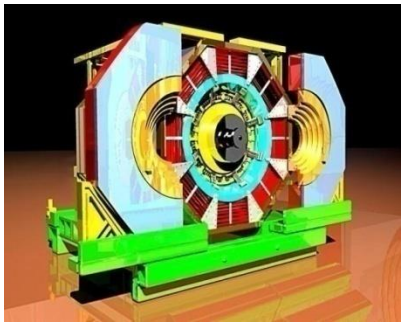
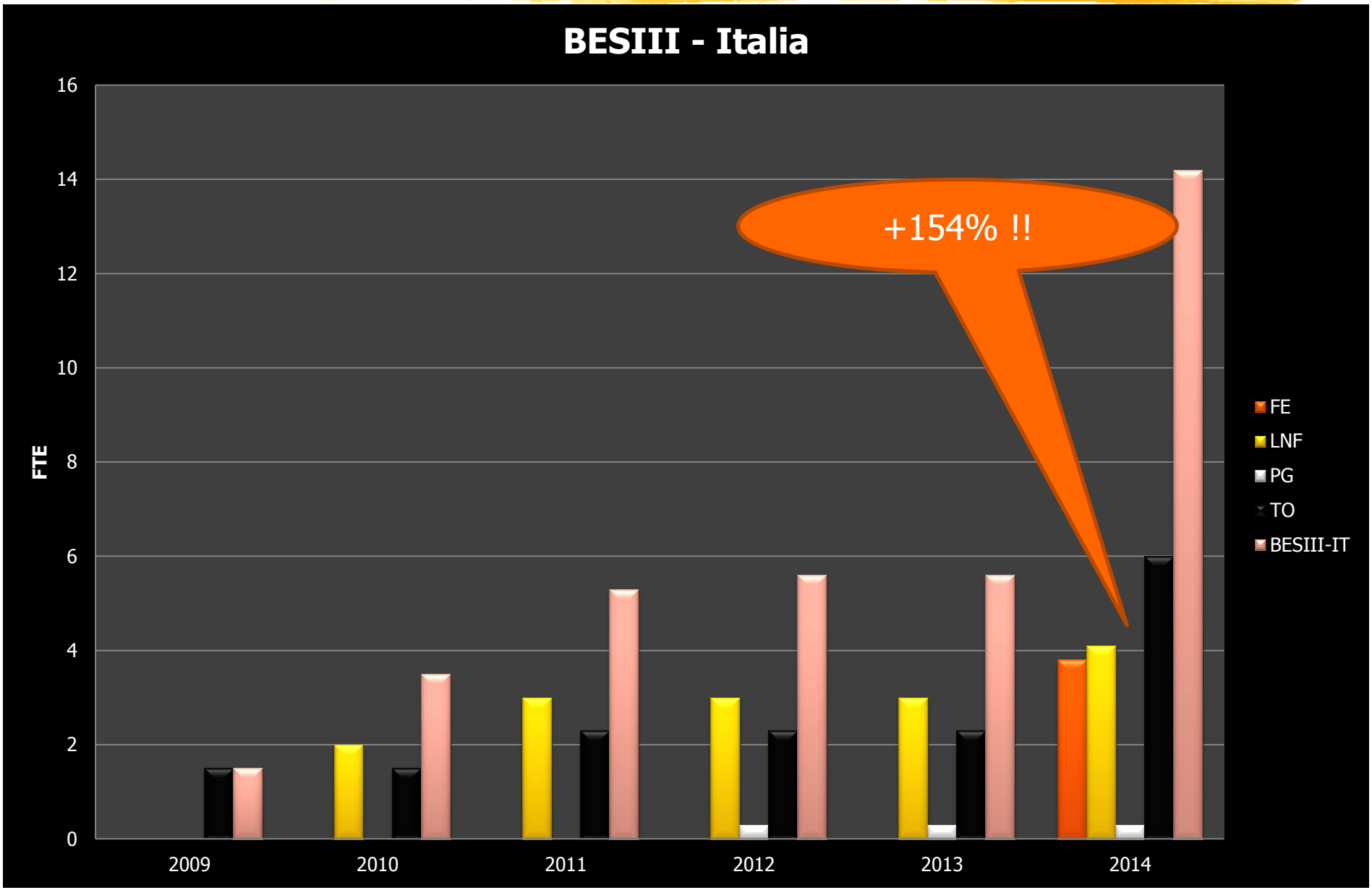
2014 INFN-IHEP Bilateral Meeting



INFN activities within BESIII

INFN – Presidenza **May 16th, 2014**

The INFN BESIII Collaboration



J/ψ Strong and Electromagnetic Decay Amplitudes

Resonant contributions

$\Gamma_{J/\psi}$ ~ 93KeV → pQCD

pQCD: all amplitudes almost real [1,2]

QCD -> Φ_p ~ 10° [1]

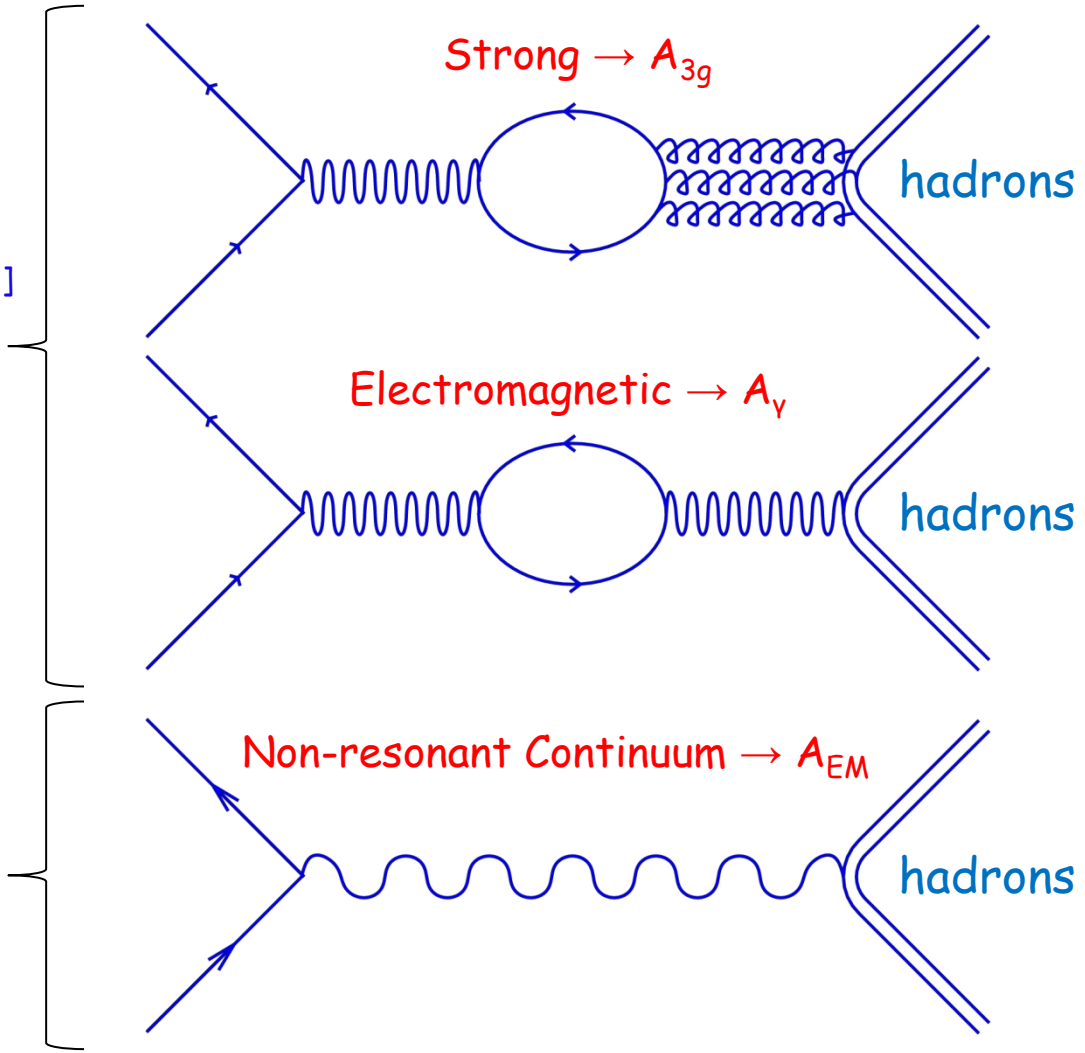
Experimental data points toward:

Φ_p ~ 90° [3,4]

Non-resonant continuum

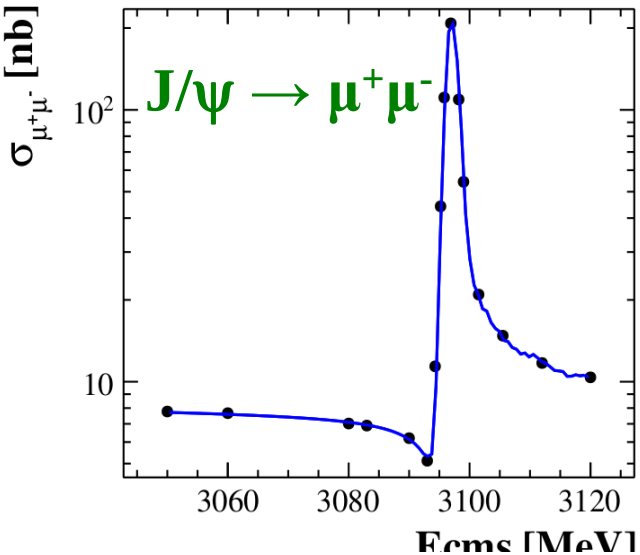
pQCD regime

$A_{EM} \in \Re$



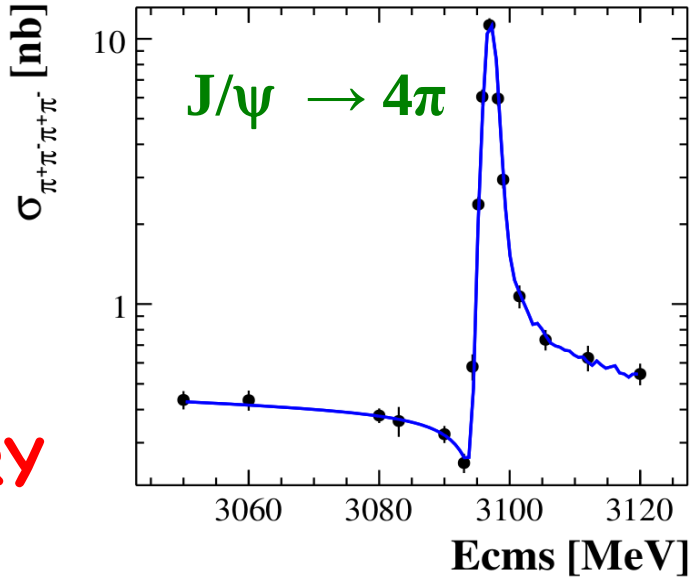
[1] J. Bolz and P. Kroll, WU B 95-35.
[2] S.J. Brodsky, G.P. Lepage, S.F. Tuan, Phys. Rev. Lett. 59, 621 (1987).
[3] L. Kopke and N. Wermes, Phys. Rep. 174, 67 (1989); J. Jousset et al., Phys. Rev. D41,1389 (1990).
[4] M. Suzuki et al., Phys. Rev. D60, 051501 (1999).

