Introduction to 5G RAN PHY Simulators in OpenAirInterface

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Outline

- Physical simulators in OAI
- RFsimulator in OAI
- Softmodem modes in OAI
- Utilizing the scope in OAI
- OAI 5G RAN Roadmap

Physical Simulators in OAI

- Physical simulators are a set of tools allowing to simulate mostly physical layer procedures, eg. channel coding and transport channels
  - Transport channel simulators: PBCHSIM, PRACHSIM, PUCCHSIM, DLSCHSIM, ULSCHSIM
  - Coding simulators: LDPCtest, polartest, smallblocktest
  - L1/L2 simulators: DLSIM, ULSIM
- Physical simulators can be used to test and debug features, evaluate performances and they are used in the CI to verify MRs

Physical Simulators in OAI

- How to build physical simulators
  - **./build_oai --phy_simulators (--sanitize-address)**
  - **make nr_pbchsim (from ran_build/build)**
- Physical simulators are configurable via command line parameter
  - -h to show help listing the options for given simulator
- Among the configuration options: SNR and channel modeling
  - default channel option is AWGN
  - TODO: implementation of 3GPP TDL channel models to verify standard compliance of receiver performances

Physical Simulators in OAI

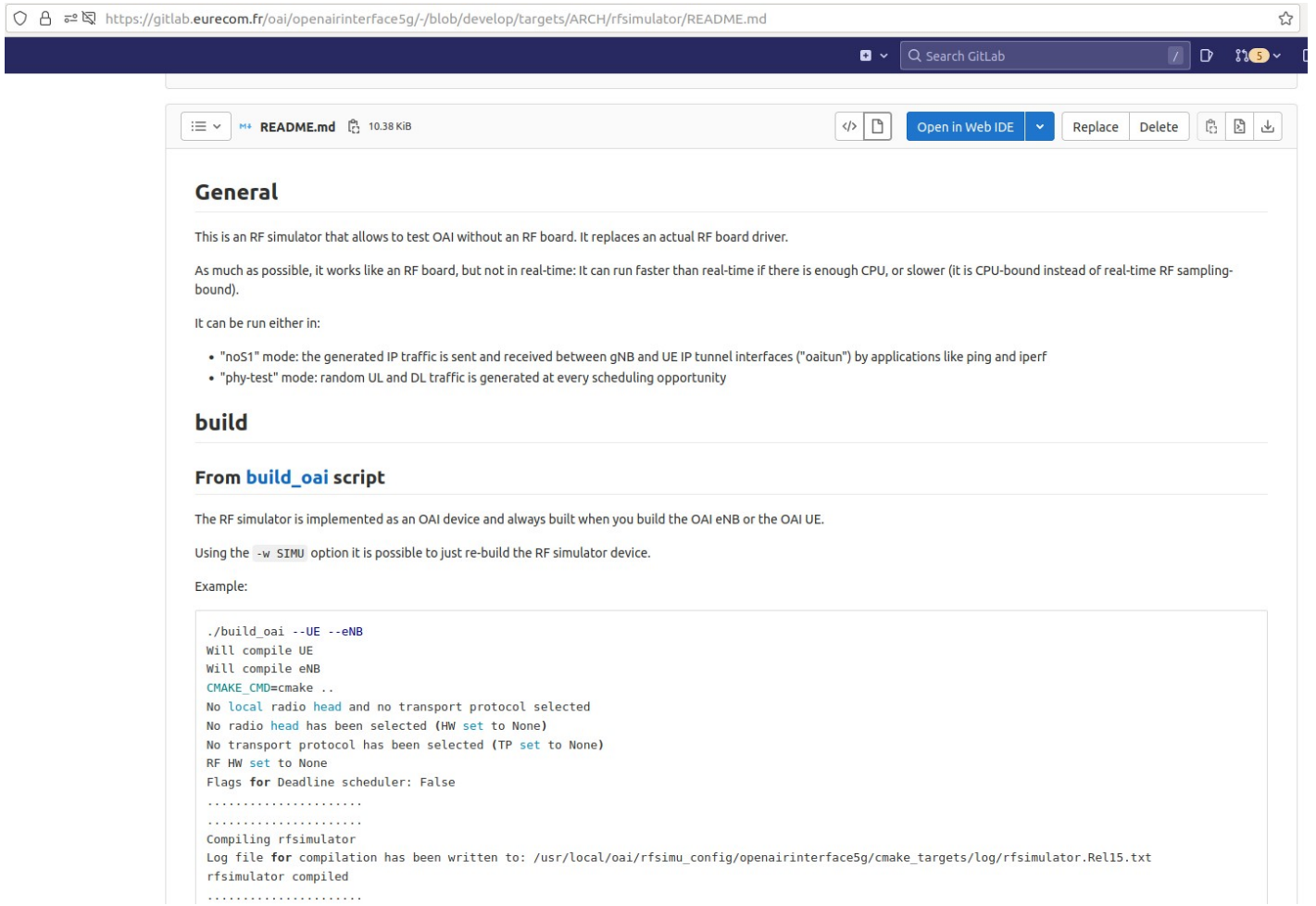
- Let’s run some PHY-SIM examples
  - **pbchsim with and w/o initial sync**
  - **pucchsim format 0 and 2**
  - **dlsim with 256QAM option and 2 layer MIMO**
  - **ulsim with -P**
  - **polartest**

