

HEPS VSIT

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# Continuous Energy Scanning at MAX IV

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## Continuous Energy Scan

- Beamlines Overview
- Continuous Scan vs Step Scan
- Parametric Trajectory motion

## System Implementation

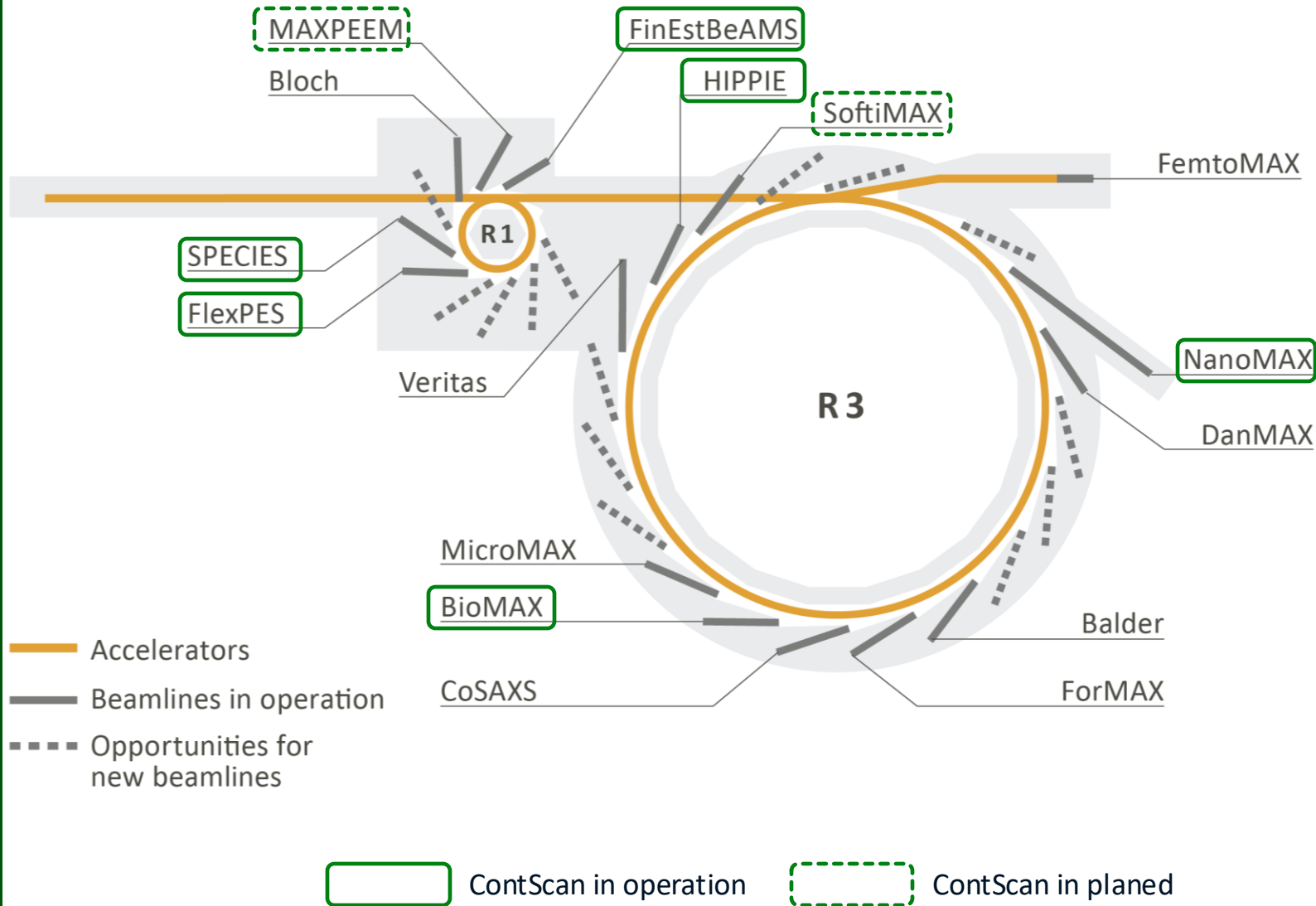
- Synchronization
- Position Based and Time Constant Based Trigger Generation
- Scan procedure

## Beamlines Use Case

- FlexPES, BioMAX, FinESTBeam etc.

