Recent results on crystal collimation for a low-background physics run at the LHC

D. Mirarchi, R. Bruce, M. D'Andrea, H. Garcia, S. Redaelli

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Outline

I. Goal for the run

II. Expected performance

III. Highlight of the run

IV. Conclusions

Outline

Goal for the run

Physics motivation

Physics motivation

??? Why running a 14 TeV High Lumi machine at

900 GeV with 5 bunches ???

From C. Schwick at LMC #359

- **Main goal** of forward physics experiments: **total p-p cross section measurement**

- **Key measurement: elastic cross section** at small scattering angle

- **Main requirements:** $\sqrt{s} = 900$ **GeV, large** β^* **and Roman Pots at 3** σ

Collimation challenge
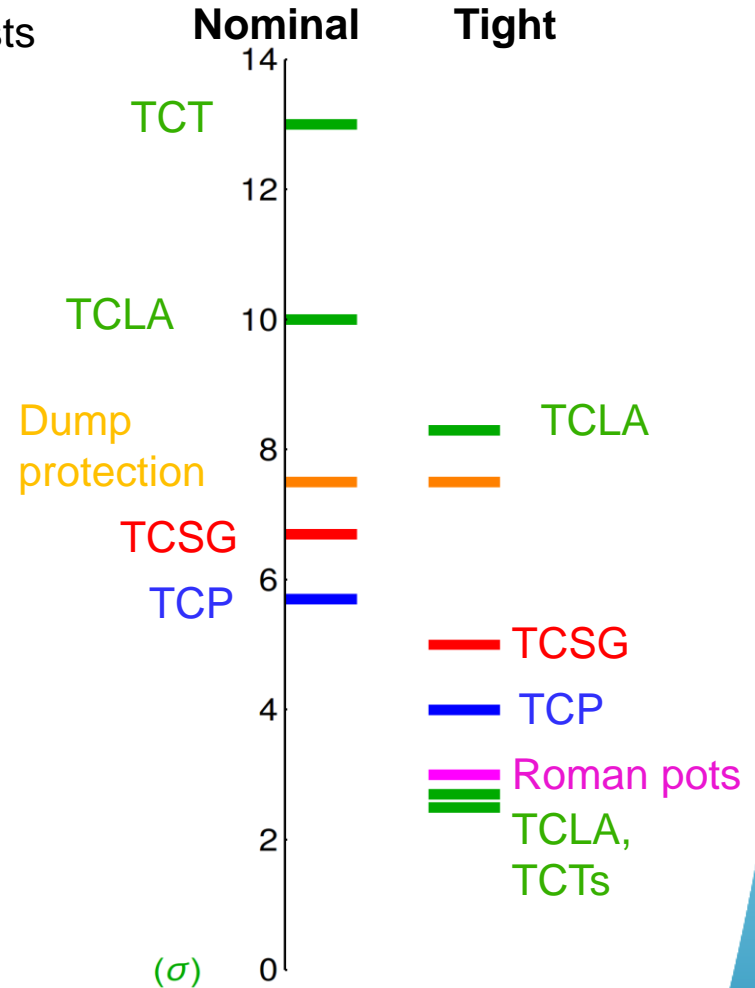
- **Very high background** in 2017 and May 2018 tests

  ✗ Impossible to make measurements

- **Solution proposed:**

  ✓ Fit a **two-stage collimation** system **between 2.5 σ and 3 σ**

  ✓ **Tungsten collimators** only for improved absorption

Primary stage at 2.5 σ
Secondary stage at 2.7 σ
Roman Pots at 3 σ
Tightest collimation ever in the LHC!

From R. Bruce at LMC #363

Crystals?

