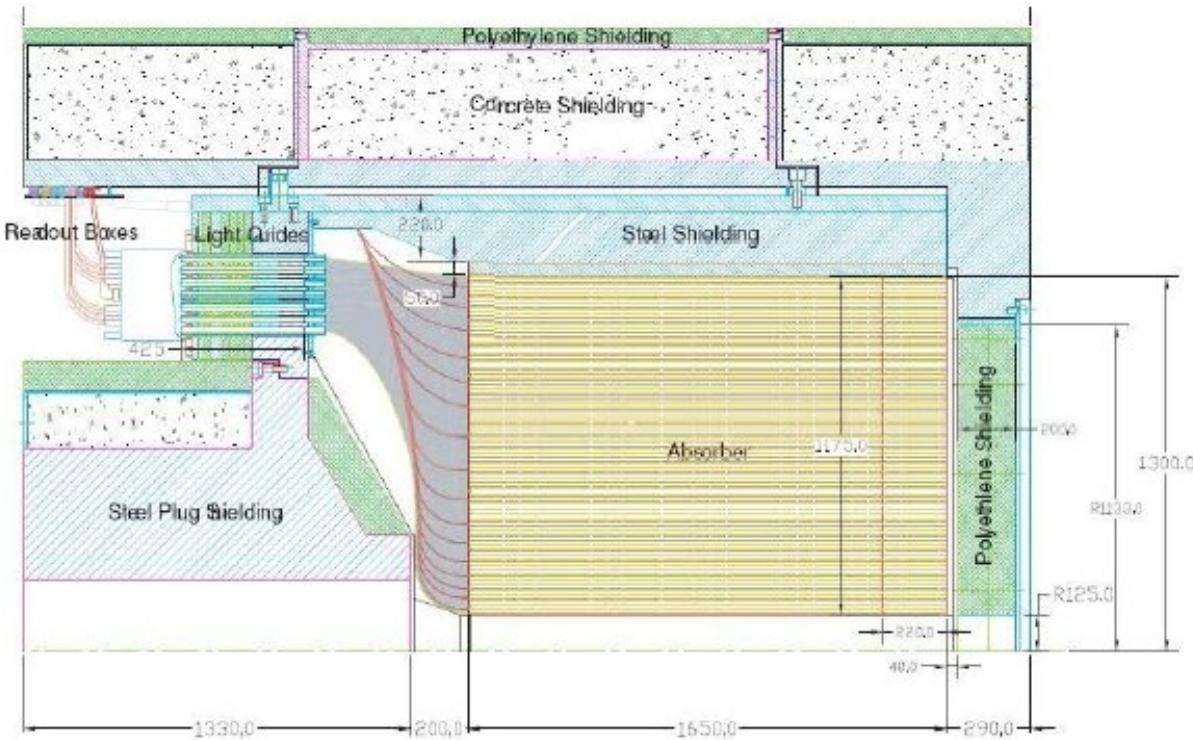
Endcap
Calorimeters





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

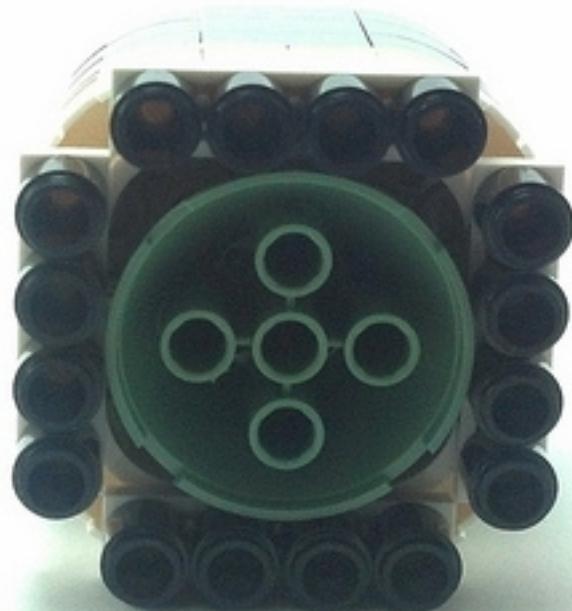
