

CMS Barrel Pixel Upgrade

Daniel Pitzl, DESY
CMS Group meeting
19.4.2010

- Document for DESY PRC submitted
- Physics studies in progress
- Work packages with Universities in HH, Ka, Ac defined
- Cost estimates received.
- Goal: ready for installation in 2015

The CMS Tracker upgrade

– DESY contributions –

April 15, 2010

- PRC document for Tracker upgrade
- Pixel and Strips
- Hamburg and Zeuthen

The DESY CMS Group

Abstract

A 4-layer low mass replacement of the CMS Barrel Pixel detector is planned for the middle of the decade. DESY is interested to contribute to the module production, in collaboration with the universities in Hamburg, Karlsruhe and Aachen. At a later stage, the entire silicon tracker needs replacement to cope at higher luminosity with increased track density and larger radiation dose while the material budget should be reduced. DESY R&D activities within the Central European Consortium involving the above mentioned universities and those in Barcelona, Louvain and Vilnius are described.

CMS pixel upgrade: 4 layers

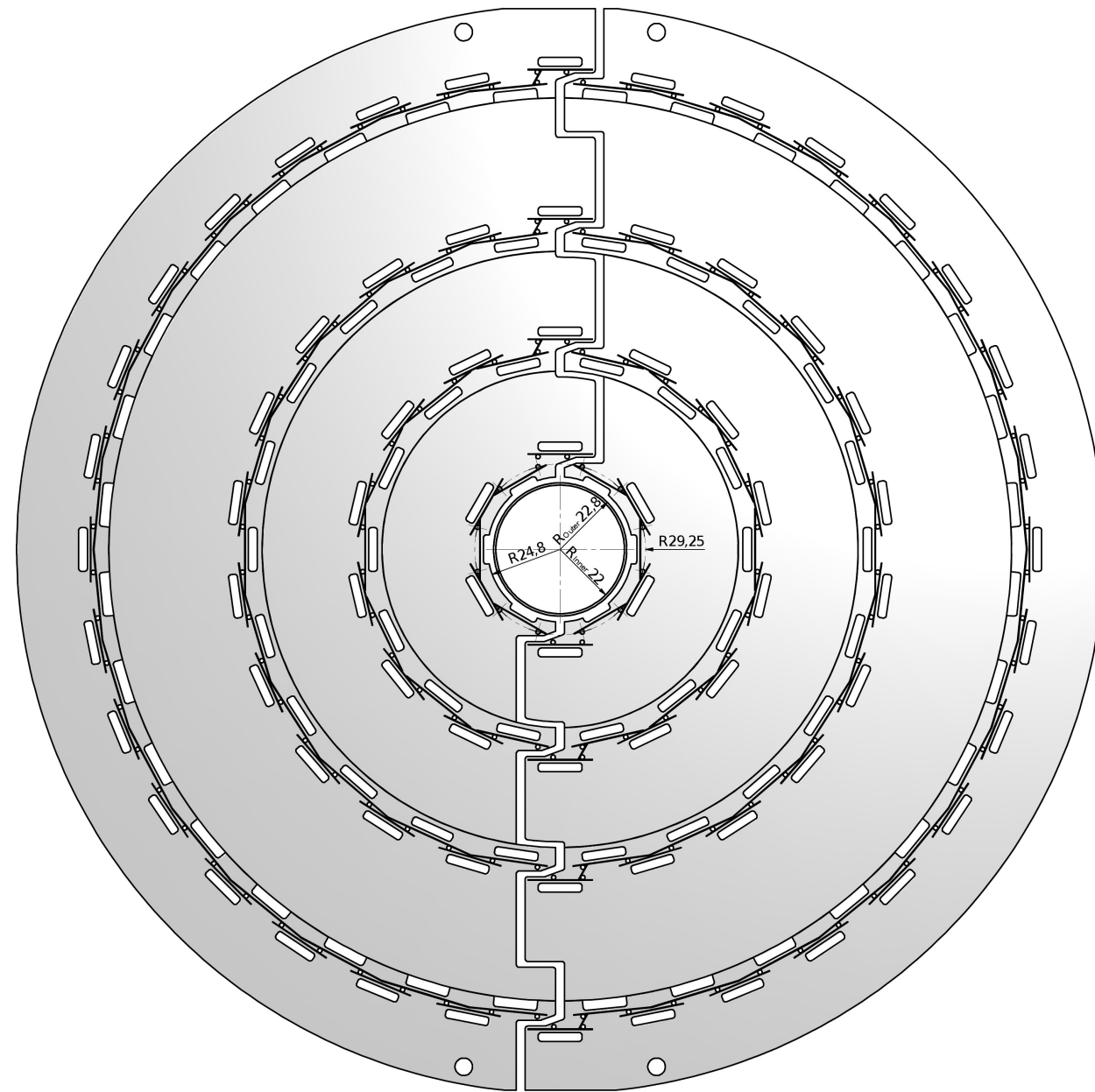
2 identical half-shells.
1184 modules (79M pixels)
(1.6 × present barrel)

