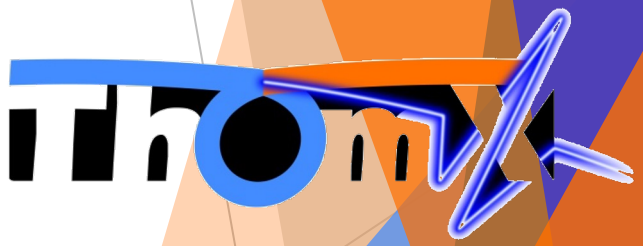
Diagnostics @ThomX

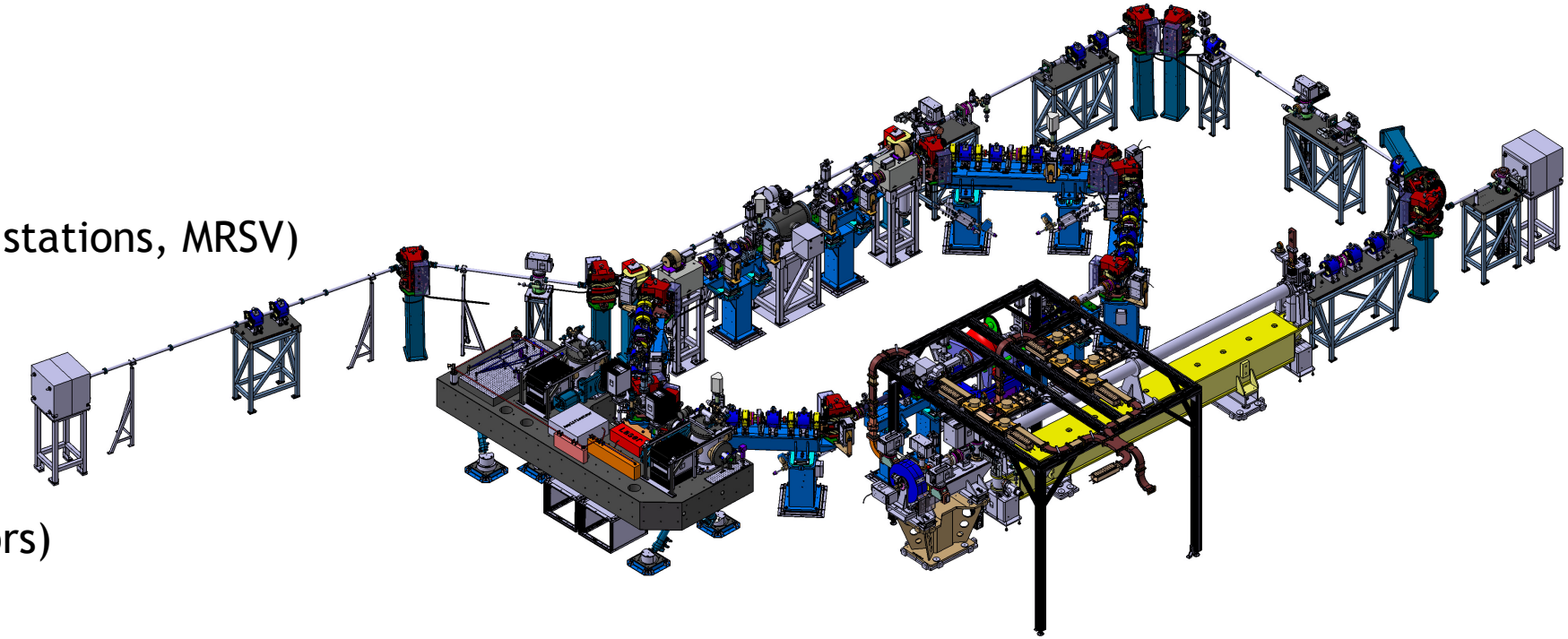


I. Chaikovska, V. Chaumat, N. Delerue (responsible),
V. Kubytskyi, V. Soskov

Programme Investissements d'avenir de l'Etat ANR-10-EQPX-51. Financé également par la Région Ile-de-France. *Program « Investing in the future » ANR-10-EQOX-51. Work also supported by grants from Région Ile-de-France.*

Diagnostics for ThomX

- Beam charge (ICT, FC)
- Beam position (BPM)
- Transverse profile (Diagnostic stations, MRSV)
- Bunch length (Streak camera)
- Beam losses (FBLM, Scintillators)



ICT: Integrating Current Transformer
FC: Faraday Cup
BPM: Beam Position Monitor
MRSV: Moniteur de Rayonnement Synchrotron Visible
FBLM: Fiber Beam Loss Monitor

