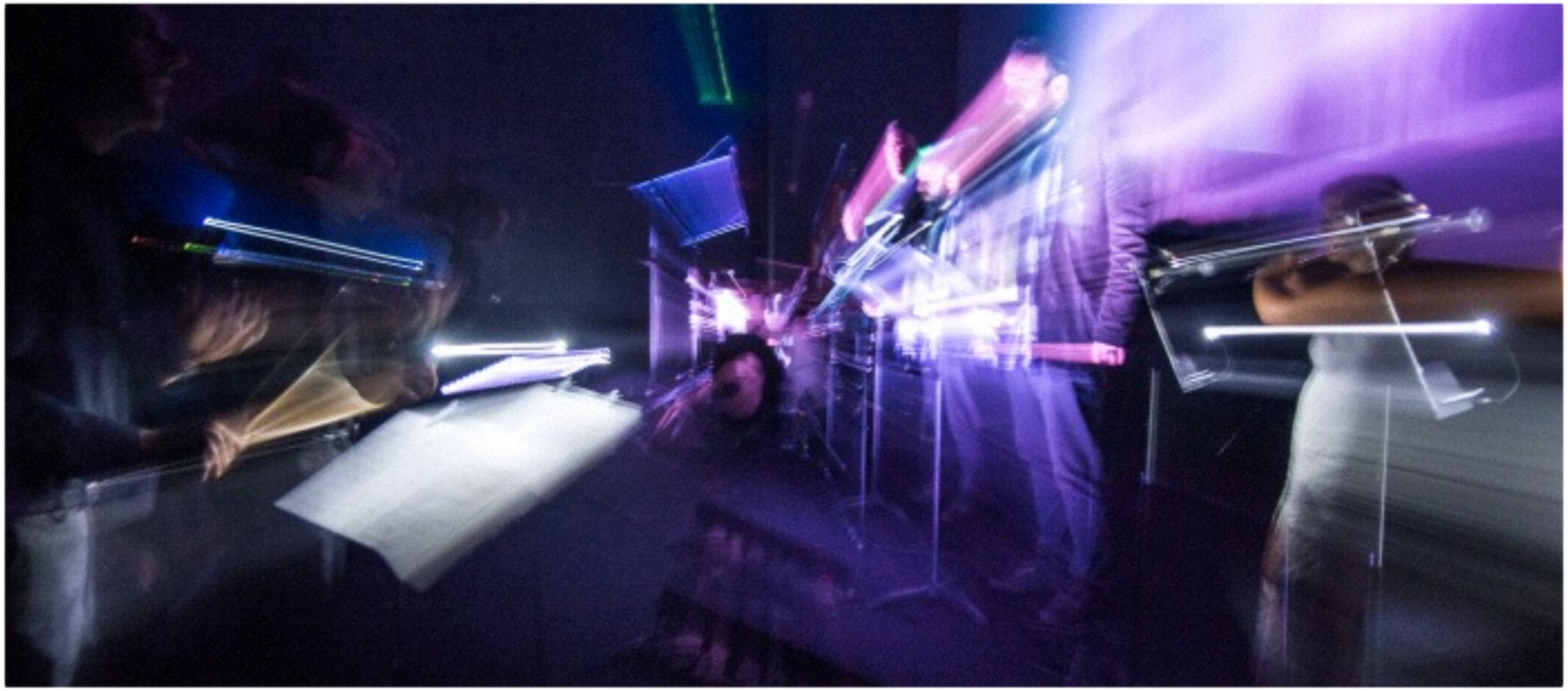

CMS Run & DPG Commissioning Workshop, Jan 24, 2017

PREPARATION FOR HIGH LUMINOSITY SCENARIOS

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High-Lumi TF Mandate

- Understand the limitations of CMS in dealing with high luminosity and high pile-up from **detectors/trigger/DAQ/computing/reconstruction/analysis**.
- Evaluate the possibility of mitigating actions, and the long-term solutions, including possible running with **lumi-leveling**.
- Focus on the conditions in 2017 and 2018, with possible extensions to conditions beyond LS2.
  - Reports for internal CMS use, and for upcoming LHC Programme Committee (LPC), LHCC meetings.
- Currently the TF meetings are held on **Wed 1–2 pm weekly**.
- INDICO category: https://indico.cern.ch/category/8576/

Thanks for all contributors!
Lots of progress since September 2016!

