Status of the halo monitor R&D and plans for the future

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11th HL-LHC Collaboration Meeting – CERN – 19-22 October 2021

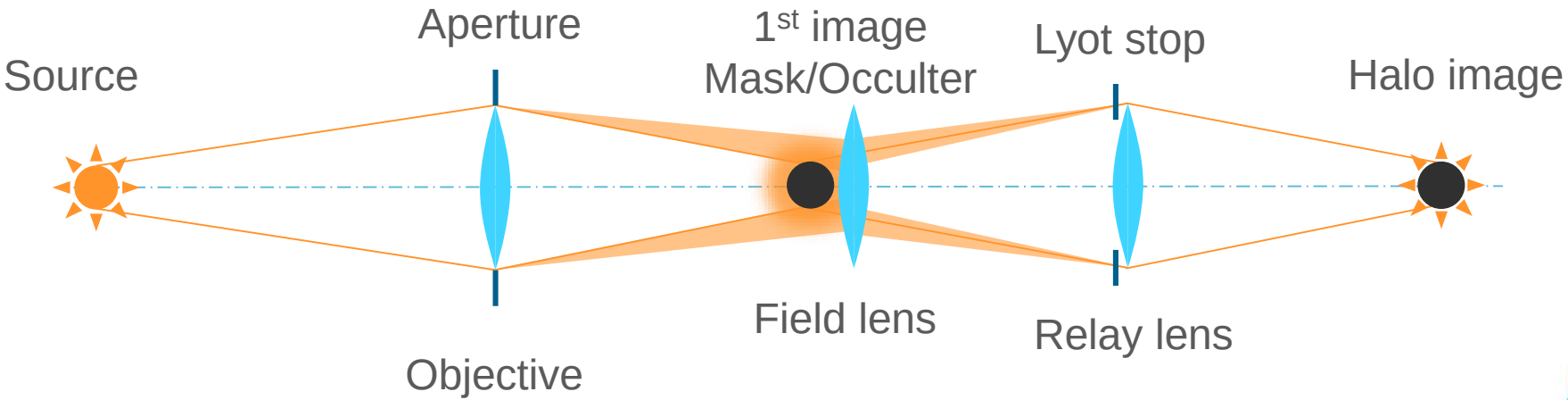
History

- Beam halo monitor R&D started in 2015 as a collaboration with KEK
- Tested first prototype during run 2
  - Based on existing coronagraph lent by T. Mitsuhashi
  - Could observe halo at injection energy by differential observation in dedicated MD
  - The system performed worse at high energy
- Design completely redone for run 3 based on reflecting telescope
  - Extensive simulations of expected performance
  - Better understanding of the coronagraph principle

Coronagraph principle

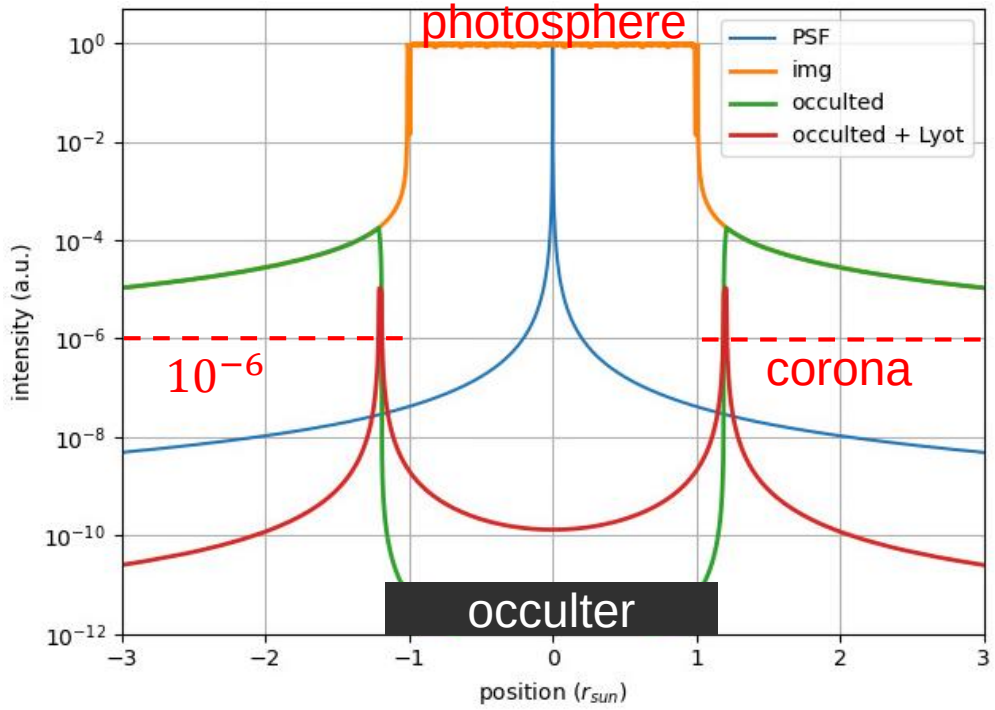
In addition to a standard imaging system

