# UV timing fiducial for LMJ x-ray streak cameras

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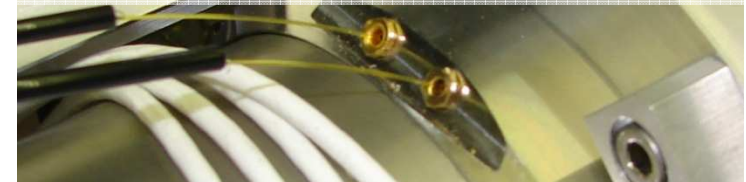LMJ XRSC – timing fiducial

2016.06.29-30

## System requirements

- 2 timing fiducial signals:
  - **chronometry**:
    timing of the acquired image with 1 pulse
  - **linearity**:
    *in situ* calibration of the sweep speed
    and checking of EM disturbance
    with 25 pulses in 2, 5, 10 or 25 ns
    (12.5, 5, 2.5 and 1 GHz)

- Temporal precision:
  ptp: **100 ps ptp needed**, 60 ps ptp wished
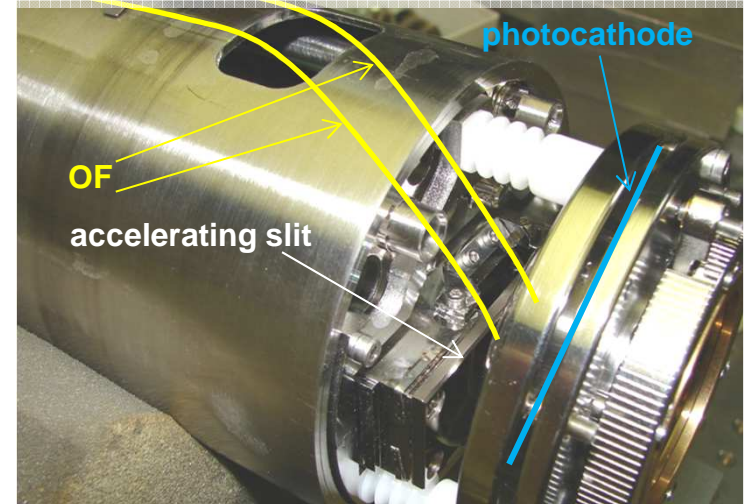  rms: **17 ps rms needed**, 10 ps rms wished

## Consequences for the SC

- Conversion of the UV fiducial by the x-ray photocathode in **reflection mode**
  → **insertion** of 2 UV optical fibers in the streak tube

- OF step index, silica, 400 µm core



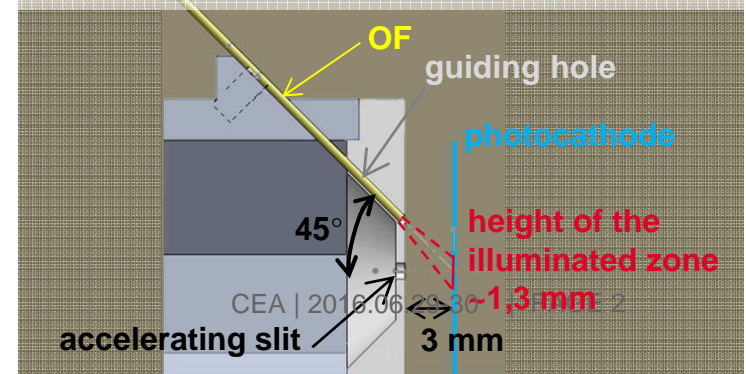hermetic feedthroughs in the streak tube's flange (stuffing box)

