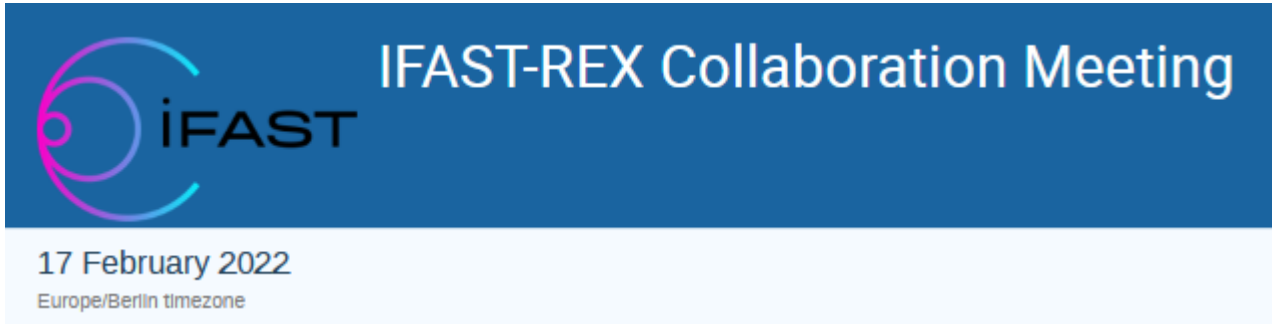


Achievements and proposals for WP 4 on detector development – Spill monitoring

I. Ortega on behalf of F. Roncarolo and the CERN SY-BI group

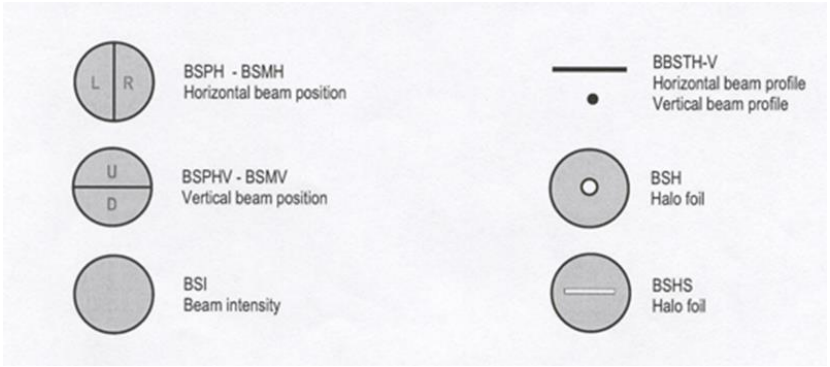
Many thanks to:
M. Duraffourg , S.Mazzoni, S. Burger, M.Martin, L.Parsons Franca, A.Navarro Fernandez
E.Calvo, B.Salvachua Ferrando, E.Effinger, C.Zamantzas
M. Krupa , A. Cristiano
J.Storey, J.Tan, S.Levasseur, H.Sandberg
N.Emriskova, R.Garcia Alia, F.Ravotti, K.Bilko
V.Kain, M.Fraser, F.M.Velotti
T.Lefevre

Contents - Introduction

- Secondary Emission Monitors (SEMs) in SPS and PS
- Longitudinal Spill Gas Detector in the PS
- Beam Loss Monitors
  - Ionization chambers
  - Diamond BLM
  - Si-diode test with heavy ions at IRRAD in 2021
- Fast Spill Monitor 1: OTR screen
- Fast Spill Monitor 2: Cherenkov quartz bar

BI @ SPS-SX – Secondary Emission Monitors

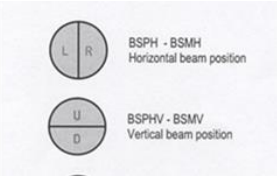
~80 monitors + ~50 in target boxes

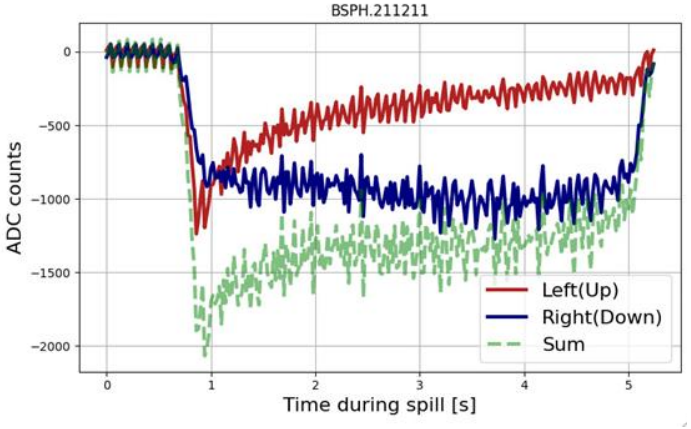


BSM(H,V)
BSI
BSG(H,V)
BBS(H,V)
BSP(H,V)

