CERN

Photon detection concept(s) -

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Outline

- Conclusion from CERN Meeting

- Taking into account recent simulations from the new interaction zone
  - What changes ?

- Can we make a plan of a realistic detection system with the present resources ?
  - Consideration on Budget, Schedule, Resources

Diagnostics for GF-OP – Conclusions from March

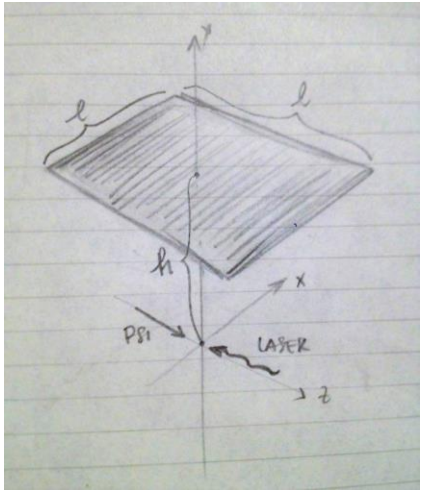
- Beam position monitors around the laser cavity
  - Button beam-position monitors (BPMW) are installed on either side of the laser cavity using the CERN DOROS acquisition system providing orbit data (integrated over 1ms) with micron resolution

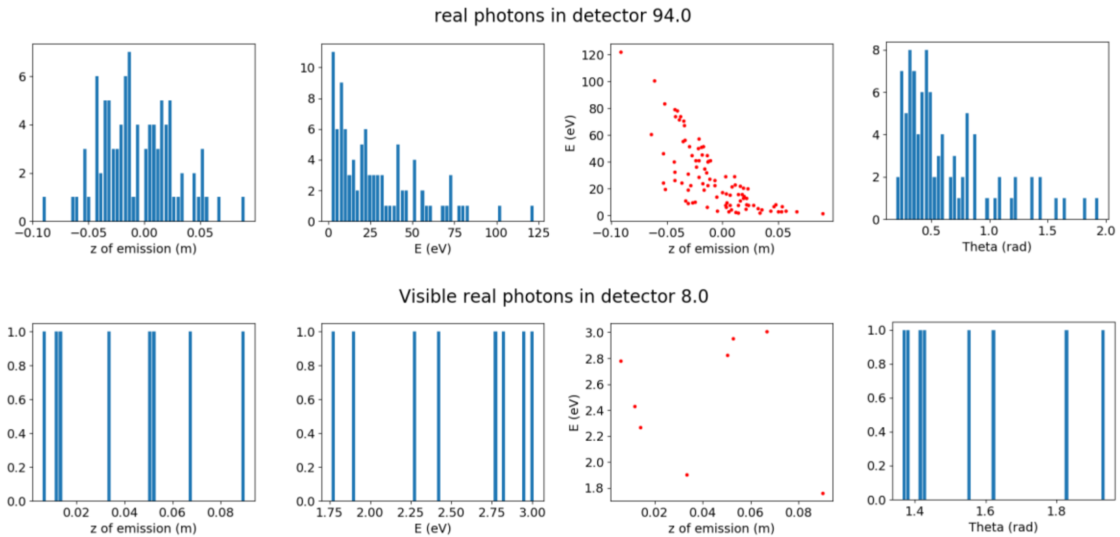
- Challenging monitors
  - Need a replacement chamber for Photon X-ray monitor
  - Challenging visible light monitor
    - Very few photons
    - If doable (depending on background light) it will require a high sensitivity (and expensive) camera and integration time of several seconds
  - At least two possible technology choices for X-ray monitor
    - Scintillation or Pixel detector ?
    - Going to more realistic detector study (simulations of realistic design size /shape, including background from beam losses in BDsim?)

Recent simulations from Camilla'talk

- Beam imaging system using emitted photons in visible range

- detector above the IP to detect visible photons (energy between 1.7 and 3.2 eV), shape: square





- These are the photons hitting the detection plane !

