CREMLIN PLUS
Connecting Russian and European Measures for Large-scale Research Infrastructures

WP5: Joint technology development around SCT and future lepton colliders

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2nd part of presentation: plan, achievements, challenges

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

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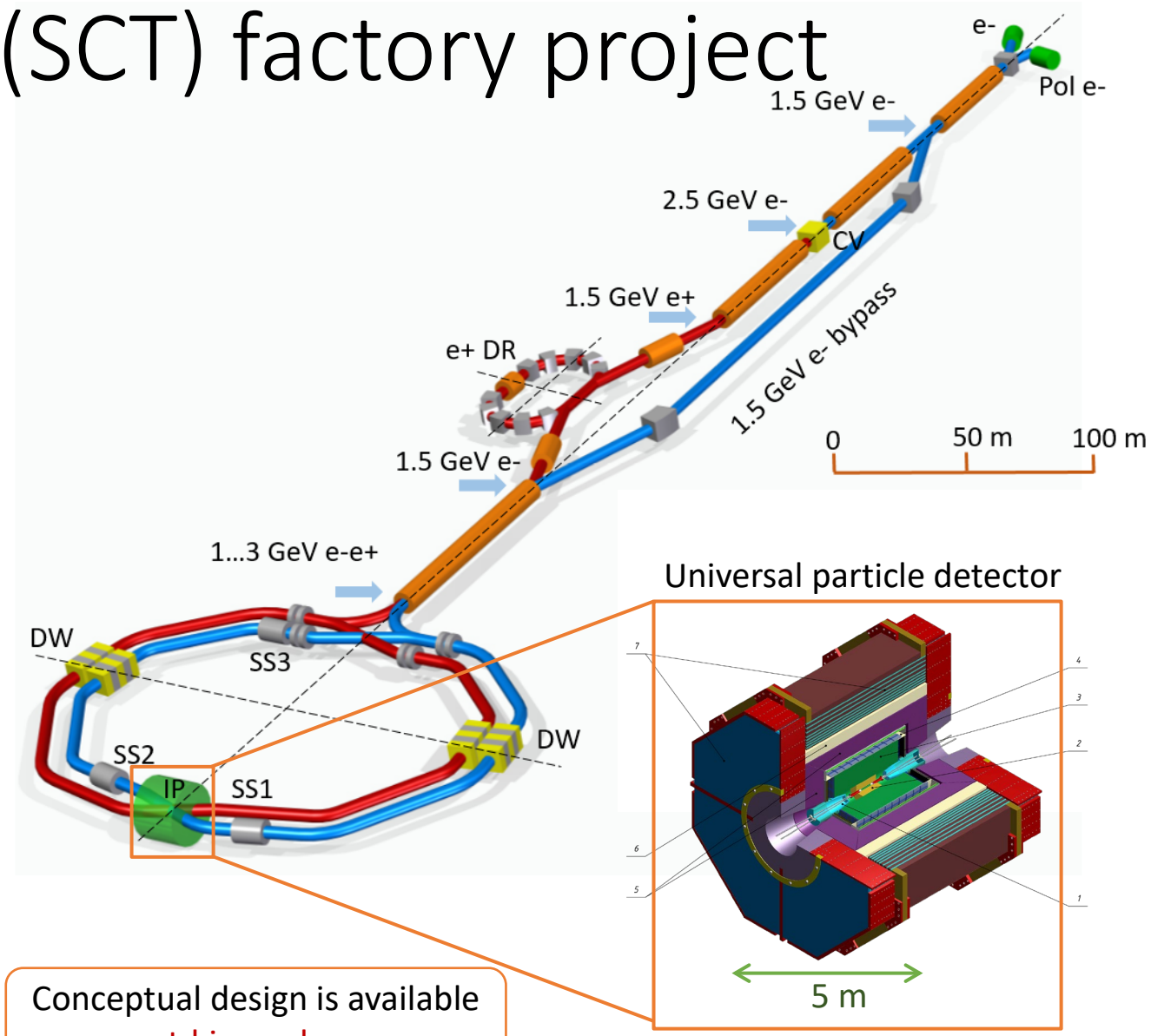
The Super charm tau (SCT) factory project

- A project of electron-positron collider for precision experiments with charm quark and tau lepton and search for new physics
  - Beam energy in the range 1.5 – 3.5 GeV
  - Luminosity $\mathcal{L} = 10^{35}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ @ 2 GeV
- State-of-the-art universal particle detector is needed for the experiment
  - Tracking system
  - Calorimeter
  - Identification of charged particles
- R&D and software development for the SCT detector constitute the main content of the CREMLINplus WP5



Conceptual design is available
ctd.inp.nsk.su

✓ Precision measurement of the τ lepton properties
✓ Michel parameters, tests of lepton universality
✓ Precision measurement of hadronic τ decays
✓ Search for CP and T violation in τ decays
✓ …

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SCT Physics Program

- ✓ Measurement of the strong phases of D decay amplitudes
- ✓ Measurement of absolute branching fractions
- ✓ Searches for rare and forbidden decays of the charm quark
- ✓ CP violation in charm
- ✓ …

Input for B meson studies at LHCb and Belle II

charm

QCD

tau

- ✓ Physics of highly-excited quarkonium
- ✓ Molecular states
- ✓ Baryon interaction at threshold
- ✓ Search for glueballs in decays of J/ψ and $\psi(2S)$
- ✓ …

Test of the electroweak sector of the SM

- ✓ Precision measurement of the τ lepton properties
- ✓ Michel parameters, tests of lepton universality
- ✓ Precision measurement of hadronic τ decays
- ✓ Search for CP and T violation in τ decays
- ✓ …

QCD, α_s, V_{us}. Test of the electroweak model, searches for non-standard contributions

