Performance Tracking across the Injector Complex

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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

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**

Performance metric per beam type across complex

- LHC beams:
  - Per machine: Transverse and longitudinal emittance
    - Average and bunch-by-bunch spread
  - Per machine: injected intensity, intensity extracted/dumped
    - Total, by bunch, bunch-by-bunch spread, splitting symmetry in PS
  - Total intensity extracted towards LHC beam 1, beam 2 for which fill number

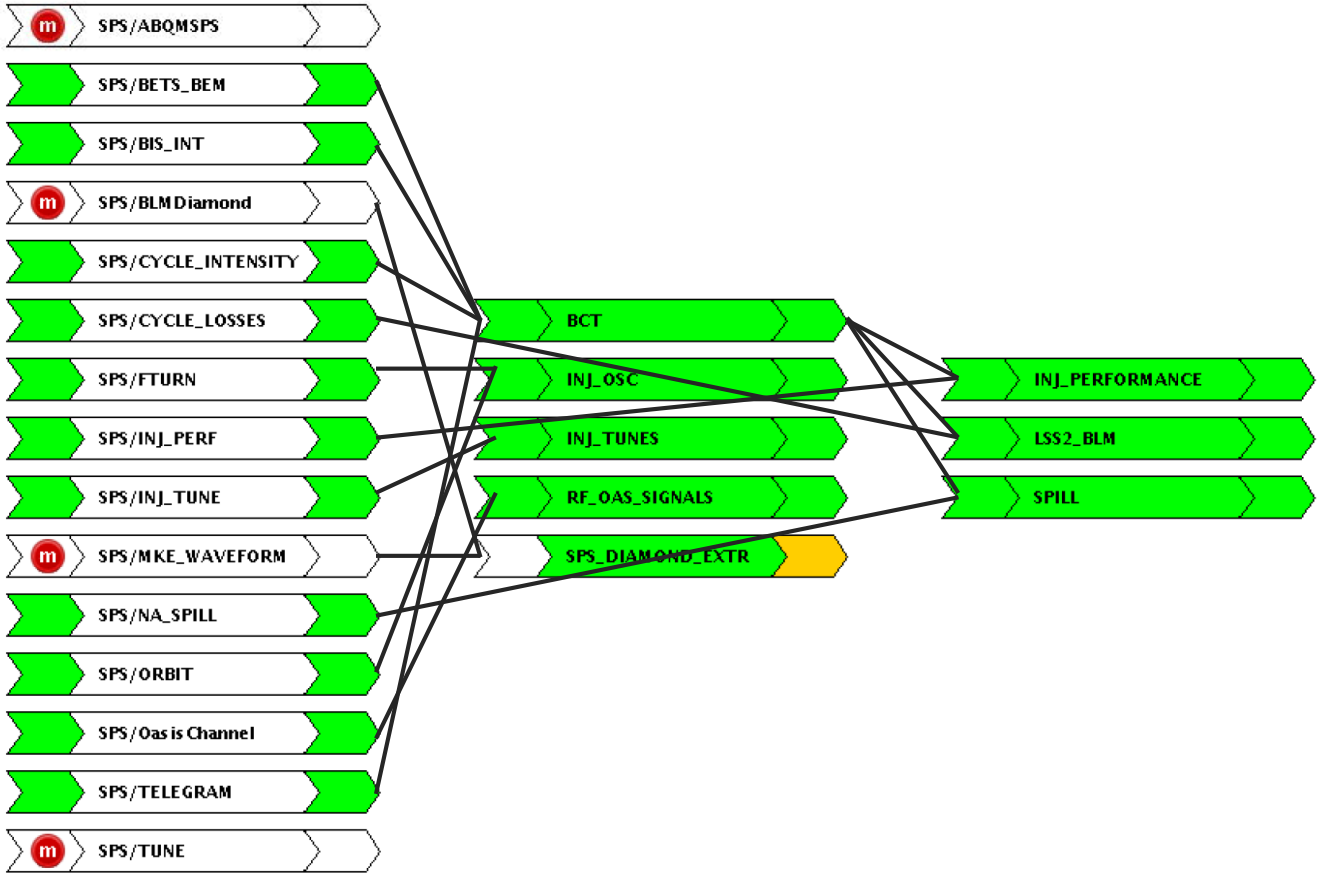
- FT beams:
  - **SPS FT beam**: splitting efficiency (PS), 200 MHz component (PS), emittance island-by-island, SPS transmission, SPS intensity extracted and on targets, losses in LSS2, emittance and intensity (PSB), spill quality SPS, extraction losses (PS)
  - **NTOF**: intensity on target, transmission through PS cycle and until target, integrated intensity per supercycle, position on target, bunch length, evolution of intensity on target versus prediction
  - **AD:** intensity extracted towards AD, bunch length and phase at extraction (PS)
  - **EAST:** spill quality, intensity extracted, losses in extraction region
  - **ISOLDE:** intensity extracted, transmission

Why event based analysis?