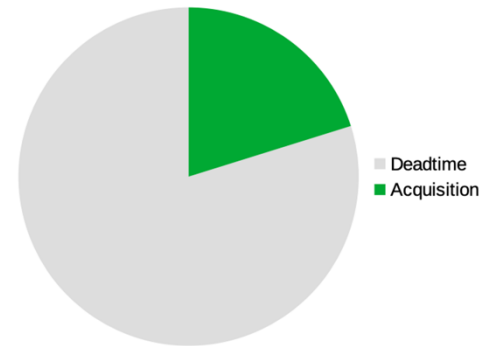
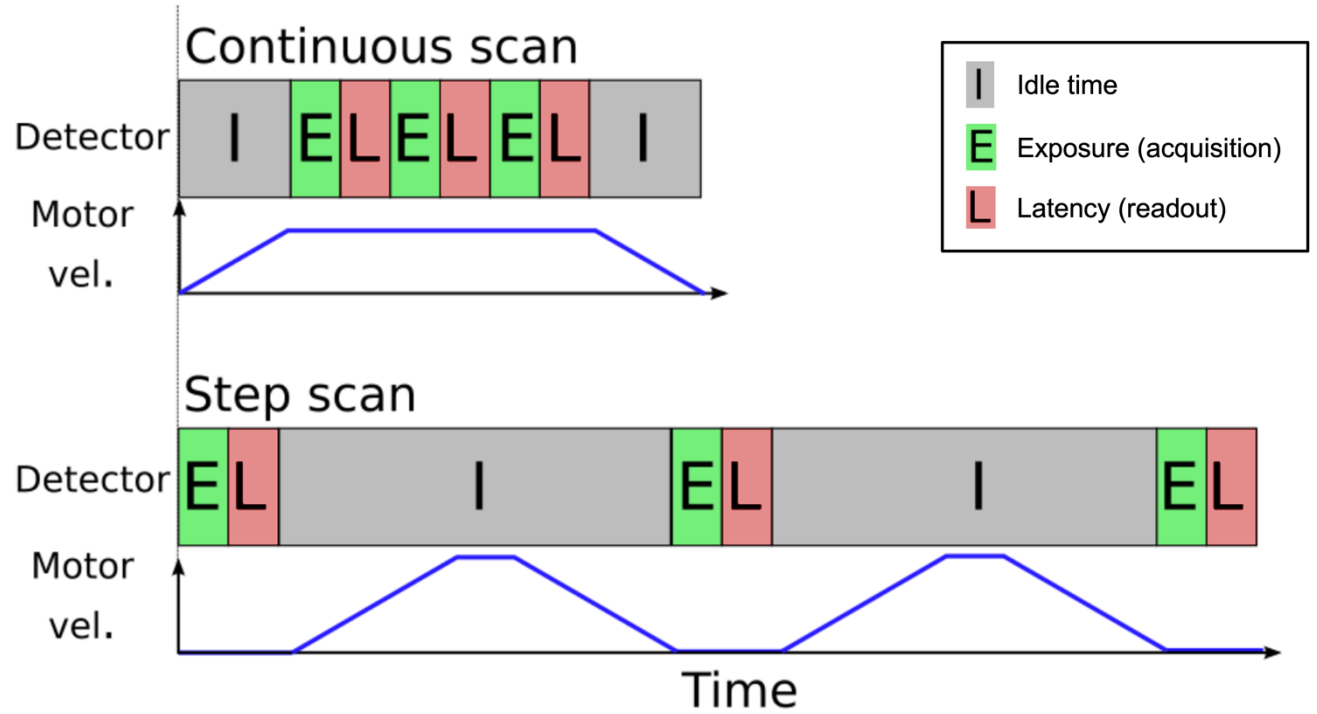
# Beamlines Overview

- 8/16 beamlines (6 in operation, 2 planned)
- Both soft and hard X-ray
- R1 (1.5 GeV) and R3 (3 GeV)

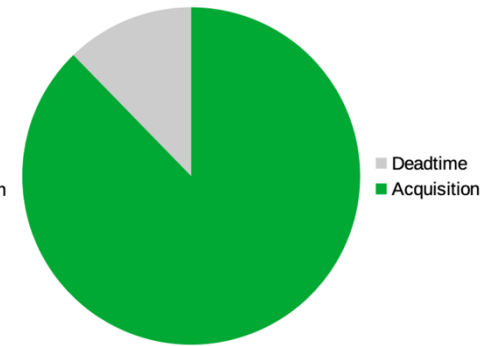


# Continuous Energy Scan

- Reduce the duration of experiments or increase the amount of data collected.
- Opposed to step scans, in continuous scans acquire the data while the motors are continuously moving.
- Measurements are triggered as soon as the correct positions are reached and made while the motor is still moving (position-based).
- It is possible with detectors that have short exposure and integration times.



