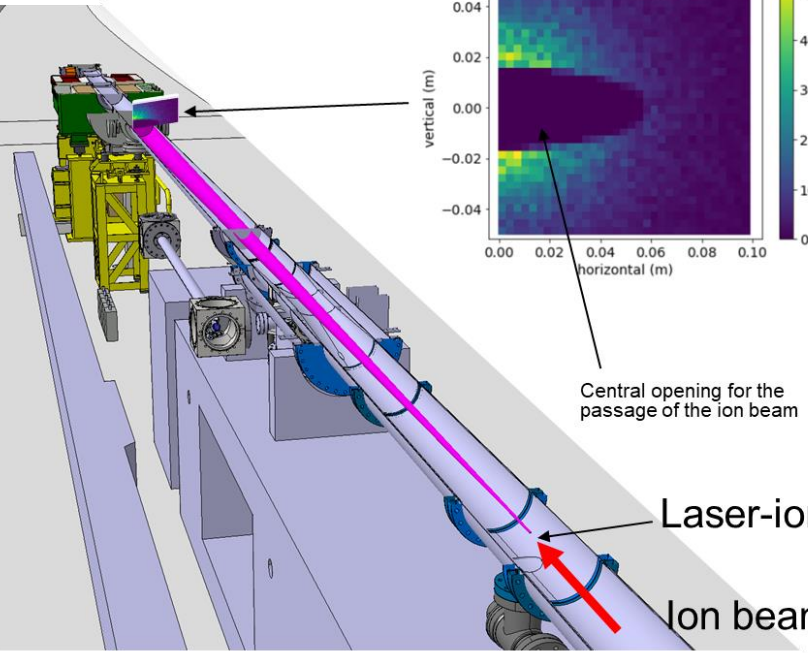

CERN

Collection of notes about photon detection @ SPS GF PoP

F. Roncarolo, E.Bravin, S.Burger, T.Lefevre

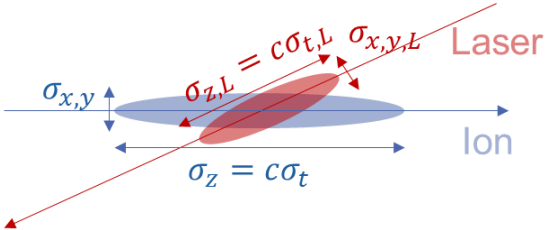
11-Dec-2023

GF PoP @ SPS



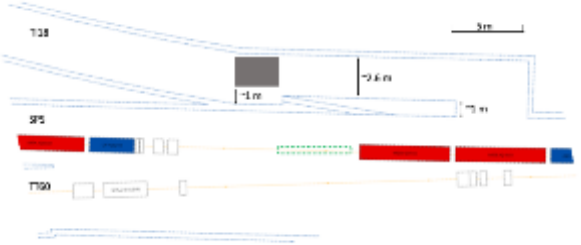
Central opening for the passage of the ion beam

- Constraints
  - Detect the X-ray photons produced at the IP
  - Simple and reliable, making use of existing
- Choice
  - Movable YAG:Ce scintillating screen with camera 7m downstream the IP
  - Central hole for the passage of the ion bunch
  - System using existing SPS beam screen design



Experimental Layout

Parameter	Value
Half-cell	621
Cell description	Dispersion suppression cell with 2 missing dipoles
Drift space	Around 13 m
Longitudinal coordinate of IP	s=6451 m
Beta x	55.32 m
Beta y	43.87 m
D x	2.46 m
D y	0 m



Ion Beam Parameters

	Value
Lithium-like lead	208Pb79+
Particle mass	193.69 GeV/c^2
Energy	18.652 TeV
Gamma factor	96
Number of ions per bunch	9E7 ions/bunch
Number of bunches	36
Particle lifetime	100 s
Relative energy spread (DE/E)	2e-4
Transverse emittance (xy)	1.5 um
Beam sizes	Sigma x = 1 mm, Sigma y = 0.83 mm, Sigma z = 6.3 cm (213 ps)
Collision angle	2.6 deg

Laser Beam Parameters

Laser Parameter	Value
Wavelength	1034 nm
Oscillation Frequency	40 MHz
Average Power	50 W
Single Pulse Energy	5 mJ (or 0.5 mJ) @ 43 kHz
Beam Sizes (Sigma)	xy = 0.65 mm, z = 2.8 ps
Collision Angle	2.6 deg

Gamma Photons

Parameter	Value
Excited state lifetime	76.6 ps
Gamma boost factor	4*gamma^2
Maximum energy of photons	44.47 keV

Photon (X-ray) detector (Phase 1)