RF Simulator in OAI

- OAI without RF board
  - Sends the I/Q samples in time domain (interface 8) between xNB and UEs
  - Transparent transmission and channel simulation are available
- All OAI options and modes are available with RFsim, as with actual RF boards
  - Important note: operations are not in real time (e.g. it is not possible to test real time throughput in a meaningful way)
  - Debug is possible: any break point works in gdb
- Exceptions: OAI UEs are not (yet) thread safe, so it need to run with multi-threading restrictions

RF Simulator in OAI

- Documentation
  - Module specific documentation is in module source code directory
  - In targets/ARCH/rfsimulator
  - As the codebase, documentation can be improved and corrected via MRs



RF Simulator in OAI

- Command line option: --rfsim
- Rfsim options in config file

```
rfsimulator :{
serveraddr = "server";
serverport = "4043";
options = (); #("saviq"); or/and "chanmod"
modelname = "AWGN";
IQfile = "/tmp/rfsimulator.iqs";
};
```

Either server (tcp listen)
Or a server IP addr

TCP port to use on server side

Saviq to record transmitted I/Q in a file
Chanmod enables the channel simulation

Channel modelling
Offers several options

A UE replay node exists for saviq option
It can use field trial captures or recorded simulation

Softmodem Modes in OAI

- **phy-test mode** is an OAI softmodem option that allows the gNB to continuously schedule DLSCH and ULSCH even without a UE
- This mode can be activated both for RFsimulator and with actual RF boards
- A use case is to test transport channels with a 5G capable signal analyzer
- Via command line parameter it is possible to configure the slots to be scheduled, the allocated resouces, MCS etc.

Softmodem Modes in OAI

- **do-ra mode** is an OAI softmodem option that allows a simulated NSA connection with only 5G terminals being present
- Also this mode can be used both with RFsimulator and actual RF boards
- It performs synchronization and contention-free random access between OAI gNB and OAI UE before starting to schedule DL and UL traffic channels
- RRC configuration of UE is done via a .raw file generated by gNB and saved in execution folder

Softmodem Modes in OAI

- Now some practical examples of modes using RF simulator
  - **phy-test mode selecting MCS, RBs and slot occupation**
  - **do-ra mode for FR1**
  - **do-ra mode for FR2**
  - **SA (without core network)**