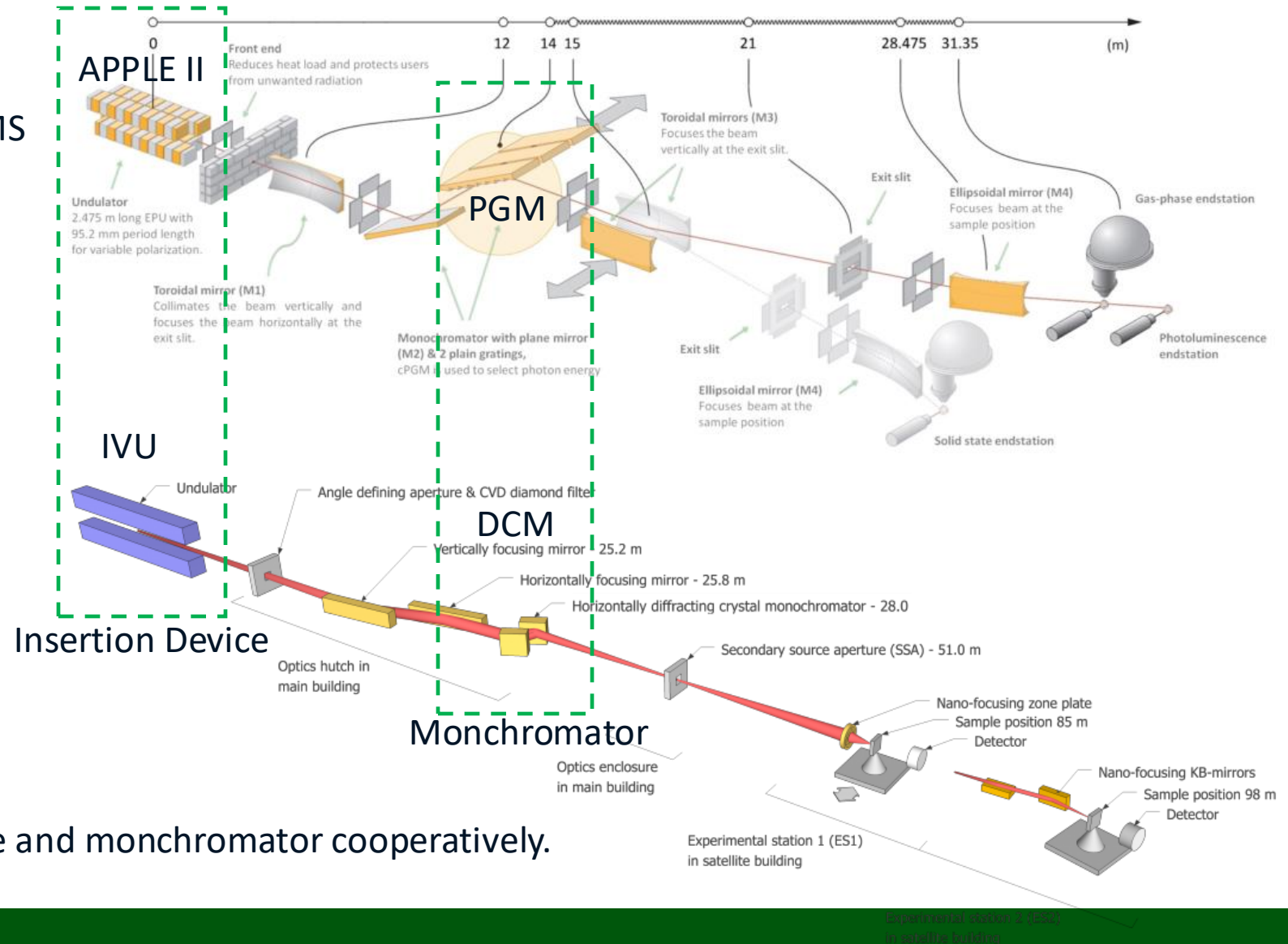
Step scan  
248 seconds



Continuous scan  
57 seconds

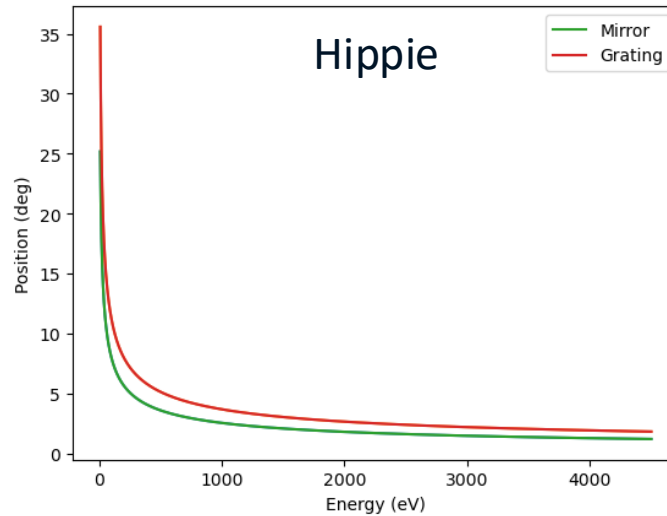
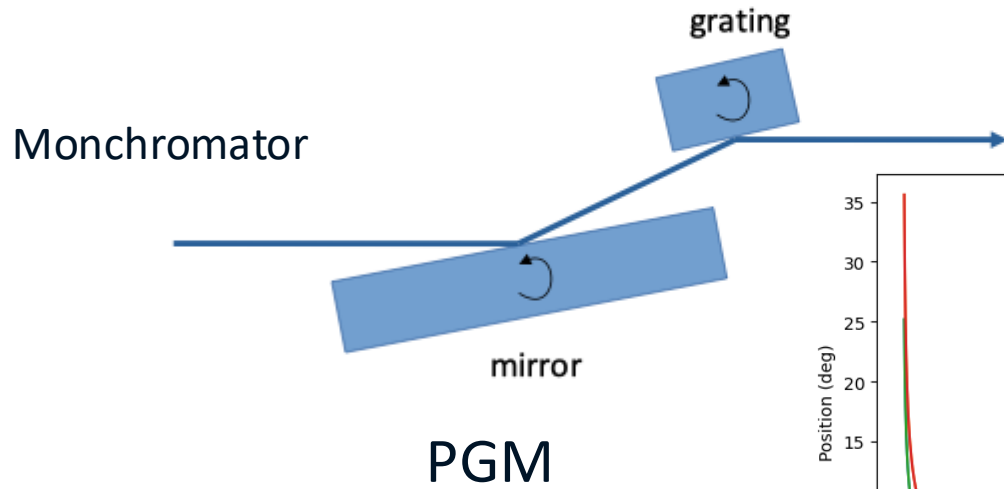
FinESTBEAMS  
(R1)

NanoMAX  
(R3)

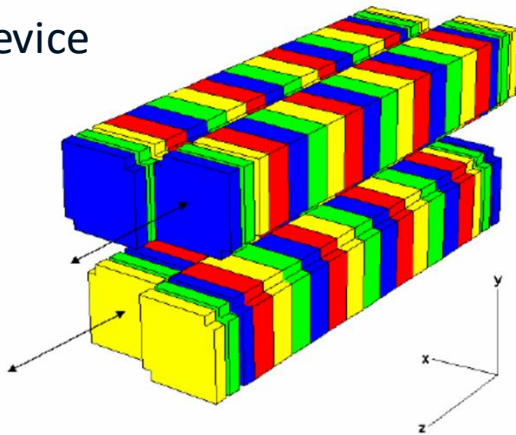


- Move both (ID) insertion device and monochromator cooperatively.

