(De)centralization of Ethereum's builder market

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Yale Duke UNIVERSITY

Security

Transparency

Technical neutrality

Immutability

Future of FinTech

Censorship Resistance

Verifiability

Decentralization, Decentralization, Decentralization!

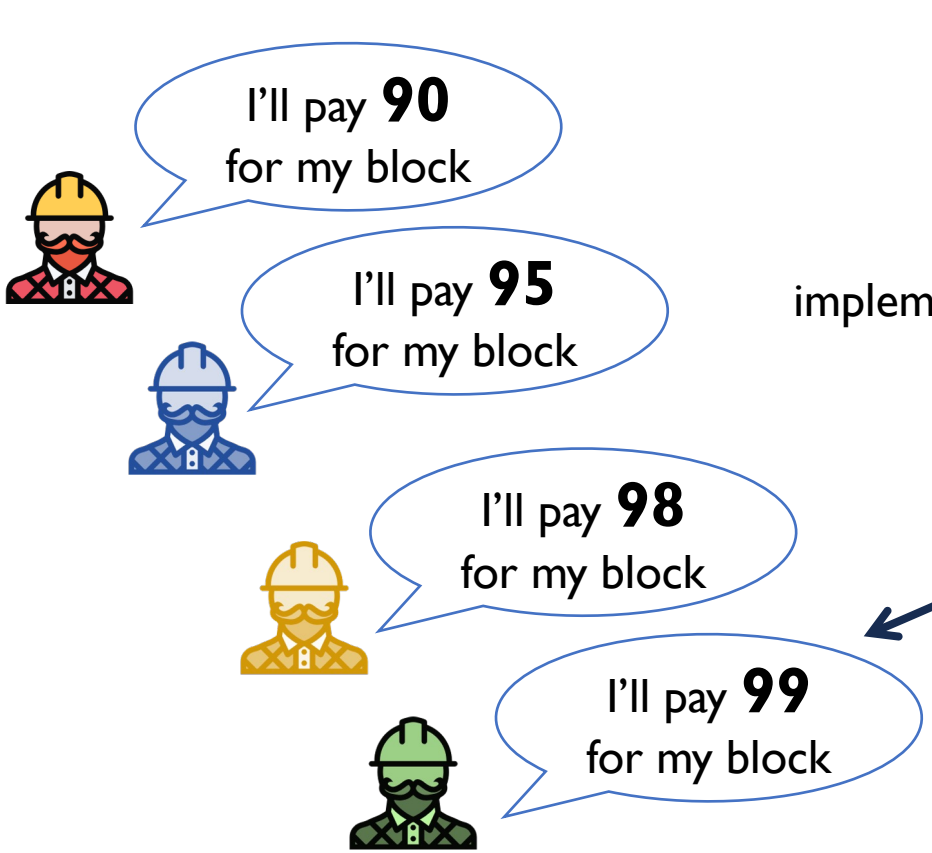
How are we doing on decentralization in practice?

MEV is a threat to decentralization

- MEV: profit from manipulating txns ordering
  - ~$1 m per day [varies, see https://explore.flashbots.net]
- MEV is a centralizing force
  - big validators (e.g., backed by trading firms) will outcompete small validators (e.g., hobbyist)
- Ethereum's solution: Proposer-builder separation (PBS)

PBS and builder market

- Idea: outsource block building (i.e., MEV extraction) to builder market.



