

High Energy Theory

BNL

April 2004

S. Dawson

Group Members

Senior staff

Creutz, Dawson, Marciano, Paige, Soni, Trueman
Pisarski

- Sabbatical at Niels Bohr Institute, Copenhagen; 9/04-9/05

Associate physicist

Kilgore

Post-docs

Berruto (lattice), Chen (Neutrinos, SO(10))

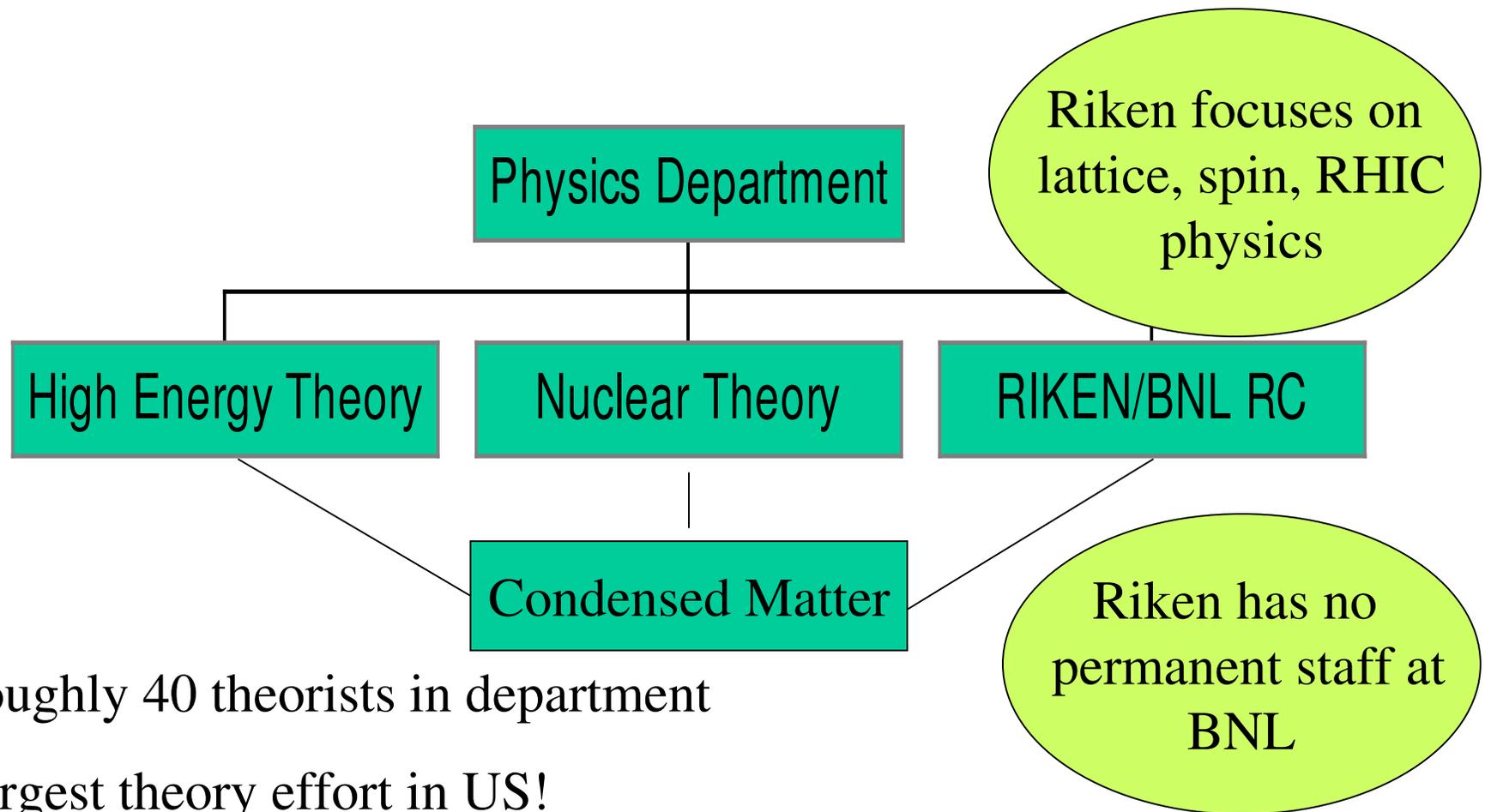
Kulesza (pQCD) (to Karlsruhe, 10/03)

Krupovnickas (Isajet/SUSY) (10/04)

CRISIS: LACK OF POST-DOCS!!!!

