ARW 2026

Toward an SI Agentic Framework for LANSCE Operation

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2026/11/19

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Outline

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- Information overload as motivation
- How LLM agents work
  - Claude Code context
  - Agents, skills, and MCPs
- LANSCE applications
  - Constraints
  - Skills and MCPs
- Examples
- Challenges

What I heard a lot

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"Oh yeah, that happened 15 years ago …"
(after hours of debugging)

The data exist?!

"there was actually a hint in the legacy work control system!"
(after days of diagnosing a device)

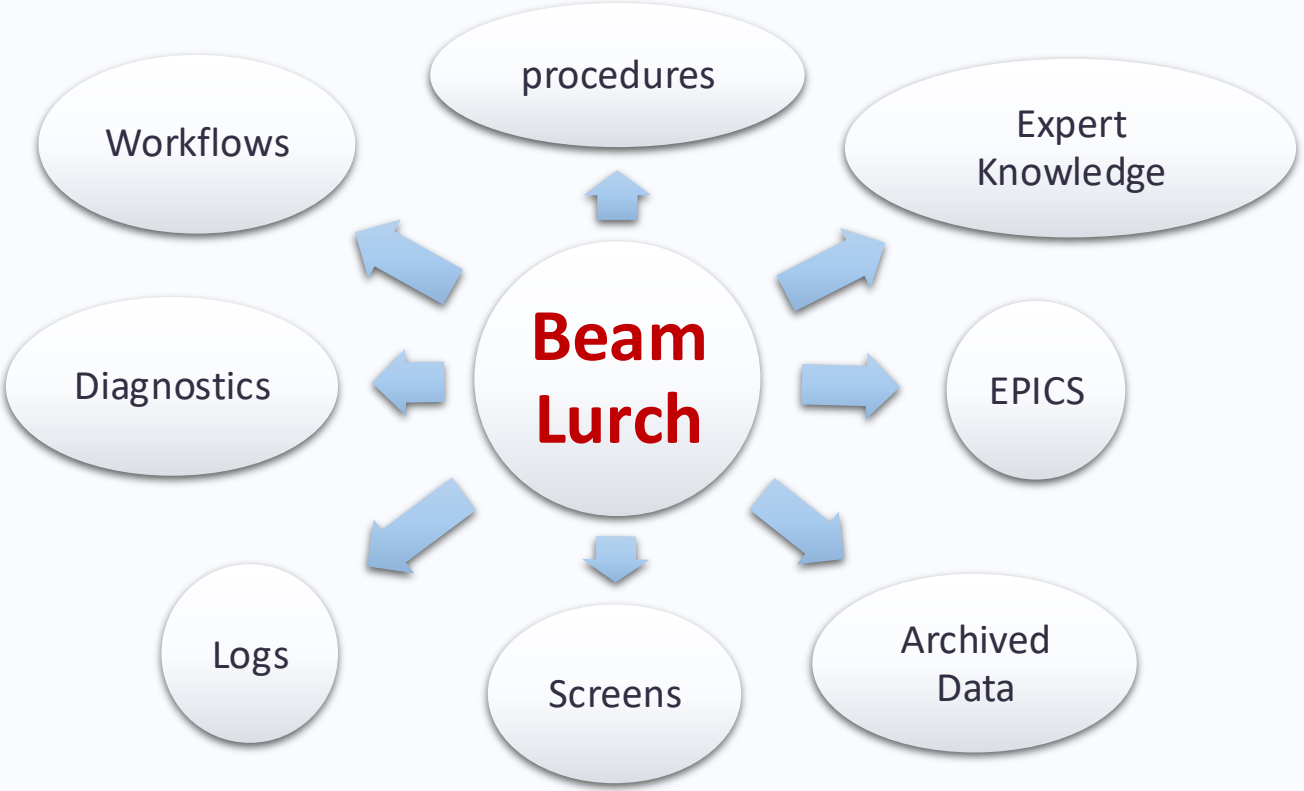
Ed is scheduled for this week? We will ramp up the current!

