Argonne National Laboratory
HEP Theory Group

Overview of the Group and Higgs and BSM Activities

C.E.M. Wagner

Argonne National Laboratory

KICP and EFI, University of Chicago

HEP Division, Argonne National Lab

January 11, 2012

E. Berger

G. Bodwin

R. Boughezal

I. Low

F. Petriello

C. Wagner

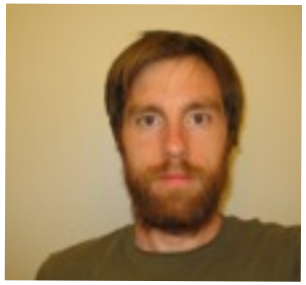
C. Zachos

Argonne HEP Theory Group.

S. Gori

J. Gainer

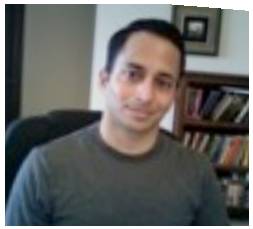
P. Schwaller



S. Quackenbush

C.R. Chen

X. Liu



S. Mantry

M. Schulze

H. Zhang

Group Members

Staff Members:

Ed Berger

Geoff Bodwin

Radja Boughezal

Ian Low (joint with Northwestern University)

Frank Petriello (joint with Northwestern University)

Carlos Wagner (joint with University of Chicago)

Cosmas Zachos

Postdoctoral Fellows :

Jamie Gainer (joint with Northwestern Univ.)

Seth Quackenbush

Pedro Schwaller (joint with Univ. of Illinois at Chicago)

Stefania Gori (joint with Univ. of Chicago)

New Arrivals (fall 2011) :

Chuan-Ren Chen

Xiaohui Liu (Joint with NW)

Sonny Mantry (LHC Fellow)

Markus Schulze (Director Postdoc position)

Hao Zhang (Joint with IIT)

Only 3 postdoc positions will be supported by long term base funding.
(2.5 positions in FY11)

Students :

Wei-Chi Huang (Northwestern Univ., student of I. Low)

Ran Huo (Univ. of Chicago, student of C. Wagner)

Ye Li (Northwestern Univ., student of F. Petriello)

Activities

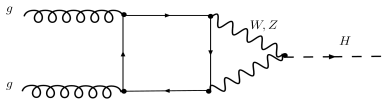
- Large productivity in areas related to phenomenology of particle physics, which has been our main research priority : Collider physics, QCD, Higgs physics, heavy quarkonia and beyond the standard model phenomenology.

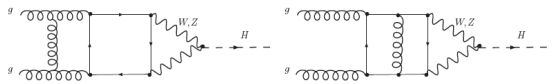
- The group has also produced relevant articles in the areas of cosmology and astroparticle physics, in particular on the questions of dark-matter and baryogenesis.

- It has also contributed to fundamental physics and to non-perturbative field theory analyses.

Higgs Production at Hadron Colliders

- Large corrections to gg → H from EW effects due to light quarks; parametrically scale like $y_{W,Z} N_F$. No mF suppression for light fermions
- what is the effect of QCD corrections to this contribution?





- No one knew! Requires 3loop multiscale calculation
- a K-factor between 1-3.5 was assumed in the literature
- Tevatron assumed a K-factor of 3.5 in their very first exclusion of SM mH= 170GeV
- Devised an EFT approach to estimate the K-factor; confirmed that 3.5 is correct

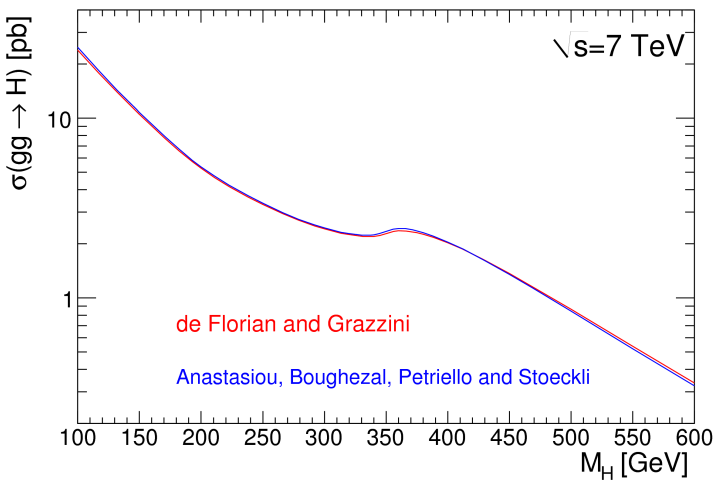
Boughezal, Petriello et al, JHEP 0904 (2009) 003

