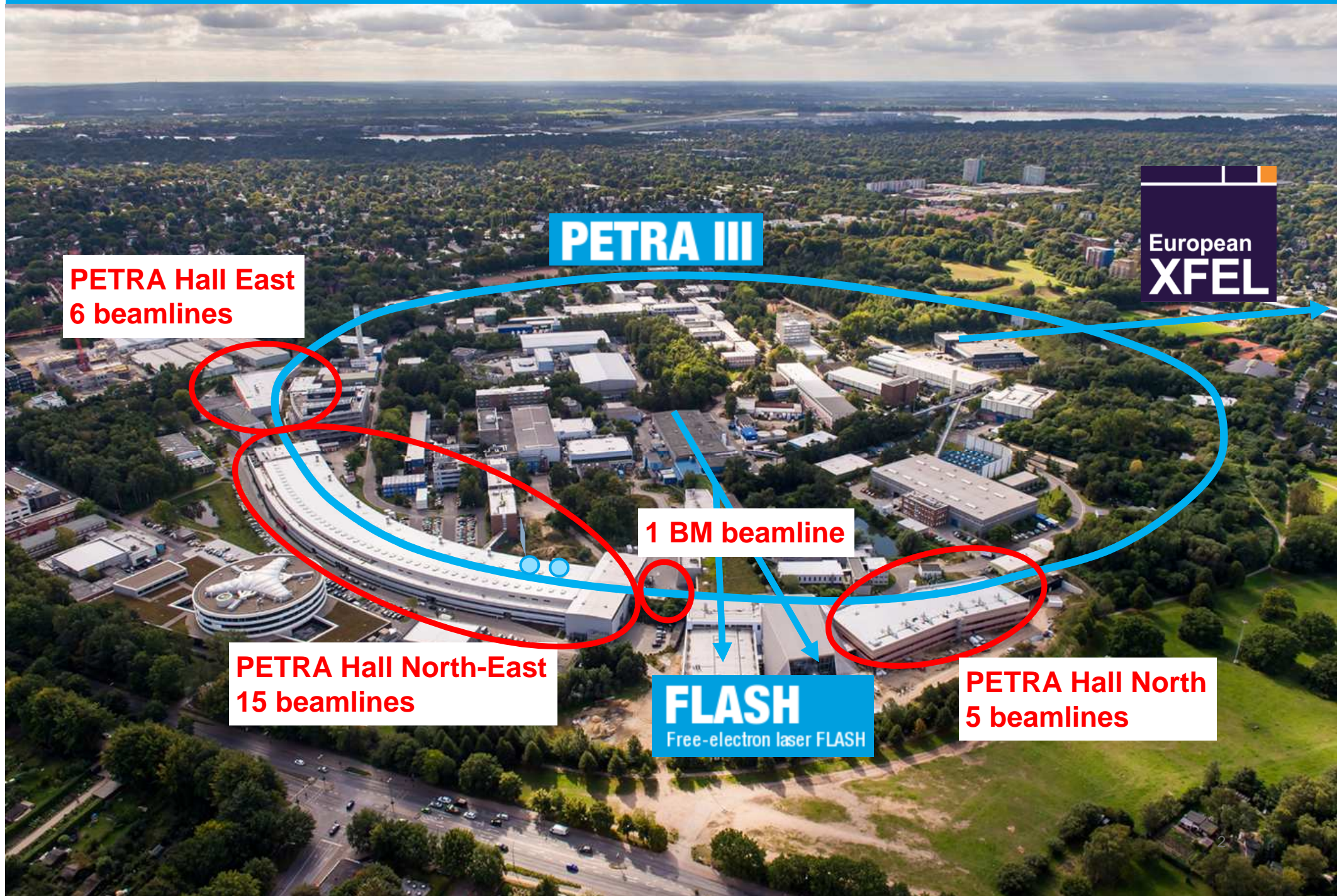


Operation of Beamlines at Petra III: Structure & Challenges

O.H Seeck



Overview of X-ray Sources on Science Campus Hamburg



PETRA III: DESY's Brilliant Hard X-Ray Source



particle energy: **6 GeV**
stored current: **100 mA (top-up)**
emittance: **1.3 nmrad**
circumference: **2304 m**
of undulators: **25 (incl. canted)**
of experiments: **50**
X-ray wavelength: **10 – 0.02 Å**
annual operation: **5000 h (4000h now)**
operation modus: **timing & continuous**
192ns 8ns spacing btw bunches

- built in 1978 (as particle physics experiment)
- rebuilt as a synchrotron radiation source starting in 2007
- user operation since 2010
- upgrade: March 2014 - April 2015
- Jan-March & Jul-Sept 2018 : Shutdown for frontend and undulator work

PETRA III : 3 Halls with 18 Beamlines active

Operating Beamlines

| | | | | | |
|-------|---------------------------------------|----------|-----|---------------|------------------|
| P01 | High Resolution Dynamics | 5– 70 | keV | U32-10m | high β |
| P02.1 | High Resolution Powder Diffraction | 60 | keV | U23-2m | high β |
| P02.2 | Extreme Conditions | 9– 77 | keV | U23-2m | high β |
| P03 | SAXS/GISAXS (micro & nano focus) | 8 – 23 | keV | U29-2m | high β |
| P04 | Variable Polarization XVUV | 0.25– 3 | keV | UE65-5m | high β |
| P05 | Imaging & Tomography (HZG) | 5 – 50 | keV | U29-2m | low β |
| P06 | Micro- and Nano Probe | 2.4 –100 | keV | U32-2m | low β |
| P07 | High Energy Materials Sciences (HZG) | 50–200 | keV | U29-2m/U21-4m | high/low β |
| P08 | High Resolution Diffraction | 5 – 30 | keV | U29-2m | high β |
| P09 | Resonant Scattering & Diffraction | 2.7 – 50 | keV | U32-2m | high β |
| P10 | Coherence Applications | 4 – 25 | keV | U29-2m | low β |
| P11 | Bio Imaging & Diffraction | 2.4 – 30 | keV | U32-2m | high β |
| P12 | Bio SAXS (EMBL) | 4 – 20 | keV | U29-2m | high β |
| P13 | Macromolecular Crystallography (EMBL) | 5 – 20 | keV | U29-2m | high β |
| P14 | Macromolecular Crystallography (EMBL) | 5 – 20 | keV | U29-2m | high β |
| P24 | Chemical Crystallography | 8, 15-45 | keV | U29-2m | high β |
| P64 | Time-Resolved- & Bio- XAS | 4 – 44 | keV | U32-2m | high β |
| P65 | High-Energy XAS | 4 – 44 | keV | U32-0.35m | high β |

