Upgrade Simulation Meeting,
CERN, Januaryr 29th 2013

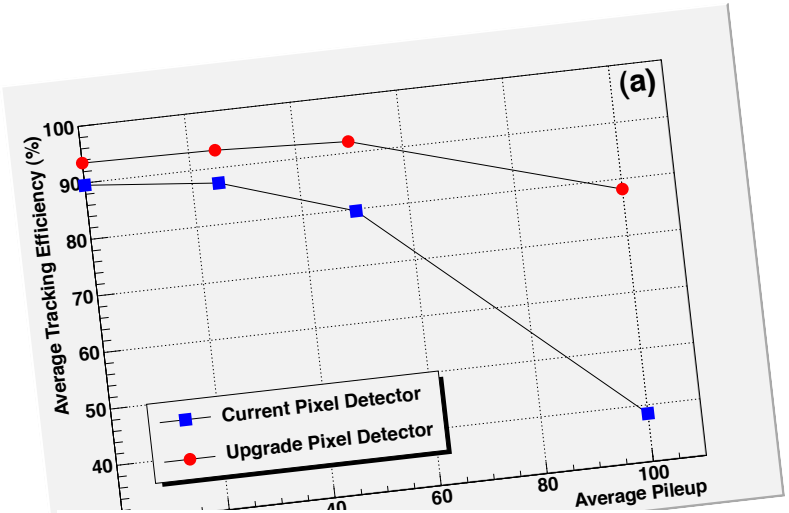
PIXEL PHASE 2 SIMULATION STATUS & PLANS

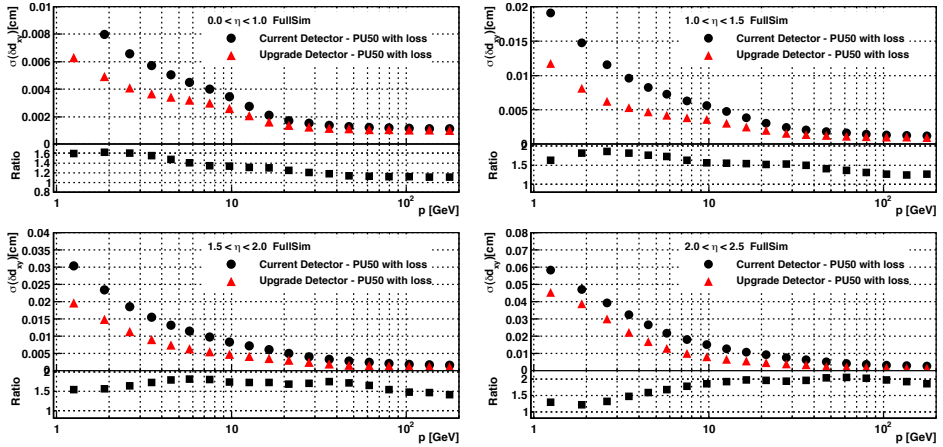
A. Tricomi (INFN Catania)

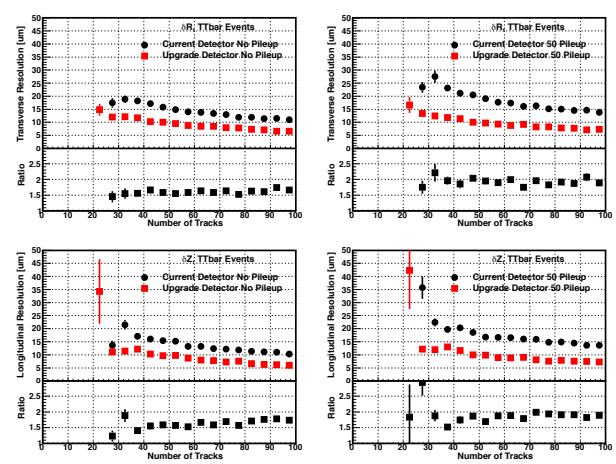
Disclaimer

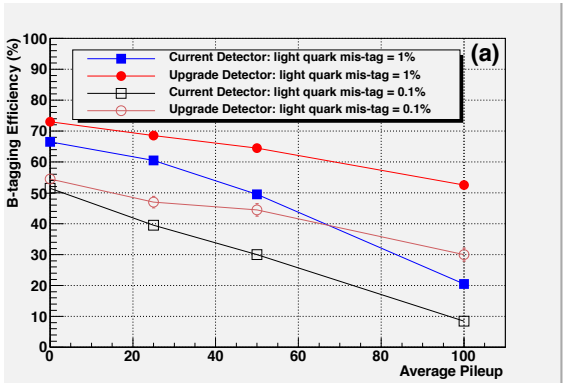
- No results for Pixel Phase 2 presented
- This talk/meeting is intended to start an iterative process between HW and SW communities
  - Remind what has been done for the TDR
  - Show what is available
  - Discuss what is feasible in short/medium timescale
  - Get input on the needs
  - Help to design a more detailed task list for Phase2 studies ready for the next Tracker week
    - Beneficial also for Phase1
    - No net separation between Phase2 Pixel wrt Phase1 & Phase2 OT

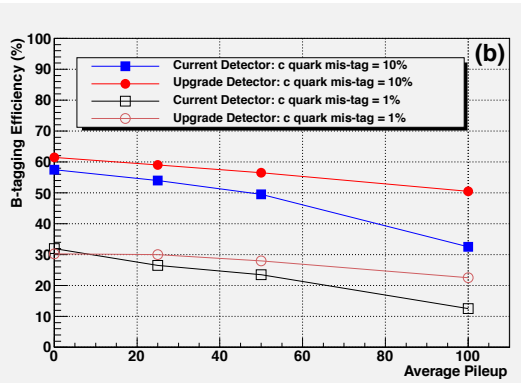
Lot of work done for the TDR











To study Phase1 performance

Pixel Upgrade dictionary

- StdGeom:
  - Current pixel detector geometry (3 barrel layers, 2 disks)
  - Current beam pipe
  - Dedicated "SLHC" release CMSSW_4_2_8_SLHC2 to use Design/Ideal conditions and same configurations/settings for tracking
  - Assumend Data Loss (50PU) ~16% @ BPIX-L1
- R30F12 geometry:
  - Upgrade geometry with 4 BPIX layers and 3 endcap disks
    - First barrel layer at R=30 with 12 faces
    - New detailed material description according to PSI drawings
    - New beampipe (Sunanda) implemented
  - CMSSW_4_2_8_SLHCtk + 520 backporting
  - Assumed Data Loss BPIX1 2.34% (other layers rescaled accordingly)
  - Baseline Phase1 geometry for TDR studies

