

Beam Performance Tracking Status

Vito Baggiolini

On behalf of V. Kain, A. Huschauer, K. Li, F. Velotti,
and BE-CO

Beam Performance Tracking (BPT)

- Mandated by the LIU project
 - Measure performance of Injectors w.r.t. the performance goals
 - Track in particular peak performance and reproducibility
- Two types of BPT:
 - Per accelerator and per beam-type (across the complex)
- Two “frequencies”:
 - Aggregated (per day) and online (cycle-by-cycle)

	Per Accelerator	Per beam-type across the complex
Aggregated	Phase1 (mid-2020)	Phase1 (mid-2020)
Online (cycle-by-cycle)	Phase2 (2021/22)	Phase2 (2021/22)

BPT timeline so far

- July: [LIU-CCC presentations](#) on BPT in LN4, PSB, PS, SPS
- August: Presentation at LIU-CCC by Verena & Alex: “[Performance tracking outcome across the Injector complex](#)”
- September: involvement of CO
 - Preliminary analysis of requirements and possible solutions by CO experts
 - [Presentation by Marine at LIU-CCC](#): Commitment from CO for Phase 1 with deadline mid-2020. Phase2 is in line with our work too.
 - Vito Baggiolini appointed to coordinate CO involvement for Phase 1
- Since October:
 - Collaboration between members of OP, ABP and OP

Work done: Knowledge sharing

- Who: Verena, Alex, Kevin, Francesco, Vito
- Knowledge shared
 - Presentations, demos and many discussions
 - Alex' optics repository and website <http://acc-models.web.cern.ch>
 - [Bare machine: Twiss at Injection, Phase Rotation](#)
 - Based on work by [Guido Sterbini](#) and [Davide Gamba](#)
 - Exploration done by [Kevin on using Bokeh](#)
- I'm impressed (but not surprised ;-)
 - ➔ The above work shall be the basis for BPT Phase 1



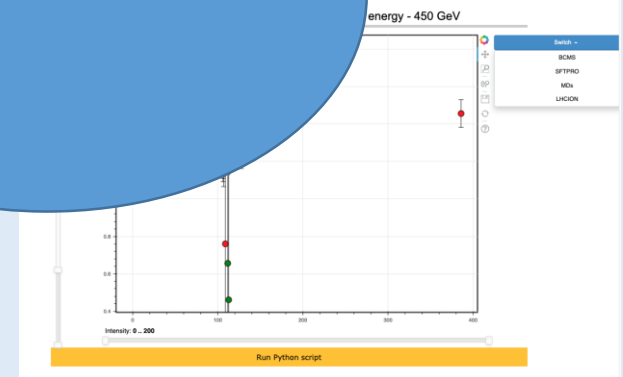
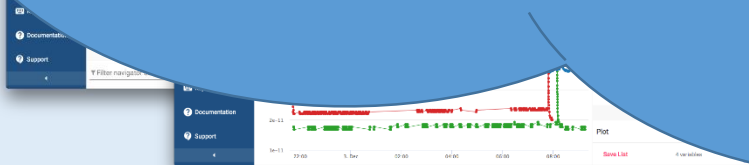
BPT Project Phase 1

- Objective: Develop a system that enables OP+ABP experts to easily **compute beam performance** and **display** the results on the **public web**
- My role (as I understand it, to be confirmed):
 - Contribute CO knowledge and best practices
 - Promote suitable CO (and IT) tools: acc-py, UCAP, NXCALS, WebTimber, ...
 - Coordinate between OP+ABP and CO, dispatch and follow up work in CO teams
 - If desired: Drive/coordinate BPT-related work outside of CO
- My approach (as always):
 - Build on existing work and ideas
 - No (“big-bang”) revolution, but evolution
 - Early involve (motivated) people from all accelerators
 - Hold regular meetings and give regular demos of new functionality

