Investigating the Viability of Exact Feasibility Testing

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Exact Feasibility Testing

- **Given:** a subset of American TV stations
- **Ask:** can they be packed into a reduced set of channels (e.g., UHF 14-30)?
  - Must respect all interference constraints
  - Must introduce no additional simplifying assumptions ("exact")
- **Goal:** obtain a correct yes/no answer to this question within a reasonable amount of time

Interference Constraints

- **Pairwise interference:** prohibit channel assignments in which interference between any pair of stations exceeds 0.5% of served population (NPRM "Option 2")
  - **Short spacing:** pairs of stations now interfering above 0.5% can continue to cause the same pairwise interference
- **Land mobile operations:** restricted joint channel assignments for stations broadcasting from given tower pairs
- **Border constraints:** protected channels near Canadian, Mexican borders

We're developing software to output "problem instances" (sets of stations + constraints) in flat, human-readable form.

Satisfiability Testing

- Given a propositional logic formula, does there exist an assignment of (true/false) values to its variables that makes the formula true?

- E.g., a formula with 4 variables and 2 "clauses":

$$(v_1 \vee \neg v_2 \vee v_4) \wedge (\neg v_1 \vee \neg v_3 \vee v_4)$$

$$[v_1, v_2, v_3, v_4] = [\text{true}, \text{true}, \text{false}, \text{false}]$$

Encoding Station Packing as SAT

One variable $v_{i,j}$ for each station i and channel j

Each station i is assigned some channel:

$$\left(v_{i,14} \vee \cdots \vee v_{i,30}\right) \quad \forall i$$

No station i is assigned two channels $k \neq l$:

$$\left(\neg v_{i,k} \vee \neg v_{i,l}\right) \quad \forall k, l$$

A pair of stations i, j are not given a forbidden joint channel assignment k, l:

$$\left(\neg v_{i,k} \vee \neg v_{j,l}\right) \quad \forall i, j, \text{constrained } k, l$$

Generating Problem Instances

- We need data to study
  - An academic research project: must rely only on publicly available (non-confidential) information
- Our approach:
  - probability distribution P over stations, probability proportional to population served (a proxy for value)
  - Start with $S = \{\}$. Then repeatedly:
    - sample a station i from P without replacement
    - check feasibility of packing $S \cup \{i\}$ into UHF 14-30
      - 30 minute cutoff
    - if proven feasible, $S \leftarrow S \cup \{i\}$
  - Result: a dataset of problem instances

Is Exact Feasibility Checking *Feasible*?

- *Enormous* SAT instances
  - 10,000s of variables; 100,000s of constraints
  - Are they solvable within a reasonable amount of time?

- I'll report on a research project investigating this question. I'd like to acknowledge:

Alexandre Fréchette

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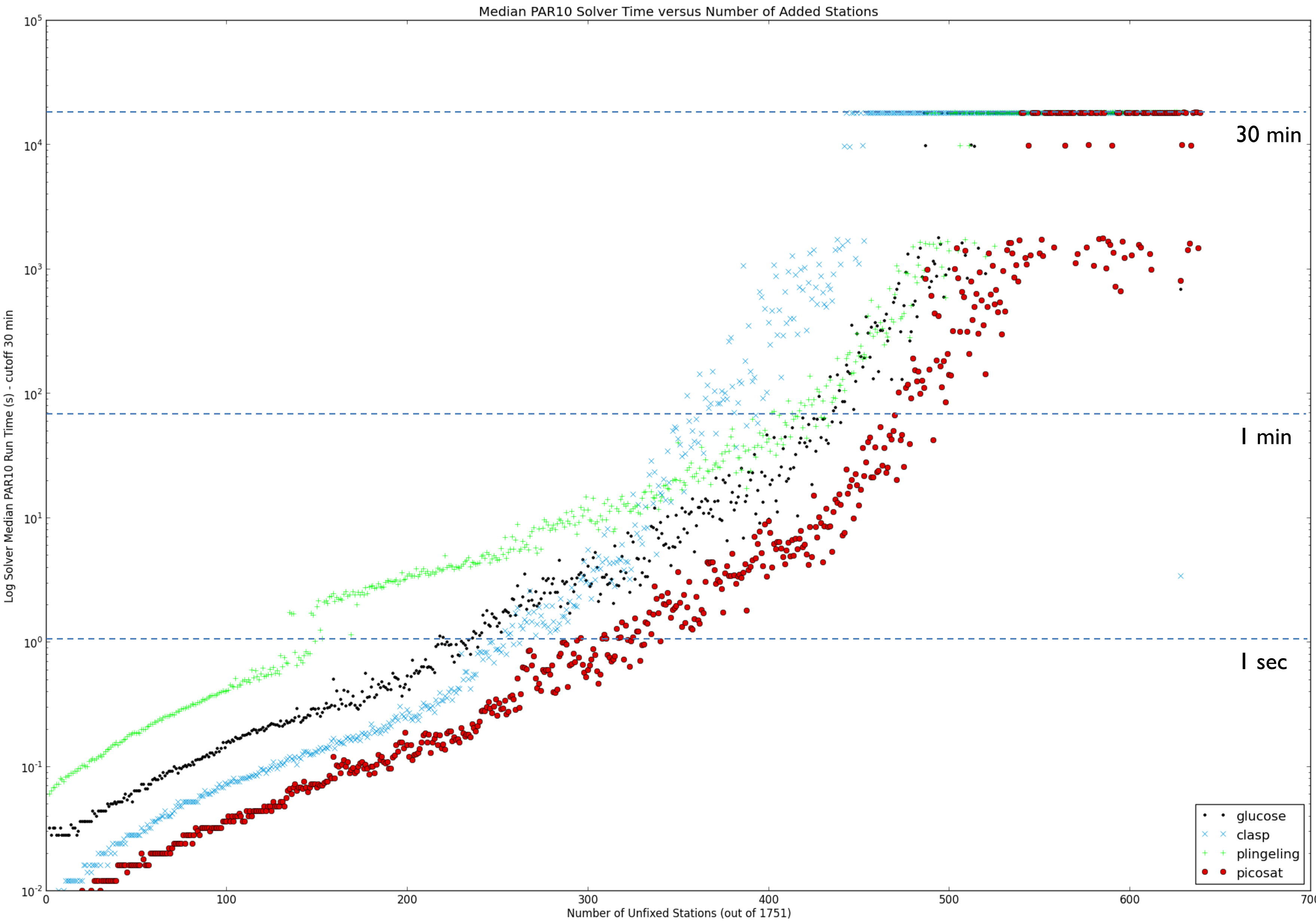
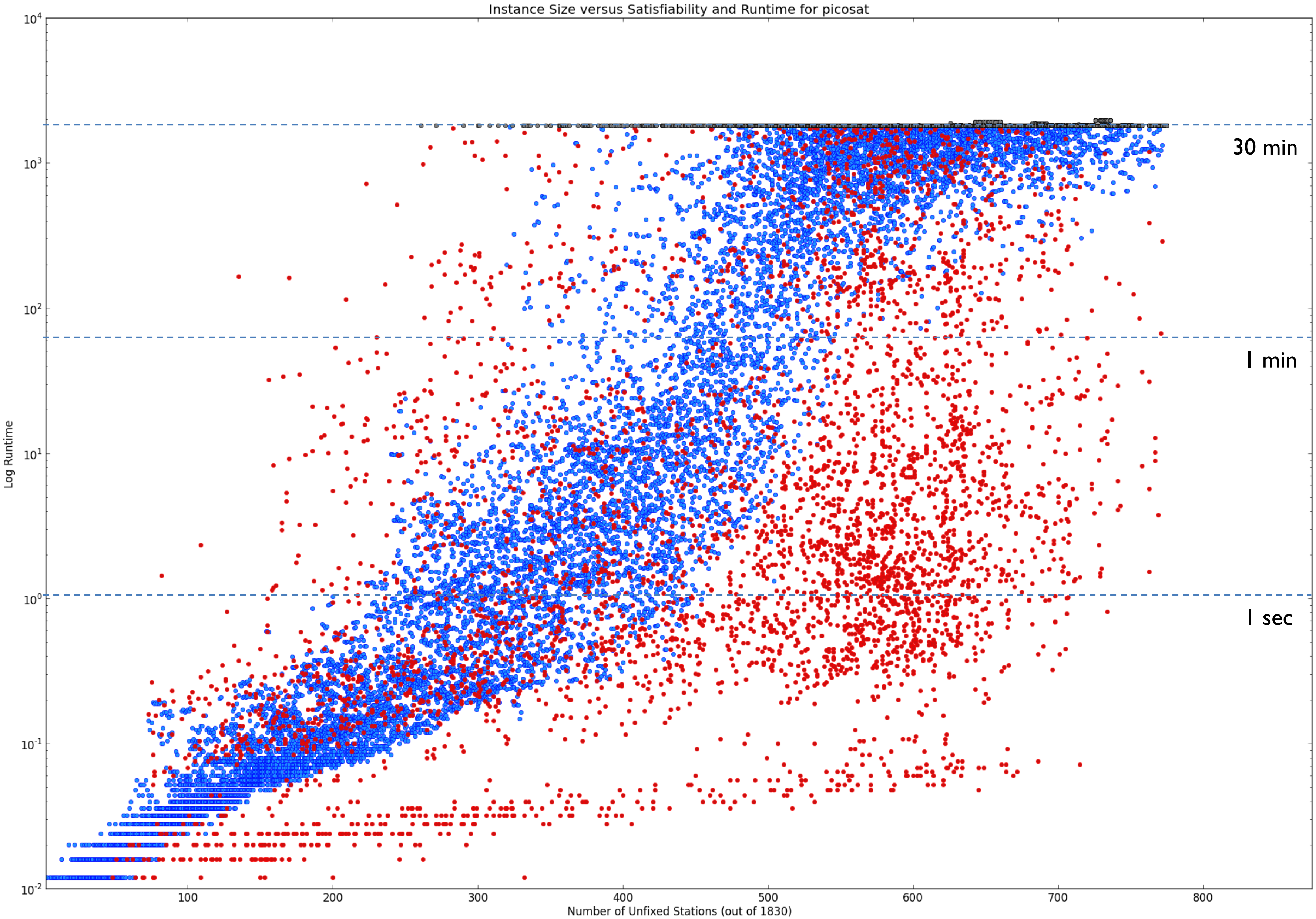
Comparing SAT Solvers