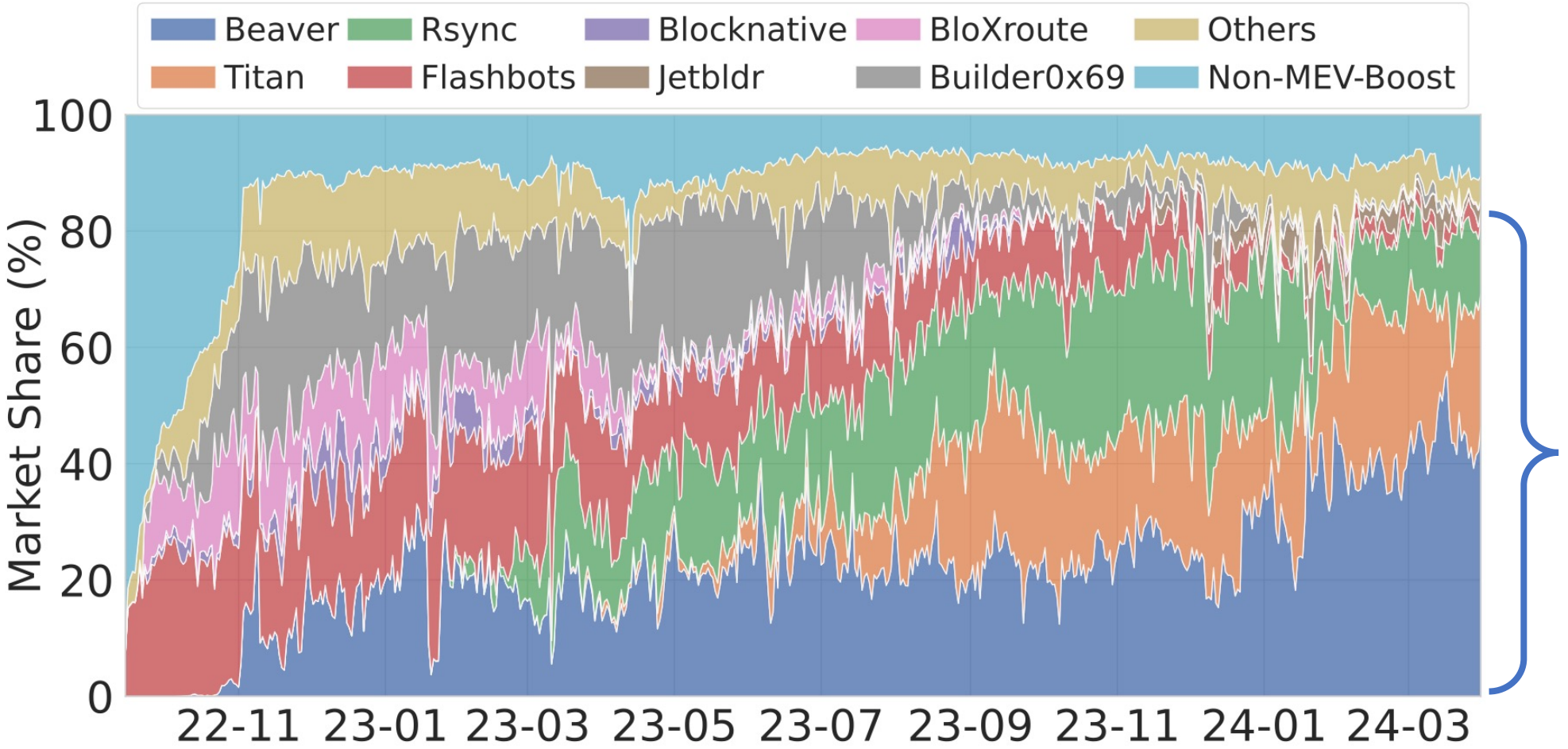
New player: Builders

implementation: MEV-Boost

validator / proposer

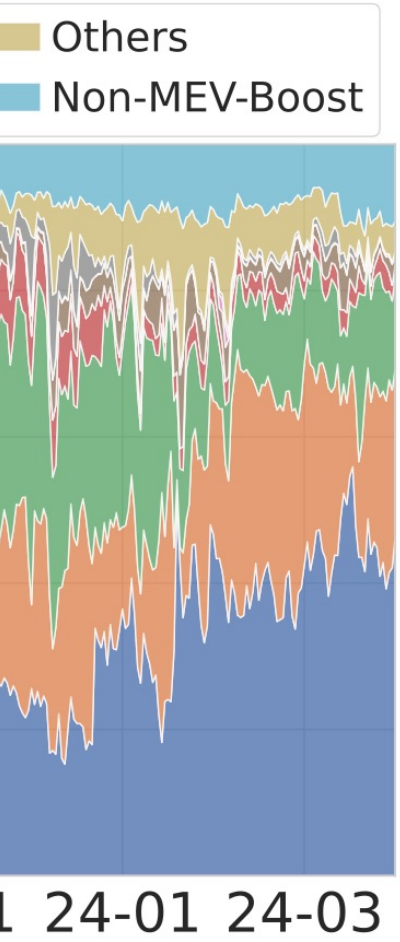
- In operation since the Merge (2022)
- Ideally, validators get most of the MEV in auction revenue

Market share of Ethereum's builders market



Three builders build ~90% blocks as of March 2024

Is centralized block building okay?



- Builder market centralization is thought to be "*okay*"
  - "`centralized block production is fine as long as [validators are decentralized]`" **--- ethereum.org**
- We are not convinced by this argument
  - Concern: proposers would incur a ***profit loss*** in a centralized builder market.
  - Proposer loss has ***undesired consequences***.

Implications of proposer loss

- #1: Instability of PBS
  - Proposers might be incentivized to extract MEV themselves.
  - Big validators have competitive advantages or small ones, leading to validator centralization.
- #2: inaccurate MEV oracles
  - Auctions are used to measure MEV (MEV oracles) (e.g., MEV burn).
  - proposer loss $\Longrightarrow$ inaccurate MEV oracles
- This talk: quantify the loss, understand its causes, and explore mitigation.

Decentralization of Ethereum's Builder Market

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Modeling MEV Auctions

- In each instance, builders submit bids in the form of (B, BV)
  - B: a block
  - BV: amount to pay if bid is accepted
- Builder's **true valuation (TV) underlying a bid B :=** balance increase after executing B
  - i.e., TV(B) is the sum of values from txns in B
- When auction concludes, B with the highest BV wins.
  - Block B is added to the blockchain
  - Builder of B gets TV
  - Builder pays the proposer BV
- Builder's profit = TV – BV