Milestone & Goals

- **2016: Limit at 1.5×10^{34} $cm^{-2}s^{-1}$ from pixel readout & dynamic inefficiency.** Should disappear in 2017 with the new Pixel.
- **2017–2018: Assess different machine scenarios** (and the corresponding Lumi and PU) for each systems, trigger, and object/physics performance.
- **Intermediate conclusion**
  (presented at Nov LPC meeting, also in the slides today):
  - **With the planned EYETS activities, all CMS detector systems expect to operate robustly in higher pileup conditions up to at least $L=2\times10^{34}$**
    (caveat: without the HE upgrade the situation might be changed.)
  - **Some adjustments are necessary as luminosities increase to keep data volumes within limits.**
- **Beyond LS2:** do not expect a different limit from 2017–2018.

All Things Considered (so far)

LHC options

peak lumi, integrated lumi, pile-up scenarios, lumi leveling…

Special Inputs

high-PU fill data (and the matching MC), high PU MC

Trigger development

(L1 single object thresholds, PU dependent rates)

- L1 thresholds given 100 kHz
- HLT paths given 1 kHz total average output rate

Detector readiness for HL

- Identify bottlenecks in readouts
- Identify areas where threshold increases are needed
- Measure impact on data volumes

POG performance

Identify loss of performance vs. pileup (PU dependence of efficiency & background for ID, ISO)

Computing & Storage

HLT farm size, and Tier-0 and GRID capacities

Analysis performance

To be discussed!

LHC 2017 Options

(From Mike Lamont's talk at Oct/17 LPC meeting)

- **2017 menu version v0.5:**

Phase	Days
Initial Commissioning post EYETS	35
Scrubbing (assuming machine stays cold)	7
Proton physics 25 ns	**152**
Special physics runs	8
Machine development	15
Technical stops	10
Technical stop recovery	4
Total	**231 days (33 weeks)**

(Might debate: initial commissioning; scrubbing; effect of magnet exchange)

Possible 2017 Parameters

	Nominal 25 ns	BCMS 25 ns
Beta* (1/2/5/8)	0.4/10/0.4/3	0.4/10/0.4/3
Half crossing angle	-185/200/185/-250	-155/200/155/-250
Nb	2748	2460
Nc	2736	2448
Proton per bunch	1.05e11	1.05e11
Emittance into SB	3.2	2.3
Bunch length	1.25	1.25
Peak luminosity	~1.41e34	~1.79e34
Peak pile-up	~37	~51
Luminosity lifetime	~21	~15
150 days	38 fb^{-1}	40+ fb^{-1}

