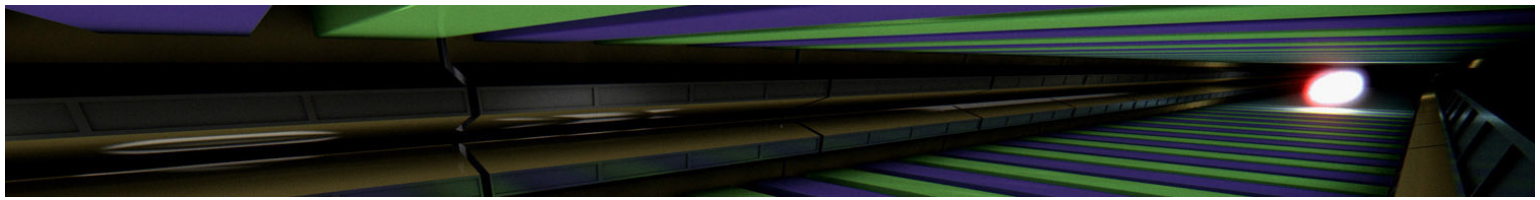
European XFEL



Beam Based Intra-Bunch Train Feedbacks

Patrick Geßler

(on behalf of all involved People)

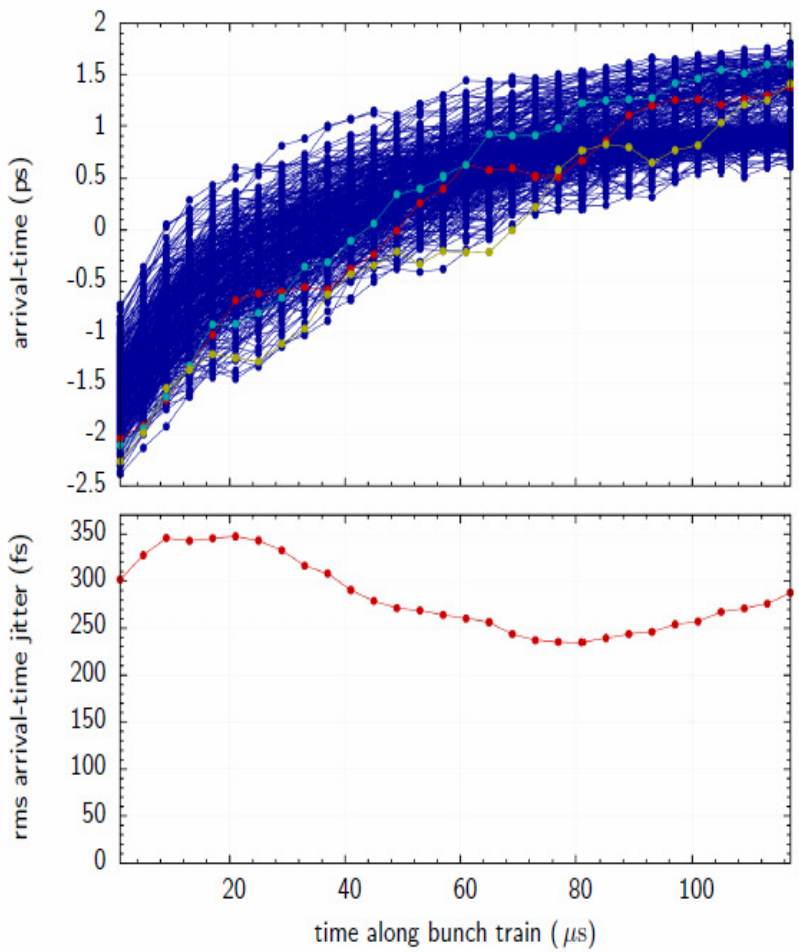
DESY

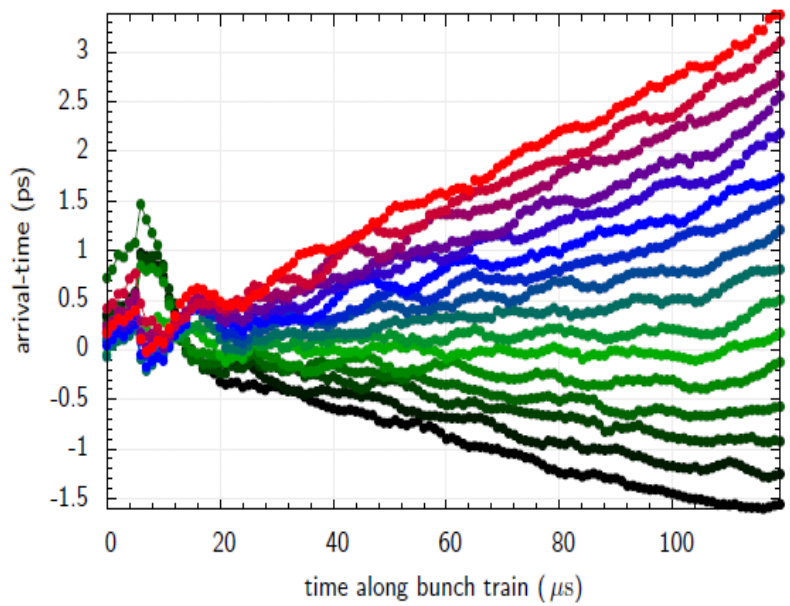
HELMHOLTZ ASSOCIATION

Agenda

- Motivation
- Studies
- Other influencing Factors
- Planned Feedback Structures
- Slow Feedbacks
- Challenges and Problems
- Summary