Recent simulations from Camilla’talk

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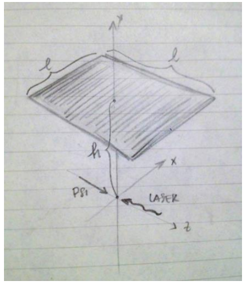
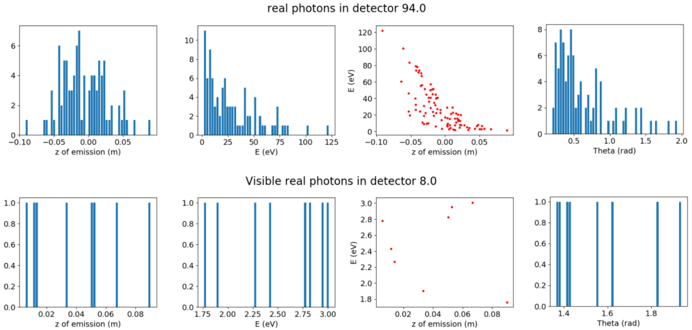
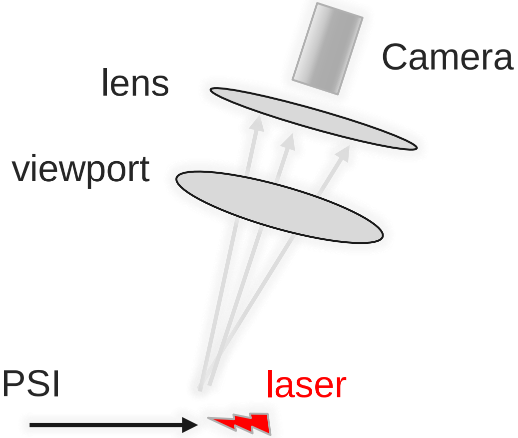






- Only a fraction of those photons will be detected by the camera
- Maybe one or two photons per bunch crossing !

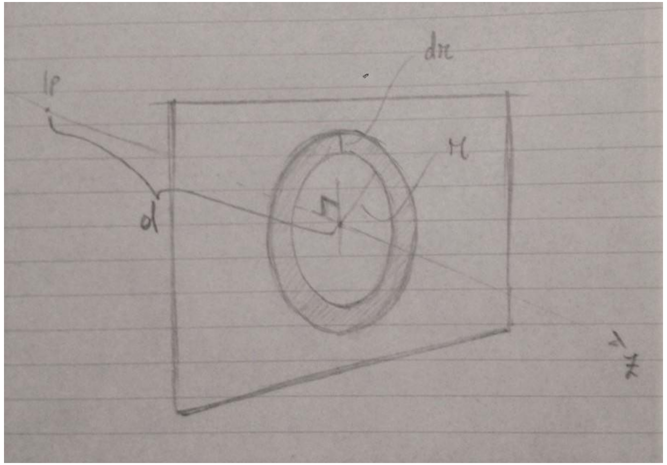
Recent simulations from Camilla'talk

- Beam imaging system using emitted photons in visible range
  - SR background for ions expected to be negligible in the visible range
  - Suppressing Background light at the level of few photons per turn is challenging
    - Requiring a perfect light tight detection system
  - Background will also come from the laser photons – this limitation should be removed using laser notch filter

