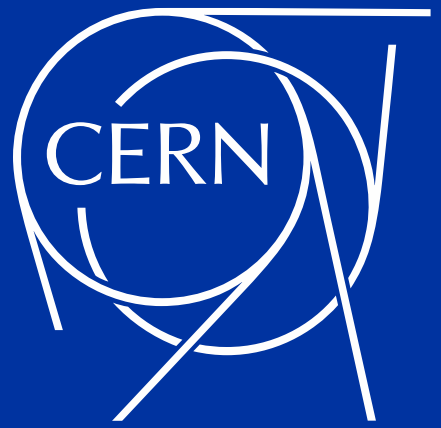
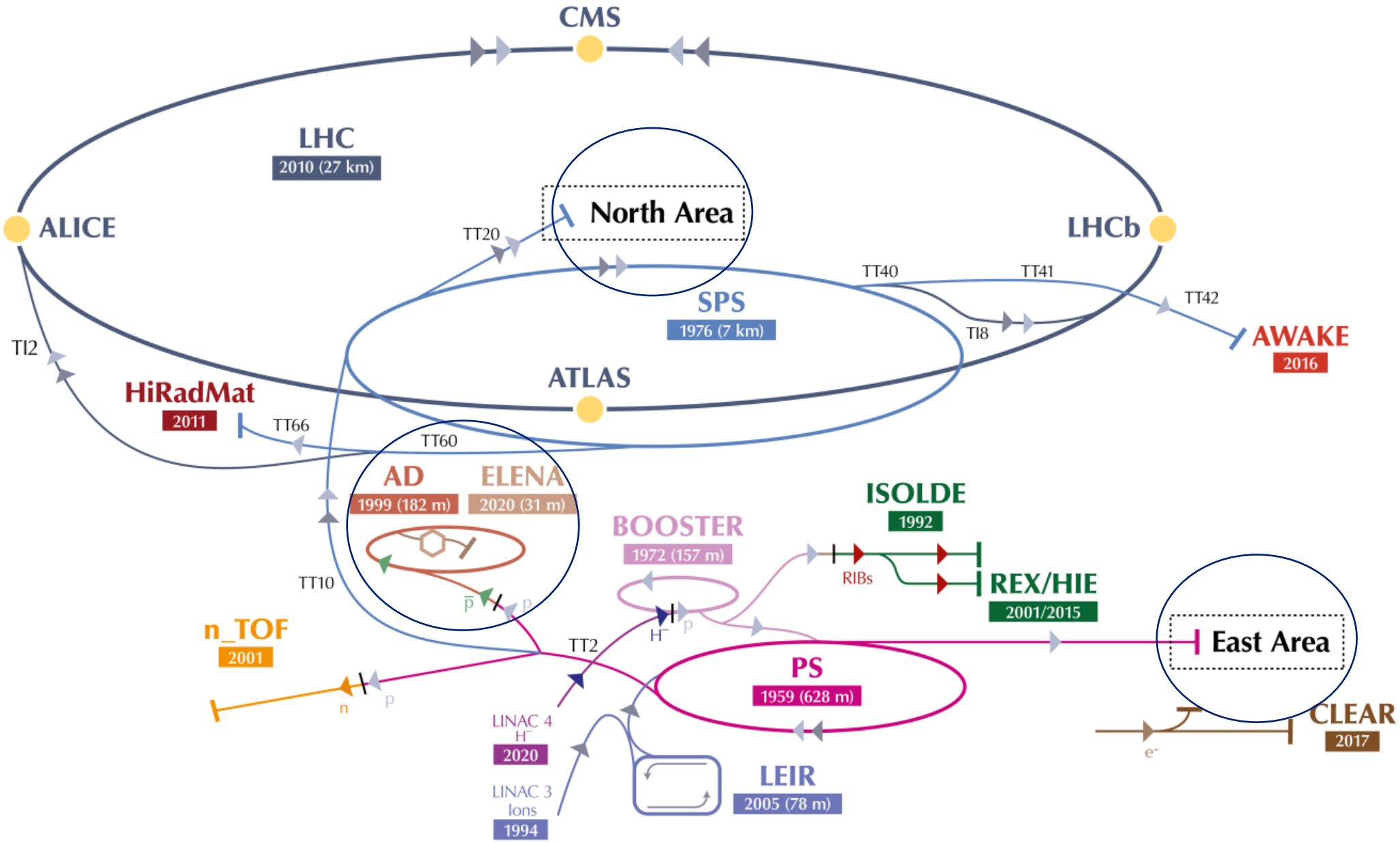


