

The DESY II Test Beam Facility



Review, Status, Future

20. June 2022 – BTTB10, Lecce (Italy)

Ralf Diener, Norbert Meyners, Marcel Stanitzki

Facility

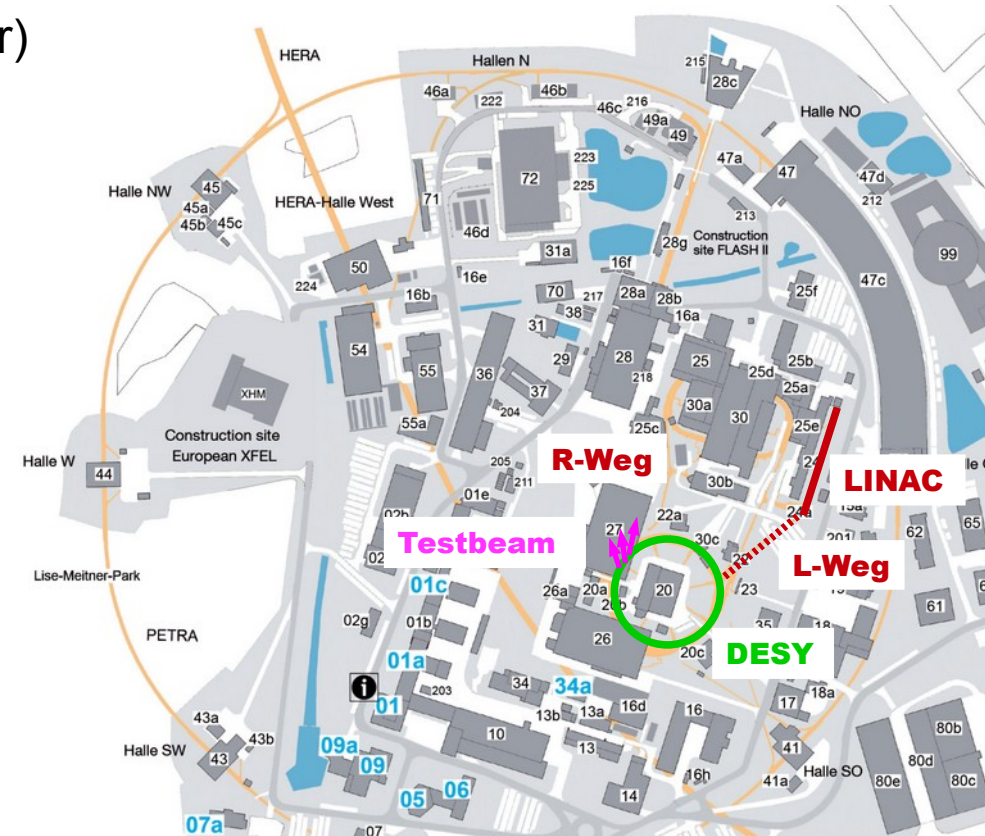
Overview and Beam Generation



Facility

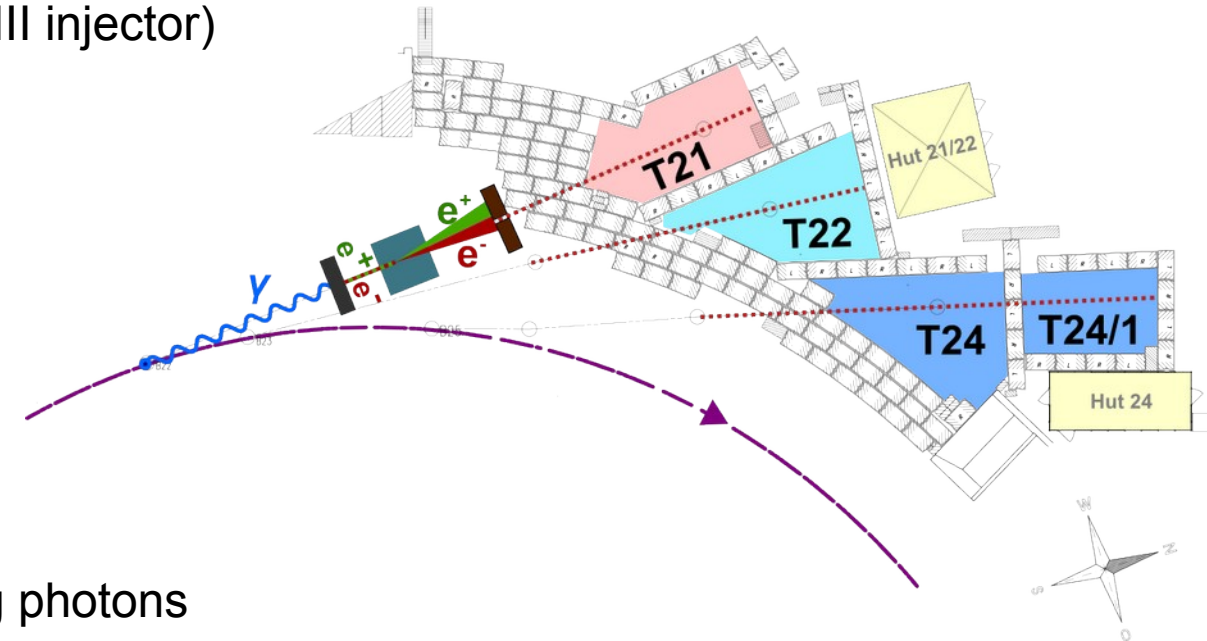
Overview and Beam Generation

- Facility parasitically fed by DESY II synchrotron (PETRA III injector)
 - 1 bunch per fill
 - 1 MHz circulation frequency
 - Energy ramps sinusoidal @ 12.5 Hz between 0.45 and 6.3 GeV
 - Very high availability (~ 99 % uptime)



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- Test beam generation:
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 - Conversion at secondary target to e^+/e^- up to 6 GeV
 - Energy selected with dipole / collimator



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 - Single electrons, rates $O(10k \text{ particles s}^{-1} \text{ cm}^{-2})$ depending on beam line, energy, converter target, collimation
- Three individual beam lines, controlled by the user: shutter, area interlock, converter, momentum + collimation

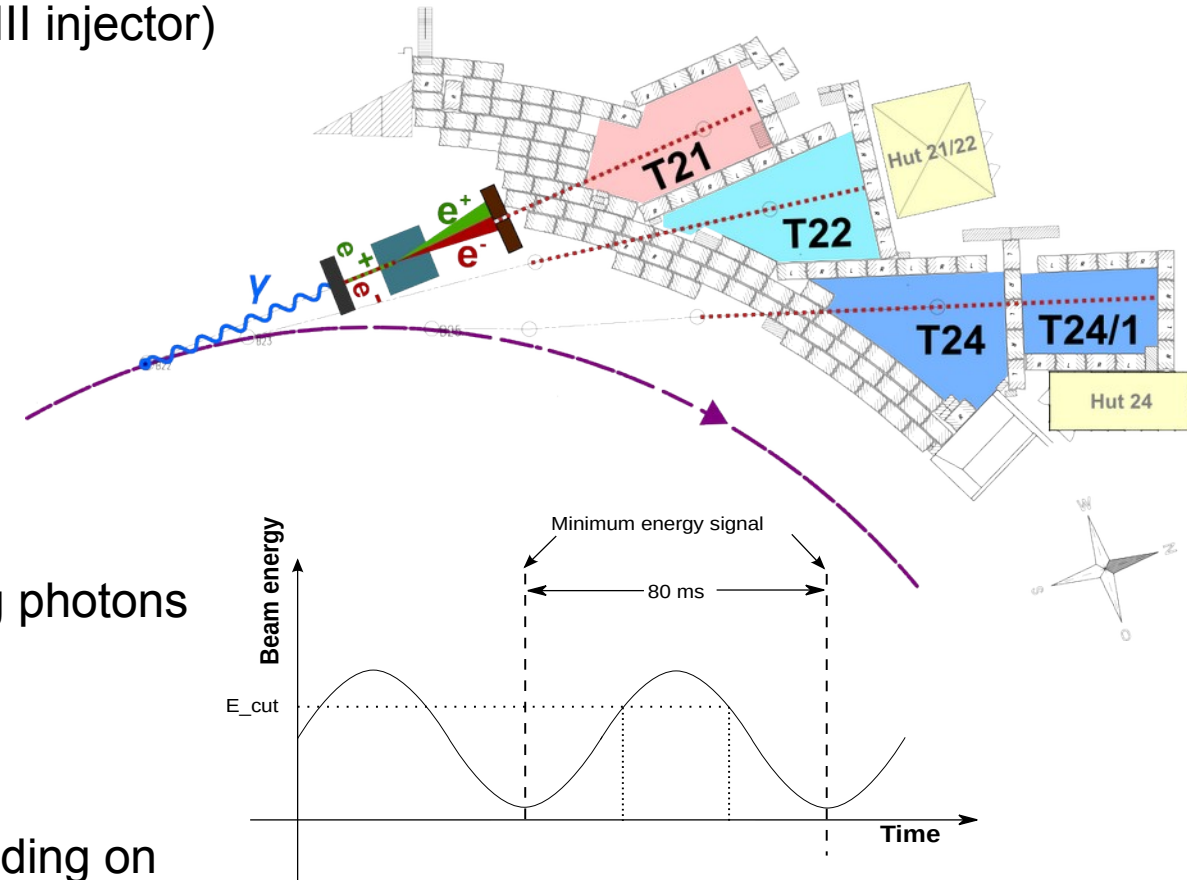
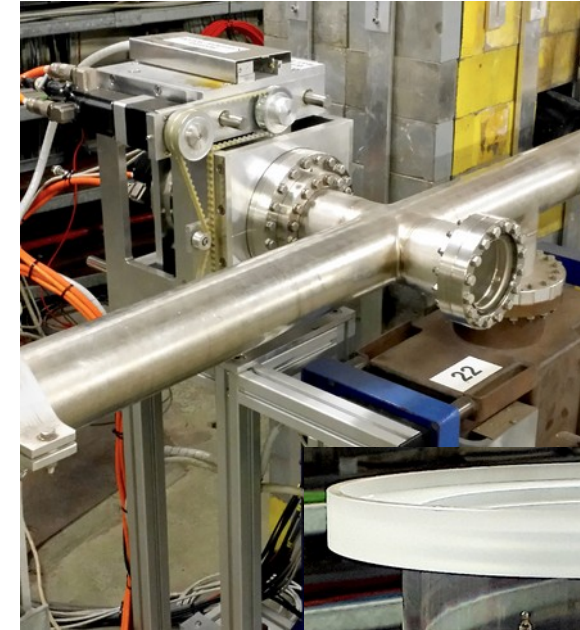