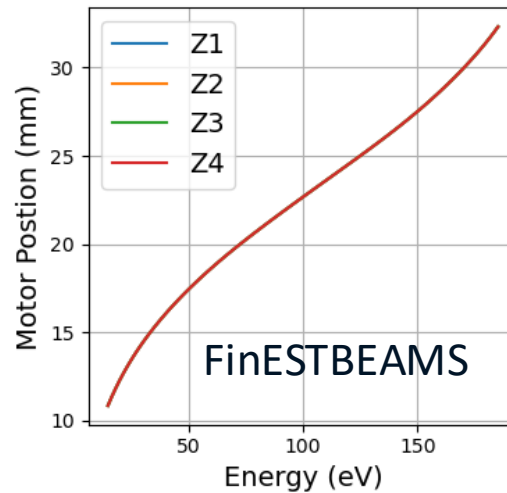
# Control Energy of X-ray



Insertion Device  
(only gap)



APPLE II



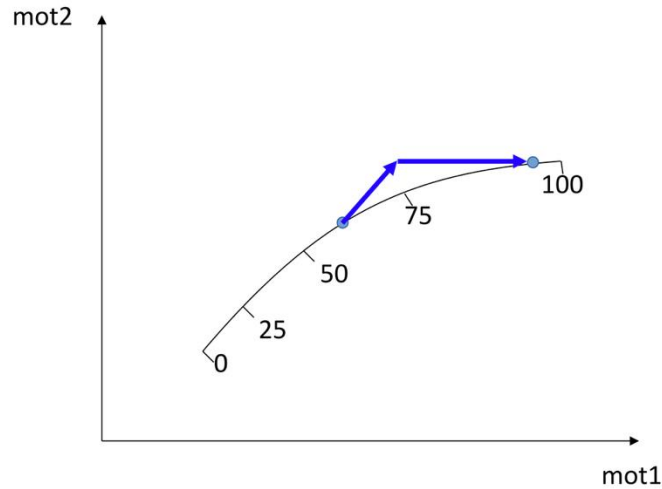
In Low Energy Range

## Combined Motion Non-linear Path

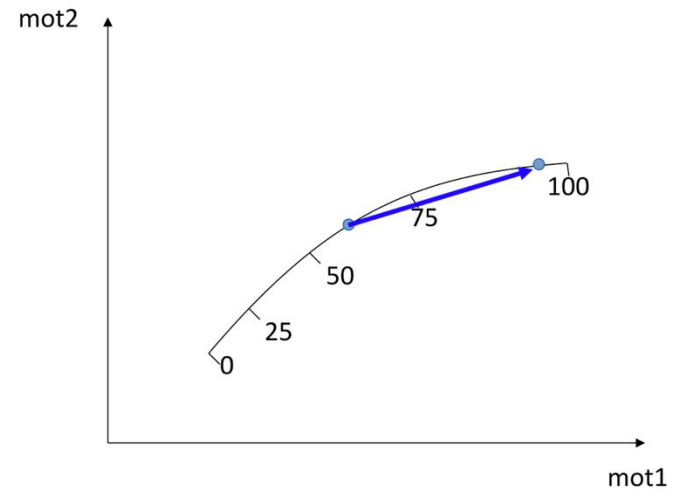
- Energy (scanned axis) is a combined motion
- Each coupled axis can move in non-linear path
- Parametric trajectory mode of the IcePAP