Diagnostics group

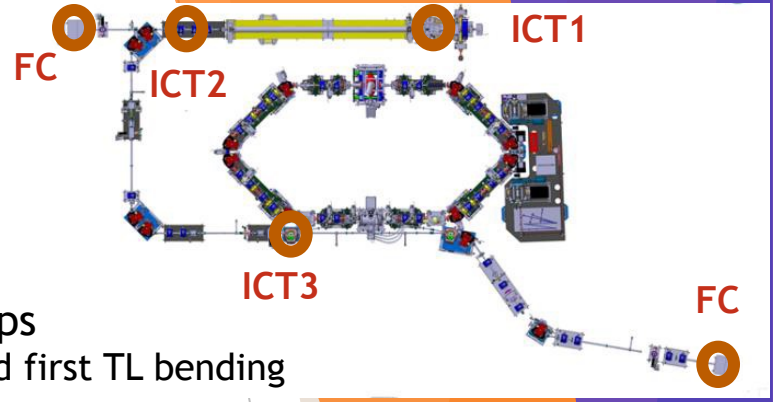
- N. Delerue (responsible) => Diag. stations, BPM, MRSV, Streak camera
- I. Chaikovska => BPM, BLM
- V. Chaumat => FC, ICT
- V. Kubytskyi => Diag. stations, MRSV, BLM, BPM
- V. Soskov => Streak camera

The biggest part of the work (conception design, technical design, production follow-up, acceptance tests…) was done by SOLEIL colleagues => N. Hubert, M. Labat

Transfert des responsabilités SOLEIL=> LAL

A lot of work done by the SDTM (design office and mechanical workshop) to design and build the diagnostics.

Charge measurement



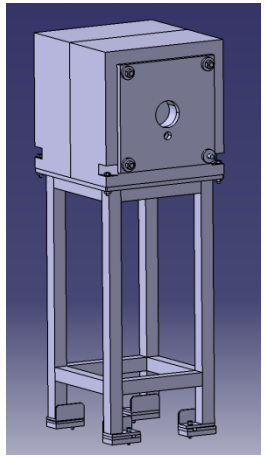
- 3 integrated current transformer (ICT)
  - Location:
    - @ LINAC entrance
    - @ Linac exit (before first TL bending magnet)
    - @ Transfer Line (before injection dipole)
  - Type:
    - In-flange integrating current transformer from Bergoz
    - Dedicated electronics BCM-IHR provides analog voltage proportional to the beam charge
    - Acquisition to be integrated in the control system (by Wavecatcher)

Expected resolution <1 pC

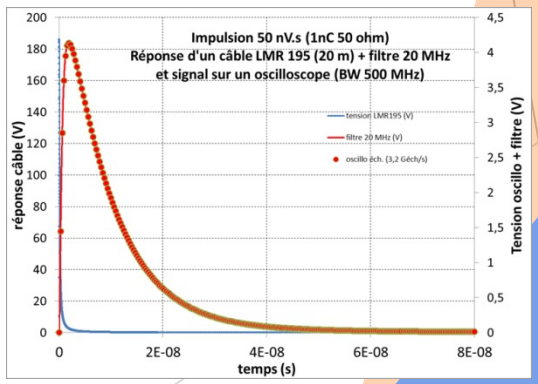
In-flange ICT & Electronics

Cf. V. Chaumat slides

- 2 Faraday cups (FC)
  - Location: in the beam dumps
    - @ the end of Linac (behind first TL bending magnet)
    - @ the end of extraction line
  - Acquisition:
    - Few tens of ns pulse to be acquired synchronously to injection or extraction trigger
    - Use of Low Pass filtering and acquisition with the Wavecatcher board (BW 500 MHz; 3.2 Gech/s). Tango device ready.



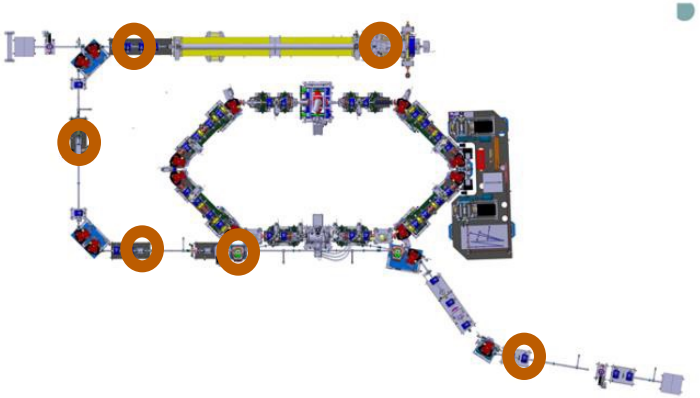
Beam dump



Low-pass filtered signal

Wavecatcher

Position measurement (BPM)