- **Scintillator and camera/photomultiplier** for flux quantification
- **Proposed scintillator**: YAG screen, typical yield: 8 photons per
- **Half-screen** surrounding the beam with clearance
  - Simulated values: Dz IP-screen 7 m, screen r_min=4 cm, r_max=6 cm
  - Large aperture screen: Total photon flux emitted: 3E13 photons/s
  - Photons recorded by camera at 50 cm: Reduced by factor 150 (to be verified, likely smaller #photons)
  - Photons flux on the camera: 2E11 photons/s (to be verified)

Screen Dimensions	R min = 4 cm Rmax = 6 cm
Small hole	25 x 12.5
Large hole	59 x 17

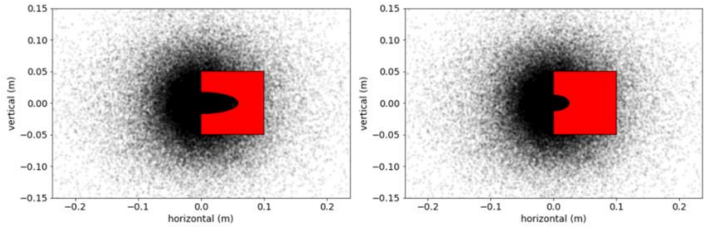


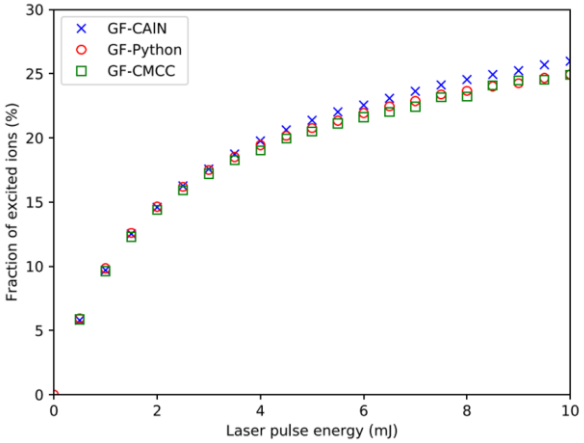
Fig. 24: Detector screens considered with elliptical holes and referred to as the large aperture, on LHS, and the small aperture, on RHS. The transported photons in the ideal conditions are shown as black dots.

Photons Flux @ detector

- Time overlap between ions and laser must be measured and adjusted to better than 0.5 ns

Laser Pulse	Excited Ions	X per Bunch Crossing
5mJ	20% with no offset (== perfect laser&ions position and time overlap?)	1.8E7
	2.7% of ions (max offset == ?)	0.24E7

Detector	Total Photon Flux	Photons Flux on Camera	
Large Aperture Screen	3E13 photons/s	Reduced by factor 150 (assuming 40 mrad acceptance for the objective)	2E11 photons/s



All to be checked

Photon (X-ray) detector (Phase 2)

- **Timepix : solid state detector capable of resolving xray position and energy (tbc)**

Chip	Dimensions
Timepix3	14 x 14 mm2
Timepix4	448 x 512 pixels, 55um2 per pixel → 24.6 x 28.2 mm2

May need multiple chip sensors

		Timepix3	Timepix4
Technology		IBM 130nm	TSMC 65nm
Pixel Size		55 x 55 µm	≤ 55 x 55 µm
Pixel arrangement		3-side buttable 256 x 256	4-side buttable 256 x 256 or bigger
Operating Modes	Data driven	PC (10-bit) and TOT (14-bit)	CRW: PC and iTOT (12...16 bit)
	Frame based	TOT and TOA	
Zero-Suppressed Readout	Data driven	< 80 MHits/s	< 500 MHits/s
	Frame based	YES	YES
TOT energy resolution		< 2KeV	< **1Kev**
Time resolution		1.56ns	**~200ps**
Readout bandwidth		5.12Gb (8x SLVS@640 Gbps)	20.48 Gbps (4x 5.12 Gbps)
Front-end		"with" Volcano	No volcano → Dynamic gain But supply only 1.2V

448 x 512

SPARE

Scintillator and PMT/Camera

Estimated Costs

Design	20 kCHF
Fabrication	20 kCHF
Screen and supports	10 kCHF
Cables and fibers	10 kCHF
Electronics	10 kCHF
Work BI-PM	2 MM
Work BI-ML	2 MM
Total	70 kCHF
Total work	4 MM

PMT, Camera?

Timepix

Estimated Costs

Vacuum tank	**40 kCHF**
Detector, cables and electronics	60 kCHF
Work EA + ML	4 MM
Work for detector design	1 MY (possibly a fellow or doctoral student)