## Status of the Laser - Based Synchronisation System.

- Design and Availability of the Beam Arrival Time Monitors after the Shutdown -

Marie Kristin Bock, FLA

for the LbSyn – Team:



- B. Beyer, M. Felber, P. Gessler, K.E. Hacker, F. Ludwig, K.-H. Matthiesen, H. Schlarb,
- B. Schmidt, J. Zemella

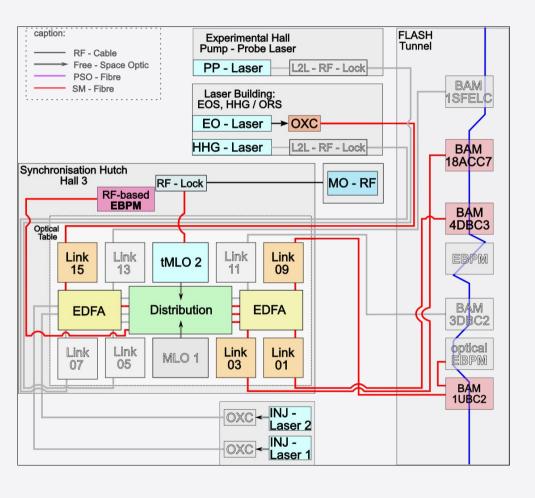


S. Schulz, L. Wissmann

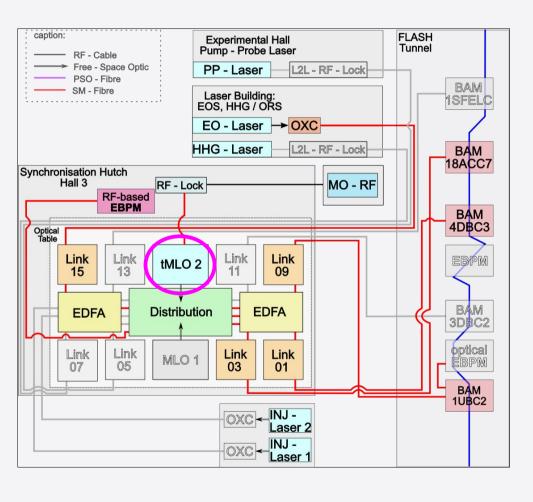


## Hardware Layout by the End of 2009

Optical Synchronisation System



## Master Laser Oscillator



### Master Laser Oscillator

#### Erbium - Doped Fibre Laser "Horst"

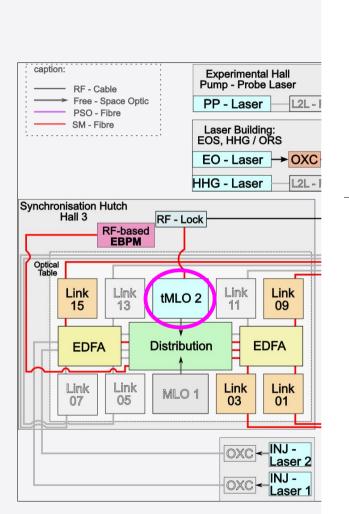
