Поиск новой физики в эксперименте АТЛАС на БАК методами машинного

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CMS
LHCb
ALICE
ATLAS

Detector components …

4 super-conducting magnets: solenoid + 3 toroids

Solenoid field 2T in inner detector region

toroid field peak strength 4T

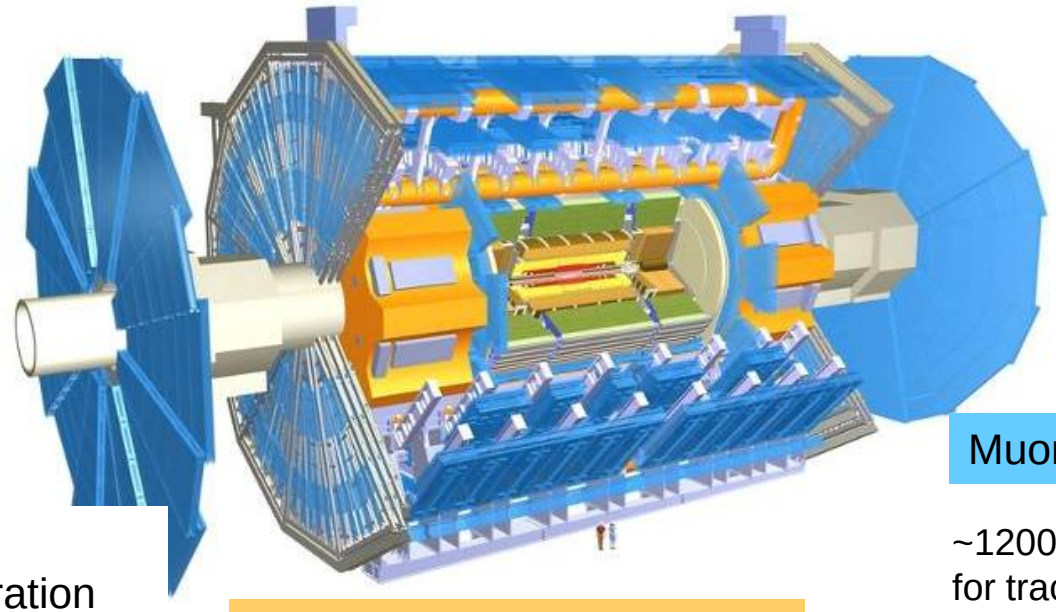
Silicon Pixel detector

80 M channels, intrinsic resolution 10 x 110 μm

Silicon tracker

~ 6 ·10^6 channels

80 μm wide strips



TileCal hadronic calorimeter

Sandwich structure: iron absorber + scintillator tiles

~ 10000 channels

Transition Radiation Tracker

Xe field straw tubes, electron – pion separation

~ 35 hits/track for track reconstruction

LAr calorimeters (EMC, HC)

~ 160000 + 10000 channels (EMC,HC)