Pixel Upgrade dictionary: looking forward

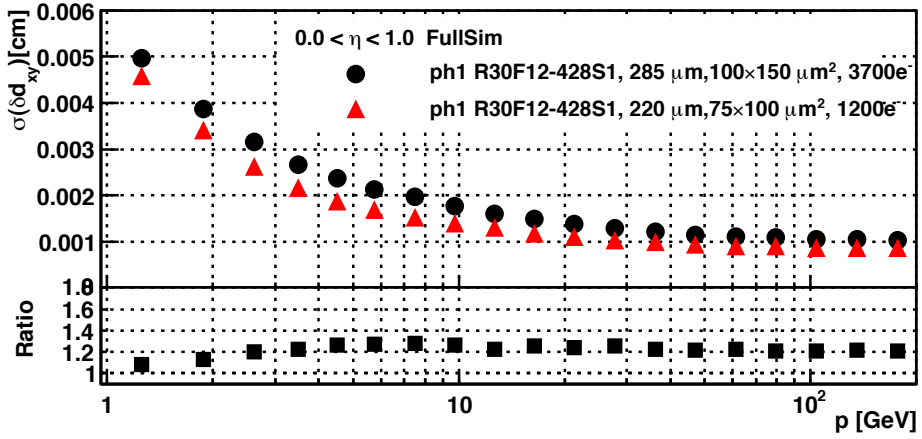
- R30F12_smpx (known as “Phase1b”):
  - Same as R30F12 but
  - Pixel size 100x75 μm^2
  - 220μm^2 thick
  - threshold=1200 e-
  - Assumed data loss = no data loss with the new chip