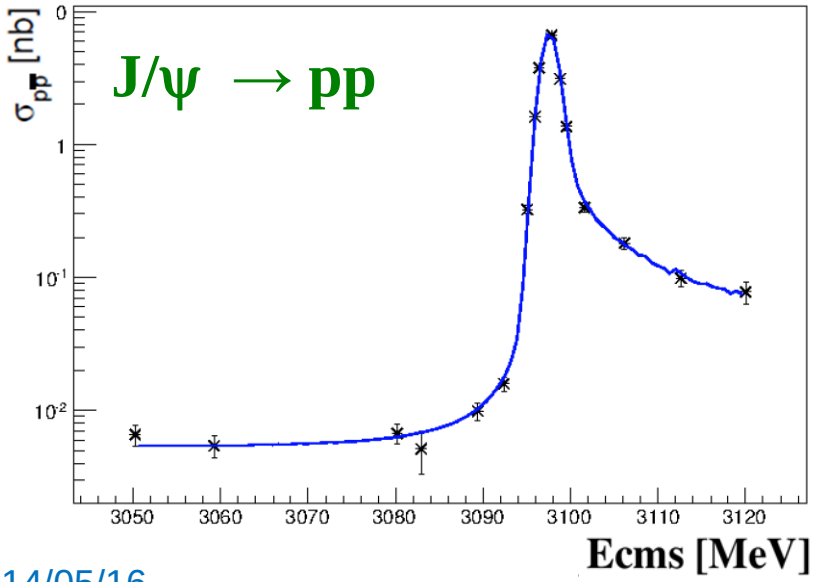
BESIII J/ψ scan



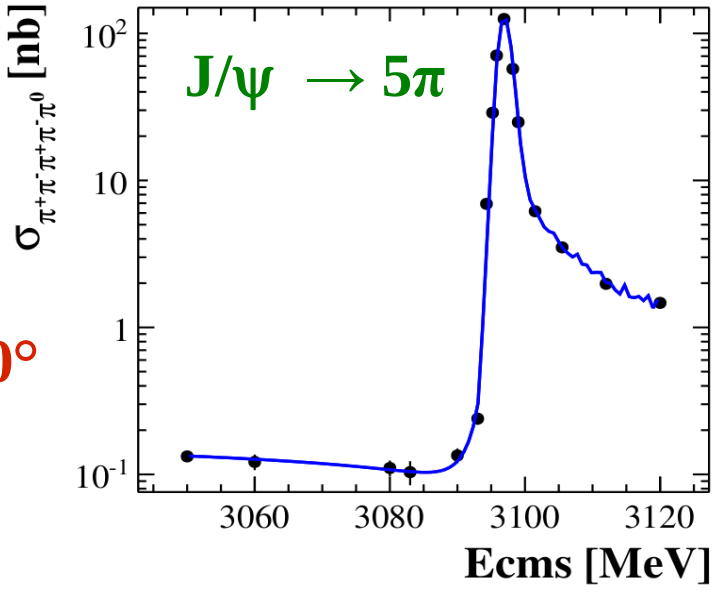
ϕ ~ 0°

PRELIMINARY





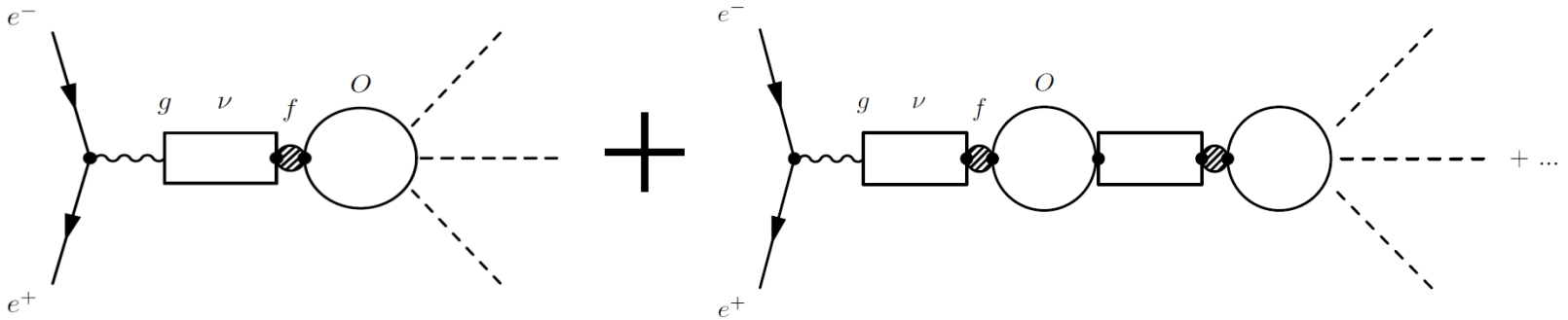
ϕ ~ 90°



Quarkonium OZI breaking decay[5]

- Quarkonium as a superposition of:
  - a narrow resonance n (coupled to leptons, but not directly to hadrons)
  - a wide resonance (a glueball O) (coupled not to leptons, but strongly to hadrons)

f is the coupling between ν and $\mathcal{O}$



- an infinity of radial O recurrences
- many referred to this model mainly to explain Br(**ψ'**) / Br(J/ **ψ**) anomalies
- **the additional 90º phase is naturally achieved**

$$A_{strong} = \frac{g\sqrt{\Gamma_{e^+e^-}} \times f \times \sqrt{\Gamma_o}}{(M_v - W - 0.5i\Gamma_v)\times(M_o - W - 0.5i\Gamma_o) - f^2}$$

assuming $\Gamma_O >> \Gamma_{J/\psi}$, $f \sim 0.5\sqrt{\Gamma_o(\Gamma_{J/\Psi} - \Gamma_v)}$

[5] Freund and Nambu, Phys. Rev. Lett. 34, 1645 (1975)

Quarkonium OZI breaking decay[5]

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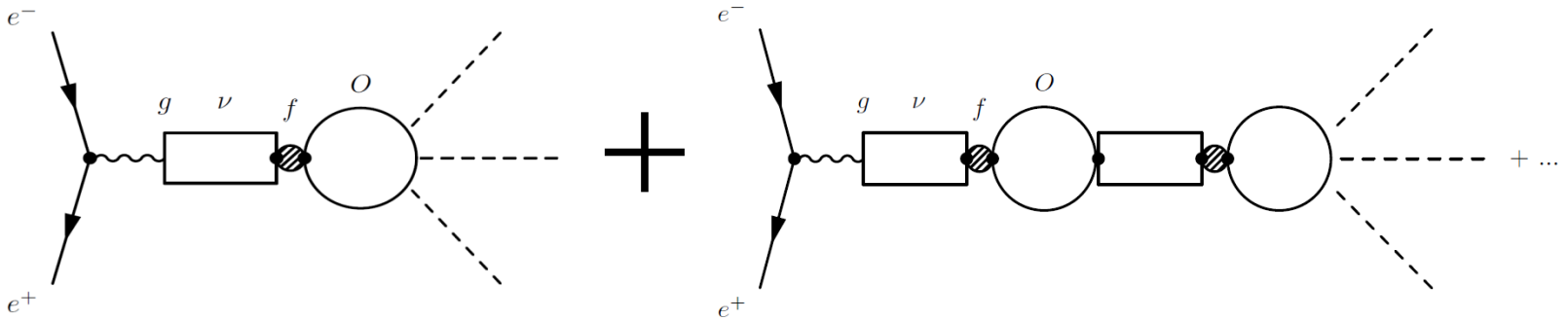


- an infinity of radial O recurrences
- many referred to this model mainly to explain Br(ψ') / Br(J/ ψ) anomalies
- **the additional 90° phase is naturally achieved**

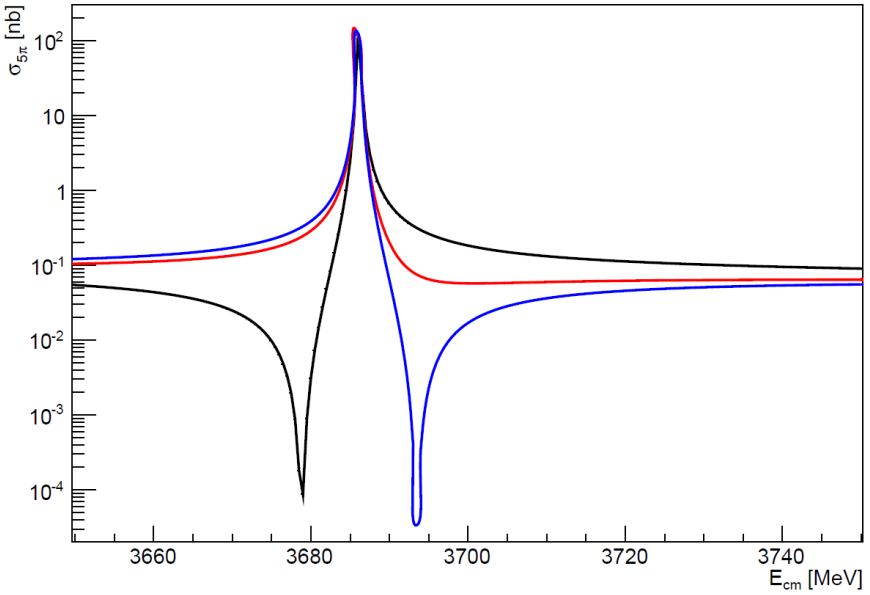
$$A_{strong} \sim \frac{ig\sqrt{\Gamma_{e^+e^-}} \times f \times \sqrt{\Gamma_o}}{\Gamma_o\left(M_{J/\Psi} - W - 0.5i\Gamma_{J/\Psi}\right)} \qquad A_{em} \sim \frac{g\Gamma_{e^+e^-}}{\left(M_{J/\Psi} - W - 0.5i\Gamma_{J/\Psi}\right)}$$

[5] Freund and Nambu, Phys. Rev. Lett. 34, 1645 (1975)