10%/√E energy resolution for e,γ

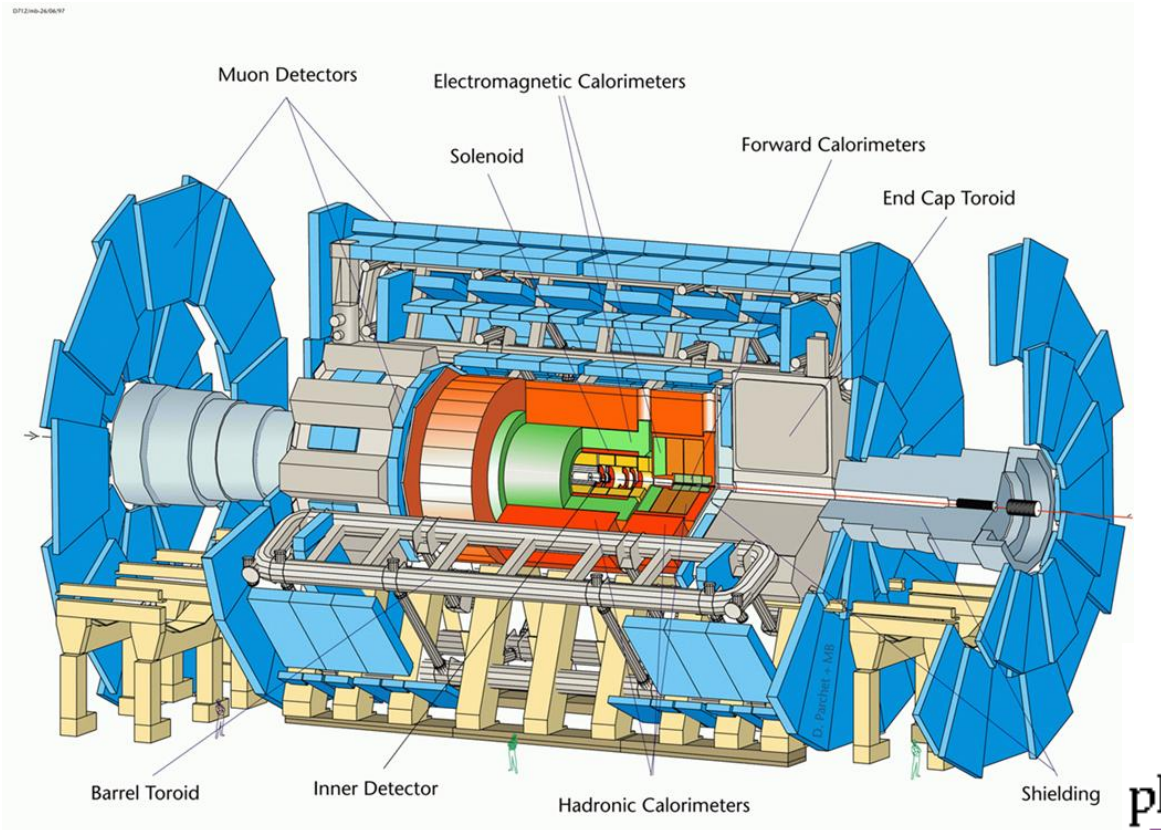
Trigger for electrons, photons and jets

Muon spectrometer

~1200 precision chambers for track reconstruction

~600 RPC and ~3600 TGC trigger chambers

Stand-alone momentum re-solution Δpt/pt < 10% up to 1 TeV



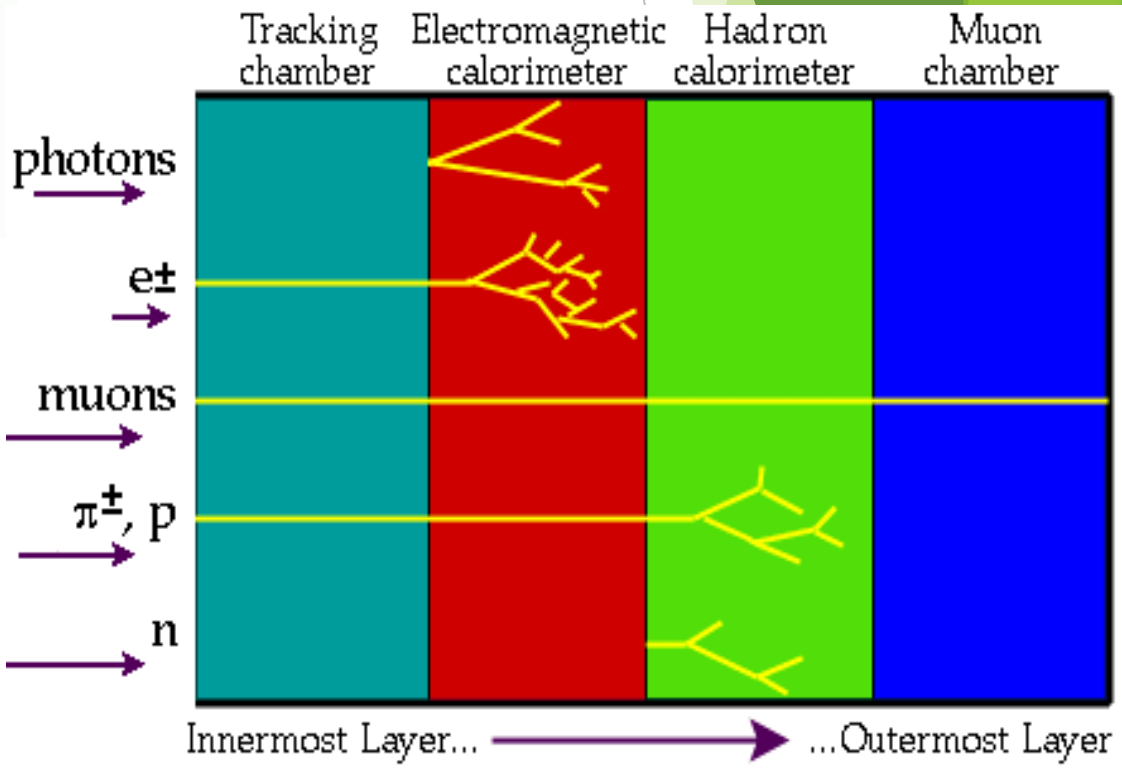
ATLAS

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~ 10^8 electronic channels
~ 3000 km of cables

- **Tracking ($|\eta|<2.5$, B=2T) :**
  - **-- Si pixels and strips**
  - **-- Transition Radiation Detector (e/π separation)**

