

# WP-5: luminosity

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**ATLAS-LUCID collaboration**

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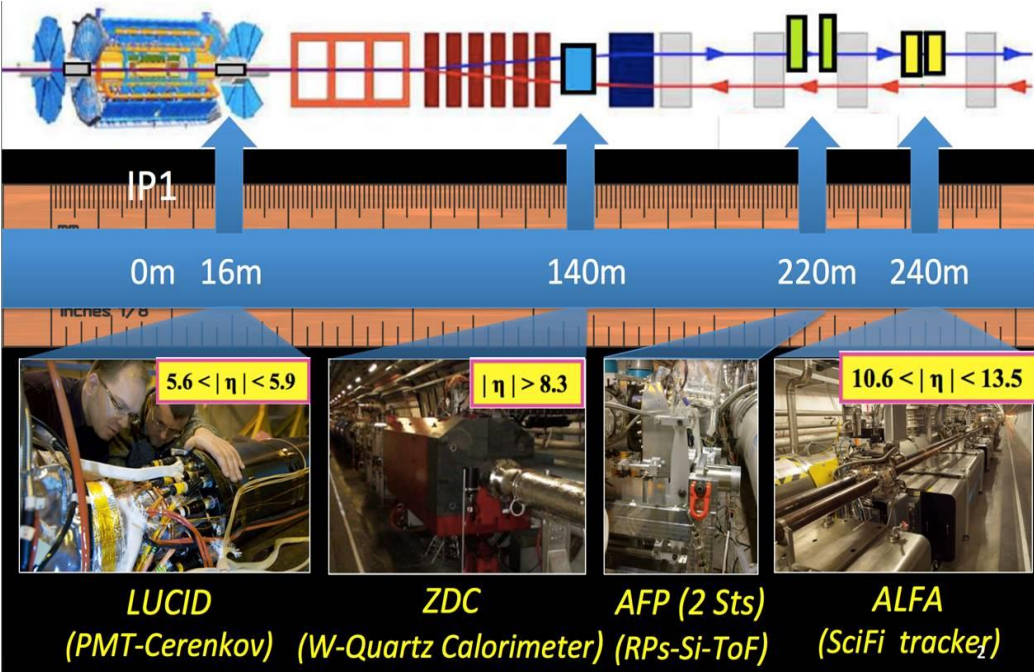
**Lund:** V. Hedberg

**Alberta:** J. Pinfold, R. Soluk, H. Wang, X. Sun

## LUCID PAPERS:

1. *G.L. Alberghi et al., Choice and characterization of photomultipliers for the new ATLAS LUCID detector, 2016 JINST 11 P05014*
2. *G.Avoni et al., The new LUCID-2 detector for luminosity measurement and monitoring in ATLAS, 2018 JINST 13 P07017*

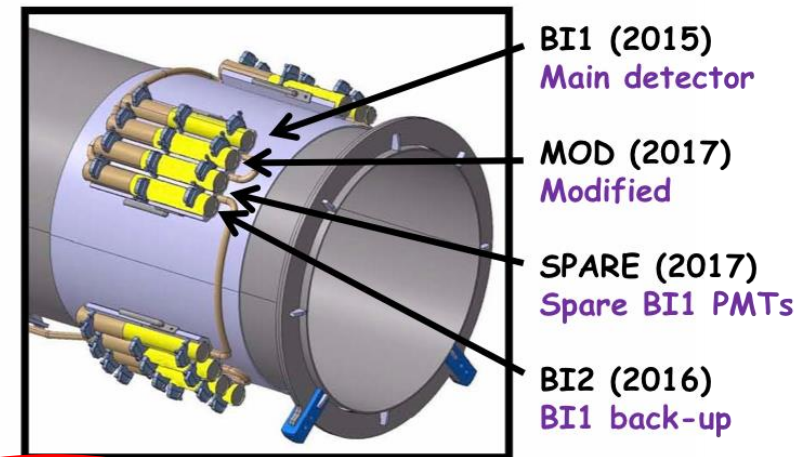
# LUCID-II (Run2)