# Icepap Parametric Trajectory Mode

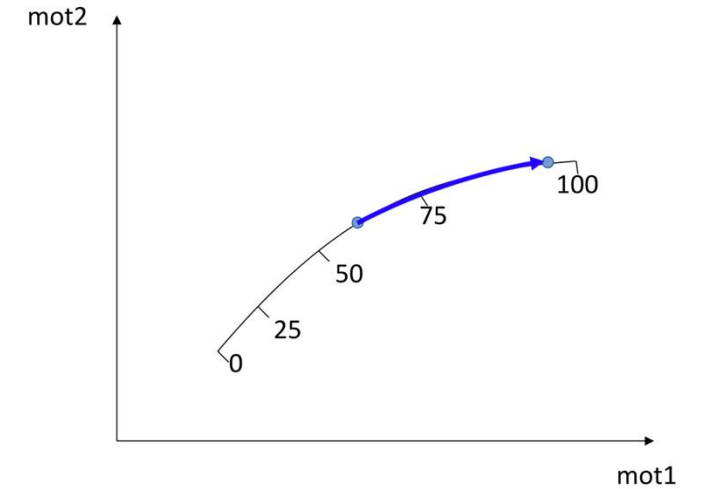
## Nominal Velocities



## Matched Velocities

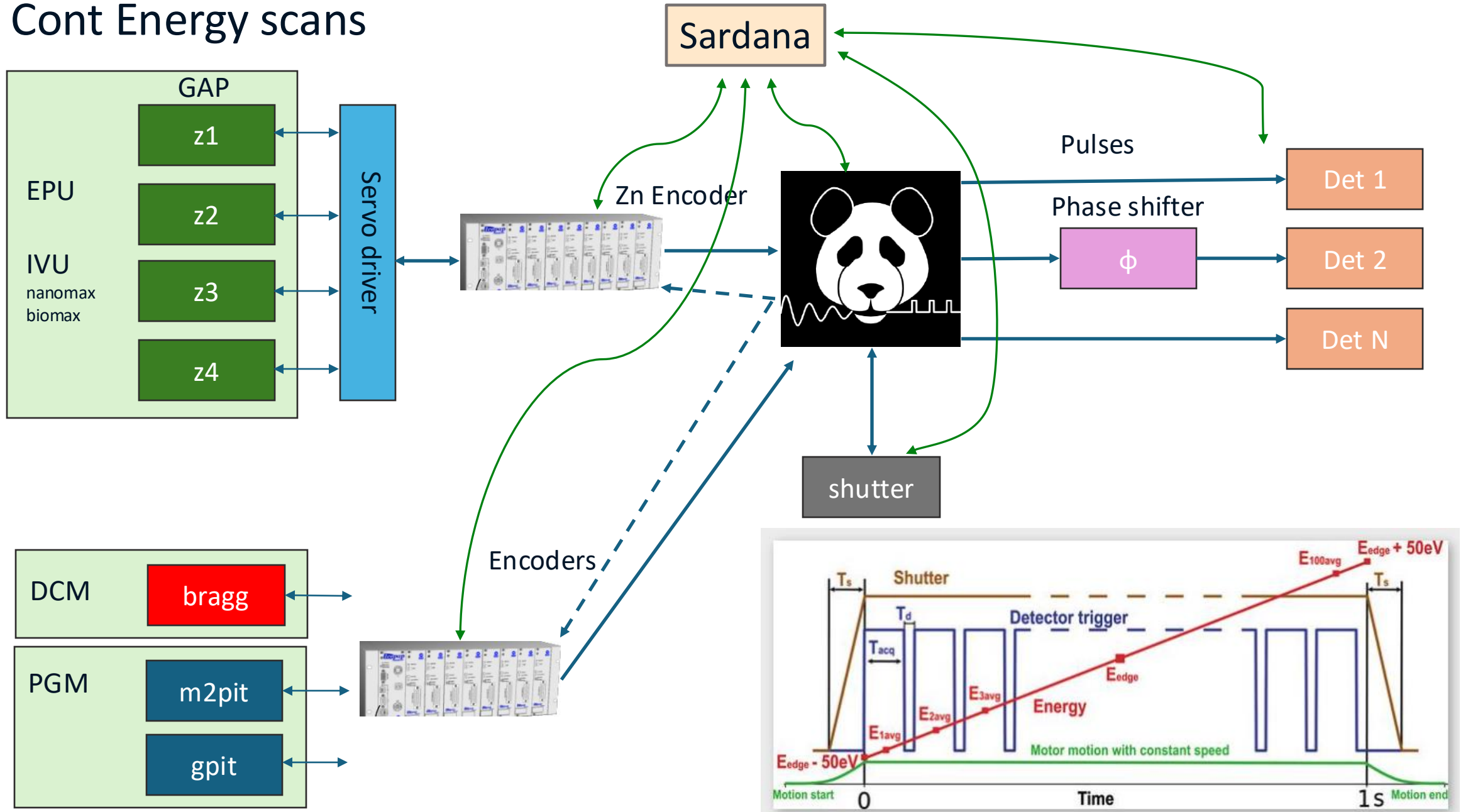


## Parametric Trajectory



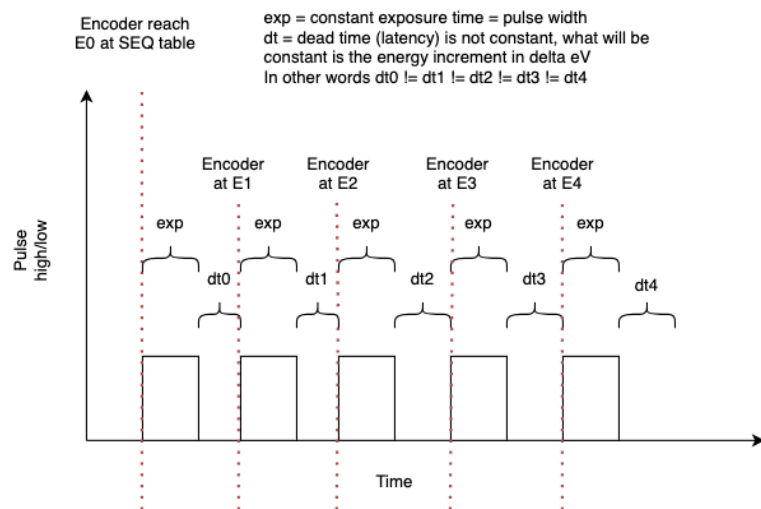
- It is possible to make non-linear movements in IcePAP keeping a constant value in eV/s.
- The trajectory tables are calculated by a sardana controller and inserted in the IcePAP driver.
- The IcePAP uses an interpolation method to follow the trajectory.
- Energy range and the number of points in the trajectory table are configurable.