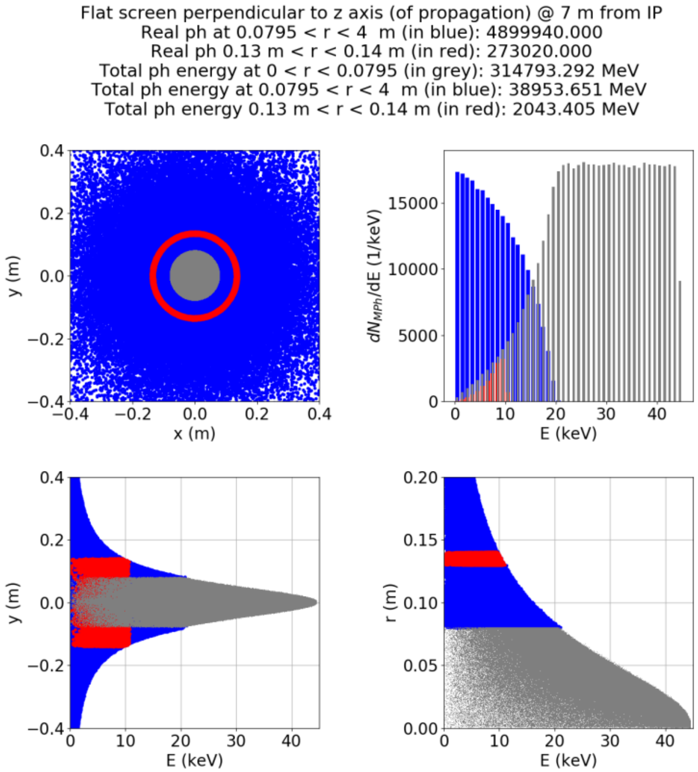
- My personal feeling is that this is quite challenging
- A viewport can be foreseen on the laser cavity vacuum chamber to investigate background light
- But I would not count on this detector to tune the experiment

X-ray photon from Camilla's talk

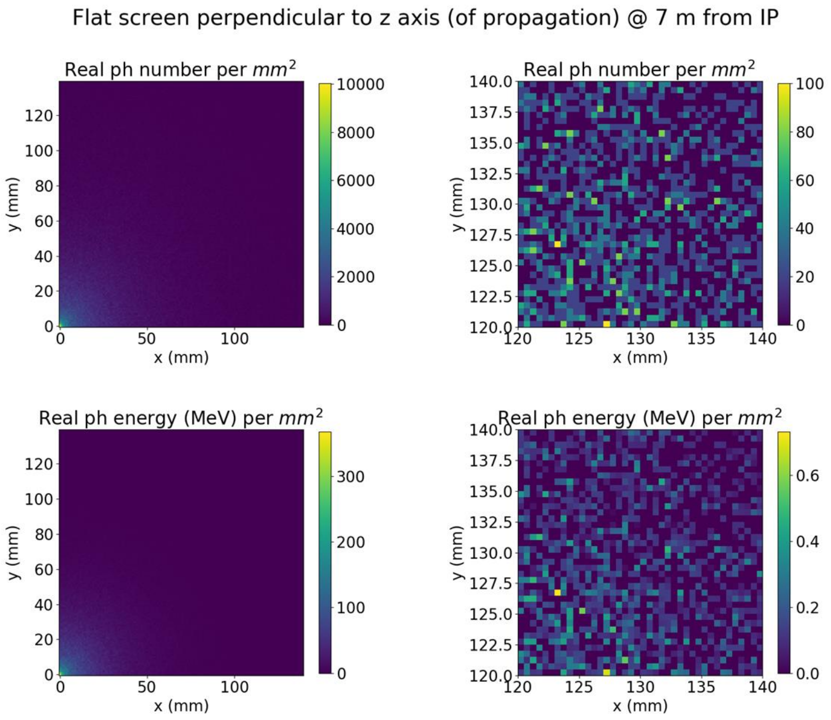
- ring detector out of the beam pipe (8 cm radius) for the photons dacaying in the forward direction