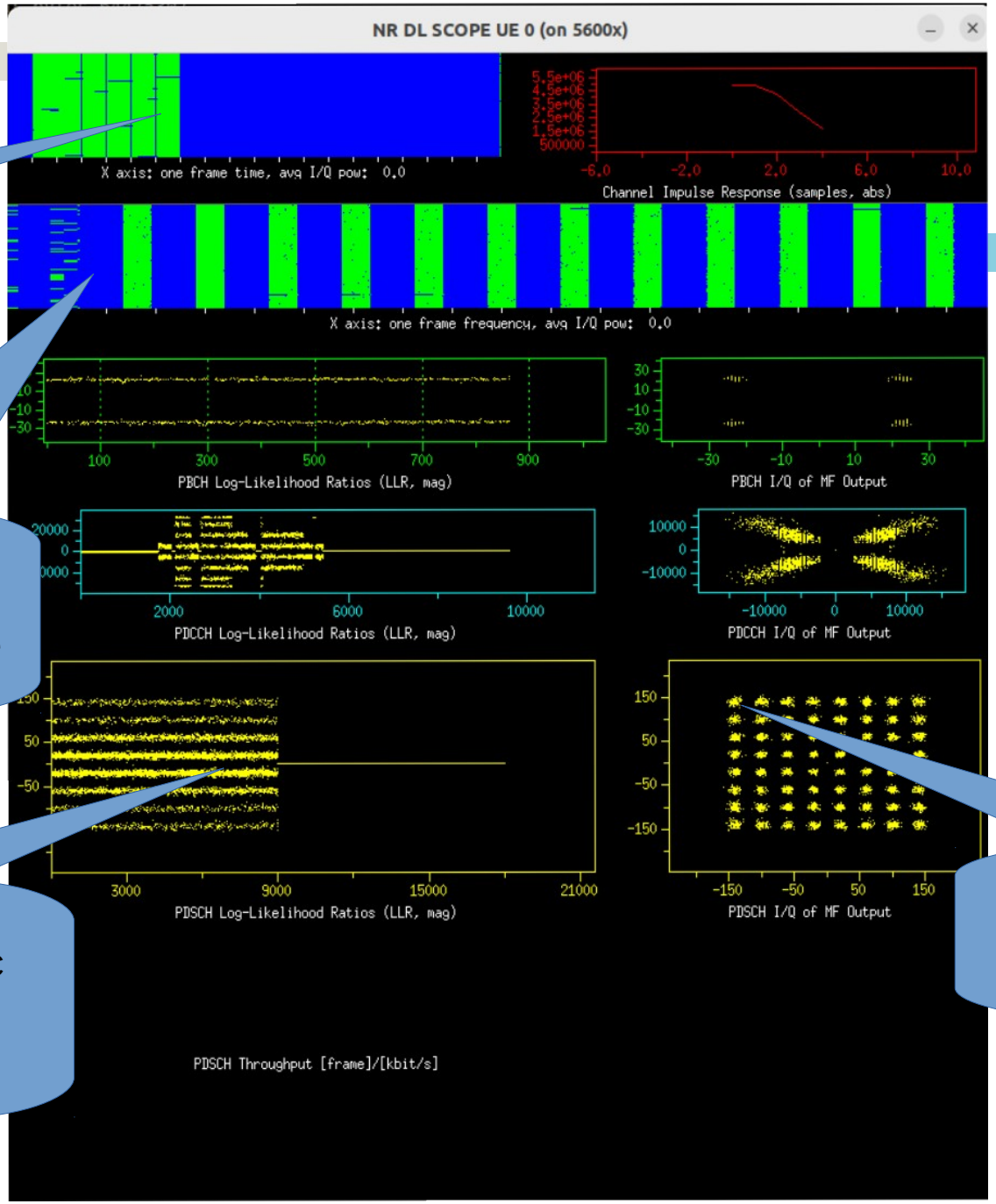
Utilizing the Scope in OAI

- The scope is a graphical interface to display transport channels
- How to build the shared libs
  - **ninja/make enbscope uescope nrscope (one shared lib for NR UE and gNB)**
  - **Or ./build_oai … --build_libs all**
- Runtime option « -d » on command line

Time domain
One line is a frame
Color is the energy relative to average

Frequency domain
One line is a frame
Color is the energy relative to average

Llr graphs
The soft symbols that will enter le FEC decoder
2 lines if 1 bit per symbol



