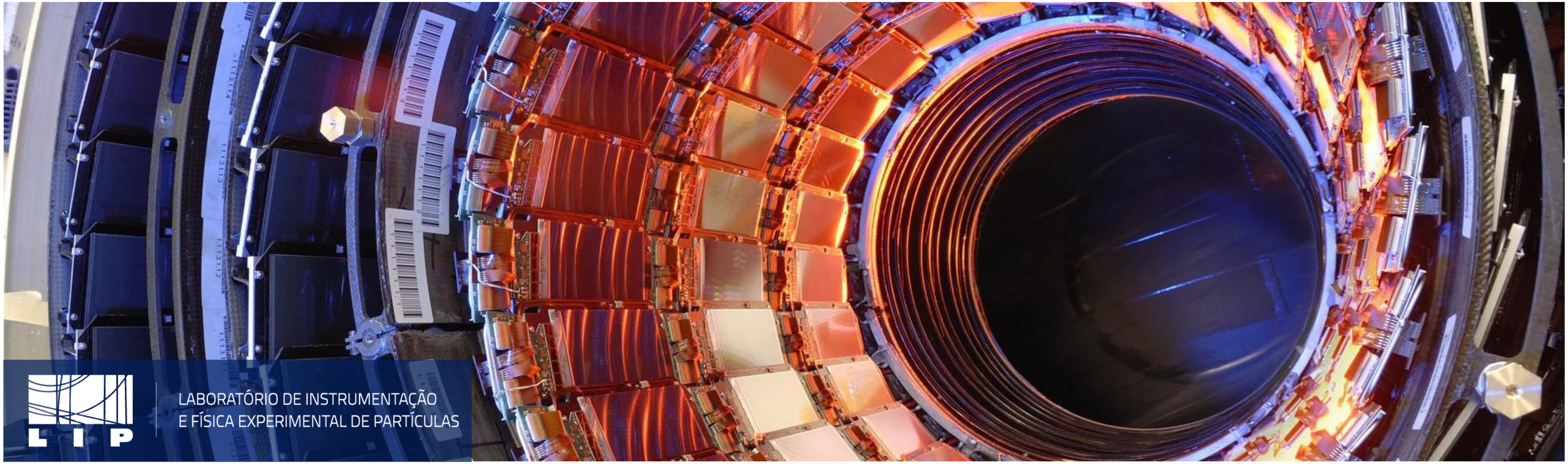
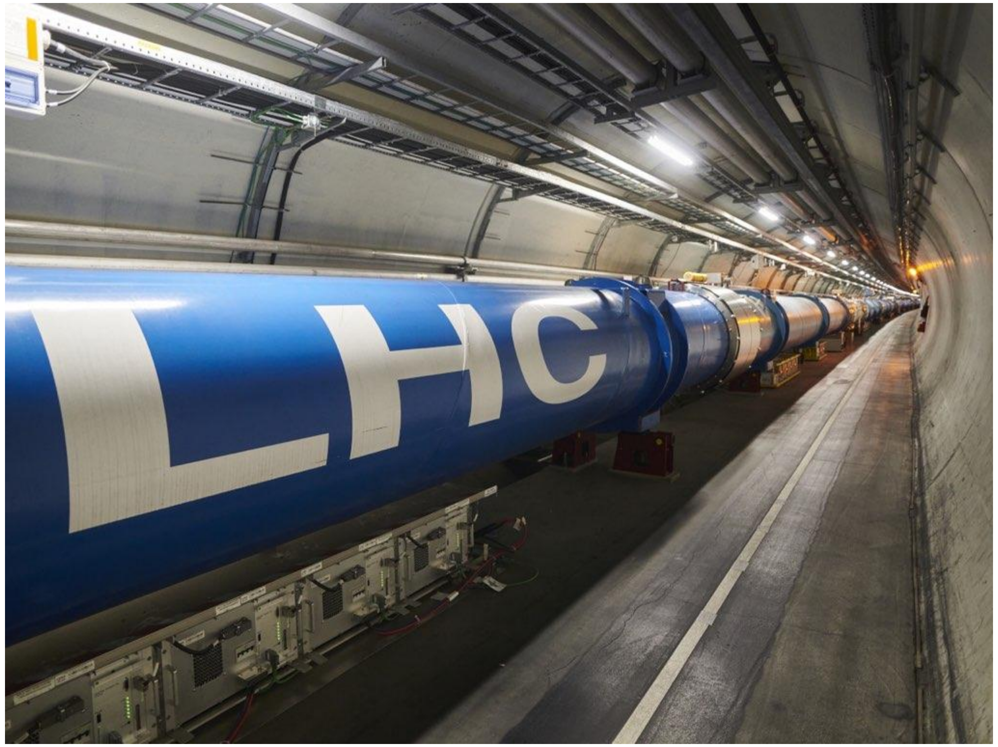
Study of central and exclusive production of tau-tau pairs in LHC

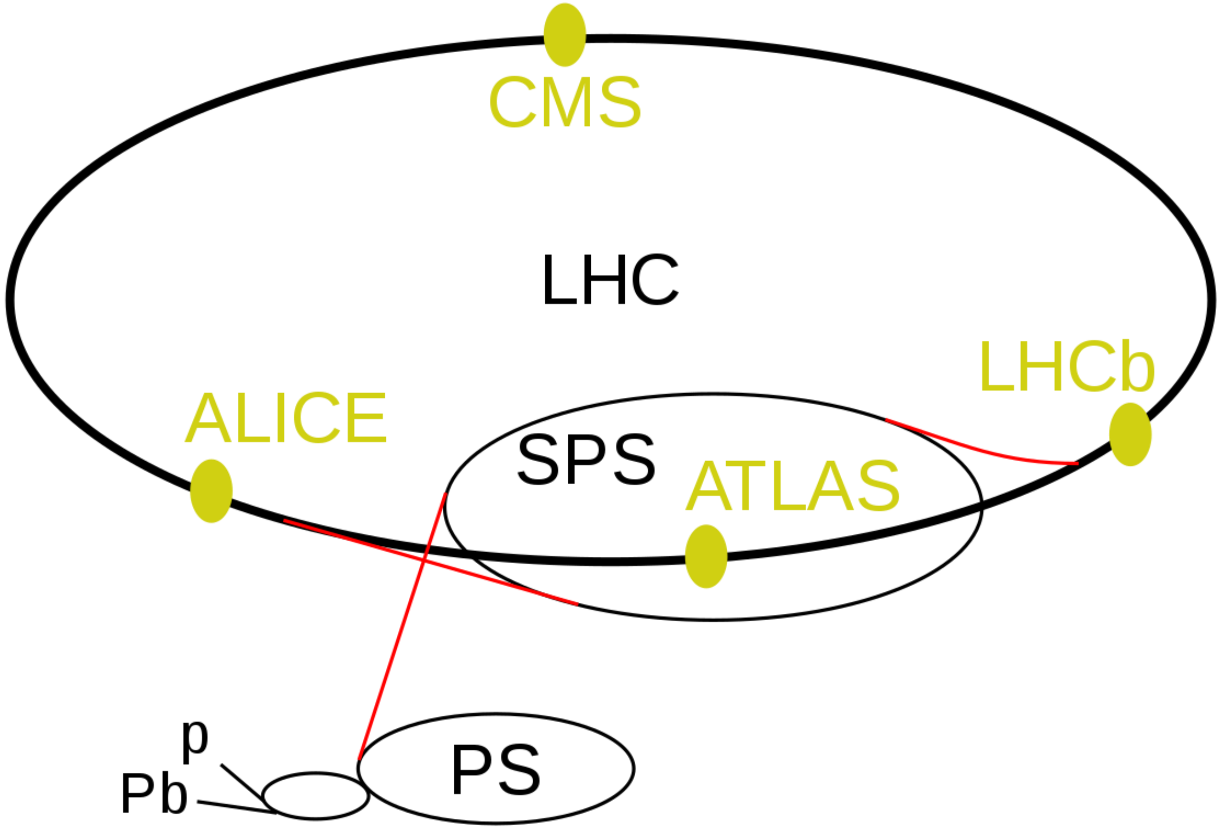
Supervisors: Matteo Pisano, Michele Gallinaro