BI @ SPS-SX - New SEM electronics (2021)

New electronics: signals during slow extraction sampled with t=20ms





DAQ can be swapped to ‘fast’ mode able to integrate fast extractions (and used for SPS bunched beam in injection line)

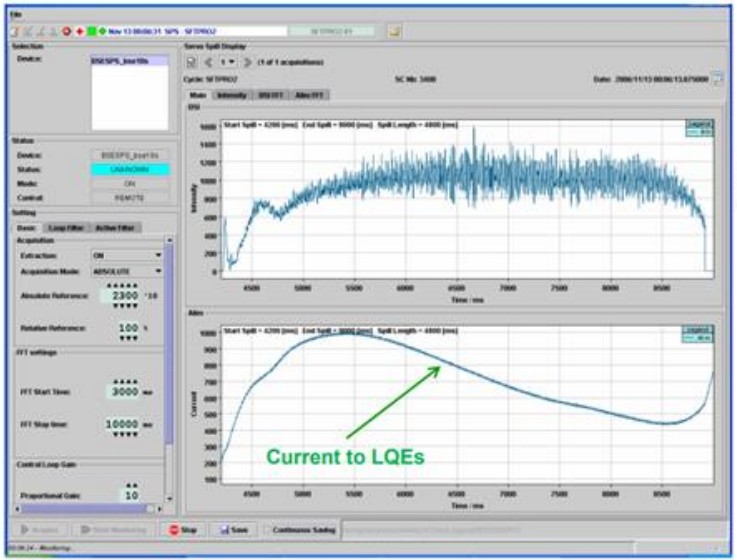
Split foil example: can see that beam is moving during spill (not possible before 2021)

BI @ SPS-SX - SEM – status/limitations

- Absolute calibration for intensity meas. very tricky
- Proper optics and transmission optimization difficult with present park
  - NA consolidation program to replace/add instruments, e.g. to have grids for better optics measurements
  - Possible new requests after 2021 experience (to complement approved consolidation)
- Robust systems, nevertheless not necessarily optimized for precise measurements (mechanical layout with stack of foils → cross talk, etc..)
  - Ongoing PhD to investigate how to improve precision
- Noise and ageing due to radiation are a ~constant concern, not improved after LS2

BI @ SPS-SX ‘Fast’ SEM detector (aka ServoSpill)

- 1 ‘fast’ (kHz) spill detector based on SE foil @ extraction
- Can be (and was) used to directly compensate spill intensity ripples
- Detector itself (SEM foil) installed since many years
- 2021: signal resulted to be very noisy, amplifier change did not solve the problem, suspect some short or leakage inside vacuum
  - Plan to refurbish detector end of 2022



BSI measurement

BI@PS-SX –Secondary Emission Monitors (SEM)

- Very similar to SPS monitors, since 2021 equipped with new SPS electronics
- Used to control extraction/transmission and monitor ProtonsOnTarget
- Absolute calibration critical (as for SPS)

