

Co-Operator: An LLM Based AI Chat Assistant to Support the Operation of GSI/FAIR Accelerators

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Rendering: GSI/FAIR, Zeitrausch

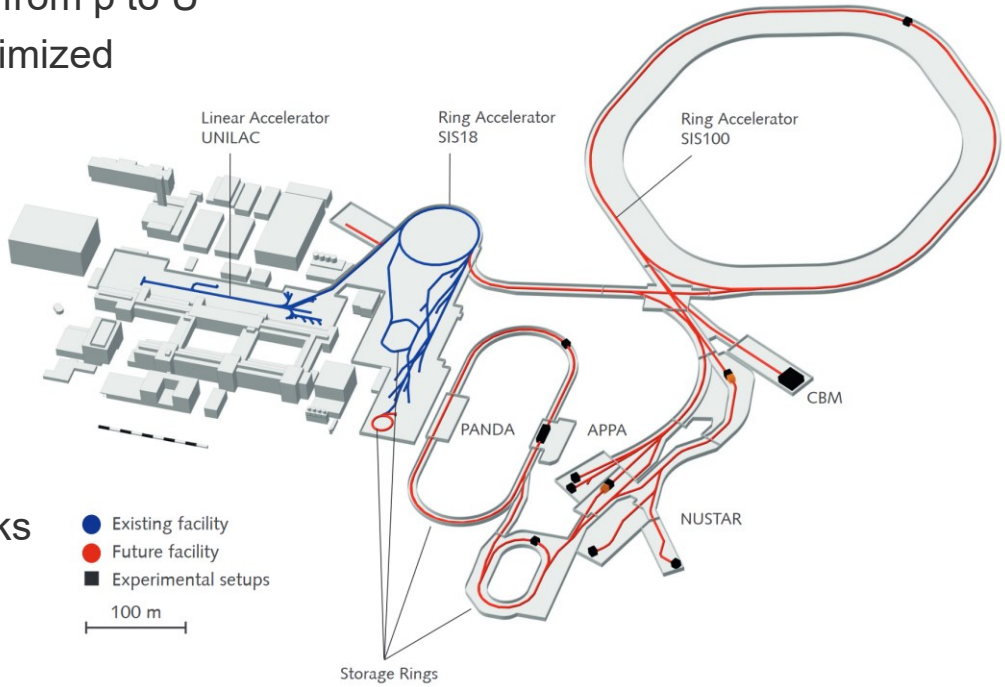
Idea / Vision

- Accelerators are huge, complex machines
  - Large variety of experiments and ions from p to U
  - Constantly being setup, tuned and optimized
  - Operated by a handful of people
  - Expert knowledge is distributed

- Chat-based AI assistant
  - To support accelerator operations
  - Esp. for new, part-time & on-call op's
  - Access to expert domain knowledge
  - Read-only access to machine, logbooks

  → **Context-aware guidance**

GSI & FAIR Accelerators



Concept

- Agentic system
  - Open source LLMs (qwen3.6-27b or gpt-oss-120b)
    - Runs on GSI-internal HPC cluster infrastructure (llmbot) [1]
  - Engineered system prompt
- Reasoning loop with extensive tool set
  - Retrieval-augmented generation (RAG) pipeline
    - Wikis, logbooks & websites
    - Hybrid search, reranking and context expansion
  - Long term memory
  - Accelerator status information



[1] A. Rybalchenko, M. Dessalvi, M. Al-Turany, *AI Inference & Document Intelligence Service for GSI/FAIR*, 28th Int. Conf. on Computing in High Energy & Nuclear Physics (CHEP 2026), Bangkok, Thailand, 2026.

