Lattice field theory

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PPAP community meeting
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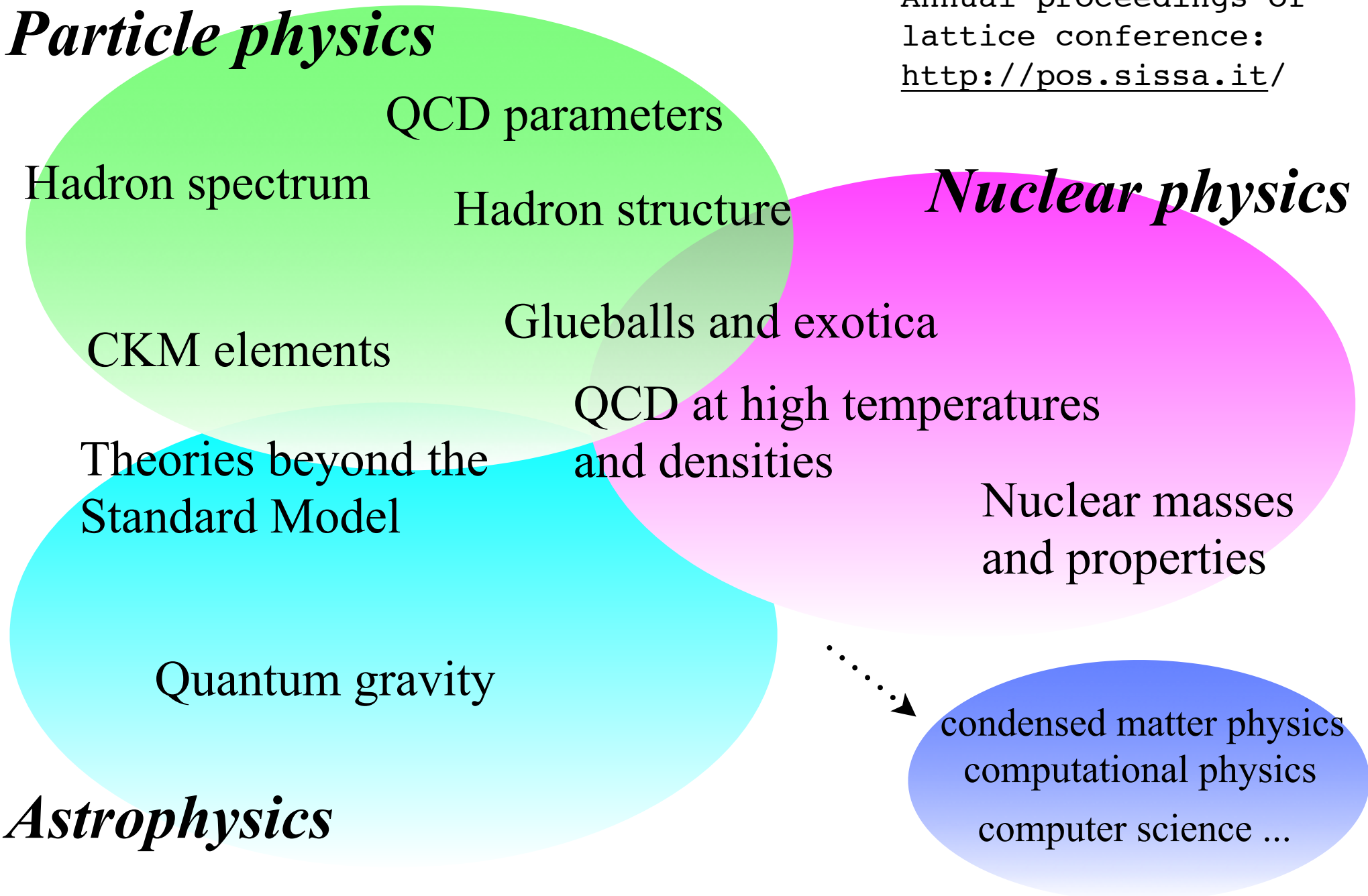
Applications of Lattice QCD/Lattice field theory

Annual proceedings of lattice conference: http://pos.sissa.it/



UK landscape - people

8 universities form UKQCD consortium of 25 academics.

UK provides ~8% of worldwide lattice community.

