PAUL SCHERRER INSTITUT

PSI

MALOJA

Scientists

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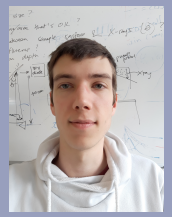
Sven Augustin

Zhibin Sun

PhD student



Jonas Knurr

Engineer

Florian Amrein

Technician

Simon Tiefenbacher

MALOJA

Molecules, **A**toms, **L**ight **O**bserved in a **J**oint **A**pparatus

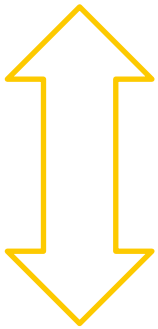
MALOJA

Maloja pass: 1815 m

Relationship to charge

Establish a commissioning plan until mid 2021 (with detail really only until summer)

- Common Overview Commissioning Plan
- List of Commissioning Tasks
- Number of shifts required per group / task
- Distinguish tasks that are independent of Aramis operation (beam priorities and parameters)
- Synchronize tasks with hardware, available manpower & Aramis Operation (DAQ, controls, general support = resource load)

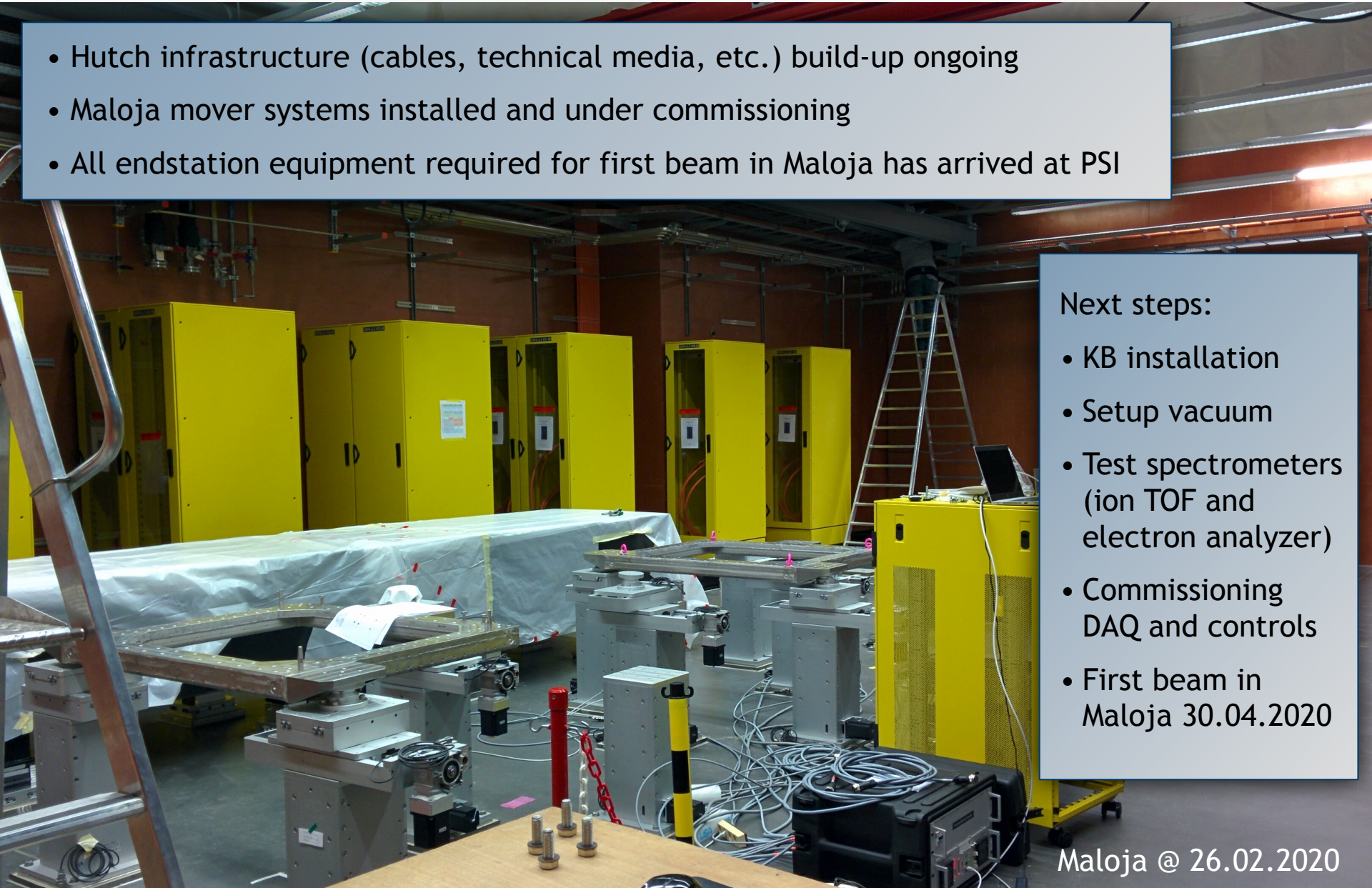


3) Maloja: *description* and *commissioning plan* (Kirsten)

Maloja: scientific and technical concepts

Current Status Maloja

- Hutch infrastructure (cables, technical media, etc.) build-up ongoing
- Maloja mover systems installed and under commissioning
- All endstation equipment required for first beam in Maloja has arrived at PSI