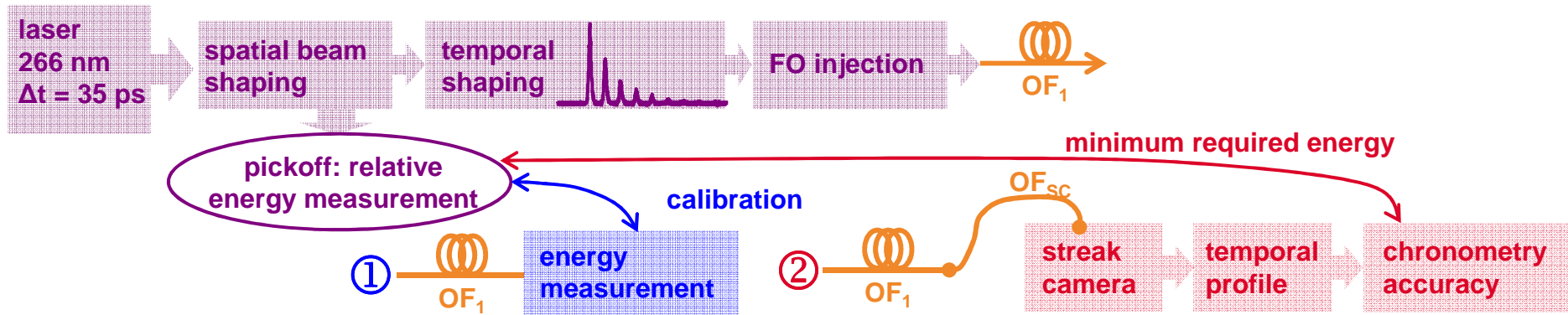FO inside the streak tube

photocathode

OF
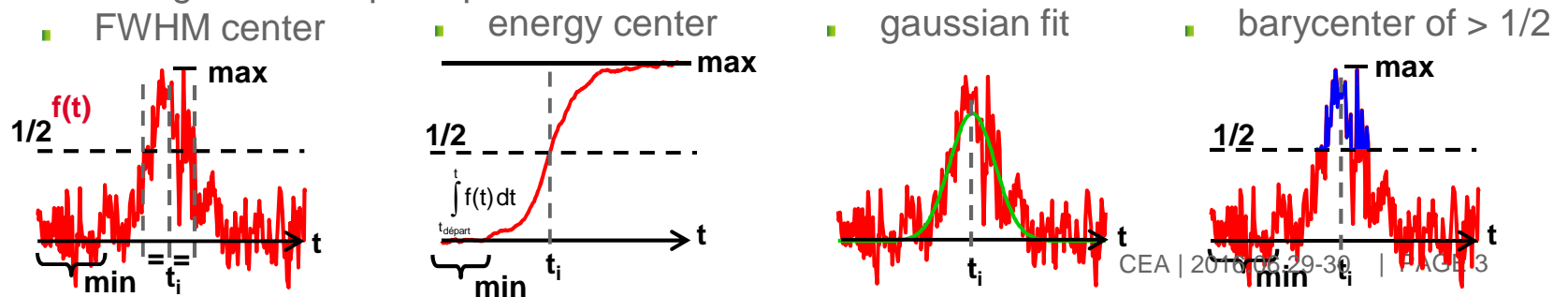
accelerating slit

section vue

OF

guiding hole

photocathode

45°

height of the illuminated zone ~1,3 mm

accelerating slit

3 mm

CEA | 2016.06.29-30

## Experimental setup

```
laser          spatial beam      temporal        FO injection          OF_1
266 nm    →    shaping      →    shaping     →                    →
Δt = 35 ps
```

pickoff: relative energy measurement

minimum required energy

calibration

OF_SC

① OF_1 → energy measurement

② OF_1 → streak camera → temporal profile → chronometry accuracy

- Measurement in 2 steps:

① calibration of energy pickoff

② chronometry accuracy: $t_0 = 1^{st}$ pulse
the chronometry accuracy $\Delta t_i$ for the $i^{th}$ pulse is overvalued by the dispersion between the n estimates of $t_i - t_0$ (contributions of $\Delta t_0$ and sweep speed repetitivity)

- Processing of the temporal profiles:

  - FWHM center
  - energy center
  - gaussian fit
  - barycenter of > 1/2

## 5 photocathodes

**70 nm Au on 12 μm Be**
**500 nm CsI + 23 nm Al on 480 nm lexan (Luxel)**
**15 nm Al on 200 nm polystyrène**
**70 nm Au on 200 nm polystyrène**
**500 nm CsI on 12 μm Be**

- The minimum required energy depends on the PC substrate and photosensitive compound

- **A few 10 nJ** injected in the streak camera's OF is sufficient to determine the pulse timing on the temporal profile with the required accuracy

- **More energy** injected in the streak camera's OF will allow to allot temporal accuracy to the other components of the UV timing fiducial system