- Occulter to remove the core light (negligible diffraction in following stages)
- Lyot stage to remove the diffraction introduced by the entrance aperture



Works well for a thermal source where the diffraction is dominated by the entrance aperture

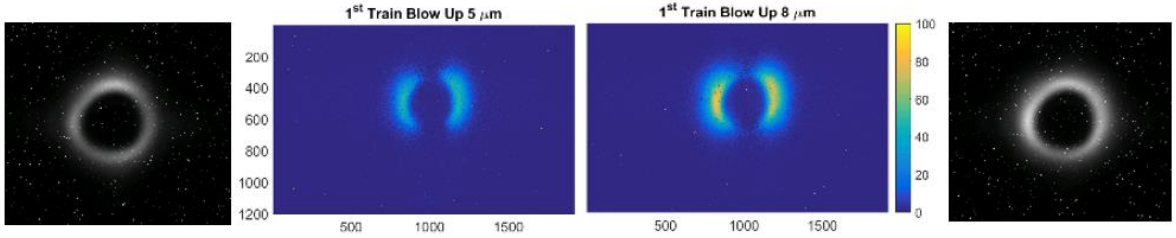
The Sun coronagraph



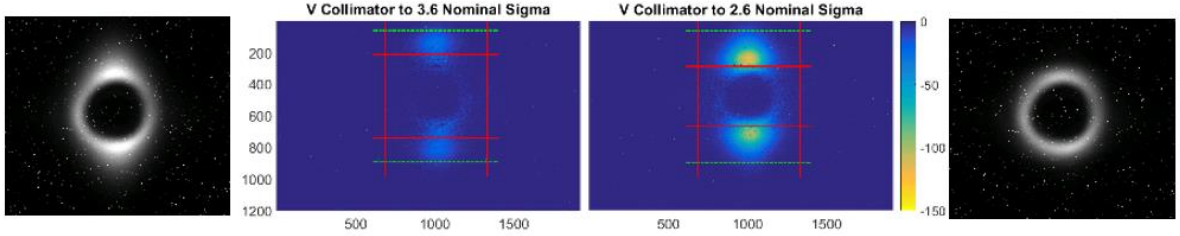
Works well because the Sun is a thermal source and it is big compared to the point spread function

Results of first prototype at 450GeV

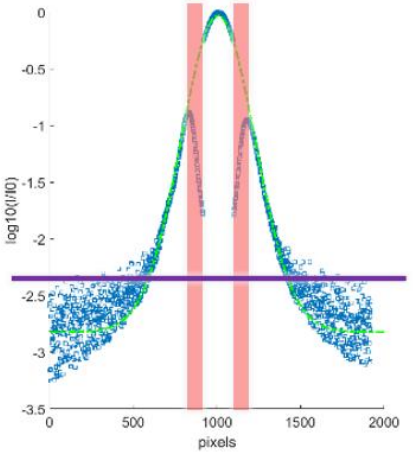
- Coronagraph images during controlled blow-up



- Coronagraph images during controlled scraping



Contrast of 2.10^-3 demonstrated
Bigger disk would have allowed going to higher contrast ?