CERN Beam Instrumentation Relevant to the Muon Collider Study

Inaki Ortega

MuCol WP8 Cooling Cell Workshop – 19 January 2024

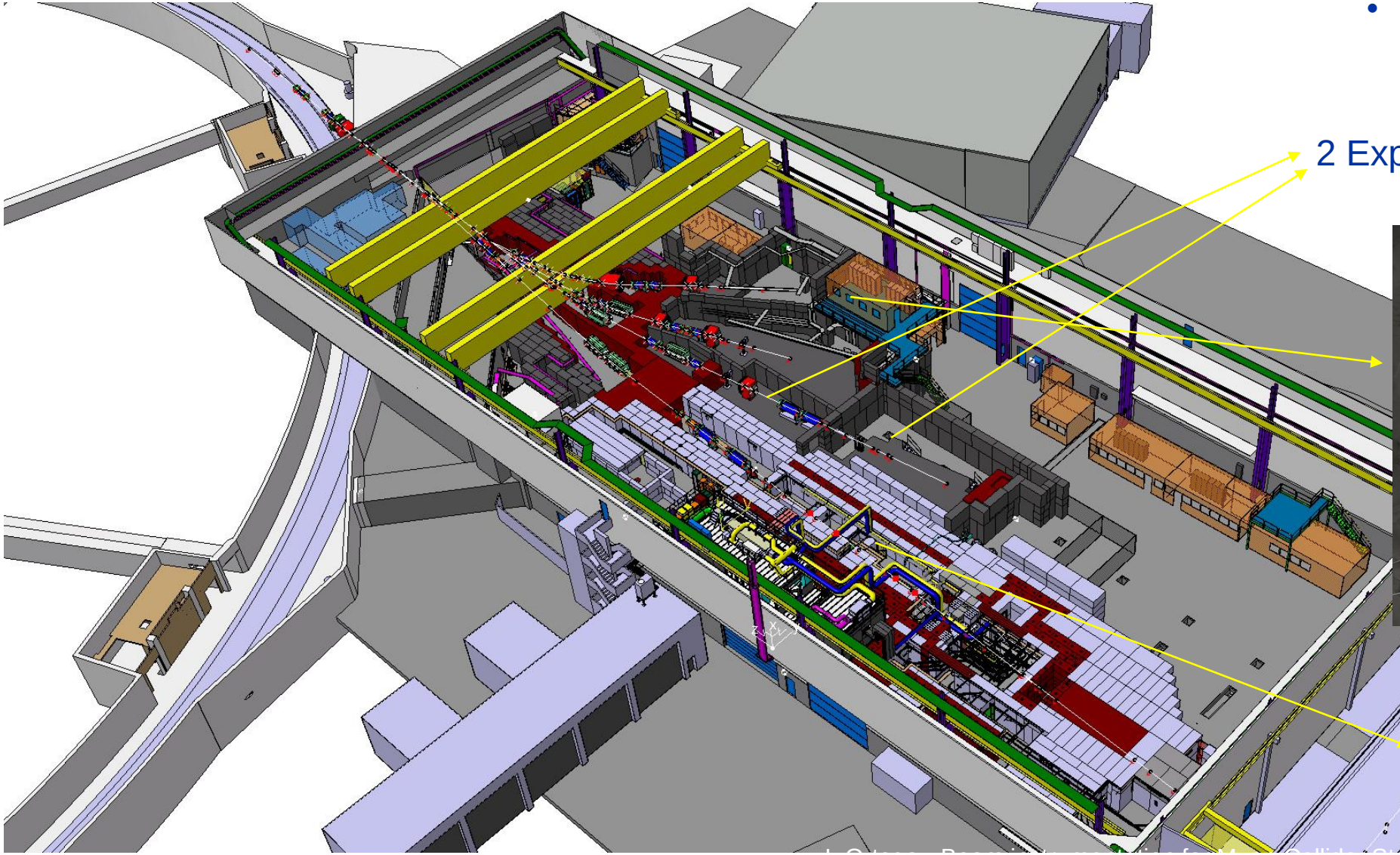
Low intensity secondary beams at CERN



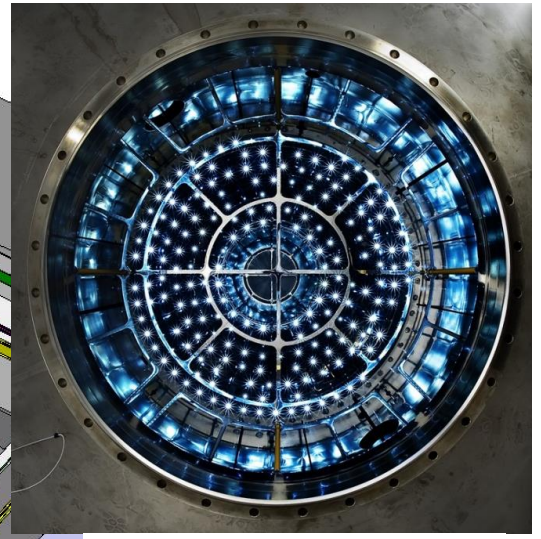
The East Area

Primary beam: 10^{11} protons 24 GeV/c from PS