$R_1 = 29$ mm, 96 modules
(if $R=22$ mm beam pipe is possible)
PSI

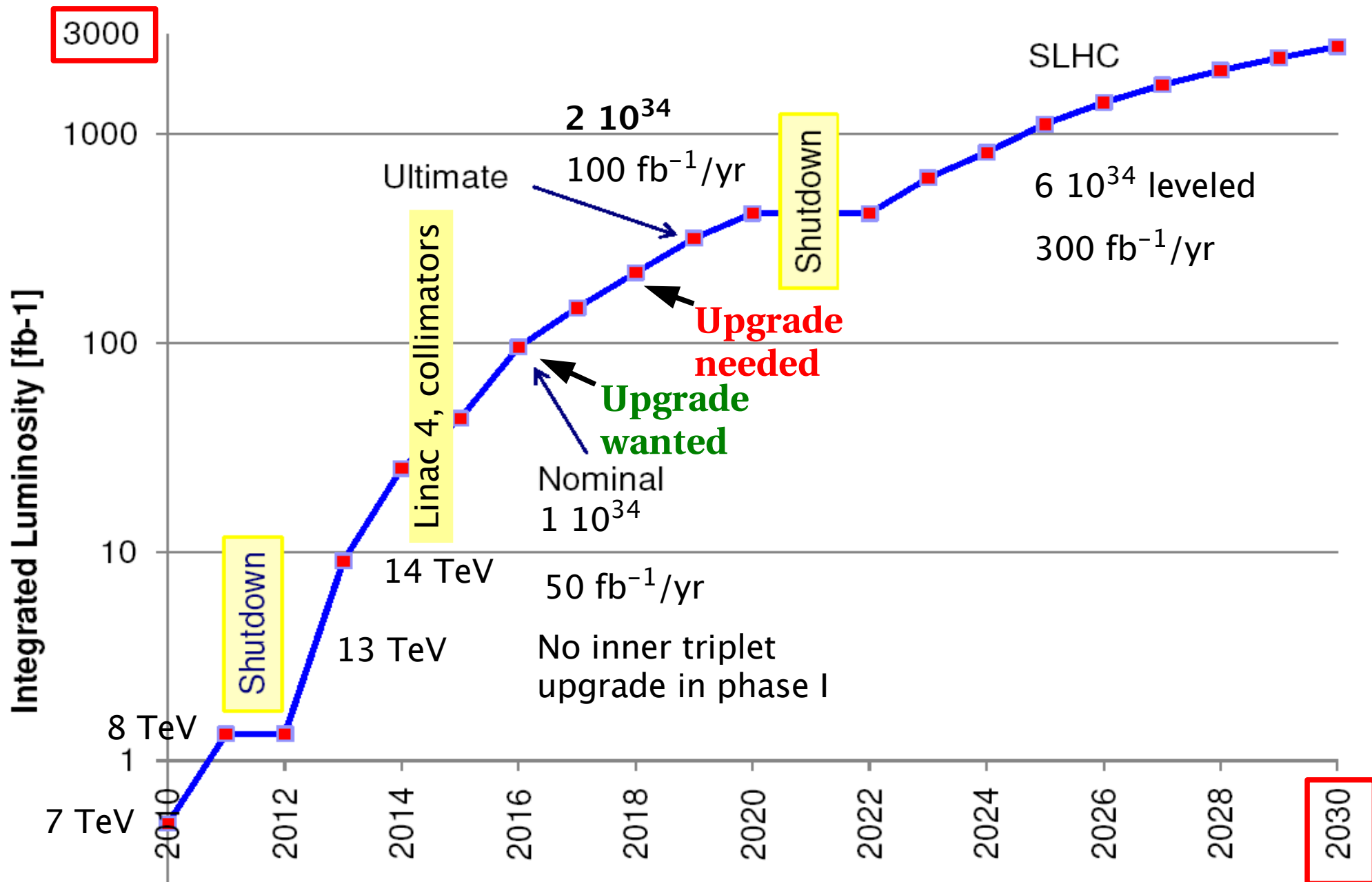
$R_2 = 68$ mm, 224 modules
PSI

$R_3 = 109$ mm, 352 modules
Italy ?

