Update on CMS activities

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HH->bbμμ analysis

Working on Bamboo-based (NANOAOD) framework:
- last time try to use bbWW selection -> factor Data/MC ~ 0.5

Switched to AN2019_090 H(μμ) selections

Muon selections:
```
mu.pt > 20.,
op.abs(mu.eta) < 2.4,
mu.mediumId, # https://twiki.cern.ch/twiki/bin/viewauth/CMS/SWGuideMuonIdRun2#Medium_Muon
mu.pfIsoId == 2, # https://twiki.cern.ch/twiki/bin/viewauth/CMS/SWGuideMuonIdRun2#Particle_Flow_isolation
```

Electron selections:
```
ele.pt > 20.,
op.abs(ele.eta) < 2.5,
ele.mvaFall17V2noIso_WP90, # https://twiki.cern.ch/twiki/bin/view/CMS/MultivariateElectronIdentificationRun2#Differences_between_V1_and_V2
```

No requirement of only two muons in the event: very low statistics

HH->bbμμ analysis

```
#####################################
#      Primary Vertex Cut           #
#####################################
noSel = noSel.refine("PrimaryVertex", cut = (tree.PV).npvsGood > 0)
# the one with the largest value of summed physics object pT^2 (PV.score) is taken to be the primary interaction vertex
if self.args.PrintYield:
    self.yields.add(noSel, title="npvsGood")
```

```
#####################################
#      3.2 Muons    Selection       #
#####################################
self.muons = op.sort(muonDef(tree.Muon), lambda mu: -mu.pt)
MuonPairs = op.combine(self.muons, N=2, pred=lambda l1,l2 : op.AND(l1.charge != l2.charge)) #op.NOT(hasAssociatedJet(l1)),op.NOT(hasAssociatedJet(l2))))
noSel = noSel.refine("TwoOppositeChargeMuons", cut = op.rng_len(MuonPairs) > 0)
if self.args.PrintYield:
    self.yields.add(noSel, title="TwoOppositeChargeMuons")
```

```
ptThreshold = {"2016" : 26.,
               "2017" : 29.,
               "2018" : 26.
               }
triggerMuObj  = op.select(tree.TrigObj, lambda trgObj: op.AND( trgObj.id == 13))
                                                                #, (trgObj.filterBits & 2) ))
MatchedMuons = op.select(self.muons, lambda mu : op.AND(mu.pt > ptThreshold[era],
                                                        op.rng_any(triggerMuObj, lambda trgObj : op.deltaR(mu.p4,trgObj.p4)< 0.1)))
noSel = noSel.refine("MatchedTriggerObject", cut = op.rng_len(MatchedMuons) > 0)
if self.args.PrintYield:
    self.yields.add(noSel, title="MatchedTriggerObject")
```

HH->bbμμ analysis

```
# - Ordered by Pt
self.ak4JetsByPt = op.sort(op.select(tree.Jet, lambda j : op.AND(
    j.pt > 30.,
    op.abs(j.eta) < 2.5,
    jetId & 1 if era == "2016" else j.jetId & 2, # bit2 is tight
    op.OR(((j.puId >> 2) & 1) ,j.pt > 50.), # Jet PU ID bit1 is loose
    op.NOT(op.rng_any(self.muons, lambda im : op.deltaR(j.p4, im.p4) < 0.4)),
    )), lambda j : -j.pt)
noSel = noSel.refine("AtLeastTwoJets", cut = op.rng_len(self.ak4JetsByPt) > 1)
if self.args.PrintYield:
    self.yields.add(noSel, title="AtLeastOneBtaggedJet")
```

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+ Control Regions (H(μμ), Z(μμ), H(b-jets), Z(b-jets), Sidebands)

- Check for failed jobs and resubmit them
- Force hadd and plotting even if no all MC samples finished to be processed
- Automatic generation of pdf file containing all plots and yields table

