



# G2-QCD – a laboratory for cold, dense matter



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## What is and why G2-QCD?

### What is G2-QCD?

- Ordinary QCD with gauge group SU(3) replaced by G2
- G2 is one of the exceptional Lie groups
- 14 gluon colors and 7 quark colors
- All representations are real

### Conceptually interesting [1]

- Same rank as SU(3)
- G2 is the smallest group with trivial center
  - Which can be efficiently simulated
- **Can answer how relevant center symmetry is**

### Practically interesting [8]

- No sign problem, even for odd number of quark flavors
- **Full phase diagram accessible to arbitrary precision**
- Still has a nucleon, in contrast to two-color QCD

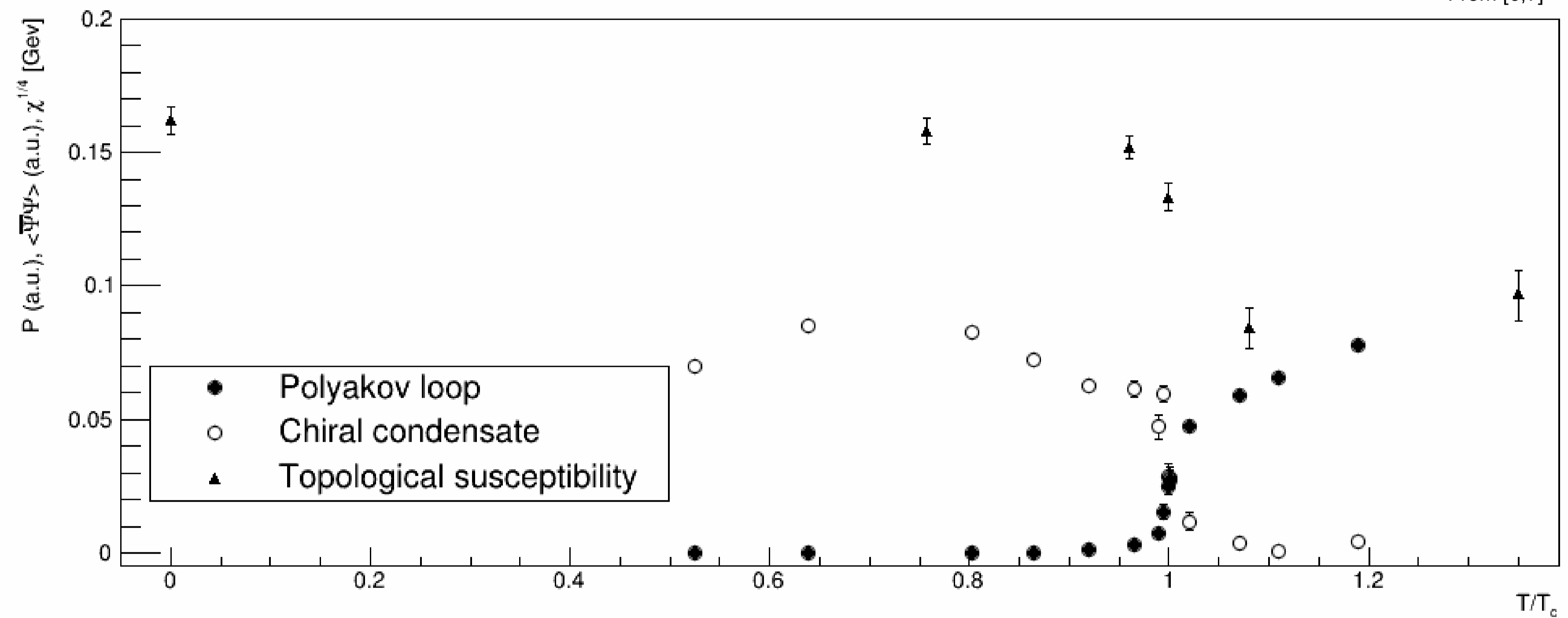
## G2-Yang-Mills theory and the role of center symmetry

### Role of center symmetry

- Is a theory with trivial center similar to one with non-trivial center?
- Yes!
  - Same low-energy physics [2,3,4,7,8]
  - First-order finite temperature phase transition [3,4,5]
  - Coinciding chiral transition [6]
  - Coinciding topological transition [8]
- Only difference: String-breaking by screening at a finite distance [1,7]
- **Center symmetry is of very limited relevance**

