

## F. PTOCHOS IS A PROFESSOR!

### 2022: THE YEAR THAT FOTIS HAS BEEN PROMOTED



#### Charged Higgs boson Hunting

|  |             |
|--|-------------|
| $t \rightarrow bH^\pm \rightarrow \tau^\pm \nu_\tau$       | 25 May 2012 |
| $H^\pm \rightarrow tb$ and $H^\pm \rightarrow t\nu$        | 31 Aug 2015 |
| $H^\pm \rightarrow \tau^\pm \nu_\tau$                      | 11 Mar 2019 |
| $pp \rightarrow t(b)H^\pm \rightarrow tb$ , all-jet        | 21 Jan 2020 |
| $pp \rightarrow t(b)H^\pm \rightarrow W^\pm H^0(\tau\tau)$ | 4 Jul 2022  |

The paper is just the beginning of the story. Ghost-busters have been called in and are working to refine our understanding of these events to see whether they provide evidence for new physics beyond the Standard Model or whether these events exploited some lack of understanding of the detector. The Tevatron may still have some surprises in store for us, and only time will tell whether we should believe in ghosts.



The following physicists played a leading role in this analysis: From left to right: Min Jeong Kim, Fotis Ptochos, Fabio Happacher. Not shown: Paolo Giromini.

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#### Search for charged Higgs bosons decaying into a top and a bottom quark in the all-jet final state

A search for charged Higgs bosons ( $H^\pm$ ) decaying into a top and a bottom quark in the all-jet final state is presented. The analysis uses LHC proton-proton collision data recorded with the CMS detector in 2016 at  $\sqrt{s} = 13$  TeV, corresponding to an integrated luminosity of  $35.9 \text{ fb}^{-1}$ . No significant excess is observed above the expected background. Model-independent upper limits at 95% confidence level are set on the product of the  $H^\pm$  production cross section and branching fraction in two scenarios. For production in association with a top quark, limits of 21.3 to  $0.007 \text{ pb}$  are obtained for  $H^\pm$  masses in the range of 0.2 to 3 TeV. Combining this with a search in leptonic final states results in improved limits of 9.25 to  $0.005 \text{ pb}$ . The complementary s-channel production of an  $H^\pm$  is investigated in the mass range of 0.8 to 3 TeV and the corresponding upper limits are 4.5 to  $0.023 \text{ pb}$ . These results are interpreted using different minimal supersymmetric extensions of the standard model.

#### CDF publishes multi-muons!

We report a study of multi-muon events produced at the Fermilab Tevatron collider and recorded by the CDF II detector. In a data set acquired with a dedicated dimuon trigger and corresponding to an integrated luminosity of  $2100 \text{ pb}^{-1}$ , we isolate a significant sample of events in which at least one of the muon candidates is produced outside of the beam pipe of radius 1.5 cm. The production cross section and kinematics of events in which both muon candidates are produced inside the beam pipe are successfully modeled

by known QCD processes which include heavy flavor production. In contrast, we are presently unable to fully account for the number and properties of the remaining events, in which at least one muon candidate is produced outside of the beam pipe, in terms of the same understanding of the CDF II detector, trigger, and event reconstruction. Several topological and kinematic properties of these events are presented in this paper. These events offer a plausible resolution to long-standing inconsistencies related to  $b\bar{b}$  production and decay.

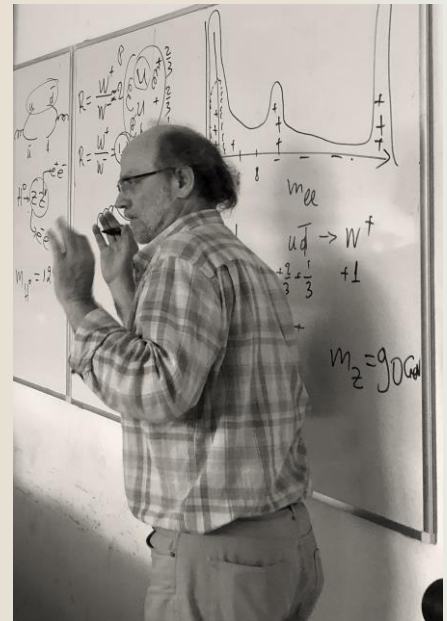
#### Higgs boson: a tool to discover new physics - $H^\pm \rightarrow HW(\tau\tau)$

