ETL schedule and next steps

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Reunión de coordinación de proyecto

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Instituto de Física de Cantabria

ETL schedule

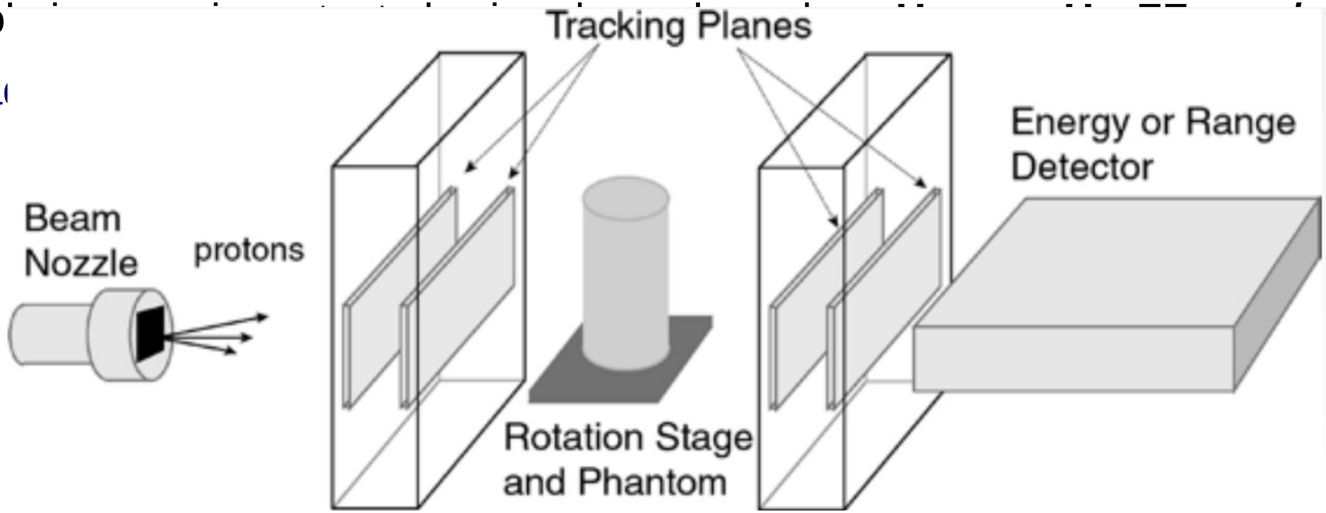
Instituto de Física de Cantabria

- System EDR to be held in 26 Oct 2026 → 1.9 option disk (4 surfaces with last only covered up to 100mm)
- LGAD pre-production received and QA/QC finished (not irradiated) → production starting in September
- ETROC to be sent for full production in Oct 2026
- Module assembly main driver of critical path → redesign of module being studied to mitigate noise
- DPG activities: MTD alignment infrastructure and algorithms to be in place by end of the year

	2026				2027				2028				2029	
Task	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
LGAD Procurement	Pre-production		Production											
Bump Bonding		Pre-production			Production									
Module assembly		Pre-production				Production								
ETROC	Pre-production		Production											
Electronics/Service Hybrid		Pre-production				Production								
Mechanics		Dee soldering												
Installation ETL-														
Installation ETL+														
Other Milestones		**System EDR**												

Signal generation steps

- The generation of the light signals depends on three steps that converge to only two in the case of fibers
  - Proton energy loss in the fiber → depends on fiber material properties, thickness and proton path
  - Light scintillation mechanism → depends on the fiber material properties and wavelength
  -
- The CMS ECAL measures the **energy of photons and electrons** reaching its volume
  - It plays a crucial ro **μ**
- Some constraints lea