A think aloud during a Collimation Working Group
"**Why don't we use the crystals?**"

First reply:
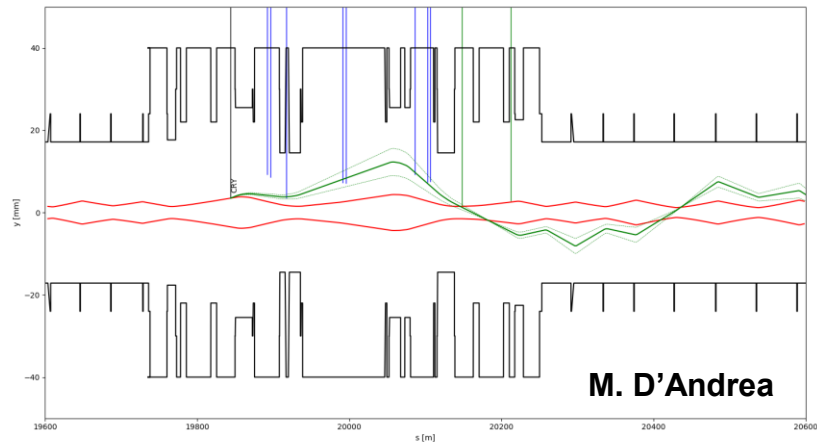"**I don't see why they should not work,
let's do some simulations…**"

Outline

Expected performance

First assessment in simulations

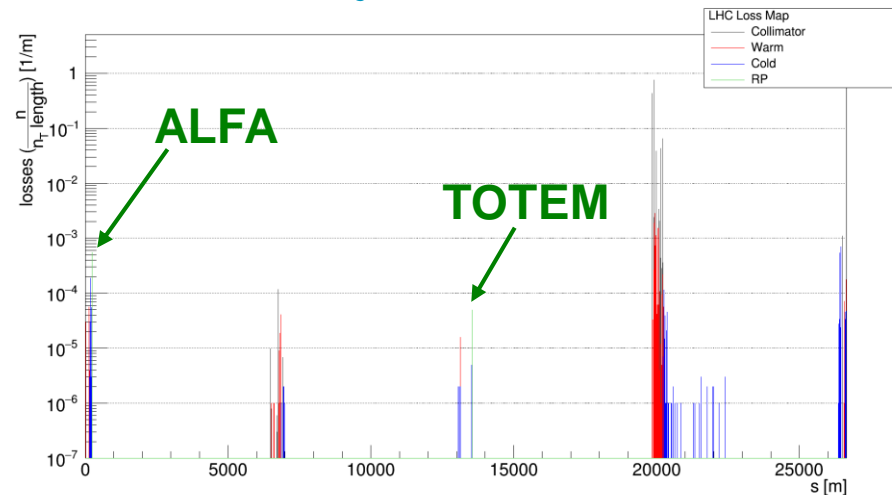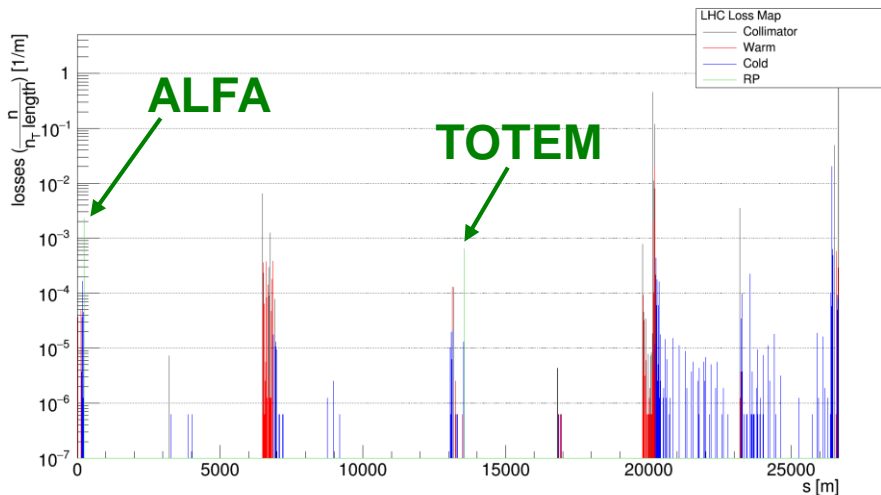**1**   Can we intercept the channeled beam in these extreme conditions?