$R_4 = 160$ mm, 512 modules
Germany



Luminosity scenario 2/2010

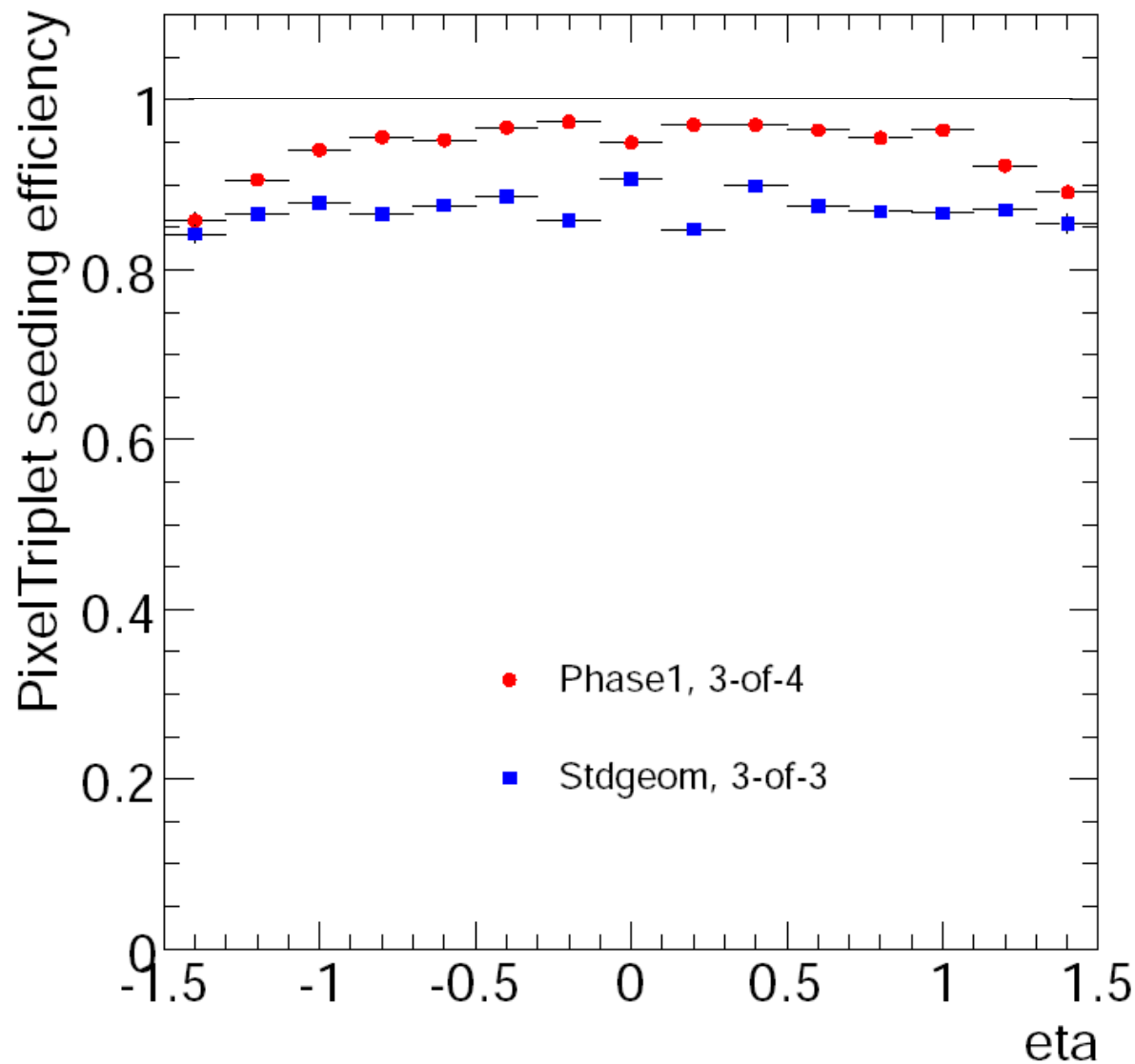


Mike Lamont, LHCC, 16.2.2010

Pixel upgrade motivations

- Prepare for 2× higher luminosity than design: $2 \cdot 10^{34}/\text{cm}^2$:
 - ▶ maintain pixel efficiency
- Less material (mechanics, chips, cooling, cables):
 - ▶ less multiple scattering, photon conversions, nuclear interactions
- 4th layer for better track seeding efficiency and improved stand-alone tracking:
 - ▶ High Level Trigger
- Smaller beam pipe for improved impact parameter resolution:
 - ▶ B-tagging
- Add redundancy in the tracking system:
 - ▶ independent of the luminosity evolution