# Cont Energy scans



# Position Based Synchronism

- Sequence tables are used to define the positions of the motors in which the detectors should be triggered.
- Sardana calculates the sequence tables and configure them in PandaBox in the beginning of the scan.
- The sequence positions in the table are yielded one after the other by a sequencer.
- The trigger is sent to the detectors when the encoder position reaches the value given by the sequencer.



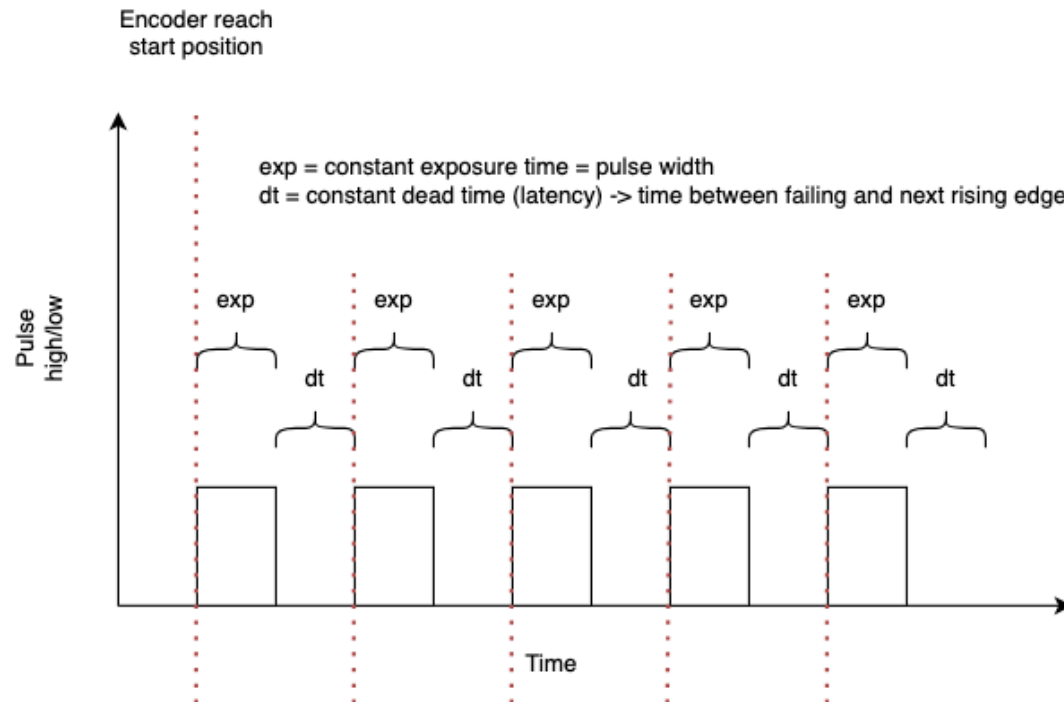
PANDA layout SEQ2 table

REPEATS	TRIGGER	POSITION
1	POSA<<POSITION	-429359
1	POSA<<POSITION	-429387
1	POSA<<POSITION	-429414
1	POSA<<POSITION	-429442
1	POSA<<POSITION	-429469
1	POSA<<POSITION	-429497
1	POSA<<POSITION	-429524
1	POSA<<POSITION	-429552
1	POSA<<POSITION	-429579
1	POSA<<POSITION	-429607
1	POSA<<POSITION	-429634
1	POSA<<POSITION	-429662
1	POSA<<POSITION	-429689
1	POSA<<POSITION	-429717