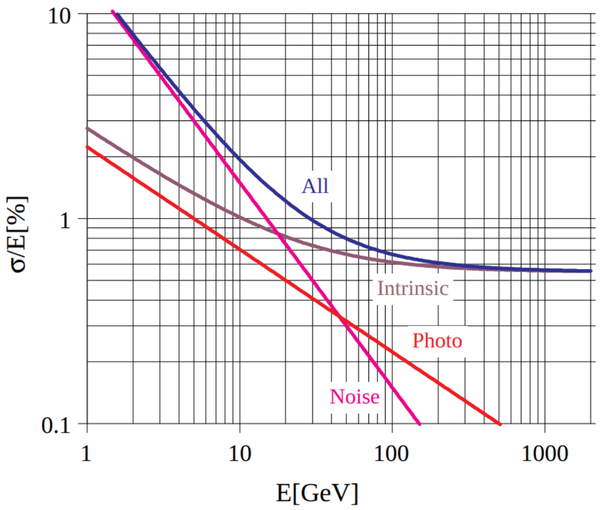


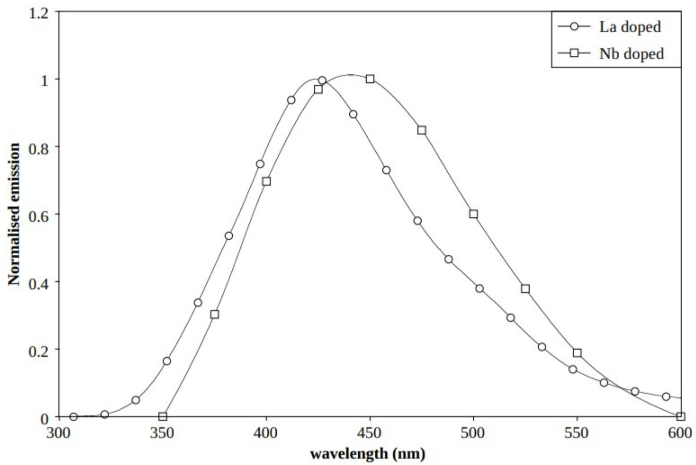
The CMS ECAL choice: Lead tungstate crystals

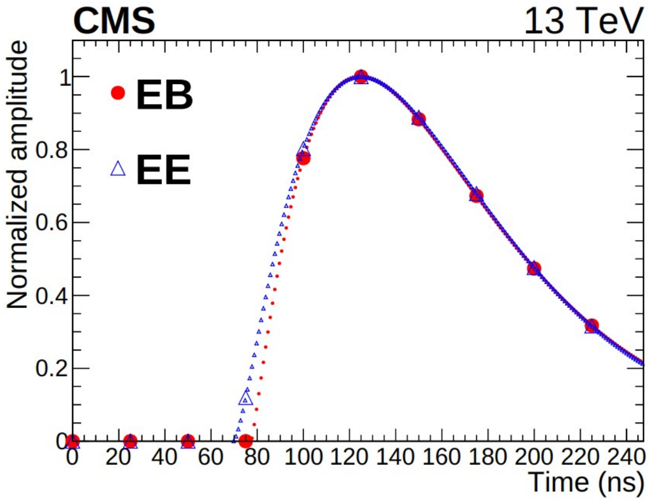
- CMS built the ECAL using ~ 23 cm **Lead tungstate crystals ($PbWO_4$)** which matches most criteria

Density (g/cm³)	Radiation length (cm)	Interaction length (cm)	Molière radius (cm)	Time constant (ns)	Thickness	Maximum of emission	Transmission at max	Light output
8.28	0.89	22.4	2.19	10	$26X_0$	440	65%	4.5 photons/MeV

- Readout is performed **using APD** → see Pietro's talk for more details on the readout chain