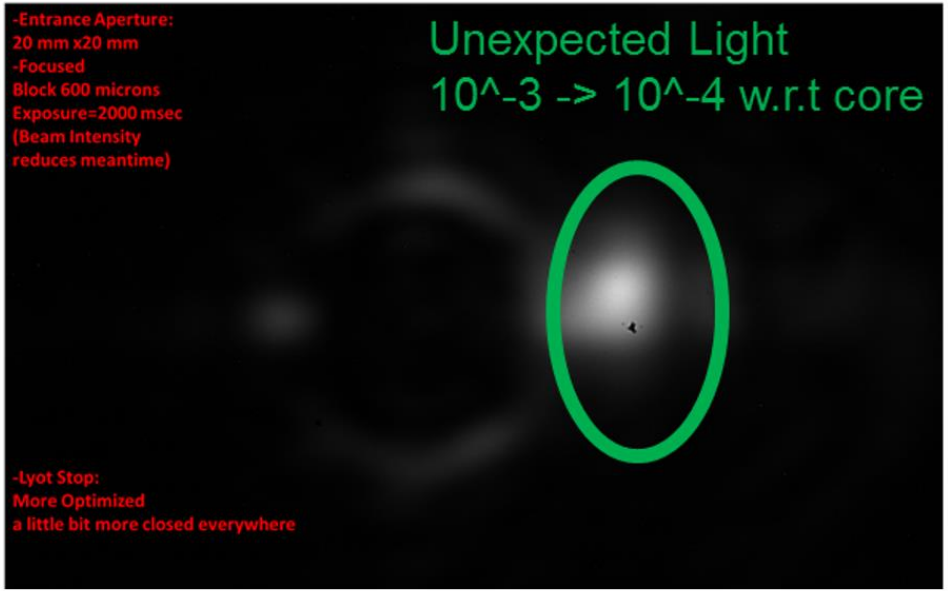


Results of first prototype at 6.5TeV

With D3 SR at 6.5 TeV,

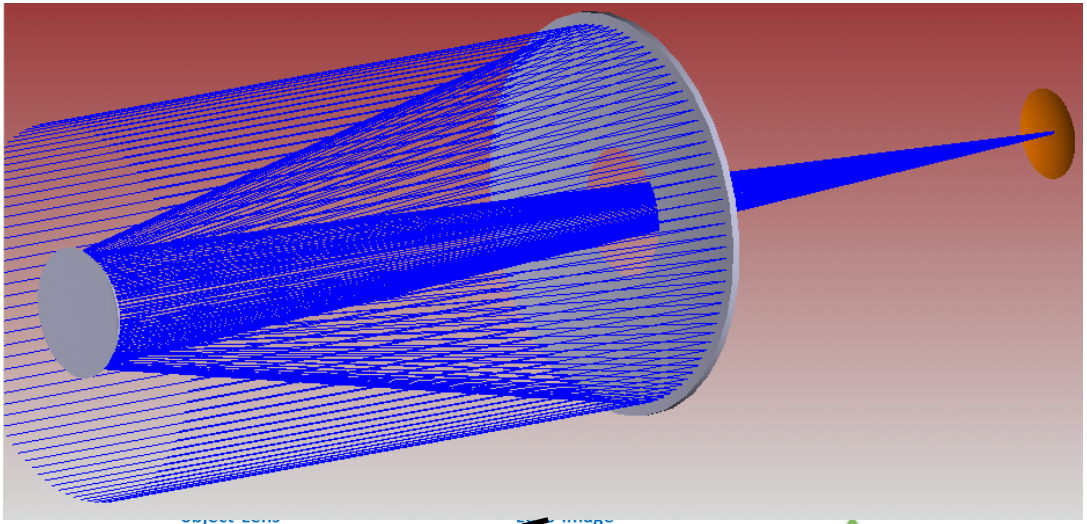
Not conclusive Pattern dominated by parasitic light