Fig.: DESY II energy cycle

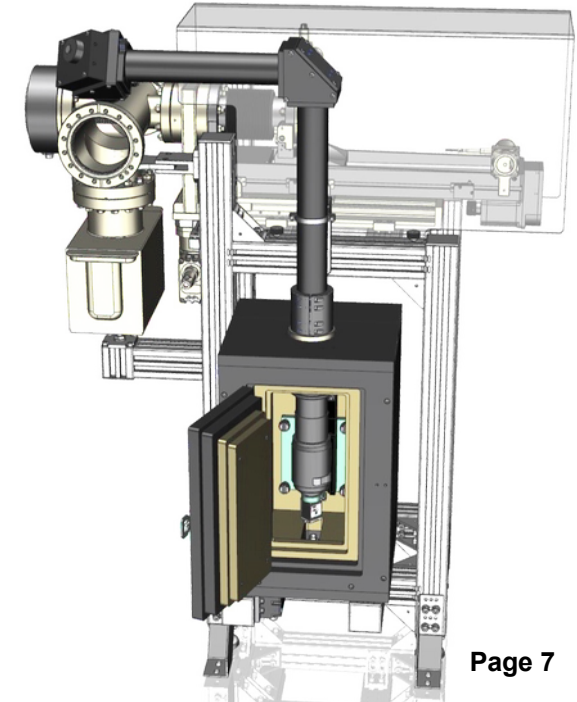
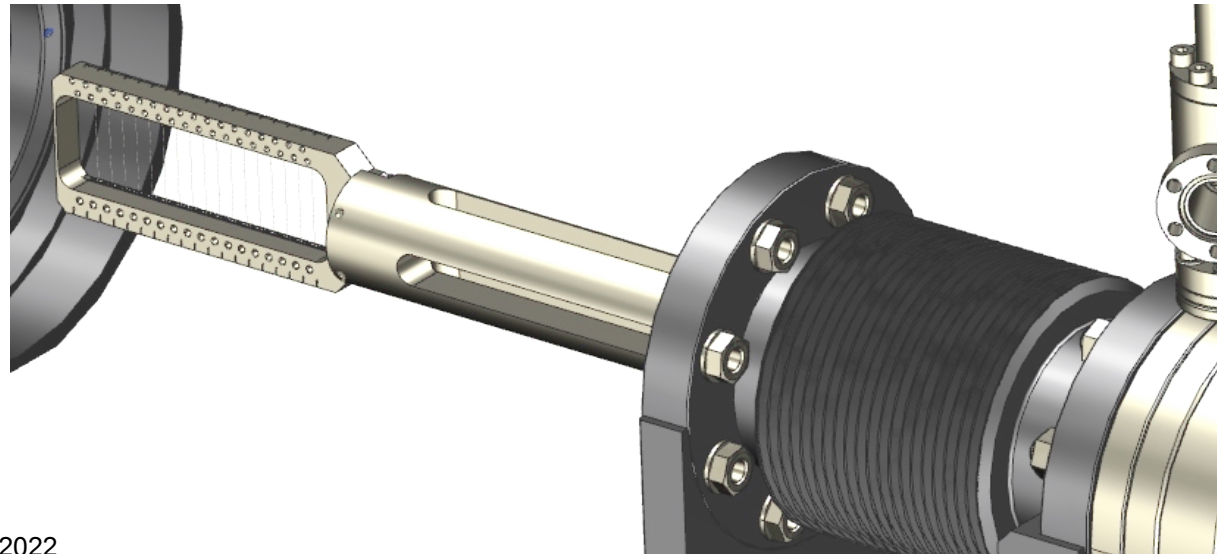
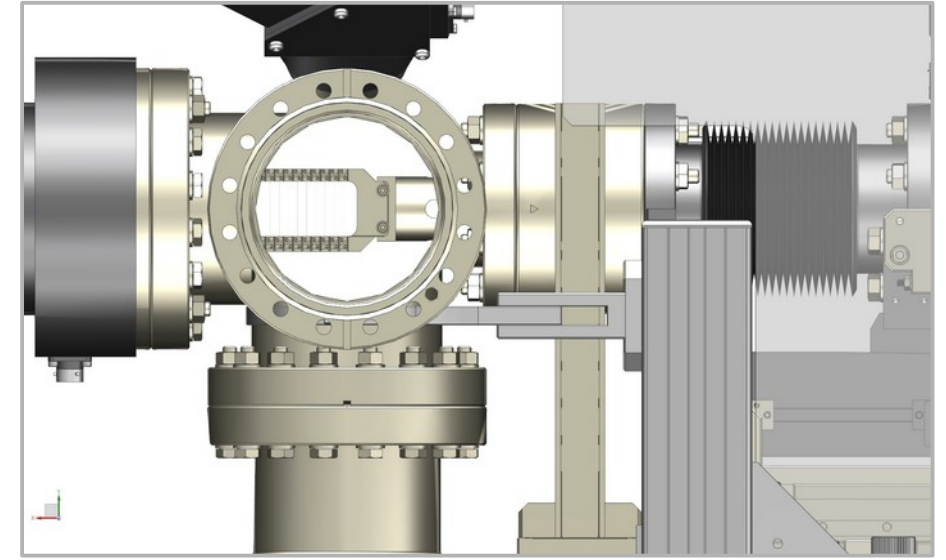
Upgrade Primary Target Stations

- Already in last years presentation:
New target stations installed in winter shutdown 20/21
- Before “revolver” with six 7 μm carbon fibers



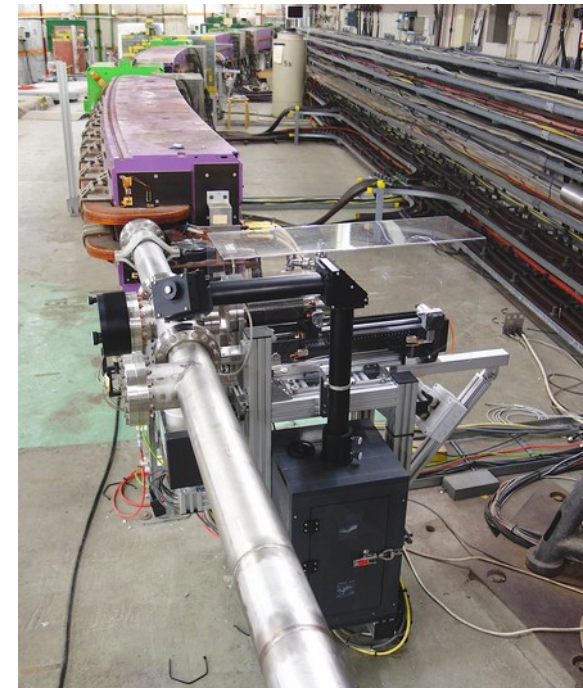
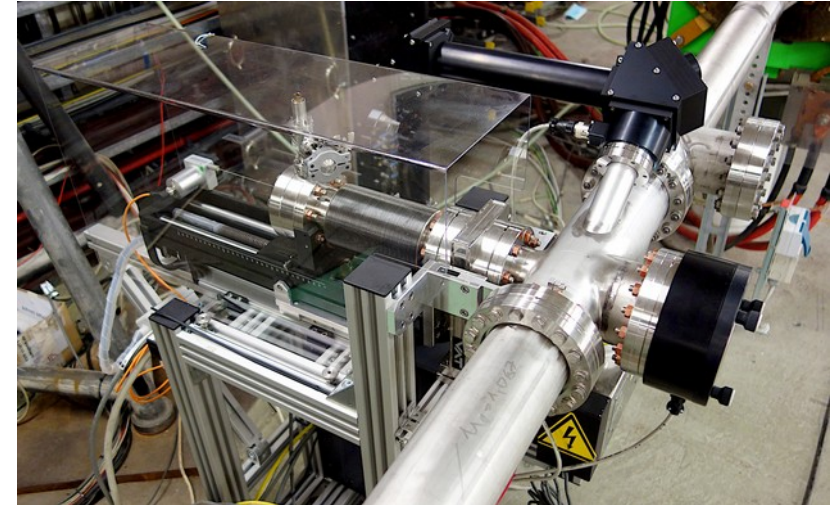
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New target stations installed in winter shutdown 20/21
- Before “revolver” with six 7 μm carbon fibers, now “harp” with ten
 - also minimizes mechanical stress on single fibers
 - Integrated seal: exchange without breaking main vacuum
 - replacing took 60-72 hours, now a few hours
 - More fail-safe test beam operation