HH->bbμμ analysis

Cat.	NoSelection	npvsGood	TwoOppositeChargeMuons
signal	17.5 ± 0.5	0.4 ± 0.0	0.0 ± 0.0
DY	1113504708.1 ± 30064845.4	73213710.3 ± 1976857.9	5134.7 ± 21
VVV	5269636.3 ± 142300.5	877836.5 ± 23706.9	110.5 ± 6.
VV	273346.4 ± 7380.4	439414.7 ± 11865.3	21.3 ± 1.
Rares	218718.2 ± 5905.5	1191373.3 ± 32177.0	5.1 ± 1.3
SingleT	709969.9 ± 19169.4	2176584.3 ± 58770.6	24.0 ± 2.
TTJets	24655.0 ± 665.7	6950002.9 ± 187673.1	173.1 ± 15
ttVX	207724.3 ± 5608.7	16071.6 ± 434.3	0.9 ± 0.1
ttbar	216553.6 ± 5847.0	6791504.1 ± 183371.4	162.5 ± 5.
GluGluToContinToZZ	960.9 ± 25.9	518.1 ± 14.0	0.1 ± 0.0
WJets	73318.1 ± 1979.6	550963599.2 ± 14876539.7	5.5 ± 14.
SM	150098.2 ± 4052.7	30480.8 ± 823.7	1.3 ± 0.4
Tot. MC	1120649688.8 ± 30257758.6	642651095.9 ± 17352037.8	5639.0 ± 22
Data	—	788079500	14715
Data/MC	—	$\boxed{1.23 \pm 0.03}$	2.61 ± 0.1

Cat.	MatchedTriggerObject	NoElectrons	AtLeastOneBtaggedJet	AtLeastTw
signal	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0
DY	4781.6 ± 202.4	4781.8 ± 202.4	319.4 ± 47.1	319.4
VVV	104.4 ± 6.4	102.2 ± 6.3	15.1 ± 2.2	15.1
VV	20.1 ± 1.1	19.4 ± 1.1	7.6 ± 0.6	7.6
Rares	4.1 ± 1.2	3.7 ± 1.2	0.5 ± 0.6	0.5
SingleT	22.9 ± 2.1	22.2 ± 2.1	9.7 ± 1.4	9.7
TTJets	158.7 ± 15.3	145.1 ± 14.8	110.7 ± 13.5	110.7
ttVX	0.9 ± 0.1	0.8 ± 0.1	0.7 ± 0.1	0.7
ttbar	154.0 ± 4.9	146.6 ± 4.7	118.4 ± 3.9	118.
GluGluToContinToZZ	0.1 ± 0.0	0.1 ± 0.0	0.0 ± 0.0	0.0
WJets	0.2 ± 13.7	0.2 ± 13.7	0.0 ± 0.0	0.0
SM	1.3 ± 0.4	1.2 ± 0.4	0.5 ± 0.1	0.5
Tot. MC	5248.2 ± 212.0	5223.2 ± 211.5	582.7 ± 50.7	582.7
Data	12901	12884	1917	1
Data/MC	2.46 ± 0.10	2.47 ± 0.10	3.29 ± 0.30	3.29

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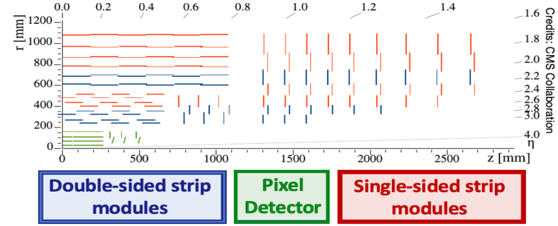
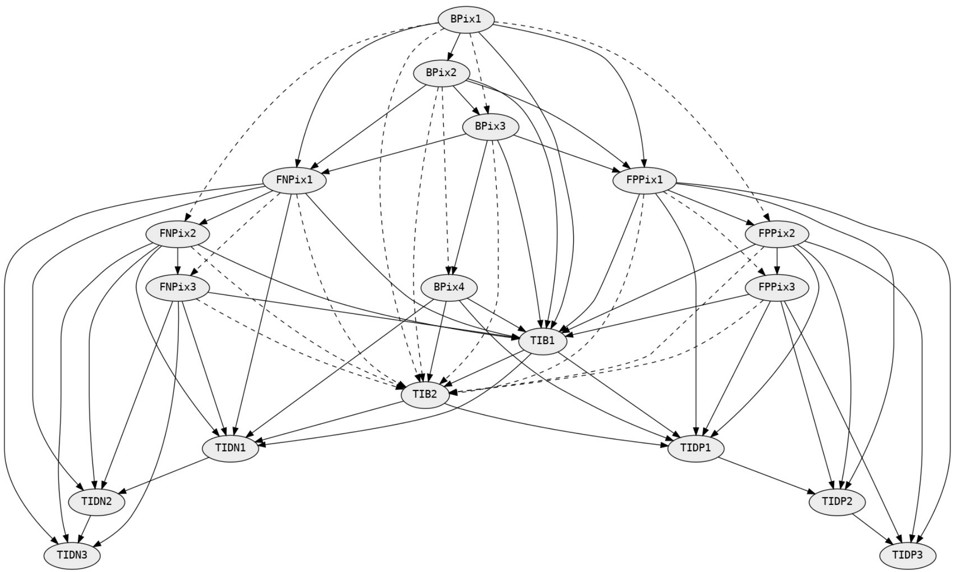
CA extension to strip