Beamlines under Commissioning

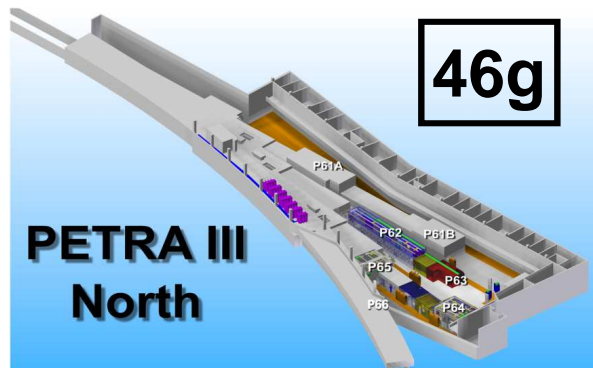
| | | |
|-----|-------------------------------|---------------|
| P21 | High Energy Materials Science | 1st beam 2018 |
| P22 | Nano X-ray Spectroscopy | 1st beam 2017 |
| P23 | Nano X-ray Diffraction | 1st beam 2017 |

Beamlines under Construction

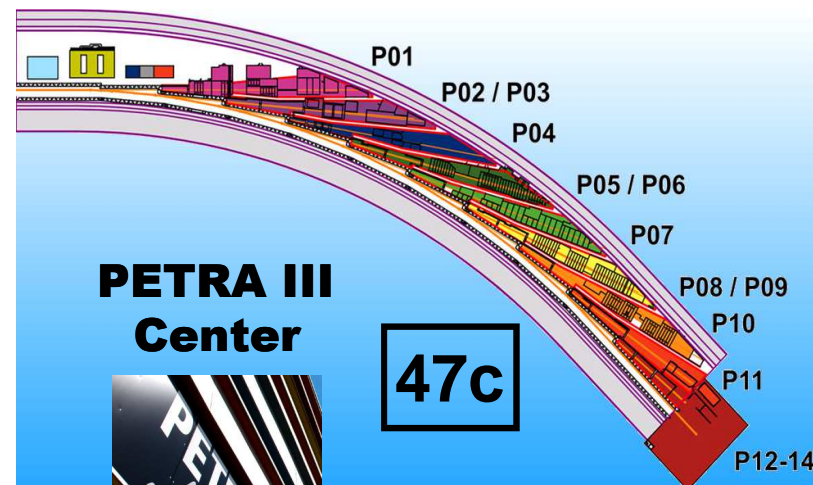
| | |
|-----|---|
| P61 | High Energy Engineering Materials Science |
| P62 | SAXS, ASAXS |
| P66 | Time Resolved Luminescence |

undefined slots

| | |
|-----|--------|
| P25 | t.b.d. |
| P63 | t.b.d. |



Paul Peter Ewald



PETRA III
Center



Max von Laue



Ada Yonath



PETRA III
East

PETRA III 2017: Machine

PETRA III

Operation period 2017

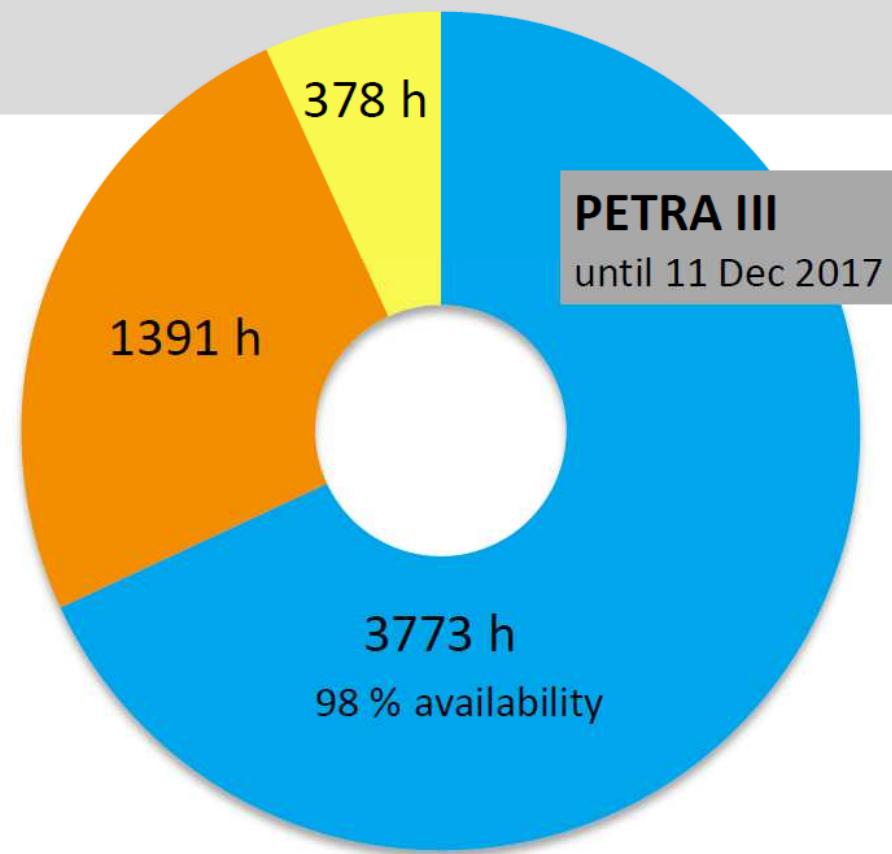
| | User beamtime | Machine studies and test runs | Maintenance | Shutdown |
|-----------------------------|---------------|-------------------------------|-------------|----------|
| 1 Jan – 11 Dec | 3773 h | 1391 h | 378 h | |
| planned for 12 Dec – 31 Dec | 228 h | 24 h | 0 h | |
| | | | | 2966 h |

run periods:
10 Apr – 6 Jul
17 Aug – 22 Dec

Availability: 98 %

Mean Time between failure: 47 h

- User beamtime
- Machine studies/Test runs
- Maintenance



Aim is to deliver 5000 h / year for X-ray users

- ➔ 4000 h for users with reviewed applications
- ➔ 500 h for commissioning
- ➔ 500 h for in-house science of BL staff