Rod [RETIRED] might know. Good that he still lives in town!
(And I know where he lives!)

Within one year, we lost a combined of 100+ years of experience in CCR

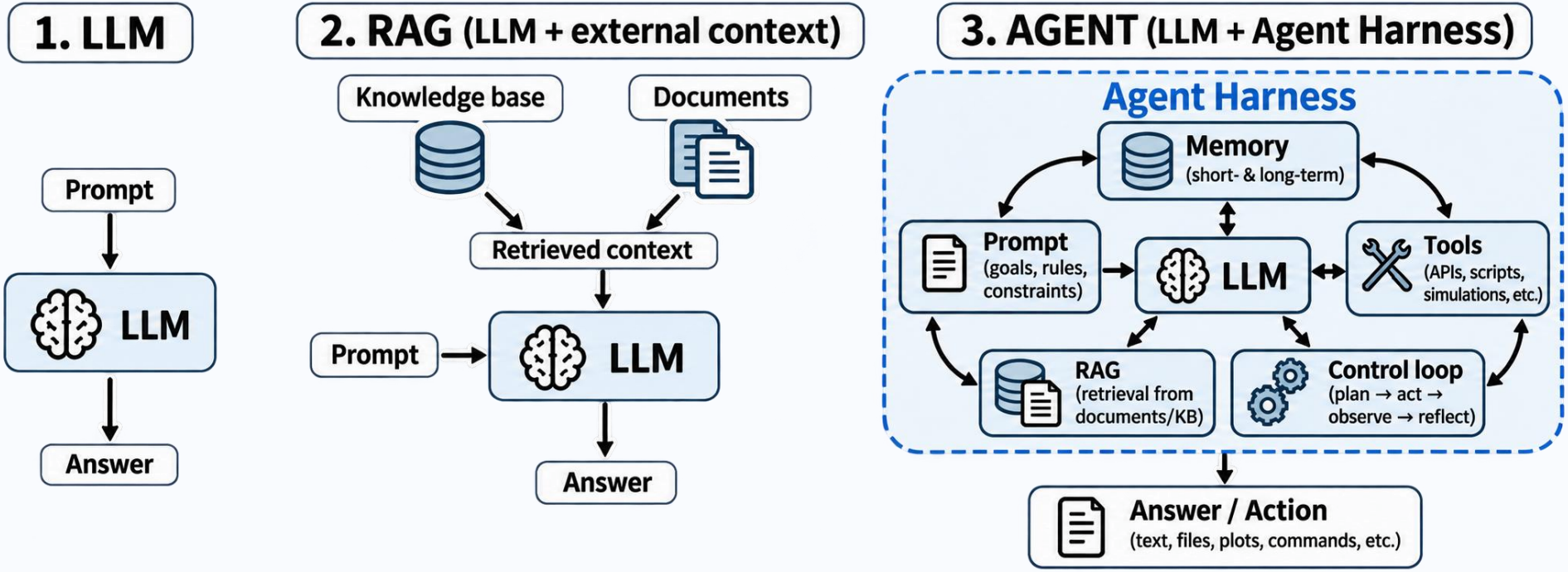
Reliability under overloading scattered information

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LLM → Agent

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Agent Capabilities for LANSCE

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Archivers	3 historical archivers
EPICS	Read-only access with full EPICS db
Documents	Layered access from general to expert
Logs	CCR and team logs
Workflow	Standard working procedure

Given the *knowledge* and *tools*, how could the SI* Agent help us?

SI* = formerly AI

Building Blocks for Agent Capabilities

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SKILLs teach agents ***how*** to perform a work. It contains
- Instructions
- Domain knowledge
- Procedures
- scripts

orchestrator



MCPs (Model Context Protocol) are standard interfaces letting agents access external tools and data.