- 6 Striplines for injector
  - 1 stripline on the LINAC
  - 4 striplines on the transfer line
  - 1 stripline on the extraction line

- λ/4 @ 500 MHz -> Electrode length = 150 mm
- Resolution requirements: < 100 µm for 1 nC
- 4 electrodes @ 45° covering ~2/3 of circumference
- Linac stripline has different design due to larger vacuum chamber diameter
- Mechanics and soldering (feedthroughs) are done at LAL
- Electrical tests and calibration done at SOLEIL

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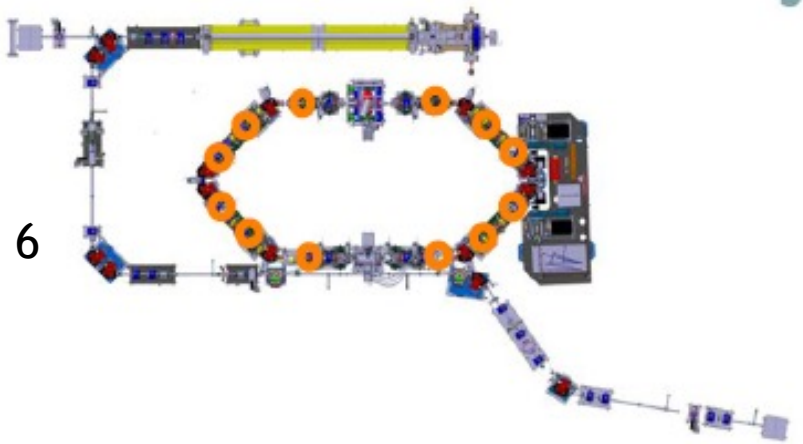
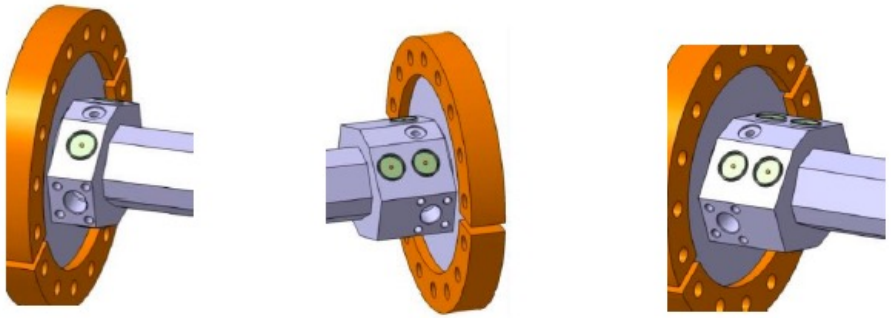
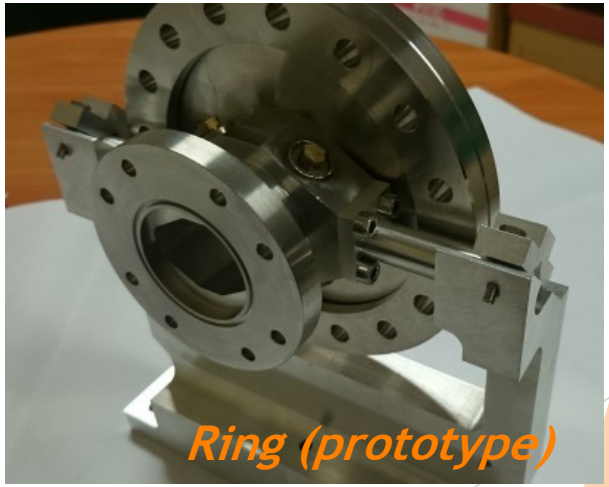
Position measurement (BPM)



- 12 button BPMs for the storage ring (4 BPM with 8 buttons, 4 BPPM with 6 buttons and 4 BPM with 4 buttons)
  - Resolution ~1 µm @ 10 Hz
  - Prototype done at LAL
  - Mechanics and soldering are done by RIAL Vacuum
  - Additional electrodes on double BPM for:
    - Transverse and longitudinal bunch by bunch feedbacks
    - Polarization for ion cleaning



4, 6 and 8 buttons BPMS



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Position measurement (BPM)

Libera Brilliance +

- Libera Brilliance+ (Instrumentation Technologies)
  - 4 BPM boards per crate
  - Data Flow:
    - Single Pass for Linac, Transfer Line and Extraction Line
    - @ 8,33 MHz (half rev. freq.) ~turn by turn data for storage ring
    - @10 Hz slow acquisition data for storage ring
  - Automatic gain control
  - Post-mortem and interlock possibilities
  - Tango device available and fully configurable embedded on the ARM processor