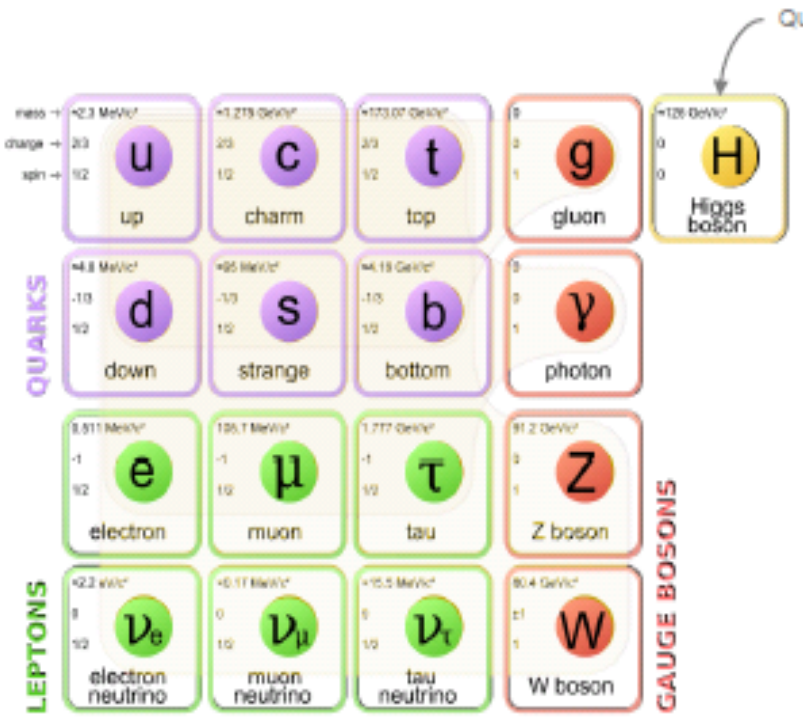
- **Calorimetry ($|\eta|<5$) :**
  - **-- EM : Pb-LAr**
  - **-- HAD: Fe/scintillator (central), Cu/W-LAr (fwd)**

- **Muon Spectrometer ($|\eta|<2.7$) :**
  air-core toroids with muon chambers



ATLAS has over 2900 scientists and engineers from 38 countries and 233 institutions, 1000 MCHF.

Everyday life, and particle physics, are described by the Standard Model (SM)