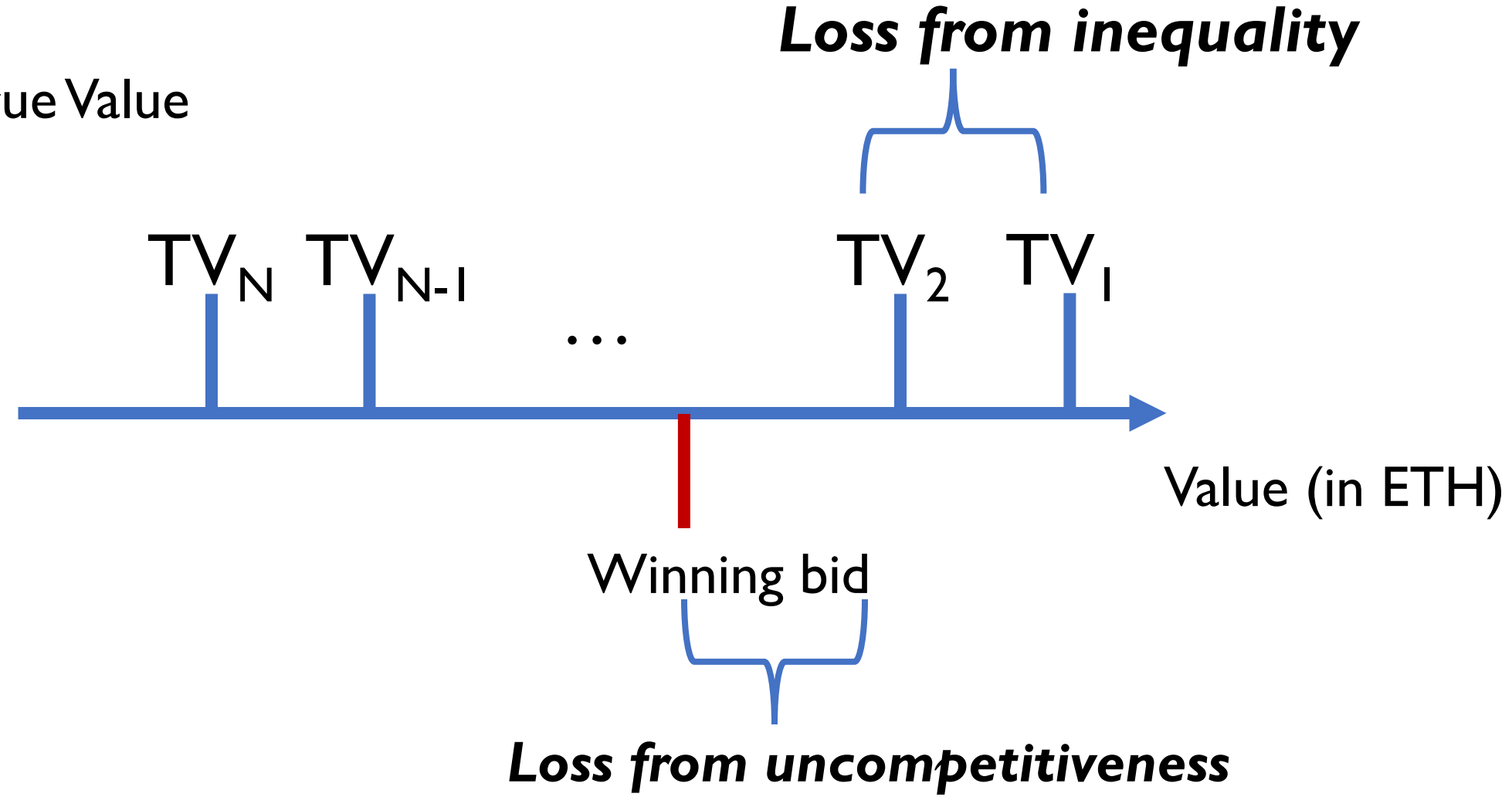
Potential reasons for proposer loss

- **1) Does the mechanism incentivize competition?**
  - Reasons for yes: MEV boost auction is akin to an English auction
  - Reasons for no: Fixed deadline may not allow full competition. Builders may collude.
- **2) Do builders have similar block-building capacity (BBC)?**
  - Counterexample: Alice extracts 100 ETH, Bob extracts 10 ETH, Charlie extracts 9.5 ETH. Assuming competitive auctions, auction revenue is $10 + \epsilon$ (far from 100)
  - i.e., Proposer can get up to 90 ETH more if they build blocks.

- Two types of loss: **Loss from uncompetitiveness**, and **loss from inequality**

Proposer loss definition

TV = True Value

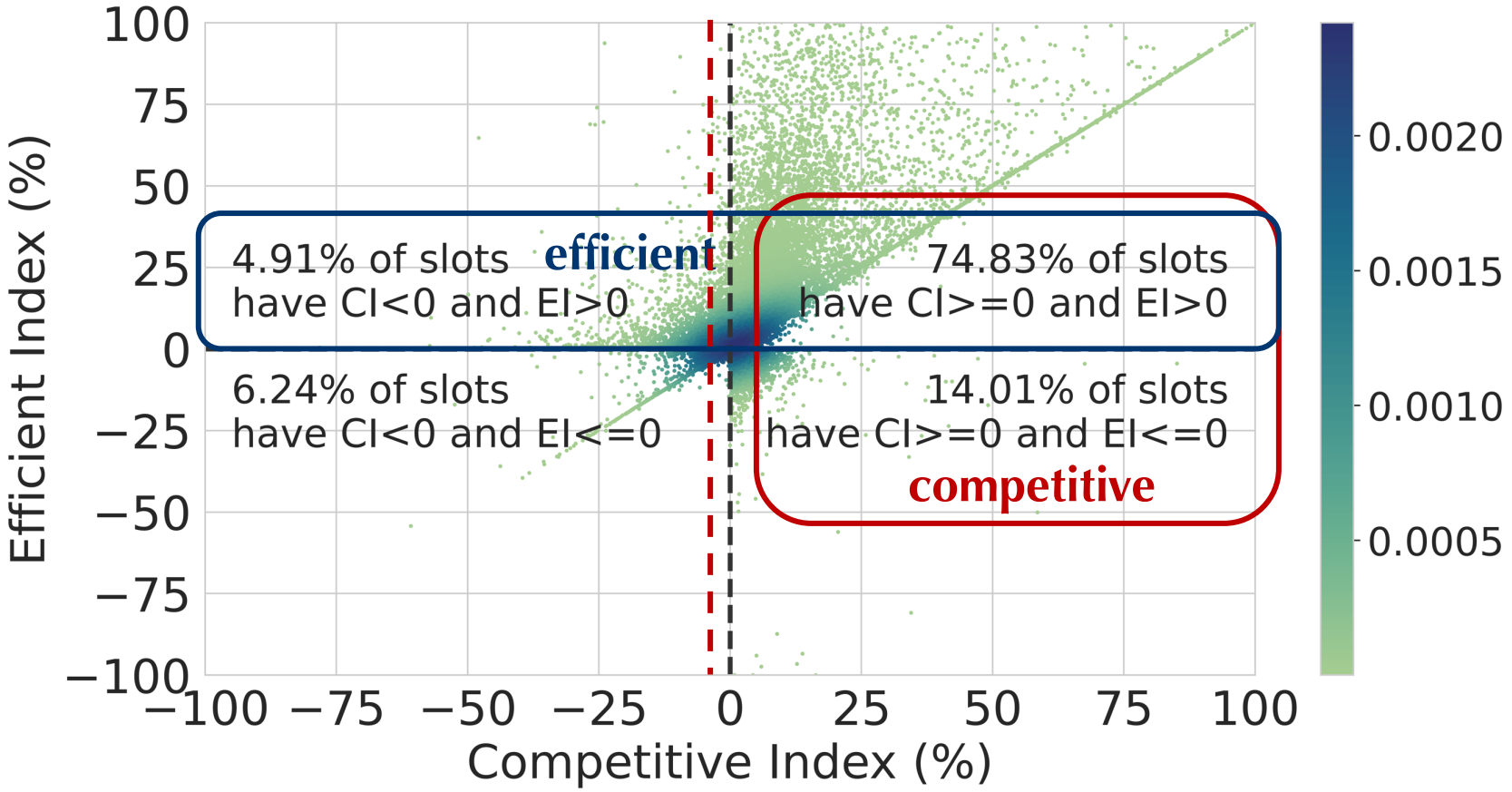


Quantification of proposer losses

- Practical challenge: auction data is not recorded on-chain
  - Blockchain only records the winning bids. We need losing bids too.
- We started to archive auction bids since 2022
  - 5 billion partial bids (block hash, bid) since Sep 2022 to March 2024 (collected by querying relays)
  - full bids (partial bids + txns) from ultra sound relay (200 GB / day)
- cross validation against public datasets & related papers

Result: competitiveness of past MEV auctions

- **Competitive := winning bid > second highest true value**
- **Efficient := winner has the highest TV**

