

PAUL SCHERRER INSTITUT



FUTURE
CIRCULAR
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Swiss Accelerator
Research and
Technology



WIR SCHAFFEN WISSEN – HEUTE FÜR MORGEN

Paolo Craievich (PSI) on behalf of the FCCee Injector collaboration

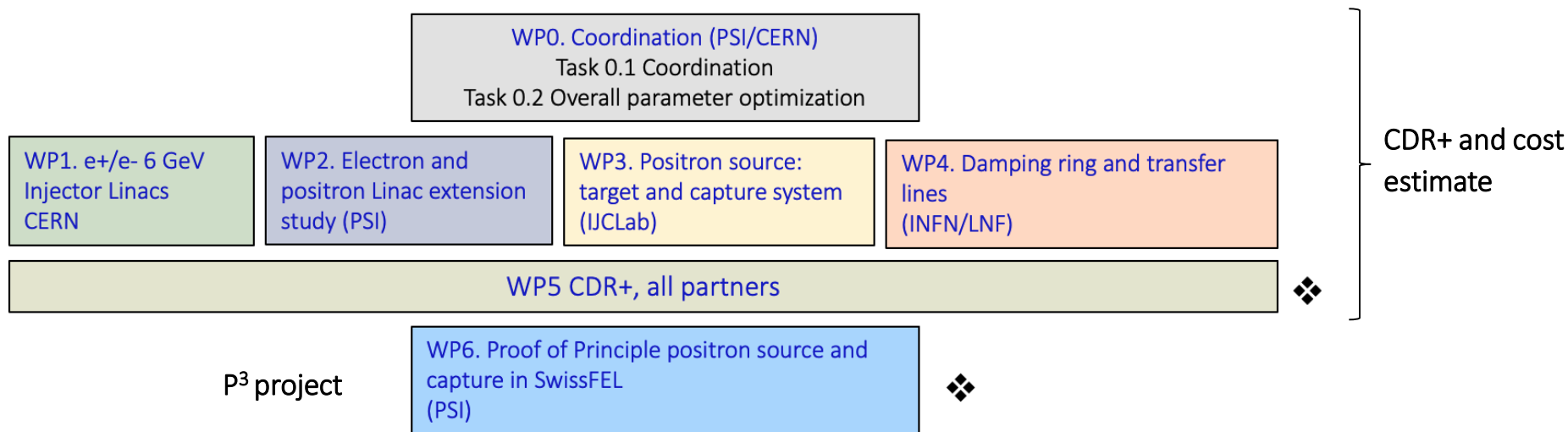
FCC-ee Injector studies

CHART Workshop 2022, PSI, 8 June 2022

- **Organization**
- **Injector parameters and main options**
 - ❖ Filling pattern for the Z-mode
- **Updated Injector Layout**
 - ❖ Electron source
 - ❖ Some general comments
 - ❖ Repetition rate for the common linac
- **PSI Positron Source (P³) project**
 - ❖ Novel components under development
- **Concluding remarks**

Collaboration between PSI and CERN with external partners:

CNRS-IJCLab (Orsay), INFN-LNF (Frascati), SuperKEKB as observer (also interested in the P³ project), INFN-Ferrara – radiation from crystal