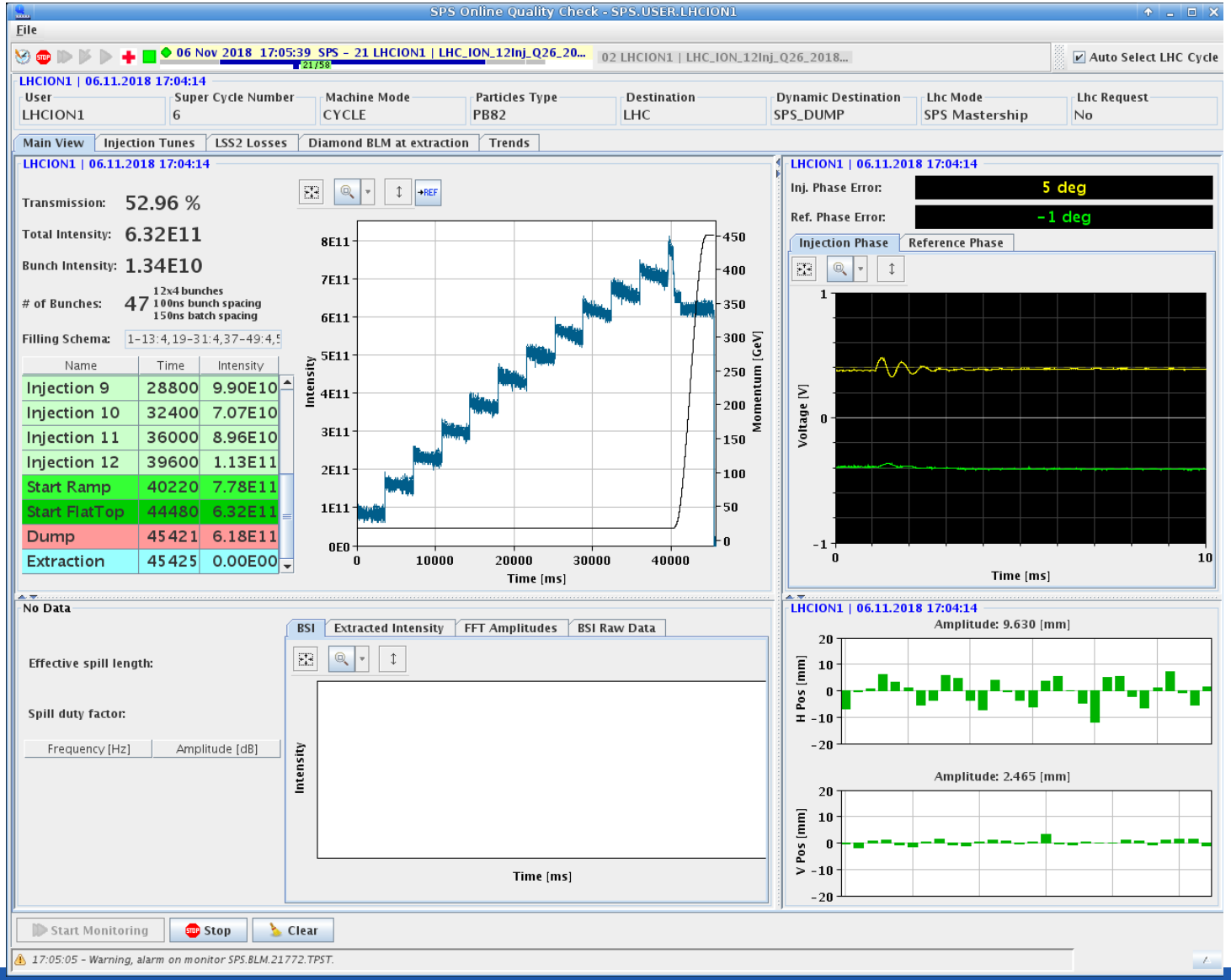
- Event = cycle
- → require practical grouping of data
  - Storage and retrieval
- Most important aspect: **online, interlinked analysis**
  - Centralize and re-use analysis results within online analysis
  - E.g. beam context analysis can be input to other analysis modules
- Events need to have (additional) identifiers: destination, LHC fill number (if destination LHC), SC number, beam ID
  - Needed for performance tracking
  - Destination not always ideal: LHC beams and emittance measurements in PSB
    - To be discussed