Tests @PHIL

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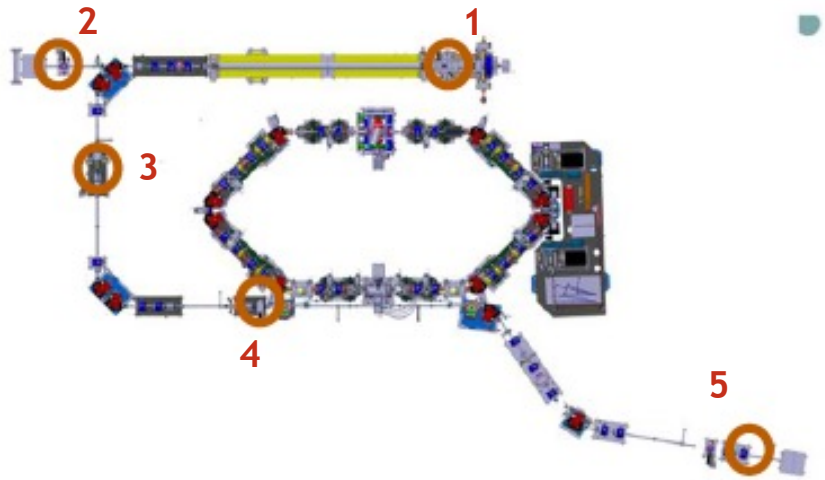
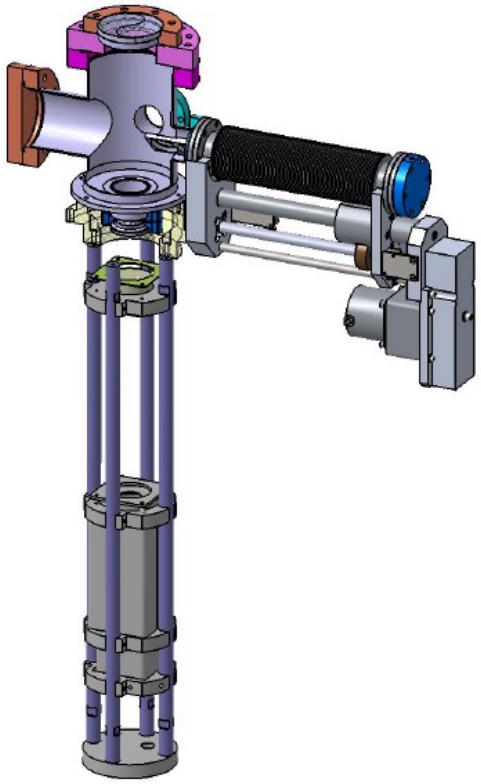
Diagnostic stations



- Location
  - 5 stations on Linac, Transfer Line and Extraction Line
- Purpose:
  - Beam size, emittance and energy measurement
- Principle:
  - Screen translation stage
    - Calibration plate
    - YAG (Ce): 25 mm diameter, 100 µm thick
    - OTR : 25 mm diameter, 100 µm aluminised silicon wafer
    - Sapphire screen (station 2 @ end of Linac)
  - View port: Fused Silica DN 60 CF
  - Imaging system
  - Gigabit Ethernet trigged CCD



Screen translation stage

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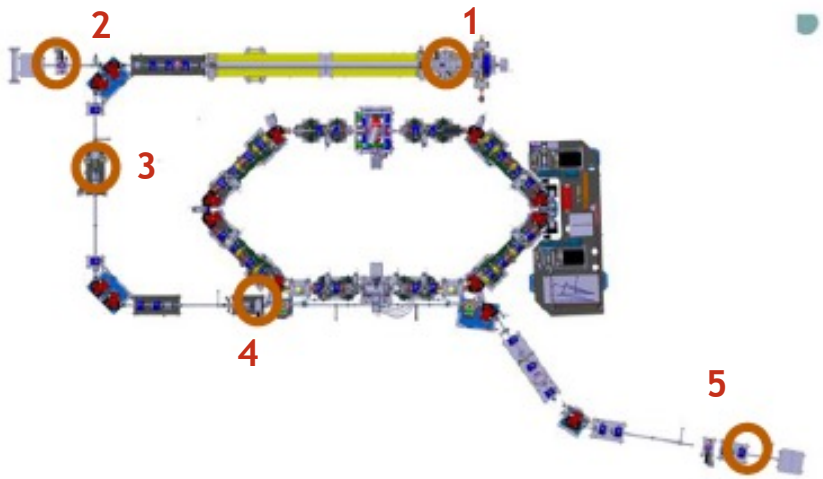
Diagnostic stations