Interns: Alexandre André, Manuel Ratola, Pedro Batista



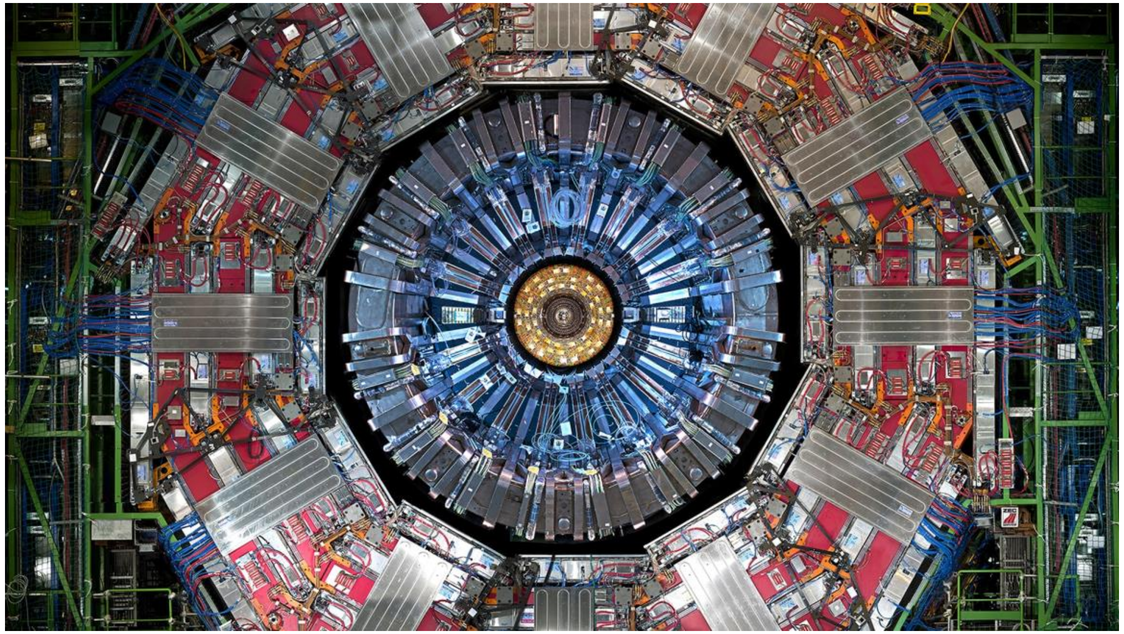
LHC-LARGE HADRON COLLIDER

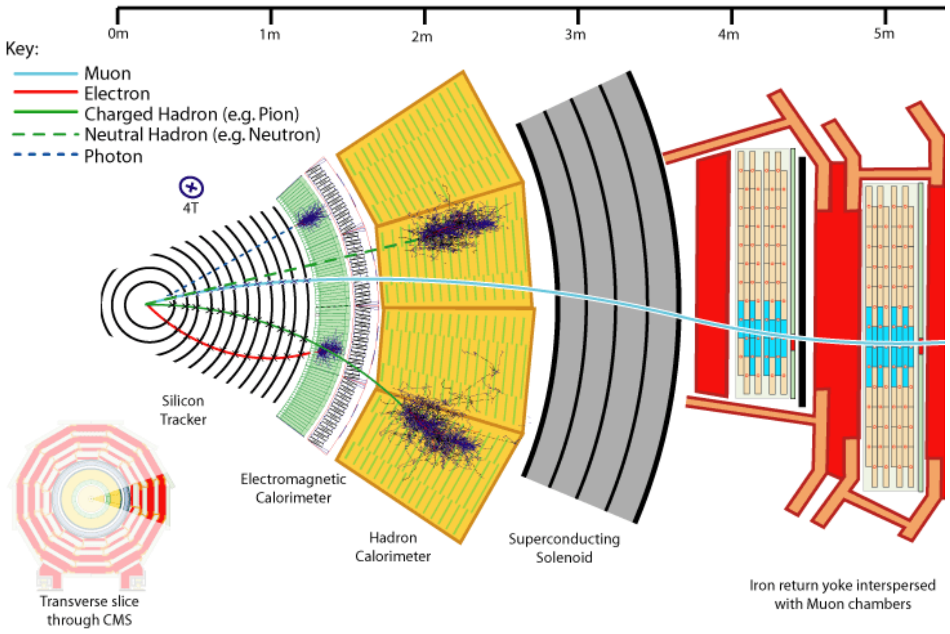




CMS- COMPACT MUON SOLENOID

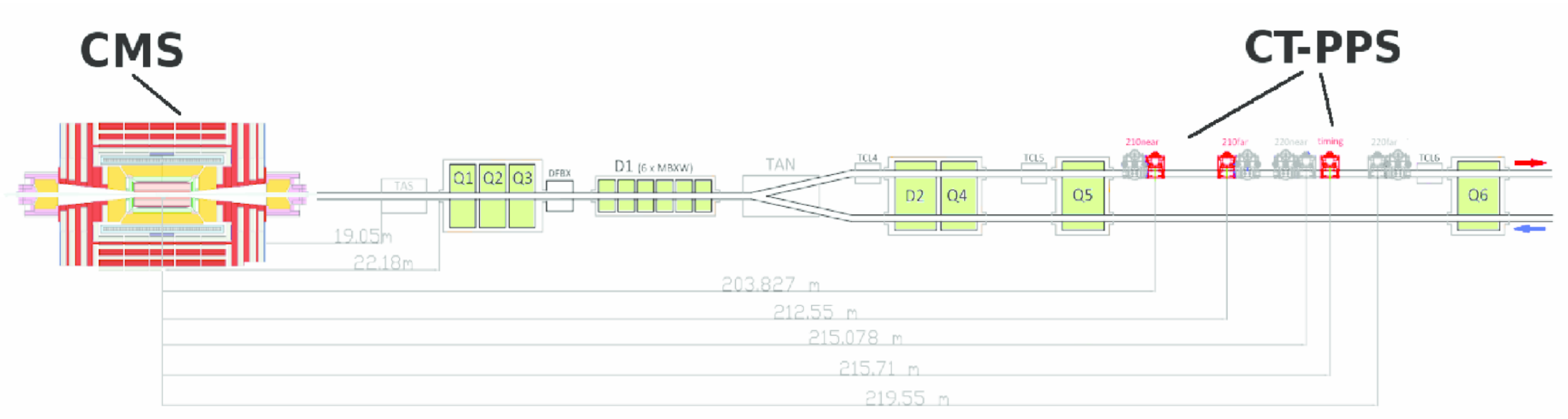
- CMS is a detector in CERN.
- Some experiments done at CMS: study Higgs Boson, exclusive processes and aspects of heavy ion collisions.

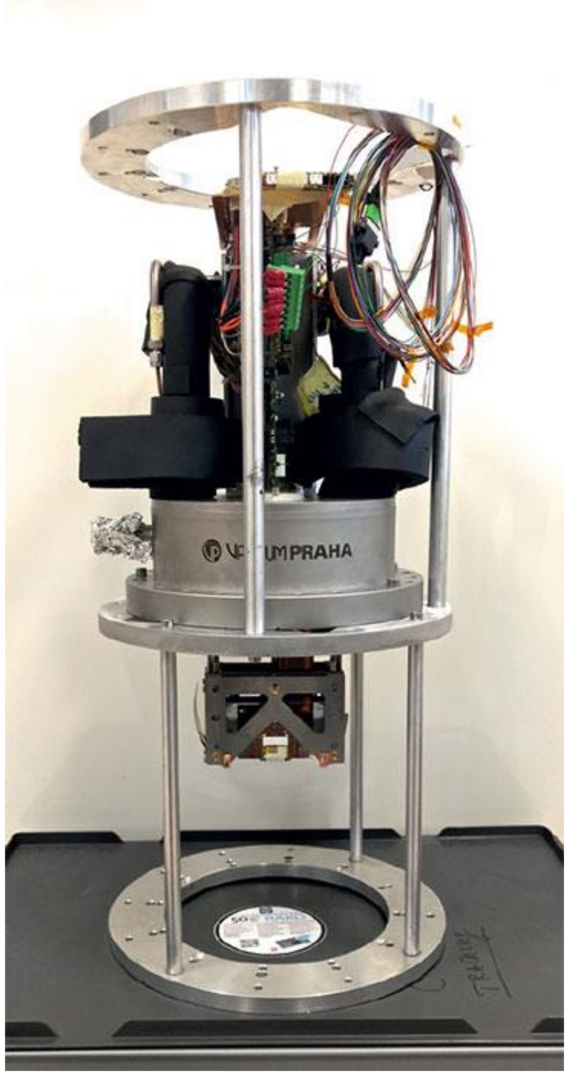




PPS- PRECISION PROTON SPECTROMETER

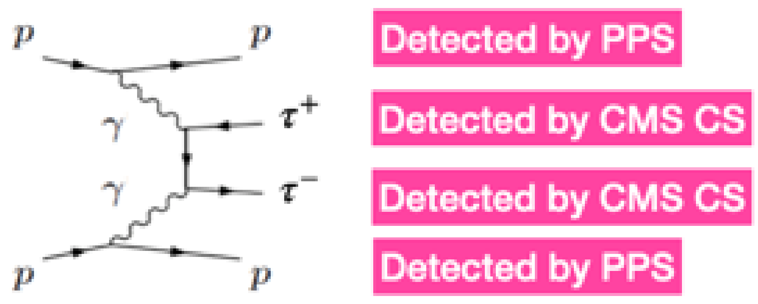
- Responsible for Proton Detection emitted with low angle