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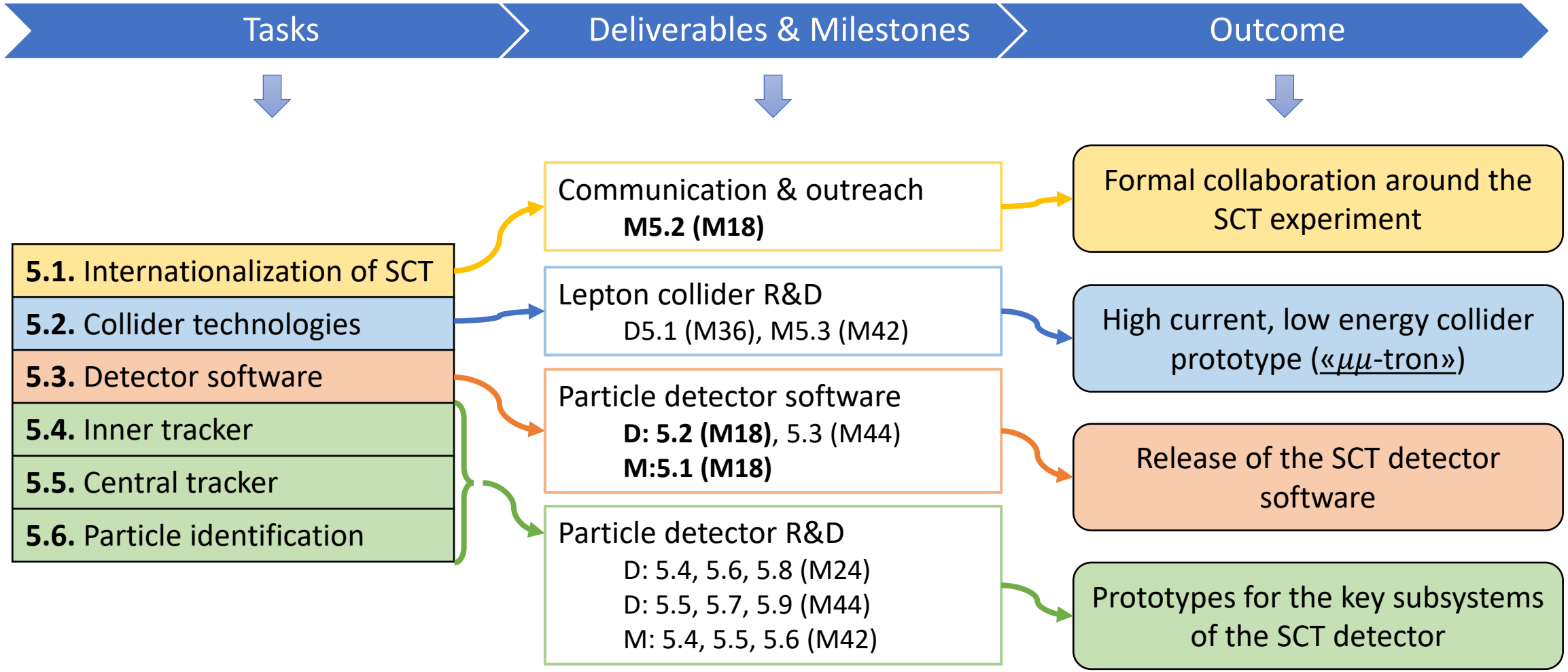
WP5 overview



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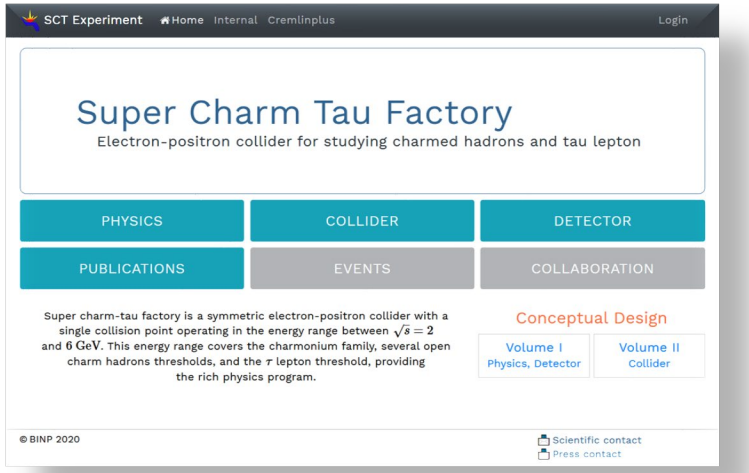
Progress

- Task 5.1. Fostering internationalization and visibility of the SCT project, support of outreach activities related to SCT

New public SCT website (prototype wip)



To be launched in 2021

Establishing formal collaboration around the SCT experiment

- M5.2 (M18)
- Formal collaboration with simplified, but clear structure is to be established in 2021
- Negotiations are in progress