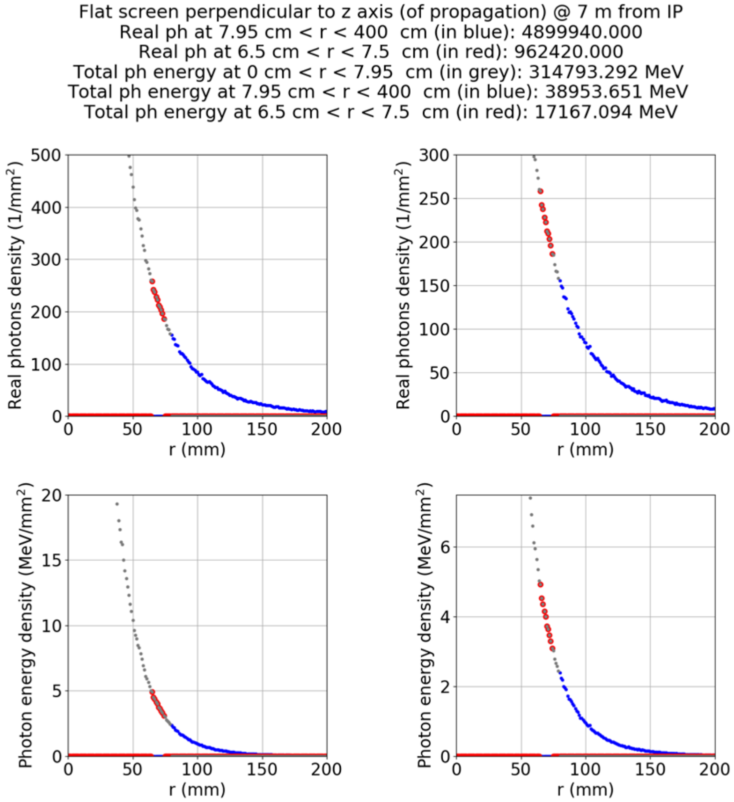


- simulations in the following for $r = 13$ cm, $dr = 1$ cm and $d = 5,\ 7,\ 9$ m



X-ray photon from Camilla's talk





X-ray photon from Camilla's talk

- Large photon fluxes of 200-250/mm^2

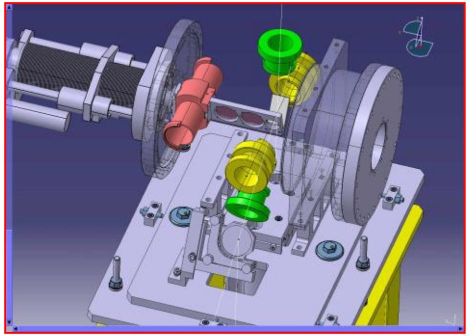
- Question is more on the detector technology choice ?
  - Semiconductor vs Scintillator

  - Performance vs Simplicity/Robustness/Cost
    - Semiconductor can provide some energy resolution, is it required for the PoP ?
    - Semiconductor are great candidate for an outside vacuum detection system (not possible on SPS)

    - Scintillating screen or scintillator coupled to PMT could work

X-ray photon from Camilla's talk

- Simple scintillator design can be done with very limited resources
- Refurbishing a CERN BTV system (screen + camera)
  - BTV can have a replacement chamber
  - It comes with CERN standard control and acquisition system
  - Normal scintillating/OTR screen to be replaced by an adequate ring scintillator screen (several option for the screen material and easy to change the screen shape if needed)
  - Would need some mechanical design/integration but no real development (possibly reusing existing equipment ?)



Conclusions

- Keep two BPMs in the laser cavity

- Do not count on visible photons detection system in the laser cavity

- Looking for the most pragmatic approach and simpler design of scintillating screen reusing on a BTV system

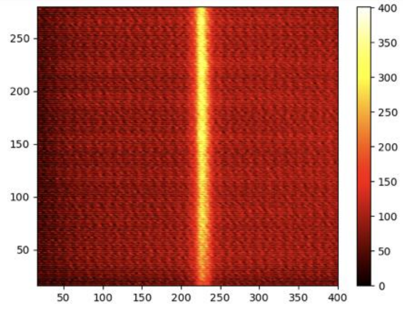
- If more resource/manpower is found, we could do better !!