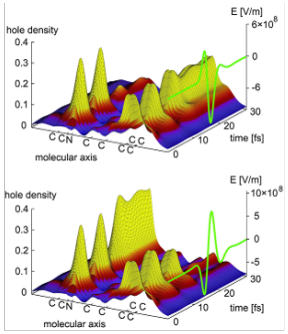
Next steps:

- KB installation
- Setup vacuum
- Test spectrometers (ion TOF and electron analyzer)
- Commissioning DAQ and controls
- First beam in Maloja 30.04.2020

Maloja @ 26.02.2020

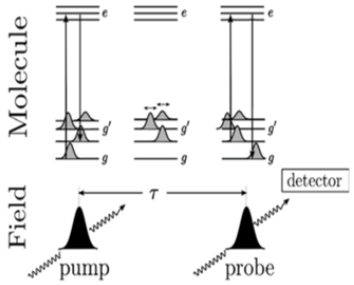
Opportunities for AMO-type science

Charge migration



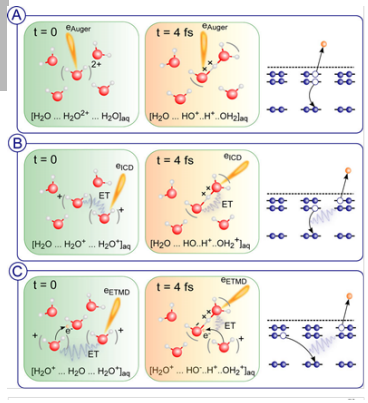
Golubev et al. Phys. Rev. A 91, 051401(R) (2015)

Non-linear spectroscopy



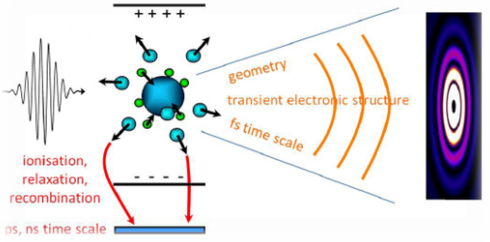
Biggs et al., PNAS 110, 15597 (2013)

Energy transfer

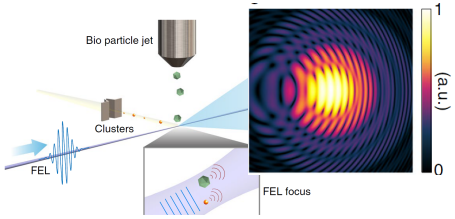


Slavíček et al., *JACS* **2014** *136* (52)

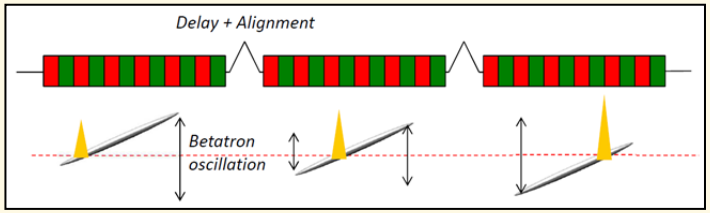
Coincident imaging and spectroscopy



Imaging dynamics

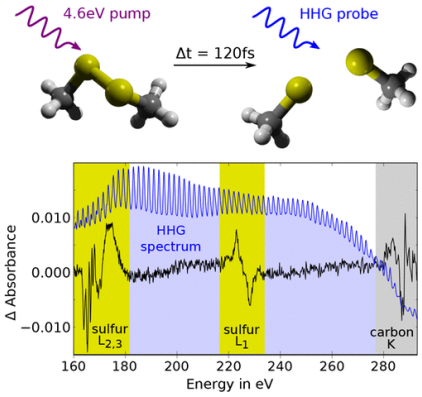


Gorkhover et al. Nature Phot 12, 150153 (2018)



New accelerator modes for attosecond and intense X-ray pulses enable new science opportunities

Transient absorption

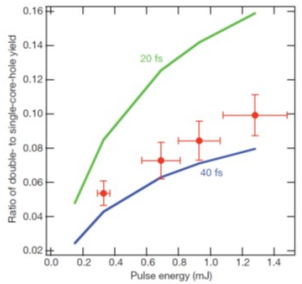


Schnorr *et al.,* Phys. Chem. Lett. 2019, 106

From 2019 workshop: Early feedback and first experiments

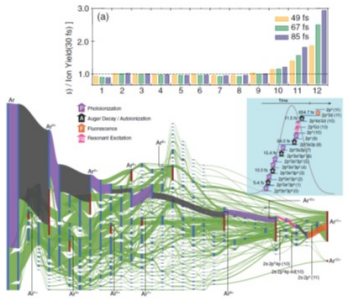
Early feedback experiments – limited pulse length with theory feedback

Auger spectroscopy



Young et al., Nature 2010 – 1st LCLS experiment

Ion yield spectroscopy



Phay Ho, Phys Rev Lett 2014

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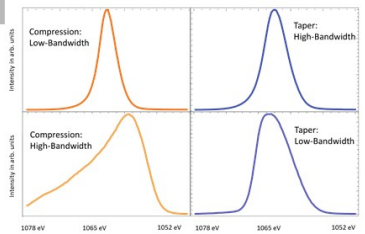
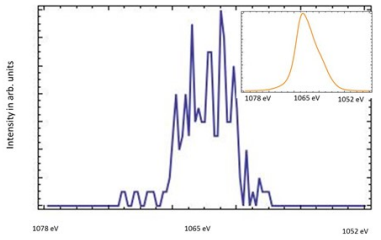
Early feedback experiments – electron spectrometer (spectra and hv)

