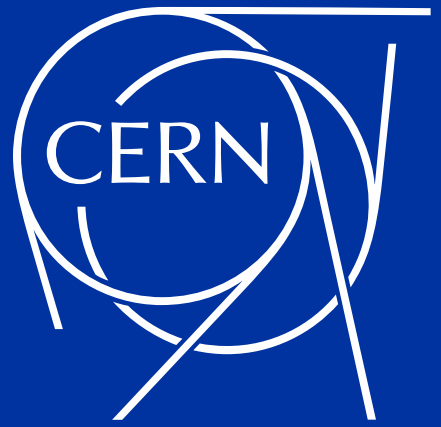


STI: Group overview for FCC-ee

S. Gilardoni, A. Lechner, A. Perillo Marcone, F. Cerutti, S. Rothe, E. Granados, M.Calviani – SY/STI

SY-FCC workshop – 4 Oct. 2024

Group structure and FCC

*sector-wise responsibilities

SY-STI (Sources, Targets and Interactions Group) as of 01.09.2024

SY
Accelerator Systems

SY-STI Group Leader:
GILARDONI Simone
Deputy Group Leader:
CALVIANI Marco

Group Assistant:
MARTAKIS Sylvia

BMI Section Beam Machine Interactions	LP Section Lasers & Photocathodes	RBS Section Radioactive Beam Sources	TCD Section Targets, Collimators & Dumps
CERUTTI Francesco	**GILARDONI Simone** *Ad Interim*	**VOLLAIRE Joachim**	**CALVIANI Marco**
- Acc. system definition - Beam loss management - Beam-matter interaction simulations* - Radiation levels* - MDI - Beam related background - R2E studies (MCWG) and coord.* - Monte-Carlo devel specifically for accelerator* - Shielding system defintion* - Crystals*	- Electron photoinjector - Photocathode devel&production* - Responsible for CTF and AWAKE photoinjector - Laser-based systems for particle production and interactions	- Irradiation station (ISIS)	- Particle sources (eg. e+)* - Target complexes (eg. BDF)* - BIDS-based system lifecycle* - BDIS full life-cycle* - Irradiation station (NEAR) - Material science - R2M*(when existing as ATS service)

3 WPs proposals consistent with group mandate

- **Beam-Machine Interaction, Radiation and Shielding (BMIRS)**
- **Beam Intercepting Devices (BIDS)**
- **Lepton production (electron for photoinjector and positrons) (LEPP)**

- **Hp: reporting to ATDC but should define also a second level management or technical coordination between the pillars to refer to?**

System definition under WP BIDS

- **Systems full lifecycle, from conceptual design of the system to dismantling and waste packaging of the assets**
  - Nothing new wrt to current systems
  - This does not include the system functional specifications that should be provided by other WPs
    e.g. level of protection of injection/extraction devices, collimation efficiency/optics in T-line and rings, impedance budget constraints, etc... and done together with other WPs (à la WP14 of HL-LHC but with separated system construction)
  - Should provide input for each of these systems at each stage of the project

System definition	Equivalent in LHC
Collimators in HEB and Collider (including synchr.)	Systems in IP3 and IP7
Injection protection elements HEB and Collider	TDIS
Extraction protection elements HEB and Collider	TCDQ/TCDS
Beam dumps pre-inject., HEB and Collider	TDE
T-line collimators	TCDIL
Masks (including IR masks and synch. radiation)	Masks
Beams stoppers	Beams stoppers
Beamstrahlung dumps	N/A

Proposal for WP BIDs definition (to be finalised)

- Development of the various beam intercepting devices within the context of the entire FCC-ee machine
- Support the redaction of the systems functional specifications
- In charge of the definition of the prototyping activities required to lead to a successful design
- Coordinate with the various services and teams to include the entire lifecycle of the components
- …

Proposal for WP BMIRS definition

- Develop common strategy for assessing and mitigating energy deposition and radiation effects
- Steers design of rad. shielding, in part. for synchrotron radiation. Follows up tech. design, construction and installation of shield.
- Quantifies the rad. levels in the tunnels to establishes radiation level specs for infrastructure and machine equipment
- Provides guidance for the integration of radiation-sensitive equipment underground
- Responsible for particle-matter interaction studies for the design of the experimental insertions
- With the MDI WG, quantifies the radiation environment in the detector and interaction region and beam-induced background
- In charge of particle-matter interaction studies for the design of FCC-ee accelerator systems
- Responsible for shower simulation studies related to machine protection
- Responsible for identifying optics, layout and hardware requirements related to beam-induced energy dep. and rad. damage