17m from IP  
 $5.6 < |\eta| < 5.9$

4 Photomultipliers  
 Cherenkov medium:  
 Quartz fibers  
 Gain calibration:  
 LED signals

4 sets of 4 Photomultipliers  
 Cherenkov medium: Quartz windows  
 Gain calibration: Bi-207 sources



Quartz fibers

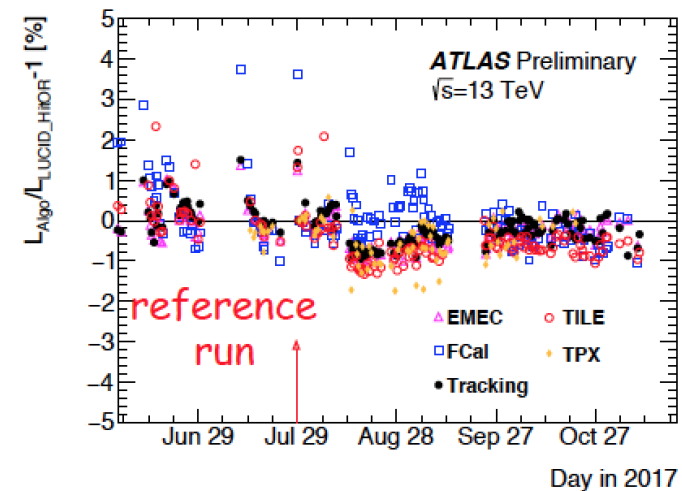
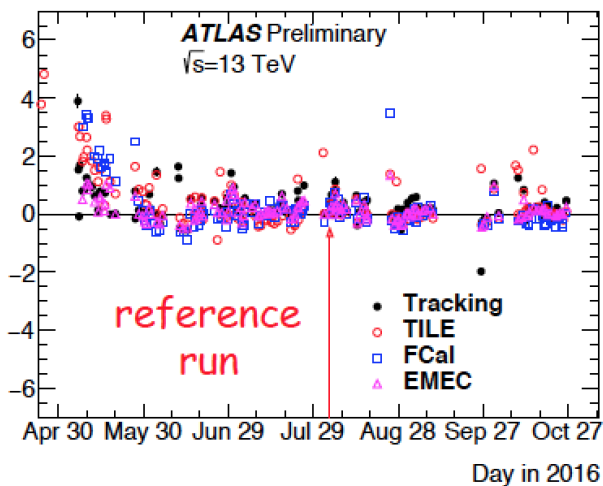
Beampipe

Carbon fiber support

# Results in Run2

- LUCID provided the official ATLAS luminosity both ONLINE and OFFLINE in all beam conditions ( $\mu$ , train configuration, pp/HI)
- Typical final precision  $<2.2\%$  including  $\sim 1.2-1.5\%$  VdM systematics (detector independent: only depends on beam-parameters knowledge: even with perfect lumi measurement VdM calibration is limiting factor)

Uncertainty (%)				
Year	VdM	Stability	Caib.transfer	TOTAL
2015	1.7	1.0	0.9	2.1
2016	1.2	0.9	1.6	2.2
2017	t.b.f	$\sim 1\%$ (t.b.f.)	t.b.f.	2.4 (prelim)
Alfa run (2012)	1.2	-	-	1.4