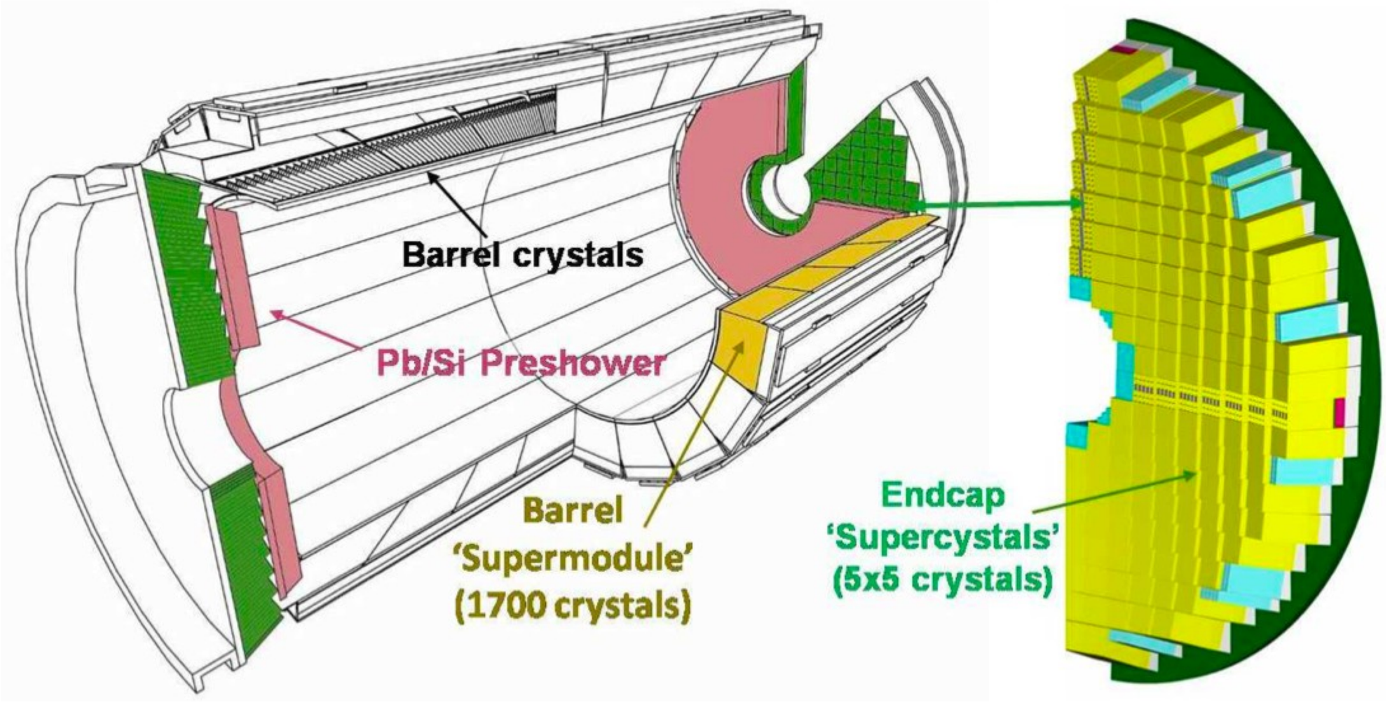


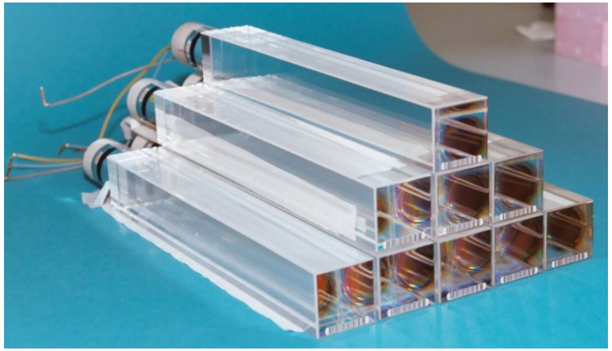


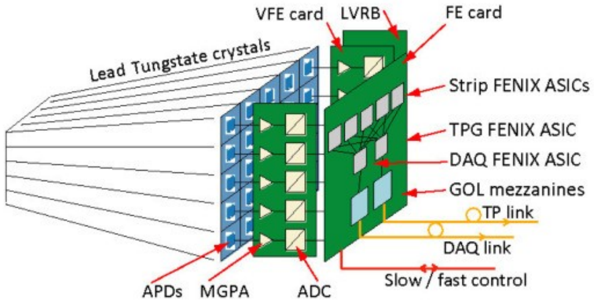


The CMS ECAL: general layout

- The CMS ECAL is divided in three parts: **the barrel (61200) and the two endcaps (14000) up to |η| < 3**
- Crystals **(2.2 x 2.2 x 23 cm^3)** are grouped and arranged in a non Interaction Point pointing scheme