Subagents



Log-reader



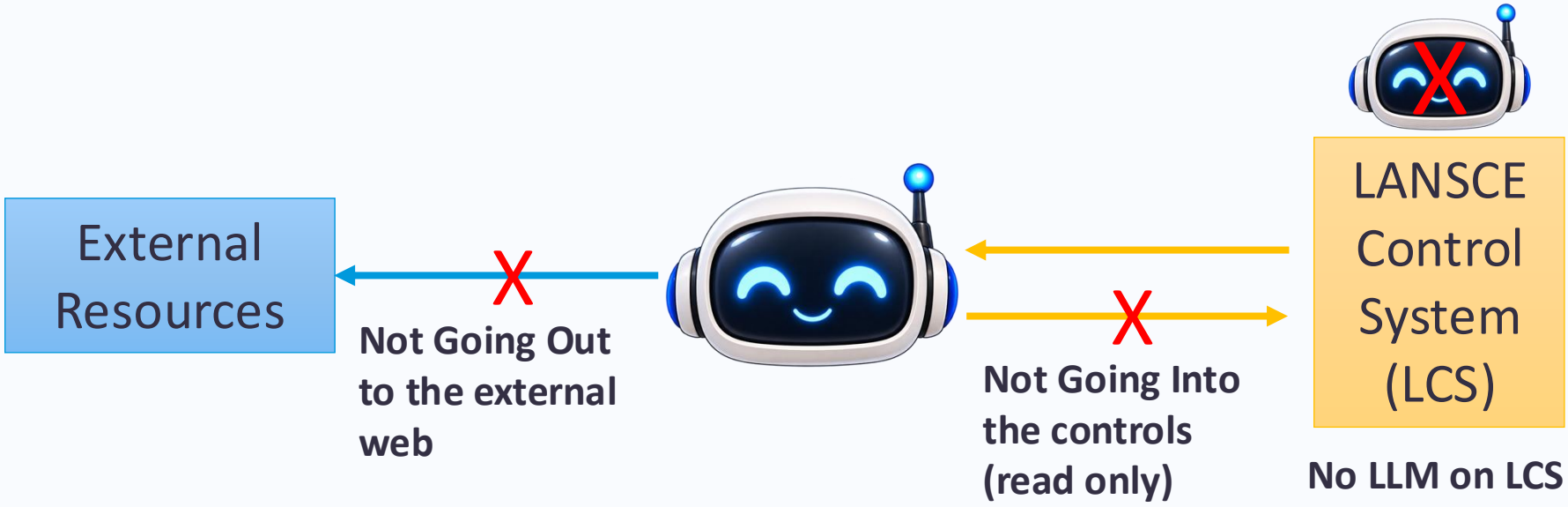
Lurch-finder



data-analyzer

Skills and MCPs are increasingly standardized between agent harnesses from different companies & open-source ones

Limitation for LANSCE



Vision: Operators in the Loop

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SI Agents assist, not control.



Choices we made

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No LLM fine-tuning/building

- Open-weight LLMs lags behind frontier models, especially non-Chinese ones

No harness development

- Big AI companies are much better at this
- Don’t struggle too much on models’ constraints today

Prioritize keyword search first

- Add semantic search only when needed

Layered Skills

- Centralized and structured knowledge system
- Skill first, agent later if needed



Document writing & Data plumbing

LANSCE Agent Framework – Integration Landscape

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Basic Skills

lansce-knowledge (v1)

archiver-skill

analysis-package

past publications (~~Classification Office~~)

Wiki

Internal documents (problem)

Workflow Skills (v1)

lansce-report

lansce-lurch

lansce-fluctuation

Documents

MCPs

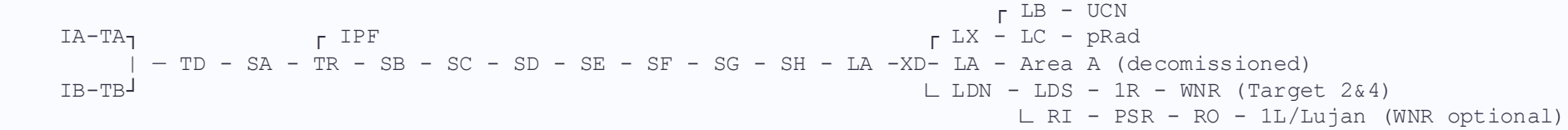
- logs-mcp
  - Control room
  - Crew chief summary
  - Physics team
  - Injector team
  - IC software and hardware
  - Work control system
  - Work control system legacy
  - Daily morning meeting (problem)
- archiver-mcp
- epics-channel-catalog
- LCS-files-mcp
- Epics via read-only gateway