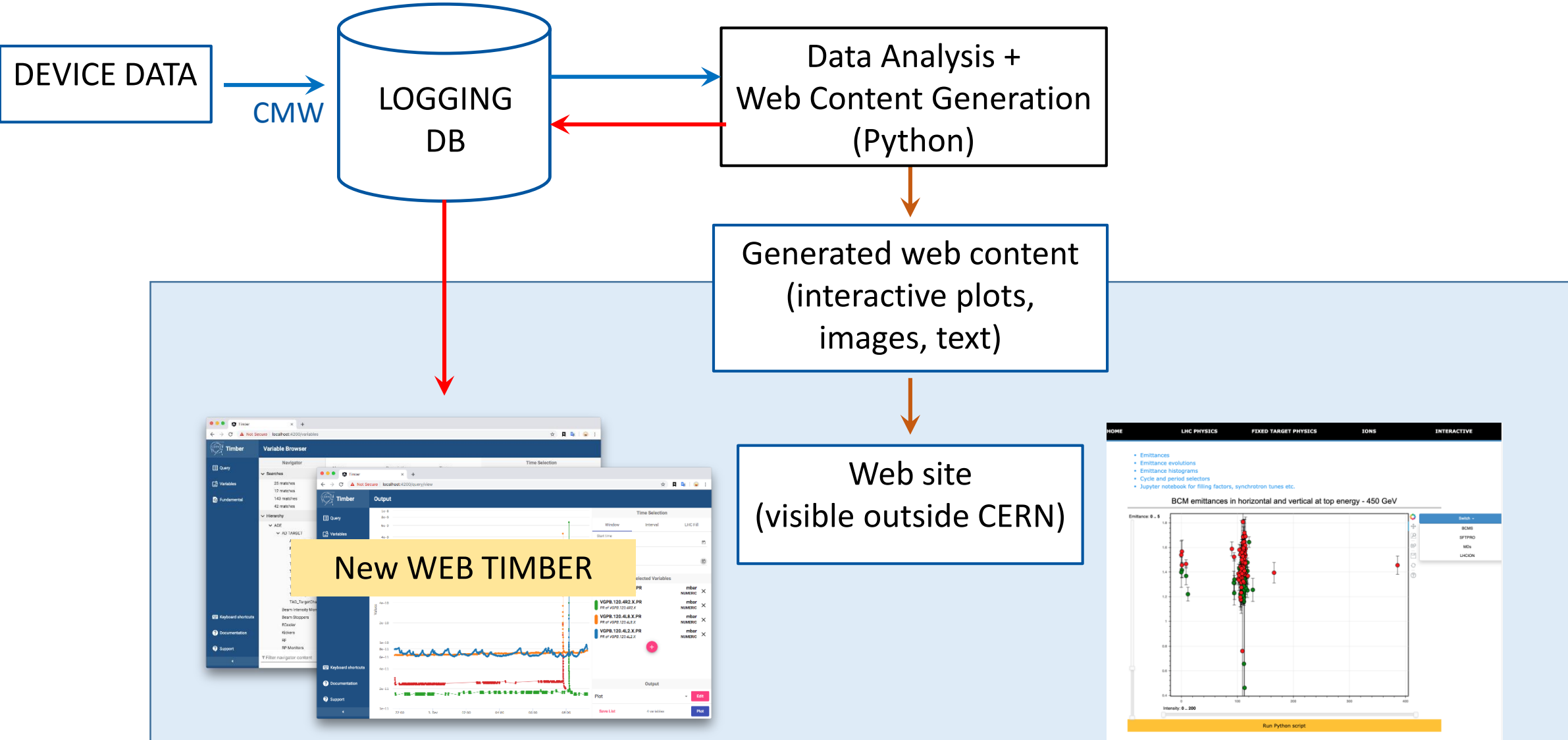
BPT Phase 1: Overview

DEVICE DATA

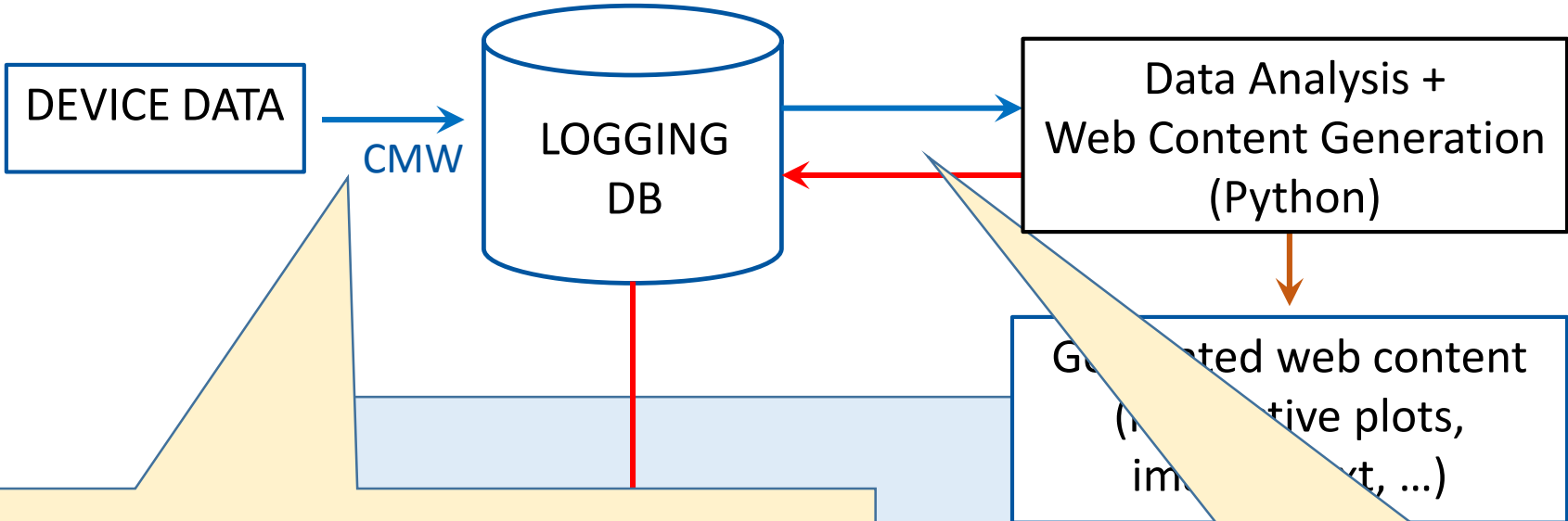
Work in Progress.
To be continuously
improved based on
gained experience



BPT Phase 1: Overview

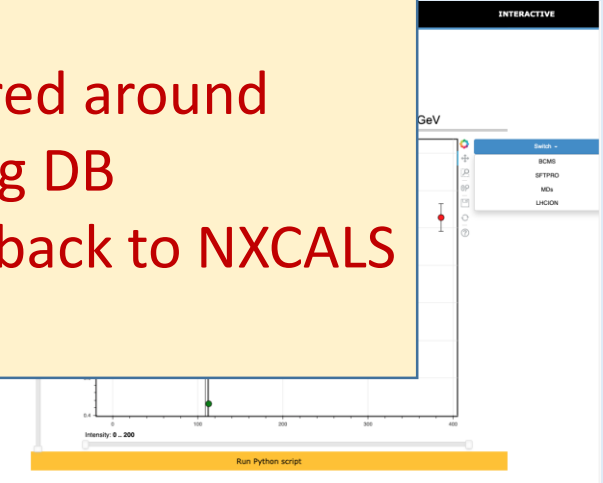
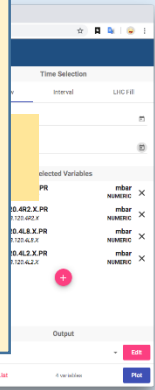


BPT Phase 1: Data



- Try to make sure all necessary data already in NXCALS
- Avoid interactions with devices during data analysis (scripts should not be time-bound)

- Analysis centered around NXCALS Logging DB
- Results stored back to NXCALS



BPT Phase1: Data Analysis and Content Generation

- Developed by ABP + OP
- Using new “acc-py” Python ecosystem
- Developed in IDE or Jupyter

Data Analysis +
Web Content Generation
(Python)

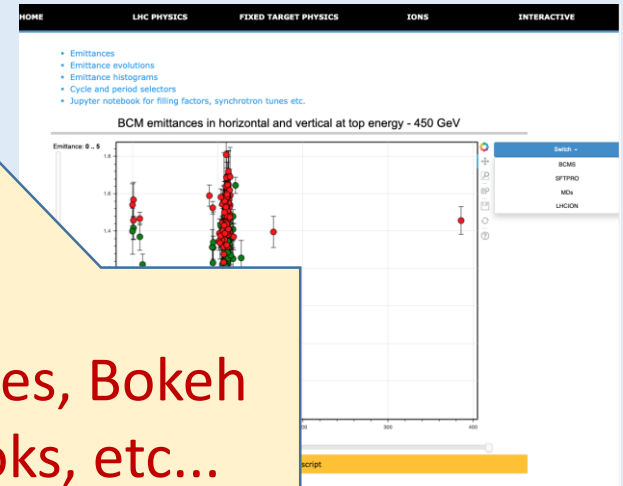
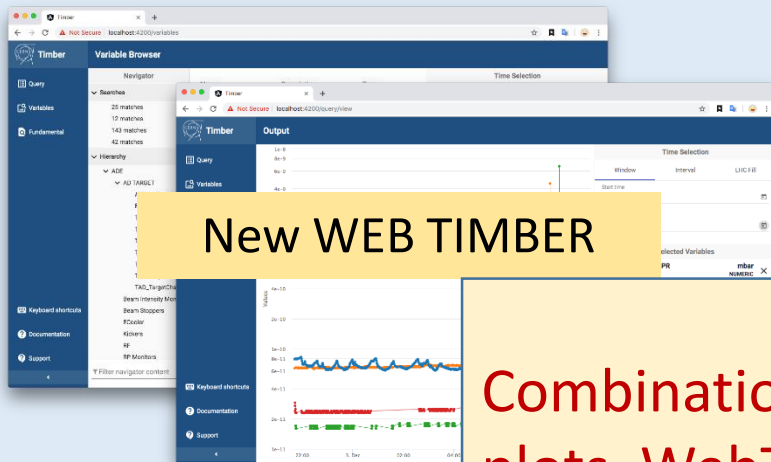
Content generated with
Python tools already used
by ABP+OP
([MkDocs](#), [Bokeh](#), ...)

Generated web content
(interactive plots,
images, text, ...)