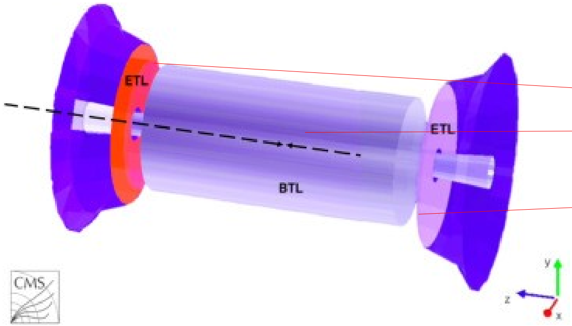


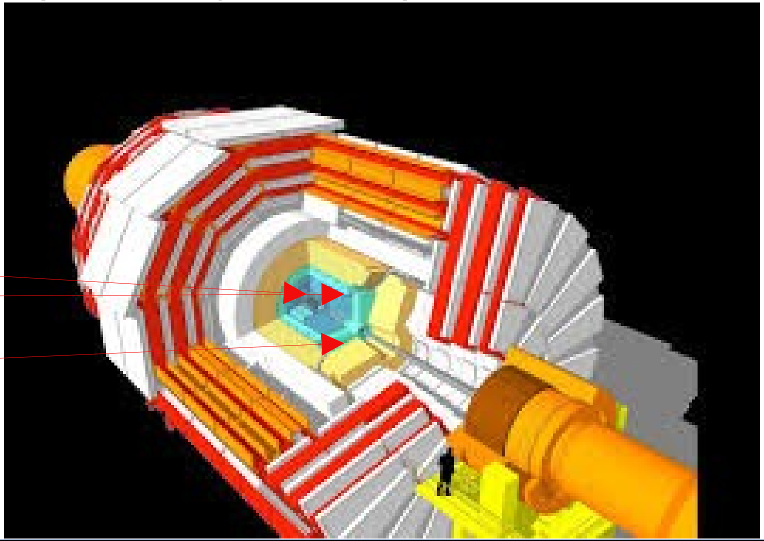




The CMS BTL: goals and requirements

- The CMS Barrel Timing layer measures the time of arrival of charge particles reaching its volume
  - It plays a crucial role discriminating pile-up from signal events in the future HL-LHC
- Some constraints leading the design and choices of the CMS Barrel Timing Layer:
  - **Small range**: Particles must loose minimal energy along the crystals (< $1X_0$)
  - **Small detector size:** The BTL has to fit the space between the tracker and the ECAL (~40 mm)
  - **Quick rise time and time resolution:** Of the order of 200 ps leading to 30-40ps final resolution
  - **Small time constant:** Avoid event pile-up (~10ns)
  - **Radiation tolerant:** Up to 1.9×10^{14} ncm^{-2}