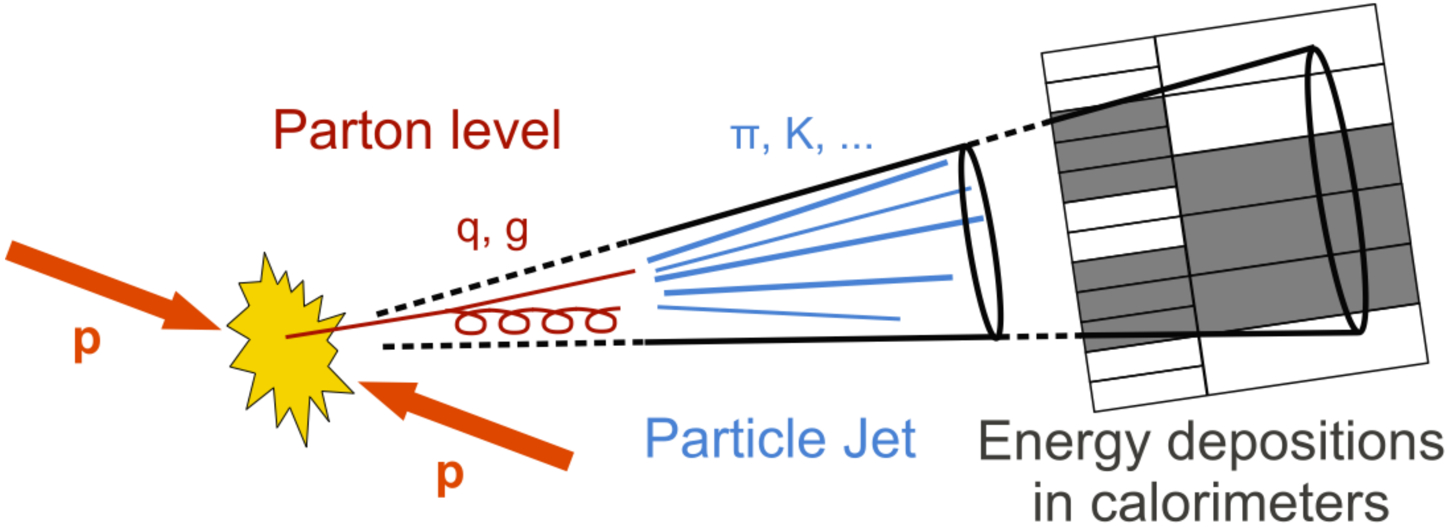


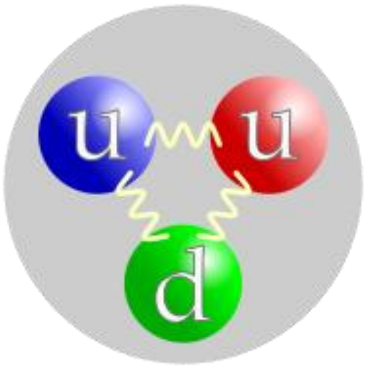


PROTON-PROTON COLLISIONS

- In IP5 the protons collide → this means that 2 quarks interact and the 4 remaining quarks originate jets in the final state.
- In our analysis we study exclusive processes characterized by undissociated protons. Because of this, there are no extra free quarks.
- The process that we study is the central exclusive production of tau-tau pairs.
- In the final state we have 3 main backgrounds: Ttjets, Drell-Yan and QCD.



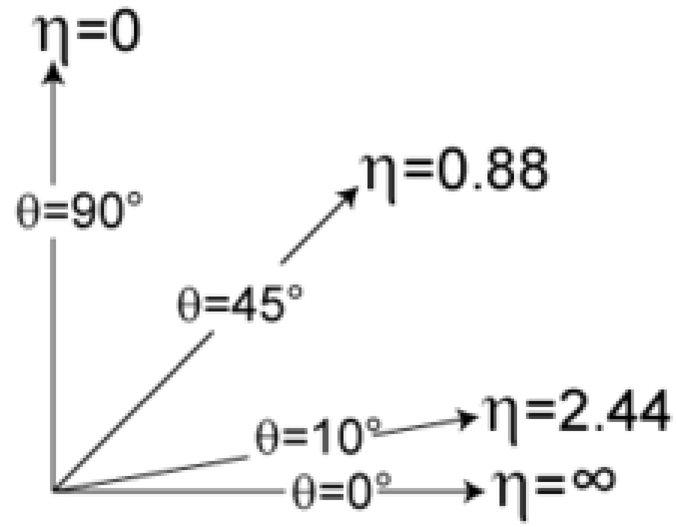




DATA PROCESSING

- Simulated data
- Triggers: HLT_IsoMu24_v
  HLT_Ele32_WPTight_Gsf_v
- Skimmings

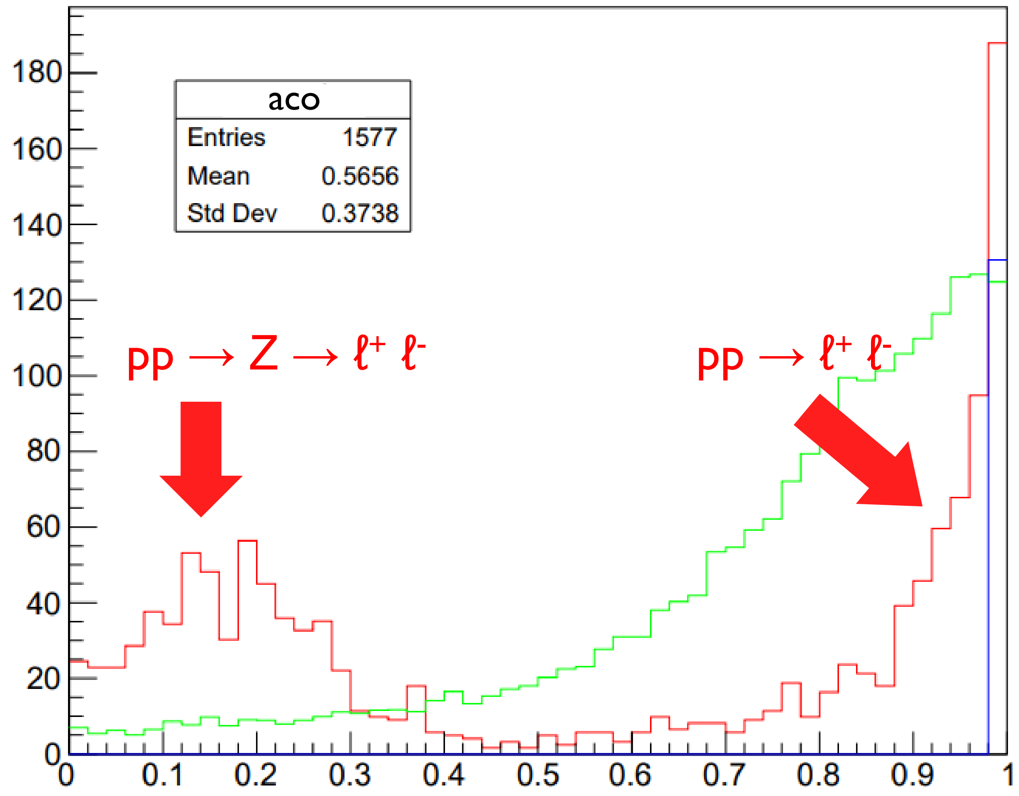
$$\eta \equiv -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$