Yes

2   Can we reduce the background?

Yes

M. D'Andrea

Standard Collimation


ALFA

TOTEM

Crystal Collimation

ALFA

TOTEM

M. D'Andrea

Setting optimization

- **Initial conditions:** setting used for **standard collimation but using crystal as primary**

- **Main changes: relaxing the hierarchy while improving performance**
  - ✓ TCTPs in IR2 and IR8 in both beams opened
  - ✓ TCTPs in IR5 of Beam 1 and in IR1 of Beam 2 opened

*Expected gain with respect to
standard collimation*
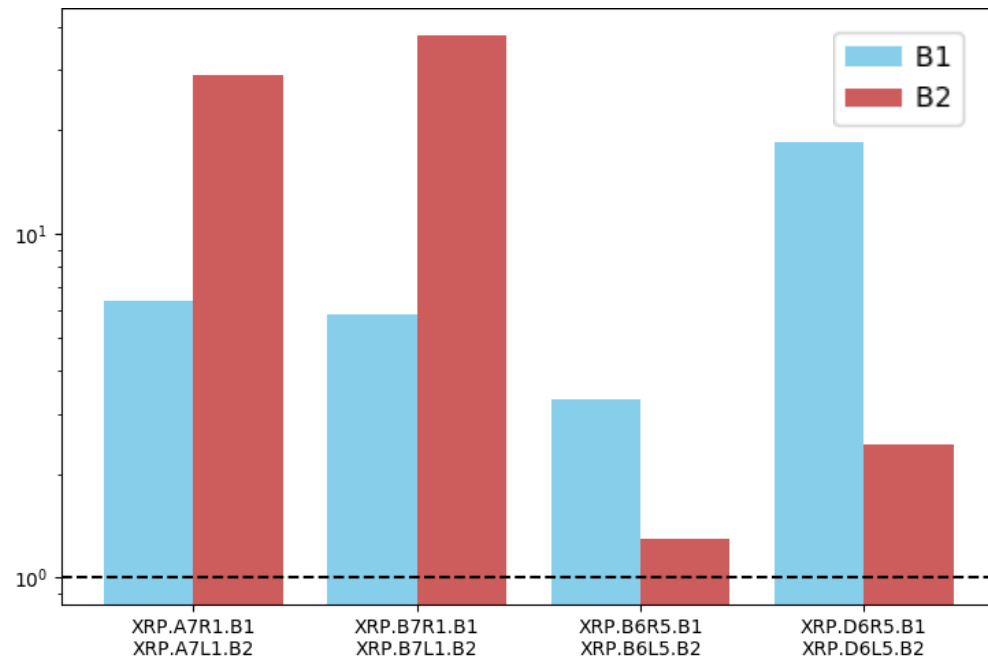
Outline

Highlight of the run

High-beta physics run at 450 GeV

- **Promising results obtained during initial tests** (crystal setup in about 15 min!)