Strong in international collaborations, e.g HPQCD, QCDSF-UKQCD, RBC-UKQCD, strongBSM ..

UK authors produced 50 top-cited lattice papers in 2008-13

UK landscape - computers

Distributed Research using Advanced Computing =

STFC's HPC facility for theoretical particle physics, astrophysics and cosmology.

Phase 2 (2012-15) - £15M capital from BIS plus input from HEIs and STFC - now operating fully as a facility: >35 projects, >400 users. Bidding to STFC for operating costs from mid-2014 on.

5 machines at 4 sites (Cambridge, Durham, Edinburgh and Leicester) - coordinated management and peer-reviewed resource allocation (starting Dec. 2012) open to all

where are the phenomenologists?

DiRAC

aim to focus on a few architectures suited to physics problems, NOT one-size-fits-all

Lattice field theory uses two machines:

1) 6-rack BG/Q at Edinburgh. 20 in top 500 (2012) - 1Pflops

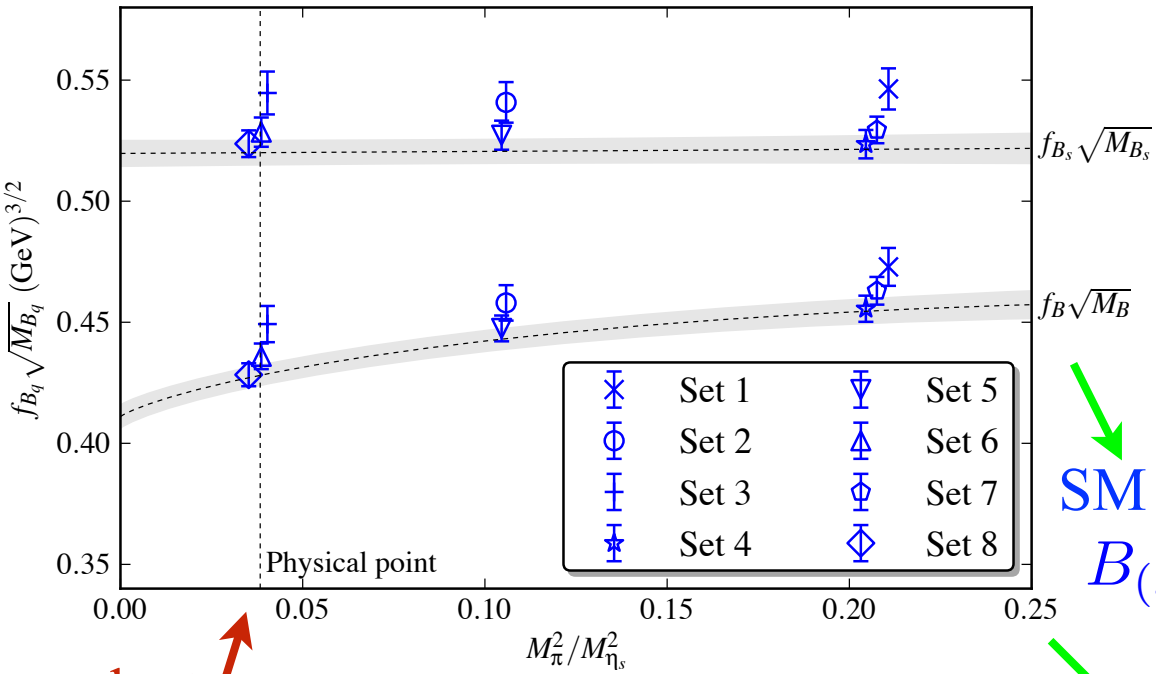
numerically more intensive calcs, e.g. gauge field generation