- A **mixed PC**, with different photosensitive compounds in the center (conversion of the x-rays in transmission mode) and on the edges (conversion ofthe UV fiducial in reflectionmode) could be realized by depositing the photocathode layers through a mask
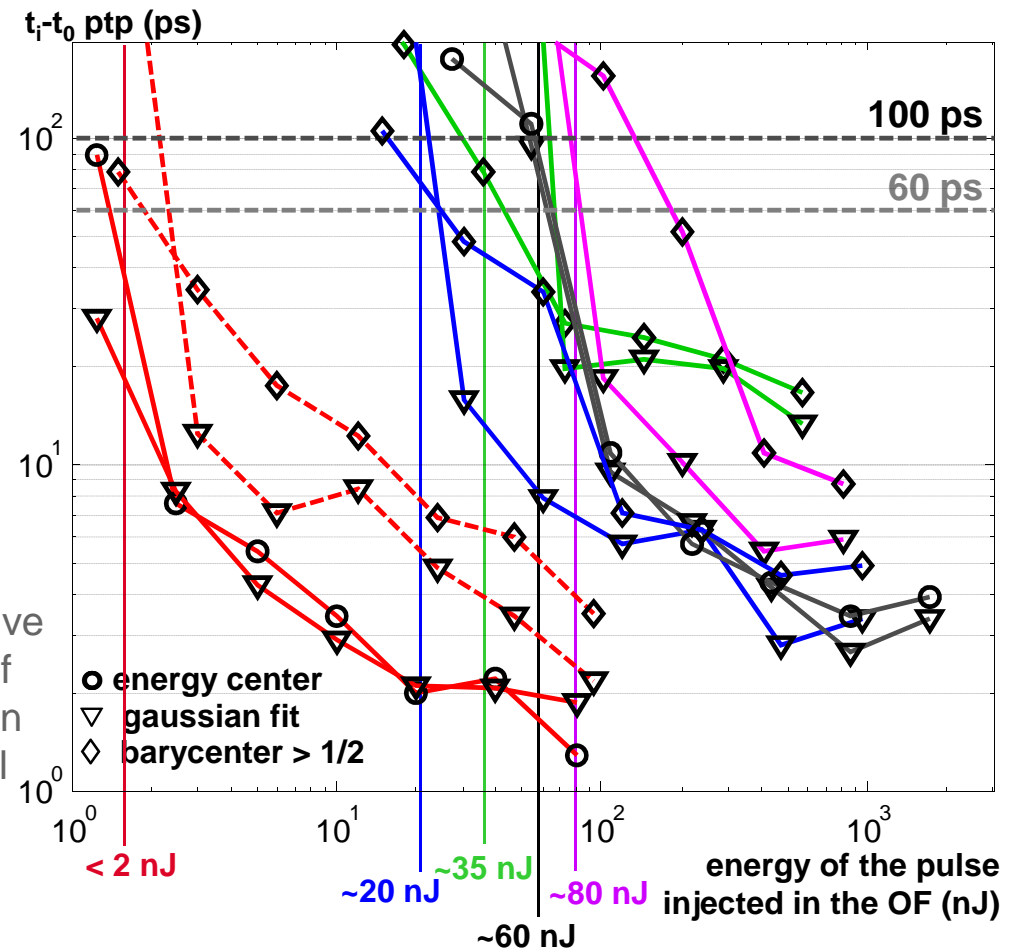
**supervision**

**trigger signal**

**laser system**

**controller**

**chiller**

**laser head**

**frequency conversion**

**spatial and temporal beam shaping**

**OF transport**

**SID**

**XRSC**

**precise timing system**

**laser pickoff**

**delay calibration**

**copy of HV ramps**

**electrical fiducial**

**oscillo-scope**

signals:

informatic (OF)

electrical

optical (free space)

optical (OF)