Constellation graphs
The signal after equalization
per physical channel

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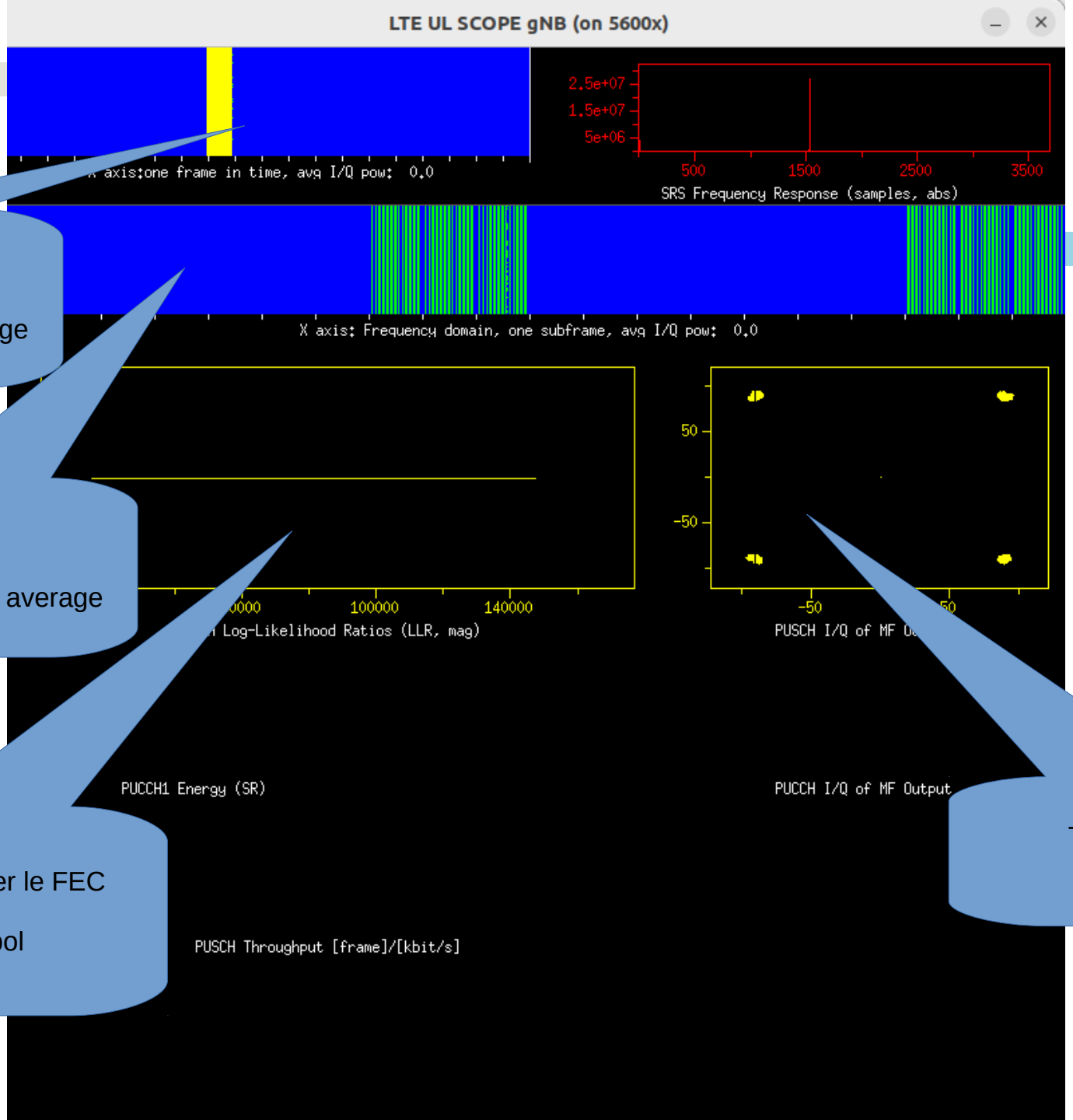