  → Decided to have the **crystals as a viable option** for the real physics run

- Operational **sequences** and **beam process** prepared for **both collimation scheme**
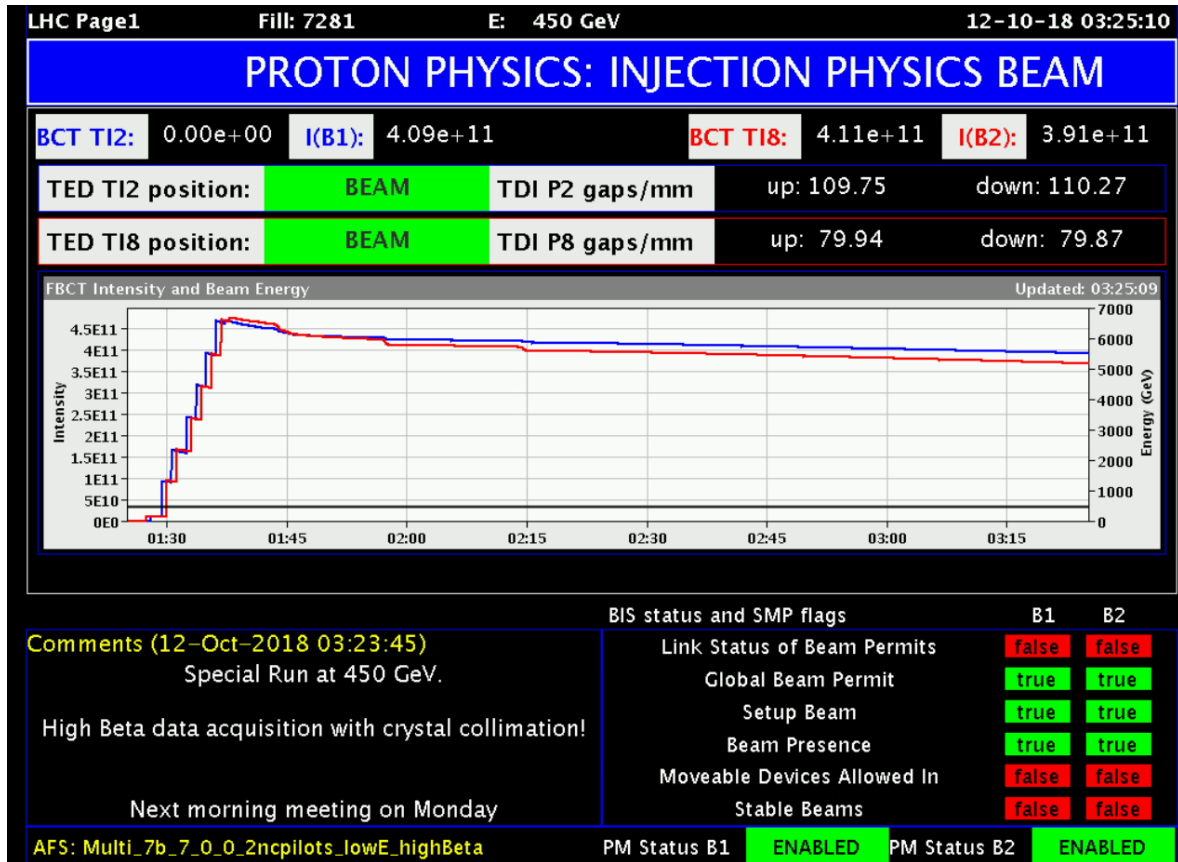
  → **Easy handling by OP**