β^*: 40cm

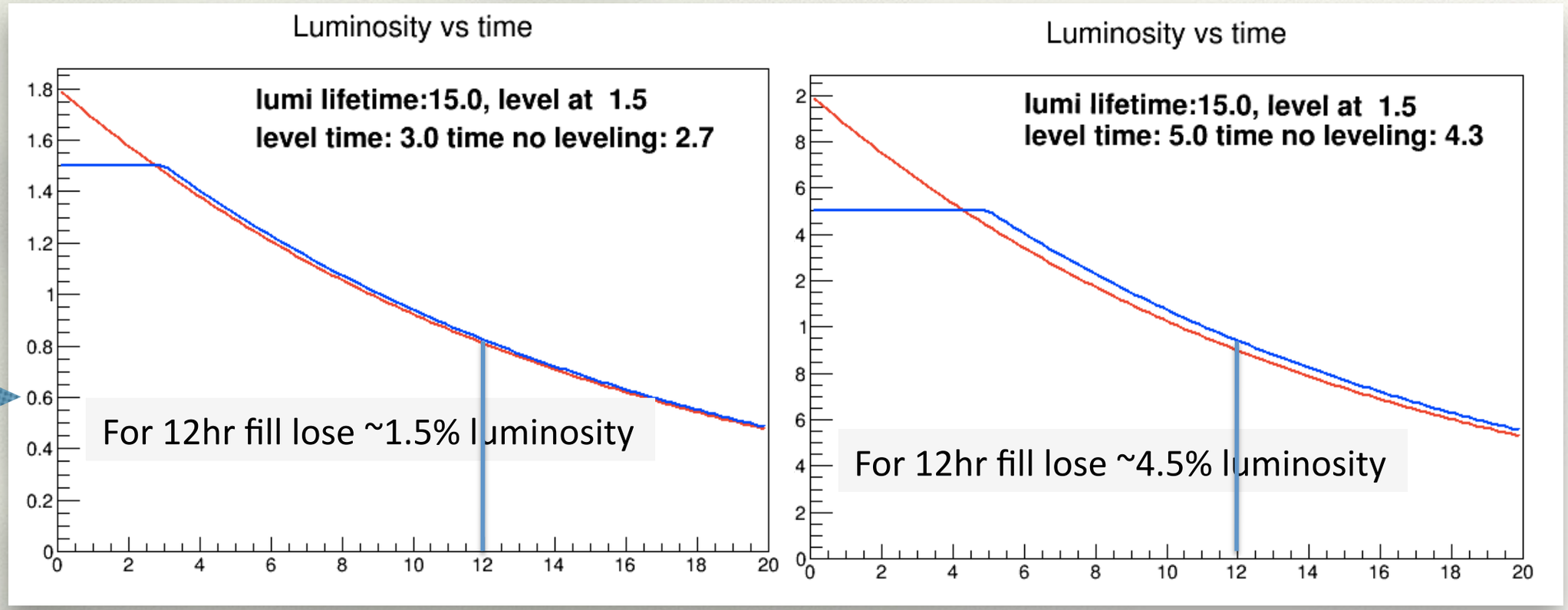
Peak luminosity	~1.52e34	~1.91e34
Peak pile-up	~40	~56

β^*: 33cm

Luminosity Leveling

(From J. Boyd's talk at LPC meeting Nov/21)

Assuming protons are lost only by burn-off



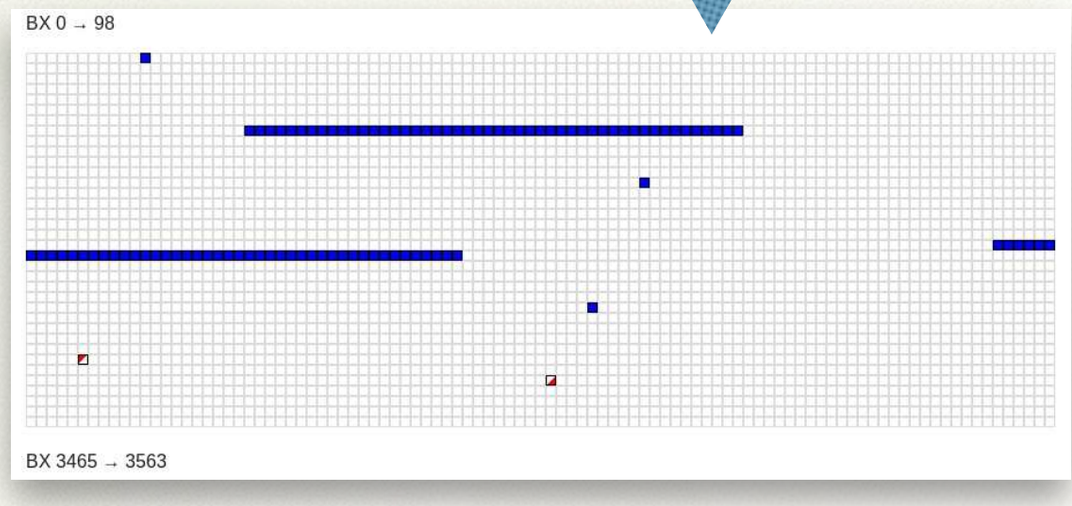
(Loss of luminosity is significantly larger if fill lost early)