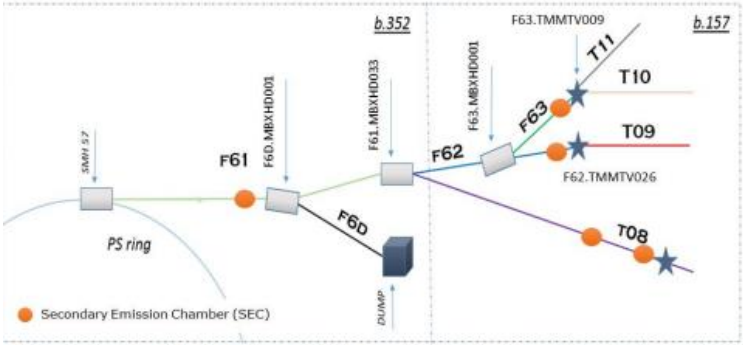
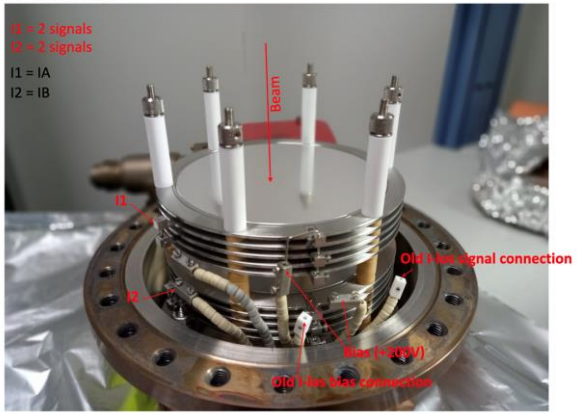
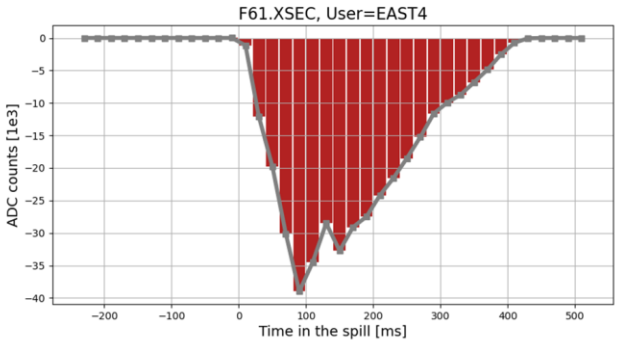


Fig. 4-26: Position of XSEC on the new East Area lines.