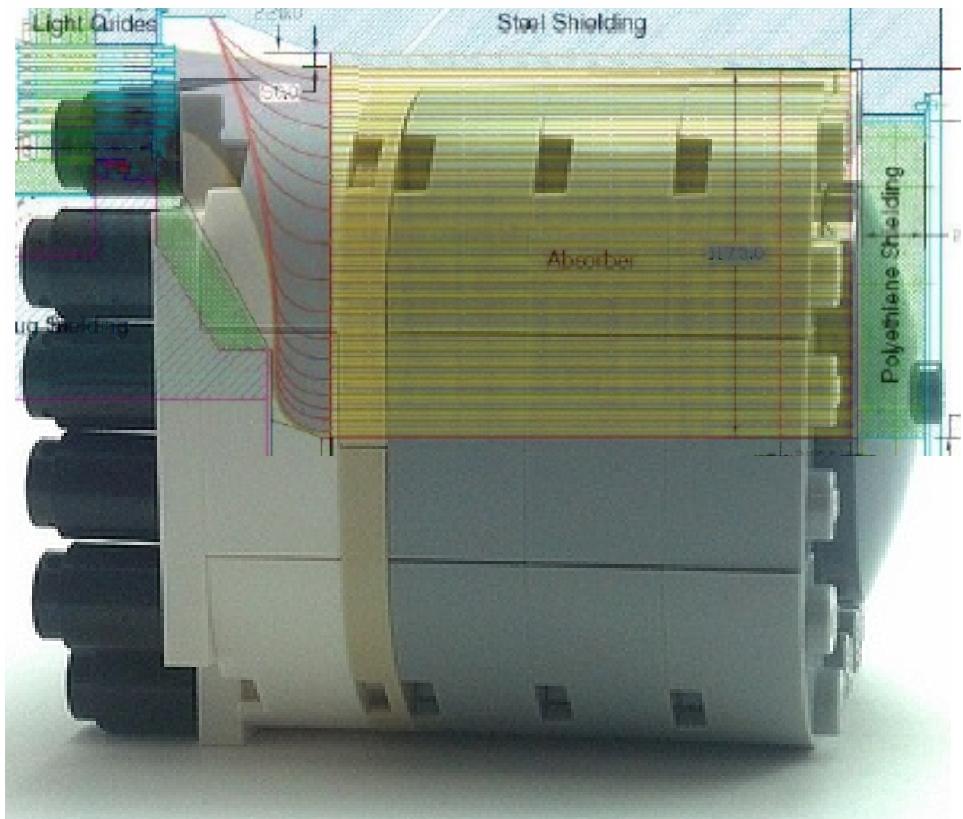


- CASTOR:
 - 0.6m wide, 1.6m long, behind HF-





LEGO® HF



Top left: Side view

Top right: Front view

Bottom right: Back view

(with plug installed)