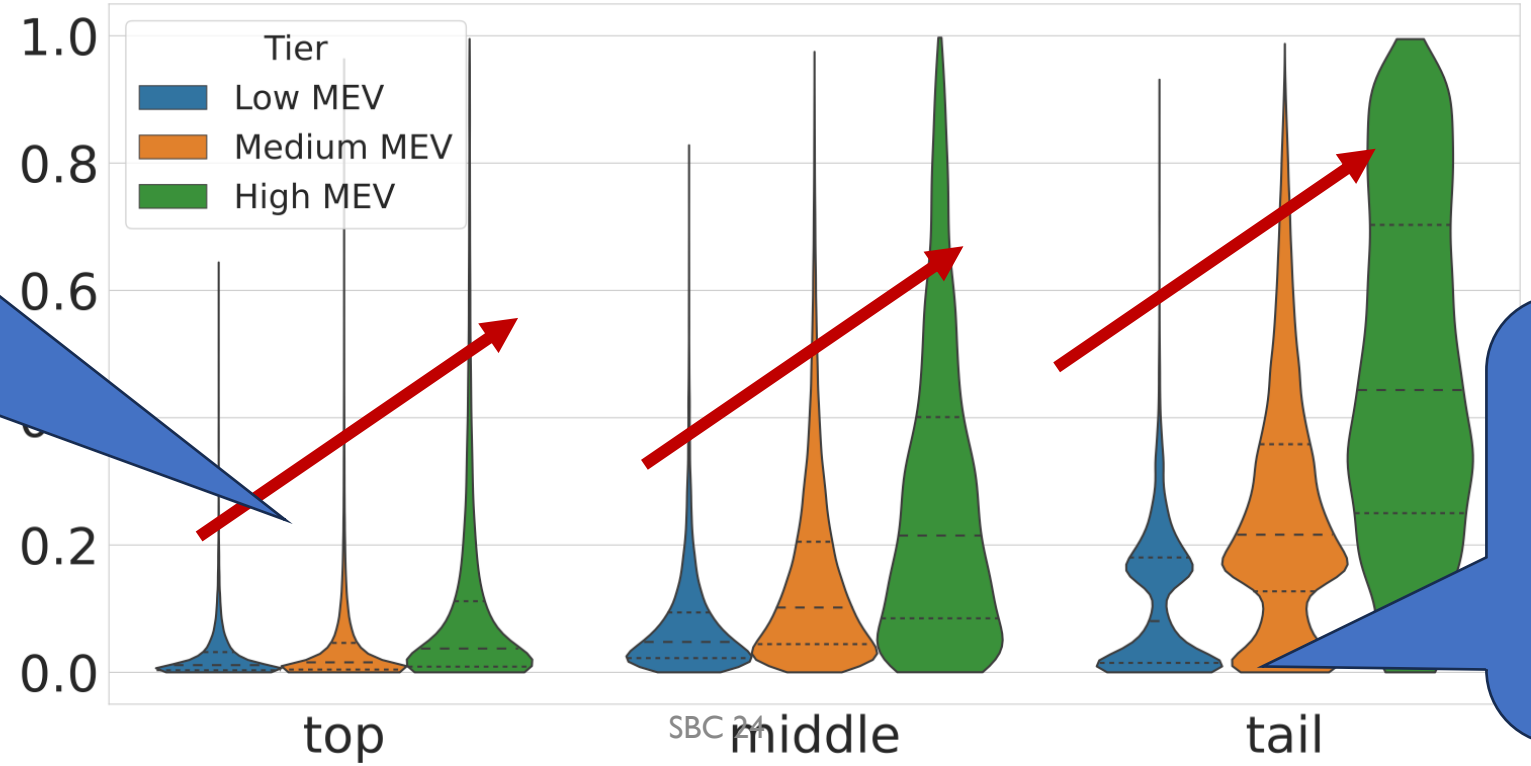


- Examined auctions from April 9-15, May 1-7, June 1-7, July 1-7, and August 1-7, 2023
- Competitive: 89%
- Efficient: 80%
- Both: 75%

Result: Inequality of block-building capacity

- **Builder's true valuable** represents its **block-building capability**
- We use Quartile coefficient of dispersion (QCD) to measure the disparity of true values (**the higher the worse**)

- Top builders have similar capability in low MEV slots.
- Inequality worsens as the MEV of a slot increases.



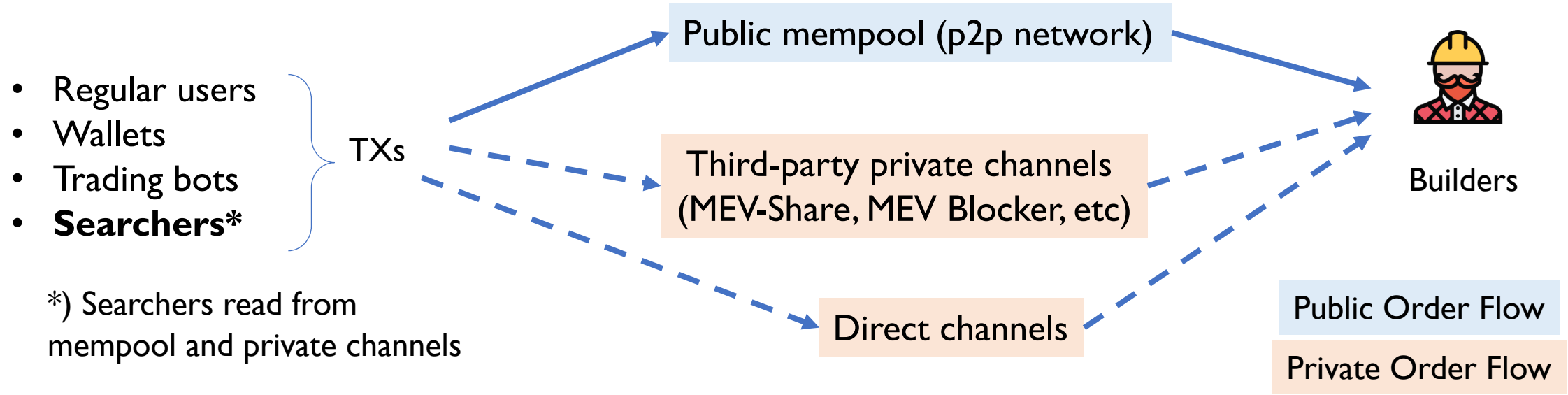
Inequality worsens as we go down the list of builder groups.

Result: proposer loss in past auctions

- Between April – August 2013:
- **Loss from uncompetitiveness is moderate (~1%)**
- **Loss from inequality (of BBC) is significant (6-12%)**

Time	Slots	Profits (ETH)	Losses-*un* (ETH) (%)	Losses-*in* (ETH) (%)
April 9-15	28,385	2,704.4	46.9 (1.7)	312.1 (11.5)
May 1-7	30,300	9,331.7	115.8 (1.2)	518.6 (5.6)
June 1-7	35,443	4,341.8	25.1 (0.6)	342.2 (7.9)
July 1-7	36,040	3,938.8	19.1 (0.5)	246.1 (6.3)
August 1-7	17,831	2,135.5	12.5 (0.6)	146.6 (6.9)

What caused inequality?