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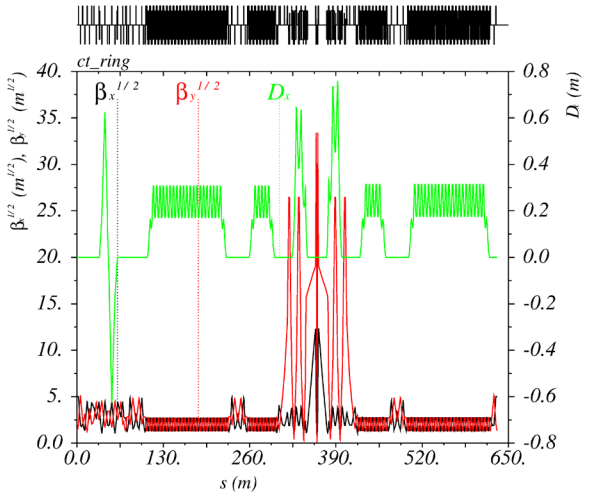
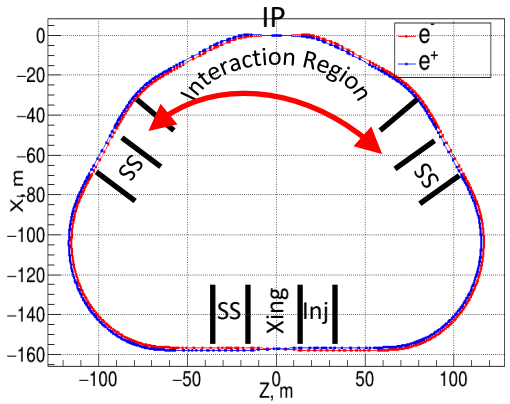
Progress

- Task 5.2. Development of collider technologies and fostering synergy between SCT, CLIC, and FCC-ee collider projects

Optimization of non-linear dynamics for reaching sufficient dynamic aperture at low energy





Strong synergy between SCT and FCC-ee development

Development of magnets

- Synergy between PERLE (iJCLab) and SCT in design and prototyping multipole magnets
- Joint work is stalled due to travel restrictions and unfortunate situation with hiring in iJCLab group

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Progress

M5.2 (M18), D5.2 (M18) ✓

- Task 5.3. Development of software for the design of an SCT detector

Release of the SCT detector software framework Aurora

- Software for full simulation of the SCT experiment is released (v1.0.0) and includes
  - Unified sensitive detectors
  - Realistic magnetic field
  - An example digitization module
  - Data analysis tools
  - Stack of external software
- Publication
  - Presented at AFAD-2021
  - Submitted to vCHEP21
  - A more detailed paper to be written in 2021

Adaptation of ILD software for SCT

- Synergy between ILD and SCT projects
- The goal is to reuse ILD software for track reconstruction in TPC
- When this is done, the simulation of SCT detector will improve considerably

SCT detector software relies on the HEP software community experience and the Turnkey Software (Key4HEP) initiative supported by EU Horizon 2020. Similar solutions adopted in other future HEP experiments (FCC, CLIC, ILC etc.)

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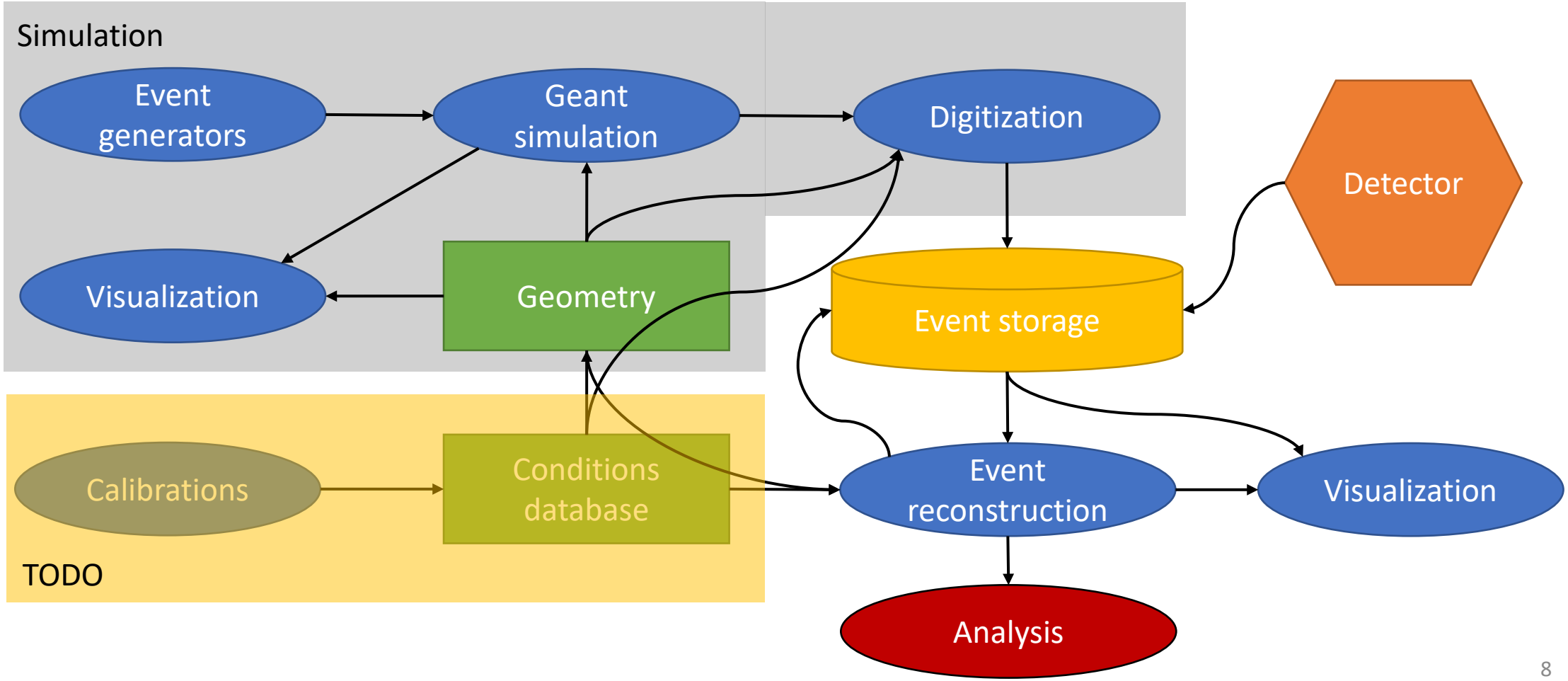
SCT detector software

