ETH zürich

Efficient Eco-Gas Optimization for RPC using Multi-Objective Bayesian Techniques

3rd DRD1 Collaboration Meeting, CERN

Presenter: Pit Bechtold

High Voltage Laboratory

Collaboration

ETH zürich

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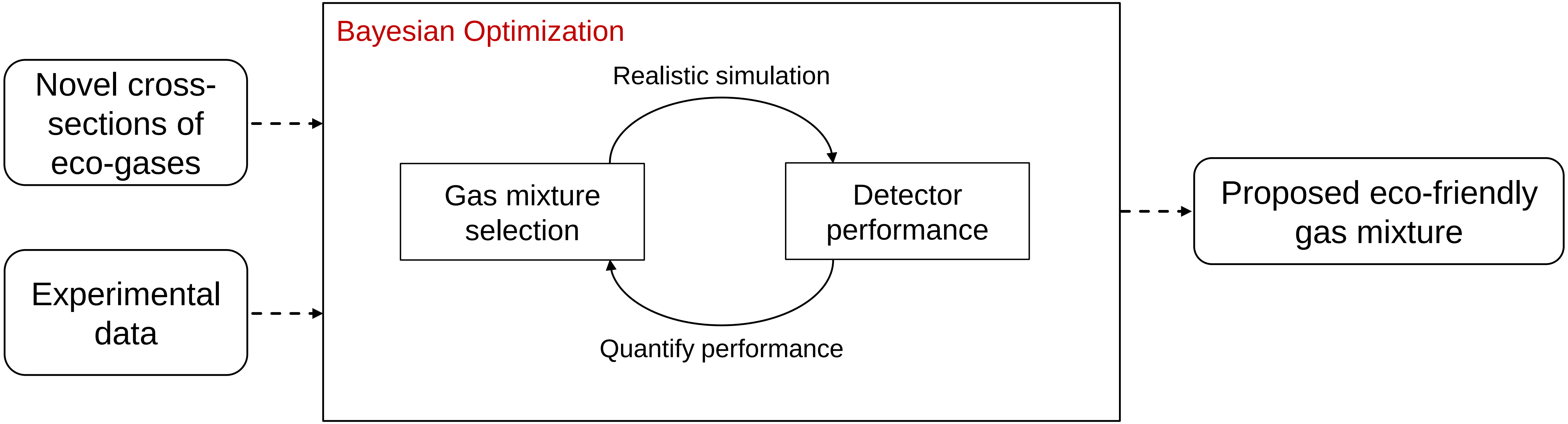
Project Objective

Research Goal

Develop an optimization framework to identify the performance trade-offs of eco-friendly gas mixtures through the prediction of the pareto-set for a set of performance metrics.



Challenges

- Optimization of CO_2-based standard mixture
- Relating performance to gas shares
- 3 DoF (Precision of 0.01%)
- Conflicting objectives

➢ "Taking the human out of the loop"