Other DESY groups don't count as „in-house“

PETRA III 2017: International user facility

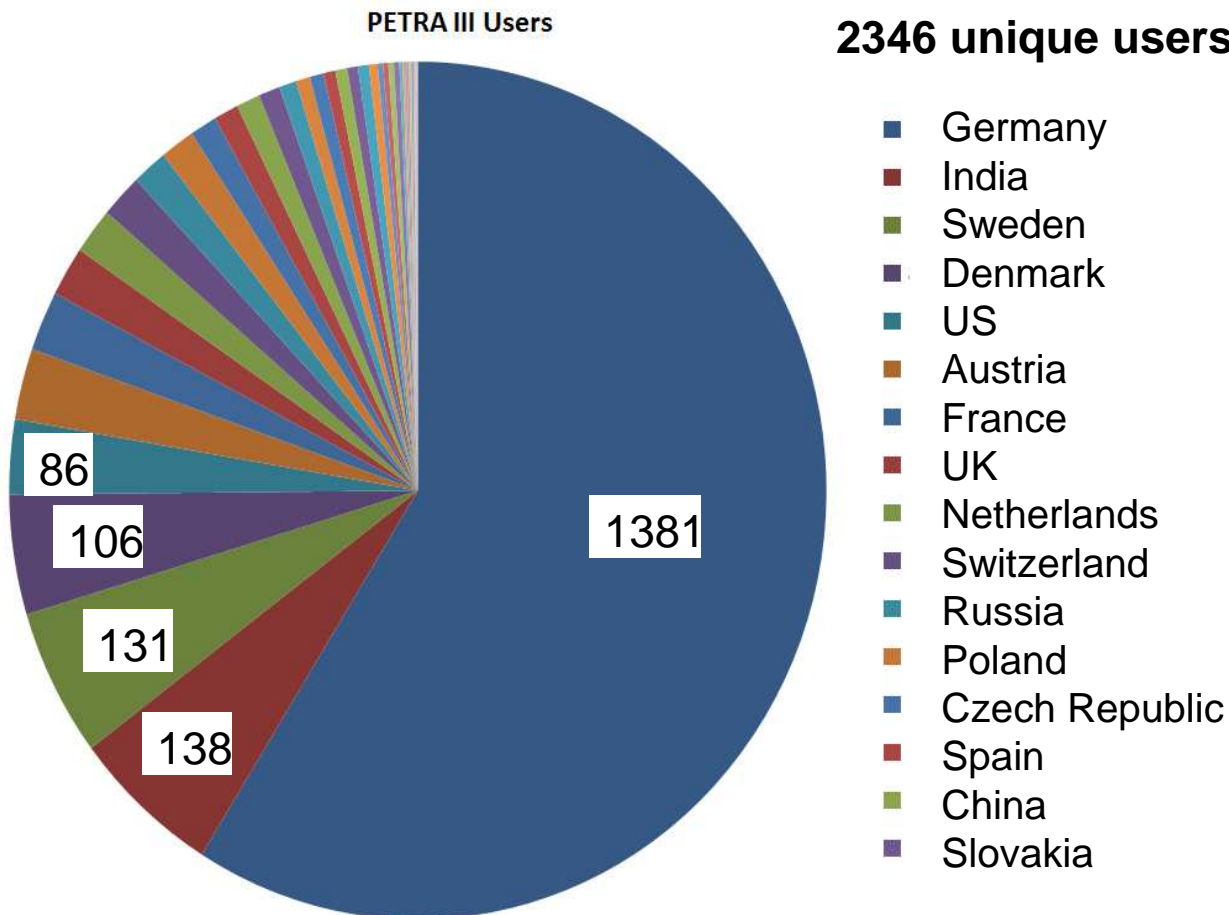
**Users (also internal) submit proposals at 2 calls a year : 1st March & 1st September
~ 500 proposals each call**

Scheduling of beamtime is done according to result of the proposal review

Overbooking of BLs P01-P11,P64,P65

| | | | |
|---------|-----|---------|-----|
| maximum | 5.0 | average | 2.6 |
| minimum | 1.8 | | |

- Beamtime and support is free
- Travel and accommodation reimbursement:
 - ➔ German users always
 - ➔ European users via CALIPSO+



Hostel on site available

- approx. 70 rooms & bath
- single room 31 EUR
- double room 39 EUR (not guaranteed availability)
- canteen available (not on holidays! => has to be changed)

Organizational Issues

DESY Organization with respect to PETRA III

Director General

Director 'Photon Science'

- Beamlines at FLASH
- Beamlines at PETRA
- Nanolab
-

service

- Undulators
- Optics & Vacuum
- Computing
- Infrastructure

Director 'Accelerators'