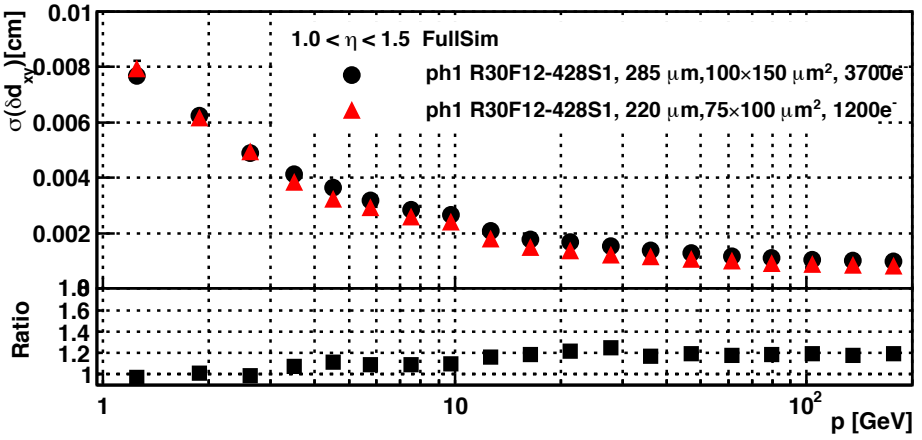
R30F12 vs R30F12_smpx

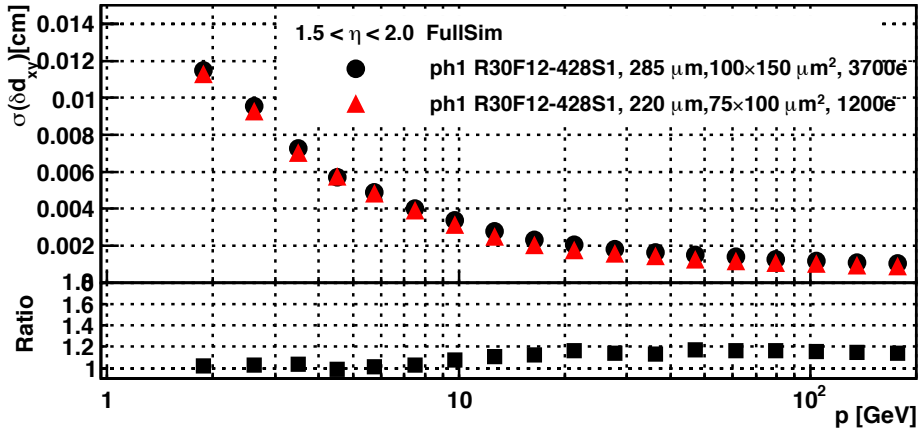
Muons (E-gun) –Transverse IP resolution

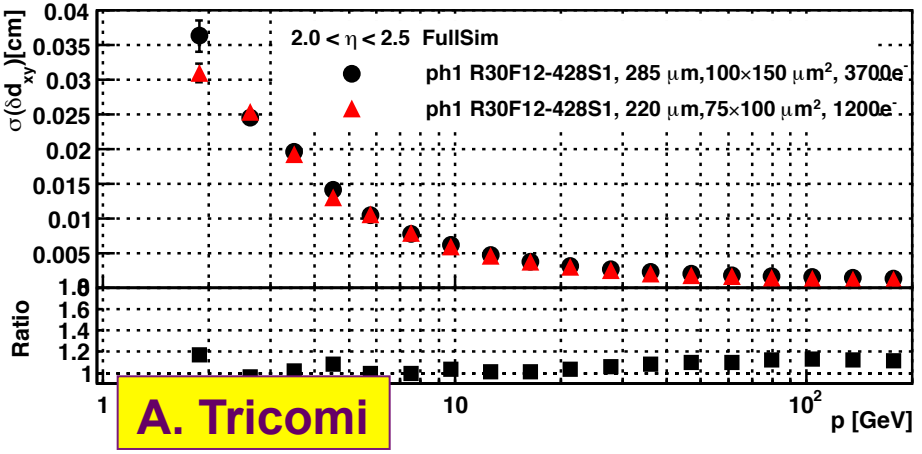
Upgrade R30F12

Upgrade R30F12 – small pitch









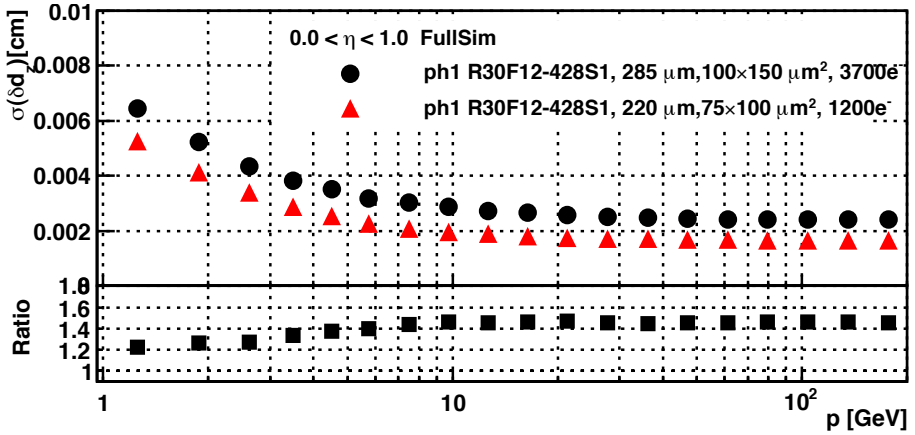
A. Tricomi

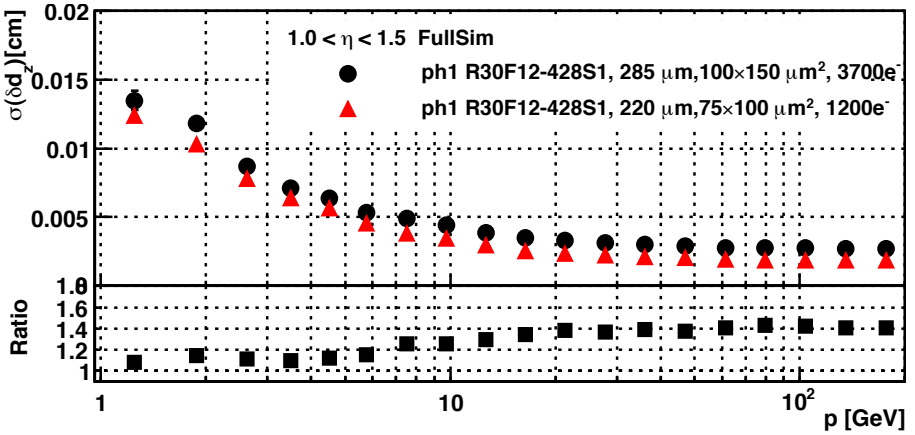
R30F12 vs R30F12_smpx

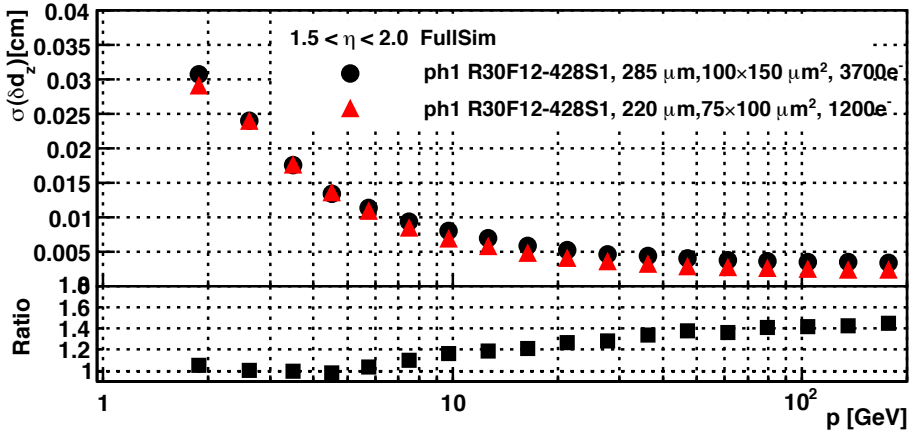
Muons (E-gun) –Longitudinal IP resolution