Proposal for WP LEPP definition

- Integration of laser beamline in the complex (particle production and interaction)
- R&D for laser systems for photoinjector and photocathodes
- Polarised sources
- Reliability studies for polarimeter

Activity definition and system ownership	Equivalent elsewhere
Positron source (including crystals)	AD/n_TOF targets
Photoinjector electron source	AWAKE/CTF
Lasers and beamline for polarimeters	Gamma Factory/CTF developments

Workforce

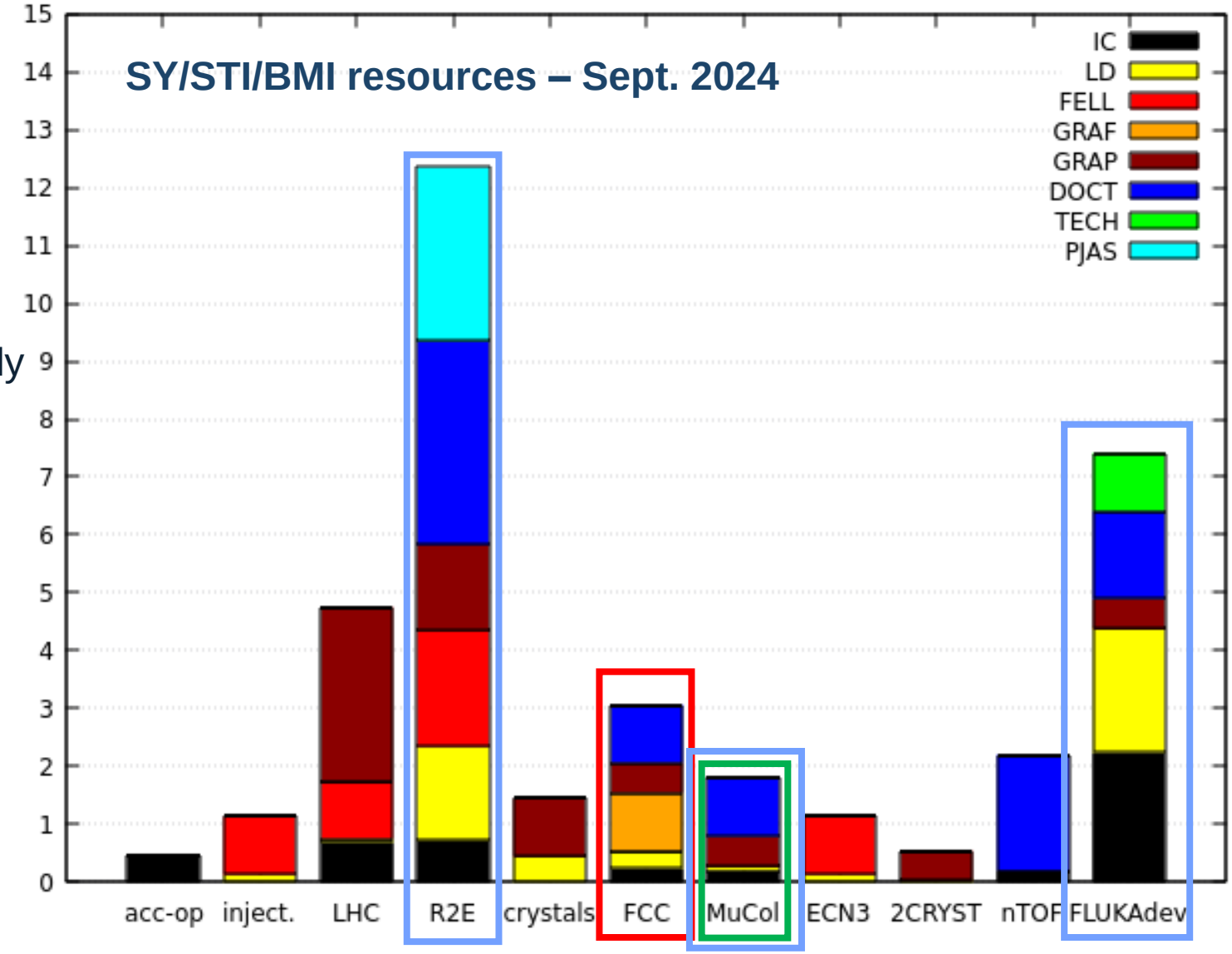
Workforce for WP on Beam-Machine interactions