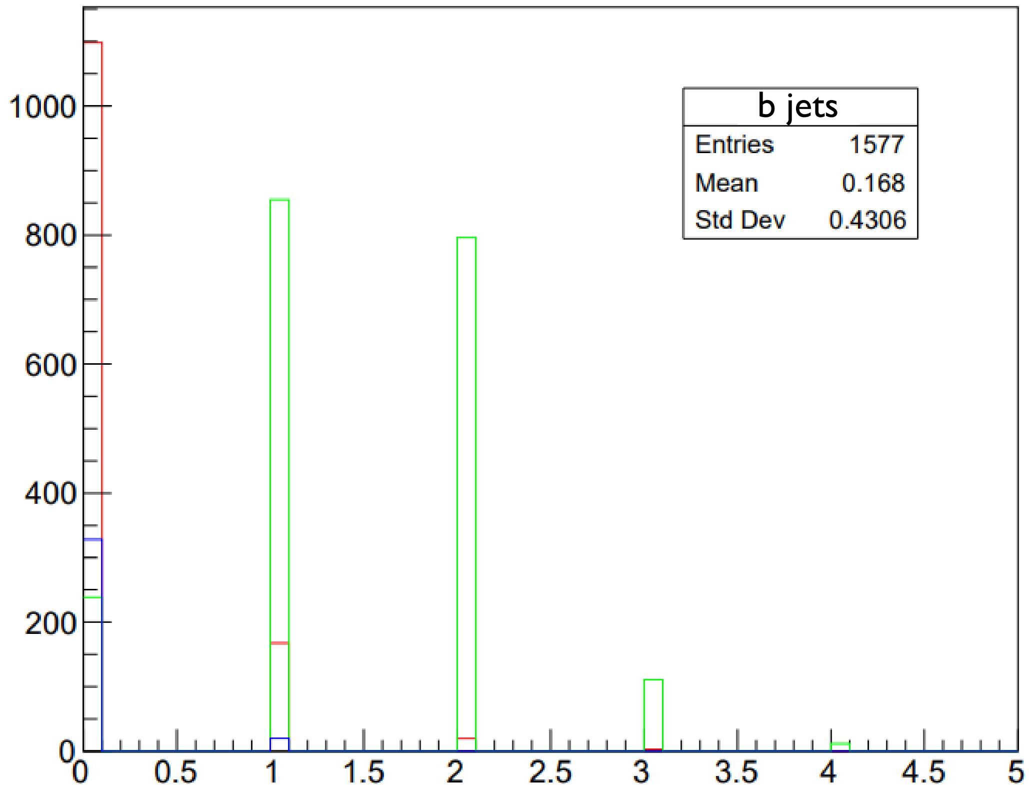
	Signal	QCD	DY	ttjets		Weights
#events tau and muon	9,371	265671	76926	13199	ttjets	0,125
#events tau and muon (opposite charge)	9,213	56908	74127	12402	DY	0,817
#events Pt(tau)>100Gev; Pt(muon)>35Gev	4,383	2550	1309	2027	Signal	0,00157
$\lvert\eta\rvert<2.4$	4,352	2403	1288	2013	QCD	1,000