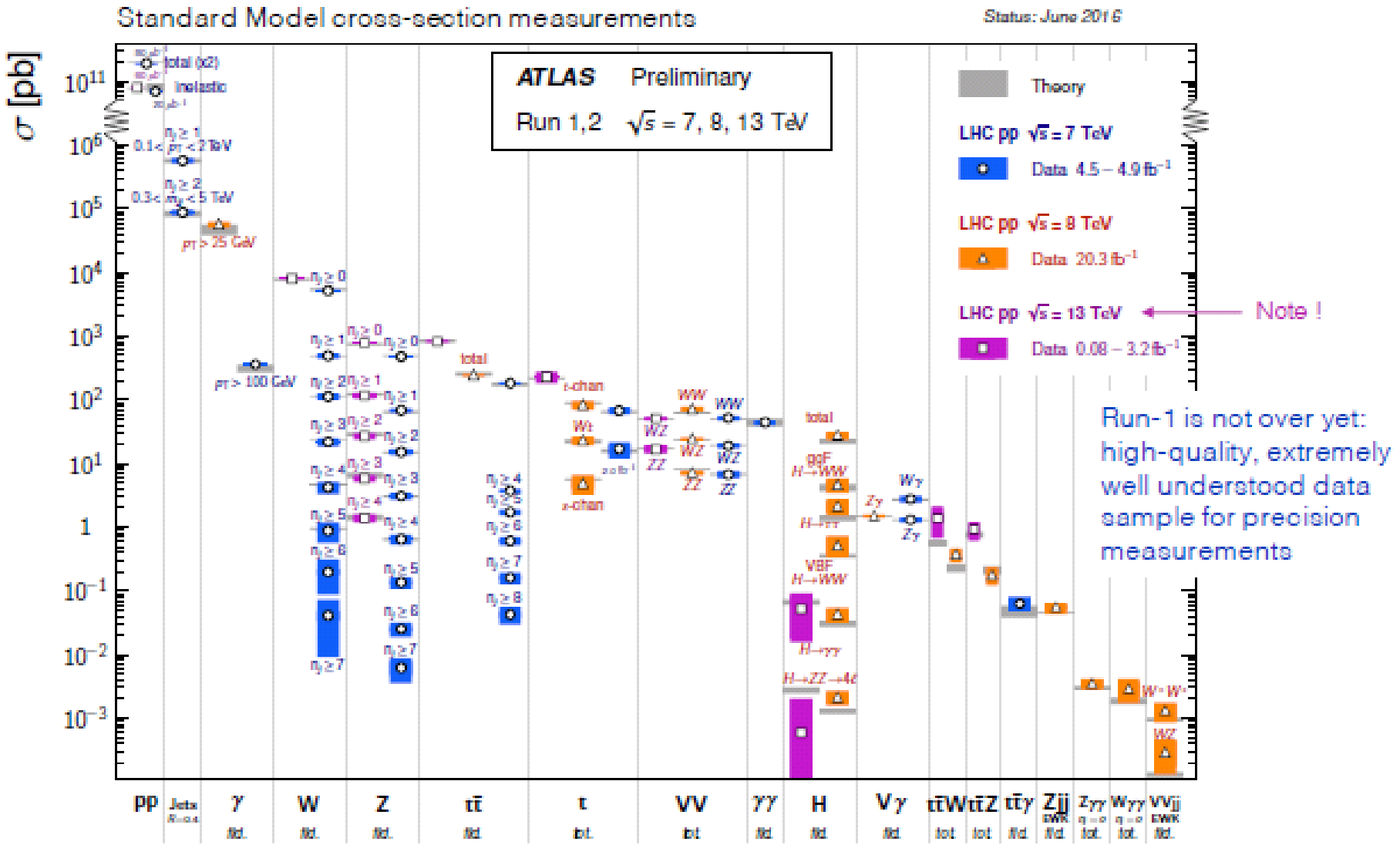


The SM is **the** legacy of 20th century particle physics

- It unifies quantum mechanics, special relativity and field theory
- It unifies electromagnetic and weak interactions
- It describes ~ all laboratory data

Is the SM the theory of everything?
Or rather of almost everything? **Or ...**

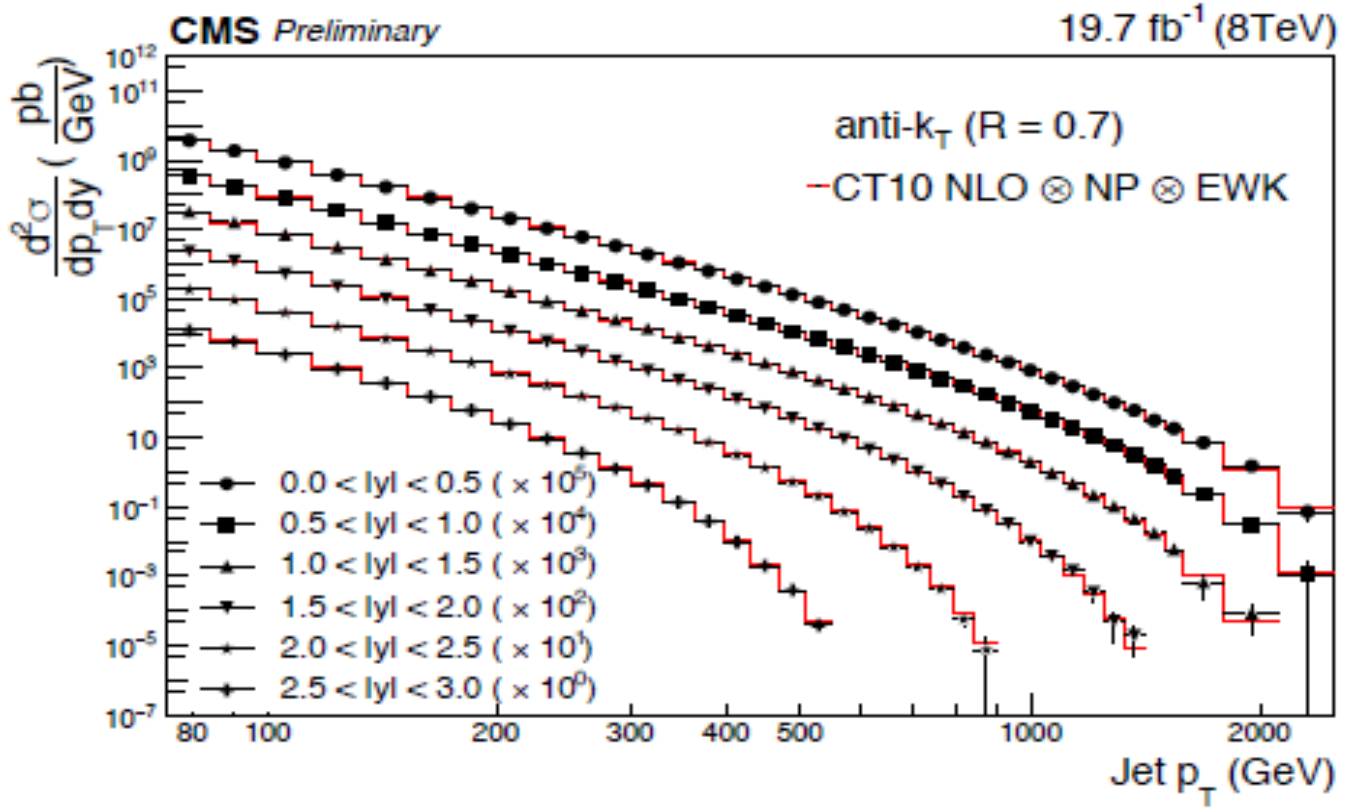
Harvest of Run-1 results (> 500 papers / exp) confirming predictive power of SM