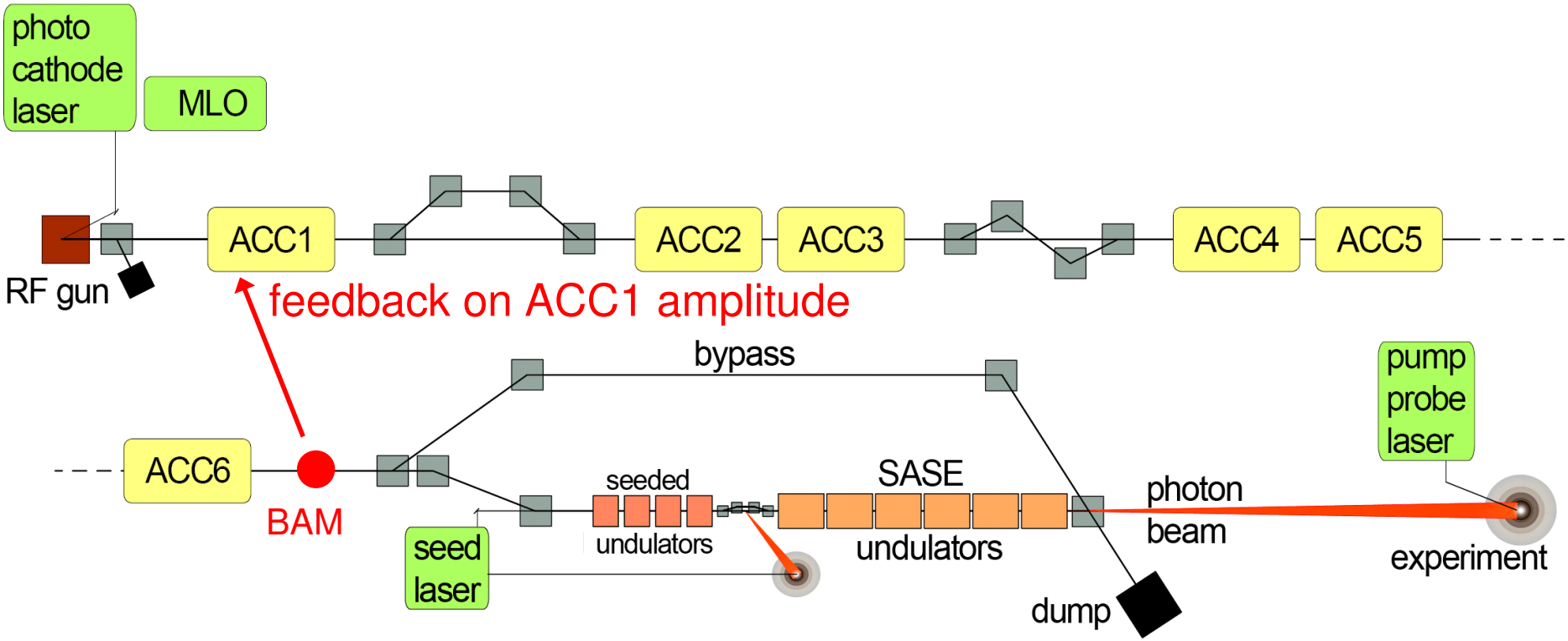
Motivation





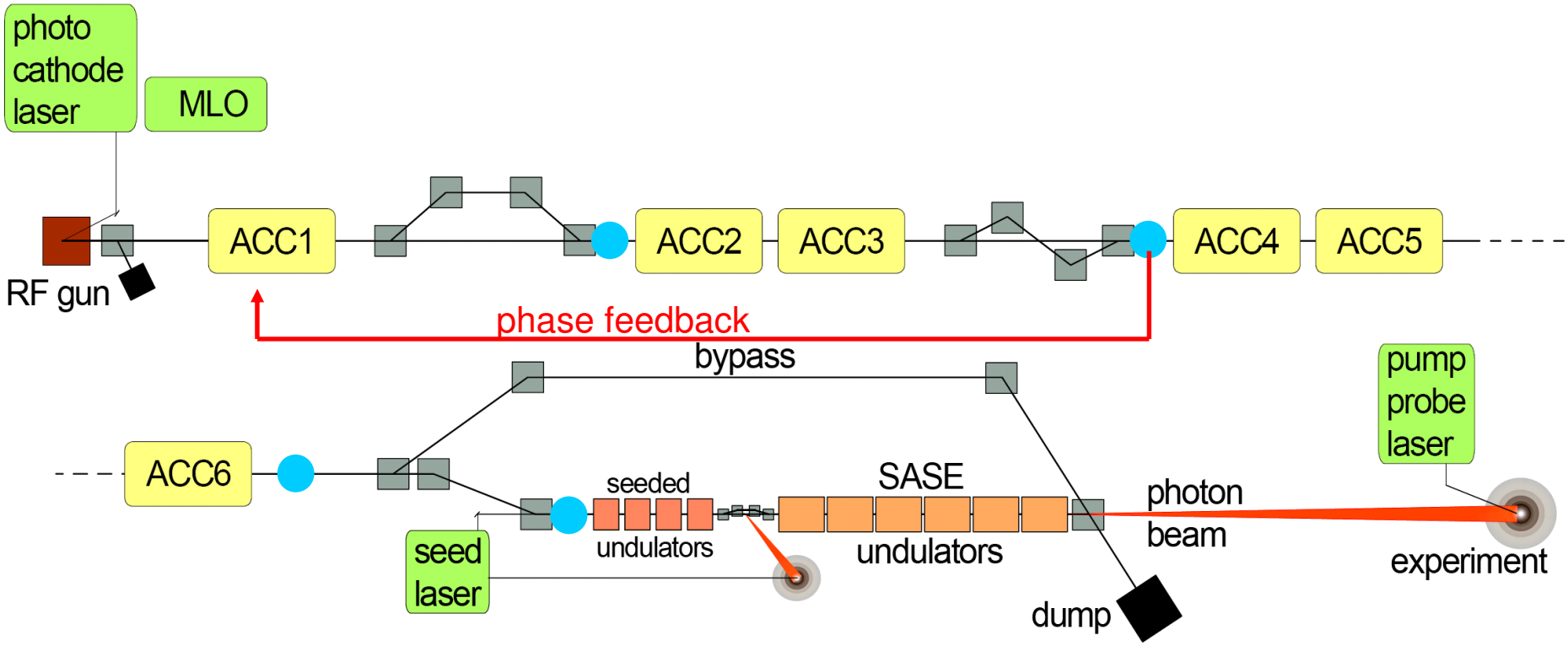
Curtsey: **F. Löhl**

Studies – BAM Feedback



Curtsey: **F. Löhl**

Studies – Pyro Feedback



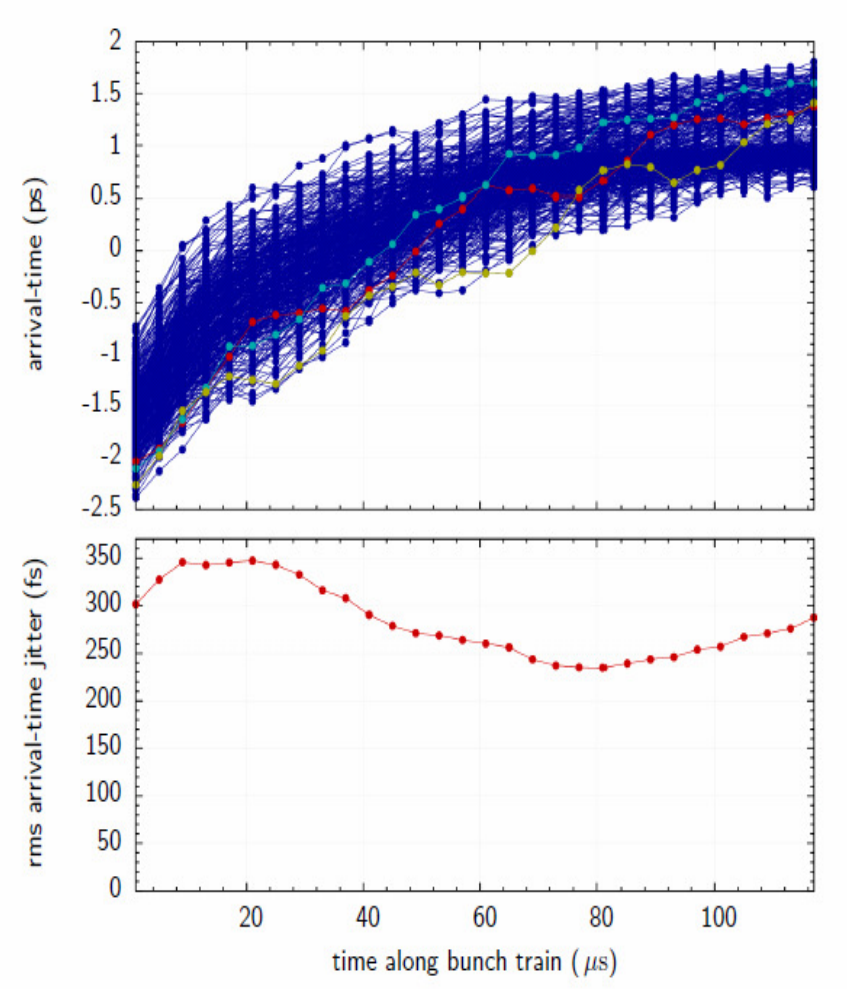
Curtsey: **F. Löhl**

Studies – Controller Structure

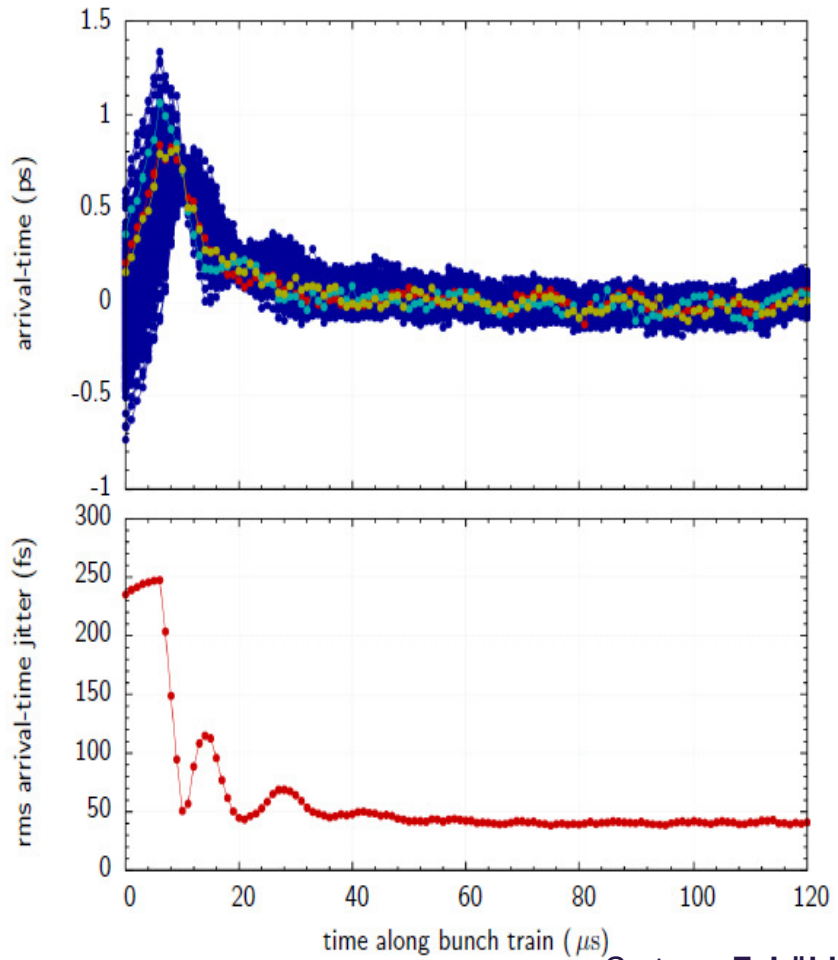