SKIMMING RESULTS

Acoplanarity



Number of b jets

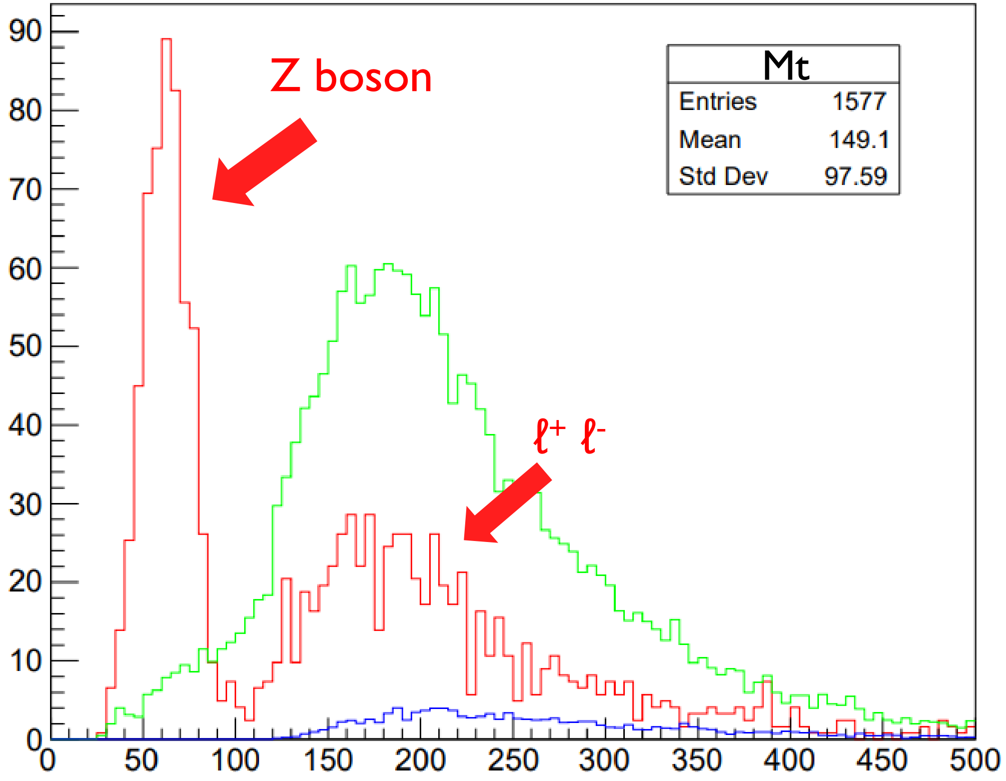


$$aco = \frac{|\theta_2 - \theta_1|}{\pi}$$

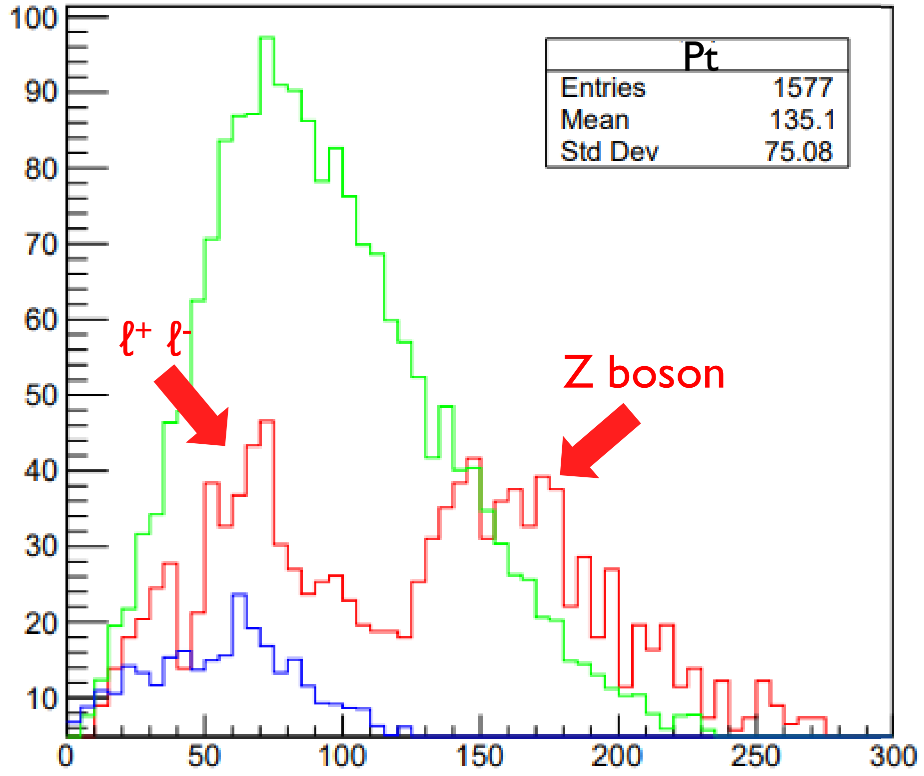
Drell-Yan Ttjets Signal

SKIMMING RESULTS

Invariant mass



Momentum

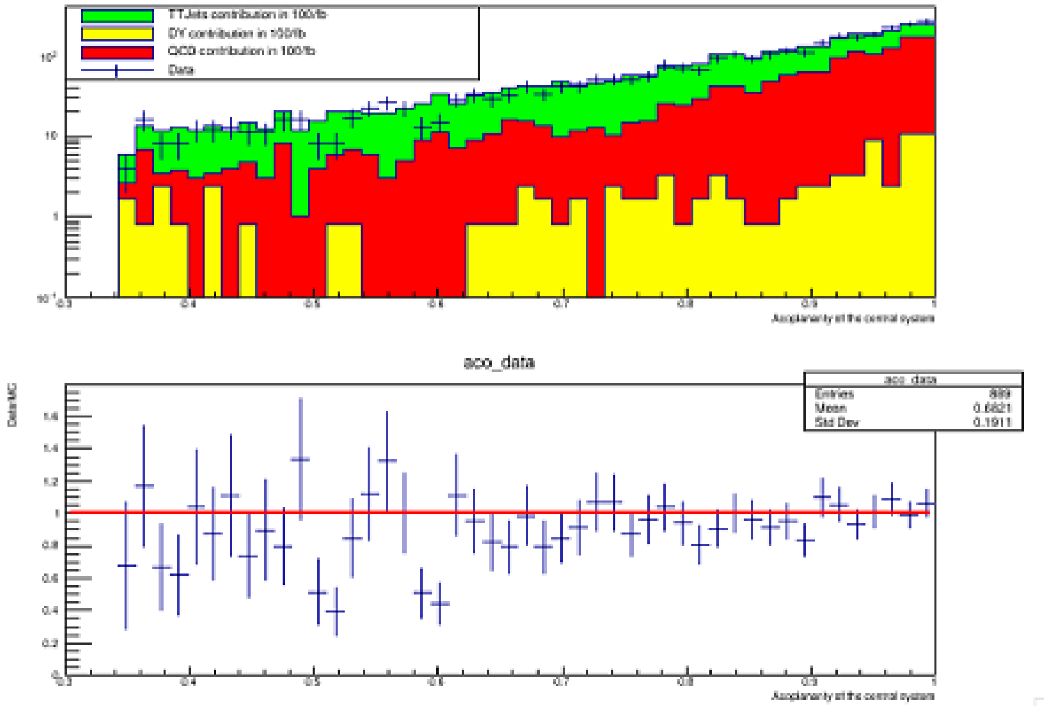


Drell-Yan   Ttjets   Signal

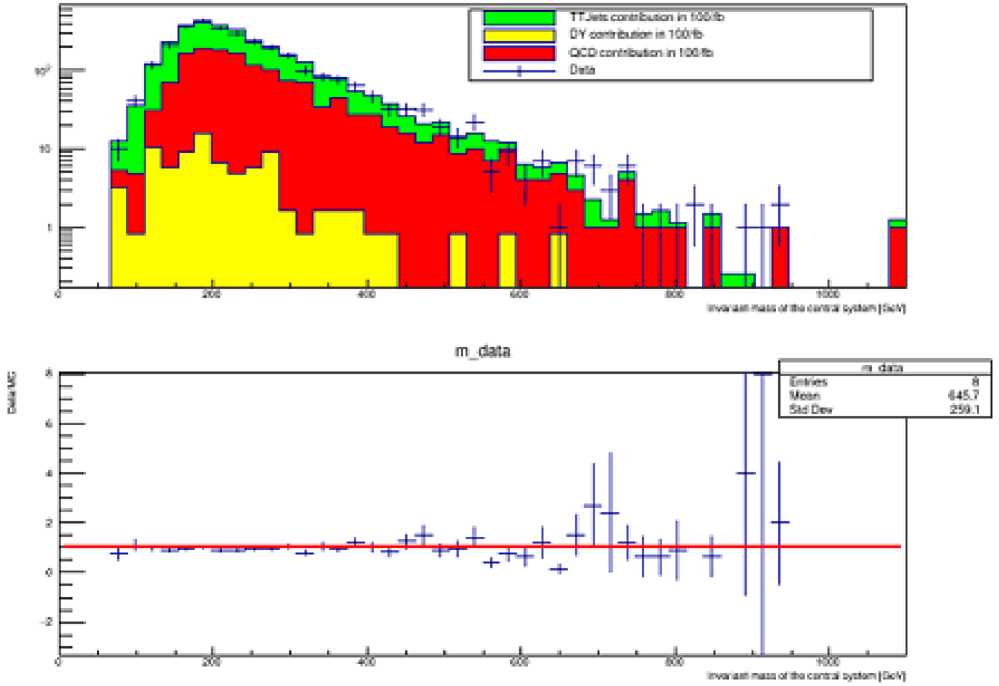
CONTROL REGIONS

- Ttjets background – 56.65%

Acoplanarity of the central system



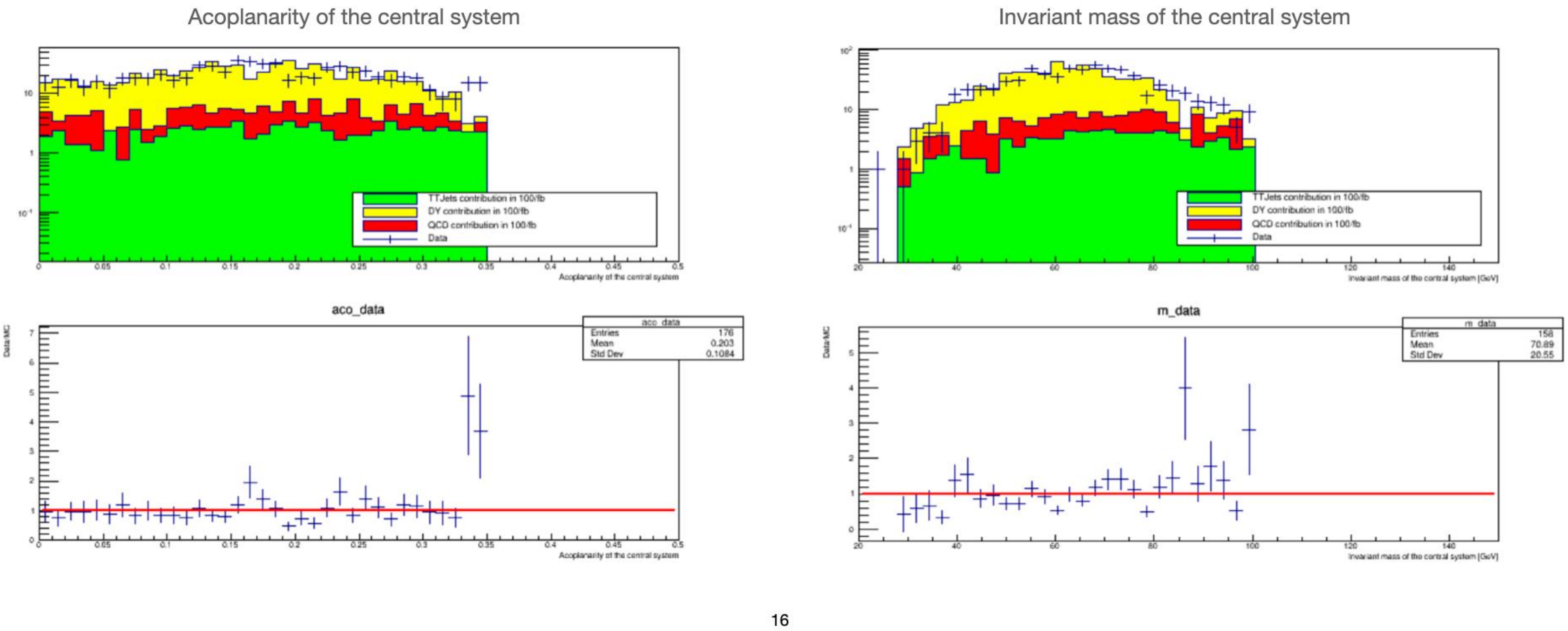
Invariant mass of the central system



$b\ jets \geq\ 1$ and $aco \geq\ 0.35$

CONTROL REGIONS

- Drell-Yan background – 79.14%

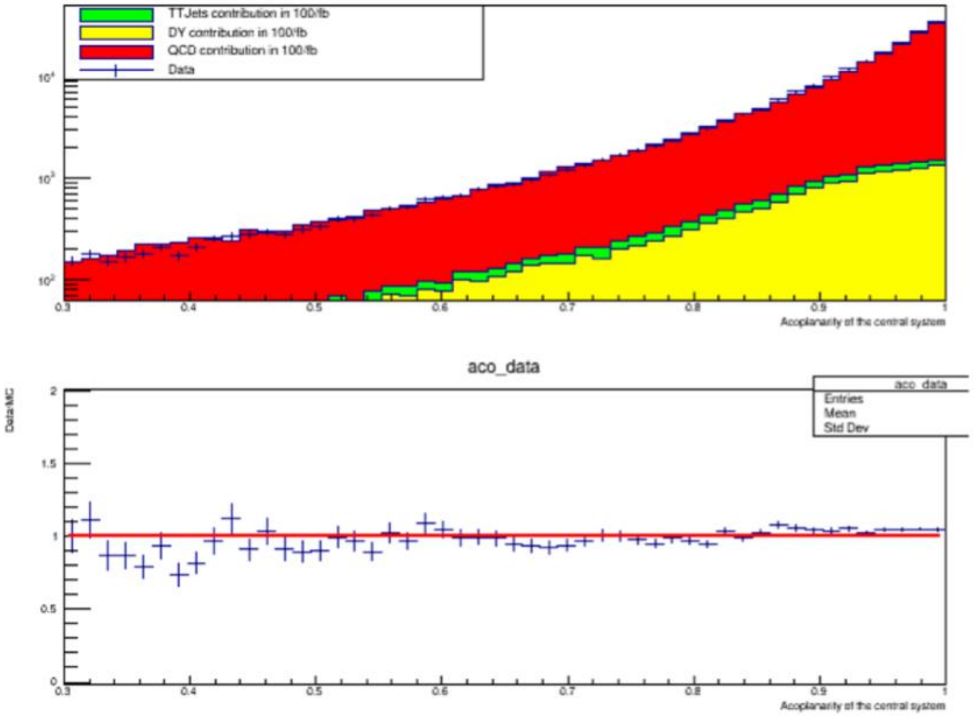


$M_t \leq 100$ GeV and $aco \leq 0.35$

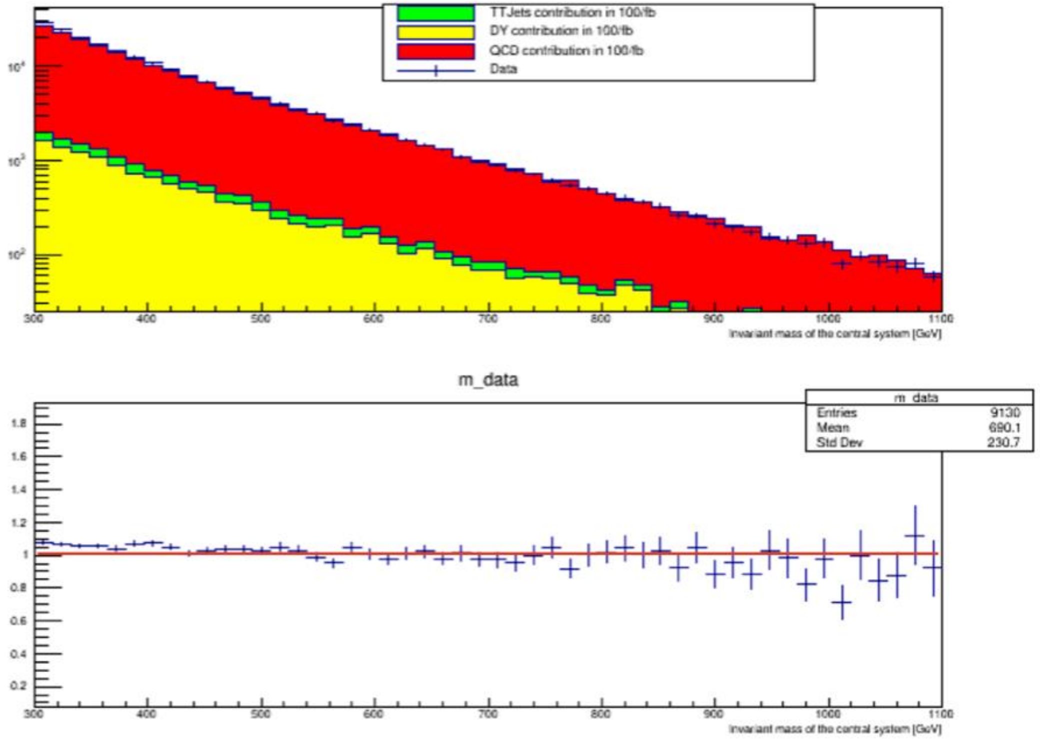
CONTROL REGIONS

- QCD background – 91,38%