Secondary beam:
- 1 – 15 GeV/c
- 10^3 - 10^6 part/burst
- 400 ms



2 Experimental areas

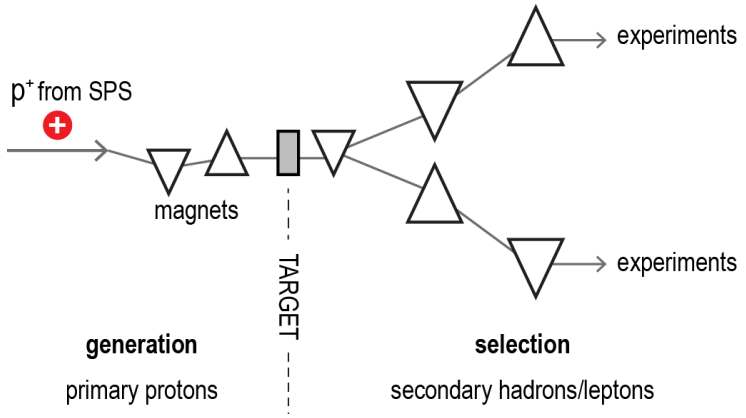


CLOUD experiment

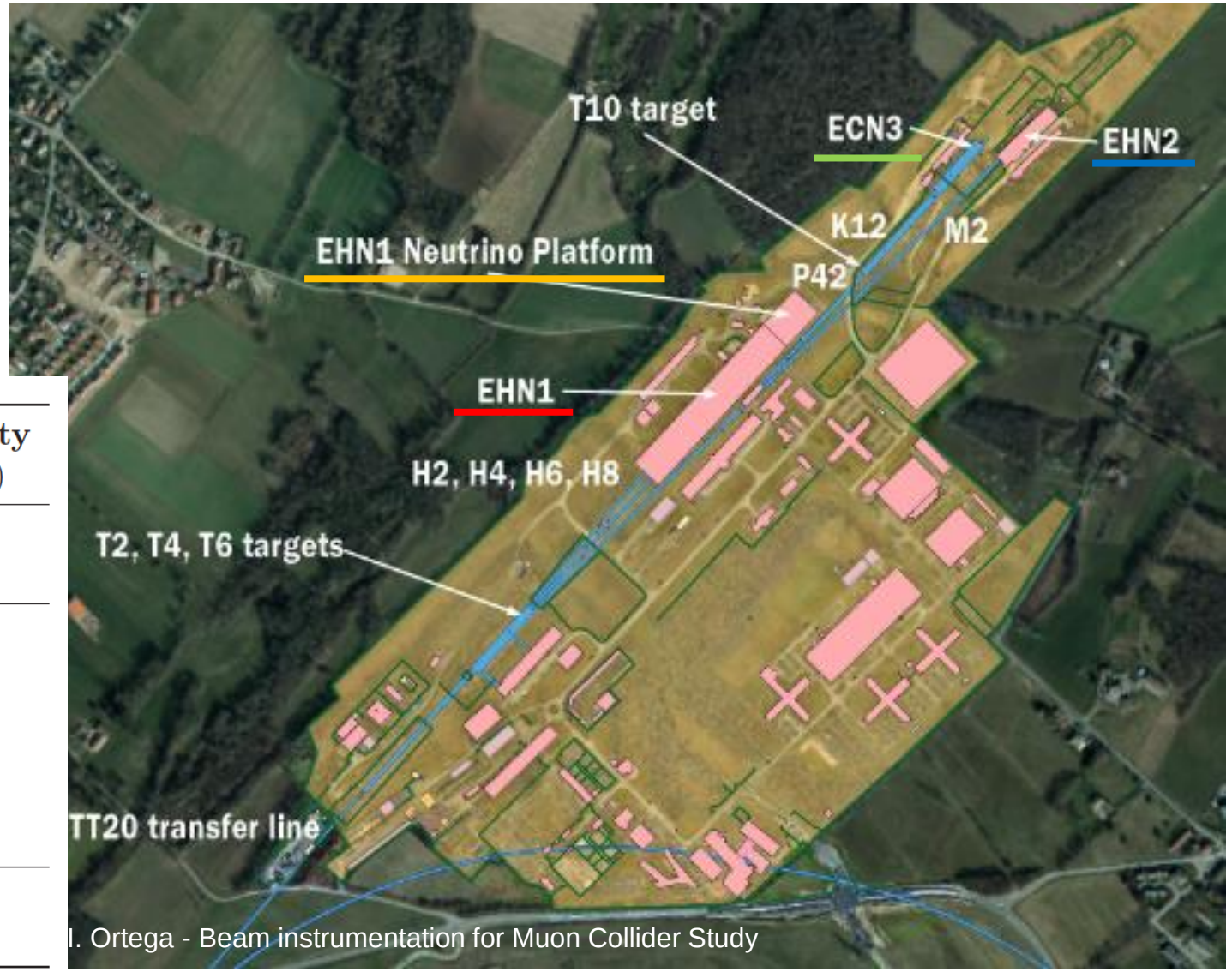
IRRAD / CHARM

The NA beam lines

10^{13} protons/ions 450 GeV/c from SPS in 9.6 seconds

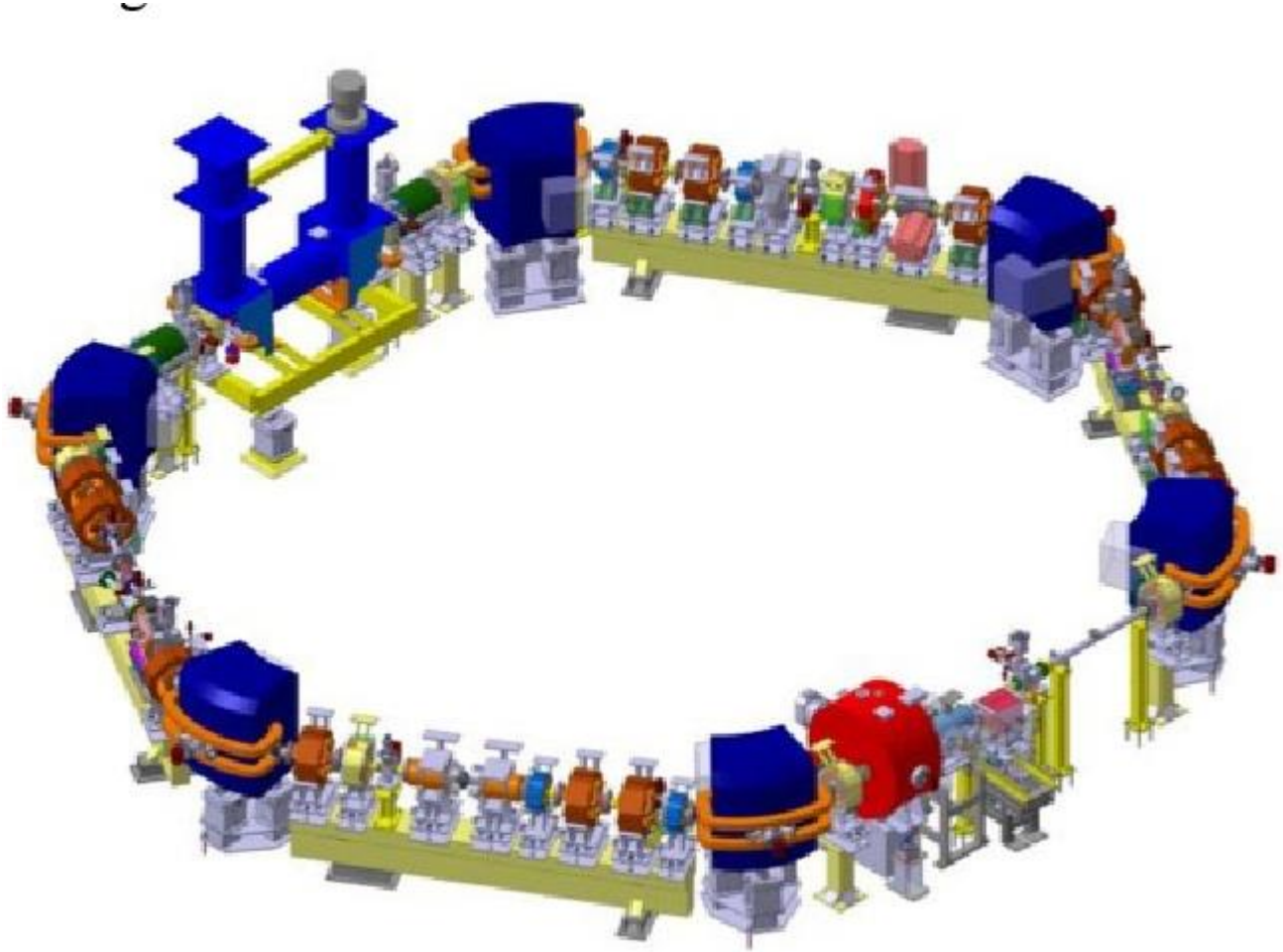


Beam type	Particle	Momentum (GeV/c/Z)	Max. Intensity (part/second)
Primary	p^+	400 - 450	10^7
	$^{208}Pb^{+82}$	32 - 380	10^7
Secondary	π^+/π^-	20 - 360	10^7
	e^+/e^-	10 - 350	10^6
	μ^+/μ^-	12 - 200	10^5
	other hadrons at lower I $(K, p^-, ...)$		
Tertiary	π^+/π^-	0.5 - 200	10^4
	e^+/e^-	0.5 - 100	10^4