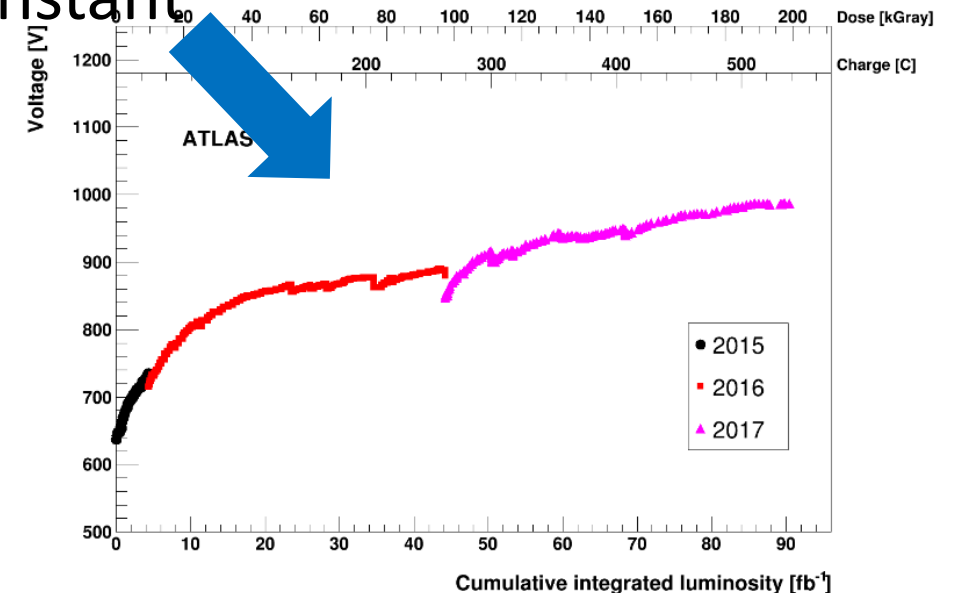
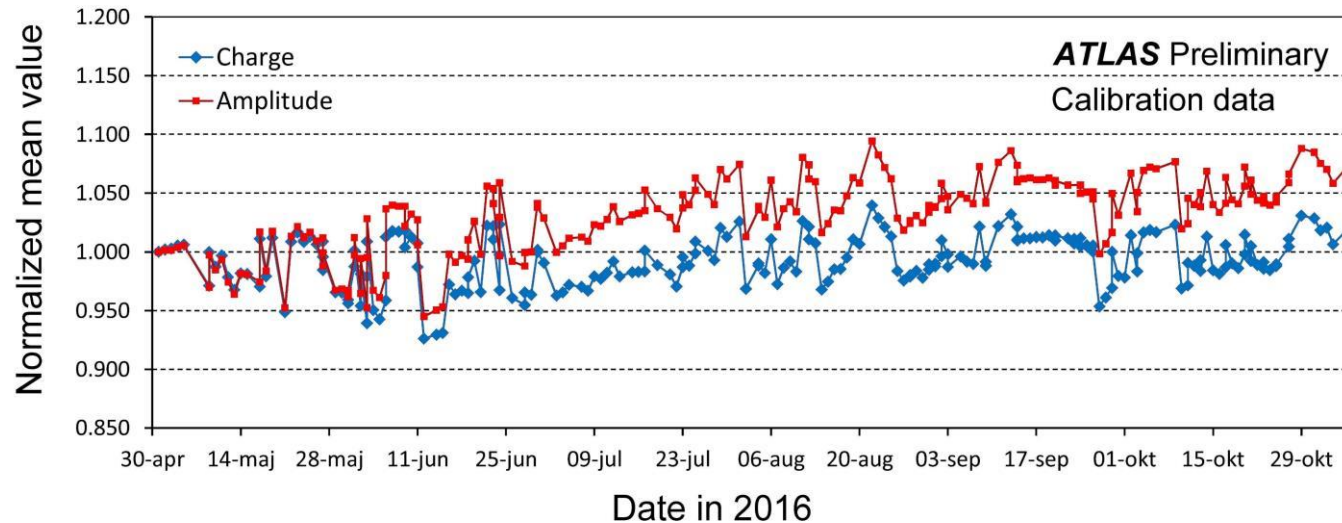
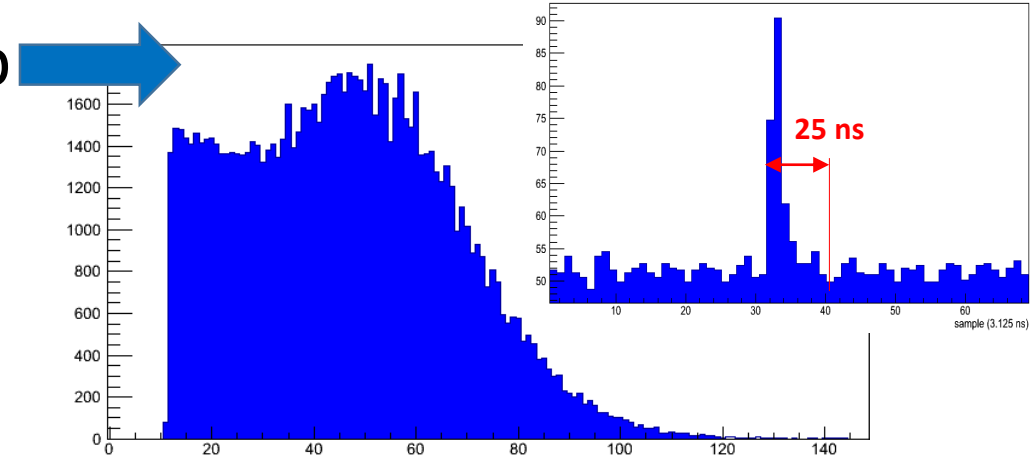