Data

Entry SKILL: LANSCE-Knowledge

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```
---
name: lansce-knowledge
description: Provides operational and accelerator-physics context for LANSCE
beamlines, diagnostics, controls, and lattice interpretation. Use this skill
whenever reasoning about LANSCE accelerator related questions, beam transport,
upstream/downstream relationships, device, EPICS/PV conventions,
acronyms/abbreviations, tuning, or troubleshooting.
---
## Beamline Description
A line plot is demonstrated in the plot below:
```

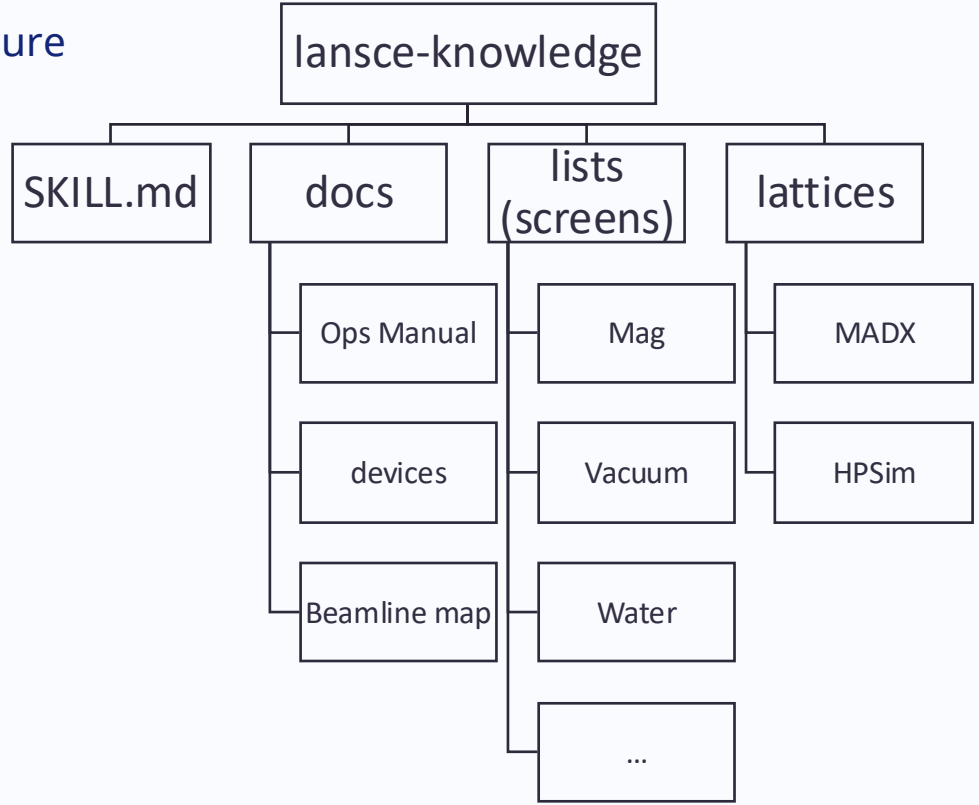