Example: Event Based Analysis SPS → SPSQC

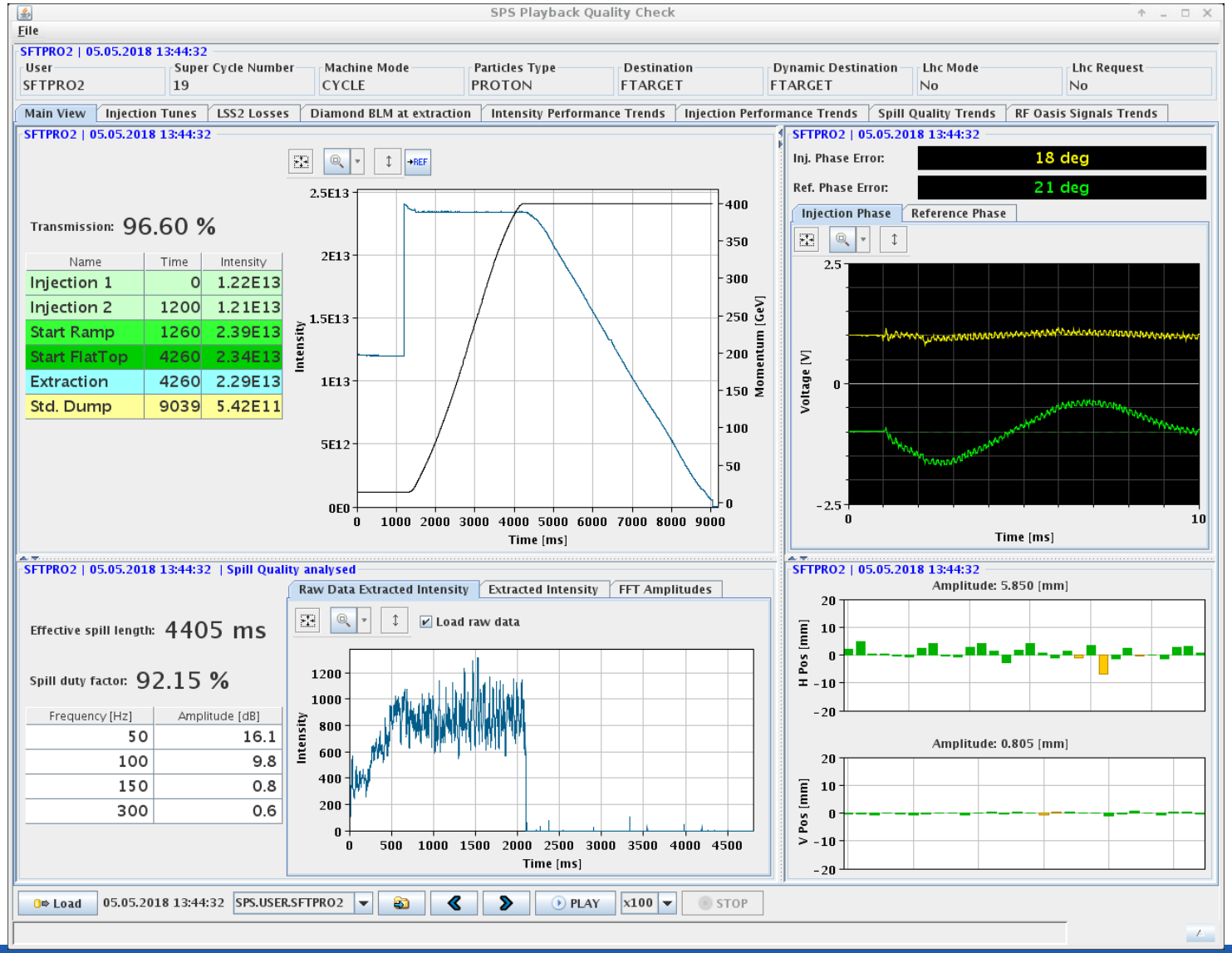
- → if you want, will organise a demo one of the next meetings