- Implements
  - Real time Arrival Time Calculation
  - PID Controller
- Adds correction values right before output

Studies – Bam Feedback

Feedback off



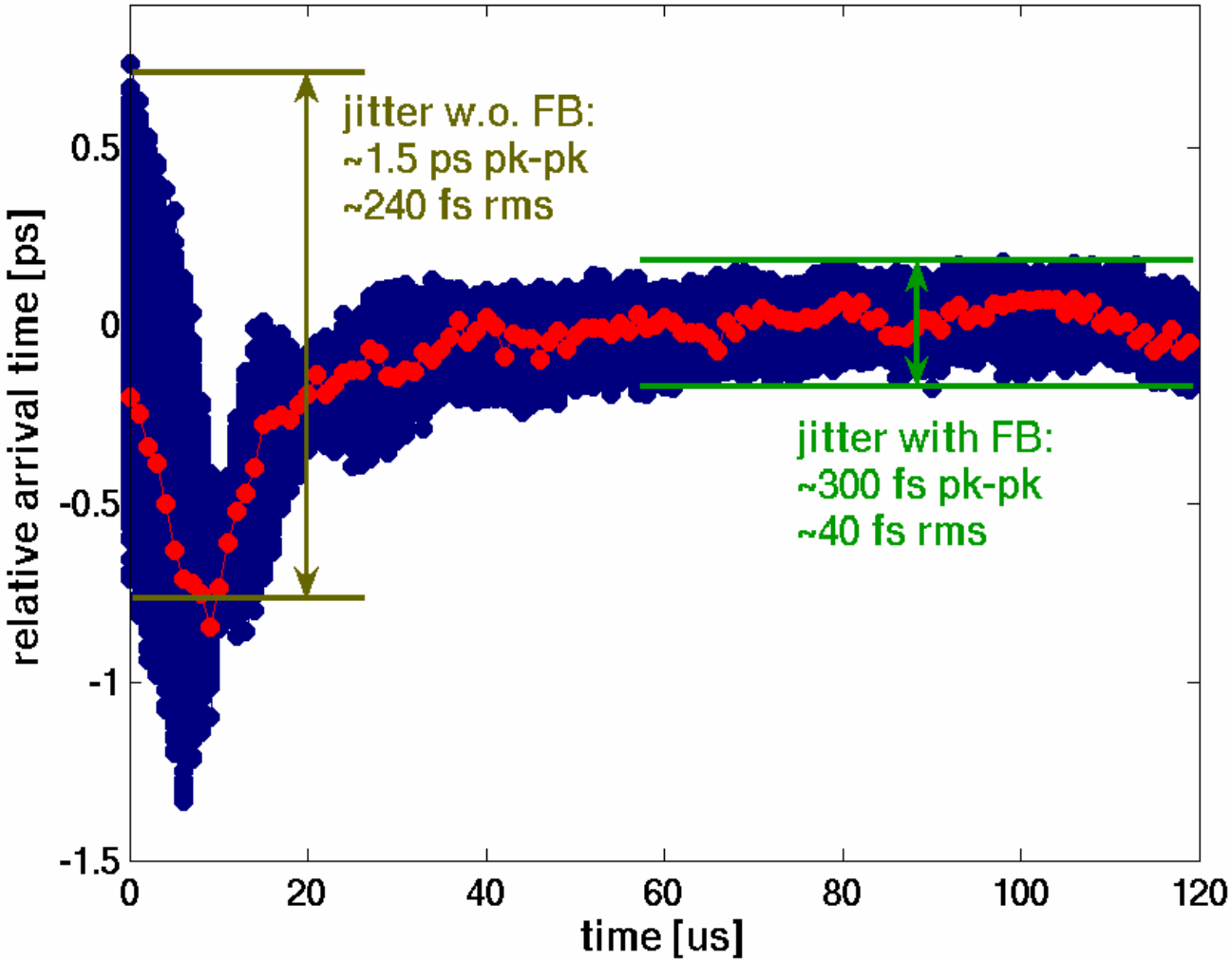
Feedback on



Curtsey: **F. Löhl**

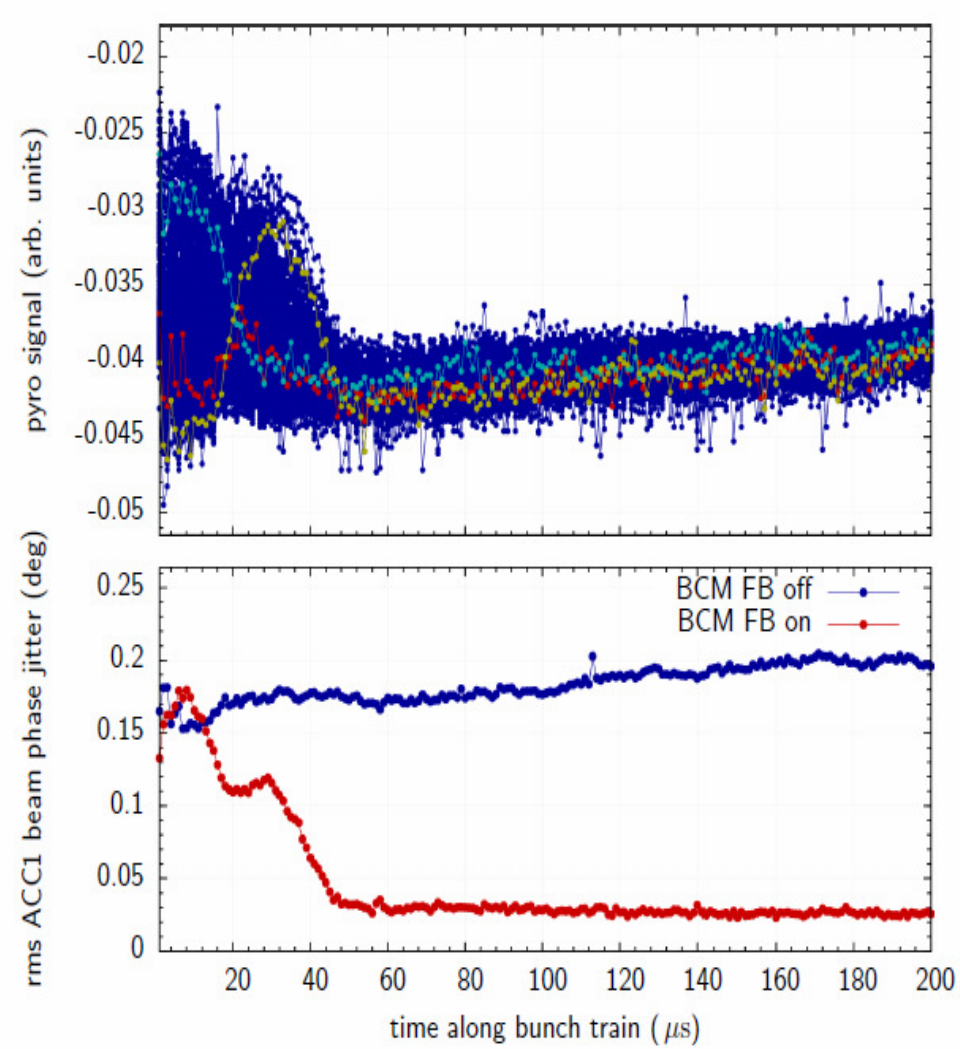
Studies – BAM Feedback

1200 shots:



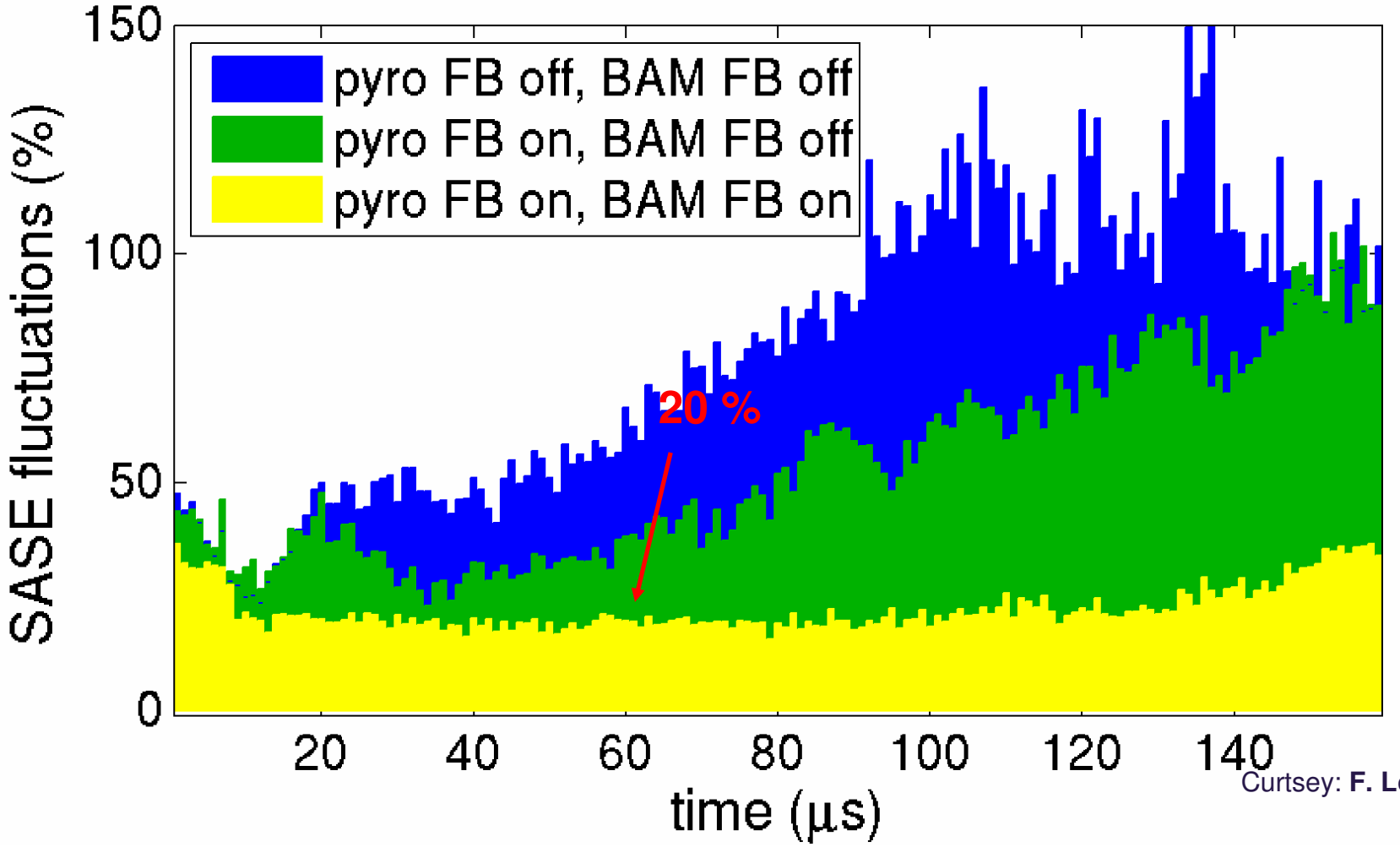
Curtsey: **F. Löhl**

Studies – Pyro Feedback



Curtsey: **F. Löhl**

Studies – Influence on SASE

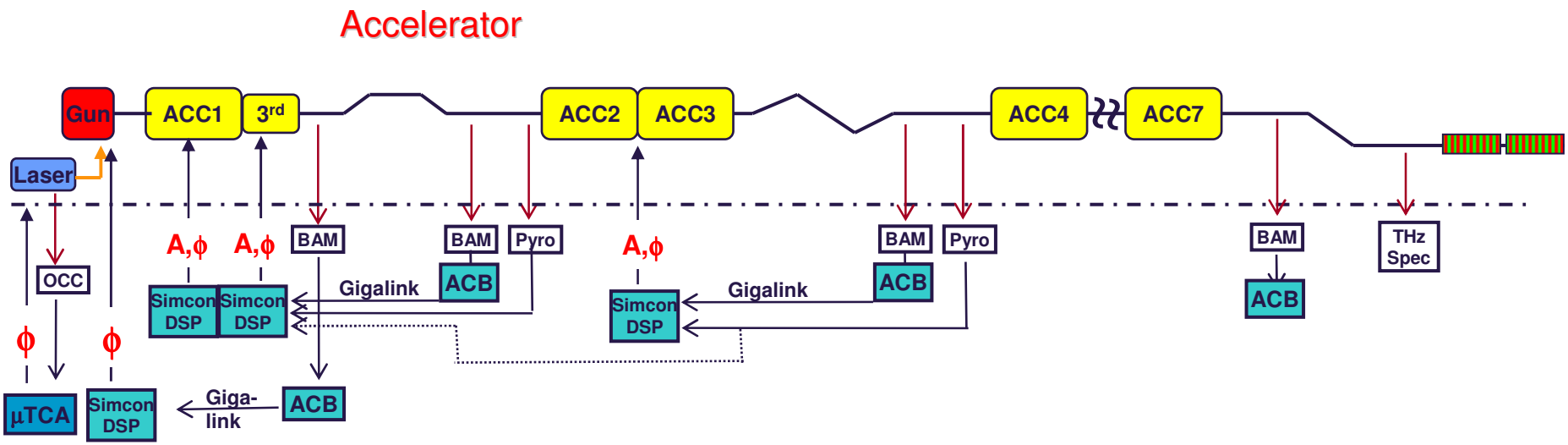


Curtsey: **F. Löhl**

Other Influencing Factors

- Injector laser Pulse Arrival
- Gun Phase
- 3rd harmonic Cavity
- ACC2/3 with BC3 on off-crest Operation

