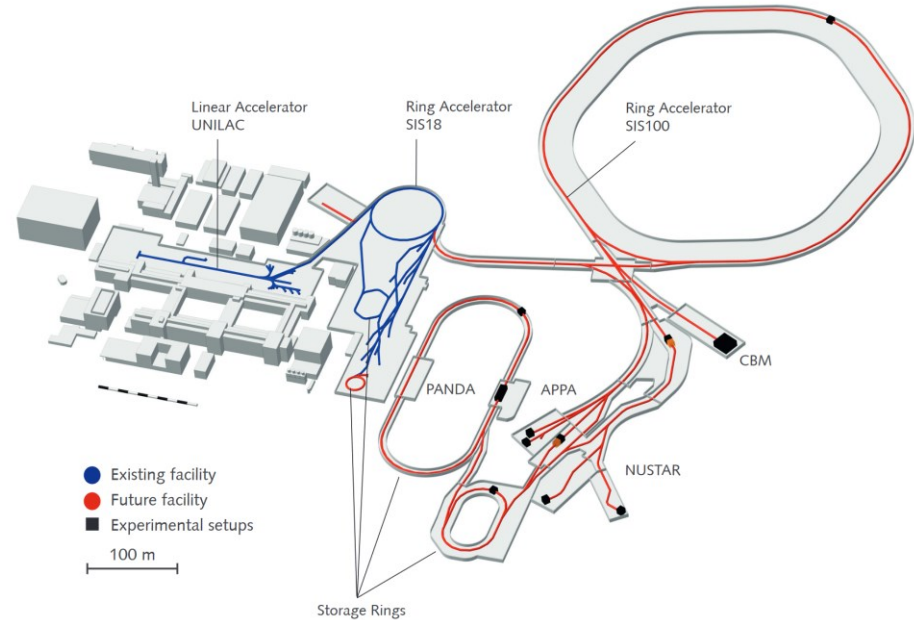


Co-Operator: An LLM Based AI Chat Assistant to Support Accelerator Operation

Philipp Niedermayer
Accelerator Operations & Development

- Challenges
 - Knowledge at GSI is scattered (various wikis, logbooks, ...)
 - **Search** is time consuming and often **yields bad results**
 - Advice from an operator: “Google it”
 - Chat-based AI assistant
 - Simplify access to expert knowledge
 - Mainly targeting accelerator operations (e.g. new & on-call op's, machine exp.)
 - Read-only access to machine, logbooks
- **Context-aware answers and guidance**

GSI & FAIR Accelerators



- Agentic system
 - Based on **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** (lexical and semantic), reranking and context expansion
 - Long term **memory** to learn from experience ⌚
 - **Skills** for recurring tasks (e.g. status report, shift summary, ...) ⌚
 - Accelerator **status analysis** ⌚



[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.

Knowledge base

- 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



...



Co-Operator

Experimental AI for chat based knowledge search and operating support



I am presenting you at an AI Workshop. Please introduce yourself to the audience.



✓ Reasoning

Hello everyone!

I'm **Co-Operator**, your AI assistant for operating the GSI/FAIR accelerator facility. My role is to support you during shifts by:

- **Answering technical questions** about devices, systems, and procedures
- **Looking up device nomenclature** and searching internal documentation
- **Performing scientific calculations** and unit conversions on the fly
- **Searching acronyms and glossary terms** to clarify terminology

Think of me as a knowledgeable colleague who's always available to help you gather information, diagnose issues, configure systems, or improve beam quality—right from your console.

I'm designed to give you quick, accurate answers so you can focus on keeping the facility running smoothly. Feel free to ask me anything related to operations, and I'll do my best to assist!

Message



PoP – Proof of



Explain the concept of chain, BP and sequence



✓ Reasoning

In the GSI/FAIR

- **Beam Production**: storage ring
- **Beam Processing**: executed in
- **Sequence**: Accelerator legacy "Virtual"

How they

These concepts

1. A **Pattern** (the
2. Each **Chain**
3. Each **Sequence**

Sources and further

- [FAIR Glossary: Multiplexing](#)
- [OPE Wiki: Glossary](#)
- [Scheduling Application Doc](#)



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).



Max energy for SIS18 uranium beam?



✓

The n

Depe

• ~1

• ~3

Note

lower

SIS18

Source

• 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:

- **GHDDI2P** : Plastic scintillation counter (Impulsmonitor)
- **GHDDI2S** : Secondary electron transmission monitor (SEM)
- **GHDDI2I** : Ionization chamber
- **GHDDT1C** : Beam transformer (*Strahltrafo*) for fast current/intensity measurement

Additional beam diagnostics in the branch:

- **Fluorescent screens**: GHDDF1 , GHDDF2 , GHDDF12
- **Profile grids**: GHDDGA , GHDDG2 , GHDDG3
- **Beam position monitor (BPM)**: GHDDX3

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.

ction orbit is also properly

the SOS GUI.

back loop.