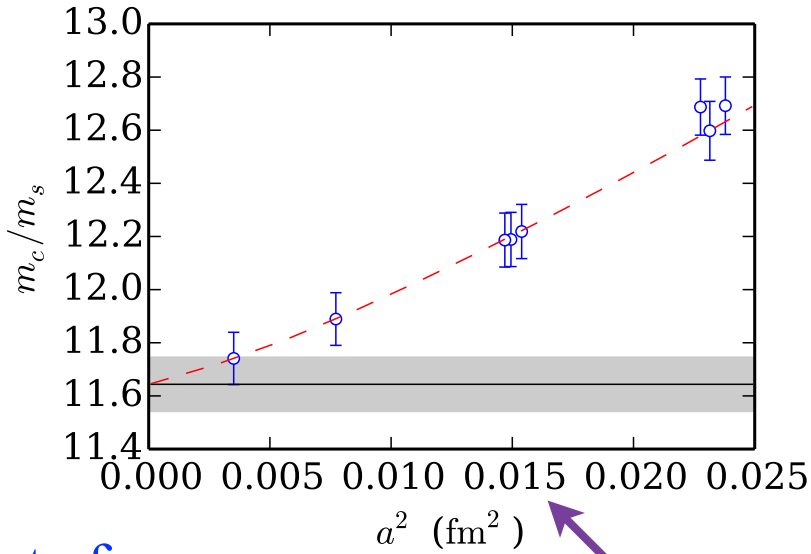
2) Sandybridge/infiniband cluster at Cambridge.
93 in top 500 (2012) - 200 Tflops

data intensive calcs, e.g. physics analysis on gauge fields

DiRAC-2 hadron physics from Lattice QCD

Decay constants for annihilation rate

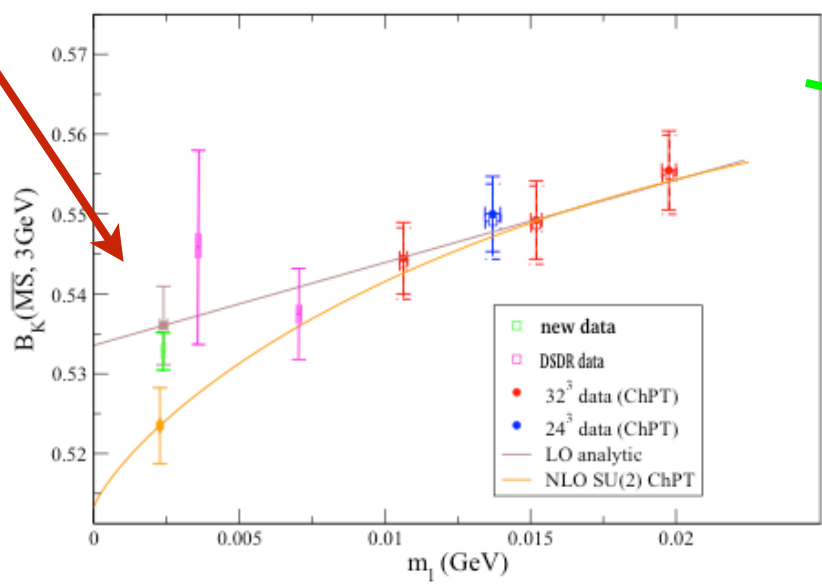




SM rate for $B_{(s)} \to \mu^+\mu^-$

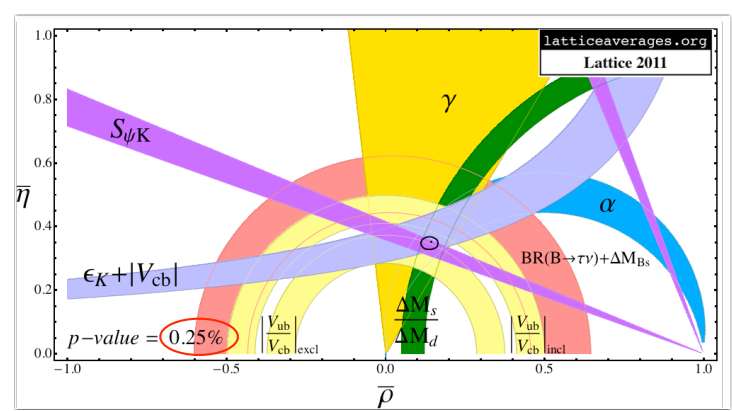
Precise quark masses and mass ratios

work at physical u/d quark masses!