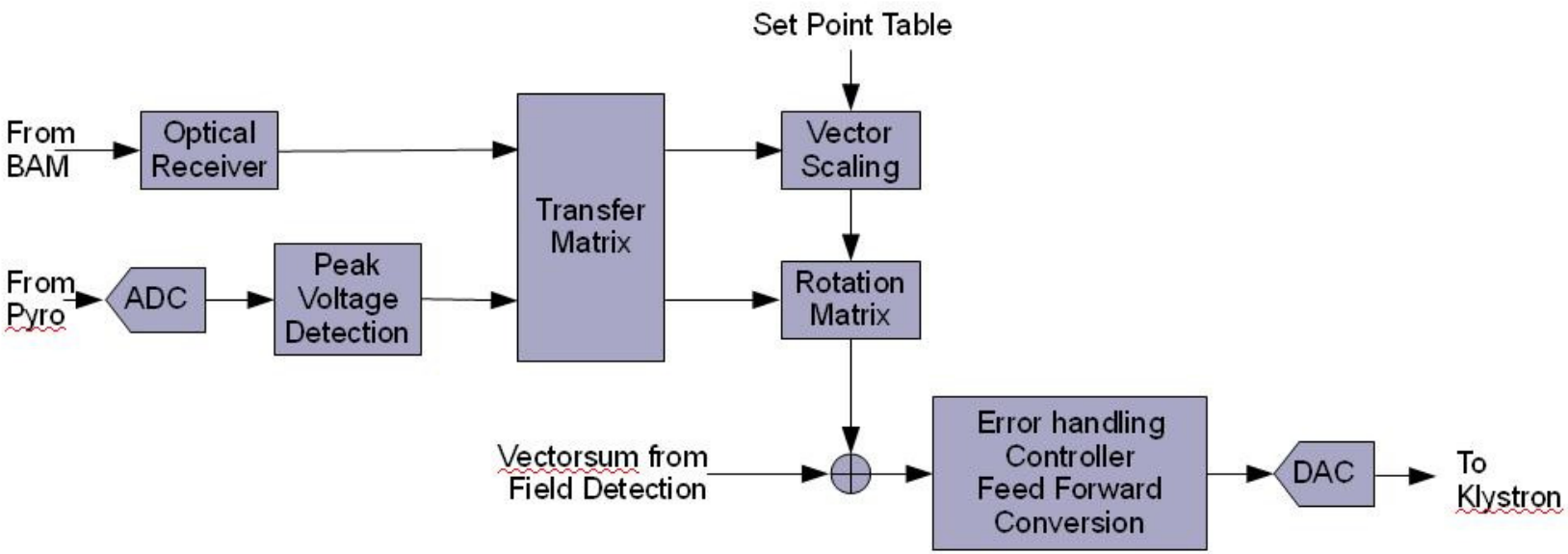
Planned Feedback Structures



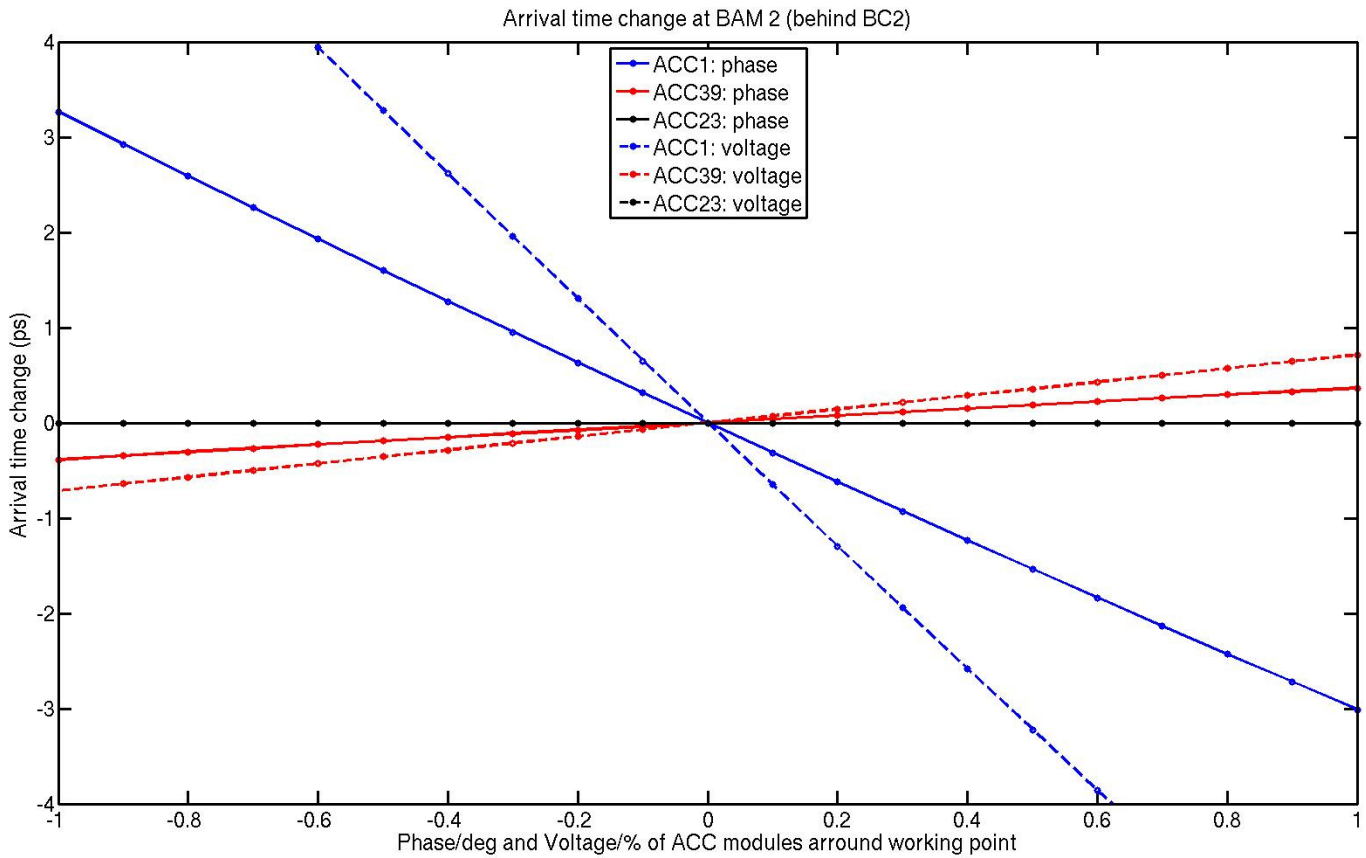
		Planned Date of operation
■	Four loops are considered Intra-bunch Train Feedbacks (IBTBF)	
1.	Based on optical cross-correlation correction of photoinjector pulse arrival (via VM on EOM)	6/2010
2.	Based on BAM 1UBC2 correction of gun phase	12/2010
3.	Based on BAM 3DBC2 & pyro signal BC2 correction of amplitude and phase of ACC1 & 3rd harmonic	8/2010
4.	Based on BAM 4DBC3 & pyro signal BC3 correction of amplitude and phase ACC23	8/2010

