First studies with VBSMELA in ZZ → 4ljj

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Concept of MELA

Well-known method in HZZ4l analysis

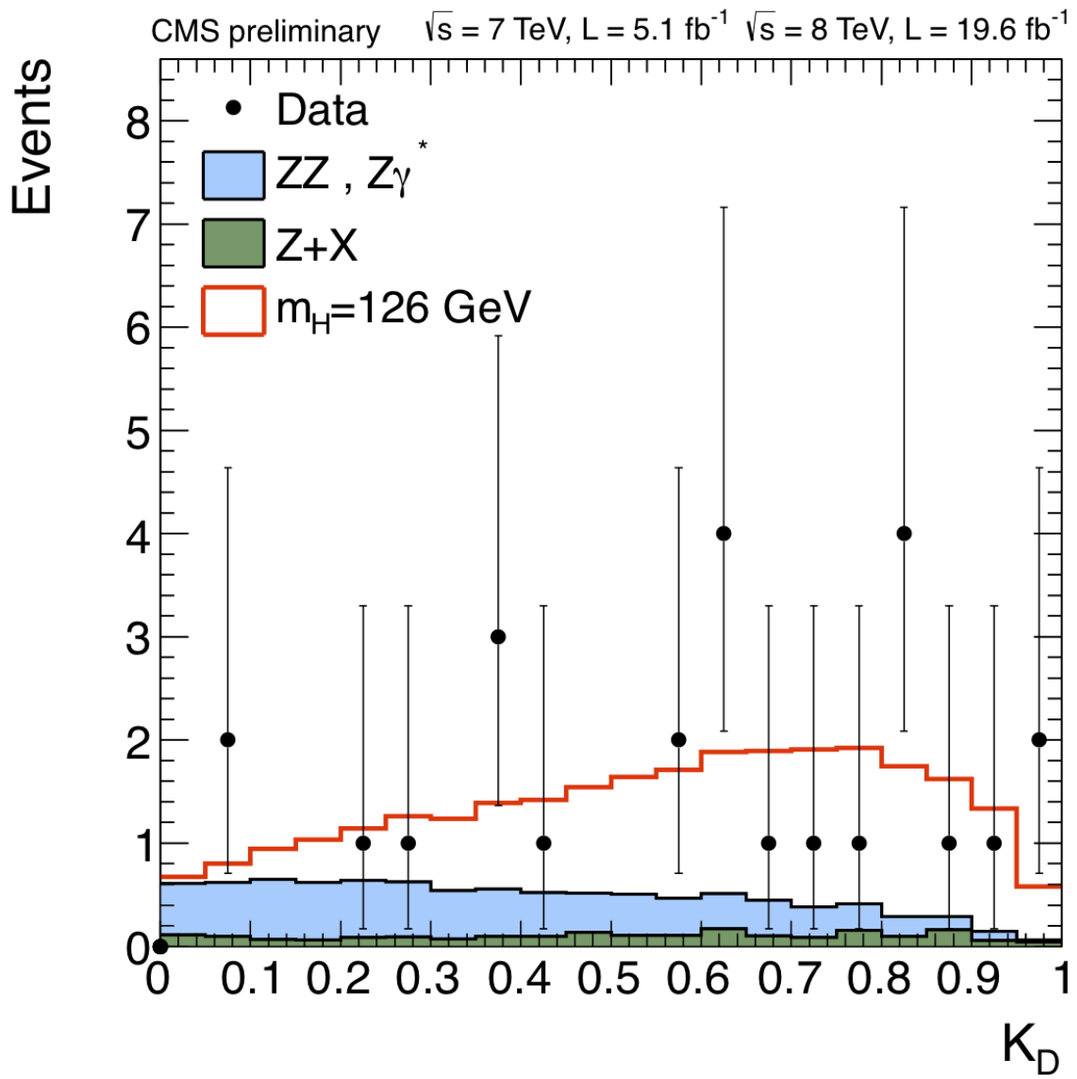
- For a given event (= 4-lepton four-momenta) construct probabilities *P* for this event to be coming from a specific production/decay process
- *P* defined using **matrix elements** computed from MC calculators **(JHUGen, MCFM …)** or analytical parameterizations