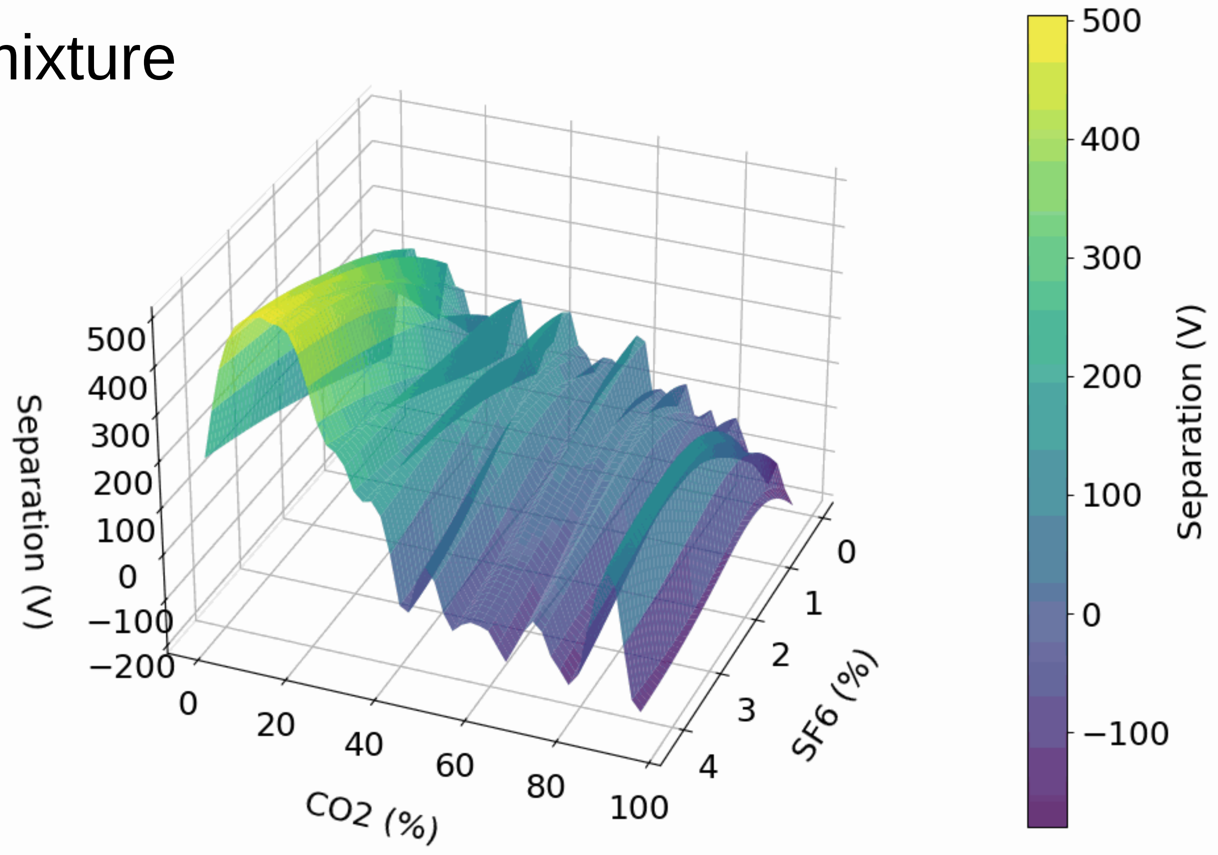


Figure: Problem space representation for avalanche streamer separation

Gas Optimization for Resistive Plate Chambers

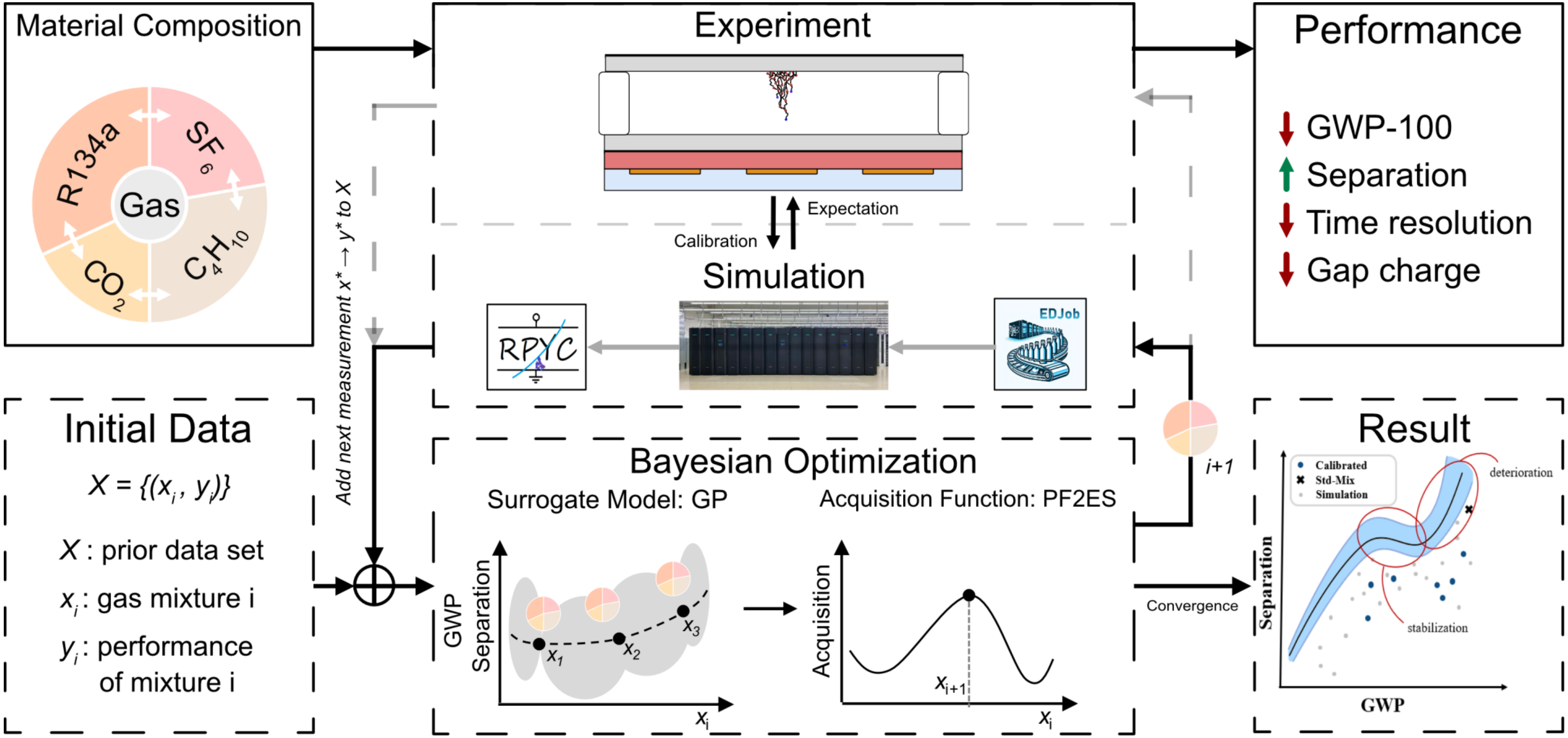


Figure: Bayesian Optimization Workflow in context of gas optimization for RPCs