- Task 5.3. Development of software for the design of an SCT detector



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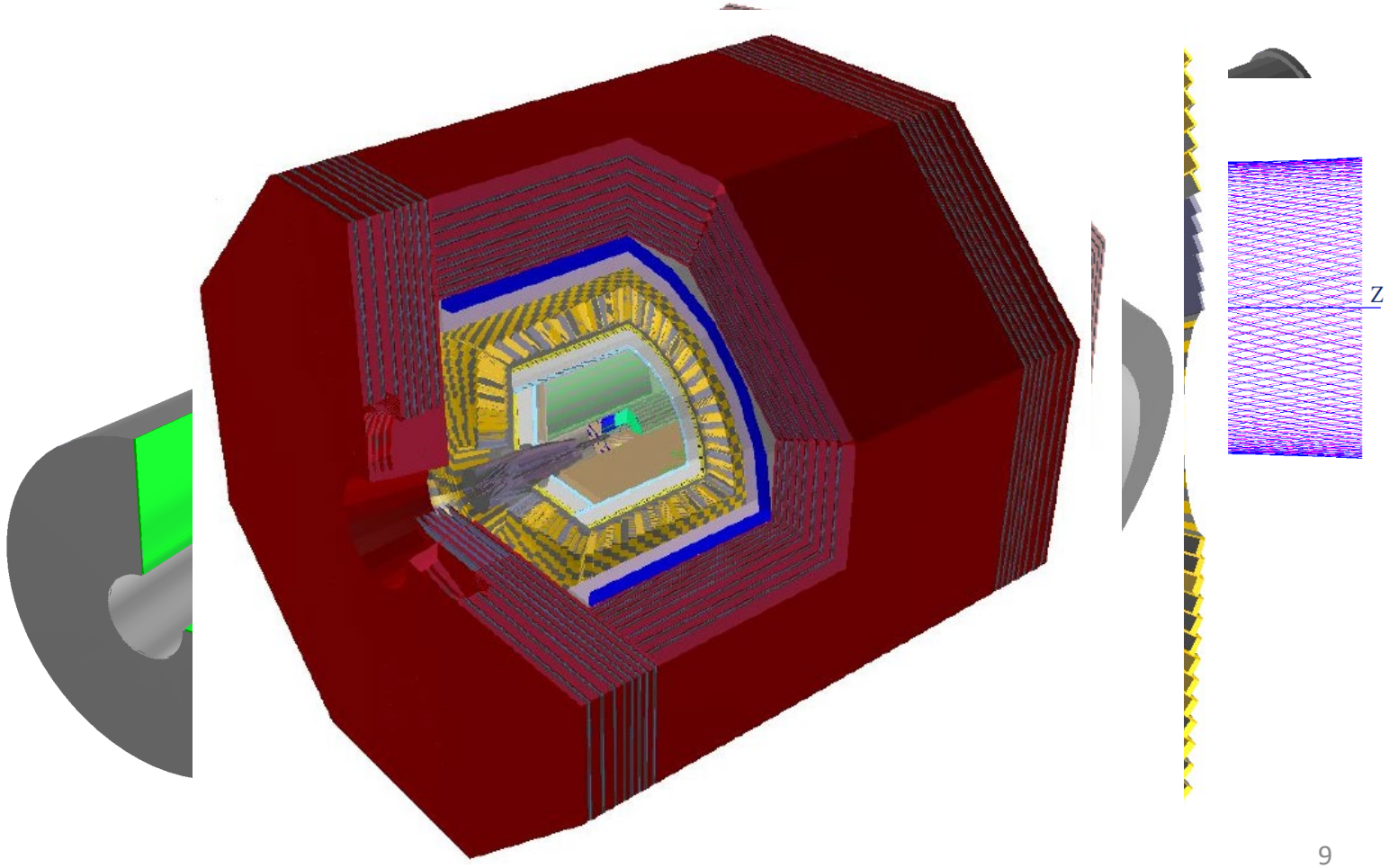
Detector geometry

- Task 5.3. Development of software for the design of an SCT detector

Subsystems described:

- Beam pipe and FF magnets
- Inner tracker
- Drift chamber
- Particle ID system
- Crystal calorimeter
- Superconducting coil
- Muon system and yoke