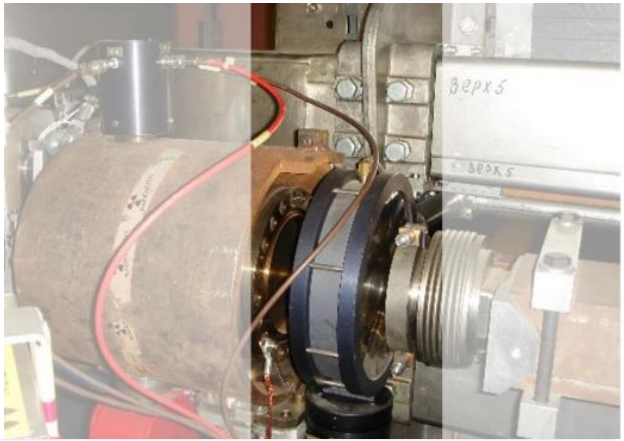
F61.XSEC-023

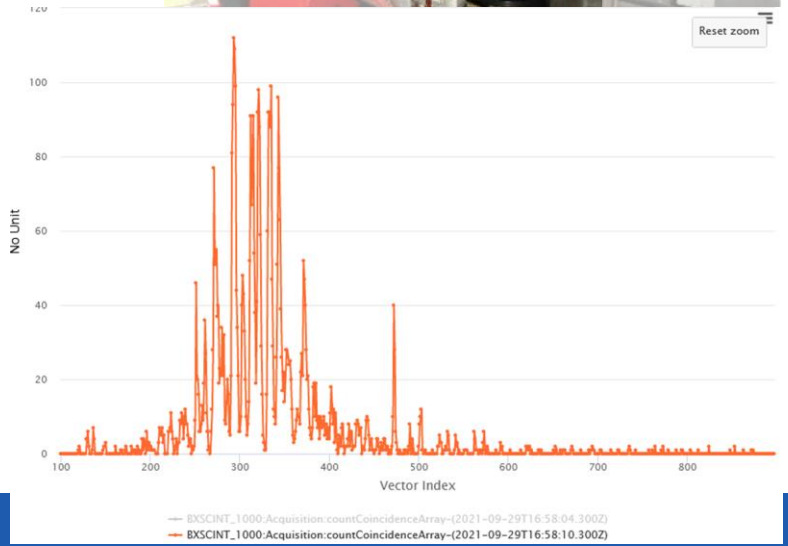




BI@PS-SX - Longitudinal Spill Gas Detector

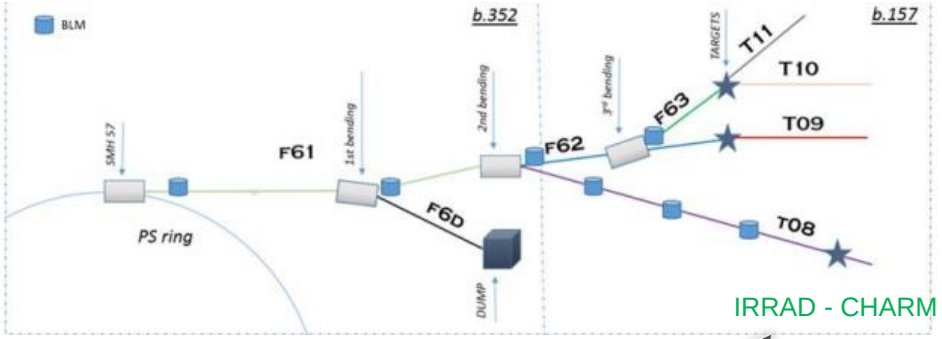
- Based on detecting light emitted by beam-gas interaction
- Tank filled with Nitrogen, ~22m from extraction point -> plan to use new brighter gases
- Two PMTs in coincidence (to suppress noise)
- DAQ: 10 kHz possible, now set to 2.5kHz
  - Ultimate BW now anyhow limited by present cables and VME bus
- TDC based DAQ under study, could reach 1 MHz





BI@PS-SX – Beam Loss Monitors BLMs

- Ionization chambers at strategic locations in transfer lines
  - Can give 100kHz in capture mode
- Fast Diamond BLMs requested for installation at PS extraction to characterize spill quality
  - Detectors as ones described later for SPS
  - 2021 request: being processed



Next slide == potential of these monitors as fast spill monitors inferred from Si-diodes tests at IRRAD

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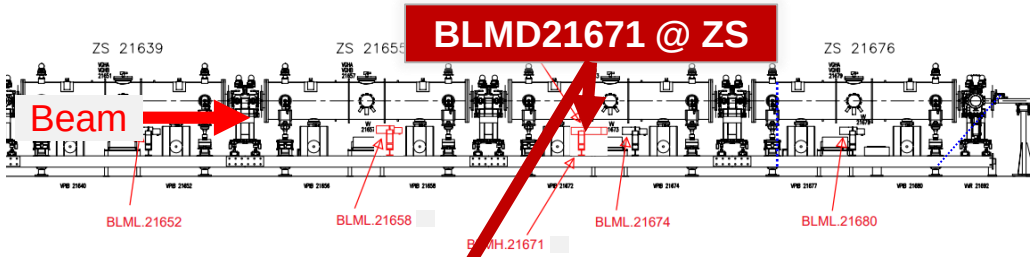
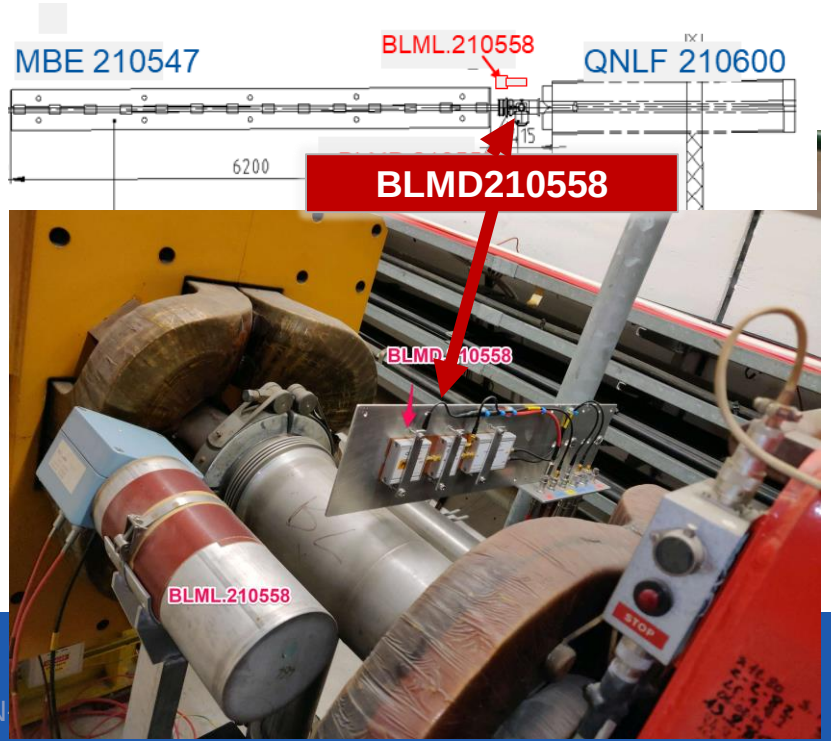
Diamond – Beam Loss Monitors (dBLM)

pCVD crystals, for beam loss monitoring and potentially a Fast Spill monitor

2 dBLM installed in SPS (@electrostatic septum and @transf. line quad)