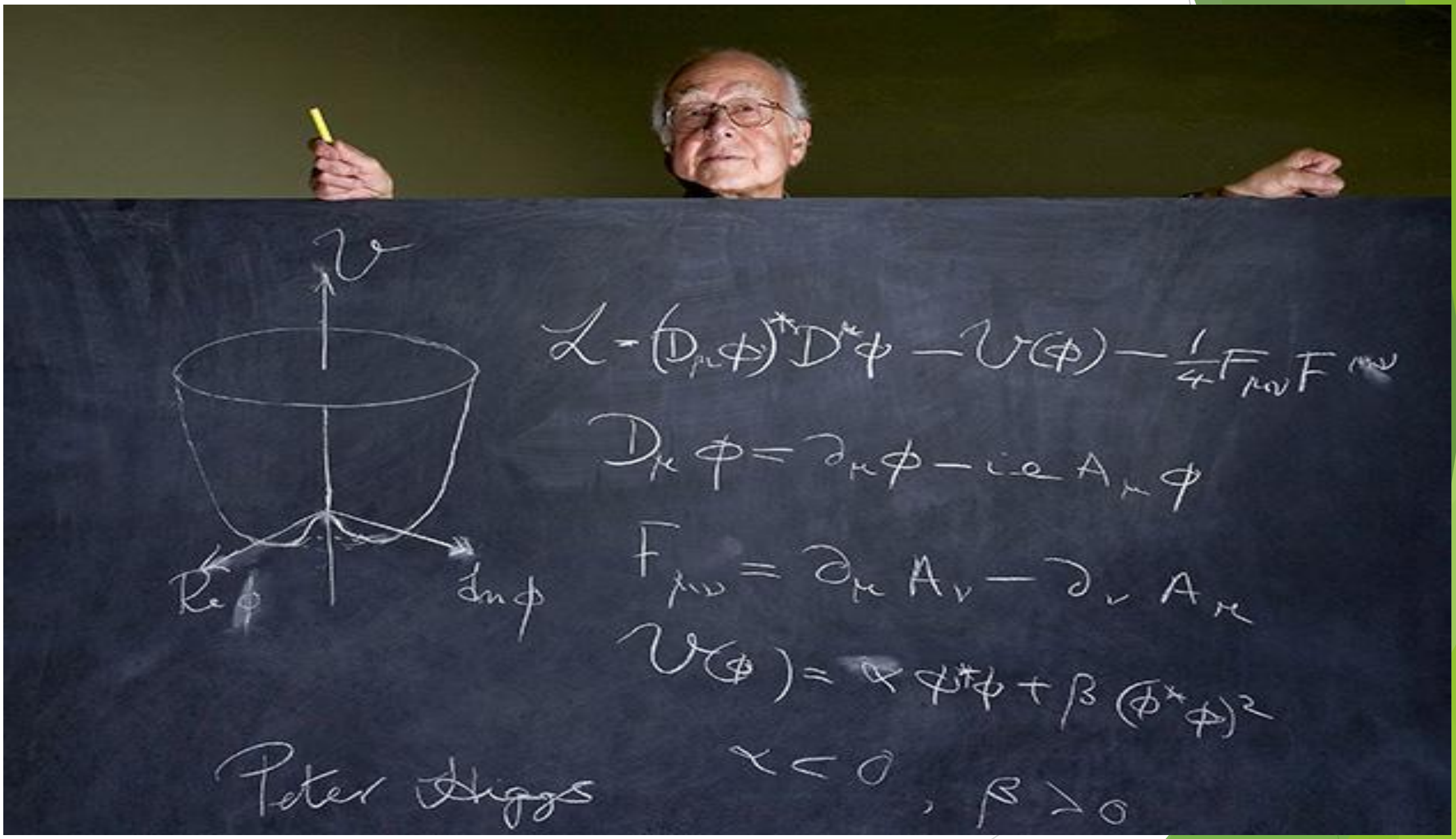
Run-1 is not over yet: high-quality, extremely well understood data sample for precision measurements

Inclusive and differential jet cross section vs. jet p_T and rapidity

Jet production [CMS-PAS-SMP-14-001]