Phase diagram of G2 Yang-Mills theory

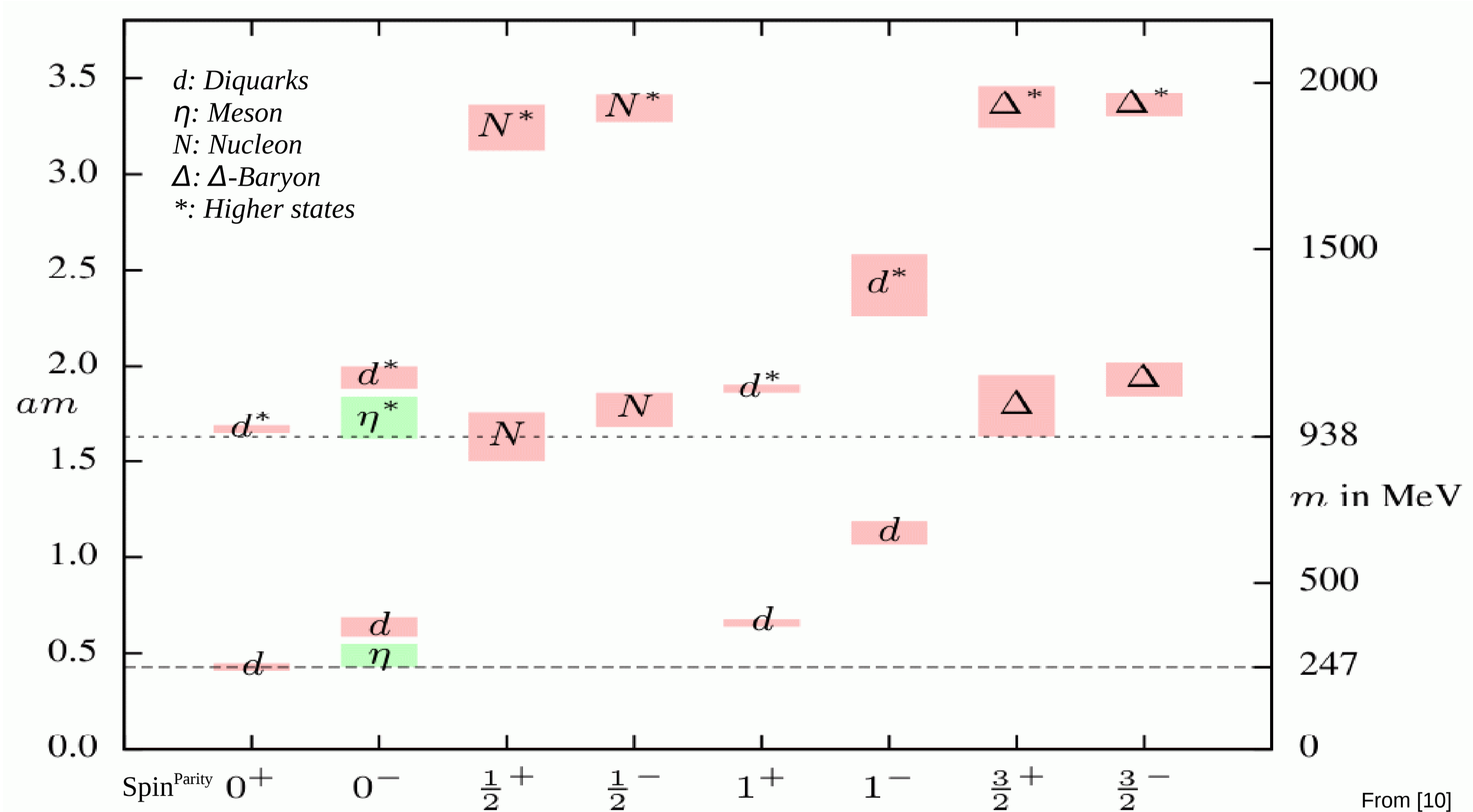
From [6,7]