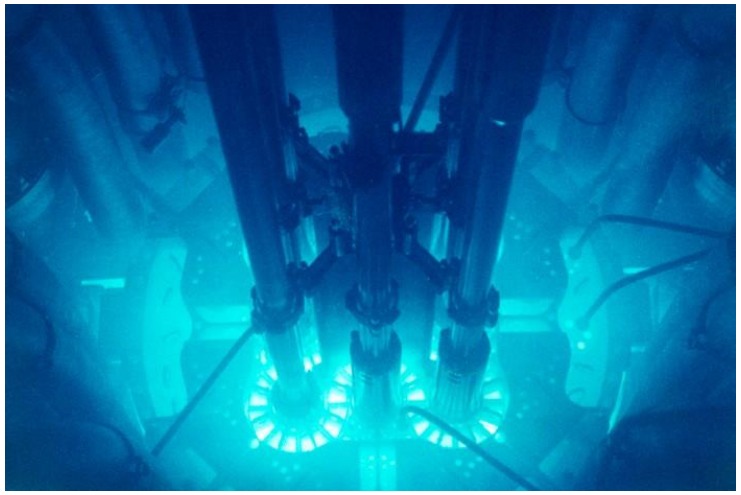


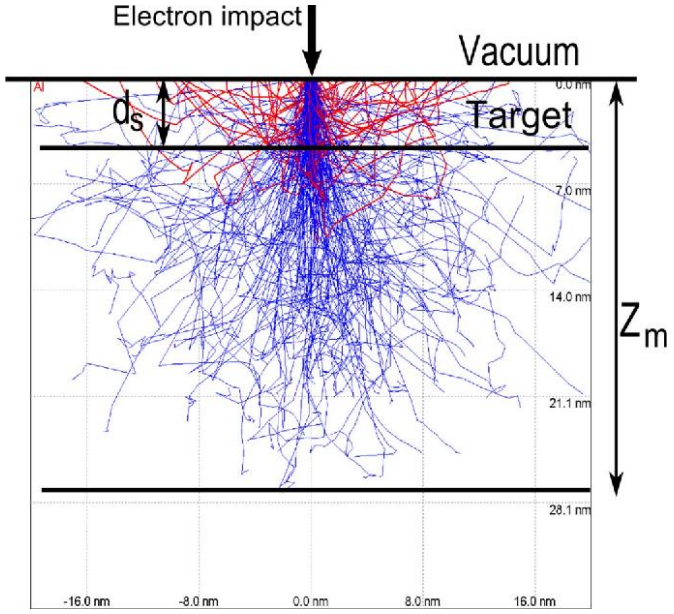
AD/ELENA

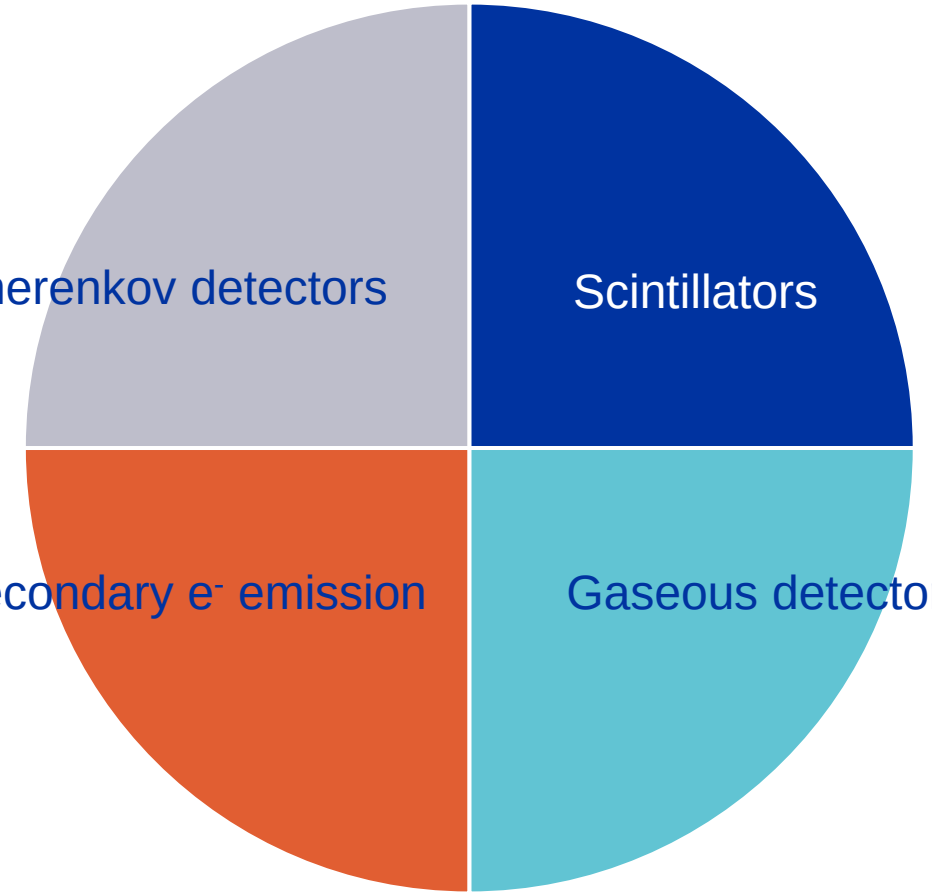
- 100 keV antiprotons
- 10^7 antiprotons per bunch
- 300 ns bunch length
- 1 to 4 bunches extracted