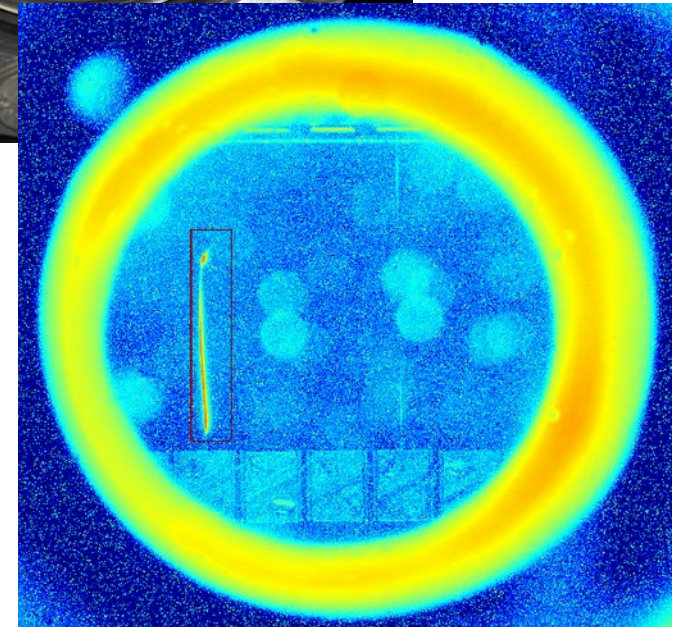
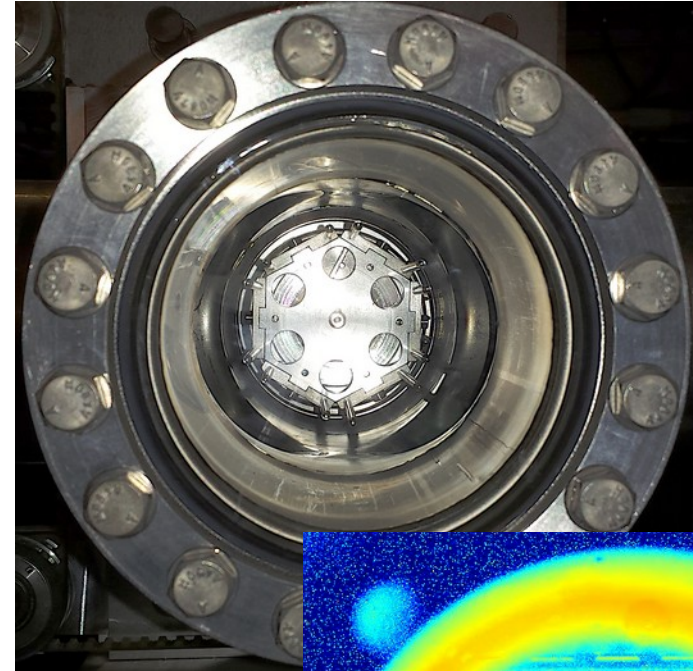
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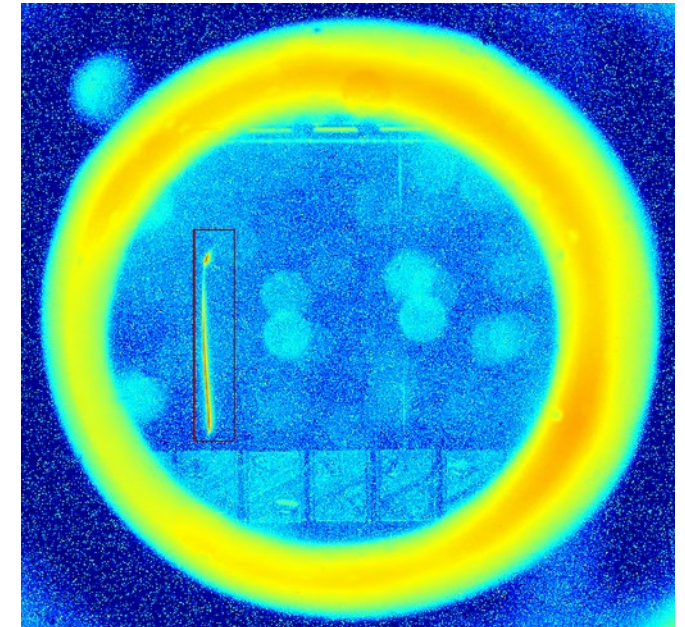
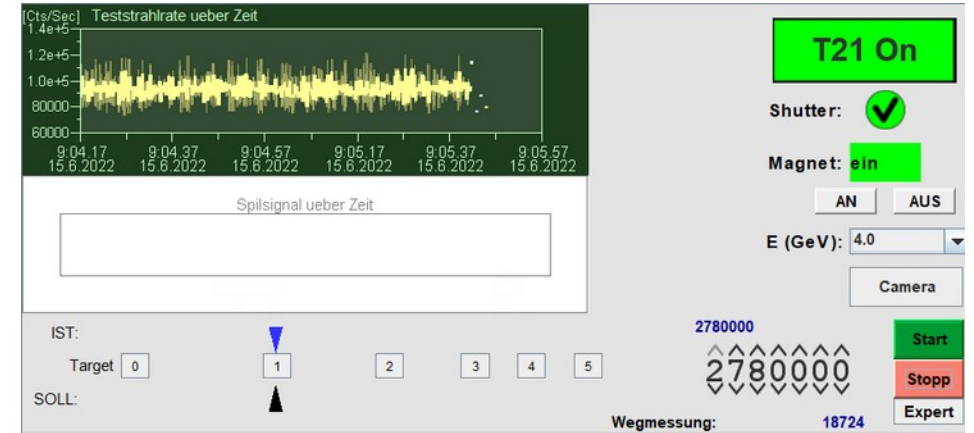
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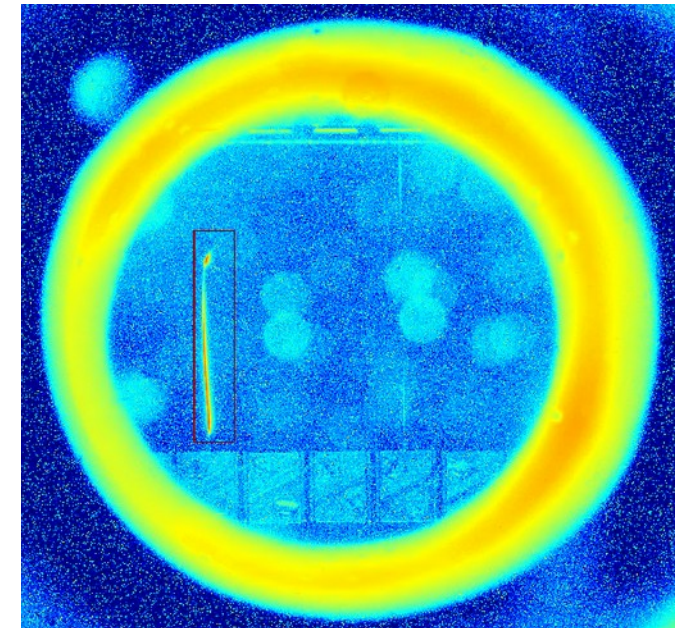
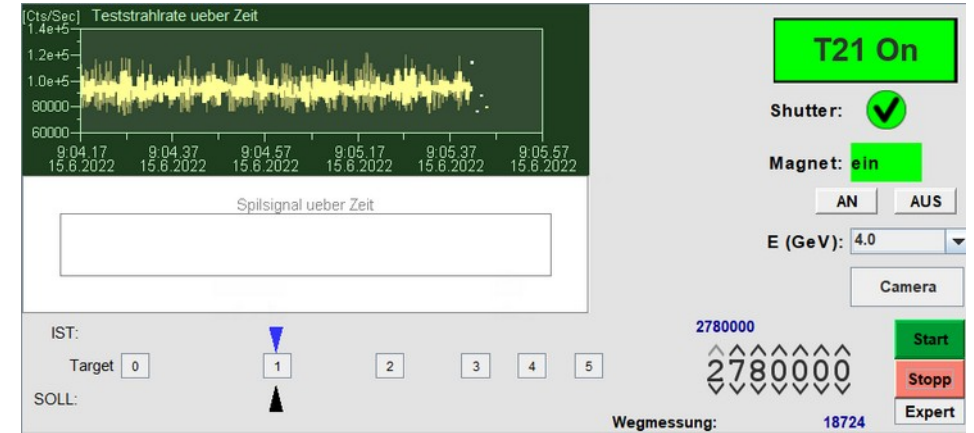
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 - replacing took 60-72 hours, now a few hours
 - More fail-safe test beam operation
 - Before: window, now integrated camera to check fiber status
 - New operating software (runs in safe-mode on the user hut PC)
- Performed very well during 2021 operation
 - New possibilities, e.g. stability in multi-bunch operation not studied yet

Big thanks for the support from our colleagues of the accelerator division



Facility

Infrastructure



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- Remote controlled 1 t and 30 kg stages
- Hall crane, up to 25 t



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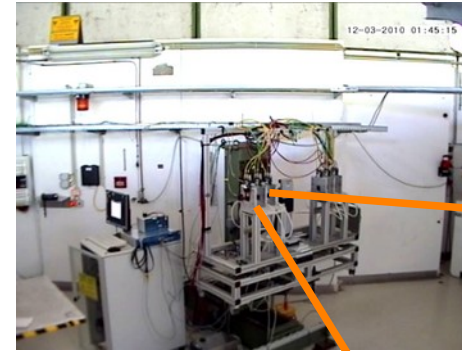
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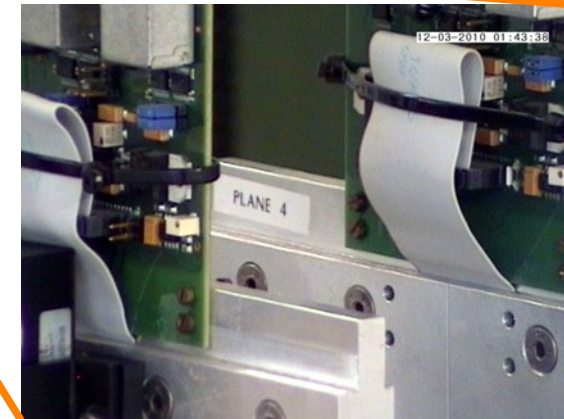
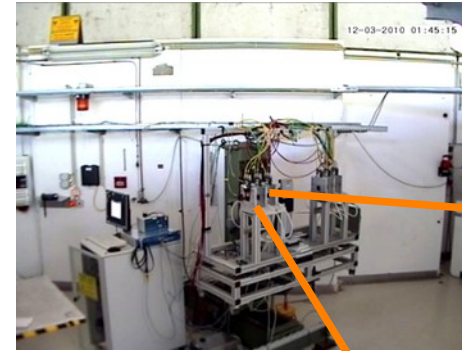
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- Remote controlled IP cameras in each area



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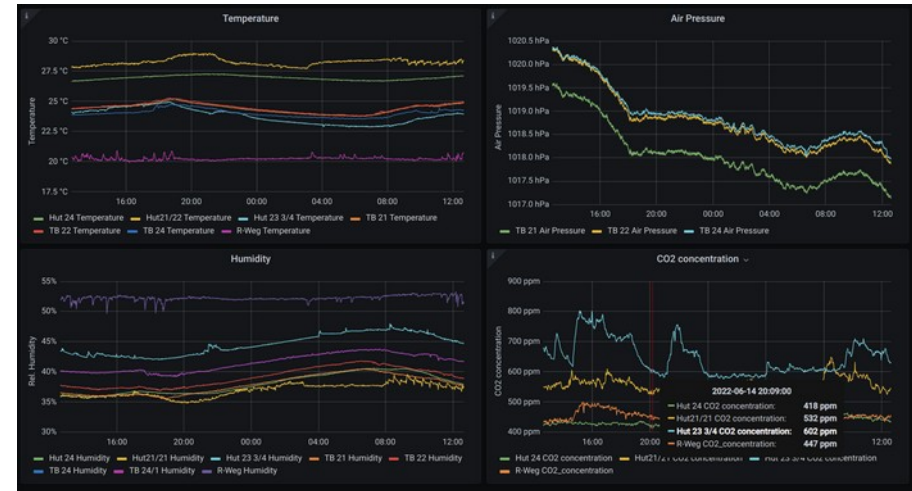
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- Dry nitrogen, cooling water in each area
- Gas cabinets in T22 and T24, flammable gas possible