Few shot average



Limited single shot



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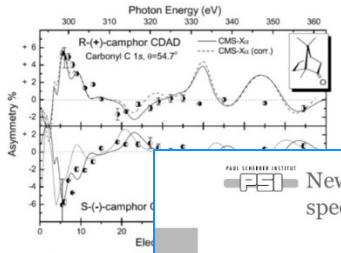
New experiments – chirality and using the flexibility of the undulators



Photoelectron circular dichroism, Marburger et al., J Chem Phys 2004

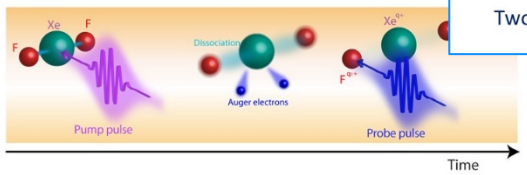
Polarization changes, sin

Note: None of u

New experiments – double x-ray pulse spectroscopy

Goals:

- Site-specific electronic excitation
- Electronic to nuclear relaxation
- Energy transfer on nanoscale



Two short (few fs) pulses with fs delay and similar color

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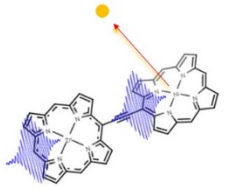
Extend hetero-site specific spectroscopy to metallo-porphyrin dimers using PES



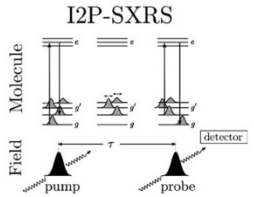
Goal:

- Use x-ray pump to create localized electronic excitation
- Di
- Va
- Fi

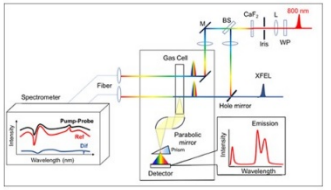
Two short (few fs) pulses with 10s f

New experiments – novel non-linear spectroscopy

I2P-SXRS



PNAS **110**, 15597 (2013) – S. Mukamel et al.



One (two) (coherent) short (fs, as) broad-bandwidth (4-8 eV) pulse

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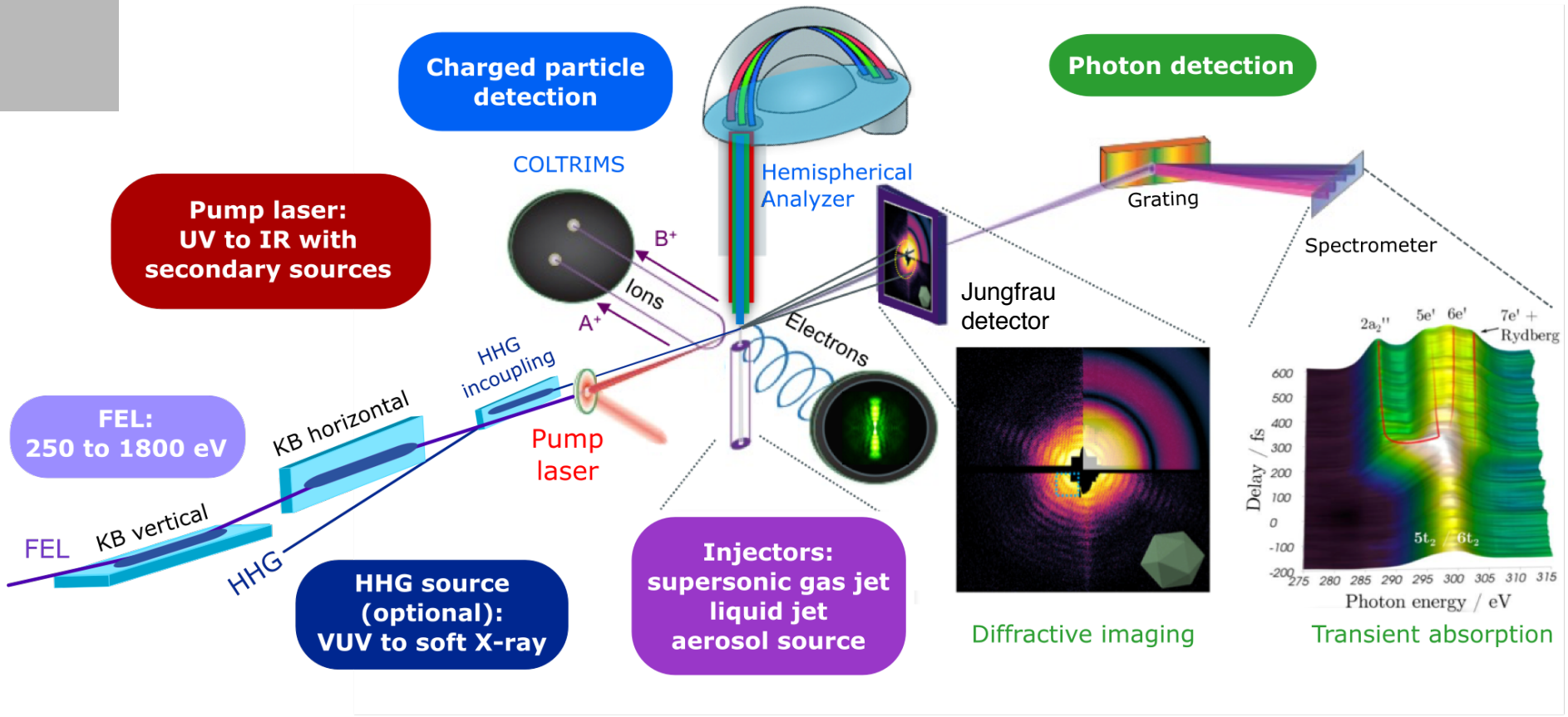
Endstation layout