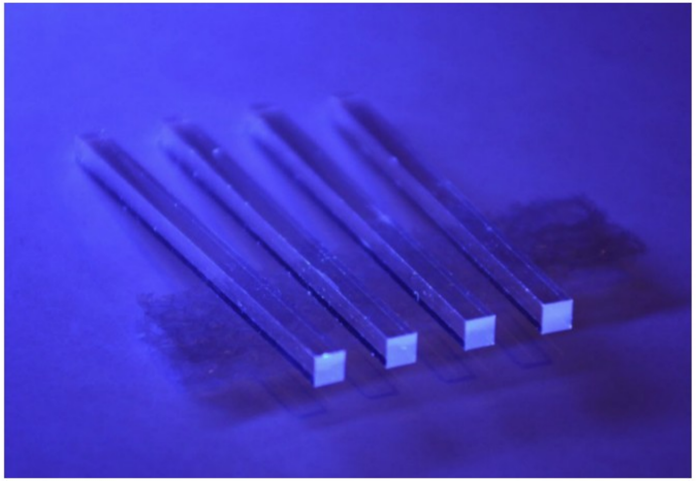


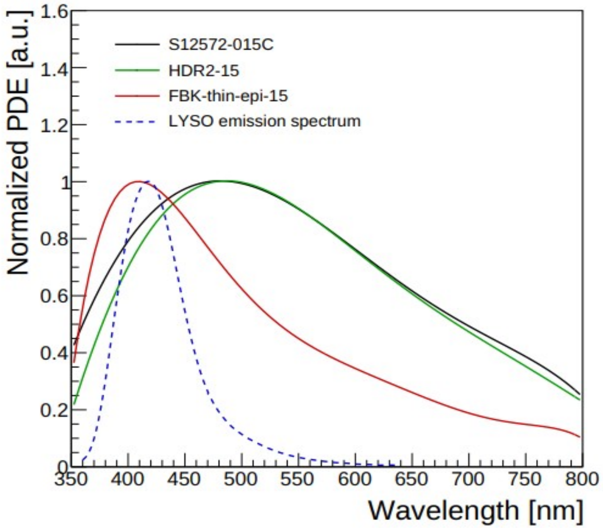
The CMS BTL: LYSO:Ce crystal bars

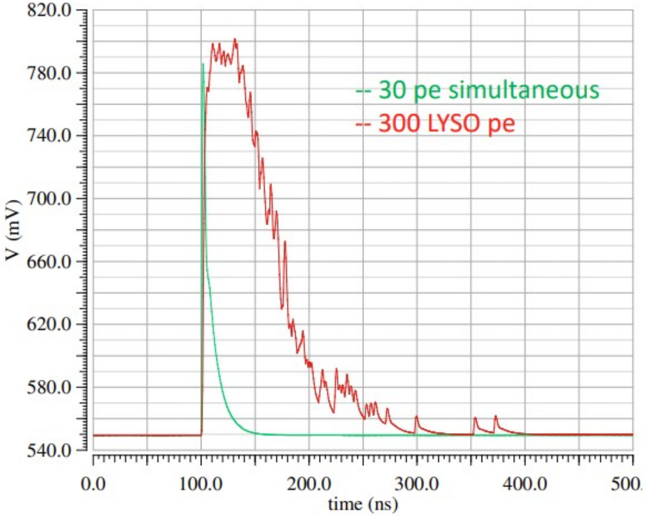
- The CMS Barrel Timing uses **LYSO:Ce crystal bars** given its **quick rise time and radiation tolerance**

Density (g/cm^3)	Radiation length (cm)	Rise Time (ns)	Time constant (ns)	Maximum of emission (nm)	Transmission at max	Light output
7.1	0.11	0.2	43	420	80%	6000 photons/MeV

- Readout is performed using SiPMs at the two sides of the crystals → see Pietro's talk for more info