Core Blocked, Lyot Stop Fully Optimized

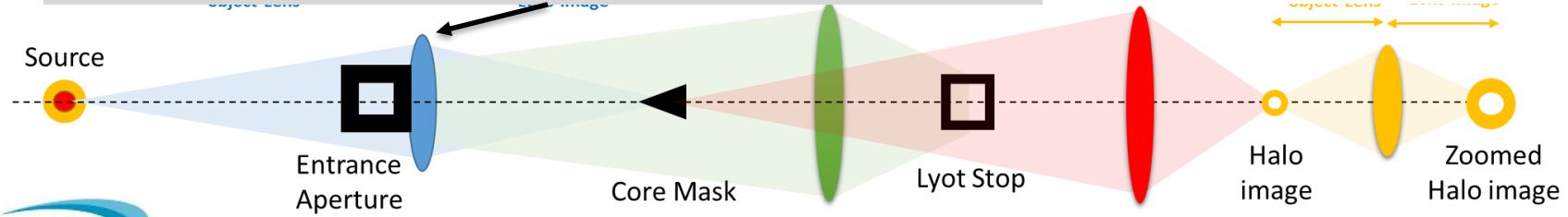


SR Coronagraph - G. Trad 15/11/2017

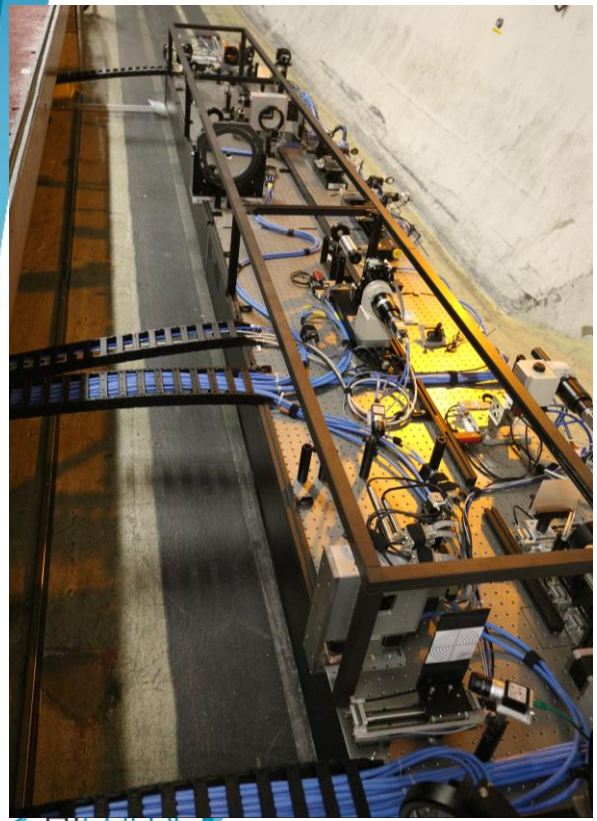
New design for run 3

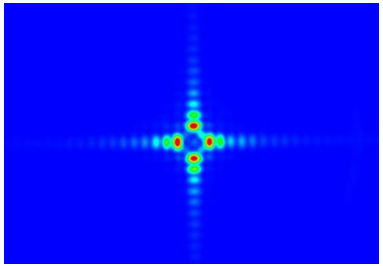


Designed based on the assumption that a larger magnification (larger core mask) would improve the contrast.
Reflective objective telescope as objective lens -> Larger magnification



New system in LHC and ISR

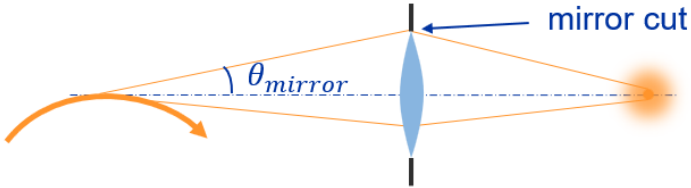




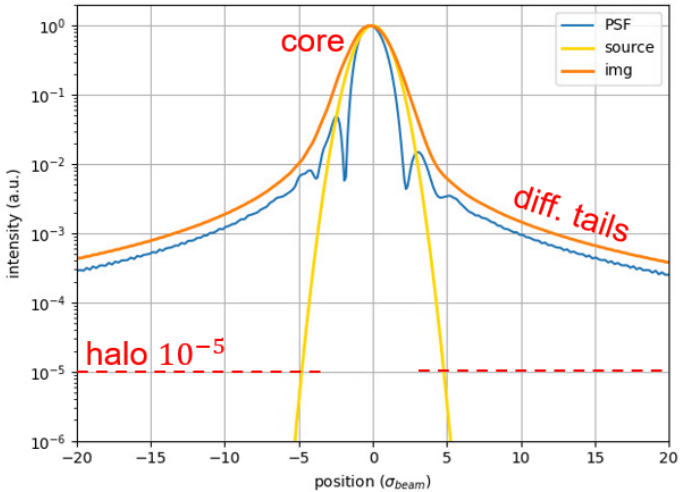
Installed a copy in the ISR in order to allow performance studies and benchmark simulations