- Injection Linac
- Booster
- PETRA III
- FLASH
- XFEL accelerator

service

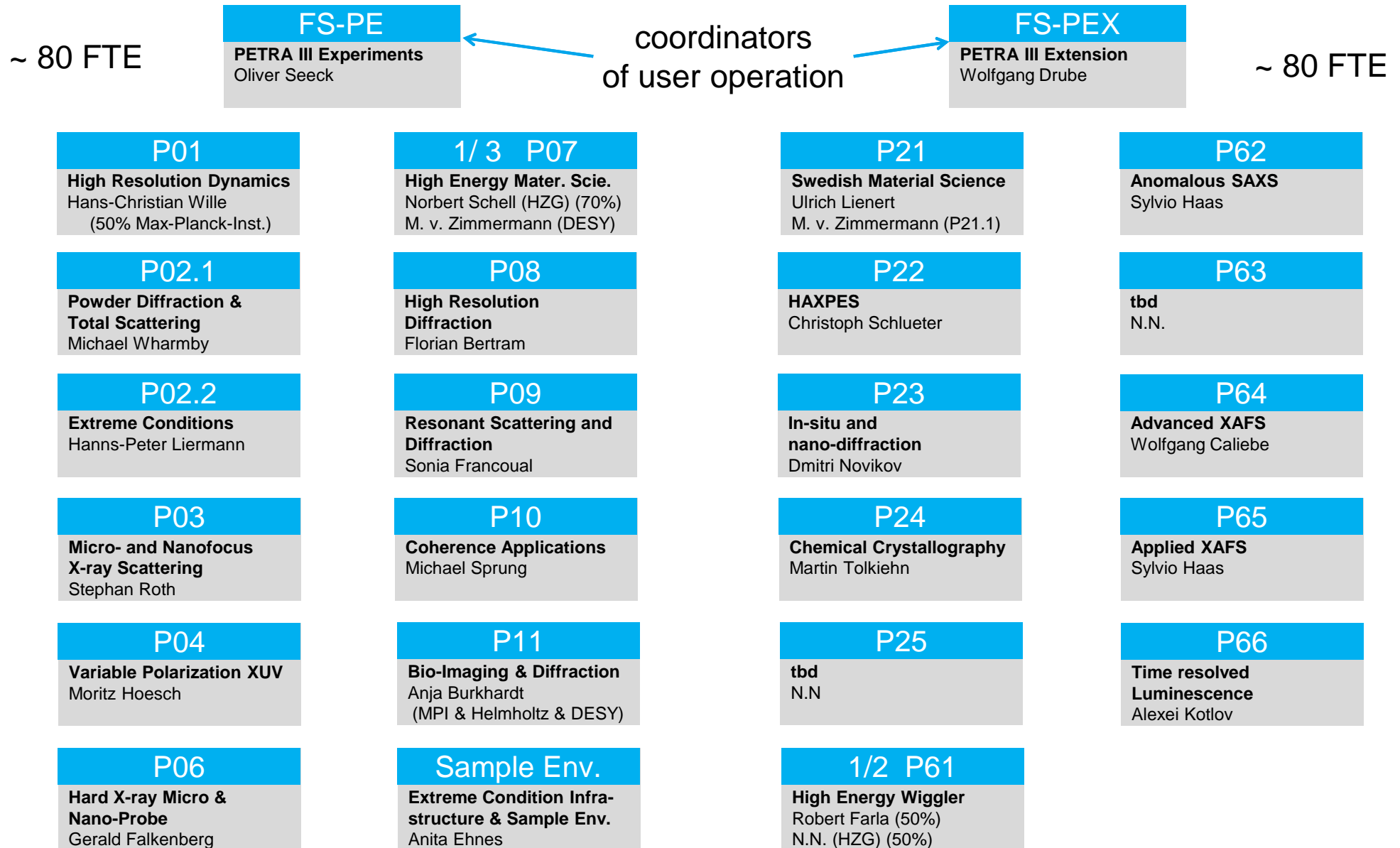
- Air conditioning
- Electric
- Survey
- Water + Cooling water
- Cryogenics
- Construction
-

more directors

Machines and beamlines are part of DIFFERENT divisions
→ unique situation → needs a lot of communications

PETRA III Organization

P05, 2/3 P07, 1/2 P61 : HZG
P12, P13, P14 : EMBL



After finalizing „PETRA Extension Project“
the two groups will be reorganized according to topics



Beamline Organization

Staff per beamline

| | |
|------------------------------|------------------------------------|
| Beamline Manager | (permanent Scientist, Team leader) |
| Beamline Scientist | (permanent Scientist) |
| Beamline Engineer/Technician | (permanent) |
| Beamline Scientist/PostDoc1 | (temporary) |
| Beamline Scientist/PostDoc2 | (temporary) |

Beamline Manager can apply for additional grants (internal/external) for additional personal

e.g. P01 has significant grants from Max-Planck Institutions:

| | |
|-------------|-------------|
| PostDoc3 | (temporary) |
| PostDoc4 | (temporary) |
| Engineer | (temporary) |
| Technician | (temporary) |
| PhD Student | (temporary) |

→ in summary 10 team members

Personal is needed to operate the beamlines successfully:

- typically 3-4 days duration of one user beamtime
- sometimes only 8 h for one user beamtime
- remote access not fully implemented yet

Also PostDocs do
user support

How is information transported

Communication

weekly Team / Beamline meeting

weekly meeting of all Teams / Beamlines for **operational issues**
+ guests from the accelerator division

weekly meeting of accelerator staff for **operational issues**
+ guests from the beamlines

weekly meeting of Team leader / Beamline managers for **computing issues**

weekly meeting of Beamline engineers & technicians for **technical issues**

bi-weekly meeting of Team leader / Beamline managers for **strategic issues**

annual 3-days photon science users meeting ~1000 users
exchange of knowledge

annual 2-days meeting of all internal PETRA III staff for
exchange of knowledge concerning operation, development and science