- **Higgs Physics at the LHC: Argonne influence**

- Provided the prediction for gg → H cross section at the Tevatron and the LHC
- Our predictions are the official cross sections used by both colliders

CERN Yellow Report 2011

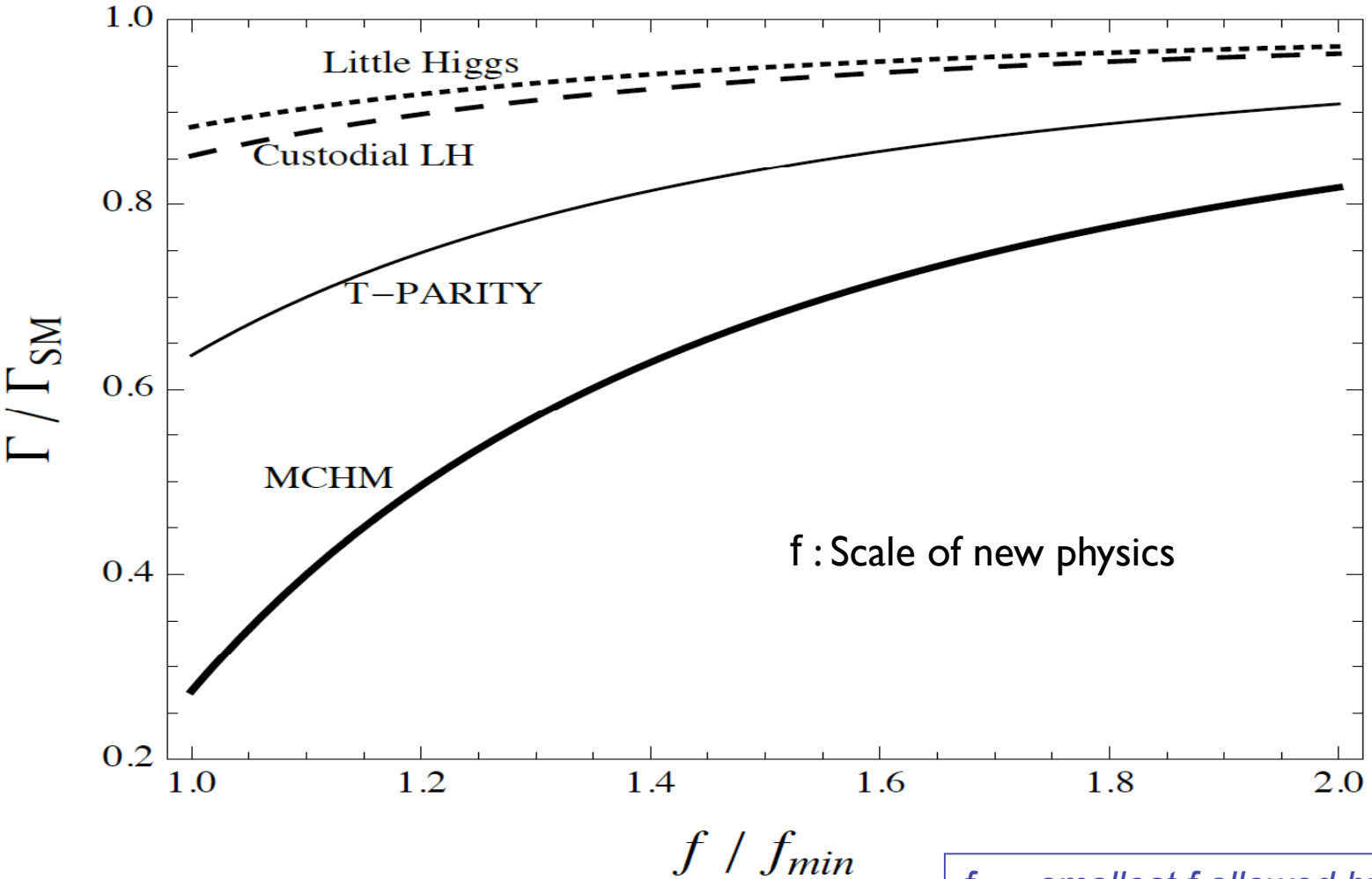
CERN-2011-002



A survey of existing composite Higgs models, where the Higgs is a pseudo-goldstone boson, confirms our general results:

1010.2753, Low and Vichi

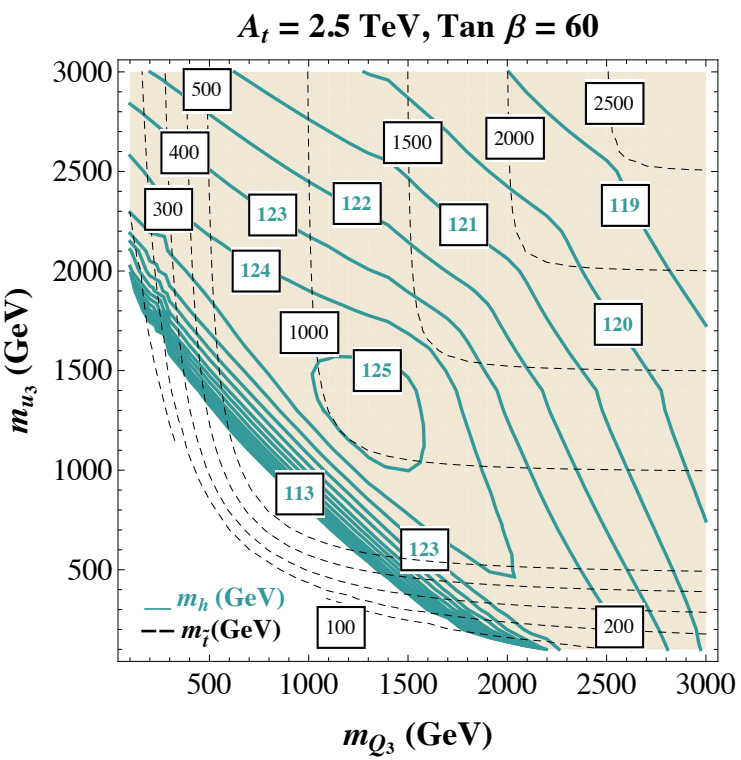
Composite Higgs Models have reduced Higgs-gluon couplings



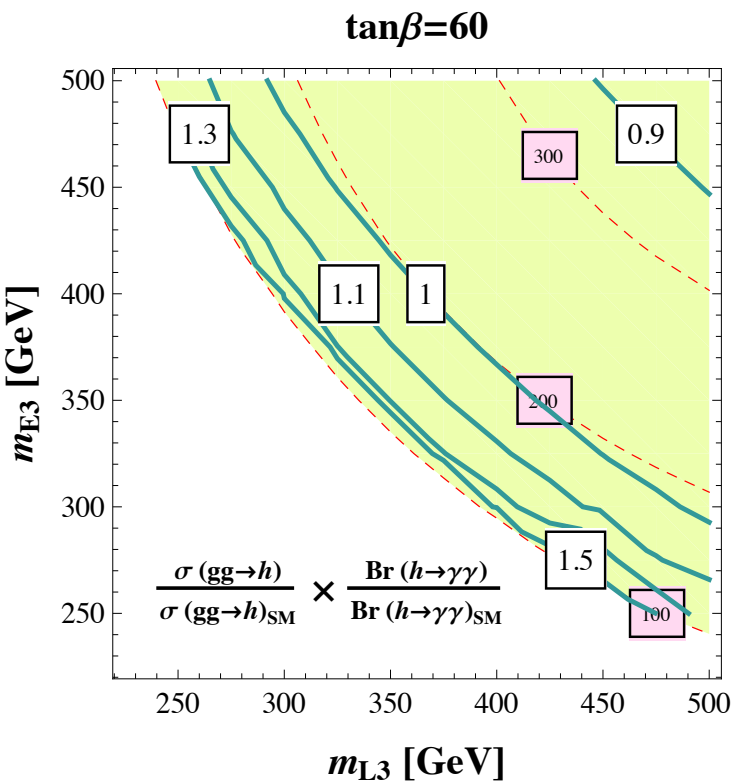
f_{min}=smallest f allowed by pEW.