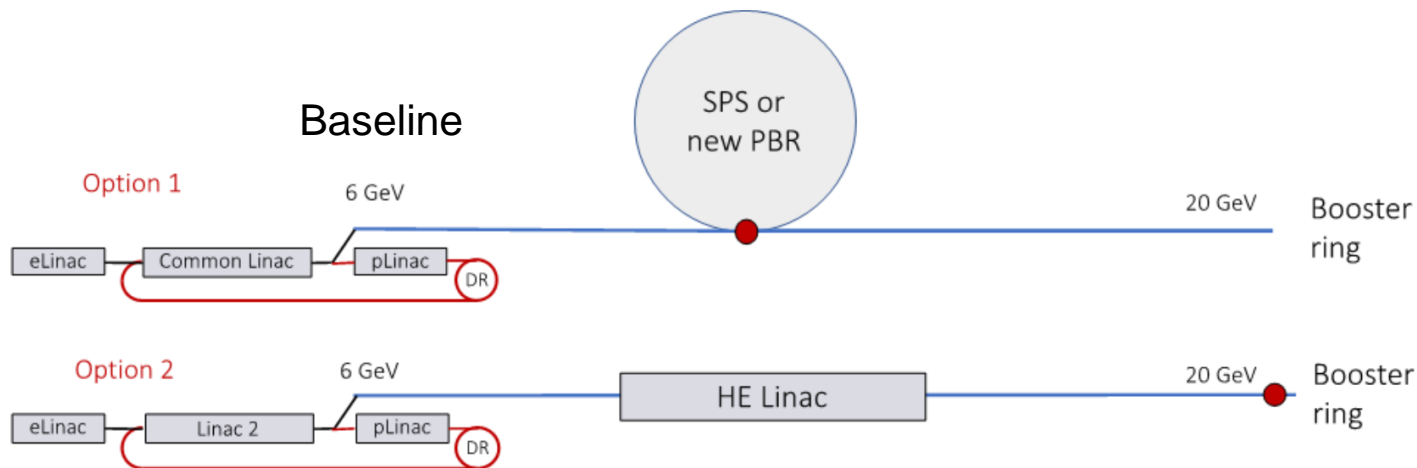


Injector parameters and main options

	Baseline	HE Linac	Unit
Ring for injection	SPS/PBR	BR	
Injection energy	6	20	GeV
Bunch population both species	3.47 (5.55)	3.12 (5.0)	1E10 (nC)
Repetition rate	200	200	Hz
Number of bunches	2	2	
Bunch spacing	17.5-50	17.5-50	ns
Normalized emittance (x, y) (rms)	50, 50	50, 50	mm.mrad
Bunch length (rms)	~1	~1	mm
Energy spread (rms)	<0.1	<0.1	%

Other important requests:

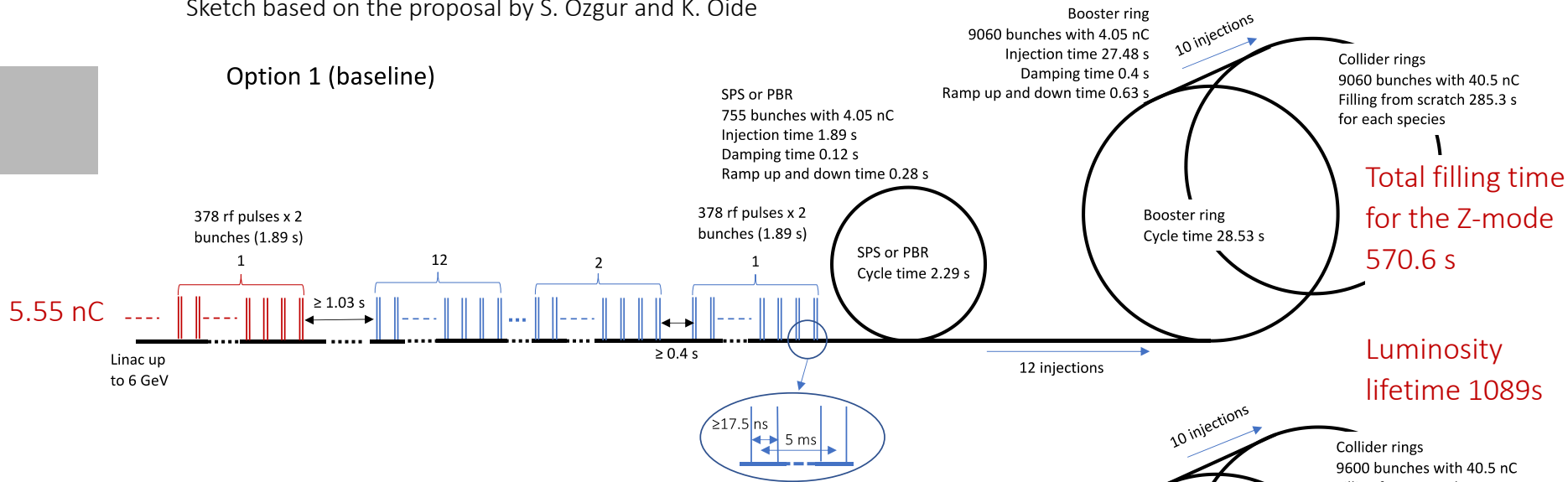
- The bunch by bunch intensity will **randomly vary 0 to 100%**, depending on the intensity balance between the collider rings
- **Bunch-by-bunch injection intensity fluctuation: 3%.**