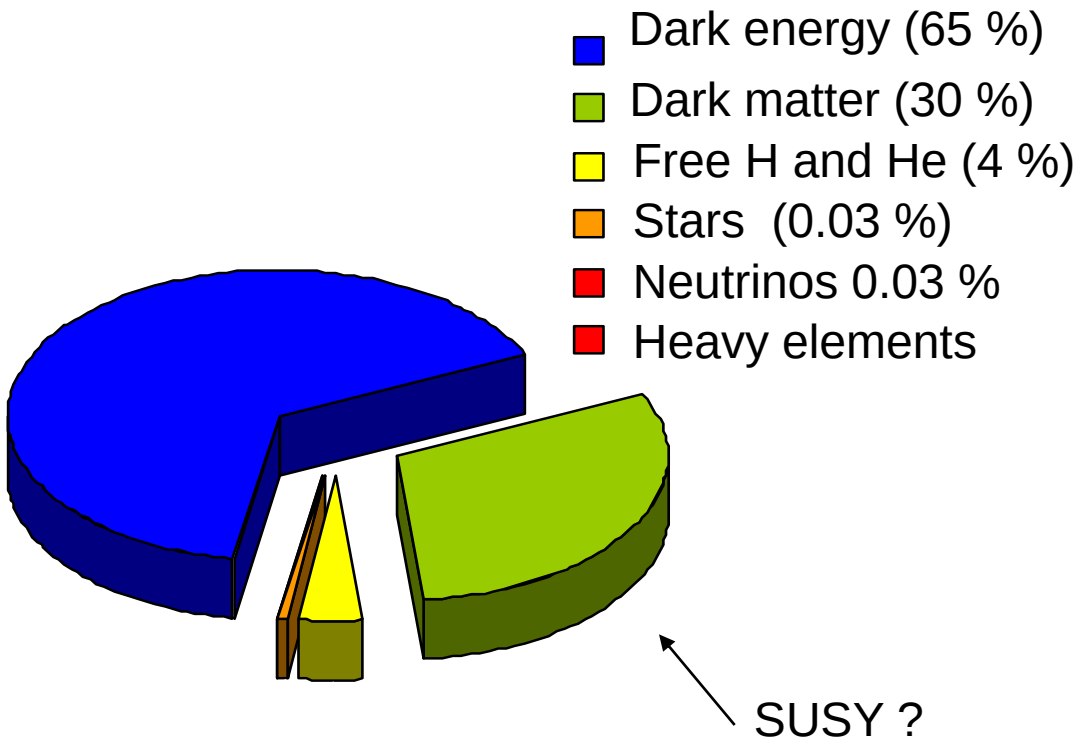


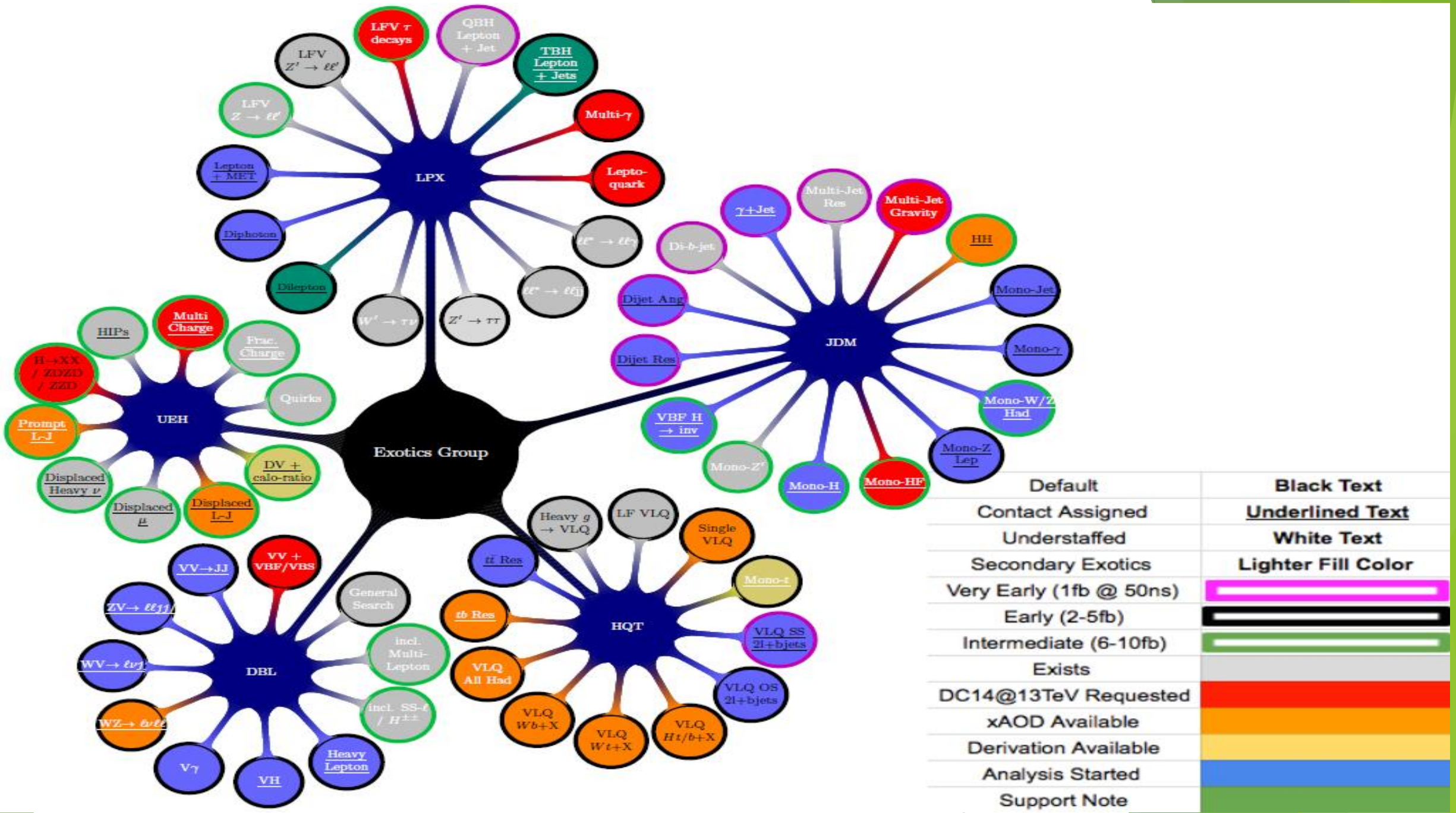
Precision measurements & theory developments (includes nonperturbative and electroweak corrections) → new quality of QCD tests at hadron colliders