```
# Section Naming:
* IA: Ion Source A for H+
* IB: Ion Source B for H-
* TA: Transport A for H+, containing a Pre-Buncher (PB)
* TB: Transport B for H-, containing a chopper, Low Frequency Buncher (LFB), PB
```

LANSCE-Knowledge

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- Layered fat SKILL with progressive disclosure
  - Enough context to know where to ask
  - Not so much to overwhelm the context
- Integration (TODO)
  - Beamline map
  - Different lattices
- Learn from human-based systems
  - Operator screens



The DTL seems to change a lot for the 1-3 months prior to 10/04 this year. Spawn a sonnet subagent to check the archiver and one to check the logs to see whether there were any major events.

Both checks came back, and the archiver and the logs agree on most dates. The biggest DTL changes in Jul–Oct trace to Module 1 drift tube 29 (DT29), which started leaking in late June.

Main events (logs, matched to archiver)

Date	What happened	Archiver signature
Jul 4–12	DT29 (`01QM29`) leak repair attempts failed and the beam was down for more than a week. A nitrogen jacket was fitted on Jul 11–12.	Forward power reads 0 until Jul 12 06:00. Module 1 tank-wall temperatures dipped to about 49 °C on Jul 11–12.
Jul 14–17	The leak returned and `01QM29` was secured. **Module 1 quads were reconfigured**: `01QM27` and `01QM29` off, `01QM28` reversed, chroma shunts changed. Module 1 LLRF was recalibrated.	Phase setpoints were retuned Jul 14–16: Module 1 phase went to 30.0°, Module 2 to about −120°, and Module 3 and 4 moved a few degrees. The `03ML010E01` tank signal stepped on Jul 14.
Jul 21–22	Sector J condensation took down TACW, TBCW and the chopper. Management decided to **retune from the source**. Module 4 vacuum tripped.	Forward power was 0 from about Jul 21 09:00 to Jul 22.
Jul 22 and Aug 1	The Module 4 quad master supply went 218 → 193 A, then up to 235 A. The Module 3 supply went to 235 A and the `02MP` supplies were raised 5 A. The DTL match on Aug 1 was the best of the year (F=0.33).	Amplitudes were set to 30% for about 12 h on Jul 29, and the `03ML010E01` step reversed on Jul 31.
Aug 3–5	Module 2 tripped twice on its DT water flow input. The `02TD819T01` thermistor was replaced.	Another small retune of all four modules. Module 1 phase went from 30.0° to about 27°.

Path for Control:

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- Tested templates in Badger, an accelerator-focused optimization software based on Xopt