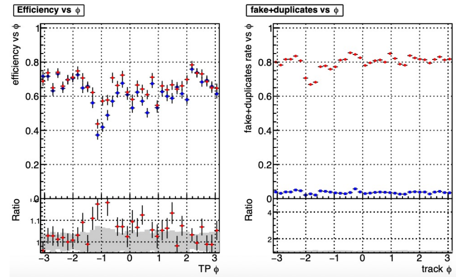
- Improvement of the workflow to accept additional parameters as input from config file (minz, maxz, maxr) to optimize them in the CA autotuning -> useful for Phase1, Phase2, HIon



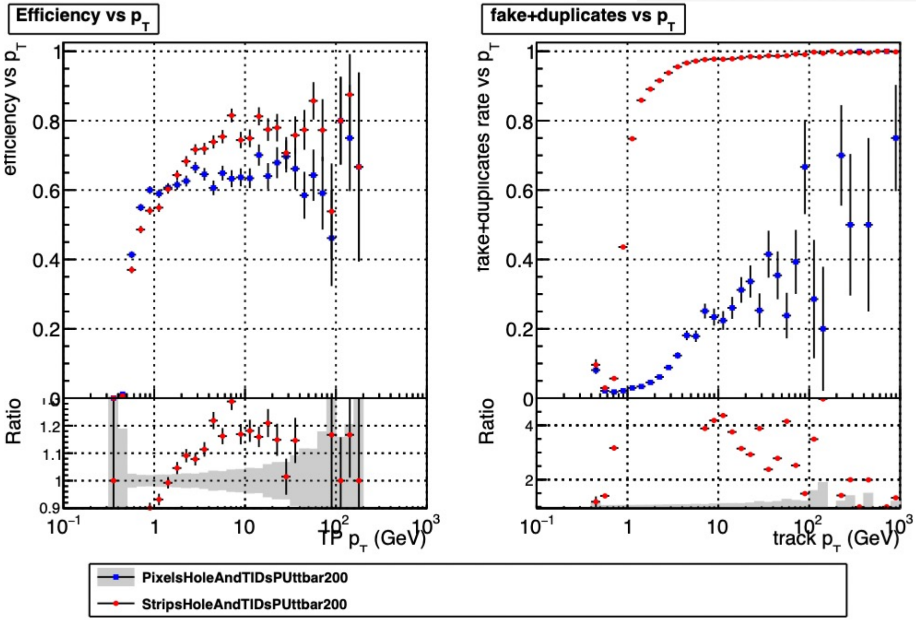



```cpp
struct LayerPairData {
  Layer inner;
  Layer outer;
  int16_t phicut;
  float minz;
  float maxz;
  float maxr;
};

enum Layer : uint8_t {
  BPIX1 = 0,
  BPIX2,
  BPIX3,
  BPIX4,
  FPIX1Pos,
  FPIX2Pos,
  FPIX3Pos,
  FPIX1Neg,
  FPIX2Neg,
  FPIX3Neg,
  TIB1,
  TIB2,
  TID1Pos2D,
  TID1Neg2D,
  nLayers
};

constexpr LayerData layerData[nLayers] = {
  {0,     96   },,      // BPIX1
  {96,    320  },       // BPIX2
  {320,   672  },       // BPIX3
  {672,   1184 },       // BPIX4
  {1184,  1296 },       // FPIX1Pos
  {1296,  1408 },       // FPIX2Pos
  {1408,  1520 },       // FPIX3Pos
  {1520,  1632 },       // FPIX1Neg
  {1632,  1744 },       // FPIX2Neg
  {1744,  1856 },       // FPIX3Neg
  {1856,  2528, true},  // TIB1
  {2528,  3392, true},  // TIB2
  {4580,  4676, true},  // TID1Pos2D
  {4988,  5084, true},  // TID1Neg2D
};
```