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Pareto Front Prediction

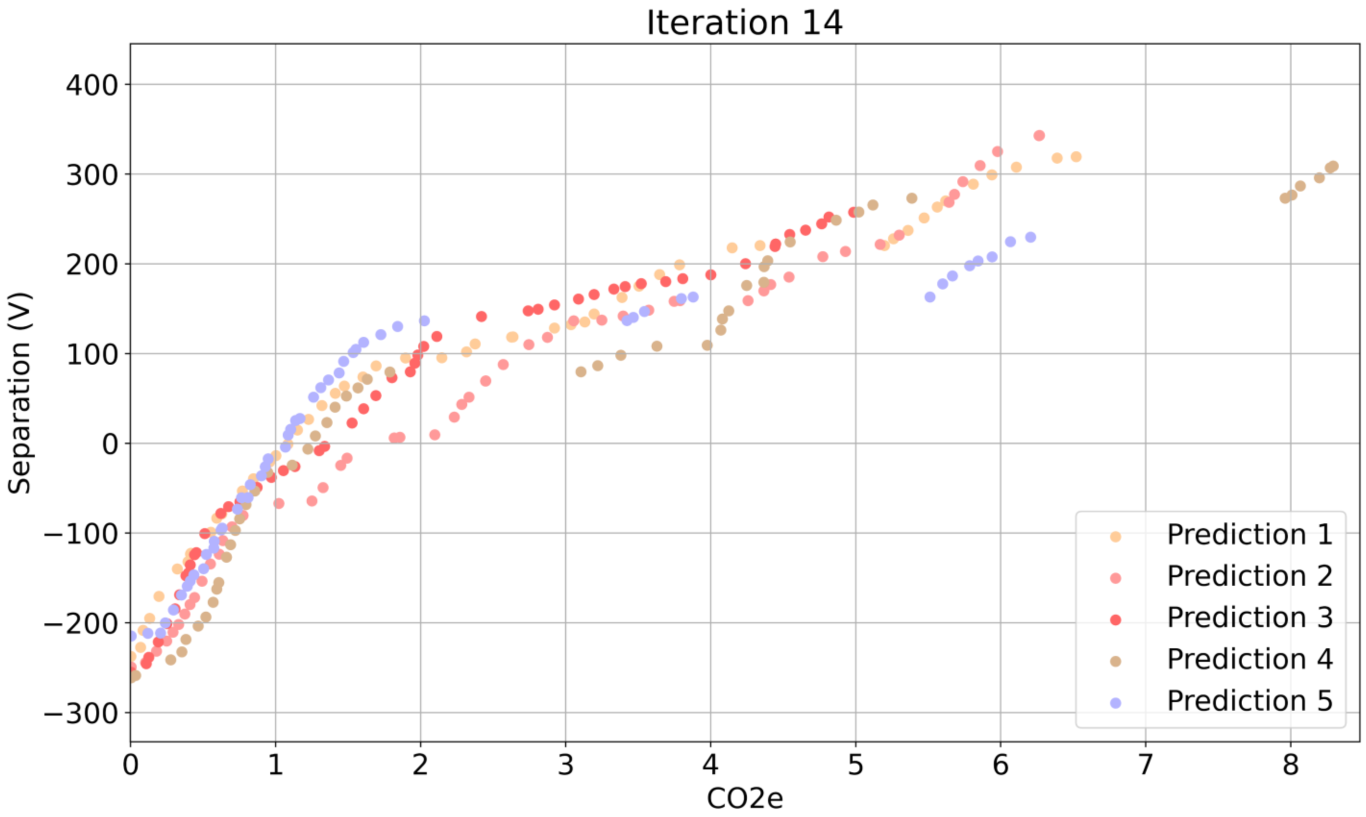


Figure: Prediction of avalanche streamer separation vs CO2e

- Set of optimal competing solutions
- Input: prior experimental data
- Solid overview after few iterations
- Either simulation or experimental data