- **Offset lumi leveling** (as already implemented for LHCb) is the most cost-effective method so far.
- The hard limit of 1.7×10^{34} from LHC inner triplet cooling can be removed. **So applying lumi-leveling or not should be most likely from experiments (us).**

→ **We can decide to have leveling or not**

High PU Test Fill

trains & isolated BXs providing different information

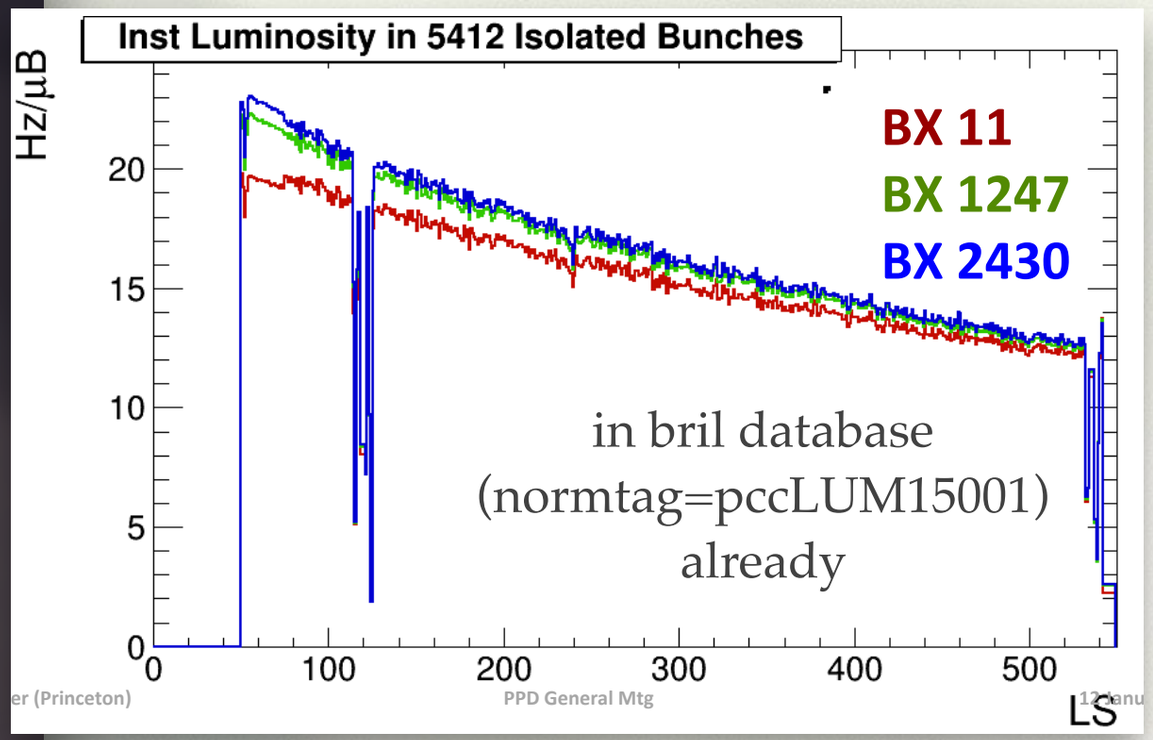


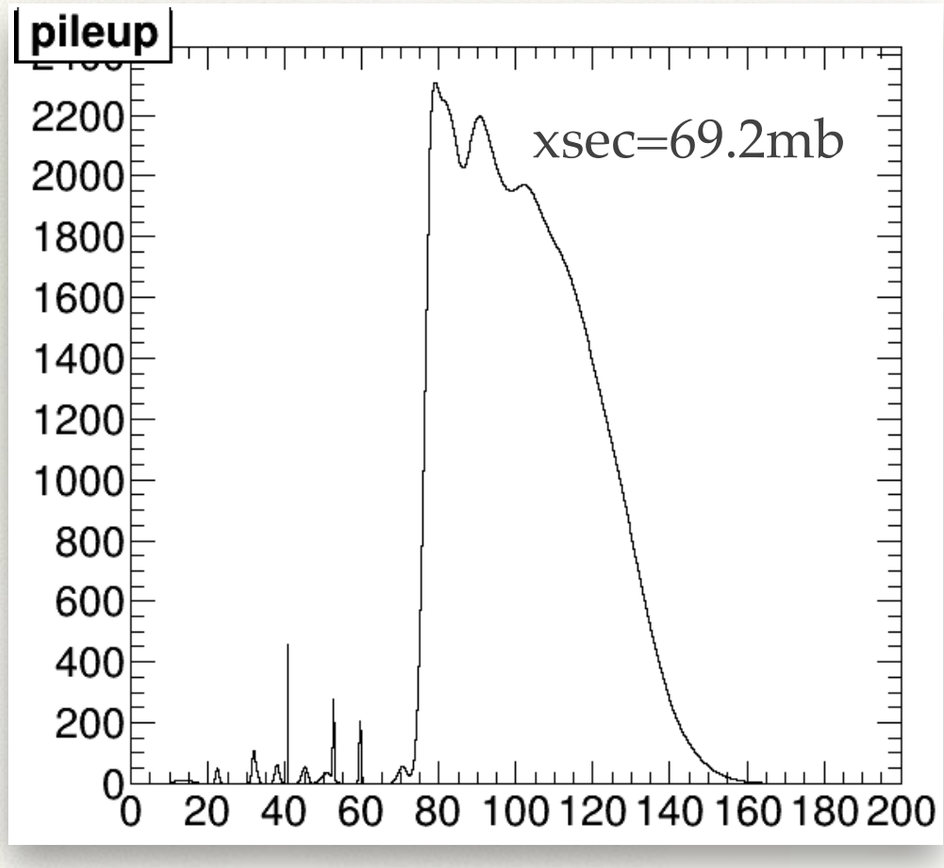
- **High PU fill 5412, run 283171:**
  - **2 trains of 48 bunches**
    ~ 1.3×10^{11} protons/bunch
  - **3 isolated colliding bunches**
    ~ **1.8×10^{11}** protons/bunch
- **Trigger:**
  - Max L1 rate = 25kHz, Max (L1+Randoms) rate = 38.8kHz
  - Prescale columns changed during the run.
- **DAQ:** data rate out of HLT peaked at ~7.6 GB/sec.
- **Tier-0:** the file size per lumi section is >50 GB/sec, data can't be reconstructed normally.
- **Extract the exact lumi profile, and produce a matched MC.**
- Studies for each system, trigger, and object performance are ongoing.

Lumi for Isolated BXs

(Chris's talk at Jan/12 PPD meeting)

- The HF and PLT(online luminometers) had very different measurements in the isolated bunches and so we left PU estimates void until Pixel Cluster Counting (PCC) was available.
  - Re-reco needed because of technical mismatch in our alcareco trigger bit and special naming conventions in this fill's HLT menu.
  - PLT is much closer to PCC's measurement: **PCC/PLT ~0.9** (HF is much farther off)