A search for a charged Higgs boson  $H^\pm$  decaying into a heavy neutral Higgs boson  $H$  and a  $W$  boson is presented. The analysis targets the  $W$  decay into a pair of tau leptons with at least one of them decaying hadronically and with an additional electron or muon present in the event. The search is based on proton-proton collision data recorded by the CMS experiment during 2016–2018 at  $\sqrt{s} = 13$  TeV, corresponding to an integrated luminosity of  $138 \text{ fb}^{-1}$ . The data



#### FINALLY F.PTOCHOS WAS PROMOTED TO A PROFESSOR

After 18 years in the Physics department of the University of Cyprus (UCY), the committee finally took the right decision to promote Associate Professor Fotis Ptochos to Professor. Fotis was born on 16th May 1964 in the most beautiful city in the world, Thessaloniki. His journey in Physics started at Aristoteles University where he pursued his bachelor's degree and graduated in 1987. He then left for the United States where he attended Harvard University, graduating with his master's degree. At Harvard, he continued with his Ph.D. studies and obtained his doctoral degree in 1998. After several academic and research positions at INFN, Fermilab, etc. he was appointed as an assistant professor at UCY in 2004. Five years later he became an associate professor, which was his position until today, 2022. During his career at UCY, he collected several grants and awards. He supervised a total of 30 undergraduate, master, and Ph.D. students and post-docs. An era of great excitement has begun for the Department of Physics and we wish Fotis all the best in his academic and research career.



#### Physicists Find Elusive Particle Seen as Key to Universe

Results are presented from searches for the standard model Higgs boson in proton-proton collisions at 8 TeV in the Compact Muon Solenoid experiment at the LHC, using data samples corresponding to integrated luminosities of up to  $5.1 \text{ fb}^{-1}$  at 7 TeV and  $5.3 \text{ fb}^{-1}$  at 8 TeV. The search is performed in five decay modes:  $\gamma\gamma$ ,  $ZZ$ ,  $\tau^+\tau^-$ , and  $b\bar{b}$ . An excess of events is observed above the expected background, with a local significance of 5.0 standard deviations, at a mass near 125 GeV, signalling the production of a new particle. The expected significance for a standard

model Higgs boson of that mass is 5.8 standard deviations. The excess is most significant in the two decay modes with the best mass resolution,  $\gamma\gamma$  and  $ZZ$ ; a fit to these signals gives a mass of  $125.3 \pm 0.4(\text{stat.}) \pm 0.5(\text{syst.}) \text{ GeV}$ . The decay to two photons indicates that the new particle is a boson with spin different from one.



#### Top Quark, Last Piece of Matter, Appears to Be in Place

We establish the existence of the top quark using a  $67 \text{ pb}^{-1}$  data sample of  $pp$  collisions at  $\sqrt{s} = 1.8$  TeV collected with the Collider Detector at Fermilab (CDF). Employing techniques similar to those we previously published, we observe a signal consistent with  $t\bar{t}$  decay to  $WWb\bar{b}$ , but inconsistent with the background prediction by  $4.8\sigma$ . Additional evidence for the top quark is provided by a peak in the reconstructed mass distribu-

tion. We measure the top quark mass to be  $176 \pm 8(\text{stat.}) \pm 10(\text{syst.}) \text{ GeV}/c^2$ , and the  $t\bar{t}$  production cross section to be  $6.8^{+3.6}_{-2.4} \text{ pb}$ .



#### Multi-Muons In CDF: The Mystery Continues

We present a phenomenological conjecture of new physics that is suggested by the topology and kinematic properties of the multi-muon events recently reported by the CDF collaboration. We show that the salient features of the data can be accounted for by postulating the pair production of three new states  $h_1$ ,  $h_2$ , and  $h_3$  with masses in the range of 15, 7.3, and  $3.6 \text{ GeV}/c^2$ , respectively. The heavier states cascade-decay into the lighter ones, whereas the lightest state decays into a  $\tau$  pair with a lifetime of the order of 20 ps.

Measurement of the  $t\bar{t}$  production cross section using heavy flavor tags in  $W + \geq 3$  jet events in  $pp$  collisions at  $\sqrt{s} = 1.8$  TeV