Use a signal/background **kinematic discriminant**:

$$K_D(\theta^*, \Phi_1, \theta_1, \theta_2, \Phi, M_{Z1}, M_{Z2}|M_{4\ell}) = P_{sig}/(P_{sig} + P_{bkg})$$

- *sig* and *bkg are* two production/decay processes one wants to separate
- **P are assumed normalized to 1:** otherwise there is a d.o.f in choosing the relative normalization of the two **(C-constant)**
- For a given 4l total mass there are 7 independent variables for which *P* are aggregated probabilities taken correlations into account

Well-known method in HZZ4l analysis



Status of MELA

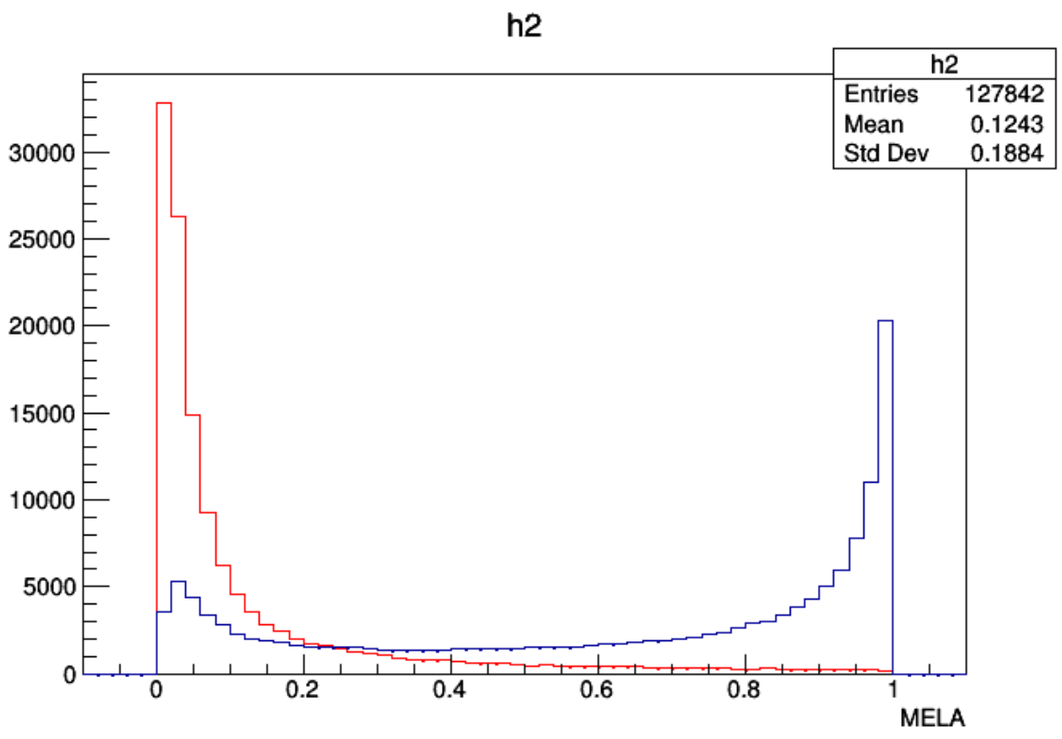
MELA V2

- Complete rewrite of interface/methods
- Addition of Mes up to *6-fermions: additional particles in the event* (other leptons/jets) can be used to target specific production modes, e.g. WH → 4l jj)

V2.0.1 released very recently

- Includes MCFM probabilities (LO QCD) for a *ZZ+2jets event* to come from:
  - QCD + 2 jets production
  - VBS production
  - EW production
- Needs 4-lepton and 2-jets input four-momenta
  - Not computed if njets < 2
  - Not computed (apparently) if one of the mll is offshell → to be clarified with authors
- Results shown here are based on a « beta » version of V2.0.1 adapted to obtain probabilities in the ROOT trees produced by the CJLST framework