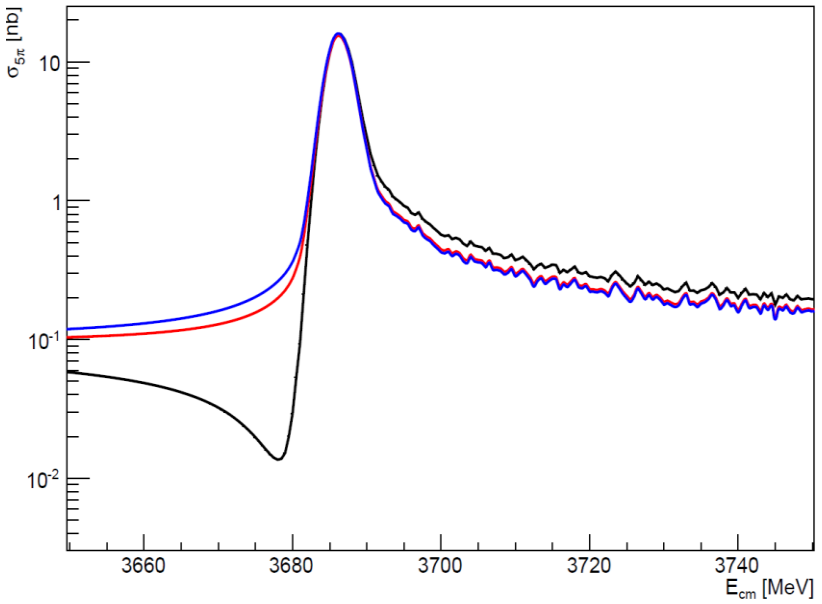
ψ' scan proposal

J/ψ → 5π

ideal σ: no ISR, no BS



observed σ: ISR (E_γ < 100MeV), BS



requested luminosity: L_{int} ψ' ~ 1 fb^{-1}

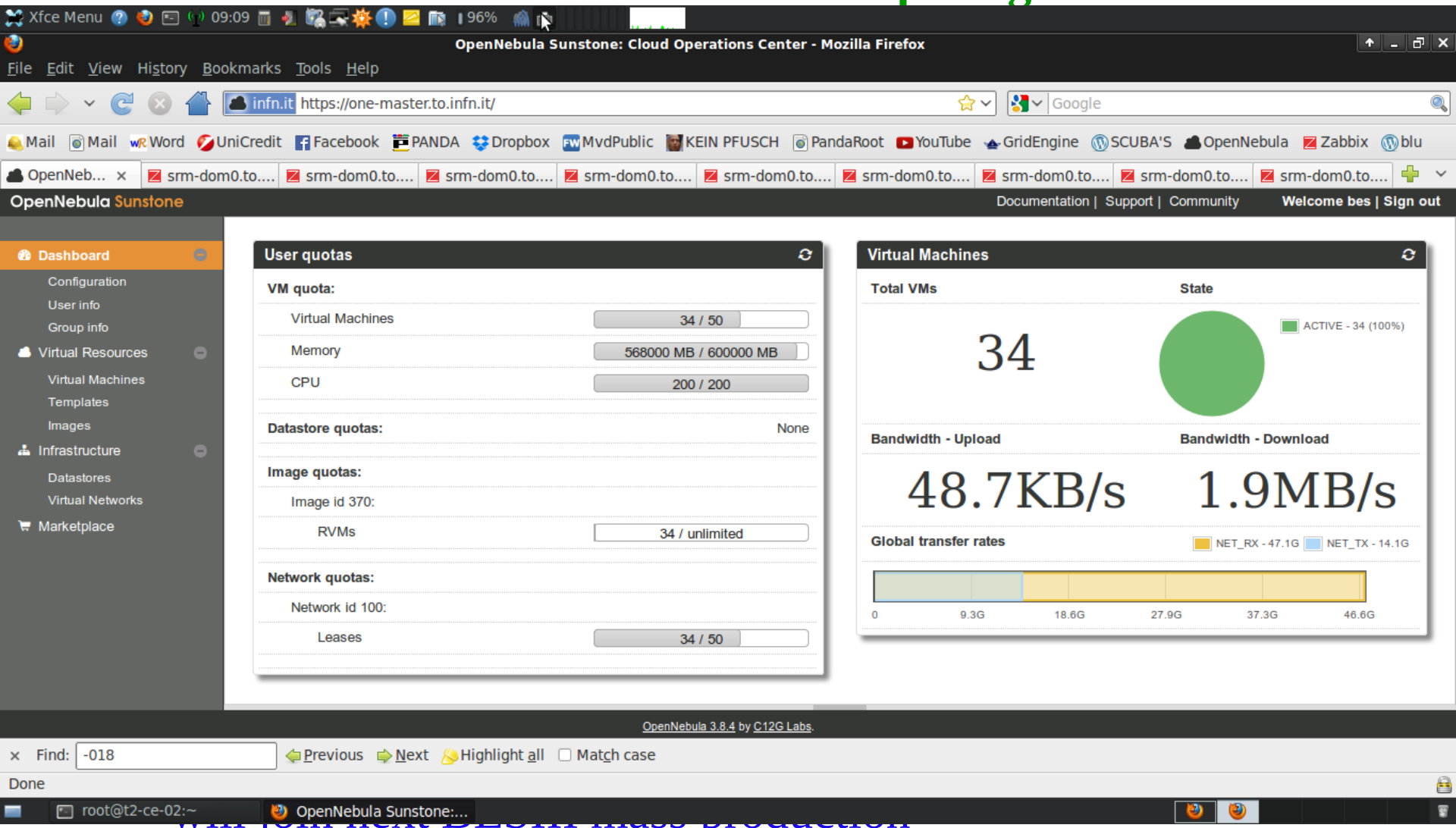
preliminary extimation: T < 1 month

The INFN virtualised on cloud BESIII Grid Tier-2

- **cloud infrastructure at INFN-TO Computing Center:**
  - first cloud infrastructure optimised for scientific computing in an INFN Section (not taking into account CNAF)
  - virtualised: VMs, farms, full Tier-2 Grid infrastructures, LANs
- **INFN ⇔ IHEP bandwidth:**
  - optimised to ~ 1Mb/s
- **BESIII activities:**
  - 2KHS06 (~ 200 cores) and 20 TB net reserved for BESIII
  - shared access to 0.7KHS06
- **INFN provides to BESIII:**
  - fully transparent Tier-2 Grid Infrastructure, accessible by IHEP
  - direct submission to CE, contestualisation via CVMFS
  - job submission in DIRAC included, from INFN and IHEP
  - will join next BESIII mass production