Simulation study: Separation vs. CO2e

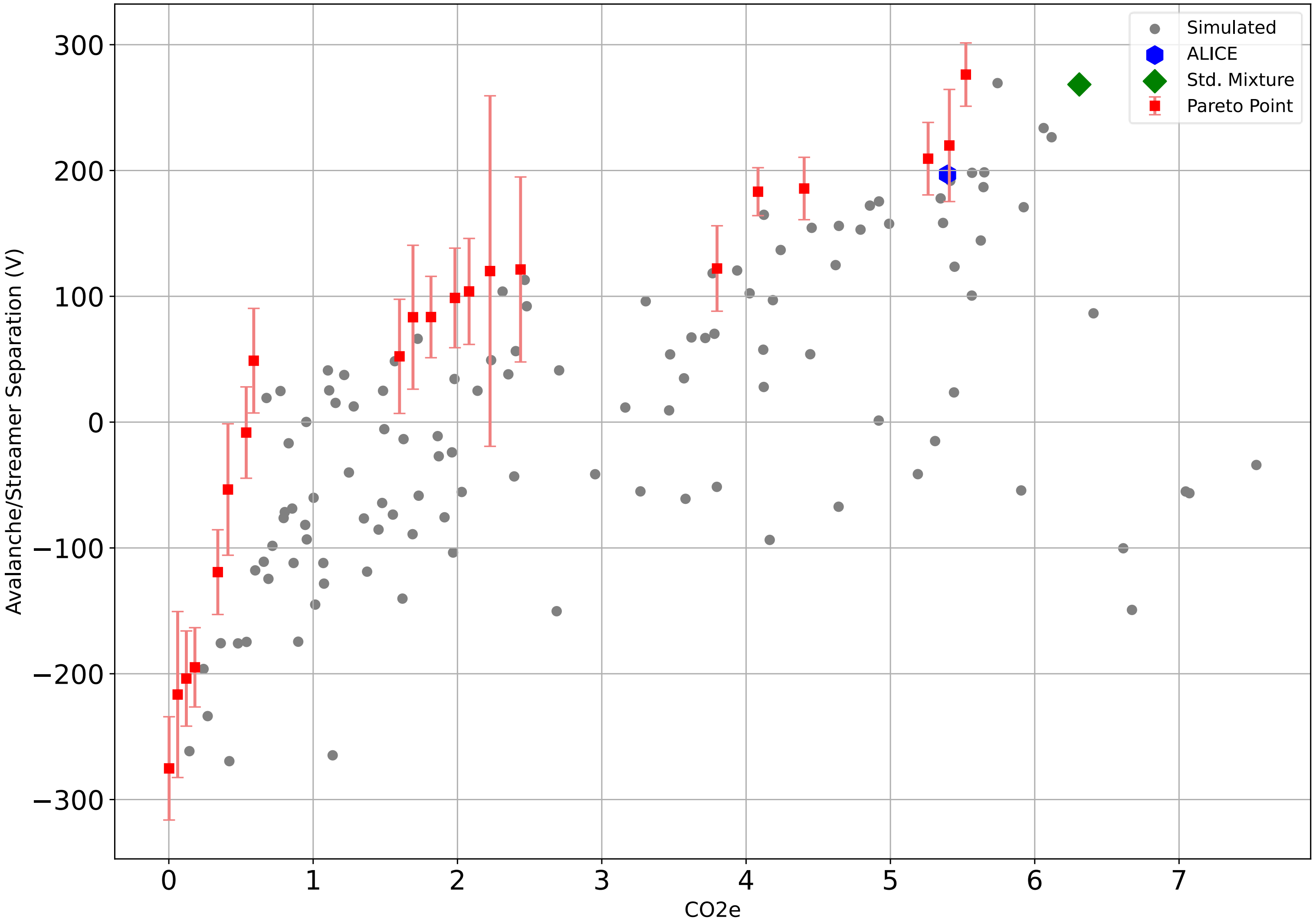


Figure: Avalanche streamer separation vs CO2e for 143 mixtures

- Each point: efficiency-streamer curve
- ~ 1000 events per high voltage point per gas (8 points)
- Possible candidates with similar performance