- A stream of TXs is called an order flow (OF)
- Public OF (i.e., mempool) is accessible by all builders.
- Private OFs have different accessibility
  - E.g., telegram bots, searchers, …

What caused inequality?

- Answer: Access barriers to profitable OFs
- Which also explains builder centralization: profitable OFs can only be accessed by a small set of builders
- Two reasons
  - There is a trust barrier between OF providers and builders
  - Strong incentive to form integration

Inequality due to trust barriers

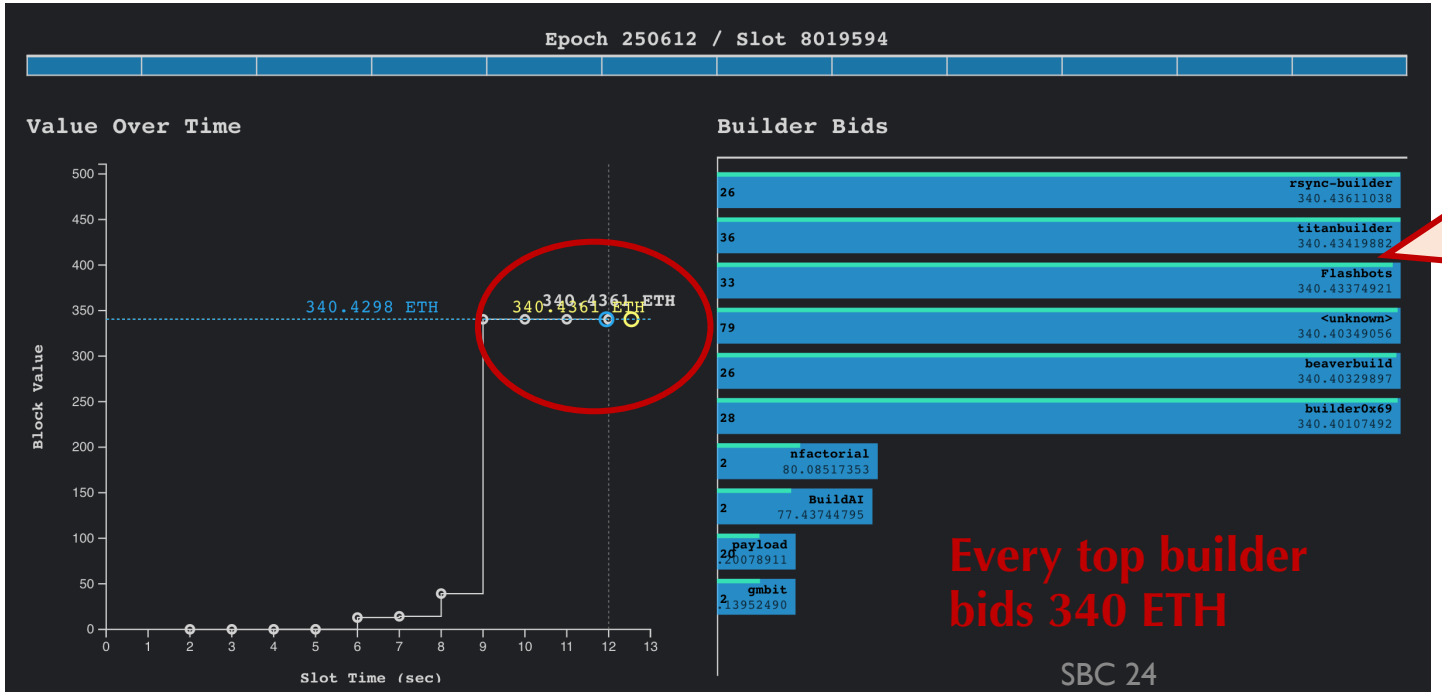
- Malicious builders can harm OF providers, e.g., by unbundling, sandwiching or imitation
- Two kinds of access barriers
  - "reputation": e.g., MEV-blocker requires 1% market share. New builders face a chicken-and-egg problem (typical reason for subsidy)
  - "obscurity for security": most searchers are anonymous
- Takeaway: need a fair exchange mechanism
  - (Centralized) platforms like MEV-Share aim to address this problem

Inequality due to integration

- Integration: exclusive OF-sharing between a provider & a builder. Usually done through private deals.
- We defined a new metric called *pivotal level* to identify integration.
- We found that ***all three top builders [~90% market share collectively] have integrated OF providers.***
  - Reveals a previous unknown integration between Banana Gun (a telegram bot) and Titan, jaredfromsubway (a sandwich searcher) and Beaver.
- Integration is a ***unique* competitive edge** for builder.
- There is ***strong incentive*** to form integration
  - It avoids competition

Incentive for integration

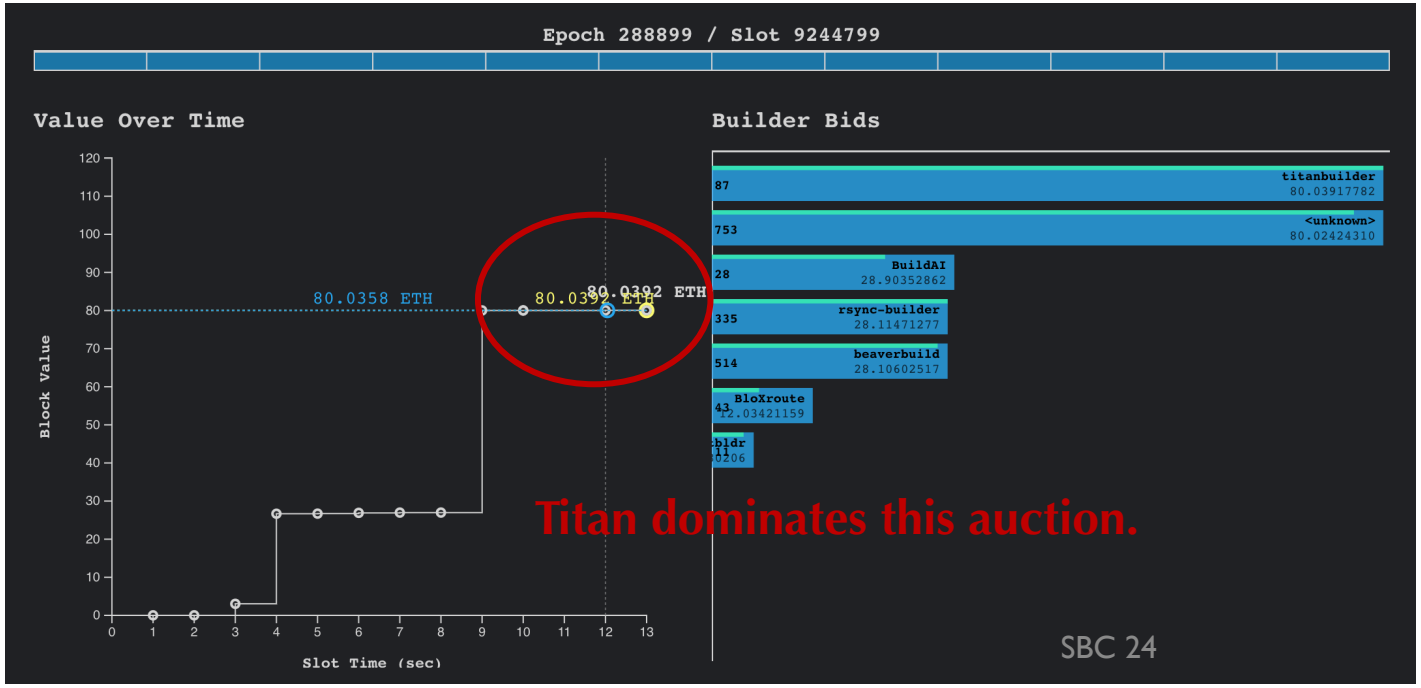
- For example, in slot 8019594, about 340 ETH came from Banana Gun (OF), and all 340 ETH was captured by the proposer.