PETRA III Organization



Today's PETRA III staff

**at the „PETRA days“ →
2 days event specialized to PETRA III operation, development and science issues**

Beamtime scheduling

Organization of Beamtime

| March 2018 | April 2018 | May 2018 | June 2018 | 2018 2018 | July 2018 | August 2018 | September 2018 | October 2018 | November 2018 | December 2018 |
|----------------|--------------|-----------|------------|-----------|------------------|---------------|----------------|--------------|---------------|---------------|
| IB | multi | 40 | multi | 1 | 40 | f61 cc # VN N | 40 | multi | 40 | multi |
| IB | multi | 40 no MDT | multi | 2 | 40 | f61 cc # VN N | 40 | multi | 40 | multi |
| | multi | 40 | multi | 3 | 40 | f61 cc # VN N | 40 MTRC | multi no MDT | 40 | multi |
| | MDT # | 40 | # | 4 | MDT # | | 40 MTRC | multi | 40 | multi |
| IB | multi | 40 | # | 5 | multi | | 40 MTRC no MD | multi | 40 | MDT |
| IB | multi | 40 | 40 | 6 | multi | f61 cc # | 40 MTRC | multi | 40 | multi |
| IB | multi | 40 | 40 | 7 | multi | f61 cc # | 40 MTRC | multi | MDT # | multi |
| IB | multi | 40 | 40 | 8 | multi | f61 cc # | 40 | # | 40 | multi |
| IB | multi | MDT # | 40 | 9 | multi | f61 cc # | 40 | # | 40 | multi |
| | multi | multi | 40 SRI/18 | 10 | multi | f61 cc # | 40 | # | 40 | multi |
| | MDT | multi | 40 SRI/18 | 11 | MDT | | 40 | # | 40 | multi |
| d IB | 40 | multi | 40 SRI/18 | 12 | multi | | MDT # | | # | MDT # |
| d IB | 40 | multi | MDT SRI/18 | 13 | multi | f61 cc-IP61 # | 40 | multi | # | multi |
| d IB | 40 | multi | 40 SRI/18 | 14 | multi | f61 cc-IP61 # | 40 | multi | # | multi |
| e so seM multi | 40 | multi | 40 SRI/18 | 15 | multi | IB | 40 | multi | # | multi |
| e so seM multi | 40 | MDT | 40 | 16 | multi | IB | 40 | multi | # | multi |
| multi | 40 | multi | 40 | 17 | multi | IB | 40 | MDT | 40 | multi |
| multi | MDT # IP21v | multi | 40 | 18 | V61 K61 f61 cc # | | 40 | multi | 40 | multi |
| e so seM multi | 40 | multi | 40 | 19 | V61 K61 f61 cc # | | MDT | multi | 40 | multi no MD |
| e so seM multi | 40 | multi | MDT # | 20 | V61 K61 f61 cc # | IB | 40 | multi | 40 | multi |
| MDT # | 40 | multi | 40 | 21 | | IB | 40 | multi | MDT | Shutdown |
| e so seM multi | 40 | multi | 40 | 22 | | IB | 40 | multi | 40 | Shutdown |
| e so seM multi | IP21 # | MDT # | 40 | 23 | V61 K61 f61 cc # | IB | 40 | multi | 40 | Shutdown |
| multi | IP21 # | multi | 40 | 24 | V61 K61 f61 cc # | IB | 40 | MDT # | 40 | Shutdown |
| multi | IP21 # | multi | 40 | 25 | f61 cc # VN N | | 40 | 40 | 40 | Shutdown |
| seM multi | IP21 Prüfung | multi | 40 | 26 | f61 cc # VN N | | MDT # | 40 | 40 | Shutdown |
| seM multi | | multi | MDT | 27 | f61 cc # VN N | IB | multi | 40 | 40 | Shutdown |
| MDT | 40 | multi | 40 | 28 | | IB | multi | 40 | MDT # | Shutdown |
| seM multi | 40 | multi | 40 | 29 | | dd e 40 | multi | 40 | multi | Shutdown |
| multi | 40 | MDT | 40 | 30 | f61 cc # VN N | dd e 40 | multi | 40 | multi | Shutdown |
| multi | | multi | | 31 | f61 cc # VN N | dd e 40 | | MDT | | Shutdown |
| 5 | 20 | 27 | 24 | | 15 | 0 | 25 | 21 | 20 | 18 |
| | | | | | 91 | | | | | 84 |

Two run periods

every 5 weeks → service week for machine/beamline maintenance

every Wednesday → service day for immediate repairs

two operation modes (timing & continuous)