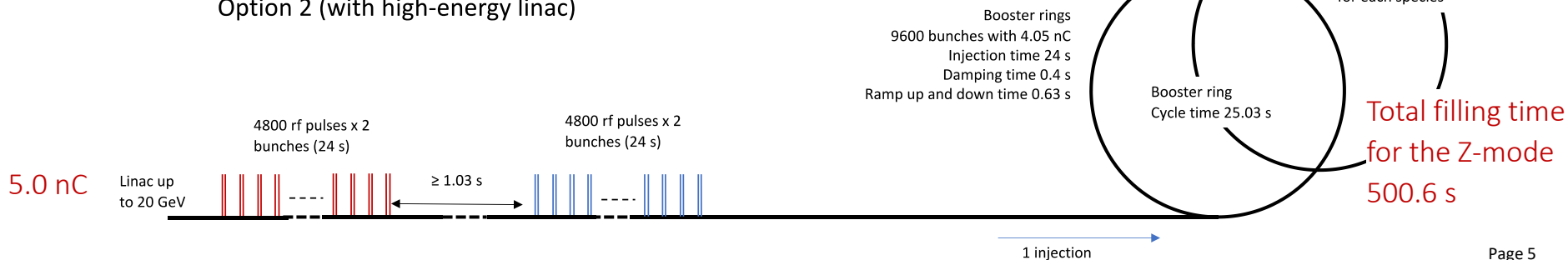
Filling pattern for the Z-mode

Sketch based on the proposal by S. Ozgur and K. Oide

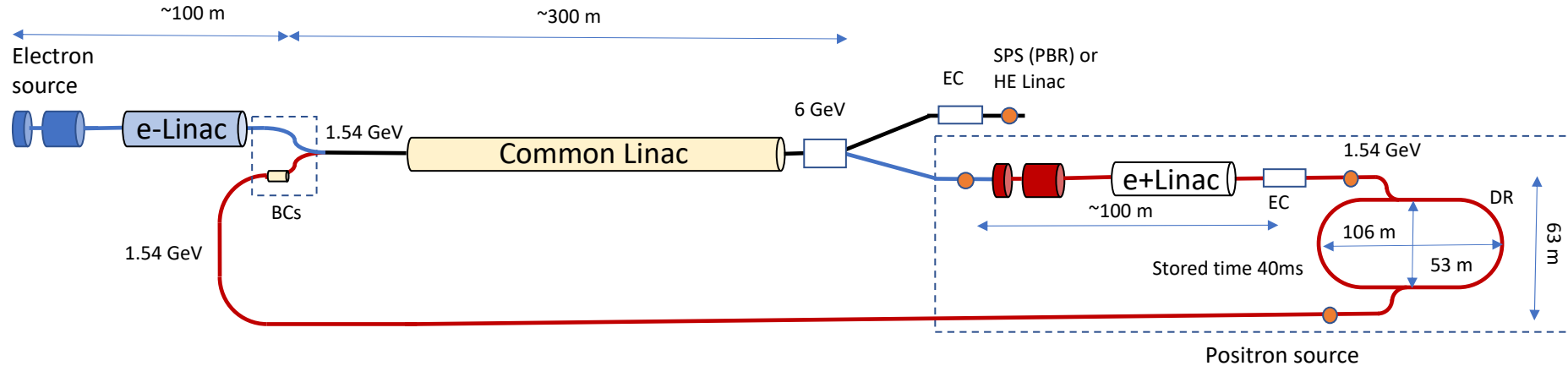
Option 1 (baseline)



Option 2 (with high-energy linac)



Injector Layout (...updated)



— Injector is splitted in WPs:

- **WP1:** Electron source, e-Linac, e+Linac, HE linac
- **WP3:** Positron generation and capture
- **WP4:** DR and transfer lines (return line and, positron bunch compression, p+linac to DR line)

— Linac efficiencies optimized: electron/positron beam with same energy, main and drive beam with same final energy