**precise timing system**

**laser system**
- controller
- chiller
- laser head
- frequency conversion

spatial and temporal beam shaping

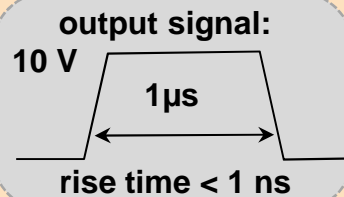OF transport

**SID**
- XRSC

**Location:** shielded room 2U 19'' rack

**Output:** 2 - 4 channels

**Jitter:** 11 ps rms

**COTS**, 15k€

**Cable length:** 30-40 m to the laser head

output signal:
10 V
1μs
rise time < 1 ns

**laser system**

**controller**

**chiller**

**precise timing system**

**laser head**

**frequency conversion**

spatial and temporal beam shaping
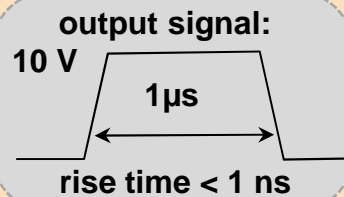
**OF transport**

**SID**

**XRSC**



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10 V
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**Location: in the experience hall,** on an optical table near each XRSC

**Max. volume: 80*35*25 cm³**

**Laser characteristics:**
Nd:YAG
single shot operation
pulse duration < 50 ps FWHM
frequency conversion to 4ω
→ 40 µJ at 266 nm

**Jitter <10 ps rms**

**COTS ?**

# DESCRIPTION OF THE TIMING FIDUCIAL SYSTEM
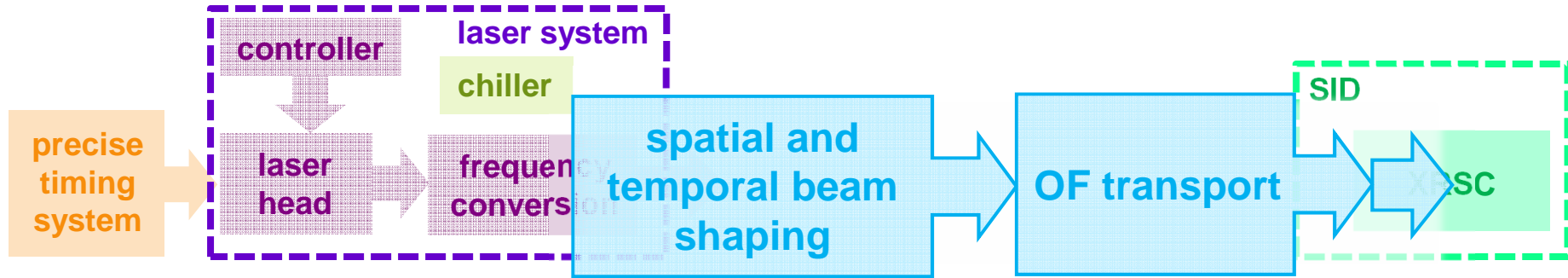
**precise timing system** → [laser system: **controller**, **chiller**, **laser head**, **frequency conversion**] → **spatial and temporal beam shaping** → **OF transport** → SID → XRSC
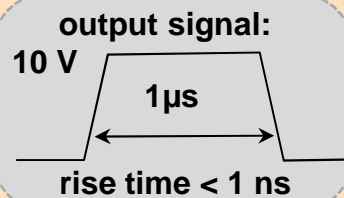
**Location:** **shielded room 2U 19'' rack**
**Output:** **2 - 4 channels**
**Jitter:** **11 ps rms**
**COTS**, **15k€**
**Cable length:** **30-40 m to the laser head**

output signal:
10 V
1µs
rise time < 1 ns

**Location: in the experience hall,** on an optical table near each XRSC
**Max. volume: 80*35*25 cm³**
**Laser characteristics:**
  Nd:YAG
  single shot operation
  pulse duration < 50 ps FWHM
  frequency conversion to 4ω
  → 40 µJ at 266 nm
**Jitter <10 ps rms**
**COTS ?**

**Location: in the experience hall,** on an optical table near each XRSC
**Spatial beam shaping:**
injection in temporal beam shaping
injection in transport OF
**Temporal beam shaping: 3 channels:**
  1. **pickoff** for delay calibration
  2. **chronometry** signal (1 pulse)
  3. **linearity** signal (comb of 25 pulses)
→ 4 different linearity signals for the 4 timebases (12.5, 5, 2.5 and 1 GHz)
**Transport optical fiber:**
Silica ~80 dB/km transmission at 266 nm
4m < length < 8m (6m inside the SID)