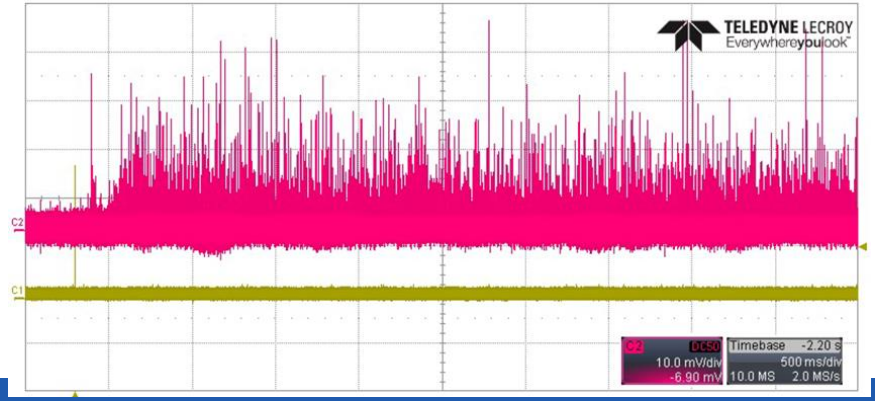




SPS dBLMs – Features and Status

SPS detectors read out via BI standard carrier board (VFC) + 2 Ch-**650 MS/s digitizer mezzanines** (detector installed in PS EA IRRAD acquired through an oscilloscope)

- Plan to use FW&SW capture mode for SX:
  - Circular buffer of 2GB (1GB per channel)
  - ~500 Msamples/channel @ 650MS/s → ~0.8 sec (full memory readout can take minutes
  - Different gating/sampling strategies under study
  - DAQ SW and logging protocols being finalized

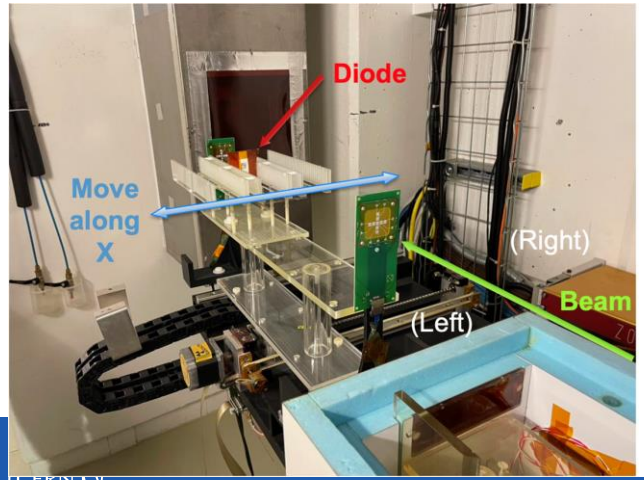


First measurements during 2021 via scope

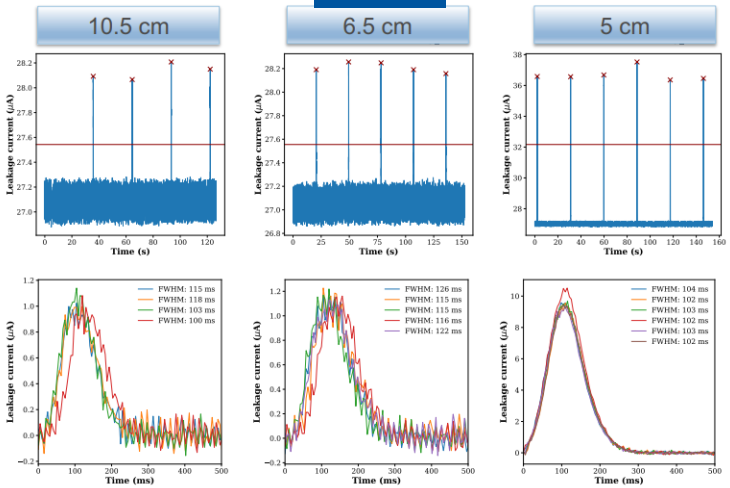
- Signal integrity issues (interference/ground loop) suspected to corrupt the signals of the ZS4 detector → To be followed up