No Summer program/few visitors

Large Theoretical Effort in Physics department



Roughly 40 theorists in department

Largest theory effort in US!

*(Some) Group Activities**

Closely linked to US experimental program: RHIC, Tevatron, LHC, B Factories, VLBL ν , LC, RSVP

□ Collider physics; connection to US ATLAS *See talk by Paige [Dawson, Kilgore, Paige]*

- Kilgore (hep-ph/0403128) *Subtraction Terms for Hadronic Production Processes at Next-To-Next-to-Leading Order*
- Kilgore (hep-ph/0304035) *Higgs Boson Production in Bottom Quark Fusion at Next-to-Next-to Leading Order*
- Dawson, Dicus, Kao, Malhotra (hep-ph/0402172) *Discovering the Higgs Bosons of Minimal Supersymmetry with Muons and a Bottom Quark*
- Dawson, Jackson, Reina, Wackerroth (hep-ph/0311067) *Exclusive Higgs Boson Production with Bottom Quarks at Hadron Colliders*
- Paige, Protopescu, Baer, Tata (hep-ph/0312045) *ISAJET 7.69: A Monte Carlo Event Generator for pp , $anti-p p$ and e^+e^- Reactions*

*Not complete list of papers

(More) Group Activities

❑ SUSY studies [Chen, Paige]

- Paige (hep-ph/0307342) *SUSY Signatures in ATLAS at LHC*
- Chen, Mahanthappa (hep-ph/0305088) *Fermion Masses and Mixing and CP Violation in SO(10) Models with Family Symmetry*

❑ Electroweak precision physics [Marciano]

- Marciano (hep-ph/0402299) *Precise Determination of $|V_{us}|$ from Lattice Calculations of Pseudoscalar Decay Constants*

❑ Neutrino studies [Chen, Marciano] See talk by Marciano

- Chen and Mahanthappa (hep-ph/0311034) *An Overview of Neutrino Masses and Mixing in SO(10) Models*
- Marciano.... (hep-ex/0306053) *Megaton Modular Multi-Purpose Neutrino Detector for a Program of Physics in the Homestake DUSEL*

Broad based, diverse program

(Still More) Group Activities

❑ **Lattice gauge theory** [Berruto, Creutz, Soni] See talk by Creutz

❑ **Field theory** [Creutz, Pisarski, Trueman]

- Creutz (hep-ph/0312225) *On the Up Quark Mass*
- Creutz (hep-lat/0312018) *Spontaneous Violation of CP Symmetry in the Strong Interactions*

❑ **Spin studies: What is the RHIC polarization?** [Trueman]

- Trueman (hep-ph/0305085) *Proton Carbon CNI Polarimetry and the Spin Dependence of the Pomeron*

❑ **B Physics** [Soni]

- Atwood and Soni (hep-ph/0312100) *Pathways to a Clean Gamma: From B to Super B Factories*
- Atwood and Soni (hep-ph/0304085) *Role of Charm Factory in Extracting CKM Phase Information via $B \rightarrow DK$*

Rob Pisarski on sabbatical:

- Rob's talks in Europe on the RHIC program:
 - Chasing the Unicorn: RHIC and the QGP (11/3/04, 18/2/04, 9/2/04)
 - All the World's (almost) a Critical Point (1/3/04)
 - Deconfining Transition as a Matrix Model of Renormalized Polyakov Loops (12/2/04, 10/2/04, 5/2/04, 28/11/03, 24/11/03)
 - Highlights of Quark Matter 2004 (2/2/04)
 - Fluctuations from Polyakov Loops, and other Means (15/12/03; 19/12/03)

Persuasive Advocate for RHIC physics!

“The unicorn is like the quark-gluon plasma: A mythical beast and hard to know when you've found it”



Lattice Effort

Spans HET/NT/RBRC

- Current research based on RIKEN QCDSF machine (600 Gflops peak)
- Next generation: RBRC-QCDOC machine (10 Tflops)
- Physics topics:
 - Hadronic contribution to $(g-2)_\mu$ (Blum)
 - Improvements to ε'/ε (smaller lattice spacing with charm included; dynamical domain wall fermions)
 - B matrix elements (needed for B_s and B_d mixing)
 - Coming soon: new B_K with domain wall fermions
 - g_V, g_A on the lattice