SNF R´equip proposal

Maloja: A flexible endstation concept

Usual AMO scheme

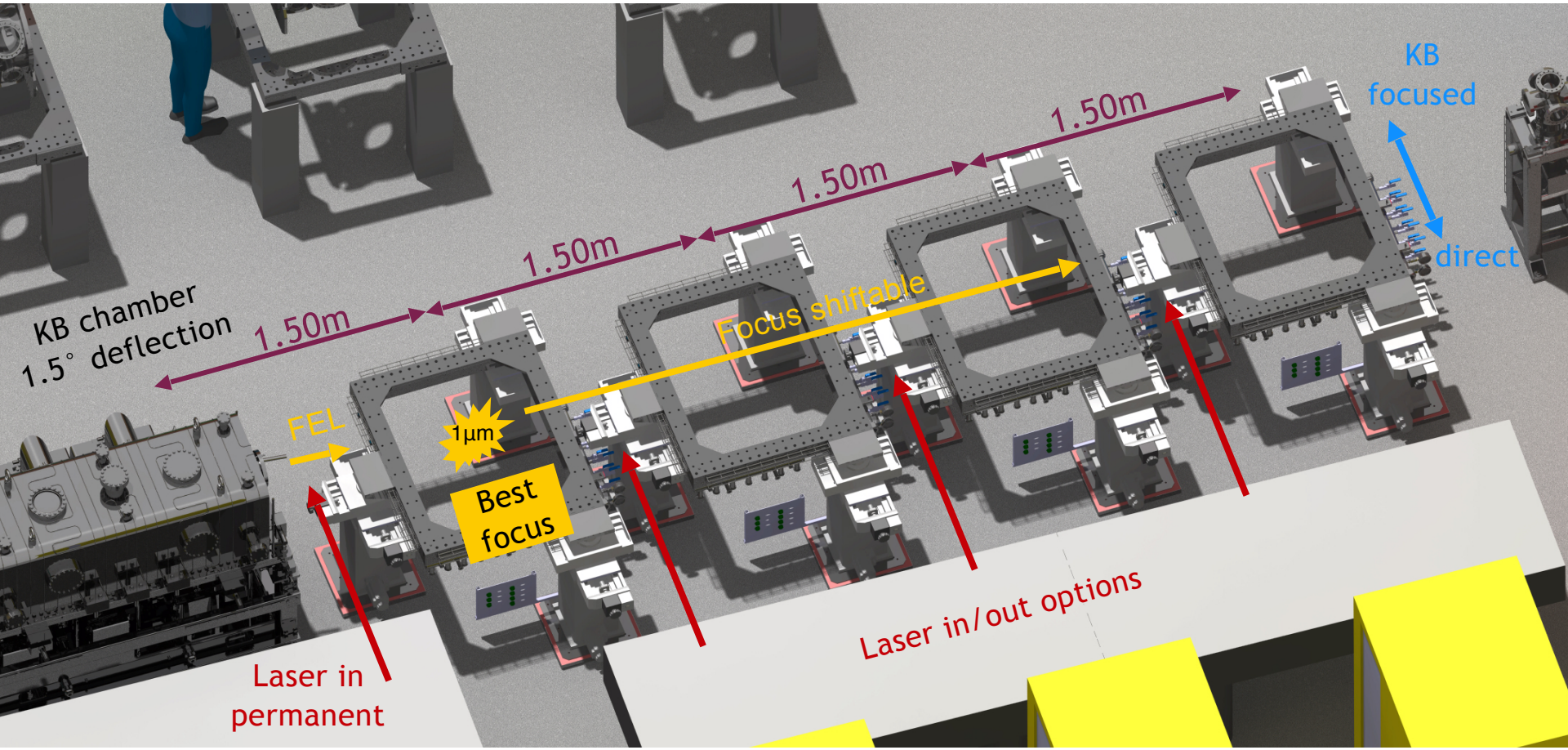
Optics	Exp	Diag			Most common approach

Our ideas…

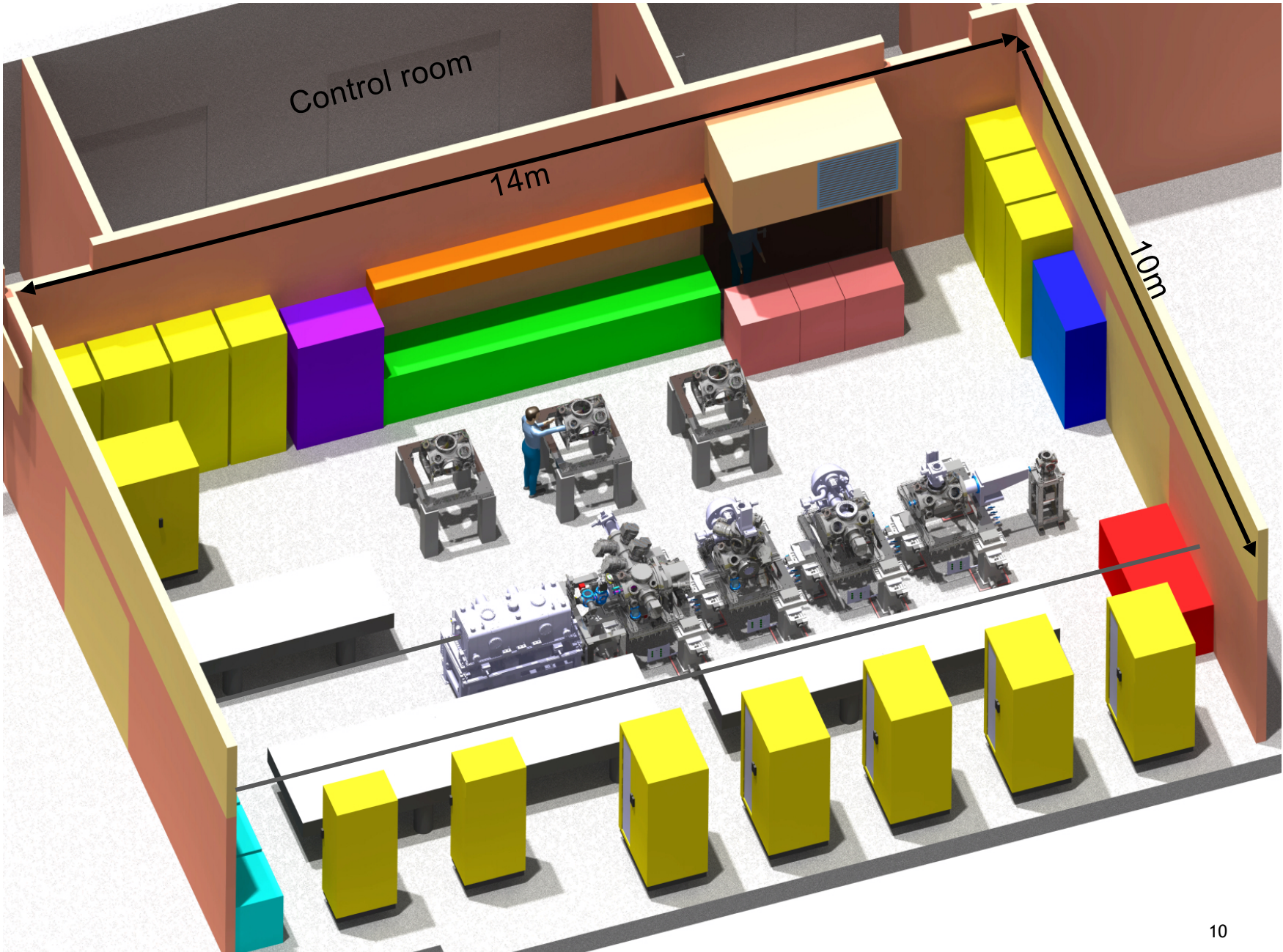
Optics	Exp	Optics	Diag	Diag	Additional secondary focus for diagnostics
Optics	Exp	Detector	Optics	Diag	Time-resolved scattering
Optics	Diag	Exp	Diag		Pre/post sample pulse diagnostics, i.e. absorption
Dir. beam	Optics	Optics	Exp	Diag	Split and Delay, non-collinear beams, etc.