Acoplanarity of the central system



Invariant mass of the central system



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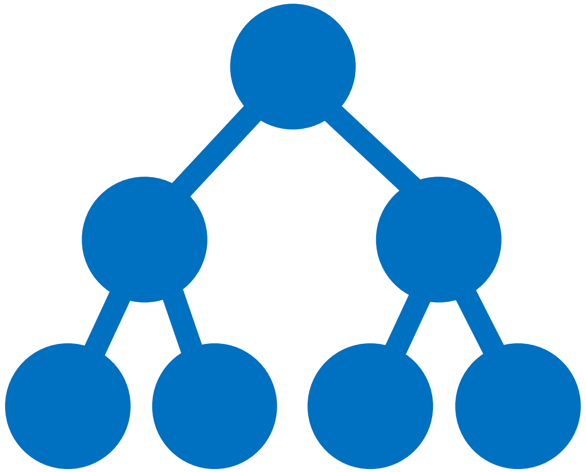
$M_t \geq 300$ GeV and $b\ jets < 1$

PROTON ENRICHMENT

Invariant mass of the central system: $M_t = \sqrt{S * \xi_1 * \xi_2}$

Momentum lost by the protons: $\xi = \frac{|P_{t,i}| - |P_{t,f}|}{|P_{t,i}|}$

Initial energy of the protons: $\sqrt{S} = 13000$ GeV



MULTIVARIATE ANALYSIS

MULTIVARIATE ANALYSIS, WHY?

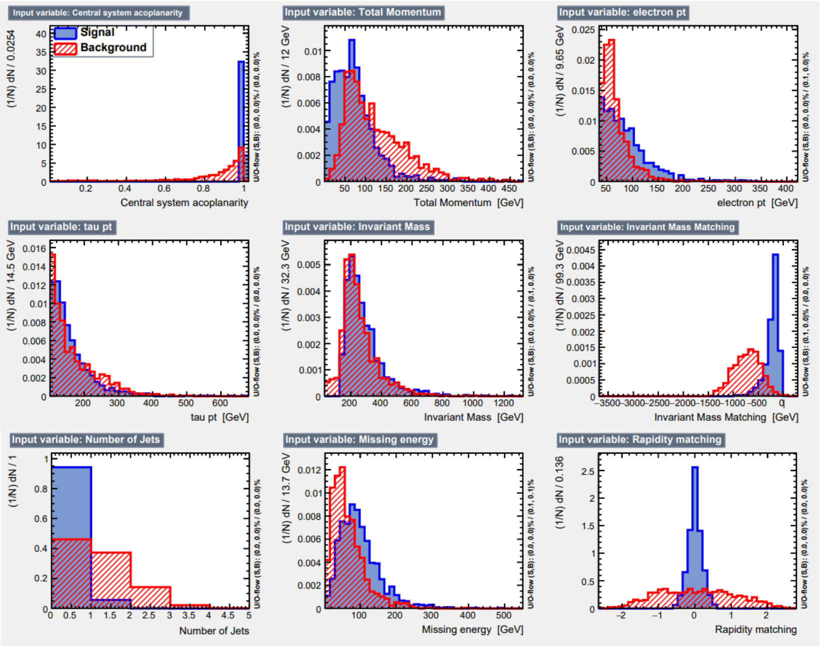
- After skimming we still don't have a good separation between signal and background

- A more sophisticated technique is needed to separate the background from the signal: multivariate analysis

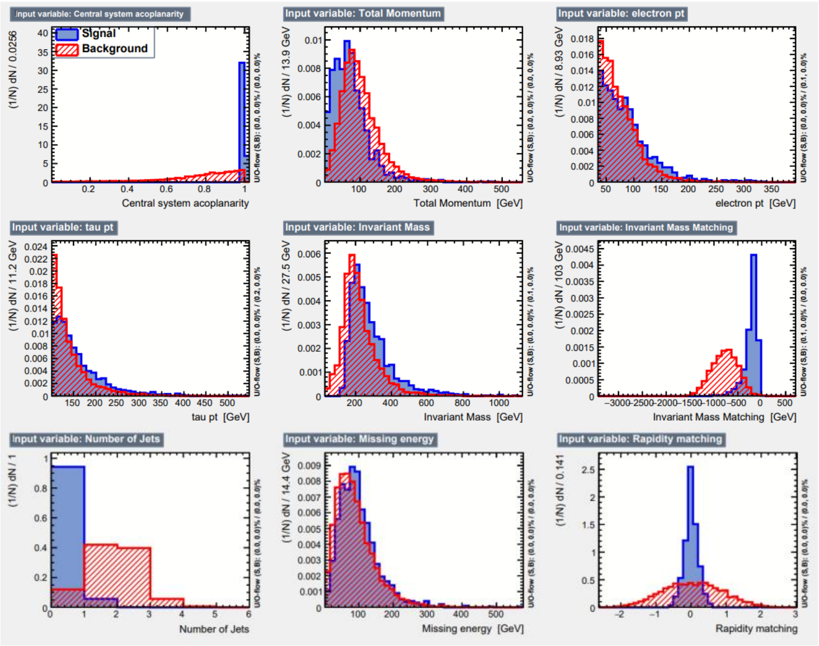
MULTIVARIATE ANALYSIS, HOW?