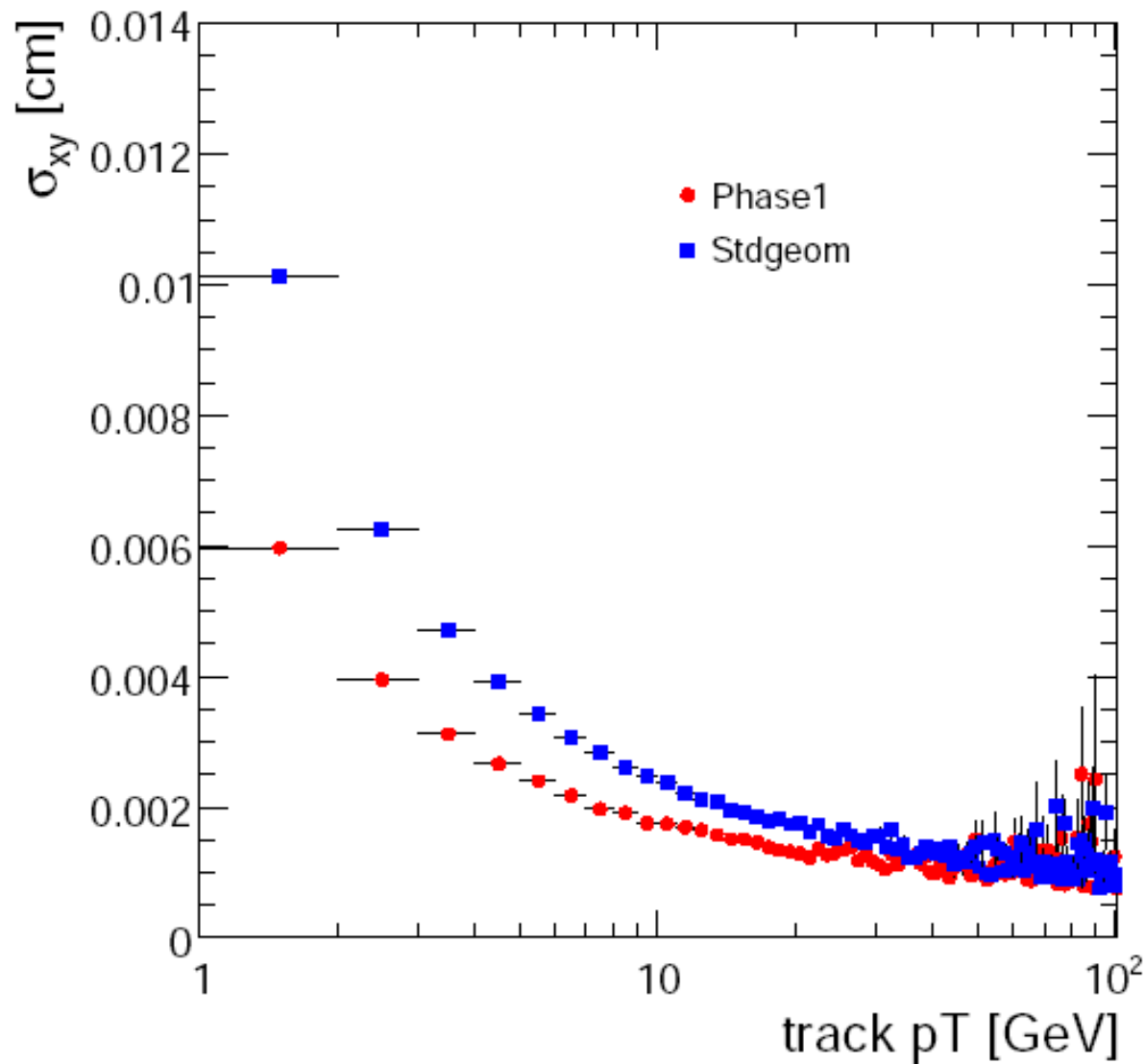
Track seeding



- M. Aldaya
- $t\bar{t}$ MC
- Pixel triplets for track seeding.
- Obvious efficiency gain with 3-of-4 vs 3-of-3.