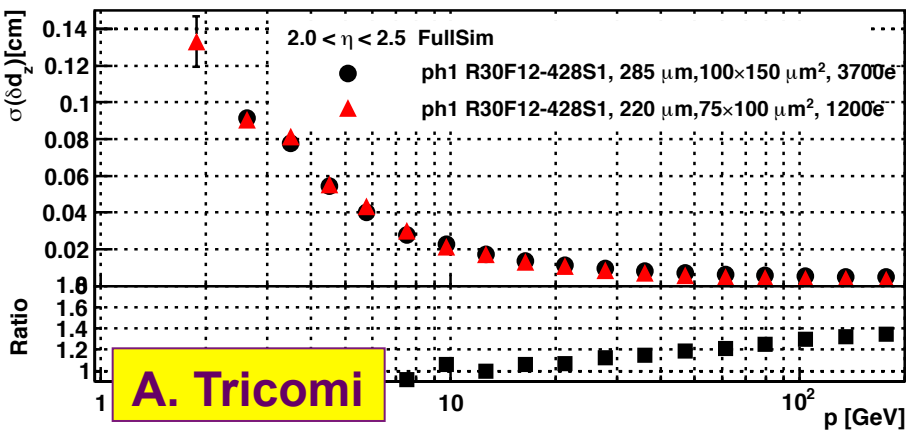
Upgrade R30F12

Upgrade R30F12 – small pitch





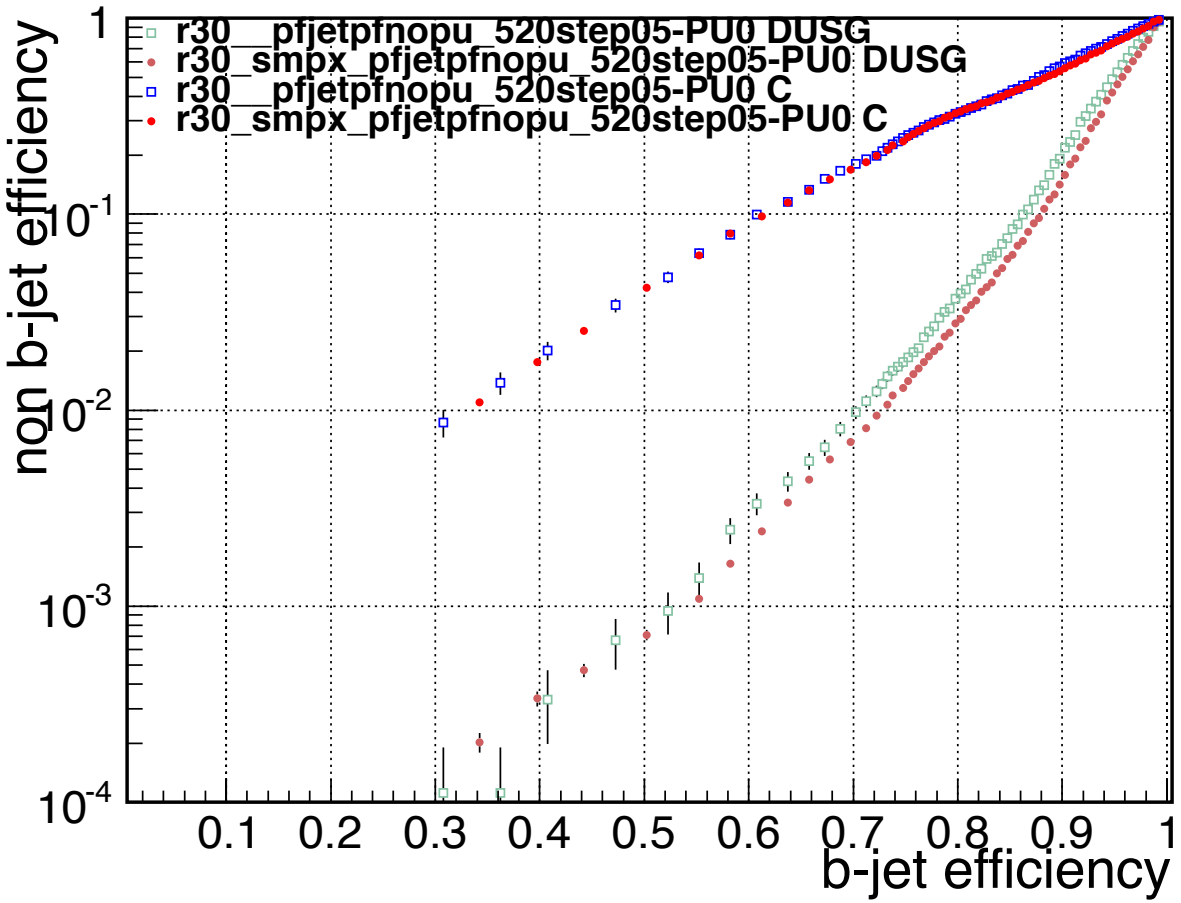




R30F12_smpx vs R30F12 b tagging

ttbar sample at <PU>=0, high purity tracks

CSV: mistag vs. b tag efficiency