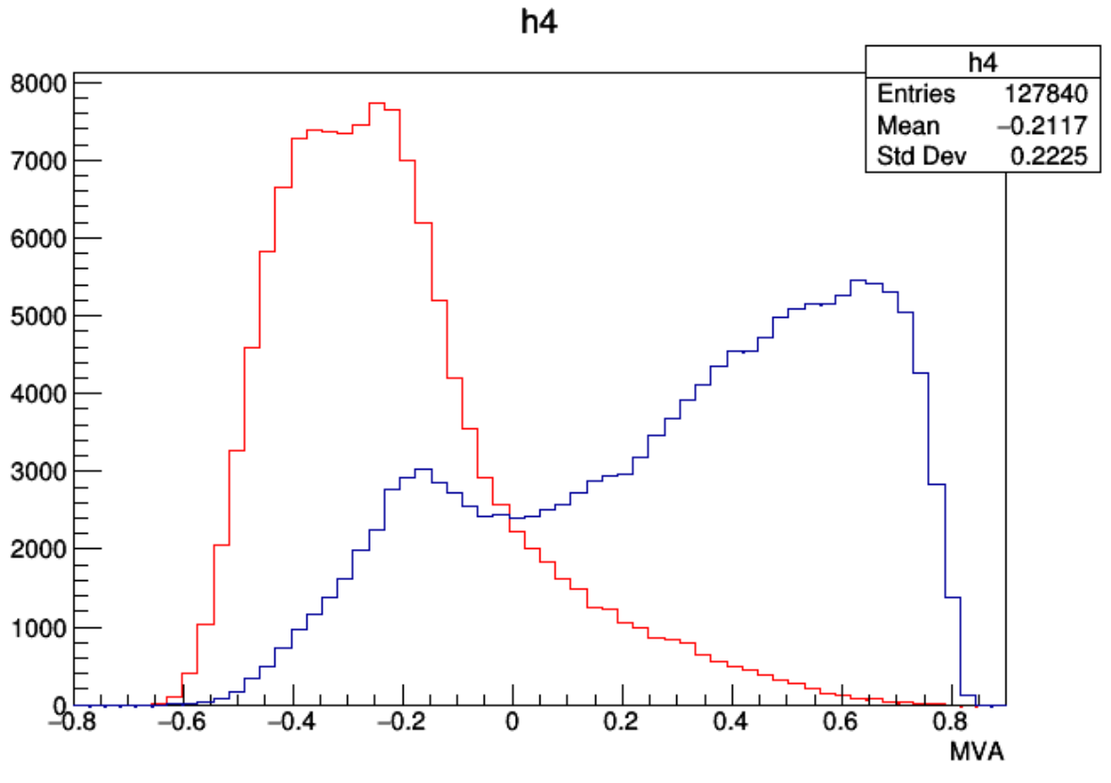
MELA and MVA



HZZ baseline selection

- njets >= 2
- 60 < mZ1, mZ2 < 120 GeV
- $K_{VBS} = P_{VBS} / (P_{VBS} + 0.2*P_{QCD})$