## G2-QCD in the vacuum

### G2-QCD – also not so different from QCD

- One (Wilson) quark flavor – results from lattice simulations [10]
- Non-trivial chiral symmetry because of group structure
- Rich hadronic spectrum [1]
  - Standard mesons and nucleons
  - One-quark-three-gluon hybrids
  - Diquarks, which are the Goldstone bosons
  - (Heavy?) Glueballs, tetraquarks, pentaquarks,...
- Hierarchy of states manifesting chiral symmetry breaking [10]
  - Light Goldstones, medium mesons and diquarks, heavy nucleons
  - No parity doublets



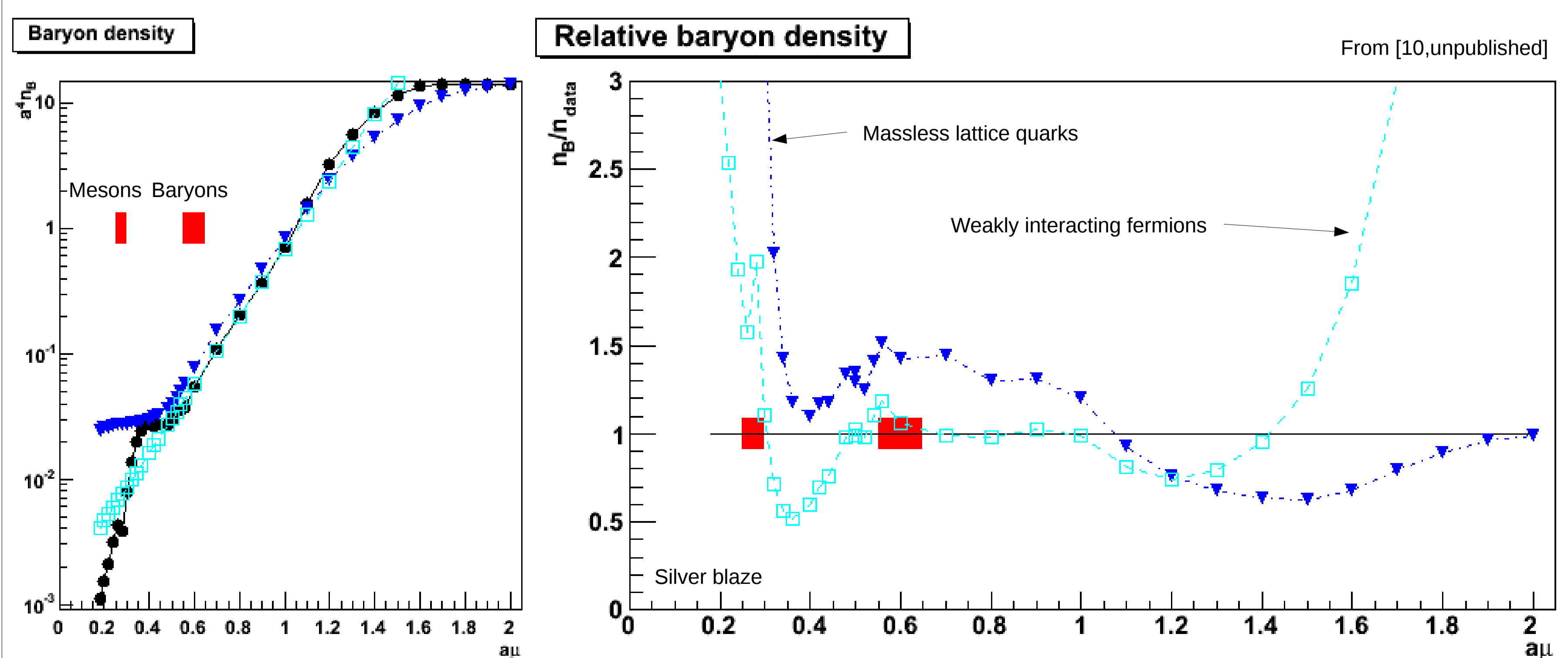
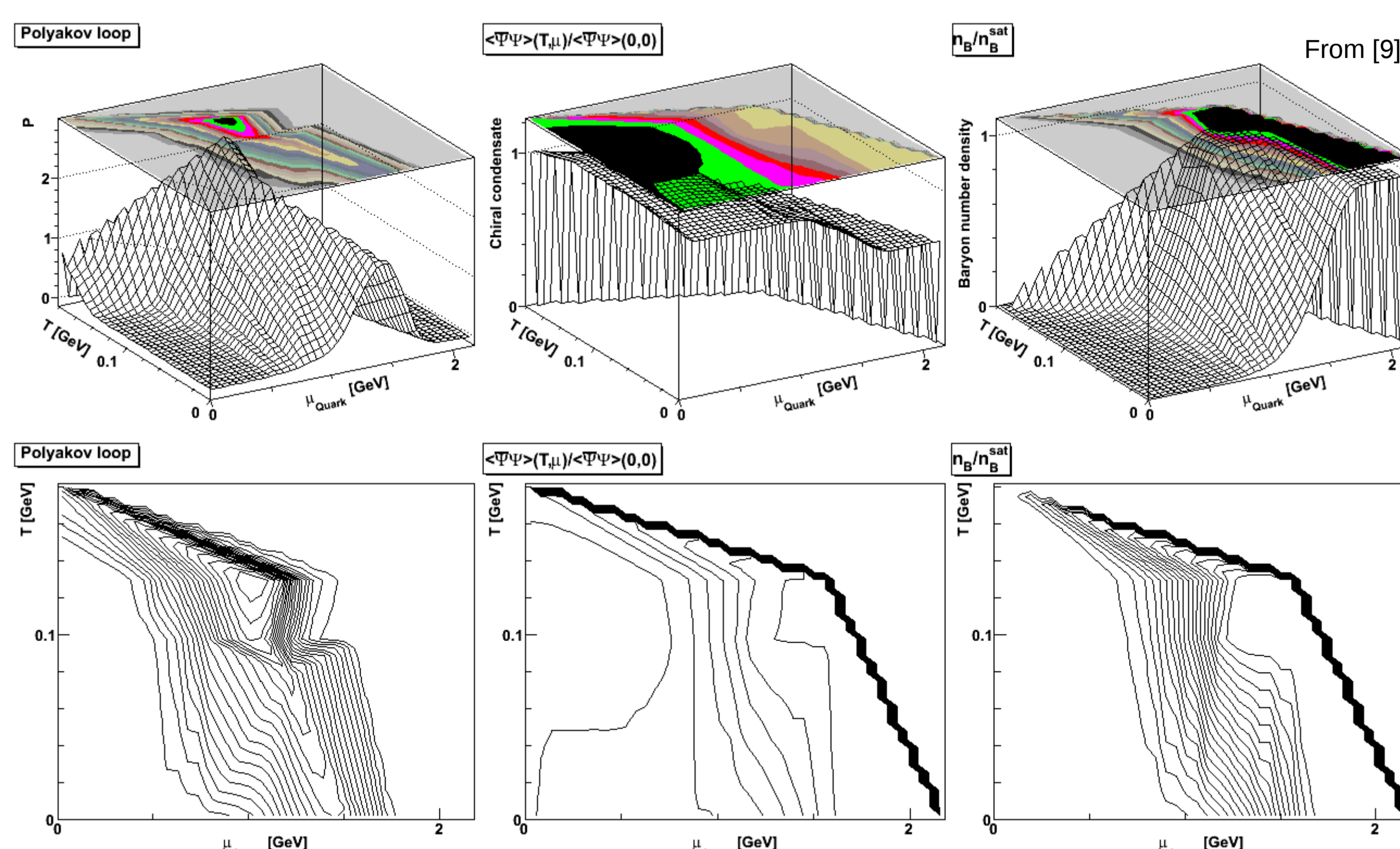
## G2-QCD phase diagram and cold, dense matter

### Phase diagram [9]

- **Expected shape**
- Silver-blaze feature at low densities
- Saturation a lattice artifact – every lattice site occupied by a quark
- Lattice artifacts set in at  $a\mu \sim 1$

### Cold, dense matter [10]

- Silver blaze onset at half diquark mass
- Intermediate phases at mesonic mass scales
- Plateau structure determined (mostly) by hadronic mass scales
- High-density regime possibly dominated by baryons – hadronic Fermi surface?
  - **Similar equation of state as heavy fermions above nucleon mass scale**



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