The INFN virtualised on cloud BESIII Grid Tier-2

- **cloud infrastructure at INFN-TO Computing Center:**

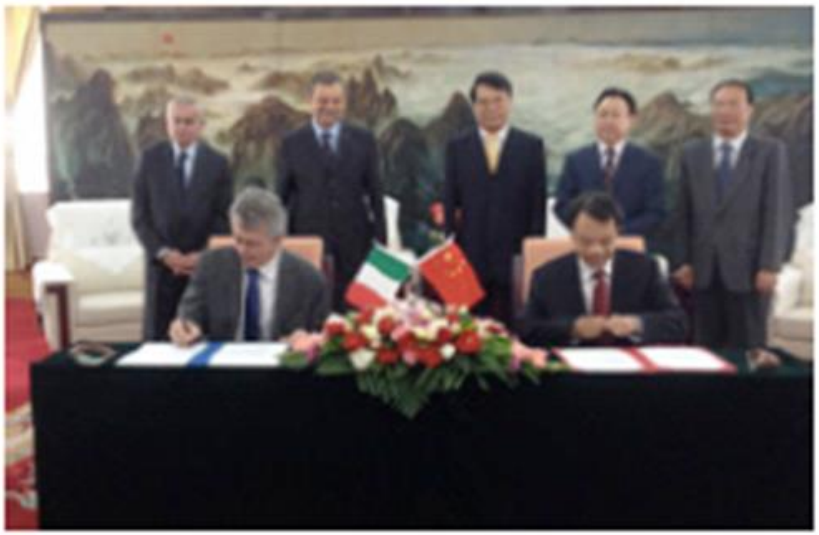


The MAE-MOST 2013-2015 CGEM Project

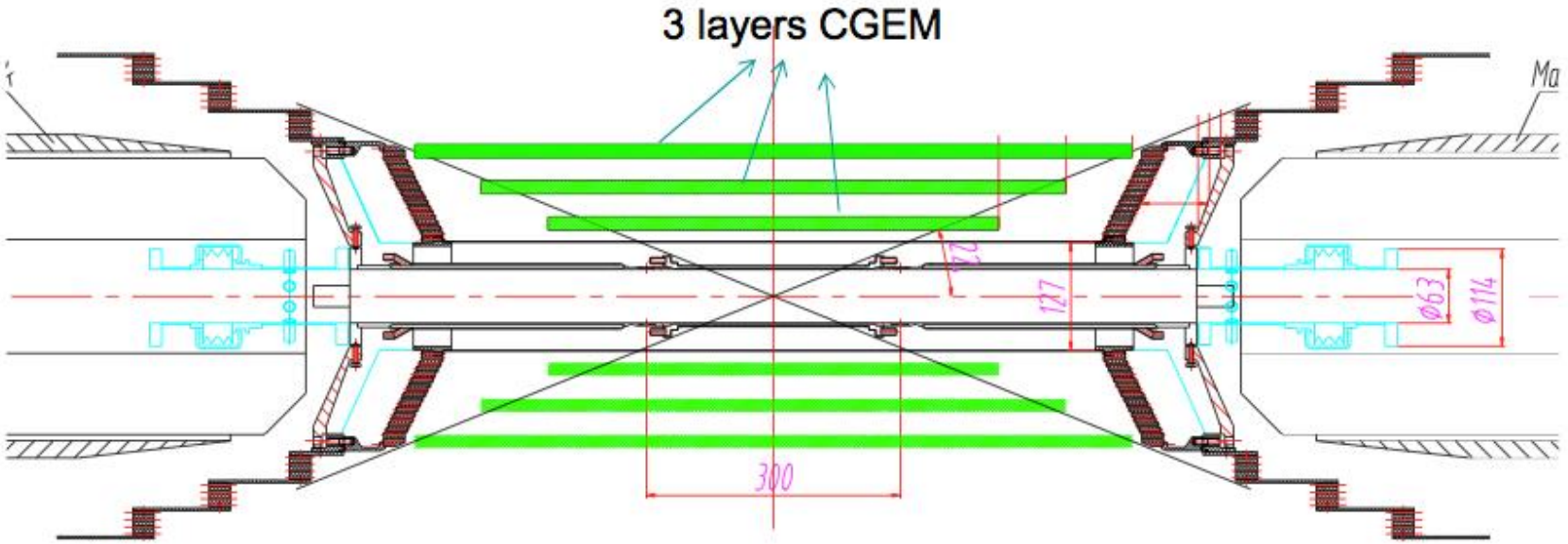
- Design, construction and test of a CGEM prototype, to be used as the first layer of a new CGEM Inner Tracker
- Design, construction and test of an analog readout system
- Budget (euros) provided by INFN, MAE and MOST within the Executive Program for Scientific and Technological Cooperation for 2013-2015: **360K€, in three years**.

Requirements for the inners tracking detector:

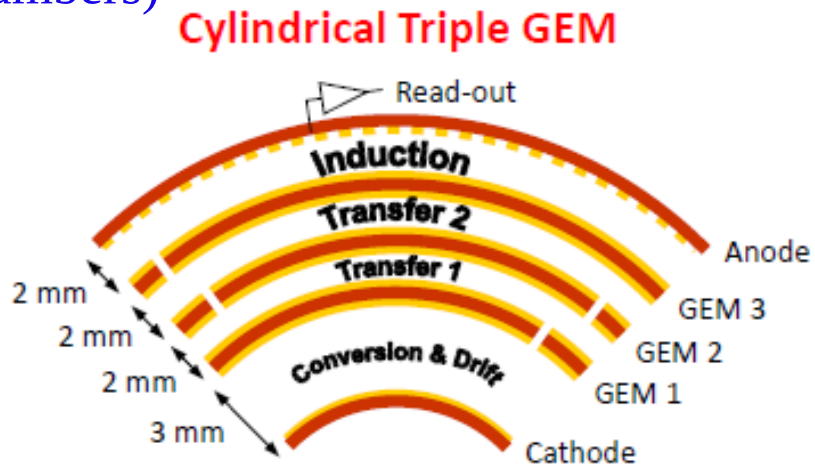
- Rate capability: ~10^4 Hz/cm^2
- Spatial resolution:
  σ_{xy} = ~100μm, σ_z < 1mm
- Momentum resolution:
  σ_{Pt}/P_t = ~0.5% @1GeV
- Efficiency = ~98%
- Material budget ≤ 1.5% all layers
- Coverage: 93% 4π
- Operation duration ~ 5 years



The BESIII CGEM-IT

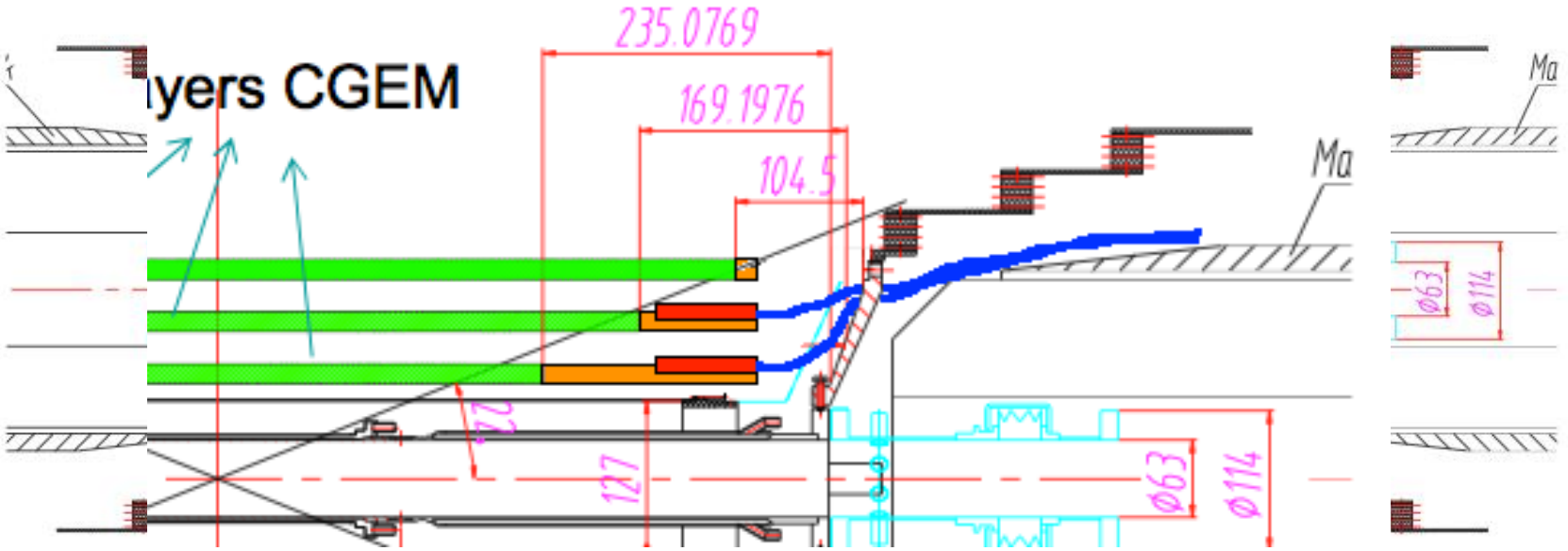


- Number of active layers: 3 (independent chambers)
- Active area
  - L1 length 532 mm
  - L2 length: 690 mm
  - L3 length: 847 mm
- Inner radius: 78 mm, Outer radius: 178 mm