v
Re φ
Im φ
$\mathcal{L} = (D_\mu \phi)^* D^\mu \phi - V(\phi) - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$
$D_\mu \phi = \partial_\mu \phi - ie A_\mu \phi$
$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$
$V(\phi) = \alpha \phi^* \phi + \beta (\phi^* \phi)^2$
Peter Higgs
$\alpha < 0, \beta > 0$

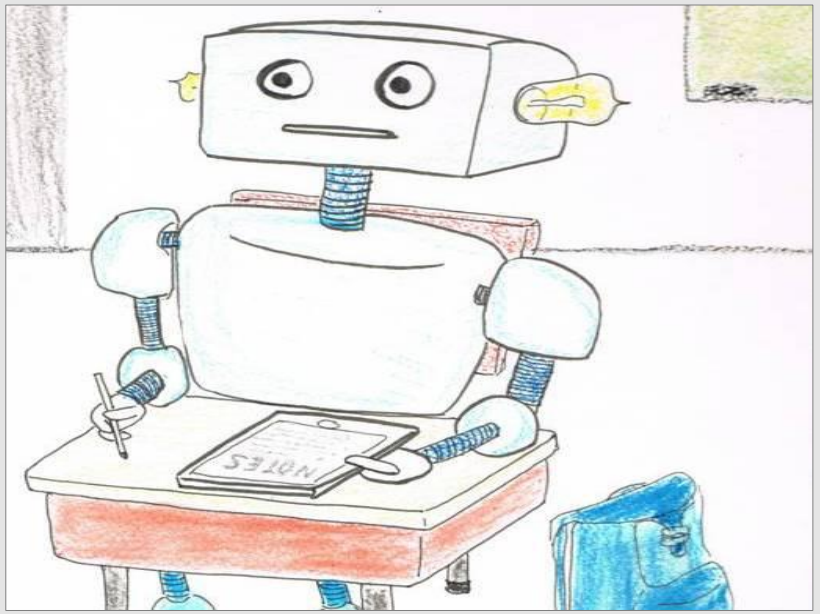
Физика за Стандартной моделью.

Motivation for BSM




Exotics Group
LPX
LFV τ decays
QBH Lepton + Jet
TBH Lepton + Jets
Multi-γ
Lepto-quark
LFV Z' → ℓℓ'
LFV Z → ℓℓ'
Lepton + MET
Diphoton
Dilepton
ℓℓ* → ℓℓγ
ℓℓ* → ℓℓjj
W' → τν
Z' → ττ
JDM
γ+Jet
Multi-Jet Res
Multi-Jet Gravity
HH
Di-b-jet
Dijet Ang
Mono-Jet
Dijet Res
Mono-γ
Mono-W/Z Had
VBF H → inv
Mono-Z Lep
Mono-Z'
Mono-H
Mono-HF
UEH
HIPs
Multi Charge
Frac. Charge
H→XX / ZDZD / ZZD
Quirks
Prompt L-J
DV + calo-ratio
Displaced Heavy ν
Displaced μ
Displaced L-J
DBL
VV→JJ
VV + VBF/VBS
General Search
ZV→ ℓℓjj
incl. Multi-Lepton
WV→ ℓνjj
incl. SS-ℓ / H±±
WZ→ ℓνℓℓ
Vγ
VH
Heavy Lepton
HQT
Heavy g → VLQ
LF VLQ
Single VLQ
tt̄ Res
Mono-t
tb Res
VLQ SS 2l+bjets
VLQ All Had
VLQ OS 2l+bjets
VLQ Wb+X
VLQ Wt+X
VLQ Ht/b+X
Default
Black Text
Contact Assigned
Underlined Text
Understaffed
White Text
Secondary Exotics
Lighter Fill Color
Very Early (1fb @ 50ns)
Early (2-5fb)
Intermediate (6-10fb)
Exists
DC14@13TeV Requested
xAOD Available
Derivation Available
Analysis Started
Support Note