- **Transverse size measurements**
- **Emittance measurement**
  - Using Quadrupole scan method
    - Measure beam size vs Qpole strength
    - Required resolution: 10 pixels/sigma
    - Devices: 1 quadrupole + screen + CCD
    - Location: @ Diag stations 2, 3 and 4
- **Energy measurement:**
  - Passing through dipole magnet → dispersion
    - <x> → E = energy
    - dx → dE = energy spread
  - Device:
    - Dipole + screen + CCD
  - Location: @ middle of transfer line (Diag Station 3) and @ dump 2 (Diag station 5)

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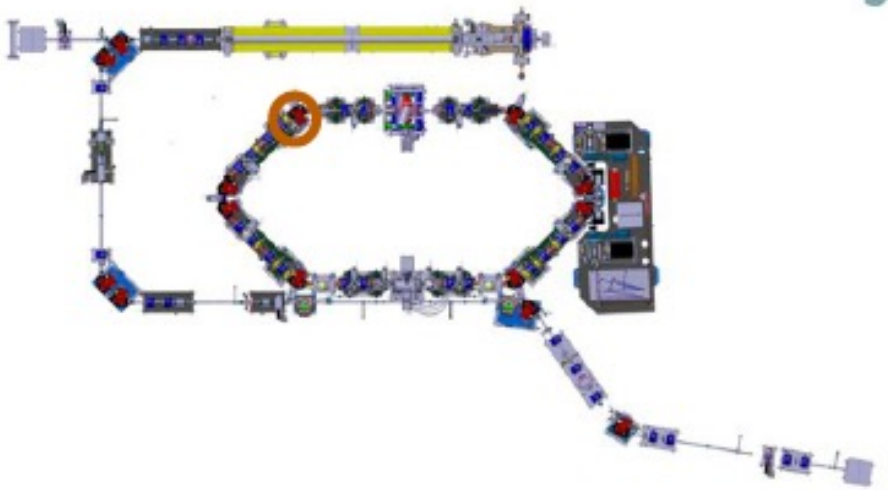
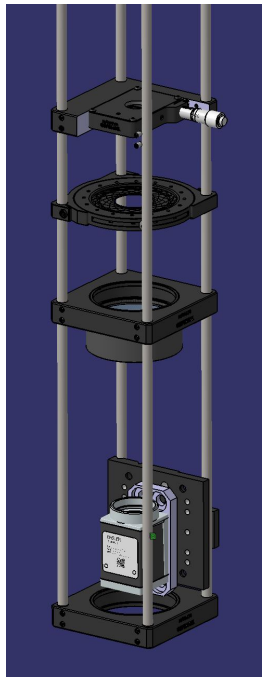
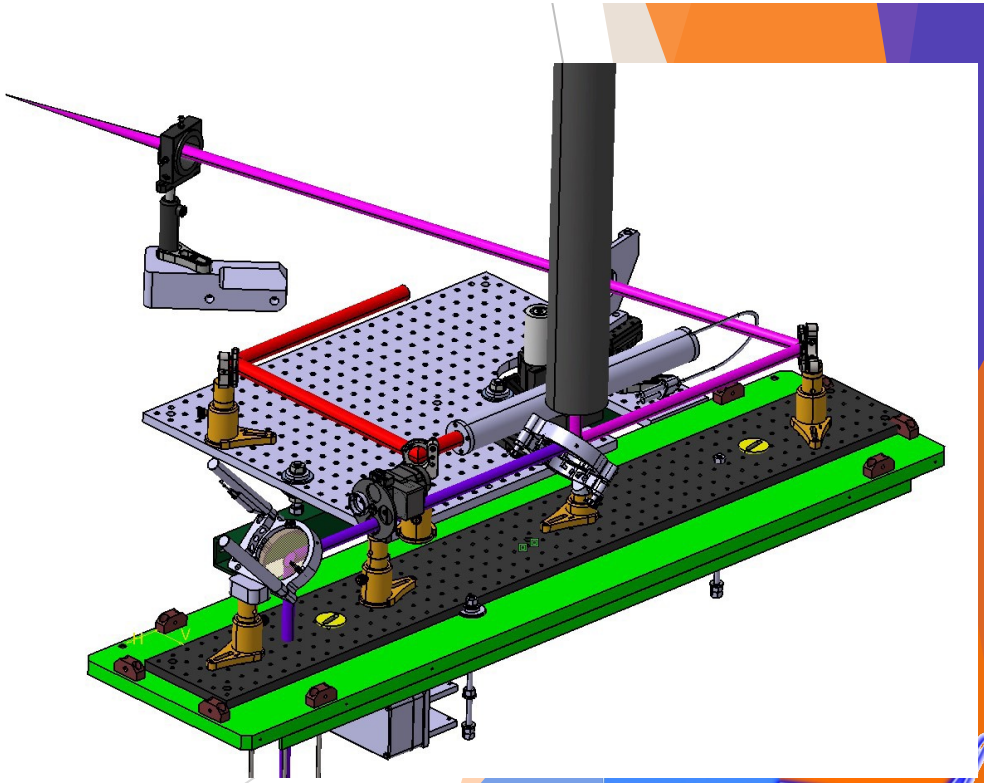
Synchrotron Light Monitor (MRSV)