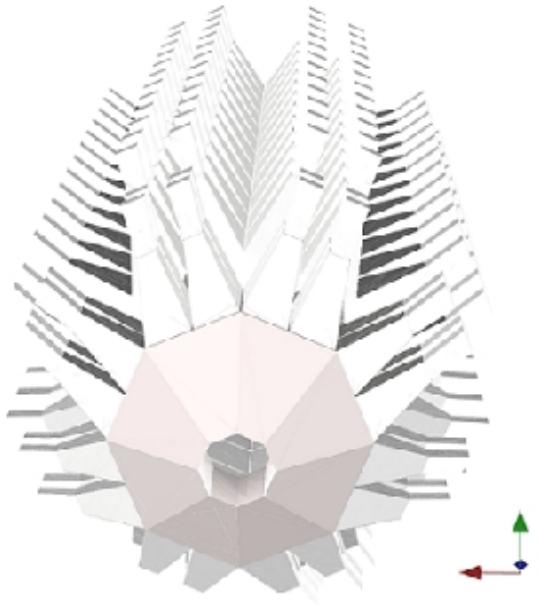


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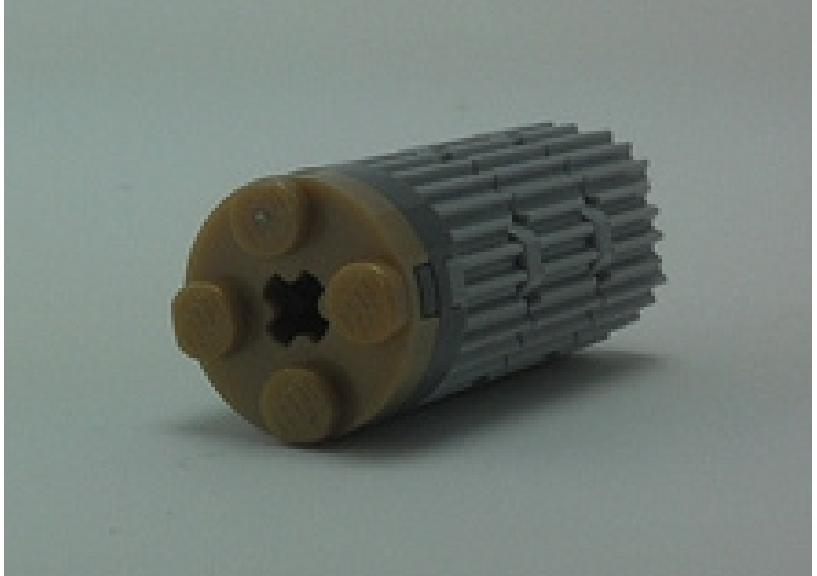




LEGO® CASTOR



CASTOR
(schematic)



CASTOR
(Lego scale)