Four independent experimental units appear ideal

Implementation of concept



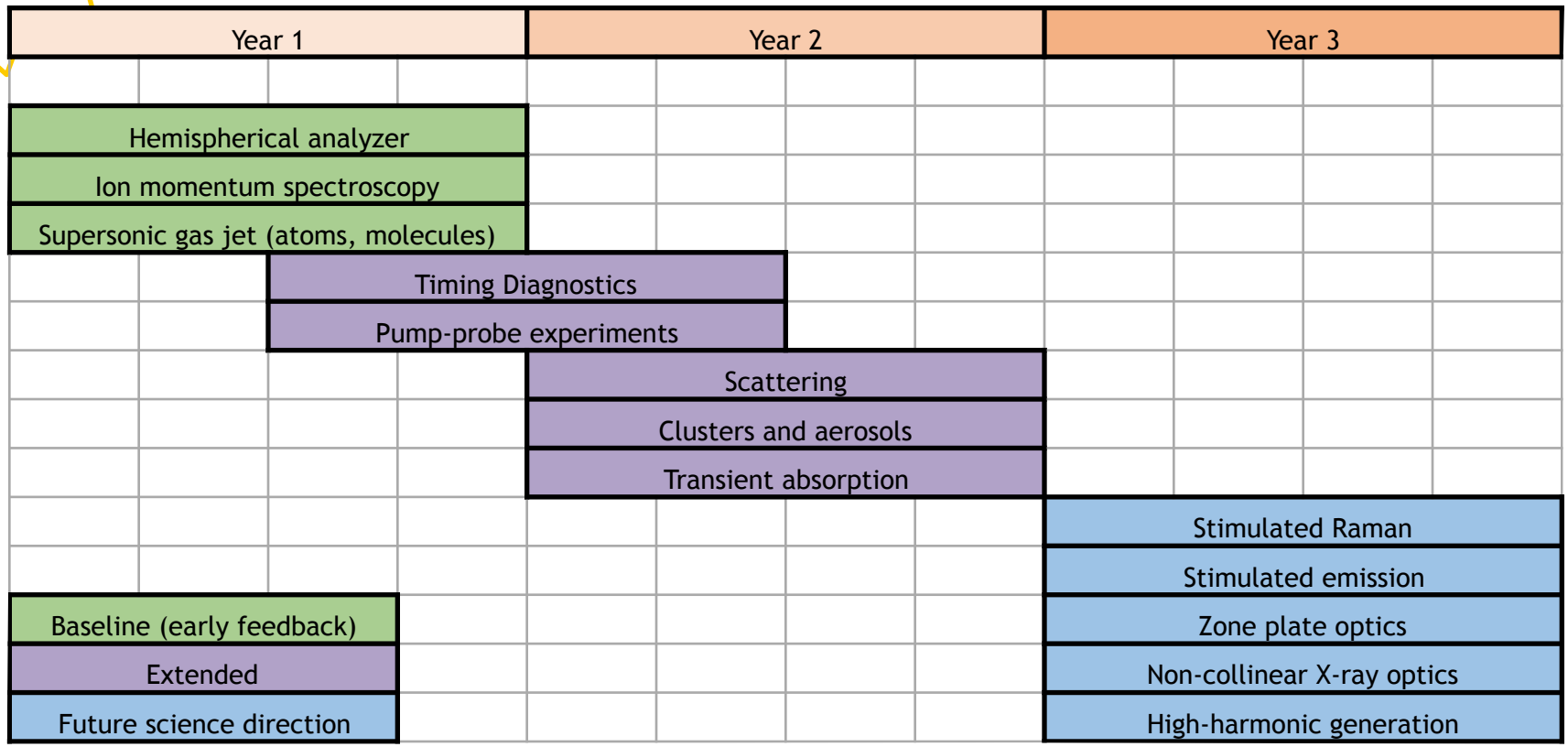
Maloja endstation and hutch layout



Maloja: following a path of increasing complexity – also reflected in commissioning

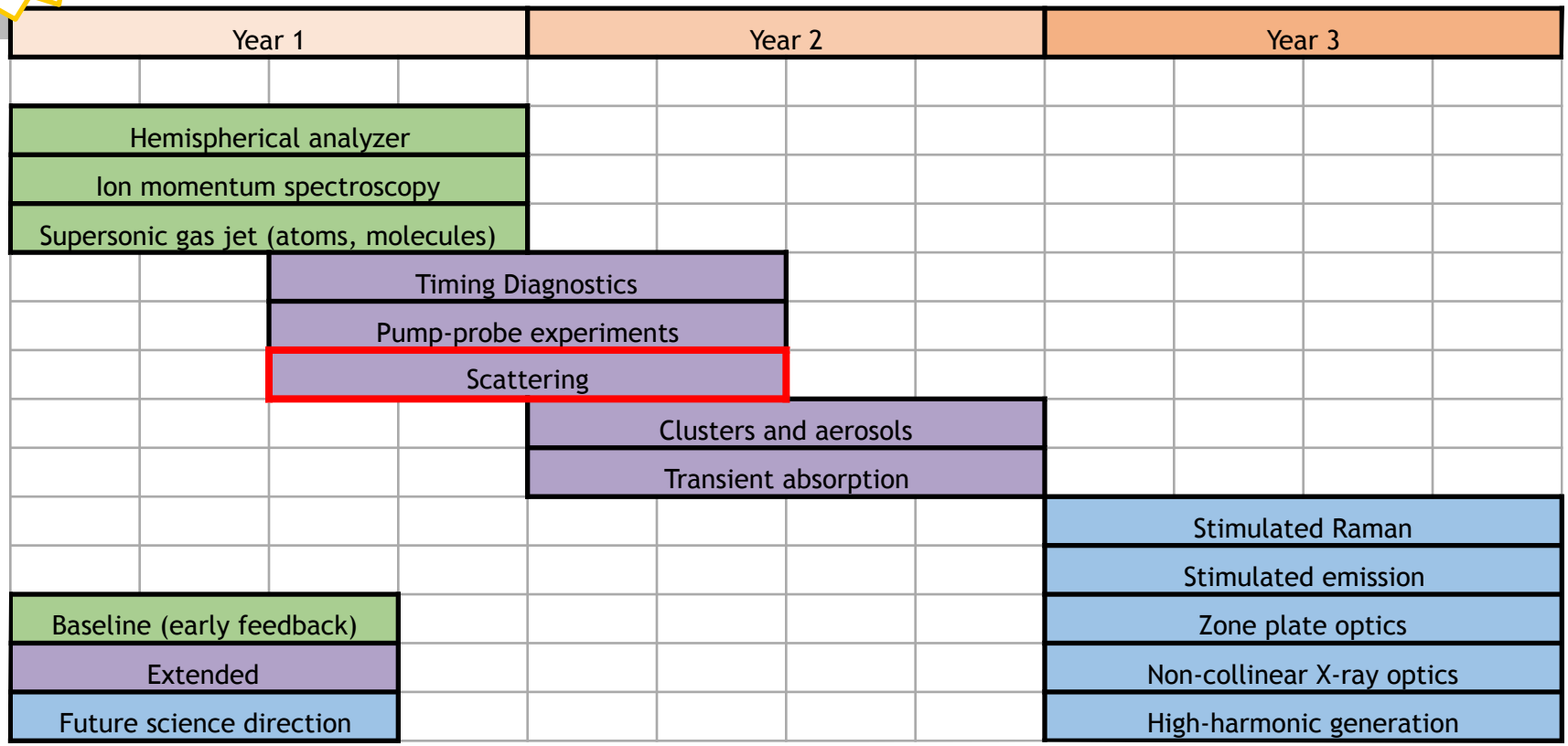
Maloja Build-Up Phases (1st plan December 2018)