- **Moniteur de Rayonnement Synchrotron Visible (MRSV)**
- Visualization of the beam in the Storage Ring in transverse plane
- A focusing lens placed between the viewport and the CCD would enable the imaging of the stored beam
- Device:
  - Dipole + Lens + CCD





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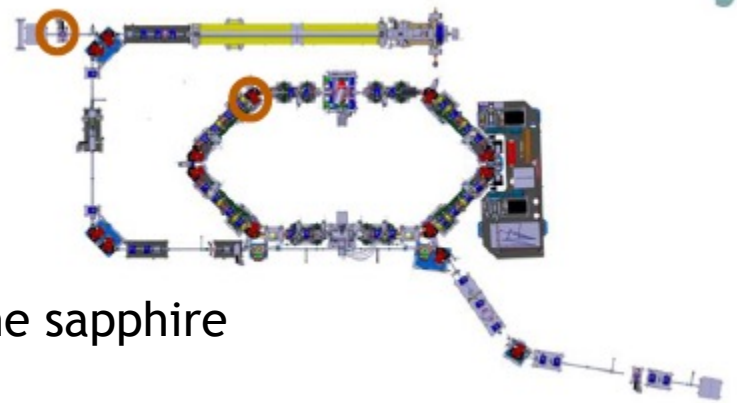
Bunch length measurement



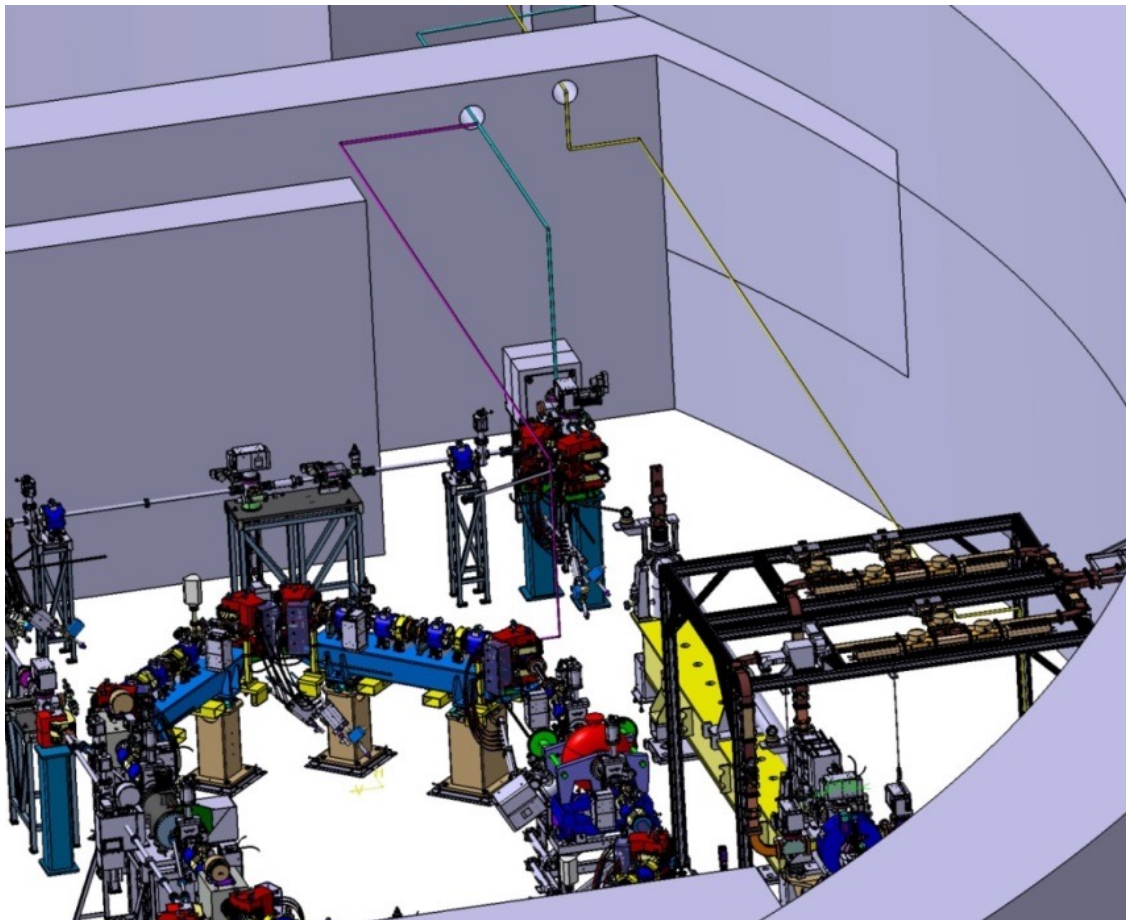
End of Linac (~4 ps expected):