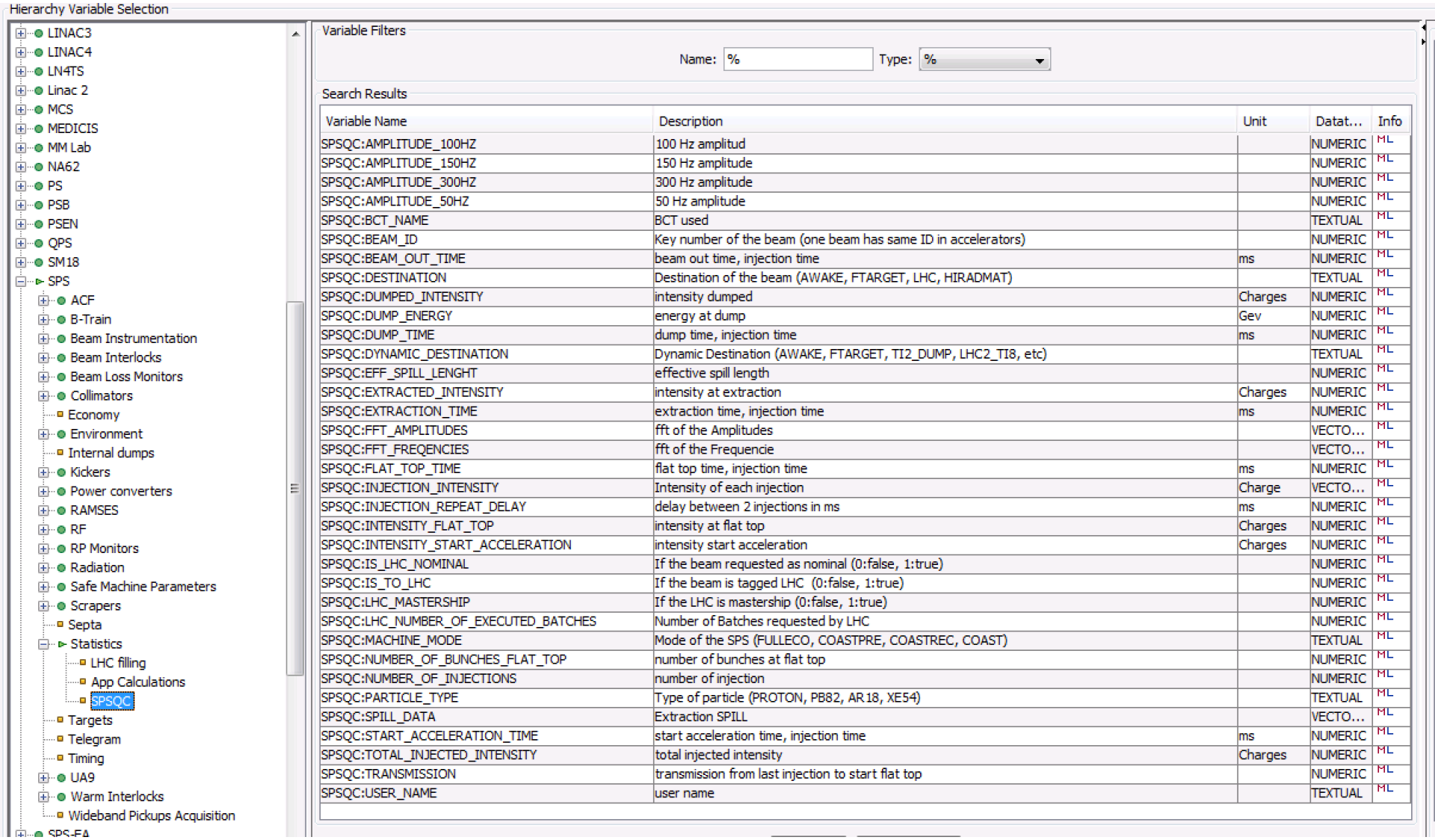
Example: Event Based Analysis SPS → SPSQC