Direct contribution

Indirect contribution from other activities

Reduced after moved to FCC

- Not included new staff for 2025 working mainly on radiation levels and system definitions.
- FCC will have more staff than LHC operation but still not sufficient to cover all requests.
- **Supervision capacity currently saturated, will improve a bit with newcomer.**

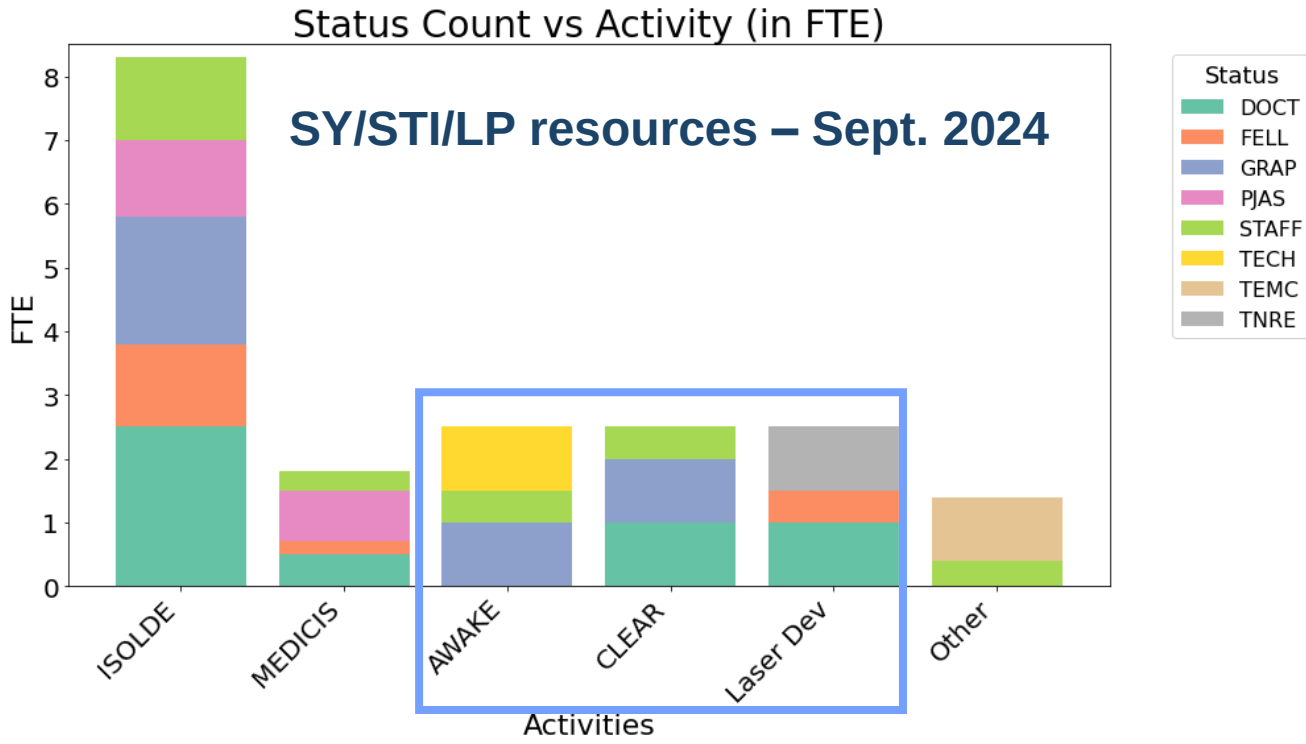


Worksforce for WP on particle production/photoinjector

Direct contribution

Indirect contribution from other activities

Reduced after moved to FCC



- **With current resources and activities not possible to have FCC dedicated workforce.**
  - **Recent approval of AWAKE2c and CLEAR OP**
  - CLEAR, MEDICIS, ISOLDE offline operating during LS3

- **New request in preparation for next MTP.**
  Only 4 staffs in the team → **Supervision capacity currently saturated.**

- For positron sources, support from other two WPs for simulations (part. prod. and e+ source) and construction

- Important to define collaboration and its evolution with PSI for electron and positron sources and test facility