Simulation study: Gap Charge vs. CO2e

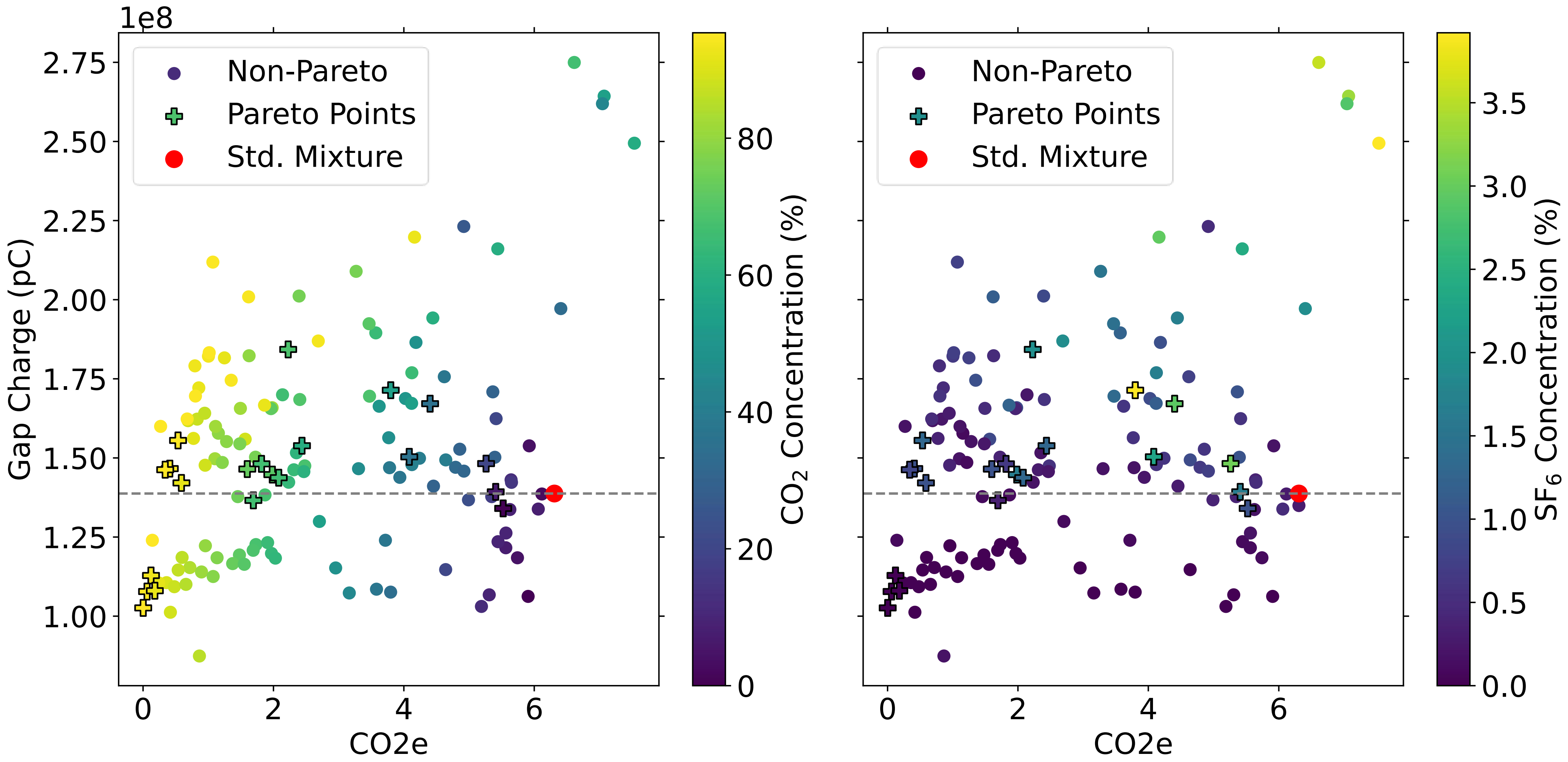


Figure: Gap Charge vs CO2e for 143 mixtures

Simulation study: Time Resolution vs. CO2e