Toolset

Knowledge
- RAG pipeline
- Wikis & docs
- Websites

Nomenclature
- Devices
- Areas
- Buildings

Acronyms
- Accelerator
- Technical
- Administrative

Isotopes
- Periodic table
- Nuclide chart

Calculator
- Unit conversion
- Ion calculator
- Formulas

Lattice tool
- Ion optics

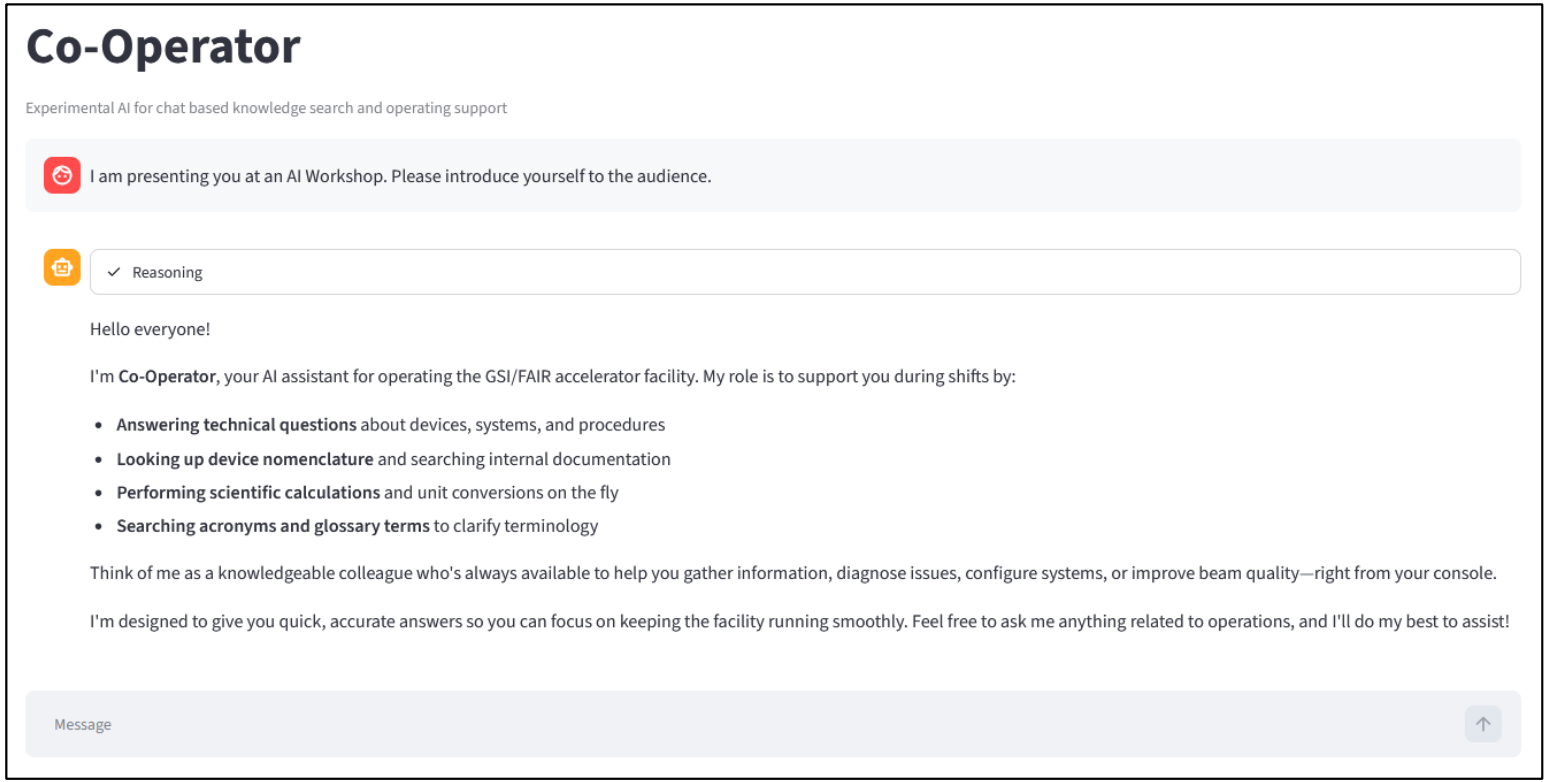
Verification
- URL check

Logbook
- Operational
- Historical

Monitoring
- Interlocks
- Radiation
- Logging

Machine state
- Beam schedule
- Timing system
- Device status

PoP – Proof of Principle Demonstration



PoP – Proof of

Explain the concept of chain, BP and sequence

Reasoning

In the GSI/FAIR

- **Beam Produ**
  storage ring
- **Beam Proce**
  executed in
- **Sequence:** A
  accelerator
  legacy "Virtu

How they

These concepts

1. A **Pattern** (th
2. Each **Chain**
3. Each **Seque**

Sources and furth

- FAIR Glossary: Multiplexing
- OPE Wiki: Glossary
- Scheduling Application Doc

Max energy for SIS18 uranium beam?

Reasoning

The n

Depe

- ~1
- ~3

Note
lower
SIS18

Sourc

- O
- G
- G

List counters in HHD branch.

Reasoning

Based on the facility nomenclature, there are **no dedicated veto counters** (`DV`) **or radiation safety monitors** (`SM`) installed in the **GHHD** (High Dose Experiment, commonly used as the SIS18 beam dump) branch.

However, the following beam diagnostic devices in the GHHD branch function as particle counters or intensity monitors:

- `GHHDDI2P` : Plastic scintillation counter (Impulsmonitor)
- `GHHDDI2S` : Secondary electron transmission monitor (SEM)
- `GHHDDI2I` : Ionization chamber
- `GHHDDT1C` : Beam transformer (*Strahltrafo*) for fast current/intensity measurement

Additional beam diagnostics in the branch:

- **Fluorescent screens:** `GHHDDF1` , `GHHDDF2` , `GHHDDF12`
- **Profile grids:** `GHHDDGA` , `GHHDDG2` , `GHHDDG3`
- **Beam position monitor (BPM):** `GHHDDX3`

If you were looking for a specific type of counter (e.g., experimental detectors, radiation dose counters, or devices in an adjacent transfer line), please clarify and I will refine the search.