An option is implemented for each detector subsystem



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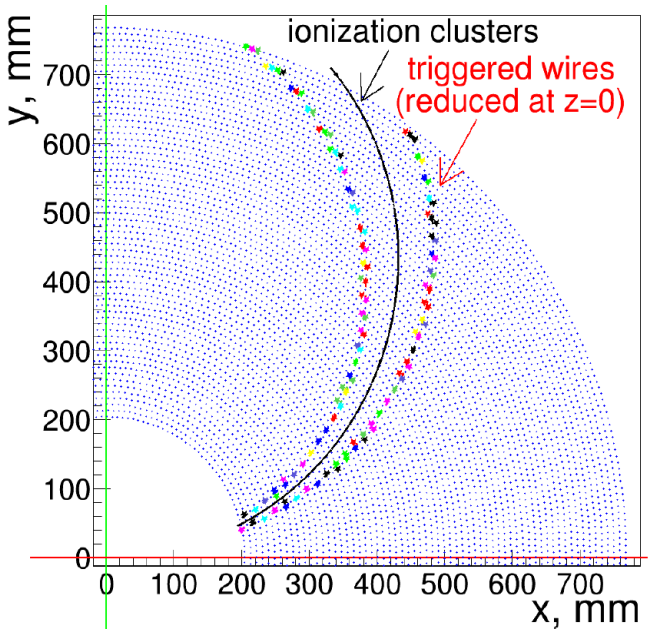
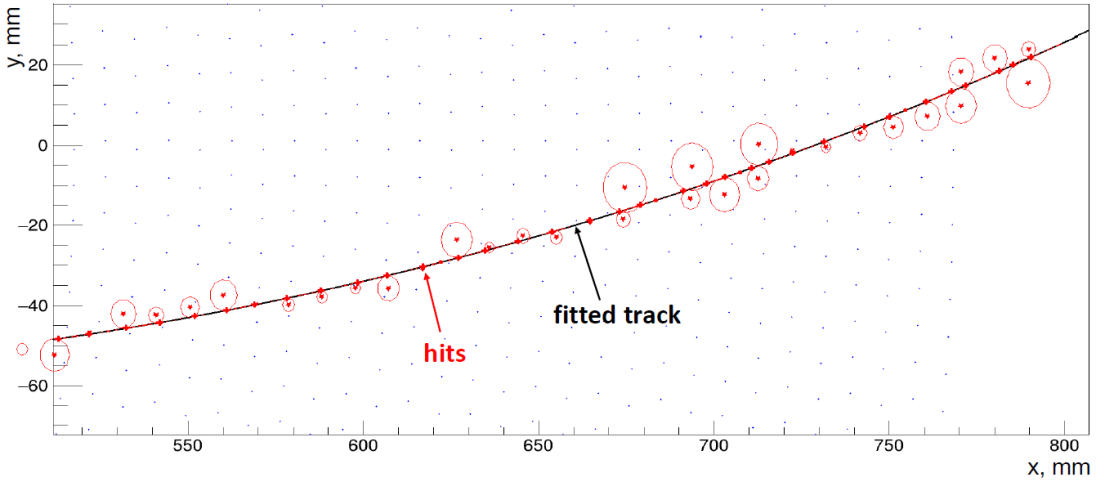
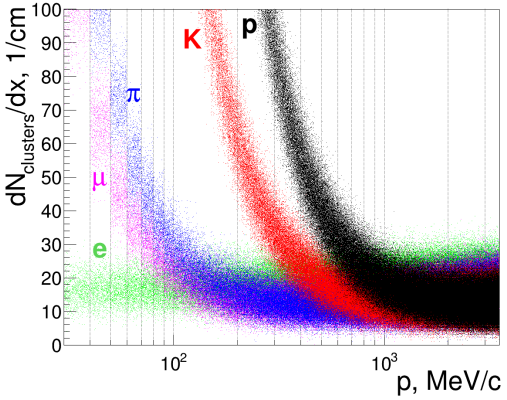
Track reconstruction

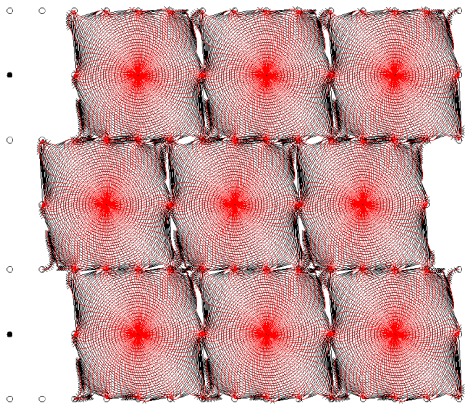
- Task 5.3. Development of software for the design of an SCT detector

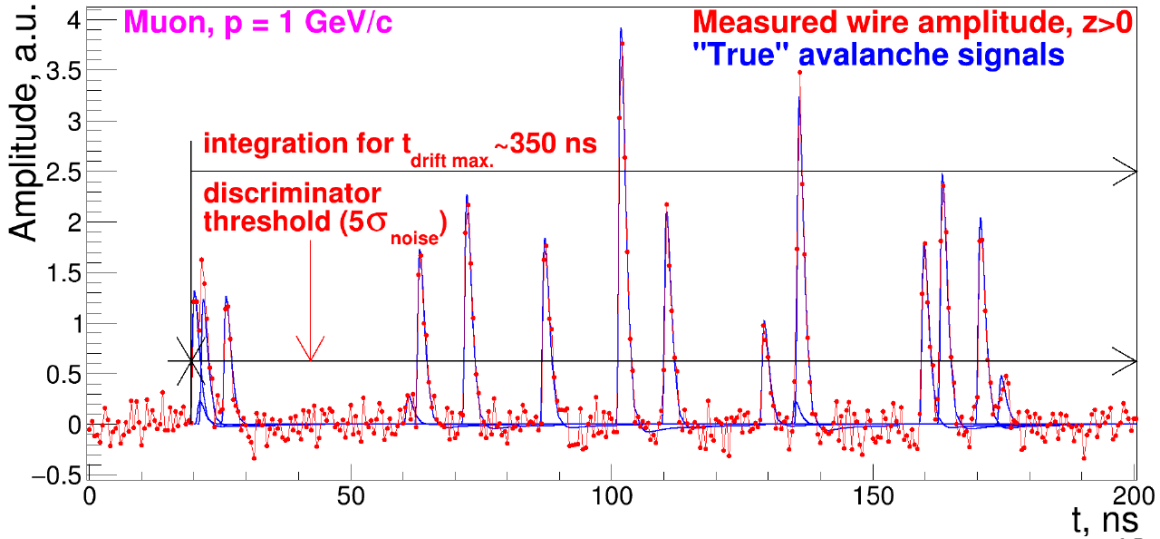
- Simulating the ionization cluster counting mode
- Boosted momentum resolution and particle identification