CA extension to strip



- Improvement of the workflow to accept additional parameters as input from config file (minz, maxz, maxr) to optimize them in the CA autotuning to **decrease fake rate**



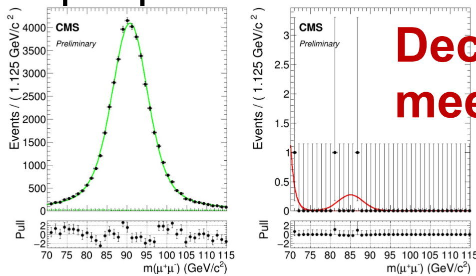
Tracking reconstruction efficiency via T&P

Tag and Probe technique is a data-driven technique widely used in CMS which uses **known resonances** (in this case **Z boson into muon pairs**), produced copiously, whose attributes are measured with high precision.

- OneProbe arbitration used to select pairs in old framework: removal of TT pairs, multiple probes associated to one tag

efficiency = (100.00 ± 0.00) %
--- parameters
Passing Probes
- $\alpha P = (-1.37 \pm 0.88) \times 10^{-2}$
- $\mu P = (9070.09 \pm 2.87) \times 10^{-2}$
- $nBkgP = (0.80 \pm 0.22) \times 10^{3}$
- $nSigP = (47.19 \pm 0.31) \times 10^{3}$
- $\sigma P = (3394.14 \pm 56.84) \times 10^{-3}$
- $\Gamma P = (500.00 \pm 6.20) \times 10^{-2}$

Failing Probes
- $\alpha F = (-99.98 \pm 64.71) \times 10^{-2}$
- $\mu F = (8500.00 \pm 210.39) \times 10^{-2}$
- $nBkgF = (0.00 \pm 0.00) \times 10^{3}$
- $nSigF = (0.00 \pm 0.00) \times 10^{3}$
- $\sigma F = (2812.38 \pm 3974.44) \times 10^{-3}$
- $\Gamma F = (120.00 \pm 238.10) \times 10^{-2}$

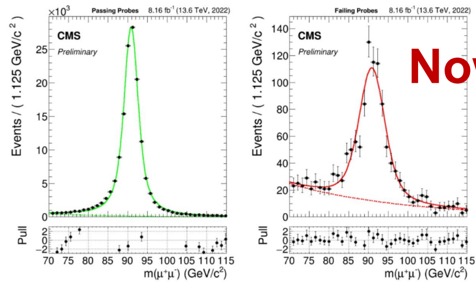


Dec meeting

Trial with exclusion of TT pairs and first good pair in the event

efficiency = (99.44 ± 0.03) %
--- parameters
Passing Probes
- $\alpha P = (-5.80 \pm 0.24) \times 10^{-2}$
- $\mu P = (9081.61 \pm 0.70) \times 10^{-2}$
- $nBkgP = (6.75 \pm 0.23) \times 10^{3}$
- $nSigP = (146.92 \pm 0.44) \times 10^{3}$
- $\sigma P = (1000.00 \pm 1.70) \times 10^{-3}$
- $\Gamma P = (303.00 \pm 1.73) \times 10^{-2}$

Failing Probes
- $\alpha F = (-3.45 \pm 0.46) \times 10^{-2}$
- $\mu F = (9084.69 \pm 17.69) \times 10^{-2}$
- $nBkgF = (0.50 \pm 0.05) \times 10^{3}$
- $nSigF = (0.83 \pm 0.05) \times 10^{3}$
- $\sigma F = (2500.00 \pm 130.44) \times 10^{-3}$
- $\Gamma F = (333.02 \pm 54.60) \times 10^{-2}$



Now