Maria Aldaya

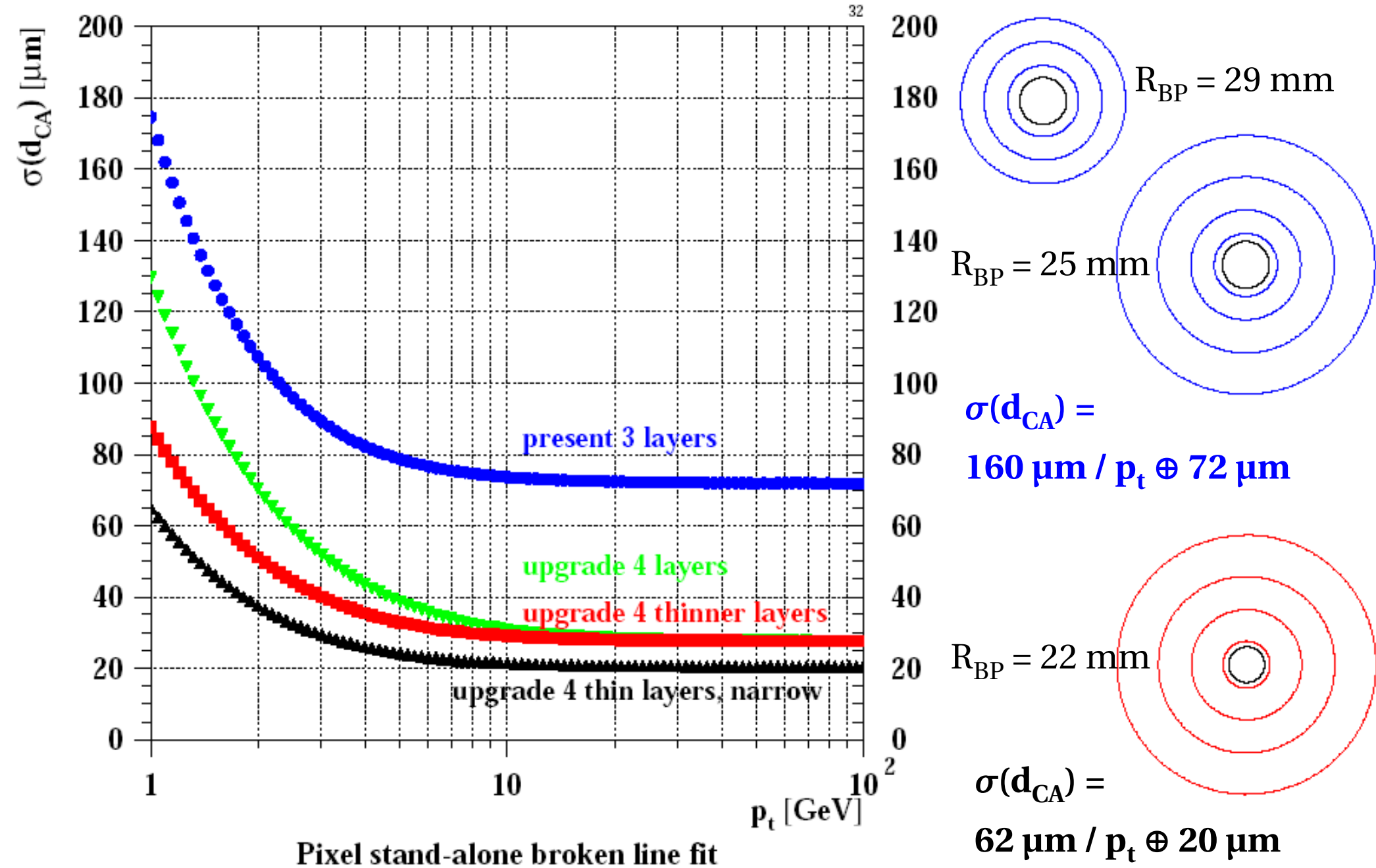
CMS impact parameter resolution



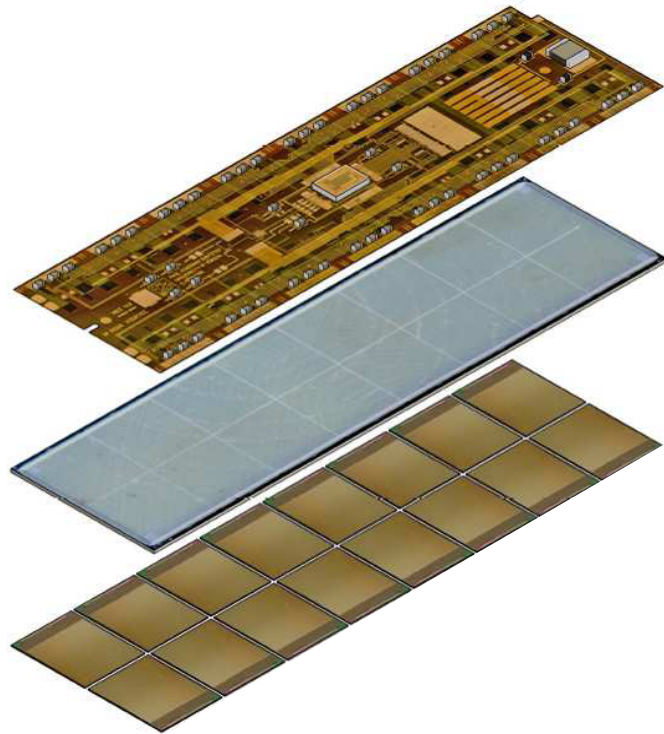
- M. Aldaya
- $t\bar{t}$ MC
- Phase 1 upgrade improvement below ~ 20 GeV due to lower material budget and smaller beam pipe.
- Impact on B-tagging under study...