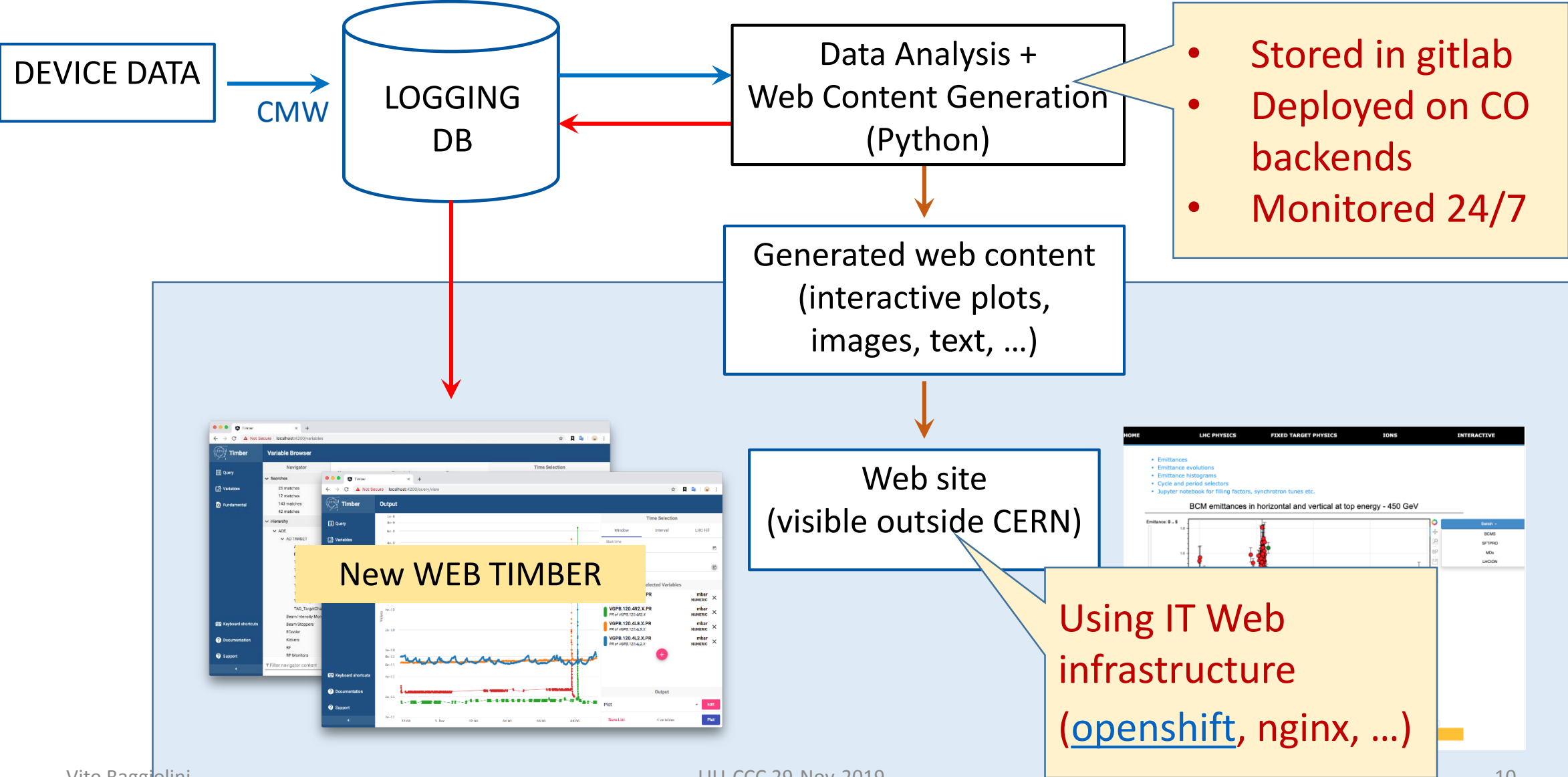
Web site
(visible outside)

New WEB TIMBER

Combination of static pages, images, Bokeh
plots, WebTimber, Jupyter notebooks, etc...



BPT Phase1: CO and IT aspects



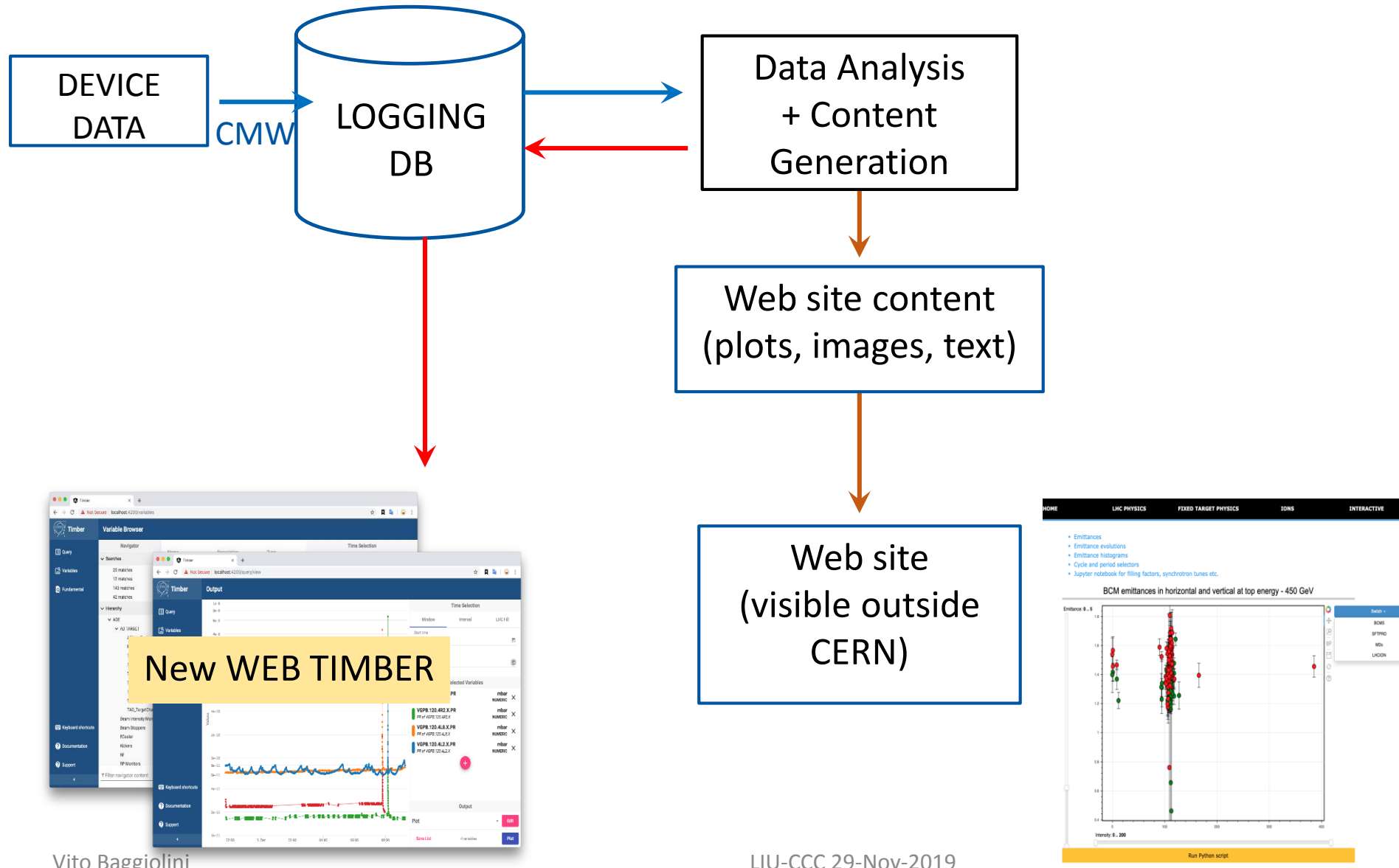
BPT Phase1: Summary of previous slides

- Data Analysis:
 - Python + data analytics tools (NumPy, Scipy, Pandas, etc.)
 - Centered around Logging DB (NXCALS)
 - Avoid direct interactions with equipment (log all needed information to NXCALS)
- Web Content creation:
 - Using [MkDocs](#), a Python-based static site generator that combines [Markdown](#) content with [Jinja2 templates](#)
 - Embed graphs produced with [Bokeh](#) and WebTimber (when ready)
 - Leverage IT web infrastructure (nginx on openshift) to make it visible on the Internet
- Development/deployment
 - New BE-CO Python distribution and tools
 - GitLab repositories, one per accelerator, grouped together by a parent project
 - Deployed on a BE-CO server
 - Monitored 24/7 (as all other CO services)