Setup of KO extraction from SIS18

Reasoning

Based on the GSI/FAIR internal documentation and the OPE Wiki, here is the standard procedure for setting up **Knock-Out (KO) extraction** from the SIS18 synchrotron using the Spill Optimization System (SOS).

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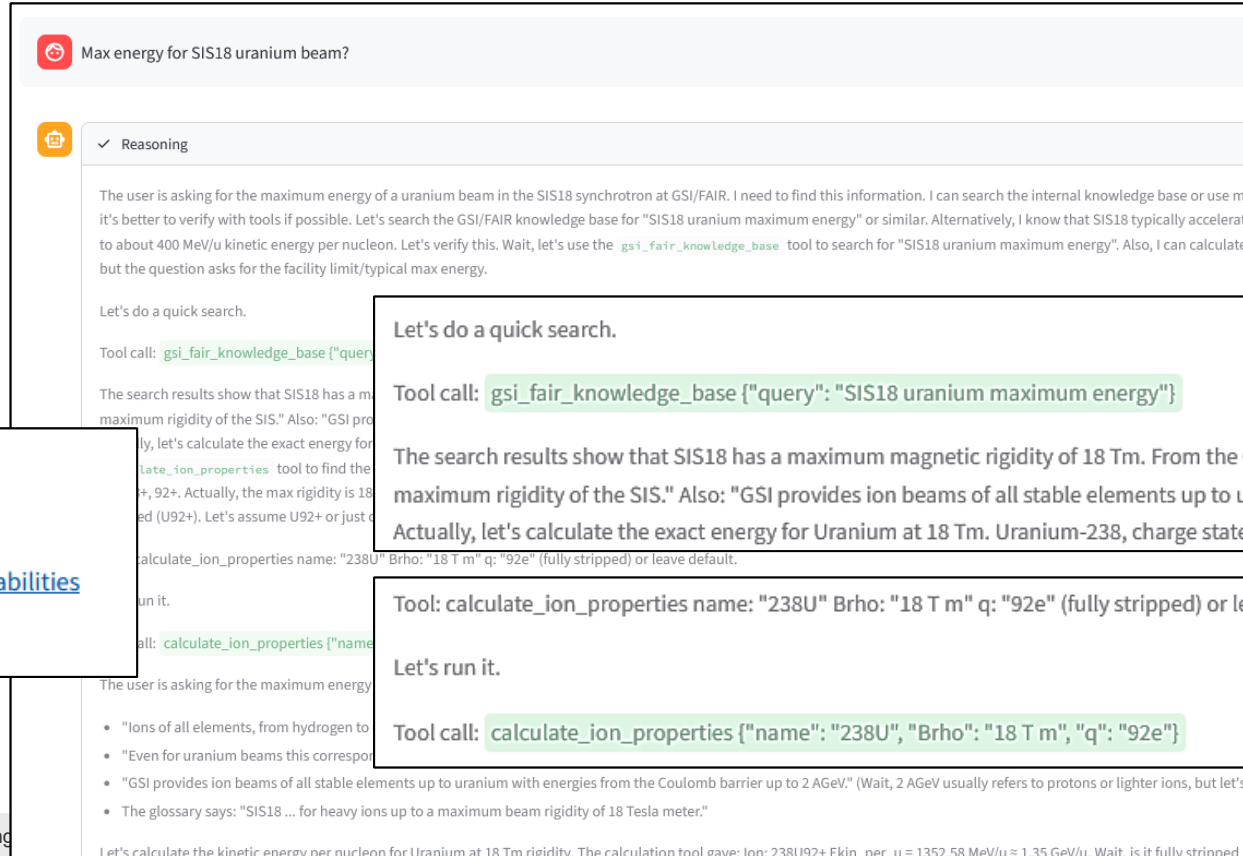
the SOS GUI.

back loop.

3. Finding the Extraction Resonance

Explainability and User Trust

- Transparent thought & tool calling process
- Citation of sources & further reading



Sources and further information:

- OPE Wiki: Maximale Strahlparameter
- GSI Website: Accelerator Complex & Research Capabilities
- Glossary: SIS18 parameters

Summary

- We are building a chat-based AI assistant to support accelerator operations
  - Simplify access to expert domain knowledge
  - Give context and machine status aware answers and guidance

- Ongoing project, we just started…
  - Ideas for future development: low-rank adaptation, extend toolset, skills & memory, …
  - **Open thesis, PhD & post-doc positions** (Prof. Dr. Ralph Aßmann, Goethe University Frankfurt)
    → **Get in touch:** assmann@iap.uni-frankfurt.de or p.niedermayer@gsi.de

Thank you for your attention!

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