Coronagraph simulations for SR in LHC (FT)

Goal: observe the halo surrounding the beam core aiming at $C \sim 10^{-5}$ at $x < 6.5\,\sigma$



Horizontal plane



Best telescope
→ **PSF ~ σ_{beam}**
Why? PSF is affected by SR opening angle and the beam is small!

Increase contrast → extremely challenging!

Let's try with a Lyot's coronagraph…

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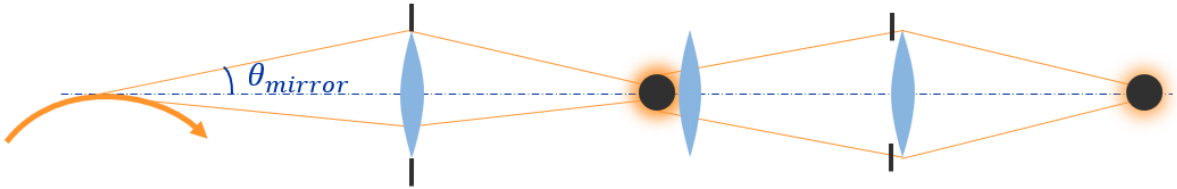

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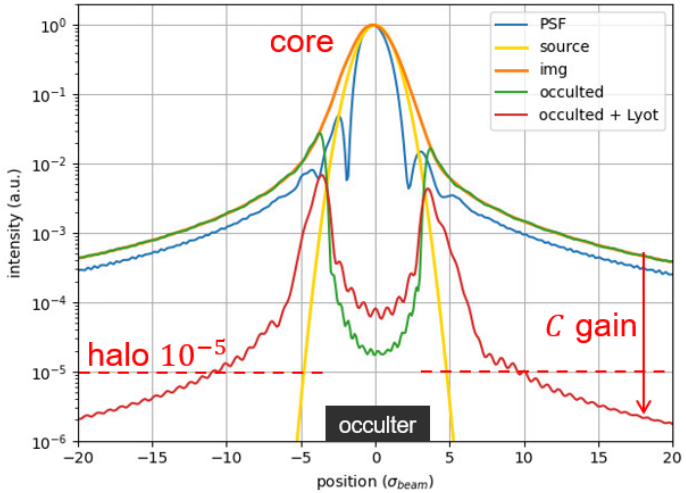

Lyot's stop **reduces diffraction tails far** ($> 7\ \sigma$) **from the core**

Not much effective in the region of interest because **PSF** $\sim \sigma_{beam}$, contrast $C \sim 10^{-3}$ at $x \approx 3 \div 6.5\ \sigma$

higher contrast ⇒ smaller PSF

The PSF is in our case a property of the SR source
To reduce PSF → move to X-Rays diagnostics (PSF~λ)