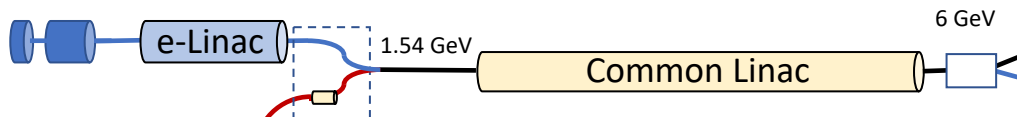
Some general comments

More details in the Scientific Report 2021: <https://chart.ch/reports/>

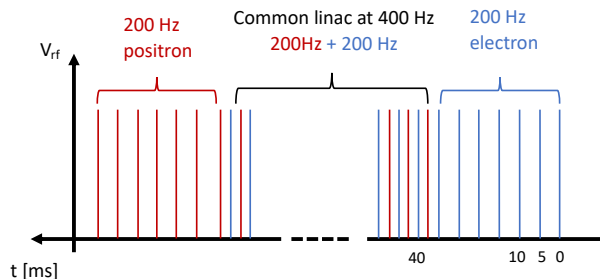
- **Still two options:** SPS or High-energy Linac to rump up the beam energy to 20 GeV
- **2-bunches at 200 Hz, time separation few tens of ns (minimum 17.5 ns),** can fullfill the specification for the collider rings
- **e+linac:** rf design well advanced, beam dynamics on-going, 2 GHz, 200 Hz
- **Positron source:** yield very promising but a more accurate investigation of the DR acceptance is on-going. **Two options still open for the AMD:** HTS solenoid or Flux concentrator
- **Target:** Engineering, intergration and radiation losses on-going for the SC/AMD based on HTS tape. We fixed the aperture for the SC/AMD.
- **Acceptance DR to be reviewed and energy compression before DR to be investigarted**
- **The concepts for the DR and the return transfer line are well established, to be decided the RF systems**

Repetition Rate for the Common Linac

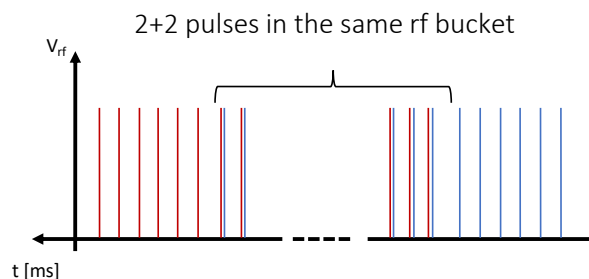
Electron
source



Common linac: repetition rate 1



Common linac: repetition rate 2



- Common linac at 200 Hz (electrons) + 200 Hz (positrons) when positrons are generated
- DR has to provide a delay of 2.5 ms to allocate the positron bunches on the on the right rf bucket
- Specifications are fulfilled for the electron bunch (beam dynamics for the e-linac and common linac well advanced), frequency 2.8 GHz, repetition rate 200 Hz+200 Hz (klystron at 400 Hz from CETD could be feasible), optimization of the RF structures on-going