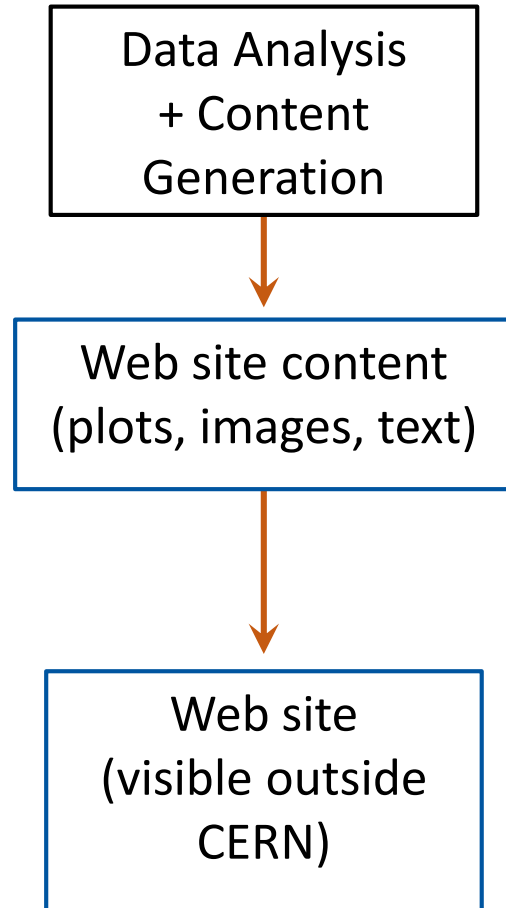
Work done: Technical Explorations

- Data analysis and website content generation
 - Demo site by Francesco (c.f. below)
 - [Bokeh feature exploration](#) by Kevin
- CO infrastructure and best practices
 - Adapted to use new acc-py distribution BE-CO has recently released
 - Review of code structure and proposals for improvements
- IT Infrastructure: Exposed on Web using two different solutions
 - Using a simple [EOS Website](#)
 - Setting up a [local web server](#) and an [nginx reverse proxy](#)
 - Many thanks to the BE-CO sysadmins and Brice Copy (BE-ICS) for their help!

Exposing Results on the Internet



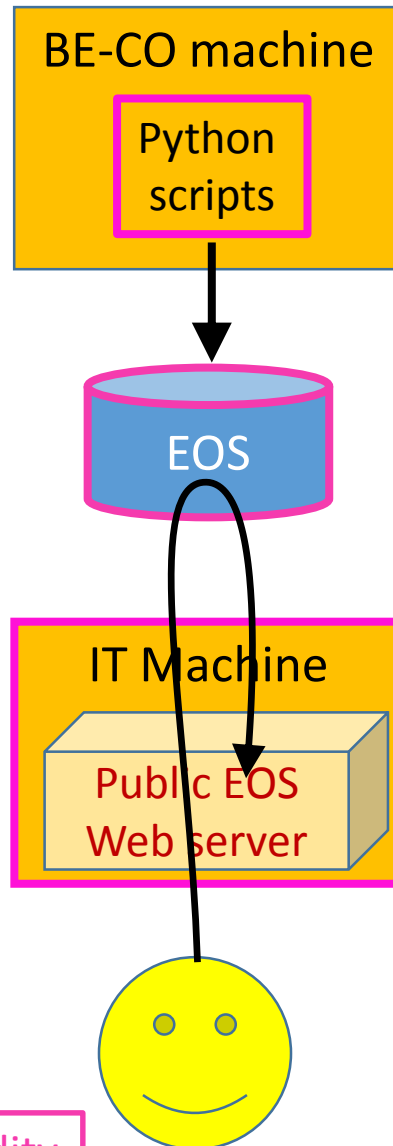
Exposing Results on the Internet



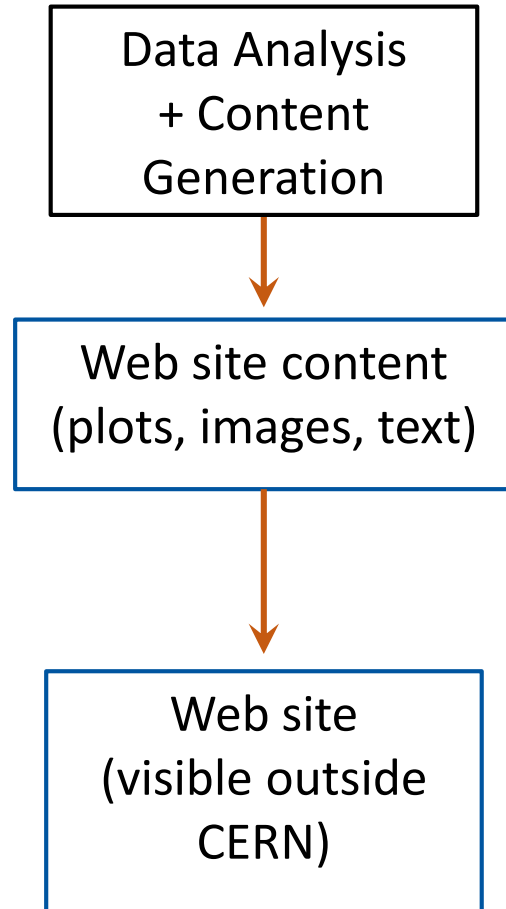
Exposing Results on the Internet

Solution 1:

- EOS file system
- Simple IT webserver
- Kerberos needed
- Static websites



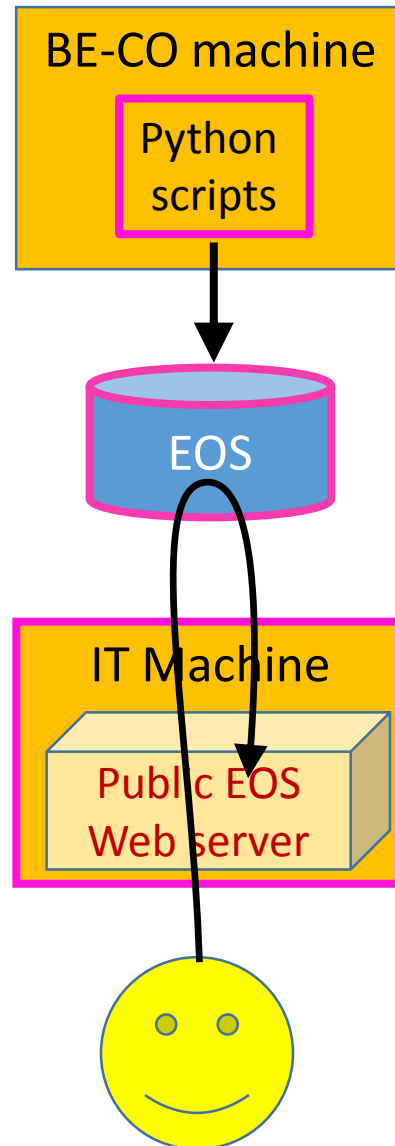
Kerberos, 25h validity



Exposing Results on the Internet

Solution 1:

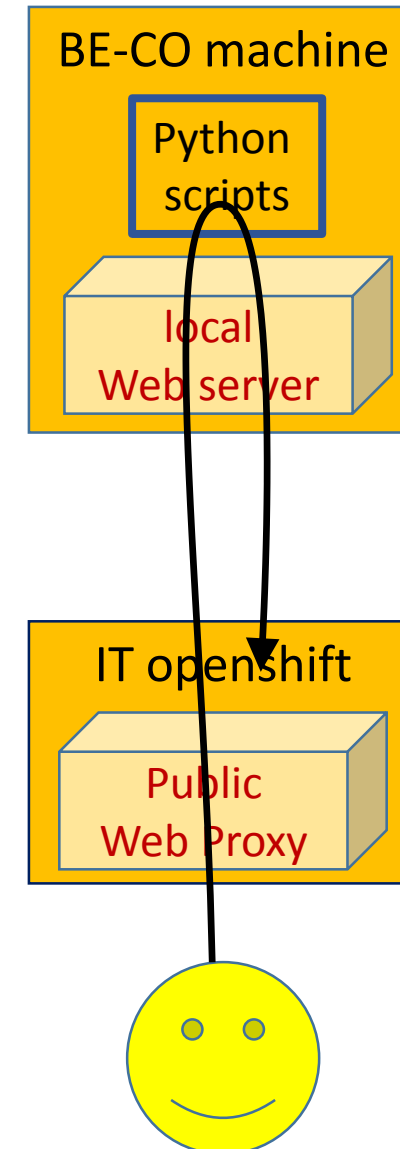
- EOS file system
- ✓ Simple IT webserver
- ✗ Kerberos needed (anacron)
- ✗ Static websites