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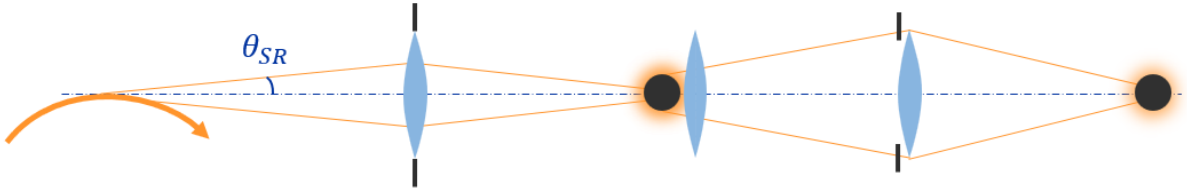
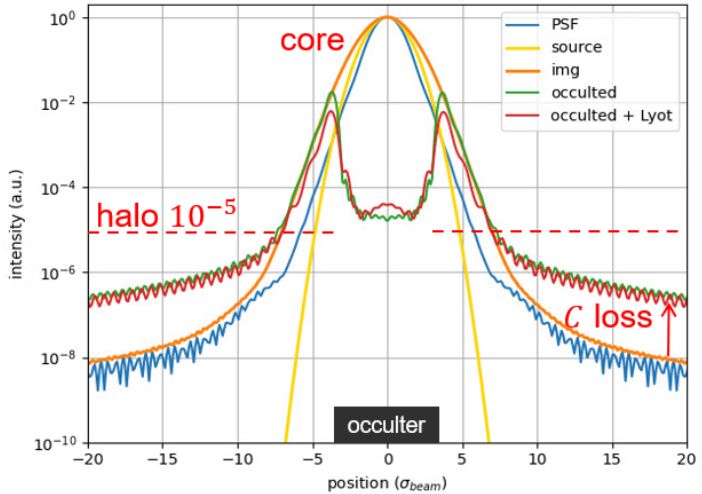


Vertical plane



Lyot's stop is just a narrower aperture of the relay system
→ **Lyot's coronagraph worsens the tails vertically**

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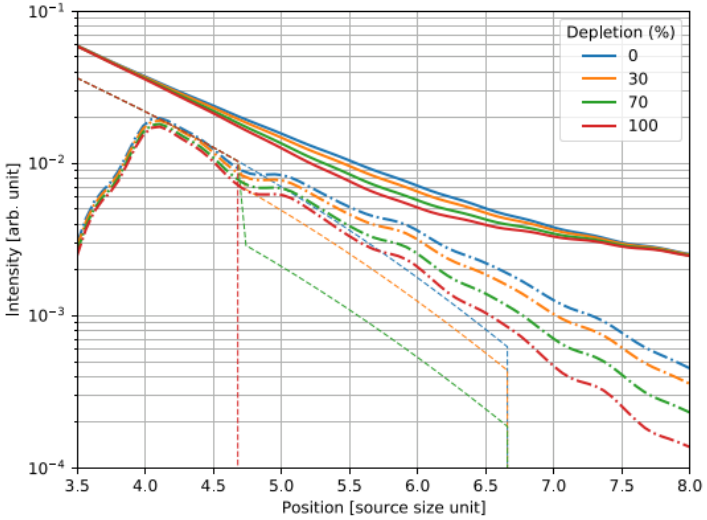
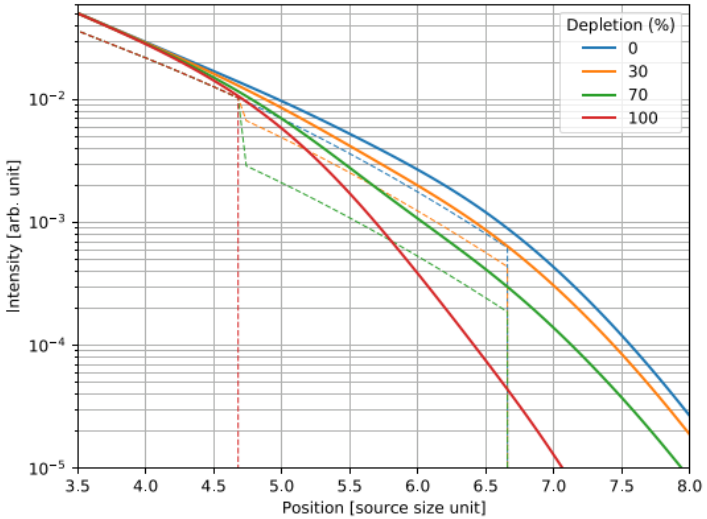
What can we see?

Measured profile of realistic proton distributions with halo suppression



Horizontal



Vertical

Solid lines are for imaging, dot-dashed lines for coronagraph
Fine-dash proton distribution

Conclusions

- New design of coronagraph implemented for run3
- Extensive simulations and better understanding of the underlying theory
  - SR in visible range cannot provide the expected performance (from the design report)
- Ongoing benchmarking of simulation in ISR and LHC
- Investigating possibility of differential measurements
- Continue investigating other options
  - X-ray and pin-hole
  - Non SR based techniques

Thank you