Banana Gun: why don't send to just one builder?

Incentive for integration

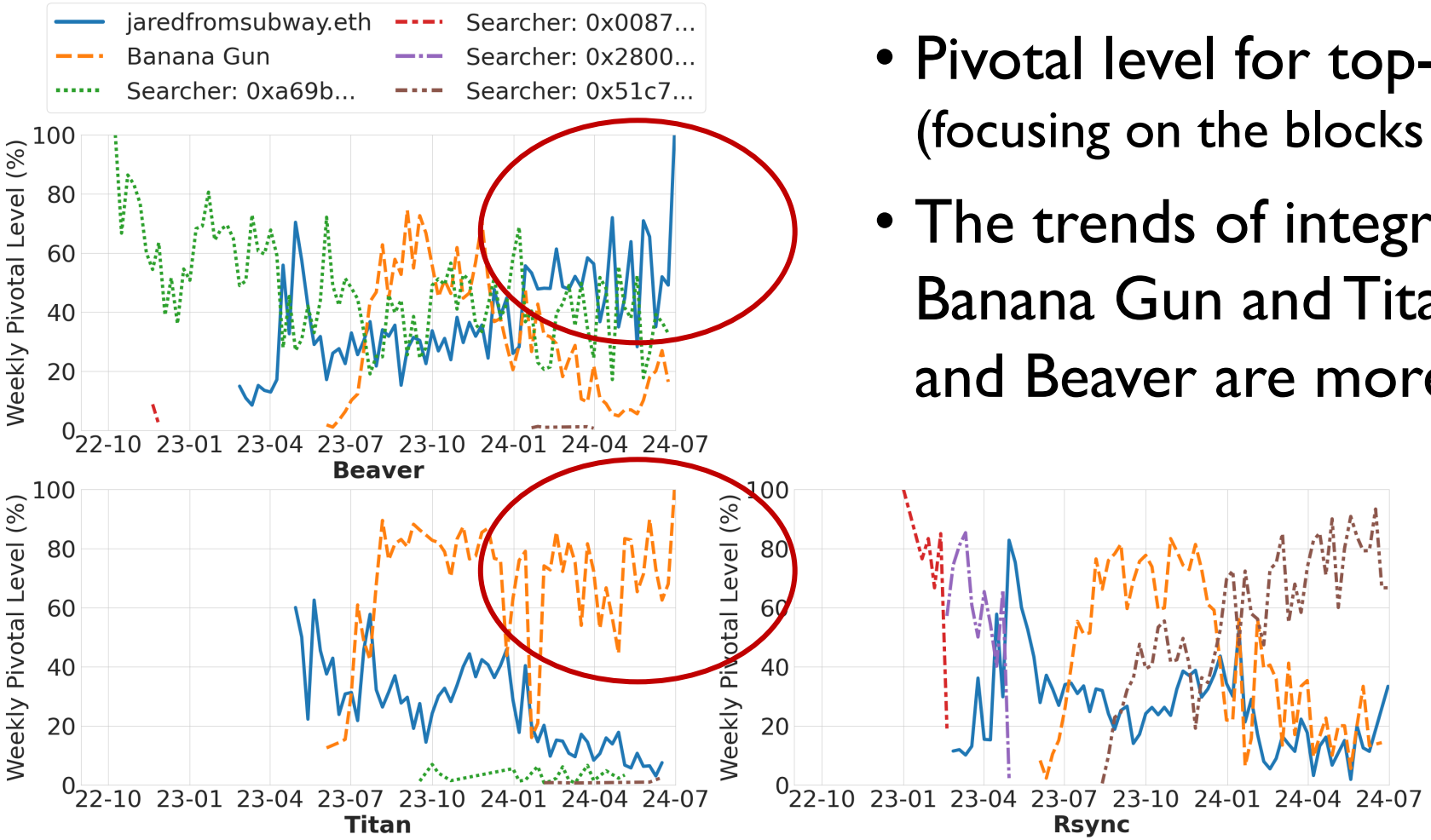
- With integration, more **MEV "escapes" the protocol**
- E.g., Top 3 builders (all with integrated OFs) made $5.5M in the first of week of June 2024!



In slot 9244799, 208 ETH came from Banana Gun, and only Titan received it. Titan paid 80 ETH to the proposer.