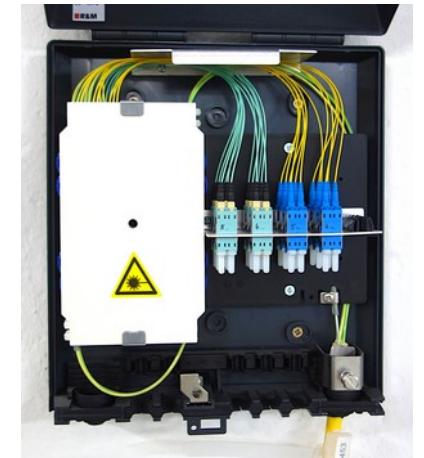
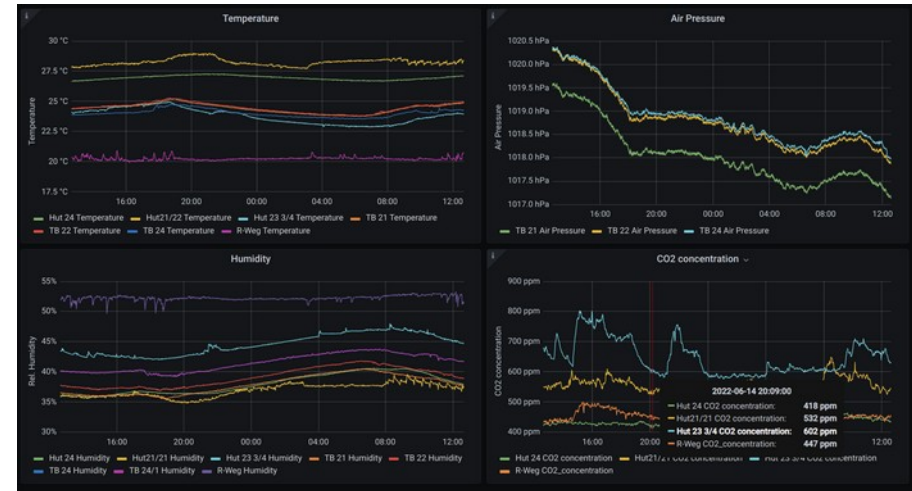
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- Weather stations, slow control system, laser alignment
- Beam monitors



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- EUDET-type beam telescope in each area (see [presentation by A. Herkert later](#))
- Remote controlled IP cameras in each area
- Dry nitrogen, cooling water in each area
- Gas cabinets in T22 and T24, flammable gas possible
- Weather stations, slow control system, laser alignment
- Beam monitors
- Patch panels
 - High voltage S-HV, BNC Coax
 - Ethernet RJ-45, optical fiber (single and multi-mode)



User Space

Replacing old Container

- Already in last years talk:
New proper hut to replace the old blue container
- Offers twice as much space, more bright
- Status then:
Has been ordered, delivery date unknown



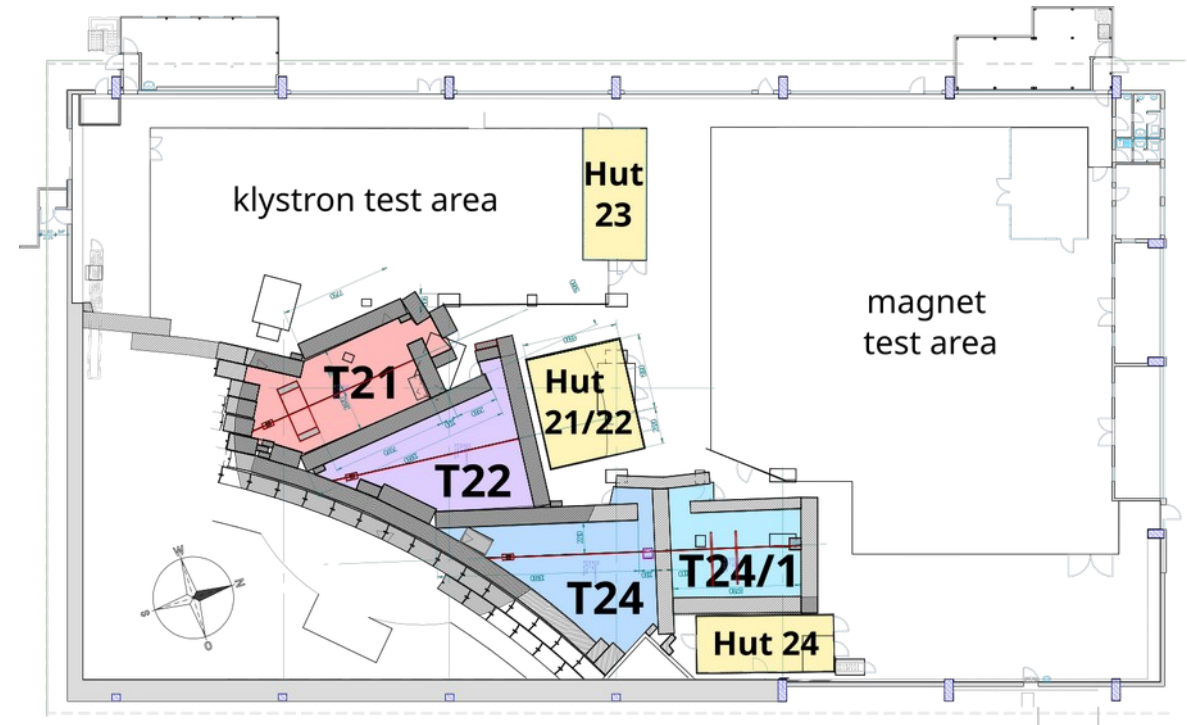
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accessible for users since June 2021



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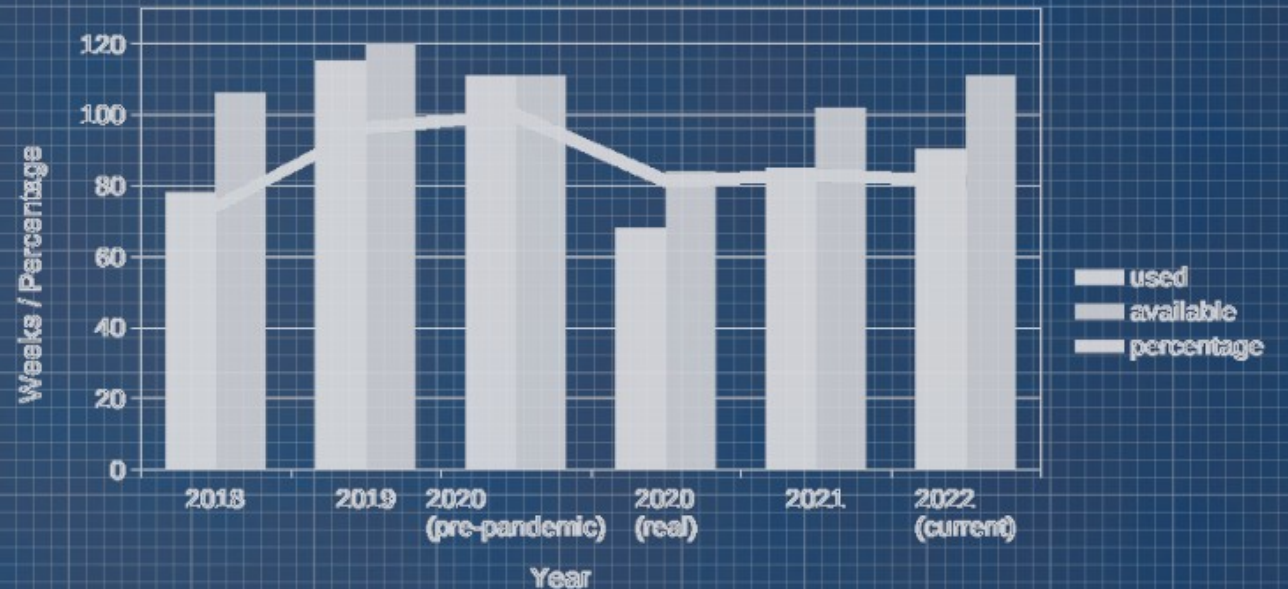
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- Status then:
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- Offers
 - Several work places, power, Ethernet, WiFi
 - Large monitor for presentations
 - Coffee machines and water boiler
 - Beam / machine status display
- In addition: garden furniture + parasols
for seating places in front of the hall



Schedule

Booking, User Statistics, Outreach

The image shows a screenshot of a complex scheduling spreadsheet. It features two main sections: 'Shutdown' and 'Summer Shutdown'. Each section contains multiple columns representing different time slots or activities, with rows indicating specific dates and user bookings. The spreadsheet is densely packed with data, including various colored cells and text entries.