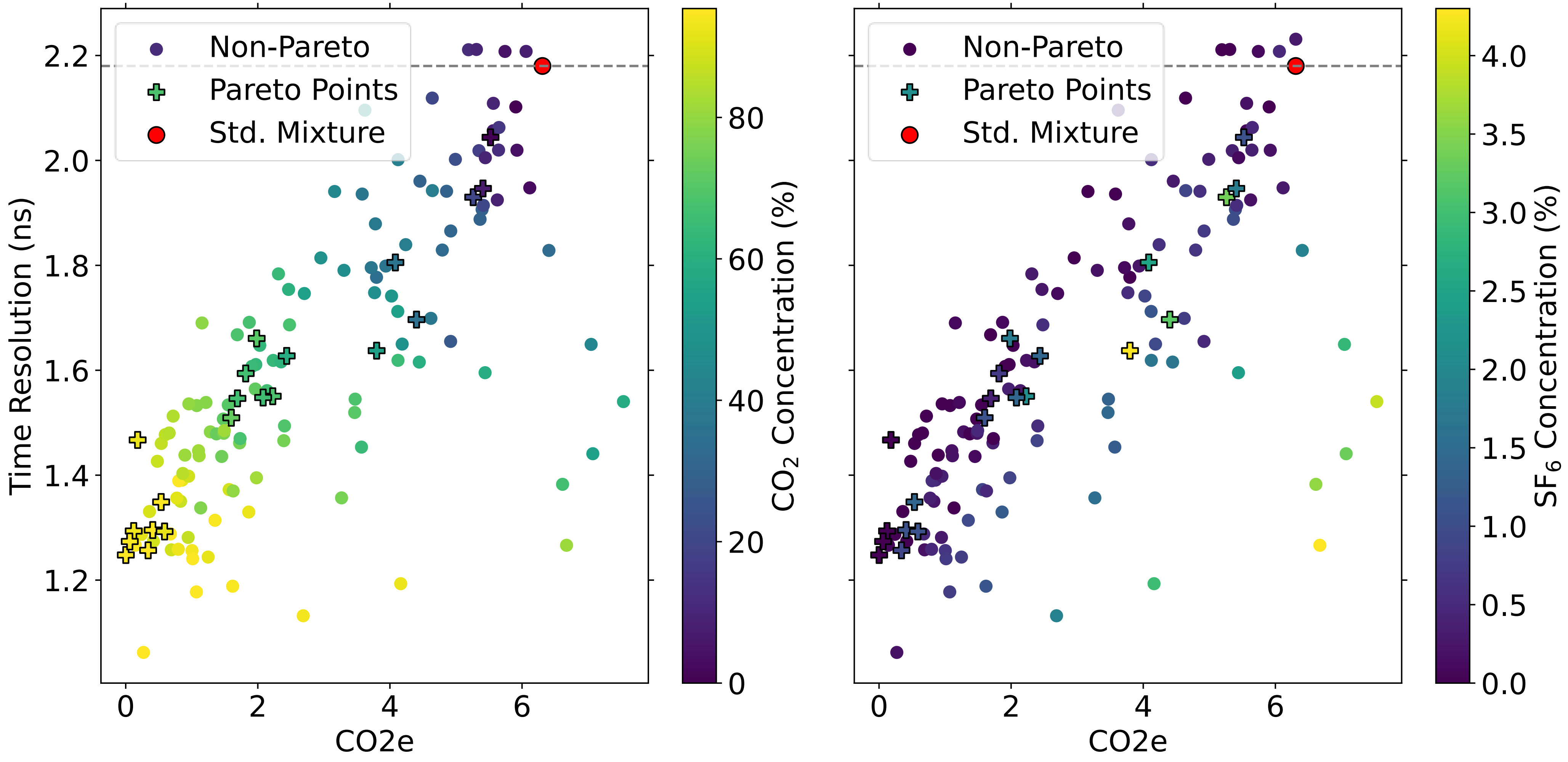


Figure: Time Resolution vs CO2e for 143 mixtures

Statistics

- Calculated 2086 swarm-parameter sets
- Simulated 143 gases over different studies