• central wavelength ~ 1560 nm

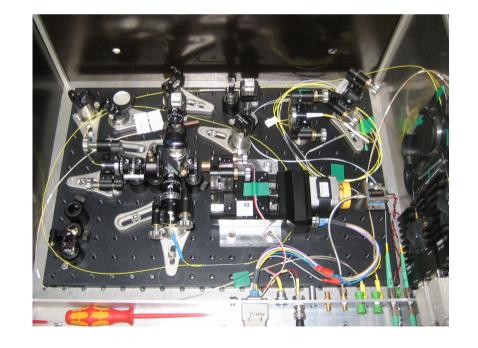
• repetition rate 216.67 MHz

• max. cw-power 215 mW

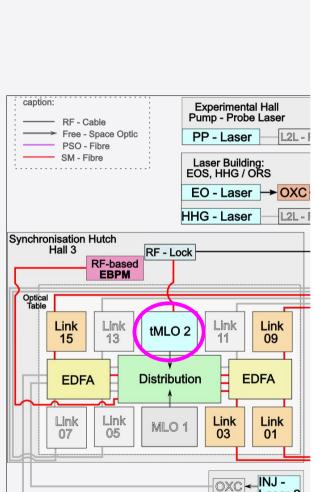
• mode-locked power ~ 65 mW

• self-made bread-board design





### Master Laser Oscillator

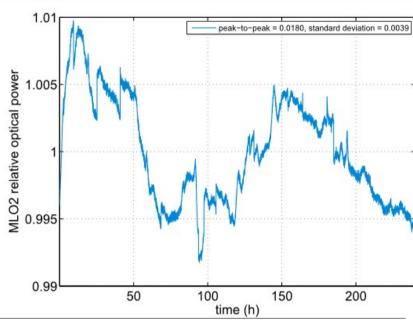


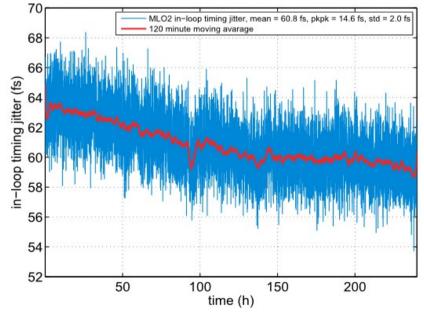
Laser 2 INJ -

Laser 1

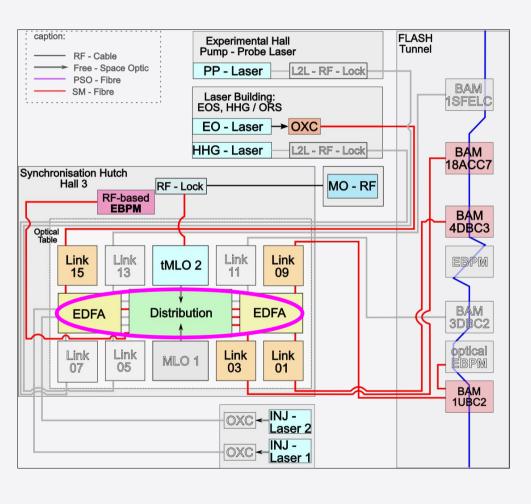
OXC

- pk-pk amplitude drift: 1.8 %
- rms amplitude drift : 0.39 %



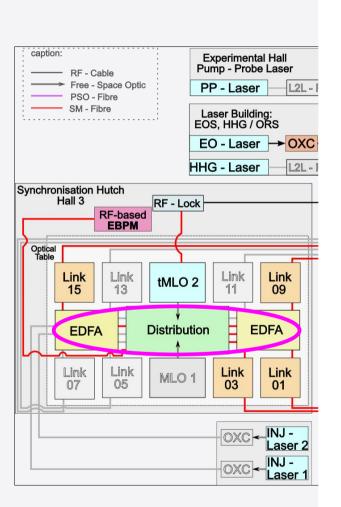


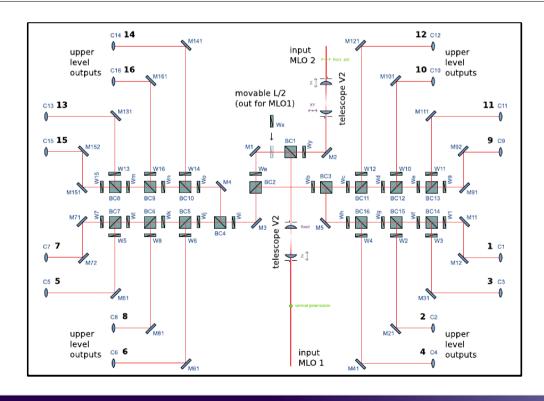
• in-loop measurement:

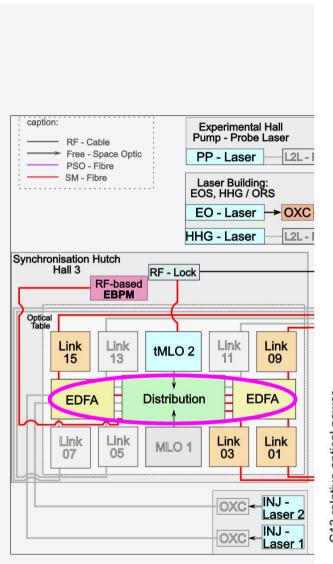


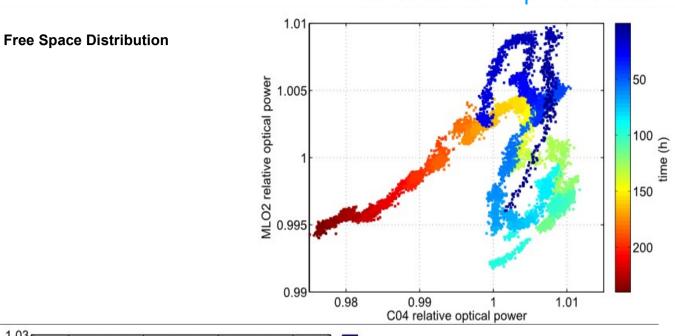
#### **Free Space Distribution**

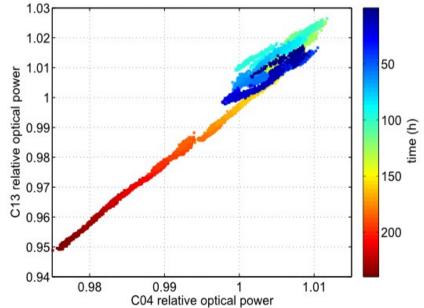
- output power of tMLO2 ~ 65 mW (mode locked)
- splitting optical power to max. 16 ports
- incoupling efficiency into collimators ~ 80 to 95 %, after optimisation
- about 4 mW optical power per port





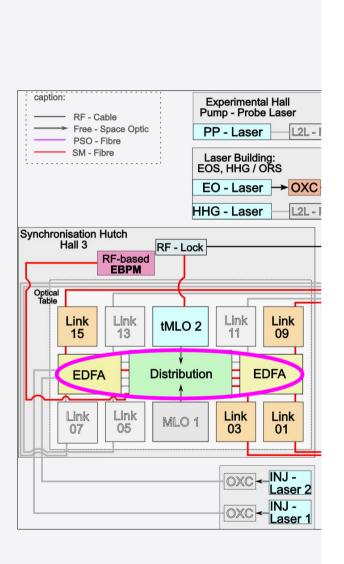




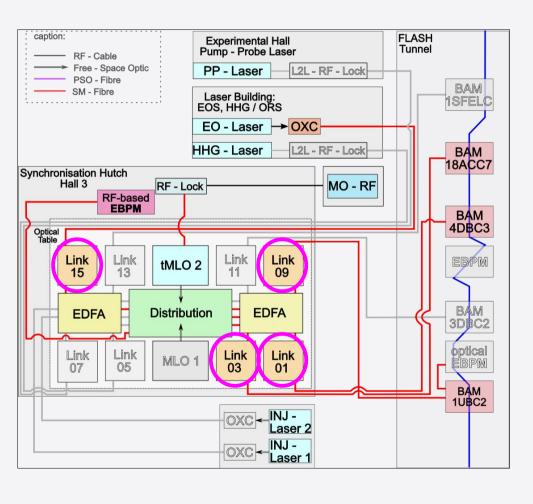


#### **Erbium – Doped Fibre Amplifiers (EDFAs)**

- dispersion compensating gain fibre
- boosting the optical power from ~4 mW to about 60 mW per Link Unit
- optimised EDFA should add less than 0.5 fs timing jitter (F. Loehl, J. Mueller)
- → will be thoroughly tested in the context of drift investigations



## Fibre Links.



Experimental Hall Pump - Probe Laser

PP - Laser

HHG - Laser

Link 11

Link

Link

Link

INJ -

INJ -

Laser 2

Laser 1

**EDFA** 

RF - Lock

tMLO<sub>2</sub>

Distribution

MLO 1

Laser Building: EOS, HHG / ORS

EO - Laser → OXC

caption:

Free - Space Optic

RF-based **EBPM** 

Link

13

Link

PSO - Fibre SM - Fibre

Synchronisation Hutch Hall 3

Link

**EDFA** 

Link

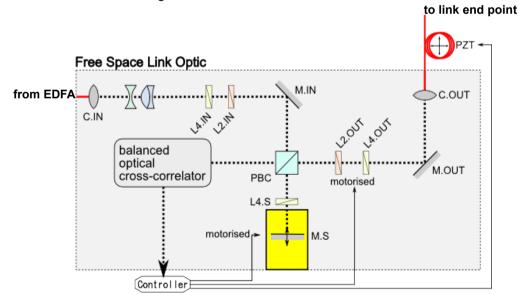
07

Optical Table

### Fibre Links.

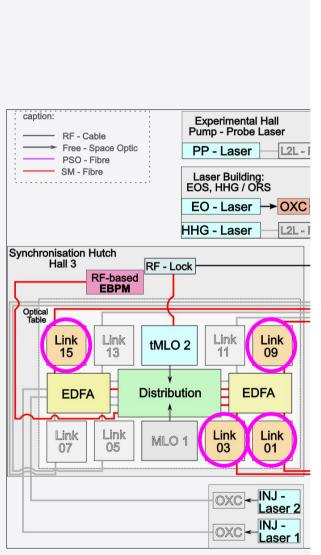
#### **Commissioning Phase Revealed Problems**

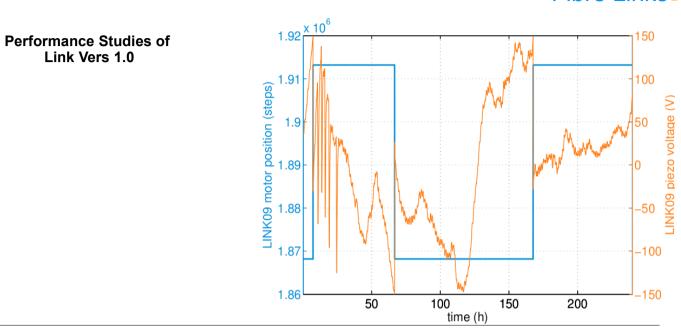
- major problem: self-made motorised delay stage
  - $\rightarrow$  (1) further development of self-made design
  - → (2) ordered 3 commercial linear stages
- a couple of "teething troubles" of Link Design Vers. 1.0
  - $\rightarrow$  (1) Jan./Feb. : only little changes (Vers. 1.1)
  - $\rightarrow$  (2) in 2011 : extensive design revision (Vers. 2.0)
- · observed large amplitude noise in all links
  - → under investigation

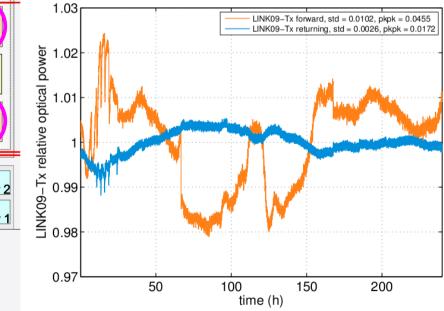




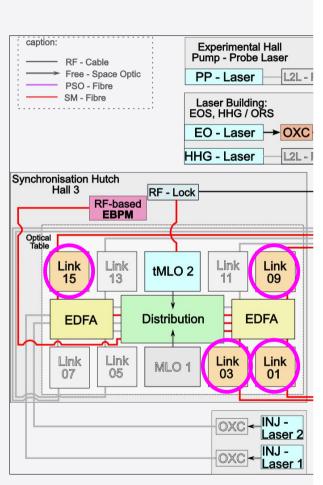
## Fibre Links.



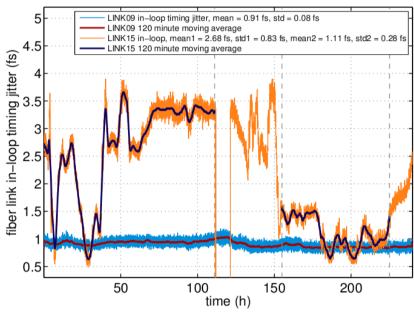




### Fibre Links.



# Performance Studies of Link Vers 1.0



#### in-loop measurement:

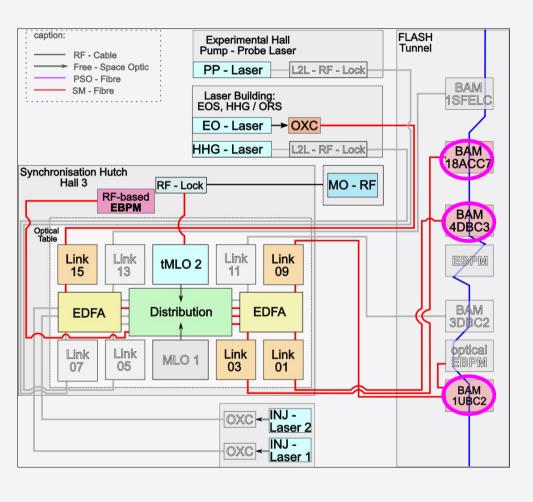
• Link 09:

mean timing jitter: 0.91 fs

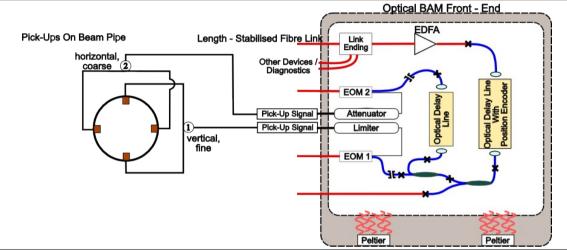
• Link 15:

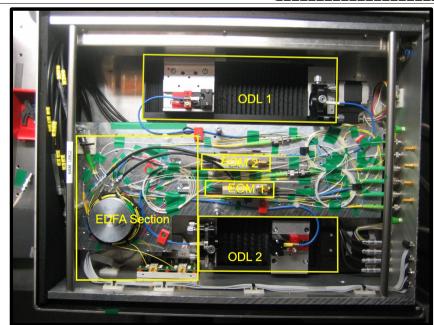
shortterm mean timing jitter:

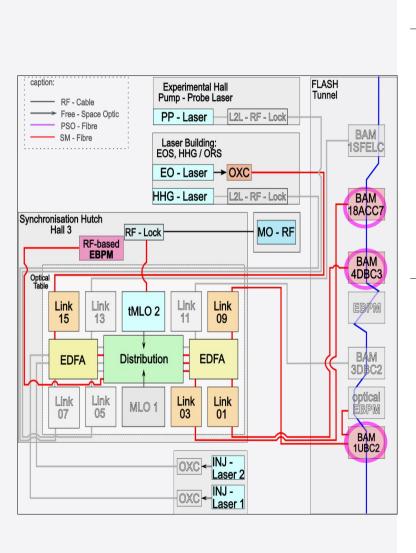
between 1.11 fs and 2.68 fs



# Major Changes of the Latest BAM compared to the BAMs Installed Further Downstream

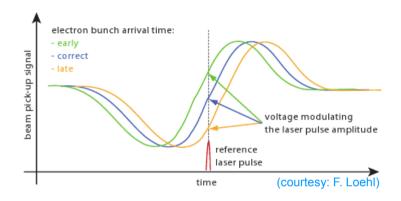






#### **Reminiscence** → **Functional Principle of BAMs**

• theory:

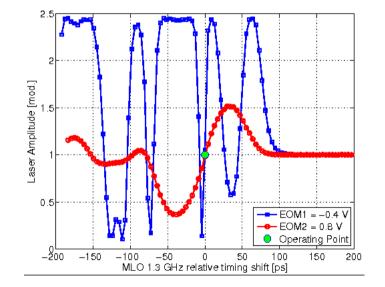


· measured:

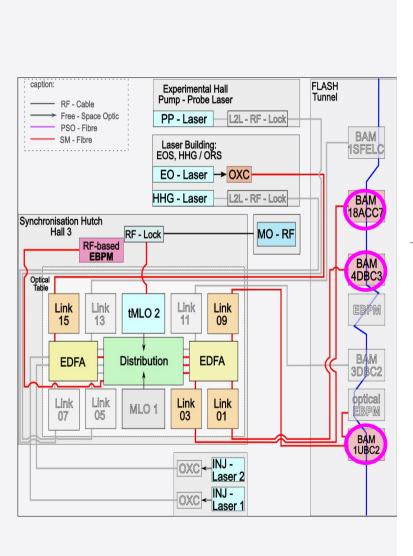
### dynamic range

• fine channel: 4 ps

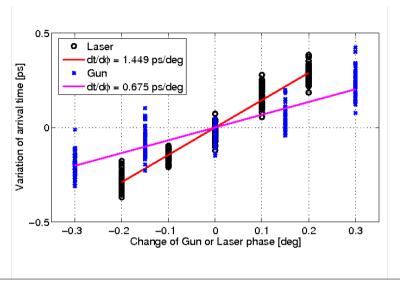
• coarse channel: 65 ps

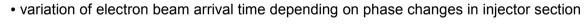


• intrinsic resolution of BAM: ~6 fs



### Measurement in August 2009 with BAM at 1UBC2

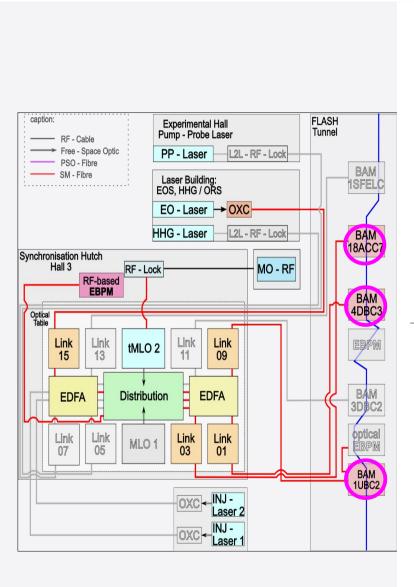




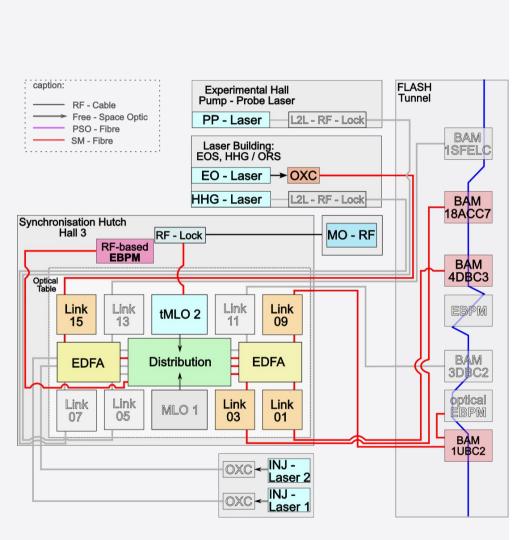
total measured value = 2.12 ps/deg

expected value = 2.14 ps/deg

• relevant for feedback implementation on the RF gun



### Master Plan.



→ Major changes to be put into practice until midyear 2010

# Master Plan Step #1

#### caption: FLASH Tunnel Experimental Hall Pump - Probe Laser RF - Cable Free - Space Optic L2L - RF - Lock PP - Laser PSO - Fibre BAM SM - Fibre Laser Building: EOS, HHG / ORS 1SFELC EO - Laser → OXC HHG - Laser L2L - RF - Lock BAM 18ACC7 Synchronisation Hutch Hall 3 MO - RF RF - Lock RF-based **EBPM** BAM 4DBC3 Optical Table Link 13 Link Link Link tMLO 2 15 09 BAM **EDFA** Distribution **EDFA** 3DBC2 optical Link Link Link Link MLO 1 <u> E</u>BPM 05 07 01 BAM 1UBC2 OXC - INJ -Laser 2 INJ -OXC-Laser 1

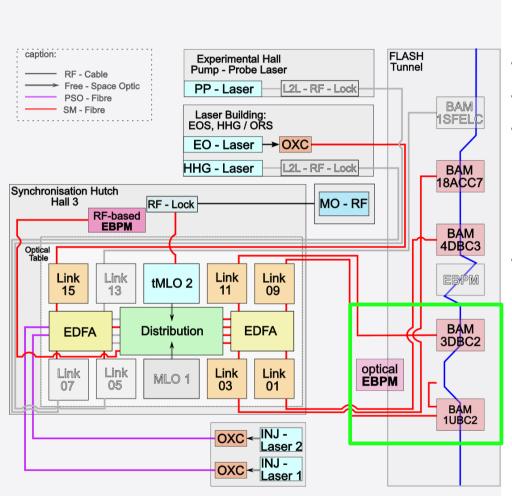
# Connecting the Injector - Lasers I & II to the Optical Reference

- preparation of optical & electronical infrastructure → end of Feb.
- commissioning of Optical-Cross-Correlator (OXC) → begin. of Mar.