Curtsey: **H. Schlarb**

Planned Feedback Structures - Controller

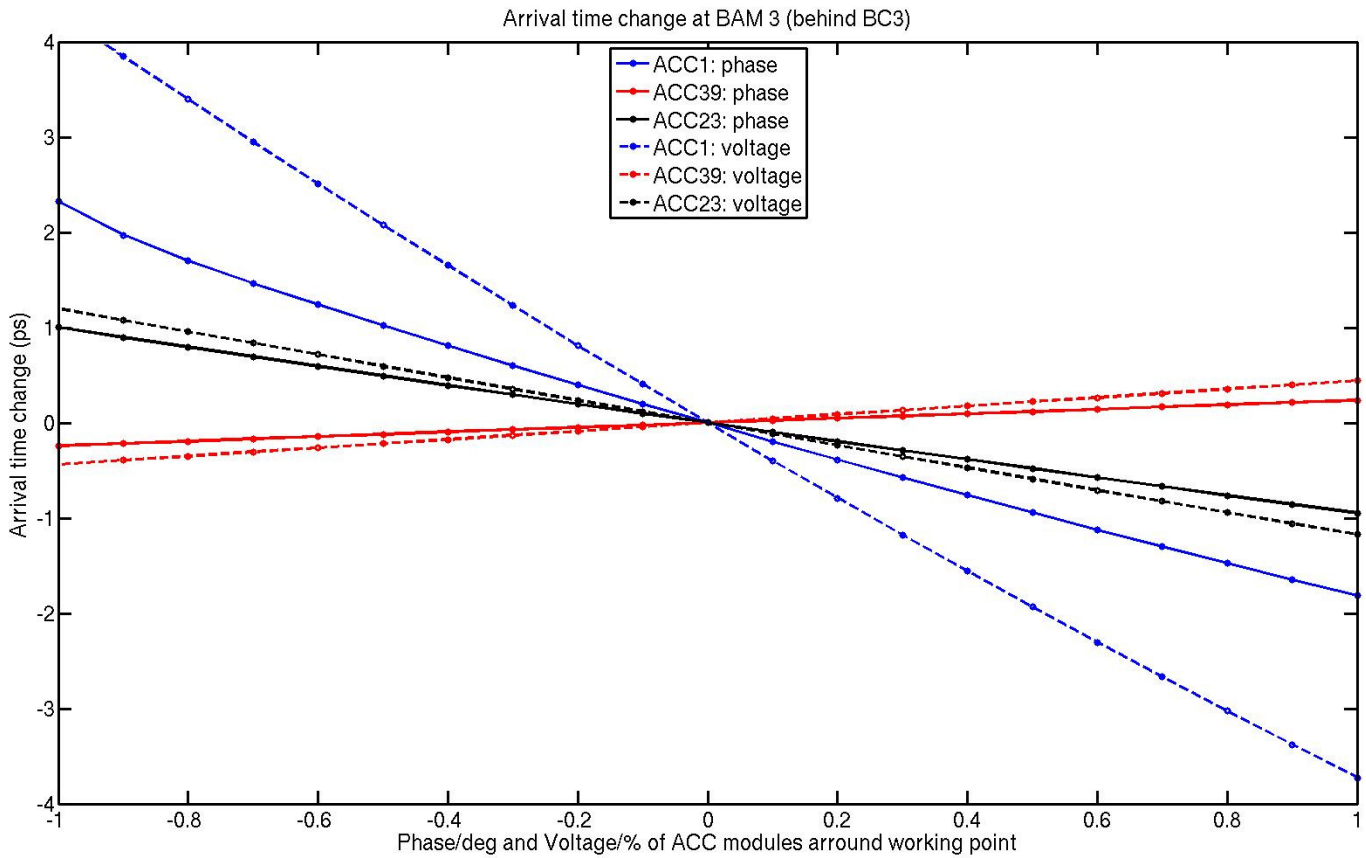


Planned Feedback Structures - Simulations



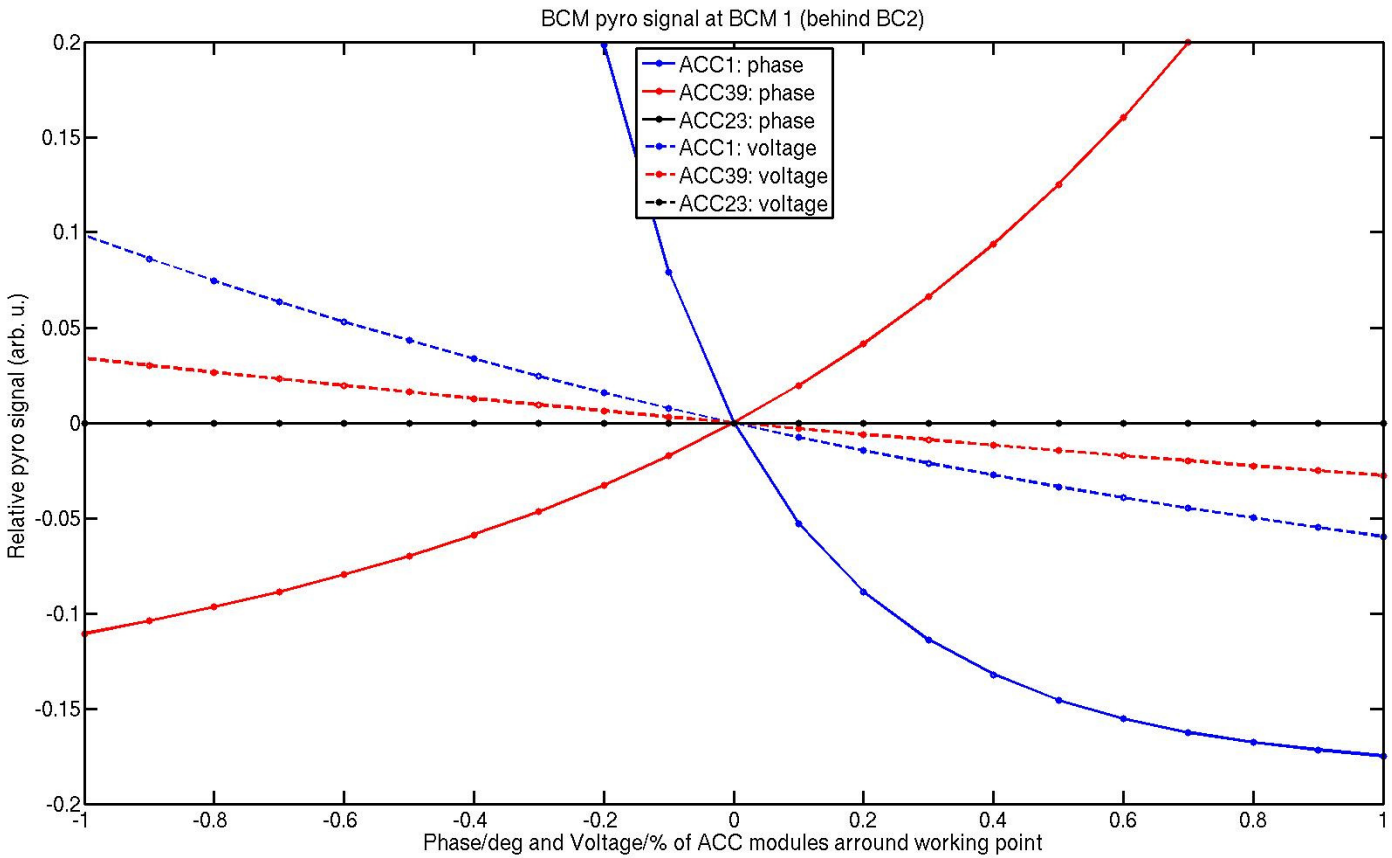
Curtsey: **C. Behrens**

Planned Feedback Structures - Simulations



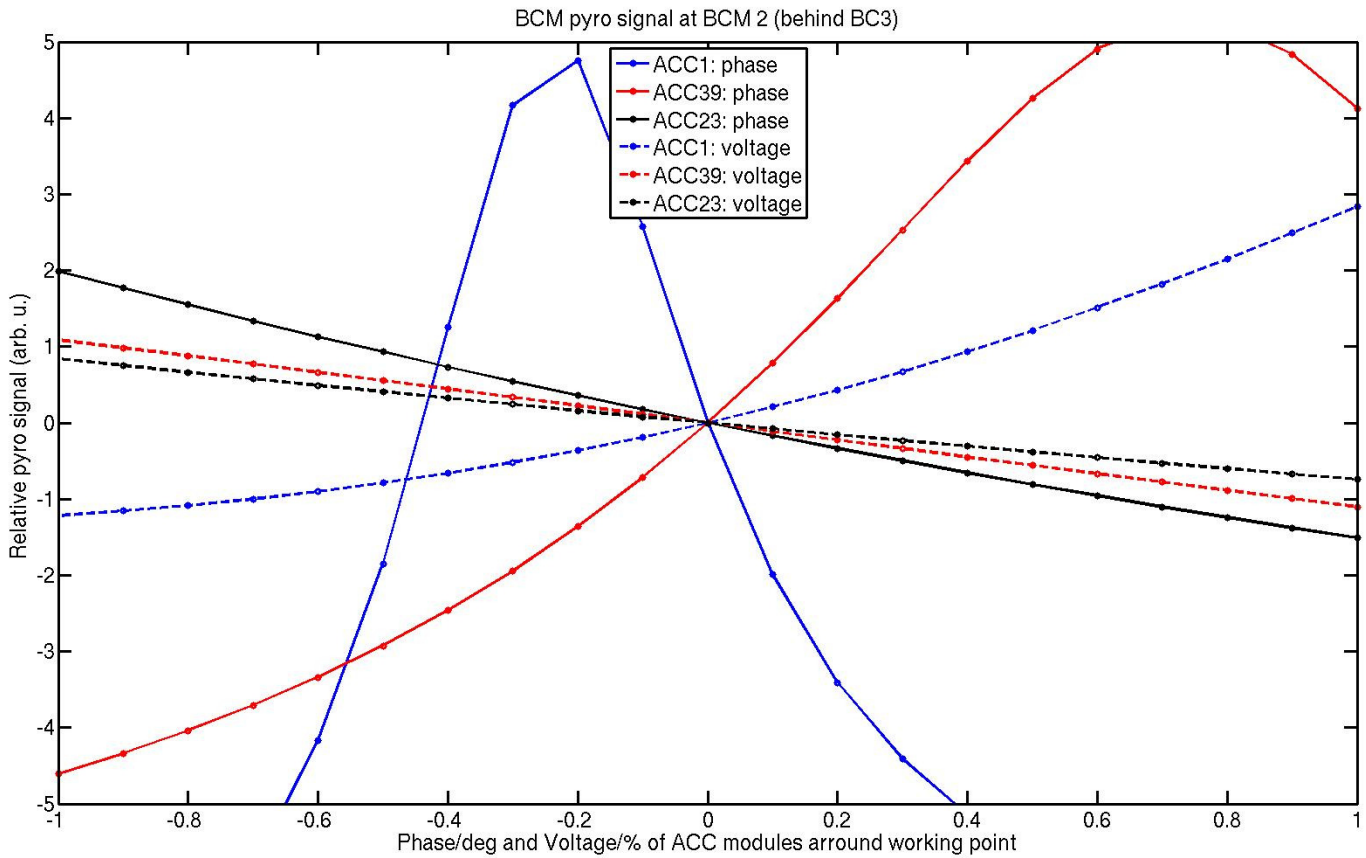
Curtsey: **C. Behrens**

Planned Feedback Structures - Simulations



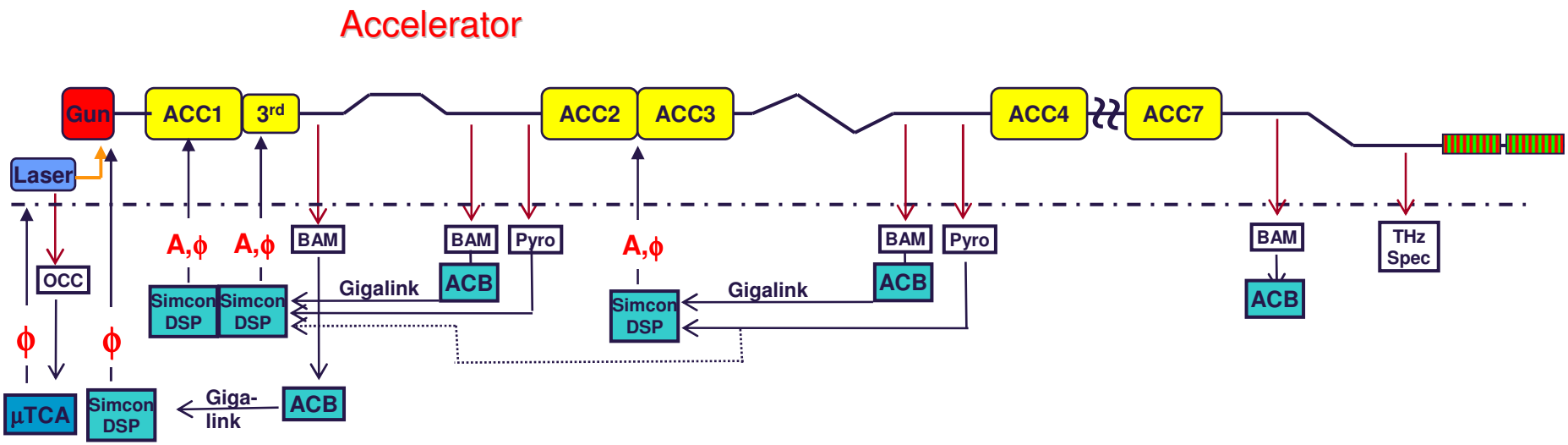
Curtsey: **C. Behrens**

Planned Feedback Structures - Simulations



Curtsey: **C. Behrens**

Planned Feedback Structures



Curtsey: **H. Schlarb**

Planned Feedback Structures - Simulations

$$M = \begin{pmatrix} \Delta t_1 \\ \Delta C_1 \\ \Delta t_2 \\ \Delta C_2 \end{pmatrix} \qquad P = \begin{pmatrix} \Delta