From Chatbots to AI Agents: Practical Applications of LLMs in Detector Physics

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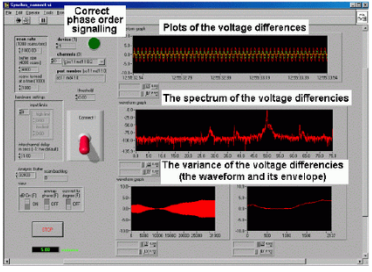
First relevant/useful information about LLM

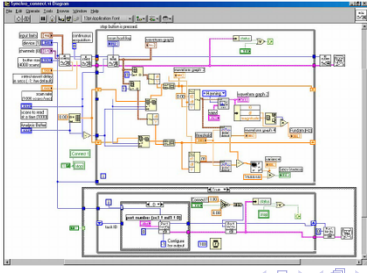
- The first useful information considering the LLM models and their usage in workflows of scientists obtained in seminars of Dr. Michaeala Liegertová (May 2025) organized by AV CR
  - link to CERNBox directory with video roecords and presentations of the individul seminars
  - some presentations (even slightly updated) are available also in English, check link
- Usage of AI chats in the group was increasing at the same time - searching for information, re-formularion of documents, simple plotting of data, etc. $\rightarrow$ successful effort to pay for LLM model within FZU (10 accounts with OpenAI subscription - probably ChatGPT Plus)



First critical usage of LLM - testing of measurement devices

- Public procurement of Keithley measurements devices (August 2025) - documentation (written by us) required testing of functionality of all delivered devices and preparation of acceptance protocol before the invoice can be delivered to FZU
- At that point absolute majority of measurement software in our lab was (and still quite is) written in NI LabVIEW software - which can be very powerful and produce GUIs natural for experimental physicists but effectively nobody (but Jiri Kvasnicka) in the group was able to create more complicated programs in reasonable time + not ideal framework for using the LLM models
- Lets try python and hopefully LLM will know how ...



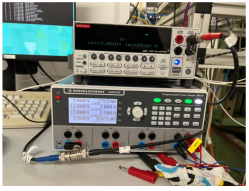


Preparation of machine control scripts in chat window

- Preparing several python scripts for testing of 4 different types of devices - all their functions + all communication interfaces (GPIB, RS232, USB, Ethernet) by writting the promts into the ChatGPT
  - initialization of devices, setup, measurement with online graphs (matplotlib), saving data, plotting data by separare python scripts
  - all tests done and protocol written within 2 days
- Shortcomings of the chosen approach
  - Python code prepared by LLM was not provided as a file but explicitly written into the chat window - slow response (several hundreds of lines per script), need to manually copy-paste code into the text file, ...
  - With increasing number of iterations the response of the ChatGPT windows was getting slower and slower $\rightarrow$ almost not usable
- If this approach needs to be used (e.g. you don't want to install agentic AI - Codex, Claude Code, ... - for some reason), it is working better - produced code is provided as formated files, faster response, ...

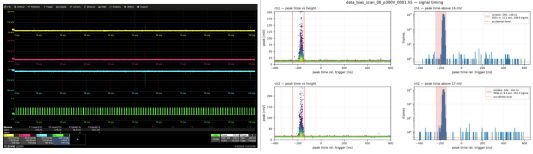
DESY testbeam of 4H-SiC samples - various devices working together

- Testbeam testing of detectors requires simultaneous operation/control of several experimental devices and synchronization of their data streams via Trigger Logic Unit (TLU)
  - DUT (with its DAQ system), Alpide telescope, Telepix, Oscilloscope, T/RH monitoring devices, LV and HV power supplies, etc.
- Colleagues from DESY are developing the (**well documented)** system called Constellation, which integrates all operated devices as Satellites with their states (initializing, launching, orbiting, running, landing, starting, stopping, etc.)
- In principle you can include whatever device into the "constellation" of your particular experiment - if the corresponding satellite exists or you are able to prepare it, and if you know how to configure it
- It is almost impossible to fully prepare for the campaign in advance - you don't have AIDA TLU or telescope in your lab, and you typically do not have sufficient time

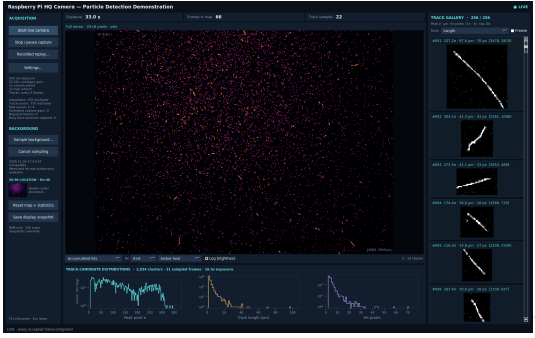

Claude Code and Codex agentic AIs in action

- AI agents quickly prepared and configured Constallation satellites for all necesary devices
  - critical testbeam infrastructure (TLU, Telescope, Telepix, Data Collector) and partially also the oscilloscope had satellites prepared by developeres - just needs to be configured and included
  - completely new satellites prepared for LV/HV power supplies, T/RH monitors based on Raspberry Pi boards, Grafana/Influx data streams, etc.
- complex Grafana monitoring with Influx data upload prepared and controlled by AI, web GUI for oscilloscope prepared by AI
- data taking and online data analysis run by AI agents based on our detailed instructions
  - operating the whole DAQ system based on Constallation - controlling power supplies, changing measurement parameters, starting and continuous monitoring of data taking runs
  - quick online analysis of data provides information based on which the agent can change measurement plan and alarm human operators



Applications of agentic AI in workflows

- 144 TB NAS server with broken OS blocked for 2 years - backup of users home directories (with significant human help), complete reconfiguration of the system, all running nicely again
- Preparation of software for control of experimental devices including user defined GUIs - TCT system, LED driver, setup for measurement of electrical characteristics of semiconductor devices, spectrometer readout (unsuccessful)
- Complete program for measurement of charged particle "tracks" with Raspberry Pi and its camera system
- Preparation of open data materials for ASEP



Applications of chat windows

- Preparation of "simple" stand-alone scripts (simple measurement control codes, various data operations and transformations, data plotting in python/gnuplot, etc.)
- Preparation and review of documents + translations
  - preparation of reports or whatever documents requiring some oficial structure
  - re-formulation of the text based on user requirements - more formal, more attractive for students, kind, etc.
  - review of documents - papers, applications, .. (is a document well written and understandable, are all critical topics discussed properly), optimization of the text for reviewers of a given journal or particular applications
- **Interpretation of experimental data**
  - discussion with AI over the unique experimental results - what could be causing the observed effect which I currently don't understand
  - interpretation of data based on accessible literature (Open Access papers, Open Data repositories) VS misunderstanding of available resouces or even halucination
  - should provide the resources based on which the interpretation was done
- **Careful work with unpublished data - training of AI models**

LLM models - current subscriptions and other resources

- OpenAI subscritpion - ChatGPT Plus
  - Currently team of 10 people, formal group owner is Marcela Mikestikova, paid once per year, 20 USD per month
- Claude Team plan for Scientists - 25 free standard seats for 12 months
  - owner is Jiri Kroll, currently we have 11 out of 25 seats occupied in this subscription, subscription will end in September 2027
- AI guides prepared by Peter Svihra
  - AI BASICS
  - Agentic AI guide (how to set up Claude Code in terminal)
  - LibreChat guide

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