- Hundreds variables → Dozens of templates
- SI Agent should suggest templates and its settings, not run it.

Poster #20

Testing

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Could the agent(s) call the right tools at the right time?

Examples

- What's the phase setpoint channel of M41?
  - Knowledge, EPICS catalog
- What's the module 15 amplitude field readback?
  - Knowledge, EPICS catalog
- What's the current at 48CM on 2025/12/19 00:00?
  - Knowledge, EPICS catalog, archiver

In practice, frontier models are too smart and makes these questions irrelevant.
Plan B: verify in real world

Example: LCTV4



Found it. LCTV4 (full name LCTV004, on the ebcams IOC) has dedicated calibration PVs:
- **LCTV004xscale** — EGU pixels/mm, horizontal scale factor
- **LCTV004yscale** — EGU pixels/mm, vertical scale factor

Let me pull their current/recent archived values.
Called plugin:physics-tools:archiver-mcp (ctrl+o to expand)

LCTV4 (LCTV004) pixel/mm conversion:
- LCTV004xscale = **4.3 pixels/mm**
- LCTV004yscale = **3.5 pixels/mm**

Both PVs (EGU: pixels/mm) live on the ebcams IOC. Only one archived update each, both stamped 2026-01-28 — so these have been static since then (no re-calibration logged since). No motion since, so treat as current unless the camera/optics were touched.

Also relevant: **there's an active elog** thread from yesterday (elog_ocp:928, 2026-10-04, Marie/Alex/Kip) collecting phosphor data on LCTV004 and others for simulation/AI dataset work — they ran into LCTV004 showing empty despite beam visible on CCR cameras (sensitivity difference fixed by adjusting LXBM3). Worth a look if your pixel/mm question is tied to that effort.

Example: LAQM1

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2026/09/18 Hours of troubleshooting for beam recovery

Peter, the crew chief, walked the equipment aisle and found LAQM01 at 10A locally, different from 484 A on the screen

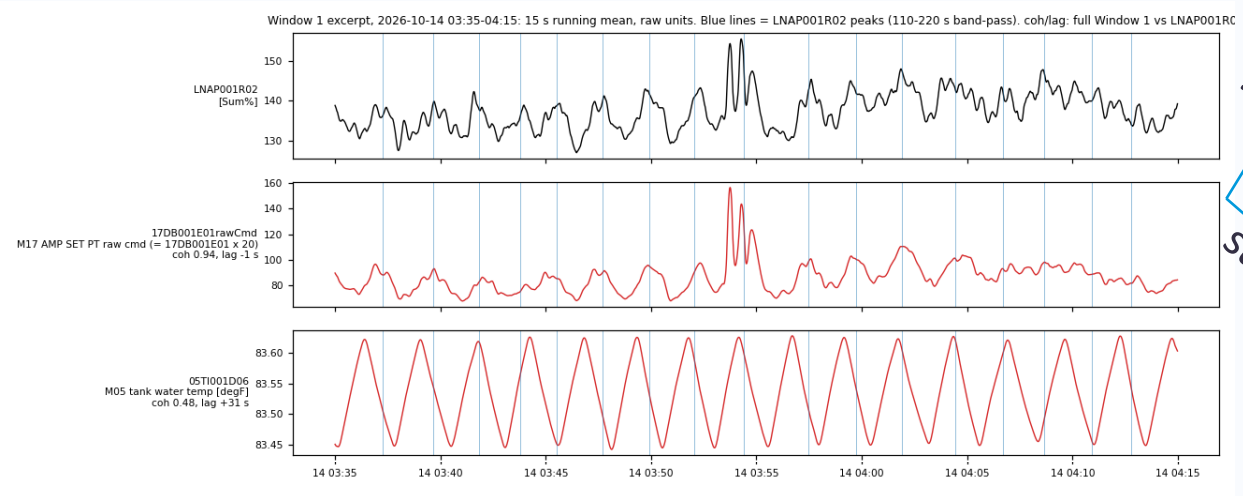
Ask agent retrospectively

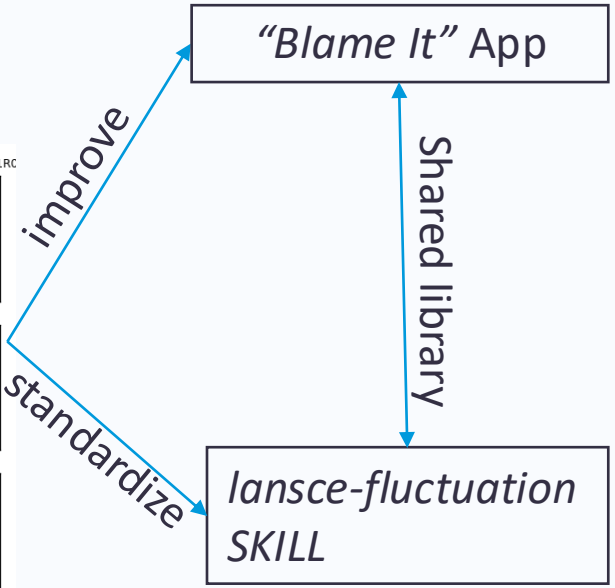
Channel	At last production (09/06 08:04)	Just before 09/14 12:19	At discovery (09/18 00:09)	Archived samples, 09/14 12:40 → discovery
LAQM001I01 (current readback)	483.64 A, OK	483.64 A	**INVALID**, last update 83.8 h old	0
LAQM002I01	487.99 A, OK	487.99 A	482.05 A, live	32,802
LAQM001voltage	4.56 V	4.56 V	**INVALID**, 83.6 h old	0
LAQM002voltage	4.53 V	4.52 V	4.44 V, live	4799
LAQM001L97 (run permit bit)	ON	ON	ON	-

Example: Linac loss fluctuation at ~150s period