NO NEED TO SCRAPING WITH CRYSTAL
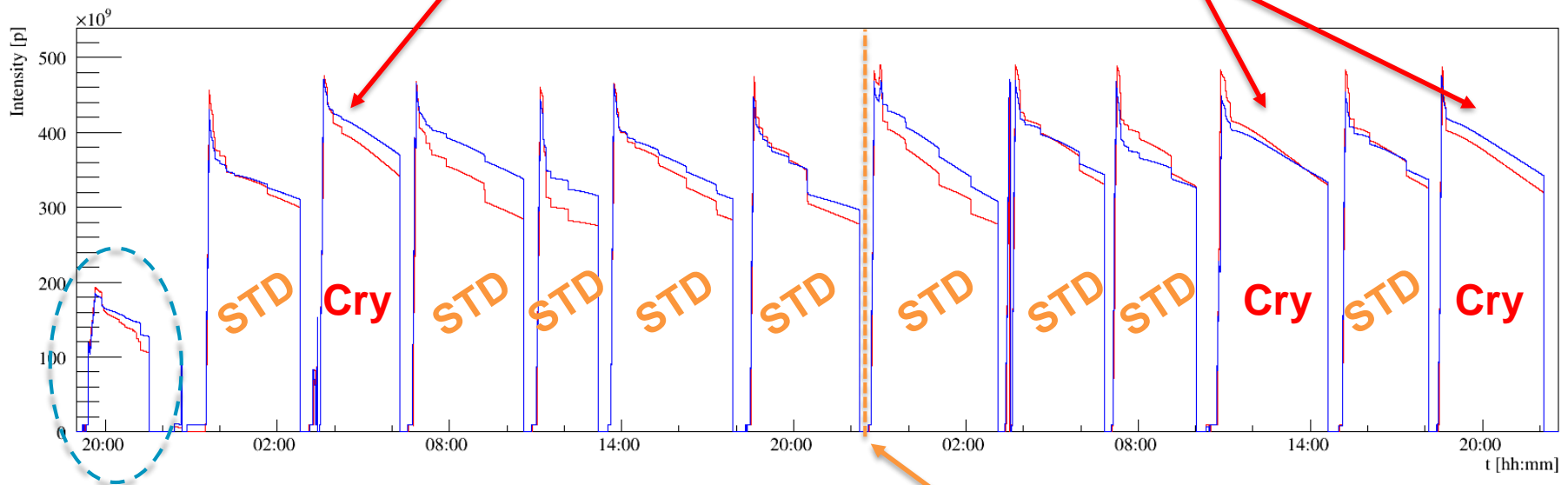
1 setup fill: confirmed alignment STD and Cry coll.

**Re-align needed for STD
Bad bkg to TOTEM following fills**

First operational use!

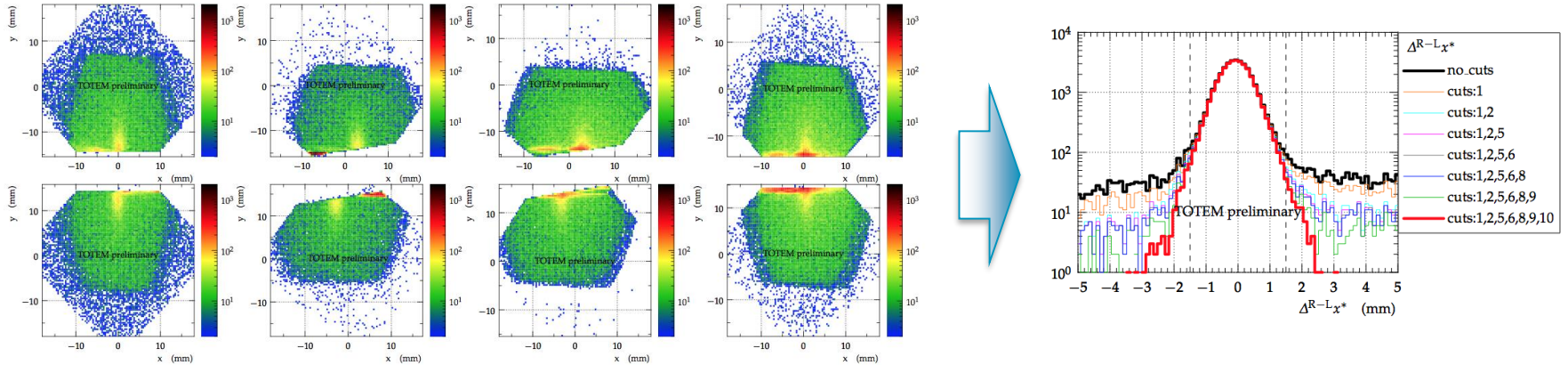**First time ever that crystal collimation was used in a real physics run**
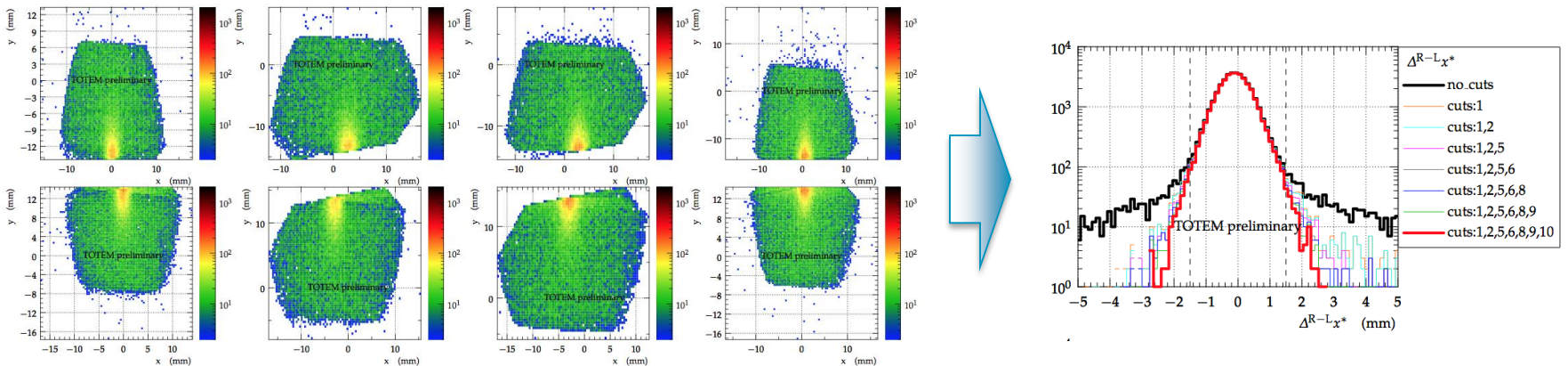
Very important milestone!