- Used 440’000 CPU-Hours @Euler HPC
- Optimization computations only in minutes

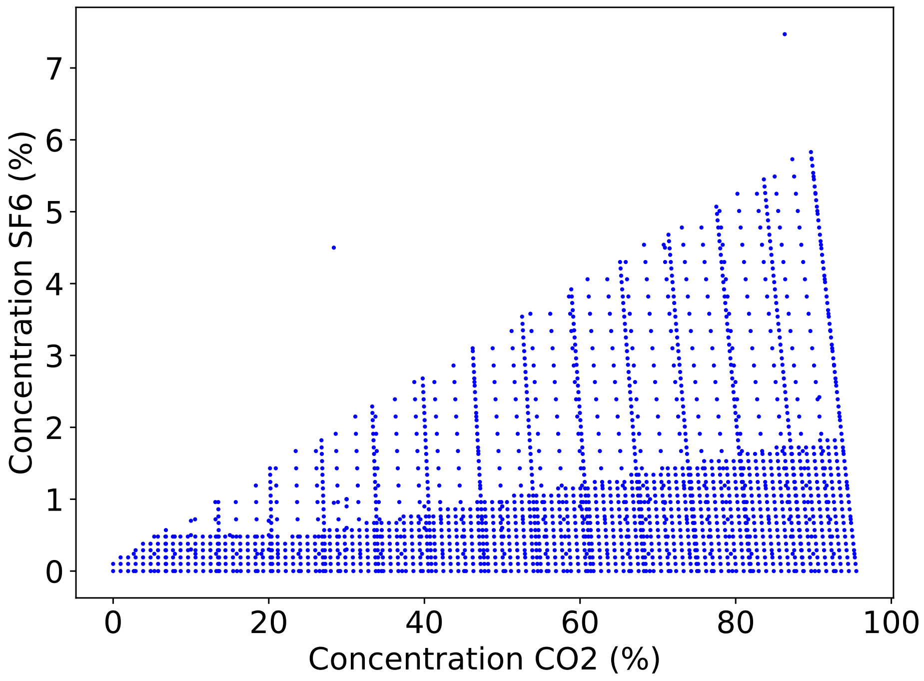
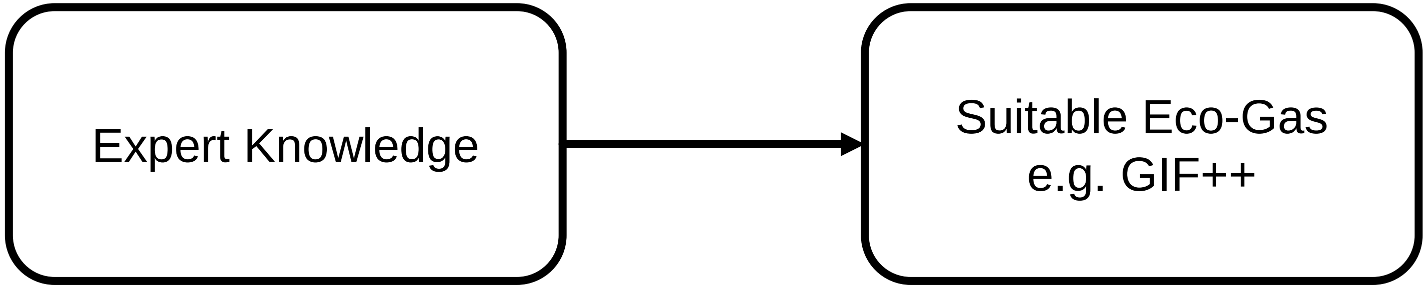