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PV	Description	Coherence	Offset
06PH001D01	MOD 5–6 PHASE MON	0.61 / 0.62	+62 / +66 s
05TI001D06	M05 Tank Water Temperature	0.48 / 0.46	+31 / +41 s
05KM001E01avg	M05 INT AMP OUTPUT PWR	0.47 / 0.48	0 / +10 s
05KM001E03avg	M05 RF OUTP RFLCTD PWR	0.48 / 0.46	about half a period
05ML001P03:prxy	M05 ref Phase	0.46 / 0.52	−1 / +9 s





It also noticed a 28 min time-shift between different servers!

Problems: The lack of documents

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LDRD reviewers' comments:

"Reviewers questioned whether the **required underlying data could realistically be obtained** within the project timeline, particularly given that **LANSCE has lost several senior staff** whose subject-matter expertise was **never formally documented** in a form suitable for AI training."

"One reviewer noted that **AI tools are best suited to well-understood, well-documented systems**, and questioned whether LANSCE currently meets that bar given the **loss of institutional knowledge**."

The best time to start was yesterday.
The second best time is today.

"Garbage In, Garbage Out" is more true with LLM



Problems: The fragmentation of documents

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Potential data sources

- LANL's storage system
- MS365 Teams/Shared Drive
  - only shared among a handful
- LCS servers
- Hidden servers requiring passwords
- Elogs: open vs password-protected
- SME's computers
- Retired SME's disconnected computers
- Binders & paper piles
  - In the offices
  - At a corner of an equipment aisle
- Hand-written notebooks

~~DocDB or CERN's EDMS~~

No facility-wide doc system

Me: How do operators learn about LANSCE?

Here: operators

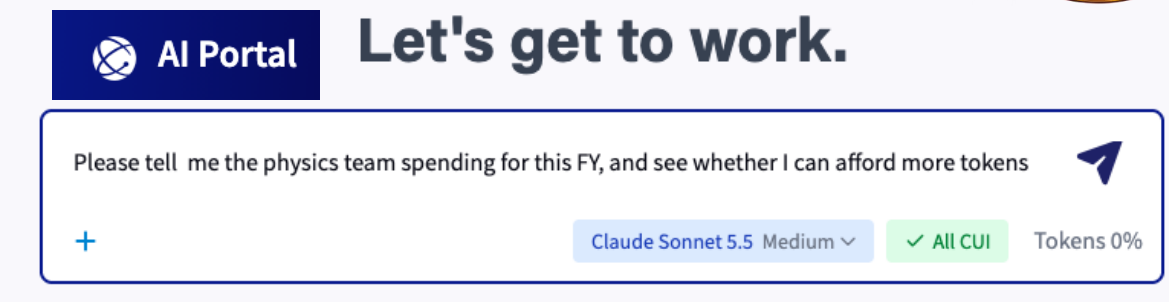


Obsolete yellowed pages in binders without electronic copies

Thank you for your attention!



My future hope:



Workflow SKILL: lansce-lurch

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```
---
name: lansce-lurch
description: Investigate a one-time change at LANSCE - the accelerator lurches
away from the production tune, has a big shift or step, deviates, losses
suddenly jump, or the tune cannot be recovered - by finding what changed since
the last good operation. Triggers: "lurch", "lurched away", "big shift",
"losses jumped", "cannot recover the tune", "what changed". NOT for a
recurring oscillation or spikes (who moves with it): use lansce-fluctuation.
---
```