Schedule

Booking/Usage Statistics

- 2021: Corona lockdown until mid-March
 - ... only campus-internal users until April 19
 - ... only national users until May 31
 - ... since June running normal, only few cancellations

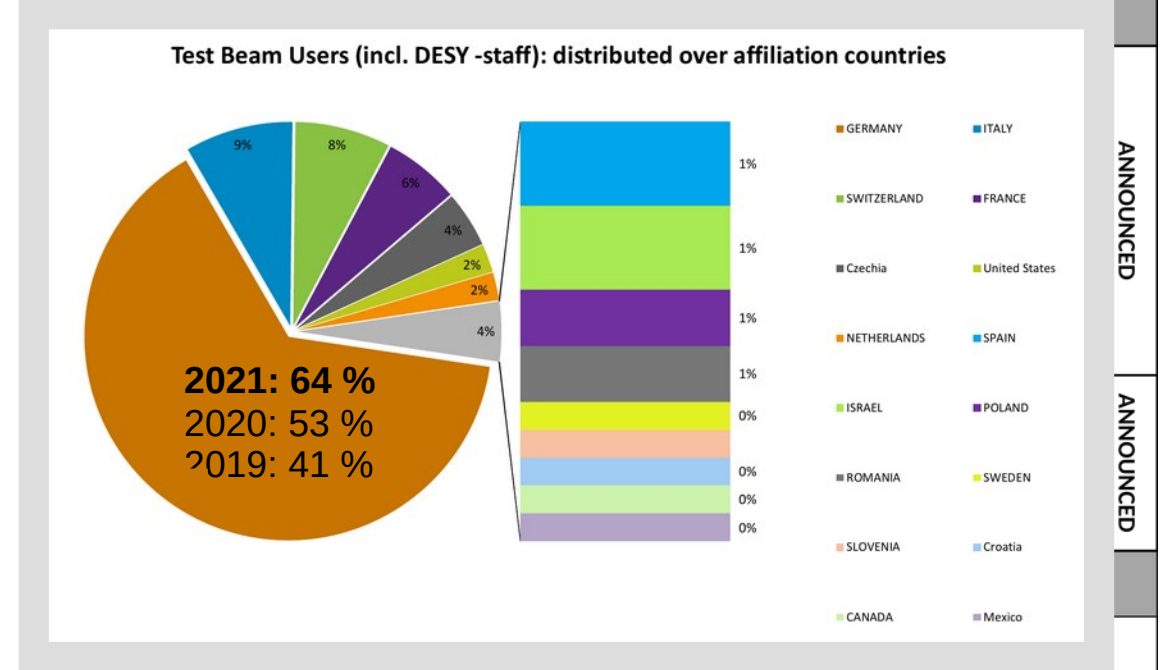
| Week | TB21 | | TB22 | | TB24/1 | | TB24 | | | | | | | | | | |
|-----------|------|------------------------|------|------------------|--------|----------------|------|---------------|---|-------------------|------------------|-------------------|--------------|-----------|---|------------------|---------------|
| | | DATA | | DATA | PC MAG | PROBES & FOCUS | | ADMA | | | | | | | | | |
| 4-Jan-21 | 1 | Shutdown | | | | | | | | | | | | | | | |
| 11-Jan-21 | 2 | | | | | | | | | | | | | | | | |
| 18-Jan-21 | 3 | | | | | | | | | | | | | | | | |
| 25-Jan-21 | 4 | | | | | | | | | | | | | | | | |
| 1-Feb-21 | | Startup | | Startup | | Startup | | Startup | | ANNOUNCED | | | | | | | |
| 8-Feb-21 | | Lockdown | | | | | | | | | | | | | | | |
| 15-Feb-21 | | | | | | | | | | | | | | | | | |
| 22-Feb-21 | | | | | | | | | | | | | | | | | |
| 1-Mar-21 | | | | | | | | | | | | | | | | | |
| 8-Mar-21 | | | | | | | | | | | | | | | | | |
| 15-Mar-21 | 11 | | | | | | | | | | CMS-Pixel-Phase2 | X | CALICE AHCAL | X | | | Telescope-Dev |
| 22-Mar-21 | 12 | CMS-Pixel-Phase2 | X | MBI | X | | | Telescope-Dev | X | | | | | | | | |
| 29-Mar-21 | 13 | CMS-Pixel-Phase2 | X | MBI | X | | | Telescope-Dev | X | | | | | | | | |
| 5-Apr-21 | | Lockdown | | | | | | | | | | | | | | | |
| 12-Apr-21 | 15 | | | | | | | | | CMS-Pixel-Phase2 | X | CMOS Strips | X | | | Telescope-Dev | X |
| 19-Apr-21 | 16 | | | | | | | | | HVMAPS | X | Bonn-CMOS | X | | | ALICE-ITS3 | X |
| 26-Apr-21 | 17 | | | | | | | | | LHCb-MightyPix | X | CALICE AHCAL | X | | | ALICE-ITS3 | X |
| 3-May-21 | 18 | | | | | | | | | CMS-Pixel-Phase2 | X | | | | | | |
| 10-May-21 | 19 | | | | | | | | | CMS-Pixel-Phase2 | X | ATLAS-ITk-Pixel | X | | | CMS-Pixel-Phase3 | X |
| 17-May-21 | | Lockdown | | | | | | | | | | | | | | | |
| 24-May-21 | 21 | | | | | | | | | CMS-Pixel-Phase2 | X | | | | | LHCb-ECAL | X |
| 31-May-21 | 22 | | | | | | | | | EP Pixel R&D | X | Mu3e-Tile | | | | LHCb-ECAL | X |
| 7-Jun-21 | 23 | | | | | | | | | EP Pixel R&D | X | TOTEM | X | | | Mimosis | |
| 14-Jun-21 | 24 | | | | | | | | | DualReadout-FA | | ATLAS-HGTD | X | LCTPC-Pix | X | | |
| 21-Jun-21 | 25 | | | | | | | | | DualReadout-FA | | ATLAS-HGTD | X | LCTPC-Pix | X | | |
| 28-Jun-21 | 26 | CMS Outer Tracker | X | ATLAS-ITk-Strips | X | T2K | | | | | | | | | | | |
| 5-Jul-21 | 27 | CMS Outer Tracker | X | ATLAS-ITk-Strips | X | T2K | | | | | | | | | | | |
| 12-Jul-21 | | Summer Shutdown | | | | | | | | | | | | | | | |
| 19-Jul-21 | | | | | | | | | | | | | | | | | |
| 26-Jul-21 | | | | | | | | | | | | | | | | | |
| 2-Aug-21 | 31 | | | | | | | | | | BL4S | X | | | | | |
| 9-Aug-21 | 32 | | | DMAPS | X | | | | | | | | | | | | |
| 16-Aug-21 | 33 | | | | | | | | | | | | | | | | |
| 23-Aug-21 | 34 | Telescope-Dev | X | | | | | Telescope-Dev | X | | | | | | | | |
| 30-Aug-21 | | Lockdown | | | | | | | | | | | | | | | |
| 6-Sep-21 | 36 | | | | | | | | | BL4S | X | CALICE AHCAL | X | | | ALICE-ITS3 | X |
| 13-Sep-21 | 37 | | | | | | | | | BL4S | X | TimePix3 | X | | | ATLAS-ITk-Strips | X |
| 20-Sep-21 | 38 | | | | | | | | | CMS-Pixel-Phase2 | X | CMS Outer Tracker | X | | | Mimosis | |
| 27-Sep-21 | 39 | | | | | | | | | CMS-Pixel-Phase2 | X | CMS Outer Tracker | X | | | Telescope-Dev | X |
| 4-Oct-21 | 40 | | | | | | | | | CMS-Pixel-Phase2 | X | Mu3e-Tile | | | | | |
| 11-Oct-21 | | Lockdown | | | | | | | | | | | | | | | |
| 18-Oct-21 | 42 | | | | | | | | | Tangerine | X | Telescope-Dev | X | | | | |
| 25-Oct-21 | 43 | | | | | | | | | Tangerine | X | CALICE AHCAL | X | | | | |
| 1-Nov-21 | 44 | | | | | | | | | CMS-Pixel-Phase2 | X | CALICE-SIW-ECAL | | | | LUXE | X |
| 8-Nov-21 | 45 | | | | | | | | | CMS Outer Tracker | X | CALICE-SIW-ECAL | | | | LUXE | X |
| 15-Nov-21 | 46 | | | | | | | | | CMS Outer Tracker | X | DMAPS | X | | | TPEX | |
| 22-Nov-21 | 47 | CMS-Pixel-Phase2 | X | CMOS Strips | X | | | TPEX | | | | | | | | | |
| 29-Nov-21 | 48 | CMS-Pixel-Phase2 | X | ALICE-ITS3 | X | | | | | | | | | | | | |
| 6-Dec-21 | 49 | CMS-Pixel-Phase2 | X | ATLAS-ITk-Pixels | X | | | | | | | | | | | | |
| 13-Dec-21 | 50 | | | ATLAS-ITk-Strips | X | | | HVMAPS | X | | | | | | | | |
| 20-Dec-21 | 51 | Babylaxo | | ATLAS-ITk-Strips | X | | | HVMAPS | X | | | | | | | | |
| 27-Dec-21 | 52 | Shutdown | | | | | | | | | | | | | | | |

Schedule

Booking/Usage Statistics

- 2021: Corona lockdown until mid-March
 - ... only campus-internal users until April 19
 - ... only national users until May 31
 - ... since June running normal, only few cancellations
- 316 user from 16 countries
Larger share of national users than usual

| Week | | TB21 | | TB22 | | TB24/1 | | TB24 | |
|-----------|---|--------|---------|-------|------------------|--------|--|------|--|
| | | DATARA | DURANTA | PCMAG | RESEARCH & FORMG | ADRIA | | | |
| 4-Jan-21 | 1 | | | | | | | | |
| 11-Jan-21 | 2 | | | | | | | | |