Lattice and CKM parameters

- Marciano (hep-ph/0402299)
 - *Precise Determination of $|V_{us}|$ from Lattice Calculations of Pseudoscalar Decay Constants*
- Use new lattice results for $f_K/f_\pi=1.201$ (8)(15)
 - Error in ratio is smaller than individual errors

$$\frac{\Gamma(K \rightarrow \mu \bar{\nu}_\mu (\gamma))}{\Gamma(\pi \rightarrow \mu \bar{\nu}_\mu (\gamma))} = \frac{|V_{us}|^2 f_K^2 m_K \left(1 - \frac{m_\mu^2}{m_K^2}\right)^2}{|V_{ud}|^2 f_\pi^2 m_\pi \left(1 - \frac{m_\mu^2}{m_\pi^2}\right)^2} \times (0.9930(35))$$

- Marciano:

$$|V_{us}| = .2236(30)$$

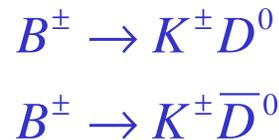
- *cf* PDG $|V_{us}| = .2196$ (26)

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = .9969 (15)$$

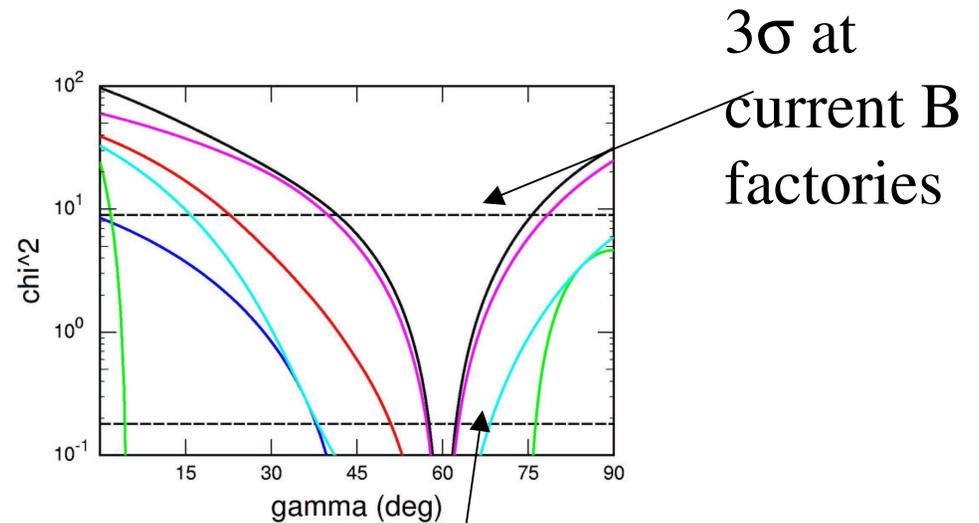
- PDG value is 2σ from 1
- New result has better agreement with 3 generation CKM unitarity

Measuring CKM Angles at B Factories

- Want to measure α , β γ separately and verify $\alpha+\beta+\gamma=\pi$
- Measure γ from direct CP violation:



- Followed by decays to common final states, eg $D^0 \rightarrow K^+\pi^-$, $D^0 \rightarrow K_s^0\omega$
- Extract γ from interference



3σ at super B factories (50X current)

**Black curve is combination
of many decays**

Teaching, etc.

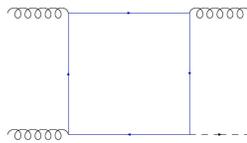
- **Marciano**, Adjunct at Yale, *Quantum Field Theory, Spring, 2002*
- **Creutz**, Adjunct at Stony Brook, *Lattice Gauge Theory, Spring, 2001*
- **Dawson**, Adjunct at Stony Brook, *Electroweak Symmetry Breaking, Fall, 2001; Particle Physics, Fall, 2003.*
- **Summer Schools**: SLAC Summer School 04, Trieste 03 (Marciano), Maria Laach 04 (Dawson), CTEQ 04 (Kilgore)

Humboldt Senior Researcher: Marciano, Pisarski

Graduate Students

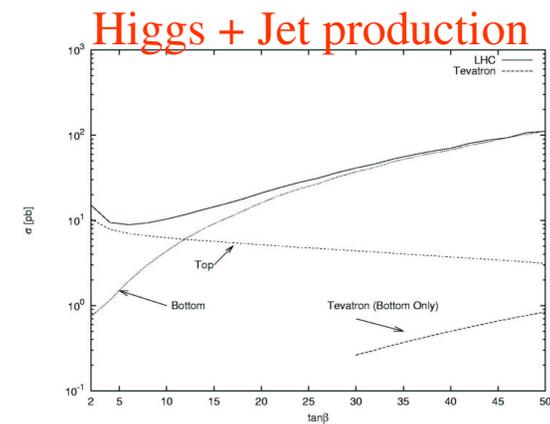
- Bryan Field (Stony Brook); Dawson
 - Graduates 5/05?