Organization of Beamtime

◀ PETRA CALENDAR OF P02.1 FROM JANUARY TO DECEMBER 2015 ▶

CLICK ON ONE CELL TO SCHEDULE IT

| W | May | W | June | W | July | W | August | W | September | W | October | W | November |
|--------|-----|--------|------|--------|------|--------|--------|--------|-----------|--------|---------|--------|----------|
| 18 Fri | 1 | 23 Mon | 1 | 27 Wed | 1 | 31 Sat | 1 | 36 Tue | 1 | 40 Thu | 1 | 44 Sun | 1 |
| Sat | 2 | Tue | 2 | Thu | 2 | Sun | 2 | Wed | 2 | Fri | 2 | 45 Mon | 2 |
| Sun | 3 | Wed | 3 | Fri | 3 | 32 Mon | 3 | Thu | 3 | Sat | 3 | Tue | 3 |
| 19 Mon | 4 | Thu | 4 | Sat | 4 | Tue | 4 | Fri | 4 | Sun | 4 | Wed | 4 |
| Tue | 5 | Fri | 5 | Sun | 5 | Wed | 5 | Sat | 5 | 41 Mon | 5 | Thu | 5 |
| Wed | 6 | Sat | 6 | 28 Mon | 6 | Thu | 6 | Sun | 6 | Tue | 6 | Fri | 6 |
| Thu | 7 | Sun | 7 | Tue | 7 | Fri | 7 | 37 Mon | 7 | Wed | 7 | Sat | 7 |
| Fri | 8 | 24 Mon | 8 | Wed | 8 | Sat | 8 | Tue | 8 | Thu | 8 | Sun | 8 |
| Sat | 9 | Tue | 9 | Thu | 9 | Sun | 9 | Wed | 9 | Fri | 9 | 46 Mon | 9 |
| Sun | 10 | Wed | 10 | Fri | 10 | 33 Mon | 10 | Thu | 10 | Sat | 10 | Tue | 10 |
| 20 Mon | 11 | Thu | 11 | Sat | 11 | Tue | 11 | Fri | 11 | Sun | 11 | Wed | 11 |
| Tue | 12 | Fri | 12 | Sun | 12 | Wed | 12 | Sat | 12 | 42 Mon | 12 | Thu | 12 |
| Wed | 13 | Sat | 13 | 29 Mon | 13 | Thu | 13 | Sun | 13 | Tue | 13 | Fri | 13 |
| Thu | 14 | Sun | 14 | Tue | 14 | Fri | 14 | 38 Mon | 14 | Wed | 14 | Sat | 14 |
| Fri | 15 | 25 Mon | 15 | Wed | 15 | Sat | 15 | Tue | 15 | Thu | 15 | Sun | 15 |
| Sat | 16 | Tue | 16 | Thu | 16 | Sun | 16 | Wed | 16 | Fri | 16 | 47 Mon | 16 |
| Sun | 17 | Wed | 17 | Fri | 17 | 34 Mon | 17 | Thu | 17 | Sat | 17 | Tue | 17 |
| 21 Mon | 18 | Thu | 18 | Sat | 18 | Tue | 18 | Fri | 18 | Sun | 18 | Wed | 18 |
| Tue | 19 | Fri | 19 | Sun | 19 | Wed | 19 | Sat | 19 | 43 Mon | 19 | Thu | 19 |
| Wed | 20 | Sat | 20 | 30 Mon | 20 | Thu | 20 | Sun | 20 | Tue | 20 | Fri | 20 |
| Thu | 21 | Sun | 21 | Tue | 21 | Fri | 21 | 39 Mon | 21 | Wed | 21 | Sat | 21 |
| Fri | 22 | 26 Mon | 22 | Wed | 22 | Sat | 22 | Tue | 22 | Thu | 22 | Sun | 22 |
| Sat | 23 | Tue | 23 | Thu | 23 | Sun | 23 | Wed | 23 | Fri | 23 | 48 Mon | 23 |
| Sun | 24 | Wed | 24 | Fri | 24 | 35 Mon | 24 | Thu | 24 | Sat | 24 | Tue | 24 |
| 22 Mon | 25 | Thu | 25 | Sat | 25 | Tue | 25 | Fri | 25 | Sun | 25 | Wed | 25 |
| Tue | 26 | Fri | 26 | Sun | 26 | Wed | 26 | Sat | 26 | 44 Mon | 26 | Thu | 26 |
| Wed | 27 | Sat | 27 | 31 Mon | 27 | Thu | 27 | Sun | 27 | Tue | 27 | Fri | 27 |
| Thu | 28 | Sun | 28 | Tue | 28 | Fri | 28 | 40 Mon | 28 | Wed | 28 | Sat | 28 |
| Fri | 29 | 27 Mon | 29 | Wed | 29 | Sat | 29 | Tue | 29 | Thu | 29 | Sun | 29 |
| Sat | 30 | Tue | 30 | Thu | 30 | Sun | 30 | Wed | 30 | Fri | 30 | 49 Mon | 30 |
| Sun | 31 | Fri | 31 | 36 Mon | 31 | | | Sat | 31 | | | | |