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Utilizing the Scope in OAI

- Configuration file need default channel definition
- Add in your configuration file the prepared default file
  - @include "channelmod_rfsimu.conf"
  - Example file for UE
- Launch the gNB and the UE
  - sudo ./nr-softmodem -O ../../../ci-scripts/conf_files/gnb.band78.tm1.106PRB.usrpn300.conf --phy-test --rfsim -d
    - -m for DLSCH MCS (27), -D downlink slots bit map (126)
  - sudo ./nr-uesoftmodem --phy-test --nokrnmod -O ./ue.conf --rfsim -d --telnetsrv --rfsimulator.options chanmod

```
uicc0 = {
imsi = "001010000000002";
key = "6874736969202073796d4b2079650a73";
opc= "504f20634f6320504f50206363500a4f";
dnn= "oai";
nssai_sst=1;
nssai_sd=1;
}
    log_config :
    {
      global_log_level                  ="info";
      hw_log_level                      ="info";
      phy_log_level                     ="info";
      mac_log_level                     ="info";
      mac_log_verbosity                 ="high";
      rlc_log_level                     ="info";
      pdcp_log_level                    ="info";
      rrc_log_level                     ="info";
      nr_rrc_log_level                  ="info";
      ngap_log_level                    ="info";
    };
@include "../../../ci-scripts/conf_files/channelmod_rfsimu.conf"
```

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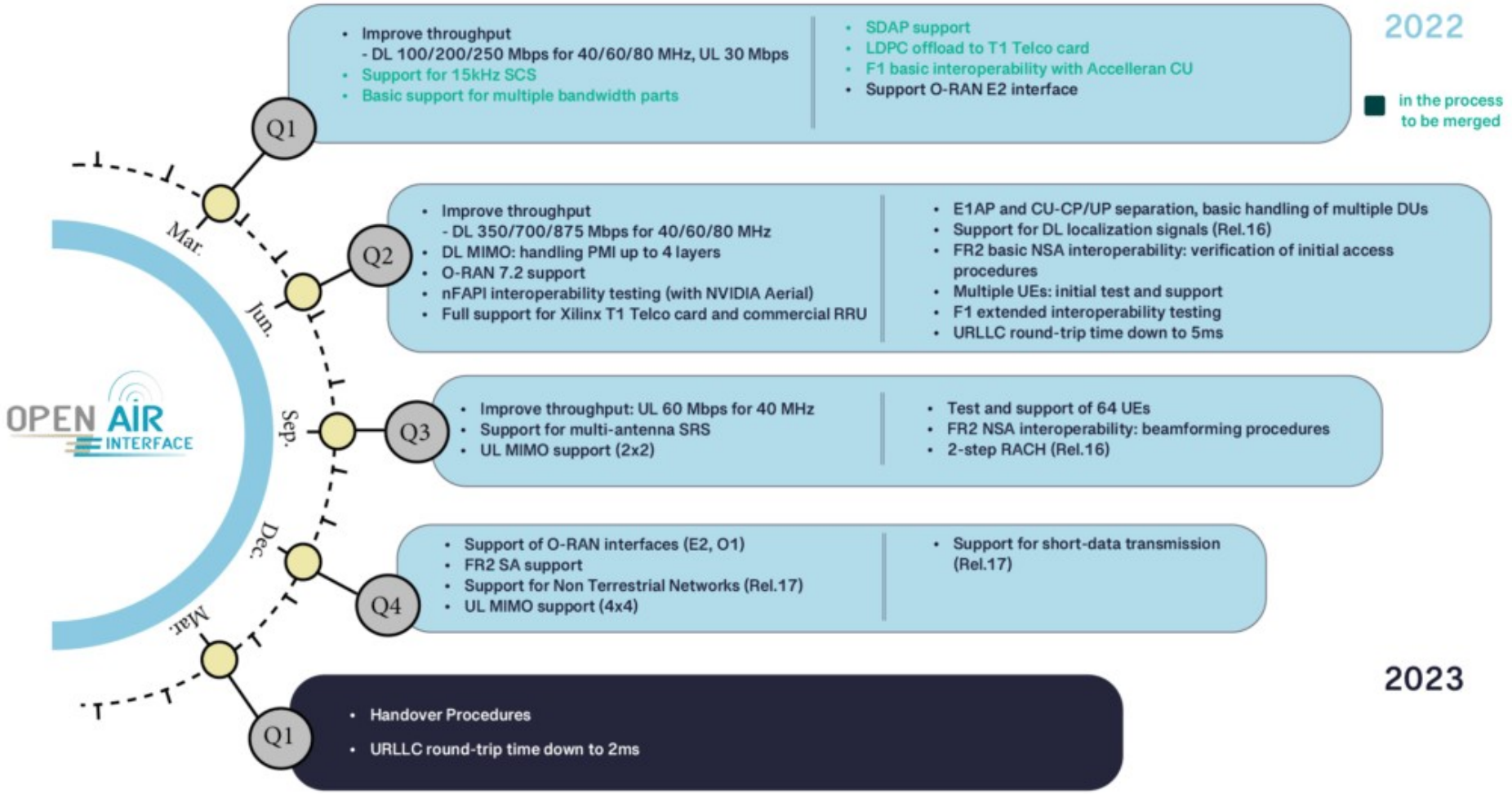
Utilizing the Scope in OAI