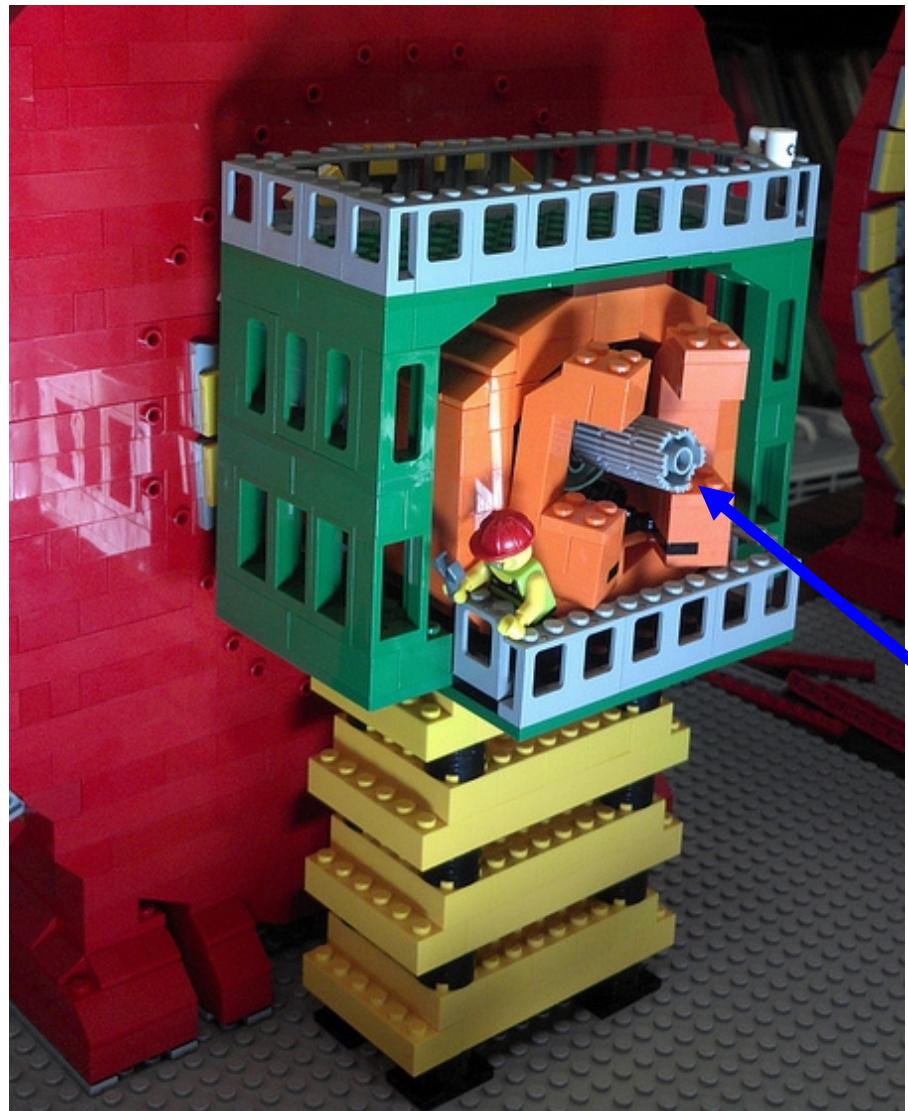
LEGO® HF+



Final HF+ (including shielding and support stand) behind muon endcap



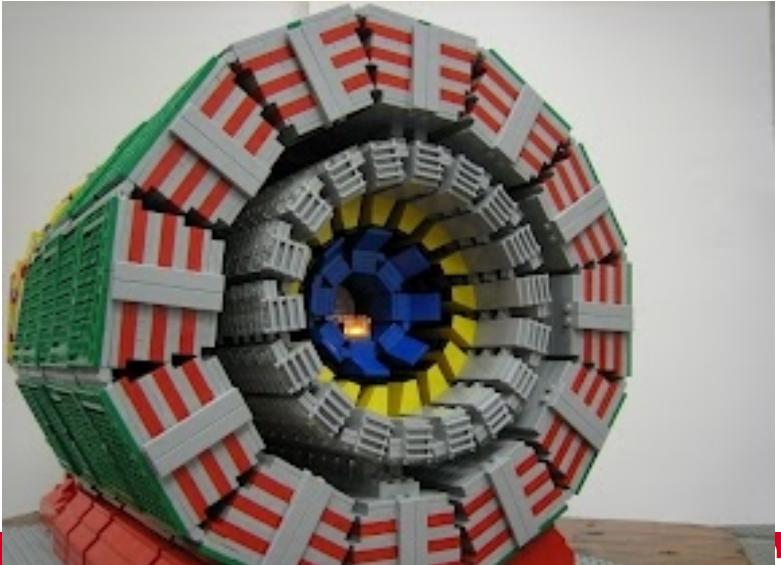
LEGO® HF- and CASTOR



CASTOR



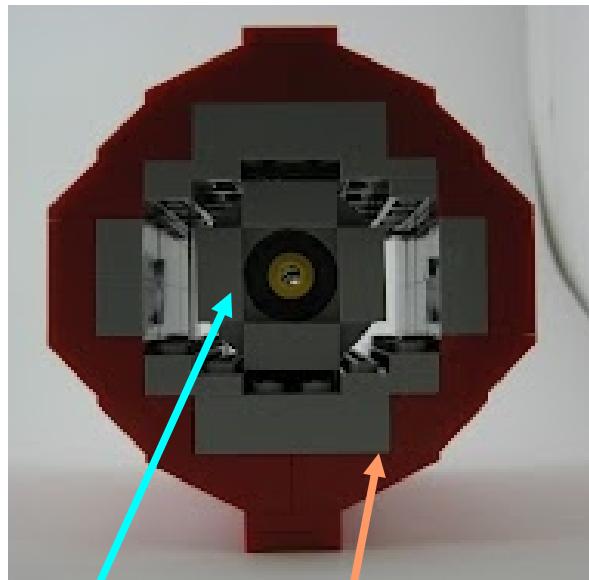
Completed Detector





Mini CMS model

- 1:200 scale

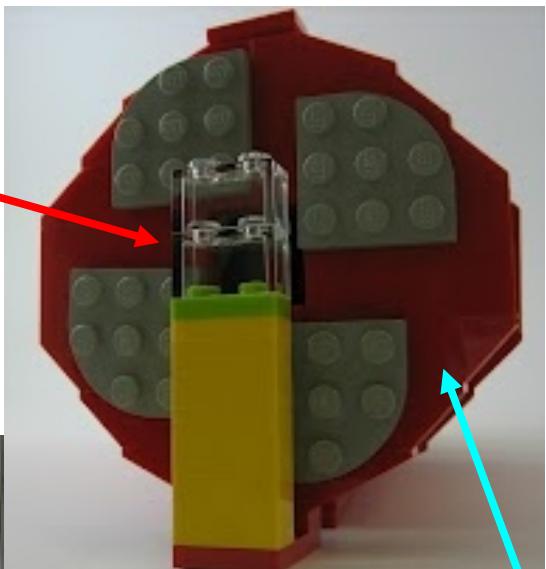


Solenoid

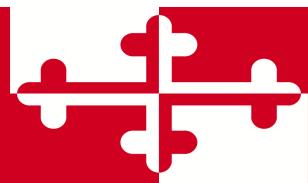
Muon ring



HF



Muon Endcap





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.





Thanks to:

- The Build Team:
 - Kevin Pedro, Ellie & Kevin Twedt, Jaime Gomez, Marguerite & Wayne Tonjes, Sarah Eno, Ernie Buchanan, Fred Buchanan, and Charlie Dawson
- Drew Baden and Nick Hammer for funding & encouragement
- Nick Hadley, Andris Skuja, and Dick Kellogg for likeness rights
- shop.lego.com for its “pick a brick” service
- Many sellers at bricklink.com