- **New Rohacell supports and anodes: material budget < 1%!**

The BESIII CGEM-IT



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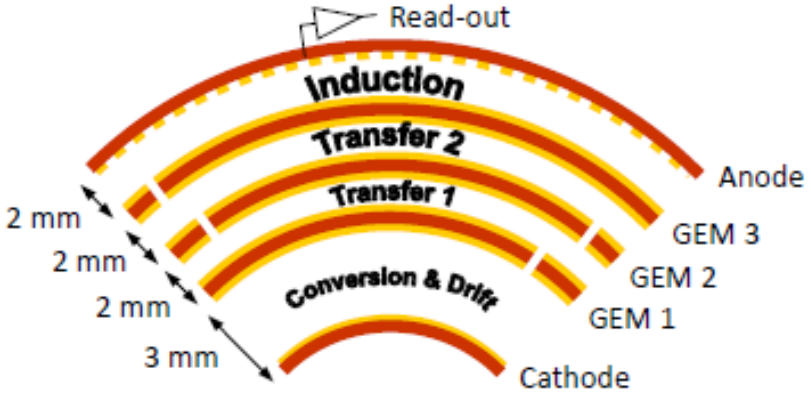
Cylindrical Triple GEM

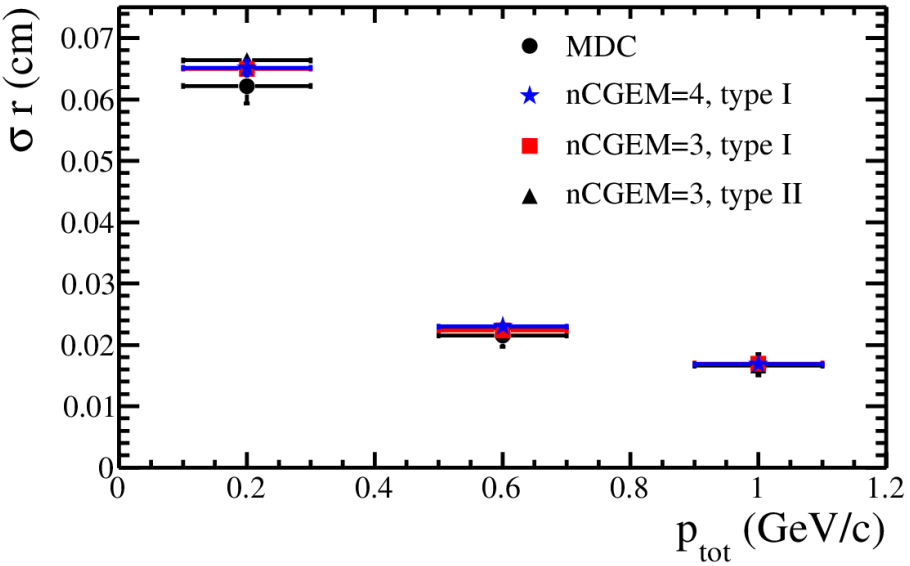


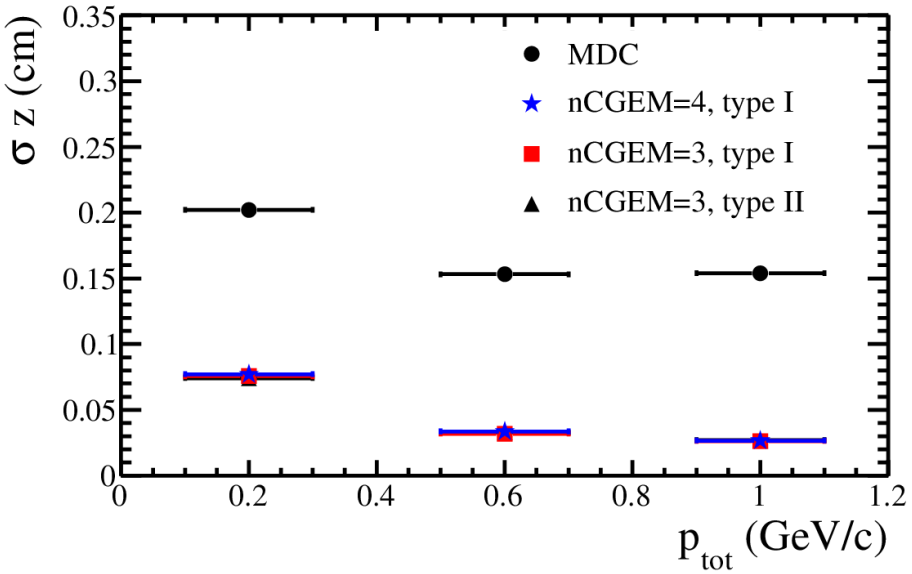
- **New Rohacell supports and anodes: material budget < 1%!**

The BESIII CGEM-IT

CGEM-IT vs MDC-IT:

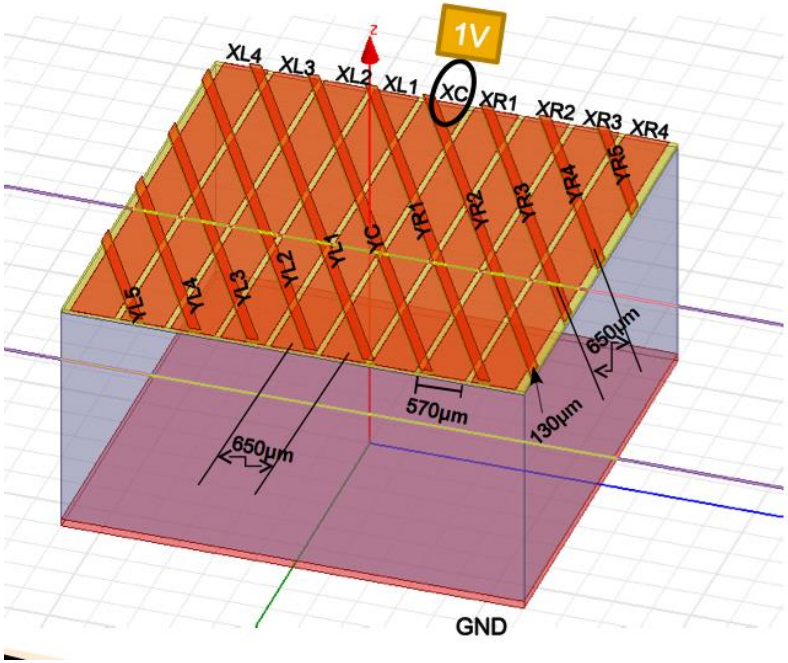
- **Improves σ_z resolution significantly**
  (by a factor of 2.6 ÷ 6)
- **Comparable σ_r resolution**
  (~5% poorer for low momentum tracks)
- **Comparable momentum resolution**
  (~5% better for high momentum tracks)