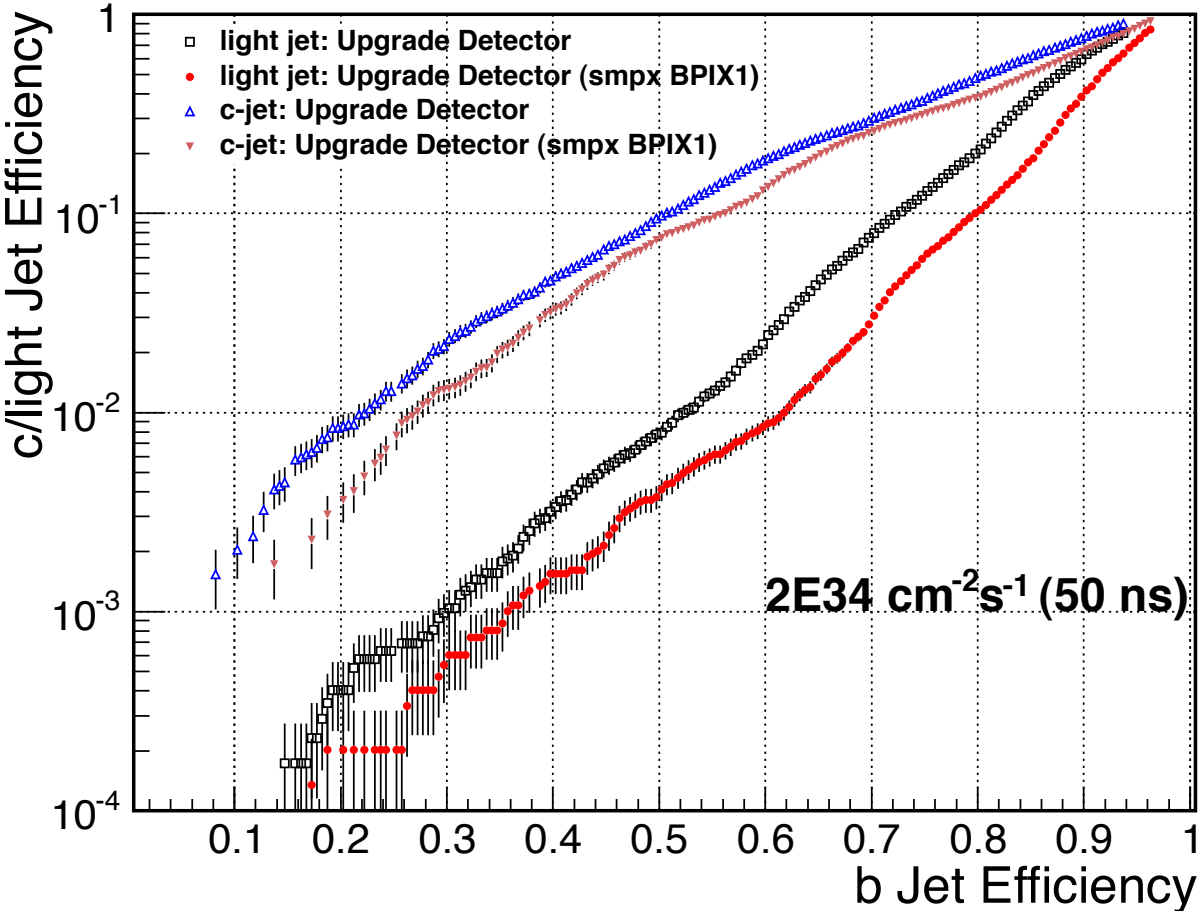


Small improvement at 0 PU wrt Upgrade Phase1 detector

But…

Small pixel scenario: btagging performance

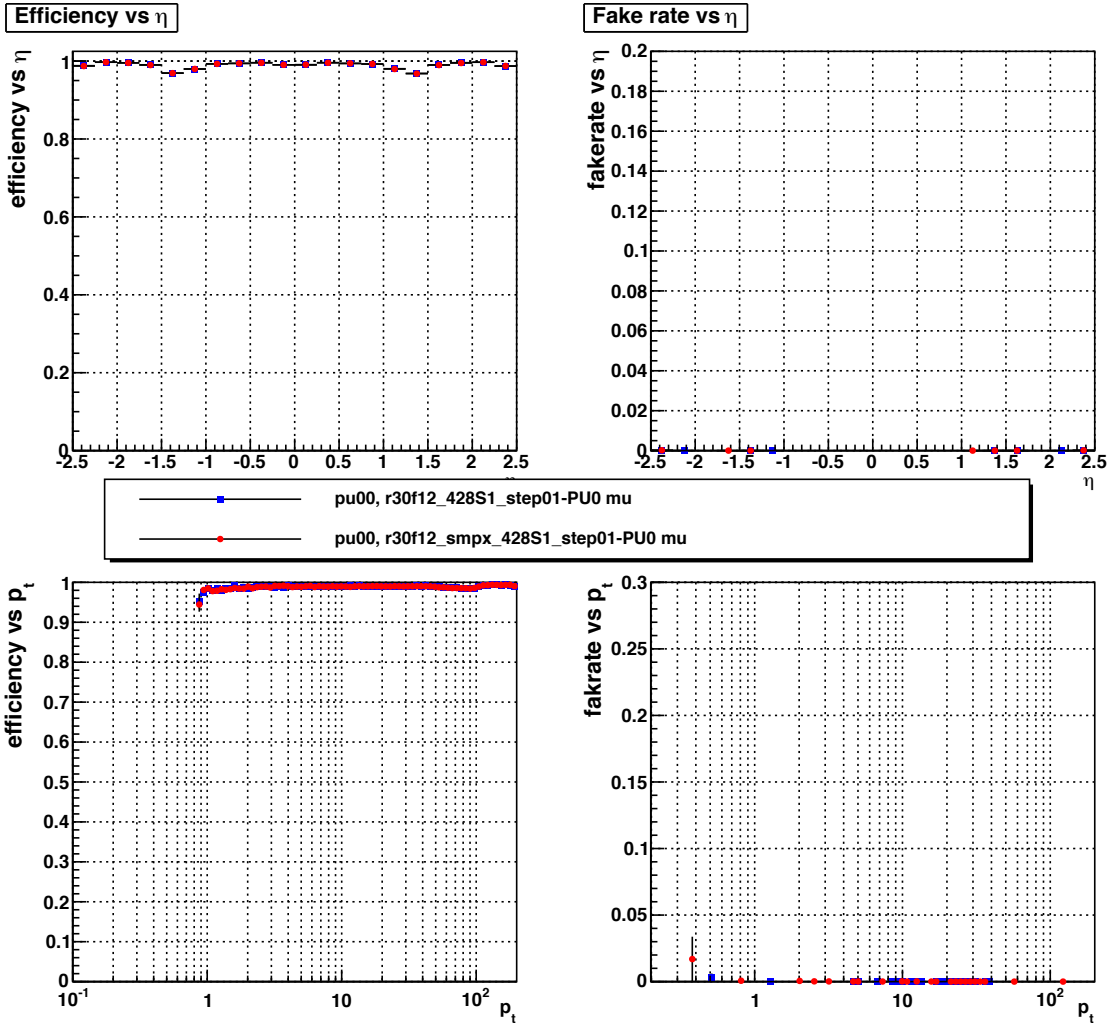
BPIX Layer1: pixel size 75x100 μm², 220 μm thickness
ROC threshold 1200 e⁻ instead of 2000