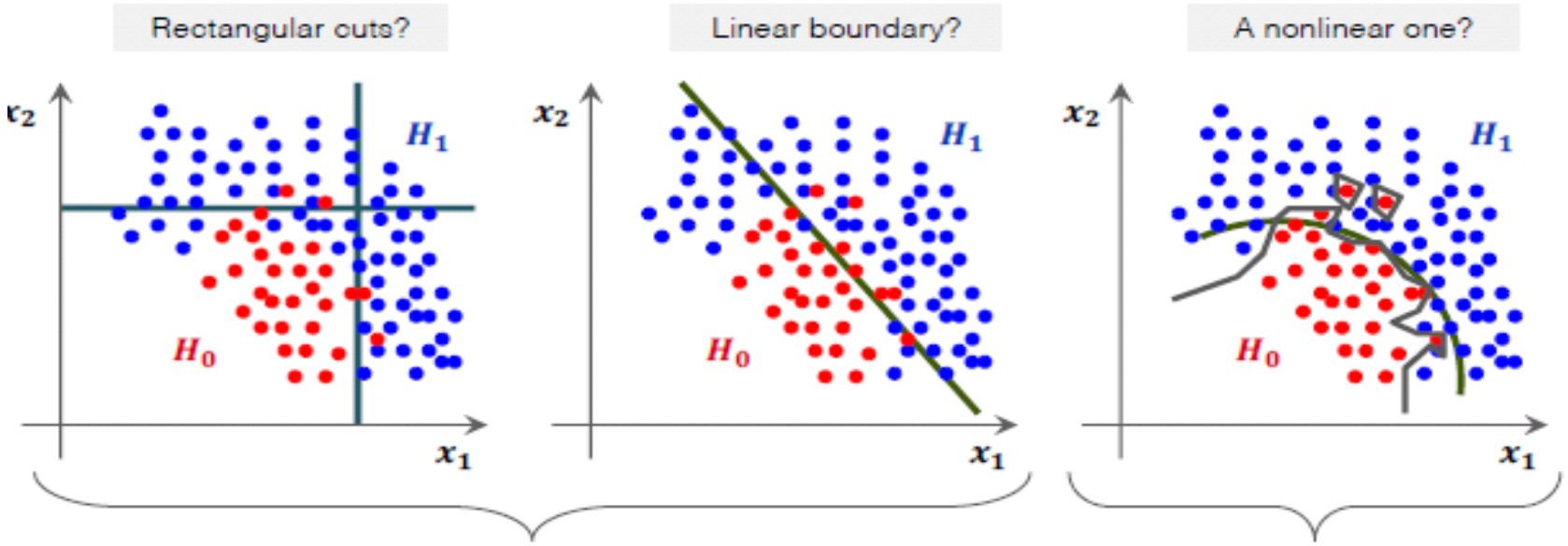
Multivariate techniques and machine learning



Event classification

Suppose data sample with two types of events: H_0, H_1

- We have found discriminating input variables x_1, x_2, …
- What decision boundary should we use to select events of type H_1?



Machine learning categories

Supervised learning: training with "events" for which outcome ("signal", "background", "regression target", …) is known, eg, from Monte Carlo simulation

Unsupervised learning: no prior knowledge about specific event classes or targets. One could then try, for example, in the given dataset to perform a

- Cluster analysis: if different "groups" are found → assign class labels
- Principal component analysis (PCA): find basis in observable space with biggest hierarchical differences in the variance → infer underlying data structure

Основной целью является разработка методики безмодельных поисков отклонений от СМ и анализ влияния статистических и систематических неопределенностей на значимость выделяемого сигнала.

План работ:
1 сем. Знакомство с предлагаемым экспериментом. Изучение литературы по использованию методов машинного обучения.

2 сем. Освоение программных средств работы с данными эксперимента. Установка
пакетов для работы с методами машинного обучения, знакомство с их функциональностью.

3 сем. Оптимизация методики безмодельных поисков отклонений от СМ и анализ
влияния статистических и систематических неопределенностей на значимость выделяемого сигнала. Доклад на конференции.

Спасибо !

Backup