## Accuracy

- Prior **calibration of temporal beam shaping**
  ➔ reduction of its contribution to the accuracy to < 5 ps ptp (= 1 ps rms)
- **Global delay calibration** with the validation shot a few minutes before each physics shot
  ➔ reduction of wander and thermal contributions
- **Streak camera contribution**
  ➔ estimated to 21 ps (= 3.5 ps rms) ptp with a CsI Pk
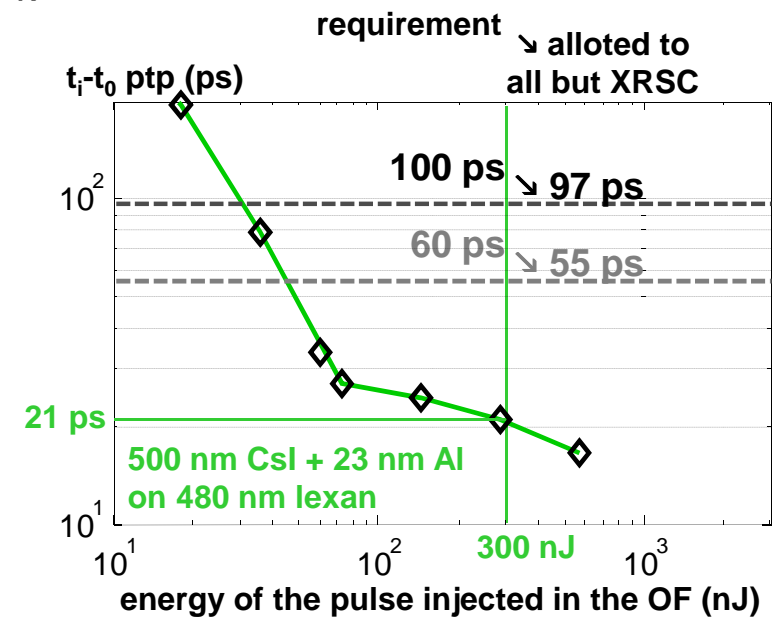- Other contributors ➔ ~ 5 ps rms ?

$$\sigma_A = \sqrt{1^2 + 3.5^2 + 5^2} = 6.2ps$$

## Jitter

- Precise timing system < 11 ps rms
- Laser < 10 ps rms

$$\sigma_J = \sqrt{10^2 + 11^2} = 14.9ps$$

$$\sigma_{tot} = \sqrt{6.2^2 + 14.9^2} = 16.1ps < 17ps$$

requirement ↘ alloted to all but XRSC

$t_i - t_0$ ptp (ps)

100 ps ↘ 97 ps

60 ps ↘ 55 ps

$10^2$

21 ps

500 nm CsI + 23 nm Al
on 480 nm lexan

$10^1$

$10^1$          $10^2$     300 nJ   $10^3$

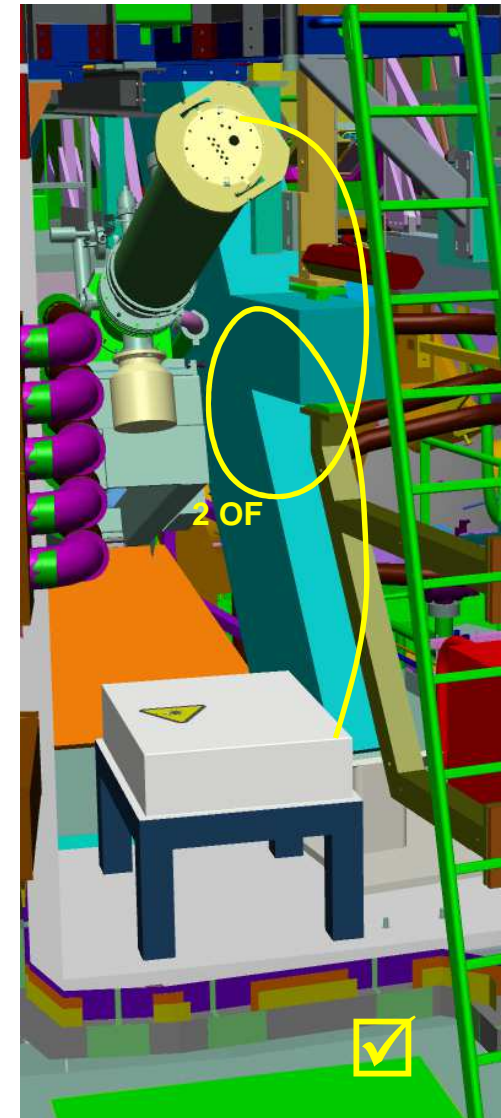**energy of the pulse injected in the OF (nJ)**