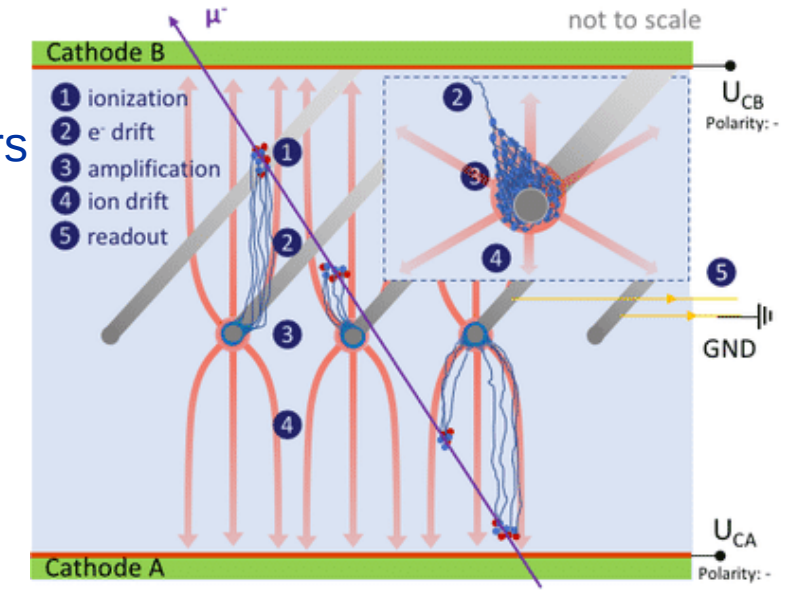


Beam instrumentation in the EA









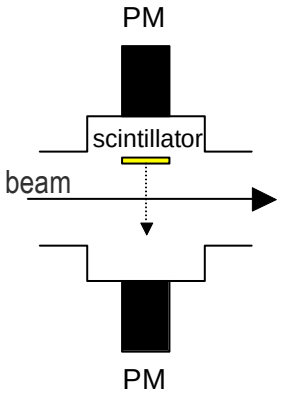
Scintillators

Scintillator paddle (XSCI)

Beam profile fibre monitor (XBPF)

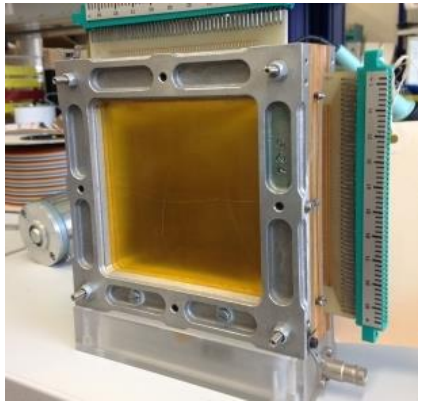
Lead crystal calorimeters (XEMC)

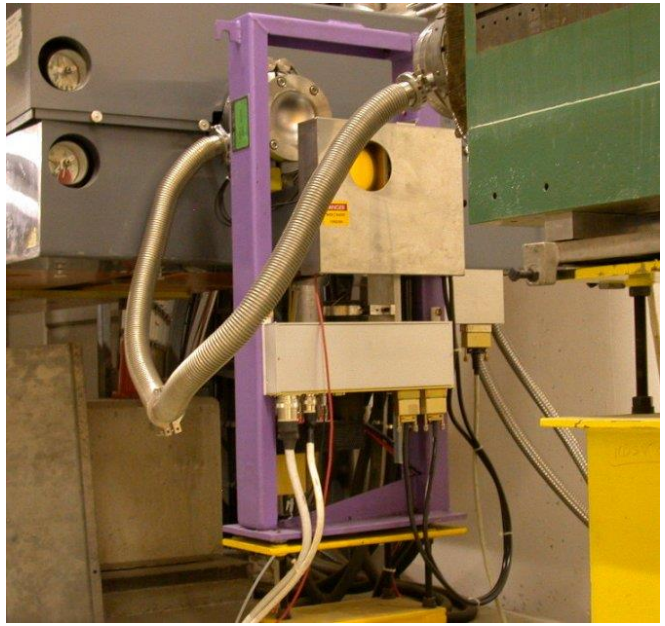
Finger scintillator scanner (FISC)



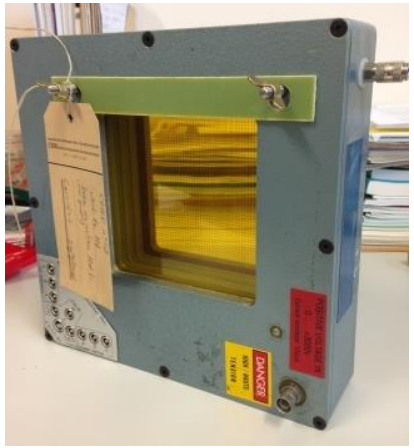
Gaseous detectors

Multi-wire proportional chamber (MWPC)