Worksforce for WP on BIDS

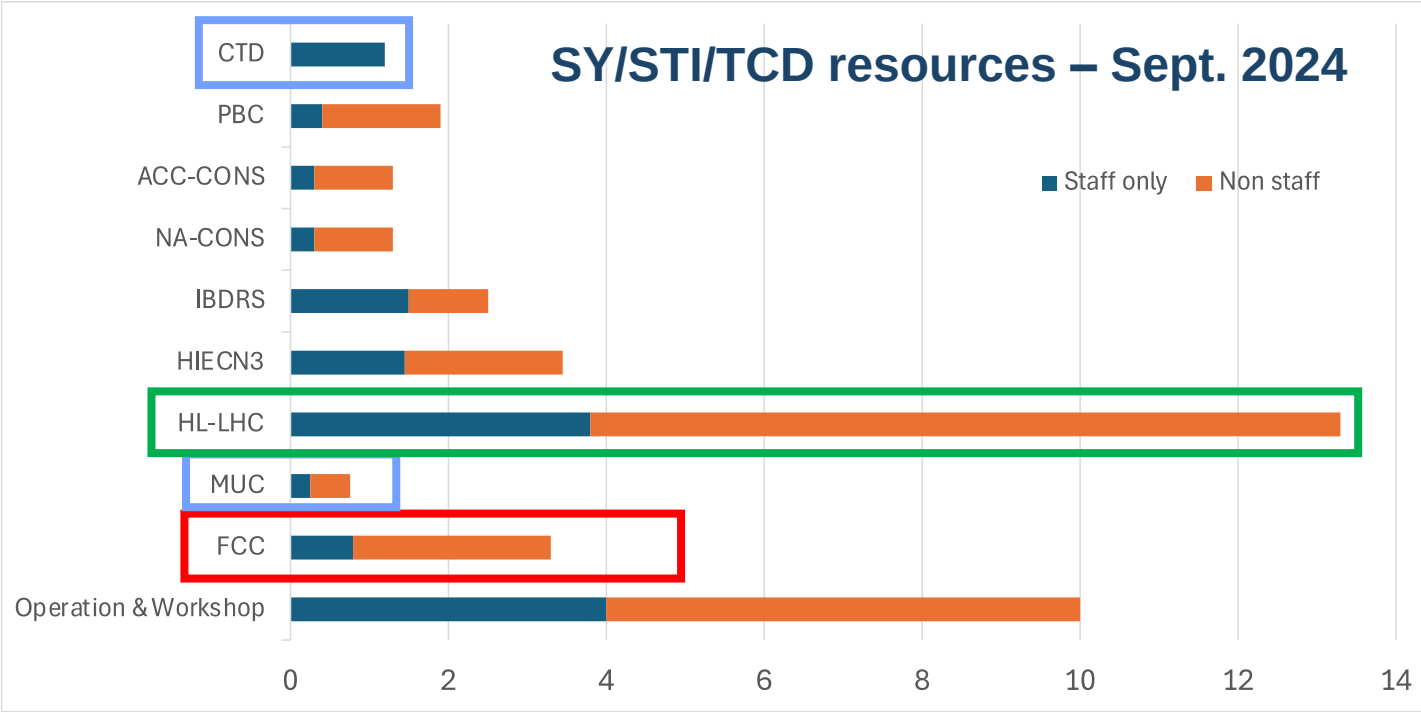
Direct contribution

Indirect contribution from other activities

Reduced after moved to FCC

- Not included new staff for FCC will have more staff than LHC operation but still not sufficient to cover all requests.

- **Supervision capacity currently saturated, will improve a bit with newcomer, but not suficiently until 2030.**



- **NB: all WPs possible increase of workworce impacted by the LS3 delay and change in scope of some PJ. HL-LHC resources committed until end of commissioning.**
- **NB: all WPs GRADs resources linked to BC/approval process/availability of resources uncertain.**

Missing resources now

- **Current resources adequate for (very) minimalistic studies as planned**
  - Already migrated resources from operation to FCC studies
  - Delay and extension of LS3 plus change in scope in some projects implies difficulties in moving existing resources to FCC
  - Will need to find a way to include prototyping activities as essential for the works
- **No resources for pre-injector beyond proof-of-principle of e+ source**
  - Need to follow-up activities from PSI (disregarding future responsibility of pre-injector)
  - Recent approval of AWAKE 2C and CLEAR 5-years extension implies no resources available for pre-injector and polarimeter (laser) pre-designs for 2027.
  - Need clarification on Linac BIDs (20 GeV dumps studies (maybe R&D required)? Collimators?)
- **Resources for HEB never defined**