Si-detectors @ IRRAD for CHIMERA

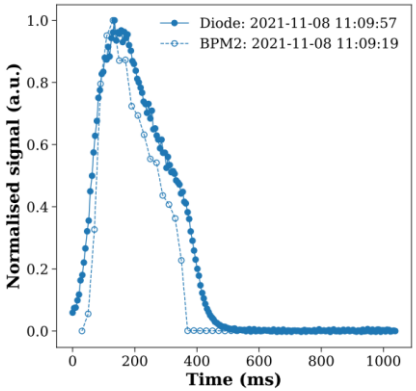
- Si diodes connected to ‘standard’ BI amplifiers (see SPS part), movable, tested via different scope/digitizers (custom made setup)
- Analysis of very recent proton and ions runs Nov 2021 on-going, here an example of ‘low frequency’ acq. (limited BW), ‘high frequency’ data being analyzed



IONS



PROTONS



Fast Spill Monitor I

Optical Transition Radiation from thin screen (Ti, 12um thick), focused on PMT

- Expect to have enough S/N and be in the 100-200MHz range of overall system BW (PMT+Head-Ampl+Cables)
- Prototype installation completed, DAQ via fast scope to characterize S/N in 2022
  - In parallel: will start designing 1-channel fast digitizer, possibly FMC mezzanine on 'BI standard' VFC

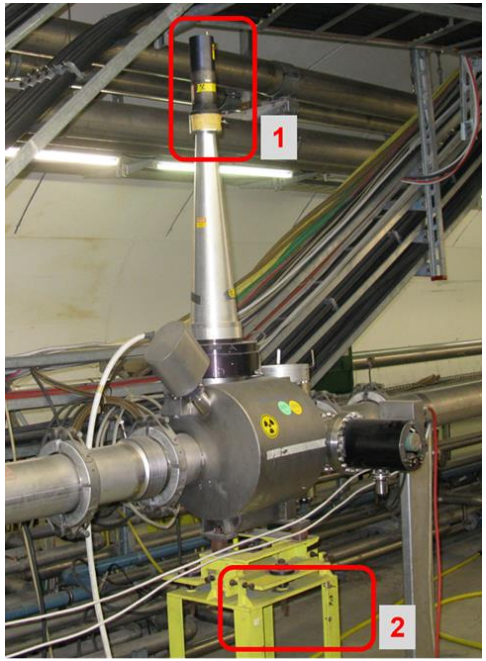


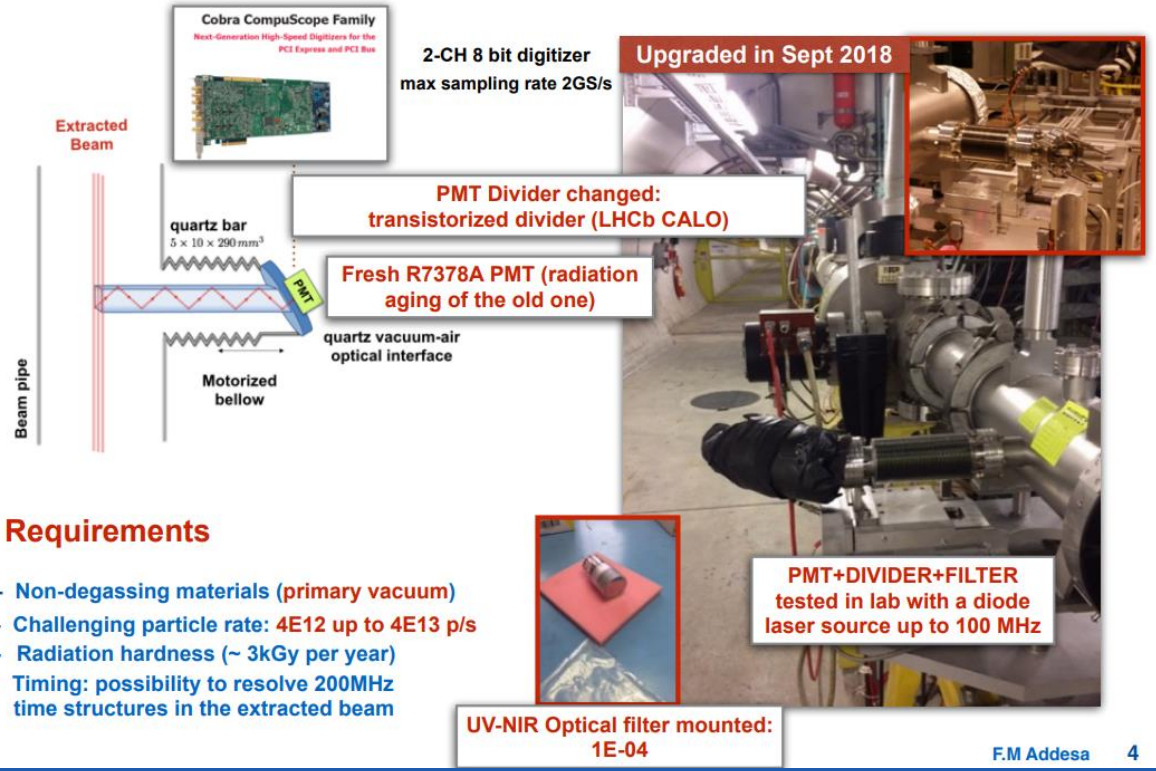
Figure 4 - Photo of BSTL.210272 (bottom). The PMT to be replaced (1) is visible at the top of the 'cone'. The new amplifier will be fixed to the girder (2).