V_1 \\ \Delta \phi_1 \\ \Delta V_{39} \\ \Delta \phi_{39} \\ \Delta V_{23} \\ \Delta \phi_{23} \end{pmatrix}$$

$$\mathrm{BAM2} \mathrel{\widehat{=}} \Delta t_1$$
$$\mathrm{BCM1} \mathrel{\widehat{=}} \Delta C_1$$
$$\mathrm{BAM3} \mathrel{\widehat{=}} \Delta t_2$$
$$\mathrm{BCM2} \mathrel{\widehat{=}} \Delta C_1$$

Planned Feedback Structures - Simulations

$$M = S \cdot P$$

$$S = \begin{pmatrix} S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{21} & S_{22} & S_{23} & S_{24} & S_{25} & S_{26} \\ S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{36} \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} & S_{46} \end{pmatrix}$$

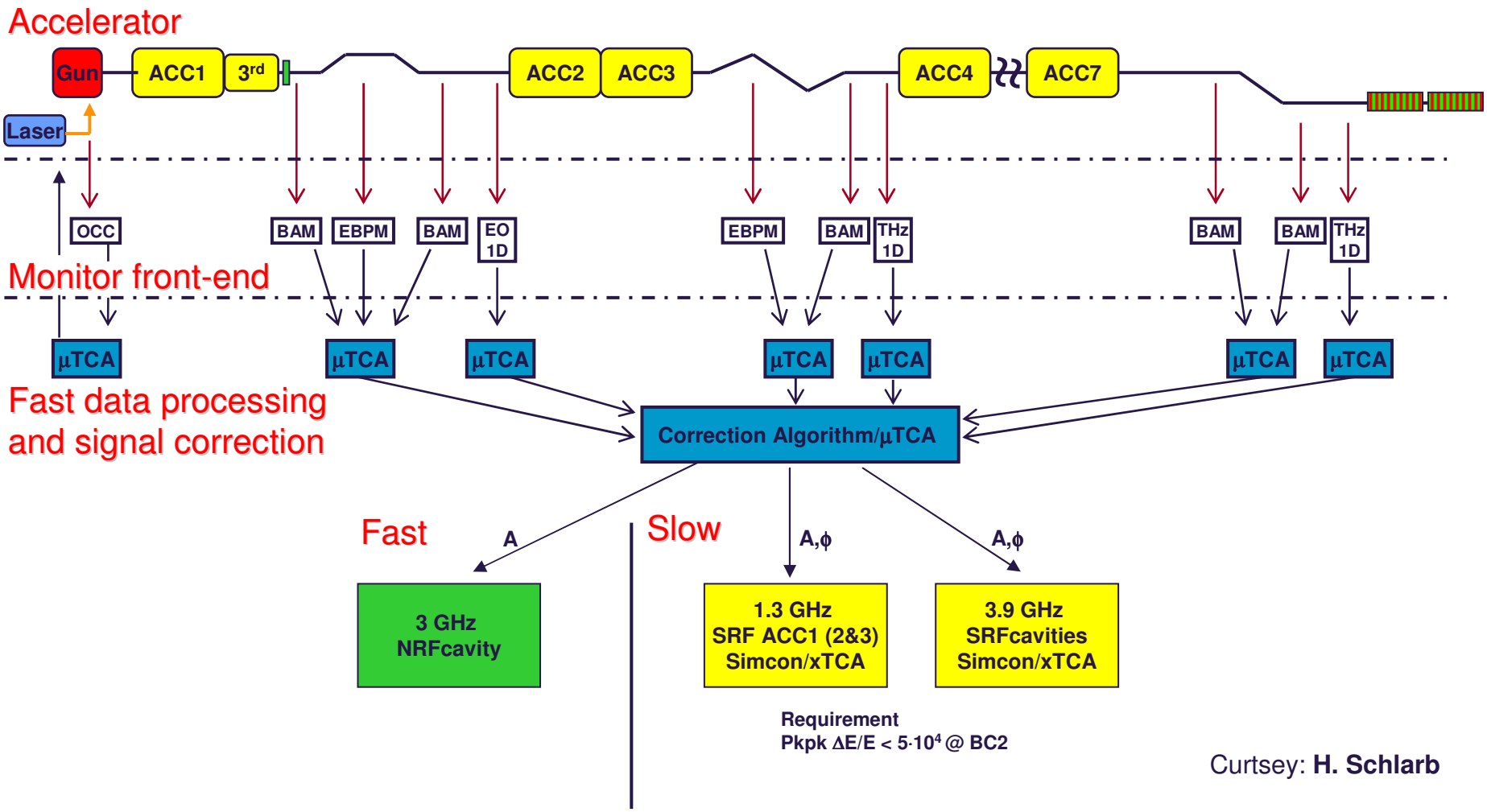
Planned Feedback Structures - Simulations