Data quality from TOTEM

- **Standard collimation: background** at sensor edges, removed with **full off-line cut**

- **Crystal collimation: no background** evident, removed with **first off-line cut**
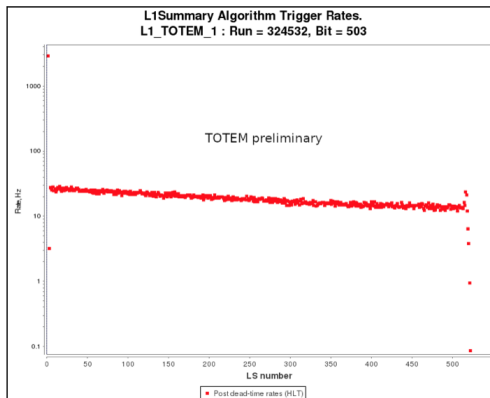
Background rate from TOTEM

- **Standard collimation:**

  - Frequent initial scraping needed to achieve a reasonable rate

  - Regular scraping needed due to the increasing rate

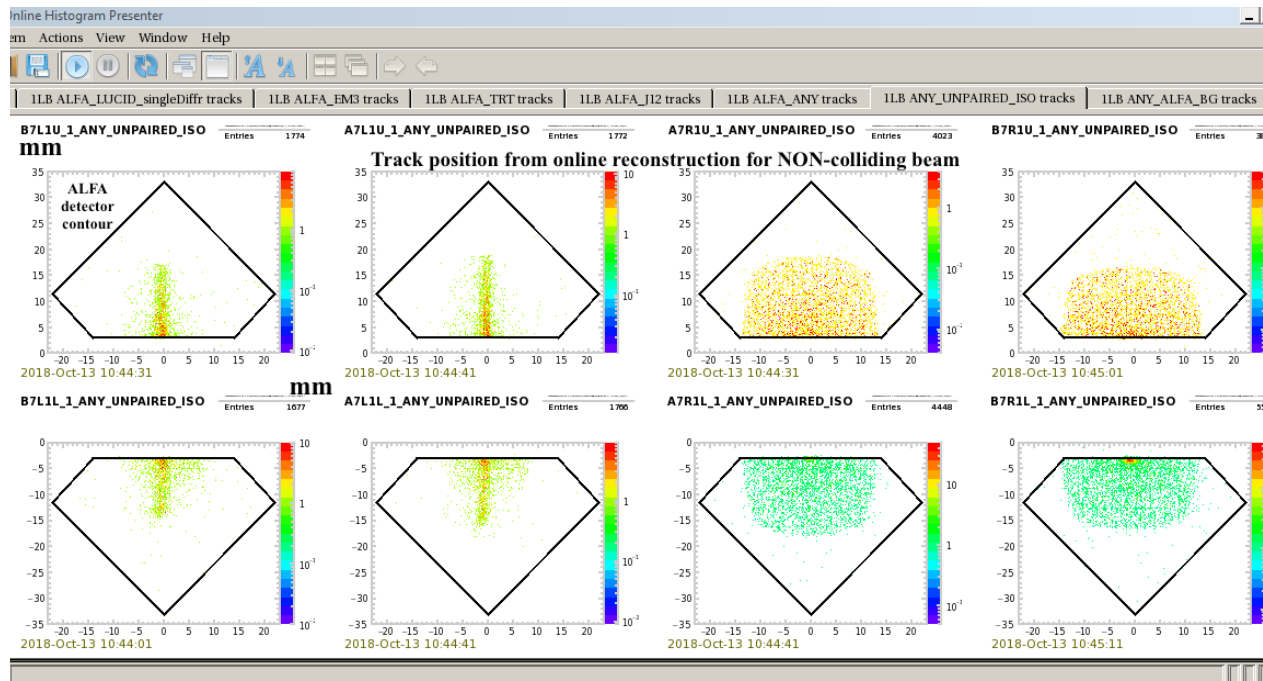- **Crystal collimation:**