F.Addesa. L.Esposito et al.

Fast Spill Monitor II

In vacuum quartz bar producing Cherenkov light

- System evolution of one used with low particle flux for crystal assisted extraction
- Can go to ~200 MHz
- Validated in 2018 with custom made DAQ
- Plan: equip it with 'BI standard' DAQ for systematic studies

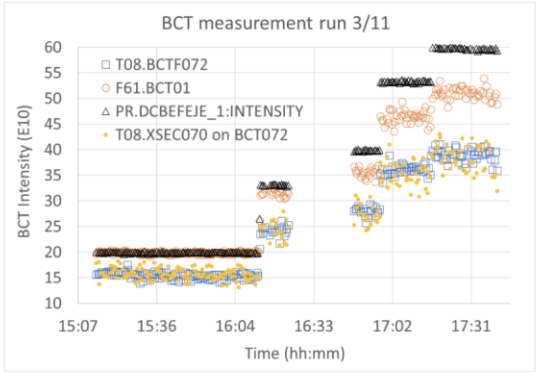


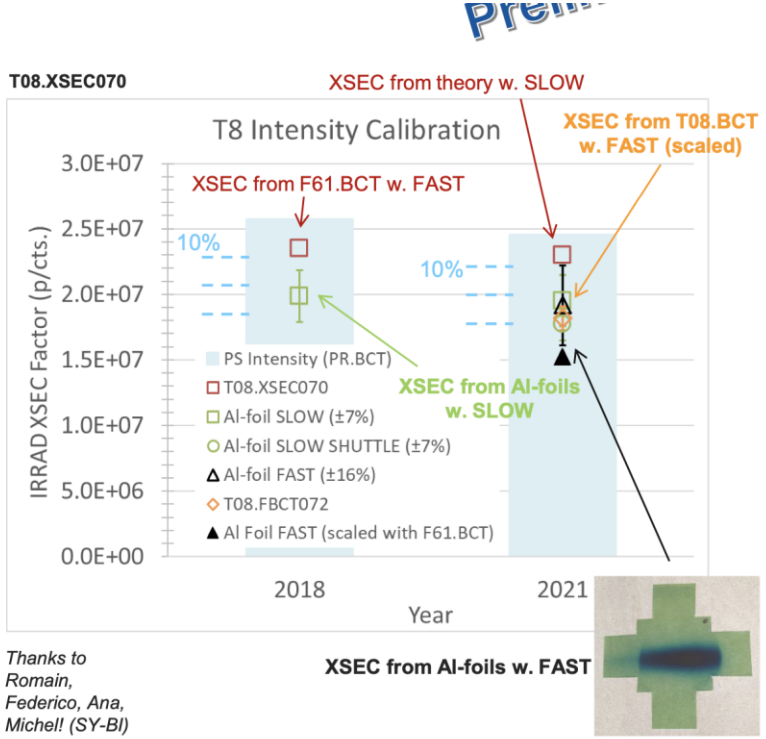
SPARE

SEM detectors Calibration

- Fast extraction: compare BCT to XSEC and Al foils activation
- Slow extraction: compare XSEC and Al foils activation
- Lot of work going on, more in 2022, converging to smaller and smaller uncertainties

Device T08.	IRRAD SEC F. (old)	New SY-BI SLOW (2021)	New SY-BI FAST (2021)
XSEC070	2.30×10^{7}	1.27×10^{8}	3.81×10^{8}
XSEC094	1.03×10^{8}	5.08×10^{8}	
	4.48	4.8	Assumption!