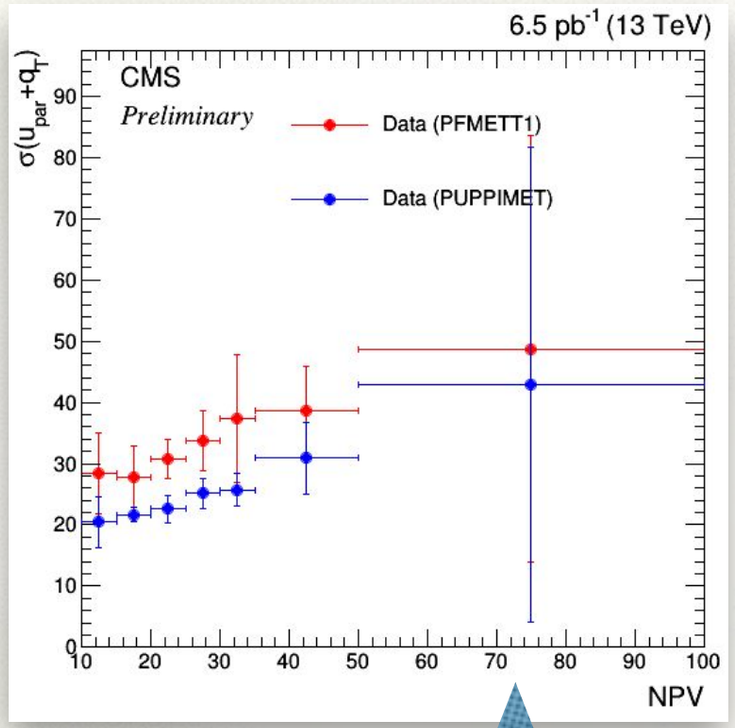




POG Studies

(From Markus's summary at Dec/14 TF meeting)

- **At Dec/8 PPD meeting, POGs reported on pile-up dependencies using 2016 data or the high PU run 283171:**
  - https://indico.cern.ch/event/594147/
  - **JME, EGM, TRK, L1T, Tau**
    (BTV reported in August already)
- **General trends:**
  - **Linear PU dependencies extends into high PU regime (PU > 45).**
  - Exceptions are L1 sum trigger (**ETM, HTT**)
- **Caveat:**
  - Tracking related observables show pixel dynamic inefficiency effect, not present in 2017 (so we hope!).
- **Next step:**
  - Analyze and tune performance using 81x simulation.