  - No need of scraping

  - Rate follow luminosity decay due to burn-off

  More integrated luminosity!

Data quality from ALFA

PRELIMINARY DATA COURTESY THE ATLAS COLLABORATION

- Potentially problematic background distributions with crystal collimation

  Signal from non colliding bunches similar to elastic scattering signature

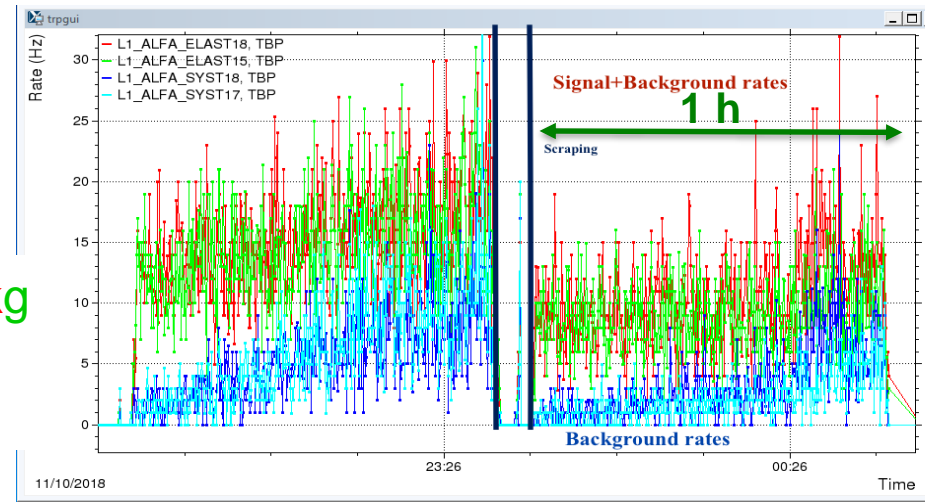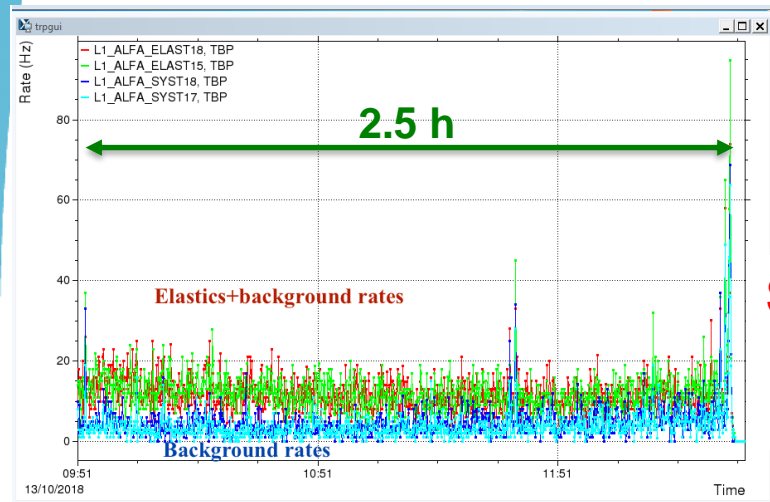# Background rate from ALFA