## Preliminary study

- Laser + spatial and temporal beam shaping and transport OF injection on an optical table

- < 2m OF between this table and the SID / MS

**XRSC in SID (~DIM)**
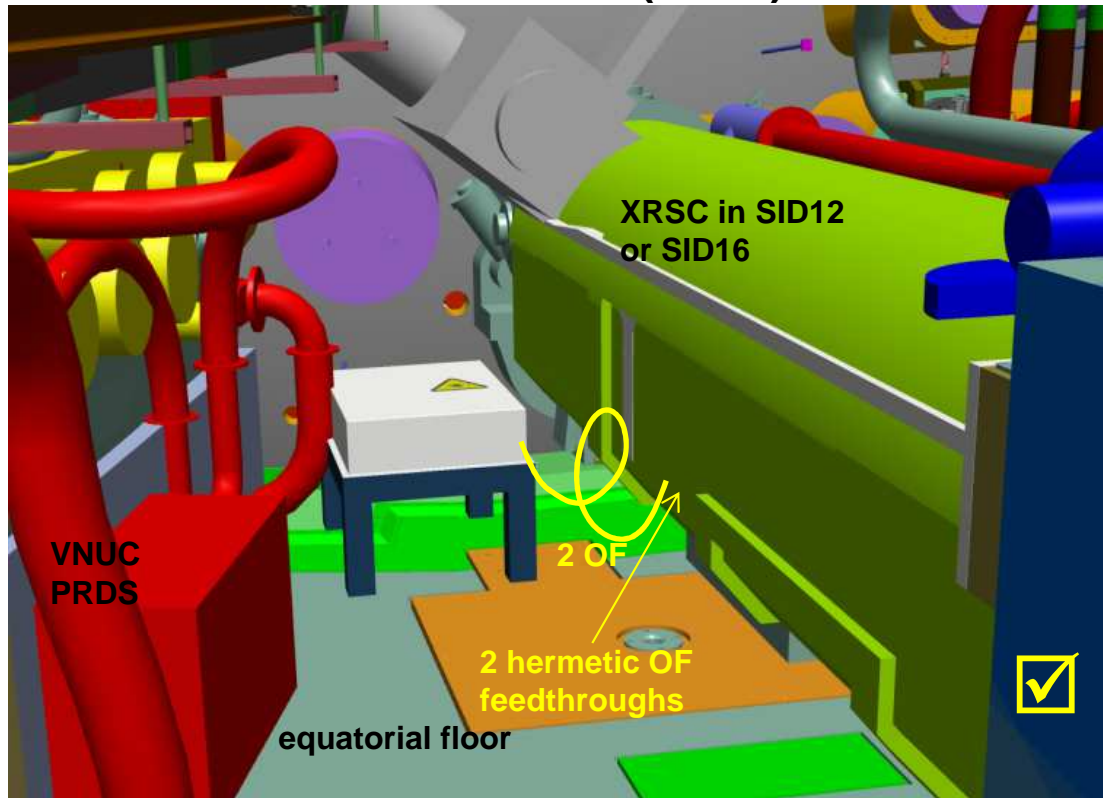
**XRSC w/o SID (behind DMX)**

## 1- from the XRSC's point of vue

- Insertion of 2 OF for the conversion of UV timing fiducial in reflection mode
- Photometric estimation with 35-ps long pulses

## 2- system architecture definition

- OTS **laser** ?
- Preliminary validation of **mechanical integration** in the EH
- Performances estimation:
  - photometric: timing accuracy alloting
  - jitter
  → **accuracy + jitter < requirement** ☺

## 3- first steps of prototyping

- Spatial and temporal beam shaping studies ⎤
- Laser performances estimation ⎦ in the next few months