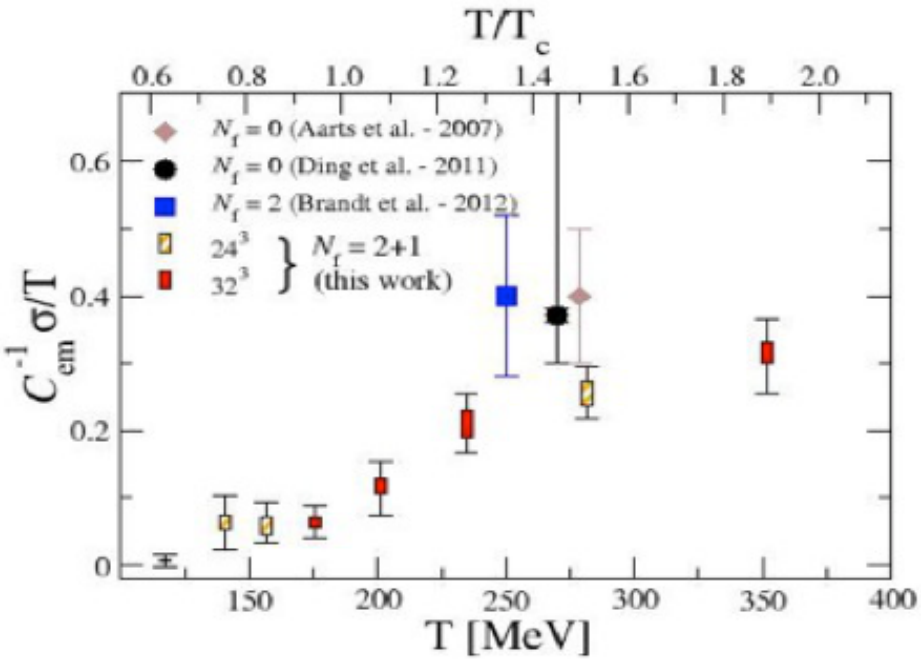


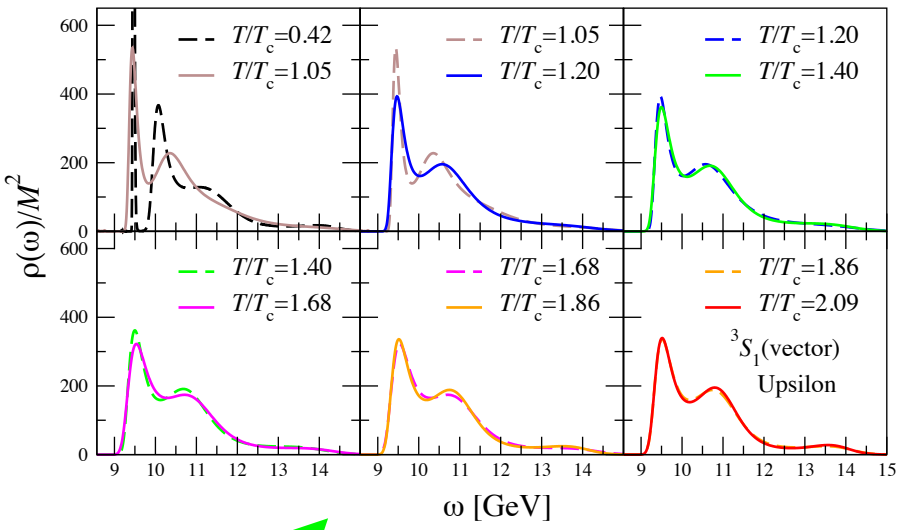
bag parameter for mixing rate

Combined with experiment, lattice QCD gives CKM elements and unitarity constraints