| | | | | | | | | |
|-----------|----|-------------------|---|-------------------|---|--|------------------|---|
| 23-Aug-21 | 34 | Telescope-Dev | X | | | | Telescope-Dev | X |
| 30-Aug-21 | | | | | | | | |
| 6-Sep-21 | 36 | BL4S | X | CALICE AHCAL | X | | ALICE-ITS3 | X |
| 13-Sep-21 | 37 | BL4S | X | TimePix3 | X | | ATLAS-ITk-Strips | X |
| 20-Sep-21 | 38 | CMS-Pixel-Phase2 | X | CMS Outer Tracker | X | | Mimosis | |
| 27-Sep-21 | 39 | CMS-Pixel-Phase2 | X | CMS Outer Tracker | X | | Telescope-Dev | X |
| 4-Oct-21 | 40 | CMS-Pixel-Phase2 | X | Mu3e-Tile | | | | |
| 11-Oct-21 | | | | | | | | |
| 18-Oct-21 | 42 | Tangerine | X | Telescope-Dev | X | | | |
| 25-Oct-21 | 43 | Tangerine | X | CALICE AHCAL | X | | | |
| 1-Nov-21 | 44 | CMS-Pixel-Phase2 | X | CALICE-SIW-ECAL | | | LUXE | X |
| 8-Nov-21 | 45 | CMS Outer Tracker | X | CALICE-SIW-ECAL | | | LUXE | X |
| 15-Nov-21 | 46 | CMS Outer Tracker | X | DMAPS | X | | TPEX | |
| 22-Nov-21 | 47 | CMS-Pixel-Phase2 | X | CMOS Strips | X | | TPEX | |
| 29-Nov-21 | 48 | CMS-Pixel-Phase2 | X | ALICE-ITS3 | X | | | |
| 6-Dec-21 | 49 | CMS-Pixel-Phase2 | X | ATLAS-ITk-Pixels | X | | | |
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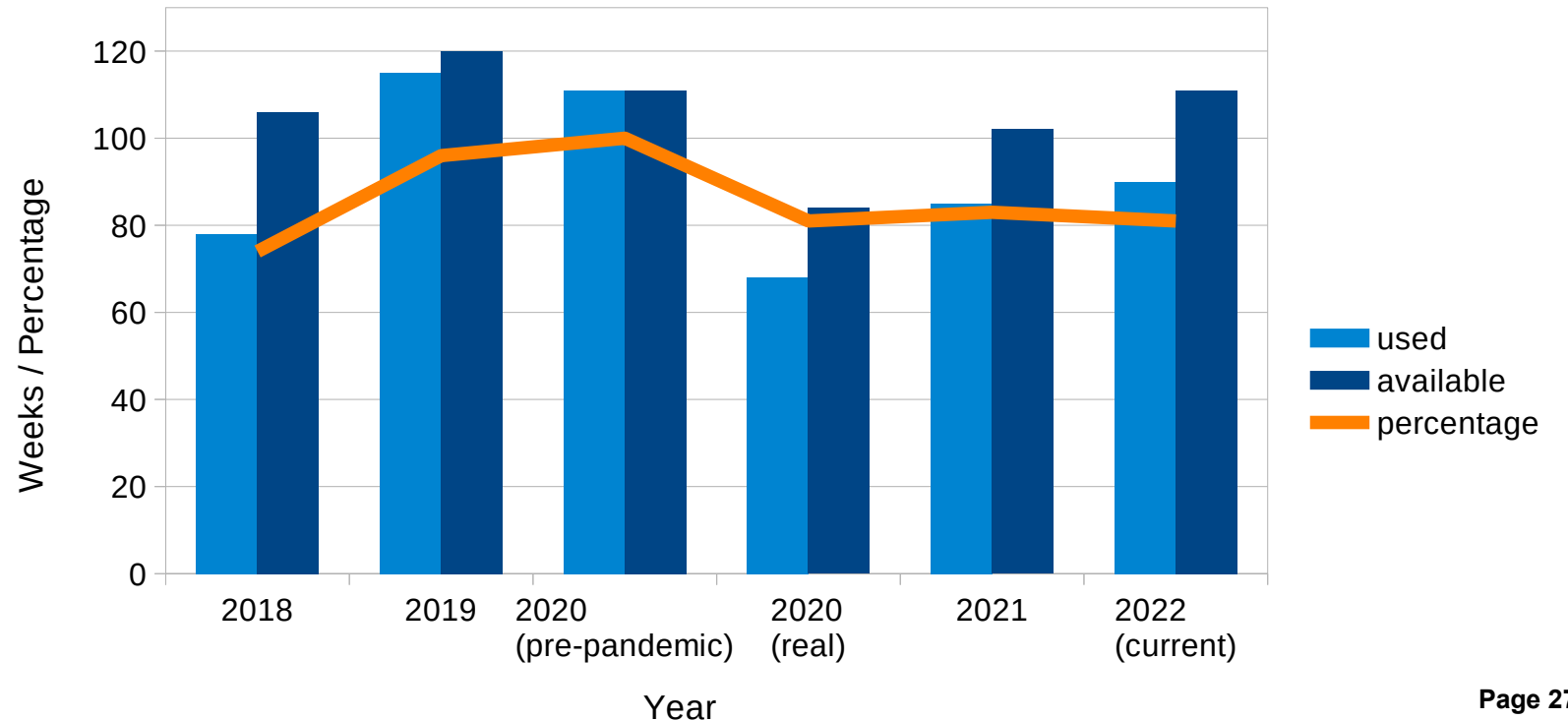
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- 316 user from 16 countries
Larger share of national users than usual
- Biggest fraction of users still had LHC background, but fell again below 50% → underlines the move towards production for HL-LHC upgrades
- 2022: pretty well booked, back to normal
 - First half year 49 / 63 weeks: 78%
 - Plan for second half 41 / 48 weeks: 85%
 → projection full year: 90 / 111 weeks: 81%
- Still a few slots open on first-come first-serve basis

| Week | TB21 | | TB22 | | TB24/1 | | TB24 | | | |
|-----------|------|----------------------|------|------------------|--------|------------------|------|-------------------|---|-----------|
| | | SATUR | | SUNDAY | PCMAG | RESEARCH & FORMG | | ADMIN | | |
| 3-Jan-22 | 1 | Shutdown | | | | | | | | |
| 10-Jan-22 | 2 | Shutdown | | | | | | | | |
| 17-Jan-22 | 3 | Shutdown | | | | | | | | |
| 24-Jan-22 | 4 | Shutdown | | | | | | | | |
| 31-Jan-22 | 5 | Shutdown | | | | | | | | |
| 7-Feb-22 | 6 | CMS-InnerTracker | X | HVMAPS | X | | | CALICE AHCAL | X | ANNOUNCED |
| 14-Feb-22 | 7 | CMS-InnerTracker | X | HVMAPS | X | | | Mimosis | | |
| 21-Feb-22 | 8 | | | | | | | Telescope-Dev | X | |
| 28-Feb-22 | 9 | ATLAS-HGTD | X | | | | | | | |
| 7-Mar-22 | 10 | ATLAS-HGTD | X | Aidainnova-WP3 | X | | | MONOPIX2 | X | |
| 14-Mar-22 | 11 | CMS-InnerTracker | X | | | | | ALICE-ITS3 | X | |
| 21-Mar-22 | 12 | CMS-InnerTracker | X | | | | | CALICE-SIW-ECAL | X | |
| 28-Mar-22 | 13 | | | | | | | CALICE-SIW-ECAL | X | |
| 4-Apr-22 | 14 | | | PSIMAPS | X | | | APIX3 | X | |
| 11-Apr-22 | 15 | | | | | | | | | |
| 18-Apr-22 | 16 | | | Telescope-Dev | X | | | | | |
| 25-Apr-22 | 17 | CMS-InnerTracker | X | Mu3e | X | | | CALICE AHCAL | X | |
| 2-May-22 | 18 | CMS-InnerTracker | X | Mu3e | X | | | TPEX | | |
| 9-May-22 | 19 | CMS Outer Tracker PS | X | MONOPIX2 | X | | | TPEX | | |
| 16-May-22 | 20 | STORM | | DSIPM | X | | | LHCb-ECAL | X | |
| 23-May-22 | 21 | STORM | | CMOS-Strips | X | | | LHCb-ECAL | X | |
| 30-May-22 | 22 | | | | | | | | | |
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| 13-Jun-22 | 24 | Tangerine | X | ATLAS-ITk-Strips | X | | | | | |
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| 27-Jun-22 | 26 | Tangerine | X | Belle-II CMOS | X | | | CMS Outer Tracker | X | |
| 4-Jul-22 | 27 | PSIMAPS | X | Belle-II CMOS | X | | | CMS Outer Tracker | X | |
| 11-Jul-22 | 28 | CMS-InnerTracker | X | Mu3e | X | | | | | |
| 18-Jul-22 | 29 | Summer Shutdown | | | | | | | | |
| 25-Jul-22 | 30 | Summer Shutdown | | | | | | | | |
| 1-Aug-22 | 31 | Summer Shutdown | | | | | | | | |
| 8-Aug-22 | 32 | Summer Shutdown | | | | | | | | |
| 15-Aug-22 | 33 | BL4S | X | | | | | TPEX | | |
| 22-Aug-22 | 34 | Summer Students | X | ATLAS-ITk-Strips | X | | | TPEX | | |
| 29-Aug-22 | 35 | Summer Students | X | ATLAS-ITk-Strips | X | | | Telescope-Dev | X | |
| 5-Sep-22 | 36 | | | | | | | | | |
| 12-Sep-22 | 37 | CMS Outer Tracker | X | CMS-InnerTracker | X | | | LUXE-ECAL | X | |
| 19-Sep-22 | 38 | BL4S | X | CMS-InnerTracker | X | | | | | |
| 26-Sep-22 | 39 | BL4S | X | Mu3e-Tile | X | | | LHCb-ECAL | X | |
| 3-Oct-22 | 40 | Telescope-Dev | X | Mu3e-Tile | X | | | LHCb-ECAL | X | |
| 10-Oct-22 | 41 | | | | | | | | | |
| 17-Oct-22 | 42 | DSIPM | X | SHIP LS-SBT | | | | | | |
| 24-Oct-22 | 43 | Mu3e | X | | | | | HEP for Teachers | X | |
| 31-Oct-22 | 44 | Mu3e | X | MONOPIX2 | X | | | Telescope-Dev | X | |
| 7-Nov-22 | 45 | Tangerine | X | MONOPIX2 | X | | | | | |
| 14-Nov-22 | 46 | | | | | | | | | |
| 21-Nov-22 | 47 | CMS Outer Tracker | X | ATLAS-ITk-Strips | X | | | PSIMAPS | X | |
| 28-Nov-22 | 48 | CMS-InnerTracker | X | ATLAS-ITk-Strips | X | | | | | |
| 5-Dec-22 | 49 | CMS-InnerTracker | X | | | | | ALICE-ITS3 | | |
| 12-Dec-22 | 50 | CEPC Vertex | X | HVMAPS | X | | | ELAD | X | |
| 19-Dec-22 | 51 | CEPC Vertex | X | HVMAPS | X | | | ELAD | X | |
| 26-Dec-22 | 52 | Shutdown | | | | | | | | |