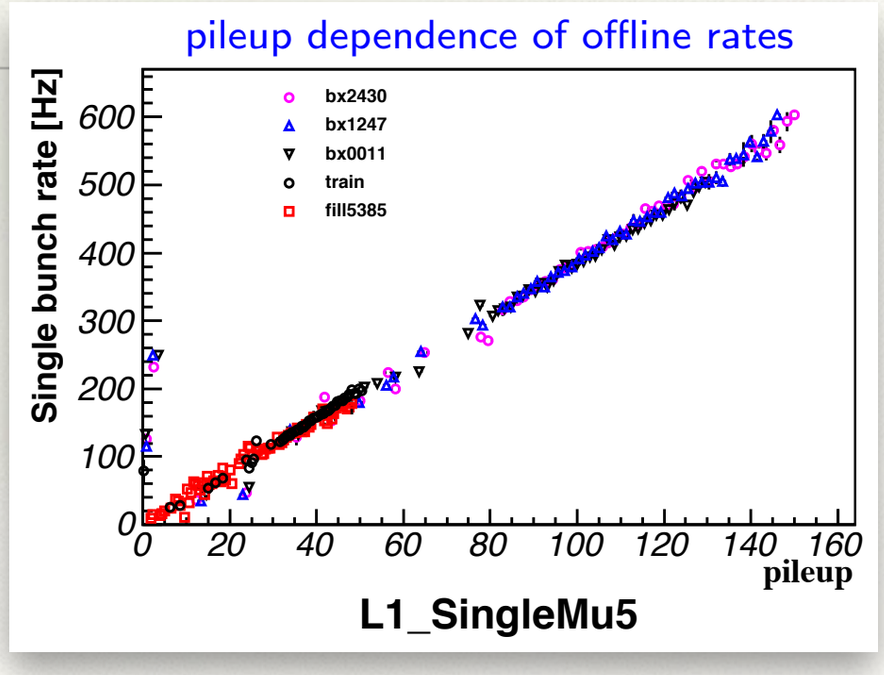


MET resolution from high PU fill

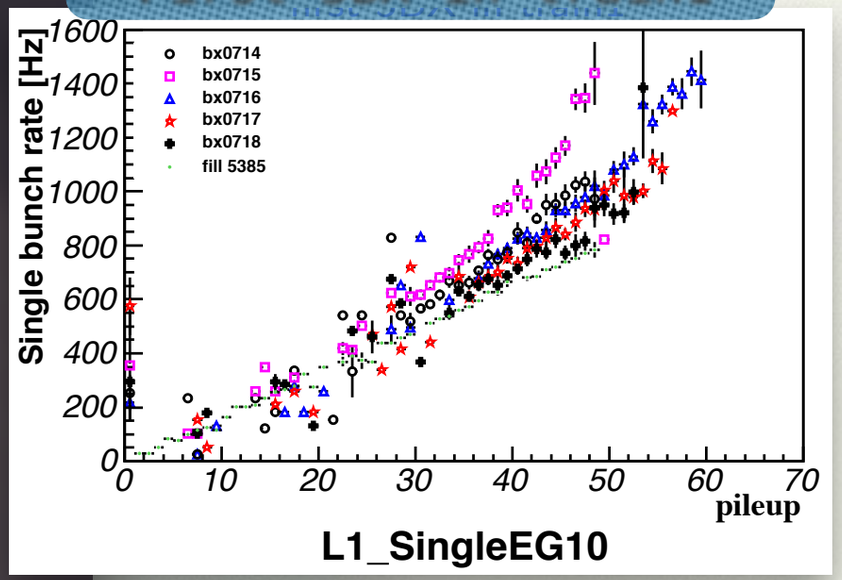
L1 Rate Studies

(From Takashi's summary at Jan/18 TF meeting)

- Studied L1 rates in terms of pileup for the high pileup run, comparing rates to those of isolated bunch fill:
  - Muon rates show linear dependence on pileup
  - Calorimeter rates show dependence on bunch position in a train to some extent
  - Strong dependence seen in energy sum rates



First 5BX in train1



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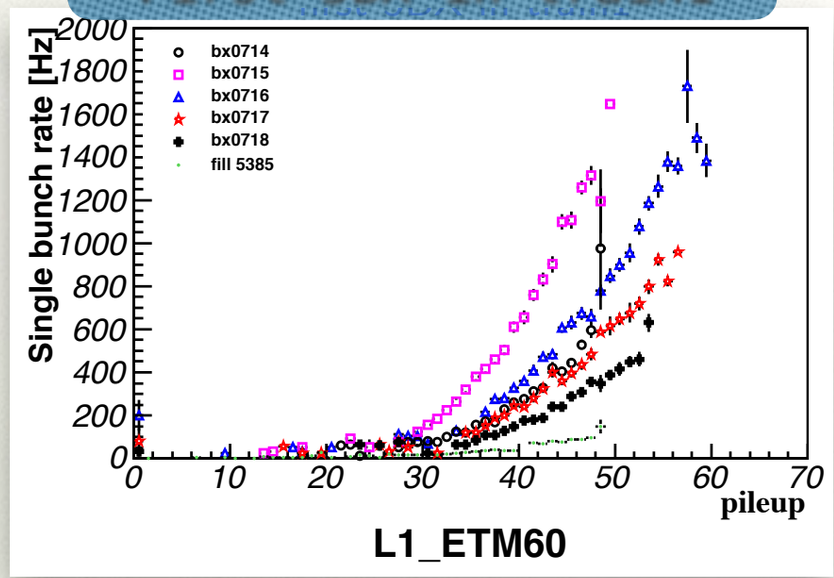

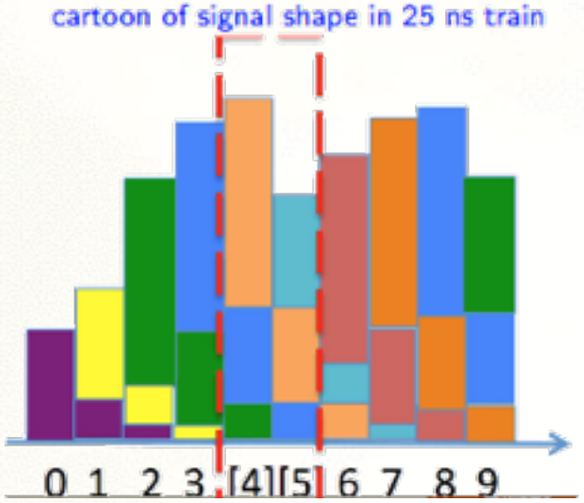

Preliminary 2017 L1 Menu (From Pamela's summary at Mumbai week)