Significant improvement at 100 PU wrt Upgrade Phase1 detector

Good news towards Phase2

Tracking performance R30F12



TenMu 0-200GeV

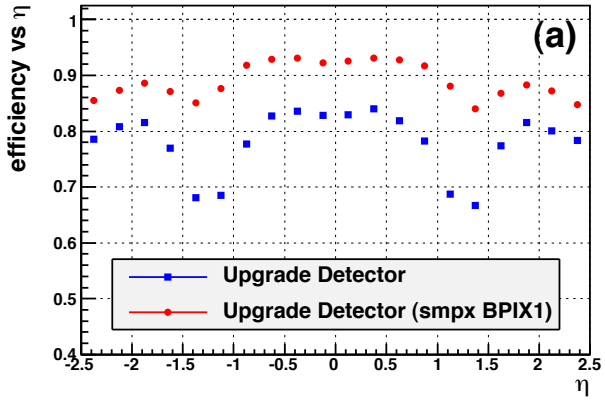
No PU

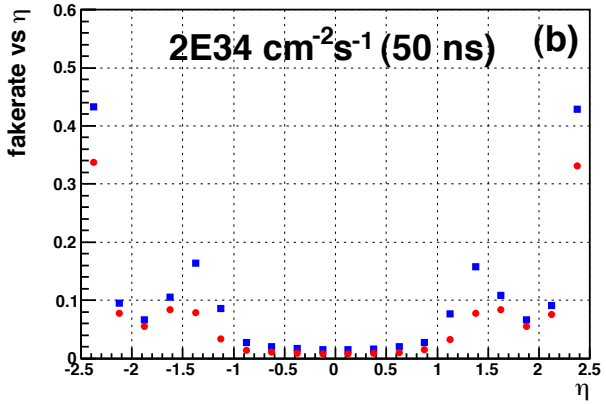
No difference at PU=0

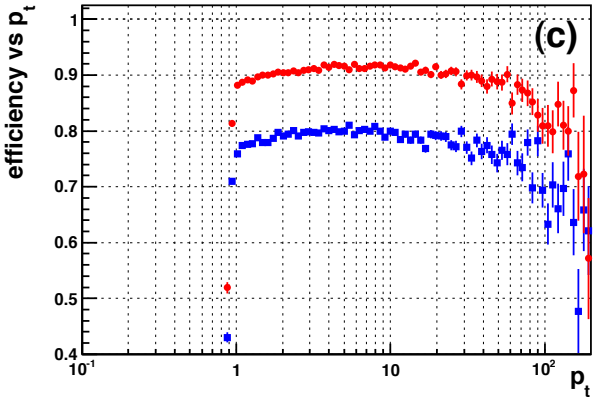
But …

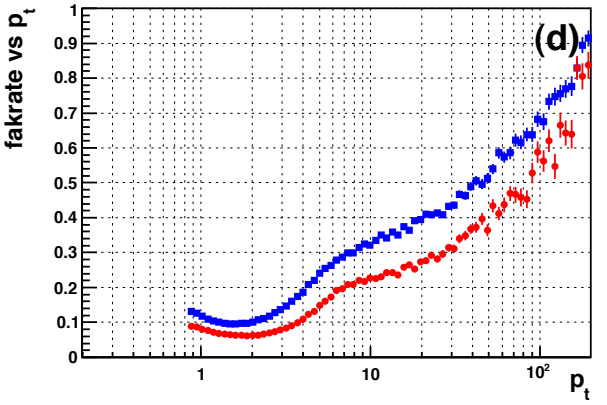
Small pixel scenario: tracking with ttbar at 100PU

BPIX Layer1: pixel size 75x100 μm², 220 μm thickness
ROC threshold 1200 e⁻ instead of 2000









Significant improvement at 100 PU wrt Upgrade Phase1 detector
Good news towards Phase2

What we learnt?

- Use of reduced pitch clearly helps to significantly improve the performance
  - For IP already at low luminosity
  - For tracking and btagging at the high PU foreseen for Phase2
- Small pixel scenario with 100x75 is NOT intended as a “final” choice
  - It is just an exercise as a starting point

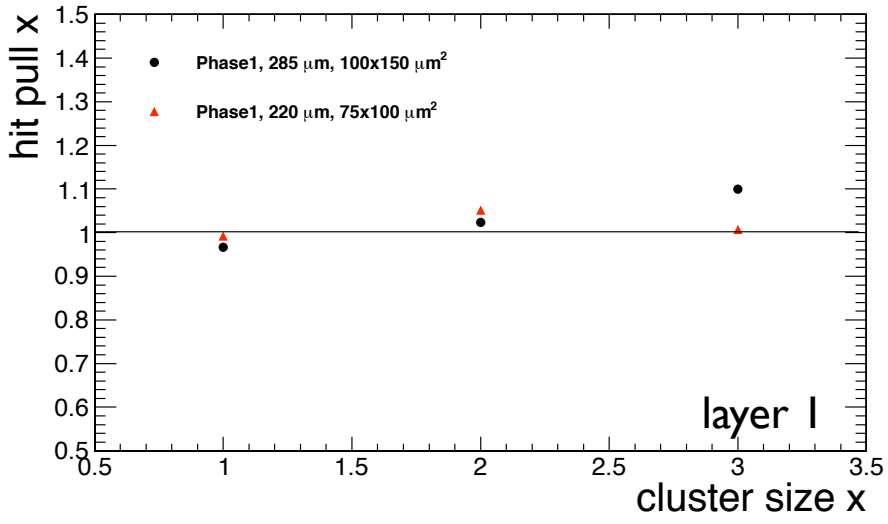
Why just this pitch?

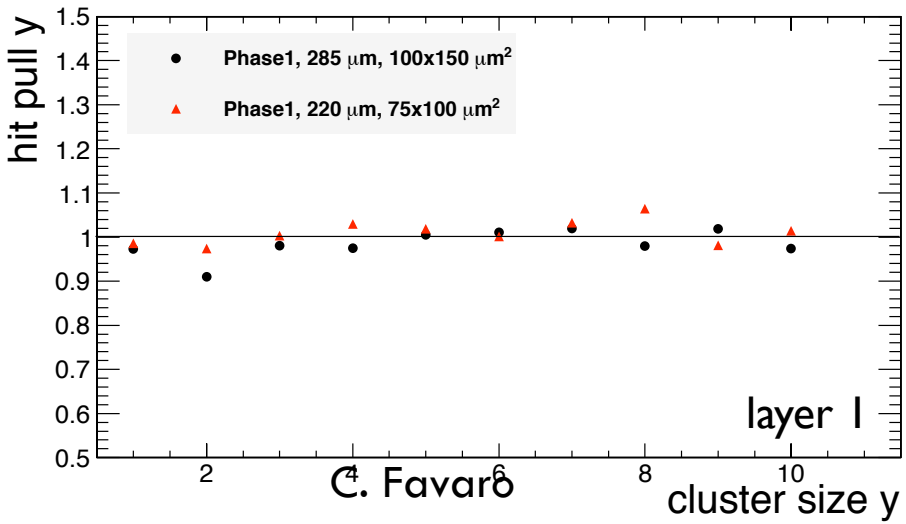
- Error assigned to hit position crucial for a proper impact parameter estimate
- Either we use
  - Pixel Templates
    - Specific of the current pitch size
    - Disable
  - PixelCPEGeneric algorithm used for hit position estimate (based on track angles and charge sharing)
    - Preliminary study needed since existing template cannot be used
    - Error estimation based only on cluster size

Hit study – local reconstruction

- Pixel local reconstruction
  - Pixel Templates disabled
  - Error estimation based only on cluster size
  - Need to be done for every pitch scenario (just chosen one!)

definition: σ of Gaussian fit of hit pull distribution





Hit study

- Pixel local reconstruction
  - Error assigned to hit position crucial for a proper impact parameter estimate
  - Pixel Templates disabled
    - Specific of the current pitch size
  - PixelCPEGeneric algorithm used for hit position estimate (based on track angles and charge sharing)
    - Preliminary study needed since existing template cannot be used
    - Error estimation based only on cluster size
- Digitization: modification made to the digitizer
  - Different RO threshold for layer 1/other BPIX layers and FPIX
    - Configurable variable in python

What can be done: short timescale

- Use the same geometry as for Phase1 and
  - Change the pixel pitch
    - Extend to other layers/Disk if needed
    - Whole machinery to evaluate hit resolution to be redone
  - Change threshold
    - Just a configurable parameter
  - Add RO inefficiency
    - just a configurable parameter
- All "easy" variation wrt Phase1 can be done in a reasonable short timescale