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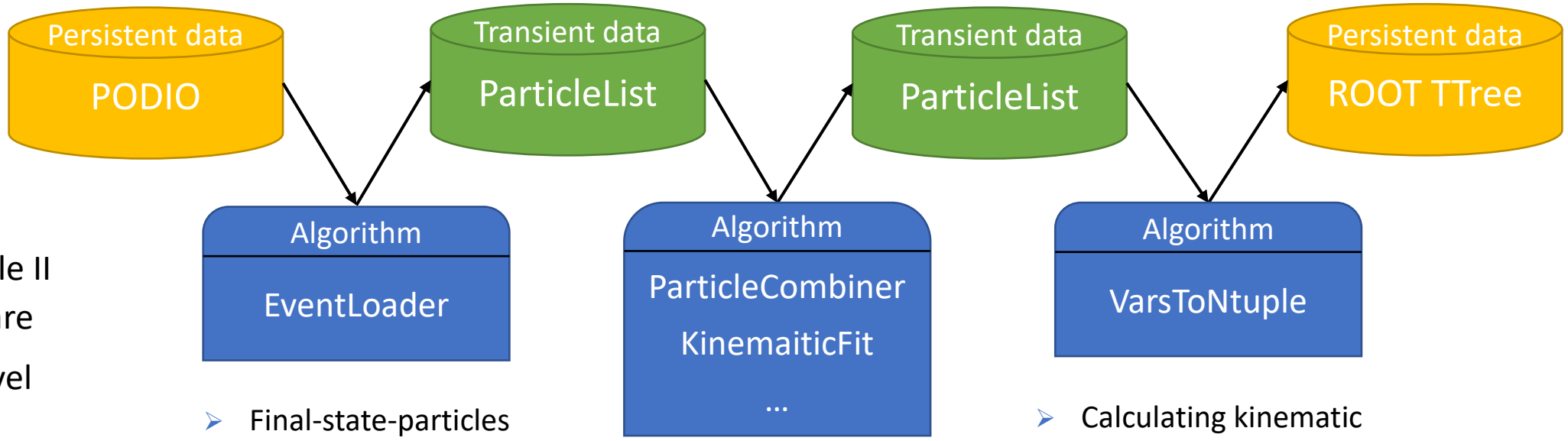
SCT event analysis

- Task 5.3. Development of software for the design of an SCT detector



- Inspired by Belle II analysis software
- Simple high-level Python API
- Easily reproducible data analysis

- Final-state-particles processing
- Kinematic cuts

- Reconstruction of particle decay chains
- Kinematic cuts

- Calculating kinematic variables to be written in output n-tuple

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Progress

- Task 5.4. Development and design of Inner Tracker for the SCT detector

INFN

Cylindrical μ-RWELL prototyping

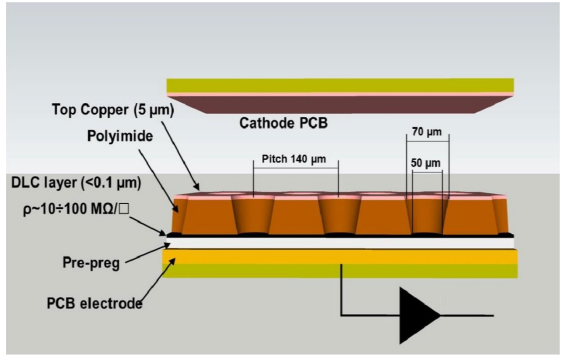
Low-material modular micro pattern gaseous detector as SCT inner tracker

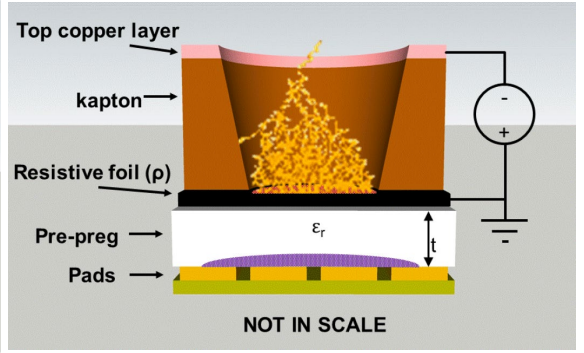
Done (M1-M12):

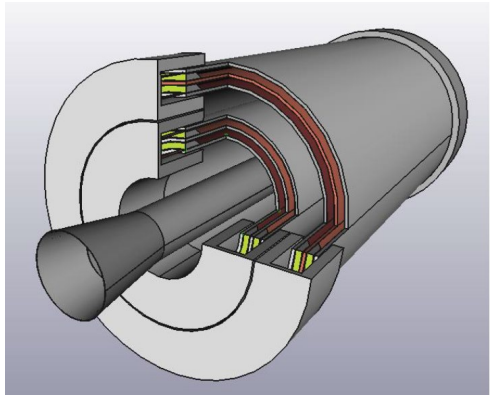
- The design of the prototype is being finalized
- Technical drawings of the prototype
- Several tests of the mechanical components of the prototype have been performed

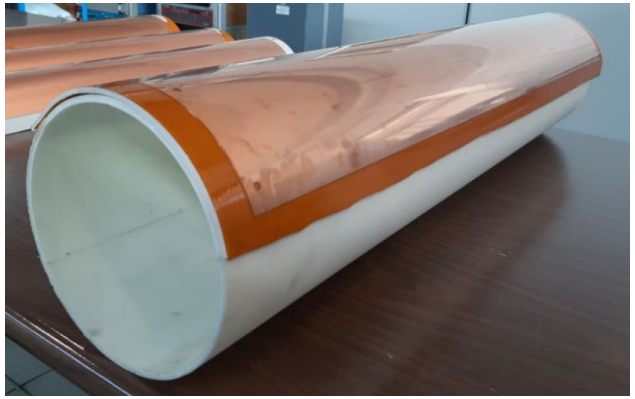
Next steps (M12-M24):