# Comments about present precision

- Precision in luminosity measurement NOT a limiting factor for most of the analyses
  - Systematics related to energy scales, resolutions, object identification, .. in general substantially larger than luminosity
  - Still some measurements limited by lumi precision (for example SM precision measurements)
- Excellent result obtained in Run-2 thanks to **redundancy** (many LUCIDs, calorimeters, tracking)
- As said VdM calibration syst ( $\sim 1.5\%$ ) is lower limit for lumi precision
  - In Phase-II requested 1% overall precision: at present personally seems to me unrealistic unless:
    - improve VdM systematics
    - Redundancy between detectors (adding HGTD to the present set of luminometers) allows for further improvement
- In general: adding lumi sources is keypoint but do not ensure automatically better result

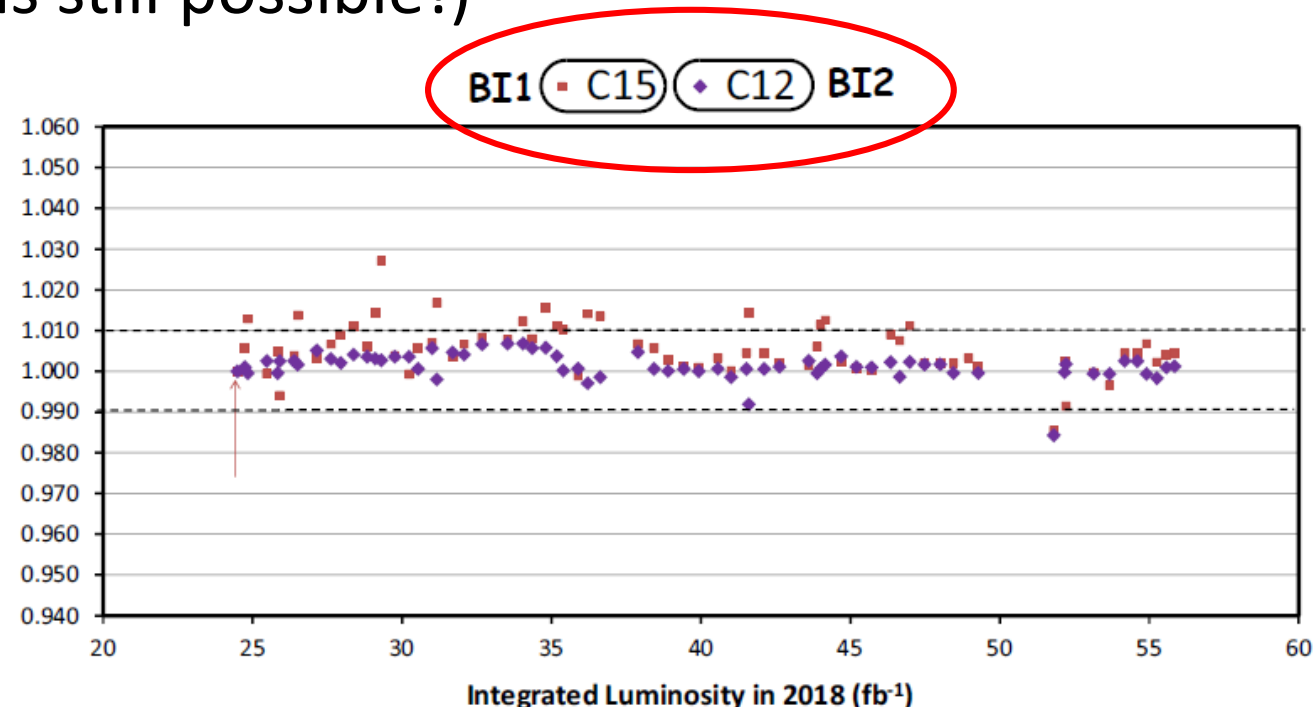
# The key to LUCID success in Run-2: the calibration system