Data Analysis
+ Content
Generation

Web site content
(plots, images, text)

Web site
(visible outside
CERN)

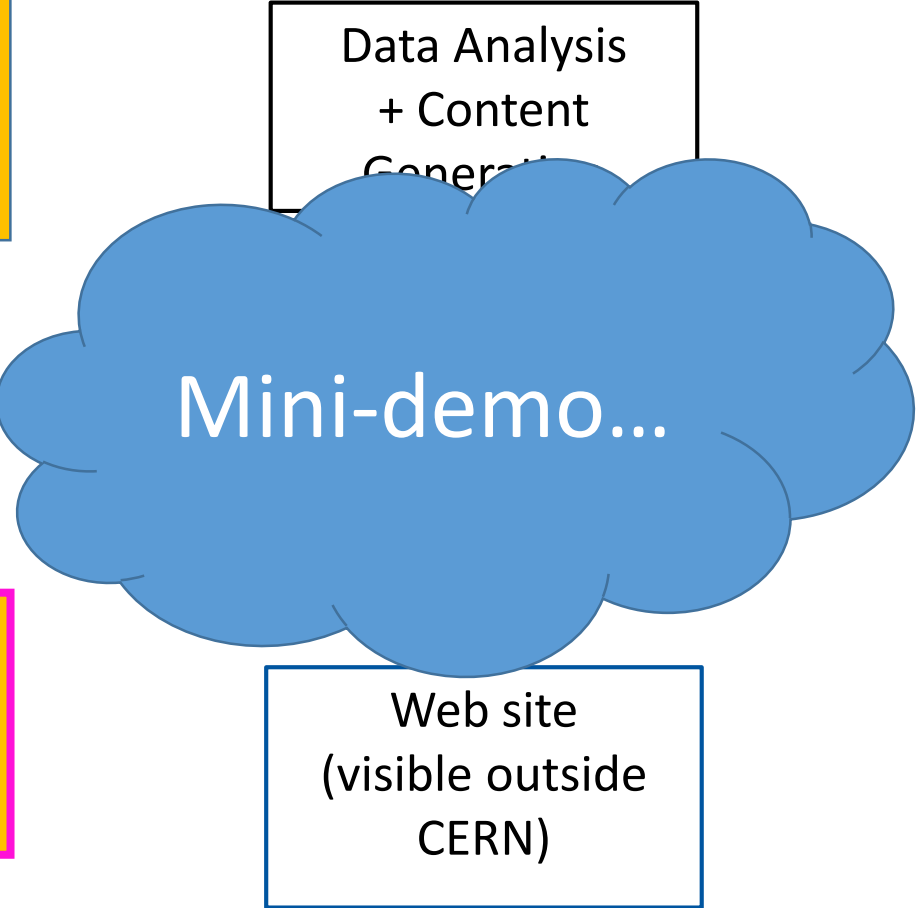
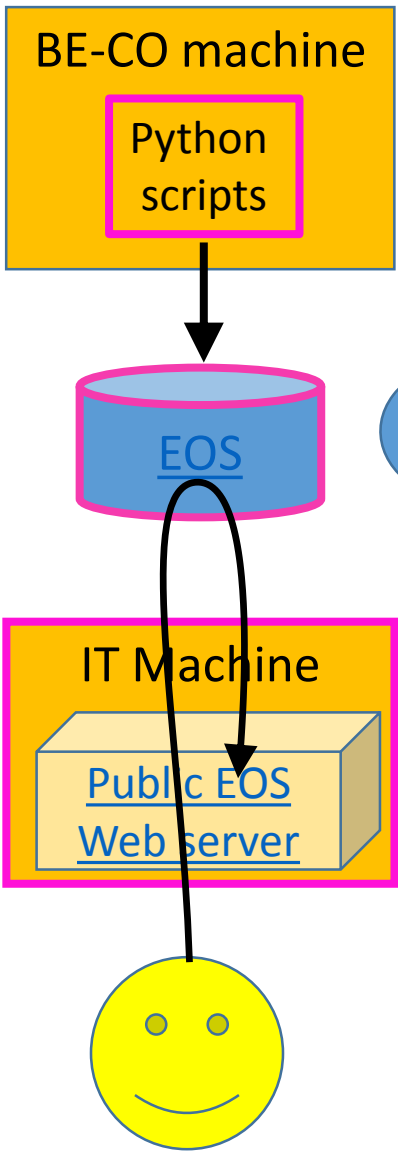


Solution 2:

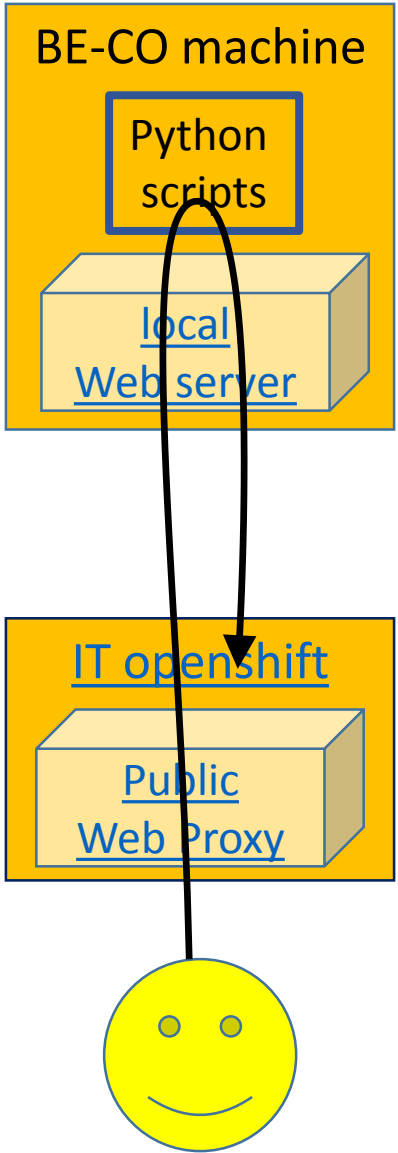
- Local web server
- Web proxy
- ✓ No Kerberos
- ✓ Interactive websites

Exposing Results on the Internet

- Solution 1:
- EOS file system
 - ✓ Simple IT webserver
 - ✗ Kerberos needed (anacron)
 - ✗ Static websites