Sum of backgrounds
Signal



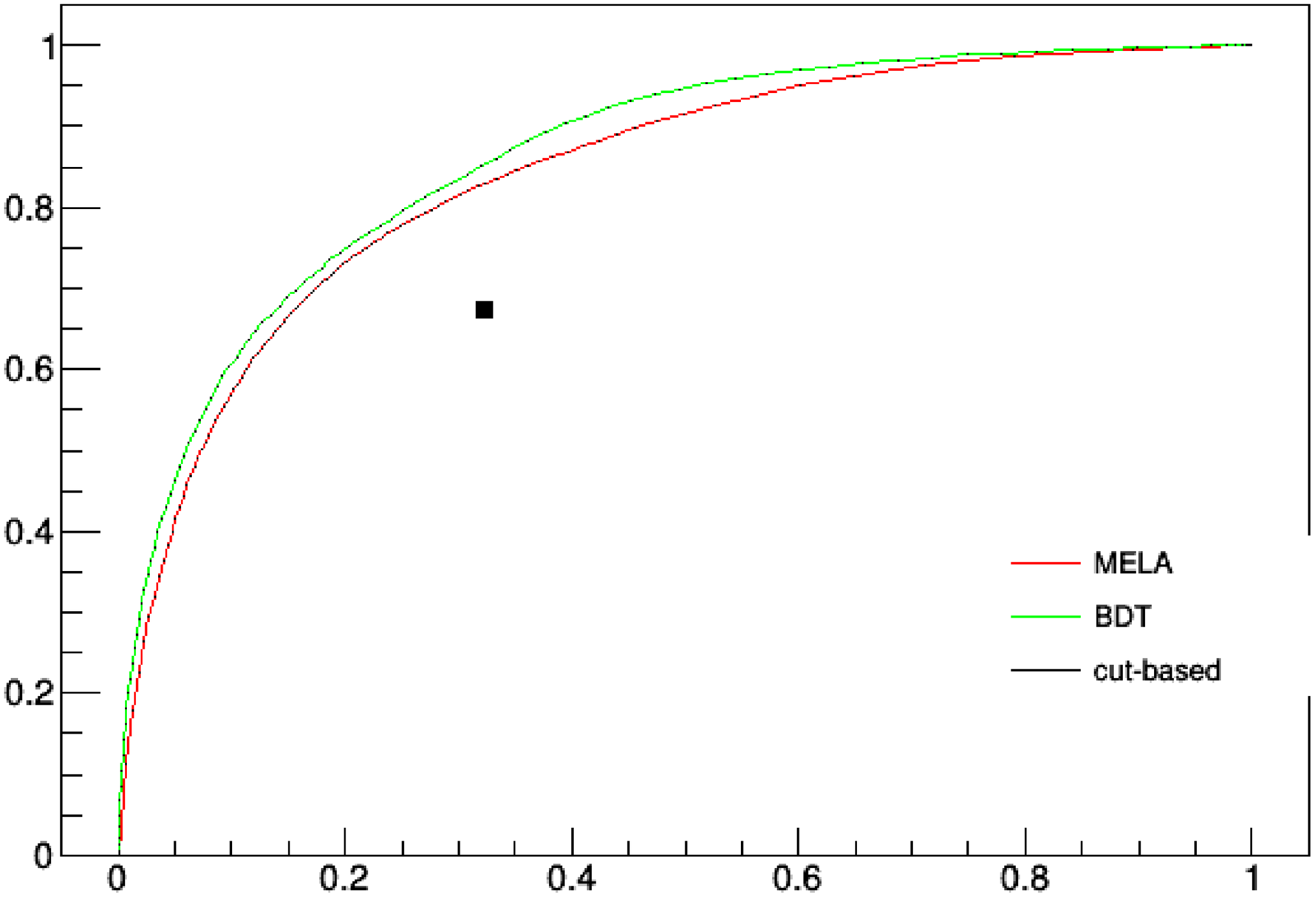
First MELA results

|DEtaJJ| > x && mJJ > y	TOTAL	x = 2 y = 250 GeV	x = 2 y = 300 GeV	x = 3 y = 300 GeV
sig	632 (100%)	411 (65%)	400 (63%)	307 (48%)
bkg	8929 (100%)	2095 (23%)	1707 (19%)	1323 (15%)

K_{VBS} > w	TOTAL	w = 0.25	w = 0.5	w = 0.75
sig	632 (100%)	478 (76%)	423 (67%)	377 (60%)
bkg	8929 (100%)	2134 (24%)	1039 (12%)	477 (5%)

The advantage over typical C&C analysis seems clear, especially at efficiencies of 50-60%

ROC Curve



Finding the optimal discriminant

Curve of signal/Sqrt(Signal + Bkg) wrt the cuts. Optimal values found to be: MELA > 0.66 and BDT > 0.34

MAX: ### Cut MELA at 0.66 : pass bkg = 4.18936 : pass sig = 3.72493 FoM = 1.32407
MAX: ### Cut MVA at 0.34 : pass bkg = 3.10582 : pass sig = 3.45895 FoM = 1.35000