5. Finding the Extraction Resonance

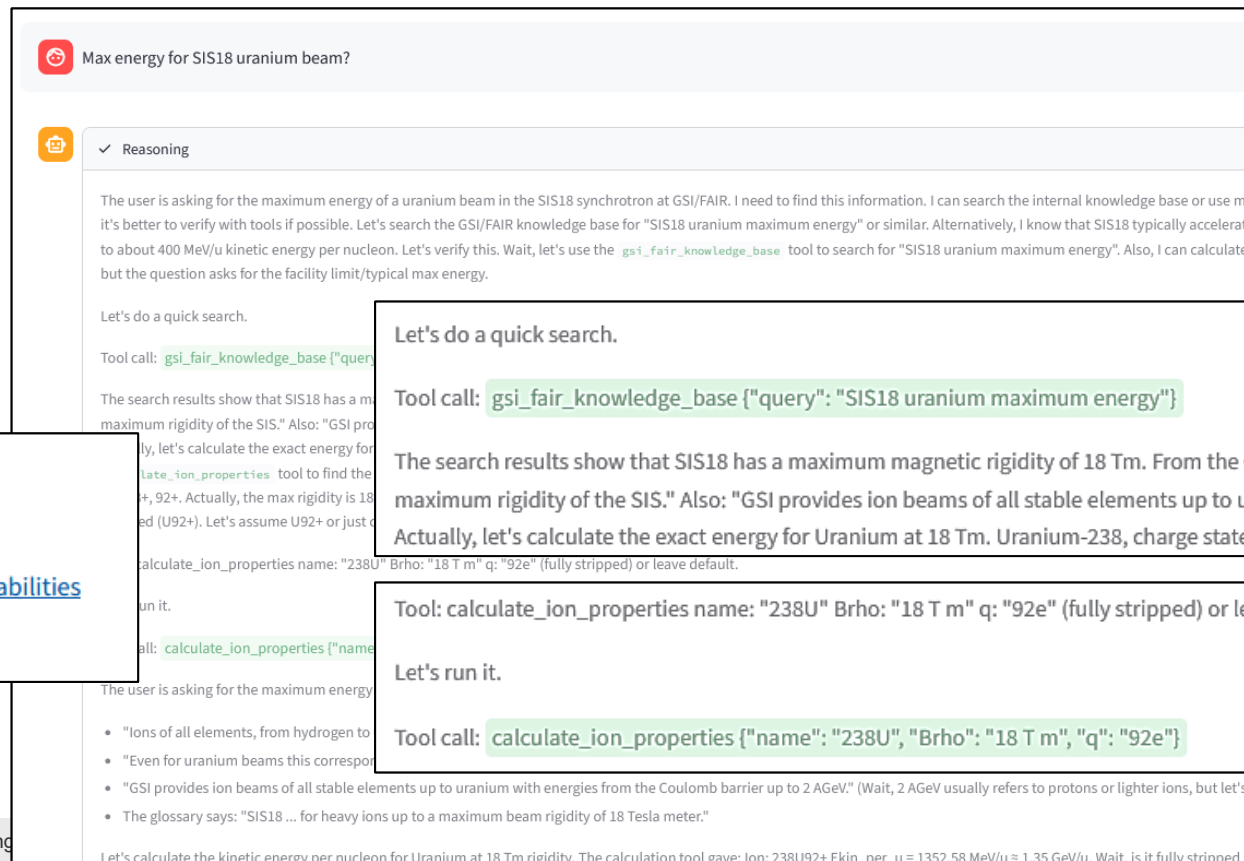
Monitor the beam position in the dump of the SIS18 (SOS GUI).

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](#)



Max energy for SIS18 uranium beam?

✓ Reasoning

The user is asking for the maximum energy of a uranium beam in the SIS18 synchrotron at GSI/FAIR. I need to find this information. I can search the internal knowledge base or use m... it's better to verify with tools if possible. Let's search the GSI/FAIR knowledge base for "SIS18 uranium maximum energy" or similar. Alternatively, I know that SIS18 typically accelerates to about 400 MeV/u kinetic energy per nucleon. Let's verify this. Wait, let's use the `gsi_fair_knowledge_base` tool to search for "SIS18 uranium maximum energy". Also, I can calculate... but the question asks for the facility limit/typical max energy.

Let's do a quick search.

Tool call: `gsi_fair_knowledge_base {"query": "SIS18 uranium maximum energy"}`

The search results show that SIS18 has a maximum magnetic rigidity of 18 Tm. Also: "GSI provides ion beams of all stable elements up to uranium with energies from the Coulomb barrier up to 2 AGeV." Wait, 2 AGeV usually refers to protons or lighter ions, but let's... Actually, let's calculate the exact energy for Uranium at 18 Tm. Uranium-238, charge state +92.

Tool: `calculate_ion_properties name: "238U" Brho: "18 T m" q: "92e" (fully stripped) or leave default.`

Let's run it.

Tool call: `calculate_ion_properties {"name": "238U", "Brho": "18 T m", "q": "92e"}`

The user is asking for the maximum energy of a uranium beam in the SIS18 synchrotron at GSI/FAIR. I need to find this information. I can search the internal knowledge base or use m... it's better to verify with tools if possible. Let's search the GSI/FAIR knowledge base for "SIS18 uranium maximum energy" or similar. Alternatively, I know that SIS18 typically accelerates to about 400 MeV/u kinetic energy per nucleon. Let's verify this. Wait, let's use the `gsi_fair_knowledge_base` tool to search for "SIS18 uranium maximum energy". Also, I can calculate... but the question asks for the facility limit/typical max energy.

- "Ions of all elements, from hydrogen to uranium with energies from the Coulomb barrier up to 2 AGeV."
- "Even for ion beams this corresponds to a maximum beam rigidity of 18 Tesla meter."
- "GSI provides ion beams of all stable elements up to uranium with energies from the Coulomb barrier up to 2 AGeV."
- The glossary says: "SIS18 ... for heavy ions up to a maximum beam rigidity of 18 Tesla meter."

Let's calculate the kinetic energy per nucleon for Uranium at 18 Tm rigidity. The calculation tool gave: `Ion: 238U92+ Fkin_per_nu = 1352.58 MeV/u ≈ 1.35 GeV/u`. Wait, is it fully stripped?

- 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
 - Based on GSI internal LLMBot infrastructure
- Ongoing project, just started...
 - Ideas for future development: low-rank adaptation, extend toolset, skills, memory, ...

Thank you for your attention!

Thanks to Alexey, Mohammad, Alexander, Frank, Rahul, Stephan