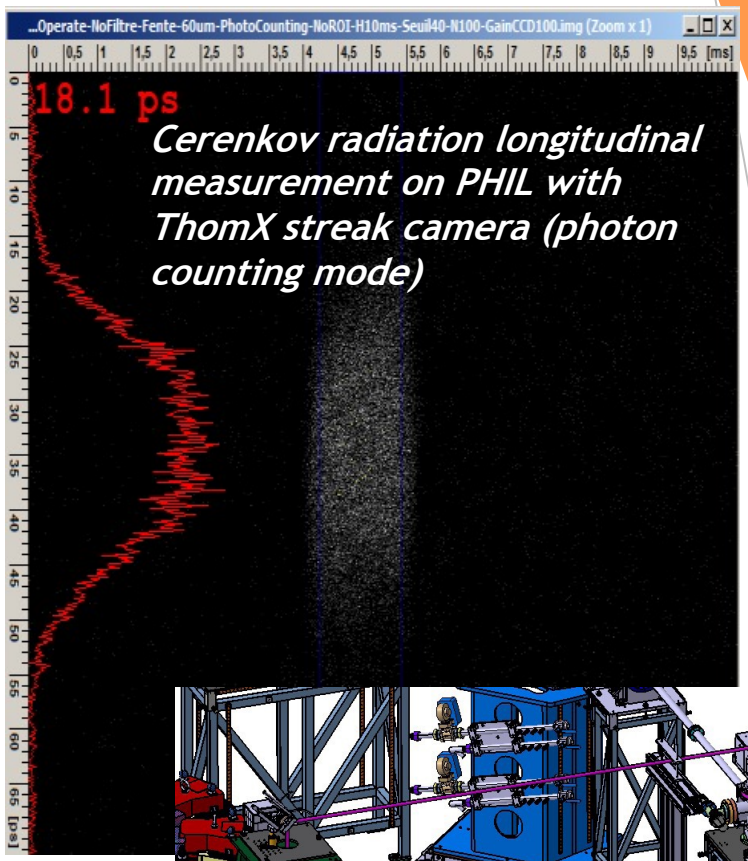
- **Cherenkov radiation** produced when the electron beam passes through the sapphire screen
- Sapphire window to extract light
- Transport the radiation to a streak camera to measure the photon pulse length.

Storage Ring (4 to 20 ps expected):

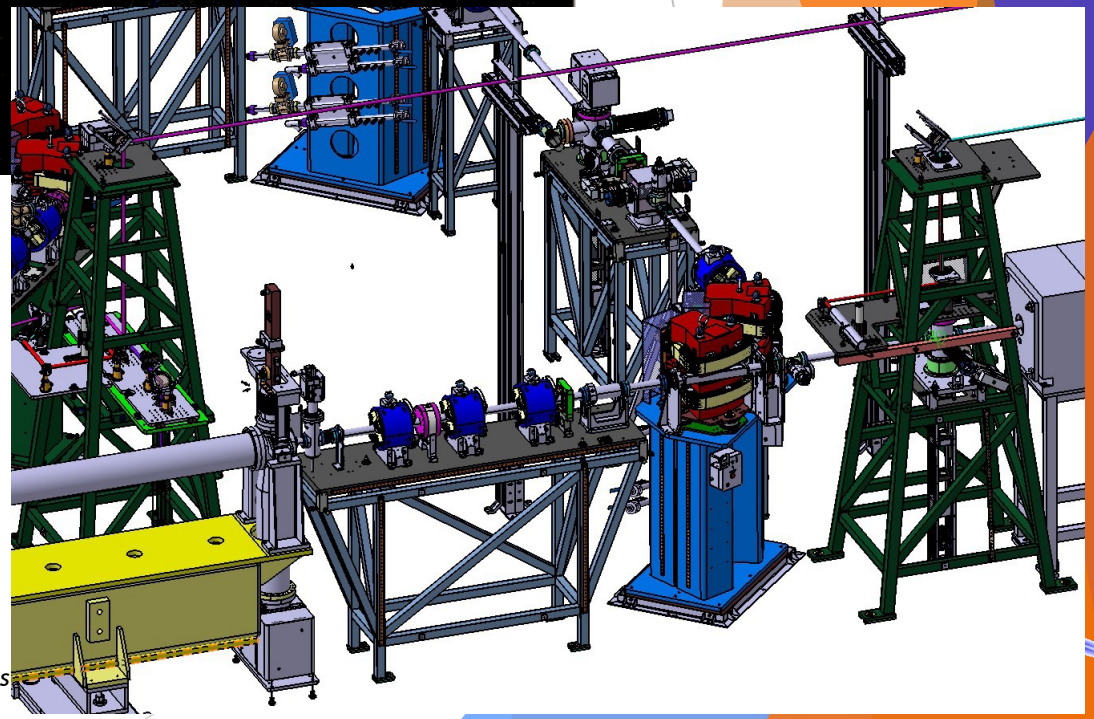
- **Synchrotron radiation** produced when the electron beam changes its trajectory in the bending magnet
- Sapphire window to extract light
- Transport the radiation to a streak camera to measure the photon pulse length.