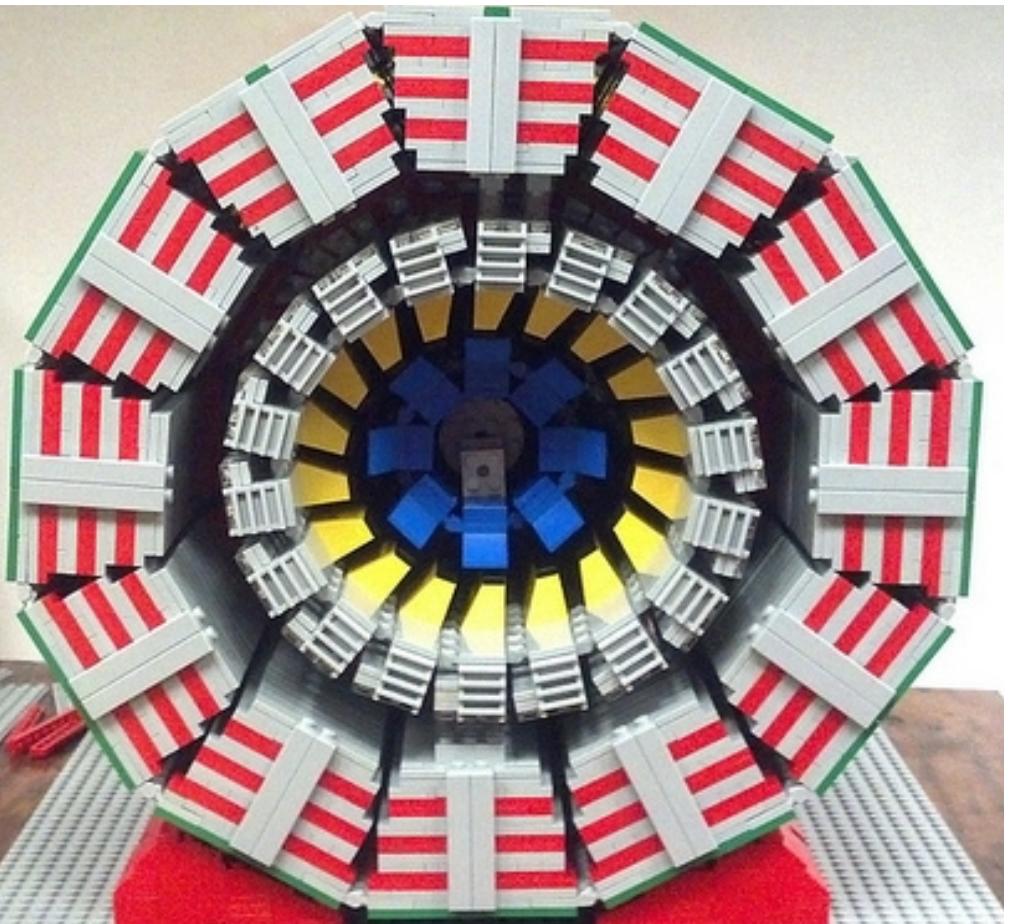
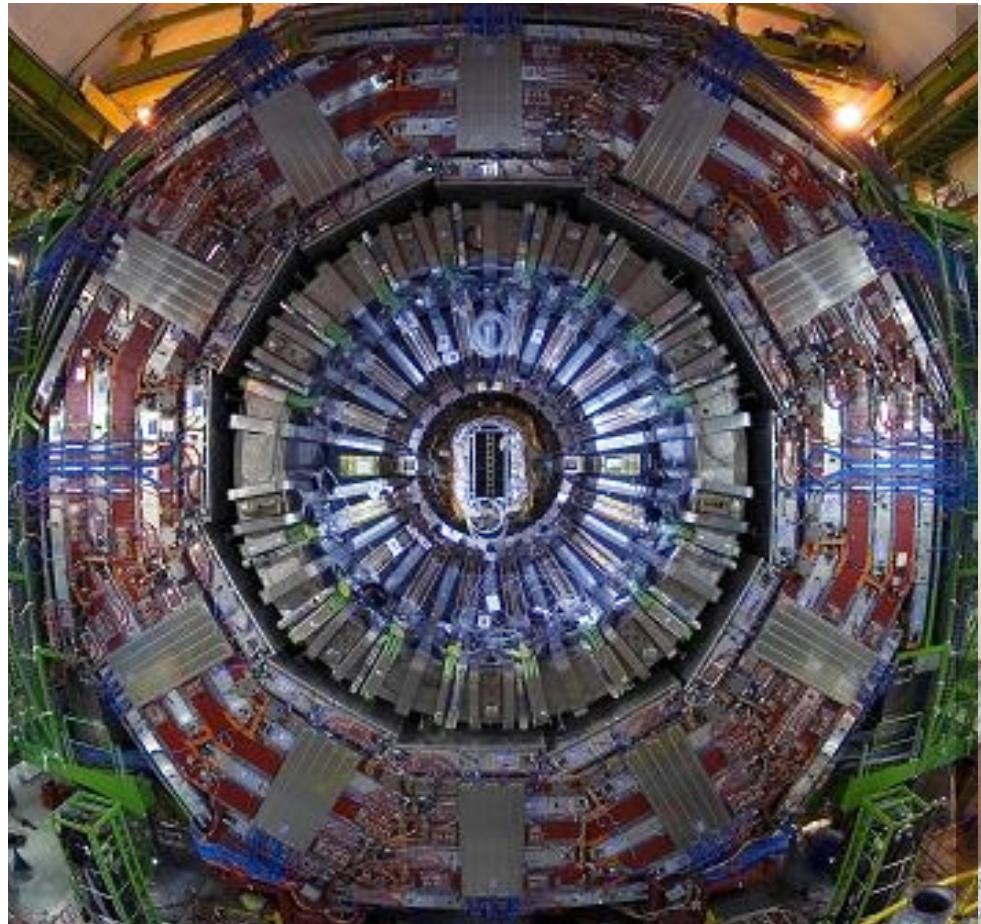




Backup Slides



Side-by-side comparison





List of BrickLink Suppliers

4 Fun Bricks & More
ACE: Blacktron Surplus LLC
Alaska Brick Movers
BAY AREA BRICKWERKS!
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