- **L1Menu rate**
  - 1.5 kHz ZeroBias,
  - 4kHz EXO NotBptxOR
  - 5kHz Buffer
  - Tuned to ~89 kHz
- **L=1.7e34**
  - Expect 83 kHz
- **L=2e34**
  - Expect 89 kHz
  - Thresholds may be higher
  - Almost no x-triggers

	1.6E34	1.7E34	2E34
L1_SingleMu	22	22	25
L1_SingleMuer	20	20	22
L1_DoubleMu	13, 6	13, 6	13, 6
L1_SingleEG	38	38	42
L1_SingleEGer	36	36	40
L1_SingleIsoEGer	34	34	38
L1_DoubleEG	25,12	25, 12	25, 13
L1_SingleJet	180	18	18
L1_DoubleJetC	112	112	112
L1_QuadJetC	50	50	50
L1_DoubleIsoTauer	30	30	33
L1_HTT	320	340	380
L1_ETM	110	120	NA

- **Note: 0th iteration – no retuning for higher lumi or PU, or L1 improvements**

Intermediate Conclusion (as presented by Greg at LPC meeting Nov/21)

- CMS phase-1 upgrade baseline: average <pileup> = 50
  - With the possibility that it may be higher at beginning of LHC fills.
- With the planned EYETS activities, all CMS detector systems expect to operate robustly in higher pileup conditions up to at least $L=2\times10^{34}$
  - Some adjustments are necessary as luminosities increase to keep data volumes within limits.
- **We are ready for higher pileup!**

Detector	1.8e34	2.0e34
SiPixel	OK (upgraded during EYETS)	OK (upgraded during EYETS)
SiStrip	OK	OK
ECAL	Changes needed, solutions exist (retune ZS threshold, spike killer, etc.).	Changes needed, solutions exist (retune ZS threshold, spike killer, etc).
HCAL	Payload is OK for HB/HF/HO. ZS threshold needs to be tuned for upgraded HE.	Payload is OK for HB/HF/HO. ZS threshold needs to be tuned for upgraded HE.
DT	OK (payload within limitation w/ reduced TDC window)	OK (payload within limitation w/ reduced TDC window)
RPC	OK (Readout chain transmission to data concentrator is bottleneck at some point L>2e34)	OK (Readout chain transmission to data concentrator is bottleneck at some point L>2e34)
CSC	OK (payload within limitation)	OK (payload within limitation)

(The caveat for HE still applies.)

Intermediate Conclusion (cont.)

- Impact of luminosity increases on L1 trigger thresholds has been evaluated with 2016 configuration
  - Studies of how this affects the CMS physics program are on-going using both simulations and high-pileup fill data
  - A program of optimisation and more sophisticated trigger logic schemes (enabled by recent L1 upgrades) is underway
- Impact of high pileup (> 50) on data quality and quality of reconstructed physics objects is not yet complete
  - Expect to have initial conclusions soon.
  - **Consensus principal:** lower average pileup conditions, for a given integrated luminosity through LS2 (or LS3), will result in higher quality physics results for CMS

Summary & Foreseeable Studies

- **The ingredients are (almost) in place:**
  - Preliminary 2017 LHC scenarios and parameters
  - High PU test fill data and the matching MC (and existing 2016 samples)
- **Preliminary L1 menu has been prepared by TSG**, at the targeting benchmarking scenarios.
- **First feedbacks from POGs are available:** either with the high PU run or 2016 data samples.
- **Foreseeable studies:**
  - Further studies for the high PU run: lumi, L1 rates, etc.
  - **For DPGs:** whether the cancellation of HE upgrade during the EYETS matters; whether the "green lights" up to ~60 pileup are still valid.
  - **Expect to hear more from POGs** regarding the PU-dependent performance.
  - **Interaction with PAGs** — studies based on tentative object performance & trigger menu are expected.