- Design of the mechanics, readout electrodes, amplification stage
- Construction of the 1st prototype









- μ-RWELL simulation is being developed within Aurora

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Progress

- Task 5.4. Development and design of Inner Tracker for the SCT detector

TPC prototyping

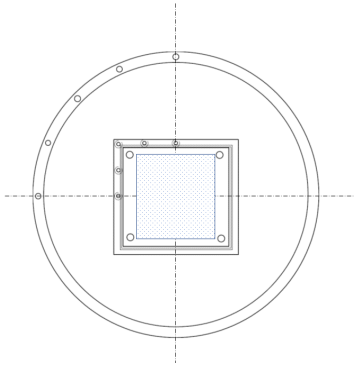
Inner tracker option with providing best reconstruction of soft tracks

Done (M1-M12):

- Field cage is ready
- Design drawings of readout end-cap and its parts are prepared
- Concept of the readout board is ready
- TDR of the prototype is on the way

Next steps (M12-M24):

- Design of the readout board
- Finish TDR for the prototype
- Assemble the prototype



- TPC simulation is being developed within Aurora

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Progress

- Task 5.5. Development and design of Central Tracker for the SCT detector

INFN

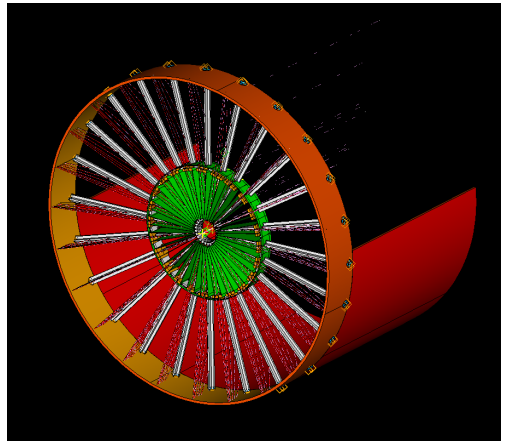
Drift chamber prototyping

Ultra-light drift chamber equipped with cluster counting/timing readout techniques

R&D on metal coating of carbon wires

- Testbench with magnetron sputtering established in BINP

- Mechanical design: from conceptual design to technical design in 2021
- Development of a new type of field wires: R&D in progress
- Development of a fast digitizer: iterative design and test are in progress



- Full simulation of DC with cluster counting is at advanced stage and is being improved

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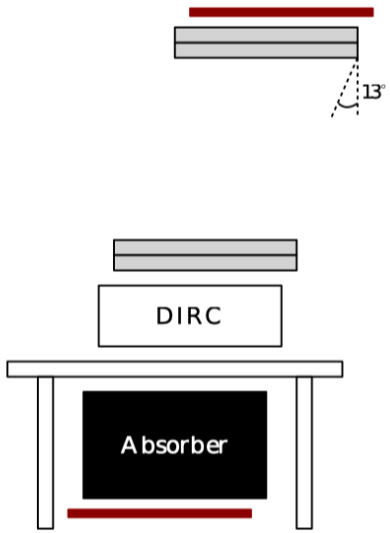
Progress

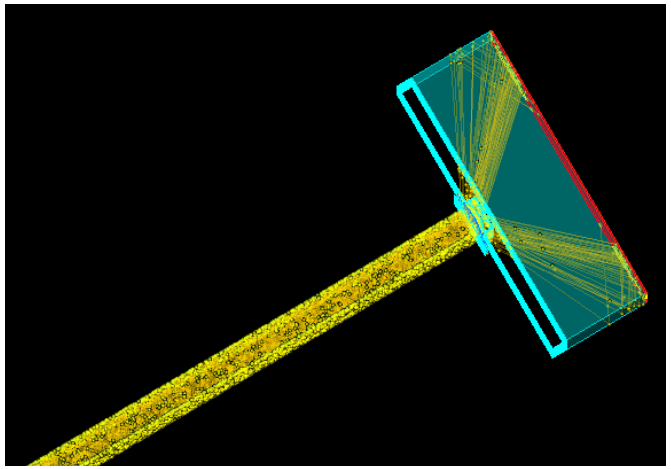
- Task 5.6. Development and design of Particle Identification system for the SCT detector

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

FDIRC prototyping

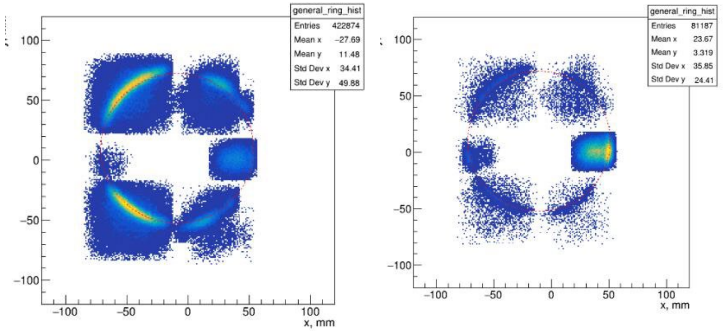
- Synergy with PANDA experiment
- Experiments with Giessen cosmic station (GCS)

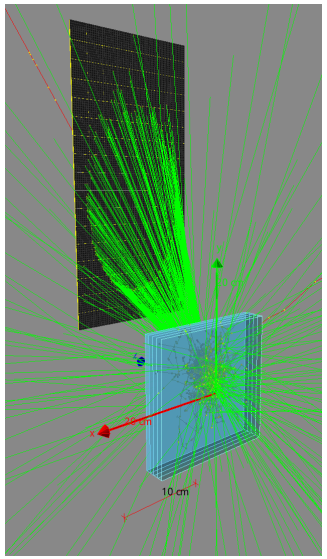




FARICH prototyping

- Prototype with full ring reconstruction:
  - Mechanical design
  - Aerogel production
  - Photon detectors
  - Readout electronics
- Beam tests with the prototype are scheduled for 2022