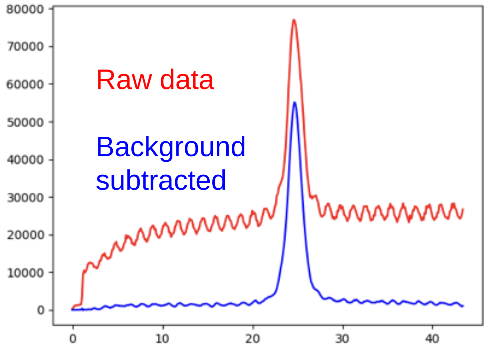
Beam diagnostics for GF-OP

- Measuring longitudinal beam cooling
  - Several monitors available in SPS with sub-ns resolution (BQM, WCT or HT-monitor)
    - Bandwidth up to 3GHz
  - Bunch-by-bunch, turn-by-turn longitudinal beam profile possible
  - Need to check if the current read-out system is adequate for our need - how many measurements per second are needed ?

Beam diagnostics for GF-OP

- Measuring transverse beam size
  - Not enough SR for ions for BSRT
  - Wire scanner – risk of stripping ?
  - Beam gas ionization profile monitor





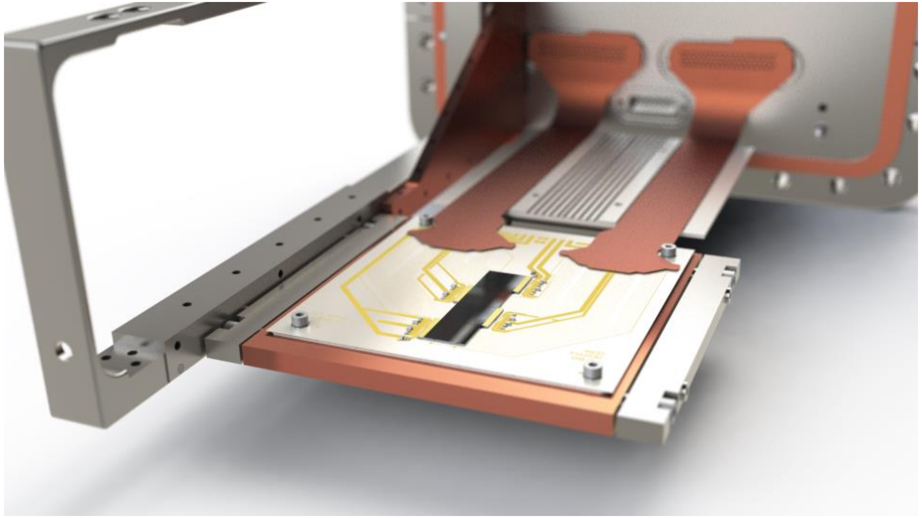
- Very clean profile after background subtraction
- Smallest intensity that can be detected in a single cycle = ~10e10 p
- Open questions and future investigations
  - Do we need gas injections ? Sensitivity with single ion bunches ?

X-ray photon Diagnostics for GF-OP

- Example on SPS using Pixel detector – Timepix3

https://medipix.web.cern.ch/technology-chip/timepix3-chip

http://bgi-web.web.cern.ch/bgi-web/



- CMOS : 256x256 pixels (55umx55um)
- Rad-hard read-out electronic system
- Operational on PS since 2017

X-ray photon Diagnostics for GF-OP

- Example on SPS using Pixel detector – Timepix3

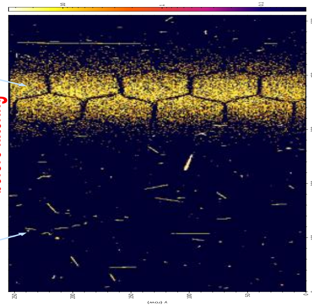
Hybrid pixel detector is sensitive to ionisation electrons **and beam loss.**

Identify clusters of pixels belonging to a common particle event. Select only clusters consistent with ionisation electrons (1-2 pixels; low energy)