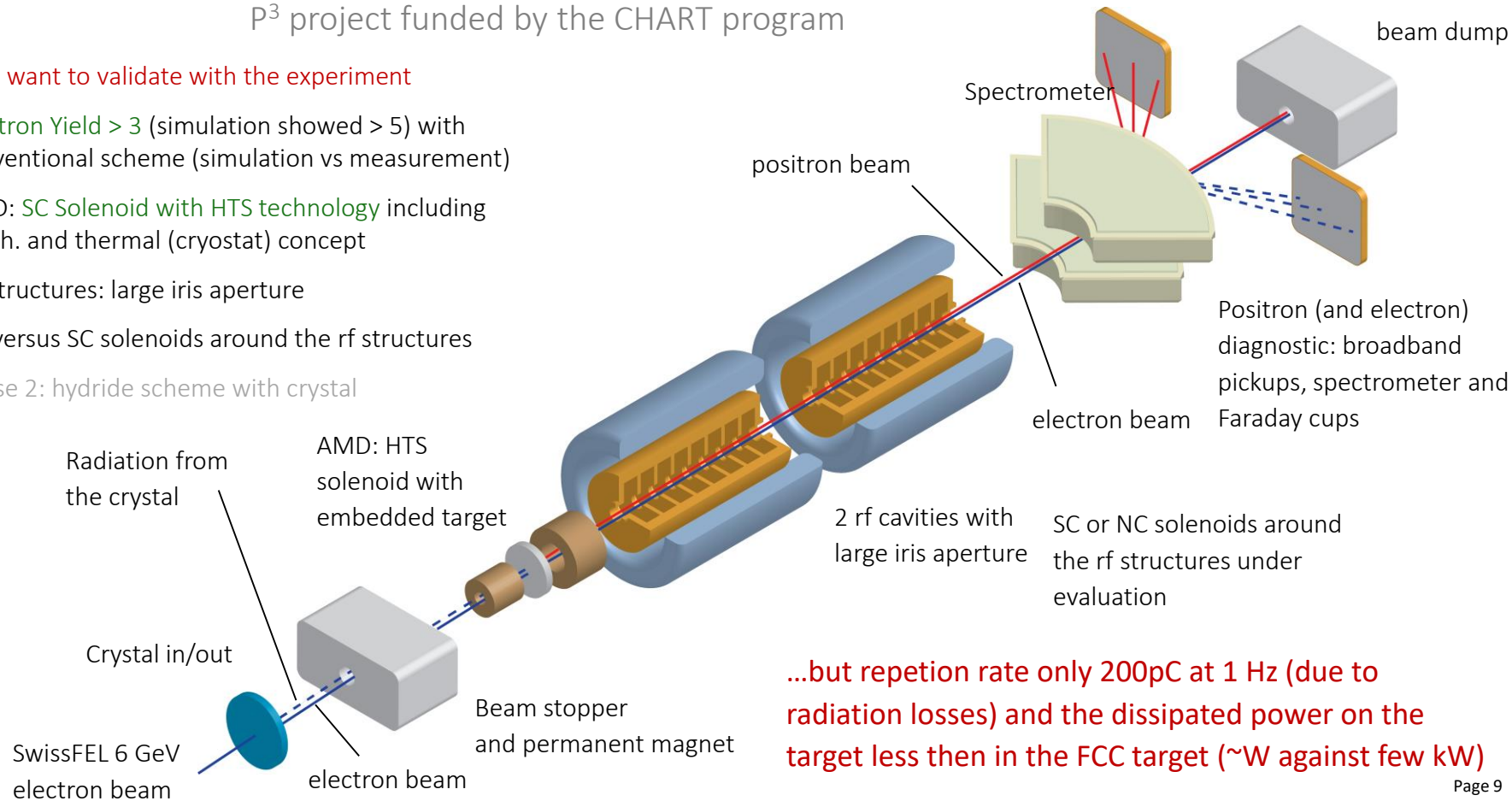
PSI Positron Source Experiment at PSI

P³ project funded by the CHART program

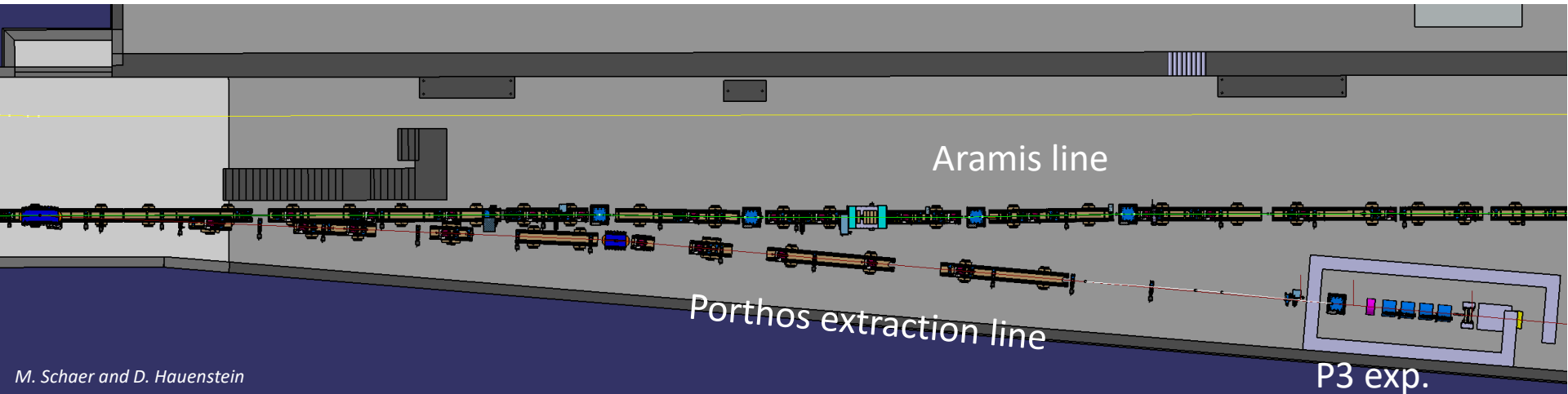
beam dump

What we want to validate with the experiment

- ✓ **Positron Yield** > 3 (simulation showed > 5) with conventional scheme (simulation vs measurement)
- ✓ **AMD: SC Solenoid with HTS technology** including mech. and thermal (cryostat) concept
- ✓ RF structures: large iris aperture
- ✓ NC versus SC solenoids around the rf structures
- ✓ Phase 2: hydride scheme with crystal