Figure: Grid space of calculated swarm parameter sets

Opportunities

- Assess performance in hours
- Integration into experimental workflow
- Facilitate «fine-tuning»
- Tool easily expandable to other geometries, gases, detectors, …



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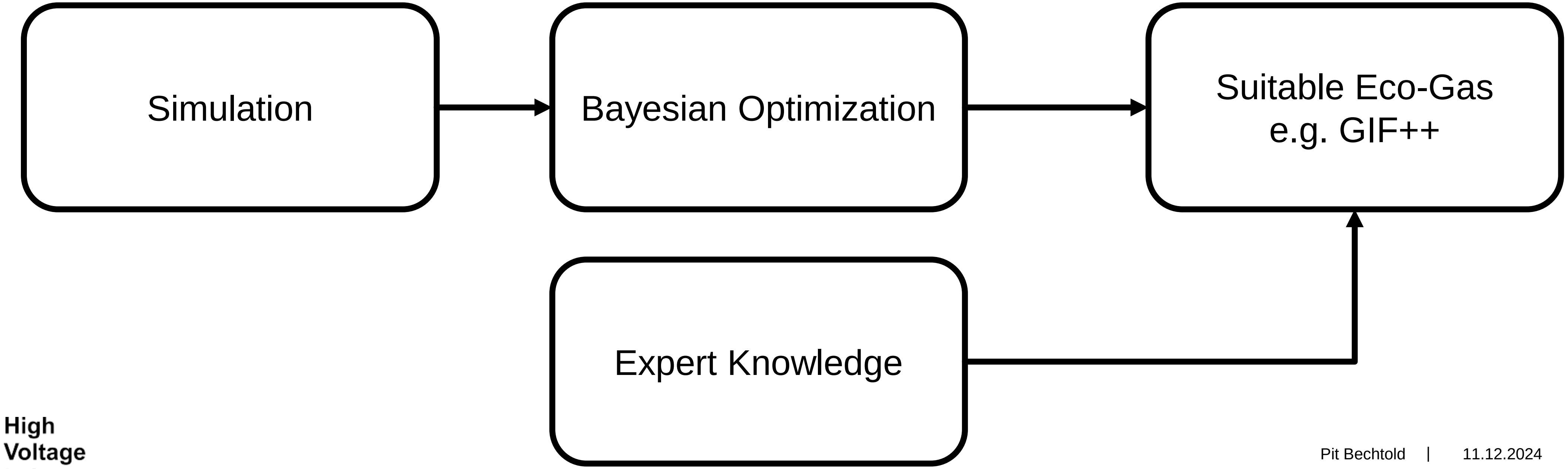

Contact Information

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Backup

Table: Std. Mixture vs. ALICE vs. Possible Candidate

Metric	Std. Mixture vs. ALICE	Std. Mixture vs. Candidate	Alice vs. Candidate
CO2e	-16.61 %	-35.29 %	**-22.40%**
GWP	+0.63 %	-13.28 %	**-13.82%**
Separation	-21.98% ±11.46%	-31.76% ±7.89%	-12.50% ±15.14%
Time Resolution	-13.52% ±3.04%	-19.07% ±2.39%	-6.45% ±3.58%
Gap Charge	9.83% ±2.53%	11.41% ±1.98%	1.45% ±2.55%
HV90	-1.86% ±0.29%	-4.85% ±0.18%	-2.94% ±0.31%

	CO2 (%)	R134a (%)	isoC4H10 (%)	SF6 (%)
Possible Candidate:	44.06	50.77	4.5	0.67