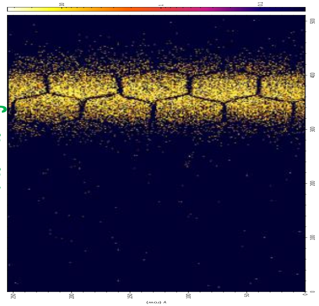
ionisation electrons

before filtering

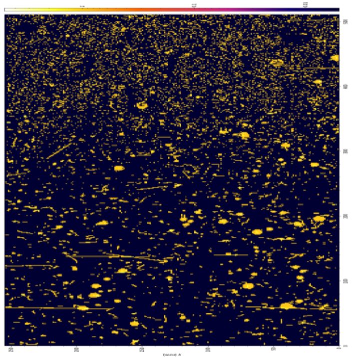
beam loss particles



after filtering

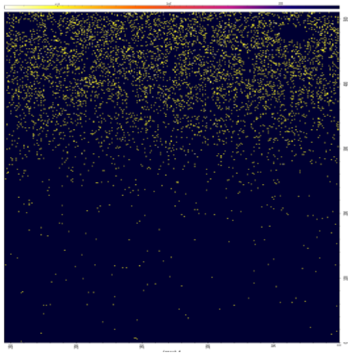


before filtering



Significant beam loss at injection (184.5ms – 185.5ms)

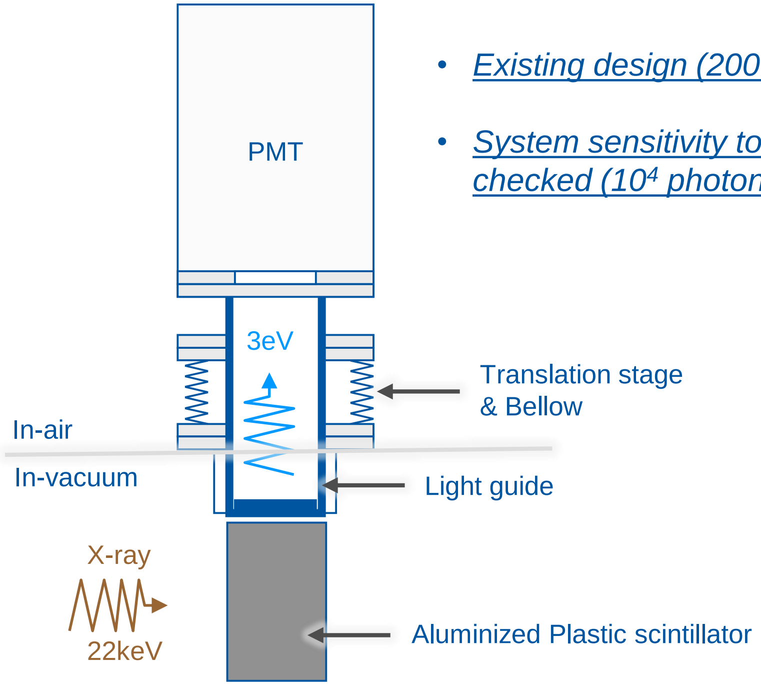
after filtering



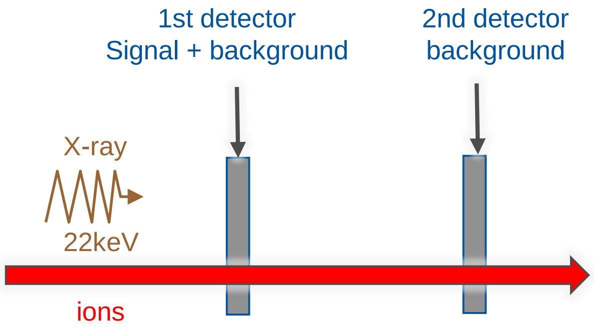
After filtering beam loss is removed (but consumes limited front-end readout bandwidth)

Beam diagnostics for GF-OP

- X-ray detection system using lead loaded plastic scintillator



- *Existing design (2001)*
- *System sensitivity to be checked (10^4 photons/pulse)*



Thank you