$$M = S \cdot P$$

$$S = \begin{pmatrix} -6.49 & -3.12 & 0.71 & 0.37 & 0 & 0 \\ -0.074 & -0.560 & -0.030 & 0.196 & 0 & 0 \\ -3.99 & -1.94 & 0.44 & 0.24 & -1.18 & -0.97 \\ 2.1 & 19.9 & -1.1 & 7.8 & -0.8 & -1.7 \end{pmatrix}$$

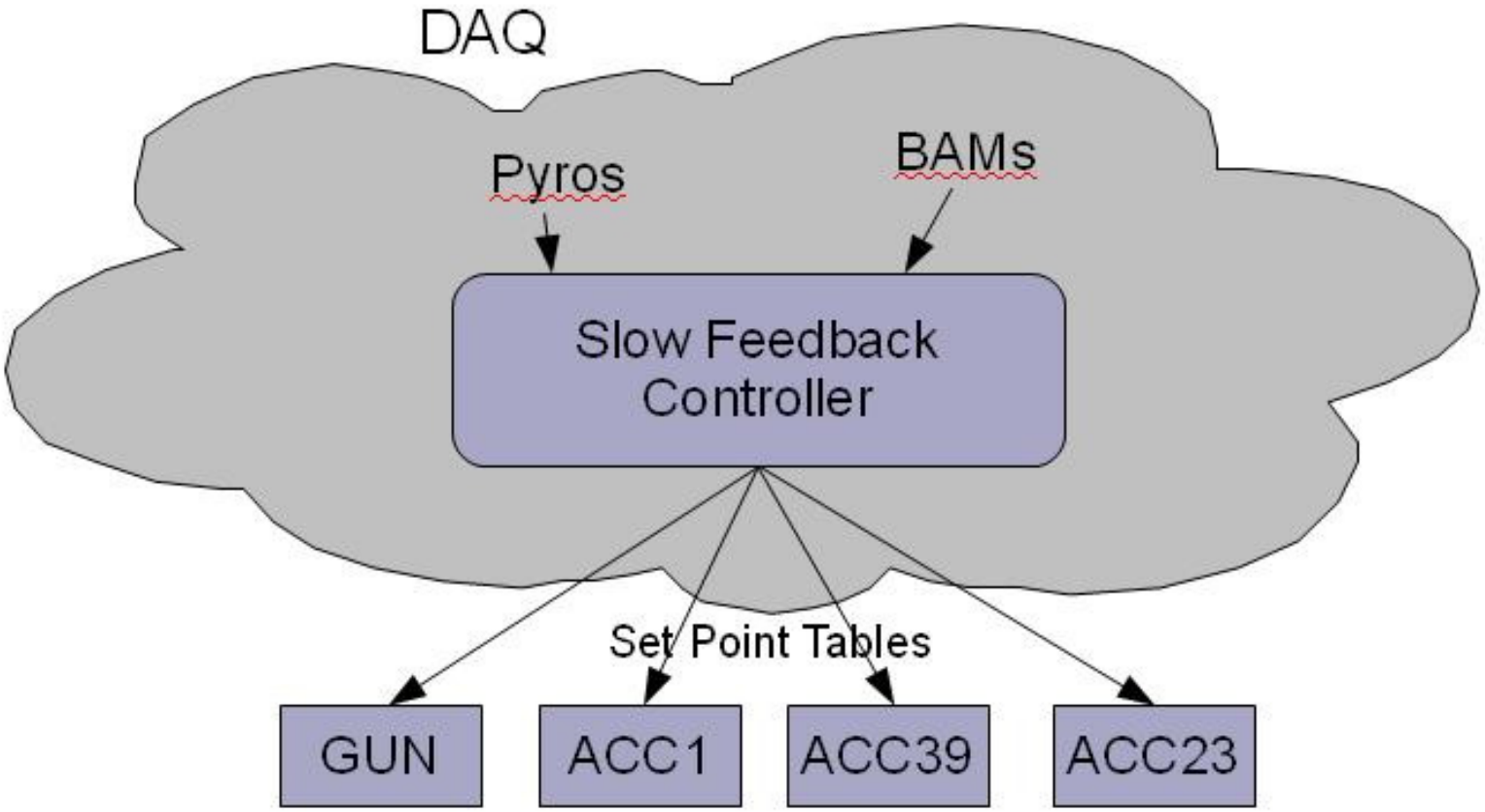
Curtsey: **C. Behrens**

Planned Feedback Structures - Future



Curtsey: **H. Schlarb**

Slow Feedbacks



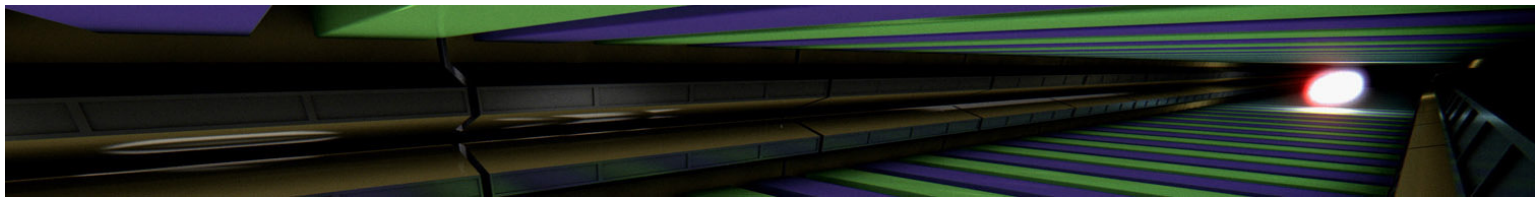
Challenges and Problems

- Timing and Synchronization of all involved Systems
  - Changes of Laser Parameters (Bunches, Reprate,…)
  - Gradients
- Avoid concurrent control loops and oscillations
- How to define Set points given by an Operator
- Error handling needs to ensure stable operation

Summary

- Investigations showed, that flatness depends on point of view
- Beam based Feedbacks are needed to stabilize beam in respect to arrival time and phase monitors
- The integration of beam based feedbacks into LLRF Controllers is going on
- A centralized controlling algorithm (based on all Monitors and Detectors) will optimize the outcome

European XFEL



Thank you for your Attention and to all involved People