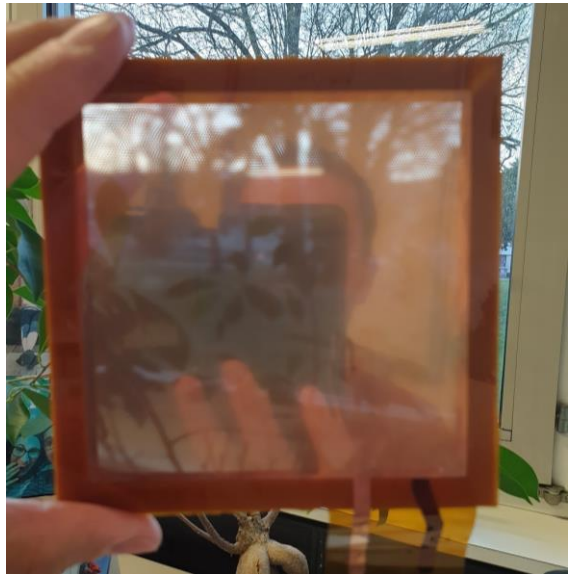




Delay wire chamber (DWC)

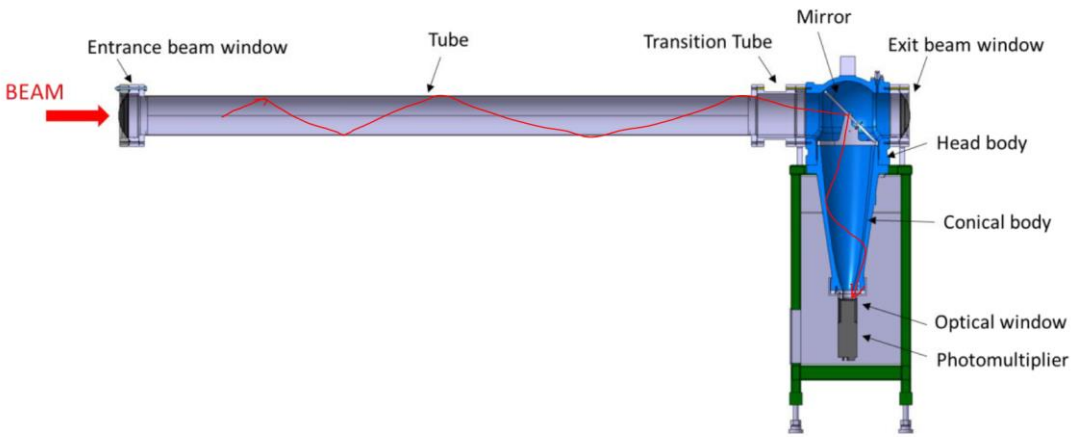


Gas electron multiplier (GEM)

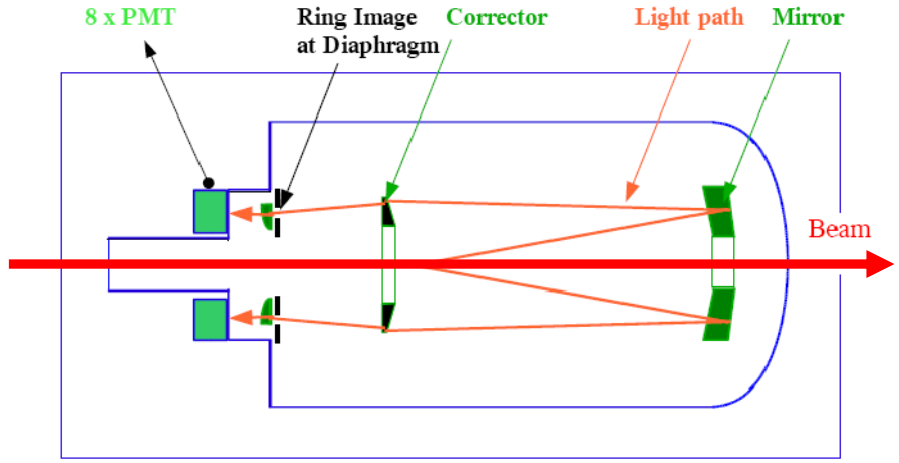


Cherenkov detectors

Cherenkov threshold counter (XCET)



Cherenkov differential counter with achromatic ring focus (CEDAR)