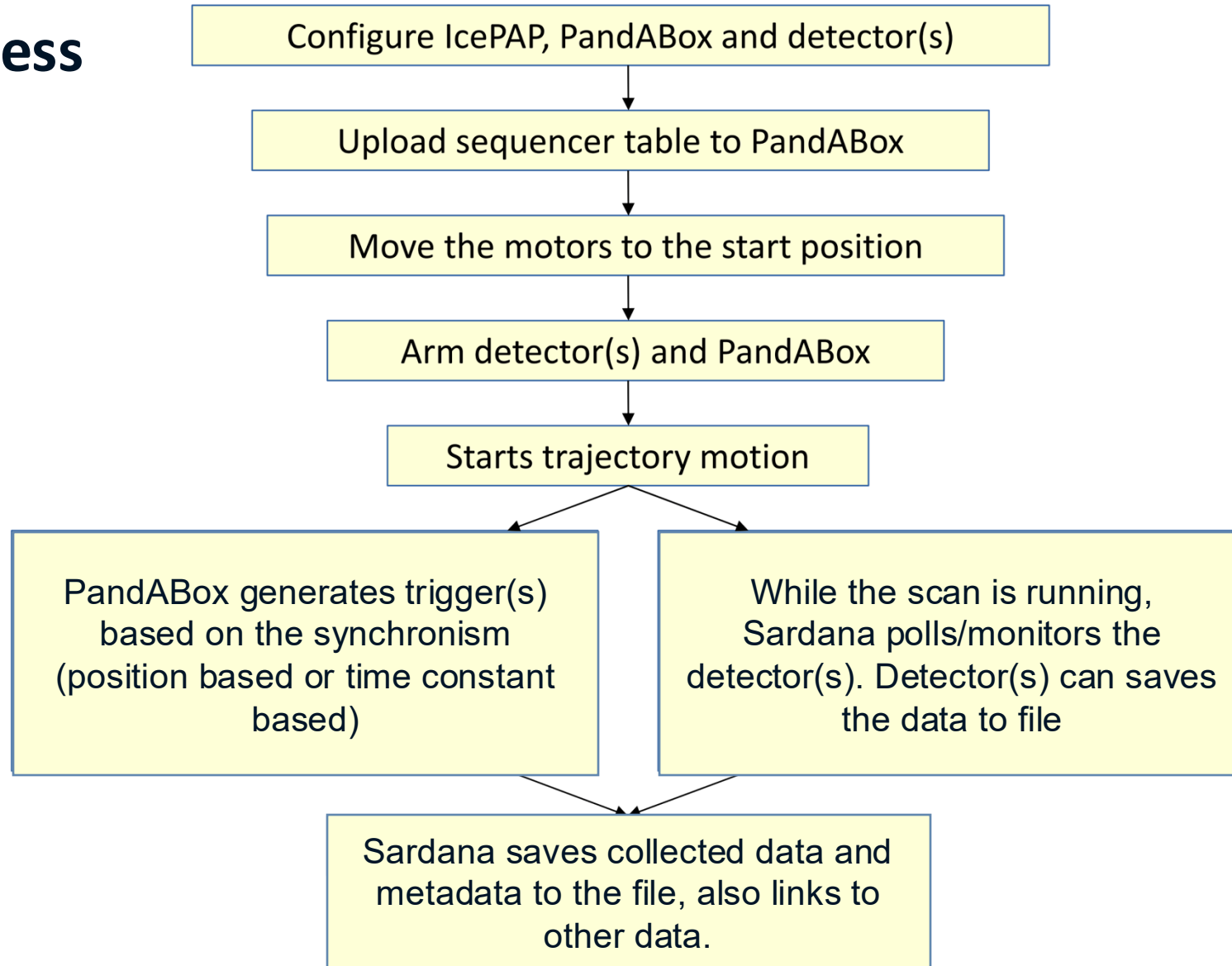
Trigger positions  
in encoder counts

# Time Constant Based Synchronism

- Only the initial position value of the scan is configured in PandaBox.
- When the encoders reach that position, PandaBox generates a burst of  $N$  triggers with  $exp$  length and  $dt$  spacing between them.
- This approach trusts that the IcePAP motors will have a constant velocity in eV/s.