What can be done: medium/ long timescale

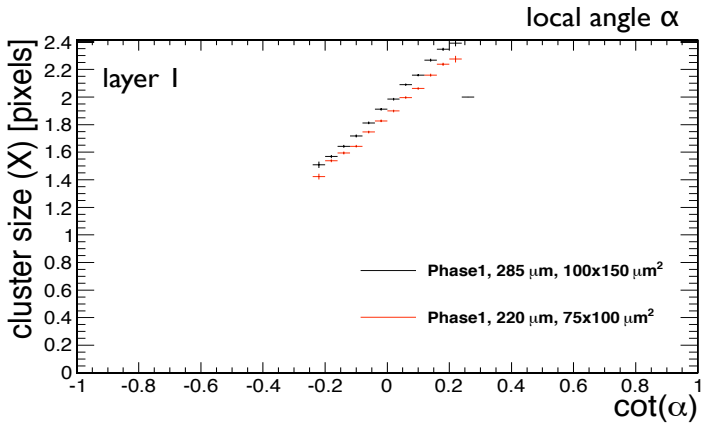
- Restore use of the template both for Phase1 and eventually "Phase1b"
- Extend use of the templates for taking into account also ageing effect
  - Plan already discussed with Morris
    - We will start soon
    - Beneficial for current, Phase1 and Phase2
- This work is of high priority but will take time

What can be done: long timescale

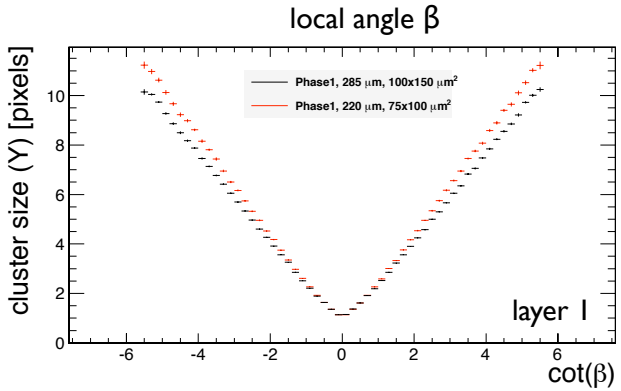
- Implement the new geometry
  - Two fold strategy not in contrast
    - TKLayout
    - Direct implementation in XML
- Extend new template strategy to the Phase2 geometry
- Start dedicated performance studies
- This is clearly the “final” goal but still most of the issues need to be addressed

Back up slides

Hit study – local reconstruction

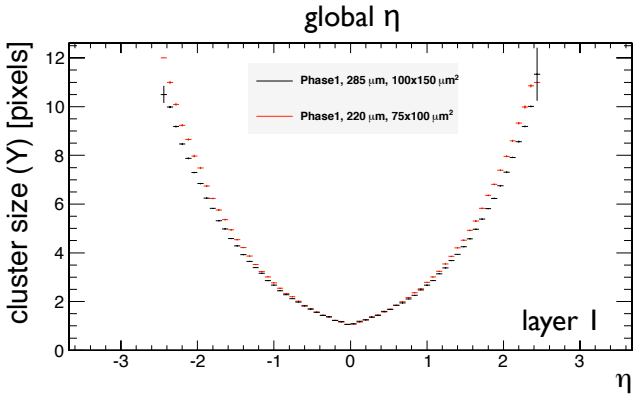


Cluster Size X & Y



~5% decrease in average cluster size x integrated over all track angles: effect of the thickness reduction

Plots may not be Up-to-date



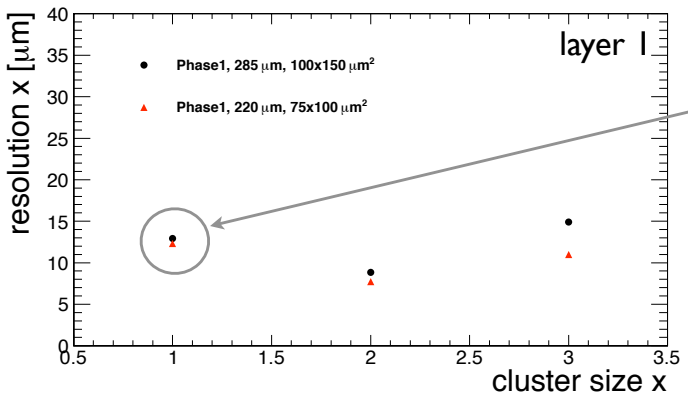
~ 7% increase in average cluster size y integrated over all track angles

C. Favaro

Hit study – local reconstruction

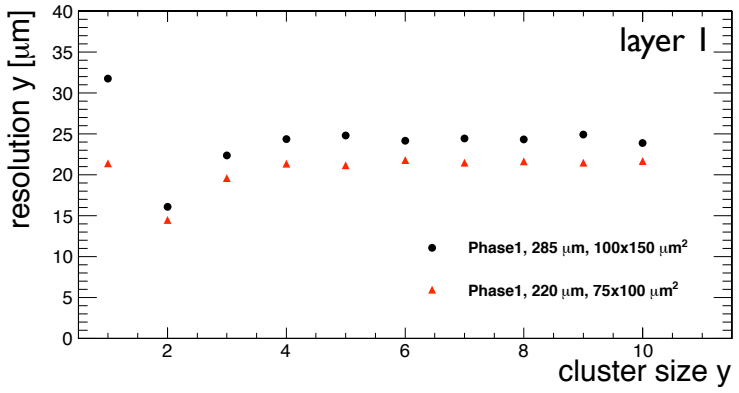
hit position resolution

definition: σ of Gaussian fit of hit residual distribution



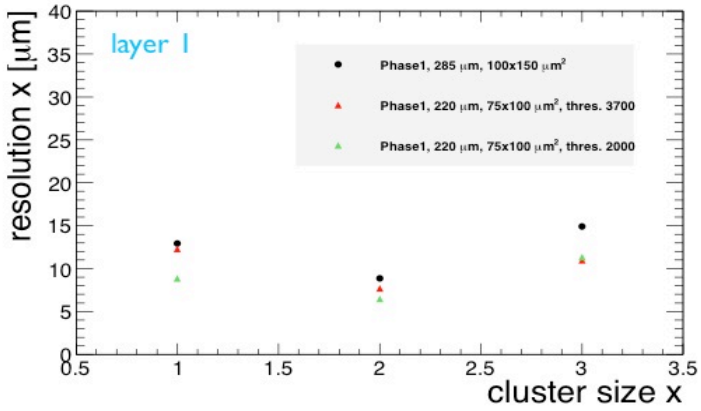
we would expect a bigger improvement for single-pixel clusters due to pitch reduction