- The idea is to consider variables that are very different between signal and background, like the acoplanarity:

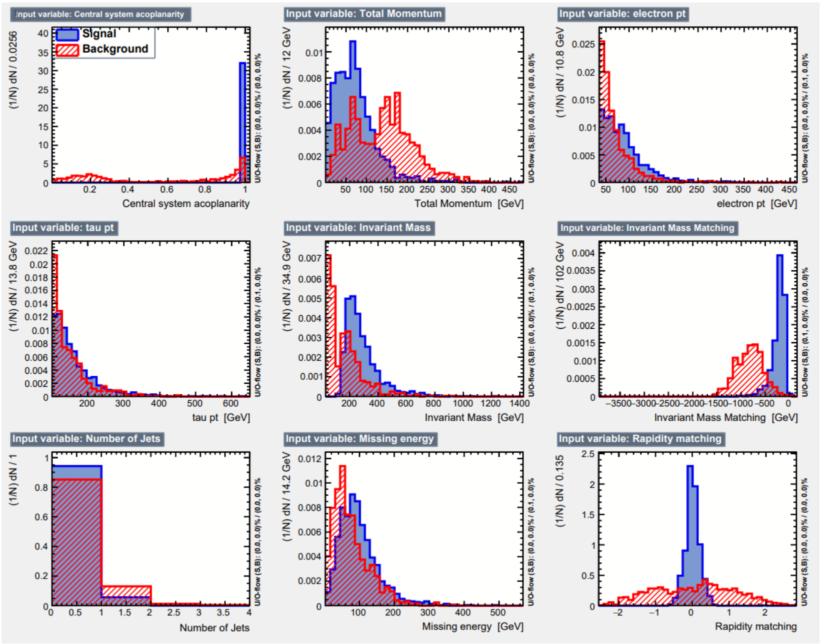
QCD



ttjets



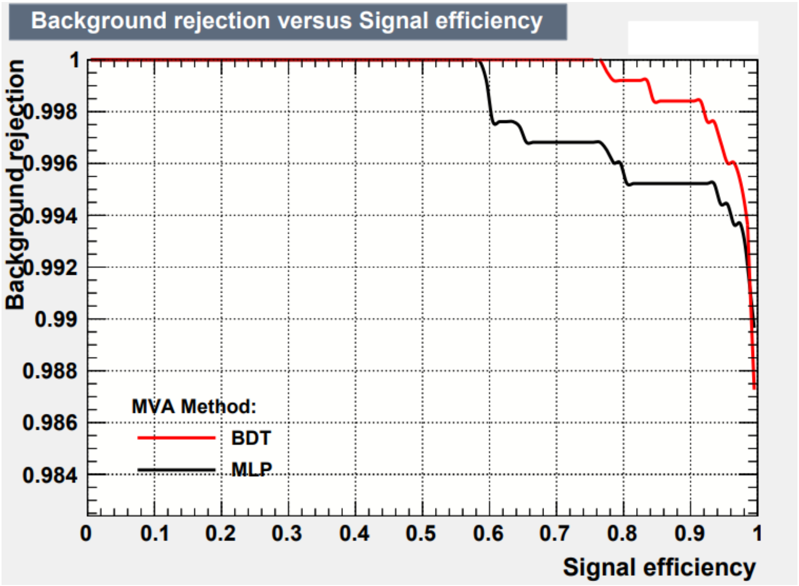
Drell-Yan



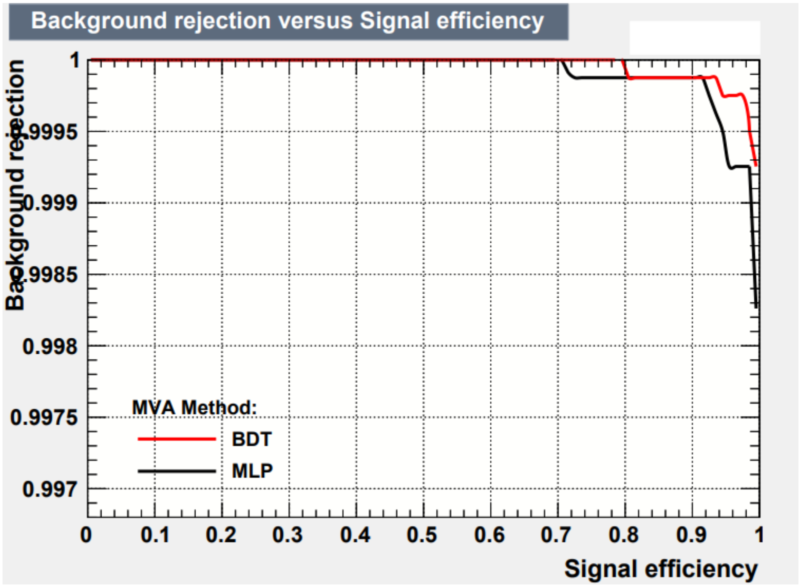
MULTIVARIATE ANALYSIS, HOW?

- We tested two MVA methods: MLP and BDT (Boosted Decision Trees)
- BTW showed a higher performance