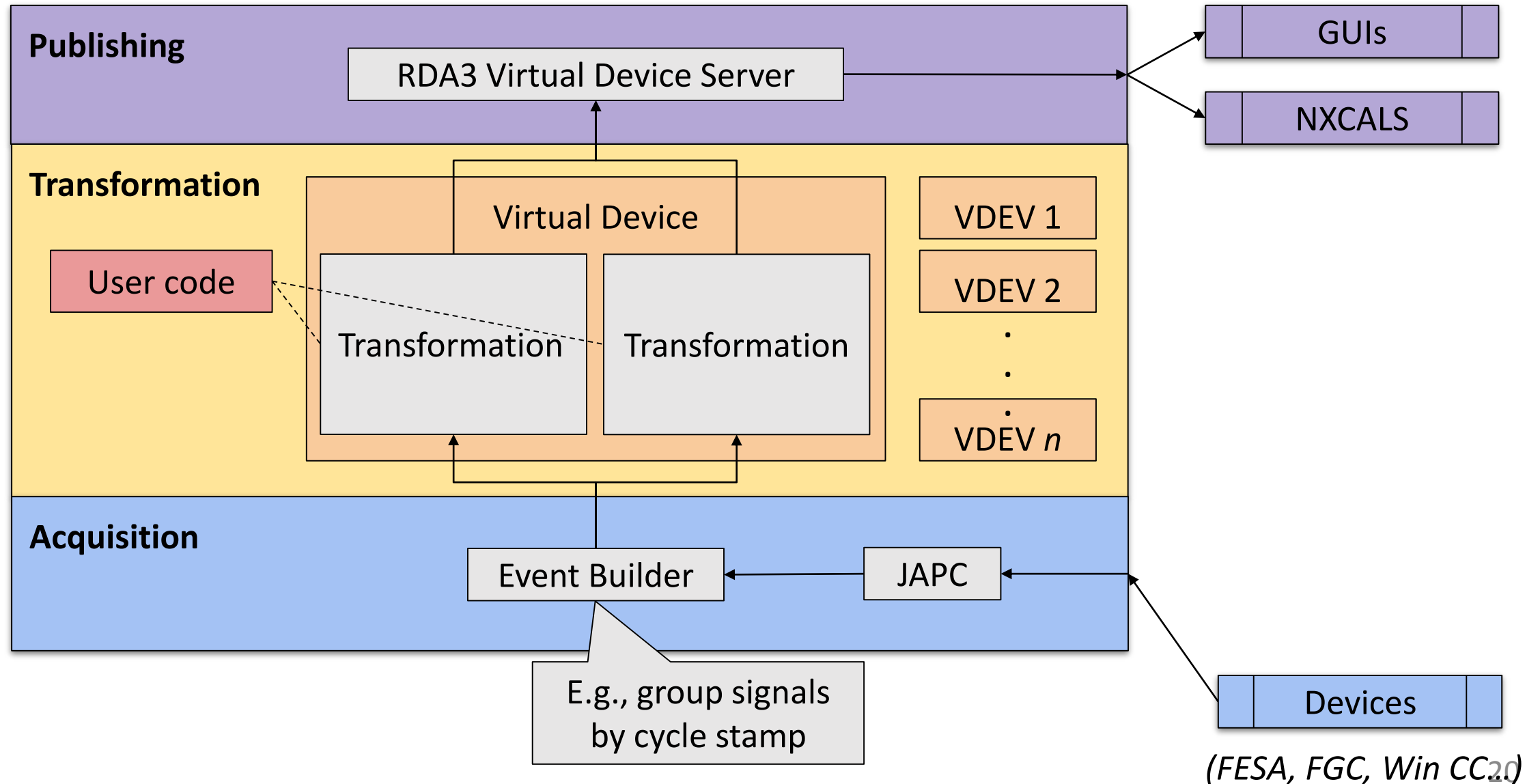
- Solution 2:
- ✗ Local web server
 - Web proxy
 - ✓ No Kerberos
 - ✓ Interactive websites



Next steps

- Finish organizing the project
 - Clearly define the Project Mandate (Purpose, Scope, Objectives) for Phase 1
 - Put together a team
 - Plan the project's timeline over the next 3 months
- Work towards BPT Version 1
 - Decide on structure to accommodate Accelerators AND beams
 - Set up gitlab projects to easily collaborate
 - Define project structure (Separate source code from the resulting data)
 - Real Server-side deployment with monitoring
 - Use NXCALS to extract and store data
 - ...

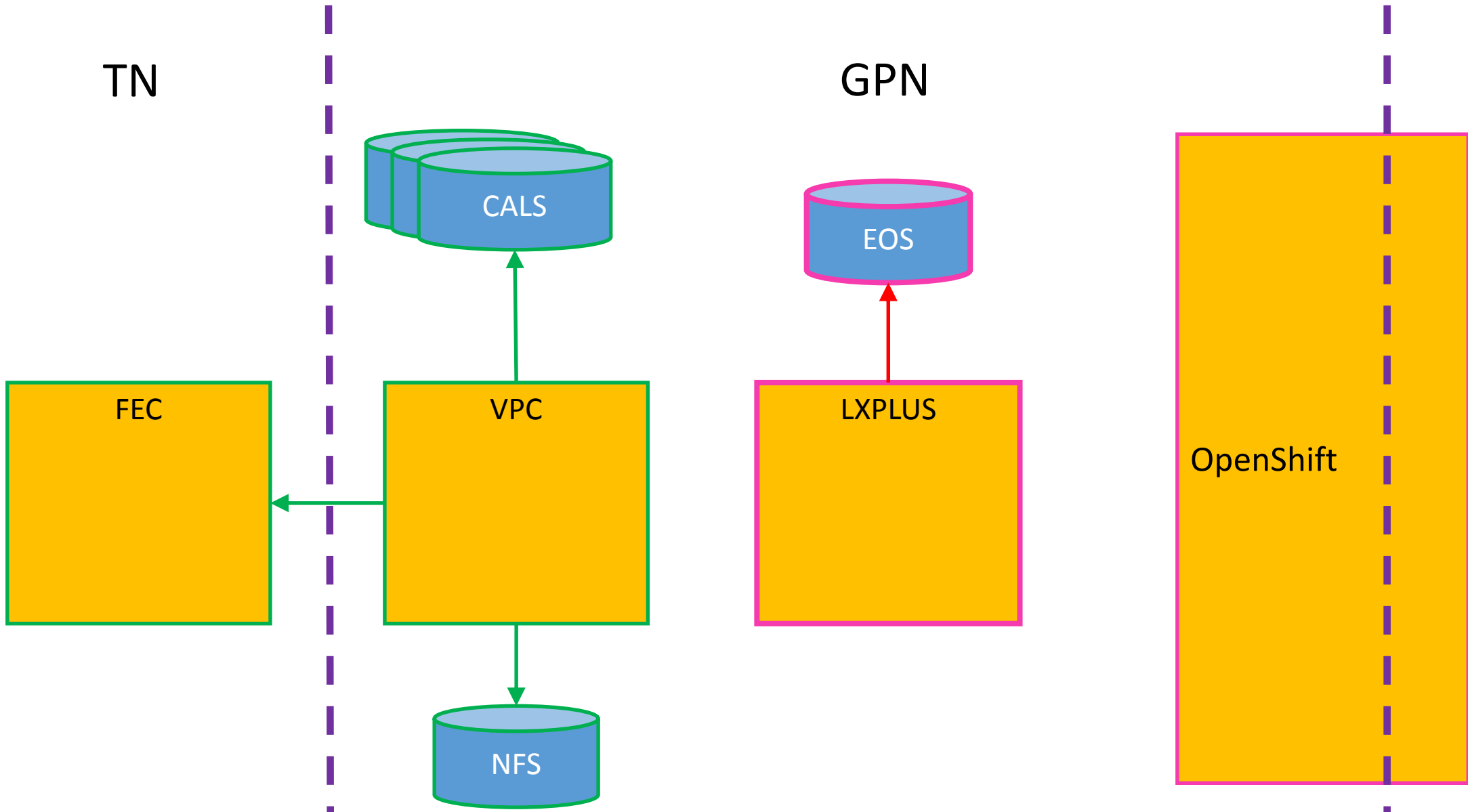
UCAP: Unified Controls Acquisition and Processing