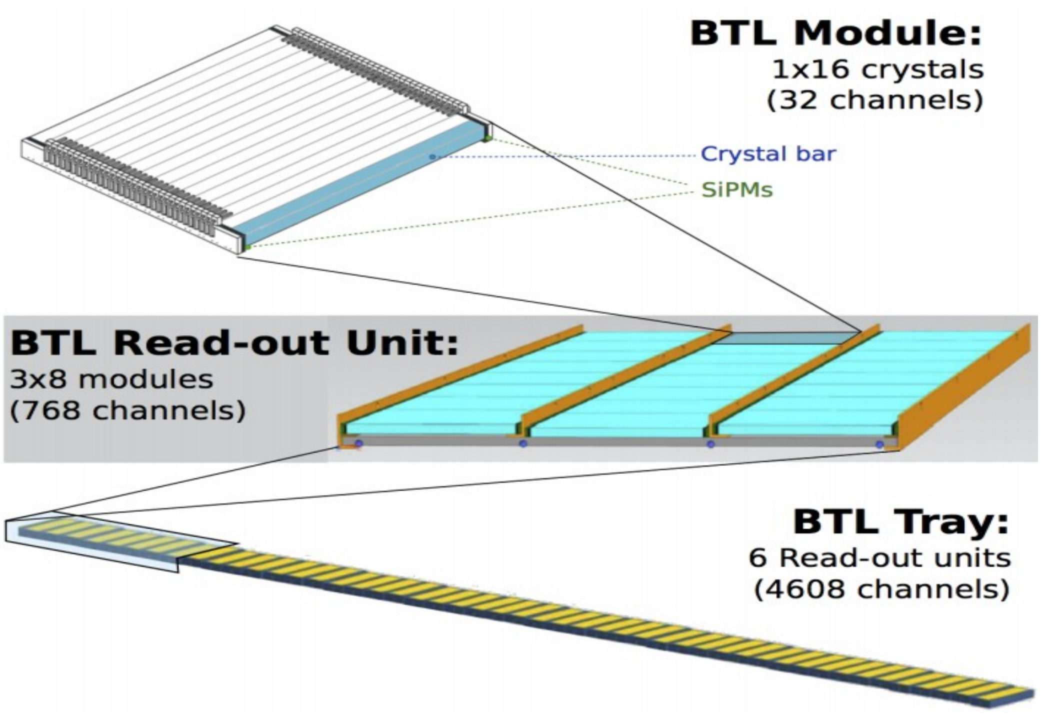


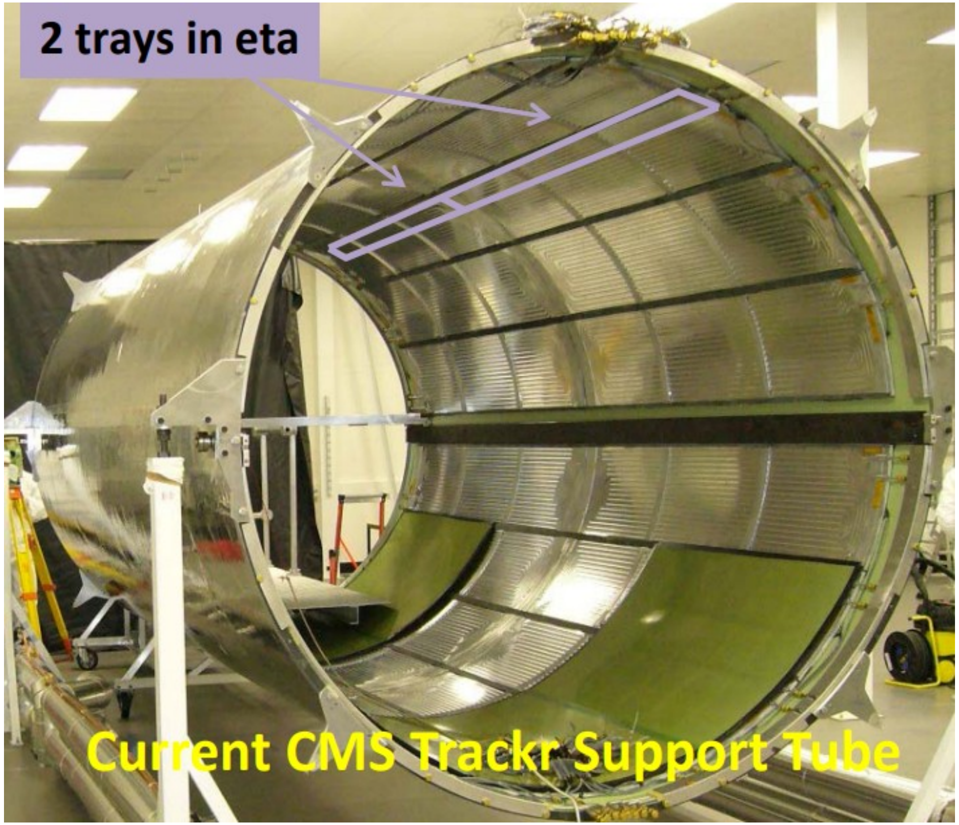




The CMS BTL: goals and requirements

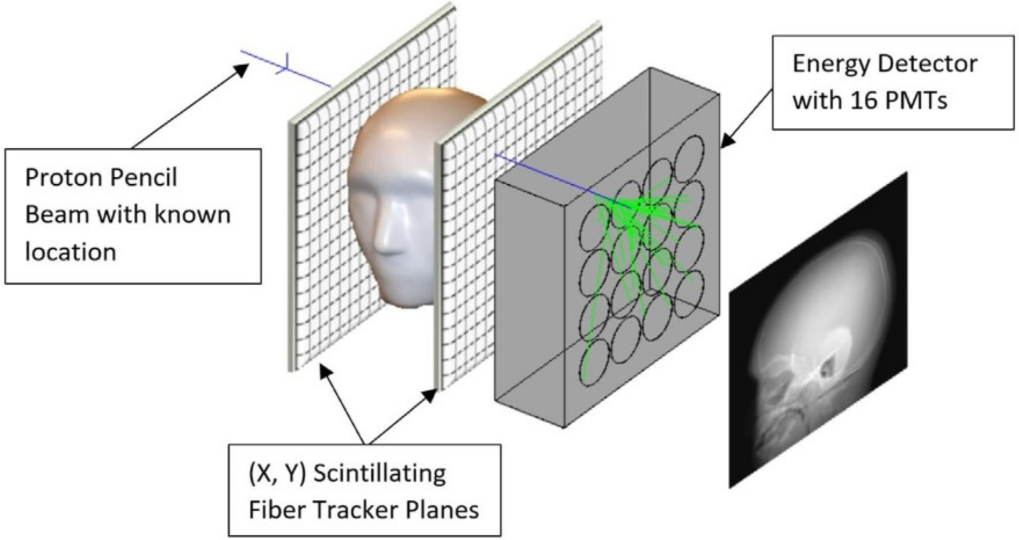
- LYSO:Ce crystals (**332k channels**) have dimensions **3x3x57 mm^3** and are grouped in modules of 16