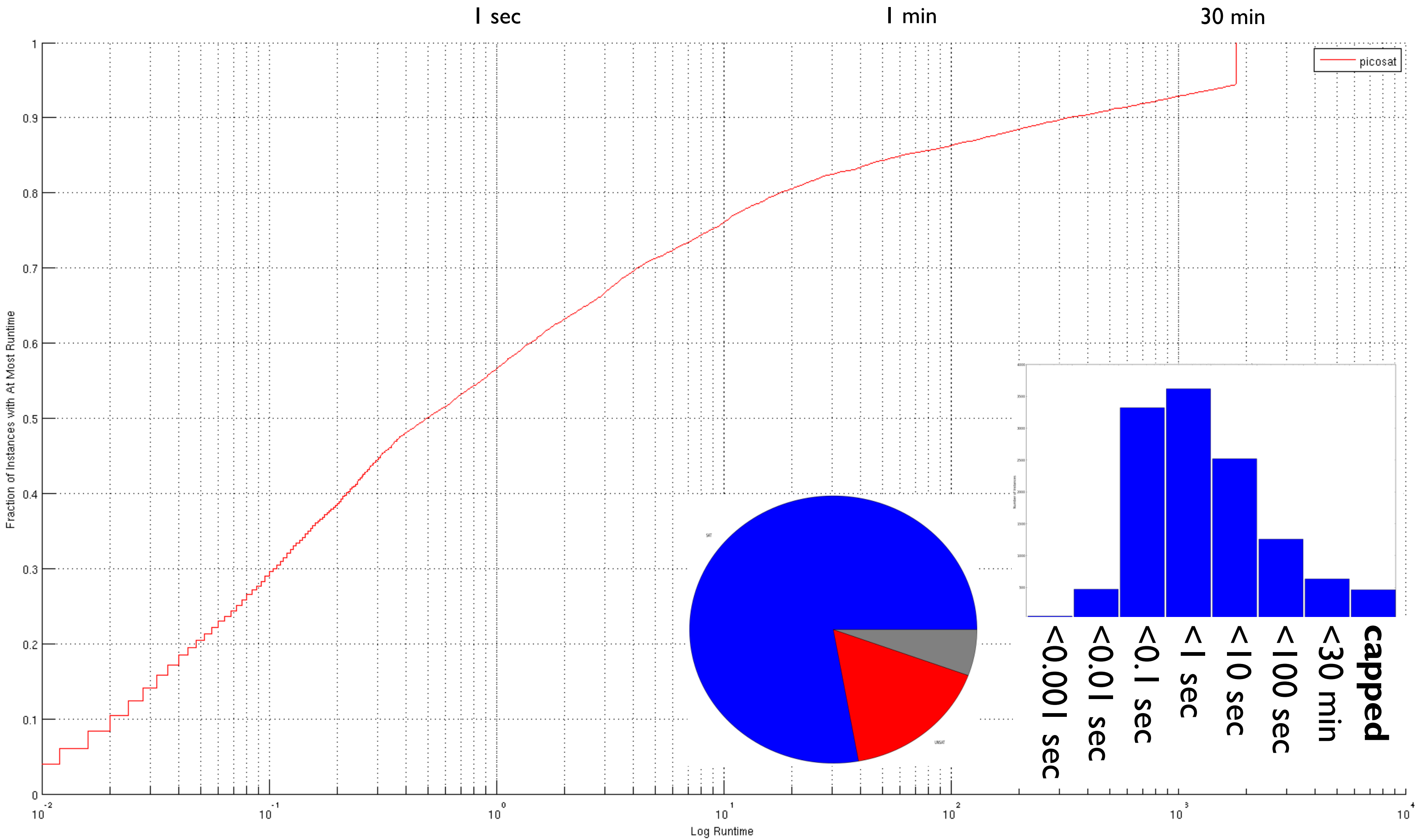
Picosat in more detail



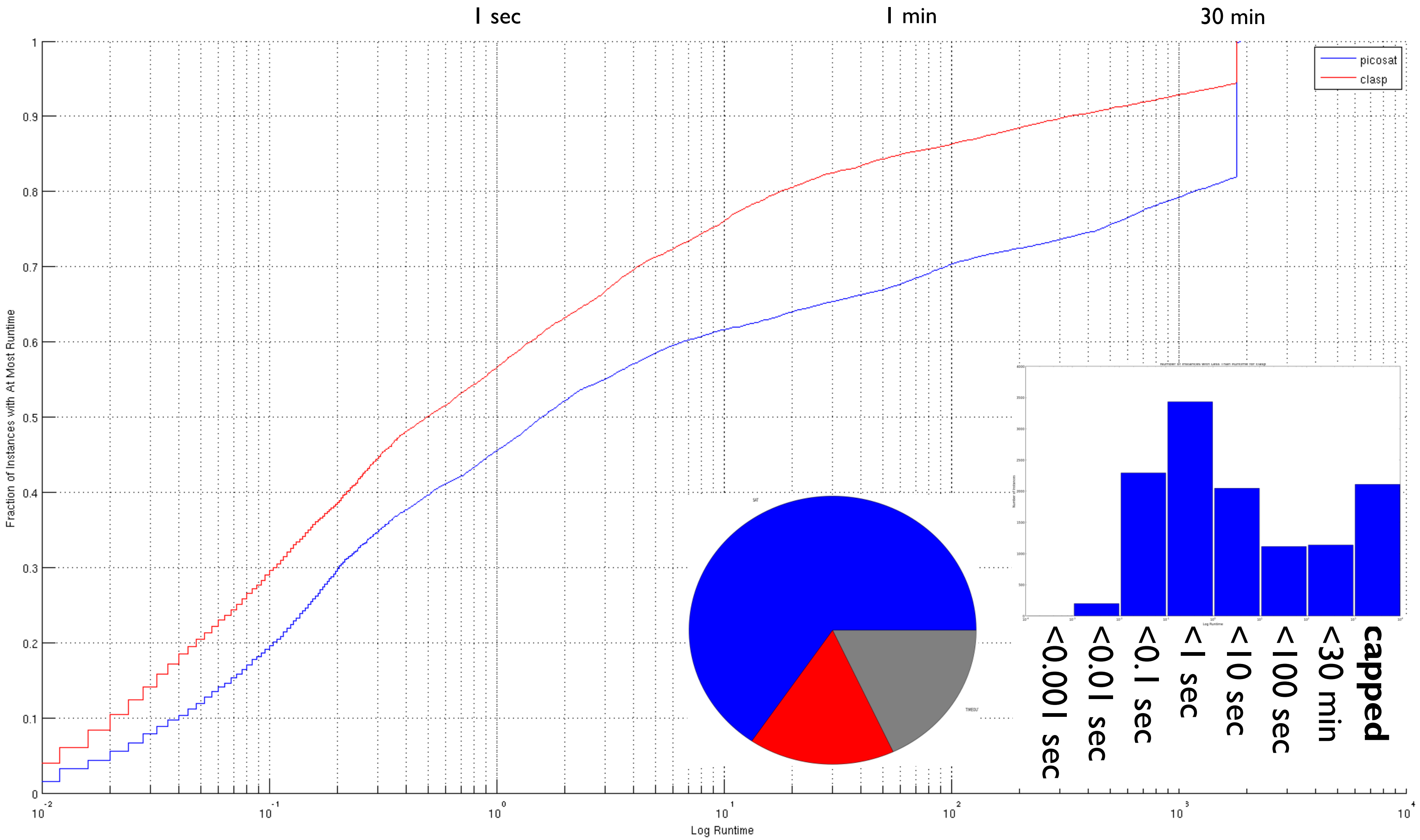
Automated Algorithm Configuration

- Many design choices are faced in the implementation of a heuristic algorithm
  - exposed by an algorithm designer as **parameters**
- A decade-long focus of my research group: *automated algorithm configuration*
  - replace human design effort with machine time
  - achieve better performance
- We used SMAC [Hutter, Hoos & Leyton-Brown, 2011]
  - a Bayesian optimization method