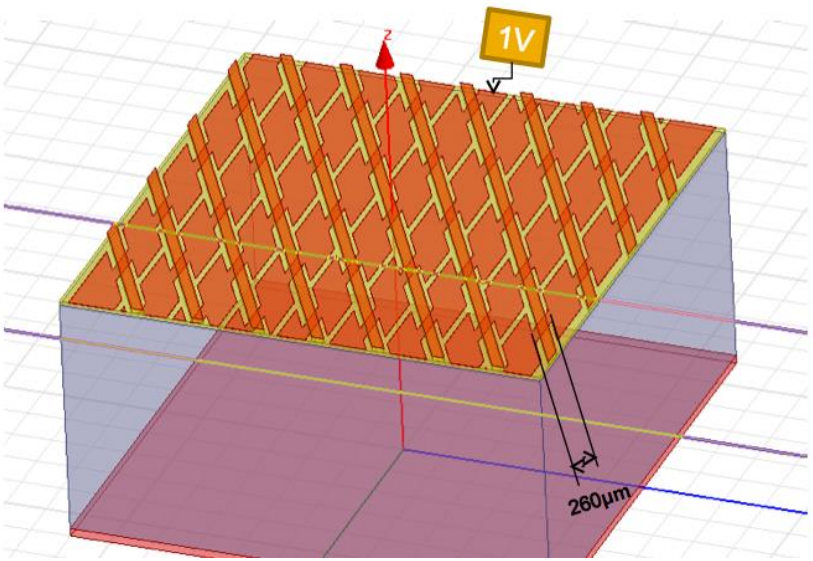




The BESIII CGEM-IT

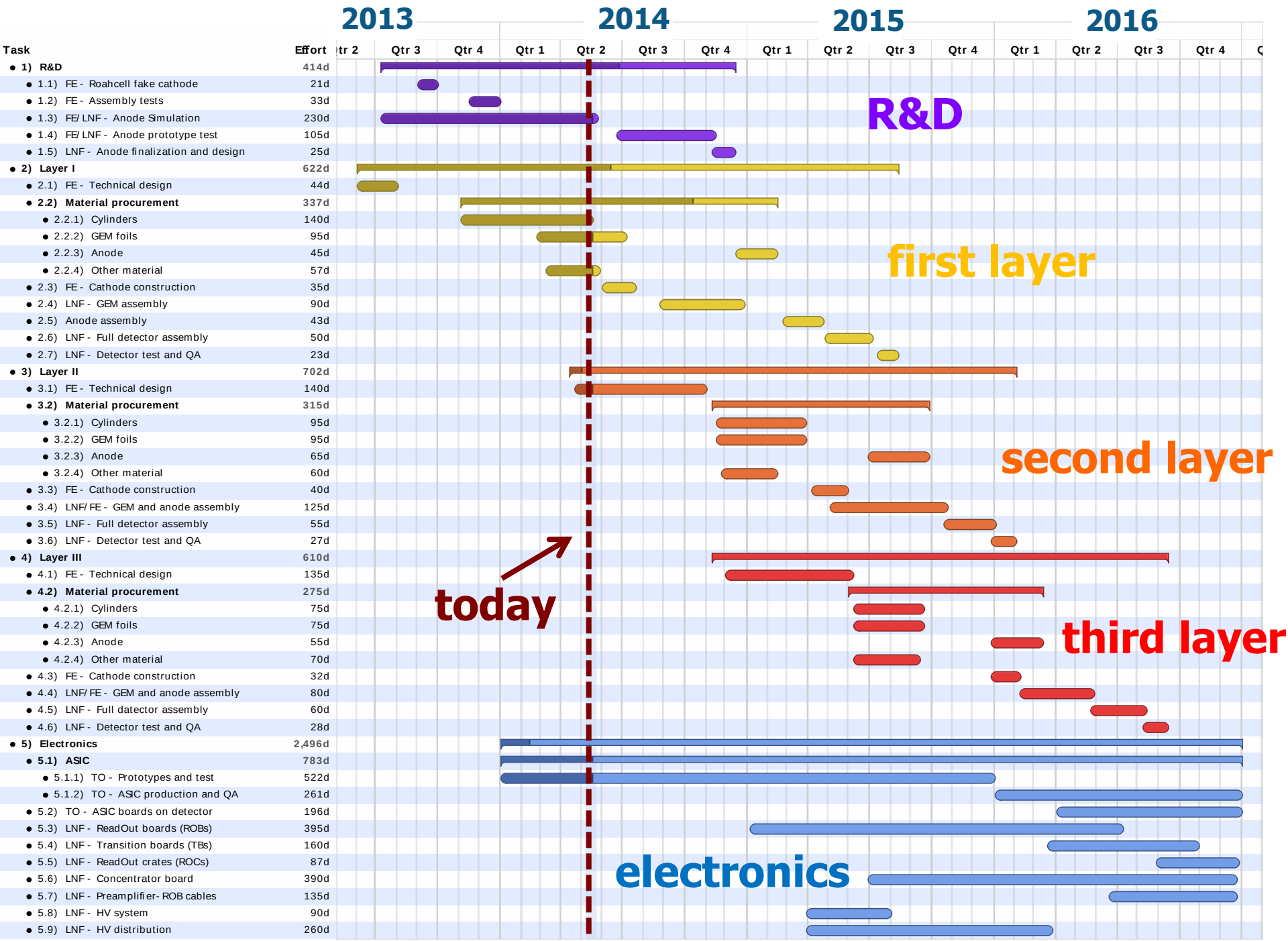
- **structual anode:**
  - different grounding (external) for reduced capacitance
  - robustness with reduced material budget
- **unique readout layout:**
  - strips *a la* COMPASS instead of pads *a la* KLOE-II
  - jagged stereo layout for reduced capacitance





The BESIII CGEM-IT FEE electronics

- BESIII B-field larger than KLOE-II: analogue readout is needed
- Readout ASIC for CGEM:
  - Modify/adapt existing ASICs in Turin developed for medical applications in IBM 130nm
- Re-design a **new analogue FE** (suited for CGEM signals)
- Use of the **same BackEnd**
- Migration to a newer and cheaper technology:
  IBM 130nm → **UMC 110 nm**
  exportable in China (implemented in Italy)
- Integration and Development of the new ASIC for CGEM:
  PhD funded by IHEP at Politecnico di Torino on INFN project


2013
2014
2015
2016
Task
Effort
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
1) R&D 414d
1.1) FE - Roahcell fake cathode 21d
1.2) FE - Assembly tests 33d
1.3) FE/ LNF - Anode Simulation 230d
1.4) FE/ LNF - Anode prototype test 105d
1.5) LNF - Anode finalization and design 25d
2) Layer I 622d
2.1) FE - Technical design 44d
2.2) Material procurement 337d
2.2.1) Cylinders 140d
2.2.2) GEM foils 95d
2.2.3) Anode 45d
2.2.4) Other material 57d
2.3) FE - Cathode construction 35d
2.4) LNF - GEM assembly 90d
2.5) Anode assembly 43d
2.6) LNF - Full detector assembly 50d
2.7) LNF - Detector test and QA 23d
3) Layer II 702d
3.1) FE - Technical design 140d
3.2) Material procurement 315d
3.2.1) Cylinders 95d
3.2.2) GEM foils 95d
3.2.3) Anode 65d
3.2.4) Other material 60d
3.3) FE - Cathode construction 40d
3.4) LNF/ FE - GEM and anode assembly 125d
3.5) LNF - Full detector assembly 55d
3.6) LNF - Detector test and QA 27d
4) Layer III 610d
4.1) FE - Technical design 135d
4.2) Material procurement 275d
4.2.1) Cylinders 75d
4.2.2) GEM foils 75d
4.2.3) Anode 55d
4.2.4) Other material 70d
4.3) FE - Cathode construction 32d
4.4) LNF/ FE - GEM and anode assembly 80d
4.5) LNF - Full datector assembly 60d
4.6) LNF - Detector test and QA 28d
5) Electronics 2,496d
5.1) ASIC 783d
5.1.1) TO - Prototypes and test 522d
5.1.2) TO - ASIC production and QA 261d
5.2) TO - ASIC boards on detector 196d
5.3) LNF - ReadOut boards (ROBs) 395d
5.4) LNF - Transition boards (TBs) 160d
5.5) LNF - ReadOut crates (ROCs) 87d
5.6) LNF - Concentrator board 390d
5.7) LNF - Preamplifier- ROB cables 135d
5.8) LNF - HV system 90d
5.9) LNF - HV distribution 260d
R&D
first layer
second layer
third layer
electronics
today