Bunch length measurement





Hammamatsu streak camera



- Complex transport path
- Precise alignment and high stability required
- Mirror support at 2.3 meter high

Beam Loss Monitors

- Fiber Beam Loss Monitor (FBLM)
  - Particle loss => electromagnetic shower passes through the fiber => generates Cherenkov light pulse in the fiber => PMT => Beam Loss location
  - 1 fiber for the Linac, 1 for the TL, 4 for the SR and 1 for the EL.

- Scintillators coupled to the PMT to monitor the local losses (e.g. @injection)
  - A few assemblies CsI(Tl) + PMT will be prepared to be used during the commissioning and operation.
  - Positioned at the specific locations (injection/extraction, LI/TL on request).
  - Auxiliary/complementary to FBLM

CsI(Tl) + PMT

Cf. V. Kubytskyi slides

Acquisition strategy for ThomX

- Main goal: to be sure that all the diagnostics are read at the same time/ correspond to the same trigger.
- 50 Hz readout is “difficult” with Tango…
- Solution:
  - implement slower readout frequency ~ 1Hz or slower at the beginning.
  - develop a Tango DS capable to acquire all the diagnostics in such a way that we can be sure that all the data on all the BPM/ICT/FC correspond to the same trigger.
  - use one DS for the injector **LinacDiagManager** (BPM/ICT/FC) and another to manage the BPM of the Ring **RingDiagManager** (BPM).

Priority for the group CC: development of the acquisition Tango DS for diagnostics

Acquisition strategy for ThomX

- There are several approaches:
  - To use the BufferFreezing feature of the Libera DS to acquire a single trigger on all the BPM and be sure that all the data on all the BPMs correspond to the same trigger.
  - Polling T2TrigCount. Pool the T2TrigCount attribute of the first Libera in the BPM list and tell it to fire an event when a new trigger is got.

LinacDiagManager DS for Diagnostics (Linac)

- Device description: LinacDiagManager device. This device computes beam charge and orbit by getting its data from another device attributes (ICT, FC and BPM). It computes the mean, RMS and Peak values of the data inside a predefined interval.
- Properties description:
  - DeviceList: device list where the data are read
  - AttributeName: attribute name to read on DeviceList for the data
  - ShortBufferSize and LongBufferSize: number of acquisitions/injections
  - OutOfTimeDeviceList: devices which received wrong EventID
- Attributes description:
  - BeamCharge + EventID + TimeStamp for every trigger: Charge(from ICT/FC) and SpSum(from Libera)
  - xOrbit, zOrbit + EventID + TimeStamp for every trigger => arrays LI (1)-TL (4)-EL (1)
  - TL for 4 BPM: xOrbitMean, xOrbitRMS, xOrbitPeak, zOrbitMean, zOrbitRMS, zOrbitPeak
  - For ShortBufferSize and LongBufferSize: EventID/TimeStamp + xMeanOrbit, xRMSOrbit, xPeakOrbit, zMeanOrbit , zRMSOrbit, zPeakOrbit
  - For ShortBufferSize and LongBufferSize: EventID/TimeStamp + MeanCharge, RMSCharge, PeakCharge
- States description:
  - ON (DiagManager is running)
  - ALARM (At least one managed device is either unreachable or in FAULT state)
  - FAULT (DiagManager intializarion or internal error)
- Commands description: Init/State/Status/Start/Stop

Write the all values to the DTB => archiving + LogFile