Maria Aldaya

Impact parameter resolution in HLT



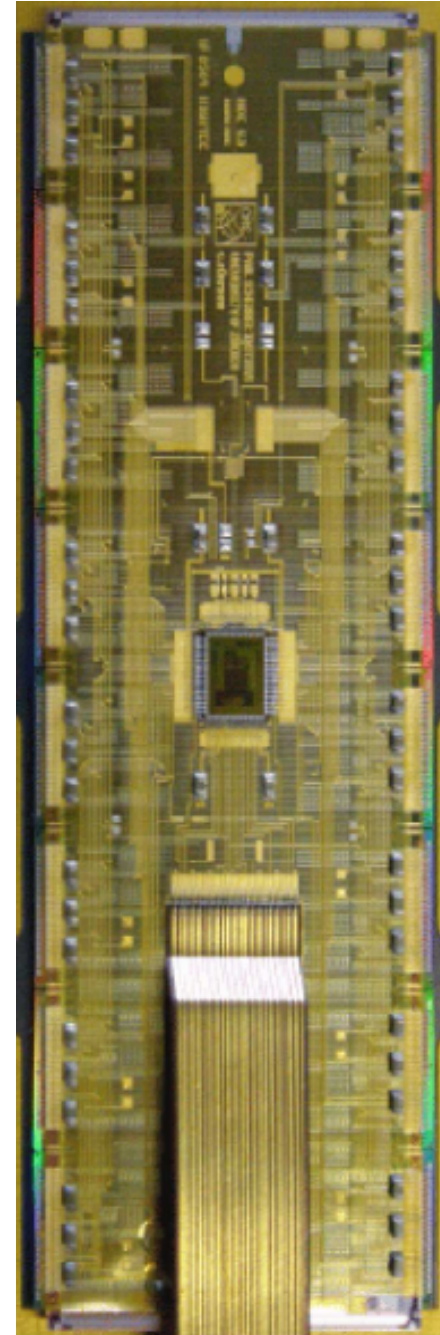
CMS barrel pixel module



High density interconnect
3-layer flexprint
glued to back of sensor

silicon sensor
 $16 \times 64 \text{ mm}^2$
66'560 pixels

16 read-out chips
bump bonded to sensor pixels
wire bonded to flex print



Work packages

task	quantity	DESY	HH	Ka	Ac
sensors I-V	700		350	350	
bare module test	700	350		350	
bond TBM to HDI	700	350		350	
glue HDI to sensor	700		350	350	
bond ROCs to HDI	400k	200k		200k	
cold calibration	700	350			350
X-ray calibration	700		350		350
layer assembly	1	1			
layer system test	1	1			
DC-DC converters	many				all

Cost estimates

- Layer 4: 512 modules + 100 spares + 88 rejects
- 700 sensors, 3 per 4" wafer, yield 2/3, CIS Erfurt 210 kEUR
- 11200 ROCs, 248 per 8" wafer, yield 3/4, IBM 100 kEUR
- 46.6M pixel, bump bonding, IZM 1100 kEUR
- 700 HDI mit SMD Bestückung, HighTec 125 kEUR
- Sensor test equipment (I-V, C-V, optical) ~40 kEUR
- Tools for gluing (workshop) ~30 kEUR
- (Wire bonder, backup for DESY ZE bonder) (300 kEUR)
- Module test equipment ~60 kEUR
- Cold test box ~10 kEUR
- X-ray test box ~50 kEUR
- System test equipment (CO2, HV, LV, DAQ, trigger) ~155 kEUR

to be shared among DESY, HH, Ka, Ac

Timeline

- Produce assembly tools start 2010
- Develop assembly procedures start 2011
- Develop testing and calibration procedures start 2010
- Bump bonding tests 2010-2011
- Decide on bump bonding technique end 2011
- Assembly and test procedures established 2012
- Receive all components for series production 2012
- Module assembly and calibration 2013-2014
- Layer system test at DESY mid 2014
- Full system test at CERN 2014-2015
- Ready for installation mid 2015

Summary

- Pixel upgrade project well defined:
 - ▶ physics gain, tasks, German partners, timeline, cost.
- Work in progress:
 - ▶ Physics studies (HLT, ttbar)
 - ▶ Chip test bench
 - ▶ Bump bonding tests to be started
- Next dates:
 - ▶ DESY PRC Apr 29/30, 2010
 - ▶ DESY Scientific Council May 17/18, 2010
 - ▶ CMS Tracker Upgrade week Elba May 24-27, 2010
 - ▶ HGF Ausbauantrag Summer 2010
 - ▶ Pixel workshop at PSI Jun/Jul 2010
 - ▶ CMS Phase 1 Upgrade TDR: end 2010