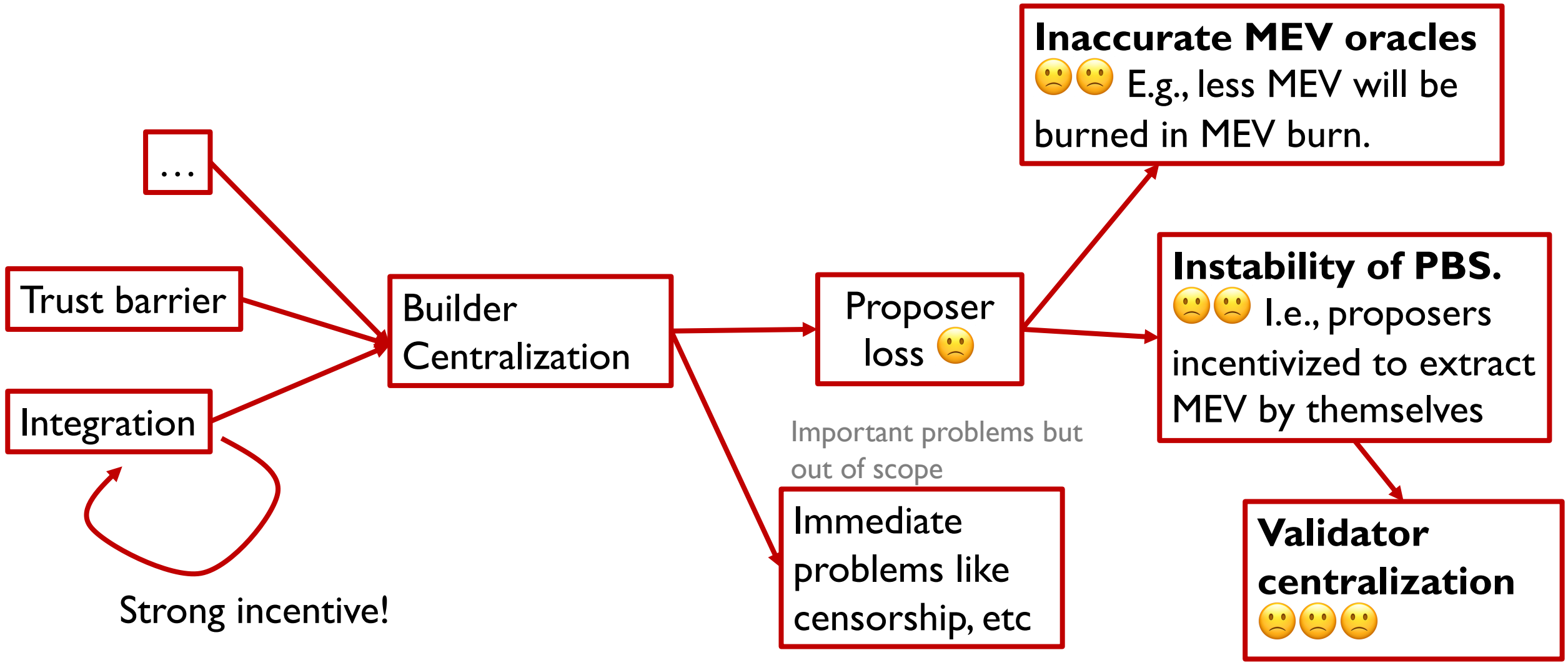
128 ETH can be shared between Banana Gun and Titan!

Trend of integration



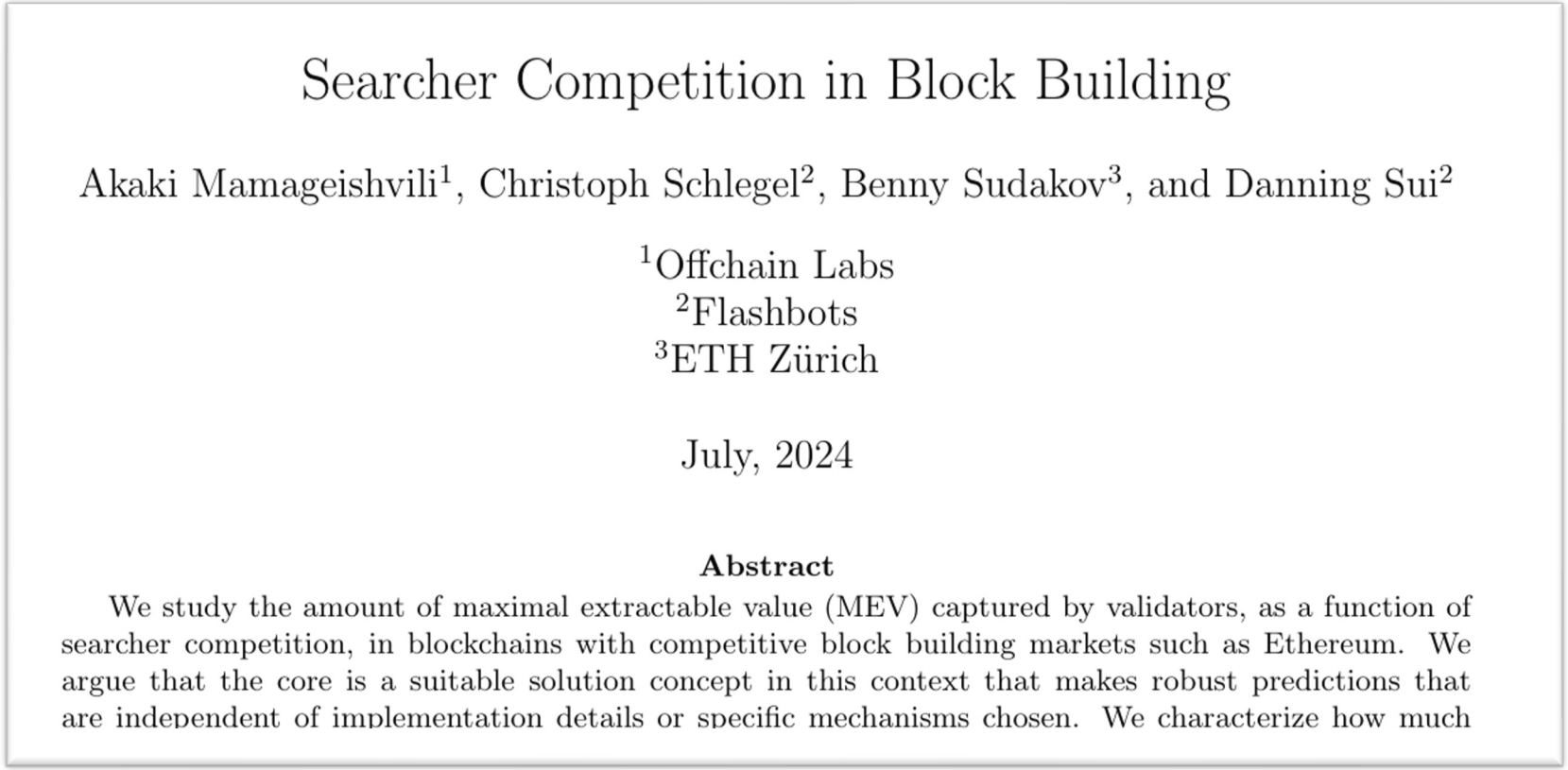
- Pivotal level for top-3 builders
  (focusing on the blocks those bid value > 1ETH)
- The trends of integration between Banana Gun and Titan, jaredfromsubway and Beaver are more obvious.