Example: Event Based Analysis SPS → SPSQC



Example: Event Based Analysis SPS → SPSQC



Variable Name	Description	Unit	Datat...	Info
SPSQC:AMPLITUDE_100HZ	100 Hz amplitud		NUMERIC	ML
SPSQC:AMPLITUDE_150HZ	150 Hz amplitude		NUMERIC	ML
SPSQC:AMPLITUDE_300HZ	300 Hz amplitude		NUMERIC	ML
SPSQC:AMPLITUDE_50HZ	50 Hz amplitude		NUMERIC	ML
SPSQC:BCT_NAME	BCT used		TEXTUAL	ML
SPSQC:BEAM_ID	Key number of the beam (one beam has same ID in accelerators)		NUMERIC	ML
SPSQC:BEAM_OUT_TIME	beam out time, injection time	ms	NUMERIC	ML
SPSQC:DESTINATION	Destination of the beam (AWAKE, FTARGET, LHC, HIRADMAT)		TEXTUAL	ML
SPSQC:DUMPED_INTENSITY	intensity dumped	Charges	NUMERIC	ML
SPSQC:DUMP_ENERGY	energy at dump	Gev	NUMERIC	ML
SPSQC:DUMP_TIME	dump time, injection time	ms	NUMERIC	ML
SPSQC:DYNAMIC_DESTINATION	Dynamic Destination (AWAKE, FTARGET, TI2_DUMP, LHC2_TI8, etc)		TEXTUAL	ML
SPSQC:EFF_SPILL_LENGHT	effective spill length		NUMERIC	ML
SPSQC:EXTRACTED_INTENSITY	intensity at extraction	Charges	NUMERIC	ML
SPSQC:EXTRACTION_TIME	extraction time, injection time	ms	NUMERIC	ML
SPSQC:FFT_AMPLITUDES	fft of the Amplitudes		VECTO...	ML
SPSQC:FFT_FREQENCIES	fft of the Frequencie		VECTO...	ML
SPSQC:FLAT_TOP_TIME	flat top time, injection time	ms	NUMERIC	ML
SPSQC:INJECTION_INTENSITY	Intensity of each injection	Charge	VECTO...	ML
SPSQC:INJECTION_REPEAT_DELAY	delay between 2 injections in ms	ms	NUMERIC	ML
SPSQC:INTENSITY_FLAT_TOP	intensity at flat top	Charges	NUMERIC	ML
SPSQC:INTENSITY_START_ACCELERATION	intensity start acceleration	Charges	NUMERIC	ML
SPSQC:IS_LHC_NOMINAL	If the beam requested as nominal (0:false, 1:true)		NUMERIC	ML
SPSQC:IS_TO_LHC	If the beam is tagged LHC (0:false, 1:true)		NUMERIC	ML
SPSQC:LHC_MASTERSHIP	If the LHC is mastership (0:false, 1:true)		NUMERIC	ML
SPSQC:LHC_NUMBER_OF_EXECUTED_BATCHES	Number of Batches requested by LHC		NUMERIC	ML
SPSQC:MACHINE_MODE	Mode of the SPS (FULLECO, COASTPRE, COASTREC, COAST)		TEXTUAL	ML
SPSQC:NUMBER_OF_BUNCHES_FLAT_TOP	number of bunches at flat top		NUMERIC	ML
SPSQC:NUMBER_OF_INJECTIONS	number of injection		NUMERIC	ML
SPSQC:PARTICLE_TYPE	Type of particle (PROTON, PB82, AR18, XE54)		TEXTUAL	ML
SPSQC:SPILL_DATA	Extraction SPILL		VECTO...	ML
SPSQC:START_ACCELERATION_TIME	start acceleration time, injection time	ms	NUMERIC	ML
SPSQC:TOTAL_INJECTED_INTENSITY	total injected intensity	Charges	NUMERIC	ML
SPSQC:TRANSMISSION	transmission from last injection to start flat top		NUMERIC	ML
SPSQC:USER_NAME	user name		TEXTUAL	ML