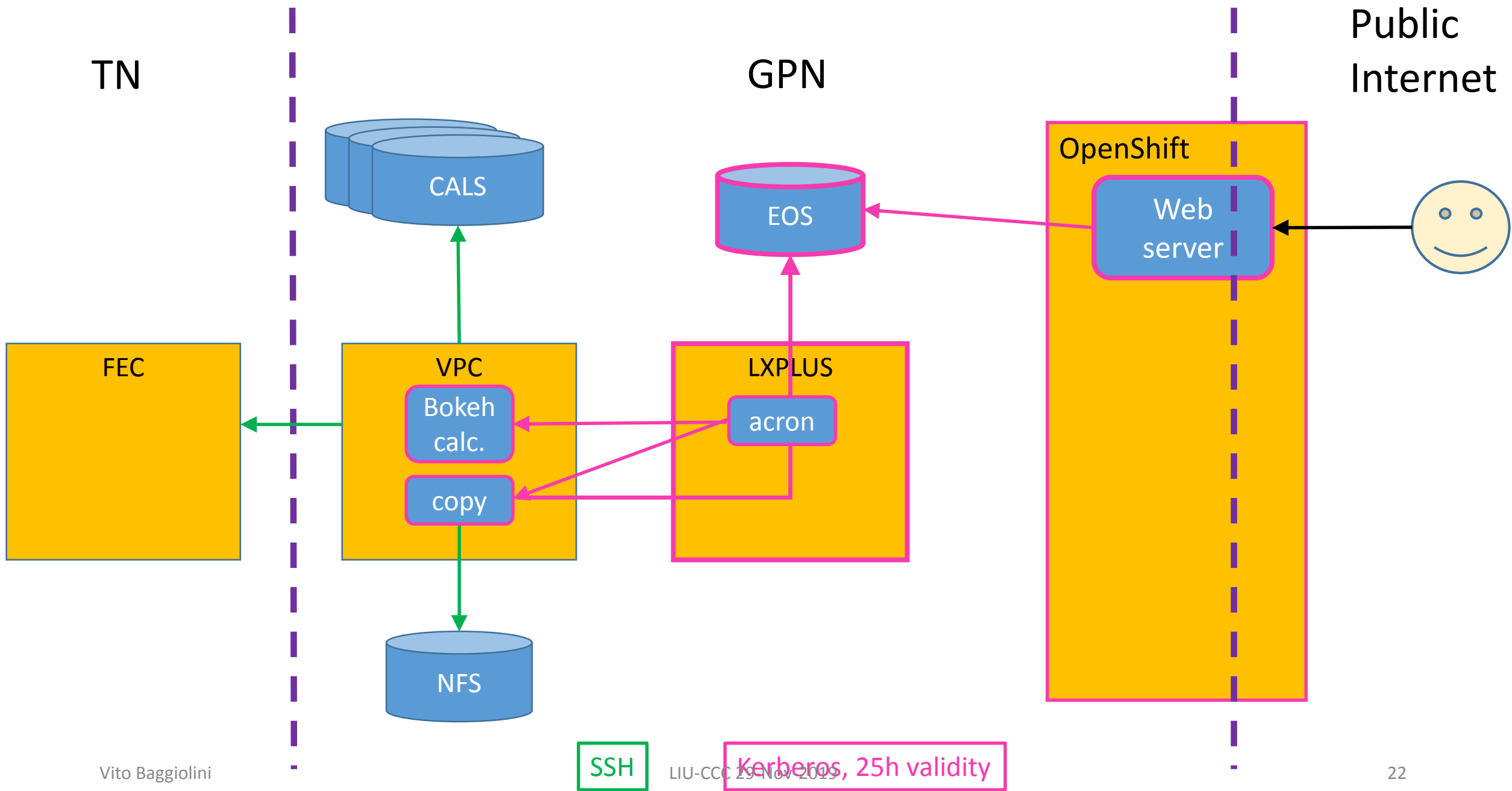


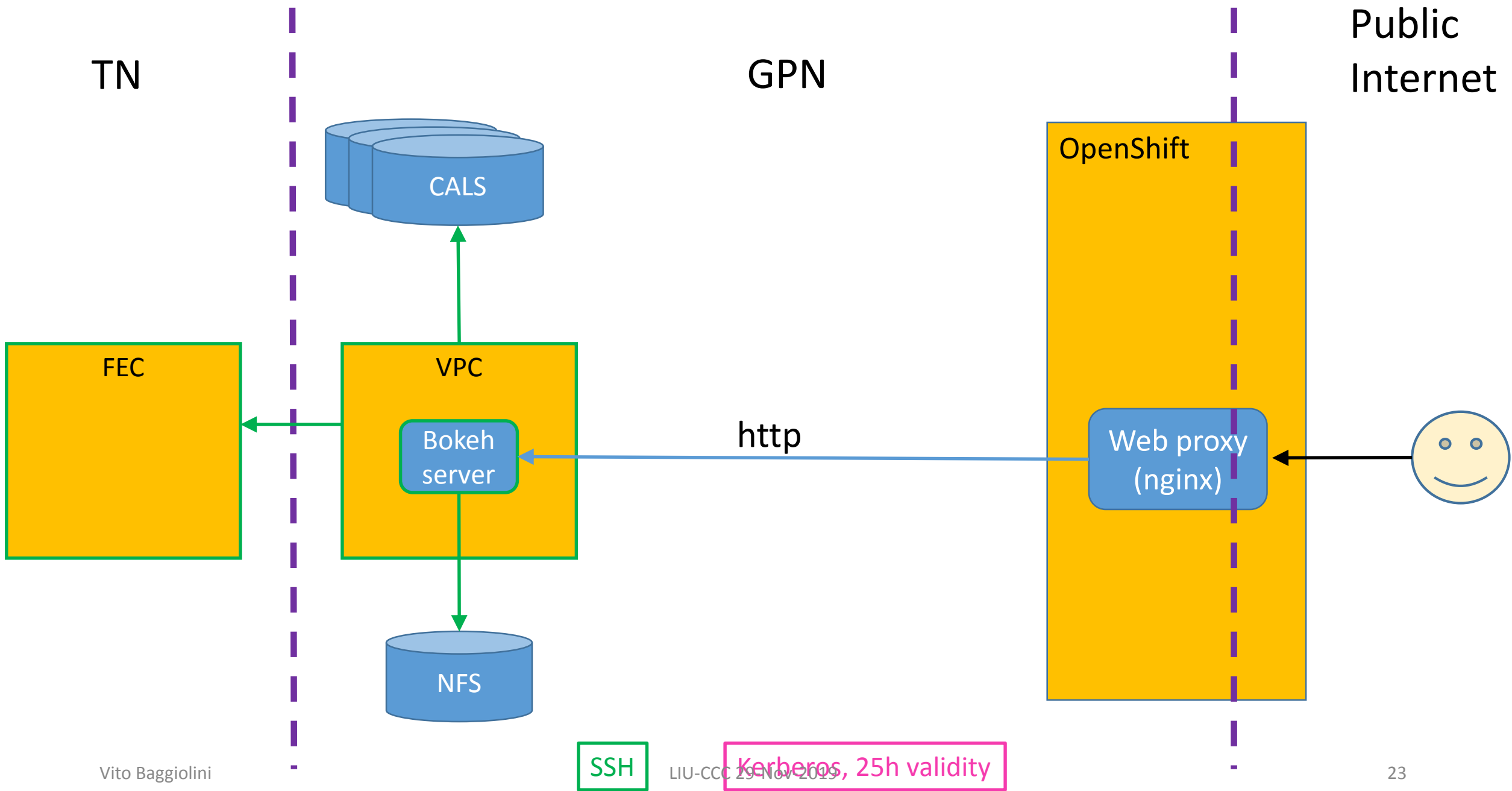
TN

GPN

Public Internet







Input from LIU project

- LIU beams will be commissioned during run 3
 - Goals in terms of intensity and brightness are defined for each year
 - The performance of the injectors will be measured with respect to performance goals
 - Peak performance
 - Reproducibility
- performance needs to be tracked

Verena at
LIU-CCC,
24 Aug 2019

Proposed means for LIU beam performance tracking should also be useable for FT performance tracking.