Schedule

Booking/Usage Statistics over the Years

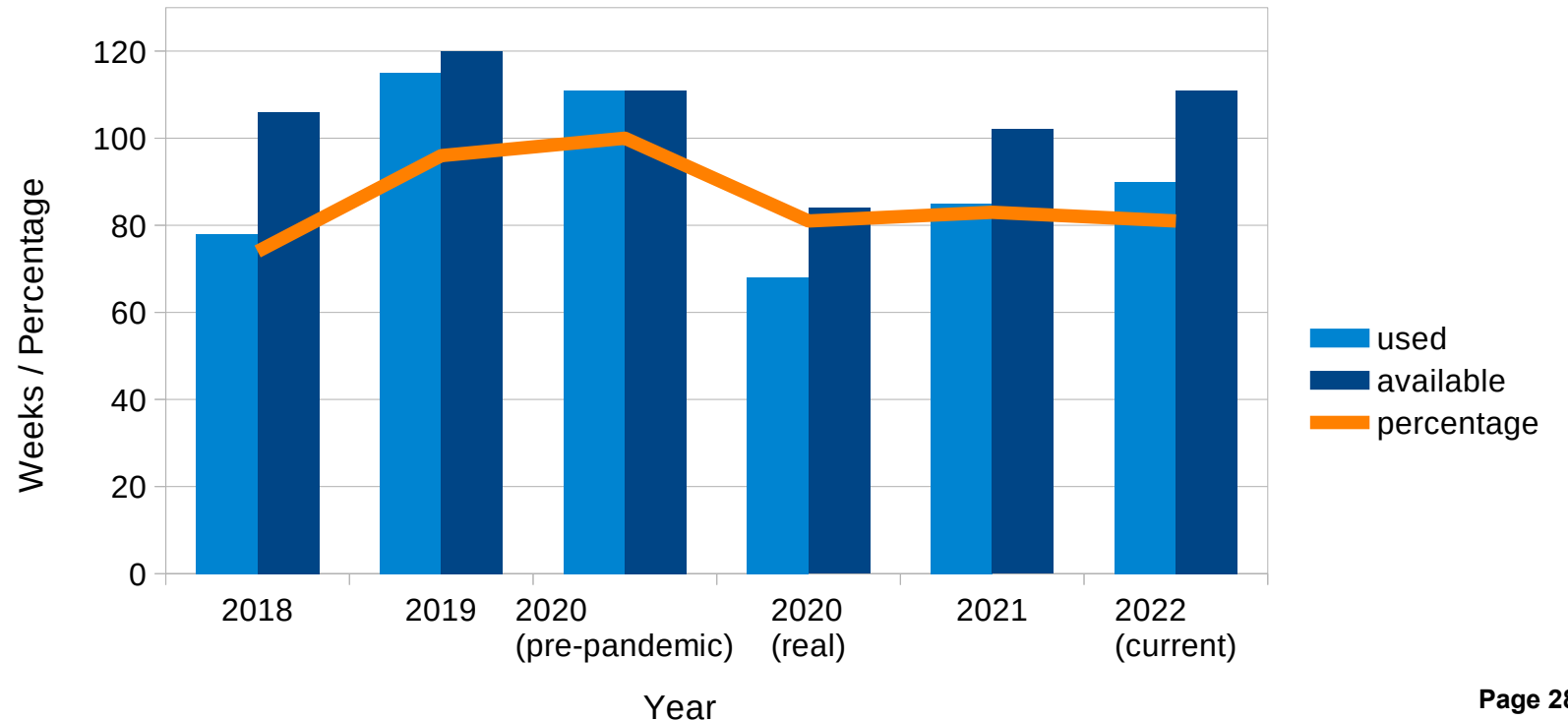
| Year | 2018 | 2019 | 2020 | 2021 | 2022 |
|---------------------|---------------|-------------|--------------------|-----------------|--------|
| Weeks (used/avail.) | 78/106 | 115/120 | 111/111 → 68/84 | 85/102 | 90/111 |
| Usage [%] | 74 | 96 | 100 → 81 | 83 | 81 |
| | new interlock | CERN TB off | | Corona shutdown | |
| Users / Countries | 283 / 17 | 702 / 31 | 345 / 27 | 316 / 16 | |



Schedule

Booking/Usage Statistics over the Years

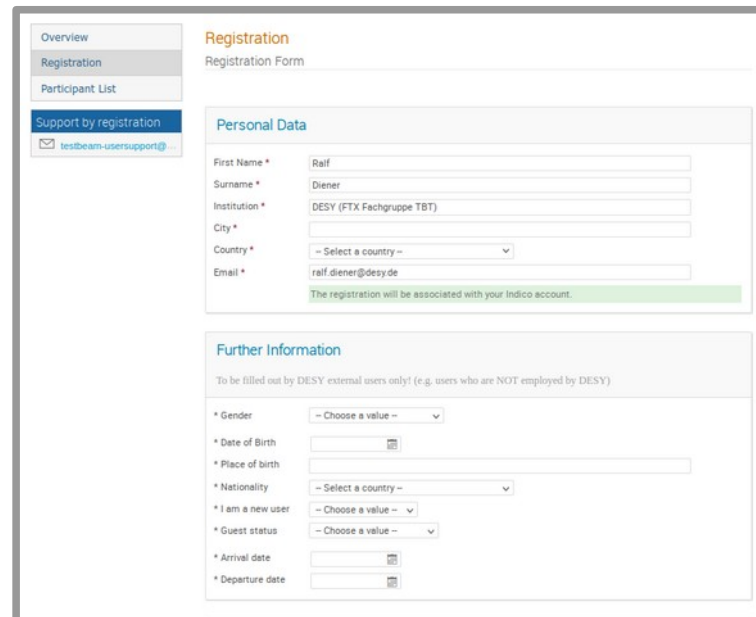
| Year | 2018 | 2019 | 2020 | 2021 | 2022 |
|---------------------|---------------|-------------|--------------------|-----------------|--------|
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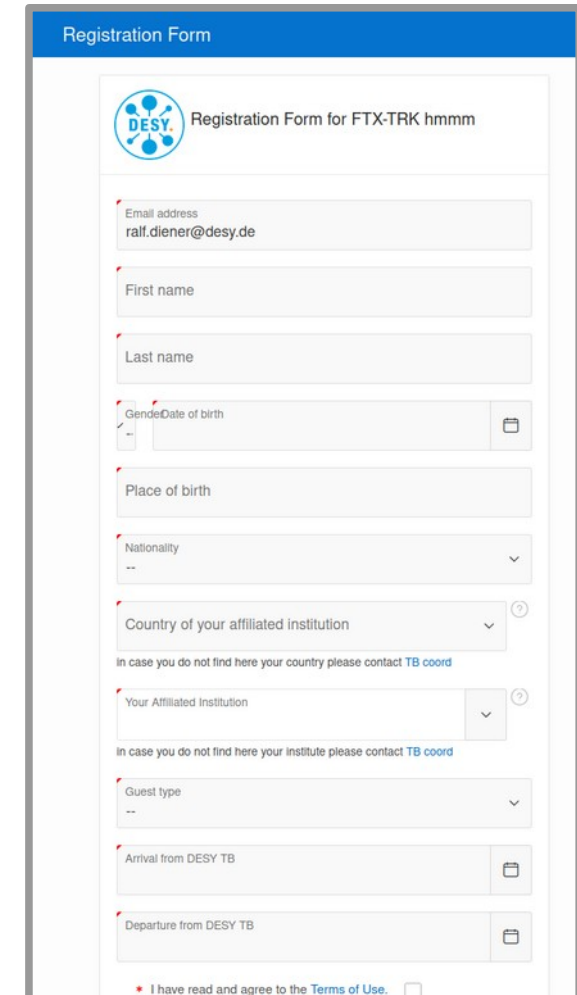
Registration

System Change

- New registration system being put into production spring 2022
- Switching from Indico- to Apex-based system
- Processes optimized for beam time booking and user registration
- More automation and direct connection to IAM (DESY Identity and Access Management system)
- Statistics for reporting integrated (before: Excel sheet)
- Status:
 - Working very well, here and there a little polishing ongoing (mostly internal automation)



The screenshot shows the 'Registration Form' in the Indico system. It features a sidebar with navigation options: Overview, Registration, Participant List, Support by registration, and a contact email. The main form is divided into 'Personal Data' and 'Further Information' sections. The 'Personal Data' section includes fields for First Name (Raif), Surname (Diener), Institution (DESY (FTX Fachgruppe TBT)), City, Country (a dropdown menu), and Email (raif.diener@desy.de). A green message states: 'The registration will be associated with your Indico account.' The 'Further Information' section contains fields for Gender, Date of Birth, Place of Birth, Nationality, 'I am a new user' status, Guest status, Arrival date, and Departure date.



The screenshot shows the 'Registration Form' in the new Apex-based system. It features a blue header with the title 'Registration Form' and a sub-header 'Registration Form for FTX-TRK hmmm'. The form includes a DESY logo and a list of input fields: Email address (raif.diener@desy.de), First name, Last name, Gender, Date of birth, Place of birth, Nationality, Country of your affiliated institution, Your Affiliated Institution, Guest type, Arrival from DESY TB, and Departure from DESY TB. A checkbox at the bottom indicates 'I have read and agree to the Terms of Use.' A note below the 'Country of your affiliated institution' field reads: 'In case you do not find here your country please contact TB coord'.