- Connect to the telnet server in the UE
  - Telnet 127.0.0.1 9090
  - Help
    - module 4 = channelmod:
channelmod help
channelmod show <predef,current>
channelmod modify <channelid> <param> <value>
module 5 = rfsimu:
rfsimu setmodel <model name> <model type>
    - If you don’t get the help on channemod, you missed to enable it in rfsimulator
      - Help is contextual
  - Command
  - channelmod modify 0 noise_power_dB -50

OAI 5G RAN Roadmap



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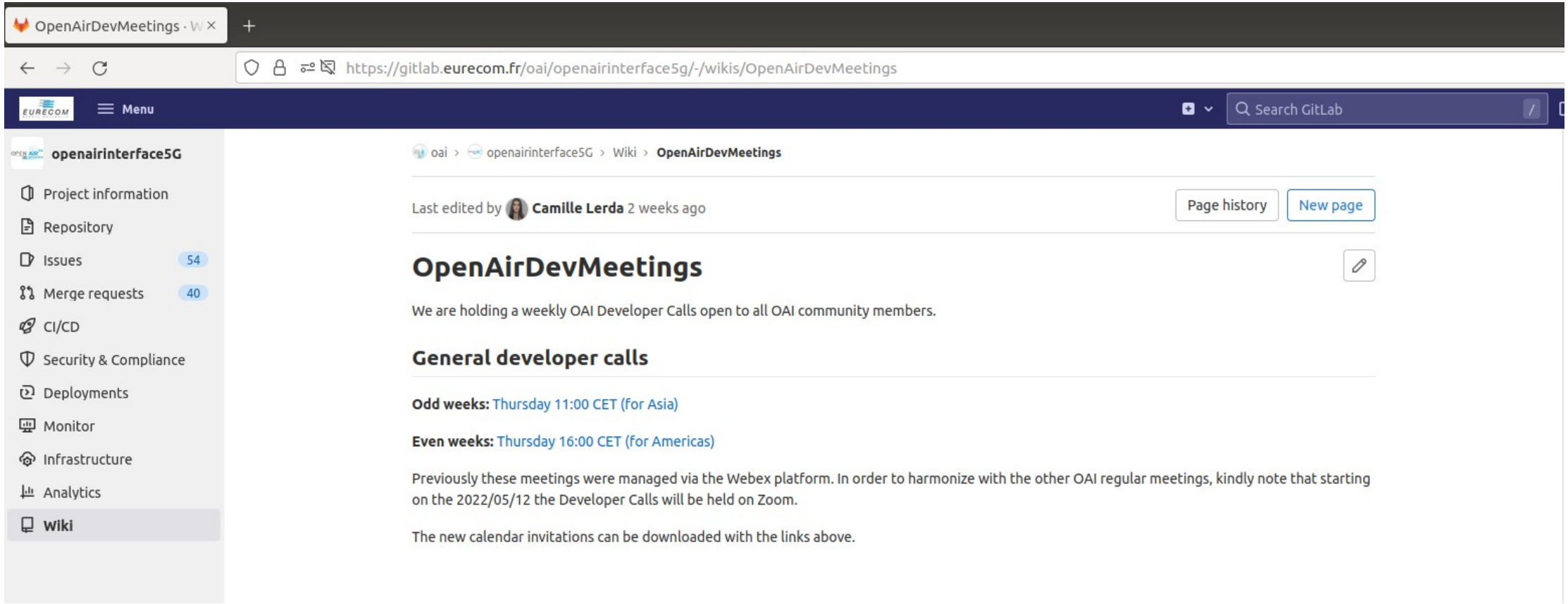
OAI 5G RAN Roadmap



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