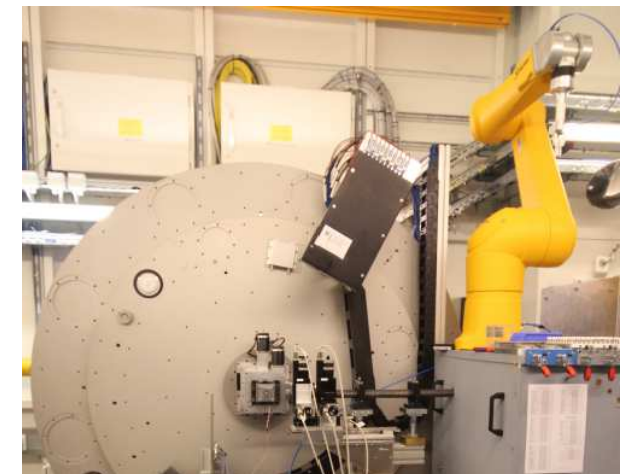
„High Through-put” beamline

e.g. „Powder Diffraction
and Total Scattering BL P02.1“

1-4 days of beamtime

- difficult scheduling
- sometimes new users at weekend
- demanding user support

Have installed robot now
for automatic measurements



Organization of Beamtime

2018 beamline P08

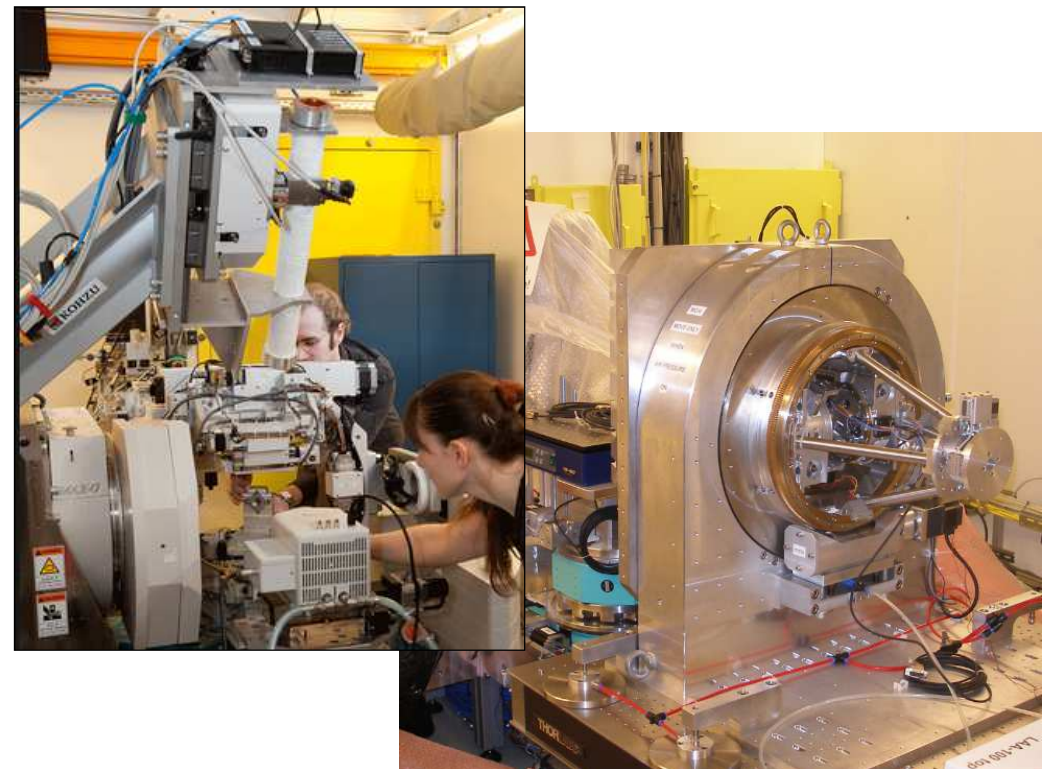
| März 2018 | April 2018 | Mai 2018 | Juni 2018 | Juli 2018 |
|----------------|---------------|-------------|--------------|---------------|
| IB | com opt | mur | Vol | Anto |
| IB | com opt | mur | Vol | Anto |
| | com opt | mur | Vol | com / inhouse |
| | MDT # | mur | # | MDT # |
| IB | Schmi | Mait | # | Sen |
| IB | Schmi | Mait | 40 | Sen |
| IB | Schmi | Mait | Bey | Sen |
| IB | Schmi | Mait | Bey | Kel |
| IB | Schmi | MDT # | Bey | Kel |
| | Schmi | Muk | Bey | Kel |
| | MDT | Muk | com GID | MDT |
| d IB | Stef | Muk | com GID | Ziss |
| d IB | Stef | Muk | MDT SRI18 | Ziss |
| d IB | Stef | Muk | Zum | Ziss |
| e so seM multi | Stef | com Lisa | Zum | Ziss |
| e so seM multi | com / inhouse | MDT | Zum | Ziss |
| multi | com / inhouse | Mald | Zum | Ziss |
| multi | MDT # IP21v | Mald | Shen | |
| e so seM multi | AVID | Mald | Shen | |
| e so seM multi | AVID | Mald | | |
| MDT # | AVID | Mald | Shen | |
| e so seM multi | AVID | com Lisa | Shen | |
| e so seM multi | IP21 # | MDT # | Shen | |
| multi | IP21 # | com GID | Sriv | |
| multi | IP21 # | com GID | Sriv | |
| com opt | IP21 Prüfung | Bas | Sriv | |
| com opt | | Bas | | |
| MDT | 40 | Bas | Anto | |
| com opt | 40 | Bas | Anto | |
| com opt | com Lisa | MDT | Anto | |
| com opt | | Vol | | |

„Complicated experiments” beamline

e.g. „High Resolution Diffraction & Liquid Scattering & Timing beamline P08

3-6 days of beamtime!

- ➔ different setups
- ➔ need a lot of time for setup
- ➔ demanding user support



Organization of Beamtime

Every user group has a responsible contact person for

- discussion of the experiment prior to beamtime
- pre-evaluation of the safety declaration and concept
- setup of the experiment
- align beamline and instruct the users
- help with the first experiments (new users only)
- discussion of the experiment during the beamtime
- on-call service (8:00h – 22:00h)
- comes to beamline to solve problems (8:00h – 22:00h)
- say good bye

All beamline staff members
have an over-hour budget
to react on urgent demands

Additional services:

technical shift service week days: 07:00h – 01:00h

technical shift service weekends: 09:00h – 23:00h

help from all infrastructure and safety groups

during weekdays: 08:00h – 17:00h

A lot of service comes on voluntary basis: On big troubles all groups will be available also beyond these times

- ➔ right now there is an over-night and weekend service gap
- ➔ needs to be closed



How to maintain quality of a beamline?

Beamline Review

Every 3-5 years: **Beamline Review to ensure quality of beamline**

- ⇒ international beamline review panel (4-5 persons)
- ⇒ reports to „Photon Science Committee)
- ⇒ generates a report and recommendations

A. Technical status of the beamlines

- How do you rate the performance of Pxx/Py on an international level?
- Do the beamlines make it possible to carry out excellent scientific work?
- How do you judge the technical design and implementation?

B. Users

- How do you rank the scientific output by the users?
- Are there potential users or communities not yet active at Pxx/Py?

C. Staff

Is the staff (size, qualification) adequate? Do you miss any competence?
How do you judge staff research done at Pxx/Py?
How do you judge staff work on technical development?

D. Future technical developments

- Is there enough effort done towards technical improvements and development?
- What would you recommend in the medium and long term?

E. Scientific perspectives

Which are in your opinion the most promising research directions at Pxx/Py for the next 5-10 years?
Is there potential for industrial applications not yet exploited?

1st day (Tuesday, October 4, 2016), 48e/L202

| | |
|---------------|---|
| 12:00 | <i>Light lunch</i> |
| 13:00 – 13:30 | Welcome and Introduction |
| 13:30 – 14:30 | The Variable Polarization XUV beamline P04 at PETRA III (45'+15') |
| 14:30 | <i>Break</i> |
| 15:00 – 15:30 | Users' highlights: <i>Tba "XMCD and related science"</i> (20'+10') |
| 15:30 – 16:00 | Users' highlights: <i>Tba "FlexIX and related science"</i> (20'+10') |
| 16:00 – 16:30 | Users' highlights: <i>Tba "PIPE and related science"</i> (20'+10') |
| 16:30 | <i>Break</i> |
| 17:00 – 17:30 | Reviewer closed session |
| 17:30 – 19:30 | Visit of beamline |
| 20:00 | <i>Dinner at Sägebiels Fährhaus</i> |