Currently private web pages per machine.

2 types of tracking required

- **Machine specific data tracking**

- Two aspects:

1. normal equipment data logging
2. Online monitoring of certain parameters and analysis (event based analysis) with GUI in the control room
 - Event based analysis for everybody?

- **Performance tracking per beam type**

- Across complex – online through web
- **Need to track beam through complex → unique SC number and beam ID**

Verena at
LIU-CCC,
24 Aug 2019

Summary, Priorities, Requirements, Deadlines

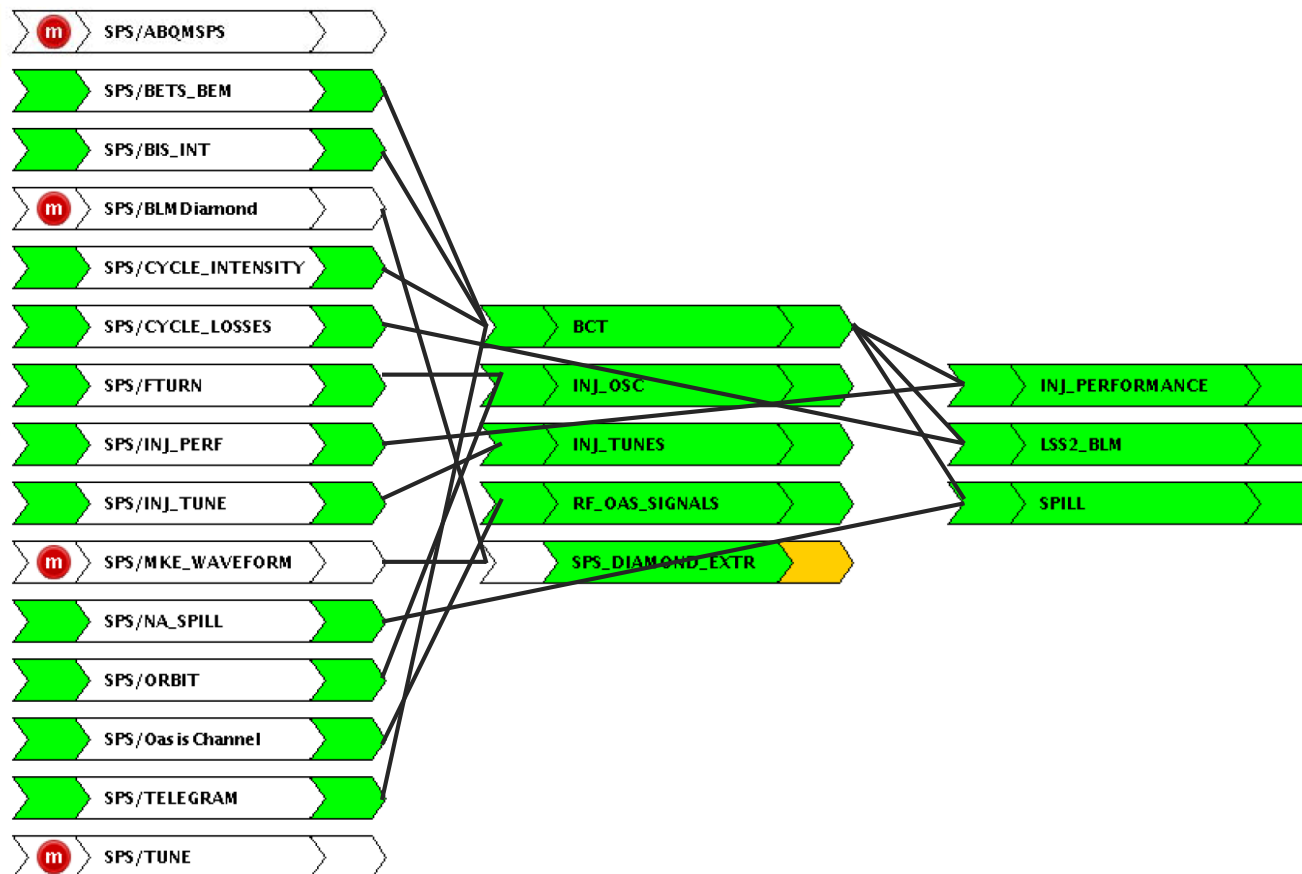
Verena at
LIU-CCC,
24 Aug 2019

- First priority: performance tracking web pages for all beam types
 - Unique identifiers for SC number and beam
 - Background process to retrieve data ready for plotting
 - Plots "prepared" by users, ideally in python
 - Needs to be ready for start-up: mid 2020
- Second priority: event based analysis: cycle-by-cycle
 - Centralized analysis, reuse analysis results as input to other analysis
 - Republish results → show in GUI, use for performance tracking
 - Results need to be ready before end of next cycle: latency requirements to be defined for small machines
 - Store grouped as event for playback
 - Needs to be developed 2021/22 for machines other than SPS

Example: Event Based Analysis SPS → SPSQC

Verena at
LIU-CCC,
24 Aug 2019

- if you want, will organise a demo one of the next meetings



Example: Event Based Analysis SPS → SPSQC

Verena at
LIU-CCC,
24 Aug 2019

SPS Online Quality Check - SPS.USER.LHCION1

06 Nov 2018 17:05:39 SPS - 21 LHCION1 | LHC_ION_12Inj_Q26_20... 02 LHCION1 | LHC_ION_12Inj_Q26_2018... Auto Select LHCION1

LHCION1 | 06.11.2018 17:04:14

User: LHCION1 Super Cycle Number: 6 Machine Mode: CYCLE Particles Type: PB82 Destination: LHC Dynamic Destination: SPS_DUMP Lhc Mode: SPS Mastership Lhc Request: No

Main View | Injection Tunes | LSS2 Losses | Diamond BLM at extraction | Trends

LHCION1 | 06.11.2018 17:04:14

Transmission: 52.96 %
Total Intensity: 6.32E11
Bunch Intensity: 1.34E10
of Bunches: 47 (12x4 bunches, 100ns bunch spacing, 150ns batch spacing)
Filling Schema: 1-13:4,19-31:4,37-49:4,5

Name	Time	Intensity
Injection 9	28800	9.90E10
Injection 10	32400	7.07E10
Injection 11	36000	8.96E10
Injection 12	39600	1.13E11
Start Ramp	40220	7.78E11
Start FlatTop	44480	6.32E11
Dump	45421	6.18E11
Extraction	45425	0.00E00

Intensity vs Time [ms] graph showing a step-like increase in intensity over time, reaching a plateau of approximately 6.32E11 at 44480 ms.

LHCION1 | 06.11.2018 17:04:14

Inj. Phase Error: 5 deg
Ref. Phase Error: -1 deg

Injection Phase | Reference Phase

Voltage [V] vs Time [ms] graph showing two horizontal lines, one yellow and one green, representing different phase errors.

No Data

Effective spill length:
Spill duty factor:
Frequency [Hz] | Amplitude [dB]

BSI | Extracted Intensity | FFT Amplitudes | BSI Raw Data

Intensity vs Time [ms] graph showing a flat line at zero intensity.

LHCION1 | 06.11.2018 17:04:14

Amplitude: 9.630 [mm]

H Pos [mm] vs Time [ms] graph showing a noisy signal fluctuating around zero with an amplitude of 9.630 mm.

Amplitude: 2.465 [mm]

V Pos [mm] vs Time [ms] graph showing a noisy signal fluctuating around zero with an amplitude of 2.465 mm.

Start Monitoring | Stop | Clear

17:05:05 - Warning, alarm on monitor SPS.BLM.21772.TPST.