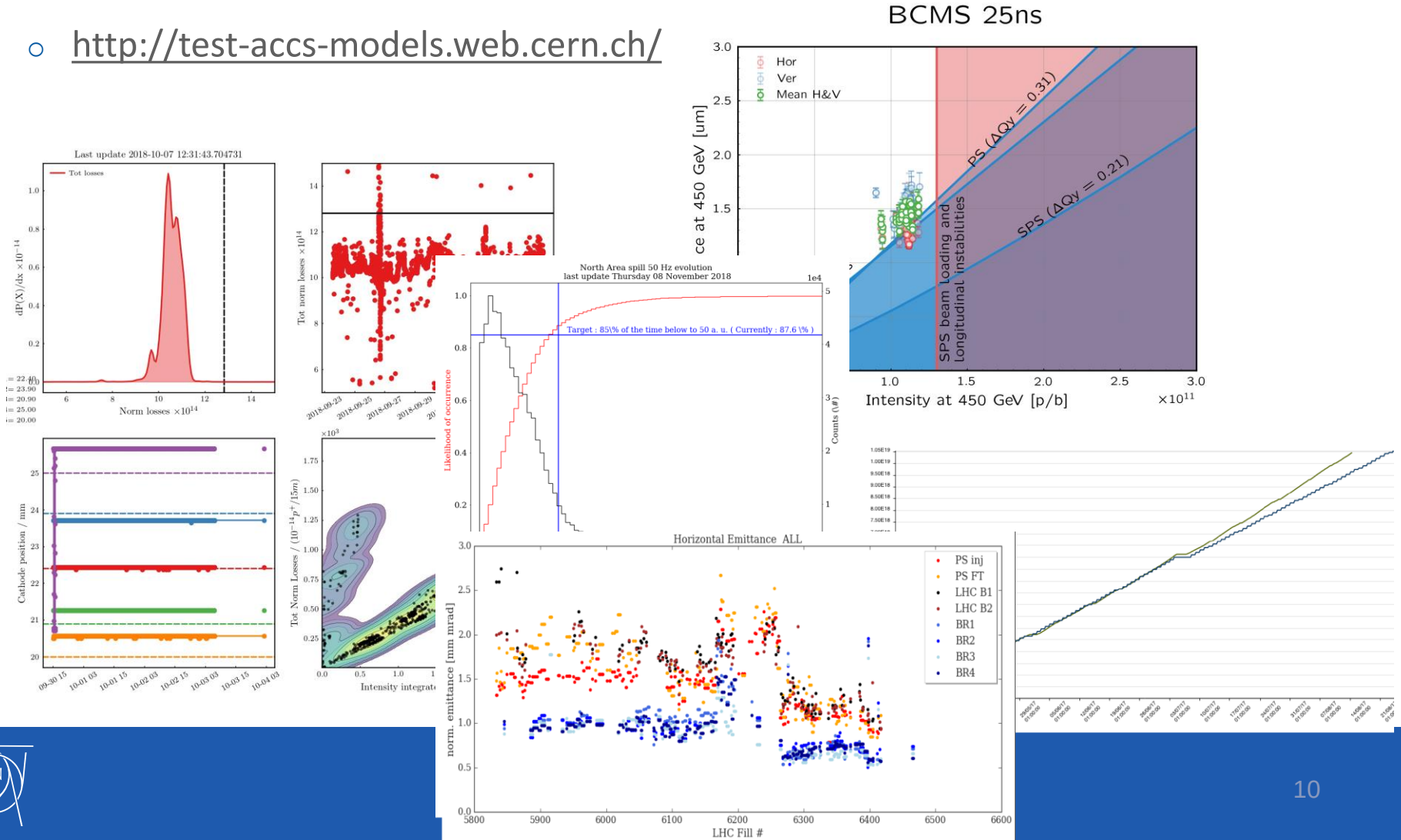
Performance per beam type across complex

- **Needs to be online and web based (also visible from outside)**

- Plots need to be continuously populated – no waiting for data from NXCALS
  - **Background process to fill data in pickles?**
  - Scripts with minor analysis for advanced plotting
  - **Need interactive scientific plotting**
  - Plots to be made by the “experts”. Use BOKEH?
    - https://bokeh.pydata.org/en/latest/

Example – webpages, scientific plotting

- http://test-project-sps-postls2-commissioning.web.cern.ch/test-project-sps-postls2-commissioning/lhc.html
- http://test-accs-models.web.cern.ch/



Ideas on how to track beam data through chain

- Data retrieval API (from probably NXCALS) must be adapted according to identifiers:
  - Identifiers unique combination, get through telegram
  - Need methods like
    - `rangeOfSCnumbersforTimeSpan(timeSpan)`
    - `getBeamIdsforSCnumber(scNumber)`
    - `getTimeSeriesDataForSCnumberAndBeamID(scNumber,beamId,timeSeriesVarialbes)`

Additional requirement for CO

- Another (independent) requirement for application development emerged in discussions:

- Possibility to acquire not only last value from equipment (option 1), but last values for a given time span (option 2) in transparent manner
  - Normal get or subscribe
  - Get with timespan goes to NXCALS without having to change APIs

Summary, Priorities, Requirements, Deadlines

- 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