2nd day (Wednesday, October 5, 2016), 48e/L202

| | |
|---------------|--|
| 09:00 – 09:30 | Users' highlights: <i>Tba "Photoemission and related science"</i> (20'+10') |
| 09:30 – 10:00 | In-house science (20'+10') |
| 10:00 – 11:00 | Future developments and challenges (45'+15') |
| 11:00 – 12:00 | Discussion and questions |
| 12:00 | <i>Lunch</i> |
| 12:30 – 16:30 | Reviewer closed session and report |
| 16:30 | Close-out with all participants |
| 17:00 | End of meeting |

Every 6 months



2-3 Beamlines
are reviewed

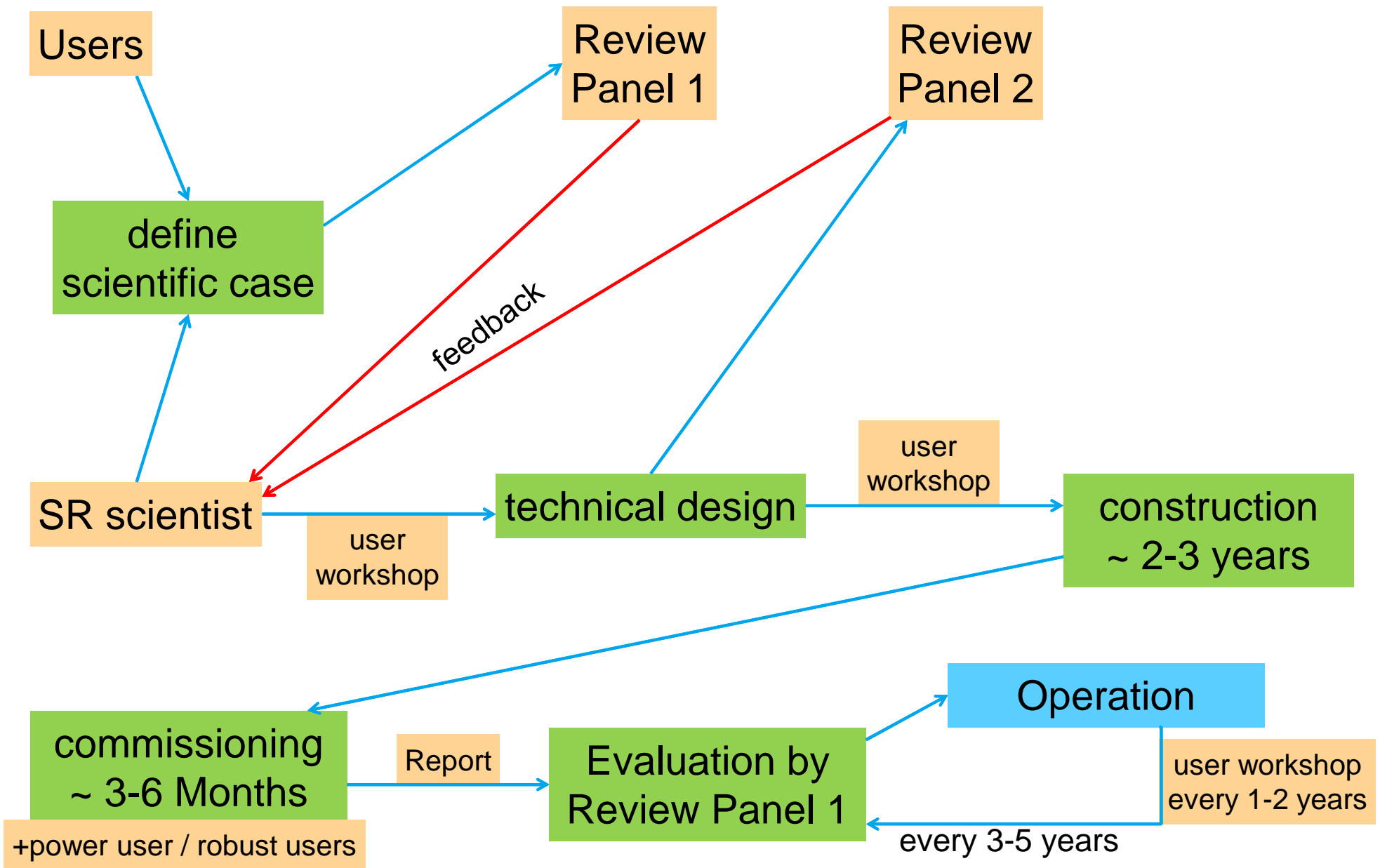
One important measure is the number
of publications

goal: > 30 publications/year

high throughput beamlines
should have more

How to make a new beamline ?

Process of making a new beamline at PETRA III



Process of making a new beamline at PETRA III

Flow chart & cost estimates

Beamline from scratch to user operation : approx 2 ½ - 3 years

| | |
|--|-----------|
| => hiring process | 4 months |
| => technical setup and evaluation | 6 months |
| => drawings, in parallel call for tender | 6 months |
| => production (internal or external) | 10 months |
| => installation | 3 months |
| => commissioning | 3 months |

Annual consumables and repairs
➔ approx. 200kEUR

Annual re- & new investments
➔ approx. 200kEUR

Costs of a standard beamline

| | |
|------------------------------------|-----------|
| - personal (40-60k EUR per person) | |
| - overhead (20-30k EUR per person) | |
| - hardware | |
| => Undulator and vacuum chamber | 500 kEUR |
| => Frontend | 500 kEUR |
| => Optics + vacuum | 1000 kEUR |
| => Two X-ray hutches | 500 kEUR |
| => Installations & Computing | 500 kEUR |
| => Experiment+Electronics | 1000 kEUR |
| => Detectors | 1000 kEUR |

Process of making a new beamline at PETRA III



Structure and budget of DESY beamlines ensure operation of beamlines with users

Right now no 24h / 7d support

Computing support has to be dramatically enhanced

Regular reviews ensure quality of beamlines

Creating new beamlines as a transparent and complicated process