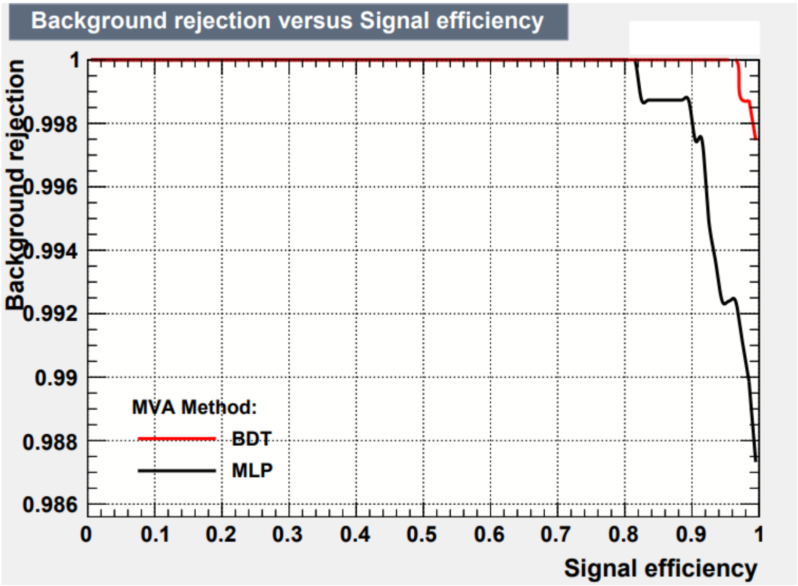
QCD



ttjets



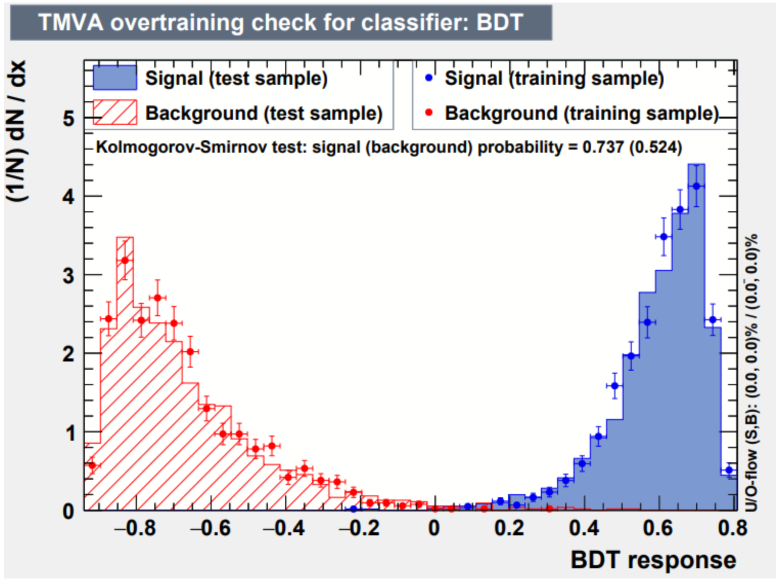
Drell-Yell



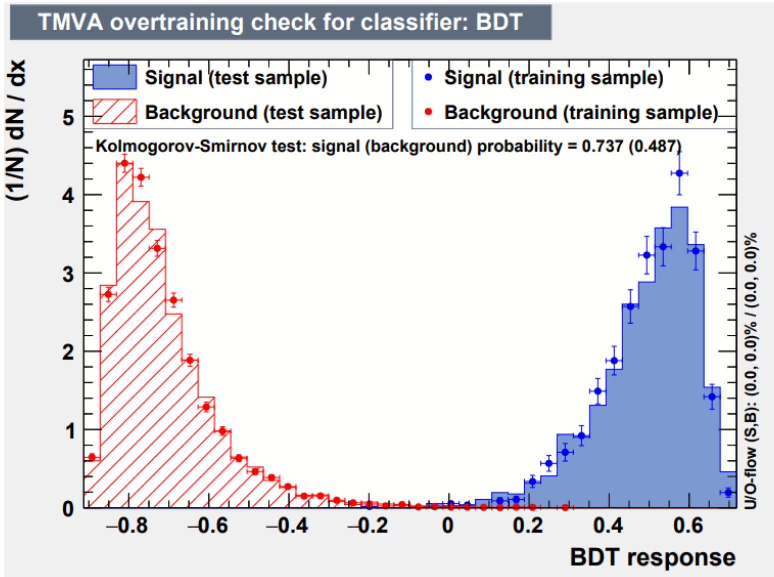
MULTIVARIATE ANALYSIS, HOW?

- The TMVA (Multivariate Analysis Tool) considers all these discriminant distributions and creates a new one called *test statistic*
- This distributions will be used as input of Higgs Combined to derive a limite on the cross section

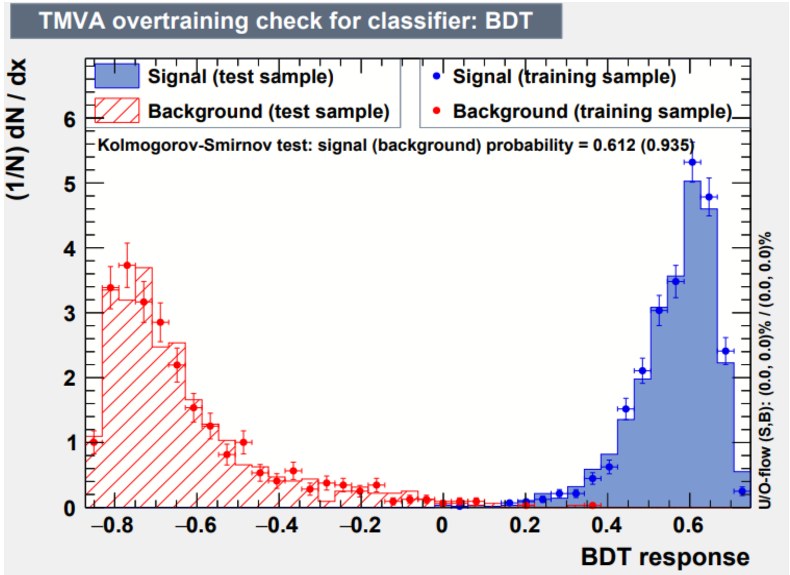
QCD



ttjets



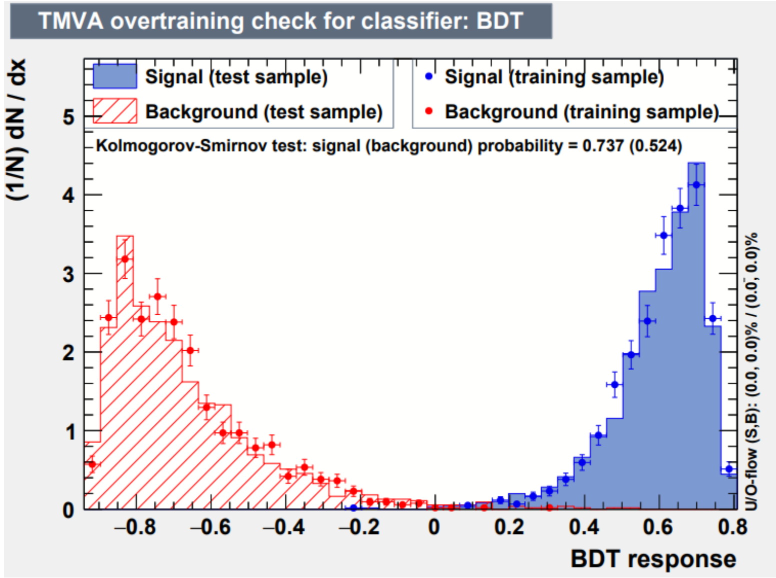
Drell-Yell



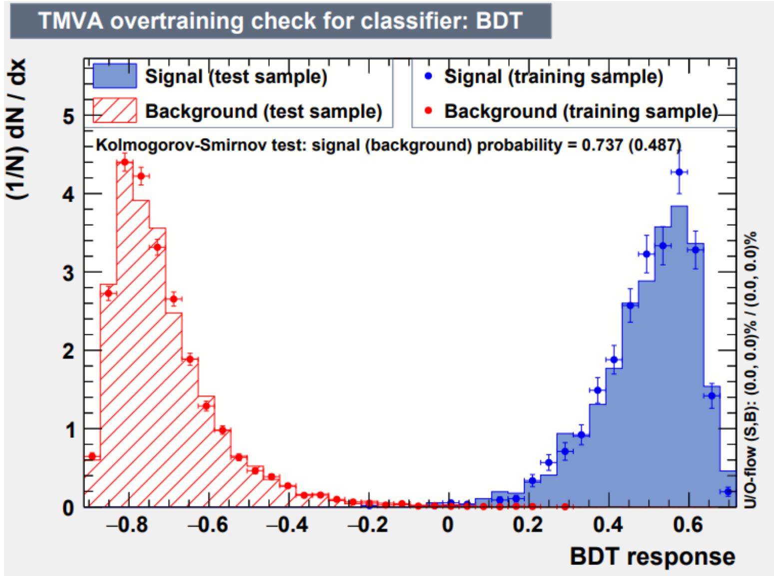
CROSS SECTION

- Higgs Combine is a tool that receive as input the output of the BDT.
- Higgs Combine sums the 3 different backgrounds from the test statistics and permits to calculate de signal strength, $\boldsymbol{r}=100^{+200}_{-60}$ (value calculated for the MuTau channel)

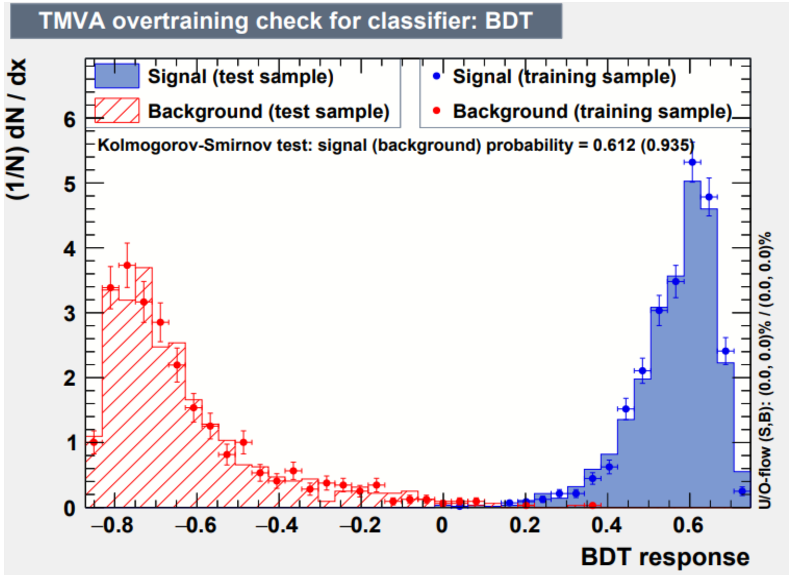
QCD



ttjets



Drell-Yell



IN CONCLUSION

In this project we went through this steps:

- Data processing
- Data verification
- Multivariate analysis
- Derivate the limit of the cross section

What we learned:

- More about particle physics in general
- How to treat data using advanced tools
- Machine learning
- More about CMS and PPS detector