Lattice QCD at high temperature, density



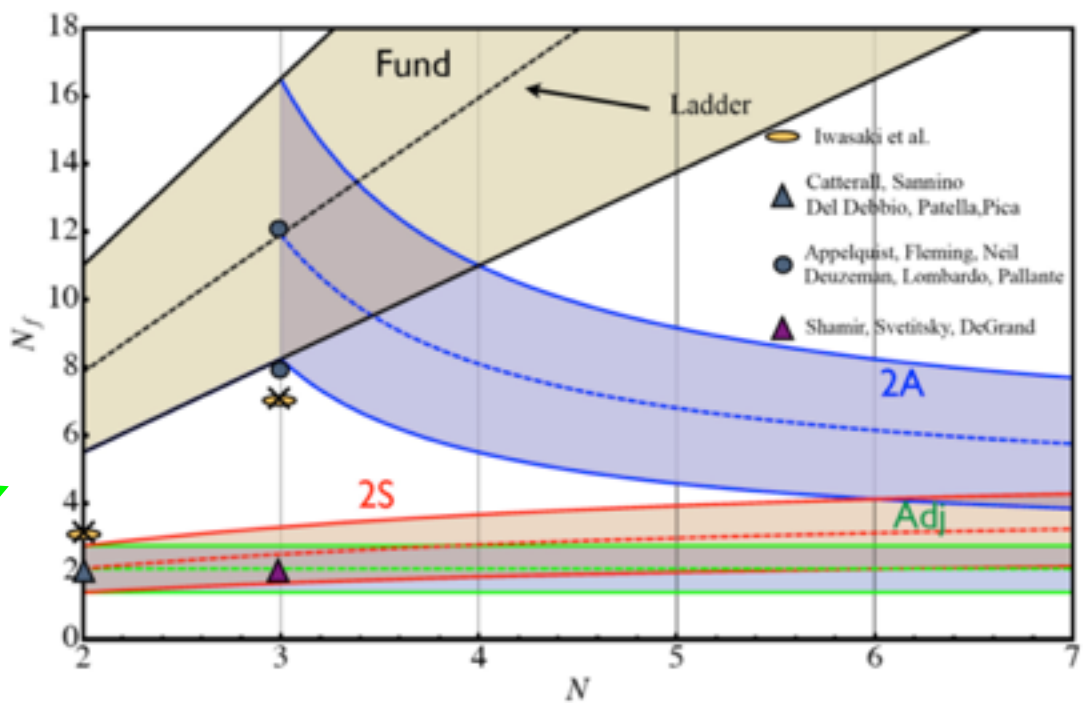


Upsilon melts at high T

Transport properties of the quark-gluon plasma

Beyond QCD ..

search for viable 'walking technicolour' theory



Future: DiRAC-3

Preparing bid to BIS for £25M capital for upgrade by factor ~10 from 2015, based around 3 machine types and RFI responses from potential vendors.

Lattice field theory prime interest in two:
"extreme scaling" and "data driven discovery"

5 Pflops, 1Pbyte

1 Pflops, 7Pbyte

- If successful will need recurrent costs for electricity and support staff.

- Increase in PDRAs and PhDs in particle theory would improve exploitation capabilities and HPC training impact.

Future (to 2018 with 10x computing power)..

- improve precision flavour physics observables →

Quantity	CKM/ expt process	Current expt Error	Current lattice Error	2018 lattice Error
f_K/f_π	$\|V_{us}\|$	0.2%	0.2%*	0.1%
$K \to \pi\ell\nu$	$\|V_{us}\|$	0.2%	0.3%†	$< 0.2\%$
f_D	$\|V_{cd}\|$	4%	2%	$< 1\%$
f_{D_s}	$\|V_{cs}\|$	2%	1%	$< 1\%$
f_B	$\|V_{ub}\|$	12%	2%*	1%
f_{B_s}	$B_s \to \mu^+\mu^-$	25%	2%*	1%
$f_{B_s}^2 B_{B_s}(\Delta M_s)$	$\|V_{ts}V_{tb}\|^2$	0.24%	10%†	3%
$\Delta M_s/\Delta M_d$	$\|V_{ts}/V_{td}\|$	0.4%	4%†	1%
B_K	$\mathrm{Im}(V_{td}^2)$	0.5%	1.5%†	$< 1\%$
$D \to \pi\ell\nu$	$\|V_{cd}\|$	3%	4%†	2%
$D \to K\ell\nu$	$\|V_{cs}\|$	0.5%	1.5%*†	0.5%
$D_s \to \phi\ell\nu$	$\|V_{cs}\|$	4%	4%*	2%
$B \to \pi\ell\nu$	$\|V_{ub}\|$	4.1%	9%†	2%
$B \to D/D^*\ell\nu$	$\|V_{cb}\|$	1.3%	2%	$< 1\%$
$B_s \to \phi\mu^+\mu^-$		20%	10%*	4%

- reduce m_b, m_c errors for 0.5% SM $\sigma(H \to b\bar{b})$
- calc. masses of $c\bar{c}$ X, Y, Z; glueballs, tetra quarks
- precision transport coefficients in QGP
- map out range of technicolor theories
- understand proton spin and size
- constrain BSM contribns to kaon mixing/proton decay
- achieve 1% on had-vac-pol contribn to muon g-2
- results for: LHC, FNAL, BES, KEK, JLAB, DAFNE, RHIC, FAIR ...