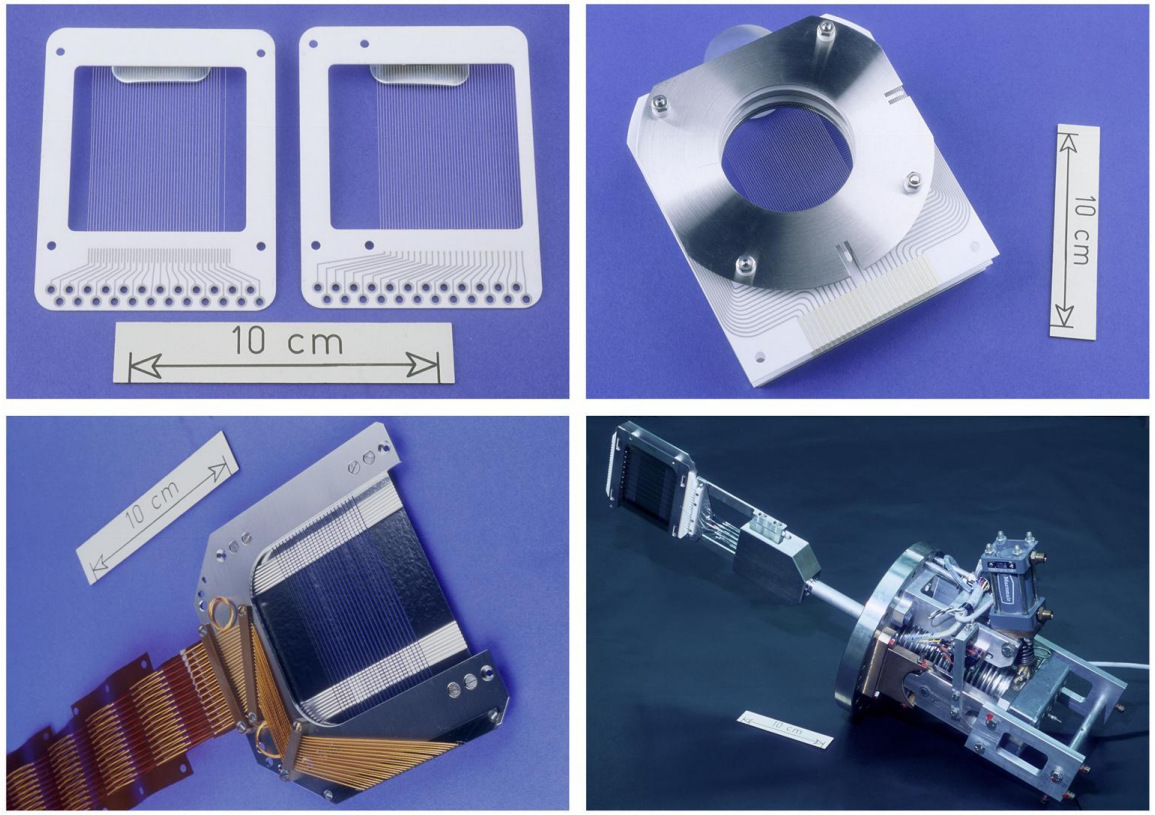


Secondary Emission Detectors

- Secondary emission monitors (beam intensities > 10^{10} particles/spill):
  - Profile & position
  - Intensity
  - Work in vacuum

- Secondary emission foils with ionising gas (intensity > 10^{7} particles/spill)
  - Intensity

- ELENA ultra-low intensity secondary emission grids (SEM Grids) (10^{7} particles/spill)
  - Profile & position
  - Work in vacuum



Notes from brainstorming session on Friday

- **Challenging to extract information from the EM field of the bunch**
  - May require interaction with an active material
- **Some techniques might work but need R&D**
  - Scintillation, silicon detectors, gaseous detectors, secondary emission, Cryogenic Current Comparator…
- **Optical Transition Radiation could work to discriminate dark current electrons (β ≈ 1) from muons (β ≈ 0.8) @ 200 MeV/c**
  - Strength, spectrum and angle of OTR emission depend on Lorentz factor
  - Caveat: photon yield is very low… OTR screens are typically used with higher intensity beams
- **Does liquid hydrogen scintillate? Can this information be used?**
- **Is 1ps bunch time structure feasible?**
- **Could a “laser scanner” be used to remove dark current electrons?**

Notes from brainstorming session on Friday

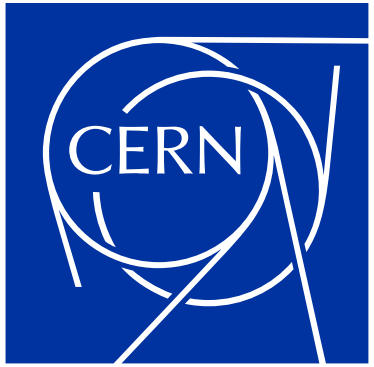
- **Profile/emittance:**
  - Scintillating fibres → challenging
  - Silicon pixel detectors (Timepix) → small active area – will it saturate?
  - Gaseous detector (wire chamber/GEM…) → used in AD
  - Scintillator/OTR screens → is the beam intensity high enough?
  - ELENA-type SEM Grids → beam intensity?
  - Scraper → destructive
- **Intensity:**
  - Beam Current Transformers → is the beam intensity high enough?
  - Scintillators → performance must be studied
  - Secondary emission monitors with gas → used in IRRAD/CHARM (East Area)
  - Cryogenic Current Comparator → expensive

Notes from brainstorming session on Friday

- **Bunch time structure:**
  - We probably need some active material interacting with the beam due to the low intensities.
  - Cherenkov or OTR based detector? Both have excellent timing properties.
- **Energy:**
  - Could Time of Flight work?
  - Electromagnetic Calorimeter → destructive
- **Beam loss monitors outside the cooling cell may be pointless (muon energy, absence of secondary particles showers) -> rely on intensity monitors**

Conclusion: challenging specifications and beam parameters. Requires careful study of all available BI detection techniques.

Feasibility studies and simulations are required for all the techniques shown. Extensive R&D is needed for some of them.



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