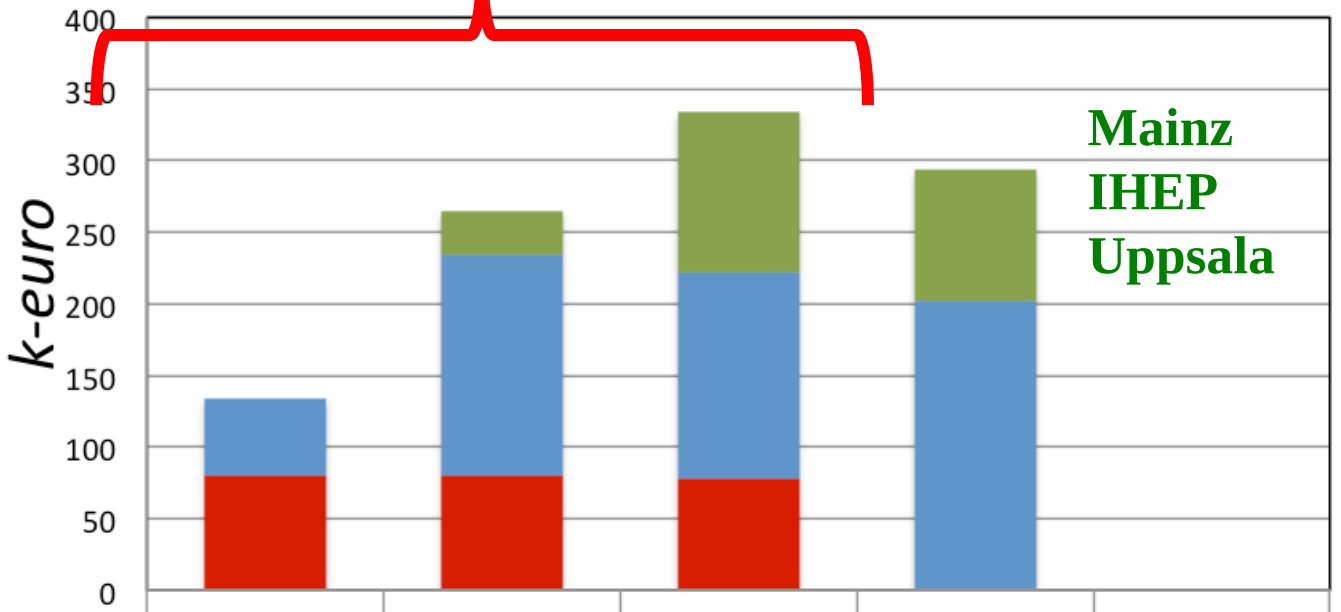
The BESIII CGEM-IT CDR

1. **Introduction**
   1. The present BESIII Inner Tracker
   2. Luminosity Issues
      1. Present and expected backgrounds
   3. Inner Tracker Upgrade Requirements
2. **Detector design**
   1. Operating principle of a triple Cylindrical GEM detector
      1. The KLOE2 Inner Tracker: know-how and first results
   2. BESIII CGEM innovations
      1. Rohacell
      2. Anode design
      3. Analog vs. digital, expectations and measurements
3. **The BESIII CGEM-IT**
   1. CGEM-IT vs DC-IT
   2. Mechanical Design
   3. Tooling and Construction
4. **Simulation of Cylindrical GEM Inner Tracker**
   1. Parametric Simulations (Liang)
   2. CGEM-IT full Offline Reconstruction
      1. Pattern Recognition
      2. Tracking
      3. Acceptance, Resolutions and Reconstruction Efficiencies
   3. Monte Carlo simulation results
      1. Physics Benchmark
5. **Front End Electronics**
   5. Requirements
      5. Power Consumption
   6. System Block Description
   7. On-Detector Electronics
      5. ASIC
   8. Off-Detector Electronics
6. **DAQ and Trigger**
   5. Requirements
   6. Dead time and bandwidth
   7. Possible second level trigger future upgrades
   8. Storage
7. **Integration of the CGEM-IT with the Spectrometer**
   5. Mechanical design
      5. Interfacing with beam pipe
      6. Interfacing with Outer DC
   6. Power Dissipation and Cooling
   7. Gas Systems
   8. HV Systems
   9. Slow Controls
8. **Money, manpower, schedule, task subdivision…..**

Financial cooperation

The full construction cost for 3 CGEM layers is about 990 k€ (not including manpower, integration and installation).
INFN has requested an external contribution of ~200 k€.

+ Exec. Prog. 70 k€ from IHEP for manpower within INFN-MAE-MOST



	2013	2014	2015	2016	2017
Other part.	0	30	112	92	0
INFN	54	155	144	202	0
Exec. Prog. Italy	80	80	78	0	0

The application to H2020-MSCA-RISE-2014

- **new call, first of its kind:**
  - merging old intersectorial calls with calls for cooperation with TCs
  - funding secondments from EU to IHEP
- **application to fund secondments focused on the BESIII CGEM-IT:**
  - title: "An innovative CGEM Inner Tracker for the BESIII Spectrometer"
  - one of the only two applications from INFN
- **INFN-IHEP cooperation seed of EU-IHEP cooperation:**
  - significant contribution from Mainz (U+HIM) and Uppsala

Participant Number	Organisation Short Name	Country	Academic	Number of secondments	Person-months	Estimated budget support (whole duration of the project)				Requested EU contribution/€
						Staff member costs	Research, training and networking costs	Management and indirect costs	Total	
1	INFN	IT	yes	111	146	292 000	262 800	102 200	657 000	657 000
2	JGU-Mainz	DE	yes	97	149	298 000	268 200	104 300	670 500	670 500
3	UUppsala	SE	yes	25	38	76 000	68 400	26 600	171 000	171 000
4	IHEP	CN	yes	13	54	108 000	97 200	37 800	243 000	0
Total				246	387	774 000	696 600	270 900	1 741 500	1 498 500

Torino INFN-Politecnico Joint PhD Curriculum

- **INFN and Politecnico di Torino:**
  - PhD sub-curriculum in Microelectronics and Integrated Electronic Devices
  - INFN provides 3 PhD grants to the sub-curriculum
- **IHEP is involved:**
  - 1 of the INFN PhD grants per PhD cycle will be funded by IHEP
  - grant reserved for a candidate selected by IHEP
  - LOI signed by IHEP on 2013/07/05
- **INFN-Politecnico:**
  - agreement to be signed soon
- **INFN-IHEP:**
  - 1 PhD student, funded directly by IHEP, already started his PhD
  - MoU to be defined and signed once the INFN-Politecnico agreement will become operational

Summary

- **INFN physics and computing activities:**
  - leading contribution in investigating amplitude phases
  - unique computing environment
- **exciting hardware R&D:**
  - CGEM inspired by KLOE-IT
  - a new detector of its kind
- **key innovations:**
  - Rohacell support
    - much more transparent to radiation
    - better rigidity with less weight
  - new analogue/digital electronics: custom ASIC
- **fast growing interaction among INFN and IHEP:**
  - extended to Germany an Sweden
  - looking for EU funds
  - involving a PhD sub-curriculum from INFN-Politecnico

Thanks!

謝謝