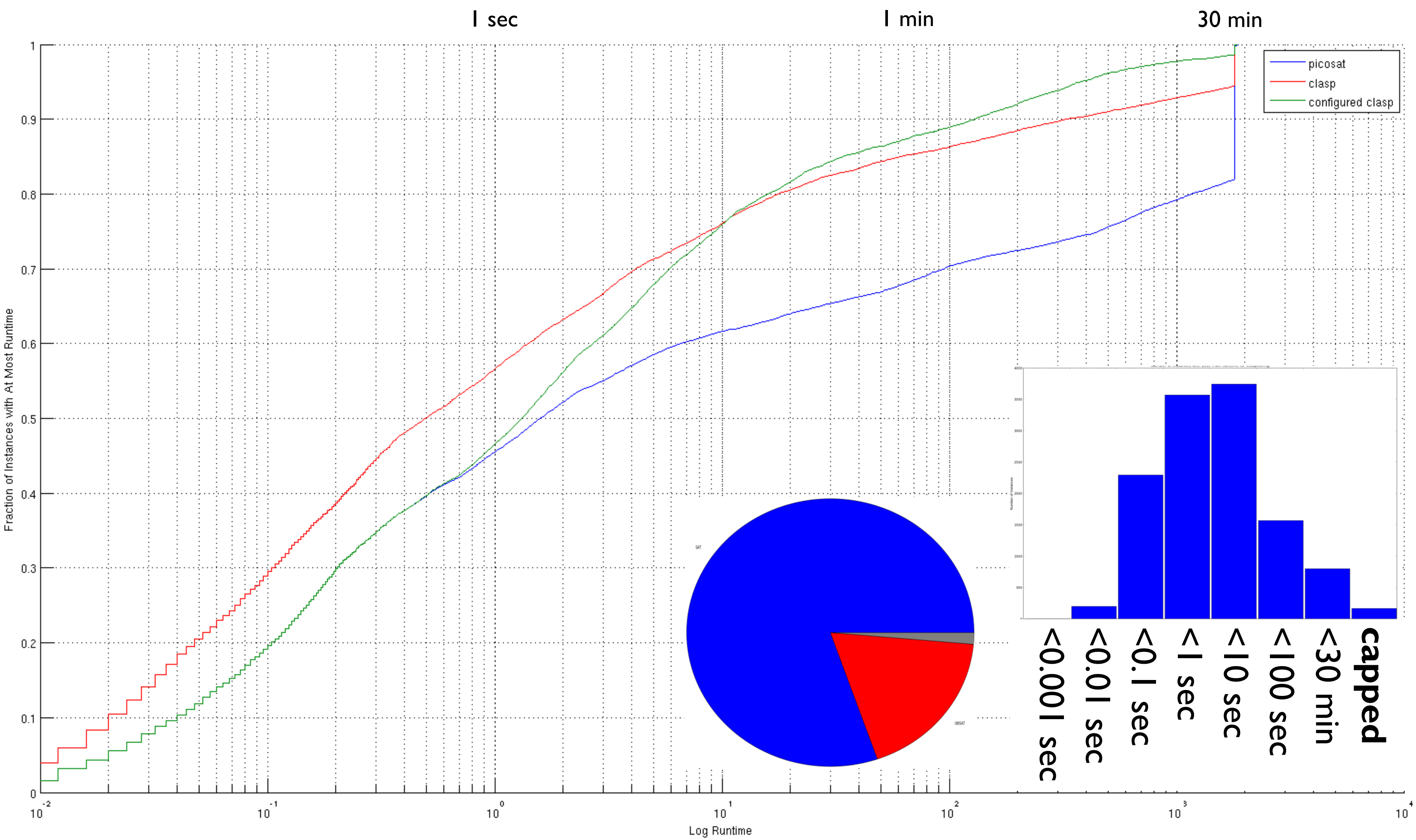
Automatic Configuration



Automatic Configuration



Automatic Configuration



Ongoing Research

- Longer, more exhaustive configuration runs
- Configuring additional solvers
- New datasets
  - same heuristic; stronger solver, more machine time
  - based on more realistic simulations
- Iterative SAT solving
- Algorithm portfolios
  - initial investigation: 2× speedup
  - could be much stronger by leveraging less similar algorithms (e.g., DAC's feasibility checker)