- Low activity liquid Bi-207 source deposited onto the PMT window
- e- signal mimick single-particles from pp
- Multiple calib. Runs after each fill
- Compare charge distribution with reference run
- Automatic HV change to keep PMT gain constant



# Current issues and impact on future LUCID

- Large radiation dose absorbed so far (>350 kGy)
  - All components tested up to 200 kGy !
- Channels started dying after about 250 kGy but not yet clear if PMTs, bases, cables (HV, signal)
- Despite about 50% of channels died in 2018 **LUCID is still measuring luminosity** (in principle until 1 PMT is still possible!)
- Need to understand responsible of death
- Last option: use fibers detector
  - Not a single fiber-PMT dead (low rad)
  - BUT these are NOT calibrated with Bi but LEDs: do not monitor fiber ageing



# Plans for LS2 (Phase-I, Run3)

- Not major changes in LUCID for phase-I. But important improvements
- Normal maintenance:
  1. Dismount everything (Dec-18 – Jan-19)
  2. Investigate source of death , repair, substitute (2019-2020)
- Improvements under investigation:
  - Put LUCID OUTSIDE the support cone (instead of inside) for easy access at every EOY stop. Allow to replace also bases, last meter of HV and signal cables (now only PMT accessible). Under discussion with ATLAS TC.
- Improvements for which work is starting (related to PRIN !).
  - Install a few fibers channels calibrated with Bi source
  - These will be prototypes for Phase-II detector (where PMTs will simply not work for even one year only !)

# Ideas for Phase-II

- Current idea is to use fibers detector calibrated with Bi-source BUT many caveats:
  1. **Technical issue**: place currently occupied by LUCID will be restricted due to changes in the VAX (new LHC vacuum devices will be placed where LUCID is now). Will there be place for LUCID-III ?
  2. **Principle issue**: Will Bi-signals be visible after a few meters fiber so to allow a reliable calibration ?
  3. **Optimization issue**: is PMT-based signal readout the best we can do ? Need to investigate other options as SiPMTs
- **Additional ideas** (to face problem 1): place LUCID channels in the region between the ITk seal plate and the HGTD cold vessel. So a completely different region (less radiation, high-pT “physics”). But there the magnetic field is large, so no hope to use PMTs (SiPMTs is a good option).



# Status activity for HL-HLC (Phase-II)

- Activity on 1 complete fiber channel will start before end 2018
- While waiting to win PRIN we'll start using:
- Progetto «neo-assunti» presented by Alberto Cervelli (INFN Bologna)
  - Person-power: **A.Cervelli, L.Fabbri, G.Cabras, B.Giacobbe**
  - At the beginning using a few fibers from spare bunch bought for present LUCID
  - PMTs also already available (spare from LUCID) + fast SiPMTs lended by FBK (Trento)
  - Bi-source about to arrive in Bologna (thanks to Sezione di Bologna)
  - Foreseen also irradiation of fibers + PMTs + bases + etc... @ ENEA (gammas 1 MGy, neutrons  $10^{15}$  n/cm<sup>2</sup>). Part of this funded by Commissione 1 (LUCID Phase-II)
  - Expected duration: whole 2019
  - Goal: prove functioning of Bi+fiber, compare PMT wrt SiPMT, build 1 full channel and characterize.
- FYI: LUCID Phase-II approved by INFN with core  $\sim$  260 kEUR (+ contingency) and 0.5 FTE additional post-doc for 4 years (2019-2022)