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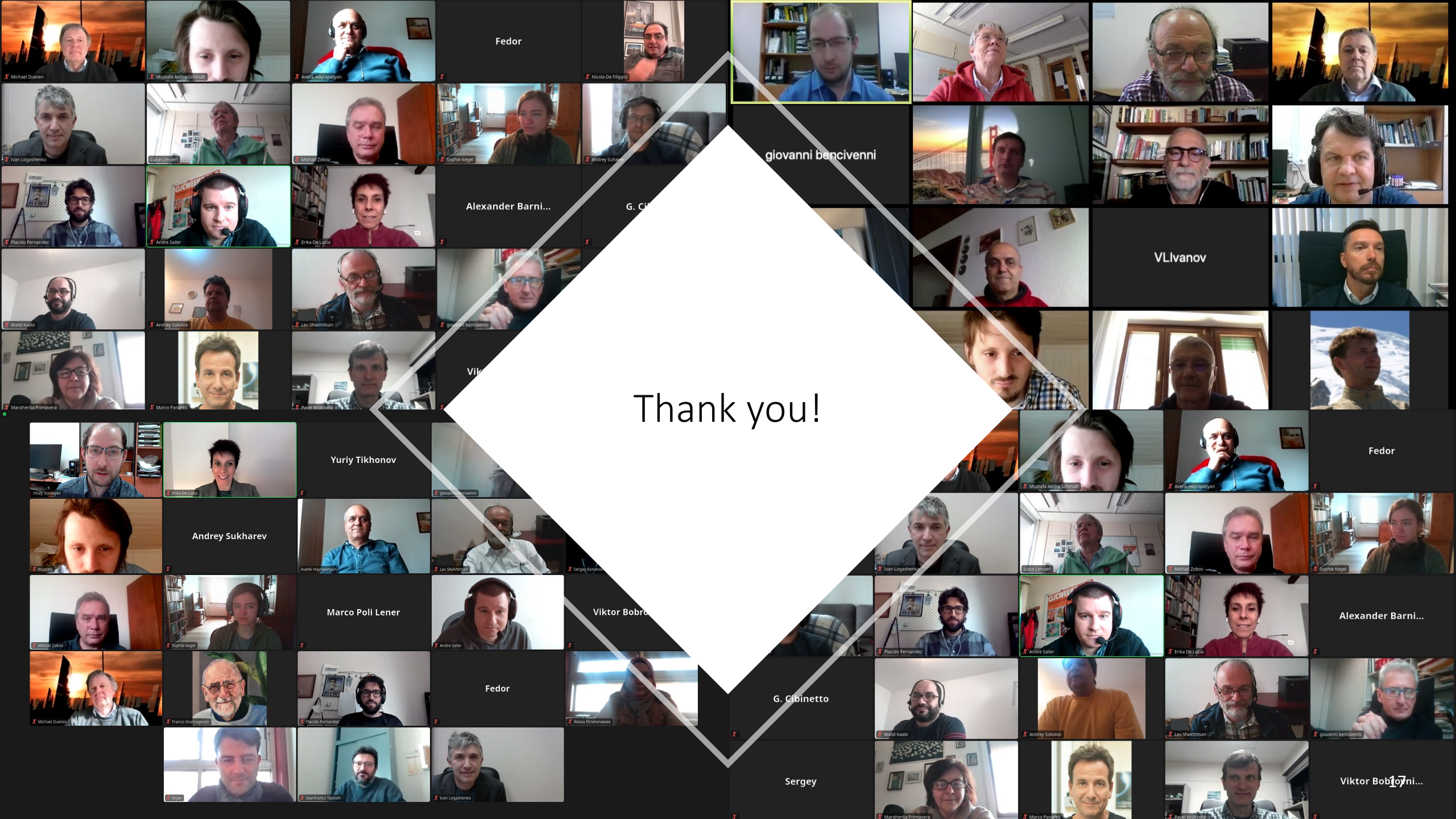
WP5 upcoming actions (M12-M24)

1. Presenting the SCT detector software release 1.0 (Milestone 5.2, M18)
2. Launching the formal collaboration around the SCT experiment (Milestone 5.1, M18)
   - CREMLINplus WP5 consortium to be the core of the collaboration
3. Construction and testing of prototypes for the SCT inner tracker
   - TPC (BINP)
   - Cylindrical μRWELL (INFN)
4. Technical design for the drift chamber prototype should be prepared before M24
5. PID (FARICH and FDIRC)
   - Testing the aerogel produced in 2020 and further refinement of the production technology
   - Manufacturing and testing 1st version of the compact front-end electronics


Thank you!

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WP5 challenges

- COVID-19 impact
  - Hardware works are already delayed by about 6 months
  - A lack of face-to-face communication, even related to the software tasks
  - We still can meet our goals on detector prototypes with a tighter schedule
- Establishing formal collaboration around the SCT experiment
  - It requires communication and decisions at the management level
- Collider technologies
  - The $\mu\mu$-tron prototype (M5.3) requires far more resources than we have within CREMLINplus

WP5 meetings and SCT workshops

Workshops on future super charm tau factories:

- December 2017, Novosibirsk (link)
- March 2018, Beijing (link)
- May 2018, Novosibirsk (link)
- December 2018, Orsay (link)
- November 2019, Moscow (link) + 1st general WP5 meeting
- November 2020, Hefei (online, link)

WP5 meetings:

- 2nd general WP5 meeting, September 2020 (online, link), 44 participants
- 3rd general WP5 meeting, February 2021 (online, link), 38 participants