A scintillator tracker for proton tomography

- One of the current designs to perform proton tomography relies on scintillator tracker planes
  - The key aspect is to use scintillator fibers with very good spatial resolution
- Some constraints leading the design and choices for this device:
  - **Small radiation length**: particles must lose minimal energy and scattering along the crystals (< $1X_0$)
  - **Spatial resolution:** the X and Y of the protons can be determined precisely (< 1mm)
  - **Additional energy detector needed.**
  - **Fast time constant:** To avoid pile-up.
- Tracker planes are crucial in order to estimate the **Most Probable Path** of the protons
  - The MPP is fundamental to estimate the energy loss of individual protons and with this the stopping power map

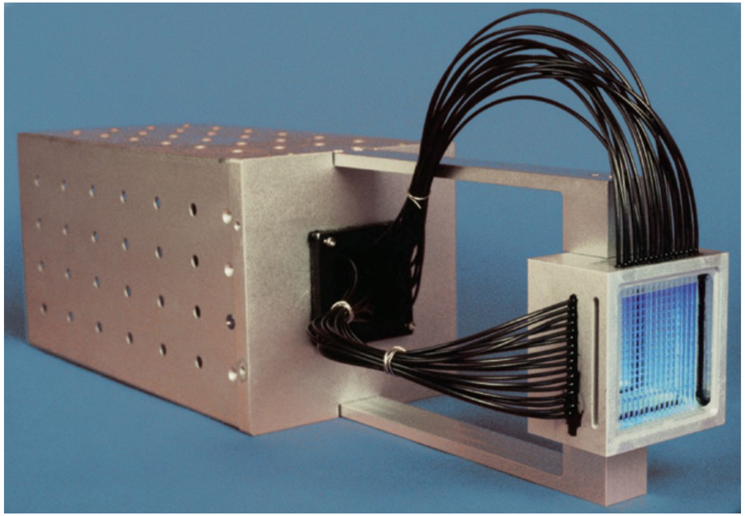


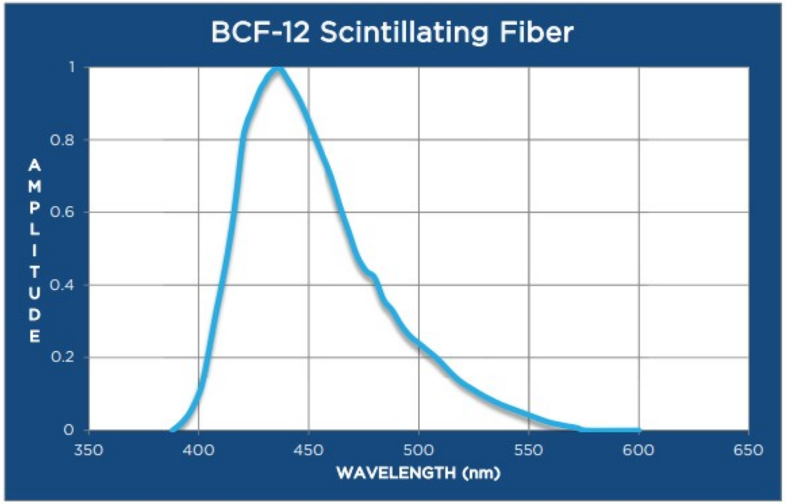
Scintillator fibers: Saint-Gobain plastic

- Tracker planes are made of 1 mm², squared, fibers from Saint-Gobain with model BCF12S-S1.00N

Density (g/cm^3)	Radiation length (cm)	Interaction length (cm)	Time constant (ns)	Maximum of emission (nm)	Trapping efficiency	Light output
1.05	41.31	77.07	3.4	435	3.44% min	8000 photons/MeV

- Readout is performed using SiPM → see Pietro's talk for details on this





Scintillator fibers: general layout for pCT

- Tracker planes contain **fibers in orthogonal directions** to provide an stereo measurement of **X** and **Y**
- **Spatial resolution** is about ~ **300 microns** (1/sqrt(12)) and **active region is about ⅔ of the total**