April 2020



Maloja Build-Up Phases (March 2020)

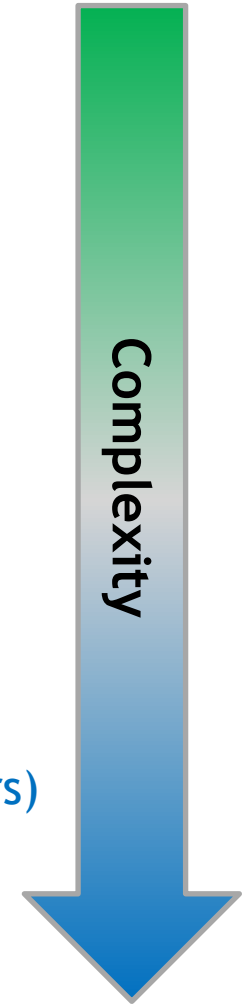
Now



Commissioning year guiding principles (strategy)

- **Goals:**
  - Functionality of components
  - Feedback to machine for FEL parameters
  - Proof of principle experiments

- **Implementation pathway:**
  - Beam Maloja and commissioning of optical components
  - Simple i.e. ion time of flight spectroscopy (feedback crude pulse length in combination with pulse energy measurements)
  - More complex i.e. electron spectroscopy (feedback spectral content, long-term polarization?)
  - Imaging capabilities (need: intense short pulses)
  - X-ray/x-ray pump/probe capabilities (need: two pulses, two colors)
  - Optical/x-ray pump/probe cabalities (need: optical laser, timing, etc)



Maloja commissioning 2020 (hardware on strategy map)

New Hardware:
- KB Mirrors
- Maloja frames and motion
- Vacuum system
- BS and non-BS cameras
- Digitizer
- Supersonic gas jet
- Ion spectrometer
- Electron spectrometer

FEL Parameters:
- At least few tens of µJ pulse energy with ~50 fs duration
- Scan polarization
- Scan pulse duration
- Scan photon energy

Tasks/experiments
- KB commissioning
- 1st FEL in Maloja
- Ion time-of-flight spectra (Feedback on pulse duration)
- Electron spectra (Feedback on average FEL spectra and bandwidth)

New Hardware:
- Jungfrau detector
- COLTRIMS spectrometer
- Laser transport
- Laser table equipment
- Laser incoupling
- Time tool
- Liquid jet

FEL Parameters:
- Few hundred µJ pulse energy with <50 fs duration
- Few fs pulses (min. 10 µJ)
- Two color X-ray pulses

Tasks/experiments
- Jungfrau commissioning
- Diffraction experiments on clusters
- COLTRIMS commissioning
- Photoelectron and ion momentum spectroscopy with two-color X-ray pulses
- Optical pump X-ray probe

New Hardware:
- User supplied equipment

FEL Parameters:
- …

Tasks/experiments
- Start pilot experiments

Mär 20 | Apr 20 | Mai 20 | Jun 20 | Jul 20 | Aug 20 | Sep 20 | Okt 20 | Nov 20 | Dez 20 | Jan 21 | Feb 21

Maloja comissioning: Short term refinements (detailed plan until summer shut-down)

Task	Goal
1st beam in Maloja	Guide FEL beam through beam line, over offset mirror onto screen in first Maloja chamber
KB optics alignment	Move in horizontal and vertical KB mirror and watch deflected and undeflected beam on screens in endstation (requires modifications on setup including venting/repump)
KB focusing all frames	Establish tightest focus in all four frames, characterize and test reproducibility and stability of mirror benders
Ion time-of-flight spectrometer	Commission ion spectrometer. This allows to give further feedback on focus and on pulse duration of FEL pulse.
Electron spectrometer	Commission hemispherical analyzer. This allows to give feedback on average FEL spectrum and bandwidth.