Interpretation of LHC Higgs results in the MSSM

The mass fixes the stop spectrum



The photon rate fixes the slepton spectrum



A 125 GeV SM-like Higgs in the MSSM and the $\gamma \gamma$ rate.
Marcela Carena, Stefania Gori, Nausheen R. Shah, Carlos E.M. Wagner,

arXiv:1112.3336 [hep-ph]

Top Quark Asymmetries A_{FB}^{t} and A_{FB}^{ℓ}

Ed Berger, C-R Chen, H Zhang (ANL); C-H Cao (Peking U); J-H Yu (MSU)

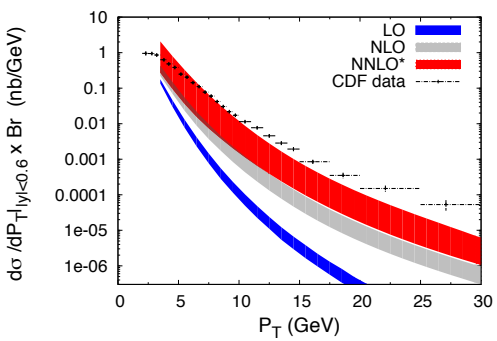
arXiv:1201.1790; ANL-HEP-PR-11-90; Phys Rev Lett (in press)

- Forward-backward asymmetries in the top quark rapidity distribution A_{FB}^{t} (CDF and DØ) and in the rapidity distribution of charged leptons A_{FB}^{ℓ} (DØ) from top quarks both exceed SM expectations
- Distribution of leptons is related to the polarization state of the top quark parent
- Show in a model-independent manner that current data on the ratio of the two asymmetries imply that *more right-handed than left-handed top quarks are produced*
- Second indication from asymmetry data of discrepancy from the SM where equal number of R- and L-handed top quarks is predicted
- Correlation of A_{FB}^{t} and A_{FB}^{ℓ} is related through top quark polarization to the underlying dynamics of top quark production. Constraint on BSM models

Heavy Quarkonium: Progress, Puzzles and Opportunities

Nora Brambilla (TU München), G.T. Bodwin (ANL), *et al.*
Eur. Phys. J. C71, 1534 (2011)

- Members of the Quarkonium Working Group (QWG) have prepared a comprehensive (181 page) document that describes recent progress in quarkonium physics and the outstanding current issues in experiment and theory.
- The document also summarizes new opportunities in quarkonium physics at present and future facilities.
- Topics covered are spectroscopy, decay, production, production in media, and the experimental outlook.
- Bodwin was a coordinator and principal author of the section on production.
- Example:



The gap between higher-order color-singlet contributions and the CDF data for the $\psi(2s)$ suggests the presence of a color-octet contribution that could be detected at the LHC.

T Curtright & C Zachos (ANL), PhysRevD83 (2011) 065019; T Curtright, X Jin, & C Zachos (ANL), arXive:1111.2649

THE GLOBAL STRUCTURE OF THE RENORMALIZATION GROUP AND LIMIT CYCLES IN QFT

Essential progress in particle physics may hinge on new quantum field theories and the understanding of their **renormalization group flows**.

▶ A general program of studying these systematically **in the large** has been initiated and produced several results and insights. Significantly, **limit cycles** were identified, where the physics repeats itself periodicaly in the logarithm of the energy, and these were demonstrated to be compatible with prevailing QFT theorems, which had been debated.

✓ Incipient lattice applications; insight into the spin glass phase of QCD; steps to the classifcation of QFTs based on their renormalization structure.

Organization of Workshops and Conferences

The group has organized local international workshops at the Argonne HEP Division in the last few years. Subjects included

Symmetry Breaking Dynamics, 2009 (jointly with Chicago, C. Zachos)

Collider Physics, 2009 (jointly with IIT, E. Berger, I. Low and C. Wagner)

ATLAS Physics Jamborees, 2009, 2010, 2011 (E. Berger and R. Yoshida)

Apart from these local workshops, members of the group have helped in the organization of numerous international workshops and conferences worldwide and have participated in several national DOE and NSF committees. Recent international conferences hosted locally by group members include

LoopFest, 2011 (R. Boughezal and F. Petriello, Organized by Argonne and NW)

Quarkonia, 2010 (G. Bodwin, Organized by Argonne and FNAL)

PreSUSY and SUSY 2011 (I. Low and C. Wagner)

All these activities enhance the visibility of the Theory group and of the HEP Division at Argonne.

A Workshop on Higgs Physics is being organized and will take place in May, 2012