Group contributions

- Coordination of FCCee radiation and shielding WG
- Contributing to FCCee MACHINE PROTECTION TASK FORCE
- Contributing to P3 efforts
- Coordination of CERN/ENEA collaboration on liquid Pb technologies
- (new) coordination of application of e- linac for potential neutron production and BS photons for various science applications

Technical challenges

- **Tunnel rediation levels**
  - Local shielding highly integrated with vacuum and magnet system for synchrotron radiation
  - System design, costs optimisation and engineering studies are highly non trivial
  - **Requires also dedicated computing infrastructure for simulations (currently funded by HL-LHC and partially by SY)**
- **Identify cost-effective solution for technologically simple assets (but with complex integration)**
  - Distributed shielding have large capital costs because of large quantities, iterative optimisation is essential
- **Beam intercepting device development in a regime with limited experience**
  - Lepton collider → building-up know how in a new energy/power density regime → See Superkekb experience
  - High photon fluences → 0.5 MW beamstrahlung
    - Prototpying of system at CERN with flowing liquid Pb essential to convince of the technical solution
  - **Early R&D and tests with beam when possible is key**
  - **Active collaboration with worldwide expert**
- **Reliability laser systems and control for particle production and interaction**
- **Production of photocathodes for polarised e- sources if baseline changes**

From conceptual design to production

Study and R&D phase is key for some of the systems:

- Can profit from existing infrastructure for systems testing
- Can profit from collaborator infrastructure, experience and expertise (PSI, KEK, etc…)
- **Needs early investment for some of proof-of-principle testing**

Industrialization of some systems can be pretty under control:

- A lot of experience from different (HL)-LHC production
- Some concerns on perennity of of some industrial partners
- Some small produciton could be in-house

Necessary to define in-kinds pretty early and plan ”B”:

- Experience with recent in-kind from Russia for HL-LHC should not be forgotten
- Early definition of roles, responsibilities and ownership and timelines required
- Future system owner should be involved from the very beginning in the optimisation, design and lifecycle assessment

Collaboration and experience from other labs

- **PSI**
  - Development of photoinjector and positron sources
  - Test stand at PSI

- **KEK – Superkekb**
  - Experience from design and operation (BIDS, beam loss management, IR desing)
  - Need defined framework for personnel exchange.
  - Polarimeter

- **ENEA**
  - Development of beamstr. liquid-lead beam dumps

- **EIC**
  - Common development for collimation systems, beam loss managament, beam-machine simulation
  - Interest in polarized lepton source developments

- **INFN**
  - MDI

- **IJCLAB – Orsay**
  - Photoinjector

- **Daresbury lab**
  - Photocathode production

Concerns

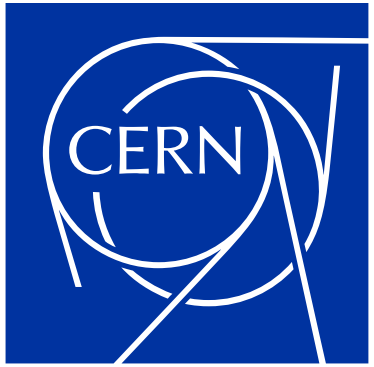
- **Pre-injector, Booster and different transfer lines definition less advanced than collider**
  - Difficult to have system description for 2025. Not clear what is needed.
  - In general, BIDS inventory based on current experience, based only of functions.
  - In view of 2027, should define precisely what systems are needed

- **Impact of R2M closure to be assessed**
  - We see already consequences on HL-LHC

Critical dependencies for pre-TDR phase

Certain input is needed well before the pre-TDR deadline (end of 2026?) → need time to adapt the conceptual and technical design of STI systems/devices

- **Optics, beam parameters and machine layout (→ Accelerator Design WG)**
  - Reference baseline for beam parameters for pre-injector
  - Need reference optics, parameters and layout since certain design choices critically depend on these (cannot adapt to frequent/short-notice changes)
- **Beam loss scenarios (→ FCC-ee Machine Protection Task Force, Acc Design WG)**
  - Need to converge on the design scenarios for collimators, protection absorbers, etc. (
- **Photon production in MDI region (→MDI Working Group)**
  - Need to converge on the design specifications for the photon dumps in the IRs (all photon sources, Beamstrahlung power with separated beams, etc.)



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