$$gg \rightarrow gh$$



• Scalar and Pseudoscalar Higgs plus one Jet Production at the LHC and Tevatron,
Field, Dawson, Smith, hep-ph/0311199

- b quarks important in MSSM for $\tan \beta > 7$
- Affects use of large m_t limit for NLO QCD corrections



- We don't adequately support students....every \$ is a struggle
- Please comment: Are students a good thing for us?

Graduate Students

- Jack Laiho (Princeton);
Soni
 - Graduates 8/04; job at FNAL
 - Supported 2003/2004 by LDRD funds

- Framework for lattice calculation of ε'/ε to next-to-leading order in chiral perturbation theory
- Previous studies at LO in chiral PT
- Mix of lattice/analytic calculations

Lattice Extraction of $K \rightarrow \pi\pi$ Amplitudes to NLO in Quenched and in full Chiral Perturbation Theory, Laiho and Soni, hep-ph/0306035

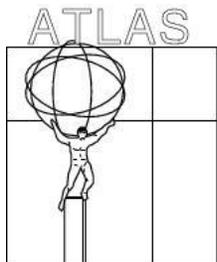
- Hatta (Tokyo); Pisarski
 - Graduated 2/04; job at BNL with RIKEN

- Phase transitions and finite temperature QCD

Deconfining Phase Transition as a Matrix Model of Renormalized Polyakov Loops, Dumitru, Hatta, Lenaghan, Pisarski, hep-th/0311223

Planning for the US HEP Future

- **Neutrino physics**
 - VLBL ν APS study working group leader (Marciano)
 - BNL working group (Chen, Marciano)
 - Underground Laboratory Steering Committee (Marciano)
- **ATLAS**
 - SUSY group leader (Paige)

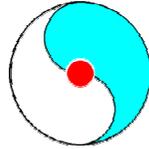


- **Linear Collider Studies**



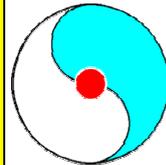
- Working group leaders (Dawson, Marciano, Paige)
- USLC Steering Committee (Dawson)
- **B Physics working groups**
 - (Soni)
- **LHC/LC Complementarity**
 - (Paige, Dawson)
- **Spin Physics at RHIC**
 - (Trueman)

SciDac Lattice
Gauge Theory All
Hands Meeting



Meetings organized by HET Group Members

Lattice QCD at Finite
Temperature and Density



Neutrino Superbeam,
Detectors, and Proton
Decay (APS Study)

April 1 - 3, 2004 *LoopFest III*
Radiative Corrections for the Linear Collider: Multi-loops and Multi-legs
Kavli Institute for
Theoretical Physics
Santa Barbara

Organizers:
Ulrich Baur
Sally Dawson
Michael Peskin
Doreen Wackeroth

<http://quark.phy.bnl.gov/loopfest3>
email: dow@ubpheno.physics.buffalo.edu

co-sponsored by BNL, KITP and SLAC

Proton Decay, Neutrino
Oscillation Detector at a
U.S. Underground
Laboratory (UCLA)

New Challenges for Lattice
Gauge Theory, Santa
Barbara, Jan-Mar, '05

BNL Summer School on
QCD Spin Physics

Support from BSA, RIKEN

Public Service

- *Editorial work*
 - *PRD* - Dawson, Pisarski, Paige
 - *JHEP* - Marciano
 - *Computers in Science & Eng.* - Creutz
- Lattice QCD SciDAC-EC
 - Creutz
- APS Service
 - APS Council, DPF chair - Dawson
 - NYSS-EC - Kilgore
- DOE Service
 - P5, Facilities - Marciano
 - HEPAP Communications - Dawson

The future:

- Most critical items:
 - Post-docs, post-docs, post-docs
 - Graduate students
 - Summer program
- Plan for changes in lattice effort
 - Connections with NT, RBRC
 - Scientific leadership
- Strong theory component of ATLAS analysis center
 - Workshops, seminars, Monte Carlo effort
 - Make BNL a center for LHC physics
- Emerging BNL interest in LSST
 - Can theory group enhance this effort?