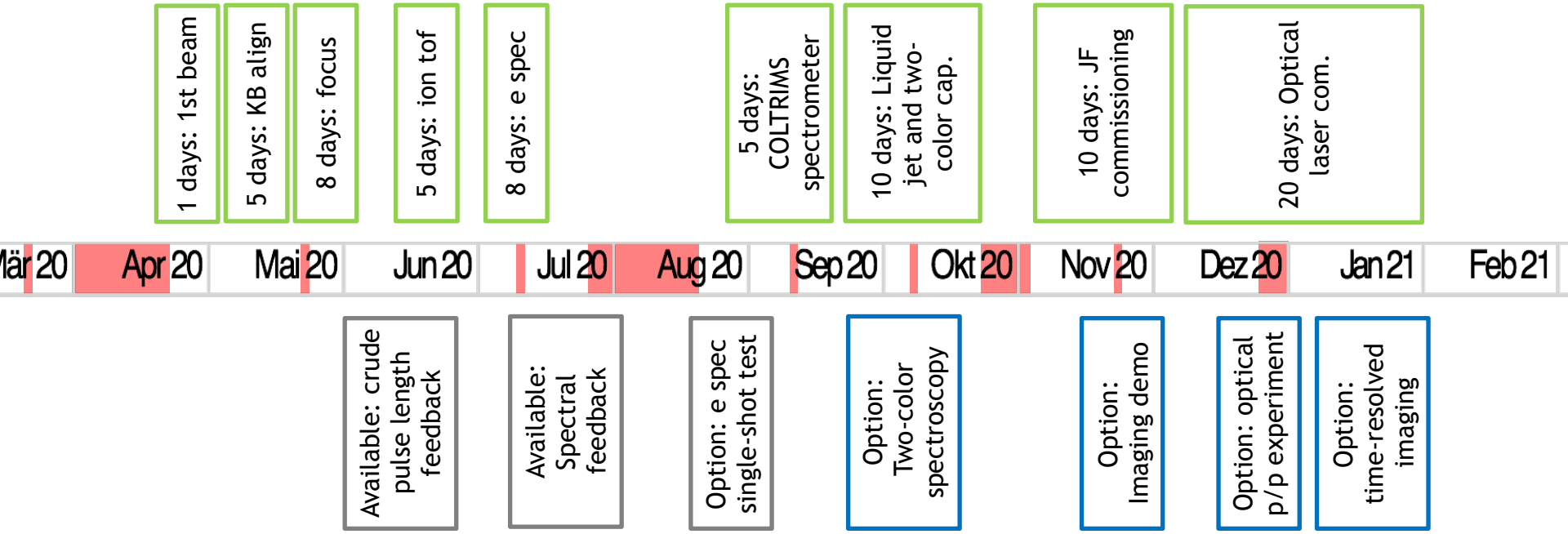
Maloja commissioning: Map of tasks to technical requirements (experiments to hardware to software)

Required infrastructure	Beam in Maloja	KB Opt. Alignment	KB Focusing all Frames	Ion Time of Flight spectrometer	Electron Spectrometer
Vacuum and Infrastructure	✓	✓	✓	✓	✓
Motion (Delta Taus and eMotors)	✓ - 1 Frame - KBs - Manipulator	✓ - 1 Frame - KBs - 2 x Manipulators	✓ - 4 Frames - KBs - 2 x Manipulators	✓ - 1 Frame - KBs - 3 x Manipulators	✓ - 2 Frames - KBs - 3 x Manipulators
Motion (SMARACT)		✓ - 3 stages XYZ	✓ - 3 stages XYZ	✓ - 3 stages XYZ	
Cameras Gige (non-BS/Avg)	✓ - 3 Basler	✓ - 4 Basler	✓ - 4 Basler	✓ - 3 Basler	✓ - 4 Basler
BS Cameras (PCO)		✓ - 1 PCO	✓ - 2 PCO	✓ - 1 PCO	✓ - 1 PCO full image BS - 1 PCO processed
DAQ	✓ -View beam	✓ - View beam - simple process.	✓ - View beam - simple process	✓ - Data readout - Scan tools	✓ - Data readout - Scan tools
Digitizers				✓ - BS readout of traces - 2 channel	✓ - BS readout of traces - 1 channel - Channel interleafing
High Voltage				✓ - ISEG HV supplies	

Maloja commissioning: Map of tasks to time (shift needs and wishes)

Tasks/experiments
- 1st FEL in Maloja (1 day)
- KB alignment (5 days)
- Focus optimization frame (8 days)
- Ion time-of-flight spectra (5 days)
- Crude feedback on pulse duration
- Hemispherical analyzer commissioning and first electron spectra (5 days)
- Feedback on average FEL spectra and bandwidth

Tasks/experiments
- Jungfrau commissioning
- Diffraction experiments on clusters
- Gas jet and COLTRIMS commissioning
- Photoelectron and ion momentum spectroscopy with two-color X-ray pulses
- Optical pump X-ray probe



Challenge: Maloja commissioning plan closely entangled with machine commissioning and performance

Summary:

- *Maloja on track for first beam in late April and start of commissioning*
- *Detailed plan until summer (total 27 days)*
  - Commissioning of baseline endstation components (27 days)
  - First feedback experiments
- *Longer plan for second half of year (45 days)*
  - Commissioning of COLTRIMS spectrometer (5 days)
  - Commissioning of imaging capabilities (10 days)
  - Demonstration of two-pulse two-color capabilities (10 days)
  - Addition of optical laser and timing diagnostics (20 days)
- *Starting of science campaign in Feb 2021*

… with variations on both directions depending on machine developments and manpower availability

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