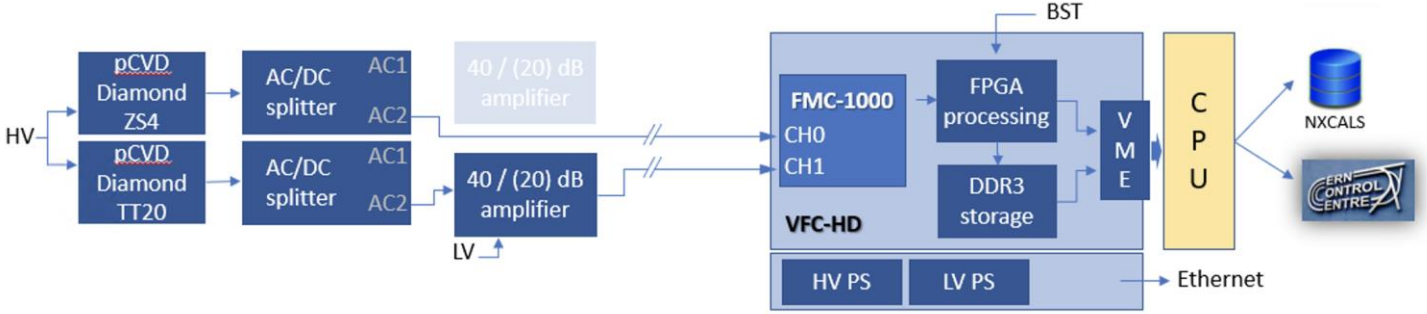


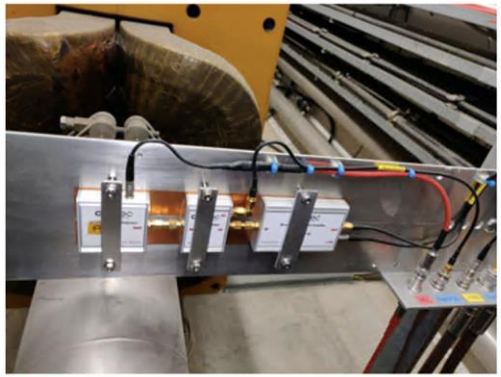
Thanks to Romain, Federico, Ana, Michel! (SY-BI)

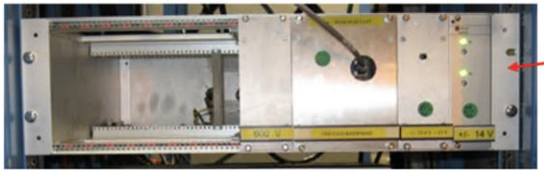
E. Calvo, E.Effinger , C.Zamantzas et al.

dBLM DAQ

Designed to be fully integrated into standard control system and logging







ELMA VME crate
+ MEN A25 CPUs
+ CTRP module
+ VFC-HD
+ FMC-1000

High and Low Voltage Supply
Controlled via an Ethernet Controller

Detector + Analog Front-end (Near observed element)

Cabling (hundreds m)

Digital Back End (In service tunnel)

BI@SPS NorthArea Consolidation List of BI items

Monitor	Required works	#Units	Projects affected	Consequences of non-upgrade
BSI	Consolidation	4	NA operation, BDF	Uncertain POT, poor TT20 splitting efficiency
BSP	Replace by SEM grids	4	NA operation, BDF	Loss of OP time for TT20 re-steering and source of inefficiency for switching extraction energy during ion run, lack of TL optics measurements
BTV	Consolidation	3	NA operation, BDF	OP time for TT20 re-steering, poor TT20 splitting
BLM	Detectors	30	NA operation, BDF	OP downtime, risk of increased beam loss
	Electronics	30		
	Cabling / installation	30		
Fast Spill Detector	Produce a new system (OTR or Cherenkov)	1	NA operation, Prerequisite for BDF	OP blind to high freq. spill quality from CCC, limiting planned machine studies to improve spill quality
Long. BLM LSS2	Produce new longitudinal BLM	1	NA op, Prerequisite for BDF	Quantification of SPS extraction efficiency limited
P42 SEM Upgrade	Produce 3 new dual plane SEM grid for P42	3	K12	No intrumentation for P42, optics issue with large beam spot on T10 cannot be diagnosed

2021 experience: not enough diagnostics to measure optics and transmission, NA CONS may be complemented by further diagnostics requests, waiting for specs