Summary: causes & implications of centralized builder markets



Solutions to pieces of the puzzle

- Problem: MEV can't be accurately measured by current MEV auctions
- Potential solution: alternative mechanisms (e.g., Mamageishvili *et al.* presented a truthful refund mechanism)



Searcher Competition in Block Building

Akaki Mamageishvili[1], Christoph Schlegel[2], Benny Sudakov[3], and Danning Sui[2]

[1]Offchain Labs
[2]Flashbots
[3]ETH Zürich

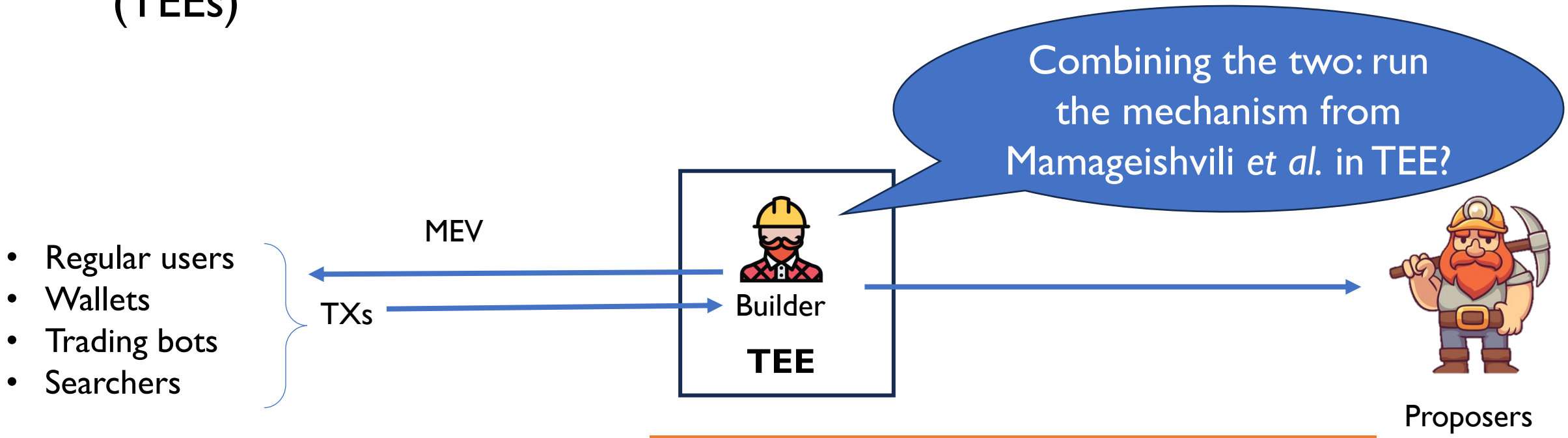
July, 2024

Abstract

We study the amount of maximal extractable value (MEV) captured by validators, as a function of searcher competition, in blockchains with competitive block building markets such as Ethereum. We argue that the core is a suitable solution concept in this context that makes robust predictions that are independent of implementation details or specific mechanisms chosen. We characterize how much

Solutions to pieces of the puzzle

- Problem: trust barrier between searcher and builders
- Potential solution: Put builders in Trusted Execution Environments (TEEs)



E.g., Flashbots run a TEE builder

Mamageishvili *et al.* is truthful assuming a monopolistic builder!

Open challenges

- How should MEV be allocated between users, searchers, builders, proposers?
- How to mitigate the negative impacts of integration?
  - Execution Auctions, PROF, etc, do not directly address this problem.
- Immediate problems like builder censorship resistance

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Blog post: https://decentralizedthoughts.github.io/2024-05-07-decentralization-ethereum/

Paper: https://arxiv.org/pdf/2405.01329

X: 0xfanzhang

Mitigation ideas

- It is possible to build an accurate MEV oracle and allocate fair MEV to proposers!
- Outsourcing block building to a TEE builder that implements a refund mechanism. For a provider, this mechanism refunds the marginal value of its TXs.
  - Trust barrier: TEE guarantees integrity and confidentiality.
  - Integration: Refunds incentivize providers to report their value truthfully. Proof is in (*Searcher Competition in Block Building, AFT'24*).

- The builder can build the optimal block and provide an accurate MEV measurement.
  - But this might not be the end state.

Mitigation ideas

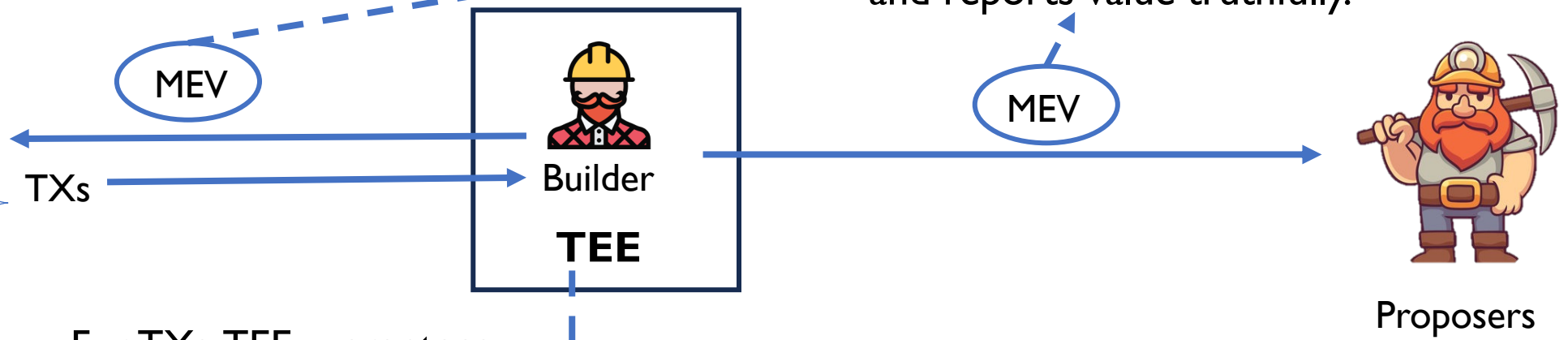
Refunds incentivize providers to report their value truthfully.
Proof is in (*Searcher Competition in Block Building, AFT'24*).

For every provider, the builder refunds the marginal contribution of its TXs to the block's TV.

Accurate MEV measurement:
every provider sends TXs to the builder and reports value truthfully.

✅ Integration

- Regular users
- Wallets
- Trading bots
- Searchers



For TXs, TEE guarantees integrity and confidentiality

✅ Trust barrier

This might not be the end state.