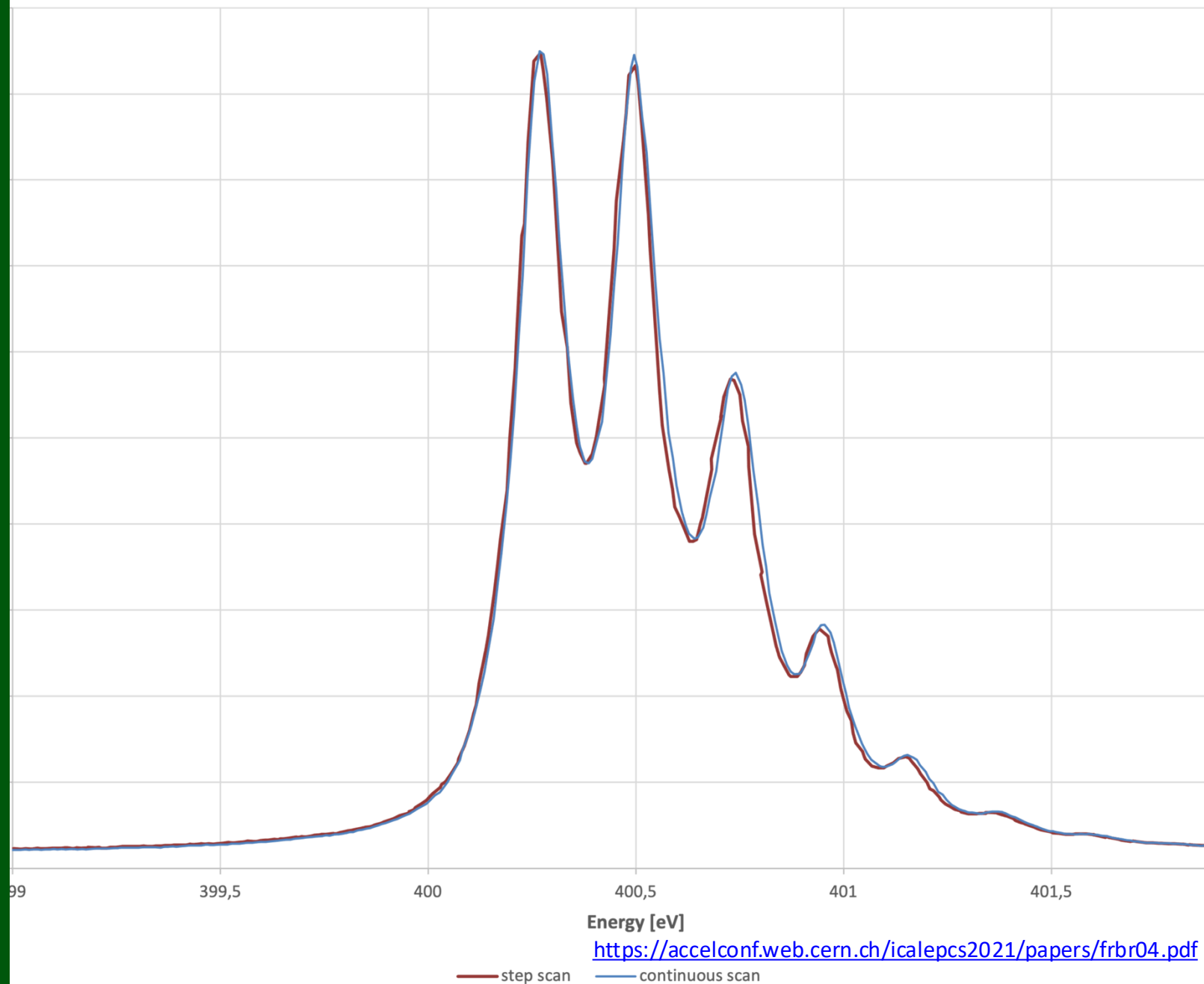
# Scanning Process



Continuous energy scan can also work with other experimental control software

# FlexPES

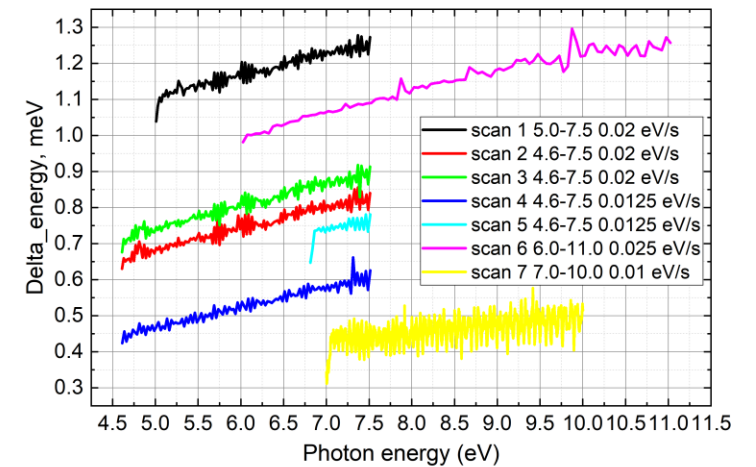
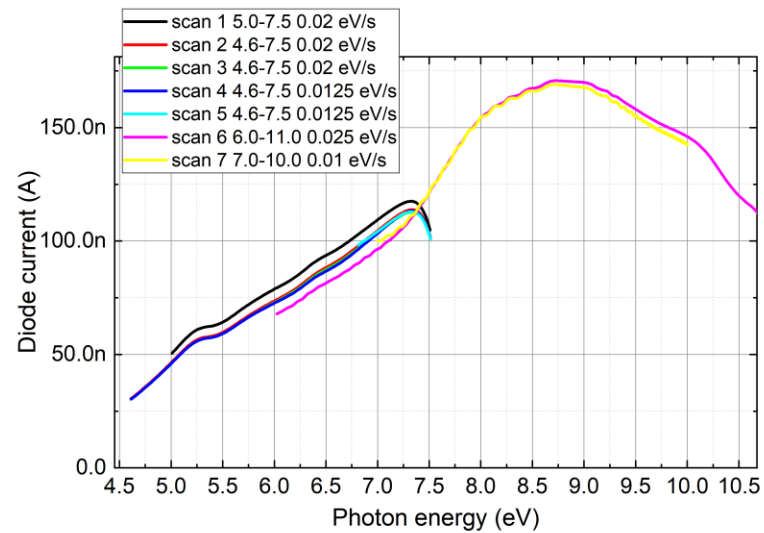
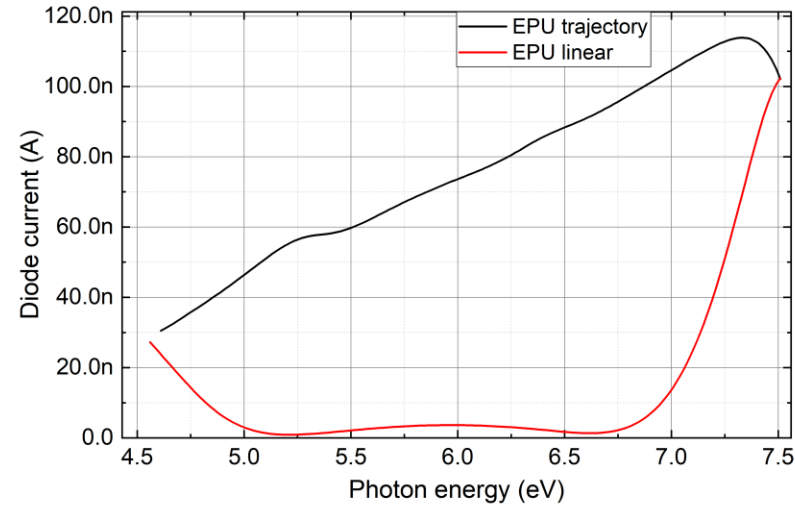
- The FlexPES beamline can do continuous scans of the beamline energy. Each scan is kept less than 50 eV.
- Planar Undulator and PGM.
- Trajectory controller simultaneously moves the monochromator mirror and grating.
- The speed gain depends on the signal intensity. Typically, from 5x to 10x
- Reduces jitter associated with inaccuracies in the step scanning





# FinESTBEAMS

- The scanned energy down to 4.5 eV
- Uses parametric trajectory for insertion device and monochromator
- synchronize by position or by time constant
- Pandabox triggers the motion



# OUTLOOK

- Include phase motors of EPU, enable to continuous scan energy in helical, inclined, even universal mode
- Implement ID gap trajectory for beamline if needed
- Hardware starts the motion

**Thank You!**  
**Questions?**