PRELIMINARY DATA COURTESY THE ATLAS COLLABORATION

Crystal collimation

Standard collimation

Same observations as for TOTEM: No need of scraping with crystals

Outline

Conclusions

Conclusions

- **From a thinking aloud** in a Collimation Working Group **to operations in about 1 month**:
  - ✓ Intense simulation studies to optimize performance
  - ✓ Preparation of operational sequences and beam process for OP use
  - ✓ Setup of the system in 15 min thanks to the knowledge acquired in MDs

- **First time ever that crystal collimation has been used operationally in a physics run!**
  - ✓ Very efficient cleaning of halo (no need for re-scraping)
  - ✓ Excellent physics data taking during long periods
  - ✓ Stable performance (retracted and inserted directly in channeling)
  - ✓ Very important milestone!

- **Excellent results obtained with TOTEM** for both background rate and distribution
  - ✓ Crystals saved the day when increased background for totem without need of re-align

- **Similar background rate for ALFA but potentially problematic distribution**
  - ✓ Settings optimized for background rate
  - ✓ Confident that also better distribution could be achieved
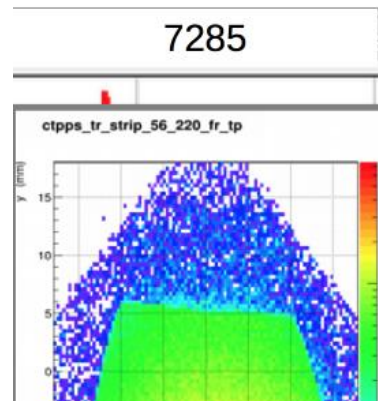
Thank you for your attention!
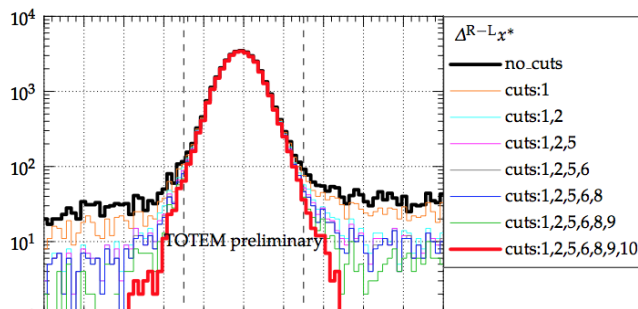

And to everyone who made this possible!

Outline

Backup

Bad background for **TOTEM**

PRELIMINARY DATA COURTESY OF J. CASPAR FOR THE TOTEM COLLABORATION

Estimate of irreducible background

- fill 7280 – standard collimation working well
  - background present (black curve has tails)
  - but treatable with offline cuts (red curve does not have tails)
- Collimation experts are convinced that repeating the setup of the collimation hierarchy the original situation could have been recovered