- Determine user target station and good operation time
  - rules for good production time
- Round 1: Common screens
  - PV screens
  - Vacuum
  - Magnets
- Round 2: First layer out from the common screens

Workflow SKILL: periodic-reports

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```
---
name: periodic-reports
description: Provide a standardized performance report for a given
period of time for the LANSCE accelerator. Trigger this skill when
the user asks how LANSCE as a whole is doing. Trigger this skill
when user is asking for a specific facility like IPF, Lujan, WNR,
pRad or UCN.
---
```

- Availability, Protons on Target
- Losses
- Major events from logs
- Using division-wide weekly email to verify
- Items to flag when detected

MCP: Logs

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Combine all logs into one sqlite database

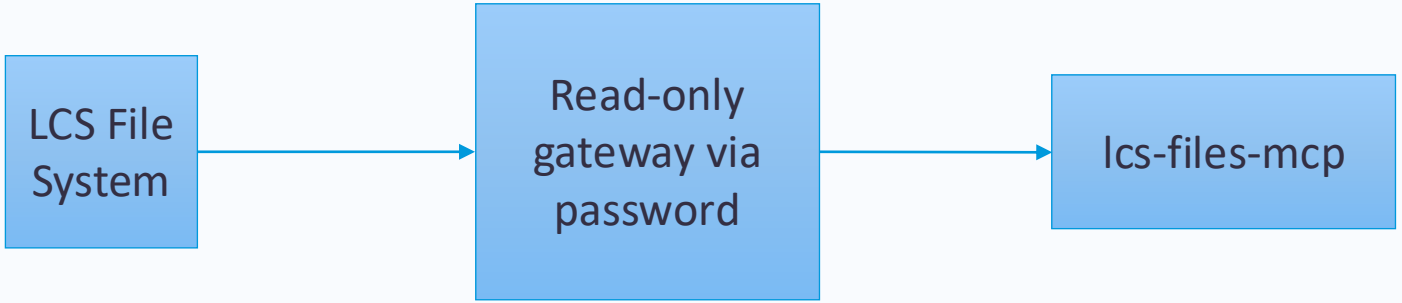
- No vectorization: word usage is very consistent
- Keyword (FTS5) search for now

Figures not included, but noted.

MCP: Download Files

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How do we prevent SI Agent from accidentally going online?



Anthropic Eco-System

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Models

Fable: World-class scientist

Opus: PhD/SME

Sonnet: Experienced engineer

Haiku: Junior engineer/assistant

Effort

Low: Quick answer, min. deliberation

Medium: Think it through

High: analyze carefully and double check

xHigh: Spend hours investigating

Max: Exhaustively investigate every angle

Examples: Alarm System Debugging

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>1000 active alarms for the new system

Not organized instructions for different scenarios

Demo:

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1L current violin plot by year

Review CCR log for outage

Design a beam line

Find contributors

Ps121

Correlation plot or analyze a certain period

LANSCE


Low-energy beam transport
H+
H-
Drift Tube Linac
Transition region
IPF
Side Coupled-Cavity Linac
pRad
UCN
Area A (inactive)
Module 1-4
TR
Module 5-48
LEBT
DTL
CCL
HEBT
PSR
Lujan Center
WNR

Examples

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TBQL5V1-4 had a big jump around 09/28

I'll check the archiver data for TBQL005V03 around that date.

Called plugin:physics-tools:archiver-mcp, plugin:physics-tools:epics-record-catalog 3 times

Confirmed — TBQL005V03 was flat at 0.0 through at least 09/18, then jumps to ~56.78 at 2026-09-28 10:08:23 and stays rock-steady there through today. That's consistent with a device being turned on (quad lens channel going from off/zero to an operating setpoint) rather than a glitch — the post-jump values are extremely stable (56.78–56.79, essentially noise-level variation). Let me check the operational logs for anything noted around that date.

Called plugin:physics-tools:logs-mcp, plugin:physics-tools:epics-record-catalog 2 times

That explains it exactly. From the WCS elog (entry elog_wcs:566, 2026-09-28):

> "TBQL4V* and TBQL5V* lost connection and show zeros. JJD 9-28-26 10:28 — DMM 13 had fatal error message on display, power cycled unit. verified in line-by-line and with CCR that TBQL004* and TBQL005* are now responding."

So the discontinuity isn't a real beam/magnet change — the TBQL004V* and TBQL005V* channels (including TBQL005V03) had lost connection to DMM 13 and were reading zeros as a stale/disconnected value, not an actual zero reading. DMM 13 hit a fatal error, was power-cycled around 10:28 on 09/28, and the channels came back responding — which lines up almost exactly with your archiver jump at 2026-09-28 10:08:23 from 0.0 to ~56.78 (the real, correct value). Everything from 09/28 onward has been stable at ~56.78–56.79, consistent with a legitimate reading rather than