...but repetition rate only 200pC at 1 Hz (due to radiation losses) and the dissipated power on the target less than in the FCC target (~W against few kW)

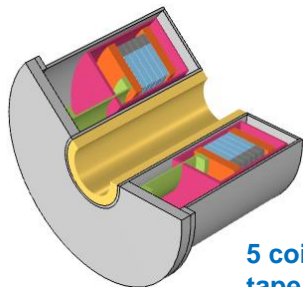


- **P³ experiment** will be installed in the extraction line for Porthos (third SwissFEL BL)
- **3D layout design well advanced**, magnets and power supplies already ordered
- **Installation plan** based on scheduled shutdowns: 3/year
- **Additional work**: a modification of the existing Aramis line is necessary to install the new extraction line
- **Radiation losses** under estimation to evaluate the additional shielding/bunker
- **HV klystron modulator and 50-m long waveguide still an open point**

Novel components under development at PSI

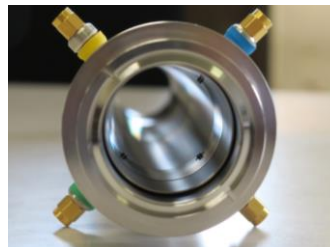


HTS solenoid integrated in the cryostat (M. Duda et al.)
Peak magnetic field: 12 T

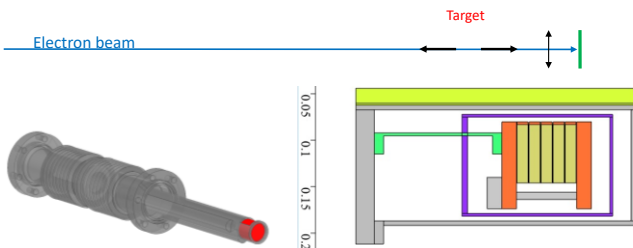
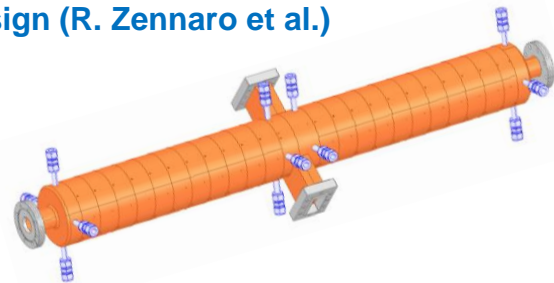


5 coils ReBCO
tape

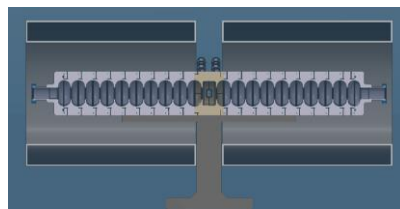
2x SW π -mode cavity (18 MV/m @ 15 MW for $\beta=2$)
Advanced RF and mechanical design (R. Zennaro et al.)



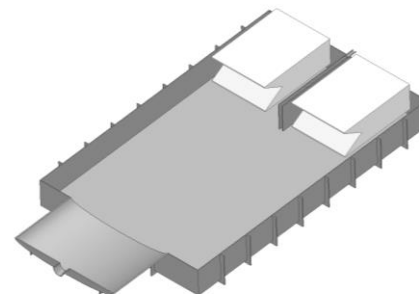
Development of broadband
pickup (summer student
project)



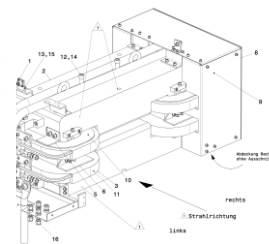
Movable Target Insertion Device



SC solenoids (NbTi)
NC (~ 0.4 T) vs. SC (1 – 1.5 T)



Special Faraday cup and spectrometer



- **FCC week:** Injector session with 10 talks: <https://indico.cern.ch/event/1064327/>
- **(Pre-)Injector study:**
 - ❖ Studies are well advanced on all parts of the injector
 - ❖ **General consideration:** As deliverable for CHART we have to provide a cost estimate for the injector. After the design phase we have to start with a cost model for the different part of the injector.
 - ❖ Next deadline: **mid study costing exercise in Summer 2023** with external reviewer
- **P³ project**
 - ❖ Concept and design phase well advanced, engineering and procurement ongoing
 - But engineering and installation at PSI are **strongly influenced** by other two major ongoing project (SLS2 and IMPACT)
 - ❖ **Budget and schedule need a review**
 - ❖ **Actual schedule:** First experiment at beginning 2025

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