- ~30% decrease for single-pixel clusters as expected from pitch reduction
- ~3 μm decrease for cluster size > 1



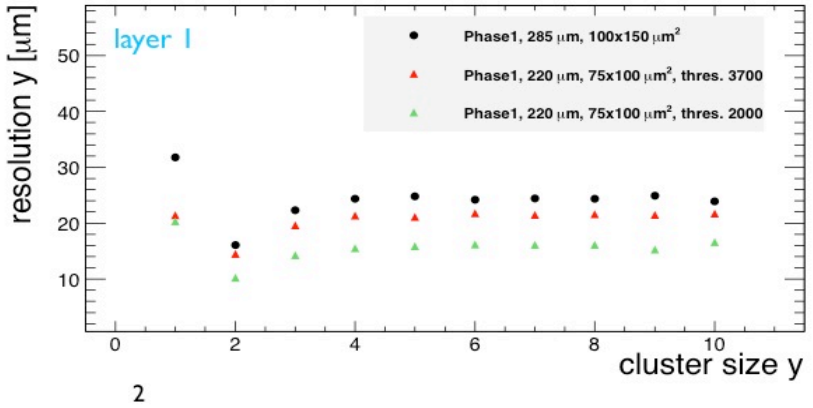
C. Favaro

Hit resolution – effect of threshold

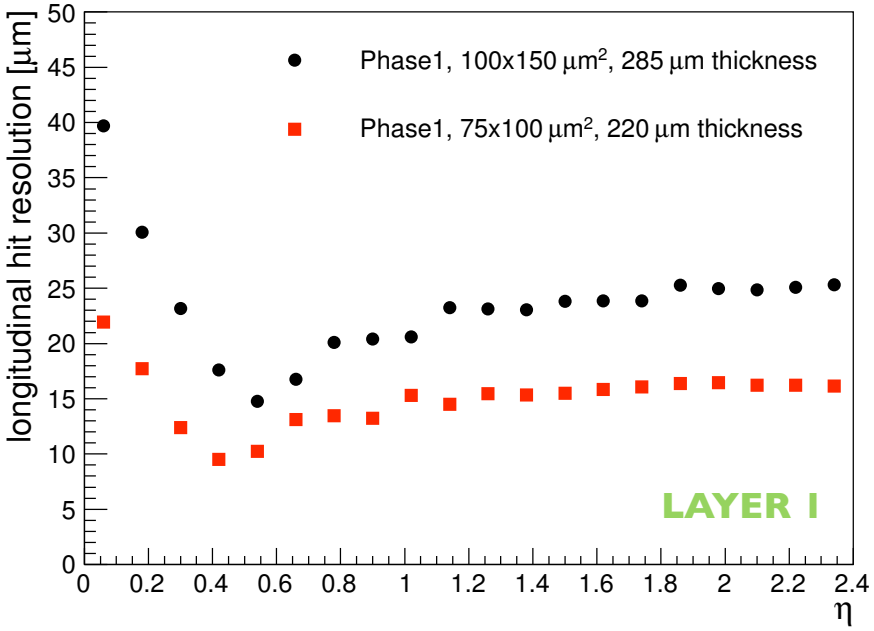


hit resolution

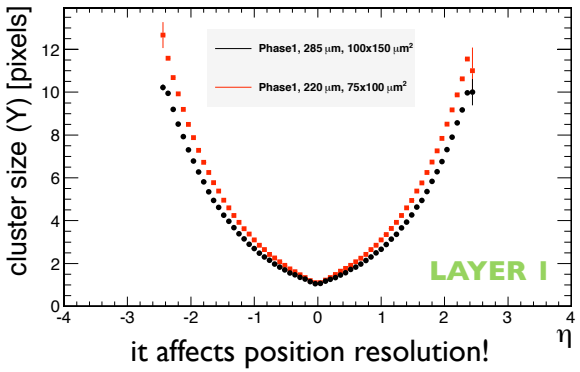
- additional decrease in position resolution produced by lower threshold
- error routine updated to take into account this decrease.



Longitudinal Hit Resolution



effect of pitch reduction in cl.size Y vs. η :

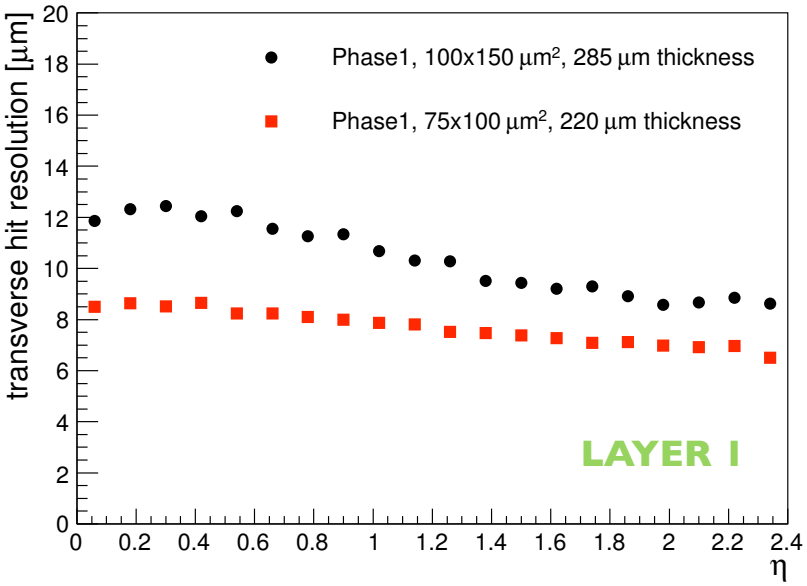


it affects position resolution!

- more than 30% improvement at η ~ 0 (single pixel clusters)
- ~10 μm improvement at |η| > 1 (significant charge sharing).

hit errors in PixelCPE code tuned accordingly!

Transverse Hit Resolution



cluster size is ~constant
in track η.
dominated by cl.size = 2.

- ~20% improvement as expected by pitch reduction
- resolution below 10 μm in full η range.

hit errors in PixelCPE code tuned accordingly