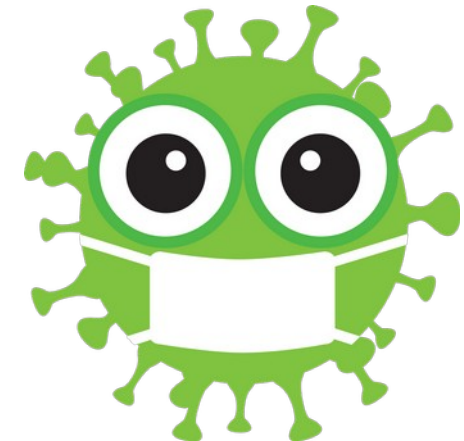
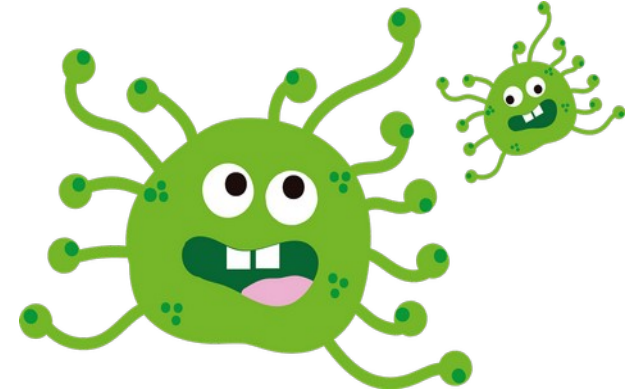
Big thanks to Natalia Potylitsina-Kube and Christine Apfel for their effort

Coronavirus/COVID-19

Specific Rules still in Place



- Same rules at all beam lines at DESY (photon science at Petra III, Flash and the test beam)
- Regularly updated, current set in-a-nutshell:
 - Mandatory PCR test and signature at beam time start
 - Limited room occupancy in the huts
 - Masks and regular self-testing strongly recommended
 - Keep team size as small as possible, registration 1 week in front
- Up-to-date rules at https://particle-physics.desy.de/test_beams_at_desy/coronavirus_covid_19/



Outreach and Education

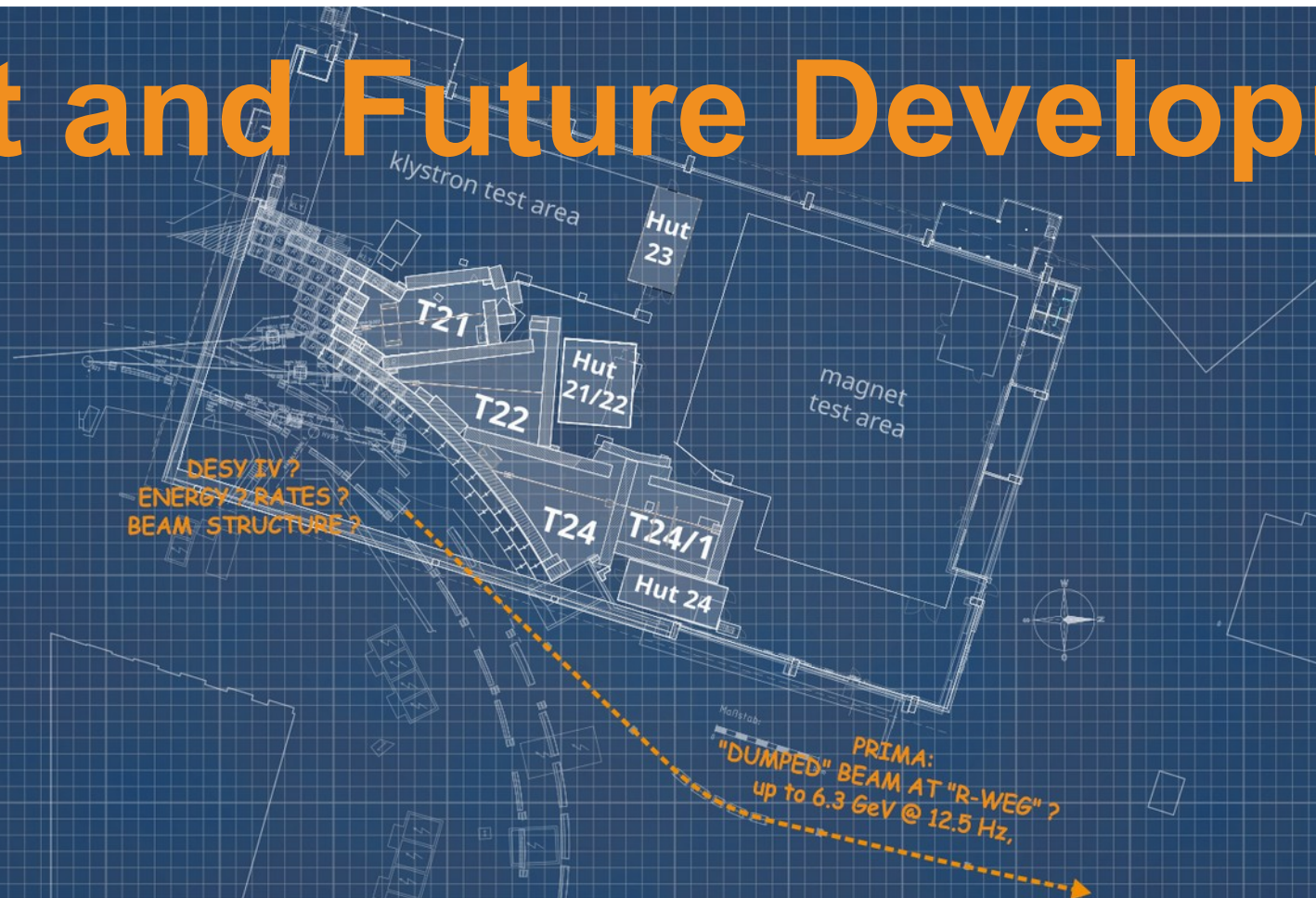
Beam Line 4 Schools

- In 2021, competition held for third time at the DESY beam lines, this time again fully in person
 - Team: “Teomiztli”
 - Escuela Nacional Preparatoria „Plantel 2“ (Mexico-City, Mexico)
 - Topic: Cherenkov Radiation in glycerol and water
 - Team: “EXTRA”
 - Liceo Scientifico Statale „A. Scacchi“ (Bari, Italy)
 - Topic: Transition Radiation (varying radiator, distance, energy)
- Programme and presentations available: <https://indico.cern.ch/event/1048101/>
- In 2022: participation of 2000 high-school students in 304 teams from 58 countries
 - In addition to two student teams at CERN, one team at DESY for 2 weeks in September
 - Winning teams will be announced soon



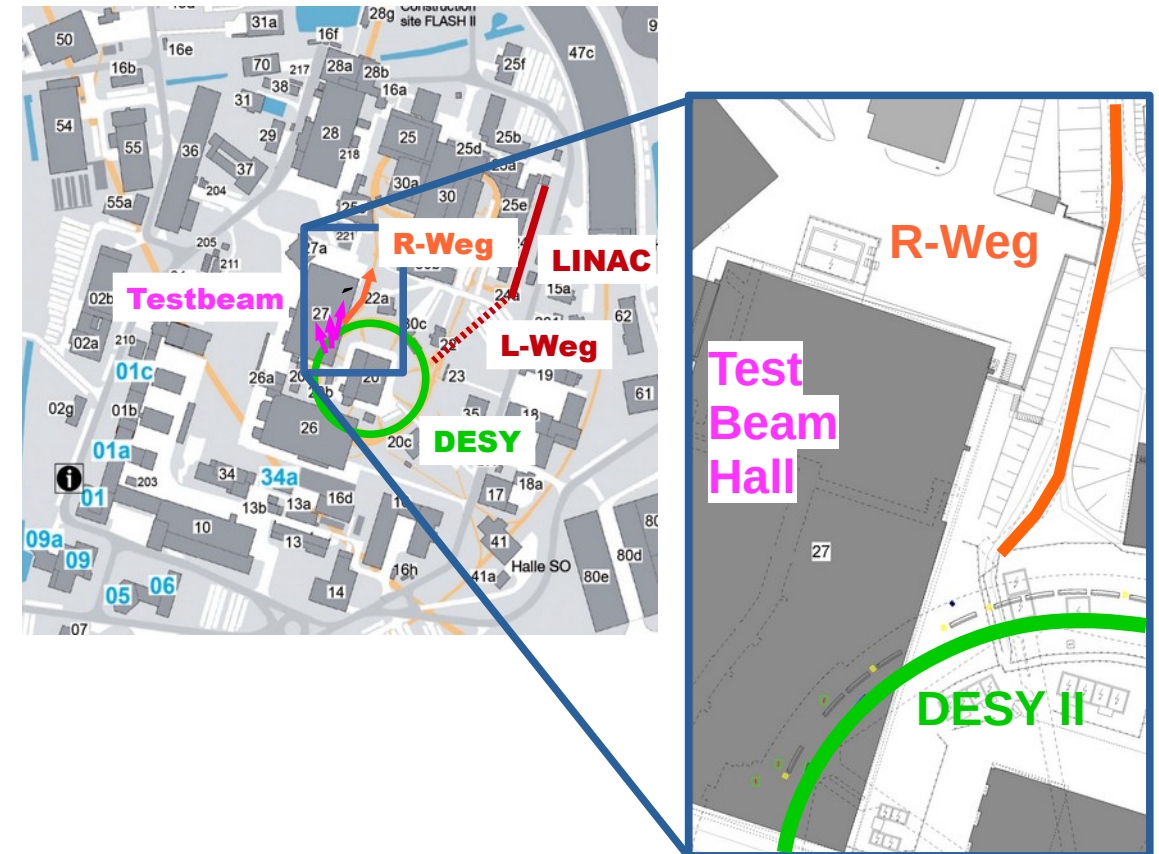
Outlook

Current and Future Developments



Direct Electron-Beam Line

- PRIMA: **PRIM**ary-beam test **A**rea in the “R-Weg” using the (dumped) direct DESY II electron beam
- Use cases
 - High intensity electron beam
 - Possibly secondary pions / muons
 - Irradiation facility, electromagnetic showers
- Status:
 - Commissioning started October 2021
 - Details in following [presentation by D. Kim](#)
- Keep in mind, area not suited for user operations: small, limited escape routes, no user hut ...
 - if tests successful, we need to find new solution/location



Test Beam Facility in Petra IV times

- Upgrade PETRA III → PETRA IV:
 - New booster synchrotron *DESY IV*
- What will happen to DESY II Test Beam facility?
 - General consensus:
test beam facility is essential
and has to be preserved
 - Options being discussed:
 - include test beams in DESY IV
 - keep DESY II running
 - include test beam lines in Petra IV
 - develop dedicated plasma linac
- Project timeline has been adjusted: shutdown 2027 → 2029



Closing Remarks

Web, Publication, Acknowledgments and TA

- More information can be found on our web page: testbeam.desy.de
- And in the reference publication:
 - *"The DESY II test beam facility"* <https://doi.org/10.1016/j.nima.2018.11.133> , NIMA, Volume 922, 1.4.2019, Pages 265-286
- Please include this acknowledgment in publications, presentations etc. based on data from DESY test beam:
 - *"The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF)."*
 - Also, don't forget the AIDA acknowledgments where applicable:
 - AIDA 2020: *"This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168."*
 - AIDA Innova: *"This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101004761."*
- Transnational access is coming back: EURO-LABS WP4 - HEP Detectors
 - In preparation, grant agreement signed, planned start September 1st