#### benefits:

- · measurement of Inj.-laser pulse arrival time jitter
- facilitate integration of Adaptive-Feed-Forward (AFF) on Inj.-Laser
   Phase

# Master Plan Step #2.



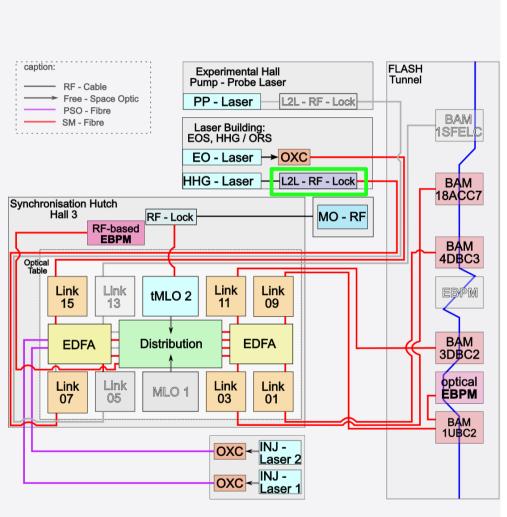
# Expanding the Laser - Based Beam Diagnosis Equipment at BC 2 and BC 3

- revision of  $^{4th}$  BAM & the optical EBPM at BC 2  $\rightarrow$  Jan. / Feb.
- at BC 3 for now no optical, but a RF-based EBPM → Feb.
- concerning the BAM 3DBC2:
  - improvements in power budget & fibre management
  - installation in tunnel & commissioning of the corresponding fibre link

#### benefits:

- operational when 1st beam through linac
- · employ in slow arrival time feedback

# Master Plan Step #3.



# Connecting the HHG - Laser to the Optical Reference

assembling hardware of Link

→ Feb. / Mar.

• upgrade of existing RF-lock box:

→ Mar. / Apr.

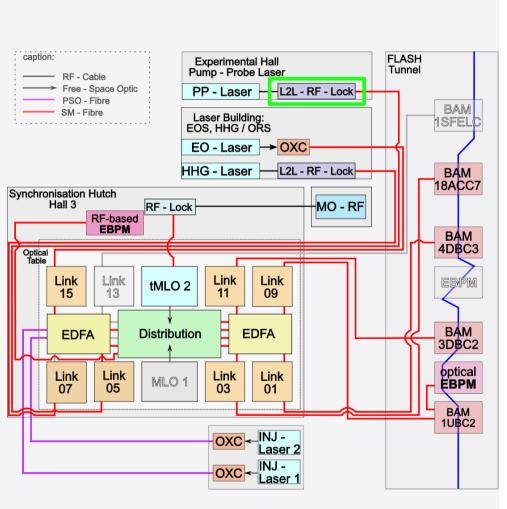
- RF generation at fibre link ending
- temperature regulation
- foreseen operability

 $\rightarrow$  mid of May

#### • milestone:

 RF - lock of the HHG Ti:Sapphire oscillator to the optical reference frequency

# Master Plan Step #4.



# Connecting the Pump - Probe - Laser to the Optical Reference

- ordering of revised Link mechanics → mid of Feb.
- duplicating RF-generation / RF-lock box → Apr.
- assembling hardware  $\rightarrow$  end of Apr.
- foreseen operability  $\rightarrow$  end of May

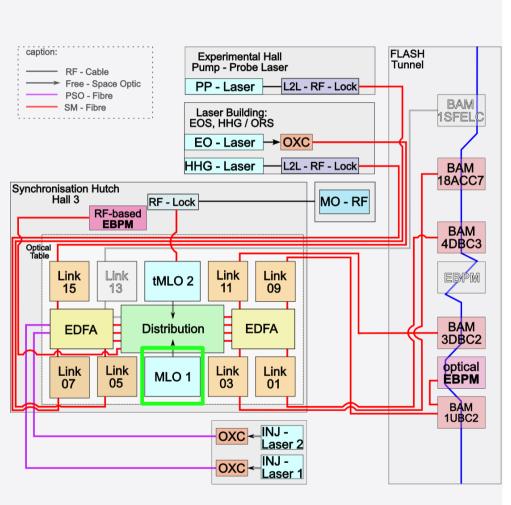
#### · milestone:

• RF - lock of the PP-laser to the optical reference frequency

#### benefits:

will be available with start of the 1<sup>st</sup> user run.

# Master Plan Step #5



### **Redundancy of the Master Laser Oscillators**

- ordered a commercial passively mode-locked soliton laser:
  - 'Origami 15' from OneFive
  - delivery 
    → end of Apr.
- commissioning & characterisation → begin. of May

#### · longterm goal:

automated switching between the two MLOs

#### · benefits:

• setting one of the preconditions for longterm stable Link operation

## Envisioned Status at the Time of the 1st User Run

